Solar Orbiter

Astrosiesta 31 Maggio 2012

M.Uslenghi

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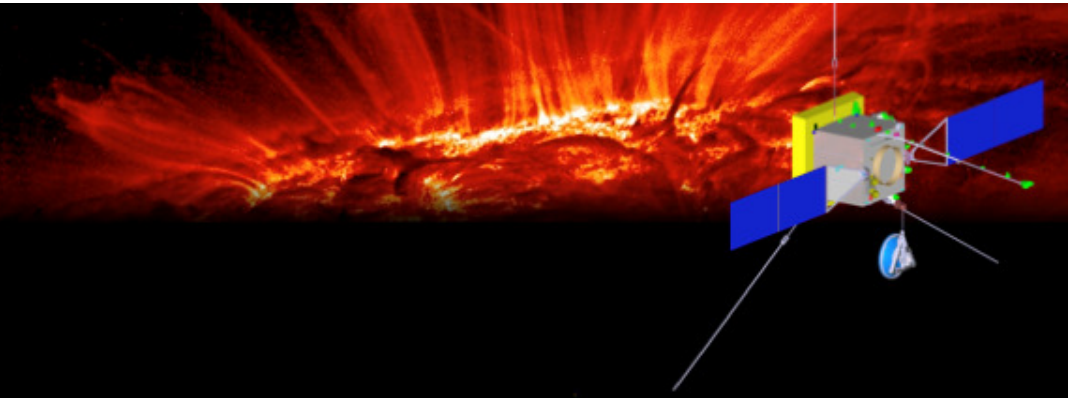
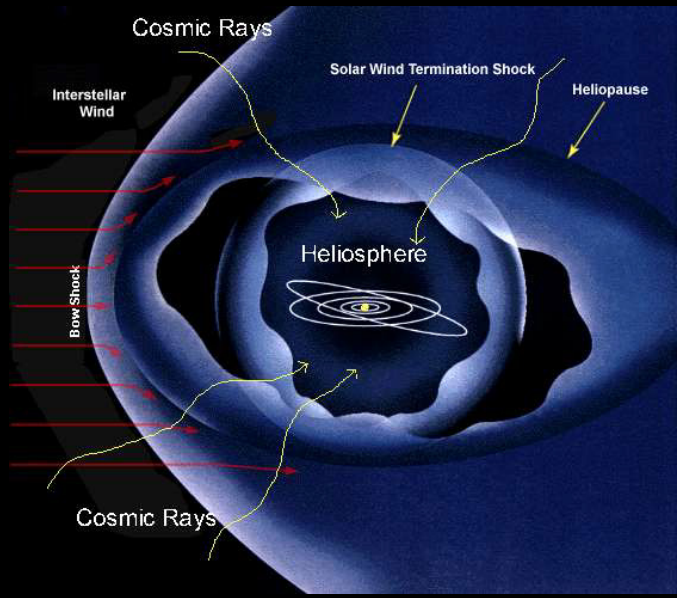


Closer to the Sun than ever before ...

…to investigate the link between the Sun and the interplanetary medium



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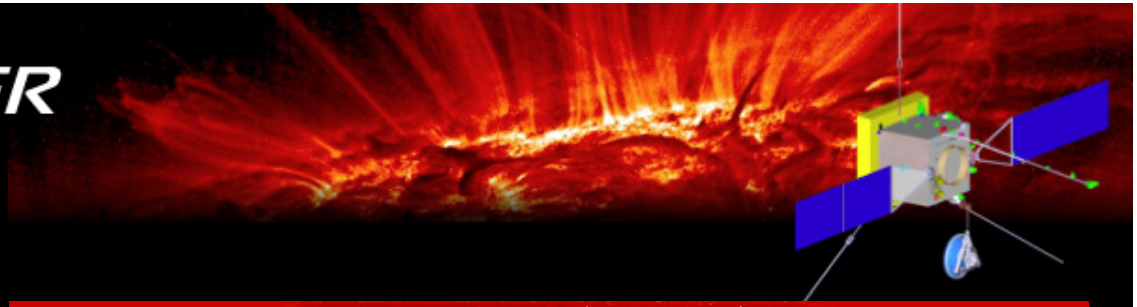
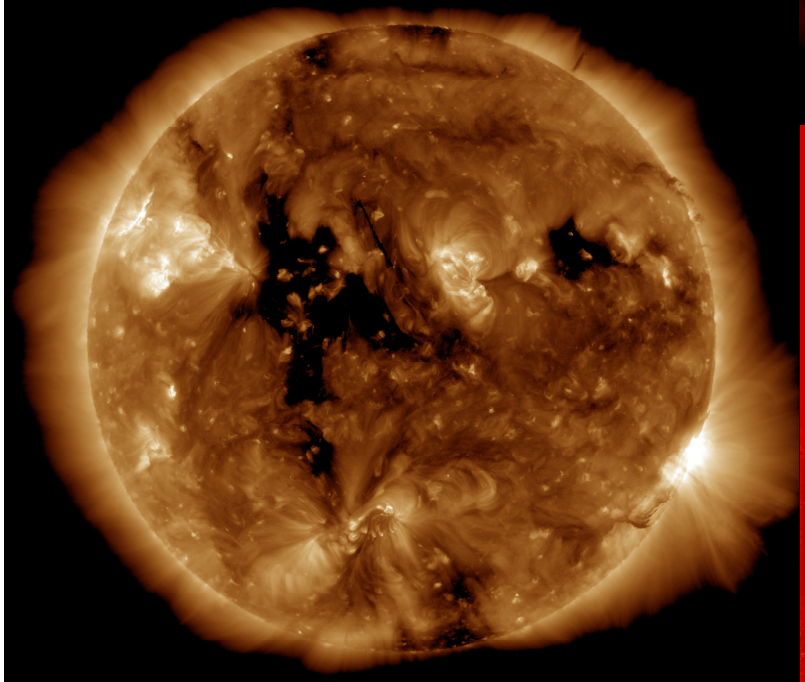
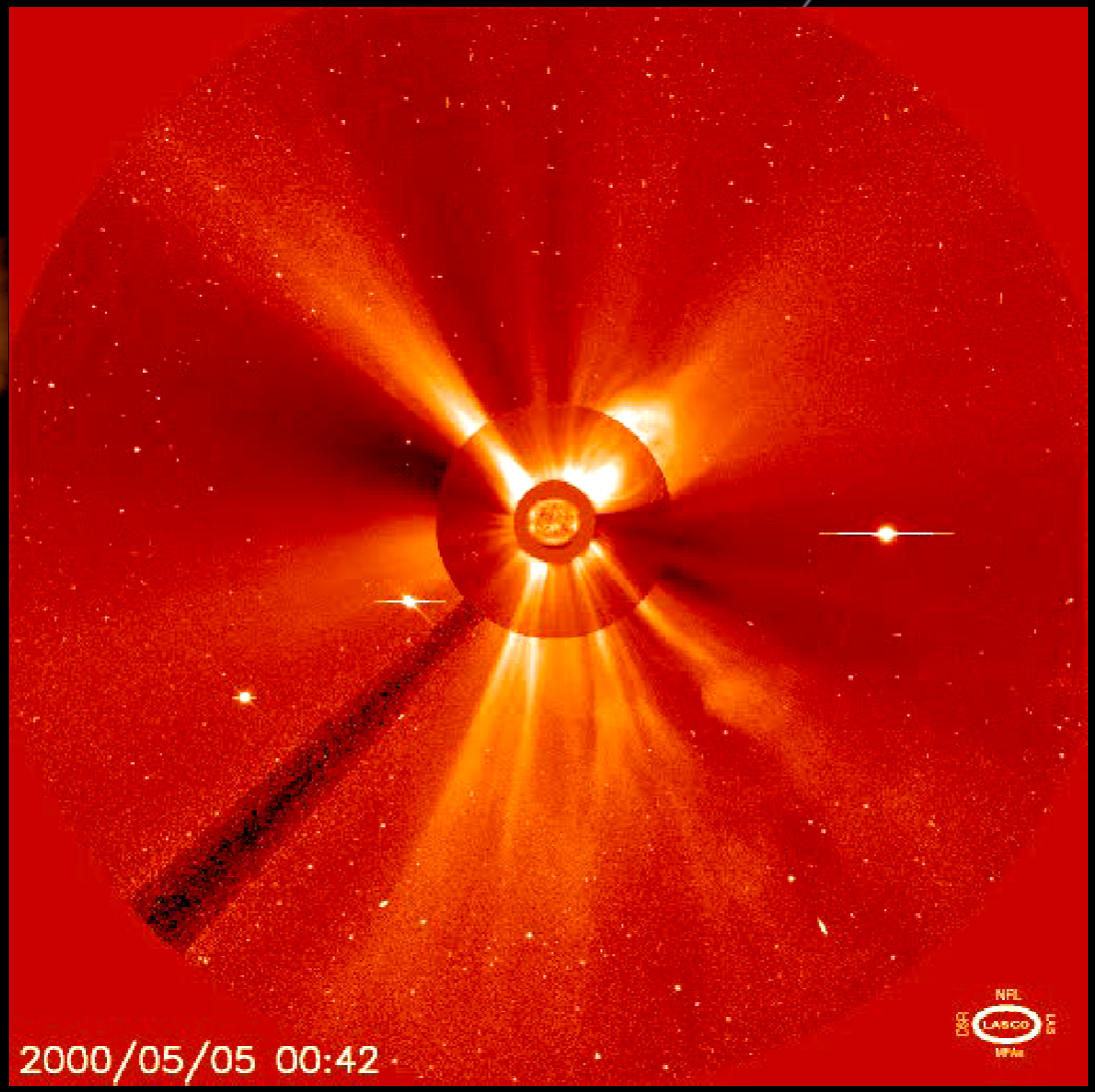




SDO/AIA- 193 20101020_193520

Come il campo magnetico variabile crea la (caldissima) corona solare e pilota la sua attivita'

Come la corona solare crea/controlla/perturba l'eliosfera



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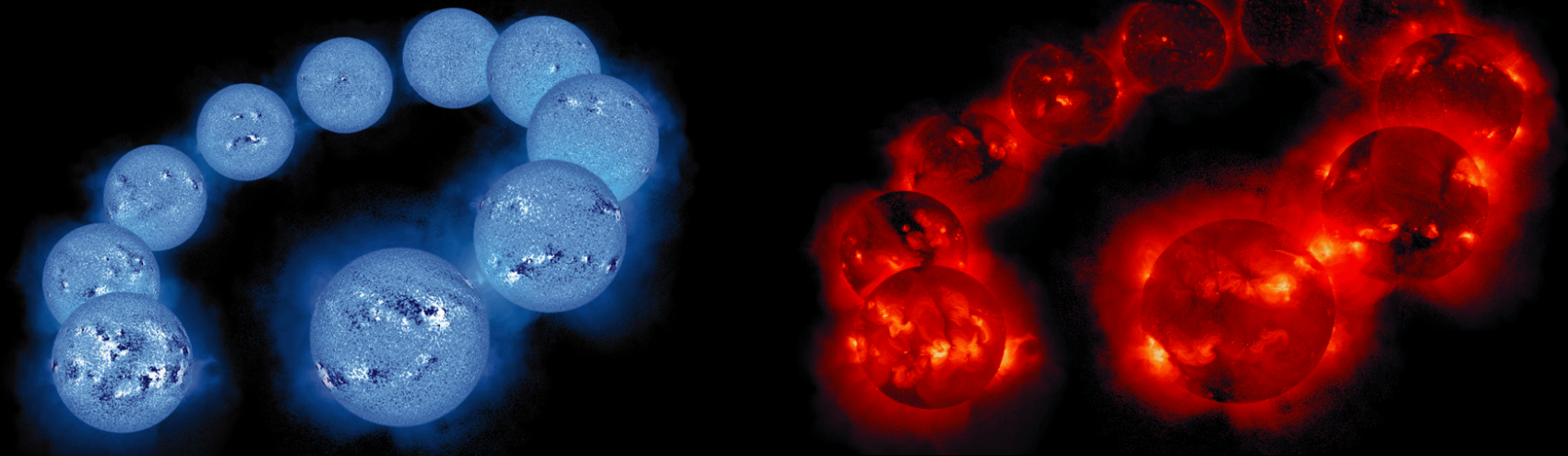
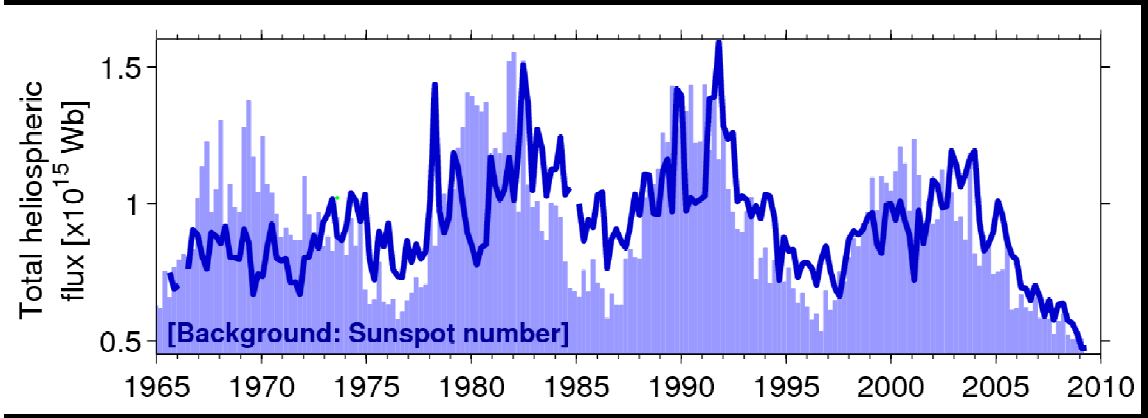
Collegare i campi magnetici solari ed eliosferici



Collegare i cicli dei campi magnetici fotosferici e dell'emissione soft-x coronale



Anomalie del ciclo magnetico (come il recente minimo solare con una durata piu' lunga del previsto)

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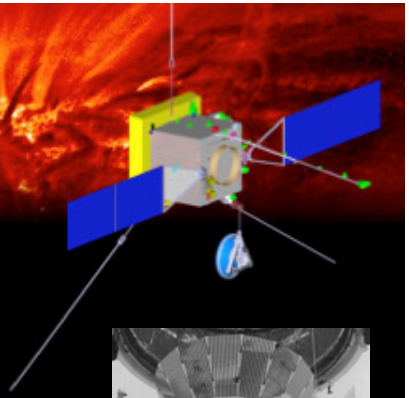


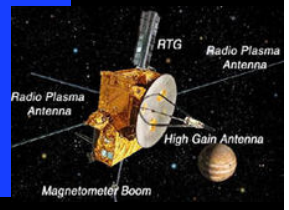
Storia delle missioni solari

- Helios I & II (NASA – Germania ovest) 1974, 1976

Distanze 0.3 - 1 AU, record imbattuto di avvicinamento al Sole 0.29 AU, solo strumentazione in-situ

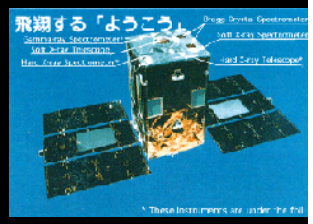
- Solar Maximum Mission SMM (NASA) 1980-1989

Studio dei flares solari in X e γ, orbita h=574 Km i=28°



- Ulysses (ESA – NASA) 1990-2009

Prima osservazione diretta della zona polare dell'eliosfera, 1.6 - 5 AU, strumentazione solo in situ



- Solar-A (Giappone, USA, UK) 1991-2001(2005)

Studio dei flares solari (soft e hard x)

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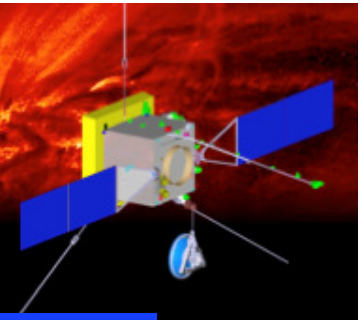
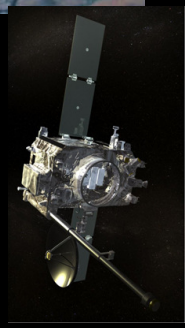
Storia delle missioni solari



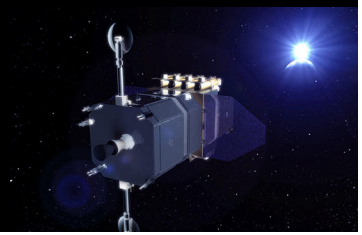
- Solar and Heliospheric Observatory SOHO (ESA-NASA) 1995-
  1st cornerstone di Horizon 2000 con Cluster
  Osservazioni del Sole da L1, senza interruzioni: strumentazione remote sensing & in situ
  Contributo italiano principale: spettrometro UVCS

- Transition Region & Coronal Explorer TRACE (NASA) 1998-2010
  SMEX, imaging VIS/UV/EUV

- Solar Terrestrial Relations Observatory STEREO (NASA) 2006-
  2 sonde gemelle -> imaging stereoscopico



- Solar Dynamics Observatory SDO (NASA) 2010-…
  I missione del programma *Living With a Star* (LWS), per capire le cause della variabilita' solare e il suo impatto sulla Terra [lws.gsfc.nasa.gov]
  Campi magnetici, Spectroscopia EUV & imaging multi-banda (VIS->EUV) alta risoluzione temporale



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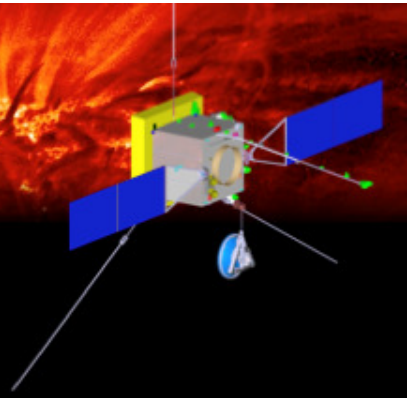

Solar Orbiter story:

1996 – SOHO inizia a mandare dati …

1998/2000 – Inizia lo sviluppo di un nuovo concetto di missione:

- fuori dall'eclittica -> studio delle regioni polari
- spettroscopia, imaging, strumentazione in situ vicina al Sole

Ottobre 2000 – selezionata dall' SPC come Flexi Mission in Horizon 2000+, per lancio nel 2008/13

Giugno 2004 – selezione confermata dall'SPC, lancio nel 2013

Ottobre 2007 - AO per il payload scientifico

Marzo 2009 – selezione del payload scientifico

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Solar Orbiter in Cosmic Vision 2015-2025

2008 – integrata in Cosmic Vision 2015-2025 come candidata missione M, lancio 2017

Marzo 2010 – l'SPC la raccomanda come 1 / 3 candidate missioni M per la fase di definizione, approccio 'fast-track' con riutilizzo delle tecnologie di Bepi-Colombo, lancio nel 2017

Febbraio 2011 - kick off del contratto industriale di fase B2 per lo spacecraft

Luglio 2011 – System Requirements Review per lo spacecraft completata con successo

Ottobre 2011 – Selezionata insieme a Euvlid per M1/M2

Aprile 2012 – Contratto industriale fasi C/D assegnato ad Astrium UK

100 Istituti scientifici europei sono coinvolti nella fase B del payload

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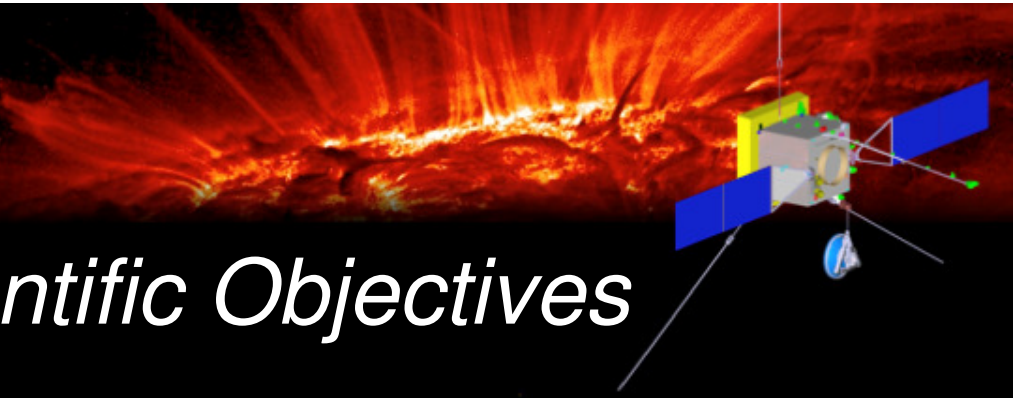

Top Level Scientific Objectives

- How does the solar dynamo work and drive connections between the Sun and the heliopshere?
- How and where do the solar wind plasma and magnetic field originate in the corona?
- How do solar transients drive heliospheric variability?
- How do solar eruptions produce energetic particle radiation that fills the heliosphere?

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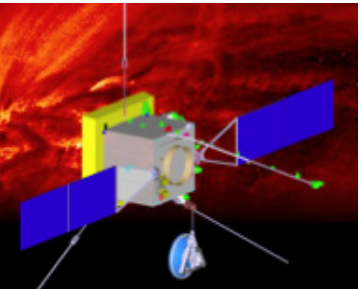
Solar Orbiter Overview



Data di lancio	Gennaio 2017
Goal primario	Come il Sole crea e controlla l'eliosfera?
Range	VIS, UV, EUV,X
Tipo	Classe M
Durata nominale	7.5 anni
Estensione	2.4 anni
Orbita	Ellittica: 0.28 AU perielio 1.2 AU afelio
Durata dell'orbita	150-168 gg 3 finestre nominali per le osservazioni remote sensing
Inclinazione rispetto all'eclittica (usa gravity assist con Venere)	> 25° (missione nominale) > 34° (estensione)
Co-rotazione	2 periodi/orbita di quasi-sincronizzazione con la rotazione solare
Spacecraft	Stabilizzato su 3 assi, puntamento continuo sul Sole
Massa	1750 Kg
Potenza	1100 W
Lanciatore	Baseline: Atlas V401 da Cape Canaveral [Ariane 5 da kourou?]

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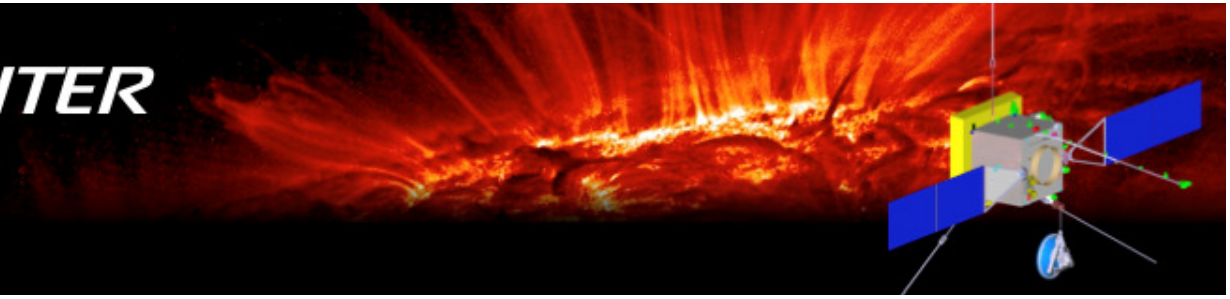
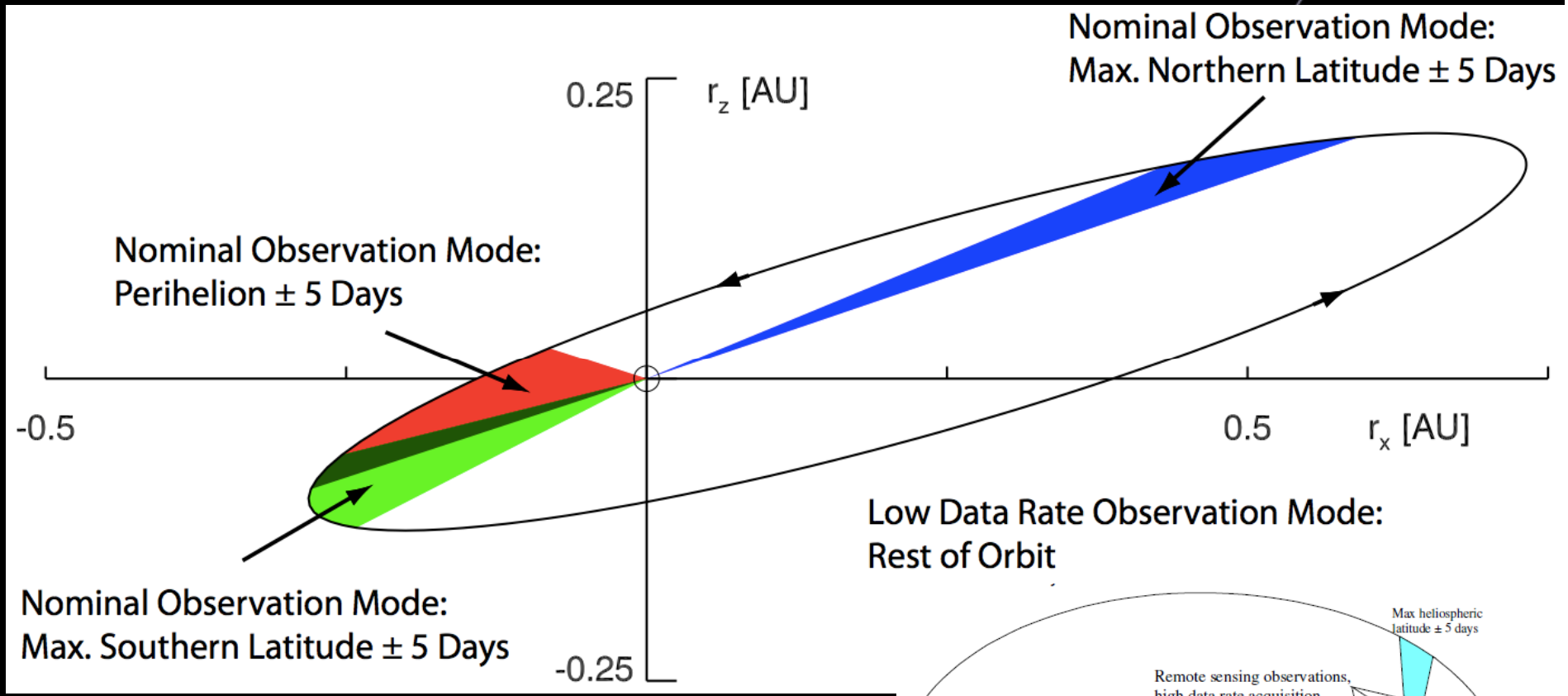
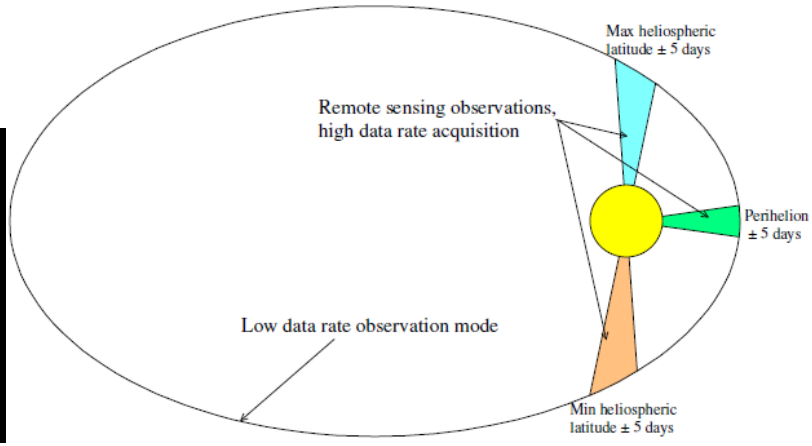
Orbita







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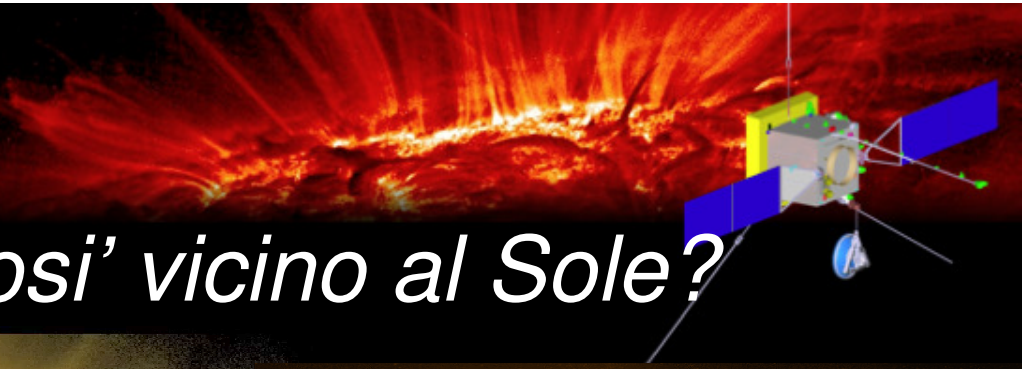
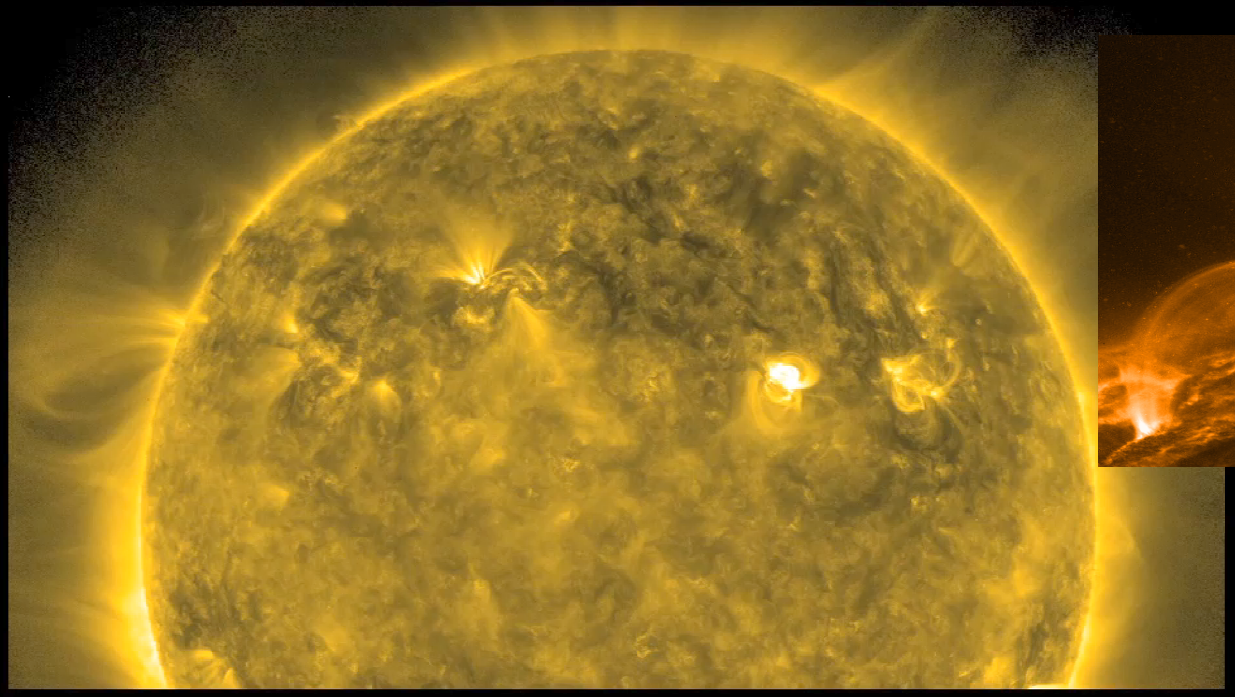
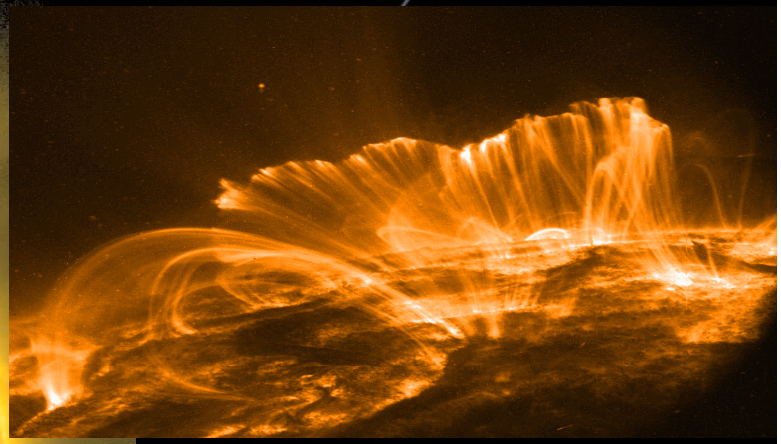
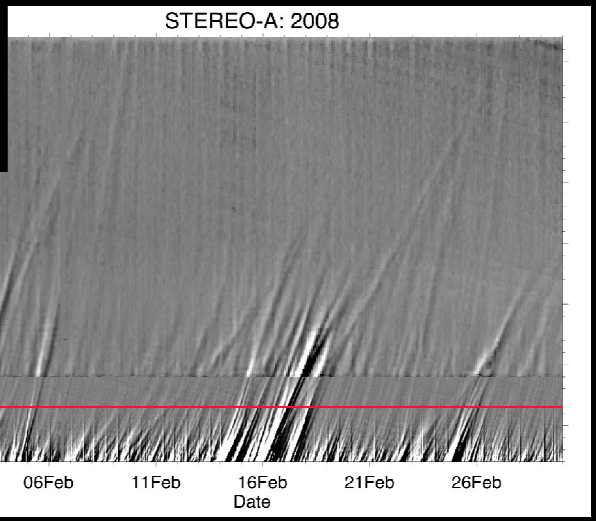


Perche' andare cosi' vicino al Sole?







I processi di riscaldamento nella corona solare agiscono su piccola scala (oltre la risoluzione attuale)

Le strutture a piccola scala variabili del vento solare collidono e si omogenizzano. Le strutture non processate possono essere analizzate andando abbastanza vicino perche' cio' non sia ancora successo …

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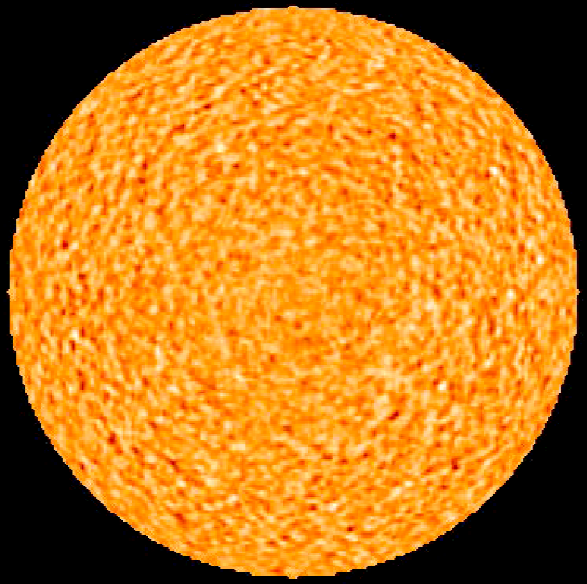
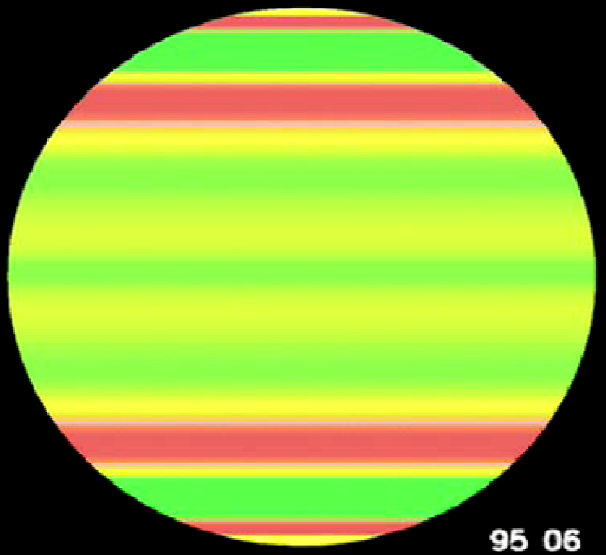
Perche' osservare le regioni polari?

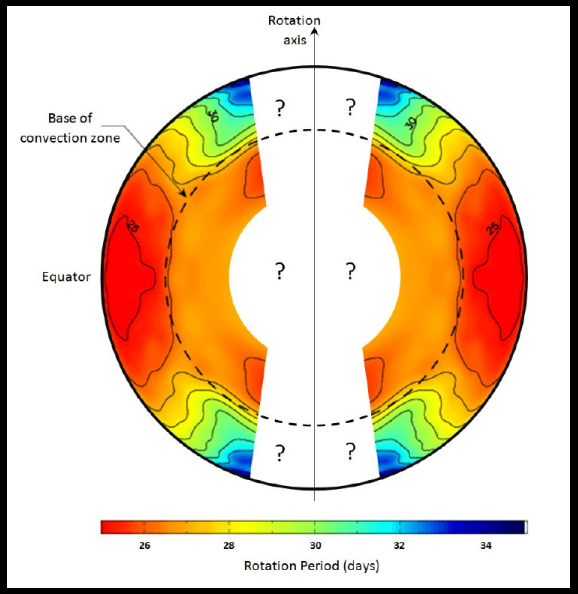
solar dynamo – polar flows



La dinamo solare opera in profondita' nella zona di convezione, dove un campo magnetico oscillante viene mantenuto dai movimenti del plasma.

La struttura e la dinamica della zona convettiva polare non sono stati ancora analizzati con l'eliosismologia.





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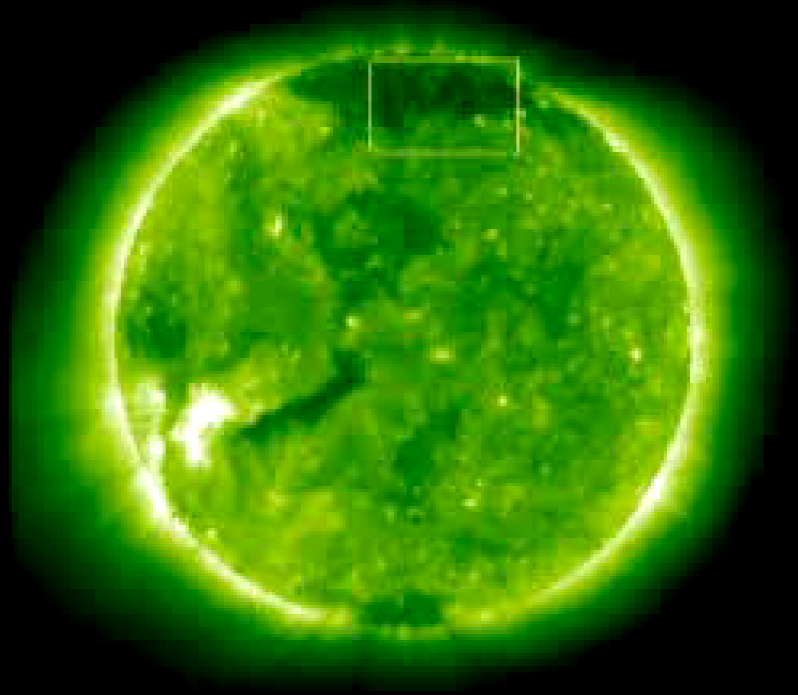
Perche' osservare le regioni polari?

Origin of the fast wind in polar coronal holes



Il vento solare veloce (800 km/s) e' accelerato nei buchi coronali polari

A causa degli effetti di proiezione e' difficile studiarne l'origine (probabilmente alla base del buco polare -> supergranulazione convettiva)

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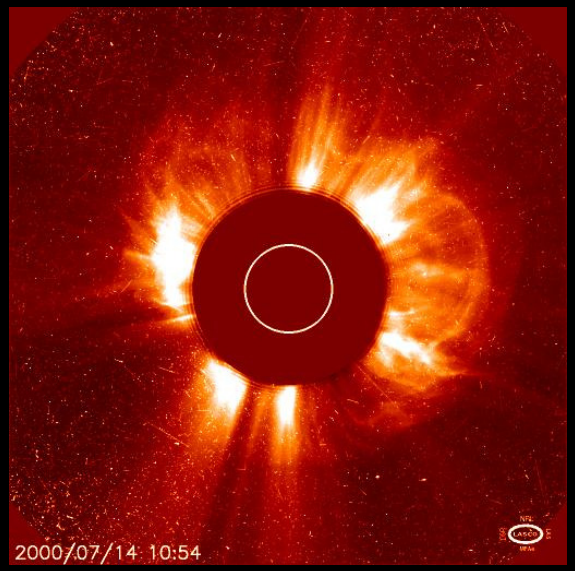
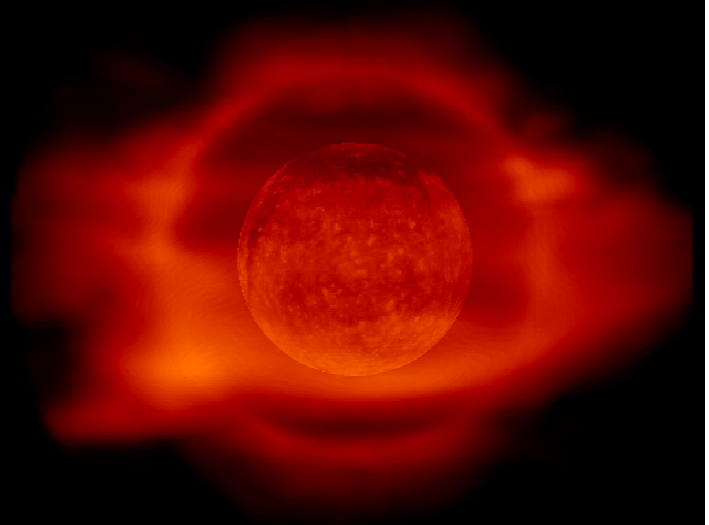
Perche' osservare le regioni polari?

3D corona – 3D coronal mass ejections





Accesso alla struttura longitudinale della corona

Osservazioni polari dei Coronal Mass Ejections (-> impatto sulla magnetosfera terrestre)

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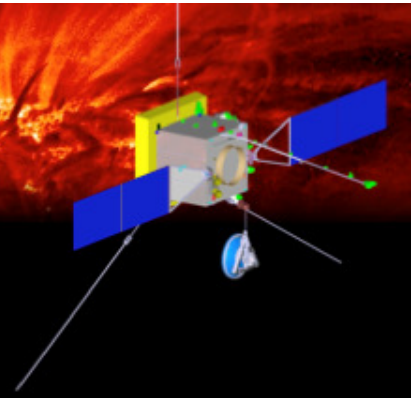
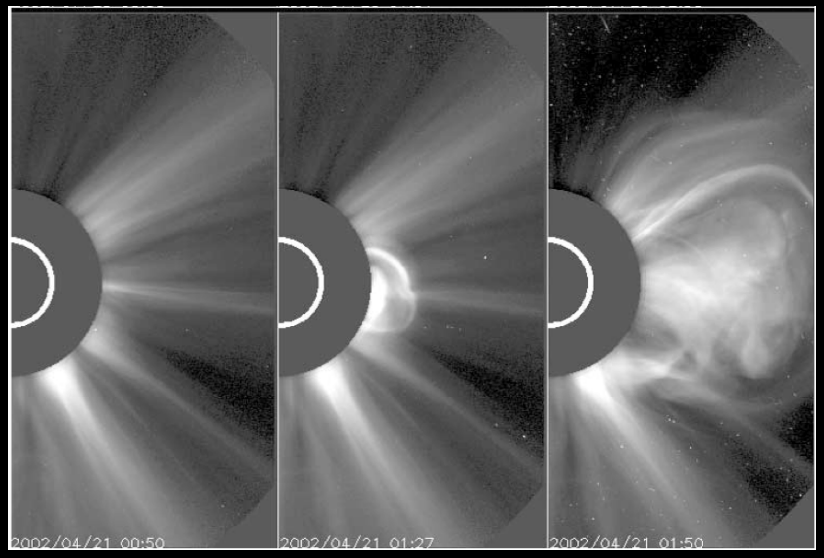


Perche' la corotazione?

Tempi scala dell'evoluzione della corona > 2-3 giorni

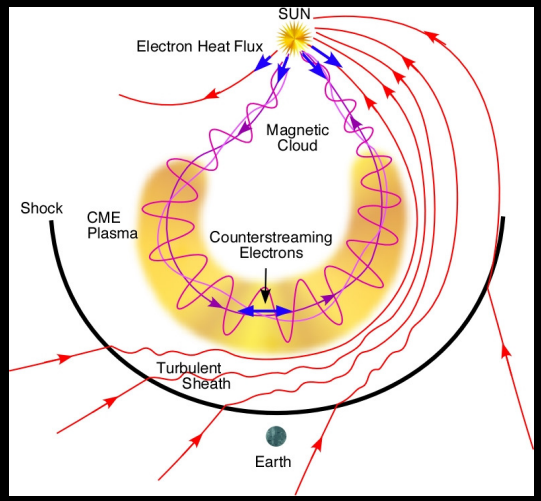


Osservazioni remote sensing: a causa della rotazione solare la corona al limbo non e' osservabile per piu' di 2-3 gg.

Questo preclude le osservazioni dell'evoluzione del campo magnetico che precede I CME, e quindi l'identificazione dei processi fisici che li generano.

Osservazioni in situ (plasma):

- permette di separare l'evoluzione instrinseca dei parametri del plasma dagli effetti della rotazione solare
- Permette di collegare I parametri del plasma all'evoluzione della sorgente solare



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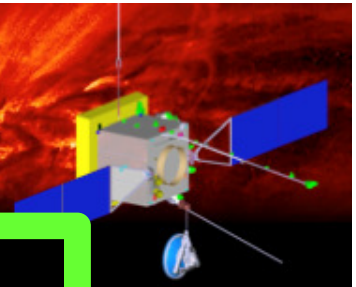
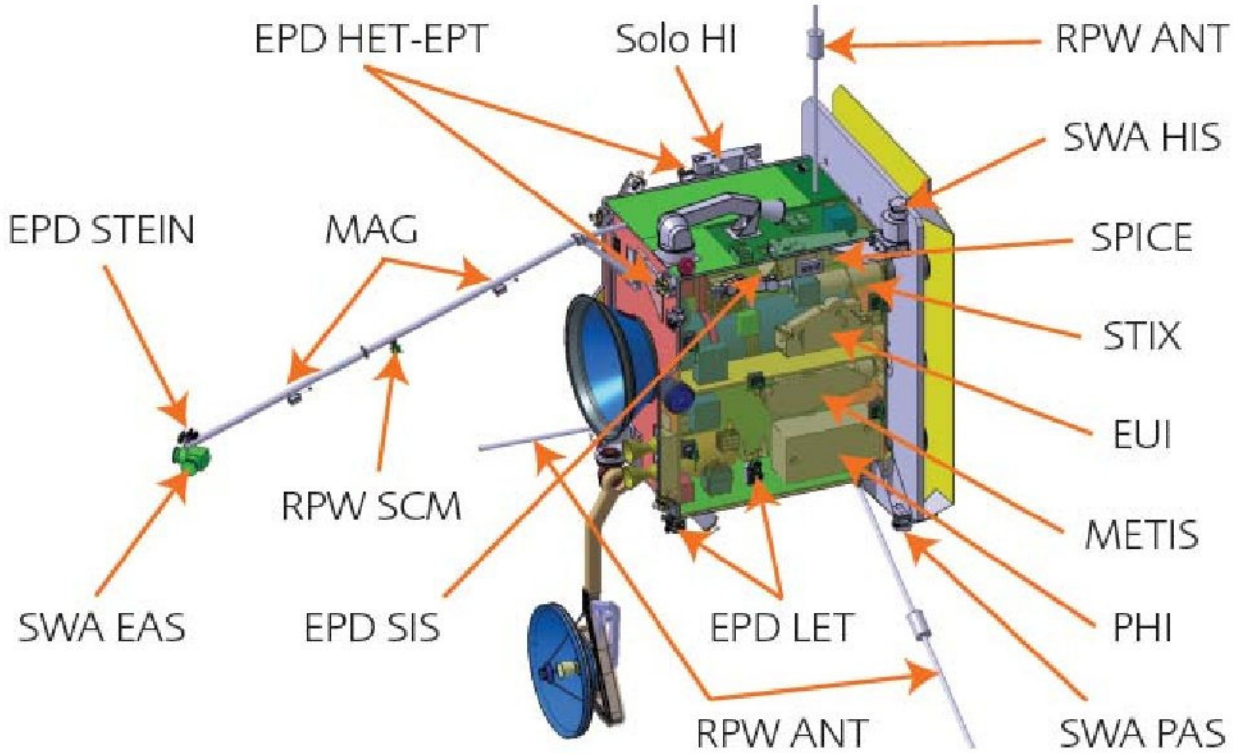


Solar Orbiter Instruments



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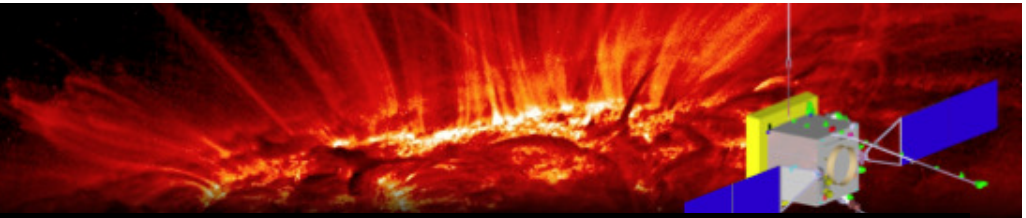

Strumento	*Collaborazione*	*Tipo di misura*
Solar Wind Analyzer (SWA) PI C. Owen, UK	UK, I, F, Japan, D, CH, USA	SW ion & electron bulk properties, ion composition (1eV- 5 keV electrons; 0.2 - 100 keV/q ions)
Energetic Particle Detector (EPD) J. Rodríguez-Pacheco, Spain	Spain, D, FI, GR, CH, F, Slovakia, USA	Composition, timing, distribution functions of suprathermal - energetic particles
Magnetometer (MAG) T. Horbury, UK	UK, A, I, H, D, F, E, DK, USA	DC vector magnetic fields (0 – 64 Hz)
Radio & Plasma Waves (RPW) M. Maksimovic, France	France, SE, CZ, NO, UK, A, D, GR, AU, I, H, FI, Russia	AC electric and magnetic fields (~DC – 20 MHz)
Polarimetric and Helioseismic Imager (PHI) S. Solanki, Germany	Germany, E, F, SE, NO, CH, AU, USA	Vector magnetic field and line-of-sight velocity in the photosphere
EUV Imager (EUI) P. Rochus, Belgium	Belgium, UK, F, D, USA	Full-disk EUV and high-resolution EUV and Lyman-α imaging of the solar atmosphere
Spectral Imaging of the Coronal Environment (SPICE) ~~D. Hassler, USA~~	ESA provided ~~USA, UK, D, F, N~~	EUV spectroscopy of the solar disk and corona
X-ray Spectrometer Telescope (STIX) A. Benz, Switzerland	Switzerland, PL, D, CZ, IRE, A, UK, F, USA	Solar thermal and non-thermal x-ray emission (4 – 150 keV)
Coronagraph (METIS) E. Antonucci, Italy	Italy, CK,F, D, GR, USA	Visible, UV and EUV imaging of the solar corona
Heliospheric Imager (SolOHI) R. Howard, USA	USA, Belgium, UK, Germany	White-light imaging of the extended corona

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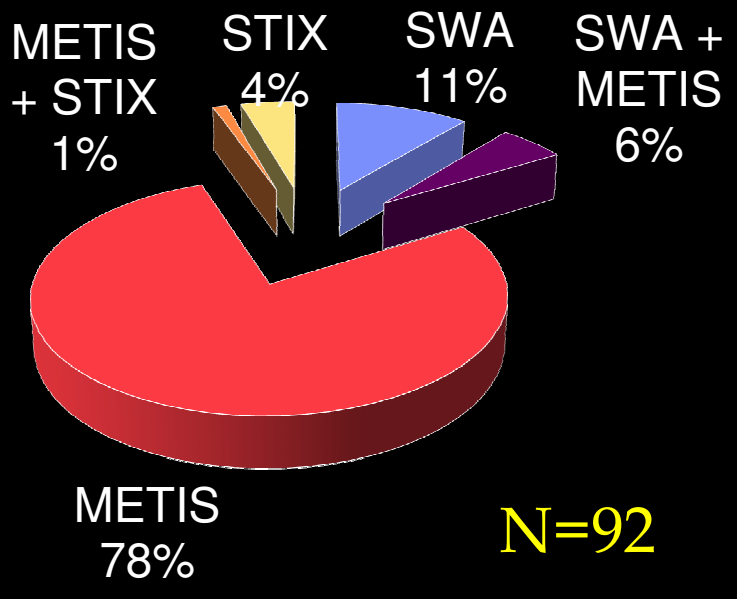
Contributo italiano a Solar Orbiter

Comunita' scientifica:



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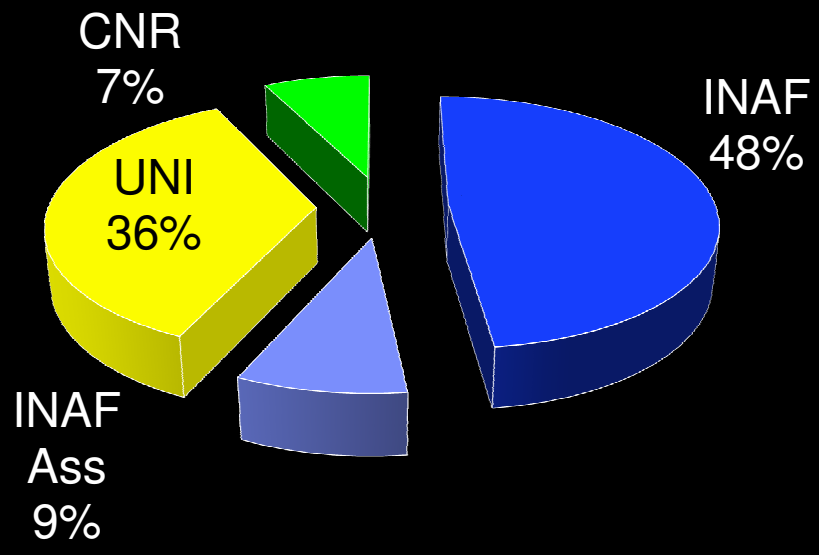

hardware team + associate scientists

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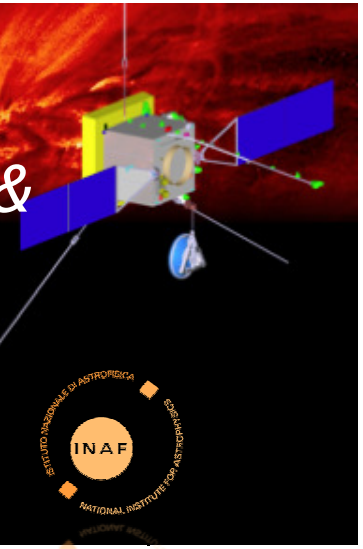
METIS - Multi Element Telescope for Imagining & Spectroscopy



- *Agenzia spaziale finanziante:* ASI
- *Partner industriali:* Thales Alenia, Selex Galileo, SwRI
- *Consorzio internazionale:*
  - Istituti INAF: IASF, IFSI, OAC, OACt, OAPa, OATo, OATs,
  - Universiita' di Firenze, Padova, Palermo, Pavia, Perugia,
  - Politecnico di Torino
  - INF-CNR, Pd
  - Max Planck Institut (MPS) Lindau, G
  - Astronomical Institute of the Czech Academy of Science (ASU-CAS), Cz
  - Institute d'Astrophysique Spatiale (IAS), F
  - Laboratoire d'Astrophysique de Marseille, F
  - Naval Research Laboratory (NRL), US
  - University of Athens, Gr
- *Associate Scientists:*
  - Istituti INAF: Oss. Arcetri, OARm
  - Universita': Calabria, Catania, L'Aquila, Perugia, Urbino, Torino, Roma II
  - INFM Genova
  - IAC Spain, Royal Obs. B, Univ. of Cambridge UK, Univ. of Michingam US

METIS INSTRUMENT
for the
Solar Orbiter Mission

Principal Investigator:
Ester Antonucci
INAF – Astrophysical Observatory of Turin, Torino, Italy

and the METIS Consortium:

CNR - Institute for Photonics and Nanotechnology, Padova, Italy
CNRS – IAS, France
INAF – IASF, IAPS, OACN, OACt, OAPa, OATo, OATs, Italy
Institute of Astronomy- Czech Academy of Science, Czech Republic
Laboratoire d'Astrophysique de Marseille, France,
Max-Plank-Institute für Sonnensystemforschung, Germany
Naval Research Laboratory, USA
Politecnico of Turin, Italy
Universities of Florence, Padua, Pavia, Italy
University of Athens, Greece

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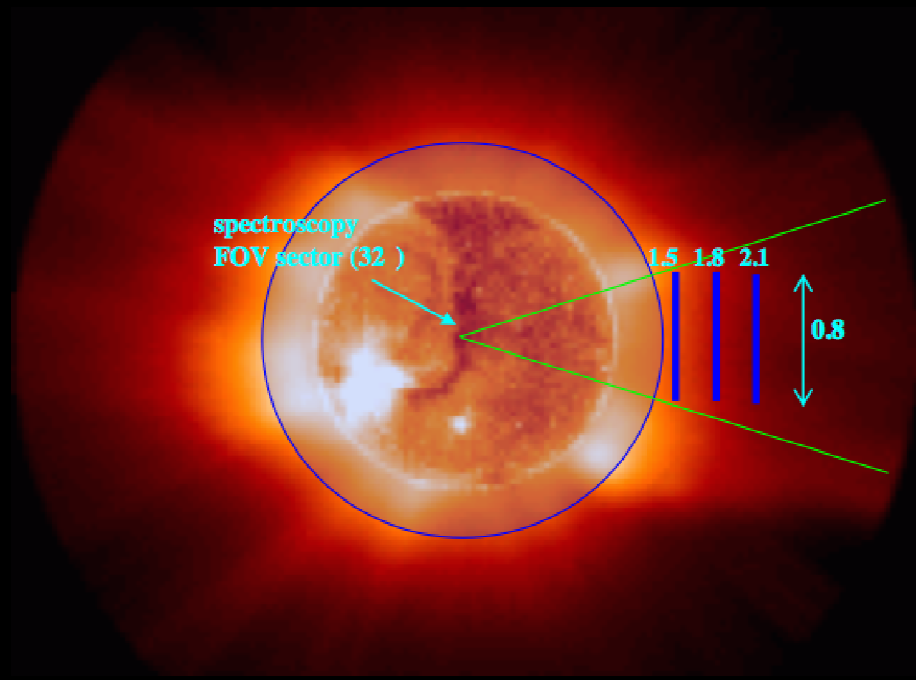
METIS

Coronografo con occultatore esterno invertito

METIS combina per la prima volta imaging/spettroscopia/polarimetria nella corona esterna (1.6 - 5.5 R) in VL, UV & EUV

- *Imaging visibile a larga banda e in luce polarizzata della corona (590-650 nm)*
- *Imaging a banda stretta nell' UV (HI Ly α, 121.6 nm) e EUV (He II Lyα, 30.4 nm)*
- *Spettroscopia HI Ly α, 121.6 nm, He II Ly α, 30.4 nm*



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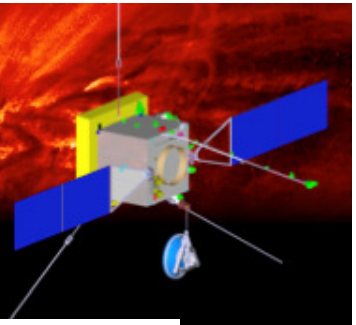

METIS Instrument Performance	
CORONAL IMAGING	
Avg. Instrumental Stray Light (B_{corona}/B_{disk})	VL $<10^{-9}$ UV/EUV $<10^{-7}$
Wavelength range:	VL: 590-650 nm; UV: 121.6 ± 10 nm EUV: 30.4 ± 2 nm
Spatial Resolution	20 arcsec
Field-of-view	1.5° - 2.9° annular, off-limb corona
CORONAL SPECTROSCOPY	
Wavelength range:	UV: 121.6 ± 0.9 nm EUV: 30.4 ± 0.22 nm
Spectral Resolution	UV: 0.037 nm EUV: 0.018 nm
Spatial Resolution	45 arcsec
Field-of-view	Slit radial positions: 1.5°, 1.8°, 2.1° Slit extension: 0.8°

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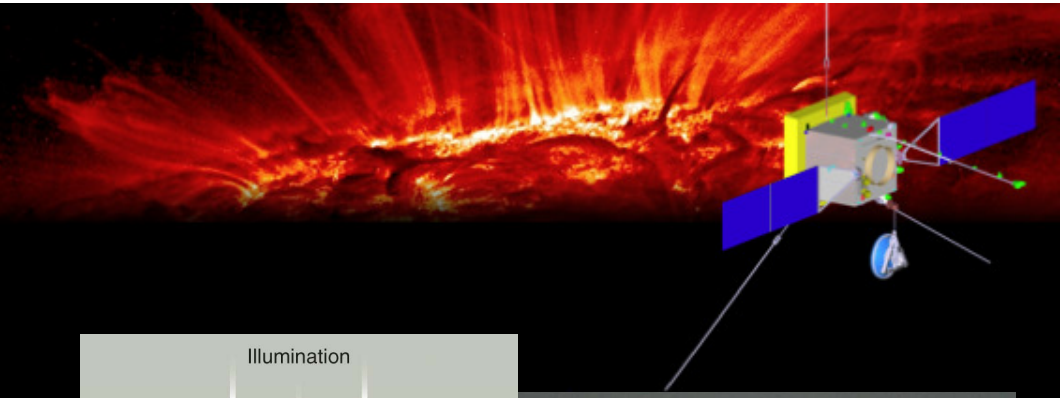
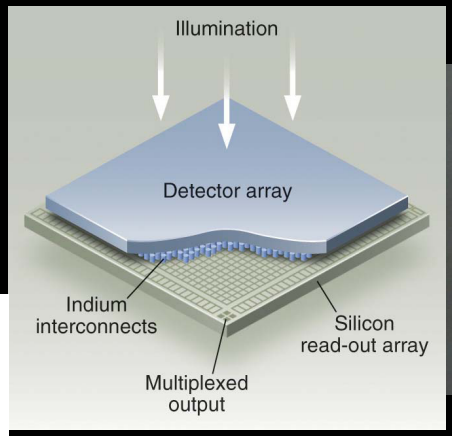
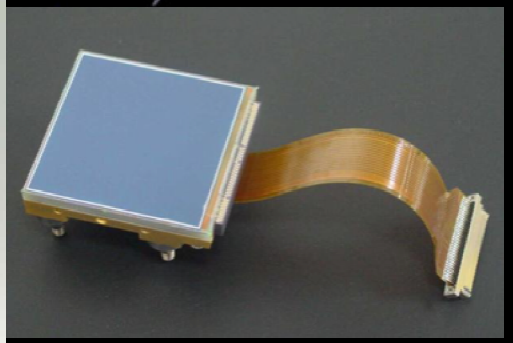
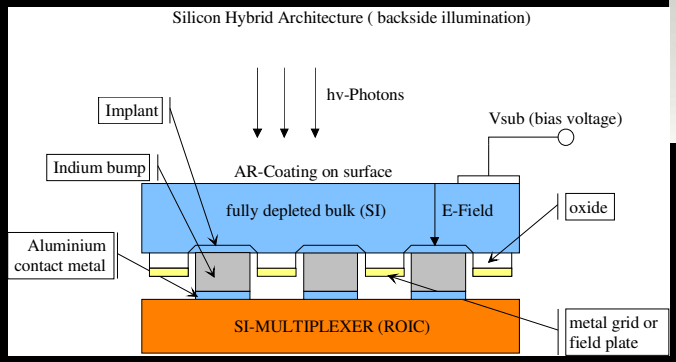
METIS Detectors



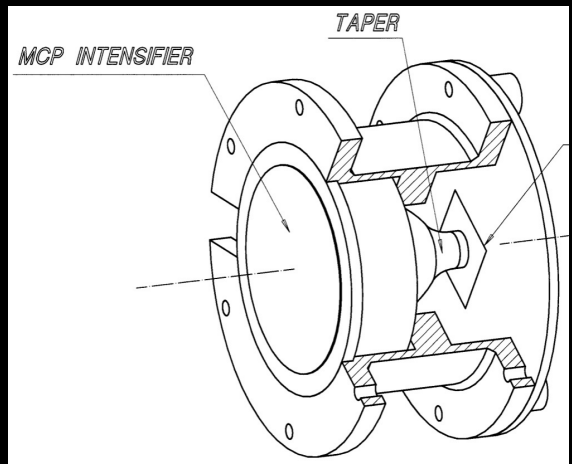
METIS **visible detector** (VLD):
2kx2k Active Pixel Sensor (APS) ibrido H2RG ROIC+HyViSI PIN array, by Teledyne

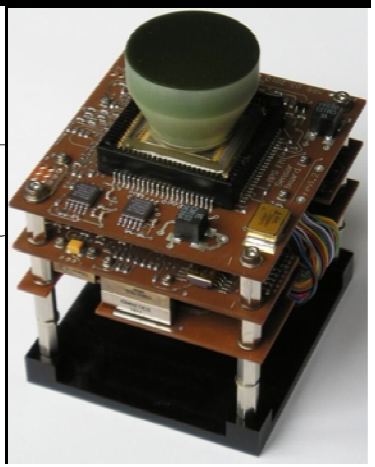






METIS **UV detector** (UVD): photon counting Intensified Active Pixel Sensor (IAPS), formato 2k × 2k, 15 µm pixel size, con capacita' di lavorare in modalita' analogica/a integrazione (30 µm pixel size, 1kx1k) per estendere il range dinamico





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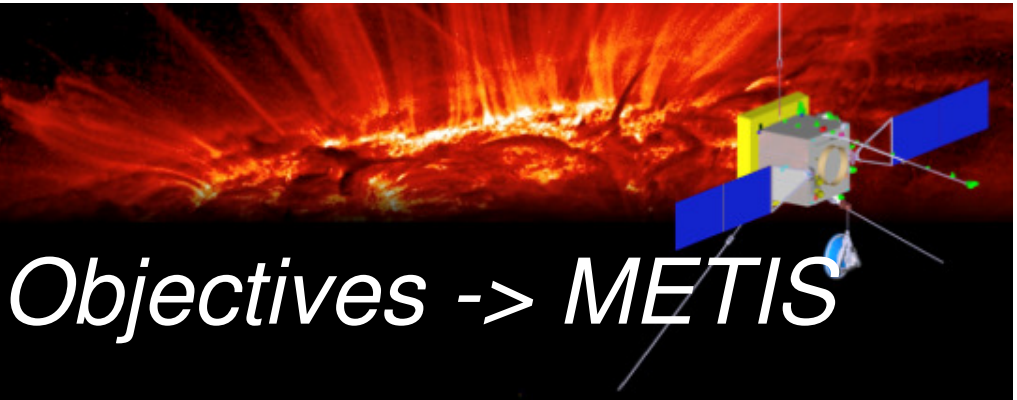

Top Level Scientific Objectives -> METIS

- How does the solar dynamo work and drive connections between the Sun and the heliopshere?

- How and where do the solar wind plasma and magnetic field originate in the corona?

- How do solar transients drive heliospheric variability?

- How do solar eruptions produce energetic particle radiation that fills the heliosphere?

by investigating the outer corona, a region which is crucial in linking the solar atmosphere phenomena to their evolution in the inner heliosphere.

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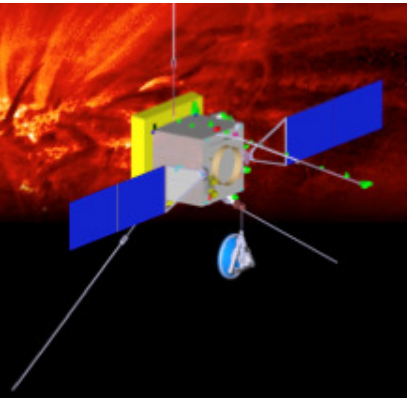

METIS Scientific Objectives

Origin and acceleration of the solar wind streams

- Energy dissipation by wave particle interaction
- Role of coronal fluctuations in the wind heating and acceleration
- Role of magnetic topology in controlling the wind speed
- Identification of the sources of the slow wind

Sources of solar energetic particles (SEPs)

- Identification of SEP accelerated by CME shocks

Origin and early propagation of coronal mass ejections (CMEs)

- Identification of the mechanism driving the eruption
- Detection of cool ejecta

Evolution of the global corona

- Evolution of the physical coronal conditions on the large-scale

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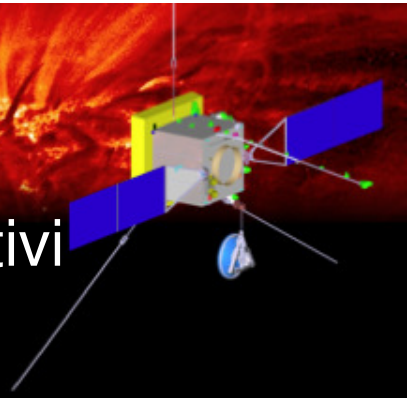

Parametri fisici necessari per affrontare gli obbiettivi scientifici di METIS:

- Densita' e^-
- Distribuzione di velocita' di H, p
- Distribuzione di velocita' di ioni HeII
- Gradiente di velocita' di fuoriuscita delle componenti coronali (H/He)
- Abbondanza relativa He/H

➧ Mappe globali in luce polarizzata visibile, in H I Ly α (121.6 nm), e in He II Ly α (30.4 nm) con risoluzione spaziale fino a 20 arcsec, risoluzione temporale fino a 1 min

- Distribuzione di velocita' lungo la linea di vista per p e H
- Velocita' lungo la linea di vista per le componenti H e He del plasma coronale
- Intensita' di He II, Si III, etc.

➧ Profili e shift doppler delle righe di H I, He II, Si III

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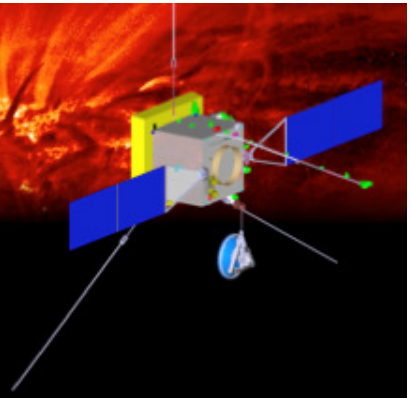

METIS Schedula

Milestones fase C/D:

- ICDR Aprile 2013
- IQR Febbraio 2014
- IFAR Dicembre 2014

Date di consegna dei modelli di METIS:

- STM Luglio 2013
- EM Gennaio 2014
- FM Gennaio 2015

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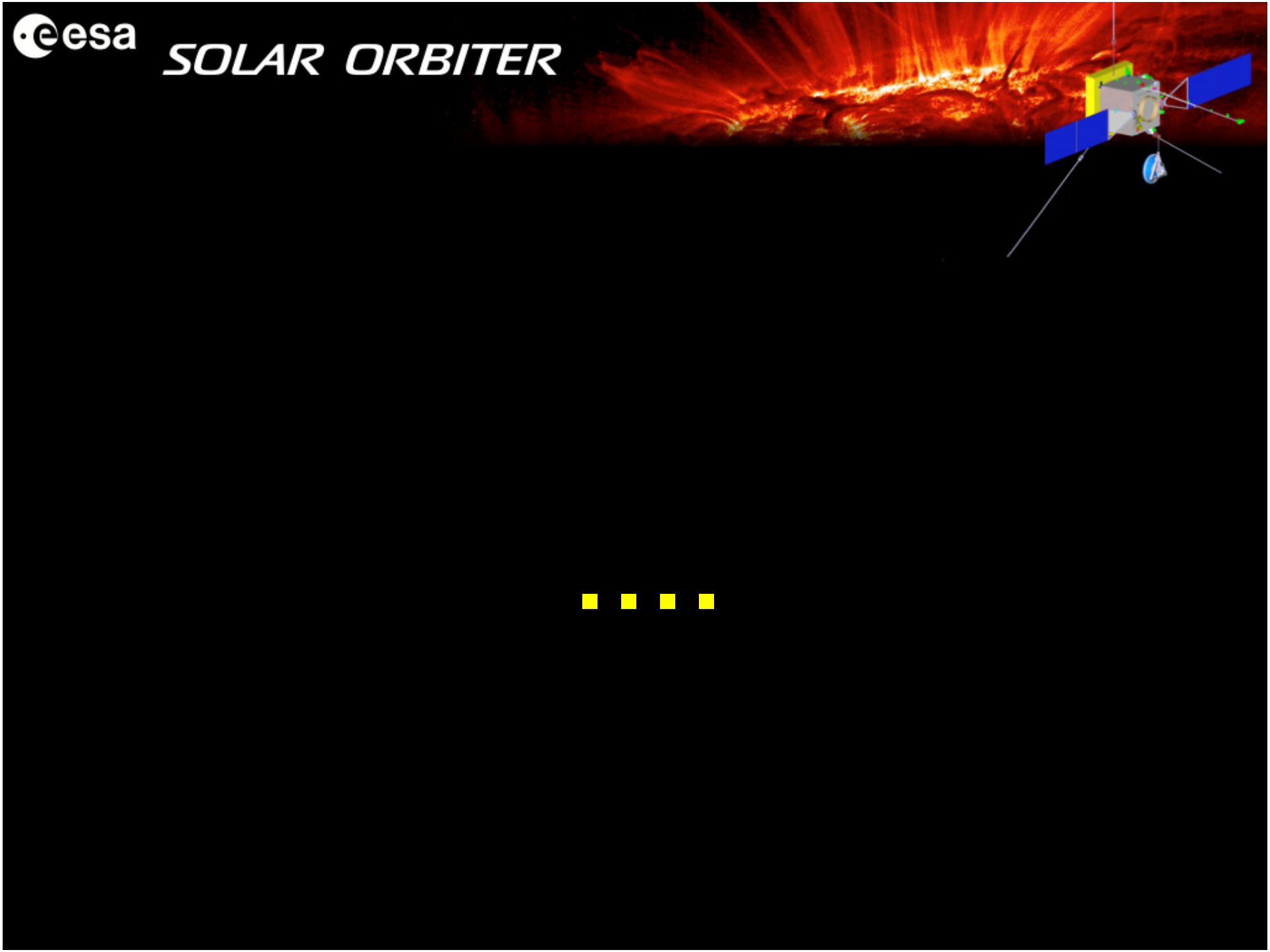

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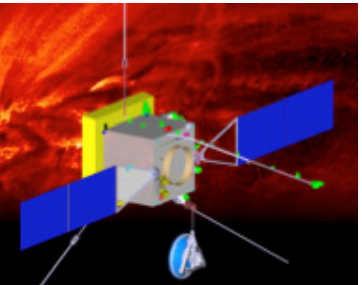


Ma il vero enigma di SOHO e' ....

'UFO' on NASA camera

By TIM UPTON

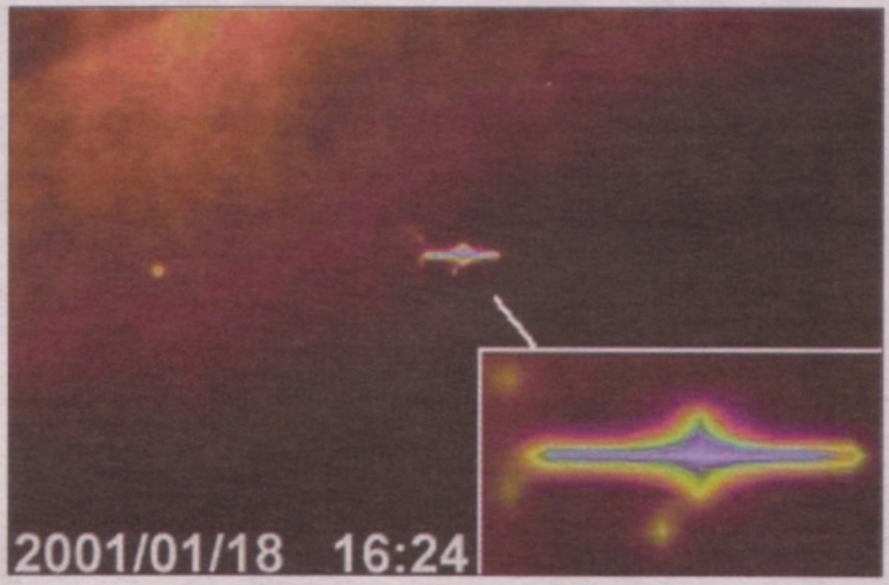
WASHINGTON: The object is certainly unidentified and appears to be flying.

Whether this enlarged image really shows a UFO piloted by aliens remains to be seen. But according to the people who released it this photo and hundreds like it are the best evidence yet of the existence of spacecraft from other worlds.

UFO investigators say the image was captured by the Solar and Heliospheric Observatory (SOHO), a NASA satellite that was launched in 1996 to observe the sun. Since then, it is said, SOHO has captured hundreds of images of UFOs moving along a kind of alien superhighway.

SOHO is more than 1.5 million kilometres from Earth, with its camera trained towards the sun. Experts say the photographed objects are likely to be only hundreds of kilometres from its lenses.

Graham Birdsall, editor of *UFO* magazine, said: "The images are irrefutable in that they are from official satellites owned by NASA. They resemble the kind of spacecraft we used to see in sci-fi films like *Star Trek*."



UTTERLY ALIEN: The image investigators say shows a UFO.

SOHO+UFO -> 2.710.000 risultati su google, 4730 su youtube

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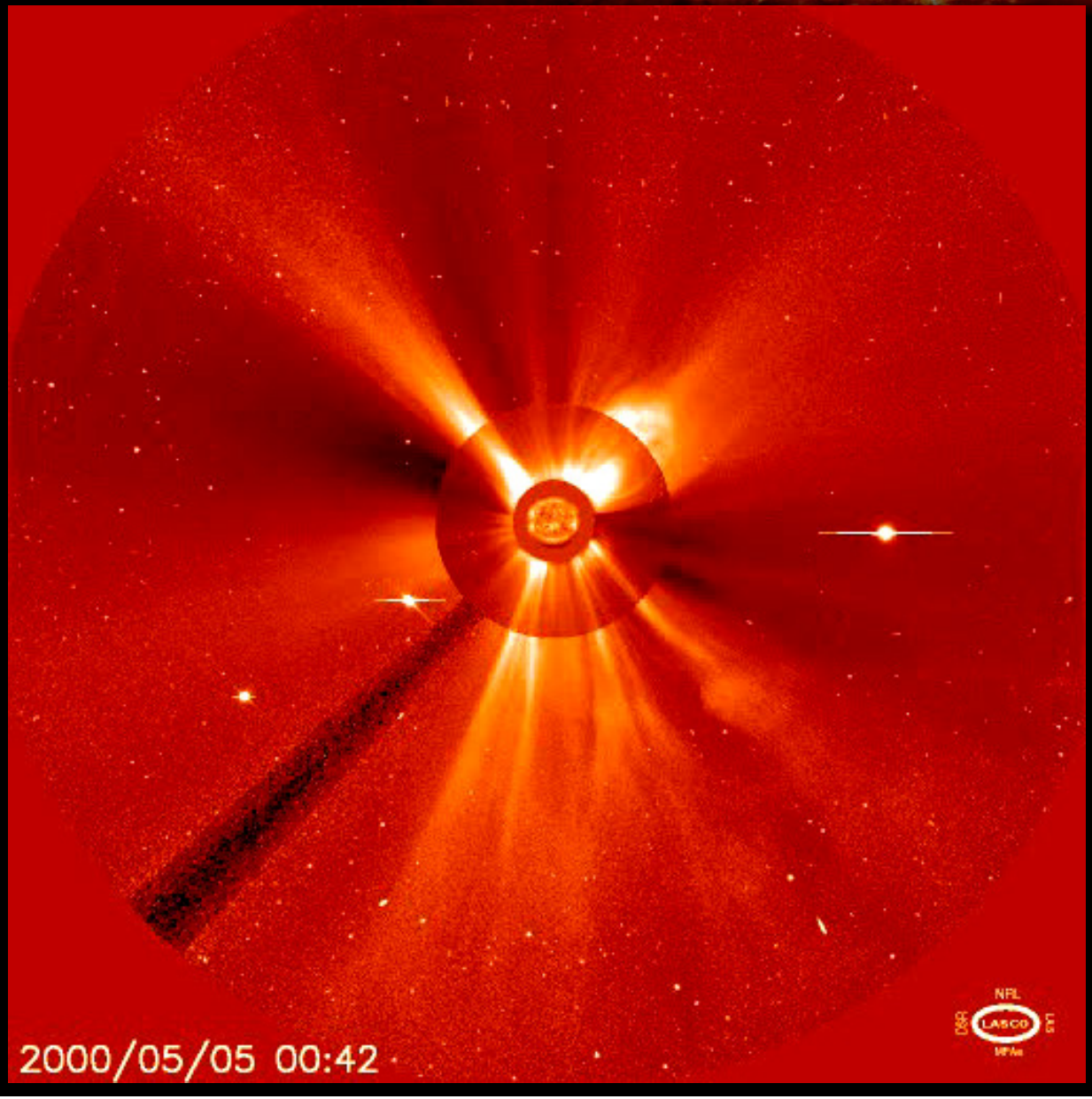

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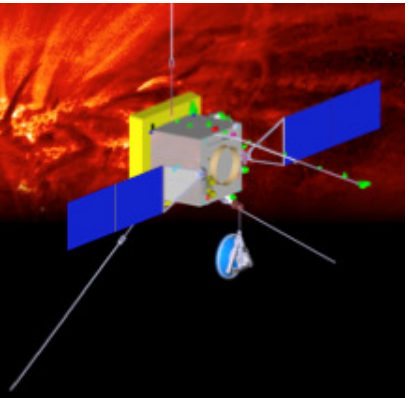

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