SEP Central/LET/HET/SIT Test Readiness Review

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version 3++ 1/19/2005

SEP Sensor Suite

- Low Energy Telescope (LET)
- High Energy Telescope (HET)
- Suprathermal Ion Telescope (SIT)
- Solar Electron and Proton Telescope (SEPT)
- SEP Central Electronics

SEP Responsibilities

- **University of Kiel** - Design/fabrication/test of SEPT telescopes
- **ESTeC** - Design/fabrication/test of SEPT electronics (except thermal balance)
- **U of MD** - Overall responsibility for design/test of SIT
- **Max Planck/Lindau** - Digital portion of SIT time-of-flight system
- **Caltech**
  - LET development/test; SEP Central electronics (except LVPS), PHA ASIC & MISC development
  - LET, SEP Central, and SEPT software development
  - LET and SEP Central GSE development
  - Overall integration/test of SEP suite
- **JPL**
  - LET/HET detector procurement
  - LET development/test
- **GSFC**
  - HET development/test including software
  - Overall SEP mechanical design and fabrication, excluding SEPT (e.g. detector, telescope, enclosure, and bracket designs)
  - Overall SEP thermal design
  - SIT fabrication/assembly/testing + SIT MISC + SIT software + SIT detector testing
  - Thermal balance of SEPT; thermal vac/balance of SIT
- **UCB** - SEP Central LVPS & SIT HVPS

Review Organization

- IMPACT held a suite-level PER in January 2004 to cover general plans and the detailed plans of the first sensors (SEPT)
- Today's review covers the test readiness and test plans for
  - SEP Central, LET, and HET
    - Alan Cummings, Dick Mewaldt, & Tycho von Rosenvinge
  - SIT
    - Peter Walpole and Glenn Mason
- Plus short status report from SEPT
  - Reinhold Mueller-Mellin
- EMC/EMI and boom suite status reports will be given by Dave Curtis

Agenda
(Winnett Lounge, Caltech)

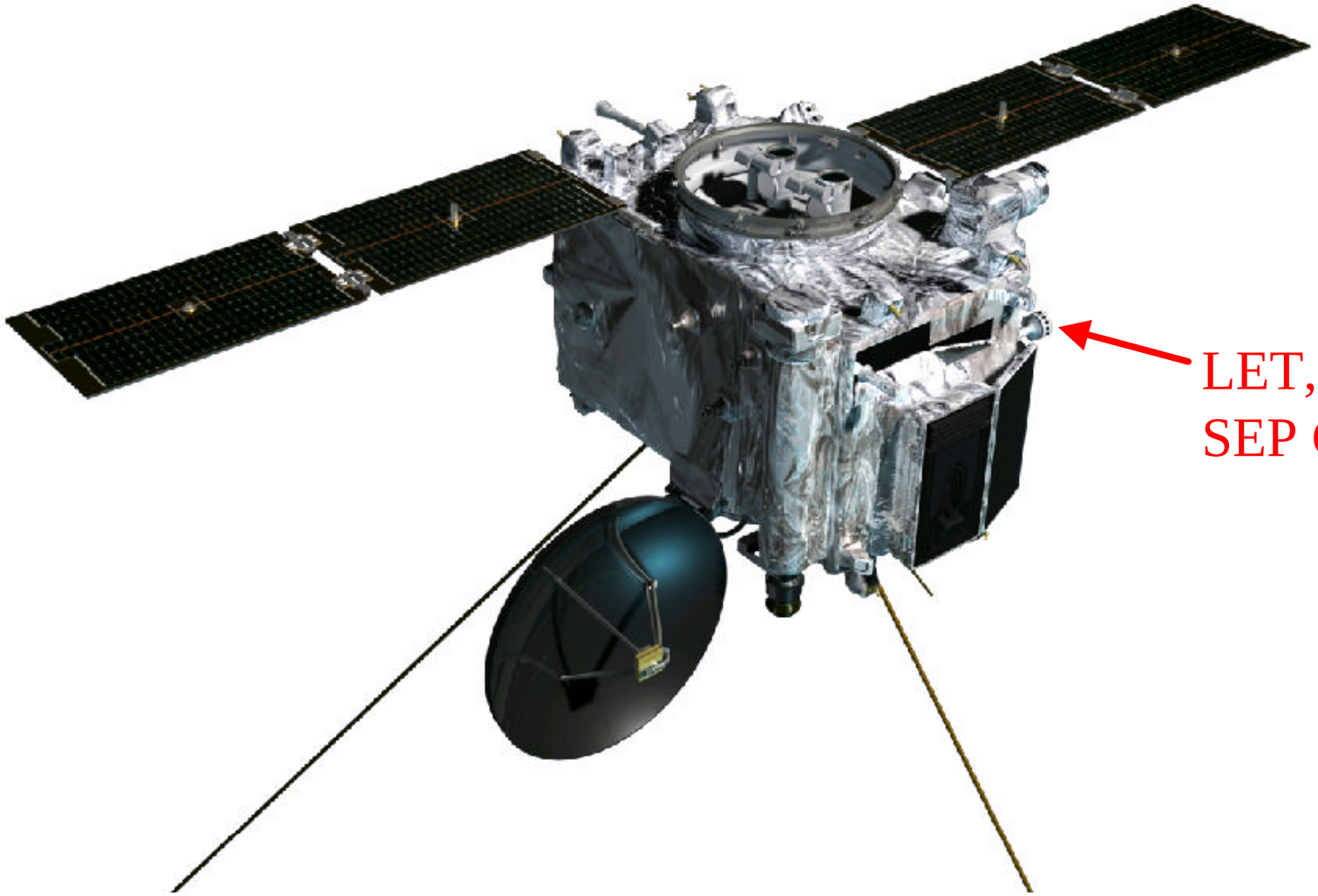
8:30 am	Welcome	Cummings
8:40 am	SEPT Sensor Update	Mueller-Mellin
9:00 am	IMPACT Suite Update	Curtis
9:30 am	HET/LET/SEP Central TRR	Cummings, Mewaldt, von Rosenvinge
10:00 am	Break	
10:15 am	Resume HET/LET/SEP…	
11:30 am	Lunch	
12:15 pm	Resume HET/LET/SEP…	
1:30 pm	SIT TRR	Walpole
2:30 pm	Review Team Caucus/Recommendations	
3:45 pm	Vacate room	

LET, HET, and SEP Central Test Readiness Review version 3++ (1/19/05)

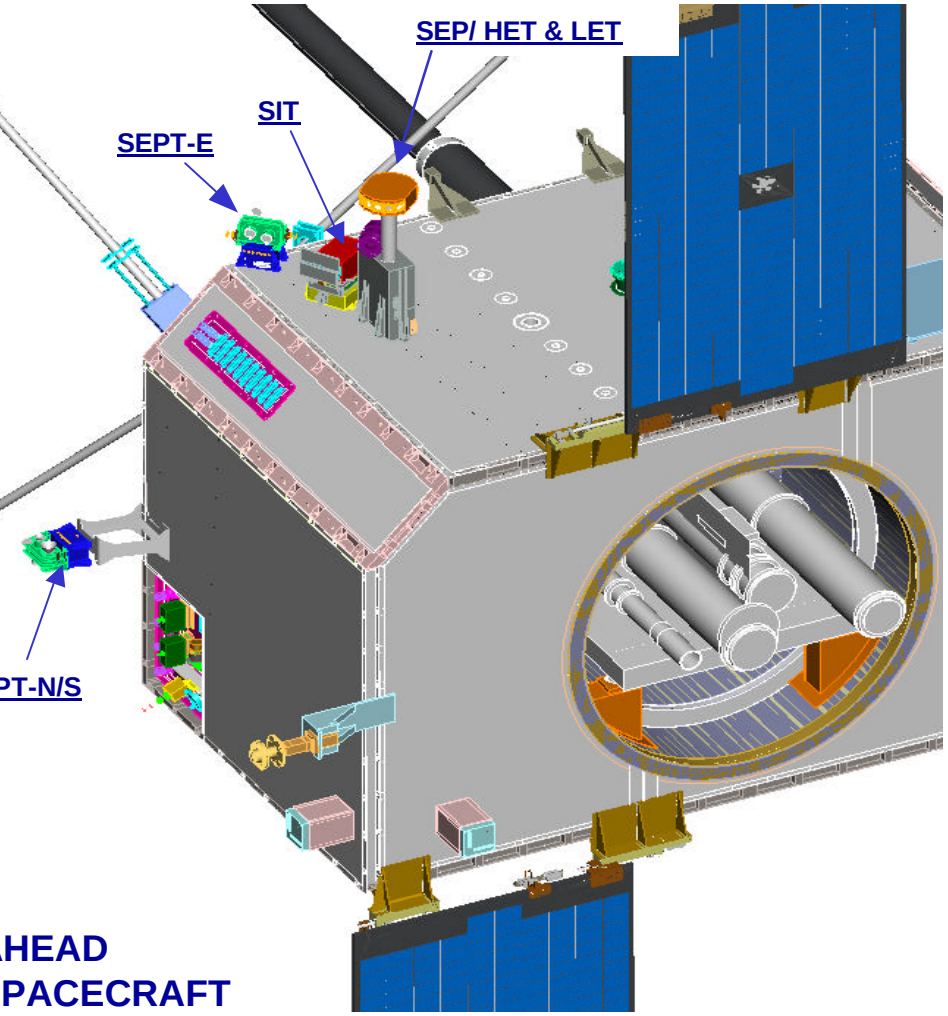
Alan Cummings, Dick Mewaldt, & Tycho von Rosenvinge

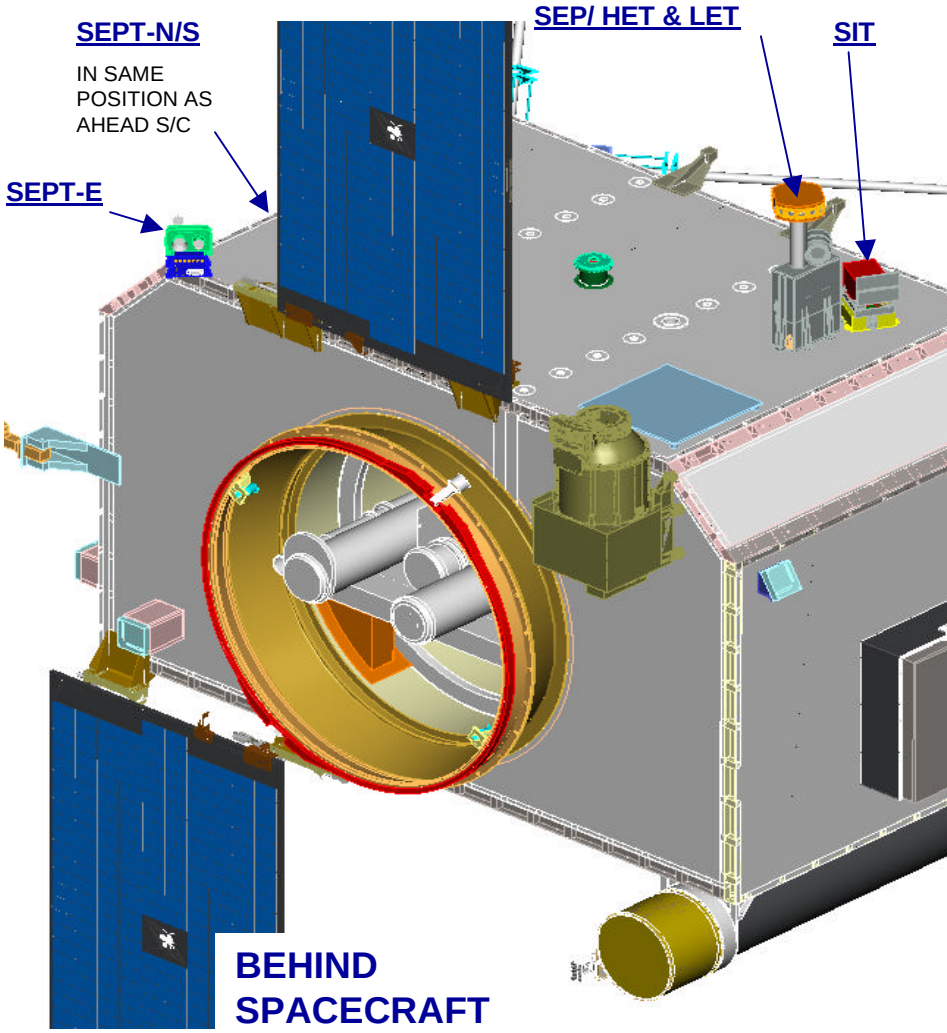
STEREO LET/HET/SEP Central

Behind Spacecraft

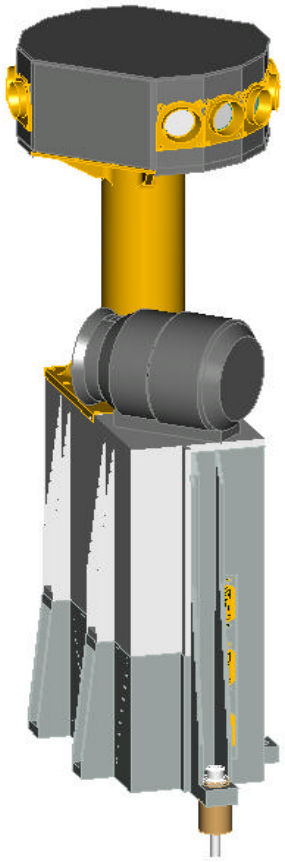


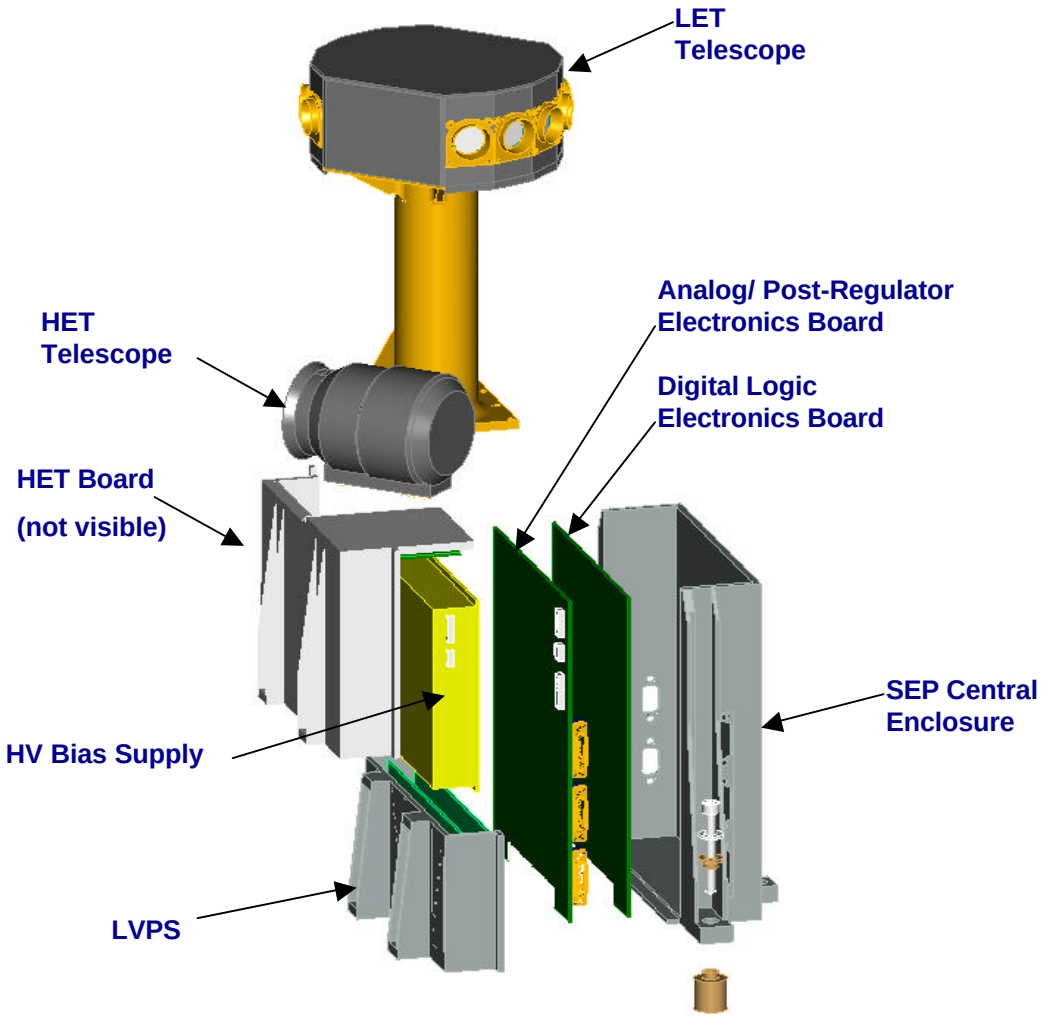
SEP Sensors on the Spacecraft





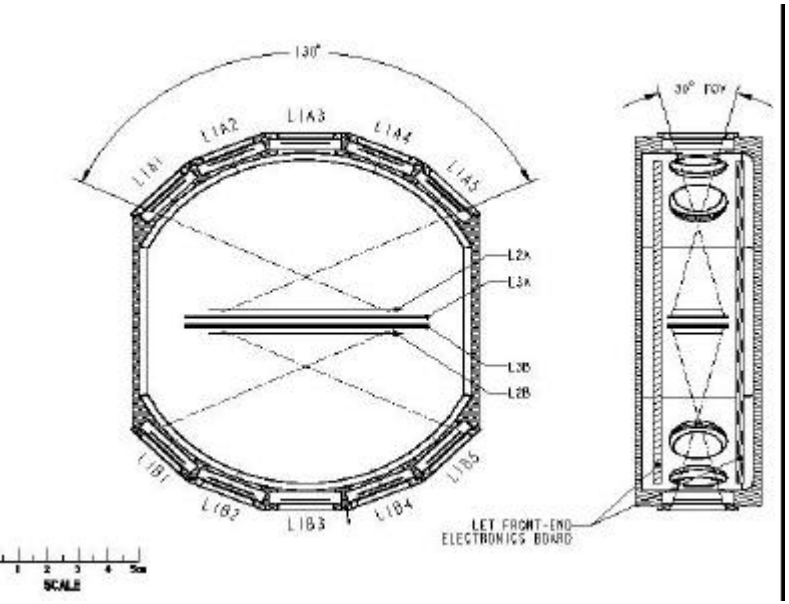
SEP Central, LET, and HET Assembly

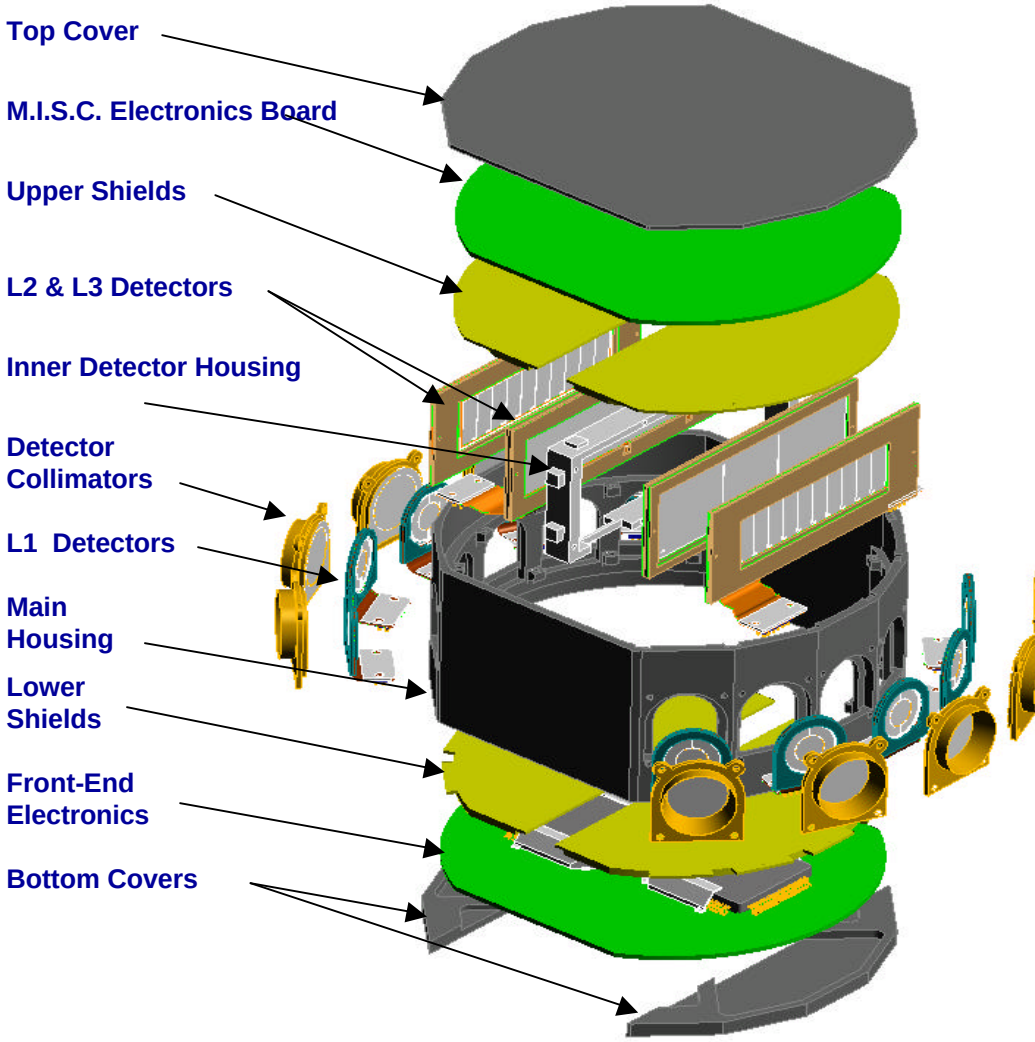




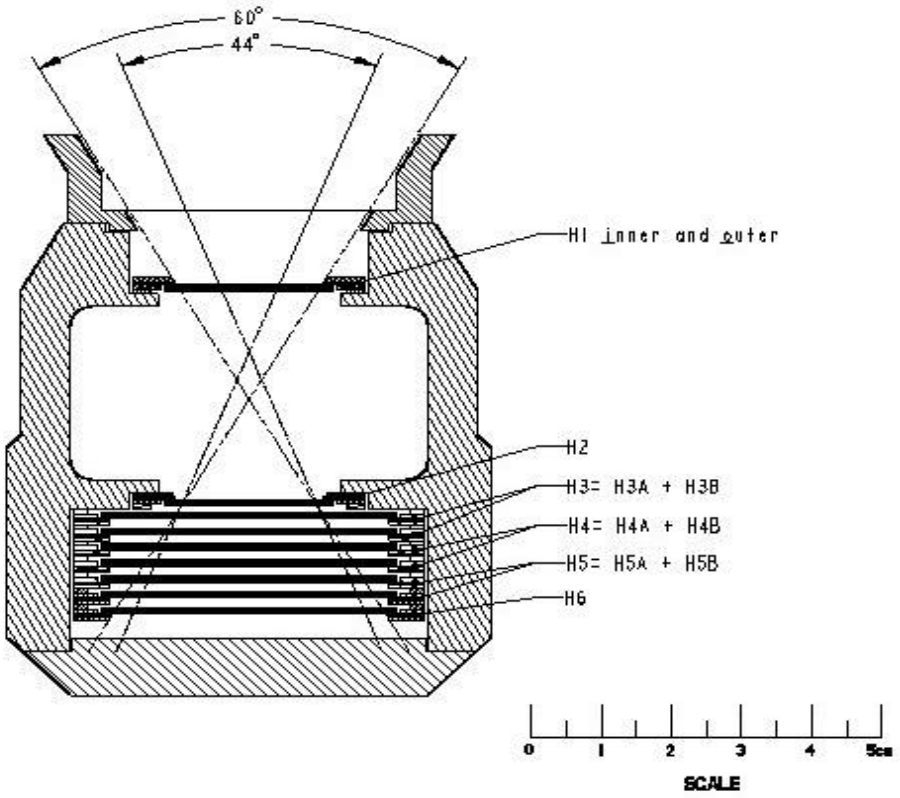
•Behind S/C configuration shown

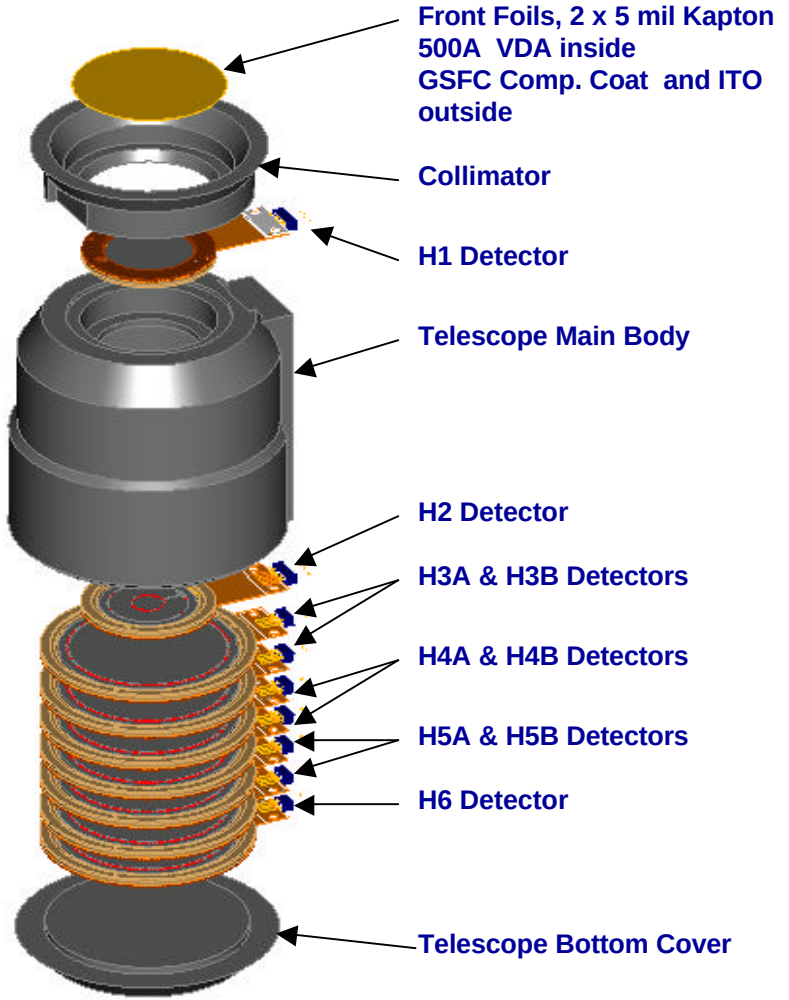
Low Energy Telescope (LET) Schematic





HET Telescope Schematic





Changes since CDR (Nov 2002)

- **Final assembly of LET and SEP Central to be in Galex class 1000 clean room instead of room 5 Downs (class 100,000 area). Also, receipt of other flight assemblies in same area.**
- **L1 detector fabrication method changed from new thinning method to conventional fabrication method.**
- **LET window changed from single window to double window and LET L1 detectors came out about 20% thicker than planned -> threshold energy for particle detection increased slightly.**
- **Several changes in the LET software to improve the data quality, as a result of analysis of data from the end-to-end test at the MSU accelerator run in July 2004.**

Extraction from STEREO Environment Definition, Observatory, Component and Instrument Test Requirements Document (7381-9003C)

1	Mechanical Environments				Reference	How
	1.1	Loads			3.4.1.1	Analysis/Test (sine)
	1.2	Stiffness			3.4.1.2	Analysis/Test (sine)
	1.3	Pressure Profile			3.4.1.3	Design
	1.4	Mass Properties			3.4.4	Analysis/Test
	1.5	Sine Survey			3.4.2	Test
	1.6	Sine Sweep			3.4.2.1	Test
	1.7	Random Vibration			3.4.2.2	Test
	1.8	Acoustic			3.4.3	Test
	1.9	Magnetics			3.5	Test
2	Thermal Environments					
	2.1	1 TV Cycle Survival			3.3.2	Test
	2.2	6 TV Cycles Operational			3.3.2	Test
	2.3	Cold Turn-on			3.3.2	Test
	2.4	Hot Turn-on			3.3.2	Test
	2.5	Balance Test			3.3.2	Test
3	Power Characteristics					
	3.1	Turn-on Transients			3.10.2	Test
	3.2	Operating Transients & Ripple			3.10.3	Test
	3.3	Turn-off Transients			3.10.4	Test
	3.4	Under & Over Voltage			3.10.6	Test
	3.5	Power Bus Short Circuit			3.10.7	Test

EMI/EMC covered separately in 7381-9030

Reasons why we are nearly ready to begin environmental testing

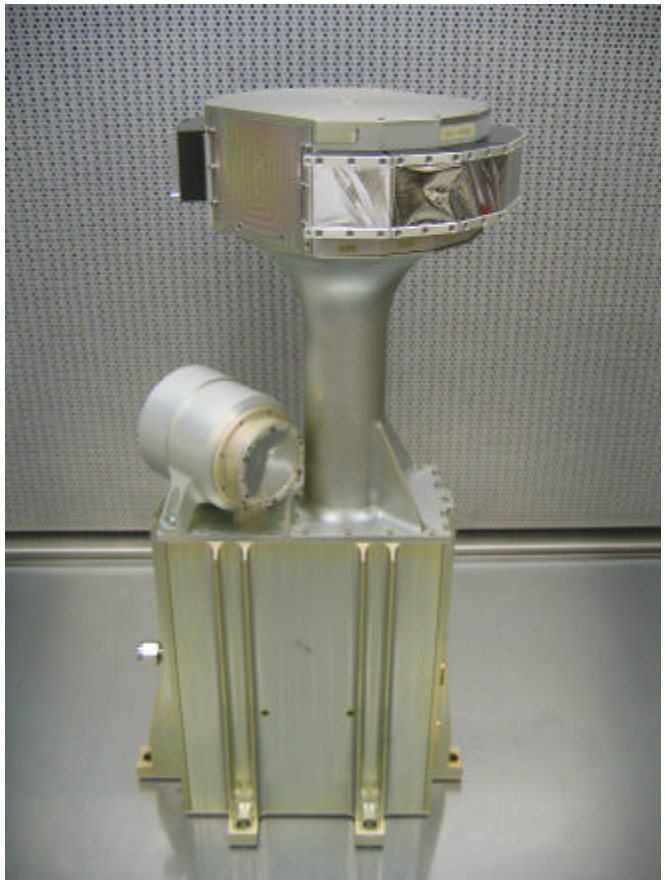
1) FM 1 and FM 2 units in nearly final configuration were assembled, working, and taken to an accelerator at MSU for end-to-end test in July 2004 and FM 1 participated in EMI/EMC test in October/November 2004
   - LET performance meets all requirements
   - HET performance degraded by cross-talk; will be fixed in S/W
2) Almost all critical pre-environmental analysis and testing are complete
   - Final CPTs to be done when final configuration of FMs established
3) All waivers approved
4) All PFRs addressed with the Project and all but one closed in “principle”
5) Comprehensive performance test procedures have been written
6) Vibration/acoustic test plan and procedure are written
7) Thermal balance/thermal vacuum test plan is written
8) Electrical and mechanical GSE are ready and harnesses will be ready by time of need

Reason why we are not ready to begin environmental testing

- PFR PR-1025 is still open
  - Infrequent (days between episodes) spontaneous reboots of SEP Central
  - Due to reversed tantalum capacitors in LVPS
  - Plan being developed
- Some relatively minor mechanical work left to do

STEREO LET/HET/SEP Central

1) FM 1 and FM 2 units in nearly final configuration were assembled, working, and taken to an accelerator at MSU for end-to-end test in July 2004 and FM 1 participated in EMI/EMC test in October/November 2004



STEREO LET/HET/SEP Central

1) FM 1 and FM 2 units in nearly final configuration were assembled, working, and taken to an accelerator at MSU for end-to-end test in July 2004 and FM 1 participated in EMI/EMC test in October/November 2004

- **Next 17 slides on LET performance presented by Dick Mewaldt**

STEREO LET/HET/SEP Central

3.6. ***LET Requirements***

Description	Goal	Requirement	Source
FOV	2 oppositely directed 130 x 30 degree fans	2 oppositely directed 100 x 30 degree fans	Derived from MRD 4.7(F,G) & CME characteristics
Energy Range (MeV/nucleon)	H: 1.4 - 6 He: 1.4 - 13 O: 2.5 – 25 Fe: 2.5 - 50	H: 1.8 - 3 * He: 1.8 - 13 * O: 4 – 25 * Fe: 4 – 25 *	MRD 4.7 (F,G)
Geometric Factor cm^2 ster	H, He: 0.9 6≤Z≤26: 4.5	H, He: 0.5 6≤Z≤26: 2	Derived from MRD 4.7(F,G) & CME characteristics
Element Resolution	Also resolve Na, Al, S, Ar, Ca	Resolve H, He, C, N, O, Ne, Mg, Si, Fe	Derived from MRD 4.7(F,G) & CME characteristics
^{4}He Mass Resolution	≤0.25 AMU	≤0.35 AMU	Derived from MRD4.7(F,G) & CME characteristics
Max Event Rate	5000 events/sec	1000 events/sec	Derived from MRD 4.7(F,G) & CME characteristics
Energy Binning	8 intervals per species for Z≥2 4 intervals for H	6 intervals per species for Z≥2 3 intervals for H	Derived from MRD 4.7(F,G) & CME characteristics
Species Binning	Add S, Ar, Ca	H, ^{3}He, ^{4}He, C, N, O, Ne, Mg, Si, Fe	Derived from Element Resolution above.
Time Resolution	1 minute H, He, 15 minutes Z≥6 4 prioritized events/sec	15 minutes 1 prioritized event/sec	Derived from MRD 4.7(F,G) & CME characteristics
Beacon Telemetry:	1 minute for H, He, 6≤Z≤26	1 minute for H, He, 6≤Z≤26	Derived from MRD 6.7.1 & CME charateristics

Summary of LET Requirements from the IMPACT Performance Specification
Version K - 2004 - Apr 01

Modified LET Energy Range Requirement

The LET part of the SEP suite measures ion composition in an intermediate energy range between the lower-energy coverage of SEPT and SIT and the higher-energy coverage of HET. In the original design of LET each of ten apertures was to be covered by a thin (8.5 micron) Kapton window identical to those flown on LEMT/Wind. In order to mitigate the risk of breaking one of these windows during launch or later during the mission, a double-window design (with two 8.5-micron Kapton windows) has recently been adopted. This new, thicker, window design increases the minimum energy required to trigger LET to ~1.8 MeV for protons, ~1.8 MeV/nuc for He, and almost 4 MeV/nuc for ions from C to Fe. The upper end of the energy range, and the charge, mass, and energy resolution of LET are not affected. The overall energy coverage of the SEP suite is also not affected because SEPT will measure protons up to 7 MeV and SIT will measure the composition of heavier ions to ~6 MeV/nuc. As a result, the SEP suite will still satisfy the Mission Requirements Document (460-RQMT-001 Rev D, Section 4.7 F&G), which requires that SEP measure the intensity, composition, energy spectra, and direction of energetic protons from 0.06 to 40 MeV, heavier ions from ~0.03 to 40 MeV/nuc, electrons from ~0.03 to 6 MeV, and 3He-rich solar particle events

STEREO LET/HET/SEP Central

Overview of LET Requirements

Description	Requirement	Goal	Capability	Verification
Field of View	2 oppositely directed 100°x30° fans	2 oppositely directed 130°x30° fans	2 oppositely directed 133°x30° fans	Geometrical analysis
Energy Range (MeV/nuc)	H: 1.8 - 3 He: 1.8 - 13 O: 4 - 25 Fe: 4 - 50	H: 1.4 - 6 He: 1.4 - 13 O: 2.5 - 25 Fe: 2.5 - 50	H: 1.65 - 6 He: 1.65 - 13 O: 3.2 - 25 Fe: 3.4 - 50	Detector thickness maps; range-energy relation; particle accelerator data (Examples below)
Geometry Factor (cm^2sr)	H, He: 0.5 6=Z=26: 2	H, He: 0.9 6=Z=26: 4.5	H, He: 4.05 6=Z=26: 4.05	Geometric analysis, Monte Carlo calc.
Element Resolution	Resolve H, He, C, N, O, Ne, Mg, Si, Fe	Also resolve Na, Al, S, Ar, Ca	H, He, C, N, O, Ne, Na, Mg, Al, Si, S, Ca, Fe	Detector maps, Monte Carlo analysis, Particle accelerator (examples below)
^{4}He Mass Resolution	= 0.35 amu	= 0.25 amu	L1L2: 0.23-0.33 L1L2L3: 0.13-.16	Detector thickness Maps (more below)
Maximum Event Rate	1000 per sec	5000 per sec	1000 - 3000 per sec	Bench tests with pulser, particle accelerator data (See data below)

Overview of LET Requirements (continued)

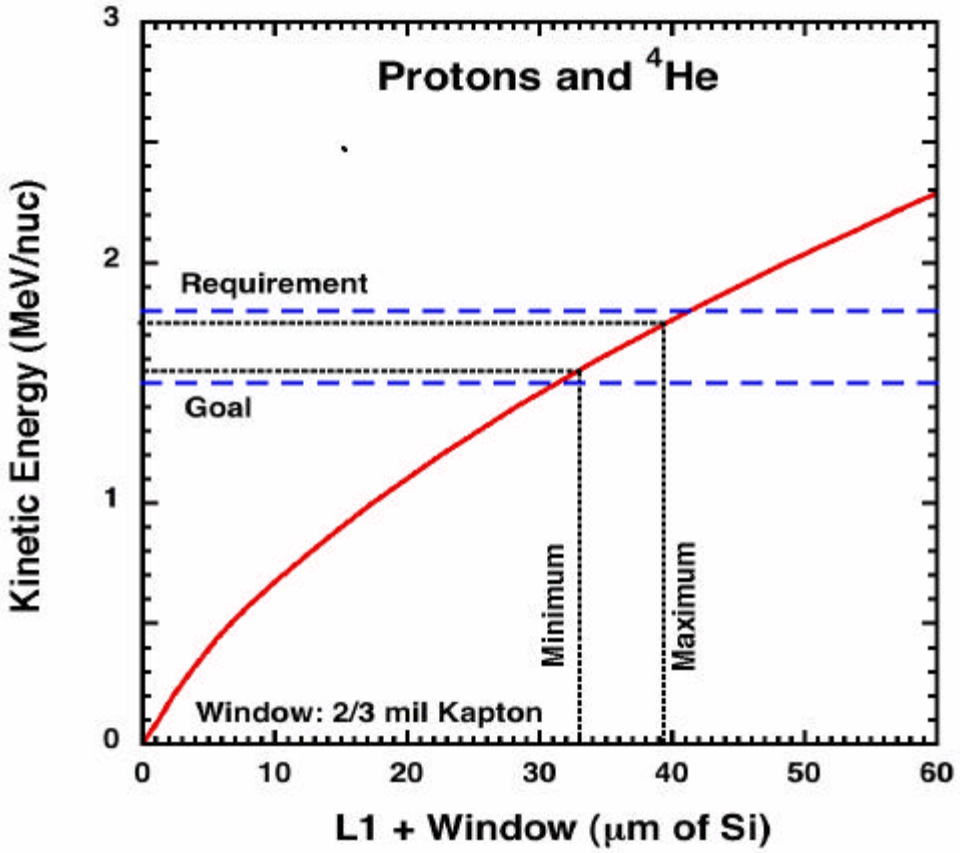
Description	Requirement	Goal	Capability	Verification
Energy Binning	6 intervals for Z = 2; 3 for H	8 intervals per species for Z = 2; 4 for H	8 intervals for Z = 2; 4 for H	Pulser calibrations, Particle accelerator data from MSU, LBL (example below)
Species Binning	H, ^{3}He, ^{4}He, C, N, O, Ne, Mg, Si, Fe	Also identify S, Ar, Ca	H, ^{3}He, ^{4}He, C, N, O, Ne, Na, Mg, Al, Si, S, Ar, Ca, Fe	Pulser, Monte Carlo, Particle accelerator (examples below)
Time Resolution	1-min H, He, 15 min Z = 6; Telem. 1 hi-priority event/s	1-min H, He, Z = 6; Telem. 4 hi- priority events/s	1-min H, He, Z = 6; Telem. 4 hi-priority events/s	Particle accelerator data (see examples below)
Beacon Telemetry	1-min for H, He, Z = 6	1-min for H, He, Z = 6	1-min for H, He, Z = 6	Tested at particle accelerator (examples below)

STEREO LET/HET/SEP Central

Requirement: H: 1.8 to 3 MeV
He: 1.8 to 13 MeV/nuc
Goal: H: 1.4 to 3 MeV
He: 1.4 to 13 MeV/nuc
Capability: H: 1.65 to >6 MeV
He: 1.65 to 15 MeV/nuc

H and He Energy Range

Based on detector thickness measurements and ADC threshold



STEREO LET/HET/SEP Central

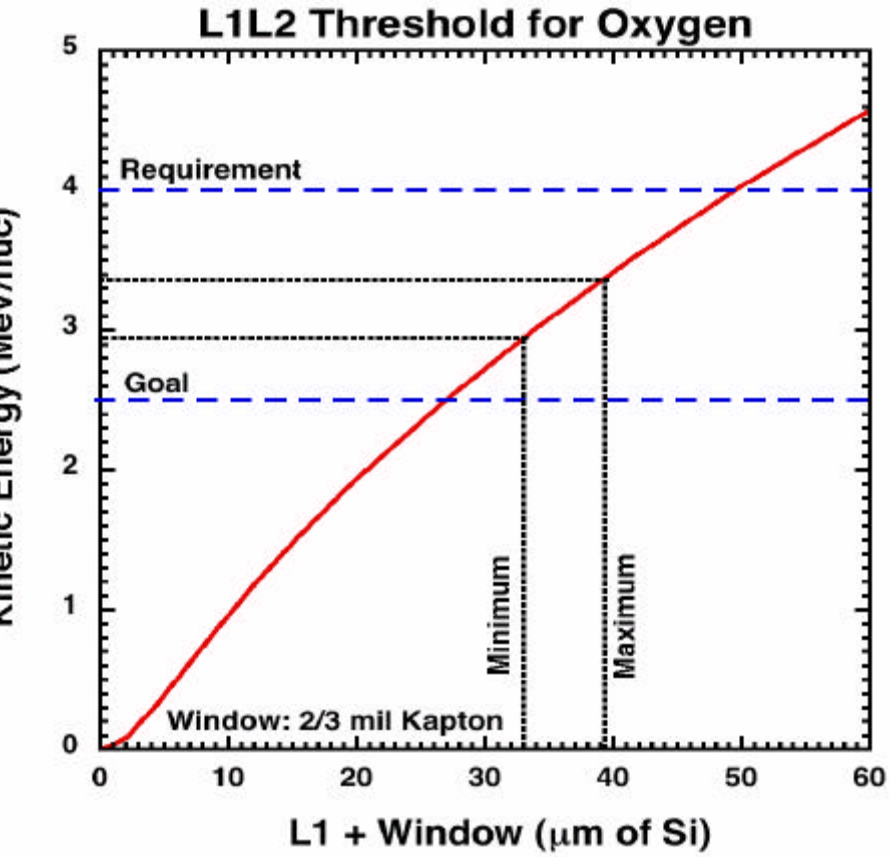
Requirement: O: 4 to 25 MeV/nuc
Fe: 4 to 50 MeV/nuc

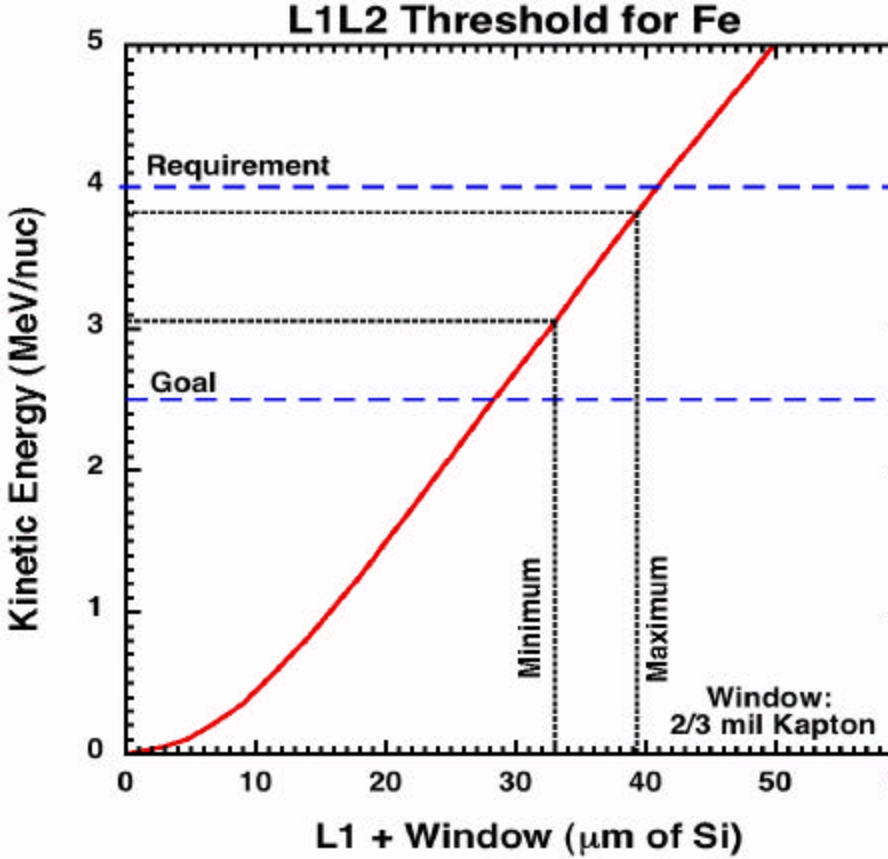
Goal: O: 2.5 to 25 MeV/nuc
Fe: 2.5 to 25 MeV/nuc

Capability: O: 3.2 to 32 MeV/nuc
Fe: 3.4 to 60 MeV/nuc

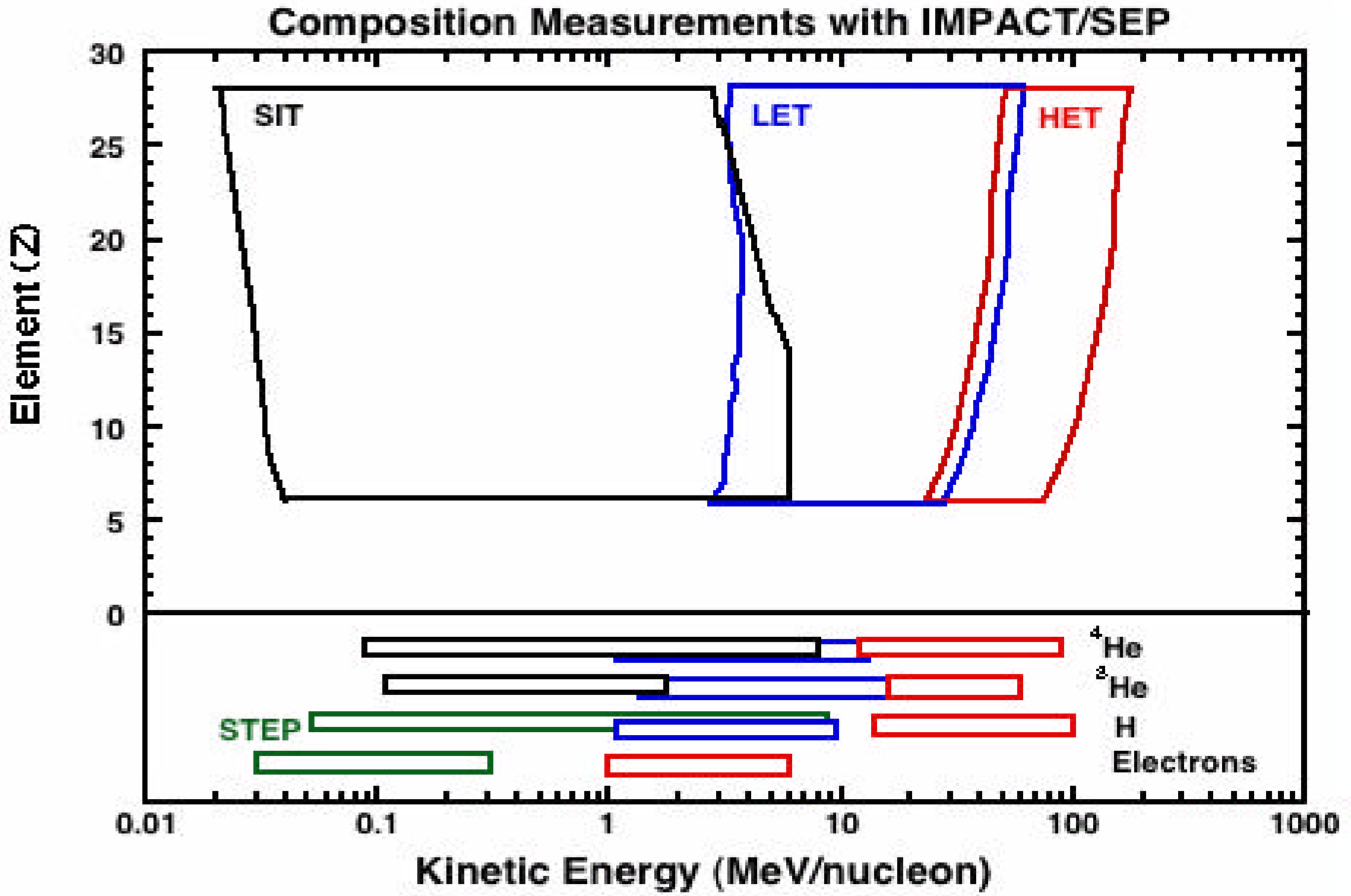
O and Fe Energy Range

Based on detector thickness measurements and range-energy relation





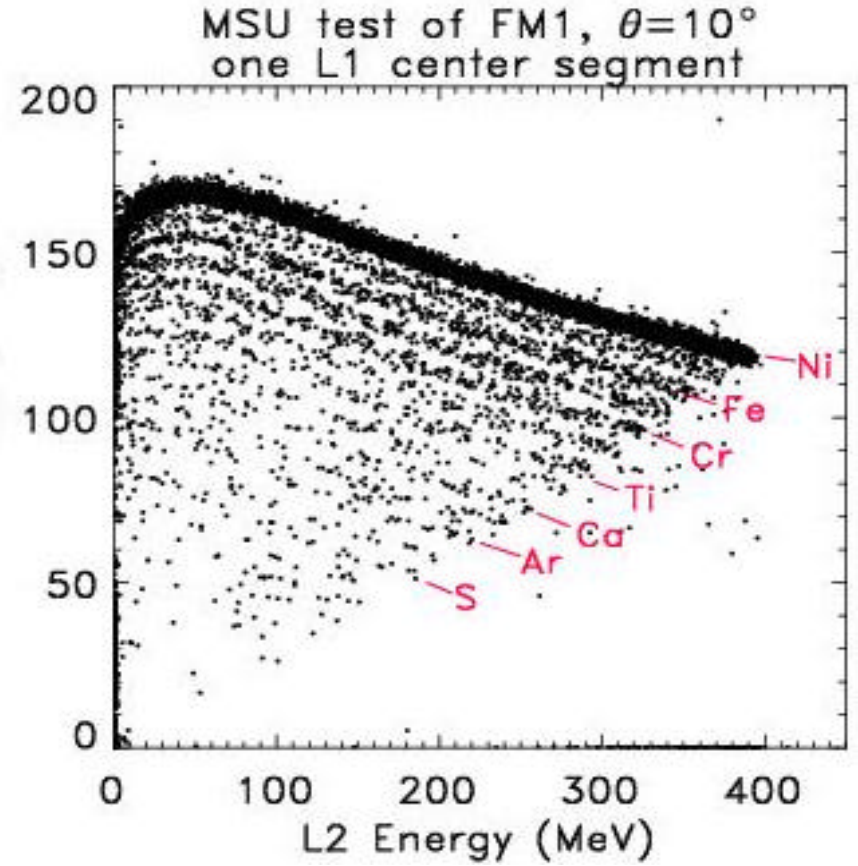
STEREO LET/HET/SEP Central

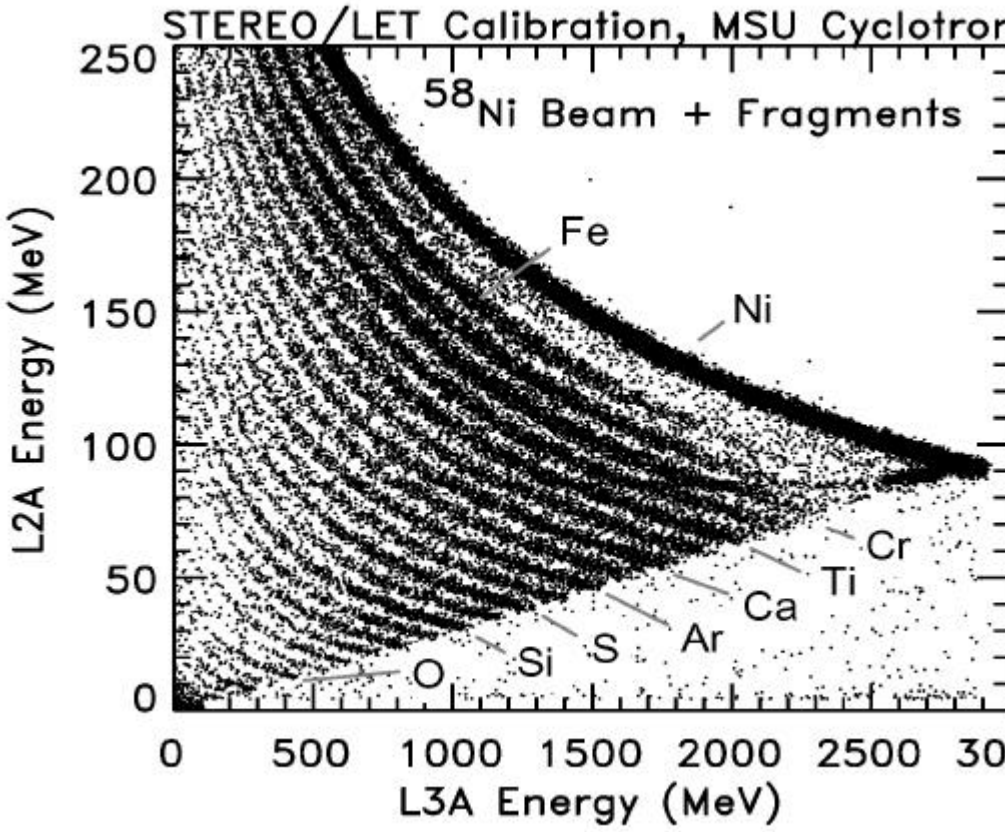


STEREO LET/HET/SEP Central

Element Resolution

Requirement: Resolve H, He, C, N, O, Ne, Mg, Si, Fe
Goal: Also resolve Na, Al, S, Ar, Ca
Capability: Resolve H, He, C, N, O, Ne, Na, Mg, Al, Si, S, Ar, Ca, Fe, Ni in L1L2L3
Resolve H, He, C, N, O, Ne, Mg, Si, S, Ar, Ca, Fe in L1L2



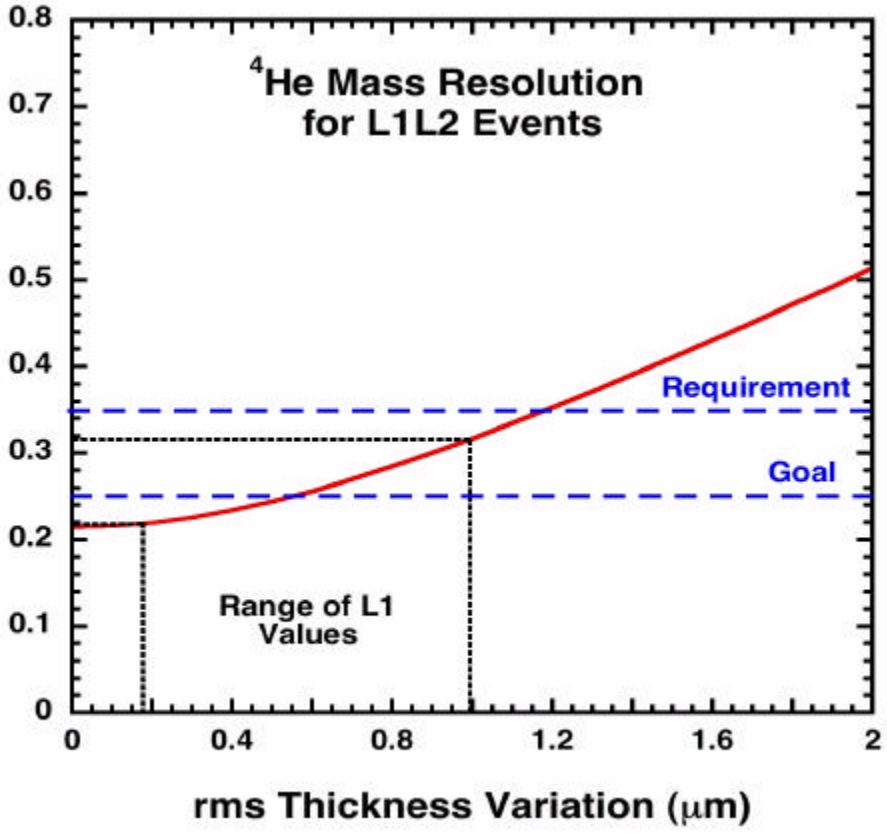


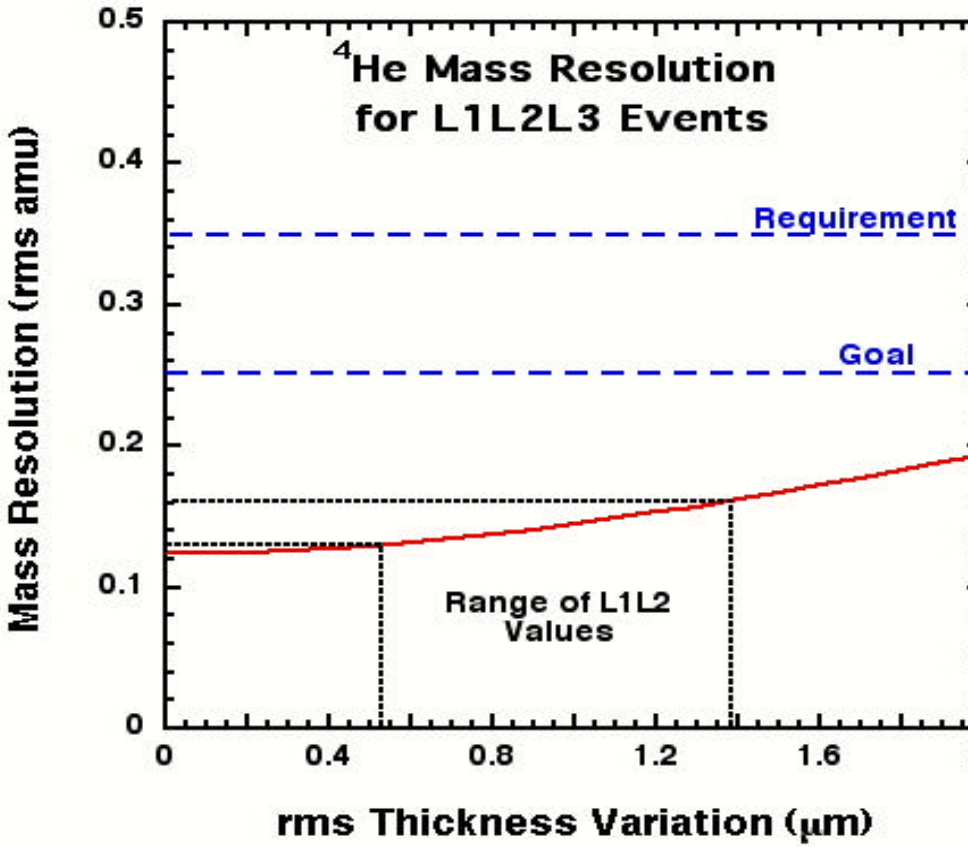
STEREO LET/HET/SEP Central

Requirement: = 0.35 amu
Goal: = 0.25 amu
Capability: 0.23 - 0.33 amu for L1L2
0.13 - 0.16 amu for L1L2L3

^{4}He Mass Resolution

Based on detector thickness uniformity and Monte Carlo simulation

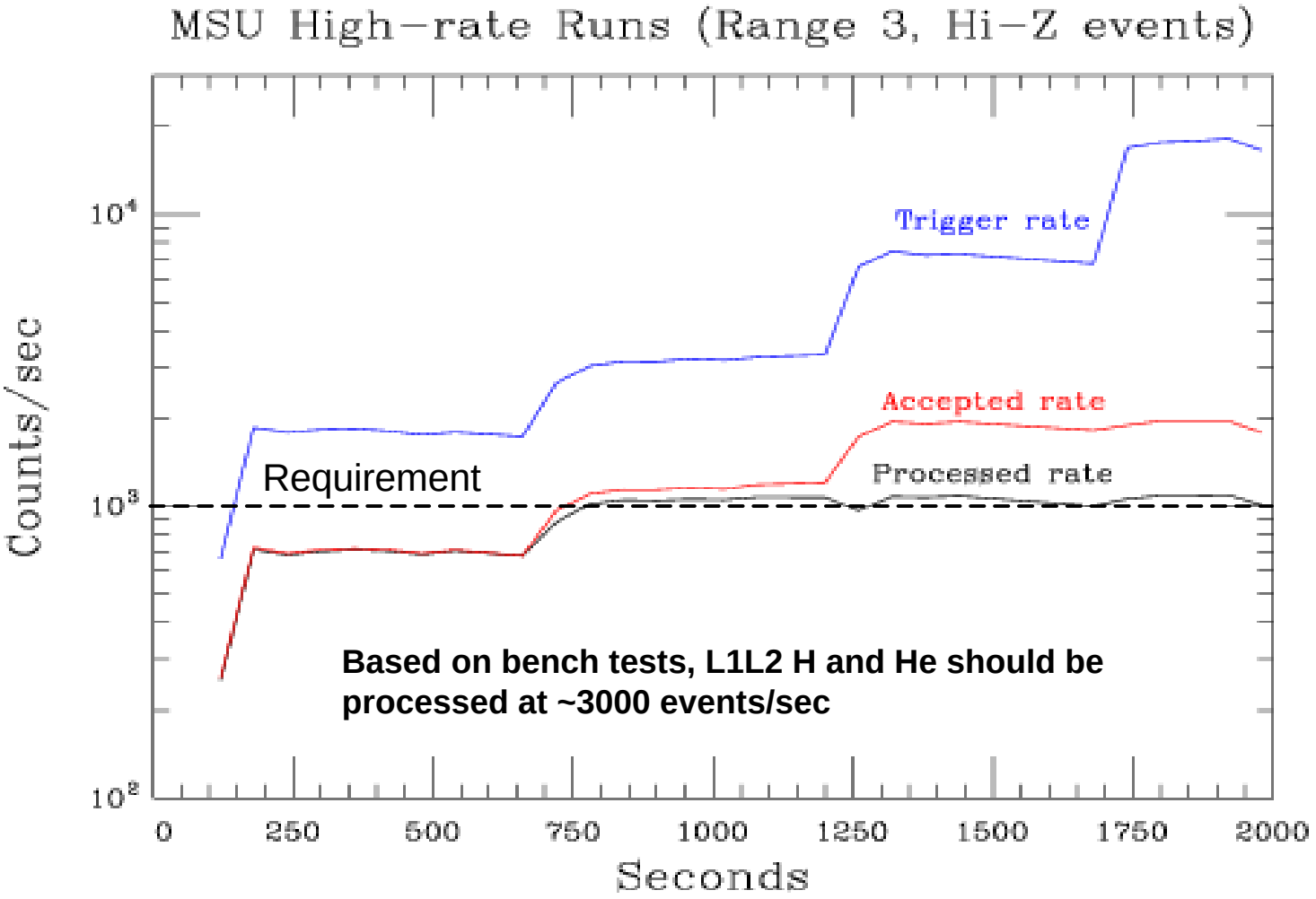




STEREO LET/HET/SEP Central

Requirement: 1000 events/sec
Goal: 5000 events/sec
Capability: 1000 - 3000 events/sec

Maximum Events Rate (On-board Analysis)

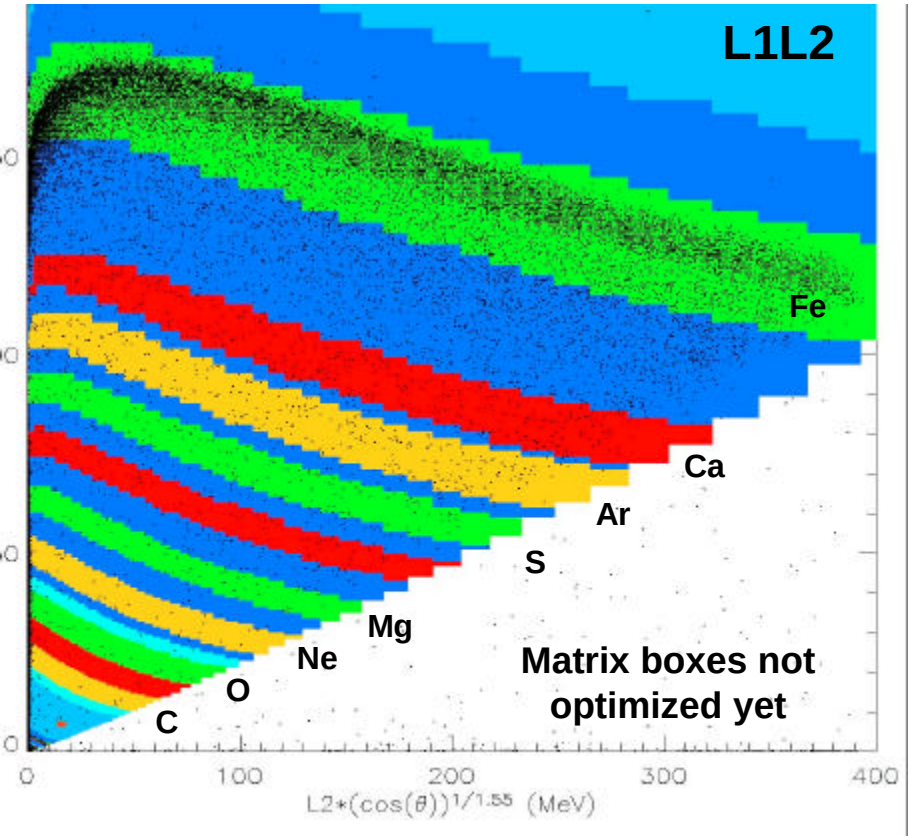


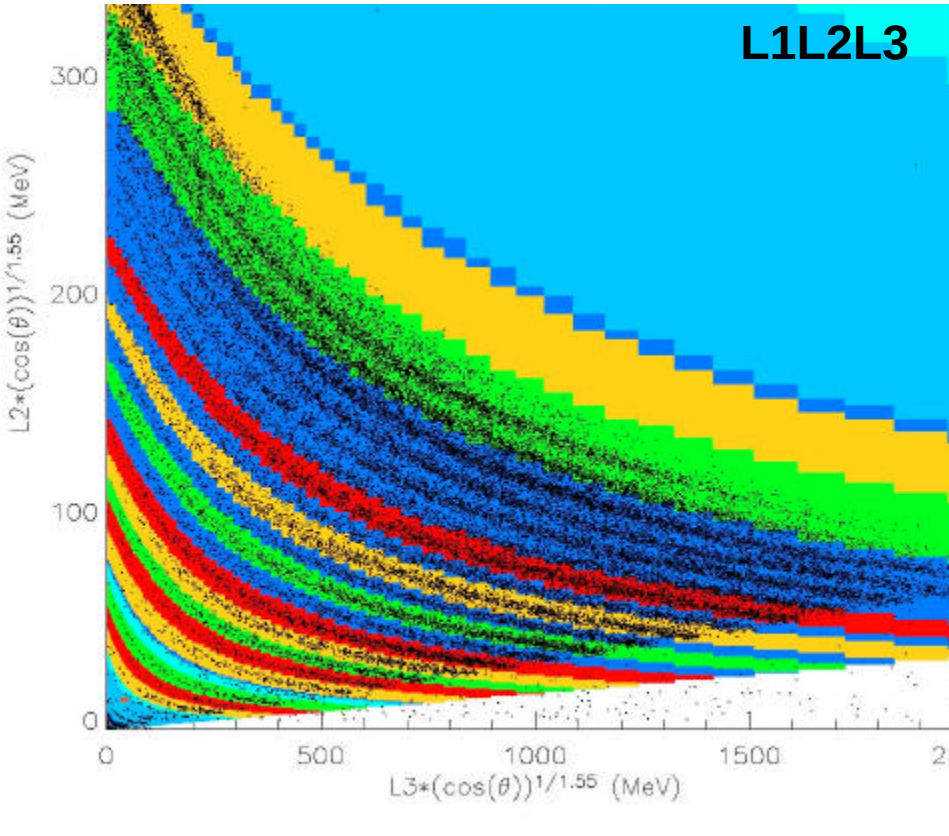
Based on bench tests, L1L2 H and He should be processed at ~3000 events/sec

STEREO LET/HET/SEP Central

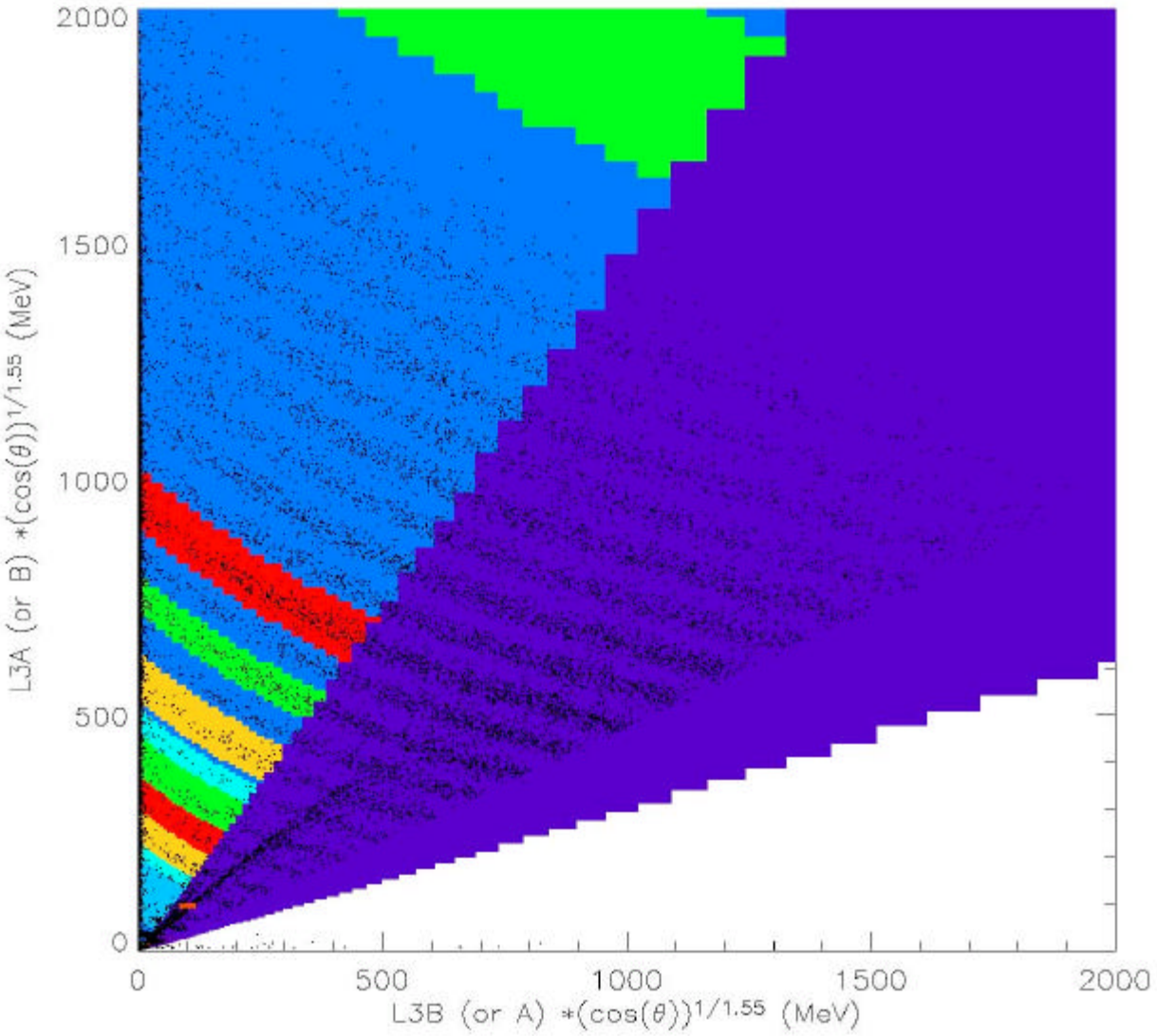
Species Binning - Onboard Analysis

Requirement: H, ^{3}He, ^{4}He,C, N, O, Ne, Mg, Si, Fe
Goal: Add S, Ar, Ca
Capability: Resolve H, He, C, N, O, Ne, Na, Mg, Al, Si, S, Ar, Ca, Fe, Ni in L1L2L3
Resolve H, He, C, N, O, Ne, Mg, Si, S, Ar, Ca, Fe in L1L2





STEREO LET/HET/SEP Central

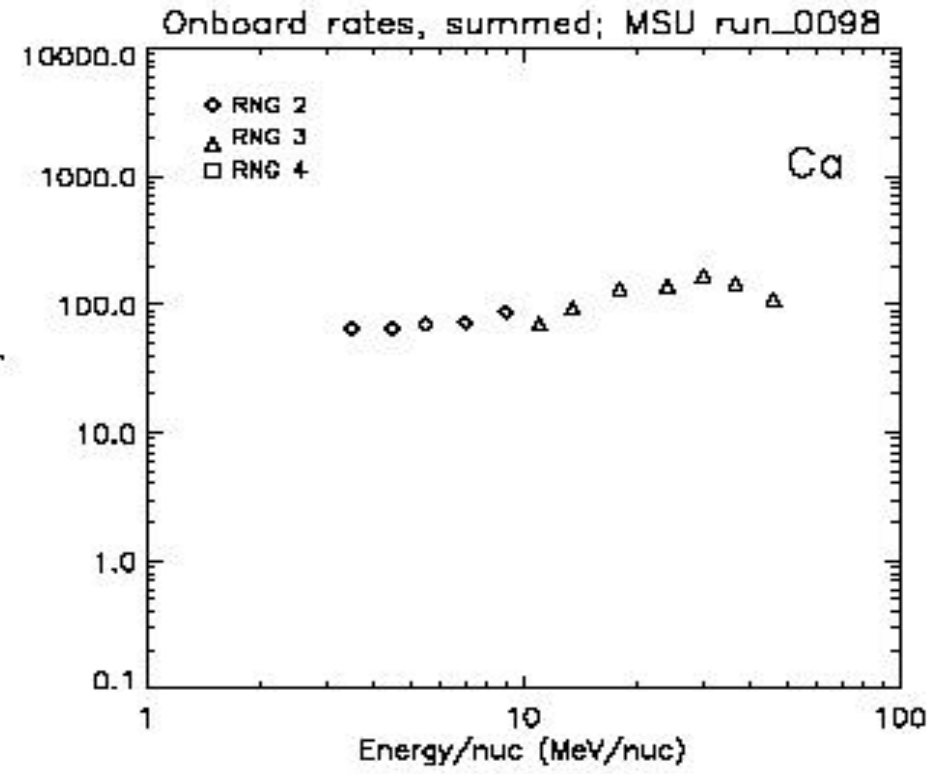


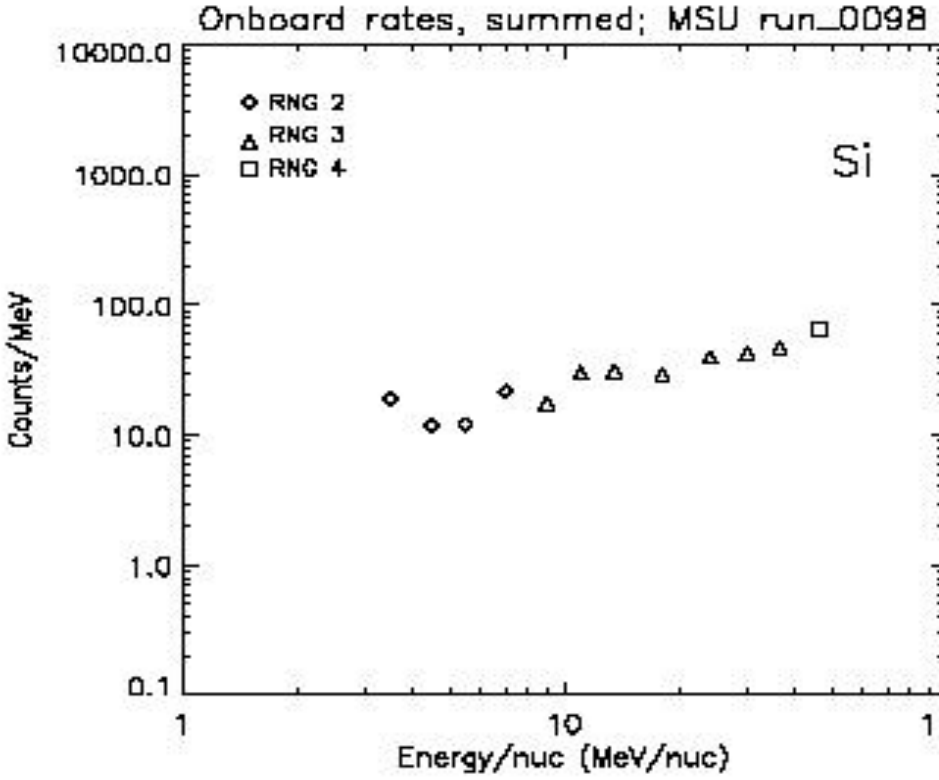
Stopping particles can also be identified in the first part of the L3b detector

Energy Binning – On-board Analysis

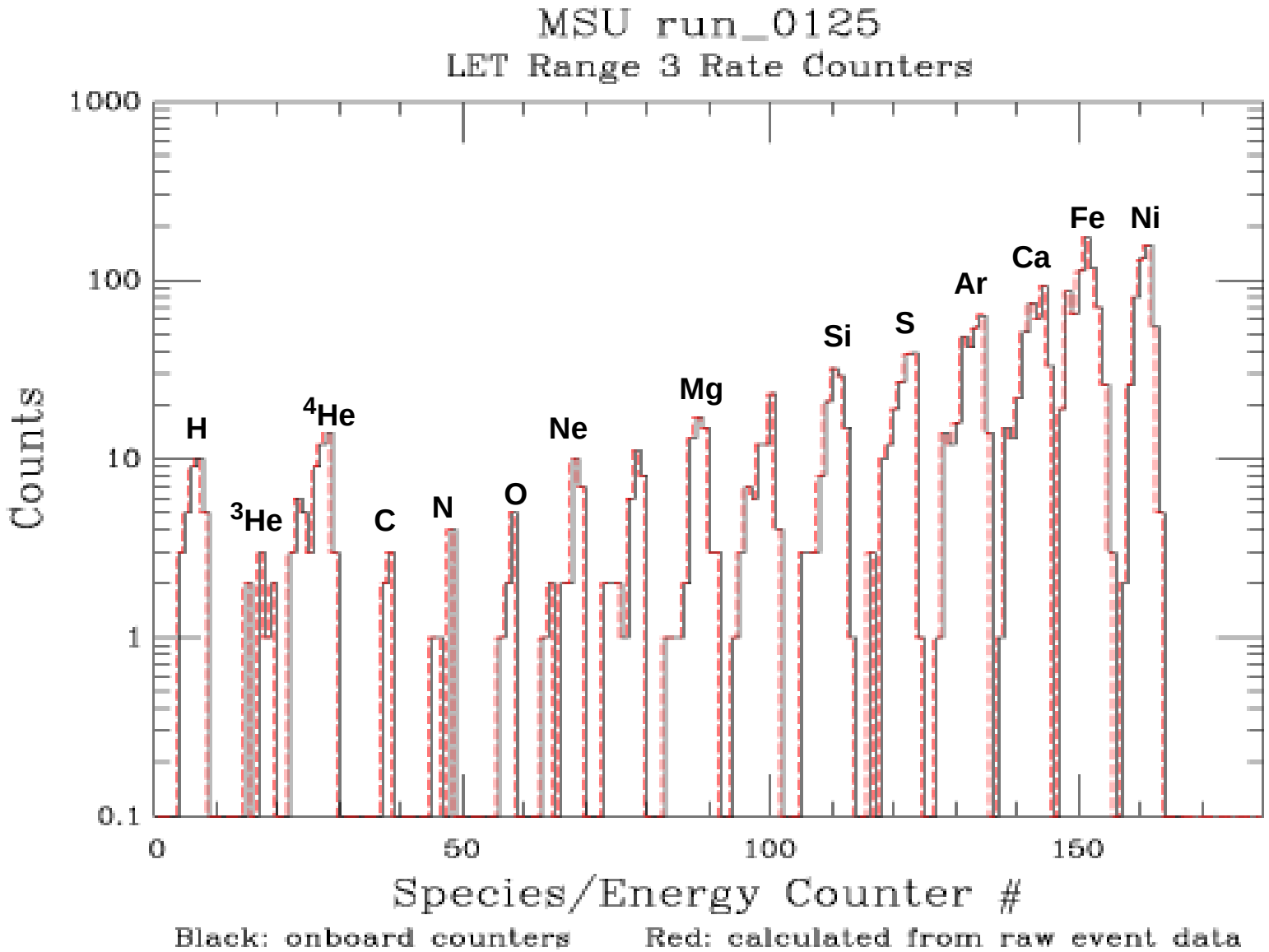
Requirement: 6 intervals per species for Z = 2; 3 for H
Goal: 8 intervals for Z = 2; 4 for H
Capability: 10 - 12 intervals per species for Z = 2; 6 for H

Validated using MSU heavy-ion accelerator data (example spectra below)





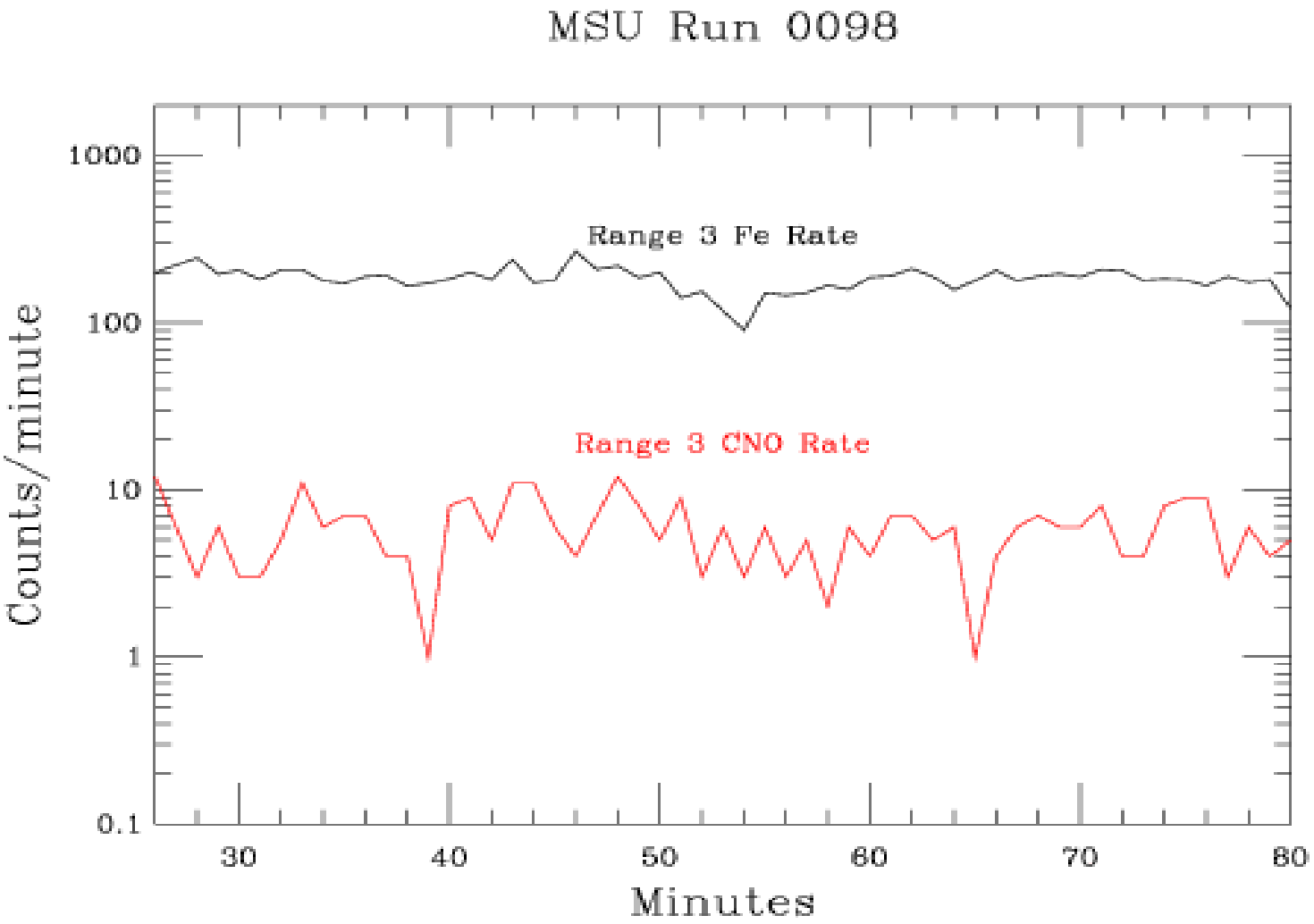
STEREO LET/HET/SEP Central



STEREO LET/HET/SEP Central

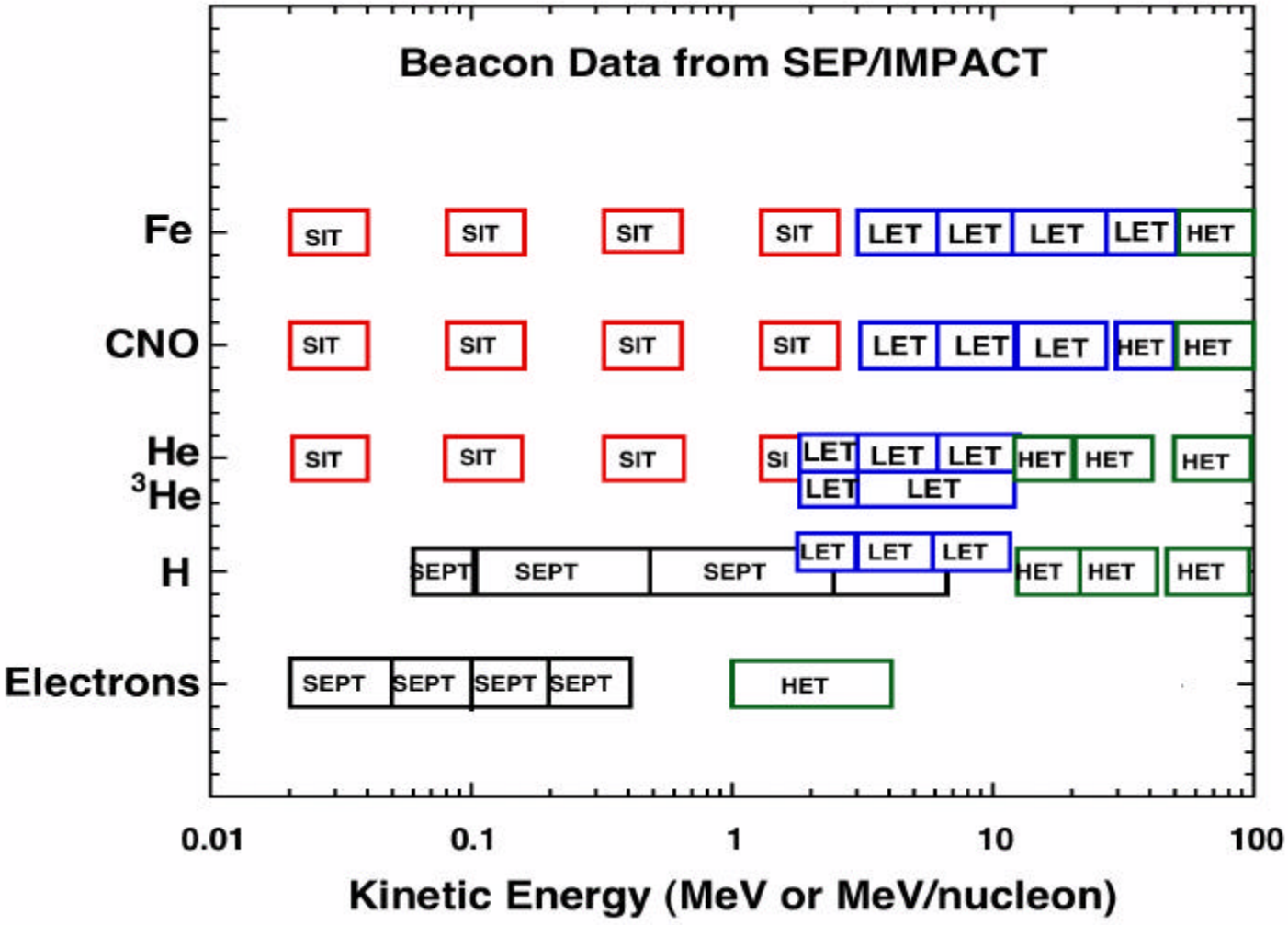
Requirement: 1 minute for H and He; 15 minutes for Z = 6
Goal: 1 minute for all species
Capability: 1 minute for all science and instrument rate data

Time Resolution



STEREO LET/HET/SEP Central

Beacon Data Contributed by the four SEP Sensors
All event totals broadcast every minute



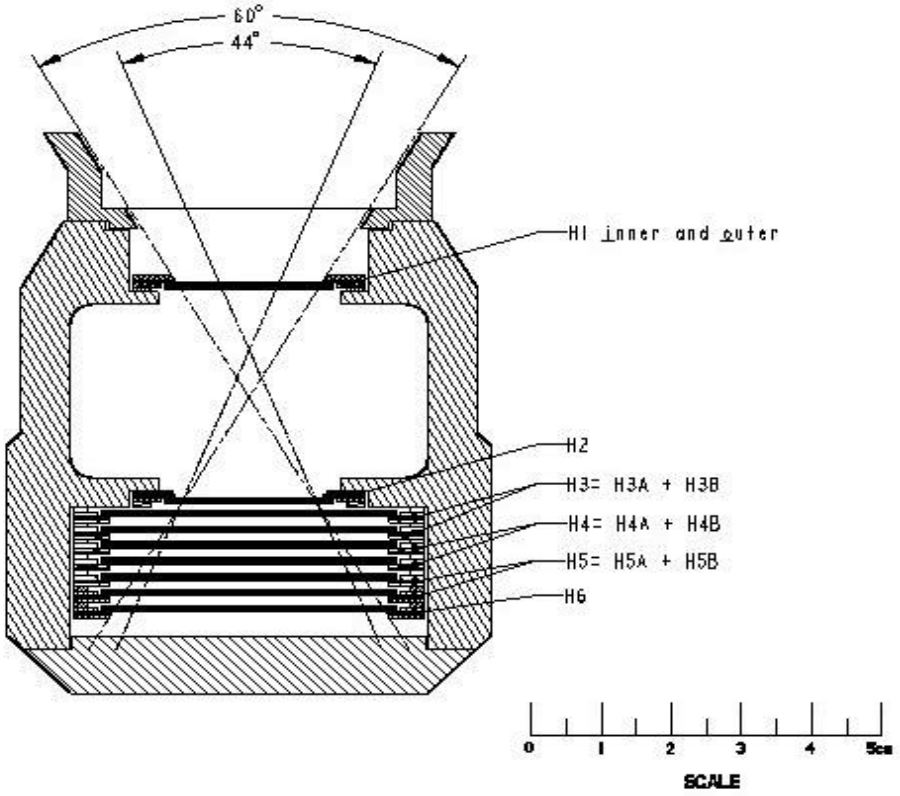
LET Performance Summary

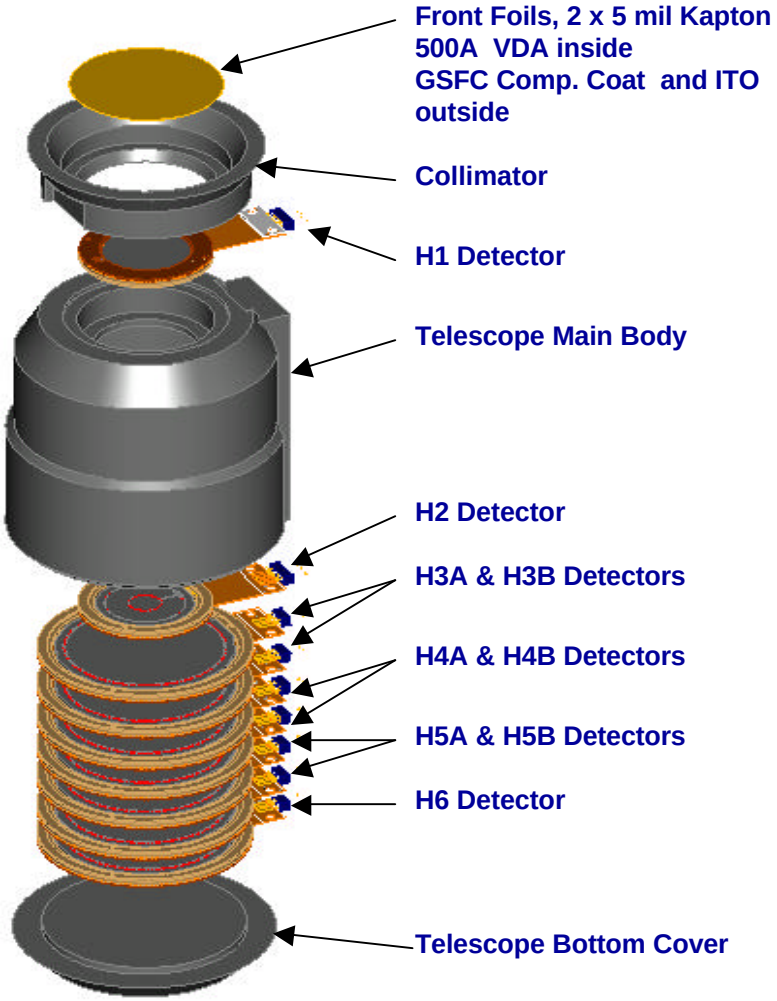
- **LET meets all requirements from the IMPACT Performance Specification**

HET Performance

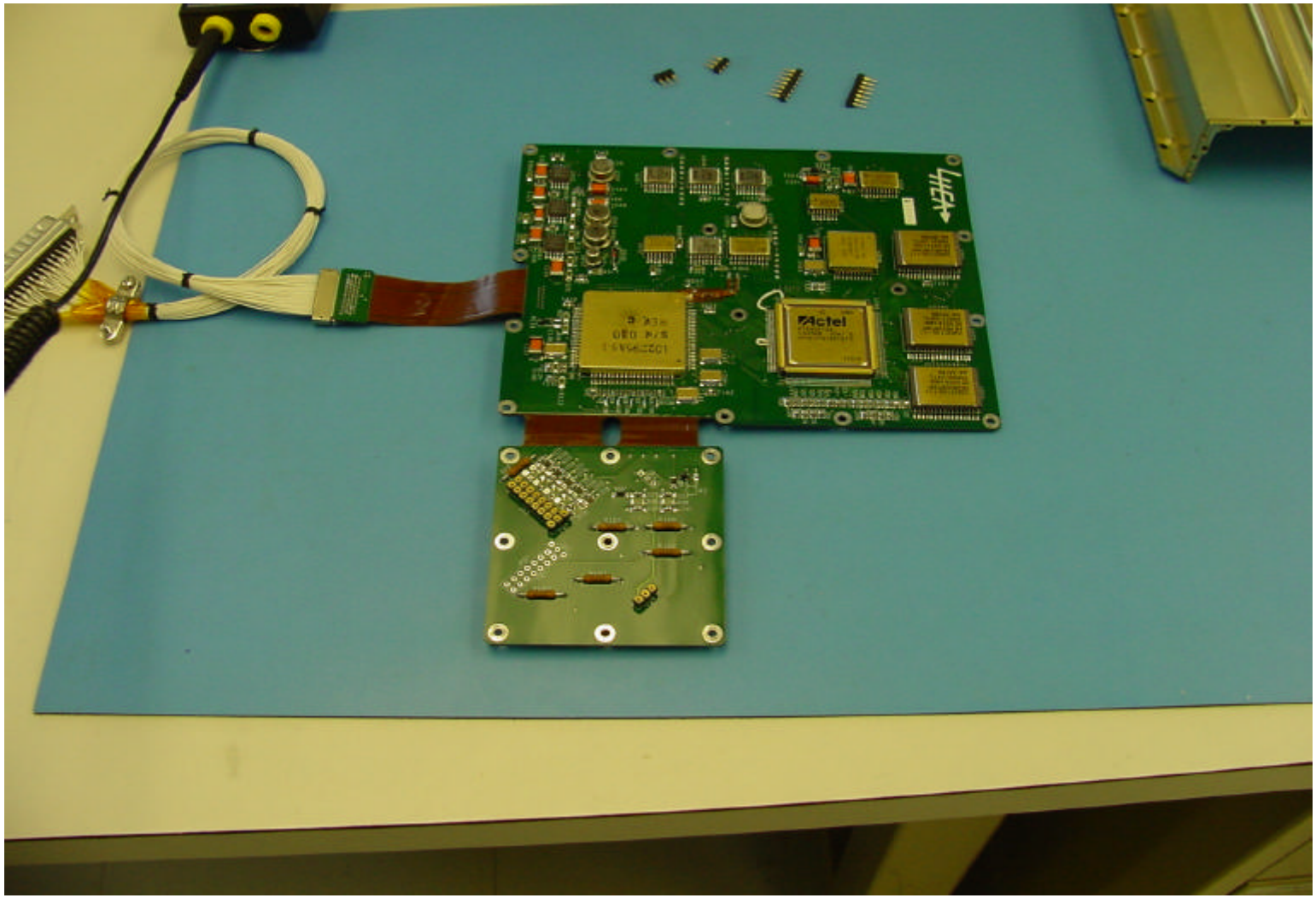
Tycho von Rosenvinge

HET Telescope Schematic

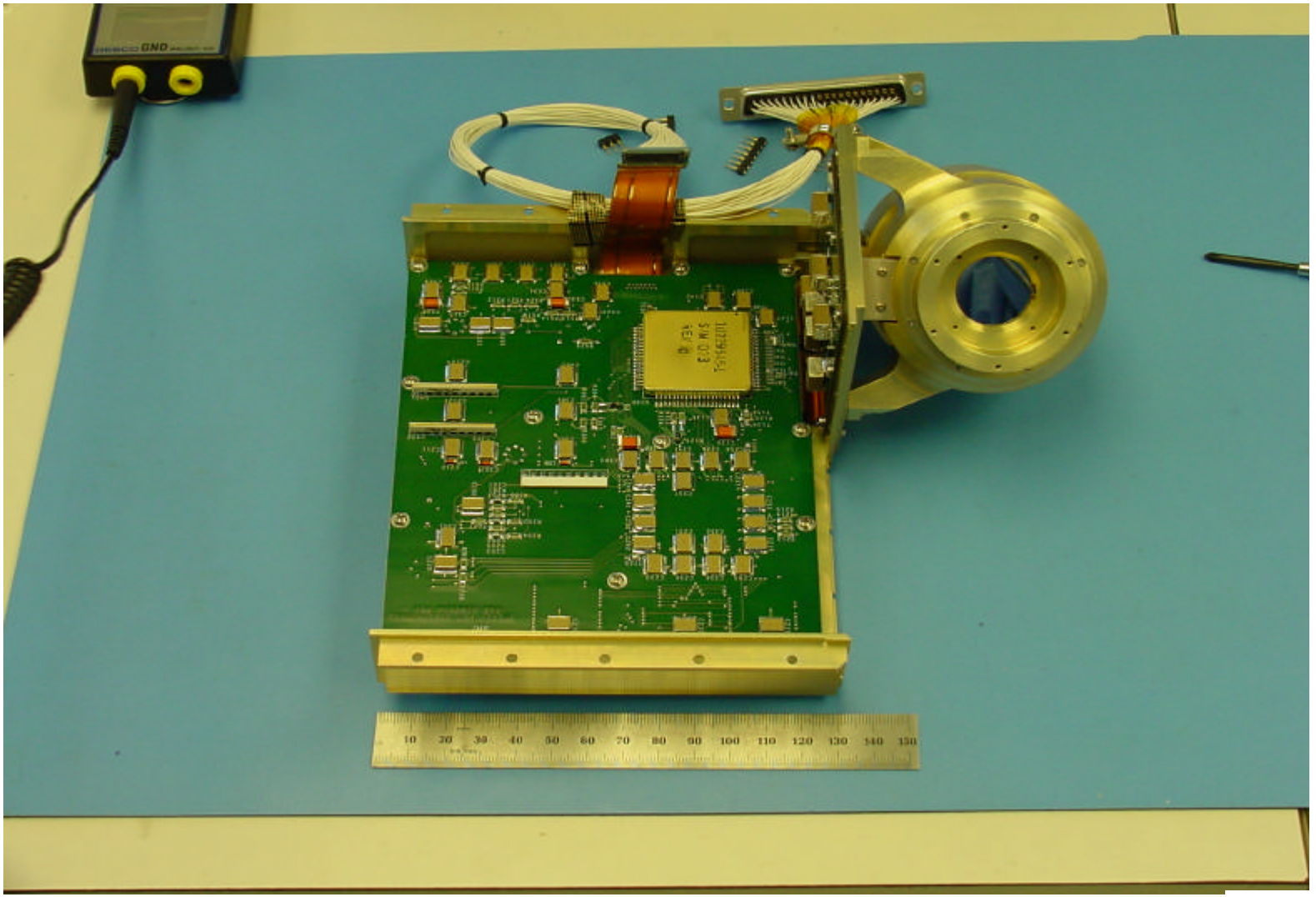




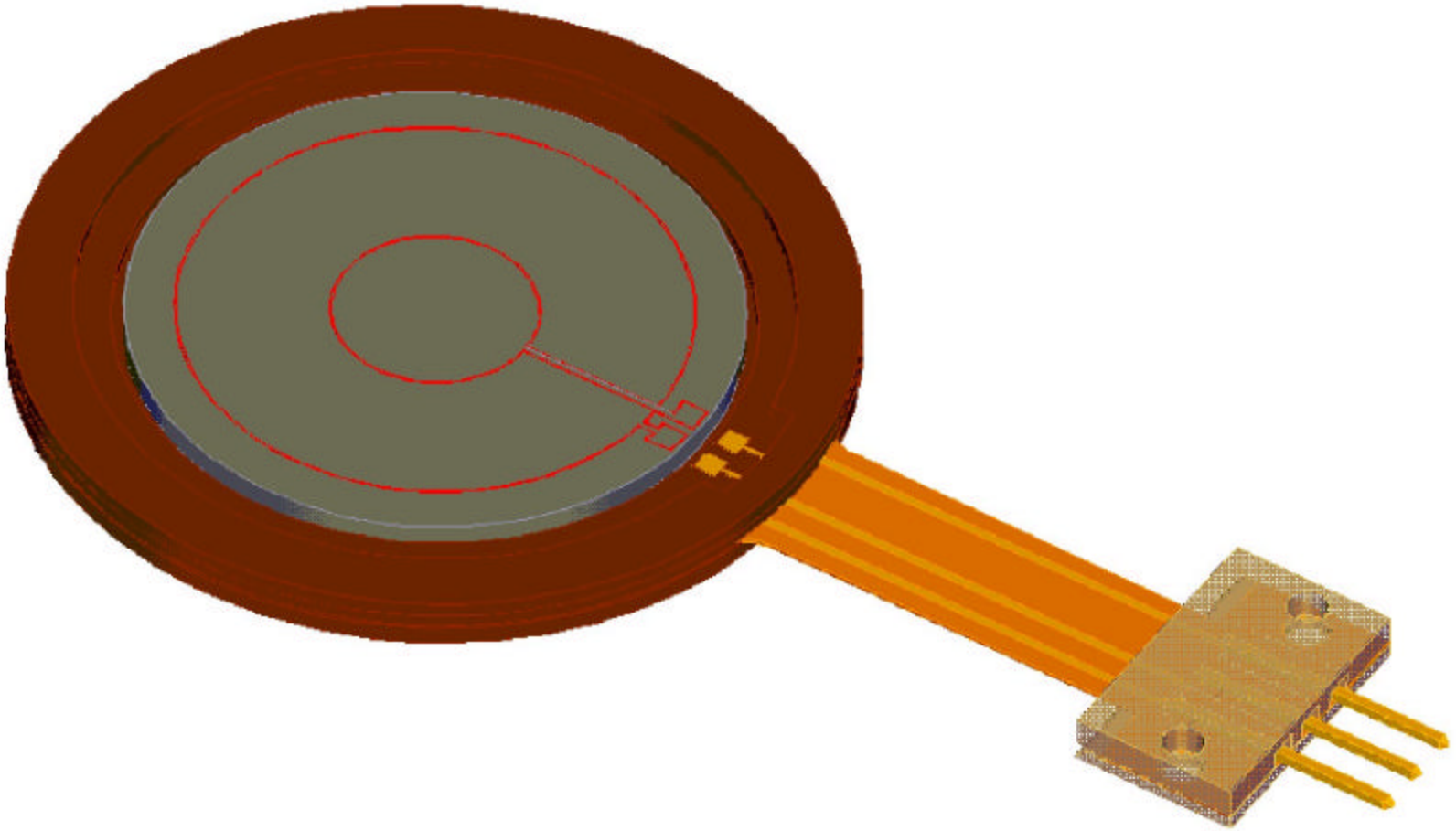
STEREO/HET



STEREO/HET



HET H1/H2 Detector



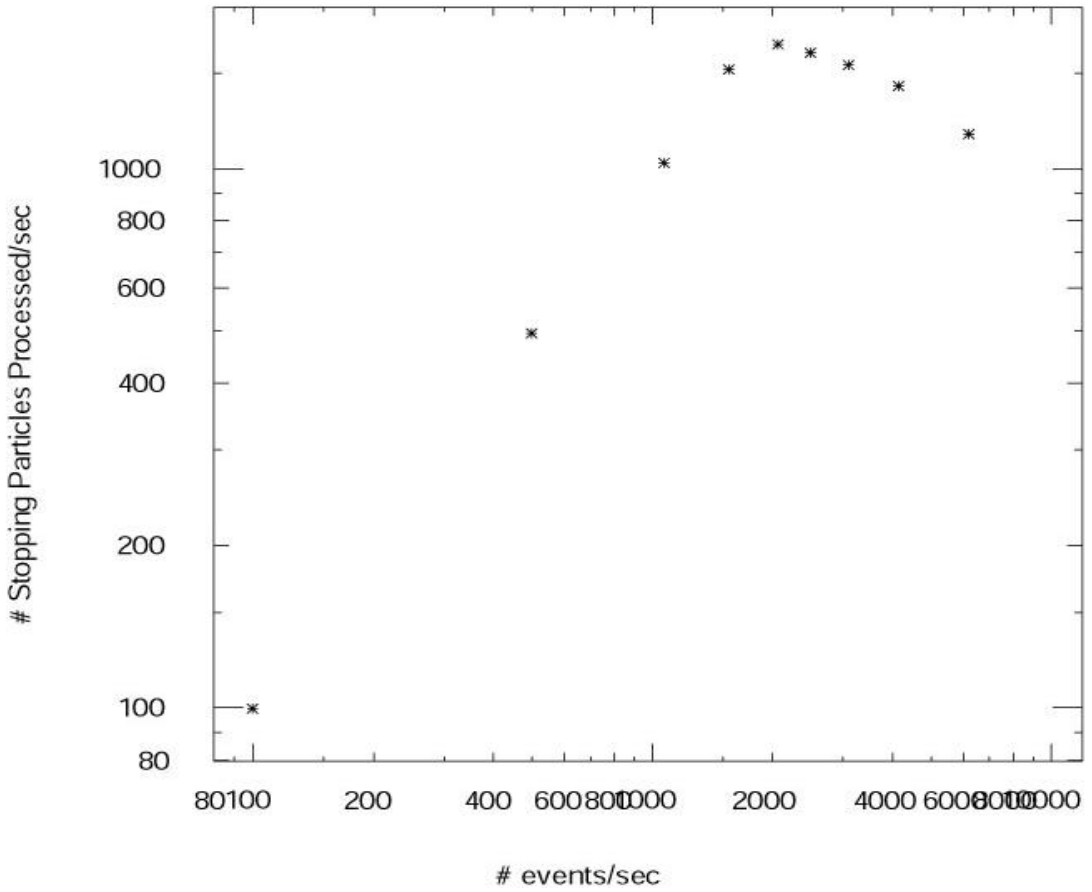
STEREO IMPACT Performance Spec: HET Requirements

Description	Goal	Requirement	Source
FOV (full angle)	58 degree cone	50 degree cone	Derived from MRD 4.7 (F,G) & CME characteristics
Energy Range (MeV/nucleon)	e: 1 – 6 MeV H, He: 13 - 100 ^{3}He: 16 – 50 ~30 to 80 for 5 < Z < 27	1 – 6 MeV 13 – 40 16 – 40 ~30 to 80 for 5 < Z < 15	MRD 4.7(F,G)
Geometric Factor, cm^2 ster	0.7	0.5	Derived from MRD 4.7 (F,G) & CME characteristics
Element Resolution, dZ (rms), for stopping particles	< 0.2 for 1 < Z < 15 < 0.3 for 16 < Z < 26	< 0.2 for 1 < Z < 15	" "
^{4}He Mass Resolution	<0.20 amu	<0.25 amu	" "
Max Event Rate	5000 events/sec	1000 events/sec	" "
Energy Binning	Eight intervals per species	Six intervals per species	" "
Species Binning	Add 15 < Z < 27	H, ^{3}He, ^{4}He, 5<Z<15, Electrons	Derived from Element Resolution Above
Time Resolution	1 minute 1 prioritized event/sec	15 minutes 0.3 prioritized event/sec	Derived from MRD 4.7 (F,G) & CME characteristics
Beacon Telemetry:	1 minute e, H, He, C, O, Ne, Mg, Si, Fe	1 minute H, He, e	" "

STEREO IMPACT Performance: HET

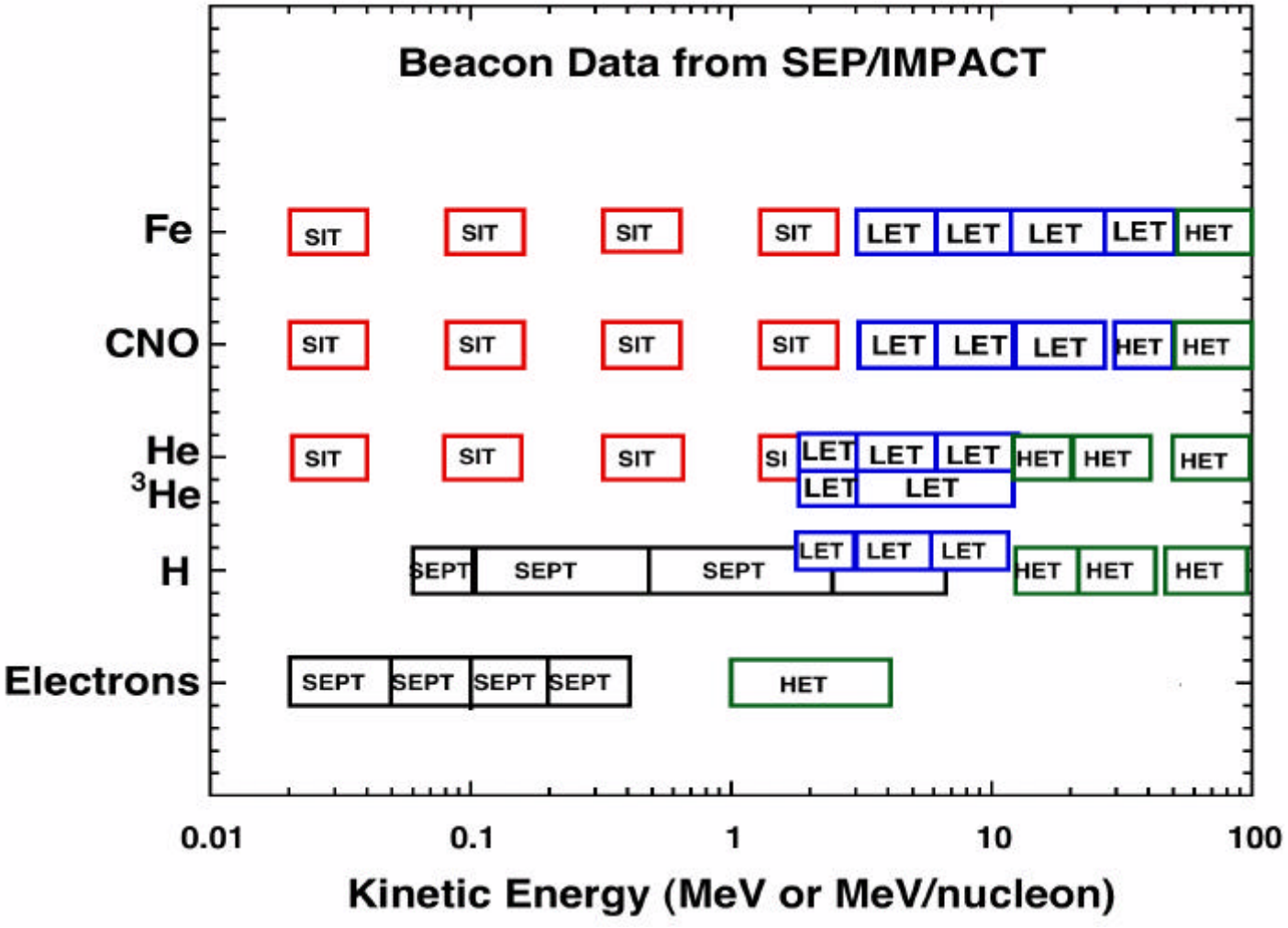
Description	Goal	Requirement	Capability	Validation
FOV (full angle)	58 degree cone	50 degree cone	58 degree cone	Geometric analysis
Energy Range (MeV/nucleon)	e: 1 – 6 MeV H, He: 13 - 100 ^{3}He: 16 – 50 ~30 to 80 for 5 < Z < 27	1 – 6 MeV 13 – 40 16 – 40 ~30 to 80 for 5 < Z < 15	0.7 – 4 MeV 13.3 – 40 stopping prtcls 17.0 – 43 O16: 30-87, Si28: 40 - 119	Monte Carlo Simulation + on-board response tables
Geometric Factor, cm^2 ster	0.7	0.5	0.66 cm2-sr	Geometric Analysis
Element Resolution, dZ (rms), for stopping particles	< 0.2 for 1 < Z < 15 < 0.3 for 16 < Z < 26	< 0.2 for 1 < Z < 15		Monte Carlo Simulation
^{4}He Mass Resolution	<0.20 amu	<0.25 amu		Monte Carlo Simulation
Max Event Rate	5000 events/sec	1000 events/sec	~ 2000 - 8000 events/sec	Ru106 source, pulser
Energy Binning	Eight intervals per species	Six intervals per species	10 stopping intervals for both H & 4He, 8 for Si	Monte Carlo Simulation
Species Binning	Add 15 < Z < 27	H, ^{3}He, ^{4}He, 5<Z<15, Electrons	Required + Z=26	By design
Time Resolution	1 minute 1 prioritized event/sec	15 minutes 0.3 prioritized event/sec	1 minute	By design
Beacon Telemetry:	1 minute e, H, He, C, O, Ne, Mg, Si, Fe	1 minute H, He, e	1 minute e, H, He, CNO, Fe	By design

HET High Rate Performance (Worst Case)



STEREO LET/HET/SEP Central

Beacon Data Contributed by the four SEP Sensors
All event totals broadcast every minute



HET Functional Tests

Test	Description	Duration	Procedure
Aliveness	Run on-board stim pulser	10 minutes	STEREO-GSFC-10.A
Limited Performance	"	30 minutes	STEREO-GSFC-11.A
Comprehensive Performance	"	90 minutes	STEREO-GSFC-12.A
Radioactive Source	Ru-106 source 10 microCuries Ambient only	10 minutes	STEREO-GSFC-13.A
Muon	Telescope vertical	12 hours	STEREO-GSFC-14.A

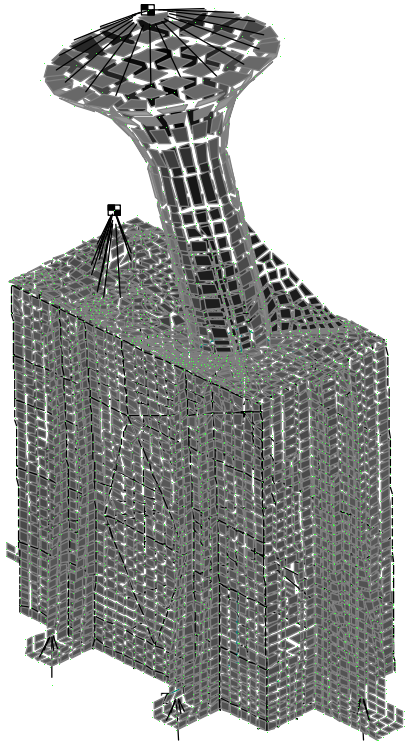
2) Almost all critical pre-environmental analysis and testing are complete

- All detectors have been through vibration and thermal vacuum screening
- Some thin detectors and thin windows have been tested successfully in two acoustics tests to qualify the design
- Mechanical analysis of LET/HET/SEP Central has been done and there are adequate safety margins against failure in vibration
- Units have been analyzed to make sure adequate venting of all volumes exists by using experience on previous instruments.
- LET/HET/SEP Central have been taken to an accelerator for an end-to-end test
  - Analysis of LET data revealed some issues; corrected in S/W
  - HET data compromised by cross-talk; will be fixed in S/W
- Also see Verification Matrices
- Final CPTs still to be done when LVPS repaired

SEP Mechanical Analysis and FEM

- **Finite Element Model: 6286 Nodes**
- **Static loads**
  - **30g from mass-acceleration curve (MAC).**
  - **30g (lateral) & 50g (thrust) using random input from 7381-9003 and applying Miles Equation.**
  - **Positive margins in all cases.**
- **Pre-test vibration analysis also performed.**
  - **Predicted modes: F_1=68Hz F_2=76Hz**
  - **Random base drive; recovered loads at LET and other locations.**
  - **Test loads were lower than static loads above.**

SEP FEM showing 1st mode at 68.4 Hz



SEP Stress Margins

- **Thrust (x-axis) loading produced peak stress of 25 ksi.**
  - **Resulted in minimum margin of +0.08.**
- **Direct random loading produced peak stress of 13.3 ksi.**
- **Force-limited random loading produced 10.4 ksi.**

SEP Minimum Margins

Component	Material	Applied Loading	Failure Mode	Safety Factor	Margin
Box Plate	**6061-T6**	**Acceleration x-axis**	**material yield**	**1.3**	**+ 0.08**
Box Plate	**6061-T6**	**Acceleration x-axis**	**material ultimate**	**1.4**	**+ 0.14**
Box Plate	**6061-T6**	**Acceleration y-axis**	**buckling**	**2.0**	**+ 0.71**
Bushing	**Ultem® 1000**	**Acceleration z-axis**	**compression**	**1.4**	**> 10**

STEREO LET/HET/SEP Central

Test Readiness Review
20 January 2005

SEP Central Verification Matrix

Verification Matrix for STEREO/IMPACT/SEP/SEP Central — Revision Date: 1/12/05
Revision Number: 8

Hardware Description				Tests																	
Level of Assembly	Item	Noise & Brkdown	Thermal vacuum	Alphas	Elect. test, rm. Temp	Elect. Test, hot	Elect. Test, cold	Vibration, Sinusoidal	Vibration, Random	Shock	Acoustics	Pressure change	Voltage margins	Thermal cycle	Thermal balance	Life Test	EMC/EMI	Magnetics	Leak	Bakeout	Contamination	Comments
C	LVPS, EM				**C**	**C**	**C**						**C**				X*					
C	LVPS, F				**C**												**C**				**C**	Limited EMC test done
C	Analog Post-reg, EM				**C**	**C**	**C**						**C**									
C	Analog Post-reg, F				**C**	**C**	**C**													**C**	**C**	Hot/cold done but not required
C	Detector bias supply, EM				**C**	**C**	**C**						**C**									
C	Detector bias supply, F				**C**	**C**	**C**													**C**	**C**	Hot/cold done but not required
C	Logic board, EM				**C**	**C**	**C**						**C**									
C	Logic board, F				**C**	**C**	**C**													**C**	**C**	Hot/cold done but not required
C	Connectors, F															**C**					**C**	
C	Harnesses, F																			X	X	
I	Instrument, EM				**C**	X*	X*						**C**									Electrical EM only
I	Instrument, F1		H		**C**	**C**	**C**	H	H	A*		**AC**	H		H	H	**C**	H		H	H	Protoflight levels for vib; full EMC at suite
I	Instrument, F2		H		**C**	X*	X*	H	H	A*		**AC**	H			H	S	H		H	H	Protoflight levels for vib; workmanship EMC

Legend:

Level of Assembly	Unit Type		X =	Test required	
			A =	Analysis	
C = Component	BB =	Breadboard	H =	Test at SEP Central/HET/LET level	
I = Instrument	EM =	Engineering Model	S =	Test at Suite level	
	PT =	Prototype	X* =	Test was once planned but is no longer necessary	
	PF =	Protoflight	A* =	Analysis was once planned but is no longer necessary	
	F =	Flight	**C =**	**Test completed**	
	F1 =	Flight unit #1	**AC =**	**Analysis completed**	
	F2 =	Flight unit #2			

SEP Central Verification Matrix Issues

- Electrical tests at hot and cold not done on EM unit, nor on FM 2
  - Tests done on FM 1 and individual boards instead
  - FM 2 will be tested at hot/cold during thermal vacuum test
- EMC/EMI not done on LVPS EM
  - Limited EMC test done on flight unit instead
- Bake out and contamination tests not yet done on flight harnesses
  - Will be done separately from thermal vacuum bake out prior to environmental tests
- SEP Central not analyzed for shock
  - Not required; no mechanisms

STEREO LET/HET/SEP Central

Test Readiness Review
20 January 2005

LET Verification Matrix

Verification Matrix for STEREO/IMPACT/SEP/LET

Revision Date: 1/12/05

Revision Number: 12

Hardware Description		Tests																				
Level of Assembly	Item	Noise & Brkdown	Thermal vacuum	Alphas &/or particle accelerator	Elect. test, rm. Temp	Elect. Test, hot	Elect. Test, cold	Vibration, Sinusoidal	Vibration, Random	Shock	Acoustics	Pressure change	Voltage margins	Thermal cycle	Thermal balance	Life Test	EMC/EMI	Magnetics	Radiation	Leak	Bakeout	Contamination	Comments
C	Detectors, PT	C	C	C	C	C	C		C		C			C								C	Acoustics in EM with windows
C	Detectors, F	C	C	C	C	C	C		C					C								C	Acoustics test on some flight detectors
C	Hybrids, PT				C	C	C												C				
C	Hybrids, F				C	C	C									X				C		C	Also standard class H tests
C	LET detector/MISC board, EM			C	C	C	C						C										Alphas done but not required
C	LET detector/MISC board, F				C																C	C	
C	Connectors, F																					C	
C	Windows, EM								X*		C			AC									Include L1 detectors for vib & acoustics
I	Instrument, F1		H	C	C	X*	X*	H	H	A*	H	AC	H		H	H	C	H			H	H	Protoflight levels for vib; full EMC at suite
I	Instrument, F2		H	C	C	X*	X*	H	H	A*	H	AC	H			H	S	H			H	H	Protoflight levels for vib; workmanship for EMC

Legend:

Level of Assembly	Unit Type		X =	Test required	
			A =	Analysis	
C = Component	BB =	Breadboard	H =	Test at SEP Central/HET/LET level	
I = Instrument	EM =	Engineering Model	S =	Test at Suite level	
	PT =	Prototype	X* =	Test was once planned but is no longer necessary	
	F =	Flight	A* =	Analysis was once planned but is no longer necessary	
	F1 =	Flight unit #1	C =	**Test completed**	
	F2 =	Flight unit #2	AC =	**Analysis completed**	

LET Verification Matrix Issues

- Life test not yet done on hybrids
  - Delayed due to schedule issues at subcontractor facility and due to L1 repairs taking precedence over this qual test on 8 hybrids
  - Will be done but will not hold up environments
- Electrical tests at hot and cold not done on FM 1 and FM 2
  - Tests done on individual boards instead
  - FM 1 and FM 2 will be tested at hot/cold during thermal vacuum test
- EM windows not subjected to random vibration test
  - Acoustics was done, which is more stringent test
  - Vibration will be done at flight unit level
- Windows not thermal cycled
  - Analysis was done to show they won't burn up
  - Very similar to windows successfully flown on WIND/LEMT instrument
- LET not analyzed for shock
  - Not required; no mechanisms

HET Verification Matrix

Verification Matrix for STEREO/IMPACT/SEP/HET

Revision Date: 1/12/05

Revision Number: 4

Hardware Description		Tests																				
Level of Assembly	Item	Noise & Brkdown	Thermal vacuum	Alphas &/or Accelerator	Elect. test, rm. Temp	Elect. Test, hot	Elect. Test, cold	Vibration, Sinusoidal	Vibration, Random	Shock	Acoustics	Pressure change	Voltage margins	Thermal cycle	Thermal balance	Life Test	EMC/EMI	Magnetics	Radiation	Leak	Bakeout	Contamination	Comments
C	Detectors, PT	C	C	C	C	C	C		C		X*			C								C	Vibration at manufacturer
C	Detectors, F	C	C	C	C	C	C		C					C									Vibration at manufacturer
C	Hybrids, PT				C	C	C												C				
C	Hybrids, F				C	C	C									X				C		C	Also standard class H tests
C	HET board, EM				C	C	C						C										
C	HET board, F				C	C	C						C								C	X	
C	Connectors F																					X	
I	Instrument F1		H	X	C	C	C	H	H	A*		AC			H	H	C	H			H	H	Protoflight levels for vib; full EMC at suite
I	Instrument, F2		H	X	C	C	C	H	H	A*		AC				H	S	H			H	H	Protoflight levels for vib; workmanship for EMC

Legend:

Level of Assembly	Unit Type		X =	Test required	
			A =	Analysis	
C = Component	BB =	Breadboard	H =	Test at SEP Central/HET/LET level	
I = Instrument	EM =	Engineering Model	S =	Test at Suite level	
	PT =	Prototype	X* =	Test was once planned but is no longer necessary	
	F =	Flight	A* =	Analysis was once planned but is no longer necessary	
	F1 =	Flight unit #1	C =	**Test completed**	
	F2 =	Flight unit #2	AC =	**Analysis completed**	

HET Verification Matrix Issues

- Life test not yet done on hybrids
  - Delayed due to schedule issues at subcontractor facility and due to L1 repairs taking precedence over this qual test on 8 hybrids
  - Will be done but will not hold up environments
- Acoustics test not done on detectors
  - Detectors are thick enough (1 mm) that it's not necessary
- HET not analyzed for shock
  - Not required; no mechanisms
- HET needs to be taken to an accelerator again
  - First test showed two types of cross-talk which were not taken into account in the on-board software design
    - Cross-talk between H1i and H1o caused rejection of events
    - Cross-talk interior to the PHASIC made stopping events to be processed as penetrating events

HET Verification Matrix Issues (continued)

- The latest version of on-board software without corrections for cross-talk is dated 9/23/04
  - This version is very stable, no known susceptibility to crashes
- The latest version of on-board software with corrections for cross-talk is dated 12/29/04
  - This version occasionally crashes
- Plan:
  - Continue to use the 9/23/04 version for environmental tests.
  - Meanwhile, update the latest version to make it stable against crashes.
  - Return to accelerator with flight units if possible, otherwise with Engineering Model

STEREO IMPACT Waiver Status

2004-Oct-7

Waiver	Description	Status
EMC1, 460-26	IDPU Single-ended interfaces	EMC & CCB Approved
EMC2, 460-28	SEP to SIT secondary power distribution	EMC & CCB Approved
EMC3A, 460-31	SEP Bias Supply not synchronized	EMC & CCB Approved
EMC4, 460-40	IDPU to STE-U secondary power distribution	EMC & CCB Approved
EMC5, 460-41	IDPU to STE-U Single-ended interface (analog)	EMC & CCB Approved
EMC6, -	SEP to SEPT single ended interfaces (digital)	EMC: Not Needed
EMC7, 463-37	STE Door Actuators	EMC & CCB Approved
EMC8, 460-42	Use of combined Signal/Power harnesses	EMC & CCB Approved
EMC9, -	SWEA bonding	EMC: Not Needed
RQMT1, 460-67	SEPT proton energy threshold 60keV	Approved
PARTS1, -	Q-tech oscillator	Closed in PCB
POWER1, 460-66	Operational & Survival heaters cause power requirements to exceed allocations, ->17.1W NTE	Approved

3) All waive approve

STEREO LET/HET/SEP Central

463-9	IDPU RAM power increase, ->19.1W	Approved
463-19	Op heater power increase, NTE -> 20.3W	Approved
STERadSrc, 460-70	STE Radiation Source	Withdrawn?
HETLET Adhesive, 463-63	HET/LET adhesive outgassing	Approved
CorkWaiver, 463-116	IMPACT/SWAVES booms cork outgassing	Approved
PHASIC_Hybrid, -	PHASIC Hybrid waiver to "known good die" requirement	Closed in PCB
H3 Detector Boards, 463-94	H3 detector board QA deviation (Pioneer)	Approved
IMPACTHarnessShield, 463-132	IMPACT harness shielding requirement waiver (deep dielectric discharge issue)	EMC & CCB Approved
SEPTThermalHardware 463-107	SEPT thermal hardware not installed during vibration testing (not powered)	Approved
EMC10, 463-131	SWEA door activation transient	EMC & CCB Approved
SWEA Shock, 463-117	SWEA/Boom self-shock test	Withdrawn, not reqd
ThermalBalance, 463-133	Thermal Balance Plan (no MAG, 1 flight unit. SWEA. STE-U separate from boom)	Approved
SWEAVib, 463-130	Vibrate SWEA off boom	Approved
Accoustics, 463-135	No acoustic test for SWEA, STE, SEPT.	Approved
IMPACT Power Allocation, 463-134	Increase NTE from 20.3 to 23.6W	Approved
EMC11	Non-flight configuration for EMC test	Approved by EMC committee, forwarded to CCB

3) All waivers approved (continued)

3) All waivers approved (continued)

- **Email waiver on use of Uralane 5753**
  - **On 10 December 2004, we requested a waiver via email to use Uralane 5753 in the L1 detector repair process.**
  - **STEREO Project Office responded positively within 3 hours and work proceeded.**

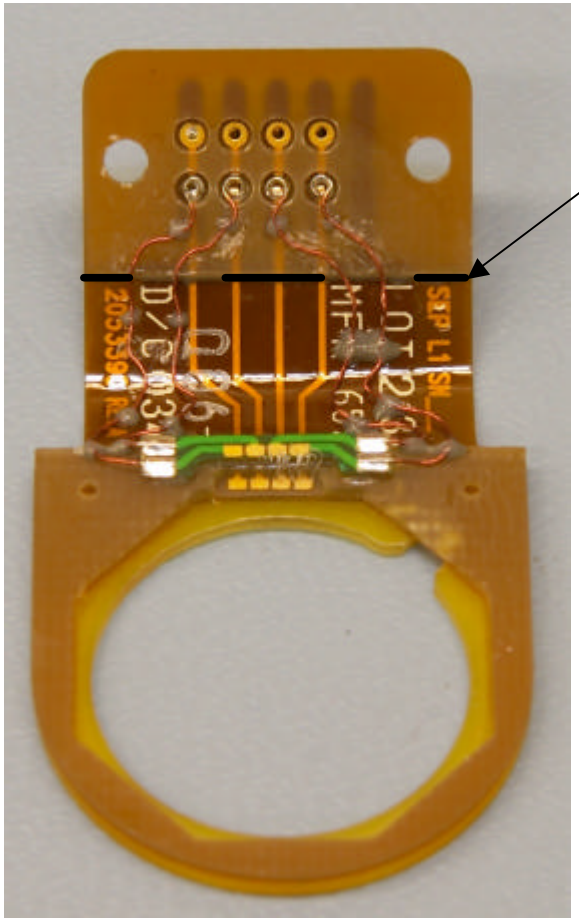
4) All PFRs addressed with the Project and all but one closed "in principle"

- **SEP Bias Supply (PFR2001)**
  - **Problem:** Output of SIT_BIAS post-regulator failed during short-circuit test
  - **Cause:** Absence of load caused output voltage to exceed 300 V and when shorted the reverse breakdown voltage of the MOSFET on the output was exceeded, causing it to fail
  - **Corrective Action:** Part replaced and procedure modified to instruct operator to adjust input frequency that sets the output voltage and make sure it does not exceed 300 V prior to short-circuit test
  - **Status:** OK to proceed with environments

4) All PFRs addressed with the Project and all but one closed "in principle" (continued)

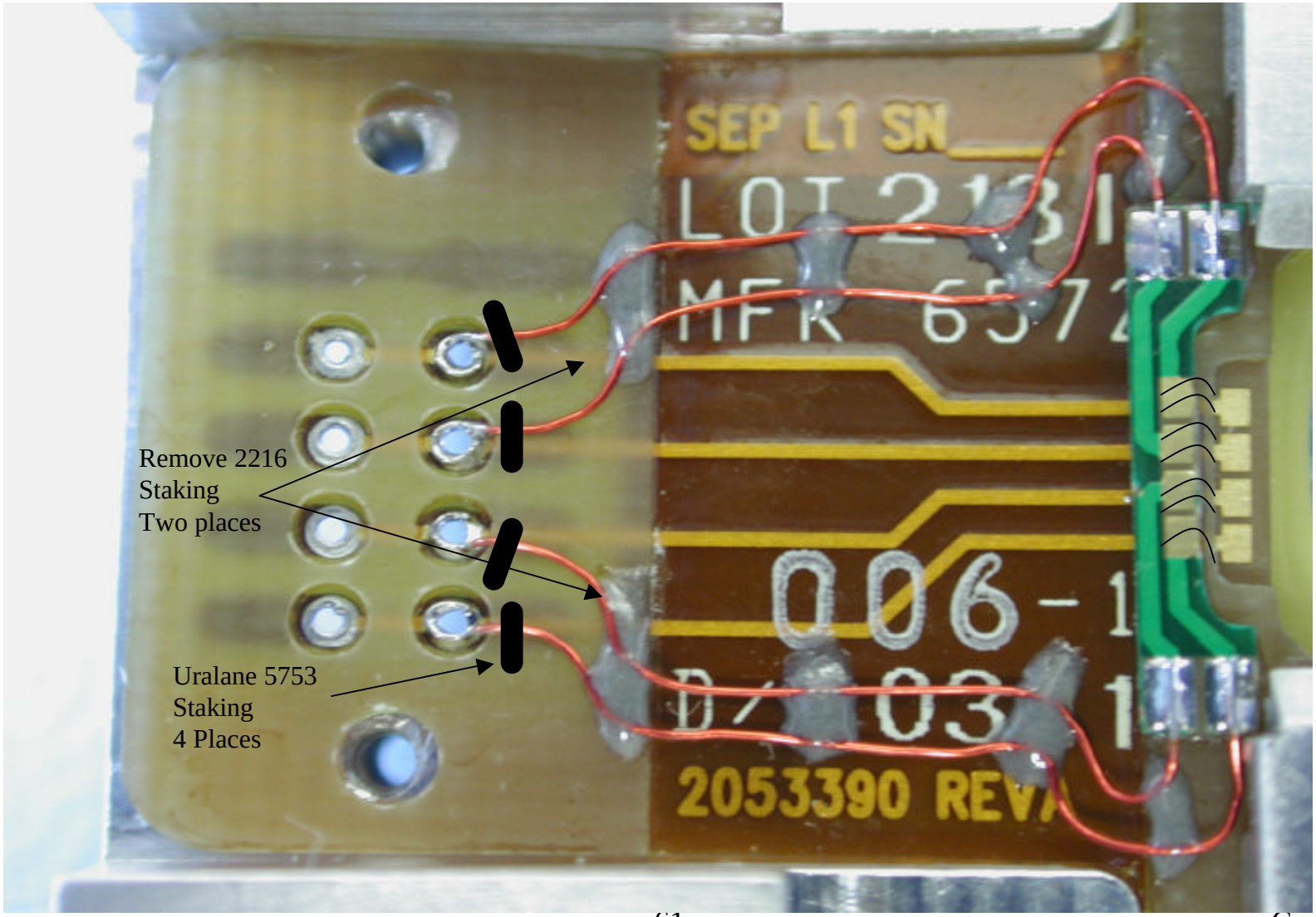
- **LET L1 detectors had broken traces in flexi-strips (PFR2002)**
  - **Problem: Some LET L1 detectors segments were not making connection to their respective electronics analysis chains after assembly of FM 1 and FM 2. Inspection showed some traces on flexistrip were cracked.**
  - **Cause: Manufacturer incorrectly added Ni plating on Cu traces on flex which made traces brittle; also the flexistrips are longer than desired and the flexis are bent in an S-shape during installation.**
  - **Corrective Action: All signal traces repaired by haywiring around them. First attempt used strain-relief epoxy blobs that were incorrectly placed, resulting in some broken wires and some stressed wires. Second round or repairs required to move epoxy blobs. Procedure for repairing broken wires not yet approved; the six detectors involved will not be in FM 1 and FM 2.**
  - **Status: OK to proceed with environments**

Fix to L1 mounts

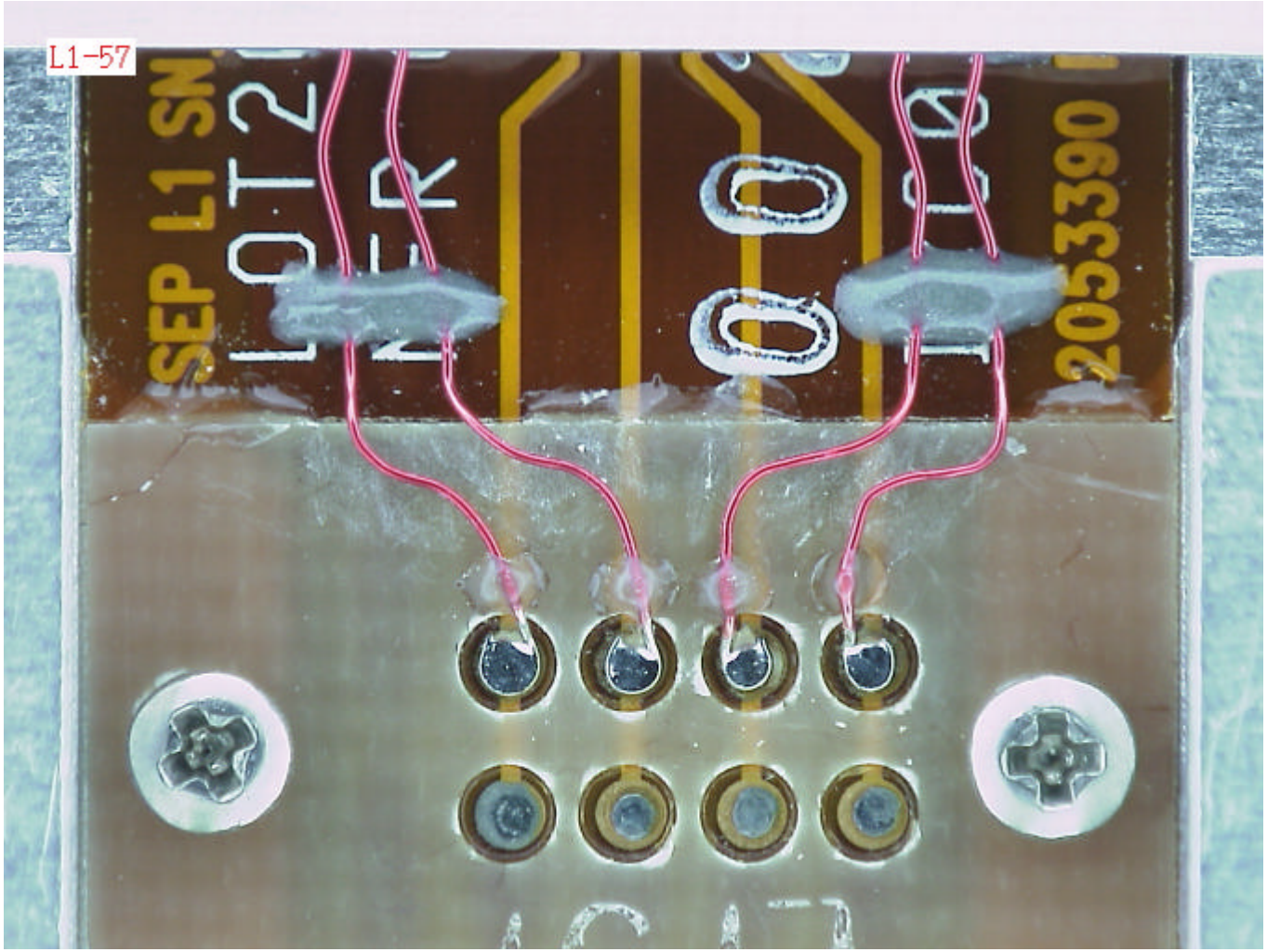


Uralane 5753 fillet
3 places
No material under wires

Fix to L1 mounts (continued)



Fix to L1 mounts (continued)



4) All PFRs addressed with the Project and all but one closed "in principle" (continued)

- **SEP intermittent reboot problem (PR-1025)**
  - **Problem:** Occasional reboots of SEP Central, HET, LET, and SIT microprocessors.
  - **Cause:** Tantalum capacitors reversed in LVPS.
  - **Corrective Action:** Replace tantalum capacitors.
  - **Status:** After repair, OK to proceed with environments.
- **Other LVPS – see Curtis presentation**

5) Comprehensive performance test procedures have been written

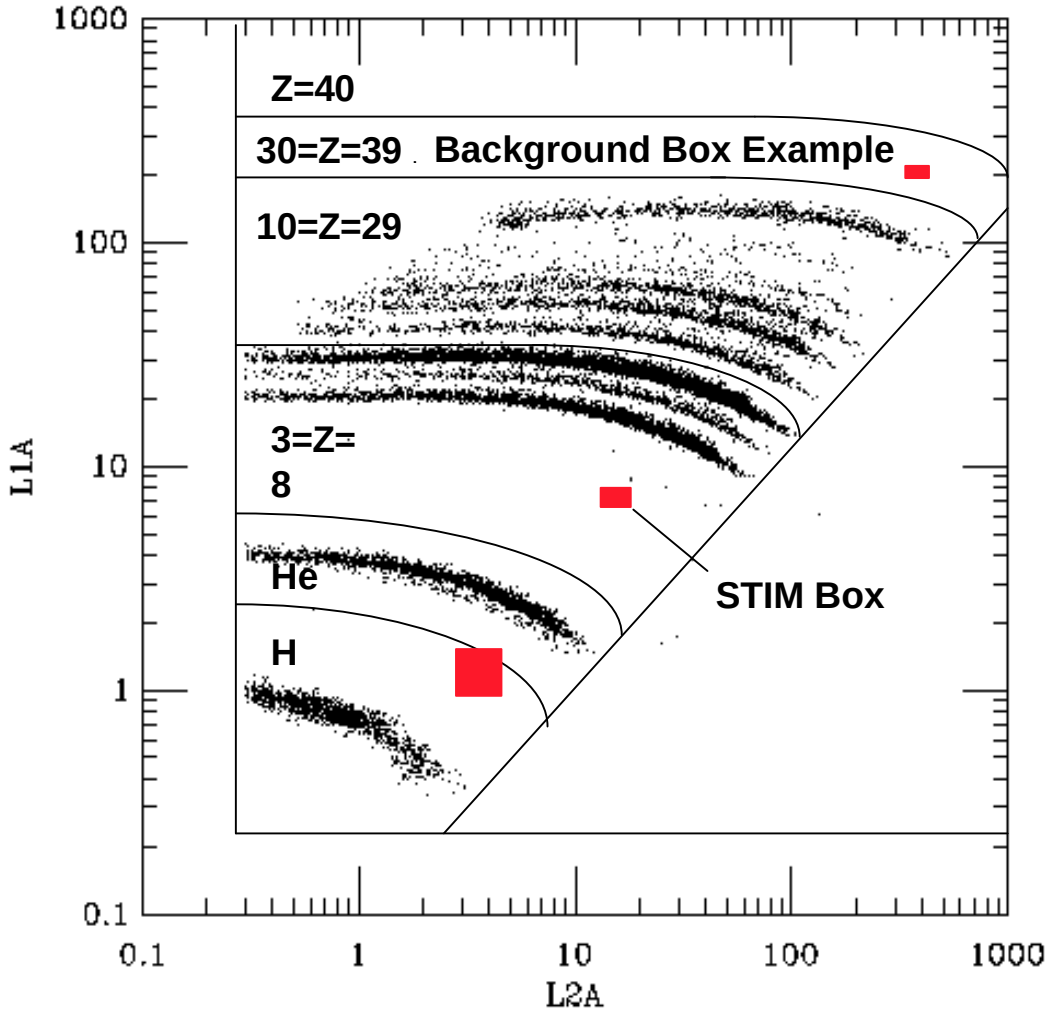
- **LET**
  - Aliveness — STEREO-CIT-024.A
  - Limited Performance — STEREO-CIT-025.A
  - Comprehensive Performance — STEREO-CIT-026.A
  - Source — STEREO-CIT-027.A
- **SEP**
  - Aliveness — STEREO-CIT-028.A
  - Limited Performance — STEREO-CIT-029.A
  - Comprehensive Performance — STEREO-CIT-030.A
  - Power On — STEREO-CIT-031.A
  - Power Off — STEREO-CIT-032.A
  - Emergency Shutdown — STEREO-CIT-033.A
- **SEP Central**
  - Aliveness — STEREO-CIT-034.A
  - Limited Performance — STEREO-CIT-035.A
  - Comprehensive Performance — STEREO-CIT-036.A
  - EEPROM Initialization — STEREO-CIT-037.A
  - EEPROM Total Failure Recovery — STEREO-CIT-038.A
  - Power Converter Test — STEREO-CIT-039.A

See von Rosenvinge presentation for HET

LET Functional Test Outline

Aliveness	Limited Performance	Comprehens. Performance	Special
Normal	Quiet Normal ADC	Quiet Normal ADC Threshold Heater Mode	Source Test
~ 5 min	~ 20 min	~ 40 min	~ 30 min

LET Aliveness (Normal) Test

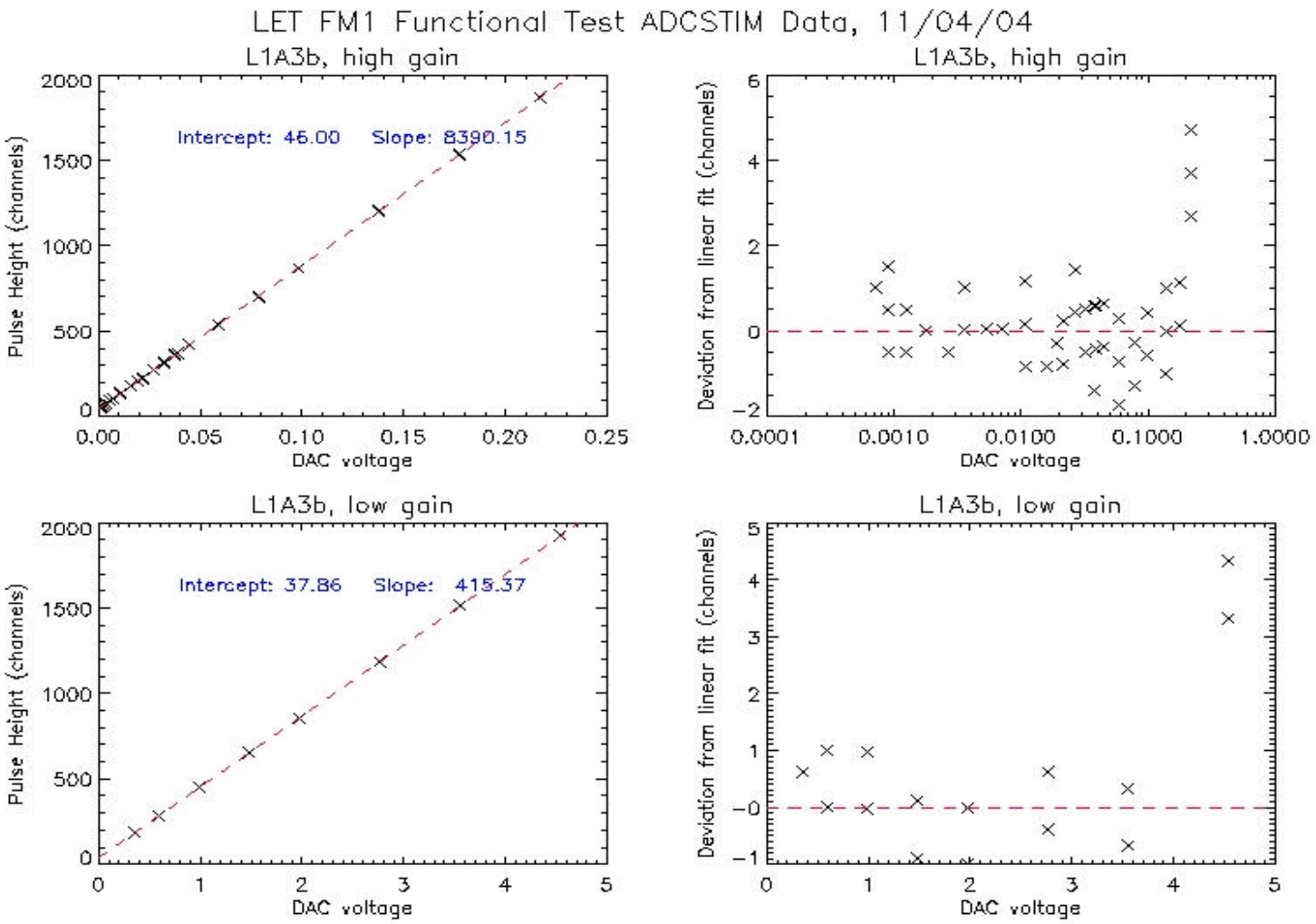


Note: L1 and L2 units are MeV

Location of STIM boxes for L1L2. Pulsing these boxes monitors front-end electronics stability, event processing software, and livetime.

STEREO LET/HET/SEP Central

- These data are for one of 30 L1 segments
- Both gains of all 54 ADCs are calibrated in ~10 minutes (32 levels total)
- Note that the deviations are small, except near full-scale



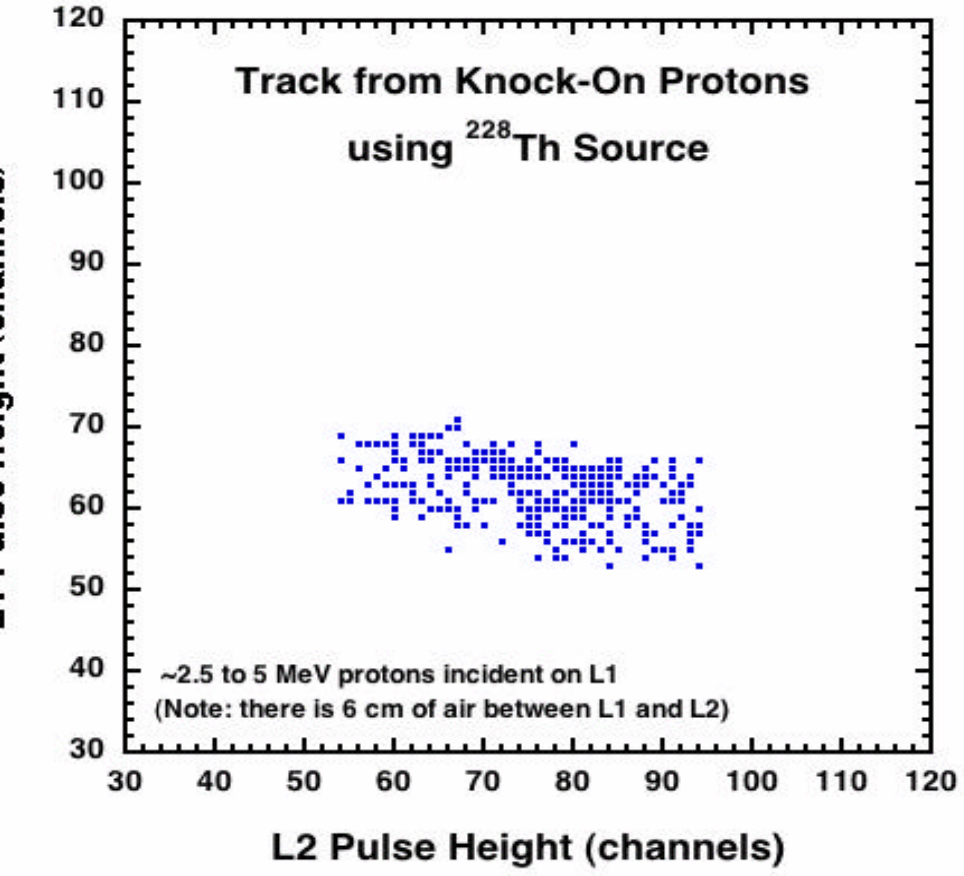
Example of LET ADC calibration data from the LE Functional Tes

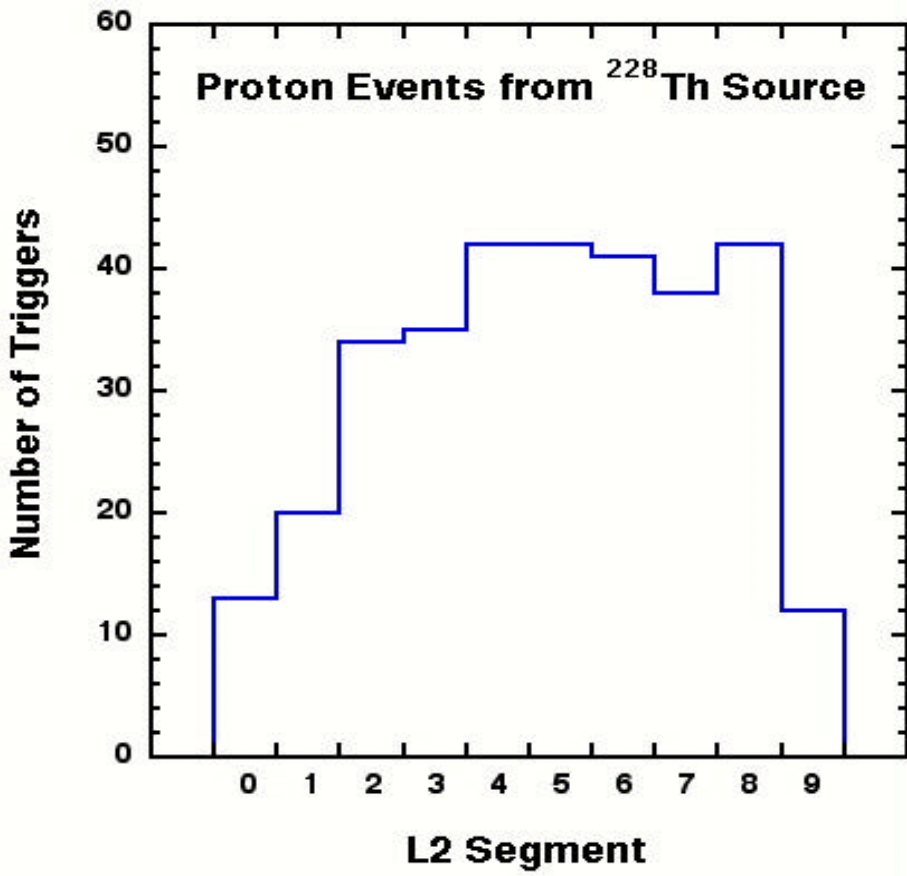
Mewaldt

The ^{228}Th Source Test

The 8.78 MeV alphas from a 1-μCi source produce knock-on protons of up to 5.6 MeV which can test all L2 and L3 detectors. Four ^{210}Po sources test the other L1 detectors on a given A/B side.

These proton events also test the on-board particle identification system





HET/LET/SEP Central CPT Setup

To be supplied

6) Vibration and acoustic test plan and procedure are written

- **Acoustic/vibration plan written by W. B. Tsoi (STEREO IMPACT Solar Energetic Particles Package (SEP) Dynamic Test Plan, IOM 352G-WBT-0507, 13 January 2005)**
  - **Sine survey before and after sine vibration on three axes (0.25 g_{pk} 5-2000 Hz)**
  - **Sine vibration sweep tests, force and response limited**
  - **Protoflight random vibration in 3 axes, each one preceded by sine survey, and each preceded by a PF-18 dB test run, and optional PF-12 dB and PF-6 dB runs**
  - **Protoflight acoustic, preceded by PF-9 dB test and optional PF-6 dB and PF-3 dB runs**
- **Acoustic/vibration test procedure written by Tim Werner (Procedure 144-D-V-101680, 10 January 2005)**

Vibration and acoustic test sequence

- **Acoustics**
  1) CPTs of SEP Central, LET (incl. Source), and HET at Caltech (FM 1)
  2) LPTs of SEP Central, LET, and HET at JPL test facility
  3) Acoustics PF-9 dB run
  4) Acoustics PF level
  5) LPTs of SEP Central, LET, and HET
  6) Repeat 1-5 for FM 2
- **Vibration**
  1) Mount FM 1 for axis X and Y test
  2) LPTs of SEP Central, LET, and HET
  3) Sine survey on axis X, 0.25 g_{pk} , 5-2000 Hz
  4) Sine vibration, level 1 (0.1*PF)
  5) Sine vibration, level 2 (0.25*PF)

Vibration and acoustic test sequence (continued)

6) Sine vibration, level 2 (0.5*PF)
7) Sine vibration, level 3 (1.0*PF)
8) Sine survey, 0.25 g_{pk} , 5-2000 Hz
9) LPTs of SEP Central, LET, and HET
10) Random vibration PF-12 dB run
11) Random vibration PF run
12) Sine survey, 0.25 g_{pk} , 5-2000 Hz
13) LPTs of SEP Central, LET, and HET
14) Repeat 3-13 for axis Y
15) Mount for axis Z
16) Repeat 2-13 for axis Z
17) CPT of SEP Central, LET (incl. Source), and HET at Caltech
18) Repeat 1-17 for FM 2 (step 17 not required before moving to step 18)

7) Thermal balance/thermal vacuum test plan is written

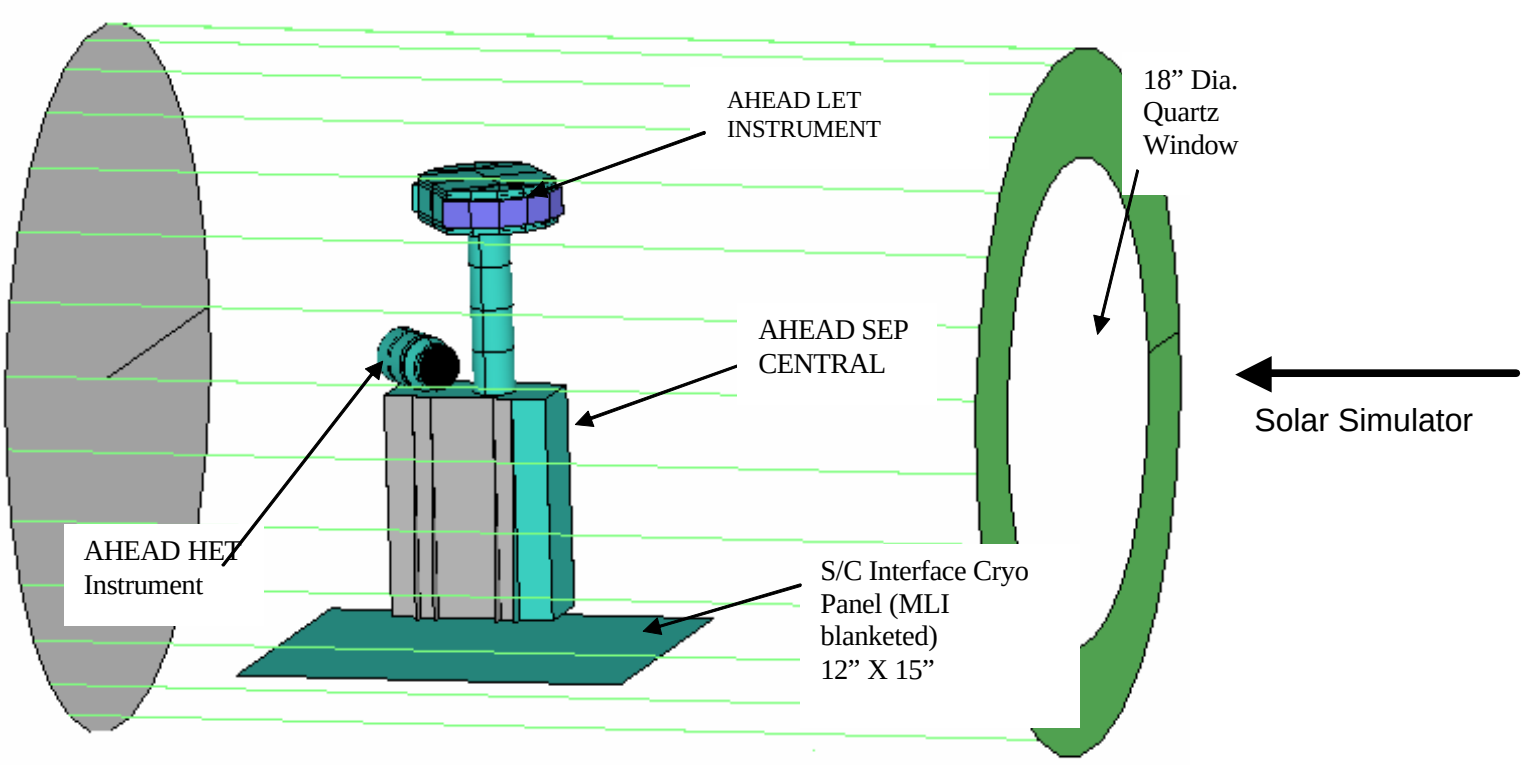
STEREO IMPACT SEP Central, HET, LET TV/TB Test Summary

- Thermal Vacuum Testing at JPL using Chamber 12
- Two SEP main assemblies from Ahead and Behind spacecraft will be subjected to thermal vacuum testing
- Test will consist of a thermal balance portion followed by thermal cycling with a chamber break in between
- Thermal Balance
  - A 12 hour bakeout will be performed at the beginning of the thermal balance
  - Test article will be single SEP Main Assembly from Ahead spacecraft consisting of SEP Main Electronics, LET and HET
  - Test article will be subjected to Thermal balance test using solar simulator capable of providing approximately 1.6 Suns
  - Test article will be equipped with Flight or Flight-like MLI blankets, cabling, grounding and mounting interface
  - Test article will be oriented in chamber with +Y axis facing the window (sun)
  - Small cold plate will be required to lower test article to position it within solar sim beam.
  - Shroud flooded with LN2 throughout TB test
  - Cold plate will be controlled to predicted spacecraft interface temperatures per ICD.
    - –13°C to +45°C during operational modes
    - –18°C during spacecraft survival mode
  - Test heaters may be used in thermal balance test for payload safety
  - Balance stability criteria: <0.1°C/hr for at least 1 hour
  - Soak for four hours after stability criterion is met

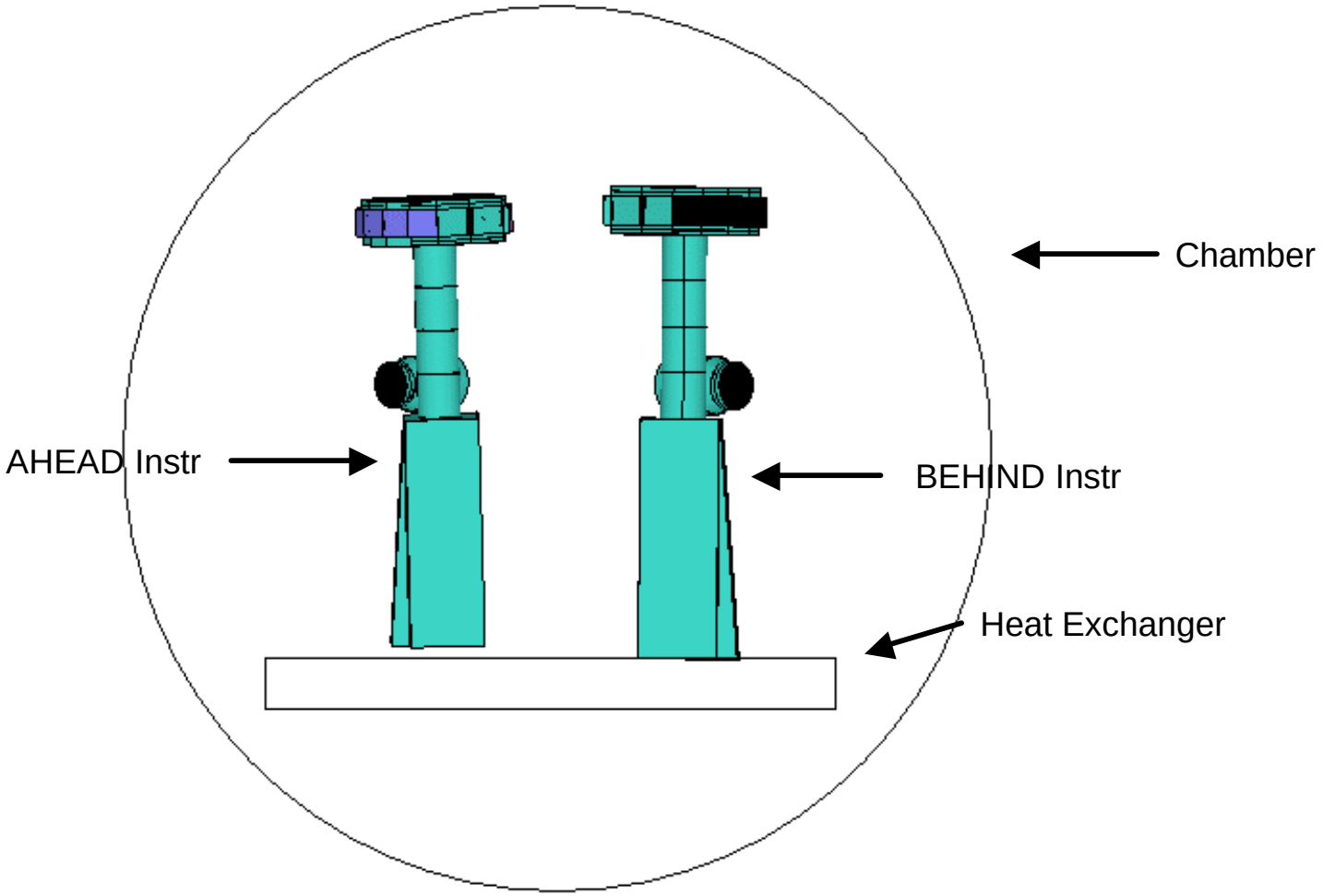
STEREO IMPACT SEP Central, HET, LET TV/TB Test Summary (continued)

- **Balance Tests**
  - Cold Surv in Sun: Instrument Off, Minimum solar flux 1308 watt/m^2, Cold plate –18°C, Surv heaters enabled
  - Cold Op in Sun: Instrument On at 30.5V, Minimum solar flux 1308 watt/m^2, Cold plate –13°C Op heaters enabled
  - Hot Op in Sun: Instrument On at TBDV, Maximum solar flux 1654 watt/m^2, Cold plate +45°C
- **Thermal Cycling**
  - Test article will be two SEP Main Assemblies from Ahead and Behind spacecraft each consisting of a SEP Main Electronics, LET and HET
  - Test article will be subjected to 6 operational and 1 survival thermal cycles
  - Survival heaters should be verified during cold survival soak
  - Test article will have MLI blankets and mounting isolation removed
  - Test article will be oriented in chamber for best fit with both SEP Main Assemblies
  - Standard cold plate for chamber will be used
  - Shroud and cold plate will be controlled to achieve desired soak temperatures on test article
  - Soak goal temperatures are:
    - Survival -35 TO +40C
    - Operational -25 TO +35C
  - Test heaters may be used in thermal cycle test to help reach soak goals and for payload safety
  - Contamination bakeout to be performed at beginning of test.

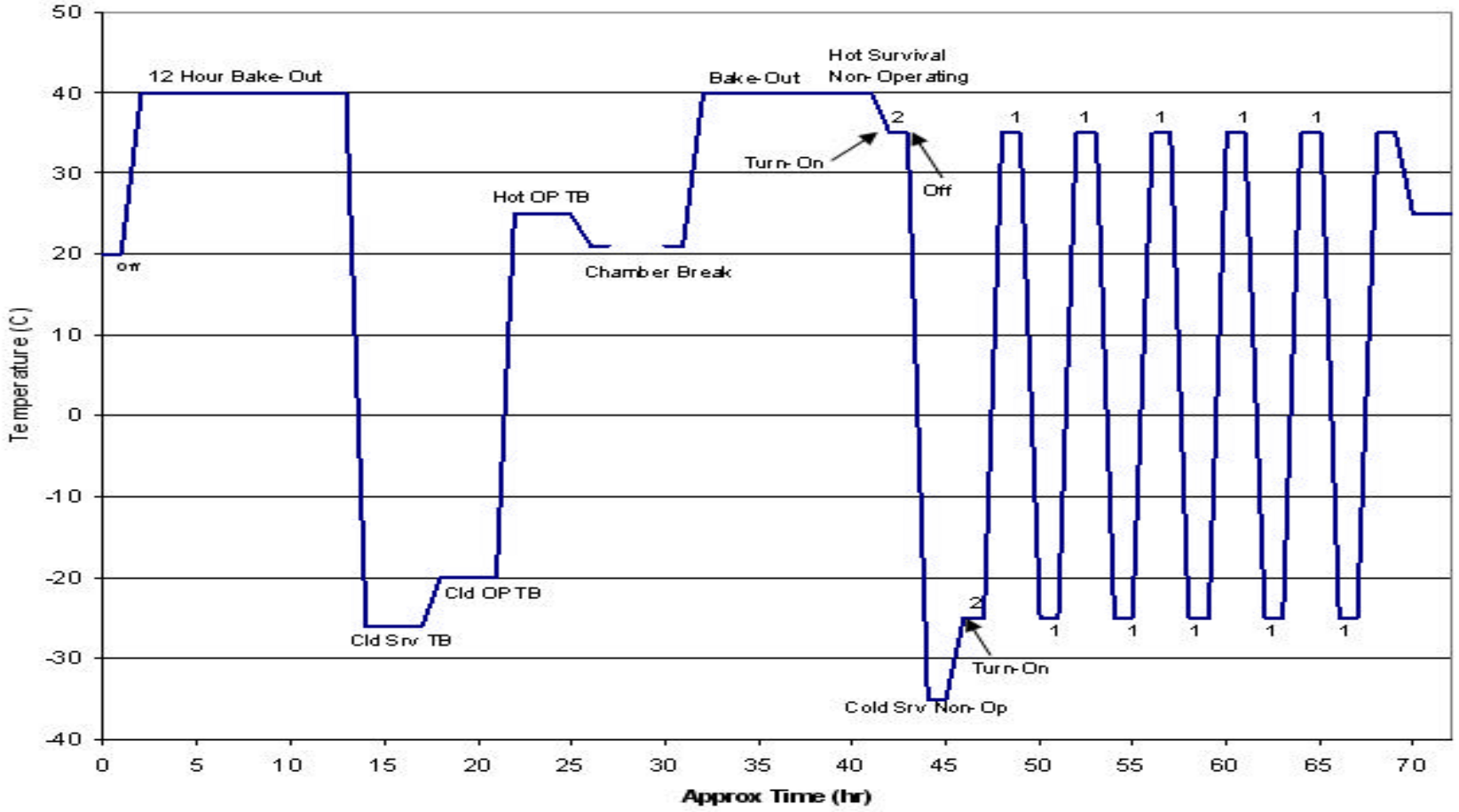
TB Test Set-up Layout



TV Test Set-up Layout



SEP Central HET/LET TB/TV Test Temperature Profile

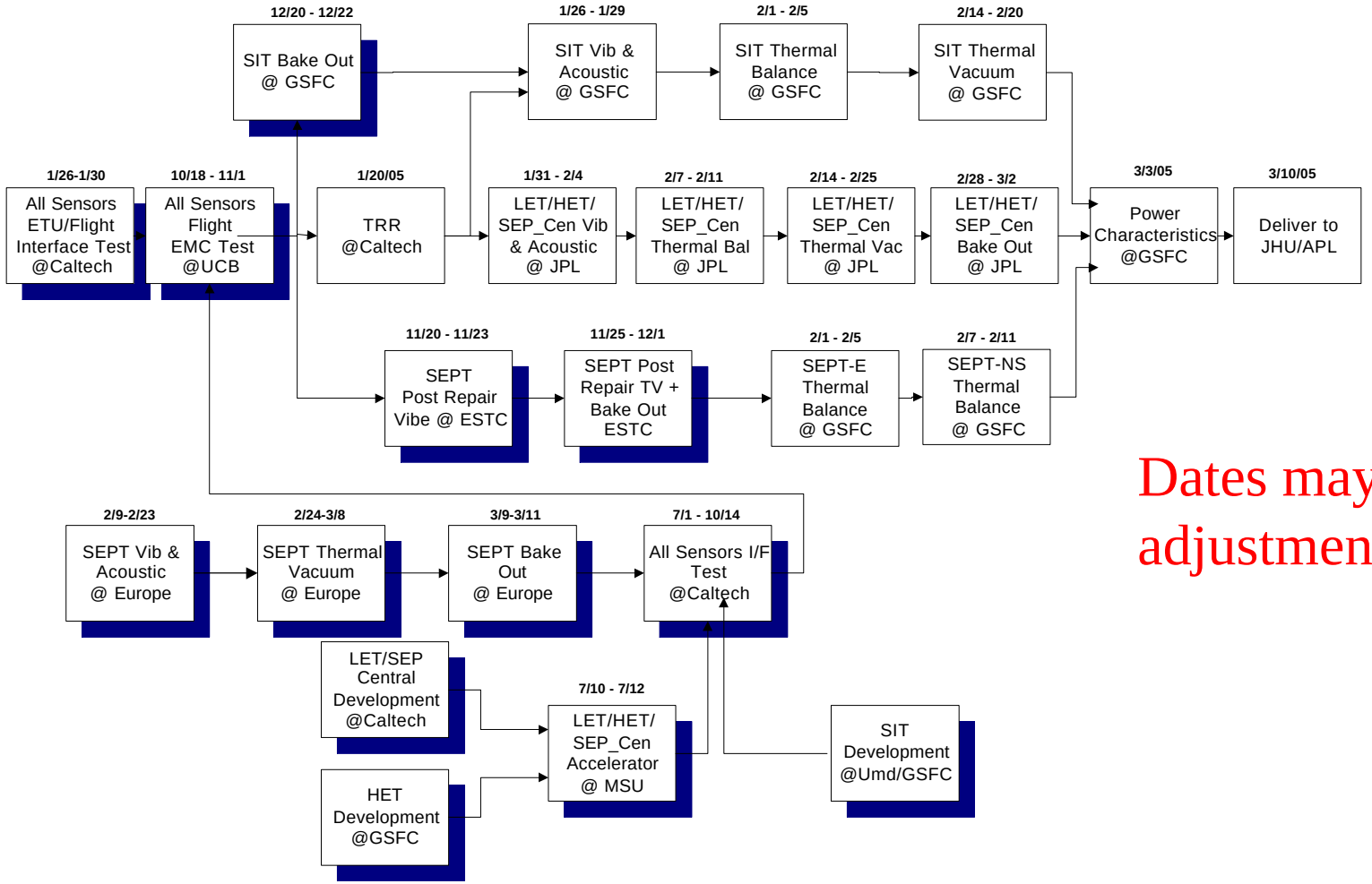


1 = Stabilize, Soak and Test Concurrently.
2 = Stabilize, Turn On, Soak and Test Concurrently.

8) Electrical and mechanical GSE are ready and harnesses will be ready by time of need

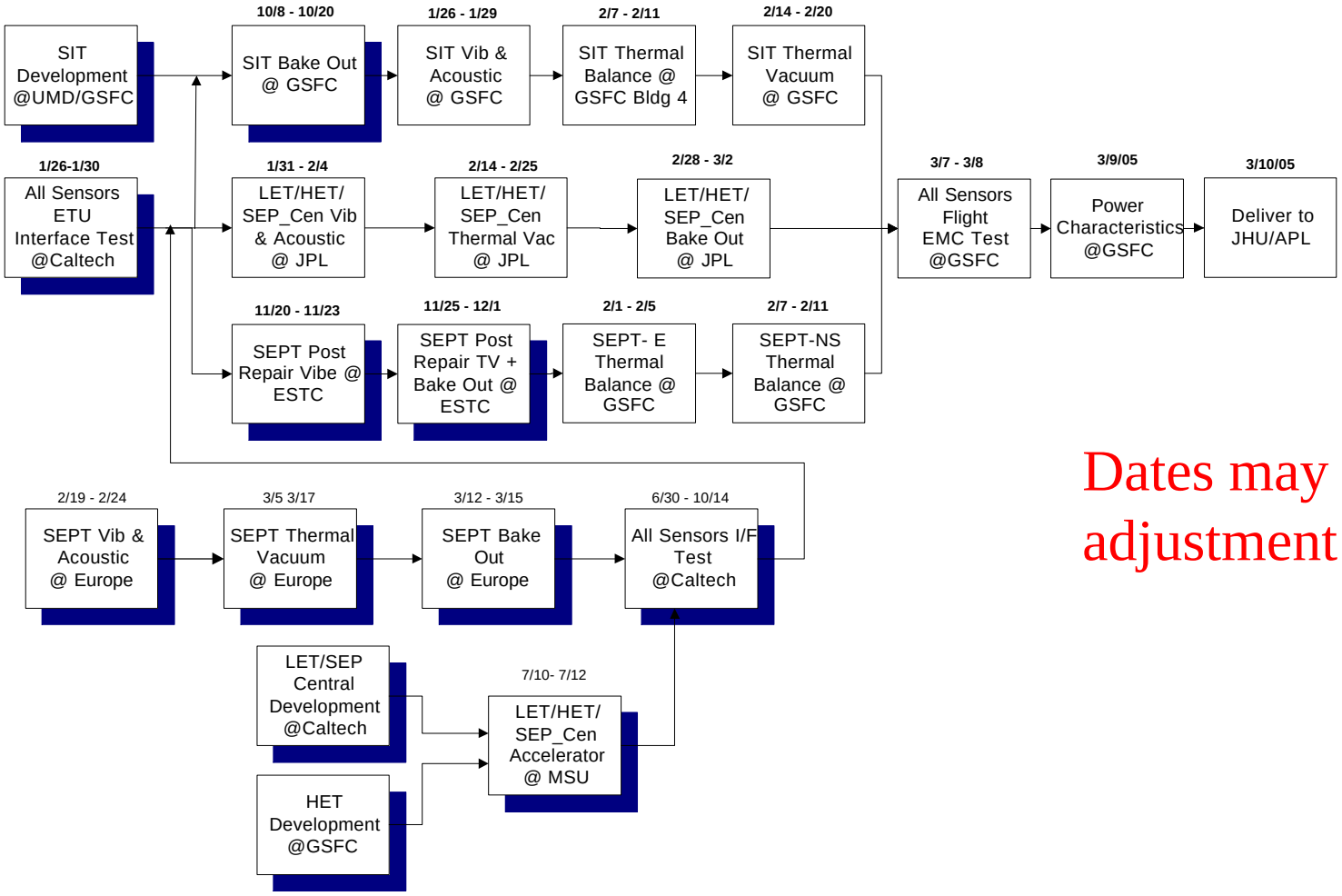
- Electrical GSE has been supporting performance tests
- Mechanical GSE ready
  - Mg plate holes drilled with SEP footprint for vibration test
  - One heat exchanger plate drilled with SEP footprint pattern for TB test; another adapter plate drilled with two SEP footprint patterns for TV test; both plates baked out
- Harnesses will be ready and baked out by time of need
- One issue open regarding blanketing of harness in thermal balance/vac test

SEP Suite FM 1 Test Flow (1/7/05)



Dates may need adjustment

SEP Suite FM 2 Test Flow (1/7/05)



Dates may need adjustment

FM 1 / FM 2 Configuration Control

- Units differ in way HET is pointing
  - Units uniquely labeled
  - FM 1 = Ahead
  - FM 2 = Behind
  - Important to get this right when mounting to S/C
- Software is slightly different for each unit and the checksum returned on boot up is unique to each unit
- Assembly and test records for each unit are maintained separately

Software Metrics: SEP Central

STEREO SEP Flight Software Metrics				
	Sep-04	Jan-05		
Current Build Version #		SEP01-06-05		
Final Build Version #		SEP01-06-06		
Completed SLOC with Unit Test	2350	2350		
Estimated final SLOC	2350	2350		
%Completed Acceptance Test				
# Discrepancy Reports Generated		33	combined with LET	
# Discrepancy Reports Open		0		
EEPROM available (kw = 1024 3 byte wds)	256	256		
EEPROM (kw) used current build	100.6	100.584		
EEPROM (kw) estimated for final build	100.6	100.584		
RAM (kw) available	128	128		
RAM (kw) used current build	76.79	76.793		
RAM (kw) estimated for final build	76.79	76.793		
Average CPU Utilization Current Build	6.50%	6.50%		
Average CPU Utilization Final Build	6.50%	6.50%		

Software Metrics: LET

STEREO LET Flight Software Metrics				
	Sep-04	Jan-05		
Current Build Version #		LET01-06-05		
Final Build Version #				
Completed SLOC with Unit Test	2760	2760		
Estimated final SLOC	2760	2760		
%Completed Acceptance Test				
# Discrepancy Reports Generated		33	combined with SEP	
# Discrepancy Reports Open		3	minor	
EEPROM available (kw = 1024 3 byte wds)				
EEPROM (kw) used current build	44.9	44.9		
EEPROM (kw) estimated for final build	44.9	44.9		
RAM (kw) available	128	128		
RAM (kw) used current build	113.9	113.878		
RAM (kw) estimated for final build	113.9	113.878		
Peak CPU Utilization Current Build (max evnts/sec)	2000	2000		
Peak CPU Utilization Current Build (requirement evnts/sec)	1000	1000		
Avg CPU Utilization (expected evnts/sec)	20	20		
Estimated final peak CPU Utilization (max events/sec)	2000	2000		

Software Metrics: HET

STEREO HET Flight Software Metrics						
	Aug-04	Sep-04	Oct-04	Nov-04	Dec-04	Jan-05
Current Build Version #	1.1					
Final Build Version #	3					
%Completed SLOC with Unit Test	9485					
Estimated final SLOC	10000					
%Completed Acceptance Test	0					
# Discrepancy Reports Generated	10					
# Discrepancy Reports Open	3					
EEPROM available (kw = 1024 3 byte wds)						
%EEPROM (kw) used current build	18.5					
%EEPROM (kw) estimated for final build	18.83					
RAM (kw) available	128					
%RAM (kw) used current build	82.9					
%RAM (kw) estimated for final build	85.73					
Peak CPU Utilization Current Build (max evnts/sec)						
Peak CPU Utilization Current Build (requirement evnts/sec)						
Avg CPU Utilization (expected evnts/sec)						
Estimated final peak CPU Utilization (max events/sec)						

Product Assurance and Safety Requirements

- Verify equipment calibration status
- Verify contamination and safety controls
- Conduct regular tail gate meetings to review test activities
- Review and approve all test procedures
- In-process inspections and test monitors
- Final data review and buy off
- Track all problem failure reports
  - Any problem during test is reported to Project within 24 Hours
  - PFRs generated promptly and proposed solution is worked with Project in real time
  - Project signs off on the closing of all PFRs

LET/HET/SEP Central Contamination Control Status/Test Constraints

- **LET & HET detectors are somewhat contamination sensitive**
  - **No doors; detectors are protected by thin windows**
  - **Detector volumes will be purged with dry N2 whenever possible and instruments will be maintained in a Class 10,000 environment or double bagged**
    - **Interruptions in purge can be tolerated**
- **Cleanliness requirements of HET, LET, SIT, LVPS, and SEP Central met with margin just prior to EMC**
  - **SEPT required additional cleaning**
  - **HET, LET and SEP Central will be inspected and cleaned as required before and after each environmental test**
- **Exteriors of assemblies must be kept clean**
  - **EMC area – just completed in November 2004 at a facility in Anaheim CA; bagging and purging kept assemblies clean**
  - **Units protected with bagging for all vibration and acoustic testing. Tent and/or bagging will be used for installation and removal of test items in the thermal vacuum chamber.**
  - **Thermal vac chamber and test cables are currently being cleaned and baked-out to acceptable outgassing levels. SEP Central electronics have already been baked-out (48 hours at 50C). Flight cable bake-out to be done at GSFC.**

Remaining Tasks Before Start of Environments

- Repair LVPS by replacing tantalum capacitors
- Install LET FM 2 outer window foils
- Elongate some holes on both LET brackets to better fit screws
- Modify swage screw head due to interference with external wall ribs
- Insert two heli coils on LVPS FM 1 box
- Tape over small holes where pins are missing (EMI/EMC concern)
- Mount both HET telescopes in their place
- Mount both LET units in their place and attach purge line
- Button up and stake both flight units after final LVPS fix
- Run CPTs
- Accumulate some trouble-free hours
- Book test facilities