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Applicable references:

These references appear in [] brackets in this document.

1 – EIS science requirements: MSSL/SLB-EIS/SP007.07
2 – MDP ICU interface document: NAO/SLB-EIS/SP/MDP3.4
3 – EIS Telecommanding Structure: MSSL/SLB-EIS/SP016.03
4 – EIS sequence structure overview: MSSL/SLB-EIS/TN014.03
5 – EIS Status: MSSL/SLB-EIS/SP017.06
6 – Scale factors for MIR motion by C. Brown, C. Korendyke, and J. Shea
7 – Action item (AI8). Solar-B EIS Science meeting, NRL, January 2002
8 – Email consultation with G. Doschek on AI8 dated the 7th November 2002.
9 – Solar-B EIS Science meeting, NRL, January 2002

Glossary and Convention:

BC	Block Command, Solar-B command parameter
CAM	EIS Camera
CMIR	EIS Coarse Mirror
EGSE	Electronics Ground Support Equipment
EIS	Extreme ultraviolet Imaging Spectrometer
FMIR	EIS Fine Mirror
FOV	Field Of View
FT	Flare Trigger
HK	Housekeeping (also called status on Solar-B)
LL	Line List
MHC	Mechanism and Heater Controller
MIP	EIS fine Mirror Initial Position (raster start position)
NA	Not Applicable
OCB	On Chip Binning (CAM function)
QL	EIS Quick Look
SIB	Satellite Information Database
X	EIS X coordinate
X_f	EIS flare position (wavelength direction)
Y	EIS Y coordinate
Y_f	EIS flare position (spatial direction)

1.0 Introduction

The EIS flare trigger detection was created in response to the following EIS science requirements [1]:

Section III, 4b:

"To generate an internal EIS solar event trigger. This should have the flexibility to change to a different study".

Section III, 4c:

"To respond to the event trigger by moving to the event and starting a new study within 30 s"

Note that the EIS flare trigger, which is documented here, is referred to as "the EIS solar event trigger" in [1]. The solar event trigger is different from the event trigger in section III, 4d [1], which is renamed as the bright point trigger. The latter requires location of an area of maximum intensity within a raster scan. The bright point trigger will be documented separately.

2.0 EIS FT proposal outline

The proposal for observing solar flares with EIS was first made in an NRL science meeting [9]. In principle, the following possibilities were considered:

1) Rastering using the 1" Slit to cover the active region.
2) Rastering using the 40" Slot to cover the active region.
3) Using a wide Slot (100" to 200") such that no rastering is performed. Note that at that time the 250" Slot wasn't introduced.

The drawback of rastering is that it will slow the flare detection considerably and observations of all regions of the flare will not be made simultaneously. Following some internal NRL discussion, it was concluded that having a wide slot would be useful for the observations of transient events of limited spatial extent. It was also acknowledged that a slot size of more than 40" would suffer from lines overlapping and may compromise the scientific value of the data. However, flares and other transient phenomenon are sufficiently small spatially that overlapping is not important for many lines, as was clearly observed from the analysis of S082-A Skylab slit-less spectra of flares. The value of S082-A type flare observations was also noted since motions in flares are large (several hundreds of km/s), making it possible to disentangle spatial from spectral effects for the largest motions. Moreover, the ability to image flares monochromatically should provide a much better measurement of the temperature structure of the soft X-ray flare plasma than is possible with broadband images. For example, coupling He II images with Fe XXIV images would detail the relationship between soft X-ray emission and chromospheric emission from footpoint regions. This type of observation can help clarify the role of chromospheric evaporation in the flare process. Also, large FOV imaging may be the best type of observation for detecting jets from the reconnection sites above the soft X-ray emitting loops.

In summary, flare detection mode can be performed using a wide slot where the need for rastering is eliminated entirely.

In order to construct **flare detection-response** observations, the following points should be considered:

1) Coarse mirror pointing to an active region exhibiting a strong magnetic shear. The active region should be positioned at the centre of the slot.
2) To determine the flare occurrence, monitor a user selected line (e.g. Fe XXIV 192 Å or He II 256 Å). The detail of the flare detection algorithm is described in section 3. Once a flare criterion is satisfied, locate the flare coordinates (Xf and Yf).
3) In response to the flare, the ICU runs a response study that uses a pre-defined exposure time or AEC (Auto Exposure Controller) to prevent the CCDs from saturating. Also the ICU has the ability of re-pointing (zooming) to the flare region to speed up the cadence. This is achieved by moving the flare to the Slot centre, via adjusting the fine mirror (X re-pointing). Also the Camera read-out can be restricted in the Y-direction (e.g. reading 256 rows instead of the nominal 512 rows such that the readout is cantered around Yf). So far it is assumed that the response study is using the wide slot and no rastering is required in this case to obtain monochromatic images of the flare. However, if spectral images are required (using the 1” or 2” slits), rastering is required and the following should be considered:

   1 - The response raster fine mirror should be positioned at Xf - ΔX, where ΔX is user selectable and can be something on the order of 60” as an example (raster span of 120”). The ICU performs the positioning of the fine mirror autonomously.

   2 - The fine mirror step size is chosen to be 1” or 2” for the response raster, for example.

   Note that if the 40” slot is used, it will still be necessary to perform rastering, although the fine mirror step size is much larger (e.g. 40” steps) and 4 or 5 exposure rasters are sufficient.

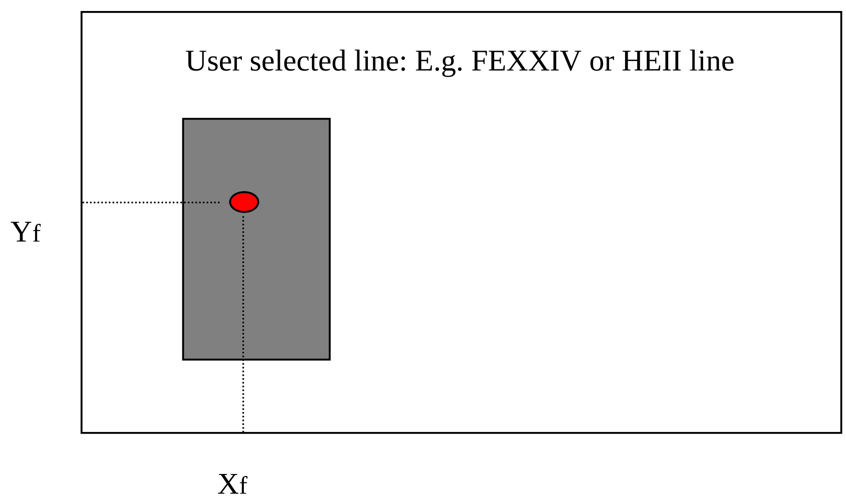
   Also note that when using “repeat raster mode”, subsequent rasters will not start at precisely the same solar location due to spacecraft motion. The SUMER instrument experience has revealed that a considerable effort is required to reconstruct these rasters.

Also the proposals outlined in [9] addressed the issues related to flare observations such as **count rate, exposure time and throughput**, based on John Mariska’s sensitivity calculation documents, primarily for Fe XXIV 192 Å and 255 Å. It was concluded that for a total intensity spread over 6 pixels, the Fe XXIV count- rates are 12,100 and 1,325 per pixel in the short and long wavelength ranges, respectively. As it is desirable to observe near the onset of the flare where the count rate is much less than the flare peak, e.g., 3 orders of magnitude below the flare peak, a 10 second exposure time would give an acceptable count rate. However, a detection two orders of magnitude below peak intensity would still result in good observations over which high-speed evaporation up-flows might be observed with a 1-second exposure time. Also the analysis used in [9] concluded that other lines could be observed (for e.g. He II 256 Å) which have a similar count rate to the long wavelength Fe XXIV 255 Å line. In conclusion, the observation of evaporative up-flowing of plasma should be possible using 1 to 10 second exposure times for flares down to a GOES class of about C3. It should be noted that the estimates given here are sketchy and are meant to spur a much more detailed calculation of what EIS should see in monochromatic images.

The EIS instrument throughput assessment was made using a pair of Fe XXIV lines with a total X length of 360 pixels and line height of 160 pixels, for exposure times of 1, 2 and 10 seconds. Assuming no data compression, the EIS will fill its Data Recorder (DR) allocation in 34, 66 and 125 minutes respectively. Thus for the shortest exposure times, EIS/DR will be filled in a time less than the 90 minutes dump interval. This is not ideal, as EIS would then need to stop observing for about 2/3 of an orbit. Of course the problem is compounded if the EIS core line list is used. One-way of reducing the DR load is by using data compression. Also using the 40" slot or slits will help as the line profiles are much narrower, but rastering must be introduced at least for the narrow slits observations.

3.0 Flare detection algorithm

The proposed EIS internal flare "hunting" algorithm is based on using the 250" slot in sit and stare mode, whose purpose is to locate the flare X and Y positions, i.e. Xf and Yf, as illustrated below:



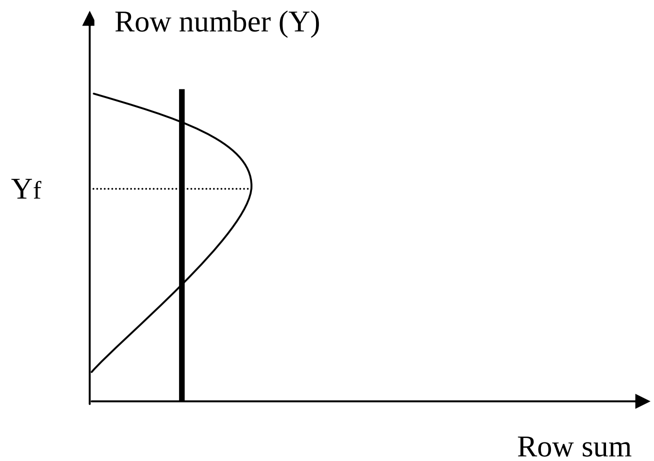
EIS CCD

The diagram above shows a software window, which represents a user selectable line within a CCD read-out region.

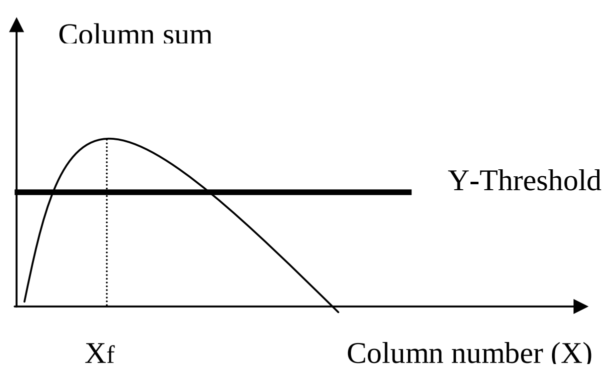
A flare criterion is satisfied if:

1) The number of row sums (line intensity) exceeds an intensity threshold (X-threshold) and
2) The number of column sums (summing in the spatial direction) exceeds a Y-threshold).

The flare Y position (Y_f) is acquired from the line intensity (row sums, i.e. summing in the X direction), as shown below:



The flare X position (X_f) is acquired from summing the columns' pixels in the Y direction (spatial direction), as illustrated below:



The flare X_f and Y_f positions are used for the response study re-pointing operations, if specified. Detailed information is given in the following sections.

4.0 EIS FT commanding

In addition to enabling the raster EIS flare trigger flag [4] and marking the flare "hunt line in the line list [4]", the following EIS flare trigger control parameters must be loaded into the EIS observation table prior to undertaking EIS flare trigger operations:

Bit 0 **Bit 31**

<table>
<tr><td colspan="2">Sequence no.</td><td colspan="2">Raster ID</td><td colspan="2">Control flags</td></tr>
<tr><td colspan="6">X Threshold</td></tr>
<tr><td colspan="6">Y Threshold</td></tr>
<tr><td colspan="6">Y CAM start address</td></tr>
<tr><td colspan="6">Y CAM height address</td></tr>
<tr><td colspan="2">X min. limit</td><td>Y min. limit</td><td colspan="2">EIS Pixel Size</td><td>Reserved</td></tr>
</table>

Where:

Sequence no.: Is an 8 bit parameter which specifies the EIS flare trigger response sequence number. This sequence will run when an EIS flare is detected. This sequence should have its raster(s) EIS flare trigger flag disabled, as a flare response is already active when a response study is invoked. The response study can be made using chained sequences. When chained, <u>all the sequences are considered as part of the same response study</u> (uninterruptible by the Solar-B deferred time command store).

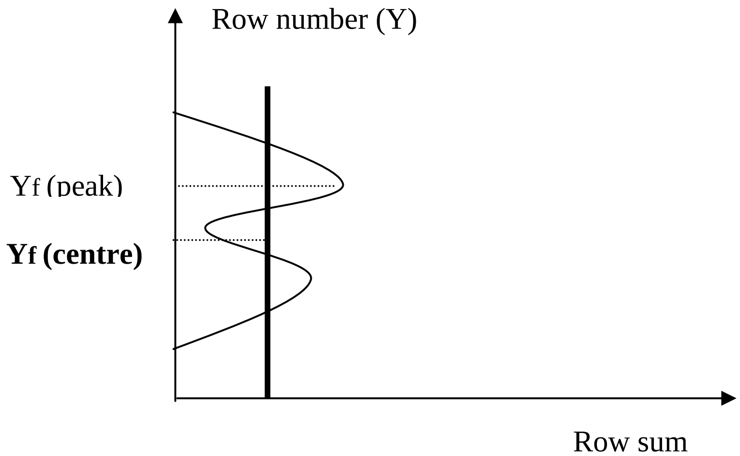
Raster identifier: Is a 16-bit parameter, which specifies the response raster identifier. Raster parameters are used for EIS autonomous re-pointing, if required. The raster ID shall be <u>present in the sequence number parameter described above (**Sequence no.)**</u>. The raster ID **must not** be 0 or 0xFFFF otherwise it will be considered on-board as an un-initialised parameter and hence as an error.

Note that it is possible to have more than 1 raster in an EIS flare response study (e.g. a background noise measurement raster and a main raster). However, X or Y re-pointing, if required, <u>can only be performed on a single raster</u> (the main response raster which is marked by this parameter). Nevertheless and due to the high response speed required, similar operations (e.g. noise measurements) can be performed from rasters that follow the main response raster, prior to terminating the response study.

Control flags: These 1-bit flags are as follows:
<u>Adjust Y</u>: When set, a re-pointing in the Y-direction is performed, via reducing the number of the CCD's rows read out. The read-out portion is centred around Y_f". Obviously, the response raster line list Y-height parameter must be less than 512 pixels.
<u>Adjust</u> X: When set, a re-pointing in the X-direction is performed, via the fine mirror. Obviously, the response raster FMIR raster scan must be less than 295".

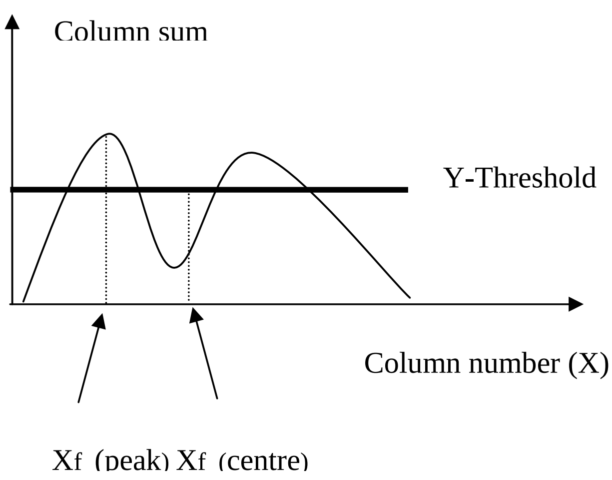
Locate Y: Locate flare Y peak (e.g. flare kernel) or flare Y centre (central to the first and last X-threshold crossings), as illustrated below. This flag can have one of the following values:

0: Locate Y_f centre
1: Locate Y_f peak



Locate X: Locate flare X peak (e.g. flare kernel) or flare X centre (central to the first and last Y-threshold crossings), as illustrated below. This flag can have one of the following values:

0: Locate X_f centre
1: Locate X_f peak



Left re-pointing: Fine mirror adjustment to centralize the flare within the flare line. Flare location to the left of $X\lambda$ (flare line centre). This flag can have the following values:
0: Subtract from fine mirror position
1: Add to fine mirror position

This parameter must be set to 0, as determined following EIS integration.
Right re-pointing: Fine mirror adjustment to centralize the flare within the flare line. Flare location to the right of Xλ (flare line centre). This flag can have the following values:
0: Subtract from fine mirror position
1: Add to fine mirror position
This parameter must be set to 1, as determined following EIS integration.
Spare flags: 2 bits

X Threshold: A 32-bit threshold used for the flare line X-direction binning (row sums).

Y Threshold: A 32-bit threshold used for the flare line Y-direction binning (column sums).

Y Start Address: The camera read-out sequence Y start address memory location (32 bit parameter). The address is generated by the CSG complier and should be treated as a constant, as long as the CAM read-out sequence is not changed. For example, using the FM CAM RROM CODE, CSD-ID 4, this parameter has the value (0x04000C00).

This parameter **must not** be set to 0 or 0xFFFFFFFF otherwise it will be considered on-board as an un-initialised parameter and hence an error.

Y height Address: The camera read-out sequence Y height address memory location (32 bit parameter). The address is generated by the CSG complier and should be treated as a constant, as long as the CAM read-out sequence is not changed. For example, using the FM CAM RROM CODE, CSD-ID 4, this parameter has the value (0x04001400).

This parameter **must not** be set to 0 or 0xFFFFFFFF otherwise it will be considered on-board as an un-initialised parameter and hence an error.

X MIN LIMIT: Number of consecutive sample measurements above which a flare trigger is considered. For example, setting this parameter to 12 means that at least 12 consecutive row sums must be above the X-threshold for “valid flare”. This is an 8-bit parameter.

Y MIN LIMIT: Number of consecutive sample measurements above which a flare trigger is considered. For example, setting this parameter to 12 means that at least 12 consecutive column sums must be above the Y-threshold for “valid flare”. This is an 8-bit parameter.

EIS Pixel Size: EIS pixel size in arcseconds. A factor of 100 is applied to this parameter. For example, if the EIS pixel size is 1.15”, then this parameter is set to 115.

Reserved: An 8-bit parameter reserved for internal use. **MUST** be set to 0.

4.1 EIS FT commanding verification

Following EIS flare trigger enabling [4], the ICU performs the following checks:

1 – Verify that the raster ID, CAM Y-start and Y-height addresses are neither 0’s nor F’s otherwise they will be considered as un-initialised or illegal values, which indicates that the EIS flare trigger control parameters in the EIS OBS table are not loaded on-board.

2 – Verify that the response sequence number in the EIS FT control parameters table is within range (0 to 127) and contains a valid checksum.

3 – Verify the presence of the raster ID (EIS FT control table parameter) in the response sequence. Matching three consecutive bytes performs this check. These bytes are the run raster command BC1, the raster ID most significant byte and the raster ID least significant byte.

4 – Verify that the response raster ID line list is in range (0 to 47) and contains a valid checksum.

If any of the above checks is failed, the ICU software autonomously disables EIS flare trigger operations, as a response is not possible. The offending error is reported in the EIS HK, i.e. status type 1 [5], FT_ERROR parameter.

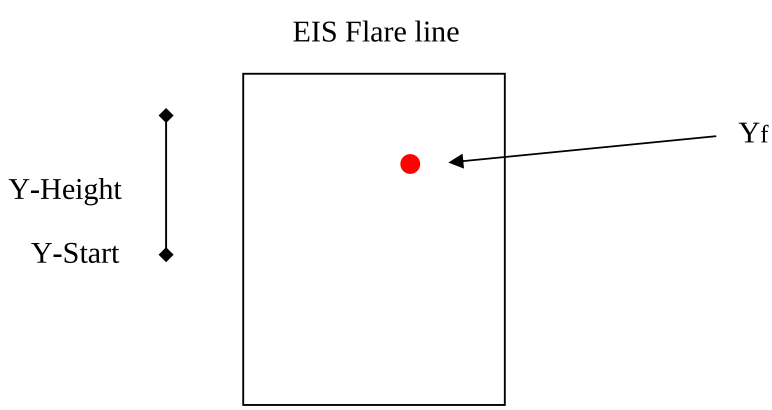
Also note that the presence of an EIS flare line marker in the **"hunt"** study line list is also checked. If no line is marked, then an error is reported in EIS HK (FT_ERROR parameter). No flare data processing is undertaken if this error is detected.

5.0 EIS X and Y flare location re-pointing

When adjust X and/or adjust Y flags are set, a re-pointing operation(s) will be undertaken in response to EIS flare detection. Re-pointing implies zooming in on the flare site with reduced FOV to speed up the cadence. The reduction in the FOV is pre-selected by the user.

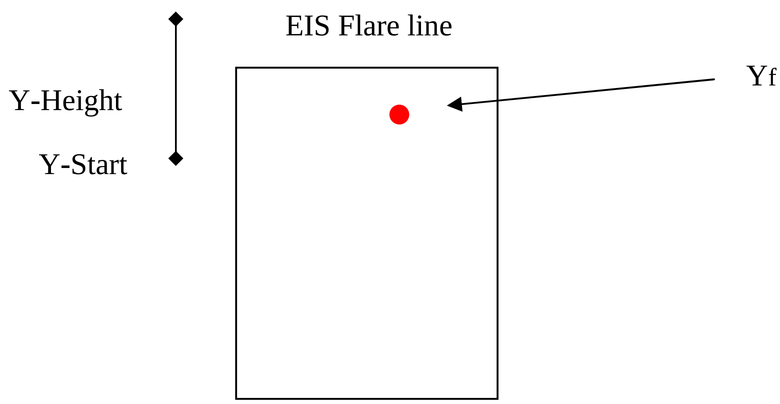
5.1 Option 1: Y adjust (re-pointing in the Y-direction)

Reducing the number of rows clocked out of the CCD performs this operation. The number of rows clocked (Y-height) is as specified in the response raster line list. However, the flare Y-start (first row to be read) is determined from the flare Y position (Y_f) such that the flare is positioned at the centre of the Y-height, as illustrated below:



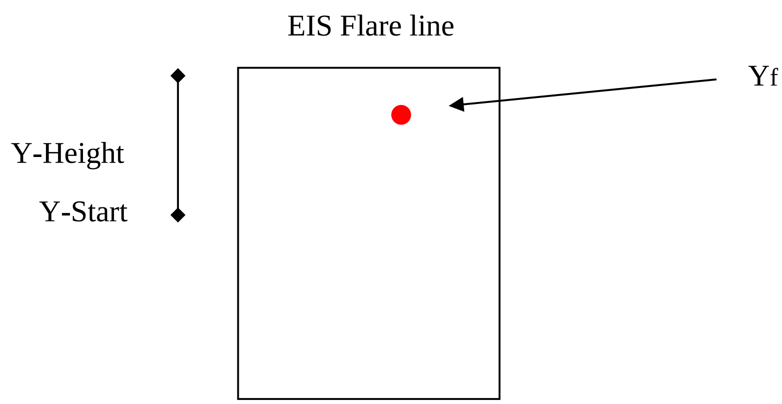
Also note that both the hunt and the response study line lists must have the same Y-start, despite that fact that the response study line list Y-start will be adjusted in response to Yf position.

Note that if the flare site is near the edge of the flare line and it is not possible to encapsulate the flare site and remain within the Y-FOV, then the read-out section is re-adjusted, as illustrated below:



Y Re-pointing error

Re-adjusted:

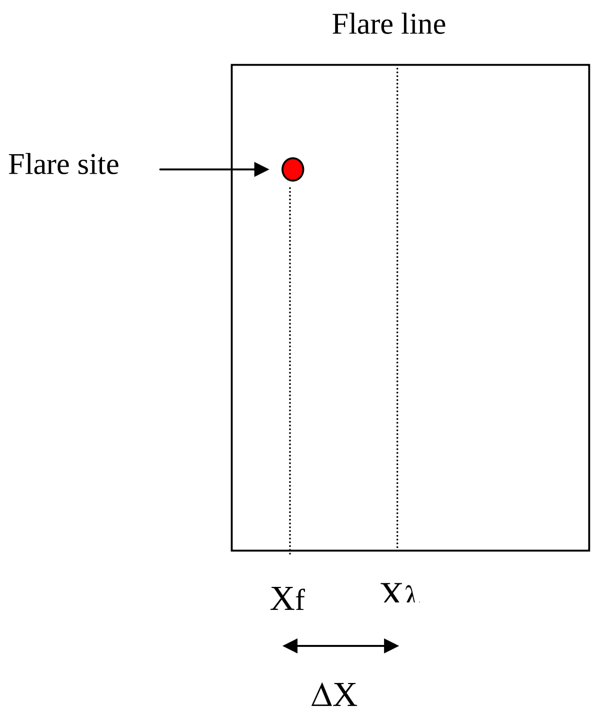


Y adjustment is performed via **re-programming the CAM**, on the fly, and **modifying the response line list Y-start**.

5.2 Option 2: X adjust (re-pointing in the X-direction)

Moving the fine mirror to the flare site performs the re-pointing operation, such that the flare is positioned at the centre of the **slot**. For sit and stare rasters, the fine mirror is positioned at the flare site (centre of slit/slot). For scanning rasters, the flare is positioned at the centre of the raster scan. Note that the flare response raster scan size (pre-determined from the ground) is acquired from the response raster, as marked by the response raster ID, using the exposure loop and FMIR mirror step size parameters.

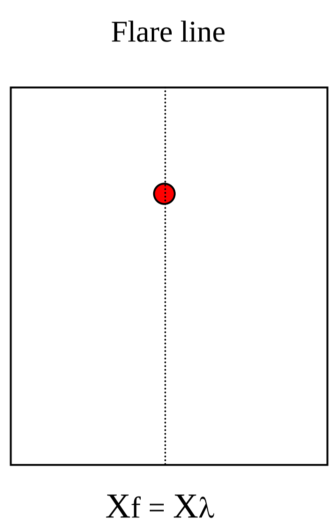
Positioning the flare at the centre of the slot is performed as follows:



1 – Measure ΔX (arcseconds), where ΔX is the distance between the flare X location and flare line centre (Xλ), as follows:

$$(\Delta X)" = \text{absolute}\ (Xf - X\lambda) \qquad \dots (1)$$

2 – Re-position the flare at the centre of the slot, as illustrated below:



This can be achieved by moving the FMIR a number of steps which is proportional to ΔX" and the FMIR slope (step size), i.e.:

FMIR position (steps) = Current FMIR position (steps) **(+ or -)** (ΔX") **/** (FMIR slope * 2) … (2)

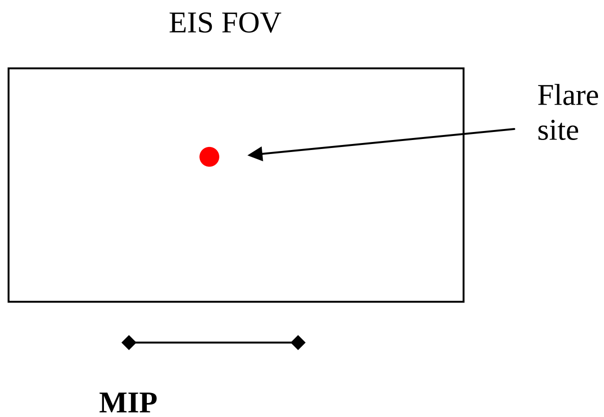
With reference to equation (2), note the following:

1 – The + or – sign depends on whether the flare is to the left or right of Xλ. The sign Is handled by the on-board software autonomously.
2 – The FMIR slope is doubled when computing an image movement, Hence the multiplication factor of 2, i.e. FMIR slope * 2 [6].

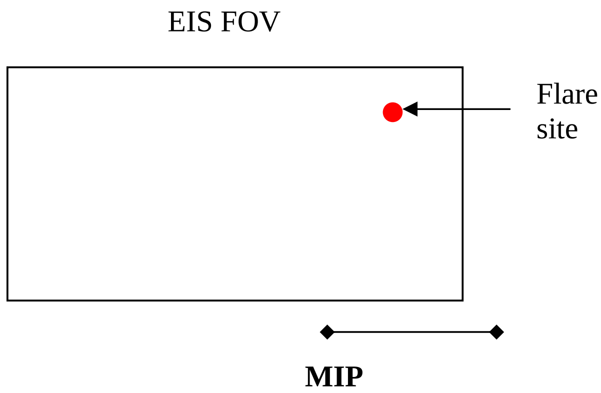
When a sit and stare raster response is required, the response raster MIP is used as given by equation 2. However, a raster scan response requires a further shift of the FMIR position, i.e.:

MIP = FMIR position (as in equation 2) – (raster scan size in FMIR steps/2)

The response MIP parameter is updated in the response raster prior to starting the flare response study, as illustrated below:

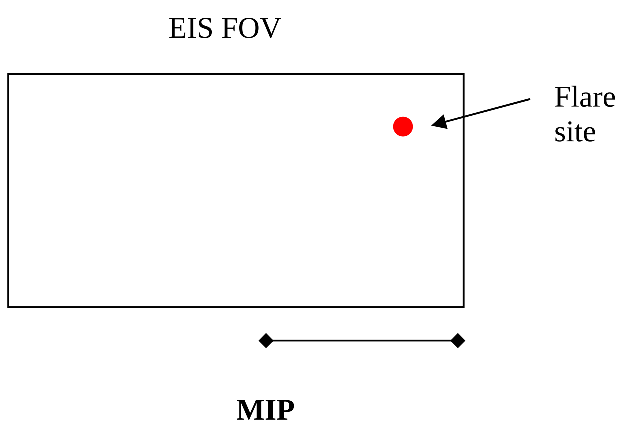


Note that if the flare site is near the edge of the field of view and it is not possible to encapsulate the flare site and remain within the X-FOV, then the raster scan section is re-adjusted, as illustrated bellow:



X re-pointing error

Re-adjusted as illustrated below:



6.0 Post flare operations

Once an EIS FT response is triggered, the ICU software **disables** mode transitions, autonomously. This is to inhibit the Solar-B OP/OG command store from accidentally aborting the response study when the next time line commands are due (deferred time commanding and flares are asynchronous). Once the response study is finished, i.e. stopped or aborted, the ICU **re-enables** the mode transitions autonomously, and starts re-accepting OP/OG commands.

Also note that the response study should run with the raster's EIS FT flag [4] disabled, as a flare response is already active.

7.0 EIS FT response termination

The issue of terminating an EIS FT was raised in one of the science meetings held at NRL [7]. This resulted in action item AI8, which is as follows:

AI8 There was concern on how to terminate the flare mode once it had actually been triggered. There seem to be several possibilities:

- **(a) Turn off the flare mode once the intensity drops below the original threshold (e.g. Yohkoh).**
- **(b) Stop the flare mode after a preset duration (e.g. 30 minutes)**
- **(c) Use the XRT FLARE OFF flag to stop the flare mode. This will only work for large flares.**

Following consultation between the authors of this document [8], the following have been concluded:

*** Turn off the flare mode once the intensity drops below the original threshold (e.g. Yohkoh).**

The case of Yohkoh (or Solar-B XRT for this matter) is not applicable to EIS. On EIS, and in response to flare detection, a study change is undertaken. A raster response, using the narrow slits/slot will alter intensities within the FOV in an unpredictable way [8]. However, for Yohkoh SXT or Solar-B XRT, the detection algorithm remains the same and there is no equivalent to EIS study changing.

*** Use the XRT FLARE OFF flag to stop the flare mode. This will only work for large flares.**

There are many problems in relying on the XRT flare flag to terminate the EIS flare trigger response. These are as follows:

1) Both XRT and EIS use intensity thresholds for flare detections. Subject to the thresholds' level settings, EIS and XRT may trigger at different points in time in response to the same flare. Indeed subject to the thresholds' level settings, EIS and XRT may not both trigger for the same flare.
2) XRT is a full sun disc imager and may trigger on a flare outside the EIS FOV. Both EIS and XRT may trigger on the same flare initially, but XRT may depart from the current flare site if it detects another flare, which may well be outside the EIS FOV.
3) The EIS flare trigger may be used for other functionality (e.g. bright point triggering), hence there should be no dependency on XRT.

In summary, the risks involved in EIS flare trigger terminating by monitoring the XRT flare flag exceed its advantages.

Note that for the XRT flare trigger, the EIS response starts when the XRT flare flag is raised and stops when the XRT flare flag resets [2]. However, following the analysis here, if the XRT changes the flare site from a flare inside the EIS FOV to outside it, then the EIS XRT flare termination becomes undetermined as XRT is no longer monitoring the old flare site which EIS is already responding to.

*** Stop the flare mode after a preset duration (e.g. 30 minutes)**

This is the only viable and risk-free approach.

8.0 EIS observation table management

As a requirement for Solar-B operations, an identical copy of the EIS OBS table on-board shall be made available to ISAS EGSE, for EIS memory management purposes. However, when re-pointing operations are undertaken, both the response sequence and the main response raster line list may be modified on-board. In order to maintain similarity between ISAS/on-board memory maps, the EIS flare trigger software task creates local copies of the response sequence and the line list, prior to modifying them. Once an EIS flare trigger response is terminated (see section 7), the local copies are re-copied to the EIS OBS table, such that the EIS OBS table is maintained in its original form.

9.0 EIS FT examples

The EIS flare trigger response was tested during the course of the ICU on-board software development. However, it should be noted here that the ultimate testing would be performed in orbit. Nevertheless, the ground testing goes a long way towards verifying the correctness of the operations and performance of the on-board software.

The aims of the testing are as follows:

1 – Verify the EIS flare location within the EIS FOV.

2 – Verify the X and Y re-pointing operations.

3 – Acquire some reasonable figures for the EIS response time.

EIS flare trigger testing was performed in two parts:

1 – Integrated EIS testing. This test is key to verifying the EIS FT re-pointing operations and will be described in section 9.1. However, due to time constraints, a maximum of only two hours testing was permitted.

2 – Testing at MSSL using the EIS pinhole camera, a standard USAF target and visible light.

9.1 Integrated EIS testing

The test was performed using the following components:

UV Source: He II (256 Å) monochromatic source
Source size: Approximately (160” X 60”). This source was in use on the day of the test.
Slit/Slot: 250” Slot

9.1.1 Reference image

Figure 1 shows a reference source image, long wavelength CCD (1024X512) pixels read-out

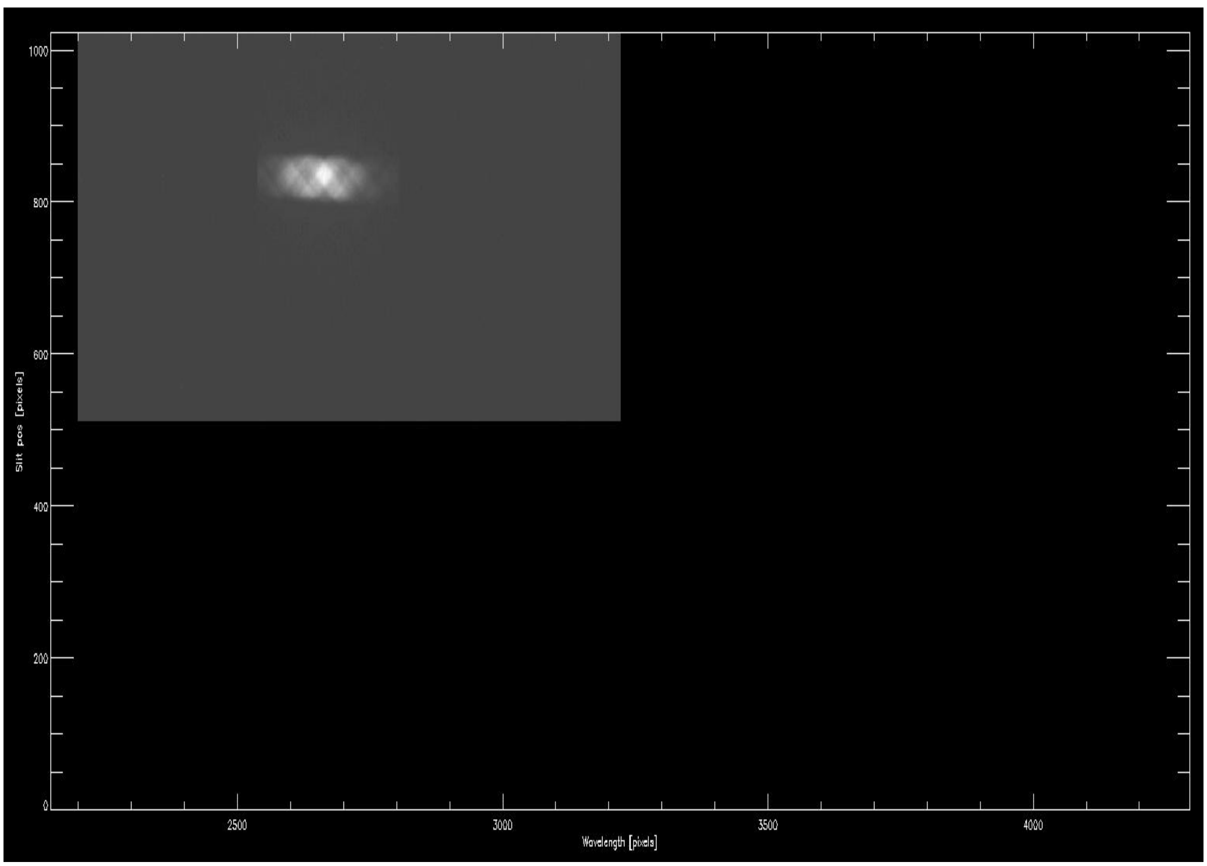


Fig. 1: Reference image

FMIR MIP = 550 steps

9.1.2 He II line with X re-pointing response (test 1)

Figure 2 shows a 250" slot image, X length = 300 pixel and Y-height = 512 pixel. The source image is shifted to simulate a flare near the edge of the slot image (FMIR position = 50 steps).

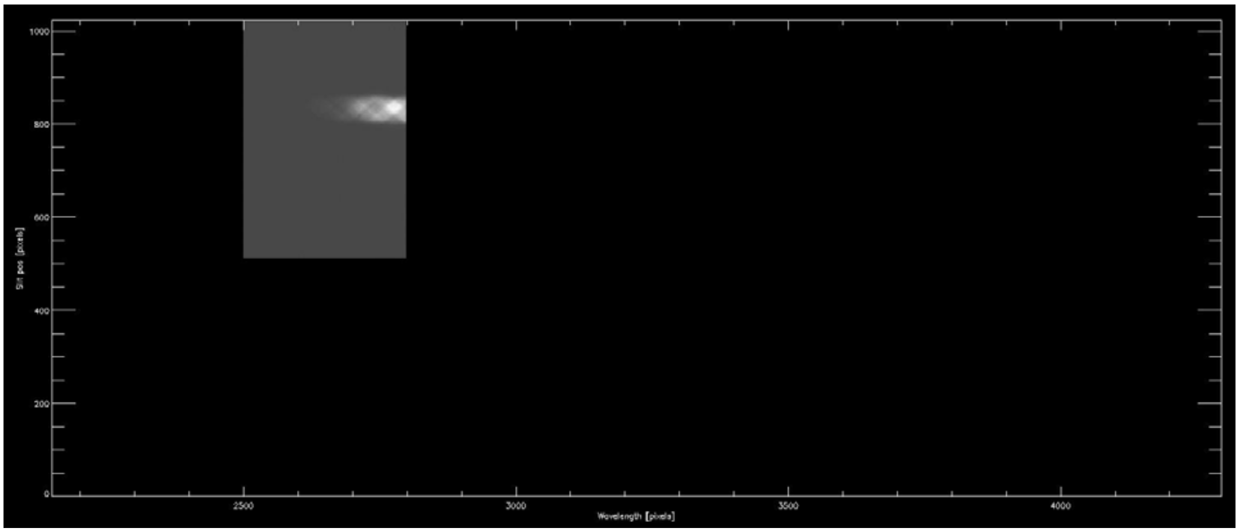


Fig. 2: Flare image

And a flare response with X re-pointing enabled (see section 5.2).

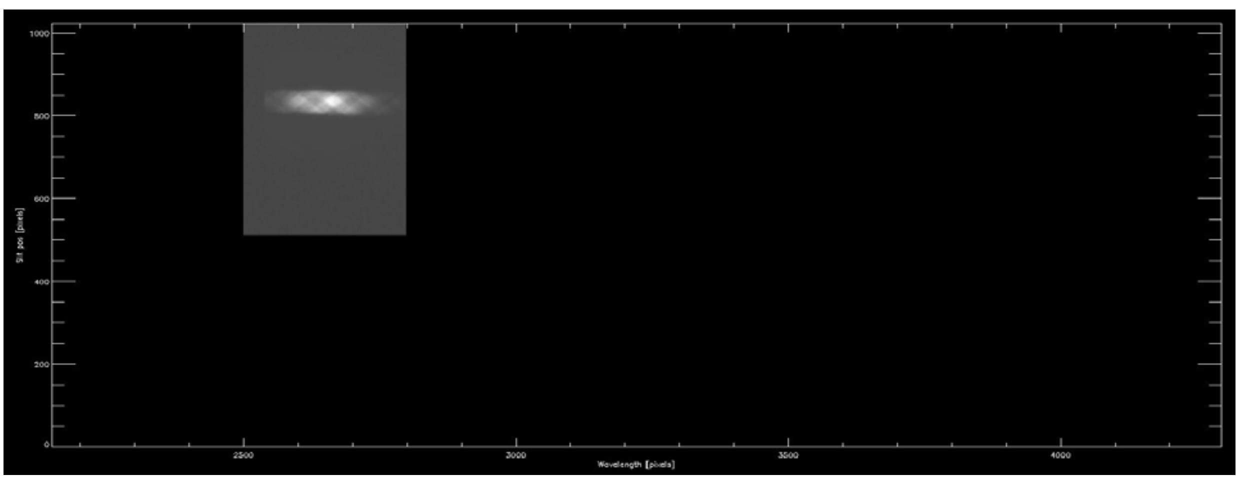


Fig. 3: EIS Flare trigger response image (sit and stare), X re-pointing enabled

9.1.3 He II line with X re-pointing response (test 2)

This test is as for that in section 9.1.2 but shifting the source image to the other slot edge (FMIR position = 1050 steps).

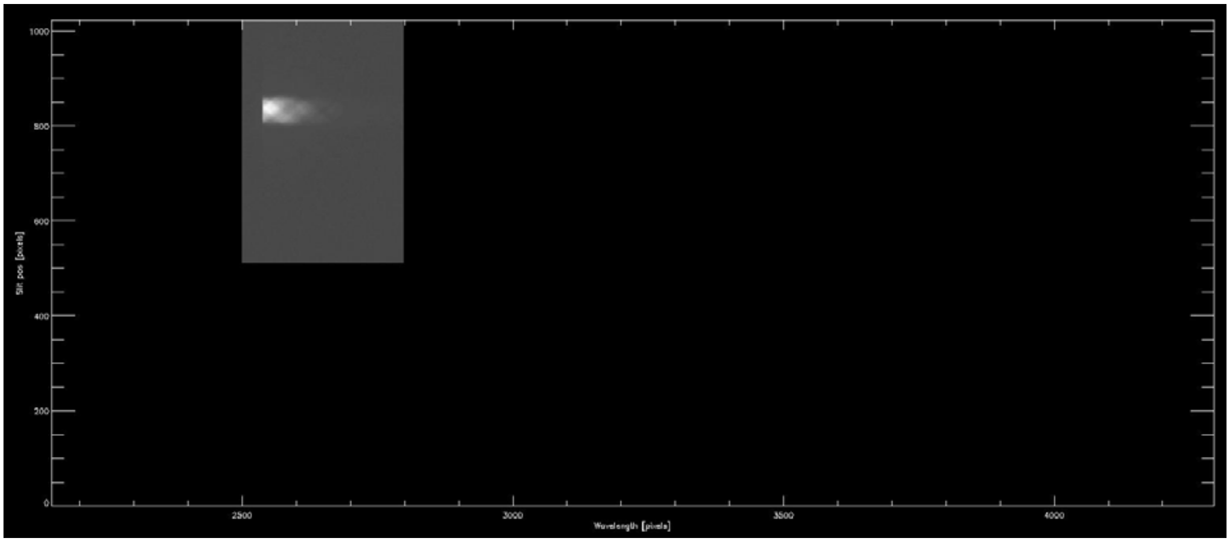


Fig 4: Flare image

And a flare response with x re-pointing enabled:

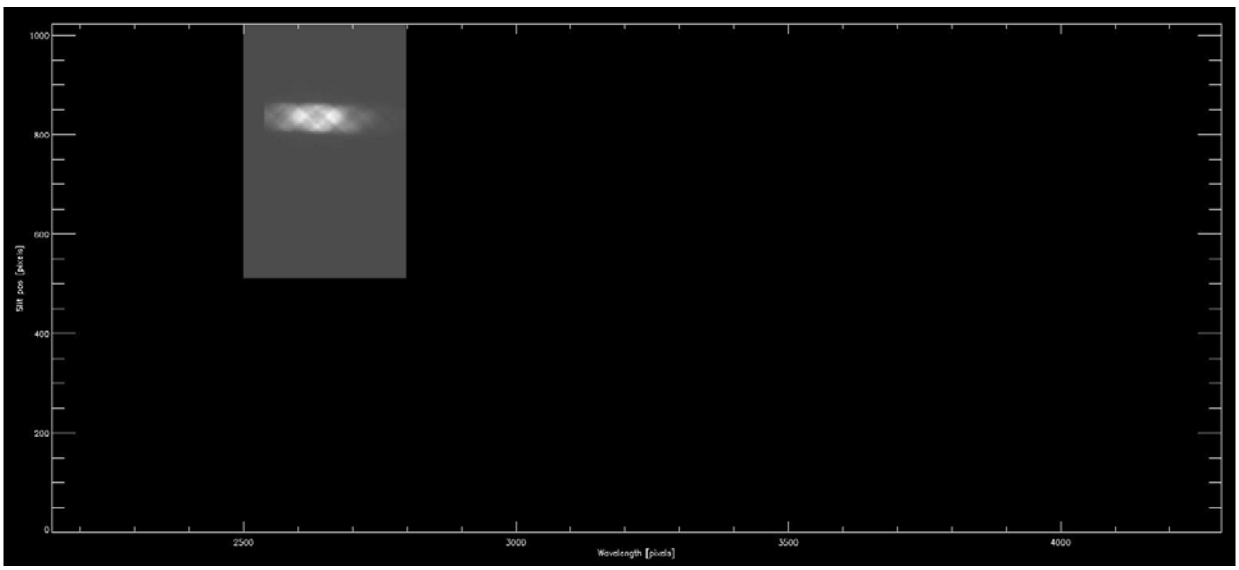


Fig. 5: EIS Flare trigger response image (sit and stare), X re-pointing enabled

9.1.4 He II line with both X and Y re-pointing enabled response

This test is as that for section 9.1.2 but enabling both X and Y re-pointing, for a sit and stare response. Y re-pointing response height = 128 pixels.

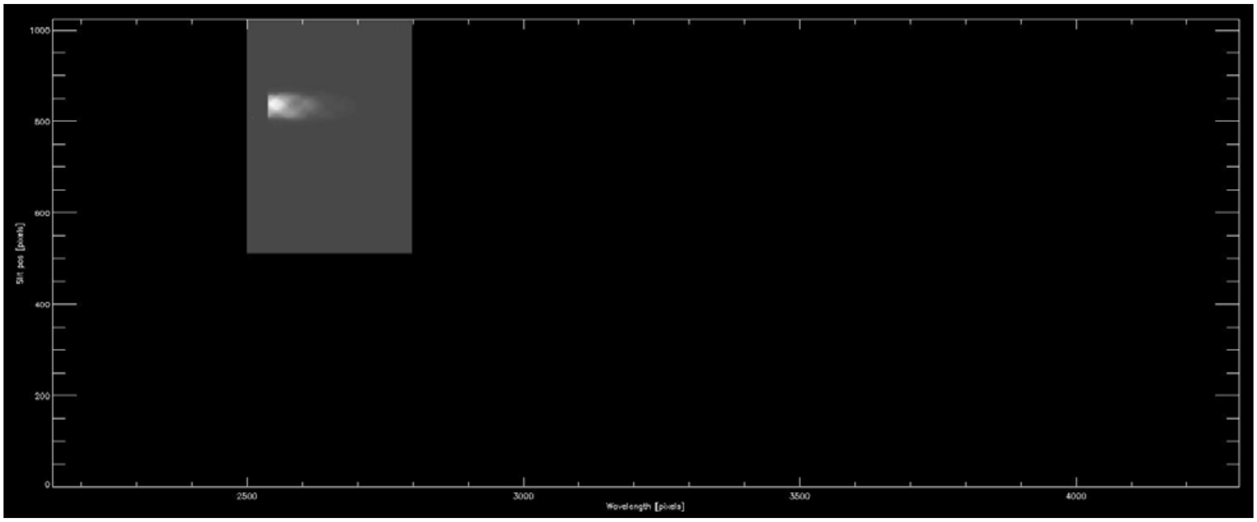


Fig. 6: Flare image

FMIR position = 1050 steps.

And a flare response:

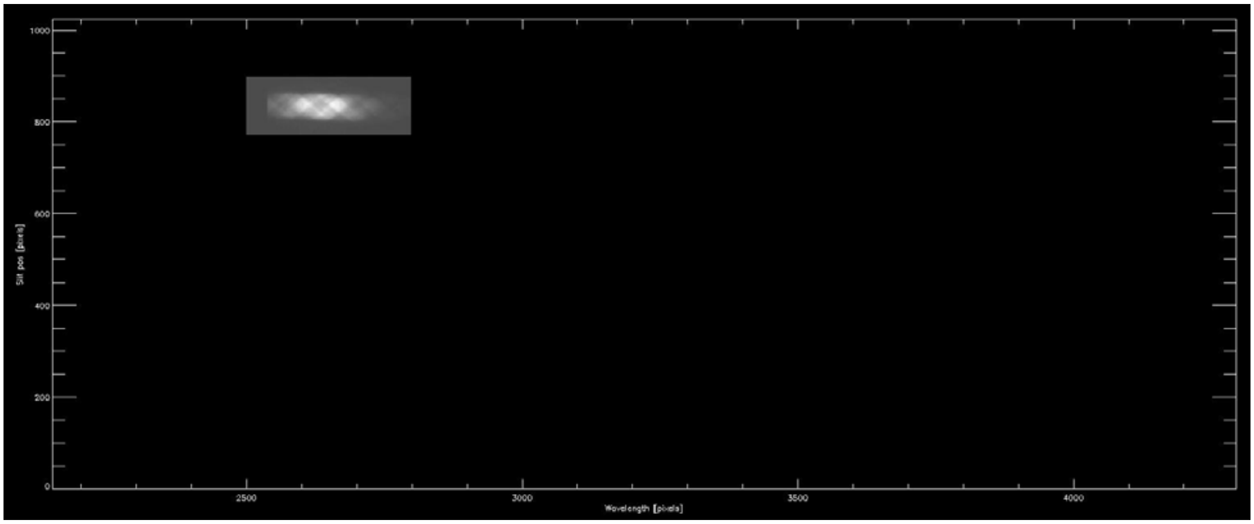


Fig. 7: EIS Flare trigger response image (sit and stare)
X and Y re-pointing enabled

9.1.5 He II line raster scan example

This test is as for that in section 9.1.4 but using a scanning raster response (4 exposures, step size of 250 steps). Note that rastering in this way is unrealistic, however it is useful in proving the concept.

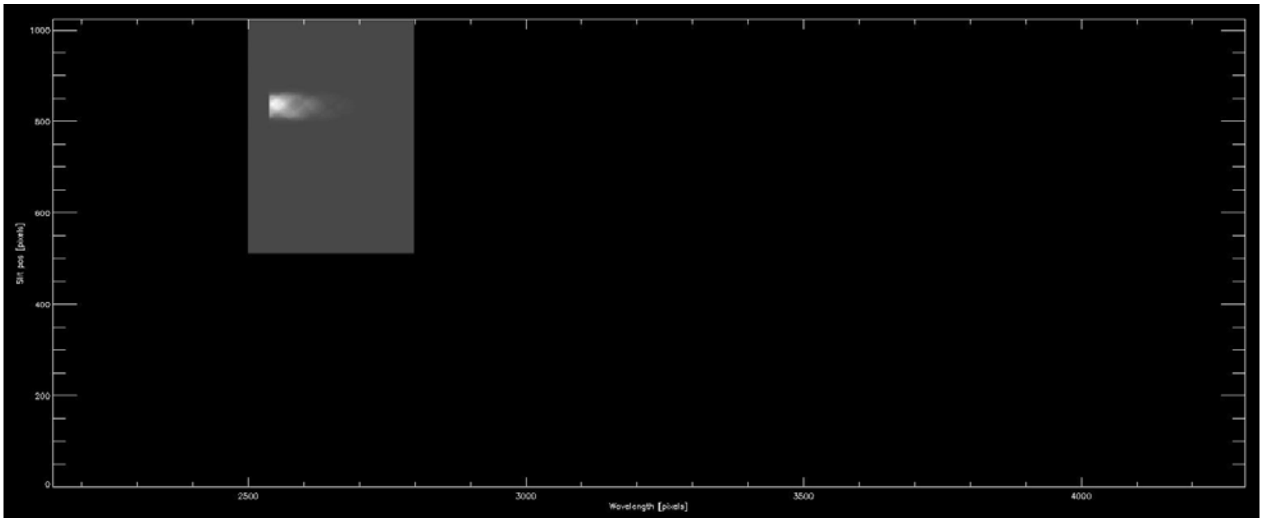


Fig. 8: Flare image

Note that there was **an error** in the fine mirror raster positions due to a software bug in calculating the raster scans size, i.e.

Raster scan size in steps = exposures number * FMIR step size

This has been corrected to:

Raster scan size in steps = (exposures number – 1) * FMIR step size

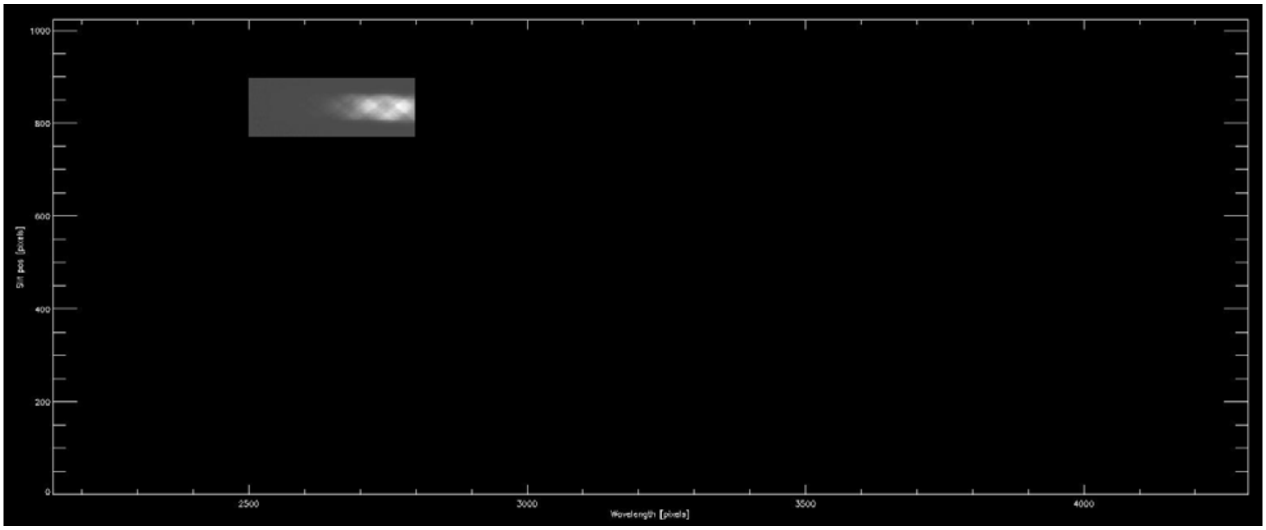


Fig. 9: EIS Flare trigger response image, exposure 1 (FMIR position = 144 steps)

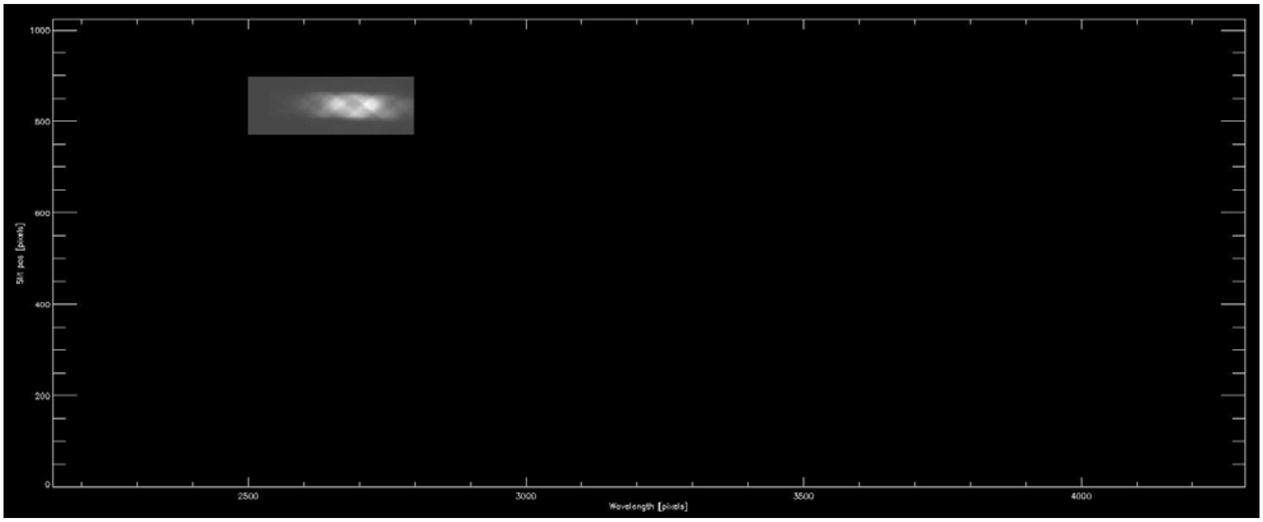


Fig. 10: EIS Flare trigger response image, exposure 2
(FMIR position = 394 steps)

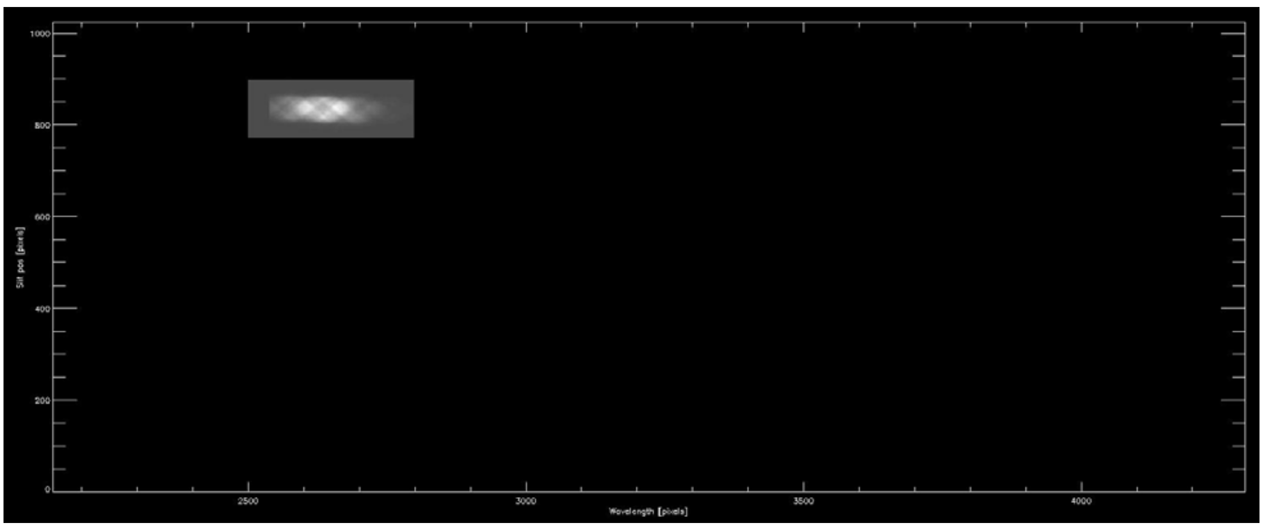


Fig. 11: EIS Flare trigger response image, exposure 3
(FMIR position = 644 steps)

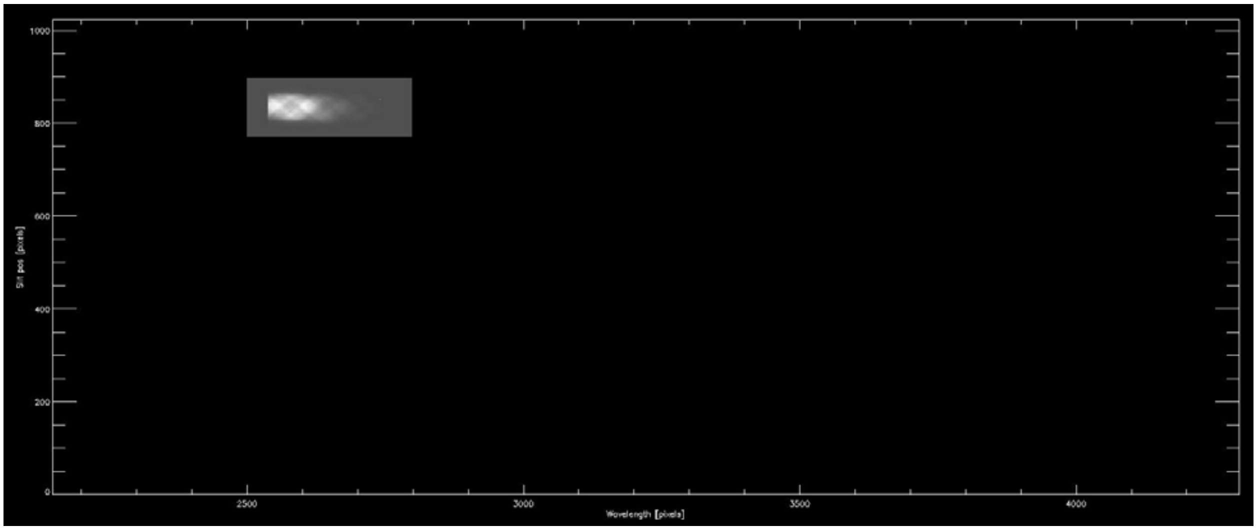


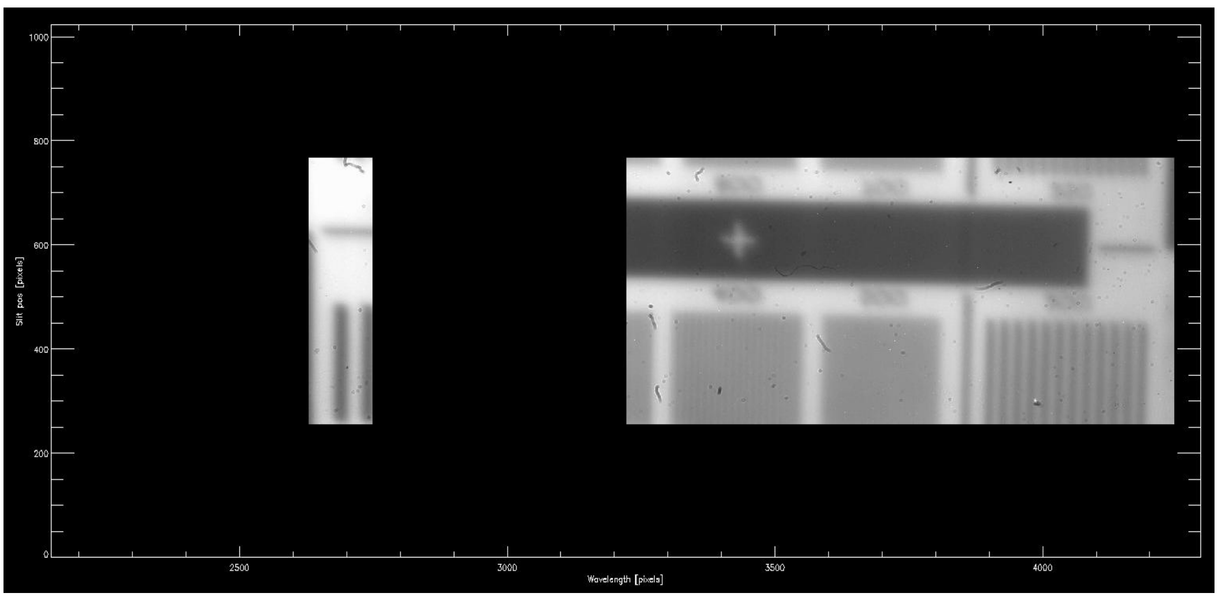
Fig. 12: EIS Flare trigger response image, exposure 4 (FMIR position = 894 steps)

9.2 Pinhole camera testing

As mentioned earlier, the EIS flare operations were also tested using the EIS pinhole camera, a standard target and visible light. One of the key tests is to verify the trigger operation using more complex flare shapes, as in the following example:

9.2.1 Reference image

Fig. 13 shows the EIS pinhole camera reference image, where a flare line of 120X512 pixels is selected. The flare line X length (120 pixels) is smaller than a standard 250" slot image, however, it is chosen to accommodate two vertical bars which would result in two peaks, as shown in Fig. 14 (EIS QL image by averaging along the slit, i.e. averaging along the Y-direction).

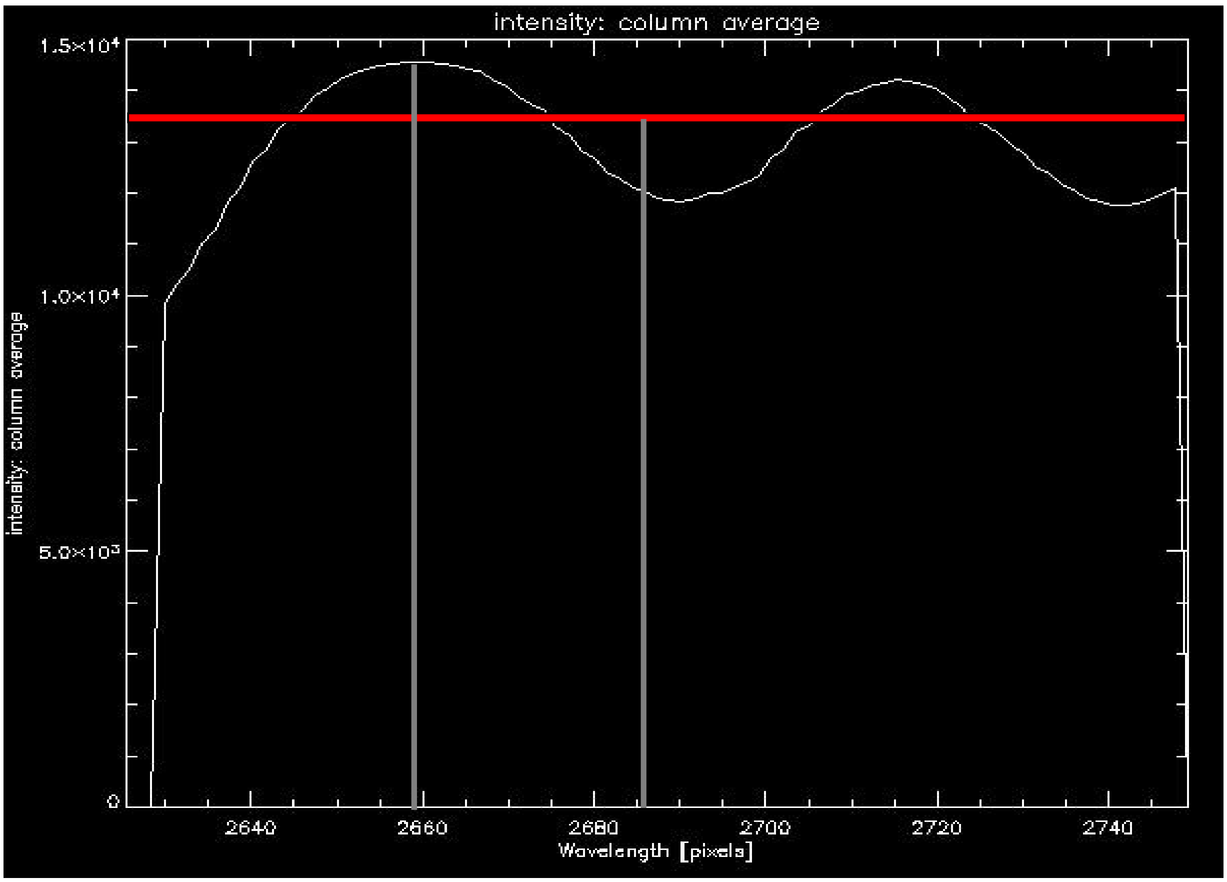


"Flare line"

Fig. 13: EIS Pinhole camera reference image showing a "flare line" of 120X512 pixels

9.2.2 Xf-peak vs. Xf-centre example

As stated in section 4, the EIS flare trigger control parameters can be set to locate the flare X peak (e.g. flare kernel) or the flare X centre (central to the first and last Y-threshold crossings). When commanded to locate flare X-peak, the flare trigger identified Xf to be **pixel 30 (relative to the flare line X length)**. However, when commanded to locate the flare centre, Xf was identified as **pixel 56 (relative to the flare line X length).**



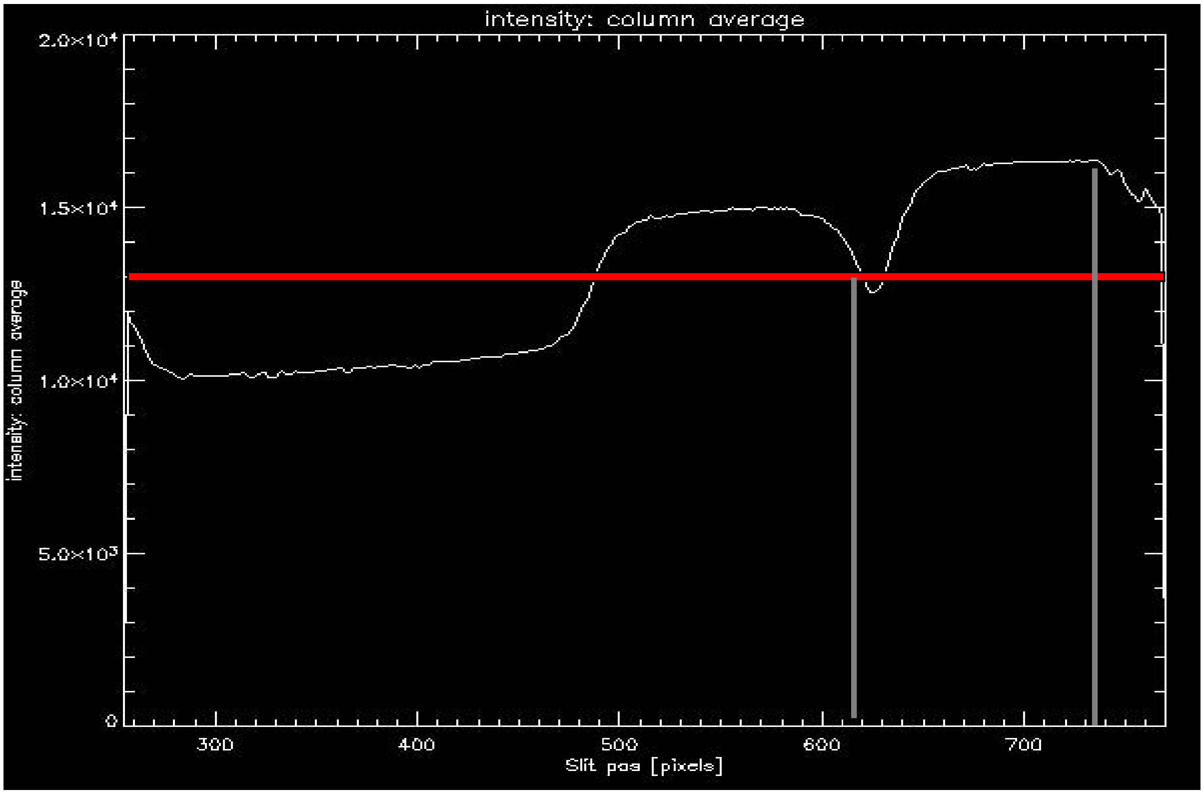
Xf peak   Xf centre

Fig. 14: EIS QL image of a flare line (120X512) (averaged along the slit) i.e. column sum average

Xf Peak: at pixel 30 (relative to the line X length)
Xf Centre: at pixel 56 (relative to the line X length)
The red line is the Y threshold position (the average and, not the absolute, threshold value is shown for illustration)

9.2.3 Yf-peak vs. Yf-centre example

As stated in section 4, the EIS flare trigger control parameters can be set to locate the flare Y peak or the flare Y centre (central to the first and last X-threshold crossings). When commanded to locate the Yf peak, the flare trigger identified the Yf to be **pixel 479 (relative to the flare line Y height)**. However, when commanded to locate the flare centre, Yf was identified as **pixel 372 (relative to the flare line Y height)**.



Yf centre **Yf peak**

Fig. 15: EIS QL image of a flare line (120X512) (averaged across the slit), i.e. row sum average

Yf Peak: at pixel 479 (relative to the flare line Y height)
Yf Centre: at pixel 372 (relative to the flare line Y height)
The red line is the X threshold position (the average, not absolute, threshold value is shown for illustration)

Note: There is an error in the EIS QL software where the top axis is labelled as 'column average'. It should read 'row average'.

10.0 Response time verification

The following measurements of 10 flares were taken by monitoring the EIS HK which is updated every 2 seconds. A response time is measured as the time between the shutter closing and the HK reporting that the flare response study is running.

Typical time: 4 seconds
Maximum time: 6 seconds

These figures should be treated as a guideline to the EIS flare trigger response time.