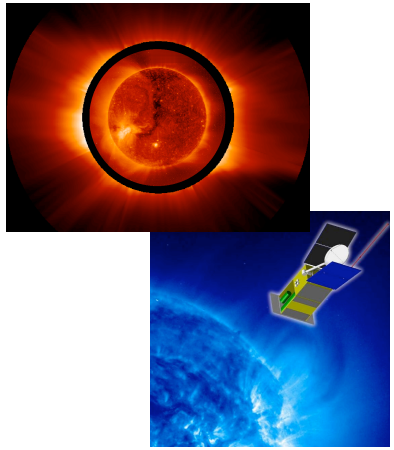


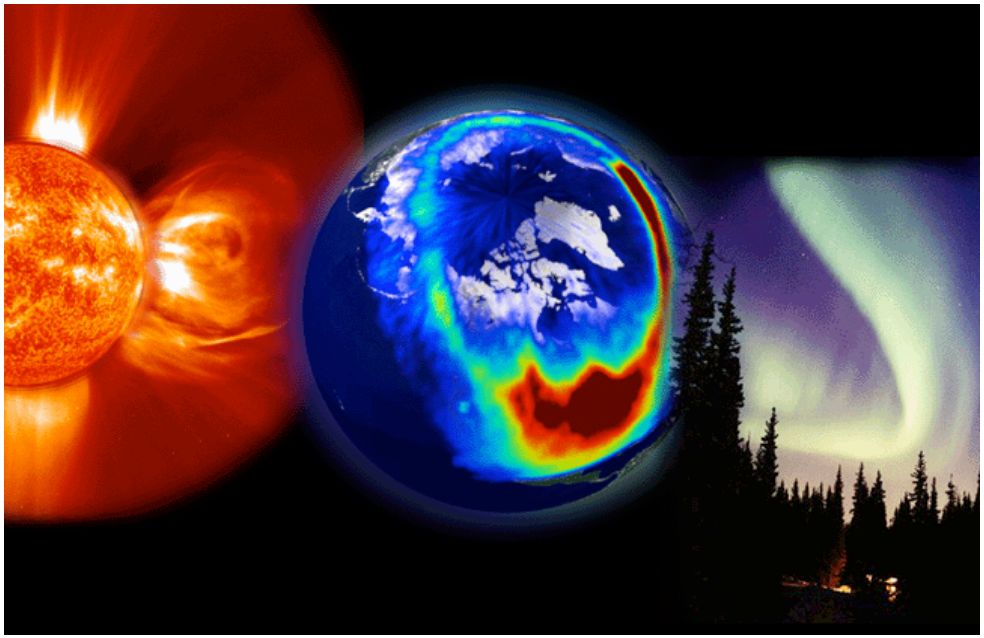
International Living with a Star - ILWS
Italian Solar Physics Programs

Ester Antonucci

Trieste April 16 2003

International Living with a Star

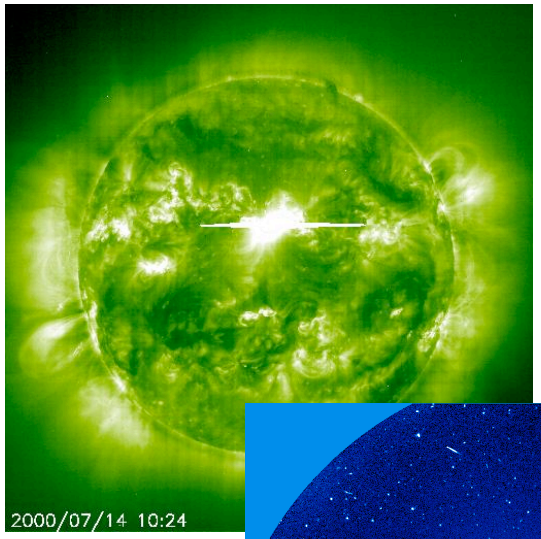
- Study the governing processes of the Sun-Earth system as an integrated entity
- Do science for both understanding and utility
- Perform simultaneous and coordinated observations in Science –Space Weather – Global Climate Change



SPACE WEATHER refers to conditions on the Sun and in the solar wind, magnetosphere, ionosphere, and thermosphere that can influence the performance and reliability of space born and ground-based technological systems and that can affect human life or health.

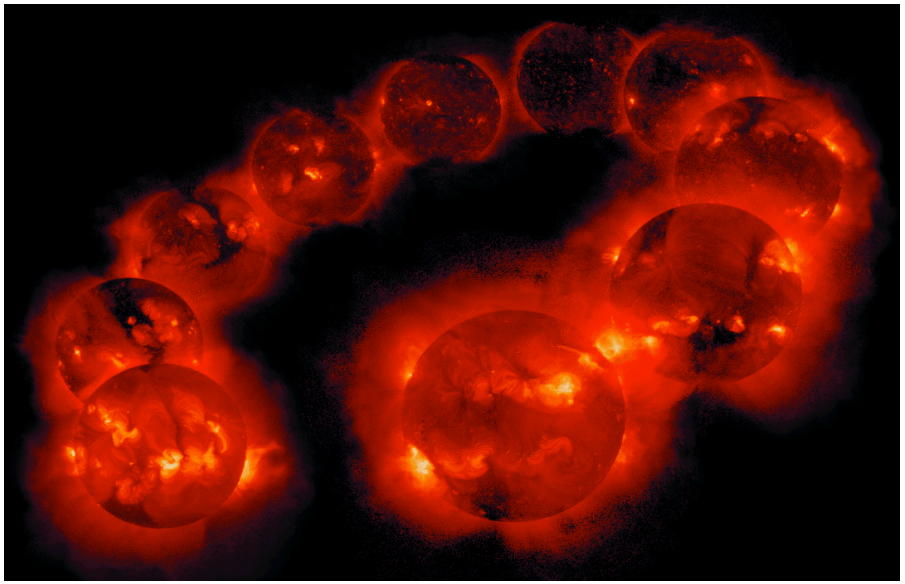
Understanding Solar Variability

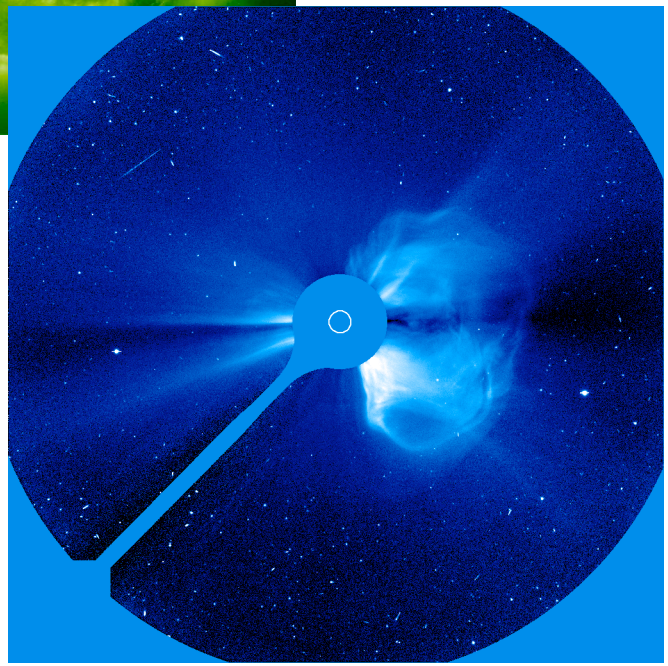
flares



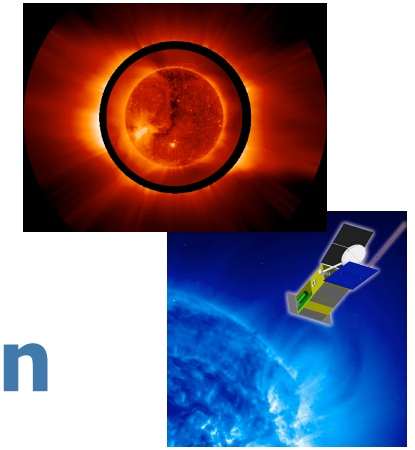
on the short time scale

on the solar cycle





coronal mass ejections (CMEs)



ILWS
Italian Solar Physics Contribution

Ongoing programs

SOHO (ESA-NASA)

Solar B (ISAS Japan)

LWS – NASA

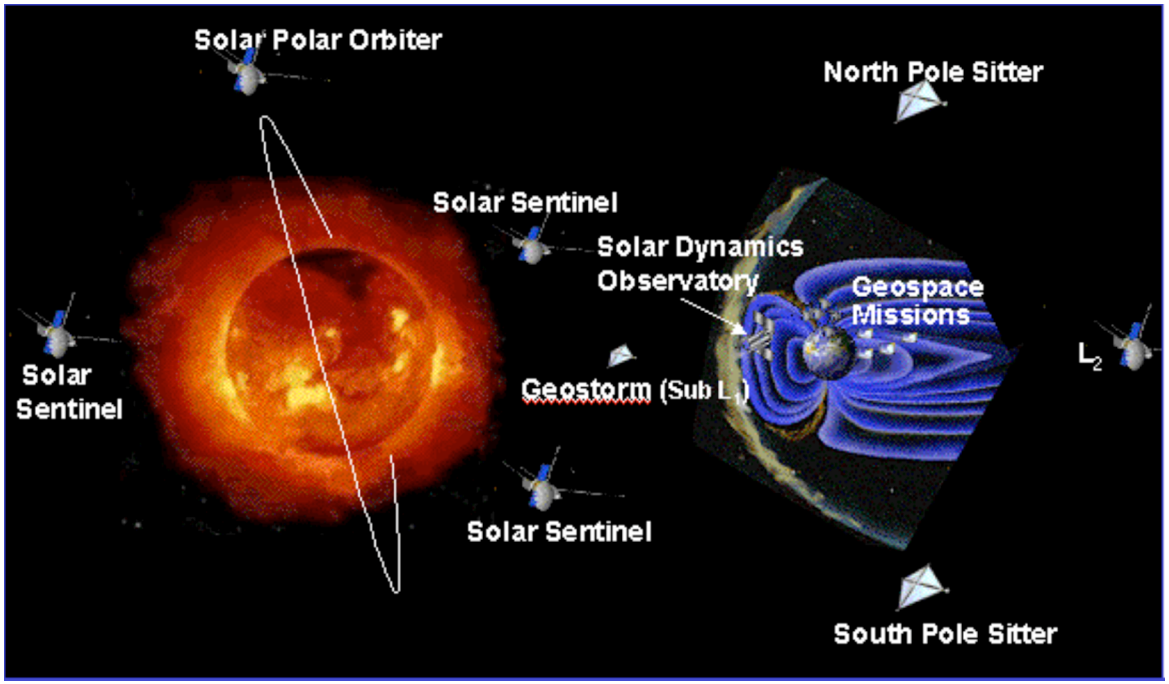
SPECTRE Solar Dynamics Observatory (NASA)

HERSCHEL (NASA)

ESA

Solar Orbiter (ESA)

Living with a Star (NASA)



Network missioni LWS:

Solar Dynamics Observatory, Sentinels
Geospace Fleet

Solar Dynamics Observatory SHARPP-SPECTRE (selected Aug 2002)
HERSCHEL Program UVCI (selected March 2003)

Solar Dynamics Observatory SDO
NASA - LWS cornerstone mission

Primary goals

- **Understand how and why the Sun varies**
- **Determine how the Sun drives Space Weather and global change**

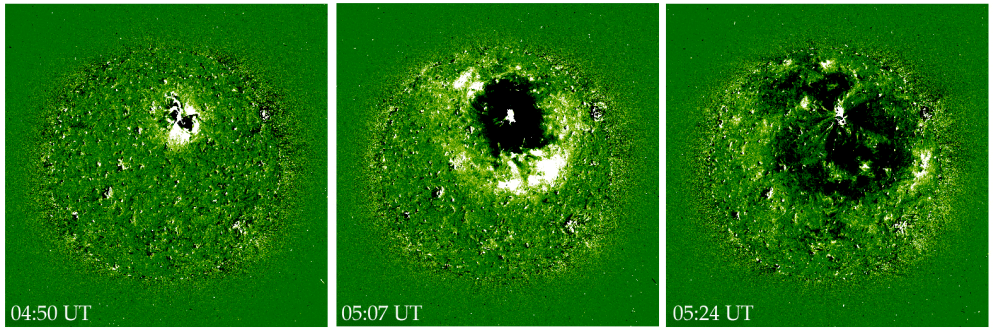
High telemetry and nearly constant solar viewing
(geosynchronous orbit to allow continuous contact at high data rate, 160 Mbps)

Launch 2007 – nominal mission 5 years

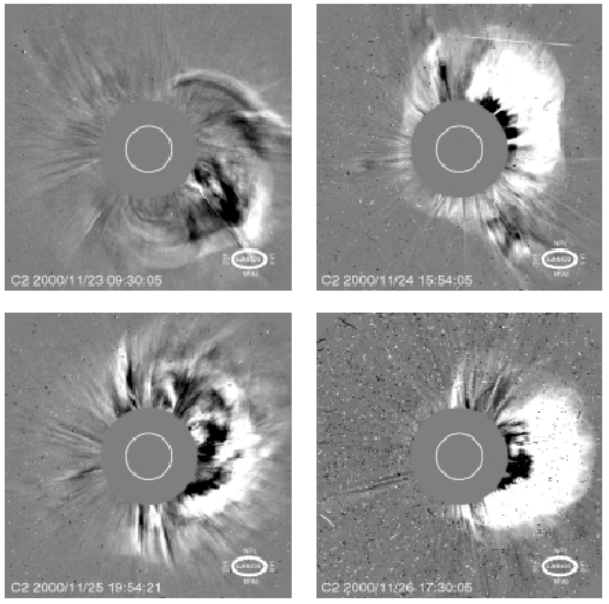
SHARPP - Solar Heliospheric Activity Research and Prediction Program

➢ **provides high spatial and temporal resolution observations of the complete solar atmosphere and its coupling to the heliosphere (0.6 arcsec, 10 sec)**

- **to trace the flow of energy and mass from the chromosphere through the corona (0.02-3 MK, up to 20 MK)**



SOHO-Extreme ultraviolet Imaging Telescope (EIT)
observations of Moreton wave expanding from coronal mass ejection (CME) initiation site
1997 May 12
First differences in Fe XII 195 Å (1.5 MK)



➢ **provides the 'STEREO 3rd eye'**

- **to reconstruct the 3D structure of Earth directed coronal mass ejections**

SHARPP SCIENCE OVERVIEW

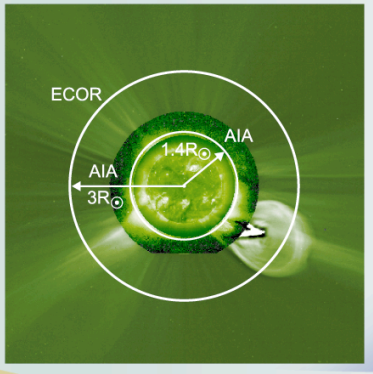
SHARPP Investigations

- *How and why does the Sun vary?*
- *How does the Sun drive the solar wind?*
- *What solar mechanisms lead to global change at Earth?*

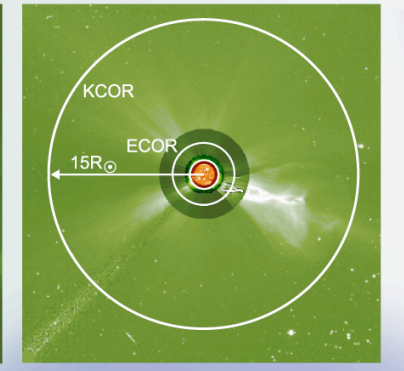
SHARPP Applications

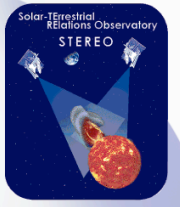
- *Significantly improve space weather disturbance predictions*
- *Provide a scientific foundation for irradiance variability proxies*
- *Offer modeling and visualization tool to the community*

The combined ECOR/AIA FOV



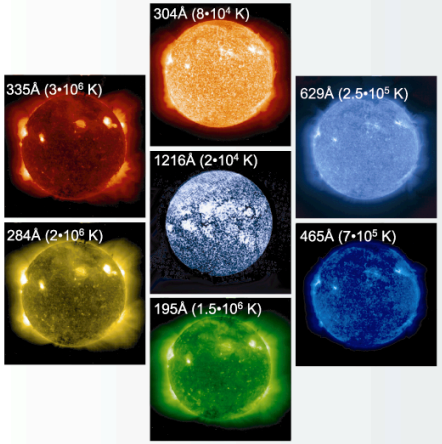
The combined SHARPP FOV



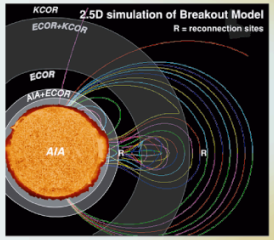


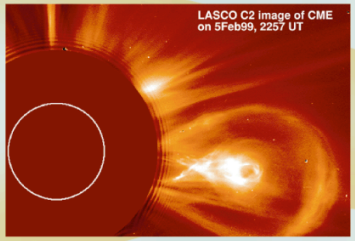
Provide a "third eye" for STEREO

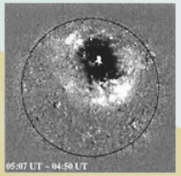
AIA provides complete coverage of the solar atmosphere from the chromosphere to the corona



Model the CME initiation process

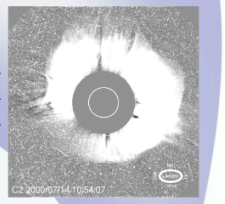




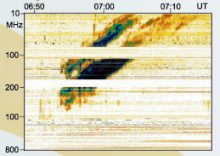


Follow the early evolution of CMEs

Monitor and assess geoeffectiveness of CMEs



Locate and track the sites of particle acceleration

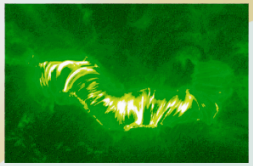


Solar wind variability

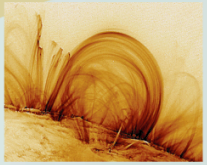
Geomagnetic Storms

Short-term variability

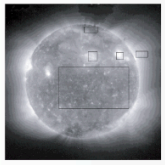
SEPs

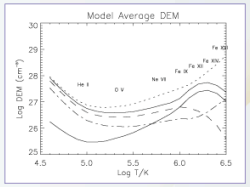


Flare emissions and structure

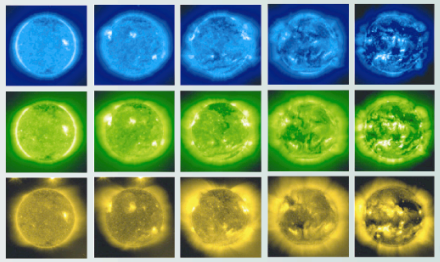


Coronal heating mechanisms





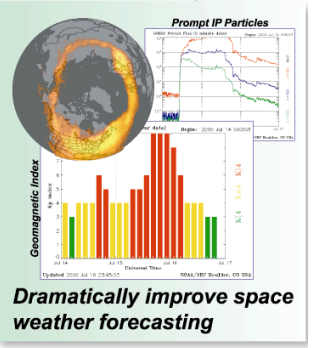
AIA DEM analysis deciphers the thermal structure of the atmosphere



AIA calibrated images determine the sources of irradiance through the solar cycle

Long-term irradiance variability

Global Change



Dramatically improve space weather forecasting

SHARPP International Consortium: Funding

SHARPP

K-COR

Guide Telescopes
SHEB
Mission Ops & Data Analysis
Software

United States

Magritte

AIA FPA

Belgium

France

AIA Optics
AIA Multilayer coating

Germany

Doors
Shutters

SPECTRE

Italy

SHARPP Instruments

- **KCOR** Visible Light Coronagraph (NRL)
- **AIA** Atmospheric Imaging Assembly including:

Magritte - 6 channels HI Ly alpha, HeII, NeVII, FeXII, FeXV, FeXVI (Belgium)

SPECTRE - OV channel 629 A (Italy)

Structure, optics, filters,
integration, alignement, calibration

additional partners (subsystems): (France, Germany)

SHARPP Instruments

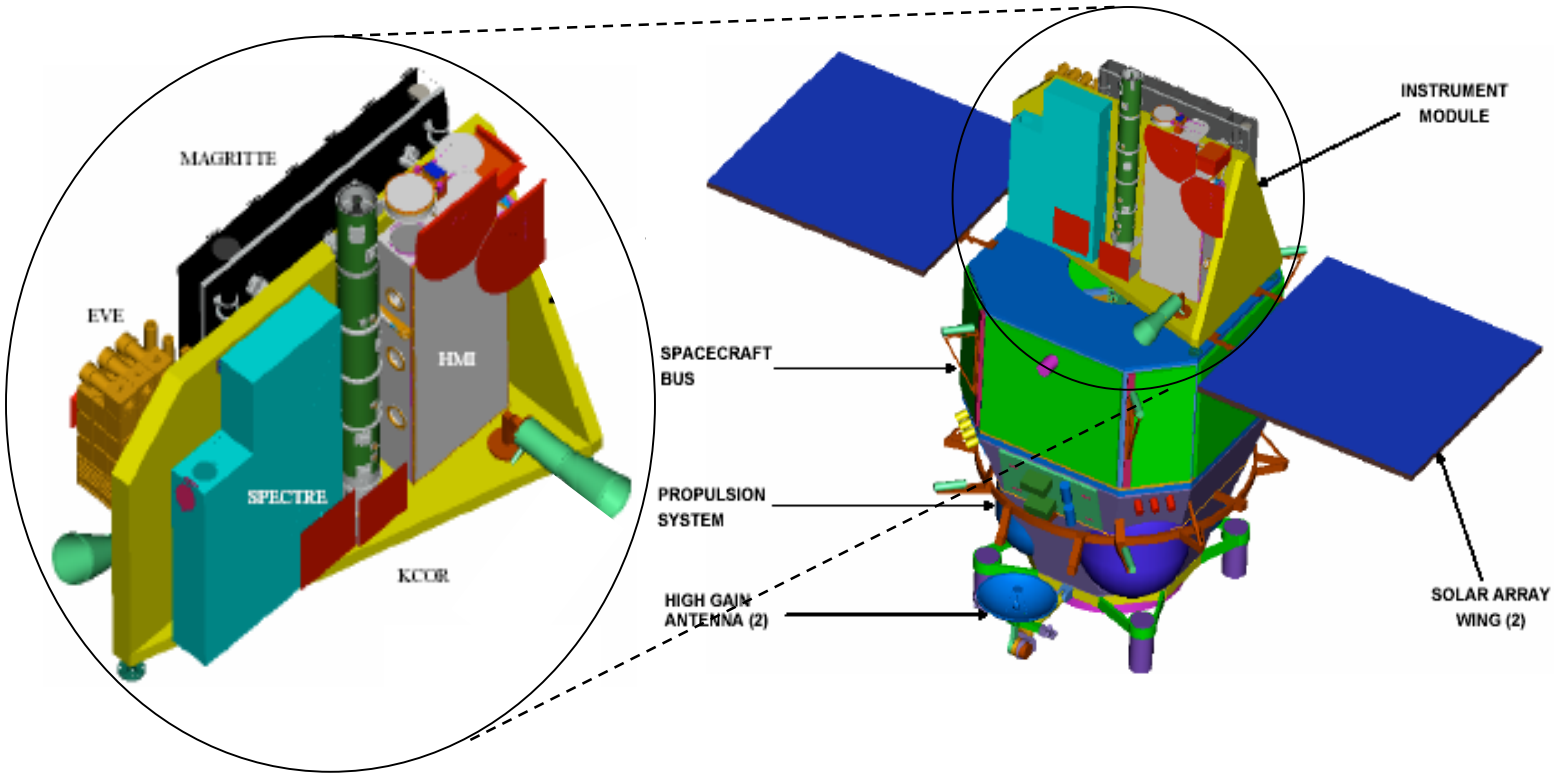
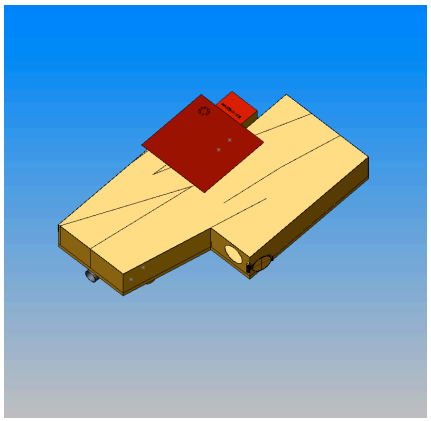
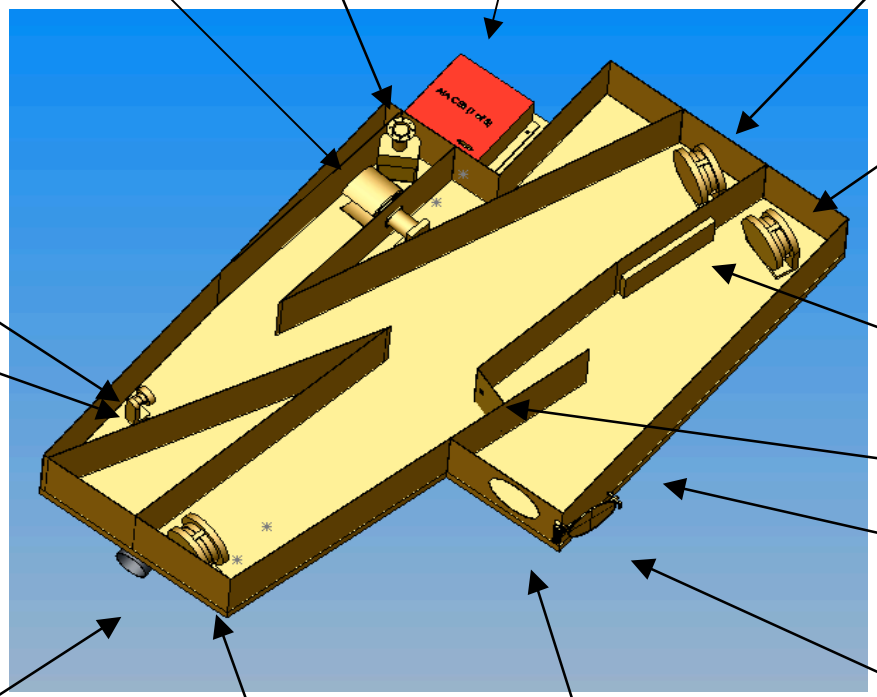


Figure 1. Right: The Solar Dynamics Observatory (SDO) satellite. Left: The Instruments payload aboard SDO includes SPECTRE-SHARPP that represents the Italian contribution to the SDO mission.

SPECTRE
Spectroheliograph for the Transition Region





CEB

Shutter

CCD-FPA

Second Wadsworth Grating

Wadsworth-Cassegrain
Secondary Mirror

IMC Actuators

Zero Order
Rejection Mirror

Field Stop

GFRP Structure,
Optical Bench
3 x Kinematic Mounts

Door

Guide Telescope

Collimating Paraboloid

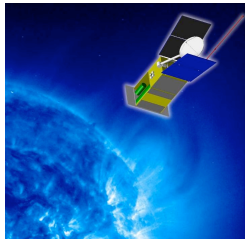
Entrance Aperture

The HERSCHEL Program
Helium Resonant Scattering in the Corona - Heliosphere

The HERSCHEL program consists of a 3-year effort to build and launch on a sounding rocket two complementary instruments for coronal and disk observations:

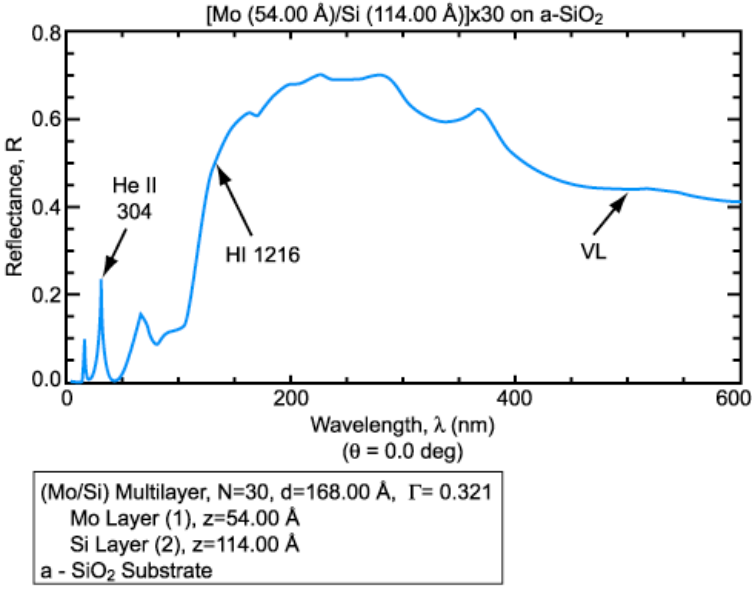
- **investigate the solar wind acceleration from a range of solar source structures**
- **obtain the first measurements of the coronal helium abundance**
- **establish proof-of-principle for the Ultraviolet Coronagraph, which is in the ESA Solar Orbiter Mission baseline**

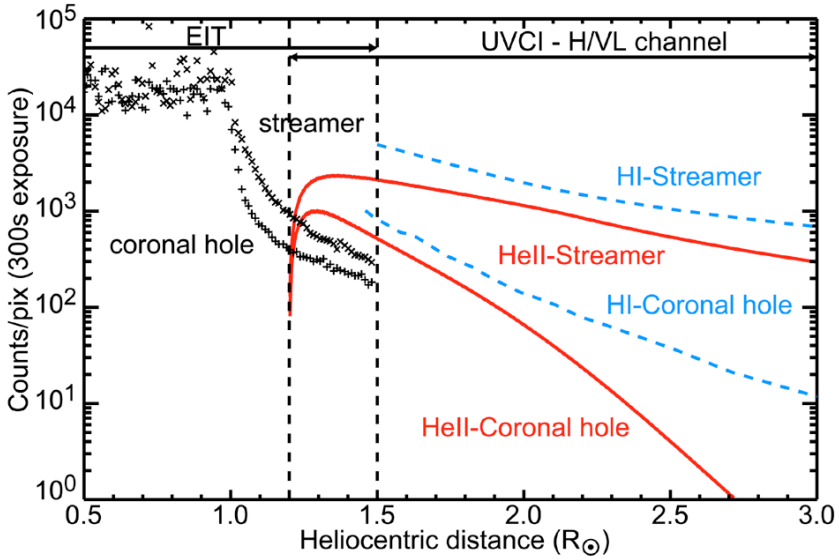
HERSCHEL: a program to test the coronagraph concept for the Solar Orbiter



UVCI: VL, HI 1216, HeII 304 coronal monochromatic imager
same optical components (except detecting systems)

multilayer mirrors





The HERSCHEL Instruments

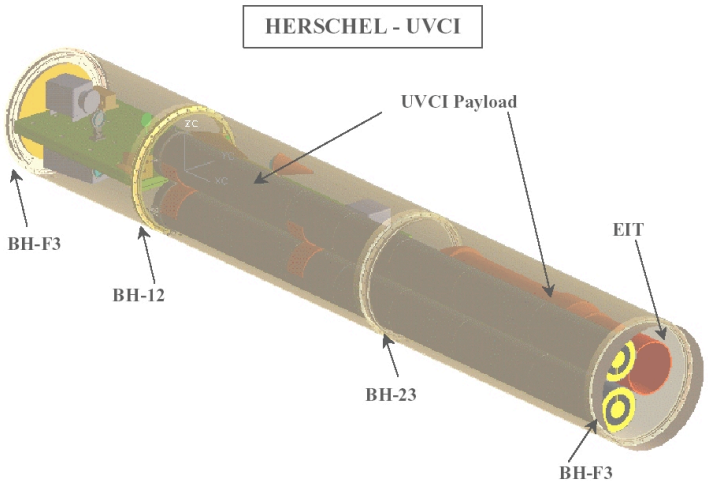
- **UVCI** Ultraviolet and Visible-light Coronagraphic Imager (Italy)

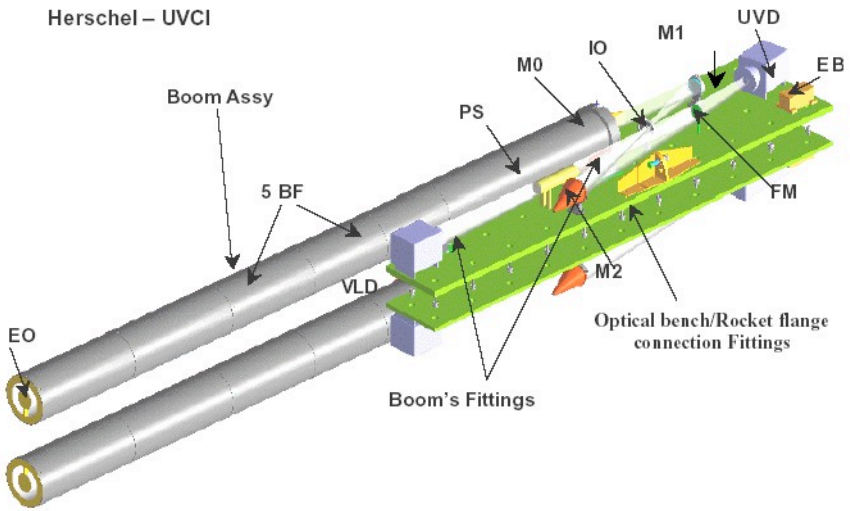
  UV (H, He) and visible-light observations of the solar corona

  same optical path for both the visible and ultraviolet

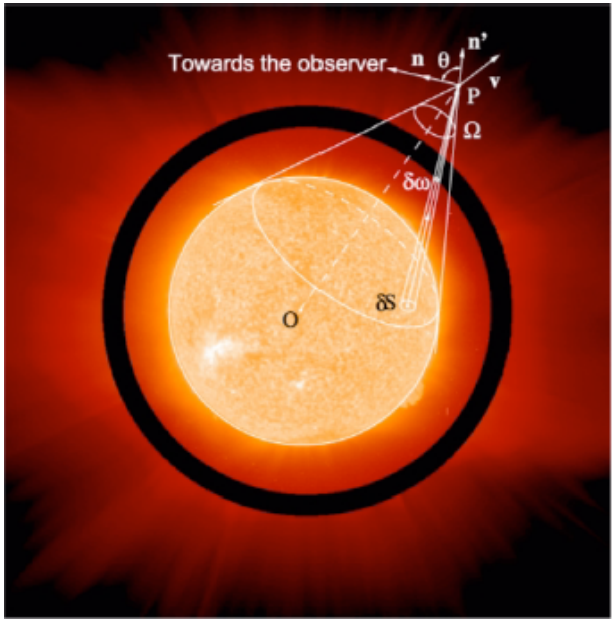
- **EIT** Extreme Ultraviolet Imaging Telescope (NRL, US)

  He observations on the solar disk





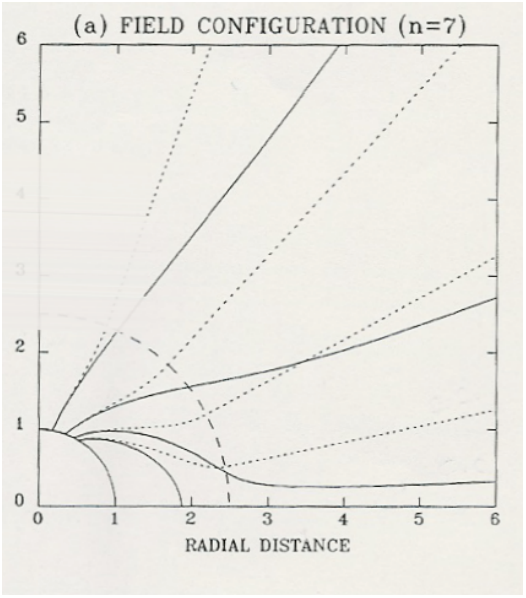
The HERSCHEL Science



Resonant scattering in corona of the chromospheric He and H emission allows to determine for the first time global maps of

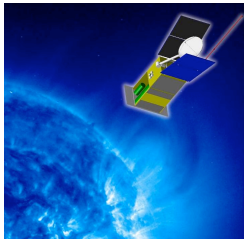
He outflow velocity
He/H abundance
He abundance modulation due to the open magnetic field expansion factor

to study the He solar wind component

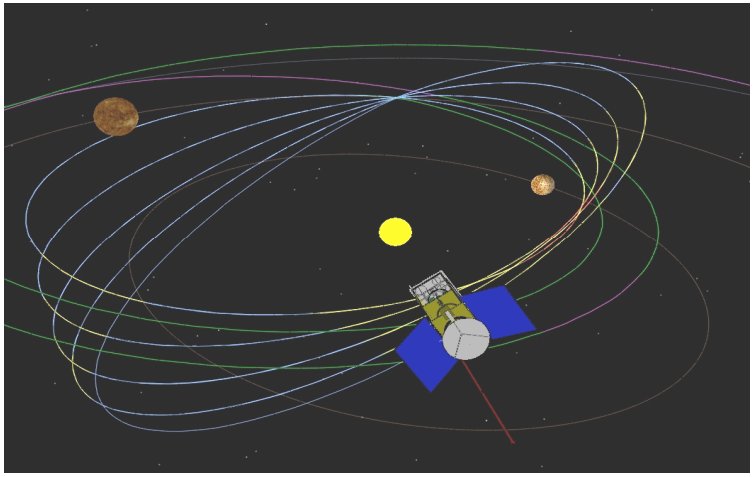


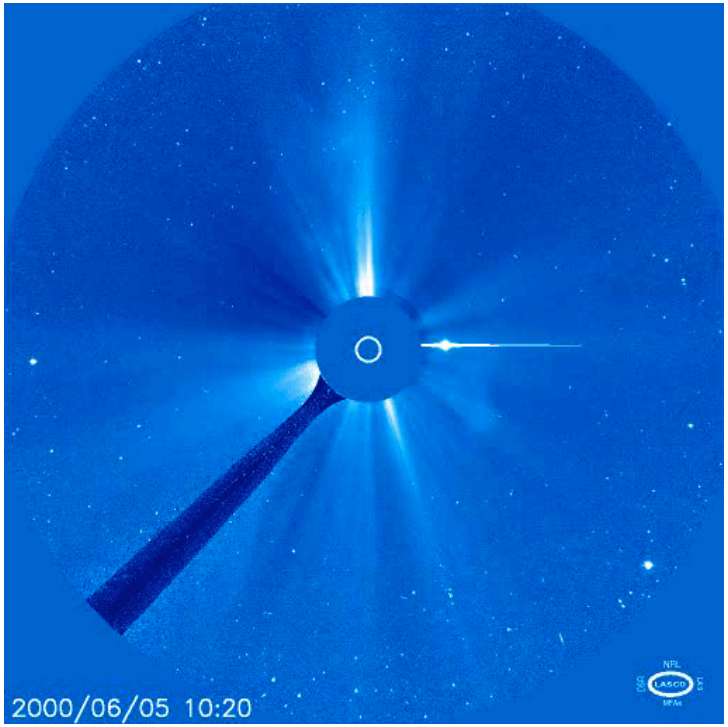
H abundance
H outflow velocity

The Future: Solar Orbiter
the solar and heliospheric ESA mission

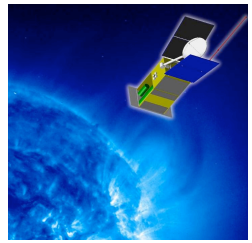


- explore unknown territory near the Sun (perihelion 45 Rs, 0.2 AU)
- deliver the first images of the solar poles
- provide unprecedented high-resolution observations of the Sun (> 35 km)
- correlate in-situ & remote-sensing measurements during co-rotation





Solar Orbiter instruments



Instrument	Visible Light Imager &Magneto		

✓
✓
✓

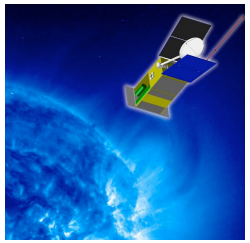
In situ

Remote sensing

Instrument	Mass	Power	Solar Wind Plasma Analyser (SWA)		

✓
✓
✓

Solar Orbiter: Ultraviolet Coronagraph

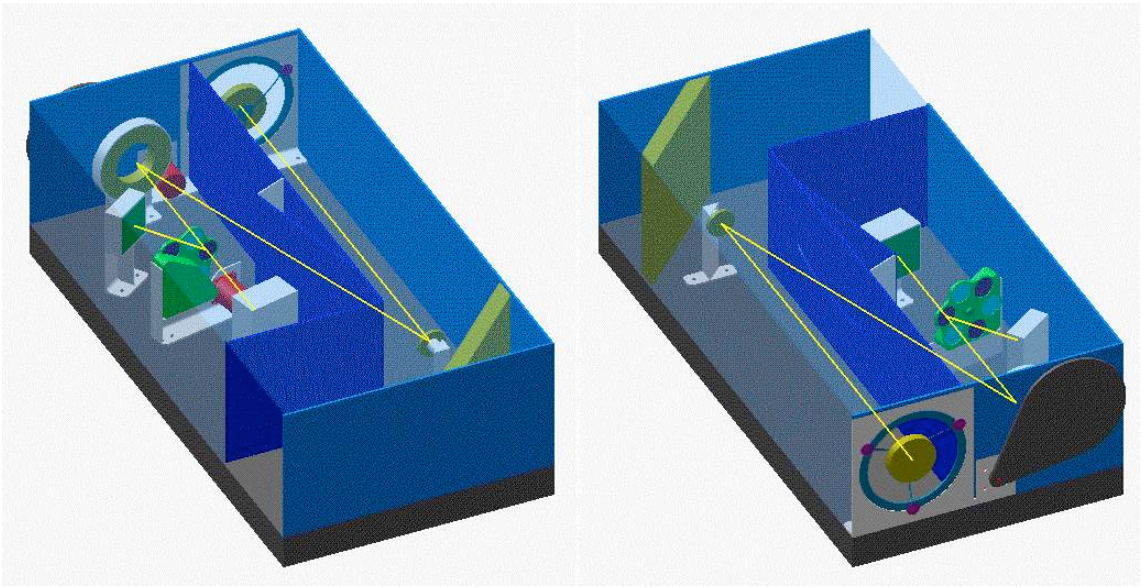


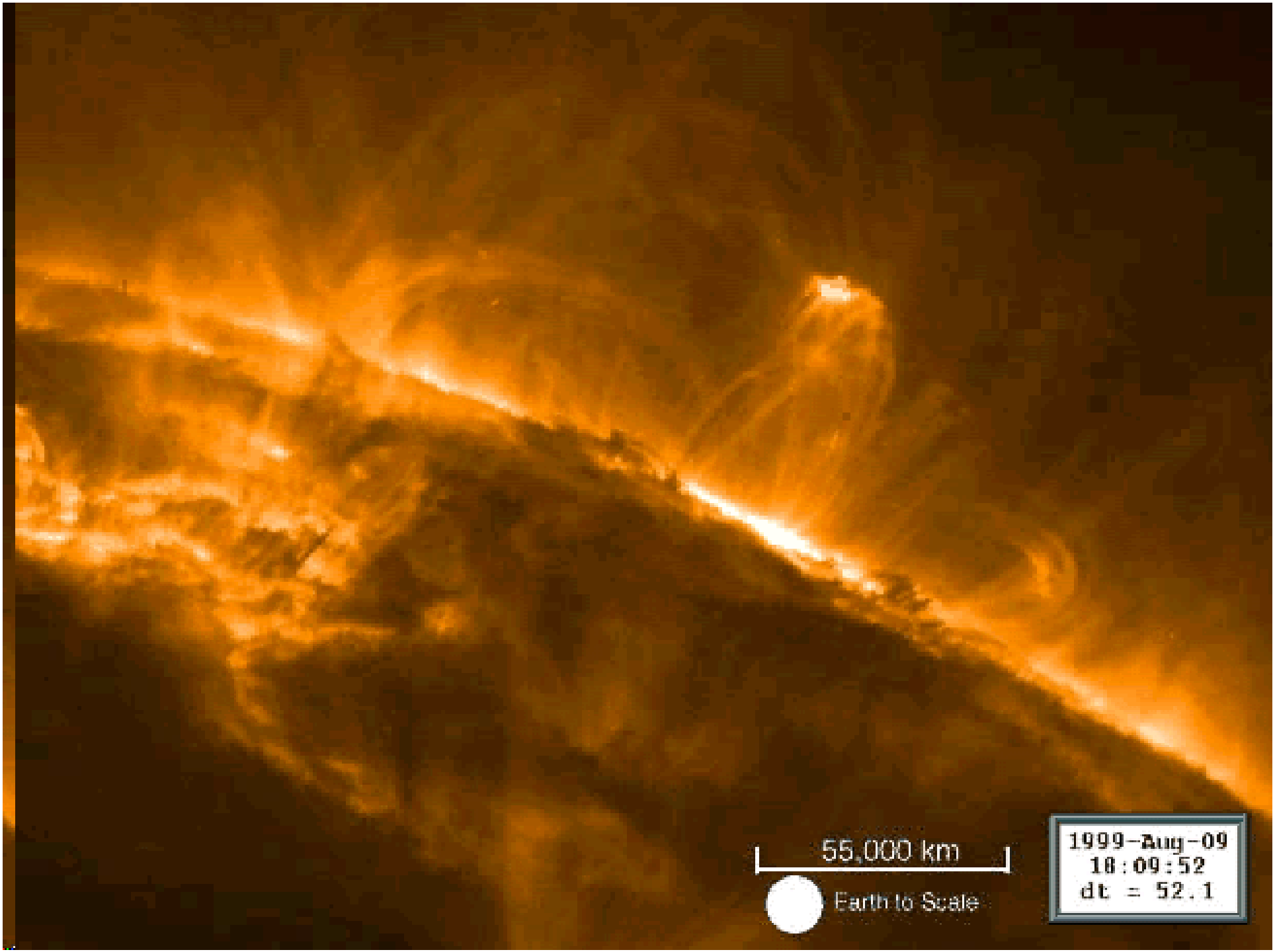
imaging of visible, H I 1216 and He II 304 corona using off-axis Gregorian with external occulter

resolving element down to 1200 km. Stray light $<10^{-8}$ (visible)

coronagraphy:

in corotation phase from high latitudes




55,000 km
Earth to Scale
1999-Aug-09
18:09:52
dt = 52.1