# Solar B - EIS

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## EIS SCIENCE REQUIREMENTS

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## CHANGE RECORD

| ISSUE | DATE | PAGES CHANGED | COMMENTS |
|---|---|---|---|
| 01 | 30 May 2000 | All new | Major revision and new reference number. |
| 02 | 29 June 2000 | 5,6 | Minor editorial changes in par III.3 and in par III.4c and III.6 |
| 03 | 4 July 2000 | 4,5,6 | Par II.9, 6X6 changed to 4X4 armins. Par III1f. If, less changed to greater. Par III.2 a&e arcsec changed to pixels. Par III2g, deadline for decision added. Par II.4, size of active region deleted. Par III.6, table modified. |
| 04 | 9 April 2001 | 4,5 | III.1a define slot sizes. III.2.e change from 1x512 pixels to 40x512 pixels III.2.f define currently available exposure times. III.2.g define AEC. III.3.c define variables of a study |
| 05 | 26 April 2001 | 4,5 | III.3c add to the variables whether the study is interruptible, on chip binning, different exposure times in a study and different line lists in a study.<br>III.4d add a separate requirement to find the brightest region in a raster. |

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|---|---|---|---|
| 06 | 1 June 2001 | | The italics are only kept for undecided issues.<br>II 8 – changed from region of brightest intensity to region of interest in order to reduce limitation. Changed to relocate autonomously and observe a different field of view to clarify that this will be carried out automatically through an algorithm which will define what the region of interest is, and that the field of view is different instead of smaller.<br>II 9 – the size of the active region is changed back to 6X6 arcmins. This can be achieved with the current design.<br>III 1a – it's -> its<br>III 1 c and f – these are now combined.<br>III 2e – only have process (remove the expose).<br>III 2 g – added vice-versa in order to allow an increasing exposure time with decreasing intensity.<br>III 3 a - added or spacecraft OP store in order to avoid confusion so that it is clear that we can switch between sequences set in an OP and not just by command.<br>III 3 e – again to avoid confusion about the way that the parameters are changed, a reference to the EIS MDP-ICU interface document is made.<br>III 4 a – add – 'or stay in the same location and change the study' to provide the flexibility for looking outside of the flare region for, for example, coronal waves.<br>III 4 d – specify that this requires information to be stored and then a decision made.<br>III2f – changes the accuracy of the exposure to 5% of the minimum exposure time rather than 5% of the exposure time. |
| 07 | 29 July 2002 | II5 | Typo in waveband – changed from 250-280 to 250-290 |

## CONTENTS

# I. **Major Science Goals**

*Coronal Heating* - to determine the physical mechanisms responsible for coronal heating in the quiet Sun and active regions (e.g. detect magnetic reconnection, wave heating).

*Transient Phenomena* - to determine the physical mechanisms responsible for transient phenomena, such as solar flares, coronal mass ejections, jets, network brightenings, in the solar atmosphere (e.g. determine energy transport and mass motions during transient events).

*Energy Transfer from the photosphere to the corona* - to investigate the causal relationship between dynamics in the photosphere and coronal phenomena (relate EIS observations to data obtained by the solar-B SOT and XRT).

## II **Science Requirements**

1) *To perform EUV spectroscopy with high spectral resolution*. EIS is required to determine Doppler velocities to an accuracy of ~ 3km/s from spectral line shifts and non-thermal motions as small as 20 km/s from line widths.
2) *To perform EUV spectroscopy with high spatial resolution*. EIS is required to resolve structures equal to 2 arcsecs resolution.
3) *To perform monochromatic EUV imaging*.
4) *To perform both the imaging and spectroscopy mode with high temporal resolution*. In spectroscopy mode, EIS is required to obtain accurate measurements of strong line intensities and line widths in < 1s in highly dynamic events such as flares, and every 10 s in less dynamic phenomena such as active region loops. For imaging, EIS is required to obtain monochromatic images of an active region in ~ 3 s for dynamic events and 10 s for active region loops.
5) *To obtain imaging and spectral measurements from spectral lines in the transition region, corona and solar flares*. This temperature range is from 0.1 MK - 20 MK, which requires observations in the extreme ultraviolet (EUV). The selected wavebands are 180-204 A and 250-290 A.
6) *To obtain accurate coronal density measurements.* EIS is required to measure densities in coronal holes (~$10^8$ $cm^{-3}$) and solar flares, which are the most dense phenomena in the solar atmosphere (~$10^{12}$ $cm^{-3}$).
7) *To respond to highly dynamic phenomena.* EIS is required to obtain high temporal resolution observations of dynamic phenomena. Since intensities will change on orders of magnitude EIS is required to change the observing mode by responding to an external or internal event trigger.
8) *To locate and change the observing mode to a region of interest.* EIS is required to be able to locate regions of higher intensity in an observation (e.g. a bright point) and relocate autonomously to observe a different field of view with a different observing sequence.
9) *To observe a range of sizes of solar phenomena.* EIS is required to observe small transient network brightenings (on order of a few $arcsecs^2$) and large active region (6X6$arcmins^2$).

## III Instrument Design Requirements

1) Pointing and Field of View

(a) To select a slit or slot as required. Four slit positions are available. Currently 3 positions have been determined - 1" for just sampling our spatial resolution, a 2" slit and a 40" slot for providing monochromatic imaging with no blending from the stronger lines. *A further large slot >100" has been decided but its final width has yet to be determined. It is limited in the current instrument design to be <250".*

(b) To point EIS in the E-W direction with a coarse pointing in the range +/- 15' with an accuracy of +/- 3". The coarse pointing will be used to obtain approximate pointing of each target.

(c) To have fine pointing in the range 0-6', with an accuracy of 0.5". It is required to point EIS with accuracy greater than the spatial resolution.

(d) EIS FOV is 360" X 512" (360" is the fine pointing range, and 512" is the maximum image height of the CCD).

(e) To have stability during an observation of 1" in 10 s (the average exposure time for the observation of an active region loop). The spacecraft $3\sigma$ stability is 0.6" in 2 s, 1.1" in 20 s and 1.7" in 1 minute.

2) Readout Issues

(a) To expose and readout the maximum image area of both CCDs (2048x512 pixels) simultaneously.

(b) To allow any fraction of a CCD to be downloaded in the spatial direction (i.e. not the full slit length). This is to allow the observation of a smaller FOV.

(c) To allow fractions of a CCD to be downloaded in the spectral direction (i.e spectral windowing).

(d) To have a minimum of 1 spectral window and a maximum of 25 spectral windows

(e) To process 40 X 512 pixels (e.g. readout time, compression) data in <1s. This is to allow the processing of one slot image (40"x512") or one spectral line with a width of 40 pixels and an image area of 1"x512" in <1s.

(f) To perform exposure times in the range 100 ms - few hundred s with an accuracy of 5% of the minimum exposure time. The ability to make shorter exposures down to 10 ms is desirable.

(g) To perform automatic exposure control. This will allow a decrease of the exposure time with an increasing line intensity and vice-versa.

(h) To perform data compression. The data compression is currently JPEG in the MDP, but the facility to include a different compression scheme in the ICU should remain open. It is required that the compression scheme or factor can be varied in different studies.

3) Mode of Observation

(a) Science operations shall be performed from ground command or spacecraft OP store.

(b) The onboard software should be designed to aid code development and to facilitate the uplinking of new software.

*(c)* The study sequences shall consist of a number of variables (exposure time, number of spectral windows, spectral window width, slit/slot size, mirror step, compression scheme, interruptible, on chip binning, different exposure times in the same study, different line lists in the same study). The variables should not be constrained in any way i.e. the spectral window width can be different for each spectral line.

(d) The instrument shall also collect data based on a number of uplinked observing sequences.
(e) The parameters (e.g. slit size, y size, exposure time) of the observation shall be changed by command via memory uplink as specified in the EIS MDP-ICU interface document NAO/SLB_EIS/SP/MDD001.03.

4) Event Trigger

(a) To respond or not to XRT's flare trigger by moving to the flare location and starting a new observation sequence or staying in the same location and changing the study. Only respond if the flare is within the EIS FOV.
(b) To generate an internal EIS solar event trigger. This should have the flexibility to change to a different study.
(c) To respond to the event trigger by moving to the event and starting a new study within 30 s
(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.

5) Instrument Health

(a) Have the ability to interrupt studies (abort or pause and restart).
(b) Monitor the health of the instrument and enter a safe mode if an anomaly is detected.
(c) The instrument must respond in an appropriate manner to spacecraft emergency.

6) Key Terms

| Key Terms | Description |
|---|---|
| Line list | List of chosen spectral lines |
| Exposure | An exposure at one slit location |
| Raster | A series of exposures to build up an image |
| Study | A sequence of rasters |
| Observation | A study which can be repeated, pointing at the same object |