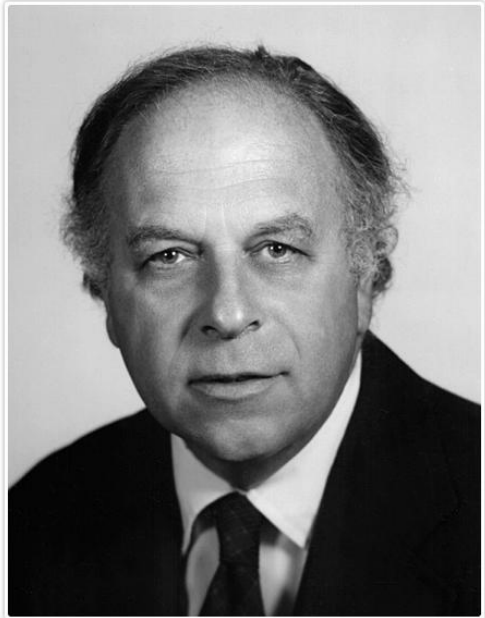


A Brief Summary of L5 Mission Concepts

Nat Gopalswamy

NASA/GSFC

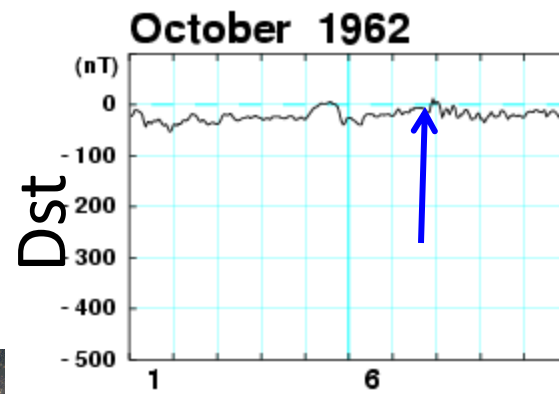
Mariner 2: Off & Above the Sun-Earth Line



C P Sonett (1924 -2011)



Mariner II



1962/10/07 15:46 UT

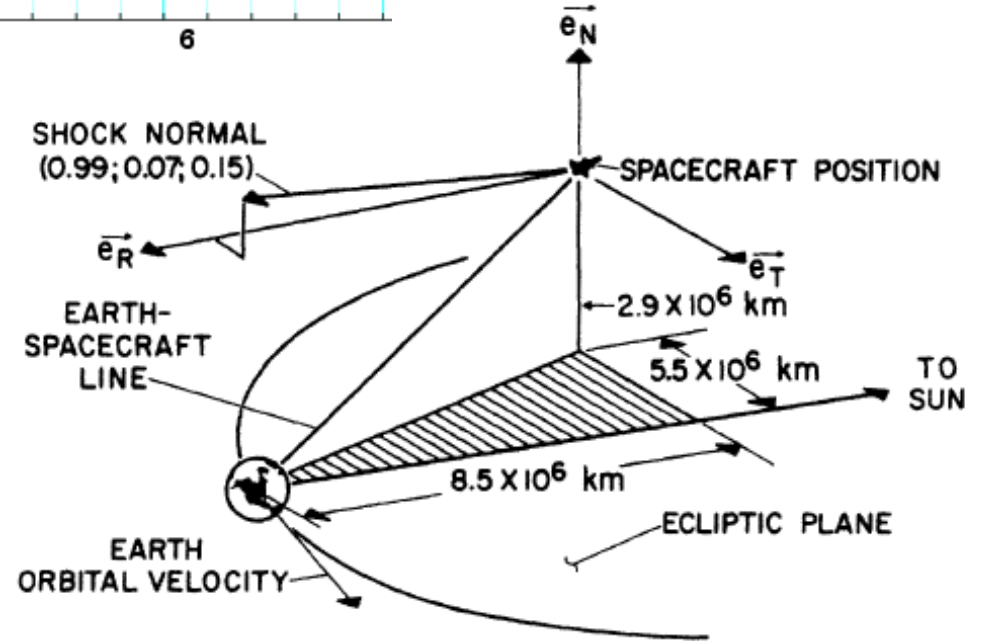


FIG. 1. Geometry of the Mariner II orbit on 7 October 1962. The shock normal direction computed from the change in the magnetic field is indicated. $\vec{e}_R, \vec{e}_N, \vec{e}_T$ are unit vectors defining a coordinate system along the radius vector from the sun, toward the ecliptic north pole, and along $\vec{e}_N \times \vec{e}_R$, respectively.

IP shock followed by a Sudden Commencement 4.7 h later - confirmed Gold (1953) suggestion

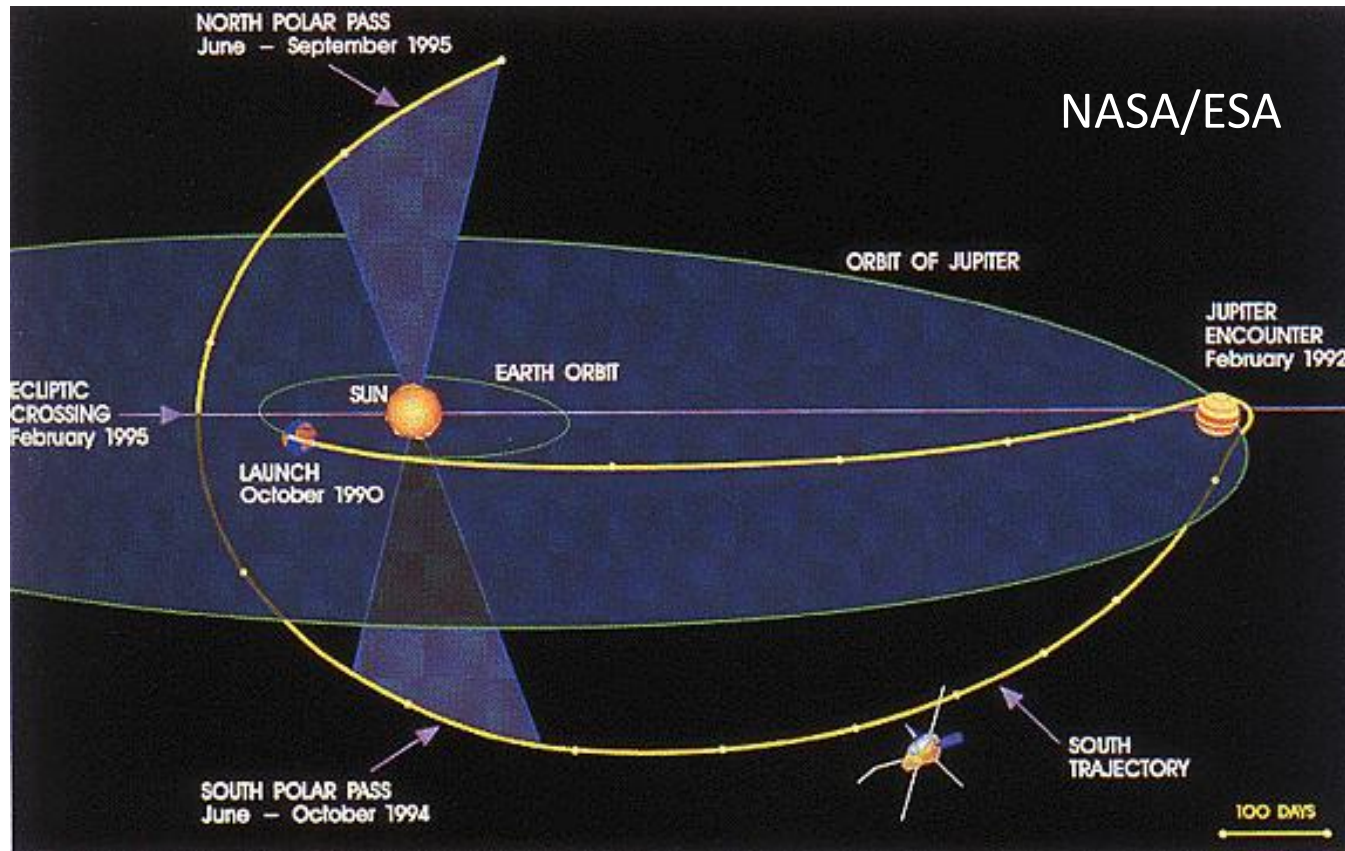
Mariner 2 was behind Earth by 36 deg Shock along Sun/SC line - glancing blow to Earth

Off the Sun-Earth Line Views

...the solar, interplanetary and galactic phenomena discovered in these years have raised many urgent scientific questions which can only be answered by direct observations and experiments **far out of the ecliptic plane** and over the solar pole to achieve a "global" concept of the Sun, the interplanetary medium and their relationship to Earth and the boundary of the heliosphere with the interstellar medium“

J. A. Simpson "Symposium on the Study of the Sun and Interplanetary Medium in Three Dimensions" May 15-16, 1975, Goddard Space Flight Center

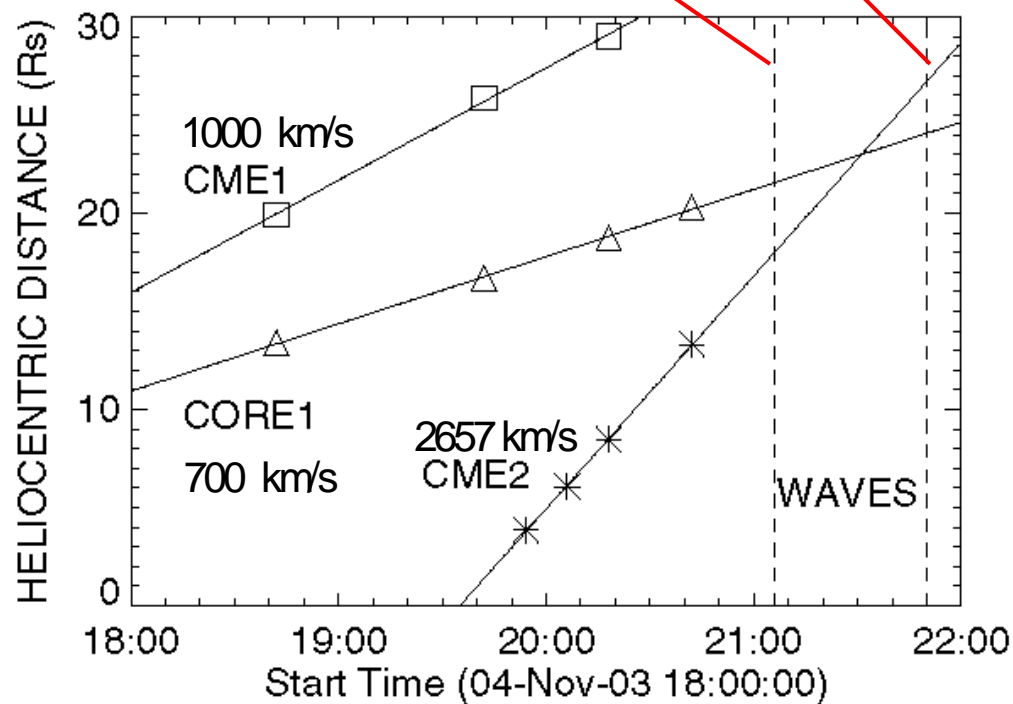
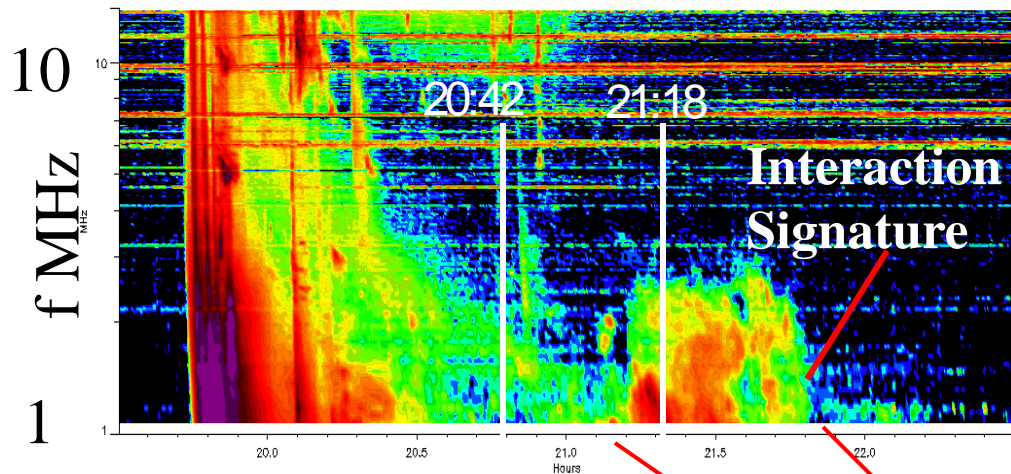
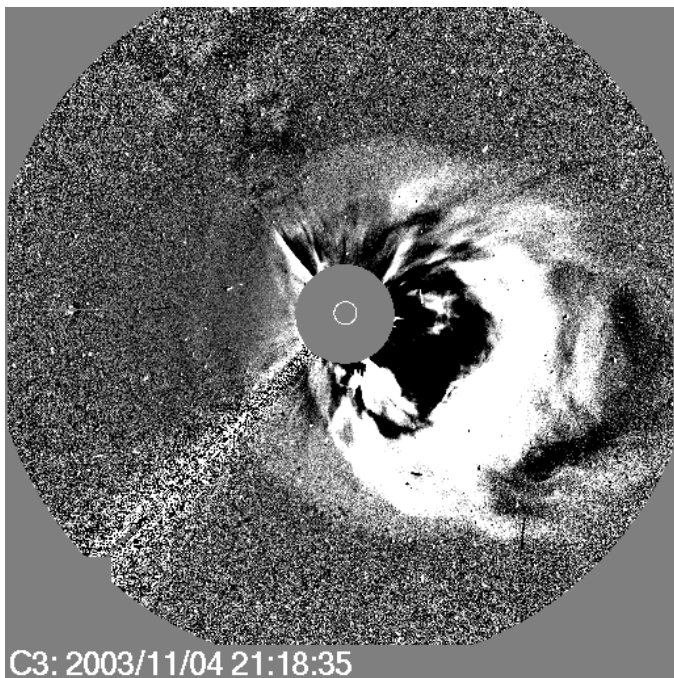
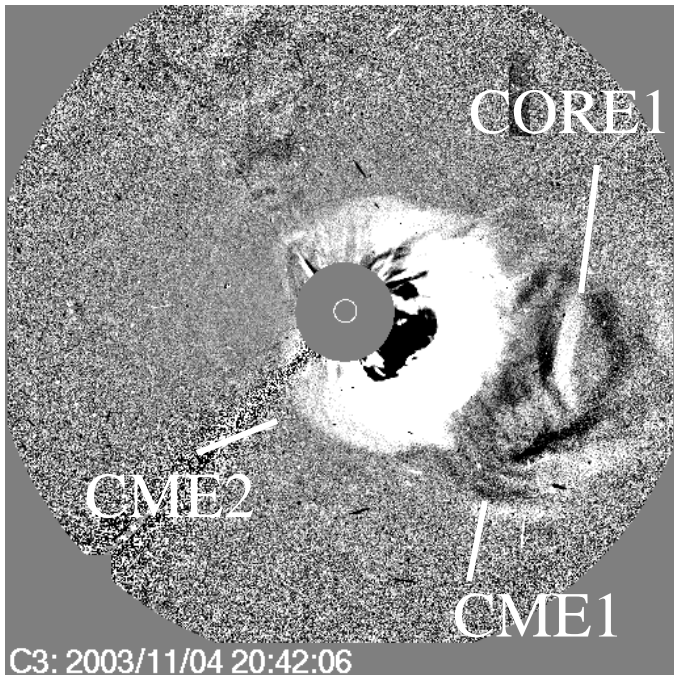
Ulysses – famous Polar Orbiter



No solar imagers

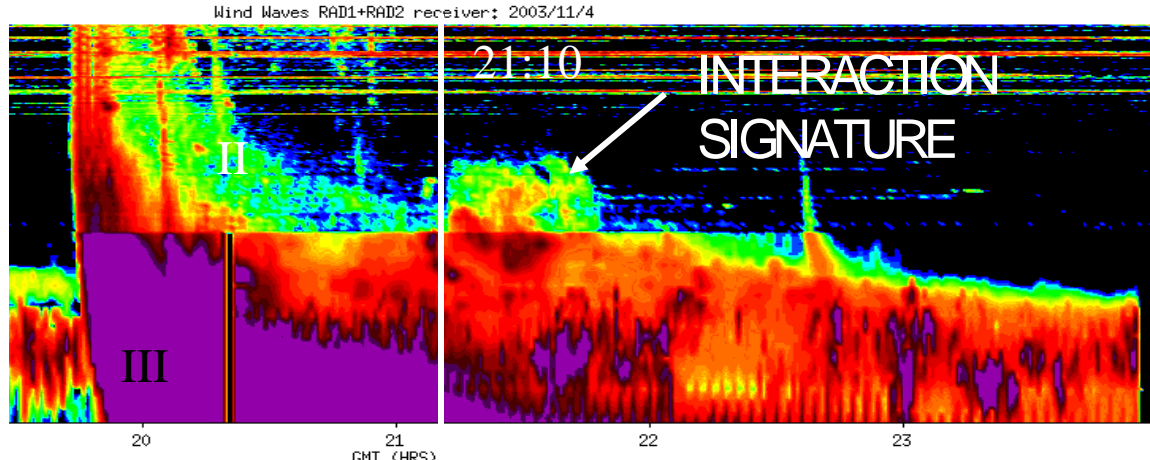
1990-2009

Comparing CMEs with Radio Data

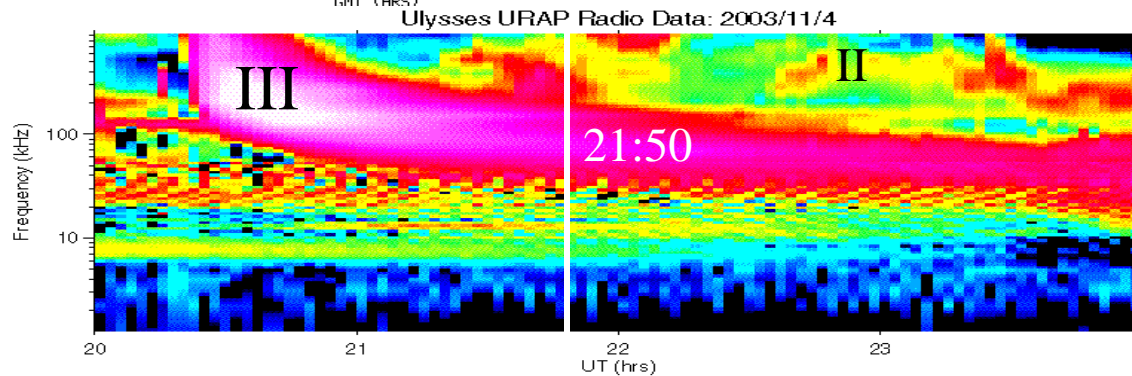


2003/11/04 Interaction Signature at Wind, Ulysses & Cassini

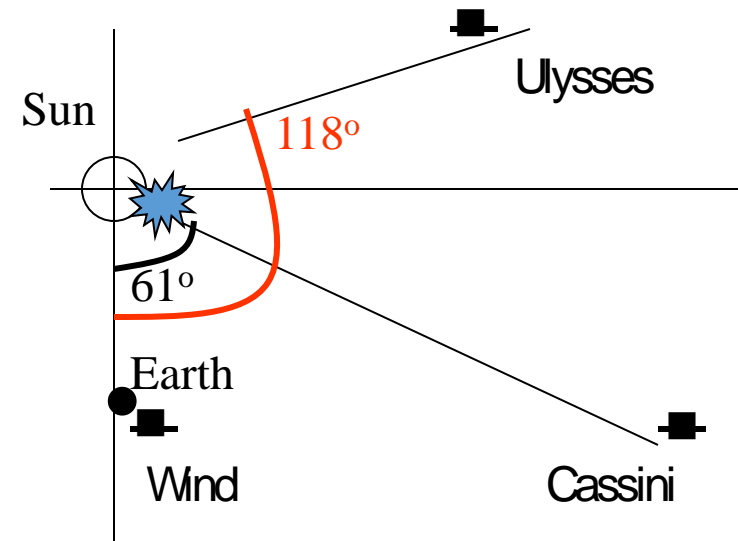
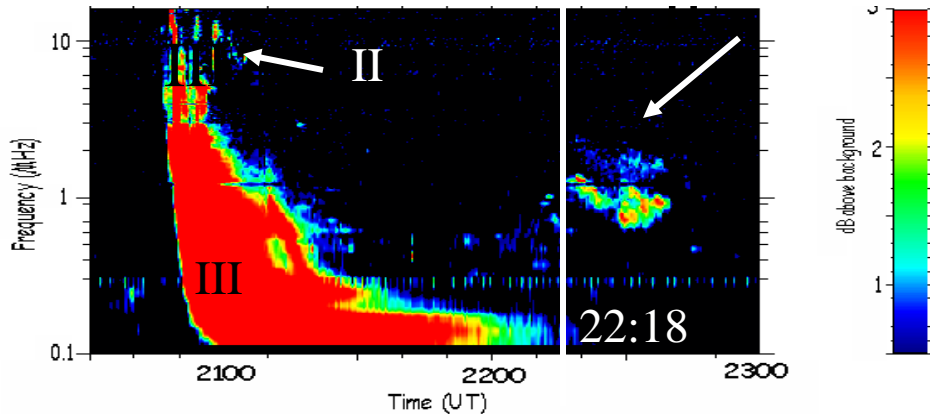
Wind
1 AU



Ulysses: 5 AU
<900 kHz



Cassini: 8.7 AU

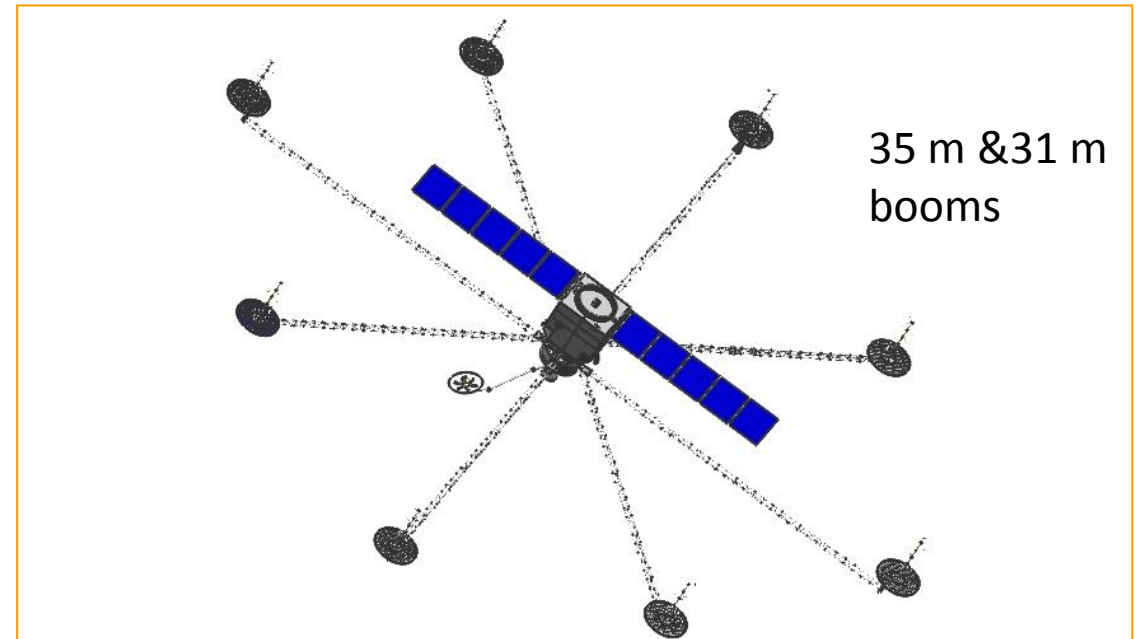


Ecliptic Plane
2003/11/04

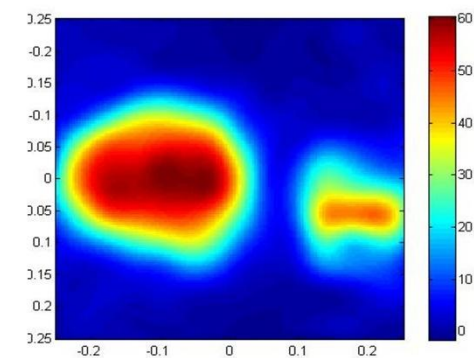
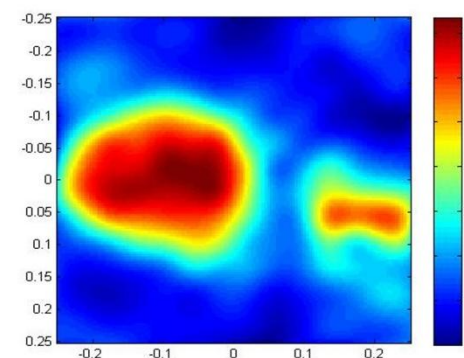
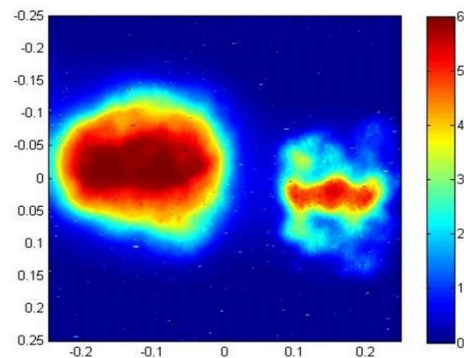
The Wind/WAVES signature starts at 21:18 was seen by Ulysses at 21:50 and Cassini at 22:18 UT (white lines). Cassini data confirms that the interaction signature is very strong

Solar Polar Orbit Radio Telescope (SPORT)

- Synthesis radio imaging at 150 MHz
- Other remote-sensing Instruments: Coronagraph, X-EUV Imager, Heliospheric Imager
- In-situ: Plasma, magnetometer, Energetic Particle detector
- Ulysses with solar imaging

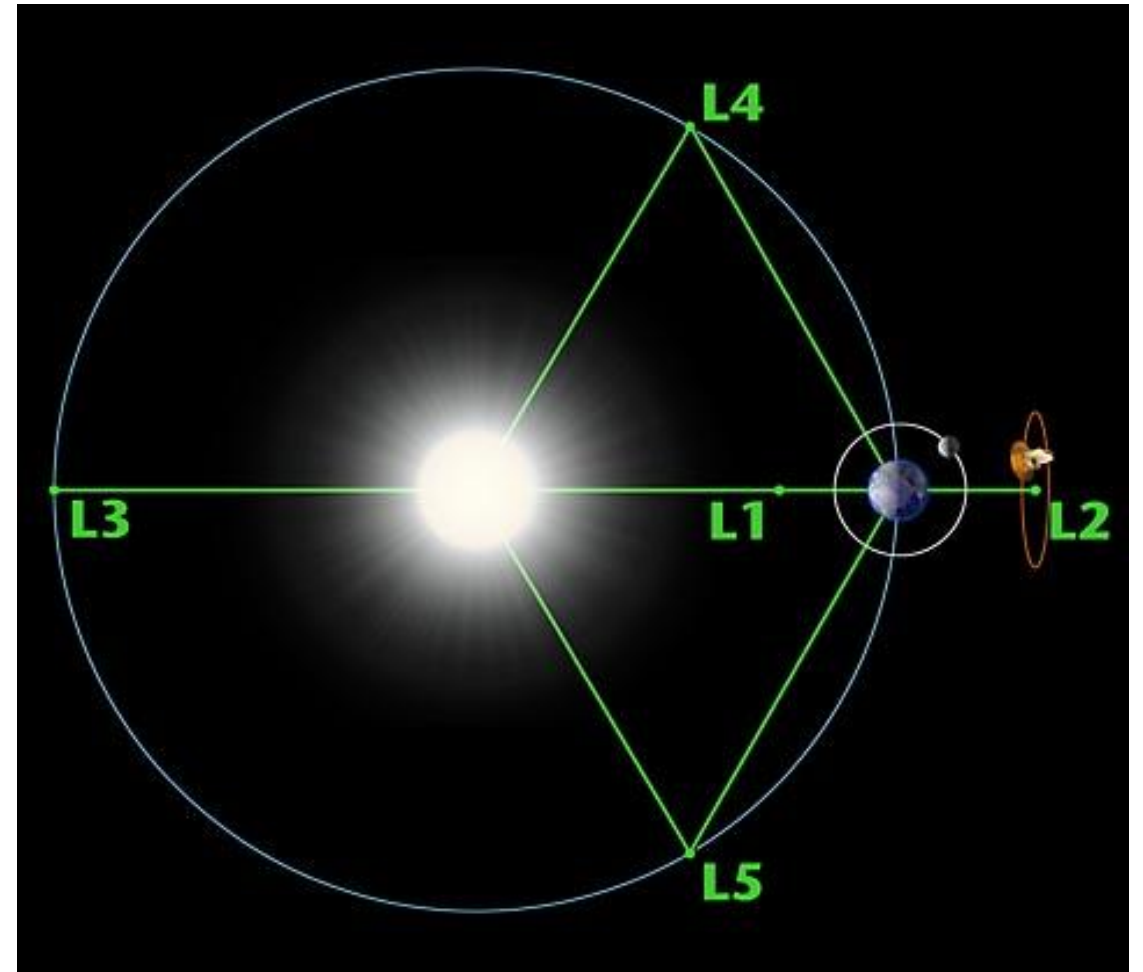


Imaging Type IV bursts associated with coronal mass ejections



In Ecliptic, Off the Sun-Earth Line

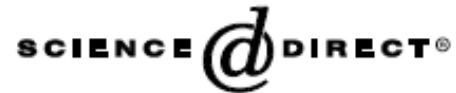
- Earth-affecting solar phenomena (space weather) CMEs, CIRs
- Stable Lagrange Points (L3, L4, L5)
- L5: Forecast of solar source arrival



Recent Concepts



Available online at www.sciencedirect.com



Advances in Space Research 35 (2005) 65–69

**ADVANCES IN
SPACE
RESEARCH**

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NICT
NASDA
ISAS

The L5 mission for space weather forecasting

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Objectives

- observing space weather phenomena,
- conducting experiments on space weather forecasting,
- contributing to international space weather observation networks

Side view of CMEs (remote-sensing)

In-situ plasma, SEPs

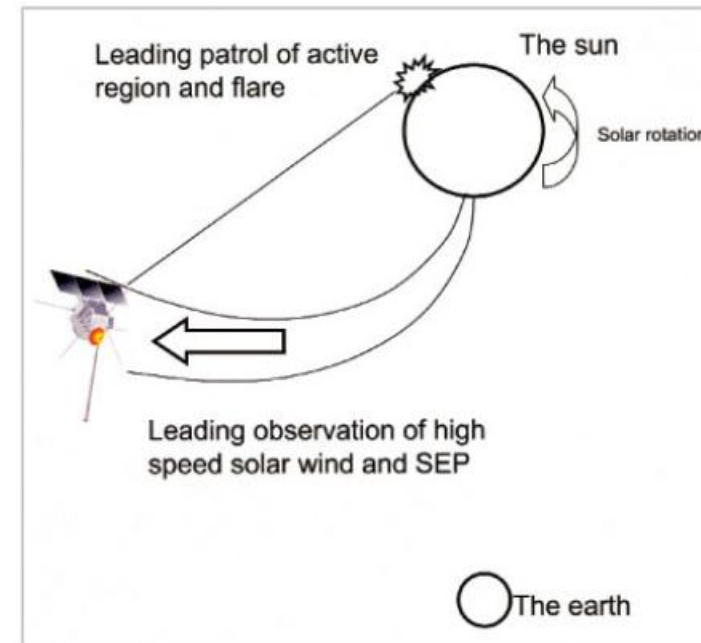
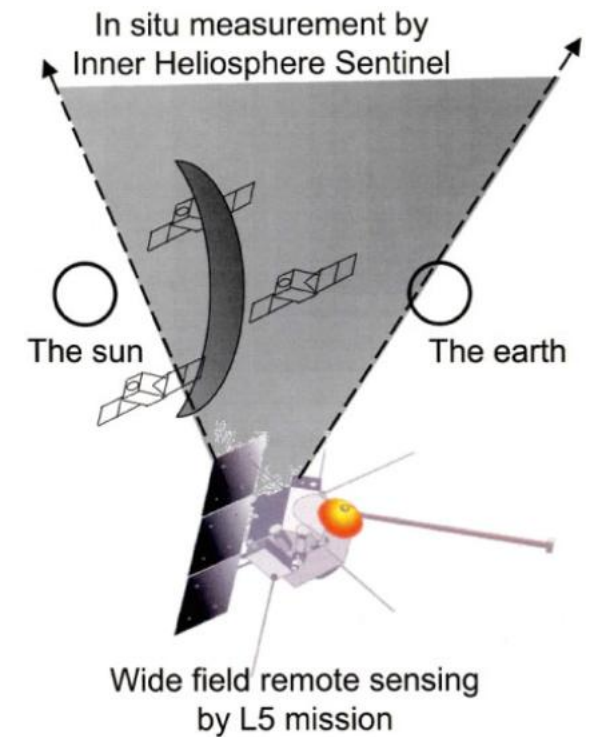
Delineate CME and shock structure

Real-time SWx data

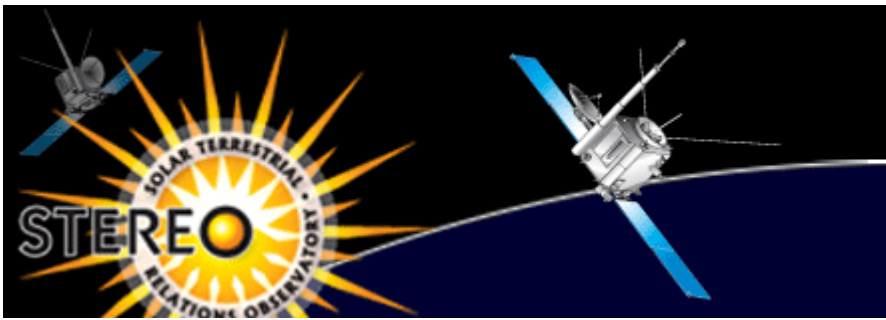
CRL L5 Candidate Instruments

- Solar full disk imager (visible)
- EUV Imager
- High resolution coronal imager
- Wide field coronal imager
- Plasma wave detector (Radio)
- High energy particle instrument
- Magnetometer
- Solar wind plasma analyzer

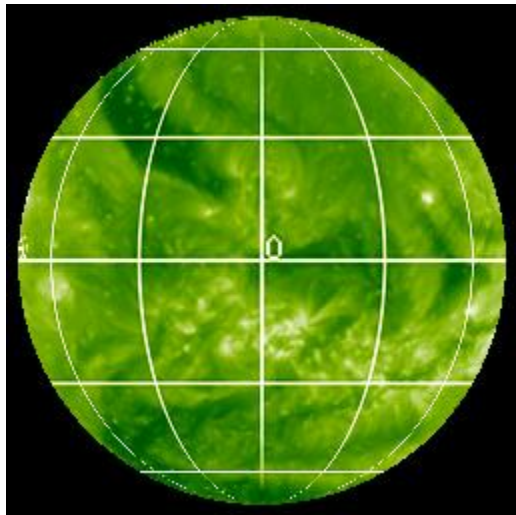
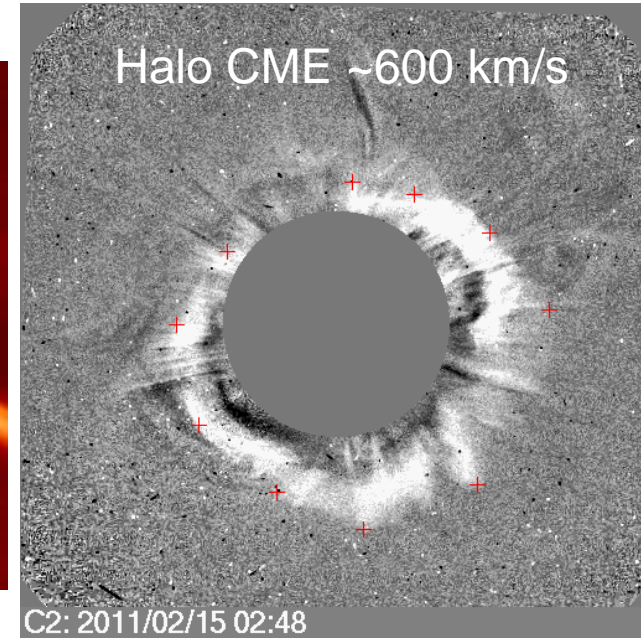
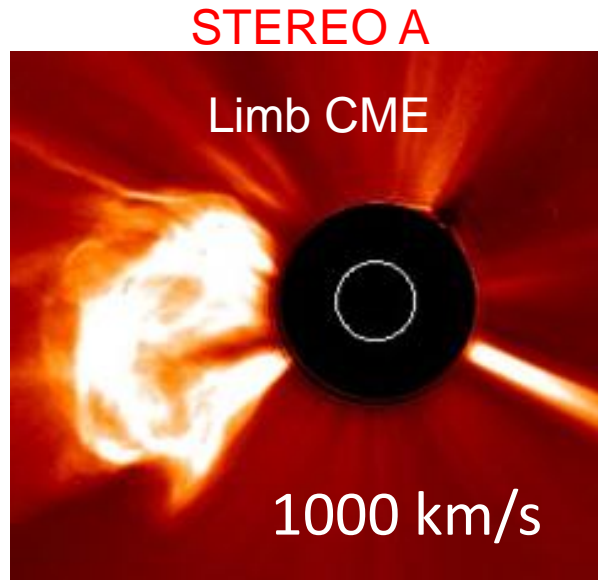
Remote sensing & In-situ instruments



CMEs, CIRs
and their
Source Regions

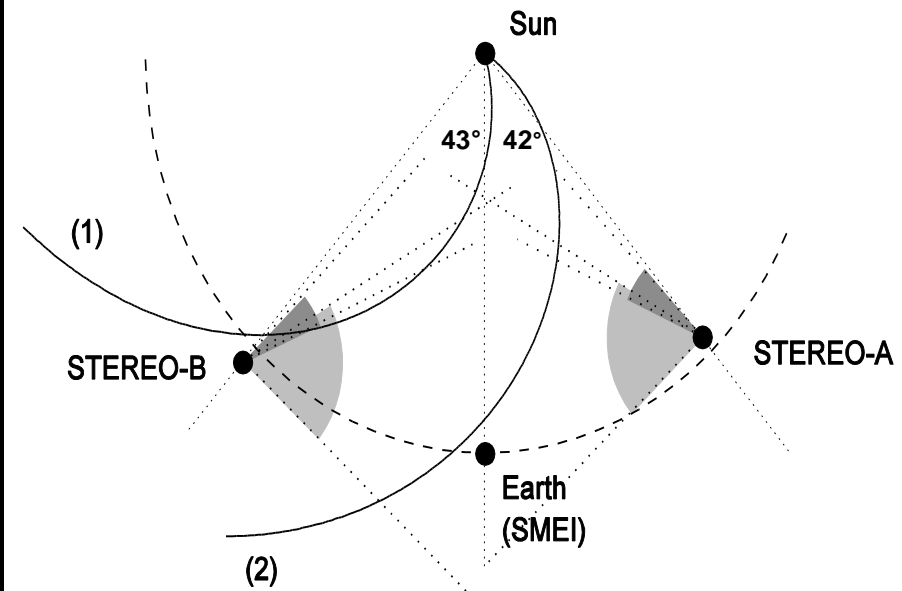
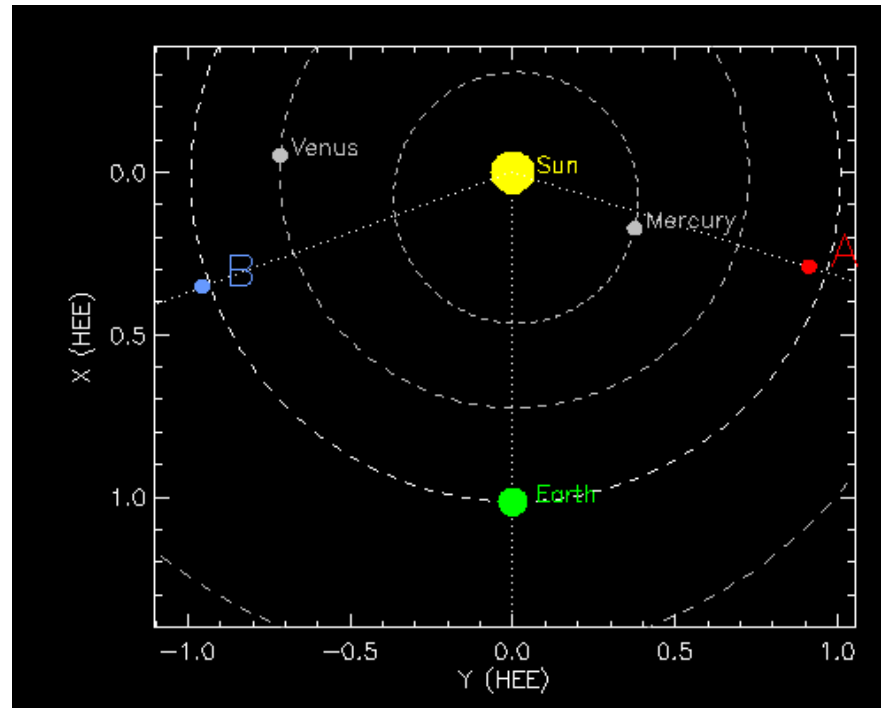


STEREO: An L5 Pathfinder



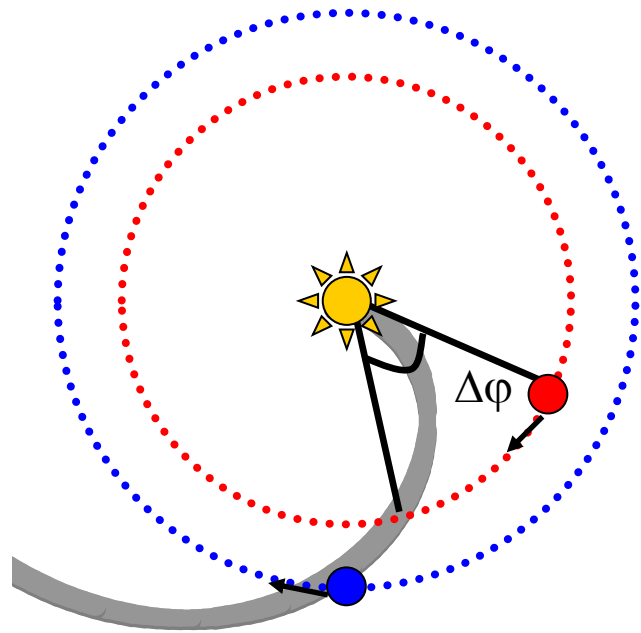
STA + STB + SDO/AIA

R. A. Howard et al. 2008



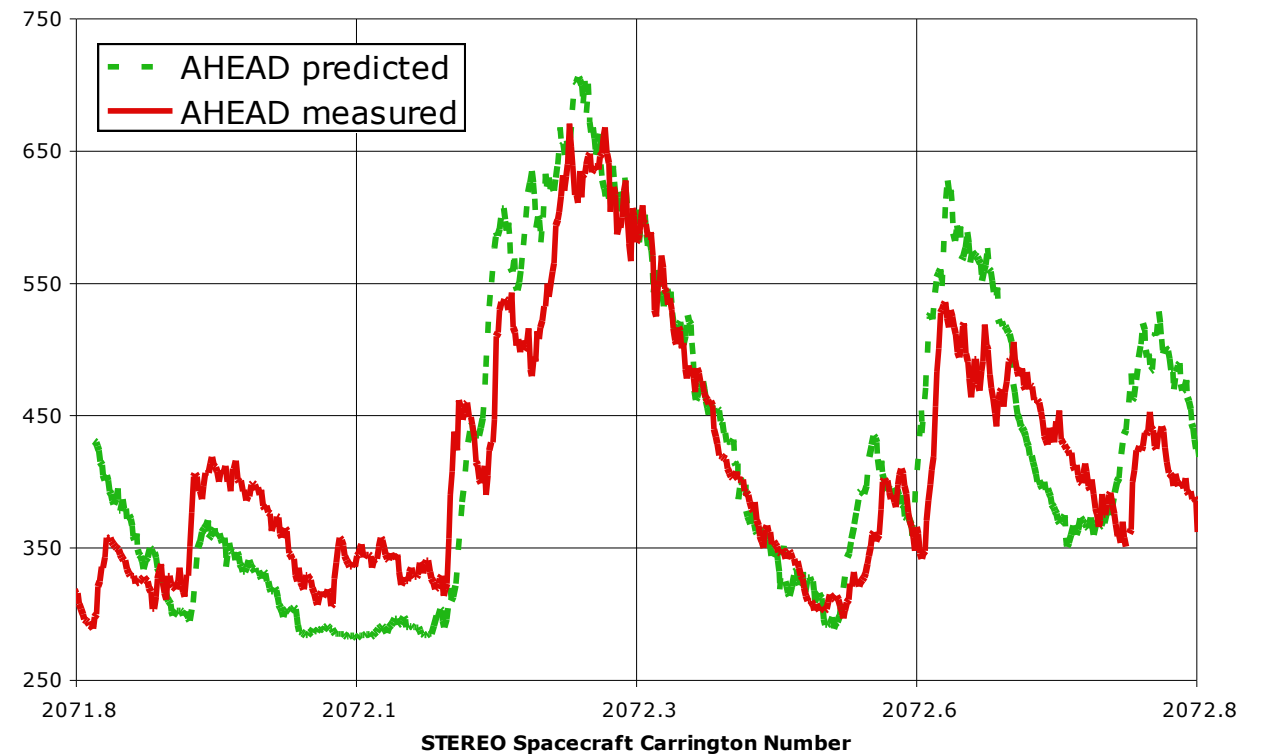
CIR Arrival Prediction from STEREO-B

Simunac et al. 2009



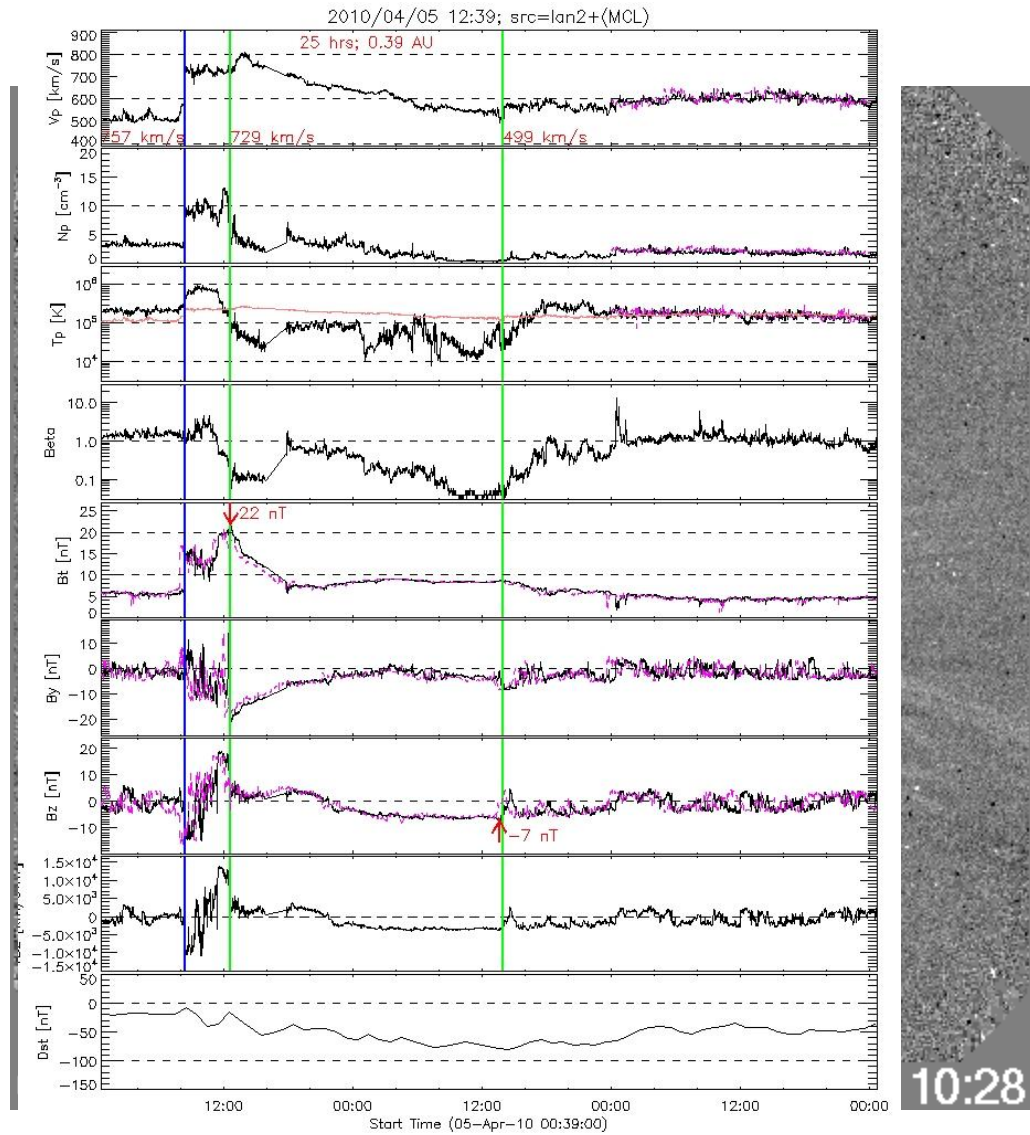
$$\Delta\phi = \frac{\Omega_{Sun}\Delta R}{V_{SW_BEHIND}}$$

Proton Bulk Speed versus Time
July 2008



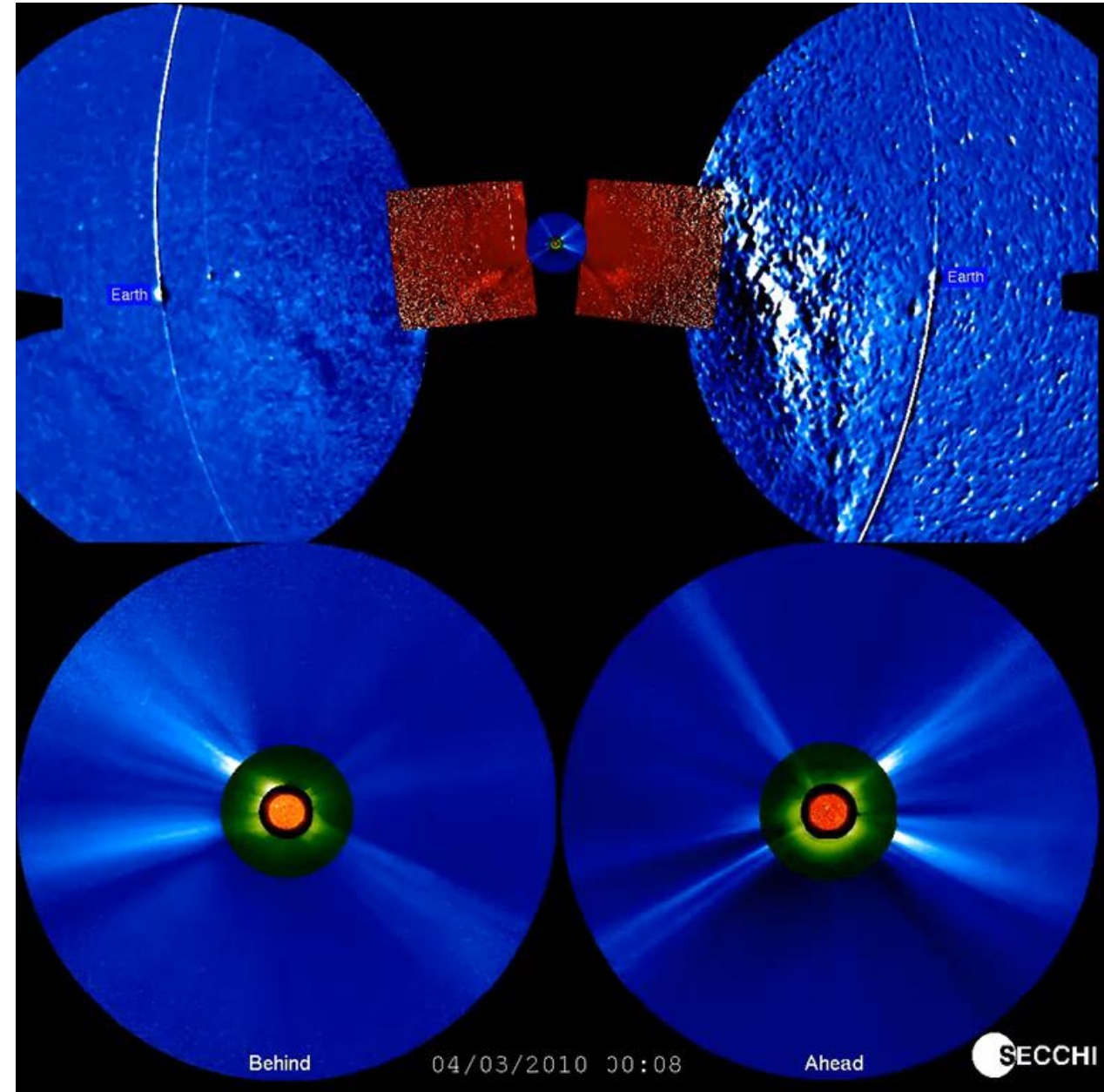
Radial and Latitudinal differences

A CME Impacting Earth



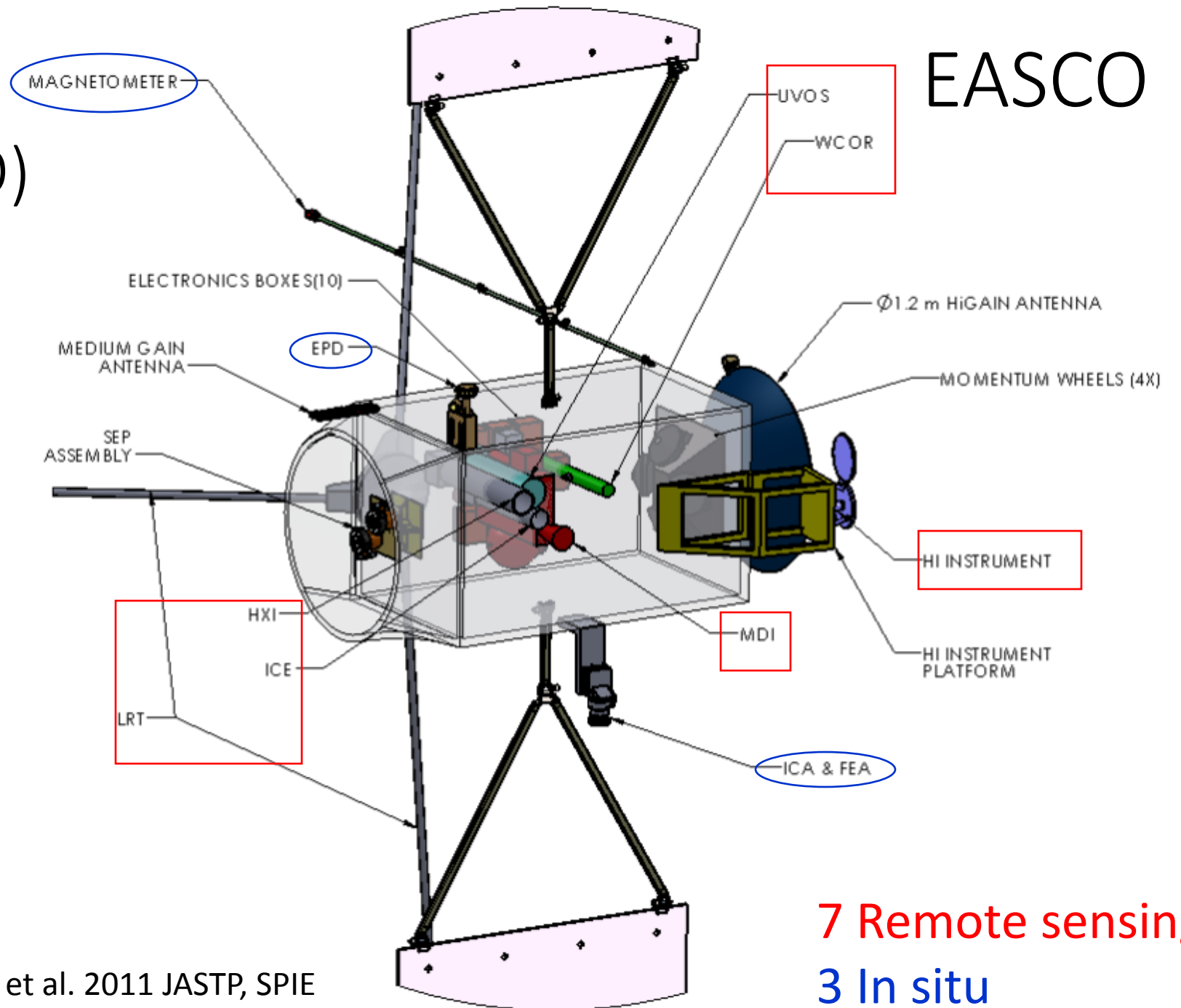
See also Davis et al. 2009 for another event

ST-A 70 deg ahead and ST-B 70 deg behind Earth

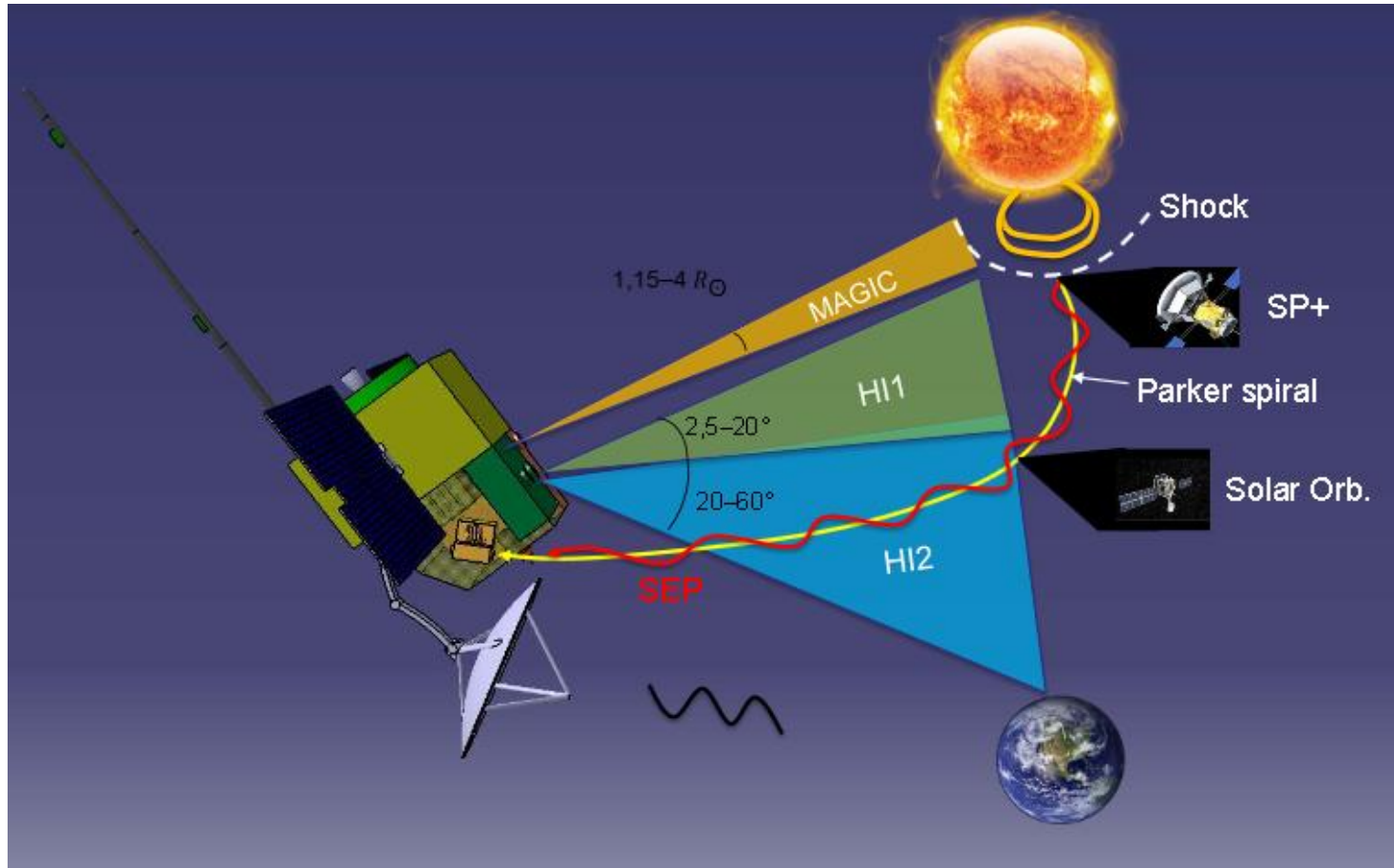


Earth-affecting Solar Causes Observatory (EASCO)

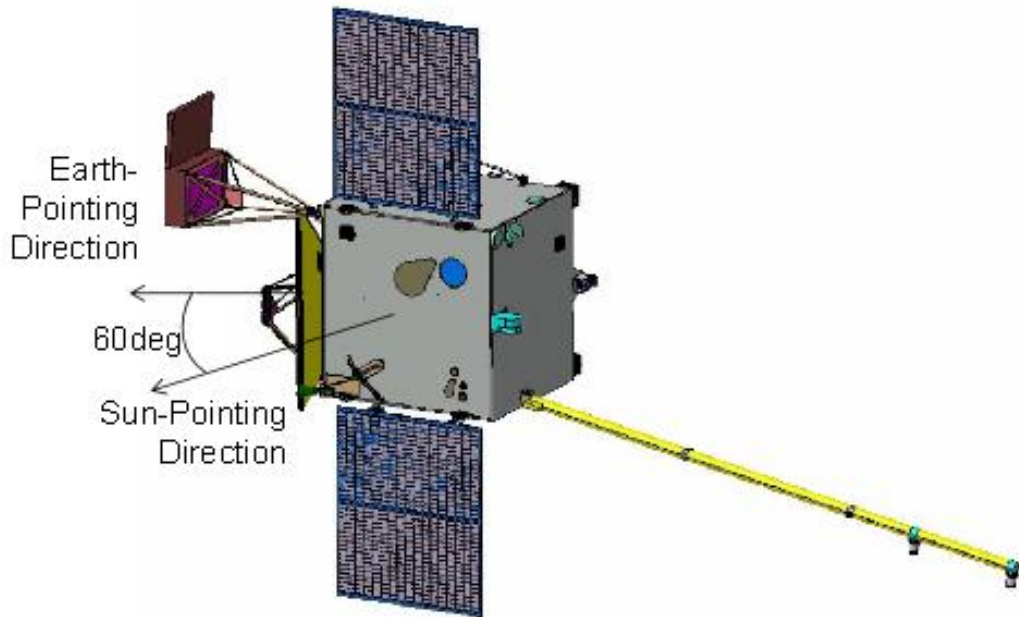
- SOHO at L5 with a magnetometer and radio telescope
- STEREO hovering around L5 with a magnetograph
- Add Hard X-ray Imager (RHESSI)
- CMEs, CIRs
- Solar interior where magnetic fields originate
- Updated synoptic maps for solar wind forecast



INvestigation of Solar-Terrestrial Activity and Transients (INSTANT)



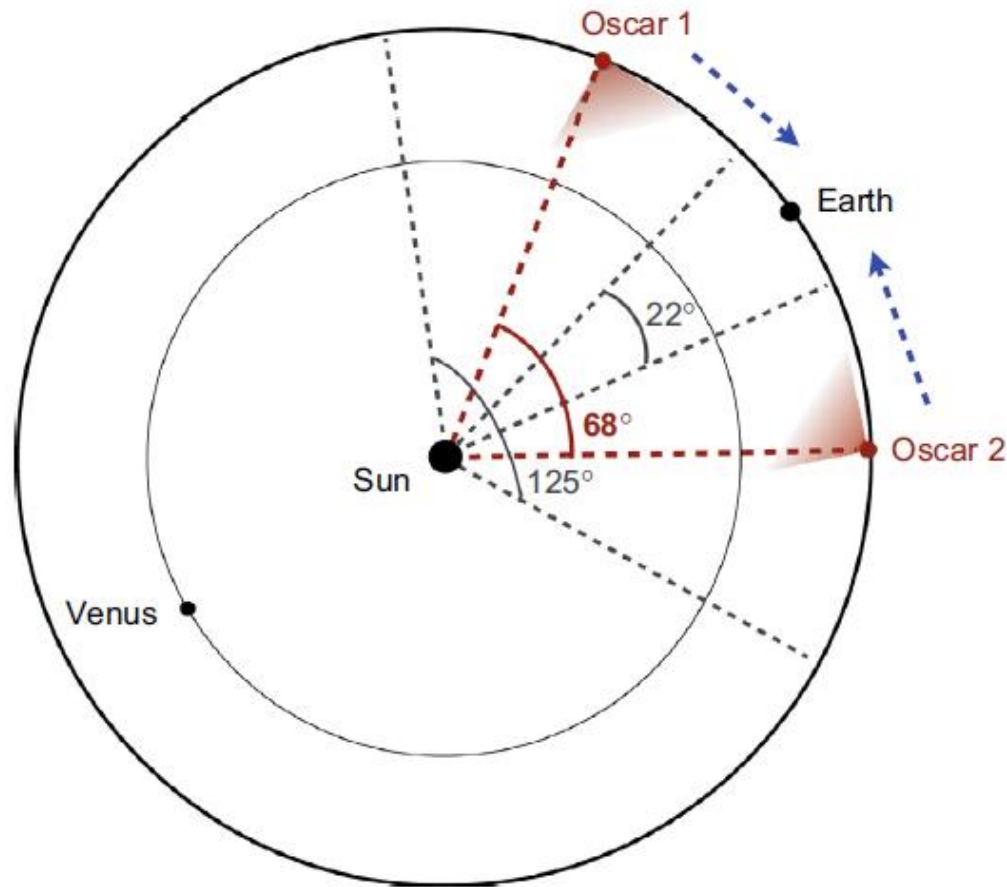
Carrington: The UK/US Operational Space Weather Mission



Trichas, L5 consortium meeting Boulder 2014

Instrument	
Coronagraph	Critical for identifying Earth-directed CME
Heliospheric Imager	Critical for identifying Earth-directed CME, and imaging arrival at Earth
Particles/fields	Measurement of CIR approaching Earth.
EUVI	To image solar active centres, in particular to assess the potential for eruptions/flare at sites as the approach locations well connected to Earth
Magnetograph	To image the magnetic structure of the photosphere at sites approaching locations well connected to Earth. Earth-directed events that originate in the field-of-view of the magnetogram, the data can be used to give an indication of the level of geomagnetic activity that will follow. Assess the potential for eruptions/flare.

A Space Weather mission concept: Observatories of the Solar Corona and Active Regions (OSCAR)



Photospheric Imager (PIM)
EUV Active Region Imager (EUARI)
Coronagraph (COR)
Heliospheric Imagers (HI)
Solar Wind Particle Monitor (SWPM)
Energetic Particle Monitor (EPM)
Magnetometers (MAG)

* STEREO + PIM

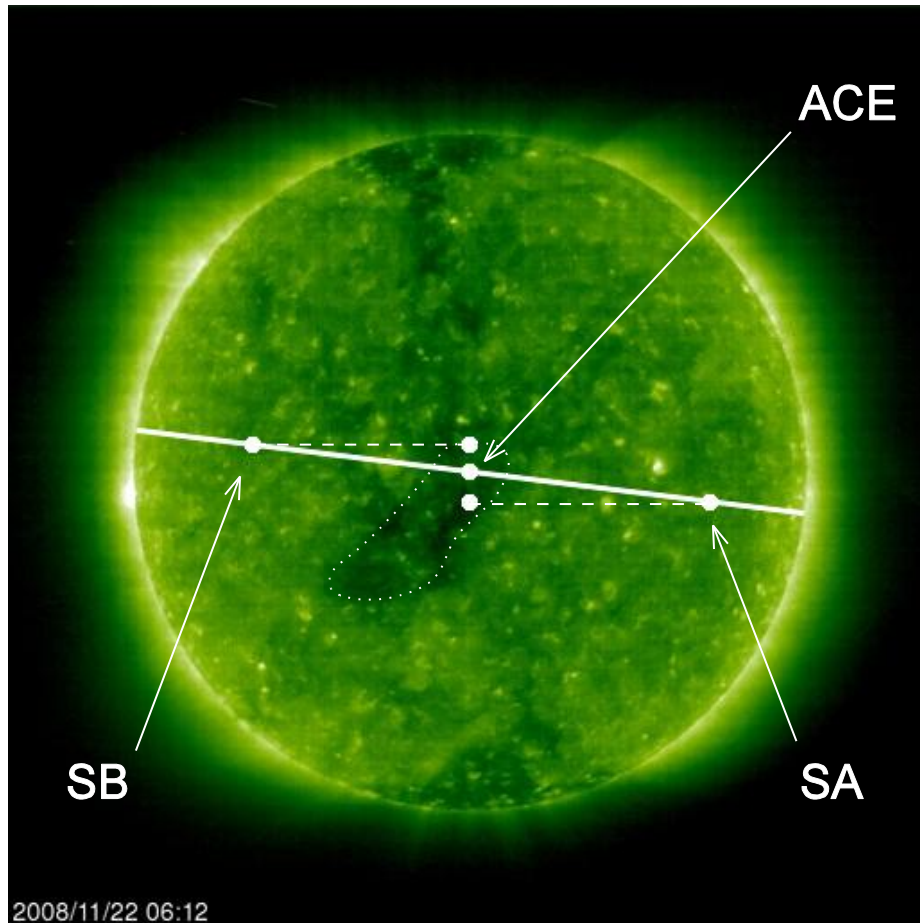
Descope option: OSCAR 2 at L5 (EASCO minus 3 instruments (HXI, OUS, LRT))

Summary

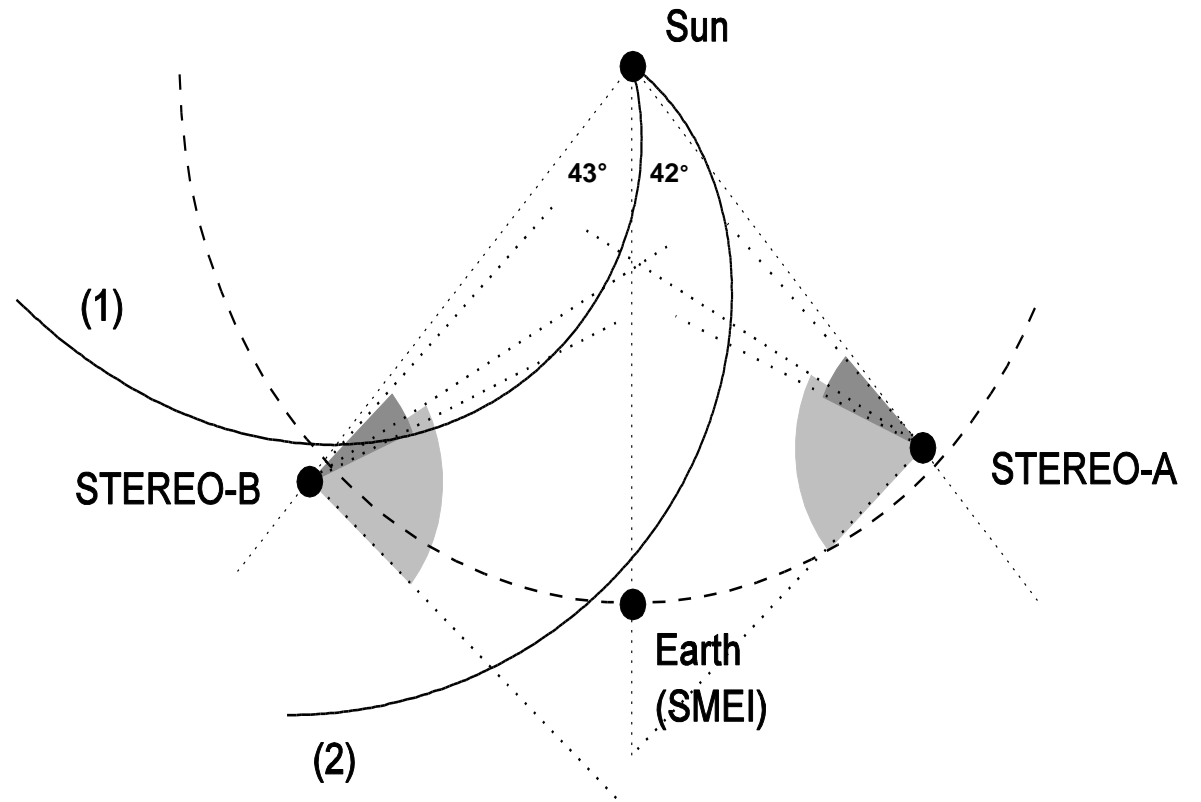
- There has been extensive discussion on the need for an L5 mission to sit and stare from L5 to reap scientific benefits as we did from SOHO and STEREO
- New science and space weather applications
- Doable with current technology and budget constraints
- The next logical step in heliophysics

Backup Slides

CIR Observed by SMEI & HIs in late Nov. 2008



Source coronal hole; SOHO EIT on 22 Nov. 2008. Circles show projected locations of 3 S/C & STEREO locations at central meridian.



courtesy: D. Webb

WCI as Key Instrument

