

Project: Solar-B

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CHANGE RECORD

ISSUE	DATE	PAGES CHANGED	COMMENTS
01	01/07/2006	All	First version
02	24/09/2009		* Removed any reference to fixed Timeline ID (planning tool modified handling) * Added a section for first 40" FMIR avoidance (FMIR post-launch FOV issue) * Added a section for planning tool operation

Applicable references:

These references appear in [] brackets in this document.

- 1 – EIS science requirements: MSSSL/SLB-EIS/SP007.07
- 2 – MDP ICU interface document: NAO/SLB-EIS/SP/MDP3.4
- 3 – EIS Telecommanding Structure: MSSSL/SLB-EIS/SP016.03
- 4 – EIS sequence structure overview: MSSSL/SLB-EIS/TN014.03
- 5 – EIS Status: MSSSL/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
EGSE	Electronics Ground Support Equipment
EIS	Extreme ultraviolet Imaging Spectrometer
FMIR	EIS Fine Mirror
FOV	Field Of View
ET	Event 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
QL	EIS Quick Look
SIB	Satellite Information Database
X	EIS X coordinate
Y	EIS Y coordinate
Ye	EIS event Y position

1.0 Introduction

The EIS event trigger (renamed EIS bright point trigger) work was undertaken in response to the following EIS science requirements [1], section 4; item d:

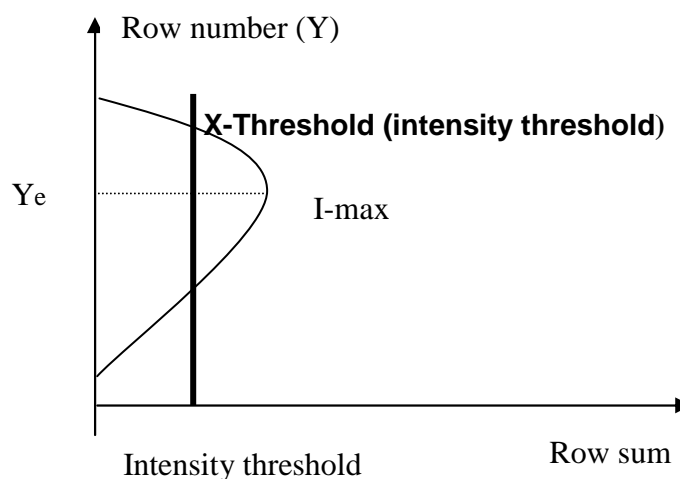
“To locate the region of interest in a raster, point to the area and start a new study. This will require information to be stored until the end of a raster at which time a response will be made”.

It is worth noting here that the **EIS event trigger** and the **EIS flare trigger** are two separate functions. The former requires the location of an area of maximum intensity within a raster scan; preferably using the 2” slit and responds to it using the 1” slit. The response is made, if conditions are met, when the detection raster is completed. The latter requires using the 266” slot in sit and stare mode and once flare conditions are met, the detection study is aborted and a response study is undertaken.

2.0 Event detection algorithm

Conceptually, the bright point detection algorithm performs its operations as follows:

1. EIS will start running a detection scan raster using typically the 2” slit.
2. For each exposure performed, measure the intensity of a pre-selected line (e.g. He II in a prominence). The intensity (called I-max which is set to zero when the raster starts) is determined by binning row pixels (i.e. summing pixels in the wavelength direction). The current exposure will have a maximum intensity if:
 - a) I-max exceeds a preset intensity threshold, as shown below:



b) The current I-max is greater than the previous I-max.

Once a new I-max is located, the event Y location (Y_e) and the event X-location (the exposure fine mirror position) will replace the previous values, as illustrated in the diagram below:



Detection raster

An example is as follows: while the scan raster is running an event is detected in fine mirror position (FMIR2). As the raster scan continues a more intense region is detected, for example at FMIR4. In this case (Y_e) replaces the old one detected in FMIR2 position and FMIR4 replaces FMIR2 as the new event X-position, i.e. the new event becomes (FMIR4, Y_e).

3. Once the raster is completed and an event is detected, a response study will be undertaken, typically using the 1" slit scan raster. The new study raster can be re-pointed with a preset X&Y raster dimension (scan length and raster Y-height). This raster can be optimally positioned around the event location (re-pointed), when specified.

Please note that a second threshold is required (Y-threshold, i.e. binning the line columns). The use of double thresholds is to minimize the impact of "cosmic rays" on the event trigger performance.

It should be noted here that the 40" slot may be used for event detections. However, this may produce a level of uncertainty in the event position in the X-direction of up to 40" (step size). Hence the response raster has to account for this (wider FOV for the response raster).

3.0 EIS ET commanding (control parameters)

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

Bit 0 (MSB)			Bit 31
Sequence no.	Raster ID	Control flags	
X Threshold (intensity threshold)			
Y Threshold			
Y start address			
Y height address			

Sequence no.: This is an 8-bit parameter which specifies the EIS event trigger response study. This study will run when an event is triggered. Note that the user will need to select the response study and it is the planning tool/CPT which provides the sequence number on-board.

Raster identifier (also called the main response raster ID): This is a 16-bit parameter, which specifies the response raster identifier and is required for the following reasons:

- 1) To allow for searching for the raster parameters in a sequence (by matching the run raster command header and the raster ID, i.e. 3 bytes). The main response raster parameters are used for EIS autonomous re-pointing, if enabled.
- 2) If more than one raster is present in the response sequence

The raster ID must be present in the response study and in the sequence specified in the sequence number parameter. **The Raster ID should not be 0 or 0xFFFF (software error trapping for un-initialised values).**

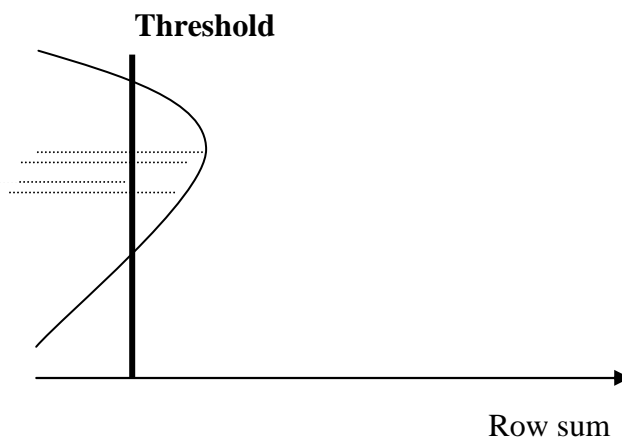
Control flags: These flags are as follows:

Adjust Y: This is a 1-bit flag, when set a re-pointing in the Y-direction is performed, via centring the raster Y-height on the event position (Ye).

Adjust X: This is a 1-bit flag, when set a re-pointing in the X-direction is performed, via the fine mirror. The response raster will be centred on the event X-position.

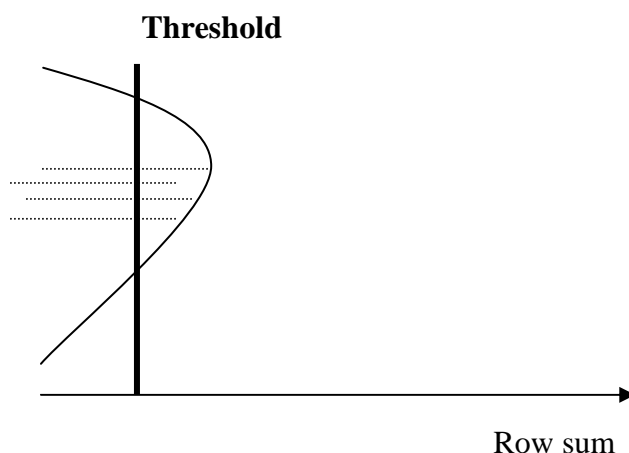
X MIN LIMIT: This is a 3-bit parameter which specifies the number of consecutive sample measurements above which an “event” is considered. For example, setting this parameter to 4 means that at least 4 consecutive row sums above the X-threshold are required before an event is considered.

In the example below (starting from the bottom), the first, third and fourth samples (row sums) are above the threshold. This “event” is discarded.



This exposure (event) is discarded

In the example below, 4 consecutive samples are above the threshold. This event is considered.



4 consecutive samples above the intensity threshold (valid event)

Y MIN LIMIT: This is a 3-bit parameter which specifies the number of consecutive sample measurements above which an event trigger is considered. For example, setting this parameter to 4 means that at least 4 consecutive column sums above the Y-threshold are required before an event is considered.

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

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

Note that the X and Y MIN limits, and the X and Y thresholds are used to minimize the impact of cosmic rays and hot pixels on the event detection and will possibly improve reliability.

Y Start Address: The Camera read-out sequence Y start address memory location (32-bit parameter). The address is generated by the CSG compiler 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 is set **internally** by the planning tool.

Y height Address: The Camera read-out sequence Y height address memory location (32-bit parameter). The address is generated by the CSG compiler 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 is set **internally** by the planning tool.

3.1 EIS ET commanding verification

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

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

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

3 – Verify the presence of the raster ID (EIS ET 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 line list is in range (0 to 47) and contains a valid checksum. Also the presence of an EIS event line marker in the “**detection**” study line list is also checked.

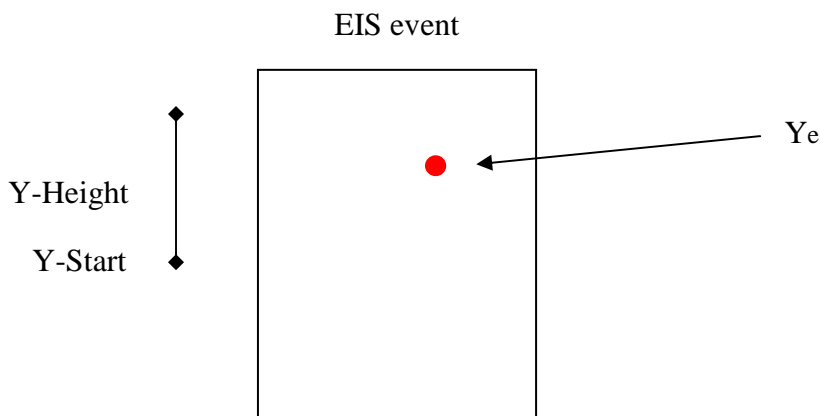
If any of the above checks fail, the ICU software automatically disables EIS event trigger operations as a response is “not possible”. The offending error is reported in the EIS HK, i.e. status type 1 [5]; ET_ERROR parameter. However, the detection study will run.

4.0 EIS X and Y event location re-pointing

When adjust X and/or adjust Y flags are set, the main response raster re-pointing operation(s) will be undertaken in response to EIS event detection. Re-pointing implies centring the response raster across the event site. The response FOV is pre-selected by the user.

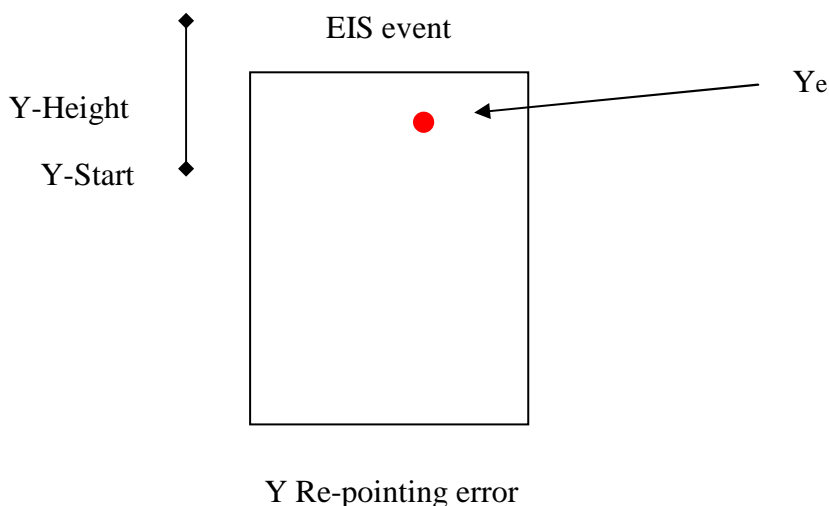
4.1 Option 1: Y adjust (re-pointing in the Y-direction)

When this flag is enabled, the event Y-start (first row to be read) is determined from the event Y position (Y_e) such that the event is positioned at the centre of the Y-height, as shown below:

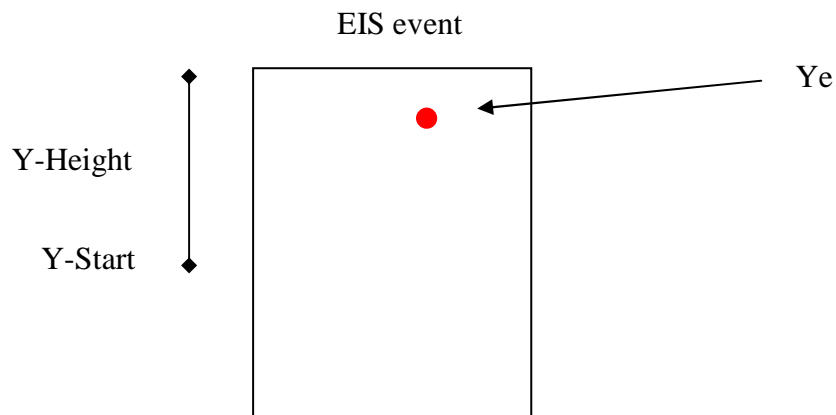


Note: Y-start is determined on-board and Y-height is as per the response raster line list.

If the event site is near the edge of the Y-FOV (600"X512") and it is not possible to encapsulate the event site and remain within the Y-FOV, as illustrated below:



Then the read-out section is re-adjusted by sliding Y-Start as shown below:



The same applies for the X-FOV re-pointing.

5.0 Recommendations for designing event trigger studies

When the event trigger was designed and coded, it was assumed that the EIS FOV was 600"x512". However, the FMIR movement is now restricted for the first 40" (recommended not to use it for the first 50", as a precaution). Note that for "normal" studies, the planning tool gives a warning regarding pointing a study within the first 40" of EIS X-FOV. However, there is nothing at present that inhibits the event trigger response from autonomously re-pointing to the first 50". In order to prevent re-pointing for the first 50", the detection raster FOV should use the following formula:

Detection raster Maximum FOV = 600" (EIS FOV) – 50" (Inhibiting zone) – (Response raster X-FOV / 2)".

This is to prevent the **response raster** from pointing to the first 50" of the EIS X-FOV.

Also the **detection raster should be pointed at** a minimum of 50" + (response raster X-FOV / 2)".

Note that the above only applies for a raster that requires re-pointing. Other response rasters (pointed from the ground) are unaffected.

The detection raster pointing information should be made available in the **instructions to planner** section of the study description.

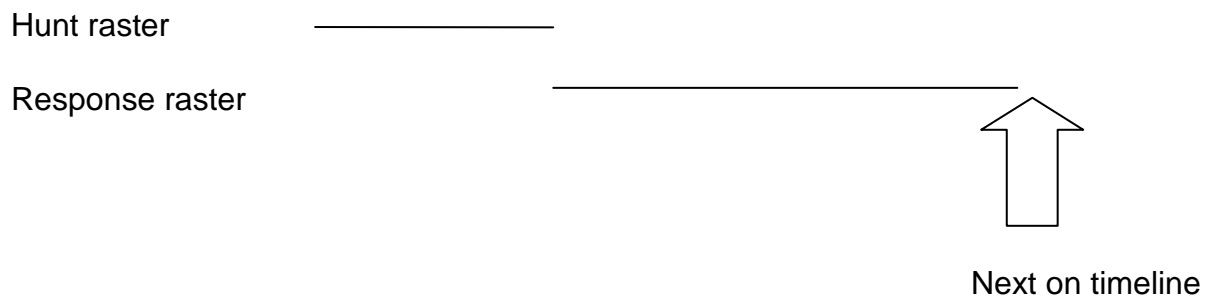
6.0 Recommendations for running event trigger studies

6.1 Detection and response studies timing

The event trigger operations should be 'fairly' deterministic as all of its components run-time is finite. Also the run-time is the simplest among other autonomous operations in terms of the run-time required and rendezvousing with the remainder of the daily plan. For

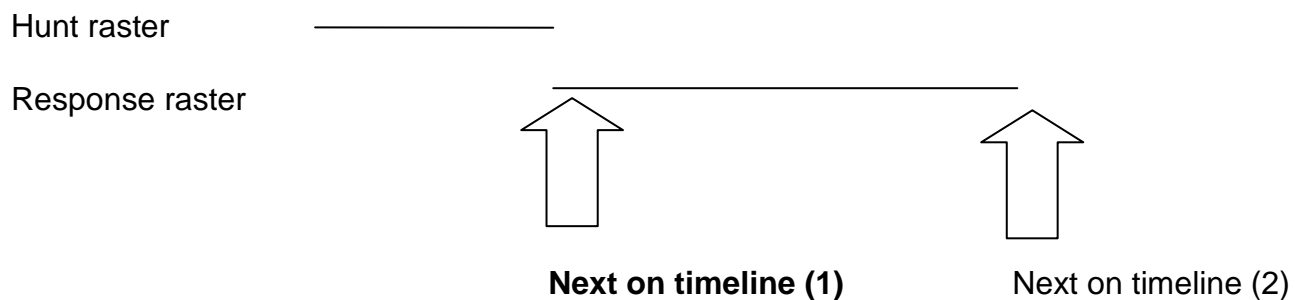
Title: EIS event Trigger

example, if the hunting raster duration is 1 hour and the response study duration is 2 hours, then possible ways of dealing with the timing issues are as follow:



In this case if no trigger takes place, a gap corresponds to the response raster run-time occur.

Or:



In this case, the '**Next on timeline (1)**' study will be ignored if the response study is run (it is not possible to abort the response study from the timeline), but undertaken if no event is triggered.

Note that no spacecraft pointing is allowed between the hunting start and the end of the response study run-time position!

The hunt raster/response raster(s) can be repeated N times in the normal way.

6.2 Response study operations

In line with other trigger operations, it is expected that the main response raster will be the first raster of the study (if multiple response rasters are required). This is not mandatory as it "may be" desirable to run a quick context raster before or after the main response raster. However, the following applies for response studies:

- 1 – Only one raster will be re-pointed per response study
- 2 – The re-pointed raster must be in the first sequence of a multiple sequences response.

In summary, a response study can contain many rasters but only one will be re-pointed and an autonomous re-pointing raster must be in the first sequence. This is to avoid overcomplicated response studies and on-board operations.

6.3 Planning tool operation

The event trigger operations can be performed either from EIS make study or EIS make plan. It is recommended that EIS make study is used to set up the event trigger operations and that EIS make plan is only used for the “fine tuning” of event trigger control parameters (e.g. fine tuning threshold levels). It is envisaged that some fine tuning of the control parameters will be required to improve performance and form part of the learning process.

7.0 Post event trigger operations

Once an EIS ET response is triggered, the ICU software **disables** mode transitions autonomously. This is to inhibit the Solar-B OP/OG (timeline) commanding from accidentally aborting the response study when the next timeline commands are due (deferred time commanding and trigger operations are asynchronous). Once the response study is finished, i.e. stopped, the ICU **re-enables** the mode transitions autonomously, and starts re-accepting OP/OG commands. It is only possible to abort the response study from the ground following re-enabling mode transitions.

Also note that the response study should run with the raster’s EIS ET flag [4] disabled, as an event response is already active!

8.0 EIS ET response termination

The event trigger operations can be either stopped when the response study is finished or aborted manually when in ground contact.

9.0 EIS observation table management

As a requirement for Solar-B operations, an identical copy of the on-board EIS OBS table shall be made available to ISAS EGSE for EIS memory management purposes. However, when re-pointing operations are undertaken, both the response study (sequence) and the main response raster line list may be modified on-board. In order to maintain similarity between ISAS and the on-board memory maps, the EIS event 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 completed, the local copies are reinstated on the EIS OBS table, such that the EIS OBS table is maintained in its original form (post uplink form).

10.0 EIS ET examples

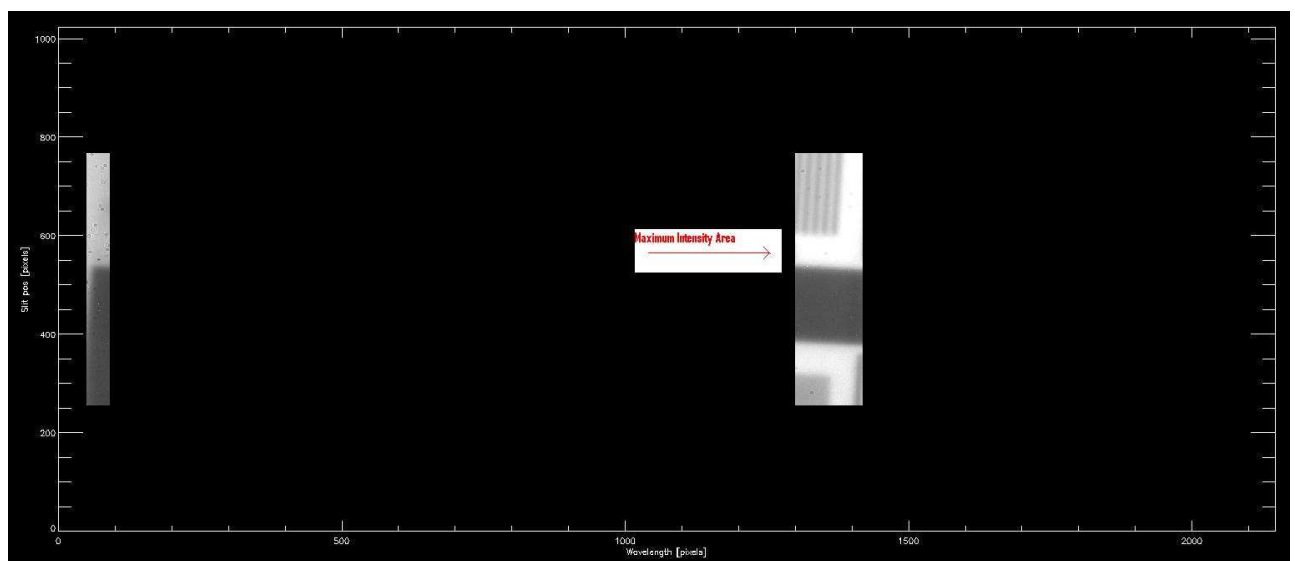
The EIS event trigger response was tested during the course of the ICU on-board software development, however, it should be noted here that the ultimate testing will be performed in orbit. Nevertheless, the ground testing goes a long way towards verifying the correctness of the operations and performance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

10.1 Pinhole camera testing

The EIS event trigger operations were tested using the EIS pinhole camera with a standard target and visible light.

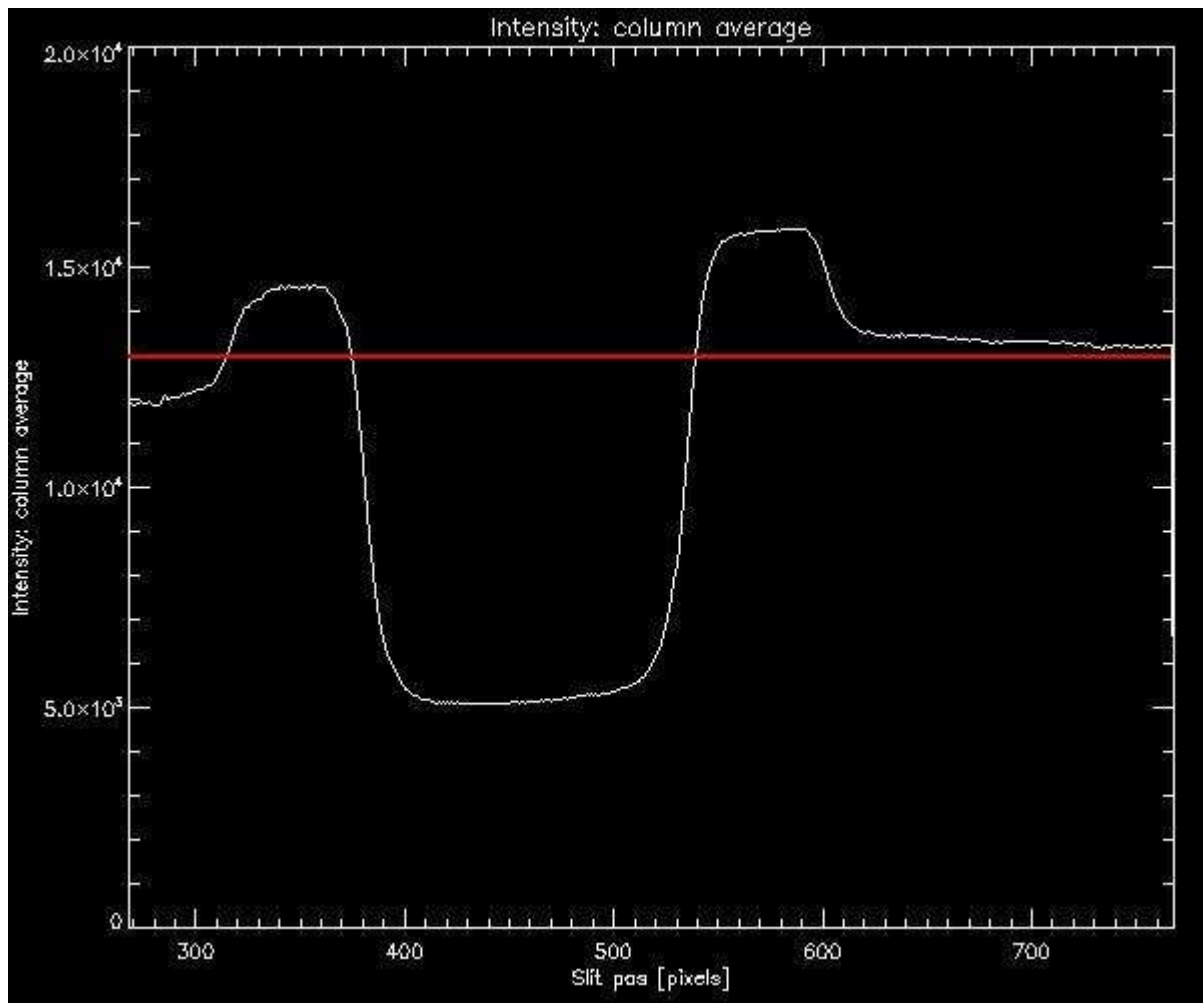
10.1.1 Reference image and performance

The figure below shows the EIS pinhole camera reference image, where an “event line” of 120X512 pixels is selected (unrealistic line width but useful for testing).



Pinhole camera reference image showing an “event line” of 120X512 pixels

The red arrow points to the area of maximum intensity within the selected line. This is also verified using the EIS QL line intensity plot, as shown below:



EIS-QL “event line” intensity (average across the slit)

Notes:

- 1) There is an error in the EIS QL labelling (Intensity: Column average) should be (Intensity: Row average)
- 2) The QL can provide the line average intensity. To convert to absolute intensity, multiply by the line width. For example, the average intensity threshold is (1.3×10^4) and to get the absolute intensity required in the ET control parameters table, multiply by the line width, i.e. ($120 \times 1.3 \times 10^4$).

The same applies for the Y-threshold (Column sum).

During testing once the hunt study run was completed an “event” was triggered. The event coordinates as reported in the ICU HK and the MD packets were:

FMIR position (steps) = 1036

Y event (pixel) = 332 (relative to EIS Y-FOV of 512) and in agreement with the QL peak intensity.

Title: EIS event Trigger

The response study re-pointing is shown below (Response Y-height = 128 pixels):

