
STEREO
IMPACT
UCB - NASA/GSFC- Caltech - U of MD - LANL - JPL - UCLA - SAIC - NOAA/SEC
U of MI - JHU/APL - MPAe - U of Kiel - CESR/CNRS - ESA/ESTEC -
DESPA/OBSPM - KFKI/RMKI

IMPACT CDR Agenda, Day 1

Overview:

8:00	Introduction & Science	Janet Luhmann
8:30	Project Overview	Dave Curtis
9:00	System Engineering	Dave Curtis

Boom Suite Subsystems:

11:00	IMPACT Boom Design	Robert Ullrich
11:30	IMPACT Boom Organization	Paul Turin
12:00	Lunch	
13:00	Magnetometer	Mario Acuña
14:00	SWEA	Claude Aoustin
15:00	STE	Steve McBride
15:30	SWEA/STE Interface	Steve McBride

IMPACT CDR Agenda, Day 2

Boom Suite Subsystems, Continued

8:00	IDPU	Dave Curtis
9:00	IDPU Flight Software	Dave Curtis
10:00	GSE/POC	Dave Curtis
10:30	Power Converters	Peter Berg
11:00	Boom Suite Thermal	Bob Eby
11:30	Boom Suite I&T	Dave Curtis
12:00	Lunch	

SEP Suite Subsystems:

13:00	SEP Overview	Tycho von Rosenvinge
13:30	SEPT	Reinhold Mueller-Mellin, Ludovic Duvet
14:30	SIT	Peter Walpole
15:30	HET	Tycho von Rosenvinge
16:30	HET/SIT Flight Software & GSE	Tycho von Rosenvinge

IMPACT CDR Agenda, Day 3

SEP Suite Subsystems, continued:

8:00	LET	Mewaldt, Cummings, Wiedenbeck, and Cook
9:30	LET, SEP Central Electronics	Rick Cook
10:00	SEP Central/LET/SEPT Software & GSE	Andrew Davis
11:00	SEP Mechanical	Sandy Shuman
11:30	SEP Thermal	John Hawk
12:00	SEP I&T	Alan Cummings
12:30	Lunch	

Suite:

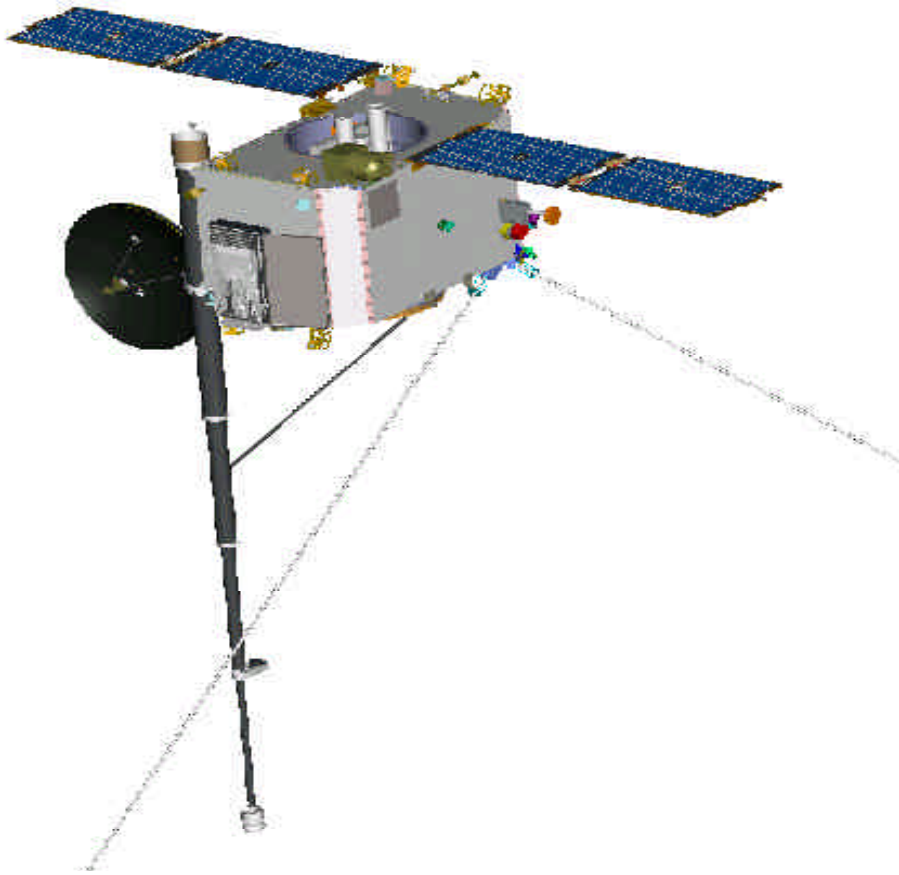
13:30	Product Assurance	Ron Jackson
14:30	Reliability	Mathew Samuel
15:00	Mission Operations Concept	Dave Curtis
15:30	MO&DA	Peter Schroeder
16:00	Wrap-up	

Introduction and Science

Janet Luhmann (PI), UC Berkeley Space Sciences Lab,
jgluhman@ssl.berkeley.edu, (510) 642-2545

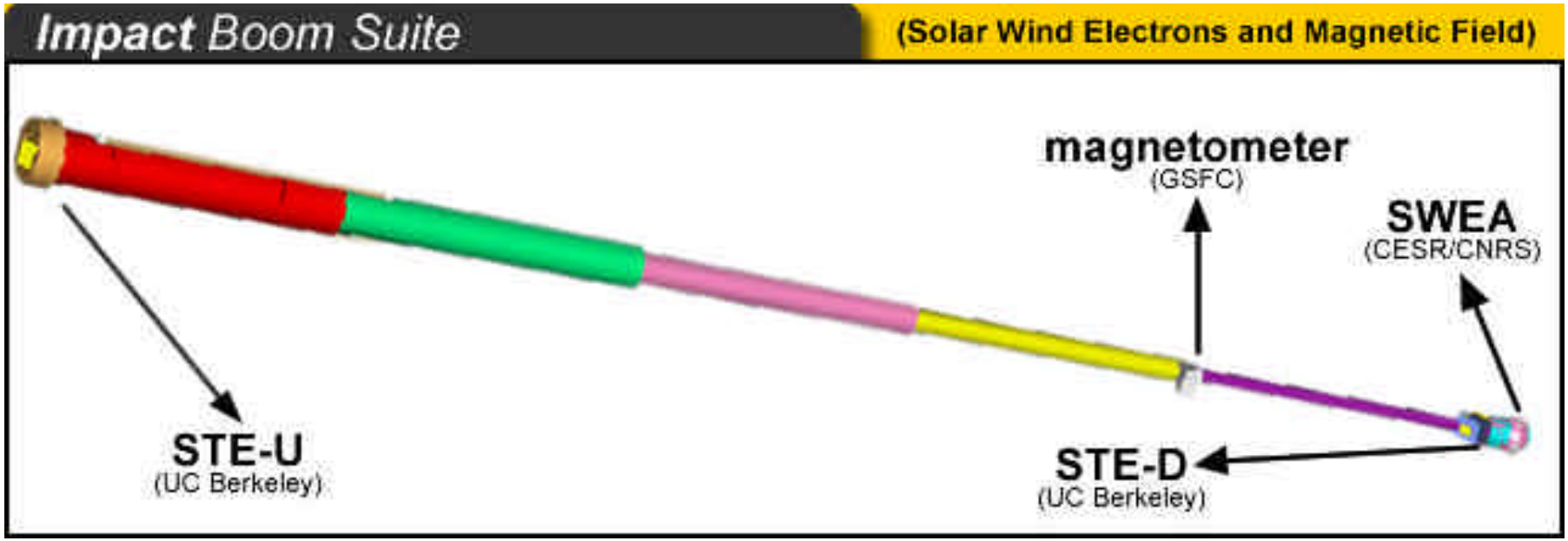
IMPACT (In-situ Measurements of Particles and CME Transients) Instrument Overview

- **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)

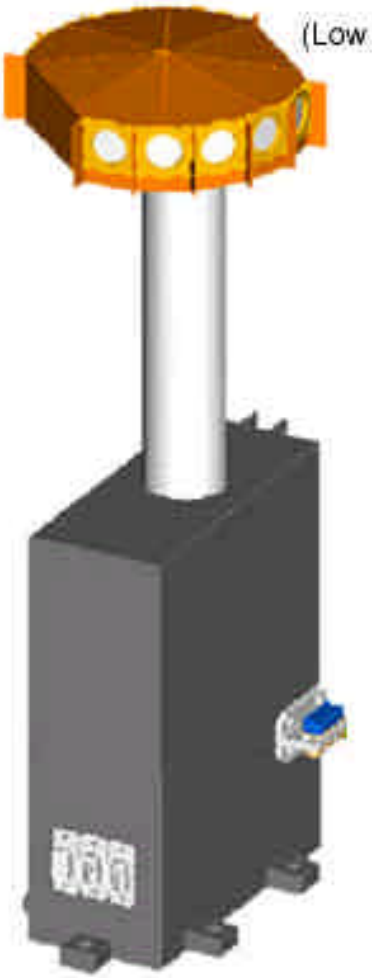


IMPACT Team Member Institutions and Primary Roles

- 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)*

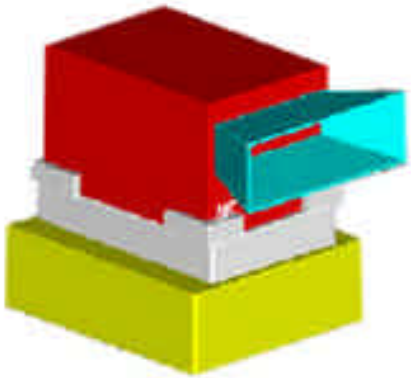

Impact Boom Suite
(Solar Wind Electrons and Magnetic Field)
magnetometer
(GSFC)
SWEA
(CESR/CNRS)
STE-U
(UC Berkeley)
STE-D
(UC Berkeley)

Impact SEP Package (Solar Energetic Particles)



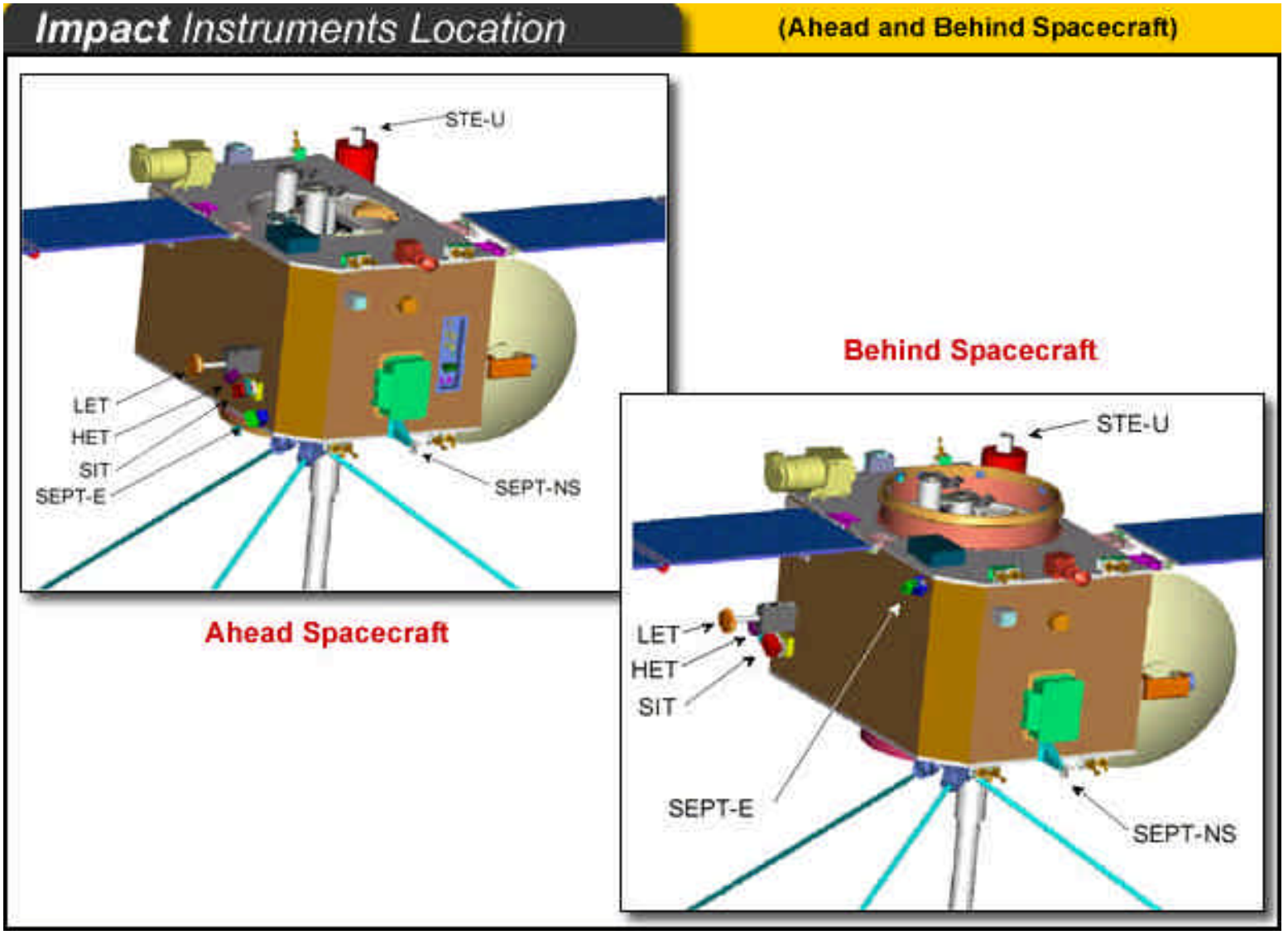
LET
(Low Energy Telescope)
Caltech/JPL

HET
(High Energy Telescope)
GSFC/Caltech



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

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


Impact Instruments Location
(Ahead and Behind Spacecraft)
STE-U
LET
HET
SIT
SEPT-E
SEPT-NS
Ahead Spacecraft
Behind Spacecraft
STE-U
LET
HET
SIT
SEPT-E
SEPT-NS

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

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

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.

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

Objective H. Solar Wind Temperature

- Level 1 Requirement: Obtain a time series of the solar wind temperature accurate to +/-10% at two points separated in solar longitude

Objective I. Solar Wind Density

- Level 1 Requirement: Obtain a time series of the solar wind temperature accurate to +/-10% at two points separated in solar longitude

Objective J. Solar Wind Speed

- Level 1 Requirement: Obtain a time series of the solar wind speed accurate to +/-10% at two points separated in solar longitude

To be addressed by 

IMPACT/SWEA: Measure the core (bulk solar wind) and halo (strahl) electron fluxes with a 360X60 degree or better field of view at energies 20-1000 eV, with angular resolution of at least 45X45 degrees and 1 minute sampling from two vantage point

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

Objective K. Solar Wind Magnetic Field

- **Level 1 Requirement: Determine the global magnetic field topology near the ecliptic by determining the magnetic field direction to +/-10%**

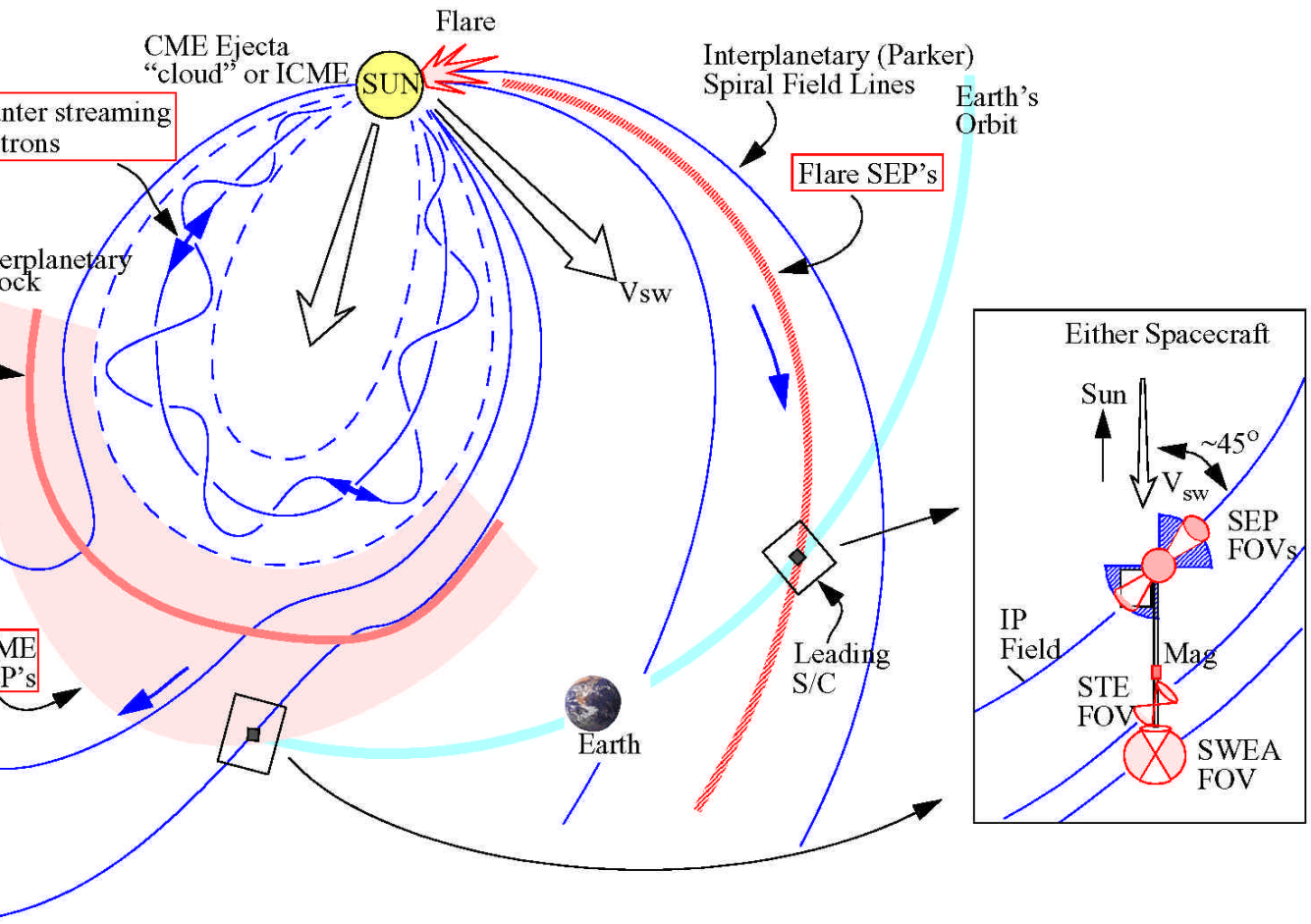
To be addressed by 

IMPACT/MAG: Measure the three components of the vector magnetic field in the range +/-512 nT with 0.1 nT accuracy at 1 second time resolution from two vantage points

Basic IMPACT Measurements

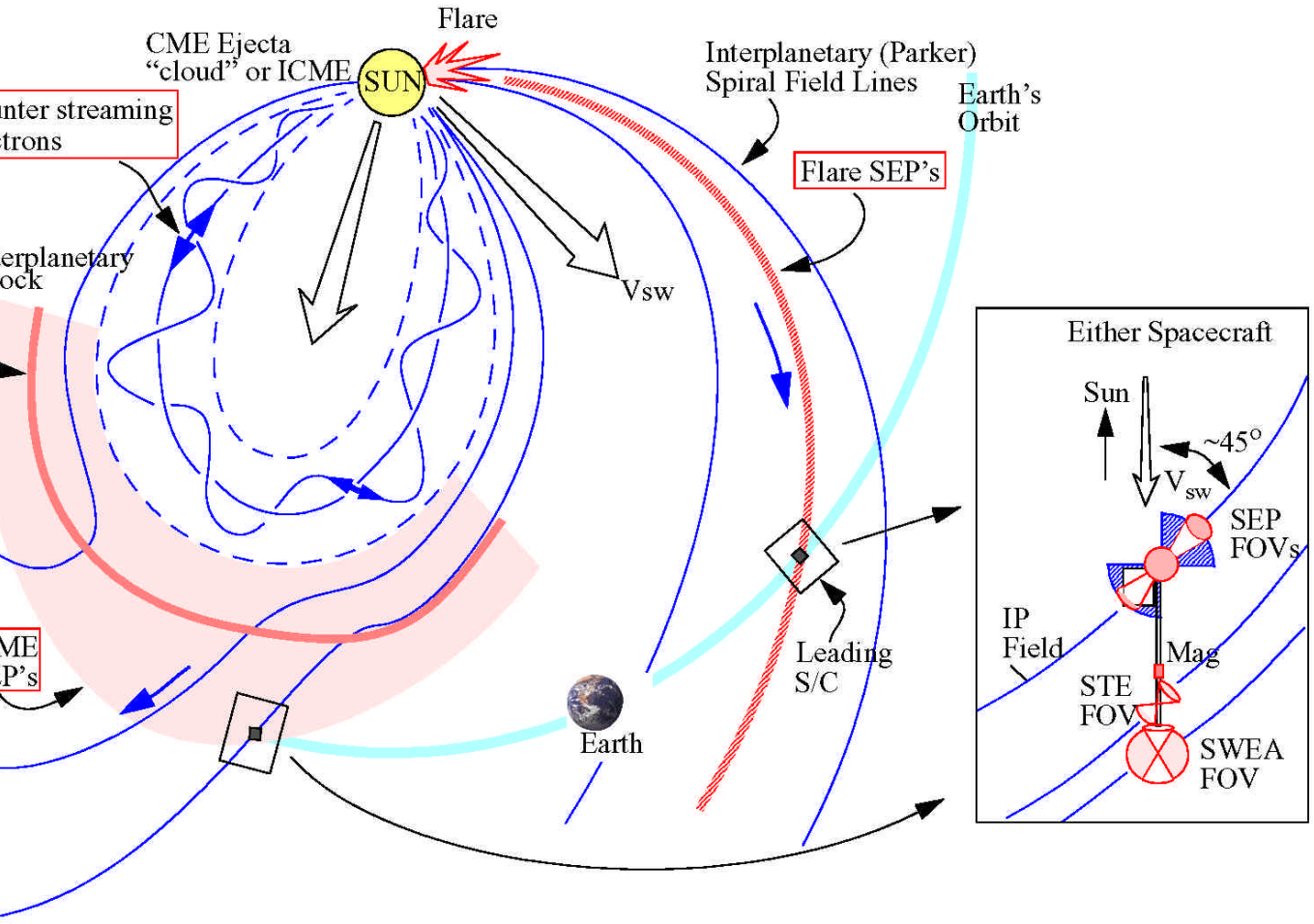
Experiment	Instrument	Measurement	Energy or Mag. field range	Time Res.	Beacon Time Res. (*)	Instrument provider
SW	STE	Electron flux and anistropy	2-100 keV	16 s	2D x 3E, 60s	UCB (Lin)
	SWEA	3D electron distrib., core & halo density, temp. & anisotropy	~0-3 keV	3D=1 min 2D=8s Mom.=2s	Moments, 60s	CESR (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)

Overall IMPACT Investigation Rationale I.



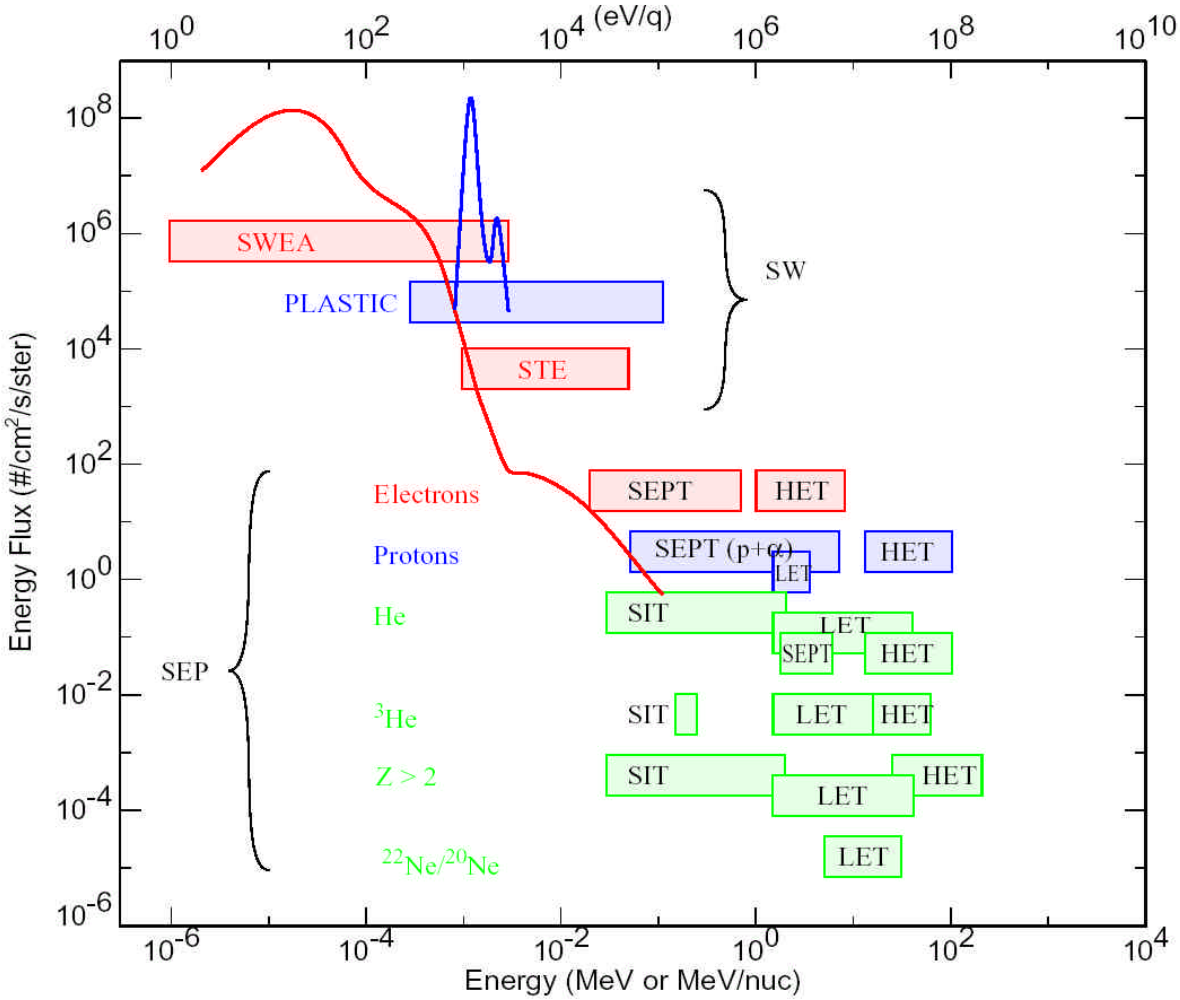
- **FOV coverage:**
  - **~4p solar wind and heat flux electron coverage to meet s wind electron and magnetic topology objectives**
  - **Parker Spiral orientations o suprathermal and energetic particle FOVs on both spacecraft- both toward and away from Sun to detect counterstreaming or backstreaming from ICME shock source**
  - **North-South (out of ecliptic) energetic particle measurements to detect SE in highly inclined magnetic situations during ICMEs and periods of isotropic distributions**

Overall IMPACT Investigation Rationale II.

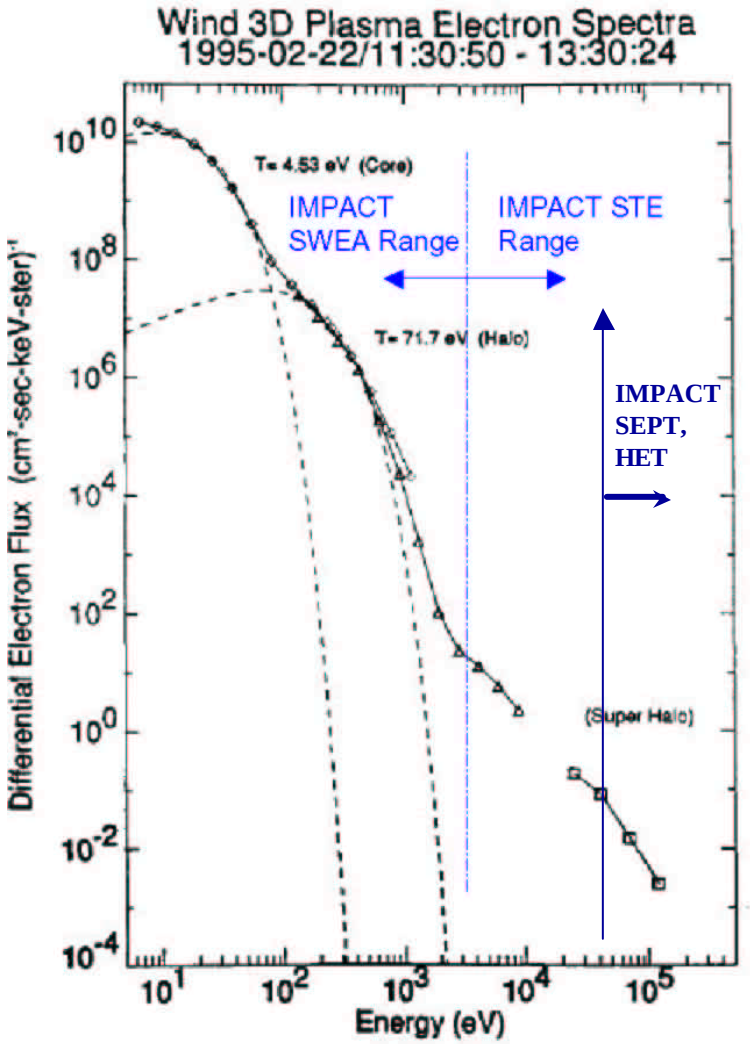


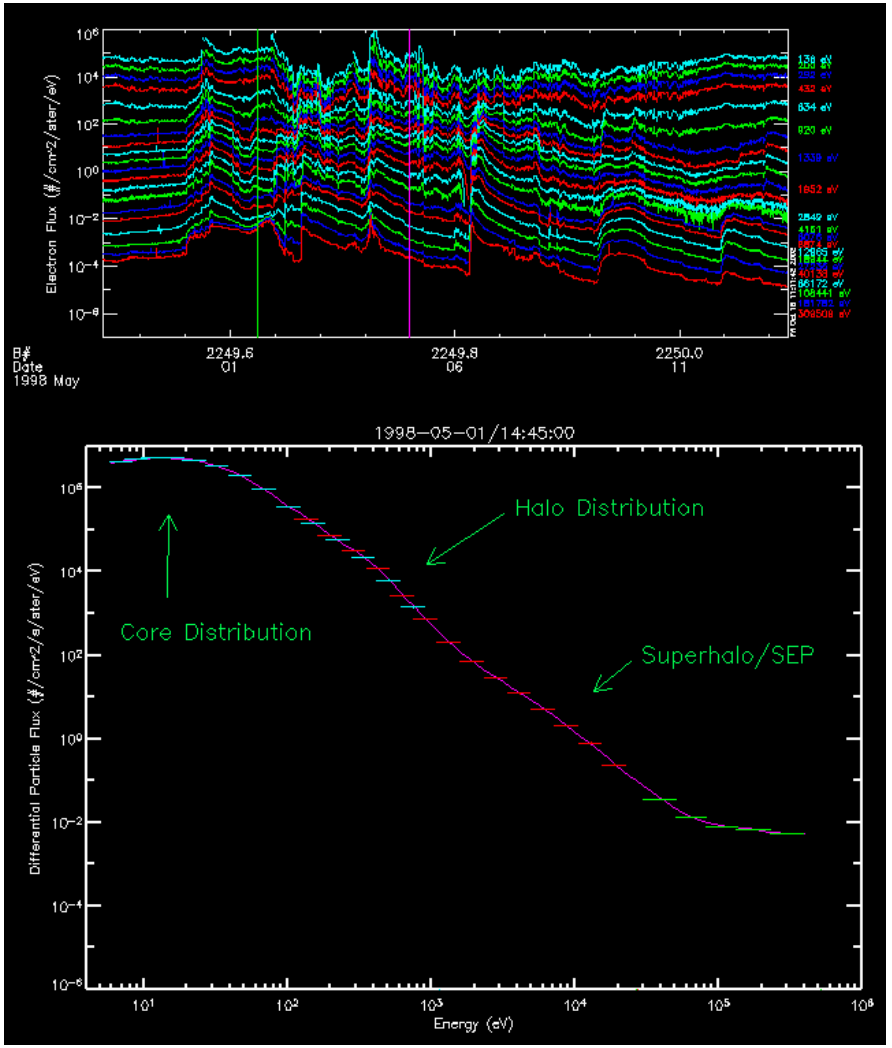
- **Energy Coverage to accomplish solar wind, magnetic topology, and SEP distribution functio and source identificatio objectives**
- **Ion Composition to accomplish SEP source objectives**
- **Clean magnetic measurements to organ and interpret particle observations and dedu solar wind and ICME magnetic topology**

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

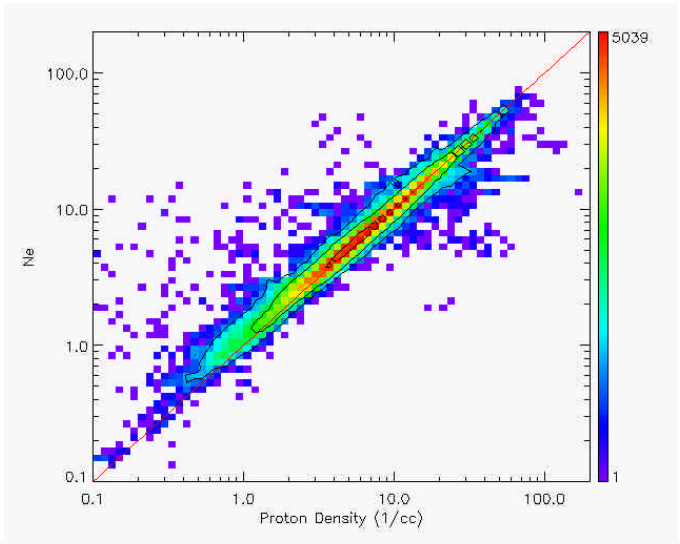


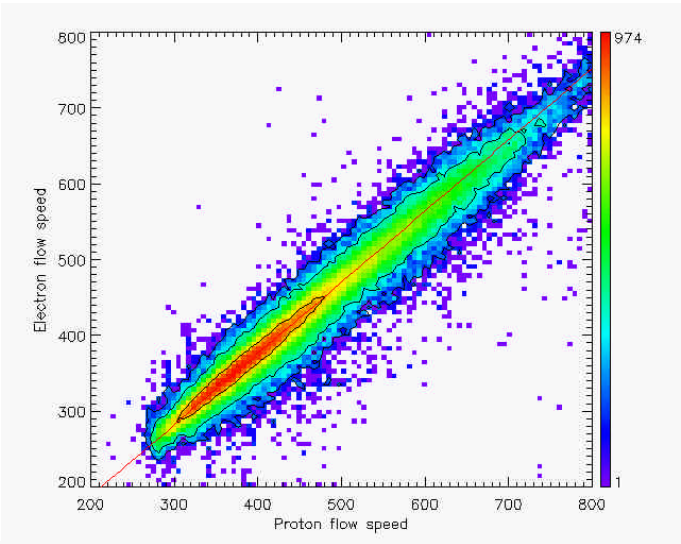
Solar Wind, Suprathermal, and SEP Electrons Flux Range and Spectral Coverage

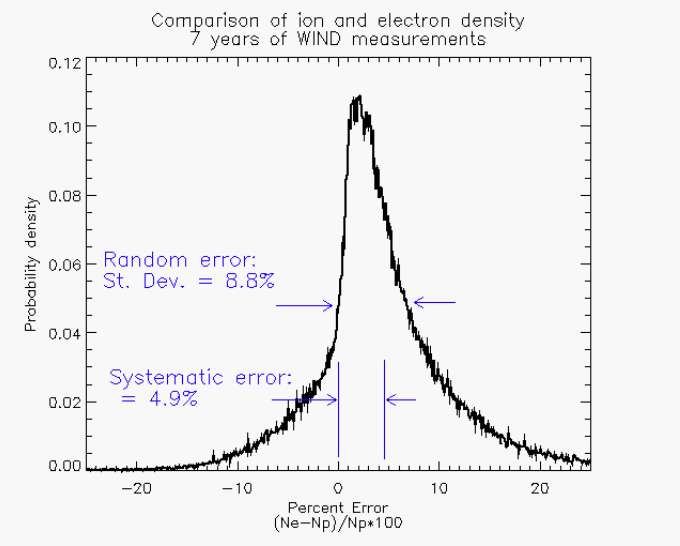


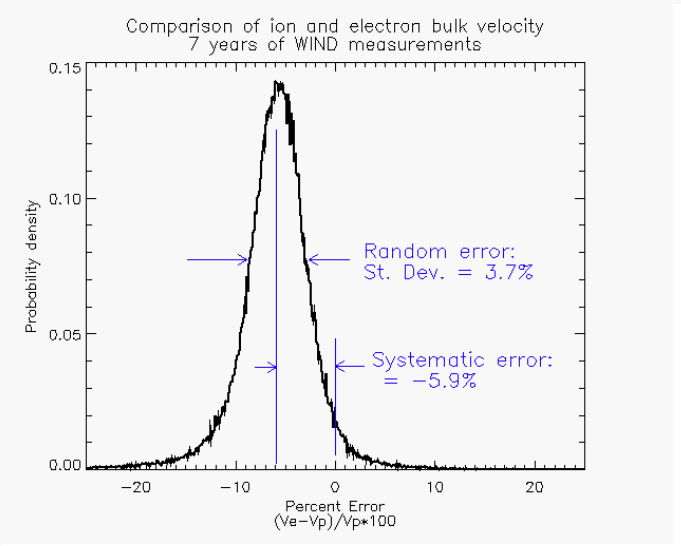


Accuracy of Solar Wind Electron Density and Bulk Velocity Measurements with a SWEA-like Instrument on WIND

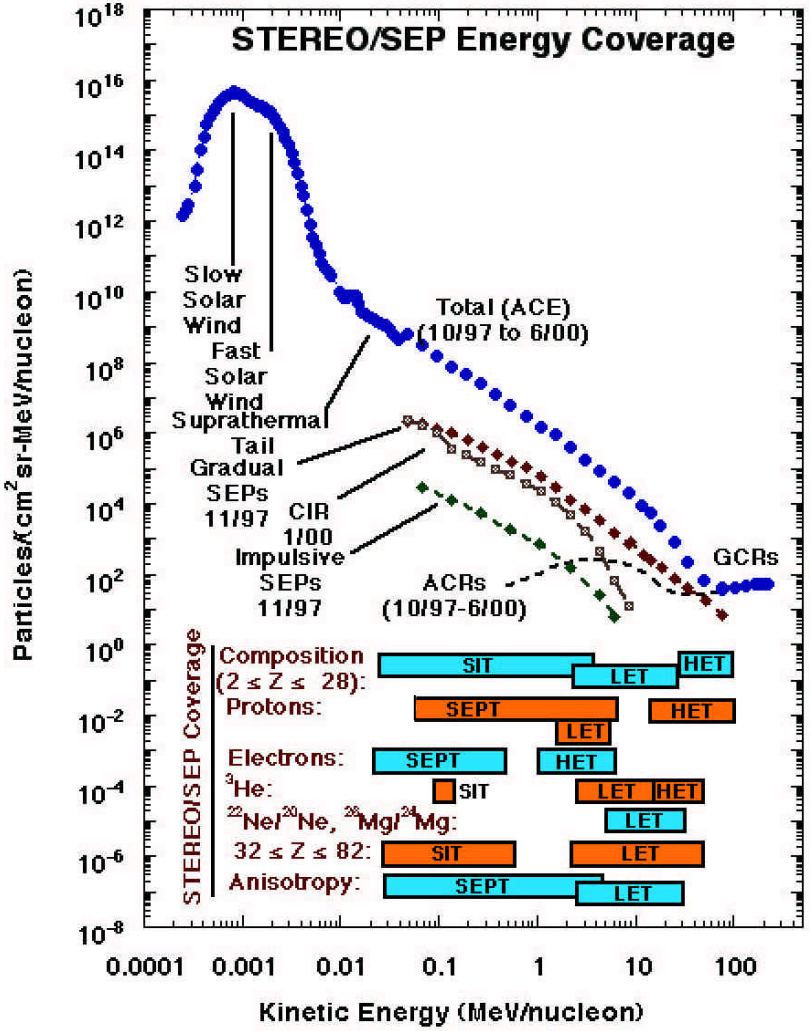




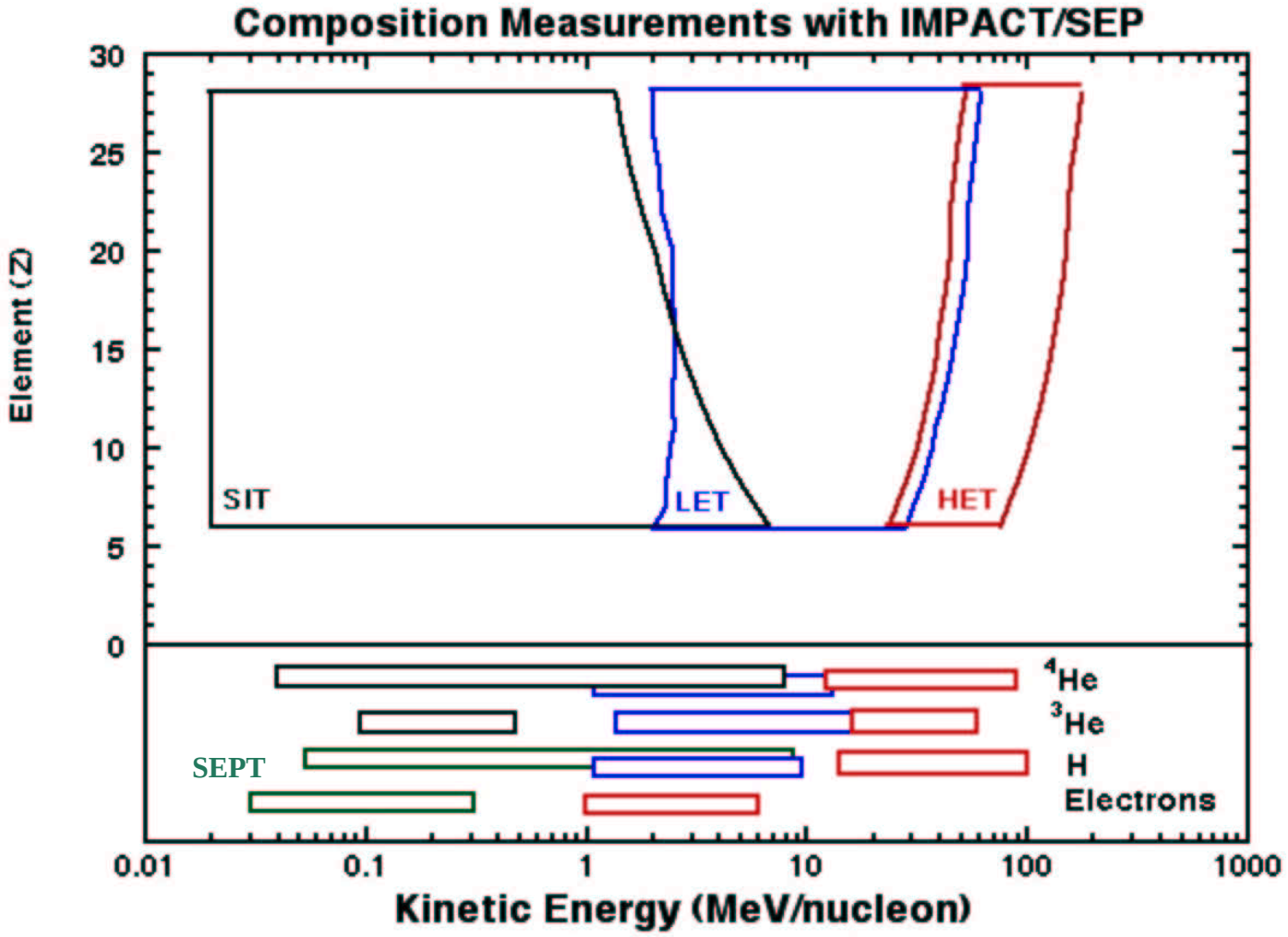




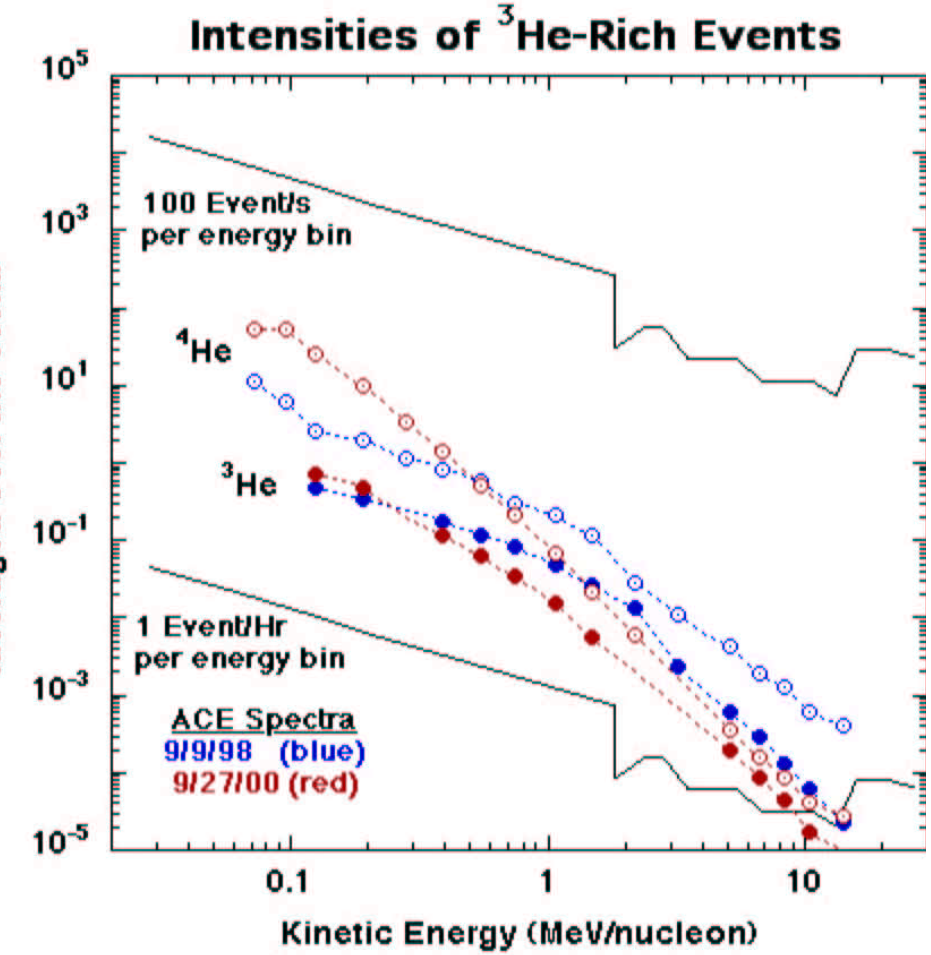
SEP Ions Spectral Coverage

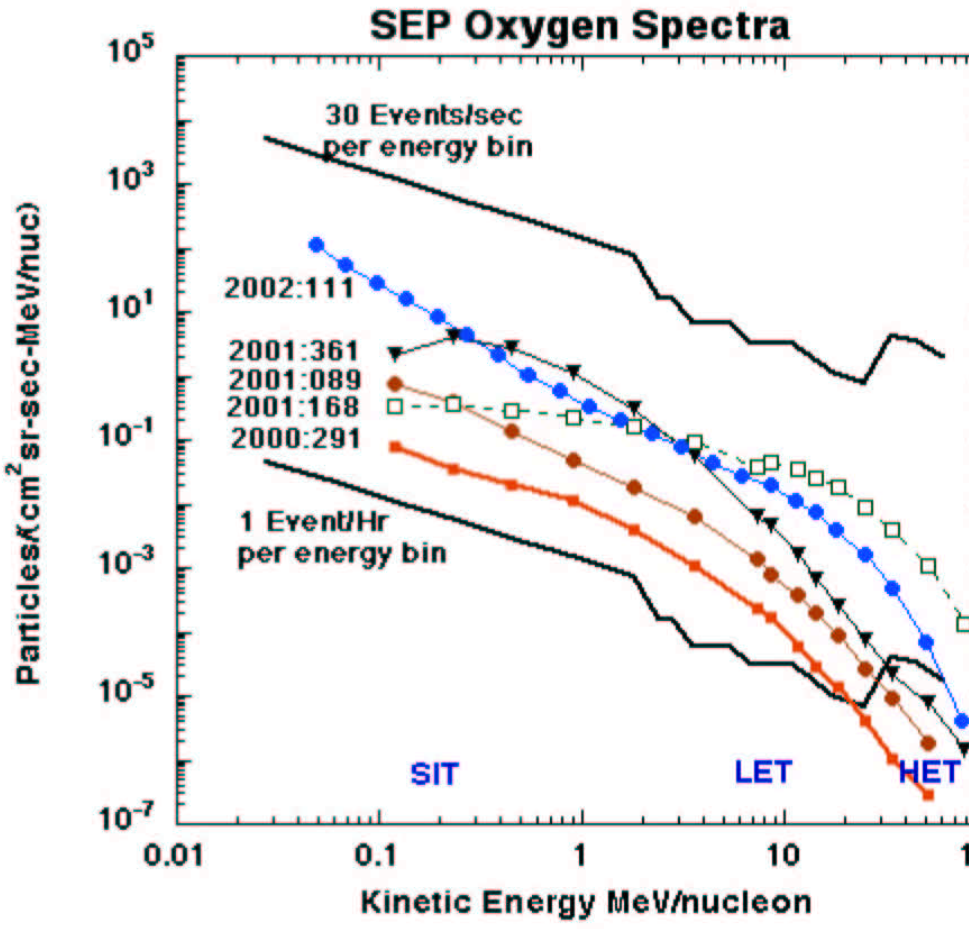


SEP Ions Composition Coverage

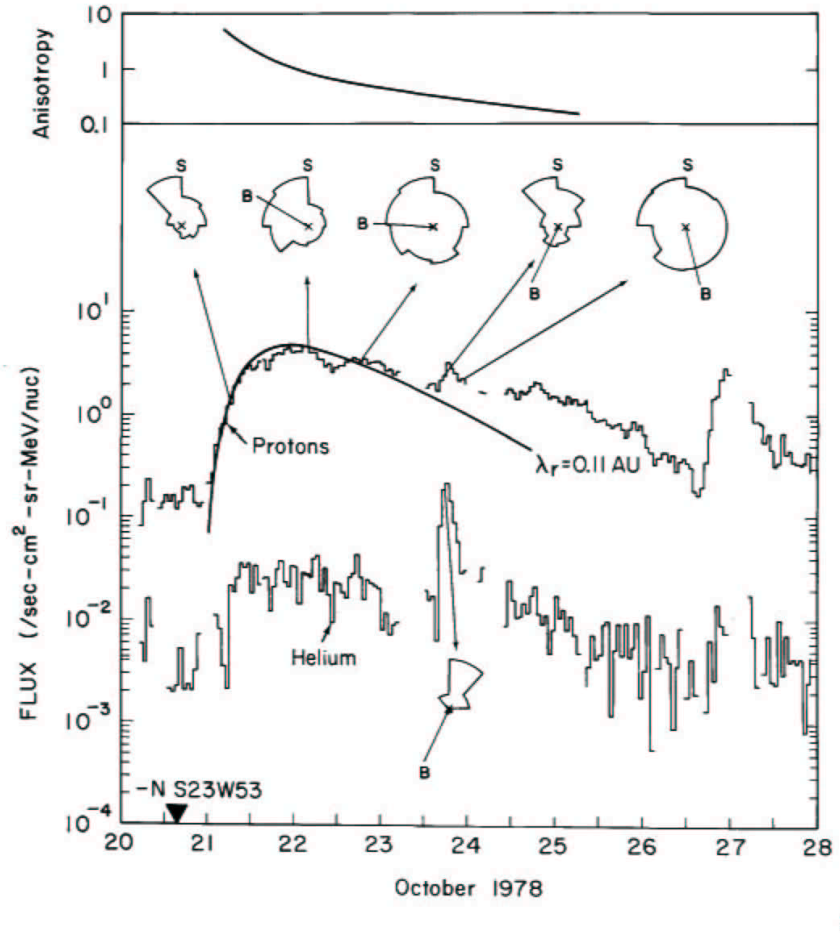


Examples of Sensitivity Ranges of IMPACT SEP Measurements Compared to Some Typical SEP Fluxes

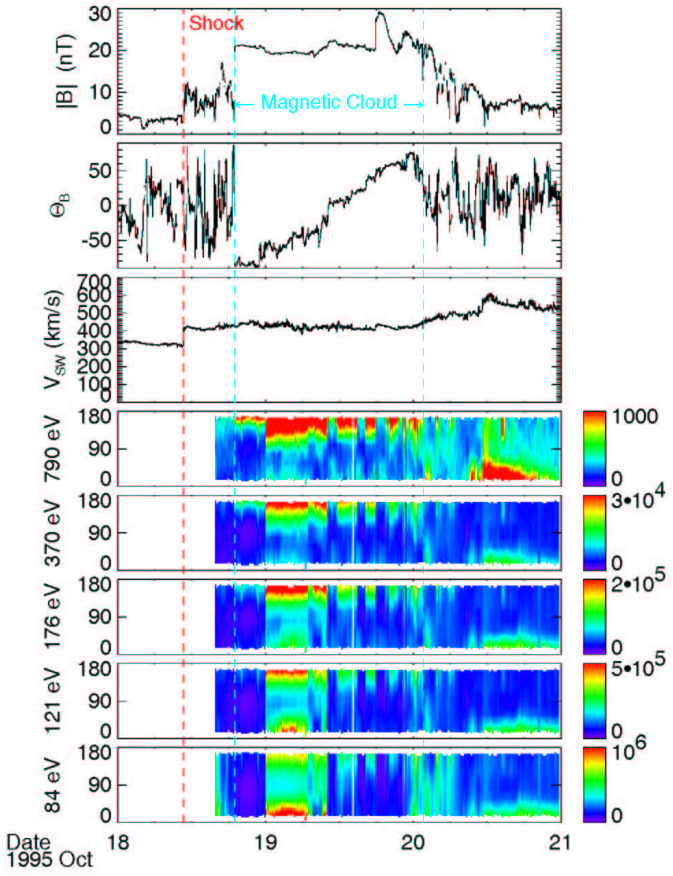




What IMPACT FOVs Must Cover

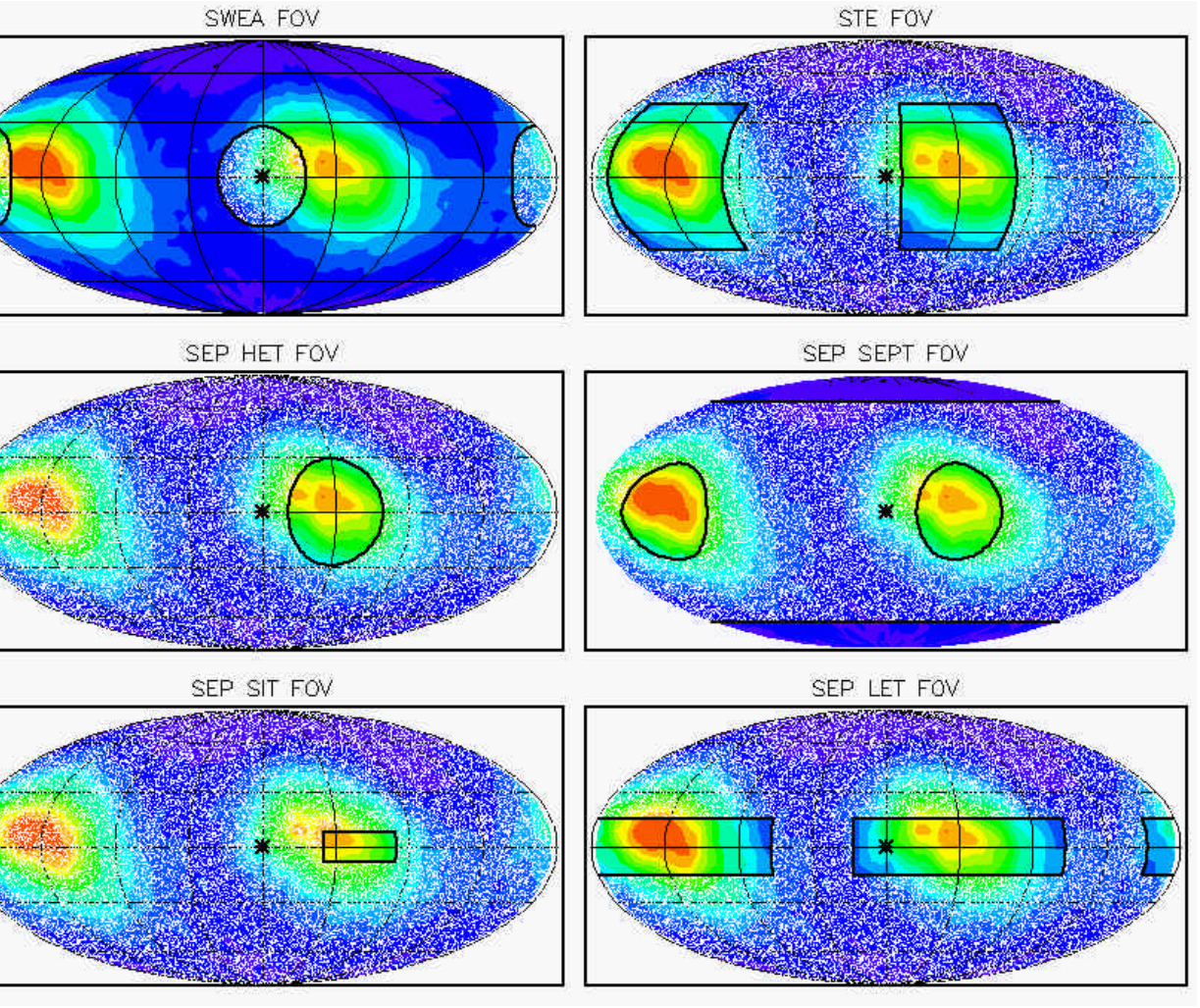


Sample SEP Event: angular distribution for gradual (ICME) and impulsive (Flare) events (B = field direction, S = sun direction)

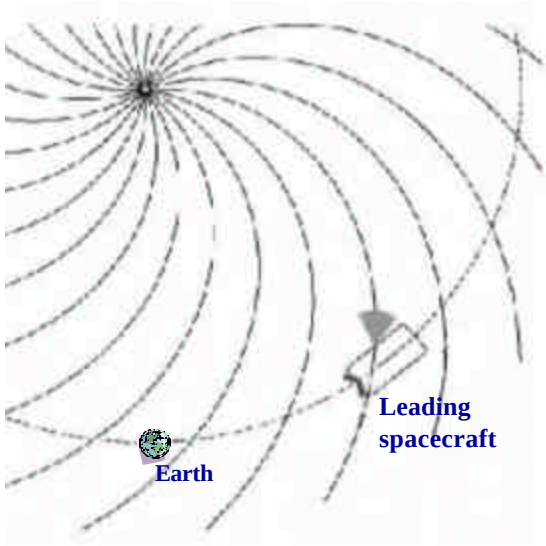


Sample SWEA ICME Event: counterstreaming electrons along magnetic field

IMPACT Directional Coverage

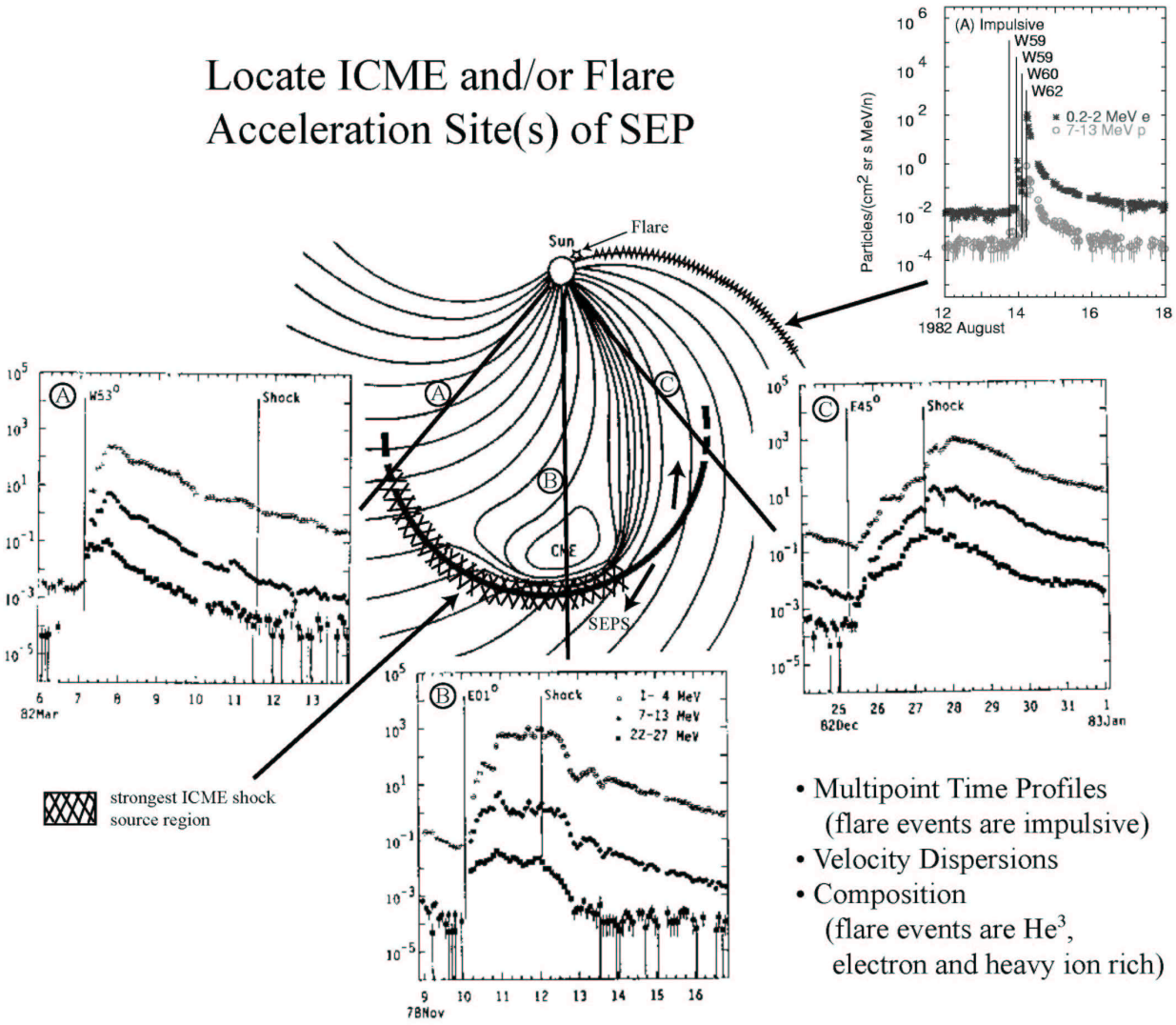


Parker Spir



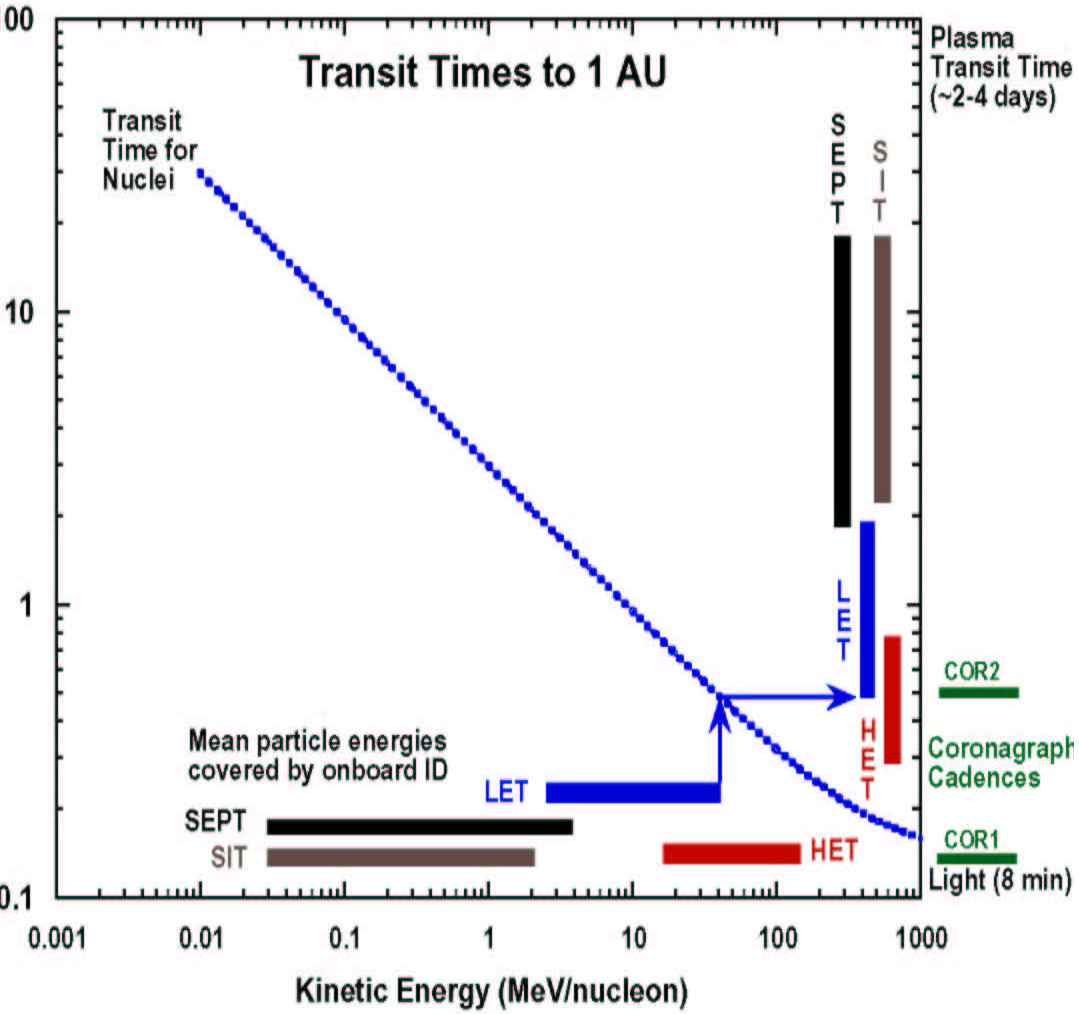
Mercator projection of 4 p angular coverage sphere. Sun in center. Contours show statistics of interplanetary field direction. Dark lines show IMPACT particle instrument fields of view.

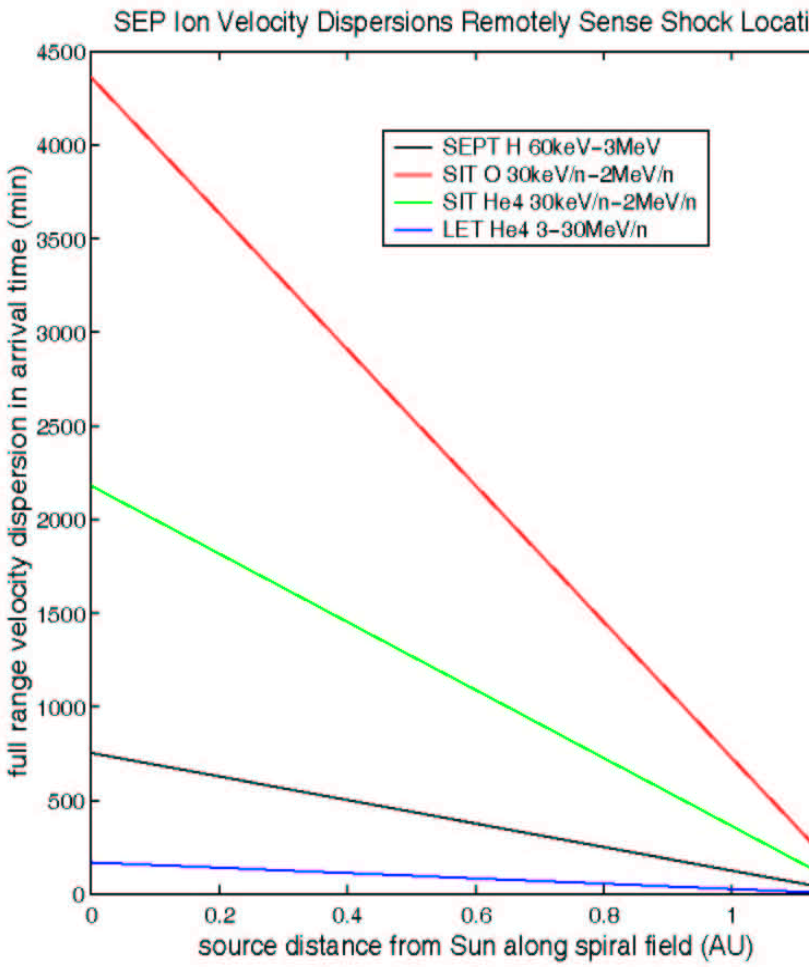
Locate ICME and/or Flare Acceleration Site(s) of SEP



- Multipoint Time Profiles (flare events are impulsive)
- Velocity Dispersions
- Composition (flare events are He^3, electron and heavy ion rich)

Acceleration Sites can be Inferred from SEP Timing





Locating Acceleration Sites and Inferring Magnetic Topology Using IMPACT Electrons

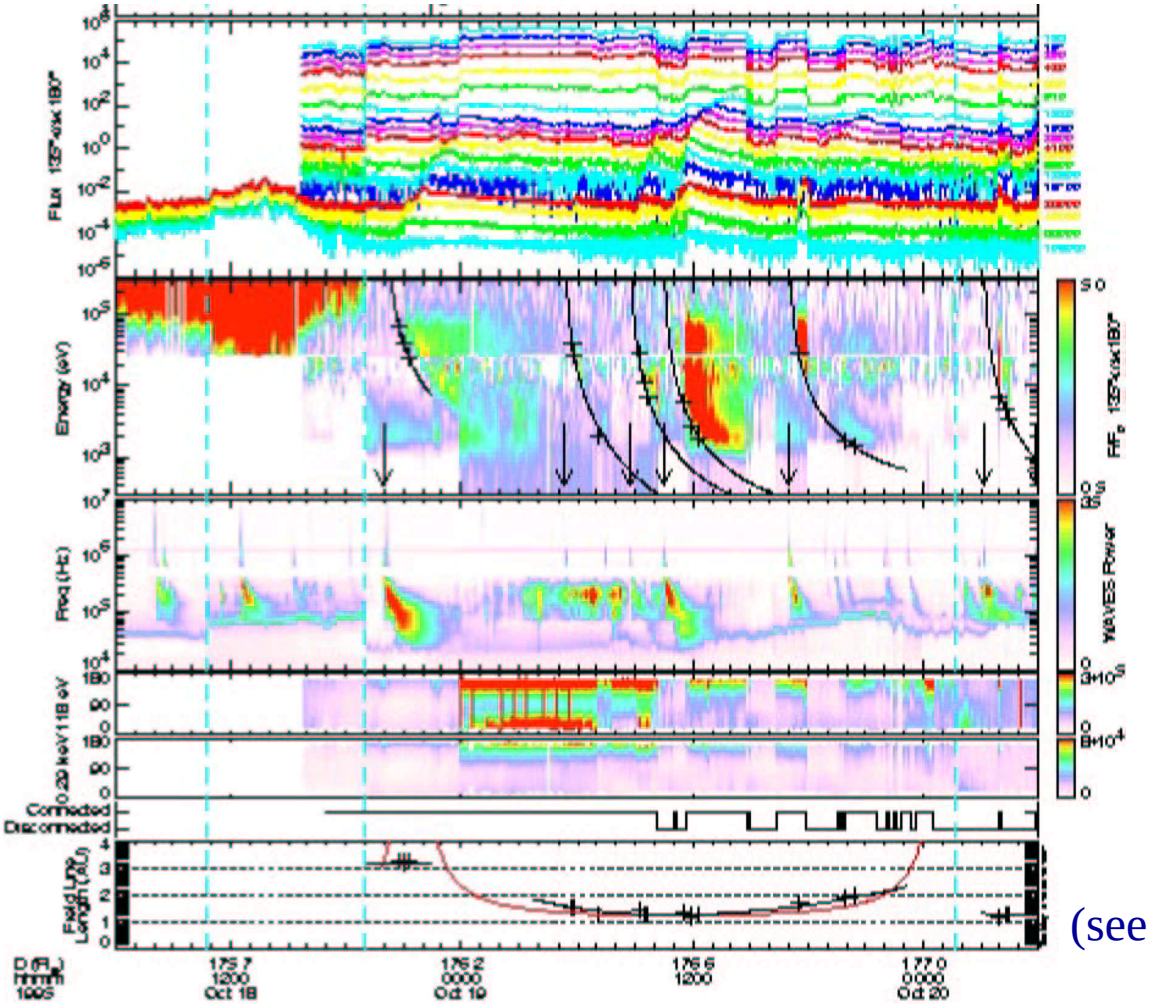
VIND SWEA, STE and
EPT-type electron
easurements

lectron velocity
ispersion gives field line
ngth, topology

adio burst gives
ectron injection times

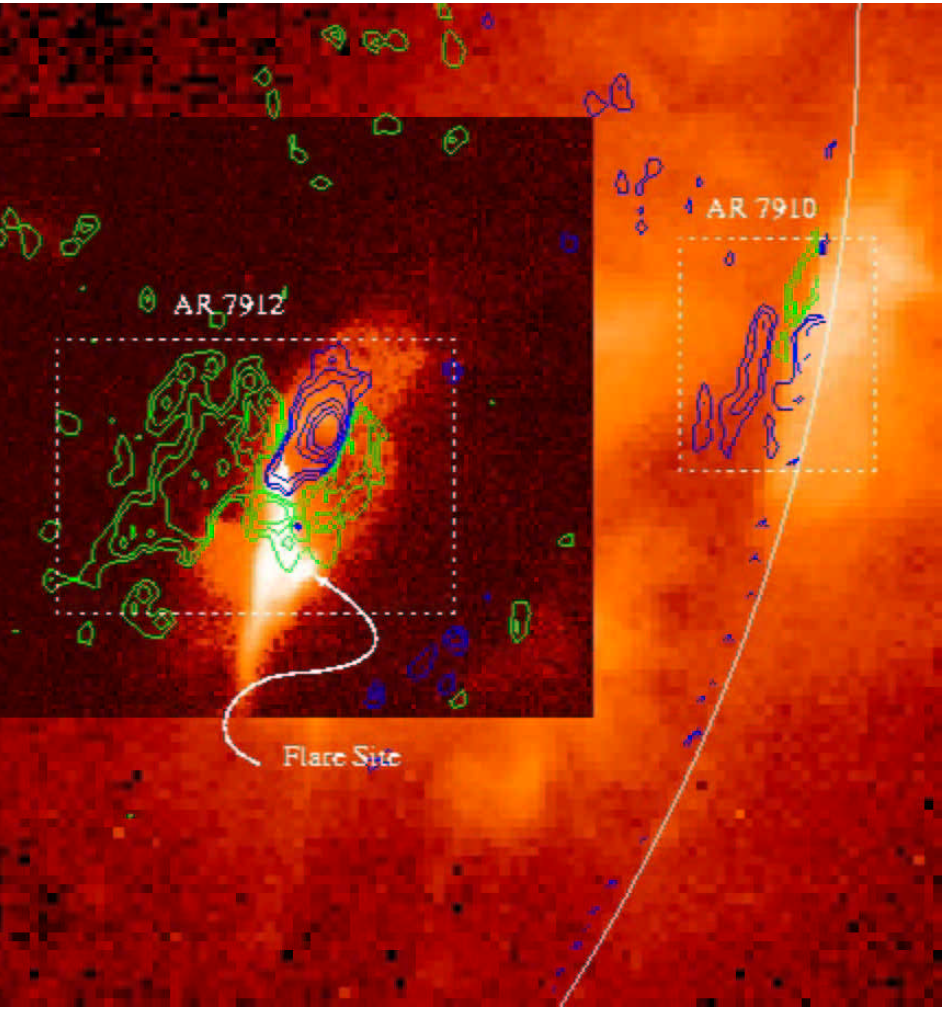
WEA-type electrons
dicate ICME field
nes solar connectivity

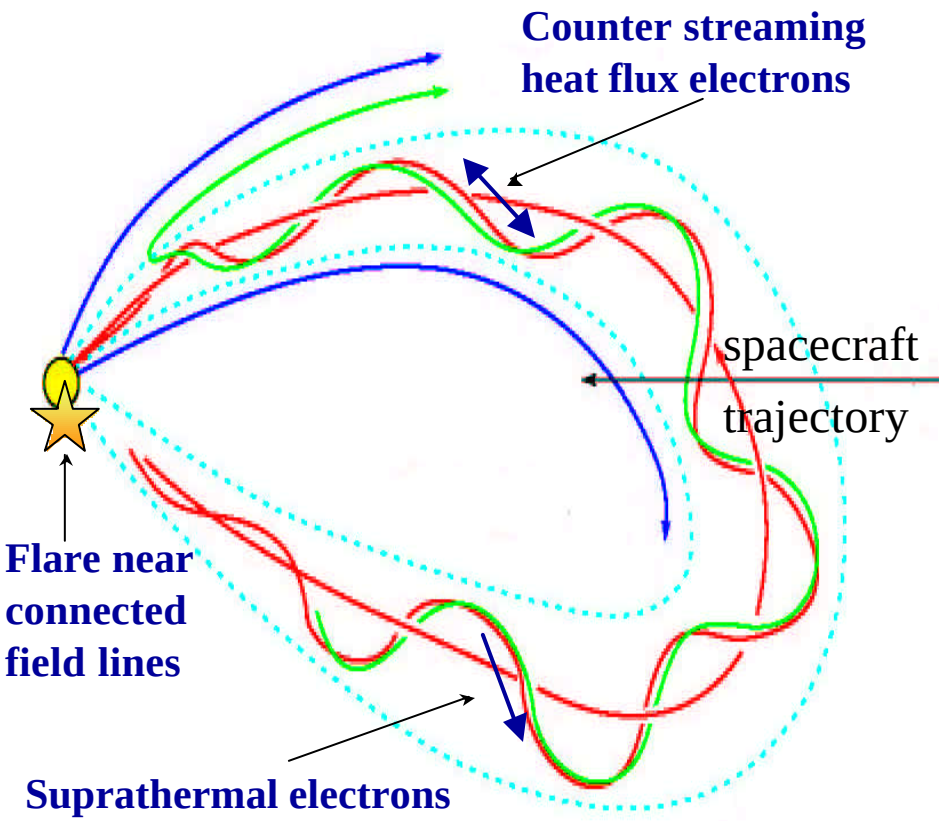
ield line length
ICME model vs.
nferred length



(see next pag

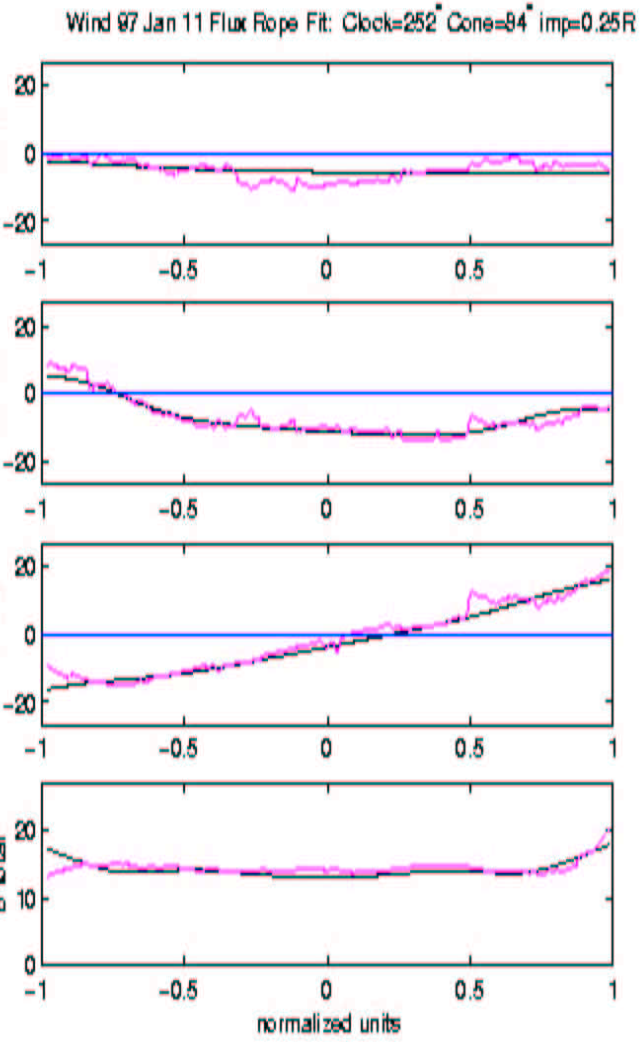
Image of Possible Flare Source of Electrons (from Yohkoh SXT)

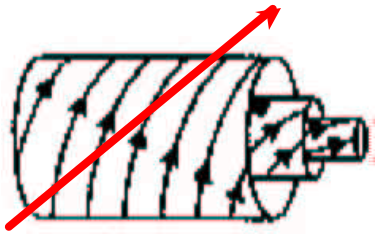




(figures from D. Larson)

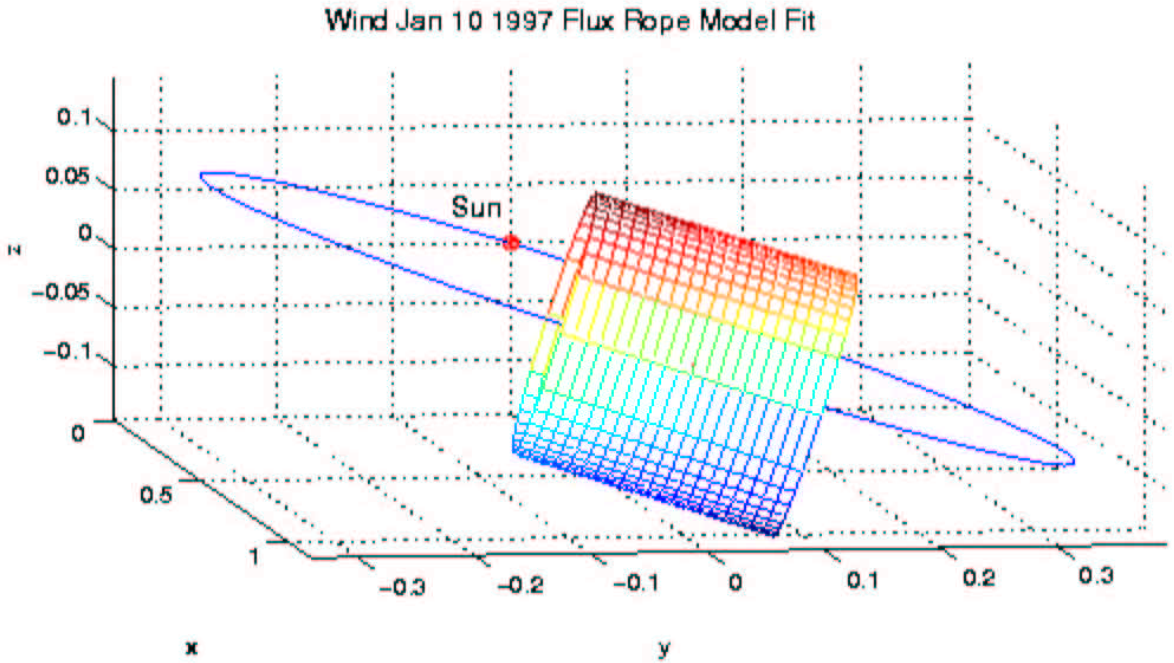
Magnetic Topology Measurements Using Magnetic Fields





Spacecraft sampling

"Fly Through" Model ICME Flux Rope (or other models) to reproduce Vector Field observations.



(flux rope fits by Tamitha Mulligan, from the paper by Yan Li et al., JGR 2001)

IMPACT Magnetometer Qualifications

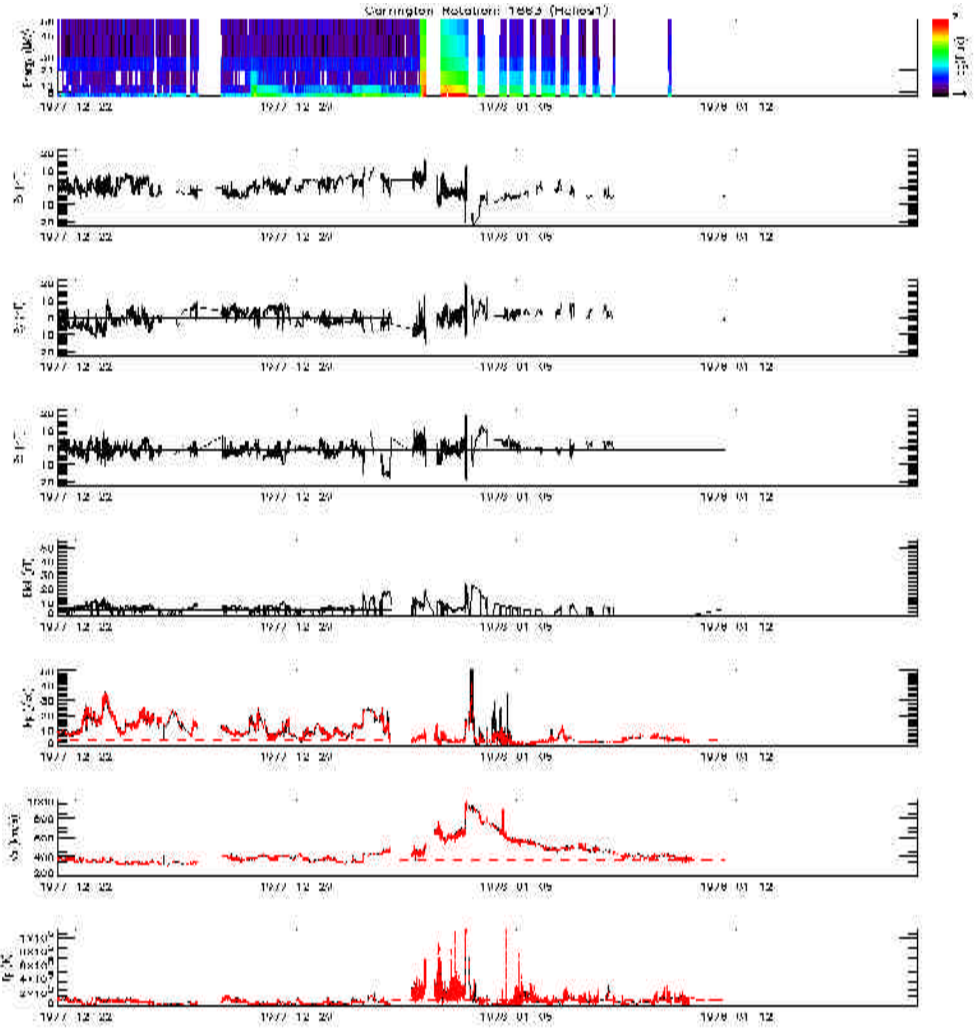
- **3 axis fluxgate**
- **± 1° alignment**
- **± 0.5° knowledge**
- **IMPACT boom to minimize spacecraft fields**
- **In-flight roll calibrations to determine final alignment**

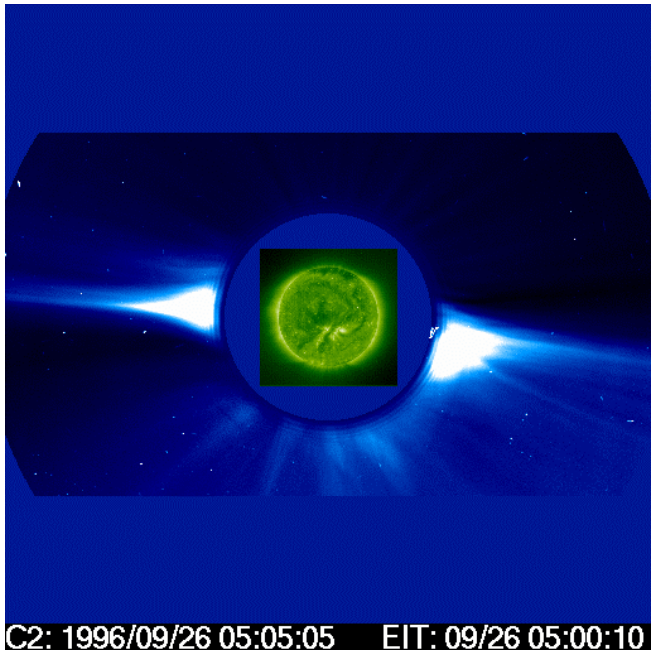
IMPACT Investigation Approaches:

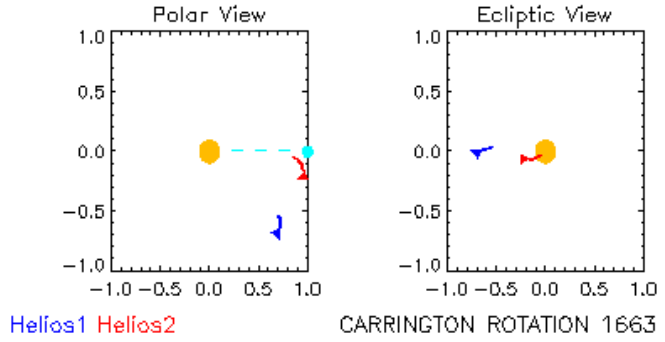
- **Multipoint interplanetary characterization of the imaged CMEs and their associated solar energetic particles (SEP) at increasing separations**
- **Quadrature measurements with imagers on STEREO and at Earth**
- **Space Weather detection, modeling and prediction**

Multipoint Measurements of ICMEs and SEP

Example from Helios 1/2 data for Carrington Rotation 1663 (left), Spacecraft locations (bottom), and SECCHI image placeholder from SOHO (S. Yashiro CDAW website images)

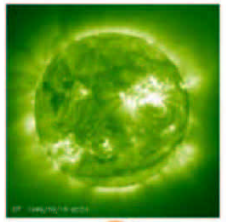




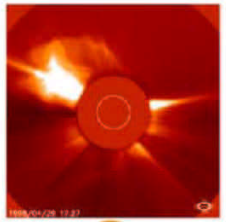


Luhmann

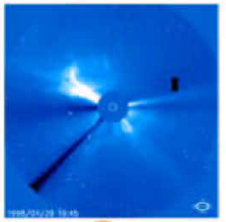
Doing STEREO Science



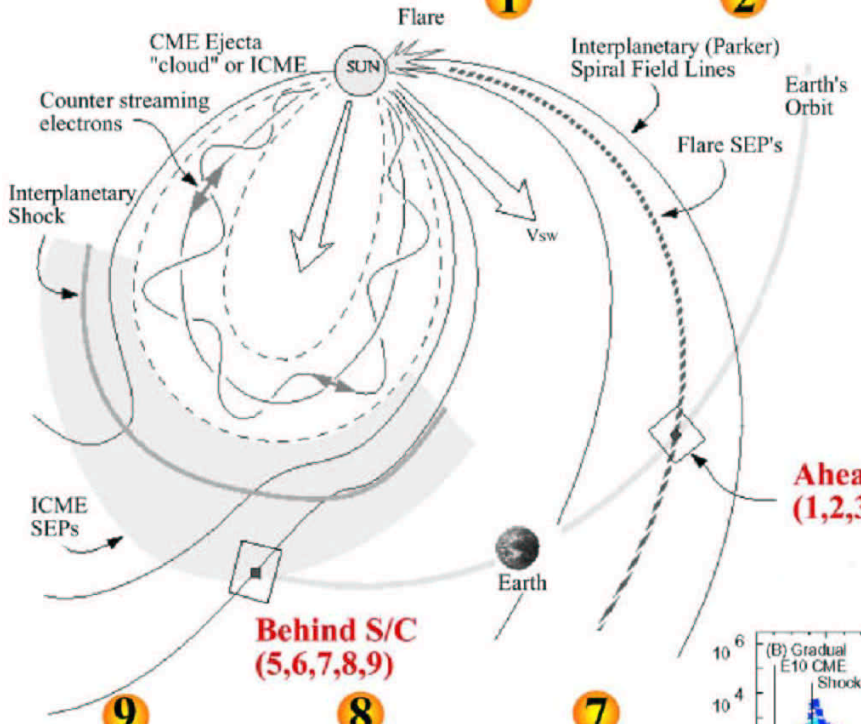
1

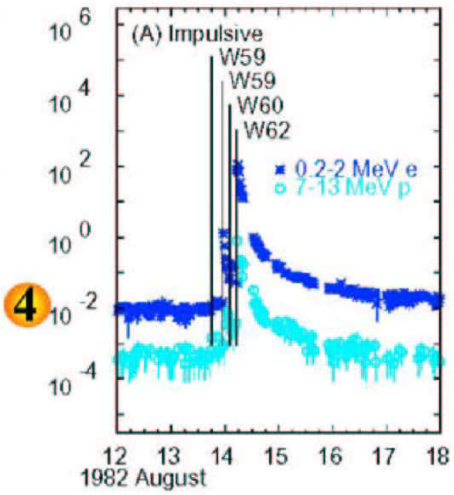


2

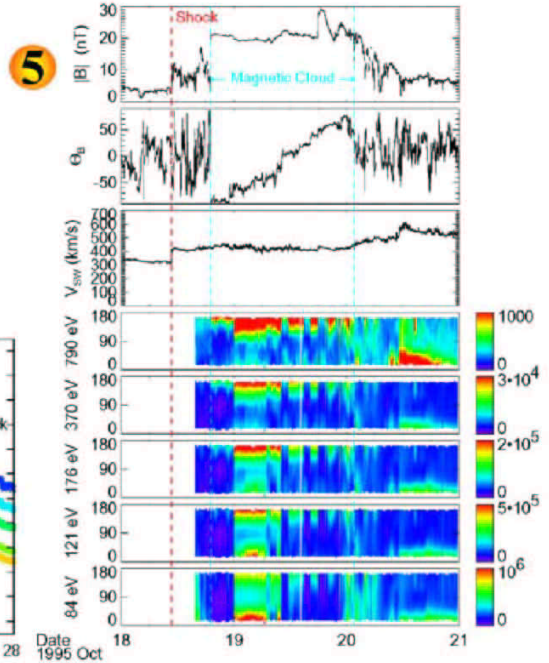


3

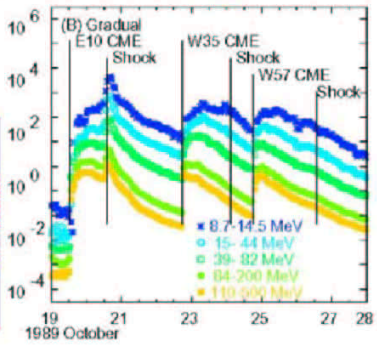




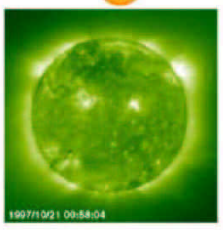
4



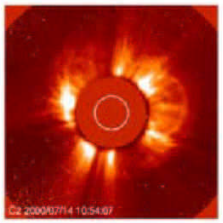
5



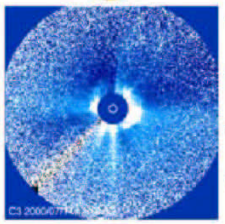
6



9

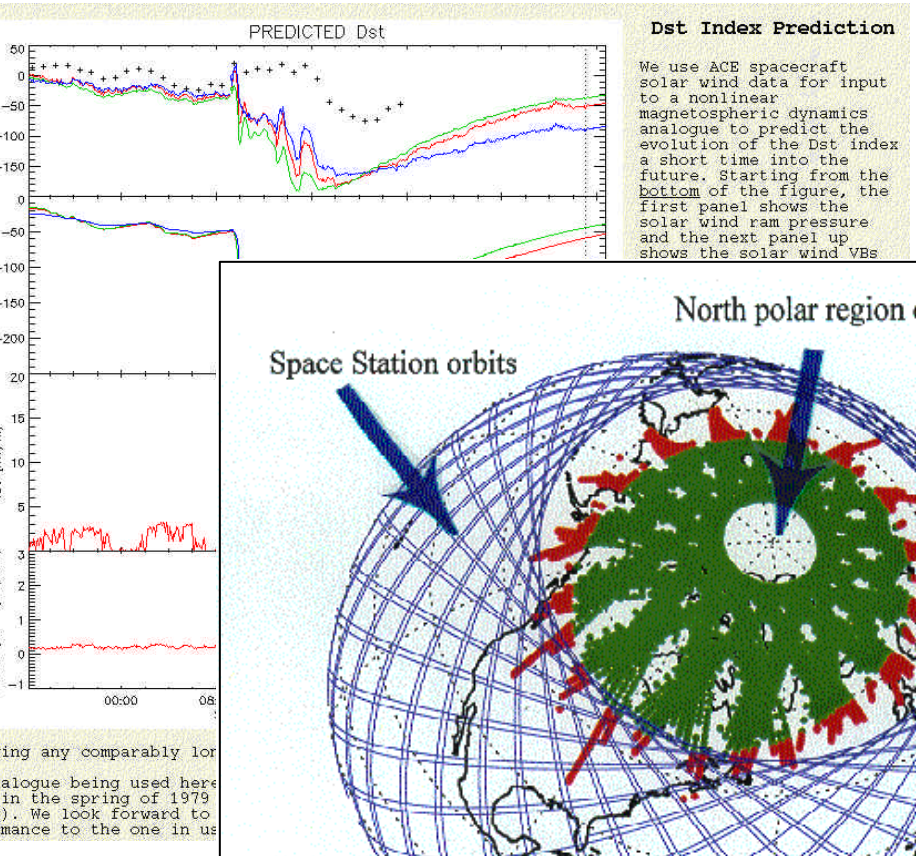


8

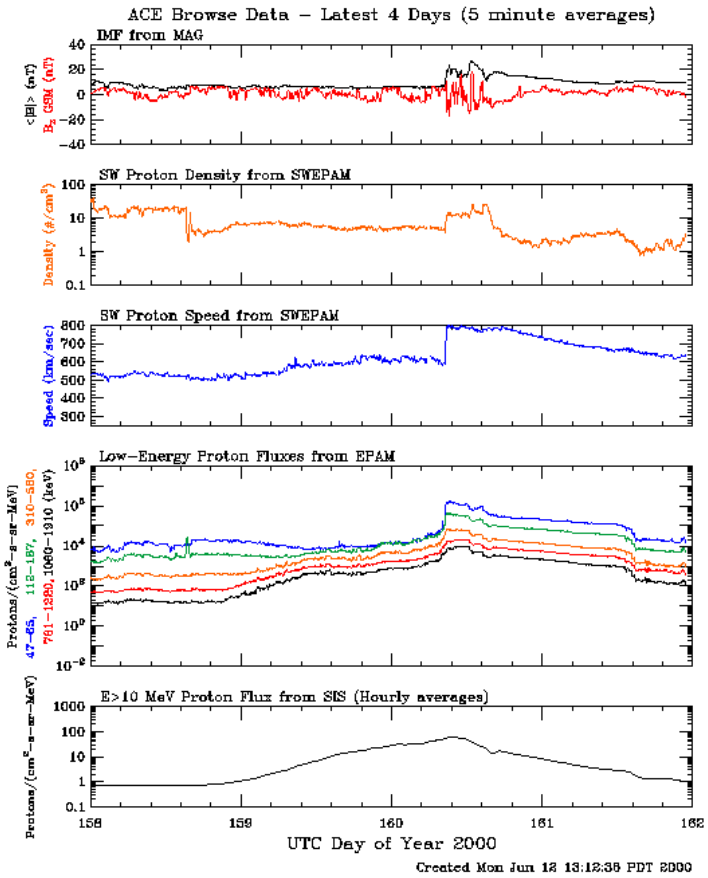


7

IMPACT Space Weather:



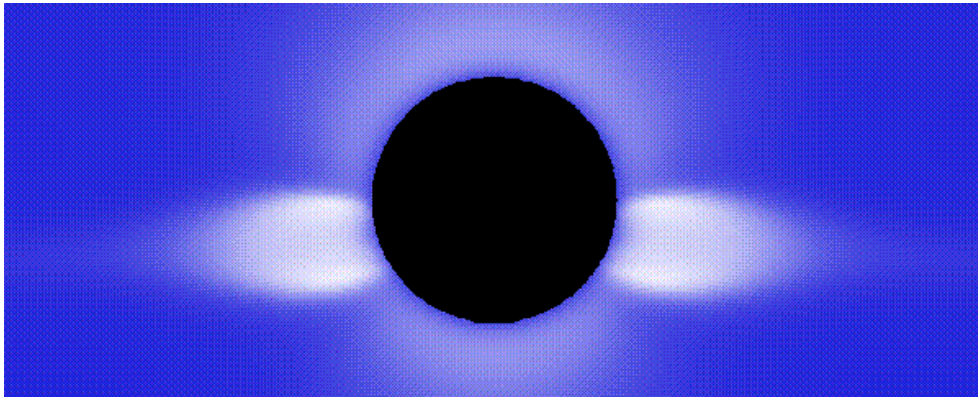
Key STEREO Beacon Contribution from MAG and SEP instruments

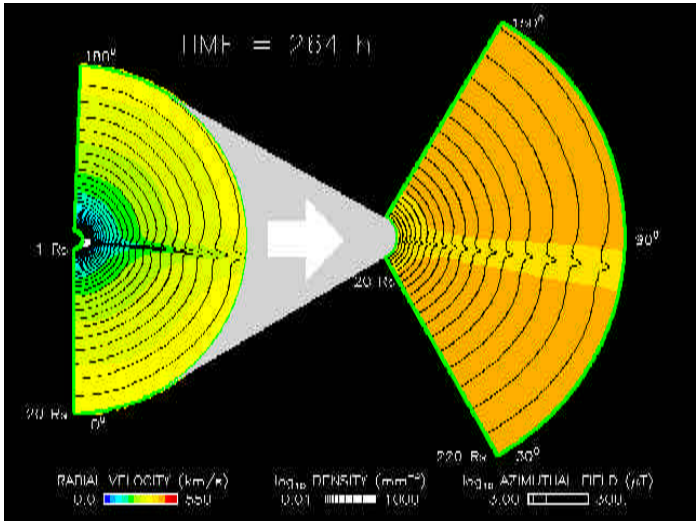


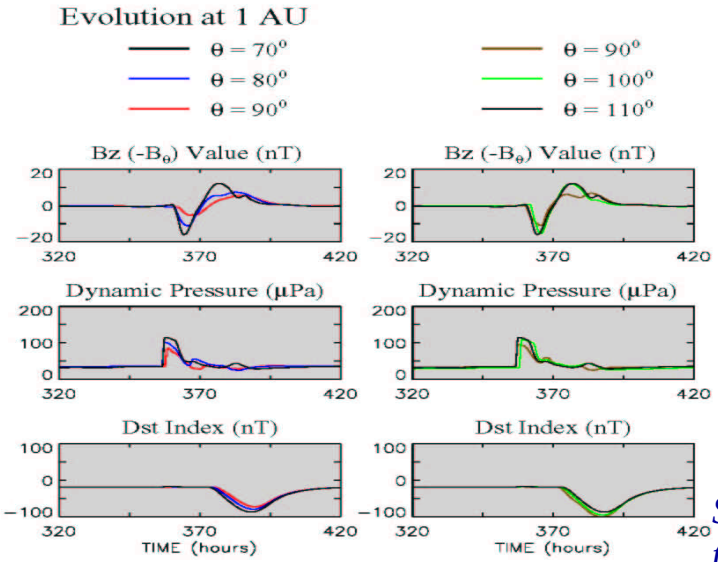
(examples from ACE Real Time Space Weather data user websites)

STEREO modeling will physically connect IMPACT observations to SECCHI images

(shown: SAIC CME model, Linker/ Odstrcil merged CME/Solar Wind model)







Simula
time se