Mookodi- System Description

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1 Introduction

Mookodi is a low-resolution spectrograph, designed to fit onto the Nasmyth port of the Lesedi Telescope, SAAO.

1.1 Purpose

This document is to provide a system description of Mookodi, its sub-assemblies, locations of adjustments and the reasons behind some of the decisions. It does not cover control software, nor procedures for setting up or testing the instrument.

1.2 Abbreviations

Abbreviation	Meaning
LJMU	Liverpool John Moores University
SAAO	South African Astronomical Observatory
CCD	Charge Coupled Device
PC	Personal Computer
PSU	Power Supply Unit
LAC	Linear Actuator Control Board
IEC	International Electrotechnical Commission
AMPS	Auxiliary Module Packaging Structure
USB	Universal Serial Bus
I/O	Input / Output
VDC	Volts Direct Current
LED	Light Emitting Diode

1.3 Related documents

Document title
Elec Dist_1_3
PanelElecDrg

1.4 Protocols

The terms Deployed and Stowed are used throughout this document. Deployed refers to deployable elements being positioned in the optical path. Stowed is when they are out of the optical path.

Axis positions and directions

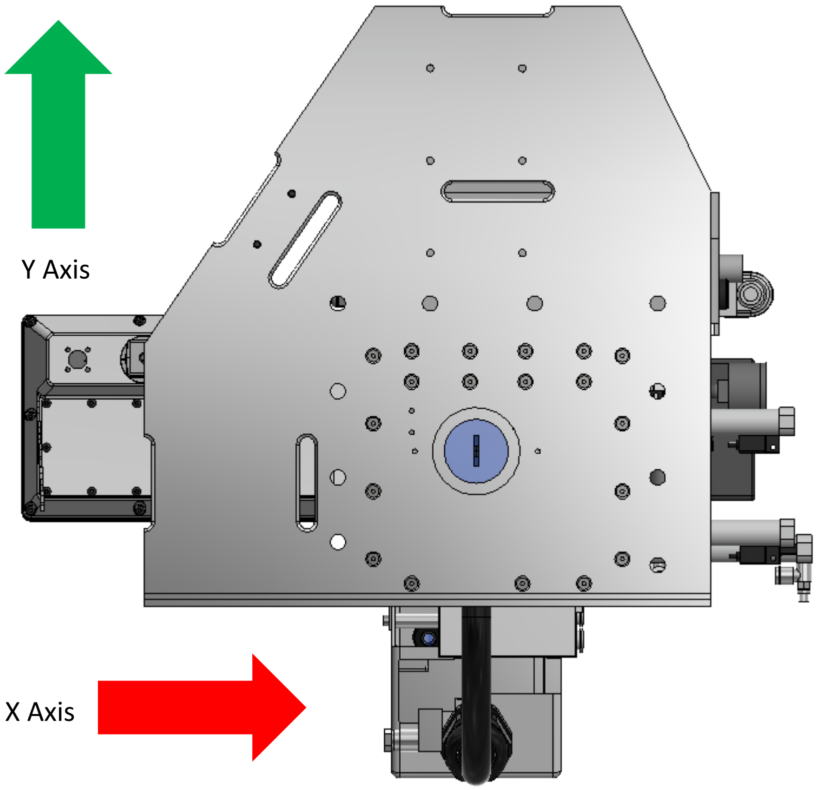

Figure 1 Front view of instrument with axis orientations

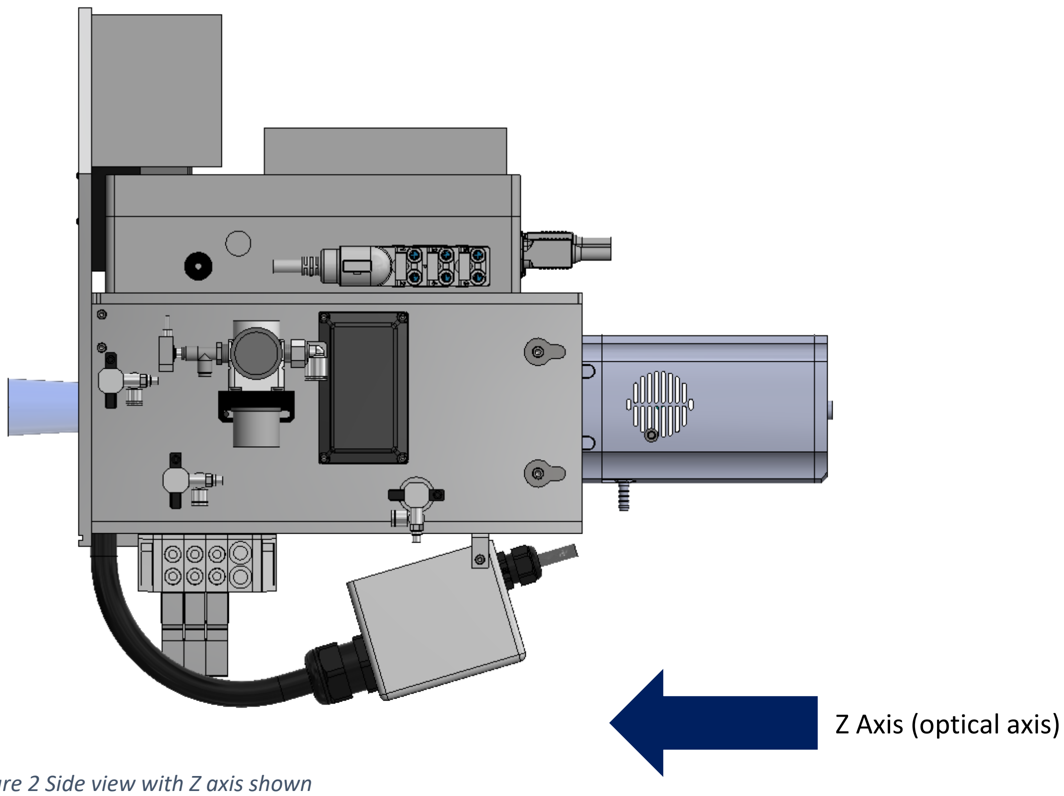

Figure 2 Side view with Z axis shown

The translucent blue region at the front of the instrument depicts the Lesedi f8 optical path as it enters the instrument.

2 Instrument sub-assemblies

Mookodi is made up of a number of sub-assemblies:

- Instrument structure
  - Light baffle
- Calibration system
  - Calibration mirror
  - Calibration light source
- Invar assembly
  - Slit assembly
  - Collimator with focus
- Filter assembly
- Grism assembly
  - Grating rotation
  - Grism optimisation
  - Grism deployment
- Camera assembly

The following items are deployable:

- Calibration mirror
- Slit
- Grism

The collimator is fixed in the optical path and the filters are selectable. As it replaces the current imager, Mookodi can be used to image and has capacity for 2 sets of 5 filters.

The slit and grism are deployed and stowed to switch between spectroscopy and imaging modes.

2.1 Instrument structure

The instrument structure is basically a box with the light path entering at one end and a camera mounted to the other end. The light path is a little offset in the X axis to allow an area for mechanisms to be 'Stowed' in.

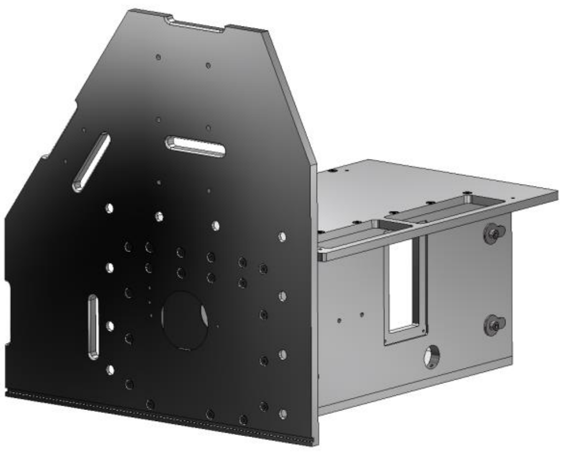

Figure 3 Instrument structure

2.1.1 Structural integrity

The lid, base and sides of the instrument give its structural integrity, one of the outcomes from the review process was distortion of the front face plate dependent on the gravity vector. This has been addressed by adding more mounting bolts from this plate to the telescope interface.

An additional brace has been added as part of the calibration mirror mount. This runs across the top of the front section of the instrument and has the calibration mirror profiled rail attached to it. A number of bolts fasten through the front face plate into this brace to further reduce the flexure of the front face plate.

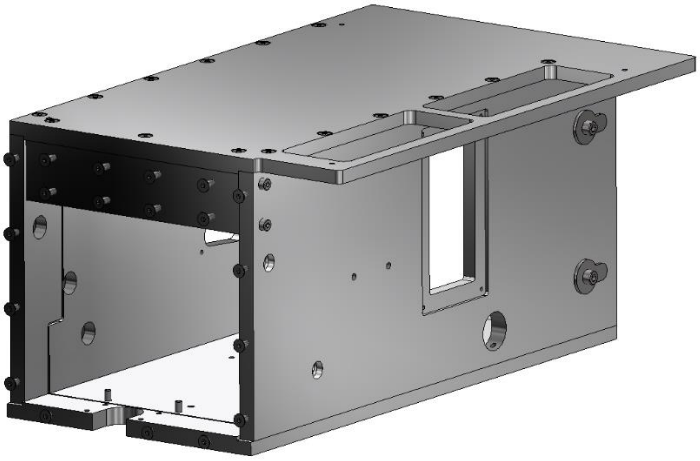

Figure 4 Image showing additional brace under lid and behind front face plate

It is held in position when the front plate is removed by two bolts in each end, through the sides of the instrument.

2.1.2 Light baffle

An issue identified with SPRAT was the requirement for a light baffle to prevent off-axis light entering the instrument through the light aperture and passing/reflecting around the slit. This has been addressed with the addition of a baffle across the instrument at the slit position. The light baffle is recessed into the instrument base, lid and sides.

Figure 5 Light baffle in blue

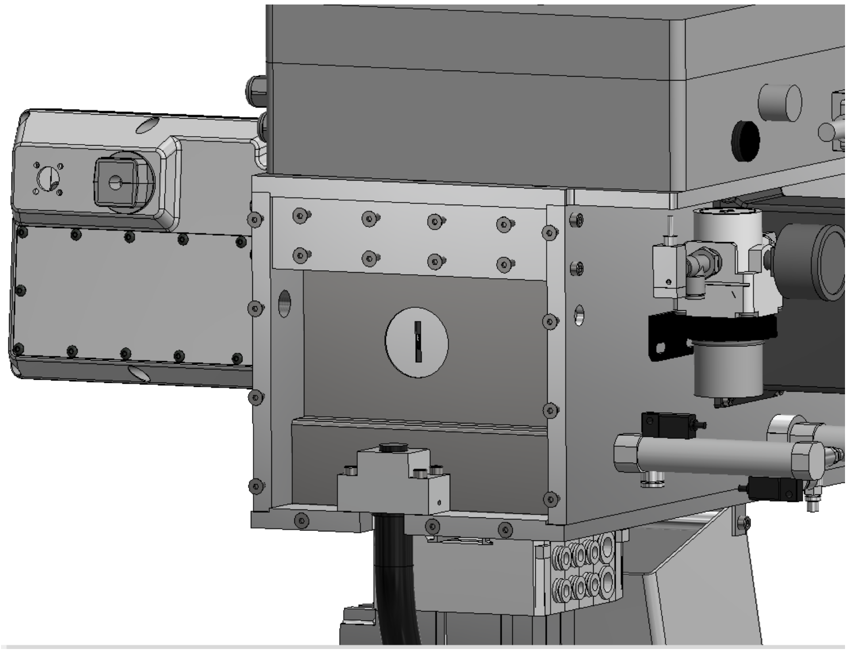

Figure 6 Light baffle with slit deployed

Additional baffles have also been fitted to each end of the collimator assembly.

2.1.3 Access to adjustments

The lid is removable without having to remove the instrument from the telescope, although the electrical panel will need to be re-positioned.

This is done by removing all the lid countersunk bolts, (note the position of the two shorter central ones), then lifting the rear of the lid to disengage from the camera plate and light baffle, then slide backwards a little to disengage from the front face plate.

A number of 'access' ports have been machined into the side of the instrument to allow for adjustment of most mechanisms without removing the instrument from the telescope, or the lid.

Caps have been fitted to all access ports

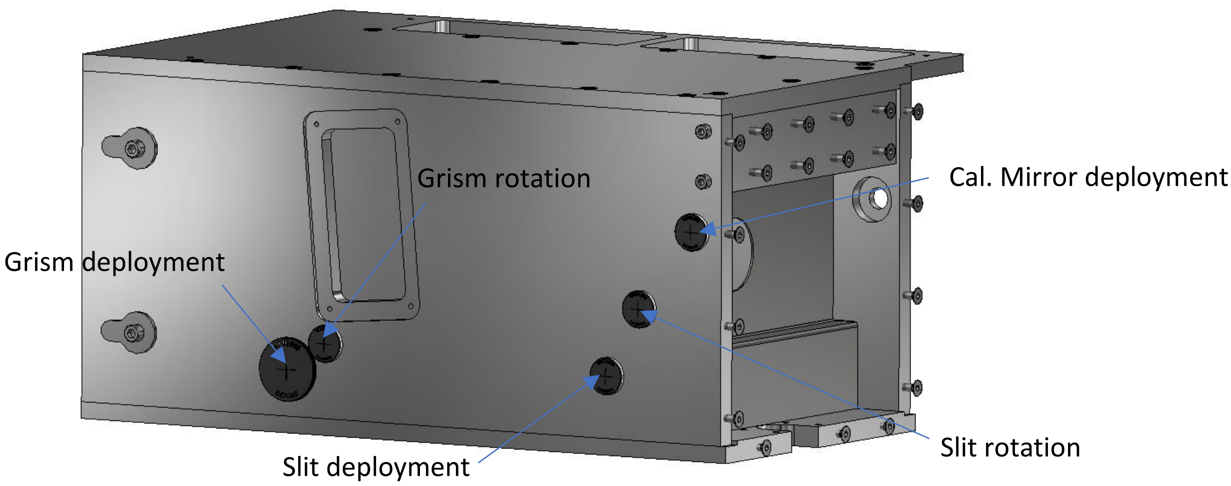

Figure 7 Access points for adjusting mechanisms

Special tools have been provided to carry out these adjustments.

Figure 8 Special tools for adjusting mechanisms

The camera is adjustable both in pitch, and forwards or back along the optical axis, though this is not a requirement. This adjustment was included to aid in eliminating potential reflections from internal surfaces causing ghosting in the image.

The only adjustments that require the removal of the lid are setting the instrument focus and the grating rotation around the optical axis, both of which are done by hand.

All adjustments will be described further in their relevant sections

2.2 Calibration system

The calibration system is made up of a deployable mirror and two light sources.

2.2.1 Deployable mirror

The mirror is a front surface silvered mirror from Edmund Optics, this is glued to an aluminium mount. This is deployed into the light path with a pneumatic cylinder, which in turn is driven by a pneumatic solenoid.

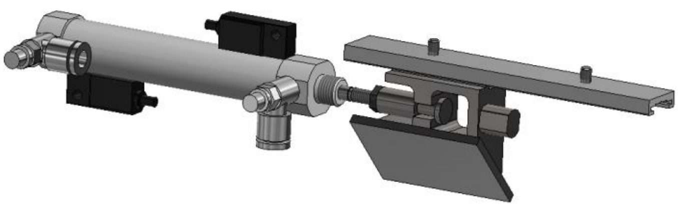

Figure 9 Calibration mirror deployment mechanism

This solenoid is a two position, spring return solenoid and can be activated manually via a small blue button on the solenoid, as with all the other solenoids.

The deployed position is set via an adjustable hard stop, accessed through the side of the instrument.

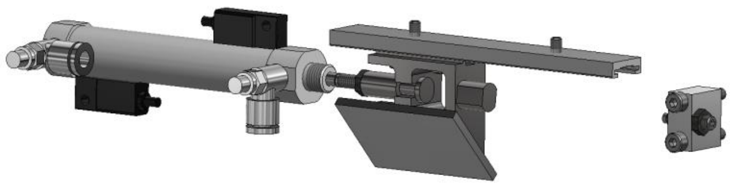

Figure 10 Calibration mirror mechanism with hard stop

2.2.2 Light sources

Two light sources are used, a Xenon arc lamp and a Tungsten bulb. These are mounted in a 'Light box', located underneath the instrument. The light from this box is transferred to the calibration mirror via a ½" optical fibre light pipe.

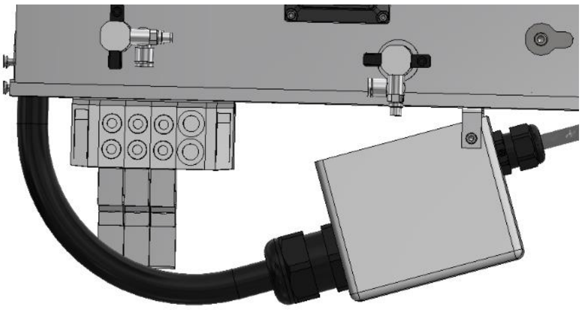

Figure 11 Light box and fibre optic

2.3 Invar assembly

To maintain the focal accuracy of the instrument over the temperature range it will be used, the slit and collimator assemblies have been mounted on an Invar base. Due to the reduced thermal expansion of Invar, and other materials used, this assembly is close to a-thermal.

The slit end of the invar assembly has been secured to the aluminium instrument base, the other end has been only clamped in the Y direction with Belleville washers, this is to eliminate deformation due to difference in thermal expansion between the instrument body and the invar base.

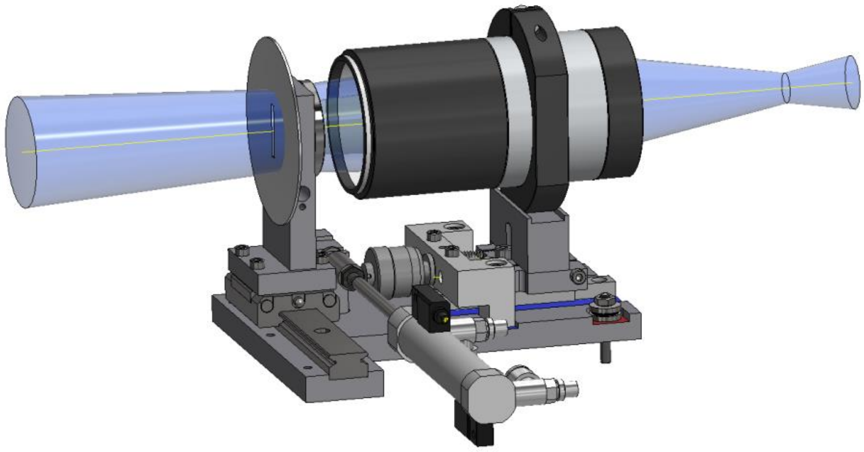

Figure 12 Invar assembly including slit and collimator assemblies

2.3.1 Slit assembly

The slit can be adjusted in rotation and deployment. The slit has two different widths and two further slit options have been supplied as spares. These can be replaced when the instrument lid has been removed. Although the slits have been produced specifically for Mookodi, the slit holder has been designed to accept off-the-shelf slits from Thorlabs if required.

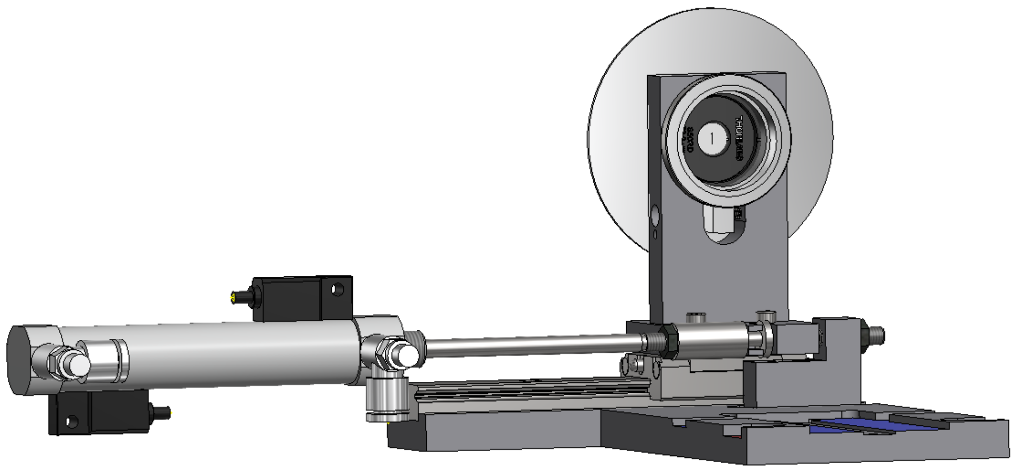

Figure 13 Slit assembly with Thorlabs slit fitted

The slit vertical alignment can be adjusted without disassembly, through the side of the instrument using the 5.5mm box spanner to release a lock-nut and the 1.5mm extended Allen key to rotate the slit about the optical axis.

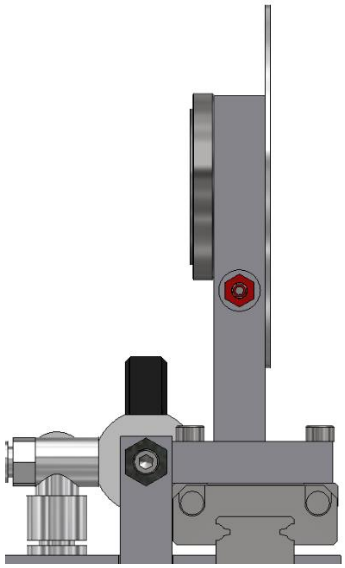

Figure 14 Slit rotation adjustment

This is a spring return mechanism. It should be noted that the knurled ring indicated in the image below has a left-hand thread. This is to ensure the rotation position isn't changed when this is tightened, as a right-hand thread would have pushed against the spring return when tightening.

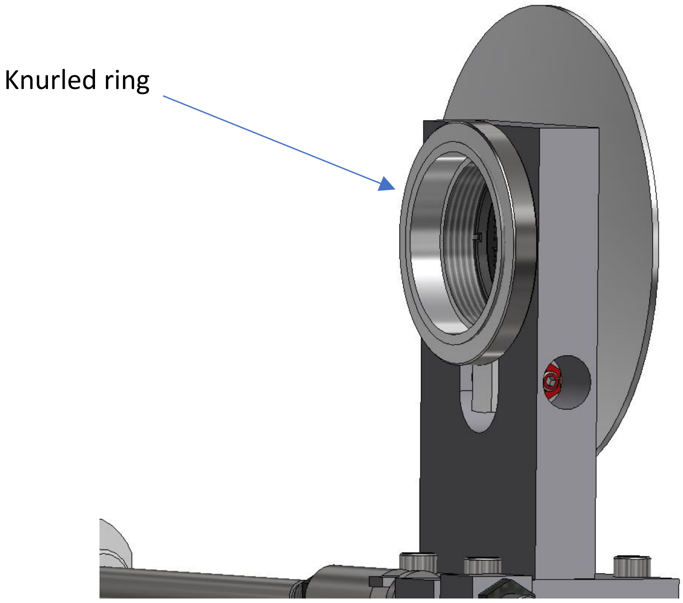

Figure 15 Knurled ring - LH thread

The slit is deployed by a pneumatic cylinder, in the same way as the calibration mirror. The deployed position can also be adjusted without disassembly, through an access hole in the side of the instrument using the 8mm box spanner and 2.5mm extended Allen key.

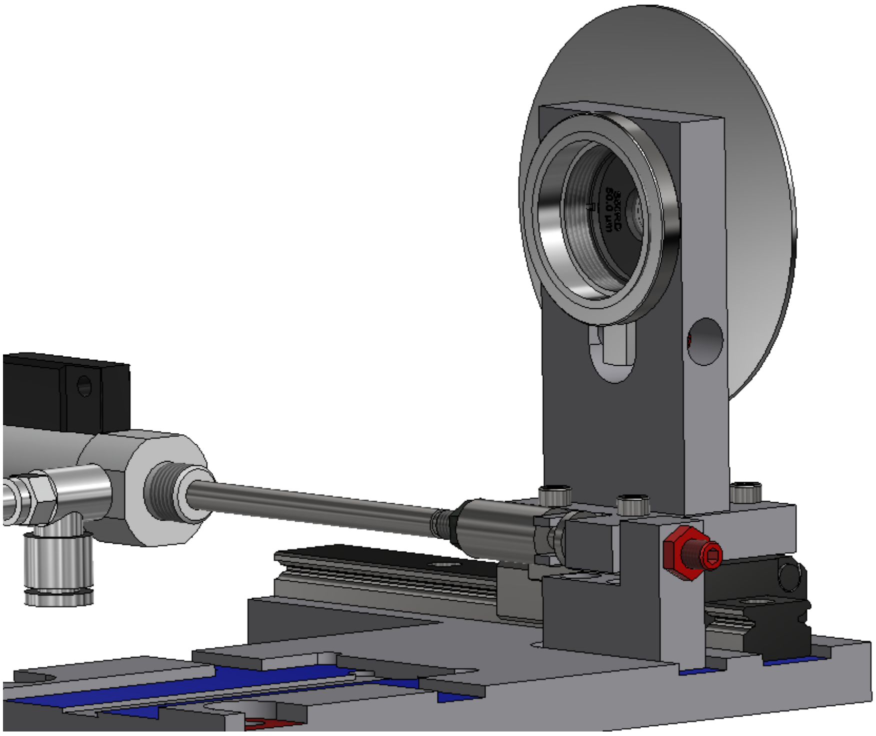

Figure 16 Slit deployment stopper

2.3.2 Collimator with focus

The collimator is made up of a lens tube and two doublet lenses from Thorlabs. This lens tube is mounted on a profiled rail and can be finely adjusted for focus via a micrometre head within the instrument. The lid must be removed to gain access to this.

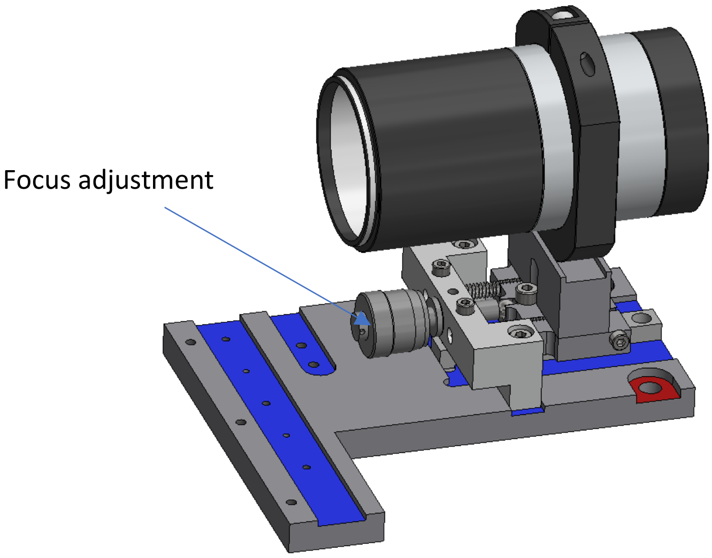

Figure 17 Collimator assembly with focus adjustment

Additional lens tubes have been fitted to both ends of the required lens tube to add additional light baffling.

2.4 Filter assembly – Designed by SAAO

The filter assembly is made up of two linear actuators from Actuonix, and two sets of five filters. These actuators can only be driven via the PC. The entire assembly is tilted off the perpendicular by 5 degrees to reduce reflected light creating ghosts.

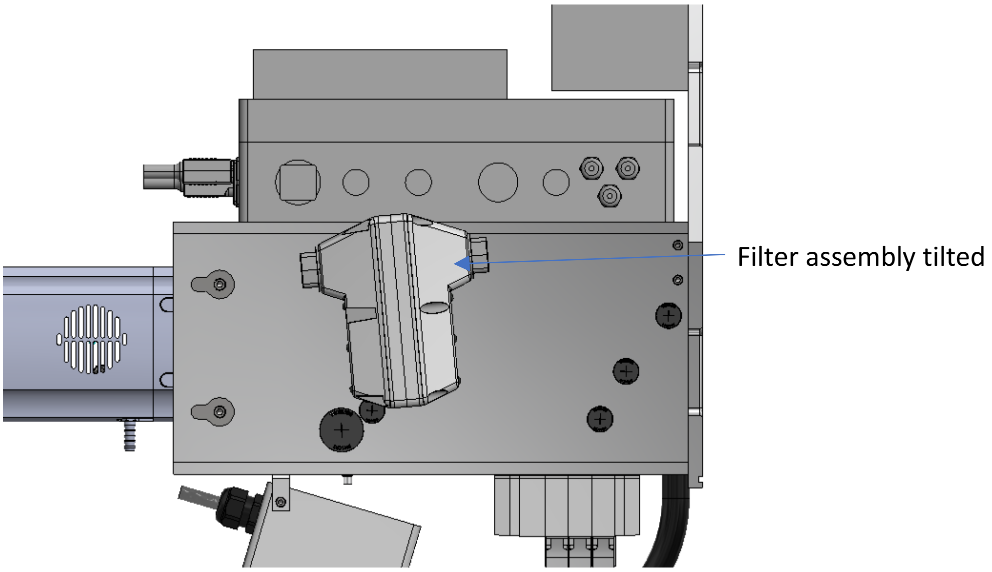

Figure 18 Filter assembly tilted

The LAC control cards for these actuators are fitted to the cover assembly, one on each side. They are connected to the PC via USB cables and have a 12VDC supply. The sides of the filter covers can be removed to gain access to these cards and some of the filters, but in practice it is difficult to replace the filters without removing the entire assembly from the instrument.

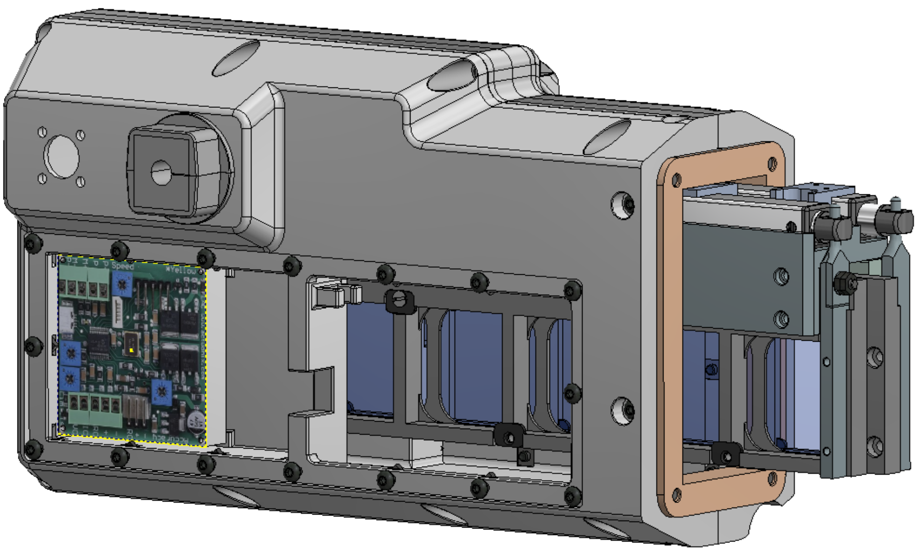

Figure 19 Filter assembly with access port removed

Separate instructions will be provided to remove the filter assembly covers and filter assembly to fit/change filters.

2.5 Grism assembly

The grism optical assembly is made up of a grating sandwiched between two prisms. The grating is the dispersive element and the prisms ensure the resulting spectrum is projected onto the CCD, so the camera does not need to be translated between imaging and spectroscopy modes. These are mounted in a structure which allows rotation of the grating about the optical axis. The instrument lid must be removed to carry out this adjustment.

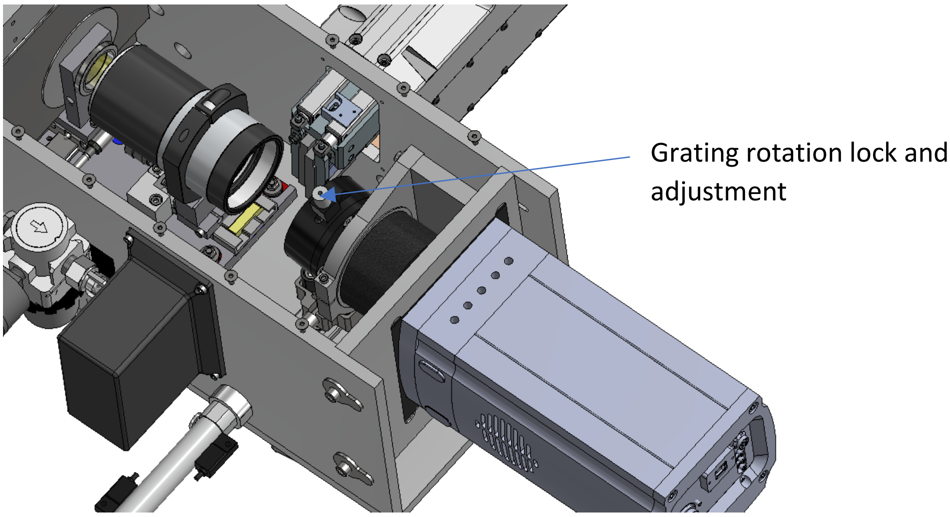

Figure 20 Adjustment for grating rotation

The grism assembly is mounted on a rotation stage from Thorlabs which can be manually adjusted in rotation around the Y-axis, through the side of the instrument to optimise the peak throughput for a particular wavelength. This can be adjusted without disassembly, through the side of the instrument.

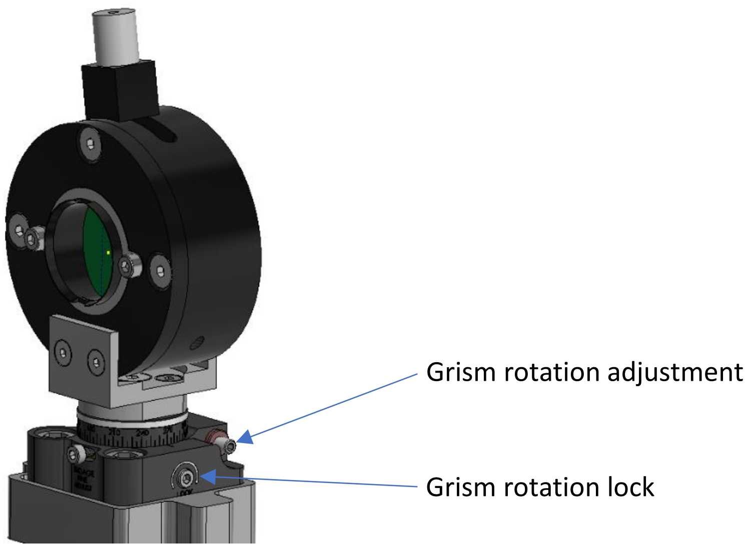

Figure 21 Grism rotation for wavelength optimisation

The above assembly is mounted on a profiled rail and is deployed via a pneumatic cylinder in the same way as the calibration mirror and slit. The deployed position is adjusted via a hard stop, accessed through the side of the instrument.

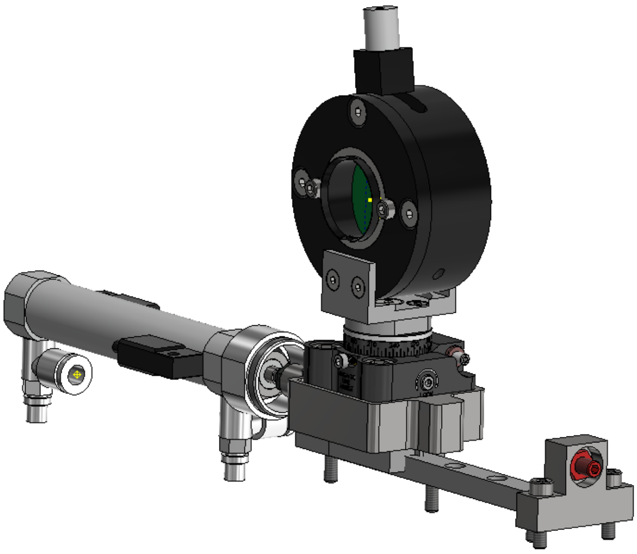

Figure 22 Grism assembly deployment dead-stop adjustment

2.6 Camera assembly

The camera assembly is made up of an Andor DU934P, deep depletion camera and a 50mm f1.4 Nikkor lens with F Mount to C Mount adaptor.

The camera is attached to the rest of the instrument via 4x M4 bolts, and is electrically insulated from the rest of the instrument via an acetal plate and 4x acetal ‘top hats’, one under each of the mounting bolts.

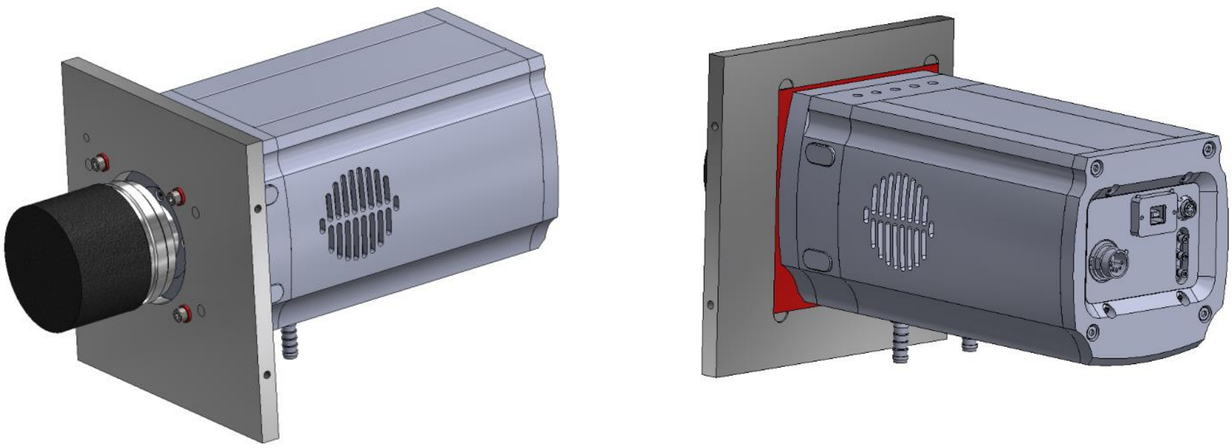

Figure 23 Camera assembly with acetal insulation highlighted

A lens support has been added to fix a problem identified during performance testing in Liverpool. This was caused a small amount of play in the Nikkor lens shifting the image under different gravity vectors. The lens support screws into the filter thread in the end of the lens and is attached to the camera mounting plate.

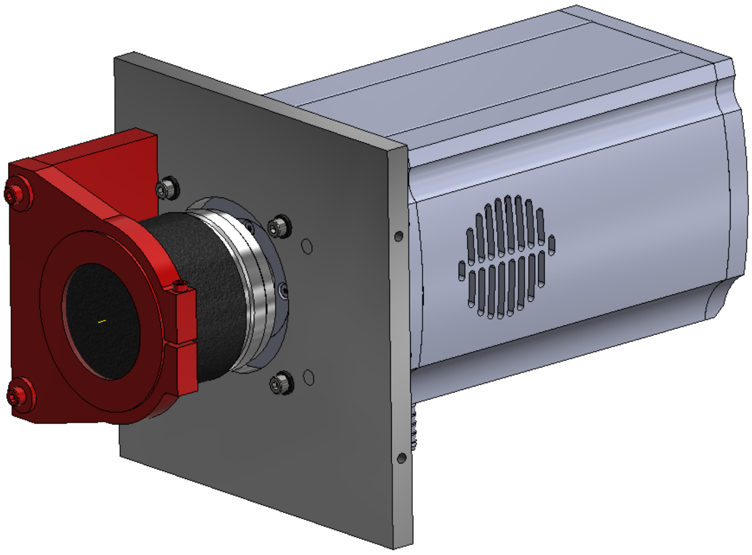

Figure 24 Camera assembly with lens support highlighted

The camera and lens assembly can be moved a small distance along the optical path, and tilted in relation to the optical path via 4x slotted holes in the side of the instrument, however this has not been required. This was included due to concerns of stray reflections from internal surfaces causing ghosting.

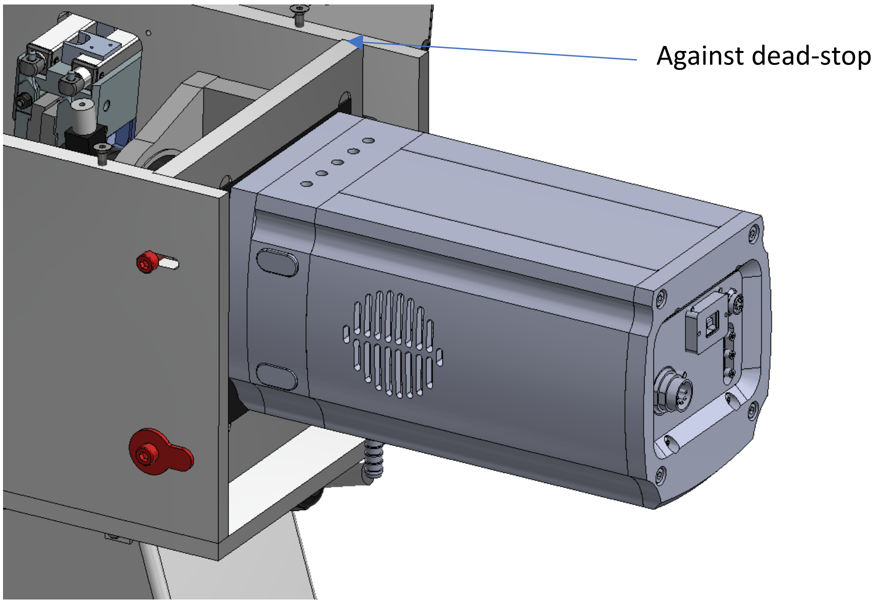

Figure 25 Camera assembly with tilt and piston adjustment in red

The default is simply to insert the camera into the instrument along the optical axis until it reaches the dead-stop. The washers over these slotted holes are teardrop shaped to help keep the instrument light-tight if it was mounted further out.

3 Pneumatic system

The pneumatic system controls the deployment mechanisms for the calibration mirror, slit and grism.

An air supply is connected to the instrument via a self-sealing, quick-release connector. The instrument has its own air pressure reducer and pressure gauge. This can be adjusted and has been initially set to 4 bar.

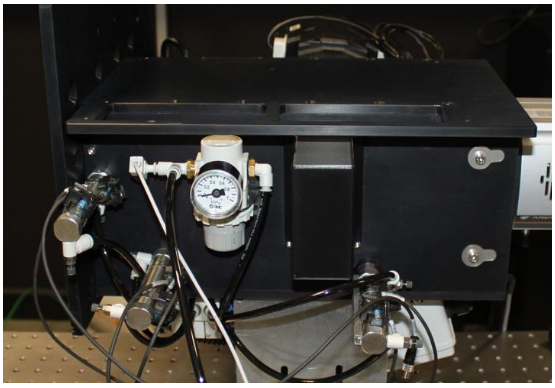

Figure 26 Air pressure reducer and gauge

Three solenoids are fitted underneath the instrument. These solenoids are all two position, spring return and can be activated via a small blue button mounted on each one.

The speed for each cylinder is adjusted via a flow controller on each end of each cylinder. The system used is 'meter-out', so the speed is controlled by reducing the air flow as it leaves the cylinder, NOT as it enters.

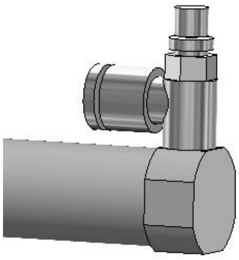

Figure 27 Meter out flow/speed controller

Each cylinder has 2x magnetic sensors, one for stowed and one for deployed position and can be adjusted along the cylinder as appropriate. If a position is changed, the corresponding sensor position will probably need to be adjusted to compensate. The cylinder sensors have orange indicator LEDs fitted to show when they are active. These are useful when setting deployment positions but can cause unwanted light in an observatory. We have found a dab of black hot-glue stops this light contamination, and can easily be peeled off later.

4 Control system

During normal operations the instrument is controlled through a computer and control panel mounted on the instrument.

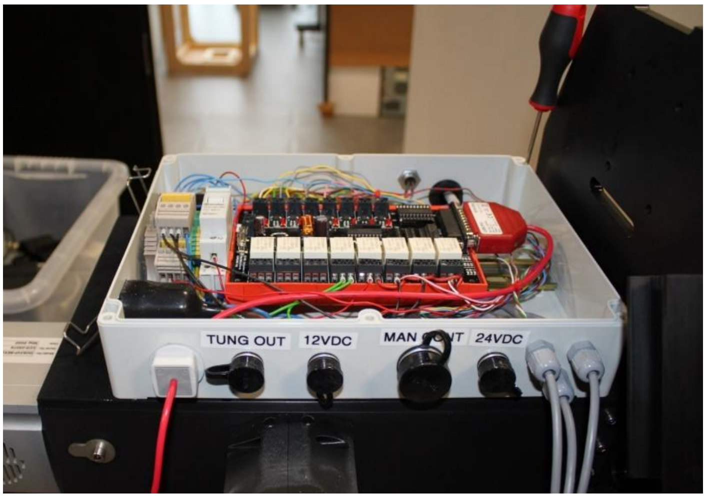

Figure 28 Instrument control panel

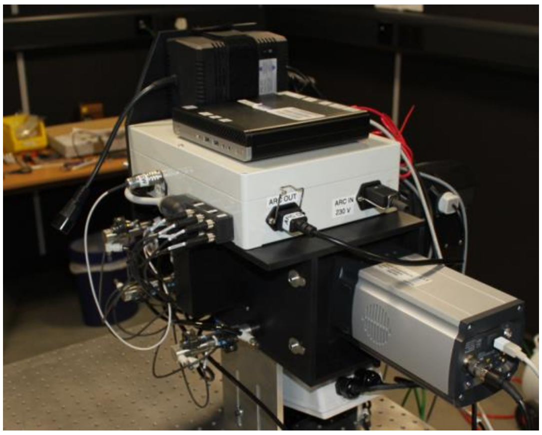

Figure 29 Instrument with control panel and control computer fitted

A manual control box has also been provided to drive each of the pneumatic cylinders and monitor the position switches, without using the control computer. This can be handy for setting up switch positions as required at the telescope. It is recommended to disconnect the red USB I/O cable from the control PC when using this to avoid conflicting with running software. Reboot the PC after re-connecting the red USB I/O cable to restore the PIO controller to a known state.

Figure 30 Manual control box

5 Ancillary equipment and electrical supply

The only pieces of ancillary equipment are the three PSUs for the control PC, arc lamp and Andor camera. These are all mounted to the instrument side of the front face plate.

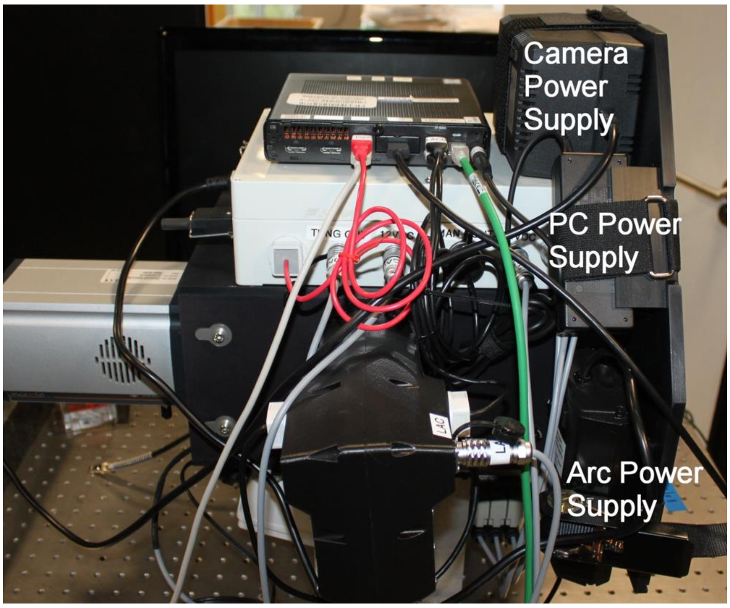

Figure 31 Power supplies on the instrument

The PC and Andor camera are powered directly from the AMPS unit, although a mains feed from the AMPS unit supplies power for the arc lamp PSU, it is switched on and off by the control computer.

Low voltage supply is via two 12VDC power supplies and one 24VDC. These are located in the AMPS unit with cables fed though the Lesedi's cable wrap to the instrument.

6 Test equipment

The test equipment provided is a laser auto-collimator and adaptor mount. When checking collimation, the grism and order blocking filter are deployed, the slit and mirror are stowed. Mis-aligned optics will produce reflections which appear outside the inner calibration ring.

The auto-collimator and adaptor are fitted onto the front face-plate.

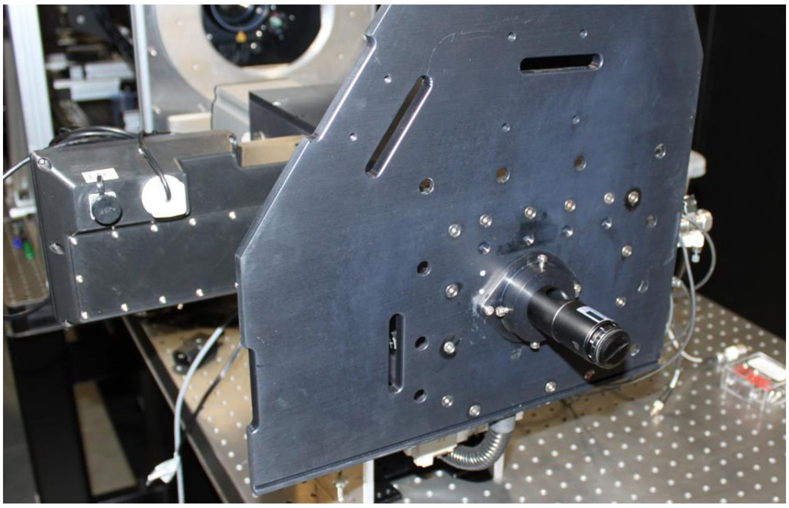

Figure 32 Instrument with auto-collimator fitted

7 Instrument mass and moment

The maximum spec for the mass and moment of Mookodi was given as 30Kg and 75Nm

The instrument with telescope interface and ancillary equipment is 29kg

The centre of gravity is 206mm from the telescope interface, which equates to 59Nm.