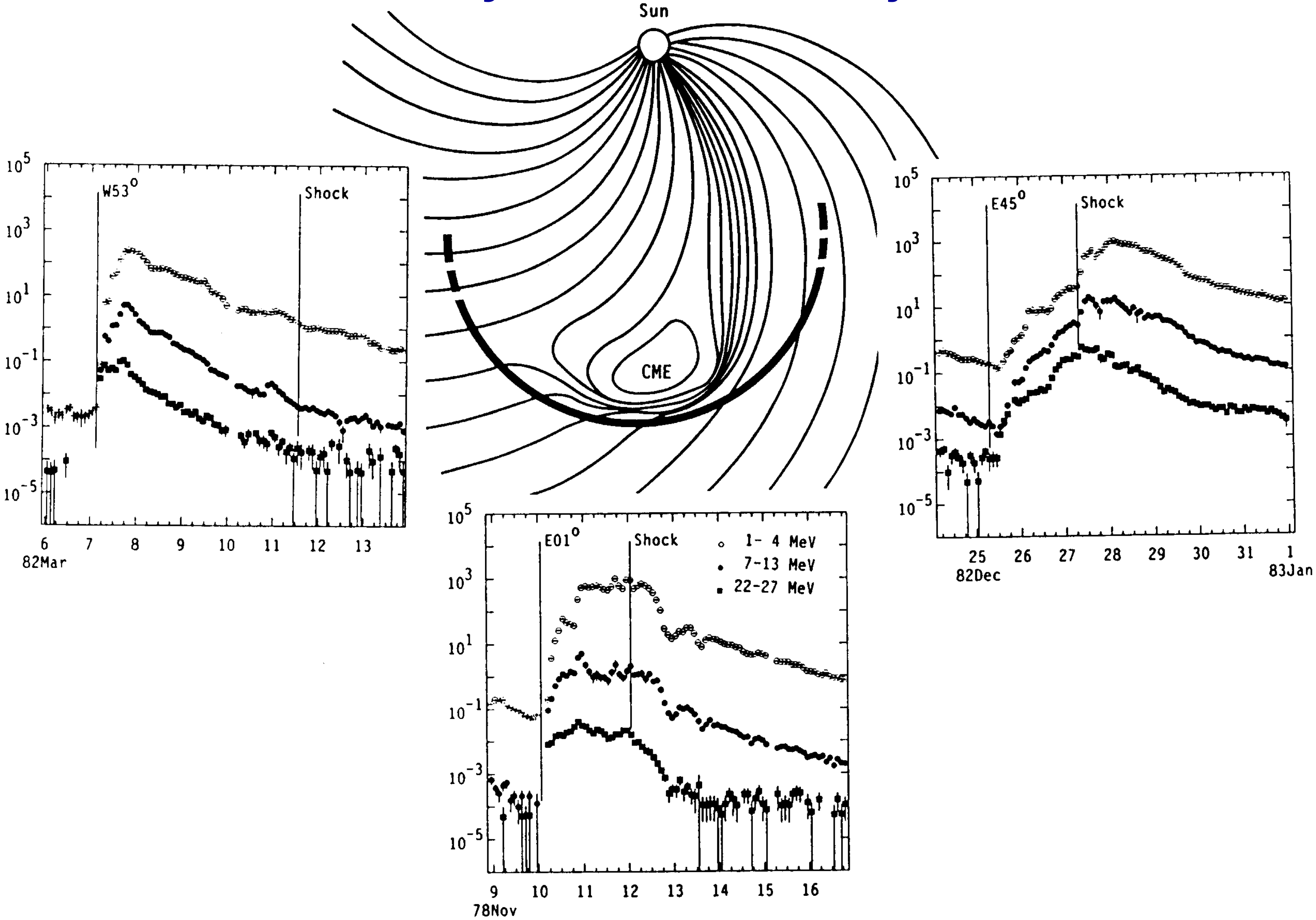
STEREO IMPACT/SEP OVERVIEW

Tycho von Rosenvinge

Solar Energetic Particles/MAG
Peer Review
2001-April-19, NASA/GSFC

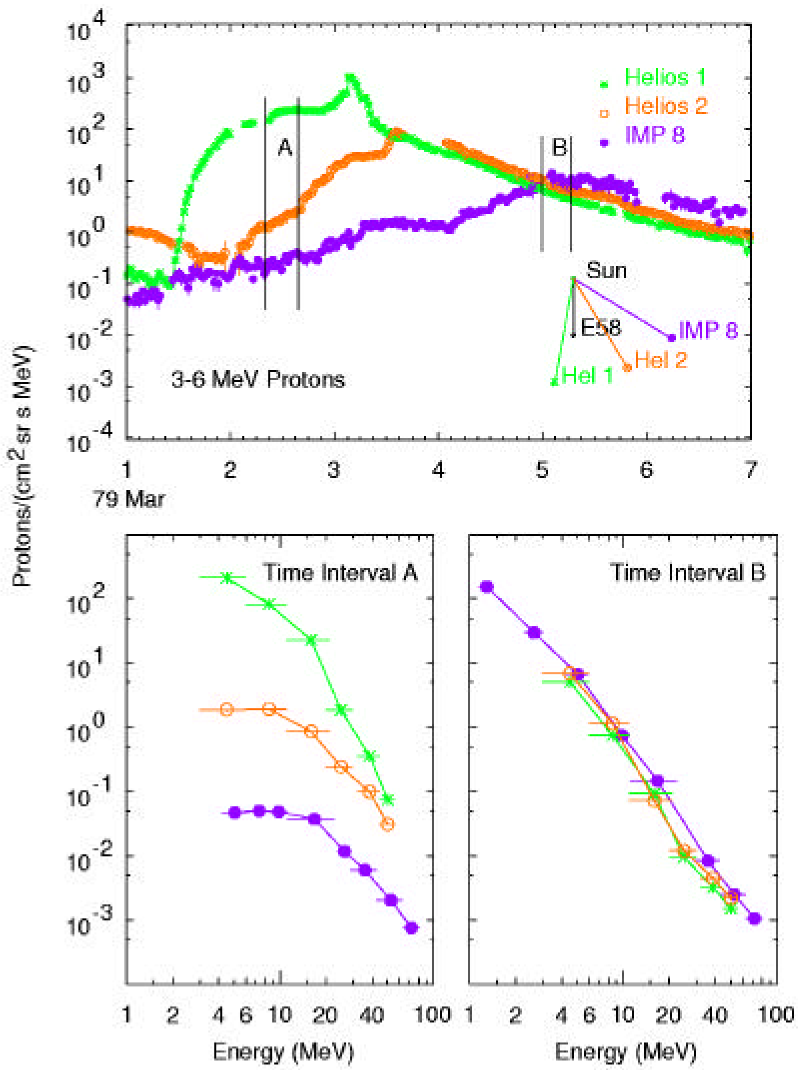
STEREO IMPACT

Science Goals: Acceleration and Transport of Energetic Particles by Coronal Mass Ejections



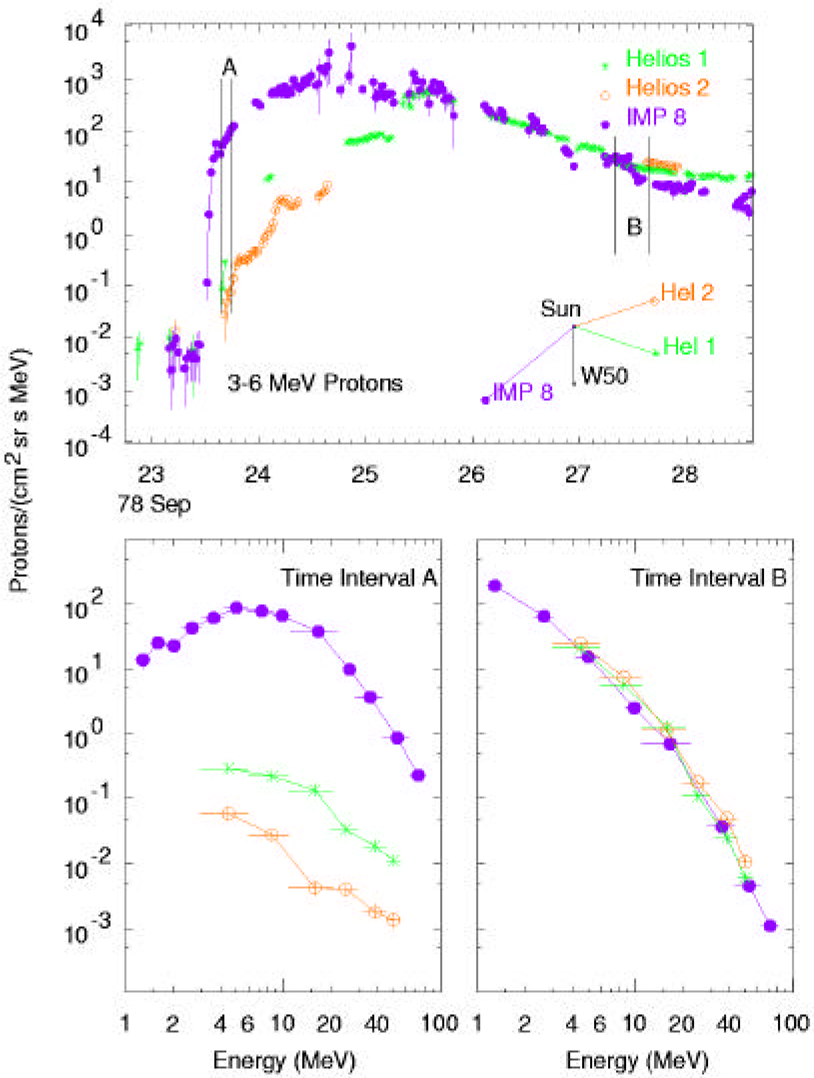
STEREO IMPACT

Reames, Kahler, & Ng 1997, ApJ 491,414



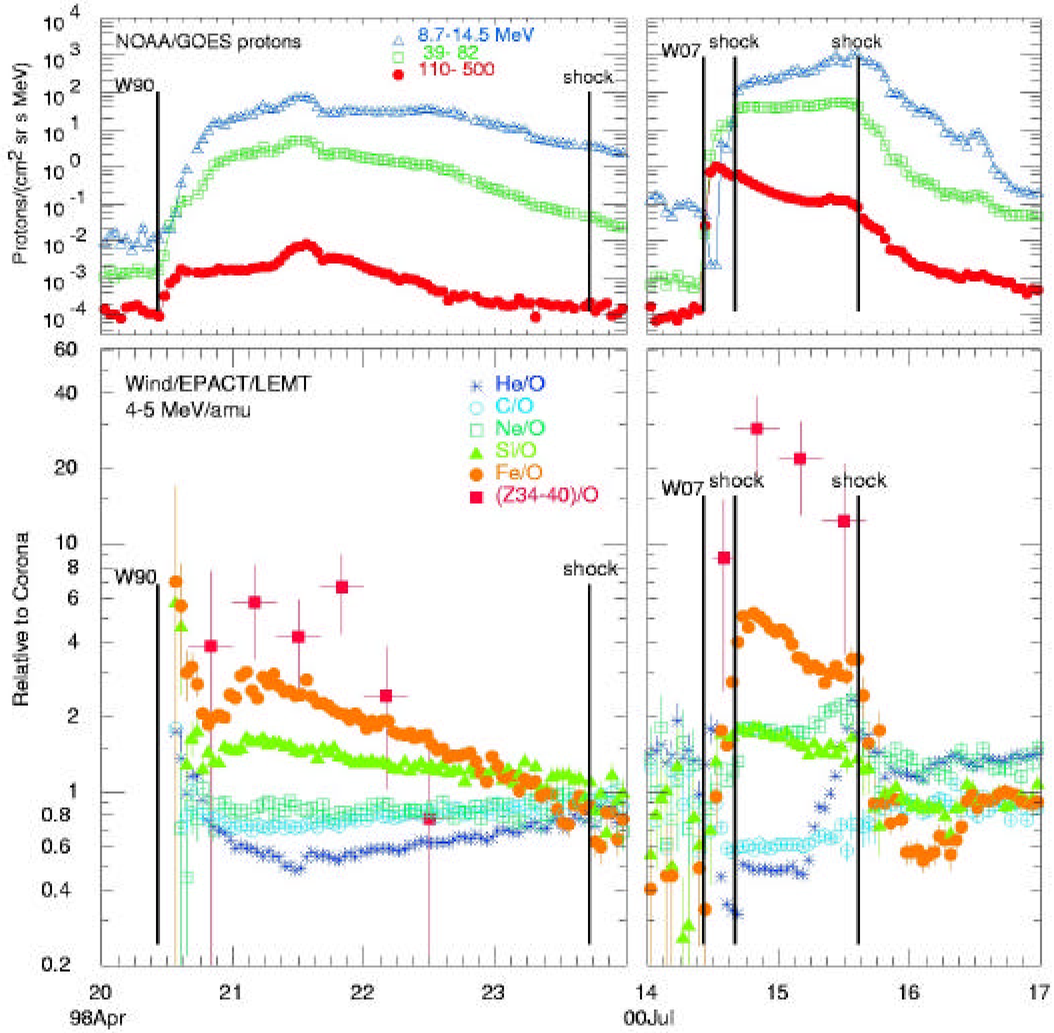
Example of simultaneous SEP observations at different solar longitudes. Note the substantial differences in intensity profiles even though the spacecraft are not widely separated in longitude.

Reames, Kahler, & Ng, 1997, ApJ 491, 414.

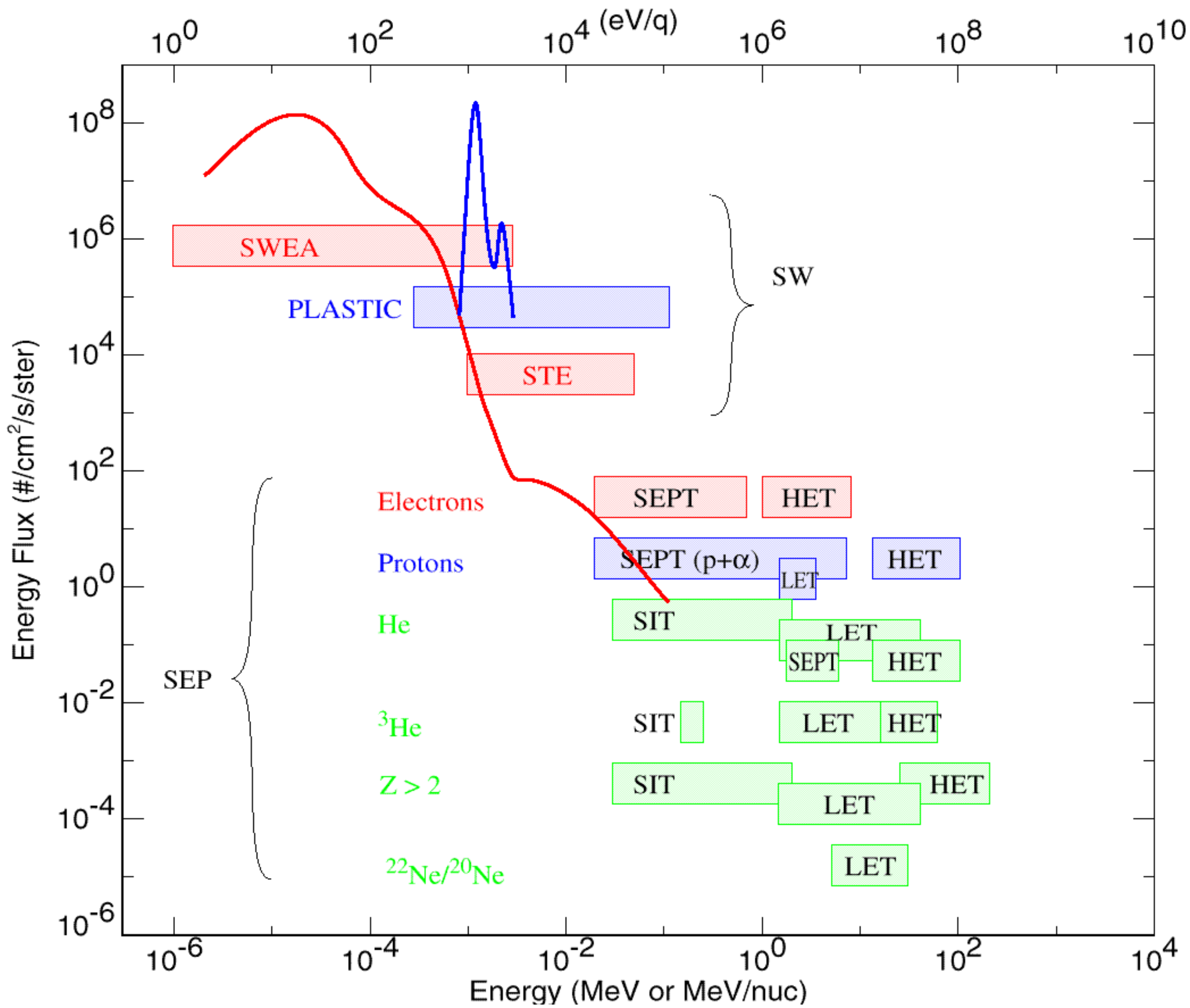


Another example of simultaneous SEP observations at different solar longitudes. Note how similar the intensity profiles are after ~ mid-day of September 25 despite the large differences in solar longitude.

SEP Elemental Abundances During Two Different Events



IMPACT / PLASTIC Energy Coverage



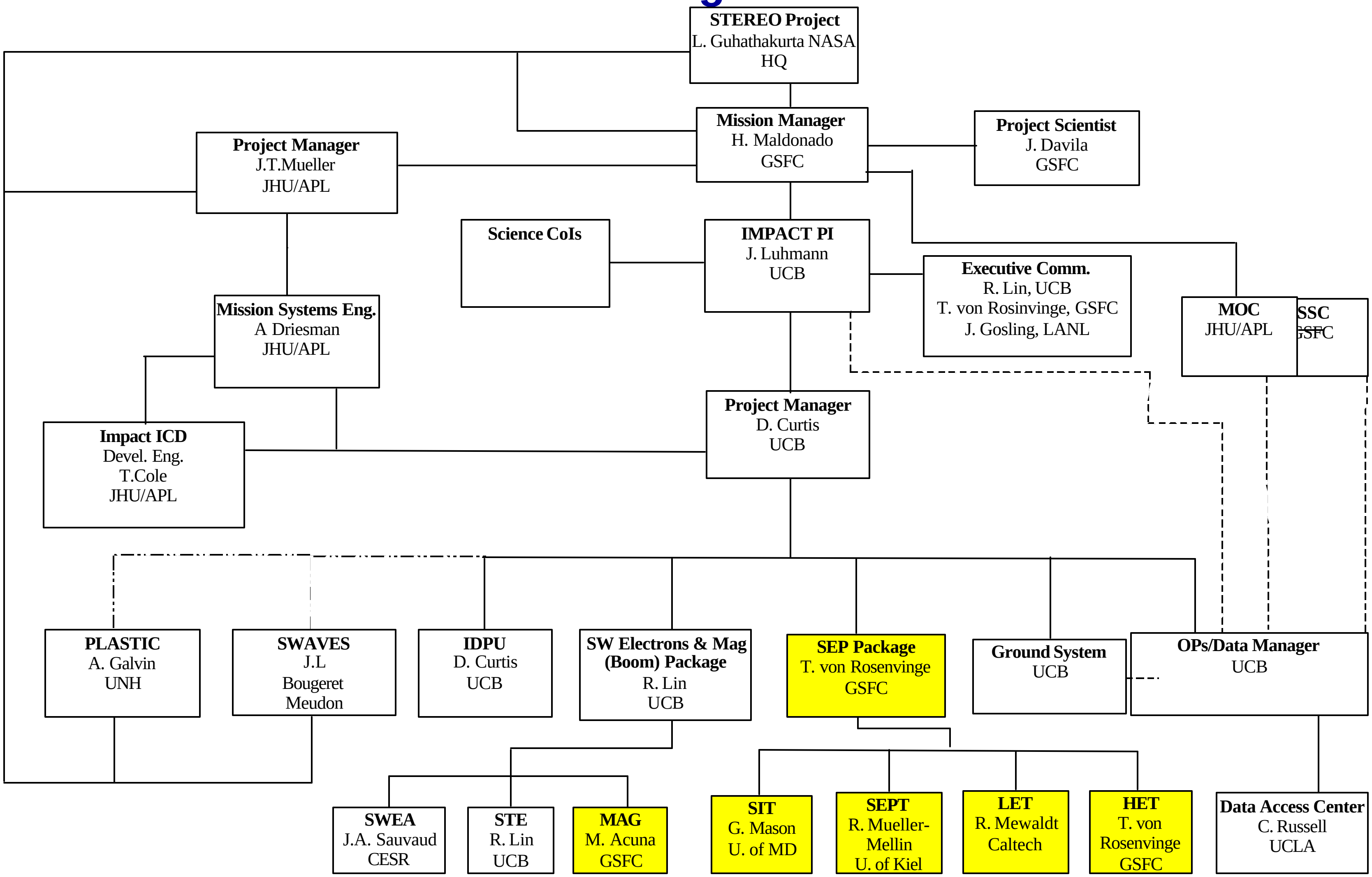
IMPACT Science Summary

Table A.1 IMPACT Summary

Experiment	Instrument	Measurement	Energy or Mag. field range	Mass (kg)	Power (w)	Data Rate (bps)	Time Res.	Instrument provider
SW	STE	Electron flux and anistropy	2-100 keV	0.35	0.20	64	16 s	UCB (Lin)
	SWEA	3D electron distrib., core & halo density, temp. & anisotropy	~0-3 keV	1.71	1.10	394	3D=1 min 2D=8s Mom.=2s	CESR (Sauvaud) + UCB (Lin)
MAG	MAG	Vector field	±500nT, ±65536 nT	0.25	0.0	154	1/8 s	GSFC (Acuna)
SEP	SIT	He to Fe ions	0.03-2 MeV/nuc	0.93	0.66	240	30 s	U. of Md. (Mason) + MPAE (Korth) +UCB (Curtis)
		^{3}He	0.15-0.25 MeV/nuc				30 s	
	SEPT	Diff. electron flux	20-400 keV	1.06	1.04	120	1 min	U. of Kiel (Mueller-Mellin) + ESTEC (Sanderson)
		Diff. proton flux	20-7000 keV				1 min	
		Anistropies of e,p	As above				15 min	
	LET	Ion mass 2-28 & anisotropy	1.5-40 MeV/nuc	0.51	0.18	320	1-15 min.	GSFC (von Rosenvinge) + Caltech (Mewaldt) + JPL (Wiedenbeck)
		^{3}He ions flux & anistropy	1.5-1.6 MeV/nuc				15 min.	
		H ions flux & anistropy	1.5-3.5 MeV				1-15 min.	
	HET	Electrons flux & anistropy	1-8 MeV	0.70	0.07	120	1-15 min.	Caltech (Mewaldt) + GSFC (von Rosenvinge) + JPL (Wiedenbeck)
		H	13-100 MeV				1-15 min.	
		He	13-100 MeV				1-15 min.	
		^{3}He	15-60 MeV/nuc				15 min	
	SEP Common	----	----	1.69	1.55	----	----	Caltech (Mewaldt) + GSFC (von Rosenvinge)
IMPACT Common	IDPU (+Mag Analog)	----	----	1.73	3.60	164 +524 Burst	----	UCB (Curtis)

IMPACT is a suite of 7 instruments built at 9 institutions by 31 Co-Investigators.

IMPACT Team Organization Chart



SEP Responsibilities

- University of Kiel
  - Design/fabrication/test of SEPT telescopes
- ESTeC
  - Design/fabrication/test of SEPT Electronics
- U of MD
  - Overall responsibility for design/test of SIT
- Max Planck/Lindau
  - Digital portion of SIT Time-of-Flight system
- Caltech
  - Low Energy Telescope development/test
  - Common SEP electronics, ASIC development, central data processing unit, Low Energy Telescopes
  - Overall integration/test of SEP package
- JPL
  - LET/HET detector procurement; LET development/test
- GSFC
  - HET development/fabrication/detector test/system test
  - LET/HET on-board algorithm development
  - Overall SEP mechanical design and fabrication (e.g. detector, telescope, enclosure, and bracket design)
  - Overall SEP thermal design
  - SIT fabrication/assembly + SIT MISC

SEP Personnel

- Tycho von Rosenvinge, SEP Coordinator/HET Design/SEP Mechanical, GSFC, tycho@lheamail.gsfc.nasa.gov
- Mike Choi, Thermal Engineer, GSFC, mchoi@mscmail.gsfc.nasa.gov
- Rick Cook, SEP Lead Electronics Engineer, Caltech, wrc@srl.caltech.edu
- Alan Cummings, SEP Project Manager at Caltech, Caltech, ace@srl.caltech.edu
- Andrew Davis, On-board Software, Caltech, ad@srl.caltech.edu
- Peter Falkner, SEPT Electronics Engineer, ESTeC, Peter.Falkner@esa.int
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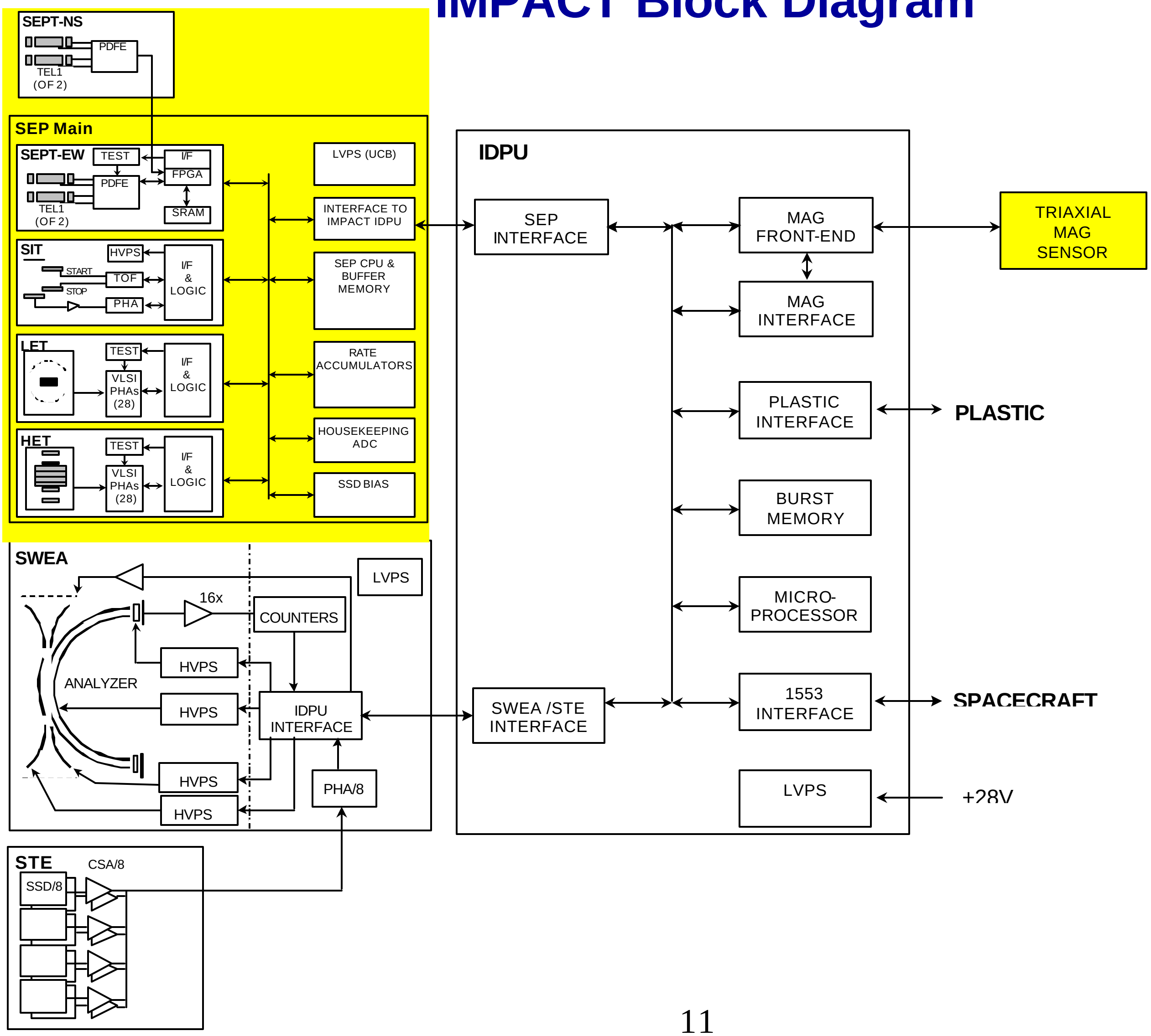
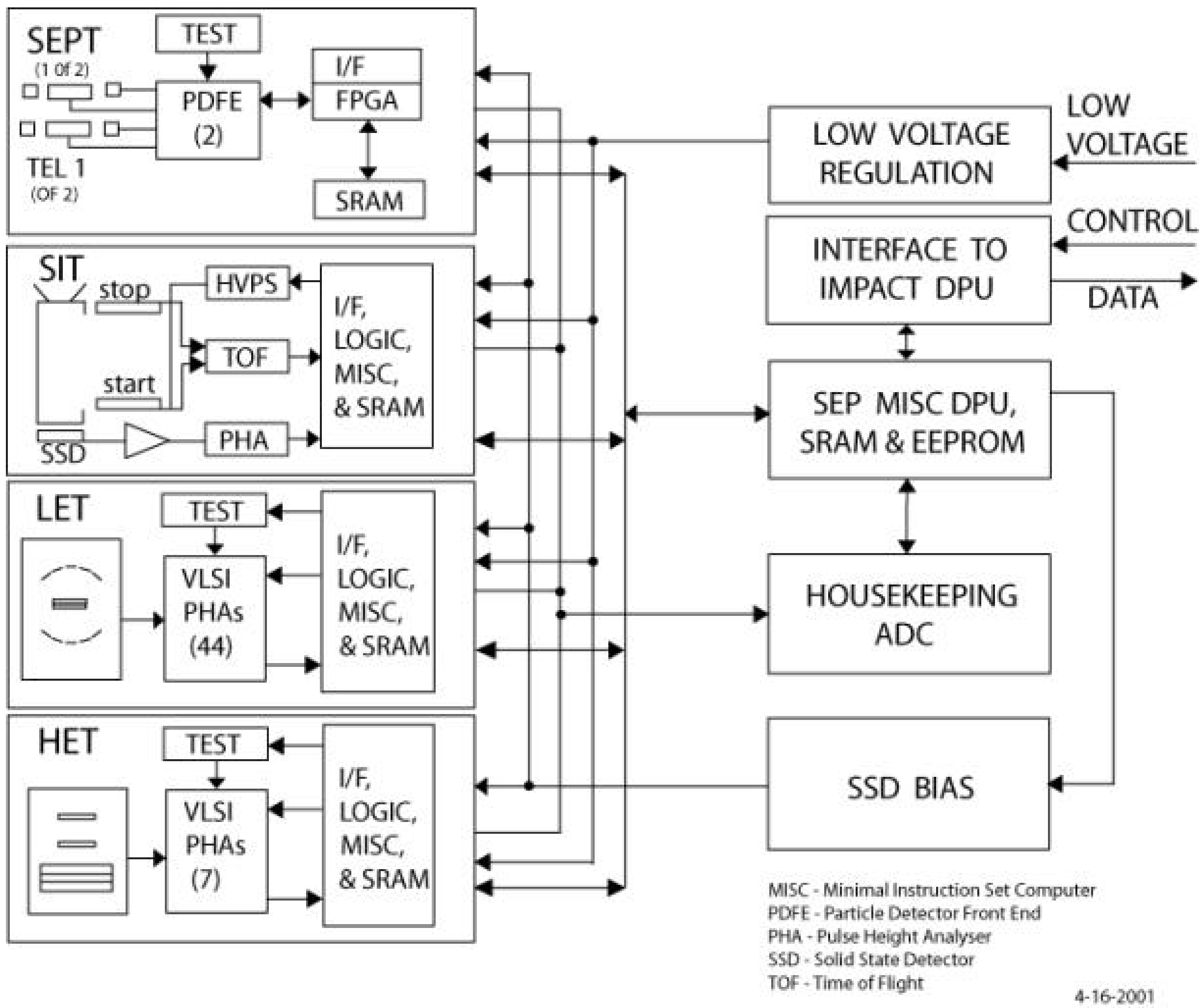
- Glenn Mason, SIT Design, UofMD, mason@sampex3.umd.edu
- Richard Mewaldt, LET Design, Caltech, rmewaldt@srl.caltech.edu
- Reinhold Mueller-Mellin, SEPT Design, UofKiel, mueller-mellin@kernphysik.uni-kiel.de
- Donald Reames, LET&HET On-board Algorithms, GSFC, reames@lheavx.gsfc.nasa.gov
- Sandy Shuman, SEP Mechanical Designer, GSFC, sandy@lheapop.gsfc.nasa.gov
- Trevor Sanderson, SEPT electronics, ESTeC, sanderson@estso3.estec.esa.ne
- Mark Wiedenbeck, LET & HET Detectors, JPL, Mark.E.Wiedenbeck@jpl.nasa.gov
- Peter Walpole, SIT Electronics Engineer, UofMD, walpole@sampex.umd.edu

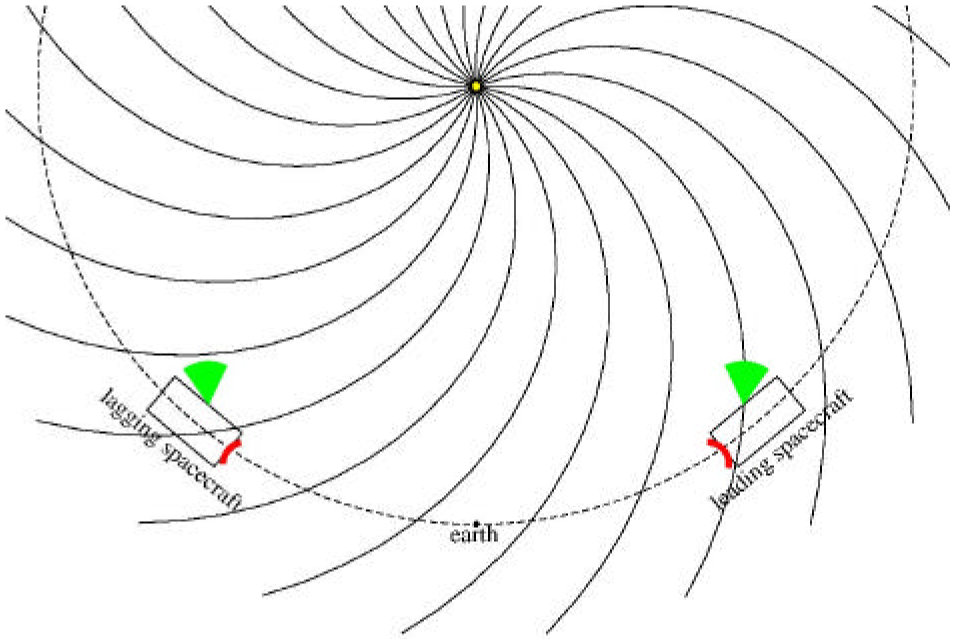
IMPACT Block Diagram



Overall SEP Block Diagram



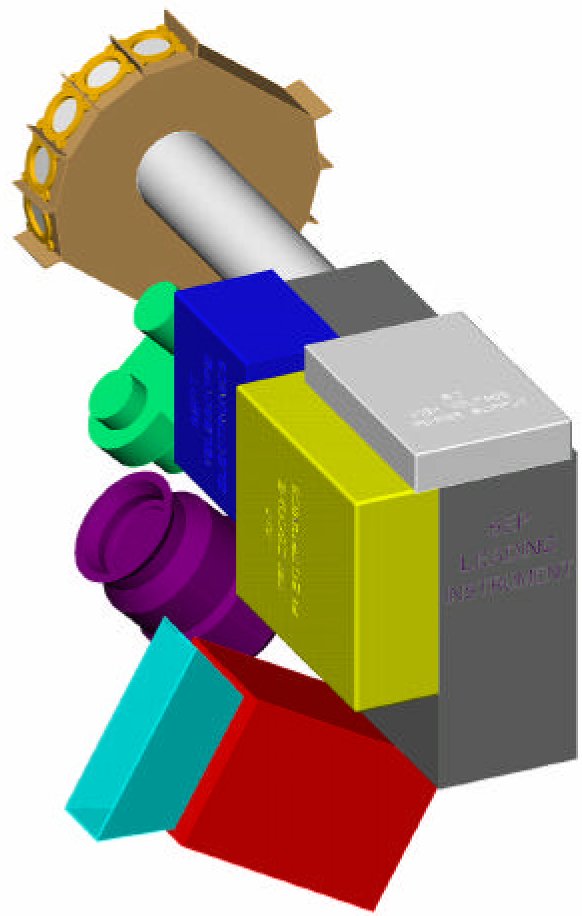
Parker Spiral Viewing



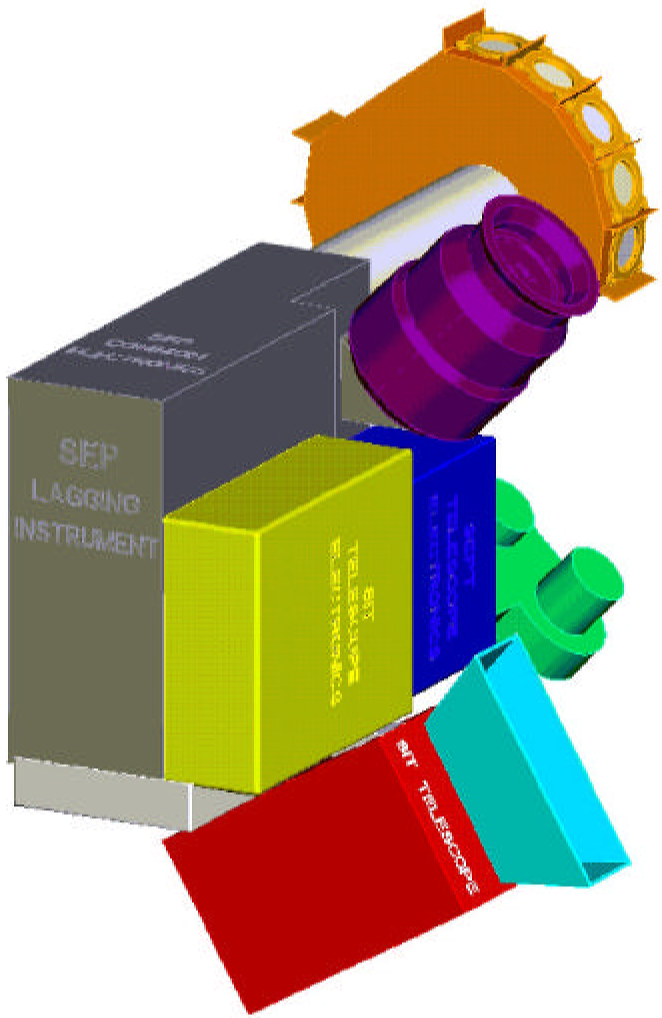
This figure shows magnetic field lines being carried radially out from the sun by the solar wind. These field lines are wrapped into a spiral (known as the Parker Spiral) due to the sun's rotation. Particles coming from the sun travel along the field lines, so the SEP Fields of View (FOVs, shown in green) need to be looking as depicted for the leading spacecraft.

The lagging spacecraft is predominantly a copy of the leading spacecraft rolled 180 degrees about the spacecraft-sun line. This points the dish antenna (shown in red) towards the earth and doesn't disturb the sun-pointing instruments. The figure shows that this 180 degree roll would cause the lagging SEP FOV pointing (incorrectly) perpendicular to the solar magnetic field lines. This means that the mounting of the SEP instruments cannot be the same on the leading and lagging spacecraft.

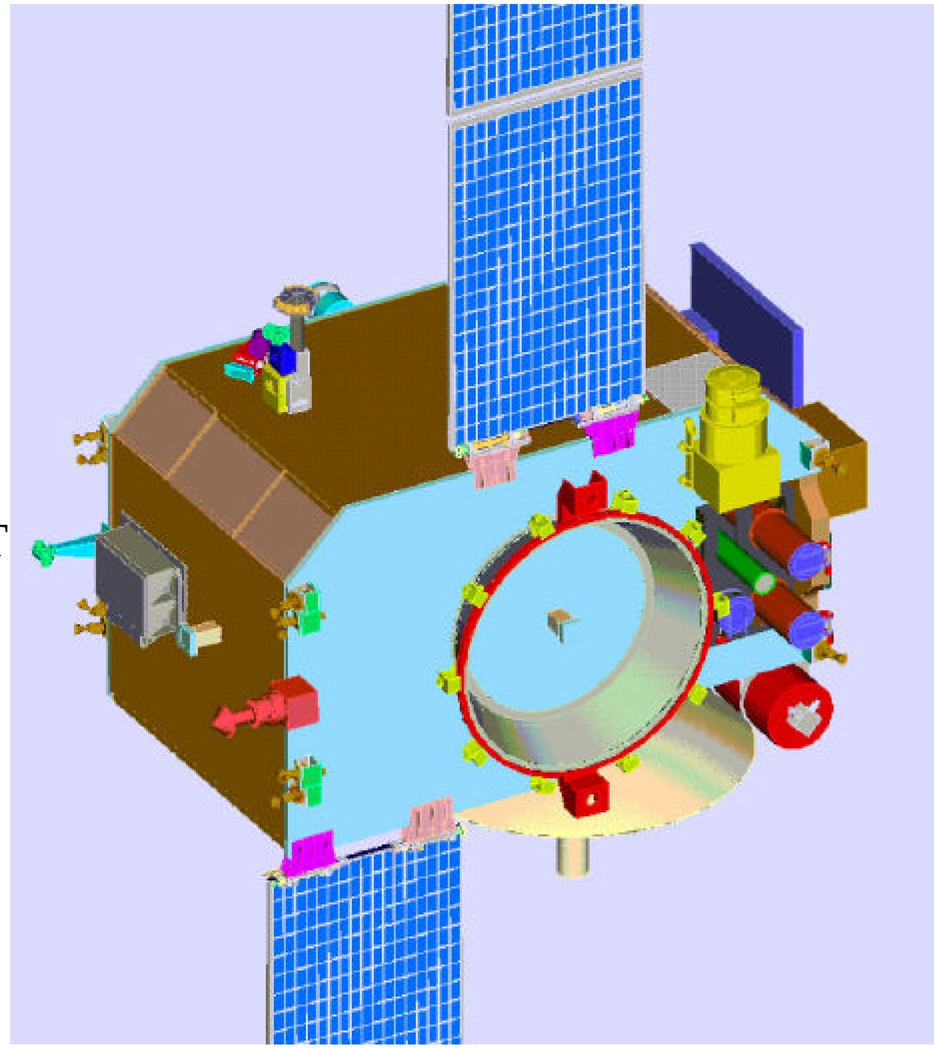
Leading SEP Configuration



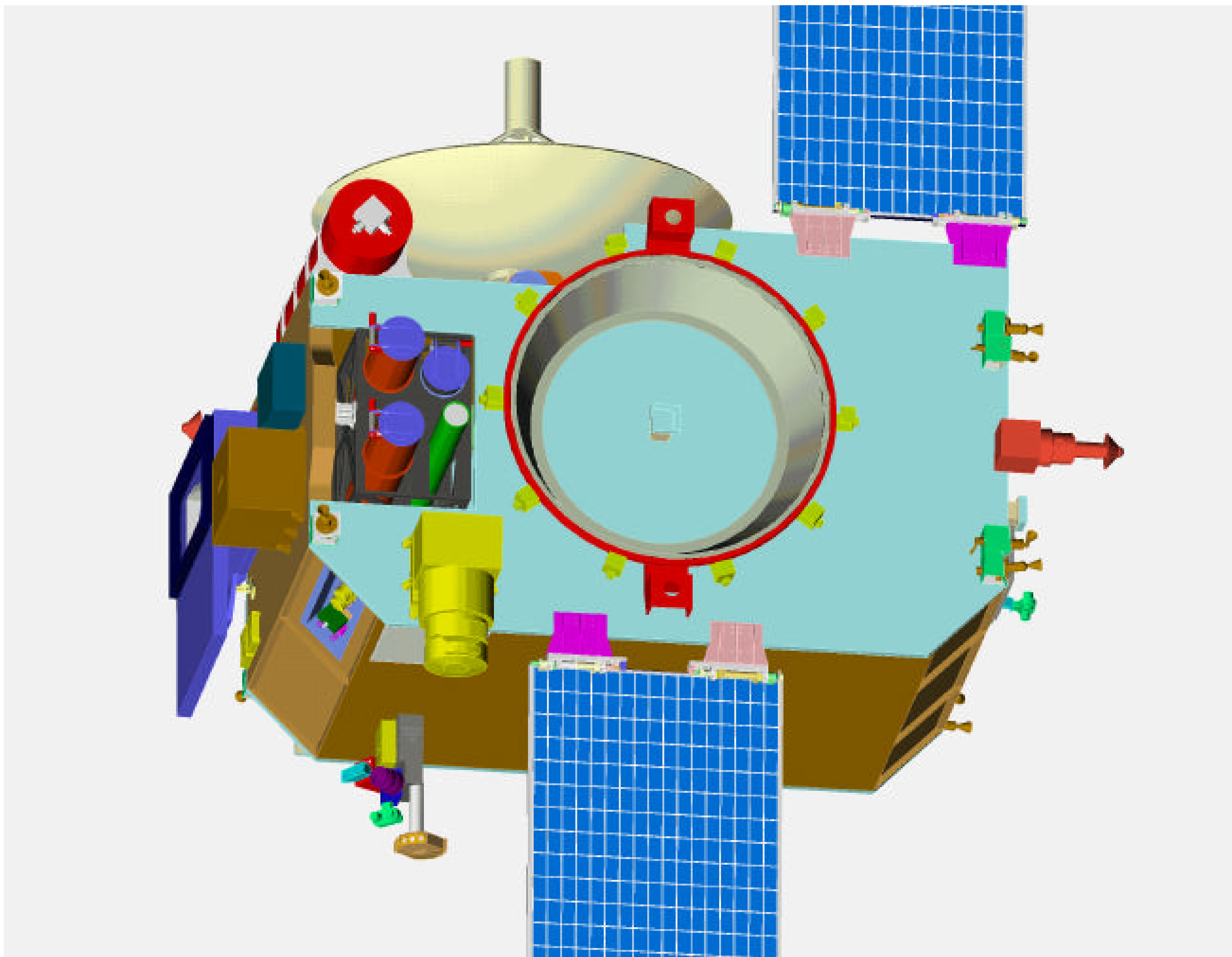
Lagging SEP Configuration



Main SEP Package Location on the Leading Spacecraft



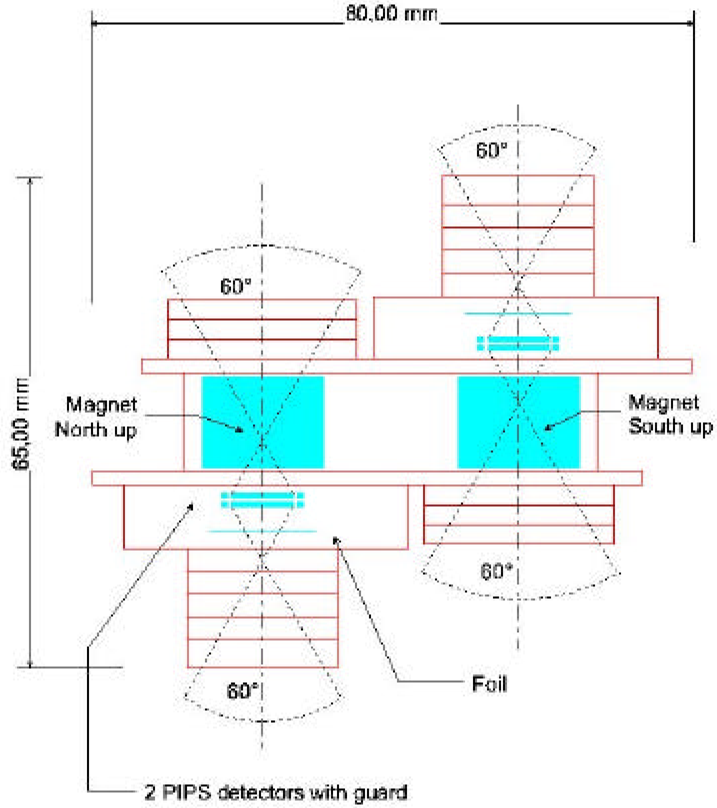
Main SEP Package Located on the Lagging Spacecraft



Solar Electron Proton Telescopes (SEPT)

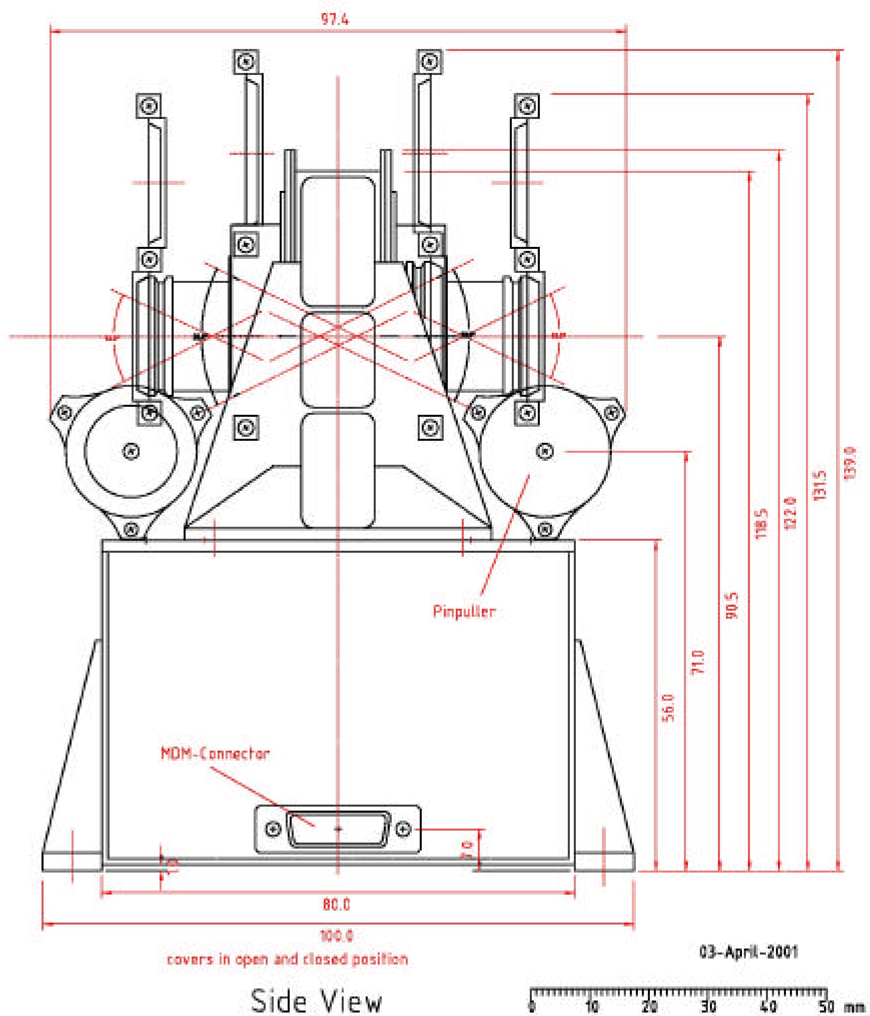
University of Kiel
ESTeC

SEPT Telescope Schematic

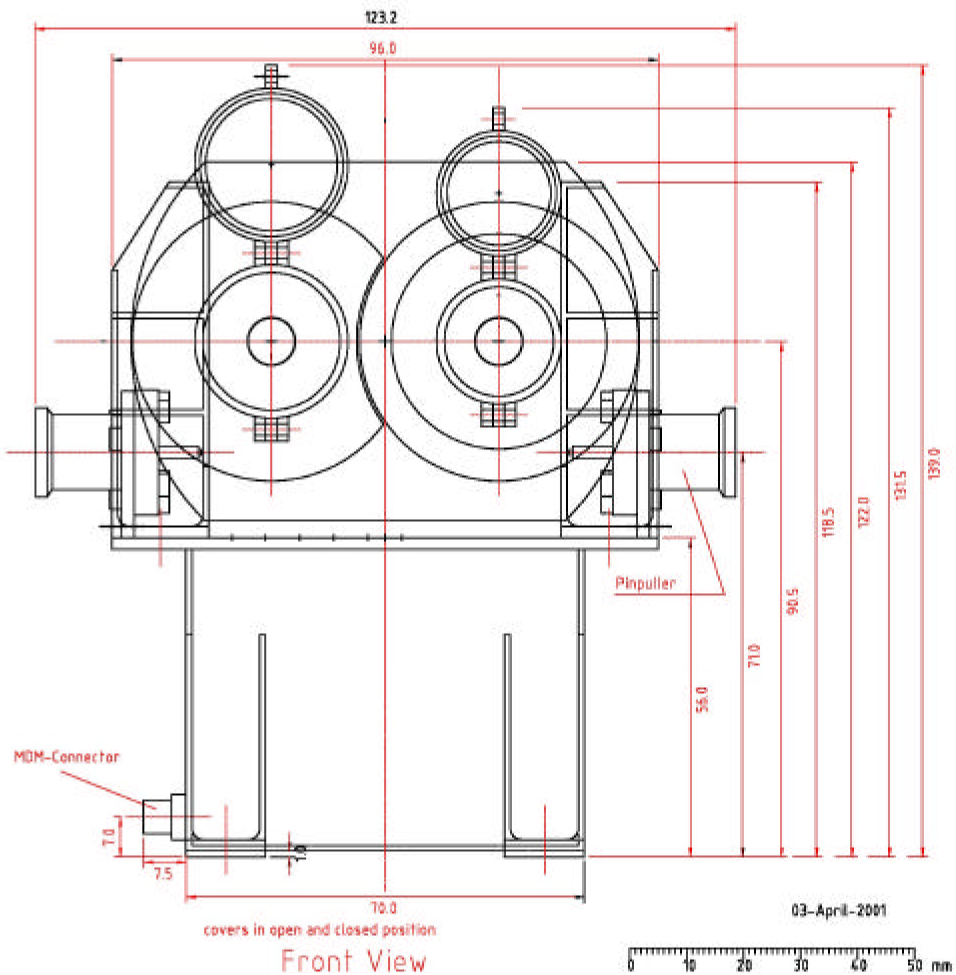


Solar Electron Proton Telescope (SEPT)
Sensor Schematics (1 of 2)
Boresight: SEPT-E in-ecliptic, SEPT-NS north-south

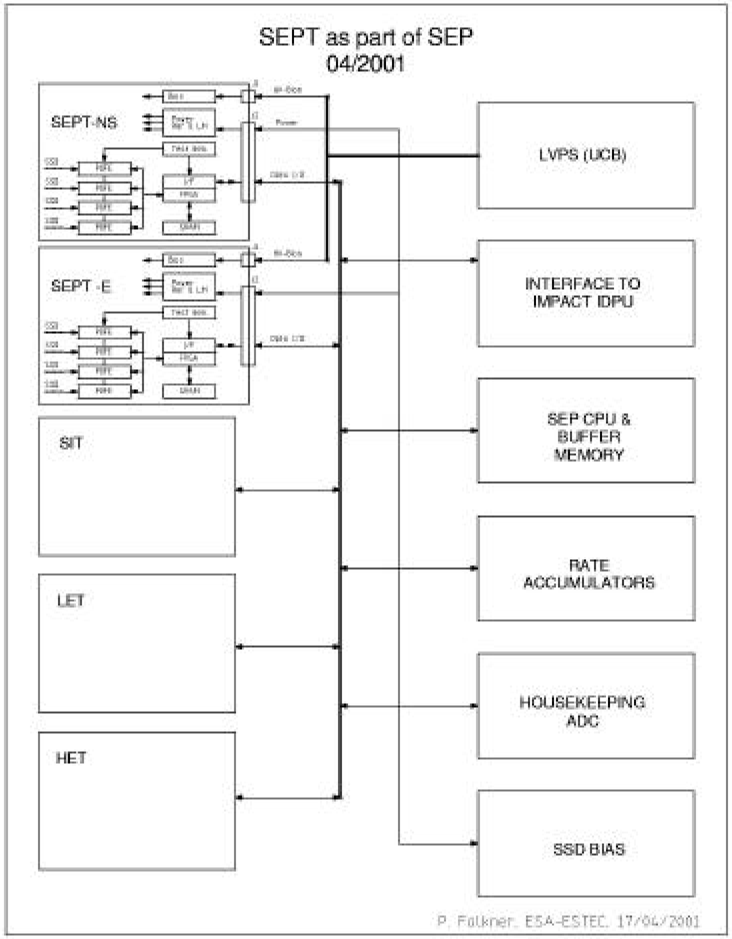
SEPT Side View



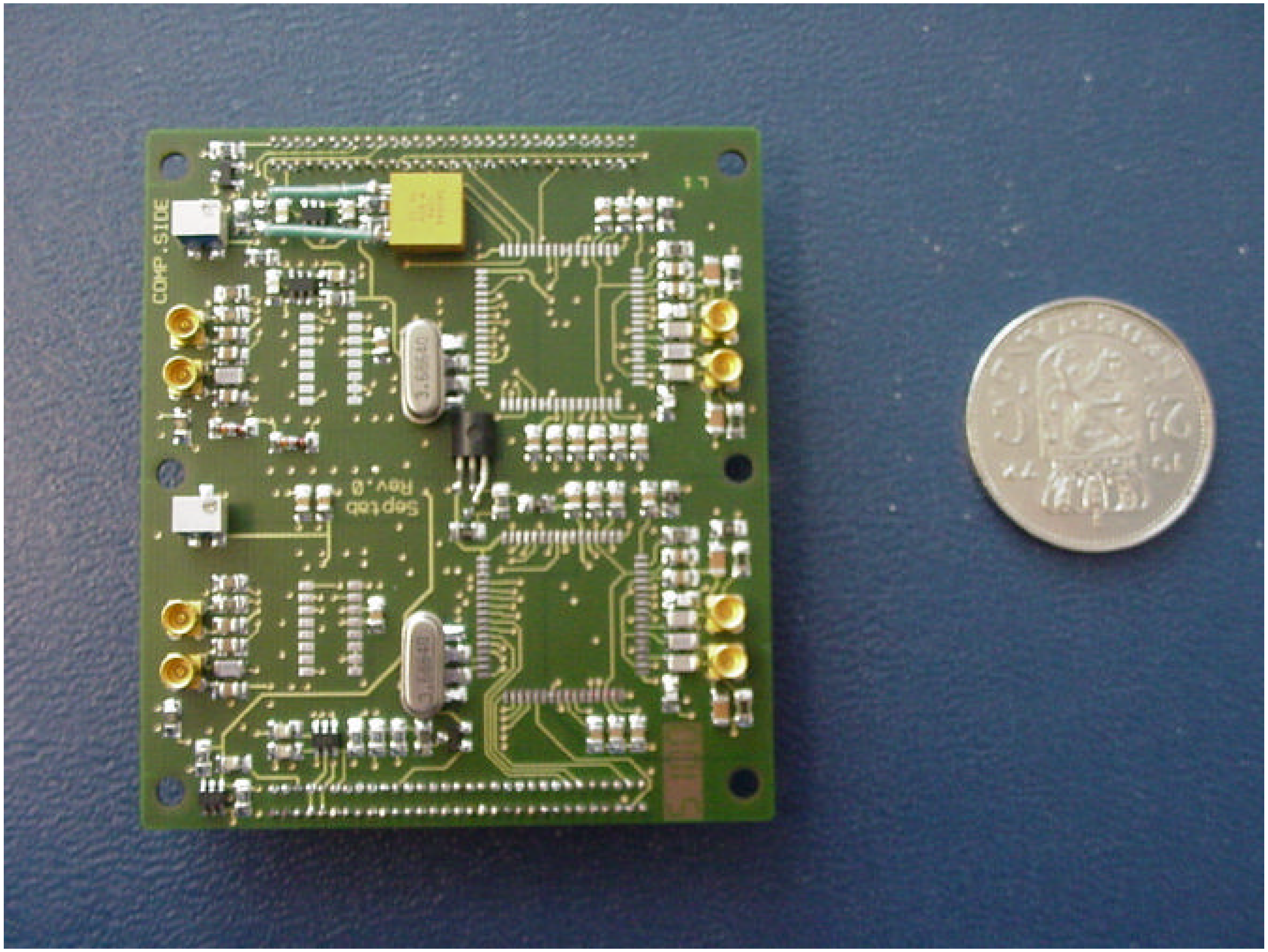
SEPT Front View



SEPT Block Diagram



SEPT Prototype Analog Electronics Board



SEPT System

SEPT consists of *(numbers given per S/C)* :

–SEPT-E:	2 double-ended telescopes	UoK
–SEPT-NS:	2 double-ended telescopes	UoK
–2 sets of pigtails to SEPT Electronics		UoK
–2 housing boxes for SEPT Electronics		UoK
–1 bracket for SEPT-NS		GSFC
–2 sets of analog and digital electronics		ESTEC
–2 sets of interconnecting harness to SEP-DPU		GSFC

SEPT Concerns

- Concern about solar heat input solved: covers for all apertures baselined (TiNi actuators)
- Concern about scattered light in apertures solved: ohmic side of detectors face open space, can be made light-tight, penalty: increase of lower energy threshold
- Concern about viewing cone obstructions continue for SEPT-NS, mitigated by reduction of cone angle from 60° to 52°
- Cross talk between inner segment (D1) and outer ring (G1)

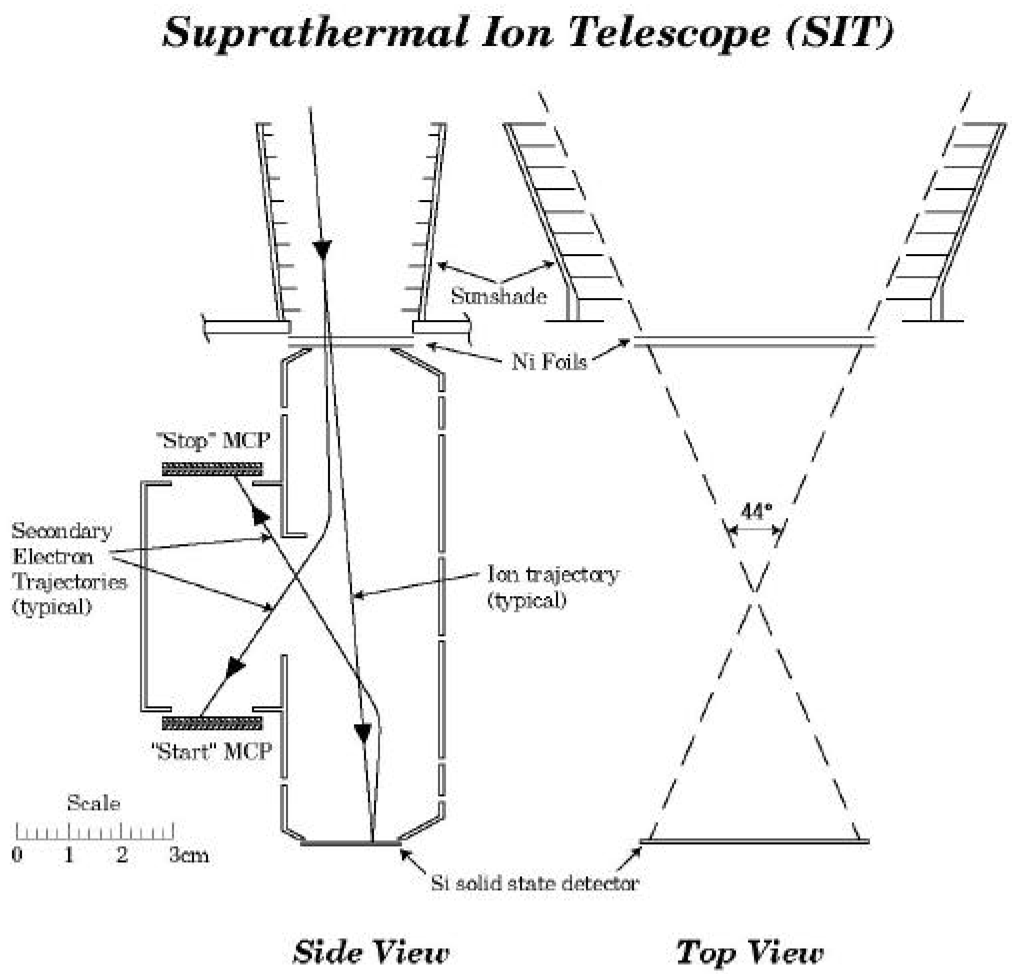
  Solution: insert narrow guard ring (C1)

  Penalty: 3 coax cables per detector instead of 2
- Cross talk between D1 and D2, no solution yet, calculate capacitive coupling using known area (52 mm^2) and distance (600 μm)
- Purging required

Suprathermal Ion Telescope (SIT)

University of Maryland
Max Planck Institut at Lindau
GSFC

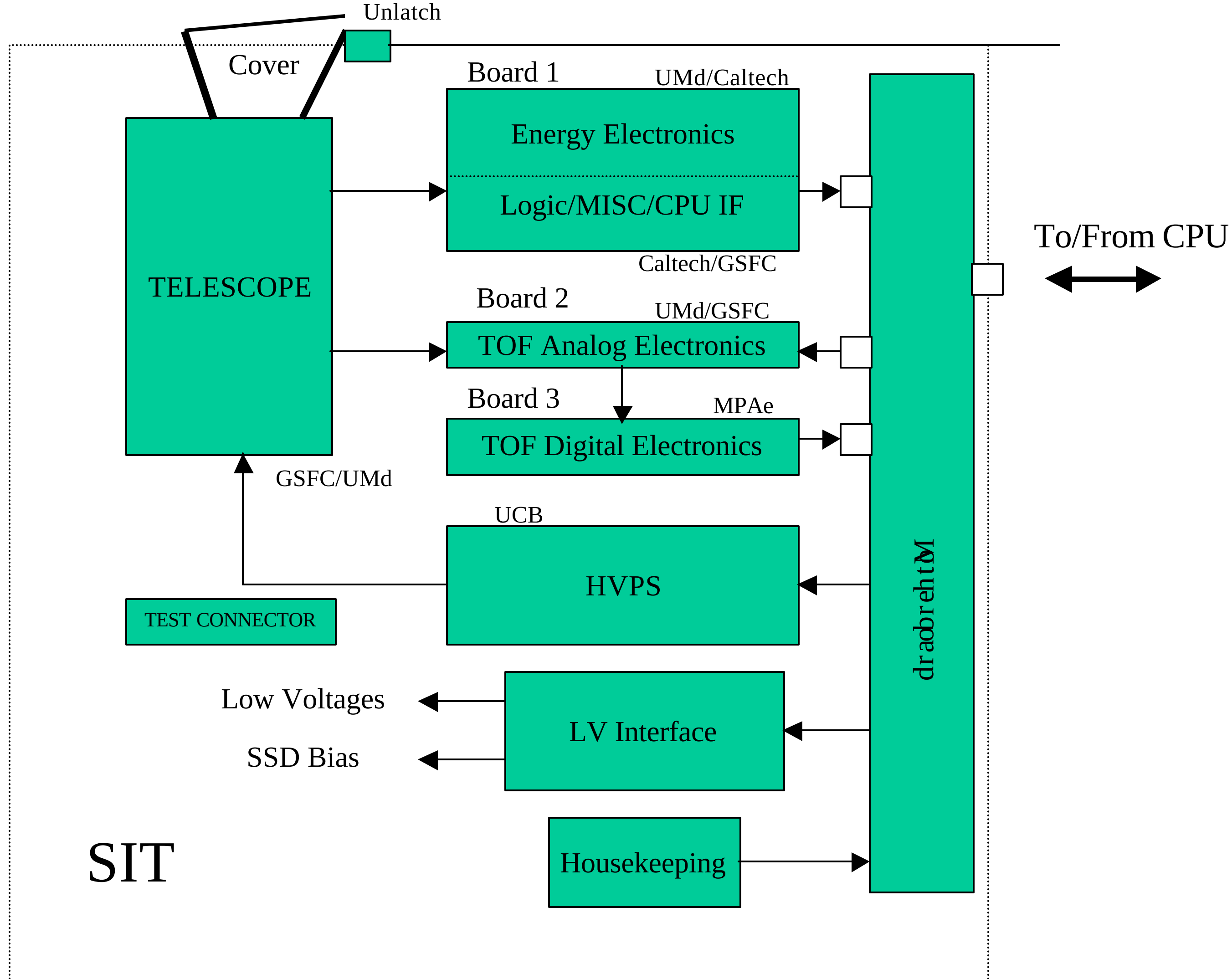
Suprathermal Ion Telescope



SIT Description

- TOF vs E
- Energy - 1 SSD
  - –surface barrier or ion implant
  - –15mm x 40 mm
  - –500u
- TOF - 1 START & 1 STOP
  - –10 cm flight path
  - –chevron pair micro-channel plates
  - –1000v bias per plate, commandable
- Foils - 2
  - –Ni
  - –1000A, on grid

SIT BLOCK DIAGRAM



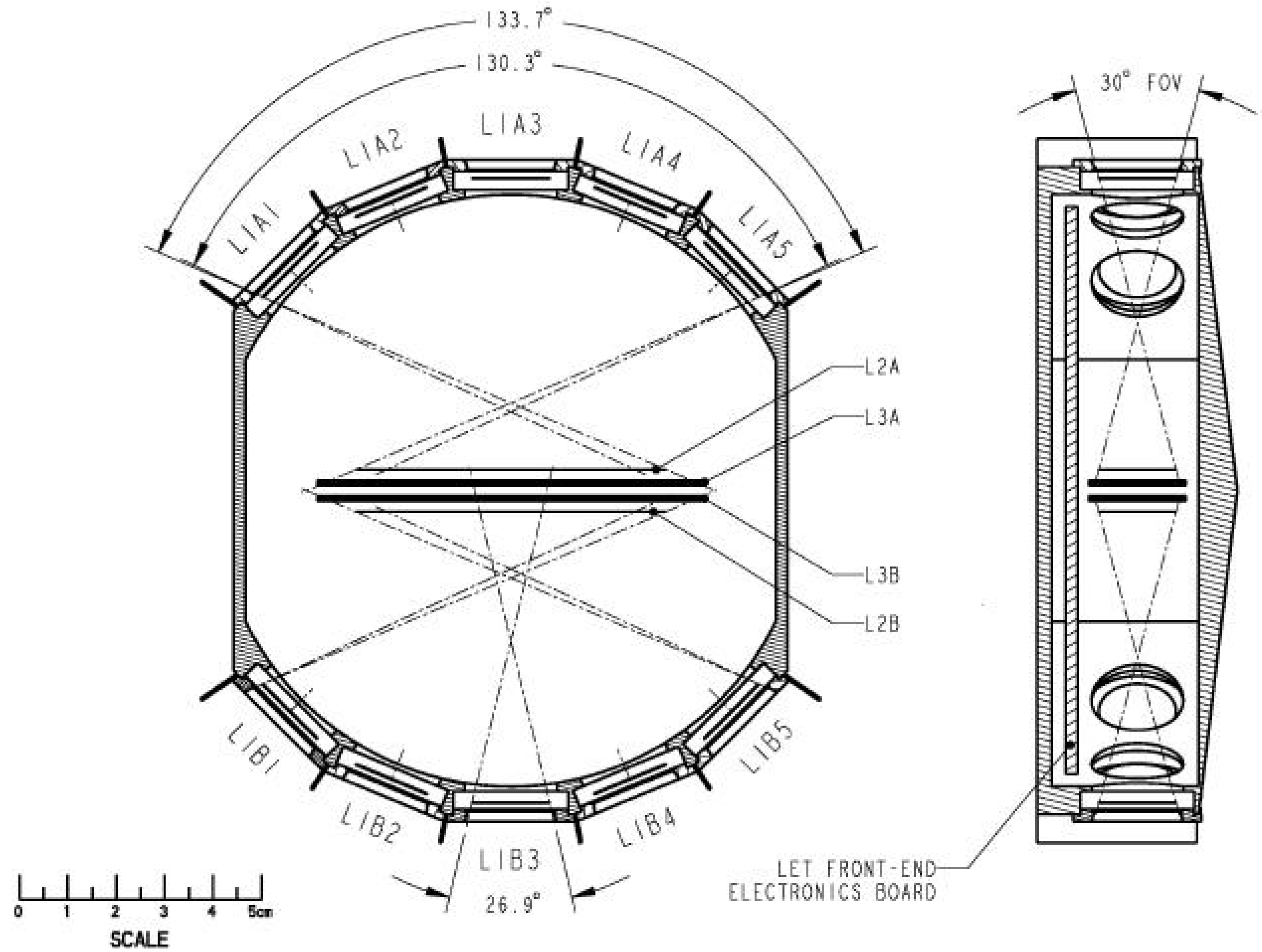
SIT High Voltage Power Supply

- Provides bias voltages to operate the microchannel plates and to "focus" the secondary electrons produced by incoming ions
- Nominal voltages: 3400,3200,2200,2000,1000 and 950 v
- Top voltage controlled by command, others change proportionally
- 0-5v control voltage
- Maximum output ~4200v
- On/Off Command : 5v level
- Disable plug to prevent operation during ground testing
- Operates on +/- 12v
- Supplied in housing by UCB

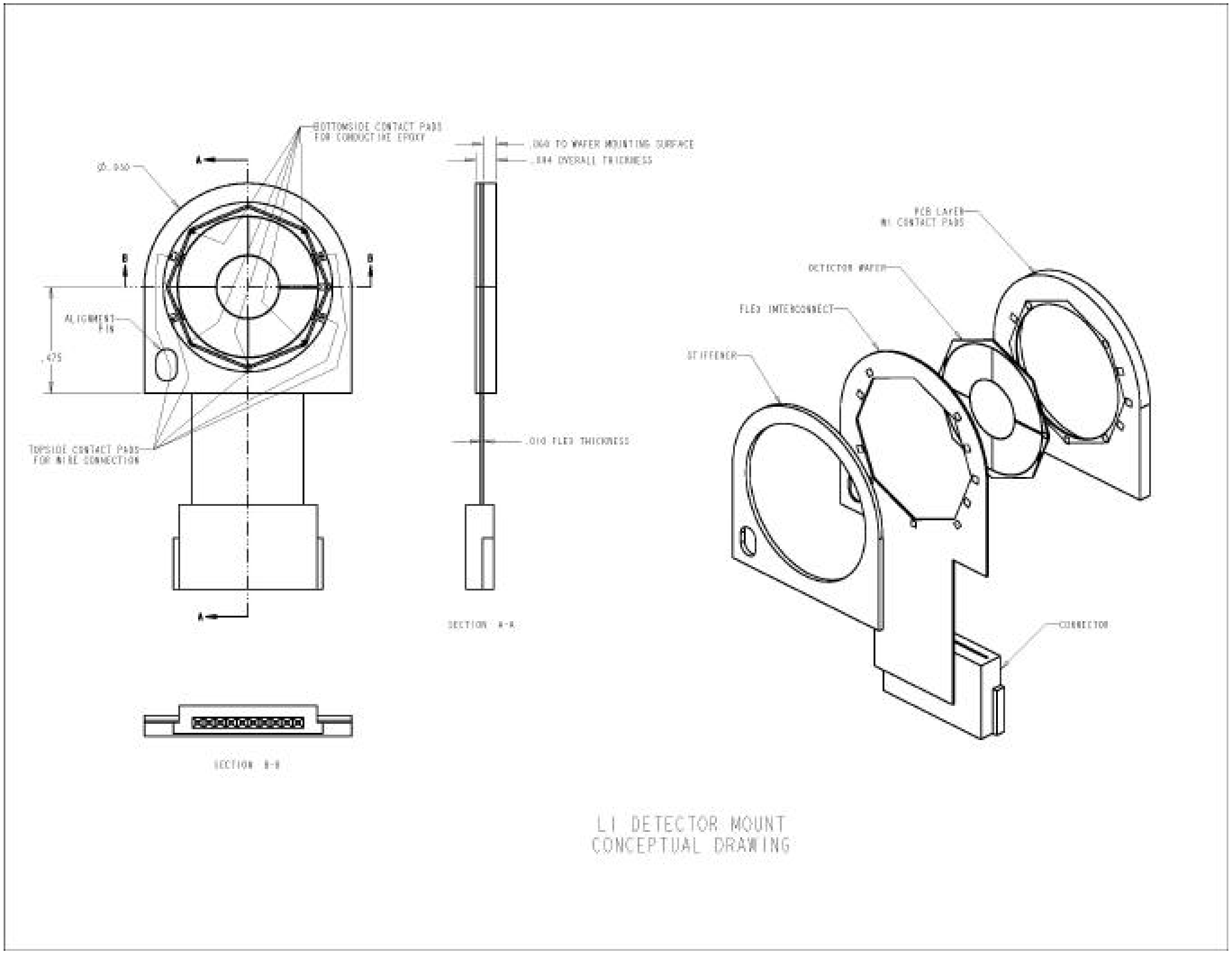
Low Energy Telescope (LET)

Caltech/JPL/GSFC

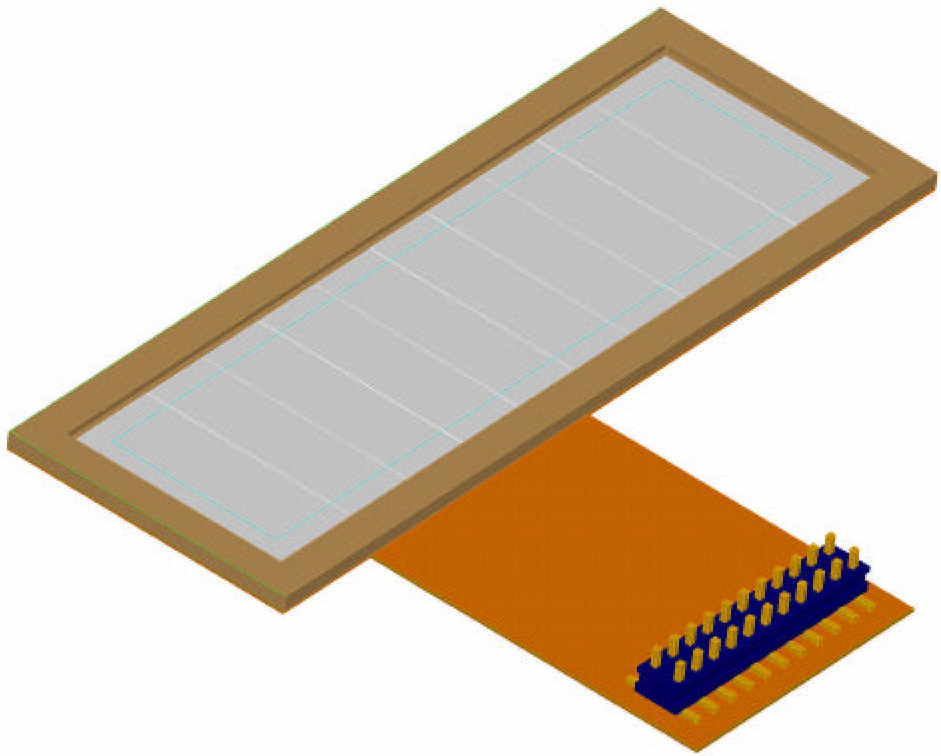
Low Energy Telescope (LET) Schematic



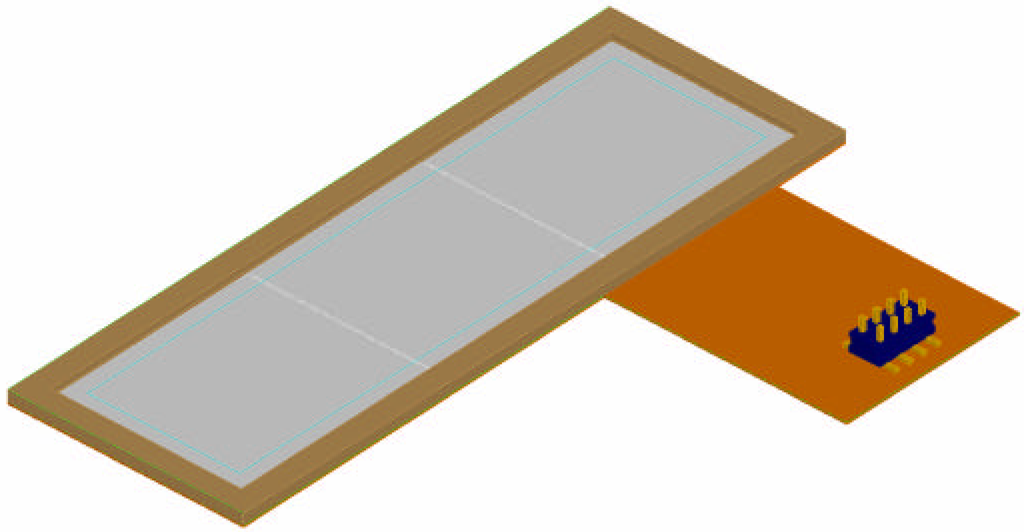
LET L1 Detector Drawing



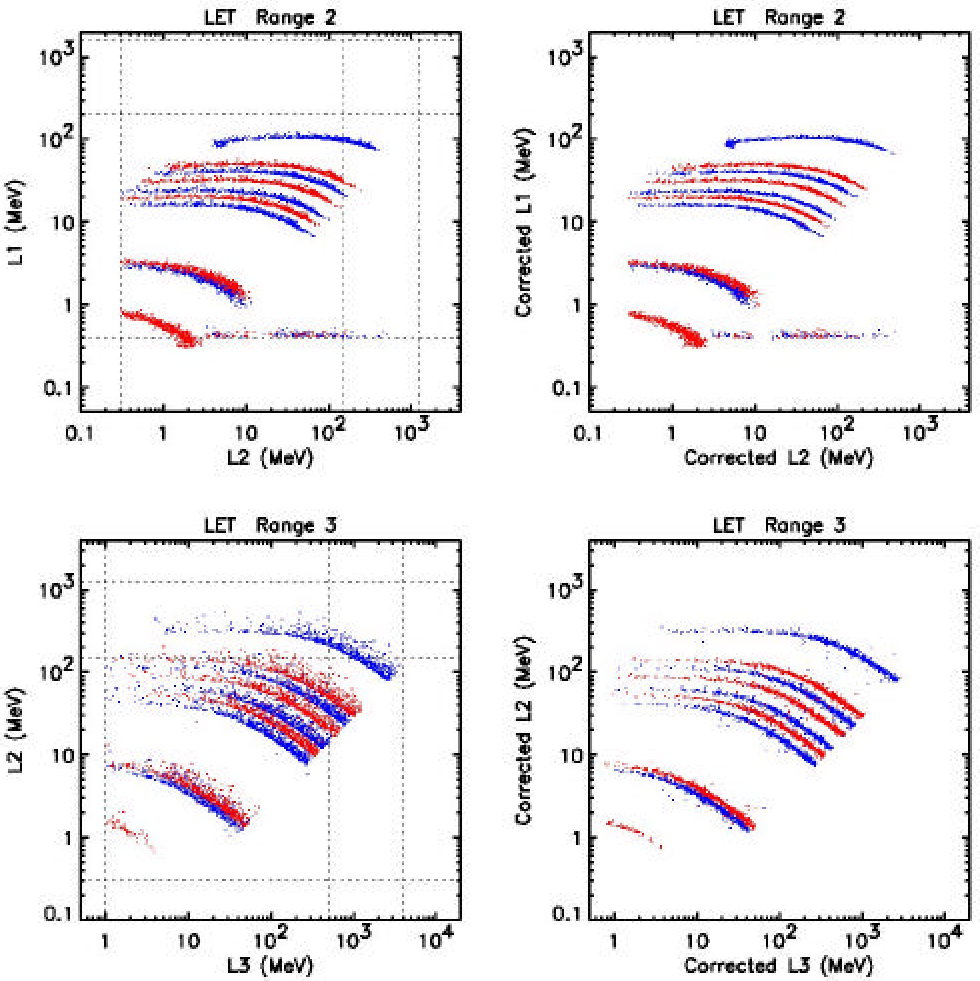
LET L2 Detector



LET L3 Detector



LET dE/dx x E Response



LET Operation During High-Rate Periods

Requirement: Provide composition and energy spectra measurements over conditions ranging from quiet-time to the largest solar events

Issue: During very high-rate periods (e.g., peak of Bastille Day 2000 event) the single-detector count rates, especially on the front detectors, can exceed 1,000,000/sec, mostly due to out-of-geometry, wide angle protons

Approach:

- L1 detectors have bull's-eye design with smaller central area
- Collimation of L1 detectors to shield against wide-angle protons
- Shield sides of telescope to reduce L2, L3 count rates
- Adjust thresholds on selected detectors to reduce overall count rates while maintaining energy and species coverage

LET Operation During High-Rate Periods … Cont

- Thresholds adjusted by ignoring high-gain response on selected detectors
- Adjustments controlled on-board by "OR" of count-rates from detectors that are not adjusted (L1A3, L1B3, L2A5, L2A6, L2B5, L2B6, L3Ai, and L3Bi)

Implementation (in order of occurrence):

- All L1o thresholds raised from 0.7 to 3 MeV
  (reduce H, He geometry by x5 and singles by x5)
- Raise all but L2A5,6, L2B5,6 thresholds from 0.3 to 4 MeV
  Raise L3Ao, L3Bo thresholds from 1 to 20 MeV
  (reduce H, He geometry by additional ~x5 factor)
- Raise all L1i thresholds except L1A3, L1B3 from 0.3 to 3 MeV
  (reduces H, He geometry & singles by additional ~x5 factor)

LET Operation During High-Rate Periods … Cont

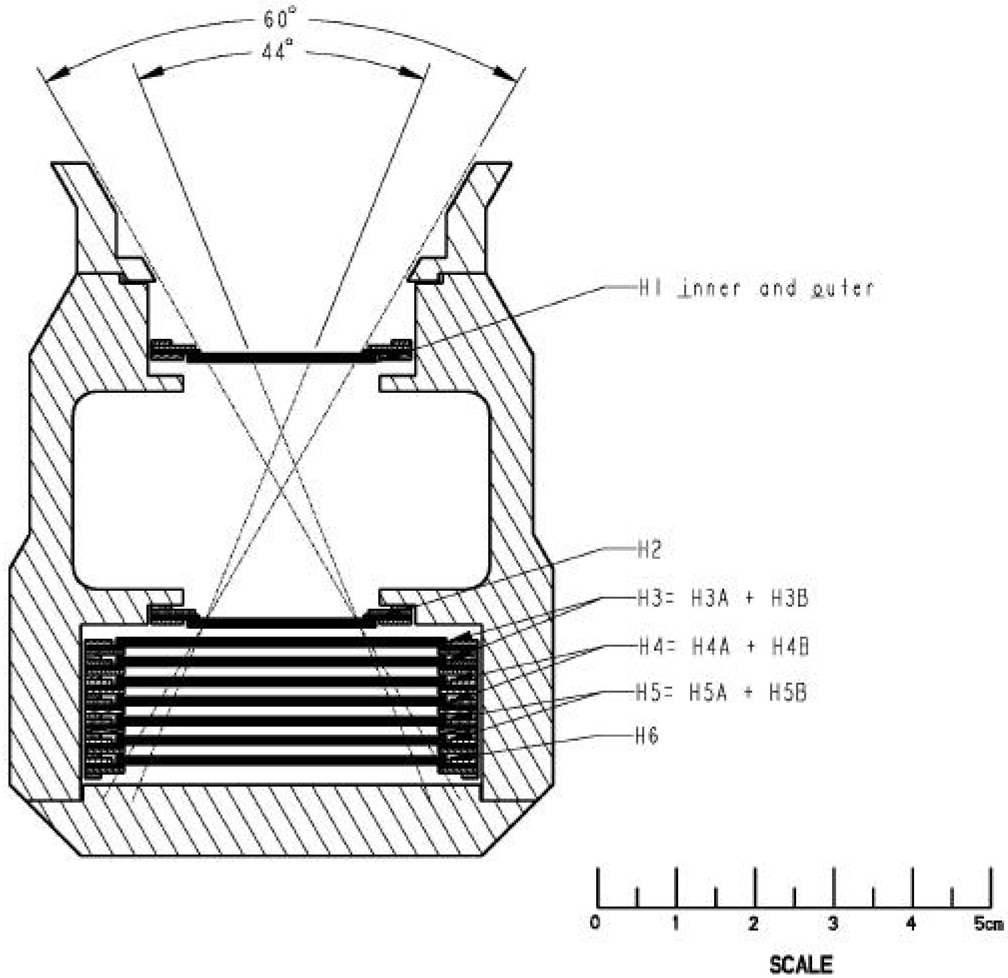
Considerations:

- To a large extent, full geometry for Z = 6 particles is maintained
- H and He coverage maintained with adequate geometry along with front/back response
- At most two thresholds used for a given detector
- Requirements for adjustments must employ hysteresis and suitable time average
- Simulations based on Wind/ACE events needed to test approach
- Test in laboratory by reducing nominal, high-gain thresholds

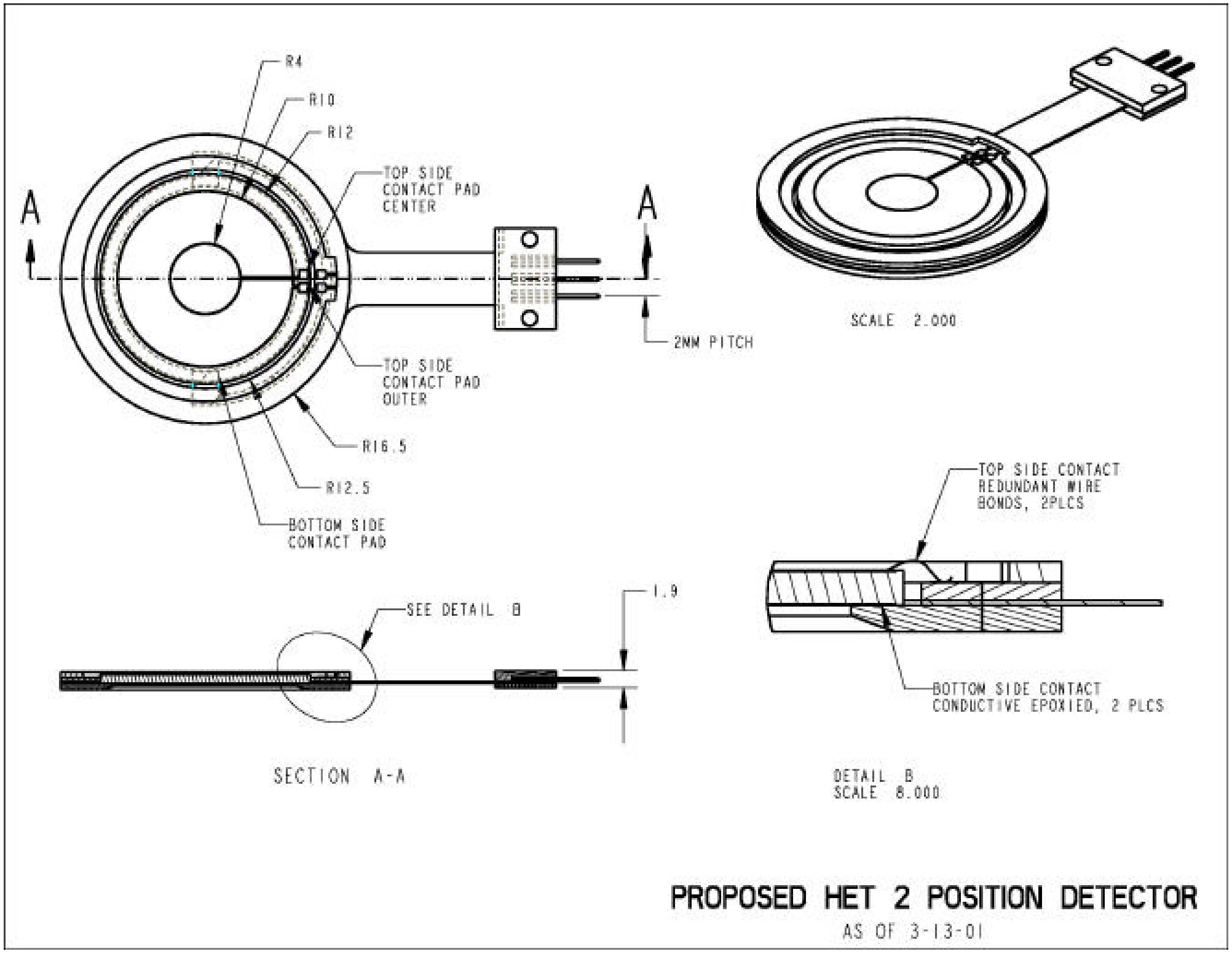
High Energy Telescope (HET)

GSFC
Caltech
JPL

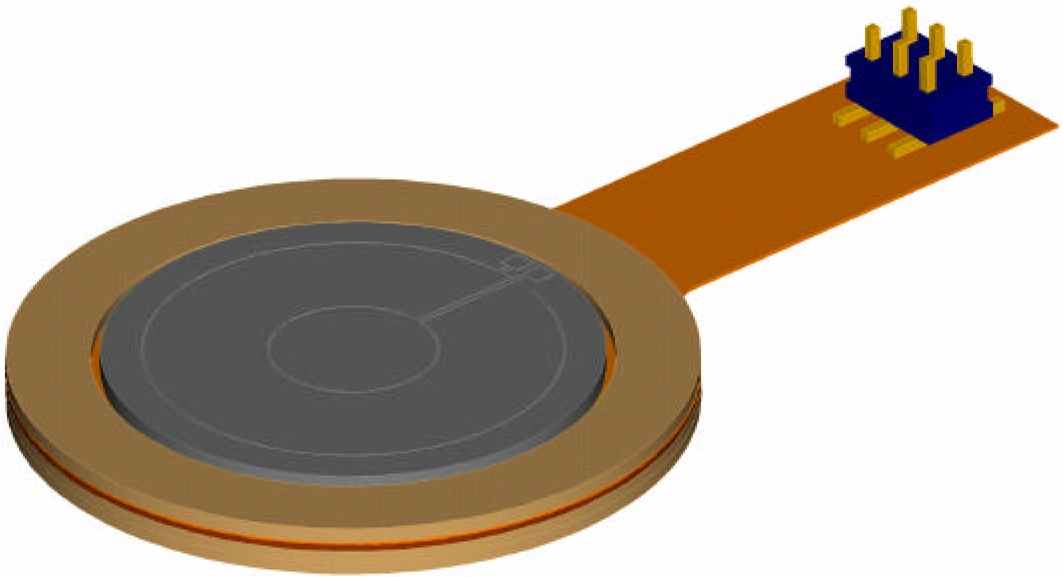
HET Telescope Schematic



HET H1 Detector Schematic



HET H1 Detector



HET Operation During High-Rate Periods

Requirement: Provide composition and energy spectra measurements over conditions ranging from quiet-time to the largest solar events

Issue: During very high-rate periods (e.g., peak of Bastille Day 2000 event) the single-detector count rates, especially on the front detector, will exceed 100,000/sec, mostly due to out-of-geometry, wide angle protons

Approach (Similar to LET):

- **H1 detector has bull's-eye design with smaller central area**
- **Collimation of H1 detector to shield against wide-angle protons**
- **Shield sides of telescope to reduce H2 to H6 count rates**
- **Adjust threshold on H1o to reduce overall count rate while maintaining energy and species coverage**

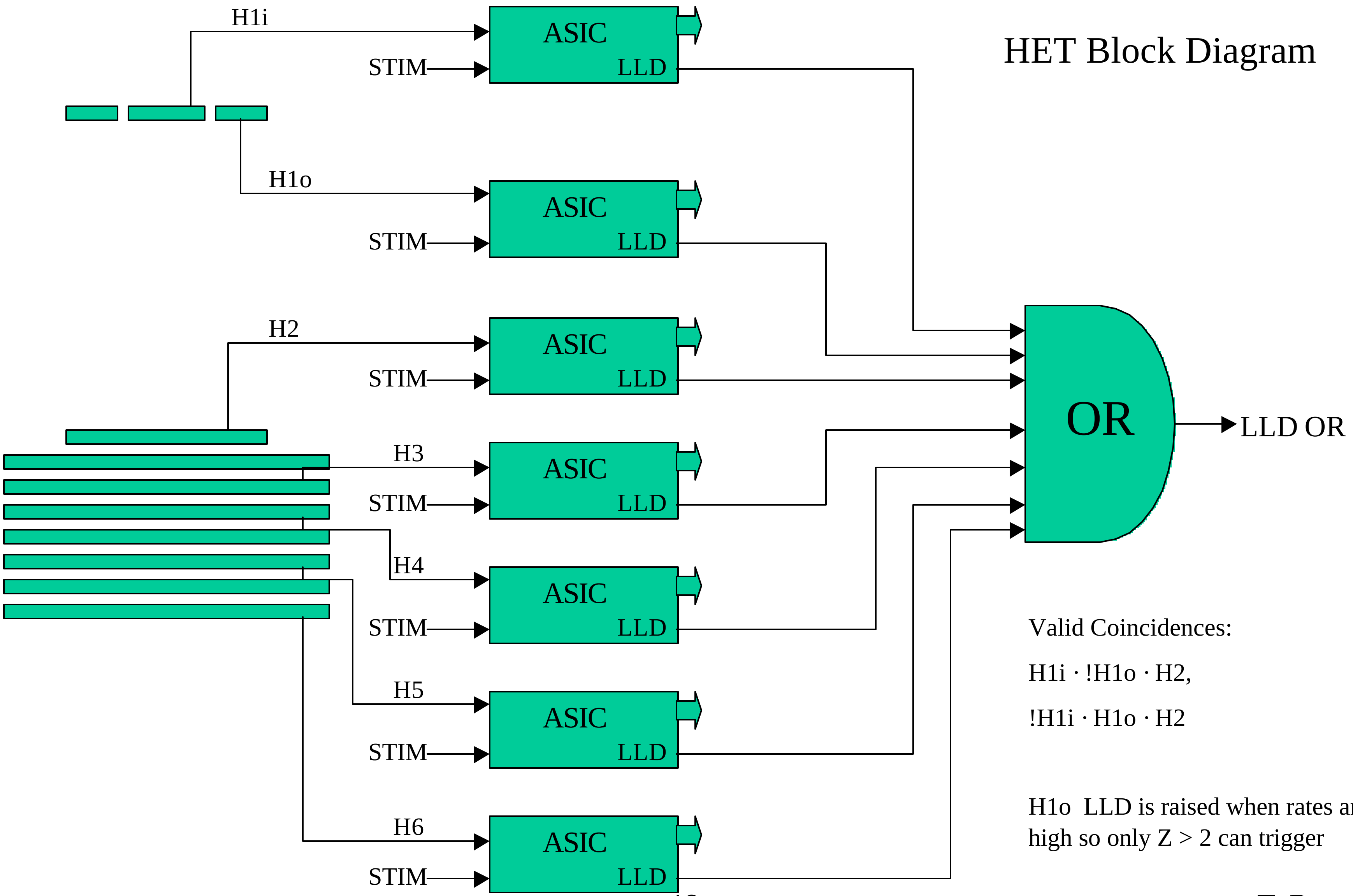
HET Operation During High-Rate Periods … Cont

- Threshold adjusted by ignoring high-gain response on selected detectors
- Adjustments controlled on-board by "OR" of count-rates from detectors that are not adjusted (H1i, H2 - H6).

Implementation:

- H1o threshold raised from 0.2 to ~16 MeV when singles rates reach TBD value.

HET Block Diagram



Valid Coincidences:

H1i · !H1o · H2,

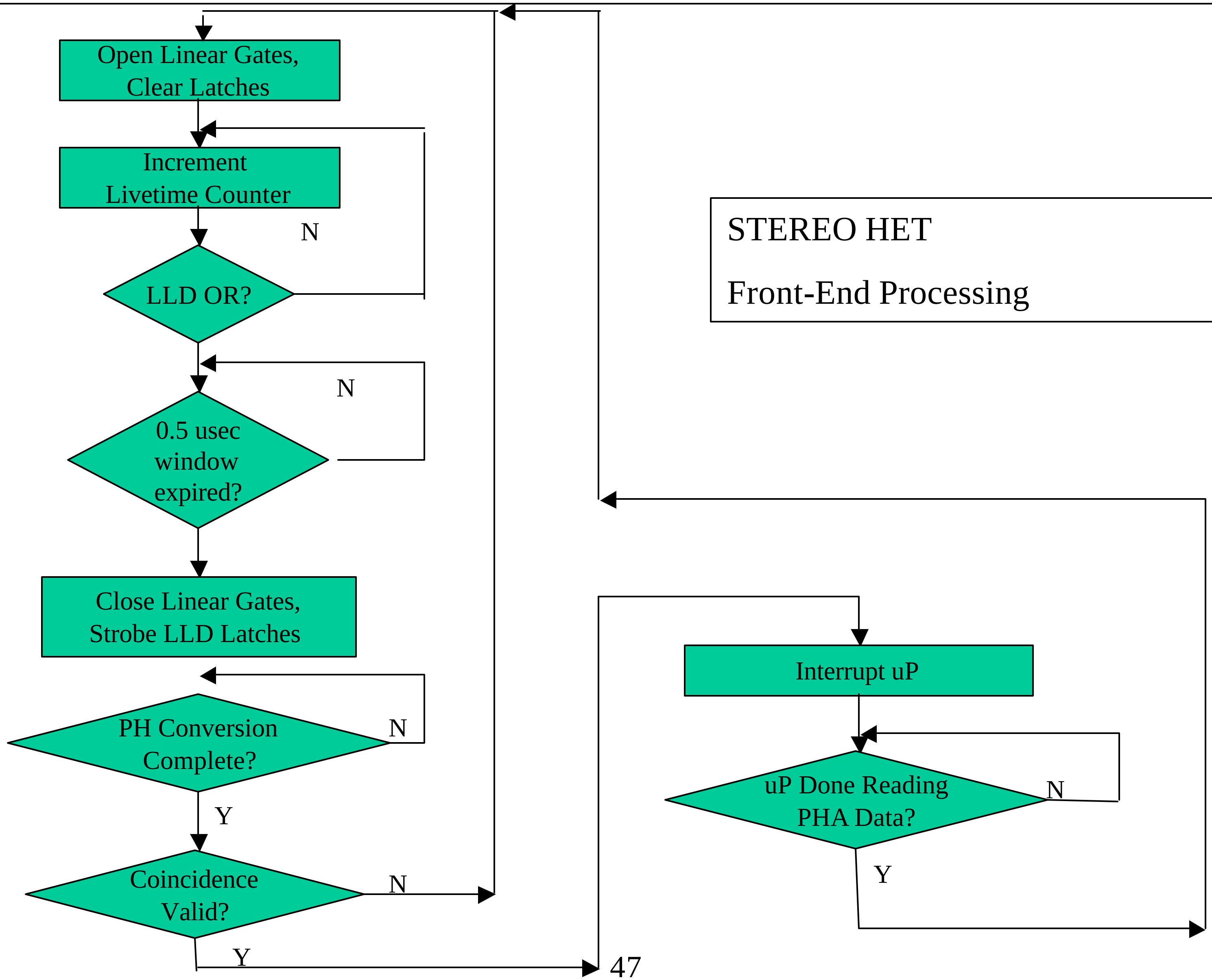
!H1i · H1o · H2

H1o LLD is raised when rates are high so only Z > 2 can trigger

STEREO IMPACT

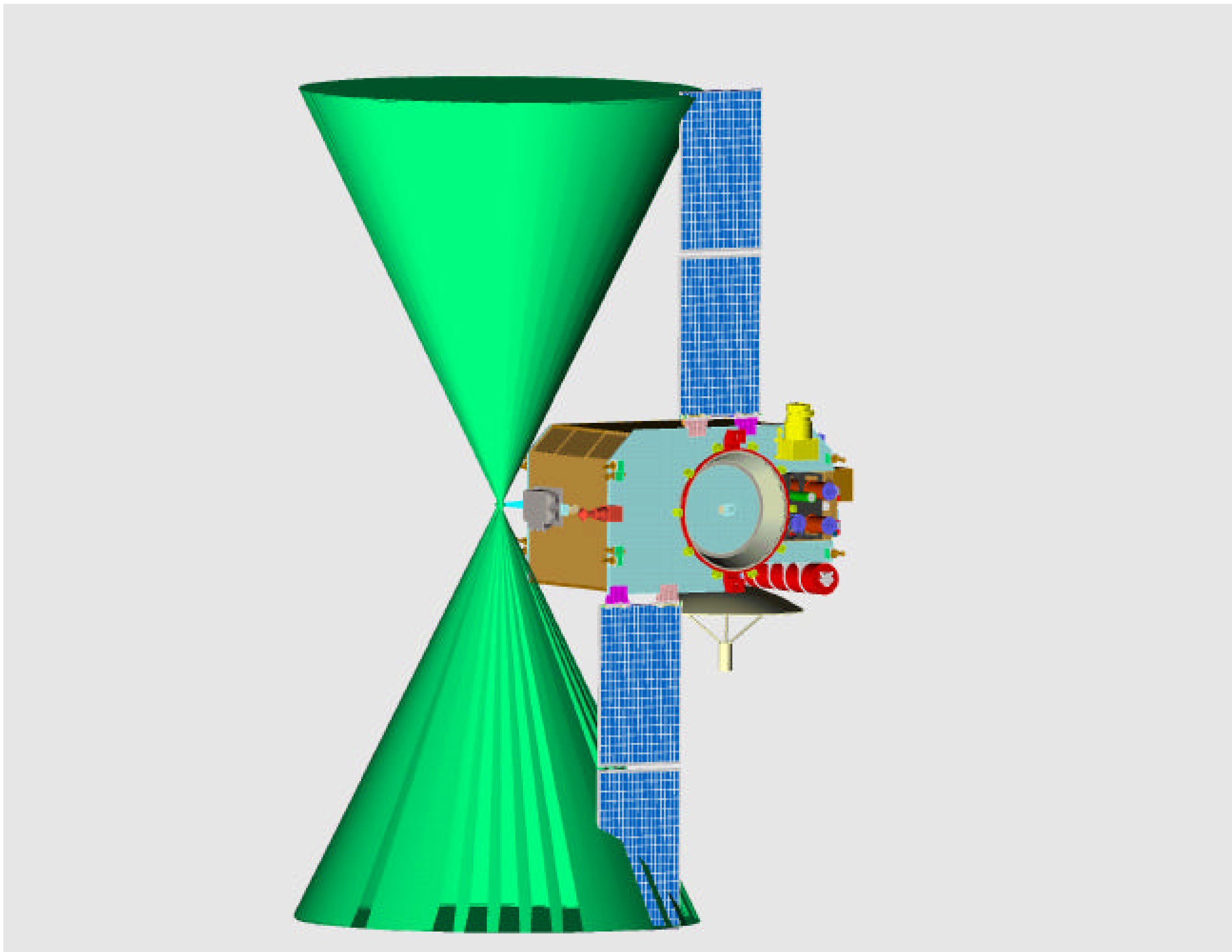
STEREO HET

Front-End Processing

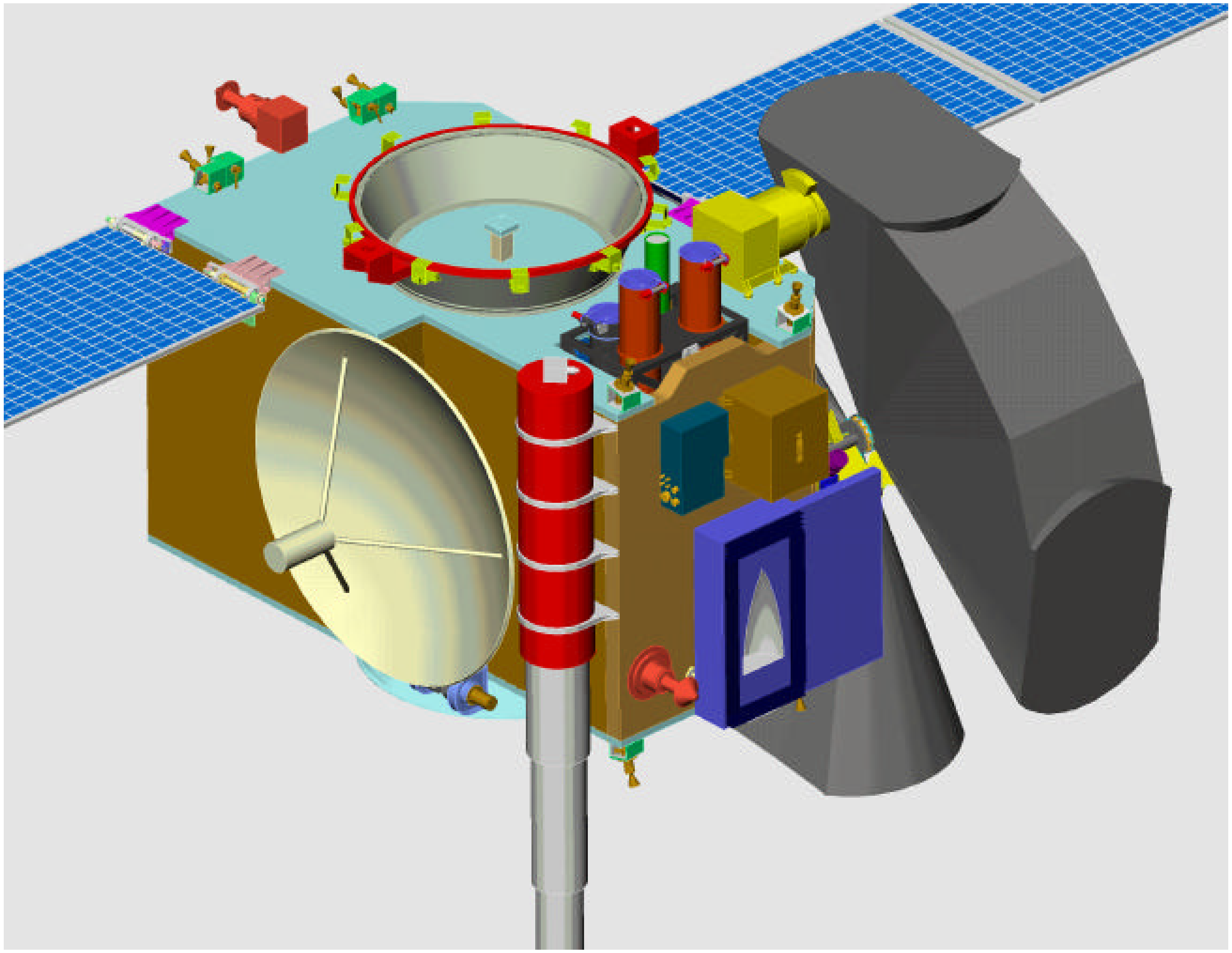


TvR

SEPT North-South Fields of View



LET Field of View Impingement with PLASTIC



MASS Allocation

SEP resources:	Mass [g]		4/19/01
Component	Update	Phase A	Diff.
SIT sensor & door	500	480	20
SIT elec. boards & wiring	370	290	80
SIT HVPS	160	160	0
------------------------	------	------	------
SIT subtotal:	1030	930	100
SEPT-NS (w/o harness)	520	440	80
SEPT-E (w/ 10cm harness)	540	460	80
------------------------	------	------	------
SEPT subtotal:	1060	900	160
LET det. & housing	515	390	125
LET electronics	235	120	115
------------------------	------	------	------
LET subtotal:	750	510	240

MASS Allocation … Cont

Component	Update	Phase A	Diff.
HET det. & housing	460	610	-150
HET electronics	160	90	70
-----------------------	------	------	------
HET subtotal:	620	700	-80
Cent. elec. encl. & hdwr	1030	750	280
El. boards, shields, harness	1090	940	150
-----------------------	------	------	------
Cent. elec. subtotal	2120	1690	430
SIT encl. & hdwr	200	N/A	200
SEPT-NS bracket	270	200	70
LET bracket	600	N/A	600
SEP bracket	N/A	1000	-1000
-----------------------	------	------	------
SEP total:	6650	5930	720

MASS Allocation … Cont

Component	Update	Phase A	Diff.
SEPT-NS harness (2m)	150	150	0
Thermal blankets	100	N/I	100

Some Controlling Documents

- **IMPACT Phase A Report covers the top level instrument performance requirements**
- **IMPACT/Spacecraft ICD covers the spacecraft interface**
- **IMPACT Serial Interface document covers the data interface between SEP and the IDPU**
- **IMPACT PAIP covers the performance assurance requirements**
- **STEREO EMC and Contamination Control plans**