Report on the effect of the current ISAAC collimator position

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Summary

In this document we discuss problems with the ISAAC collimator and show how the current collimator position affects science data.

Collimator general

The ISAAC collimator is used to focus the slit mask wheel onto the detector. The collimator has a different optimal position for each combination of different elements in the beam (e.g. each instrument mode and filter). All the optimal positions for SW imaging are fairly similar, as are all the positions for LW imaging, however there is quite a difference between the SW and LW positions.
The ISAAC collimator is mechanically unreliable and often gets stuck. This has the effect of increasing the image size and ellipticity in imaging, and of increasing and distorting the full width half max (fwhm) of the spatial profile and increasing the line tilt in spectroscopy.
In imaging we can reduce the effects of the bad collimator position by using the telescope to focus. In spectroscopy this is not possible as we need the object to be in focus on the slit. Therefore when the collimator is stuck we aim to put it in a reasonably good position for spectroscopy and then use the telescope to focus for imaging if necessary. This works well for SW imaging. In LW imaging we never get quite as good IQ using this method as we do when the collimator is working.

Collimator problems

Since 2 Aug 2002 the collimator has been stuck. Initially it was stuck at a position that produced significant distortions in the spectroscopic spatial profiles. On 20 Oct 2002 we moved the collimator while the instrument was warm, to a position that gives better spectroscopic IQ. The collimator is likely to remain in this position for some time.

Image quality

Test description

We have performed various tests to measure the image quality and quantify the distortion introduced by the bad collimator position. For each of these tests we provide results for the two different collimator positions. Position 1 is from 2 Aug 2002 - 19 Oct 2002. Position 2 is from 20 Oct to the present.
There is a pinhole mask in the ISAAC slit mask wheel which has several pinholes regularly spaced across the field of view. These are effectively point sources at the slit mask wheel. Images of the pinhole mask show the amount of distortion introduced by the collimator. By taking spectra of a continuum lamp or, at longer wavelength, the thermal background, through the pinhole mask we can look at the spatial profile of the spectra. Similar spectra of arc lamps give us a measure of the amount of line tilt (this only gives useful results for SW (0.98-2.5μm) spectroscopy. In the L and M bands there are not enough arc lines.)

Table 1: Results of the SW & SWLW imaging tests with pinhole mask

pre-move			post-move		
SW imaging tests with pinhole mask					
filter	sigma	axis ratio	filter	sigma	axis ratio
J	<0.7	>0.7	J	<1	>0.8
Js	<0.7	>0.7	Js	<1	>0.8
H	<0.9	>0.7	H	<1.1	>0.8
Ks	<0.8	>0.7	Ks	<1.1	>0.9
SWLW imaging tests with pinhole mask					
no data			J+Block	<1	>0.8
			H	<1.1	>0.8
			Ks	<1.1	>0.9

Table 2: FITS images of SW and SWLW pinhole mask tests

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Test results

Imaging

We have taken images through the pinhole masks for the SW broad band filters of the Hawaii (J,Js,H,Ks) and the Aladdin (J+Block,H,Ks) arms.
The pinhole mask images have been analysed using sextractor. For each pinhole image we measure the size of the major axis, the position angle of the major axis with the x-axis (measured counter clockwise), and the ratio of the axes (minor/major). The size of the major axis measured by sextractor is defined as the maximum spatial rms of the object profile along any direction. Table 1 gives the range of these measured quantities for each image. Table 2 in the online version of this document gives links to the FITS files of these images. Figure 1 is a visualization of the sextractor results, showing the measured ellipses and their positions on the array. The size of the ellipses in this figure is exaggerated.
For these filters, the image quality with the current collimator position is acceptable. (We have also checked some of the narrow band filters, with the same result).
For the LW imaging (e.g. L & M band filters), the image quality in similar tests is very bad and we have to use the telescope to focus the image (which produces acceptable image quality).

Spectroscopy

For the pinhole mask + continuum spectra we have measured the gaussian fwhm of the spatial profile at 9 positions on the detector - at rows y $\approx$ 780, 320 and 80, and at x=200, 600 and 850 for collimator Position 1 and x=250, 500, 750 for collimator at Position 2. (The slightly different measurement positions for the different collimator positions are of no significance). The results are given in Table 3. If there is a significant spatial distortion it is noted as d (double peaked) or a (asymmetric) in the table. The plots of the spatial profiles at these positions in Figure 2 (SWS) and Figure 3 (LWS) give a better idea of the spatial distortion. Note that in the LWS hot pixels were not removed from the Position 1 data, and this causes additional spikes in a few of the profile plots (for 3.55 μm at x,y = (500,750) (750,750) (750,75) and for 4.75 μm at x,y = (500,75)).
It is clear from the fwhm values and from the plots of the spatial profile that Position 2 (current position) produces better spectroscopic IQ than Position 1.
Sextractor was used to analyse the pinhole mask + arc lamp spectra. Again we measure the size and axis ratio of the pinhole images, and also the position angle (tilt) of each pinhole image. The position of the pinholes in the mask mean that we get 3 good spectra per image (from the central pinoles), at rows 780,320 and 80. In Table 5 we give the range of results per spectrum on the detector. The position angle is the angle between the major axis and the x-axis, measured counter clockwise (i.e. 90 degrees is aligned with the y-axis, that is, no tilt). In science data the absorption and emission lines will be tilted. This tilt should not be confused with the large scale tilt and curvature of the spectra,

Table 3: Results of spectroscopy tests with pinhole mask and halogen lamp/thermal background. Measurements of the spatial fwhm at 9 positions on the image. 'd' denotes a double-peaked profile and 'a' denotes an asymmetric profile.

Position 1				Position 2			
SWS MR 1.25 μm							
spatial fwhm				spatial fwhm			
row	x=200	x=600	x=850	row	x=250	x=500	x=750
785	4.9d	3.8a	4.4a	780	3.5	2.7	2.7
320	3.5	3.5	4.0	320	2.4	2.6	2.8
80	5.4d	4.5a	5.3a	80	4.1	3.6	4.1
SWS MR 1.65 μm							
row	x=200	x=600	x=850	row	x=250	x=500	x=750
785	5.4d	4.5d	5.0a	780	4.1	3.4	3.4
320	4.1	4.1d	4.6a	320	2.9	3.0	3.3
80	6.0a	4.9a	5.8	80	4.6	4.0	4.3
SWS MR 2.16 μm				SWS MR 2.10 μm			
row	x=200	x=600	x=850	row	x=250	x=500	x=750
785	4.9d	4.1d	4.2a	780	4.2d	3.4a	3.1
320	3.5	3.5d	3.8a	320	2.9	3.0	3.3
70	4.3a	4.2a	4.6a	80	4.6d	4.0d	4.3d
LWS MR 3.55 μm							
row	x=200	x=600	x=850	row	x=250	x=500	x=750
780	4.0d	3.7a	3.8a	780	3.0	2.8	2.7
315	2.6a	3.4a	3.8d	320	2.4	2.8	3.1
70	4.3a	4.2a	4.6a	80	4.1a	4.0	4.3
LWS MR 4.75 μm							
row	x=200	x=600	x=850	row	x=250	x=500	x=750
780	4.0d	4.0a	4.2a	780	3.0	3.0	3.0
315	3.5a	4.0a	4.3	320	2.8	2.9	3.3
70	4.8a	4.8a	5.2	80	4.1a	3.8	4.2

Table 4: FITS images of spectroscopy tests with pinhole mask and halogen lamp/thermal background.

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Table 5: Results of spectroscopy tests with pinhole mask and arc lamps

pre-move				post-move			
SWS MR 1.25 μm							
row	sigma	axis ratio	tilt	row	sigma	axis ratio	tilt
780	<2	>0.6	50-60	780	<1.6	>0.6	40-60
320	<2	>0.6	45-60	320	<1.6	>0.6	40-60
80	<2.4	>0.6	60-70	80	<2	>0.5	60-75
SWS MR 1.65 μm							
row	sigma	ellip	tilt	row	sigma	ellip	tilt
780	<2.4	>0.6	50-65	780	<1.8	>0.6	50-70
320	<2.3	>0.6	40-60	320	<1.8	>0.6	40-60
80	<2.8	>0.6	60-80	80	<2.2	>0.6	60-70
SWS MR 2.16 μm				SWS MR 2.10 μm			
row	sigma	ellip	tilt	row	sigma	ellip	tilt
				780	<1.8	>0.6	50-70
	no data			320	<1.6	>0.6	45-60
				80	<2	>0.6	60-70

the tilt of the absorption/emission lines will remain after this large scale tilt has been removed.

Figure 1: Plots of SW imaging tests using pinhole mask. For each collimator position and filter we show the size and ellipticity of the images of the pinholes. The ellipse sizes have been exaggerated.

Position 1: 2 Aug - 19 Oct 2002

Position 2: 20 Oct 2002 onwards

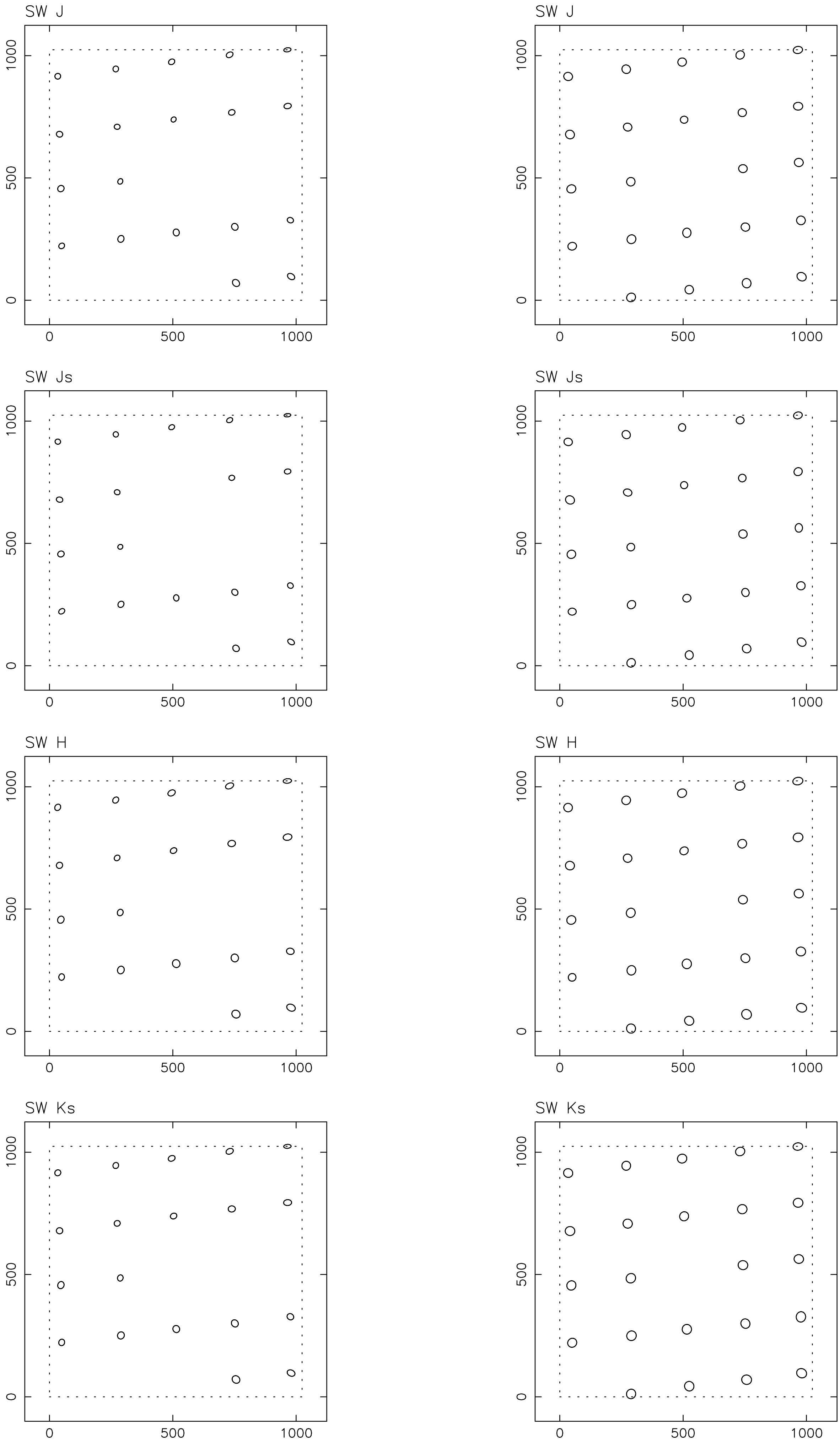

Figure 2: SW spectroscopy pinhole + halogen spatial profile plots.
The left hand column shows plots with collimator in Position 1 (2 Aug - 19 Oct 2002), the right hand column with collimator in Position 2 (20 Oct 2002 onwards). The spatial profile is plotted for 9 positions on the detector for each of three central wavelengths.

Position 1: 2 Aug - 19 Oct 2002

Position 2: 20 Oct 2002 onwards

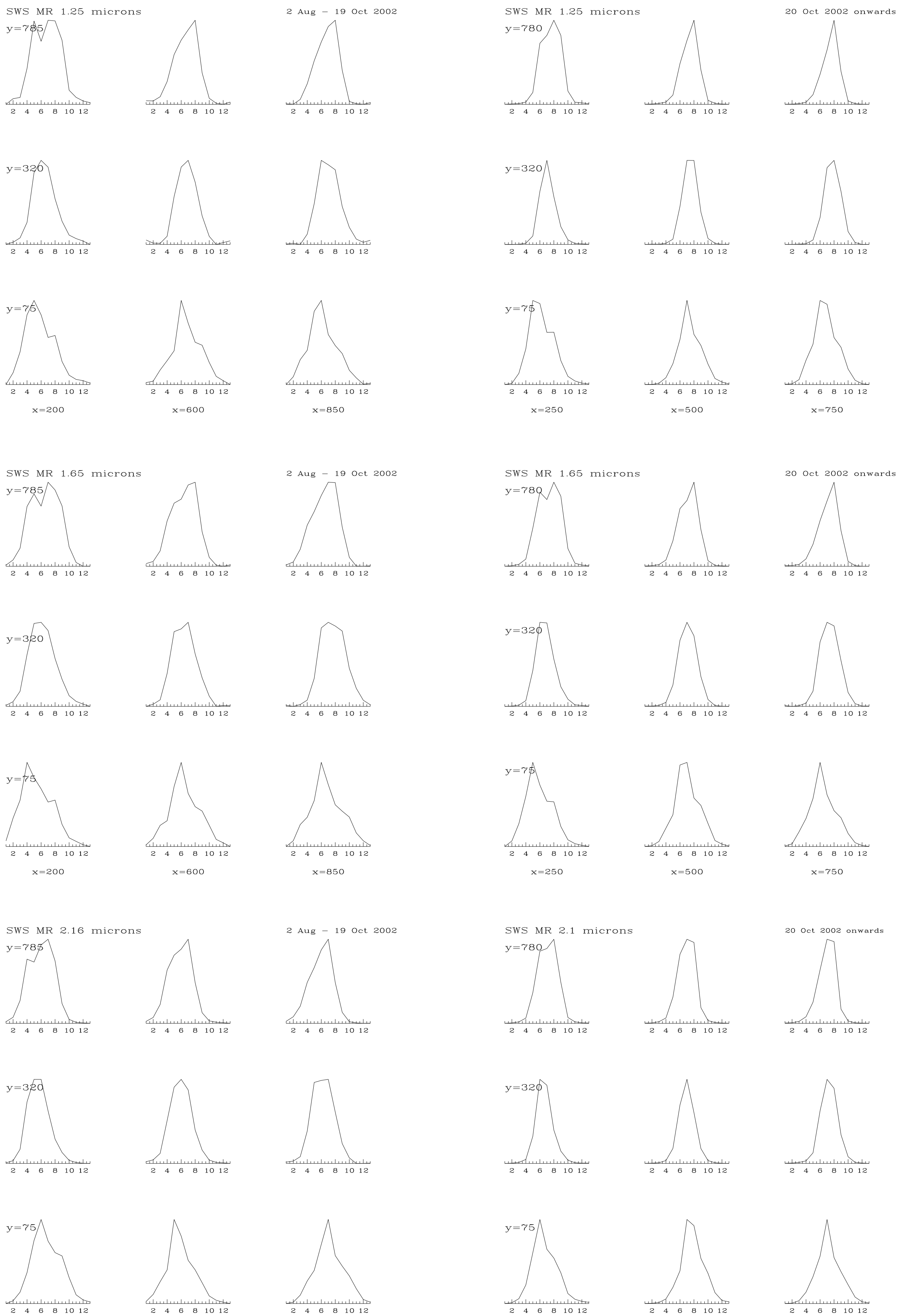

Figure 3: LW spectroscopy pinhole + halogen spatial profile plots.
The left hand column shows plots with collimator in Position 1 (2 Aug - 19 Oct 2002), the right hand column with collimator in Position 2 (20 Oct 2002 onwards). The spatial profile is plotted for 9 positions on the detector for each of two central wavelengths. Note that hot pixels were not removed from the position 1 data, and this causes additional spikes in a few of the profiles.

Position 1: 2 Aug - 19 Oct 2002

Position 2: 20 Oct 2002 onwards