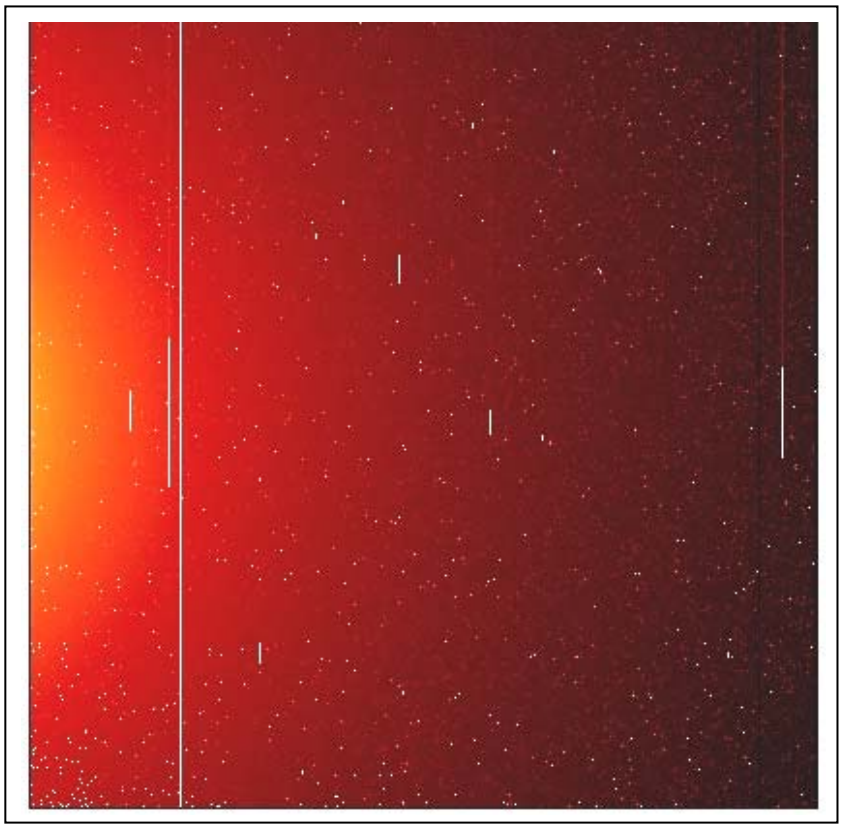
THE UNIVERSITY OF BIRMINGHAM

Heliospheric Imager - Update of activities at Birmingham & RAL

CLRC
Rutherford Appleton Laboratory



Richard Harrison, RAL, Principal Investigator

Chris Eyles, Birmingham University, Project Manager

(* Note HI presentation by CSL on optical design and test activities)

Heliospheric Imager – Update

SECCHI Consortium Meeting - April 2003

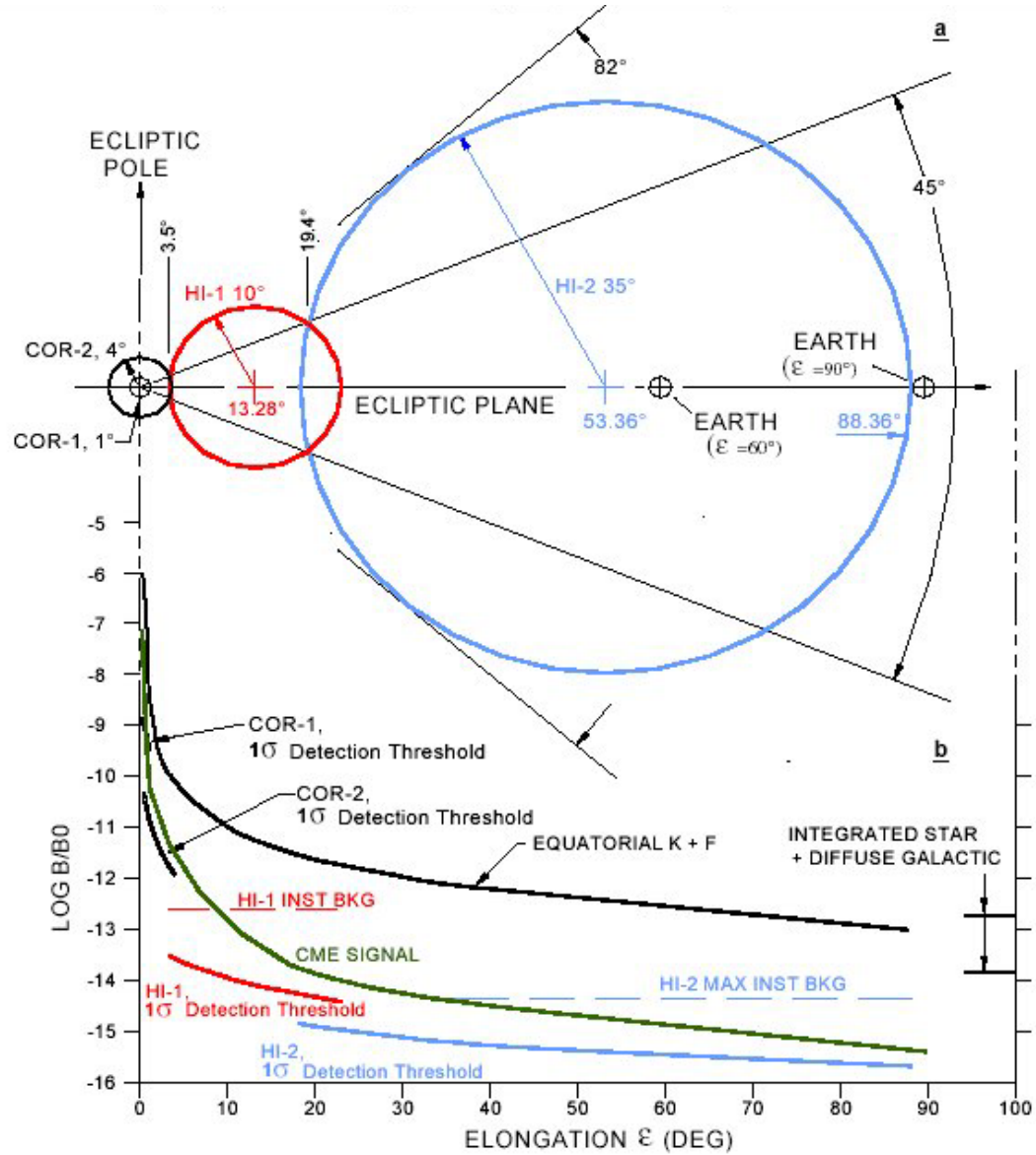
- Reminder of instrument basics
- Status of build at Birmingham
- Image saturation & Blooming
- Earth/Moon Occulter
- Image simulation - including non-shutter operation
- Operations Preparation

HI 'Firsts'

- First opportunity to observe Earth-directed CMEs along the Sun-Earth line in interplanetary space - first to detect CMEs in a field of view including the Earth.

- First opportunity to obtain stereographic views of CMEs in interplanetary space - to investigate CME structure, evolution and propagation.

- UK STEREO Web site: http://www.stereo.rl.ac.uk



The Observational Challenge

Geometrical Requirements:

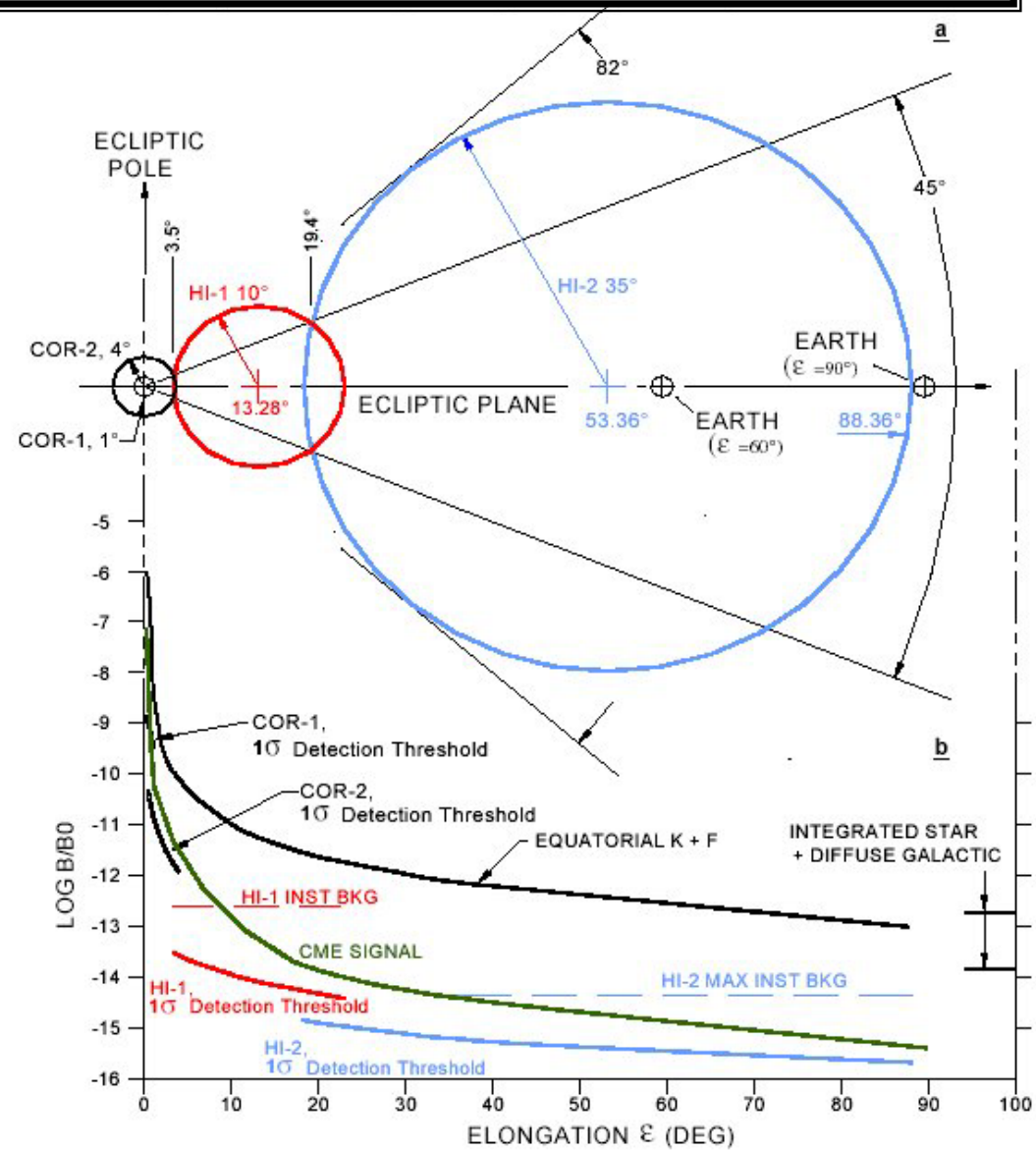
To View the Sun-Earth line with Unbroken Coverage from corona to Earth orbit.

Opening angle of 45° governed by average CME width over equator.

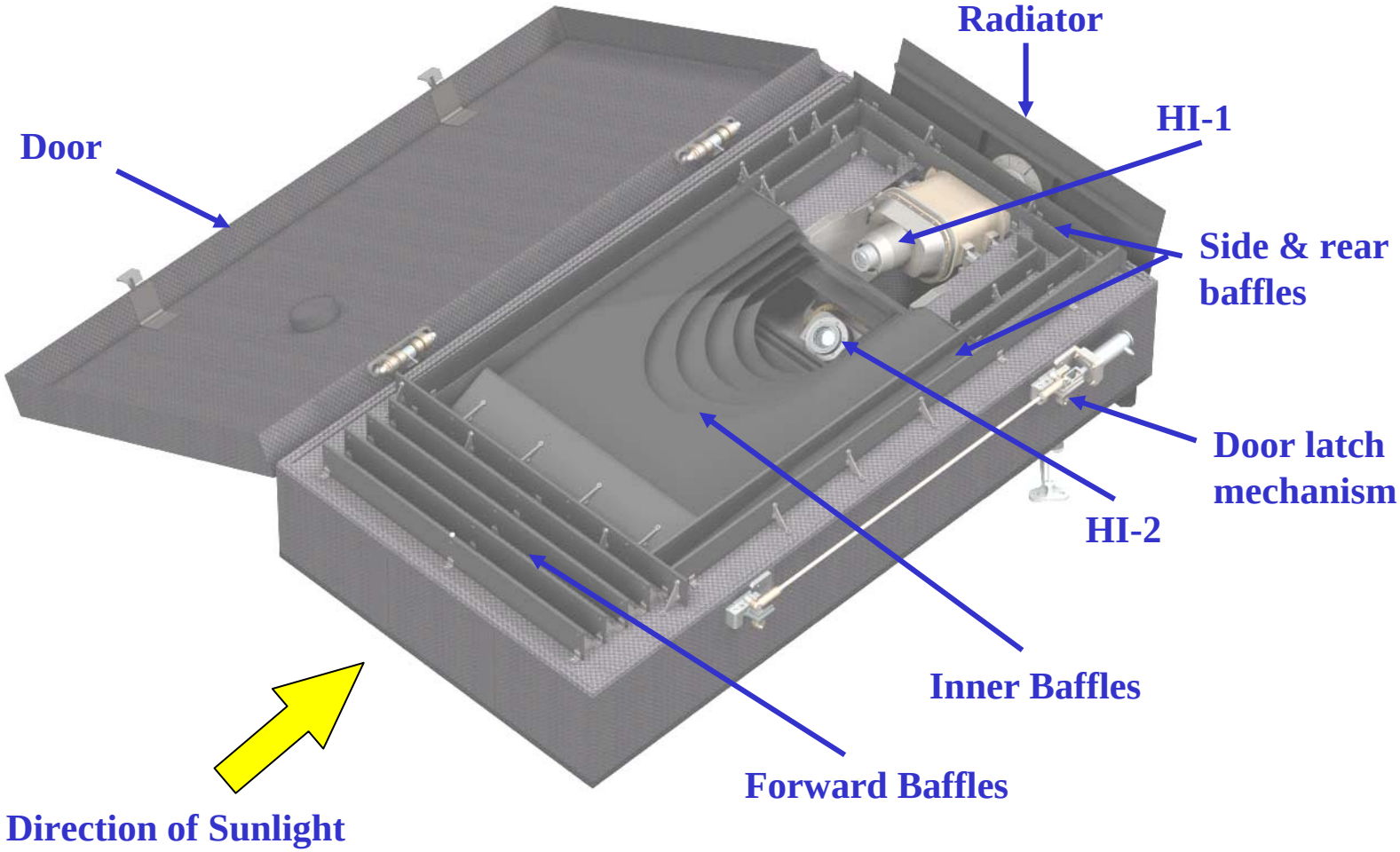
Brightness Levels:

Need to achieve rejection to < 3×10^{-13} & < 10^{-14} B/Bo to detect CME signal.

Must contend with contributions from the F-Corona, planets, stars, the Earth and Moon.



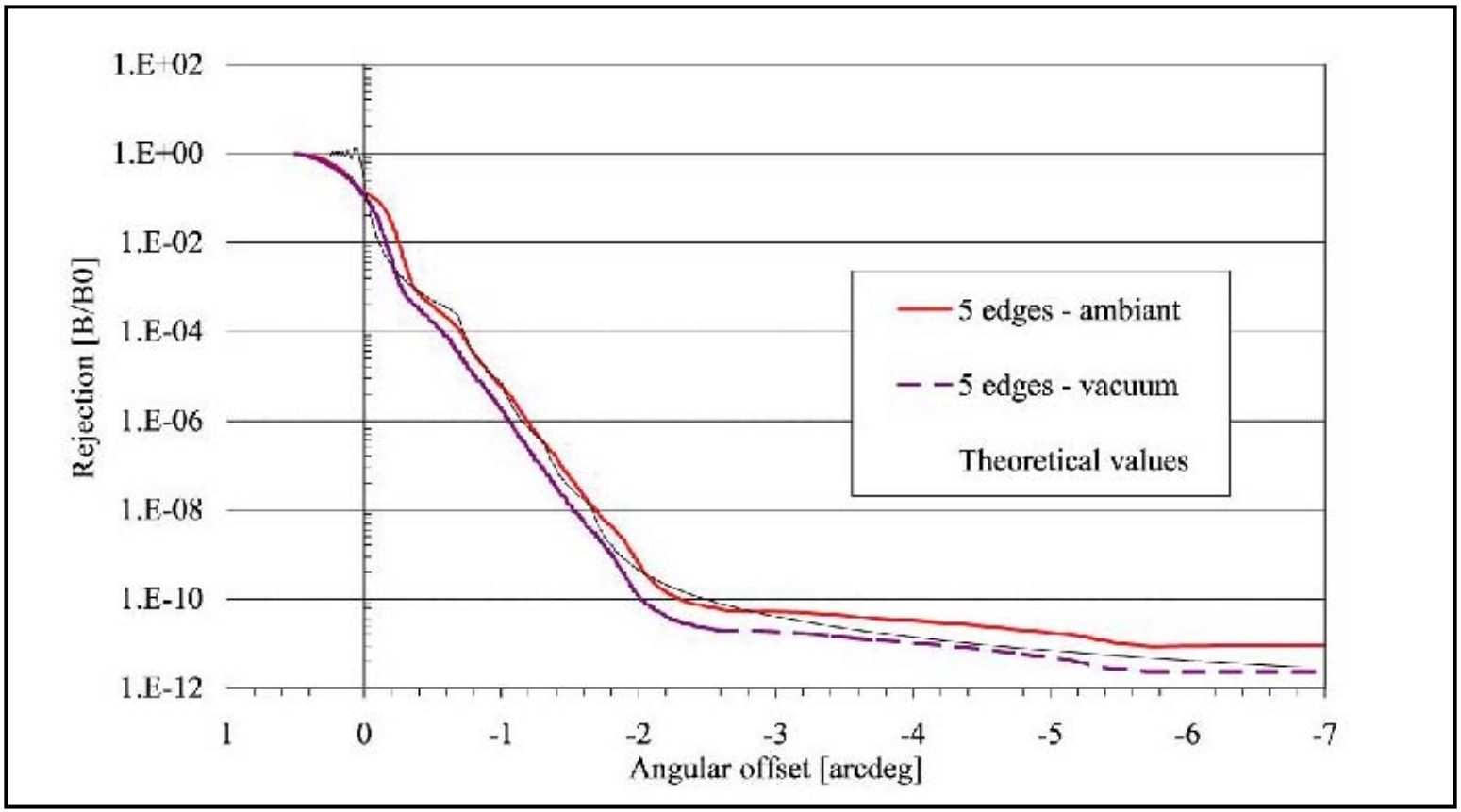
The HI Basic Design



HI - The Basic Parameters

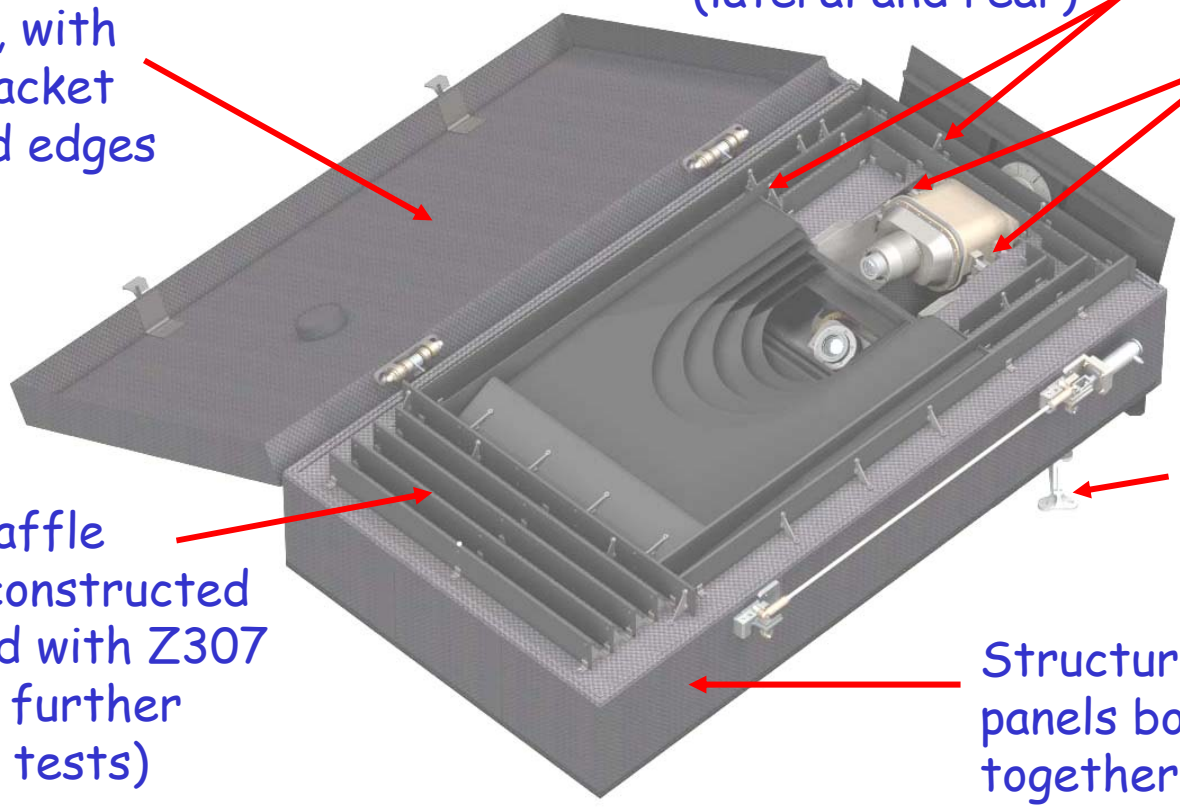
	HI-1	HI-2
Centre of Field-of-View Direction	13.65^{o} from Sun along ecliptic	53.35^{o} from Sun along ecliptic
Angular Field-of-View	20°	70°
Coronal Coverage	12 - 84 R_{sun}	66 - 318 R_{sun}
Overlap With COR2	12 - 15 R_{sun}	N/A
Overlap With HI-1	N/A	66 - 84 R_{sun}
Baseline Image (2 x 2 Binning)	1024 x 1024	1024 x 1024
Image Pixel Scale (Binned)	70 arcsec	4 arcmin
Spectral Bandpass	630 - 730 nm	400 - 1000 nm
Exposure Time	12 - 20 s	60 - 90 s
Nominal Images Per Sequence	70	50
Required Cadence (Per Sequence)	60 min	120 min
Brightness Sensitivity	3×10^{-15} B_{sun}	3×10^{-16} B_{sun}
Straylight Rejection	3×10^{-13} B_{sun}	10^{-14} B_{sun}

Front Baffle Performance



CSL Data for front baffle mock up assembly – additional light rejection of order 10^{-4} from optical system achieves required rejection levels
(* Note additional presentation on optical aspects of HI by CSL)

HI EQM Build Status



Door panel completed, with bonded bracket inserts and edges

CFRP stock has been produced for remaining linear EQM baffles (lateral and rear)

Trunion mounts for focal plane assembly completed

Mounting legs completed

Forward baffle assembly constructed and painted with Z307 (ready for further stray light tests)

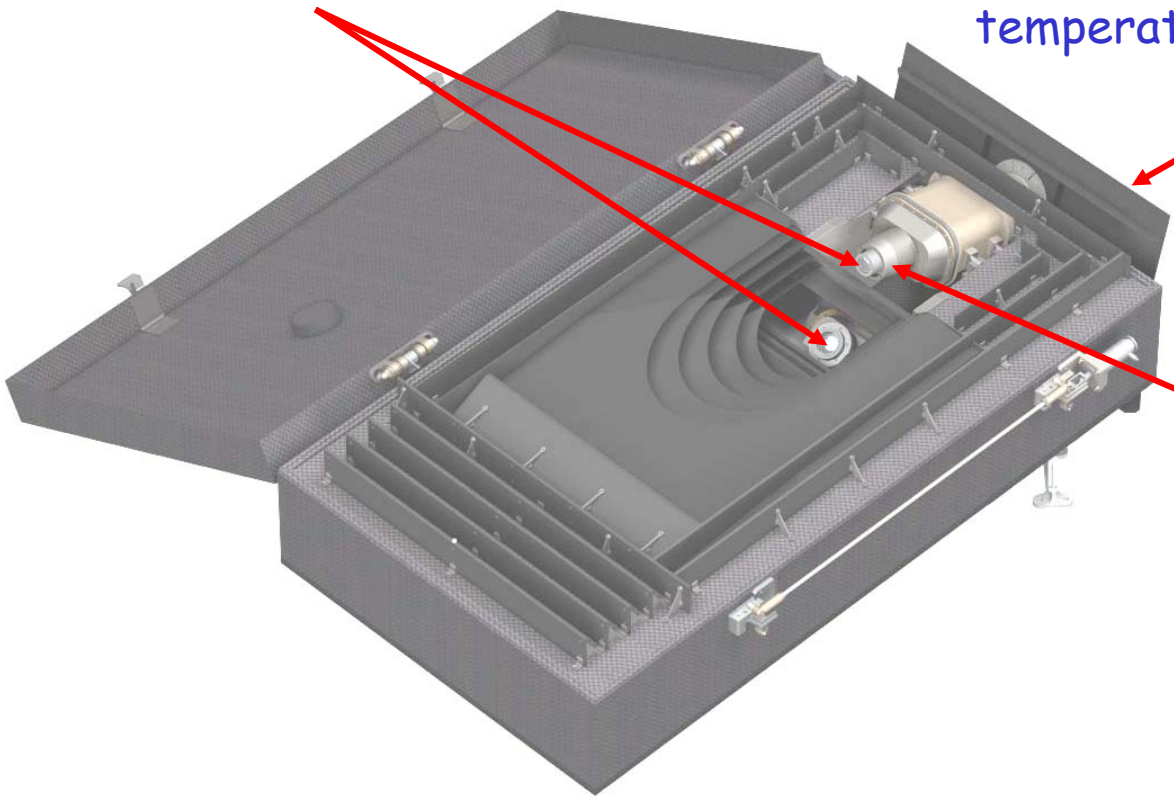
Structure component panels bonded together

- Development model camera electronic boxes completed, tested and delivered to NRL & RAL.

HI Optical/Thermal Status

Manufacture of optical elements completed by ICOS (London), final polishing completed and test data with CSL prior to final assembly of lens 'barrels'

Thermal model updated. Overall gradients under 3°C (acceptable). When final updates completed, radiator sizes to be optimised & contamination heater & camera electronic box survival temperature to be addressed.

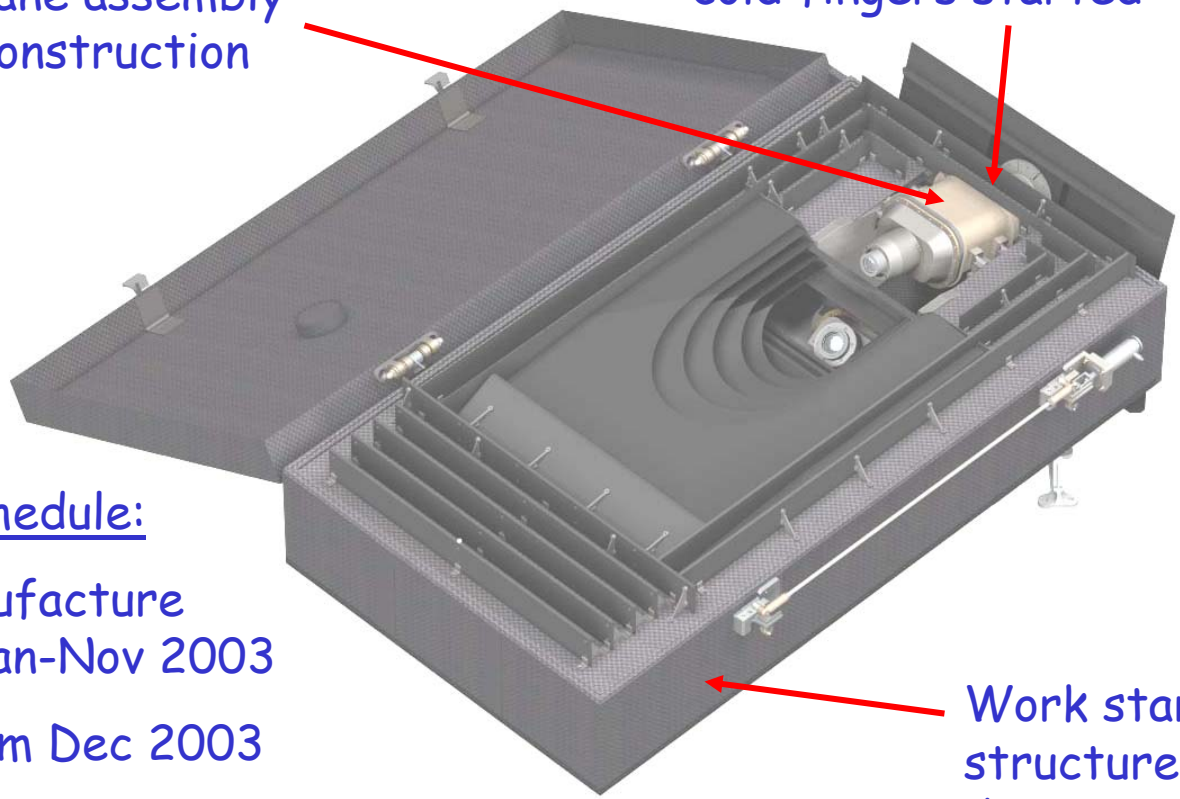


ICOS manufacturing dummy lens barrel for trial run of black chrome treatment

HI FM Build Status

Components of the focal plane assembly under construction

FM HI cold fingers 'roughed out' of raw material. Machining of HI-1 cold fingers started

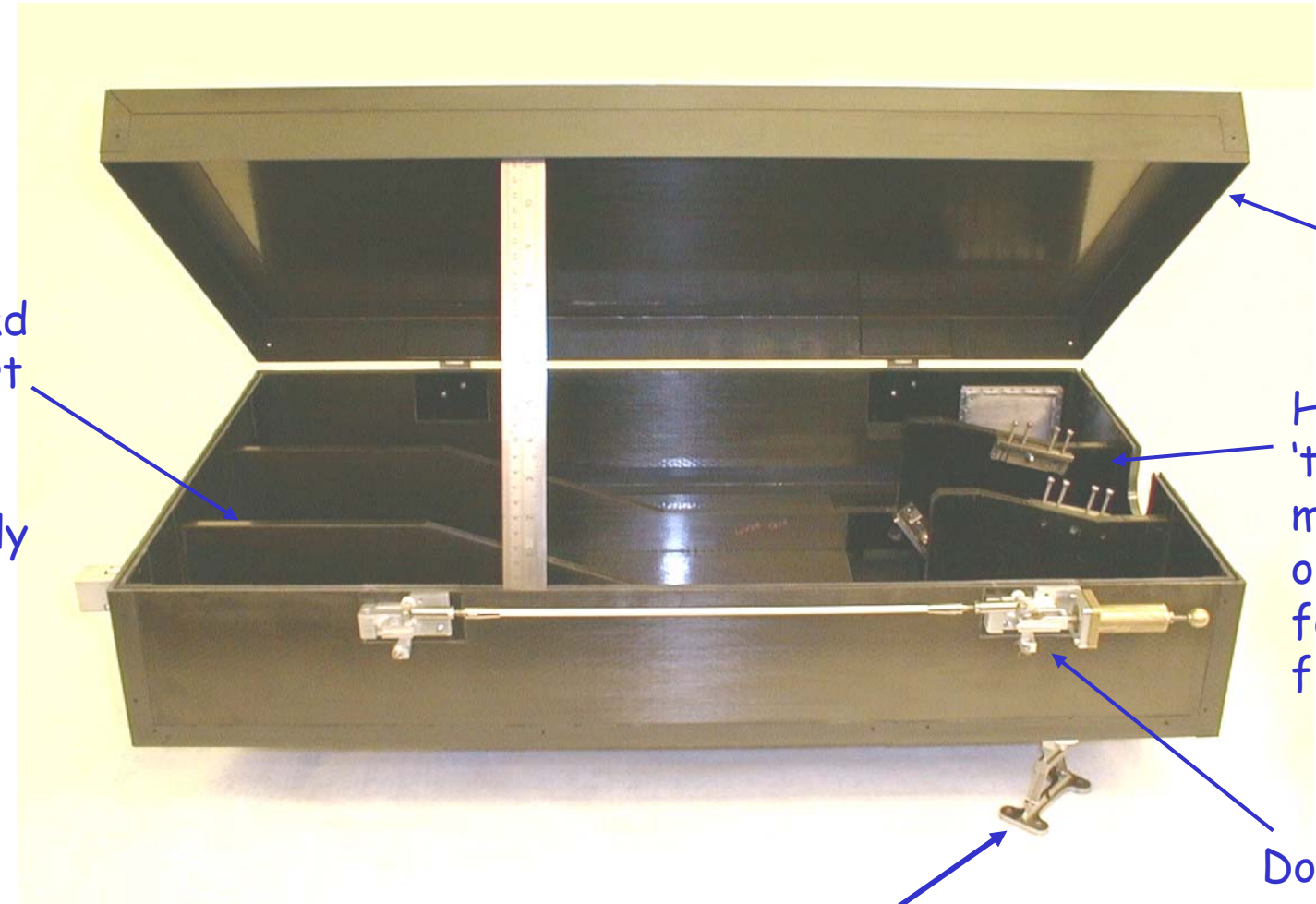


Work started on HI structure detailed FM drawings

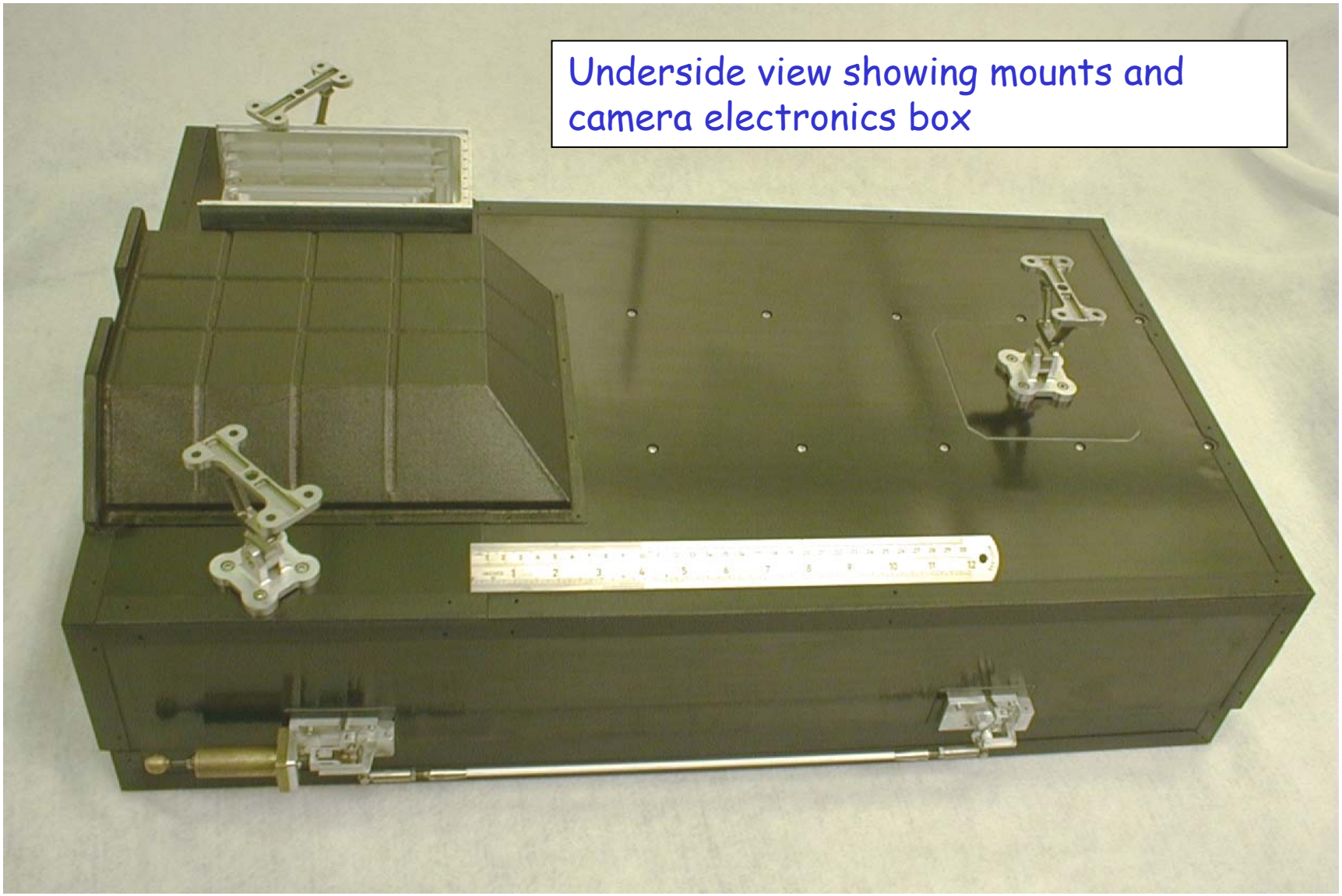
HI FM Schedule:

- FM manufacture Jan-Nov 2003
- AIV from Dec 2003
- HI deliveries May & June 2004

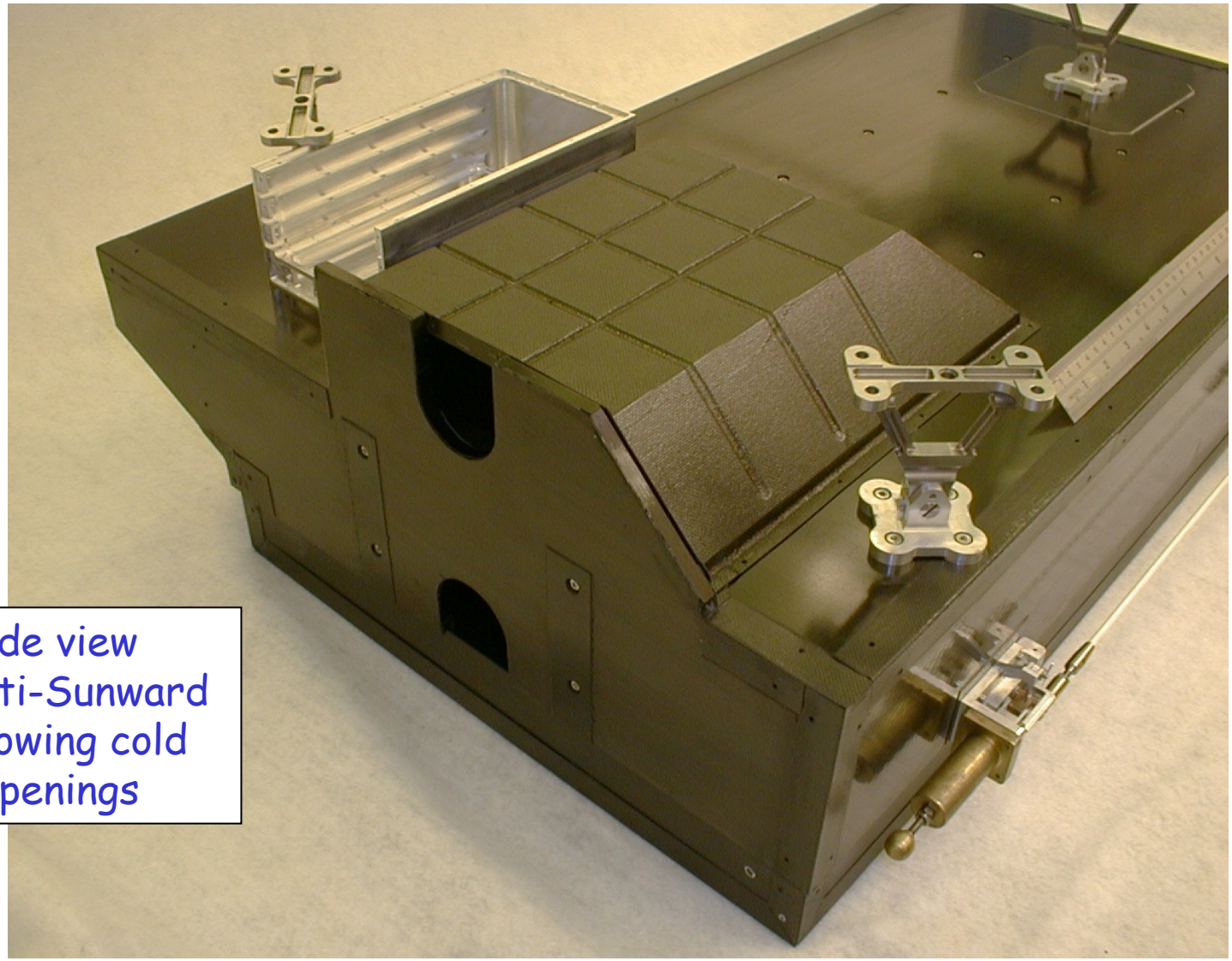
EQM - Structure



EQM - Structure



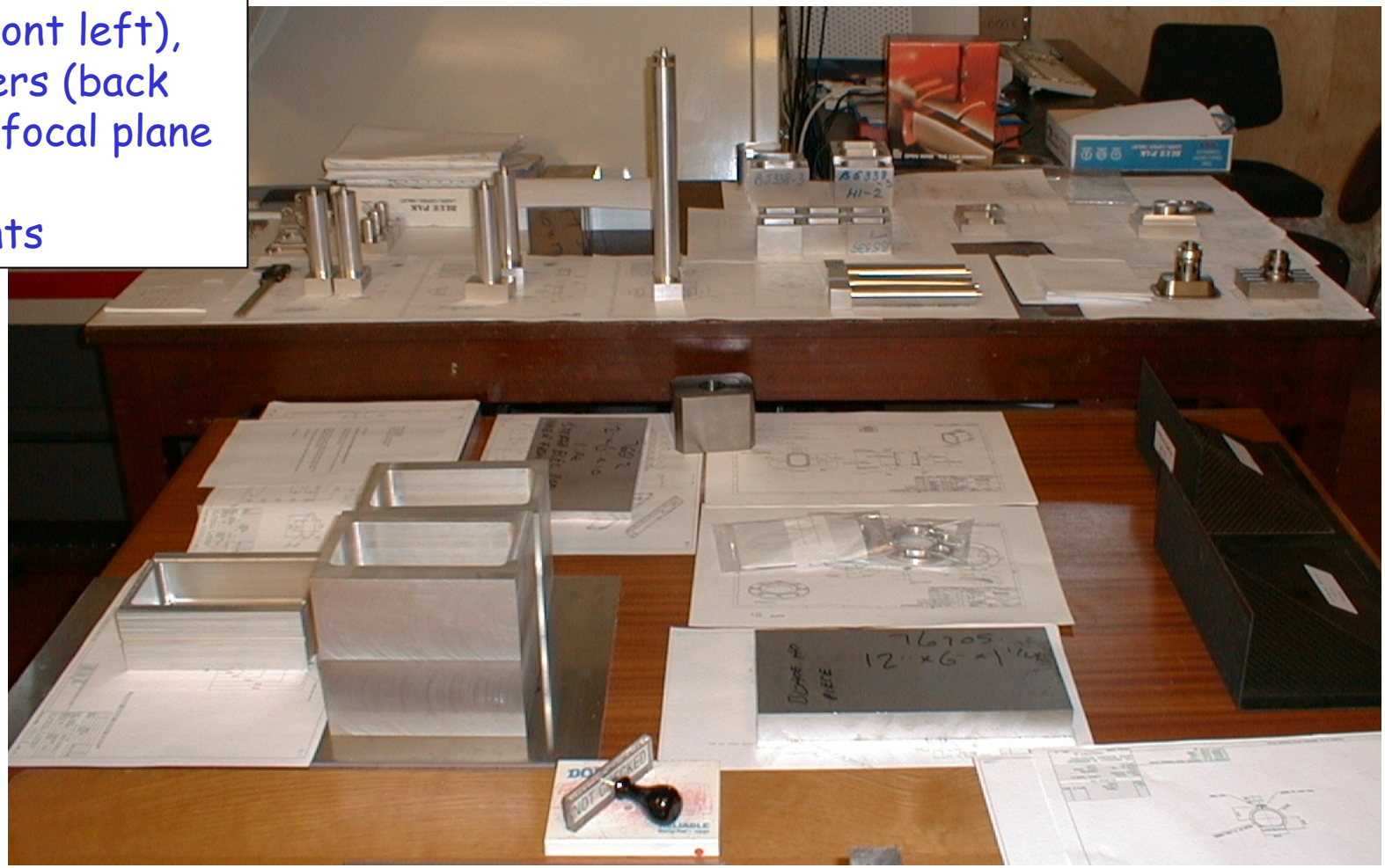
EQM - Structure



Underside view from anti-Sunward side, showing cold finger openings

EQM/FM - Manufactured Parts

Manufactured parts, including electronics boxes (front left), cold fingers (back left) and focal plane assembly components



EQM/FM - Manufactured Parts

Manufactured components of the HI mount assemblies

Saturation & Blooming

- The HI CCD pixels saturate at 250,000 photons which, at a DQE of 80% means 200,000 electrons.

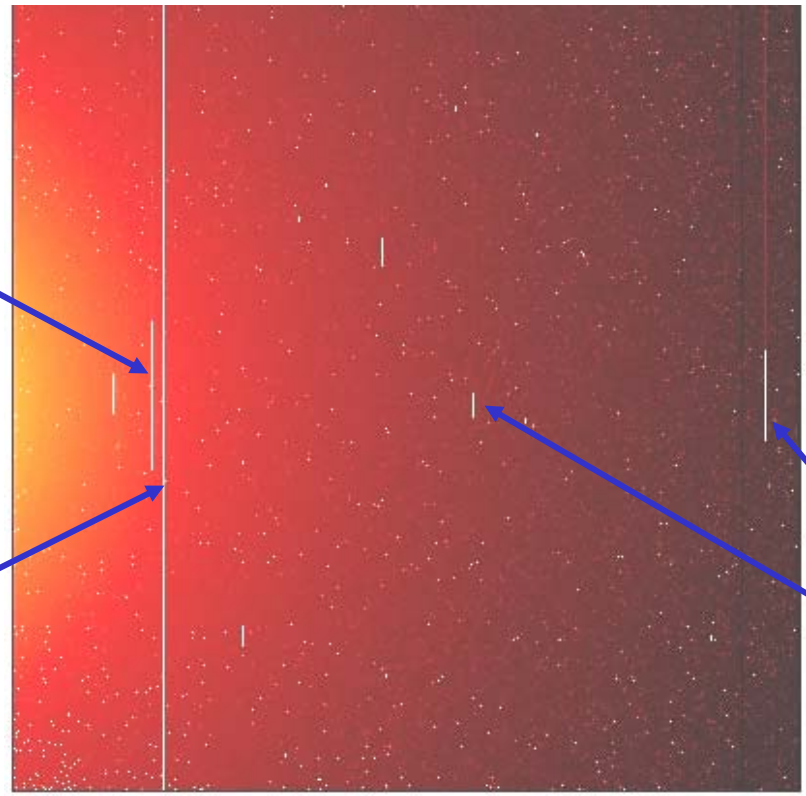
- Most stars & planets do not saturate. Anything brighter than Mag 5 will saturate. Calculated saturation factors for nominal HI-1 and HI-2 exposures (12 s & 60 s) are tabulated (from 'Image Simulations for the HI', R.A. Harrison, 20 January 2003):

Object	*HI-1 (12 s)*		*HI-2 (60 s)*	
Venus (-4.6)	**5280**		**29758**	
Jupiter (-2.6)	**854**		**4800**	
Mercury (-1.8)	**402**		**2268**	
Mars (-1.6)	**341**		**1925**	
Sirius (-1.47)	**300**	**[<1]**	**1697**	**[<1]**
Mag. 0	**77**	**[1]**	**434**	**[1]**
Mag. 1	**31**	**[1]**	**174**	**[1]**
Mag. 2	**15**	**[1]**	**87**	**[4]**
Mag. 3	**4**	**[1]**	**25**	**[14]**
Mag. 4	**2**	**[4]**	**13**	**[48]**

[* Number of such sources in FOV given in brackets]

Saturation & Blooming

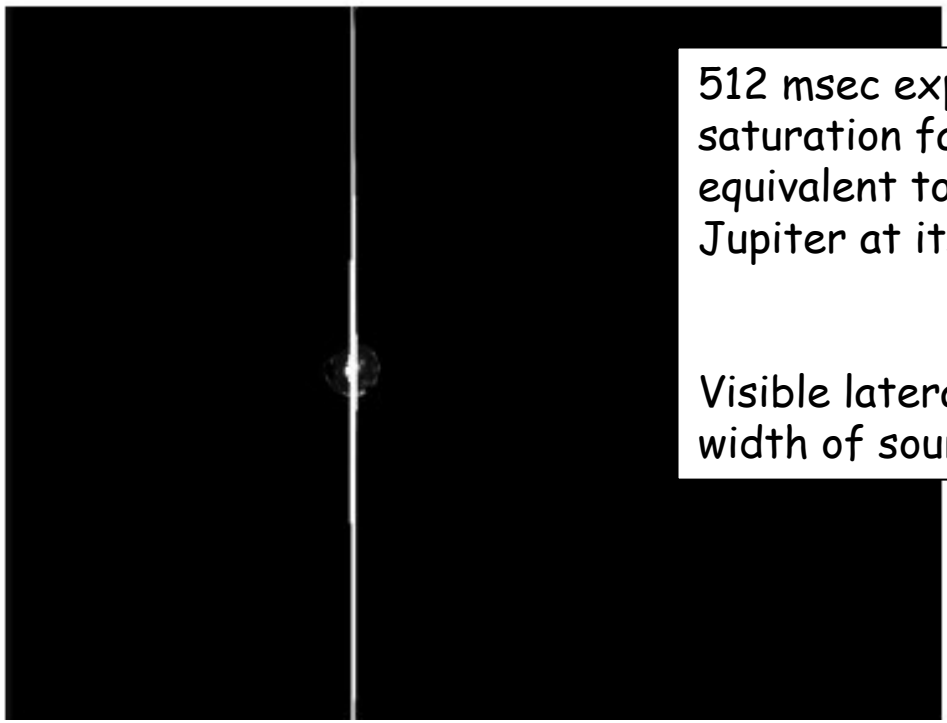
- We anticipate saturation factors of up to 30,000 and must be sure that these do not swamp the detectors.
- Blooming up and down columns is OK - we expect the loss of a small number of columns - but do not want excessive cross-column blooming, resulting in the loss of large areas of the image.



HI-2 Modelled Image showing the expected saturation from 4 planets and some brighter stars - <u>assuming no cross-column blooming.</u>

Saturation & Blooming

- Detector tests at NRL have investigated CCD saturation/blooming to saturation factors of 150,000 (Report by R. Kroeger, 24 March 2003).
- Blue LED placed in focal plane - 10 column wide (130 micron) point-like illumination.
- Conclusion: Blooming is confined to 'local' columns for all stellar and planetary intensities anticipated.

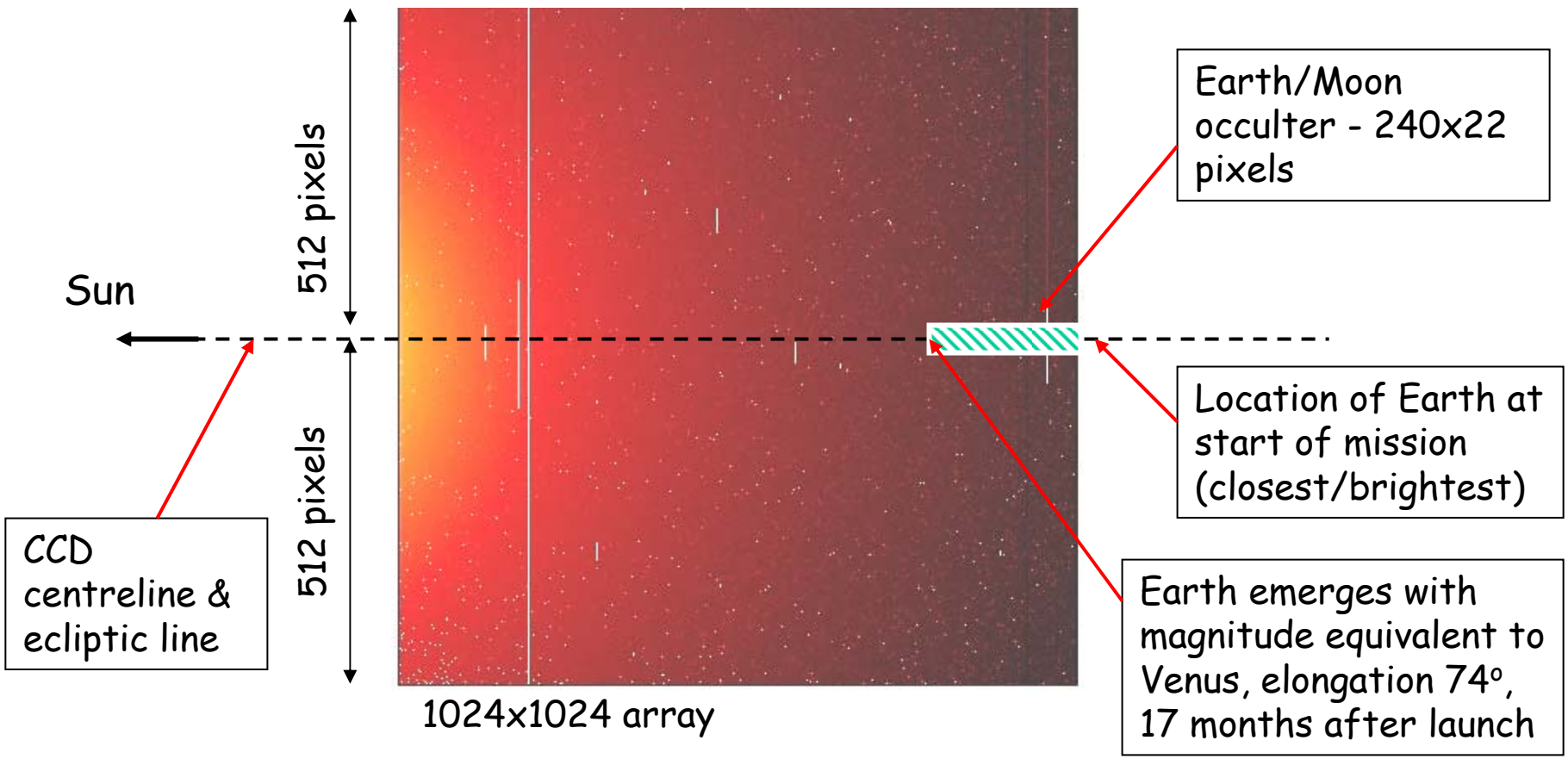


512 msec exposure producing saturation factor of 764 - equivalent to a source near Jupiter at its brightest in HI-1.

Visible lateral spread is due to width of source.

Earth Occulter

- One exception! The Earth/Moon system near mission start will produce a saturation factor of 1,250,000. Thus, we will occult the Earth for the first phase of the mission.



HI – Image Simulation

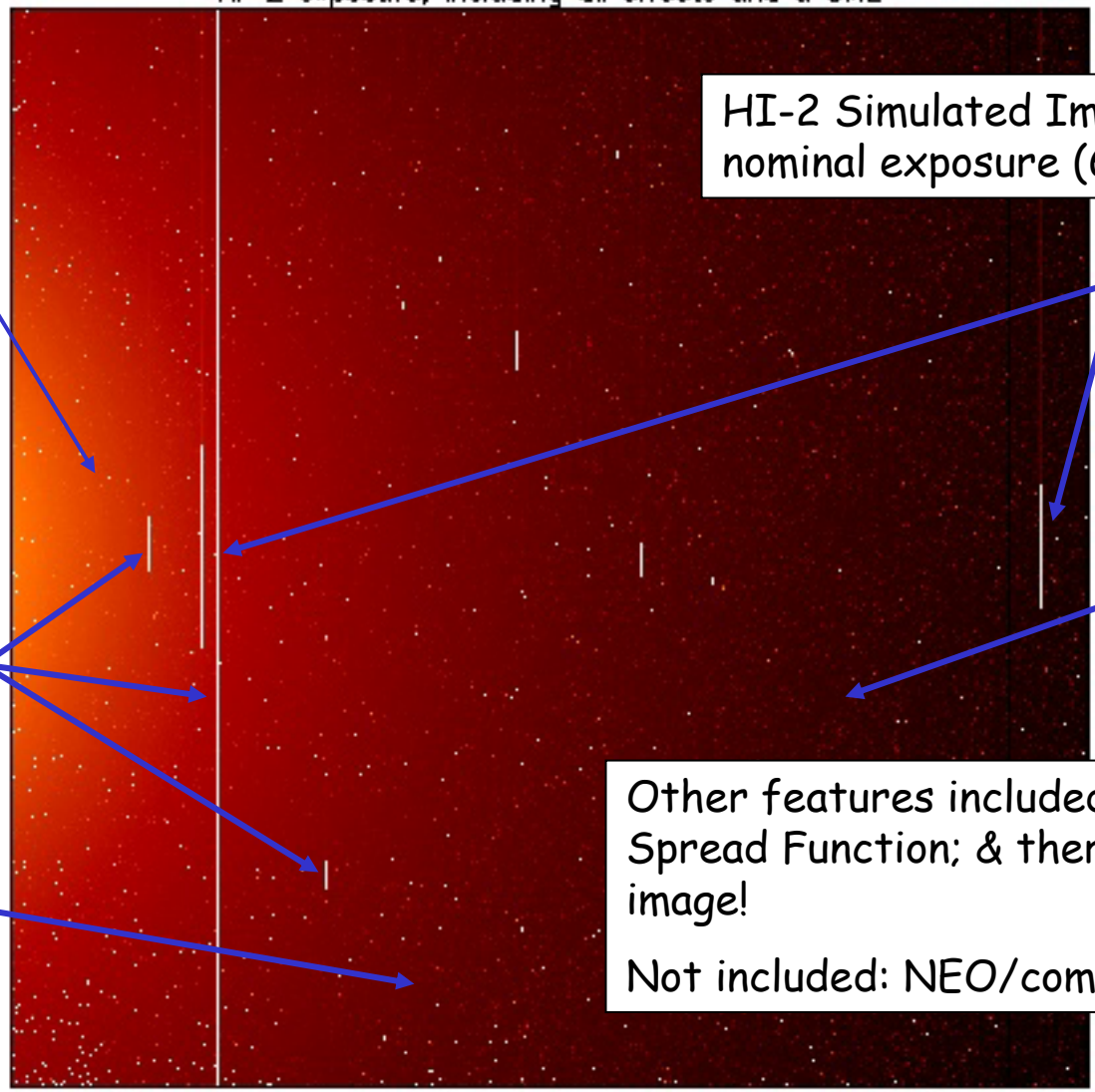
What will the HI images look like? HI image simulation activity started in Autumn 2002. See 'Image Simulations for the Heliospheric Imager', R.A. Harrison, 20 Jan 2003, and http://www.stereo.rl.ac.uk.

Purpose:

- To assess the impact of all sources and effects, including saturation, non-shutter operation etc…
- To investigate image processing requirements for, e.g. cosmic ray correction, F-corona & stellar subtraction techniques, and other techniques for the extraction of CME and other science data.
- To provide a tool to explore operations scenarios with the user community.

In addition to demonstrating that HI works, and exploring the ways we can use it, these efforts are providing requirements to the on-board and ground software efforts, to operations planning etc...

HI - Image Simulation



F-corona & scattered light

HI-2 Simulated Image - nominal exposure (60 s)

Planets

Stellar 'background' down to 13th mag.

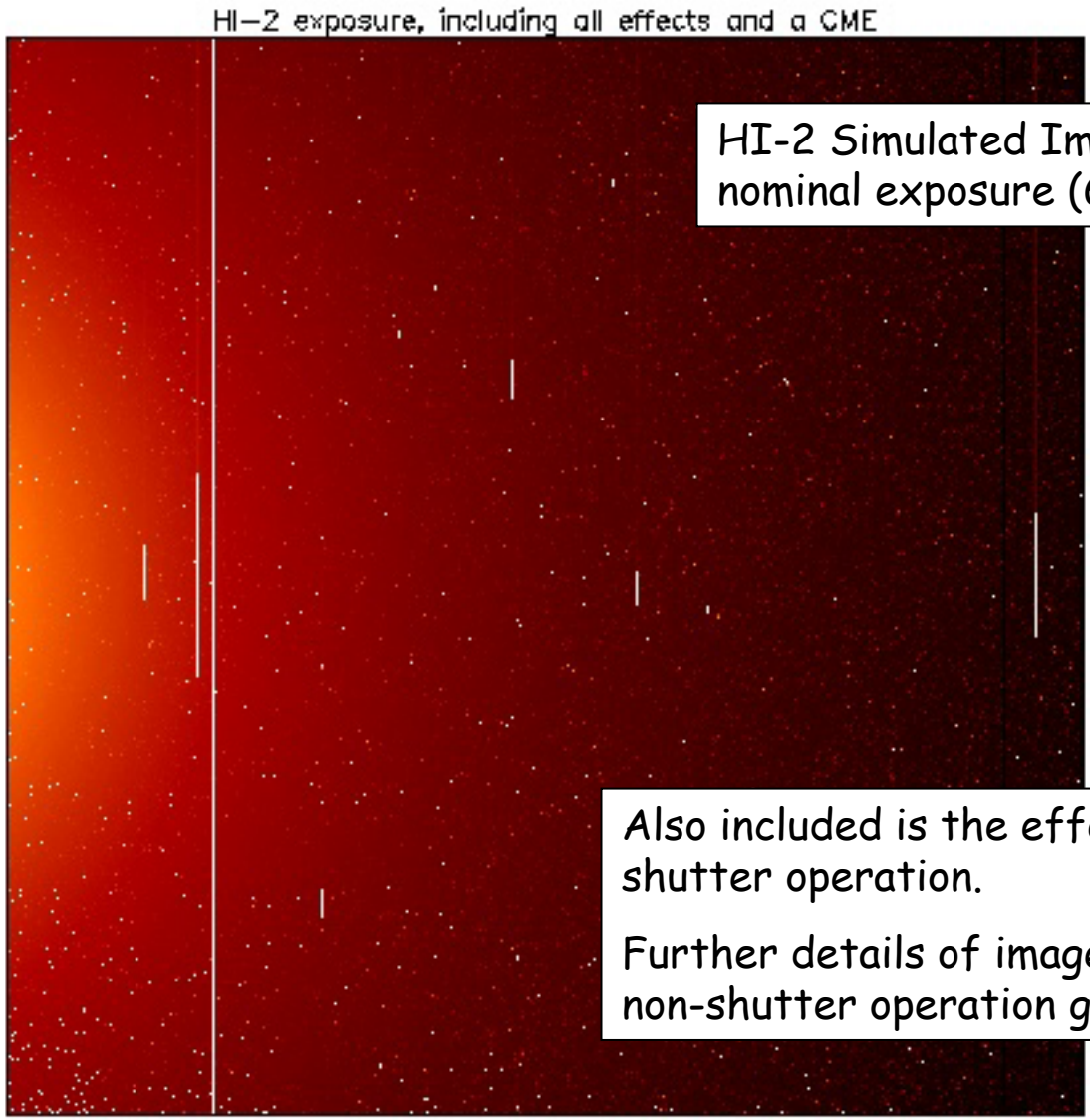
Saturation of brightest planets & stars

Cosmic rays

Other features included: HI Point Spread Function; & there is a CME in the image!

Not included: NEO/comets, Earth/Moon

HI - Image Simulation



HI-2 Simulated Image - nominal exposure (60 s)

Also included is the effect of the non-shutter operation.

Further details of image simulation and non-shutter operation given in later talk.

HI - Operations Preparation

Operations Preparation Activities:

- 'HI Operations Document' (at http://www.stereo.rl.ac.uk), R.A. Harrison, Version 3, 7 February 2003. Outlines plans for operation and exploitation of HI.
- UK STEREO Science Team - set up to consider observation schemes, for SECCHI - i.e. schemes to address specific scientific questions. Original set included in Operations Document. See talk by Sarah Matthews.
- UK STEREO Web site set up at http://www.stereo.rl.ac.uk - includes open access to Operations Document and Image Simulation reports as well as observing scheme discussion.
- Requirements on software (on board and ground), on planning and operation of SECCHI, have been identified from the above and forwarded to NRL. (e.g. 11 requirements on on-board software, 18 requirements on ground software and 3 other recommendations, came out of the Operations Document alone).

HI – Operations Preparation

Operations Preparation - Involving the solar community & generating public interest:

- UK Solar-B/STEREO science meeting March 2003 at MSSL - used to advertise HI/SECCHI to UK solar community with open discussion on use of SECCHI. Up to 5 new observing schemes suggested and being written up for the next version of the HI Operations Document. These include the benefits of combining HI and IPS observations, observations of comets in 3D etc...

- Royal Astronomical Society meeting, London, March 14, used to 'announce' STEREO to a wider solar and STP community - included RAS Press Release on UK involvement in STEREO and Solar-B (resulting in 5 interviews - with a substantial article in The Times, reports in the Guardian, the Daily Mail, an interview on British Satellite News TV and London's 'Divercity' radio station).