STEREO IMPACT

Selected viewgraphs from

Janet Luhmann's Nov 2002 CDR presentation

IMPACT / SIT: science impact of a loss of the SIT measurements

Glenn Mason, University of Maryland

using material from the CDR presentation of:

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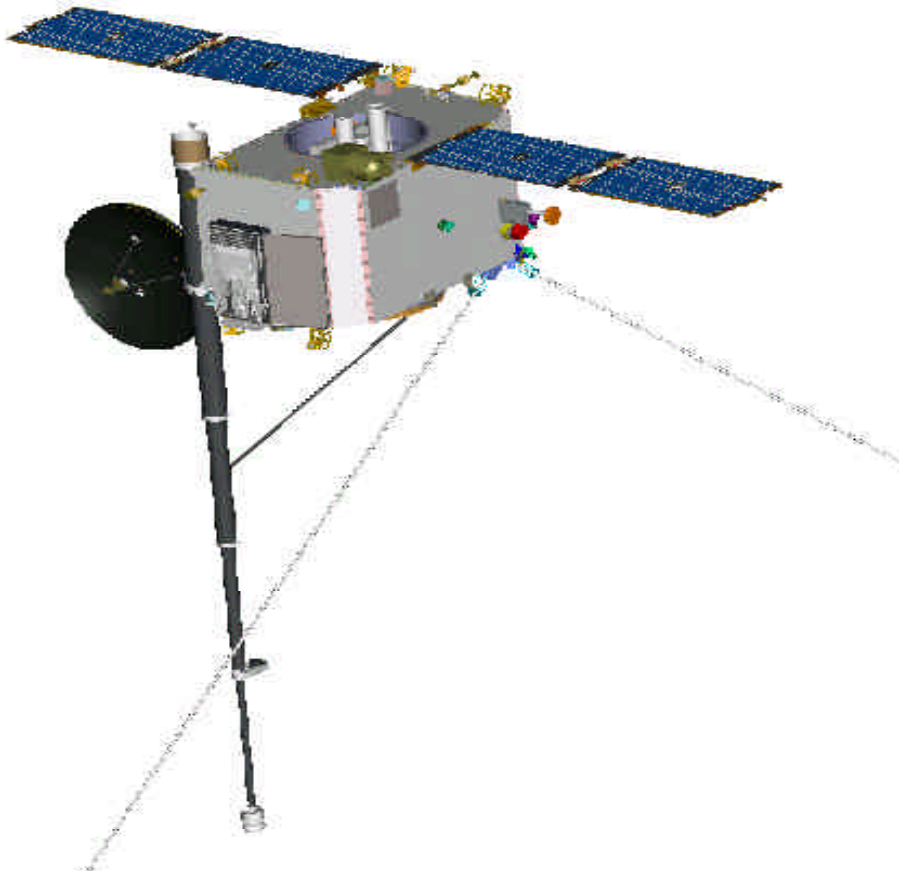
Note: my comments added to Janet's slides are in green

Summary

- **SIT measures ion composition in the energy range between PLASTIC and LET (see page 12)**
  - **Loss of SIT will eliminate ion composition measurements in this range, leaving only SEPT's proton measurement**
- **MRD Level 1 Science Requirements relating to SEP (F&G) are fairly broad, and only refer to composition in the derived "Instrument Requirements" column as a "heavy ion" measurement**
  - **Without SIT the heavy ion measurement will be lacking for part of the energy range specified under Instrument Requirements.**
  - **It could be argued that the SEP suite without SIT could still do a fair job of meeting the Science Requirements. (see page 10)**
- **As part of the reliability assessment it was determined that the SWAVES measurement can meet the those top level science requirements (F&G – see last page).**

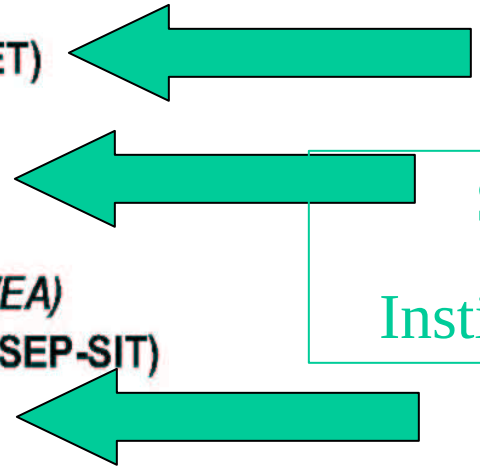
IMPACT (In-situ Measurements of Particles and CME Transients) Instrument Overview

- **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)
- **Support:**
  - IMPACT Boom
  - SEP Central
  - Instrument Data Processing Unit (IDPU)

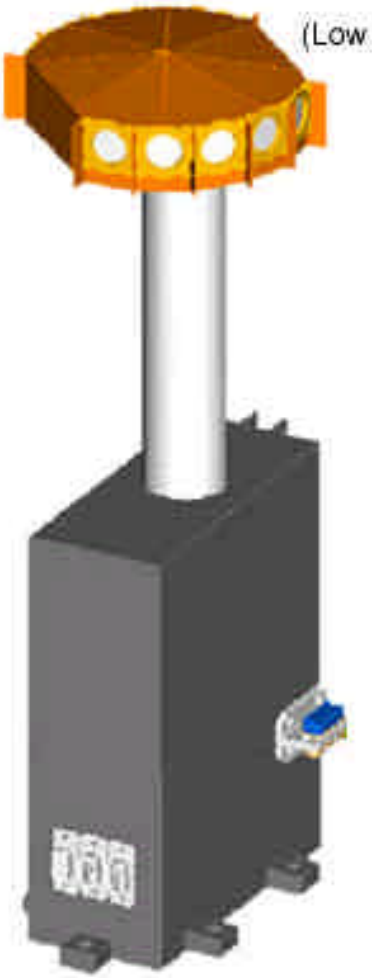


IMPACT Team Member Institutions and Primary Roles

- 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)*

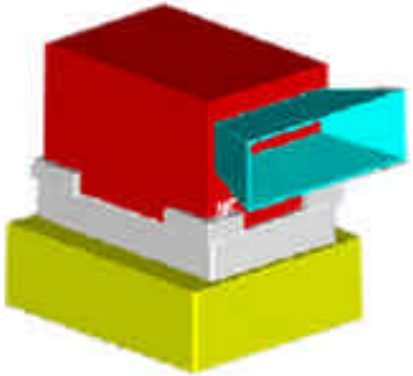


Impact SEP Package (Solar Energetic Particles)



LET
(Low Energy Telescope)
Caltech/JPL

HET
(High Energy Telescope)
GSFC/Caltech



SIT
(Supra-Thermal Ion Telescope)
U of MD/MPAe

SEPT
(Solar Electron Proton Telescope)
U of Kiel/ESTEC

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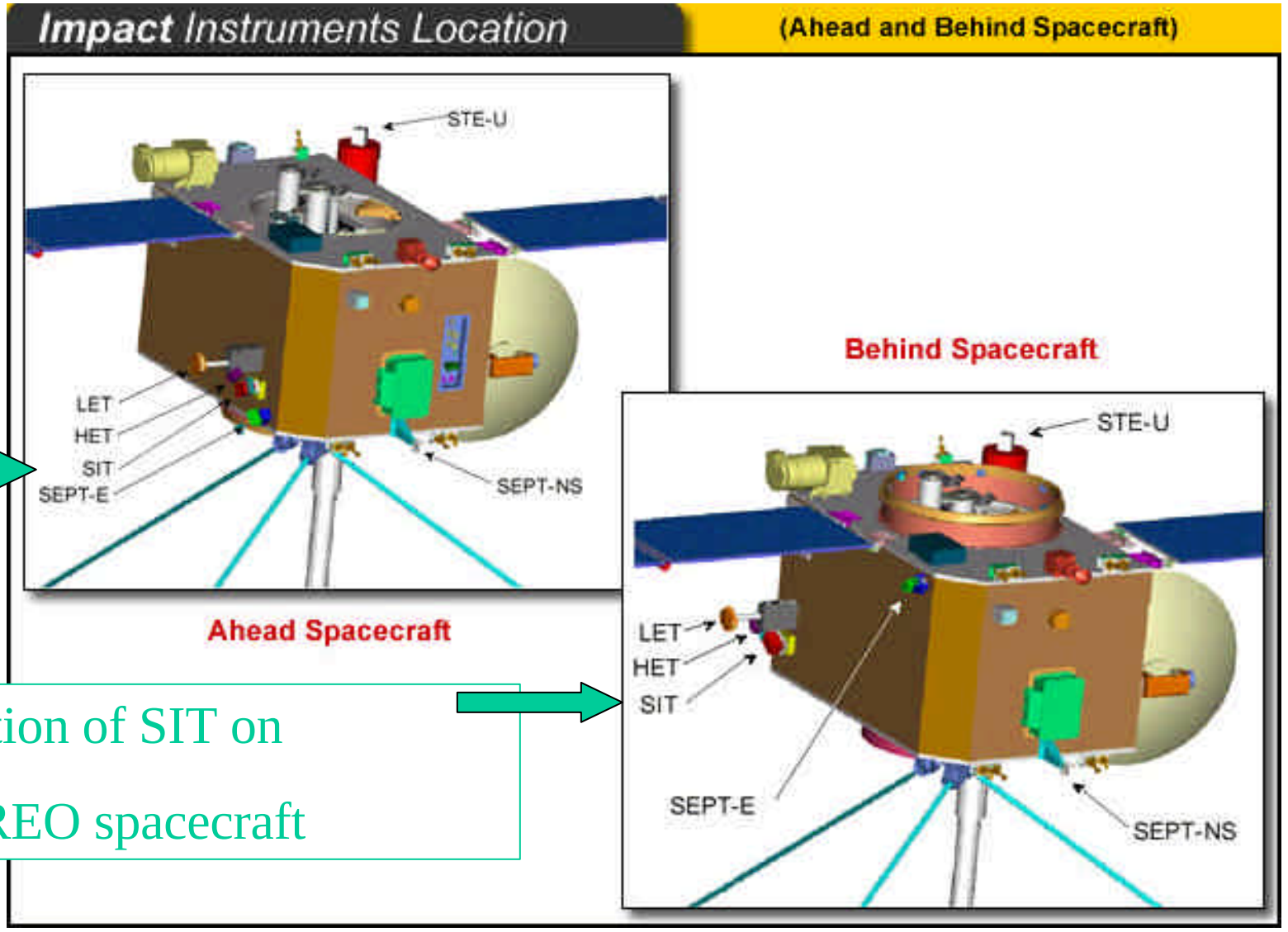

Location of SIT on STEREO spacecraft

STEREO Mission Objectives from the MRD

- **Understand the causes and mechanisms of CME initiation**
- **Characterize the propagation of CMEs through the heliosphere**
- **Discover the mechanisms and sites of energetic particle acceleration in the low corona and interplanetary medium**
- **Develop a 3D time-dependent model of the magnetic topology, temperature, density, and velocity structure of the ambient solar wind**

Lead to the science objectives and instrument goals on the next pages

STEREO Science Objectives from the MRD – toward which IMPACT is a prime contributor

- **Objective F. Energetic Particle Distribution Function**
  - Based on energy (spectral) coverage, directional coverage, flux range sensitivity
- **Objective G. Location of Particle Acceleration**
  - Based on suprathermal and SEP energy (spectral) coverage, temporal resolution (timing accuracy), angular resolution, SEP ion composition, and magnetic field information
- **Objectives H, I, J. Solar Wind Temperature, Density, Speed**
  - Based on moments of solar wind particle distribution functions, which in turn require appropriate spectral coverage and directional coverage (note solar wind electrons are more nearly isotropic than solar wind ions because their thermal velocities are comparable to the solar wind bulk velocity)
- **Objective K. Solar Wind Magnetic Field**
  - Based on vector (3 orthogonal component) magnetic field measurements in accurately known directions and with appropriate sensitivity range

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IMPACT addresses these STEREO Science Objectives and Level 1 Science requirements from the MRD

Objective F. Energetic Particle Distribution Function

- **Level 1 Requirement: Characterize the distribution functions to an accuracy of +/- 10% for electrons and ions with energies typical of solar energetic particle populations**

Objective G. Location of Particle Acceleration

- **Level 1 Requirement: Determine the location of particle acceleration in the low corona to within 300,000km in radius and in interplanetary space to within 20 degrees in longitude**

To be addressed by

SIT addresses a portion of the SEP measurements:

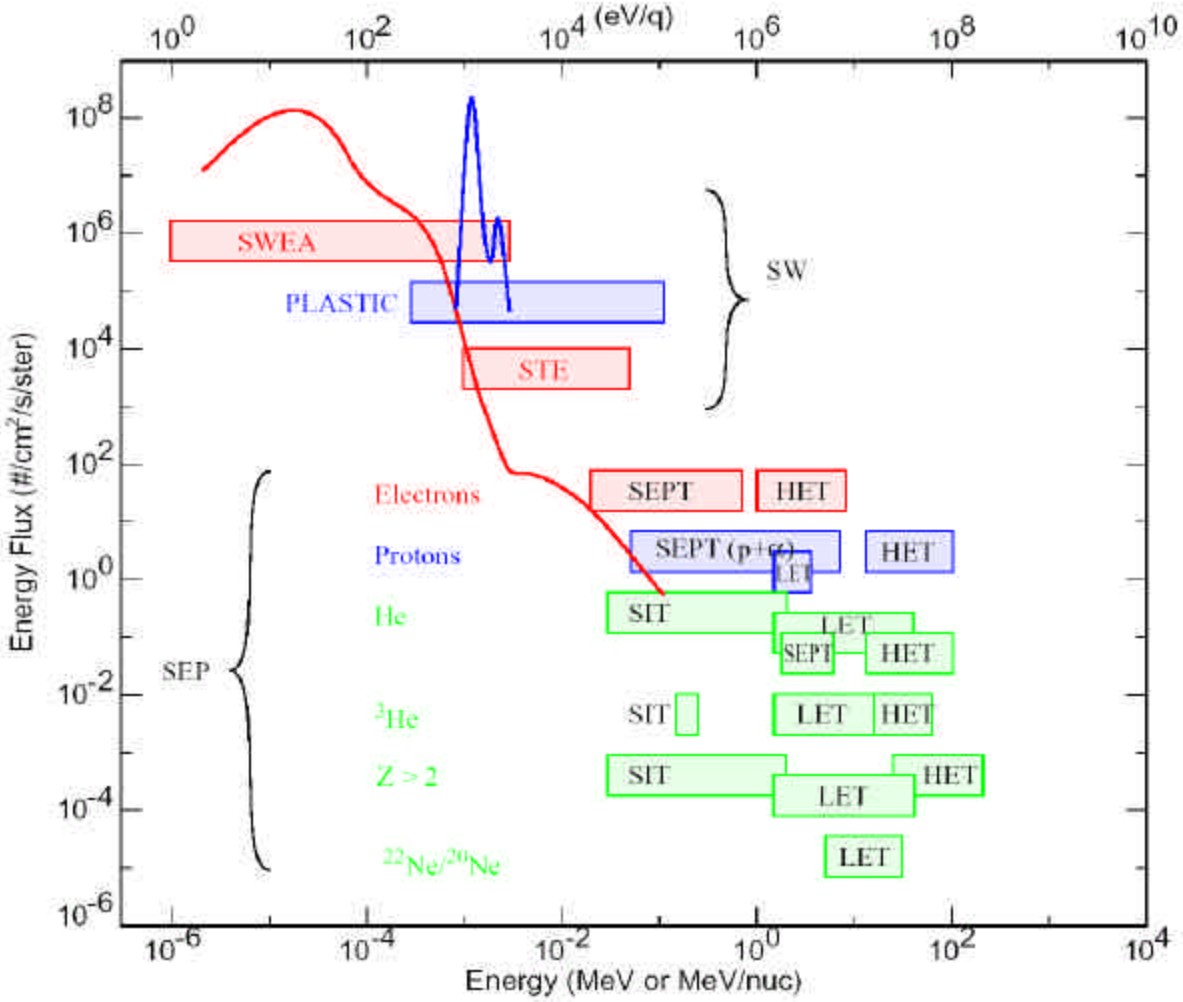
IMPACT/STE: Measure the suprathermal halo/super-halo electron fluxes over electron energies 5-100 keV, spanning th gap between SWEA and SEP electron measurements, along th nominal interplanetary field direction with at least 1 minute time resolution from two vantag points. Measurements shall include fluxes, energy spectra, and direction of arrival.

IMPACT/SEP: Measure the intensity, composition, and ener spectra and direction of energet ions and electrons from two vantage points, including proton from 0.06 to 40 MeV, heavier ion from ~0.03 to 30 MeV/nuc, electrons from ~0.03 to 6 MeV, and 3He-rich solar particle events.

Basic IMPACT Measurements

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	1 min	3S x 2E, 60s	U. of Md. (Mason) + MPAE (Korth) + GSFC (von Rosenvinge)
		^{3}He	0.15-0.25 MeV/nuc	1 min	----	
	SEPT	Diff. electron flux	20-400 keV	1 min	3E, 60s	U. of Kiel (Mueller-Mellin) + ESTEC (Sanderson)
		Diff. proton flux	60-7000 keV	1 min	3E, 60s	
		Anistropies of e,p	As above	15 min	----	
	LET	Ion mass numbers 2-28 & anisotropy	3-30 MeV/nuc	1-15 min.	2S x 2E, 60s	Caltech (Mewaldt) + GSFC (von Rosenvinge) + JPL (Wiedenbeck)
		^{3}He ions flux & anistropy	2-15 MeV/nuc	15 min.	1E, 60s	
		H ions flux & anistropy	1.5-6 MeV	1-15 min.	1E, 60s	
	HET	Electrons flux	1-6 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)

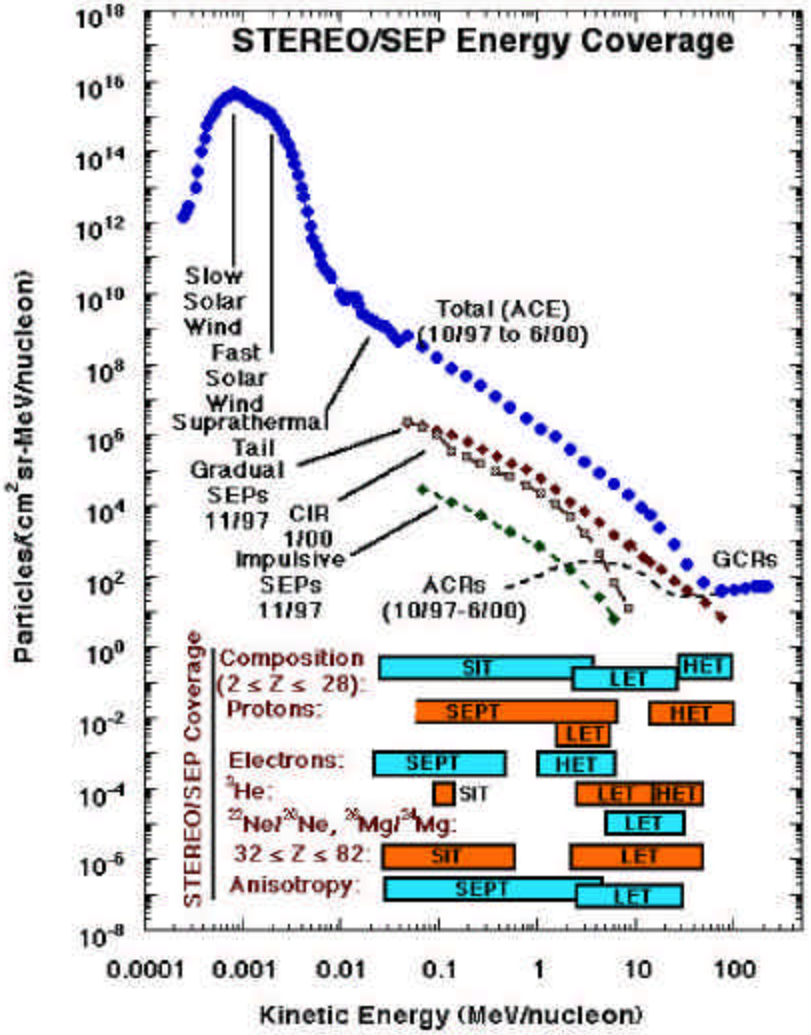
IMPACT Particles Domain: Solar Wind, Suprathermal and SEP electrons, SEP ions



SIT covers:

- energy range between solar wind and energetic particles for Helium and heavier ions
- identifies impulsive flares with much greater sensitivity than at higher energy

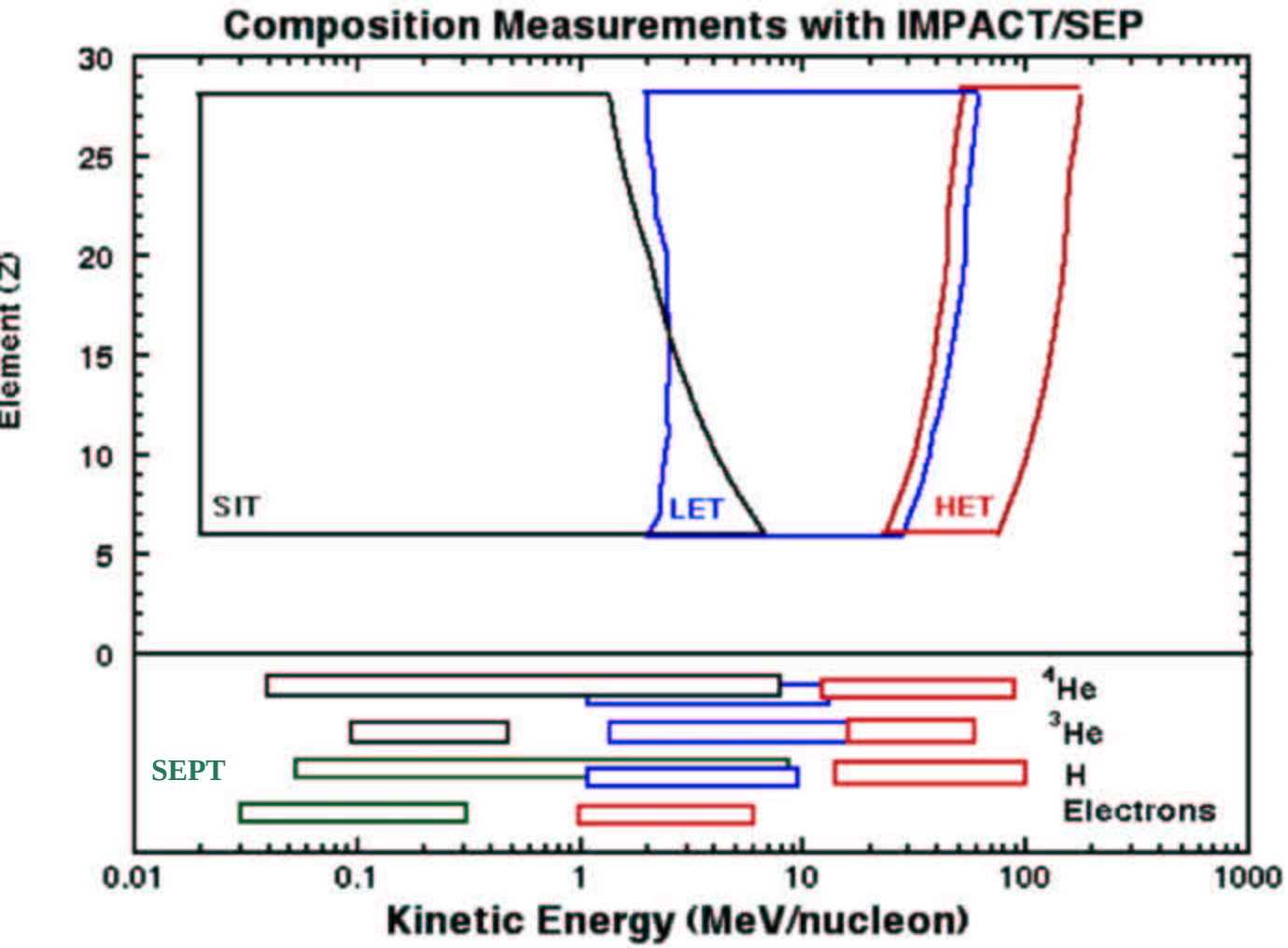
SEP Ions Spectral Coverage



SIT coverage also includes:

- traveling interplanetary shocks
- corotating shocks
- provides link between suprathermals (the seed population) and energetic particles >30 MeV that are key to spacecraft and astronaut activities

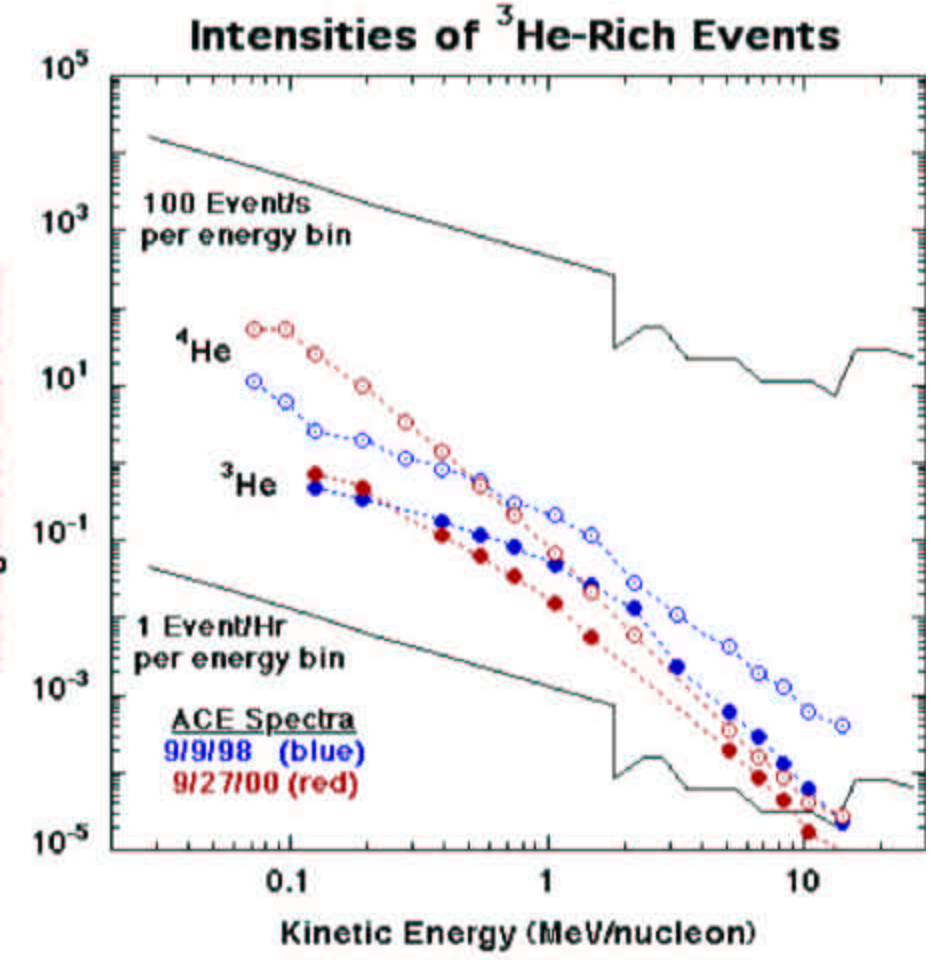
SEP Ions Composition Coverage

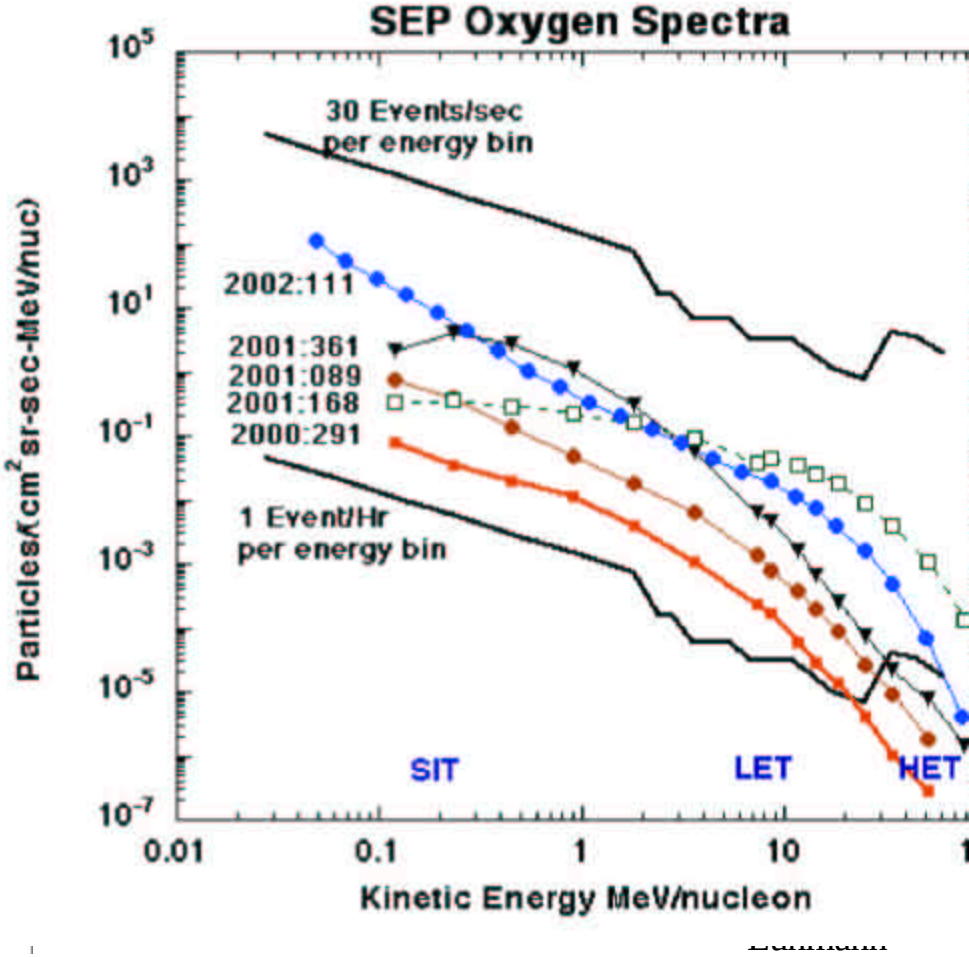


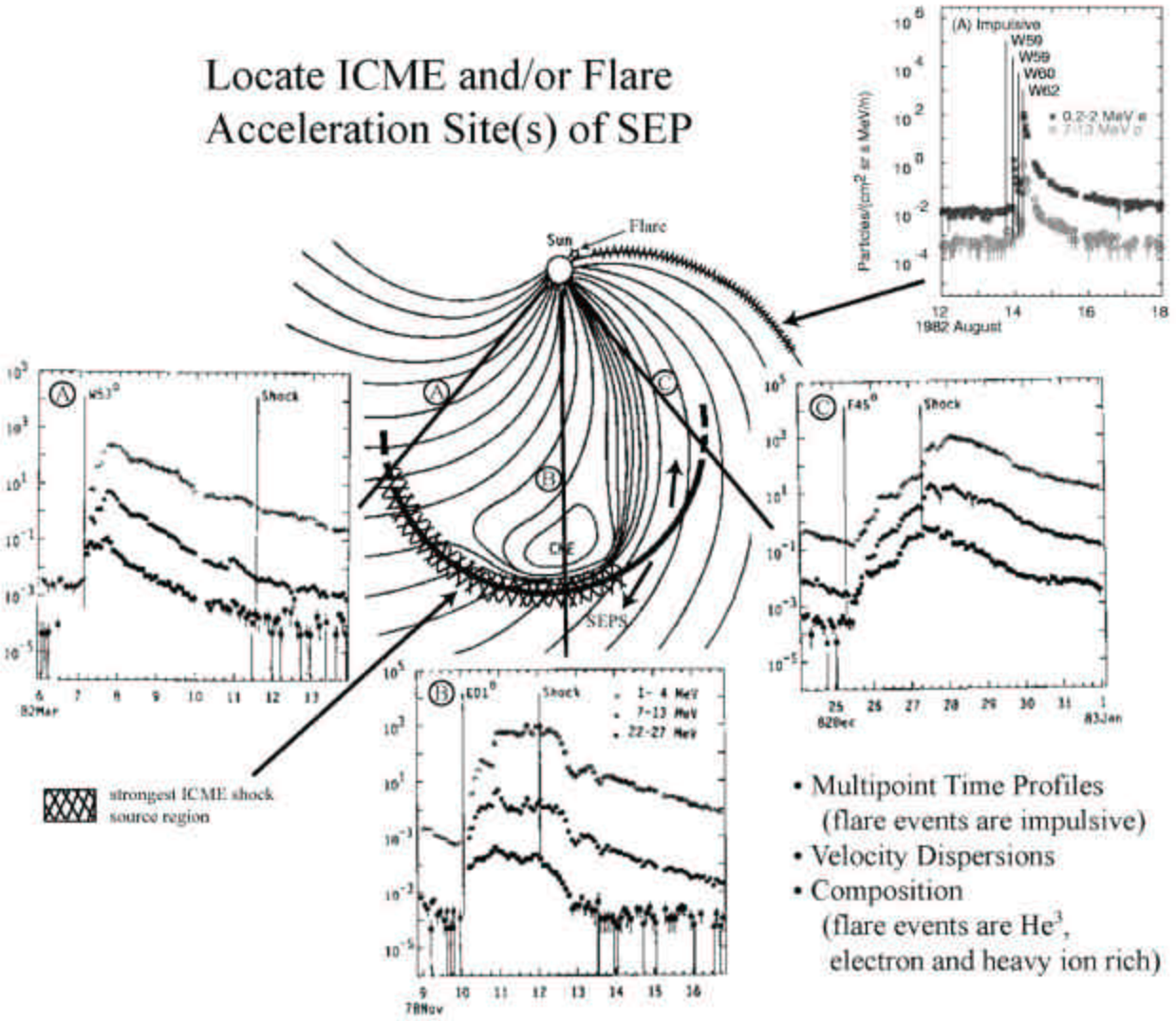
the SEPT portion of IMPACT covers protons in the SIT range, but all information about the heavier ions -- needed to understand particle acceleration -- depends on SIT

Examples of Sensitivity Ranges of IMPACT SEP Measurements Compared to Some Typical SEP Fluxes --

Because of spectral form, SIT can detect events too small to be observed at higher energies

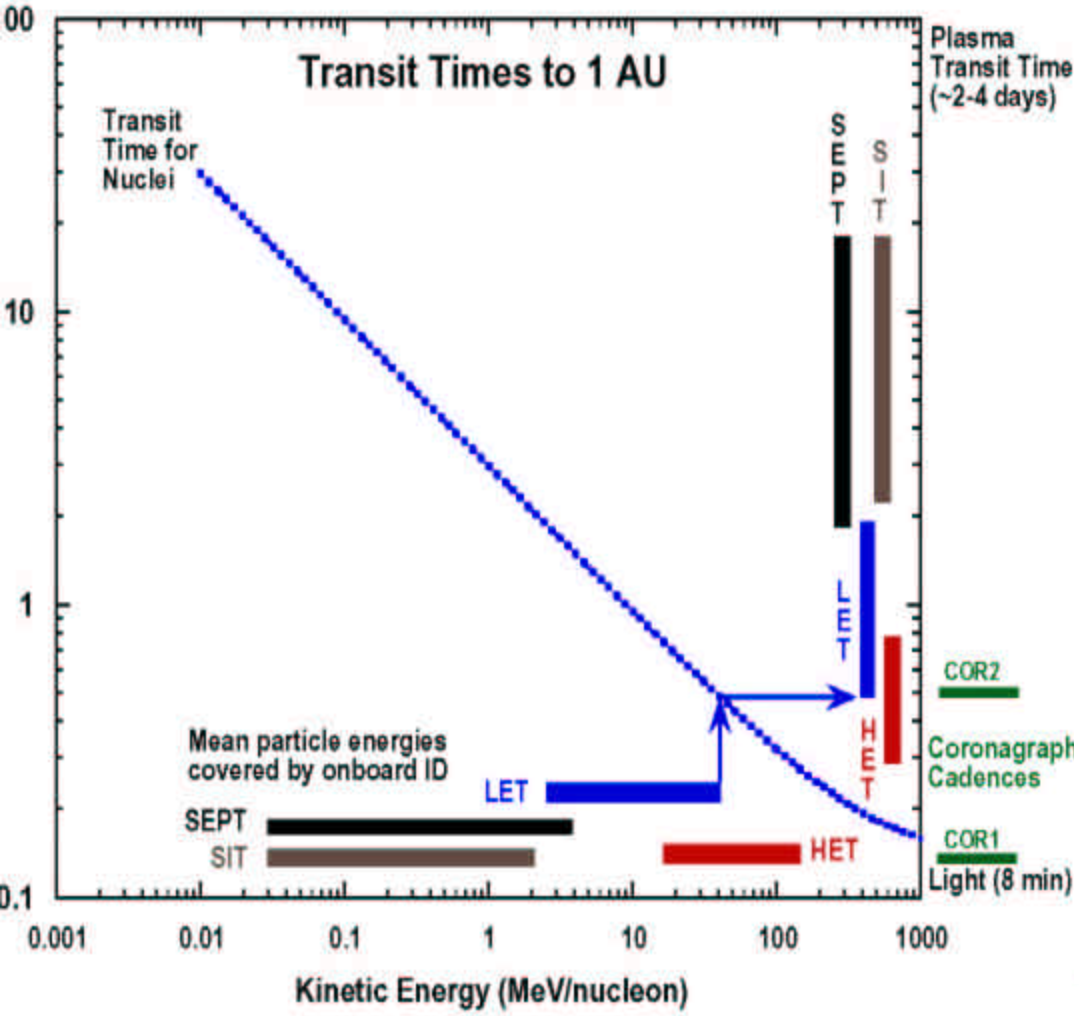


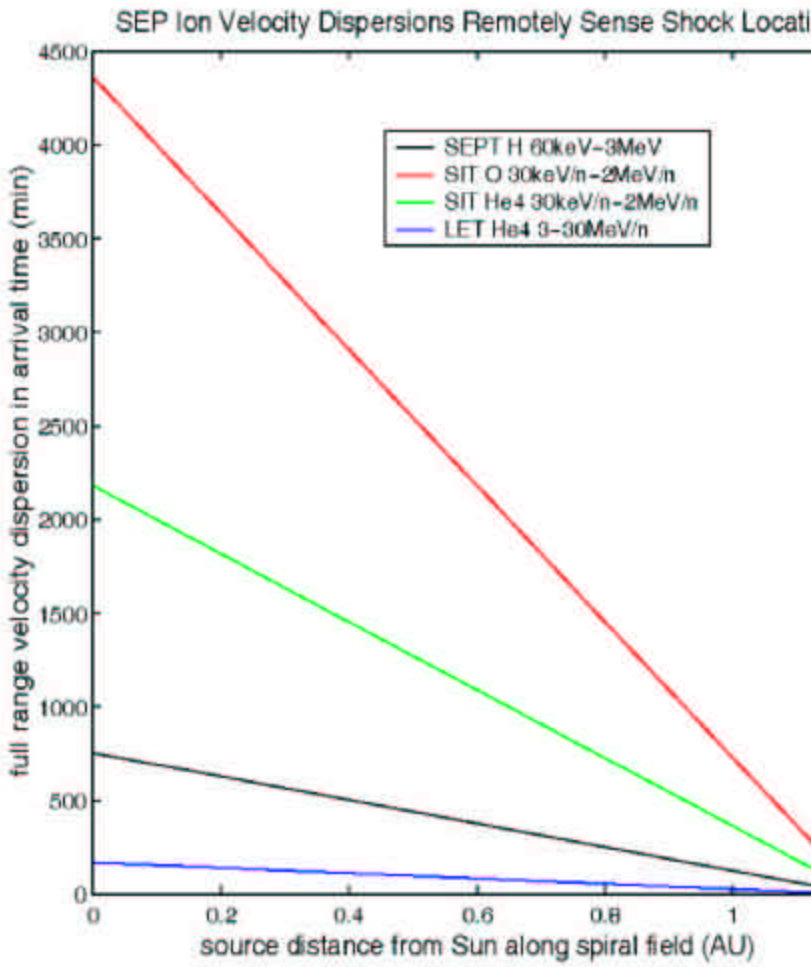



Locate ICME and/or Flare
Acceleration Site(s) of SEP
(A) Impulsive
W59
W59
W60
W62
1982 August
Sun
Flare
SEPs
Shock
strongest ICME shock
source region
• Multipoint Time Profiles
(flare events are impulsive)
• Velocity Dispersions
• Composition
(flare events are He3,
electron and heavy ion rich)

Acceleration Sites can be Inferred from SEP Timing --

SIT can identify the low energy particles more cleanly than SEPT since it see heavy ions that are less susceptible to contamination from other particle source populations





Summary of key SIT science contributions:

• coverage of suprathermal through energetic particle range connects low and high-energy portions of SEP suite:

- identify impulsive SEP events with high sensitivity
- identify seed population accelerated by CME driven shocks
- provide low energy portion of solar particle distribution functions
- identify the source location low energy ions by measuring their arrival times

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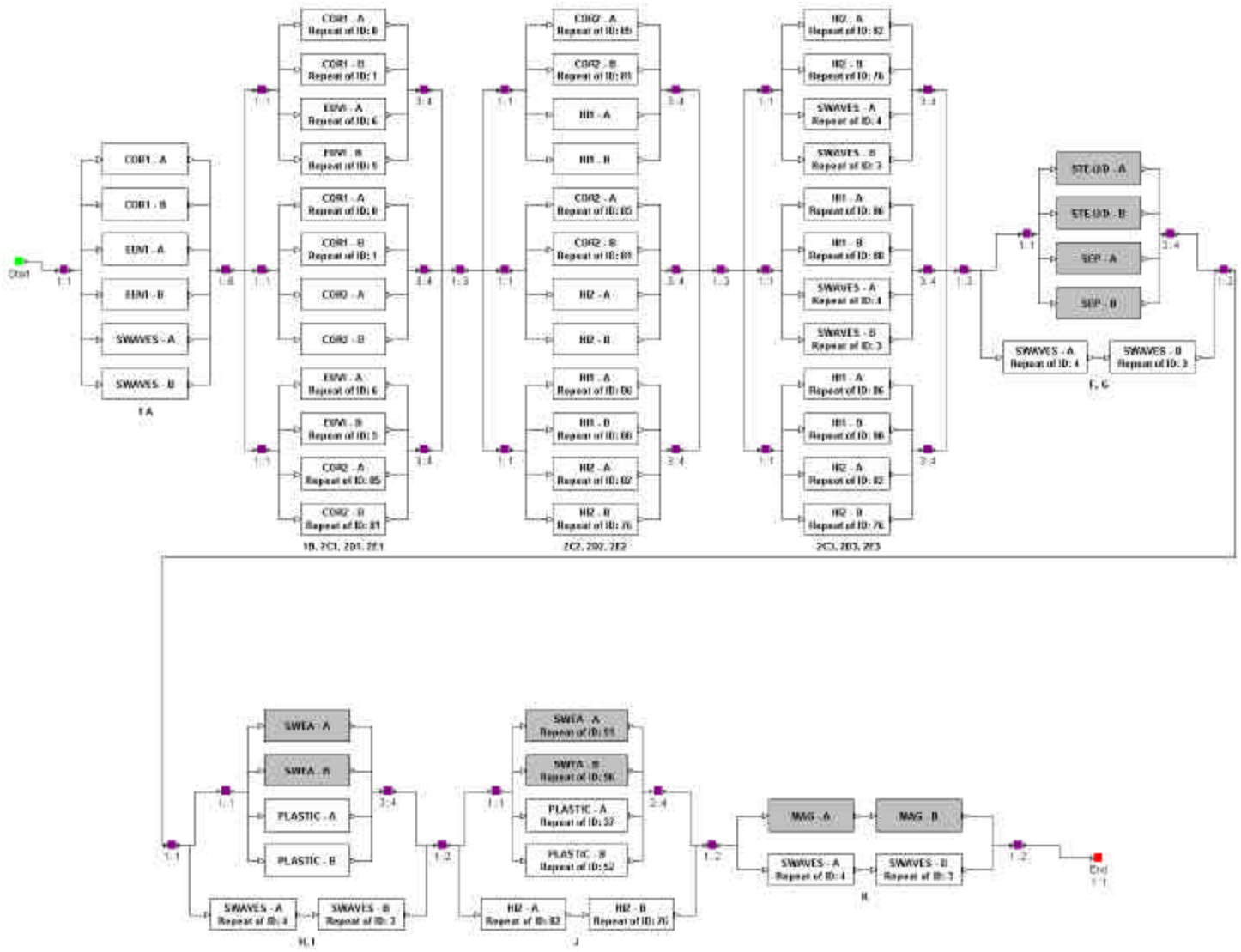
Full Mission (0-820 days)/Minimum Mission (0-240 days)
Reliability Block Diagram (RBD)



Ahead
Behind
PACT Items in Gray

Luhmann