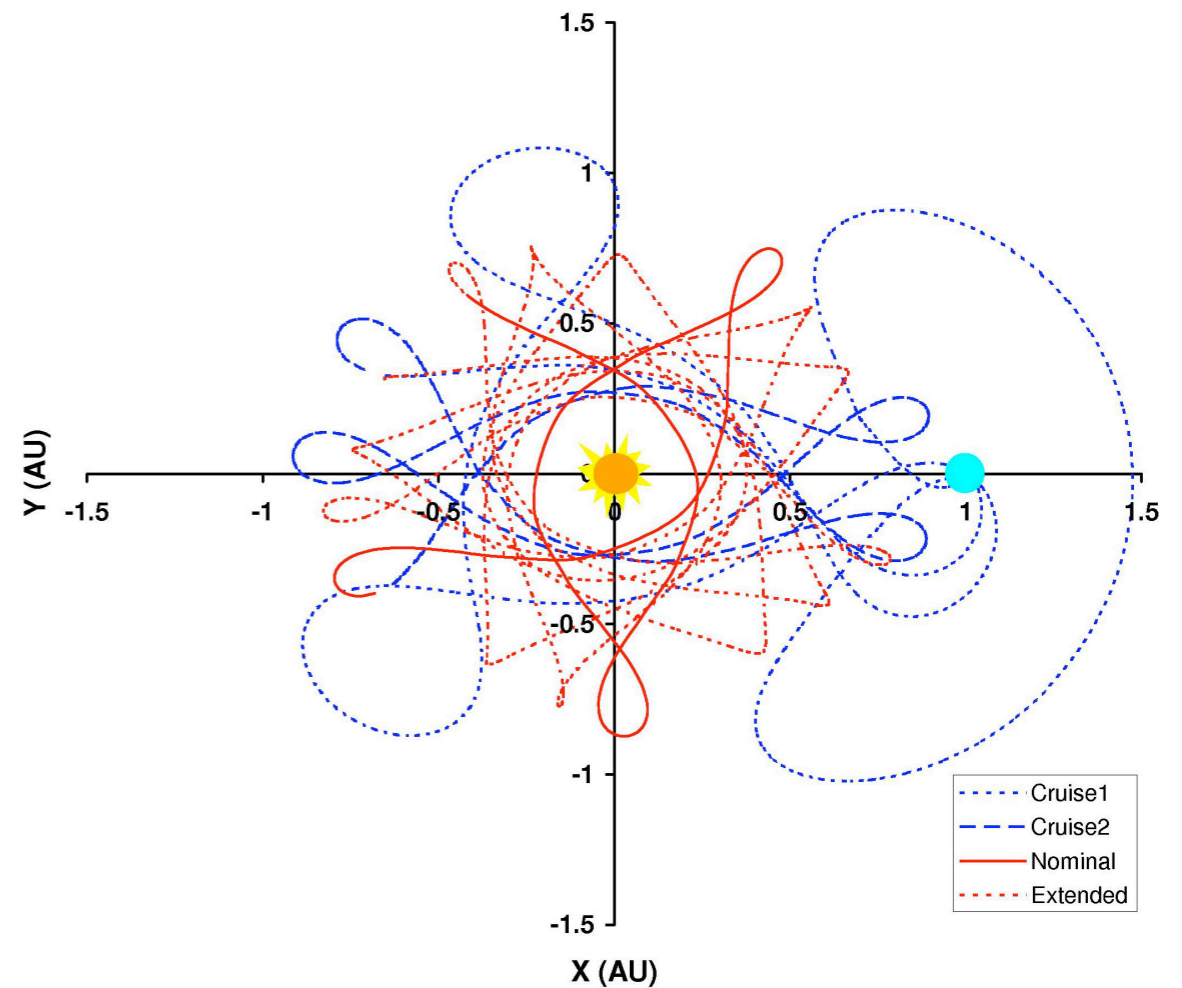
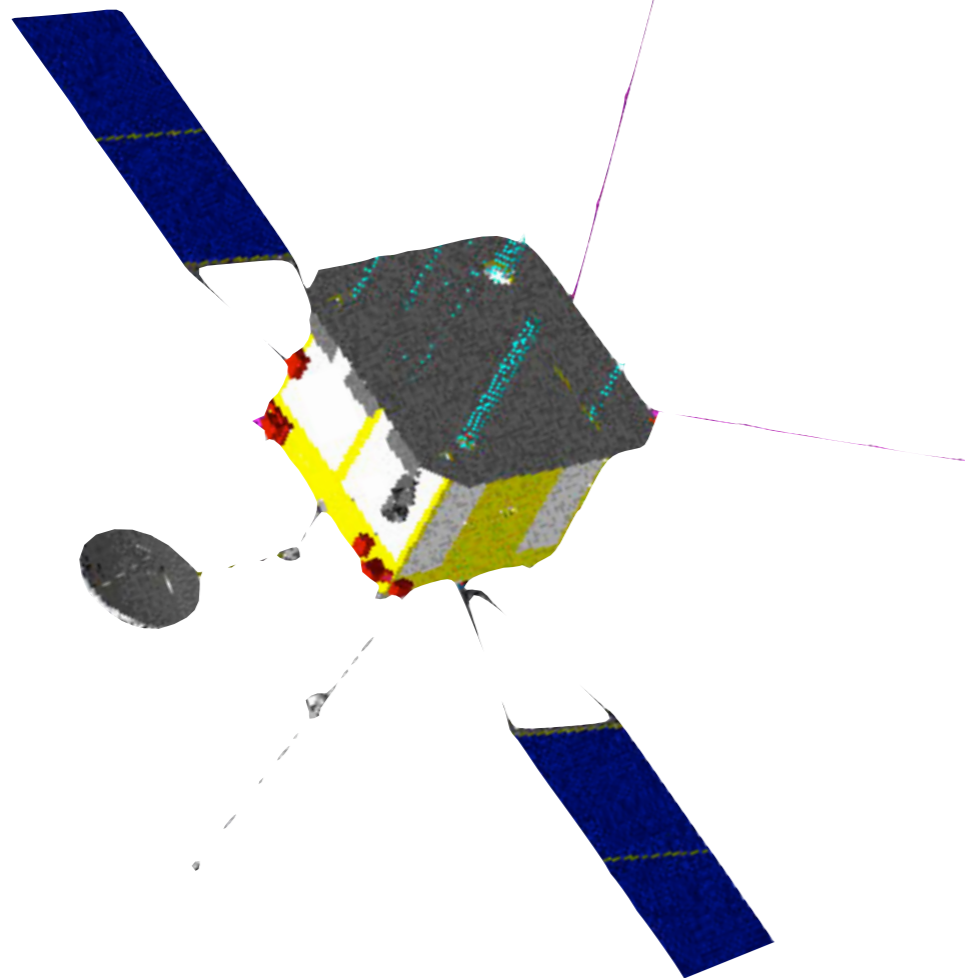




SOLAR ORBITER

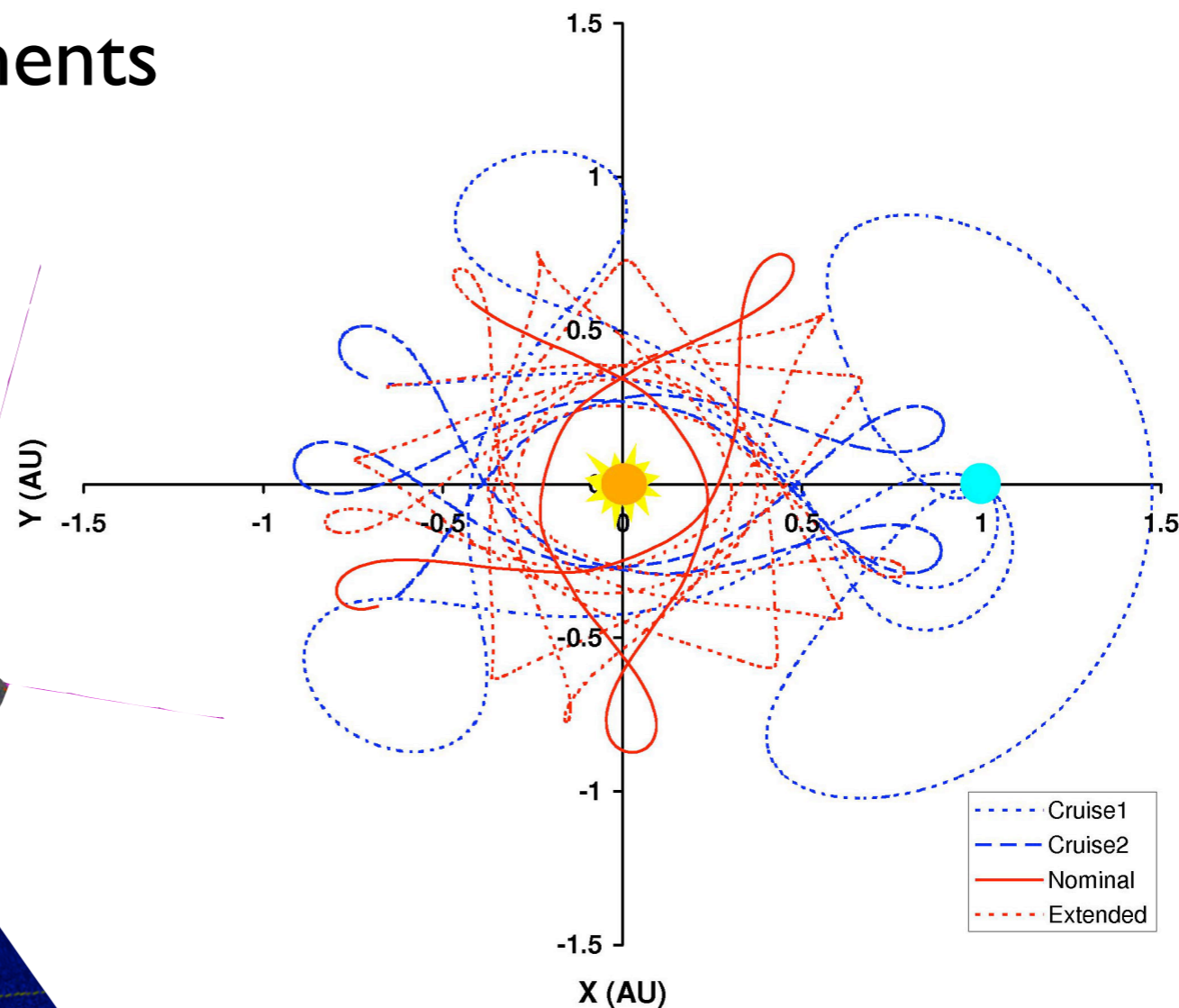
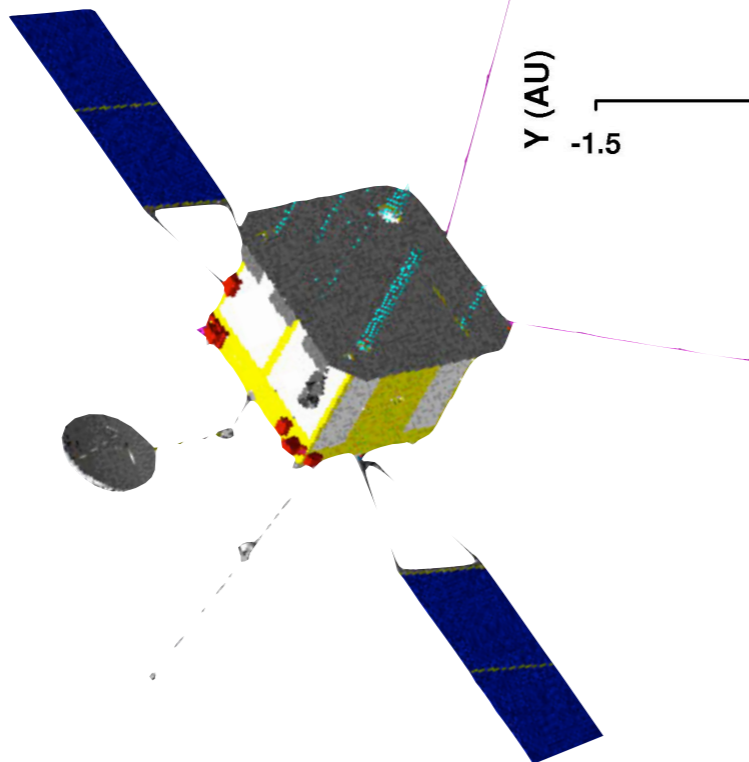
Linking the Sun and Inner Heliosphere



Outline



- Science goals of Solar Orbiter
- Focus of HELEX joint mission
- Mission requirements
- Science payload
- Status update



Top level scientific goals of Solar Orbiter




- Determine the properties, dynamics and interactions of plasma, fields and particles in the near-Sun heliosphere
- Investigate the links between the solar surface, corona and inner heliosphere
- Explore, at all latitudes, the energetics, dynamics and fine-scale structure of the Sun's magnetized atmosphere
- Probe the solar dynamo by observing the Sun's high-latitude field, flows and seismic waves

Combination of remote sensing + in-situ

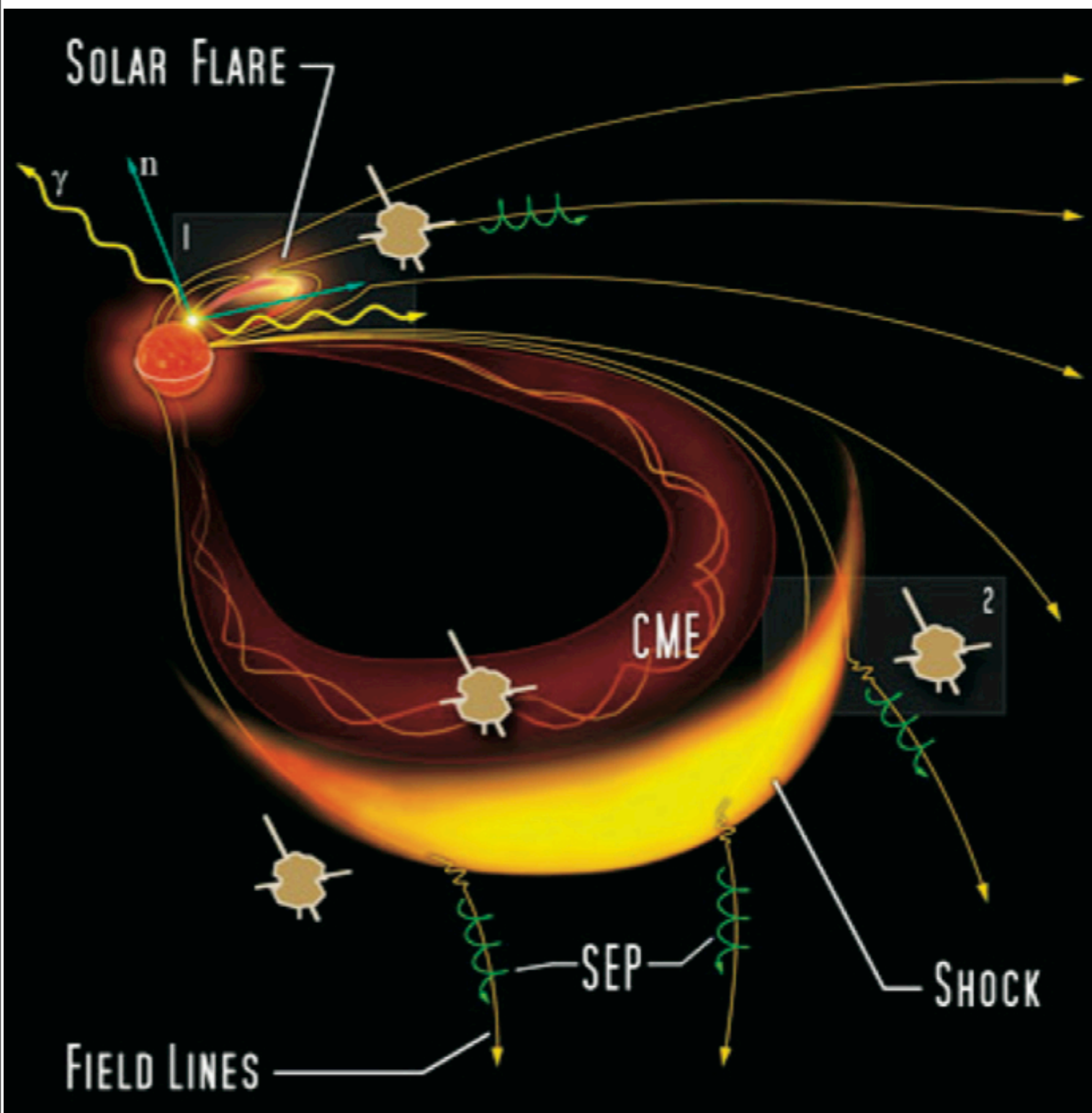
Focus of HELEX Joint Mission

HELEX (Heliospheric Explorers) = Solar Orbiter + Solar Sentinels

Primary Objectives:

-  Determine the sources, acceleration mechanisms and transport processes of solar energetic particles
-  Determine how coronal mass ejections (CMEs) evolve from the Sun to the inner solar system
-  Determine the origins of solar wind streams and interplanetary magnetic fields

Identify the Sources of Energetic Particles



Problem:

The relative importance of acceleration processes due to flares and CME-driven shocks cannot be determined at 1 AU due to particle mixing.

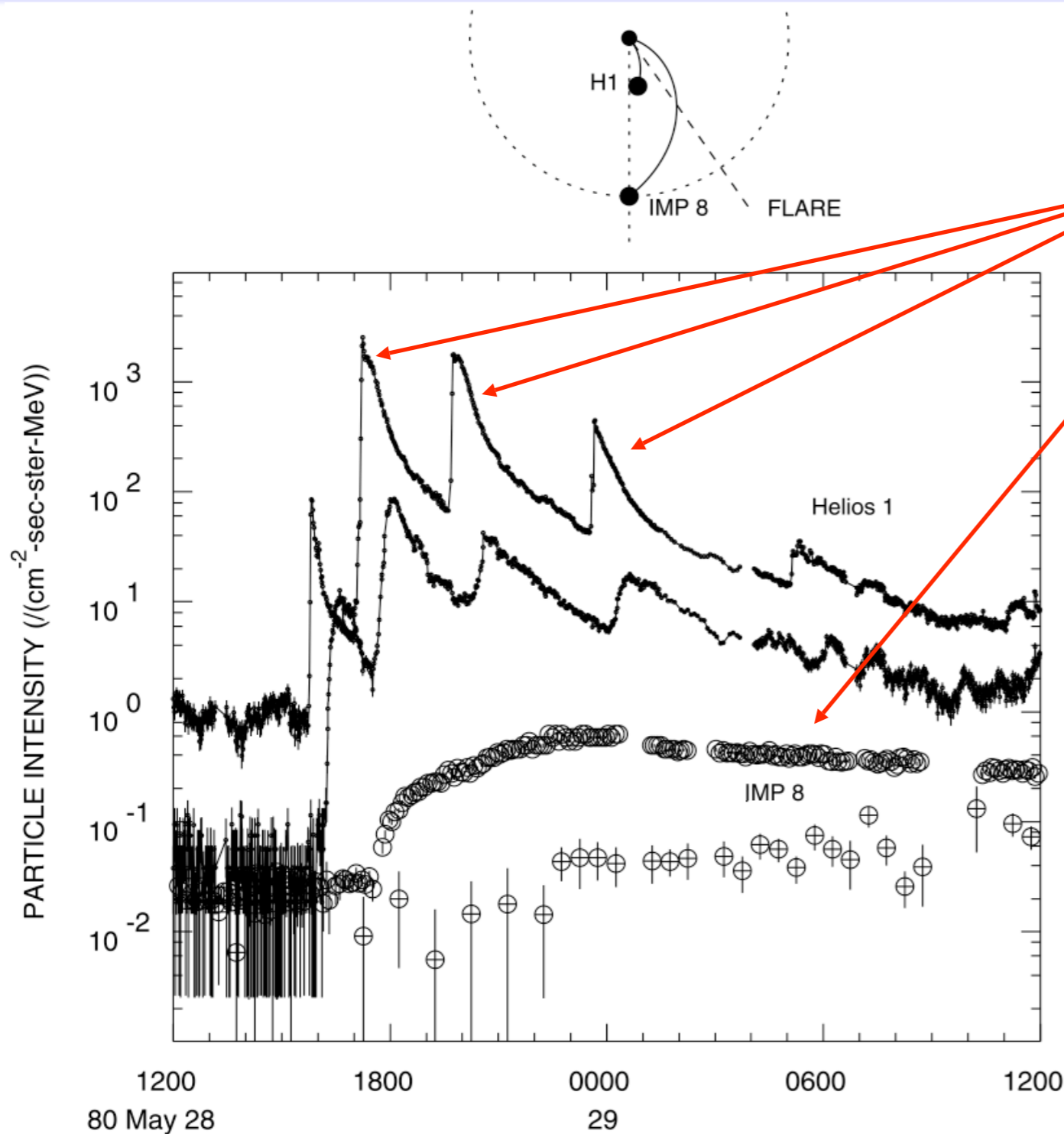
Solution:

Simultaneous in-situ measurements of energetic particles within ~ 1 mean-free-path (~ 0.35 AU) of their acceleration site and magnetically connected to flare site + shock fronts by the three Sentinels and Solar Orbiter

Plus:

Concurrent remote imaging of flares, wide field-of-view coronagraphy of CMEs and spectroscopic identification of the CME-driven shocks from Solar Orbiter.

Localize the Sources of Solar Energetic



Problem:

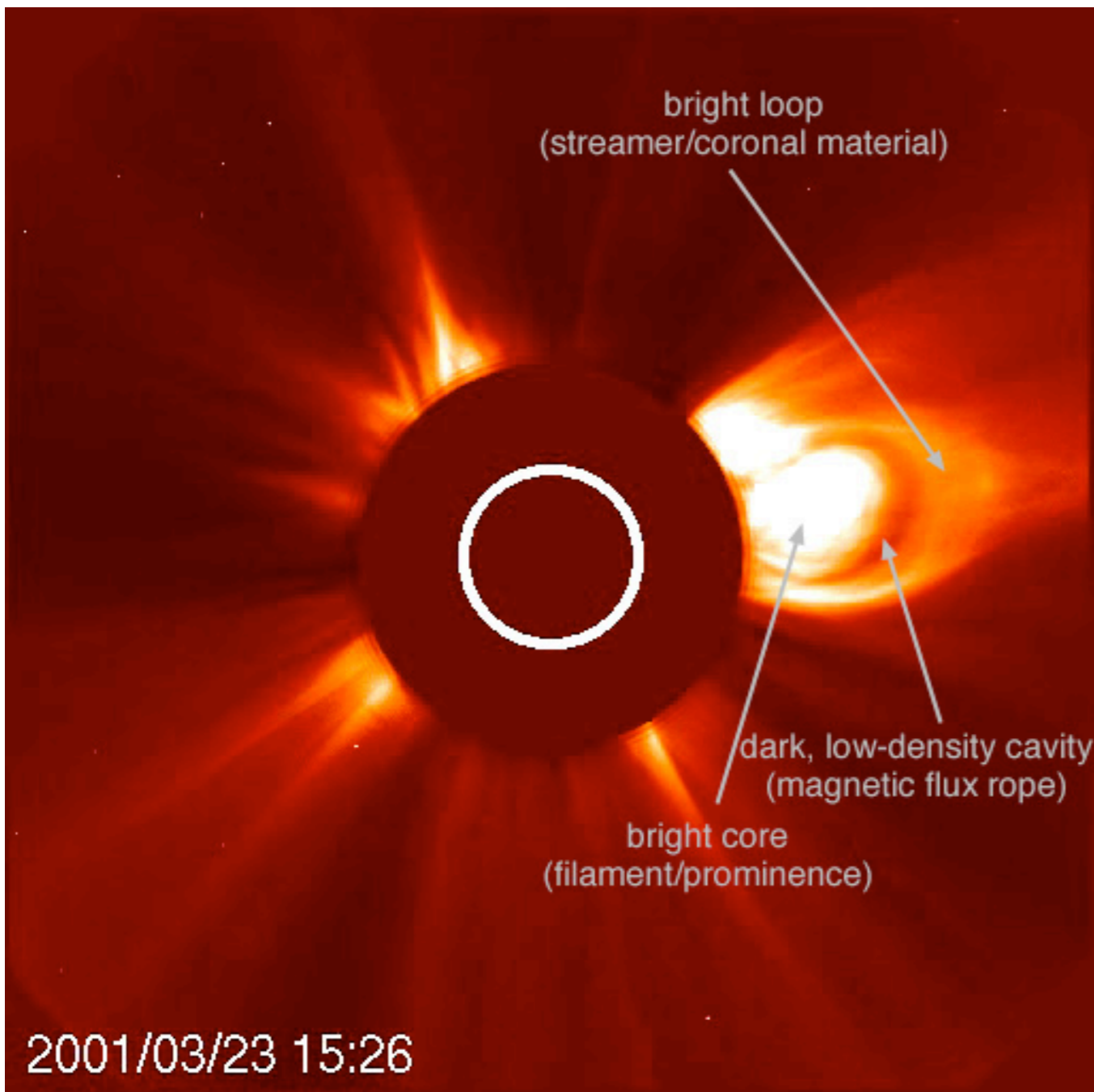
Multiple SEP events easily separated close to the Sun as demonstrated by Helios, but are all mixed together by the time the SEPs reach Earth orbit.

Solution:

- Sentinels: near-Sun energetic particle observations to distinguish separate events
- Solar Orbiter: provide information on solar structures to establish their connection to solar source regions

Wibberenz & Cane, ApJ, 650, 1100, 2006

How is the structure of ICMEs related to their origin?



SOHO/LASCO C2 image showing the classic three-part structure of a CME

Problem:

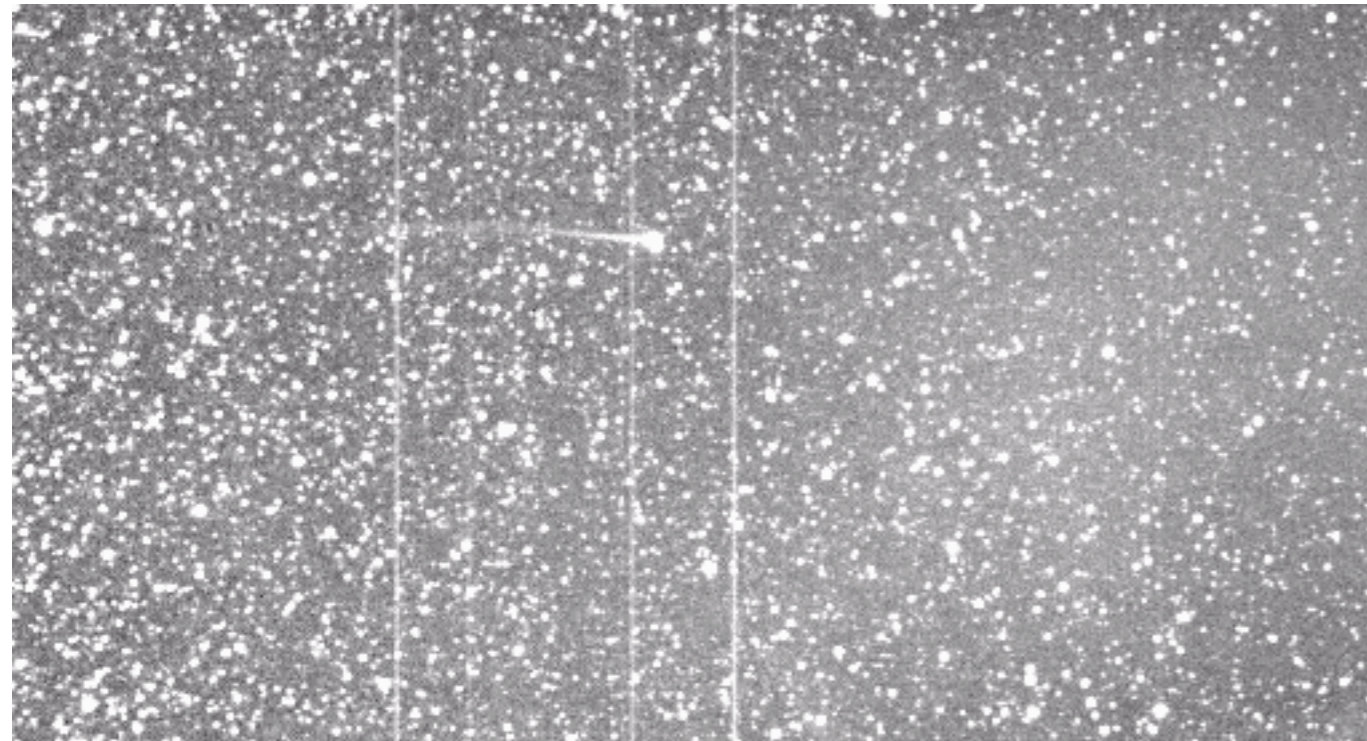
- Models: All interplanetary CMEs (ICMEs) should be flux ropes, independent of initiation
- Observations: not true at 1 AU for $> 50\%$ of ICMEs

Solution:

- Solar Orbiter: track CME as it travels over Sentinels
- Sentinels+Solar Orbiter: measure CME properties in situ
 - Relate white light structures and spectroscopic plasma diagnostics to local plasma properties
 - Identify the various solar sources of the CME structures.

Structure and Evolution of Transients

Example: An ICME strikes Comet Encke



STEREO/HI observation, 4/20/2007

Problem:

Line-of-sight ambiguities do not allow definitive determination of solar wind transient structures.

Observed:

ICME passing over Comet Encke illustrates the value of in-situ observations made in FOV of a white-light imager.

Solution:

Remove line-of-sight ambiguities from Solar Orbiter remote observations by multi-point Sentinels in-situ observations
→ Determination of ICME structure and evolution.

What are the origins of solar wind streams and the heliospheric magnetic field?

Problem:

Origin of the slow solar wind is hotly debated.

Possible source regions:

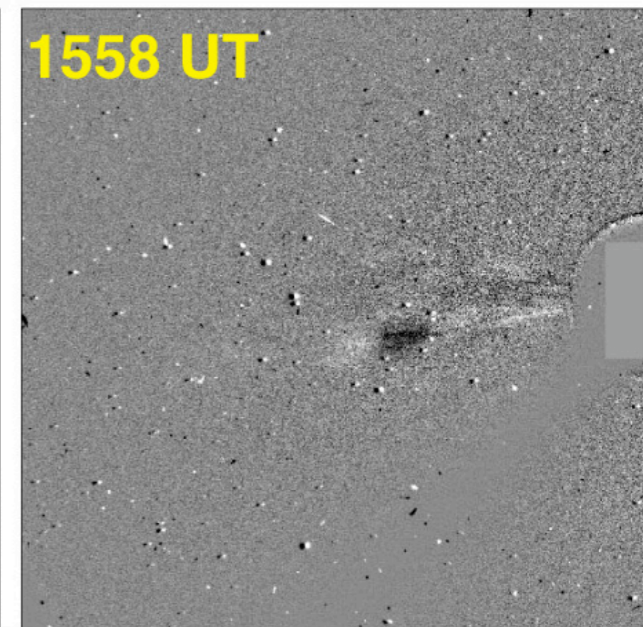
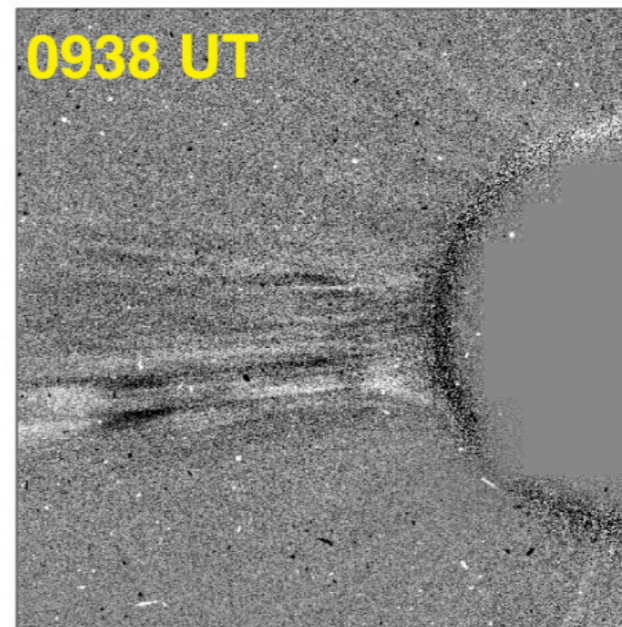
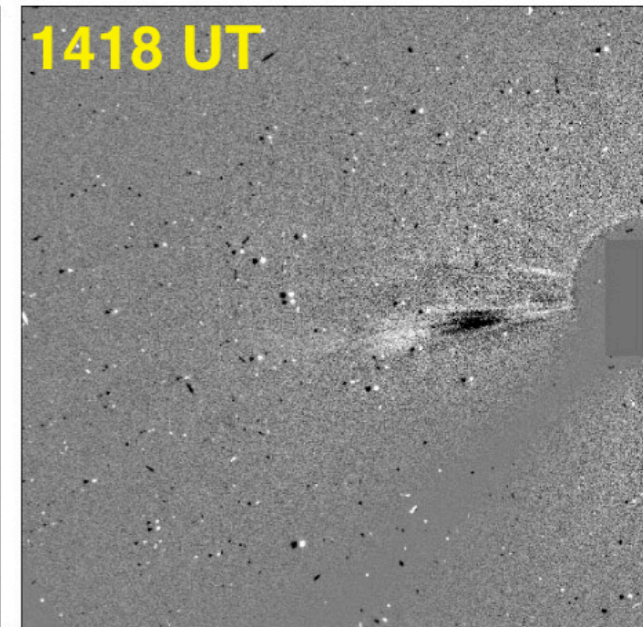
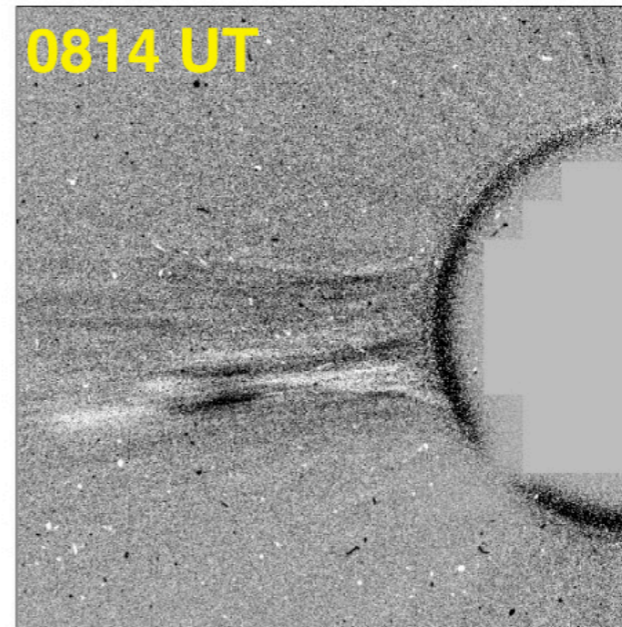
- edges of streamers
- boundaries of coronal holes
- tops of streamers

Observed:

Considerable structure inside streamers.
However, these structures are completely washed out at 1 AU.

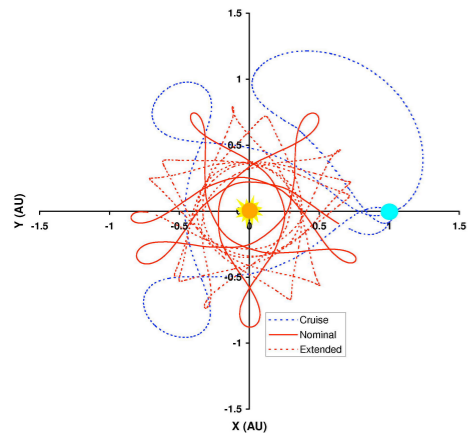
Solution:

A combination of near-Sun in-situ observations with concurrent remote imaging will allow the tracing of narrow slow solar wind streams to their origination sites.



Sheeley, ApJ 1997

Solar Orbiter Mission Requirements



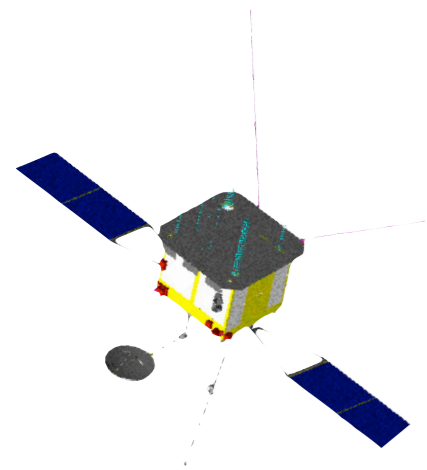
Orbit:

- Reach orbit with perihelion between 0.2 and 0.25 AU
- Increase inclination w.r.t. Sun's equator to:
 - $\geq 30^\circ$ for nominal mission (goal)
 - $\geq 34^\circ$ for extended mission (goal)



Launch:

- 2015 (2017 as back-up):
 - NASA-provided launch (Atlas V or Delta IV) as baseline
 - Soyuz-Fregat 2-1b from Kourou as back-up
- N.B. Sentinels to be launched separately (~ 2 years later)*

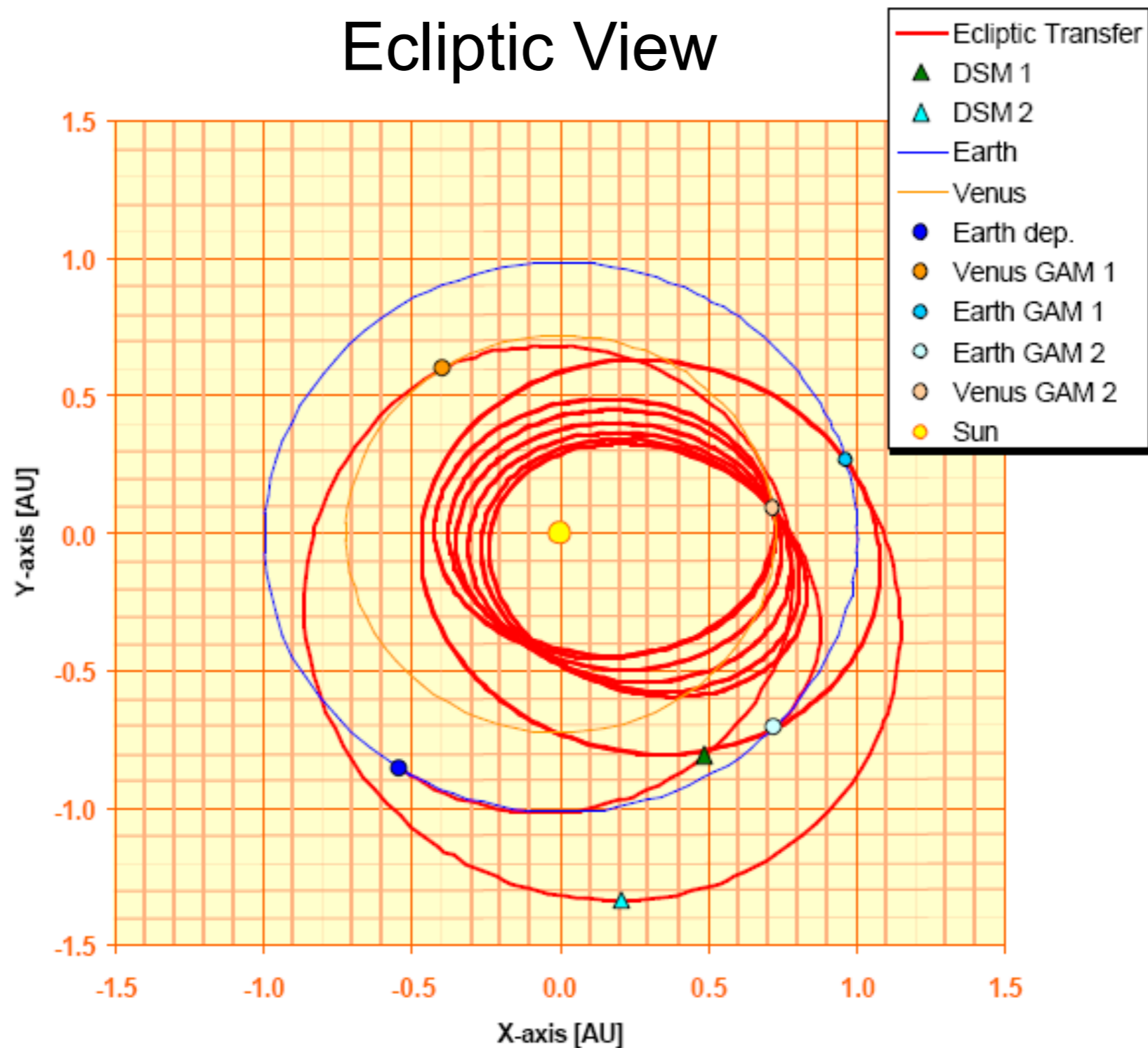


Science Payload:

- Mass: 180 kg *max. incl. maturity margin*
- Power: 180 W *max. incl. maturity margin*

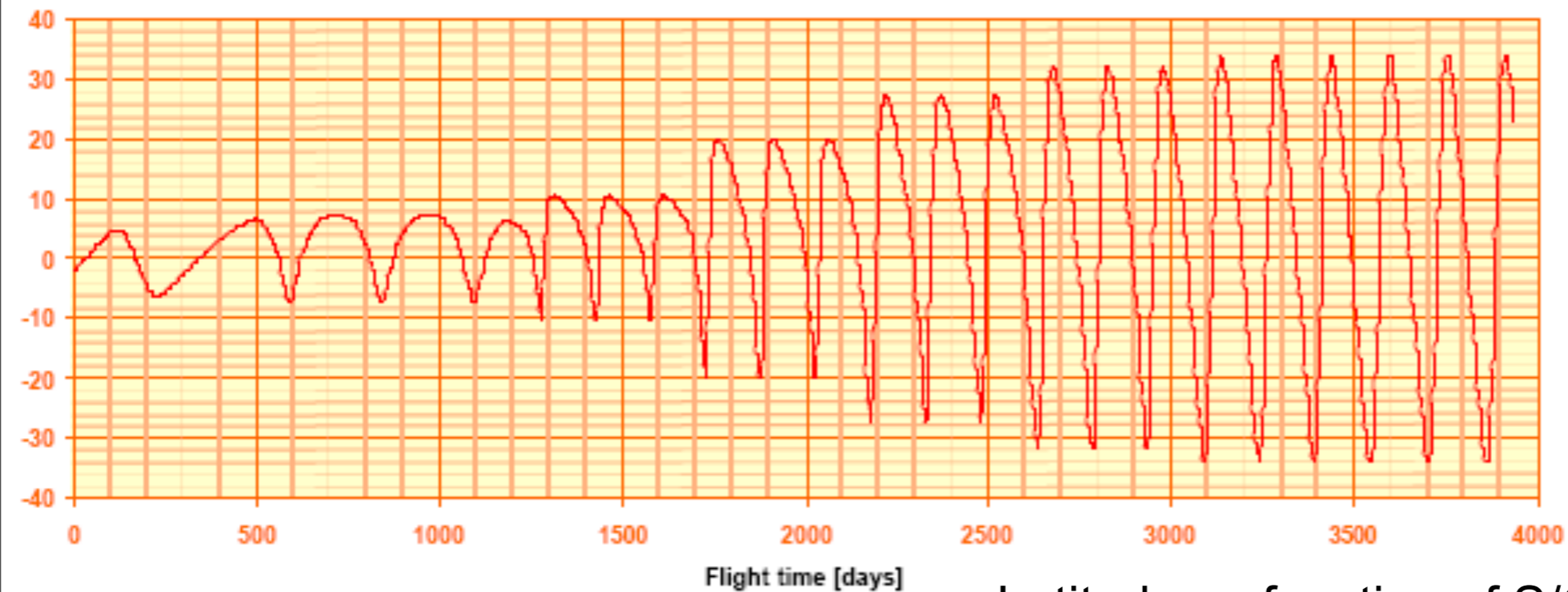
2015 launch: Spacecraft Trajectory

Ecliptic View

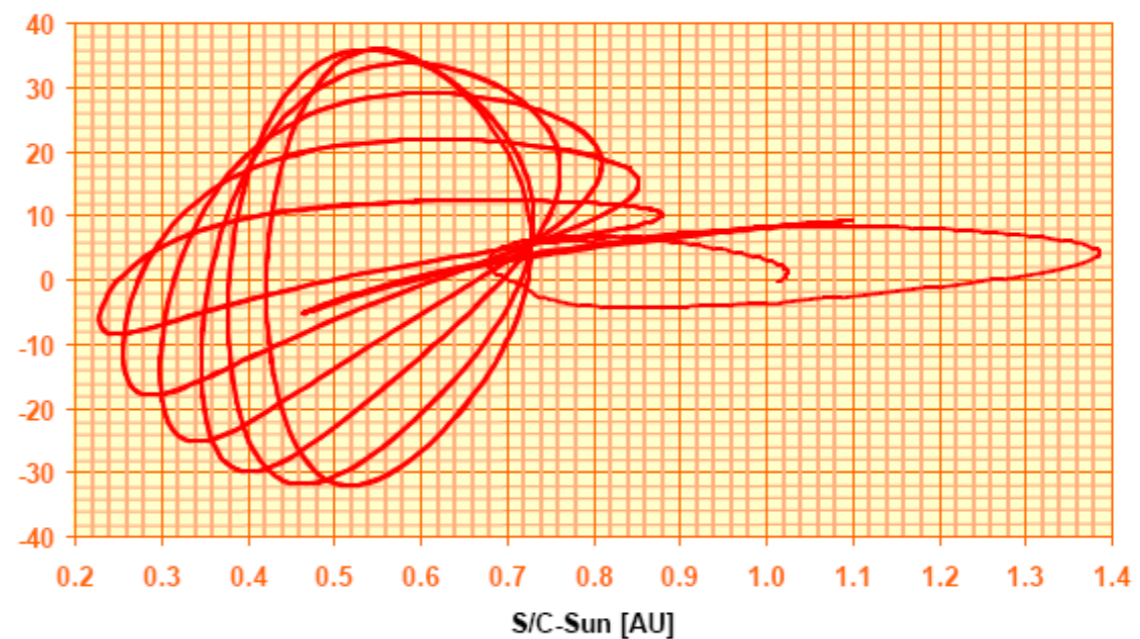


2015 launch: Spacecraft Trajectory

Solar Latitude as function of time

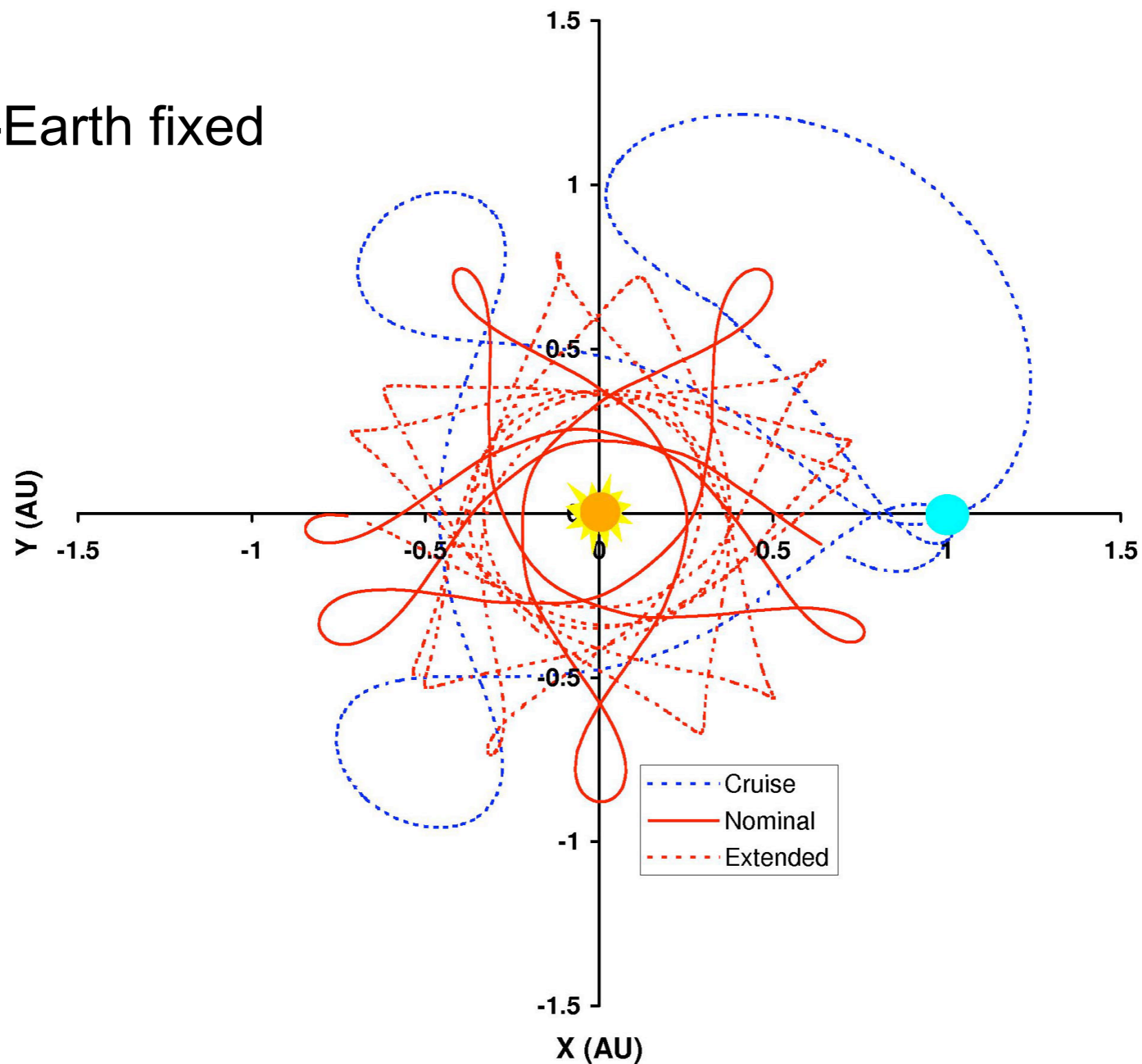


Latitude as function of S/C-Sun distance



2015 launch: Spacecraft Trajectory

Sun-Earth fixed



Science Payload

ESA Announcement of Opportunity

- Released 18 Oct 2007
- 12 replies received by the 15 Jan 2008 deadline
- Another 2 (US-led) proposals received by 6 Feb 2008 (deadline extended specifically for this purpose)

NASA SMEX Focused Opportunity for Solar Orbiter

- Released 28 Oct 2007
- Deadline 1 Feb 2008

Solar Orbiter Instrument AO

Proposals received by ESA

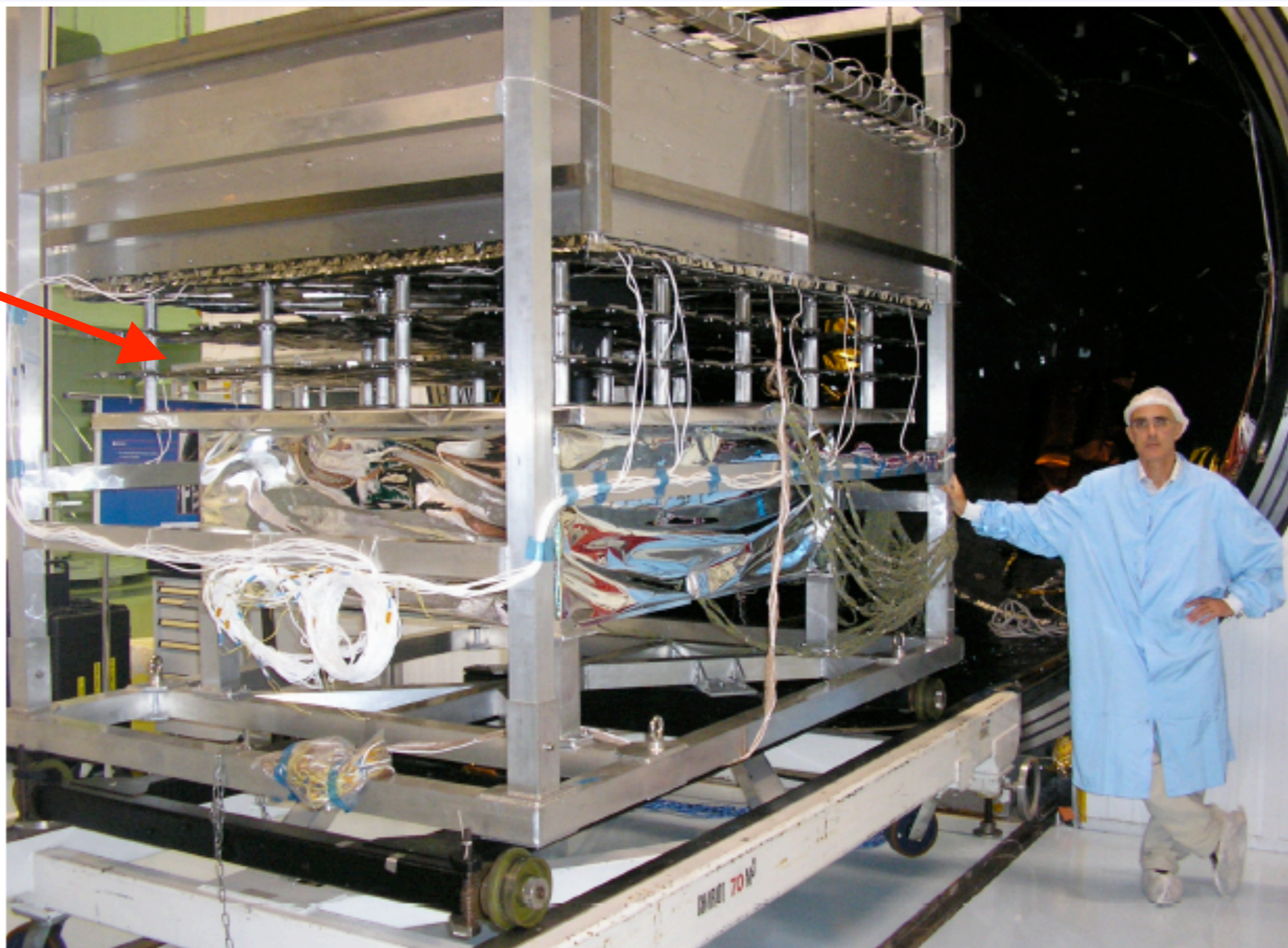
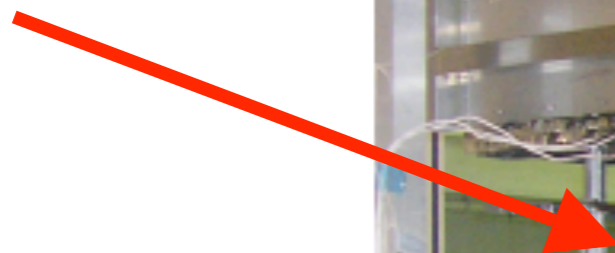
| Instrument | Proposal Acronym | Reference Payload Acronym |
|---|-------------------------|----------------------------------|
| Solar Wind Plasma Analyzer | SWA | SWA |
| Radio and Plasma Wave Analyzer | RPW | RPW |
| Magnetometer | MAG | MAG |
| Energetic Particle Detector | EPD | EPD |
| Energetic Particle Telescope | EPT | EPD |
| Dust Particle Analyzer | SODA | DPD |
| Visible Imager & Magnetograph | PHI | VIM |
| EUV Spectrometer | METIS/EUS | EUS |
| EUV Imager | EUI | EUI |
| Coronagraph | METIS/COR | COR |
| Spectrometer/Telescope Imaging X-rays | STIX | STIX |
| | | |
| Neutral Solar Wind Detector | SCENARIO | |
| Solar Luminosity and Irradiance Monitor | SLIM | |

Recent and on-going Activities

- HELEX Joint Science & Technology Definition Team report released in Sep 2007
- Parallel heat shield and system assessment studies:
Final presentations in Oct 2007
- ESA and NASA instrument AOs released in mid-Oct 2007
- Industrial phase B1 (18-month definition phase):
started in mid-March 2008
 - Industry team led by EADS/Astrium, sub-contractor Thales-Alenia
- Instrument proposal evaluation in progress

Recent and on-going Activities

heat shield
breadboard



The End

