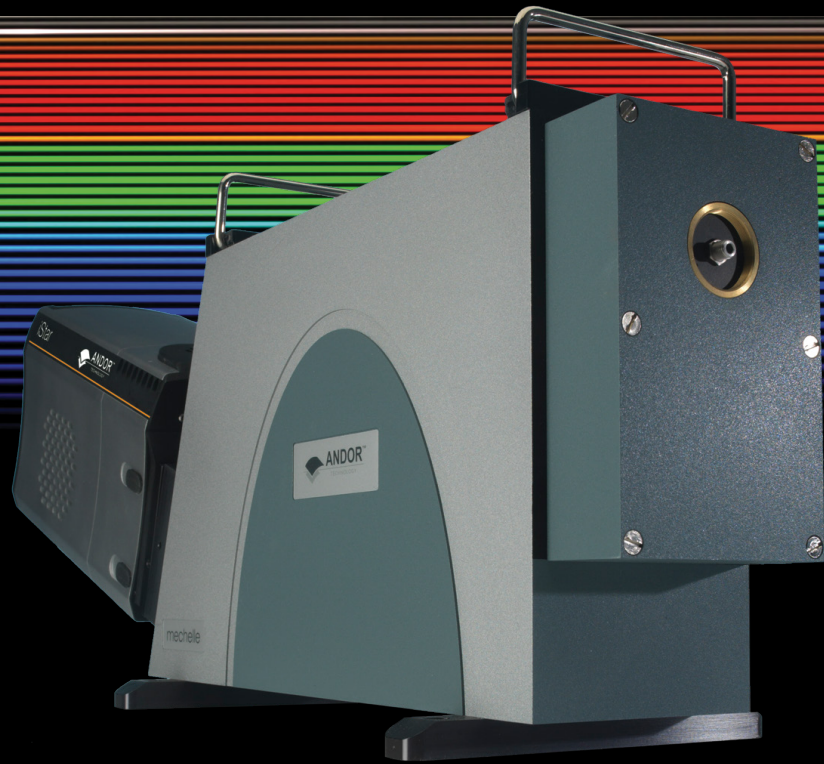


Mechelle

VERSION 4.2 REVISED 06 OCT 2020



User Guide

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REVISION HISTORY

Version	Released	Description
1.0	12 Nov 2004	Initial Release
2.5	30 Sep 2005	-
2.6	21 Aug 2006	-
3.0	21 Jul 2011	-
3.1	31 Jul 2011	-
3.2	13 Dec 2011	-
4.0	07 Feb 2017	Updated to current format (all sections revised) Information updated for USB camera models.
4.1	27 Feb 2020	Updated laser safety information.
4.2	06 Oct 2020	Updated laser safety information.

FUTURE VERSIONS OF THE MANUAL

Changes are periodically made to the product and these will be incorporated into new editions of the manual. New versions of Andor manuals are made available through MyAndor <http://my.andor.com/login.aspx> so please check for new versions of the manual. If you do not have an account please register at <http://my.andor.com/Register.aspx>. If you find an error, or can suggest an improvement to this manual, please contact Andor Customer Support with details of the issue.

SAFETY AND WARNING INFORMATION

**PLEASE READ THIS INFORMATION FIRST**

1. **IMPORTANT:** This product may come with the optional CC52 Collector/Collimator with Alignment Laser, which emits laser radiation that is potentially hazardous, so please read the laser safety information following this section very carefully.
2. IEC Technical Document IEC TR 60825-14 recommends the presence of a Laser Safety Officer (LSO) depending on the laser class. However, national guidelines should be referred to.
3. Ensure that the 'Working with Optical Fibres' guidelines in this user guide is followed as these are easily damaged.
4. To ensure correct and safe operation of this product, please read this guide before use and keep it in a safe place for future reference.
5. If the equipment is used in a manner not specified by Andor, the protection provided by the equipment may be impaired.
6. Before using the system, please follow and adhere to all warnings, safety, manual handling and operating instructions located either on the product or in this guide.
7. The Mechelle a is a precision scientific instrument containing fragile components. Always handle with care.
8. This product is not designed to provide protection from ionising radiation. Any customer using this product in such an application should provide their own protection.
9. The Andor Mechelle is for use in research laboratories and other controlled scientific environments.
10. This equipment has not been designed and manufactured for the medical diagnosis of patients.
11. Do not expose the product to extreme hot or cold temperatures.
12. Do not expose the product to open flames.
13. Do not allow objects to fall on the product.
14. Do not expose the product to moisture, wet, or spill liquids on the product. Do not store or place liquids on the product. If spillage occurs on the product, switch off power immediately and wipe off with dry, lint-free cloth. If any ingress has occurred or is suspected, unplug mains cable, do not use, and contact Andor service.
15. There are no user-serviceable parts in the product. If the enclosure is opened the warranty will be void.
16. Only use accessories that have been specified and approved for use with this product by Andor.

MANUAL HANDLING

Due to the delicate nature of some of the components within, care must be exercised when handling this product. Proper manual handling techniques are important when unpacking and installing the system to ensure that the integrity of the product is safeguarded and individuals involved are not exposed to unnecessary manual handling risks, such as:

- Lifting a load that is too heavy
- Poor posture or technique during lifting
- Dropping a load
- Lifting objects with sharp edges

SHIPPING AND STORAGE CONDITIONS

Unpacking and Inspection:

- Carefully unpack the unit and retain packaging to return equipment for servicing.
- If the equipment appears damaged in any way, return it to sales outlet in its original packaging. No responsibility for damage arising from the use of non-approved packaging will be accepted.
- Ensure all items and accessories specified in the packing list are present.

If any items are missing, please contact your local sales representative.

SPECIAL WARNINGS ABOUT LASERS

CAUTION – USE OF CONTROLS OR ADJUSTMENTS OR PERFORMANCE OF PROCEDURES OTHER THAN THOSE SPECIFIED HEREIN MAY RESULT IN HAZARDOUS RADIATION EXPOSURE

- This product includes lasers, or is designed to be upgraded with lasers, so you must be aware of the hazards associated with the use of the powerful laser radiation that can be emitted by this product
- Laser radiation differs from ordinary light primarily because its optical power can be concentrated into a narrow, low-divergence beam, whereas, for example, a standard light bulb diffuses its light in all directions and thus spreads out its power. It's a bit like the difference between walking outside on a sunny day versus having the sun's light concentrated on your skin using a magnifying glass
- Skin damage or deeper injury can be caused by lasers, but the eye is especially susceptible as laser light can be collimated into a narrow beam that can enter the eye and permanently damage the retina with life-changing consequences.
- Be aware that visible laser light is dangerous as well as invisible, that this laser product is not fully safe as you usually have access to hazardous laser radiation. Laser safety for this type of product is about reducing risk, rather than being able to eliminate it because access is required for the performance of this product
- Andor strongly recommend that all facilities have an established system for the safe use of lasers as per their national regulations and occupational health and safety legislation. *IEC TR 60285-14 Safety of laser products – Part 14: A user's guide* and the *American National Standard for the Safe Use of Lasers (ANSI Z136.1)* are standard references for good practice

USE OF THE OPTIONAL CC52 COLLECTOR/COLLIMATOR WITH ALIGNMENT LASER

The intended use of this laser product is only when the Laser Module is connected into the CC52 Collector/Collimator (see Section 2.4). The Laser Module should only be powered when fully assembled in this configuration to reduce the exposure to laser radiation. The Laser Module by itself and the Laser Module when connected just to the fibre should not be powered as the laser output in these two scenarios is unnecessary and is greater than that emitted by the CC52 Collector/Collimator.

If cleaning, assembling or disassembling this equipment, ensure that the power is disconnected.

GUIDELINES FOR THE SAFE OPERATION OF LASER PRODUCTS

Please note that not all of the following guidance may apply to your product, e.g. you may not have invisible lasers.

1. Never look into a laser beam either directly or indirectly.
2. Read the safety instructions supplied with all equipment in the system.
3. Ensure that the laser equipment is used in accordance with national guidelines.
4. Ensure all personnel requiring access to the product are fully trained in both using the product and the general use of lasers.
5. Ensure users are familiar with the hazardous properties of lasers, especially that laser safety hazards differ from those of normal light/radiation sources as they are highly-concentrated, very low divergence beams of radiation.
6. Ensure end-users are familiar with the operation of the laser's key switch control, interlocks, emission LEDs and other safety features.
7. Restrict and control access to the area(s) where laser(s) are in use to those persons who are trained in the dangers of lasers and trained on the safety precautions to be observed when working with lasers.
8. Ensure that all interlocks are connected and functioning correctly, where applicable.
9. Ensure suitable laser warning signs are prominently displayed in the area the system operates.
10. If the system is not in use, turn the laser off using the key switch, where applicable.
11. Do not attempt to disassemble the unit housing the lasers or any part of the system. If there is a problem please contact Andor directly (see Section 1.1, 'Technical Support').
12. On a daily basis, or before every use, verify that the laser interlock circuit (if applicable) is working by confirming that the laser emission indicator on the source(s) turns off when any of the following are done:
 - The microscope ocular eyepieces are activated/engaged for viewing.
 - The articulated transmitted light arm on inverted microscopes is tilted back from the functional vertical position before using the system.
 - Each beam splitter is removed from the unit.
 - Any other interlocks on your system.
13. Fluorescent cards should be used to visually locate and indicate the output of invisible wavelengths at all times, where applicable.
14. Additional precautions may need to be implemented as the necessary precautions will be specific to each system installation, configuration and typical mode of use. The responsible Laser Safety Officer must assess and implement the necessary precautions to avoid possible exposure to hazardous radiation during use.
15. We recommend that a copy of the latest edition of *IEC 60285-1 Safety of laser products – Part 1: Equipment classification and requirements* is purchased by the Laser Safety Officer for reference, as well as *IEC 60825-14 Safety of laser products – Part 14: A user's guide*.

LASER CLASS PRACTICAL DIFFERENCES

The practical differences between the main classes are as follows as defined in IEC 60825-1 Annex C and Table F.2:

Class	Overview*	Eye	Diffuse Reflections	Skin	Fire	Hazard Detail †
1	Safe under reasonably foreseeable conditions	Safe	Safe	Safe	Safe	Laser products that are safe during use, including long-term direct intrabeam viewing, even when exposure occurs while using telescopic optics.
2	Low power; eye protection normally afforded by aversion & active responses	Safe momentarily, due to natural aversion behaviour, i.e. you will close your eye lids and look away	Safe	Safe	Safe	Laser products that emit visible radiation that are safe for momentary exposures but can be hazardous for deliberate staring into the beam. The time base of 0,25 s is inherent in the definition of the class and presumption is that there is very low risk of injury for momentary exposures that are somewhat longer.
3R‡	Direct intrabeam viewing may be hazardous	Not considered intrinsically safe	Safe	Safe	Safe	Not considered intrinsically safe, the risk is limited because – unintentional exposures would rarely reflect worst-case conditions of (e.g.) beamalignment with a large pupil and worst-case accommodation with the entire beam energyentering the eye, – of the inherent reduction factor (safety margin) in the MPE, – of natural aversion behaviour for exposure to bright light for the case of visible radiationand by the response to heating of the cornea for far infrared radiation.The risk of injury increases with exposure duration, and exposure may be hazardous for ocular exposure under worst-case conditions or for intentional direct intrabeam viewing.

Class	Overview*	Eye	Diffuse Reflections	Skin	Fire	Hazard Detail †
3B	Direct intrabeam viewing normally hazardous, i.e. direct viewing of beam with eye	Hazardous	Normally safe	Lasers which approach the Class 3B AEL may produce minor skin injuries. However, this is only likely if the beam has a small diameter or is focussed.	Risk of igniting flammable materials for same lasers mentioned under "Skin"	Laser products that are normally hazardous when intrabeam ocular exposure occurs (i.e. within the NOHD) including accidental short time exposure
4	High power; diffuse reflections may be hazardous	Hazardous	May be hazardous	Hazardous	Often represent a fire hazard	Everything above Class 3B

* See IEC 60825-1 Table F.2

† See IEC 60825-1 Annex C

‡ CDRH Class IIIa is almost identical to Class 3R and 21CFR § 1040.10 (b) (8) describes the hazard as “depending upon the irradiance, either an acute intrabeam viewing hazard or chronic viewing hazard, and an acute viewing hazard if viewed directly with optical instruments”.

The following terms are defined as follows:

- **Intrabeam ocular exposure:** Getting your eye in the way of a laser beam.
- **Nominal Ocular Hazard Distance (NOHD):** Distance from the output aperture beyond which the beam irradiance or radiant exposure remains below the appropriate corneal maximum permissible exposure (MPE).
- **Accessible Emission Limit (AEL):** Maximum accessible emission permitted within a particular class, i.e. the limit at which one class transitions into another.
- **Maximum Permissible Exposure (MPE):** Level of laser radiation to which, under normal circumstances, persons may be exposed without suffering adverse effects.

LASER PRODUCT SAFETY STANDARDS

If your product contains lasers, it has been designed and manufactured to comply with the international laser product safety standard IEC 60825-1 and the U.S. CDRH Regulation 21CFR § 1040.10 to reduce risk as far as is reasonably practicable. Our Customer Support Team, where applicable, install the system according to the same standards, but if there has been an agreement that you should install all or part of the laser product system, then you take responsibility to install this according to the same standards.

EYE PROTECTION

Eye Protection is not required for the safe use of the device as the only radiation observable (without intentional misuse) is directionally stable, diffuse and highly divergent from the designated aperture which is static and labelled.

If eye protection is deemed desirable by the local Laser Safety Officer, Andor recommends the following products:

- 360 nm to 510 nm – Kentek KXP-4001 Spectacles
- 510 nm to 670 nm – Kentek KRA 6702 Spectacles

WORKING WITH OPTICAL FIBRES

1. Only service personnel authorised by Andor should remove or inspect fibres as these are part of the installed protective housing
2. The laser radiation passing through fibres is potentially hazardous, so great care should be taken to avoid exposure to this radiation
3. Ensure fibre cables are not bent tightly or general mishandled as this may damage the internal optical fibre
4. Ensure that the minimum bend radius is never exceeded when handling, which is recommended to be 300 mm
5. For transport or storage, fibre cables should be coiled with a diameter of 300 mm or greater
6. Optical fibres are prone to damage by bending local to the connector
7. The coupler is not designed to withstand pulling of the fibre. If the fibre is pulled, the system performance could be compromised or the system may fail
8. Locate the laser source and any other connected devices within 2 m of each other so that the interconnecting fibres are not stretched, bent, or constrained

LASER SAFETY AND PRODUCT COMPLIANCE LABELS

GENERAL SYMBOLS



WARNING: Laser Radiation



This product meets the requirements of the applicable CE-marking directives of the EU

ME-OPT-0007 COLLIMATOR/COLLECTOR LASER SAFETY LABEL



LASER APERTURE

Note that as this is a Class 2 product, the laser aperture isn't marked as stated in IEC 60825-1 § 7.8; however, it should be clear that the laser is emitted from the large opening to the left of the "starburst" laser safety warning symbol.

LASER CLASSIFICATION AND WARNING

This is a Class 2 product that will harm your eyes if you stare into it. See section on 'Laser Class Practical Differences' above. Do not stare into the beam.

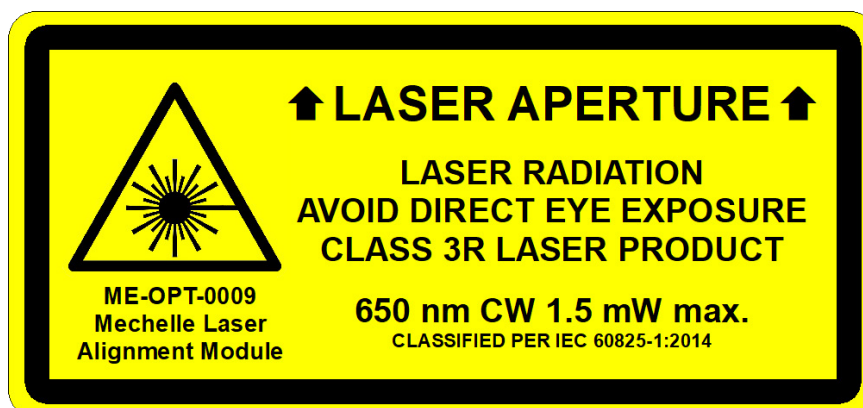
RADIATION OUTPUT

The 'maximum output' defined by IEC 60825-1 § 3.58 and § 7.9 is "the maximum accessible emission that is used to determine the class of the laser product". Note that this is as measured using a 7 mm aperture stop at 100 mm from the accessible aperture of the collimator as per Condition 3, which simulates eye exposure. However, the total optical power right at the output of the collimator is equal to the Classification Radiation Output marked on this product.

STANDARDS INFORMATION

IEC 60825-1:2014 has been used to determine the classification of the product and to provide the Radiation Output marked on the product.

ME-OPT-0009 LASER ALIGNMENT MODULE SAFETY LABEL



LASER APERTURE

The indicated position of the Laser Aperture is where the laser is emitted from this product.

LASER CLASSIFICATION AND WARNING

This is a Class 3R product that could harm your eyes if they are exposed to the beam. See section on 'Laser Class Practical Differences' above for more details. Avoid direct eye exposure to the laser beam.

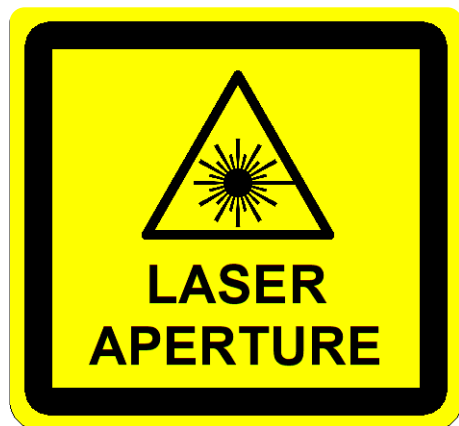
RADIATION OUTPUT

The 'maximum output' defined by IEC 60825-1 § 3.58 and § 7.9 is "the maximum accessible emission that is used to determine the class of the laser product". Note that this is as measured using a 7 mm aperture stop at 100 mm from the accessible aperture of the module as per Condition 3, which simulates eye exposure. However, the total optical power right at the output of the module will be higher, typically 5.35 mW at the closest point of human contact.

STANDARDS INFORMATION

IEC 60825-1:2014 has been used to determine the classification of the product and to provide the Radiation Output marked on the product.

ME-OPT-0009 FIBRE OUTPUT LASER APERTURE SAFETY LABEL



As the fibre can be disconnected from the ME-OPT-0007 Collimator/Collector, laser radiation can be emitted from the output, so it is labelled as a 'Laser Aperture'. Although the output would be classified as Class 2 because it is typically 0.15 mW under IEC 60825-1 Condition 3, this is superfluous as it is attached to a Class 3R product, the Laser Module. Note the total optical power right at the output of the fibre is higher, typically 1.65 mW.

CDRH CERTIFICATION LABEL

This self-certifies that we comply with the U.S. CDRH laser regulations.



Manufactured by
Andor Technology Ltd
Belfast BT12 7AL U.K.
www.andor.com

Complies with 21 CFR
1040.10 and 1040.11
except for conformance
with IEC 60825-1 Ed. 3.,
as described in Laser
Notice No. 56, dated May
8, 2019

SECTION 1: INTRODUCTION

Thank you for choosing the **Andor Mechelle**, which offers several innovations to the spectroscopist. The Andor Mechelle spectrograph is based on the echelle grating principal and has a patented optical design, which gives extremely low cross-talk, equally spaced order separation and maximum resolution, compared with other spectrographs. The Mechelle offers a simultaneously recorded wavelength range from UV to NIR with very high resolution and no overlapping wavelengths.

- The Mechelle features patented, corrected off-axis optics enabling the user to achieve maximum throughput and optimum Gaussian line shape and resolution. This translates to a wide wavelength range from the deep UV through to NIR, with full spectral continuity, no gaps and no overlapping wavelengths. You get the whole spectrum in one single acquisition. The maximum wavelength range is set by the detector sensitivity and the low wavelength limit is set by the absorption of air.
- The spectrograph has a rugged compact design with no moving parts, enabling the Mechelle spectrograph to withstand more physical handling than other high performance spectrographs. This makes the Mechelle an ideal spectrograph for OEMs and non-lab based applications, from zero gravity experiments to operation in high temperature environments. The unit can also be evacuated for working in the deep UV.
- Andor have utilised many years experience in spectroscopy to deliver a software platform designed for spectroscopists. The Solis software allows direct control over spectrograph functionality. A user-friendly on-screen dashboard allows the user to acquire data, calibrate spectral displays, and manipulate post acquisition data. The speed of the system is only dependent on the integration time, readout rate of the camera and the PC capabilities.
- The Andor Solis software is also compatible with other spectroscopic data analysis like GRAMS/AI. Mechelle spectrographs are integrated with CCD, sCMOS or ICCD detectors from Andor Technology, which enables the user to rapidly obtain accurate data. This makes the Mechelle spectrograph highly attractive to many spectroscopic applications like Laser Induced Breakdown Spectroscopy, Raman spectroscopy or Laser ablation.

1.1 TECHNICAL SUPPORT

If you have any questions regarding the use of this equipment, please contact the representative* from whom your system was purchased, or:

Europe

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Beijing,
100089
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Fax. +86 (0) 10 5884 7901

* The latest contact details for your local representative can be found on the [Contact and Support](#) page of our website.

1.2 DISCLAIMER

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1.3 COPYRIGHT AND PROTECTIVE NOTICES

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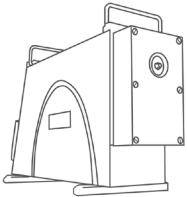
The publication of information in this documentation does not imply freedom from any patent or proprietary right of Andor Technology Ltd. or any third party.


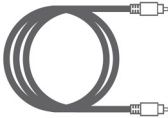


1.4 TRADEMARKS AND PATENT INFORMATION

Andor and the Andor logo are trademarks of Andor Technology Ltd. Andor Technology Ltd. is an Oxford Instruments company. All other marks are property of their owners. Changes are periodically made to the product and these will be incorporated into new editions of the manual.

1.5 SUPPLIED COMPONENTS

The Andor Mechelle is supplied with the following standard components:

Description	Quantity
 Mechelle 5000 echelle spectrograph	1

Description	Quantity	Description	Quantity
 I ² C, shutter and temperature cable	1	 50 µm core, UV-enhanced fibre optic cable (ACC-ME-OPT-8004)	1 x 2m
 SMA adapter (and insertion tool)	1	 Solis or Mechelle SDK-Software (if ordered)	-

NOTE: Refer to Camera Specifications sheet for parts supplied with the specific camera model.

Slit type and model, and optional shutter are ordered separately.

1.5.1 OPTIONAL COMPONENTS

Optional and replacement parts are listed below:

Description	Order Code
Mercury-Argon calibration lamp with SMA connector	ACC-LK-HGAR-OCE
Deuterium-Halogen lamp, radiometrically calibrated (230 to 1,050 nm)	LK-DHRD-OCE-CAL
UV-NIR light collector/collimator with alignment laser for F/# = 2 collection	ME-OPT-0007
Mechelle shutter unit (recommended when using iKon-M DU934P-yy-9FL)	ME-SHT-9002
Mechelle 25 x 25 µm slit	ME-SLT-25x25
Mechelle 10 x 50 µm slit	ME-SLT-10x50
Mechelle 50 x 25 µm slit	ME-SLT-50x25
Mechelle 25 x 50 µm slit	ME-SLT-25x50
Mechelle 50 x 50 µm slit	ME-SLT-50x50
Mechelle 100 x 50 µm slit	ME-SLT-100x50
Mechelle 200 x 50 µm slit	ME-SLT-200x50

SECTION 2: PRODUCT OVERVIEW

2.1 EXTERNAL COMPONENTS OF THE MECHELLE

This section outlines the main components and features of the Mechelle.

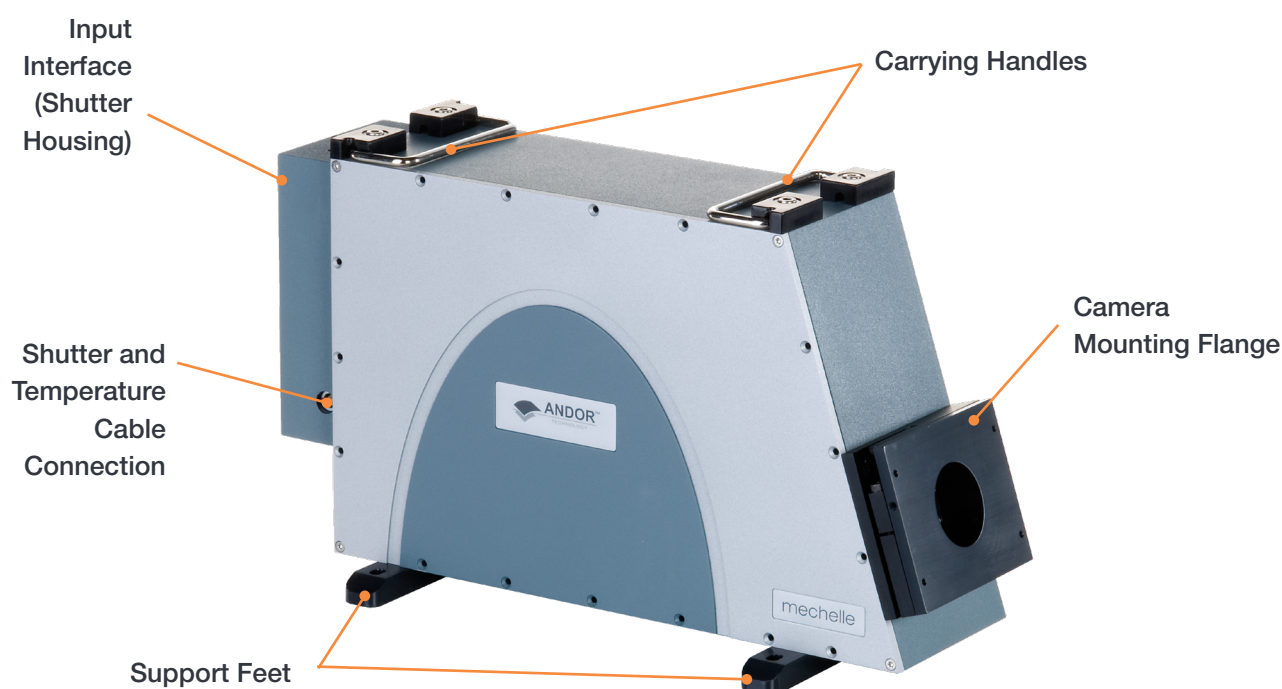


Figure 1: The Mechelle spectrograph

Input Interface (Shutter Housing)

For coupling to optical source via a fibre-optic and/or slit. A shutter can be built into the housing as an option (e.g. for CCD cameras to avoid image smearing during readout or for ICCD cameras to take background or protect the photocathode between experiments).

Shutter Cable Connection

For connection of the temperature sensor and optional shutter to the detector.

Carrying Handles

Two handles can be used to transport the Mechelle and fold down when not in use.

Camera Mounting Flange

For connection to camera e.g. Andor iStar CCD or sCMOS (4 off, 6/32 x 3/8 UNC).

Support Feet

Two support feet provide a stable platform for the Mechelle. These can be secured to an optical bench or removed.

2.2 INTERNAL COMPONENTS OF THE MEHELLE

The main internal parts of the Mechelle are summarised below (refer to Appendix B for the principles of operation and also www.andor.com/learning-academy/echelle-spectrographs-a-flexible-tool-for-spectroscopy-raman-and-libs-spectroscopy).

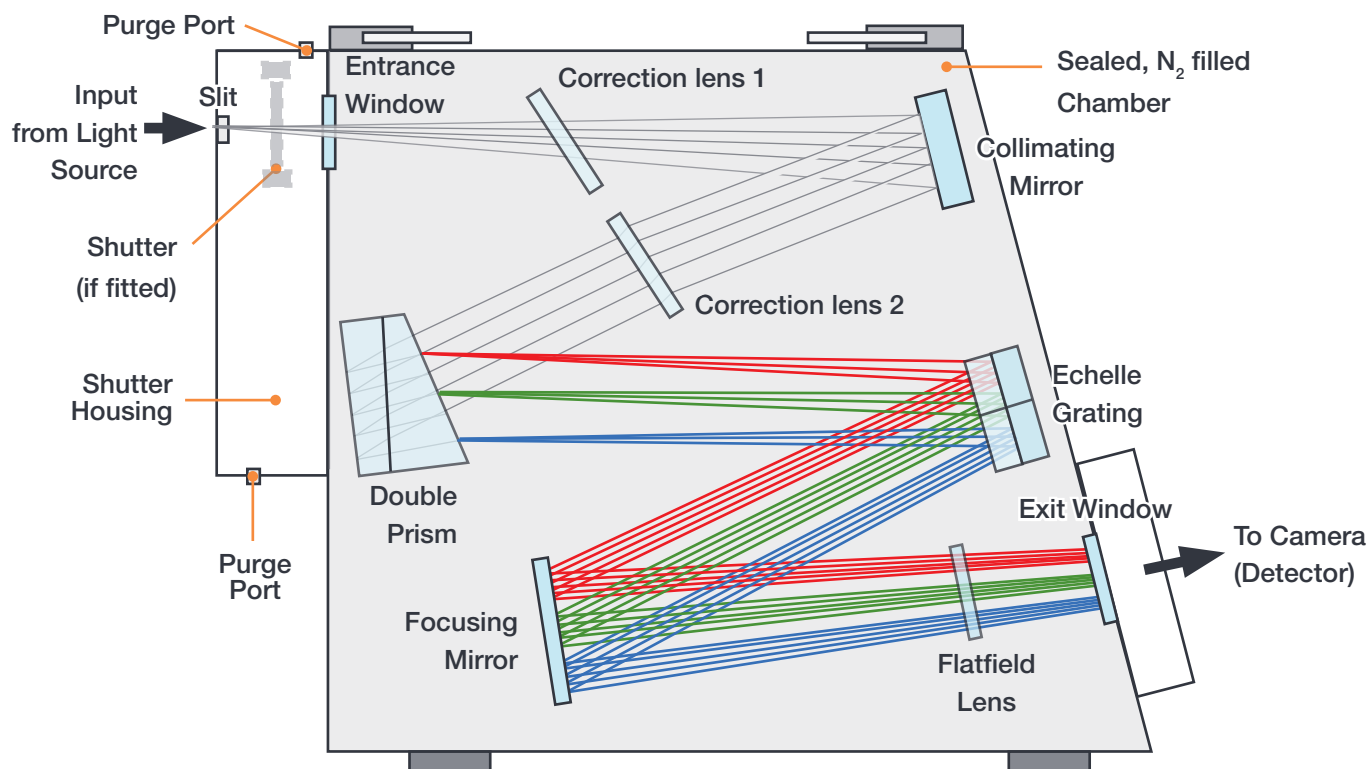


Figure 2: Internal Components of the Mechelle (for illustration only)

Entrance Window

The entrance and (exit) window prevents ingress of dust and contaminants, and allows the internal space to be sealed and purged with N₂ for best UV transmission.

Correction Lenses:

Two custom-made correction lenses are utilised to achieve good imaging resolution.

Collimating lens

This element ensures that light incoming on the dispersive element (prism) is collimated.

Echelle Grating

This type of grating provides good efficiency performance over a large number of orders and wavelength range. Its groove density also dictates the spectral resolution.

Double Prism

The broadband double prism design is used to achieve semi-equal order spacing for ultra-low cross-talk.

Exit Window

The exit (and entrance) window prevents ingress of dust and contaminants and allows the internal space to be sealed and purged with N₂ for best UV transmission.

Purge Ports

The shutter housing can also be flushed with dry gas to remove any water vapour using the two purge ports to maximize UV light transmission..

2.3 ENTRANCE APERTURE SLIT

The standard Mechelle is supplied with the SMA connector and brass tool (**Figure 3, left**). The maximum aperture height recommended to avoid order crosstalk is 50 μm . The entrance aperture can be either, a direct fibre input, a slit or a pinhole. When a fibre-optic input is used, the best arrangement for maximum throughput is to have the fibre itself as the aperture. In that case the fibre diameter should not exceed 50 μm .

In some applications fibre-optics cannot be used, particularly in the UV region, due to the lack of throughput, so a **Slit Disc** must be used (**Figure 3, right**).

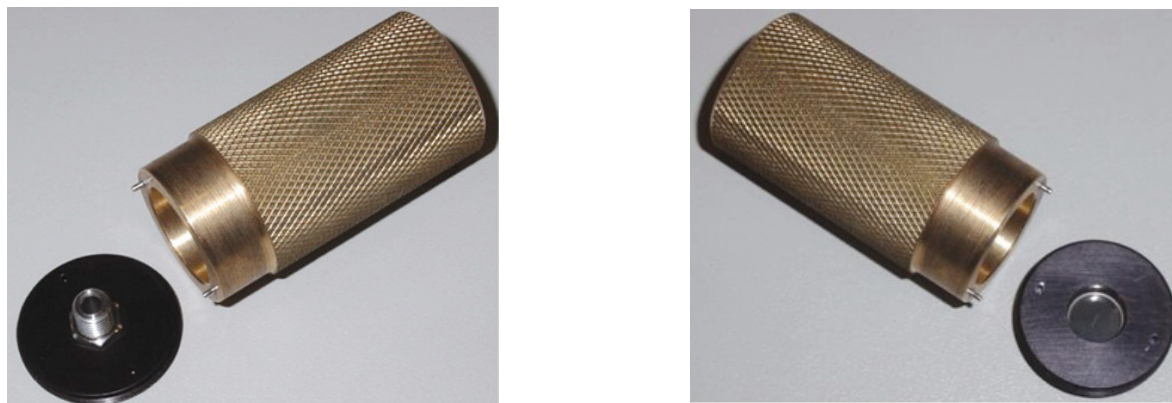


Figure 3: (Left) SMA connector and brass insertion tool, (Right) Slit disc and brass insertion tool

The most common slit size used is a rectangular 25 μm x 50 μm (W x H) slit. Other apertures such as a 50 μm x 50 μm , or 50 μm pinhole can also be used. However, these wider slits will provide a lower resolution than the 25 μm x 50 μm slit, but yield a higher throughput. The maximum recommended slit width is 200 μm .

NOTE: If a 10 μm x 50 μm slit is used the resolution of the system will improve but throughput will be reduced.

The exchange procedure for the SMA and other adapters is shown in **Section 6.3**.

2.3.1 OPTIONAL ST & FC FIBRE ADAPTERS

Optional **ST** and **FC** fibre adapters can also be used with the Mechelle spectrograph.

NOTE: After changing slit to fibre, the unit must be recalibrated.



Figure 4: (left) FC Connector, (right) ST Connector

2.3.2 SHUTTER

The Shutter is an optional item on the Mechelle system.

- If an ICCD camera is used, the image intensifier acts as the shutter (however a mechanical shutter may still be used as a way to minimise photobleaching of the intensifier).
- If a CCD camera is used, a shutter must also be used to ensure that no light falls on the sensor during the readout.

The shutter (if fitted) is located behind the slit in the shutter housing. The shutter housing contains an electronic shutter driver which connects through the Shutter/Temperature cable.

To improve the optical performance (especially in the UV region) the shutter housing can be flushed with dry gas to remove any water vapour. This can be done via the two access holes (normally sealed by grub screws) which are located at the top and bottom of the shutter housing, as shown in **Figure 5**.

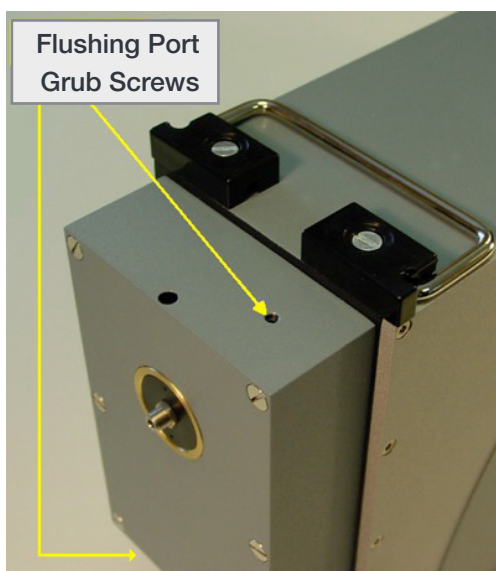


Figure 5: Shutter housing and flushing ports

The slit rotation can be adjusted using an Allen Key as shown below in **Figure 6**.



Figure 6: Adjusting slit

2.4 OPTIONAL CC52 COLLECTOR/COLLIMATOR WITH ALIGNMENT LASER

NOTE: Please see laser safety advice at beginning of user guide.

To increase the light collection efficiency (F/# or N.A.) of the Mechelle, a UV-NIR achromatic collecting/collimating lens/mirror system, the **CC52**, has been designed. It has been optimised to ensure that all photons with wavelengths in the range 200 - 950 nm are collected at a high F/2 aperture and 'squeezed' into the Mechelle F/7 aperture.

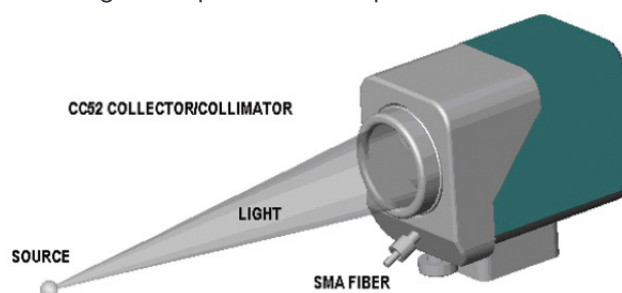


Figure 7: The CC52 Collector/Collimator

Parameter	Specification
F/number	2
Focal Length	52 mm
Aperture	30 mm
Object Distance	200 mm to Infinity
Wavelength Range	200 - 950 nm
Fibre Optics Connector	Standard SMA
Items Included	3V adapter

An alignment laser is also provided with the CC52. When coupled to the collector / collimator, the user can optimize the light collection from a precise point in the sample/experiment where the laser spot is best focused. After optimization, the fibre is disconnected from the laser and coupled to the Mechelle input.

- To focus the CC52 loosen the locking screw and move the fibre coupler in and out inside CC52 to achieve the smallest laser spot at the sample and collection area of interest. If the light source is at 50 cm or more from CC52, remove the front lens from the CC52.
- Remember to lock the position by tightening the locking screw.

NOTE: These accessories are not provided as standard with the Mechelle spectrograph and must be ordered separately.



Figure 8: Laser Alignment Module Fitted to the Collector/Collimator.

SECTION 3: INSTALLING THE MECHELLE SPECTROGRAPH

3.1 UNPACKING & HANDLING

Carefully remove the Mechelle from its packaging. Refer to the packing list to confirm all components are correct and undamaged. Allow the spectrograph to sit in the laboratory environment for a couple of hours to adapt to the ambient temperature.

3.2 ATTACHING THE CAMERA AND CAMERA ALIGNMENT PROCEDURE

NOTE: If you have purchased an Andor camera (such as the iStar) with your Mechelle spectrograph, it is normally attached and pre-aligned at the factory.

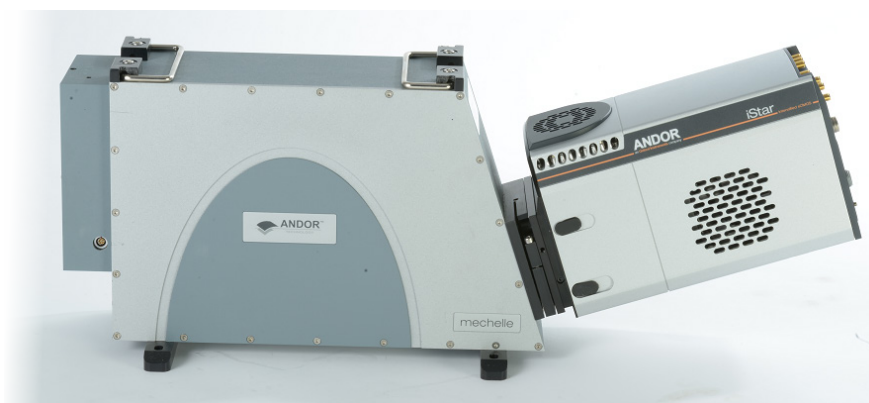


Figure 9: Mechelle with iStar Camera Attached

1. If the camera is not attached, or has been removed the camera must be aligned and focused again when it is put back on.
2. Attach the camera to the mounting flange - 4 off, 6/32 x 3/8 UNC (refer to your camera manual).
3. Loosen the grub screws (x3) and the cap head screw (x1) located on the top, bottom and one side of the camera flange.

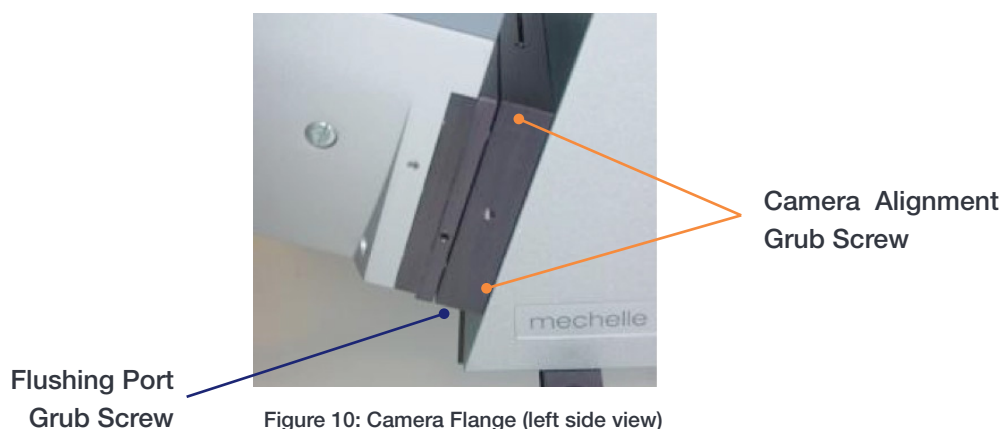


Figure 10: Camera Flange (left side view)

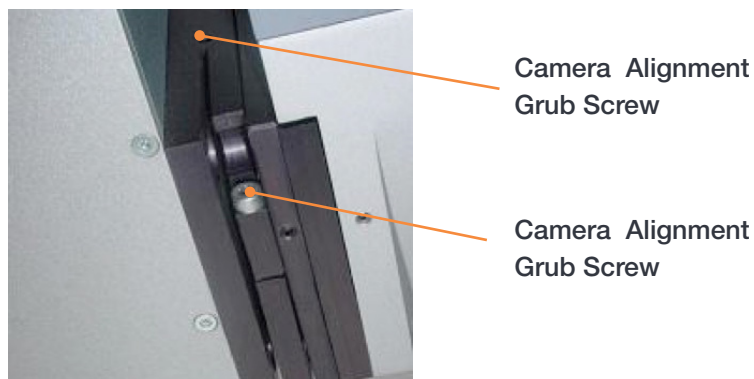
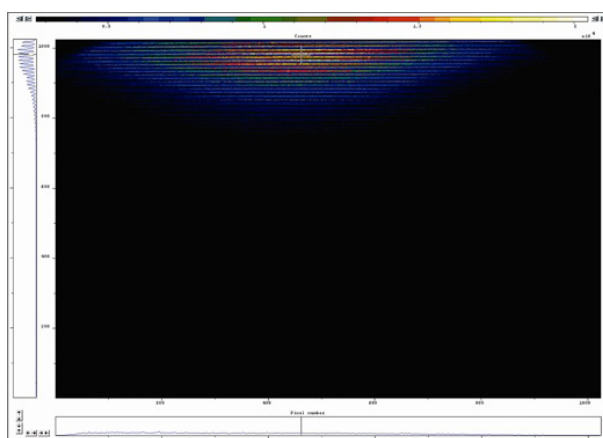
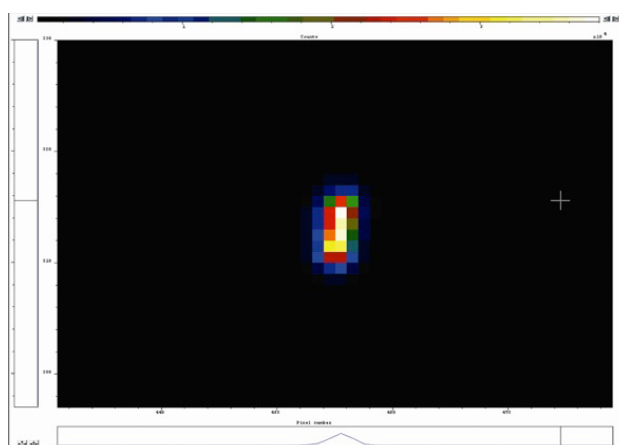


Figure 11: Camera Flange (right side view)

4. Couple a spectral lamp to the spectrograph (e.g. Mercury-Argon).
5. Rotate and focus the camera to achieve the smallest spots possible (3 pixels FWHM in CCD and 5 pixels FWHM in ICCD in x-direction).
6. Also ensure that the 253 nm line from Hg source falls near the following pixels (X = 500, Y = 300) with ± 10 pixels margin.
7. Tighten the grub screws (x3) and the cap head screw (x1).
8. To check the alignment, use a CW source (e.g. Tungsten or desktop lamp) and re-calibrate. The pattern on the image as shown on this example should be as near to horizontal as possible.



9. To focus the camera, move it forward/backwards in increments. The spot on the image as shown below should be as small as possible (This image is also used to align the slit).



3.3 CALIBRATION SOURCE

To wavelength calibrate the Mechelle spectrograph a spectral calibration source is needed. A Mercury/Argon lamp is recommended for Mechelle calibration. Example wavelengths shown below- please refer to information supplied with your reference lightsource.

Hg Wavelengths (nm)	Ar Wavelengths (nm)
253.652	696.543
296.728	706.722
302.150	714.704
302.347	727.294
313.155	738.398
313.184	750.387
334.148	763.511
365.015	772.376
365.484	794.818
404.656	800.616
407.783	811.531
433.922	826.452
434.749	842.465
435.833	852.144
491.607	866.794
546.074	912.297
576.960	922.450
579.066	

3.4 CONNECTING A USB BASED CAMERA

Refer also to the manual for your specific camera model- information for an Andor iStar model shown below:

1. Connect the USB cable between the camera and a USB port of the control PC. The iStar CCD is connected via USB 2.0 and the iStar sCMOS via USB 3.0).



Figure 12: iStar CCD USB 2.0 (left), iStar sCMOS USB 3.0 (right)

2. Connect the I²C shutter/temperature cable between the Mechelle and the camera.

NOTE: The shutter is optional when using the Mechelle with the Andor iStar intensified camera. However it is recommended to protect the image intensifier photocathode from photobleaching during experimental ‘dead-time’.

3. Proceed to **Section 3.5**.

3.5 INSTALLING ANDOR SOLIS SOFTWARE FOR WINDOWS (8, 8.1 AND 10)

1. Terminate and exit any applications which are running on the PC.
2. Insert the Andor Solis CD. The InstallShield Wizard should now start. If it does not start automatically, run the file setup.exe directly from the CD.
3. Select appropriate location for installation of software and drivers on your computer / network.
4. When prompted, select required Camera model e.g. iStar or iKon-M and the requested details.
5. Continue installation and restart your computer - when prompted - to successfully complete the installation.
6. The shortcut icon for Solis will appear on the desktop on re-start.
7. The Camera and Spectrograph are now ready to be connected to a PC / laptop and powered on.

3.6 NEW HARDWARE WIZARD

When connected to a PC for the first time, the **New Hardware Wizard** screen will appear.

1. Select the **'No, not this time only'** option then click **Next>**.
2. Select the **'Install from a list or specified location (Advanced)'** option then click **Next>**.
3. Navigate to the directory where the Andor Solis software was installed to on the PC, then click **Next> so that the Installation Wizard can start.**
4. Click the **Finish** button to complete the installation.

Note: If the USB model camera is connected to a different USB port, steps 1 – 4 will have to be repeated on the first connection only.

5. A system message will appear to indicate that the device has been successfully installed.

Note: You can check that the camera is correctly recognized and installed by opening the Device Manager (Devices and printers) in Windows, Control Panel. The Mechelle and camera will show under the Devices list.

NOTE: On the first startup of Solis, you may be required to direct the software to the drivers. If so, select the directory that Andor Solis was installed to.

3.7 START-UP DIALOG

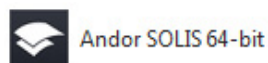
On start-up of Solis software a dialog may appear if multiple cameras are connected to your PC.

1. Highlight the **Andor** camera model (The Serial Number can be found on the label on the camera)
2. Click **OK** to continue with the selected camera.

SECTION 4: USING THE MECHELLE

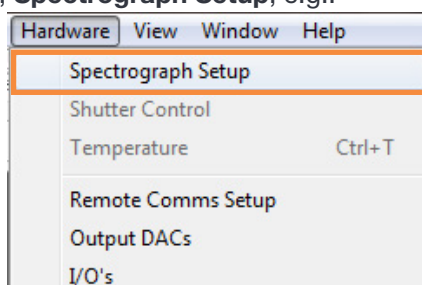
4.1 LAUNCHING THE SOFTWARE

The Mechelle and camera can be controlled via Andor Solis and the software is launched by clicking on the Andor Solis icon which was created when the software was installed.

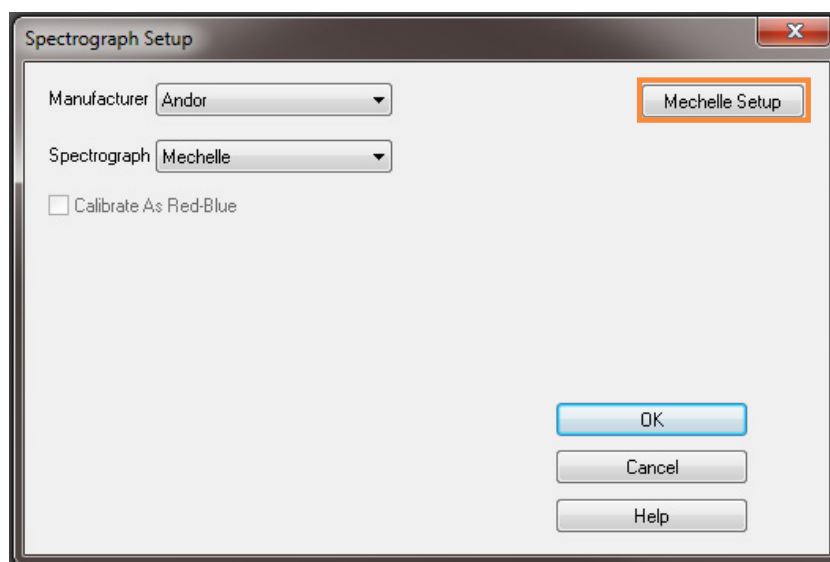


4.2 SETTING UP THE MECHELLE IN THE SOFTWARE

From the Main Window, select Hardware, **Spectrograph Setup**, e.g.:

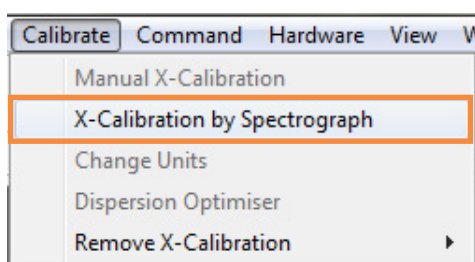


The **Setup Spectrograph** dialog box appears. Select **Andor** from the **Manufacturer** drop-down menu and **Mechelle** as the **Spectrograph**.

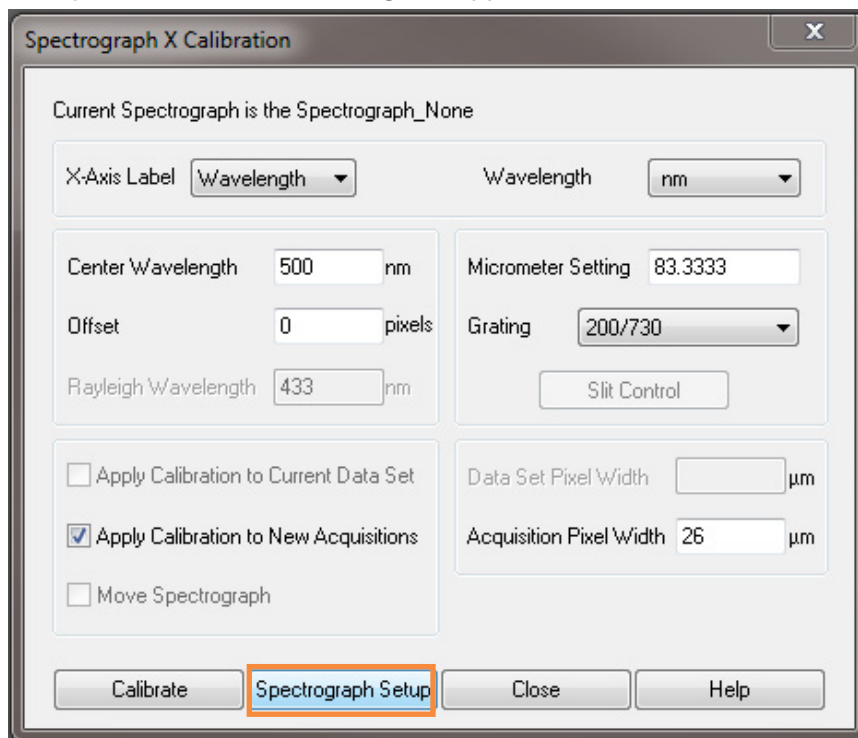


The **Mechelle Setup** button should then appear. Click this button to access the Mechelle parameter user interface.

Users can alternatively access this interface from the Main Solis menu through **Calibrate, X-Calibration by Spectrograph**:

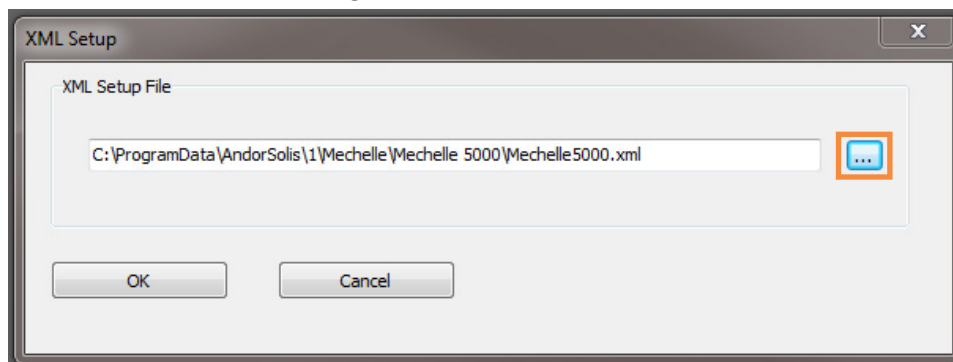


In this instance, the **Spectrograph X-Calibration** dialog box appears:



Click on the **Spectrograph Setup** tab and the **Spectrograph Setup** dialog box appears.

In the **XML Setup** File field of the **Mechelle Setup** dialog box, click on the **...** button, then locate and select the appropriate **.xml** file for the Mechelle model being used.



Click the **Open** button.

Click OK. If prompted to restart, do not restart at this point during the setup procedure, as the configuration file (holding the Mechelle setup parameters) will be saved later.

The **Mechelle Setup** screen will then appear again.


4.2.1 EXTRACT SPECTRUM

The **'extract spectrum from acquisitions'** option must be selected if the user wishes the spectrum to be generated or updated following every acquisition.

For real-time analysis, **'extract spectrum in video mode'** or **'extract spectrum during kinetic series'** should be enabled. For acquisition rates greater than 10 Hz in kinetic mode, it is recommended to un-select these options as the spectrum extraction from the image takes ~ 100 ms and can therefore impact the actual acquisition rates. In this case, after acquisition of the echellogramme images at the desired rate, spectra are then extracted post-acquisition.

4.2.2 ORDER LINES

The **'draw order lines on the image'** option superimposes a theoretical echellogramme of the expected orders position based on current wavelength calibration. It is an extremely useful visual tool to check the system calibration accuracy. Displaying order number and center wavelength on the image provide also additional useful information during the calibration process.

NOTE: After the application restarts, the draw order lines on image button  will also be shown on the right side of the main window toolbar. This button also toggles this option ON and OFF.

The **Calibration Temp** window indicates the Prism temperature during calibration and the **Current Temp** window indicates the actual prism temperature.

4.2.3 TEMPERATURE AND CALIBRATION

The Calibration Temp. field indicates the prism temperature at time of last calibration and the Current Temp. field indicates the actual prism temperature.

Users must select option **'Image temperature adjustment'** (right hand side) to ensure Echellogramme calibration accuracy is maintained if prism temperature changes. It is recommended that **'Save current calibration'** (bottom left) is selected to ensure new wavelength calibration are permanently saved.

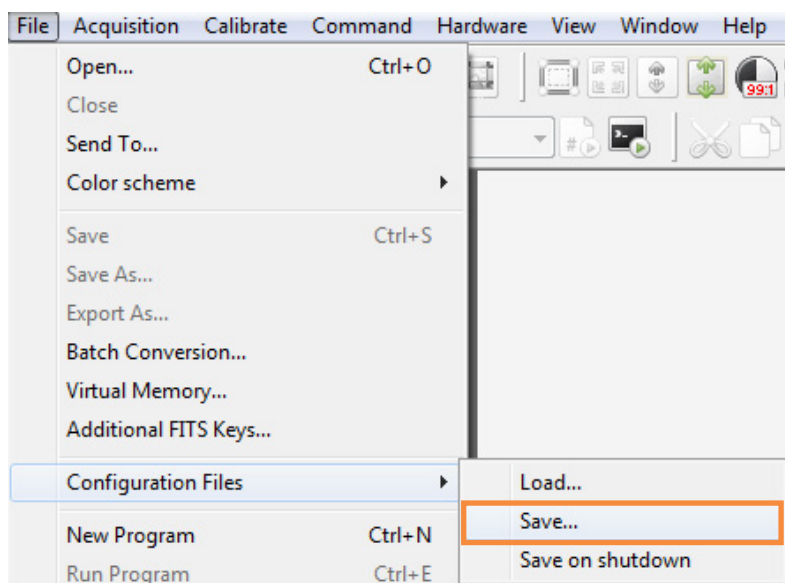
4.2.4 OPTIONS (OTHER)

The **'Crosstalk removal order'** feature ensures that potential ghost spectral features generated from a given order into adjacent orders is removed.

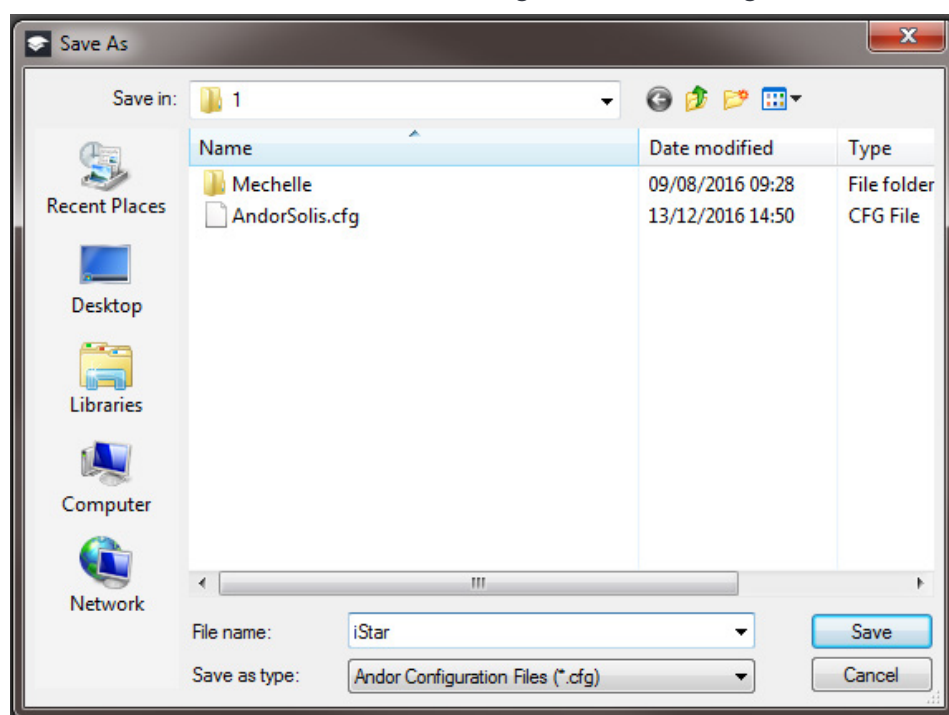
The **'channel height'** relates to the expected height (in pixels) of the echellogramme orders (up to 5 pixels). The higher the order, the more signal from the echellogramme will be used to extract the spectrum but with slightly higher chance of ghost spectral features appearance.

'Automatic peak finder' allows spectral features to be labeled with the closest atomic species selected in the periodic table (see section 4.5.2)

Close all dialogue boxes, then save:

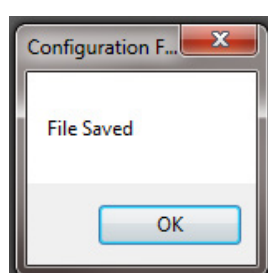


NOTE: The configuration file must be named either `istar.cfg` or `AndorSolis.cfg`.




After the **Save** button is pressed, choose to overwrite the existing file if appropriate.

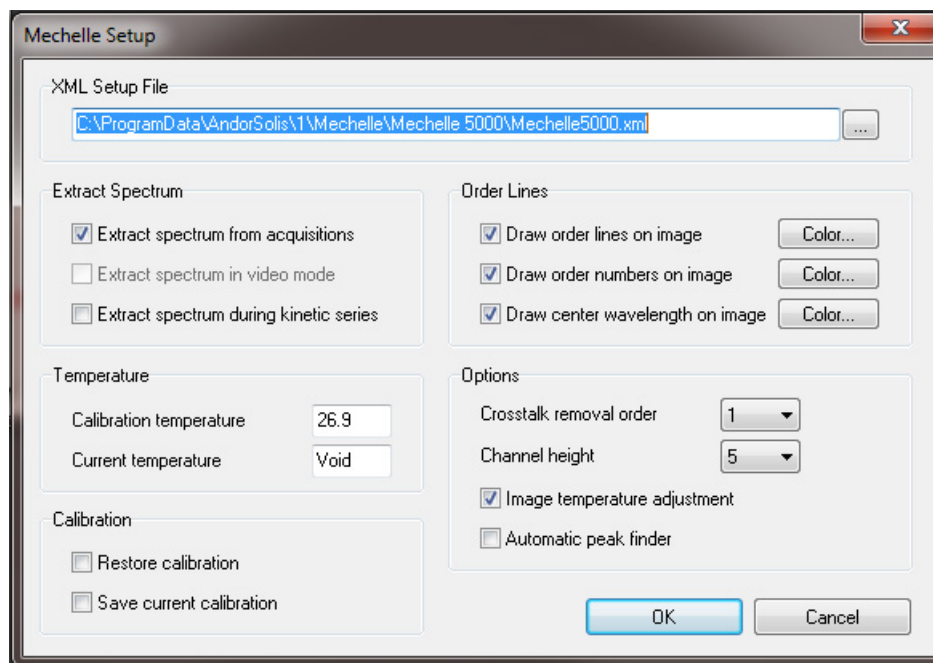
Then Click **OK**.



THE APPLICATION MUST THEN BE RESTARTED BEFORE THE MECHELLE SYSTEM CAN BE USED.

After the system restarts, the **Solis splash screen** will appear followed by the **Main Window** again.

On the Main Window, click the  button and the **Setup acquisition** dialog box will appear.




Select the required parameters then click **OK**.

Following restart of the Application, select the appropriate detector acquisition parameters in Setup CCD (for iStar CCD or iKon platforms) or on the real-time control interface (for iStar sCMOS). For details on how to setup the different acquisition parameters of detectors that can be coupled to Mechelle, please refer to the relevant user guide for either iStar CCD, iStar sCMOS or iKon CCD.

NOTE: The CCD should also be cooled at this point. The camera and software guides provide full details of how data can be acquired and manipulated.

If light coupling configuration to the Mechelle is done through a fibre, please ensure that the fibre optic is secured to the Mechelle SMA/FC adapter (itself securely secured in the Mechelle input housing).

4.3 ACQUIRING DATA

To acquire your data, click the  button on the Main Window. The configuration file (.cfg) that comes with the Andor software enables the system to make an acquisition using a number of default conditions including sensor exposure time, intensifier gate width and delay, camera trigger mode and kinetic series/single acquisition mode..

The acquired data will appear in Data Windows #0 and #1, as shown in the example below.

#0 will show the raw data as an image and #1 will show the extracted spectrum from #0.

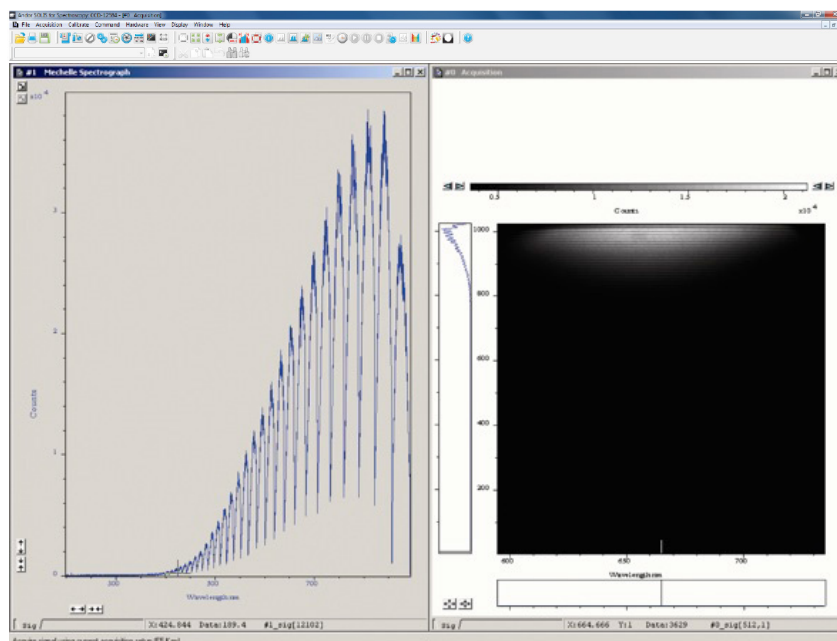


Figure 13: Example of Acquired Data.

NOTE: For further information on how to interact with the acquisition window to change display preferences (e.g. intensity scale or zoom), please consult the user's guide for the camera you are using.

4.4 WAVELENGTH CALIBRATION USING A MERCURY-ARGON SPECTRAL LAMP

The Mechelle Spectrograph and camera are pre-aligned and calibrated at the factory - it is however strongly recommended to perform a calibration on first operation of the system after reception and in the laboratory environment of use.

The Mechelle must be re-calibrated if any of the following occur:

- The ambient temperature changes more than $\pm 5^{\circ}\text{C}$ from calibrated temperature
- The fibre optic is changed
- The Entrance Slit is changed to a fibre, or vice versa
- The camera is moved or re-aligned
- The shutter housing is removed

To do this you should switch on a reference source (the procedure below uses a Mercury-Argon lamp with a wide spread of spectral features from UV to NIR) and acquire a signal.

NOTE: If the Mechelle has a slit option, make sure that the Mercury lamp is set at 50 cm from slit and filling the F# of the Mechelle.

Look at the image of 253.652 nm line in #0, which should appear near the middle of the detector ($X \approx 500$, $Y \approx 300$ for Mechelle 5000) it should look similar to that shown below:

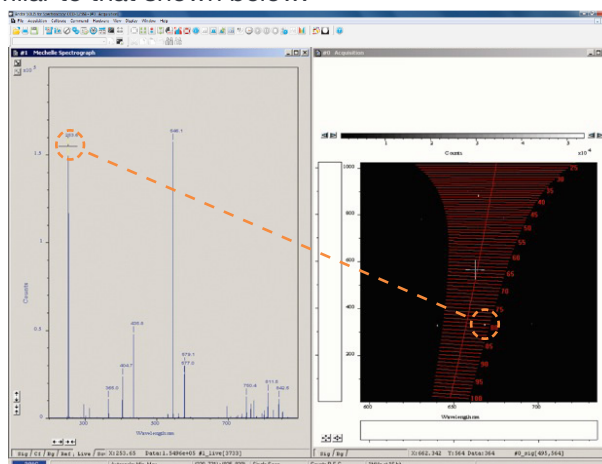


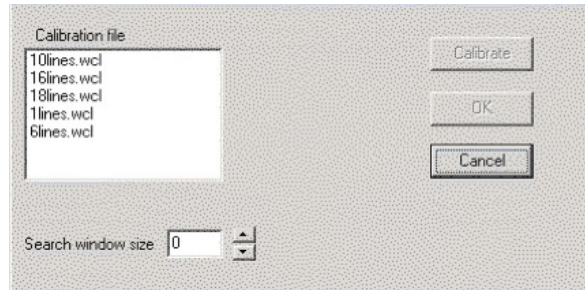
Figure 14: Data captured from an Hg Ar calibration source

If the Mechelle has a fibre option, couple the other end of the fibre to the lamp.

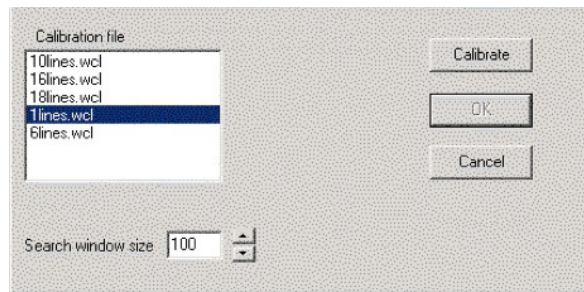
NOTE: At that stage ensure that the brightest features on the image are not saturated. If it is not the case, please reduce the detector exposure time, gate pulse width or gain (in the case of iStar).

4.5 CALIBRATION

Click the  button on the main window and the **Select Calibration File** dialog box will appear:



Start the calibration procedure by selecting the 1lines calibration file and a large search window as shown in the image below. The files with higher number of lines will be used sequentially as calibration progresses successfully.



The **Search window size** option defines the side of the area (in pixels) that the software will use to search for the position of a spectral line contribution on the echellogramme image. Based on the previous or default calibration, the program will look for each calibration line within the defined search area.


If too low a number is selected, the calibration procedure may not find some of the calibration lines. Too large a number increases the risk of the software finding the wrong line.

If a reasonably good calibration exists, a suitable selection for this parameter is from 20 to 50.

When the calibration button is pressed, the **Results of Mechelle calibration** screen appears. The success of the calibration can be judged from this information.

Found Lines:			Line Details:	
Wavelength	Order	Intensity	X	Y
253.65	179	36725	489.66	303.22
			Measured	474.8
			Calculated	474.8
			Residuals	0
			FWHM	4.28

Residual Maximum: 5



IMPORTANT: Please Confirm that your 253.65 line is located at (x:474 y:297)

Use Calibration Results (Save)

Discard Calibration Results (Cancel)

If the error “Error only n lines found out of n ” appears check the following:

1. Search window size is too small.
2. Spectral lines are very weak. To compensate, increase detector exposure time, gain or gain pulse width.

The Found Lines table (see the previous page and **Figure 15 below**), contains the calibration wavelengths and their order numbers. The third column represents the intensity of this line in counts.

The table on the right-hand side, entitled Line Details, shows initial, measured and calculated positions of a given calibration lines. All co-ordinates are in units of the pixel size. The initial position of the lines as calculated from the “old” set of wavelength calibration constants, i.e. calculated from previous calibration.

The second row contains the measured pixel co-ordinates and the third row contains the pixel co-ordinates calculated from the “new” (not yet stored) wavelength calibration constants.

The fourth row contains the residuals, i.e. the difference between the calculated and measured co-ordinates.

The fifth row shows the full width half maximums calculated for each of the lines.

The residuals, both in the horizontal (X) and vertical (Y) directions, are plotted in a diagram. The size of the plotted area equals the size of the search window.

If one line calibration file is used, the residuals (in X and Y direction) equal zero.

The optimum wavelength calibration is performed if the selected “calibration wavelength file” contains several (≥ 5) lines, as shown:

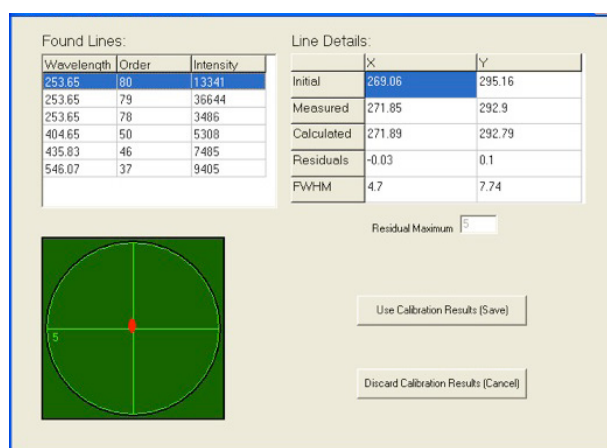


Figure 15: Calibration results screen for 6 lines

A good calibration based on several lines should have a maximum residual of less than one pixel in the x and y directions for lines within the echellogram funnel. Lines outside the funnel are used for extra calibration accuracy, but the spectrum is only extracted from within the funnel; lines outside the funnel may have residuals slightly greater than 1 pixel. If the red dot on the target moves away from the centre of the cross-hairs when the **Found Lines** are tabbed down, the calibration is unsuccessful and must be discarded. This plot is the graphical representation of the **Residuals** values from the Line Details section. The calibration is accepted by pressing the **Use Calibration Result (Save)** button. **If residuals are bigger than Residuals Maximum, the software will not allow the calibration to be saved.**

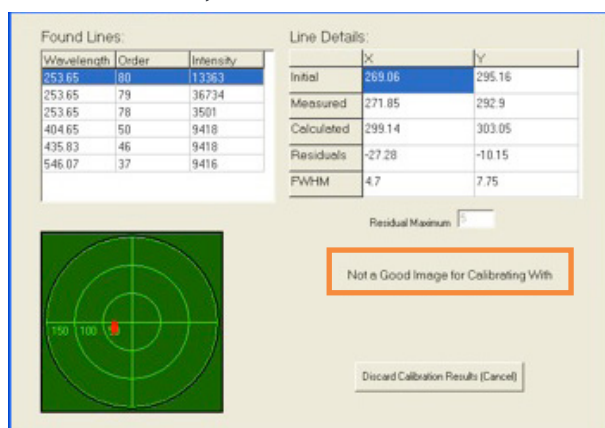


Figure 16: Example showing unsuitable calibration

After the “new” calibration parameters have been saved, all subsequent measurements will be based on these. It is advisable to perform a one-line calibration first, as described above using a large search window, then use several line calibration file and restrict the search window to 10 - 20 pixels. This will ensure that the optimum calibration will not identify the wrong line. Also make sure none of the lines saturate the detector.

NOTE: To use a large number of calibration lines (>12 lines), it is recommended to use the Accumulation mode of the detector to increase the signal-to-noise ratio of the acquired signal and therefore ensures that weaker calibration lines are properly detected and located on the echellogramme.

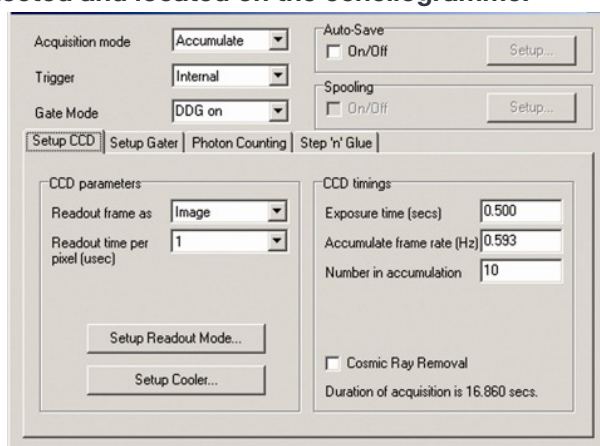
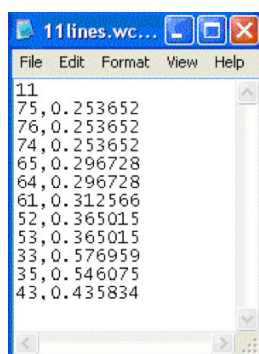


Figure 17: Accumulate Settings

4.5.1 CALIBRATION FILES

There are a number of calibration files in the list. Each file contains the calibration line information for wavelength calibration. This file can be prepared using any editor. An example of such a Wavelength Calibration file is shown here:



The first line of the file contains a number of calibration lines. Each line entry contains the spectral order of the line and its wavelength in μm given with an accuracy of at least 6 decimal places. Items are comma-separated. The spectral order can be calculated as follows:

$$\text{Spectral order} = \text{Order wavelength constant} / \text{wavelength } (\mu\text{m})$$

The table below shows the Order wavelength constant for each Mechelle model:

MECHELLE MODEL/ CAMERA MODEL	ORDER WAVELENGTH CONSTANT
ME 5000 / DU934 (iKon-M)	20.139
ME 5000 / DH334T (iStar 334 CCD or iStar sCMOS)	20.139

NOTE: The .xml file also contains this information.

Use the nearest integer of the calculation quotient as the spectral order number. If the quotient is close to half way between two orders (e.g. 75.38) the same line can be entered in two spectral orders, namely order 75 and 76. In such a case the line should be entered as two separate entries in the calibration file.

4.5.2 DISPLAYING RESULTS

After the system has been calibrated and the image has been captured, the spectra can be displayed according to the preference of the user. From the Main Window, select **Display** and choose **Display preferences**.

The **Display preferences** dialog box will be displayed:

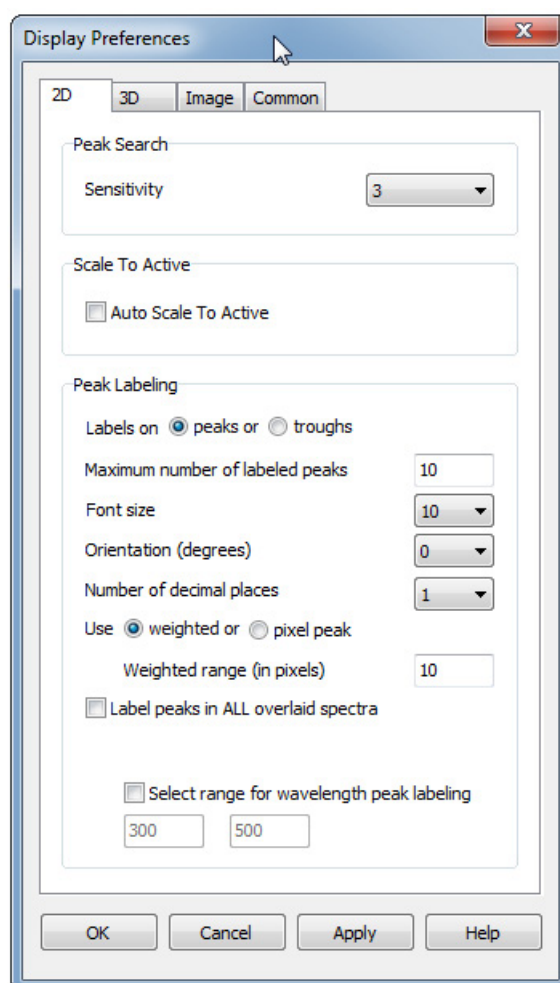



Figure 18: The Display Preferences Menu

The user can then select the format required.

Individual elements can also be filtered using a Periodic Table selector. This is initiated by clicking the  button on the Main Window.

The **Periodic Table of Elements** dialog box will be displayed as per **figure 18** below. The user can then select the atomic species of interest (alongside their ionisation levels) to identify the relevant element from this screen.

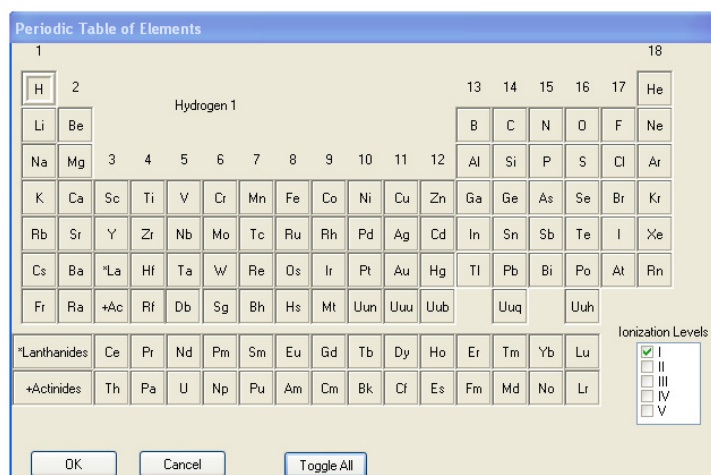
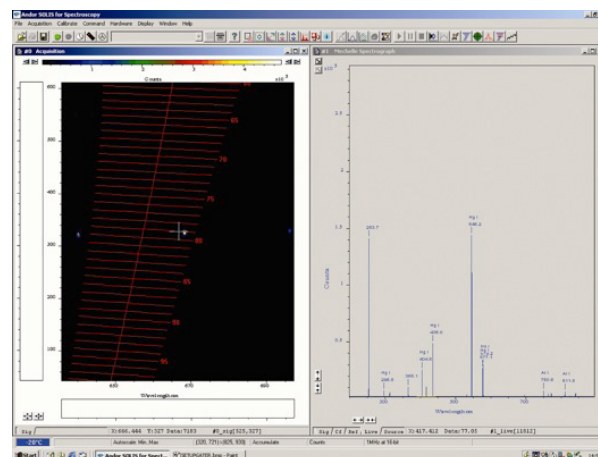
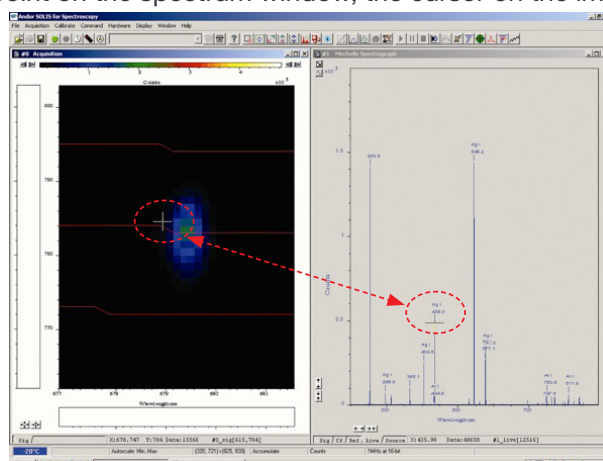


Figure 19: The Periodic Table Menu

The results of the Display preference and/or Periodic table selections are displayed on the Main Window, where the software has labeled the spectral features based on theoretical wavelength (according to NIST database) of the atomic species selected.



When the cursor is moved to a point on the spectrum window, the cursor on the image moves to the corresponding line:



4.6 CROSS TALK

Cross talk is the unwanted contribution from one order crossing to the adjacent order (or orders) that shows as an extra 'ghost' line on the spectrum. Cross-talk amplitude depends on many parameters:

1. The **Distance between orders**: Larger distance results in smaller cross talk. This distance depends on the optical design of the Mechelle and cannot be changed. The Mechelle has a large distance between orders because of the patented dual prism design.
2. **Channel height**: This is software controlled and cross talk is proportional to the channel height, note that when channel height is reduced, the amplitude of the signal will also be reduced.
3. **Slit height of fibre diameter**: Cross-talk also increases with slit height (or fibre diameter).

There is no standard definition of cross talk and all Echelle-based spectrograph manufactures (except Andor) do not specify the cross talk.

To set up the number of orders for which crosstalk correction should be applied, open the **Mechelle Setup** screen then select the required number from the **Crosstalk Removal Order** drop-down menu:

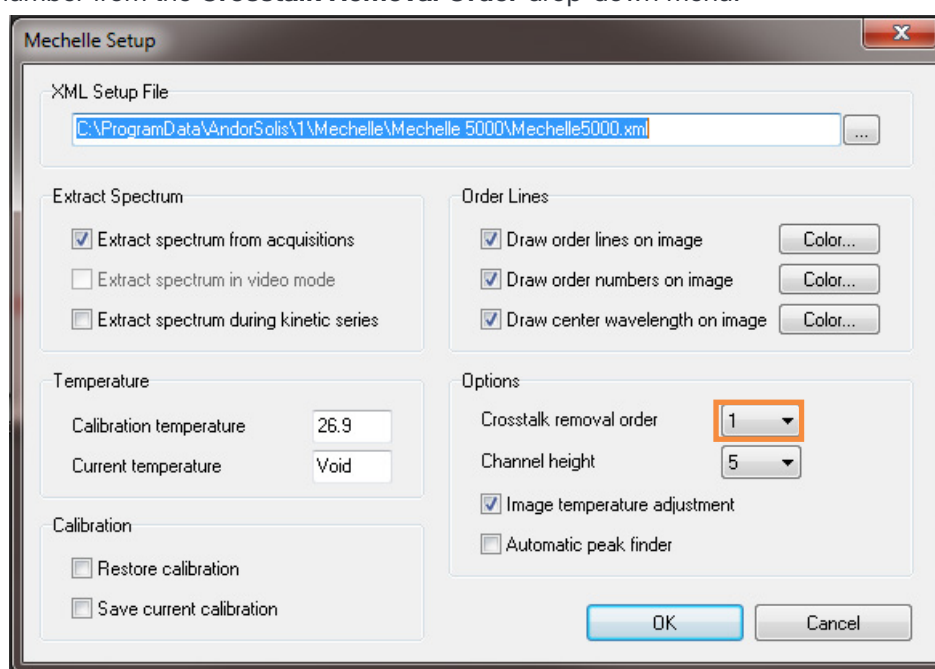


Figure 20: Selecting the Crosstalk Removal Options

To remove cross-talk lines, click the  button.

NOTES:

1. This function removes up to three orders. For example, if large ($> 50\mu\text{m}$) fibre is used, more than one cross talk will be seen. Also if the sensor over-saturates and smears then more than three orders may be seen. Please ensure that no saturation is present of the sensor during acquisition to ensure recording of the best qualitative data.
2. When cross talk is removed, the software will show a zero value to indicate that cross talk lines have been removed.

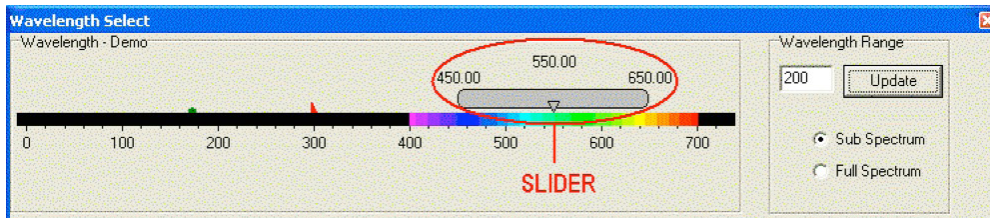
4.7 SUB-SPECTRUM

To see a full spectrum, a full image (e.g. 1024 x 1024 pixels) must be read out which could take more than one second. In order to speed up number of spectrum per second, a sub-Spectrum can be used.

Click the  button and the **Wavelength Select** screen will appear with the **Wavelength Range** option:



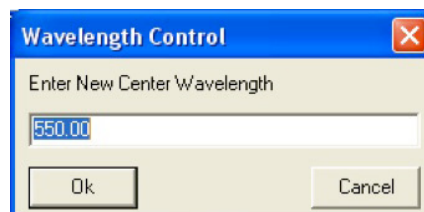
Select **Sub Spectrum**. The **Wavelength Select** dialog box will then appear:



The slider shown above can then be used to select the required wavelength. The slider has three labels displayed above it displaying the start, centre and end wavelengths currently in effect. The values displayed correspond to the position and width of the slide bar in relation to the wavelength scale shown.

The start, centre and end wavelengths can be changed in one of two ways:

1. By dragging the slider with the mouse. This is done by positioning the cursor within the slider (cursor changes to pointing hand), holding down the **LEFT** mouse button and dragging the slider to the new centre wavelength required. Placing the cursor at either side of the slider allows you to nudge it towards the cursor (use the **LEFT** mouse button for coarse nudges and the **RIGHT** mouse button for fine nudges). The size of the nudges can be defined by the user but the defaults are 10nm for course nudges and 1nm for fine nudges.
2. By using the **Wavelength Control** dialog box shown below. This is accessed by positioning the cursor on the wavelength value on the slider then clicking the **LEFT** mouse button. The dialog box then appears:



Type in the required wavelength then click **Ok**.

The sub-image area required is calculated by the software and displayed in the image window (#0) (see figure 21 below). Only the sub-image is then read out and a sub-spectrum is extracted from it.

NOTE: In Full Spectrum mode, the software automatically calculates the background subtracted from spectrum. In Sub-spectrum mode, the software does not calculate the background therefore a background corrected is required.

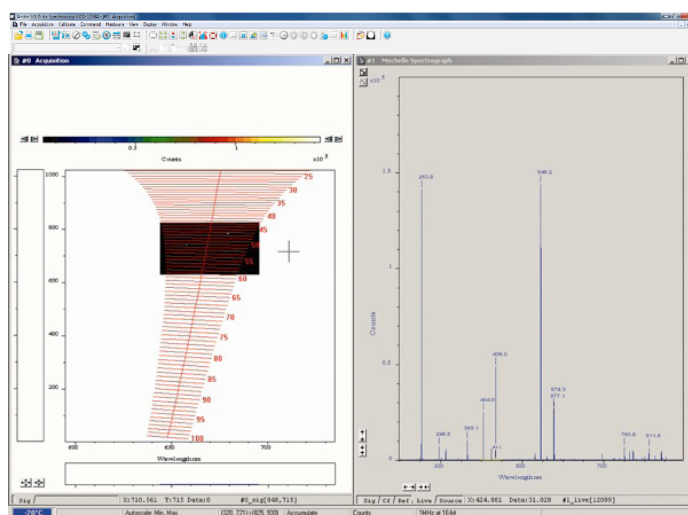


Figure 21: Example of a sub-image area

4.8 ECHELLE GRATING EFFICIENCY

Echelle gratings produce a series of different orders over the entire spectral range of interest (e.g. the ME5000 model produce around 80 orders). When the grating is used in the Littrow angle, the grating efficiency at its maximum in the middle of each order. However the efficiency drops to about half of this value at the extremities of each order. An Echelle grating is blazed for all wavelengths in a spectral range for a given diffraction order.

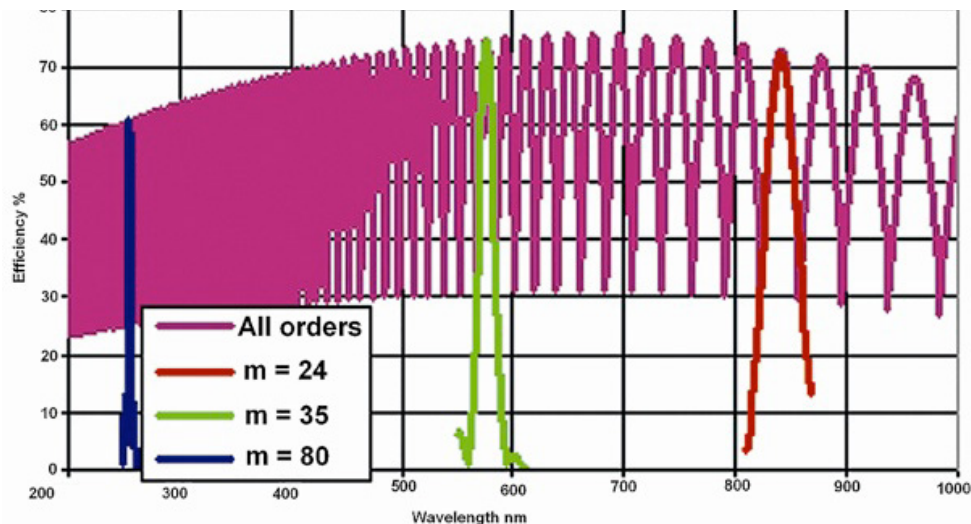


Figure 22: An Illustration of Echelle Grating Efficiency

The effect of the grating efficiency can be clearly observed when a **Continuous Wave (CW)** light source is used. **Figure 23** below shows a typical spectrum of deuterium CW light source. Echelle grating efficiency can be corrected with the aid of Standard lamps (also known as “black body” lamps) and software logarithm.

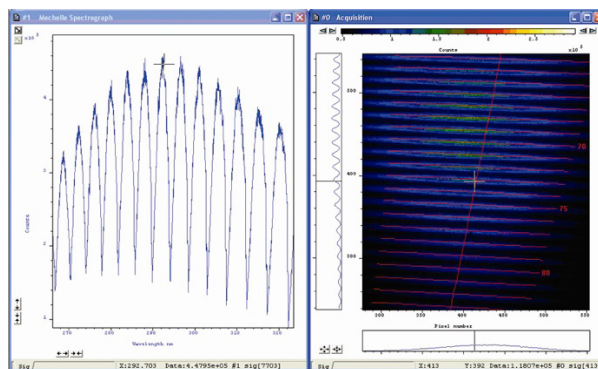


Figure 23: Deuterium CW Light Source Spectrum

4.9 STANDARD LAMPS

Operating and maintaining black body sources is a difficult and skilled task and is usually only done by national standards labs such as the National Institute of Standards and Technology (**NIST**) in the USA (formerly known as **NBS**). A more practical calibration source is a CW incandescent tungsten filament lamp that has been calibrated against a black body source. These filament lamps are known as primary working standard lamps; some are of particularly elaborate design with special filaments and stress-free envelopes, but all give good uniform illumination and are operated from well regulated power units.

These primary working standards remain at NIST, but NIST will supply a secondary working standard and its power unit, calibrated from the primary working standard, or they will calibrate a lamp and power unit supplied by you (National labs in other countries offer similar services). Also there are some commercial companies selling these standard lamps.

The lamps are supplied with calibration data consisting of a printed list of Irradiance outputs at different wavelengths at a specified distance from the lamp. These secondary standards are expensive and have short life times (about 200 hours). General purpose filament lamps, graded for good uniformity, are more commonly used as standards; these have been calibrated against a secondary standard and give traceable accuracies of 5% to 10%.

Since the Mechelle has a very wide wavelength range, the standard lamp used must cover the same wavelength range or more. Unfortunately there is no lamp that can cover 200 nm - 975 nm, therefore two lamps are required to carry out this procedure. Typically a deuterium lamp is used from 200 - 400 nm then a Quartz Tungsten Halogen (**QTH**) lamp is used from 380 - 975 nm. Deuterium lamps are arc lamps filled with deuterium at low pressure. They produce high, spectrally smooth, UV output with little visible and IR, this makes them ideal as UV spectral irradiance standards. For reasons we will not go into here, accuracy and reproducibility in this wavelength range is about half that attainable in the visible range.

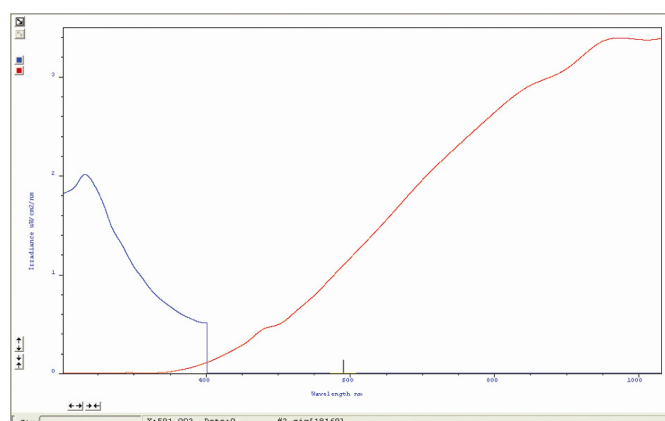


Figure 24: Spectral irradiance output of a deuterium standard lamp and QTH

Many commercial companies supply both QTH and deuterium standard lamps with regulated power units, and cover the wavelength range of 200 nm - 1100 nm. **Figure 24** above shows a typical output data from a commercially available Deuterium-Tungsten lamp.

Before commencing relative intensity correction the following criteria must be met:


1. The standard calibration data relating to your particular standard lamps are saved in text files (*.txt) in specified directory. These files will most likely have been supplied by your lamp vendor. Each line of the file contains a wavelength (in nm) and an irradiance value ($\mu\text{W cm}^{-2} \text{nm}^{-1}$) separated by one or more spaces or tabs. If a file is not supplied with your lamp, you may use a text editor to create one of your own from the lamp vendor's data sheet.

NOTE: The two files must have at least 50 nm overlap.

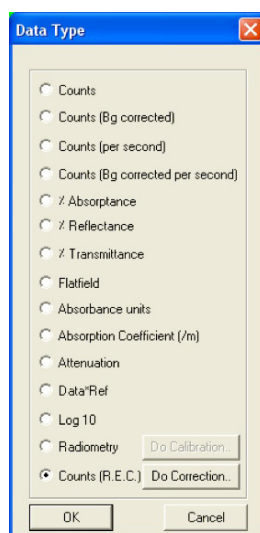
2. Full-spectrum mode is selected
3. Accurate wavelength calibration is carried out
4. Select setup acquisition mode to either "single scan" or "Accumulate"

Refer to detector specification to find the detector spectral range, e.g. iStar 18F-03 spectral range (180 - 850 nm).

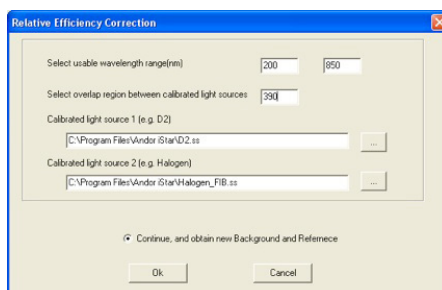
4.10 GRATING EFFICIENCY CORRECTION PROCEDURE

To correct for grating efficiency, either click the  button or select **Acquisition, Setup date type** from the drop-down menu, select **Counts (R.E.C.)** then click on the **Do correction** button.

NOTE: R.E.C. stands for Relative Efficiency Correction.

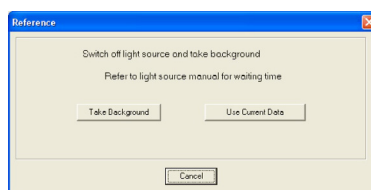


The **Relative Efficiency Correction** dialog box will appear:



- Select usable wavelength range, this is a combination of spectrograph range and Detector spectral range, e.g. if an Detector iStar 18F-03 is used (spectral range 180 - 850 nm) with an ME5000 (wavelength range 220 - 975 nm). The minimum wavelength will be determined by the ME5000 (200 nm) and the maximum wavelength will be determined by the detector (850 nm), therefore the usable wavelength range will be 220 - 850 nm
- Select wavelength overlap between the two calibrated light sources, e.g. if a deuterium lamp/QTH lamp is used, the overlap should be set around 390 nm
- Select the appropriate standard calibration data file saved on the computer.

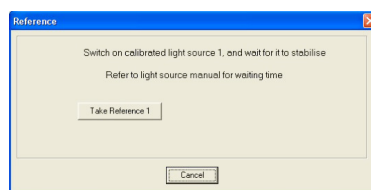
Switch off the light source and then click Take Background:



Switch on calibrated light source 1 and wait for it to stabilise (refer to the light source manual for the waiting time).

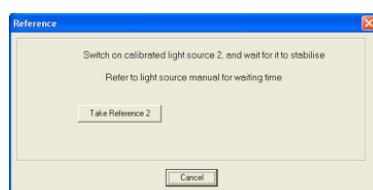
NOTE: Source 1 is the source with the shorter wavelength range (e.g. deuterium)

Click **Take Reference 1**:



Switch off source 1, switch on source 2 and wait for it to stabilise.

Click **Take Reference 2**:



Your calibration is now complete. It is recommended to save the configuration file, so you don't have to repeat this calibration again if you switch off the PC.

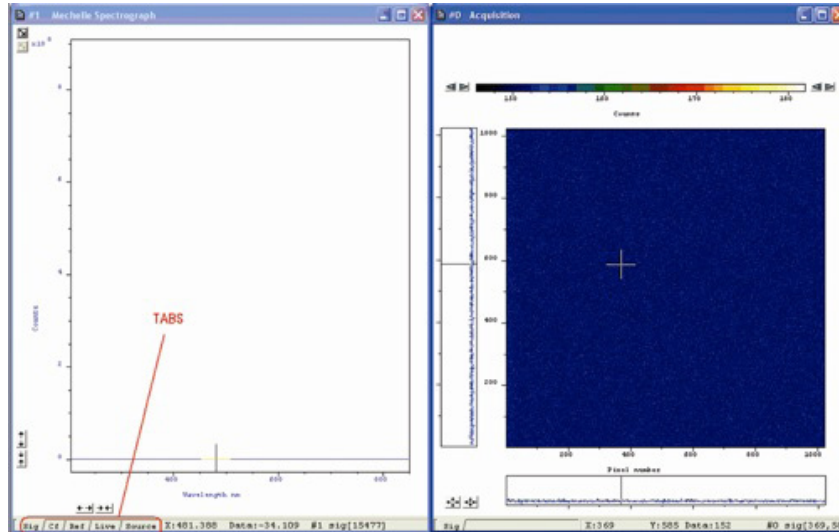
On the **Save Configuration** dialog box, click **Yes**:

Select same configuration file name (**istar.cfg** for the iStar detector or **AndorSolis.cfg** for CCD), then click **Save**.

Replace the existing configuration file by clicking on **Yes** and the new configuration is now saved.

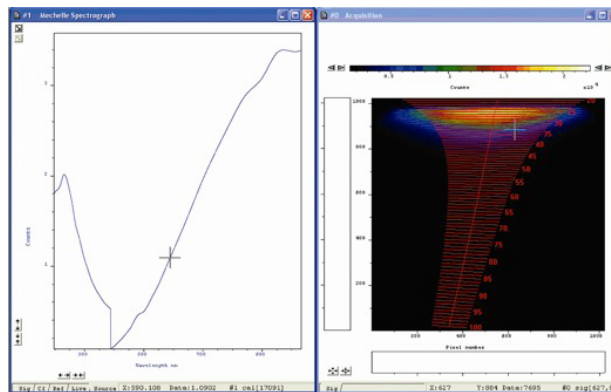
Click **OK**.

After completing the previous steps, the relative efficiency correction is now complete and the system ready for use.

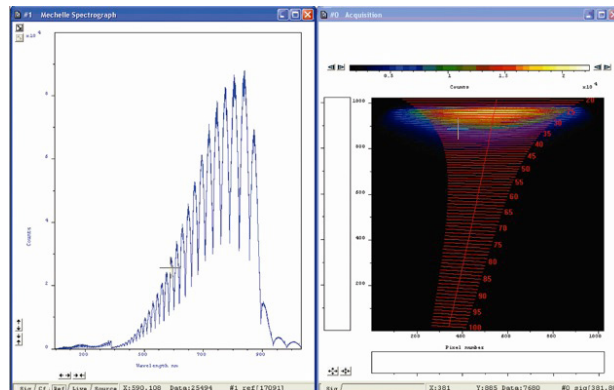


NOTE: Window #1 above contains the following five tabs:

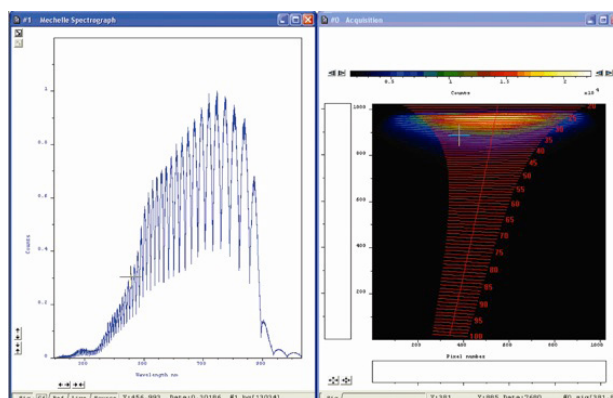
1. **Source:** the manufacturers data for the lamp.



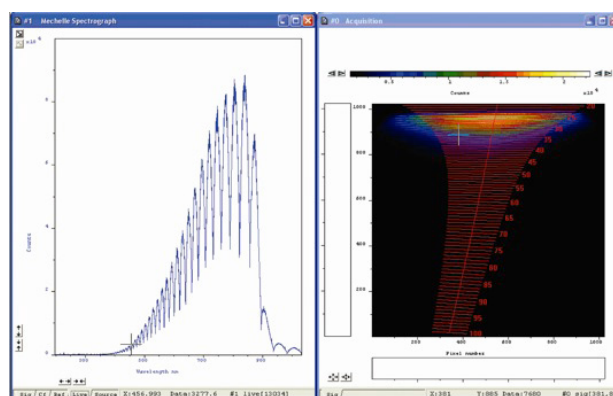
2. **Ref:** the data recorded when the standard lamp is switched on minus the background scans.



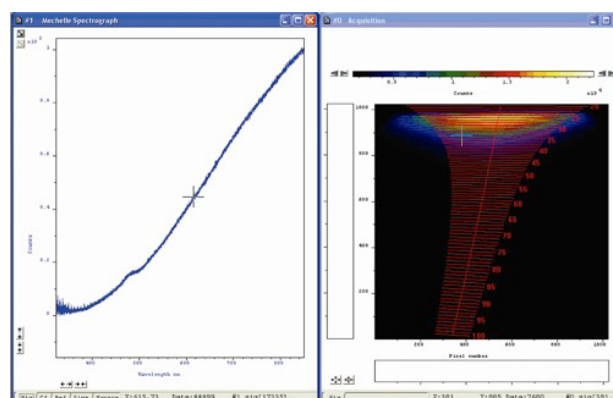
3. **Cf**: the correction factor calculated for source data and Ref data:



4. **Live**: the row data of a new signal. An example for a QTH lamp is shown below:



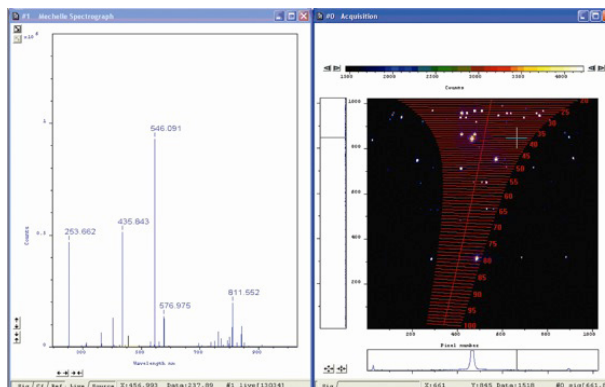
5. **Sig**: the new data after applying the correction factor Cf. An example is shown below:



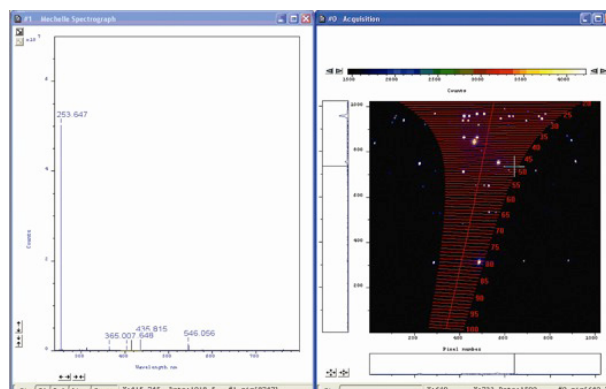
4.10.1 REC EXAMPLE 1

The following example shows the effect of the relative efficiency correction.

- The following figure shows the row data (live) from a mercury lamp, it shows that the intensity of the 546 nm line has double the intensity of the 253.7 nm line.

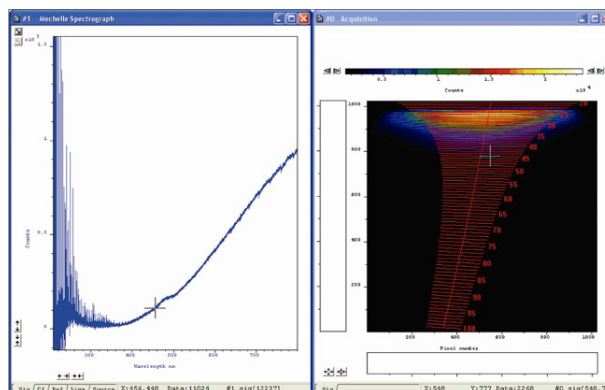


- The following figure shows the same data after applying the relative efficiency correction. Here the intensity of 546 nm line is much lower than the 253.7 nm line.



4.10.2 REC EXAMPLE 2

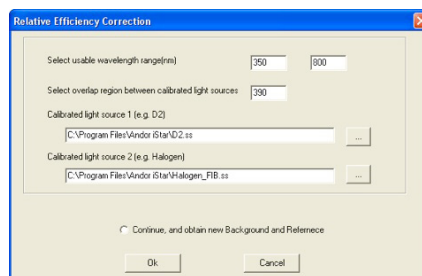
The following figure shows the signal from a QTH lamp after applying the relative efficiency correction. It is clear that there are very large noise levels at the lower wavelengths (200 - 350 nm). This is caused by a lack of signal from the light source.



This part of the wavelength can be removed by changing the usable wavelength range in the relative efficiency correction. This can be done by following the procedure shown on the next page.

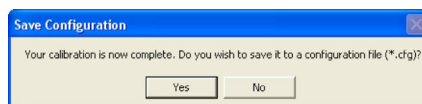
4.11 RELATIVE EFFICIENCY CORRECTION

Click the button and the **Relative Efficiency Correction** dialog box appears:

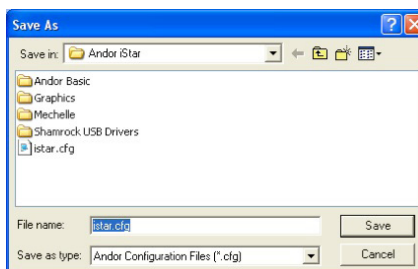


Change the usable wavelength range to be between 350 - 800 nm.

NOTE: Do not take a new Background or Reference at this point. Click Ok and the Save Configuration dialog box will appear:



Click **Yes** and the **Save As** dialog box will then appear:



Type in the required filename (e.g. **Istar.cfg**), then click **Save**. When a new acquisition is taken, the new wavelength range will be shown:

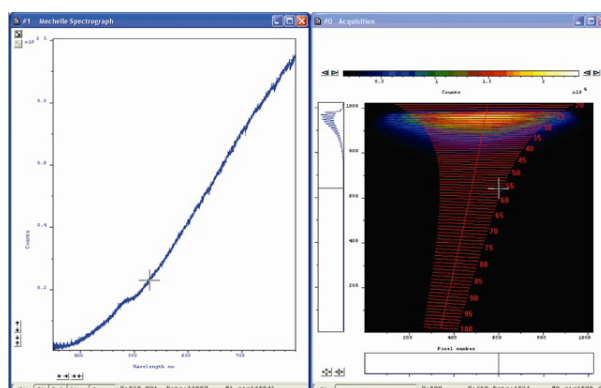


Figure 25: Corrected signal from QTH lamp after changing the usable wavelength range

4.11.1 EFFECT OF AMBIENT TEMPERATURE ON THE RELATIVE EFFICIENCY CORRECTION

When the ambient temperature changes, the refractive index of the prisms will change which result in a shift of the orders in the vertical direction, i.e. the light of a certain wavelength will fall on a different pixel on the sensor. Since there is a small variation between the response of pixels, therefore the relative efficiency correction will not be valid and the corrected signal should look like that shown below:

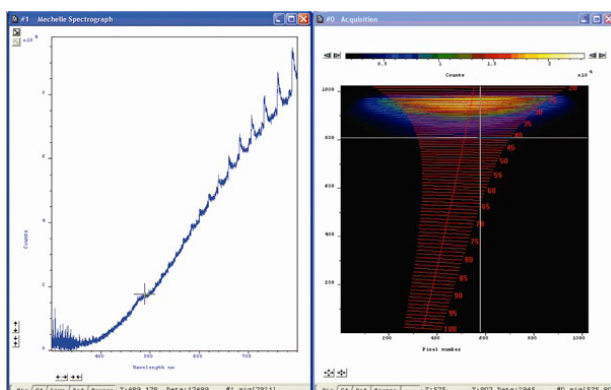




Figure 26: Effect of the temperature change on relative efficiency corrected signal


NOTE: If the ambient temperature is changed by $\pm 3^{\circ}\text{C}$, the Relative Efficiency Correction will not be valid and the corrected signal will look similar to the above, but the wavelength calibration will remain accurate.

4.11.2 RELATIVE EFFICIENCY CORRECTION WITH SUB-SPECTRUM


To carry out the relative efficiency correction with sub-spectrum, the following procedure must be carried out:

1. Firstly, take a full spectrum as described previously.
2. Click the  button to select the wavelength range required and click update.
3. Close the wavelength selector window.
4. Click  and carry out the **Relative Efficiency Correction Procedure**.

NOTES:

1. **Do not take a scan between selecting the wavelength range and relative efficiency procedure. If you do, the button will not be active, i.e.** 
2. **If the wavelength range is changed, the following message will be displayed:**



The **REC** procedure must then be repeated. The software will also change the acquisition settings to **Full Image** for the next acquisition only to prepare for Relative Efficiency procedure. Just click the  button and carry out the procedure again.

3. **If the sub-spectrum set is between 400 - 975 nm, only a QTH Standard lamp is needed, so the deuterium lamp is not necessary**

SECTION 5: TROUBLESHOOTING

The optics in the Mechelle spectrograph are factory adjusted before delivery and the design features few adjustable or moving parts. Therefore it requires minimal interaction once setup in the software and in use. Refer to the troubleshooting sections of your camera and software guides. If you need further assistance please contact Andor Customer Support. The details of your nearest representative can be found on our website.

SECTION 6: MAINTENANCE

DO NOT TRY TO OPEN THE MECHELLE SPECTROGRAPH. IF YOU OPEN IT, THE WARRANTY WILL BE VOID.

Maintenance of the Mechelle spectrograph is minimal. There are no user-serviceable parts inside the spectrograph. The optics in the Mechelle spectrograph are factory adjusted before delivery. Inside the Mechelle spectrograph there are sensitive parts that must be handled by authorised personnel only in a dust free, clean environment. Please observe the following general precautions:

- When the Mechelle is not being used, it is recommended to protect the fibre optic input connection with the protection cap, included in the delivery
- Never use aggressive cleaning substances, e.g. benzene, spirit, nitro solvents, etc. commonly found in labs. Such substances may destroy or damage the surface on which they are applied
- During use, the Mechelle should be protected from hard shocks or strong vibrations
- The Mechelle should be protected from high humidity levels and temperature changes
- It is important not to scratch the surface of the fibre ends, as this significantly will reduce the light input. It is therefore recommended to always keep the protection cap on each end of the fibre when it is not in use. The fibre itself should be cleaned only by dry dust free air or adequate fluids for optical surfaces

6.1 PURGING THE SHUTTER HOUSING

Although the main enclosure of the Mechelle is sealed and filled with Dry Nitrogen (or evacuated), air is also present in the small space between the camera and the spectrograph in the shutter housing. This may reduce the throughput of the spectrograph in the UV. This can be flushed out with dry gas to remove the water vapour. Flushing is done via the two ports (1x each side of the camera flange, normally sealed by grub screws).

6.2 EXCHANGING APERTURE SLIT OR FIBRE ADAPTERS

When larger fibre (>50 μm diameter) must be used, a combination of slit and fibre can be used. The slit will determine the resolution of the spectrograph and the large fibre will ensure higher transmission of light. In this case the SMA connector is removed, the slit disk is attached to the Mechelle then the SMA connector attached after the slit disk as shown below.

Optional FC and ST adapters (see **Section 2.3.1**) are fitted in the same way.

NOTE: After changing slit to fibre, the unit must be recalibrated.



Figure 27: Fitting an SMA connector over the slit disc using the brass insertion tool

6.3 REPLACEMENT PARTS

There are no user replaceable parts- for assistance please contact your nearest Andor representative (see **Section 1.1**) if required.

SECTION 7: TECHNICAL SPECIFICATIONS

7.1 GENERAL SPECIFICATIONS

	ME5000 / ISTAR 334	ME5000 / IKON-M
Wavelength Range*	200 – 975 nm with spectral continuity, no gaps	
Focal Length	195 mm	
Aperture	F/7	
Spectral resolution ($\lambda/\Delta\lambda$) FWHM	4000 (4 pixels FWHM)	5000 (3 pixels FWHM)
Dispersion	$\lambda/16400/\text{channel}$	
Channel height	5 pixels, 3 pixels, 1 pixel, switch selectable	
Channel width	1 pixel	
Min distance between orders	9	
Max distance between orders	14	
Number of channels in range	25500	
Horizontal Magnification	0.81	
Vertical Magnification	1.66	
Stray light	1.5×10^{-4} measured at 20 nm from 633 nm laser line	
Optical Axis	165.1 mm [6.50 inches] with feet 155.1 mm [6.1 inches] without feet	
Shutter rate	1 Hz (optional)	

* This is the Mechelle wavelength range and if a shorter spectral range detector is used, this range will be reduced. For example, if an iStar DH334T-18F-03 was used (spectral range = 180 - 850 nm), the overall wavelength would be 200 - 850 nm.

7.2 MECHANICAL SPECIFICATIONS

Length	350 mm [13.8"] without camera
Width	100 mm [3.94"] without feet
Height	200 mm [8.66"] without feet
Weight	10 kg [22 lb]

7.3 OPERATING & STORAGE CONDITIONS

Operating Temperature	20°C to 30°C ambient
Storage Temperature	< 70% (non-condensing)
Storage Temperature	-25°C to 50°C

7.4 ME-OPT-0007 COLLIMATOR/COLLECTOR WITH ALIGNMENT LASER SPECIFICATIONS

Wavelength	650 nm nominal (640 nm to 665 nm)
Beam Diameter at Laser Aperture	25 – 47 mm
Adjustable Beam Divergence*	0 – 10.29° (0 – 180 mrad)‡
Maximum Power Output for Classification†	0.5 mW max.
Maximum Power Output at Aperture	As previous

* Beam divergence is defined as the full-angle, i.e. from edge to edge.

‡ When not virtually collimated, the beam converges to a 2 mm approx. focal spot and then diverges again.

† See comments in 'Laser Safety and Product Compliance Labels' about 'Radiation Output' definition in IEC 60825-1

7.5 ME-OPT-0009 LASER ALIGNMENT MODULE SPECIFICATIONS

Wavelength	650 nm nominal (640 nm to 665 nm)
Beam Diameter at Laser Aperture	2 mm
Beam Divergence Value*	12° (209.44 mrad)
Maximum Power Output for Classification†	1.5 mW max.
Maximum Power Output at Aperture	5.35 mW typ.

* † As previous table

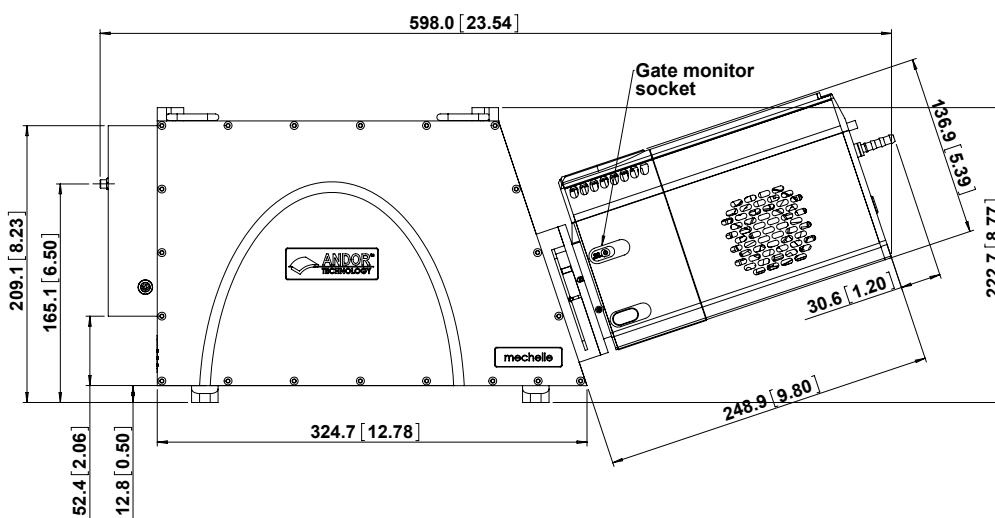
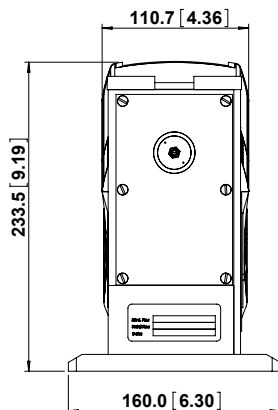
7.6 SPECIFICATIONS FOR FIBRE OUTPUT ATTACHED TO ME-OPT-0009 LASER MODULE

Wavelength	650 nm nominal (640 nm to 665 nm)
Beam Diameter at Laser Aperture	50 µm
Beam Divergence Value*	26.45° (461.64 mrad)
Maximum Power Output for Classification†	0.2 mW max.
Maximum Power Output at Aperture	1.65 mW typ.

* † As previous table

APPENDIX A: MECHANICAL DRAWINGS

Dimensions mm[inches]



APPENDIX B: REFERENCE INFORMATION

ECHELLE THEORY

Echelles are a special class of high-angle gratings, rarely used in orders below $m = 5$ and sometimes used in orders beyond 100. Because of order overlap, some type of filtering is normally required with higher-order grating systems. This can take several forms, such as cut-off filters, detectors insensitive to longer wavelengths, or cross-dispersion in the form of prisms or low-dispersion gratings. The latter approach leads to a square display format suitable for corresponding types of array detectors.

Figure 28 below shows the grating angles and **figure 30** shows the optical layout of the spectrograph.

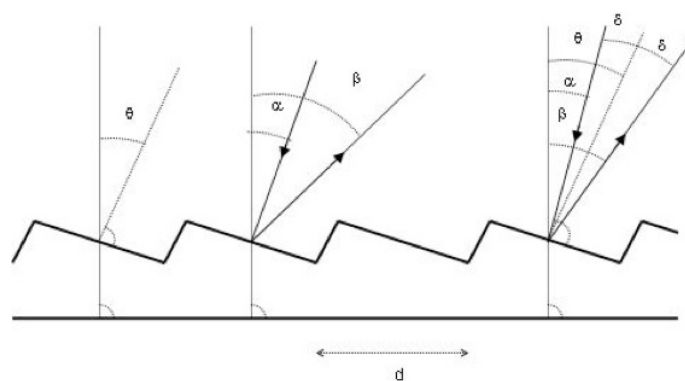


Figure 28: Equation Angles

α = incidence angle
β = diffraction angle
d = grating constant ($d \approx 5 - 30 \mu\text{m}$)
f = focal length
θ = blaze angle $\approx 60^\circ$
m = diffraction order ($m \approx 50$)
N = total number of grooves W/d
W = width of grating

B1.1- GRATING EQUATION

- $m\lambda = d (\sin\alpha + \sin\beta) \rightarrow m\lambda_m = k \rightarrow \lambda_m$ overlap
- $\beta > 0$ when incident and diffracted rays on the same side of grating normal
- Max. intensity for wavelengths satisfying the grating equation at angles $\alpha + \beta_0 = 2\theta \rightarrow m\lambda_m = d (\sin\alpha + \sin\beta_0)$
- Special case $\alpha = \beta_0 = \theta$ = condition for auto-collimation

The design of the echelle system can be optimised for resolution giving $\lambda/\Delta\lambda \sim 5 \times 10^4$, however this would only have a bandwidth of ~ 60 nm. To simultaneously observe a broad atomic spectrum, from 200 nm, where line density is high, to ~ 920 nm (main spectral response for sulphur species), the resolution will be in the region of 5×10^3 .

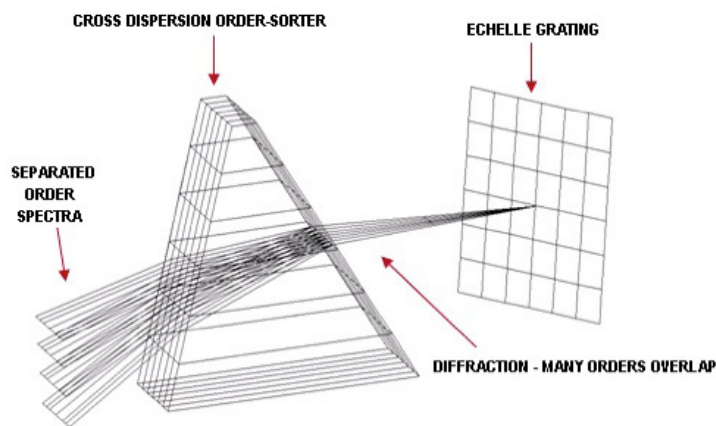


Figure 29: Schematic representation of echelle grating order-sorter combination

B1.2 - ECHELLE LAYOUT

The layout of the echelle is shown in **figure 30** below. The patented, dispersion balanced order sorting system provides a uniform distribution of the spectral orders. The order sorter works like an achromatic lens, correcting the non-uniform order distribution caused by a single prism order sorter, as used in other échelle spectrographs. This results in efficient use of the sensor area and allows a large bandwidth to be easily achieved.

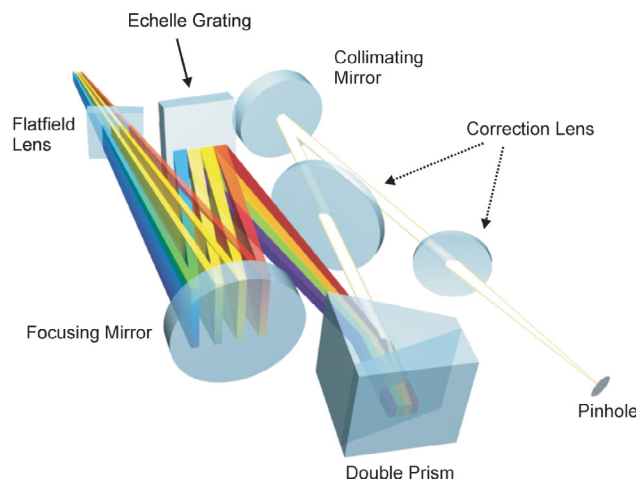


Figure 30: Optical layout of the echelle design

Figure 31 Shows the Mechelle layout using a patented combination of prisms and grating to obtain equally spaced orders at the focal plane of the instrument, as well as simultaneous large bandpass and high spectral resolution.

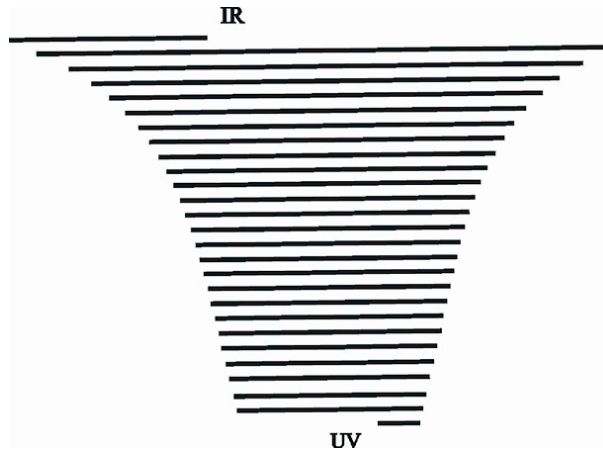


Figure 31: Equally separated spectral orders by using prism and grating design

Figure 32 shows the result of using a single prism. Without this order sorting system, the resolution together with high bandwidth cannot be achieved:

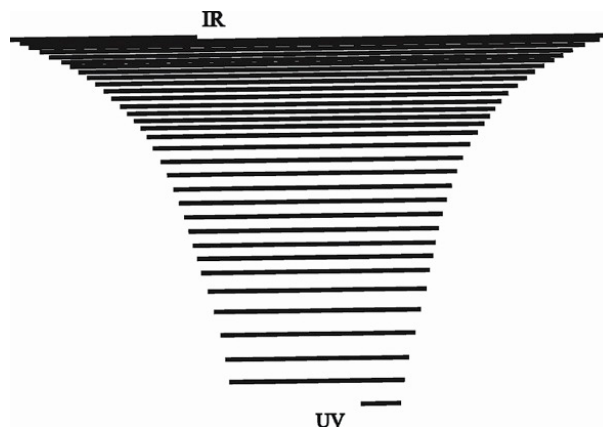


Figure 32: Single prism used for separating spectral orders compressing the orders towards IR.

A single grating would result in compression of orders in UV.

The bandwidth or free spectral range, F_λ , for any single order, m , can be defined by the following equation:

$$F_\lambda = \frac{\lambda_m^o}{m(1 - (2m)^{-2})}$$

Where λ_m^o is the centre wavelength of any order as shown in **figure 33** below. This enables the resolution, **R**, (equation below) of the spectrograph to be calculated, where **FWHM** is the minimum or desired **F**ull **W**idth at **H**alf **M**aximum on the CCD or ICCD detector, and CCDWidth is the width of the image area on the CCD.

$$R = \frac{\text{CCDWidth} (m_{\min} + 0.5)}{\text{FWHM}}$$

The overall bandwidth depends on the number of orders that can be placed on the detector multiplied by the bandwidth of each order as given by F_λ . The number of orders that can be placed on the detector is determined by the distance **L_T**, (shown in **figure 33**) between the orders. The design utilised by the Mechelle lead to 80 orders being imaged at the instrument focal plane.

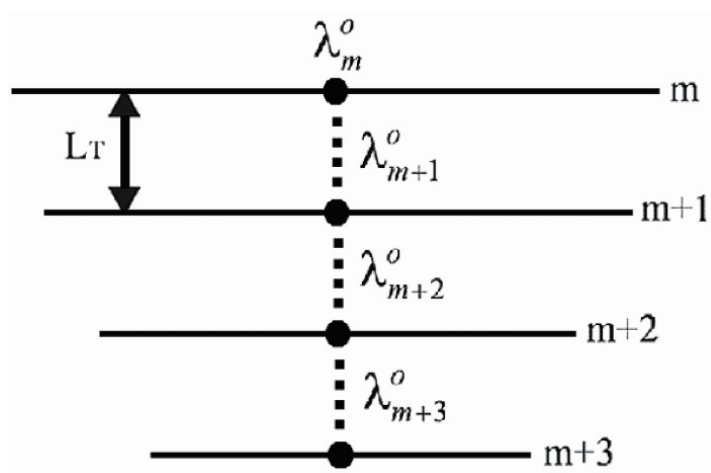


Figure 33: Detailing four spectral orders, indicating distance between orders, L_T and centre wavelengths

B2 - SAMPLE IMAGES

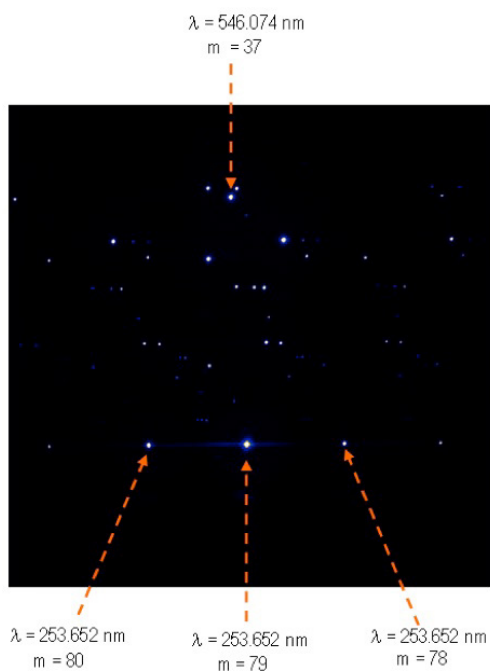


Figure 34: Image of Mercury-Argon lamp obtained using Mechelle ME5000 fitted with iStar DH334T

APPENDIX C: OTHER INFORMATION

TERMS AND CONDITIONS OF SALE AND WARRANTY INFORMATION

The terms and conditions of sale, including warranty conditions, will have been made available during the ordering process. The current version may be viewed at: http://www.andor.com/pdfs/literature/Andor_Standard_Warranty.pdf

WASTE ELECTRONIC AND ELECTRICAL EQUIPMENT REGULATIONS 2006 (WEEE)

The company's statement on the disposal of WEEE can be found in the Terms and Conditions

