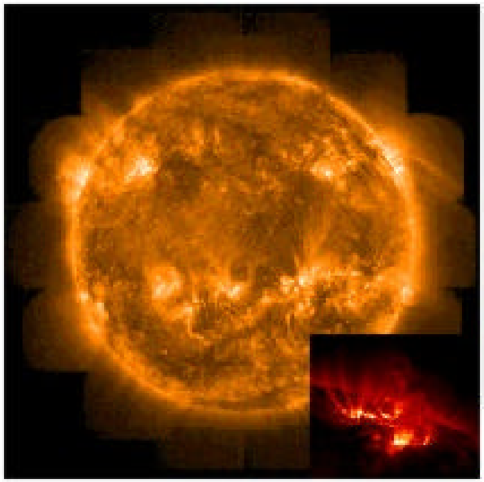
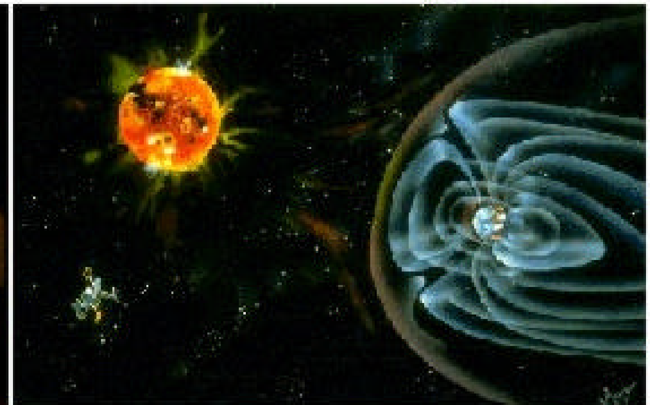




IMPACT
measures the invisible particles
and fields that reach across
interplanetary space from the
Sun to affect the Earth

Volume 1

STEREO IMPACT Introduction & Science Overview

IMPACT Preliminary Design Review

IMPACT Web Site: http://sprg.ssl.berkeley.edu/impact

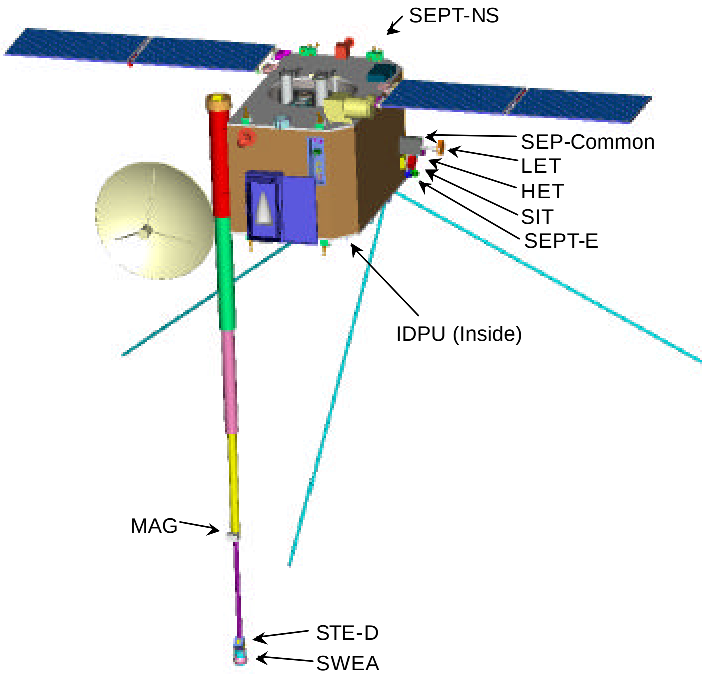
Agenda

11 Sept.		
09:00	Introduction, Science Overview	Luhmann
09:45	IMPACT Project Overview	Curtis
10:00	IMPACT System Engineering	Curtis
11:00	Reliability	Sanford
11:15	MAG	Acuna
12:00	Lunch	
13:00	Boom (Mechanical, Thermal)	Ullrich
14:00	SWEA	Cotin
15:00	STE	Curtis
16:00	IDPU / LVPS	Curtis
17:00	EGSE	Curtis
17:30	Suite Integration and Test	Curtis
12 Sept.		
09:00	SEP Overview	Tycho
10:00	SEPT	Tycho
11:00	HET	Tycho
12:00	Lunch	
13:00	LET, LET/HET Detector Status	Wiedenbeck
14:00	SEP Central Electronics (&LET electronics)	Cook
15:00	SIT	Mason
16:00	SEP Mechanical & FOV	Tycho
16:45	SEP Thermal	Hawk
17:00	SEP I&T	Tycho
17:30	SEP Issues and Concerns	Tycho
17:45	Mission Operations & Data Analysis plans	Curtis
18:00	Action Item Review	

IMPACT (In-situ Measurements of Particles and CME Transients) Instrument Overview

- **Boom Suite:**
  - Solar Wind Electron Analyzer (SWEA)
  - Suprathermal Electron Telescope (STE)
  - Magnetometer (MAG)

- **Solar Energetic Particles Package (SEP)**
  - Suprathermal Ion Telescope (SIT)
  - Solar Electron and Proton Telescope (SEPT)
  - Low Energy telescope (LET)
  - High Energy Telescope (HET)



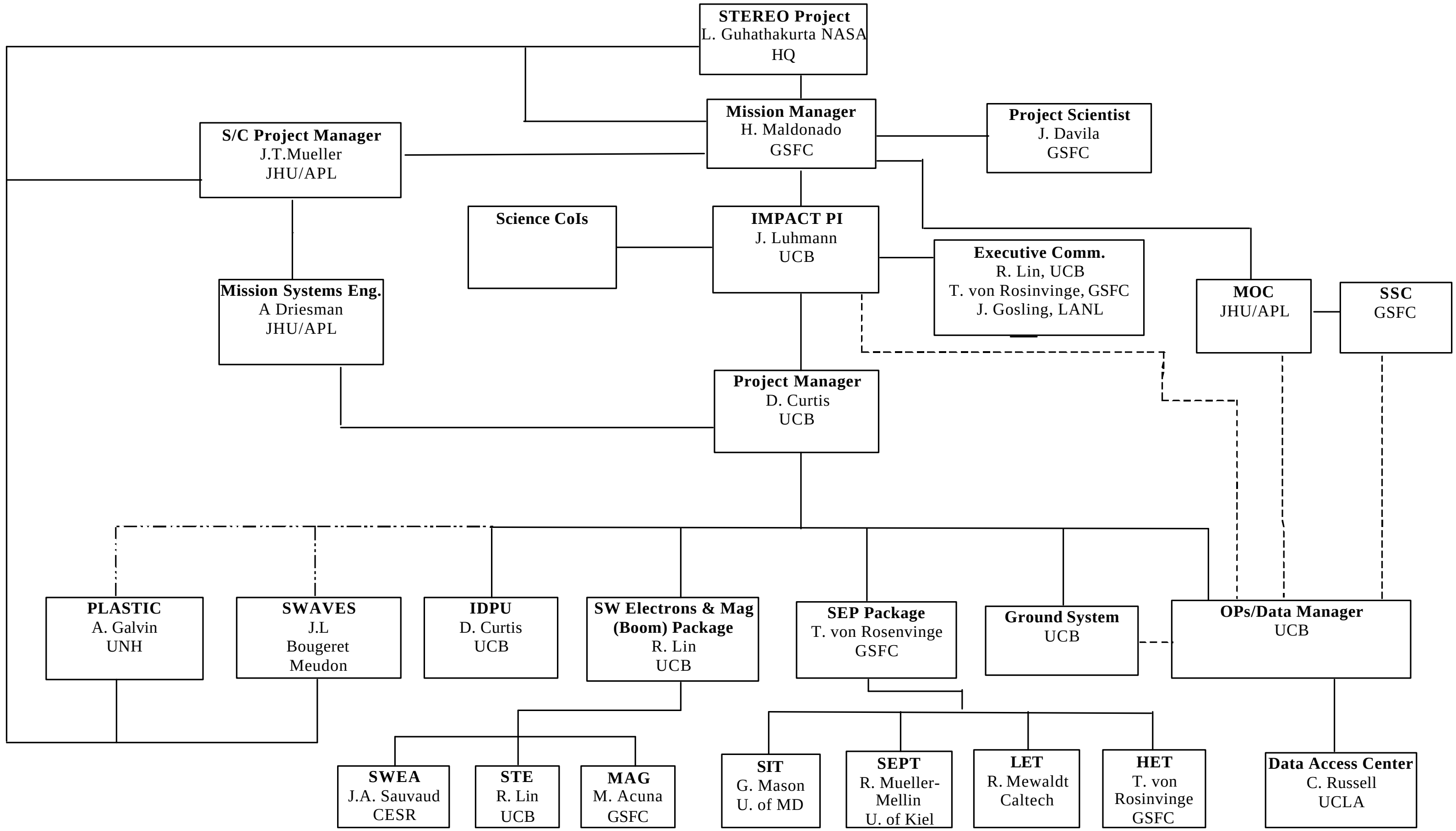
Investigation Goals and Objectives

- The equivalent of an L1 solar wind electron / SEP (Solar Energetic Particle) monitor for each imager in the STEREO pair
- In-situ measurements complementing limb observations by imagers on the partner spacecraft
- Long periods of longitudinally separated, identical in-situ measurements to deduce large scale structures
- A data management plan integrating solar wind electron, SEP, and magnetometer measurements, in coordination with PLASTIC solar wind ions, SWAVES plasma and radio waves, and SECCHI imaging
- A data analysis plan with a critical modeling component to make physical connections between the solar (imaging, SWAVES) and in-situ observations
- Connections to space weather applications via in-situ beacon data on the solar wind electron, interplanetary transients, and SEPs plus insights from science analyses

Team Member Institutions and Primary Roles

- **University of California, Berkeley-Space Sciences Laboratory (IMPACT Management,SWEA,STE,IDPU)**
- **NASA Goddard Space Flight Center (MAG,SEP-LET,HET)**
- **California Institute of Technology (SEP-LET,HET)**
- **University of Maryland (SEP-SIT)**
- ***University of Kiel (SEP-SEPT)***
- ***Centre d'Etude Spatiale des Rayonnements CESR (SWEA)***
- **Los Alamos National Laboratory (Science Integration, SEP-SIT)**
- ***Max Planck Institut fur Aeronomie (SEP-SIT)***
- **Jet Propulsion Laboratory (SEP-LET,HET)**
- ***ESTEC-European Space Agency (SEP-SEPT)***
- ***DESPA Observatoire de Paris-Meudon (SWAVES/IMPACT coordination)***
- **University of California, Los Angeles (MAG, IMPACT Data Web)**
- **SAIC-Science Applications International Corporation (IMPACT Modeling)**
- **NOAA Space Environment Center (IMPACT Modeling, Space Weather Applications)**
- **University of Michigan (IMPACT Modeling)**
- ***KFKI-Hungarian Research Institute for Particle and Nuclear Physics (SEP Modeling)***

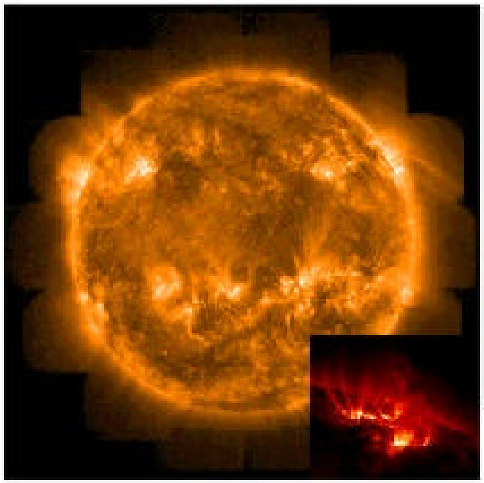
Organization Chart

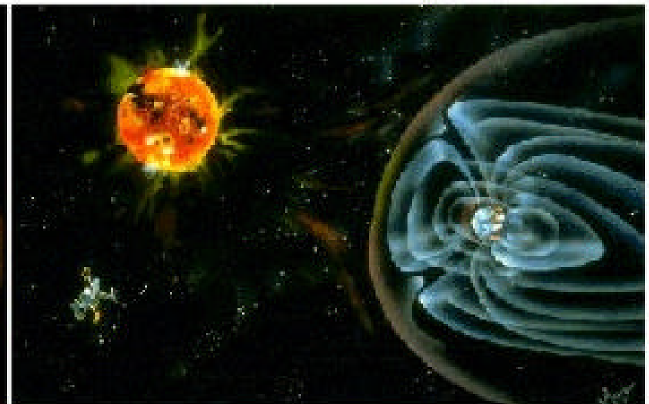


Communications

- **Within Team:**
  - Bi-weekly Team telecons followed by e-mail summaries (also archived on team website)
  - Weekly SEP group telecons
  - Project Manager website with reports, schedules, action items, etc.
  - Semi-annual Team meetings
  - E-mails, telecons as needed

- **With Project:**
  - Weekly All-Project telecons participation (Curtis, von Rosenvinge, Luhmann)
  - Weekly Project/IMPACT telecons
  - Participation in Bi-monthly APL Coordination Meetings as needed
  - Peer Reviews
  - Support Project site visits
  - Support Biannual SWG meetings





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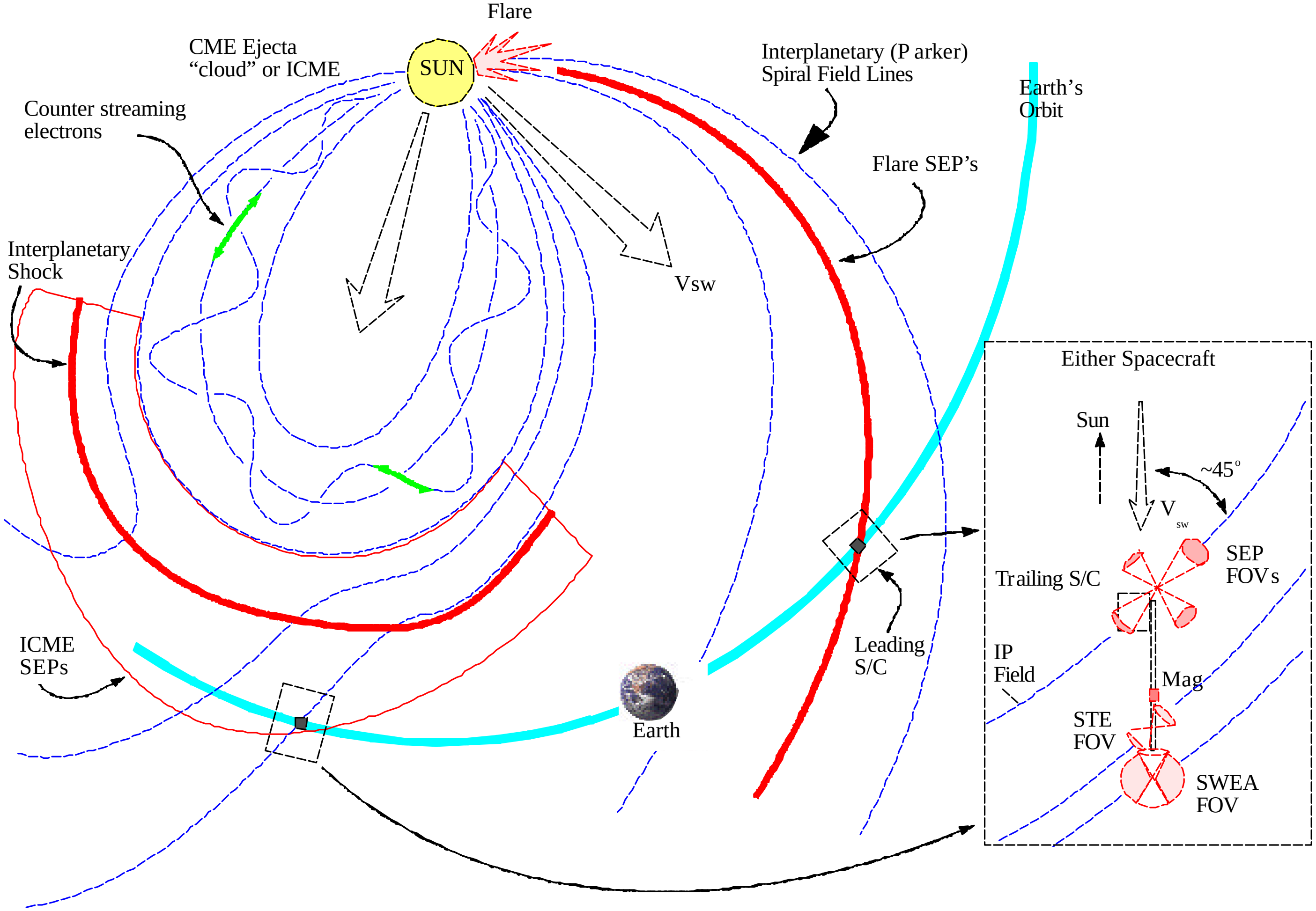
In Situ Measurements



Janet Luhmann

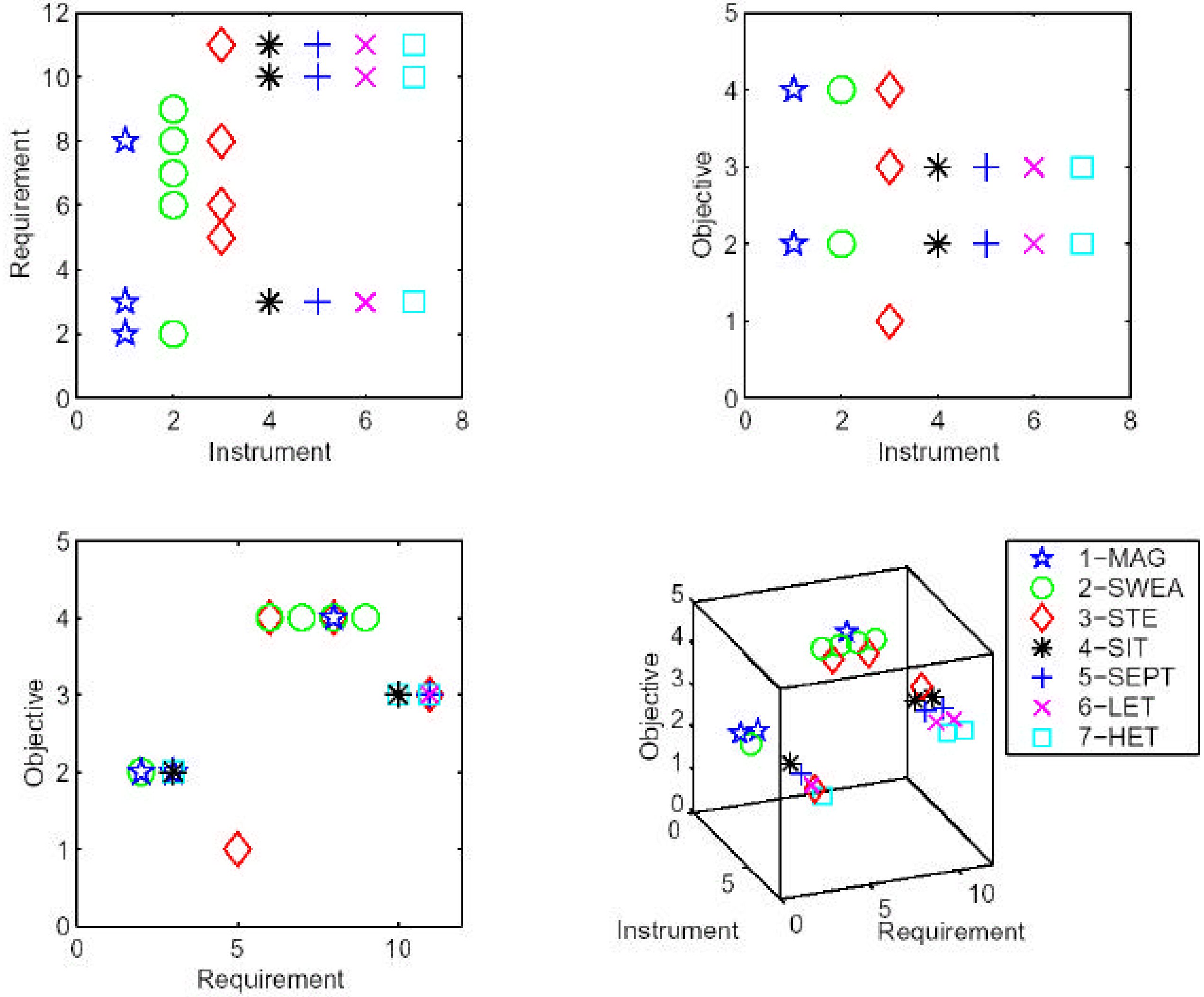
STEREO Science Objectives

1. **Understand the causes and mechanisms of CME initiation.**
   - *STE*
2. **Characterize the propagation of CMEs through the heliosphere.**
   - *MAG,SWEA,SIT,SEPT,LET,HET*
3. **Discover the mechanisms and sites of energetic particle acceleration in the low corona and the interplanetary medium.**
   - *STE, SIT, SEPT, LET, HET*
4. **Improved determination of the structure of the ambient solar wind.**
   - *MAG, SWEA, STE*

STEREO Level 1 Science Requirements

1. Determine the evolution of the CME mass distribution as the CME propagates from the low corona to 1 AU (Objective 2)
2. Determine the CME speed as the CME propagates from the low corona to 1 AU (Objective 2) ***MAG, SWEA***
3. Determine the direction of CME propagation as the CME evolves from the low corona to 1AU (Objective 2) ***MAG,SIT,SEPT,LET,HET***
4. Determine the CME initiation time to an accuracy of order 10 minutes. (Objective 1)
5. Determine the location of CME initiation to within +/- 1 deg solar latitude and solar longitude. (Objective 1) ***STE***
6. Obtain the time series of solar wind temperature measurements at two points separated in solar longitude. (Objective 4) ***SWEA, STE***
7. Obtain the time series of solar wind velocity measurements at two points separated in solar longitude. (Objective 4) ***SWEA***
8. Obtain the time series of solar wind magnetic field measurements at two points separated in solar longitude. (Objective 4) ***MAG, SWEA, STE***
9. Obtain the time series of solar wind density measurements at two points separated in solar longitude. (Objective 4) ***SWEA***
10. Determine the location of particle acceleration in the low corona and through the interplanetary medium. (Objective 3) ***SIT, SEPT, HET, LET***
11. Characterize the energetic particle distribution functions in situ for electrons and ions at particle energies typical of solar energetic particles. (Obj. 3) ***STE, SIT, SEPT, HET, LET***

IMPACT Level 1 Science Requirements and Objectives

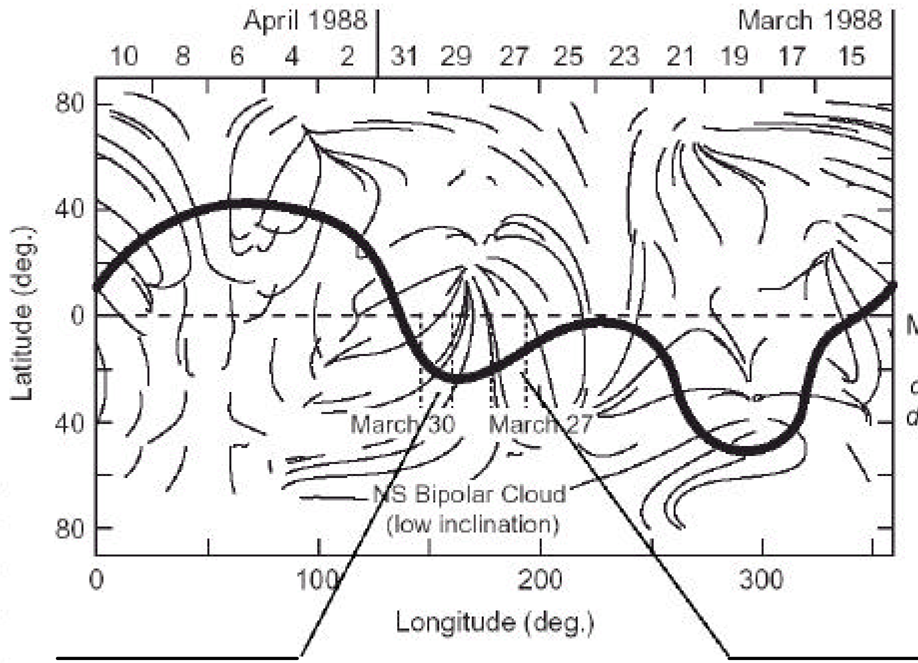


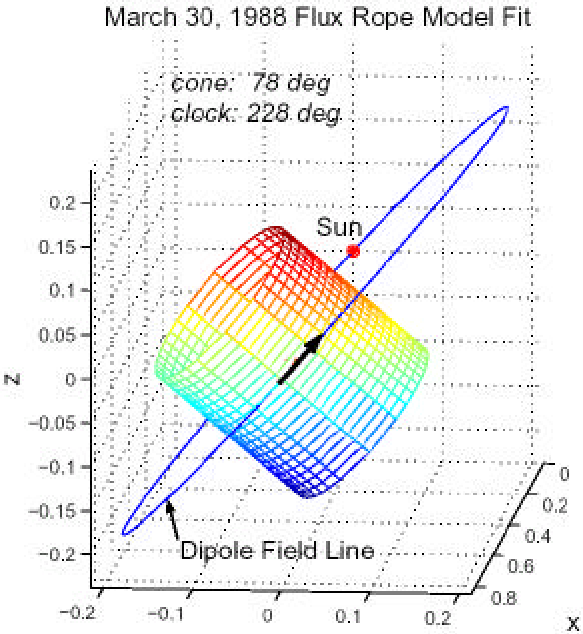
This chart shows graphically the relationship between the Four STEREO Objectives, Eleven Level 1 Science Requirements, and the IMPACT Instruments

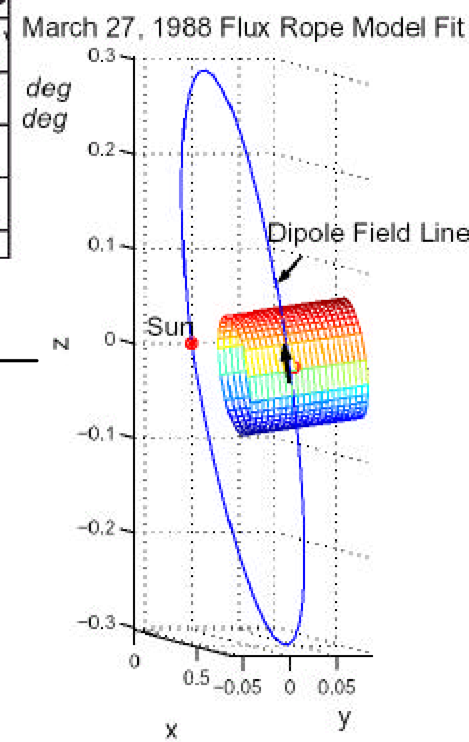
MAG Science

- **Identify ICMEs at one or two of the STEREO sites, providing information on their global scale and uniformity, including their associated interplanetary shocks (strength, surface orientations), compressed solar wind sheaths, and internal field configurations (e.g. flux rope or other, flux rope orientation, size, and handedness, and ejecta flux content)**
  - *for relating to the solar observations and determining potential geoeffectiveness*
- **Define ambient solar wind conditions at the two spacecraft, including stream structures and interfaces, and heliospheric current sheet crossings**
  - *for relating to solar observations, and determining potential geoeffects from high speed streams and stream interfaces alone, as well as the effects of the ICME on ambient conditions, and ambient conditions on the ICME*
- **Organize local particle (solar wind and SEP) distribution functions including IMPACT/SWEA, STE, and SEP electrons, and PLASTIC and IMPACT/SEP ions.**
  - *SWEA heat flux electrons for inferring field topology and connections to the Sun, STE electrons for inferring field connections to active regions, PLASTIC solar wind and ICME ions for deducing plasma ion sources, and SEPs from SIT,SEPT,LET,HET for deducing SEP origin, acceleration, and propagation processes*
- **Determine properties of low frequency waves in the interplanetary medium**
  - *for characterizing waves at ICME shocks that play a role in SEP acceleration and propagation, and large Alfven wavetrains that sometimes accompany ICMEs and produce geoeffects of their own*
- **Provide a measure of one of the fundamental heliospheric MHD parameters**
  - *for comparisons with 3-D models of shocks and other solar wind and ICME features that will be used to connect the SECCHI observations to the STEREO in-situ observations*

MAG Science







Cylindrical magnetic flux rope model fits to ICMEs show orientations controlled by coronal magnetic field structure.

(Figure courtesy of T. Mulligan, UCLA)

SWEA Science

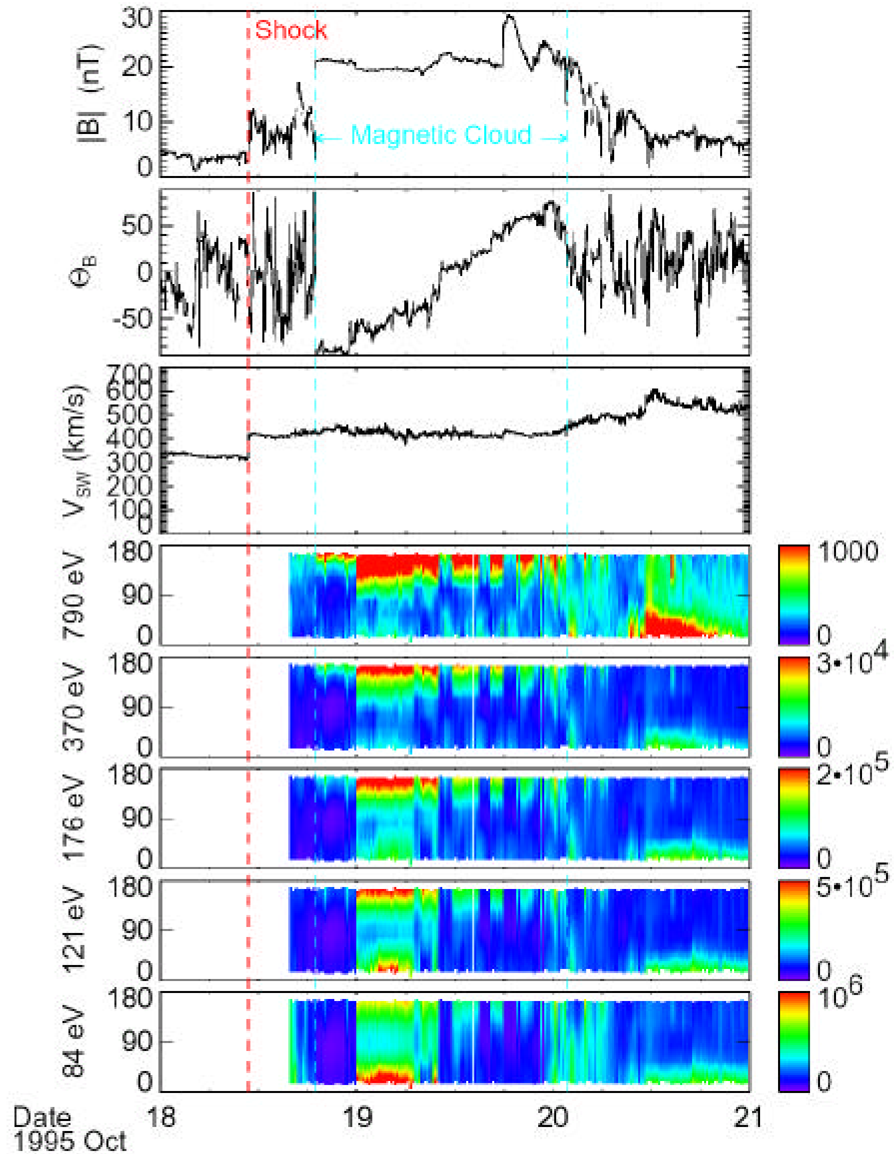
SWEA measures the 3-D electron distribution function from ~0-3000 eV with nearly complete (90% of 4π) angular coverage. This energy range includes the thermal core population (<60 eV) and the highly anisotropic, suprathermal halo population (>60 eV) that carries the majority of the solar wind heat flux. Some specific goals of SWEA are to:

- **Provide direct comparison of in-situ density measurements with coronagraph images.** SECCHI coronagraph images are a measure of column integrated electron density and can be compared to electron density measured in-situ by SWEA on the complementary STEREO spacecraft.
- **Determine magnetic field topology.** Suprathermal (>60 eV) electrons are excellent tracers of magnetic field topology. For example, Bi-directional streaming is a signature of magnetic field lines that are connected at both ends to the Sun.
- **Provide a remote probe of coronal electron temperature.** Measurements of the slope of the distribution function at electron energies > 100 eV provide a tool for remote sensing of the inner coronal electron temperature.
- **Identify ICMEs at one or both of the STEREO spacecraft locations.** Bi-directional electron distribution are one of the primary signatures of ICMEs. These measurements are also useful for identifying ambient solar wind conditions such as stream structures, interfaces and heliospheric current sheet crossings.
- **Provide measurements of fundamental plasma parameters.** Density, velocity, electron temperature and pressure measurements are critical for comparison with 3-D models of solar wind and ICME propagation and relating to solar observations and determining potential geoeffectiveness.

SWEA Science

"Strahl" electrons in the SWEA ~80eV – 1keV energy range often show counterstreaming, field-aligned beams inside the CME-related interplanetary "flux rope", suggesting connection to the Sun at both ends.

(Figure courtesy of D.Larson, UCB)



Janet Luhmann

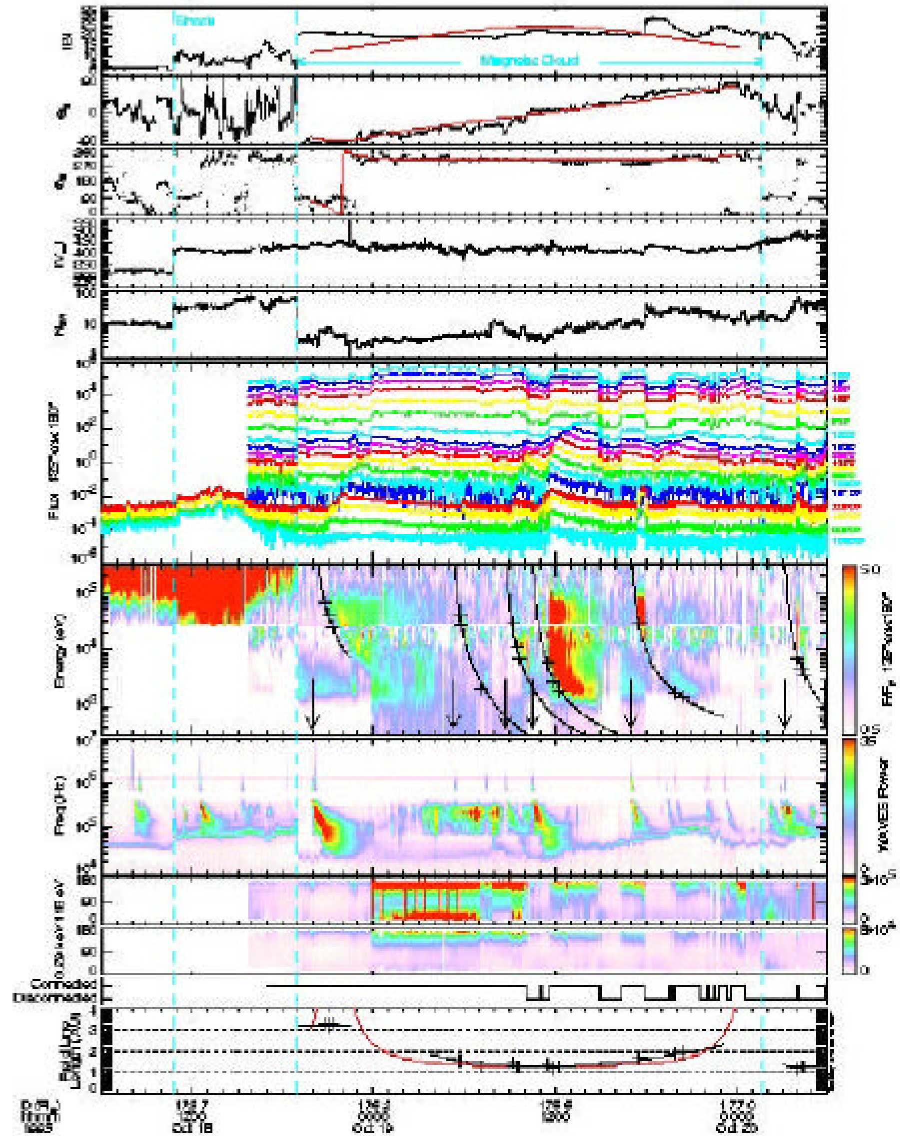
STE Science

STE measures electron fluxes in the 2-100 keV energy range where shock acceleration and flare-site acceleration begin to become important sources.. Some specific goals of SWEA are to:

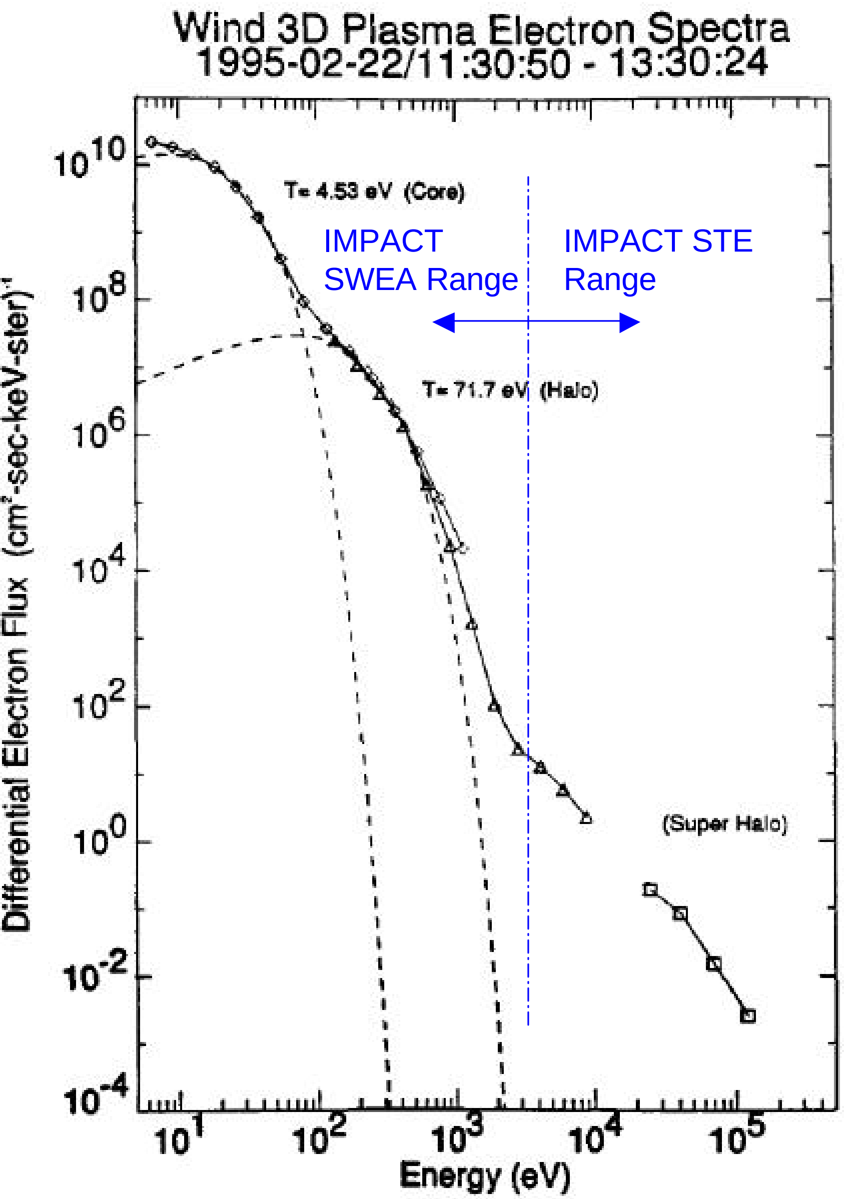
- **Identify the solar source and magnetic footpoints of ICMEs.** Impulsively accelerated electrons detected in an ICME can be tracked by the type III radio burst they produce from 1 AU back to the Sun, where the parent flare-like event can be imaged.
- **Determine the length of field lines in ICMEs.** The field line length can be obtained by analyzing the velocity dispersion (the arrival of the faster electrons first) in impulsive events.
- **Probe particle acceleration near the Sun in both impulsive and gradual (CME-related) solar energetic particle (SEP) events.** Energy loss effects in traversing the corona will show up in the STE energy range, thus providing the column depth to the acceleration region. Velocity dispersion studies of STE electrons and SEP ions probe the timing and heights of the ion and electron acceleration.
- **Probe the in situ acceleration of electrons by ICME shocks waves, and identify the shock parameters that lead to type II radio emission.** The ICME shock accelerated ~1-10 keV electrons produce the type II radio emission used to track ICMEs from the Sun to 1 AU. STE measurements will probe the in situ acceleration of electrons by ICME shocks and determine the shock parameters that lead to type II radio emission.
- **Identify the source (presently unknown) of the superhalo (~1-100 keV) electrons that are always present in the interplanetary medium.** STE's high sensitivity will enable unambiguous measurements of angular distributions and spectra to identify the source.

STE Science

STE energy range (>3keV) suprathermal electrons show a velocity dispersion inside ICMEs, indicating field line path-length to an active region source. Radio bursts accompany the injections.

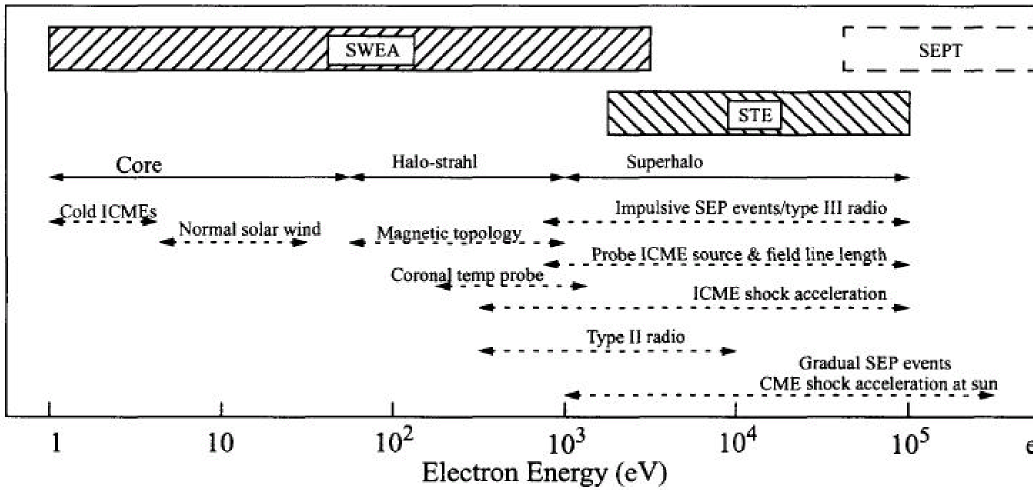


(From Larson et al., 1997)



Boom Suite Science

Together, SWEA and STE cover the entire spectrum of interplanetary electrons below SEP energies, giving IMPACT the ability to trace CME-related magnetic fields, as observed by MAG, to their sources.



(WIND data from Larson et al., 1996)

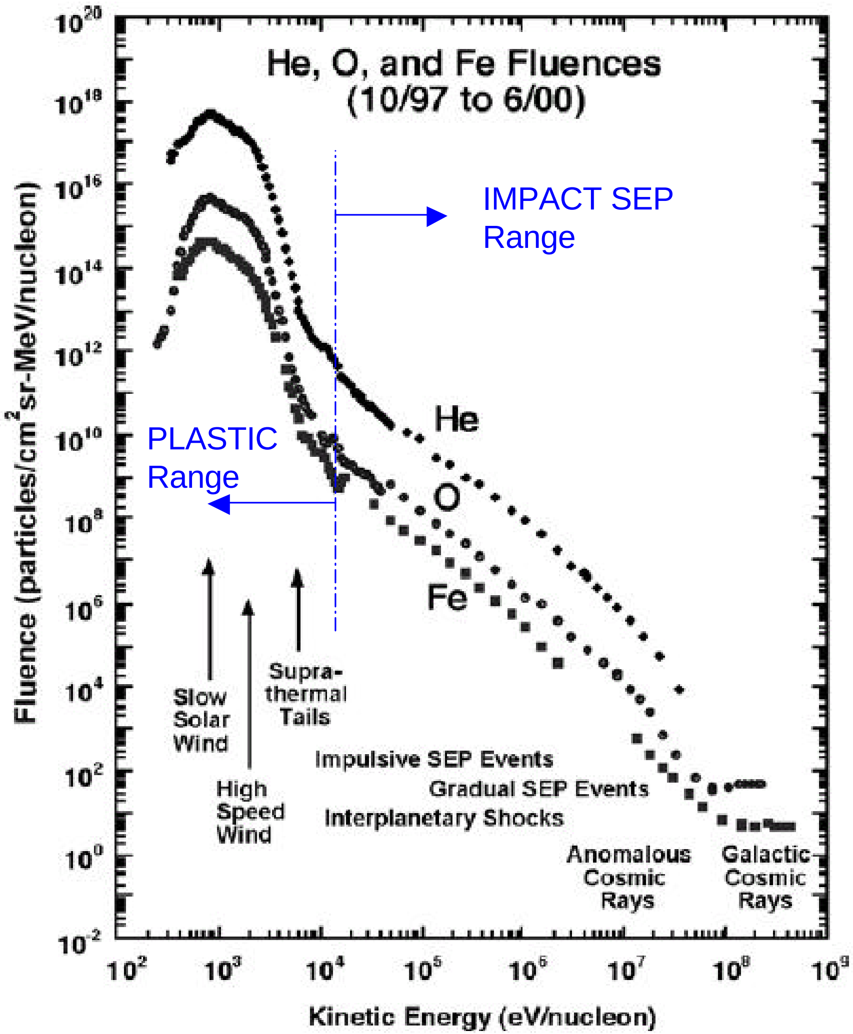
SEP Science

- **Solar Energetic Particle (SEP) studies with STEREO have four main objectives:**
  - **To understand how and where CMEs accelerate charged particles**
  - **To characterize properties of the subset of CMEs that do accelerate particles**
  - **To complement STEREO images by sensing remotely ICME and magnetic field structures**
  - **To develop tools for improved forecasts of large SEP events and/or to warn of their onset**
- **To address these objectives requires:**
  - **Composition over a broad energy/intensity range**
  - **Excellent temporal resolution**
  - **Spatially separated spacecraft**
- **Composition data from LET, SIT and HET will:**
  - **Distinguish flare-accelerated & CME-shock accelerated particles**
  - **Identify seed populations (coronal, solar wind, suprathermal ions, pickup ions)**
  - **Investigate the physics of particle acceleration with ions of differing charge/mass ratios (Fe/O, 3He/4He,22Ne/20Ne, p/e)**
  - **Investigate how proton-generated waves throttle escape of various species from the shock**

SEP Science (Continued)

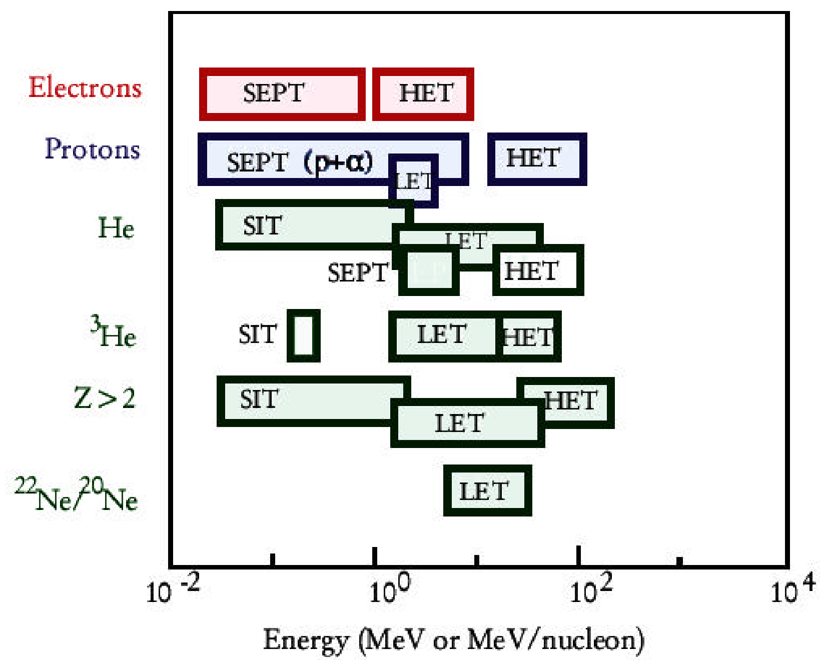
- **Broad energy coverage (HET/LET/SIT for composition; SEPT for protons/electrons) will:**
  - Allow comparison of measured energy spectra with acceleration models
  - Provide a larger event sample (from small flare-related events to large CME-driven events)
  - Investigate acceleration processes continuously from injection energies to their upper limit
  - Measure 10 to 100 MeV/nucleon proton & alpha-particle intensities of space weather interest
  - Provide a broad range of particle intensities for the STEREO Beacon Mode
- **Spatially separated measurements are needed to:**
  - Investigate the spatial extent of acceleration along the shock
  - Measure in situ interplanetary parameters of CMEs that accelerate particles seen by trailing S/C
  - Develop tools to enable forecasts of SEP radiation hazards with future interplanetary networks
- **In summary, SEP IMPACT Measurements will address key objectives for STEREO and Living with a Star:**
  - Provide "ground-truth" for interpreting CME images in terms of energetic-particle production and transport, and for investigating the consequences of CMEs
  - Provide the tools to understand and eventually forecast large solar particle events
  - Provide key data for the STEREO Beacon Mode
  - Address important LWS goals that include investigating the solar-cycle and spatial dependence of solar-particle events and mitigating solar-particle risks

SEP Science

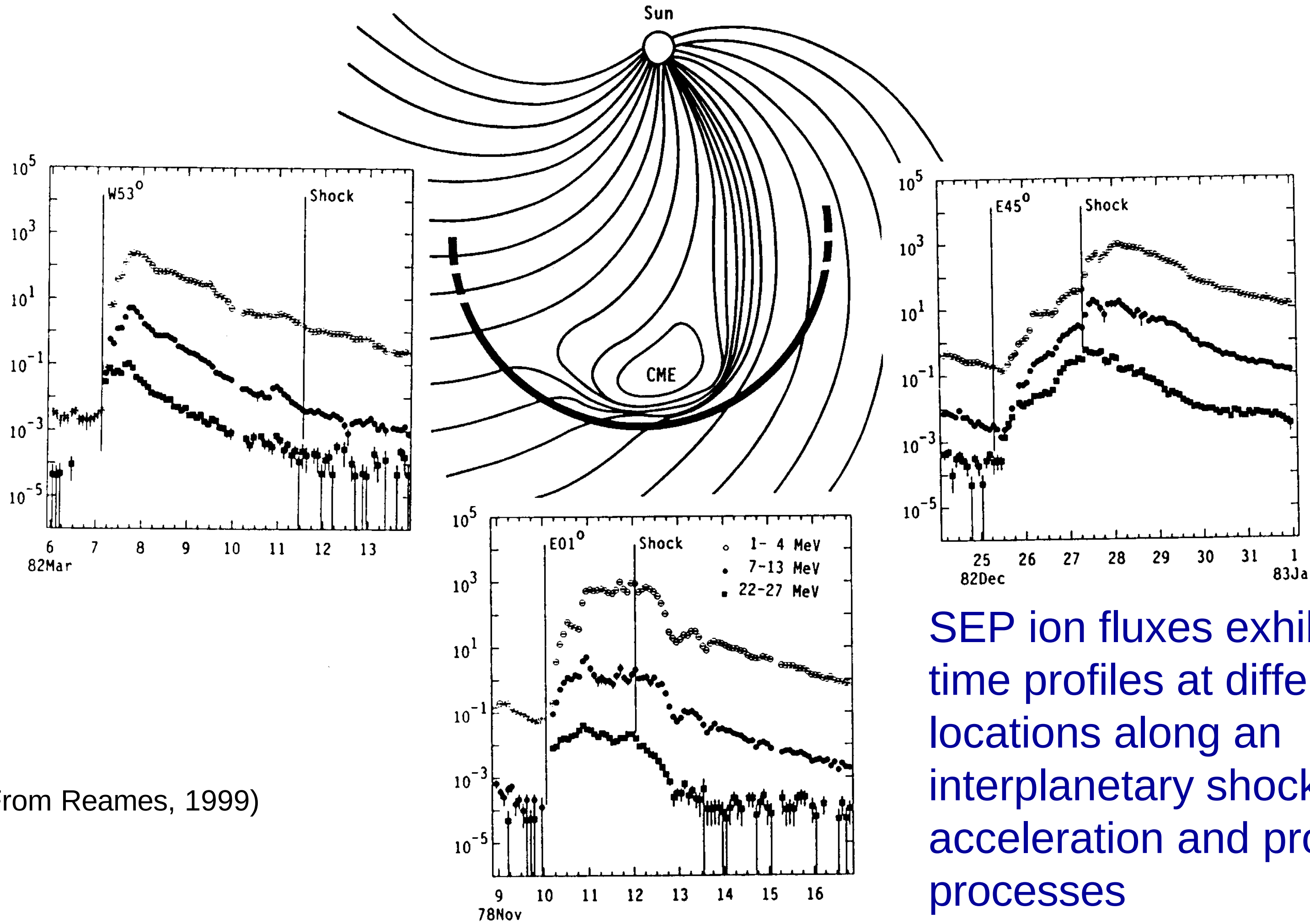


Interplanetary ion spectrum for several species from solar wind through SEP energies, from ACE, showing IMPACT's range of measurement

(adapted from the ACE science center news letters, figure by Mewaldt, Gloeckler and Mason)



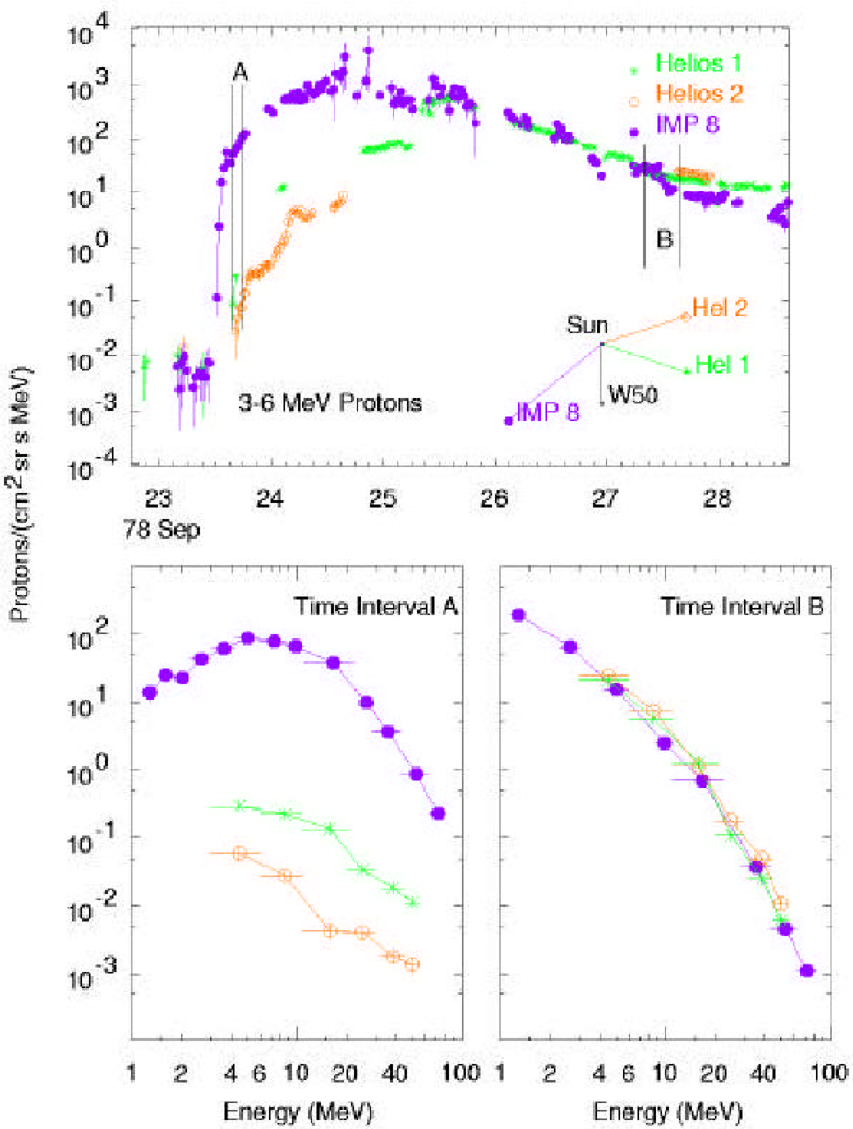
Science Goals: Acceleration and Transport of Energetic Particles by Coronal Mass Ejections



(From Reames, 1999)

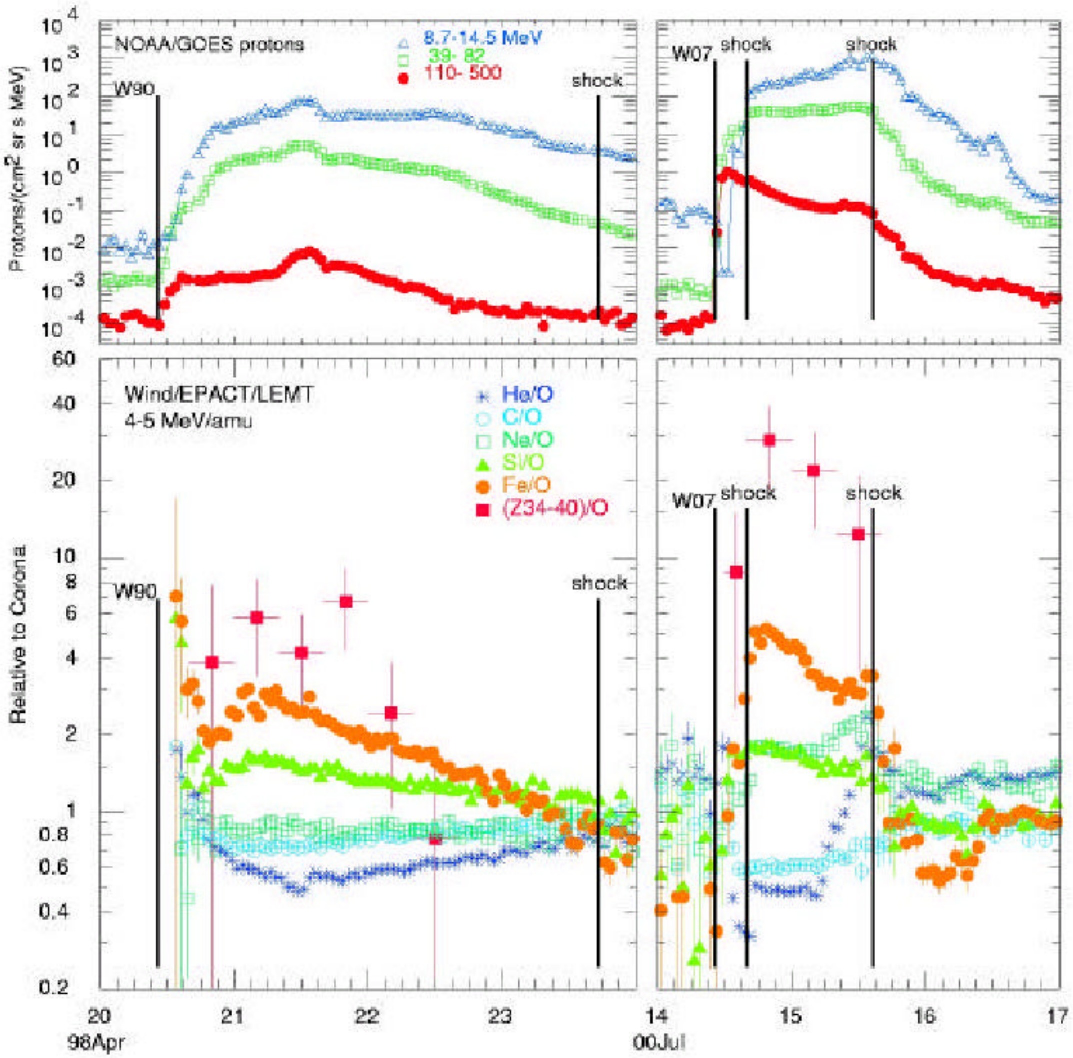
SEP ion fluxes exhibit different time profiles at different locations along an interplanetary shock, related to acceleration and propagation processes

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



SEP observations at different solar longitudes show substantial differences in intensity profiles even though the spacecraft are not widely separated in longitude. The measured energy fluxes and spectra reflect these differences.

SEP Elemental Abundances During Two Different Events

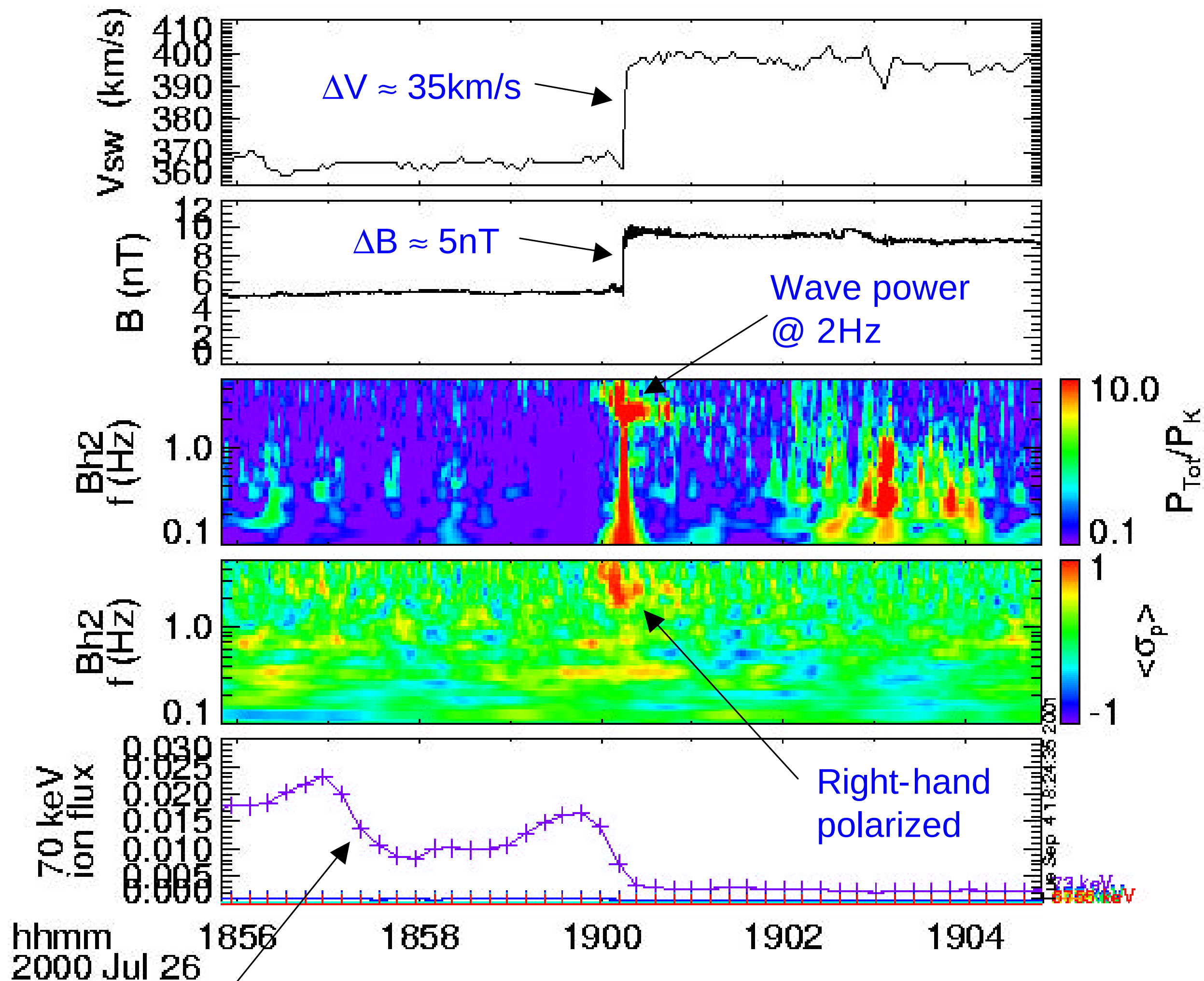


SEP ion composition information indicates whether sources are coronal (e.g. flare related) or interplanetary shock generated.

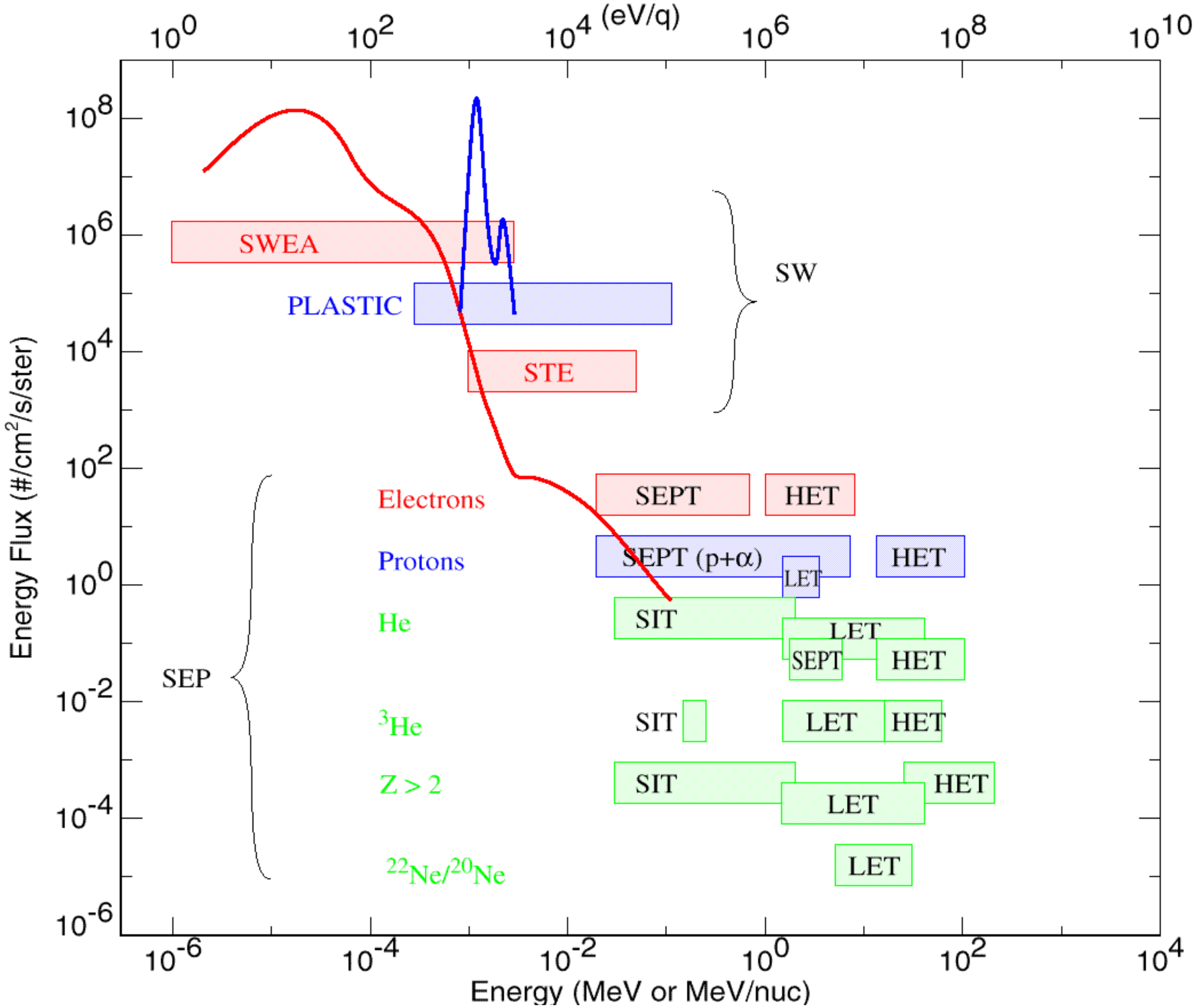
(From Reames, Ng,and Tylka, 2000)

Burst Mode Science

Example of weak Interplanetary shock observation enhanced by Burst Mode



IMPACT / PLASTIC Energy Coverage



Janet Luhmann

Science Summary

IMPACT Science Summary

Experiment	Instrument	Measurement	Energy or Mag. field range	Time Res.	Beacon Time Res. (*)	Instrument provider
SW	STE	Electron flux and anistropy	2-100 keV	16 s	2D x 3E, 60s	UCB (Lin)
	SWEA	3D electron distrib., core & halo density, temp. & anisotropy	~0-3 keV	3D=1 min 2D=8s Mom.=2s	Moments, 60s	CESR (Sauvaud) + UCB (Lin)
MAG	MAG	Vector field	±500nT, ±65536 nT	1/4 s	60s	GSFC (Acuna)
SEP	SIT	He to Fe ions	0.03-2 MeV/nuc	30 s	3S x 2E, 60s	U. of Md. (Mason) + MPAE (Korth) + GSFC (von Rosenvinge)
		^{3}He	0.15-0.25 MeV/nuc	30 s	----	
	SEPT	Diff. electron flux	20-400 keV	1 min	3E, 60s	U. of Kiel (Mueller-Mellin) + ESTEC (Sanderson)
		Diff. proton flux	20-7000 keV	1 min	3E, 60s	
		Anistropies of e,p	As above	15 min	----	
	LET	Ion mass 2-28 & anisotropy	1.5-40 MeV/nuc	1-15 min.	2S x 2E, 60s	Caltech (Mewaldt) + GSFC (von Rosenvinge) + JPL (Wiedenbeck)
		^{3}He ions flux & anistropy	1.5-1.6 MeV/nuc	15 min.	1E, 60s	
		H ions flux & anistropy	1.5-3.5 MeV	1-15 min.	1E, 60s	
	HET	Electrons flux	1-8 MeV	1-15 min.	1E, 60s	GSFC (von Rosenvinge) + Caltech (Mewaldt) + JPL (Wiedenbeck)
		H	13-100 MeV	1-15 min.	1E, 60s	
		He	13-100 MeV	1-15 min.	1E, 60s	
		^{3}He	15-60 MeV/nuc	15 min	----	
	SEP Common	----	----	----	----	Caltech (Mewaldt) + GSFC (von Rosenvinge)
IMPACT Common	IDPU (+Mag Analog)	----	----	----	----	UCB (Curtis)

(*) E=Energies, S=Species, D=directions

IMPACT Science Concerns

- Continuous data
- Average interplanetary field pointing for SEP instruments
- Unobstructed FOVs
- 3-6 m boom/mast with STE in shadow
- Electrostatic and Magnetic "Cleanliness"
- Closely coordinated operations with PLASTIC and SWAVES
- Resources

IMPACT Project Overview

Organization

- IMPACT Suite managed by PI (Luhmann) and PM (Curtis) at UCB
  - SEP Team coordinated by von Rosenvinge at GSFC
  - Boom suite coordinated by Bob Lin at UCB
- Instrument Hardware developed at Co-Investigator Institutions (lead institution and Co-I listed):
  - MAG at GSFC (Acuna)
  - SWEA at CESR (Sauvaud)
  - STE at UCB (Larson)
  - Boom at UCB (Ullrich)
  - IDPU at UCB (Curtis)
  - HET at GSFC (Tycho)
  - LET at Caltech (Mewaldt)
  - SEPT at Kiel (Mueller-Mellin)
  - SIT at University of Maryland (Mason)
  - SEP Common Electronics at Caltech (Mewaldt)

Contracting

- Project Contracts UCB
  - Phase A, Bridge contract complete
  - Phase B/C/D Contract in place
- UCB Subcontracts Caltech/JPL, University of Maryland, LBNL, UCLA
  - Phase A, Bridge contract complete
  - Phase B/C/D subcontracts in place (?)
- Modeler's subcontracts on hold until closer to launch
- GSFC funded directly by Project
  - Funding in place
- Project contracts with LANL directly
  - Phase A, Bridge contract complete
  - Phase B/C/D contract in place (?)
- CESR funded by CNES (France)
  - Funding in place
- Kiel, Max Planck funded by DLR (Germany)
  - Funding in place
- ESTEC funded by ESA
  - Funding in place

Development Plan

- Each subsystem will develop some level of ETU to prove the design concept
- The different ETUs shall be tested together to verify interfaces
- Most ETU testing will be complete by CDR
- ETUs shall be maintained through the life of the mission to provide a test bed for changes
- Flight unit assembly shall generally start following CDR
  – Long lead flight part procurement shall start following PDR
- Subassemblies shall be functionally tested and calibrated at the home institution
  – Some environmental tests will be performed at the subassembly level, such as Vibration and Thermal Vacuum, on a case by case basis.
- SEP subassemblies shall be integrated and tested at Caltech
- Boom subassemblies shall be integrated and tested at UCB
- The full suite will come together for EMC testing

Schedule

- Complex multi-institutional interlocking development effort
- A top-level set of mile-stones marking the interactions between institutions has been developed
- Lower-level schedules maintained by each institution, linked to the top level milestone schedule
- Milestone schedule has been hierarchically divided into Top level and SEP
  - SEP deliveries to the rest of the team described on the top-level schedule
  - Deliveries internal to SEP described by the SEP milestone schedule
  - SEP Milestone schedule controlled by SEP team

IMPACT Milestone Schedule

ID	Task Name	Start
1	**IMPACT_Milestones**	**2/2/00**
1	**Project Phases**	**2/2/00**
7	**Project Milestones**	**2/2/00**
8	IMPACT Phase A Contract	2/2/00
9	SRR	5/24/00
11	PDR	9/30/01
18	CDR	11/1/02
25	PER	9/7/03
32	Instrument Delivery	10/1/04
33	Launch	11/12/05
34	**IMPACT Milestones**	**6/9/00**
35	**System (UCB)**	**6/9/00**
36	Phase A Report	8/30/00
37	Spacecraft ICD Draft	10/31/00
38	Spacecraft ICD Signoff	9/30/01
39	IDPU/Instrument Interface Spec D	6/9/00
43	SWEA ICD Draft	3/6/01
47	IMPACT/SWAVES ICD Draft	9/30/01
48	**Power (UCB)**	**7/31/00**
49	Draft LVPS Requirements	7/31/00
52	Freeze LVPS Requirements	9/30/01
56	ETU STE Bias Available	3/1/02
58	ETU SIT HVPS Available	4/25/02
60	ETU IDPU LVPS Available	5/17/02
63	ETU SEP LVPS Available	6/14/02
65	ETU SWEA/STE LVPS Available	7/1/02
68	ETU PLASTIC LVPS to UNH	11/1/02
70	FM1 Power Supplies Available	6/3/03
75	FM2 Power Supplies Available	12/3/03
77	**IMPACT Boom (UCB)**	**9/30/01**
78	Prototype Boom Available	9/30/01
80	FM1 Boom Available	11/18/03
81	FM2 Boom Available	11/18/03
82	**IDPU (UCB)**	**7/19/01**
85	MAG/DCB PWB Form Factor	7/19/01
89	ETU IDPU Complete	8/23/02
93	FM1 IDPU Complete	11/6/03
97	FM2 IDPU Complete	3/18/04

ID	Task Name	Start
99	**SWEA/STE (UCB)**	**12/28/01**
101	ETU STE Complete	12/28/01
103	FM1 STE Complete	9/26/03
105	FM2 STE Complete	1/30/04
107	ETU SWEA Complete	7/26/02
110	FM1 SWEA Complete	12/19/03
113	FM2 SWEA Complete	2/27/04
114	**SWEA (CESR)**	**7/12/02**
116	ETU SWEA to UCB	7/12/02
119	FM1 SWEA to UCB	11/3/03
122	FM2 SWEA to UCB	1/1/04
124	**MAG (GSFC)**	**1/17/02**
125	ETU MAG to UCB	1/17/02
128	FM1 MAG to UCB	6/2/03
130	FM2 MAG to UCB	12/1/03
134	**SEP (GSFC/Caltech)**	**1/24/03**
135	ETU SEP to UCB for Interface Te	1/24/03
137	FM1 SEP to UCB for Interface Te	4/16/04
139	FM1 SEP to UCB for EMC	6/25/04
141	FM1 SEP to UCB	9/10/04
142	FM2 SEP to UCB	9/10/04
143	**PLASTIC (UNH)**	**6/1/01**
144	PLASTIC Software Requirements	6/1/01
146	PLASTIC Simulator to UCB	11/1/02
148	ETU IDPU/PLASTIC test at UNH	10/1/03
149	FM IDPU/PLASTIC Test at UNH	5/3/04
150	**GSE (UCB)**	**12/20/01**
151	PLASTIC IDPU Simulator to UNH	11/1/02
153	MAG IDPU Simulator to GSFC	12/20/01
155	SEP IDPU Simulator to Caltech	12/20/01
156	SWEA/STE IDPU Simulator to U(	12/20/01
158	Command & Display GSE Rev 1 .	12/13/02
160	MAG Science Display Available	12/27/02
162	SWEA Science Display Available	1/24/03
164	STE Science Display Available	2/7/03
165	**Spacecraft Emulators (APL)**	**6/22/01**
166	Emulator #1 Hardware to UCB	6/22/01
167	Emulator Interim Software (Telem	7/1/02
169	Emulator Hardware #2 to UCB	12/2/02
170	Emulator Full Software to UCB	12/2/02

SEP Milestone Schedule

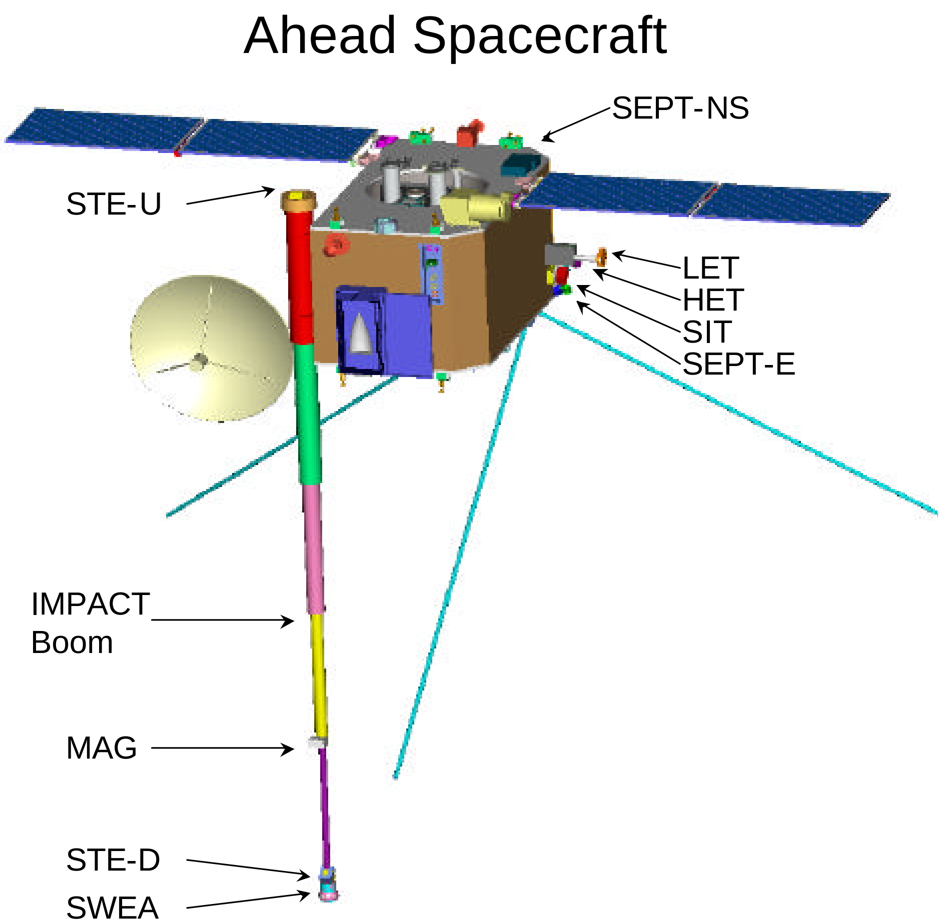
Peer Review, SEP	4/19/01
Phase B start	6/1/01
Peer Review, IDPU	6/13/01
VLSI chip definition to SIT & HET	6/27/01
Peer Review, Wrapup	8/2/01
PDR	9/11/01
Confirmation Review	3/4/02
Phase CD start	3/4/02
Flight VLSI chips delivery to SIT & HET	4/17/02
All flight detectors ordered	4/29/02
LVPS EM available from UCB	6/17/02
Prelim. I/F test with IDPU	10/4/02
CDR	11/4/02
Detector testing complete	2/3/03
GSE ready	4/28/03
HET delivery to Caltech	6/11/03
Boards fabricated and tested	7/4/03
Integration of LET complete	7/23/03
SIT delivery to Caltech	7/30/03
Integration of HET complete	9/3/03
SEPT delivery to Caltech	9/10/03
Integration of SIT complete	10/22/03
Final flight firmware complete	10/22/03
Integration of SEPT complete	12/10/03
Integration of LET/HET/SIT/SEPT complete	2/4/04
Ready to integrate SEP with IDPU	2/23/04
End-to-end test at accelerator	5/10/04
SEP Env Test Starts	5/31/04
IMPACT EMC Test Starts	6/25/04
Functional/env. testing complete	9/10/04
SEP Delivery to UCB	9/10/04
Pre-ship review	9/27/04
Launch	12/8/05

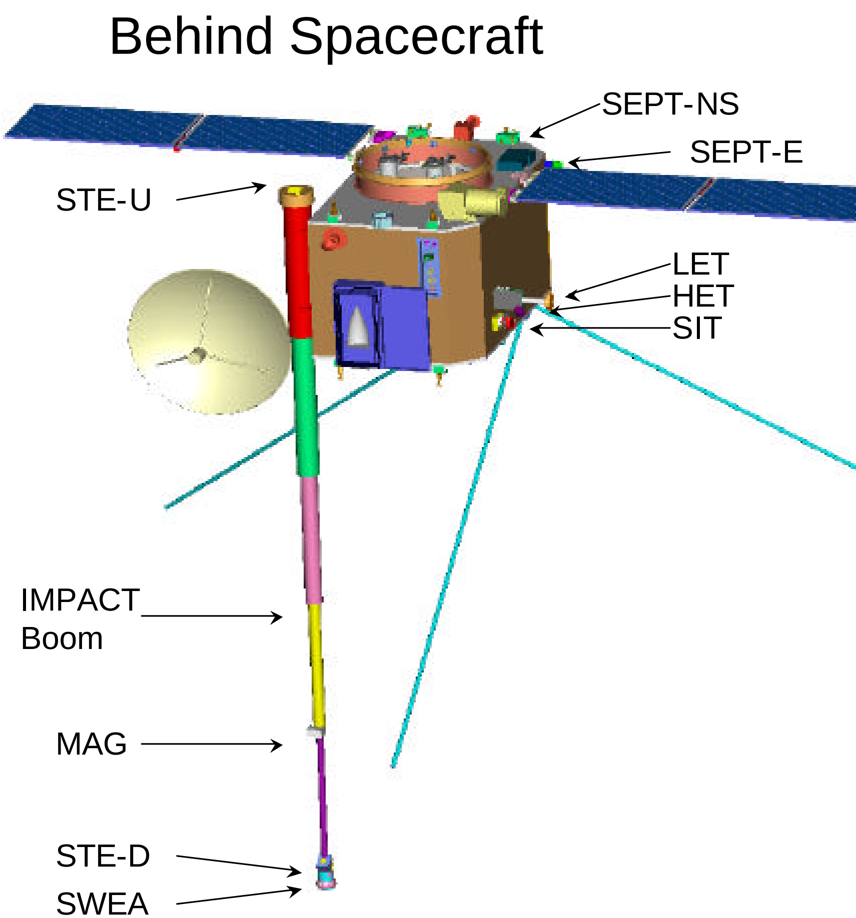
Schedule Analysis

- The suite flight hardware first all come together at the EMC test. The pacing item in scheduling the EMC test is currently the SEP delivery from Caltech (following SEP calibration and thermal vac)
- There are 7 weeks of slack in the SEP schedule prior to EMC
- A number of subsystems pace the SEP development with similar amounts of slack:
  - The VLSI (ASIC) used in HET, LET, and SIT
  - The LET board
  - The LET MISC board
  - The SSD bias supply
  - SEP Firmware
- There are 2 weeks of slack between EMC testing and delivery to the spacecraft
- There is some distributed slack in the development effort based on conservative scheduling estimates

SYSTEM ENGINEERING

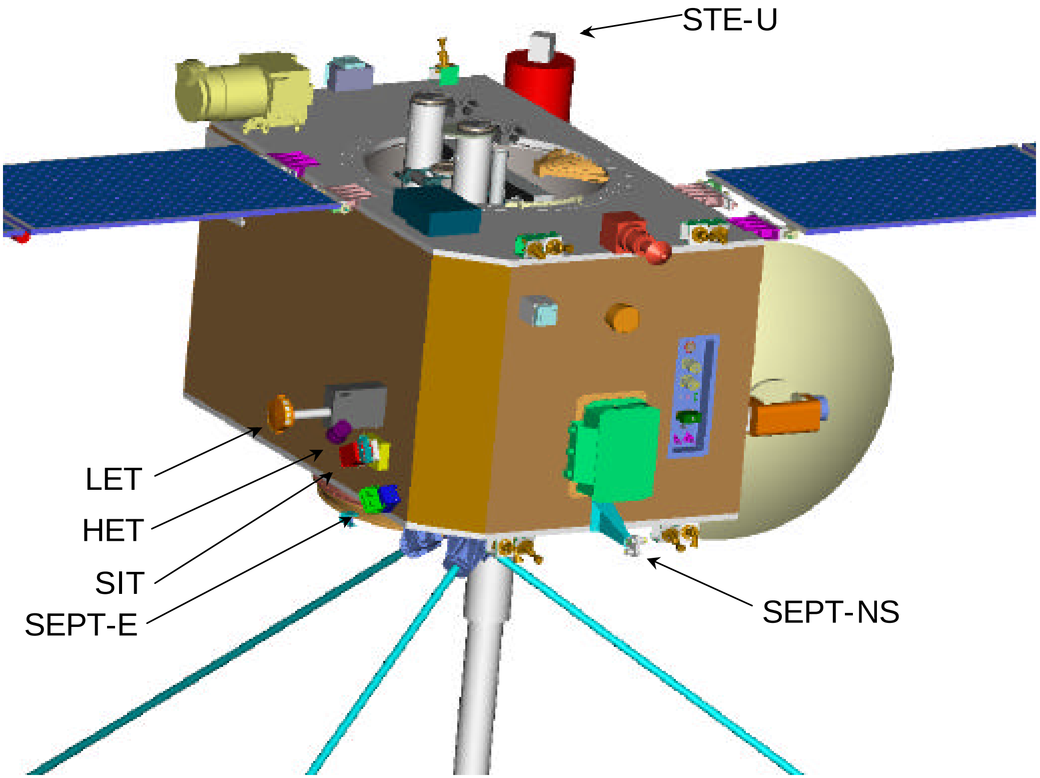
IMPACT Instrument Locations on the Spacecraft



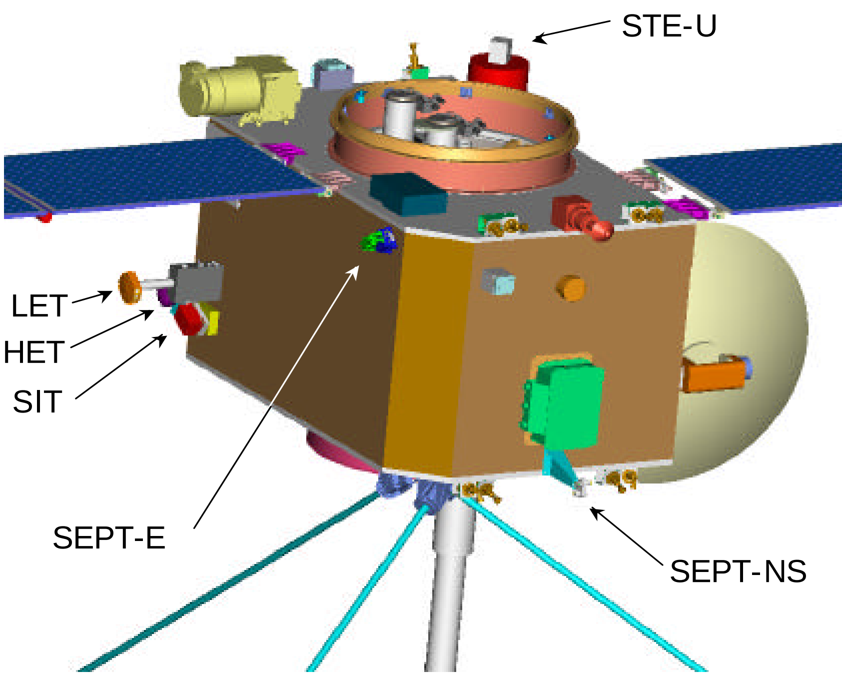


IMPACT Instrument Locations on the Spacecraft

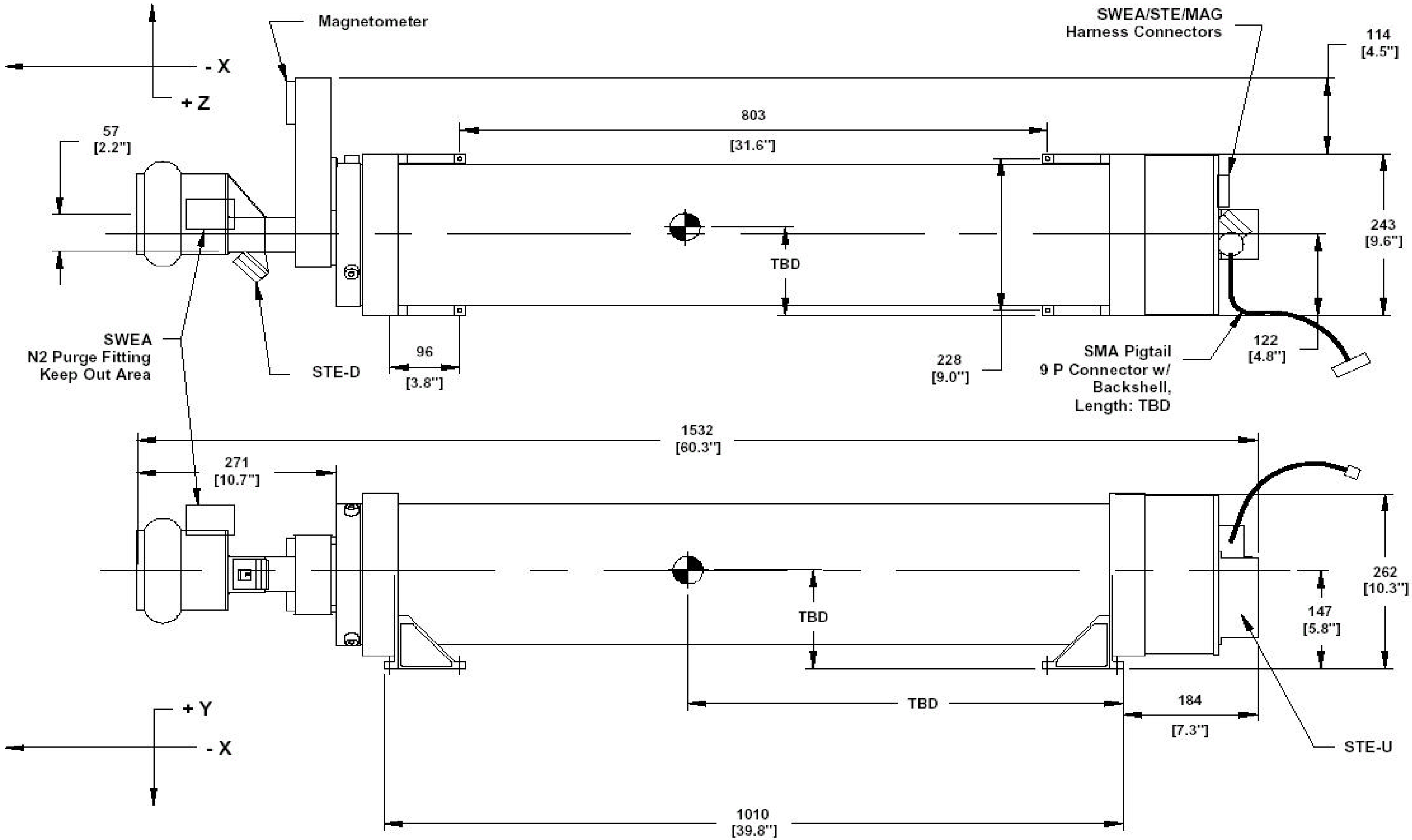
Ahead Spacecraft



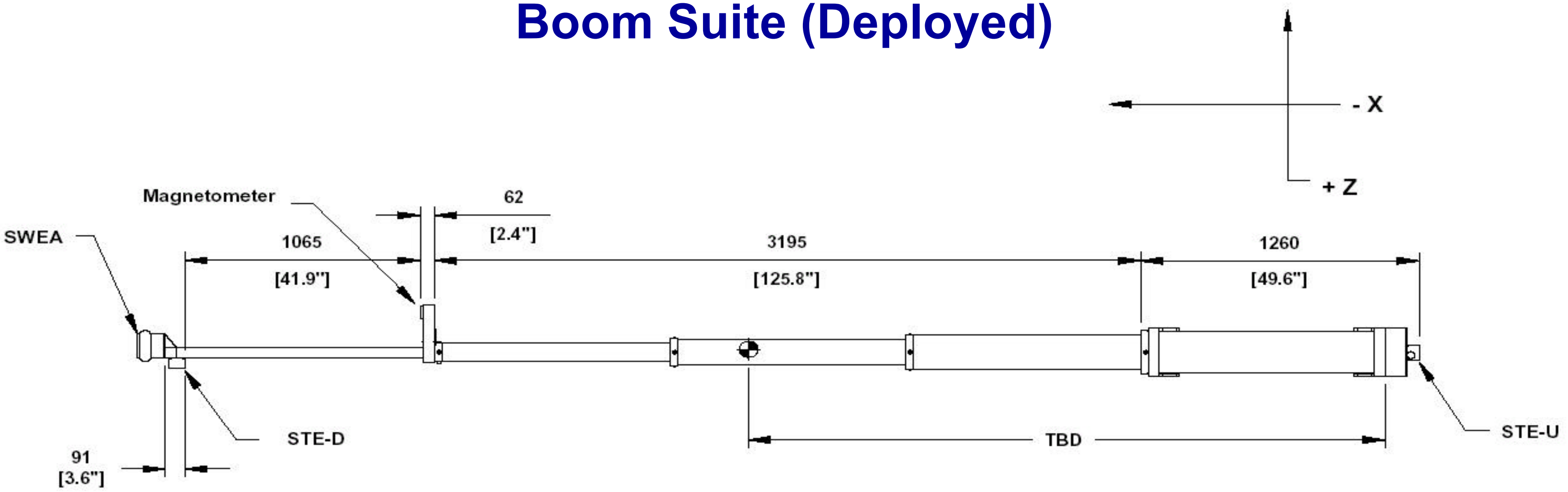
Behind Spacecraft

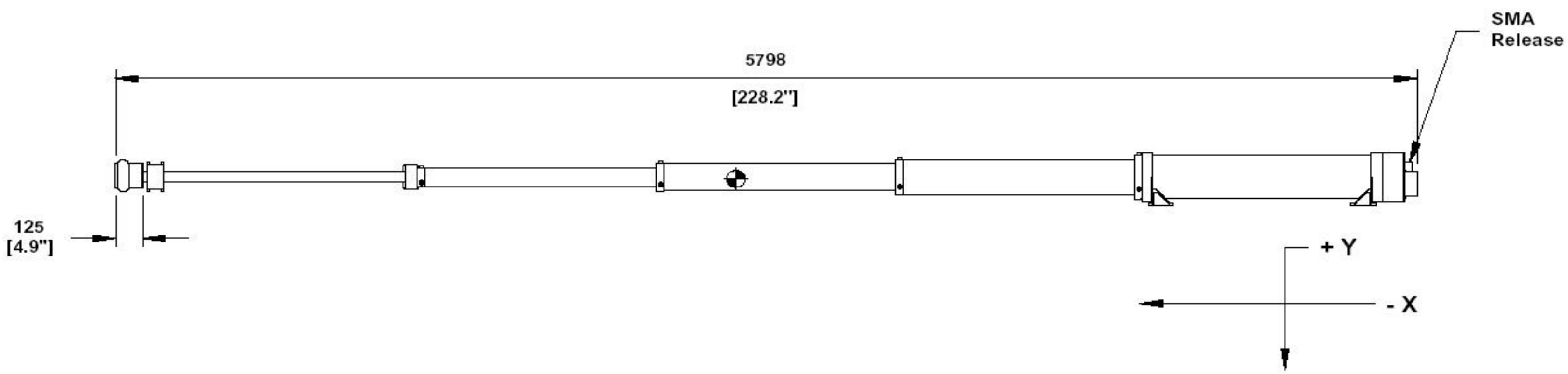


Boom Suite (Stowed)



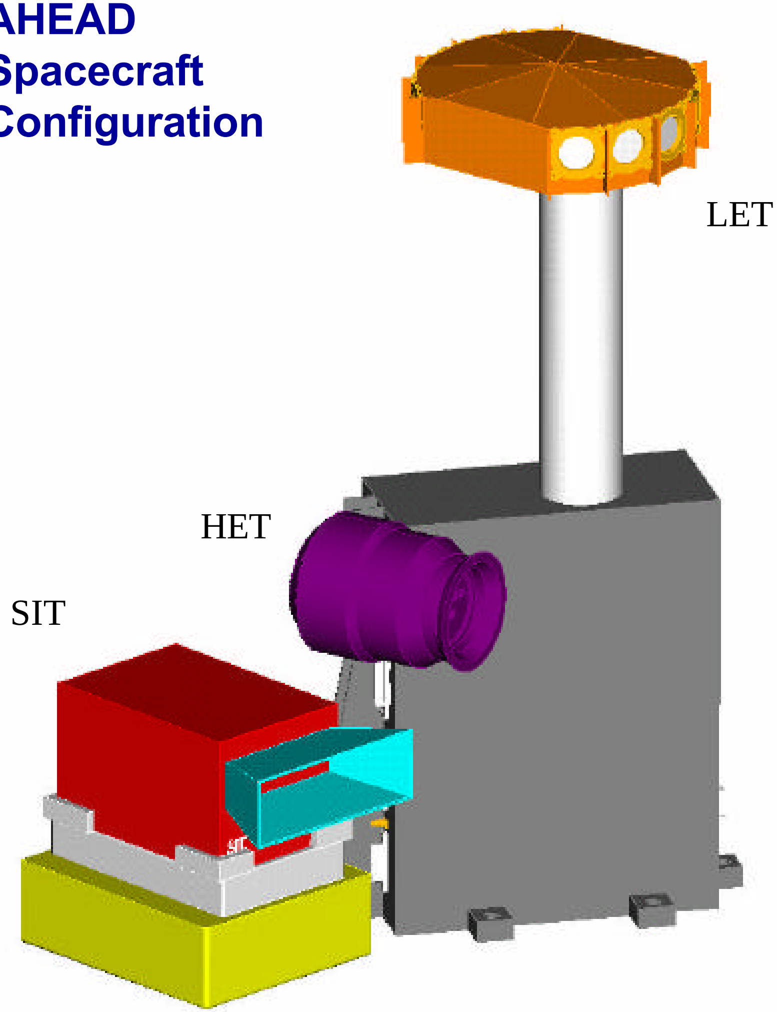
Boom Suite (Deployed)



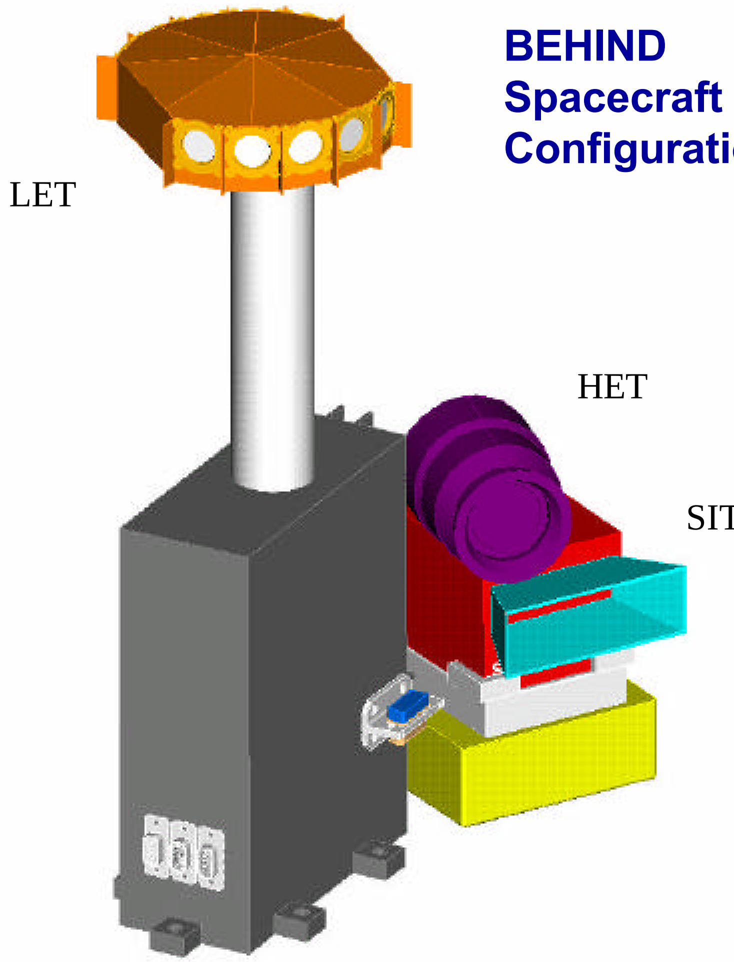


SEP HET/LET/SIT/Common Electronics

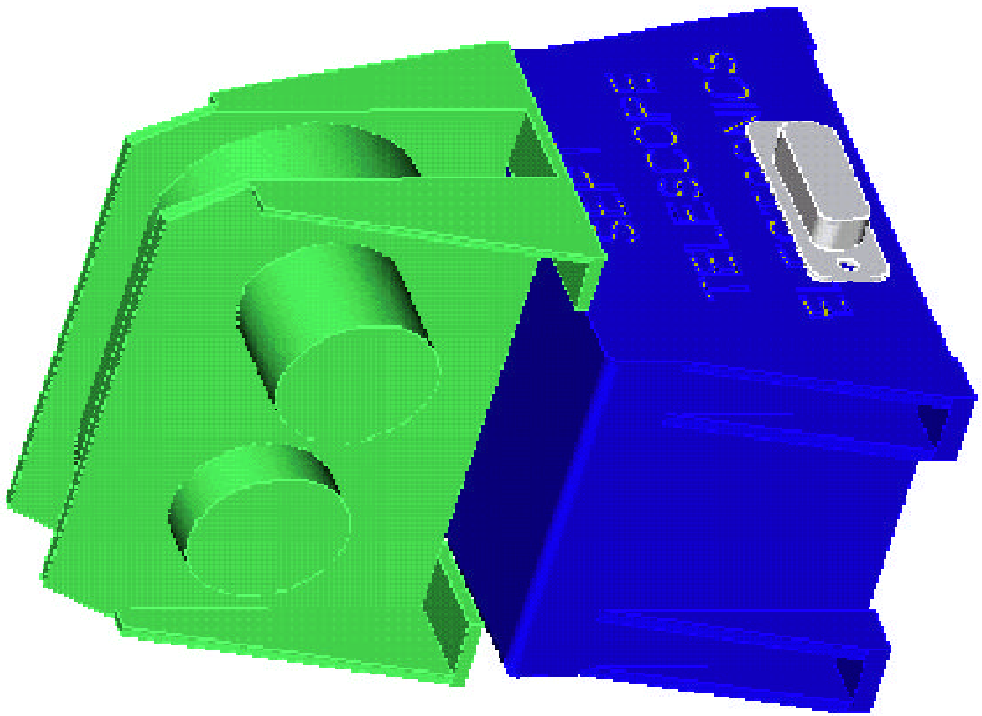
AHEAD Spacecraft Configuration



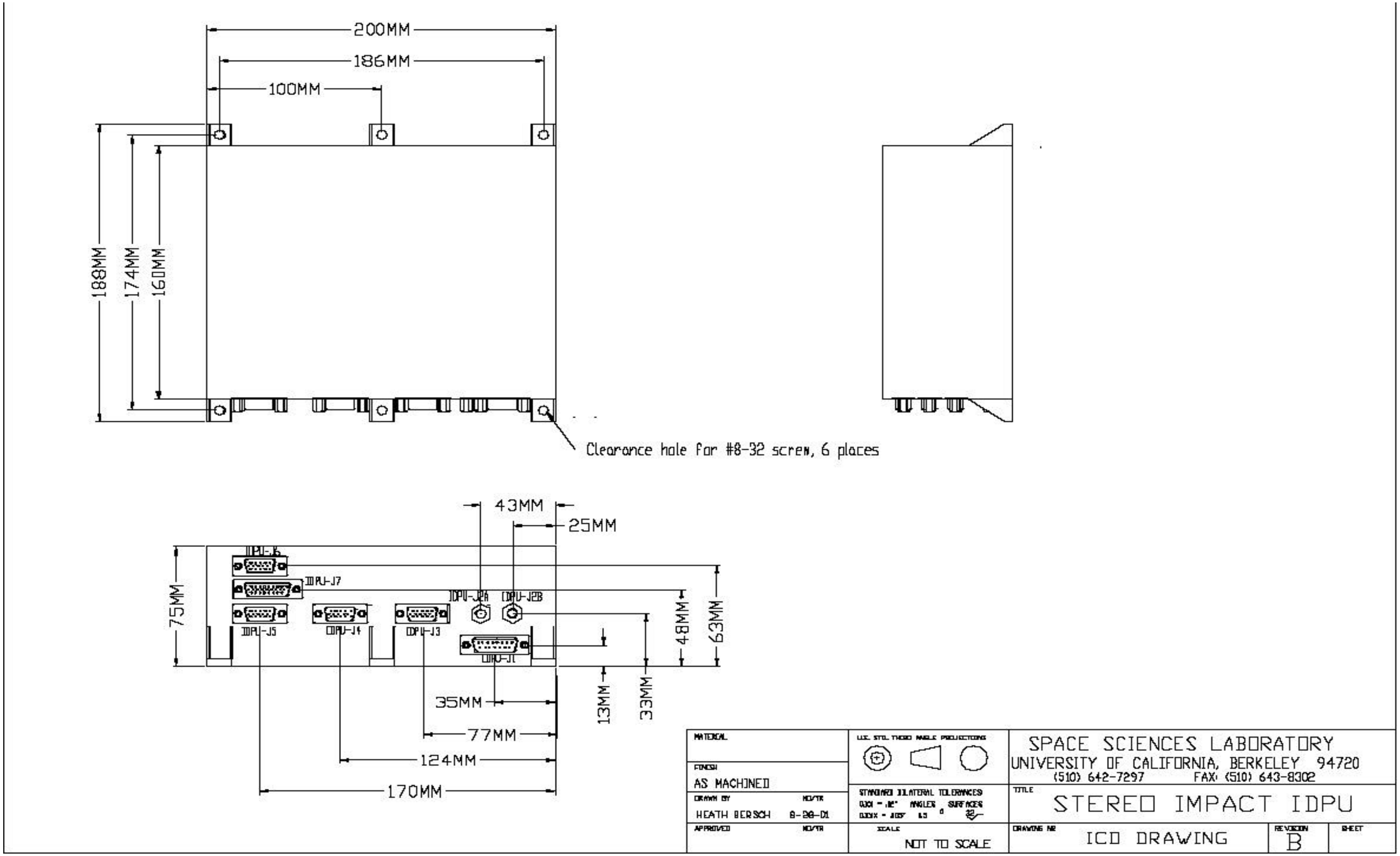
BEHIND Spacecraft Configuration



SEP/SEPT



IDPU


200MM
186MM
100MM
188MM
174MM
160MM
Clearance hole for #8-32 screw, 6 places
43MM
25MM
75MM
IDPU-J6
IDPU-J7
IDPU-J2A
IDPU-J2B
IDPU-J5
IDPU-J4
IDPU-J3
IDPU-J1
48MM
63MM
13MM
33MM
35MM
77MM
124MM
170MM
MATERIAL
FINISH
AS MACHINED
DRAWN BY
HEATH BERSCH
8-28-01
APPROVED
SPACE SCIENCES LABORATORY
UNIVERSITY OF CALIFORNIA, BERKELEY 94720
(510) 642-7297 FAX: (510) 643-8302
TITLE
STEREO IMPACT IDPU
SCALE
NOT TO SCALE
DRAWING NO
ICD DRAWING
REVISION
B
SHEET

Heritage

Instrument	Institution	Heritage
MAG	GSFC	Wind, MGS, ACE, LP
SWEA	CESR / UCB	MGS, Cluster, Giotto, Wind, FAST, LP
STE	UCB	Wind, HESSI
Boom	UCB	FAST, LP, POLAR
SEPT	Keil / ESTEC	Helios, ISEE, Phobos, VEGA, Galileo, SOHO, Wind, Equator-S
SIT	UMd / GSFC	ACE, Wind, SAMPEX
HET	GSFC / Caltech	ACE, Wind
LET	Caltech / GSFC	ACE, Wind, Geotail
IDPU	UCB	HESSI, FAST, LP, Cluster, Wind, Polar

Instrument Requirements

- Instrument Performance Requirements documented in IMPACTPerformanceSpec_E.doc
- Instrument Interface & Resource Requirements documented in IMPACT/Spacecraft ICD
- Environmental test requirements documented in 7381-9003
- Contamination Control requirements documented in 7381-9040
- EMC requirements documented in 7381-9030
- Mission Assurance Requirements based on Project System Safety Mission Assurance document, and implemented in IMPACT PAIP
- Programatic requirements (deliverables, cost, schedule, etc.) covered in IMPACT contract

MAG Performance Requirements

Description	Goal	Requirement
Noise level	0.01 nT	0.01 nT
Absolute Accuracy	+/- 0.1 nT	+/- 0.1 nT
Range	+/-512 nT, +/-65536 nT	+/-512 nT, +/-65536 nT
Drift	+/-0.2 nT/yr	+/-0.2 nT/yr
Time Resolution	1/4 sec. 1/32 sec. (Burst)	1 sec.

MAG addresses mission level 1 requirements:

- 01.01.0002, CME Speed
- 01.01.0003, CME Direction
- 01.01.0008, Magnetic Field Measurement

SWEA Performance Requirements

Description	Goal	Requirement
FOV	360 x 130 degree	360 x 60 degrees
Resolution	22.5 degree	45 degrees
Energy	1 to 3000eV	20 to 1000eV
Energy Resolution (Telemetry)	65%	100%
Geometric Factor	0.01 cm^2 ster E(eV)	0.001 cm^2 ster E(eV)
Max Count Rate (per 22.5 degree sector)	1E6 counts/sec	1E5 counts/sec
Time Resolution	1 minute (3D) to 2 seconds (moments, burst)	1 minute

SWEA addresses mission level 1 requirements:

- 01.01.0002, CME Speed
- 01.01.0006, Solar Wind Temperature
- 01.01.0007, Solar Wind Velocity
- 01.01.0008, Solar Wind Magnetic Field
- 01.01.0009, Solar Wind Density

STE Performance Requirements

Description	Goal	Requirement
FOV	Two opposite 80 x 80 degree	60 x 60 degree
Resolution	80 x 20 degrees	60 x 20 degrees
Energy	2 - 100 keV	5 – 100 keV
Energy Resolution (Telemetry)	35%	100%
Energy Resolution (Electronic)	300eV FWHM	2keV
Geometric Factor	0.4 cm^2 ster	0.1 cm^2 ster
Background	<1c/s/detector	<30c/s/detector
Max Count Rate (per detector)	100,000 counts/sec	10,000 counts/sec
Time Resolution	16 seconds 2 seconds (burst)	1 minute

STE addresses mission level 1 requirements:

- 01.01.0005, CME Initiation Location
- 01.01.0006, Solar Wind Temperature
- 01.01.0008, Solar Wind Magnetic Field
- 01.01.0011, Energetic Particle Distribution Function

SIT Performance Requirements

Description	Goal	Requirement
FOV	17 x 44 degrees	17 x 44 degrees
Energy	30-2,000 keV/nuc He-Fe	30-2,000 keV/nuc He-Fe
Mass Resolution	0.85 AMU (^{16}O at 100keV/nuc)	0.85 AMU (^{4}He at 1MeV/Nuc)
Energy Resolution	20keV FWHM	35keV FWHM @ 22C
Geometric Factor	0.4 cm^2 ster	0.4 cm^2 ster
Background	10^{-2} events/sec in quiet time	10^{-2} events/sec during vac test
Max Event Rate	1000 events/sec	1000 events/sec
Time Resolution	1 Minute	15 Minutes

SEP (HET, LET, SEPT, and SIT) addresses mission level 1 requirements:

- 01.01.0003, CME Direction
- 01.01.0010, Location of Particle Acceleration
- 01.01.0011, Energetic Particle Distribution Function,

SEPT Performance Requirements

Description	Goal	Requirement
FOV	2 sets of oppositely directed 52 degree cones each for electrons and protons	2 sets for electrons and protons, each with: 2 oppositely directed view cones in-ecliptic, 2 oppositely directed view cones off-ecliptic, 45 degree full opening angle
Energy	20-400 keV electrons, 20-7000 keV protons	30-400 keV, electrons 30-2000 keV, protons
Energy Resolution (Telemetry)	20% electrons, 20% protons	30%, electrons 30%, protons
Geometric Factor	0.52 cm^2 ster, electrons, 0.68 cm^2 ster, protons	0.4 cm^2 ster, electrons, 0.4 cm^2 ster, protons
Background	< 0.2 counts/s on ground, 20°C	< 2 counts/s on ground, 20°C
Max Event Rate	25,000 counts/s at 2.2 MeV 250,000 counts/s at 55 keV	25,000 counts/s at 2.2 MeV 250,000 counts/s at 55 keV
Time Resolution	60 sec	60 sec

SEP (HET, LET, SEPT, and SIT) addresses mission level 1 requirements:

- 01.01.0003, CME Direction
- 01.01.0010, Location of Particle Acceleration
- 01.01.0011, Energetic Particle Distribution Function,

LET Performance Requirements

Description	Goal	Requirement
FOV	2 oppositely directed 130 x 30 degree fans	2 oppositely directed 100 x 30 degree fans
Energy Range (MeV/nucleon)	H: 1.4 - 6 He: 1.4 - 13 O: 2.5 – 25 Fe: 2.5 - 50	H: 1.5 - 3 He: 1.5 - 13 O: 3 – 25 Fe: 3 - 25
Geometric Factor cm^2 ster	H, He: 0.9 5<Z<27: 4.5	H, He: 0.5 5<Z<27: 2
Element Resolution	Also resolve Na, Al, S, Ar, Ca	Resolve H, He, C, N, O, Ne, Mg, Si, Fe
^{4}He Mass Resolution	<0.25 AMU	<0.35 AMU
Max Event Rate	5000 events/sec	1000 events/sec
Energy Binning	8 intervals per species for Z>1 4 intervals for H	6 intervals per species for Z>1 3 intervals for H
Species Binning	Add S, Ar, Ca	H, ^{3}He, ^{4}He, C, N, O, Ne, Mg, Si, Fe
Time Resolution	1 minute H, He, 15 minutes Z>5 4 prioritized events/sec	15 minutes 1 prioritized event/sec
Beacon Telemetry:	1 minute for H, He, 5<Z<27	1 minute for H, He, 5<Z<27

SEP (HET, LET, SEPT, and SIT) addresses mission level 1 requirements:

- 01.01.0003, CME Direction
- 01.01.0010, Location of Particle Acceleration
- 01.01.0011, Energetic Particle Distribution Function,

HET Performance Requirements

Description	Goal	Requirement
FOV (full angle)	58 degree cone	50 degree cone
Energy Range (MeV/nucleon)	e: 1 - 8 H, He: 13 - 100 ^{3}He: 16 – 50 ~30 to 80 for 5 < Z < 27	1 – 6 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	< 0.3 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	15 minutes 1 prioritized events/sec	15 minutes 0.3 prioritized event/sec
Beacon Telemetry:	1 minute H, He, e	1 minute H, He, e

SEP (HET, LET, SEPT, and SIT) addresses mission level 1 requirements:

- 01.01.0003, CME Direction
- 01.01.0010, Location of Particle Acceleration
- 01.01.0011, Energetic Particle Distribution Function,

Intra-Instrument Interfaces

- Interfaces to IDPU documented by:
  - Serial Instrument Interface document covers the common hardware
  - IDPU Flight Software Requirements covers the software
  - Harness Specification covers harnesses between instruments
  - Documents controlled by UCB
- Interfaces between SEP instruments covered:
  - SEP ICD covers electrical interface
  - SEP Software Development Plan covers software requirements
  - Documents controlled by Caltech
- Interface to PLASTIC covered by:
  - Serial Instrument Interface document, controlled by UCB
  - PLASTIC Flight Software Requirements, controlled by UNH

Resource Allocations

Instrument	Mass CBE, kg	Mass NTE, kg	Mass Margin, %	Power CBE, W	Power NTE, W	Power Margin, %	bps
SEP:							
LET	0.75			0.77			320
LET Bracket	0.60						
HET	0.66			0.35			120
SEP Common Elec.	1.92			0.53			
SEP LVPS	0.20			2.12			
SEP Main Total	4.13			3.77			440
SIT	1.23			1.27			240
SEPT-E	0.52			0.50			30
SEPT-NS	0.52			0.50			30
SEP-NS Bracket	0.27						
SEP Blankets	0.15						
SEP Grand Total	6.82	8.09	16%	6.05	7.40	18%	740
BOOM:							
SWEA:							
SWEA (CESR)	1.21			0.54			394
SWEA/STE I/F	0.30			0.30			
SWEA/STE LVPS	0.20			0.63			
SWEA Total	1.71			1.47			394
STE (STE-D)	0.35			0.10			64
SWEA Op Htr				0.50			
STE Op Htr				0.25			
MAG Sensor	0.25						192
Mag Op Htr				0.50			
SWEA/STE/MAG Blankets	0.10						
Sunward STE (STE-U)	0.35			0.10			
Boom Harness	0.83						
Boom	8.00						
Boom Totals	11.59	14.20	18%	2.32	3.50	34%	650
IDPU:							
Mag Card	0.30			0.38			
DIB Card (STE)	0.30			0.20			
DPU Card	0.30			0.80			
S/C Interface (on DPU card)				0.50			
IDPU LVPS	0.20			1.07			
Mag Heater Control	0.07						
BOX	0.96						
IDPU Total:	2.12	2.54	17%	3.55	4.30	18%	164
Burst Telemetry							546
Harness (average of A&B)	1.24	1.47	16%				
TOTAL	21.76	26.30	17%	11.91	15.20	22%	2100

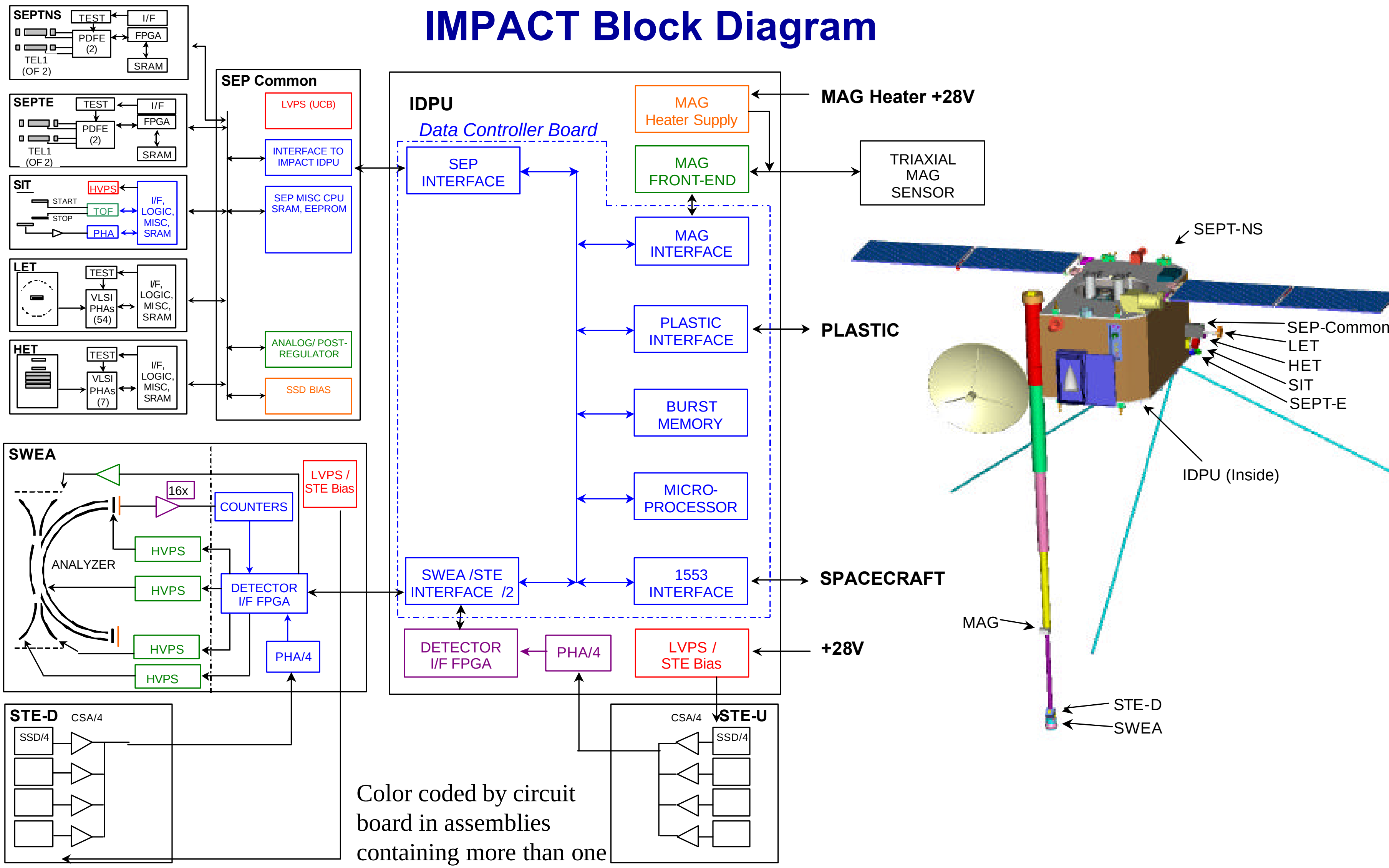
Other Resource Issues			
Actuator Firing Current	**Type**	**Current@28V**	**Time**
SWEA Cover	TiNi P5-403	.75A	<100ms
SIT Cover	TiNi P5-403	.75A	<100ms
SEPT Covers	TiNi P5-403	.75A	<100ms
STE Cover	SMA	350mA	2s
BOOM Release	TiNi P5-405	.75A	<100ms
Survival Heaters			
Circuit	**Location**	**Power**	
IDPU/MAG	MAG	0.2W	TBR
SWEA/STE	SWEA/STE	1.3W	TBR
SEP/SEPT-NS/SEPT-E	SEP/SEPT-NS/SEPT-E	3.5W	TBR

Mass & Power Margin Requirements:

- 15% at PDR
- 10% at CDR

SWEA Operational Heater Requirement is TBR

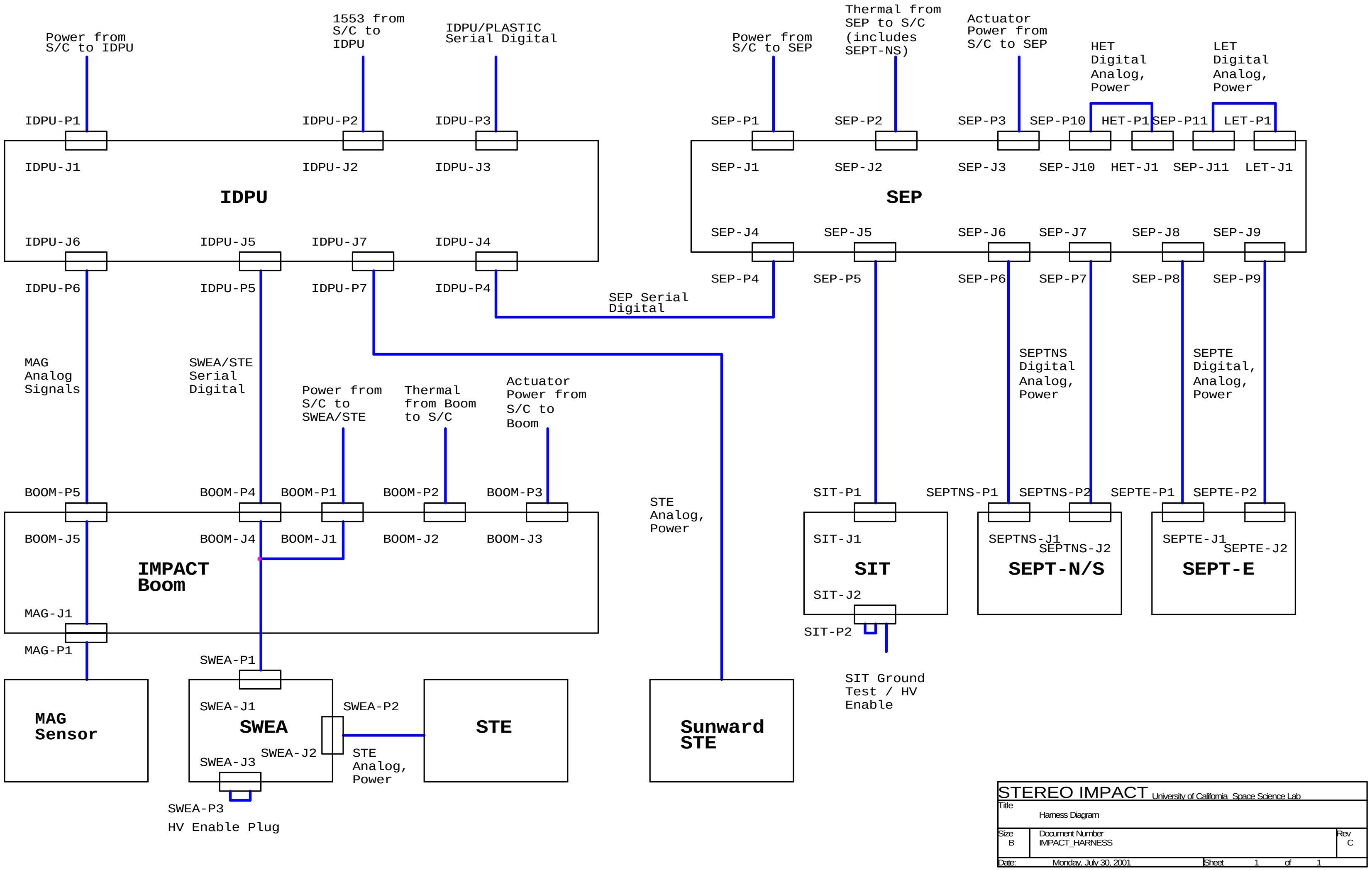
IMPACT Block Diagram



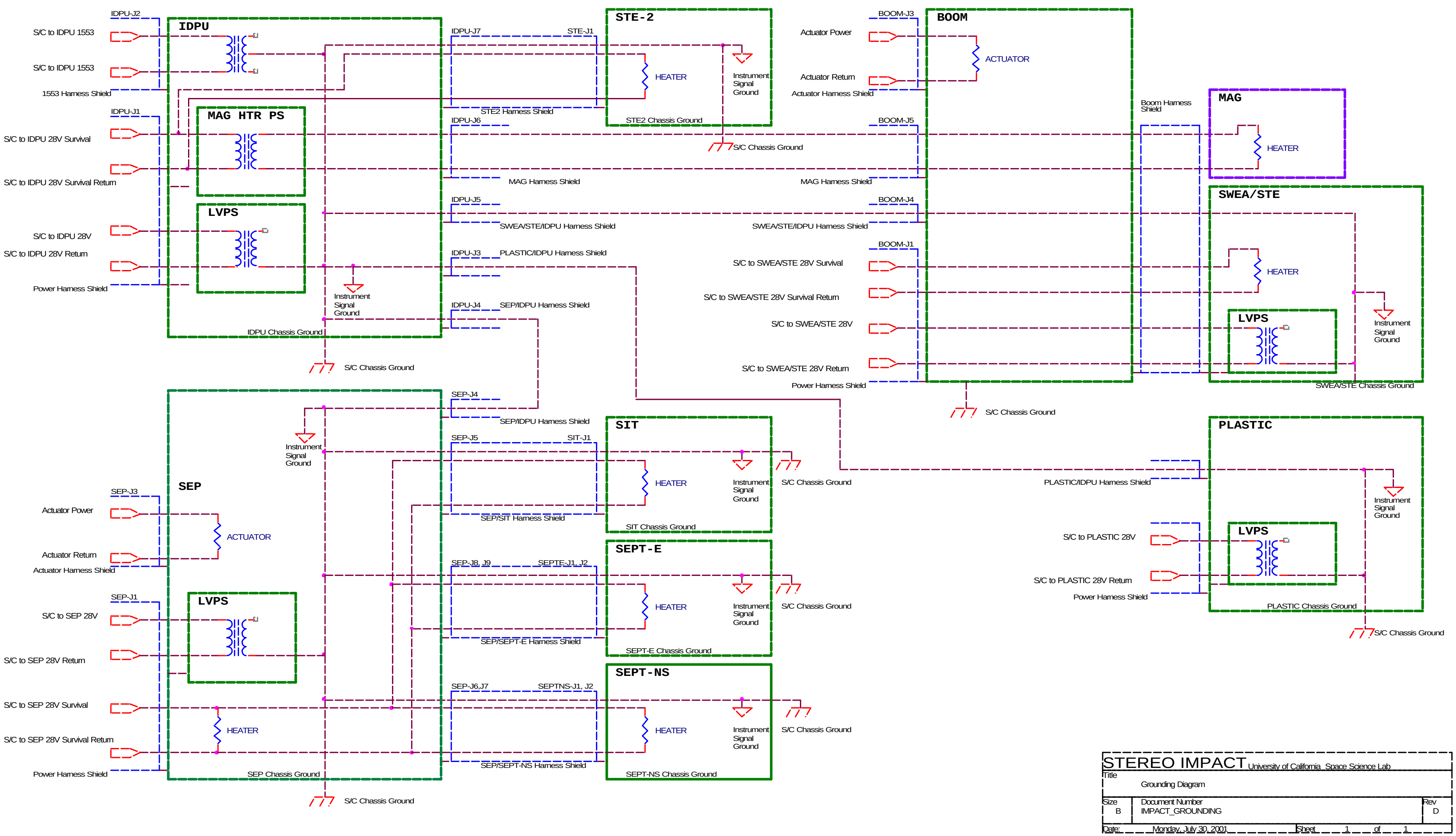
Color coded by circuit board in assemblies containing more than one board.

David Curtis

IMPACT Harness Diagram



IMPACT Grounding



Configuration Control

- Preliminary IMPACT Configuration Control Plan submitted
- Problem reporting & Failure Review process described in IMPACT PAIP
  - Project to appoint a voting member of the IMPACT Failure Review Board
- IMPACT will comply with Project-level CM Plan on Project-controlled documents (Class 1 changes)
  - IMPACT PM takes the lead role in interfacing with Project CM
- Suite-level CM controlled by PM
  - Resources, Interfaces, Plans
  - Controlled documents maintained and controlled via a web site
  - PM controls changes at this level, as well as waiver/deviation process
- Subsystem-level CM controlled by instrument lead engineers
  - Schematics, As-built drawings, Travelers, Flight Software
  - Subsystems come under Suite-level CM when delivered to integration

Performance Assurance

- **IMPACT Performance Assurance Plan submitted to Project**
  - Plan responds to the Project Mission Assurance Requirements Document
  - Plan covers all IMPACT Flight hardware/software and critical GSE development at all IMPACT institutions developing flight equipment
  - Mostly approved, pending an issue with Foreign CoI plan
  - Plan uses existing in-house procedures and practices (mostly based on NHB rather than ISO-9000)

Contamination Control Plan

- **IMPACT PAIP includes a section on Contamination Control adequate for IMPACT requirements**
  - **Primarily a set of procedures with a proven track record**
  - **PAIP Includes standard materials outgassing requirements**
- **Project Contamination Control Plan has additional requirements**
  - **Vacuum Bakeout**
  - **Surface Cleanliness**
  - **These requirements will be addressed mostly late in the I&T flow, with more relaxed requirements early, followed by cleaning and bakeout**
- **IMPACT has Contamination Requirements at the Observatory Level**
  - **All instruments are purged and have non-flight covers to protect sensitive detectors (some have in-flight deployable covers)**
  - **There is a concern about humidity and strong solvents, mostly taken care of by the purge, but some solvents will be forbidden near the instruments (to be addressed in contamination control plan)**

Top 10 Risks

No.	Risk Item	Score	Mitigation	Mitigation Schedule						
				PDR	Bread-board Test	CDR	Sub-system Test	System Test	Env test	Early Orbit Test
UCB_1	ITAR restriction of information exchange with foreign CoIs may result in problems not discovered until late in the program	MEDIUM	Various channels of communication have been found within the ITAR restrictions to allow adequate information flow. Some exchanges are still forbidden and may cause a problem.	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM	LOW
UCB_2	Increasing documentation requirements distract key personnel from design tasks	MEDIUM	Negotiate documentation requirements to minimize impact	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM	LOW
UCB_4	The IDPU is a single point failure mechanisim for the IMPACT suite and PLASTIC	HIGH	IDPU is a simple, reliable system. Extra attention will be paid to ensuring its reliability	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
UCB_5	IMPACT boom is a new design. Failure could affect Imager pointing requirements as well as boom-mounted instruments.	HIGH	Design for reliability. Early development and test to ensure reliability.	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH	HIGH
UCB_10	Complex Interlocking IMPACT schedule increases risk of late delivery to spacecraft	MEDIUM	A milestone schedule of deliveries has been set up to minimize schedule interaction and give power to control schedule to institutions while maintaining top level schedule slack	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM	LOW
UCB_15	GSFC Approval Requirements could delay instrument delivery or add cost	MEDIUM	Difficult to asses, history is mixed	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM	LOW
UCB_16	STE Detectors are a new technology	MEDIUM	Early testing to prove design	MEDIUM	MEDIUM	LOW	LOW	LOW	LOW	LOW
UCB_18	LET Detectors from a new manufacturer	MEDIUM	Working with manufacturer on process	MEDIUM	MEDIUM	LOW	LOW	LOW	LOW	LOW
UCB_21	Custom VLSI used in SEP may has schedule and cost risk	MEDIUM	Early development to prove design	MEDIUM	MEDIUM	LOW	LOW	LOW	LOW	LOW
UCB_23	Non-standard parts qualification failure could impact delivery schedule	MEDIUM	Early parts selection and screening	MEDIUM	MEDIUM	LOW	LOW	LOW	LOW	LOW

- Identified HIGH risk items have LOW probability of occurrence but HIGH Impact
- 13 Additional Moderate and Low-score risks identified, not listed here
- These risks are entered in the Project Risk Management Database
- IMPACT Management team have taken the GSFC Risk Management course

Trade Studies

No.	Trade Study Title	Description	Status	Decision Schedule: PDR	CDR	Bread-board Test	Sub-system Test	System Test	Env test	Early Orbit Test	Result
I-1	LVPS Topology	Select a toplogy that meets the EMI requirments and mass/volume constraints with maximum efficiency and reliability	CLOSED	X		X					Topology selected
I-2	SIT TOF Design	Select a TOF design that meets the timing requirements with acceptable power and avoiding ITAR problems	CLOSED	X		X					First design failed to meet requirement. Existing WIND design exported with Project help
I-3	SEP Configuration	Minimize FOV incursions, mass, complexity	CLOSED	X							Configuration selected in coordination with APL and Project
I-4	SEP processor selection	Trade capability, power, software logistics	CLOSED	X							MISC Selected
I-5	SEP detector size	Trade sensitivity vs saturation in a large event	CLOSED	X							Sizes selected. Segmented detectors used in some cases
I-6	MAG ADC selection	Simplify ranging system, improve transient response vs new ADC	CLOSED	X							Select 2-range system
I-7	STE detector FETs, preamp	minimize noise vs availability, reliability	OPEN		X	X					Have two candidates. Testing in progress
I-8	Split STE	Trade cost, resources, complexity vs FOV	CLOSED	X							STE is split
I-9	Parts selection	Trade reliability, screening costs vs performance, power (Mostly in analog front end, LVPS circuits)	OPEN		X	X					Where non-standard parts selected, pending results of screening
I-10	Boom length	Trade stability/reliability vs SWEA/STE FOV	CLOSED	X							After STE split, select shorter boom, incur some SWEA FOV blockage
I-11	Detector Doors (STE, SEPT)	Concern about contamination and overheating from sunlight exposure	CLOSED	X							Reclosable door selected for STE, 1-time doors selected for SEPT
I-12	HET Replacement	HET (along with some LET detectors) were to be provided by Waseda University, which did not get funded. Study alternatives.	CLOSED	X							Alternatives presented to Project (since additional funding required). Low cost HET selected.
I-13	Boom Trades	Select a boom that meets the requirements with minimum resources (especially $)	CLOSED	X							Project selected UCB Telescoping boom concept
I-14	SWEA/STE LVPS Size	Select geometery for UCB part of SWEA/STE	OPEN		X						Pending rough layout of LVPS

Peer Reviews

- **IMPACT supported a series of peer reviews, attended by Project-appointed reviewers**
  - **SWEA / STE / Boom at UCB, March 6 2001**
    - **17 Actions, 5 still open**
  - **SEP / MAG at GSFC, April 19 2001**
    - **26 Actions, 14 still open**
  - **IDPU at UCB, August 1 2001**
    - **4 Actions, all closed**
  - **System / Cleanup at UCB, August 2 2001**
    - **17 Actions, 1 closed**
    - **This list is very recent; more are "closeable" as of PDR.**
- **Status of open action items from the instrument reviews shall be discussed in the related sections below**

System Peer Review Action Item Status

#	DB#	REGARDING	REVIEWER WRITE-UP	CLASSIFICATION/ STATUS	DISPOSITION
2		IMPACT	IMPACT needs to provide input to the IMPACT Reliability Analysis with respect to the IMPACT science requirements needed to meet the mission success criteria.	Action Item /Open	Preliminary inputs provided as indicated in the Reliability section of the PDR. We expect more detailed discussions to follow
3		IMPACT	The EMI closeout of the IMPACT connectors and harness needs to be decided. Currently, IMPACT plans to use Micro D connectors on the boom boxes. Weight also needs to be considered in designing the closeouts. The Instrument EMI Peer Review is the appropriate place for this topic to be discussed.	Action Item /Open	Connector EMI closeout was discussed at the EMI peer review August 30/31. The gasket requirement is under review (should be closed by Spacecraft PDR). If it is determined that gaskets are not required, IMPACT plans to sue a taped closeout rather than a backshell for intra-instrument harnesses (TBR)
4		IMPACT	The current electrical design of the IMPACT suite includes ground loops with SIT, SEPT-NS, and SEPT-E. The EMI committee needs to decide to accept or reject this design. This topic is appropriate for the Instrument EMI Peer Review.	Action Item /Open	Grounding was discussed at the EMI peer review August 30/31. Looking into the possibility of an AC rather than DC connection between signal and chassis ground in SEPT to remove DC currents in spacecraft structure. Once the plan is firm a waiver will be submitted
5		IMPACT	Some notional mounting scheme needs to be detailed on the mechanical drawings of the SEP package, SIT, and the SEPTs.	Action Item /Open	See SEP PDR Presentation
6		IMPACT	The current SEP Survival Upper Temperature Limit is +30C. Action is to verify that this number is an actual "hard" requirement.	Action Item /Open	This number is correct. Known failures of detectors used in SIT above 30C. Some relief is possible on other SEP survival limits (+40C).
7		IMPACT	The IMPACT Risks need to be re-evaluated (i.e. Criticality, Probability of Occurrence). Action is to re-evaluate the risks and include a risk matrix in the IMPACT PDR presentation.	Action Item /Open	Risks have been updated (but Project database has not, pending access problems)
8		IMPACT	The trade studies presented should include a status and decision or decision timeframe. Action is to prepare a trade study matrix and present at IMPACT PDR.	Action Item /Open	Done.
9		IMPACT	The swing volume (a 2-D view for each plane) of any deployable covers should be detailed on the mechanical drawings of all applicable IMPACT components.	Action Item /Open	In work. To be complete by Spacecraft PDR (part of ICD)
10		IMPACT	The thermal testing of the IMPACT booms should be performed at the boom deployment temperatures if possible.	Action Item /Open	See Boom presentation

System Peer Review Action Item Status

#	DB#	REGARDING	REVIEWER WRITE-UP	CLASSIFICATION/ STATUS	DISPOSITION
11		IMPACT	Determine who will determine/verify thermal models.	Action Item /Open	This relates to designing the Thermal Balance tests. For the boom, this is a UCB issue. It is still unclear for the SEP boxes. This needs to be worked with APL before CDR,
12		IMPACT	Ensure there are no patent problems using the MISC design.	Action Item /Open	None. Based on Public Domain design.
13		IMPACT	Identification of the critical path in the schedule.	Action Item /Open	Done (in PDR presentation)
14		IMPACT	Determine how many hours will the life test will be.	Action Item /Open	Current plan is 100 hours minimum trouble free hours at time of delivery to spacecraft.
15		IMPACT	Capture a bakeout scheme.	Action Item /Open	Box-level bakeout scheme captured by I&T plan (in PDR presentation). Subassembly bakeout scheme for thermally sensitive instruments is still in work.
17		IMPACT	Determine what grade of parts SWEA will be using and verify that it is acceptable to the Project via the PAIP.	Action Item /Open	CESR part of SWEA uses Grade 3 parts, as described in the PAIP and delivered parts list. These are in review by Project.
18		IMPACT	Have the contamination control personnel verify that the composite boom material is usable.	Action Item /Open	See Boom Presentation

IMPACT Reliability Analyses as of PDR

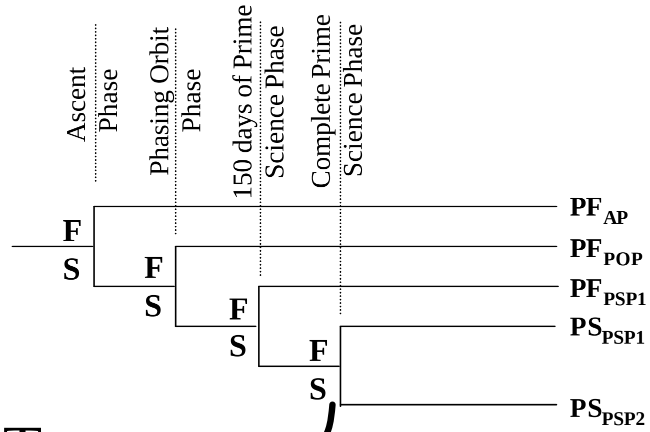
David Bogart
SRS IS

IMPACT STEREO Reliability

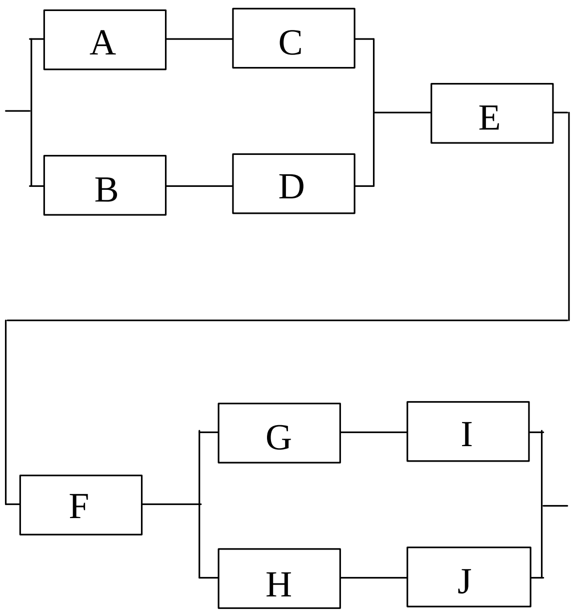
- A Comprehensive PRA approach is planned, including Event Trees, Fault Trees, RBDs and Predictions
  - RBDs and Fault Trees are highly dependent on defining essential elements of the science
  - Science mission is considered in 2 parts, (1) the first 150 days of science, and (2) after 150 days through 2 years of science
  - Iterative approach involves Systems Engineer, Instrument Managers, and Lead Designers to have greatest impact on design
  - Deterministic Models are used until increasing complexity dictates use of Monte Carlo simulations
- Probability data is derived from MIL-HDBK-217 and Manufacturer’s data, combined with On-orbit experience.

STEREO Reliability Methodology

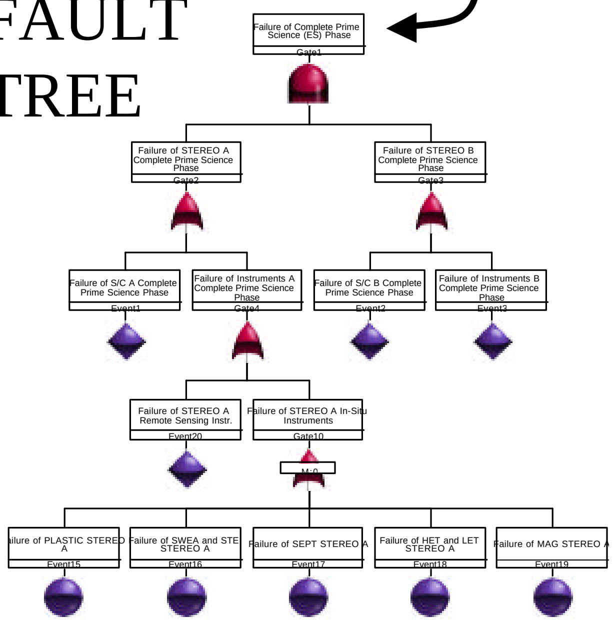
EVENT TREE



RBD and PREDICTIONS

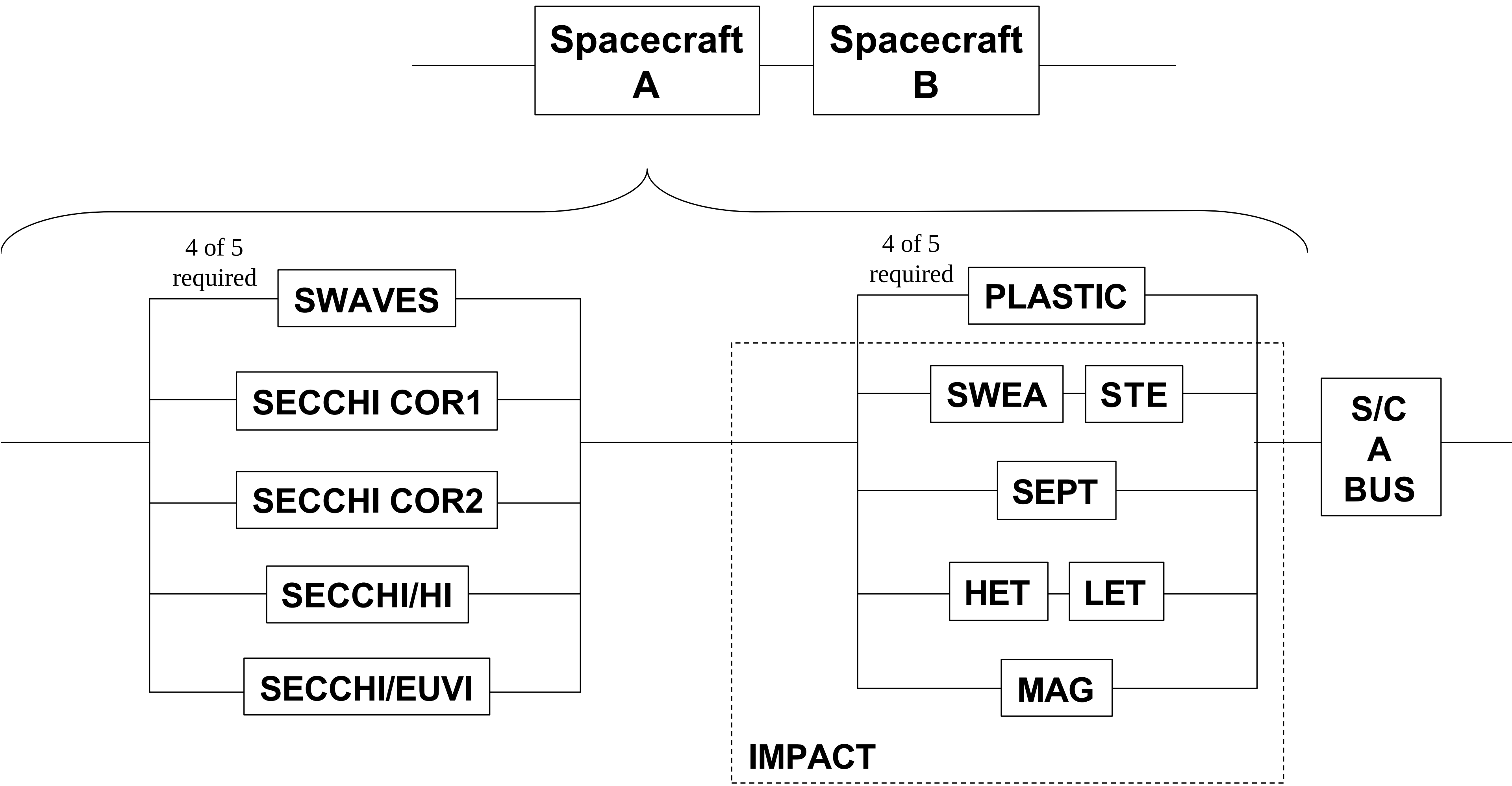


FAULT TREE

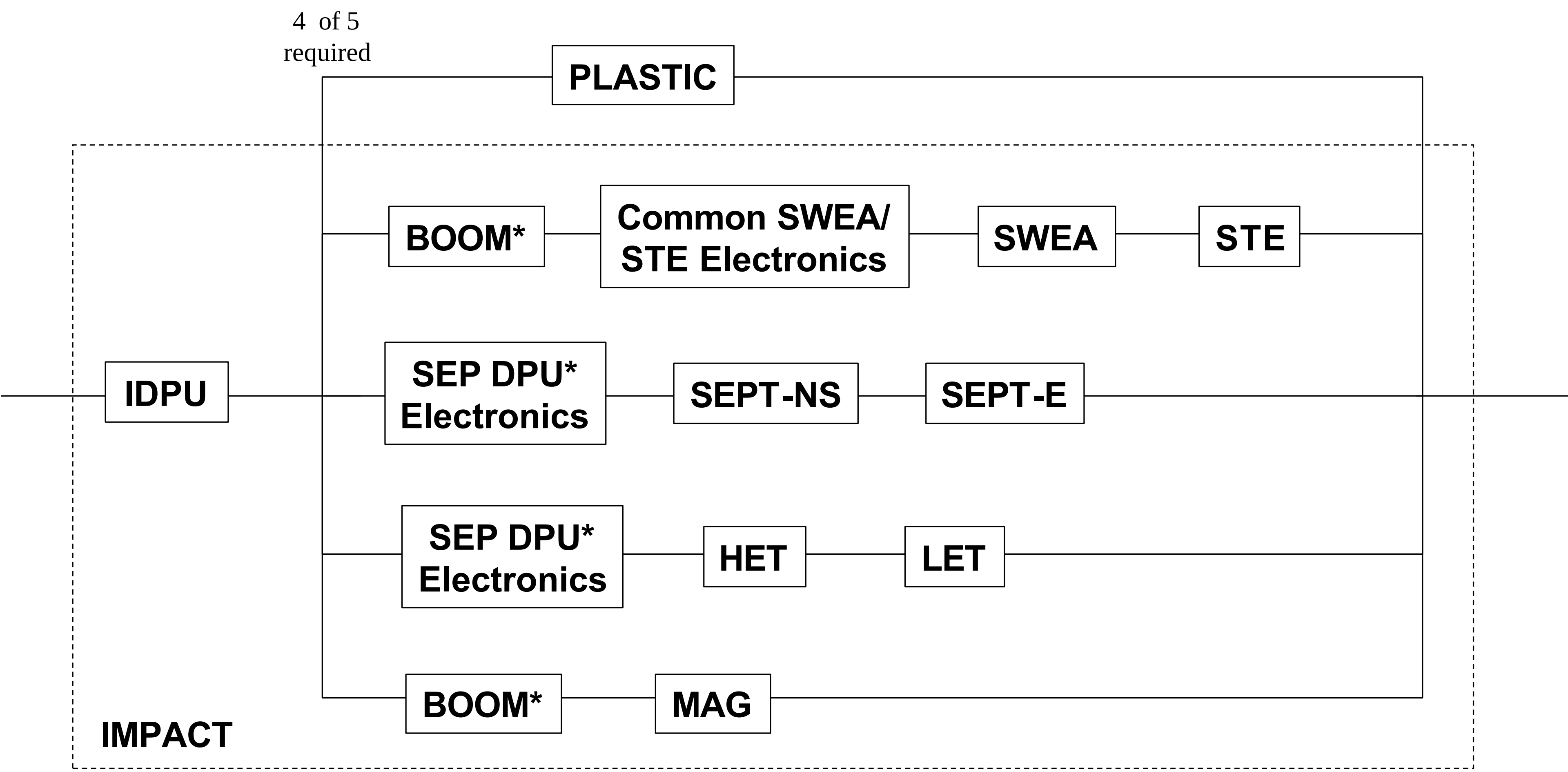


Probabilistic Data

Reliability Block Diagram for the First 150 Days of Prime Science



Reliability Block Diagram for In-Situ Instruments



*** Signifies repeated block, i.e., if it fails, it fails everywhere it appears.**

STEREO IMPACT/MAG

Preliminary Design Review
Presentation

M. H. Acuña, GSFC

MAG Science

- **Identify ICMEs at one or two of the STEREO sites, providing information on their global scale and uniformity, including their associated interplanetary shocks (strength, surface orientations), compressed solar wind sheaths, and internal field configurations (e.g. flux rope or other, flux rope orientation, size, and handedness, and ejecta flux content)**
  - *for relating to the solar observations and determining potential geoeffectiveness*
- **Define ambient solar wind conditions at the two spacecraft, including stream structures and interfaces, and heliospheric current sheet crossings**
  - *for relating to solar observations, and determining potential geoeffects from high speed streams and stream interfaces alone, as well as the effects of the ICME on ambient conditions, and ambient conditions on the ICME*
- **Organize local particle (solar wind and SEP) distribution functions including IMPACT/SWEA, STE, and SEP electrons, and PLASTIC and IMPACT/SEP ions.**
  - *SWEA heat flux electrons for inferring field topology and connections to the Sun, STE electrons for inferring field connections to active regions, PLASTIC solar wind and ICME ions for deducing plasma ion sources, and SEPs from SIT,SEPT,LET,HET for deducing SEP origin, acceleration, and propagation processes*
- **Determine properties of low frequency waves in the interplanetary medium**
  - *for characterizing waves at ICME shocks that play a role in SEP acceleration and propagation, and large Alfven wavetrains that sometimes accompany ICMEs and produce geoeffects of their own*
- **Provide a measure of one of the fundamental heliospheric MHD parameters**
  - *for comparisons with 3-D models of shocks and other solar wind and ICME features that will be used to connect the SECCHI observations to the STEREO in-situ observations*

Science Summary

IMPACT Science Summary

Experiment	Instrument	Measurement	Energy or Mag. field range	Time Res.	Beacon Time Res. (*)	Instrument provider
SW	STE	Electron flux and anistropy	2-100 keV	16 s	2D x 3E, 60s	UCB (Lin)
	SWEA	3D electron distrib., core & halo density, temp. & anisotropy	~0-3 keV	3D=1 min 2D=8s Mom.=2s	Moments, 60s	CESR (Sauvaud) + UCB (Lin)
MAG	MAG	Vector field	±500nT, ±65536 nT	1/4 s	60s	GSFC (Acuna)
SEP	SIT	He to Fe ions	0.03-2 MeV/nuc	30 s	3S x 2E, 60s	U. of Md. (Mason) + MPAE (Korth) + GSFC (von Rosenvinge)
		^{3}He	0.15-0.25 MeV/nuc	30 s	----	
	SEPT	Diff. electron flux	20-400 keV	1 min	3E, 60s	U. of Kiel (Mueller-Mellin) + ESTEC (Sanderson)
		Diff. proton flux	20-7000 keV	1 min	3E, 60s	
		Anistropies of e,p	As above	15 min	----	
	LET	Ion mass 2-28 & anisotropy	1.5-40 MeV/nuc	1-15 min.	2S x 2E, 60s	Caltech (Mewaldt) + GSFC (von Rosenvinge) + JPL (Wiedenbeck)
		^{3}He ions flux & anistropy	1.5-1.6 MeV/nuc	15 min.	1E, 60s	
		H ions flux & anistropy	1.5-3.5 MeV	1-15 min.	1E, 60s	
	HET	Electrons flux	1-8 MeV	1-15 min.	1E, 60s	GSFC (von Rosenvinge) + Caltech (Mewaldt) + JPL (Wiedenbeck)
		H	13-100 MeV	1-15 min.	1E, 60s	
		He	13-100 MeV	1-15 min.	1E, 60s	
		^{3}He	15-60 MeV/nuc	15 min	----	
	SEP Common	----	----	----	----	Caltech (Mewaldt) + GSFC (von Rosenvinge)
IMPACT Common	IDPU (+Mag Analog)	----	----	----	----	UCB (Curtis)

(*) E=Energies, S=Species, D=directions

MAG Technical Summary

Instrument Characteristics:

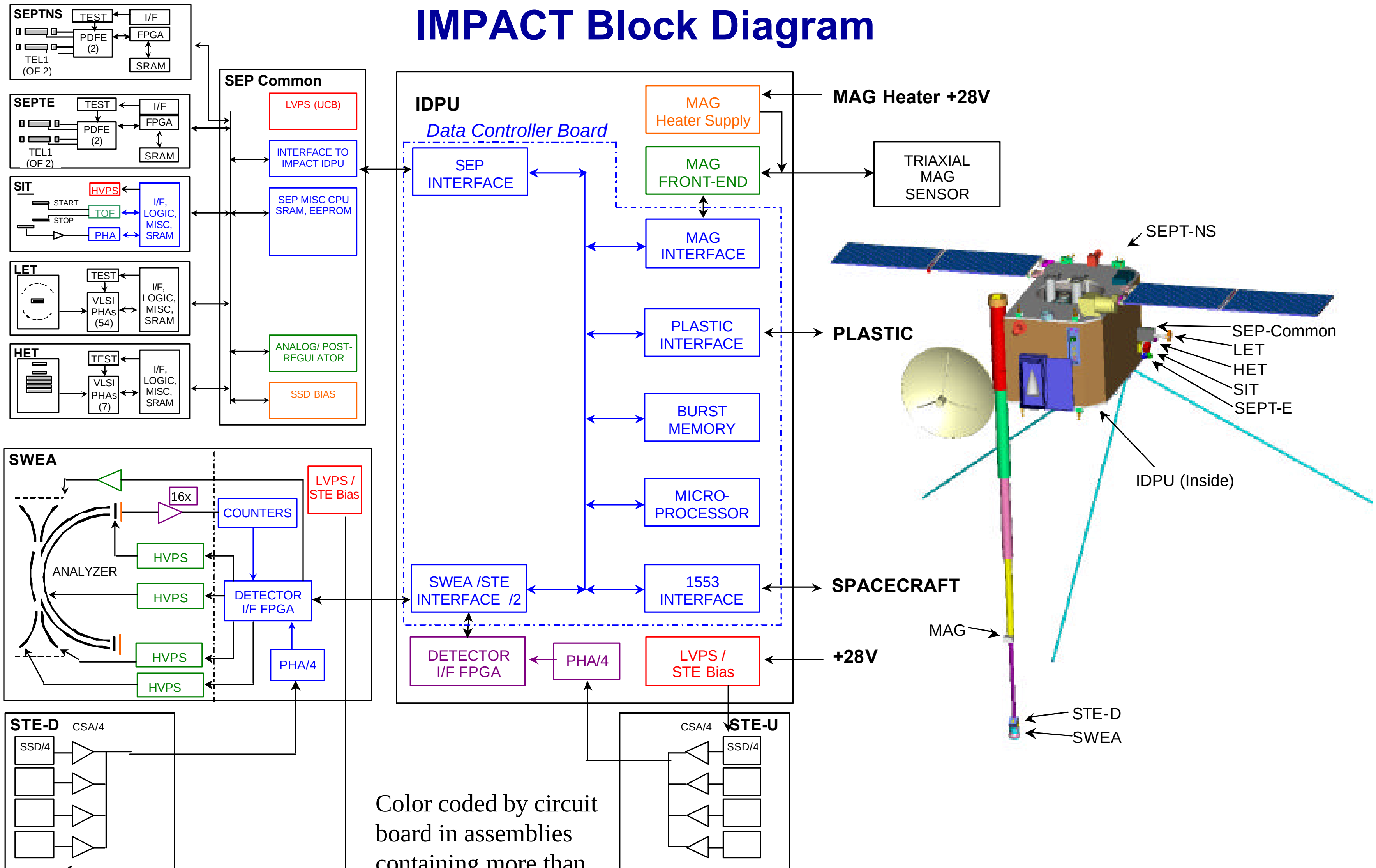
- **Dual-range, <u>single</u> triaxial fluxgate magnetometer**
- **Wide dynamic range: ± 0.01 nT to ± 65,536 nT in two dynamic ranges: ± 512 nT and ± 65,536 nT**
- **Allows for testing in the Earth's field without special equipment – significant simplification and cost savings**
- **Instrument heritage spans > 30 years and > 40 instruments including VOYAGER, WIND, NEAR, ACE, DMSP, LP and MGS**
- **Fluxgate sensor & electronics manufactured and tested at GSFC and integrated into IMPACT IDPU and Boom**
- **Foldback current limiting isolators to protect IDPU power supply in case of failures**
- **MAG software already developed by UCB for MGS and LP**

MAG Performance Requirements

Description	Goal	Requirement
Noise level	0.01 nT	0.01 nT
Absolute Accuracy	+/- 0.1 nT	+/- 0.1 nT
Range	+/-512 nT, +/-65536 nT	+/-512 nT, +/-65536 nT
Drift	+/-0.2 nT/yr	+/-0.2 nT/yr
Time Resolution	1/4 sec. 1/32 sec. (Burst)	1 sec.

MAG addresses mission level 1 requirement 01.01.0008, Magnetic Field Measurement, which in turn is related to Science Objective 4, Improved determination of the structure of the ambient solar wind.

IMPACT Block Diagram



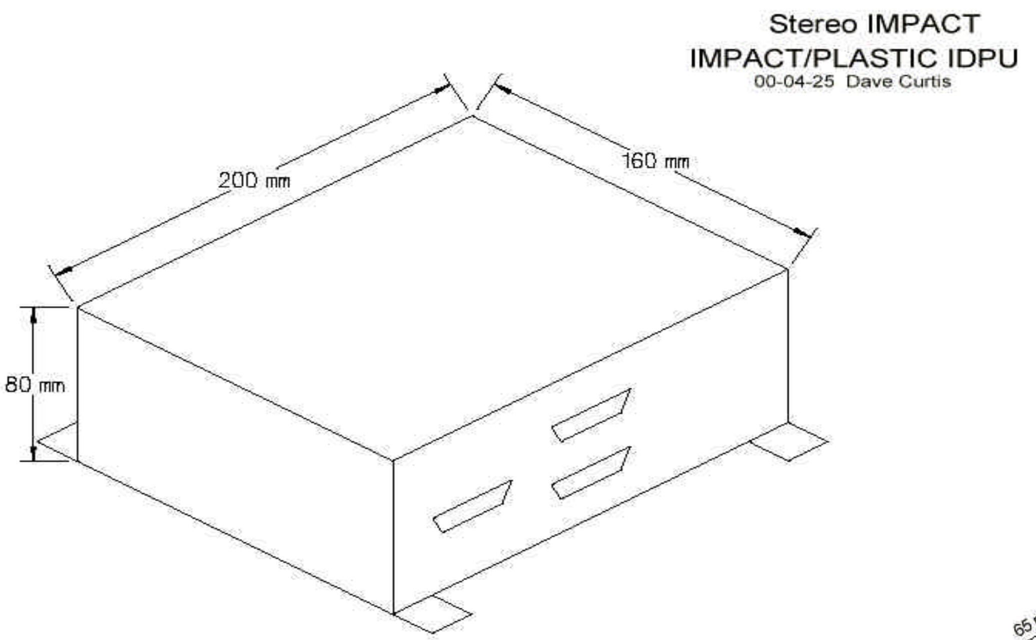
Color coded by circuit board in assemblies containing more than one board.

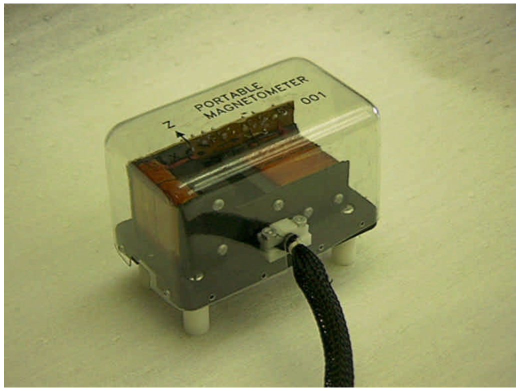
David Curtis

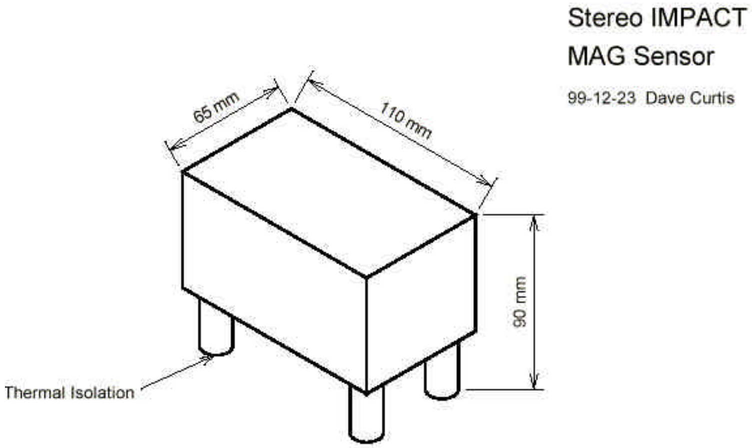
Boom Resources

Instrument	Mass CBE, kg	Mass NTE, kg	Mass Margin, %	Power CBE, W	Power NTE, W	Power Margin, %	bps
BOOM:							
SWEA Total	1.71			1.47			394
STE (STE-D)	0.35			0.10			64
SWEA Op Htr				0.50			
STE Op Htr				0.25			
MAG Sensor	0.25						192
Mag Op Htr				0.50			
SWEA/STE/MAG Blankets	0.10						
Sunward STE (STE-U)	0.35			0.10			
Boom Harness	0.83						
Boom	8.00						
Boom Totals	11.59	14.20	18%	2.32	3.50	34%	650

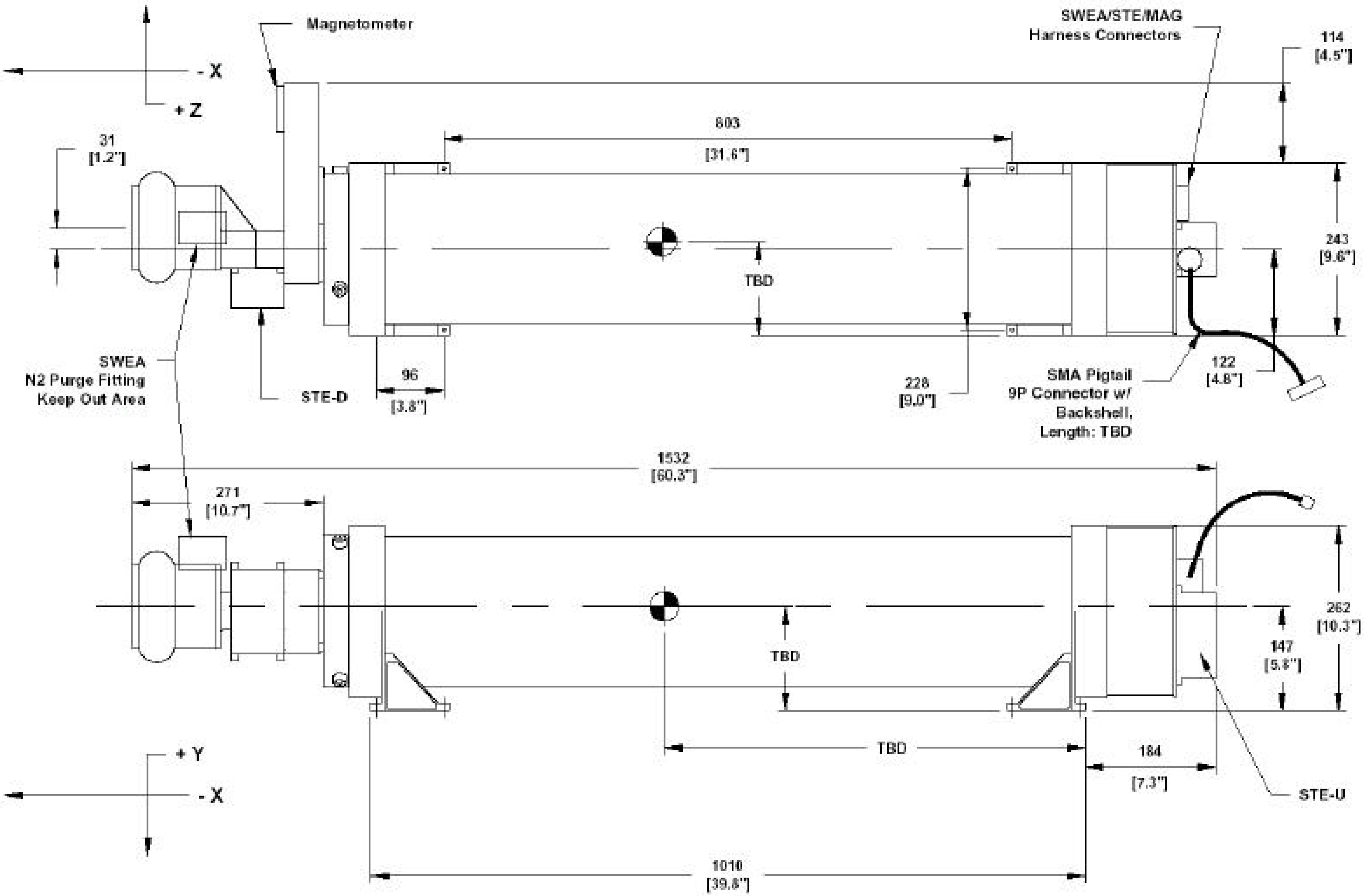
STEREO IMPACT/MAG



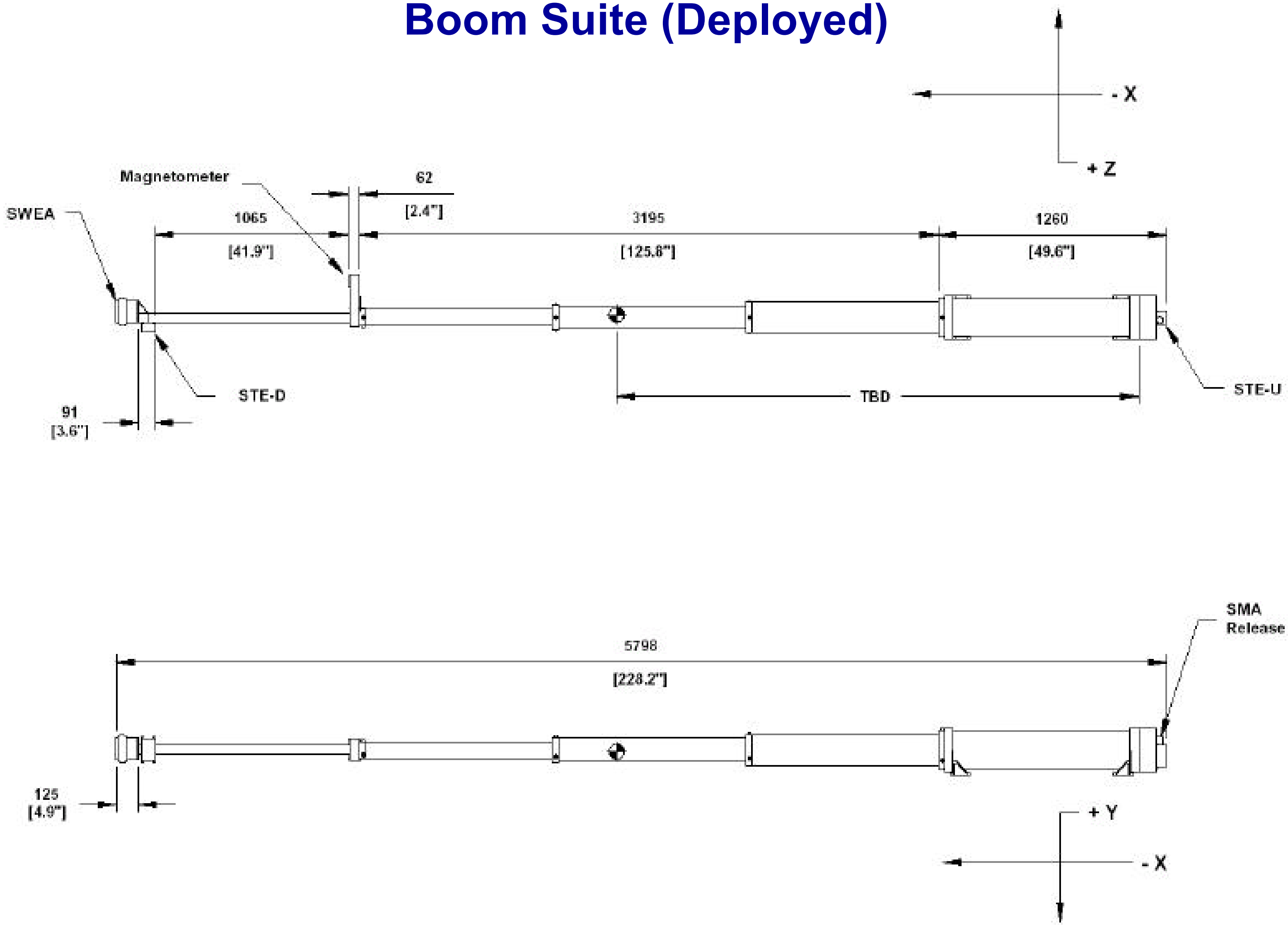




Boom Suite (Stowed)



Boom Suite (Deployed)



Resource Allocations

Instrument	Mass CBE, kg	Mass NTE, kg	Mass Margin, %	Power CBE, W	Power NTE, W	Power Margin, %	bps
SEP:							
LET	0.75			0.77			320
LET Bracket	0.60						
HET	0.66			0.35			120
SEP Common Elec.	1.92			0.53			
SEP LVPS	0.20			2.12			
SEP Main Total	4.13			3.77			440
SIT	1.23			1.27			240
SEPT-E	0.52			0.50			30
SEPT-NS	0.52			0.50			30
SEP-NS Bracket	0.27						
SEP Blankets	0.15						
SEP Grand Total	6.82	8.09	16%	6.05	7.40	18%	740
BOOM:							
SWEA:							
SWEA (CESR)	1.21			0.54			394
SWEA/STE I/F	0.30			0.30			
SWEA/STE LVPS	0.20			0.63			
SWEA Total	1.71			1.47			394
STE (STE-D)	0.35			0.10			64
SWEA Op Htr				0.50			
STE Op Htr				0.25			
MAG Sensor	0.25						192
Mag Op Htr				0.50			
SWEA/STE/MAG Blankets	0.10						
Sunward STE (STE-U)	0.35			0.10			
Boom Harness	0.83						
Boom	8.00						
Boom Totals	11.59	14.20	18%	2.32	3.50	34%	650
IDPU:							
Mag Card	0.30			0.38			
DIB Card (STE)	0.30			0.20			
DPU Card	0.30			0.80			
S/C Interface (on DPU card)				0.50			
IDPU LVPS	0.20			1.07			
Mag Heater Control	0.07						
BOX	0.96						
IDPU Total:	2.12	2.54	17%	3.55	4.30	18%	164
Burst Telemetry							546
Harness (average of A&B)	1.24	1.47	16%				
TOTAL	21.76	26.30	17%	11.91	15.20	22%	2100

Other Resource Issues			
Actuator Firing Current	**Type**	**Current@28V**	**Time**
SWEA Cover	TiNi P5-403	.75A	<100ms
SIT Cover	TiNi P5-403	.75A	<100ms
SEPT Covers	TiNi P5-403	.75A	<100ms
STE Cover	SMA	350mA	2s
BOOM Release	TiNi P5-405	.75A	<100ms
Survival Heaters			
Circuit	**Location**	**Power**	
IDPU/MAG	MAG	0.2W	TBR
SWEA/STE	SWEA/STE	1.3W	TBR
SEP/SEPT-NS/SEPT-E	SEP/SEPT-NS/SEPT-E	3.5W	TBR

Mass & Power Margin Requirements:

- 15% at PDR
- 10% at CDR

SWEA Operational Heater Requirement is TBR

MAG Sensor Alignment

- **IMPACT/MAG has a modest alignment requirement:**
  - ±1º alignment
  - ±0.5º knowledge
  - Should be obtainable by mounting tolerances
  - MAG sensor axes should be aligned parallel to the S/C maneuver (principal) axes.
  - In-flight roll calibrations will be used to determine final alignment

Magnetics

- **Magnetic Goals, as measured at the MAG sensor:**
  - **±0.03nT Dynamic**
  - **±1nT Static**
- **Magnetics Control Plan to be implemented using GSFC instrumentation and support. Objective: minimize dynamic fields from S/C and instruments**
- **Use of magnetic materials avoided/controlled**
- **Current loops need to be eliminated/compensated**
- **Items close to MAG sensor of particular concern (since field falls off at least as $1/R^3$)**
- **MAG team working closely with APL to help meet these requirements at minimum cost**
  - **Magnetics Control Seminars at APL**
  - **Screening of spacecraft components**
  - **System level magnetic tests during I&T to verify performance**
- **Mission Requirements: (a) Periodic (monthly) Spacecraft rolls, (b) MAG ON during boom deployment to calibrate spacecraft generated DC magnetic fields**

Magnetics (2)

- Power system and solar array are primary targets of magnetic reduction effort followed by reaction wheels and propulsion system components.
- Shared magnetics data base and tests with MESSENGER
- Successful prior experience with many missions: WIND, POLAR, GEOTAIL, ACE, Mars Global Surveyor, etc.
- Minimal cost and schedule impact assured by early detection/solution

GSE

- **Electrical GSE includes:**
  - Spacecraft-provided spacecraft interface simulators
  - UCB provided Telemetry/Command GSE (also used at spacecraft-level I&T and mission ops)
  - Electrical GSE are typically PC-based systems with commercial or custom interface cards to provide interface signal simulation
- **MAG team will provide magnetic screening GSE and I&T support instrumentation**

Instrument Handling

- **Magnetized materials or tools near MAG sensor prohibited at all times. Demagnetize and Screen tools through QA function during I&T**

On-Orbit MAG Commissioning Phase

- Would like IMPACT/MAG powered on and the IMPACT boom deployed as soon as possible after launch. This will provide valuable data for modeling of the spacecraft field, and can also provide deployment engineering confirmation/diagnostics
- Perform calibration roll maneuvers 30+ days after launch

Rolls

- Slow spacecraft rolls about the sun-line are required to calibrate the MAG DC offsets during the commissioning phase
- Rolls are also desirable for the other IMPACT instruments, to separate spatial effects from spacecraft effects in the measured particle distributions
- Rolls should occur in a low field region such as the solar wind
- Several rolls are desirable in case the ambient magnetic field is active during the measurement
- Rolls later in the mission, every six months, will measure the drift in the spacecraft DC fields and MAG sensor offsets

Trade Studies

No.	Trade Study Title	Description	Status	Decision Schedule							Result
				PDR	CDR	Bread-board Test	Sub-system Test	System Test	Env test	Early Orbit Test	
I-1	LVPS Topology	Select a toplogy that meets the EMI requirments and mass/volume constraints with maximum efficiency and reliability	CLOSED	X		X					Topology selected
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I-11	Detector Doors (STE, SEPT)	Concern about contamination and overheating from sunlight exposure	CLOSED	X							Reclosable door selected for STE, 1-time doors selected for SEPT
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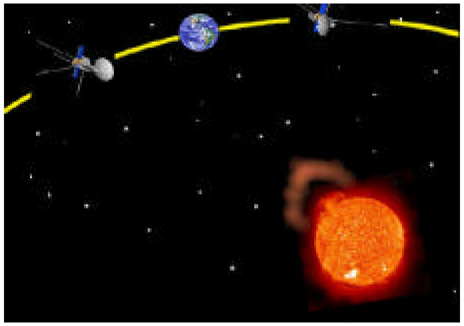
I-13	Boom Trades	Select a boom that meets the requirements with minimum resources (especially $)	CLOSED	X							Project selected UCB Telescoping boom concept
I-14	SWEA/STE LVPS Size	Select geometery for UCB part of SWEA/STE	OPEN		X						Pending rough layout of LVPS

IMPACT/MAG Current Status

- Baseline design has been optimized for surface mount components to miniaturize instrument electronics. Parts selection strategy developed
- Miniature test coaxial cables provided by UCB and tested successfully on fully functional breadboard
- 16-20 bit sigma-delta low power A/D converter(s) selected for implementation. Identical to NEAR, MESSENGER
- Preliminary Interfaces to IDPU and Boom defined
- Preliminary assessment of SWEA/STE/cable magnetics and grounding architecture under way. No major problems anticipated

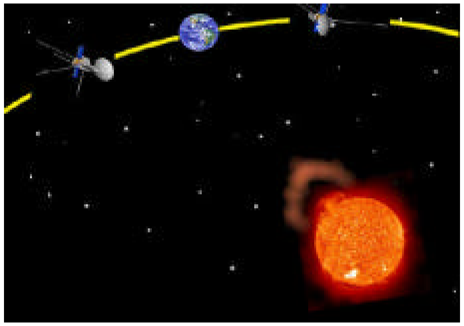


Stereo Impact Boom

Preliminary Design Review

Johns Hopkins University
The Applied Physics Lab

Table of Contents



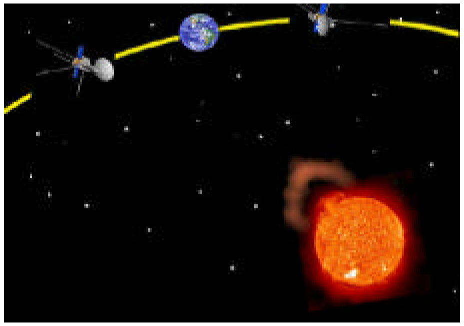
Stereo Impact Boom

Flow down science requirements for the Impact Boom

1) Magnetometer >= 3m from S/C
2) Magnetometer >= 1m from other instruments
3) SWEA 130^0 X 360^0 FOV, clear of S/C.
4) STE
   a. 60^0 X 60^0 FOV (80^0 X 80^0 goal) clear along Parker Spiral both inward and outward looking.
   b. Operational temperature: -20^0C to –40^0C (TBC).
   c. No exposure to Sun, thruster plumes.

Spacecraft Requirements

1) Stowed length =< separation plane to separation plane: 61", 1549mm.
2) Boom doesn't interfere with HGA: height overall including blankets =< 12", 305mm.
3) Stiffness > 0.5Hz (TBC) Goal; 0.3Hz Requirement (from Astromast Spec)



Stereo Impact Boom

System Requirements

1) Materials, Methods and Processes: first revision complete.
2) EMC / EMI
   a. Per Program Specification, in accordance with APL Document No.7831-9030
   b. Boom surface statically dissipative: < 10^8 ohms / sq.
   c. Harness double shielded:
      i. Outer shield: Stacer + braid (in final segment of boom).
      ii. Inner shield: aluminized kapton (TBC)
   d. Harness specified in Impact Harness Document.
3) Cleanliness
   a. Fabrication: Class 100,000.
   b. Integration: Class 10,000 (TBC).
4) Risk assessment: Item; mitigation.
   a. Tube jam; Ensure clearances, material compatibilities, verify by testing.
   b. Incomplete tube travel; Design Stacer for 5X needed force, ‘kick’ spring deployment initiator, low friction rollers.
   c. Pin(s) not locked; Ensure clearances, material compatibilities, redundant pin / socket pairs, verify by testing.
   d. Cryogenic temperature issues; Perform LN_2 dunk of glue joint (done) – design is valid, include mechanical fasteners as redundant retainers for critical glue joints.

Stereo Impact Boom

e. Loss of rigidity due to incomplete tube travel; Restoring / centering moment given by offset between pairs of rings: worst case - pins at sockets, not engaged, restoring moment, at any pin / socket location, is 0.04 kg-m; for a zero-extension situation, ie. release operates but Stacer does not deploy, the restoring moment is 4.95 kg-m.

5) Product Implementation and Assurance Plan

a. Per Impact PAIP.

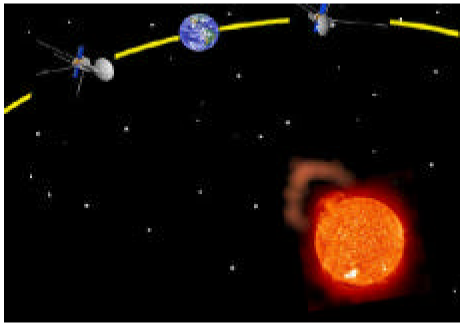
b. No EEE parts.

6) Long lead items:

a. Stacer: ~26 weeks.

b. Gr/E tubes: 15 – 20 weeks.

c. SMA releases mechanisms: 8 weeks.



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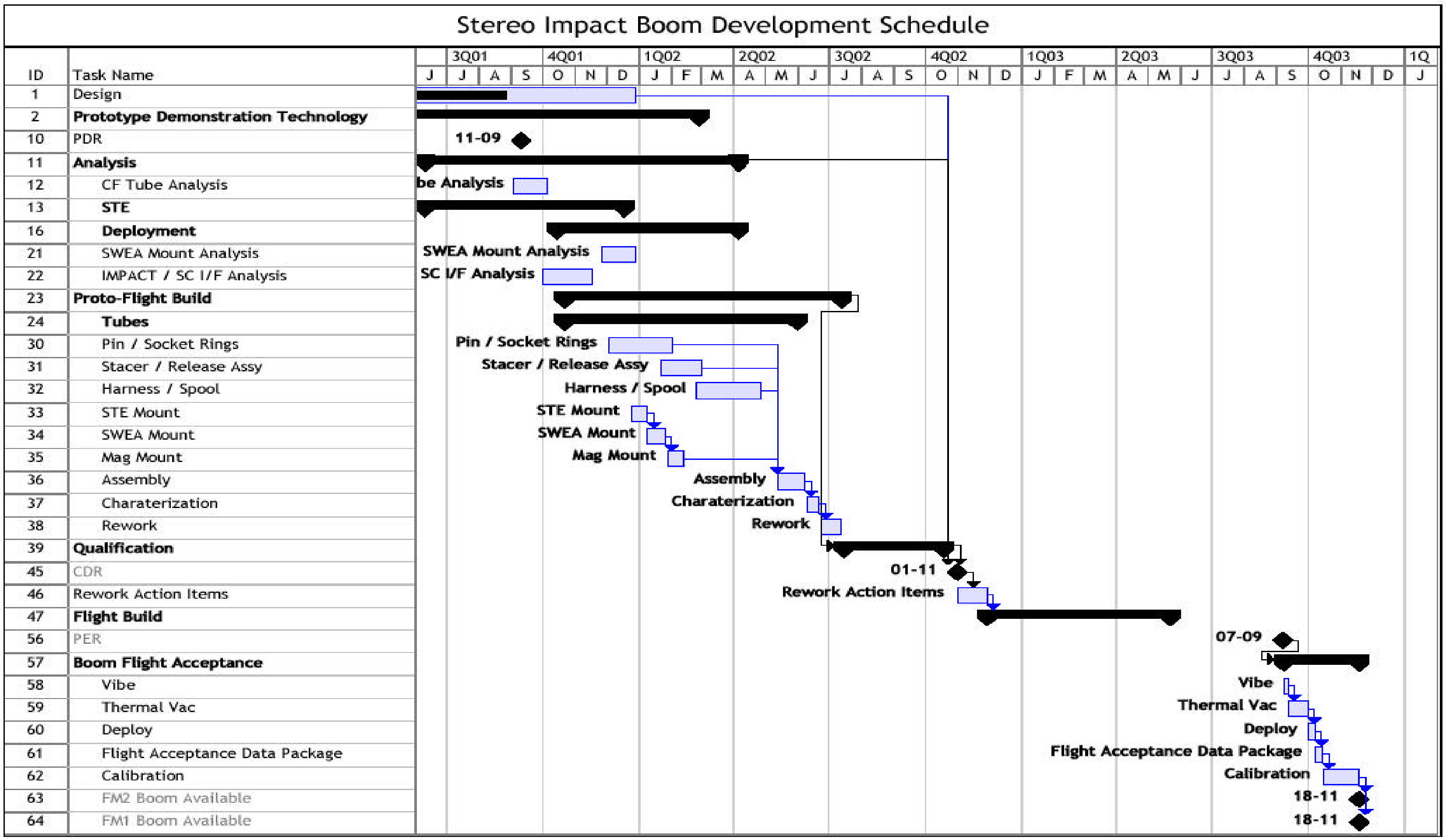
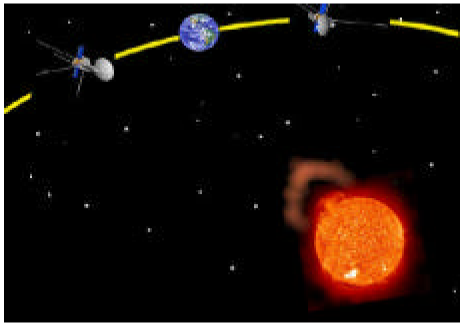
Stereo Impact Boom

Development Plan





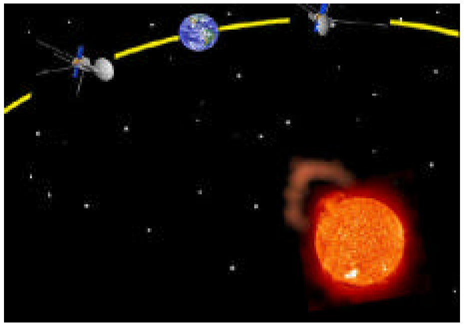
Stereo Impact Boom

Test Sequence

1) EM Qualification (per GEVS-SE Rev. A; APL# 7381-9003; TBC)
   a. Proof Load: 1.25 times expected load. (Design Goal: 100 X)
   b. Vibration: 14.1 G_{rms} ; facility: GSFC or Wylie Lab (TBC).
   c. Thermal Vacuum / balance: 4 cycles @ +50^{0}C / –40^{0}C (TBC) in < 10^{-5} Torr vacuum; facility: UCB (TBC).
   d. Deployment + boom characterization: length, target accuracy, mass properties @ UCB.
2) FM1 & FM2 Acceptance (per GEVS-SE Rev. A; APL# 7381-9003; TBC)
   a. Proof Load: 1.25 times expected load.
   b. Vibration: 10.0 G_{rms}
   c. Thermal Vacuum: 4 cycles @ +40^{0}C / –40^{0}C (TBC) in < 10^{-5} Torr vacuum
   d. Deployment + boom characterization: length, target accuracy, mass properties @ UCB, EMI (TBD).

Mechanical GSE

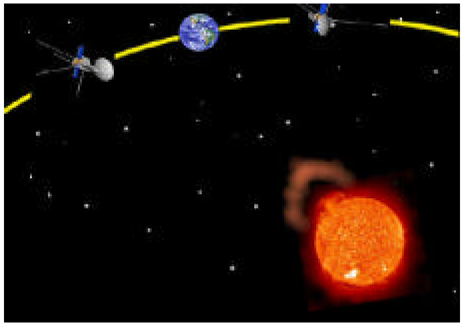
1) Tube / ring bond assembly fixtures
2) Deployment offload fixture(s) for:
   a. EMC characterization
   b. Thermal vacuum
   c. First motion at S/C integration (TBC)
3) Stowing fixture(s) and tools.
4) Shipping containers



Stereo Impact Boom

Design Trades made

1) Selection of current configuration:
   a. Longeron style: Cost > $1M., exceeds budget; cost over-runs, late deliveries not uncommon.
   b. Swing-arms: Can not meet Magnetometer basic 3m distance requirement without 3 or more pivot joints / arms. Stowing, sequence and reliability of deployment questionable.
   c. Telescoping: New for this application, meets science and budget requirements, combines many heritage technologies.
   d. Stacer only: possible alternative, would require active pointing means with feedback; not as rigid as telescope style.
2) Length: finalized (in wet concrete) for the current spacecraft baseline.
3) Prelim. instrument interfaces: finalized (also in wet concrete) for the current spacecraft baseline.
4) FOV's
   a. STE: split into 2 separate locations: STE-U (up, towards sun) and STE-D (down, away from sun); 80^0 X 80^0 FOV unobstructed. A reduction of the STE-U maybe needed for sun avoidance (TBC).
   b. SWEA: 130^0 by 2π radians, impingements by solar arrays, corner of lead S/C. New S/C baseline would require a boom >10m long to avoid these impingements. Current design with impingements is accepted by Co-I's.
5) Lock pin design: includes roller in tip to lower friction, reducing needed force for deployment, lower particle generation.
6) Retraction pin serves provides roller alignment during deployment. Removes multiple guide tracks down length of tube, requires only 1 set per segment, relieving tight tolerance requirements.



Stereo Impact Boom

Current Design Status

Spacecraft baseline design, as of 13 August 2001.

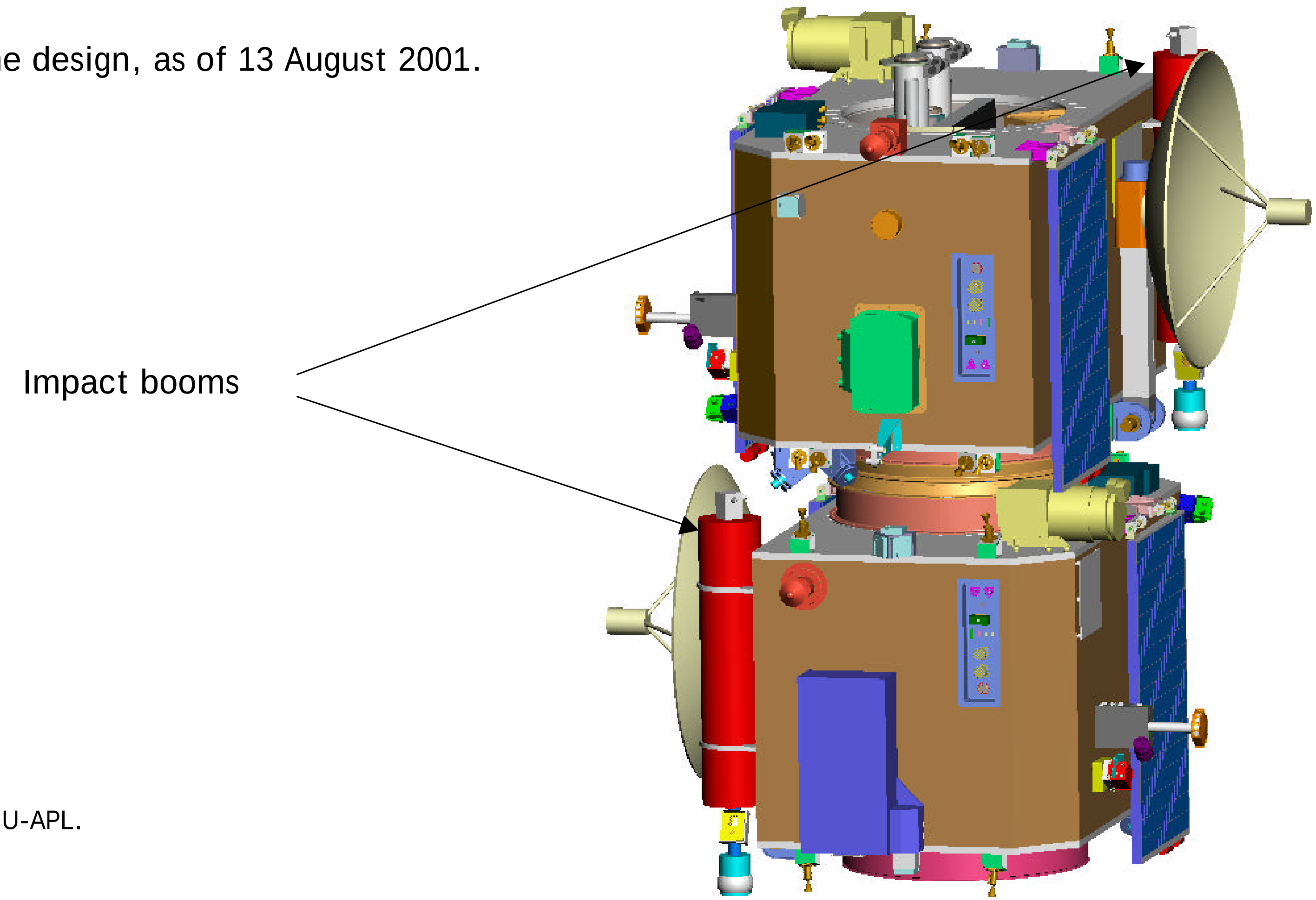
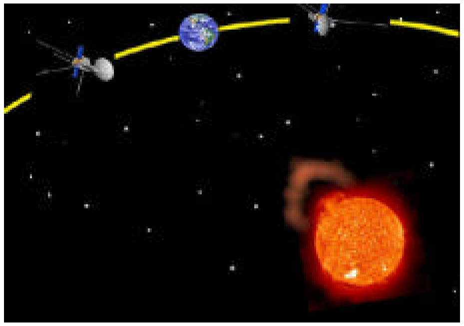
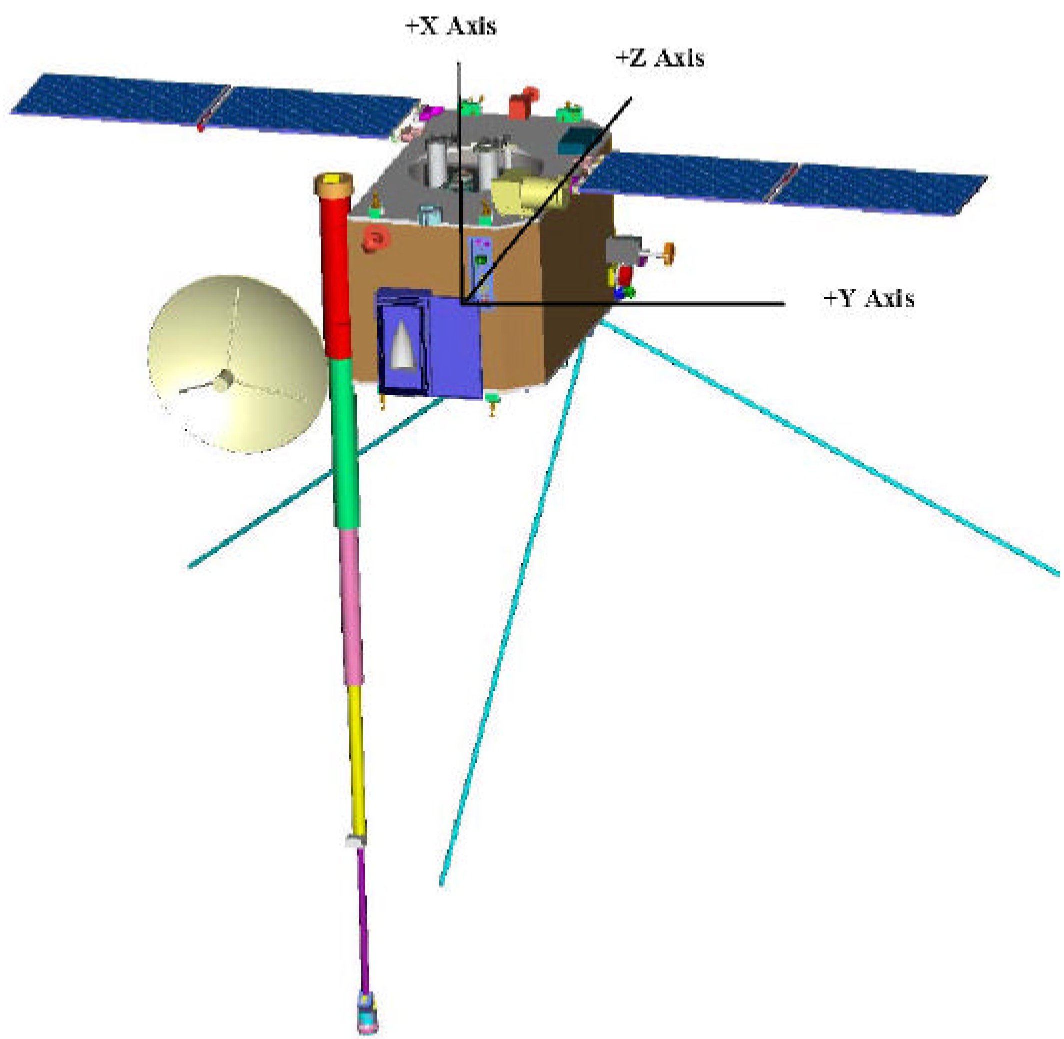


Illustration courtesy JHU-APL.

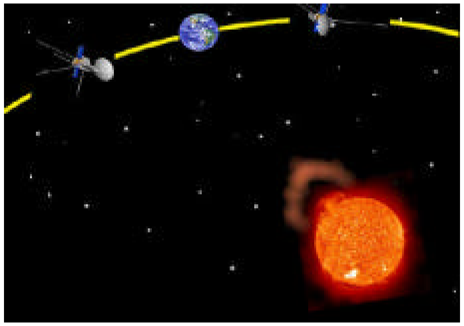


Stereo Impact Boom



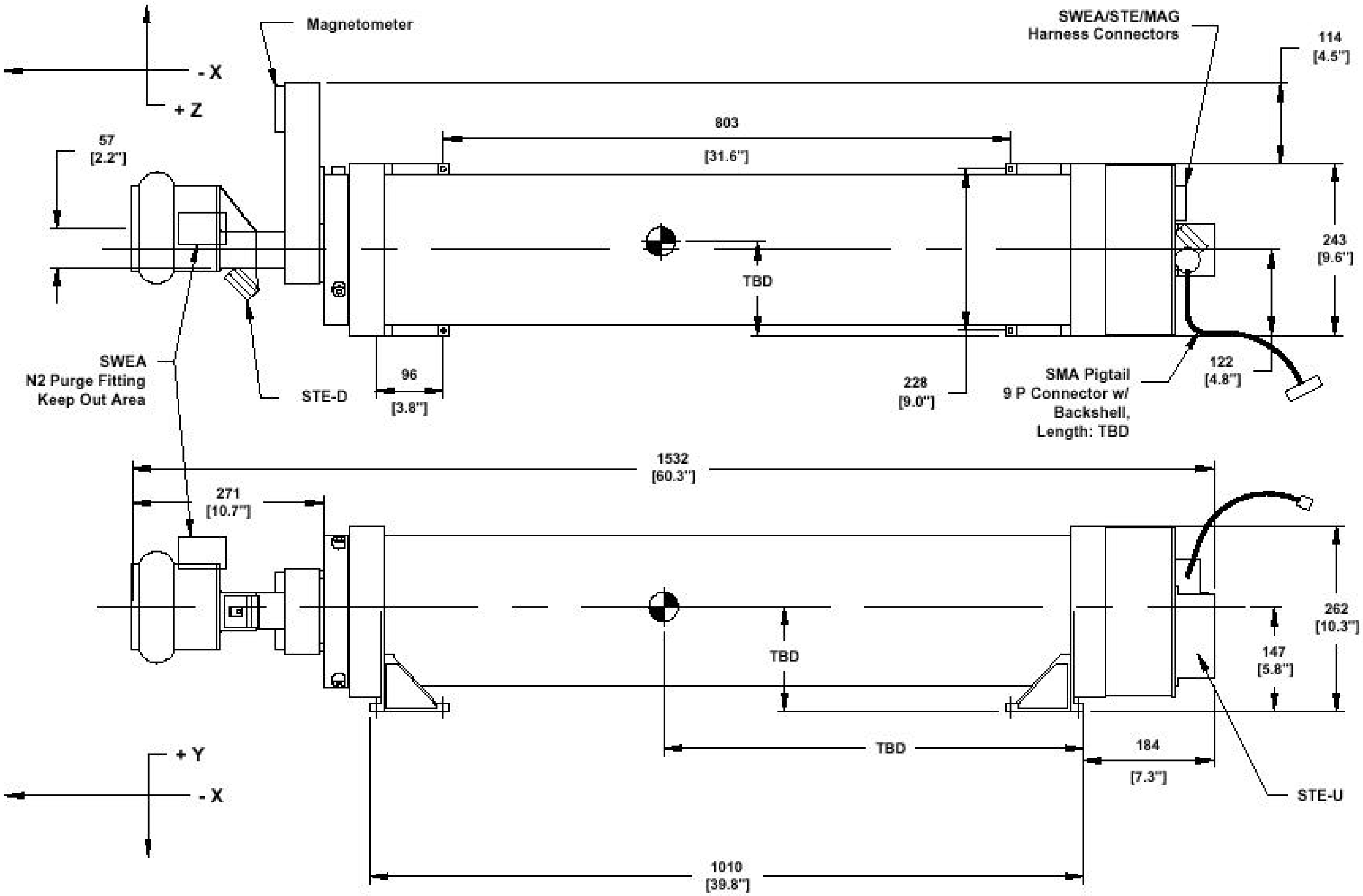
Impact boom deployed, with spacecraft coordinate system

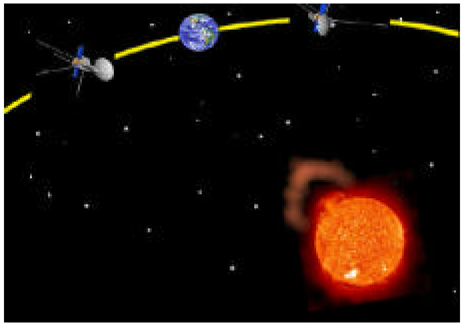
Illustration courtesy JHU-APL.



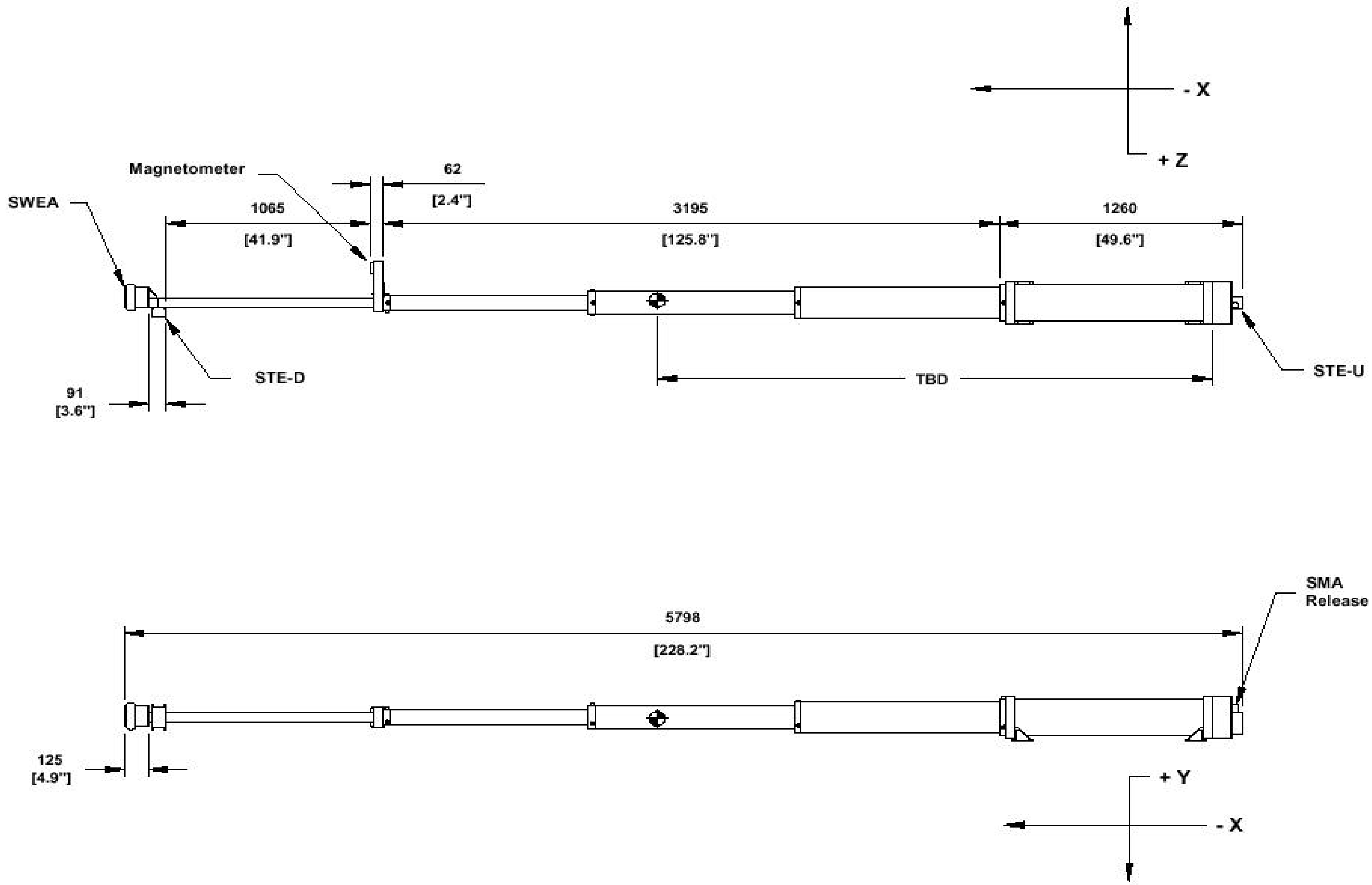
Stereo Impact Boom

Stowed configuration

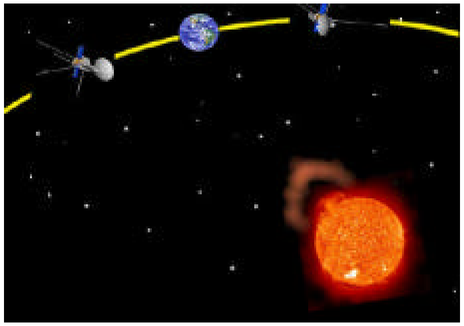




Stereo Impact Boom



Deployed configuration

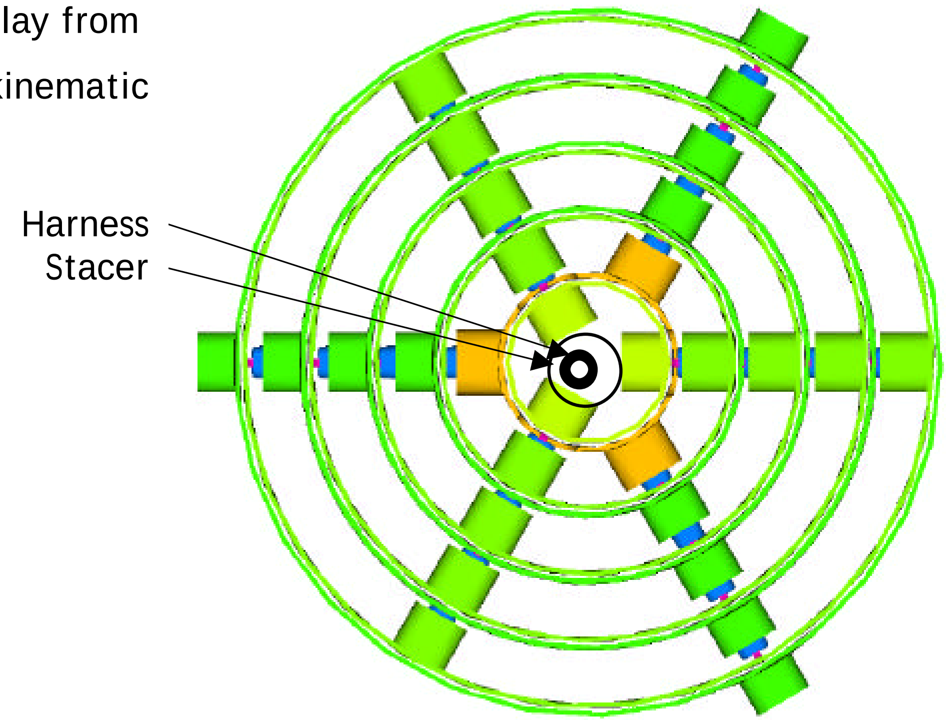


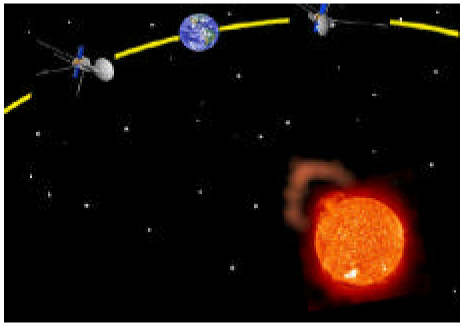
Stereo Impact Boom

Boom Assembly Overview

Top view: stowed position, no instrument brackets shown. Rollers rest on tube surfaces. Lock pins are blue, rollers magenta, Gr/E tubes are thin white rings between green and orange rings. For deployment, pins roll along tubes until end of travel, then extend 8mm radially to mate with sockets, both have an included cone angle of 10^0 to provide a 'self-locking' interface.

An offset of 1.0mm of 3 of the 6 sockets takes up the play from clearances between the pins and sockets, providing a kinematic mounting. The rings shown are schematic in the sense that the webs, cutouts, covers, and fillets that eventually appear in the final design have not been added. Only the minimum structure necessary to hold the pins in place is included. Manufacturability issues are held as a background consideration, to be folded into the final designs.

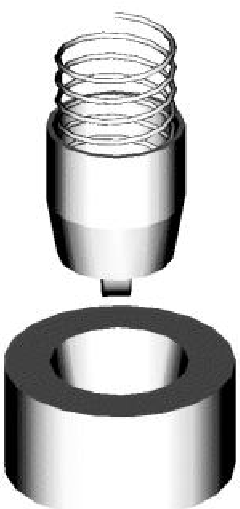


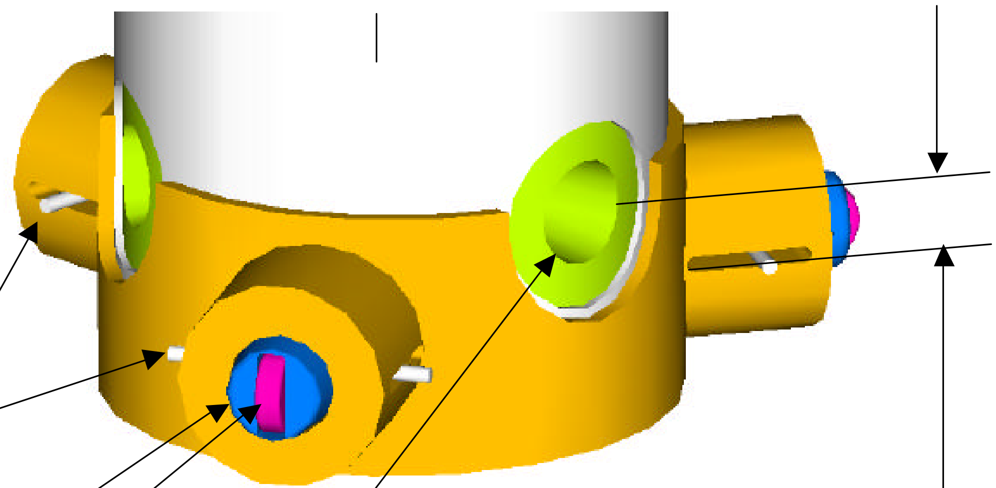


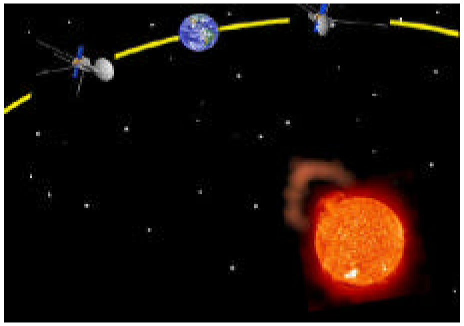
Stereo Impact Boom

Pin detail

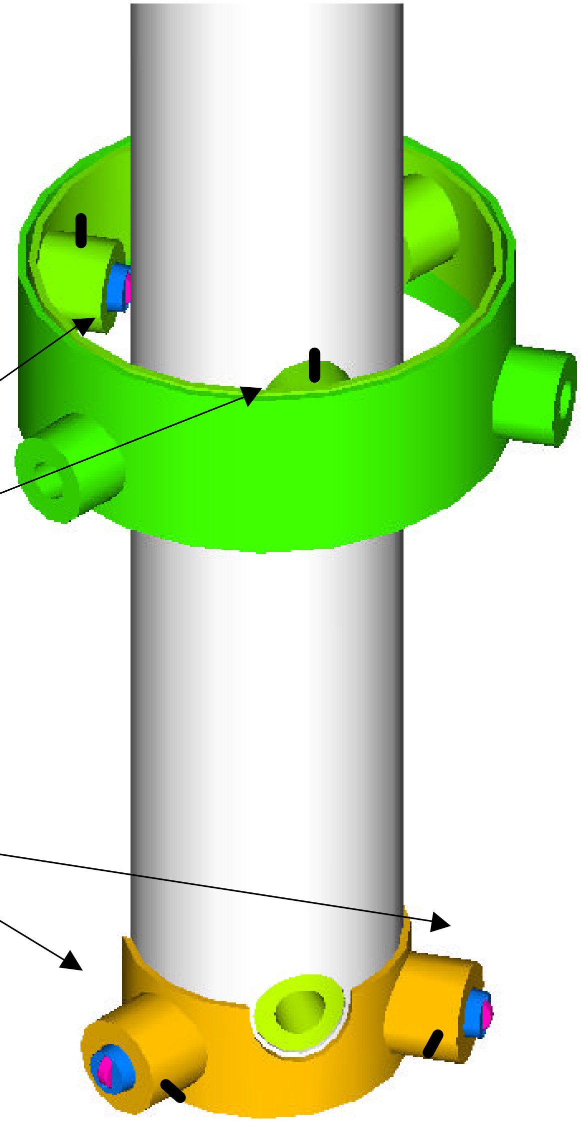
Roller: PEEK, roll pins: 300SSt, locking pin: 6061T6xx Al, ring: 6061T6xx Al, adhesive: Hysol 9309NA structural epoxy. Offset between lower and upper lock pin centerlines: 10mm, provides restoring moment.







Stereo Impact Boom

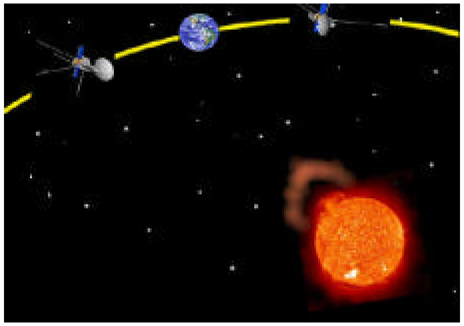


Boom Deployment Detail:

Mid-deployment of inner tube is shown. Outer tube, guide track have been removed. Rollers ride on tube surfaces.

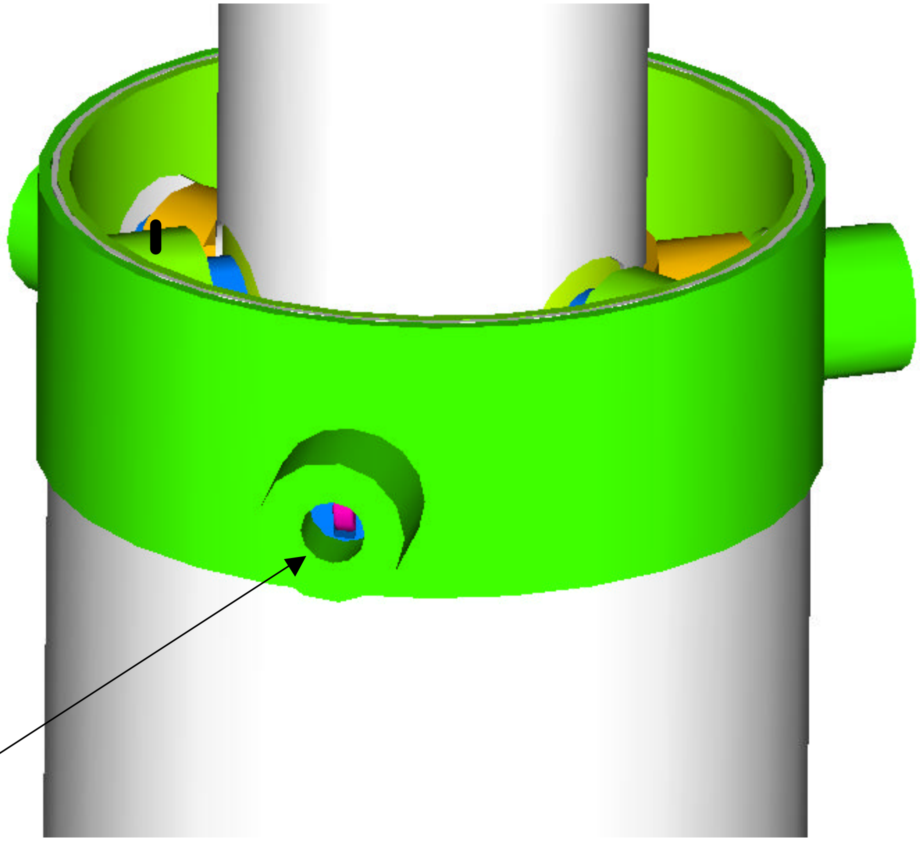
Upper rollers travel on outside of inner tube. End of internal guide pin visible.

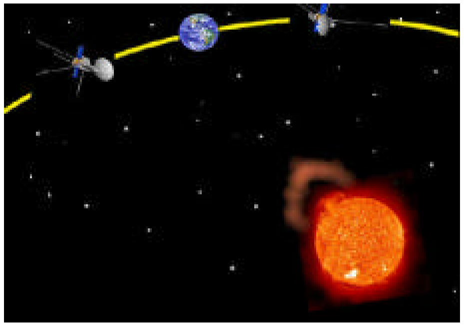
Lower rollers travel on inside of outer tube (not shown).



Stereo Impact Boom

Inner tube fully deployed, pins inserted into sockets. Pattern repeats for each segment.
Boom stiffness goal: >0.5 Hz.

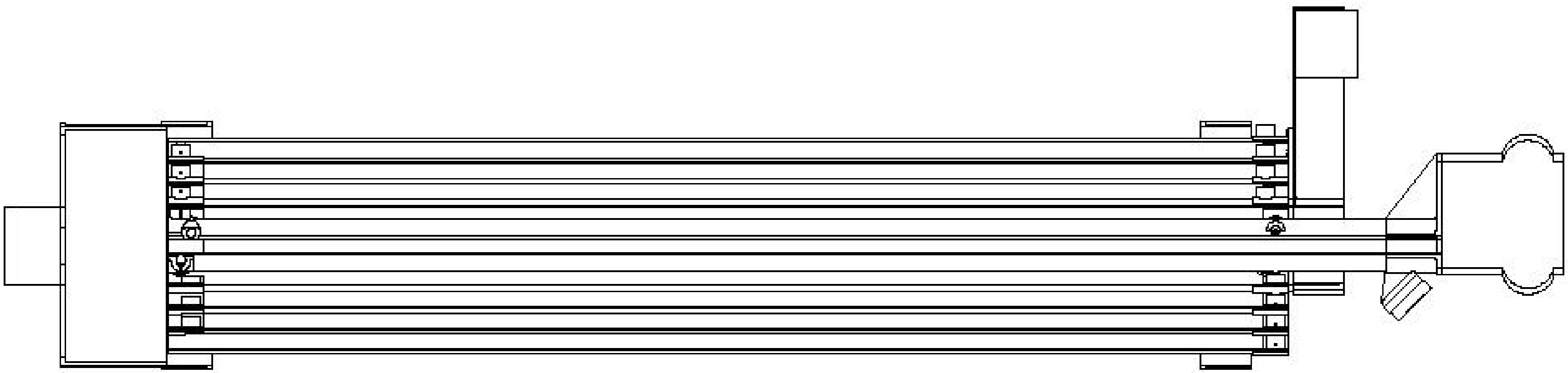




Stereo Impact Boom

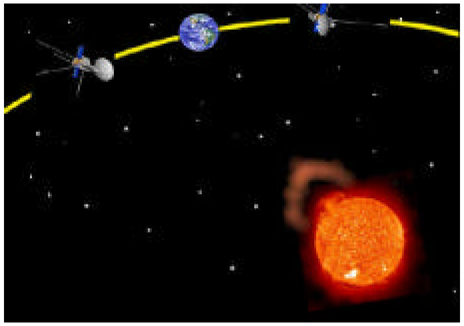
Background information for design:

For launch, the tube segments are retained by an SMA pin puller through a hole in the Stacer tip piece, which in turn is connected to the innermost (50mm diameter) tube. The tubes are held in place for

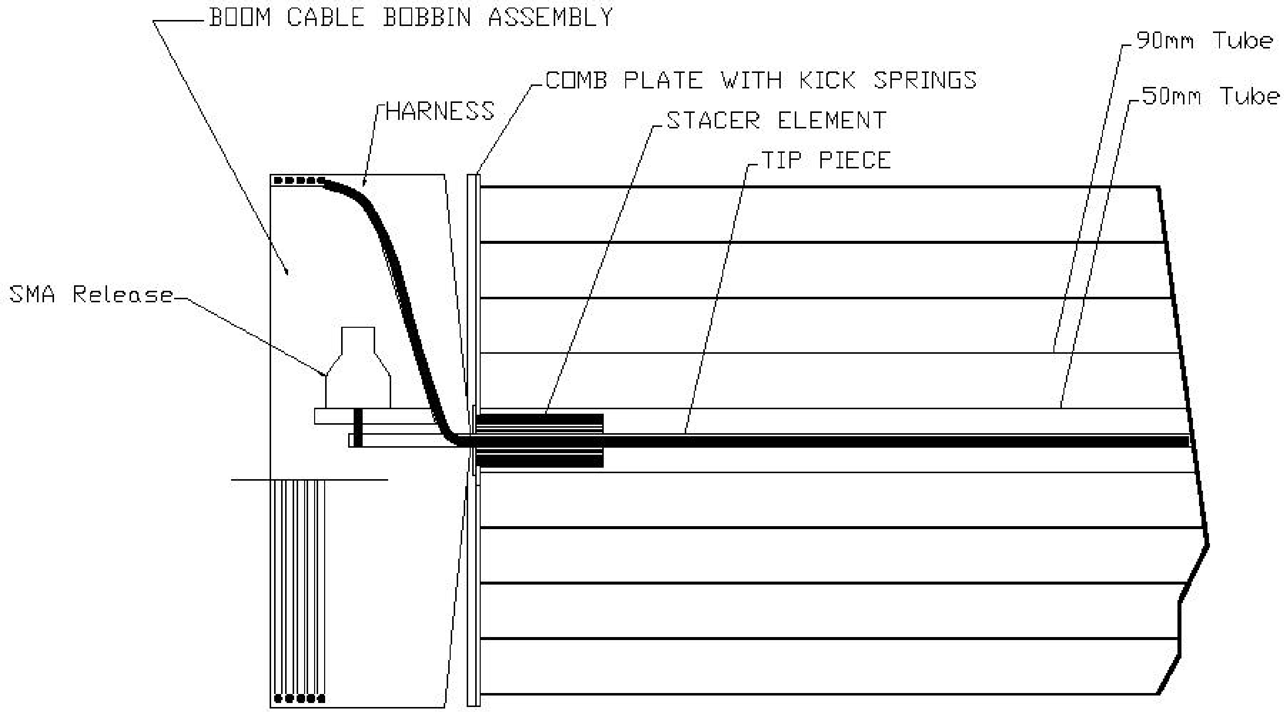


launch by comb-like devices attached to the spool mounting plate and the Magnetometer mount.

Kick springs located in the spool mounting plate initiate deployment when the SMA is triggered. The Stacer provides the extension force. As the Stacer deploys, the harness is withdrawn from the spool and pulled into the center of the Stacer / tube assembly. A swivel is incorporated into the Stacer attachment at the joint of the smallest diameter tube and the next segment out to relieve the accumulated turns from the Stacer's deployment.



Stereo Impact Boom

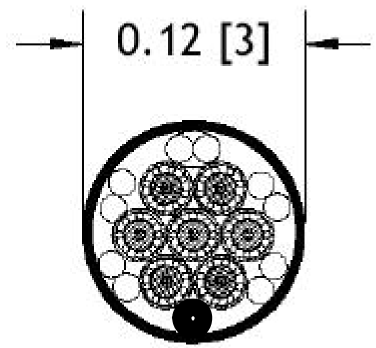


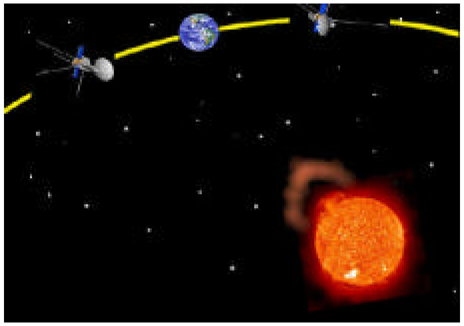
Stacer, spool and harness

Detail section of harness, spool and SMA release. This is almost identical to FAST axial boom harness storage and Stacer release. Stacer is stowed inside of the 50mm diameter tube. Tip piece projects to receive pinpuller. The harness serves as Stacer velocity control, set by the bobbin radii and clearances to the spool wall. The Stacer is a helically wound, 6.02m (237”) long by 100mm (4”) wide strip of Elgiloy: cold rolled, buffed, and coiled with a helix angle of 55^0 and a final tip diameter of 12mm (0.5”). It is stowed inside a canister for launch, and when released, transfers the stored strain energy into kinetic energy, thus deploying with great force. The 5 connectors from the S/C to the SWEA / STE science & power; Mag; and boom release & thermal are located on the base plate of the bobbin assembly.

Harness

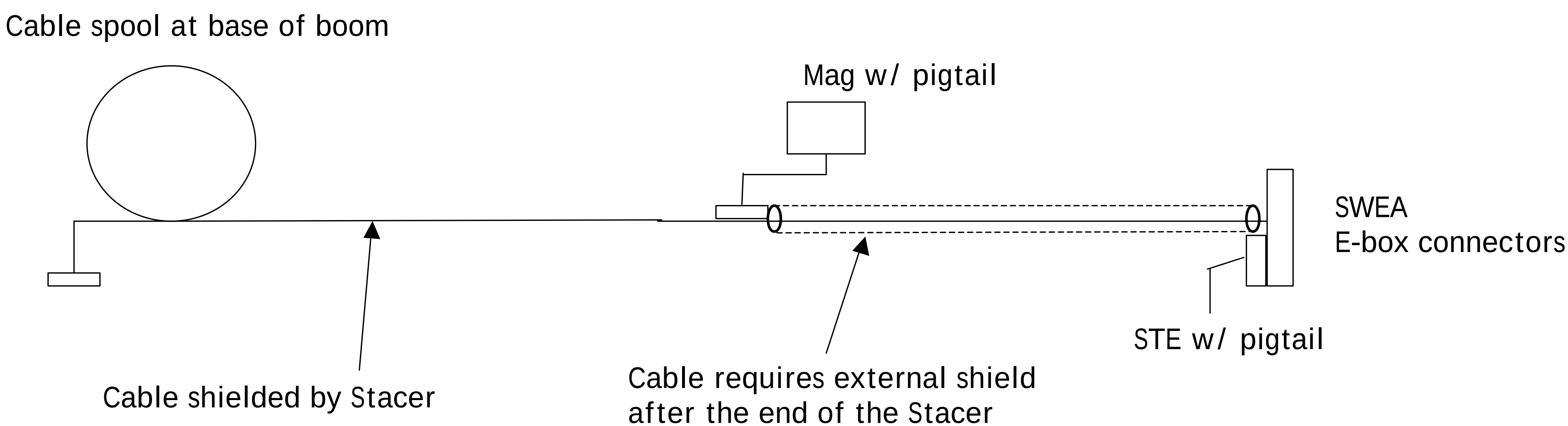
The harness consists of a custom fabricated wire bundle routed up the center of the boom. The bundle contains 7 coaxial cabless, 4 #26 Ga twisted pairs, and a single #26 Ga twisted shielded pair (for Mag AC heater). A common, taped, over-shield of the wires extends from the boom base to MAG-J1 and SWEA-P1, and will be tied to chassis ground at both ends (the bottom of the boom and SWEA; MAG). This assembly is additionally shielded by the Stacer (grounded at S/C), and will have another braid over-shield from the exit of the Stacer up to the SWEA / STE. The thermal blankets will be connected to the over-shields' ground. The design of the spool and bobbin are dependent on the 'hand' of the cable, so a preliminary mock-up is being built up to get a baseline for stiffness. The coax are a custom fabrication: #36 Ga center wire with E-PTFE jacket. Aluminized kapton wrap with 8 #38 Ga drain wires, and a final E-PTFE wrap jacket. The exterior is expanded PTFE wrapped. The coaxes are the same as used for Cluster, Polar, FAST and other space applications. These have been selected for their ability to carry the high data rates required, while still fitting in the envelope of the boom.



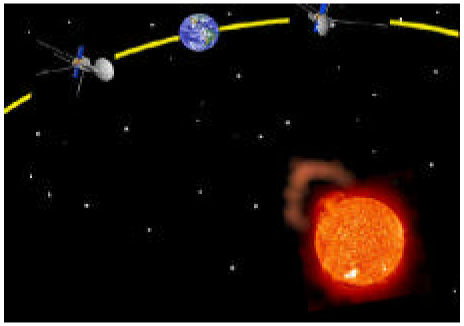


Stereo Impact Boom

Harness Schematic



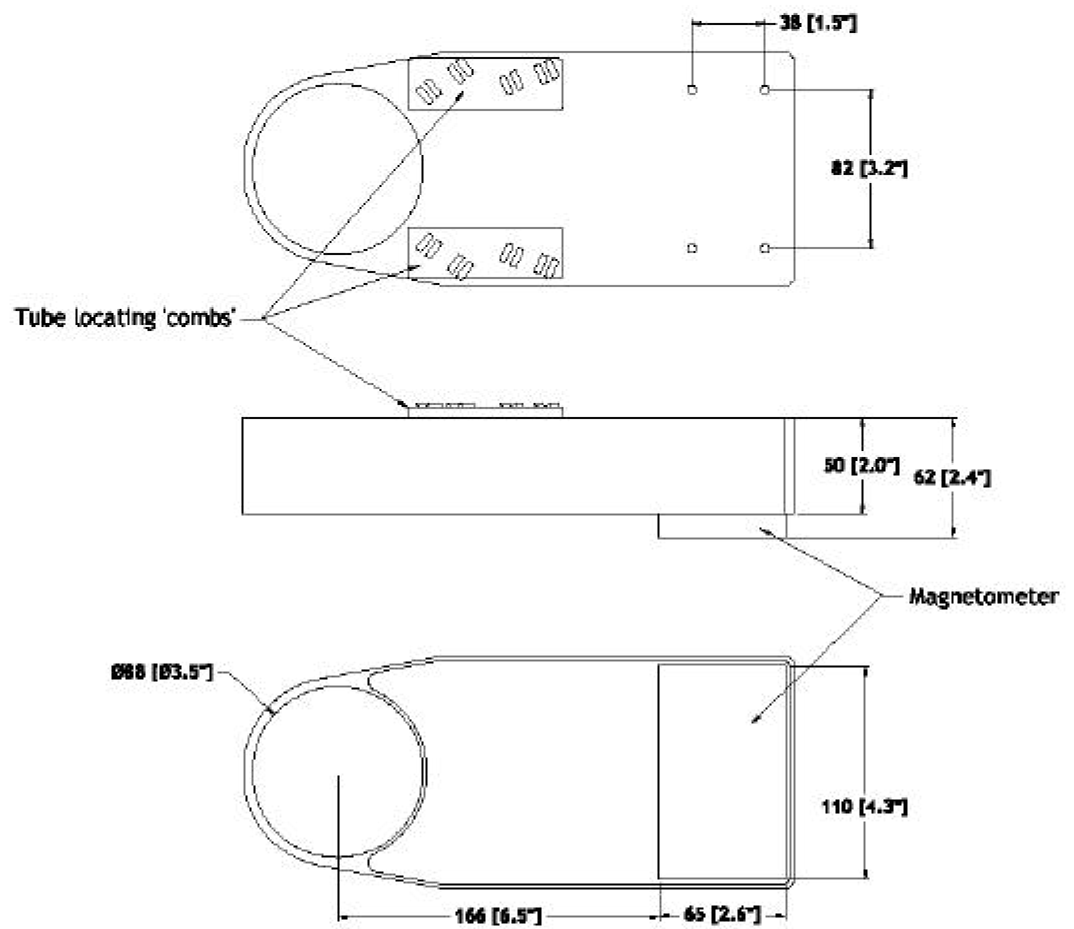
The Magnetometer ‘pigtail’ is connected just past the end of the Stacer. The remainder of the harness, no longer surrounded by the Stacer, is sheathed in a copper braid, and captured in the final tube. It is routed to the SWEA mount, where the harness is terminated at the connector. The harness will be designed as a separate entity, and installed into the boom complete with connectors.



Stereo Impact Boom

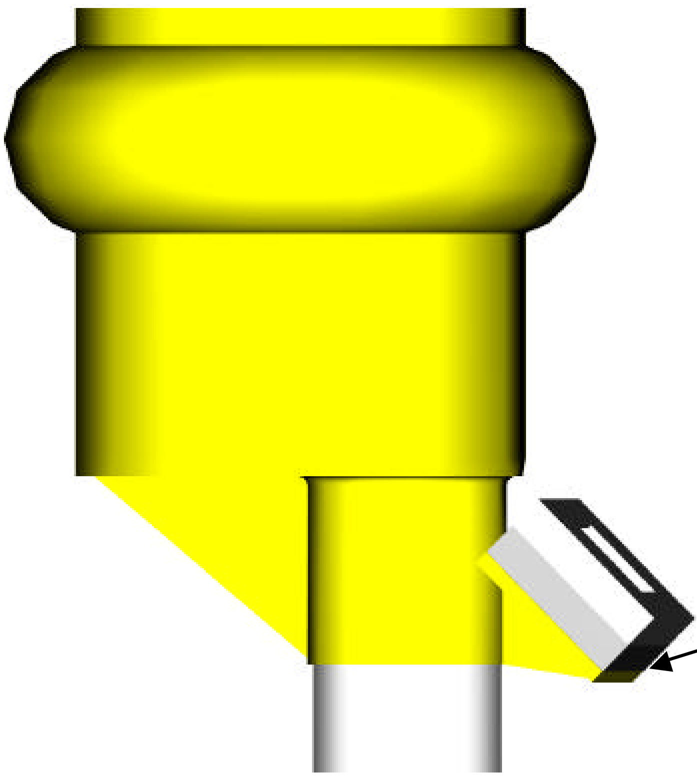
<u>Magnetometer Mount</u>

Preliminary design, showing single piece fabrication of PEEK high performance engineering plastic. The second and third views show 'comb' for capturing tube for launch. Magnetometer is mounted via 4 screws through the base of the tray.



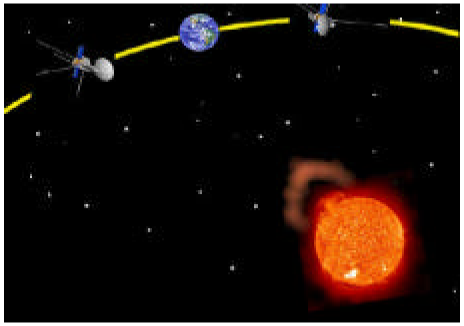
Stereo Impact Boom

STE / SWEA Mount



Fabricated from 6061-T6xx Aluminum, incorporates both instruments in a compact package. Enhances thermal control by increasing conduction, common blanketing. The SWEA is mounted to the extreme end, where its 2P radian FOV is unobstructed, and the STE-D is mounted to the side. The STE reclosable shutter and actuator are not shown.

STE thermally isolated from main mount with FR mounts

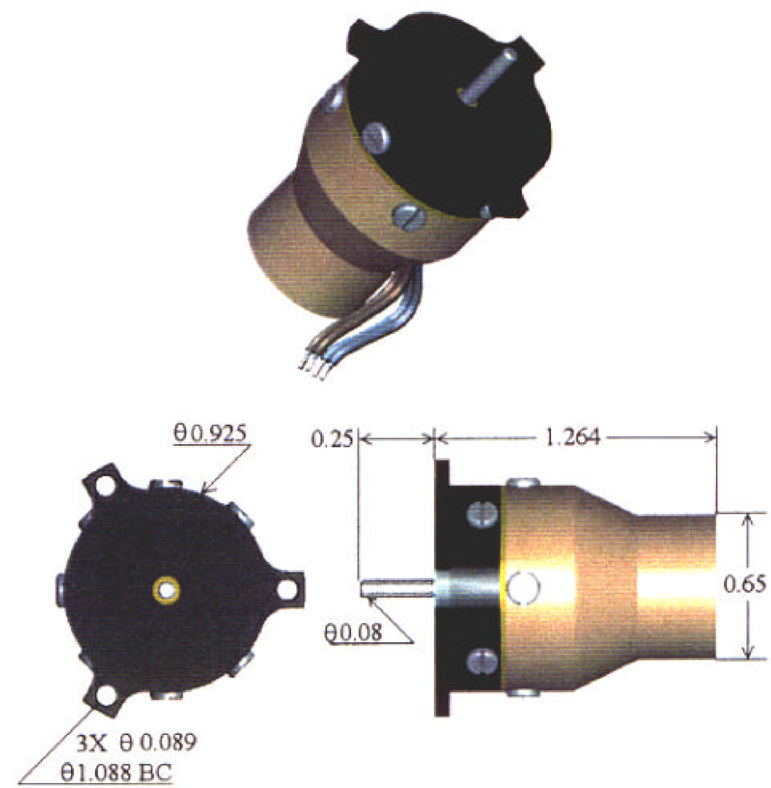


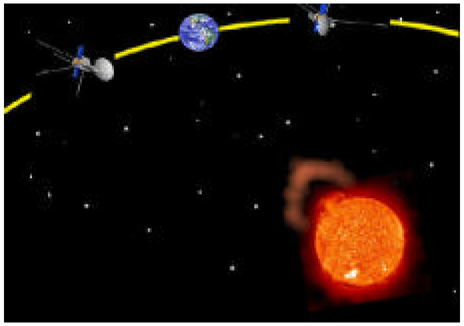
Stereo Impact Boom

Shape Memory Alloy Release

The Model P5-405-6RS is the latest addition to the P5 Pinpuller product line. It was specially designed for the Jet Propulsion Laboratory to be used aboard the Mars 2001 spacecraft. This embodiment incorporates redundant SMA (Shape Memory Alloy) triggers with integrated shut off switches, a convenient 3 ear mounting flange, and optional enclosure (as shown). As with all TiNi Pinpullers the P5-405-6RS uses the same ball-lock trigger mechanism developed under TiNi patent # 5,771,742 issued in June of 1998. Reset is achieved by manual re-extension of the pin via two access holes at the base of the pinpuller.

* Custom configurations as to pull force, retraction stroke, and mounting interface are readily attainable.

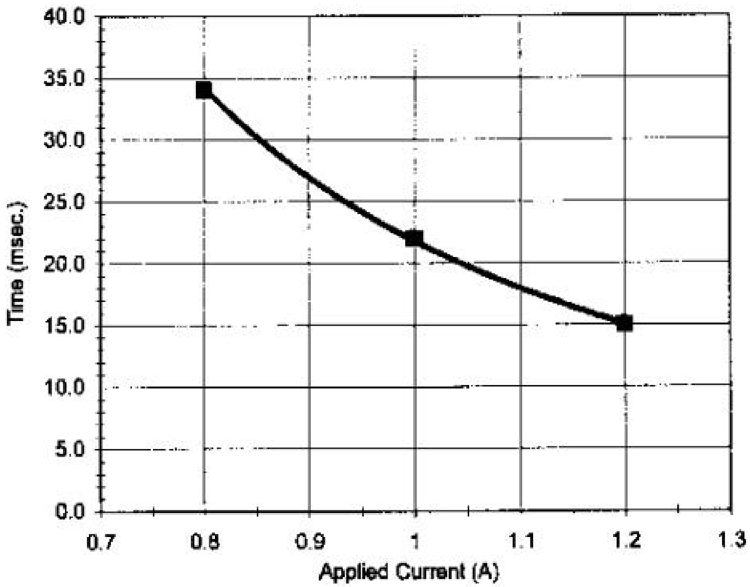




Stereo Impact Boom

Function Time

(@ 20 °C)

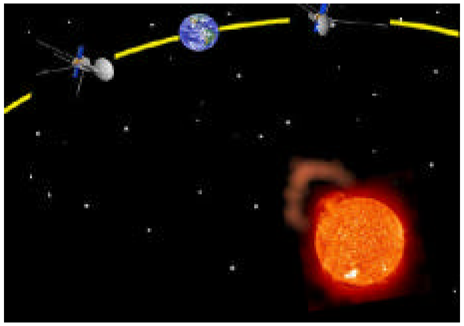


Specifications

Pull Force	22.3 N	(5 lb-f)
Pull Stroke (minimum)	6.35 mm	(0.25 in)
Power Consumption	6 Watts @ 1 Amp	
Operational Current	0.5 to 1.5 Amp	
Actuator Resistance	6.0 ohms	
Life	> 100 cycles	
Minimum Operating Temp.	<-50 °C	(<-58 °F)
Maximum Operating Temp.	+70 °C	(+158 °F)
Mass	30 gm	(1.0 oz)

Features:

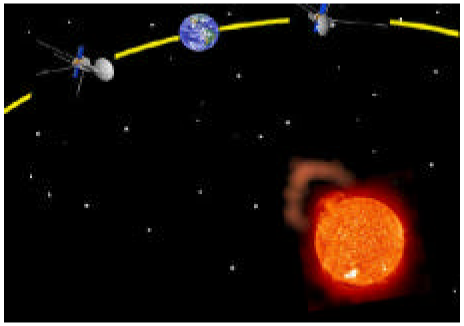
Reusable
Redundant SMA Trigger
Integrated Shut-Off Switches



Stereo Impact Boom

Thermal

Initial thermal studies have been made for the boom and some of the instruments. The current estimate for the SWEA / STE shows operational heaters are required. For SWEA, the instrument dissipates ~1.5W, and requires an additional 1W at 50% duty cycle. The STE has a lower desired op-temp and minimal power dissipation, and requires ~0.5W, again at ~1/2 duty cycle. These heaters are software controlled. The Gr/E tube near the SWEA / STE will conduct away ~0.007W at -100^{0} C. The Mag has its own AC heater, and will be fully blanketed. The Gr/E tube section between the Mag and the SWEA / STE has been identified as a possible location for some thermal tape. The details remain to be established. This would keep the heat loss from the tube lower. The midsections of the boom will be radiating to free space, and will drop to an estimated range of -150^{0} C to -200^{0} C. These temperature extremes have led to the inclusion of metal fasteners between the inner and outer rings, capturing the Gr/E tube to prevent loss of rigidity due to possible thermal failure of glue lines. The spacecraft end of the boom has a blanket completely surrounding the outer most tube. The interior of the boom behaves as a black body, so it must be thermally isolated from the s/c deck. There is significant heat input to the STE-U end, temperatures are expected to be in the -20^{0} C. range. This end will be blanketed to keep the STE-U cold.



Stereo Impact Boom

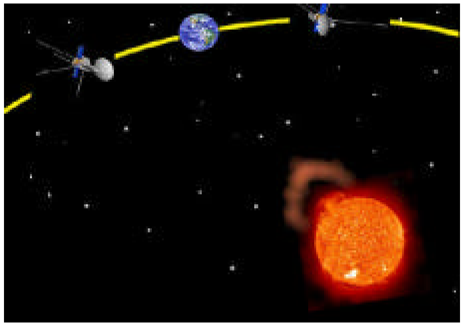
Peer Review Status

6 March 2001 Review

14	**133**	**IMPACT Boom**	Can the boom tube maintain the deployed frequency requirement under expected on-orbit thruster loads without the plungers? The Stacer (deployment force) may provide the required preload (at the end of deployment) to meet this requirement without the complication of the plungers and rails design. A boom frequency requirement should be incorporated into the Instrument Requirements Document. Also, an analysis should be performed to show that the boom design meets the given frequency requirement.	**Action Item / Open**
17	**136**	**IMPACT Boom**	Need to determine co-ax size to determine mechanism used for deployment.	**Action Item /Open**
20	**137**	**IMPACT Boom**	The current understanding is that there is a requirement for this that was provided in the original boom proposal and should be reflected in the design. My understanding is that the stiffness requirement for the IMPACT boom is 0.68 Hz, which matches the stiffness of the earlier proposed Astromast boom. Action to determine what the stiffness requirement is and include the requirement in the IRD.	**Action Item/ Open**

1 August 2001 Review

10		**IMPACT**	The thermal testing of the IMPACT booms should be performed at the boom deployment temperatures if possible.	**Action Item /Open**
18		**IMPACT**	Have the contamination control personnel verify that the composite boom material is usable.	**Action Item /Open**



Stereo Impact Boom

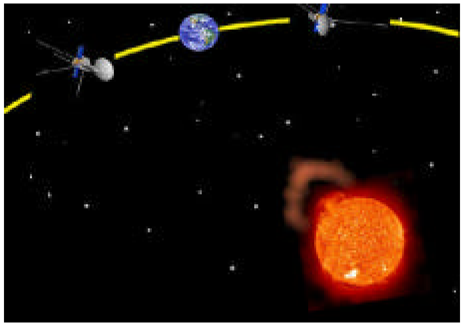
#133: The boom cannot meet the stiffness spec. without full locked deployment. The offset of the rollers provides a centering moment. Current range of moments: 0.04kg-m to 5kg-m. depending on deployment position, based on current spring values.

#136: See page 18.

#137: 0.68 is the calculated value for a 1 piece boom of carbon fiber. The value being held as a goal is 0.5Hz. The requirement is 0.3Hz. (from extendible longeron style boom).

#10: The thermal testing is being planned for nominal deployment temperatures, currently TBC at $+50^{0}$C / -40^{0}C. for Qualification and $+40^{0}$C for Acceptance.

#18: Contamination issues for the Gr/E boom: the sample is ready for inspection.



Stereo Impact Boom

Remaining Issues

Thermal data need to be fed back to optimize designs.

Structural properties need further analysis, testing. Keep APL updated with current design.

Summary

Final design imminent.

Thermal, structural requirements, and initial ICD have been established.

A prototype will be made and tested.

Details for all the different subsystems need to be integrated. The basic subsystems for the Impact boom have a long flight heritage, and are mature technologies: Stacers, GR/E structures, Shape Memory Alloy releases, all are iterations of proven designs. The integration into a telescoping boom is the next step.

Schedule is generous, no time constraints to impede forward progress.

STEREO IMPACT

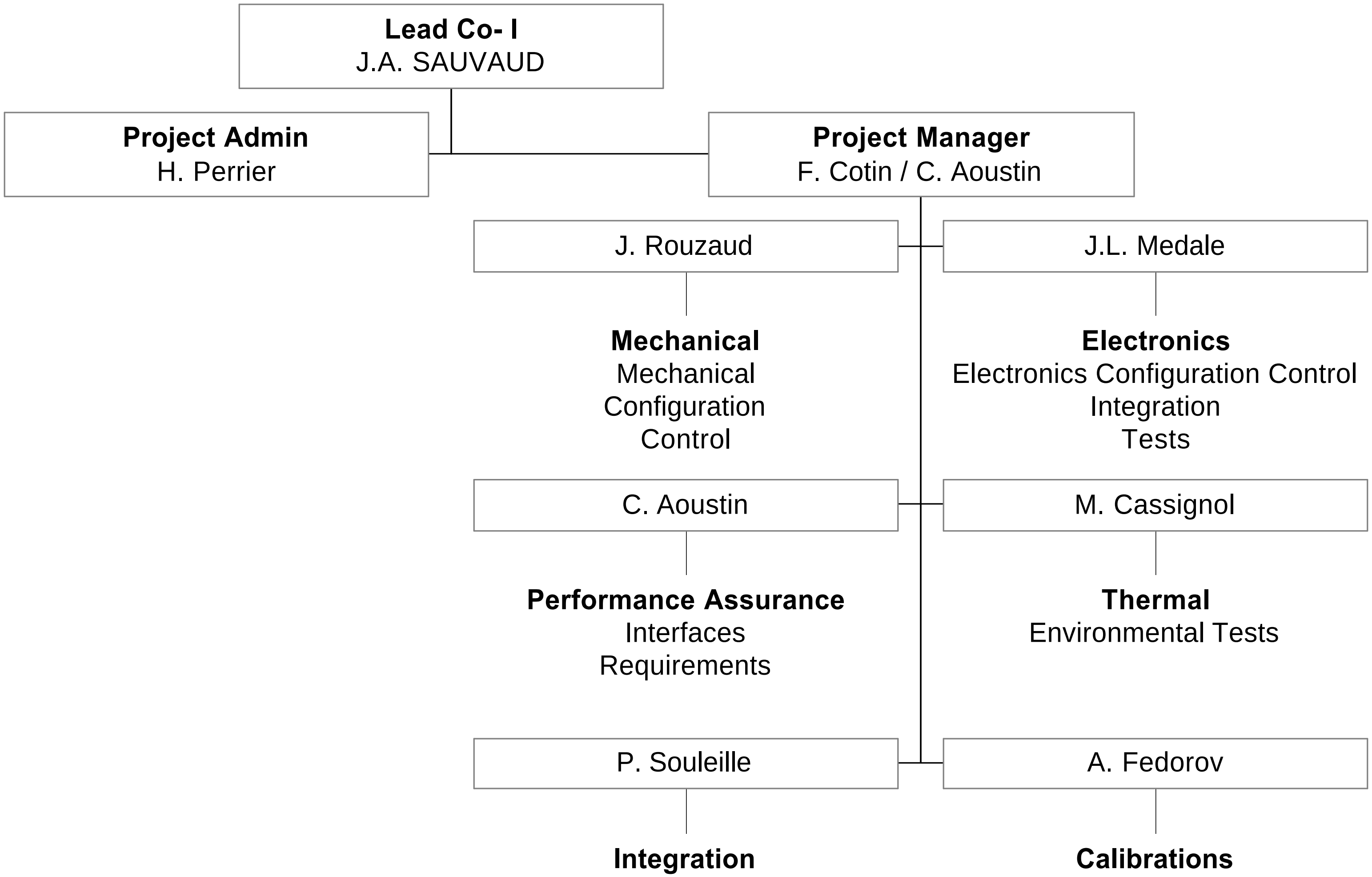
PRELIMINARY DESIGN REVIEW

SWEA (CESR PART)

Prepared by : J.A. Sauvaud
F. Cotin
J.L. Medale
J. Rouzaud
M. Cassignol
C. Aoustin

CESR – Centre d'Etude Spatiale des Rayonnements
9 Avenue du Colonel Roche – 31028 Toulouse Cedex France

SWEA DEVELOPMENT
PROJECT ORGANIZATION



MODEL PHILISOPHY

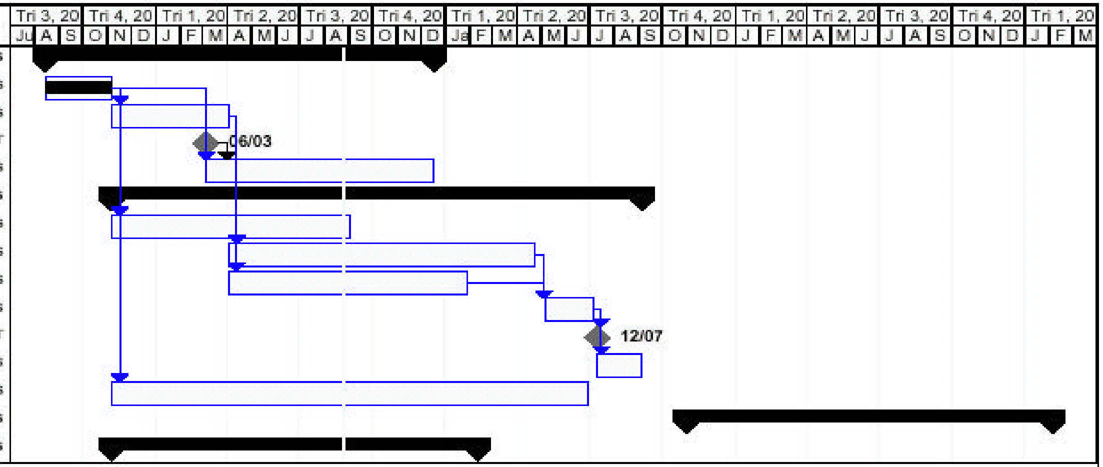
- TWO ELECTRICAL TEST UNITS – ETU – WILL BE ASSEMBLED
  - One complete
    - It will be used at CESR to prepare calibrations
  - One with a limited number of preamplifiers and without retractable cover
    - It will be delivered to UCB for interface test, software testing and UCB test setup checkout

- TWO FLIGHT MODELS

- SPARE PARTS

SCHEDULE

N°		Nom de la tâche	Durée
1		**SWEA Design**	**350 jours**
2	✓	Preliminary SWEA Design	12 sms
3		Detail Design	21 sms
4	✓	SWEA ICD Draft	0 jour
5		Final SWEA Design	41 sms
6		**SWEA ETU**	**478 jours**
7		ETU Parts Procure	43 sms
8		Analyzer ETU Fabricate	55 sms
9		Electronics ETU Fabricate	43 sms
10		SWEA ETU Assembly & Test	9 sms
11		ETU SWEA to UCB	0 jour
12		SWEA ETU Test	8 sms
13		SWEA Long Lead Parts	85,8 sms
14		**SWEA FM1, FM2, Spare**	**330 jours**
24		**GSE**	**330 jours**



Projet: IMPACT_MAG
Date: Ven 24/08/01 12:06

Tâche — Fractionnement — Avancement — Jalon — Récapitulative
Tâche reportée — Fractionnement reporté — Jalon reporté — Avancement reporté — Tâches externes
Récapitulatives du projet — Jalons externes — Échéance

Page 1

- Measure wide energy range 0 to 5000 eV with high spectral and angular resolution
- At low energy (≤20 eV) have the capability to :
  - Improve the nominal energy resolution
  - Reduce geometrical factor
- Field of view
  - 360° in a plane, combined with +/- 65° coverage in elevation out of plane
- Space resolution : 22,5 degrees x 22,5 degrees
- Geometric factor 0,01 cm^2 ster E (eV)
- Maximum count rate (per 22,5 degree sector) : 1.10^6 counts/sec
- One complete sequence of measurements in 2 sec
- Low power, weight

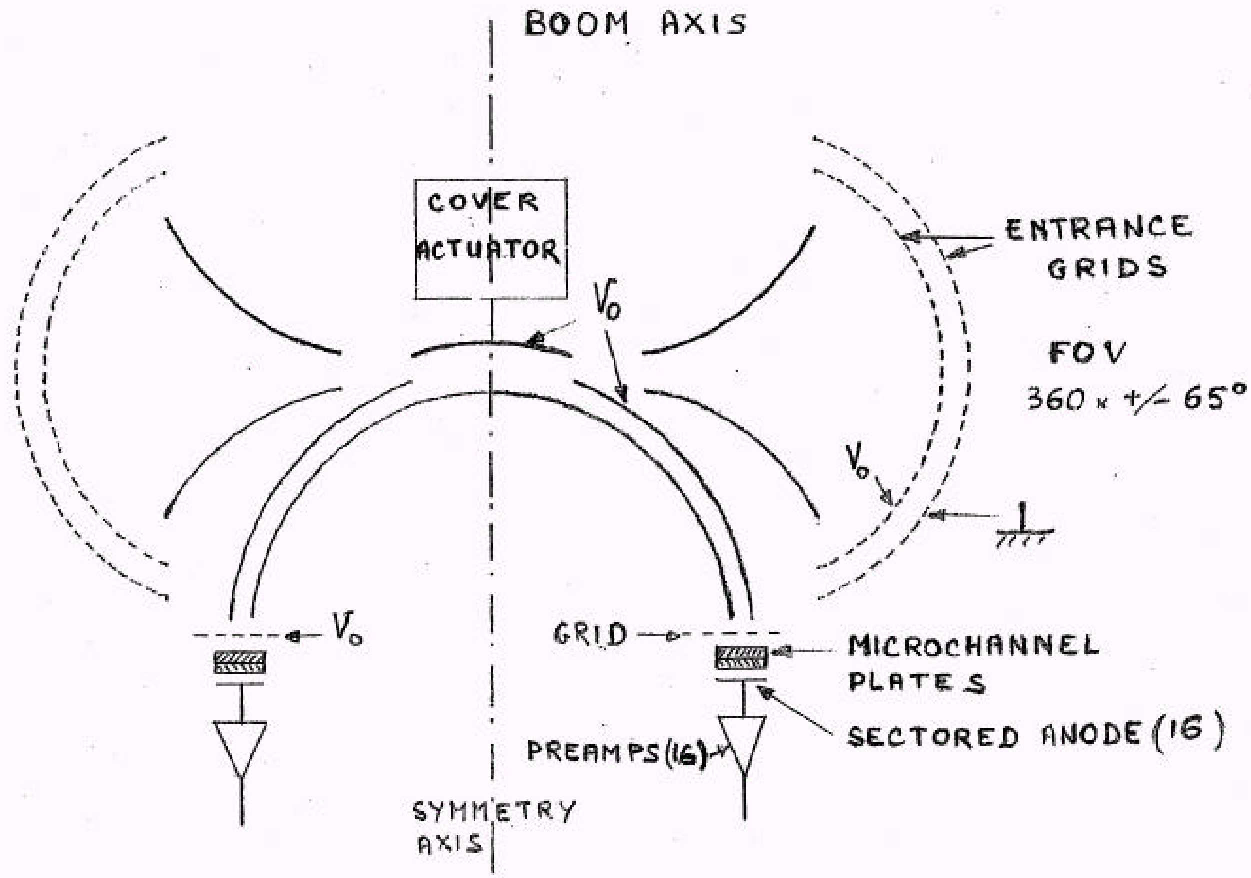
- Stereo impact
  - Performance specifications Vers D 2001-Jul-09
- Stereo impact
  - SWEA UCB to CESR Interface Control Document Vers C 2001-Jun-05
- Stereo impact
  - Harness specification Vers C 2001-Aug-01
- Grounding Diagram Rev D 2001-July-30
- Stereo impact
  - Performance Assurance Implementation Plan Vers B 2001-Jun-25
- Stereo
  - Contamination Control Plan Rev B 7381-904C
- Stereo
  - Environnment Definition, Observatory,Component
  - and Instrument Test Requirements Document Rev D 7381-9003
- EMC
  - Guidelines for the STEREO Instruments 24-jan-00

- One electrostatic optics made of :
  - An ElectroStatic « top-hat » Analyzer (ESA), 360° field of view, with outer hemisphere at allowed variable potential Vo
  - 2 deflectors in front of analyzer entrance
  - 2 toroidal grids :
    - outer one at spacecraft ground
    - inner one at Vo potential

electrons from a selected energy and one elevation angle are focused on :

- Microchannel plate detector – two rings
- 16 sectors anode to provide 22,5° resolution in azimuth
- A retractable cover

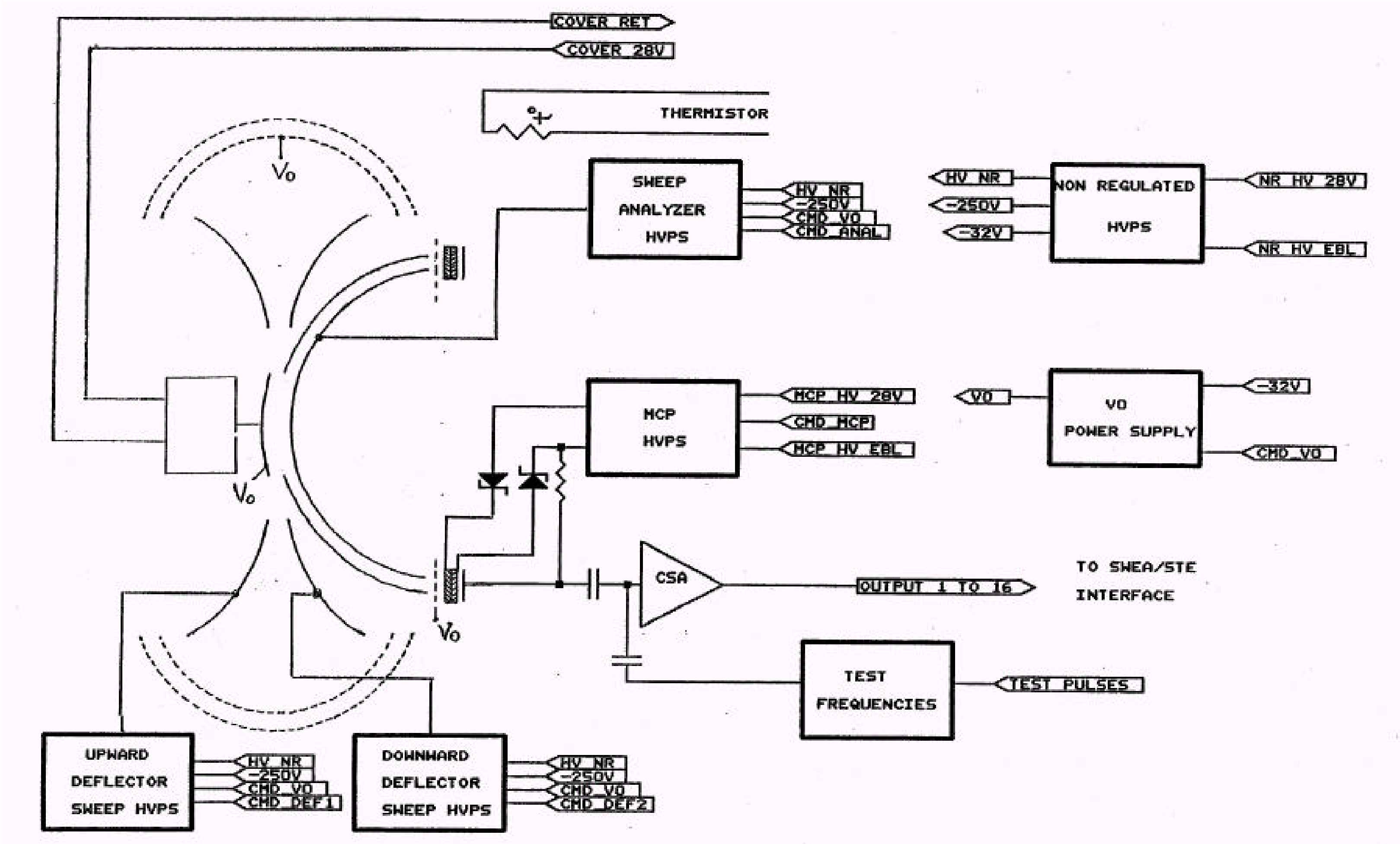
SCHEMA OF ELECTRON ANALYZER



SWEA FRONT-END ELECTRONICS DESCRIPTION

- 16 charge sensitive preamplifiers (CSP) and discriminators
- One non regulated High Voltage Power Supply (HVPS) that supply :
- 3 High Voltages Amplifiers (HVA) programmed by analog voltage levels
  - Must have a wide dynamic range (O to + 1500 volts)
  - Must track together well
  - Have fast rise time and fall time (1 kV/300 µsec)
  - Analyzer : HVA (0 to + 750 volts) deflector 1 or 2 : HVA (- 25 to + 1500 volts)
- One programmable power supply (Vo : 0 to – 25 volts)
- One regulated HVPS for MCP (0 to + 3500 volts)
- Anodes and preamplifiers closely coupled

SWEA FRONT END BLOCK DIAGRAM



- Top-hat analyzer parameters are :
  - $R_{out} =$ 40,3mm $R_{in} =$ 37,5 mm   ? R/R_{in} = 0,075
  - Energy to analyzer voltage ratio   T/qV   k = 7
  - Energy resolution   ? ≅ 10 %
- With 50 logarithmic energy steps between E_0 = 1eV and E_{49} = 5000eV
  - ΔE/E ≅ 0,173   and V_{max} = 714 Volts
    V_{min} = 0,14 Volt
- By applying a Vo potential to the inner toroidal grid and the outer hemisphere of the analyzer we can :
  - Reduce the geometric factor by a factor of $[1 + Vo/k (Vo-V)]^2$
  - Improve the energy resolution by a factor of [1 + Vo/k (Vo-V)]
- This improvement at low energy will be obtained if high voltages and Vo potential are precise and stables

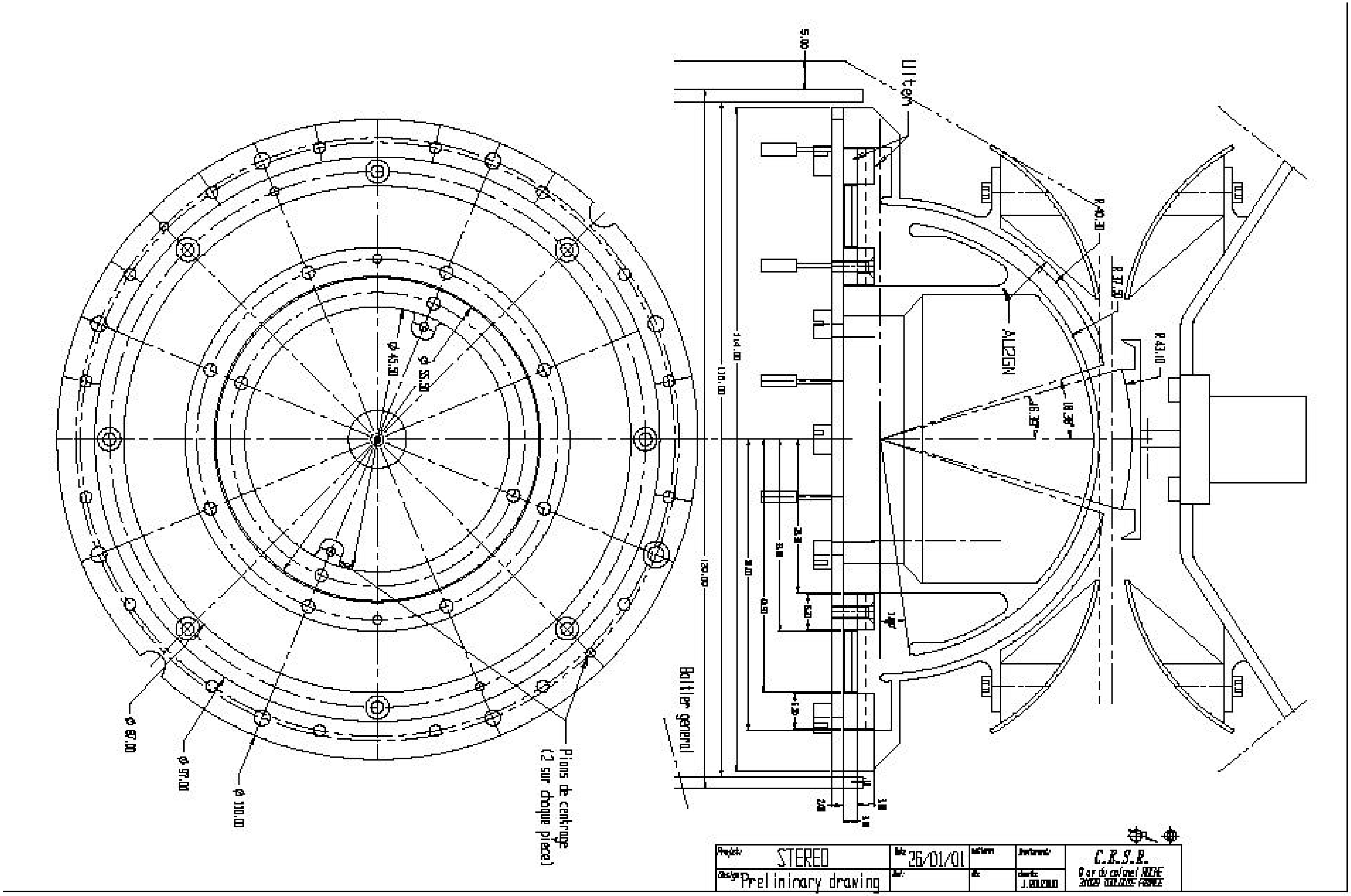
- Top hat analyzer
  - Manufactured with the standard process (scalloping)
  - Inside surfaces of analyzer covered with black conducting coating
- Deflectors
  - Simulations of particle collection shows dissymetry between positive and negative elevation
  - Manufactured in ULTEM and recovered with gold
- MPC
  - Two complete rings stacked with 50 µm space between them
  - Mounting on board with all high voltage coupling components
  - One grid in front at Vo potential and entrance of MCP at + 300 volts
- Grids
  - Each surface obtained with 4 sectors
  - One support structure in AU2GN with 8 ribs
- Retractable cover : actuated with shape memory alloy pinpuller

Top-hat analyzer has nearly identical geometry as the one flying in HIA Cluster Instrument

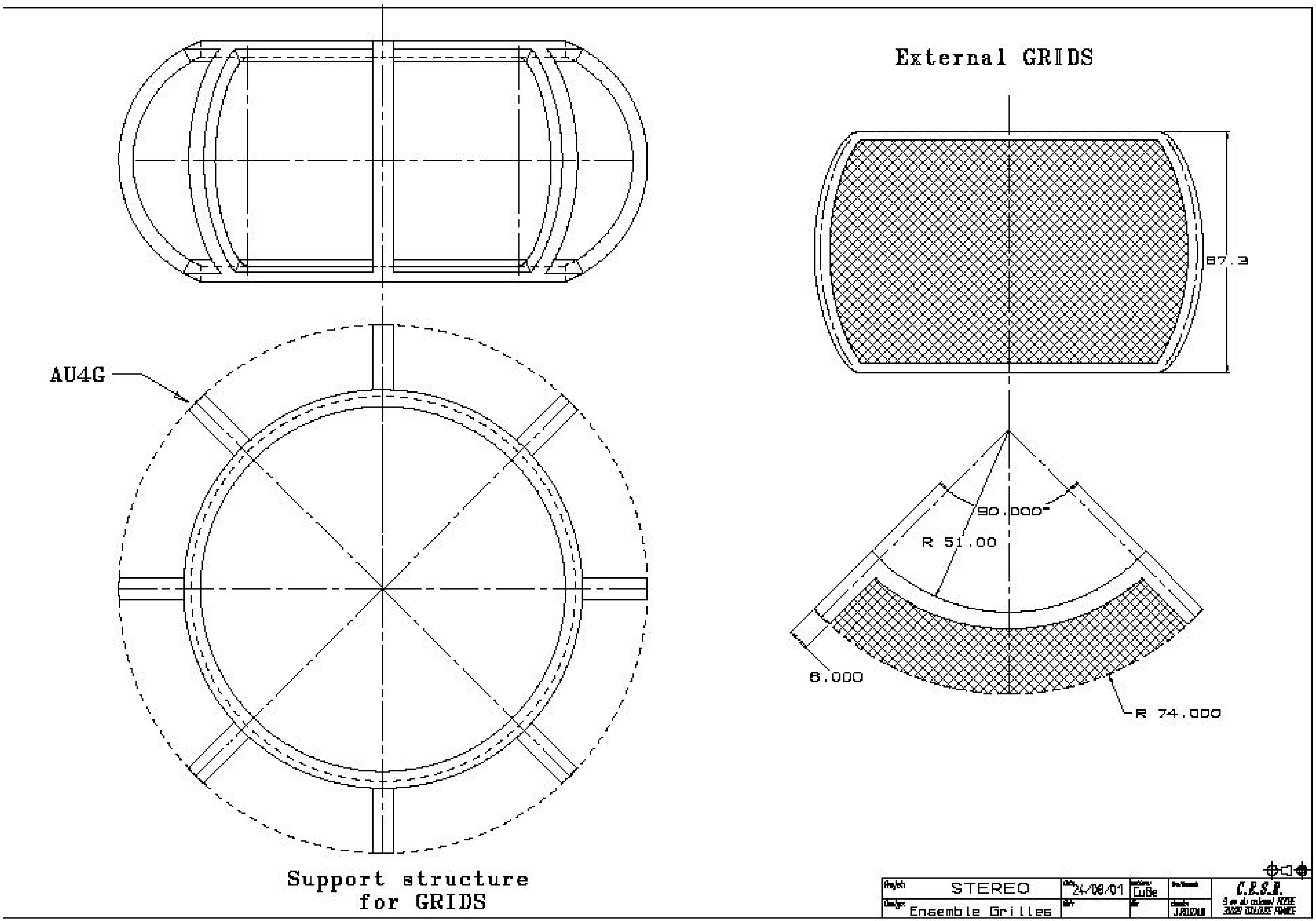
MCP are identical to GIOTTO-RPA one and other space instruments (Wind,…)

Deflectors and grids are modified version of MGS Instrument

ANALYZER DESIGN (3/4)

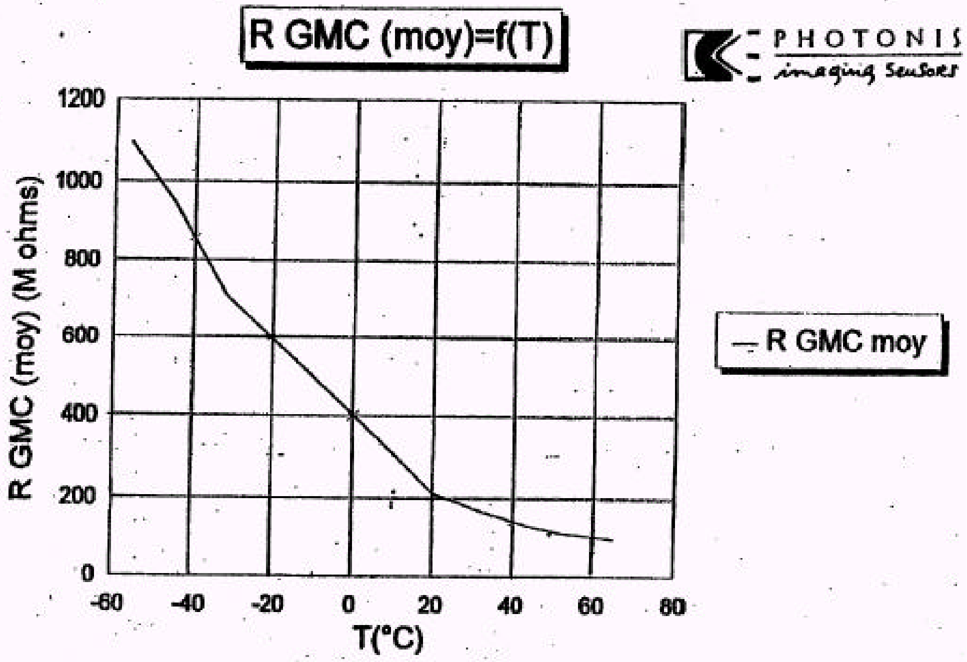


ANALYZER DESIGN (4/4)



**SPECIFICATIONS
(CLUSTER TYPE)**

OUTER DIAM :	**87 ± 0,2 MM**
INNER DIAM :	**66 ± 0,2 MM**
THICKNESS :	**1 ± 0,2 MM**
MICROCHANNEL	
DIAMETER :	**12,5 MICRONS**
ANGLE :	**8°**
METALLISATION :	**N_I - C_R**
A SET OF TWO RINGS	
R_{TOT} =	**30 TO 45 MΩ**
(AT R.T.)	



FRONT-END ELECTRONICS DESIGN (1/3)

- Charge sensitive preamplifier-discriminator : A – 111 F AMPTEK
  - Threshold adjustable during calibrations between 5. 10^4 and 5.10^5 electrons
  - Pulse width : 260 to 310 us
  - Maximum count rate : 2.5 10^6 CPS (periodic)
- Test input with capacitor designed on the printed circuit
- Test pulses delivered by a counter, driven by a programmable frequency up to 1 MHZ
- Preliminary lay-out of preamplifier board made
- Manufacturing specifications ready

FRONT-END ELECTRONICS DESIGN (2/3)

- High Voltage Power Supply for MCP
  - Range : 0 to + 3500 volts
  - Command : analog voltage 0 to - 5 volts
  - on/off by enable command
  - + 28 V supply routed via the enable plug
  - Housekeeping :analog voltage 0 to + 5 volts
- Breadboard mounted and tested
  - With various loads simulating MCP
  - With temperature range +30°C, -80°C

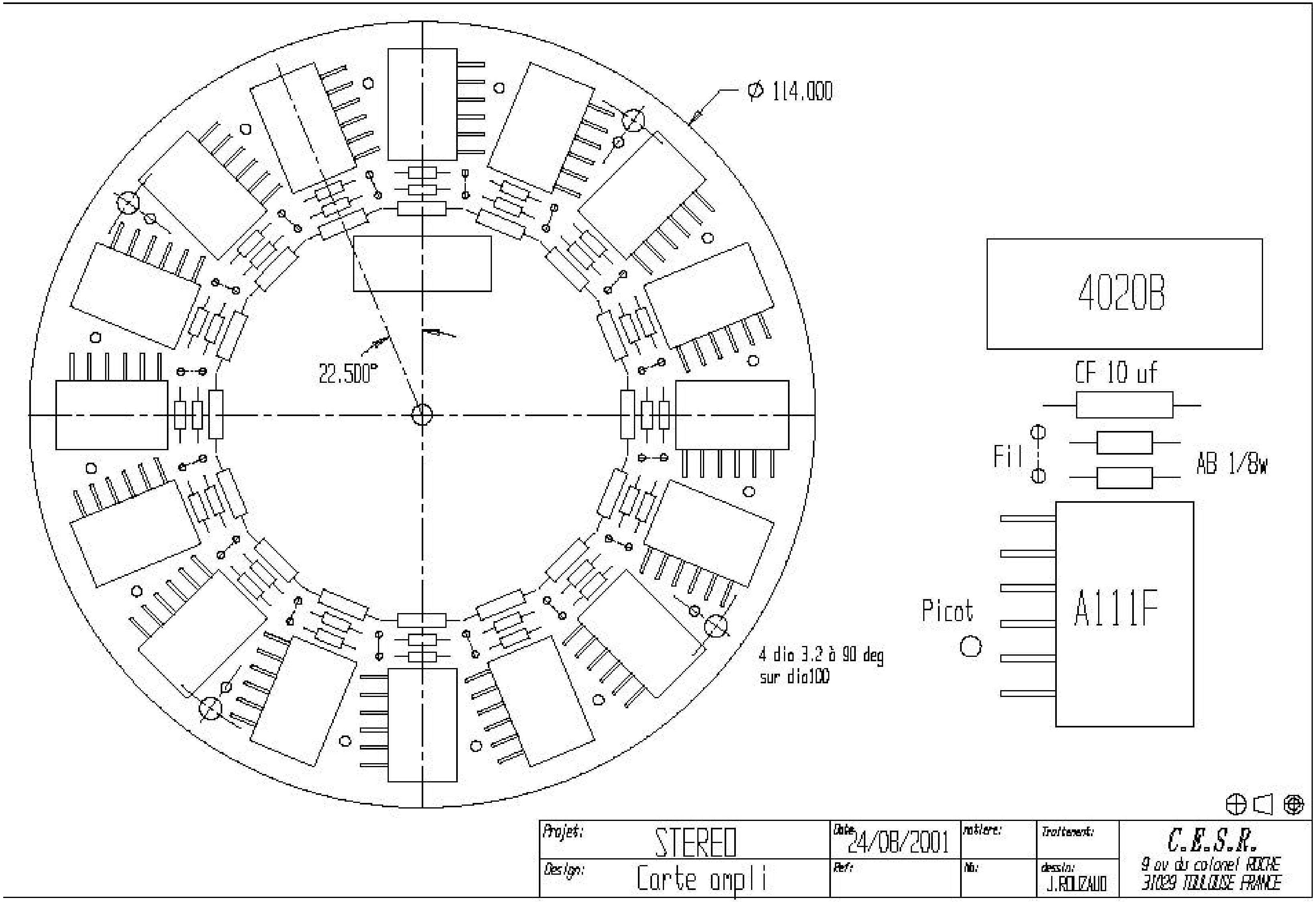
High Voltage Power Supply for analyzer and deflectors

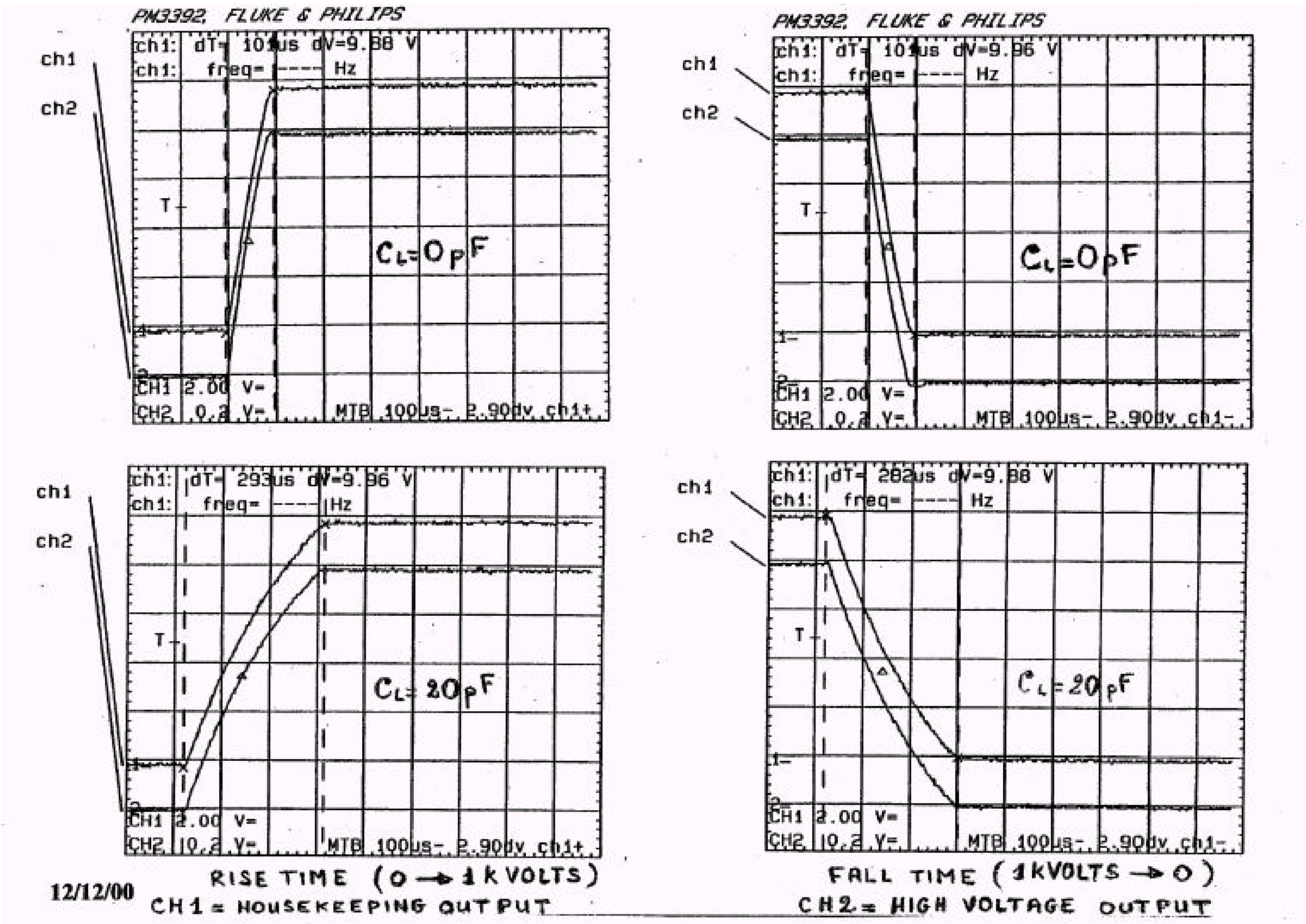
- One non regulated power supply generating all voltages required by the high voltage amplifiers (+1700V, -250V, -5VNR, +5VNR, -32V)
  - On/off by enable command
  - Housekeeping : analog voltage 0 to + 5 volts
  - + 28 V supply routed bia the enable plug

- 3 High Voltage Amplifiers made with high voltage optocouplers developped at CESR
  - Command analog voltage 0 to –5 volts
  - Housekeeping : analog voltage –50mV to +5 volts
  - Current transfer ratio > 0,5 %
  - 3 kV isolation voltage
  - Slew rate ≥ 1 kV/300 µsec (20 pF Load)

- Evaluation with different Op. Amp.in order to obtain best accuracy and stability
  - LT 1024 selected

PREAMPLIFIER BOARD




PM3392 FLUKE & PHILIPS
ch1
ch2
ch1: dT= 101us dV=9.88 V
ch1: freq= ---- Hz
CH1 2.00 V=
CH2 0.2 V=
MTB 100us- 2.90dv ch1+
C_L=0pF
ch1: dT= 101us dV=9.96 V
MTB 100us- 2.90dv ch1-
ch1: dT= 293us dV=9.96 V
C_L=20pF
ch1: dT= 282us dV=9.88 V
12/12/00
RISE TIME (0 → 1 k VOLTS)
FALL TIME (1 kVOLTS → 0)
CH1 = HOUSEKEEPING OUTPUT
CH2 = HIGH VOLTAGE OUTPUT

SWEA MECHANICAL DESIGN APPROACH AND FEATURES

- **SWEA is composed of an electrostatic optics, 3 electronics boards, one housing**
- **Packaging design approach is based on having :**
  - The electrostatic analyzer mounted on the MPC Board
  - The 3 electronics board mechanically assembled together and with feedthrough contacts for electrical connections
  - Grid structure is mounted on the housing and support upward deflector, cover and cover actuator
- **Connection with the interface board (UCB) with a pig-tail connector (micro-D 51 pin)**
- **Electrical cables routed to the top of the instrument through two ribs of the grid structure** (cover + 28V, cover Ret, deflector 1 voltage)

  Vo will be distributed to the cover via the inner grid
- **Purging tube is going through holes at the center of electronic boards to the MCP isolated between mounting board and outer hemisphere of the analyzer**
- **Venting by small holes at the base of the analyzer**

THERMAL DESIGN APPROACH AND FEATURES 1/2

- In normal operation instrument will be in the shade
- Temperature will be programmed to a set point with the help of an operational heater controlled by software
- In no operating mode, SWEA is provided with 1,00 watt (TBC) through a thermostatically controlled heater
- Temperature dependant of mean value of S for the detector aperture and thermal conduction with the boom
- Due to the relative complexity of this aperture (2 toroidal grids with large transparency, shape of deflector), mean S was estimated between 0,05 and 0,15

THERMAL DESIGN APPROACH AND FEATURES 2/2

- Detail analysis in progress with :
  - New value for the power dissipation (1,47 watts)
  - Conductance to boom 0,013 W/K Boom temperature : -90°C
  - Grids golded (?=0,03) and KAPTON MLI (?=0,025, α=0,016)
  - Solar thermal constant : 1068 w/m^2 , 1366,5 w/m^2 , 1769 w/m^2

  Preliminary results are :

  In operating mode T = 238 K

  Non operating mode

  back illuminated T = 249 K to 256 K
  lateral illuminated T = 294 K to 315 K

- Need test to validate a model
- One sensor will monitor temperature of the MCP

MASS ALLOCATION AND STATUS

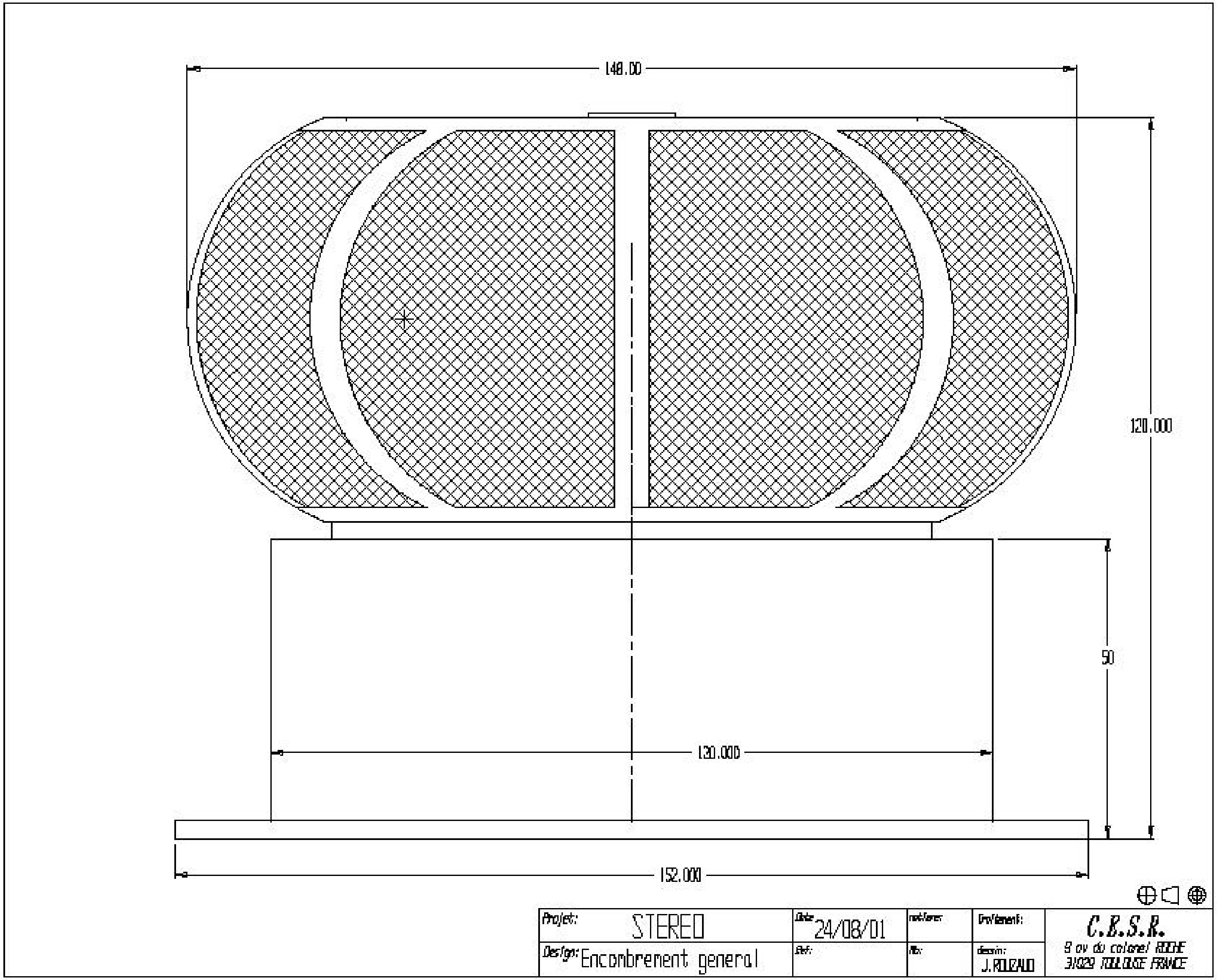
SUB SYSTEM	ESTIMATE	ALLOCATION
Analyzer deflectors, Grids and top structure	440	1 210 g
Retractable cover and actuator	30	
MCP board	200	
Preamplifier board	100	
HVPS board	150	
Mechanical housing	230	
Connector, cabling…	60	
Total	1 210 g	

Thermal blanket
Heaters and thermoswitches

SUBSYSTEM	PHASE A (mW)	CURRENT (mW)	TEST CONDITIONS
Preamplifiers dis.	100	100	
HVPS MCP	250	211 – 230	Vs = 2500 V R = 50MO
HVPS analyzer	100	45 min 102 max	C_L = 20pF
HVPS deflectors	60	40 min 140 max	
Vo polarisation	30	50	
Total	540	446 min 662 max	

Allocation 540 mW

SWEA SIZE


148.00
120.000
50
120.000
152.000
Projet: STEREO
Date 24/08/01
Design: Encombrement general
C.E.S.R.
J.ROUZAUD

- Small experienced group : P.A integrated into the engineering tasks
- PAP (ref : SWEA-AP-0044-CESR) describes the way that the intent of PAR will be met within the constraints of budget and as makes sense for a small group
- Hardware development and fabrication work will be performed using CNES and ESA standard PA/QA procedures
- PA organization
  - Lead by PM/PAM F. Cotin/C. Aoustin assisted by CNES
  - EEE Parts J.L. Medale
  - MMP J. Rouzaud
- Reliability
  - Instrument designed to permit ease of assembly, test, within contraints of mass and power
  - All designs are internally reviewed before release and manufacturing agreement
  - Design checked to satisfy derating levels under worst case condition

- No exposed high voltages

CONTAMINATION CONTROL

- MCP are extremely sensitive to contamination from air condensables, humidity and particulates
- Detector to be protected through launch by sealing analyzer in a dry nitrogen atmosphere with in-flight retractable cover
- Material selection inside of sealed system to be carefully controlled
- In addition SWEA will have a non-flight cover to improve contamination resistance and protect delicate grids
- SWEA will have attachment for permanent purging
- Purging with dry Nitrogen (boil-off) : 5 liters/hour
- Few-hours interruption in the purge flow is acceptable in clean environment

- Preliminary components list prepared
  - Ref : SWEA-AP-0048-CESR
- All parts purchases by CESR
- Most of the parts purchased to specification SCC Level C equivalent to :

– Class B	MIL	M 38510	Integrated circuits
– JANTXV	MIL	S 19500	Active components
– LEVEL	R	MIL ER	Passive components

- When purchased at lower level, tests for upgrading will be performed by a specialized company in Toulouse – HIREX – (LT 1024 for example)

MATERIALS, MECHANICAL PARTS AND PROCESSES

- Preliminary declared materials list and declared processes list prepared
  - Ref : SWEA-AP-0050-CESR and SWEA-AP-0049-CESR

- Mechanical pieces (electrostatic optics and housing)
  - Preliminary study prepared by CESR
  - Detail manufacturing drawings, machining of all pieces, surface treatment subcontracted to a company in Toulouse - COMAT – working for space instrumentation

    Grids will be manufactured by CORIMA
  - Integration at COMAT facilities with CESR collaboration

- Electronics boards
  - Detail schemas prepared by CESR
  - Lay-out of printed boards, components soldering subcontracted to a company in Toulouse – MICROTEC – working for space instrumentation
  - Printed boards manufactured by SYSTRONICS at space level
  - Integration of MCP on detection board at CESR
  - Electrical tests, vacuum tests at board level and assembly at CESR

SWEA (CESR) VERIFICATION MATRIX

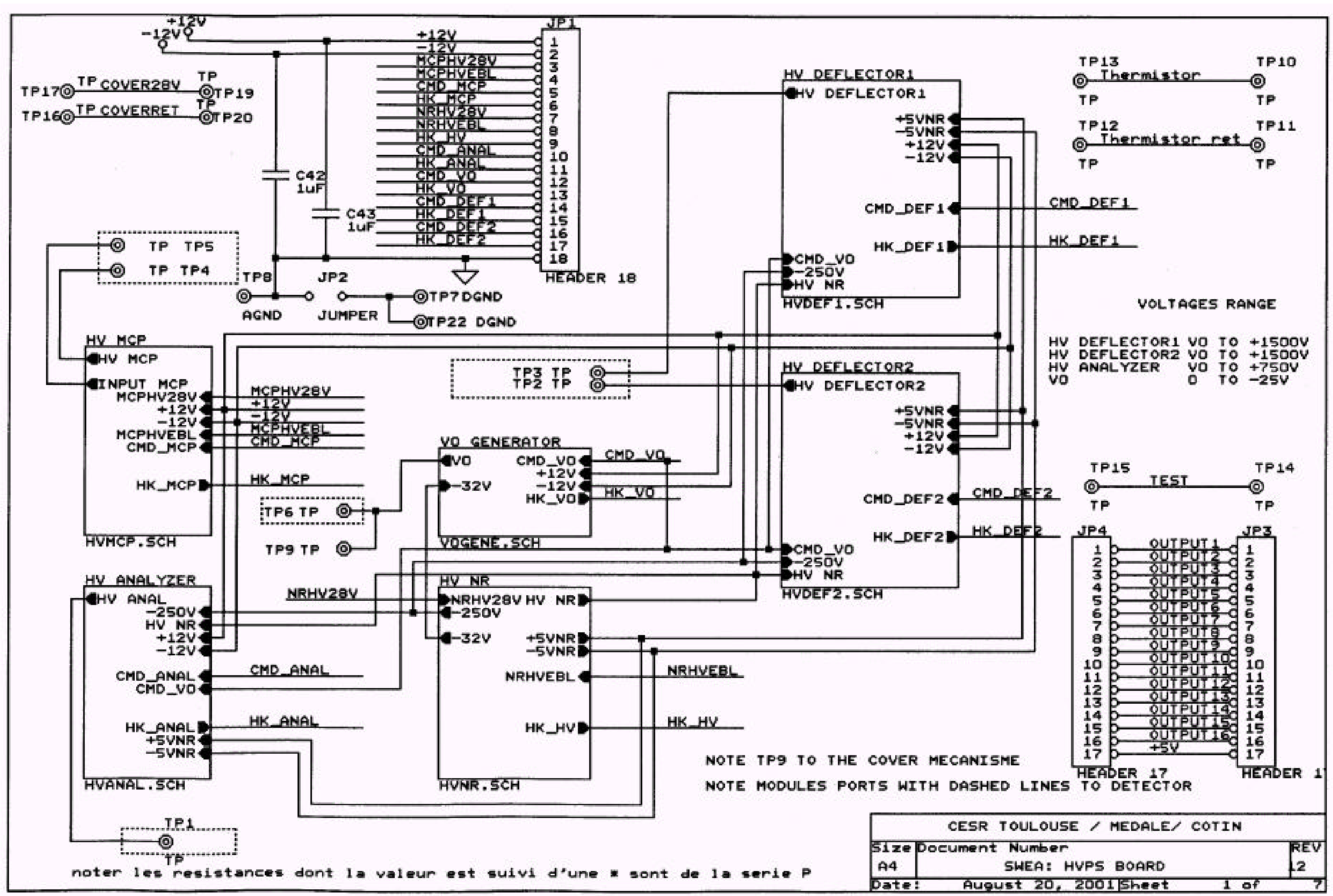
HARDWARE DESCRIPTION	TEST	ETU	FM	SPARE
1/ **Component Level**				
MCP	Gain		x	x
Preamplifier	Threshold		x	x
	Dead Time		x	x
Optocouplers	Current transfer ratio	x	x	x
2/ **Subsystem Level**				
Preampli – board	Electrical tests (gain, threshold)	x	x	x
HVPS board	Electrical tests	x	x	x
	Thermal tests	x	x	x
All boards (3)	Bake-out	x	x	x
3/ **Instrument**	Vibrations	x	(*)	
	Electrical tests	x	x	x
(*) Environmental tests on complete unit at UCB	Gain and noise tests (in vacuum)	x	x	x
	Beam calibration	x	x	x
	Interface verification	x	x	x
	Thermal balance	x	(*)	
	Thermal test in vacuum	x	X	x

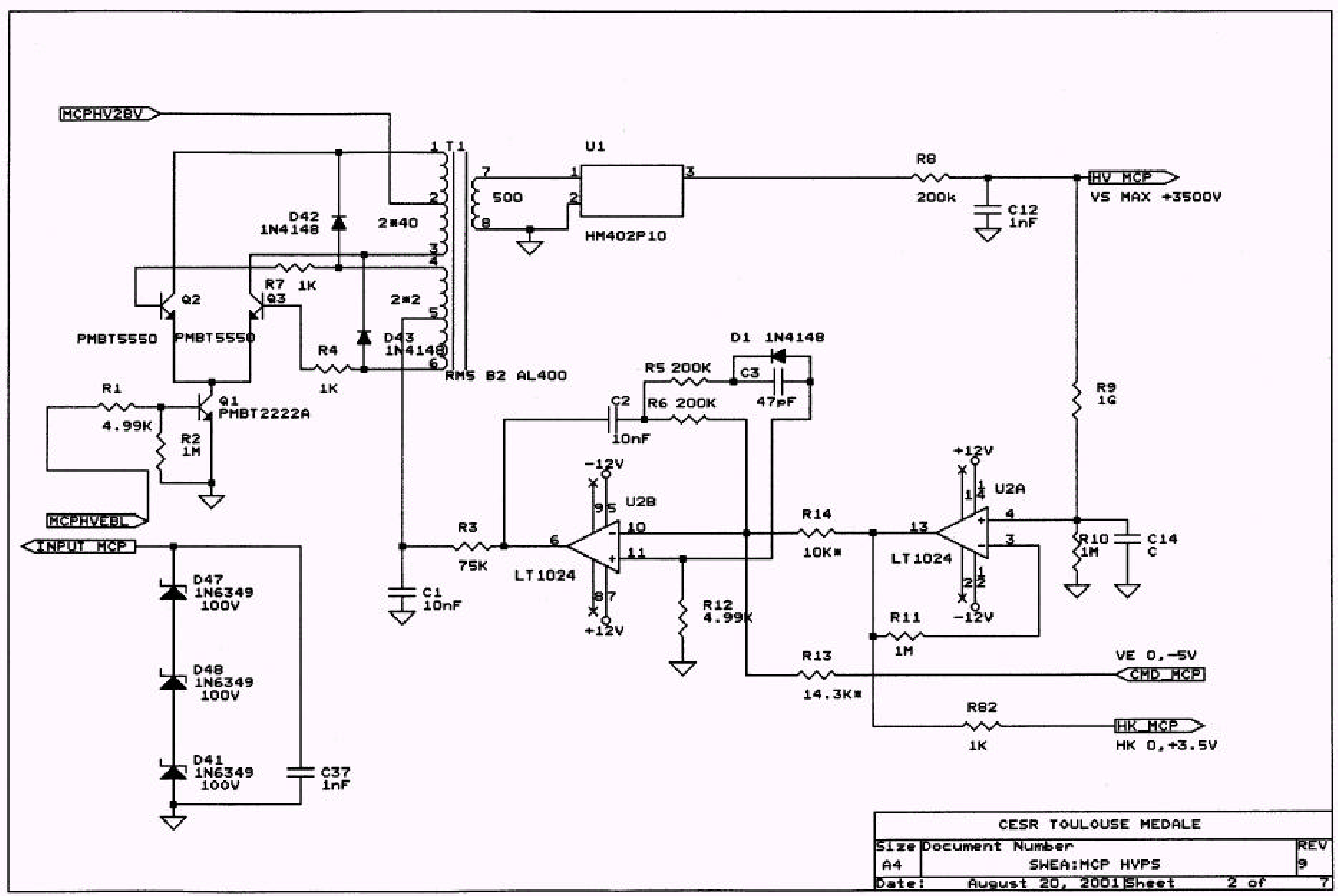
VERIFICATION PLAN

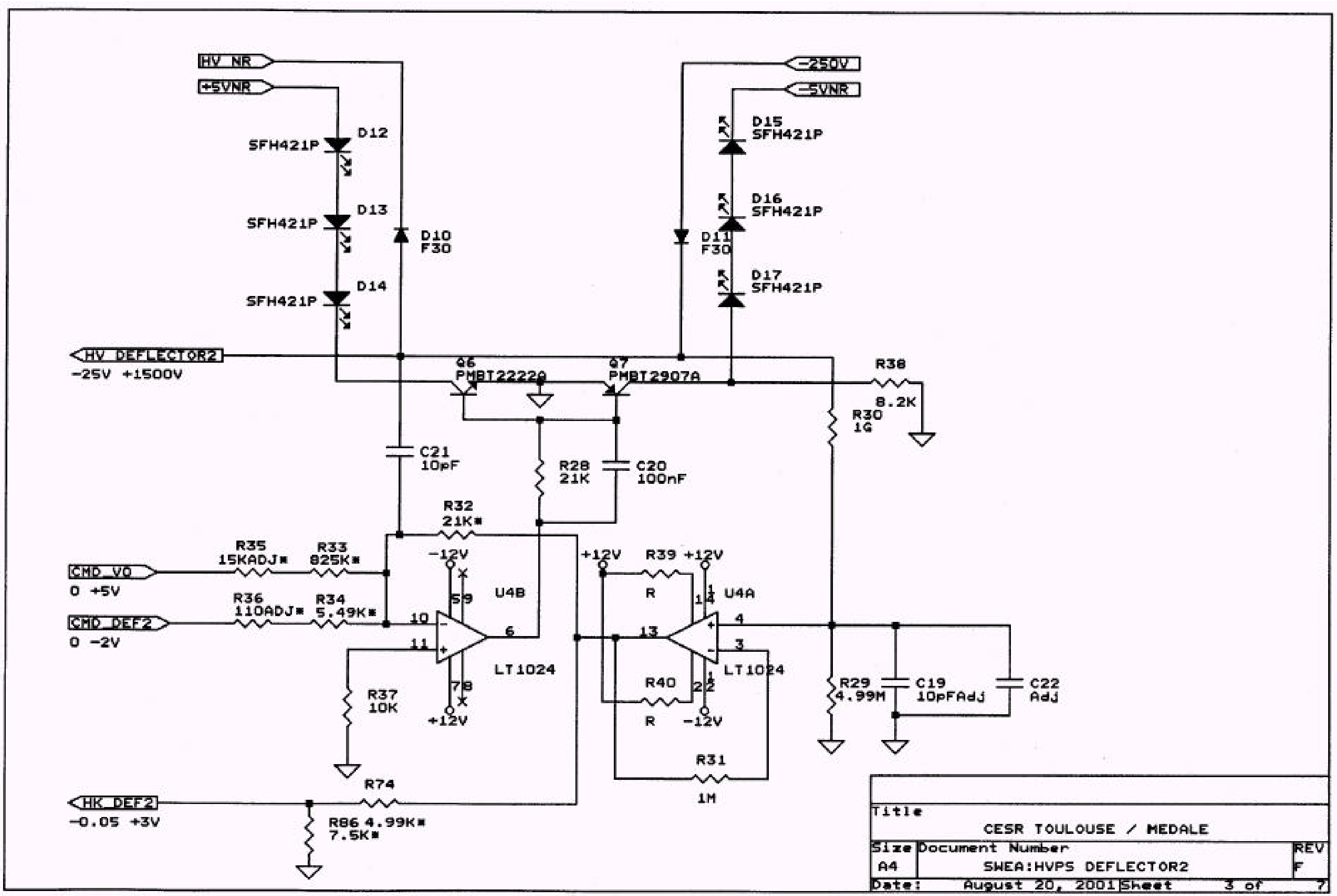
- Boards testing limited to electrical functional tests and thermal calibrations
- Remaining tests performed at the instrument level as appropriate
- Vacuum test to be performed at CESR as part of preliminary calibrations
- Thermal/vacuum, vibrations, EMC/EMI will be performed at UCB
- At component level
  - Microchannel plates : gain uniformity, channel bias angle effects
  - Preamplifiers : threshold sensitivity, dead time
  - High voltage power supplies : sweep, rise an fall times, accuracy, stability
- At subsystem level
  - Energy-angle response without and with deflection at high energy
  - Interface to SWEA/STE interface

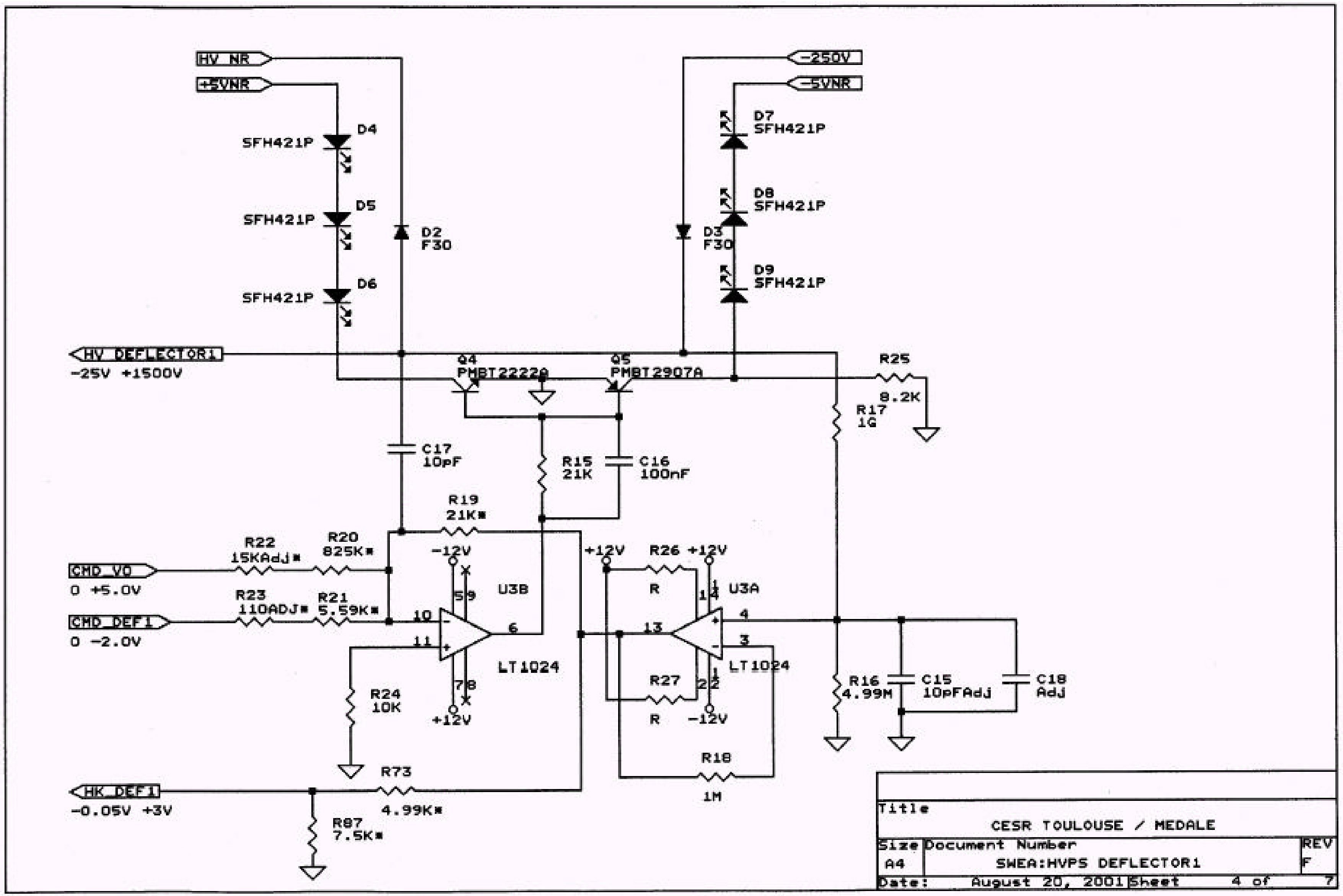
CONCERNS/PLANNED RESOLUTIONS TECHNICAL RISK IDENTIFICATION CRITICALITY

ITEM	CRITICALITY	ACTION
• Weight	Minor	Detail design action
• Grids manufacturing	Major	Other manufacturer identified – contact will be established
• Grid transparency	Minor	Trade off between structural rigidity and transparency
• Cover actuator	Minor	Obtain detail information with help of UCB
• Deflector shape	Minor	Detail design action
• Thermal	Major	Detail design action Test on a breadboard


JP1
+12V
-12V
MCPHV28V
MCPHVEBL
CMD_MCP
HK_MCP
NRHV28V
NRHVEBL
HK_HV
CMD_ANAL
HK_ANAL
CMD_VO
HK_VO
CMD_DEF1
HK_DEF1
CMD_DEF2
HK_DEF2
HEADER 18
TP17
TP COVER28V
TP19
TP16
TP COVERRET
TP20
C42 1uF
C43 1uF
TP TP5
TP TP4
TP8
JP2
AGND
JUMPER
TP7 DGND
TP22 DGND
HV DEFLECTOR1
+5VNR
-5VNR
+12V
-12V
CMD_DEF1
HK_DEF1
CMD_VO
-250V
HV NR
HVDEF1.SCH
TP13
Thermistor
TP10
TP12
Thermistor ret
TP11
VOLTAGES RANGE
HV DEFLECTOR1 VO TO +1500V
HV DEFLECTOR2 VO TO +1500V
HV ANALYZER VO TO +750V
VO 0 TO -25V
HV MCP
INPUT MCP
MCPHV28V
MCPHVEBL
CMD_MCP
HK_MCP
HVMCP.SCH
TP3 TP
TP2 TP
HV DEFLECTOR2
CMD_DEF2
HK_DEF2
HVDEF2.SCH
VO GENERATOR
VO
-32V
CMD_VO
HK_VO
VOGENE.SCH
TP6 TP
TP9 TP
TP15
TEST
TP14
JP4
JP3
OUTPUT1
OUTPUT16
+5V
HEADER 17
HV ANALYZER
HV ANAL
-250V
HV NR
CMD_ANAL
CMD_VO
HK_ANAL
+5VNR
-5VNR
HVANAL.SCH
NRHV28V
HV NR
NRHV28V
-250V
-32V
NRHVEBL
HK_HV
HVNR.SCH
NOTE TP9 TO THE COVER MECANISME
NOTE MODULES PORTS WITH DASHED LINES TO DETECTOR
TP1
TP
noter les resistances dont la valeur est suivi d'une * sont de la serie P
CESR TOULOUSE / MEDALE/ COTIN
Size
A4
Document Number
SWEA: HVPS BOARD
REV
2
Date: August 20, 2001
Sheet 1 of 7


MCPHV28V
T1
1
2
3
4
5
6
7
8
2*40
2*2
500
RM5 B2 AL400
U1
HM402P10
D42
1N4148
D43
1N4148
R7 1K
Q2
Q3
PMBT5550
PMBT5550
R4
1K
R1
4.99K
Q1
PMBT2222A
R2
1M
MCPHVEBL
INPUT MCP
D47
1N6349
100V
D48
1N6349
100V
D41
1N6349
100V
C37
1nF
R8
200k
C12
1nF
HV MCP
VS MAX +3500V
R9
1G
D1 1N4148
R5 200K
C3
47pF
C2
10nF
R6 200K
R3
75K
C1
10nF
-12V
+12V
U2B
LT1024
R12
4.99K
R14
10K*
U2A
LT1024
R10
1M
C14
C
R11
1M
R13
14.3K*
VE 0,-5V
CMD_MCP
R82
1K
HK_MCP
HK 0,+3.5V
CESR TOULOUSE MEDALE
Size
A4
Document Number
SWEA:MCP HVPS
REV
9
Date: August 20, 2001
Sheet 2 of 7


HV_NR
+5VNR
-250V
-5VNR
D12
SFH421P
D13
SFH421P
D14
SFH421P
D10
F30
D11
F30
D15
SFH421P
D16
SFH421P
D17
SFH421P
HV_DEFLECTOR2
-25V +1500V
Q6
PMBT2222A
Q7
PMBT2907A
R38
8.2K
R30
1G
C21
10pF
R28
21K
C20
100nF
R32
21K*
R35
15KADJ*
R33
825K*
CMD_V0
0 +5V
R36
110ADJ*
R34
5.49K*
CMD_DEF2
0 -2V
-12V
U4B
LT1024
+12V
R37
10K
+12V
R39
R
U4A
LT1024
R40
R
-12V
R31
1M
R29
4.99M
C19
10pFAdj
C22
Adj
R74
HK_DEF2
-0.05 +3V
R86 4.99K*
7.5K*
Title
CESR TOULOUSE / MEDALE
Size
A4
Document Number
SWEA:HVPS DEFLECTOR2
REV
F
Date: August 20, 2001
Sheet 3 of 7


HV_NR
+5VNR
-250V
-5VNR
D4 SFH421P
D5 SFH421P
D6 SFH421P
D2 F30
D3 F30
D7 SFH421P
D8 SFH421P
D9 SFH421P
HV_DEFLECTOR1
-25V +1500V
Q4 PMBT2222A
Q5 PMBT2907A
R25 8.2K
R17 1G
C17 10pF
R15 21K
C16 100nF
R19 21K*
R22 15KAdj*
R20 825K*
CMD_VD
0 +5.0V
R23 110ADJ*
R21 5.59K*
CMD_DEF1
0 -2.0V
-12V
+12V
U3B
LT1024
R24 10K
R26 R
R27 R
U3A
LT1024
R18 1M
R16 4.99M
C15 10pFAdj
C18 Adj
HK_DEF1
-0.05V +3V
R73 4.99K*
R87 7.5K*
Title
CESR TOULOUSE / MEDALE
Size
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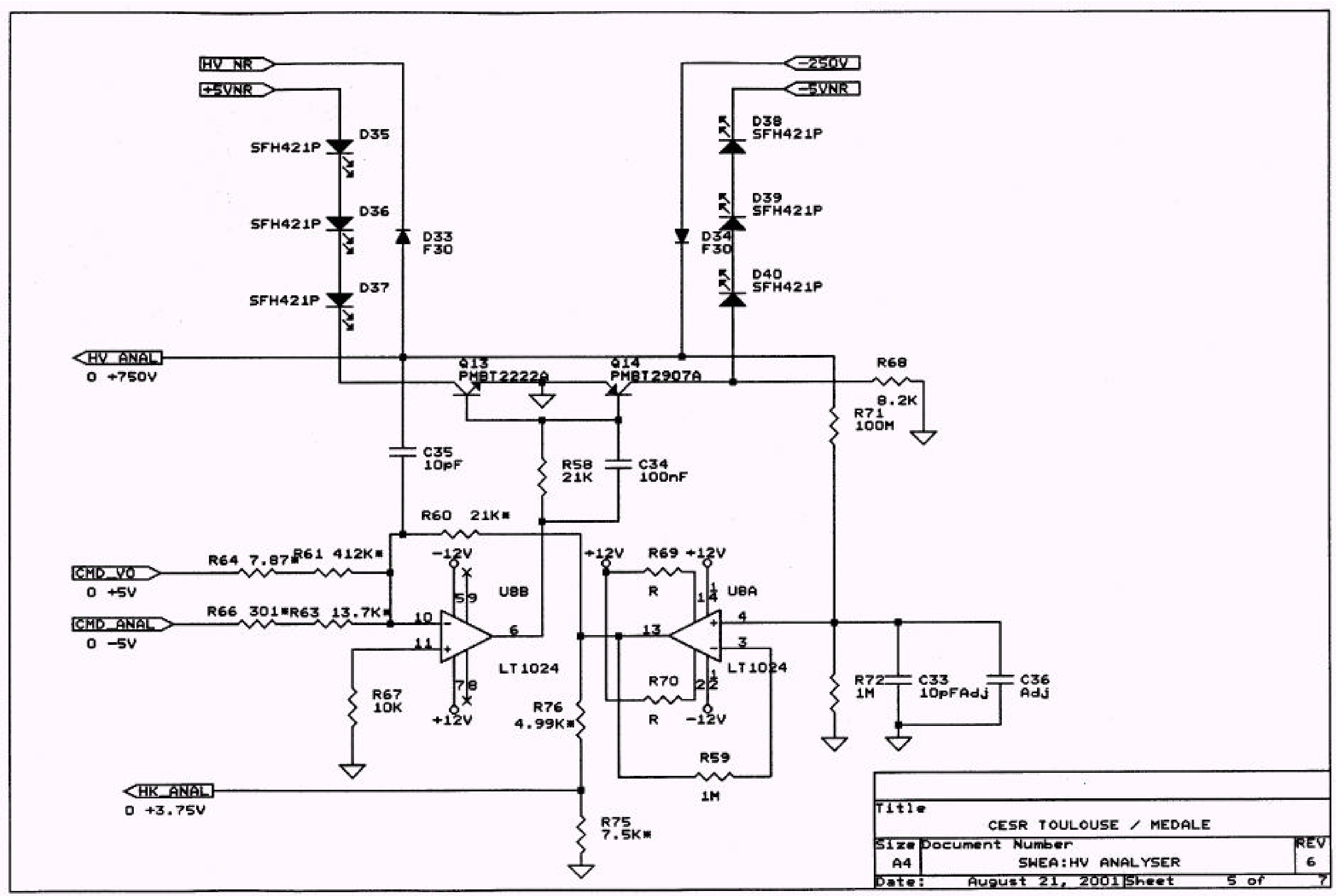
Document Number
SWEA:HVPS DEFLECTOR1
REV
F
Date: August 20, 2001
Sheet 4 of 7


HV NR
+5VNR
-250V
-5VNR
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D36 SFH421P
D37 SFH421P
D33 F30
D34 F30
D38 SFH421P
D39 SFH421P
D40 SFH421P
HV ANAL
0 +750V
Q13 PMBT2222A
Q14 PMBT2907A
R68 8.2K
R71 100M
C35 10pF
R58 21K
C34 100nF
R60 21K*
R64 7.87*
R61 412K*
CMD_VO
0 +5V
R66 301*
R63 13.7K*
CMD_ANAL
0 -5V
-12V
+12V
U8B
LT1024
R67 10K
R69
U8A
R70
R72 1M
C33 10pFAdj
C36 Adj
R76 4.99K*
R59 1M
HK_ANAL
0 +3.75V
R75 7.5K*
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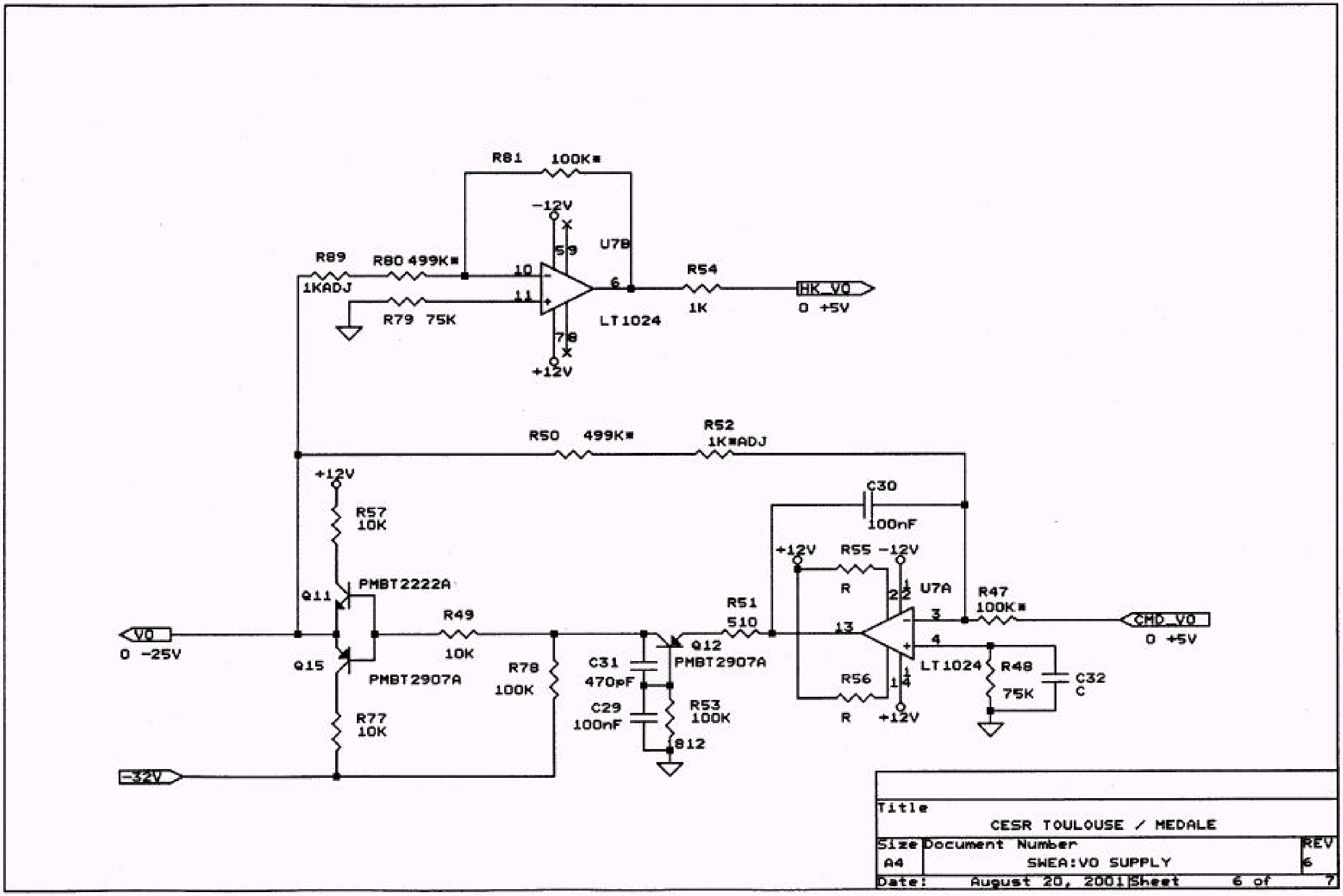
CESR TOULOUSE / MEDALE
Size A4
Document Number SWEA:HV ANALYSER
REV 6
Date: August 21, 2001
Sheet 5 of 7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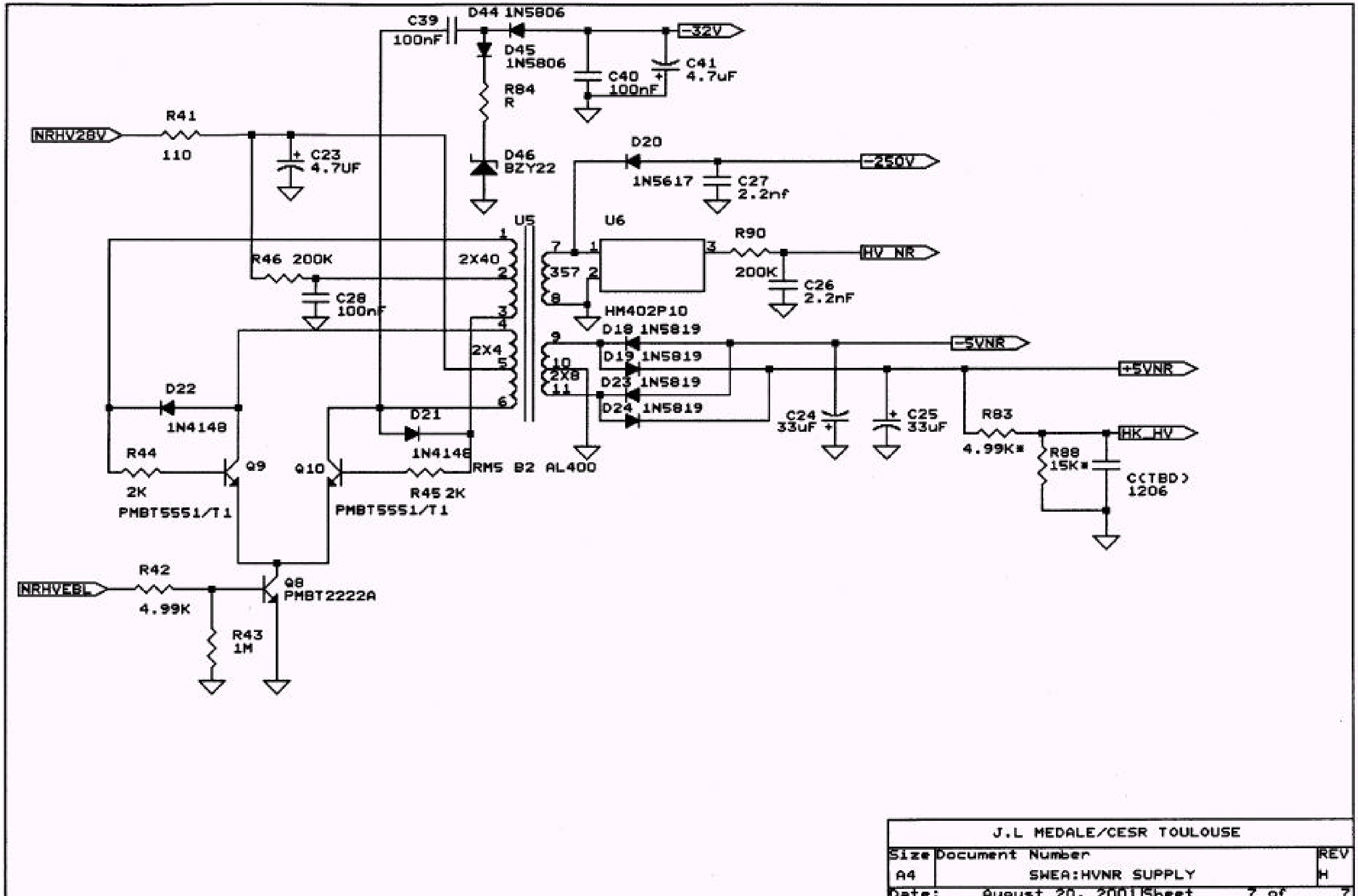
-12V
U7B
R89
1KADJ
R80 499K*
R79 75K
10
11
6
LT1024
+12V
R54
1K
HK_VO
0 +5V
R50 499K*
R52
1K*ADJ
+12V
R57
10K
Q11
PMBT2222A
VO
0 -25V
Q15
PMBT2907A
R49
10K
R77
10K
-32V
R78
100K
C31
470pF
C29
100nF
Q12
PMBT2907A
R53
100K
R51
510
C30
100nF
+12V
R55 -12V
R
U7A
13
R56
R
+12V
R47
100K*
CMD_VO
0 +5V
LT1024
R48
75K
C32
C
Title
CESR TOULOUSE / MEDALE
Size Document Number
A4
SWEA:VO SUPPLY
REV
6
Date: August 20, 2001 Sheet 6 of 7


C39
100nF
D44 1N5806
D45
1N5806
-32V
C40
100nF
C41
4.7uF
R84
R
R41
NRHV28V
110
C23
4.7UF
D46
BZY22
D20
1N5617
-250V
C27
2.2nf
U5
U6
R90
2X40
R46 200K
357
HV_NR
200K
C26
2.2nF
C28
100nF
HM402P10
D18 1N5819
-5VNR
2X4
D19 1N5819
+5VNR
2X8
D23 1N5819
D22
D24 1N5819
C24
33uF
C25
33uF
R83
D21
1N4148
HK_HV
1N4148
4.99K*
R44
Q9
Q10
RM5 B2 AL400
R88
15K*
C(TBD)
1206
2K
R45 2K
PMBT5551/T1
PMBT5551/T1
R42
Q8
PMBT2222A
NRHVEBL
4.99K
R43
1M
J.L MEDALE/CESR TOULOUSE
Size
Document Number
REV
A4
SWEA:HVNR SUPPLY
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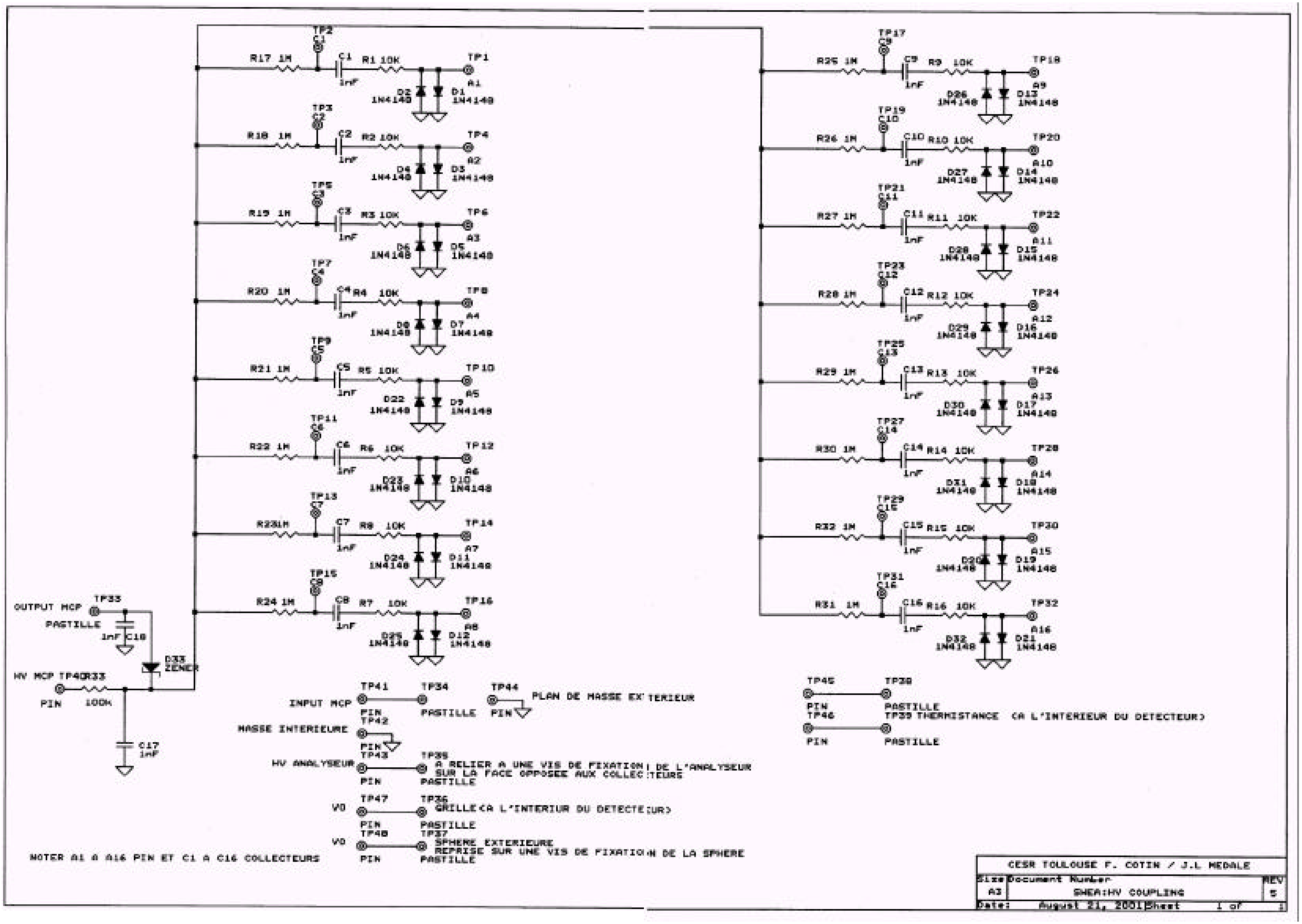
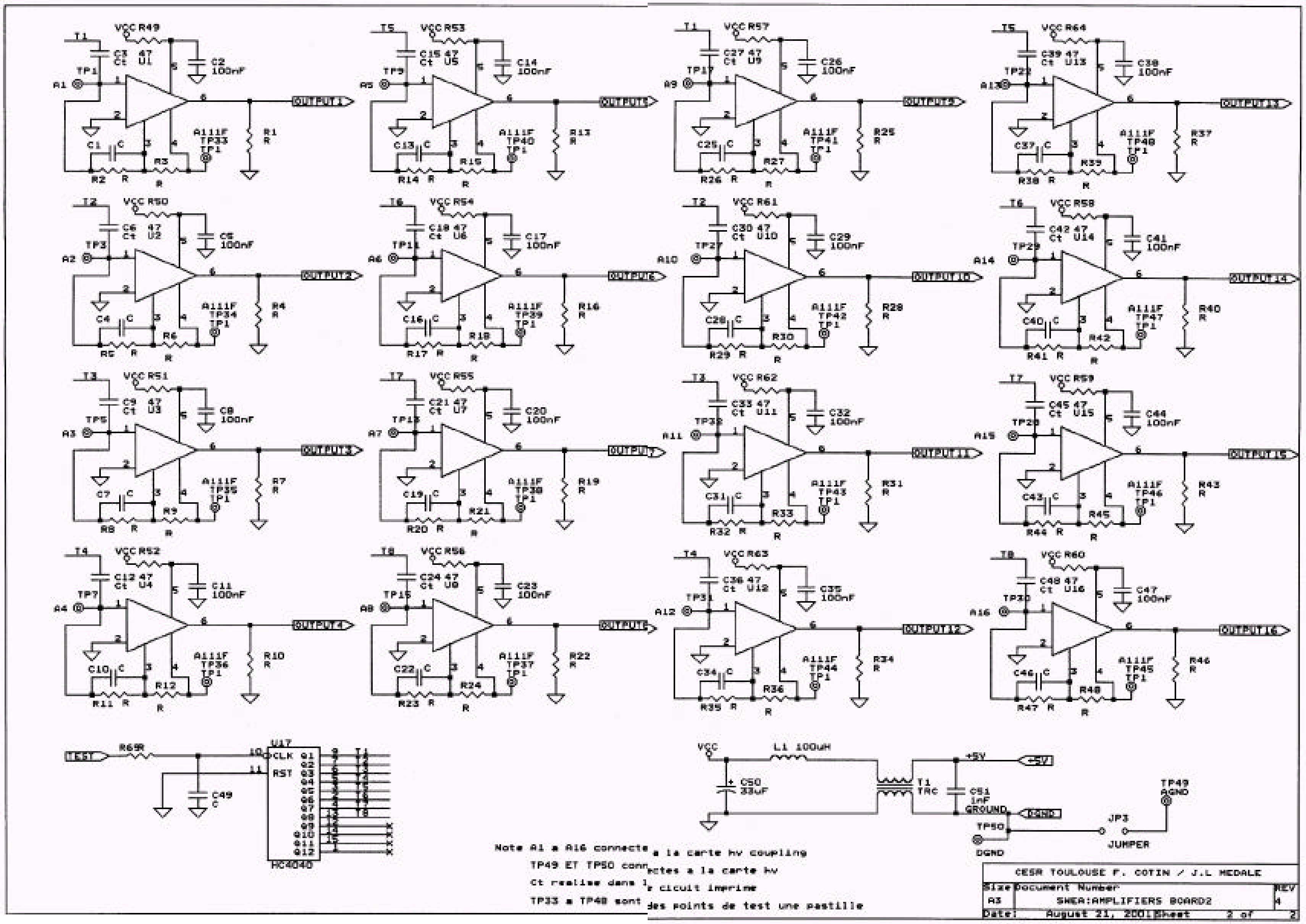
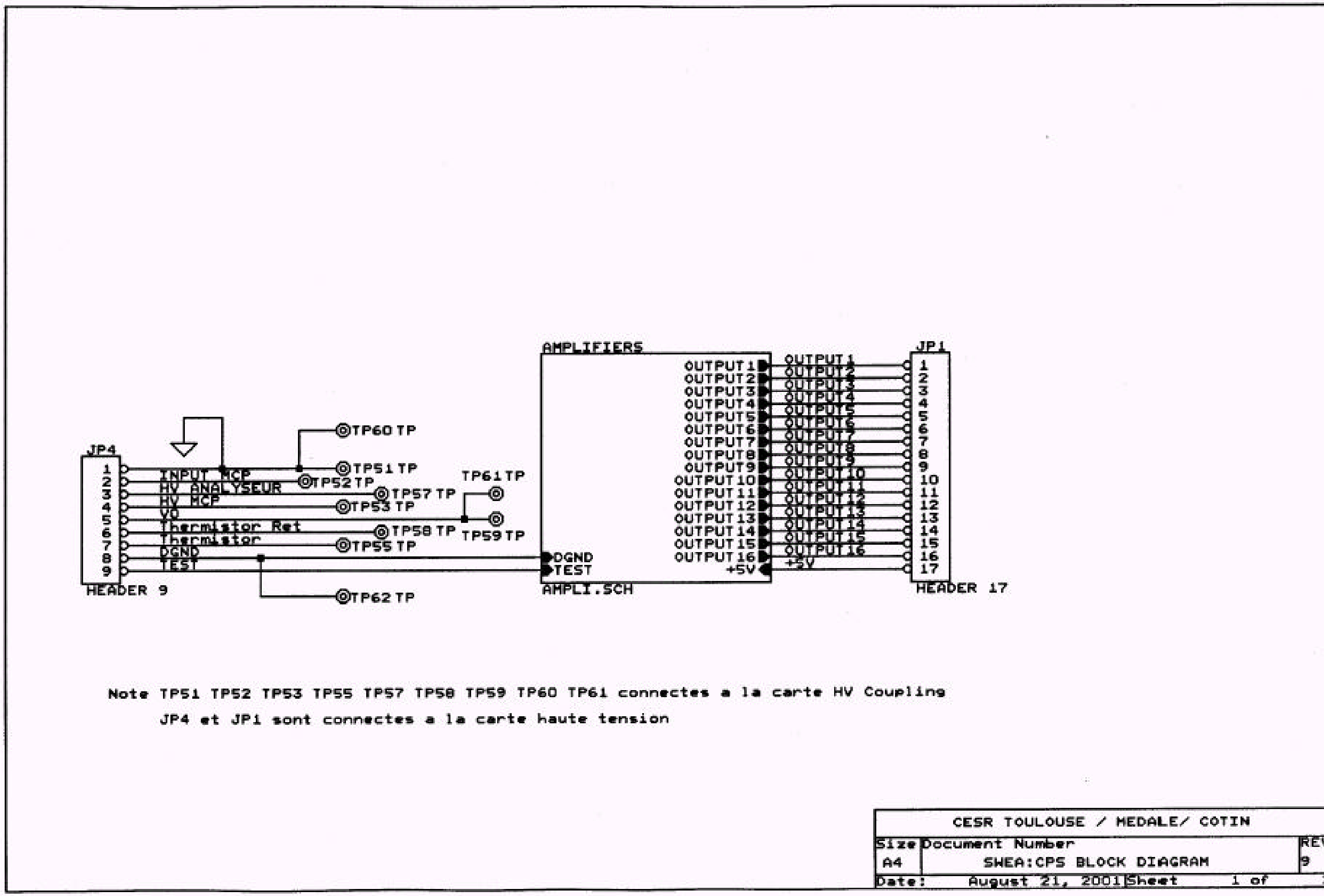
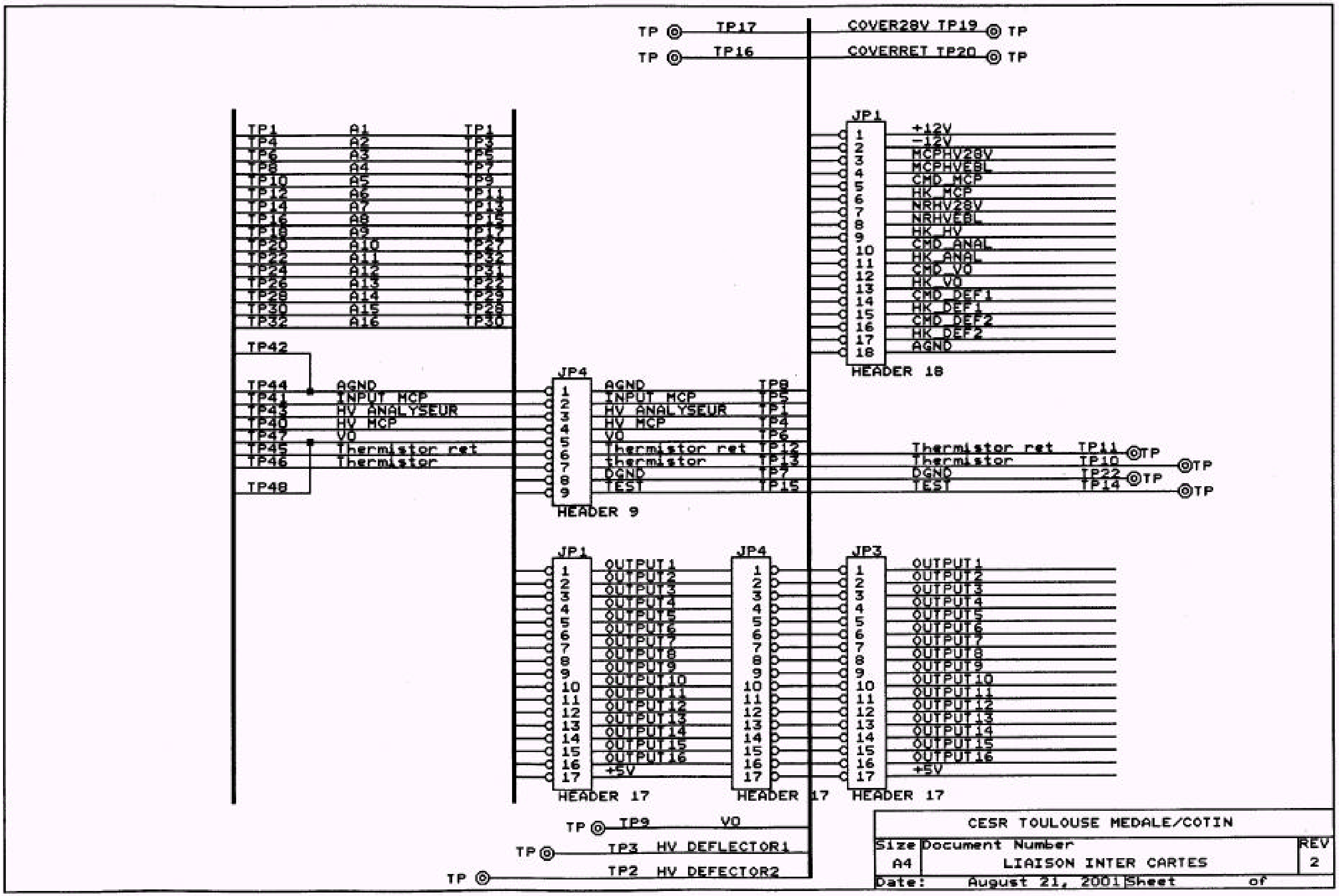
Date:
August 20, 2001
Sheet
7 of 7


OUTPUT MCP
TP33
PASTILLE
1nF C18
D33 ZENER
HV MCP TP40 R33
PIN 100K
C17 1nF
R17 1M
C1 1nF
R1 10K
TP1
A1
D2 1N4148
D1 1N4148
R24 1M
C8 1nF
R7 10K
TP16
A8
R25 1M
C9 1nF
R9 10K
TP18
A9
R31 1M
C16 1nF
R16 10K
TP32
A16
TP41 INPUT MCP PIN
TP34 PASTILLE
TP44 PIN PLAN DE MASSE EXTERIEUR
TP42 MASSE INTERIEURE PIN
TP43 HV ANALYSEUR PIN
TP35 A RELIER A UNE VIS DE FIXATION DE L'ANALYSEUR SUR LA FACE OPPOSEE AUX COLLECTEURS PASTILLE
TP47 V0 PIN
TP36 GRILLE (A L'INTERIUR DU DETECTEUR) PASTILLE
TP48 V0 PIN
TP37 SPHERE EXTERIEURE REPRISE SUR UNE VIS DE FIXATION DE LA SPHERE PASTILLE
NOTER A1 A A16 PIN ET C1 A C16 COLLECTEURS
TP45 PIN
TP38 PASTILLE
TP46 PIN
TP39 THERMISTANCE (A L'INTERIEUR DU DETECTEUR) PASTILLE
CESR TOULOUSE F. COTIN / J.L MEDALE
Size A3
Document Number SWEA:HV COUPLING
REV 5
Date: August 21, 2001
Sheet 1 of 1


OUTPUT1
OUTPUT2
OUTPUT3
OUTPUT4
OUTPUT5
OUTPUT9
OUTPUT10
OUTPUT11
OUTPUT12
OUTPUT13
OUTPUT14
OUTPUT15
OUTPUT16
A111F
TEST
HC4040
VCC
L1 100uH
C50 33uF
T1 TRc
C51 1nF
+5V
GROUND
DGND
TP49 AGND
TP50
JP3
JUMPER
Note A1 a A16 connecte a la carte hv coupling
TP49 ET TP50 connectes a la carte hv
Ct realise dans le circuit imprime
TP33 a TP48 sont des points de test une pastille
CESR TOULOUSE F. COTIN / J.L MEDALE
Size Document Number REV
A3 SWEA:AMPLIFIERS BOARD2 4
Date: August 21, 2001 Sheet 2 of 2


AMPLIFIERS
AMPLI.SCH
JP4
HEADER 9
INPUT MCP
HV ANALYSEUR
HV MCP
VO
Thermistor Ret
Thermistor
DGND
TEST
TP60 TP
TP51 TP
TP52 TP
TP57 TP
TP53 TP
TP58 TP
TP55 TP
TP61 TP
TP59 TP
TP62 TP
OUTPUT 1
OUTPUT 2
OUTPUT 3
OUTPUT 4
OUTPUT 5
OUTPUT 6
OUTPUT 7
OUTPUT 8
OUTPUT 9
OUTPUT 10
OUTPUT 11
OUTPUT 12
OUTPUT 13
OUTPUT 14
OUTPUT 15
OUTPUT 16
+5V
JP1
HEADER 17
Note TP51 TP52 TP53 TP55 TP57 TP58 TP59 TP60 TP61 connectes a la carte HV Coupling
JP4 et JP1 sont connectes a la carte haute tension
CESR TOULOUSE / MEDALE/ COTIN
Size Document Number REV
A4 SWEA:CPS BLOCK DIAGRAM 9
Date: August 21, 2001 Sheet 1 of 2


TP17
TP16
COVER28V TP19
COVERRET TP20
JP1
+12V
-12V
MCPHV28V
MCPHVEBL
CMD_MCP
HK_MCP
NRHV28V
NRHVEBL
HK_HV
CMD_ANAL
HK_ANAL
CMD_VO
HK_VO
CMD_DEF1
HK_DEF1
CMD_DEF2
HK_DEF2
AGND
HEADER 18
JP4
AGND
INPUT MCP
HV ANALYSEUR
HV MCP
VO
Thermistor ret
Thermistor
DGND
TEST
HEADER 9
HEADER 17
TP9 VO
TP3 HV DEFLECTOR1
TP2 HV DEFECTOR2
CESR TOULOUSE MEDALE/COTIN
Size A4
Document Number
LIAISON INTER CARTES
REV 2
Date: August 21, 2001 Sheet of

SupraThermal Electron Detector (STE)

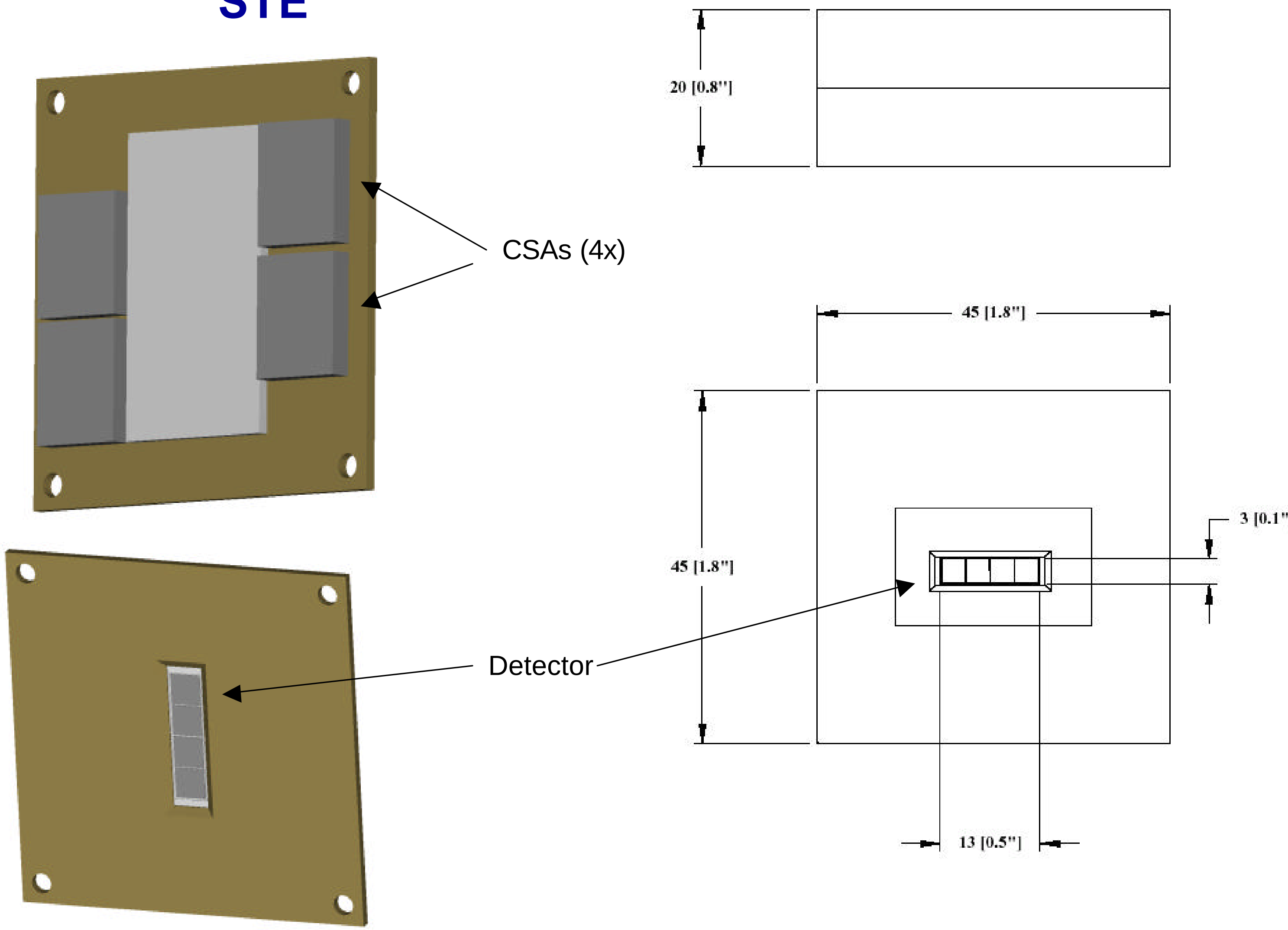
STE Overview

- STE is a new instrument to cover the electron energy range 2-20keV (between SWEA and SEPT) with enhanced sensitivity
  - Reasonably sized electrostatic analyzers have insufficient sensitivity
  - Standard silicon detector telescopes cannot reach this low an energy
- STE uses small, low capacitance, passively cooled silicon detectors with ultra low noise electronics
  - Similar detectors have been successfully used for X-rays down to 1keV
  - Interpolation of dead layer information from larger detectors indicates electrons down to 2keV can be measured
- A large FOV is required to cover the solar wind electrons and back-streaming electrons
  - Two oppositely directed 80 degree by 80 degree FOV oriented along the Parker Spiral covers the halo electron distribution the majority of the time.
  - Detector sensitivity to visible light requires the FOV to be clear of any object that can scatter sunlight

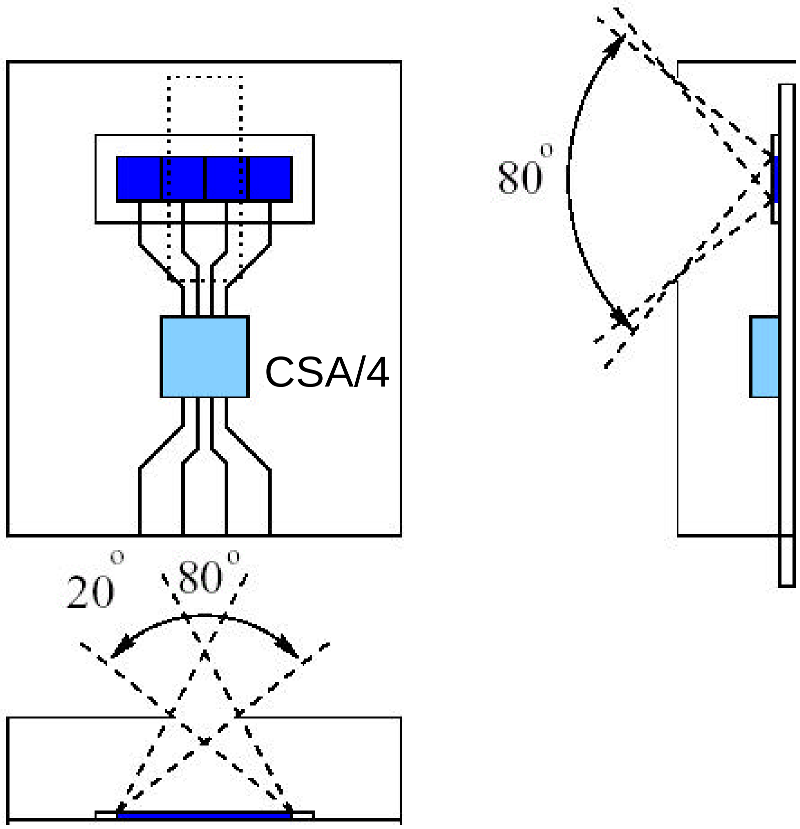
STE Performance Requirements

Description	Goal	Requirement
FOV	Two opposite 80 x 80 degree	60 x 60 degree
Resolution	80 x 20 degrees	60 x 20 degrees
Energy	2 - 100 keV	5 – 100 keV
Energy Resolution (Telemetry)	35%	100%
Energy Resolution (Electronic)	300eV FWHM	2keV
Geometric Factor	0.4 cm^2 ster	0.1 cm^2 ster
Background	<1c/s/detector	<30c/s/detector
Max Count Rate (per detector)	100,000 counts/sec	10,000 counts/sec
Time Resolution	16 seconds 2 seconds (burst)	1 minute

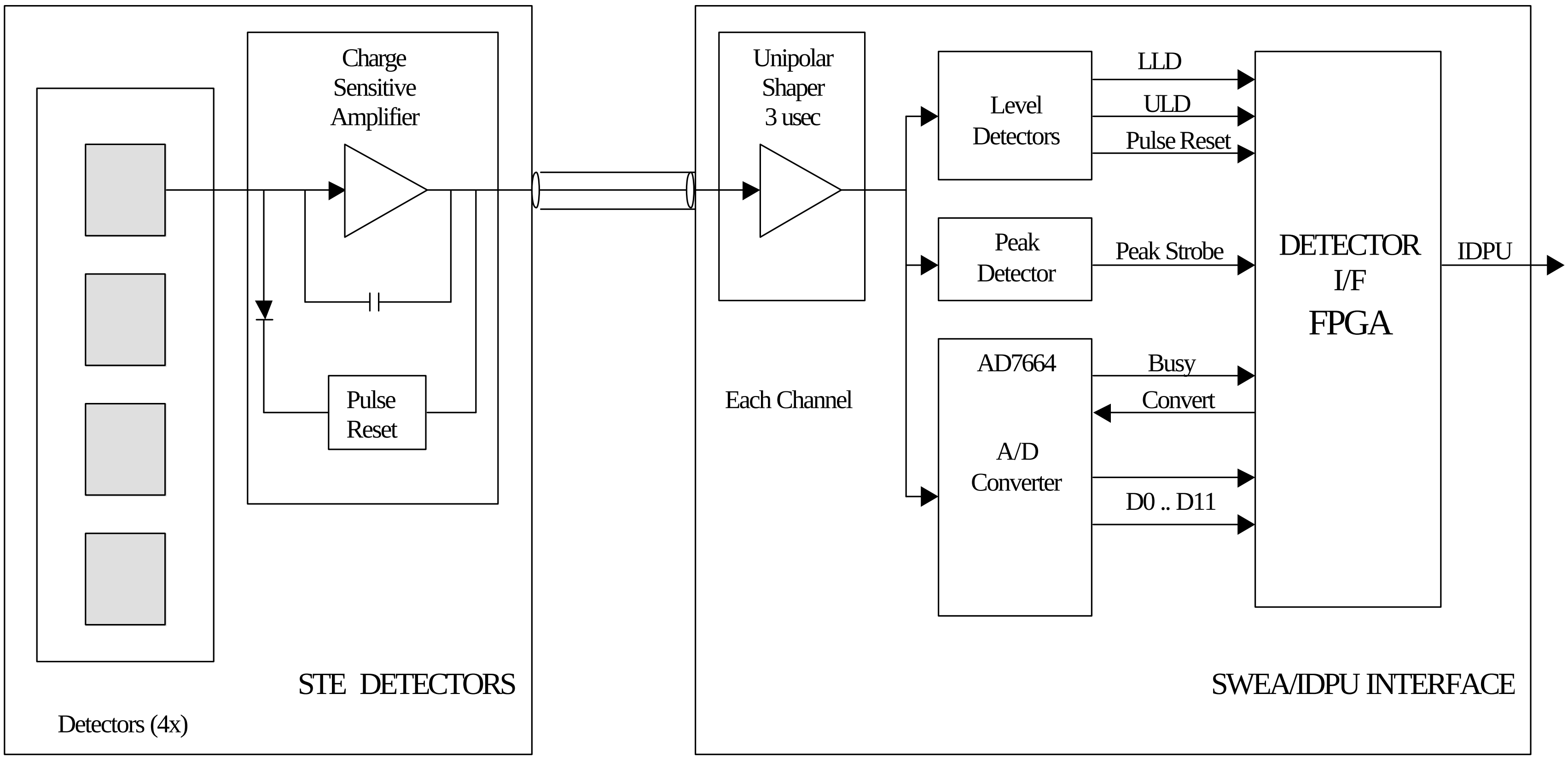
STE



STE Optics



STE Signal Chain (one of 4)



STE Design

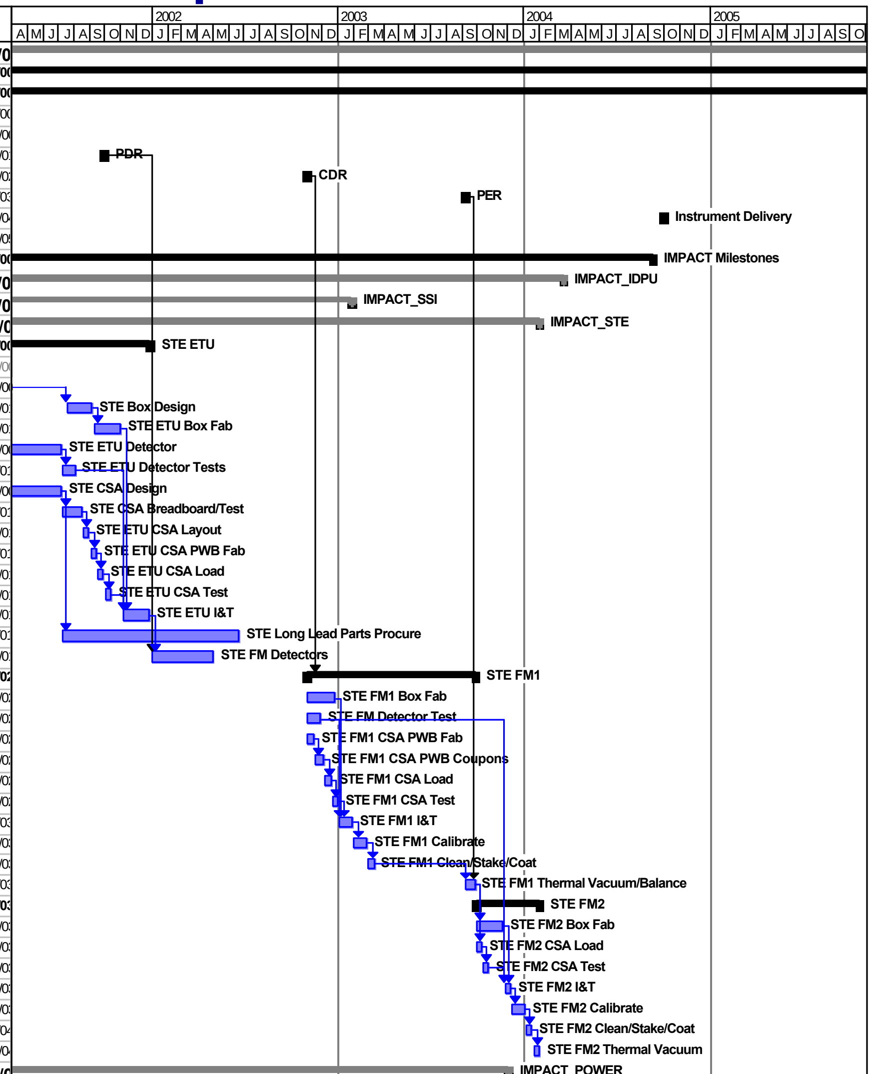
- There are 2 STE Units per spacecraft
  - STE-U (Upstream), mounted on the sunward (fixed) end of the boom
  - STE-D (Downstream), mounted near SWEA at the end of the boom
  - Divided to provide clear fields of view
- The STE Units contain only the detectors and preamps
  - Minimizes thermal dissipation to simplify passive cooling
- The rest of the electronics is located in SWEA and the IDPU, and is discussed later
- STE must have reclosable doors
  - Contamination on the ground, during launch, and during thruster firings
  - Damage due to overheating if detector is exposed to sunlight
  - Simple SMA actuators similar to ones designed for HESSI will be used, controlled by the IDPU

STE Development Plan

- **A Breadboard STE has been developed and is currently in test to verify the design**
  - Prototype (possibly Flight) detectors have been fabricated by LBNL
  - A Breadboard Charge Sensitive Amplifier showing 750eV noise has been designed and fabricated, and is now in test at LBNL
  - Breadboard Pulse Height Analyzer (shaper, ADC) has been designed and fabricated and is now in test at UCB
  - Integrated tests with electrons shall start shortly at UCB
- **Once the breadboard tests verify the design, an ETU shall be built to verify the layout and mechanical design, and thermal sensitivity**
  - This should be complete by CDR
- **Two flight units shall be fabricated following CDR**

STE Development Schedule

ID	Task Name	Start
1	**IMPACT_Milestones**	**2/2/0**
1	**Project Phases**	**2/2/0**
7	**Project Milestones**	**2/2/0**
8	IMPACT Phase A Contract	2/2/0
9	SRR	5/24/0
11	PDR	9/30/0
18	CDR	11/1/0
25	PER	9/7/0
32	Instrument Delivery	10/1/0
33	Launch	11/12/0
34	**IMPACT Milestones**	**6/9/0**
2	**IMPACT_IDPU**	**1/1/0**
3	**IMPACT_SSI**	**2/2/0**
4	**IMPACT_STE**	**5/26/0**
2	**STE ETU**	**5/26/0**
3	SRR	5/24/0
4	STE Optics Design	5/26/0
5	STE Box Design	7/16/0
6	STE ETU Box Fab	9/10/0
7	STE ETU Detector	5/26/0
8	STE ETU Detector Tests	7/9/0
9	STE CSA Design	5/26/0
10	STE CSA Breadboard/Test	7/9/0
11	STE ETU CSA Layout	8/20/0
12	STE ETU CSA PWB Fab	9/3/0
13	STE ETU CSA Load	9/17/0
14	STE ETU CSA Test	10/1/0
15	STE ETU I&T	11/5/0
16	STE Long Lead Parts Procure	7/9/0
18	STE FM Detectors	12/31/0
21	**STE FM1**	**11/1/0**
22	STE FM1 Box Fab	11/1/0
23	STE FM Detector Test	11/1/0
24	STE FM1 CSA PWB Fab	11/1/0
25	STE FM1 CSA PWB Coupons	11/15/0
26	STE FM1 CSA Load	12/6/0
27	STE FM1 CSA Test	12/20/0
28	STE FM1 I&T	1/3/0
29	STE FM1 Calibrate	1/31/0
30	STE FM1 Clean/Stake/Coat	2/28/0
32	STE FM1 Thermal Vacuum/B	9/8/0
34	**STE FM2**	**9/29/0**
35	STE FM2 Box Fab	9/29/0
36	STE FM2 CSA Load	9/29/0
37	STE FM2 CSA Test	10/13/0
38	STE FM2 I&T	11/24/0
39	STE FM2 Calibrate	12/8/0
40	STE FM2 Clean/Stake/Coat	1/5/0
41	STE FM2 Thermal Vacuum	1/19/0
5	**IMPACT_POWER**	**7/31/0**



STE Verification Plan

Revision Date: 8/27/01
Revision Number: 1

Hardware Description		Test																		
Level of Assembly	Item	Elect. test, rm. Temp	Bench Calibration	Elect. Test, hot	Elect. Test, cold	Vibration, Sinusoidal	Vibration, Random	Shock	Acoustics	Thermal Vacuum	Voltage margins	Thermal cycle	Thermal balance	Life Test	EMC/EMI	Magnetics	Beam Calibration	Bakeout	Contamination	Comments
C	Detector, EM	X																		
C	Detector, F	X																	X	
C	Preamp, BB	X	X																	
I	Instrument, BB	X	X	X	X						X						X			
I	Instrument, ETU	X	X	X	X												X			
I	Instrument, F	X	X	X	X	H	H	H	A	X	X		X	X	H	X	X	X	X	

Legend:

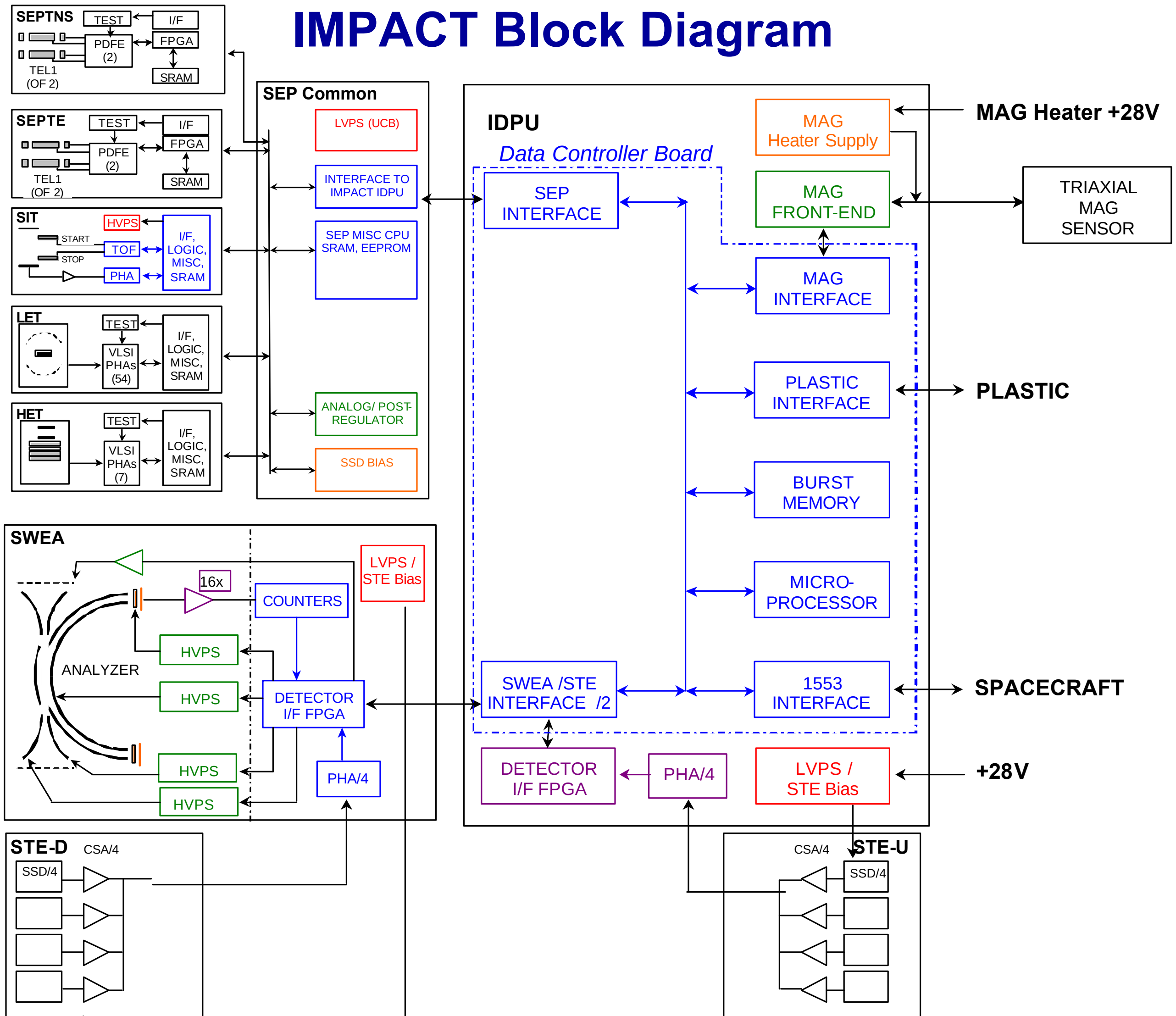
Level of Assembly	Unit Type		
C = Component	BB Breadboard	X =	Test required
I = Instrument	EM Engineering Model	A =	Analysis
	PT Prototype	H =	Test at higher level of assembly
	PF Protoflight		
	F = Flight		

SWEA / STE Interface

SWEA/STE Responsibilities

- SWEA - CESR
  - Includes Electrostatic optics, MCP detector, HVPS, Preamps
- STE - UCB
  - Detectors and Preamp design from LBNL
- SWEA/STE Interface - UCB
  - Includes LVPS, STE Bias Supply, Controls, PHA, Accumulators, Interface to IDPU
  - Mounted in the base of SWEA

IMPACT Block Diagram



David Curtis

STE Interface Accommodation

- There are 2 STE Units per spacecraft
  - STE-U (Upstream), mounted on the sunward (fixed) end of the boom
  - STE-D (Downstream), mounted near SWEA at the end of the boom
- The STE Units contain only the detectors and preamps
- The rest of the STE-U electronics are mounted in the IDPU
- The rest of the STE-D electronics are mounted in the base of SWEA
- A common circuit board design shall be developed for both the SWEA and IDPU hosted electronics
  - The PWB shall also include SWEA Interface electronics
  - The SWEA interface electronics shall not be populated in the IDPU-hosted PWB
- The interface electronics includes shaper, ADC, binning electronics, (collectively called the Pulse Height Analyzer, or PHA) and Serial Instrument Interface to the IDPU processor

SWEA/STE Interface Requirements, IDPU

- Interface between SWEA and STE instruments and the IDPU
- IDPU Interface:
  - Mode Commands to control instrument settings
    - No high-bandwidth requirements; instrument runs itself
  - Data Readback
    - SWEA Counters, STE Accumulator, Housekeeping
    - About 50kbps throughput required
    - Sequencer to automatically sample & read out data
  - Common timebase clock for synchronized, low-jitter, deterministic sampling
  - Common interface design with other instruments to IDPU
    - Common development
    - Common GSE
  - Minimize number of wires down IMPACT boom
  - Meet EMC requirements
- Implementation Described in IMPACT Serial Interface document and IDPU presentation

SWEA/STE Interface Requirements, SWEA

- **SWEA Interface:**
  - Provide interface to the CESR-provided analyzer per the SWEA ICD
  - Voltage control for 5 analyzer voltages
    - MCP, VO, Analyzer, Deflector 1, Deflector 2
    - VO, Analyzer & Deflector Supplies must have programmable waveforms
      - 625 samples/second, 2 second period
    - Analyzer and Deflector supplies are referenced to VO in the supplies to simplify controls
    - Analyzer requires a 16-bit DAC to get sufficient accuracy (5%) over the dynamic range (3000x)
    - Deflector supply controls should be multipliers based on Analyzer control to minimize dynamic range requirements (1% of Analyzer voltage)
  - Counters for Anode 16 pulses (logic pulses)
  - 6 Voltage and one temperature housekeeping monitors
  - Test pulse generator (digital pulses), HV Enables (logic levels)
  - SWEA Cover Actuator power (switched 28V primary)

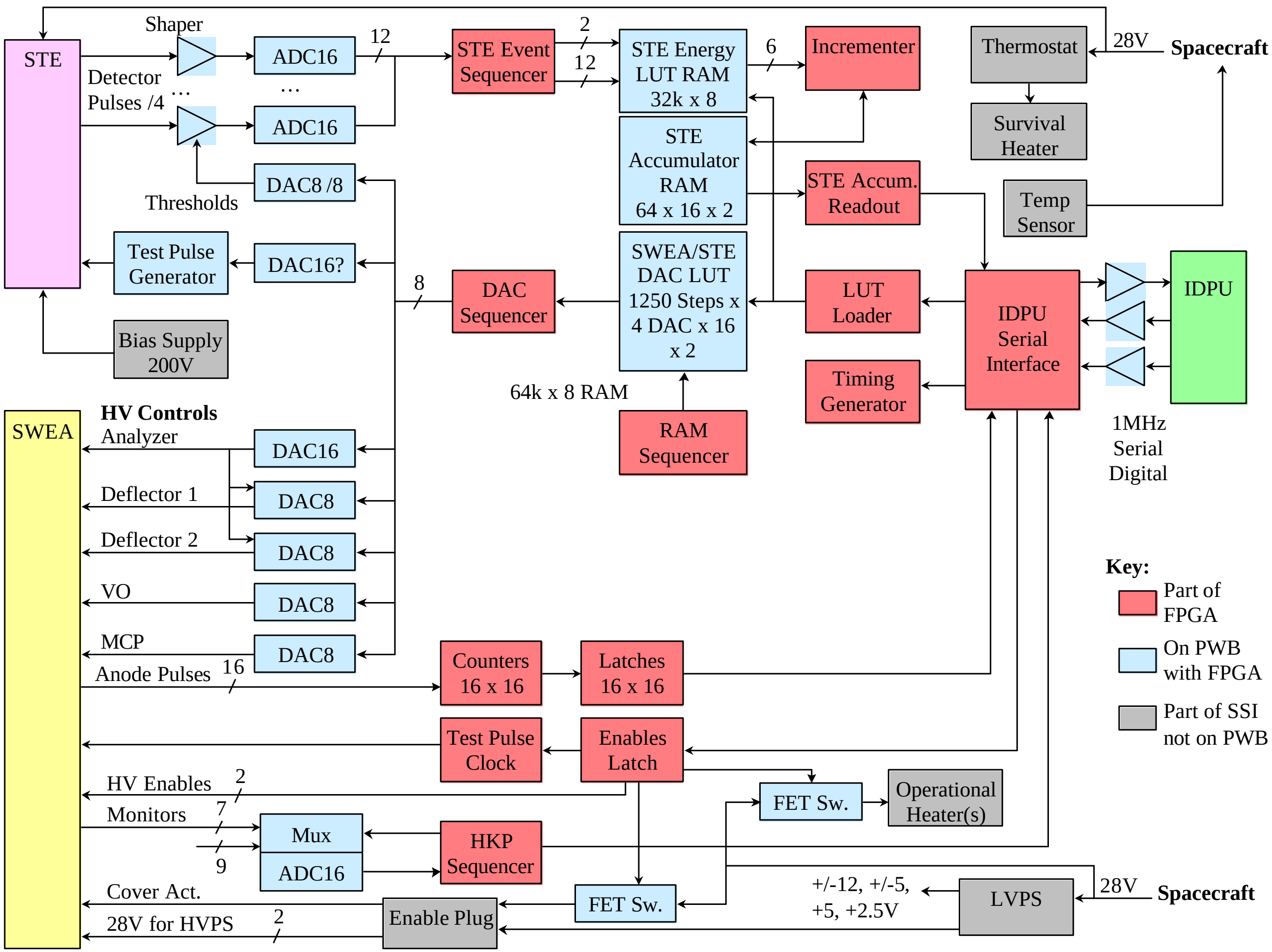
SWEA/STE Interface Requirements, STE

- **STE Interface:**
  - 4 analog chains
    - Charge Sensitive Amplifier inside STE
    - Shaper
    - Discriminator (programmable threshold)
    - ADC (200x dynamic range, 5% DNL -> 14-16 bit ADC)
  - Pulse height analyzer
    - Programmable Energy binning to 16 log-spaced energy channels
    - 64-channel double-buffered accumulator (16E x 4 Det.)
    - >15KHz/detector throughput
  - Test pulse generator to test electronics
    - Ramped-amplitude pulse generator
    - Capacitively coupled into preamp inputs
    - When pulser active, only allow events near pulse times
  - Temperature housekeeping monitor
  - Cover Actuator power (switched 28V primary)

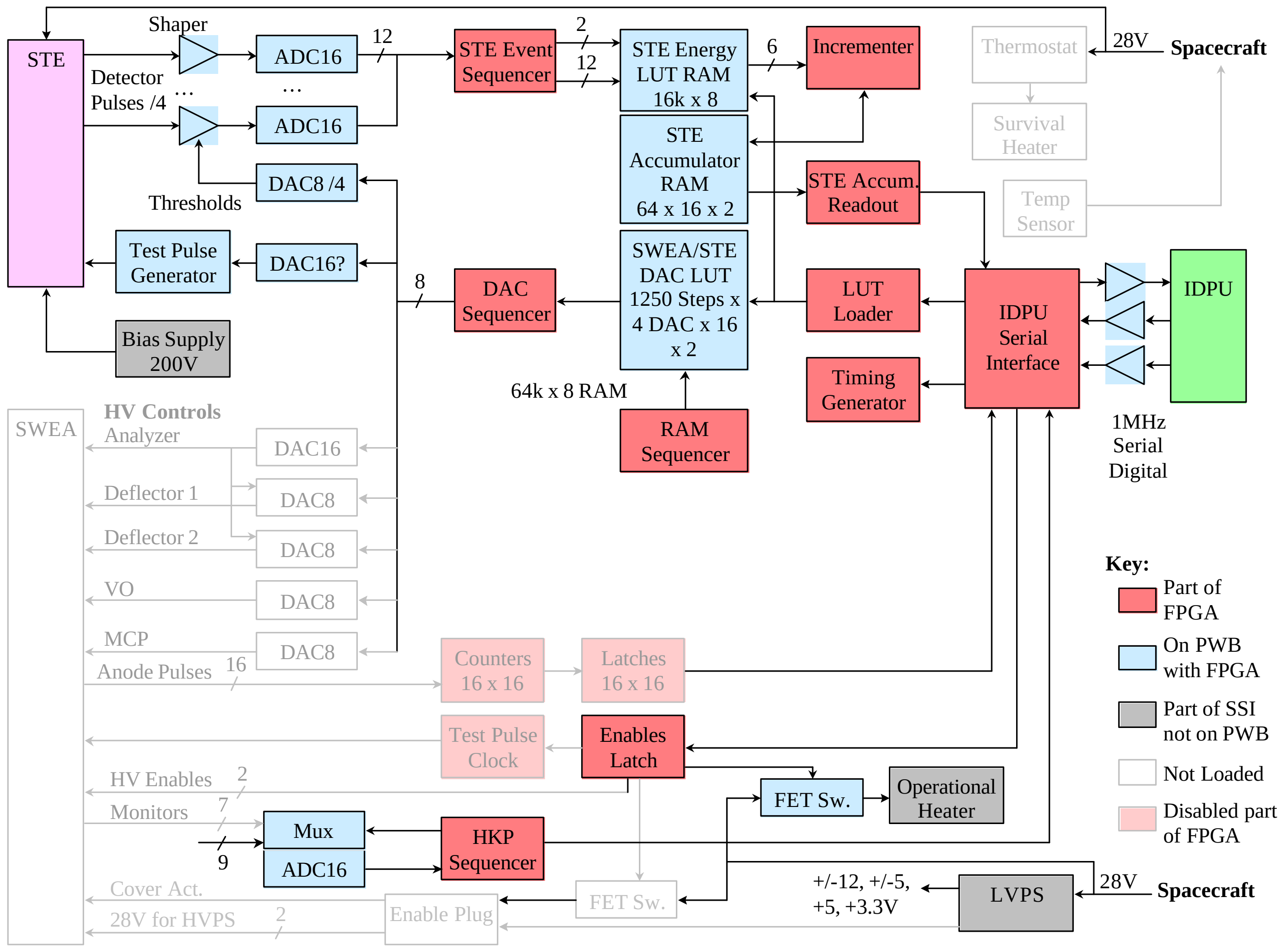
SWEA/STE Interface Requirements, Misc

- Miscellaneous Requirements
  - Survival heaters (thermostatically controlled)
    - SWEA and STE in parallel on one spacecraft circuit
    - SWEA heater/thermostat part of SWEA/STE Interface
  - Operational Heaters
    - SWEA and STE heaters powered off the primary 28V
    - IDPU-Software Controlled FET switches
  - Spacecraft-monitored temperature sensor (in SWEA)
    - Only one to minimize wires down boom; two instrument-monitored sensors when SWEA/STE is on.
    - Mounted in SWEA/STE Interface
  - Green-tag Enable Connector
    - Separate loops to enable:
      - MCP HV
      - Analyzer/Deflector HV
      - SWEA Cover

SWEA/STE-D Interface Block Diagram (In SWEA)



STE-U Interface Block Diagram (In IDPU)



SWEA/STE Interface Logic

- SWEA/STE Interface Logic implemented in an FPGA, augmented with a memory for Look-up tables (LUT) and STE accumulator
- Actel RT54SX32S baselined
  - Common FPGA selected for IMPACT team
  - Rad tollerant (100krads)
  - High Rel available
  - 2880 logic modules
- Actel specification to be developed by SSL (Curtis)
- Actel design to be developed/tested by Elf
  - Same arrangement & personnel used on HESSI
- Power is constrained (budget is 100mW for the Logic)
  - 1MHz clock looks adequate for sequencers
  - Asynchronous and/or slow clocks to be used where sensible
    - Ripple counters will be used for SWEA accumulators
- Attention will be given to good Actel design practices

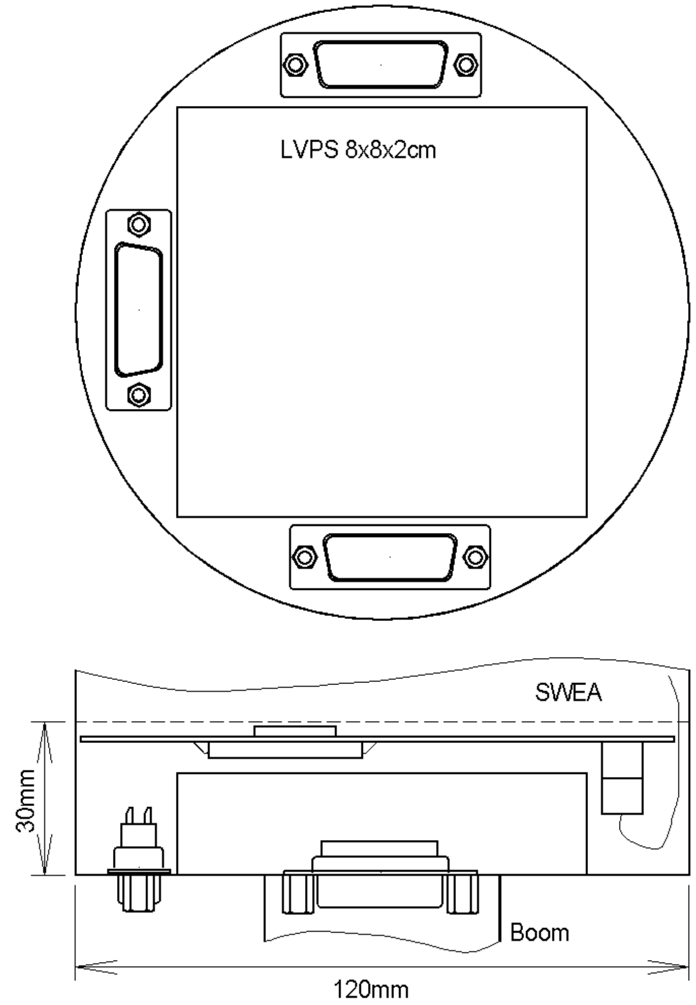
SWEA/STE Interface Memory Requirements

- The memory is used for:
  - STE Energy Look-up Table
    - 12-bit ADC output plus 3-bit detector ID results in a 4-bit energy bin number, plus the same 3-bit detector ID
    - 32k x 8 bits
  - STE Accumulator
    - 16 Energies, 4 Detectors, 16 bit accumulators, double-buffered
    - 256 x 8 bits
    - Incrementer uses up to 4 memory cycles to increment an accumulator; Read, Increment, Write 8 LSB, repeat for 8 MSB on carry out of LSB
  - SWEA DAC Waveform Look-Up Table
    - Fastest waveform update rate is deflectors, at 625Hz
    - Typically only one DAC updated per step
      - code in RAM as 8-bit ID plus 8-bit value
      - Sequencer reads out DAC settings until STOP bit in ID set
    - 2 second period; sized at 1250 samples * 4 DACs * 16 bits * 2 buffers = 20k x 8

SWEA/STE Interface Memory Requirements (Continued)

- **Total Size requirement < 64Kbytes**
  - Could reduce to 32Kx8 by using common STE LUT for all detectors
  - Will use common SRAM with IDPU - 512Kx8
- **Access Rate:**
  - STE Accumulation: 15,000 events/sec/det * 4 Det * 5 cycles/event = 300,000 cycles/second (includes LUT & Accumulate)
  - STE readout: 1MHz serial bitrate to IDPU (burst) = 63,000 cycles/second max (Note: reset accumulator following readout of full accumulator, so no bandwidth impact)
  - LUT Write: 1MHz serial bitrate from IDPU (burst) = 125,000 cycles/second max
  - SWEA LUT readout; Up to 5 DAC bytes need to be updated in one sample interval (625Hz) = 3,125 cycles/second MAX (Note: DACs are double-buffered)
  - Total bandwidth required: 491KHz
  - Using 1 RAM cycle per 1MHz clock, can allocate 8 fixed time slots at 125KHz: 5 for STE Accumulation, 1 for STE readout, 1 for LUT write, and one for SWEA LUT readout (allows up to 30,000 STE events/sec/det)

SWEA/STE Interface Layout



SWEA/STE Interface Mechanical

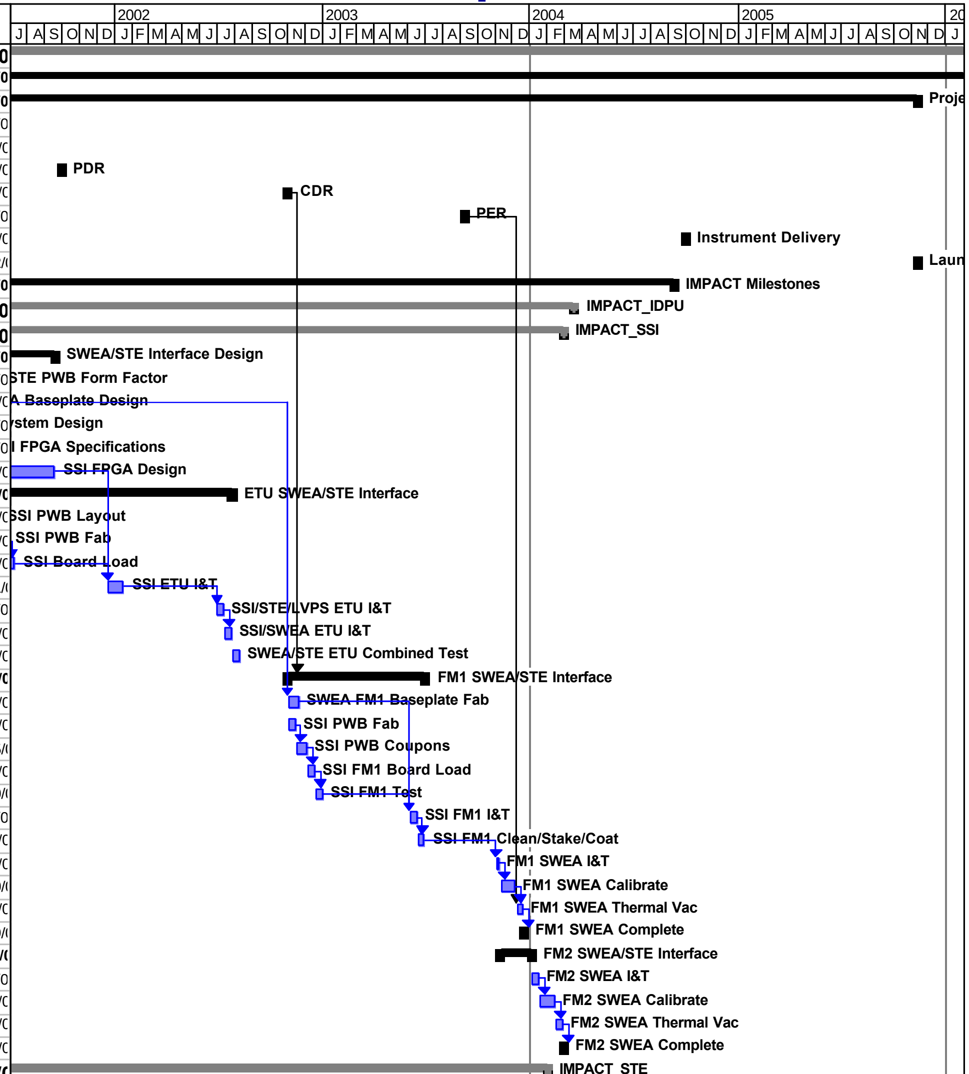
- SWEA/STE Interface is mounted in the base of SWEA
  – UCB provides electronics mounted to the end-plate of the SWEA electronics enclosure
- Volume: 12cm diameter cylinder 3 cm long
  – LVPS takes 2cm, remainder fits on one PWB 12cm in diameter, 1 cm high
  – LVPS space allocation is probably too small
    - Baseline LVPS is 10x10x2 cm, while we have room for 8x8x2
    - Space is constrained by SWEA and STE FOV, and by undeployed boom length
    - SWEA FOV can handle up to 15.2cm diameter.
    - Final diameter is TBR, following a rough layout of the LVPS in the next few weeks.

SWEA/STE Interface Development and Verification Plans

- An ETU of the SWEA/STE Interface shall be developed at UCB
  - FPGA developed by ELF
  - Interface tests with STE, SWEA, and IDPU
  - Support SWEA & STE Functional & performance tests at UCB
- Four Flight Units shall be developed and tested at UCB
  - Two for IDPU, without SWEA Interface
  - Two with SWEA Interface
- The interface circuits shall be be functionally tested with the STE ETU and Flight Units per the STE verification plan
- The interface circuits shall be environmentally tested with the IDPU and SWEA units respectively per their verification plans.

SWEA/STE Interface Development Schedule

ID	Task Name	Start
1	**IMPACT_Milestones**	**2/2/0**
1	**Project Phases**	**2/2/0**
7	**Project Milestones**	**2/2/0**
8	IMPACT Phase A Contract	2/2/0
9	SRR	5/24/
11	PDR	9/30/
18	CDR	11/1/
25	PER	9/7/0
32	Instrument Delivery	10/1/
33	Launch	11/12/
34	**IMPACT Milestones**	**6/9/0**
2	**IMPACT_IDPU**	**1/1/0**
3	**IMPACT_SSI**	**3/6/0**
1	**SWEA/STE Interface Design**	**3/6/0**
3	SWEA/STE PWB Form Fact	3/6/0
4	SWEA Baseplate Design	3/20/
5	SSI System Design	3/6/0
6	SSI FPGA Specifications	4/3/0
7	SSI FPGA Design	5/15/
9	**ETU SWEA/STE Interface**	**5/15/**
10	SSI PWB Layout	5/15/
11	SSI PWB Fab	6/12/
12	SSI Board Load	6/26/
14	SSI ETU I&T	12/21/
17	SSI/STE/LVPS ETU I&T	7/1/0
19	SSI/SWEA ETU I&T	7/15/
21	SWEA/STE ETU Combined Test	7/29/
23	**FM1 SWEA/STE Interface**	**11/1/**
24	SWEA FM1 Baseplate Fab	11/1/
25	SSI PWB Fab	11/1/
26	SSI PWB Coupons	11/15/
27	SSI FM1 Board Load	12/6/
28	SSI FM1 Test	12/20/
30	SSI FM1 I&T	6/3/0
31	SSI FM1 Clean/Stake/Coat	6/17/
33	FM1 SWEA I&T	11/3/
34	FM1 SWEA Calibrate	11/10/
36	FM1 SWEA Thermal Vac	12/8/
37	FM1 SWEA Complete	12/19/
40	**FM2 SWEA/STE Interface**	**11/10/**
48	FM2 SWEA I&T	1/5/0
49	FM2 SWEA Calibrate	1/19/
50	FM2 SWEA Thermal Vac	2/16/
51	FM2 SWEA Complete	2/27/
4	**IMPACT_STE**	**5/26/**

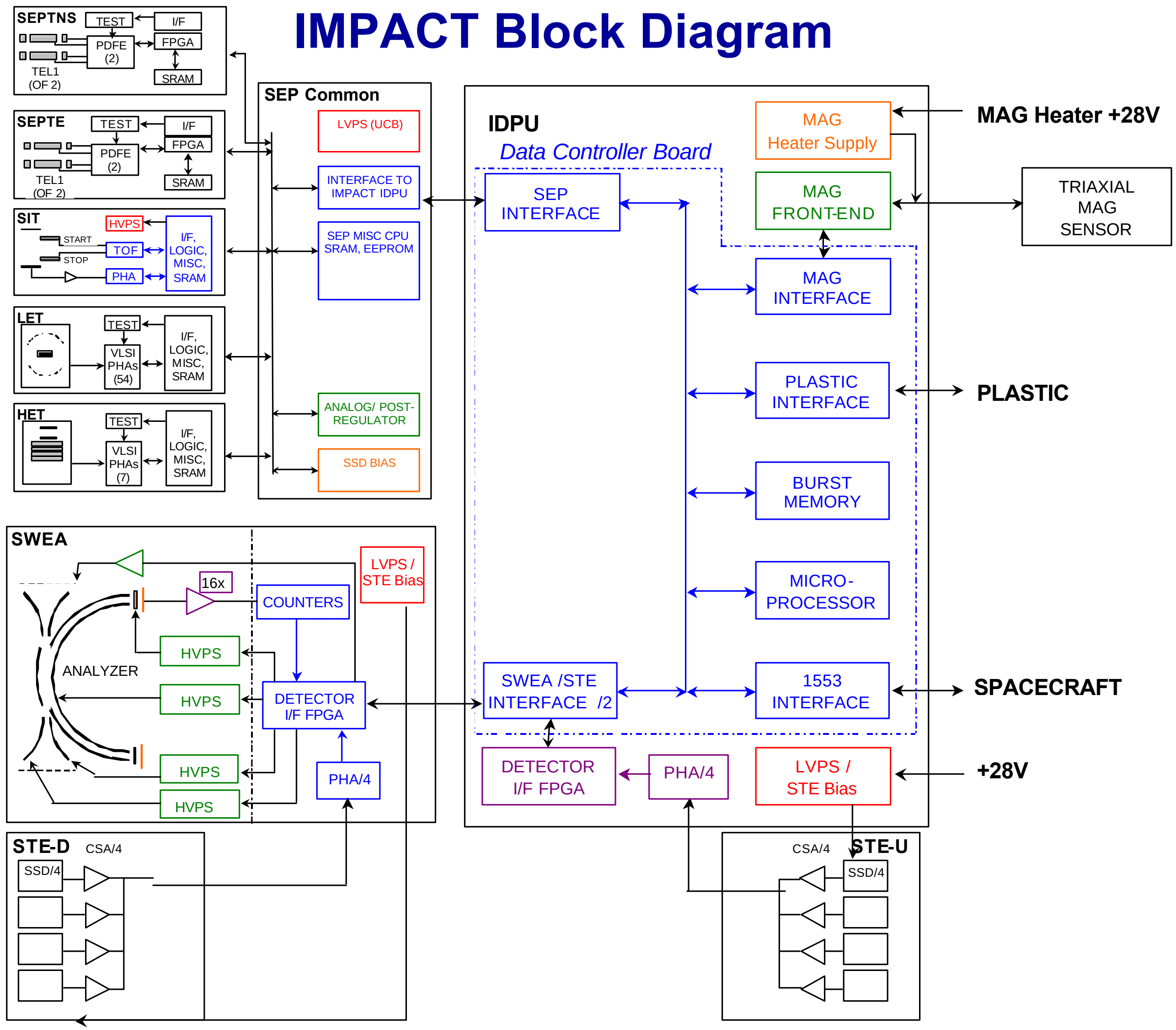


SWEA/STE Peer Review Open Action Items

#	DB#	REGARDING	REVIEWER WRITE-UP	CLASSIFICATION/ STATUS	DISPOSITION
7	**128**	**IMPACT STE and SWEA**	Both STE and SWEA have relatively warm cold limits (-50C and -20C, respectively), but they have no power allocated for thermal control in a very cold environment. Simple thermal analysis could be done to develop a heater power estimate. Action is to build a thermal model to run all thermal scenarios for STE and SWEA.	**Action Item /Open**	**Operational heaters have been allocated to SWEA, STE, and MAG based on thermal modeling. The SWEA model needs more work to come to a consistent heater size.**

Instrument Data Processing Unit (IDPU)

IMPACT Block Diagram



IDPU Requirements

- A single-point interface between the IMPACT and PLASTIC instruments and the spacecraft C&DH system (1553 bus)
- Provide instrument control, data collection, compression, and formatting for the IMPACT and PLASTIC instruments
  - Note SEP has its own processor, so the IDPU acts mostly as a bent pipe for commands and telemetry to SEP
- Provide a home for miscellaneous instrument electronics, such as the MAG front end and the second STE front end
- Provide a common design, simple serial interface to the instruments tailored to meet the instrument needs
  - Instrument mode commands
  - Instrument data collection
  - Common sample and spacecraft timing distribution
- Provide a 2Mbyte Burst Memory to record short intervals of high time resolution data

IDPU Interfaces

- Spacecraft 1553 Interface
  - Command, Telemetry, Status, Timing
  - SWAVES Burst Trigger Exchange
    - RT to RT once a second in each direction
- Spacecraft 28V power interface
  - powers IDPU, MAG, STE-U
- Spacecraft Thermal Interface
  - Coupled to Spacecraft Deck, -23 to +55C Design/Test limits
- Serial Instrument Interfaces
  - SEP, PLASTIC, SWEA/STE
  - MAG and STE-U interfaces to internal cards
- MAG Sensor Interface
  - To MAG Front End Card in IDPU
- STE-U Interface
  - To STE Front End card in IDPU

IDPU Resources

IDPU:	Mass, kg	Power, W
Mag Card	0.30	0.38
DIB Card (STE)	0.30	0.20
DPU Card	0.30	0.80
S/C Interface (on DPU card)		0.50
IDPU LVPS	0.20	1.07
Mag Heater Control	0.07	
BOX	0.96	
IDPU Total:	2.12	3.05

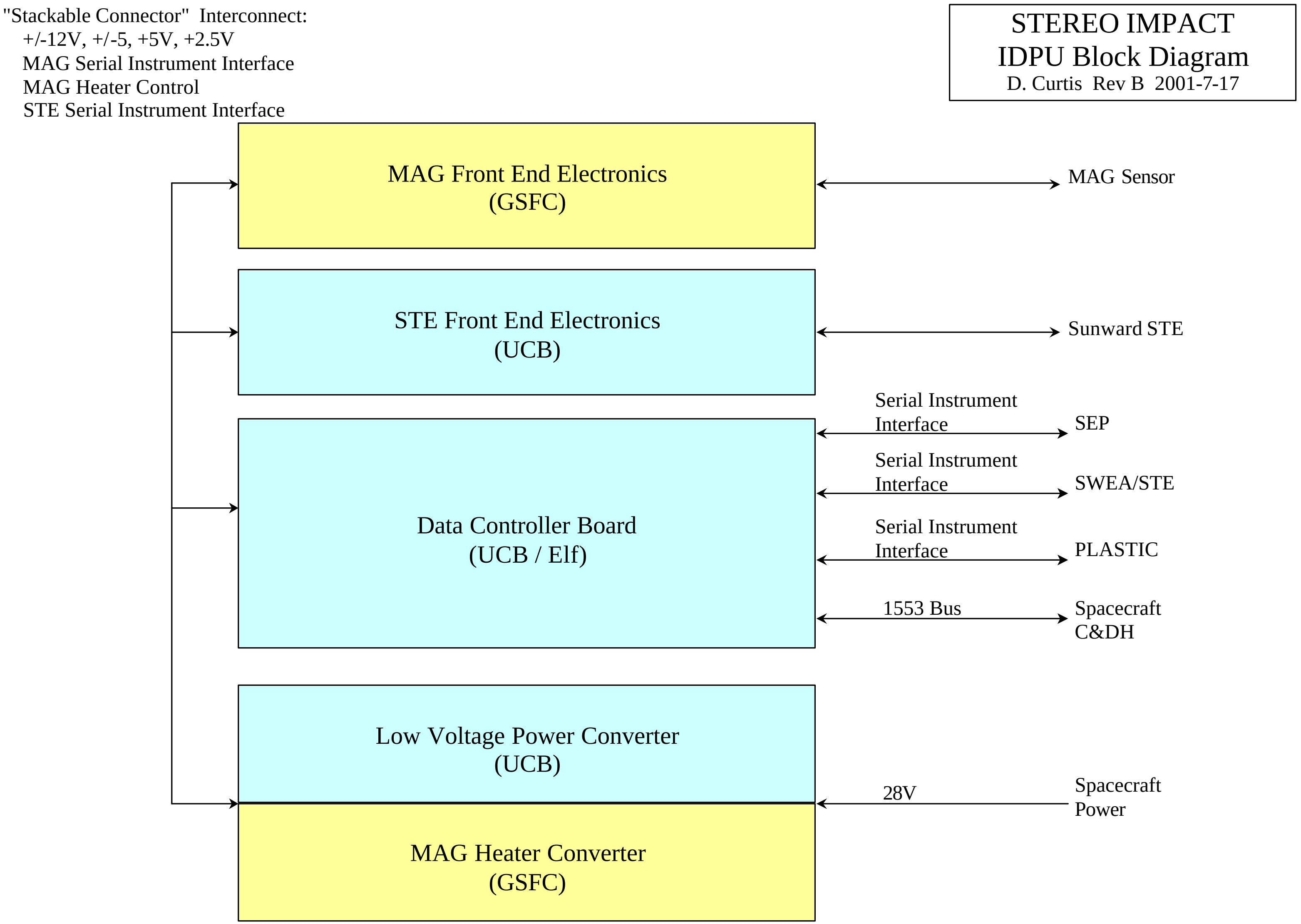
IDPU:	Packet Header	50
bps	Packet Collect Time	50
	Housekeeping	32
	Playback Beacon	32
	Burst Playback	486
	Total	650

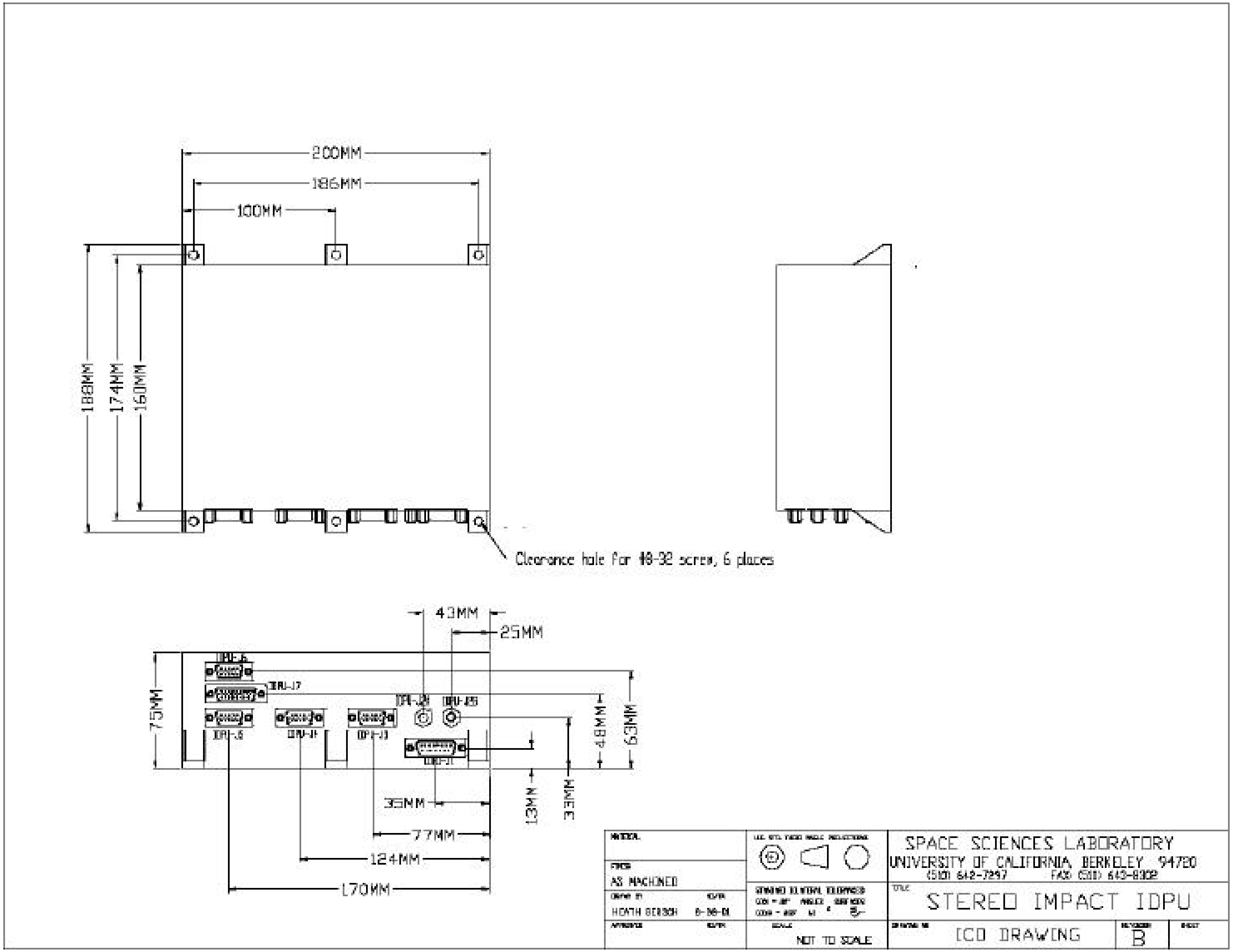
IDPU Responsibilities

- System Design – Dave Curtis
- MAG Analog – GSFC / Mario Acuna
- MAG Heater – GSFC / Mario Acuna
- LVPS – Peter Berg
- Data Controller Board, FPGAs – Elf / Dorothy Gordon
- STE Detector Interface Board – Steve McBride
- Mechanical Design – Heath Bersch
- Flight Software – Dave Curtis
- EGSE:
  - IDPU Simulator Hardware – Elf / Dorothy Gordon
  - IDPU Simulator Top Level Software – Mike Hashii
  - IDPU Simulator SWEA, STE, MAG Software – Mike Hashii
  - IDPU Simulator PLASTIC Software – UNH
  - IDPU Simulator SEP Software - Caltech
  - Command & Display GSE – Mike Hashii
  - SWEA, STE, MAG Science Displays – Mike Hashii
  - SEP Science Displays – Caltech
  - PLASTIC Science Displays - UNH

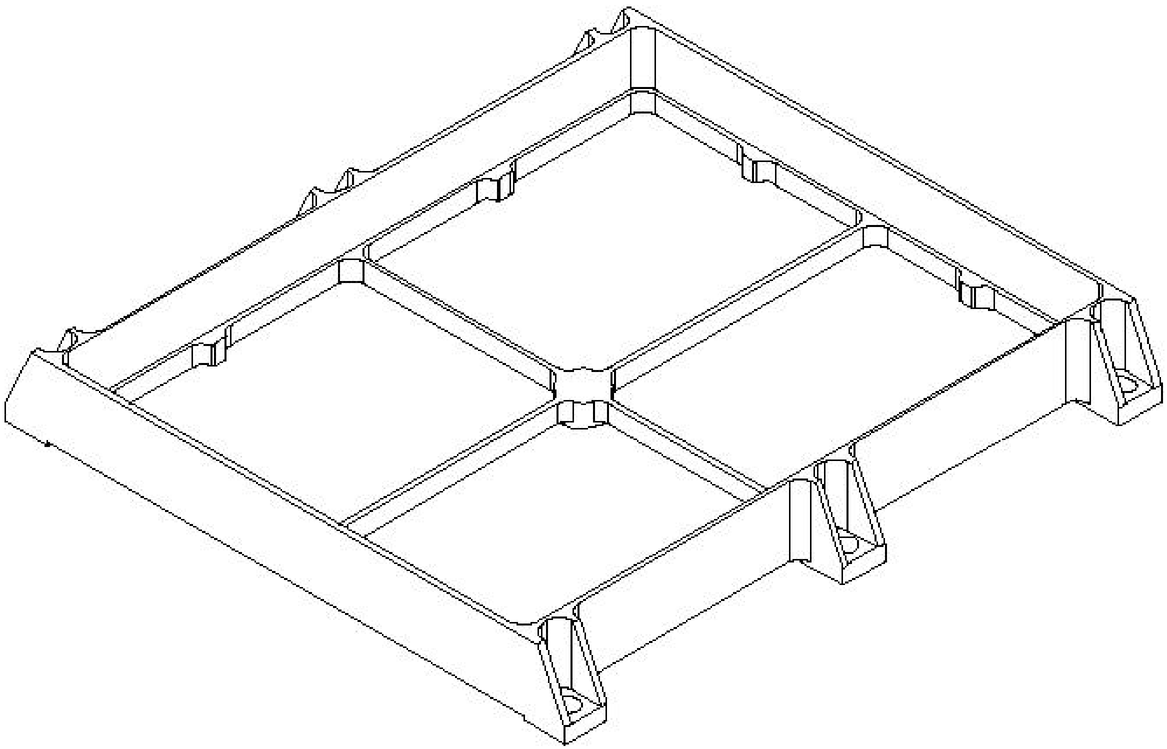
Controlling Documents

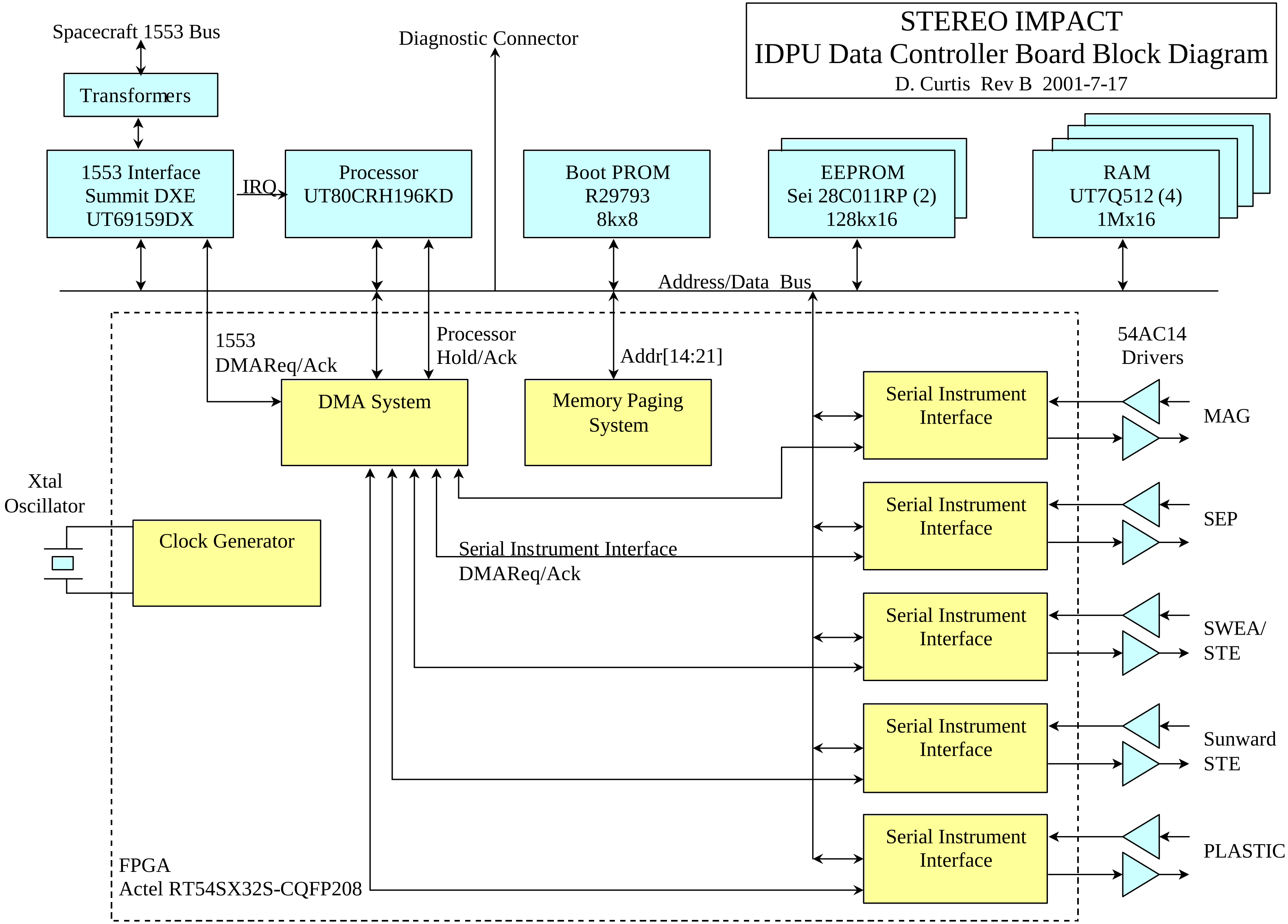
- IMPACT Performance Requirements Document covers Science Requirements on the IMPACT Suite
- IMPACT / Spacecraft ICD covers the spacecraft interface
- IMPACT Serial Interface document (ICD) covers the data interface between Instruments and the IDPU (including PLASTIC)
- IMPACT PAIP covers the performance assurance requirements
- STEREO EMC and Contamination Control plans
- IDPU Specification Document describes the IDPU (Data Controller Board) Hardware
- IDPU Software Requirements Document describes the Flight Software Requirements
- IDPU Software Development Plan described flight software development
- IDPU Simulator Specification covers the IDPU Simulator GSE Hardware


"Stackable Connector" Interconnect:
+/-12V, +/-5, +5V, +2.5V
MAG Serial Instrument Interface
MAG Heater Control
STE Serial Instrument Interface
STEREO IMPACT
IDPU Block Diagram
D. Curtis Rev B 2001-7-17
MAG Front End Electronics
(GSFC)
MAG Sensor
STE Front End Electronics
(UCB)
Sunward STE
Serial Instrument Interface
SEP
Serial Instrument Interface
SWEA/STE
Data Controller Board
(UCB / Elf)
Serial Instrument Interface
PLASTIC
1553 Bus
Spacecraft C&DH
Low Voltage Power Converter
(UCB)
28V
Spacecraft Power
MAG Heater Converter
(GSFC)


200MM
186MM
100MM
188MM
174MM
160MM
Clearance hole for #8-32 screw, 6 places
43MM
25MM
75MM
48MM
63MM
13MM
33MM
35MM
77MM
124MM
170MM
AS MACHINED
HEATH BERSCH
NOT TO SCALE
SPACE SCIENCES LABORATORY
UNIVERSITY OF CALIFORNIA, BERKELEY 94720
STEREO IMPACT IDPU
ICD DRAWING
B

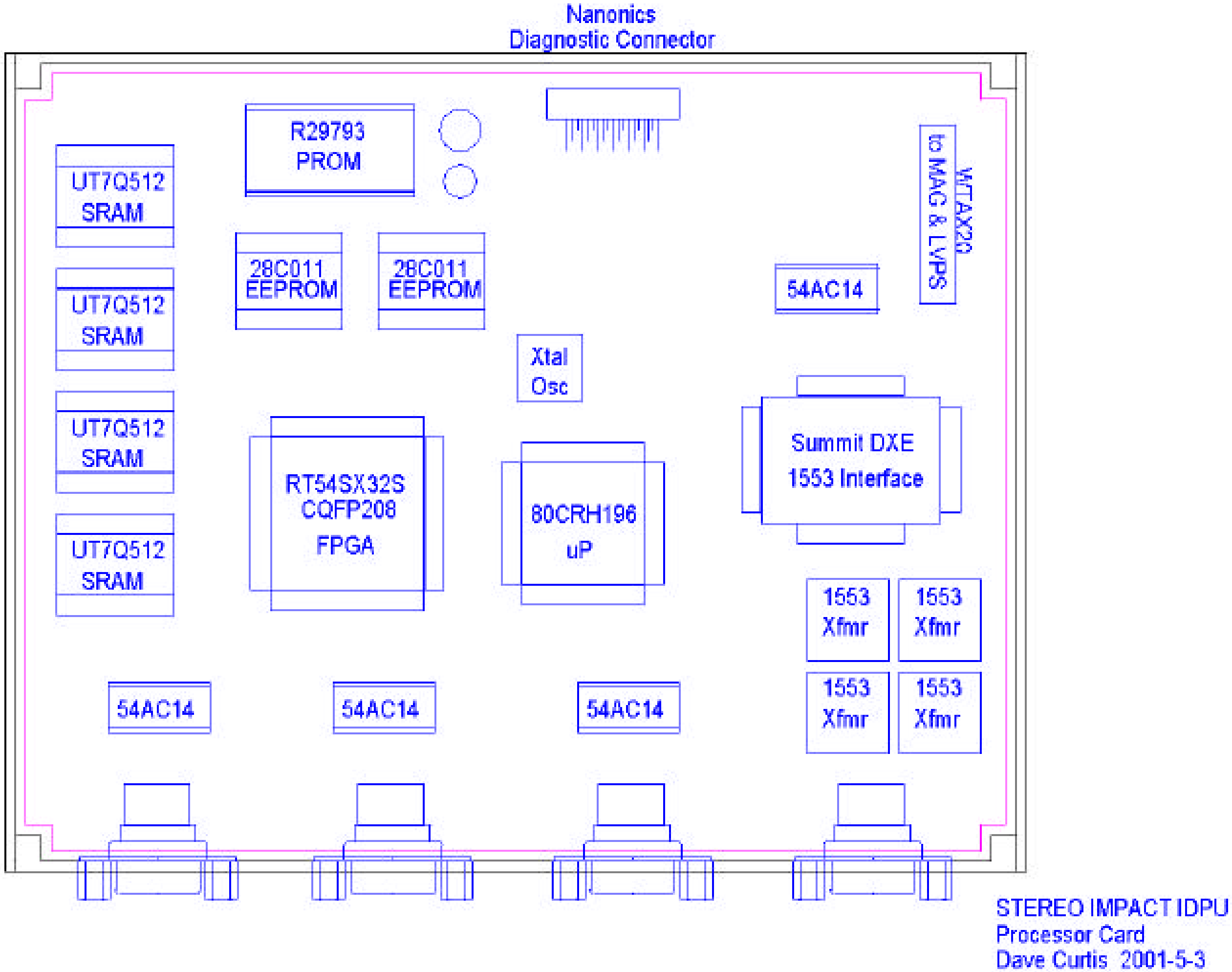
IDPU Card Tray





STEREO IMPACT
IDPU Data Controller Board Block Diagram
D. Curtis Rev B 2001-7-17
Spacecraft 1553 Bus
Transformers
Diagnostic Connector
1553 Interface Summit DXE UT69159DX
IRQ
Processor UT80CRH196KD
Boot PROM R29793 8kx8
EEPROM Sei 28C011RP (2) 128kx16
RAM UT7Q512 (4) 1Mx16
Address/Data Bus
1553 DMAReq/Ack
Processor Hold/Ack
Addr[14:21]
54AC14 Drivers
DMA System
Memory Paging System
Serial Instrument Interface
MAG
Xtal Oscillator
Clock Generator
Serial Instrument Interface
SEP
Serial Instrument Interface DMAReq/Ack
Serial Instrument Interface
SWEA/ STE
Serial Instrument Interface
Sunward STE
Serial Instrument Interface
PLASTIC
FPGA
Actel RT54SX32S-CQFP208

Data Controller Board Layout



Processor

- UT80CRH196KD available high-rel, rad-hard from UTMC
- 16-bit micro controller based on Intel design
- Can clock up to 20MHz; limited by low-power RAM access speed to 12MHz. Adequate throughput with generous margins (2x) at 8MHz.
- Low power processor with high speed ALU for computational tasks (SWEA and PLASTIC moment computations)
- 64Kbyte addressing requires a paged memory system
- Low Power standby mode allows extra processor margin to be designed in without wasting power (put processor to sleep when not being used)
- Built in watchdog timer
- Built in serial interface for diagnostics
- Processor Bus Arbitration scheme for Direct Memory Access scheme to get data in and out quickly with little processor overhead

Memory

- Boot PROM contains startup code and ability to reload EEPROM and RAM from ground command
  - 8 kbytes adequate; estimate about 5kbytes usage.
  - RAD Hard Bipolar PROM with power switch (off when not used)
- EEPROM contains normal operational code and look-up tables
  - 128Kx16 is huge over-kill; Estimate 18kbytes of flight code.
  - Sei rad tolerant package, low SEU rate, no SEL
  - In-flight reprogramable via Boot PROM
- 2Mbytes of static rad-hard RAM (UTMC 512K x 8), mostly for Burst memory plus some telemetry buffering

1553 Interface

- UTMC Summit part
  - RAD Hard, High Rel, Highly Integrated
- Connected to processor memory via DMA
  - Control tables
  - Data buffers
  - Low processor overhead

Data Controller Board FPGA

- Processor Interface Logic implemented in an FPGA
- Actel RT54SX32S baselined
  - Common FPGA selected for IMPACT team
  - Rad tollerant (100krads)
  - High Rel available
  - 2880 logic modules
- Actel specification to be developed by SSL (Curtis)
- Actel design to be developed/tested by Elf
  - Same arrangement & personnel used on HESSI
- Attention will be given to good Actel design practices

Processor Interface Logic

- **Instrument Serial Interface Implementation**
  - DMA telemetry into processor memory to off-load processor
- **Spacecraft interface glue logic (another DMA channel)**
- **Synchronous clock generation based on a 24MHz crystal**
  - 1553 interface (24MHz)
  - Processor clock (8MHz)
  - Serial interface clock (1MHz)
  - Sampling clock (divided down from 1MHz by instruments)
  - Processor Timing Interrupt (64Hz)
- **Memory Paging**
  - Processor 64kbyte addressing broken into four 16kbyte blocks
  - Each block can be paged into one of 128 RAM pages, or 16 EEPROM pages
  - Boot PROM comes in in boot page on reset

DPU Bus Arbitration - Latency and Loading Effects

Bus Client	CPU Bus Load (msec)	Max "Stackup" Delay (msec)	Allowable Delay (msec)	% Latency Margin
1553 Bus (SuMMIT)	2.04	0.7	5	86%
Plastic	13.5	1.2	16	92.5%
Mag	0.176	1.2	16	92.5%
SWEA	3.44	1.2	16	92.5%
STE-U	0.044	1.2	16	92.5%
SEP	0.086	1.2	16	92.5%

Total (Average) CPU Bus Loading due to SuMMIT/Telemetry DMA and associated overhead: 1.93%

Maximum time claimed by Hardware Subsystem during any CPU Bus Grant: approximately 3µsec
Maximum Instantaneous CPU Bus Loading due to SuMMIT/Telemetry DMA and associated overhead: 18%

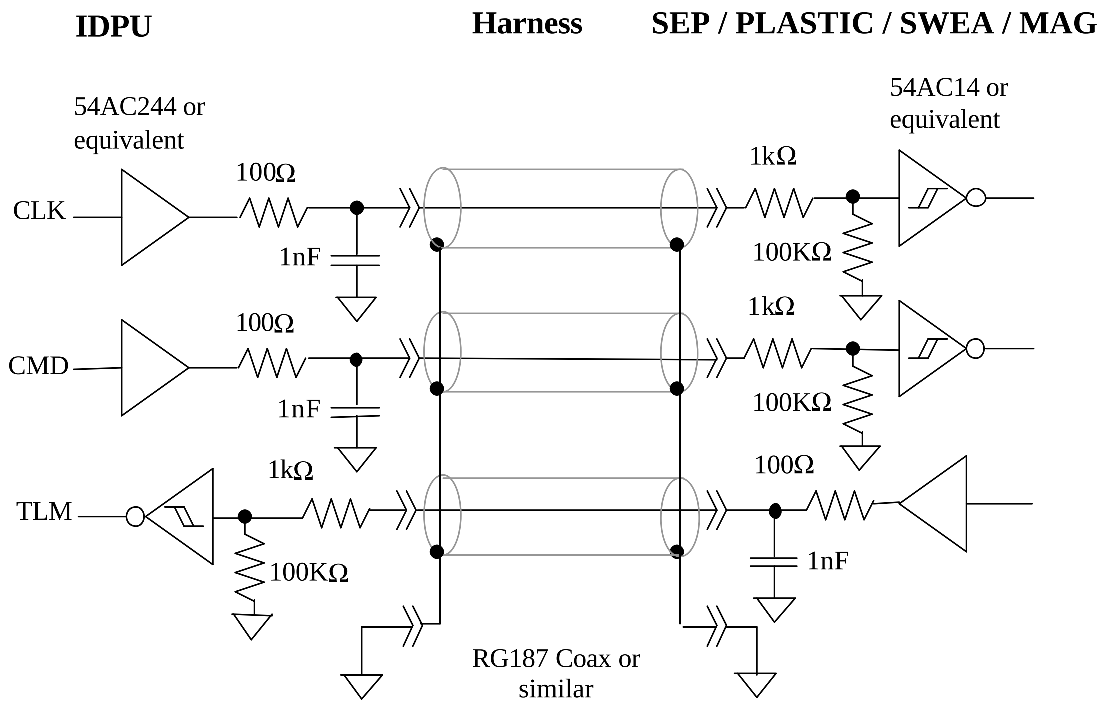
Calculations based on:

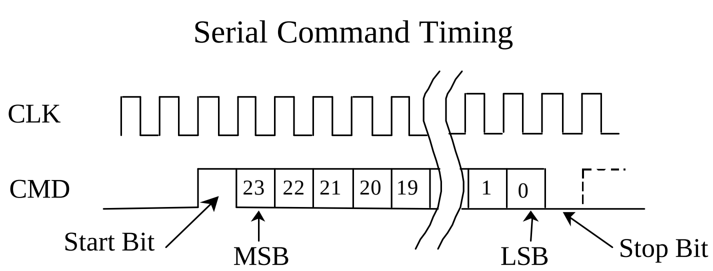
- Memory Arbitor running at 24MHz
- Each Memory Access incurs 2 Wait States
- SuMMIT is highest priority; telemetry clients are random priority; CPU is lowest priority
- Worstcase CPU Bus Loading calculation assumes separate bus negotiation is required for each DMA transaction
- SuMMIT is programmed for circular message queues, memory based interrupt logs, and non-buffered mode
- 1553 Bus Traffic: 20 (32 word) commands and 25 (32 word) telemetry messages per second

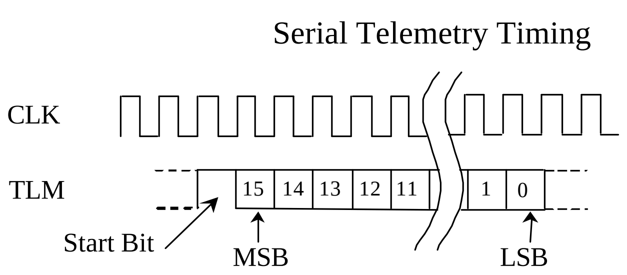
Serial Instrument Interface

- Interface between IDPU and MAG, SWEA/STE, SEP, PLASTIC, and STE-U
- As defined by IMPACT Serial Interface document
- Three-wire serial digital single-ended interface
  - Continuous 1MHz Clock
  - Serial Data Out (Command)
  - Serial Data In (Telemetry)
- R-C rise time limiters to reduce EMC
  - OK by Manning (SWAVES)
- Coax or shielded wire harness
  - Breadboard shows good waveforms and timing with an 8m harness
- No handshaking; system designed to handle maximum throughput at both ends
- No gating; start/stop bit synchronization like RS232
- 24 bit Commands in data out (8 bit ID, 16 bit data)
- Blocks of 16-bit Telemetry in
  - Blocks include an identifying header (5 bit ID, 10 bit block length)
- Synchronous 1-second time tic command

Serial Instrument Interface







STE Detector Interface and MAG Front End Boards

- **These board are housed in the IDPU box, but are logically part of the instruments, and are described in the STE and MAG sections.**
- **They are provided power by the IDPU LVPS, and are connected to the IDPU via Serial Instrument Interfaces identical to the remote instruments, but via internal connectors.**

IDPU Manufacturing, Integration, and Test Plans

- The IDPU Box, DCB, STE DIB, and LVPS are built at UCB
- The MAG Front End and heater controller are built by GSFC
  - MAG card tray provided by UCB
  - An IDPU simulator GSE allows the MAG to be tested and calibrated in a stand-alone mode prior to delivery to UCB for integration
- An ETU will be built prior to CDR
  - Verifies IDPU design prior to flight build
  - Verifying interfaces with instrument ETU
  - Flight Software Build #1 used for ETU tests
  - Used for subsequent Flight Software development
- Two flight units will be built following CDR, and integrated at UCB
  - The Boot code PROM and Flight Software Build #2 are installed at this time
- Vibration and Thermal Vacuum tests performed at the box level
- The final build of the flight software is acceptance tested and installed
- A series of interface tests with the instruments is made, followed by an EMC test of the suite.
- Prior to delivery, the IDPU is cleaned and baked out.

IDPU Verification Matrix

Revision Date: 8/23/01
Revision Number: 1

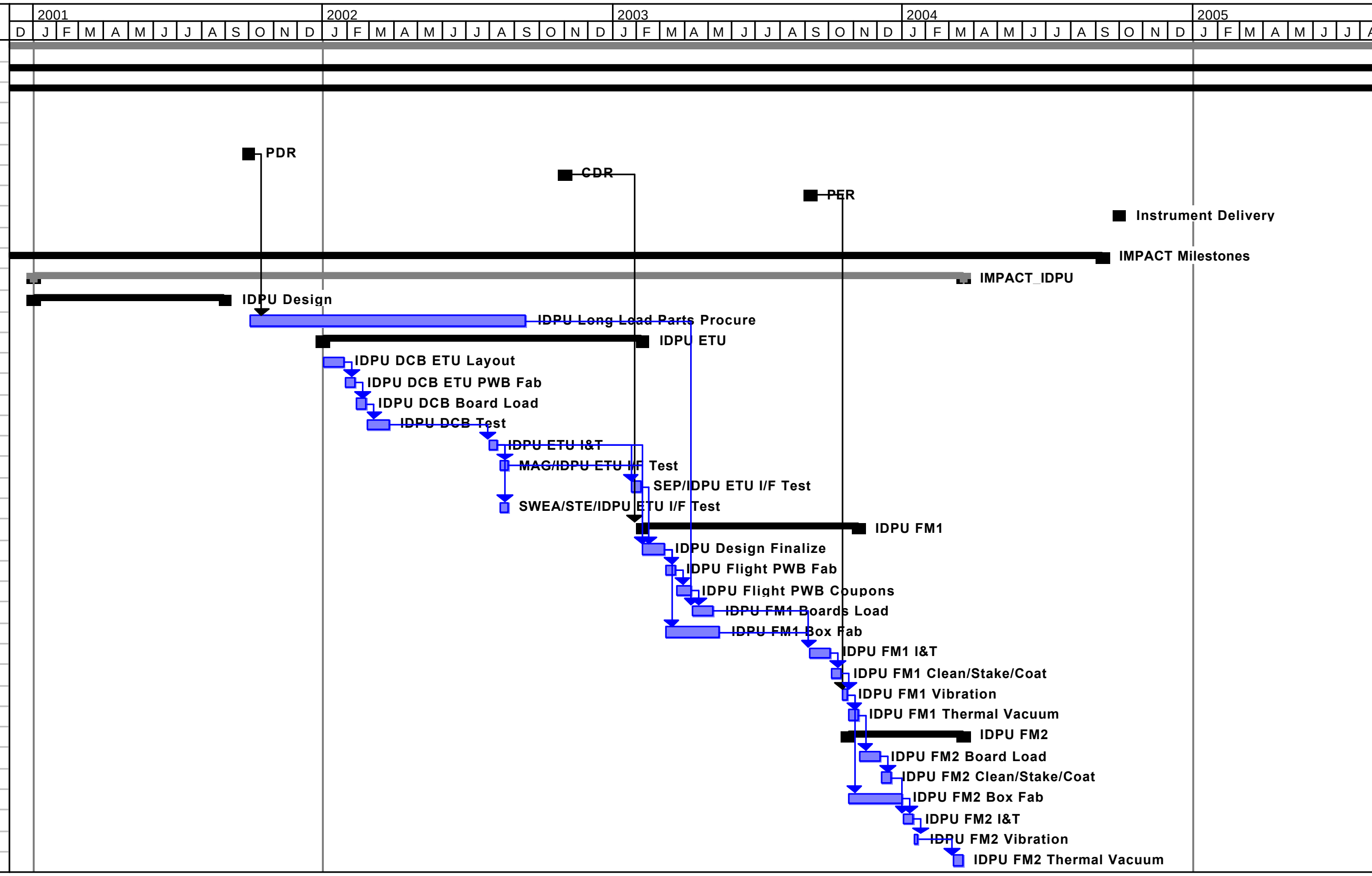
Hardware Description		Test																	
Level of Assembly	Item	Elect. test, rm. Temp	Elect. Test, hot	Elect. Test, cold	Vibration, Sinusoidal	Vibration, Random	Shock	Acoustics	Pressure change	Voltage margins	Thermal Vacuum	Thermal balance	>100 hours Operation	EMC/EMI	Magnetics	Leak	Bakeout	Contamination	Comments
C	PWB, EM	X								X									
I	IDPU EM	X	X	X						X			X	X					
C	PWB, F	X								X							X		
I	IDPU, F	X	X	X	X	X	X		A	X	X		X				X	X	EMC at Suite level

Legend:

Level of Assembly	Unit Type		Tests
			X = Test required
			A = Analysis
C = Component	BB =	Breadboard	
I = Instrument	EM =	Engineering Model	
	PT =	Prototype	
	PF =	Protoflight	

IDPU Schedule

ID	Task Name
1	**IMPACT_Milestones**
1	**Project Phases**
7	**Project Milestones**
8	IMPACT Phase A Contract
9	SRR
11	PDR
18	CDR
25	PER
32	Instrument Delivery
33	Launch
34	**IMPACT Milestones**
2	**IMPACT_IDPU**
1	**IDPU Design**
8	IDPU Long Lead Parts Procure
9	**IDPU ETU**
11	IDPU DCB ETU Layout
12	IDPU DCB ETU PWB Fab
13	IDPU DCB Board Load
14	IDPU DCB Test
15	IDPU ETU I&T
17	MAG/IDPU ETU I/F Test
20	SEP/IDPU ETU I/F Test
23	SWEA/STE/IDPU ETU I/F Test
26	**IDPU FM1**
27	IDPU Design Finalize
28	IDPU Flight PWB Fab
29	IDPU Flight PWB Coupons
30	IDPU FM1 Boards Load
31	IDPU FM1 Box Fab
35	IDPU FM1 I&T
36	IDPU FM1 Clean/Stake/Coat
38	IDPU FM1 Vibration
39	IDPU FM1 Thermal Vacuum
41	**IDPU FM2**
42	IDPU FM2 Board Load
43	IDPU FM2 Clean/Stake/Coat
44	IDPU FM2 Box Fab
47	IDPU FM2 I&T
48	IDPU FM2 Vibration
49	IDPU FM2 Thermal Vacuum



Low Voltage Power Converters

LVPS OVERVIEW

- INPUT IS SPACECRAFT 28 VOLTS (22-35 VOLTS NOMINAL)
- COMPLIES WITH 7381-9030 GUIDELINES
- DEDICATED SUPPLIES PER SUBSYSTEM
- TOPOLOGIES CHOSEN TO PROMOTE EFFICIENCY
- ALL SUPPLIES SYNCHRONIZED TO CRYSTAL CONTROLLED 100KHZ MULTIPLES
- SUPPLIES ARE SOFT STARTED TO MINIMIZE TURN-ON STRESSES – INPUT CURRENT CONTROLLED
- TRANSFORMERS FARADAY SHIELDED TO REDUCE ELECTROSTATIC NOISE

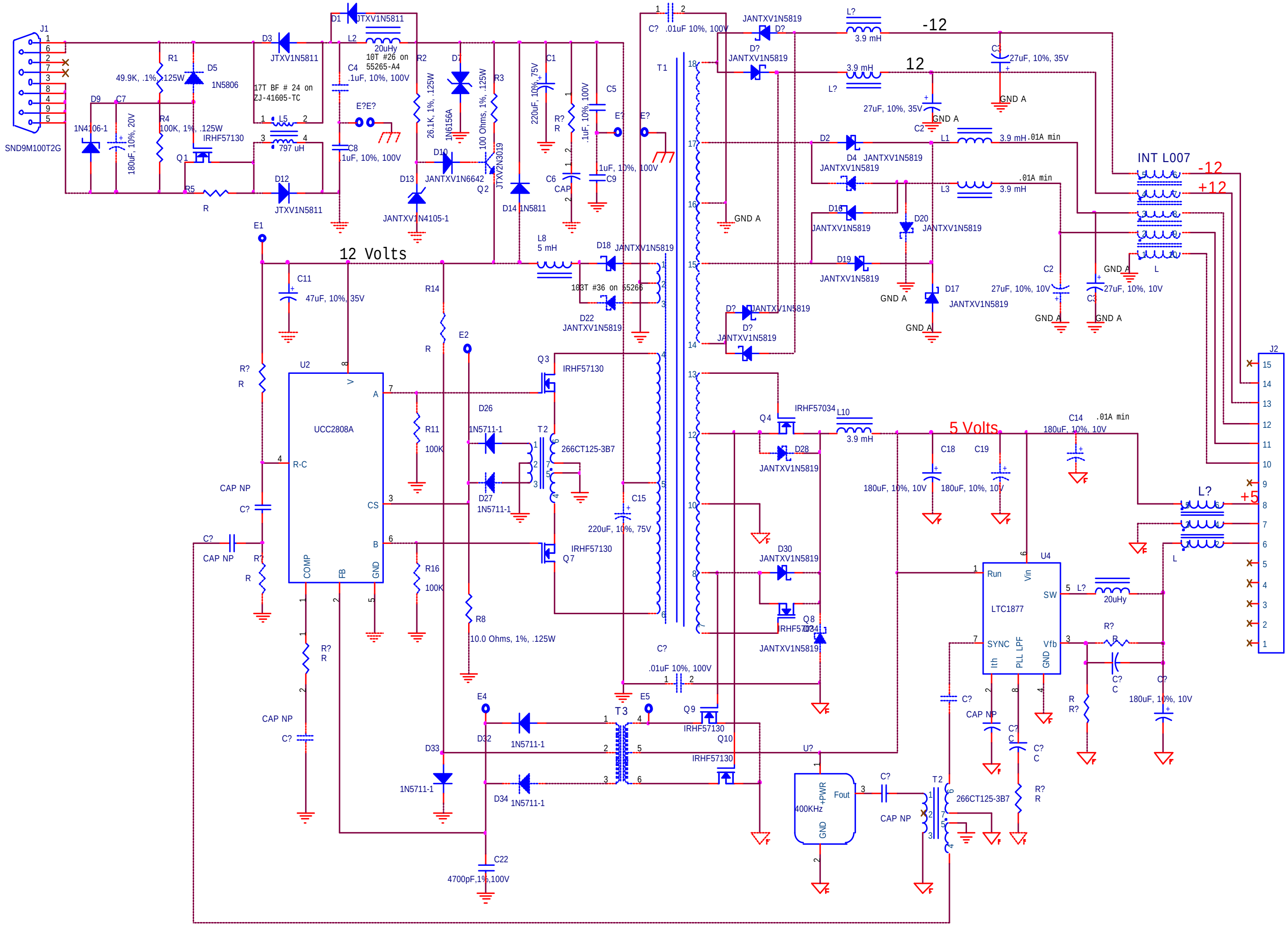
LVPS OVERVIEW CONTINUED

- INPUT TO SUPPLIES EMPLOYS BOTH COMMON MODE AND DIFFERENTIAL MODE FILTERS TO IMPROVE NOISE SUPPRESSION
- OUTPUTS EMPLOY COMMON MODE FILTERS TO IMPROVE NOISE SUPPRESSION
- INPUT IS SPACECRAFT 28 VOLTS (22-35 VOLTS NOMINAL)
- GENERATION 5 FETS USED FOR MAXIMUM EFFICIENCY
- USE SCREENED COTS INTEGRATED CIRCUITS

STEREO IMPACT

Preliminary Design Review
2001-September 11,12

IDPU LVPS



David Curtis

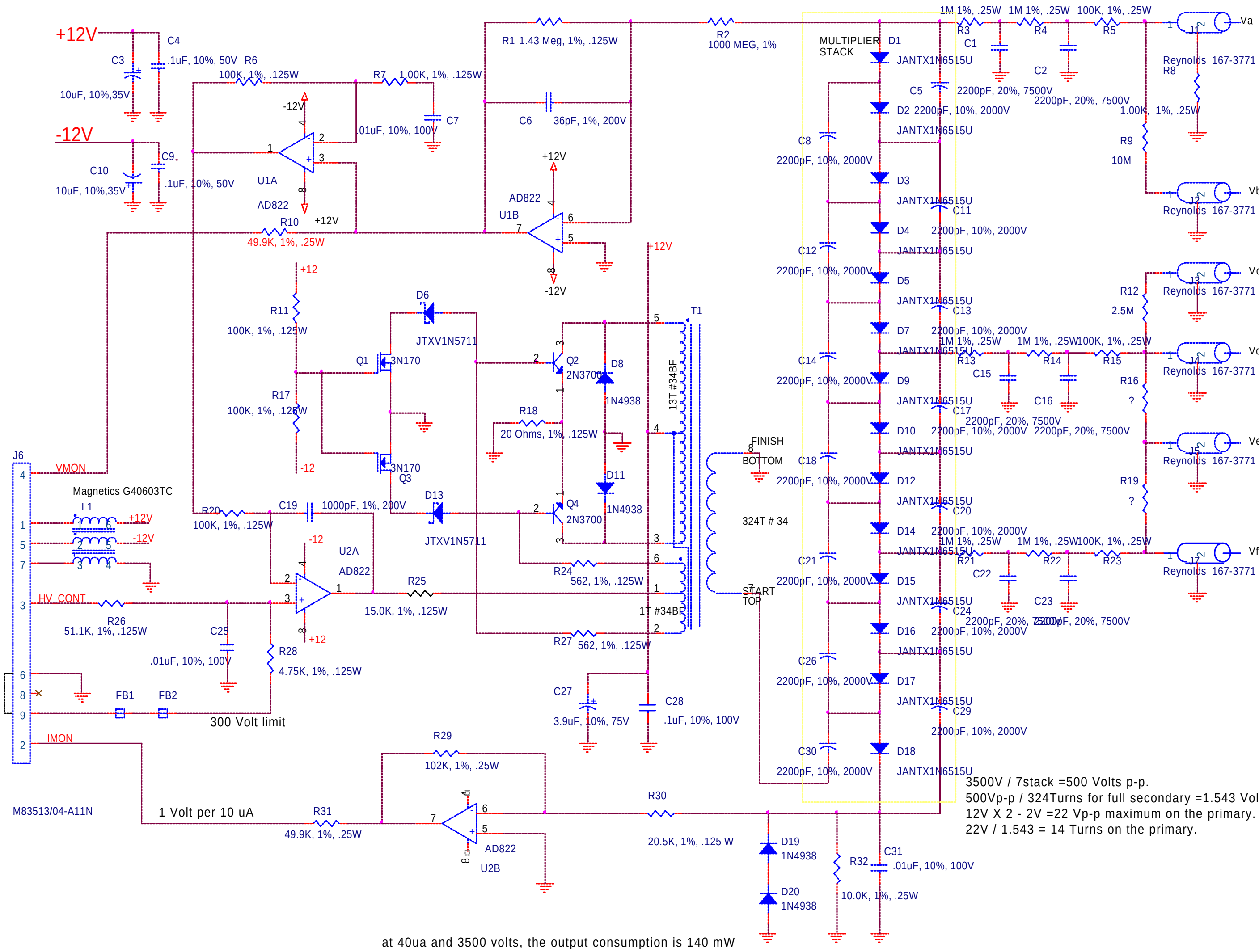
LVPS VOLTAGES

- **IDPU:**
  - ± 12 Volts Analog
  - ± 5 Volts Analog
  - -200 Volts Bias
  - +5V Digital
  - +2.5 Volts
  - Efficiency ~65%
  - Output Power = 2.5 Watts
- **SWEA:**
  - ± 12 Volts Analog
  - ± 5 Volts Analog
  - - 200 Volts Bias
  - +5 Volts Digital
  - +2.5 Volts
  - Efficiency ~60%
  - Output Power = 1.0 Watts
- **PLASTIC**
  - ± 12 Volts Analog
  - ± 5 Volts Analog / Digital
  - +2.5 Volts
  - Efficiency ~ 75%
  - Output Power = 7.11 Watts
- **SEP**
  - ± 12 Volts Analog
  - +5 Volts Analog
  - +7.5 Volts Analog
  - +3.3 Volts Digital
  - +5 Volts Digital
  - +2.5 Volts Digital
  - -5.2 Volts Digital
  - 3500V HVPS located in SIT
  - Efficiency ~ 65%
  - Output Power = 3.9 Watts

SIT HVPS

- SUPPLY IS SINE WAVE FOR LOWEST NOISE
- SIX OUTPUT TAPS, MAXIMUM VOLTAGE IS 3500 V
- RUNS AT ~ 65 KHZ
- INPUT IS ± 12 VOLTS FROM SEP SUPPLY
- OPERATES AT SEA LEVEL AND DEEP SPACE
- EFFICIENCY ~ 60 %

SIT HVPS



at 40ua and 3500 volts, the output consumption is 140 mW

FAB AND TEST NOTES

- MAGNETICS WOUND AT SSL
- HIGHER VOLTAGE MAGNETICS VACUUM IMPREGNATED
- CIRCUITS TESTED FOR STABILITY, REGULATION, NOISE AT TEMPERATURE, INPUT AND OUTPUT EXTREMES

POWER SUPPLY AVAILABILITY

- **ETU**

IDPU	6/02
SEP	7/02
SWEA	8/02
PLASTIC	11/02

- **FLIGHT**

FM1	6/03
FM2	12/03

POWER SUPPLY CONCERNS

- COMBINATION OF LOW POWERS, NOISE AND EFFICIENCY CREATE OPPOSING REQUIREMENTS
- RADIATION ENVIRONMENT
  - SOLUTION APPROACH
    - USE COTS PARTS AND SCREEN FOR PERFORMANCE AND/OR REPACKAGE
    - OVER CURRENT PROTECTION WHERE POSSIBLE

IDPU Flight Software

IDPU Software Requirements

- First draft of Software Requirements Document 6/01
- First draft of PLASTIC software requirements from UNH 6/01
- Top level requirements:
  - Support Spacecraft 1553 Interface per the Instrument ICD
  - Support Instrument Interfaces per the hardware and software specification
  - Collect, compress, and format telemetry data into CCSDS packets
  - Pass on mode-setting commands from the ground to instruments
  - Limited automation:
    - Set SWEA offset voltage to track spacecraft bias voltage
    - PLASTIC solar wind tracking and entrance system selection
    - MAG ranging
  - Instrument safing (response to HV anomaly, and spacecraft thruster/power down notifications)
  - Support a Burst memory system to collect high time resolution data for short intervals based on a burst trigger criteria
  - Share burst trigger data with SWAVES via RT to RT 1553 transfers

IDPU Software Architecture

- Use a simple custom polling loop operating system
  - Tasks requiring fast turn-around are associated with the timer or other interrupt
  - Slower tasks run out of a polled loop in foreground
  - No preemptive scheduling or dynamic memory allocation required
  - Similar to schemes used on many previous instruments
- Tasks are modular and as independent as possible
  - Especially PLASTIC, to allow independent operation by UNH
- Hardware designed to relieve software of most time-sensitive tasks
  - Instrument sequencers allow instruments to cycle independantly
  - DMA system collects data into IDPU memory automatically
- Code will utilize software watchdogs on each task, together with a hardware watchdog, to monitor operation
- Software will regularly re-load all instrument registers to protect against SEU
- On reset the system will boot from the boot PROM, which will then verify the contents of the EEPROM, and transition to EEPROM code. A new EEPROM or RAM code image can be loaded by the boot PROM from ground commands

MAG Software Requirements

- Average MAG data to 4 samples/second, format into CCSDS packets
- Format 32 sample/second data into CCSDS packets for Burst memory
- Average MAG data to 1 minute and pass to Beacon telemetry formatter
- Perform ranging functions to select one of two gains based on previous measurements (only expected to be used on the ground)

SEP Software Requirements

- Pass on all SEP command packets (by ApID) and Spacecraft Time via Serial Instrument Interface
- Pass on all Telemetry Packets received via Serial Instrument Interface to Telemetry packet queue
- Pass SEP Housekeeping data received via the Serial Instrument Interface to Housekeeping packet formatter
- Pass SEP Beacon data received via the Serial Instrument Interface to Beacon packet formatter

STE Software Requirements

- Initialize and periodically reload STE Energy to Accumulator look-up table via Serial Instrument Interface from IDPU EEPROM
- Initialize and periodically reload STE threshold DAC values via Serial Instrument Interface from IDPU EEPROM
- Log-compress counters and format into CCSDS packets to pass to the Burst system
- Time Average and Log Compress counters and format into CCSDS packets for real-time telemetry
- Time and Space Average and Log Compress counters and pass to Beacon telemetry formatter

SWEA Software Requirements

- Initialize and periodically reload SWEA voltage waveform look-up table via Serial Instrument Interface from IDPU EEPROM
- Initialize and periodically reload SWEA control registers via Serial Instrument Interface from IDPU EEPROM
- Accumulate raw counter measurements into a three-dimensional distribution measurement
- Compute Moments, Pitch Angle Distributions and Full 3D distributions with desired time and space resolution and format into CCSDS packets for the Burst, Real Time, and Beacon telemetry streams
- Adjust SWEA bias voltage based on measured distribution function to offset spacecraft charging effects

PLASTIC Software Requirements

- Instrument Control Tasks:
  - Decoding and routing instrument mode and table load commands
  - Controlling the energy at which apertures are switched based on measured count rates
  - Controlling "Solar Wind Tracking Mode" when Bursts are triggered to get high time resolution data
  - HV safing in response to an Arc
- Data Tasks: Collect, compress, and format
  - Housekeeping data
  - Monitor Rate data
  - Matrix data (from the classification board)
    - Proton and Alpha Moments
    - Reduced Proton and Alpha Distributions
    - Heavy Ion Distributions
  - Raw Event Data
    - Event Prioritization
  - Beacon Mode data

Burst System Requirements

- High time resolution sampling of selected data
  - MAG @ 32Hz
  - SWEA, STE at 2 seconds
  - PLASTIC H,He at 4 seconds
- Continuous data collection into a circulating buffer
  - PLASTIC burst mode must be triggered, and so is not continuously recorded
  - Buffer sized for on the order of 10 minutes of high time resolution data
- Continuous evaluation of burst trigger criteria based on instrument data
  - Trigger on changes in SWEA count rate in a selected energy band
  - Trigger cooperatively with SWAVES based on SWAVES activity
- Freeze collection buffer a fixed interval after the trigger event to provide data both before and after the trigger
- Continue to look for more triggers,saving the "best" event in the time interval between burst playback
  - Play back burst data using a fraction of the normal telemetry on a continuous basis.

IDPU Flight Software Resource Estimates

Task	Processor Cycles, %	Code Size, kbytes	Buffer Memory, kbytes
Service Software:			
Operating System	1%	0.3 (b)	32.0
1553 Interface	1%	3.0 (b)	8.0
Command Router	<1%	0.7 (b)	10.0
Telemetry Packet Queue	<1%	0.3 (b)	10.0
Burst System	1%	1.0	1500.0 (*)
Serial Instrument Interfaces	1%	0.5	75.0
Housekeeping	<1%	0.2 (b)	0.6
Beacon Telemetry	<1%	0.2	0.6
Event Logging	<1%	0.3 (b)	0.6
Safing	<1%	0.5 (b)	0.3
MAG Software	1%	0.5	1.2
SEP Software	1%	1.0	2.5
SWEA Software:			
SWEA Moments	20%	1.0	17.0
SWEA Distributions	4%	2.5	10.8
SWEA Misc.	1%	1.0	2.5
STE Software	1%	1.0	3.7
PLASTIC Software:			
PLASTIC Distribution	6%	2.0	185.6
PLASTIC PHA	5%	0.5	46.6
PLASTIC Moments	5%	1.0	45.6
PLASTIC Misc.	1%	1.0	2.5
Total	**55%**	**18.0**	**1955.1**
Available	100%	32 (**)	2048
% Usage	55%	56%	95%

(*) Nominal value. Burst memory will expand to use all unallocated memory space.

(**) 32K is maximum code that can be paged into memory at one time. Paging code in and out is a complication, but possible.

(b) To be included (at least in part) in Boot PROM. PROM = 8kbytes, usage = 66%

Software Development Plan

- First draft Software Development Plan 8/01
- IDPU Flight Software to be developed at UCB by a single programmer
- Code to be developed in modular, structured assembly code
- Software to be developed and tested on the ETU IDPU, with ETU Instruments or simulators
- Software to be tested at the module level, then at the IDPU level in an acceptance test, and finally at the system level in interface and suite tests
- Software to be developed in builds of progressing complexity:
  - First Build to test processor hardware
  - Second build provides at least minimal functionality required to verify suite hardware (without automation and more complex telemetry products)
  - Third build should be for Flight
- Prior to installation in the flight hardware, code is maintained using a log book which contains the development history, testing, problems, etc.
- Following installation in flight hardware, software is under the same control as the hardware (configuration control, problem reports, etc.)

Software Development Tools

- Use Commercial Phyton PC-based 80C196 development tools
  - Assembler/Linker
  - Simulator (for early module testing)
- ROM Emulator (for fast testing)
- Logic analyzer (for those subtle timing problems)
- ETU Data Controller Board
  - Note that IDPU Simulator GSE is based on the same architecture as IDPU DCB (commercial 80C196KD with similar memory and FPGA); can be used for early software development and test
- EGSE:
  - APL Spacecraft Emulator
    - UCB-developed Command and Telemetry GSE
    - UCB-developed Science Display GSE (MAG,SWEA,STE)
    - SEP, PLASTIC Science Display GSE
  - UCB-developed Instrument Simulator
  - Instrument ETUs
  - UNH-provided PLASTIC simulator

Software Development Schedule

• Software Development Plan	PDR (9/01)
• Software Requirements Document(s)	PDR (9/01)
• Software Requirements Review	12/01
• Software Design Complete, start Coding	1/02
• First Build Complete, ETU Available	8/02
• Software Design Review (part of CDR)	CDR (11/02)
• Critical Code Walkthrough / Acceptance Test Review	6/03
• Boot PROM Acceptance Test	8/03
• Boot PROM Install in DCB of FM1	9/03
• Second Build Complete	9/03
• Third Build Complete, Acceptance Test	3/04

Ground Support Equipment

IDPU Simulator GSE

- Developed at UCB (with Elf)
- Provides ability to test instruments in the absence of the IDPU and verify the instrument/IDPU interface
- Consists of a black box (IDPU Simulator GSE, ISG) plus a PC
- ISG includes most of the functionality of the Data Controller Board, minus the 1553 interface
  - Includes a commercial 80C196 processor, FPGA with an early version of the flight DCB FPGA
  - Interfaces with PC via the printer port
  - Designed to IDPU Simulator Specification Document by Elf (who also designs the DCB)
  - Can be used as a test bed for IDPU software
  - Has an added Instrument Simulator feature which works the serial instrument interface in the reverse direction for IDPU testing
- PC software shall be developed at UCB
  - Based on LabWindows CVI development system
  - HESSI GSE heritage; STOL-like scripted command system
  - Science display modules written at the instrument home institution

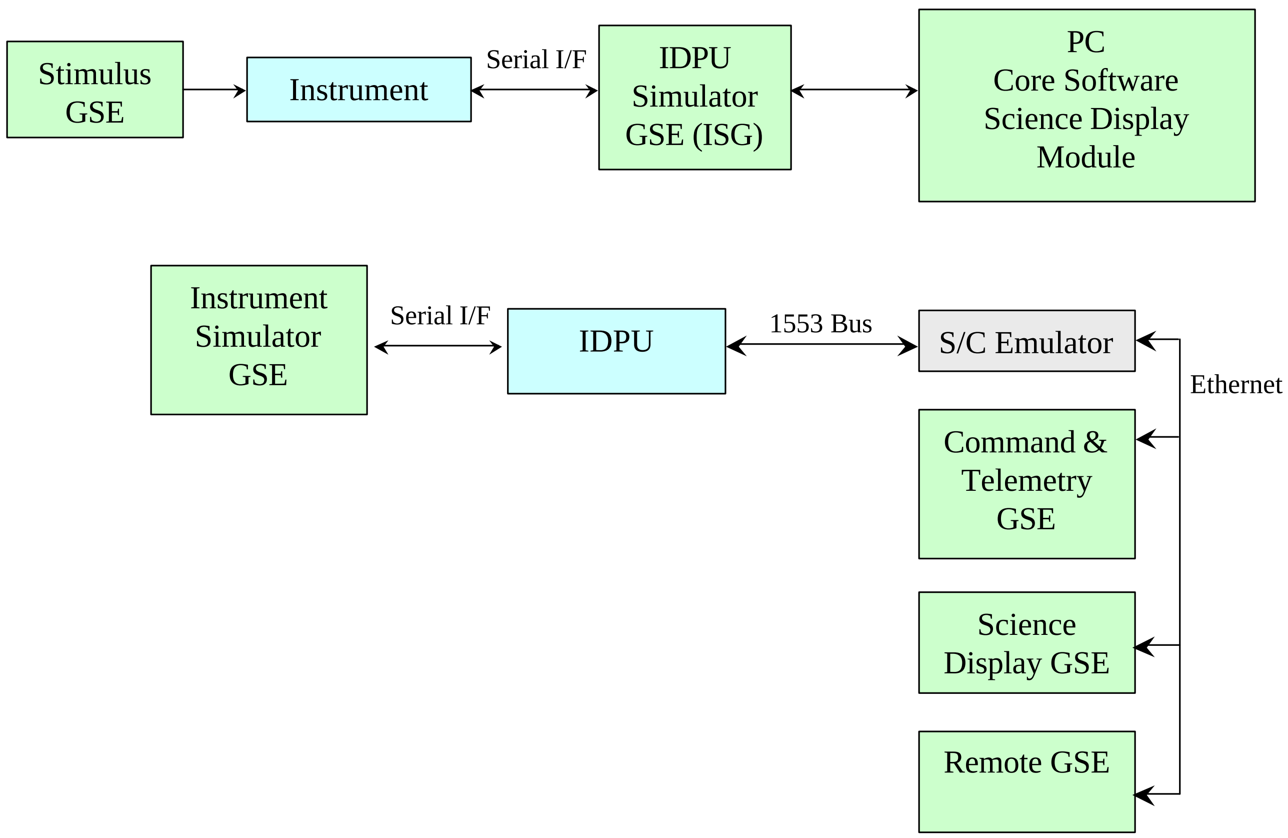
Command & Telemetry GSE

- Works with Spacecraft Emulator at suite I&T level
- Works with MOC at Spacecraft I&T level
- Runs commands and command scripts
  - STOL-like language
- Remote commanding & display via secure internet connection
- Displays housekeeping and instrument status information with limit-checking / alarms
- PLASTIC command scripts may be run on the IMPACT C&T GSE, or on a separate C&T GSE running the same software

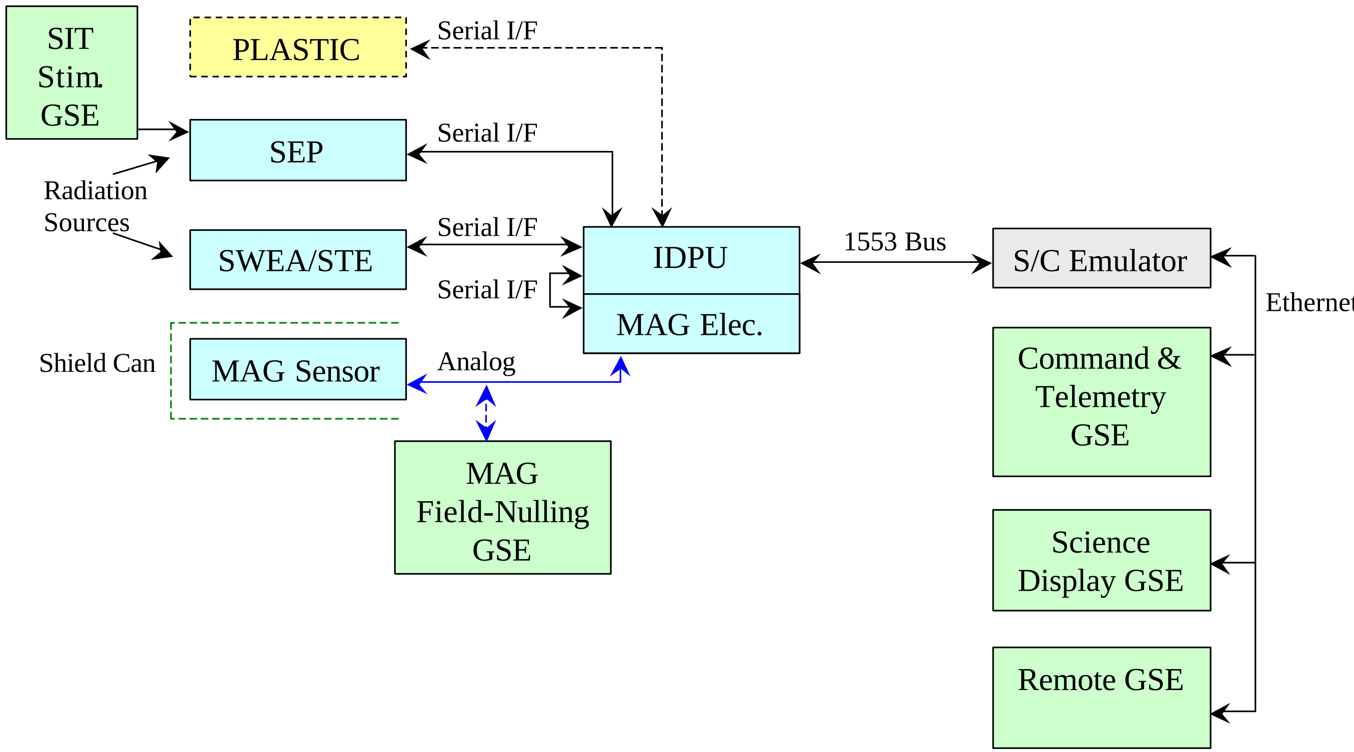
Science Display GSE

- **Decodes and Displays science data from instruments**
- **Provides adequate information to determine the health and functionality of the instrument in the I&T, Commissioning, and mission environment**
- **Runs on a second workstation (PC) in order to provide more display space, separate science and engineering functions, and improve the reliability of the C&T system**
- **Science Display GSEs will get data from the MOC or Spacecraft Emulator**
- **Science displays shall be developed by the instrument teams:**
  - **MAG, SWEA, STE – UCB / Hashii**
  - **SEP – Caltech**
  - **PLASTIC – UNH**

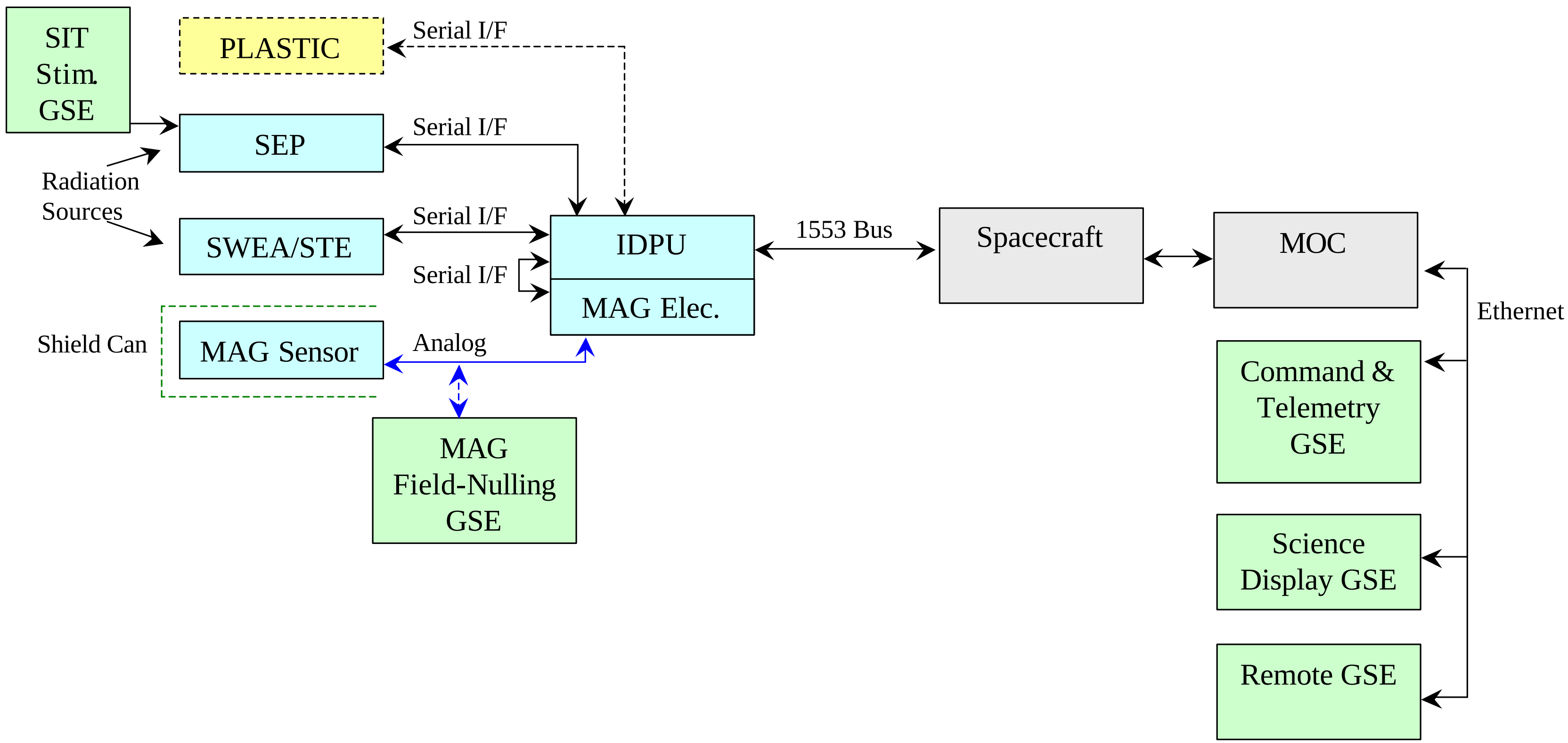
Instrument Bench Checkout Configuration



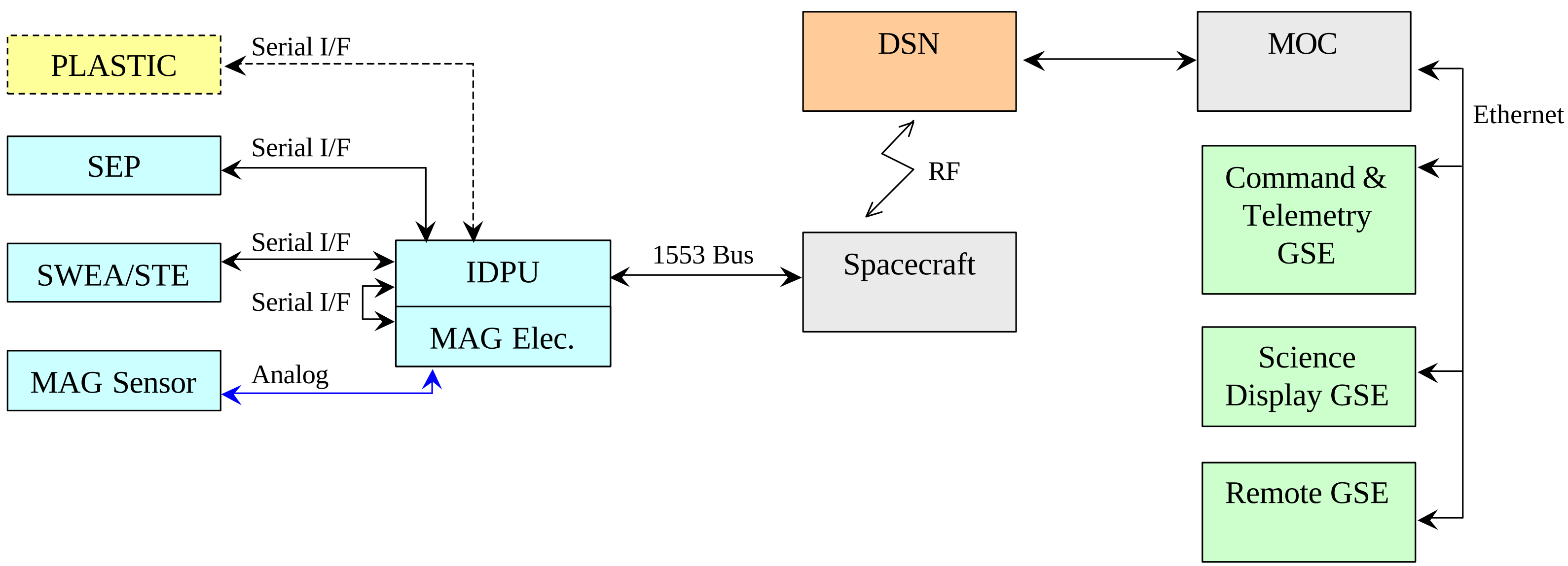
IMPACT Suite Integration GSE Configuration



IMPACT Spacecraft Integration GSE Configuration



IMPACT Mission Operations GSE Configuration



GSE Software Development

- The IMPACT IDPU Simulator, Command & Telemetry, and Science GSE are PC-based systems running LabWindows-CVI based software
- The software is based on a long series of GSE developed at Berkeley, most recently for Lunar Prospector and HESSI.
- The software is modularized so that much of the existing code will be usable
- The software already has most of the features required (user interface, command scripting, database-driven command encoding and telemetry decoding, TCP/IP data interface, data decommutation and limit-checking, some science displays)
- The programmer who developed the most recent version of the GSE (HESSI) is base-lined to develop the IMPACT version.

SUITE INTEGRATION AND TEST

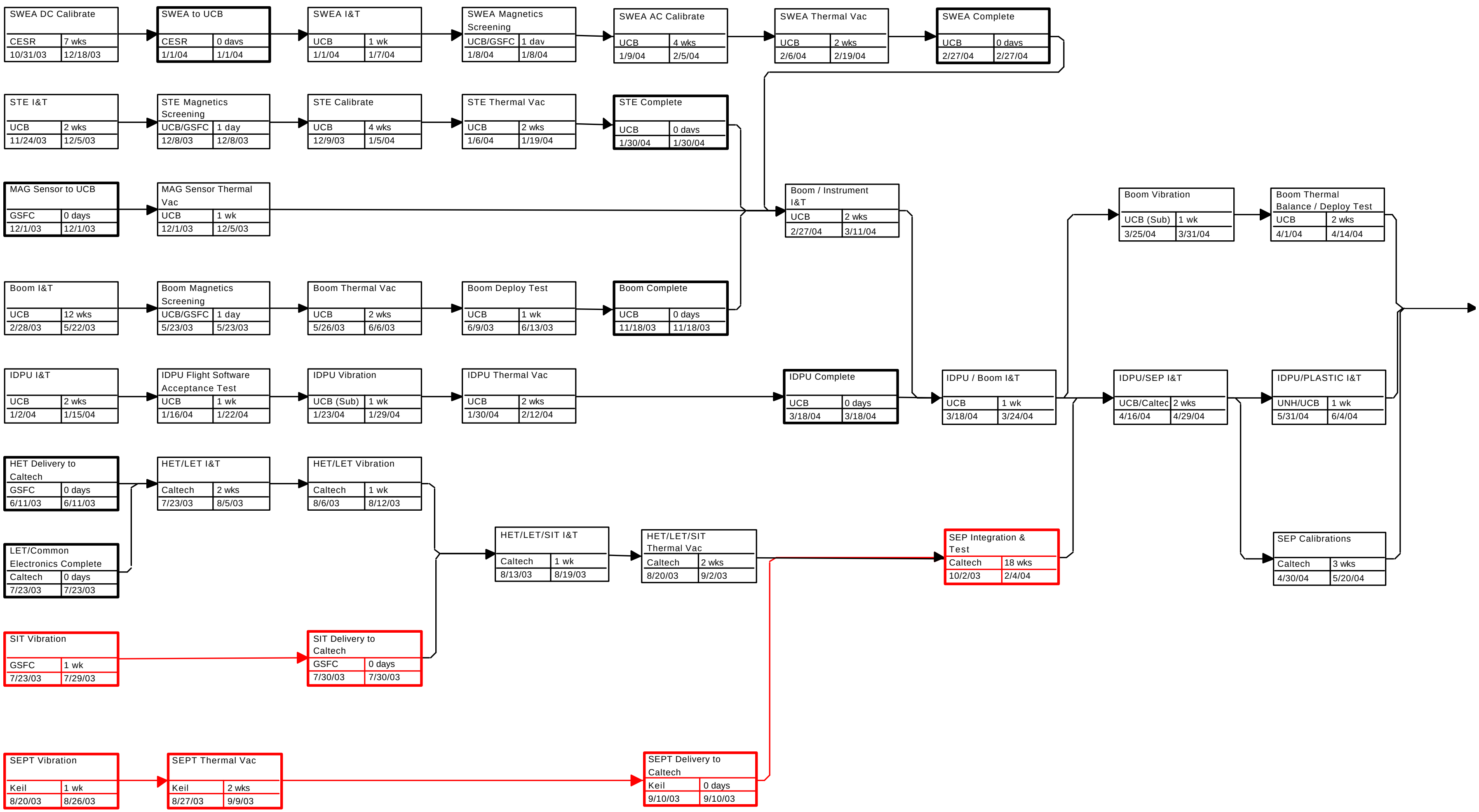
Verification Matrix

- The verification matrix will consist of the instrument performance requirements matrix plus selected functional and environmental requirements to verify compliance with the documented Mission Environmental Requirements and ICD
  - Performance Requirements listed above. Most will be verified during calibrations or by analysis
  - Functional Requirements to be verified by a Comprehensive Functional Test, mostly aimed at verifying electrical functionality and compliance with the electrical interfaces in the ICD
  - Software Requirements to be verified in a system-level acceptance test prior to committing to Flight Hardware
  - Environmental requirements shall be verified by test or analysis as described in the Verification Plan, outlined below.

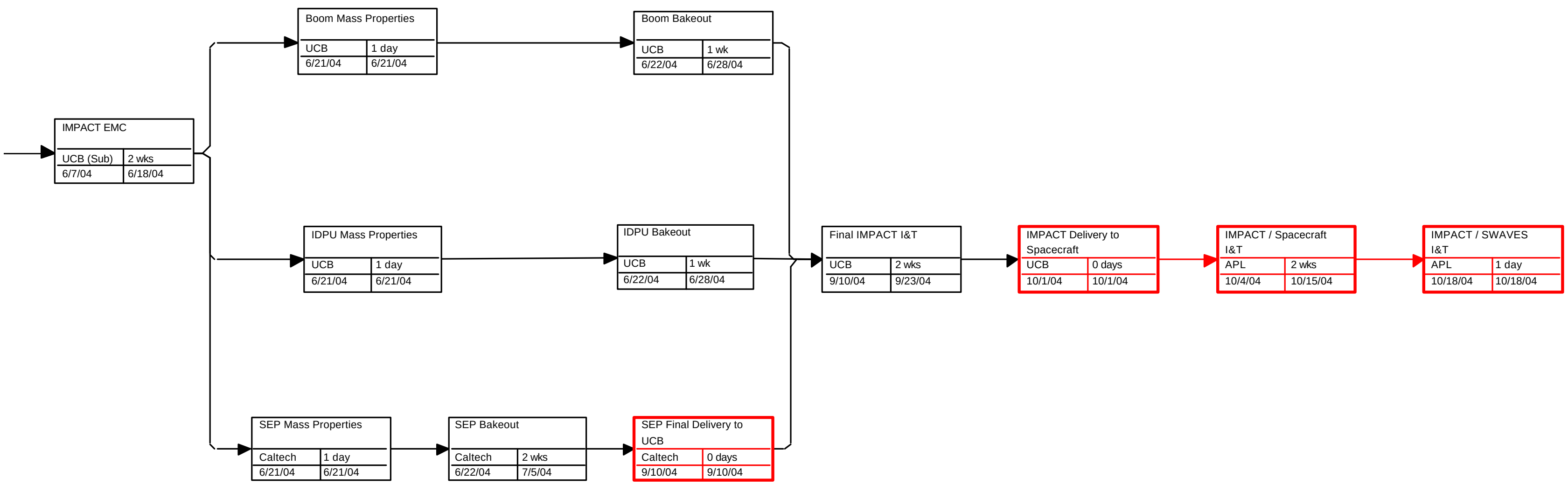
Suite Environmental Test Matrix

System	EMC	Bakeout	Thermal Vac Cycling (Op/NonOp)	Thermal Balance	Sine Vib	Random Vib	Mass props	Failure Free Hours
SEP								
- SEPT-NS		√	-15 - +10C -25 - +30C	TBR	√	√	√	
- SEPT-E		√	-15 - +10C -25 - +30C	TBR	√	√	√	
- SIT		√	-15 - +10C -25 - +30C	TBR	√	√	√	
- HET, LET, Common Elec.		√	-15 - +10C -25 - +30C	TBR	√	√	√	
Boom Assy		√		TBR	√	√	√	
- Boom	Mag Screening		TBD					
- SWEA	Mag Screening		-25 - +30C -30 - +50C					
- STE	Mag Screening		-50 - -30C -50 - +40C					
- Mag Sensor			-20 - +45C -20 - +45C					
IDPU		√	-23 - +55C -30 - +60C		√	√	√	
Flight Harness		√						
IMPACT Suite	RS,RE,CS,CE per EMC Requiurements							100

Integration & Test Flow



Integration & Test Flow (Continued)



SEP I&T

- Four instruments tested separately to the extent possible
  - LET at Caltech/JPL
  - HET at GSFC
  - SIT at UMd/GSFC
  - SEPT at Kiel
- SEP Common integrated & tested at Caltech
  - Low Voltage Power Supply from UCB
  - Detector bias supply from Space Instruments
  - Analog/post-reg board from Space Instruments
  - Logic board from Caltech
  - Mechanical parts from GSFC
- SEP Common/IDPU interface test at UCB and/or Caltech
- Integrate into SEP system at Caltech
- Test SEP at Caltech
- Vibration/Thermal vac/Thermal balance at JPL
- EMI/EMC at UCB with the IMPACT suite

Suite I&T Flow

- **Boom Suite:**
  - SWEA fabricated & calibrated at CESR, delivered to UCB
  - SWEA integrated with interface electronics, tested, Thermal Vac tested at UCB
  - STE fabricated, calibrated, thermal-vac tested at UCB
  - MAG sensor fabricated, calibrated, thermal-vac tested (?) at GSFC
  - Boom fabricated, tested, thermal vacuum tested, vibrated at UCB
  - Boom/MAG/SWEA/STE integrated at UCB
  - Boom vibrated, thermal balance, mass props, baked out as a suite
- **IDPU**
  - MAG analog fabricated, tested, calibrated at GSFC
  - LVPS, DCB, DIB, box fabricated and tested at UCB
  - IDPU Integrated, tested, thermal vac tested, mass props, vibrated at UCB
- **IMPACT Suite:**
  - Suite integrated at UCB, functional & EMC testing (with PLASTIC)