STEREO IMPACT/SEP OVERVIEW

Tycho von Rosenvinge

tycho@milkyway.gsfc.nasa.gov

301-286-6721

Solar Energetic Particles

Critical Design Review

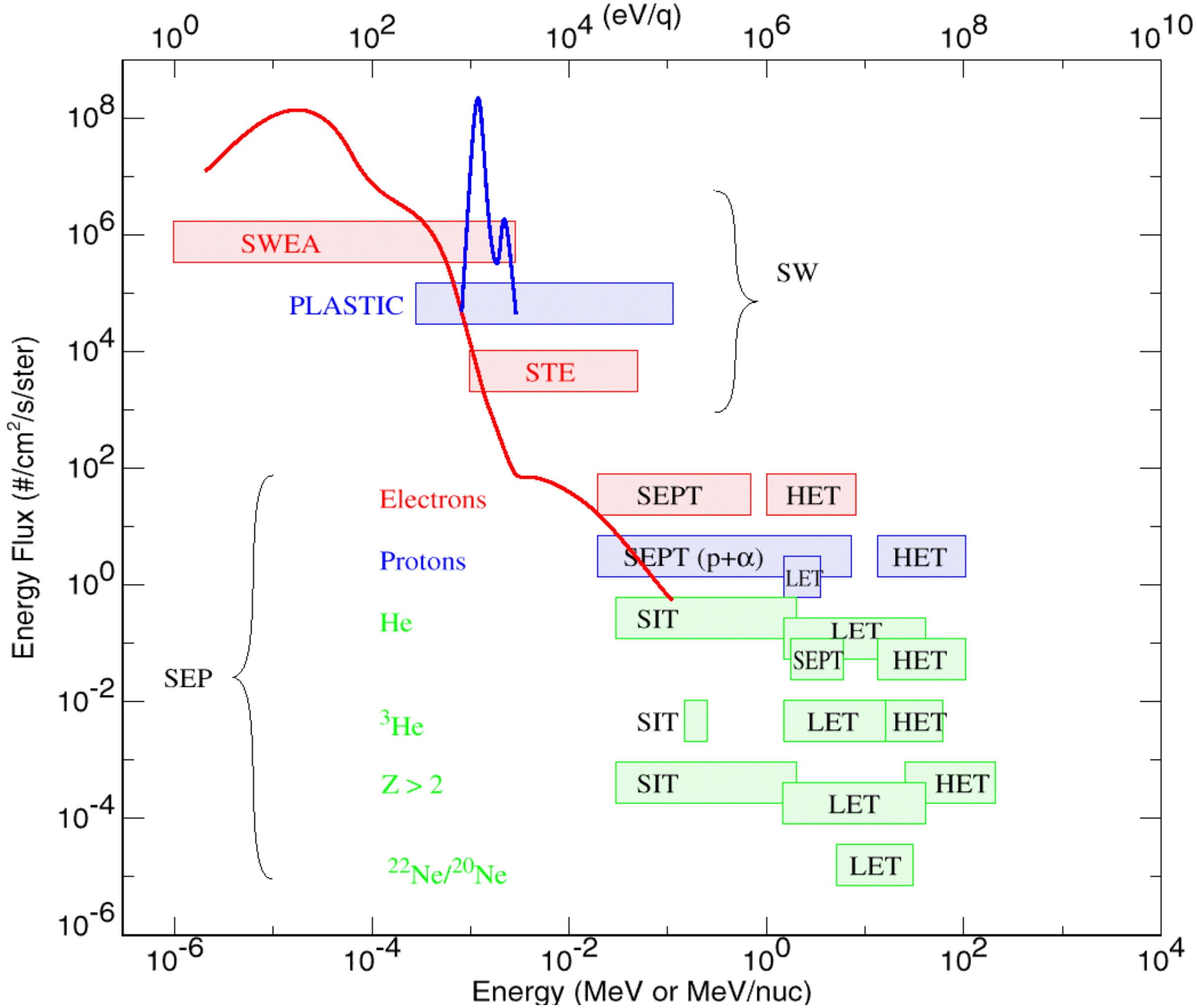
IMPACT Science Summary

Table A.1 IMPACT Summary

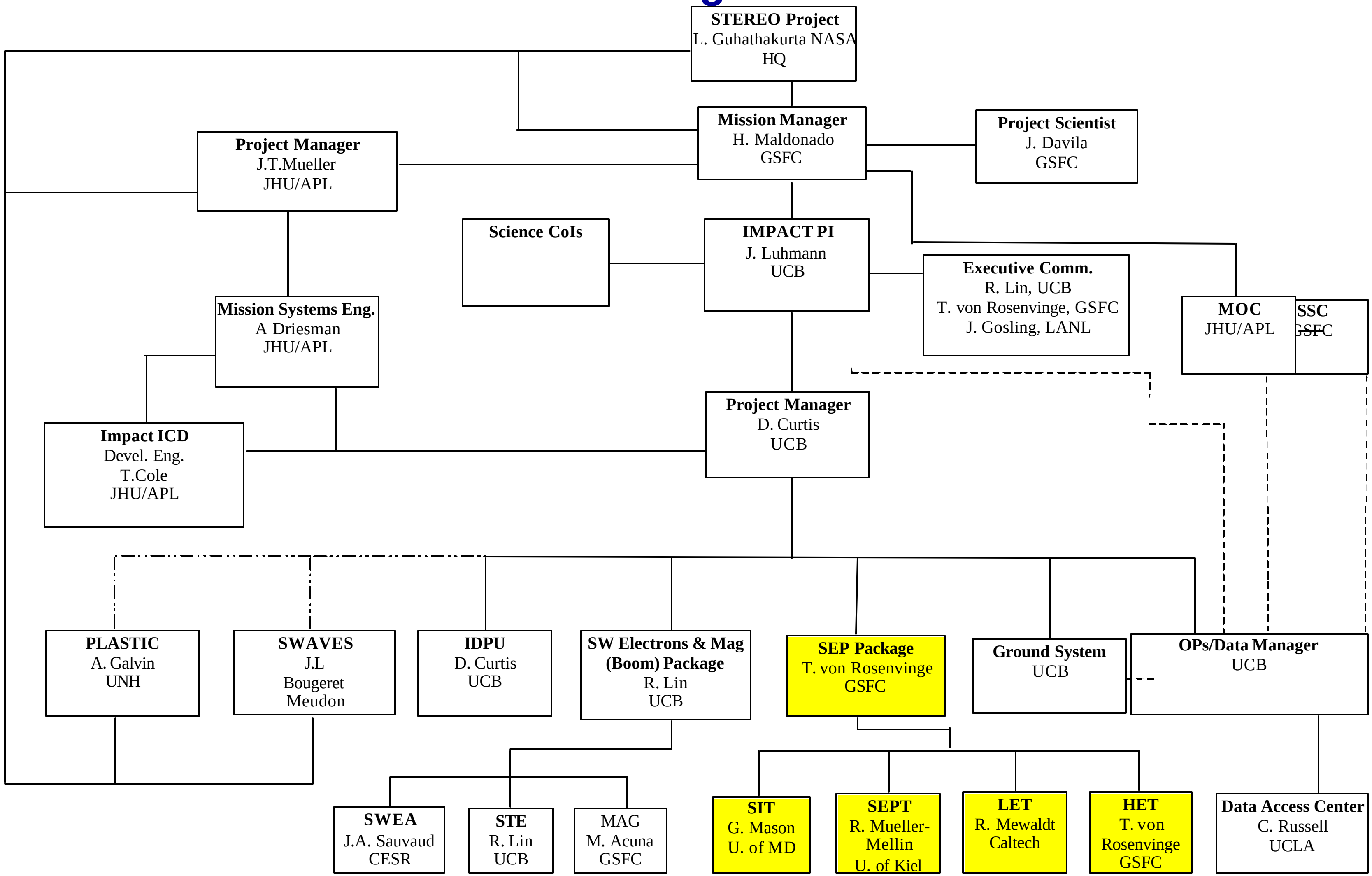
Experiment	Instrument	Measurement	Energy or Mag. field range	Mass (kg)	Power (w)	Data Rate (bps)	Time Res.	Instrument provider
SW	STE	Electron flux and anistropy	2-100 keV	0.35	0.20	64	16 s	UCB (Lin)
	SWEA	3D electron distrib., core & halo density, temp. & anisotropy	~0-3 keV	1.71	1.10	394	3D=1 min 2D=8s 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	1.33	1.36	418	1 min	U. of Md. (Mason) + MPAE (Korth) +UCB (Curtis)
		^{3}He	0.15-0.25 MeV/nuc				1 min	
	SEPT	Diff. electron flux	20-400 keV	1.11	0.99	70	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	0.84	0.88	557	1-15 min.	Caltech (Mewaldt) + GSFC (von Rosenvinge) + 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	Electron flux	1-6 MeV	0.71	0.37	209	1-15 min.	GSFC (von Rosenvinge) + Caltech (Mewaldt) + 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	----	----	2.90	4.1	----	----	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 / PLASTIC Energy Coverage



IMPACT Team Organization Chart



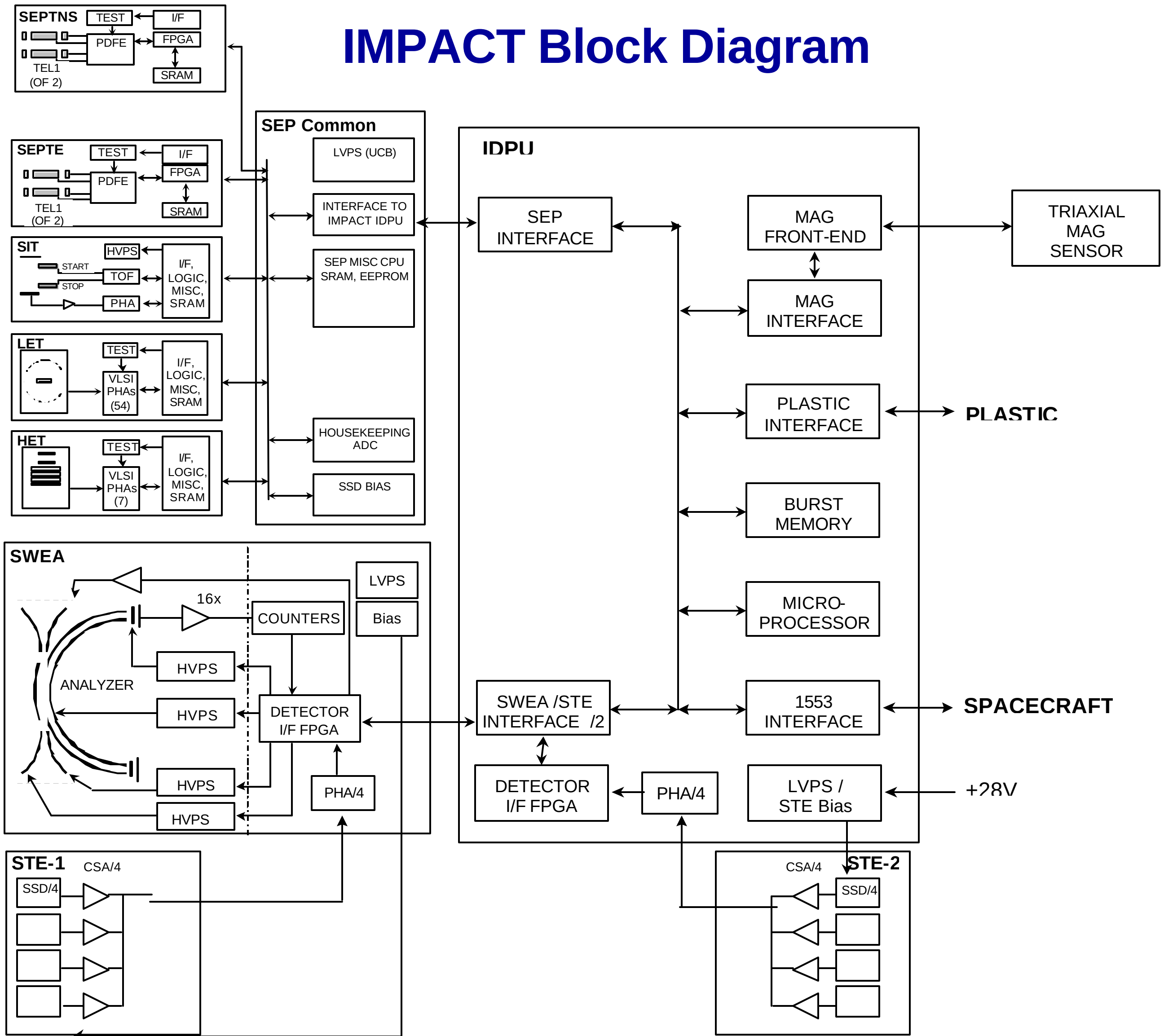
SEP Responsibilities

- **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, PHA ASIC development, Minimal Instruction Set Computer development
  - Overall integration/test of SEP package
- **JPL**
  - LET/HET detector procurement; LET development/test
- **GSFC**
  - HET development/fabrication/detector test/system test
  - GSFC MISC + HET/LET on-board algorithm development
  - Overall SEP mechanical design and fabrication, excluding SEPT (e.g. detector, telescope, enclosure, and bracket designs)
  - Overall SEP thermal design
  - SIT fabrication/assembly + SIT MISC + SIT Software

SEP Personnel

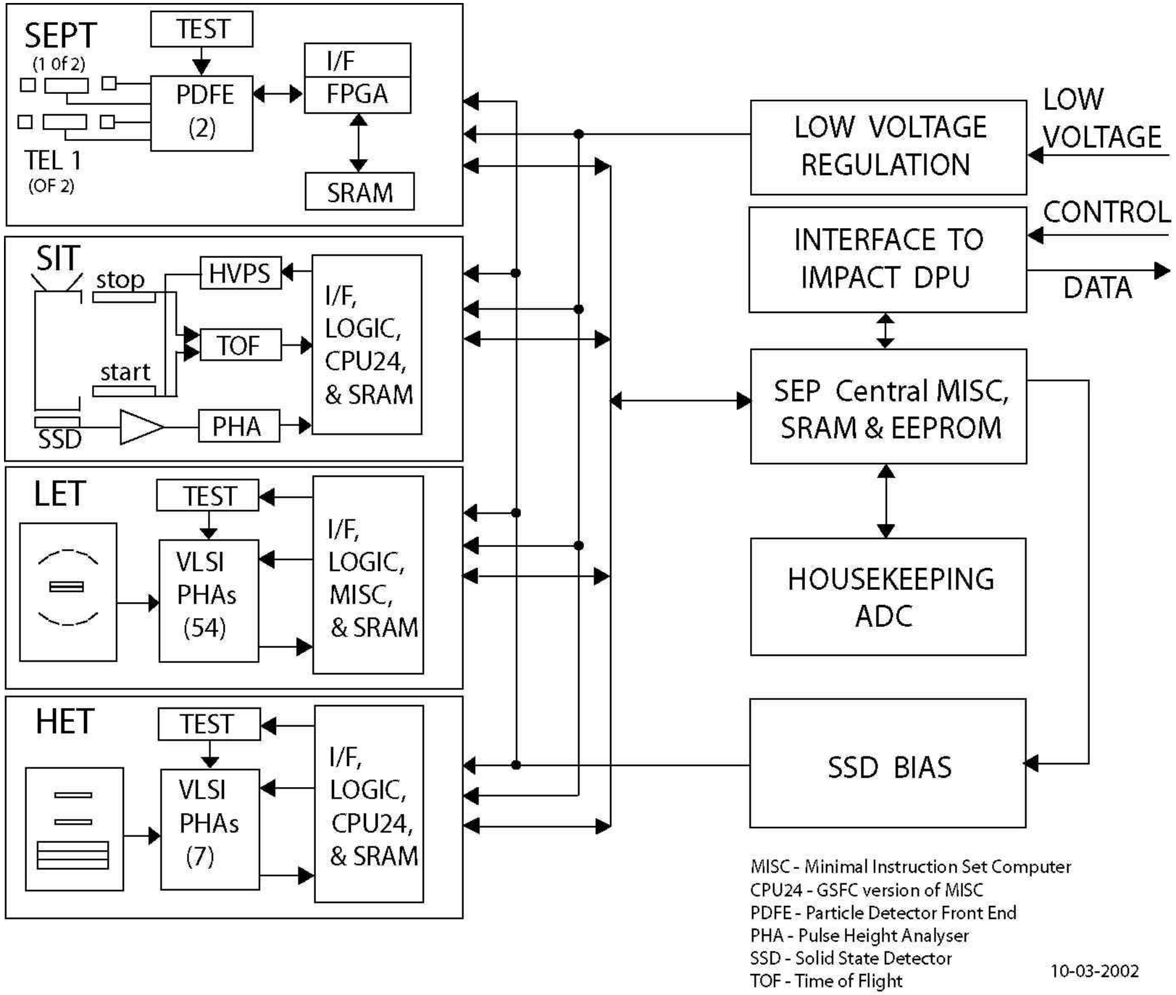
- Tycho von Rosenvinge, SEP Coordinator/HET Design/SEP Mechanical, GSFC, tycho@milkyway.gsfc.nasa.gov
- Bob Baker, Electronics Engineer, GSFC, baker@lheapop.gsfc.nasa.gov
- Rick Cook, SEP Lead Electronics Engineer, Caltech, wrc@srl.caltech.edu
- Alan Cummings, SEP Project Manager at Caltech, Caltech, ace@srl.caltech.edu
- Andrew Davis, On-board Software, Caltech, ad@srl.caltech.edu
- Ludovic Duvet, SEPT Electronics Engineer at ESTeC, Ludovic.Duvet@rssd.esa.int
- John Hawk, Thermal Engineer, GSFC, john.hawk@gsfc.nasa.gov
- Branislav Kecman, Electronics Engineer, Caltech, kecman@srl.caltech.edu
- Axel Korth, SIT TOF, MPI Lindau, korth@linmpi.mpg.de
- Horst Kunow, SEPT, UofKiel, kunow@kernphysik.uni-kiel.de
- 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
- Larry Ryan, HET electronics engineer, GSFC, larry@milkyway.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
- Kristin Wortman, On-board Software, GSFC, wortman@lheapop.gsfc.nasa.gov

IMPACT Block Diagram



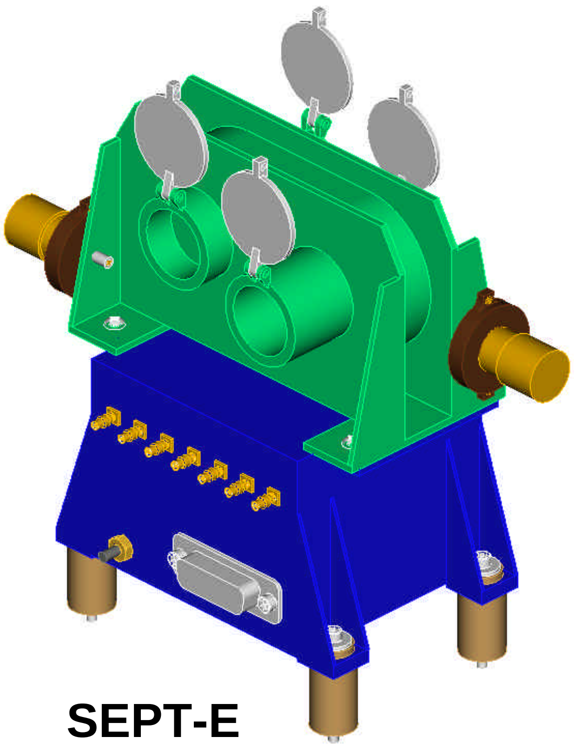
TvR

Overall SEP Block Diagram

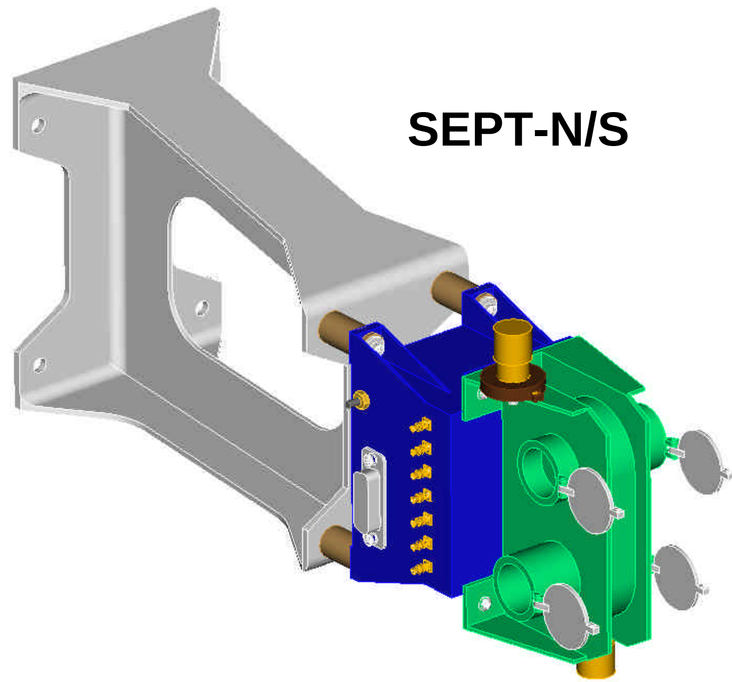


SEPT-Ecliptic and SEPT-NorthSouth

One SEPT-E and one SEPT-N/S are mounted on each spacecraft. They are identical except for how and where they are mounted to the spacecraft.

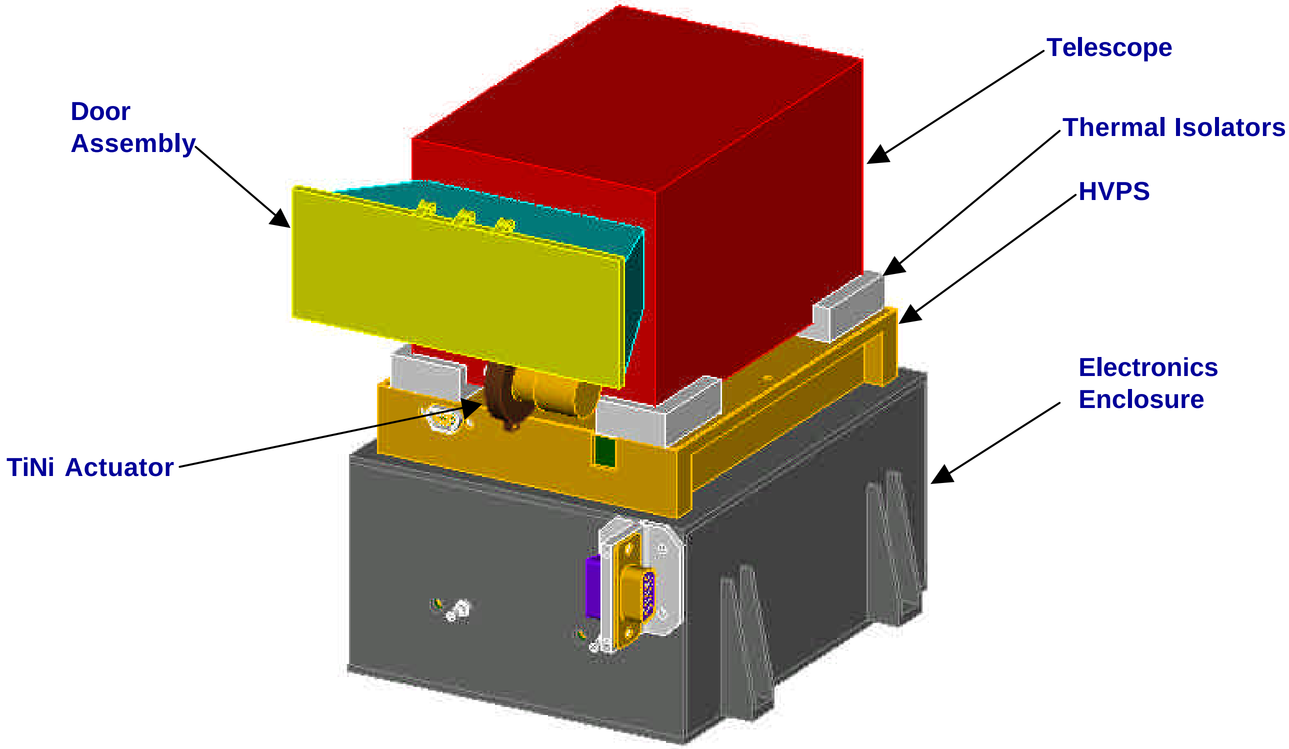


SEPT-E

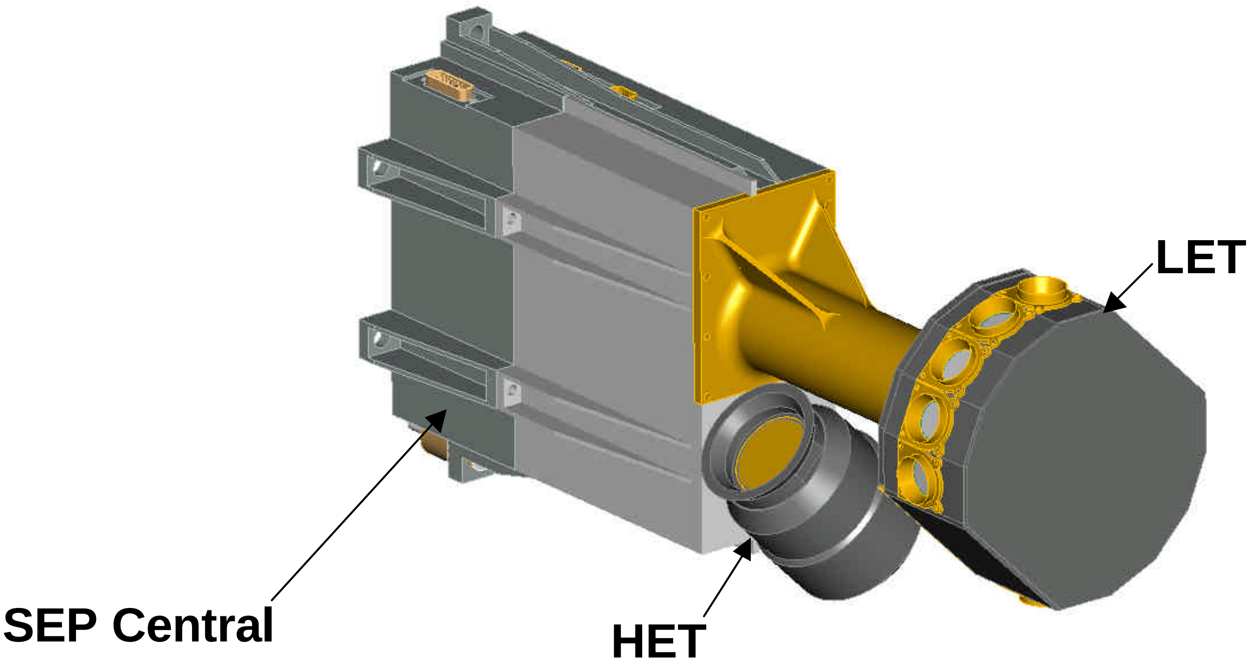


SEPT-N/S

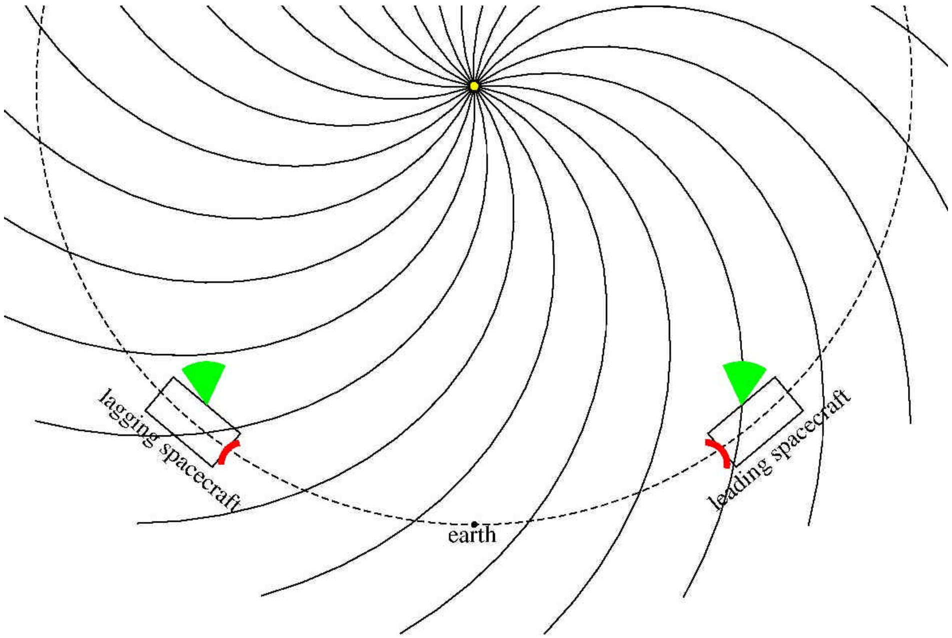
SIT Instrument Assembly



HET/LET/SEP Central



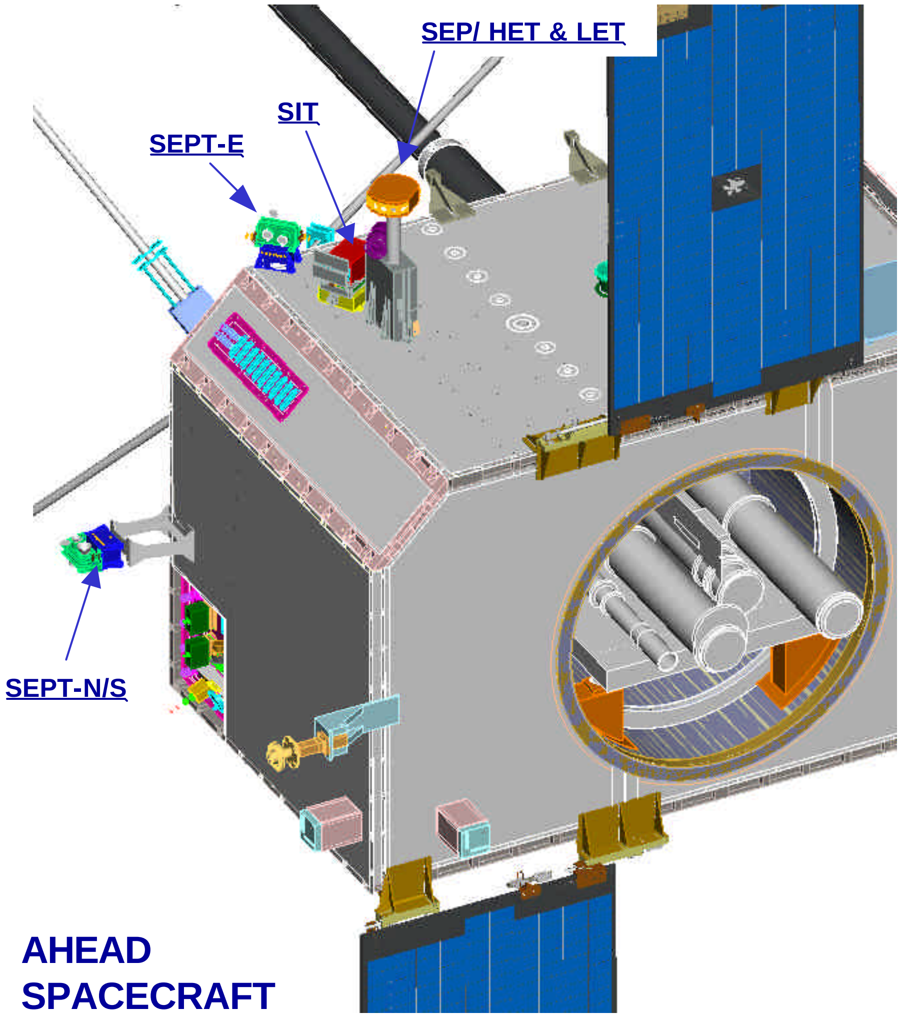
Parker Spiral Viewing

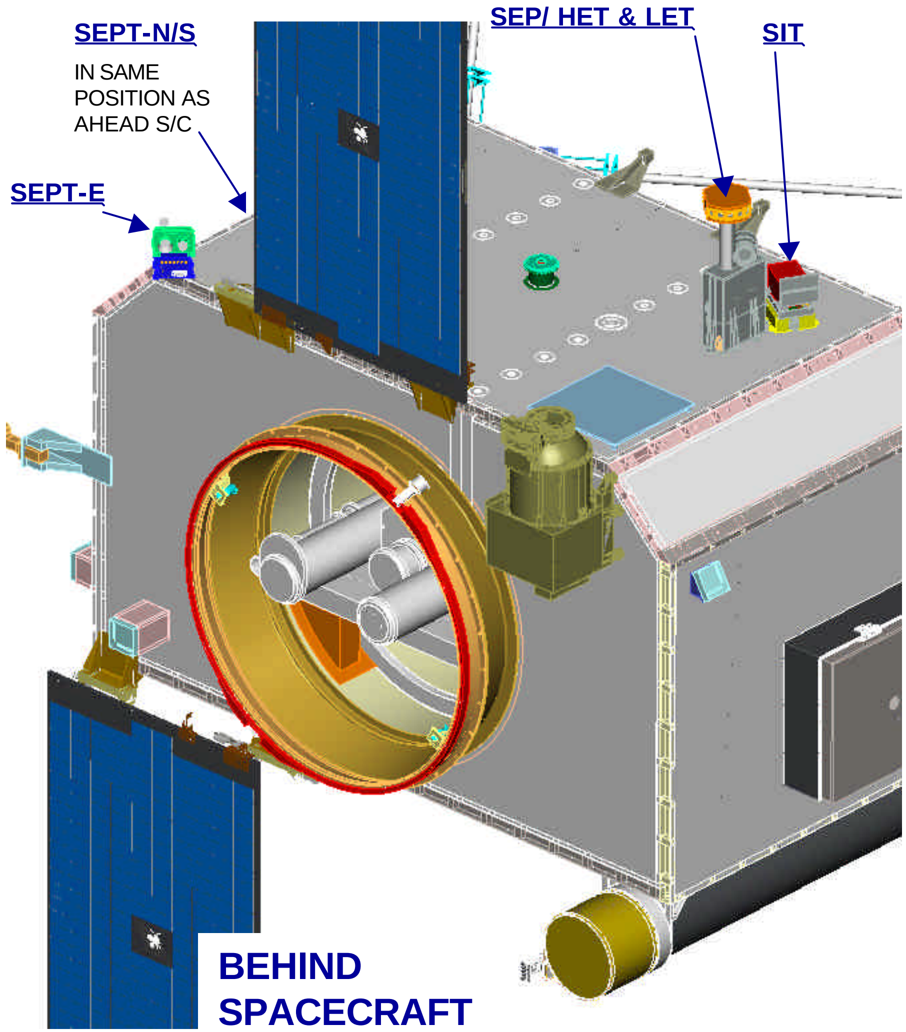


This figure shows magnetic field lines being carried radially out from the sun by the solar wind. These field lines are wrapped into a spiral (known as the Parker Spiral) due to the sun's rotation. Particles coming from the sun travel along the field lines, so the SEP Fields of View (FOVs, shown in green)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

SEP Instrument Suites





SEP Measurement Techniques

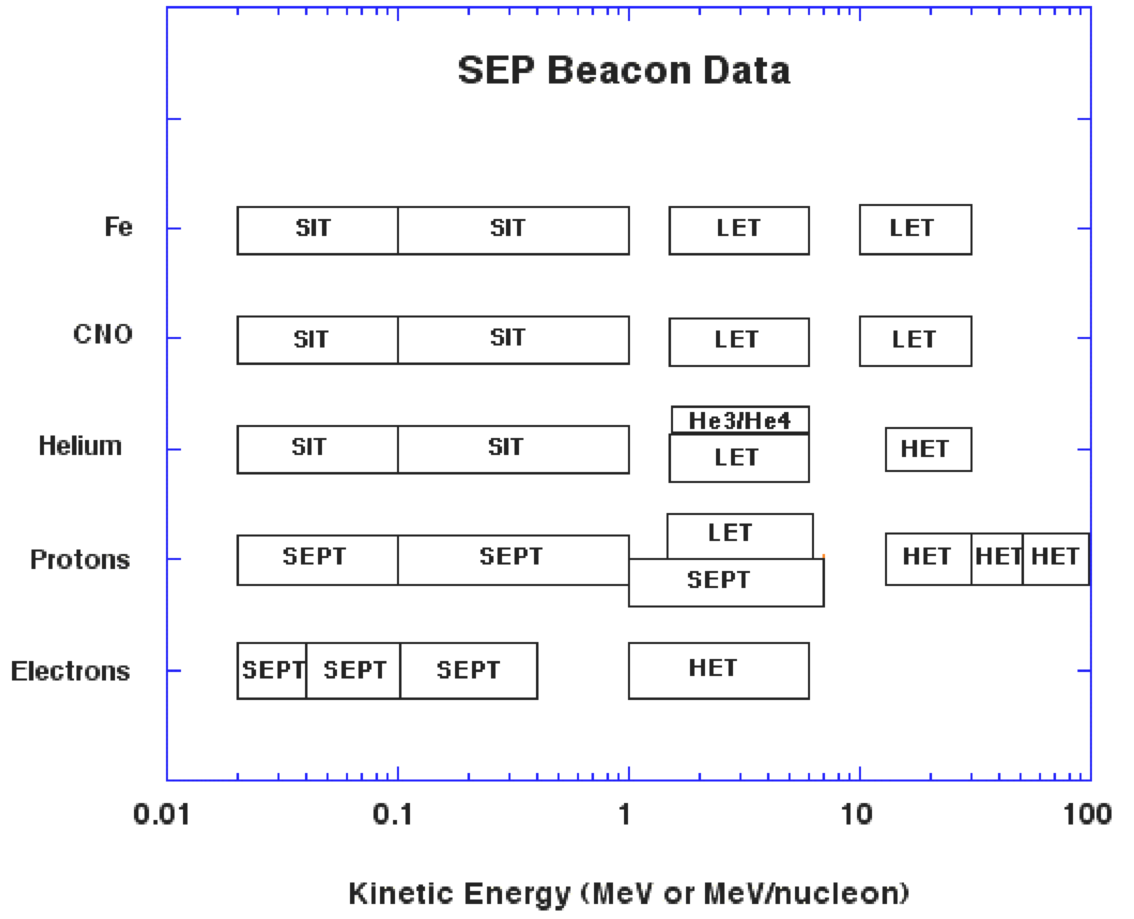
- **Solar Energetic Particle Telescopes**
  - measure electrons, protons, and He
  - use combination of deflection magnets, thin foils, and solid-state detectors
  - uses multiple look directions to measure particle anisotropies
- **Suprathermal Ion Telescope**
  - measures intensities of low energy ions, predominantly He to Fe
  - uses combination of two microchannel plates to measure time-of-flight and a solid-state detector to measure total energy
- **Low Energy Telescope**
  - measures intensities of protons, He, and heavier nuclei up to Fe
  - uses solid-state detectors to determine particle energy and type using the so-called dE/dx by residual E method
  - measures particle anisotropies in the ecliptic plane
- **High Energy Telescope**
  - measures intensities of electrons, protons, He and heavier nuclei up to Fe
  - uses solid-state detectors and dE/dx by residual E method to determine particle type and energy

Radioactive Sources

The following radioactive sources will be required for testing the SEP instruments during integration and test

- **SEPT:**
  - one 10 microCurie Co-60 source (e + gamma)
  - not required in thermal vacuum test
- **SIT:**
  - one 500 microCurie Am-241 source (alpha particles)
  - required in thermal vacuum test
- **LET:**
  - two 10 microCurie Th-228 sources (alpha particles)
  - eight 1 microCurie Po-210 sources (alpha particles)
  - not required in thermal vacuum test
- **HET:**
  - one 1 microcurie Ru-106 source (e + gamma)
  - not required in thermal vacuum test

SEP Beacon Data



SEP Reviews

- IMPACT SEP/MAG Peer Review at GSFC, April, 2001
- IMPACT Preliminary Design Review at APL, September, 2001
- LET and SEP Central Software Requirements Review at Caltech, April, 2002
- HET/SIT Software Requirements and Software Design Review at GSFC, August, 2002
- SEPT Door Mechanism Review at Kiel, Sept. 23, 2002
- SIT Door Mechanism Review at GSFC, November 15, 2002
- Status of Action Items:
  - All RFA’s are closed except for ones from the HET/SIT Software Review, 10 of 13 from the SEPT Door Mechanism Review, and any which may be generated by the SIT Door Mechanism Review
  - Responses have been recently provided to all HET/SIT Software Review RFA’s (but none have been closed out)

SEP Contamination Control

- **Sensitivity to volatiles**
  - **Solid-state detectors and microchannel plates are sensitive to low levels of volatile contamination**
  - **This has been addressed in the Project level Contamination Control Plan**
- **Purge/ Flow Rates**
  - **All purge rates are passively controlled by sintered metal flow restrictors with an input pressure of 15 PSI**
  - **1 liter/hour (each): SEPT-E, SEPT-N/S, HET**
  - **5 liters/hour (each): SIT, LET**
- **Refurbishment**
  - **It is possible that SIT will need to be removed from the spacecraft after spacecraft thermal vacuum testing is complete in order to replace a solid-state detector or microchannel plate**

SEP resources: Mass [g] 11/12/02

Component	PDR	CDR
SIT sensor & door	500	483
SIT elec. boards & wiring	370	518
SIT HVPS	160	260
SIT encl. & hdwr	200	200
------------------------	------	------
SIT subtotal:	**1230**	**1461**
SEPT-NS	520	666
SEPT-E	520	666
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SEPT subtotal:	**1040**	**1332**
LET det. & housing	515	565
LET electronics	235	306
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LET subtotal:	**750**	**871**
HET det. & housing	500	500
HET electronics	160	239
------------------------	------	------
HET subtotal:	**660**	**739**

SEP resources: Mass [g] cont. 11/12/02

Component	PDR		CDR	
Cent. elec. encl. & hdwr	1500		1575	
El. boards, shields, harness	1090		1354	
------------------------	------		------	
Central electr. subtotal:	**2590**		**2929**	
SEPT-NS bracket	270		270	
LET bracket	600		600	
------------------------	------		------	
SEP subtotal:	**7140**	26 AWG	**8202**	28 AWG
SEPT-NS Ahead harness	185	@ 1.7 m	186	@ 2.13 m
SEPT-NS Behind harness	293	@ 2.9 m	290	@ 3.48 m
SEPT-E Ahead harness	73	@ 0.4 m	94	@ 0.94 m
SEPT-E Behind harness	240	@ 2.3 m	210	@ 2.44 m
Thermal blankets	120		120	
SEP Ahead total:	**7518**		**8602**	
SEP Behind total:	**7793**		**8822**	

SEP resources: Power [mW] 11/12/02

Component	PDR	CDR
SIT HVPS & energy el.	473	332
TOF electronics	680	871
MISC @ 4 MHz & DAC	120	161
------------------------	------	------
SIT subtotal:	**1273**	**1364**
SEPT-NS	502.5	493
SEPT-E	502.5	493
------------------------	------	------
SEPT subtotal:	**1005**	**986**
PHASIC hybrids	486	486
+5V reg, -5V ref, etc.	N/A	217
HK ADC	65	6
MISC @ 8 MHz	223	230
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LET subtotal:	**774**	**939**

SEP resources: Power [mW] cont. 11/12/02

Component	PDR		CDR	
PHASIC hybrids	63		63	
+5V reg, -5V ref, etc.	N/A		103	
HK ADC	65		6	
MISC @ 8 MHz	223		230	
------------------------	------		------	
HET subtotal:	**351**		**402**	
Analog/Post-Reg	208		181	
Logic (MISC @ 4MHz)	120		124	
SSD Bias Supply	202	@ +20 C *	99	@ +20 C *
------------------------	------		------	
Central electr. sub.:	**530**		**404**	
SEP subtotal:	**3933**		**4095**	
LVPS (@ 65% eff.)	**2118**		**2205**	
------------------------	------		------	
SEP total:	**6051**		**6300**	

* SSD Bias Supply capable of consuming 195 mW @ +35 C & end of detector life.
If 5 unique detectors short-circuited, it consumes 320 mW @ +35 C & end of life.

SEP resources: Data rate [bit/s] 11/12/02

Component	PDR	CDR		
	Science	Science	HK	Beacon
SIT	243.6	417.6	1.2	3.2
SEPT	69.6	69.6	2.4	5.9
LET	348	556.8	0.5	6.1
HET	139.2	208.8	1.2	3.7
Central electronics	0	0	3.2	0.3
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SEP subtotal:	**800.4**	**1252.8**	**8.5**	**19.2**
CCSDS packet header	N/A	52.8	0	0
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SEP total:	**800.4**	**1305.6**	**8.5**	**19.2**

SEP resources: Data rate [bit/s] cont. 11/12/02

- **Science data**
  - **2088 bits/packet (w/o packet headers)**
  - **36 CCSDS packets/minute distributed as follows:**
    LET - 16, SIT - 12, HET - 6, SEPT - 2

- **Housekeeping data**
  - **64 bytes/minute**
  - **1 message/minute. Bytes/minute distributed as follows :**
    LET - 4, SIT - 9, HET - 9, SEPT - 18, SEP Central - 24

- **Beacon data**
  - **144 bytes/minute**
  - **1 message/minute. Bytes/minute distributed as follows:**
    LET - 46, SIT - 24, HET - 28, SEPT - 44, Status - 2

International Activities, SEP

- **TOF system being built by Max/Planck Lindau using UMd designs**
  - GSFC arranged for drawings & documents to be transferred
  - Prototype circuit has been received in US
- **Caltech/U. Kiel/ESTeC**
  - Regular teleconferences seem to be adequate to this point
- **Caltech/Micron/LBL/JPL interaction on L1 detector**
  - Micron Ltd. will process front side of 300 um thick, 4” wafers
  - Wafers will be sent to LBL/JPL for thinning to 20 um in detector active areas
  - Wafers will be returned to Micron for processing the backside
- **Other Detectors**
  - Detector mounts manufactured in the US have been sent to Micron via GSFC
- **Will need GSFC assistance with some hardware transfers**
  - No TAA’s at Caltech; XFRs between Micron and Caltech will be done via GSFC
  - SEPT hardware needs to be imported and possibly exported

On-Orbit Time Line Constraints

- SEPT and SIT have to wait until well after turn-on before opening doors (~2 months for A spacecraft, ~3 months for B spacecraft)
  - Reason is that there can be off-pointing maneuvers of as much as 45 degrees with respect to the spacecraft-sun line which could cause direct sunlight on detectors (SEPT) or on very thin (~1000 Angstroms) Ni foils (SIT)

IMPACT/SEP Top Risks

- LET L1 detector fabrication
  - Issues will be discussed in Mark Wiedenbeck's presentation
  - Significant recent progress has been made with both Plan A and Plan B
  - Nominal decision date: 12/10/02
- Thermal
  - Sun-staring detectors and windows can see very large temperature swings (e.g. detectors can change by as much as ~ 55 degrees C)
  - Availability and grounding of thermal blanketing material
    - ITO on GSFC composite on Kapton is base-lined
  - non-trivial operational and survival heater power requirements
- Vibration
  - LET is mounted fairly far out from spacecraft in order to clear field of view
    - Vibration calculations are being undertaken now
  - SEPT-N/S is also mounted out on a bracket
    - Initial calculations indicate OK but more detailed calculations will be performed soon
- Contamination
  - Solid-state detectors and microchannel plates are sensitive to contamination by volatiles
  - SIT is the most sensitive (may need refurbishment after spacecraft thermal vacuum test)
  - All SEP instruments will be purged up until launch
  - Have worked closely with Project/APL Contamination Control Committee on this issue