High Energy Telescope (HET)

GSFC
Caltech
JPL

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HET Performance Requirements

Requirements are from the Level 1 Mission Requirements Document

Section 4.1.1.12:

"Develop distribution functions to an accuracy of ± 10% for electrons and/or ions with energies typical of solar energetic particle populations."

Appendix A-3:

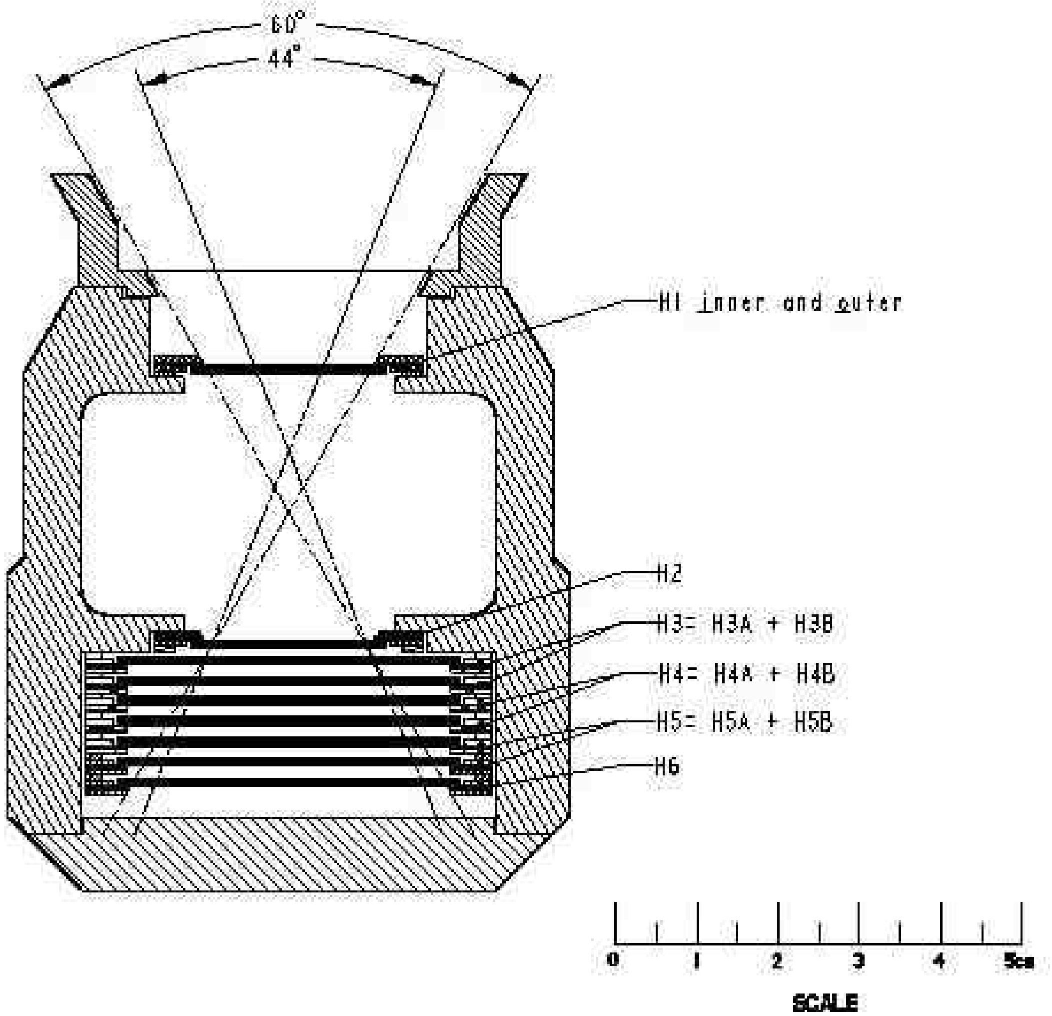
"HET: Shall detect the highest energy SEP ions and electrons in at least a 50 degree conical FOV, with detectors covering electrons 1-6 MeV, H and He 13-40 MeV/nuc, and heavier ions 30-80 MeV/nuc. Mass resolution shall be better than 0.25 amu for 3He and 4He. Time resolution shall be 1 minute for H, He Beacon data, and 15 minutes otherwise. Shall handle up to at least 1000 events/second."

HET Performance

We currently expect to be able to meet the goals in the table below

Description	Goal	Requirement
FOV (full angle)	58 degree cone	50 degree cone
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
Geometric Factor, cm^2 ster	0.7	0.5
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
Time Resolution	1 minute 1 prioritized event/sec	15 minutes 0.3 prioritized event/sec
Beacon Telemetry:	1 minute e, H, He, C, O, Ne, Mg, Si, Fe	1 minute H, He, e

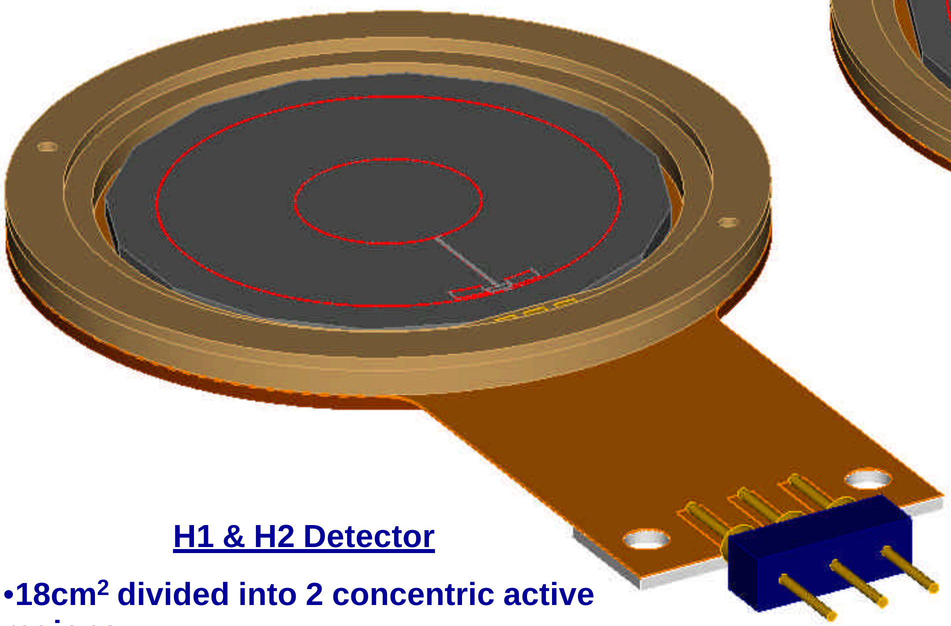
HET Telescope Schematic

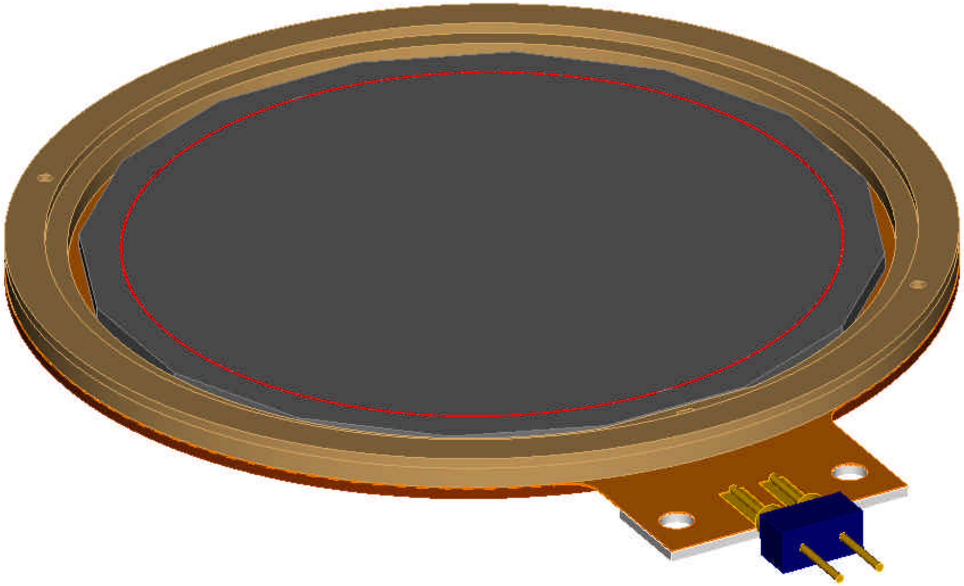


HET Telescope

- Telescope has 9 silicon wafer ion-implanted detectors.
- The front two detectors are spaced apart in order to set a 60 degree opening angle.
- Telescope body provides ~9mm of aluminum shielding to block particles from entering through the housing body.
- Front foil will be coated with Goddard composite coating and ITO on the outside and 500 Angstroms of VDG on the inside.
- Telescope is mounted directly on the top of the main SEP enclosure to allow the length of the cables from the detectors to their amplifiers to be minimized
- HET utilizes the Caltech PHA chip (PHASIC) + an ACTEL chip which contains the remaining front-end electronics and MISC processor (CPU24)

HET Silicon Wafer Detectors





H3 – H6 Detectors

- 65 cm^2 single active region
- 1.0mm thick
- Mounted in Flex-Rigid mount
- 7 detectors per telescope

H1 & H2 Detector

- 18 cm^2 divided into 2 concentric active regions
- 1.0mm thick
- Mounted in Flex-Rigid mount
- 2 detectors per telescope

HET Thresholds and Gains

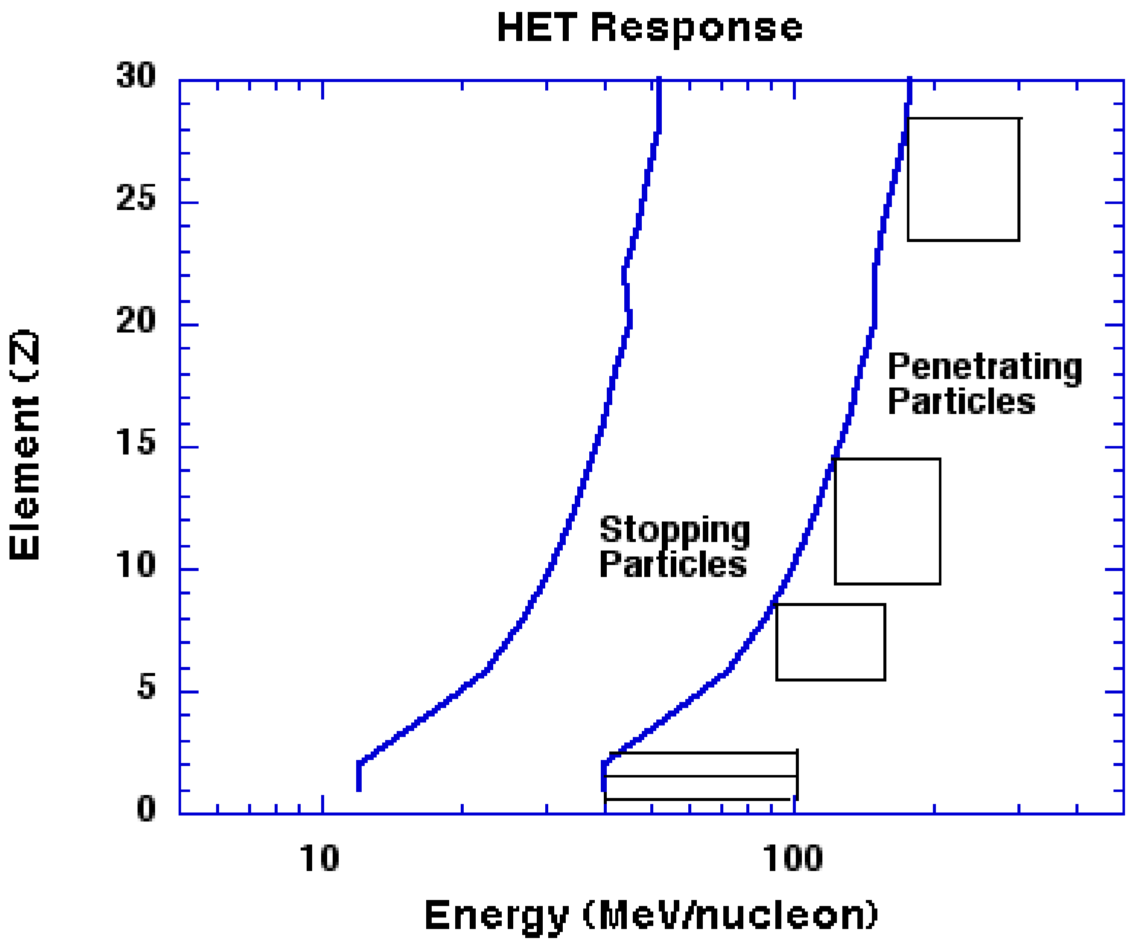
							HET Thresholds and Gains										8.30.01
					Minimum	Nominal	Min.	Hi-gain	Hi-gain	Delta (2)	Max.	Min.		Nom (3)	Lo-gain	Lo-gain	
			Detect.	Est. (1)	Thresh	Hi-gain	Hi-gain	Full	channel	Threshold	Hi-gain	Lo-gain	Delta (2)	Hi-Rate	Full	channel	Total
	Area	Thick	Cap.	Noise	(MeV)	Thresh	Setting	Scale	width	Adjust.	Thresh	Thresh	Adjust.	Thresh	Scale (4)	width	Dynamic
Detector	cm2	(micron)	(pf)	(MeV)	(=5 x n)	(MeV)	(MeV)	(MeV)	(MeV)	(MeV)	(MeV)	(MeV)	(MeV)	(MeV)	(MeV)	(MeV)	Range (5)
H1i	0.5	1000	6	0.037	0.185	0.20	0.1841	92	0.045	0.006	5.84	3.68	0.09	0.20	1841	0.899	9951
H1o	2.64	1000	30	0.037	0.185	0.20	0.1841	92	0.045	0.006	5.84	3.68	0.09	16	1841	0.899	9951
H2	3.14	1000	36	0.037	0.185	0.20	0.1841	92	0.045	0.006	5.84	3.68	0.09	0.20	1841	0.899	9951
H3,H4,H5	12	2000	273	0.080	0.400	0.45	0.3989	199	0.097	0.012	12.65	7.98	0.19	0.45	3989	1.948	9973
H6	12	1000	137	0.037	0.185	0.20	0.1841	92	0.045	0.006	5.84	3.68	0.09	0.20	1841	0.899	9951

The maximum H1, H2 energy-loss to meet the science requirements is ~75 MeV; the maximum of interest is ~3000 MeV

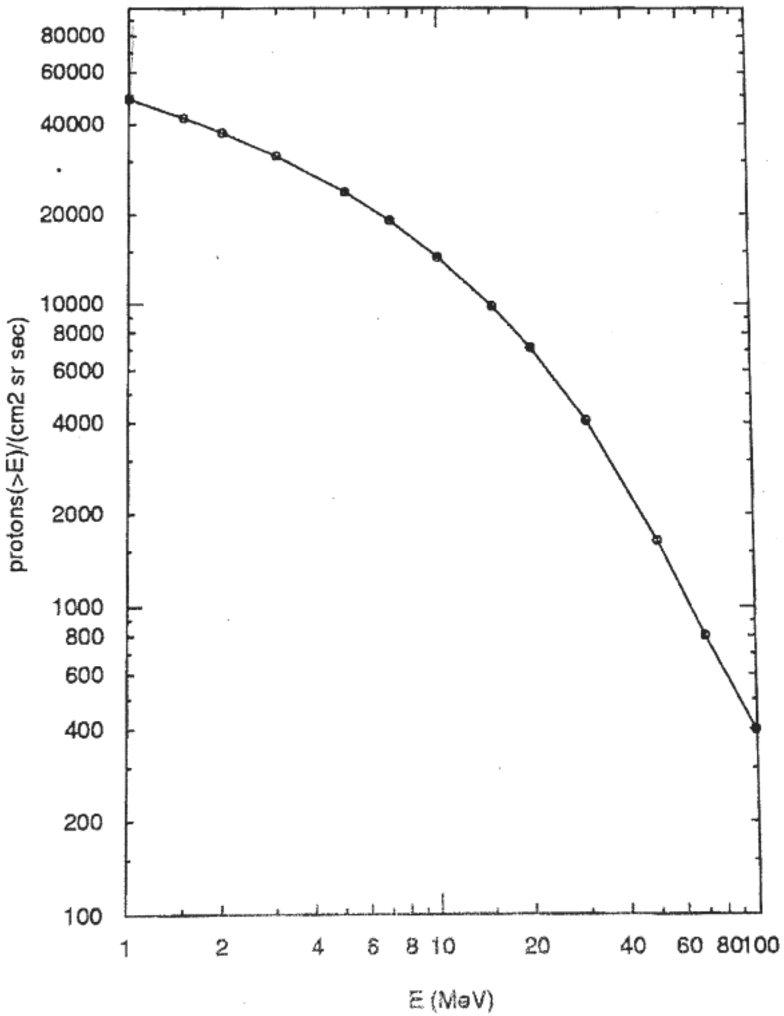
The maximum H3, H4, H5 energy-loss to meet the science requirements is ~100 MeV; the maximum of interest is ~4000 MeV

Notes:
(1) Noise estimated by W. R. Cook, taking into account all known contributions
(2) Nominal thresholds can be adjusted (by command) to accommodate range of thicknesses and noise
(3) For some L1i and L2, and for L1o, L3o, and H1o the low-gain thresholds will be raised during very high-rate periods
(4) Dynamic range = 500 for both low and high gain; nominal high/low gain factor = 20
(5) Ratio of Lo-gain full scale to minimum hi-gain threshold (5 times noise)

HET Energy/Particle Response



Bastille Day Event Proton Spectrum



Compiled by
Allan Tylka, NRL

HET Counting Rates

Proton Counting Rates Based Upon the 14 July 2000 Event Peak Intensity	
H1i Singles Rate	17,000/sec
H1i + H1o Singles Rate	100,000/sec
H1i.H2 Coincidence Rate	1400/sec
(H1i + H1o).H2 Coincidence Rate	8000/sec

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, swamping the system

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**
- **Sides of telescope shielded 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'd

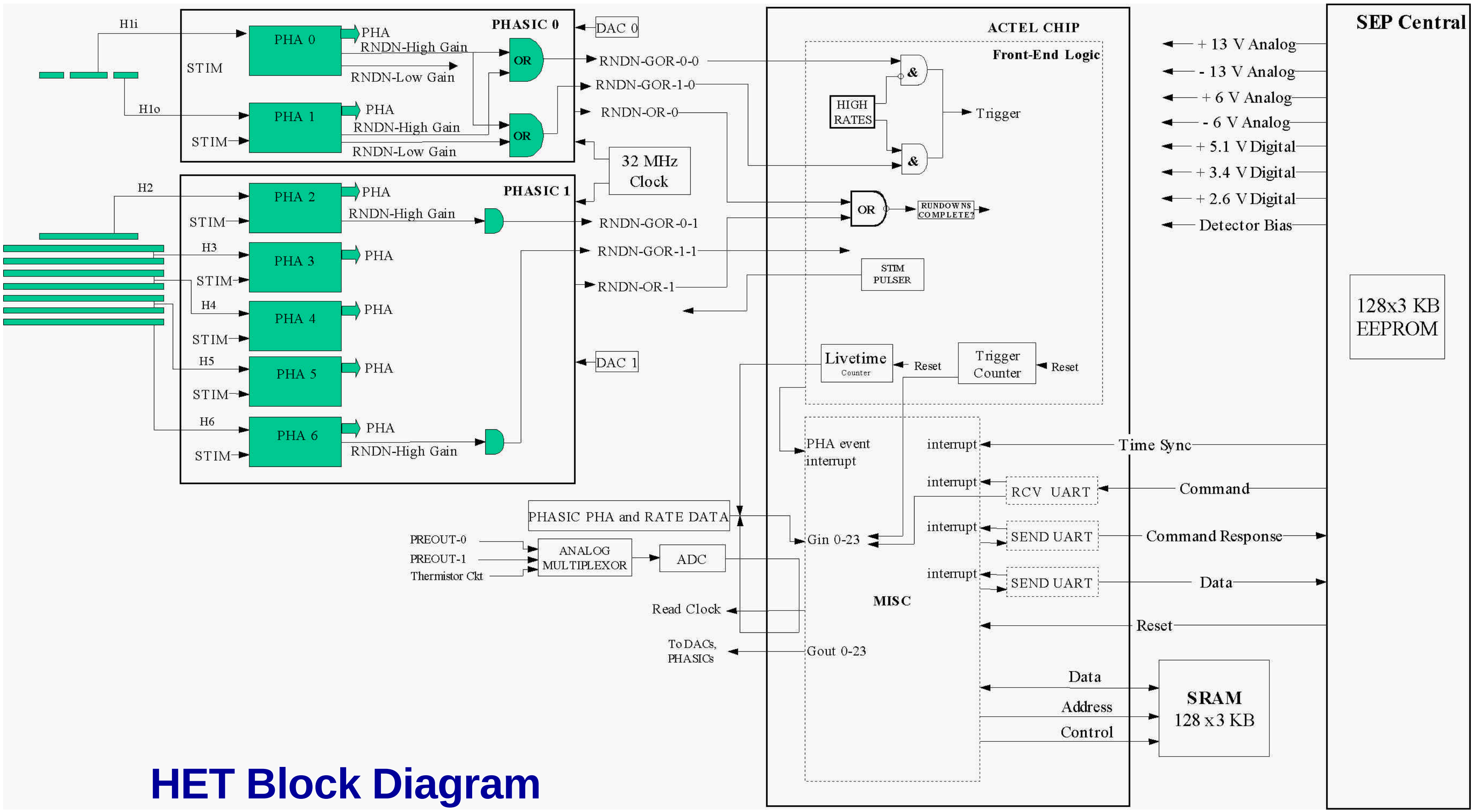
- **Threshold adjusted by disabling high-gain response of H1o and raising threshold of H1o low gain section to 20 MeV**
- **Adjustments controlled on-board by H1i count-rate (not adjusted)**

Implementation:

H1o threshold raised from 0.2 to ~20 MeV when H1i singles rate reaches 4000 counts/second. Also disable high-gain response of H1o. Resume low rate configuration when H1i singles rate falls below 2000 counts/second.

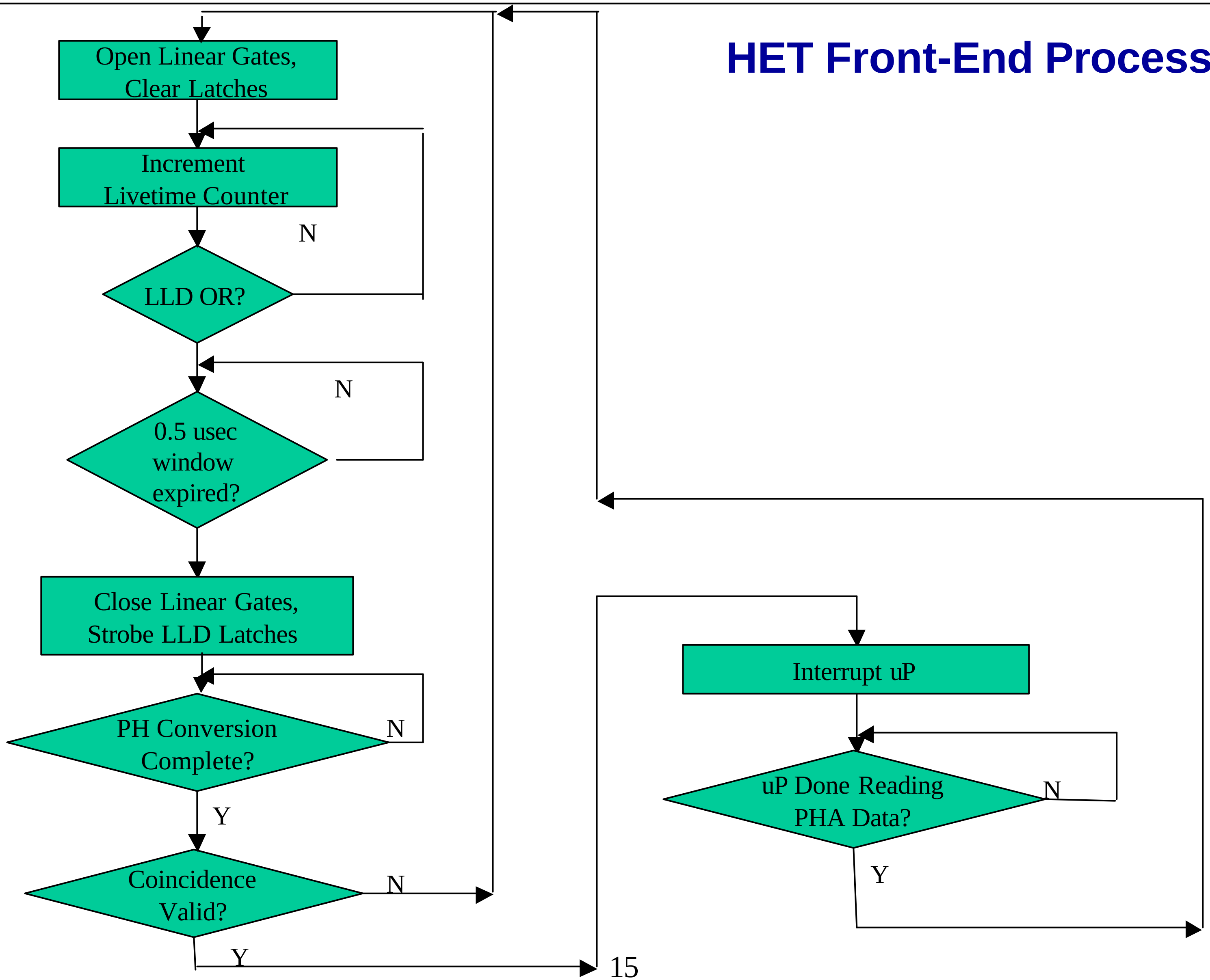
STEREO Pulse Height Analyzer ASIC (PHASIC)

- **PHASIC contains all front-end signal pulse processing electronics for reading out the HET detectors.**
- **Contains 16 complete dual-gain pulse height analyzers (PHAs), each with:**
  - **Preamplifier, configurable to various detector capacitances and output ranges**
  - **Two complete shaping amplifier / linear gate / Wilkinson ADC chains, with combined dynamic range of 10,000 (full scale/threshold)**
  - **Programmable thresholds**
  - **Bias switching to enable or disable power individually to each PHA**
  - **23-bit scalar for counting trigger rate**
- **HET will use two PHASIC chips for reading out its detectors**
  - **PHASIC #1 to read out H1i and H1o detectors**
  - **PHASIC #2 to read out H2, H3, H4, H5, and H6 detectors**
  - **Two PHASICs used to minimize potential for channel-to-channel crosstalk and to provide more energy combinations for the on-board test pulser**
  - **Unused PHA channels will be powered off–no additional power will be required to use two PHASICs instead of one**
  - **PHASICs will reside on opposite sides of the HET Electronics Board from each other**
  - **PHASICs will be daisy-chained for commanding and data readout**

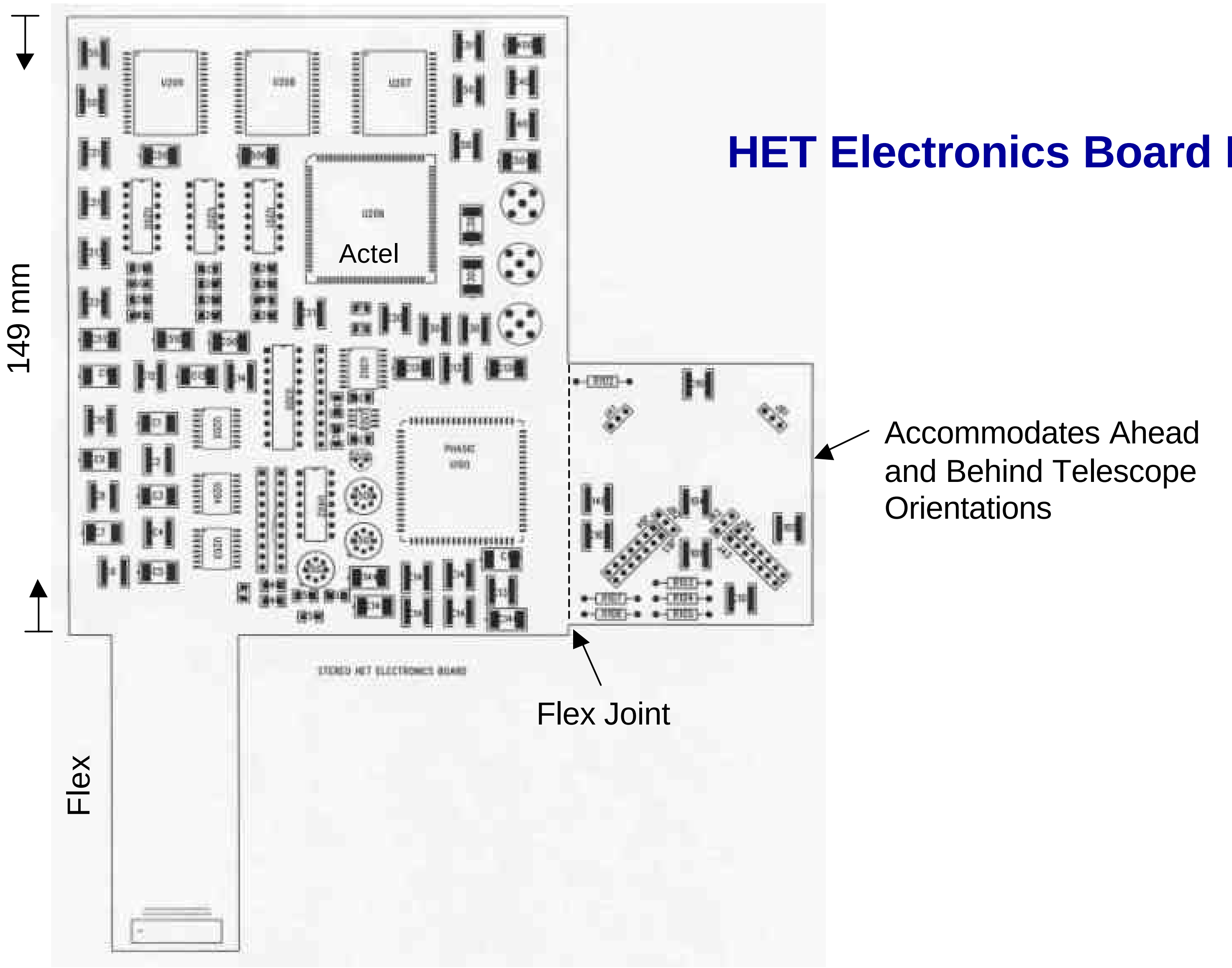


HET Block Diagram

HET Front-End Processing



HET Electronics Board Layout



	CDR	PDR
Mass (g)		
HET detector & housing	500	500
HET electronics	239	160
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Total:	**739**	**660**
Power (mW)		
HET VLSI (PHASIC)	63	63
+5VA & -5VA regulators	103	N/A
Housekeeping ADC	6	65
MISC @ 8 MHz	230	223
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Total:	**402**	**351**
Bit Rate (bit/s)		
Science	208.8	139.2
Housekeeping	1.2	1.6
Beacon	3.7	3.7
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Total:	**213**	**145**

HET Verification Matrix

Verification Matrix for STEREO/IMPACT/SEP/HET

Revision Date: 11/9/02
Revision Number: 3

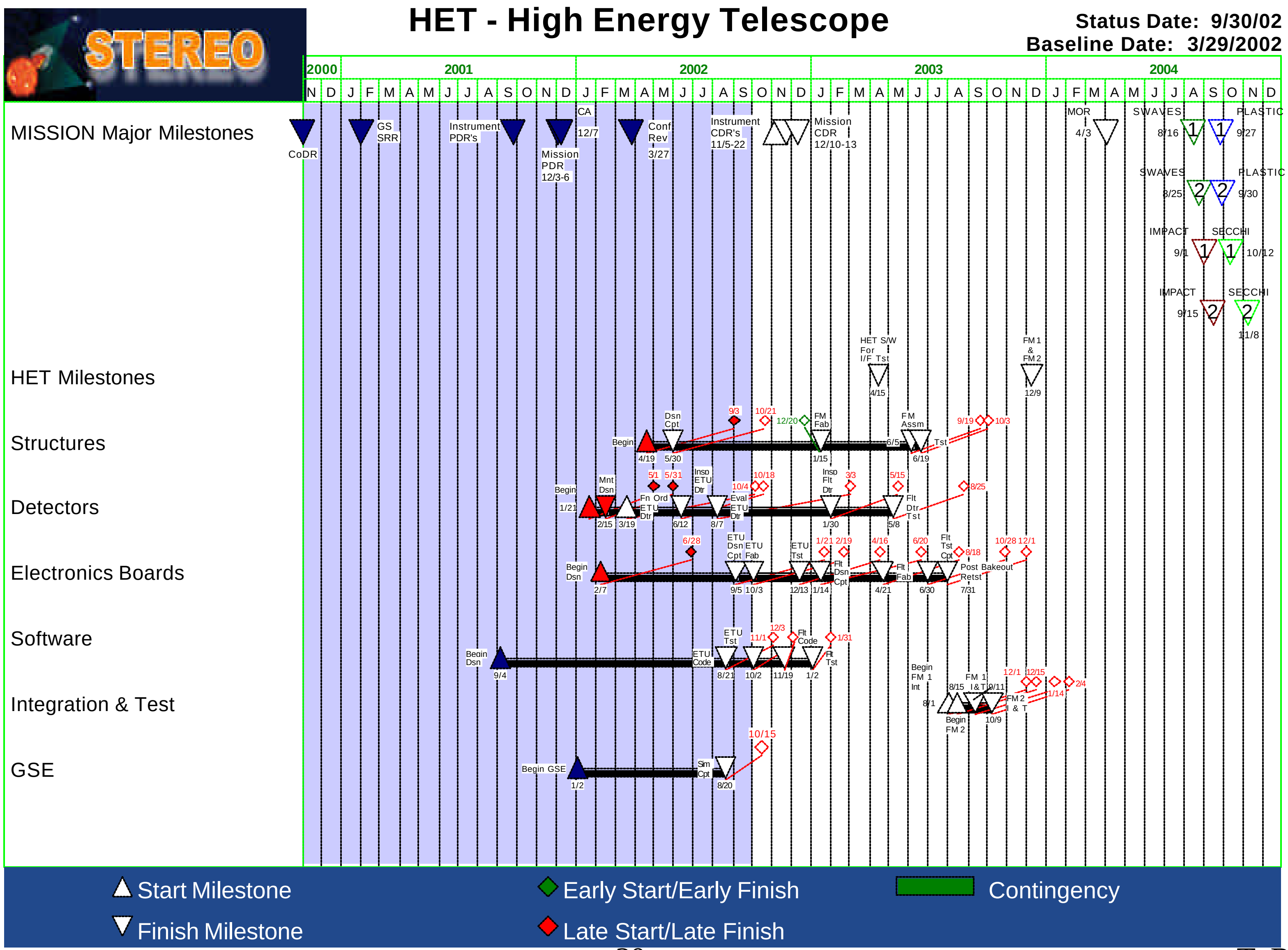
Hardware Description		Tests																					
Level of Assembly	Item	Noise & Brkdown	Thermal vacuum	Alphas &/or Accelerator	Elect. test, rm. Temp	Elect. Test, hot	Elect. Test, cold	Vibration, Sinusoidal	Vibration, Random	Shock	Acoustics	Pressure change	Voltage margins	Thermal cycle	Thermal balance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

Legend:

Level of Assembly	Unit Type		Tests	
			X =	Test required
			A =	Analysis
C = Component	BB =	Breadboard	H = test at a higher level of assembly	
I = Instrument	EM =	Engineering Model		
	PT =	Prototype		
	F =	Flight		
	F1 =	Flight unit #1		
	F2 =	Flight unit #2		

HET Testing

- HET detectors will be performance tested and thermal vacuum tested at GSFC
- Electronics/software testing will also be performed at GSFC with HET GSE
- Mu mesons produced in the atmosphere provide penetrating particles for testing the HET at low rate. This will be done various times prior to delivery to Caltech, and mu mesons will be monitored during spacecraft testing
- Accelerator tests at Michigan State University will provide the most detailed tests of HET performance
- A thermal vacuum test of the complete HET will be performed prior to delivery to Caltech
- A preliminary magnetics test will be performed at GSFC prior to delivery to Caltech
- Vibration, EMC, Magnetics, and Thermal Vacuum testing will occur after the HET is integrated with the LET at Caltech



STEREO
HET - High Energy Telescope
Status Date: 9/30/02
Baseline Date: 3/29/2002
2000
2001
2002
2003
2004
MISSION Major Milestones
HET Milestones
Structures
Detectors
Electronics Boards
Software
Integration & Test
GSE
Start Milestone
Finish Milestone
Early Start/Early Finish
Late Start/Late Finish
Contingency

HET Status

- **Detectors**
  - **H3 detector mounts have been supplied to Micron and detectors are being manufactured now**
  - **H1 detector mount design has been submitted to second manufacturer due to failure of first manufacturer to deliver flight quality mounts**
- **Electrical Design**
  - **A test PHASIC and MISC have been undergoing tests for several months and are now well understood**
  - **preliminary layout of HET electronics board has begun**
  - **front-end electronics (to be in same Actel chip as CPU24 MISC) has not been implemented yet**
- **Mechanical Design**
  - **largely complete**
- **Software**
  - **SW Requirements and SW Design Peer Review held in August**
  - **Event queuing and stopping particle algorithm have been coded for CPU24; PHASIC commanding capability, initial event gathering and GSE data displays all available**
  - **Flight telemetry output format has been defined**