High Performance Image Control System Ver. 9.1

HiPic users manual

By Hamamatsu Photonics Deutschland GmbH

This manual was produced using *ComponentOne Doc-To-Help*.

Contents

Introduction

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Security/Precautions

This chapter deals with the precautions you should observe when handling and operation the devices used in your system. This is of course primarily to avoid risk of dangers related to your live and health (like electrical shock) but also to prevent any damage to the used device (like damage due to overexposure). Please read the following chapters carefully and don't operate the devices unless you are sure that you are operating them on a save basis.

Precautions of individual devices

At first please read the safety instructions of the individual devices. Every device has its own handling manual where its safety precautions are described properly.

Overexposure

One risk for an operated device is that it might be overexposed, which in certain cases may lead to a damage or even the destruction of the device. Devices which may be damaged during overexposure are Image intensifiers, other type of tube cameras and also some kind of CCD cameras at least if they are exposed under special conditions (UV, very strong light etc.).

CCD cooler / vacuum

Be also careful to operate the CCD cooler, an option water cooler and an optional vacuum pump in the proper way. Please read the handling instructions of these devices carefully. Also open or close attached valves only in the correct order. Otherwise condensation on the CCD chip or contamination may occur.

Image Intensifier

An image intensifier is a device which is very sensitive to illumination and can be easily damaged. This is especially true when the high voltage is applied to the photocathode. If a system which includes an image intensifier is operated illumination should very low in the beginning and stepwise increased by continuously monitoring the output on the computers screen with the maximum available contrast enhancement appropriate for the given case.

X-Ray Tubes

When using and controlling X-ray tubes with this program all national and international regulations concerning the operation of X-ray radiation have to be strictly obeyed. A correct shielding and correct connection of interlock switches and other security measures have to be done in accordance with the installation manual and the regulations defined by law.

Every risk of damage and injury has to be avoided.

Help / Info

HiPic is designed to offer a user-friendly operation system for these cameras as well as all basic image processing functions needed for routine work. In many cases the user can just guess by the command names and the arrangement of the user I/F controls how a desired function works.

How do I get more information about this program?

The following possibilities are available to get more information about this program, what it can do and how this can be achieved.

- A windows help system explains - divided in small easy to understand topics - the program and all its parts
- For those how like to study the feature of this with the help of a printed manual also such a manual is available.

In which circumstances should I read the information in this documentation?

- To get started with the digital image processing system.
- To get detailed information about complex operation methods and procedures. Since HiPic is a "look and feel" program, you may not need this manual for your daily work. However there are several functions which may not be understood easily by just using the program. We have put priority to explain such items in this manual.

How do I use this help system?

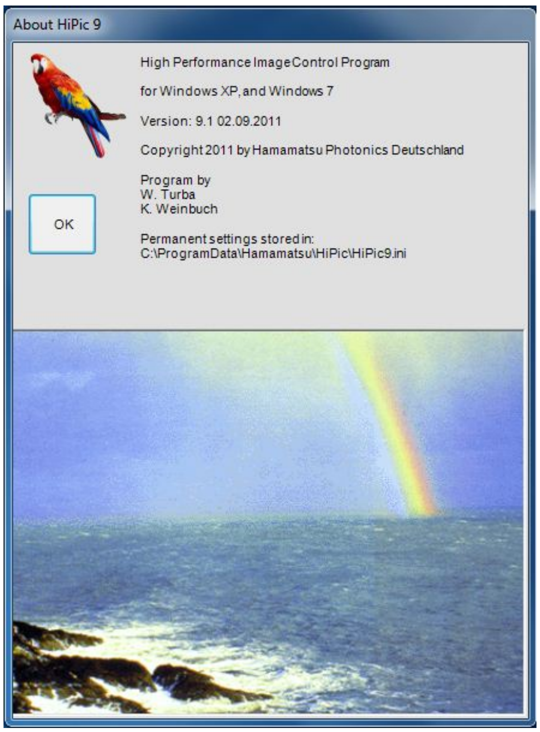
To use this help system simply press F1 from the program or double-click to the Help file from the explorer. The Help system will open the help dialog.

Help

The help system can also be invoked by executing the Help… menu entry from the Info main menu.

About

Executing the About menu entry from the Info main menu shows the about Dialog which gives you information about the current program version and other version related information.



Screenshots in this help system

Screenshots are used extensively to demonstrate the operation and behavior of the program in principle. However, depending on the Operation system, the color scheme and also other setting in your program the program may look like slightly different.

Features

General

The **Hipic (High Performance image control) software** is an image processing software for high performance CCD cameras. It can be used in combination with most Hamamatsu digital cameras like the ORCA-Flash 2.8, ORCA-R^2, ORCA-D^2,ORCA, ORCA II, C4880, C8800, C9100, C9300 cameras, standard analog video cameras (CCIR or EIA standard), TDI cameras (C10000) and X-ray TDI cameras, CMOS X-ray flat panel sensors and X-Ray TDI and line sensors.

The camera is connected to an IBM-compatible PC via a frame grabber board. The board performs tasks like digital image acquisition, pseudo-colour generation or image accumulation.

In order to work with HiPic you have to install a hardware lock.

If this is not installed, HiPic works in demonstration mode only.

The HiPic is available as 32 bit as well as 64 bit application software.

What is new in version 9.1?

The following features are new or improved in version 9.1 compared to version 9.0:

- The distribution contains a native 32 bit application as well as a 64 bit application.
- The application checks the operating system and displays _D2HLink_39711
- Also the “Select new camera” wizard only offers valid choices.
- The 64 bit application has some smaller limitations: The function to make a Gauss fit for FWHM calculation on the quick profile is disabled.
  The possibility of running scripts within the RemoteEx is disabled.
- New installers have been added to install the Sapera library and the related device drivers.
- Functions for image analysis and ROI handling have been added to the RemoteEx.

- A protocol can now be written when MFX (Micro Focus X-Ray) sources are used.

Hints for users familiar with version 7 or before

Between version 7 and version 8 the whole user interface has been redesigned. Users familiar with older versions (like version 7 or 6) may find several features confusing at the first glance. This is due to the fact that some features have been improved to comply with modern windows standard. Reading the following small chapter may help to resolve this confusing situation.

Options

First of all such users may desperately search for options at well defined locations and cannot find them any more. The solution is simple: All options including the former camera setup parameters have been collected in the options dialog and can be called with the main menu entry **file – options** or with a context sensitive menu. Please see also the chapter Basic operations - Options and Selecting Measurement parameters – Options in the document.

Right mouse click redefined

Another change was to introduce context sensitive menus with right mouse click. As a consequence the right mouse click which is used to zoom out images is no longer available. There are two solutions for this: Generally speaking all right mouse clicks are replaced by the shift key. In other words zoom out can be done by Shift Key + Left Mouse click. The second solution is to use the context sensitive menu to select the zoom factor directly. Please see also the chapter Context sensitive menus and zoom in this document.

ROIs

The third topic which is very different from earlier versions is how to draw and handle ROIs. The biggest difference is that a new ROI can only be draw when a ROI type is selected in the toolbar. After selection the ROI this ROI type is no longer valid thus the ROI cannot be easily overwritten. To draw more then one ROI just select a ROI type again. To select one ROI just click to it and to delete press the delete key. The new ROI types "Full horizontal" and "Full vertical" may satisfy the request from many users in the past. Please see also the chapter The Elements of the user I/F - ROIs and Image display Windows – ROIs in this document.

Supported hardware and hardware setup

Image sensors

The HiPic supports the following image sensors:

Area CCD Cameras:

ORCA-Flash 2.8, ORCA-R^2, ORCA-D^2, C9300, C8800, ORCA AG, ORCA-ER, C4742-95 (ORCA 100), C4880 (includes C4880-00, C4880-10, C4880-20, C4880-21, C4880-30, C4880-31, C4880-40, C4880-50, C4880-60, C4880-91, C4880-92, C4880-93, C5987, C6918-05, C7190-10), C4880-8X (includes C6790-8X), C8000-10, C7300, ORCA-HR,

TDI Cameras:

C10000-201, -401, -505, -601, 7-01

Analog CCD Cameras:

C8000-20 (includes C7190-2X, C7190-4X, C7190-5X)

X-Ray TDI and Line Sensors:

C7390, C8133, C8750, C9750, C9133, C10650, C10800

X-Ray Flat panel sensors:

C7921, C7942, C7943, 9250, C9250, C9321, C9720, C10013, C10158, C10322D, C10500D, C10900, C10901, C9311, C9312, C9252DK, C10502D

X-Ray CCD dental camera

C9266

Please note that color cameras are not supported at all by this program.

Auxiliary devices

All currently available Hamamatsu MFX (Microfocus X-ray) sources are supported as auxiliary devices.

Frame Grabber

The following frame grabber boards are supported.

Fire Wire A and B

Board	Comment
IEEE 1394 OHCI PCI board	
On board fire wire I/F on desktop or laptop PC	
IOI IEEE 1394B OHCI PCIe board	This is the only one recommended for Fire Wire B cameras (ORCA-R^2, ORCA-D^2)

Camera Link

Board	Company	Bus	Configuration
X64 Xcelera-CL PX4 DUAL	Dalsa	PCIExpress X4	Medium config.
X64 Xcelera-CL LX1 BASE	Dalsa	PCIExpress X1	Base config
X64 Xcelera-CL PX4 FULL	Dalsa	PCIExpress X4	Full config

PC-CamLink	Dalsa	PCI32	Base config
PHOENIX-AS-PHX-D24CL-PCI32B	AS	PCI32	Base config
PHOENIX-AS-PHX-D24CL-PE1	AS	PCIExpress X1	
PHOENIX-AS-PHX-D48CL-PE1	AS	PCIExpress X1	Medium config.
PHOENIX-AS-PHX-D48CL-PE4	AS	PCIExpress X4	Medium config.
PHOENIX-AS-PHX-D64CL-PE4	AS	PCIExpress X4	Full config.
PHOENIX-AS-PHX-D48CL-PCI64	AS	PCI64	Medium config.
PCI-1426	NI	PCI32	Base config
PCI-1428	NI	PCI32	Base config
X64-iPro Light	Dalsa	PCI64/ PCI32	Base config
X64-Full	Dalsa	PCI64/ PCI32	Full config.

Notes:
AS: Active Silicon
NI: National Instruments
The PCCamLink is discontinued

RS422/LVDS

Board	Company	Bus	Comment
PHOENIX-AS-PHX-D36-PCI32	AS	PCI32	LVDS only (but works with RS422 as well)
PHOENIX-AS-PHX-D36-PE1	AS	PCIExpress X1	LVDS only (but works with RS422 as well)
PCI 1422	NI	PCI32	LVDS or RS422
PCI 1424	NI	PCI32	LVDS or RS422
X64 XCelera LVDS	Dalsa	PCIExpress X4	LVDS only (but works with RS422 as well)
PC-DIG	Coreco/ Dalsa	PCI32	Exists in RS422 or LVDS version

The following grabbers are discontinued:
PC-DIG (Dalsa)
PHOENIX-AS-PHX-D36-PCI64 (AS)
PC-CamLink (Dalsa)

Limitations on 64 Bit operating systems

The 32 bit software can be used on 64 bit operating systems as well. There are some limitations when using specific hardware. The following hardware do not have drivers for 64 Bit operating systems:
IC-PCI, PC-DIG, PC-CamLink, PC-Vision, PCI 1422, PCI 1424, Active Silicon PCI boards, PC2Vision PCI bus version.

The boards XCelera PX4, LX1 and PC2Vision PCI-Express version can only be used with the 64 Bit version of the HiPic because no WOW64 bit driver is available. The 32 bit application does not work with these boards.

Required Computer

Any state of the art PC with Windows XP or Windows 7 can be used to operate the Software.

Be careful that the PC has enough free slots to place the required interface boards. A parallel port or USB port is required for the hardware lock. Please also make sure that slots are suitable to contain the interface boards, for example not all PCI Express slots support PX4. In rare cases the computer is incompatible with the interfaced boards. It is out of control of Hamamatsu to ensure compatibility in all cases and Hamamatsu cannot be made liable for such problems even though we try to do everything to avoid any problem. If large images have to be viewed a large monitor is advantageous.

The standard software is a 32 bit software and intended to be run on a 32 bit operating system. If hardware drivers for WOW64 are available this program can also work on a 64 bit operating system. In this case it works as a 32 bit application on the so called WOW64 (Windows on Windows) subsystem. Please check with Hamamatsu if the hardware you intend to use (frame grabber etc.) is compatible with such configuration.

A 64 bit version of the HiPic is on the distribution CD which can be used on 64 Bit operating systems. When using this version no WOW64 but standard 64 Bit drivers for the hardware are necessary.

Internal driver and DCAM driver

To understand which cameras or more precisely speaking which combinations of cameras and frame grabbers are supported we have to know that there are two methods of interfacing the camera/frame grabber:

- Internal driver (using software modules written together with the main application)
- DCAM API (using software modules provided by the manufacturer, Hamamatsu KK Japan)

Many combinations of cameras/frame grabber are supported using both methods. However there are combinations of cameras/grabbers which are only supported by one of these methods. The following is an overview of hardware supported by internal drivers. To find out which cameras/grabbers are supported by DCAM please see the release notes on the DCAM section of your distribution CD or consult the following website.

http://www.dcamapi.com/

In almost all cases you do not need to know about this selection because it is done very easily with the Using the "Select new camera Assistant…" (page 14) function.

Installation

This chapter describes the hardware configuration, set-up and software installation of the HiPic system. If your system was already pre-installed by Hamamatsu you do not need to read his chapter.

Note: Please install the software at first and install the hardware in a second step.

Setup launcher

HiPic software is delivered on a CD.

Note: You should install the plugin boards like frame grabbers or IEEE1394 adapters into your computer **after** the software installation is completed.

Start Windows XP or Windows 7.

Insert the CD into you CD drive. The installation program will normally be started automatically by a "autostart" routine.

If it does not run automatically, select "**Run**" from the "**Start**" menu and type **D:\Setup** then click **"OK"** (assuming that your CD drive has the drive letter D:) or select the directory **D:** and double click on the file Setup.exe.

The set-up program will start displaying the setup launcher dialog.

The setup launcher is a collection of setup programs from Hamamatsu and third parties to install the main program, several drivers and other utilities.

Notes: Please make sure that elder versions of all programs/drivers and utilities are uninstalled before the new version is installed.

Please collect information about the camera type and interface type (grabber, IEEE1394 etc.) before you start the installation.

Program installation

Start with the program installation by pressing the **"1. HiPic Program"** button.

Follow the instructions displayed on the screen.

After installation of the Hipic you will find the following three icons on the desktop:

HiPic Main program

HiPic RemoteEx program

RemoteEx Client sample program

Installing the 64 Bit Version of HiPic

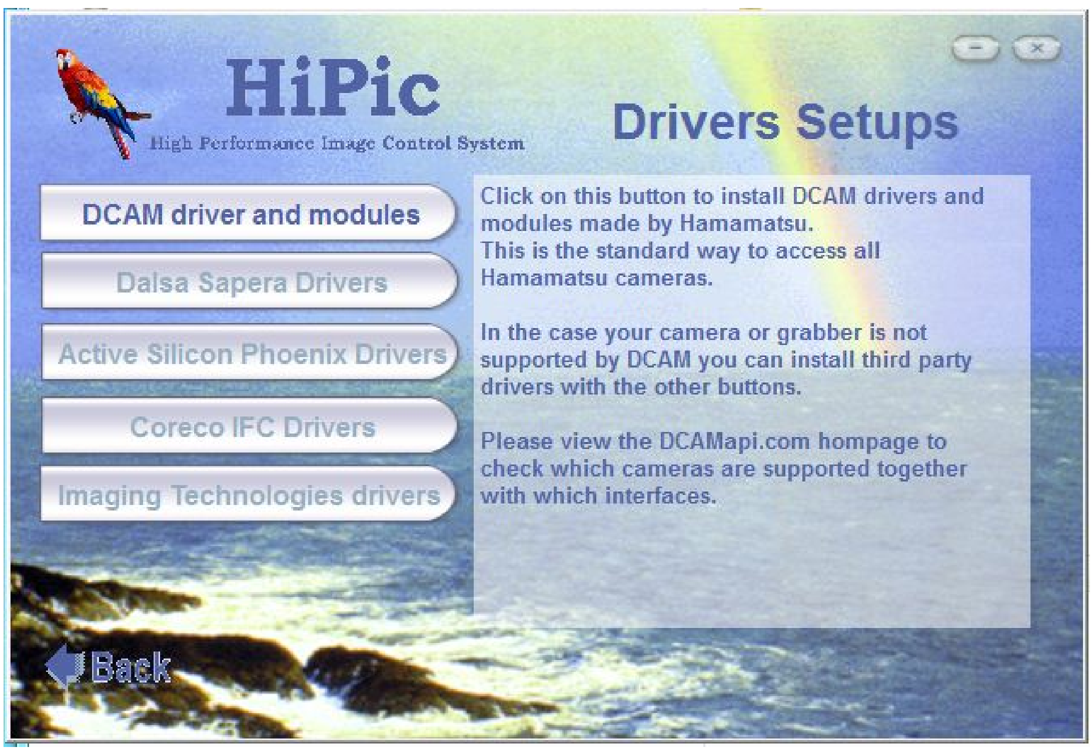
The distribution CD contains a subdirectory with all the files necessary to operate the 64 bit HiPic. To install this version please click to “HiPic 64 Bit Application” and follow the instructions which appear.

Hardware lock

The software is protected by a hardware lock. Install the drivers of the hardware lock by clicking to **“2. Hardware protection”**.

Driver Installation

Install all necessary drivers to operate the additional hardware by clicking to**”3. Drivers”** and select the drivers you need.



If your are not sure which drivers you should use start the HiPic and press Using the "Select new camera Assistant…" (page 14) function. This will guide you through the camera selection process step by step. At the end of this process you will get a summary of the camera / frame grabber combination and an instruction which additional drivers to install.

After completion of the installation you have to re-boot your system.

Hardware installation

Proceed with following steps to install the hardware of your HiPic system:

Step 1: Install the frame grabber or IEEE1394 interface board in your computer.

Be sure to install the frame grabber / IEEE1394 board in a suitable slot. Disconnect the computer from power and open the computer. Handle these boards with precaution. Be sure that such work is done by authorized personal only.

Step 2: Install the software protection.

Connect the hardware lock (this is a 25 pin connector labeled with the name of the program or a USB stick type) to the parallel port (LPT1) or an USB port of your computer. The hardware lock is delivered with the HiPic program disk.

Step 3: Make the cable connections

- Connect all cables of your computer (AC cable, keyboard, mouse, monitor etc.)
- Connect all AC line cables of your other devices.
- Connect the camera to the input connector of the frame gabber board.
- Connect the camera head to the camera controller.
- Connect the serial cable to a **serial interface** port (default: COM 1) of your computer if the camera requires such connection. You can use any COM port, but you have to indicate this port during start-up. If you use a camera with CameraLink interface all control commands are sent via the CameraLink cable, so no additional serial interface cable is required.
- When using a MFX: Install the MFX (Microfocus X-ray tube) according to the installation manual and connect the serial cable to a free COM port at the computer side.
- Connect the water cooler (in case of a water cooled camera type).

Changing/Selecting different hardware from the intro screen.

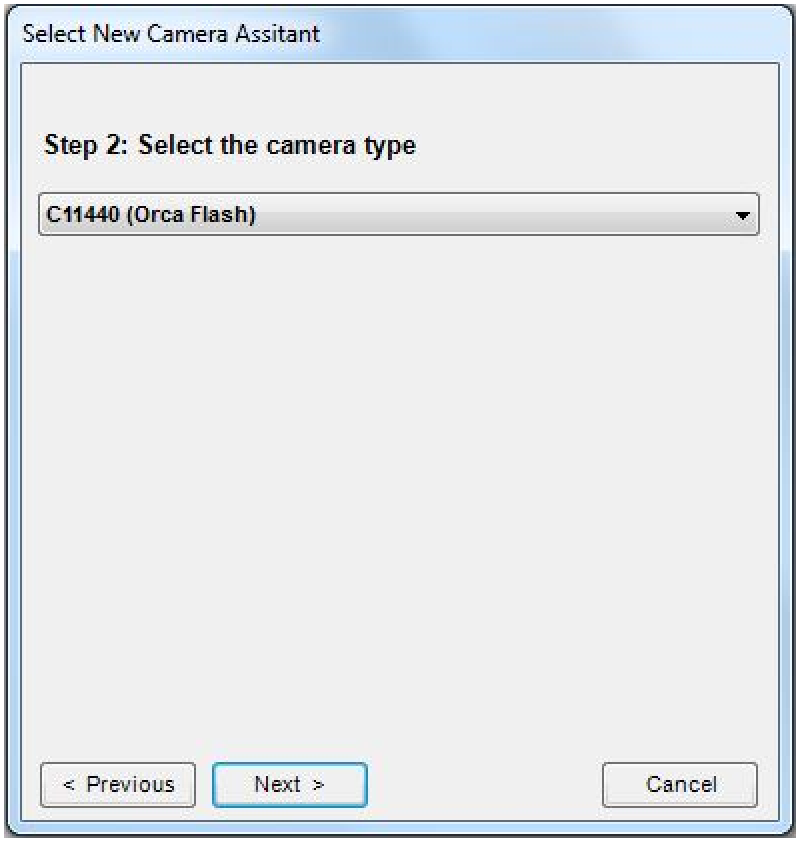
Normally the correct access mode (internal driver/DCAM API), the frame grabber and the camera selection are done by a Hamamatsu engineer during installation. Only in seldom cases - like if you selected a wrong camera model or if you want to change it later - you have to change it after you started the program but before you start the program finally by clicking OK.

Using the “Select new camera Assistant…”

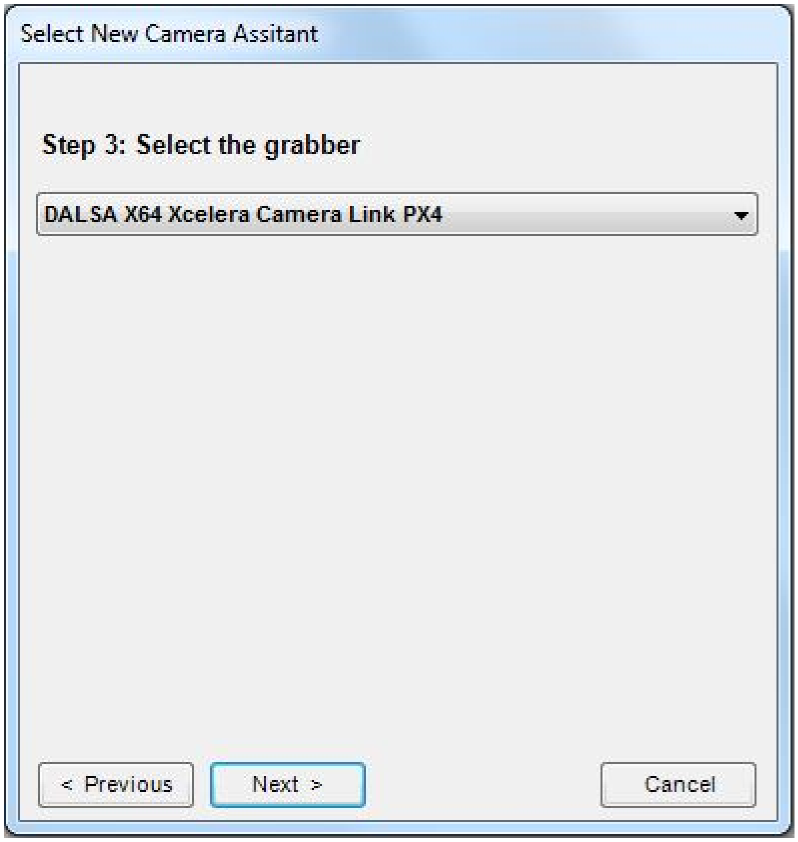
If no camera has been selected or if you want to change the selected camera you can select all settings required by a camera / frame grabber combination in a very convenient way by using the “Select new camera Assistant…” and following the steps. As an example we show the setup of an Orca Flash camera operated by an XCelera board.

In the first step we select “Camera Link”

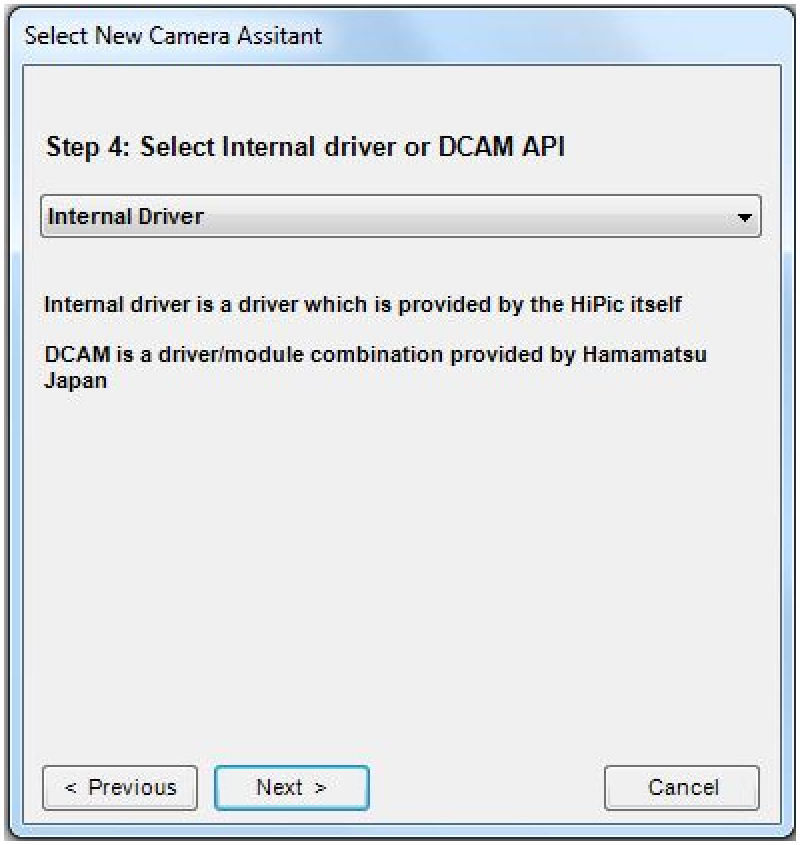
Then we select the camera:



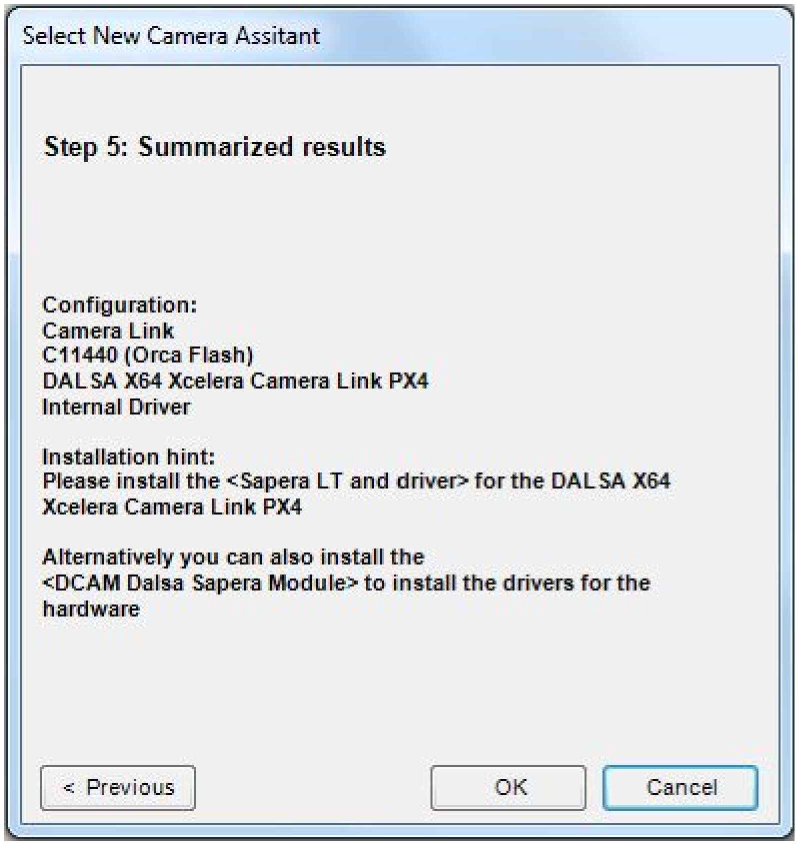
Then we select the grabber:



Then we select whether we want to access the camera through internal driver or DCAM. Both ways are valid and depends on the users taste. The user I/F between both methods may vary slightly:



As a last step we get a summary of the selection and an instruction which driver or libraries have to be installed to operate this camera and grabber:

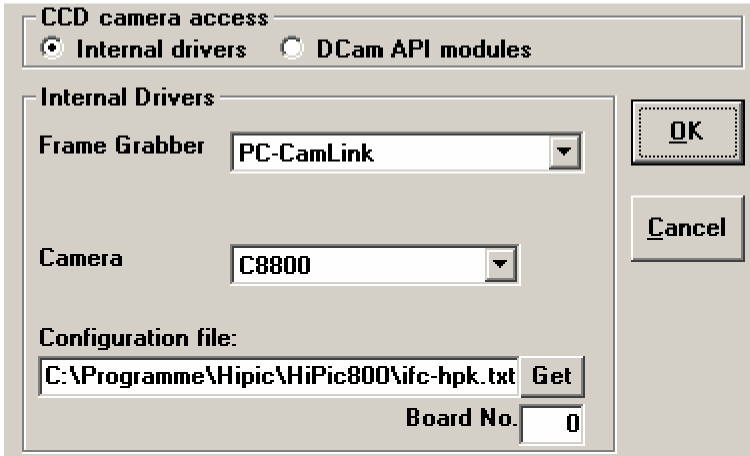


In some cases I we have do add some special settings. This is the case if we need to specify:

- A COM Port number
- A special COM port baud rate (different from 9600 baud)
- A system number not equal to 0. This is the case if you have installed several board of the same type or supported with the same library.
- If several cameras are supported through DCAM at a time you may need to select the correct model number.

Changing CCD camera setting

Alternatively we can also select the grabber / camera / configuration file manually. In this case you should be sure to specify the correct grabber, camera number, configuration file and board number.



Note: The program will save your settings automatically. When you start it the next time you will find that the previous settings are already set.

If all settings are finished you have to click **OK** in order to start the application.

Camera configuration files

The following camera configuration files are delivered with the HiPic. These files are installed and specified at installation time. Only if you change the frame grabber (or in certain cases also the camera) you need to change this specification manually.

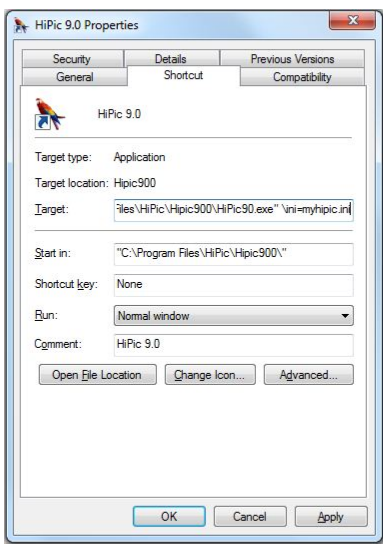
Configuration file..	**...with frame grabber...**	**... for the cameras**
DIGITAL.CNF	IC-PCI+AM DIG	All digital cameras like C4742 (ORCA) series and C4880 series
CCIR.CNF	IC-PCI+AM VS	For analog video cameras with CCIR standard
EIA.CNF	IC-PCI+AM VS	For analog video cameras with EIA standard
PCVSCCIR.CNF	PCVision	For analog video cameras with CCIR standard
PCVS_EIA640.CNF	PCVision	For analog video cameras with EIA standard

PCDig.txt	PCDig	All digital cameras
Ifc-hpk.txt	PCDig/PCCamLink	All digital cameras
Hamamatsu_DCAM.pcf	Phoenix grabber	All digital cameras
Hamamatsu_DCAM.ccf	X64 Xcelera, X64 Full, X64 iProLight	All digital cameras
P2V_CCIR.ccf	PC2-Vision	CCIR cameras
P2V_EIA.ccf	PC2-Vision	EIA cameras
The National Instruments frame grabber PCI 1422, PCI 1424, NI PCI 1426, PCI 1428 and PCI 1429e do not require such file.		

Setting a different file as *INI file.

The HiPic uses the file hipic9.ini in the windows or the documents and settings directory as the default to store all parameters.

To specify a different file as the file which stores permanent parameters a command line argument can be used. The command line can be specified in the link to the program.



Instead of the default target:

“C:\Program Files\Hipic\HiPic910\HiPic91.exe”

you can use the following statement:

“C:\Program Files\Hipic\HiPic910\HiPic91.exe /ini=myhipic.ini”

If the /ini=file statement contains a full path statement this path is used otherwise the file is searched in the windows directory.

Start option by command line argument

There are two ways to start the HiPic in a different way than normal which can be used by specifying a command line option:

/Boot=Quick	Starts the HiPic without Intro screen.
/Boot=Live	Start the HiPic without Intro screen and executes LIVE mode with the latest settings immediately

Basic operations

This topic describes how to perform basic operations of the program, how to get started and how to get familiar with it in short time.

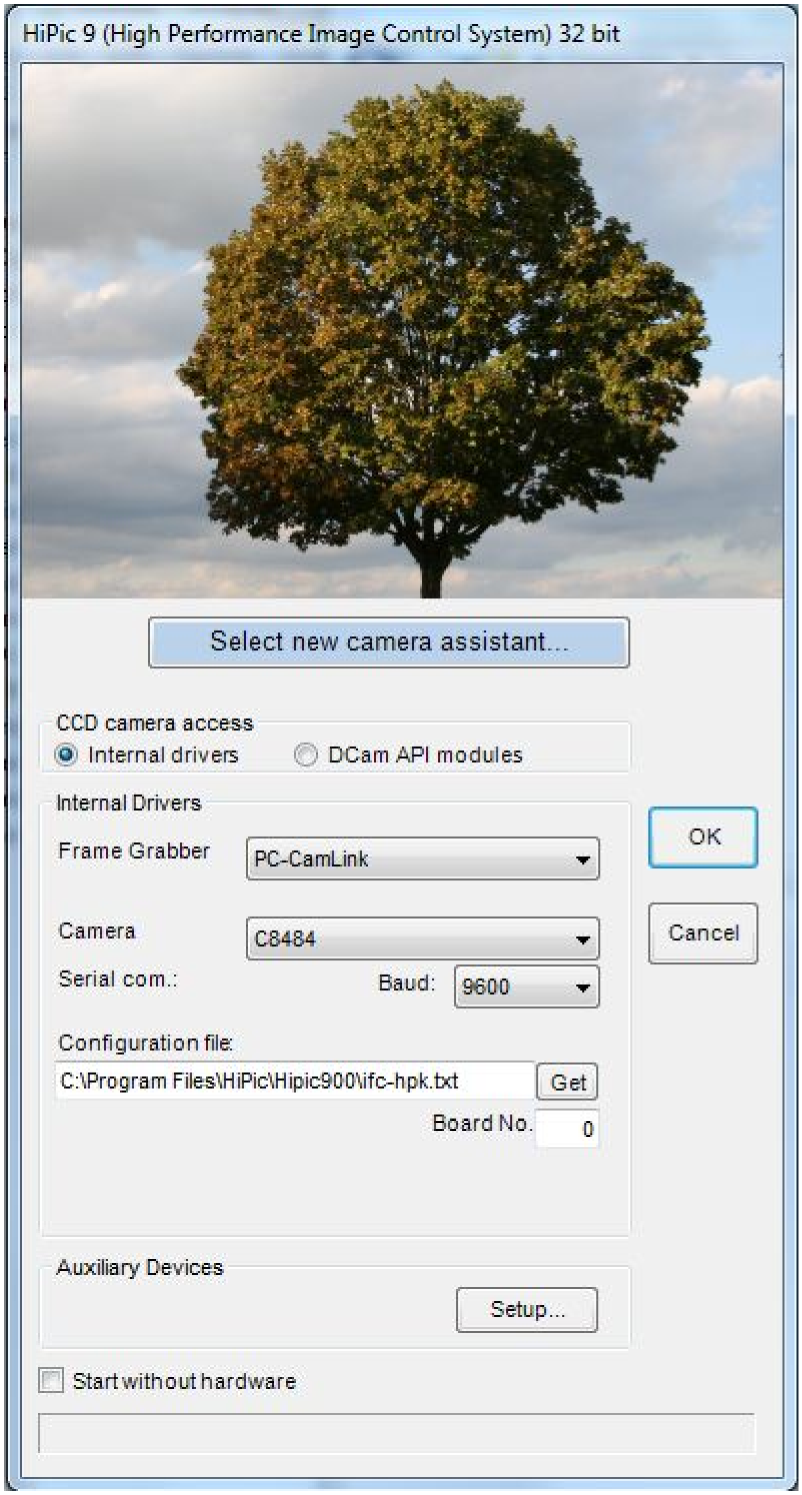
Getting started

This topic describes how to get started with the program.

Start the program

To start the program simply click to the icon  displayed on the desktop or select the appropriate command within the program tree: Start – Programs – HiPic 9 – HiPic 9.1. . If you are familiar with the windows explorer and with starting programs by clicking on the executable files you can also locate the application directory and double-click to hipic91.exe .

The introduction screen will appear. While this screen is open you can select access mode (internal driver/DCAM), frame grabber, camera and in certain cases also COM port and baud rate of the serial communication.

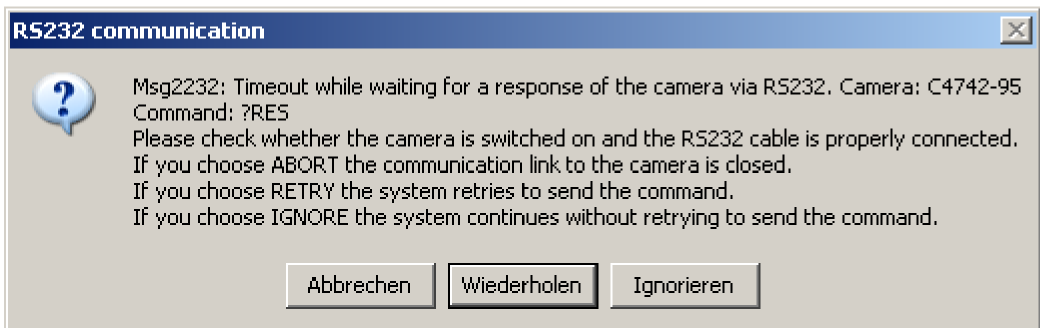


All these settings have been done during setup and/or installation by a Hamamatsu engineer and are kept permanently. We therefore assume that we do not need to make any modifications here and we can go on starting the program by hitting Enter or clicking to the OK pushbutton. If you like to Cancel the starting process click to Cancel now.

Sometimes you want to start the program just for viewing and analyzing images. This can be done by selecting the option “Start without hardware”. This option is active only for the current session and will be reset the next time you start the program again.

Serial communication problems during startup

Most CCD cameras are controlled by a serial interface (sometimes this serial interface is operated through the cable which also transfers the digital data. This is the case for Camera Link cameras). If a problem during serial I/F communication happens the RS232 Timeout dialogue will appear.



RS232 Timeout dialogue

Several reasons can lead to such a timeout. In most cases either the RS232 cable is not connected or the device is simply not switched on. Another reason can be that the wrong baud rate (clock speed) is selected in the startup screen. Most cameras use 9600 baud, however the camera you are using may need a different setting. Correct the error here and go on by selecting “Retry”. Sometimes only a certain serial command cannot be understood by the camera. In such cases Ignore continues the program without sending the command again. Abort aborts the communication process closes the communication and continues the program without any communication.

Acquiring images from a camera

We assume that the CCD camera is already switched on.

If the camera is equipped with water cooling switch on the cooling water now. Some older cooled cameras have a vacuum pump to avoid condensation on chip. If so, please switch on this vacuum pump and open all necessary valves as has been explained during installation of the system. Most modern cameras however do not have such peripheral equipment as they are permanently sealed and there is nothing to do here.

Images can be acquired using the camera acquisition dialog. Even though the acquisition dialogs for different cameras look somehow different you will find the pushbuttons for Live mode and Acquire mode on every camera acquisition dialog. Most dialogs have also a Single image pushbutton which acquires an image with the parameters selected for live mode. Any image acquisition can only be started if the camera acquisition dialog is visible. This is to avoid acquisition with wrong or unexpected parameters. If the camera acquisition dialog is not visible, the first attempt to acquire an image will place the acquisition dialog on screen and only the next trial will start the acquisition.

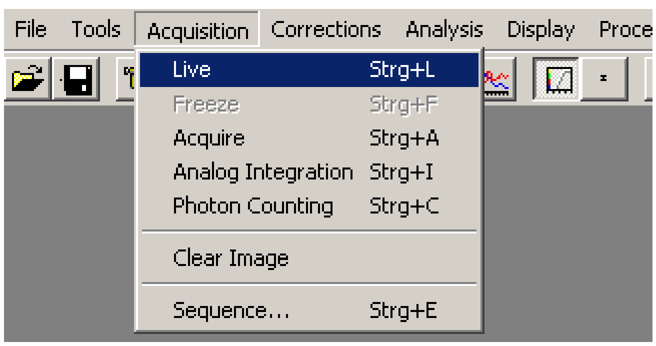
Live mode/Single image

Live mode is a mode to acquire and display images continuously. This mode is available for all cameras. In case of C4880 and ORCA II type cameras, the camera is switched to the fast readout mode. If a user wants to get only one single image with the currently selected parameters most camera acquisition dialogs have a single image function. Some cameras have a control to select the scan speed on every Acquisition tab so that there is the possibility to assign an individual scan speed to each acquisition mode.

To start Live mode proceed as follows:

1.) Show the acquisition dialog

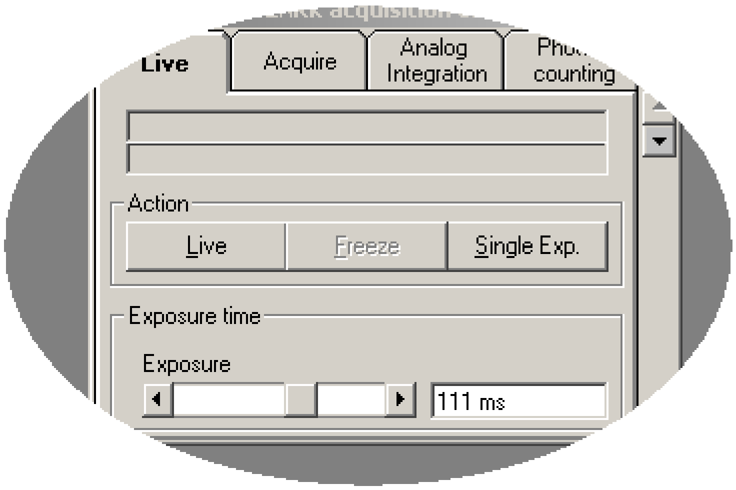
Select Live from the Acquisition menu



- or –

Click to the Live Toolbar button

The acquisition dialog will appear on screen



2.) Start Live mode

(If the acquisition dialog was already visible Live mode will start with step 1.))

To Start the LIVE mode

Click to the Live pushbutton on the Acquisition dialog

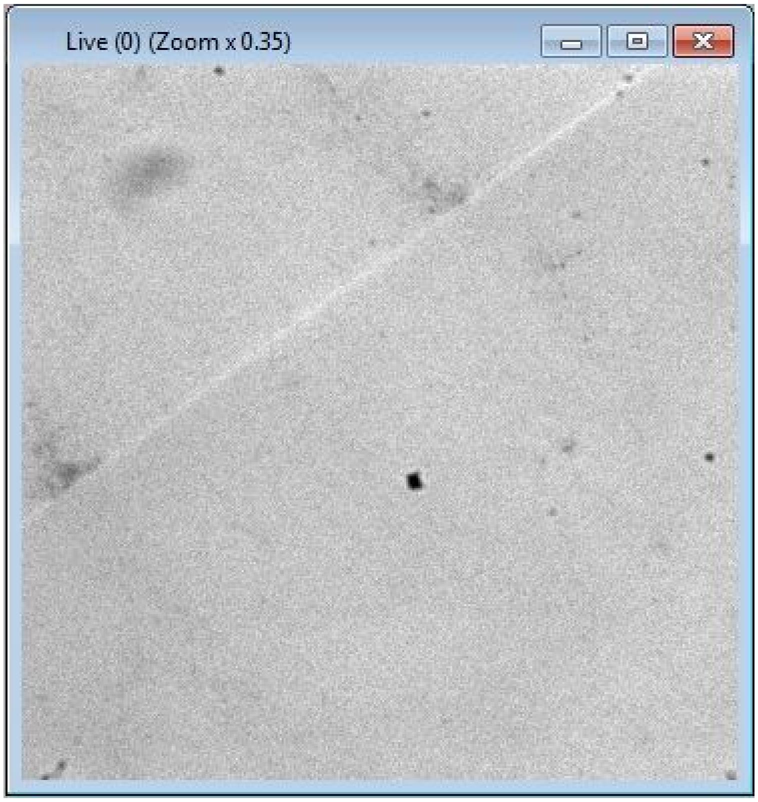
- or –

Click to the Live Toolbar button

- or –

Select Live from the Acquisition menu

The live image will appear on screen and show a continuously updated image.



To stop LIVE mode

Click to the Freeze pushbutton on the Acquisition dialog

- or –

Click to the Freeze Toolbar button

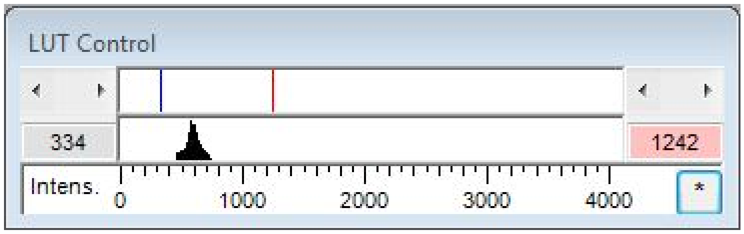
- or –

Select Freeze from the Acquisition menu

To execute single exposure Click to Single Exposure on the acquisition dialog.

LUT

If you acquire images you will find that the images are frequently displayed with too low or too strong contrast. If you acquire images under low light level conditions the display may be too dark. Use the LUT tool to adapt the image display to the desired contrast.



Lut tool.

The LUT tool has two cursors (two colored lines, one is blue and one is red) which defines the intensity limits of the currently displayed intensity range. To find the correct range the easiest way is to click on the small asterisk  on the right bottom side of the LUT tool. A similar pushbutton can be find on the toolbar: 

Please see also the chapter LUT, LUT Parameters and the Appendix LUT in this document.

Change the display size of the image (zooming)

Important note for users of previous versions: While older versions (before version 8) of this programs use the right mouse button to zoom out, this version uses the left mouse button + Shift key to zoom out.

Once an image is acquired it will be displayed on screen within a window. Depending on the number of pixels in the image and the resolution of the computers screen the image may be either too small or too large to be seen correctly. Therefore the image can be zoomed with a factor larger than one (if the image is too small) or a factor smaller than one (if the image is too large).

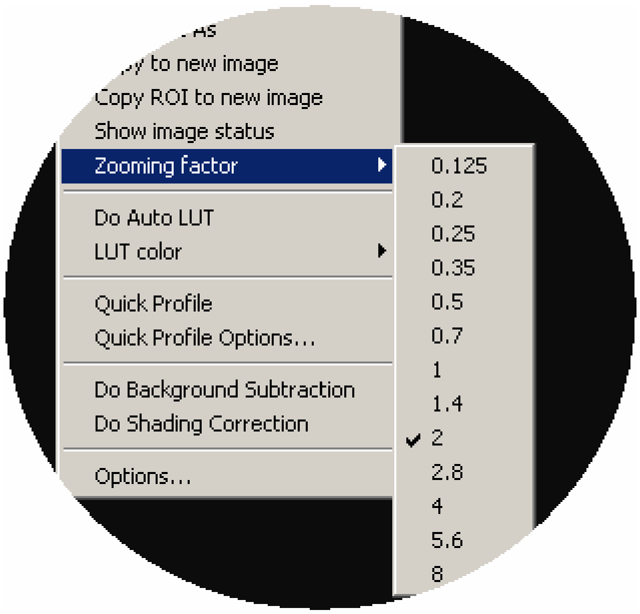
To change the zooming factor of an image

1.) Select zooming on the toolbar


2.) Click on the image with the left mouse button to enlarge the image and click with the left mouse while holding down the Shift key to reduce the image.

\- or -

Select the zooming factor with the context sensitive menu by clicking on the image with the right mouse button.



See also the chapter Image Display Windows in the document.

Setting camera parameters

If the image you get by this procedure is not satisfactory there may be several reasons. In case of a cooled camera you may need to switch on the peltier cooler now. It may be necessary to focus or adjust the optics and it may also be necessary to adjust the exposure time here. The most important camera parameter is the exposure time. With very few exceptions all CCD cameras have an exposure time control on the camera acquisition dialog.

In general it is a slidebar where you can increase the exposure time by clicking on the right arrow and decrease it by clicking on the left arrow. Normally also an edit box allows to enter the exposure time directly. In this case the exposure time should be activated by pressing the Tab key.

When entering the exposure time by the edit box and the inputted exposure time is not an element of the list there are two possible behaviors depending on the camera type. Some cameras simply select the list entry which is closest to the selected exposure time. Other cameras just set the entered exposure time even if it is not a member of the list. In this case there is no relationship between the slider setting and the real exposure time.

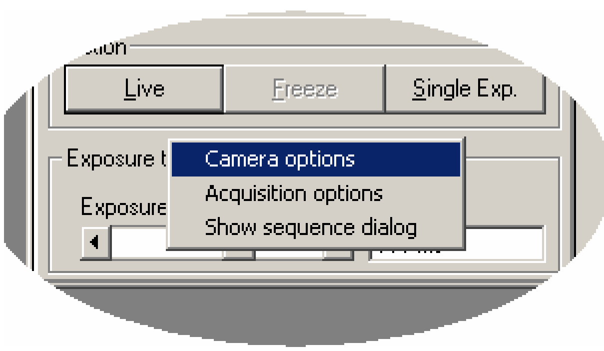
If the image you get is too faint increase the exposure time, if it is too bright decrease the intensity. If portions of the image became red (or white in the case the color setting is rainbow) the CCD camera is saturated, which means the exposure time is too high. If the intensity is still too high you may need to decrease the light level of your sample or close the iris of your optics.

See also the chapter CCD camera control and CCD camera in the document.

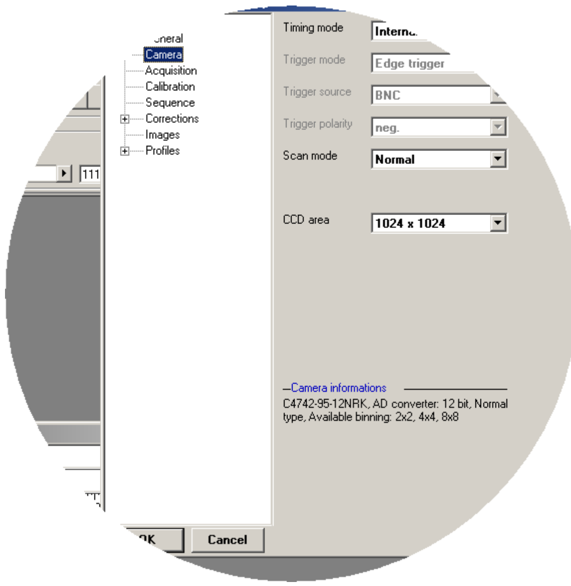
Acquisition/Options dialog

The exposure time however is only one parameter of the CCD camera which can be set by the software. Depending on the type of CCD camera many other parameters can be set now. It is a good idea to consult the CCD cameras hardware or operations manual and find out which features and parameters are provided by the model. All these features can by controlled from the software by using two main dialogs: the camera acquisition dialog and the options dialog. The parameters are separated in a way that parameters which are normally used and changed very often can be found in the camera acquisition dialog. To avoid that the camera acquisition dialog is burdened with many - often unchanged – parameters, these less needed parameters are collected in the camera options dialog.

The camera acquisition dialog is always placed on screen when you execute an acquisition command. The simplest way to show the camera options dialog is to right click on the camera acquisition dialog and select Camera options.



The camera options dialog will then appear on screen.



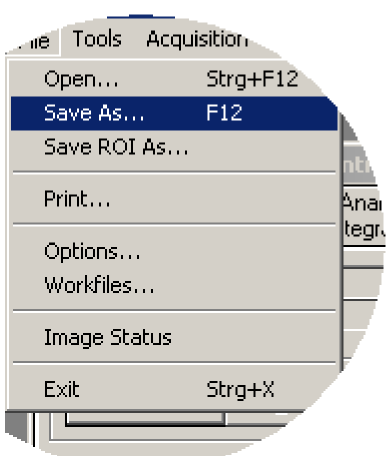
Once the camera options dialog is displayed you can make all modifications of camera parameters. When clicking OK these modifications will me applied, when clicking to Cancel the old settings are restored. See also the chapter List of all camera dialogs for details.

Saving and loading images

Once you have acquired useful image data you may want to save them to disk.

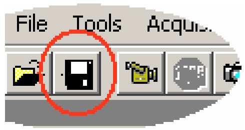
To save an image to disk proceed as follows:

Select the File – Save As menu command.

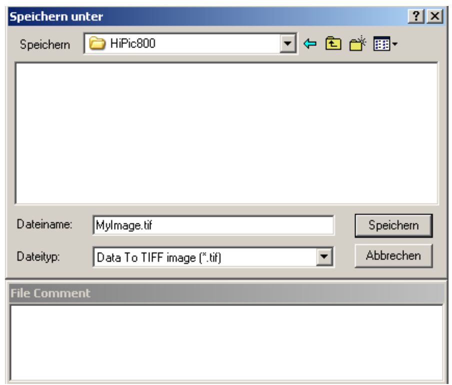


- or -

Click to the Save As toolbar button



A dialog appears to allow specifying file name directory and filing type of the file. Additionally you can type a comment which is then saved into the file header. There are several file types which you can use. At start we recommend to use either ITEX (*.img) or Data2Tiff (*.tif) as these file types allows to store the full dynamic range in an image.



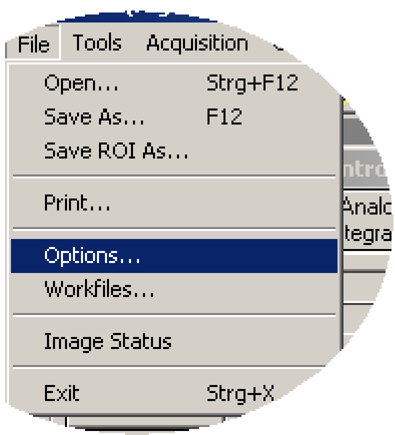
Click to Save if you want to save the image now or Cancel if you want to cancel the save operation.

See also the chapter Saving and loading images in this document.

Options

The exact behavior of the program is specified in different options dialogs. To access the options either

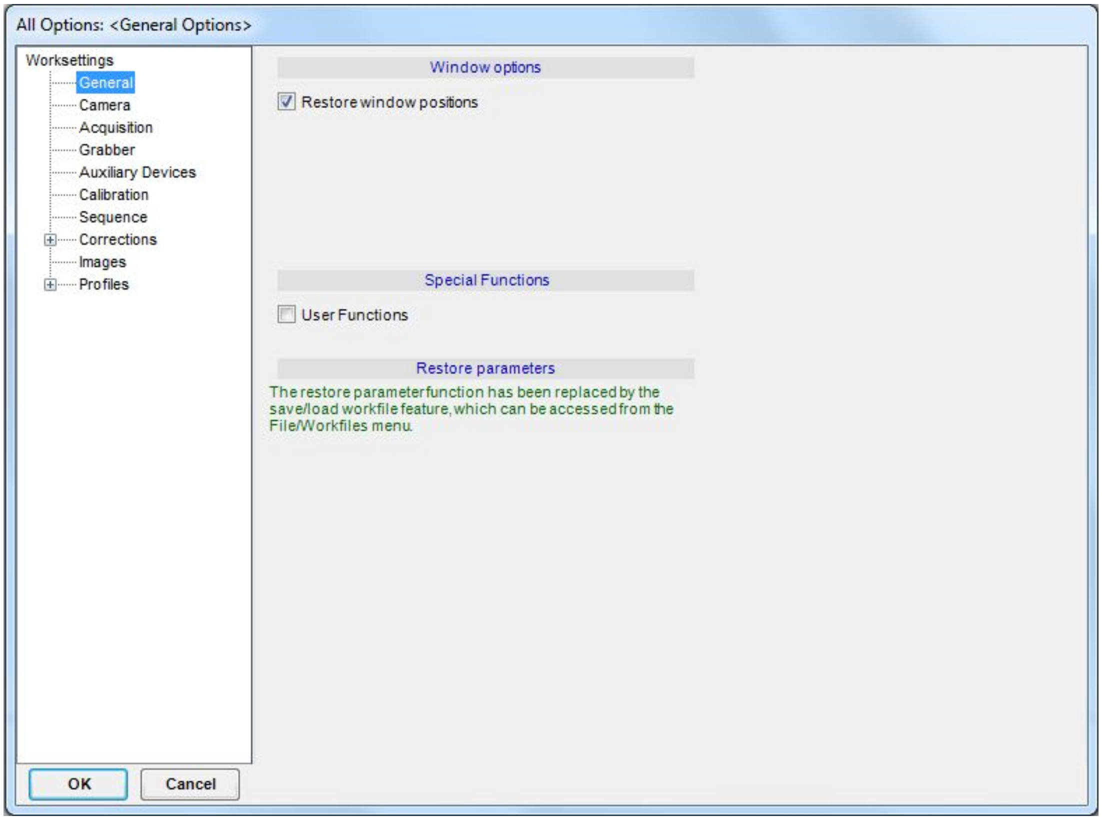
Click the File – options menu

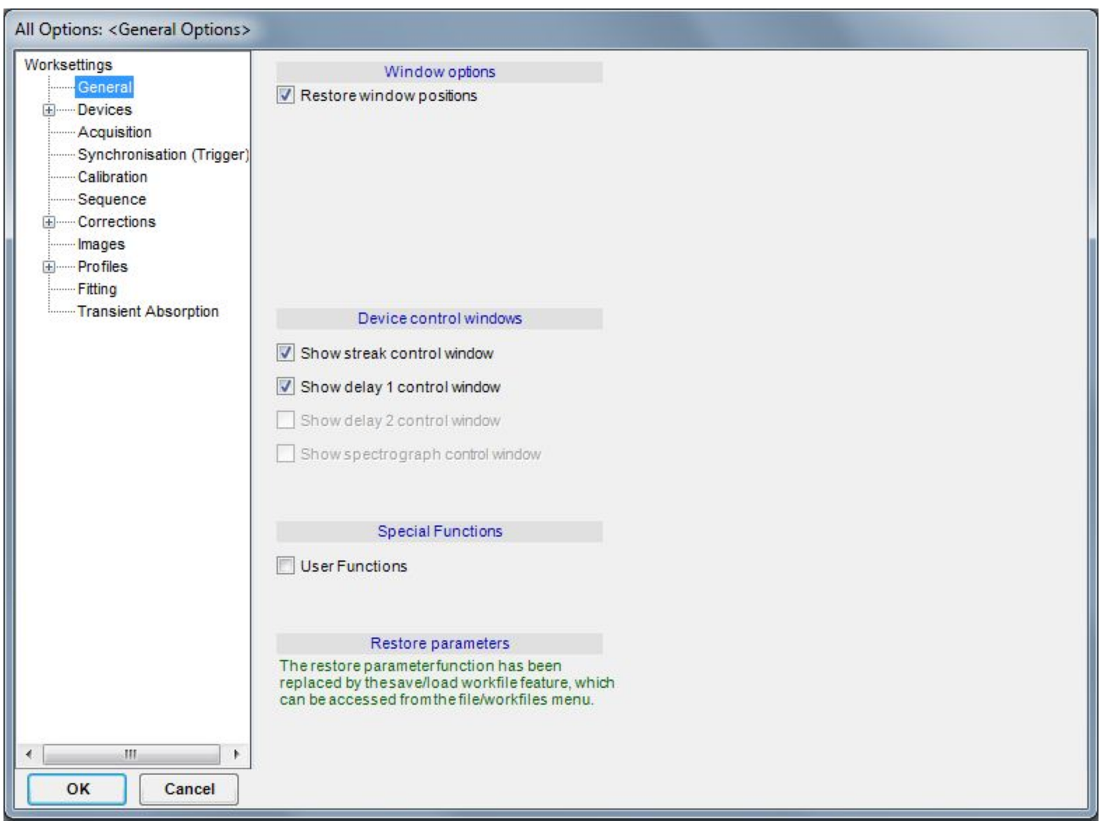


- or -

Click with the right mouse button on the dialog in which circumstance you want to specify options.

The options dialog will appear





The options dialog contains all options of all different areas of the software. To navigate between different dialogs the tree control on the left side can be used. The individual options dialog will then appear on the right side. The options dialog is a modal dialog which means you have to close it before you can continue your work. Clicking to OK closes the dialog and applies all changes to the software. Clicking to Cancel closes the dialog and restores the settings of the software which have been active before the Options dialog has been called.

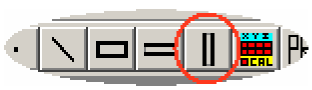
See also the chapter Options in this document.

Quick profile

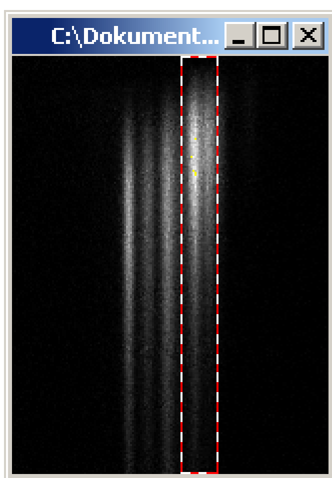
During image acquisition one or more profiles could be shown on the same window where the image data is displayed. Because it is immediately updated when a new image appears it is also called quick profile.

To display a quick profile:

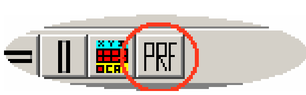
1.) Select the type of quick profile you want to get on the tool bar. We assume that we want to display a vertical profile over the full size of the image.



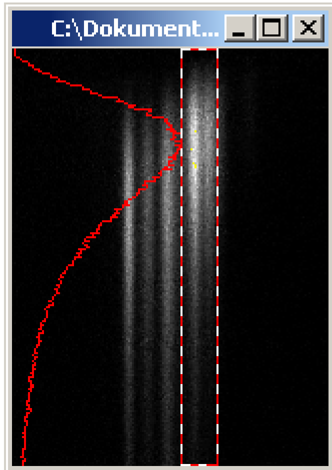
2.) Click to the image with the left mouse button and move the mouse while holding down the left mouse button. A new full size vertical ROI will be created.



3.) Click to the PRF button on the toolbar.



The quickprofile appears.



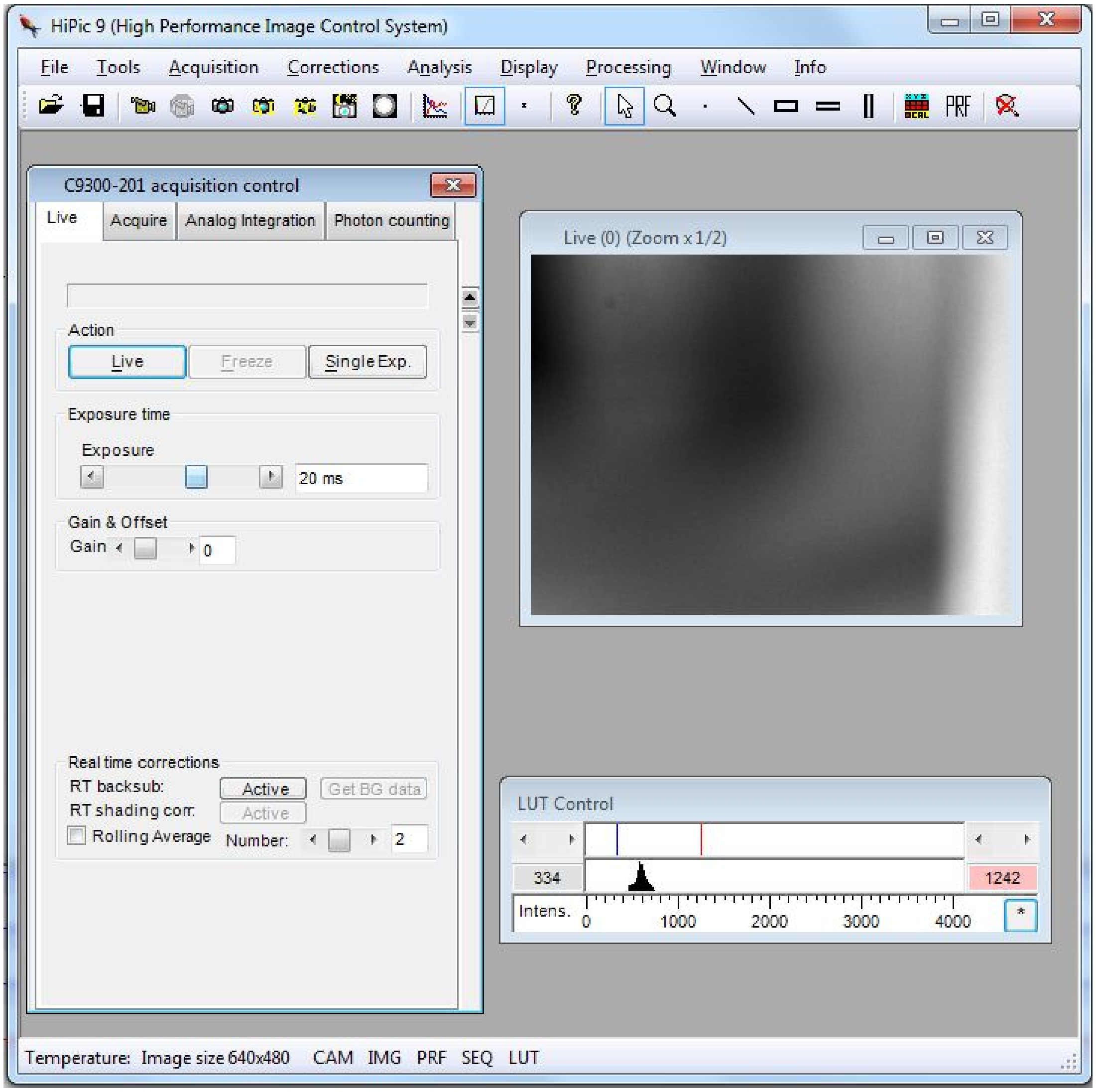
Clicking to PRF button on the toolbar again hides the quickprofile.

To move the ROI click on the ROI with the left mouse button and move the mouse.

To delete the ROI make sure that the image dialog is the active window and press the Del key on your keyboard. See also the chapter Image Display and LUT - Quick profile Selecting Measurement Parameters – Quickprofile for details.

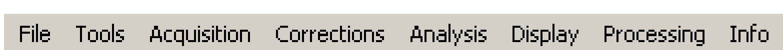
The elements of the user I/F

This chapter explains the basic elements of the user interface and its general functionality. Every function is explained in more detail in further chapters if necessary. The following screenshot shows the main window after program start.



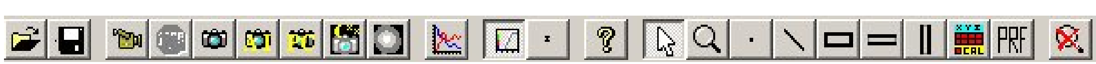
The menu

The menu of the program allows easy access to the most important commands. It consists of the main menu and a submenu for every entry in the main menu.



The Toolbar

The toolbar is a selection of pushbuttons which provides easy access to many important commands.



The status bar

On the bottom part of the program window status information is displayed. The content depends on the actual conditions. E.g. during LIVE mode the actual frame rate will be displayed

While the mouse cursor is inside of an image window, the co-ordinates and the intensity value at the current mouse position are displayed.

Child windows and System modal windows

Some windows used in the software are placed in the client area of the main window and cannot be larger than the main window. These windows are called child windows. Most of the windows in this software are child windows like the acquisition dialog or the image display windows.

Other windows are used to make special setting and it is useful that the process of setting is finished when the user wants to continue his routine work. These windows are so called modal (or system-modal) windows. Other windows of the software e.g. the main window cannot be accessed unless the modal window has been closed. Normally these modal windows have two push button on the bottom:

- A pushbutton OK to apply the settings and close the dialog
- A pushbutton Cancel to restore the previous settings and close the dialog.

Options, Acquisition and Tool dialog windows

There are three different types of dialogs within this software:

- Option dialogs
- Acquisition dialogs
- Tool dialogs

Option dialogs

Option dialogs allow to set values of certain parameters which specify the behavior of the software. These parameters are static settings, which are normally restored from one session to the next. Option dialogs have to be closed after the settings are done to continue with the work.

Acquisition dialogs

Acquisition dialogs are dedicated to create image and related data. They are placed in the client area of the main window and can coexist with other windows especially image display windows.

Tool dialogs

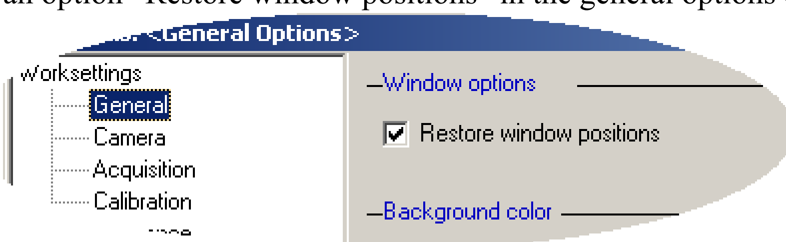
Tool dialogs are dedicated to create other type of data like calibration data or defect pixel data which are further used for certain system settings. They are also placed in the client area of the main window and can coexist with other windows especially image display windows. These dialogs are normally not used during routine work

Arranging windows/Activating dedicated windows

To perform several tasks normally several dialogs have to be on the screen. This can sooner or later lead to an untidy and somehow messy screen. Even though the user still may need several dialogs at once there are two measures to handle this problem

Restore window positions

One can arrange the windows freely at the screen and there is an option to restore a window at the same location where it has been previously. There is an option “Restore window positions” in the general options dialog.



If this option is checked the position of every window will be remembered and the window placed at the same location where it has been. So it is easy to arrange the dialogs in a fixed way where they can be find easily.

Find windows which are hidden under other windows

On the status bar there are some pushbuttons which makes it very easy to get the desired windows on top which are mostly used:

These pushbuttons can be used to show the dialogs if they are already on screen but hidden under another dialog (if they are not on screen nothing will happen).

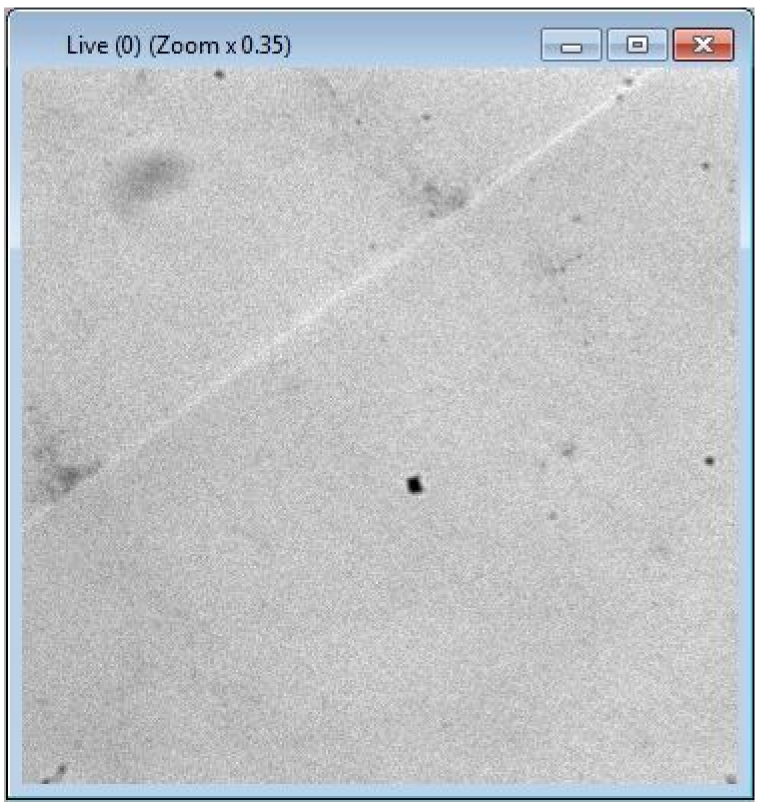
CAM Shows the camera acquisition dialog

IMG Shows all image display windows

PRF	Shows all dialogs related to profile
SEQ	Shows the sequence dialog
LUT	Shows the LUT tool

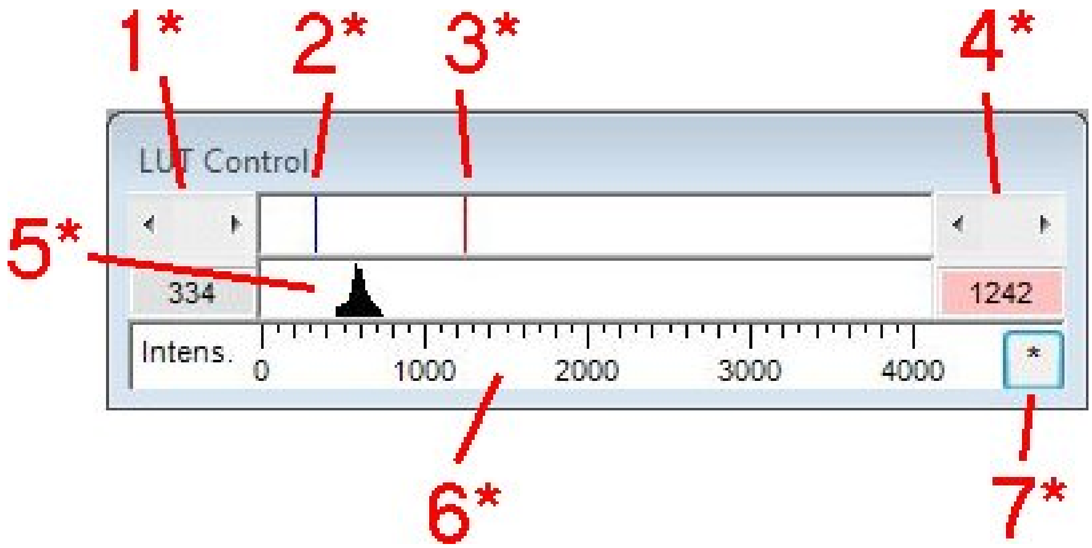
Image display windows

Image data is displayed on separate image display windows. A maximum of 20 image display windows can be displayed at once. Once an image window is created an entry is made in the menu windows. If more than one window is displayed at a time one of these is always the current (or selected) one. Every function which refers to image data is always processed on the current window. As an example, if you want to save one specific image to file click on the image windows caption (or to another part of the image). This makes the image the current one. Then click to the Save As function to save the current image.



LUT

The LUT tool is used to control the image display by manipulating its brightness and contrast.



1*: Slide bar to change the lower limit

2*: Lower Limit

3*: Upper Limit

4*: Slide bar to change the upper limit

5*: Histogram

6*: Input intensity scale

7*: Pushbutton for Auto LUT

The LUT Tool

If you acquire images you will find that the images are frequently displayed with too low or too strong contrast. If you acquire images under low light level conditions the display may be too dark. Use the LUT tool to adapt the image display to the desired contrast.

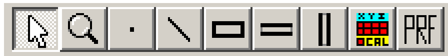
ROIs

There are many image processing functions which refer to image data like saving the data to file or extracting profile data. Most of these functions however can not only be applied to the full image but also to a subset of the image data. For this purpose Regions of Interest (shortly called ROI) can be used. There are different types of ROIs which can be used for different purposes. The types of ROIs are:

- Point ROI
- Arbitrary line ROI
- Rectangle ROI
- Rectangle ROI with full size in horizontal direction

 Rectangle ROI with full size in vertical direction

To create a ROI first of all select the ROI type on the toolbar:

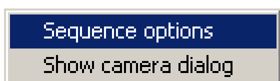


Then draw the ROI with clicking to the starting point with the left mouse button, then draw the mouse to the end point of the ROI and release it. Afterwards you can move the ROI by clicking to it with the left mouse button and moving the mouse to the desired position. You can select up to 10 different ROIs on one image. A more detailed description of how to create, select, delete and use ROIs can be found in the chapter ROIs

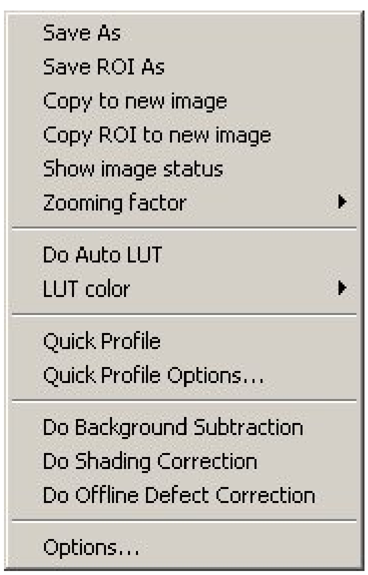
Context sensitive menus

From any given dialog the user can reach the most related dialogs and commands by just right click to the dialog. A context sensitive menu will appear and show commands which may be important in this circumstance. We wand to look at two different examples to show this feature:

If you click with the right mouse button on the sequence dialog you will get the following menu:

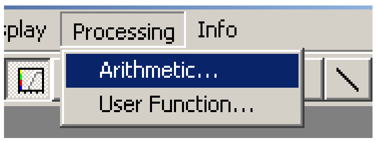


If you click with the right mouse button on the image display dialog you will get the following menu:



Using commands from the menu

The menu is a way to easily access the most important commands or dialogs. It consists of the main menu which can be seen on the top of the main window and several submenus. To select a submenu click to the main menu entry and select the submenu entry. For example of you want to select the arithmetic menu first click to processing main menu, then select Arithmetic and click to it.



The main menu

The menu of the program consists of the following main entries:

Command	Description
File	Contains a set of commands related to image files and other general properties
Tools	Contains commands to create special data
Acquisition	Contains commands to acquire image data
Corrections	Contains commands to perform different corrections on images
Analysis	Contains commands to analyze image data
Display	Contains commands to control and optimize image display
Processing	Contains image processing commands
Window	Contains commands to select and close image display windows
Info	Contains commands to get information about the program and a tool to communicate with the camera directly

File Menu

The file menu contains the following entries

Open	Loads an image or image sequence in IMG, TIFF or other formats.
Save As	Saves the current image or image sequence in IMG, TIFF or other formats.
Save ROI As	Saves the specified ROI of the current image or image

	sequence in IMG, TIFF or other formats.
Print	Print the current image
Options	Shows a dialog which displays and allows to modify all available options
Workfiles	Allows to save and load all current options and other settings to a file
Image status	Shows the current image status
Exit	Shuts down the program

Tools menu

The tools menu contains the following entries

Calibration files	Shows a dialog which allows to create, modify and save calibration files
Defect pixels	Shows a dialog which allows to analyze images containing defect pixel

The acquisition menu

The acquisition menu contains the following entries

Live	If the Acquisition dialogue is not opened, it will be opened as you click this button for the first time. If you click it while the Live mode dialogue is open, image acquisition in **Live** mode will be started. The acquisition parameters as shown in the Live mode dialogue are used.
Freeze	**Live** mode stops. The last image will remain in memory..
Acquire	If the Acquisition dialogue is not opened, it will be opened as you click this button for the first time. If you click it while the Acquire mode dialogue is open, an image acquisition in **Acquire** mode will be executed. The acquisition parameters as shown in the Acquisition mode dialogue are used
Analog Integration	If the Acquisition mode dialogue is not opened, it will be opened as you click this button for the first time. If you click it while the Analog integration mode dialogue is open, an image acquisition in **Analog integration** mode will be executed. The acquisition parameters as shown in the Analog integration mode dialogue are used.
Photon Counting	If the Acquisition mode dialogue is not opened, it will

be opened as you click this button for the first time. If you click it while the Photon counting mode dialogue is open, an image acquisition in **Photon Counting** mode will be executed. The acquisition parameters as shown in the Photon counting mode dialogue are used. See.

Clear Image	The **Clear Image** command clears the image data
Sequence	This command shows the sequence dialog which allows the acquisition of a series of images with storage on computer memory (RAM) or hard disk. This dialog includes also a sequence replay function.

The Corrections menu

The acquisition menu contains the following entries

Background subtraction	This function allows subtracting a background image. This can be used to subtract the camera dark current
Shading correction	This functions allows to correct the shading of images

The analysis menu

The analysis menu contains the following entries

Profile	This function allows to display and analyze profiles
Histogram	This function allows analyzing the intensity distribution (histogram) of an image.
3D-Data	This function allows displaying image data in a numerical (table) form.

The display menu

The display menu contains the following entry:

LUT…	This function shows the LUT parameters dialog on screen. The LUT parameters dialog allows to change parameters like to color of the display.

The Processing menu

The Processing menu contains the following entries:

Arithmetic…	This function allows to perform arithmetic operations on image data
User	This function allows to execute user function commands

function…

Superimpose… This function allows to superimpose the image data of two images

The Window menu

The Window menu displays all the currently available image windows. It also contains the “Close All” command which allows closing all image windows with one command.

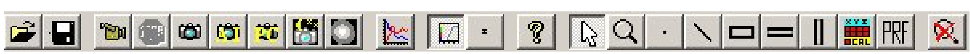
The Info menu

The Info menu contains the following entry:

Help…	This function calls the help dialog
RS232…	This function allows to send and receive commands from the connected camera (if it is connected by RS232)
About…	This function displays the About dialog which tells the user details about the version of the program

Using commands from the toolbar

The toolbar – similar to the menu – allows to access the most important commands in a very easy way. To execute a command by the toolbar simply click to the icon on the toolbar.



Most of these icons can be understood without an explanation.

The following is an explanation of all toolbar icons used on the toolbar:

	Open	Opens an image file
	Save As	Saves the currently selected image to file
	Live	Starts live mode (or shows the camera acquisition if not on screen)
	Freeze	Freezes live mode
	Acquire	Acquires an image in Acquire mode
	Analog Integration	Acquires an image in Analog Integration mode
	Photon Counting	Acquires an image in Photon Counting mode

	Background Subtraction	Applies Background Subtraction to the currently selected image
	Shading Correction	Applies Shading Correction to the currently selected image
	Profile	Shows or hides the profile dialog
	LUT dialog	Shows or hides the LUT dialog
	About	Shows the About dialog
	Pointer	Selects Pointer mode. This allows selecting and modifying ROIs.
	Zoom	Selects zooming mode. This allows to change the zooming factor of the image
	Create Point ROI	Selects Point ROI mode. This allows creating a Point ROI.
	Create Line ROI	Selects Line ROI mode. This allows creating a line ROI.
	Create general rectangle ROI	Selects Rectangle ROI mode. This allows creating a rectangle ROI of any size.
	Create horizontal rectangle ROI (full image width)	Selects horizontal rectangle ROI mode. This allows creating a rectangle ROI with full horizontal size.
	Create vertical rectangle ROI (full image height)	Selects vertical rectangle ROI mode. This allows creating a rectangle ROI with full vertical size.
	ROI Interface	Shows or hides the ROI Interface dialog
	Quick profile	Shows or hides the quick profile
	Unzoom current	Sets the current image to the default zooming factor

CCD Camera control

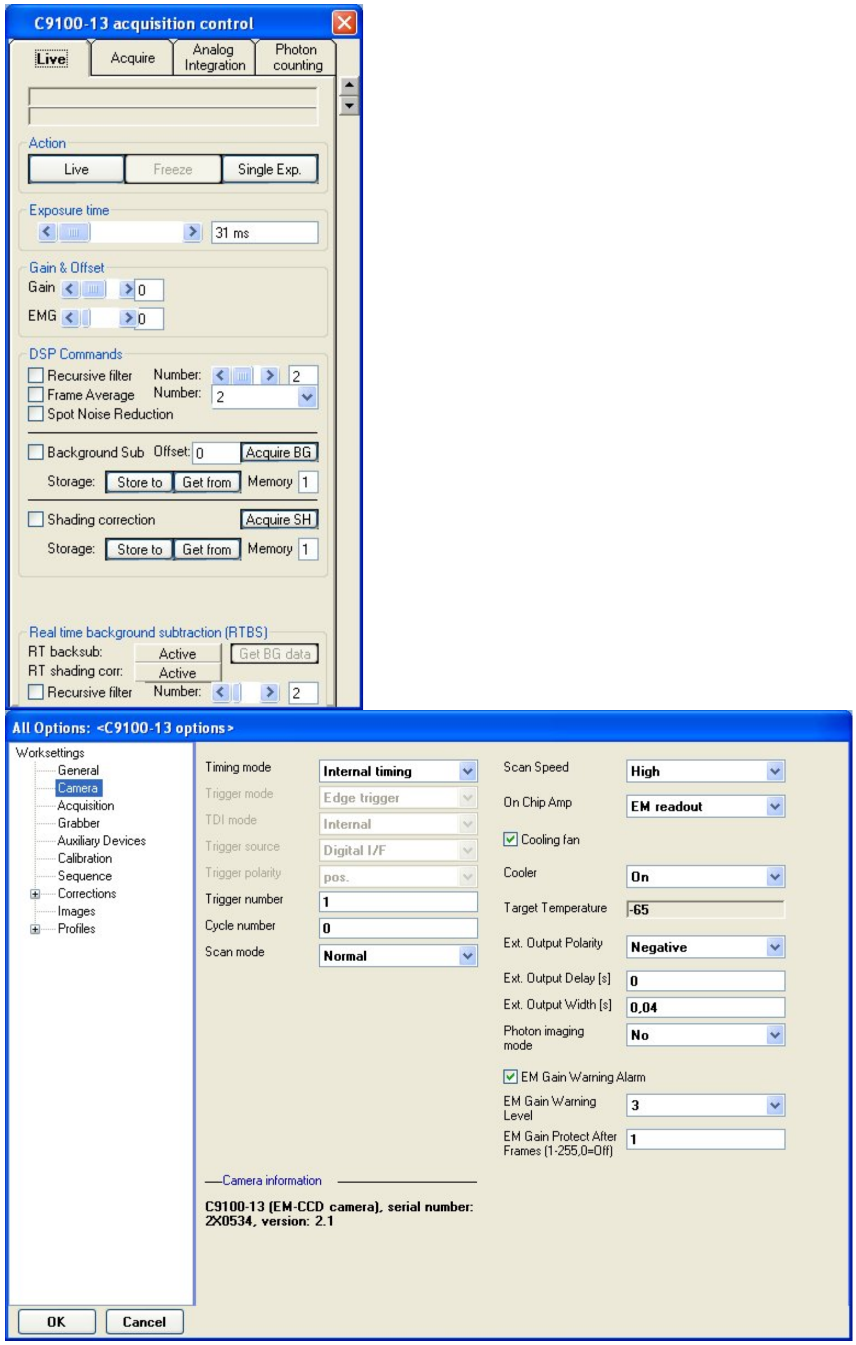
Hamamatsu CCD cameras and other imaging devices are sophisticated state of the art technical devices which in general have many different operation modes. To get familiar with these operating modes you should consult your operations manual of the CCD camera. Depending on your purchase contract there may also be an installation and introduction done by a Hamamatsu engineer on your site. Also this introduction is a good opportunity to get familiar with the features and operations modes of the camera. Most of the features of your CCD camera can be controlled by software (There may be some features which can only be controlled by hardware devices like potentiometers or the like. In this case you cannot control the features by software).

Acquisition/Options Dialog

All features can be controlled by two dialogs:

The camera acquisition dialog and the camera options dialog. In very few cases there is a third dialog which controls the subarray feature of the camera. The camera acquisition dialog is a dialog which is placed on the client area of the main window and can stay there without a limitation. The camera options dialog is showed as a modal dialog. This means that the options dialog has to be closed before the user can continue his routine work.

As the features of different cameras are different also the camera control dialogs look different. As an example we show the camera acquisition dialog and camera options dialog of the ImagEM (C9100-13).

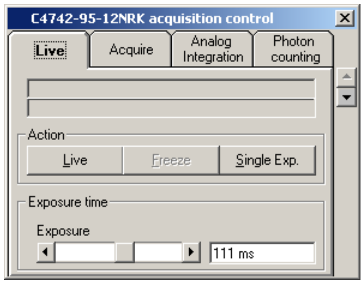


Often/Seldom used parameters

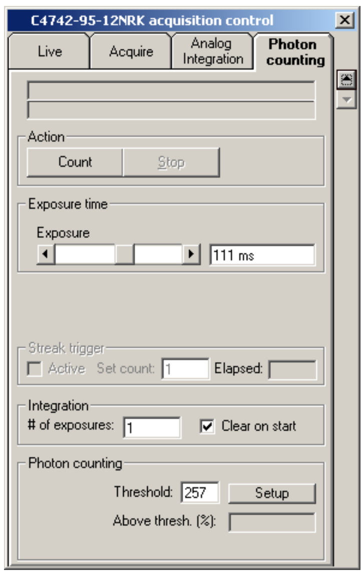
The parameters to control a camera are distributed in a way so that the seldom used parameters are placed in the camera options dialog, whereas parameters which are likely that they are used more often are placed in the camera acquisition dialog.

Camera acquisition dialog: Smaller/larger

The camera acquisition dialog can be made smaller or larger with two small arrows on the upper right side. Depending on the number of acquisition parameters the user wants to see he can make the dialog smaller or larger



Small camera dialog



Large camera dialog

Acquisition modes

Different acquisition modes can be used to acquire image data from a camera. The parameters a stored together with the acquisition mode and reactivated when the user reselects the acquisition mode.

Camera/Acquisition parameters

There are parameters which directly modifies settings inside the camera. We call these parameters camera parameters.

There are parameters which do not change any setting inside of the camera but still influences the result of the acquisition, like the exposure number of an Analog Integration. We call these parameters acquisition parameters.

Value range of parameters

Depending and the camera and the setting of other parameters the value range of certain parameters can vary. For example if the Binning mode is set to 1 x 1 for an Orca camera, subarray settings for X and Y can range from 8 to 1024. If the same Orca camera is operated in 2 x 2 binning the subarray settings can only range from 8 to 512. Many parameters are depending on each other. If possible parameters are arranged in a way the parameters from the options dialog influence parameters in the acquisition dialog but not vice versa.

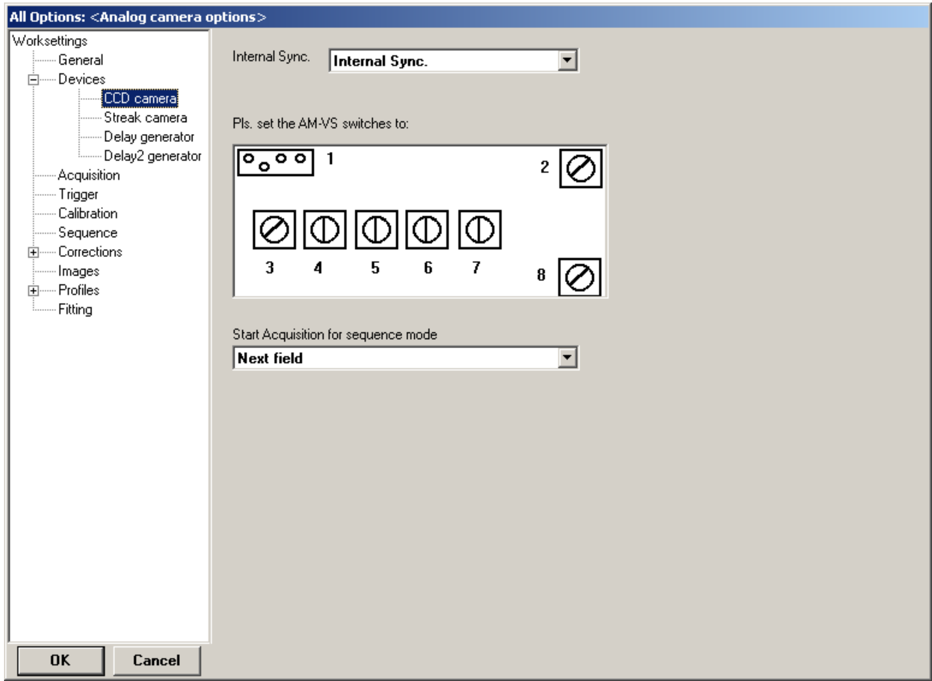
List of all camera dialogs

This topic includes screenshots of all supported cameras and a list of supported parameters by these cameras. Please note that for many of these cameras there are subversions and optional features which leads to the fact that certain parameters are only available for certain cameras. If you are not certain please verify the precise camera type number, consult your camera documentation, get information from our website (www.hamamatsu.de or www.hamamatsu.com) or contact your local Hamamatsu dealer.

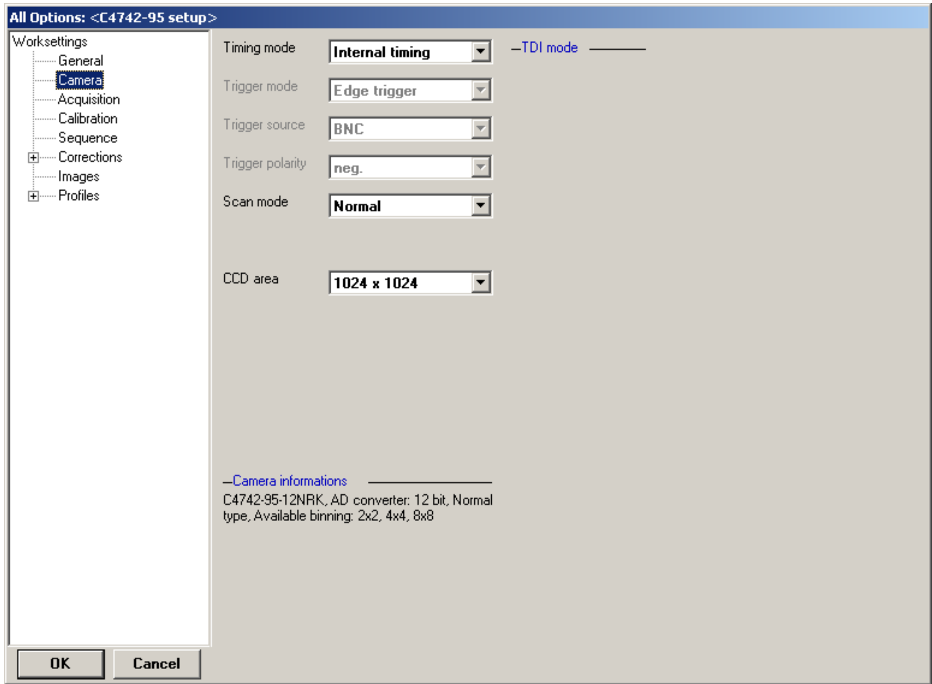
Both the Camera acquisition dialog and the Camera options dialog are showed in the following list.

Analog camera

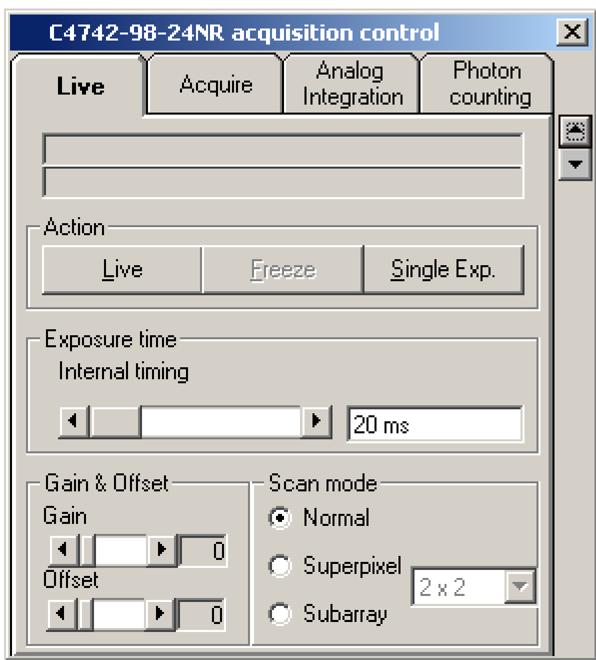
This camera selection includes all cameras which output a standard video signal (either CCIR or EIA). Among others these are the Hamamatsu C2400, C3077 and C5405.

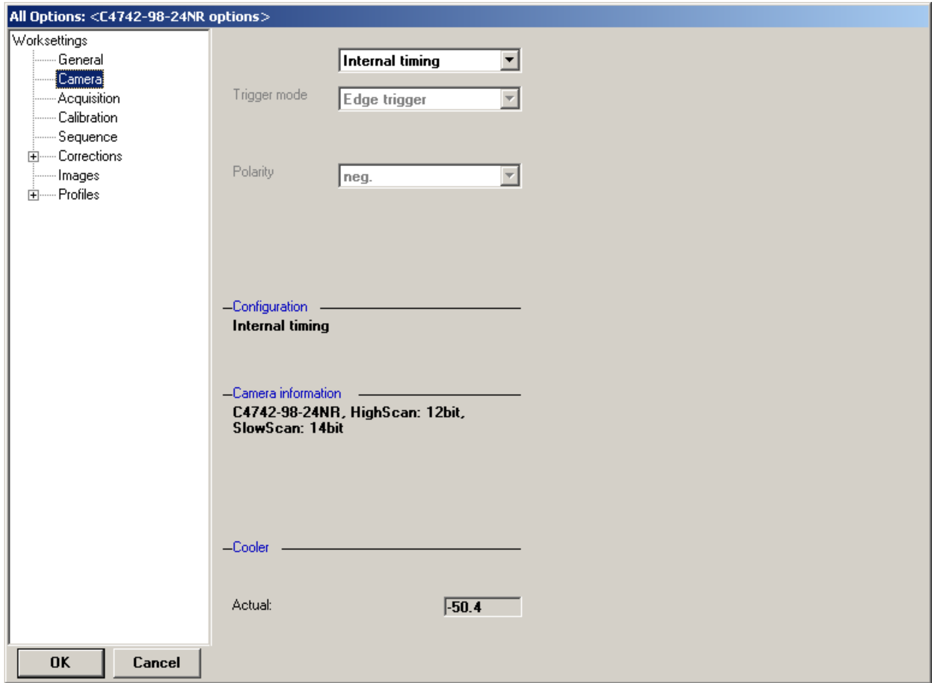


C4742-95 (ORCA) + C8484



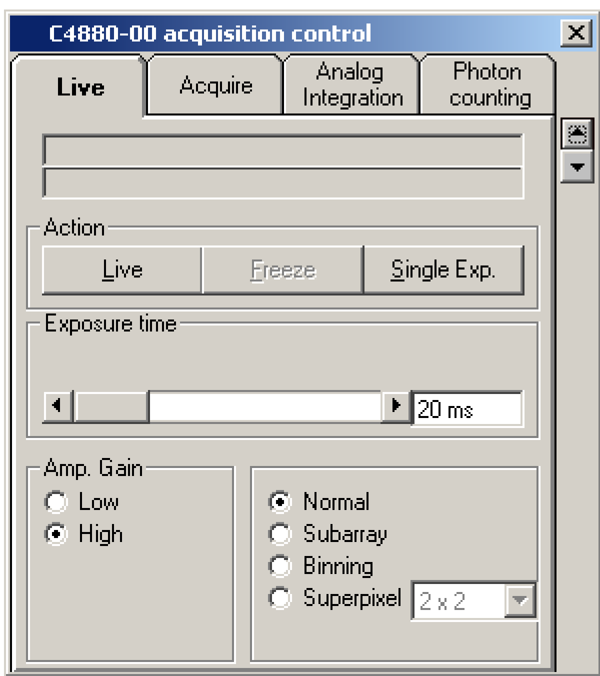
C4742-98 (ORCA II)

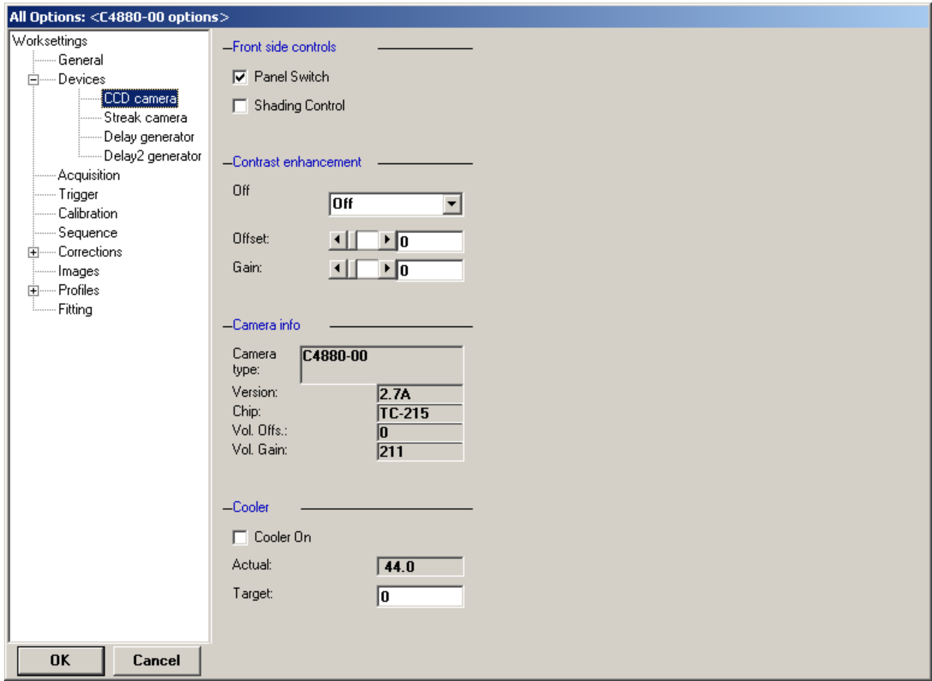




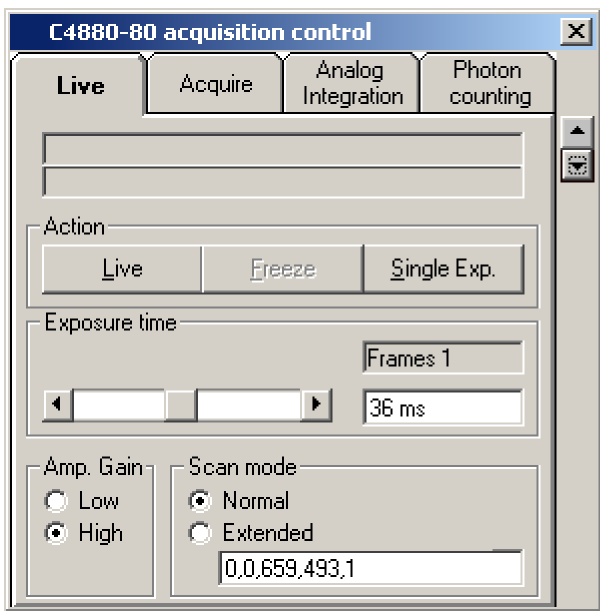
C4880

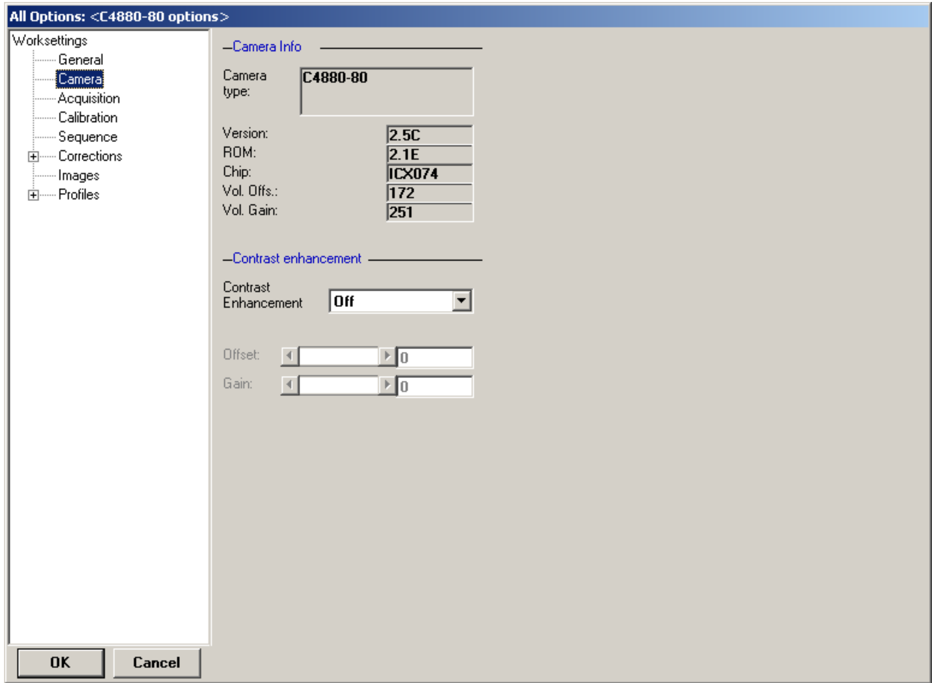
The C4880 standard model comprises all sub types of the C4880 except the C4880-8X. It includes the special versions which have incorporated an image intensifier C4880-91, C4880-92, C4880-92, C5987 and C6918-05.



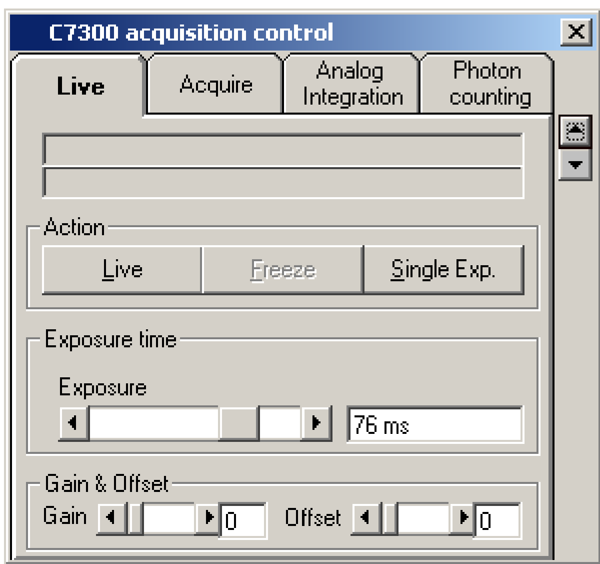

All Options: <C4880-00 options>
Worksettings
General
Devices
CCD camera
Streak camera
Delay generator
Delay2 generator
Acquisition
Trigger
Calibration
Sequence
Corrections
Images
Profiles
Fitting
Front side controls
Panel Switch
Shading Control
Contrast enhancement
Off
Off
Offset:
0
Gain:
0
Camera info
Camera type:
C4880-00
Version:
2.7A
Chip:
TC-215
Vol. Offs.:
0
Vol. Gain:
211
Cooler
Cooler On
Actual:
44.0
Target:
0
OK
Cancel

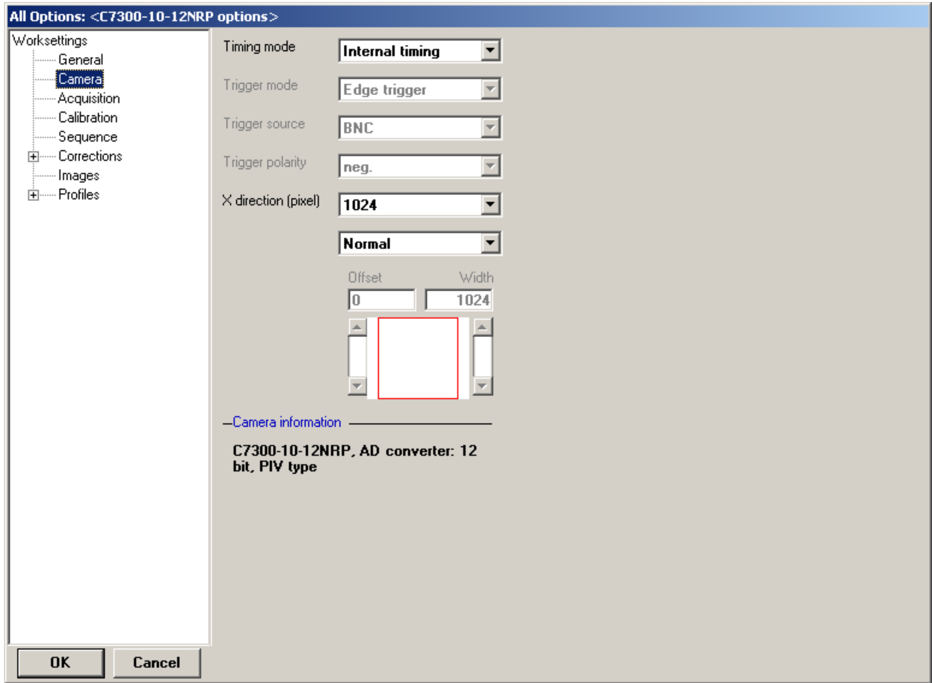
C4880-8X


C4880-80 acquisition control
Live
Acquire
Analog Integration
Photon counting
Action
Live
Freeze
Single Exp.
Exposure time
Frames 1
36 ms
Amp. Gain
Low
High
Scan mode
Normal
Extended
0,0,659,493,1

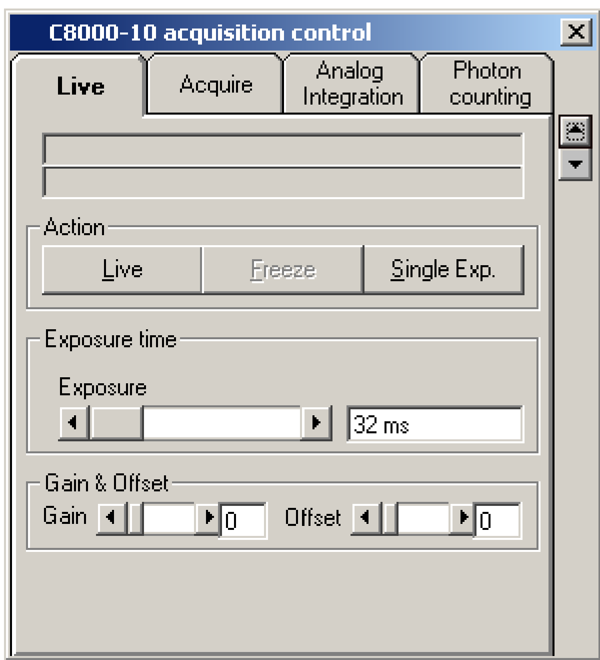

All Options: <C4880-80 options>
Worksettings
General
Camera
Acquisition
Calibration
Sequence
Corrections
Images
Profiles
Camera Info
Camera type:
C4880-80
Version:
2.5C
ROM:
2.1E
Chip:
ICX074
Vol. Offs.:
172
Vol. Gain:
251
Contrast enhancement
Contrast Enhancement
Off
Offset:
0
Gain:
0
OK
Cancel

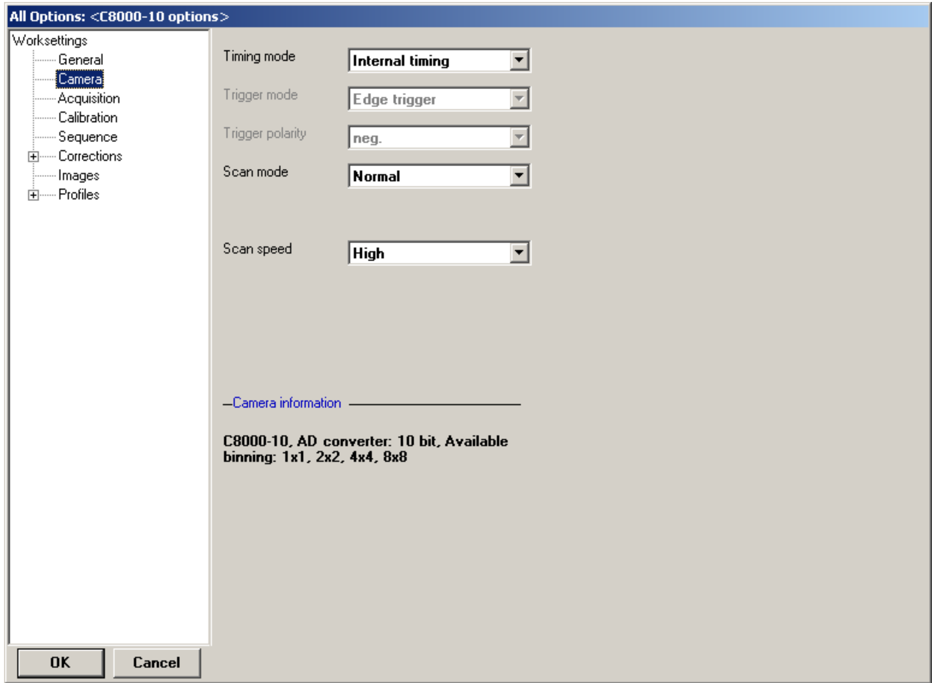
C7300


C7300 acquisition control
Live
Acquire
Analog Integration
Photon counting
Action
Live
Freeze
Single Exp.
Exposure time
Exposure
76 ms
Gain & Offset
Gain
0
Offset
0

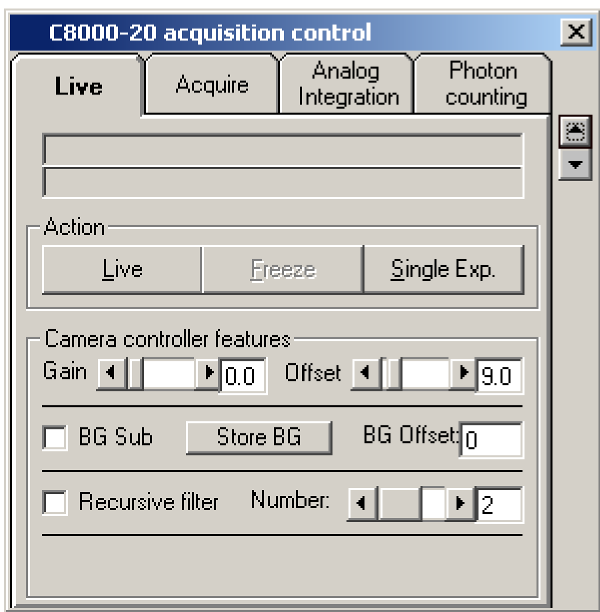

All Options: <C7300-10-12NRP options>
Worksettings
General
Camera
Acquisition
Calibration
Sequence
Corrections
Images
Profiles
Timing mode
Internal timing
Trigger mode
Edge trigger
Trigger source
BNC
Trigger polarity
neg.
X direction (pixel)
1024
Normal
Offset
Width
0
1024
Camera information
C7300-10-12NRP, AD converter: 12 bit, PIV type
OK
Cancel

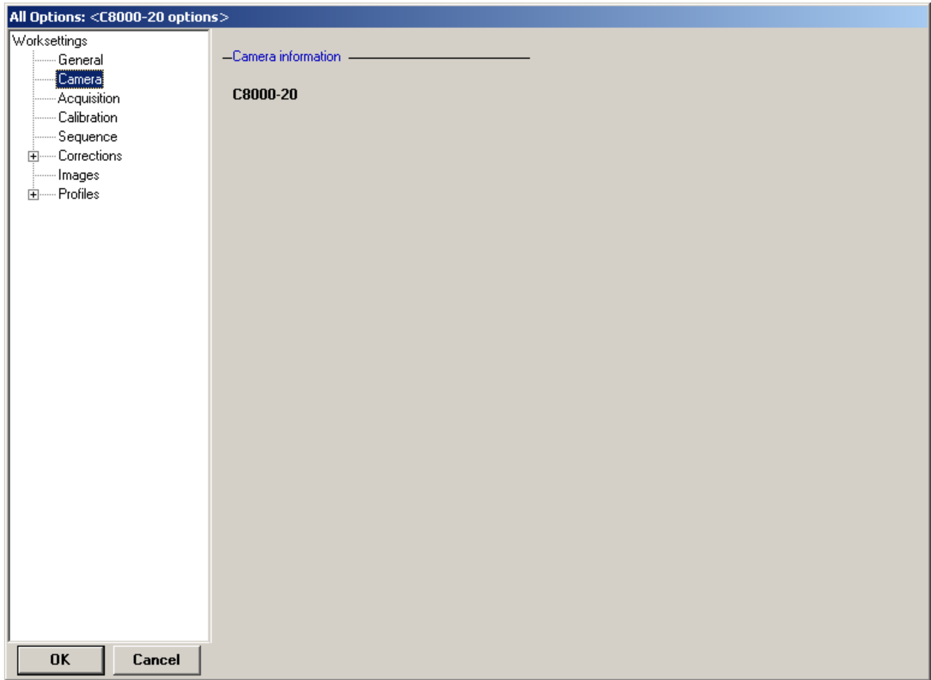
C8000-10


C8000-10 acquisition control
Live
Acquire
Analog Integration
Photon counting
Action
Live
Freeze
Single Exp.
Exposure time
Exposure
32 ms
Gain & Offset
Gain
0
Offset
0

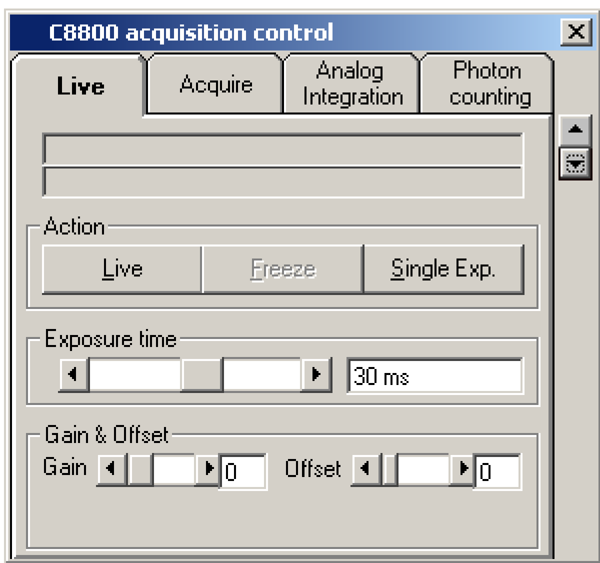

All Options: <C8000-10 options>
Worksettings
General
Camera
Acquisition
Calibration
Sequence
Corrections
Images
Profiles
Timing mode
Internal timing
Trigger mode
Edge trigger
Trigger polarity
neg.
Scan mode
Normal
Scan speed
High
Camera information
C8000-10, AD converter: 10 bit, Available binning: 1x1, 2x2, 4x4, 8x8
OK
Cancel

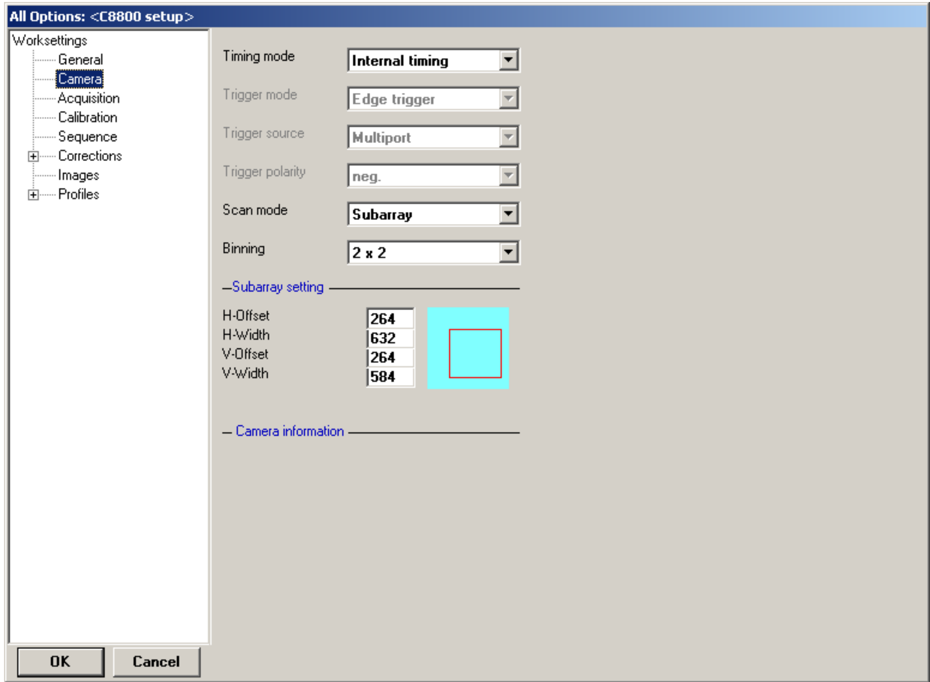
C8000-20


C8000-20 acquisition control
Live
Acquire
Analog Integration
Photon counting
Action
Live
Freeze
Single Exp.
Camera controller features
Gain
0.0
Offset
9.0
BG Sub
Store BG
BG Offset
0
Recursive filter
Number:
2

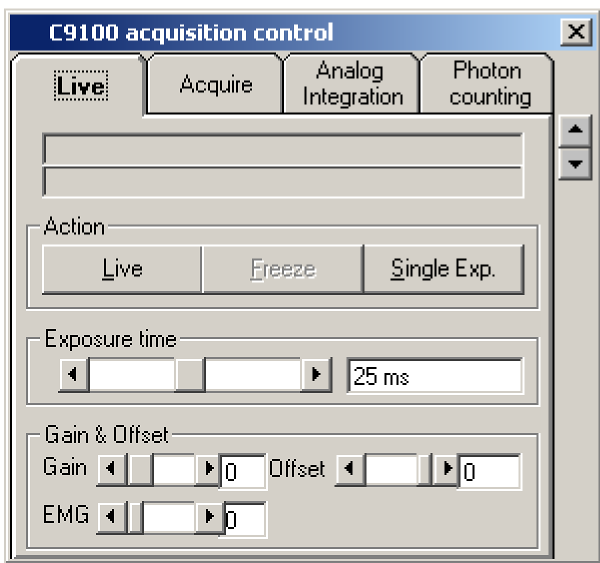

All Options: <C8000-20 options>
Worksettings
General
Camera
Acquisition
Calibration
Sequence
Corrections
Images
Profiles
Camera information
C8000-20
OK
Cancel

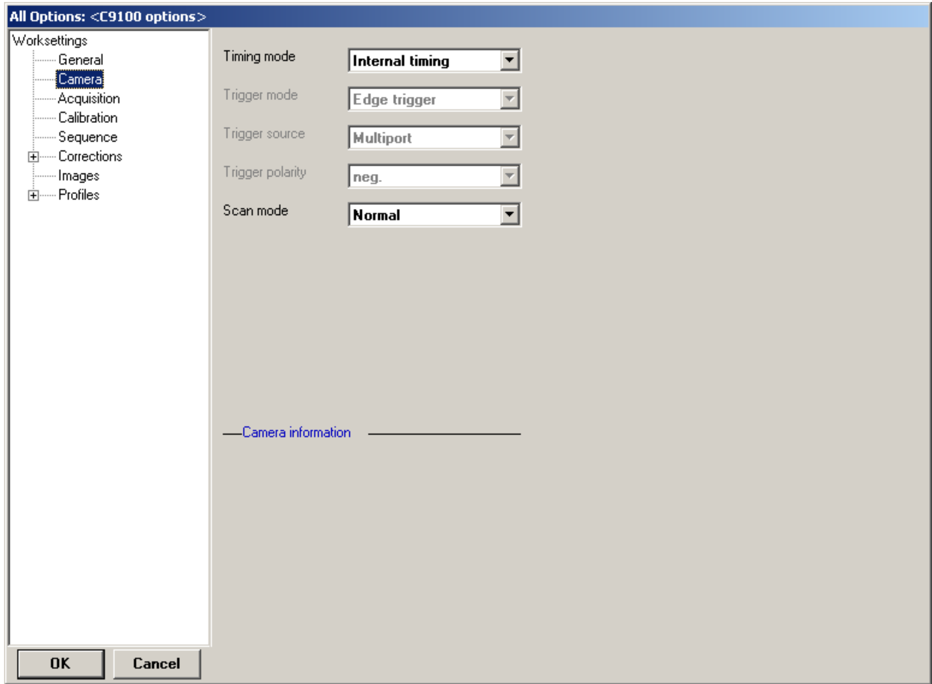
C8800


C8800 acquisition control
Live
Acquire
Analog Integration
Photon counting
Action
Live
Freeze
Single Exp.
Exposure time
30 ms
Gain & Offset
Gain
0
Offset
0

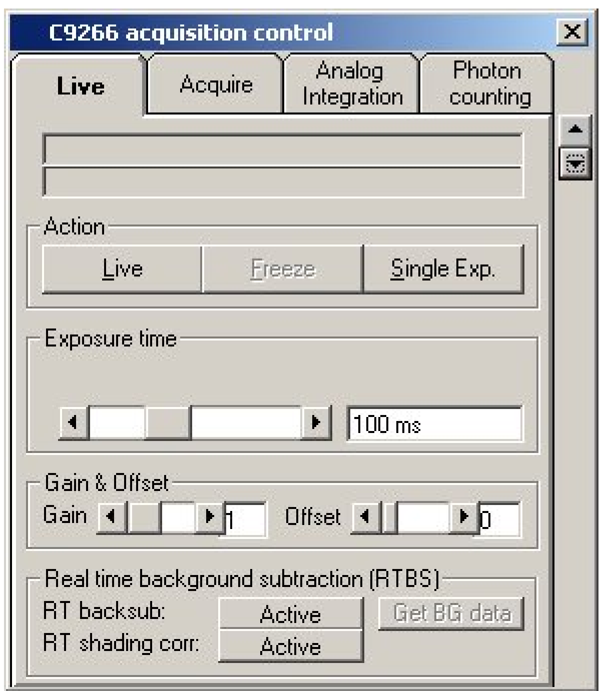

All Options: <C8800 setup>
Worksettings
General
Camera
Acquisition
Calibration
Sequence
Corrections
Images
Profiles
OK
Cancel
Timing mode
Internal timing
Trigger mode
Edge trigger
Trigger source
Multiport
Trigger polarity
neg.
Scan mode
Subarray
Binning
2 x 2
Subarray setting
H-Offset
264
H-Width
632
V-Offset
264
V-Width
584
Camera information

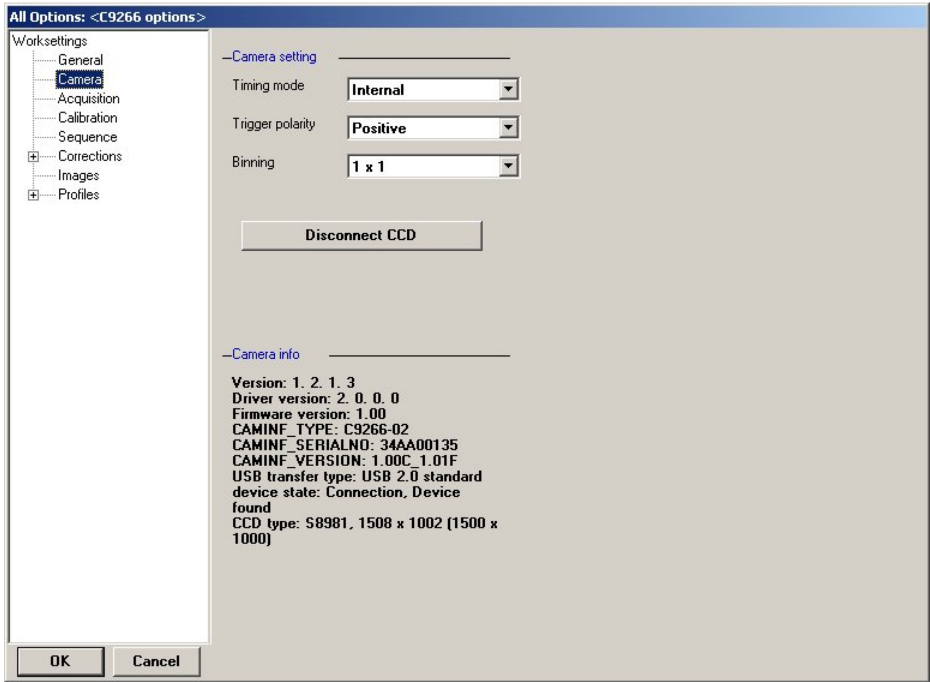
C9100


C9100 acquisition control
Live
Acquire
Analog Integration
Photon counting
Action
Live
Freeze
Single Exp.
Exposure time
25 ms
Gain & Offset
Gain
0
Offset
0
EMG
0

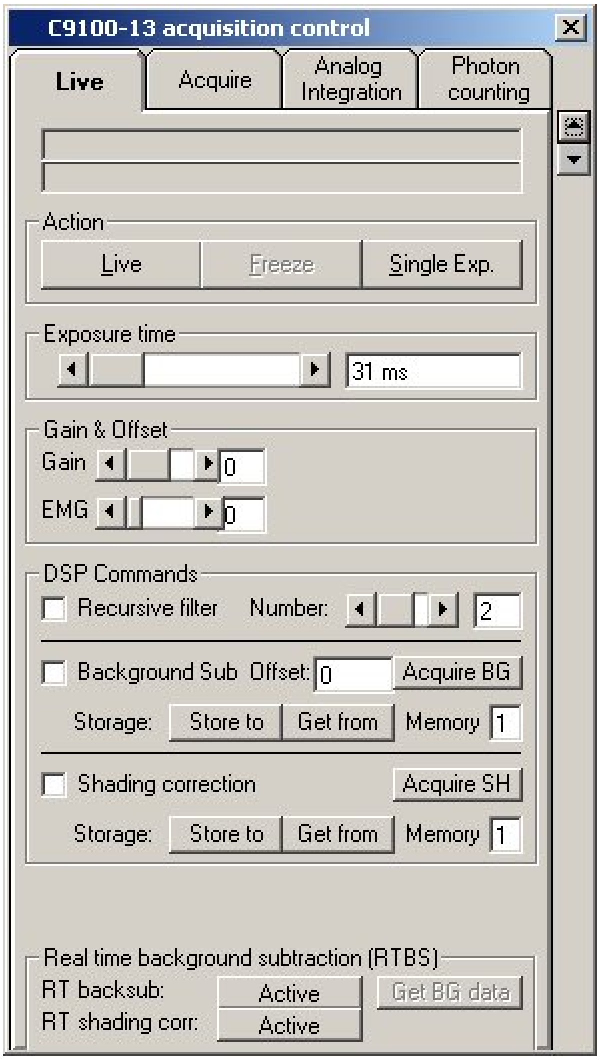


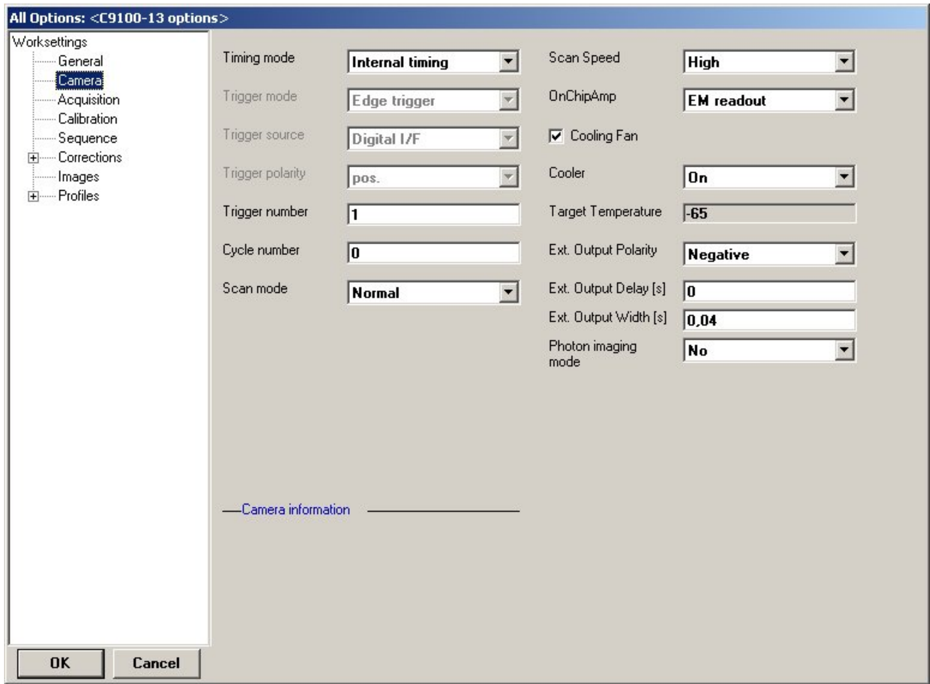
C9266 X-Ray dental sensor



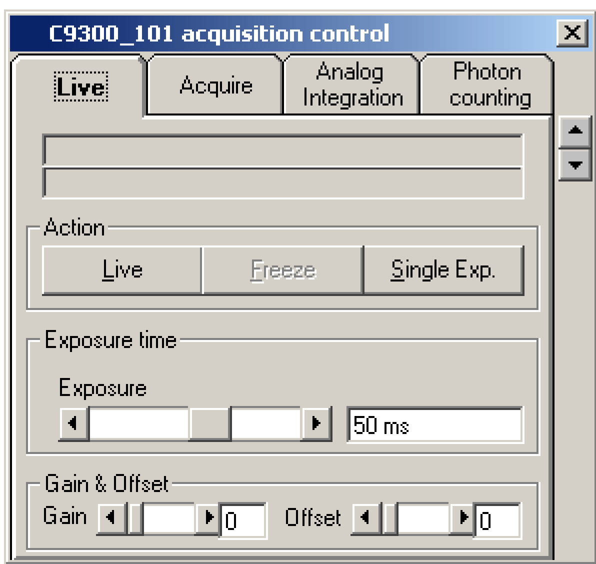

All Options: <C9266 options>
Worksettings
General
Camera
Acquisition
Calibration
Sequence
Corrections
Images
Profiles
Camera setting
Timing mode
Internal
Trigger polarity
Positive
Binning
1 x 1
Disconnect CCD
Camera info
Version: 1. 2. 1. 3
Driver version: 2. 0. 0. 0
Firmware version: 1.00
CAMINF_TYPE: C9266-02
CAMINF_SERIALNO: 34AA00135
CAMINF_VERSION: 1.00C_1.01F
USB transfer type: USB 2.0 standard
device state: Connection, Device found
CCD type: S8981, 1508 x 1002 (1500 x 1000)
OK
Cancel

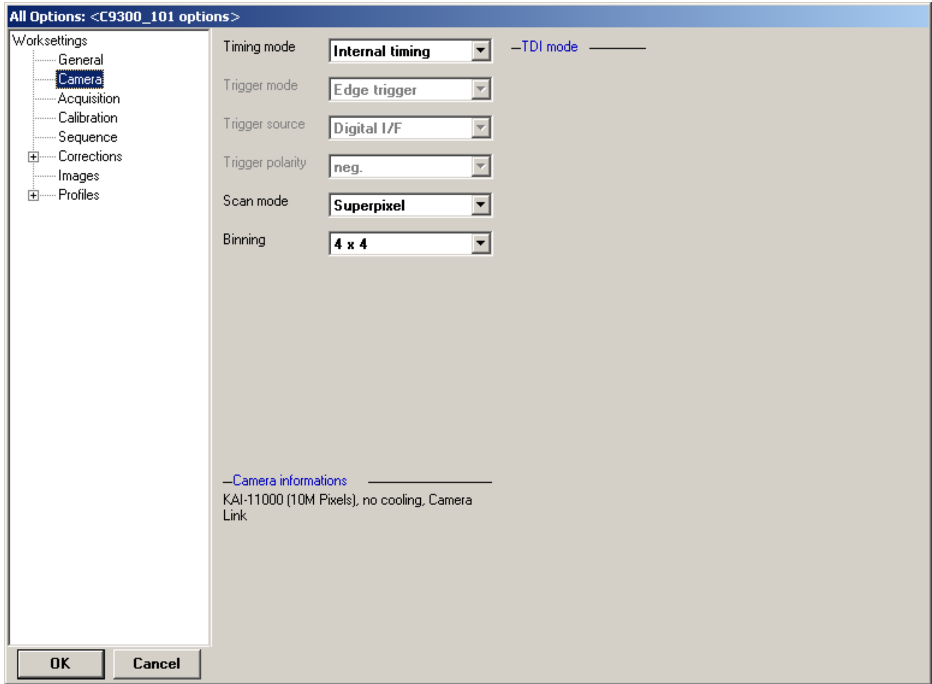
ImageEM (C9100-13)



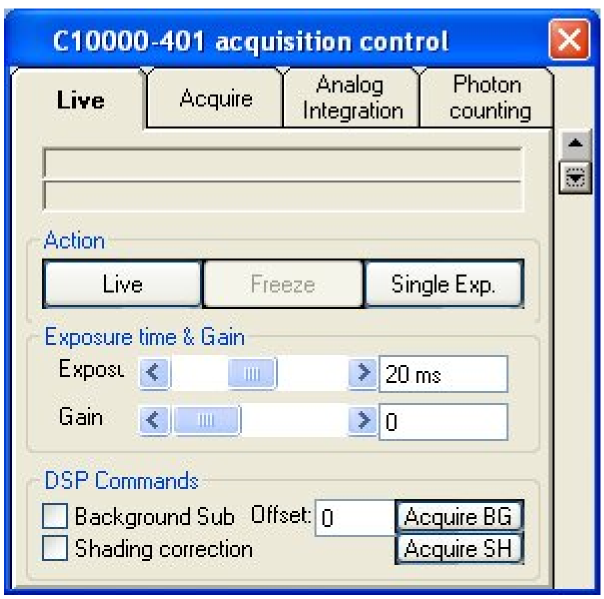

All Options: <C9100-13 options>
Worksettings
General
Camera
Acquisition
Calibration
Sequence
Corrections
Images
Profiles
Timing mode
Internal timing
Trigger mode
Edge trigger
Trigger source
Digital I/F
Trigger polarity
pos.
Trigger number
1
Cycle number
0
Scan mode
Normal
Scan Speed
High
OnChipAmp
EM readout
Cooling Fan
Cooler
On
Target Temperature
-65
Ext. Output Polarity
Negative
Ext. Output Delay [s]
0
Ext. Output Width [s]
0,04
Photon imaging mode
No
Camera information
OK
Cancel

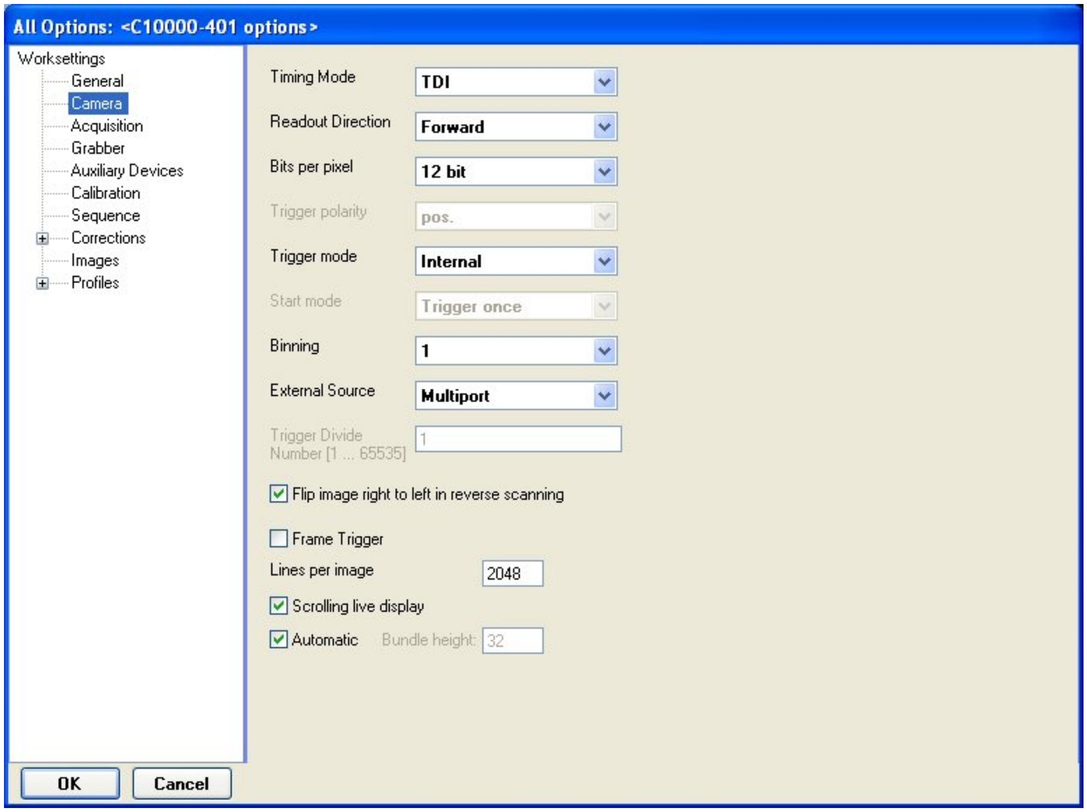
C9300

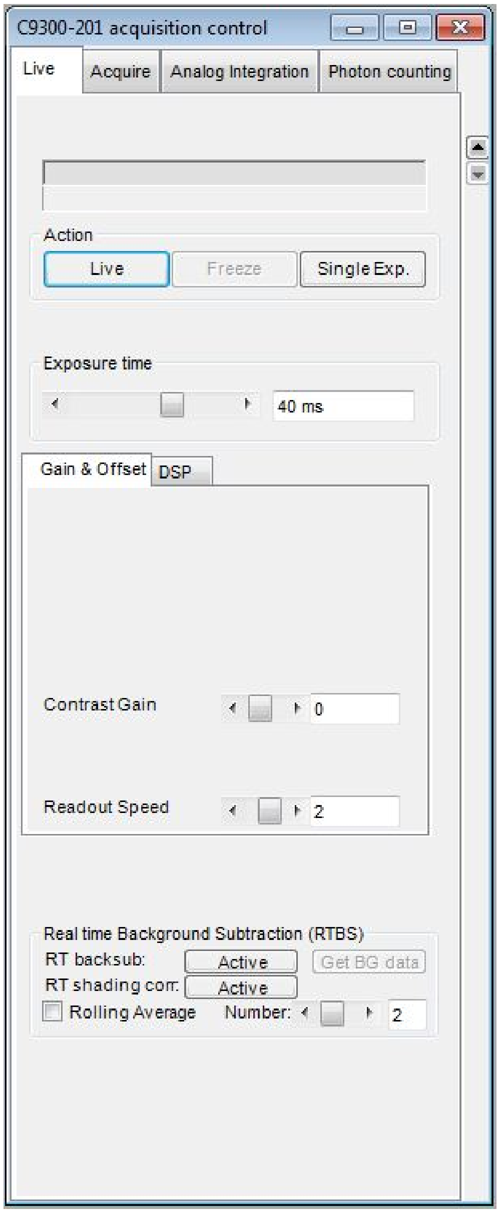

C9300_101 acquisition control
Live
Acquire
Analog Integration
Photon counting
Action
Live
Freeze
Single Exp.
Exposure time
Exposure
50 ms
Gain & Offset
Gain
0
Offset
0

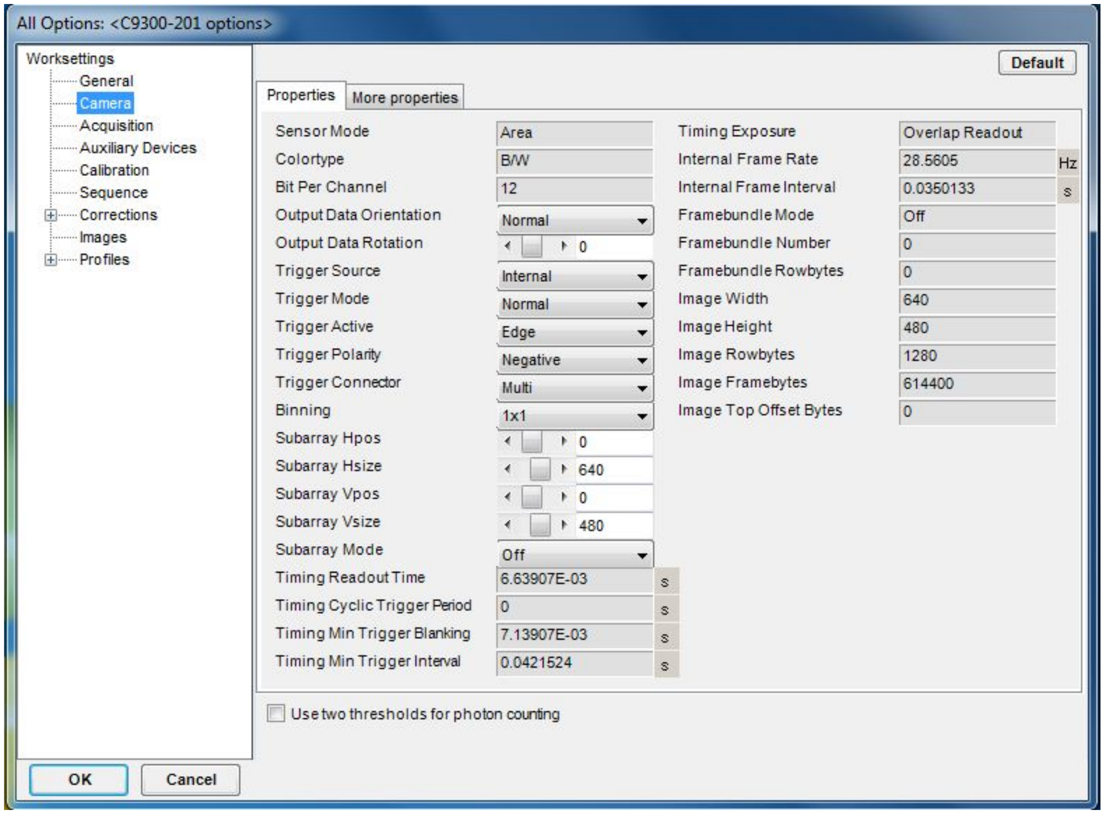

All Options: <C9300_101 options>
Worksettings
General
Camera
Acquisition
Calibration
Sequence
Corrections
Images
Profiles
Timing mode
Internal timing
TDI mode
Trigger mode
Edge trigger
Trigger source
Digital I/F
Trigger polarity
neg.
Scan mode
Superpixel
Binning
4 x 4
Camera informations
KAI-11000 (10M Pixels), no cooling, Camera Link
OK
Cancel

C10000


C10000-401 acquisition control
Live
Acquire
Analog Integration
Photon counting
Action
Live
Freeze
Single Exp.
Exposure time & Gain
Exposu
20 ms
Gain
0
DSP Commands
Background Sub
Offset:
0
Acquire BG
Shading correction
Acquire SH

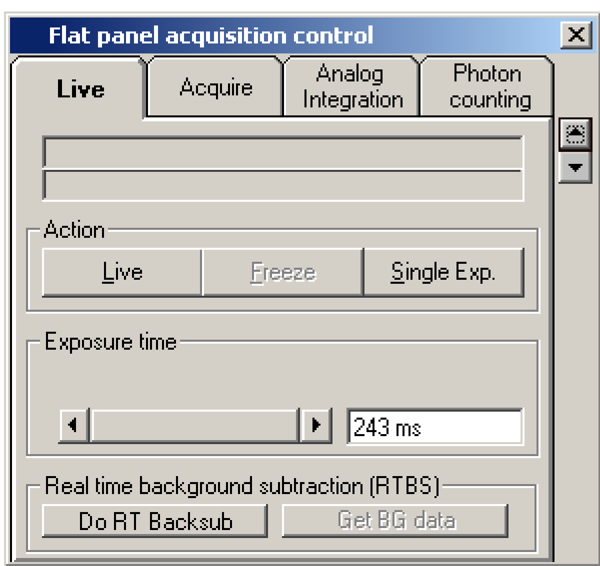

All Options: <C10000-401 options>
Worksettings
General
Camera
Acquisition
Grabber
Auxiliary Devices
Calibration
Sequence
Corrections
Images
Profiles
Timing Mode
TDI
Readout Direction
Forward
Bits per pixel
12 bit
Trigger polarity
pos.
Trigger mode
Internal
Start mode
Trigger once
Binning
1
External Source
Multiport
Trigger Divide Number [1 ... 65535]
1
Flip image right to left in reverse scanning
Frame Trigger
Lines per image
2048
Scrolling live display
Automatic
Bundle height:
32
OK
Cancel

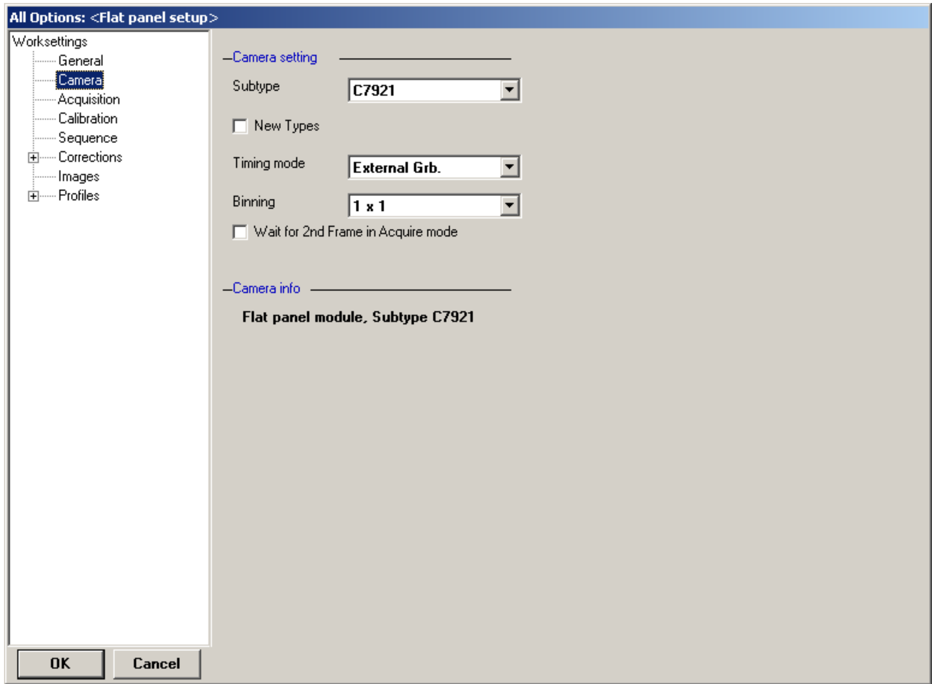

C9300-201 acquisition control
Live
Acquire
Analog Integration
Photon counting
Action
Live
Freeze
Single Exp.
Exposure time
40 ms
Gain & Offset
DSP
Contrast Gain
0
Readout Speed
2
Real time Background Subtraction (RTBS)
RT backsub:
Active
Get BG data
RT shading corr.
Active
Rolling Average
Number:
2



X-Ray Flat Panel

There is a variety of Hamamatsu X-Ray flat panel sensors. The following models are currently supported: C7942, C7943, C7921, C7920, C9728/C9730 /C9732 (USB, with DCAM), C9250, C9311, C9312, C9321, C10013, C9252, C10322, C10500D, C10502D, C10900, C10901, C10158).

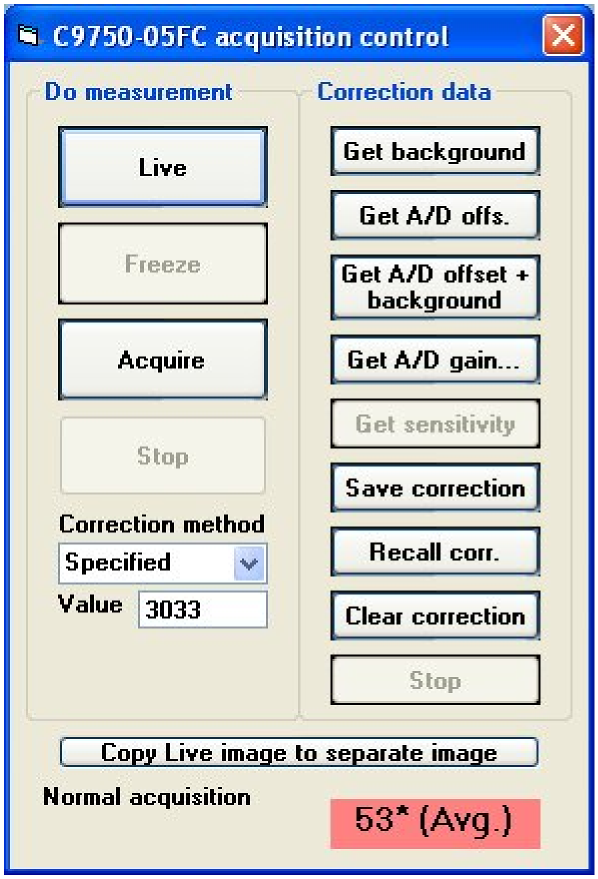


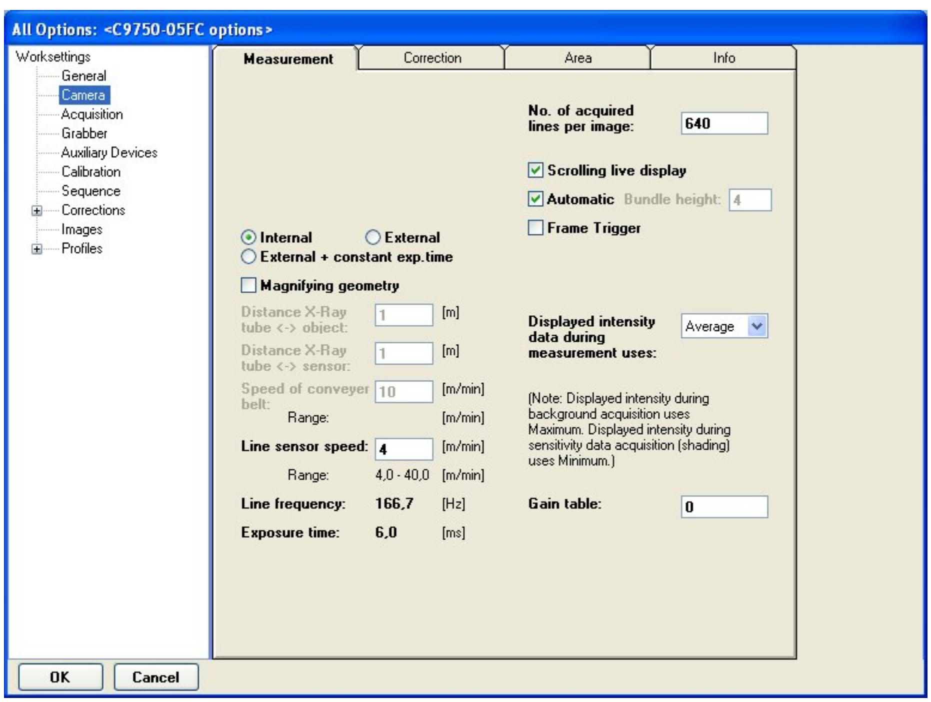


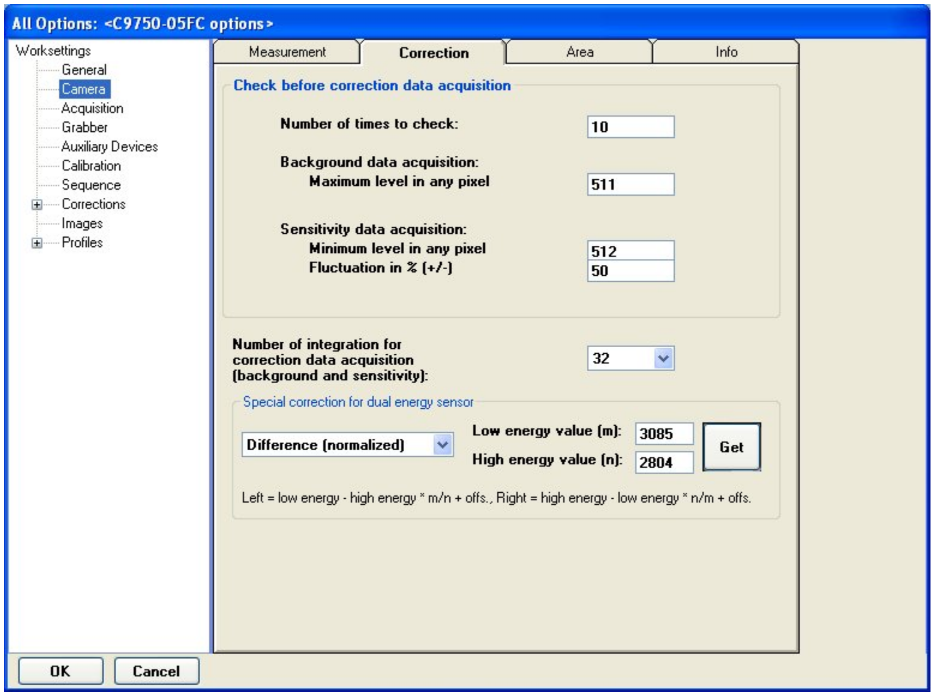
X-Ray Line Sensor

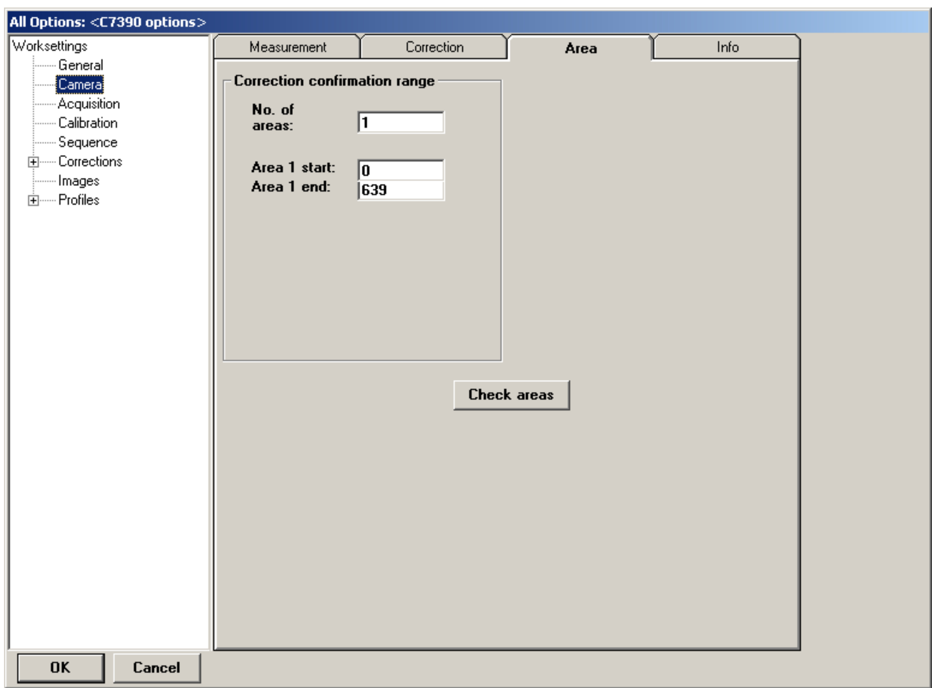
The HiPic also supports Hamamatsu X-Ray line sensors. The following models are currently supported:

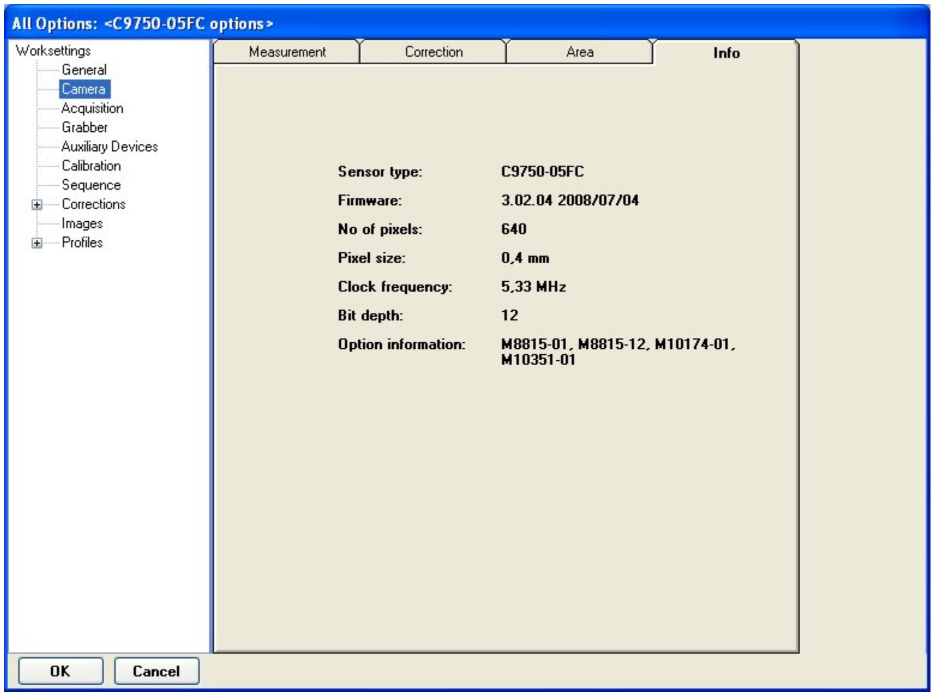
C7390, C8133, C8750, C9750, C9133, C10800.


C9750-05FC acquisition control
Do measurement
Correction data
Live
Freeze
Acquire
Stop
Correction method
Specified
Value
3033
Get background
Get A/D offs.
Get A/D offset + background
Get A/D gain...
Get sensitivity
Save correction
Recall corr.
Clear correction
Stop
Copy Live image to separate image
Normal acquisition
53* (Avg.)


All Options: <C9750-05FC options>
Worksettings
General
Camera
Acquisition
Grabber
Auxiliary Devices
Calibration
Sequence
Corrections
Images
Profiles
Measurement
Correction
Area
Info
No. of acquired lines per image:
640
Scrolling live display
Automatic
Bundle height:
4
Frame Trigger
Internal
External
External + constant exp.time
Magnifying geometry
Distance X-Ray tube <-> object:
1
[m]
Distance X-Ray tube <-> sensor:
1
[m]
Speed of conveyer belt:
10
[m/min]
Range:
[m/min]
Line sensor speed:
4
[m/min]
Range:
4,0 - 40,0
[m/min]
Line frequency:
166,7
[Hz]
Exposure time:
6,0
[ms]
Displayed intensity data during measurement uses:
Average
(Note: Displayed intensity during background acquisition uses Maximum. Displayed intensity during sensitivity data acquisition (shading) uses Minimum.)
Gain table:
0
OK
Cancel


All Options: <C9750-05FC options>
Worksettings
General
Camera
Acquisition
Grabber
Auxiliary Devices
Calibration
Sequence
Corrections
Images
Profiles
Measurement
Correction
Area
Info
Check before correction data acquisition
Number of times to check:
10
Background data acquisition:
Maximum level in any pixel
511
Sensitivity data acquisition:
Minimum level in any pixel
Fluctuation in % (+/-)
512
50
Number of integration for correction data acquisition (background and sensitivity):
32
Special correction for dual energy sensor
Difference (normalized)
Low energy value (m):
3085
High energy value (n):
2804
Get
Left = low energy - high energy * m/n + offs., Right = high energy - low energy * n/m + offs.
OK
Cancel


All Options: <C7390 options>
Worksettings
General
Camera
Acquisition
Calibration
Sequence
Corrections
Images
Profiles
Measurement
Correction
Area
Info
Correction confirmation range
No. of areas:
1
Area 1 start:
0
Area 1 end:
639
Check areas
OK
Cancel



List of camera parameters

The following is a complete list of all camera parameters, its range of values and an explanation of the meaning of the parameter.

Parameter	Range	Description
Binning	1x1 / 2x2 / 4x4 / 8x8 / 16x16 / different factors in two directions	A special readout mode of Hamamatsu digital cameras. Already in the camera the charges from a predefined number of pixel is accumulated. The accumulated charge signal is then digitized and read out. Binning allows getting higher camera sensitivity and reducing the amount of data. Of course this function works in expense of spatial resolution.
Hor. Binning	Integer number	Binning factor in horizontal direction
Ver. Binning	Integer number	Binning factor in vertical direction
Trigger polarity	Positive / Negative	Defines the active level of an electrical signal starting a camera exposure. If Trigger polarity is negative a falling edge (transition from high to low) starts image exposure (provided that the camera is switched to edge trigger mode).
Scan	Normal/ Superpixel /	Scan mode defines how the content of a CCD

Mode	Subarray / Interlace / Outline / Extended	chip is read out. Normal: The whole CCD chip is read out pixel per pixel Superpixel: A special binning mode where a square number of pixel is binned (e.g. 2 x 2, 4 x 4). This function can be used to increase camera sensitivity, increase the readout rate (frame rate) and reduce the amount of data. Subarray: Only a user-predefined area of the CCD is read out. This function can be used to reduce the amount of data and speed up the readout, if only a part of the image is necessary for analysis. Interlace: A mode where every second line is read out. Outline: A mode where the full chip is read out with low resolution and high frame rate
Light mode	Low/High Or 0-1	Two different settings of the camera can be selected. In Light mode "**Low**" (="0") the camera works with reduced sensitivity but maximum dynamic range, while in Light mode "**High**" (="1") the camera works with maximum sensitivity at a slightly lower dynamic range.
Scan speed	High / Low or High / Low / medium or 0 / 1 (0=fast, 1=slow) or (single tapped / dual tapped mode)	Speed of CCD readout. This is mainly determined by the pixel clock of the camera. Fast readout has the advantage of high frame rate, whereas slow readout results in high dynamic range. Sometimes slow readout is called high precision mode. Cameras with slow readout are also called slow-scan cameras.
Trigger Mode	Edge / Level / PIV	This parameter defines how a camera reacts on an external trigger. Edge: Starts exposure with a (rising or falling according to polarity) edge of an electrical signal (Normally a TTL signal) Level: Exposure starts with an edge (falling or rising according to polarity) and stops with the

		inverse edge of an electrical signal (Normally a TTL signal) PIV: PIV stands Particle image velocitometry. With an edge (falling or rising according to polarity) of an electrical signal (Normally a TTL signal) two images are acquired and readout within short time.
Timing mode	Internal / External or Internal / External Grb / External Lemo or Internal / External Edge 2 / External Level 1 / External Level 2 / External Edge 1	The timing or timing mode defines whether start and stop of an exposure is defined internally (in the camera) or by an external electrical signal Internal defines the timing inside the camera where External starts/stops exposure by an electrical signal. External-Grb defines the timing by the connected frame grabber External Lemo defines the timing by an electrical signal inputted by a Lemo connector External Edge 1 or 2 and External Level 1 or 2 are special timing modes dedicated to the C9266 X-ray dental sensor (see C9266_InstructionManual.pdf delivered with the C9266 for details)
H-Offset	Integer number	Horizontal offset
H-Width	Integer number	Horizontal width (Setting used only in subarray sacn mode)
V-Offset	Integer number	Vertical offset (Setting used only in subarray scan mode)
V-Width	Integer number	vertical width (Setting used only in subarray scan mode)
X direction (pixel)	Integer number	Size of the acquired image in X-direction
Scan Area	Two integer numbers	Number of pixel in both directions (x and y)
Trigger source	BNC / D-Sub / Digital I/F / Multiport	BNC: A BNC connector normally at the rear side of the camera controller D-SUB: A 9 pin D-Sub connector at the rear side of the camera controller Digital I/F: An electrical signal normally connected from the digital data connector of the

		camera to the frame grabber Multiport: A 4 pin Hirose type connector at the camera head, which eventually has other features on other pins.
Exposure time	Time in h, m, s, ms, us, ns / External / Controlled by PC	The exposure time is the time the CCD camera is sensitive to light. This timing is dependent on timing and trigger mode and electrical signals applied to the camera controller or head. In internal mode and in special other externally triggered modes like the edge trigger mode this time is just specified as a time in physical units (e.g. seconds). In other cases like level trigger modes it is defined by the length of the electrical pulses. In again other cases it is defined by the PCs clock or by the timing of external events.
Gate delay	Time in h, m, s, ms, us, ns	The delay time after a gate pulse. Specified in physical units.
Gain/Amp gain	Low / high / super-high or 0-255 or 0 / 1 or 0 / 1 / 2	Gain or Amp gain specifies the setting of an analog amplifier inside the CCD camera controller or head. Sometimes the range of settings depends on other parameters like scan speed.
MCP (MCP gain)	Integer number	MCP gain specifies the setting of a high voltage applied to a photocathode inside an image intensifier placed on the front of a CCD camera.
EMG	Integer number	EMG specifies the gain of an electron multiplying device inside a CCD camera.
Offset	Integer number	Offset specifies an analog which is subtracted to the analog signal of the CCD chip. It is normally used in combination with gain of amp gain.
Panel switch	On / Off	Specifies whether a small panel on the front side of the CCD camera controller is active of not. If Off the parameters can be specified only by software.
Shading control	On / Off	Specifies whether an analog shading corrector is active on the front side of the camera.

Contrast enhancement	Off / Potentiometer / Computer control	Specifies whether and how an analog contrast enhancement is active and whether the parameters can be specified by potentiometers or by computer control.
Target temperature	Real number, normally in Steps of 5 degrees.	Sets the temperature the peltier cooler tries to reach at the location of the chip.
Actual temperature	Real number normally with a precision of 0.1 degree.	Displays the actual CCD temperature
ROM version	String	Displays the ROM version
Chip type	String	Displays the Type of CCD chip
Vol. Offs.	Integer number	Displays the potentiometer setting for offset
Vol. gain.	Integer number	Displays the potentiometer setting for gain
Shutter control	"Auto" / "Open" / "Close" / "Close on readout"	Control how a mechanical shutter which is mounted on the front side of the CCD behaves Auto: Always closed expect during camera exposure Close: Closed Open: Opened Close on readout: Always open, except during readout of an image
Optical Black	On / Off	Optical black defines whether black lines and columns on the left and top side of the CCD (normally covered by black cover) are readout
Trigger number	Integer number	Number of triggers applied to the CCD camera before it readouts an image
Cycle Number	Integer number	Number of cycles for an EM-CCD camera
On Chip Amp	EM readout / CCD readout	Readout mode of an EM CCD camera.
Ext. Output Polarity	Positive / Negative	Polarity of the trigger output of an EM-CCD camera

Ext. Output Delay [s]	Floating point number	Delay of the trigger output of an EM-CCD camera in seconds
Ext. Output Width [s]	Floating point number	Width of the trigger output of an EM-CCD camera in seconds
Photon imaging mode	No / middle / high	A mode to increase sensitivity under very weak light conditions (patented by Hamamatsu Photonics KK)
Mode	Internal Trig. / Ext.Trig./Time / Ext. Trig./Event / Ext. Trig./Level / Ext. Trig./Stop	Mode is comparable to a combination of Timing and trigger mode. These modes are special trigger modes of the C4880 standard camera. Please refer to the camera manual and the related timing diagrams for details.
BG sub	Checked/Unchecked	Starts or stops a background subtraction function inside the camera
Recursive filter	Checked/Unchecked	Starts or stops a recursive filter function inside the camera
Recursive filter number	Integer number	Defines the recursive filter number fro the Recursive filter operation
High voltage	Checked / Unchecked	Applies or switches off high voltage
EB-Gain	Integer number	Sets the voltage on an electron bombarded CCD.
Sensitivity	Checked / Unchecked	Switches on or off the sensitivity parameter of a camera
Subtype	String	Defines which type of Flat panel is used. Normally this type is detected automatically.
New types	Checked/Unchecked	Sometimes Flat panels have older and newer types of the same device. Newer types normally have a Lemo connector at the camera front side.
Frame time	Any time in physical units	Interline CCD cameras: For interline cameras exposure and readout can be performed simultaneously. For exposure times <= readout time the frame time is always the readout time. For exposure times > readout time the frame time is always the exposure time. Full frame transfer CCDs: For full frame transfer CCD cameras exposure and readout is always

done separated. This means frame time = exposure + readout time.

CCIR/EIA video type cameras: The frame time for standard video readout cameras the frame time is always fixed (40 ms for CCIR and 33 ms for EIA).

The following parameters can be found on the camera acquisition dialog. They are however no parameters which are contributed by the cameras behavior, but are parameter which are due to the acquisition process, therefore we call it acquisition parameters.

Start acquisition for sequence mode	"Next field", "Odd field", "Even field"	This parameter refers to images acquired by an analog CCD camera. It defines whether during sequence acquisition of full frames should start with an odd field an even field or the next field.
Wait for 2nd Frame in Acquire mode	Checked/Unchecked	This parameter defines whether for acquisition of flat panel images in acquire mode the system should ship the first frame and record only the second
Frame grabber trigger	Checked/Unchecked	This parameter defines whether acquisitions from an analog camera should start with an electrical signal applied to the FG trigger input (FG=frame grabber). This parameter applies only to standard video camera signals.
Frame trigger	Checked/Unchecked	This parameter defines whether acquisitions from a line sensor or TDI camera should start with an electrical signal applied to the frame trigger input.
Integrate after trigger	Integer number	This parameter defines whether the system should average a specified amount of frames after the reception of a trigger.
# of exposures	Integer number	In analog integration mode this parameter defines how many frames are summed up in memory
Clear on	Checked/Unchecked	This parameter defines whether the

Start		currently selected image should be cleared when starting image acquisition. If this parameter is not selected one can continue to acquire data starting with the data in the currently selected image
Photon counting threshold	Integer number	Threshold above parts in the image are regarded as photon spots
Use S/W trigger with single acquisitions	Checked/Unchecked	Cameras operated by DCAM module can have the option to be operated in Software Trigger mode. This is a mode where the software can control the start of an acquisition (Normally the exposure it either started by an internal mechanism or by external trigger). Together with single acquisitions this feature is used if the option “Use S/W trigger with single acquisitions” is selected. Otherwise software trigger mode is not used.
Rolling average	Checked/Unchecked	An image processing function which reduces the noise by combining the current image with the previous image (Live mode only).
Number (for Rolling average)	2- 255	Indicates the strength of the Rolling average function. The higher the number the stronger is the noise reduction but the more lag is introduced to the image.

Acquisition modes

Four image acquisition modes (Live, Acquire, Analog Integration and Photon Counting) can be controlled from the camera acquisition dialog.

There are two ways to open this control:

1. Choose the desired acquisition mode from the **Acquisition** menu.

2. Click on the desired acquisition mode button as described below

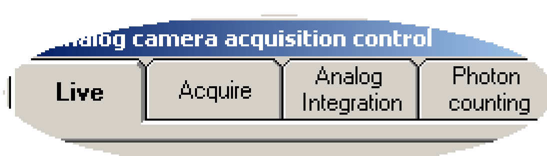
	Live mode	If the Acquisition dialogue is not opened, it will be opened as you click this button for the first time. If you click it while the Live mode dialogue is open, image acquisition in **Live** mode will be started. The acquisition parameters as shown in the Live mode dialogue are used.
	Freeze Live mode	**Live** mode stops. The last image will be stored.
	Acquire	If the Acquisition dialogue is not opened, it will be opened as you click this button for the first time. If you click it while the Acquire mode dialogue is open, an image acquisition in **Acquire** mode will be executed. The acquisition parameters as shown in the Acquisition mode dialogue are used.
	Analog integration	If the Acquisition dialogue is not opened, it will be opened as you click this button for the first time. If you click it while the Analog integration mode dialogue is open, an image acquisition in **Analog integration** mode will be executed. The acquisition parameters as shown in the Analog integration mode dialogue are used.
	Photon counting	If the mode dialogue is not opened, it will be opened as you click this button for the first time. If you click it while the Photon counting mode dialogue is open, an image acquisition in **Photon Counting** mode will be executed. The acquisition parameters as shown in the Photon counting mode dialogue are used. See.

The acquisition buttons work different depending on the display status of the acquisition window:

If the window is closed, it will be opened by clicking one of the buttons.

If the window is already opened, the corresponding acquisition function will start after pressing an acquisition button. The acquisition will be made with the parameters set in the corresponding tab control.

The camera acquisition dialog has four tabs to control the different acquisition modes.



The camera and acquisition parameters of every acquisition mode is stored internally and reactivated if the acquisition mode is selected again.

The camera acquisition dialog can be changed in its size using the two pushbuttons on the right side of the dialogue.

If you want to see the whole window with all options, you have to choose the largest size.
However after you have finished initial settings, you may not need to see all setting features of the control. Then you can make it smaller and display just the controls you need for your work (e. g. start acquisition and set exposure).

If the Acquisition Dialog is opened once, you can switch between the different modes either by selecting the desired mode from the main menu or by selecting the tab corresponding to the desired mode.

Each acquisition can be started by a hot-key and stopped by pressing the ESC key.

Hot-keys for start of an acquisition are:

Ctrl +L	Live
Ctrl +F	Freeze
Ctrl +A	Acquire
Ctrl +I	Analog integration
Ctrl +C	Photon counting

Live

Live mode is a mode in which images are acquired continuously. It is intended for monitoring images with maximum speed. It differs from other acquisition modes from display window handling. Live images are always displayed in the same window, while in other modes each new image can be displayed in a new display window.

The acquisition speed is displayed in the status bar. This feature can be used to control whether the camera is operated correctly.

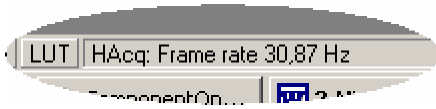


Image quality can be improved by using real time background subtraction (RTBS), real time shading correction (RTSH) and Rolling average.

Acquire Mode

Acquire mode is very similar to Live mode Single image with two exceptions:

1.) It can contain different camera parameters as the Live mode. Thus it is easy to use two different camera parameter sets just by switching back and forth from Live to Acquire mode.

2.) Acquire mode does not use always the same window. Normally with every new acquisition the measurement data is written to a new image and displayed in an individual window. This prevents overwriting of already acquired data.
Note: There is an option in the images options called "Acquire always to the same window". If this option is checked all new acquisitions are directed to one image and are displayed in the same window which means that the previous image data is overwritten without warning.

Difference between Live and Acquire mode

Acquire mode is mainly intended to acquire measurement data whereas live mode is mainly intended for checking and adjustment purposes. In the case of a so called dual scan cameras like the C4880 and ORCA II there is an additional feature associated with the different acquisition modes:

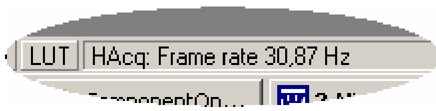
Live mode and photon counting mode is operated with fast scan mode whereas Acquire mode and Analog integration mode is operated in slow scan mode. This enhances the meaning of Live mode as a fast operating mode for adjustment and checking purposes where Acquire mode is a measurement mode in which the camera is used in a high precision mode with maximum bit range.

Note: The feature that Live and Photon counting mode is operated in fast scan mode and Acquire and Analog integration is operated in slow scan mode is only available if the camera is used with internal drivers. If the camera is operated by a DCam module the setting of scan mode is done in the camera options and is valid for all acquisition modes.

Analog Integration

Analog Integration is a mode where a number of images from the camera are accumulated in the frame memory up to 16 or 32 bit depth. (16bit/32 bit).

The acquisition speed is displayed in the status bar. This feature can be used to control whether the camera is operated correctly.

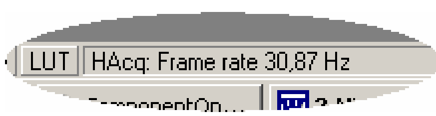


Photon Counting

Photon Counting is a mode in which single photon events are added up in the frame memory. If the signal integration time is sufficiently long, a very high signal-to-noise ratio can be achieved. This mode also effectively suppresses certain crosstalk effects inherent to some image intensifiers. A dynamic photon counting mode allows temporal analysis of photon counting images.

Note: This mode is only useful if an image amplification device such as an image intensifier allows to see the effect of a single photon. Most cameras do not have this feature!

The acquisition speed is displayed in the status bar. This feature can be used to control whether the camera is operated correctly.



See also the chapter Photon counting in this document for details.

Camera data types and data storage

Depending on the data delivered by the camera and the acquisition mode the result image will be stored in different types of images.

The data type of cameras range from 8 to 16 bit.

Data type of cameras

In practice the following data types can be delivered from the camera:

8, 10, 12, 14, 16 bit (all unsigned values)

According to the data type possible output values are

Camera Data Type (bit)	Value range
8	0 to 255
10	0 to 1023
12	0 to 4095

14	0 to 16393
16	0 to 65535

Storage types

Image data is stored in three different types:

8, 16 (signed) and 32 bit (signed)

According to the data storage type possible the following values can be stored

Storage (bit)	Value range
8	0 to 255
16	- 32768 to 32767
32	- 2.147.483.648 to 2.147.483.647

To store the images correctly the following storage types will be used. To avoid overflow when integration images in Analog integration mode an option "32 bit in Analog integration" can be used.

Camera Data Type (bit)	Storage Type (bit), Live mode	Storage Type (bit), Analog Integration mode	Storage Type (bit), Analog Integration mode with option 32 in AI
8	8	16	32
10	16	16	32
12	16	16	32
14	16	16	32
16	32	32	32

Photon counting images uses 16 bit as data storage type normally, if the option "32 bit in Photon counting" is set 32 bit is used.

Corrections

Corrections are used to compensate artifacts of CCD cameras, optics and other components used in the system. See also the chapter corrections in this document for more details.

Background subtraction correction

Most cameras delivers a nonzero signal even if they are not illuminated with light.

This has mainly two reasons:

1.) Image data is normally digitized by an A/D converter which outputs only positive numbers (including zero). Therefore it is an advantage to adjust the A/D offset in a way that already with no illumination there is a nonzero output. Otherwise small signals still leads zero as an output and cannot be measured. Additionally every camera has a so called fixed pattern which is present in every image. To subtract this fixed pattern a background subtraction can be used. However if the signal is zero for low intensities a dark image does not contain the fixed pattern and consequently cannot be subtracted.

2.) Even with no illumination the sensor accumulates some charges which leads to a nonzero signal

As a consequence the most important correction method is a function which subtracts a dark data from the measurement data. See also the chapter Corrections - Background Subtraction in this document.

Standard background subtraction

Standard background subtraction is a function which subtracts a dark image from the given data. This is always executed after the image acquisition as a post process. The dark image can be either directly acquired from the camera or it can be read from an image file. There is an option to automatically call this post process after the image acquisition. This automated process is always called when an image acquisition finishes. This is:

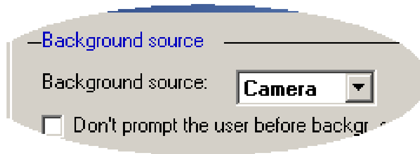
In Live mode when the live mode has been freezed.

In Acquire mode when the image is completely acquired.

In Analog integration mode and photon counting mode when all images which should be summed up in memory are acquired

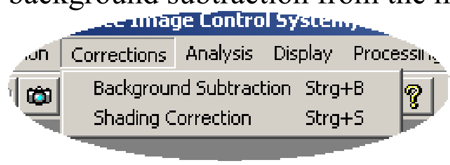
To operate background subtraction from camera

1.) Select Camera as the background source in the background options.



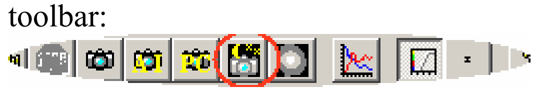
2.) Acquire an image

3.) Start background subtraction by either executing background subtraction from the menu:



- or -

Execute the Background subtraction icon on the toolbar:

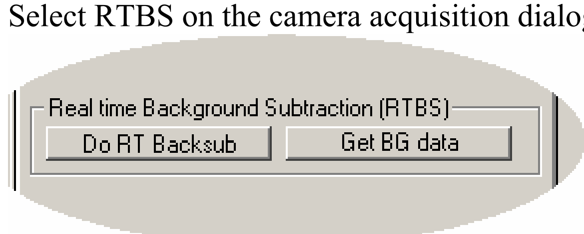


RTBS (real time background subtraction)

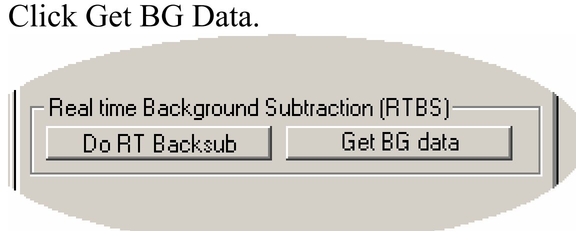
Sometimes a background subtraction makes a so big difference on the image result that the user wishes that such background subtraction is also performed during live mode. This is a feature which can be called directly from the camera acquisition dialog. The data used as a background image can be either come from the camera directly or from an image file.
To execute real time background subtraction proceed as follows

1.) Start Live mode

2.) Select RTBS on the camera acquisition dialog.



3.) If there is no image in the background buffer which is the case at program start get new background data: Click Get BG Data.



This puts the next acquired image in the RTBS

background buffer.
Whenever you want to use a newer background image click Get BG Data.

Note: Real time background subtraction is also very useful to eliminate unwanted signal from an image.

Camera provided function

Some cameras have a built in background subtraction. In such cases the software only controls the camera feature but does not execute a background subtraction as an own function. Thus controlling the built in background subtraction with additionally executing the background subtraction functions from the software may lead to undesired results.

Cameras with built in background subtraction feature are:

- C7190-21, C7190-23 and C7190-43 (video readout EB-CCD)
- C8000-20 (video readout BT CCD)
- The C10000-401 and C10000-701
- X-Ray Line sensors like C7390, C8133, C8750, C9750 and C9133
- The C9100-13 (ImagEM)

Shading correction

The **Shading Correction** command corrects intensity non-uniformities of an image. In principle this is done by a pixel by pixel division of the intensity in the measurement image and the shading reference image. See also the chapter Corrections -Shading correction in the document.

To perform shading correction proceed as follows:

1.) Record a shading reference image. This image should represent the sensitivity distribution of the system.

2.) Perform background subtraction on this shading reference image.

3.) Save the image to hard disk.

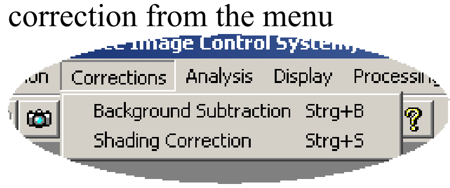
4.) Specify the image as the shading image in the shading correction options. To do this click to the pushbutton

Get at the left side of the edit field for the shading file.

5.) Acquire your image data which you want to be shading corrected.

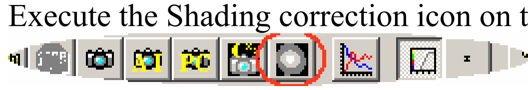
6.) Perform background subtraction on this image.

7.) Start Shading correction by either executing shading correction from the menu



\- or -

Execute the Shading correction icon on the toolbar:



Note: Item 1) – 4) have to be performed only once if the system sensitivity does not change

Defect pixel correction

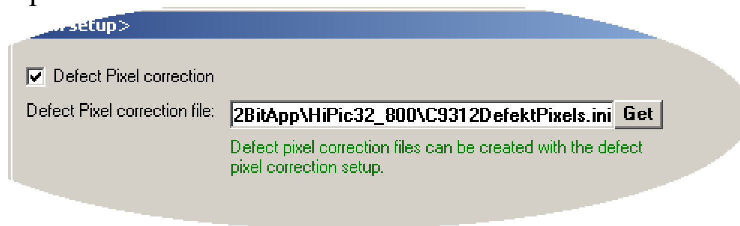
This function corrects defective pixel of a sensor by replacing them with not defective neighbors. Defects in this sense can be either single pixels complete lines or complete columns. A defect is regarded as either a hot pixel, which has too high intensity when not illuminated or a dead pixel which has too low intensity when illuminated. See also the chapter Corrections – Defect Pixel Correction in this document.

To activate the defect pixel correction proceed as follows:

1.) Create a defect pixel correction file by using the defect pixel correction tool and save it to a disk file. See the chapter Defect pixel correction tool.

2.) Specify the name of the defect pixel file in the defect pixel correction options and activate the checkbox

Defect pixel correction:



With every new acquisition the data is automatically corrected according to the information in the defect pixel file.

Rolling average

While all the a.m. corrections improve the image quality there is another operation which also improves image quality without being a correction in the strict sense: It is the **rolling average** function which is available in live mode only.

Rolling average is an image processing function which reduces the noise by combining the current image with the previous image (Live mode only).

The number which can be set from 2 t o255 indicates the strength of the **rolling average** function. The higher the number the stronger is the noise reduction but the more lag is introduced to the image.

Saving and loading images

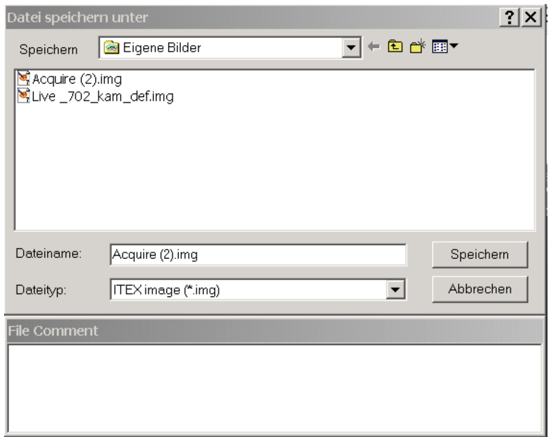
This topic describes how to save or load images. Please see the Appendix Image File Formats for details.

Saving images

The **Save As..** *command opens a dialogue where you can input file name, file type, drive and directory name for the image file to be saved. The complete image will be saved.*
The **Save ROI As**.. *command saves the partial image within the currently selected rectangular ROI .*

Choose **Save As...** from the **File** menu.

If you want to save a part of the image only, you have to select the ROI **before** you open the **Save ROI As...** dialogue!



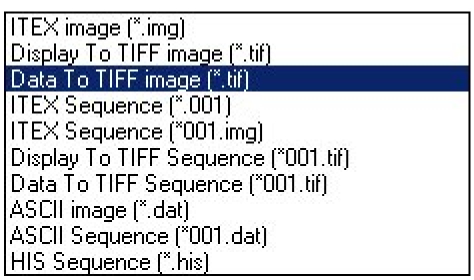
Save As... dialogue

If you select **Cancel** the program cancels the operation.

The dialogue behaves like a standard Windows dialogue. It allows to select the directory where the file shall be saved, to define new directories, to display the file list in different formats etc.

After selecting the desired directory, you have to type the desired file name in the **File name** textbox.
Note: The correct file extension (e.g. ".tif" or ".img") will be automatically appended to the file name. If you type a file extension which is not identical to the file extension as defined by the file type (e.g. you type "image.pix"), the correct file extension will be appended automatically (e.g. "image.pix.tif").

Image data are saved in a format as selected in the **Save as type** list. Following formats are supported:



Save as type list

The file formats for image sequences will be available only, if the current image is a sequence image.

See the appendix of a description of all these file formats.

In the text box below the **Save As..** or **Save ROI As...**dialogue you can input a comment. This comment will be saved to disk together with the image file and it can be used to identify the image later on.

Loading images

This command allows loading and displaying an existing image file.

The **Open...** command pops up a dialogue similar to the **Save As...** dialogue. You have to select an image file type which you want to load and display. To select a file you can either input a file name in the file name text box or double-click on the filename in the file list.

If the selected file is part of an image sequence, the sequence, starting at the chosen file number will be loaded.

Following file types can be read by this program:

ITEX files and sequences, TIFF files and sequences (however not 24 bit color TIFF images), DPC files and DPC sequences.

File info

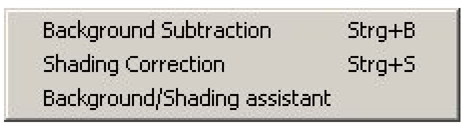
As soon as you have selected a file, detailed information about the actually selected file will be displayed in the **File info** table below the dialogue. The content of this dialogue is same as the **Image Status** display explained below.

Corrections

This topic describes the details of all image correction methods.

Overview

In the corrections menu you find commands which are related to image data corrections:



The menu items which can be executed from the correction menu are:

Background Subtraction, Shading correction and Background/Shading assistant

Background Subtraction, Shading correction, Curvature correction and Background/Shading assistant

The Real time background subtraction and the real time shading correction can be invoked from the camera acquisition dialog.

The defect pixel correction is automatically performed once it has been activated in the defect pixel correction options or can be applied after image acquisition (offline defect correction).

A background/shading assistant can help you to handle background and shading corrections easily.

Background Subtraction

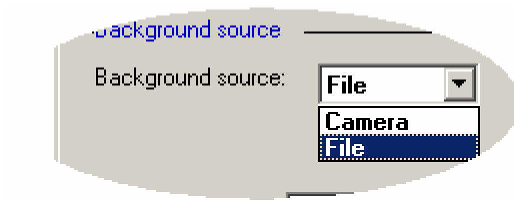
The **Background subtraction** command subtracts a background image from the current image in the frame buffer. How this is done is determined by the settings in the background correction options.

If you want to automatically subtract background after each acquisition, you can select the **Auto Backsub** item in the background correction.

In Live Mode there is also the possibility to perform Real time background subtraction (RTBS), which displays the corrected image after every single acquire image.

The Background subtraction function allows you to subtract the camera dark current from an acquired image. The function can also be used to subtract offset signals of other origin such as undesired background light or stray light.

Background subtraction can be performed either "from camera" or "from file" depending on the setting in the background correction options.



Background Subtraction from Camera

When the option **Camera** is selected a new background image is acquired after each image acquisition and then subtracted from the acquired image. This means, the background image is taken after the data acquisition.

The background image is automatically acquired with the same parameters (such as exposure time and camera gain) as the acquired image. This method is easy to use and convenient if the exposure time is not too long. (In case of long exposure times you may wish to use the "from file" method instead.).

Following description refers to a configuration where a C4880 type camera (except C4880-8X and C4880-40) with a mechanical shutter is used.

The check box **Acquire image with open shutter** defines whether the C4880 shutter will be closed or opened during background acquisition. In most cases you will prefer that the shutter is closed automatically during background acquisition since this is the most convenient way. However, if you want to subtract also background light which has an external origin (such as stray light), you could disable this automatic shutter control by selecting the check box.

Following description refers to a configuration where an analog video camera or another camera without mechanical shutter (e.g. C3077, C4880-80, C4880-40 or C4742-95) is used.

If **Don't prompt the user before backgr. sub** is not selected the user is prompted to close any external shutter or switch off the illumination light or take a similar action to avoid that the light signal comes to the camera during background acquisition. If the option **Don't prompt the user before**

backgr. sub is selected the user is **__not__** prompted to take any such action and Background subtraction immediately proceeds.

Background Subtraction from File

In case of long exposure times, the "from camera" method may become inconvenient since it would take the same time to acquire the background image after every data acquisition. In these cases, it is preferable to save a background image to hard disk once and load it every time it is needed. Of course, this makes sense only if you can assume that the same background image can be used for a series of data acquisitions (i.e. the acquisition conditions, like exposure time, will not change considerably.)

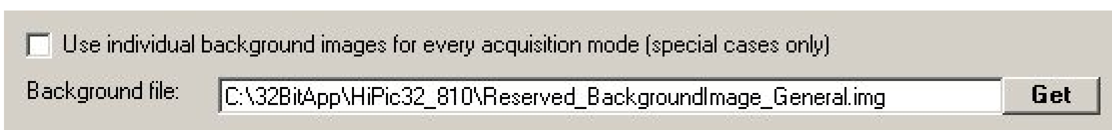
To perform background subtraction "from file" select the option **File**.

In some cases the readout parameters are different for different acquisition modes. In such cases you want to specify different files for the different acquisition modes (special case).

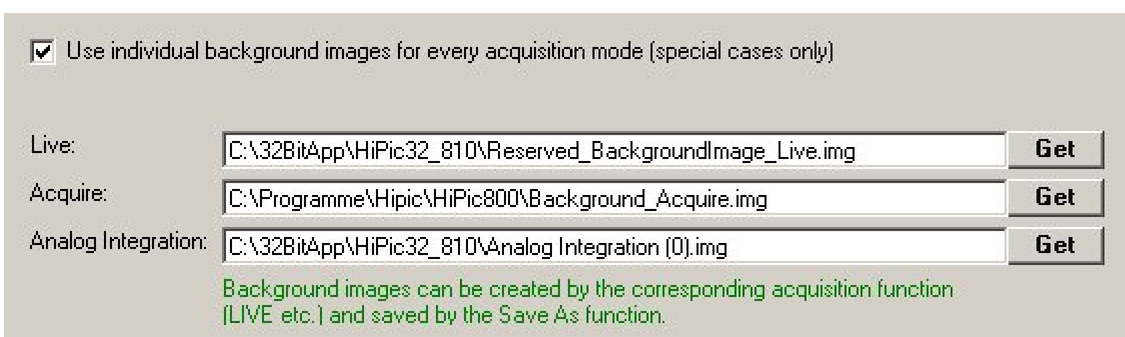
In many other cases (standard case), however, we do not want to specify several files for different acquisition modes and we assume that one file is suitable for every acquisition mode.

__Note:__ When using the "from file" method the user must take care by himself that the background image contains suitable background data.

There is a checkbox where we can distinguish between these two cases. The default setting is that we do not distinguish between different acquisition modes and want to specify one single background file for every case.



Setting which uses one background file only (default)



Setting which uses different background files for different acquisition modes.

Press **Get** to open a file selection dialogue and select the desired file.

Save a background image

To obtain a valid background image you simply take an image under background light conditions with the desired image parameters which you want to use for your measurement, e.g. correct exposure time, scan area, binning factor etc. Save this image by using the **Save as...** command.

Warnings

If the file which you defined as background image file (see below) does not fit to your measurement conditions (e.g. if the binning factors are different) you get an warning message when executing **Background subtraction** and you are prompted to prepare a suitable file and try background subtraction again.

In some case, e.g. if temperature conditions or exposure conditions are very much different for the image in the background image file and in the frame buffer, you will get a warning message before the subtraction is performed and you can decide whether to proceed anyway or you want to prepare another background image. This should be just a hint from the program that the data may not be well suitable, but -as said above- the choice is yours.

Note: Background subtraction "from file" always subtracts pixels which have the same locations on the frame buffer one by one. Images which serve as background images should not have been shifted to another location (e.g. by loading it to a different location and saving it), and conditions like binning factors and optical black parameters should not differ.

Details About Background Subtraction

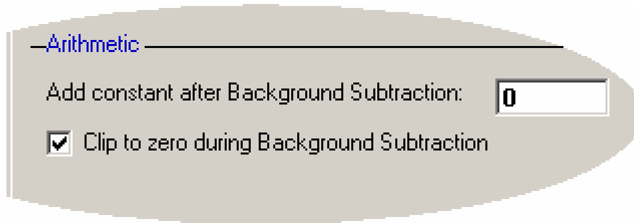
Note: This chapter contains information about how the background subtraction process works.

If the original image or parts of it and the background image have similar intensities and/or if the original image is completely dark on some areas, negative intensity values may result in several pixels after background subtraction. There are, however, some reasons not to allow negative values in the image:

- Negative intensity values often do not have a physical meaning (there is no "negative light intensity").
- Image processing programs often cannot interpret negative values correctly.

Considering all these arguments HiPic handles the question of negative values as follows:

The user can select if the images should be clipped to zero or not during background subtraction by selecting or deselecting the checkbox Clip to zero during background sub. 8 bit images are always clipped to zero.



Considering Images which have acquired with a different integration count

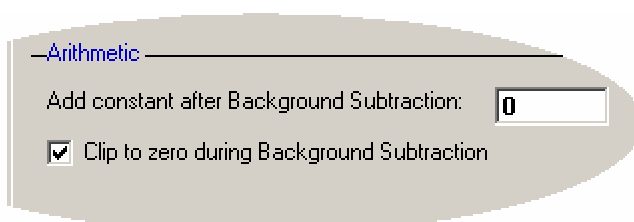
This software allows integrating several camera images to one single image in Analog Integration mode. Software Versions prior to Version 8.1 did not allow to use images with different integration count for background subtraction, which leads to the necessity to acquire new background data for a different integration count. Version 8.1 and higher is now able to use any integration count number for the background image (as long as other parameters like image area or binning are suitable, as was described already earlier).

To increase precision and reduce noise it is recommended to use an integrated image as background image. The integration count should at least be (or better higher) as high as in the data which we want to correct.

Constant

You can add a **constant** during background subtraction process.

This is especially useful when normal acquisition modes are used and negative values would be clipped to zero. By adding a constant you will see the image noise correctly even in dark areas. To add a constant during background subtraction processing you simply enter the desired offset value in the edit box **Add constant after background subtraction**.



If you add a positive constant it may happen that the current bit range is exceeded. In this case the values are clipped to the maximum possible value within the bit range (e.g. 255 in 8 bit images, 1023 in 10 bit images and 4095 in 12 bit images). Therefore it is recommended to choose a constant not higher than necessary (the amount of noise is normally only a few counts). The constant is used for "from camera" type subtraction as well as for background subtraction "from file".

Real time corrections

There are two type of real time corrections: Real time background correction (RTBS) and Real time shading correction (RTSH).

Real time background correction

Background subtraction is a method of subtraction images directly from live images prior to display it. It can be invoked on the Live tap of a camera acquisition dialog. If “File” is selected as the background source in the background options, the specified file is used as the default data for real time background subtraction.

The “Get BG Data” command acquires new background data from the camera. The toggle switch “RT Backsub active” starts the background subtraction process. or stops it.

Note: The Get BG Data command is only available when Live mode is running.

Let’s assume you have selected “File” as the background source in the background options and you have acquired new data during real time background subtraction. If you then close the program or start another background subtraction you will be asked whether you want to save this newly acquired background data permanently and use it for any subsequent background subtraction.

Real time shading correction

Once the real time shading correction (RTBS) is active, the real time shading correction (RTSH) becomes available. It uses the file specified in the shading correction options (see below for details). To start real time shading correction click to the toggle switch “RT shading corr. Active”

Shading Correction

The **Shading Correction** command corrects intensity non-uniformities of an image in the frame buffer. How this is done is determined by the settings in the shading correction options.

If you want to automatically correct shading after each acquisition, you can select the **Auto Shading** item in the shading correction options.

If your want to correct every image display in LIVE mode you can also use the real time shading correction (RTSH, see above).

Shading correction is a method to flatten a spatially non-uniform sensitivity of the complete imaging system.

Due to several reasons an imaging system can have a non-uniform sensitivity at different locations. The reasons may be uneven illumination, lens shading (vignetting) or different sensitivity of the CCD pixels. If an image intensifier is used, the image intensifier may have a spatially varying light amplification.

All these effects can be compensated by a multiplicative correction which we -by convention - call shading correction.

Get a Shading Reference Image

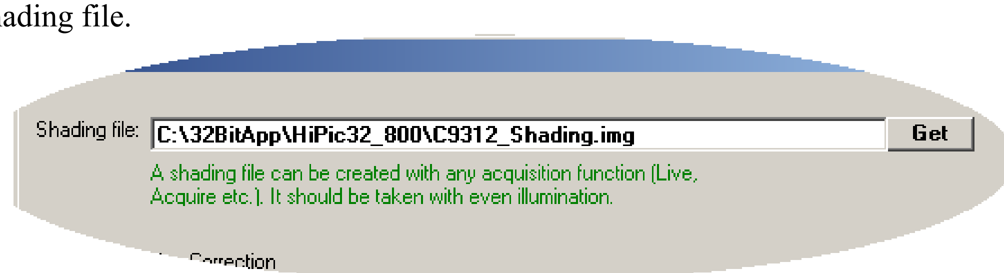
To be able to perform shading correction one must first acquire a shading reference image. A shading reference image is taken from a scene which is completely flat (homogenous illumination) within the field of view.

First, acquire this image by the imaging system, and then perform background subtraction on this image. Then you have to store the reference image using the **Save as...** command. Pay attention that the shading reference image should not have an intensity value of zero or close to zero at any pixel.

Sometimes, especially if one has to work under low light level conditions it may be very difficult or even impossible to obtain a shading reference image. In this case, shading correction can not be applied.

Declare an Image as Shading Reference Image

Specify the image as the shading image in the shading correction options. To do this click to the pushbutton Get at the left side of the edit field for the shading file.



Algorithm of Shading Correction

General

During shading correction the following calculation is performed:

$$C_{(x,y)} = \frac{D_{(x,y)} * K}{S_{(x,y)}}$$

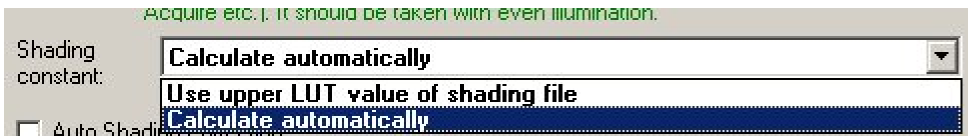
C: Corrected image data (output image)
D: Uncorrected image data (input image)
K: Constant
S: Shading reference image

The calculation is performed with long integer arithmetic.

Constant K

The constant **K** can be specified by the user. At locations where $K = S_{(x,y)}$ the data will not be changed, at locations where $S_{(x,y)} < K$ the image intensity will be enhanced after shading correction, and at locations where $S_{(x,y)} > K$ the image intensity will be reduced after shading correction.

Depending on the setting in the shading options either the Upper LUT value of the shading reference image is used as the constant K or this constant will be calculated automatically according to a well defined criteria (Recommended, Default).



When using the upper LUT value of the shading reference image the following is normally valid:
When setting the LUT values by the AUTO LUT function the upper LUT cursor will be set around the maximum value of the shading reference image. Normally shading data have a maximum intensity at the centre of the image and will slightly decrease at the image borders. Thus shading correction with a shading reference image where the LUT cursors have been set by the AUTO LUT function will keep the image intensity in the centre and enhance it at the borders. In almost every case this is the most convenient and easiest way of specifying the constant K.

When calculating the constant K automatically the average value of the center part (half size in both dimensions) of the shading image is used as the constant K.

Shading correction automatically accounts for chip type, frame-buffer type and binning factor, thus you can compensate an image which has been taken from the camera in normal mode with an image taken in 2 x 2 binning mode. Generally speaking the correction is always done with the pixels from the shading reference image which corresponds to the same location **on chip**.

The normal clipping is performed when the data exceed the current bit range. When zero is found in the shading reference image the corresponding pixel is not corrected (Shading reference images should not have zero values as a contents). The shading data should be background subtracted and should **not** be shading corrected itself. Otherwise an error message will be issued and the shading correction is not performed.

Defect Pixel Correction

The defect pixel correction corrects defective pixels of a sensor by replacing their value with the average value of not defective neighbors.

In a first step (by using the defect pixel correction tool), bad pixels, lines or columns of the camera are detected. The co-ordinates of the bad pixels are then stored in a special data file.

During normal operation with the sensor the defective pixels are then corrected if the pixel correction function is enabled.

The intensity value of a defective pixel, line or column is calculated by the intensity values of the neighboring pixel.

Defect pixel correction tool

The defect pixel correction tool is designed to generate coordinate data from image data showing defects. These coordinates are then used to correct images when they are acquired.

The procedure of getting coordinates of defects has to be done just once for a detector. In later sessions the stored pixel mask data will be used for correction.

Step 1

Acquire and store images with hot and/or dead pixel:

The recommended procedure is to acquire an image with a homogeneous illumination (only small grey level variation) at average pixel intensity of 50% of the maximum value. Whenever possible it is recommended to acquire the image in Analog Integration mode with sufficient integration count. Use the camera binning mode settings and exposure time settings which you will typically use for routine operation.

Save the image on your hard disk.

This image will be further used to calculate dead pixel (which have significantly reduced sensitivity) and hot pixel (which have a high dark current).

If you will use the detector with several binning modes, you have to record one image of any binning mode.

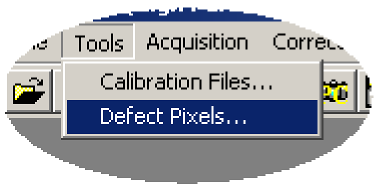
If you are planning to correct for hot pixel only, you may acquire an image without illuminating the detector (dark image).

You can also acquire a dark image and an image with illuminated detector and later use the dark image for hot pixel correction and the illuminated image for dead pixel correction.

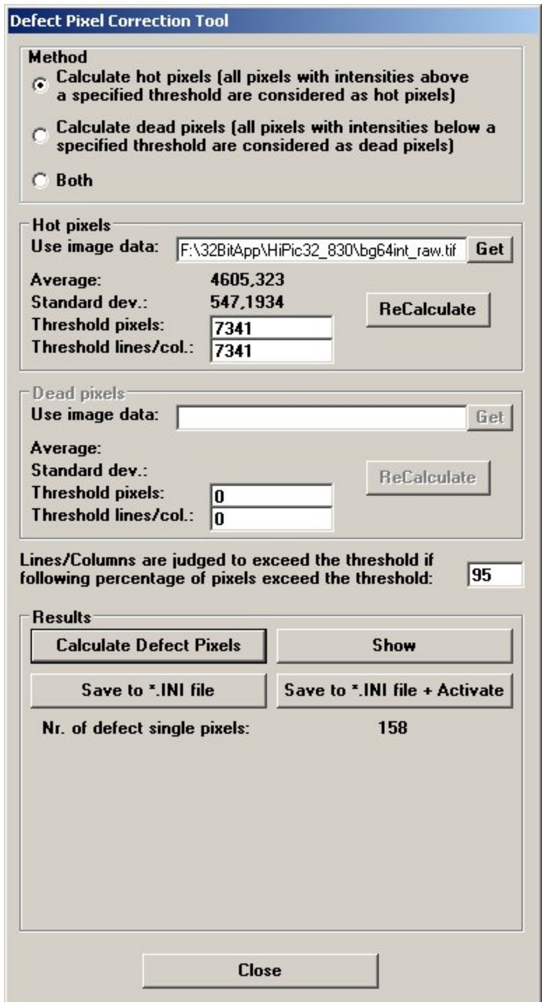
Step 2

Defect Pixel localizing tool

Select **Defect pixels**… from the **Tools** menu to open the Defect pixel correction tool.



The Defect pixel correction tool will appear.



Step 3

At first you have to decide which method you want to apply. Select **Calculate hot pixels...** if you want to correct the pixels which have a higher dark signal than average pixel. Select **Calculate dead pixels...** if you want to correct the pixels which have a lower sensitivity than average pixel. Select **Both** if you want to correct hot and dead pixel (this is usually recommended).

Step 4

Select the defective pixel images in the defect pixel tool. If you have acquired different images for hot and dead pixel, please select the corresponding images in the sections.

Step 5

The system will suggest a reasonable threshold for discriminating normal pixel from bad pixel. The threshold is an intensity value which is related to the average intensity value and the standard deviation of the reference image. The value suggested by the software can be manually changed if the correction map is not reasonable upon customer's considerations.

Press **ReCalculate** in the Hot pixel and/or Dark pixel section to calculate the suggested threshold value again if it has been manually modified.

A separate value for singular pixel and lines/columns can be selected. These values may have to be chosen upon the features of individual sensors. If it turns out that the recommended values do not lead to satisfying results manual change is recommended. We can not give general recommendations for optimizing the threshold. User has to change and try.

An additional threshold is applied for lines/columns. Lines/columns are considered as defective if the percentage of defective pixel in a line or raw exceeds the value defined in Threshold lines/Columns.

Usually a value greater than 80% leads to reasonable results.

Step 6

After completing the threshold settings you have to click **Calculate defective pixel**. Then the defective pixel mask will be calculated. You can see the number of defective pixels and lines/columns indicated below the Calculate defective pixel button. The calculation will take a few seconds. As soon as „finished" is displayed the calculation has ended.

Step 6a

Optionally you can shot the defects by clicking to the **Show** command. They are displayed as overflow values in either the hot or dead pixel file (A new image is created, the old image is not overwritten).

Step 7

Finally you have to save the defective pixel mask in a specific file (*.ini file).

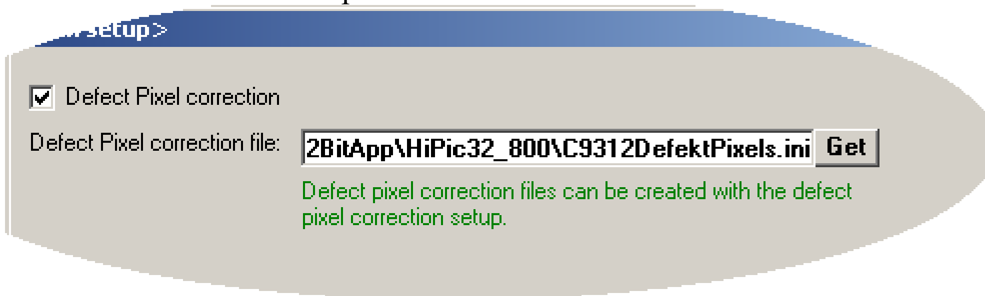
Press **Save to *.ini file** and then select file name and directory.

If you additionally want to activate this defect pixel information you can use the **Save to *.ini file + Activate** command.

Note: When you generate different pixel masks with different binning factors of the same detector you have to choose the same file for all pixel masks. The data are then all collected in one *.ini file. As the file already exists ins this case you get a warning message that this file already exists. Please ignore this message and continue saving the data to this file.

Enabling defect pixel correction

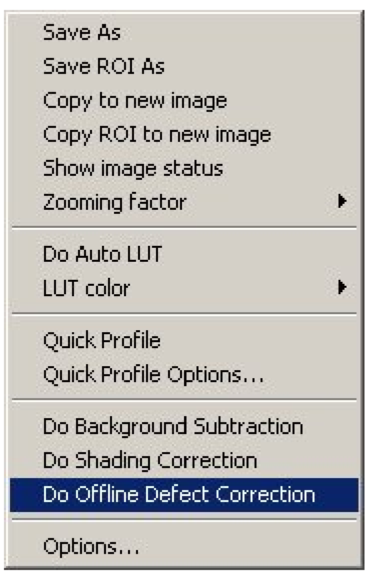
Specify the name of the defect pixel file in the defect pixel correction options and activate the checkbox Defect pixel correction:



With every new acquisition the data is automatically corrected according to the information in the defect pixel file. If you select **Save to *.ini file + Activate** on the Defect pixel tool this is automatically done.

Offline Defect Pixel Correction

There is also an offline defect pixel correction available for images which have not been corrected during acquisition. This offline defect pixel correction can be executed with the context sensitive menu.

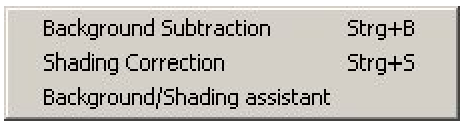


If you execute this command your will be asked which defect pixel map you want to use for this correction. The file selected in the “Defect Pixel Options” will be selected as the default.

Background/Shading correction assistant

To make the process of acquiring data and defining the settings for background correction or background and shading correction more easy and getting familiar with these corrections the background/shading correction assistant can be used. It guides you through the process of acquiring background/shading data and makes all necessary settings for you. It is strongly recommended for beginners to use the default/recommended settings initially. Once you got familiar and used to these settings you can easily use other more specific settings as well.

The Background shading correction assistant can be invoked with the Correction - Background/shading correction menu entry

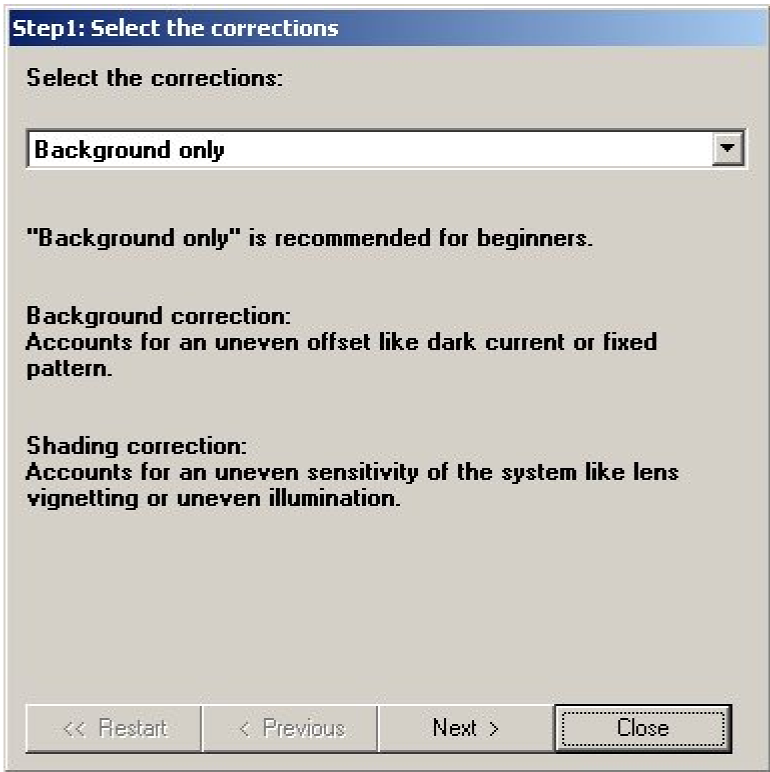


A dialog will appear and asks you for several settings. We recommend to use the default/recommended settings. We also recommend to start with background subtraction only first and once you are familiar with it use Background/ and Shading correct.

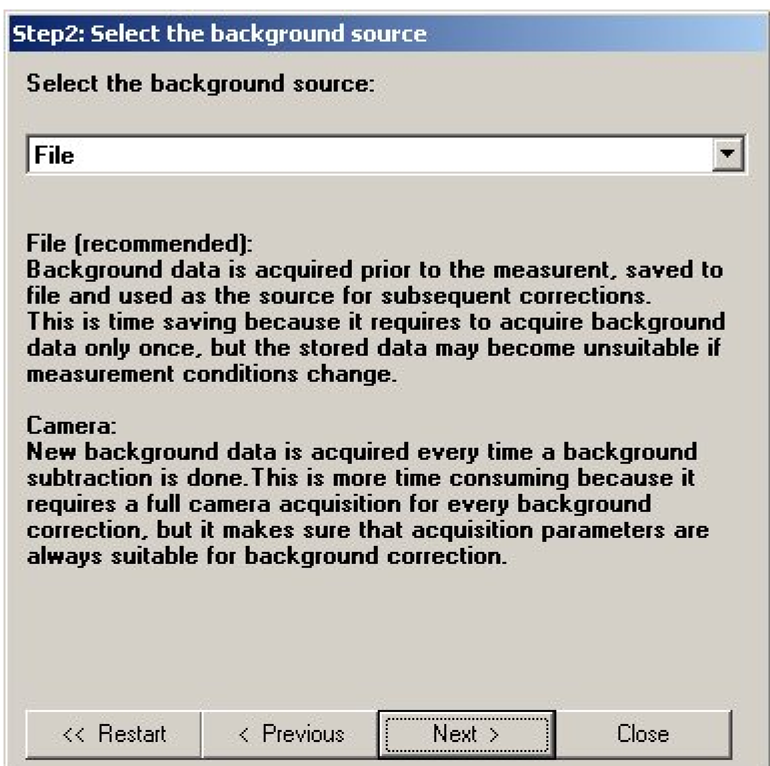
Performing Background subtraction

To perform background subtraction with the background/shading correction assistant invoke the background/shading correction assistant with the menu command "Background/Shading assistant" from the corrections menu.

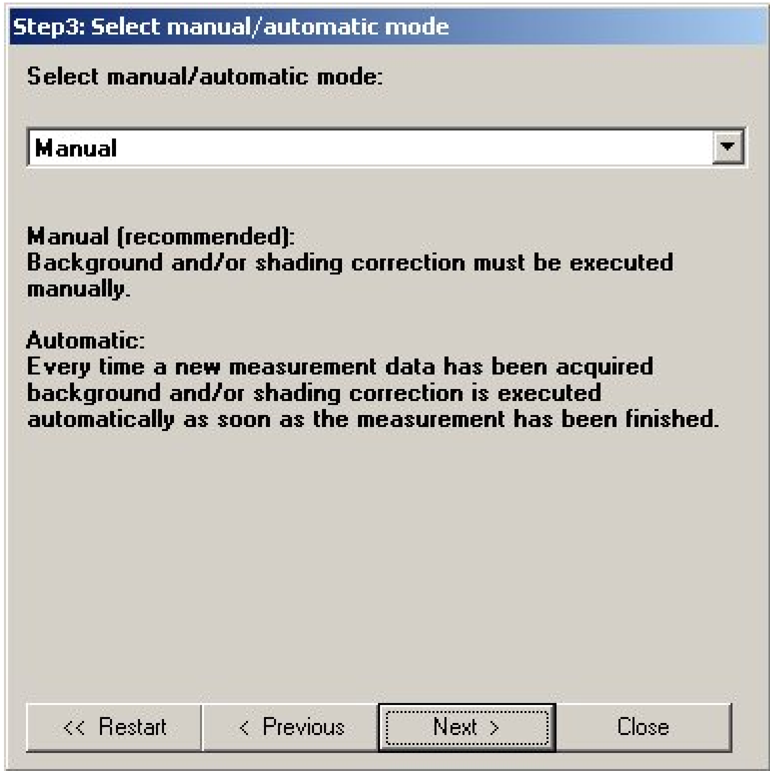
The following dialog will appear:



Select Background only (default) and click to Next. The next dialog will appear:



Select File (default) and click to Next. The next dialog will appear:



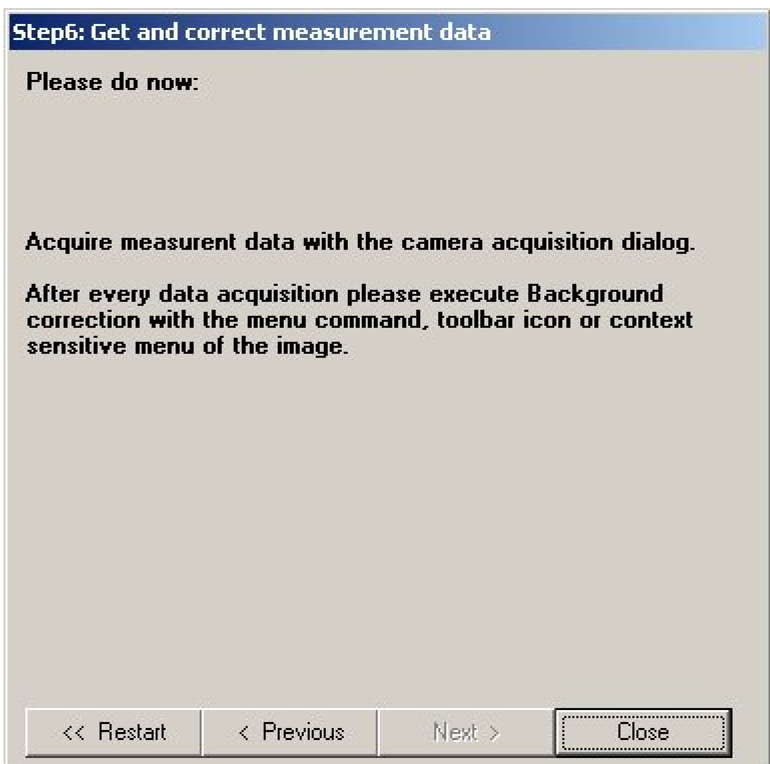
Select Manual (default) and click to Next. The next dialog will appear:

You should now acquire a background image which represents the background of your measurement. This image should be taken under the same conditions as the image you want to acquire for your measurement (i.e. binning, image size, analog gain settings etc.). Please use the camera acquisition dialog to acquire the image now. It is recommended to use the same acquisition mode as you want to use for your measurement (LIVE, ACQUIRE, ANALOGINTEGRATION).

Alternatively you could also use an image you have already saved to disk. Please load this image now or make it the current image (by clicking to it) if it has been loaded already.

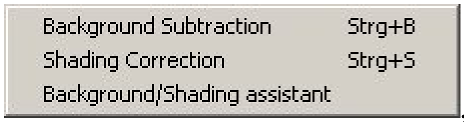
If this is finished, click to next. The software will save this image to a default file name and select this file in the background options automatically. You will get an informative message similar to the following:

After clicking to OK, you will get the next dialog:



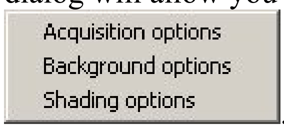
At this time you are finished with acquiring and setting up and you can acquire measurement data and correct them with the acquired background image.

To subtract background data from a given image you can use the Background subtraction menu item from the corrections menu



, the Background Toolbar Icon , the context sensitive menu of the image which you want to correct (Click with the right mouse button to the image), the Real time background subtraction feature or the automatic background subtraction mode (this has to be selected from within the background options).

Clicking with the right mouse button to the background/shading assistant dialog will allow you to go directly to the background options.

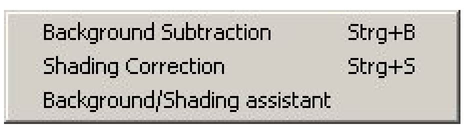


. These options contain more specific settings related to background subtraction.

Performing Background subtraction and Shading correction

We assume that you are familiar with acquiring background data with the Background/Shading assistant. If not, please read the previous topic.

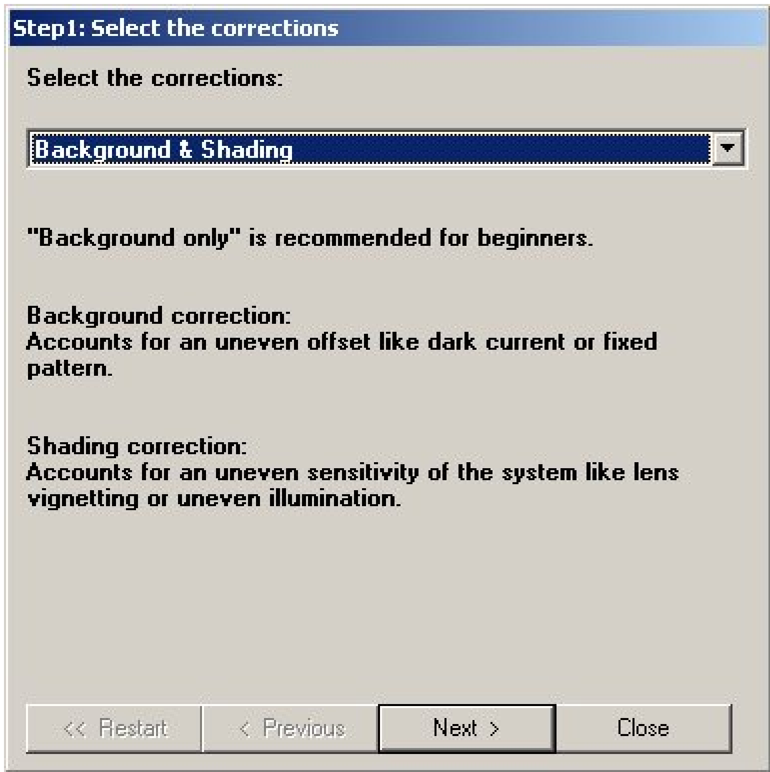
The Background shading correction assistant can be invoked with the Correction - Background/shading correction menu entry



A dialog will appear and asks you for several settings. We recommend to use the default/recommended settings.

To perform background subtraction and shading with the background/shading correction assistant invoke the background/shading correction assistant with the menu command “Background/Shading assistant” from the corrections menu.

The following dialog will appear:



Select Background & Shading and click to Next.

Select File (default) and click to Next. The next dialog will appear:

Select Manual (default) and click to Next. The next dialog will appear:

You should now acquire a background image which represents the background of your measurement..

If this is finished, click to next. The software will save this image to a default file name and select this file in the background options automatically. You will get an informative message.

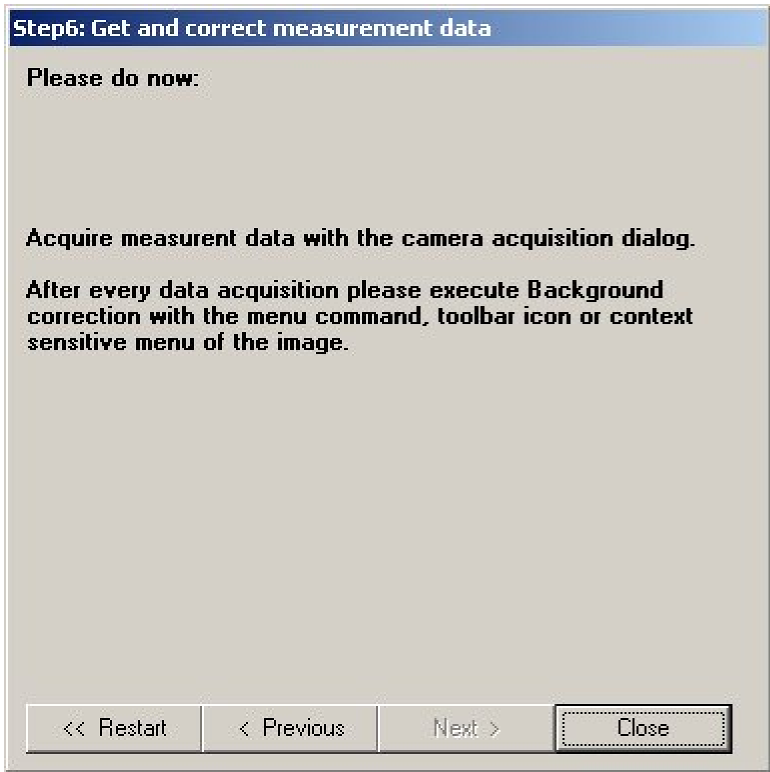
After clicking to OK, you will get the next dialog:

Acquire a shading image now. This shading image should represent the sensitivity variation of your system, which you want to account for. You can use any acquisition mode for this acquisition, but you should select a mode which outputs the full camera image (e.g Subarray mode is not suitable).

Alternatively you could also use an image you have already saved to disk. Please load this image now or make it the current image (by clicking to it) if it has been loaded already.

If this is finished, click to next. The software will save this image to a default file name and select this file in the shading options automatically. You will get an informative message similar to the following:

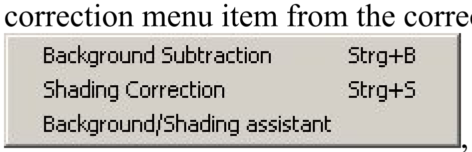
After clicking to OK, you will get the next dialog:



At this time you are finished with acquiring and setting up and you can acquire measurement data and correct them with the acquired background and Shading image.

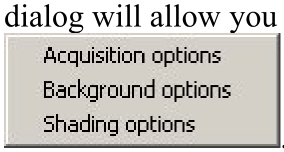
Subtract background data as described in the previous topic.

To perform shading correction from a given image you can use the Shading correction menu item from the corrections menu



, the Background Toolbar Icon, the context sensitive menu of the image which you want to correct (Click with the right mouse button to the image), the Real time Shading correction feature or the automatic Shading correction mode (this has to be selected from within the shading options)

Clicking with the right mouse button to the background/shading assistant dialog will allow you to go directly to the shading options.



. These options contain more specific settings related to shading correction.

Reserved Filenames

As the Background/shading assistant saves and uses file to store background and Shading data there are several filenames you should not use by yourself. It is not recommended to replace or delete these files. The reserved file names are the following files within your application directory:

`Reserved_BackgroundImage_General.img`

`Reserved_BackgroundImage_Live.img`

`Reserved_BackgroundImage_Acquire.img`

`Reserved_BackgroundImage_AnalogIntegration.img`

`Reserved_ShadingImage.img`

Other Options

There are two more choices you can select if you run the background/Shading assistant.

In step 2 you can select “Camera” instead of “File”. In this case the background data is not saved to a file. Every time a background image is needed for a correction a new image is acquired from the camera. This setting does not influence the handling of shading data.

In step 3 you can select “Automatic” instead of “Manual”. In this case Automatic background subtraction and/or Automatic Shading correction is selected which means that after every acquisition immediately an background subtraction and/or Shading correction is performed. This options interferes with the real time background subtraction and the real time shading correction and should not be used if you intend to use the real time background subtraction and the real time shading correction.

There are several other options in the background and the shading options dialog. Please study these options if the standard behavior does not fit your needs.

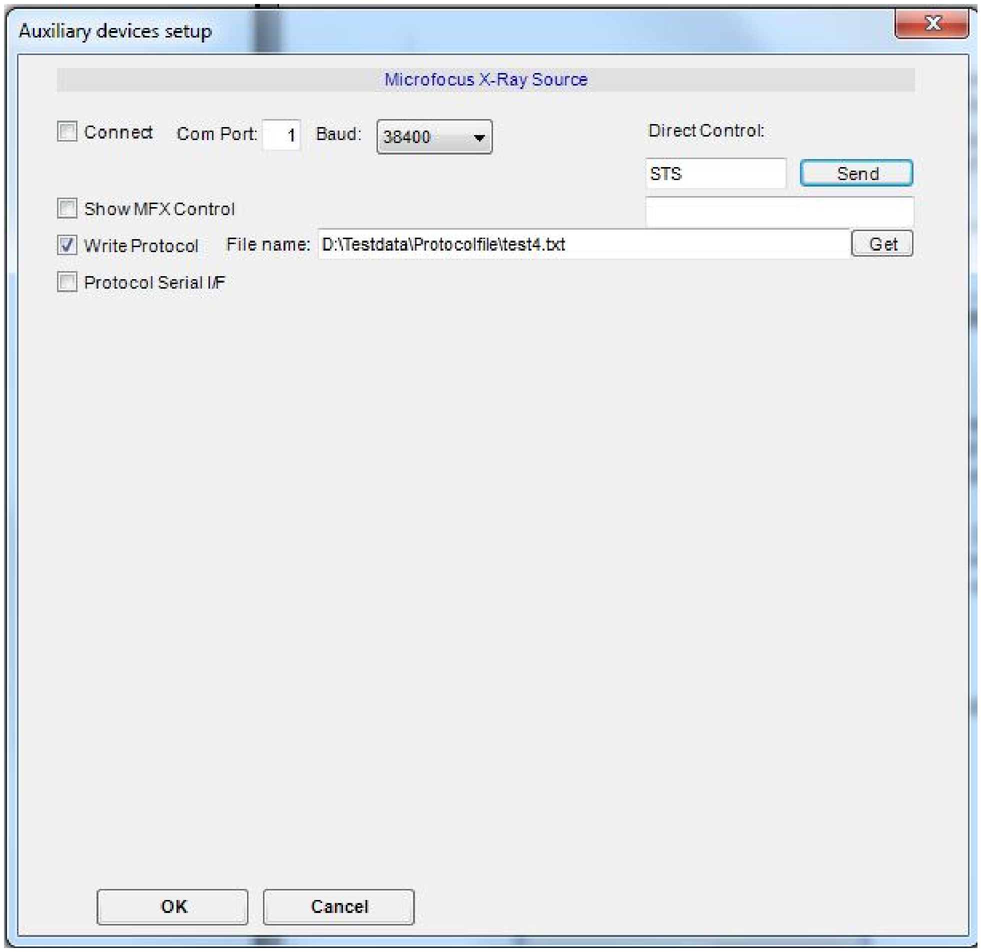
Auxiliary Devices

Options dialog

The Auxiliary options dialog allows to setup a Hamamatsu Microfocus X-ray tube.

When starting the HiPic click to setup within the auxiliary devices frame:

The Auxiliary devices setup will appear.



Select the COM port and Baud rate and click to connect. If the MFX can be connected an informative string will appear telling the type number of the MFX.

At the right side of this dialog the user can communicate directly with the MFX by typing in commands. Our sample shows the result of the command STS (status), the MFX responds STS 2 (standby).

Warning: Do not type in commands if you are not completely sure about the precise meaning of these commands.

A protocol can be written which writes down all the changes happening at the MFX. If "Protocol Serial I/F" is selected all serial communication is written to the protocol file. This enlarges the amount of data written to the protocol drastically.

Microfocus X-rax Tubes (MFX) control

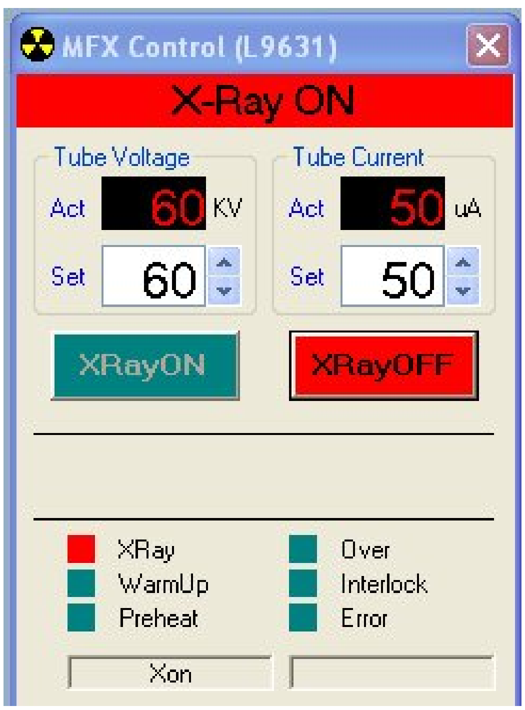
Introduction

The HiPic supports Microfocus X-Ray tubes from version.8.4. Standard operation procedures like X-Ray On and X-Ray Off, setting of voltage and current and the inquiry of the tube status is supported by the MFX-control dialog. Other commands can be typed in the options dialog.

Warning: A X-Ray tube is a hazardous equipment. Don't use it unless you are authorized to operate it and unless you are familiar with the safety precautions of the X-Ray facility. Do not type in commands if you are not completely sure about the precise meaning of these commands.

Operating the MFX

After starting the HiPic the MFX control window will appear.



There are two pushbuttons to switch on the X-ray tube and to switch it off. The user can set the target voltage and target current by typing it to the corresponding edit boxes labeled with "Set". Above the edit boxes to set the current and voltage two display fields show the current (actual) voltage and current. Depending on the tube characteristics it may take some time until the final voltage and current target is reached.

Some status indicators below shows important status information such as X-Ray on or Interlock open. In detail this is:

XRay	Turns red if X-ray radiation is emitted

WarmUp	Turns red if Warm up is in progress
Preheat	Turns red if preheat is under progress
Over	Turns red if over condition has occurred
Interlock	Turns red if the interlock switch is open
Error	Turns red if an error has occurred

Other dedicated commands can be sent to the MFX in the options dialog.

Right click to the MFX Control dialog to get a context sensitive menu to call the MFX options dialog.

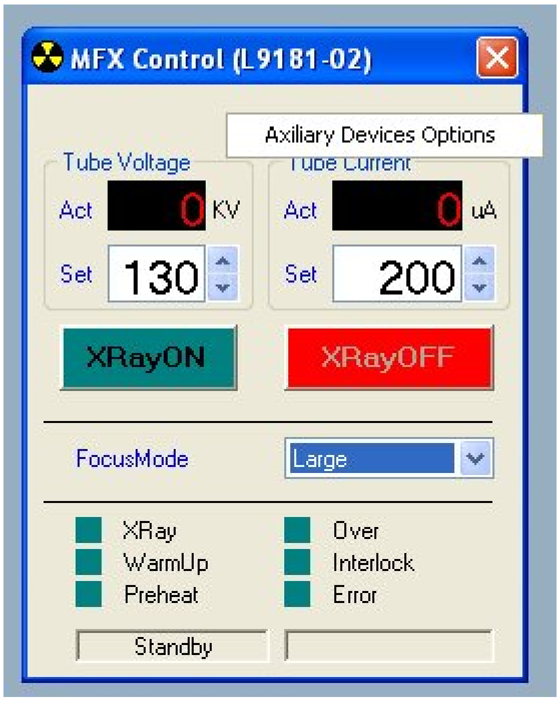


Image Display & LUT

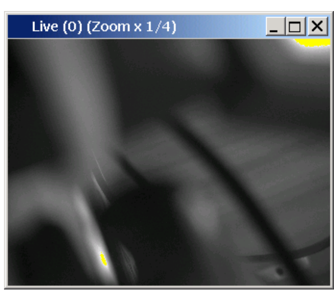
This topic contains details of image display and LUT and its operation.

Image display windows

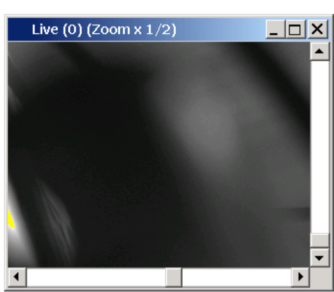
Up to 20 images can be displayed at a time. Each image has its own status. All image processing functions refer to the currently selected image (called "**current image**" in this manual). If you click to an image it becomes the current image.

Each image has its own properties concerning the LUT and color selection.

The image is always displayed within a window with a specific zoom factor. Zoom factors from 1/8 to 8 are available. When the image with the current zoom factor does not fully fit into the window, scrollbars appear on the side and only a portion of the image is displayed.

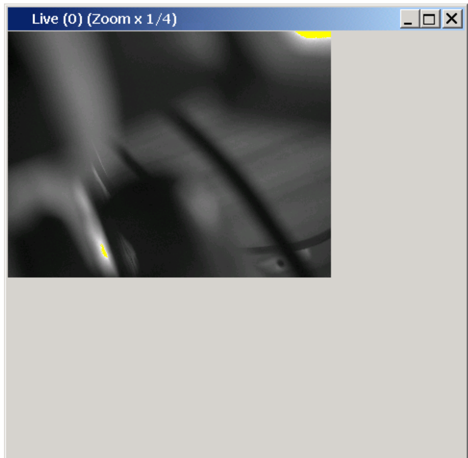


The whole image displayed



Only a part of the image is displayed

When the window is larger than the area which is needed for the image a part of the window remains white.



When the image is smaller than the display window

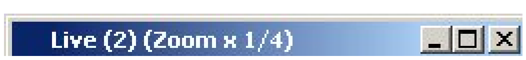
You can freely select the size of the window. Sometimes one wants to set the window size to exactly match the image size. In such case it is sufficient to double-click to a grey area on the image window or to select the image and press the function key F2. When the window is smaller than the image there is a small grey area on the lower right corner where one can click.

The caption of the window contains information about the image (image mode, file name, zoom factor). Some functions resize the window automatically so that the image fits into the window automatically (e.g. Acquire, Open.., Background Subtraction).

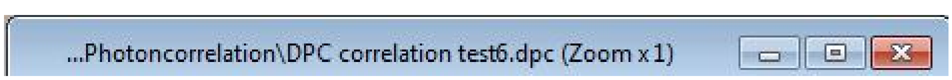
Caption

The image caption shows the image file name and the zooming factor.

If the image is not yet saved a default name is assigned derived from the acquisition with which it has been created and the internal image number.



If the string to display is longer than the available space it is truncated from the left and cutted at the directory borders:



Zoom

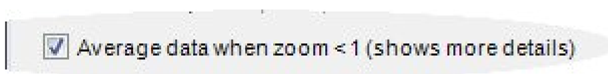
When the Zoom tool is selected the left mouse buttons can be used to change the zoom factor. The zoom factor is increased by a factor of approximately 1.4 when clicking with the left mouse button to the current image area. The zoom factor is decreased by a factor of two when clicking with the left mouse button while holding down the shift key.

The zoom factor ranges from 1/8 to 8.

The point where the user clicks to the image becomes the centre point of the image. Thus when you want to magnify a certain location it is sufficient to click to this location with the left mouse button.

If there are scroll bars on the right or bottom side of the window, just a part of the image is displayed. The scroll bars can be used to scroll to a location which is currently not displayed. It is however more convenient to zoom out with the left mouse button while holding down the shift key until the portion of the image which should be displayed becomes visible. Then click to this location with the left mouse button to magnify it.

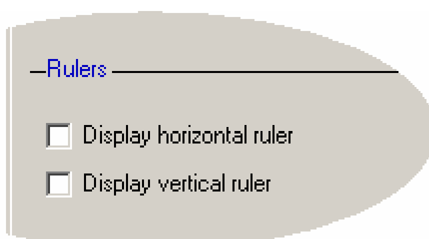
There is an option **"Average data when zoom<1 (shows more details)"** in the image options:



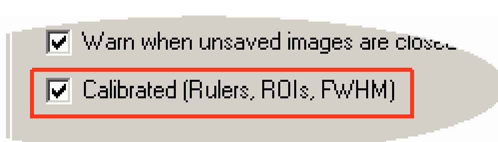
If this option is checked and the zoom factor is less than 1 the display data of neighboring pixels are averaged. If the zoom is smaller than one single pixels or lines with the width of 1 could be otherwise completely hidden. The computational expense is higher if this option is checked but the display precision is higher and the noise appearing in the image is reduced.

Rulers

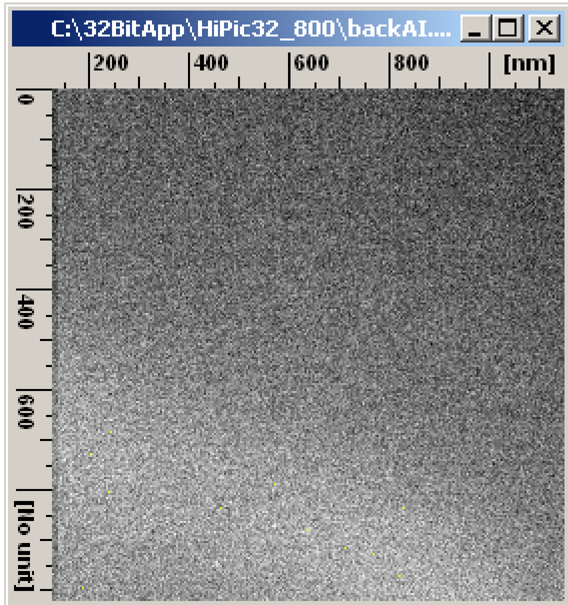
Rulers can be used to display pixel numbers or physical units in the image. To show or hide rulers open the images options (right click in the image display and select Options…).



To select whether the rulers should display calibrated units or pixels select the calibrated checkbox.



After closing the Images Options with OK all images contains the desired rulers.



Quickprofile

The quickprofile is a profile which is directly displayed on the image window and updated with every new image display.

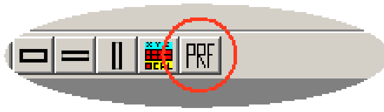
The quickprofile always shows the profile data extracted from the image based on the rectangular ROIs in this image.

Rectangular ROIs with full horizontal width () are always displayed as a horizontal profile.

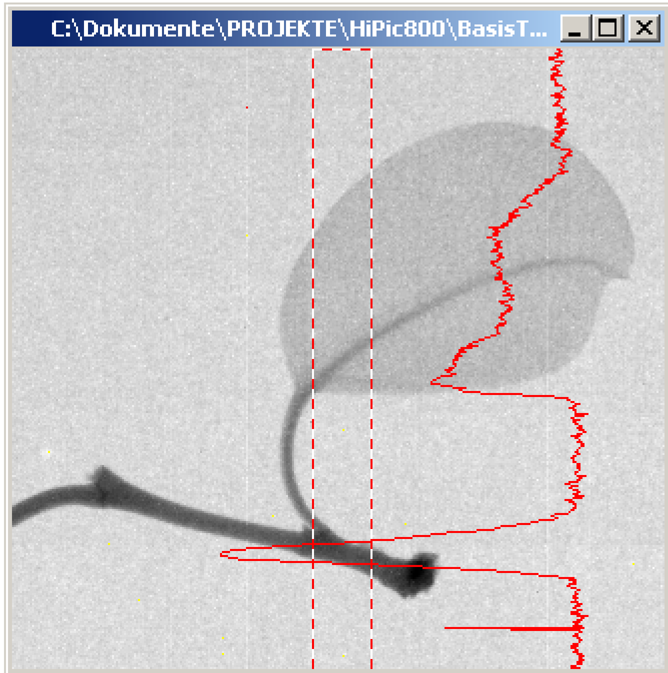
Rectangular ROIs with full vertical height () are always displayed as a vertical profile.

Arbitrary rectangle ROIs can be either displayed horizontally, vertically or not displayed. These three possibilities can be selected in the quick profile options:

To switch on the quick profile display toggle the status of the quick profile pushbutton on the toolbar or click with the right mouse button on the image display and select Quick Profile.

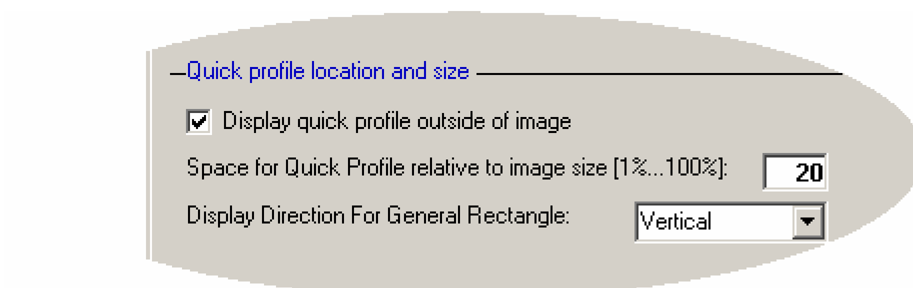


Normally the quick profile is displayed on the same area as the image.

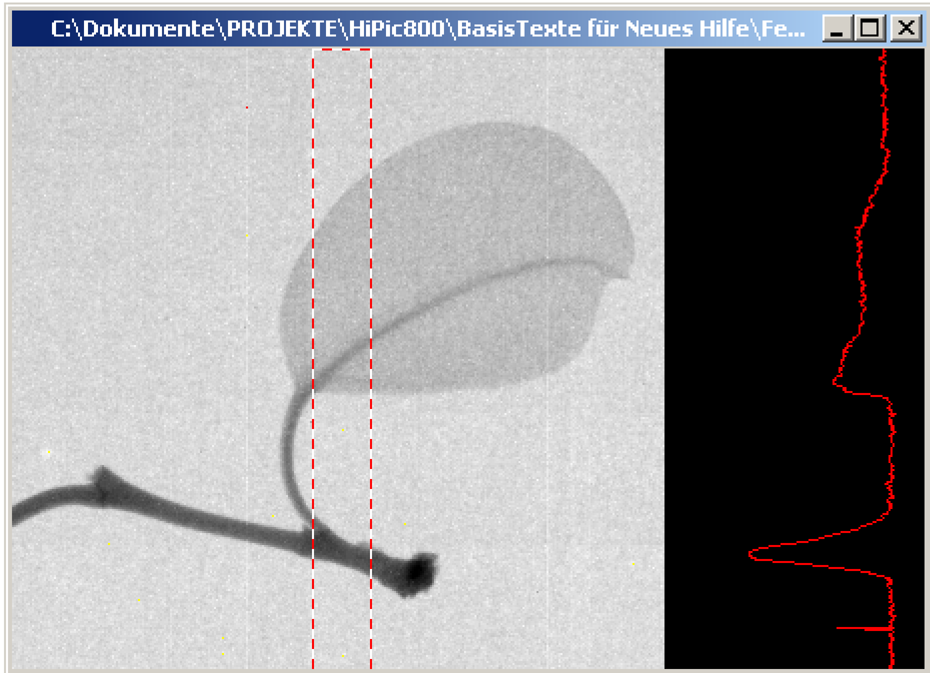


Alternatively the quickprofile can also be displayed in a separate area outside the image display area. To select this alternative call the quick profile options and select Display quick profile outside of image.

Additionally the user must specify how large the display should be. A percentage has to be specified which determines how large the quick profile are should be relative to the image size.



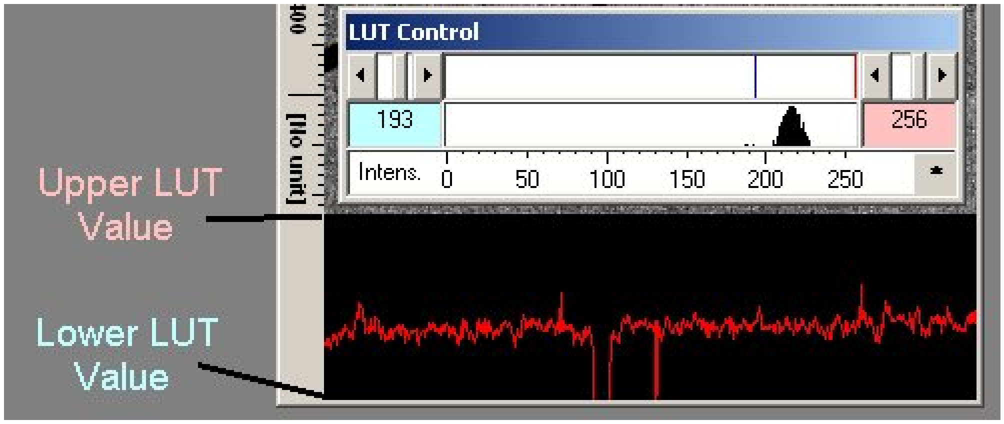
The quick profile then appears outside of the image.



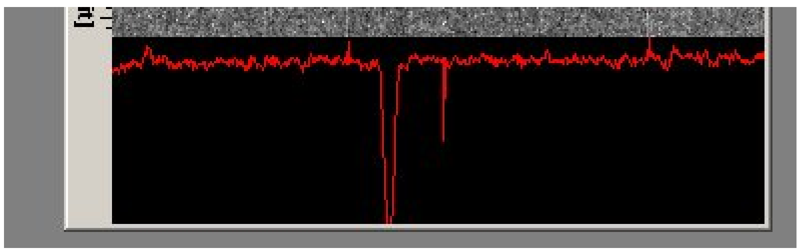
The size of the quick profile depends on the option settings for Adjust quick profile height:

If “Use LUT values” is selected the upper and lower LUT limits are used as the limiting values. Portions of the quick profile which are beyond these limits are no displayed because they would lay outside the window which is used for the quick profile (This is either the image display window or a separate window neighboring the image display).

If “Use Min/max values” is selected the minimum and maximum values are use as the limiting values. In this case the Min/Max of every profile individually is used for optimum display range which mean that the intensities between profile are not comparable. If you want to compare intensities you should select “Use LUT values”, which apply to all profiles in the same way.



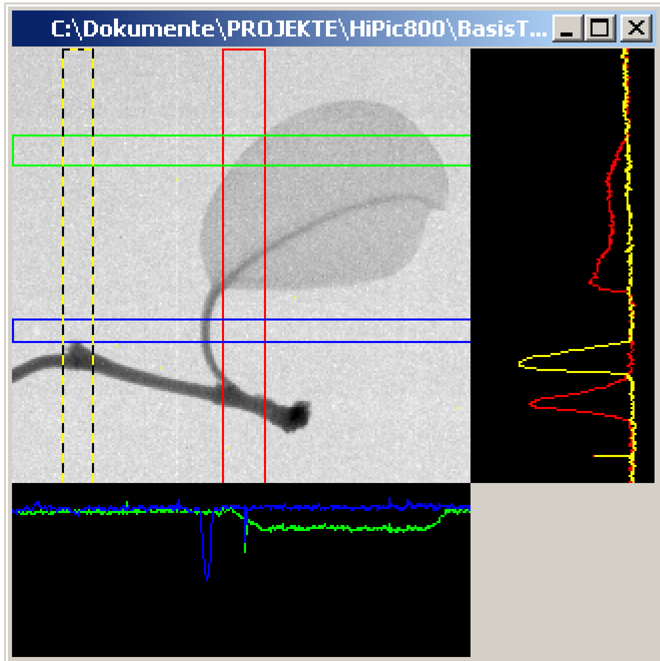
“Adjust quick profile height” set to “Use LUT values”



“Adjust quick profile height” set to “Use Min/max values”

Different from other functions not only the currently selected ROI contributes to the quickprofile display but all suitable rectangle ROIs. If the quick profile should be displayed outside of the image the outer areas appear and disappear automatically when needed.

Several quick profiles can be displayed in the same window. In this case the relation between ROI and Quickprofil can be easily recognized by the color.

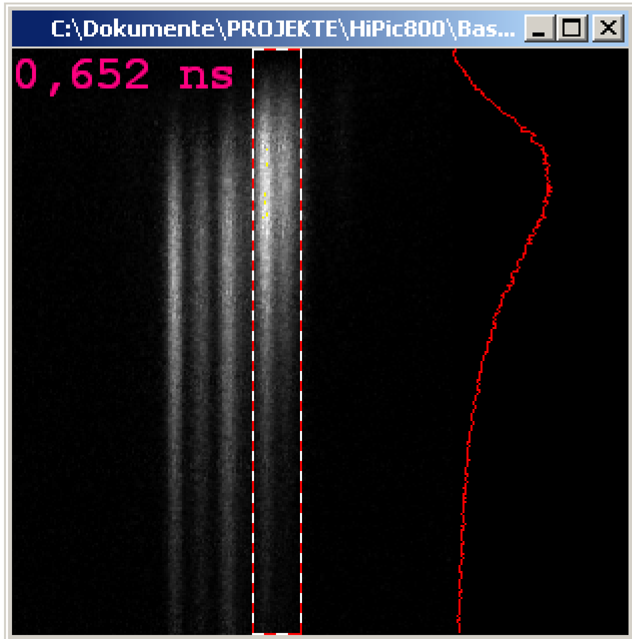


FWHM

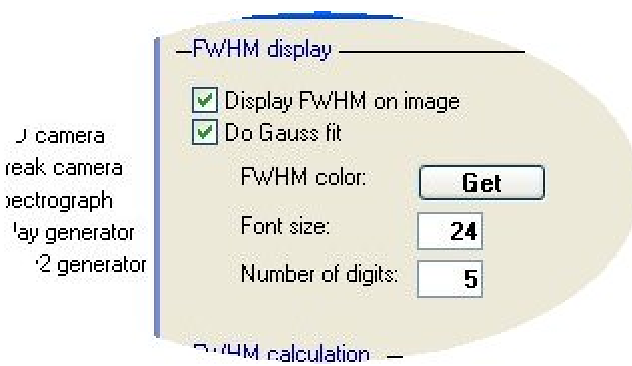
In some specific circumstances the user wants to get a Full width half maximum (FWHM) analysis of the currently selected ROI.

The result will be displayed on the left upper corner of the image.

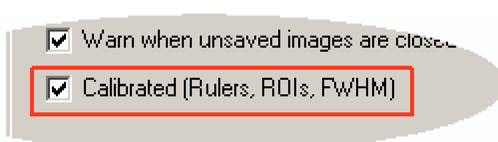
This information can be used for checking and adjustment purposes. If **"Do Gauss Fit"** is selected, a gauss fir is done and the gauss profile displayed in white. If the fit succeeds the gauss profile is displayed in white color additionally to the profile. If **"Do Gauss Fit"** is not selected or if the Gauss Fit fails, the conventional method of getting the FWHM is applied. This method searches the half height at both sides from the maximum.



The quick profile options contains some parameters to determine size, color and precision



The decision whether the FWHM should be displayed in pixels or in calibrated units is made in a parameter in the images options:



ROIs

Frequently you will have to select special areas on an image. For example you may sometimes want to save only a part of the image. In order to do this you will need a tool to select a special area of the image, a region of interest (ROI).

You can select up to 10 individual ROIs (Region Of Interest) for every image, but only one ROI is the currently active one.

Types of ROI

There are different types of ROIs which can be used for different purposes. The types of ROIs are:

 Rectangle ROI

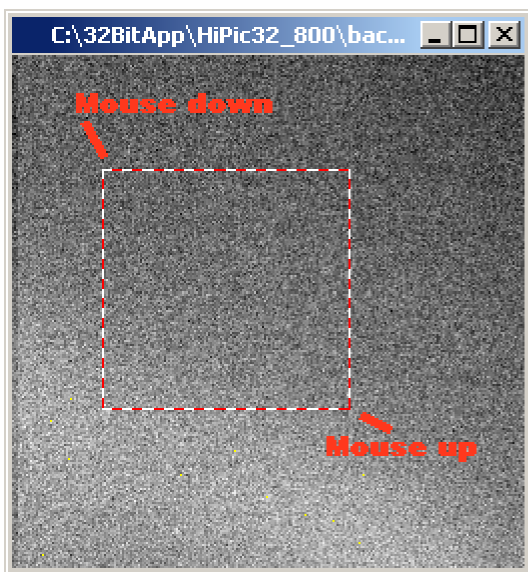
 Arbitrary line ROI

 Point ROI

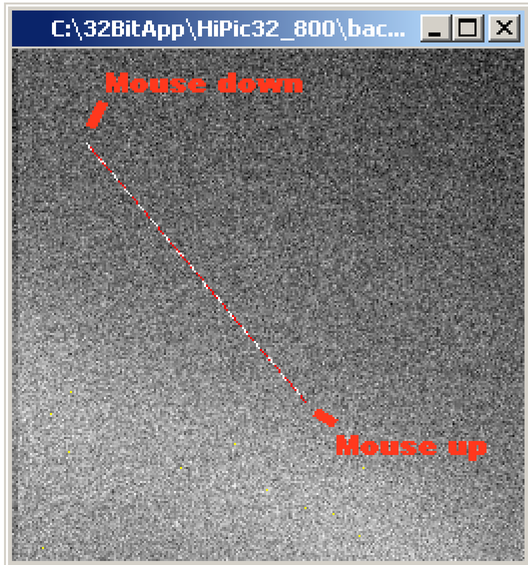
 Rectangle ROI with full size in horizontal direction

 Rectangle ROI with full size in vertical direction

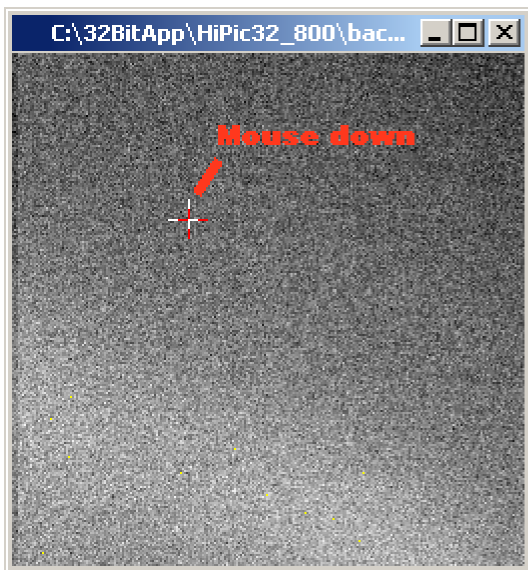
A Rectangle ROI is a ROI which starts at any arbitrary point and ends at another arbitrary point. The two points are combined to yield a rectangle ROI.



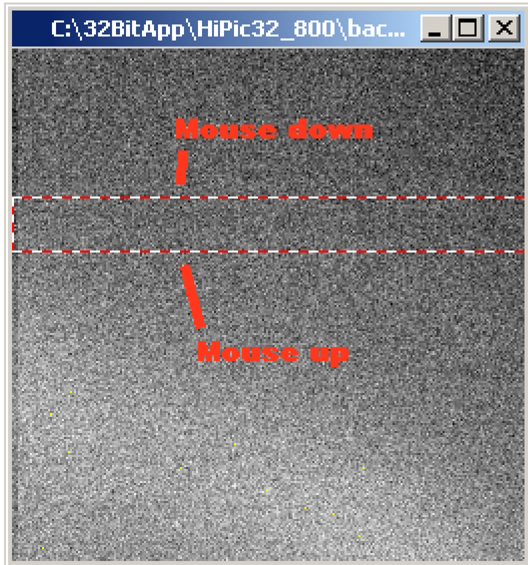
A Line is a ROI which starts at any arbitrary point and ends at another arbitrary point. The two points are combined to yield a rectangle.



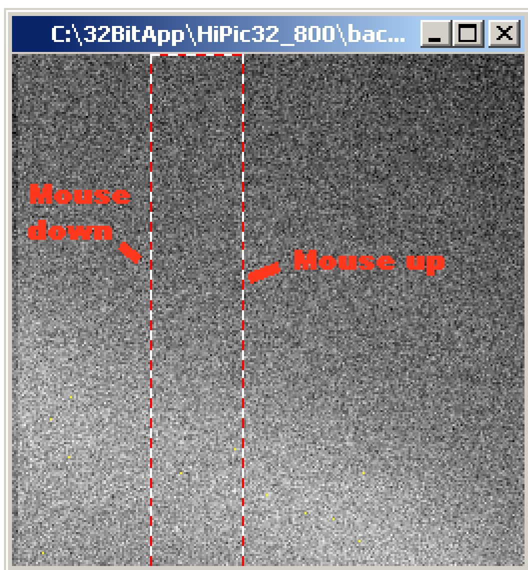
A point ROI is a ROI defined at the point where the mouse is clicked.



A Rectangle ROI with full size in horizontal direction is a ROI which extends to the full horizontal width but can be arbitrary in its vertical starting and ending point.

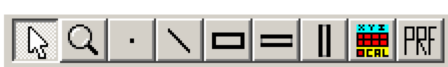


A Rectangle ROI with full size in vertical direction is a ROI which extends to the full vertical height but can be arbitrary in its horizontal starting and ending point.



Create ROI

To create a ROI first of all select the ROI type on the toolbar:



Then draw the ROI with clicking to the starting point with the left mouse button, then draw the mouse to the end point of the ROI and release it. Once a ROI is created the ROI toolbar automatically switches to the pointer tool.

Move/Resize/Delete

To move the ROI select the Pointer on the ROI toolbar (after creation of a ROI this is automatically selected), click on the image display with the left mouse button and move the mouse.

To delete a ROI activate the image by clicking on its caption and type the Del Key or the d key.

To resize a ROI hold down the shift key and click and hold down the left mouse button and move the mouse until the ROI has the desired size.

Alternatively a ROI can be moved by using the cursor keys (left, right, up, down). Each time you press one of the keys the ROI is shifted by 1 pixel. If you press the CTRL key + one of the cursor keys, the ROI is shifted by 10 pixel, if you press CTRL+ALT + one of the cursor keys, the ROI is shifted by 100 pixel.

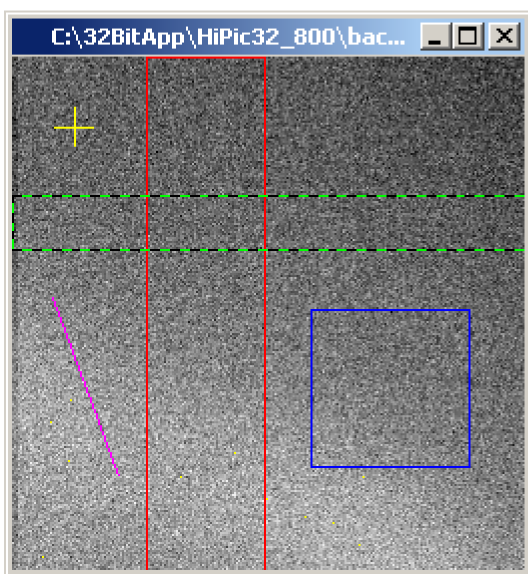
If you press the Shift key + one of the cursor keys, the lower right corner will be shifted (ROI size is changed).

If you want to expand an ROI over the entire horizontal or vertical image area, you can select an ROI and press H to extend the ROI over the maximum horizontal area, or V to extend it over the maximum vertical area, or F to extend it over the full image.

To precisely position or size an ROI the ROI Interface can be used.

Multiple ROIs

If the user wants to select several ROIs he has to select the desired ROI type again and create the next ROI as he did with the first one.



Select/Delete

Always one of the ROIs is the selected one and every image processing function (like the Save ROI as) is always using the selected ROI. The selected ROI is drawn with as dashed line.

A maximum of 10 ROIs can be selected at once and every ROI has its individual color.

To select a ROI different from the currently selected one just click with the mouse on or near the ROI or use the n key to change to the next ROI. Typing the n key (next) selects all ROIs one after the another.

Typing the Del-key or the d-key always deletes the currently selected ROI and automatically selects another one if there is still any ROI which is active.

Mouse Coordinates

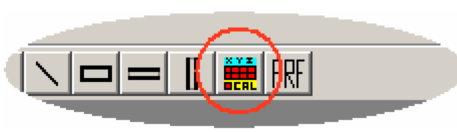
While the mouse cursor is inside of an image window, the co-ordinates and the intensity value at the current mouse position are displayed.

Status display including actual pixel intensity information.

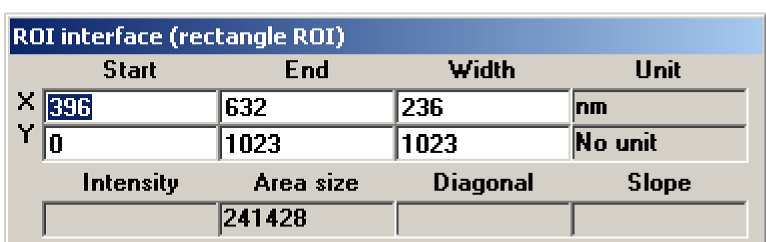
ROI I/F

The ROI Interface is a dialog which is designed to precisely define or read the coordinates of the currently selected ROI of the currently selected image.

To show the ROI I/F toggle the state of the ROI I/F button.



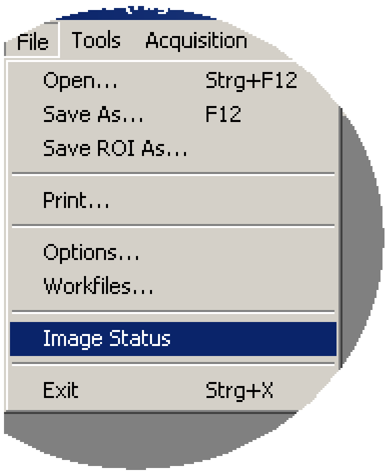
The ROI I/F will appear on screen and show the coordinates of the currently selected ROI. Changing the Selected ROI will automatically update the information in the ROI I/F.



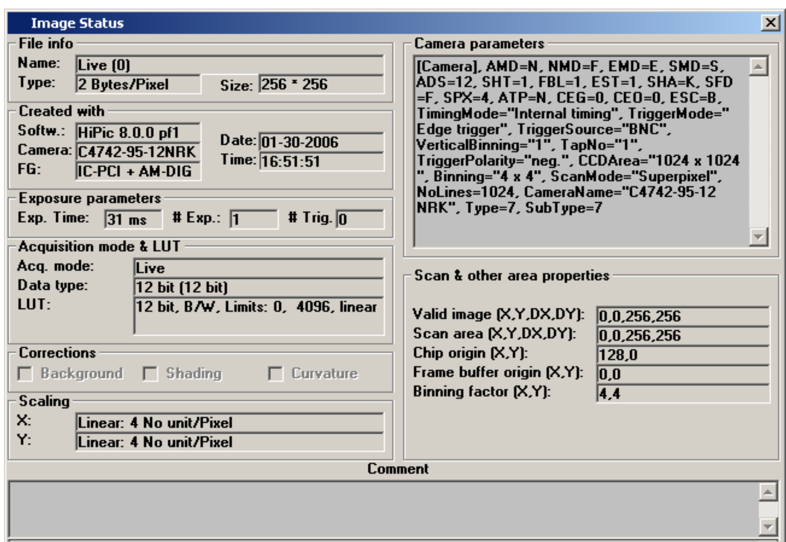
Depending on the type of ROI either only the Start values (point ROI), or Start and End values (Line ROI) or Start, End and Width values (All three types of rectangle ROIs) can be inputted.

Image Status

Every image contains information about date and time, size, camera settings, calibration and many other parameters which are related to this image. To see this information select the Image Status menu from the file menu.



The image status will be displayed on screen.



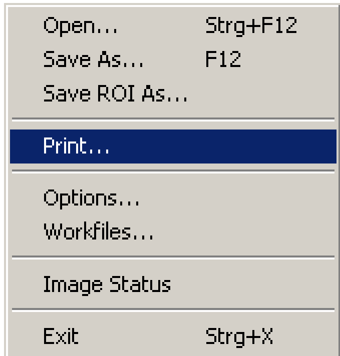
Context sensitive menu

The context sensitive menu which appears if the user clicks with the right mouse button on the image display has the following entries:

Save As	Saves the image to file
Save ROI As	Saves the currently selected ROI of the image to file
Copy to new image	Copy the current image to a new image.
Copy ROI to new image	Copy the current selected ROI of the image to a new image.
Show Image status	Shows the image status
Zooming factor	Allows to set the zooming factor to the desired value
Do Auto LUT	Executes Auto LUT
LUT Color	Allows to set the LUT color to the desired value
Quick profile	Shows or hides the quick profile
Quick profile options	Shows the quick profile options
Do Background Subtraction	Executes background subtraction
Do Shading Subtraction	Executes shading correction
Options…	Shows the images options.

Print Images

The currently selected image can be printed by using the print menu command.

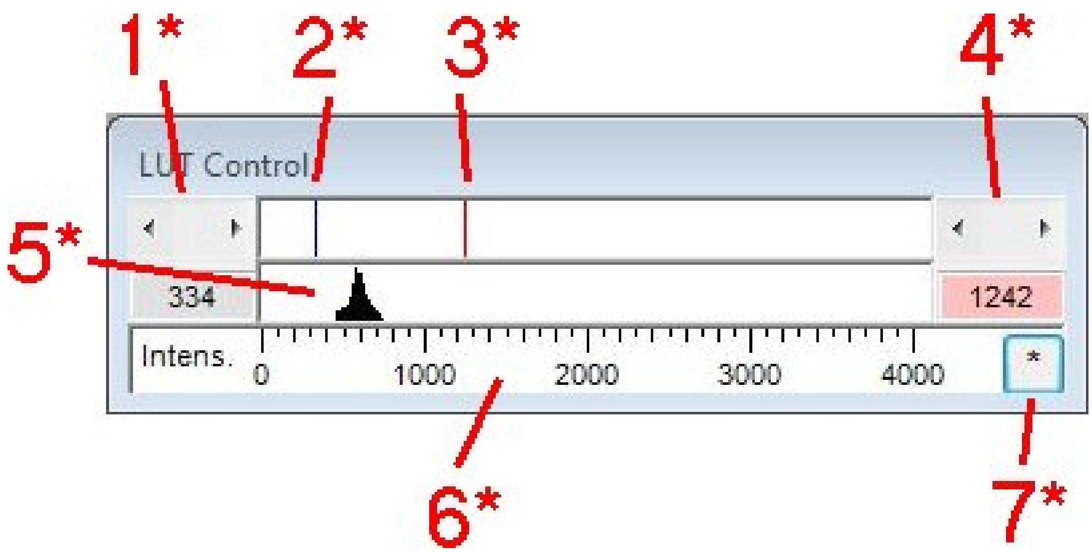


A printer setup dialog will appear. Make your selection and Click OK to print the image.

LUT

General

The LUT tool is used to control the image display by manipulating its brightness and contrast.



1*: Slide bar to change the lower limit

2*: Lower Limit

3*: Upper Limit

4*: Slide bar to change the upper limit

5*: Histogram

6*: Input intensity scale

7*: Pushbutton for Auto LUT

The LUT Tool

If you acquire images you will find that the images are frequently displayed with too low or too strong contrast. If you acquire images under low light level conditions the display may be too dark. Use the LUT tool to adapt the image display to the desired contrast. This is done by defining the lowest and highest grey value which shall be displayed.

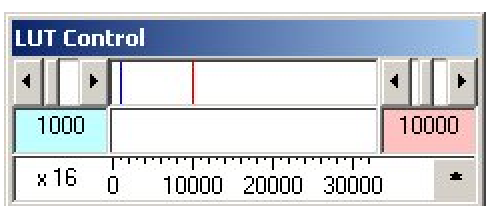
The tool contains an area with two cursors which represents a lower (blue cursor) and an upper limit (red cursor) for the LUT. The meaning of the values of these cursors is described below. The cursors can be moved by clicking next to them and dragging them while the left mouse button is pressed. When you use the right mouse button instead, both cursors will move simultaneously, keeping their distance constant. An alternative way to move the cursors is provided by the two sets of slide bars at the left and right side of the LUT tool. Two display boxes (blue and red) display the exact numerical values of the two cursors.

You can easily see how the image contrast is changed when you change the upper or lower limit as the current image is updated after any change in the LUT control.

The bottom part of the LUT shows a scale representing the input intensity values. In 8 bit mode the scale ranges from 0 to 255, in 10 bit mode from 0 to 1023, in 12 bit mode from 0 to 4095 and in 16 bit mode from 0 to 32767.

At the centre part of the LUT tool (above the scale) a histogram is displayed where the user can see the frequency by which intensity values are present in the image. This histogram can be used as a guide for setting the LUT limits.

The LUT tool is re-sizeable horizontally. If the LUT tool is longer, the intensity scale can be seen and accessed with higher precision but the histogram display will need more time to update.



LUT tool when using 32 bit image data files

When 32 bit image data file format is used (e.g. with 16 bit digital cameras) the string “x16” in the lower left corner of the window indicates that the intensity figures shall be multiplied by 16 to give the real intensity data values.

Upper and lower limits

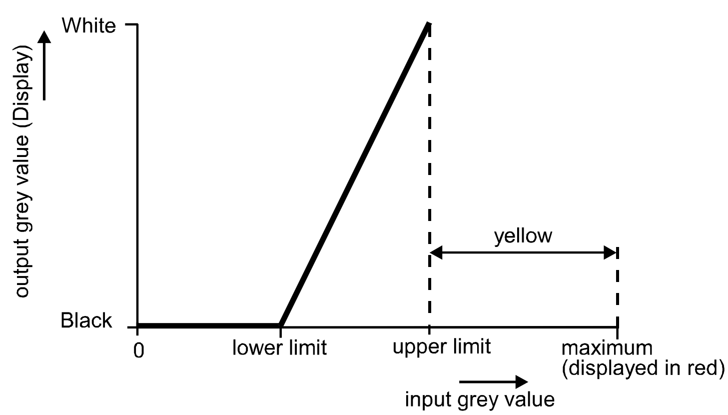
The software allows displaying images either in black and white or in pseudocolor mode (see). The meaning of the LUT limits is explained below for both modes.

Intensity values between the lower and the upper limit are displayed using the full range of the LUT (either in grey-scale or in color). The values above the upper limit (which exceed the current LUT) are displayed in yellow (in case of grey-scale LUT) or black (in case of color LUT).

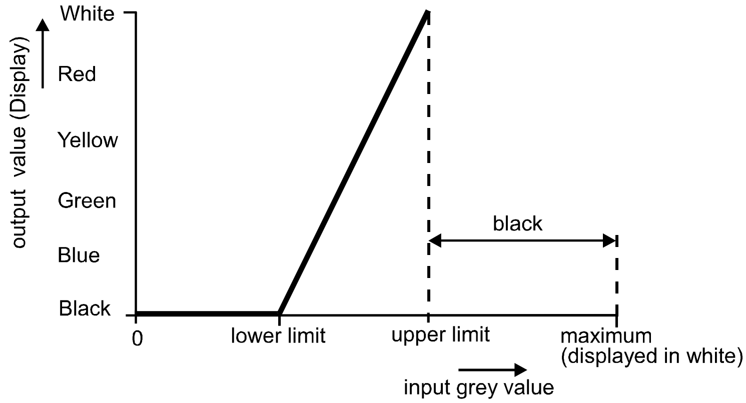
The uppermost intensity value of the current acquisition mode is displayed in red (grey-scale LUT) or in white (color LUT). Areas in these colors indicate an overflow of the CCD camera. For 10 bit images the overflow value is 1023 and for 12 bit images it is 4095. Be sure to reduce your light intensity if you encounter this situation.

Display mode	*Smaller than blue cursor*	*Between cursors*	*Greater than red cursor*	*Saturatio n*
B/W	*Black*	*Black to white*	*Yellow*	*Red*
B/W inverted	*Yellow*	*White to black*	*white*	*Red*
Pseudocolor	*Black*	*Blue to red*	*Black*	*White*
Pseudocolor inverted	*Black*	*Red to blue*	*Black*	*White*
B/W without using colors	*Black*	*Black to white*	*White*	*White*
B/W without using colors inverted	*White*	*White to black*	*Black*	*White*

Table: Image color-coding in different display modes



Mapping of LUT values for black and white LUT

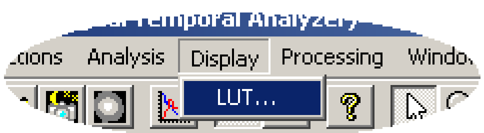


Mapping of LUT values for color LUT

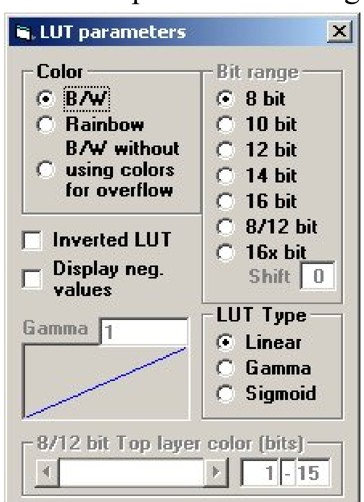
LUT parameters

With this function you can select several properties of the display like color, linearity or the display of negative values.

Choose **LUT** from the **Display** menu to display the LUT parameters dialogue.



The LUT parameters dialog appears:



LUT parameter dialogue box

Within the dialogue box you can select the LUT type (either black-and-white or rainbow) by clicking to the **B/W** or **Rainbow** radio button in the **Color** frame.

B/W will produce a grey scale display where data overflow is marked by yellow and red color, while **Rainbow** will produce a pseudo-color display where different intensities are coded as different colors. **B/W without using**

colors for overflow will produce a grey scale display where data overflow is not marked by yellow and red color.

Note: Overflow means A/D overflow of the camera A/D converter or when the range of the data storage type is exceeded.

Inverted look-up table

It is possible to apply an inverted look up table. This means that all intensity values are inverted (image looks like a negative image).

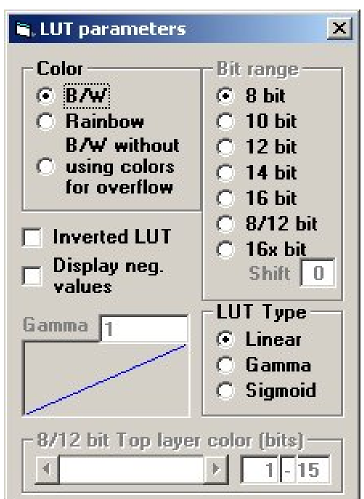
Display negative values

In most cases negative images values, even though they may appear due to some operation like background subtraction, may not be of any interest for the display. In very special cases a user may want to display it as well. For this purpose the option "Display neg. values" is provided. If this option is selected, negative values will be displayed in the same brightness or color as the positive value with the same absolute value.

Non-linear contrast enhancement

The standard (default) enhancement mode offers a linear enhancement between the lower and upper limits.

Sometimes, however, a non-linear enhancement function may be preferred. This program supports two non-linear modes: Gamma and Sigmoid.



LUT dialogue with linear contrast enhancement

Then set the enhancement factor (gamma-factor or sigmoid factor) by clicking and dragging the enhancement curve in the graphic box. Alternatively you can insert the desired factor into the textbox **Gamma**. Leave the text field with the TAB key to activate the setting.

Choose LUT type according to your desire by selecting the related radio button in the LUT type section.

Set the Gamma or Sigmoid parameters either by clicking in the box where the transfer curve is drawn and dragging the curve (current image will be updated immediately) or by inserting the desired factor in the textbox Gamma followed by pressing the TAB key to activate the new factor.

Optimize contrast enhancement

By clicking the small asterisk at the lower right side of the LUT tool or the corresponding button in the menu bar you can force LUT limits being calculated automatically according to the intensity values present in the image. This is an easy way to adapt the LUT settings to the current image and to obtain optimum digital contrast enhancement.

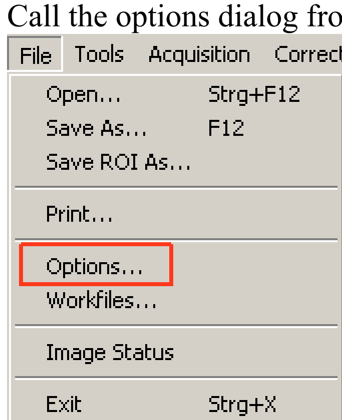
Selecting measurement parameters

This topic describes in detail how the user can influence the behavior of measurements and other actions of the program. This is done by so called options.

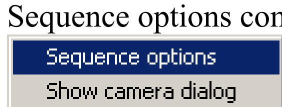
Options

All options are accessible from one single options dialog. To call the options menu there are two ways:

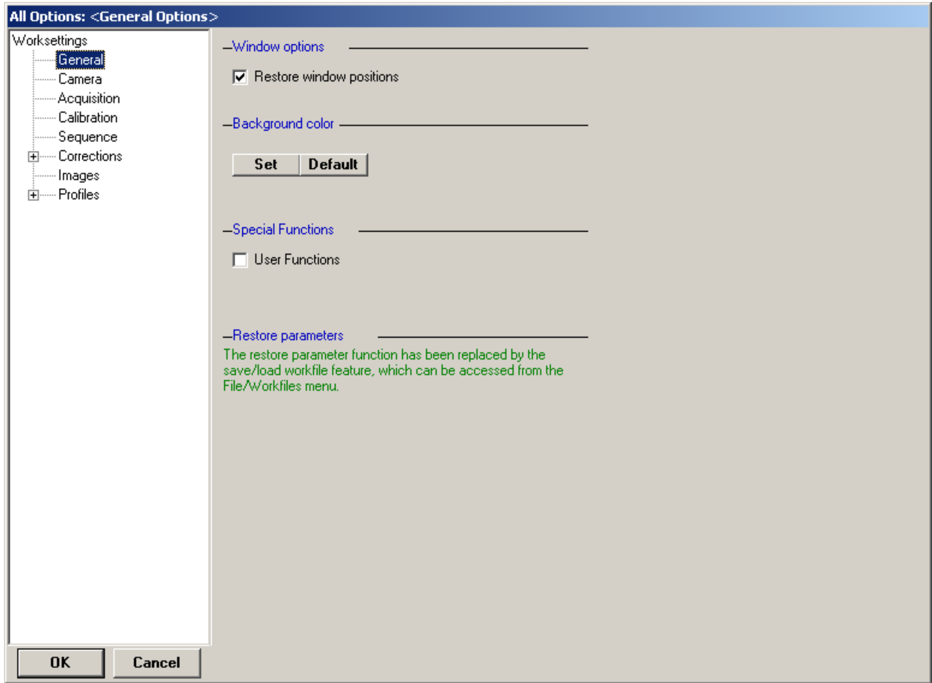
1.) Call the options dialog from the menu:



2.) Click with the right mouse button to a dialog where you want to get the related options dialog. If you for example click to the sequence dialog you will get the context sensitive menu for sequence which contains the Sequence options command.



General options



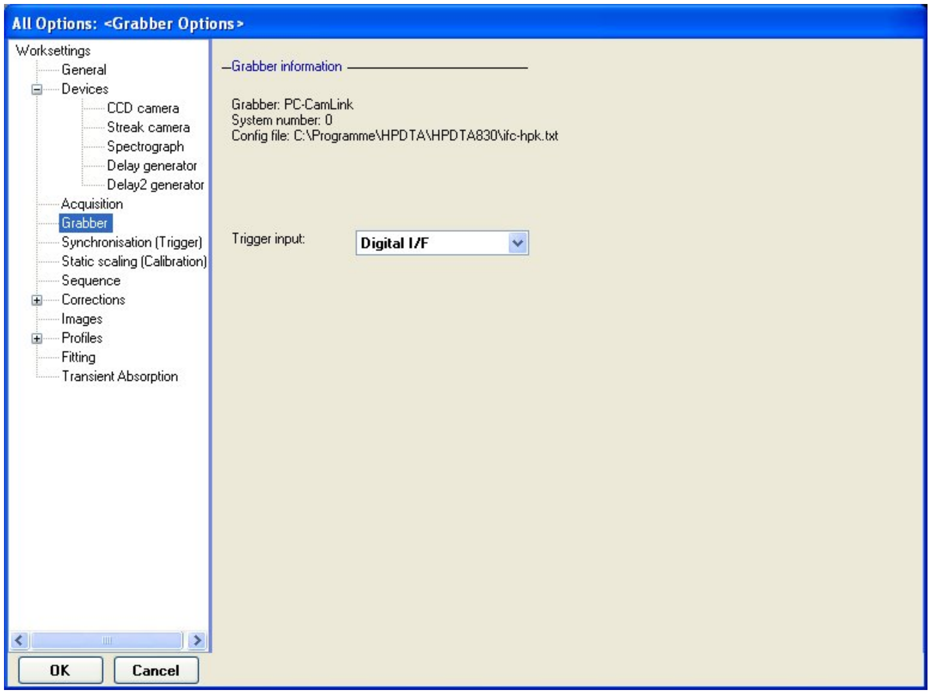
Restore window positions	If this option is checked, the program stores the position and size of every window when it is closed. The settings will be restored, when the window is opened for the next time
Background color: Set	A color selection window will be displayed where you can choose the background color of the program main window
Background color: Default	Sets the default background color of the program main window
USER function	When the **UserFunctions** option is checked, function calls to a DLL named CUSTOMER.DLL are enabled. With this option the user can implement his own control and data analysis functions into

CCD camera

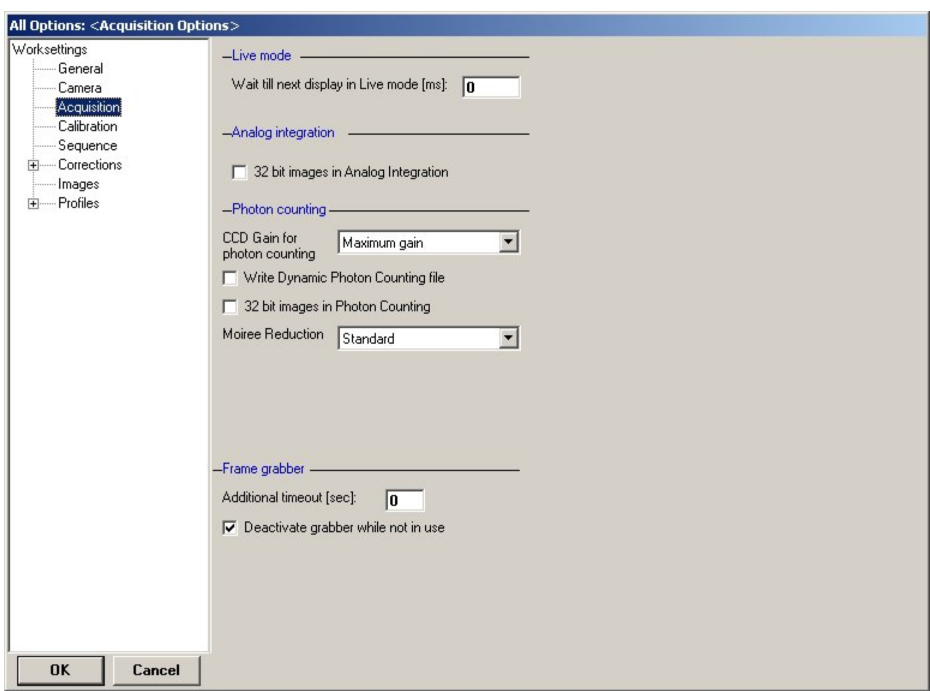
The CCD camera options dialog shows all options which can be specified to define the CCD cameras operation. Depending on the type of CCD camera these options look different.

Grabber options

The grabber options look different for every grabber. The following is a typical case:



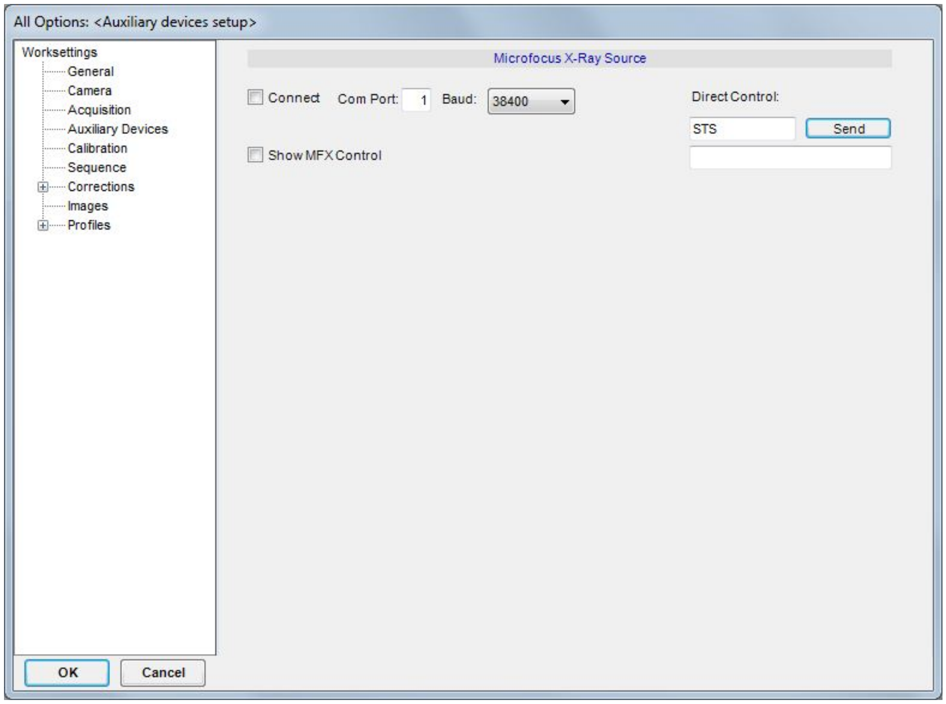
Acquisition



Wait till next display in LIVE mode [ms]:	Displays a new live image only if the specified time in ms has been elapsed since the last displayed image.
32 bit images in Analog Integration	If this option is set result images in Analog Integration mode will always be 32 bit. Note: If the camera outputs 16 bit images the resulting images will be always 32 bit images (to allow storing signed values) independent of this option.
CCD Gain for Photon Counting	This option allows specifying the default CCD camera gain setting in photon counting mode. You can select between "Maximum gain" and "Minimum gain". It is recommended to use "Maximum gain" unless the photon spots get saturated. The CCD gain can also be modified manually.
Write Dynamic Photon Counting file	If **Write dynamic photon counting file** is selected, the recording of photon counting images in the special DPC file format is enabled. In a DPC files the x-y co-ordinates of each photon and the time when it has been detected are recorded. This allows making a time dependent analysis of photon counting images.
32 bit images in Photon Counting	If this option is set result images in Photon counting mode will be 32 bit. Otherwise the result images will be 16 bit images.
Moiré reduction	This option specifies how strong Moiré reduction should take place. It is recommended to keep this parameters at its default value "Standard".
Additional timeout [sec]:	The parameter **Additional timeout (sec)** can be used to define an additional timeout, after which an image acquisition will be stopped, if no response comes from the camera. Usually this time should be 0. Only in some special case when you get timeout errors before an image acquisition has been finished, you may increase this parameter. Normally the timeout is automatically calculated: Timeout = System defined timeout (derived from the exposure time) + Additional timeout (sec). This parameter is very rarely needed in the current version of the software.
Deactivate grabber while not in use	This deactivates the grabbing driver while it is not use, e.g. after clicking to freeze. If this option is not selected acquisition may start faster.

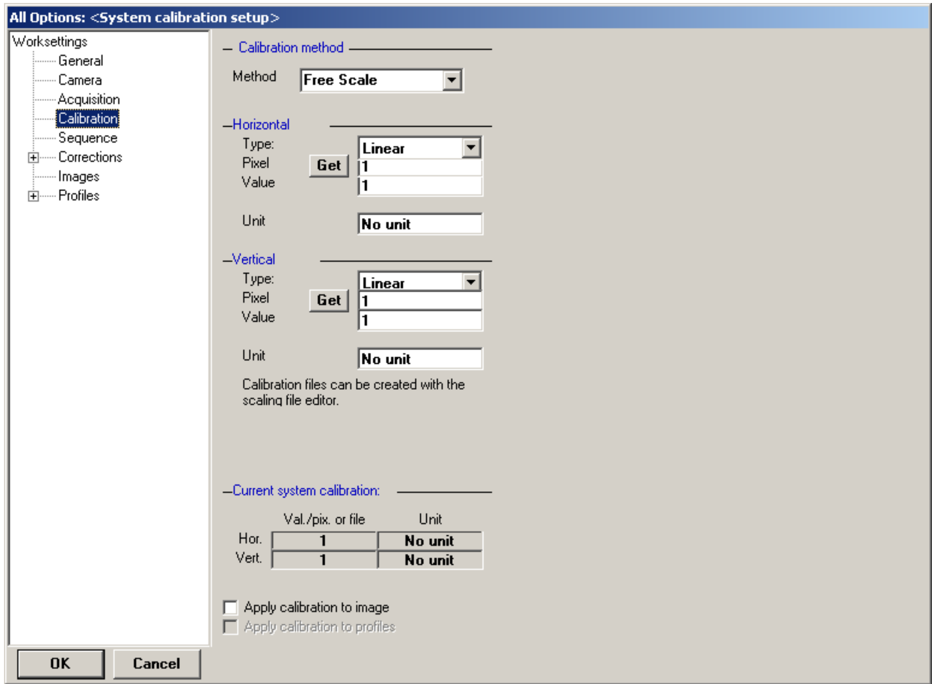
Note. For most grabbers this setting does not have any effect. Please keep this setting as it is (selected).

Auxiliary Devices



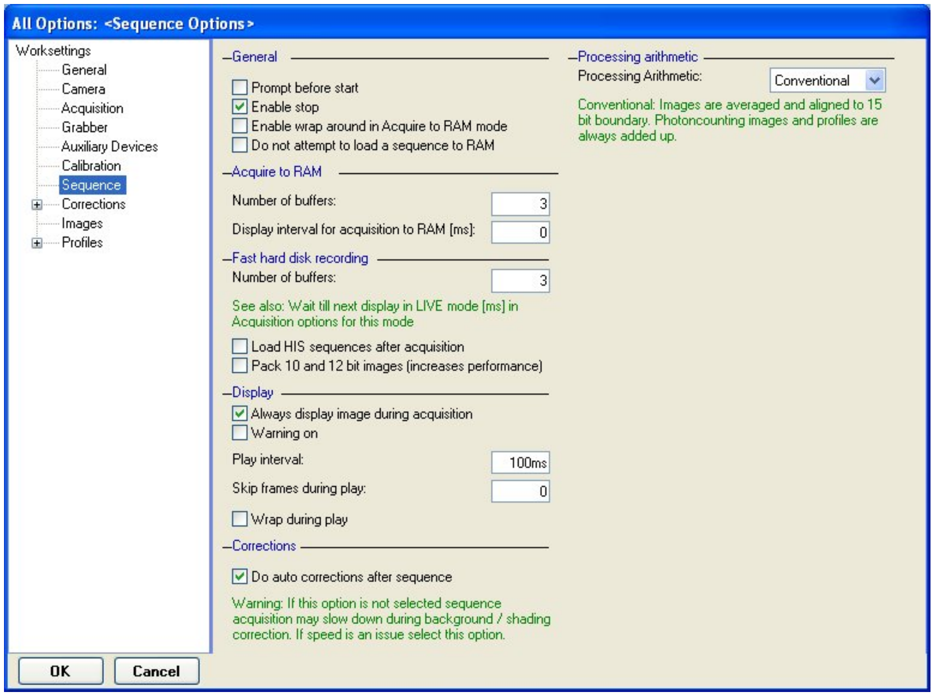
Microfocus X-Ray Source	Section containing all controls for a Microfocus X-Ray Source
Connect	Connects the Microfocus X-Ray Source by RS232
Com Port	Com Port number to which to connect the Microfocus X-Ray
Baud	Baud rate of the RS232 connection. State of the art MFX tubes normally have 38400 baud, older devices normaly have 9600 baud
Direct control	Contains controls to send and receive commands from the Microfocus X-Ray Source directly
Text box left of "Send" pushbutton	Edit box to input the string to send
Send	Executes sending
Text box below "Send" pushbutton	Edit box to display the received string from the MFX tube

Calibration



Calibration method	Methods to tell the system which scaling it should apply for the X and Y axis. Existing methods are: No calibration. Square calibration, free calibration.
Horizontal	Calibration for the horizontal direction
Vertical	Calibration for the vertical direction
Current system calibration	The currently active calibration for the complete system

Sequence

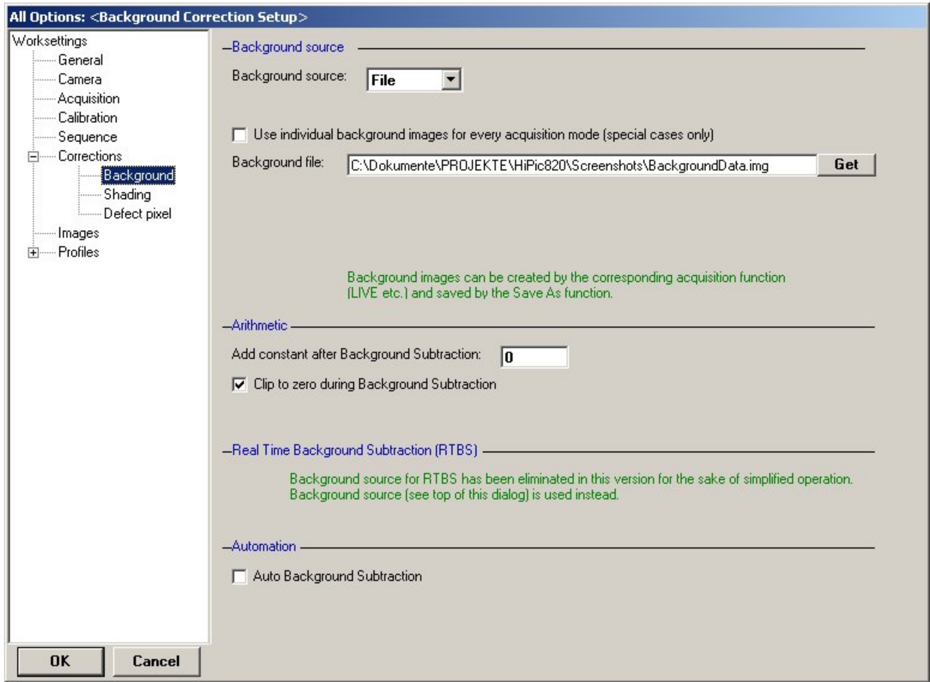


Prompt before start	Normally a sequence acquisition is not started immediately after you click **Start Acquisition** in the sequence acquisition dialogue. Before the acquisition actually starts, an initialization procedure is executed. If **Prompt before start** is selected, the system will display a message box after the initialization is completed. Sequence acquisition will be started immediately after you click OK in this message box. This is useful if you want to precisely control the starting time of sequence acquisition.
Enable stop	If **Enable stop** is selected, it will be possible to stop sequence acquisition at any time. If it is not selected, sequence acquisition can be stopped only by the user function. Of course sequence acquisition will stop latest when the pre-selected number of images has been acquired. If **Enable stop** is selected, the sequence acquisition may be slightly slower on older computer.
Enable wrap around in Acquire to RAM mode	If **Enable wrap around** is selected, the sequence function will allow to acquire a sequence in the wrap around mode. This function is only available, when the **Enable stop** is selected.
Acquire toRAM: Number of	Number of buffers used for acquisition to RAM as an intermediate storage between acquisition and the

buffers	applications sequence RAM. These buffers are normally managed by the frame grabber driver.
Display Interval for acquisition to RAM [ms]	Interval in ms which have to pass before a new sequence image is displayed. The acquisition continues during this time. This can reduce the CPU load for display images especially for high rep rate images and improve acquisition performance.
Do not attempt to load a sequence to RAM	Normally loading a sequence will always try to load the sequence to RAM. If this succeeds operations and display can then be executed at maximum speed. However if after loading a part of the sequence there is not enough RAM all images are unloaded and only checked. If normally the sequences are too large to fit into the RAM this is just waste of time. If the option **Do not attempt to load a sequence to RAM** is active the system does not attempt to load the sequence.
Number of buffers	Number of buffers used for fast hard disk recording as an intermediate storage between acquisition and hard disk write. These buffers are normally managed by the frame grabber driver.
Load HIS sequences after acquisition	HIS sequences are always written to a file. If this option is active the file is automatically selected as the current sequence.
Pack 10 and 12 bit images(increases performance)	10 and 12 bit images are packed internally, which increases the saving speed and the storage depth. **Warning:** If you want to perform background subtraction with the option “Clip to zero during background subtraction” not selected (in other words: if you want to create signed data) in a later step you should not use this option.
Always display image during acquisition	If this option is active the image is always displayed during the acquisition process. **Warning**: this option may slow down the recording speed !
Warning on	If warning on is active a display shows the remaining time in seconds until the next acquisition starts. Additionally the background color of the main window changes to red shortly before the next acquisition starts. This option is only effective of Fixed intervals with a long interval is specified.
Play interval	Defines the time in ms between two images for the display in play mode.

Wrap during play	If during play of a sequence it encounters an end it restarts from the other end and runs continuously.
Do auto corrections after sequence	If the checkbox **Do auto corrections after sequence** is checked, all correction functions, as background or shading correction, are performed after a complete sequence has been acquired. A background image will be acquired only once at the end of the sequence. If this checkbox is unchecked, the corrections will be made after acquisition of each image. It may depend on your experiment, which mode to use: The mode **Do auto correction after sequence** allows a much faster processing of an image sequence. We recommend using it as default. However there may be circumstances which do not allow to use this mode, e.g. if the background image is changing after each acquisition. Then it is better to perform background subtraction immediately after an image has been acquired with a newly acquired background image.
Processing arithmetic:	Defines the way how averageimages are processed. The user can select between Conventional, Average and Add. See the chapter Sequence acquisition Processing Sequences- Arithmetic for details.

Background

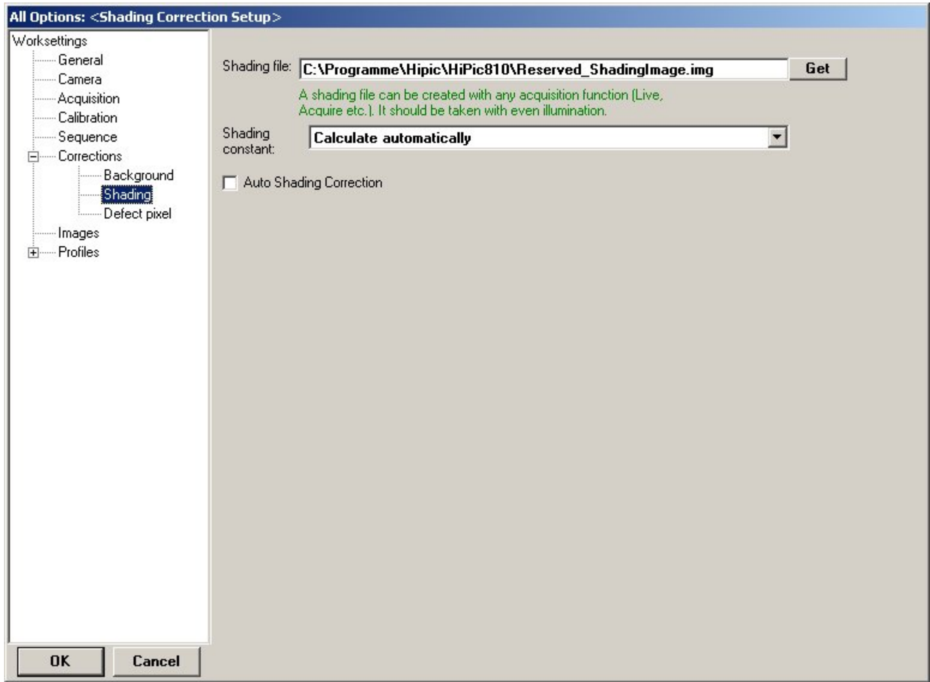


Background source	Defines the source of the background data. Available choices are Camera or File.
Use individual background images for every acquisition mode (special case only)	When we select to use File as a background source we can furthermore select whether we want to specify one single file for all acquisition modes (default) or whether we want to specify a different file for every acquisition mode. This can be useful if scanning options link scan speed are different in different acquisition modes.
Take background image with open shutter	Normally the CCD cameras shutter is closed during background subtraction from camera. If this options is selected the background image is taken with open shutter.
Don't prompt the user before backgr. sub.	If **Don't prompt the user before backgr. sub** is not selected the user is prompted to close any external shutter or switch off the illumination light or take a similar action to avoid that the light signal comes to the camera during background acquisition. If the option **Don't prompt the user before backgr. sub** is selected the user is **not** prompted to take any such action and Background subtraction immediately proceeds.
Background file for: Live	File for background subtraction in Live mode
Background file for:	File for background subtraction in Acquire mode

Acquire

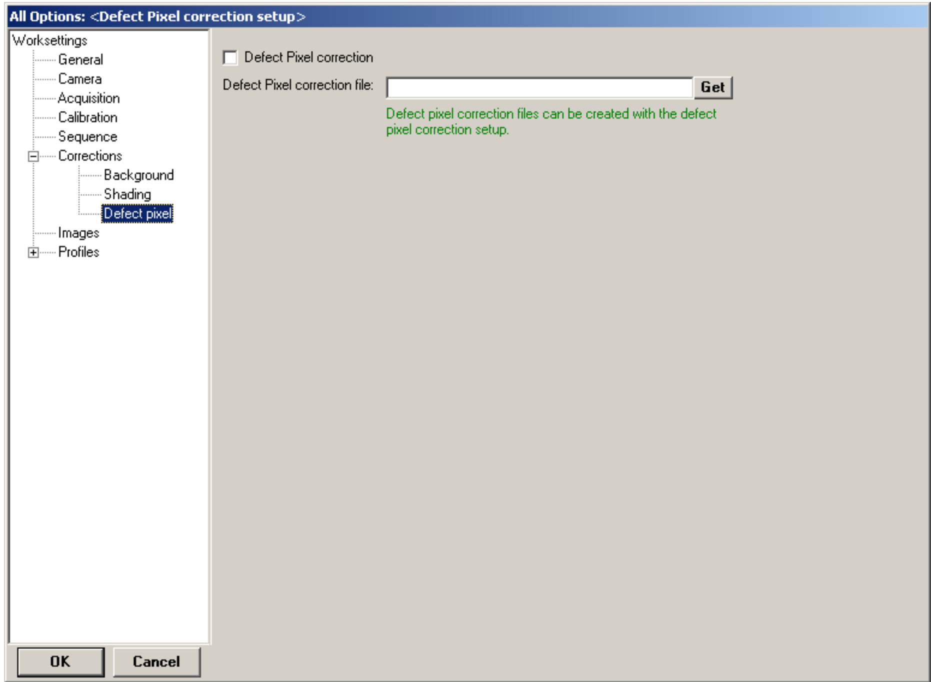
Background file for: Analog Integration	File for background subtraction in Analog Integration mode
Add constant after background subtraction	You can add a **constant** during background subtraction process. This is especially useful when normal acquisition modes are used and negative values would be clipped to zero. By adding a constant you will see the image noise correctly even in dark areas. To add a constant during background subtraction processing you simply enter the desired offset value in the edit box **Add constant after background subtraction**. If you add a positive constant it may happen that the current bit range is exceeded. In this case the values are clipped to the maximum possible value within the bit range (e.g. 255 in 8 bit images, 1023 in 10 bit images and 4095 in 12 bit images). Therefore it is recommended to choose a constant not higher than necessary (the amount of noise is normally only a few counts). The constant is used for "from camera" type subtraction as well as for background subtraction "from file".
Clip to zero during background subtraction	Negative intensity data may appear after background subtraction. If this command is selected, negative intensity data are clipped to zero.
Auto background subtraction	When the **Auto Backsub** option is checked, background subtraction is automatically performed after an image acquisition. Please refer to for details about Background subtraction.

Shading



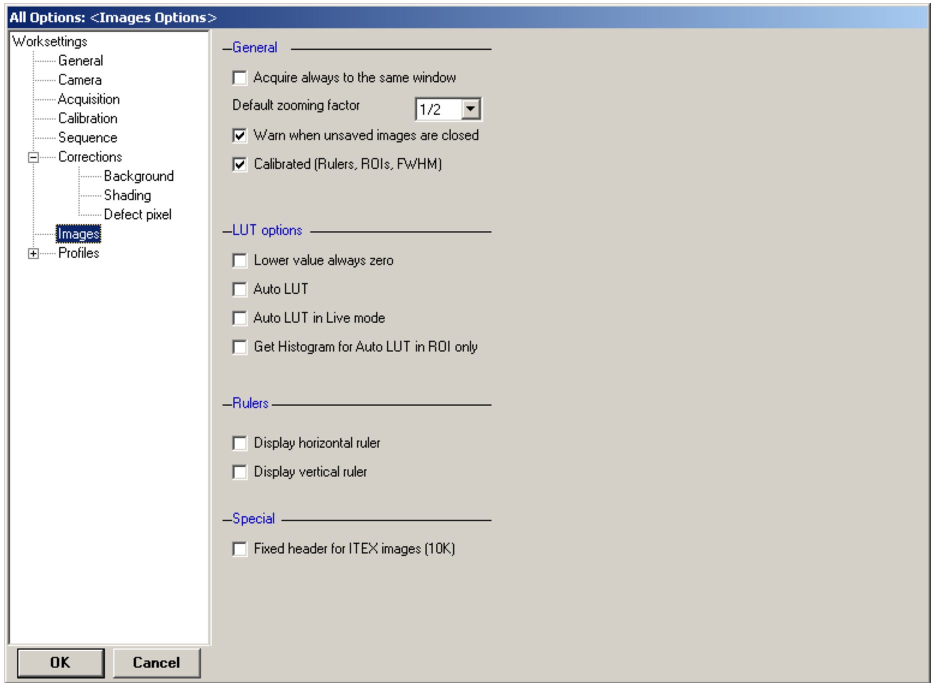
Shading file	Image file used for shading correction
Shading constant	This option defines the method how to get the shading constant: If “Calculate Automatically” is selected, the software calculates the constant according to the image data in the inner part of the shading image. If “Use upper LUT value of Shading file” is selected, the upper LUT value of shading file is used as the constant. Note: In this case the upper LUT value within the shading file has to be selected correctly prior to saving the shading file.
Auto shading correction	If this options is selected a shading correction is executed automatically after image acquisition

Defect pixel



Defect pixel correction	If this options is selected defect pixel correction is executed
Defect pixel correction file	This file specifies the coordinates of the defects for the defect pixel correction

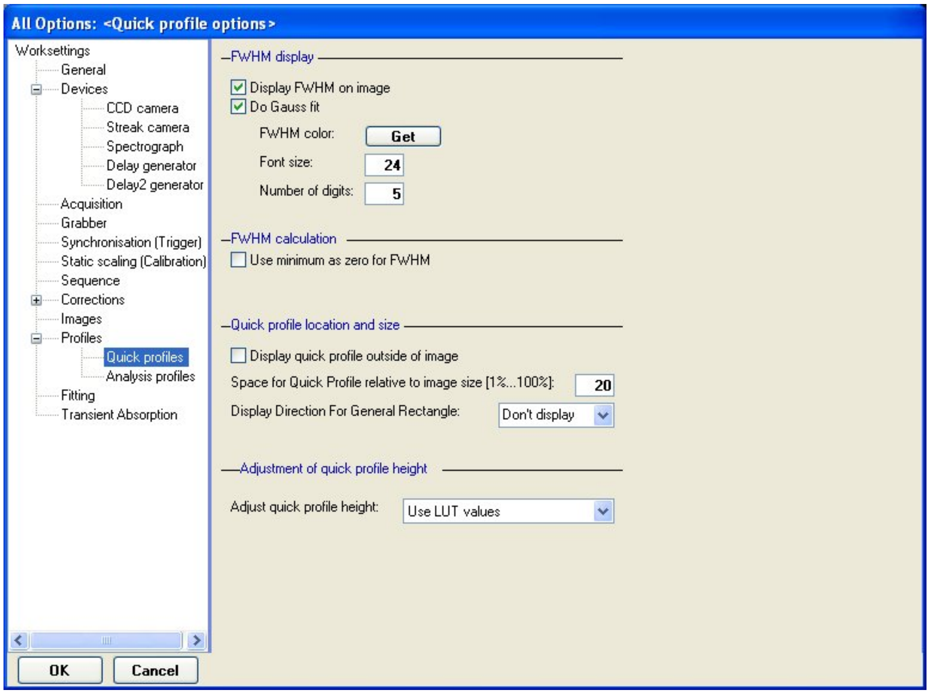
Images



Acquire always to the same window	When the option **Acquire always to the same window** is selected the **Acquire** and **Analog Integration** functions always use the same image window for acquisition. This is useful to avoid that the PC memory is quickly used up for storage of images. The default behavior concerning new images is as follows: The Live mode always acquires to the same window. The image load function opens always a new image. The Acquire and Analog Integration function opens up a new window every time they are invoked.
Default zoom factor	When a new window is opened a default zooming factor is used for the display.
Warn when unsaved images are closed	When a window is closed and the image is not or not fully saved the program issues a warning prior to closing the window (default). When the checkbox is not selected the program does not issue such a warning.
Calibrated (Rulers, ROIs, FWHM)	Defines whether the labeling of Rulers ROIs and FWHM are in calibrated units or in pixels.
LUT lower side = 0	When this option is checked the lower limit of the LUT will always be set to 0 when automatic LUT calculation is executed (e.g. by pressing the „*“ button of the LUT tool or by using AUTO LUT mode). If the option is unchecked the lower value will be calculated according to the data.
Auto LUT	When the **Auto LUT** option is checked the LUT is

	adapted automatically during image acquisition (e.g. during analog integration and photon counting), after acquisition, background subtraction and loading an image.
Auto LUT also during LIVE mode	When this option is checked the image contrast will be updated by the AUTO LUT function whenever a new image is displayed in Live mode.
Auto LUT optimized for selected ROI	When this option is checked the Auto LUT function will optimize the image contrast for grey values which are within the boundaries of the actual ROI. This allows optimizing the contrast based on the grey levels within a limited image area. If no ROI is selected, the whole image area will be considered as actual ROI. This function will be only active if Auto LUT is enabled.
Display horizontal ruler	Defines whether or not a horizontal ruler is displayed in the image
Display vertical ruler	Defines whether or not a vertical ruler is displayed in the image
Fixed header for ITEX images (10K)	The image status information is stored in a string in the image file header. Normally the length of this string varies with its content. However, in some cases it is desired that the header has a fixed length. If this option is checked the length of the header is always 10K.

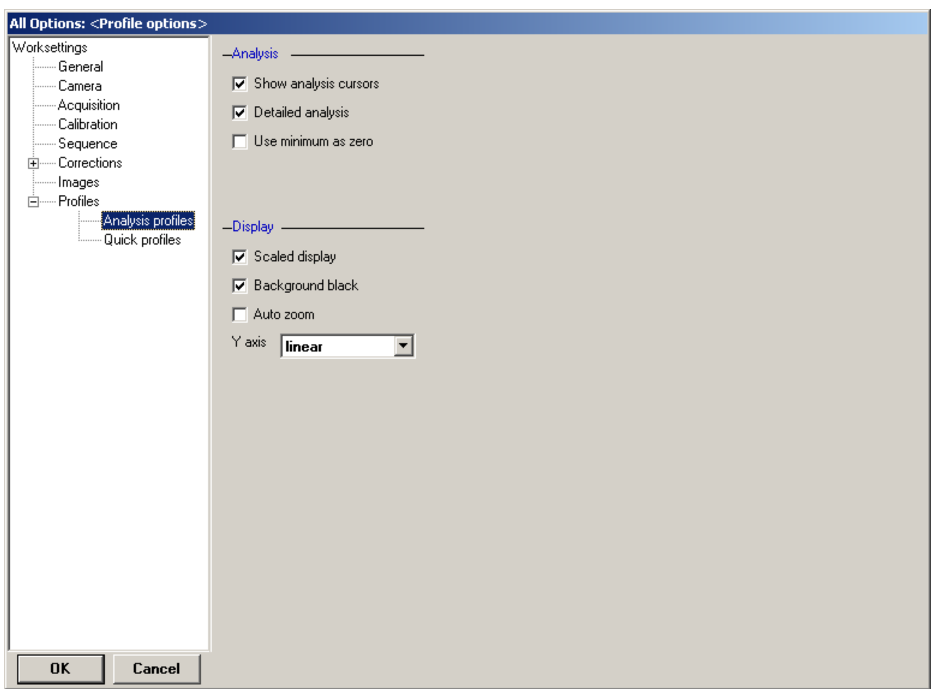
Quick profile



Display FWHM on image	Defines whether or not a FWHM value should be displayed in the image
Do Gauss Fit	If Do Gauss Fit is selected, a gauss fir is done. If the fit succeeds the gauss profile is displayed in white color additionally to the profile. If Do Gauss Fit is not selected or if the Gauss Fit fails, the conventional method of getting the FWHM is applied. This method searches the half height at both sides from the maximum^.
FWHM color	Defines the color in which the FWHM letters should be displayed
Font size	Defines the Font size in which the FWHM letters should be displayed
Number of digits	Defines the precision with which the FWHM should be displayed
Use minimum as zero for FWHM	Defines whether or not the Minimum of the profile should be used as the zero point for FWHM calculation
Display quick profile outside of image	Defines whether or not the Quick profile should be displayed outside of the image. If not it is displayed at the same area than the image.

Space for Quick Profile relative to image size [1%...100%]:	Defines how large the space for the quick profile should be relative to the image size. This option applies only to cases where the Quick Profile is displayed outside to image.
Display direction for general rectangle	This option defines whether and how an arbitrary rectangle should have a Quick Profile display or not. Possible values are: Don't display, Horizontal, Vertical
Adjust Quick profile height	Defines how to adjust the height of the displayed quick profile. If "Use LUT values" is selected the upper and lower LUT limits are used as the limiting values. If "Use Min/max values" is selected the minimum and maximum values are use as the limiting values.

Analysis profiles



Show analysis cursors	When Show analysis cursors is selected, two cursors appear on the **Profile Display** Window and the **Profile Analysis** window appears on the screen.
Detailed analysis	If the **Detailed analysis** is selected under the **Options** menu several additional numerical values

	will be displayed.
Use minimum as zero	For some functions the "zero point" has to be determined. By default this point is exactly at intensity =0. However, if the option **Use Minimum as zero** under the **Options** menu is selected the minimum found in the region between the two cursors is regarded as the zero point. This is very useful if the profile contains an undesired offset.
Scaled display	When **Scaled Display** is active, the scaling data attached to the profile is used to get the correct physical value for every data point. If **Scaled display** is inactive corresponding pixel values are displayed. With this option you can even display profiles with different units. All analysis values are displayed in scaled values or in pixels according to this option.
Background black	**Background black** determines whether the profile background will be displayed black or white.
Auto zoom	If **Auto zoom** is selected, the system performs a zoom operation whenever a profile has been changed. This ensures that always the best display mode is selected to show all actual profiles within the display window with maximum size (like the Zoom all button).
Y-Axis	There are three different possibilities for display of the intensity axis. It can be either displayed linear or logarithmic with the base 10 or with the base e. This can be selected by choosing one of the options **Linear, Log(base e)** or **Log(base 10).**

Please note: The spectrograph calibration is not part of the hardware profile as it is subject to frequent changes. The spectrograph calibration is stored with other permanent settings like the options and can be saved and recalled by using workfiles.

Saving and loading parameters

Permanent parameters

If the users closes a session and reopens it most of the parameters are remembered permanently and restored once the session is reopened. In other words most of the parameters used in the software are permanent.

There are a few parameters which may confuse the user if they are restored from one session to the next. These parameters are set to a default value when a new session is opened.

To demonstrate this we take the external trigger mode of a CCD camera. The external trigger mode switches the CCD camera to a mode where it only acquires images if a trigger is applied to the camera. We assume that a user which has operated the CCD camera in external trigger mode the day before reopens the session the next day and starts live mode. But due to the fact that the camera is switched to external trigger mode it does not acquire images. It may take long time for the user to remember that he applied triggers to the camera the day before and he may be confused.

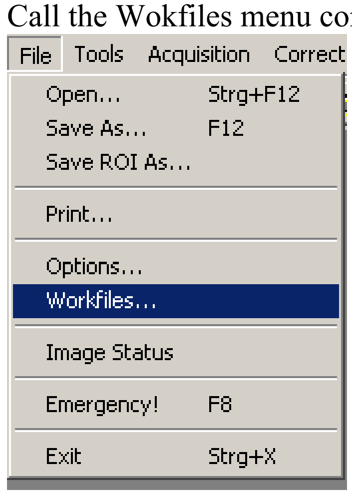
Workfiles

In other cases the user may want to exactly reproduce the experimental conditions he had the day before. In this case he may use the Save/Load workfile feature of the software.

Saving a workfile saves all current parameters (even those which are not permanent in the previously explained sense). Loading a workfile restores all parameters stored previously in this file.

To save the current set of parameters to a workfile proceed as follows:

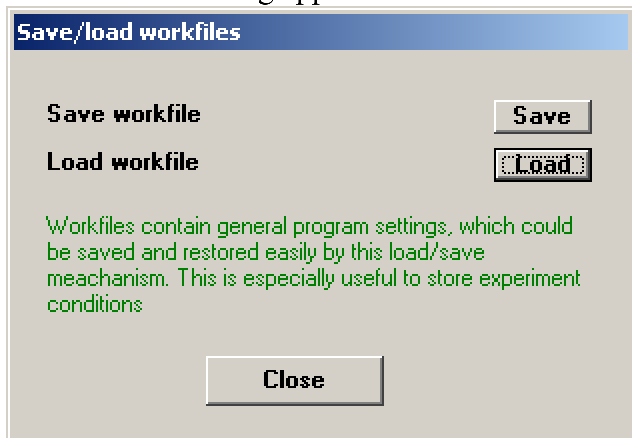
1) Call the Wokfiles menu command.



- or -

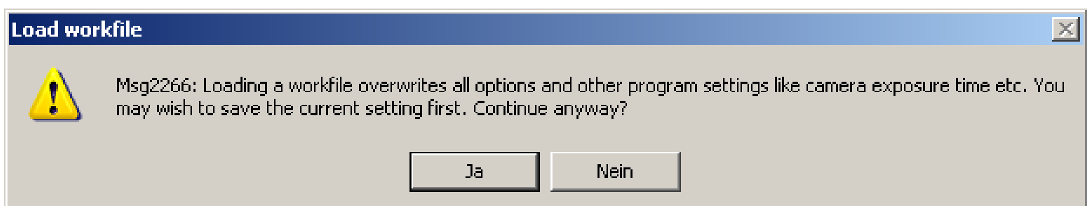
Right click to the programs client area and select Workfiles…

The Workfile Dialog appears:



2) Select Save and enter a file name on the file dialog which appears

To Load a Workfile call the Workfile dialog and Select Load.
A warning will be issued saying that all settings will be overwritten by the new settings in the workfile.



Note:

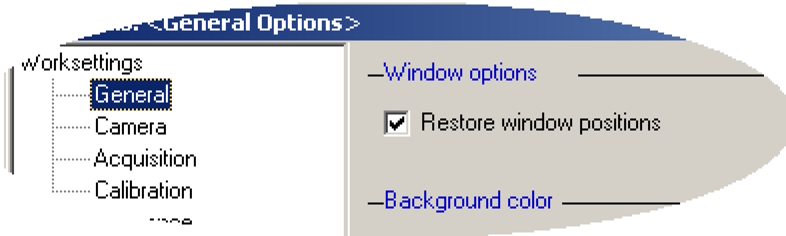
If you are not sure do not load the new parameters

- or -

Save the current settings to another workfile first, and then load the new workfile.

Image positions

A special parameter in the general menu defines whether all window positions are restored once the window is opened again. This feature allows the user to tidy up his user interface and to place all dialogs at a location where he is used to search it.



If this option is not checked all windows are loaded to a default position.

Note: If it happens that dialogs are suddenly lost - because they are opened at locations outside of the main dialog -, switching off this feature, closing and reopening the software causes all dialogs to appear at default locations. Any “lost” dialogs can be found in this way.

Calibration & Analysis

These topics deals with the calibration of image and profile data and its analysis

Calibration

Calibration allows to assign physical units to image and profile data. First you can learn what calibration means in this program. Then you get an introduction to the different calibration methods (linear and table type) used in this software. In the topic "System, Image and Profile Calibration" you learn about the hierarchical ordering of calibration. The following chapters show how to make the set-up of calibration for the different methods.

Please see also the Appendix Calibration File Format for details.

What is Calibration?

When acquiring images with a two-dimensional camera, light intensities are measured at certain detector elements. These elements are called pixels. Of course there is some spatial relationship (correspondence) between the pixels and the real world. The camera may look into a room with an ordinary objective lens, or it may look at some microscope image. In all cases there is a specific spatial correspondence between the image on the camera and the real world. Calibration is a way to get quantitative information about the real world by extracting data from the camera image.

The geometrical transformations made during calibration process may be simple or more complicated depending on the type of transformation the physical measure undergoes in the complete system:

The simplest (and most often used) way of calibration is to attach a single calibration factor to the system. The pixel distance from one point to the next is then just multiplied by that factor.

The most general way of calibration is to allow a totally free mathematical co-ordinate transformation function like:

X_scaled =X_scaled (X_camera,Y_camera)

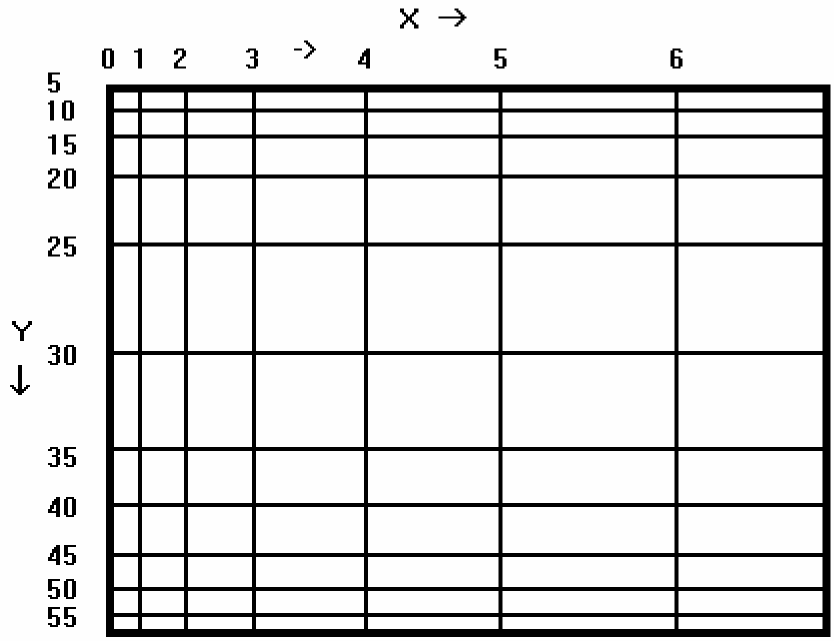
Y_scaled =Y_scaled (X_camera,Y_camera).

Such a very general calibration method, though it is the most versatile one, has three disadvantages:

- To perform such a calibration one would need two two-dimensional calibration arrays of the size of horizontal x vertical pixel number (x 4 byte at least).

- Lines with X_scaled =const or Y_scaled =const are no longer straight, making it very difficult to extract profiles along such lines (what the user typically wants to do).
- It is very complicated to handle this calibration scheme considering how the calibration data could be entered by the user.

Due to practical considerations a calibration scheme has been implemented which is easy to use but versatile enough for most cases. This calibration scheme has the following possibilities and restrictions:



Example image of calibration (non-linear in X and Y direction)

- Lines with X_scaled =constant or Y_scaled =constant always have to be parallel to the camera axes.
- The scales in X and Y can be linear or non-linear. In the latter case they have to be monotonous (increasing or decreasing).
- Non-linear calibration is realised by function tables (called Table Calibration) and any functional relationship can be modeled freely by the user, as long as the "monotony condition" is met.

Linear calibration in both dimensions enables the user to measure data along any arbitrary direction (also non-parallel to the axes).

Linear/Table

The system calibration contains two sets of calibration data: One for the X axis and one for the Y axis. Each calibration axis can either be of linear or of table type.

The **linear calibration** consists of a calibration factor and a unit. When the unit is the same for both directions and the calibration is linear in both axes, the calibration information can be attached to profiles generated in any arbitrary direction. When the dimension is not the same in both directions or when table calibration is used at least for one axis, only horizontal or vertical profiles can be scaled.

When linear calibration is used the origin for the calibration data of intensity profiles is always the starting point of the profile. The calibration of a profile therefore looks always like:

Pixel No.	Calibration value
0	0
1	1 * Factor
2	2 * Factor
n	n * Factor

Thus, the absolute value will depend on the location of the starting point. If normal images are analyzed this is what the user typically wants. As a consequence, however, if you want to compare two profiles they should start at the same location. If you want to compensate an offset simply change the starting point.

The **table type calibration** consists of a table of **n** floating point values and a unit. **n** corresponds to the number of pixel in the axis. The **n** values reside in a calibration file with the extension **.scl** and are read automatically into memory when needed. The table may contain any values provided that they are strictly monotonous, either increasing or decreasing. (In other words, the function which the table resembles must be invertible.)

If you want to make non-linear calibration or attach absolute values to certain pixels or if you want to create calibration information which does not start at the value zero (e.g. for a spectrograph) you should use table calibration. Table calibration always yields the same scaled value at the same pixel location. Therefore absolute comparison is possible even if the profile windows do not start at the same location.

System / Image / Profile Calibration

The program distinguishes between the **system calibration**, the **image calibration**, and the calibration for every intensity **profile**.

System, image and all profiles individually can have different calibration information.

The calibration which is assigned to the system is always automatically applied to the current image at the moment the image is acquired. In case a profile is extracted from an image, the current image calibration is applied to the profile. The system passes its calibration to the image, and the image passes its calibration to the profiles.

For this transmission mechanism the following situations may appear:

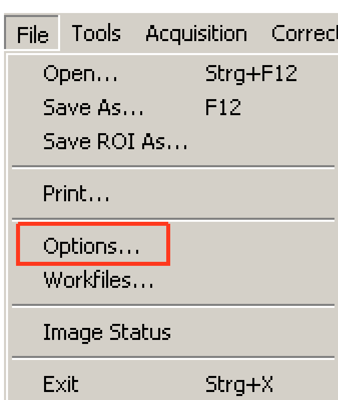
- The system calibration attaches information to the pixels on the chip (camera). If the image origins on chip and on frame-buffer are not the same, the system calibration must be shifted accordingly.
- If binning is active during image acquisition, the system calibration is modified accordingly. This means, internally a table will be compressed accordingly, and a calibration factor will be multiplied by the binning factor. All these mechanisms are fully automatic and do not require special care from the user.
- When a profile is extracted from the frame-buffer the valid image area is regarded and automatically checked whether the profile sampling window is contained in the valid image area. If not, the user will be prompted to modify the profile sampling window, extend the calibration data linearly or do not assign any calibration information to the profile.

The calibration is always automatically attached to the images and profiles and re-activated when images and profiles are reloaded from disk. In most cases the system calibration can also be reconstructed from the information in the image or profile.

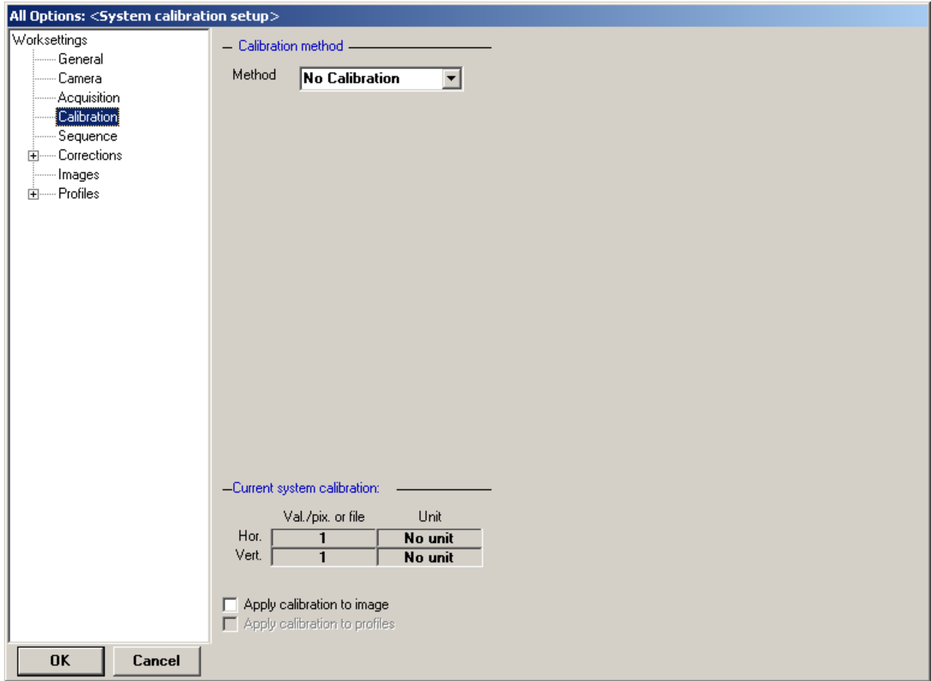
Using Different Calibration Methods

There are several methods to tell the system which calibration it should apply for the X and Y axis.

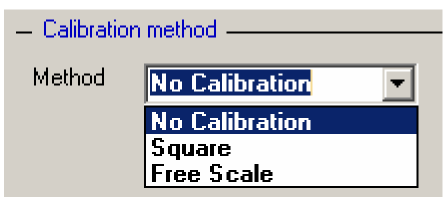
To tell the system which calibration method he should use show the calibration options by calling the Options dialog from the menu



and select Calibration within the Tree dialog on the left side.



Calibration information can be different for the X and the Y Axis. The Calibration method deals with the way how to specify the calibration for both Axis.



There are three different methods:

No Calibration	No Calibration information is assigned to X and Y Axis
Square	A linear Calibration is assigned to X and Y Axis. Both calibration factors are identical
Free Scale	A different Calibration can be specified for the X and Y Axis. Both Axis can have linear or table calibration

No Calibration

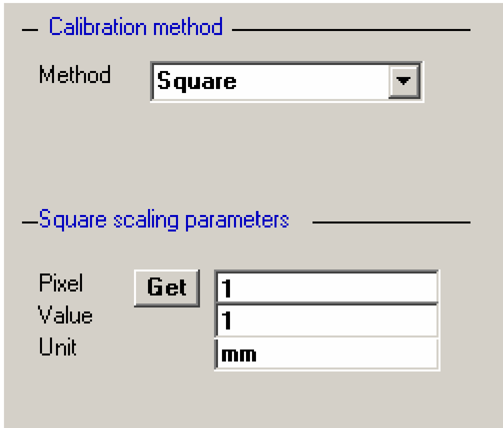
Select **No Calibration** to enable the square calibration method.

No Calibration is assigned to X and Y axis.

Note: Technically speaking this is not true. Instead a linear calibration with the factor 1 and the unit "No Calibration" is assigned to both X and Y Axis.

Square calibration

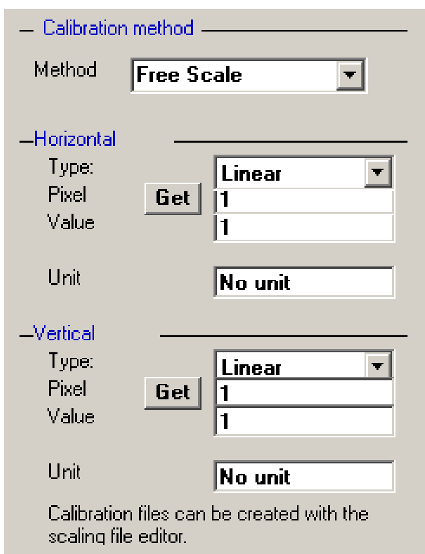
Select **Square** to enable the square calibration method.



You can specify a pixel distance a physical distance related to this pixel distance and the associated unit. If the currently selected image has a line ROI which is the currently selected one pushing the Get will calculate the pixel distance from the start and end point of this line ROI.

Free Calibration

Select **Free Scale** to enable the free calibration method.



The user can select the calibration type and the unit independently for both directions. For each direction five values can be specified:

Type, Pixel, Value, File and **Unit.**

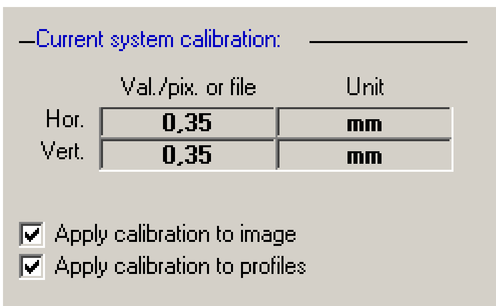
When selecting the linear calibration, the meaning of **Pixel, Value** and **Unit** is the same as for square calibration. The only difference to square calibration is that you are specifying the calibration for each axis separately. Hence, for horizontal calibration you specify a horizontal pixel distance and for vertical calibration a vertical distance. For the ease of input you have to select a rectangular ROI where either its width or its height are used to calculate the pixel distance depending on the axis direction.

When selecting table calibration **Value** is no longer valid, the entry **File** is valid instead. By pushing the small button **Get** on the right side of the **File** entry you can choose a calibration file from a file list.

System Calibration

The lower part of the calibration dialog informs the user about the current system calibration (the calibration which was active before the calibration options dialog has been called).

After you have selected calibration values these are assigned to the system calibration. You additionally have the choice to assign these values to the currently selected image and to profiles.



Profiles

A profile is a one-dimensional data extracted from an image.

Quick profiles

The easiest way of extraction profiles is to use the quick profile feature where profiles extracted from horizontal or vertical Region of interests (ROIs) are displayed on the same window than image.

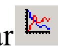
Analysis profiles

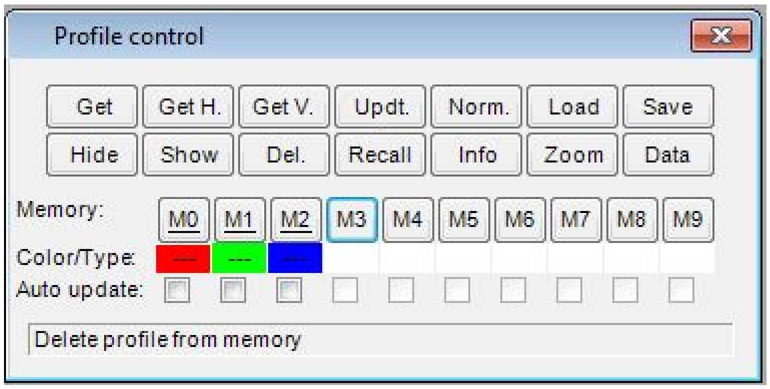
Profile Analysis extracts one-dimensional intensity data from the image along user-defined positions, attaches scaling information and calculates and displays various information about these data.

In the following eight sections you learn how to use the profile analysis tools. First you get general information about the profile tools, followed by a detailed description of the profile control and profile display window. Then you learn how to acquire and display profiles, how to attach scaling to the profiles and how to make a more detailed analysis. Finally you get *information about how to handle profile data and how to export them to other programs.*

Please see also the appendix [Profile File Format] for details.

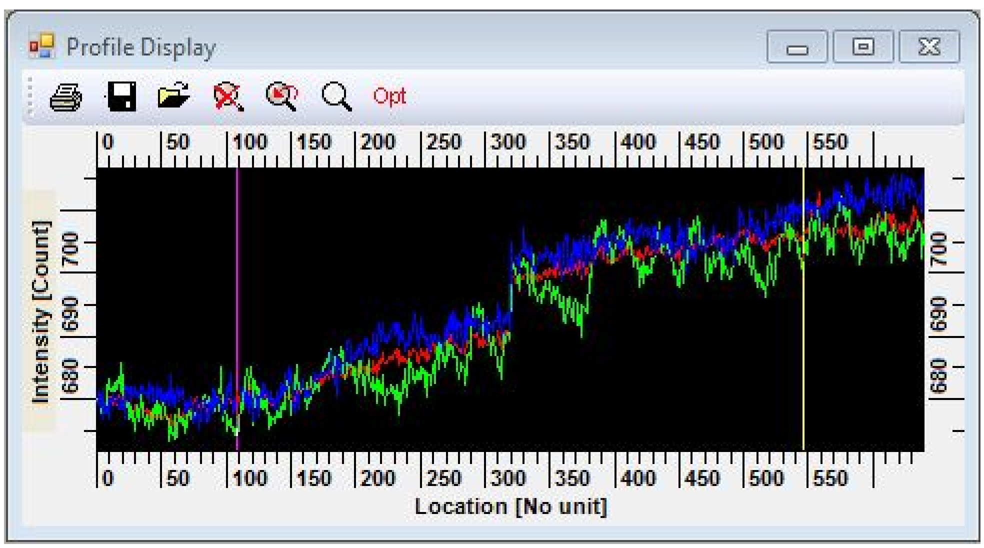
General Information on Profile Analysis

Choose **Profile** from the **Analysis** menu to display the Profile Control and the Profile Display dialogue boxes or toggle the state of the profile button on the toolbar .



Profile control dialogue box

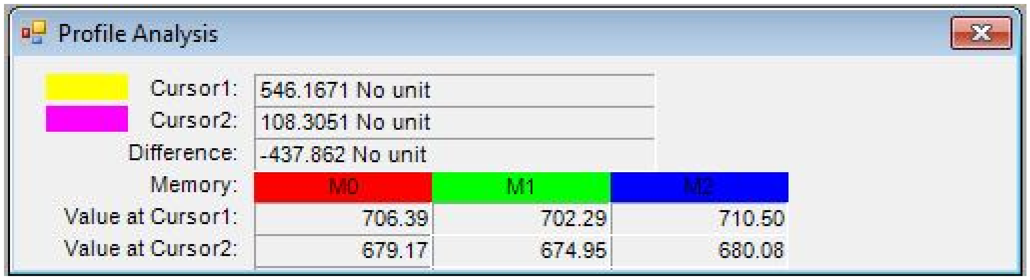
The **Profile Control** dialogue box offers a variety of controls to acquire, display and handle profiles.



Profile display dialogue box

The **Profile Display** window is used to display the profiles. It can be freely resized by the user. A toolbar on top of the **Profile Display** dialogue box offers a variety of display and analysis options.

When the option **Analysis** on the **Profile Display** dialogue box is selected, the **Profile Analysis** dialogue box appears on the screen in its standard size.

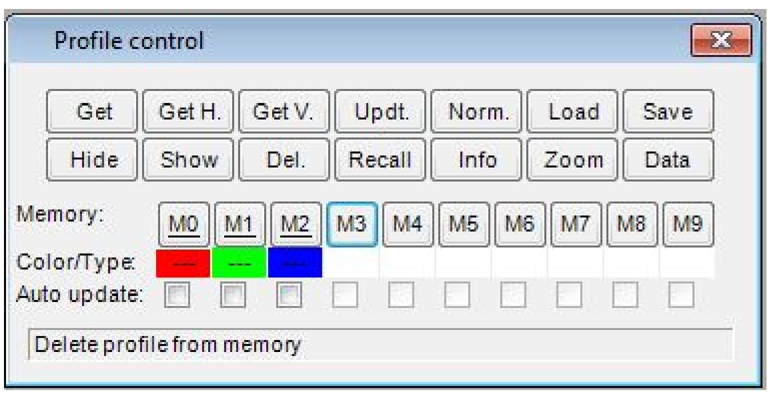


Standard type of the profile analysis dialogue box

If the option **Detailed analysis** is additionally selected the **Profile Analysis** dialogue box becomes larger and displays several additional analytical data.

The Profile Control

The **Profile Control** dialogue box is designed in the sense that you first select the desired action (command button) and then the desired memory the action should work on. The last command remains active unless another command button is pressed. For example if you want to delete several profiles it is sufficient to click the **Del** push-button once and then the memory buttons whose profiles you want to delete.



Profile control dialogue box

The **Profile Control** window contains the following parts:

- A series of command buttons on the top of the window.
- 10 memory buttons
- 10 small fields below the memory buttons displaying the color and the type of the profile (these fields are invisible if the memory is empty)
- 10 check boxes to specify the **Auto update** function

- A text box displaying messages such as a brief description of the currently selected command or an error message

The command buttons activate the following commands:

Get	Acquires a profile with arbitrary starting and ending points (requires a line ROI)
GetH	Acquires a horizontal integrated profile (requires a rectangular ROI)
GetV	Acquires a vertical integrated profile (requires a rectangular ROI)
Updt	Updates the profile from the current image (at the same position and direction).
Norm.	Normalizes all other profiles to the maximum height of the selected memory. This allows to compare profiles which differs strongly in intensity.
Load	Loads a profile from disk into memory. If the profile is a part of a profile sequence the sequence will be loaded starting with the file you selected
Save	Saves a profile from memory to disk. If the profile is acquired from an image sequence, profile data for all images of the sequence will be saved.
Hide	Hides a profile. It disappears from the **Profile Display** window.
Show	Shows a profile which previously has been hidden.
Del.	Deletes a profile from memory (Caution: this command is irreversible).
Recall	Shows the profile sampling window on the current image and displays its co-ordinates in pixels and scaled units in the message field. The selected ROI becomes the current ROI. Its parameter can be changed now (e.g. using the ROI info tool).
Info	Shows the **Profile Info** window, which contains the full information about the profile and the parent image
Zoom	Adjusts the scale of the **Profile Display** window so that the selected profile will best fit into it.
Data	Displays the content of a profile memory in a text box.

Acquiring Profiles

There are three types of profiles: **Line** profiles, **Integrated Horizontal** profiles and **Integrated Vertical** profiles.

Before you acquire profiles, you may want to assign scales to the X-and Y-axis of the image.

To select any type of profile you first have to select an appropriate ROI. If more than one ROI is selected for an image all profile actions always refer to the currently selected ROI (this is the one which is displayed with a dashed line).

When you want to get a **Line** profile select a line-type ROI . Press **Get** and the memory button where you want to store the profile. The profile values are sampled along the specified line with a step width of one pixel thus preserving the assigned scaling in case of linear scaling.

Integrated Horizontal profiles and **Integrated Vertical** profiles are sampled along the sensor axis either horizontally or vertically.

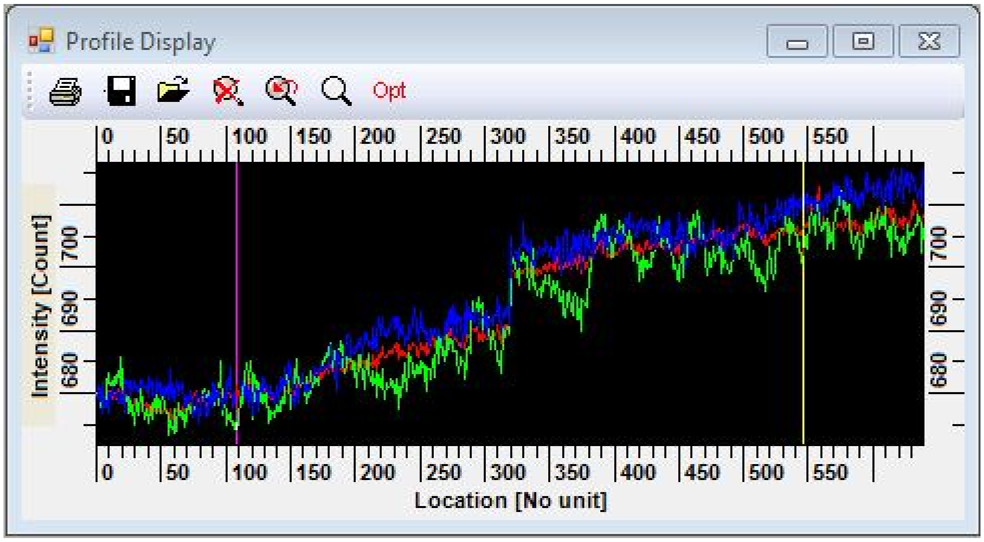
When you want to get an **integrated** profile select a rectangular ROI (Any of the three selections , or). To get either of both profile types press the **GetH** or **GetV** command button and click to the memory button where to store the profile. Depending on the type of profile (horizontal or vertical) a profile is extracted from the image within the specified window. The pixel intensities are averaged (integrated and normalized by the sampling window width) along the direction perpendicular to the profile direction. Since the values are averaged they will be independent of the width of the profile sampling window and fractional pixel intensities may occur with integrated profiles.

When there is already a profile in the specified memory the previously selected profile sampling window is displayed as default. If you select the **Updt** command you automatically get the same profile type as it has been in the memory before with the previously selected profile sampling window, but the data are re-calculated from the current image (which may have changed).

When the **Auto update** checkbox is clicked for an already existing profile the profile is automatically updated when the image data have changed. This function is triggered for example by image acquisition, by dark subtraction, by loading an image from disk, and so on. This checkbox has to be clicked if the profile shall be saved during profile sequence acquisition.

Displaying Profiles

The **Profile Display** window is used for displaying the extracted profiles.



Profile display window

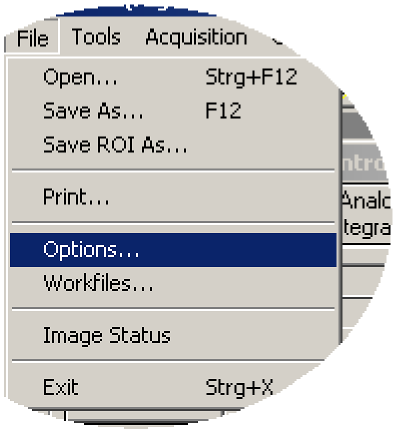
The full area of the **Profile Display** window is used to display the profiles. Several profiles can be displayed at a time, provided that the scaling unit is the same. (The scaling may be different, but the unit must be the same.) Hence it is possible to simultaneously display profiles which were derived from different images, even with different scaling.

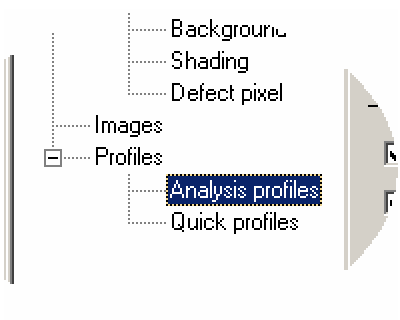
*Note: The system is not able to compare profiles with the same physical dimensions but with different units like **mm** and **cm** or **m.***

Above the profile display you will find a task bar with functions to save and load ROI sets, to print profiles and to set some preferences.

Print Profile	Prints the profile display window on your printer
Save ROI	Save the actual set of ROIs
Load ROI	Load a previously saved set of ROIs
Unzoom	Zooms out completely. (Then the intrinsic limits will determine the zoom ranges).
Zoom last	Restores the last zoom setting. This is useful is you have zoomed too deeply into a profile and you want to get back one step. **Note**: By using this command repeatedly you can alternate between two defined zoom settings.
Zoom all	Optimizes the zoom factor to display all actual profiles in a maximum size
Options	Opens a dialogue box to set profile display options

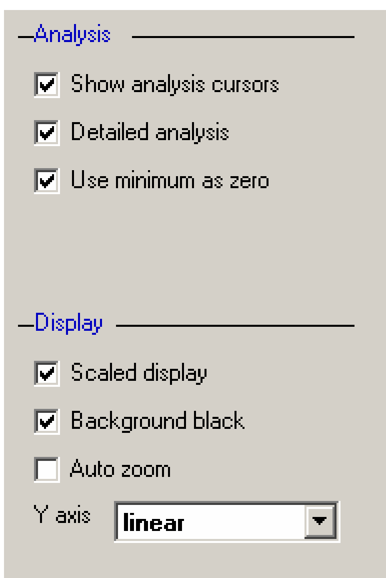
To Open the Profile options either call the options menu and select the Analysis Profile item on the tree control





or right click to any of the profile dialog windows.

The Analysis Profile dialog will appear.



Profile options

In the profile display options dialogue you can set following parameter:

When **Analysis** is selected, two cursors appear on the **Profile Display** Window and the **Profile Analysis** window appears on the screen.

The option **Detailed Analysis** and **Use Minimum as zero** are explained in the chapter "Profile Analysis".

When **Scaled Display** is active, the scaling data attached to the profile is used to get the correct physical value for every data point. If **Scaled display** is inactive corresponding pixel values are displayed. With this option you can even display profiles with different units. All analysis values are displayed in scaled values or in pixels according to this option.

There are three different possibilities for display of the intensity axis. It can be either displayed linear or logarithmic with the base 10 or with the base e. This can be selected by choosing one of the options **Linear, Log(base e)** or **Log(base 10).**

Background black determines whether the profile background will be displayed black or white.

If **Auto zoom** is selected, the system performs a zoom operation whenever a profile has been changed. This ensures that always the best display mode is selected to show all actual profiles within the display window with maximum size (like the Zoom all button).

By using the mouse you can interactively **zoom** into a portion of the profile as follows:

- Move the mouse cursor to one of the corners which define the area you want to zoom in.
- Press the **right** mouse down.
- Move the mouse to the opposite corner of the area you want to zoom in.
- Release the mouse button.

You can repeat this process as often as you like.

Every profile has its intrinsic **data limits**. These are defined by the first and last data point in the X direction and by the data type and the detailed circumstances of the exposure in the intensity direction. When the **Unzoom** function is executed these intrinsic limits are used to define the zoom ranges. If more than one profile is displayed the absolute maximum and minimum values of the intrinsic limits of all these profiles are determined. The intrinsic limits for different type of data are as follows:

If a memory contains a profile the "Mn" text on the push-button is underlined. In addition, the type of profile can be determined by the small symbol below the button.

\ is displayed for line profiles,

--- for integrated horizontal profiles and

| for integrated vertical profiles.

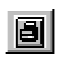
s profile sequence

f profile file

a averaged profile

If a memory contains a profile which is not hidden then the background color under the symbol is the same as the profile's color. If it is hidden, that color is white.

You can temporarily hide a profile by clicking the **Hide** button in the Profile control dialogue box. But the system may also hide a profile automatically. This happens if you display a scaled profile with a unit different to that of other profiles in the display. In this case, the other profiles will be hidden (until you **show** them again).

When selecting **Print Profile**  from the **Profile Display** window the systems sends a hard-copy of the current **Profile Display** window to the Windows printer currently installed.

Profile Scaling

In the moment a profile is generated the scaling information is transferred from the image to the profile. When an integrated horizontal or vertical profile is generated the scaling for the corresponding axis is transferred from the image to the profile. If a line profile (arbitrary direction) is generated scaling information is only transferred when the scaling for both axes are linear and have the same unit. If the scaling factor is not the same for both directions, the angle of the profile sampling line is taken into account and a new scaling factor which is corrected for the profile direction is calculated. If the starting point of the line is Sx,y, the ending point of the line is Ex,y and the scaling factors are SCx and SCy, then the new scaling factor SCn is:

$$SC_n = \sqrt{\frac{((S_x - E_x)*SC_x)^2 + ((S_y - E_y)*SC_y)^2}{(S_x - E_x)^2 + (S_y - E_y)^2}}$$

The numerator is an expression for the scaled length of the line, while the denominator is an expression for its pixel length.

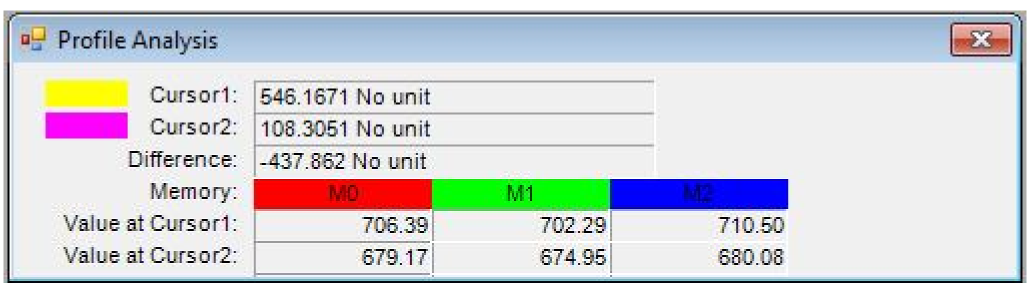
Scaling information cannot be attached to the profile when the profile sampling window is extended beyond the valid image area (because the image scaling is defined only inside the valid image area) and a warning message will appear.

The user can select among following possibilities:

- If the user selects **Clip profile to image area** the overlapping area between the valid image and the previously selected profile sampling window is used for the profile generation.
- If the user selects **Get new profile** he can define the profile sampling window again. The previously selected area will serve as the default.
- If he selects **Extend scaling data linearly** the scaling factor is calculated as if the profile sampling window had been within the valid image. This works only for linear scaling.
  The user can select whether he wants to clip the profile sampling window to the valid image.
- If the user selects **Do not assign scaling data** the profile will obtain no scaling at all (will remain non-scaled, and its values will be pixels).

Profile Analysis

When **Analysis** from the **Option** menu of the Profile Display window is selected, the **Profile Analysis** window will appear on the screen in its standard size and two cursor will appear within the **Profile Display** window.



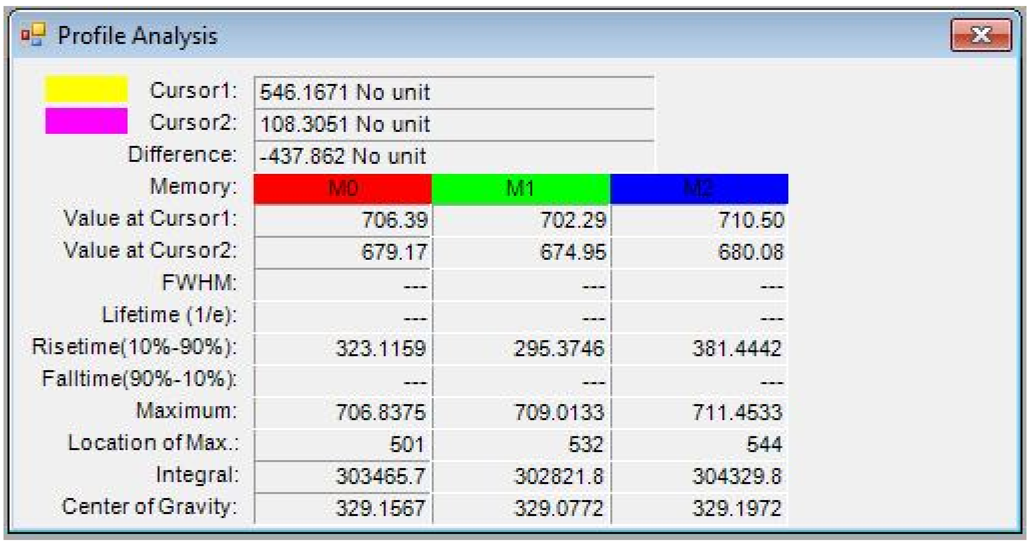
Profile analysis window

You can move the cursors by clicking and dragging them with the left mouse button (like the cursors on the LUT tool). The profile analysis display shows the X-values (pixel numbers or scaled values) and the difference between the two cursors. This is useful for measuring distances. It also shows the intensity values of all profiles at the cursors locations. If the cursor is out of the range of a profile the strings "out>" or "<out" will appear instead of a number.

Note that the movement of the cursors is not bound to the profile channels. If you move them between two channels an interpolated value between the two neighbor channels will be used. The colors of the profiles are displayed in the text box showing the memory numbers. This Profile Analysis window can show the intensity values of all memories at one time (up to 10 memory buffers). If more memories are going to obtain profiles the width of the window will increase automatically.

When **Scaled Display** is selected under the **Options** menu all values are scaled values, otherwise all displayed values are pixel values. During movement of the cursors the values **Cursor1, Cursor2, Difference, Value at cursor1** and **Value at cursor2** are updated continuously.

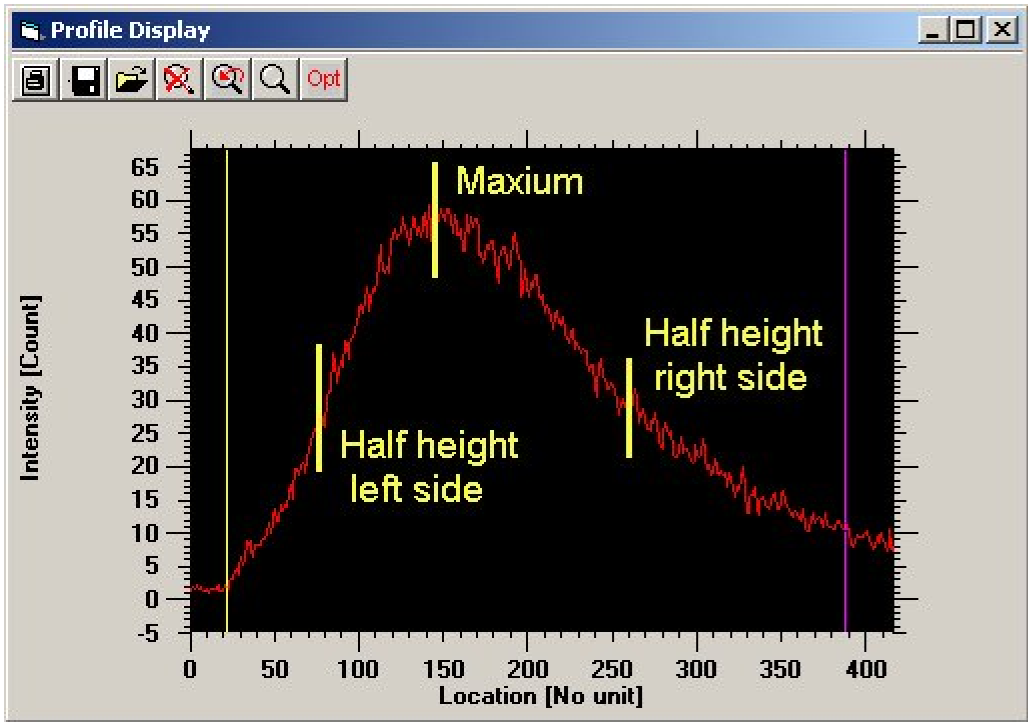
If the **Detailed analysis** is selected under the **Options** menu several additional numerical values will be displayed.



Profile analysis window (extended type)

The profiles are analyzed in the region between the two cursors and the values for **FWHM** (full width at half maximum), **Lifetime**, **Risetime**, **Falltime**, **Maximum, Location of Max., Integral** and **Center of Gravity**. These values are updated when the cursor is placed at a certain location and the mouse is released. They are not continuously updated during mouse movement.

All these analysis functions first search for the absolute maximum in the interval between the two cursors.



Data which are analyzed from an intensity profile

It does not matter whether cursor 1 is at the right side of cursor 2 or vice versa. The region for the analysis is always extended to the next measuring point. (This may be important to know when the selected area is very small.) After the absolute maximum has been found, the profile is scanned until its value becomes smaller or equal to a certain value. (For example, for the FWHM this value is just half the value of the maximum.) When the value lays between two data values a linear interpolation is made to find an estimation for the correct value.

For some functions the "zero point" has to be determined. By default this point is exactly at intensity =0. However, if the option **Use Minimum as zero** under the **Options** menu is selected the minimum found in the region between the two cursors is regarded as the zero point. This is very useful if the profile contains an undesired offset.

The values are calculated as follows:

Value	Search starts at	Direction	Search value	Search value if "Use Minimum as zero"
FWHM right	Maximum	to right	(Max)/2	(Max+Min)/2
FWHM left	Maximum	to left	(Max)/2	(Max+Min)/2

Lifetime top	=Maximum			
Lifetime right	Maximum	to right	Max/exp(1)	(Max-Min)/exp(1)+Min
Risetime 10%	Maximum	to left	Max*0.1	(Max-Min)*0.1+Min
Risetime 90%	Maximum	to left	Max*0.9	(Max-Min)*0.9+Min
Falltime 90%	Maximum	to right	Max*0.9	(Max-Min)*0.9+Min
Falltime 10%	Maximum	to right	Max*0.1	(Max-Min)*0.1+Min

FWHM=FWHM right-FWHM left

Lifetime=Lifetime right-Lifetime top

Risetime=Risetime 90%-Risetime 10%

Falltime=Falltime 10%-Falltime 90%

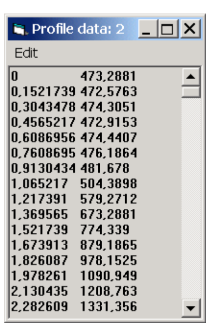
Note: The purpose of these simple analysis functions is to get fast information about the profile characteristics. The usefulness for precise analysis, however, is limited.

Integral calculates the integral (area under the profile) between the two cursors. (This can e.g. be used to calculate pulse energies).

Center of Gravity calculates the center of gravity of the profile between the two cursors. This can be used to calculate the position of a relatively broad pulse with greater precision than the Peak function.

This fast analysis cannot replace a thorough data analysis which is often necessary. Especially the fast analysis tends to be quite sensitive to noise. A thorough analysis would often require treatments like Fourier analysis, filtering, curve fitting, etc. which are out of scope of the functions built into the HiPic.We recommend to use specialized software for those higher requirements.

Displaying Profile Data



Profile display text box

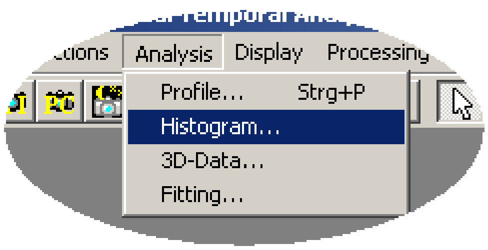
When the **Data** command is selected on the **Profile Control** dialogue box the content of the profile data is displayed in a text box **Profile X Data** where X stands for the number of the profile (e.g. Profile 0 Data).

The data contains two entries for each data point (X and Y) separated by a TAB character. The data points are separated by CR+LF characters. X is the assigned scaling value and Y the intensity value.

Histogram

Histogram analysis is a statistical analysis of intensity data within an user-defined area of interest

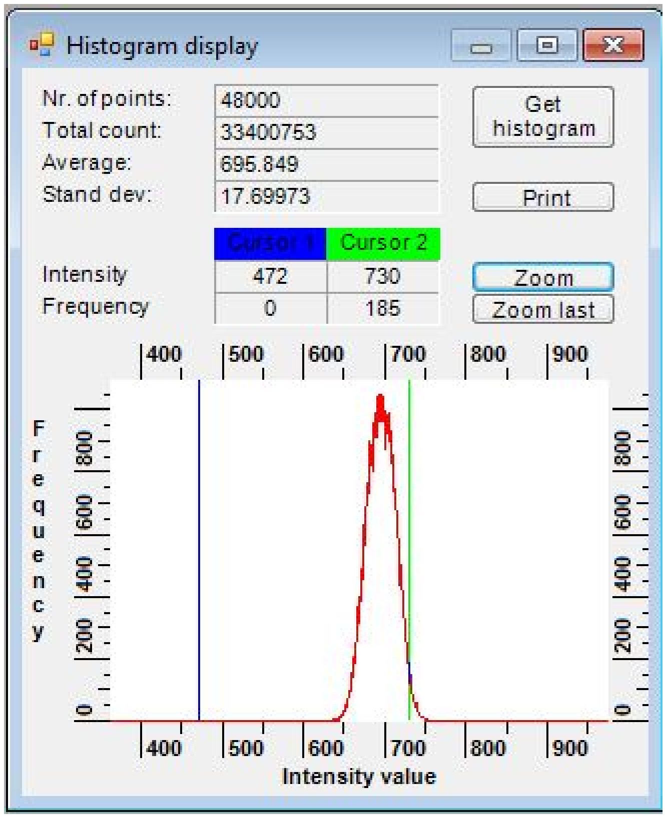
Choose **Histogram** from the **Analysis** menu to display the Histogram window.



Select a rectangular Area of Interest) If no ROI is defined, the histogram will be calculated from the whole image area.

Click **Get Histogram** to get the intensity histogram.

The histogram window displays the calculated histogram. By clicking the right mouse button and moving the mouse into the histogram display a cursor will appear. You can see some statistical data for the selected intensity like how often this intensity value appears in the specified region (**Total Count**), average intensity value (**Average**)or standard deviation (**Stand. Dev**.). These data may sometimes be useful for signal characterization (e.g. noise characterization). Move the cursor to inspect the data of other intensity values.



Histogram window

A portion of the histogram can be displayed by zooming with the right mouse button. Clicking to zoom displays the whole histogram correctly. Zoom last restores the last zoom window.

Note: Due to technical reasons 14 and 16 bit image data can be analyzed by the Histogram function only with reduced accuracy.

3D Data

This function allows to display numerical intensity data from within a user-defined area of interest.

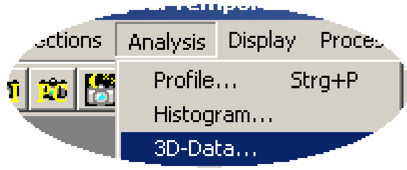
Extract 3D Data from an Image

The image data is displayed in a text box by this function. As the maximum number of characters in a text box is 32000 normally not all pixels values can be displayed. Therefore only every nth Pixel value is displayed. n is determined by the size of the area to display or the area will be modified.

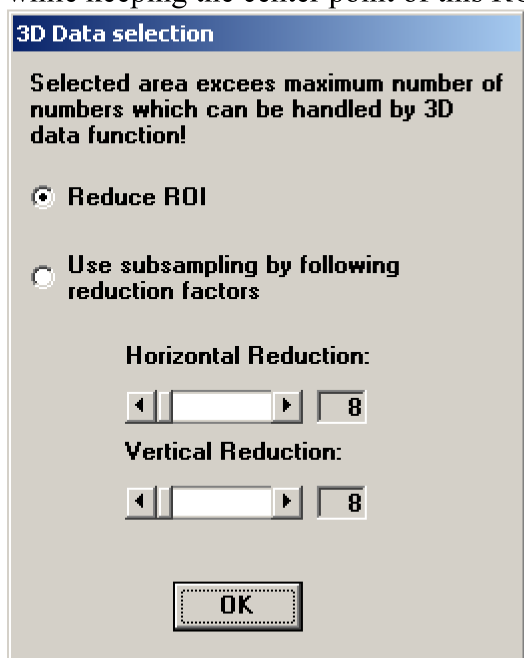
To extract 3D Data from an image proceed as follows:

1. Select a rectangle ROI within you image

2. Choose **3D Data** from the **Analysis** menu.



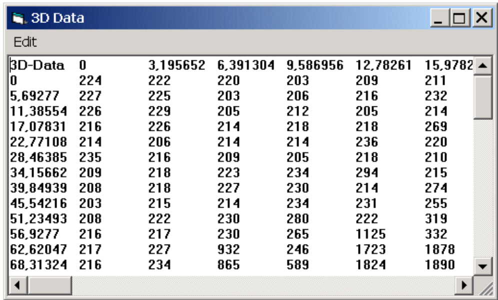
3. If the Area is larger than the amount of data which can be displayed in the text box the user is prompted to select the area from where to extract the 3D data. According to the size of the area one has to select the factor n for every direction from the 3D data selection dialogue box. Alternatively the user can select whether he wants the software to automatically reduce the ROI while keeping the center point of this ROI.



3D data selection dialogue

4. The minimum values for the horizontal and vertical reduction (means maximum amount of data) are predefined. If one wants to select less data points one has to increase the values for horizontal and vertical reduction. After you click OK the 3D Data will be extracted from the current image and its numerical values will be displayed in the 3D Data dialogue box.

The pixels values of one line are separated by TAB characters. Different lines are separated by CR+LF characters. The first line contains scaling information in the X direction. The first column contains scaling information in the Y direction.



3D-Data	0	3,195652	6,391304	9,586956	12,78261	15,9782
0	224	222	220	203	209	211
5,69277	227	225	203	206	216	232
11,38554	226	229	205	212	205	214
17,07831	216	226	214	218	218	269
22,77108	214	206	214	214	236	220
28,46385	235	216	209	205	218	210
34,15662	209	218	223	234	294	215
39,84939	208	218	227	230	214	274
45,54216	203	215	214	234	231	255
51,23493	208	222	230	280	222	319
56,9277	216	217	230	265	1125	332
62,62047	217	227	932	246	1723	1878
68,31324	216	234	865	589	1824	1890

3D Data dialogue box

Note: An alternative method to get image data in Text-Format is to save images in ASCII format. With this format the full image can be saved but the amount of data will be rather high.

Special acquisition modes & special setups

This topic describes the operation of special configurations or special setups in the sense that these setups behave somewhat different from what is described in other topics of this document. The setups described here differ especially in the way image data is generated or displayed.

This is true for line sensor data and TDI mode camera where – even though we still can think of image data delivered by the camera – not individual images are delivered from a camera but a continuous stream of line data.

In this sense also a PIV mode camera behaves a little bit different from ordinary cameras because the TDI mode camera always delivers a pair of images with every trigger.

Finally the way images are created by Hamamatsu X-ray Flat panel sensors are a little bit different because these sensors require two triggers to trigger a single frame and also these sensors operate best if they are triggered continuously. Therefore a special acquisition mode is provided if synchronization with a pulsed X-Ray source is needed.

Line sensors

This topic describes how to acquire image data from an X-ray Line sensor and how to set camera and acquisition parameters.

Introduction

The line sensor differs somewhat in the way how image data is acquired. Instead of images of a well defined size the line sensor delivers continuously line data.

Scrolling display

To cope with this feature a different type of image display can be used to visualize the image data. Image data is still displayed in a two dimensional window; however the data is updated as a new bundle of lines has arrived from the grabber to show always the most recently acquired lines. The size of this window is identical with the number of pixel in horizontal direction. The size of this window in vertical direction is – however – arbitrary and can be defined by the user as long as the memory limitations of the frame grabber board is not exceeded.

Corrections

Corrections as background and shading corrections are performed inside the line sensor. The way how to perform the image corrections thus differs a little bit from the way corrections are done with ordinary area scan cameras. The software built in features available from the toolbar and the menu should no be used. This may lead to undesired results. Instead correction should be performed by using the commands on the camera acquisition dialog as described in the related topic.

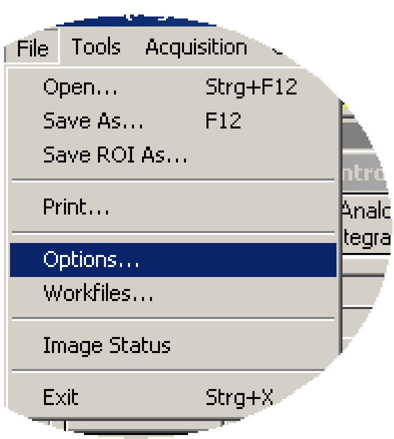
These functions allow executing functions inside the line sensor to acquire and store correction data.

As a consequence of the acquisition process also the defect pixel correction cannot be used.

Line sensor Options

In the X-ray line sensor options dialogue several parameters of the sensors can be set.

Click the File – options menu and select camera on the tree control of the left side.



The Line Sensor Options dialog will appear on screen.

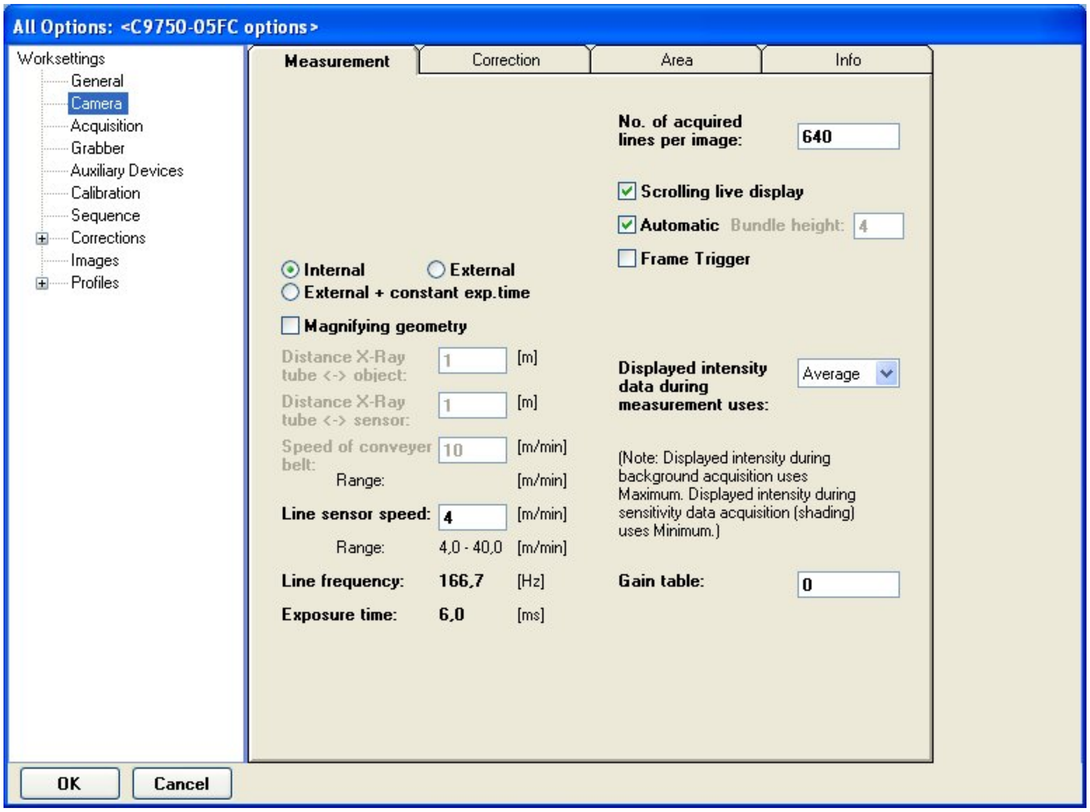
The Line Sensor Options dialog contains several tabs for groups of camera and acquisition parameters.

These groups are:

Measurement   Defines how basic measurements are performed.

Correction	Defines how corrections are performed
Areas	Allows specifying areas along the line sensor where correction or acquisition is treated in a special way.
Info	Display information about the currently select line sensor

Line sensor measurement parameters



Line Sensor Options dialog – Measurement tab

Several basic settings of the Sensor can be selected in measurement tab of the line sensor options dialog. The user normally wants to select these settings once and keep them for some time. Therefore these settings are stored and automatically used for your next session with. Press **OK** to memorize and activate the options parameter after you have made any changes in the options dialogue.

Trigger Mode

Three different trigger modes are offered. In **Internal** mode the lines are read out as defined by the speed parameters as explained in the section below. In **External** mode the start of the readout of a single line is triggered with an external trigger signal applied to the sensor. The exposure time is defined by the external trigger interval. In **External+constant exp.time** mode the start of the readout of a single line is also triggered by an external trigger signal applied to the sensor. The exposure time is defined by the Line Sensor Speed parameter as explained below.

Timing in Internal mode

The sensor timing in internal mode can be defined in two different ways:

- by using the magnifying geometry parameters or
- by using the Line sensor speed parameter

Choose the method **Magnifying Geometry Parameters** if the line sensor is not in proximity to the samples. In this case a magnification factor has to be considered.

To apply this method you have to click at the **Magnifying geometry** box. Then you can insert three parameters which define the geometrical magnification on your set-up. You have to insert the distance between X-ray source and object in meter (**Distance X-Ray tube <->object**), the distance between X-ray source and sensor in meter (**Distance X-Ray tube <-> sensor**) and the speed in which your samples are moved in meter per minute (**Speed of conveyor belt**). The most suitable sensor timing will be automatically calculated based on these data. The timing will be made to obtain a square size pixel format.

Choose the method **Line sensor speed** if the sensor is very close to the sample plane. In this case no geometrical magnification has to be considered.

This mode is active if the box **Magnifying geometry** is unchecked.

You have to define only a single parameter: the speed with which the samples are moved in meter per minute (**Line sensor speed).** The timing parameter to obtain a square size pixel format will be automatically calculated**.** Make sure that the inserted parameter is within the permitted range which is displayed below the Line sensor speed input box.

The calculated line frequency and exposure time will be displayed on the lower left side of the options dialogue.

The parameter **Line sensor speed** will be used also to calculate the exposure time when the sensor is used in the trigger mode **External+const exp. time**.

The parameter **No. of acquired lines per image** defines how many lines will be displayed in an image. A typical range is 500 to 1000 lines. The range may be limited by the frame grabber used in your configuration.

The **Frame Trigger** option defines whether an image is acquired starting from an electrical trigger. This can be used to start scanning whenever the object of interest comes close to the line sensor.

The **Scrolling Live Display** option defines whether the system acquires all lines of an image prior to display it (non scrolling mode) or whether the image is automatically updated as soon as a (small) portion of lines appear (scrolling mode).

To set no scrolling live display set the following:

To set the scrolling live display set:

If Automatic is selected the systems calculates the bundle height according to the line speed. The bundle height can also be inputted manually if the calculated bundle height is not convenient for the user or if there are some problems.

Important Note: Depending on the frame grabber, the computers speed, line rate, bundle height and overall image size data corruption may occur in Scrolling live display mode. This cannot be avoided for all possible combination of parameters. In such cases please switch to non scrolling live display.

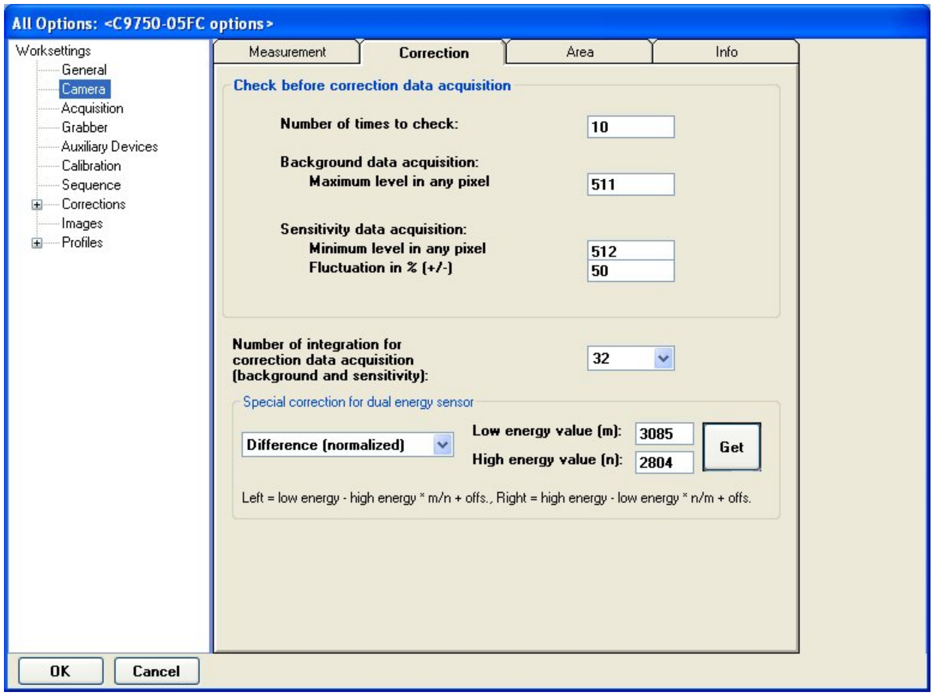
The parameter **Displayed intensity data during measurement uses:** defines the type of data displayed in the acquisition dialogue. The data may help to optimize the setup by choosing an adequate intensity level. Three data types can be displayed.

-Average intensity within a line

-Minimum intensity within a line or

-Maximum intensity within a line

Line sensor correction parameters



Line Sensor Options dialog – Correction tab

In the Correction dialogue several set-up parameter for background and shading correction can be defined.

Please make sure that these settings are correctly made before you execute background or shading correction.

Before background or shading correction will be executed the software checks if reasonable conditions are set to perform these corrections. For background correction the X-ray source has to be switched off, for sensitivity correction the X-ray source has to be switched on and no sample shall be in the image area.

The background correction will be executed only if the maximum intensity level within a line does not exceed the intensity value defined in the **Background data acquisition:Maximum level in any pixel** parameter. Typically this may be set to a value 200 to 300.

The sensitivity correction will not be executed if the minimum intensity level in a line reaches an intensity value higher than defined under **Sensitivity data acquisition:Minimum level in any pixel**.

The parameter **Number of times to check** defines how many lines will be checked with regards to above threshold parameters before background correction or shading correction will be started. Only if the condition is true for the defined number of lines correction will start.

The parameter **Number of integration for correction data acquisition** determines how many lines will be averaged in order to calculate the background and shading correction parameters. A typical value is 32.

For dual energy sensors a special real time correction can be selected to compare high and low energy part of the sensor.

This correction assumes that the low energy part of the sensor is outputted al the left side and the high energy part of the sensor is outputted al the right side of the data. It can be specified whether both parts are divide or subtracted. For the subtraction normalizing values can be inputted or defined by defining a ROI.

The left and right part of the data is replaced by two calculations based on the original data.

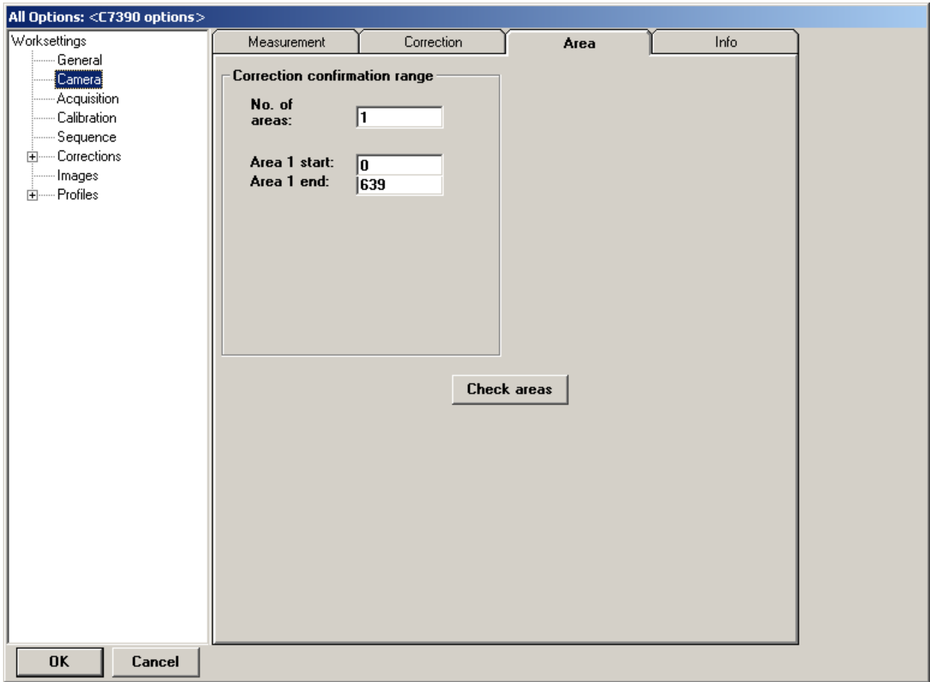
The following settings can be selected:

None	No calculation
Quotient	Left = low energy / high energy + offs
	Right = high energy / low energy + offs.
Difference (normalized)	Left = low energy - high energy * m/n + offs.
	Right = high energy - low energy * n/m + offs.

M and N are values which can be entered manually to the text boxes labeled with “Low energy value (m)” and “High energy value (n)” or by selecting a ROI in the inside the low energy area (left half) and pushing the “Get” pushbutton.

Important note: Please do not use this option for other types of sensors, it may give unpredictable results.

Line Sensor area specification



Line Sensor Options dialog – Area tab

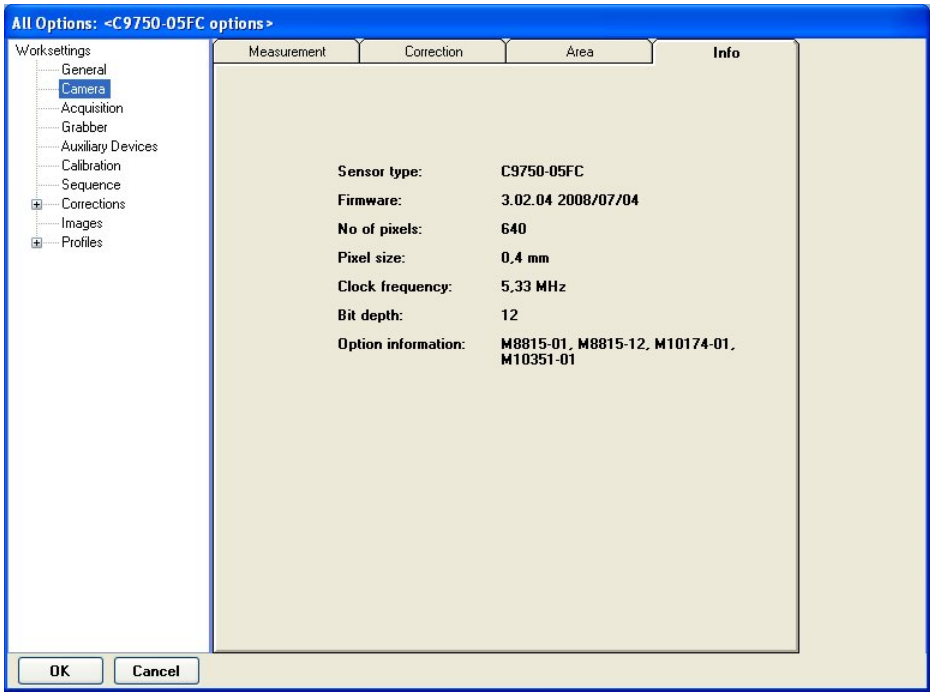
In the **Area** dialogue you can exclude certain parts of the image from processing.

The section **Correction confirmation range** allows excluding certain image areas from the background and shading correction. The section **Output mask** allows masking image areas in the image display. The determined areas will be masked displayed in black.

Set **No. of areas:** to define how many areas you want to define (maximum is 4).

Then define the start and end pixel of each range.

Line sensor information display



Line Sensor Options dialog – Info tab

In this dialog the camera version and some important features of the sensor are displayed.

Image Acquisition

Execute Live and Acquire

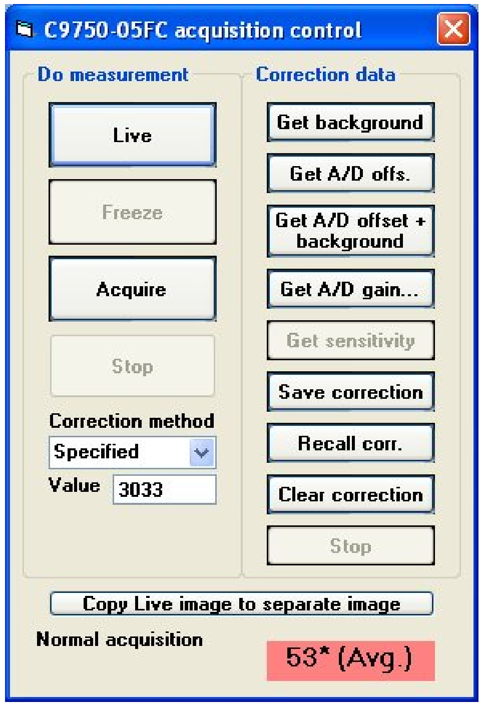
Choose **Live** from the **Acquisition** menu to display the acquisition dialogue.

In this dialogue you can control image acquisition and acquisition of correction data**.**

Press **Live** to display the actual live image. When you click **Freeze** the image acquisition stops and the last image acquired is displayed.

Press **Acquire** to acquire a single image.

The number of lines displayed in one image is defined in the options dialogue.



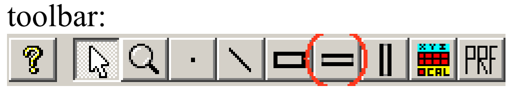
Live mode dialogue

Display a quick profile

A **QuickProfile** can be displayed during **Live** mode and after image acquisition has been terminated.

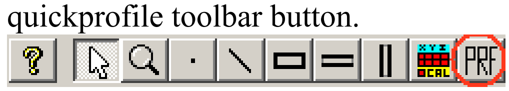
To show a quick profile proceed as follows:

1.) Select a rectangle ROI with full horizontal width on the toolbar:

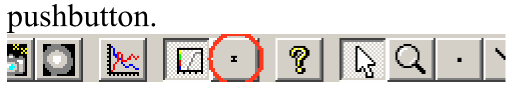


2.) Define a ROI on the Live mode image with clicking and dragging with the left mouse button.

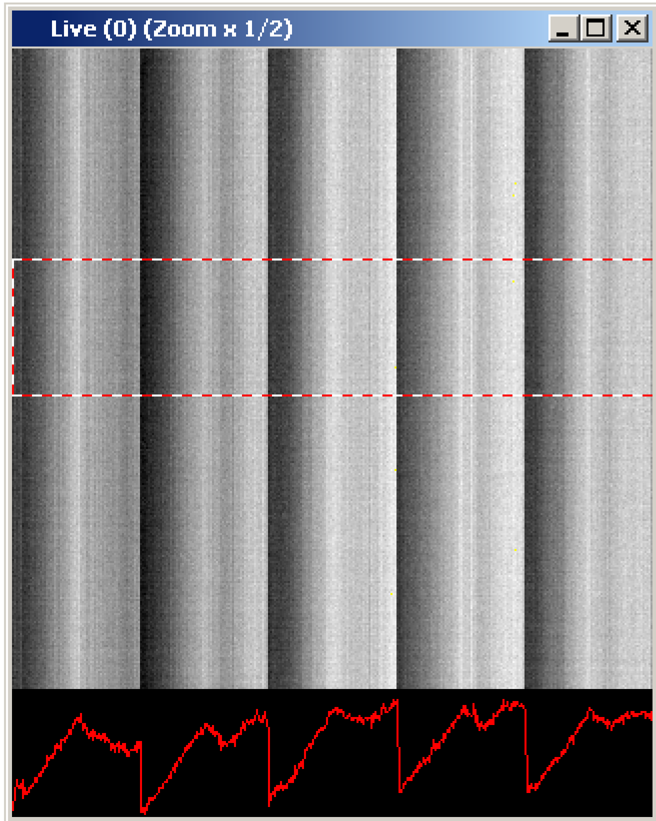
3.) Switch on the Quickprofile by clicking on the quickprofile toolbar button.



4.) Adjust the LUT to display the desired range of intensities. A simple way of adjusting the LUT in an optimum way is to click to the AutoLUT toolbar pushbutton.



This is how an uncorrected line sensor image with maximum LUT contrast enhancement and no X-Ray radiation normally looks like.



Execute Corrections

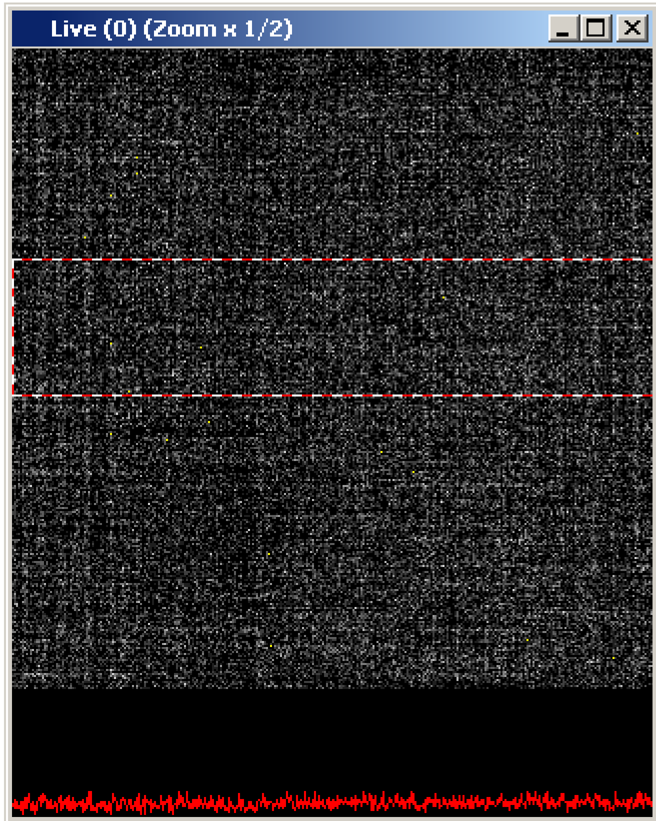
You can also start acquisition of correction data from this dialogue.

Normally you start by acquiring a background data set.
To do this you have to switch off your X-ray source and press **Get Background**.
Now the system will check if the conditions as defined in the options dialogue are true. If so, background data will be acquired.

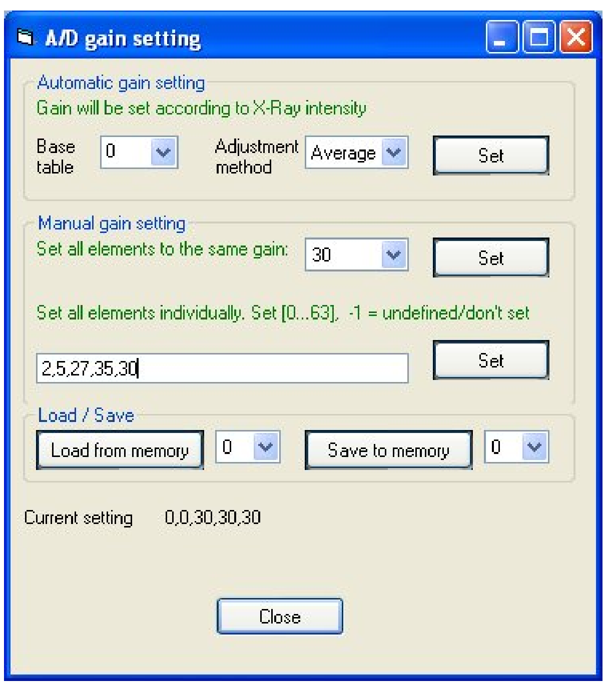
Second step is to set the A/D converter offset.
To do this you have to switch off your X-ray source and press **Get A/D offs**.
Now the system will check if the conditions as defined in the options dialogue are true. If so, A/D offset data will be acquired.

You can also do the first and second step in one sequence by pressing **the Get A/D offset + background** button.

After getting background data successfully the image of the Line sensor – again with maximum LUT contrast enhancement - will look like this:



Some line sensors allow setting a different gain for every module. To do this push “Set A/D gain…” and the A/D gain setting dialog will appear.



The easiest way is to execute the automatic gain setting based on a give gain table.

Secondly one can set the gain of all modules to the same gain.

Thirdly one can set every module individually by typing all desired gain settings separated by comma.

And finally on can load and save the settings from and to internal memories.

Third step is acquiring the shading data set.
To do this you have to switch on your X-ray source and make sure that there is no object in the image area. Then press **Get sensitivity**.
Now the system will check if the conditions as defined in the options dialogue are true. If so, shading data will be acquired.

Correction data will be automatically used during **Live** or **Acquire** mode.

You can save a set of correction data by pressing the **Save correction** button.

You can recall a correction data set which you have saved earlier by pressing the **Recall corr.** Button.

Press **Clear correction** in order to clear the actual correction data set.

After the correction data are applied to the raw image data the intensity values may be drastically changed. In order to correct this you can choose one of 5 **Correction methods** in order to decide which mean intensity level will be used for correction. This defines a correction factor used for image display.

-Average will correct the intensity values to reach the mean intensity value of the uncorrected image.

-Max. will correct the intensity values to the maximum intensity value of the uncorrected image.

-Min. will correct the intensity values to the minimum intensity value of the uncorrected image.

-User will correct the intensity values to the intensity value defined in the **Value** box.

A special version of the X-ray Line sensor is based on a TDI chip. This version has additionally to the mentioned parameters an area mode where the full area of the chip is read out and a 2 x 2 binning mode.

PIV mode

Introduction

PIV (particle image velocitrometry) mode is a special acquisition mode to acquire a pair of image data acquired within short time starting from an external trigger.

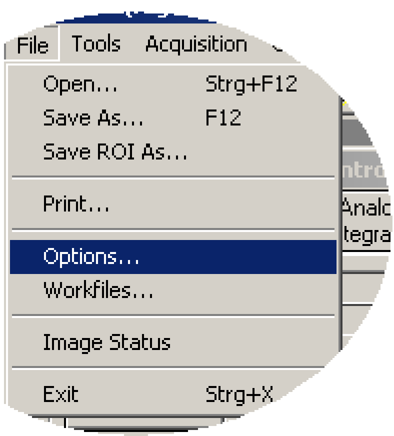
Note: PIV is not a feature of standard cameras. Only special cameras offer this feature. If you cannot find the PIV feature in the camera options this may by an indication that your camera does not support this feature.

Normal image acquisition algorithms like LIVE or Acquire mode acquire only one image at a time so we have to acquire the data in a special way if we want to get both images.

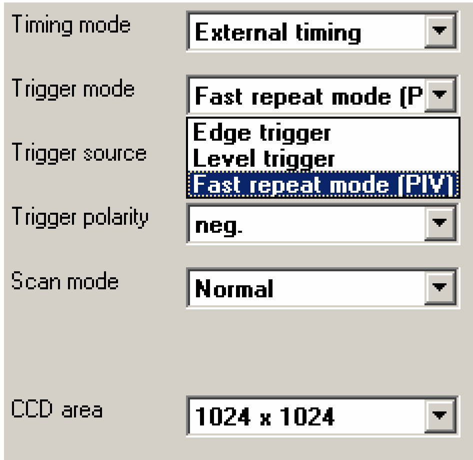
Setting the camera to PIV mode

PIV mode can be selected in the camera options dialog. Once this mode is selected every trigger will cause the camera to output two images.

To Select PIV mode open the camera options dialog by clicking the File – options menu and select camera on the tree control of the left side.



Select PIV in the camera options dialog and close this dialog by clicking to OK.

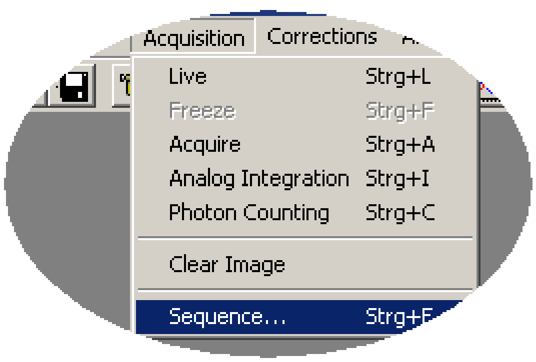


To check the functionality you can use the LIVE mode. With every trigger you should see both images appearing shortly one after another.

Recording two PIV images in sequence mode

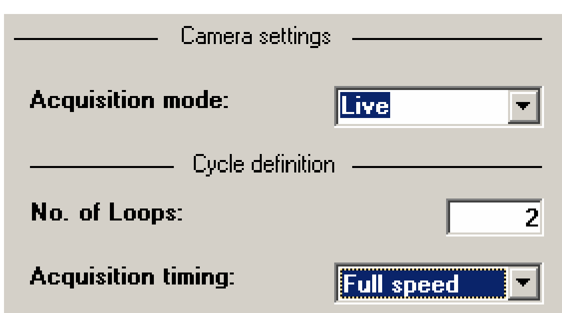
To record both images coming from the camera with one trigger we use the sequence mode.

To call the sequence dialog execute the Sequence menu.



The sequence dialog will appear.

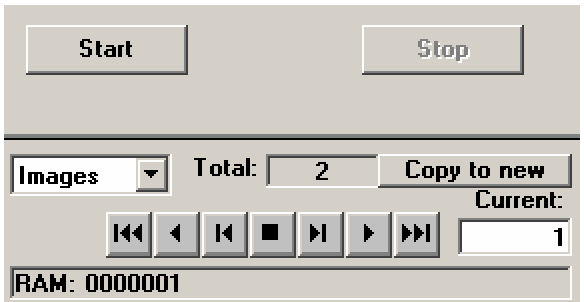
Select Live for the acquisition mode, 2 for the number of loops (or a multiple of 2 if you want to record several pairs of PIV images) and Full speed for the Acquisition timing.



Then select Store to RAM as the data storage option.

Then click to Acquire on the acquisition TAB.

After execution of the first trigger the sequence dialog will show 2 acquired images



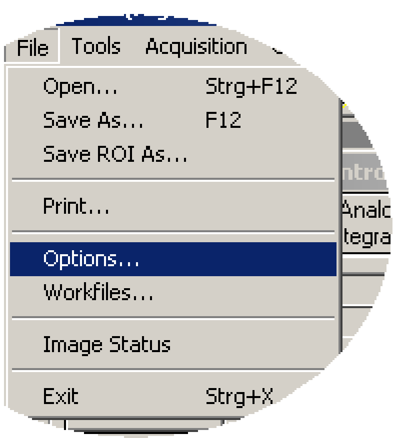
Please refer to the topic [sequence acquisition](#) for details of sequence mode.

X-ray Flat Panels

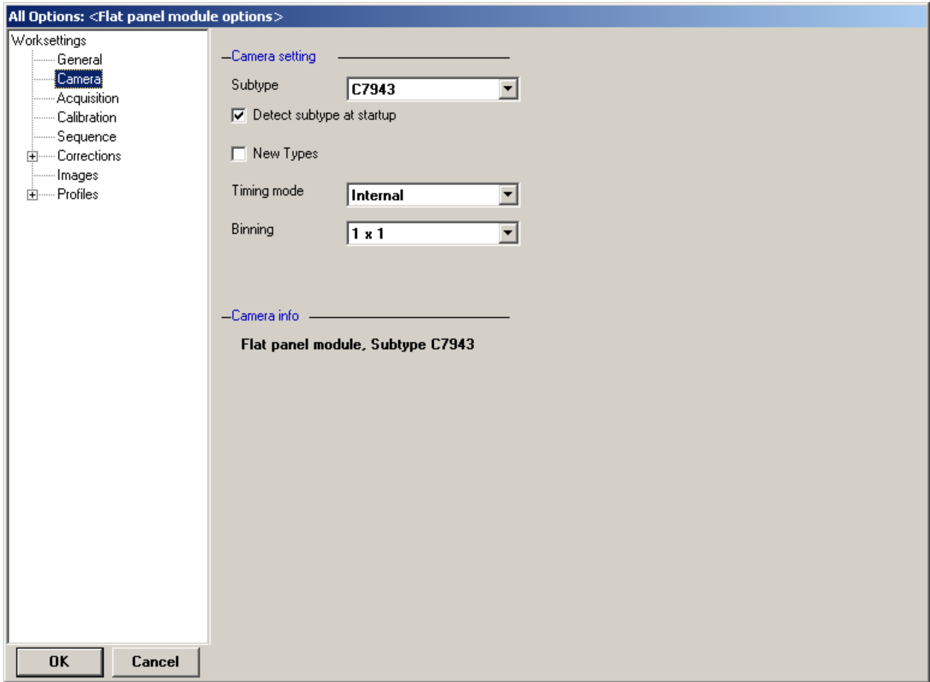
Options

In the Flat Panel options dialogue several parameters of the sensors can be set.

Click the File – options menu and select camera on the tree control of the left side.



The Flat Panel options dialog will appear



Sensor options dialogue

Several basic settings of the Sensor can be selected here.

Subtype

Select the sensor type you use. Normally the subtype is automatically detected according to the frame time in internal mode.

Detect Subtype at Startup

This option defines whether the subtype should be detected at startup or not. If the system cannot detect the subtype due to some reason it is an advantage to select this option and to manually select the subtype. These settings are remembered permanently and activated in future sessions.

New Types

Some of the sensors (C7942, C7943 and C7921) supported here have been shipped in an "old" version initially, which cannot be distinguished by the software. Therefore the user has to confirm whether his sensor is an old or new model. The old models of these sensors did not have a Lemo connector for trigger input and the number of valid pixels was slighty different.

Timing mode

If **Internal timing** is used the exposure time is controlled by the sensor. The exposure time is then determined by the sensor model and binning mode. If **External Grb.** is used, exposure time and/or start of exposure is controlled by a trigger signal generated by the frame grabber. The user can set the exposure time in the acquisition dialogue
If **External Lemo** is selected, exposure time and start of exposure is controlled by an electrical signal applied to the Trigger signal connector at the

Flat Panel ("Lemo connector"). For details please refer also to the sensor manual.

Binning

Several binning formats can be selected depending on the selected subtype. There are also sensors which do not support binning. Frame rate depends on the binning mode selection.

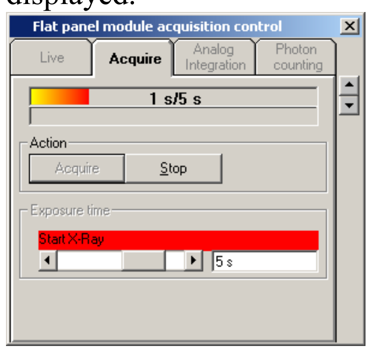
Wait for 2nd Frame in Acquire mode

This mode can be used only if an External timing mode was selected.

If the user clicks to Acquire the following happens.

1.) The HiPic starts image acquisition and waits until the first frame has been readout completely.

2.) Then it displays a text in red color indicating the user that he now can apply a pulsed X-Ray source. The X-Ray pulse can be applied as long as the red color is displayed.



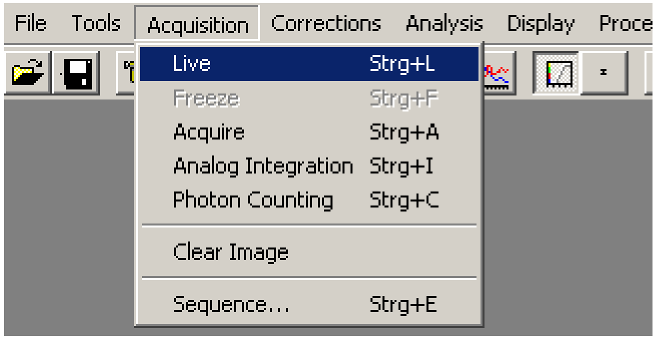
This feature can be used to manually synchronize the acquisition with an external X-ray source. The X-Ray Source must be synchronized with the flat panel and the acquisition process (The software must be the master). Due to the design of the flat panel there is currently no way to synchronize the Flat panel with the X-ray source as a master.

Camera information

Here the camera version and some important features of the sensor are displayed.

Live Mode

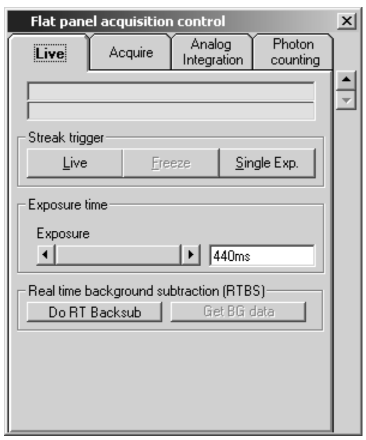
Select Live from the Acquisition menu.



The Flat Panel camera acquisition dialog will appear and show the Live Tab.

In this dialogue you can select **Live**, **Freeze** and **Single Exp.**. Press **Live** in order to start image acquisition. When you click **Freeze** the image acquisition stops and the last image acquired is displayed.

Press **Single Exp**. to acquire a single image.



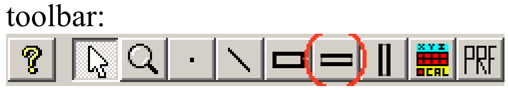
Flat Panel camera acquisition dialog.

Display a quick profile

A **QuickProfile** can be displayed during **Live** mode and after image acquisition has been terminated.

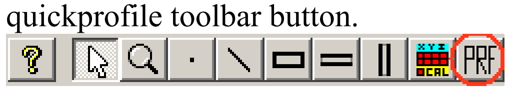
To show a quick profile proceed as follows:

5.) Select a rectangle ROI with full horizontal width on the toolbar:

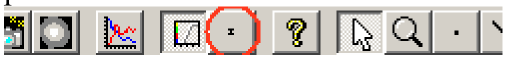


6.) Define a ROI on the Live mode image with clicking and dragging with the left mouse button.

7.) Switch on the Quickprofile by clicking on the quickprofile toolbar button.



Adjust the LUT to display the desired range of intensities. A simple way of adjusting the LUT in an optimum way is to click to the AutoLUT toolbar pushbutton.



Exposure time

Exposure time can be set if trigger mode is set to External Grb. in the options dialogue. In Internal mode the exposure time is defined by the sensor, in External Lemo mode it is defined by the electrical signal.

Real-time background subtraction

Real-time background subtraction is an operation where a background image is continuously subtracted from the acquired live images. This function can be used to subtract a background like mottle image, intensity offset signals etc. from images.

To execute background subtraction you have to decide if you want to acquire a new background image or if you want to use any saved image as background: Open the dialogue **Background-Corrections** options and select or deselect the checkbox **Get real-time backsub data from camera**. The way how to get the background image depends on this setting:

- **Get real-time backsub data from camera** is checked:
  Acquire a new background image in Live mode with your camera by clicking the button **Get BG data** in the **Live** menu while your camera is working in Live mode.
- **Get real-time backsub data from camera** is unchecked:
  Use an image from file as background image (use this function if you have stored a background image on your hard disk before). After you press the **Get BG data** in the **Live** dialogue a file selection dialogue will be opened. Select the file which you want to use as background image for real-time background subtraction.

To start real-time background subtraction press **Do RT Backsub** while the camera is working in **Live** mode.

The subtracted image is now displayed. In many cases you may have to change the contrast settings with the LUT tool now in order display the resulting images in good contrast.

Press **Do RT Backsub** again to stop real-time subtraction.

Acquire mode

Choose **Acquire** from the **Acquisition** menu to display the Flat Panel camera acquisition dialog.

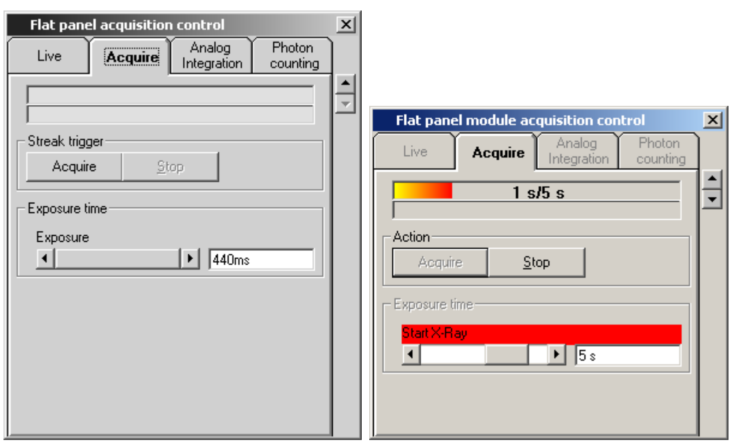
The Flat Panel camera acquisition dialog will appear and show the Live Tab.

The commands in this box are similar as explained under the chapter with the exception that only single images can be acquired by pressing the **Acquire** button. The next incoming image will be stored.

As the X-ray Flat Panel Sensors offer limited control of acquisition timing (also depending on the Timing mode chosen in the options dialogue), you may sometimes get unexpected image results, especially if you expect to synchronize the image acquisition to external events (e.g. a pulsed X-ray source). In order to offer a better timing control the option **Wait for 2nd image in Acquire mode** has been implemented.

If this has been activated the following will happen:

1) The HiPic starts image acquisition and waits until the first frame has been readout completely.
2) Then it displays a text in red color indicating the user that he now can apply a pulsed X-Ray source. The X-Ray pulse can be applied as long as the red color is displayed.



Acquire mode dialogue (left standard mode, right “Wait for 2nd Frame” mode)

Analog Integration

Analog Integration with X-ray Flat Panels adds up a number of images in the frame.

Choose **Analog Integration** from the **Acquisition** menu to display the Analog integration dialogue.

Its parameters are similar to those of the **Live** window. Additionally you can specify the parameter **# of Exposures** in the section **Integration**, which determines how many images will be accumulated.

If **Clear on start** is checked, the last image which has been acquired will be cleared. If it is not checked, new images will be added to the last image.

Press **Integrate** to start acquisition and integration of a number of images (as defined under **# of Exposures)**.

Introduction to TDI mode

TDI (time delayed integration) is a mode where an area sensor is operated similar than a line sensor. The object is moved along the camera and the charges in the camera are shifted synchronous to the moving object.

The TDI camera outputs – different from an area camera which outputs the data in units of one frame which is a well defined number of lines – a continuous stream of lines. For better visibility the display is still done like an ordinary area camera displaying several lines at once. This number is however arbitrary and can be freely selected by the user according to his needs.

An additional feature called “Scrolling Live Display” displays the data continuously while scrolling the content of the already outputted image to the top and adding new data from the bottom. This is done in so called bundles, a relatively small number of lines.

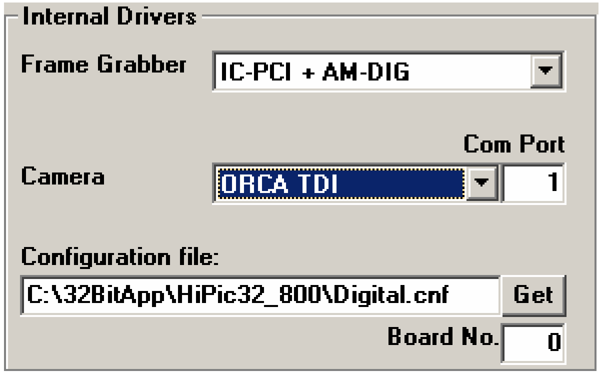
TDI mode with ORCA

Note: TDI mode is not a feature of the standard ORCA camera. Only special cameras offer this feature. If you cannot find the TDI mode feature in the camera options this may by an indication that your camera does not support this feature.

Selecting TDI mode

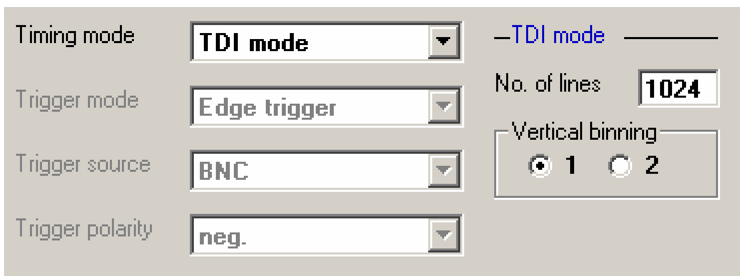
When starting the HiPic the user has to select

ORCA TDI as a camera.



Note: The Orca TDI camera is only supported by IC-PCI + Am-DIG and the PCDig frame grabber.

Select the TDI mode in the camera options.



Specify the number of lines in the vertical direction which is used to display the image and the binning factor in vertical direction.

Live and Acquire mode

If you start Live mode an image is displayed which is updated as fast as possible and shows always the most recent lines acquired by the frame grabber.

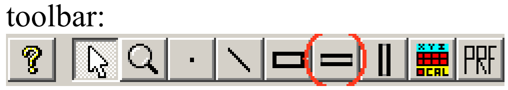
Acquire mode acquires the specified number of lines and outputs them in an image.

Display a quick profile

A **QuickProfile** can be displayed during **Live** mode and after image acquisition has been terminated.

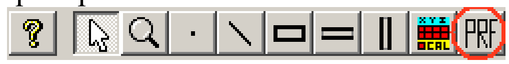
To show a quick profile proceed as follows:

8.) Select a rectangle ROI with full horizontal width on the toolbar:

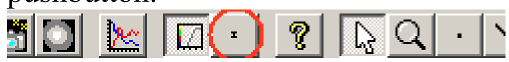


9.) Define a ROI on the Live mode image with clicking and dragging with the left mouse button.

10.) Switch on the Quickprofile by clicking on the quickprofile toolbar button.



11.) Adjust the LUT to display the desired range of intensities. A simple way of adjusting the LUT in an optimum way is to click to the AutoLUT toolbar pushbutton.



TDI Mode with C10000

TDI mode cameras from Hamamatsu are designed to scan images with high speed, high sensitivity. Special models are even sensitive in the UV. Even though their operation principle is very similar to a full frame CCD camera from the users point of view they behave very similar to a line scan camera.

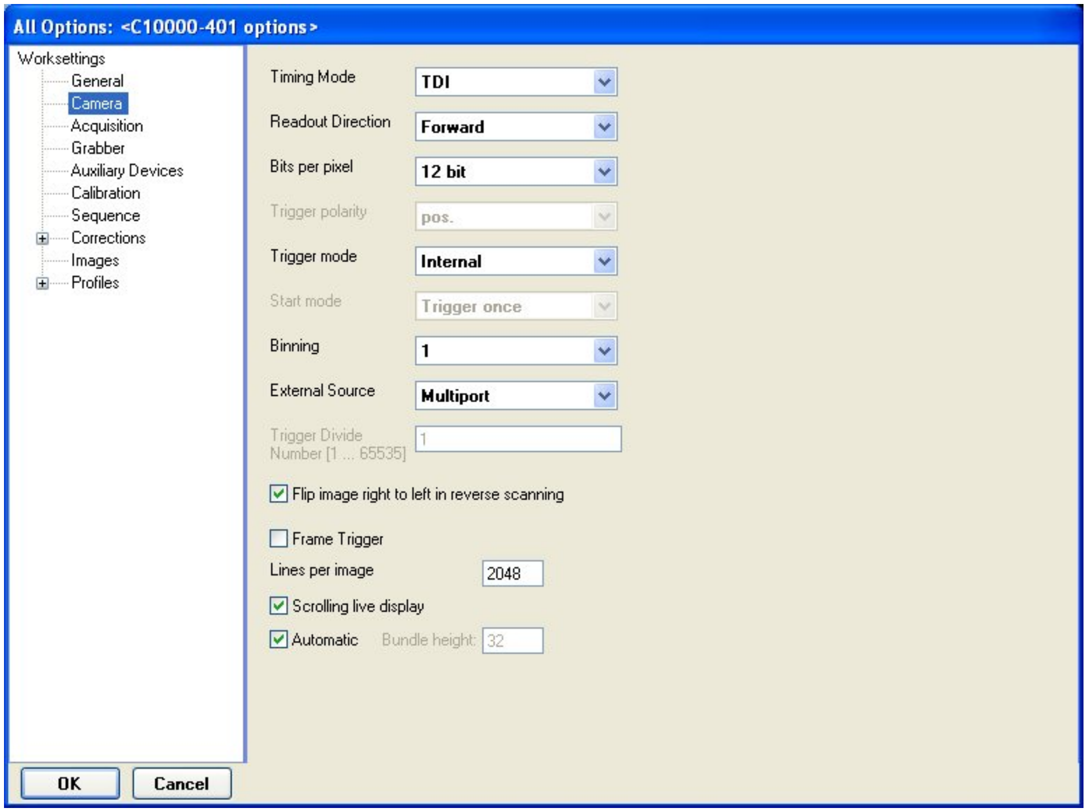
The Hamamatsu TDI sensor C10000 has two readout modes: Area and TDI mode. In area mode they operate like a CCD camera and output a two dimensional image. In TDI mode they scan the image synchronized to a moving sample (e.g. a conveyer belt).

Area Mode

In Area Mode the sensor is readout as an ordinary area sensor. This is useful for focusing the optics. Set the Sensor Mode to Area and the exposure time to an appropriate value. For focusing purposes this is sufficient.

TDI mode

TDI mode is the actual measurement mode of this sensor. Even though the TDI mode is a kind of line sensor mode, which means that line data is continuously output without vertical blank the outputted data is organized in larger quantities which define one image. The image height which should be used for display is arbitrary but should be large enough to be able to view items which should be on screen for the same time. The maximum height of such an image is set to 4096.



C10000 options dialog

To setup TDI mode the following properties have to be set:

Set sensor mode to TDI

Set readout direction to forward or reverse

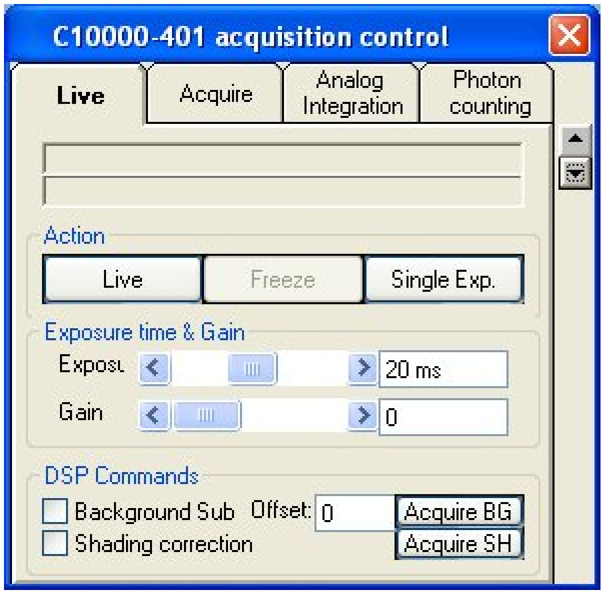
Set the bit depth to 12 or 8 bit.

Set the trigger mode to internal or external. In external mode you have to set also trigger polarity, trigger input and the trigger divide number. You also have to apply trigger pulses to the trigger input of the camera.

Set the number of lines which should be readout for one image

Set the exposure time to an appropriate value in the acquisition dialog.

The camera has a built in background and shading correction which can also be operated from the C10000 acquisition dialog.



C10000 acquisition dialog

Normal and scrolling LIVE display.

The **Scrolling Live Display** option defines whether the system acquires all lines of an image prior to display it (non scrolling mode) or whether the image is automatically updated as soon as a (small) portion of lines appear (scrolling mode).

To set no scrolling live display set the following:

To set the scrolling live display set:

If Automatic is selected the systems calculates the bundle height according to the line speed. The bundle height can also be inputted manually if the calculated bundle height is not convenient for the user or if there are some problems.

Important Note: Depending on computers speed, line rate, bundle height and overall image size data corruption may occur in Scrolling live display monde. This cannot be avoided for all possible combination of parameters. In such cases please switch to non scrolling display mode.

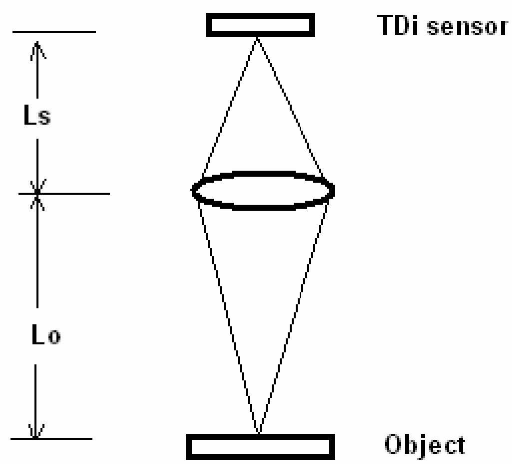
Exposure time in TDI mode

The exposure time in TDI mode is to be set so that the scanning is synchronized to the object movement.

The Exposure time (Exp) can be calculated using the number of Lines used for scanning (N) and the line frequency (F).

Exp = N / F

Using a magnification not equal to 1 we get the following relations:



Ls: Distance Sensor – Objective lens

Lo: Distance Object – Objective lens

M= ls / lo (Magnification)

The moving object is imaged on the Sensor thus the speed of the object (So) translates to the so called line speed Ss (a virtual movement) on the sensor.

Ss = So * M

The line speed translates to the line frequency (F) using the sensor cell size (C). In other words if the sensor is readout with this line frequency the object image gets square pixels

F = Ss / C

We then get the exposure time:

Exp = N / F = N * C / Ss = (N * C) / (So * M)

Exp = (N * C) / (So * M)

where

N: Number of lines used for TDI scanning [1]

C: Cell size [m]

So: Speed of the moving object [m/s]

M: Magnification on the object [1]

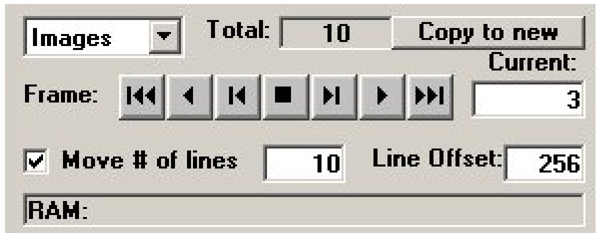
In the case of the C1000-401 sensor N = 128 and C = 12* e-6 m (=12 um).

Using Sequences

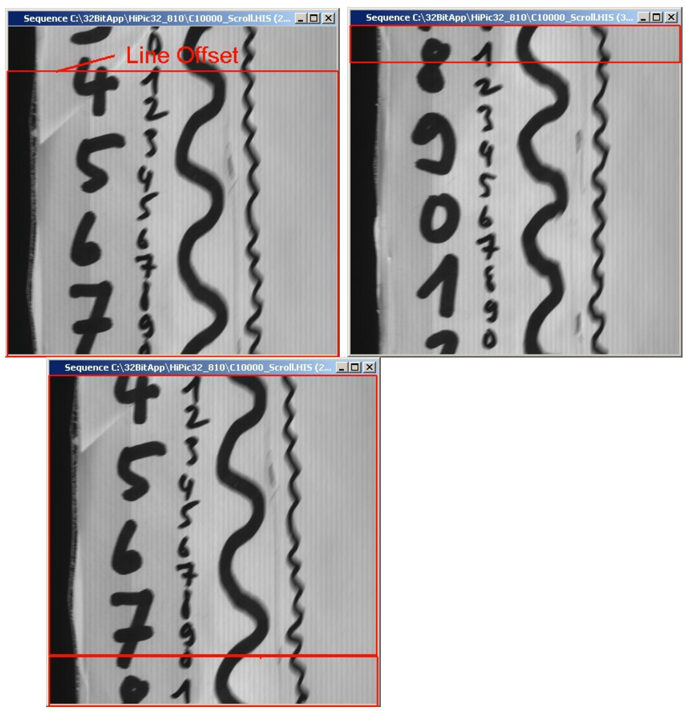
All kind of sequence can be used in combination with TDI mode. The image data is then saved in units of images where one image contains the specified number of lines. An additional method can be used to move the image data not only in units of these images but continuously.

With normal images the sequence dialog looks like this:

With such kind of line data the sequence dialog get some more controls:



If the checkbox “Move # of lines” is activated not only the saved images are displayed as they are saved, but positions between the individual images are displayed. If the Line Offset is nonzero starting from this line number the current selected image is displayed and a part of the next image is added on the bottom part of the image (very similar to the scrolling live display). The Backward, Play backward, Forward and Play Forward pushbuttons then act no longer on full images but “move” image just the specified number of lines.



Original images saved on disk and displayed image with “Line Offset” (Red marks are only used for illustrating purposes they are not displayed in the real image).

Important notes using image sizes

The displayed image size is always the same as acquired during sequence acquisition and cannot be enlarged during display. Therefore it is important to select the value “Lines per image” large enough to see all details which the user wants to see at the same time.

The “lines per image” value defines the number of buffers used internally for the scrolling display. To avoid image data loss it is important to make this value sufficiently large.

Forward/Reverse scanning

The HiPic automatically flips image data in reverse scanning if the option “Flip image right to left in reverse scanning” is selected.

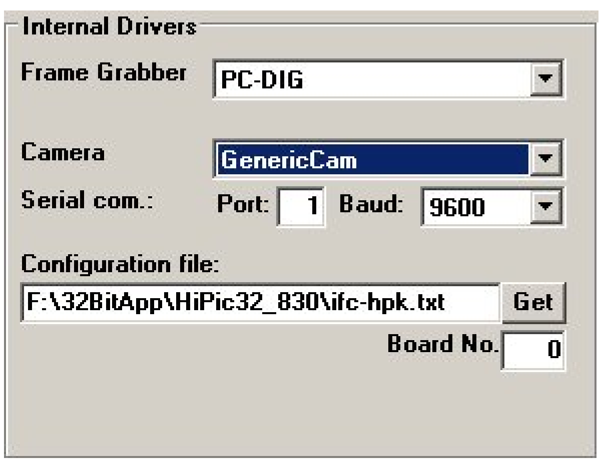
Operating C10000 by using DCAM API interface

If the C10000 camera is operated through the DCAM API interface the controls are similar to the ones described above even though the look a little bit different and may be arranged differently.

Generic camera

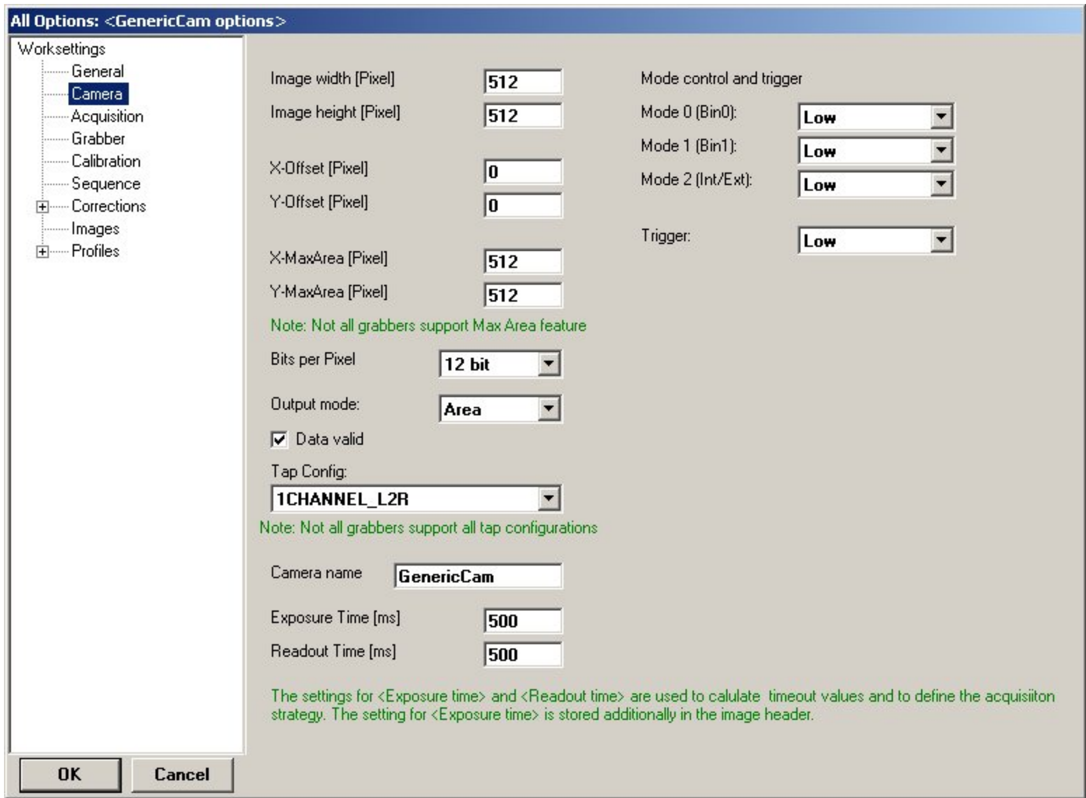
Selecting Generic Camera

By selecting this camera model one can input image data from a third party camera by a frame grabber.



Generic Camera Options Dialog

To adapt the frame grabber to the parameters of the camera the generic camera options dialog can be used.



The generic camera options dialog has the following options:

Image Width	Width of the image in pixels
Image Height	Height of the image in pixels
X-Offset	Horizontal offset in pixels
Y-Offset	Vertical offset in pixels
X-Max-Area	Number of pixels outputted by the camera in X-direction.
Y-Max-Area	Number of pixels outputted by the camera in Y-direction.
Bits per Pixel	Number of bits per Pixel
Output mode	Can either be line or area mode
Data Valid	Sets the data valid option (Camera Link only)
Tap Config.	Tap configuration. Describes the number of TAPs and how they are combined to the final image
Camera Name	Name of the camera. Can have an arbitrary value. Is only used for documentation purposes
Exposure time	Value which is used to calculate timeouts and defines the acquisition strategy. Most frame grabbers does not need this value.
Readout time	Value which is used to calculate timeouts and defines the acquisition strategy. Most frame grabbers does not need this value.
Mode control:	TTL value outputted at a freely programmable output. Possible values a

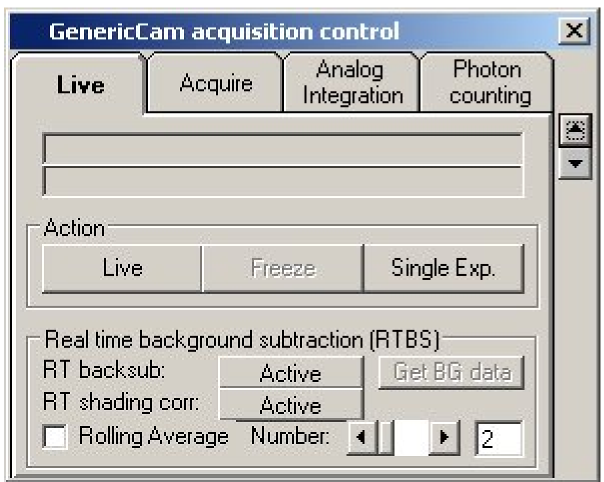
Mode0-2	low or high
Trigger	TTL output which can be Low, High or set to a defined frequency (Pattern).
Interval time	Time which defines the frequency of the outputted pattern (f=1/T).

There is the possibility to communicate with the camera by a serial port which has been opened for this camera by using the RS232 tool.

Note: If a camera requires grabber parameters which are not mentioned here, they could eventually be set by using a configuration file. Most frame grabbers support such configuration files. Please the configuration program of the frame grabber how to set parameters and its meaning.

Generic camera acquisition dialog

Camera image can be acquired with the generic camera acquisition dialog.



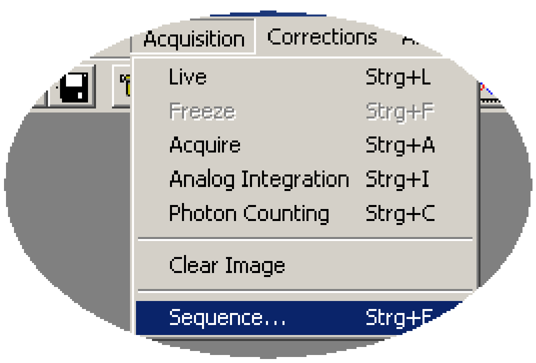
Sequence acquisition

In sequence acquisition mode a series of images and/or profiles can be acquired. Dependent on the settings the sequence is recorded to the computer RAM (fast method, but length of recording is limited by RAM size) or to hard disk. The sequence function can save and load sequences and replay the sequence. Also sequences of intensity profiles can be recorded.

Note: At any time only **one** sequence can be active (either image or profile sequence).

There are three different ways (RAM, HD one file per image, HD one single streaming file) of storing sequence images. Depending on the complexity of image acquisition not all three ways of storing are available.

Sequence operation is controlled from the sequence dialog. To call the sequence dialog execute the Sequence menu.



The sequence dialog will appear.

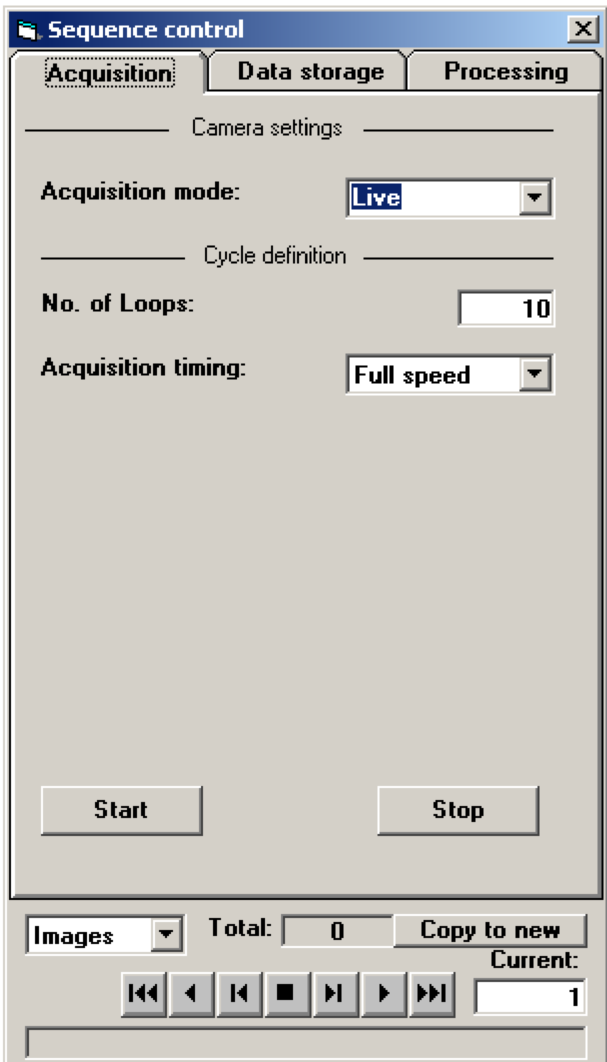
The sequence acquisition dialog has three tabs where different types of parameters can be specified

Acquisition   Defines which and how images acquire and in which

	timing this should be done.
Data Storage	Defines which types of data should be saved (images and/or profiles) and how and where these should be stored
Processing	Allows to process the collected sequence data (average)

Selecting acquisition parameters

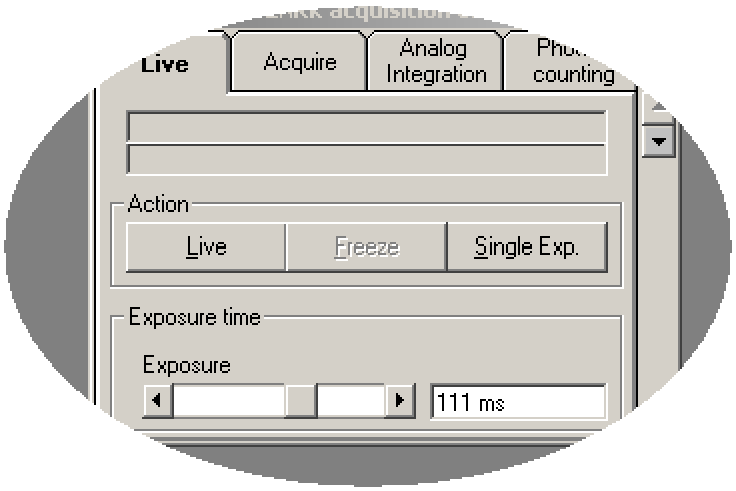
To specify the acquisition parameters select the Acquisition tab.



Acquisition mode and camera parameters

The first thing to specify is in which acquisition mode the image data is acquired.

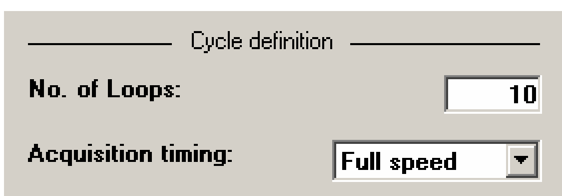
Images are acquired with the acquisition parameters specified in the camera acquisition dialog with the parameters specified in the corresponding tab:



Also the camera parameters specified in the camera options are valid for the selected acquisition.

Cycle definition

The next things to specify are the properties of the cycle. The user has to specify how many loops he wants to perform and whether this should take place with full speed or predefined fixed interval.



No. of loops specifies how many images are acquired and stored.

Choices of Acquisition timing are **Full speed** or **Fixed intervals**. If you select **Full speed** the camera is running freely and the sequence is recorded with this timing. Immediately after the acquisition and storage of an image the next acquisition will be executed. The time interval is just defined by the exposure time, the readout time, the response time of the mechanical shutter and the data storage time.

Note: Fast hard disk recording works with **Live** mode and **Full speed** setting only.

If you select **Fixed intervals** you can define the interval from one acquisition to the next (examples of allowed formats: 500ms, 2.5s, 1m). This interval should of course be larger than the time needed for acquisition, readout and data storage.

Other information on the acquisition tab

Depending on the data storage the program may display other information on the acquisition tab.

These may be information about remaining disk space if saving to HD

In the case fast hard disk recording is used the available buffers during acquisition is displayed and if there were lost frames due to limited hard disk performance.

In the case of long interval time and if the options Warning on is selected in the sequence options the remaining time to the next acquisition is displayed.

Start sequence acquisition

If all parameter are selected clicking to start starts the sequence acquisition process.

The precise behavior of this process is defined be several parameters in the sequence options.

Prompt before start

One option defines whether the sequence option should start immediately after the Start button is pressed or not.

If this option is selected the software shows a dialog and does not start until the User Clicks to OK

This feature can be used to precisely start the sequence.

Enable stop

Set **Enable stop** in the sequence options in order to enable the possibility to stop the image acquisition at a desired time.

On older computers this function may sometimes slow down the sequence acquisition a little bit. This option should be selected normally. Only in cases where cameras with very high frame rate are used it may be an advantage to deselect this option.

Wrap around

A sequence acquisition to RAM offers the possibility to use the specified number of images as a ring buffer. Once the last image has been reached it restarts from the first image overwriting older images by newer one. To activate this option the user has to select Enable wrap around in Acquire to Ram mode in the sequence options dialog

Then a checkbox at the acquisition tab will appear.

If the user selects this option the sequence acquisition will restart automatically once it has reached the end of the buffer. In this measurement mode the sequence acquisition does not end until the user stops the acquisition with the Stop button. The most recent acquired images are kept after stopping the acquisition.

Note: This option is only effective if the images are acquired to RAM.

Display during acquisition

Normally all sequence images are displayed during acquisition. Sometimes the frame rate is so high that the image acquisition is slowed down just because of the image display. In such case the option “Always display image during acquisition” in the sequence options should be switched off.

Sometimes the image display speed can be influenced by the image zoom factor. Many graphics boards have the feature that image display with zoom 1 is faster than image display with other zooming factors.

Note: In Fast hard disk recording mode (Live streaming) you can also use the option “Wait till next display in LIVE mode [ms]” to avoid slowing down the acquisition only due to highly repeating image display.

Fast hard disk recording

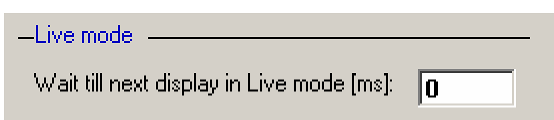
Fast hard disk recording starts the LIVE mode and writes all images to the specified frame.

Important! For the optimum performance of the hard disk write operation the routine to check the hard disk performance must have been executed before.

The fast hard disk recording functions assumes that there is no acquisition in progress. If there is an acquisition in progress - even a LIVE mode acquisition – the fast hard disk recording issues an error message and does not start.

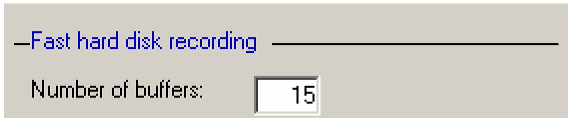
If the camera has a very high frame it may happen that image display speed slows down the overall acquisition speed. There is a way to completely switch off the image display. However this is not what a user normally wants. There is another way to acquire images with high speed without displaying all images in full speed.

There is an option in the acquisition options which allows specifying an interval time. Even if new live images are acquired they are not displayed unless the specified time has elapsed.



If for example we take a camera which outputs 150 frames / sec, we may want to save all images to hard disk (and this is normally possible because the image size is small in such case) but we do not need to display 150 frames / sec. If we specify 50 ms as a waiting time, the image display is limited to 20 frames / sec which is still sufficient for observing the image in real time but does not slow down hard disk recording.

If the grabber model which you use supports image buffering (Phoenix, X64, PCDig, PCCamLink, National Instruments boards, DCAM drivers), the buffers can be used and the buffer size can be defined by the user.



The number of buffers must be large enough to buffer timing interval where the hard disk is busy. Depending on the hard disk this is typically in the order of ½ or 1 second. The number of buffers has to be selected in a way that it can buffer images which arrive in this interval. If we acquire images from an ORCA in 2x2 binning mode we have a frame rate of approximately 16 frame / sec. If we assume a maximum busy time of the hard disk of ½ sec we have to provide at least 8 buffers. This number should not be larger than necessary because it consumes RAM memory but is should also be large enough to prevent lost frames.

During acquisition a display of the currently free buffers is visible and an information whether and how many frames have been lost already.

Optimize acquisition speed in fast hard disk recording

If lost frames appear during fast hard disk recording there are the following countermeasures which could be eventually done:

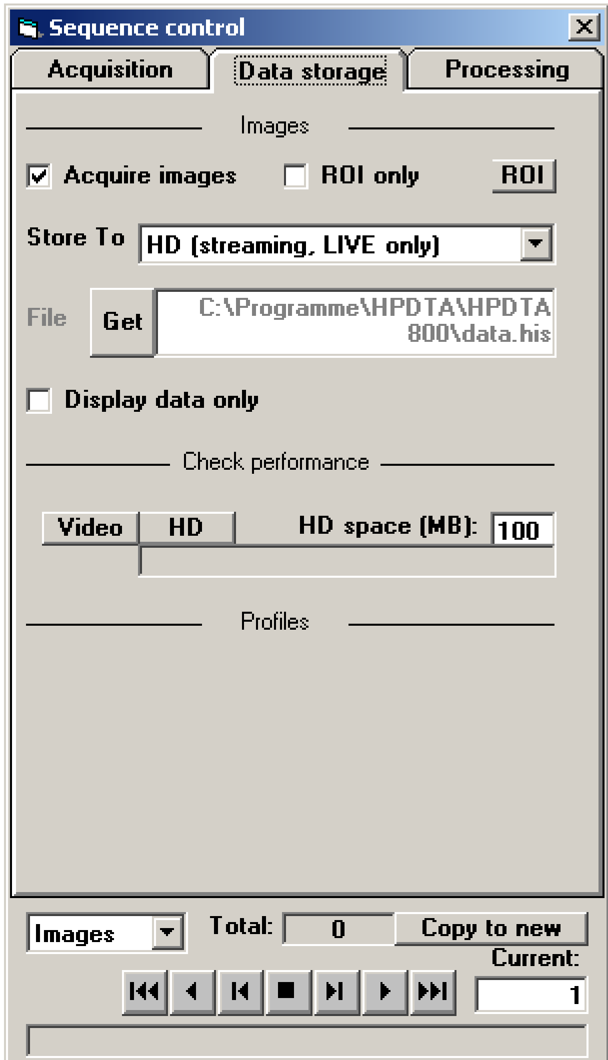
- Execute Check perform. HD
- Use a value larger than zero in the acquisition options “Wait till next display in Live mode [ms]”. This lowers CPU load used for display.
  or
  Completely switch off the image display during sequence (uncheck “Always display image during acquisition”)
- Increase the number of buffers
- Use a different (faster) hard disk
- Use display data instead of the full camera data
- Acquire only an ROI
- Use a camera mode which produces less data like binning
- Increase frame time by increasing the exposure time

If there are still lost frame it is recommended to acquire image data to RAM.

Data storage options

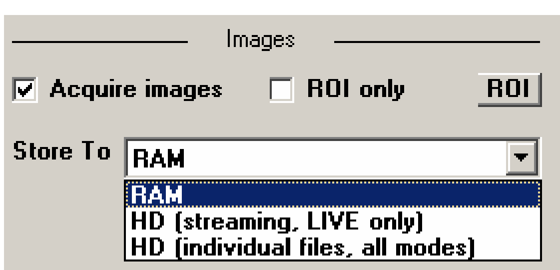
To specify the data storage parameters select the data storage tab.

On this tab the user can define whether the software should store image and/or profiles and how and where to these data are stored.



Storing images

In most cases the user wants to store images



To do so select “Acquire images”. As an additional feature the user can specify to store only part of the image. For this purpose he can specify a ROI from where image data is stored. To do so select a Rectangle ROI on the image click the pushbutton ROI and select the selection ROI only.

If you select **Store to RAM** the sequence will be recorded to the computer RAM. Use this in order to acquire a sequence with the highest speed. However you may also have to consider that the RAM is limited so the number of images you can record is limited. If you specify a loop number larger than the amount of physical memory, the software only acquires a smaller number of images and stops then.

For storing to hard disk there are two possibilities:

- HD (streaming, LIVE only)
- HD (individual files, all modes)

HD (streaming, LIVE only) is also called fast hard disk recording or just streaming is the fastest way to save image data to file. It is however limited to LIVE mode and full speed acquisition.

In other cases like Analog Integration mode or fixed interval you have to use HD (individual files, all modes). In such cases the Store to selection does not offer the possibility of HD (streaming, LIVE only). Please see also the appendices ITEX Sequence, TIFF Sequence, ASCII Sequence and HIS Image sequence file.

Differences between storage modes

There are several differences between these three modes. The following table shows the most important differences.

Topic	Store to RAM	HD (streaming, LIVE only)	HD (individual files, all modes)
Space	Limited to free physical RAM space	Limited only to HD space	Limited only to HD space
Permanent Storage	Has to be saved to individual files after acquisition	One single file	Many files linked only by naming
Acquisition mode	All acquisition modes	LIVE mode and full speed acquisition only	All acquisition modes
Speed	Fast, can acquire in full speed from every camera	Fast, but limited to hard disk performance. A sophisticated buffer	Slow

		management tries to avoid lost frames	
ROI	Can acquire ROI	Can acquire ROI. Allows to save only display data (data reduced to 8 bit)	Can acquire ROI
File type	*.img, *.tif,*.dat,*.his	*.his	*.img, *.tif,*.dat
Corrections	All corrections available	Images have to be saved to individual files first, then all corrections available	All corrections available
File management	The Windows Explorer may take long time for file management operations if the number of files is larger than 10000.	No problems with Windows Explorer. File size may be eventually too large to move (Several GB can be acquired within short time)	The Windows Explorer may take long time for file management operations if the number of files is larger than 10000.
Security against hangup	In case of hangup data is lost.	In case of hangup data is lost.	Data acquired until hangup is available.

Additional features and limitations of fast hard disc recording

Please consider following limitations of the **Fast hard disc** recording mode: It applies to images acquired in Live mode only. It applies only to sequences acquired at full speed. If the grabber model which you use supports image buffering (Phoenix, X64, PCDig, PCCamLink, National Instruments boards, DCAM drivers), the buffers can be used and the buffer size can be defined by the user. A precise time stamp can be expected only if Phoenix, X64, PCCamlink or PCDig frame grabber boards are used. With other configurations (especially in all configurations used with DCAM) the time stamp may not be accurate.

You have the additional possibility to save data as 8 bit only if you additionally check **Display data only**. The images will be saved in a contrast setting as displayed on the screen.

Please make sure that the LUT setting is reasonable before you acquire an image with this option selected. If you are using a camera with more than 8 bit per pixel output, the **Display data only** function will reduce the amount of data to be saved. Even a computer with limited performance may be fast enough to save such sequences.

The data saved in fast hard disc recording mode is written to one single file. This avoids delays due to file management but may be difficult to handle once the file is very large.

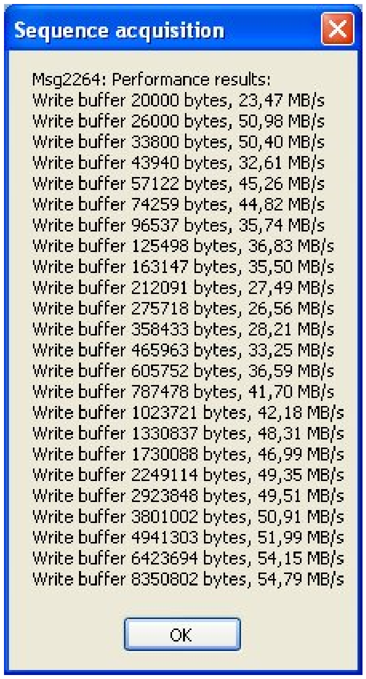
Check performance of hard disk recording

You can check the performance of your recording system for the fast hard disk recording mode.

If you click the **Check perform. Video** button, the time needed to display an image on your monitor will be measured and displayed.

If you click on **Check perform**. **HD** the performance (byte per second) of your hard disk will be checked with a file size as determined by the **HD space (MB)** parameter. Before you click on the **HD** button you have to insert a reasonable figure in the **HD space (MB)** text box. The measurement may take several minutes depending on your computer performance and file size selected.

The result of the analysis is shown in a table (see below). You can use this information to check if your configuration is fast enough to record images in LIVE mode on your hard disk.



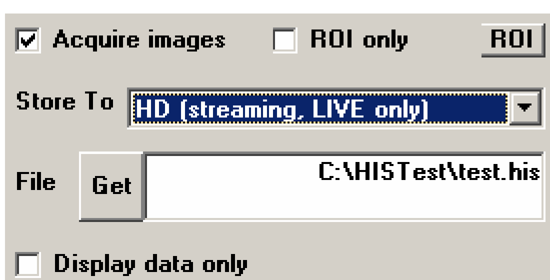
Important Note: The information gained in the **Check perform. HD** will be used to optimize data access to the hard disk. Executing this test is essential for the optimum performance of the hard disk recording function. It is also important that the **HD space (MB)** parameter is set sufficiently large. 100 MB is the minimum reasonable value, any value larger than this increases the precision and significance of this test. Please also redo the test if you change to another hard disk.

Specifying file names

If a sequence should be saved to a file or a set of files additional controls for file specification will appear.

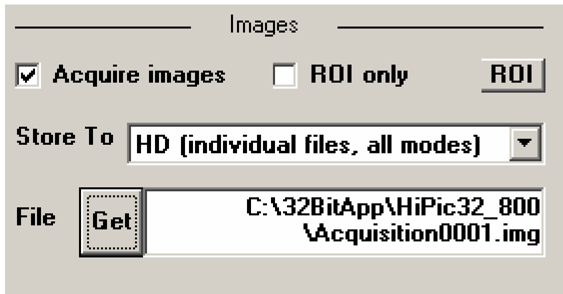
In the case of fast hard disk recording one has to specify a single file with the extension *.his. To browse the hard disk for a directory and file name click to the pushbutton Get.

Additionally the user can specify whether only 8 bit data (as displayed on screen) should be saved. To do so select the option Display data only.



In the case of storing images to individual files the images are stored to a set of images linked by the same base name added by a number indicating the individual sequence image.

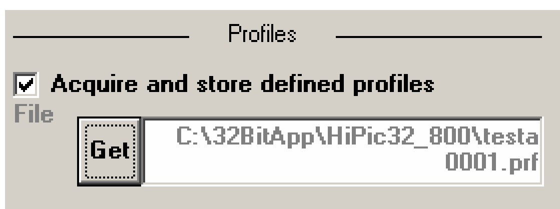
In this case the user has to specify a single file with the extension *.img or *.tif or *.dat but with a number for the start of the sequence. To browse the hard disk for a directory and file name click to the pushbutton Get.



Note: Please make sure the number of digits is large enough to number all images. Example: If you want to acquire 5000 images you need to specify at least four digits in the file name.

Storing profiles

In other cases the user wants to store profiles (or images and profiles).



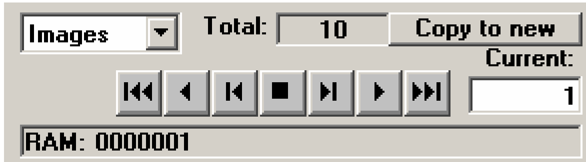
If you select **Acquire and store defined profiles**, all intensity profiles with defined and displayed ROIs will be stored. You have to select the file name in the file text box. Profile sequences are always stored to disk.

Image Sequence display (normal images)

To control the display and replay of a sequence the controls on the lower part of the sequence dialogue are used. If you run the program in demo mode you still can display and replay existing sequences.

Unless a sequence is already opened, you have to open a sequence using the File – Open dialogue or acquire a new sequence.

Select **Images** in the Sequence control – Acquisition dialogue to display a sequence of images (only necessary if an image sequence and a profile sequence are currently loaded).



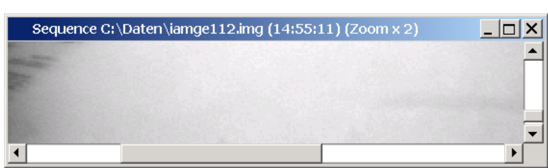
The controls in the center are used to specify the image within the sequence. The text box **Current** shows the index of the image currently shown. You can enter the desired image number, switch to the first (with) or last image (with) or switch to the next (with) or previous image (with). You can automatically replay the sequence backward or forward with the controls

and . The parameter **Interval** in the sequence options defines the time for which each image will be displayed.

If the parameter **Wrap** in the sequence options is selected, the sequence display will be continued until the user stops it by pressing the (=Stop) button.

If you want to extract a single image from the sequence you can use the push-button **Copy to new image** to create a single image with the same data as the current image. This is displayed in a separate window.

The currently displayed image within the sequence contains some useful information in the window title bar: The word "Sequence", the file name (or the image number if the sequence is not yet saved), the time and the zooming factor. If the image is the first image within a sequence the time parameter shows the time when the image was acquired (11:08:09). If it is another image it shows the offset to the first image in milliseconds (e.g. 147 ms). Therefore an exact timing can be reconstructed. If **Full speed** was selected during acquisition the time when the image has been read out completely is registered, if **Fixed Timing** was selected the start time of the acquisition command is registered. This is normally more precise.

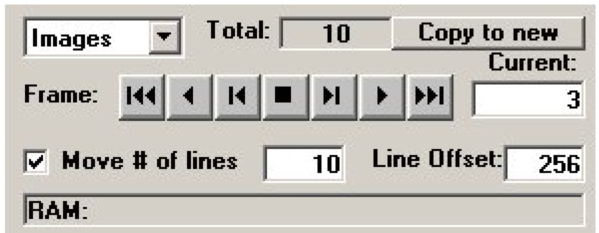


Title bar of a sequence image

Image Sequence display (Linesensor and TDI data)

In the case of line sensors sequence data is saved similar to image data in portions of individual images with fixed width and height however the meaning of the data is more like a continuous stream of lines. As a consequence the user may want to see not only the (more or less arbitrary) packages of saved data but any position between these packages. The software provides a method to select not only data which starts at full image borders but also between these image borders. The image header contains information whether the data has the character of line data.

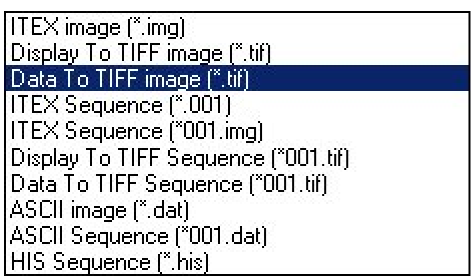
With such kind of line data the sequence dialog get some more controls:



If the checkbox “Move # of lines” is activated not only the saved images are displayed as they are saved, but positions between the individual images are displayed. If the Line Offset is nonzero starting from this line number the current selected image is displayed and a part of the next image is added on the bottom part of the image (very similar to the scrolling live display). The Backward, Play backward, Forward and Play Forward pushbuttons then act no longer on full images but “move” image just the specified number of lines.

Sequence image file naming conventions

When you select the **Save as..** function within the **File** menu you will find several formats to save image sequences:



Save as.. *file type list*

1. ITEX sequence
All images of a sequence are saved to separate ITEX-files. These files are only linked together by the naming convention. There are two possible naming conventions:

*.001 format

Example1: Starting name: TEST.001
Sequence: TEST.001, TEST.002, TEST.003 ...
Example2: Starting name: TEST.031
Sequence: TEST.031, TEST.032, TEST.033 ...
Note: This format should not be used any more,

since it may not be supported in future versions of this program. It is only provided due to compatibility reasons with previous versions.

*001.img format

Example: Starting name: TEST145.IMG
Sequence: TEST145.IMG, TEST146.IMG, TEST147.IMG etc.

The default extension is 001 and the user only has to select a file base name. In this case the files are named NAME.001, NAME.002 etc.

When saving a sequence one has to select the starting name. All other file names are derived starting from this file name:

Note: The numbering can have up to 7 digits

2. TIFF sequence format.
   There are two ways to save image sequences in TIFF format:

2.1. **Data to TIFF** sequence
Images are saved in 8 or 16 bit TIFF format, depending on the depth of the image buffer. If the image buffer is 8 bit, TIFF will be 8 bit deep, otherwise it will be 16 bit deep.

"Data to TIFF" preserves the measurement data. The saved image data do not depend on the LUT settings, although the LUT settings are saved in the TIFF header and restored from it when re-loading such an image.

2.2. **Display to TIFF** sequence
Images are saved in 8 bit TIFF format. This is a color-palette format. If the LUT is grayscale when saving the TIFF file, the palette contains gray scales, otherwise it contains hued colors.

"Display to TIFF" does not preserve the measurement data. Its purpose is to store pictures which look like the image on the monitor screen. So, the contents of image data depend on the current LUT settings. Use "Disaplay to TIFF" if you want to save images for presentation purposes, but never try to store your measurement data this way!

3. **ASCII** sequence
Images are saved in ASCII format. Note that ASCII format does not preserve any calibration information.

The files created can be read with the **Open** function (however ASCII files can not be read by this program). Depending on the file format you choose, you can either display single images or a whole sequence.

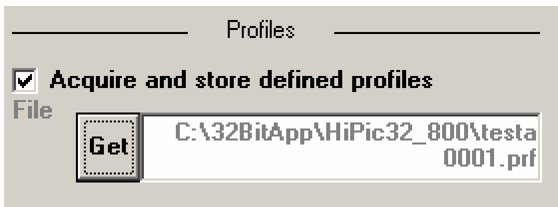
If you execute image processing operations on a sequence all sequence images are treated in parallel. This is true for **Background subtraction** (the background image is taken and is subtracted from all images**), Shading correction**, **Arithmetic operations** and **Map values by LUT**.

4. **HIS** sequence
All images of a sequence are saved in one single file. This allows using full performance of your computer system. It is the fastest way to record images on hard disk. You have to use this format if you use the **Fast hard disk** recording mode.

Profile sequences

Profile sequence acquisition

Select **Acquire and store defined profiles** in the Sequence – Data storage dialogue to enable recording of profile sequences.



Also a base file name or the name of the first profile within the sequence has to be defined. During sequence acquisition the system adds four digits to the base name: The first digit specifies the profile memory number and the last three or four digits the number of the series. For example a profile name test6001.prf indicates the profile memory number 6 and the first exposure

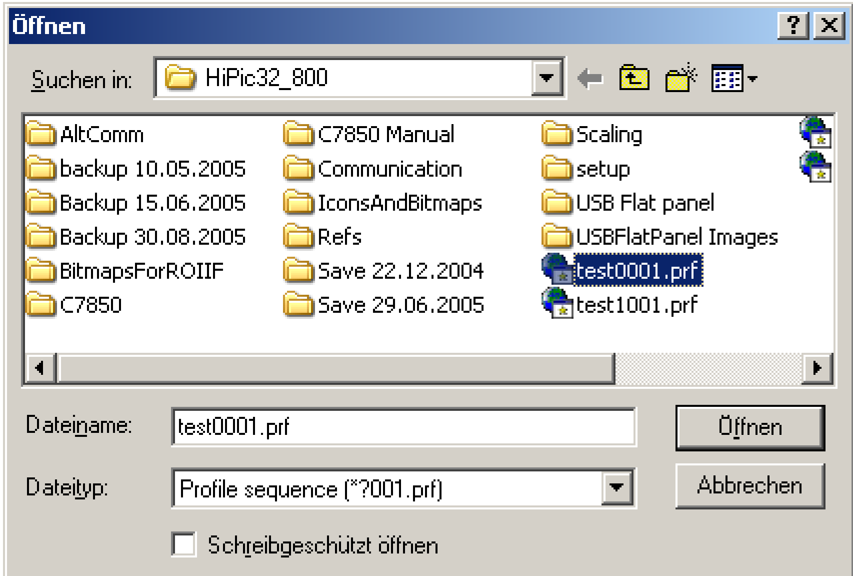
Before you can start to record a sequence of profiles, you have to get a sample images and define the profiles.

Profile sequences are recorded for all profiles for which ROIs are defined.

Then you have to define the timing parameters of a sequence as described in the chapter above. After pressing **Start Acquisition** a series of profile files will be stored.

Profile sequence display

Unless you have just recorded a sequence, you need to load one from disk before you can display it . Use the **Load** function of the profile dialogue in order to open a profile sequence. You have to select Profile sequence in the file type selection, otherwise only a single profile is loads. If there have been several profiles where a ROI was specified then several profiles are loaded at the same time. All these profiles together are called one sample (In the case of images as sample is always on image).



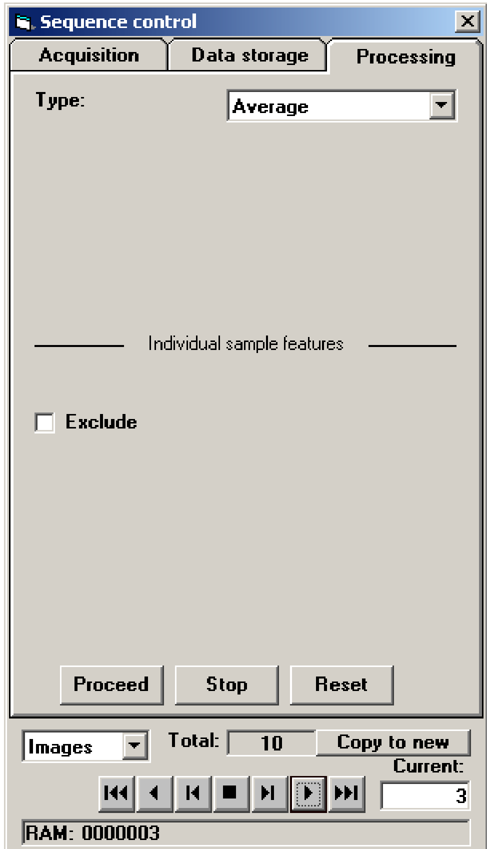
Select **Profiles** in the Sequence control – Acquisition dialogue to display a sequence of profiles.

The way how to use the profile sequence dialogue is analog to the image display.

Processing sequences

It is possible to do some post processing operations with image and profile sequences. Choose the **Processing** tab from the **Sequence control** to display the dialogue for sequence processing. It is possible to

- Average a number of images or profiles



Sequence processing dialogue

Arithmetic

When averaging images or profiles, different options for the data processing can be used.

Method	Normal Images	Photon counting Images	Normal Profiles	Photon counting Profiles
Conventional	Averaged and aligned to 15 bit boundary	Added Up	Averaged	Added Up
Average	Averaged	Added Up	Averaged	Added Up
Add	Added Up	Added Up	Added Up	Added Up

The data storage type of the result image will be a 16 bit normally. It will be 32 bit type if the original images are 32 bit images or if the option “Add” is used.

Align to 15 bit boundary means that the full dynamic range of signed 16 bit images is used to avoid rounding errors. Technically speaking it means a bit shift by to shift of (15-n) to the MSB where n is the bit depth of the single image (12 for a 12 bit image).

Please use the option “Processing Arithmetic” to select the method.

The word “Conventional” means that previous versions always used this somehow complex but reasonable arithmetic method.

Averaging

If you press **Average**, all data (images or profiles) of the current sequence will be averaged. This can be used for creating noise reduced data.

It is possible to exclude some data of the sequence from averaging. This is e.g. useful, if one or several data of the sequence show unwanted contents.

Display the data you want to exclude from averaging and click **exclude this sample** in order to eliminate this data from averaging.

Finally, hit the **Proceed** button.

In case of image data, the result will be displayed in a new image window. In case of profiles, the result will be displayed in the **Profile Display** window.

Optimizations

The sequence mode is a rather complex and powerful mode. It can be influenced by many options and parameters. Sometimes the setting of a parameter influences the performance of the acquisition in a certain way. Generally speaking the more tasks the sequence should perform the slower it is. If you want to emphasize a specific performance parameter you should look at the following hints. We distinguish the topics according to the performance parameter speed, number of images and size and complexity on hard disk.

The following are suggestions what you can do if you do not reach the desired performance. Not all suggestions may yield the desired result and not all suggestion may lead to an improvement. It depends on the detailed circumstances which measure will lead to the desired performance.

Speed

Try the following measures if the program does not acquire images at the desired speed.

- Verify the frame rate of the camera. Use a camera mode with higher frame rate if the current frame rate is not sufficient.

- Use acquire to Ram instead of Acquire to hard disk
- Use Fast hard disk recording instead of individual files if you need to write to hard disk.
- If you want to acquire profiles, acquire images only first, then extract profiles in a second step
- Even if you need individual files acquire to streaming file first, then convert to individual files.
- If using Acquisition to RAM:
  Use a value larger than zero in the sequence options "Display Interval for Acqusition to RAM [ms]". This lowers CPU load used for display.
  or
  Completely switch off the image display during sequence (uncheck "Always display image during acquisition")
- If using Live Streaming:
  Use a value larger than zero in the acquisition options "Wait till next display in Live mode [ms]". This lowers CPU load used for display.
  or
  Completely switch off the image display during sequence (uncheck "Always display image during acquisition")
- Perform "Check HD" performance when using streaming files prior to acquiring data.
- Use a fast hard disk when writing to files.
- Use 1 x 1 binning for display if you want to keep display on.
- Use 8 bit (display data) only (Warning: This reduces S/N of the data. Can eventually result in slower acquisition).
- Use an ROI for writing the data.
- Change the camera to a higher binning if possible.
- Switch off real time corrections (real time background subtraction, real time shading correction) and do these corrections afterwards.
- Do auto corrections after sequence acquisition.
- Uncheck "Enable Stop" when acquiring to RAM
  (Only rare cases, not recommended normally)

- Use “Full speed” instead of fixed intervals
- Use camera modes with faster interval time
- Use Live mode or Acquire mode instead of Analog integration or Photon counting
- Use DPC mode and extract a sequence later instead of acquiring sequence of photon counting images
- Do not show quick profiles while fast hard disk recording
- Use bit packing when using fast hard disk recording (can eventually result in slower acquisition)
- Use a faster computer
- Increase the number of buffers for fast hard disk recording if lost buffers appear.

Number of images

Try the following measures if the program does not acquire the desired number of images.

- Use Fast hard disk recording or individual files instead of RAM.
- Use camera modes with less pixels like binning or sub array.
- Save ROI only.
- Close other applications when acquiring to RAM.
- Input more RAM in case of acquiring to RAM.
- Use 8 bit (display data) only

Size on Hard disk or handling complexity

Try the following to reduce the amount of disk size which is used for the data or decrease handling complexity.

- Use camera modes with fewer pixels like binning or sub array.
- Use 8 bit (display data) only
- Save ROI only.
- Use Fast hard disk recording to save only one file
- Use bit packing when using fast hard disk recording

Photon Counting

Introduction

***Photon Counting** is a mode in which single photon events are added up in the frame memory. If the signal integration time is sufficiently long, a very high signal-to-noise ratio can be achieved. This mode also effectively suppresses certain crosstalk effects inherent to some image intensifiers. A dynamic photon counting mode allows temporal analysis of photon counting images.*

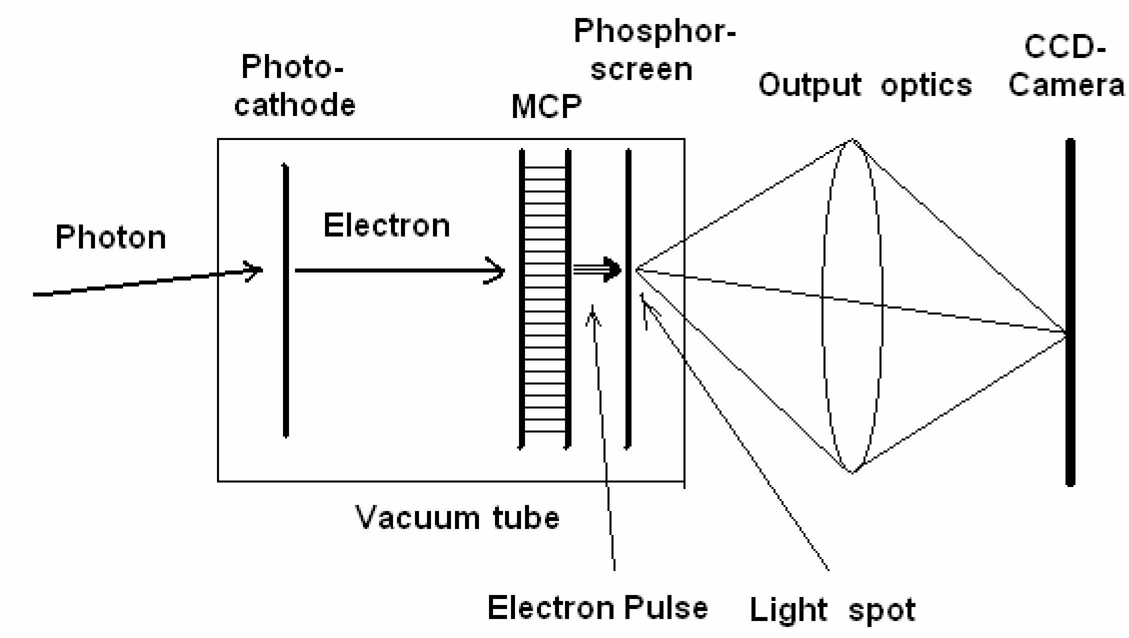
Required Hardware

Note: Photon counting mode is only possible if dedicate hardware requirements are fulfilled. A standard CCD camera is not able to perform photon counting.

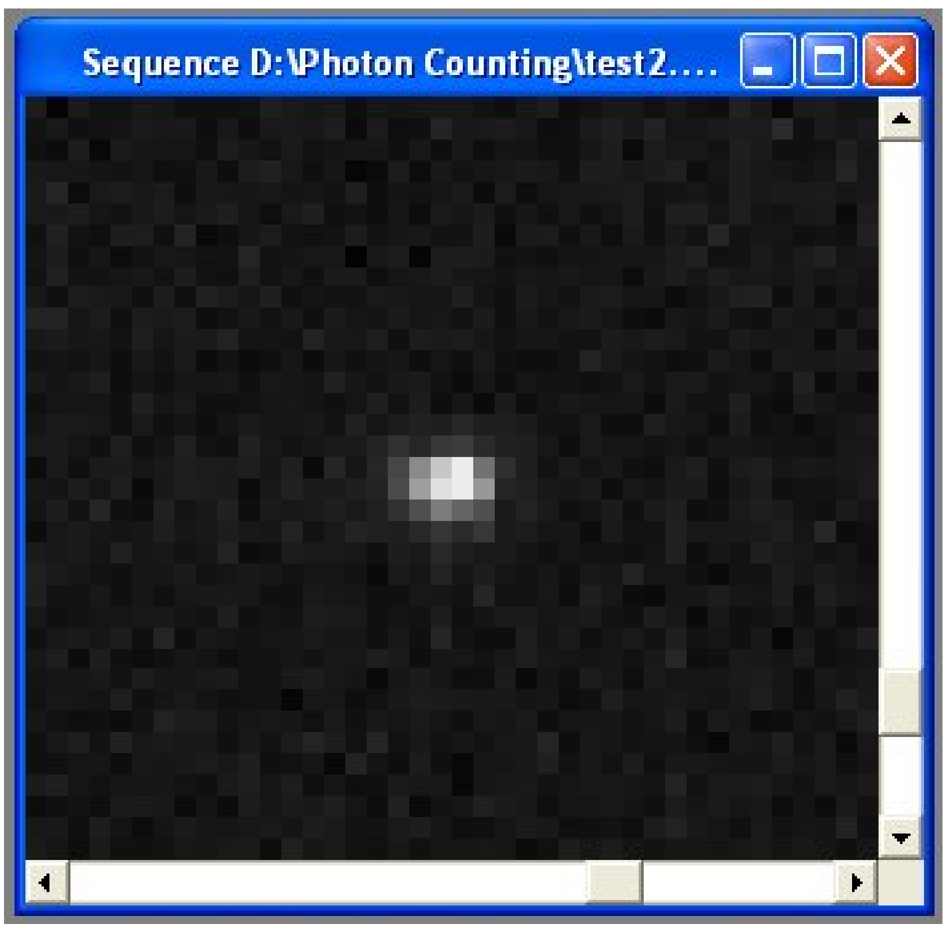
The following drawing shows the typical hardware required for photon counting.

It shows the vacuum tube including Photocathode MCP and phosphor screen as well as the output optics and CCD camera.

Starting from a photon an electron is created at the photocathode. This electron is multiplied inside the MCP and finally hits the phosphor screen. A small light spot is emitted at the phosphor screen and imaged to a CCD camera by the output optics.



The CCD camera finally registers a small light spot for every photon (see the following screenshot).



Conditions for Photon Counting Mode

Sensitivity to single photons

Photon Counting requires that the system sensitivity is high enough to see single photon events. This is not the case if a CCD camera is used without any other light amplification device. Such a light amplification device could be an image intensifier whose gain is sufficiently high.

Low light level

Photon counting can only be performed properly if the light intensity is low enough.

In case that the photon spot areas of two photons overlap at the same image on the CCD they will be recognized as only one photon event. To avoid such a counting error the probability of a "two-photon event" should be low.

Basic principle of photon counting

Threshold

The first principle of photon counting is that only the portions of the image are regarded where the intensity exceeds a certain **threshold**. Only these portions contribute to the result. The setting of this threshold is depending on features of the camera and of the photon spots which are recorded by the camera. This feature results in high processing speed which allows us to use photon counting in real time.

Reduce the spot information to a single count

Another important feature of the used algorithm is that then whole information of a single photon spot is reduced to a single count.

Coordinate determination

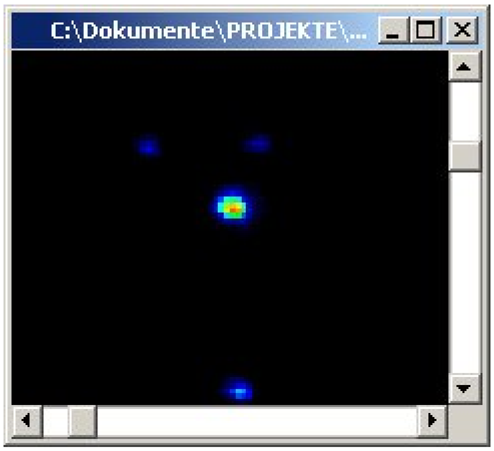
The third principle is that for every photon spot we determine as precise as possible the coordinates of the photon. This allows us to perform a two dimensional photon counting.

Photon counting algorithm and implementation

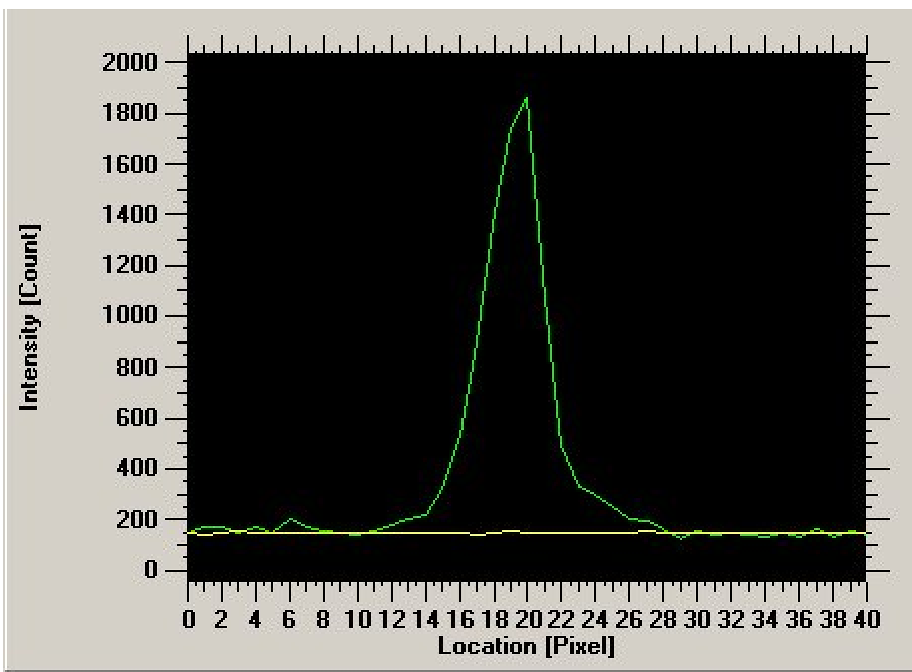
Background subtraction and threshold calculation

In a first step a background subtraction is performed and every pixel below a certain threshold is set to zero. The background subtraction reduces the effect coming from uneven CCD camera background (fixed pattern) or hot pixels.

The raw data of photon counting processing looks like:

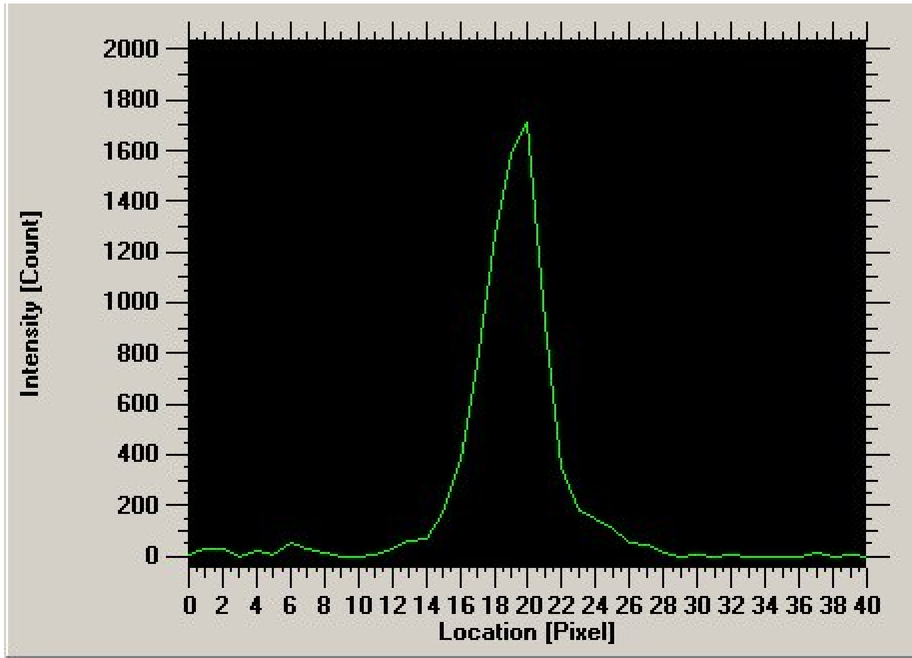


All processing steps are done with two dimensional data but for the ease of illustration we just use a one dimensional view of the data:

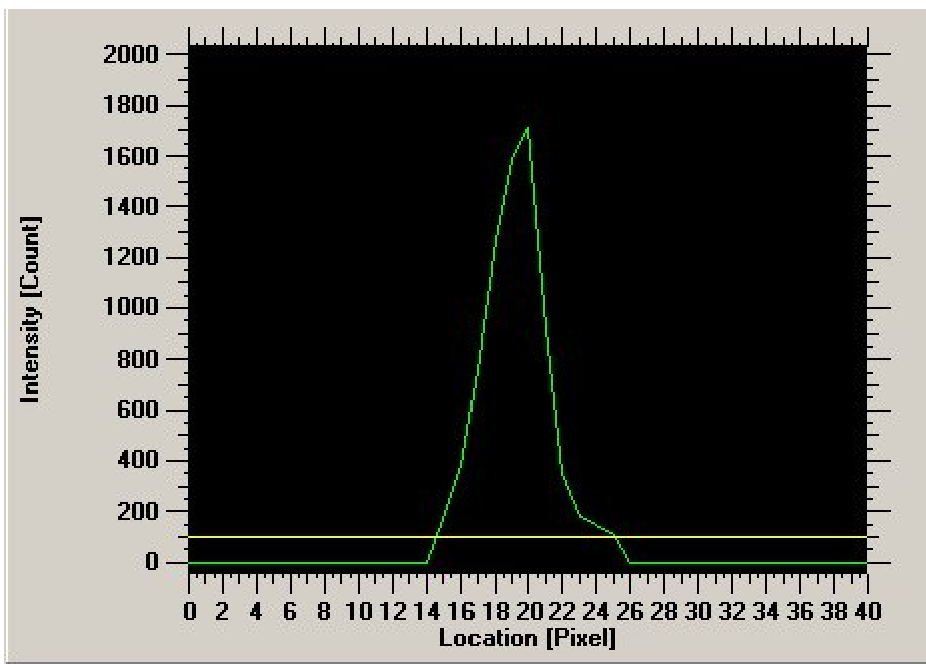


The green one is the raw photon data whereas the yellow one is the background data.

After background subtraction we get:



If we apply a threshold of 100 we get the following:



Coordinate calculation

Further processing steps uses only data which is non-zero, which increases processing speed drastically. For every photon we find its coordinates x and y. In our one dimensional example the location of the photon would be pixel 20.

Advanced processing

Advanced processing steps reduces moiré pattern which may appear in systems with discrete pattern of different size (in our case MCP and CCD) cells and handles bordering effect.

Data Storage

The data is stored in an image which means that the frame buffer is increased for every photon at the photon location or it is written to a so called DPC file which allows performing dynamic photon counting analysis.

Counting errors and maximum count rate

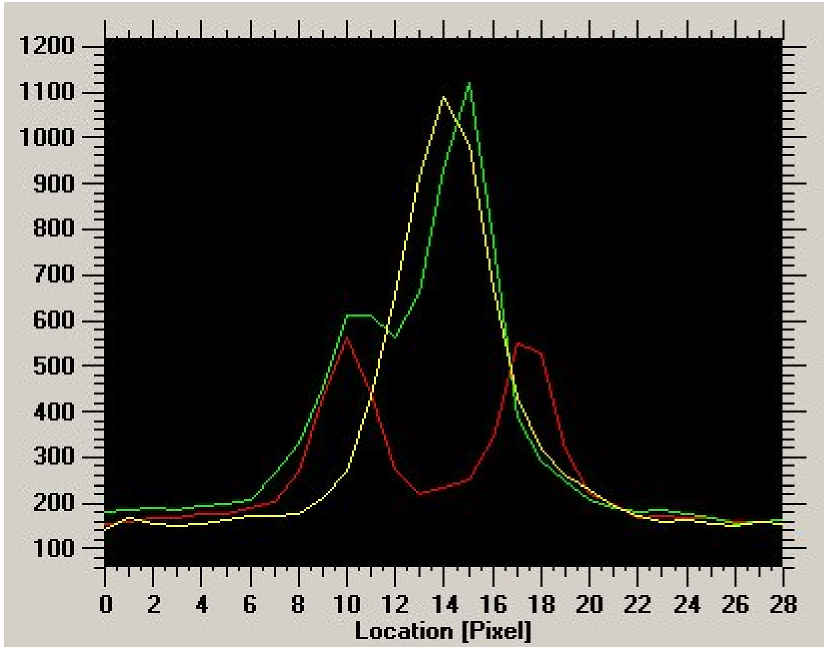
Correct threshold

An important factor for precise photon counting is the correct selection of the threshold. If the threshold is too low the system will count events which come from noise of the CCD system and which are no real photons. Be sure that the photon counting acquisition really counts no photons if there is no light.

As the number of electrons arriving at the output has a certain distribution (we call this pulse height distribution) the brightness of the photons spots vary strongly. On other words: There are photons which produce a higher signal then others. If the threshold is too high, not all of the photons are counted.

Overlapping photon spots

The photon counting algorithm can count photons as individual photons only if they are separated from each other. The following screenshot will illustrate this. The red and green lines represent intensity distributions originating from two photon whereas the yellow line can be judged as a single photon only (even though there may have been two photons)



The probability of double photons which are counted as a single one because they overlap is a measure of the counting error.

A good indication of this probability is the percentage of the image which is "covered" by photons, in other words the percentage of the image which exceeds the threshold. The smaller this percentage is the smaller is the probability that a "new" photon hits an already recorded one. To keep this value small the "single photoelectron" probability should be made small by reducing the intensity of the light signal or minimizing the single photoelectron spot size. Increasing the frame rate reduces the number of photons detected on a single CCD frame thus decreasing the counting error.

Practical experiments have showed that the counting error have approximately the same value than the “above threshold” value.

This program displays the current percentage of pixels above the threshold in a specified ROI. This value should not exceed a few percent (around 5%).

Maximum count rate

The maximum count rate we can achieve with a give system depends on the size of the photon spots, the CCD camera frame rate and – of course – on the required precision.

Operating Photon Counting

Photon Counting Setup

Before you start photon counting image acquisition **background data has to be acquired** and a suitable **threshold has to be set**. A sophisticated automatic setup routine has been implemented to acquire background data and automatically searches for the most suitable threshold.

Open the camera acquisition dialogue and select the photon counting tab and press **Setup** to start this routine. The program automatically acquires background data and performs histogram analysis. Then it starts photon counting acquisition in test mode to get an optimal threshold for the given system . Finally it proposes certain values necessary for the photon counting, as described in the chapter. Depending on the detector settings and type of detector, the procedure may take several minutes.

Note 1 During this setup the amplification device (MCP) should not be active otherwise wrong thresholds are calculated.

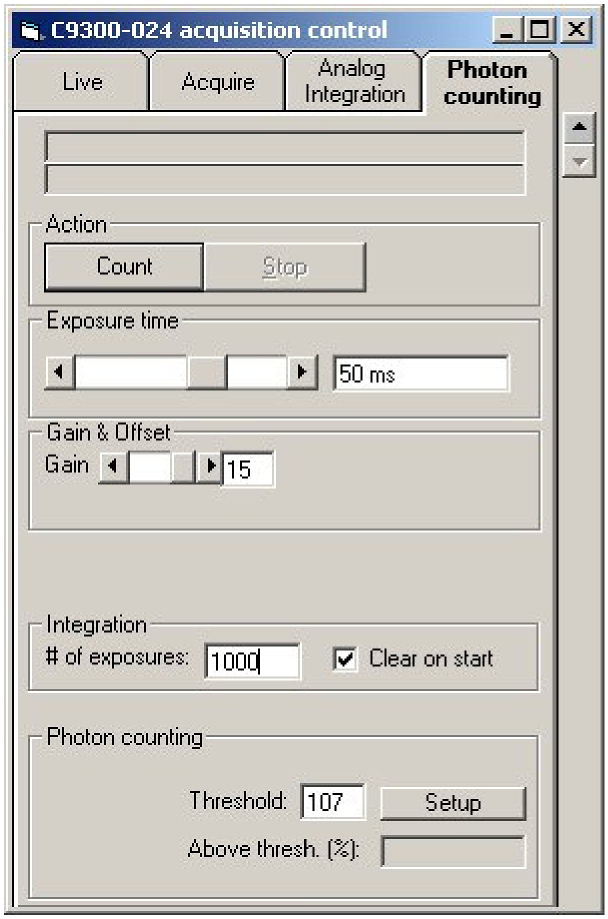
Note 2 If you did not perform Photon Counting Setup before you start photon counting acquisition, the system will prompt you to do so first. If you prefer to enter the threshold manually, you can ignore this message. This prompt is re-activated after you changed some parameters (like CCD exposure time) that can affect the proper threshold determination.

Note 3 In some rare cases the threshold has to be modified after photon counting setup to yield good results. In any case of doubt please contact your local Hamamatsu representative.

In case of a dual tapped camera like the C9300-201 two thresholds can be specified separately. The photon counting setup determines these two thresholds automatically.

Photon counting acquisition

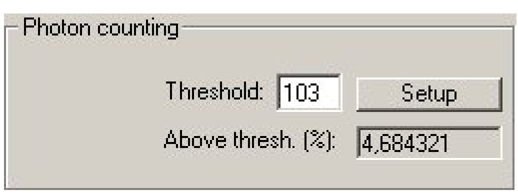
After you have executed Photon counting setup you can start to acquire photon counting data. Set your amplification device (MCP) to maximum gain, select the number of integrations and start photon counting.



The exposure time can be set freely but it is recommended to set it close or equal to the camera frame time. If the exposure time is set smaller then the frame time signal is wasted (this may be desired if the signal is strong), if the exposure time is set larger then the frame time the maximum possible count rate is decreased.

The photon counting process is continuously monitored and two types of messages are output.

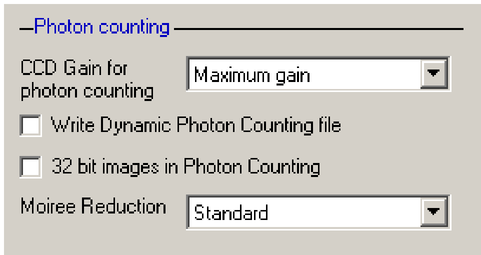
The first is information about the number of pixels which exceed the threshold. As explained earlier this value should not exceed 5%.



The system also monitors whether the CCD camera becomes saturated . while looking at photon spots (Saturation always means loss of information). In such cases a warning message appears at the top part of the acquisition dialog and it is recommended to reduce the CCD camera gain (see also the option “CCD Gain for photon counting”). This message is only output in case of a problem.

Options related to photon counting

There are the following options related to photon counting in the acquisition options dialog:



The Selection box for **CCD Gain for photon counting** allows specifying the default CCD camera gain setting in photon counting mode. You can select between “Maximum gain” and “Minimum gain”. It is recommended to use “Maximum gain” unless the photon spots gets saturated.

If **Write dynamic photon counting file** is selected, the recording of photon counting images in the special DPC file format is enabled

If **32 bit images in Photon Counting** is set result images in Analog Integration mode will always be 32 bit.

The selection of **Moiré Reduction** specifies how strong Moiré reduction should take place. It is recommended to keep this parameters at its default value “Standard”

Dynamic Photon Counting (time resolved 2-D photon counting)

The standard photon counting mode just accumulates the photons detected during the acquisition period. If you want to record also the time when a photon has been detected, you can use the Dynamic Photon Counting acquisition mode. If this mode is enabled, a DPC-type file will be generated where the x-y co-ordinate of each photon is registered as well as the time when it has been detected. In a later analysis step this file can be used for temporal analysis of photon counting images.

Please see also the Appendix DPC File Format for details.

Acquisition

To activate the dynamic photon counting mode you have to select the item **Write dynamic photon counting file** in the menu Setup - Options-Display.

Then start photon counting image acquisition as described above.

Before the acquisition will start, a file name selection dialogue will be shown. There you have to define the file name of the file where the image data will be stored. For these files a special file extension is used: *.dpc. In this file the x-y co-ordinates of each photon and the time (CCD frame number) when it was detected are stored. The time resolution is limited by the frame rate of the camera you use for image acquisition.

In parallel to the data recording in the DPC file, an accumulated photon counting image is generated as described above.

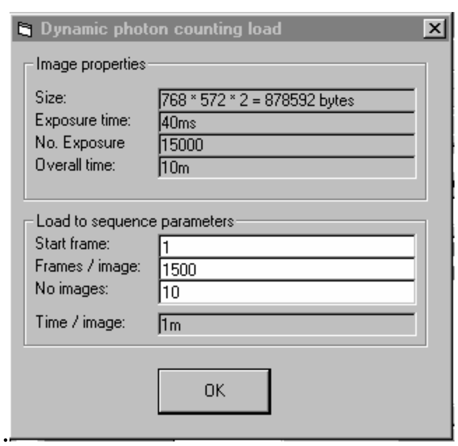
Analysis

There are two ways to use dynamic photon counting image files of the DPC format:

If you want to see the accumulated photon counting image without using the time information you can load the file by selecting the "dpc file" format in the File – Open dialogue.

If you want to analyze the temporal information of a DPC file you have to open the file by selecting the "dpc sequence" format in the File – Open dialogue. Then an image sequence will be generated from the file.

After you opened the file a dialogue is displayed where you can set several parameters of the image sequence which will be generated:



Dynamic photon counting load dialogue

In the upper part of this dialogue several basic parameters of the DPC file are displayed, like file size, exposure time of one frame, number of exposures and total acquisition time.

In the lower part you can set parameters of the sequence which will be generated:

Start frame sets the frame of the photon counting image at which the sequence will start. **Frames /image** define the number of frames which will be accumulated for one image of the sequence and **No images** defines the number of images of the sequence.

Example (shown in above dialogue): If data were recorded with 15000 camera frames and you intend to split the data into 10 images, each image will be calculated from 1500 frames.

Set the **No. images** parameter to define the number of sequence images you want to generate. Wrong inputs are automatically corrected. The header of the sequence images will show the time of the first image of the time frame.

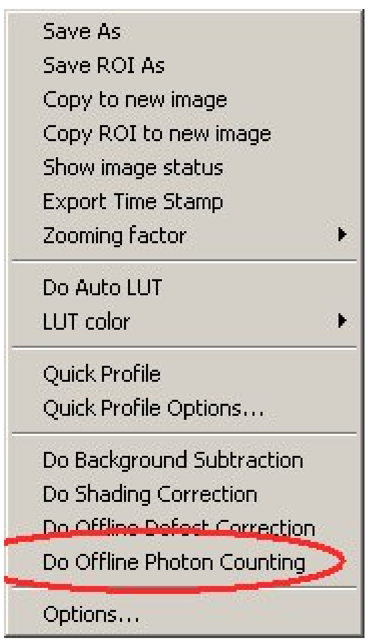
Click **OK** to generate the sequence after you defined the sequence parameters. The generated sequence is a normal image sequence and can be treated in the standard fashion.

For information about handling and analysis of image sequences please refer to the chapter.

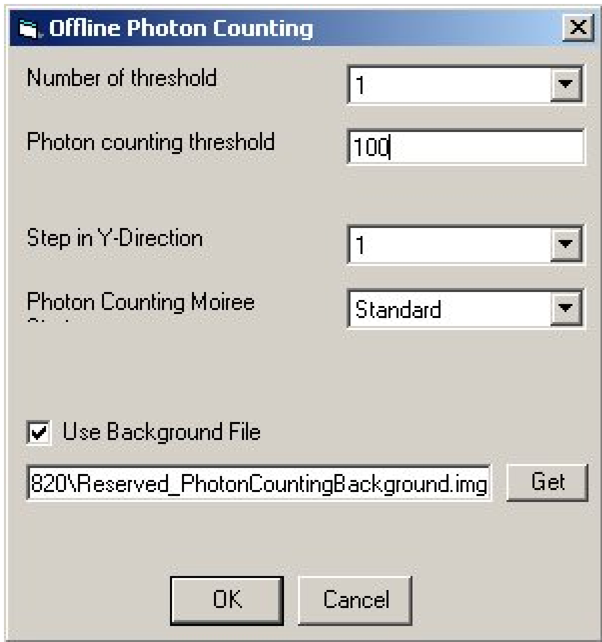
You can find a description of the DPC file format in Appendix F. You can use this if you want to use your own program for analysis of DPC files.

Offline photon counting

Offline photon counting can be performed on the basis of sequence data. To perform Offline photon counting right click with the mouse to a sequence and select:



Then please select the photon counting parameters:



Select the appropriate parameters and click to OK. A message box will appear telling you the progress of offline photon counting analysis and the value of the **Above Threshold** parameter.

Reserved Filename

Please note that the photon counting setup saves the background data to a special file inside the application directory. Do not delete or modify the following reserved file:

`Reserved_PhotonCountingBackground.img`

Otherwise photon counting may no longer work as expected.

Image processing

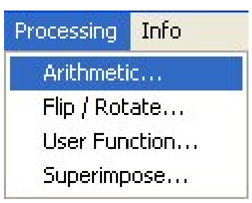
This topic describes how to apply image processing function.

Arithmetic

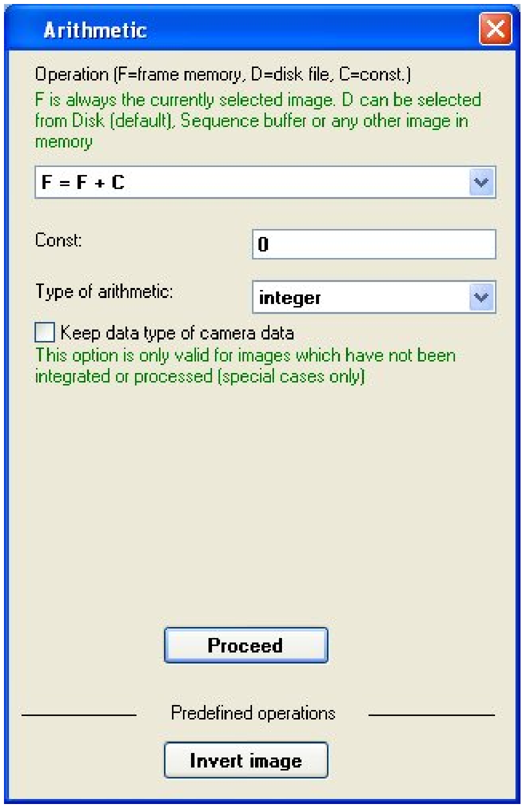
Arithmetic operations on an image or among two images can be made by using the Arithmetic commands.

General

Choose **Arithmetic** from the **Processing** menu to display the Arithmetic dialogue.



The Arithmetic dialog will appear.



Arithmetic dialogue

The arithmetic functions can be used for tasks like subtracting or multiplying two images. These functions will always work on the current image and will change that image.

Caution: Save your original image first if you need to keep it.

Both, unary and binary operations are possible. In case of binary operations the first operand is always the current image and the second operand is always an image in a file on a disk.

Note: You can select a partial area of the image and the function will be performed only inside that area.

Important: Please make sure that no rectangular ROI is selected if you want to perform the operation on the whole image!

In case of binary operations the system always automatically calculates the overlapping area between the two images and will perform the function only on that area.

Selecting Constant and Arithmetic type

In addition, for all functions (also the unary ones) a constant may be defined as a calculation parameter. This constant has to be input into the edit box named **Const.**

You may also specify which type of arithmetic is used for the calculations, (long) integer or floating-point arithmetic. If the given constant is an integer value by default the arithmetic type is integer but you can force the program to use floating-point arithmetic, if you like. Choose the desired radio button in the frame **Type of arithmetic used.**

After you pushed the **Proceed** button the program calculation will start.

Note: The time required for a calculation will depend on the speed of your computer.

Second image

In the case a second image is required for the operation the user has to select the type of second image. He can select from the following selection:

Disk — The second image will be loaded from disk. A file name has to be specified in the case

Sequence — The currently selected image from the sequence buffer will be used.

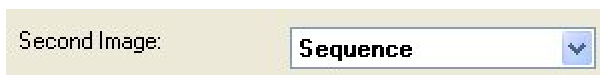


Image in memory — An image which is already loaded to memory will be used.

Available operations

The following unary operations are available:

F=F+C	Adds a constant (integer only)
F=-F+C	Inverts the frame-buffer contents (integer only)
F=F*C	Multiplies the frame-buffer by a constant (integer or float)

F=F/C	Divides the frame-buffer by a constant (integer or float)
F=ln(F)*C	Calculates the natural logarithm (float only)

The following binary operations are available:

F=F+D+C	Adds a constant and a disk file to the frame-buffer (integer only)
F=F-D+C	Adds a constant and subtracts a disk file from the frame-buffer (integer only)
F=F*D/C	Multiplies the image in frame-buffer with a disk file (integer or float)
F=F/D*C	Divides the image in frame-buffer by a disk file (integer or float)

Based on these Functions one predefined operation is provided to invert the image content.

Execution and Clipping

All integer operations are performed with long integers (4 byte) and are done in a way to minimize rounding errors (e.g. multiplication is done before division etc.).

During processing the result values are clipped to the limit of the data storage type which is

Data type	Lower	Upper
8 bit	0	255
16 bit	-32768	+32767
32 bit	-2.147483.648	2.147483.647

Sometimes it is important the data limits of the camera are not exceeded. In this case the clipping is done to the intrinsic data limits of the camera which are

8 bit	0	255
10 bit	0	1023
12 bit	0	4095
13 bit	0	8191
14 bit	0	16383
16 bit	0	65535

To perform this type of clipping select the option Keep data type of camera data.

Predefined operations

Predefined operations are operations on the image content which have well defined operators and constants. Currently there is only one predefined operation, it inverts the image data. If for example the image is a 12 bit image the inverted image is calculated by

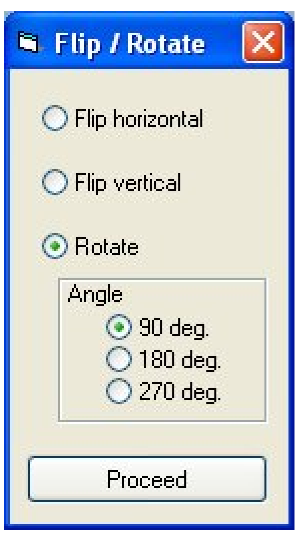
$I_{new} = (4095 - I_{old})$

which leads zero for the highest intensity and 4095 for the lowest intensity. A similar effect can be achieved if the LUT option "Invert" is selected, with the difference that the LUT operation does not change the data whereas the processing functions changes the data.

Flip and Rotate

The content of the image can be flipped horizontally and vertically and also rotated by 90, 180 and 270 degree. The operation is always applied to the currently selected image. If a sequence is selected the operation will be performed on all images of the sequence.

Choose **Flip/Rotate** from the **Processing** menu to display the Flip / Rotate dialogue.



To operate Flip or rotate select the desired operation and click Proceed.

Superimpose

Superimpose is a function which can overlay two images. This chapter is split into two parts. In the first part you can learn how Superimpose technically works. In the second part you learn how to operate the Superimpose function.

Technical Explanation of Superimpose

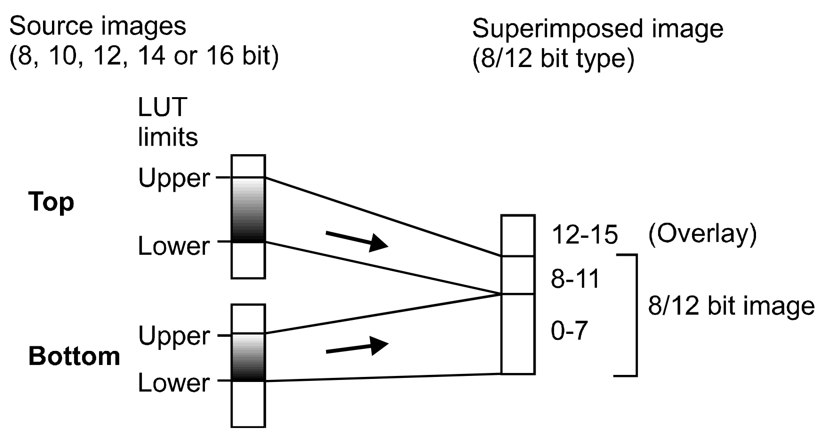
Two layers within the image memory are used to display two images simultaneously: The **bottom layer** and the **top layer** (see figure below).

The bottom layer is displayed in the color scale currently selected (either B/W or color). The display of the bottom layer can be modified with the LUT tool like at any other image.

The top layer overlays the bottom layer. The top layer is displayed in colors when the bottom layer is B/W and it is displayed in B/W when the bottom layer is colored. Thus, you can easily distinguish between the two layers.

The bottom layer is displayed with 8 bit grey level resolution and the top layer is displayed with 4 bit grey level resolution. The image containing both layers is 12 bit deep and can additionally contain an overlay.

When images are superimposed, the source images must be reduced in its dynamic range to 8 bit for the bottom layer and 4 bit for the top layer. This is done in a similar way as the output LUT displays images: The full dynamic range of data (e.g. 12 bit) is reduced to 8 bit which is also output on the monitor. The LUT cursors saved with the source images are used to reduce the dynamic. This means if the LUT settings were appropriate to display the image correctly the images with reduced dynamic range also yield a correct image.

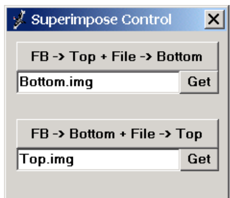


Scheme: How two source images are superimposed

Sometimes it happens that the top image hides wide areas of the bottom image. Therefore a possibility has been provided to make the display of intensity values representing low intensity values of the top image transparent. If more and more of the lower intensity values are transparent only the high intensity parts of the top image remain visible and you can more and more see all parts of the bottom image.

The Superimpose Control

Choose **Superimpose** from the **File** menu to display the Superimpose dialogue.



Superimpose dialogue

The **Superimpose Control** dialogue contains several controls to handle the superimpose function.

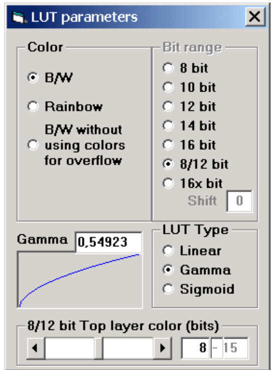
With the two push-buttons on the top of the Superimpose Control dialogue **FB → Top + File → Bottom** and **FB → Bottom + File → Top** a superimposed image can be created in one step. The current content of the frame buffer (current image) is transferred to one layer whereas the other layer is created using the data from a file.

With the push-button **FB → Top + File → Bottom** the current image is transferred to the top layer and the bottom layer is loaded from a specified file.

With the second push-button **FB → Bottom + File → Top** the current image is transferred to the bottom layer and the top layer is loaded from a specified file.

To specify the file which should be used as bottom or top layer image a file name must be entered into the text box below the corresponding push-buttons. The **Get** push-button on the right side can be used to select a file name out of a file list.

Use the LUT tool to change the brightness of the bottom image and **the 8/12 bit Top layer color** slider of the LUT parameter dialog to change the top image color settings.



LUT parameter dialogue

Example: A typical application of the superimpose function is present in the field of fluorescence microscopy. One wants to display an image of the illuminated sample showing the sample structure in detail together with an image of the fluorescence labeled parts.

The normal procedure for to get a superimposed image is as follows:

One first acquires the image with the illuminated sample and saves it to a file, using the **Save Image** command.

This file name has to be selected as file reference for the bottom layer by inserting the file name into the text box below the button **FB** → **Top + File** → **Bottom**.

Then acquire an image of the fluorescence light.

By pressing the push-button **FB** → **Top + File** → **Bottom** the superimposed image is created.

Average

Average is a function which is based on an image or profile sequence. Please see the chapter Averaging (page 243) for details.

Creating data for special purposes / Tools

Tools are dialogs which are used to create special data which is used inside the program for different purposes.

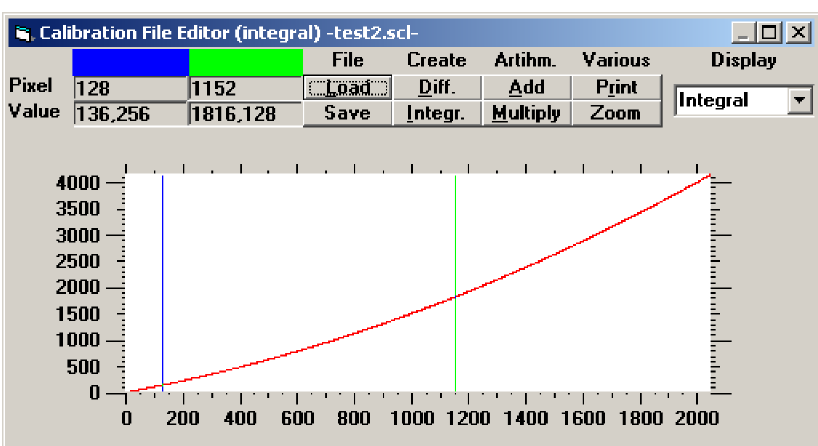
Calibration file editor

The calibration file editor tool is used to create, view and edit calibration files (tables).

Calibration files are files which contain floating point entries (old type calibration files contain 1024 or 1280 entries) in either ascending or descending order. They must be strictly monotonous. They are used to assign calibration information to the system. Please see also the Appendix Calibration File Format for details.

If you want to add new calibration tables, be sure to have the necessary data (polynomial coefficients) prepared.

Choose **Calibration File Editor** from the **Tools** menu to display the Calibration File Editor.



Calibration File Editor

It displays the values of the floating point numbers as a graphical curve. The display can be either integral or differential. If the display is integral the values themselves are displayed. If the display is differential the differences of neighboring values are displayed. One can look at values by moving a cursor to a special location. Additionally the dialog shows the filename (if any) in the caption, the pixel number of the actually displayed value, the value itself in numerical form, and an indication whether the display is integral or differential.

The dialog contains the following pushbuttons

Title	**Command**	**Function**
File	Load	Loads a calibration file into the memory and displays it.
	Save	Saves the current set of data to a calibration file on disk.
Create	Diff.	Opens a dialogue where a set of calibration data starting from a differential polynomial can be calculated.
	Integr.	Opens a dialogue where a set of calibration data starting from an integral polynomial can be calculated.
Arith	Add	Adds a value to the polynomial.
	Multiply	Multiplies the polynomial with a value.
Various	Print	Print calibration file data.
	Zoom	Adjusts the zoom in a way that the data is fully visible within the Calibration Files editor's window.

File Load loads a calibration file into memory and displays it. This function automatically checks whether the specified file is a valid calibration file or not.

File Save saves the current set of data to a calibration file on disk. It is only enabled when valid calibration data are defined.

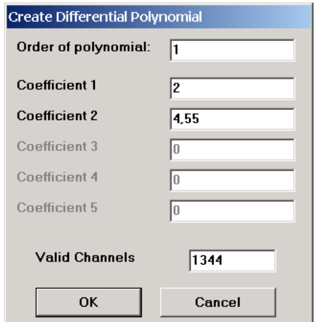
Create Differential Polynomial allows calculating a set of calibration data starting from a polynomial specifying the differences of data values.

$Diff = A0 + A1*i + A2*i^2 + ...$

A0: Coefficient 0
A1: Coefficient 1 etc.
An: Coefficient n (if the order of the polynomial is n)

If you push the **Create Diff.** pushbutton the dialogue **Create Differential Polynomial** is opened

To create a polynomial select the order of polynomial first. Then insert the coefficients. Finally press **OK** to confirm the data input.



Create differential polynomial

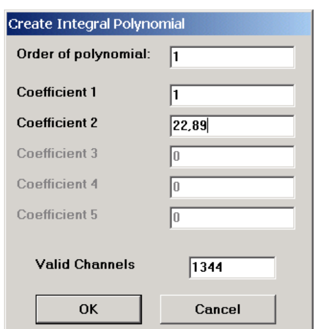
Create Integral Polynomial allows calculating a set of calibration data starting from a polynomial specifying the data values.

$$Value = \sum_{0}^{x} A0 + A1 \times i + A2 \times i^2 + \ldots$$

A0: Coefficient 0
A1: Coefficient 1 etc.
An: Coefficient n (if the order of the polynomial is n)

If you push the **Create Integr.** pushbutton the dialogue **Create Integral Polynomial** is opened

To create a polynomial select the order of polynomial first. Then insert the coefficients. Finally press **OK** to confirm the data input.



Create integral polynomial

The maximum polynomial order allowed is five for the integral and the differential polynomials.

Artih. Add Adds a value to the polynomial. If you click to the pushbutton Artih. A input box opens where the user can input a number. The number is added to the current values.

Artih. Multiply multiplies the polynomial entries with a value. If you click to the pushbutton Artih. Multiply an input box opens where the user can input a number. The polynomial entries are multiplied with this number.

A combo box labeled **Display** defines whether the calibration data is displayed in an integral (All items are displayed as they are) or a differential way (The difference of two adjacent entries is displayed).

By zooming with the right mouse button a part of the calibration data can be viewed

Defect pixel correction tool

The defect pixel correction function corrects defective pixel of a sensor by replacing them with not defective neighbors. The Defect pixel correction tool allows creating defect pixel data. See also the chapter Defect pixel correction tool for details.

Programming techniques

This topic deals with sophisticated programming techniques which can be used by expert users to extend the features of this software.

User function

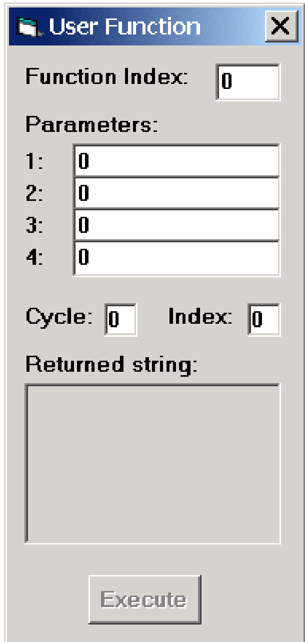
User function is a feature that allows the user to implement any own functionality at specific locations within HiPic E.g. control of other devices or online analysis of data.

General

When the **UserFunctions** option is checked, function calls to a DLL named CUSTOMER.DLL are enabled. With this option the user can implement his own control and data analysis functions into HiPic

Choose **User Function** from the **Processing** menu to display the User function dialogue.

This function is kept for compatibility reasons with elder versions.



User function dialogue

User function is a feature of HiPic which allows the user to implement his own routines into the system. When the option **User Functions** from the **Options** menu is selected, the system calls the function `UserFunction` within a DLL with the name CUSTOMER.DLL from various locations. The definitions of the Function `UserFunction` is given below:

```
int FAR PASCAL UserFunction(int iIndex, char far *
sStatusString, int iStringLen, char far *
sBackString, int nBackStringMaxLen, int far *
nBackStringLen, float ftPar1, float ftPar2, float
ftPar3, float ftPar4, int iCycleIndex);
```

A dummy DLL is already delivered with the distribution disk and can be used as a prototype to built user-specific functions. The function **`UserFunction`** is called from various locations from within HiPic e.g. before and after an acquisition. The dummy DLL contains a list of all locations from where the Function is called. The parameter `iIndex` indicates from which location within HiPic the call came (e.g. Start of Acquire, Live etc.)

Function Parameters

The meaning of the parameters is as follows:

Parameter	Meaning
`iIndex`	Location from where the call came
`sStatusString`	Status string indication information about the image
`iStringLen`	Length of the status string in bytes

`sBackString`	String which can be handled back to HiPic Under certain circumstances this string is appended to the comment area of the status string (see below).
`nBackStringMaxLen`	Maximum number of bytes for the string of `sBackString`
`nBackStringLen`	Length of the string handled back (must not be bigger than `nBackStringMaxLen`)
`ftPar1`	Parameter which can be handled to the Function*
`ftPar2`	Parameter which can be handled to the Function*
`ftPar3`	Parameter which can be handled to the Function*
`ftPar4`	Parameter which can be handled to the Function*
`iCycleIndex`	Cycle number (when the Function called from within the cycle, Index numbers 25, 26, 27 only)

*: The user has to input these parameters in the user function dialogue

Memory and Display parameters

- handled to the UserFunction with the sBackString parameter -

2,-1,0,0,1000,1018,0,0,1000,1018,0.25,3288,1688,
0 1 2 3 4 5 6 7 8 9 10 11 12

4,140,297,485,309,148176908,2097152,150274064,1048576,
13 14 15 16 17 18 19 20 21

123896328,1318,96622516,10340,LIVE (0),0,3
22 23 24 25 26 27 28

0: iBytesPerPixel
1: fDisplayOnVGA
2: areSource.iX
3: areSource.iY
4: areSource.iDX
5: areSource.iDY
6: areImgToDisplay.iX
7: areImgToDisplay.iY
8: areImgToDisplay.iDX
9: areImgToDisplay.iDY
10: ftZoom
11: FormImageDisplay.hwnd

12:	FormImageDisplay.PicImage.hwnd
13:	iROIType
14:	areROI.iX
15:	areROI.iY
16:	areROI.iDX
17:	areROI.iDY
18:	lDataHandle
19:	lDataBytes
20:	lDisplayHandle
21:	lDisplayBytes
22:	lStatusHandle
23:	lStatusBytes
24:	lScalingHandle
25:	lScalingBytes
26:	sFileName
27:	fDataSaved
28:	iPRFDirection

Notes:

areSource:	Coordinates of the stored image.
fDisplayOnVGA:	0=Image is not displayed, -1 is displayed on the VGA screen
areImgToDisplay:	Coordinates of the image which is display within the window FormImageDisplay.PicImage
ftZoom:	Zooming factor range: 0.25, 0.5, 1, 2, 4
FormImageDisplay.hwnd:	Handle of the Window containing the displayed image including caption, white areas and scroll bar.
FormImageDisplay.PicImage.hwnd:	Handle of the Window containing the image area (areImgToDisplay) only.
iROIType:	NONE =0, ZOOM = 1, ROIPOINT = 2, ROILINE = 3, ROIRECTANGLE = 4, ROIMODIFY = 5
areROI:	Area of the user specified ROI.
lDataHandle:	Memory is allocated with the GlobalAlloc function. To use the memory call lpvData=GlobalLock(lDataHandle) to unlock it call lpvData=GlobalUnlock(lDataHandle).
lDataBytes:	Number of Bytes allocated for the data.
LDisplayHandle, lDisplayBytes:	Same for Display data (8 bit per pixel)
LStatusHandle, lStatusBytes:	Memory area used to store the status string in the case another image is activated.
lScalingHandle, lScalingBytes:	1280 single (=float, 4 byte) values containing the scaling table, in the case table scaling is used
sFileName:	Name which appears in the image caption. In the case the image is saved it contains the full path of the file name.

fDataSaved:	0 if the image data is created or modified, -1 if the image is saved.
iPRFDirection:	Direction of the quick profile (HORINTEGRPROFILE = 2, VERINTEGRPROFILE = 3)

If the image does not exist (e.g. if the UserFunction is called prior to the acquisition) the sBackString is empty and iLenBackString=0.

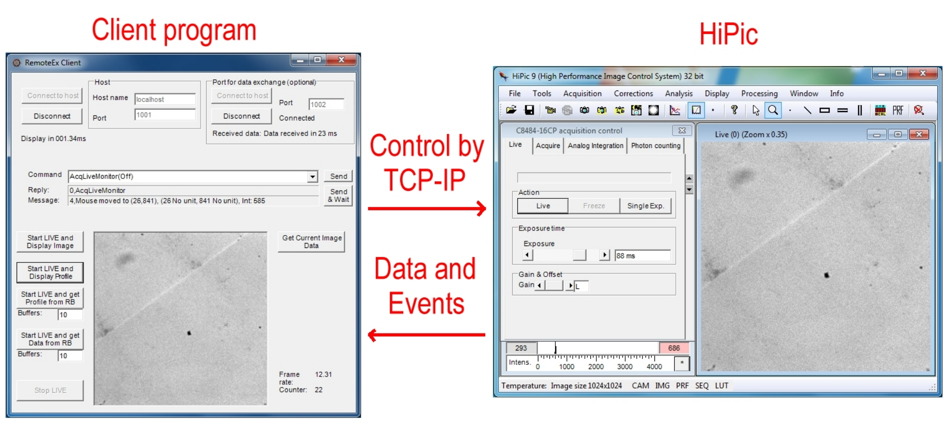
If the string exceeds 255 characters it will be truncated to 255 characters.

User Function Dialog

The **User function** dialogue can be used to check the DLL function. It allows to enter the function index and the 4 parameters and returns the Cycle number, the index number and the returned string. The 4 free parameters which are entered at the corresponding locations are always passed to the function independent whether the function is called from the User function dialogue or from within HiPic. These parameters can be used to rule specific behavior or the user function.

RemoteEx

RemoteEx allows to control the HiPic from another application via a text based communication which is exchanged by TCP-IP (see drawing). This allows to control the software from another application on the same computer or an application on another computer. The other application can also be based on a different operating system like UNIX or Linux provided this operating system is able to communicate via TCP-IP. See the "Remote Ex programmers Handbook" in your application directory for details.



Script programming

The RemoteEx program also allows running script files to generate easily automated measurement cycles. Please see the “Remote Ex programmers Handbook” for details.

Accessing the CCD camera directly

The RS232 command can be used to watch or send control commands to a camera which is controlled by a serial command I/F. This feature is operable if the serial commands are transferred to the camera by a Windows COM port or by a dedicated com port of the frame grabber (like the Camera Link frame grabbers) It is mainly intended for diagnostics purposes and should not be used under normal circumstances.

If you choose **RS232** from the **Info** menu the Communication dialogue appears.

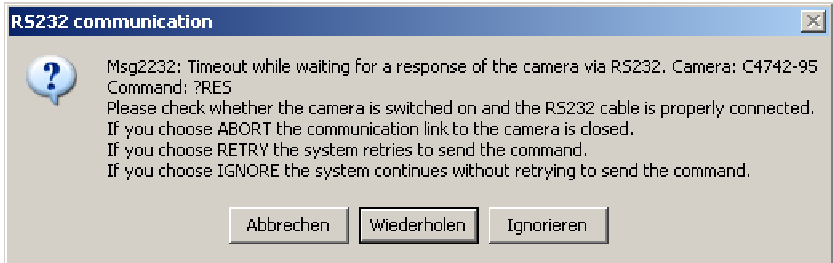
It shows the commands sent to the camera by the program and the response strings received from the camera.

Also, the user can send commands to the camera manually (see the camera manual for details on the commands and their syntax). To send a command, write your command into the text box **Command to send** and push the **Send** button. The received response string is displayed in the display box **Received string**.

As long as the input focus is at the RS232 dialogue the user no longer can see commands sent and strings received in the meantime (Otherwise the user's commands would be permanently overwritten by the system's commands and could not be entered correctly). Once the user sets the focus to another window the RS232 dialogue continues to display all system messages.

RS232 communication dialogue

If, at any time during program operation, there should be a time-out problem with the serial communication to the camera, the program will display the following **RS232 Timeout** dialogue.



RS232 Timeout dialogue

You can either select **Retry** to retry to communicate via RS232, **Continue** to continue the program without sending the command, or **Close** to close the communication link. When selecting **Retry** you can change to another COM port.

Appendix

Image file formats

The following describes the image file formats used in the program

ITEX image (*.img format).

This is one of the standard image formats (the other standard format is “Data to TIFF image”) which maintains the full information of all images and is compatible with all data processing functions of this program. If it is not intended to export image data to other programs, we recommend using this format.

Notes: If a camera with 16 bit data output is used, the image files will be saved in 16bit/pixel format. Images saved in the 32 bit data format can not be loaded in software versions lower than 6.1.

The .IMG file format used in HiPic is compatible to the ITEX format.

Bytes	Content
0-1	Characters IM
2-3	Comment length (byte)
4-5	Width of the image in pixels
6-7	Height of the image in lines
8-9	X-Offset
10-11	Y-Offset
12-13	File type:
	0=8 Bit, 1=Compressed (Not used), 2=16 Bit, 3=32 Bit

14-64	Reserved
64-nnn	Comment area containing the **status string**
nnn+1-End	Data Area (one or two bytes per pixel stored in row order from the top to the bottom of the image)

Note: If Table Calibration is used, the Calibration tables are stored after the end of this section. Please see the Appendix Status String Format for details.

TIFF format

***TIFF** (Tagged Image File Format) is a widely used image format and supported by most image-processing and word-processing software packages.*

The software also supports this file format. Two types of TIFF files can be generated.

TIFF images are stored using TIFF format version 6.0. When Calibration tables are used, these are appended to the normal data according to the status string which is saved in the comment tag.

Data to TIFF image

***Data to TIFF image** allows to save image data with full data depth in TIFF format. The file will contain **8 or 16 bit** data without the LUT transformation.*

Note: Though 16 TIFF files are true TIFF files according to their definitions, not many other programs support this relatively new data format yet. If you are not sure whether your image analysis program can handle these files try it and use standard TIFF, as generated with the **Display to TIFF image** in the case your program cannot handle them.

Images stored in 32 bit format will be saved in 16bit/pixel format. Most upper 16 bits are used. Lower bits are skipped.

Note: If the current image is part of a sequence, you have the choice to save the full sequence or only the current image.

Display to TIFF image

If ***Display to TIFF image is selected,*** *a (palletized)8 bit TIFF image will be saved.*

The function of this command is to create a TIFF file which **looks** exactly like the image which you see on the display screen, including contrast enhancement by the LUT. It does, however, **not** contain the full data bit depth of the image, and hence it should not be used to store measurement results for other than display purposes.

ROI overlay and QuickProfile will not be saved.

The TIFF image looks exactly like the image which you see on the monitor.

Note: If you want to load TIFF images within this program later on, always use the **Data to TIFF image** format.

Note: Display to TIFF will reduce the bit depth of the images!

If you want to store image data in another file format than IMG or TIFF, save them as TIFF first and use a graphic program (PhotoShop, Paint Shop Pro, Corel PhotoPaint) to convert the format.

Note: If the current image is part of a sequence, you have the choice, if you want to save the full sequence or only the current image.

ITEX Sequence

This command allows saving a sequence of images which has been previously recorded with the ***Sequence*** *function.*

You have to choose the name for the first image in the sequence. The system will ***automatically*** name all other images. Sub-areas of images (ROIs) can be selected.

Note: There are two naming conventions for naming a sequence: NAMEXXX.IMG and NAME.**XXX** where XXX is a numeric expression (e.g. 001).

Select the file format ITEX Sequence (*001.img) to save a sequence in the format NAMEXXX.img.

Select the file format ITEX Sequence (*.001) to save a sequence in the format NAME.XXX. **Note**: This format may not be supported in future versions of this program. It is only provided for compatibility reasons with older program versions!

TIFF Sequence

also supports TIFF file format for image sequences. Two types of TIFF file sequences can be generated:

Data to TIFF Sequence

Data to TIFF Sequence *allows to save image sequence data with full data depth in TIFF format. The files will contain **8 or 16 bit** data without the LUT transformation.*

Note: Though 16 bit TIFF files are true TIFF files according to their definitions, not many other programs support this relatively new data format yet. If you are not sure whether your image analysis program can handle these files try it and use standard TIFF, as generated with the **Display to TIFF Sequence** in the case your program cannot handle them.

Images stored in 32 bit format will be saved in 16bit/pixel format. Most upper 16 bits are used. Lower bits are skipped.

The sequence will be recorded in the naming convention NAMEXXX.tif.

Display to TIFF Sequence

If **Display to TIFF Sequence** *is selected**,** 8 bit TIFF files will be saved.*

The function of this command is to create a sequence of TIFF files which **look** exactly like the images which you see on the display screen, including contrast enhancement by the LUT. They do, however, **not** contain the full data bit depth of the original images, and hence this format should not be used to store measurement results for other than display purposes.

Note: If you want to load TIFF images within this program later on, always use the **Data to TIFF image** format.

The sequence will be recorded in the naming convention NAMEXXX.tif.

Note: Display to TIFF will reduce the bit depth of the images!

If you want to store image data in another file format than IMG or TIFF, save them as TIFF first and use a graphic program (PhotoShop, Paint Shop Pro, Corel PhotoPaint) to convert the format.

ASCII image

Image data can be saved in ASCII format. The data are stored without any header information. Each pixel data is separated by a TAB character. The end of each line is indicated by carriage return + line feed.

The data can not be read by this program. ASCII files can be read by many spreadsheet programs like Excel and data analysis programs like Origin.

The extension *.dat is used for indicating ASCII image files.

ASCII Sequence

Image sequences can be saved in ASCII format using this format. The data are stored without any header information. Each pixel data is separated by a TAB character. The end of each line is indicated by carriage return + line feed.

The data can not be read by this program. ASCII files can be read by many spreadsheet programs like Excel and data analysis programs like Origin.

The naming convention NAMEXXX.dat is used for this file format.

HIS image sequence file

The HIS format is used for image sequences acquired with the fast hard disk recording mode. A full image sequence is stored in one single file. Please refer also to.

Following is a detailed description of the HIS file format:

A) General

There are two types of headers (with almost identical format)

First header of every channel

Header describing all following images within a sequence

The content is:

1. First header of every channel

- Image format (width etc.)
- Channel number
- Number of images in the file
- Number of additional cannels
- Time stamp
- Marker
- Info about channel x (Comment string, variable length)

This header has variable length size (Length is determined by comment)

2. Header describing all following images within a sequence

- Image format (width etc.)
- Channel number
- Time stamp
- Marker

This header has variable length size (Length is determined by comment)

The header is always immediately followed by the data of one image.

B) Universal case

1. First header of every channel

Bytes	Content
0-1	Character IM
2-3	Comment length in Bytes (ComLen)
4-5	Width of the image in pixels (iDX)
6-7	Height of the image in lines (iDY)
8-9	X-Offset (iX)
10-11	Y-Offset (iY)
12-13	File Type 1=8bit, 2=16bit, 3=32bit, 6=12bit[1)], 11=24bit RGB, 12=48bit RGB, 13=96bit RGB (not used now), 14=36bit RGB[1)]
14-17	Number of images in this file for this channel (-1=unknown)
18-19	Number of additional channels in the file
20-21	Channel number
22-29	Time stamp of image 0 (double)
30-33	Marker
35-64	Additional information (can be used freely by the application)
64 to 64+ComLen-1	Comment area can contain any information. There is no restriction in lenght (except that a two byte variable is used for specifying the length). The HiPic/HPDTA stores a string in the format of an INI file and scaling tables here (if scaling is table type).

64+ComLen to 64+ComLen+DatLen -1	Data of image

2. Header describing all following images within a sequence

Bytes	Content
0-1	Character IM
2-3	Comment length in Bytes (ComLen)
4-5	Width of the image in pixels (iDX)
6-7	Height of the image in lines (iDY)
8-9	X-Offset (iX)
10-11	Y-Offset (iY)
12-13	File Type 1=8bit, 2=16bit, 3=32bit, 6=12bit[1)], 11=24bit RGB, 12=48bit RGB, 13=96bit RGB (not used now), 14=36bit RGB[1)]
14-17	=0

18-19	=0
20-21	Channel number
22-29	Time stamp of image 0 (double)
30-33	Marker
34-64	Additional information (can be used freely by the application)
64 to 64+ComLen-1	Comment area can contain any information. There is no restriction in lenght (except that a two byte variable is used for specifying the length). The HiPic/HPDTA stores a string in the format of an INI file and scaling tables here (if scaling is table type).

64+ComLen to 64+ComLen+DatLen -1	Data of image

Remarks:

[1)] 12 bit grayscale images and 36 bit RGB images are stored bit-packed with this setting

C) Standard case (one channel)

1. First header of every channel

Bytes	Content
0-1	Character IM
2-3	Comment length in Bytes (ComLen)
4-5	Width of the image in pixels (iDX)
6-7	Height of the image in lines (iDY)
8-9	X-Offset (iX)
10-11	Y-Offset (iY)
12-13	File Type 1=8bit, 2=16bit, 3=32bit, 11=24bit RGB, 12=48bit RGB, 13=96bit RGB (not used now), 14=36bit RGB
14-17	Number of images in this file (-1=unknown)
18-19	=0
20-21	=0
22-29	Time stamp of image 0 (double)
30-33	Marker
34-64	Additional information (can be used freely by the application)
64 to 64+ComLen-1	Comment area can contain any information. There is no restriction in lenght (except that a two byte variable is used for specifying the length). The HiPic/HPDTA stores a string in the format of an INI file and scaling tables here (if scaling is table type).

64+ComLen to 64+ComLen+DatLen-1	Data of image

2. Header describing all following images within a sequence

Bytes	Content
0-1	Character IM
2-3	Comment length in Bytes (ComLen)
4-5	Width of the image in pixels (iDX)
6-7	Height of the image in lines (iDY)
8-9	X-Offset (iX)
10-11	Y-Offset (iY)
12-13	File Type 1=8bit, 2=16bit, 3=32bit (not used now), 11=24bit RGB, 12=48bit RGB, 13=96bit RGB (not used now), 14=36bit RGB
14-17	=0
18-19	=0

20-21	=0
22-29	Time stamp of image 0 (double)
30-33	Marker
34-64	Additional information (can be used freely by the application)
64 to 64+ComLen-1	Comment area can contain any information. There is no restriction in lenght (except that a two byte variable is used for specifying the length). The HiPic/HPDTA stores a string in the format of an INI file and scaling tables here (if scaling is table type).

64+ComLen to 64+ComLen+DatLen-1	Data of image

Profile File Format

The format of the profiles files written by Hipic is as follows:

;"HiPic 6.2 Profile" 1.)

;"HiPic,5.0,1,4.0,3,6,3,3,373,3868,1,01-28-1994..." 2.)

;585,70,799,411 3.)

;342,0,3 4.)

;1,1.515152,"ps ","scal1 " 5.)

0,357.4605

1.515152,360.8232

3.030303,354.1535

4.545455,352.8047

1) Identification line (contains ;"HiPic 6.2 Profile").
2) Status string in "", preceded by semicolon.
3) Start and end position of the profiles in the form: StartX, StartY, EndX, EndY. For Integrated profiles it indicates the position of two opposite corners of the rectangle used for integration, preceded by semicolon.
4) Number of data points, X-Offset (always 0) and Profile Type:
   1=line, 2=Integrated horizontal, 3=Integrated vertical, preceded by semicolon.
5) Calibration Type (1=Linear, 2=Table), Calibration Factor (linear Calibration only), Unit in "", Calibration

file without extension (table Calibration only), preceded by semicolon.

6) Data in subsequent lines, as many lines as number of data
points. Format: X, Y value

Calibration File Format

Calibration files are used to provide nonlinear or special Calibration. They contain a list of floating point numbers (4 byte type, called float or single). Each number corresponds to one pixel on the chip. The Calibration file does not contain a unit nor the information for which direction the Calibration is applied. Calibration files must always have the extension **.SCL**. The floating point numbers must be strictly monotonous (ascending or descending), otherwise the file is not accepted by the system as a valid Calibration file. The format of the file is as follows:

Bytes 0-3	Value0
Bytes 4-7	Value1
Etc.	Etc,
Bytes n*4 - Bytes n*4+3	Value n

Note: The Calibration data is directly written to the image file if the Calibration type is table. The tokens ScalingXFile and ScalingYFile contains an address where the Calibration table is written in the file. An asterik „*“ or a plus „+“ indicates the address. The asterik indicates that the Calibration has 1024 entries, the plus indicates 1280 entries. If it contains e.g. the entry *473533 the Calibration data is written in the image file at an offset of 473533 bytes. The format #xxxxxxx,yyyy means the table with yyyy entries and address xxxxxxx.

DPC File Format

Dynamic photon counting images are saved in the DPC file format. In a DPC file the x-y coordinate of each photon and the time when it has been detected are recorded.

Bytes	Content
0-1	Characters IM
2-3	Comment length in bytes (ComLen)
4-5	Width of the image in pixels (iDX)
6-7	Height of the image in lines (iDY)
8-9	X-Offset (iX)
10-11	Y-Offset (iY)
12-13	File type: 2=16 Bit
14-64	Reserved
64-nnn	Comment area can contain any information. It is used by the program to store the status string and the Calibration tables (if any)
nnn+1-End	Data Area (Starts at address 64+ ComLen)

The **Data Area** looks like n times the following diagram, where there is one set of such data for every frame. The first entry is the time stamp relative to the origin in ms, followed by a the coordinates of all photons counted within this frame. The end of the data for the first frame is indicated by a delimiter (0xFFFFFFFF). This is repeated for all frames recorded.

Byte	Coordinates	Remark
00-03	Timestamp	Time in ms from first image (long int)
04-05	X0	Photon 0, X-Coord.
06-07	Y0	Photon 0, Y-Coord.
08-09	X1	Photon 1, X-Coord.
10-11	Y1	Photon 1, Y-Coord.
Etc.	Etc.	Etc.
Etc.	Etc.	Etc.
20-24	0xFFFFFFFF	Delimiter (Long int, all bits set to 1)

Status String Format

The status string is a string which is attached to an image and to profiles derived from an image. It contains all information about the image. The following is a sample string and the description of the different information. The status string contains only ASCII strings separated by comma.

The image status is saved as one string and it is organized like a *.INI file. It contains different sections where every section can contain tokens with assigned values. Other programs like remote control client programs or just any different image processing programs can add their own sections to save special data without disturbing the HiPic. It is, however, important to know that several of the entries in the status string are mandatory. Otherwise the file cannot read by the programs correctly. So be careful if you modify any of the tokens mentioned here. This is especially important for the Sections [Acquisition] and [DisplayLUT].

As an example we take the following status string (It was created when acquiring an image from the C7342-95 camera):

[Application],Date="06-03-2004",Time="16:03:46",Software="HiPic",Application=1,ApplicationTitle="High Performance Image Control System",SoftwareVersion="7.0.0",SoftwareDate="19.05.2004"

[Camera],AMD=N,NMD=S,EMD=E,SMD=N,ADS=12,SHT=150,FBL=1,EST=1,SHA=F,SFD=F,SPX=2,ATP=N,CEG=0,CEO=0,ESC=B,TimingMode="Internal timing",TriggerMode="Edge trigger",TriggerSource="BNC",TriggerPolarity="neg.",CCDArea="1280 x 1024",Binning="2 x 2",ScanMode="Normal",CameraName="C4742-95-12NRB",Type=7,SubType=7

[Acquisition],NrExposure=1,NrTrigger=0,ExposureTime=16 ms,AcqMode=1,DataType=3,DataTypeOfSingleImage=3,ShadingCorr=0,CurveCorr=0,areSource="0,0,1280,1024",areGRBScan="0,0,1280,1024",pntOrigCh="0,0",pntOrigFB="0,0",pntBinning="1,1",BytesPerPixel=2,BacksubCorr=0

[Grabber],ConfigFile="C:\32BitApp\HiPic32_700\PCDig.txt",Type=3,SubType=1

[DisplayLUT],EntrySize=3,LowerValue=0,UpperValue=4096,BitRange="12 bit",Color=3,LUTType=0,Gamma=1,First812OvlCol=1,Lut16xShift=0,Lut16xOvlVal=32767

[Scaling],ScalingXType=1,ScalingXScale=1,ScalingXUnit="No unit",ScalingXScalingFile="No scaling",ScalingYType=1,ScalingYScale=1,ScalingYUnit="No unit",ScalingYScalingFile="No scaling"

The name of every section is enclosed in brackets []. Every token is separated from it's value with a "=" character. The tokens are separated from each other with comma. After one section there can be a Carriage Return – Line Feed combination, but this is optional.

As an example we take the "SoftwareVersion" token with the "Application" section. It's value is "7.0.0". The value can be enclosed by quotes if necessary, but this is optional. Lets take the "EntrySize" token from the "DisplayLUT" section. It's value is "3" (But no quotes are used). When quotes are used the value can even contain commas like the "pntOrigCh" token within the "Acquisition" section. Section and token names are case sensitive which means "camera" and "Camera" are different.

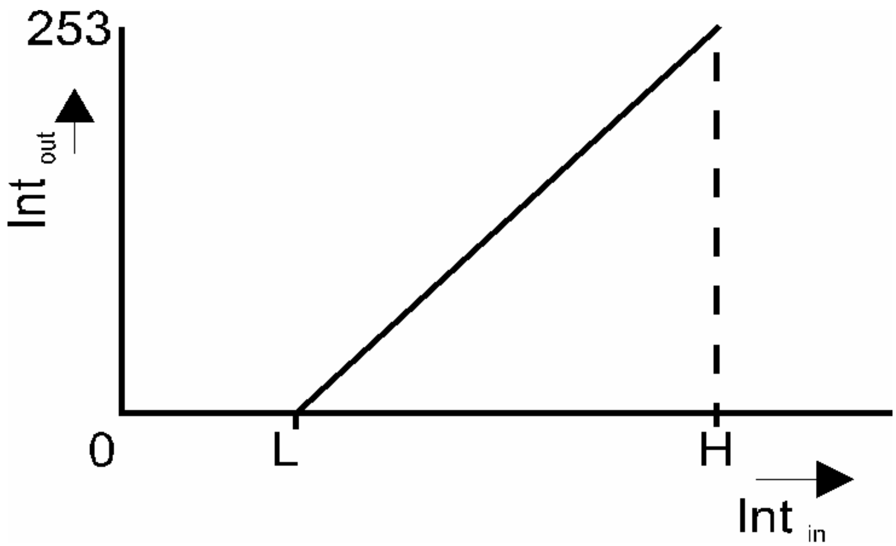
LUT

There are three types of LUT:

Linear LUT (default)

This LUT makes a linear grayscale transformation between the input image data and the displayed data.

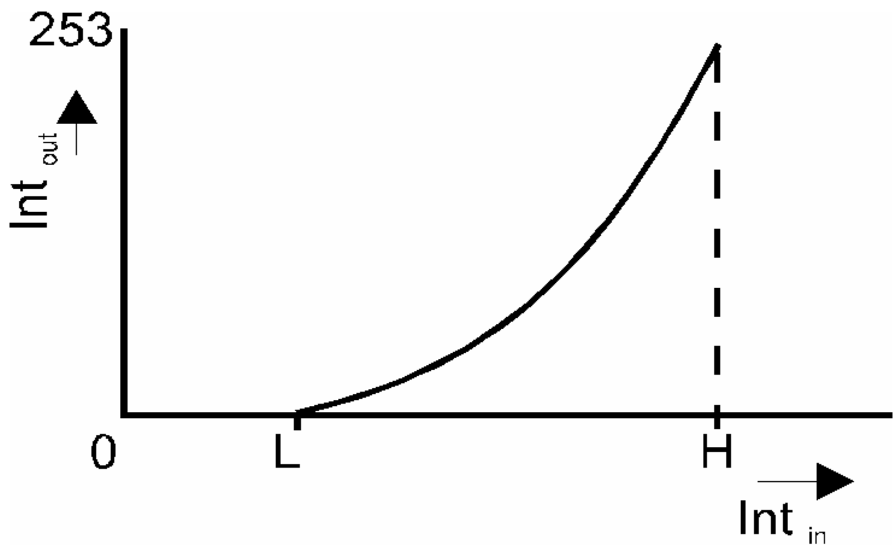
$$Int_{out} = \frac{Int_{in} - L}{H - L} * 253$$



Gamma LUT

This LUT makes a nonlinear grayscale transformation according to following algorithm:

$$Int_{out} = \left[\frac{Int_{in} - L}{H - L}\right]^{k} * 253$$



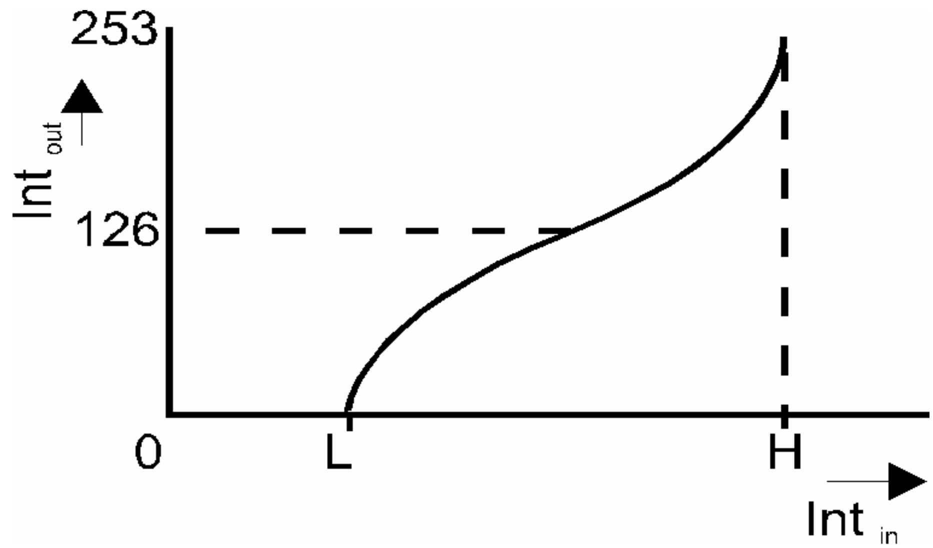
Sigmoid LUT

This LUT makes a nonlinear grayscale transformation according to following algorithm:

$$Int_{out} = \left[\frac{Int_{in} - L}{\frac{H-L}{2}}\right]^k *126$$ for $$Int_{in} < \frac{H-L}{2} + L$$

and

$$Int_{out} = 253 - \left[\frac{H - Int_{in}}{\frac{H-L}{2}}\right]^k *126$$ for $$Int_{in} \geq \frac{H-L}{2} + L$$



Error handler

Though the program is carefully designed, planned, coded, tested and debugged, software which exceeds a certain amount of code cannot be absolutely bug free in every circumstances and with all available parameter settings. As a consequence this program also may have certain bugs which are not detected during test but which may appear at customers site. To allow easy debugging and ensure program quality a powerful error handler has been established within this program. When a fatal error occurs the chain of function calls and other important data is written to a file before the program is ending. This file can be used to locate the origin of the error as quickly as possible.

When such an error occurs a message-box appears informing the user that such an error has appeared and all information has been written to the file **ERRORS. TXT** within the directory in which the programs EXE file is located. If such bug has occurred at your side please send this file to your local **Hamamatsu** dealer.

Glossary of Terms

Acquire Mode

A scanning mode of C4880 type cameras. In the C4880 terminology it is called "Slow Scan Mode". This mode allows to acquire single images with the highest possible quality.

Analog Contrast Enhancement

C4880 cameras and C4742 cameras have an analog contrast enhancement circuit built in. It allows to increase the analog amplifier gain (before the signal is digitized) and to subtract a analog offset signal. In case of C4880 cameras the enhancement function works in Live Mode only.
This function can be used to spread the contrast of an image within a desired intensity range.

Analog Video Camera

In this manual standard video cameras, which offer an analog video output signal according to RS 170 or CCIR (System B) standard are called "Analog video cameras". Hamamatsu offers for example the types C3077 (2/3"), C5405 (½") and C 5403 (1/3").

Background Subtraction

Subtraction of a background image from an acquired image. The background image is typically a image acquired under complete darkness. This image contains the camera readout noise, dark current and offset signals. Sometimes this function is called "Dark subtraction" or "Dark current subtraction".

Binning Mode

A special readout mode of C4880 and C4742 cameras. Already in the camera the charges from a predefined number of pixel is accumulated. The accumulated charge signal is then digitized and read out. Binning allows to get a higher camera sensitivity and reduce the amount of data. Of course this function works in expense of spatial resolution.

Current image

The image window which is the active window, or which was the last active image window before another (non-image) window was opened.

DCAM, DCAM driver

DCAM driver are unified software drivers supplied for most of the cameras. The Hamamatsu DCAM driver concept allows to change easily between different camera and interface versions.

DDE

Dynamic data exchange. This function allows to send measurement data automatically to another program (like Excel), where they can be further processed. DDE is supported for export of profile and 3-D analysis data.

Fast Scan Mode

Same as Live mode.

High Precision Scan Mode

Same as Acquire mode.

IC-PCI

Frame grabber board with PCI bus. Different versions are available: 2M/DIG with 2 MByte frame memory for digital input signals, 2M/VS with 2MByte frame memory for analog video signals and 4M/DIG with 4 MByte frame memory for digital input signals.

Interlaced

A way of image data readout from standard analog video cameras. One image (frame) is read out as two fields.

Live Mode

A mode to acquire and display images continuously. This mode is available for all cameras. In case of C4880 type cameras, the camera is switched to the fast readout mode.

LUT (Look up table)

A conversion table which is internally calculated to convert intensity values. It can be used to convert black and white images into pseudocolor images or to make contrast enhancement.

Menu Bar

Main application control window. From this window you can control all sub-menus and commands.

Photon Counting

A special image processing mode which can be used in combination of image intensifier with C4880, C4742 or Analog video cameras. If the gain of the intensifier is high, single photon events can be detected by the camera as a relatively bright spot. The photon counting function can process these images and record each spot a single photon event. This mode allows to accumulate low light level images with best signal to noise ratio and highest sensitivity.

Realtime background subtraction

A background image is continuously subtracted from images acquired in Live mode. This function is usefull to subtract mottle images or dark current images.

ROI

A Region Of Interest (ROI) is a part of the image which was selected by the user using the ROI definition tools

Calibration

If physical dimensions are assigned to images or profiles, we call it scaling (for example µm or m, wavelength etc.). The scales may be of linear or non-linear type.

Scanning mode

The C4880 allows to work with two different scanning modes. Fast scanning mode is mainly applicable for image adjustment (focusing), while the high precision mode is used for precise image acquisition. In HiPic the fast scanning mode is called "Live mode" and high precision mode is called "Acquire mode"

Sequence

The Sequence function allows to automatically record large numbers of image and/or profile data, stored either in RAM or on hard disk.

Shading Correction

A uneven image brightness is called shading. It can be corrected by multiplying each pixel of an image by a correction factor. Typically the correction factors are obtained from an reference image.

Subarray Readout Mode

A readout mode of C4880 cameras. Only a user-predefined area of the CCD is read out. This function can be used to reduce the amount of data and speed up the readout, if only a part of the image is necessary for analysis.

Superimpose

A image processing function to overlay two images.

Super Pixel Mode

A special binning mode where a square number of pixel is binned (e.g. 2 x 2, 4 x 4). This function can be used to increase camera sensitivity, increase the readout rate (frame rate) and reduce the amount of data.

TIFF

Image file format. TIFF is widely used as image format. Most application programs can import TIFF files.

User Functions

In order to extend the functionality of the program to users needs, it is possible to call user-programmed DLL functions from many locations within the program, especially within the acquisition procedures. These function calls are called user function calls.

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