ISIS PLC commissioning

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1.1.1 Slit-width measurements

Calibration lamps in use: tungsten lamp
Set-up: grating H2400B, $\lambda_c = 5000$ Å, bfold 1, bin blue 1 1, rspeed blue slow, exposure time = 13 s
Description: take flats of 13 s in the given set-up with a slit width of 3, 2.75, 2.5, 2.25, 2, 1.75, 1.5, 1.25, 1, 0.75, 0.5, 0.4, 0.3 and 0.25 arcsec. Take 11 biases.
Objectives: to check the slit width absolute calibration with the new PLC controllers.

1.1.2 Arc calibrations

Calibration lamps in use: cuar+cune
Set-up: all ISIS gratings, no dichroic, slit width 1 arcsec
Description: take an arc in each of configurations as in Table 1.

grating	cenwave (Å)	total spectral coverage (Å)
R158R	7500	3735:11265 (5300:10000)
R316R	6450	4521:8379 (5300:8379)
R316R	8650	6721:10579 (6721:10000)
R600R	5900	4873:6927 (5300:6927)
R600R	7000	5973:8027
R600R	8200	7173:9227
R600R	9200	8173:10227 (8173:10000)
R1200R	5600	5072:6127 (5300:6127)
R1200R	6200	5672:6727
R1200R	6800	6272:7327
R1200R	7400	6872:7927
R1200R	8000	7472:8527
R1200R	8600	8072:9127
R1200R	9200	8672:9727
R158B	4500	1182:7817 (3200:5300)
R300B	4500	2730:6269 (3200:5300)
R600B	4000	3087:4912 (3200:4912)
R600B	4500	3587:5412 (3587:5300)
R1200B	3600	3130:4070 (3200:4070)
R1200B	4250	3780:4720
R1200B	4900	4430:5370 (4430:5300)

Table 1: Set-up for arc and tungsten lamp calibrations.

Objectives: to check the position and intensity of arc lines.

1.1.3 Throughput measurements

Calibration lamps in use: tungsten lamp
Set-up: all ISIS gratings, no dichroic and dichroic 5300, slit width 1 arcsec
Description: take at least one flat-field exposure for each grating (you can use set-up from Table 1) with and without a dichroic.
Objectives: to check a spectrograph throughput using tungsten lamps.

1.1.4 Collimator movements

Calibration lamps in use: cuar+cune
Set-up: any grating, both red and blue arm. Red arm GG495 in use
Description: set-up the spectrograph for the selected grating in red and blue arm of ISIS following the usual procedure. Pay attention whether everything is OK with collimator movements, i.e. best spectrograph focus is reached after applying collimator offset recommended by Hartmann tests.
Objectives: to test the accuracy of collimator movements.

1.1.5 Check nominal collimator position

Calibration lamps in use: tungsten lamp
Set-up: any grating for which the spectrograph is set-up; both red and blue arm
Description: after the spectrograph is set-up for the selected gratings, insert Engineering 1 dekker and select position: dekker 7, which is 0.3 arcsec slit. Take exposures changing the collimator value to find the best spatial focus and compare with the best spectral focus.
Objectives: to check that the spectrograph is not astigmatic at its nominal collimator positions.

1.1.6 Bfold movements

Calibration lamps in use: any
Set-up: any
Description: use bfold 2, 1 and 0 and take exposures.
Objectives: to check the correct movement of the bfold mechanism.

1.1.7 Slicer

Calibration lamps in use: any
Set-up: any
Description: insert slicer and take test exposures.
Objectives: to check that slicer is working as expected.

1.1.8 Polarization unit – spectropolarimetry

Calibration lamps in use: cuar+cune, tungsten lamp
Set-up: any arm of ISIS (bfold 0 or 1)
Description:

Setting-up the detector
• set-up the spectrograph without any polarization optics with dekker in the clear position (dekker 8)
• insert polarization dekker into position 3 (dekker 3)
• take a flat-field exposure and define appropriate window
• insert quarter-wave plate and calcite into the beam
• add 9200 units to the actual collimator position
• take an arc and measure FWHM of one isolated arc line close to the center of the spectrum. Change the collimator value by 500, make another arc and measure FWHM again. Repeat until the minimum FWHM is obtained
• test whether the spectrograph is anastigmatic in the chosen collimator value. Use Eng 1 dekker (dekker 7) and check FWHM of tungsten lamp exposures

Linear polarimetry
• insert polarization dekker into position 3 (dekker 3)
• insert half-wave plate and calcite into the beam
• insert MF-POL-PAR polaroid from the AG main filter unit
• take a flat-field exposure at several half-wave plate angles (close to 0 deg). Find at which angle the contrast between the ordinary and extraordinary rays is maximal (8 deg was observed in the past $\Rightarrow$ the difference $\delta = 8 - 0 = 8$ deg)
• take 4 exposures with the half-wave plate at angles $0{+}\delta$, $45{+}\delta$, $22.5{+}\delta$ and $67.5{+}\delta$ deg

Circular polarimetry
• insert quarter-wave plate and calcite into the beam
• insert MF-POL-PAR polaroid from the AG main filter unit and dekker in position 3
• take a flat-field exposure at several quarter-wave plate angles. Find at which angle the contrast between the ordinary and extraordinary rays is maximal (42 deg was observed in the past, and we have to add 45 deg for circularly polarized light $\Rightarrow \Delta = 42 + 45 = 87$ deg)
• take 2 exposures with the quarter-wave plate at angles Δ, $90{+}\Delta$ deg

Objectives: check that ISIS polarization mechanisms are working as expected.

1.1.9 Polarization unit – imaging polarimetry

Calibration lamps in use: tungsten lamp
Set-up: any arm of ISIS (bfold 0 or 1)
Description (follow the recipe Image Polarimetry with ISIS on ISIS web-page):
• mount the Savart (calcite) analyzer in the multi-slit position of the ISIS slit carriage
• mount the mirror in a grating position
• set the central wavelength = 0 Å

• mount the filter slide/slides in their position below the ISIS slit unit
• move the filter slide/slides to a position between normal positions 1 and 2, which is position 3 (using ISIS GUI or ICS)
• insert half-wave plate into the beam
• set-up the window appropriately
• take a flat-field exposure
• focus the spectrograph
• insert a polaroid into the beam
• take exposures at four different angles of the half-wave plate, separated by 22.5 deg (lpol red <exp time>)

Objectives: check that the peak counts have switched beams between 0 and 45, and 22.5 and 67.5 deg of the half-wave plate. Check that the new filter position (position 3) is not vignetting the beam.

1.2 On-sky tests

1.2.1 Slit alignment on sky

Description: acquire a star on slit in sky PA = 0 (then 90) and nod the telescope North-South (then East-West) into few more positions along the slit length. Use narrow slit, e.g. 1 arcsec.
Objectives: to see whether the star is well centered on slit in all positions along the slit length in sky PA = 0 and 90.
Conditions required: any, except thick clouds.

1.2.2 ISIS service observations

Description: observing ISIS service proposals.
Objectives: test the normal ISIS use during the night.
Conditions required: proposal dependent.

2 Commissioning report

2.1 Off-sky tests

2.1.1 Slit-width measurements

Status: commissioned
Review: a slit-width offset was determined from a set of tungsten lamp exposures keeping the exposure time constant and changing a slit-width from 3 – 0.25 arcsec. For all images, bias level was subtracted and a mean level of counts/pixel was measured. The resulting slit-width offset can be determined from a linear fit to the flux versus slit width dependency.

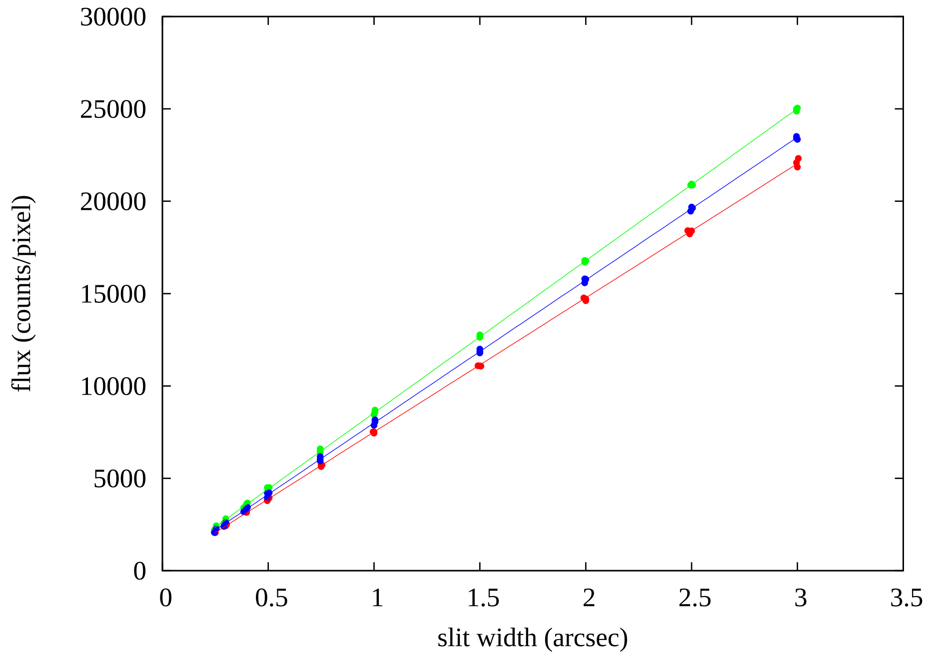

Figure 1: The mean level of flux on bias-subtracted images is plotted versus a slit width. The three lines are linear fits corresponding to three different set-ups: using dichroic 5300 and blue arm (green line), using dichroic 5300 and red arm (blue line) and using blue arm only and no dichroic (red line). For each set-up and each slit-width position, three images were taken at 3 different telescope elevations: 90, 60 and 30 degrees (points overlap each other).

On 7th June 2012 a slit width versus telescope elevation was tested (images r1797633–84, r1797718–70). In Fig. 1 the three lines are linear fits corresponding to three different ISIS set-ups, to check the consistency: using dichroic 5300 and blue arm (green line), using dichroic 5300 and red arm (blue line) and using blue arm only and no dichroic (red line). The three linear fits have 0 flux at the slit width of -0.035 arcsec, see the zoom image in Fig. 2. For each set-up and each slit-width position, three images were taken at three different telescope elevations: 90, 60 and 30 degrees (see Fig. 2, as in Fig. 1 points at different telescope elevations cannot be recognized easily as they overlap each other). As expected, the slit width behaves in a same way for all three tested telescope elevations, and for three different set-ups.

Before applying a new slit-width offset, on 20th June 2012 a slit-width offset was re-determined (images r1804442–58) and the resulting offset was -0.07 arcsec. The equivalent offset of -15 μm was applied to PLC program, resulting in a final value of 2191 μm. After checking again a slit-width offset (images r1804485–96 taken on 20th June 2012), the very small offset of -0.005 arcsec was measured.

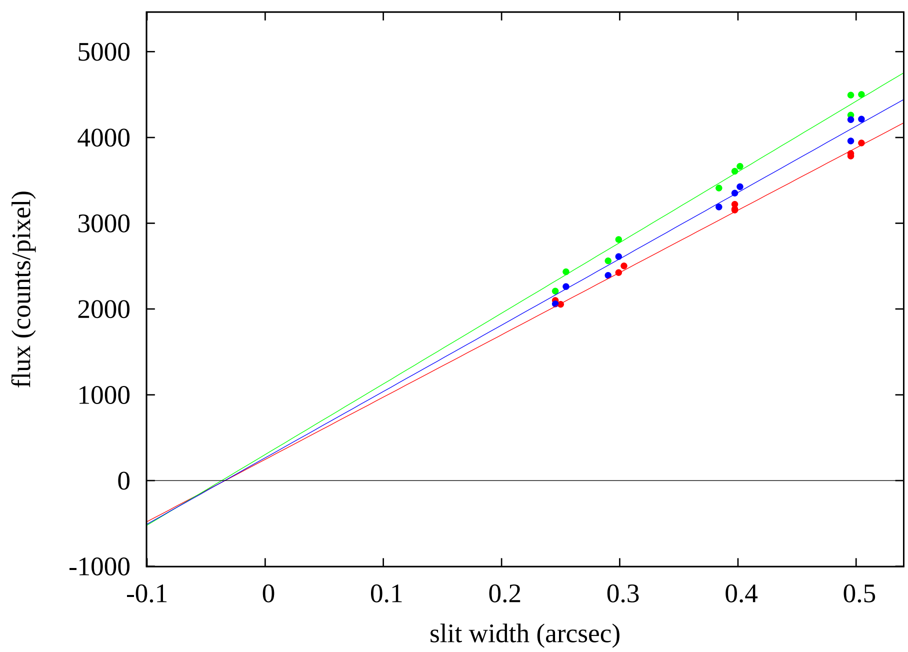

Figure 2: Zoom of Fig. 1. It is clearly seen that all three linear fits have the same slit-width offset, thus the slit width behaves in a same way for all three tested telescope elevations, and for three different set-ups.

There might be a dependence of the slit width on temperature; ISIS instrument specialist will monitor this possibility in the future.

2.1.2 Arc calibrations

Status: commissioned
Review: grating offsets were defined so that the demanded central wavelength is obtained in the middle of the non-vignetted area rather than in the middle of the CCD. In the blue arm, the middle of the non-vignetted area is on the pixel y = 2075, in the red arm it is on the pixel y = 2000.

The user acceptance data were taken on 14th February 2012 and new grating offsets in the database were defined:
MAJOROFFSETREDGRATING -223 (for REDPLUS)
MAJOROFFSETBLUEGRATING +600 (for EEV12)

On 1st June 2012 these grating offsets were checked for all gratings and various central wavelengths, as in Table 1. For the red arm and all configurations, the central wavelength was found very close to the middle of the non-vignetted area (see Table 2), as desired. On the other hand, the central wavelength for the blue arm was systematically shifted, and the final central wavelength for different gratings was reached with much larger range of values compared to the red arm (see Table 2).

Subsequently, mechanical engineers checked the blue grating mechanism, but they did not find any mechanical problems.

On 20th June 2012 a new set of images was taken to double check the central wavelength of the blue arm again, and results very similar to the ones taken on 1st June 2012 were obtained (see Table 2), confirming that a new offset is needed. At the same time, the red grating was checked again with very similar good results as previously.

On 21st June 2012 a new grating offset was defined for the blue arm in the database:
MAJOROFFSETBLUEGRATING +660 (for EEV12)

Due to the larger range of actual central wavelength values reached for different gratings in the blue arm (see Table 2), the offset was defined as a compromise between the highest and lower resolution gratings. Thus, the demanded central wavelength for the highest resolution grating (H2400B) falls above the middle of the non-vignetted area in the blue arm (which means that the real central wavelength is smaller than requested), and for lower resolution gratings falls below the middle of the non-vignetted area (which means that the real central wavelength is larger than requested).

After the new offset was defined, the central wavelength was checked again (see results in Table 2). The final results are satisfactory. The central wavelength command works very well for the red arm, but one needs to be aware of the fact that for the blue arm the final values are not so accurate and should be checked at the telescope if a very good accuracy is required for the observations.

The final values for grating offsets are:
MAJOROFFSETREDGRATING -223 (for REDPLUS)
MAJOROFFSETBLUEGRATING +660 (for EEV12)

2.1.3 Throughput measurements

Status: commissioned
Review: tungsten lamp exposures were taken in each configuration as in Table 1 and compared with images from the past with same/similar configuration (taken before the conversion to PLC controllers). Maximum counts/pixel and general shape of the tungsten lamp exposures were checked. The conclusion is that both counts/pixel and general shape are consistent between tungsten lamp exposures from the past and present, for both arms, and the results are summarized in Tables 3 and 4 for the blue and red arm, respectively.

grating	cenwave (Å)	exp. (s)	cenwave y pixel (image) 20120601/02	20120619/20	20120620/21
R158B	4500	40	2118 (r1796059)	2096 (r1804427)	2037 (r1804723)
R300B	4500	40	2119 (r1796066)	2114 (r1804429)	2035 (r1804722)
R600B	4500	60	2126 (r1796072)	2118 (r1804437)	2037 (r1804720)
R600B	4000	60	2099 (r1796073)	2091 (r1804438)	2006 (r1804721)
R1200B	4900	60	2101 (r1796051)	2093 (r1804439)	2025 (r1804695)
R1200B	4250	60	2093 (r1796052)	2089 (r1804440)	2019 (r1804696)
R1200B	3600	60	2089 (r1796053)	2088 (r1804441)	2015 (r1804697)
H2400B	5000	80	2150 (r1796013)	2148 (r1804414)	2118 (r1804693)
H2400B	4500	80		2155 (r1804415)	2109 (r1804692)
H2400B	4000	80		2144 (r1804416)	2099 (r1804694)
R158R	7500	2	1993 (r1796485)	1994 (r1804426)	
R316R	8650	2	2002 (r1796547)	1998 (r1804431)	
R316R	6450	3	1995 (r1796548)	2001 (r1804432)	
R600R	9200	2	2008 (r1796537)	2004 (r1804433)	
R600R	8200	2	2000 (r1796538)	2005 (r1804434)	
R600R	7000	2	2000 (r1796539)	2007 (r1804435)	
R600R	5900	8	2000 (r1796541)	2007 (r1804436)	
R1200R	9200	3	2005 (r1796516)	2006 (r1804417)	
R1200R	8600	3	2000 (r1796517)	2002 (r1804418)	
R1200R	8000	3	2004 (r1796518)	2006 (r1804419)	
R1200R	7400	2	1998 (r1796519)	2002 (r1804422)	
R1200R	6800	3	2000 (r1796520)	1997 (r1804423)	
R1200R	6200	4	2004 (r1796521)	2009 (r1804424)	
R1200R	5600	8	2000 (r1796523)	2005 (r1804425)	

Table 2: A summary of cuar+cune lamp observations for the blue and red arm of ISIS obtained on 1st – 21st June 2012. The grating offsets were defined so that the central wavelength is obtained in the middle of the non-vignetted area of the CCD, which is on pixel y = 2000 and y = 2075 for the red and blue arm, respectively. The right side of the table shows y pixel value of the demanded central wavelength. It can be seen that for the red arm the resulting central wavelength command works very well, reaching the demanded position (y = 2000) with a very good accuracy. For the blue arm, the demanded position (y = 2075) is less accurate, and a compromise between the highest and lower resolution gratings was chosen to define a grating offset. See the text for more details.

Note that for the red arm there is a noticeable central wavelength shift between images from the past and present, due to the central wavelength refinement after PLC conversion, and due to inaccurately defined central wavelength offset in the past.

grating	image	cenwave (Å)	Dichroic	exp. (s)	binning	slit (arcsec)	ND	date
R158B	r1796060	4500	No	2	1 1	1	0.3	20120601
R158B	r1796061	4500	D5300	3	1 1	1	0.3	20120601
R158B	r1726233	4500	D5300	2	1 1	1	0	20111202
R300B	r1796063	4500	No	2.5	1 1	1	0.2	20120601
R300B	r1796065	4500	D5300	2	1 1	1	0	20120601
R300B	r1696129	4500	D5300	2	2 1	1	0	20110922
R600B	r1796067	4000	No	8	1 1	1	0	20120601
R600B	r1796068	4000	D5300	8	1 1	1	0	20120601
R600B	r1796069	4500	D5300	5	1 1	1	0	20120601
R600B	r1796070	4500	No	4	1 1	1	0	20120601
R600B	r1733206	4450	D5300	6	1 1	1	0	20111223
R600B	r1733227	4550	D5300	6	1 1	1	0	20111223
R1200B	r1796046	3600	No	60	1 1	1	0	20120601
R1200B	r1796047	4250	No	17	1 1	1	0	20120601
R1200B	r1796048	4250	D5300	17	1 1	1	0	20120601
R1200B	r1796049	4900	D5300	8	1 1	1	0	20120601
R1200B	r1796050	4900	No	8	1 1	1	0	20120601
R1200B	r1713057	4250	D5300	10	1 1	1.5	0	20111108
R1200B	r1713067	4900	D5300	6	1 1	1.5	0	20111108
H2400B	r1796011	5000	No	38	1 1	1	0	20120601
H2400B	r1796012	5000	D5300	38	1 1	1	0	20120601
H2400B	r1605472	4700	D5300	25	2 1	1	0	20110616

Table 3: Summary of tungsten lamp observations in blue arm taken on 1st June 2012 and older observations used for a comparison of a throughput. For a future reference, note that a grating offset has been changed on 21st June 2012 (see section §2.1.2).

2.1.4 Collimator movements

Status: commissioned
Review: after the conversion to PLC controllers, the Hartmann test for focusing the spectrograph recommended opposite collimator movements. The reason was that left and right Hartmann shutters were reversed in the PLC controllers and the high level software did not reflect this (see FR 20051). After fixing the problem, the Hartmann test works as expected.

2.1.5 Check nominal collimator position

Status: commissioned
Review: the nominal collimator values with no extra refractive components (dichroics,

grating	image	cenwave (Å)	Dichroic	exp. (s)	binning	slit (arcsec)	ND	date
R158R	r1796486	7500	No	2	1 1	1	1.3	20120601
R158R	r1796487	7500	D5300	2	1 1	1	1.3	20120601
R158R	r1726228	7500	D5300	2.5	1 1	1	1.3	20111202
R316R	r1796542	6450	No	2.5	1 1	1	1.1	20120601
R316R	r1796543	6450	D5300	2.5	1 1	1	1.1	20120601
R316R	r1796545	8650	D5300	2	1 1	1	0.9	20120601
R316R	r1796546	8650	No	2	1 1	1	0.9	20120601
R316R	r1585867	6450	D5300	2.5	1 1	1	0.9	20110510
R600R	r1796527	5900	D5300	2	1 1	1	0.5	20120601
R600R	r1796528	5900	No	2	1 1	1	0.5	20120601
R600R	r1796531	7000	No	2.5	1 1	1	0.8	20120601
R600R	r1796532	7000	D5300	2.5	1 1	1	0.8	20120601
R600R	r1796533	8200	D5300	2.5	1 1	1	0.8	20120601
R600R	r1796534	8200	No	2.5	1 1	1	0.8	20120601
R600R	r1796535	9200	No	2	1 1	1	0.6	20120601
R600R	r1796536	9200	D5300	2	1 1	1	0.6	20120601
R600R	r1662405	8200	D5300	5	1 1	1	1.1	20110726
R1200R	r1796494	5600	No	2	1 1	1	0	20120601
R1200R	r1796495	5600	D5300	2.5	1 1	1	0	20120601
R1200R	r1796498	6200	D5300	2.5	1 1	1	0.3	20120601
R1200R	r1796499	6200	No	2.5	1 1	1	0.3	20120601
R1200R	r1796500	6800	No	2	1 1	1	0.3	20120601
R1200R	r1796501	6800	D5300	2	1 1	1	0.3	20120601
R1200R	r1796504	7400	D5300	2.5	1 1	1	0.5	20120601
R1200R	r1796505	7400	No	2.5	1 1	1	0.5	20120601
R1200R	r1796506	8000	No	2.5	1 1	1	0.5	20120601
R1200R	r1796507	8000	D5300	2.5	1 1	1	0.5	20120601
R1200R	r1796509	8600	D5300	2	1 1	1	0.3	20120601
R1200R	r1796510	8600	No	2	1 1	1	0.3	20120601
R1200R	r1796512	9200	No	2.5	1 1	1	0.3	20120601
R1200R	r1796513	9200	D5300	2.5	1 1	1	0.3	20120601
R1200R	r1713072	5600	D5300	2.5	1 1	1.5	0.2	20111108
R1200R	r1713282	7930	D5300	2.2	1 1	1.5	0.5	20111109

Table 4: Summary of tungsten lamp observations in red arm taken on 1st June 2012 and older observations used for a comparison of a throughput.

filters, polarisation module) between the slit and the collimators are 5400 μm for the blue arm, and 9300 μm for the red arm, which are very similar values to the ones from the past.

The offset between the best spatial and spectral focus is the same as before the conversion to PLC controllers.

2.1.6 Bfold movements

Status: commissioned
Review: bfold moves as expected.

2.1.7 Slicer

Status: commissioned
Review: slicer works as expected. Tungsten lamp flats and cuar+cune calibration lamps exposures were taken to measure the throughput and central wavelength. Images: r1804686–91.fit (20120620). Note: dome lights were on during tests due to other simultaneous work at the telescope.

2.1.8 Polarization unit – spectropolarimetry

Status: commissioned (13th February 2012)
Review: the red arm of ISIS was used. Set-up: grating R316R, $\lambda_c = 6435$ Å, GG495 in use, bfold = 0, rcoll = 10315 μm. The set-up was checked without any polarization optics in the light path. After inserting the polarization dekker into position 3, the window = [900:1220,1:4200] was enabled (image r1756991). After inserting the quarter-wave plate and calcite into the beam, the best spectrograph focus was found at the collimator value 19515 μm (images r1756993–7002), which means that the offset caused by polarization optics is 9200 μm, the same value as documented in the past. The Eng 1 dekker, position 7, was used to measure the spatial profile FWHM of the flat-field spectra to evaluate the spectrograph anastigmatism (images r1757003–8). The best spatial profile was found at the collimator position of 17515 μm, which is 2000 μm less than the best spectral focus and is similar offset as the one seen for a normal ISIS spectroscopy. Zero angles were measured for the linear (images r1757009–21) and circular polarimetry (images r1757022–26). The zero angle was $\delta = 10$ deg and $\Delta = 88$ deg for the linear and circular polarimetry, respectively. Both measurements are very close to the values reported in the past. The astronomy documentation on ISIS spectropolarimetry needs to be revised.

2.1.9 Polarization unit – imaging polarimetry

Status: commissioned (21st June 2012)
Review: the blue arm of ISIS was used to address the filter vignetting seen in the past and the set-up was prepared according to the section §1.1.9. Set-up: mirror in a grating position, $\lambda_c = 0$ Å, bfiltb 4 (inter-mediate position of the filter for imaging polarimetry), bfold 1, bcoll = 5407 μm, hwin, mslit (carrying a Savart analyzer). A window = [700:2148, 1600:2500] was defined as the best using tungsten lamp exposure (image r1804698). A set of images with different collimator values (in the range of 2500 – 30000 μm) was taken

in order to find the best focus of the collimator (images r1804699–711). The original collimator position (bcoll = 5407 μm) was found to be the best collimator focus value. After inserting a polaroid into the beam exposures at half-wave plate angles of 0; 22.5; 45 and 67.5 deg were taken (images r1804712–19). As expected, ordinary and extraordinary beams switched peak counts between exposures at 0 and 45 degrees of half-wave plate, and between 22.5 and 67.5 degrees. There was no issue with the new filter position vignetting the beam. The astronomy documentation on ISIS Image polarimetry needs to be revised.

2.2 On-sky tests

2.2.1 Slit alignment on sky

Status: commissioned
Review: the object was acquired on the slit close to the edge of the field of view of the slit-viewing camera and then moved along the slit south and west by 180 arcsec, for sky PA = 0 and 90, respectively. After the movement, the star was found centered on the slit, which means that ISIS slit alignment is very good.

2.2.2 ISIS service observations

Status: commissioned
Review: everything works as expected.