Recent Developments for Solar Exploration

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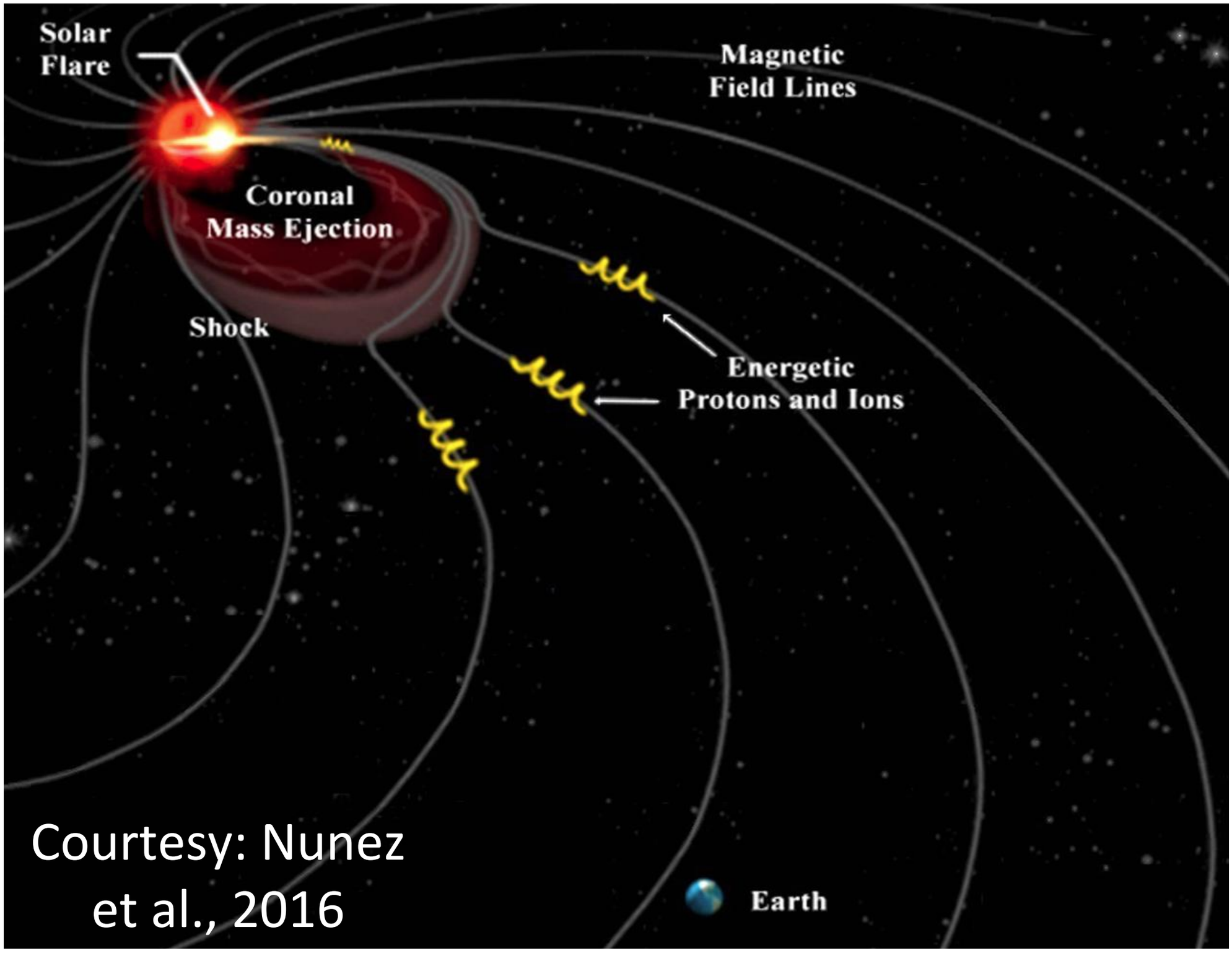
Courtesy: NASA

Courtesy: NASA

Remote Sensing: is the science of acquiring and processing information about an object without being in physical contact **(Ground & Space)**



Courtesy: Nunez et al., 2016

Source:
Sun, GCR

Interplanetary:
Propagation

Effect:
Planets

Sources: Sun, GCR

Sun:

Solar wind – Continuous flow of charged particles from the Sun which permeates the solar system

CMEs – Significant release of plasma and associated magnetic field from the solar corona

CIRs – Interaction regions between fast- and slow-solar wind that rotates with the Sun

Flares – Sudden release of energy in the form high energy radiation

GCR:

A highly energetic atomic nucleus or other particle travelling through space at a speed approaching that of light.

Measurement

Particles: (In-situ)

Charged Particles (Electrons, Protons, Heavier nuclei; Cosmic Rays bombarding Earth from all directions)

Neutrals (e.g. Neutrinos; Due to nuclear reactions inside stars)

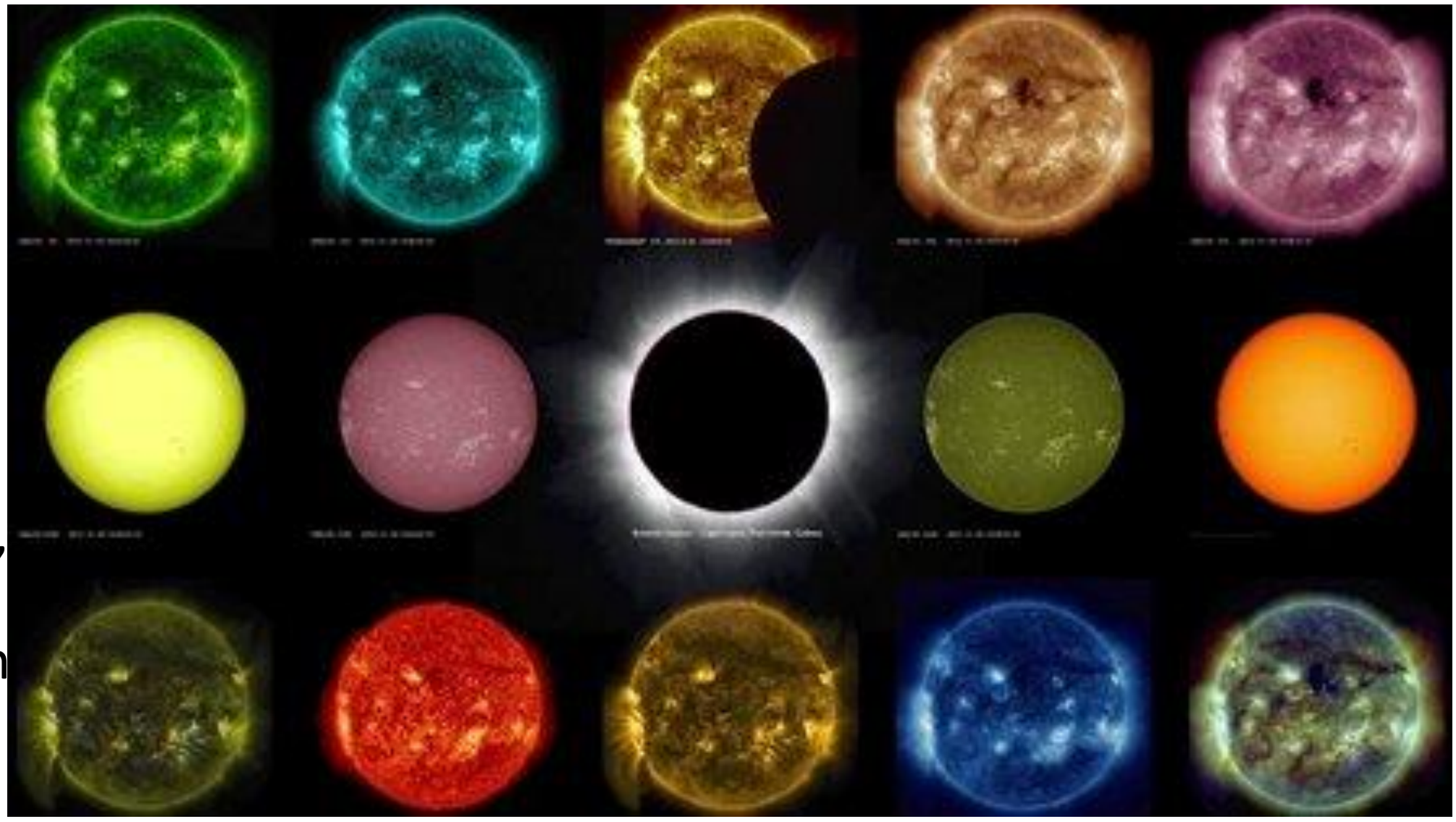
Radiation: (Remote)

Electro-magnetic radiation (photons: photometry, spectroscopy, and polarimetry)

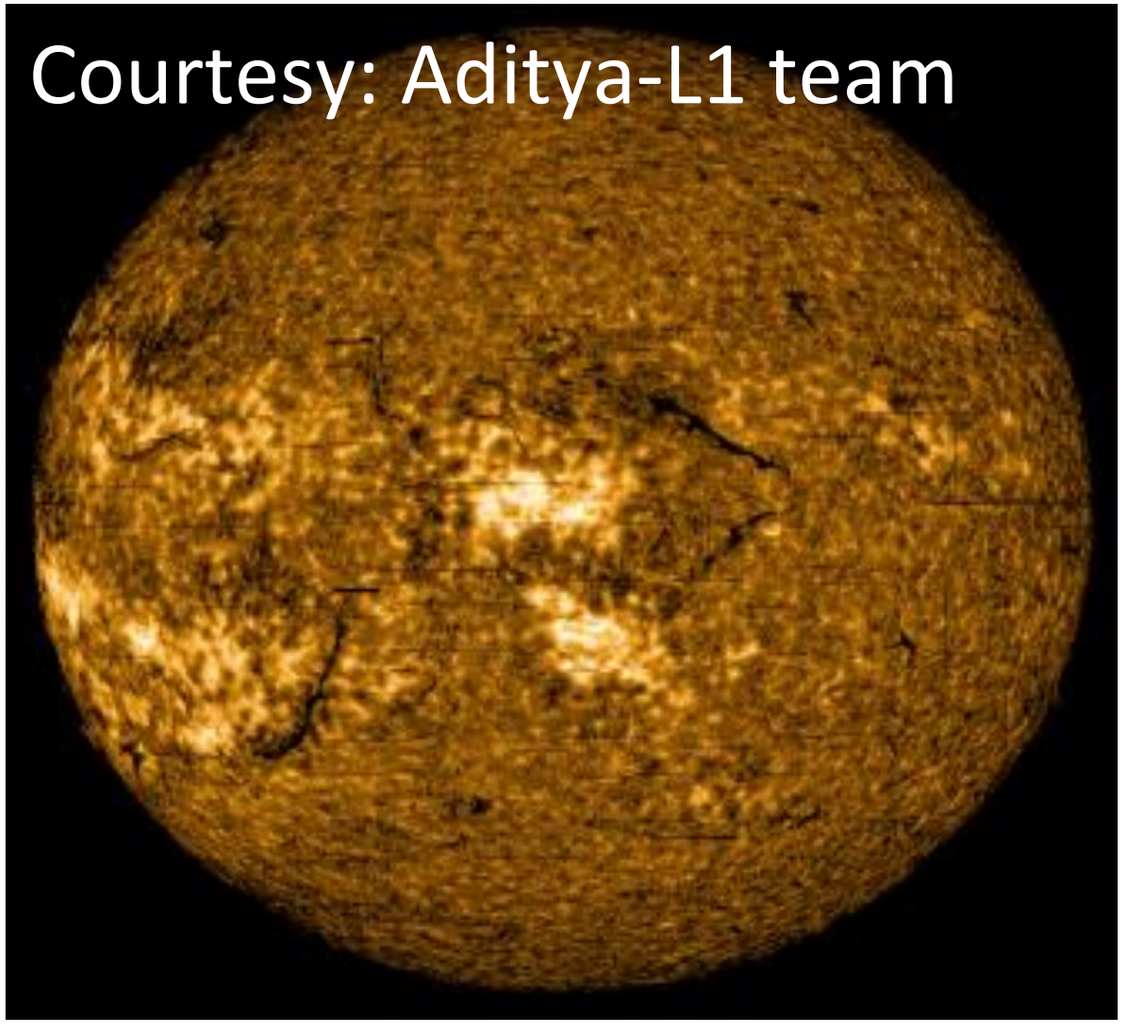
Instruments for Sun

Interior:
Dopplergram

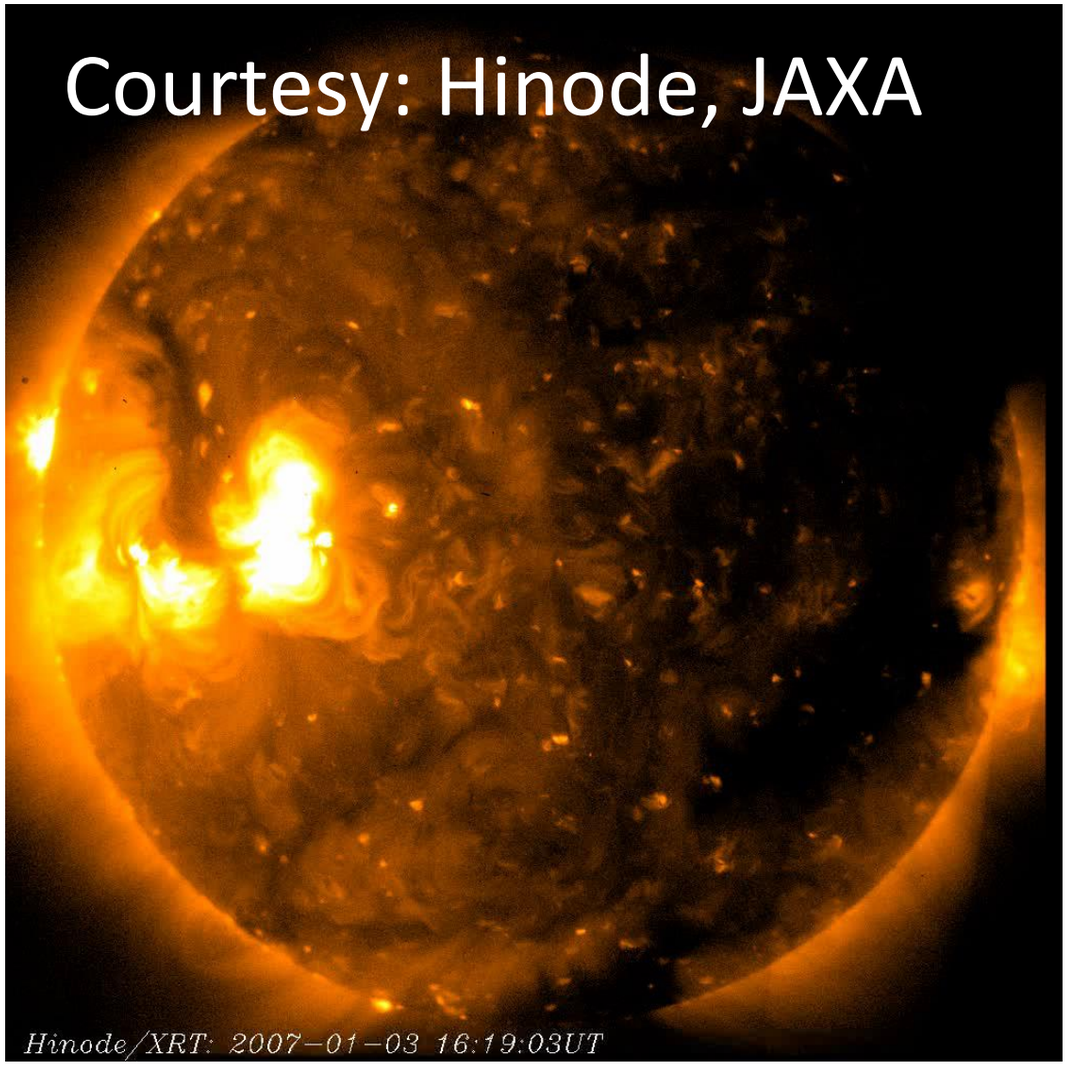
Atmosphere:
Imagers,
Dopplergrams,
Vector
Magnetograph
Coronagraphs



NUV and X-ray

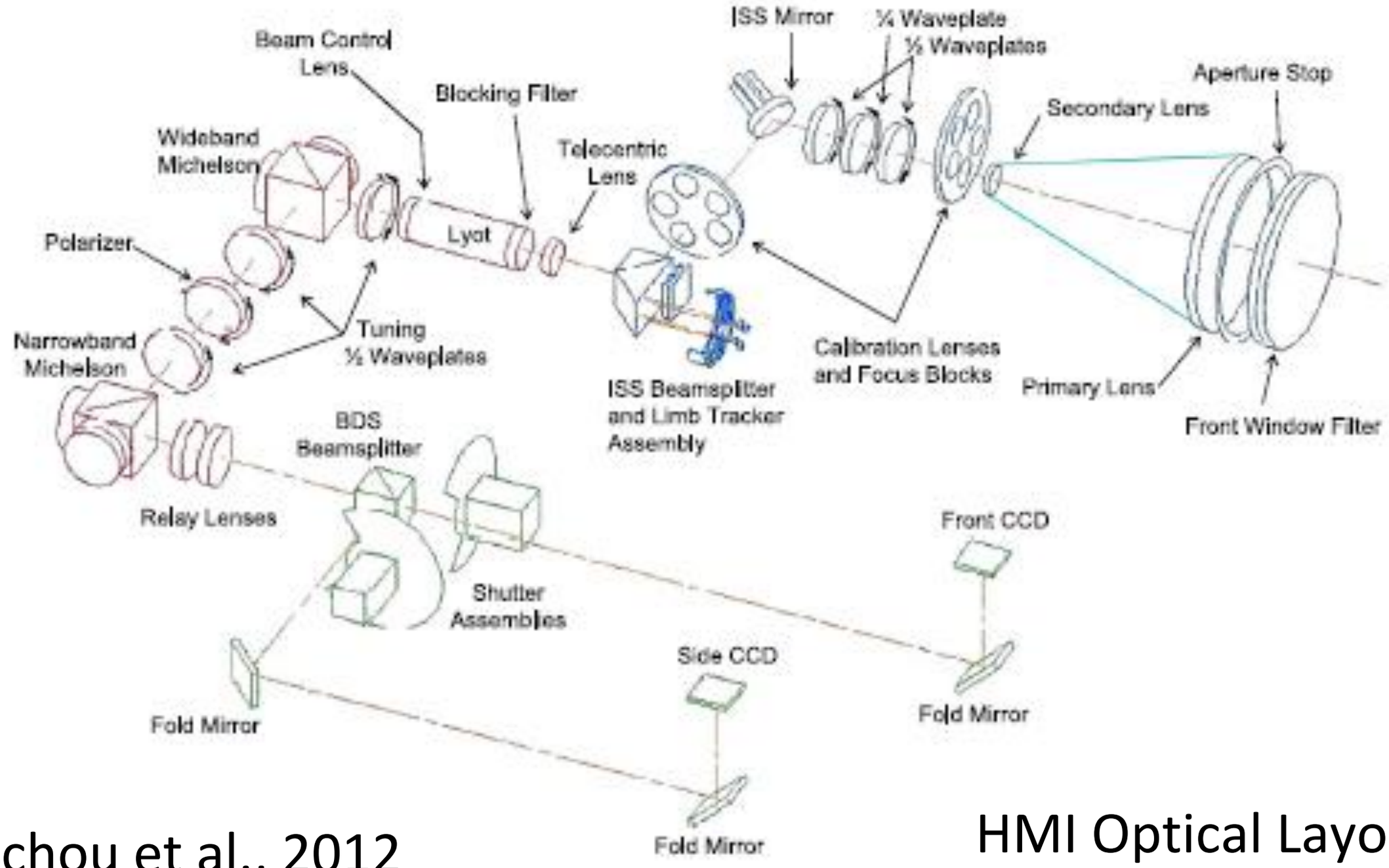


Stitched image from IRIS – Mg filter



X-ray Image

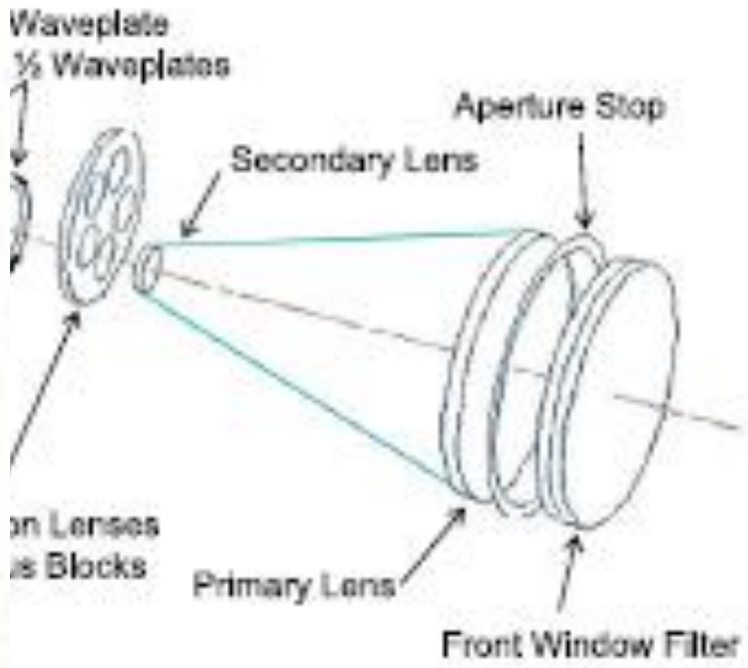
Dopplergram & Magnetogram



Schou et al., 2012

HMI Optical Layout

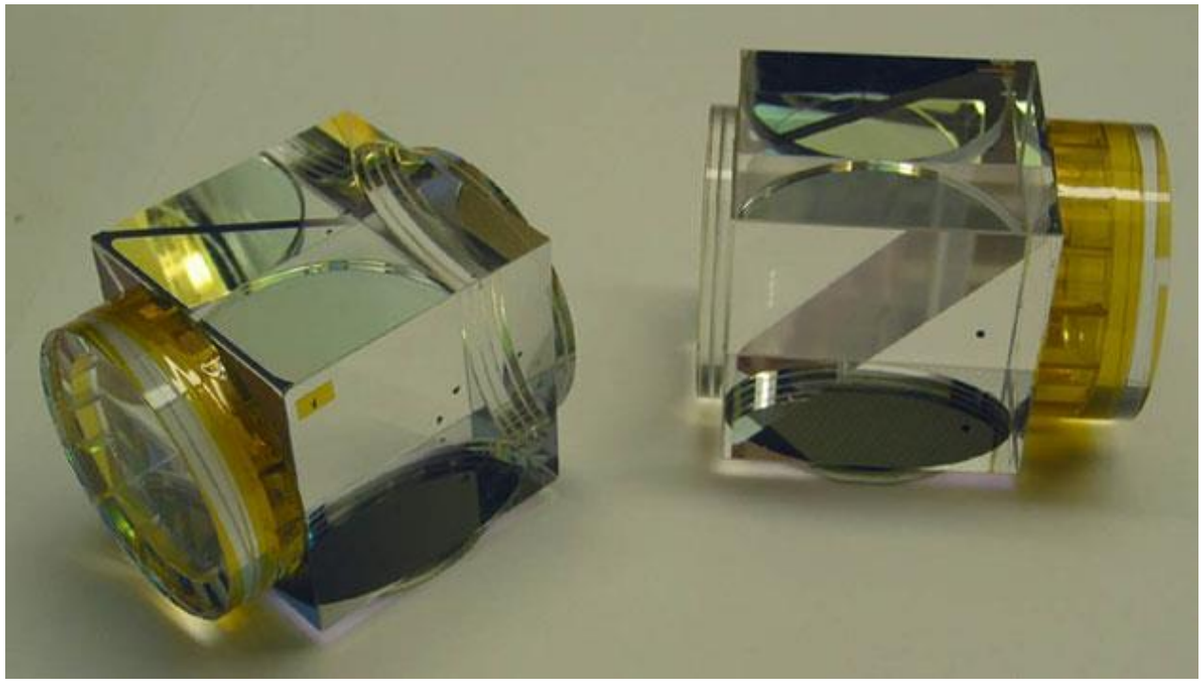
D



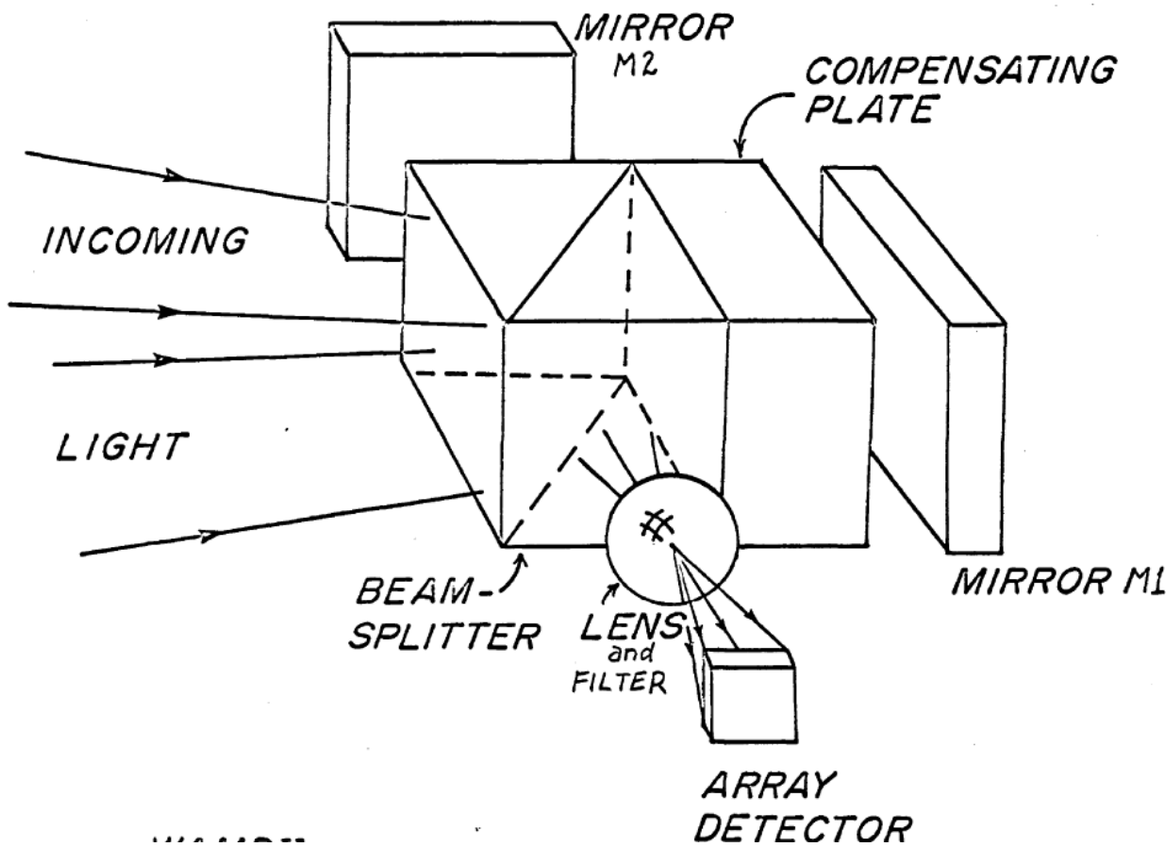
HMI Optical Layout

Sc

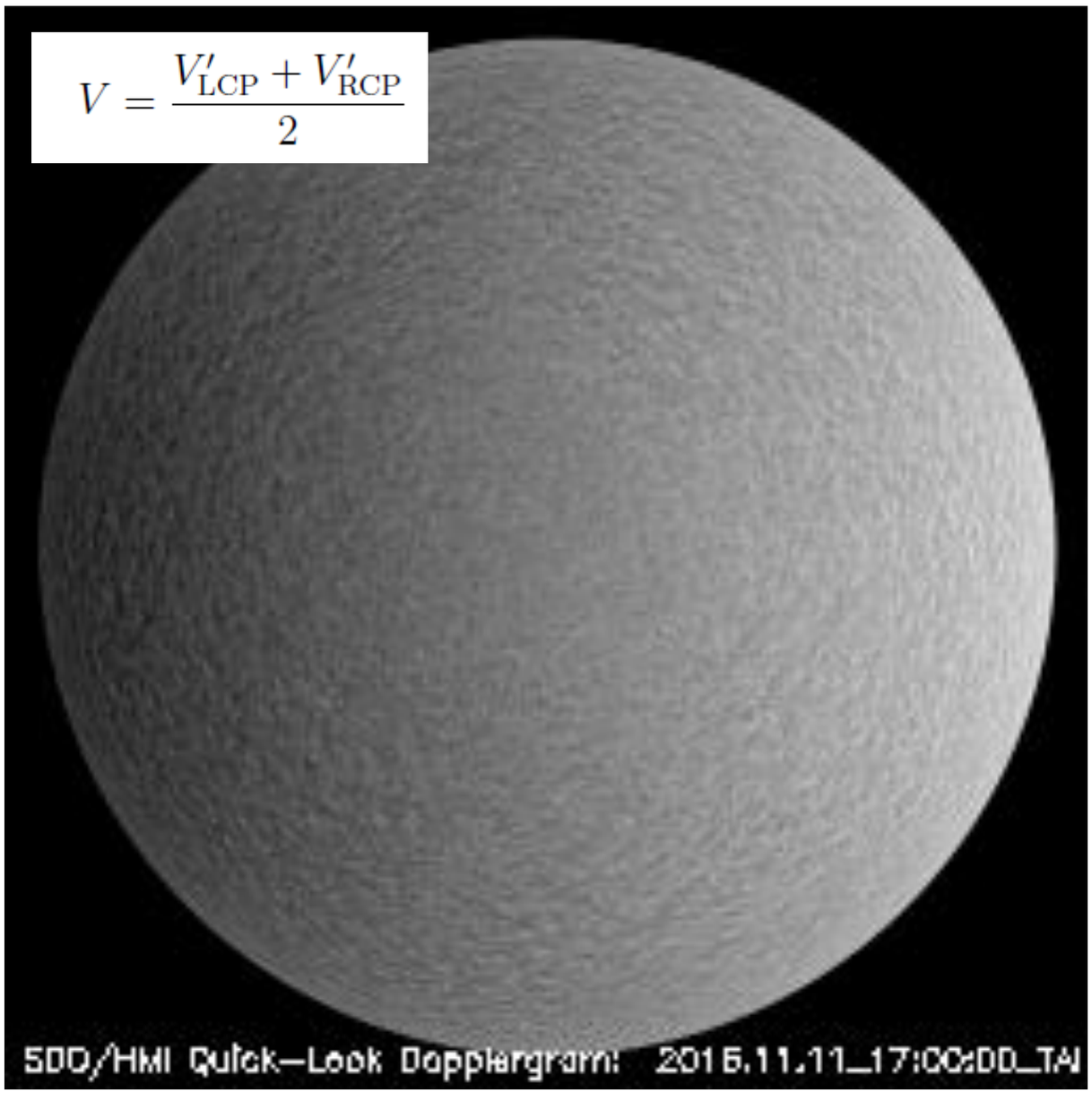
Michelson Interferometer

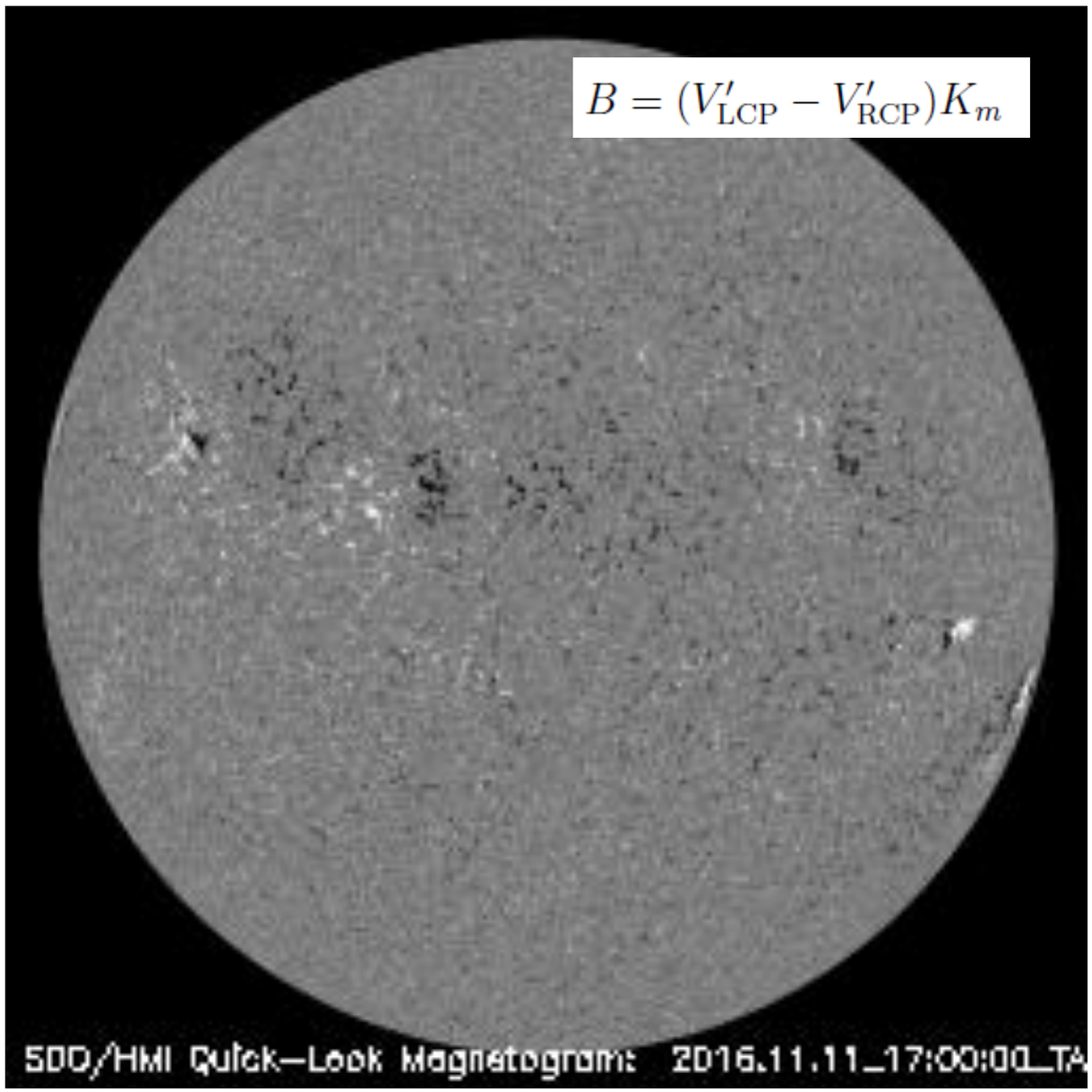


Schou et al., 2012

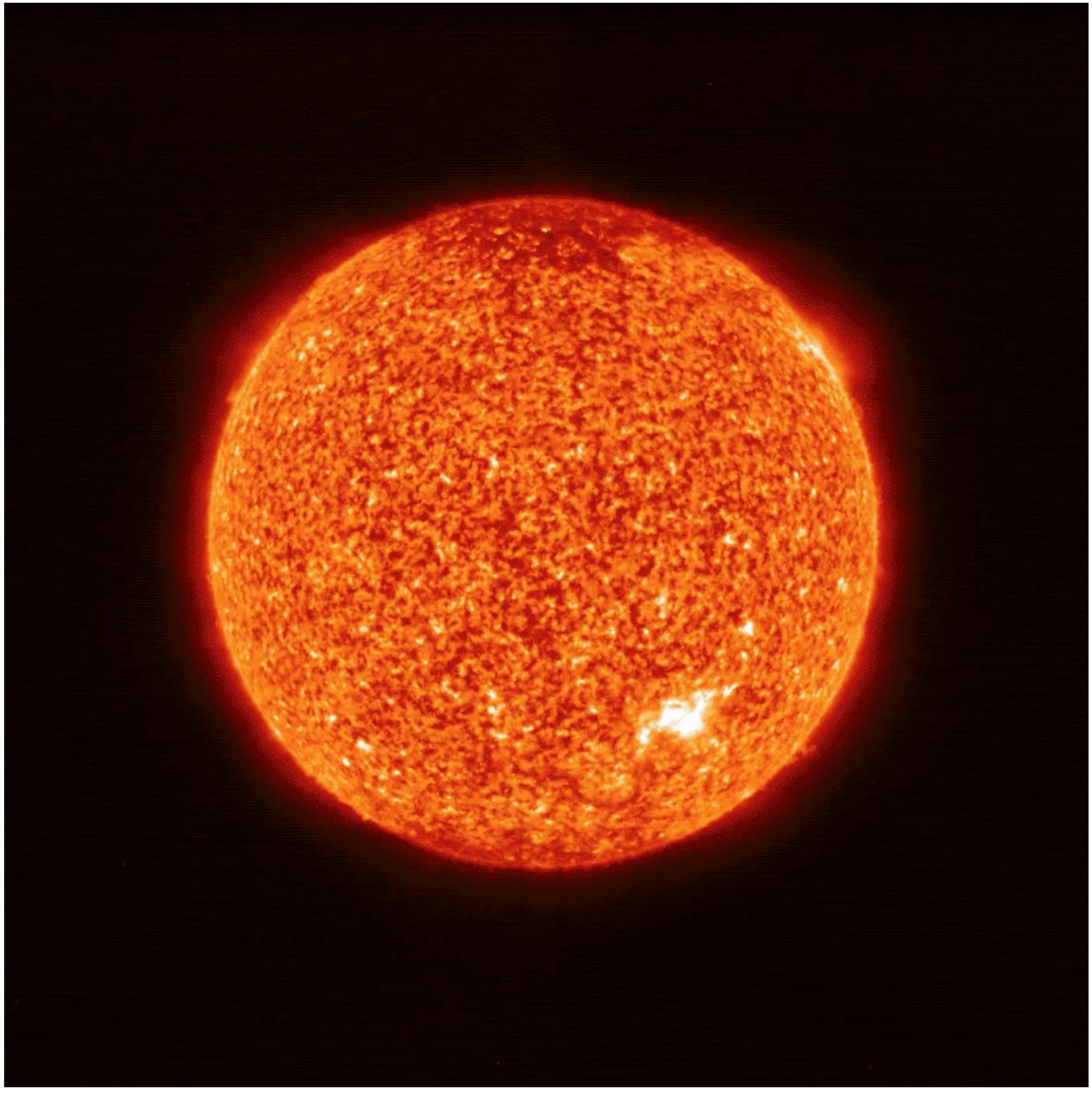


Dopplergram & Magnetogram





Solar Orbiter View



Courtesy:
ESA

Field

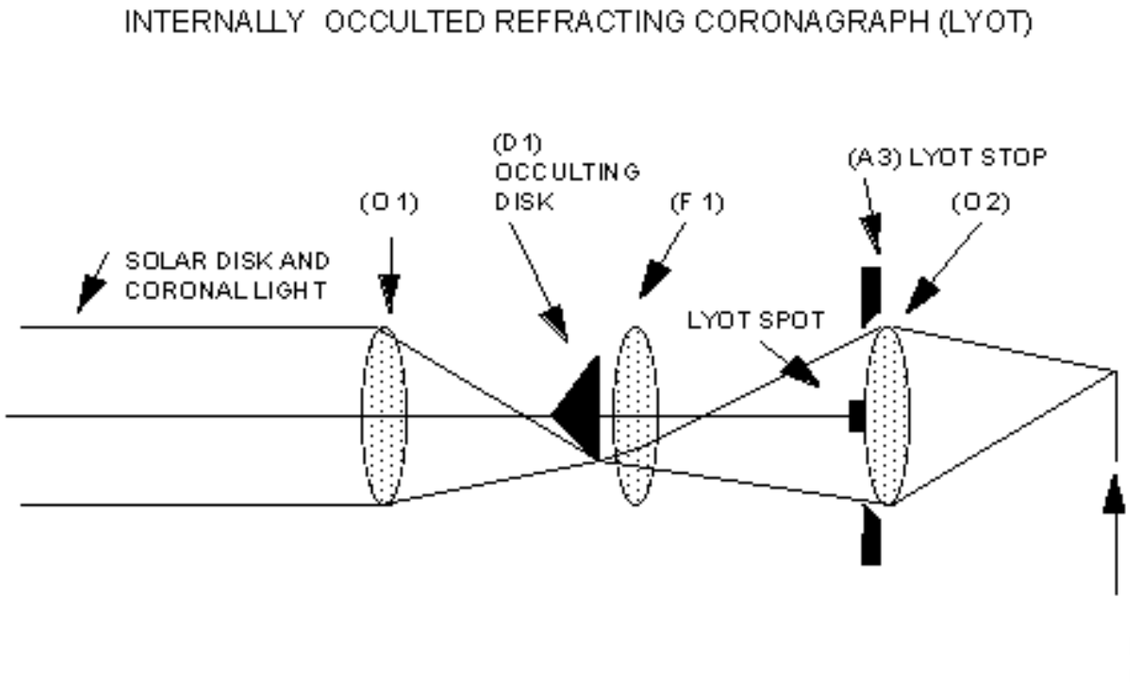
azimuth

Vector Magnetograms

Incl

cont

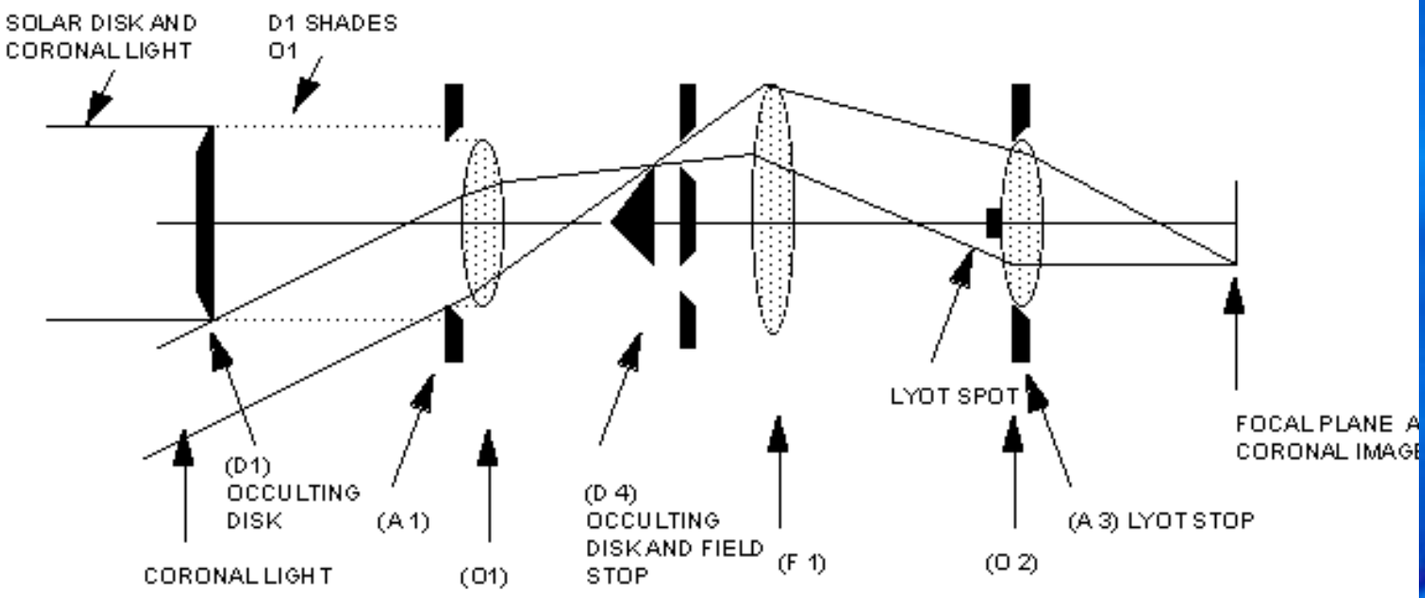
Coronagraphs



Internally Occulted

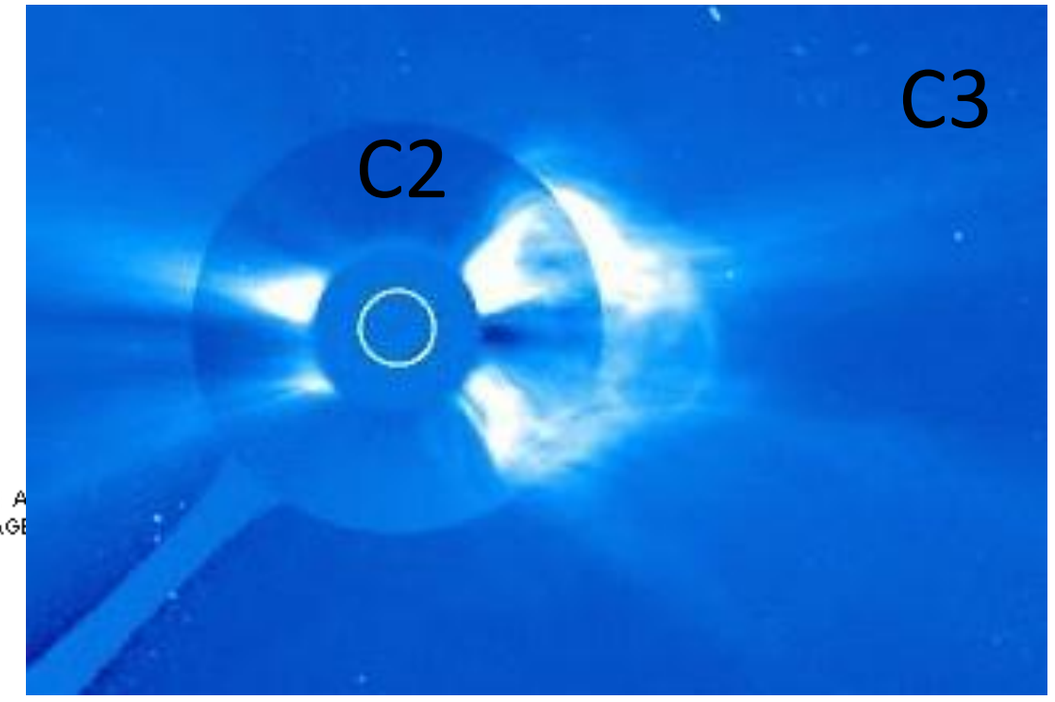
LASCO-C1
Closest to the Sun

Coronagraphs



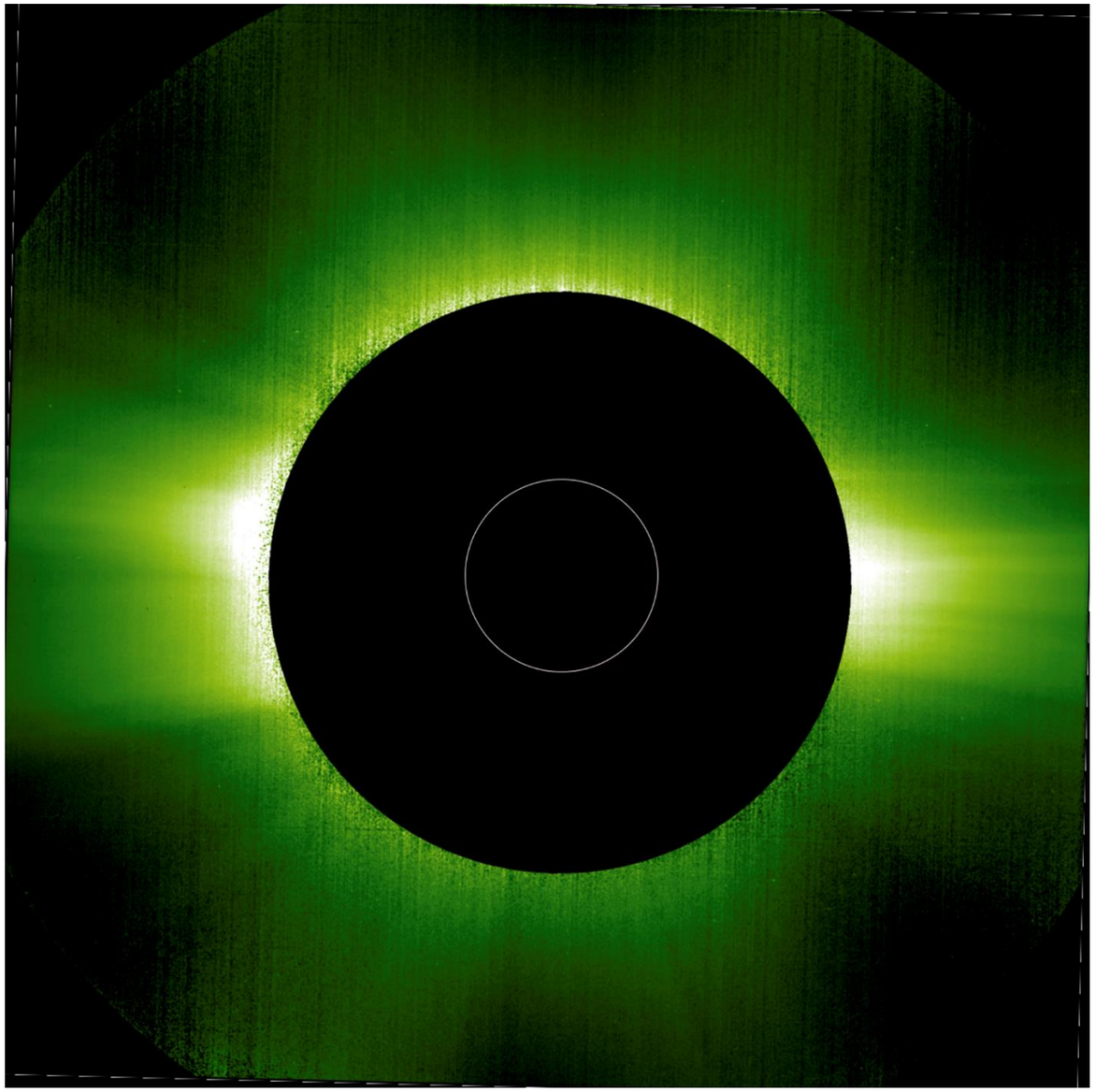
EXTERNALLY OCCULTED REFRACTING CORONAGRAPH (NEWKIRK)

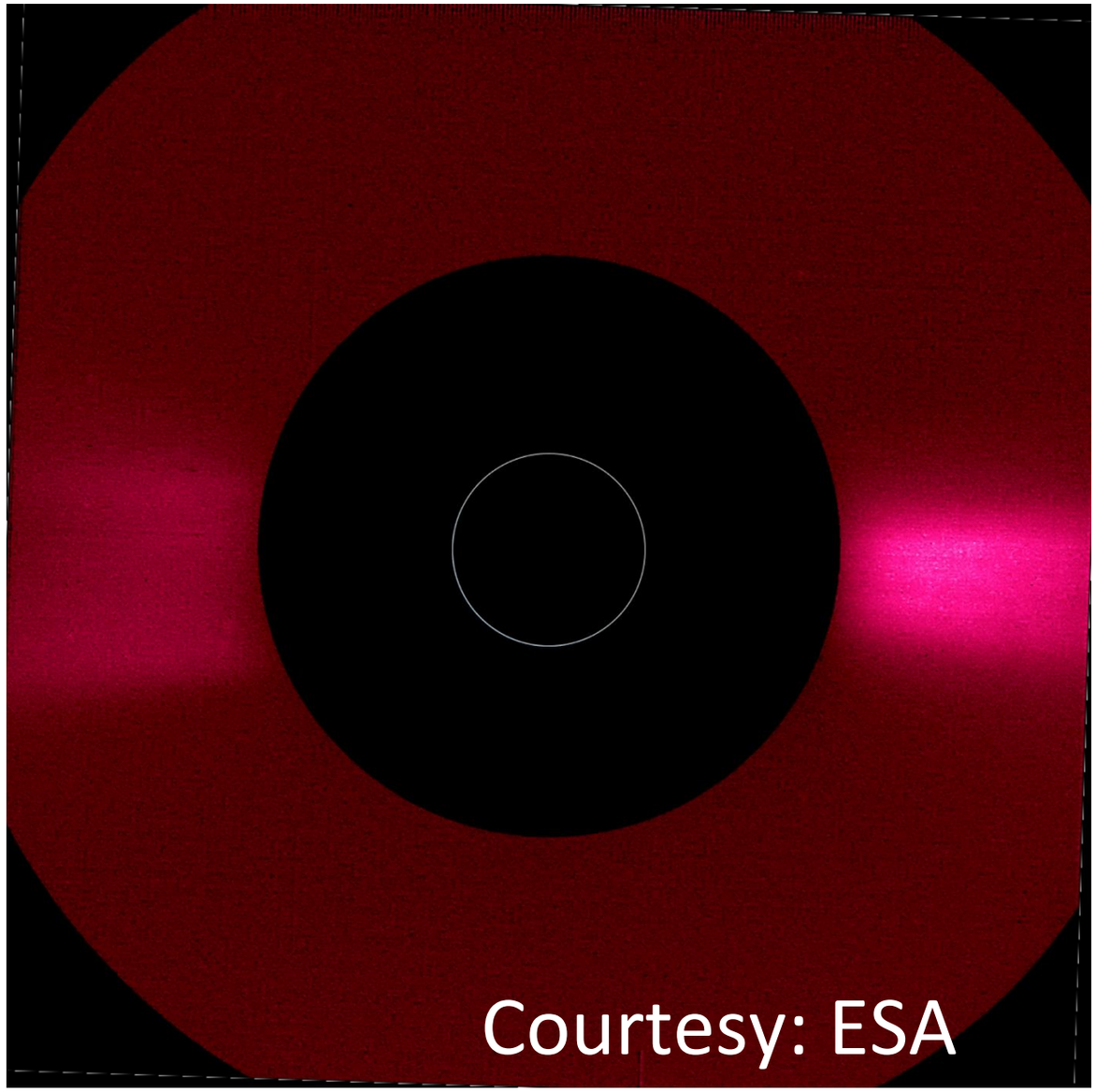
Externally Occulted



LASCO-C2 & C3
Pioneer instrument for CME

METIS – Optical and UV

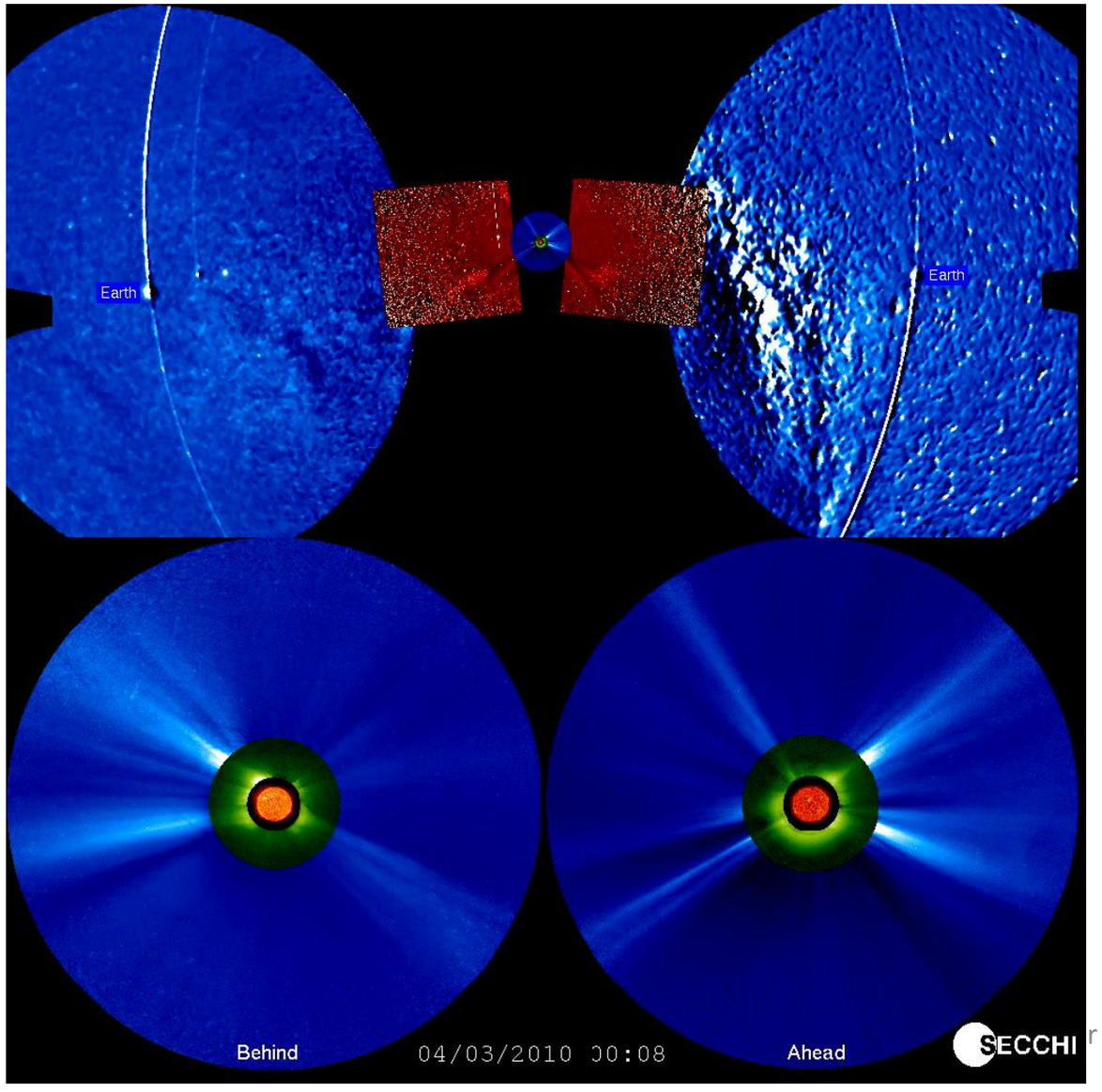




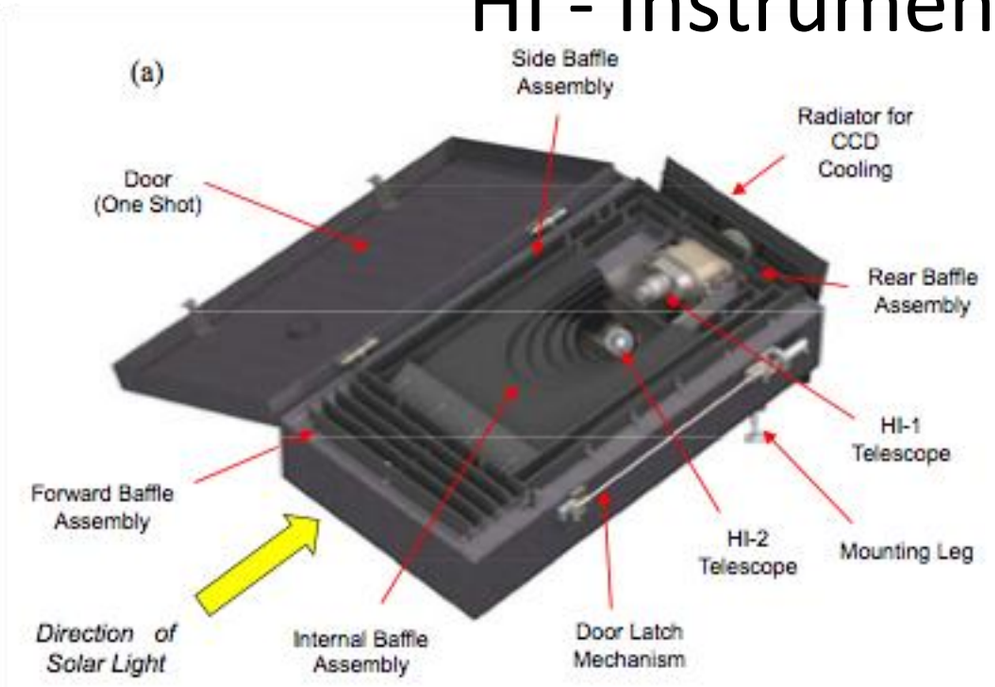
Courtesy: ESA

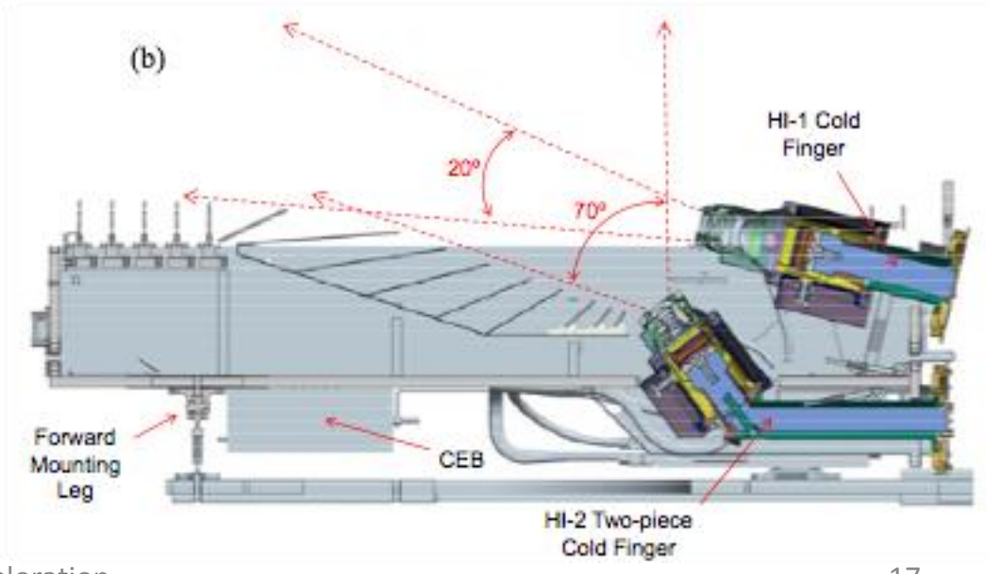
Instruments for Heliosphere

- Heliospheric Imagers
- Inter-planetary Scintillations



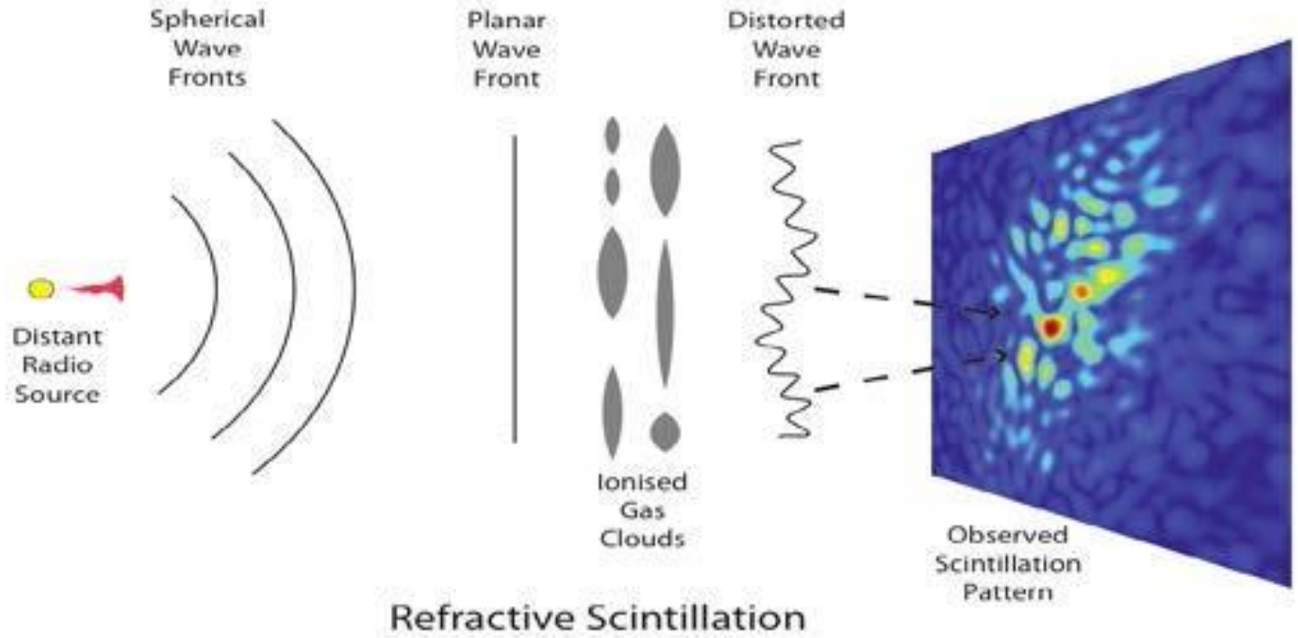
HI - Instrument

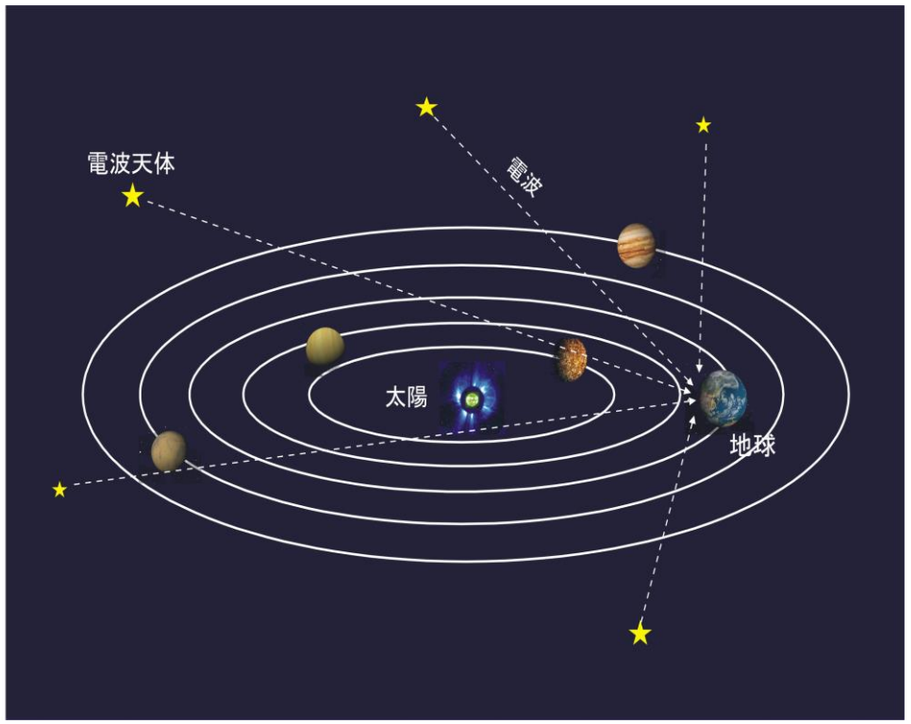


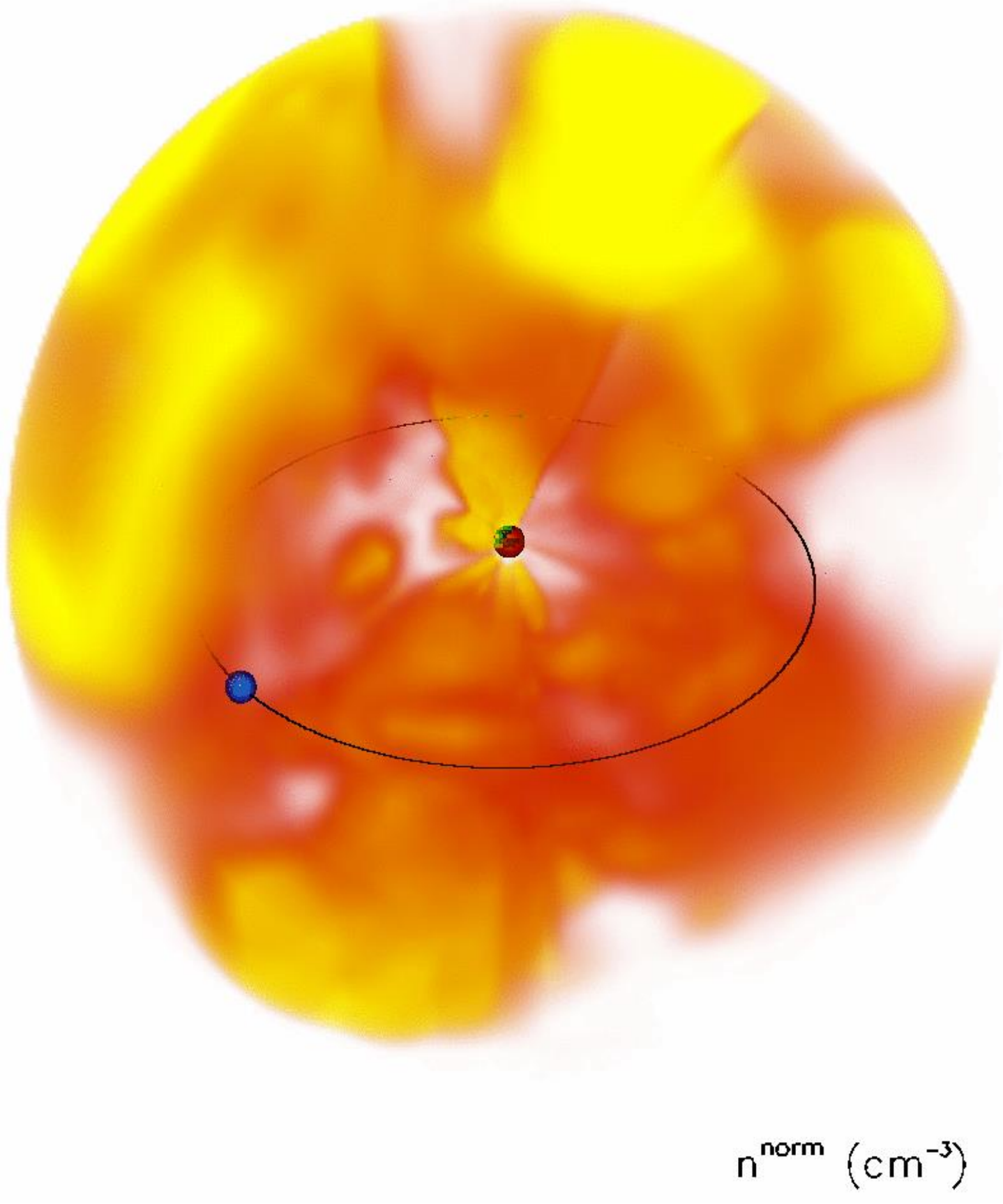


Courtesy: STEREO

Interplanetary Scintillation

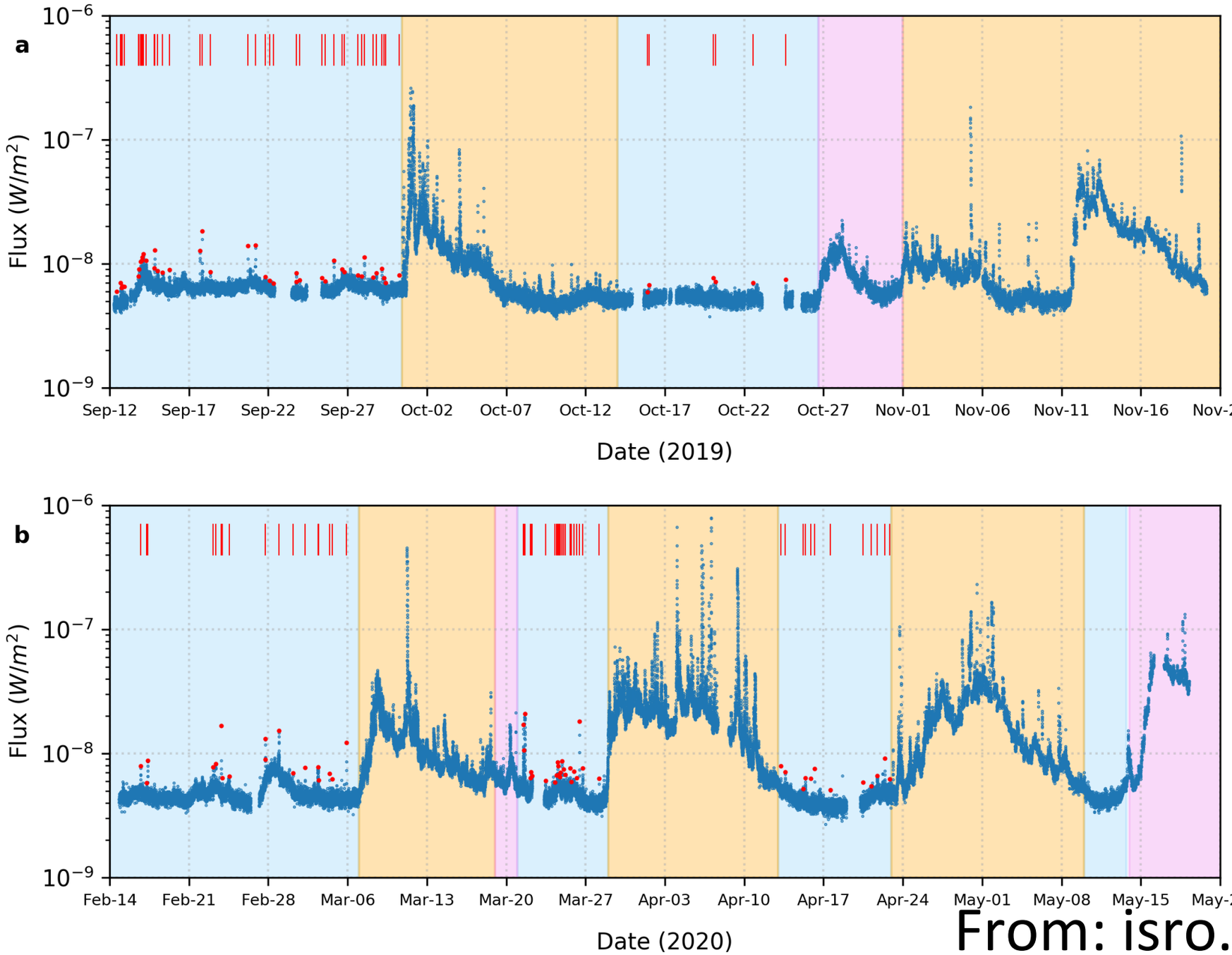






Observation from Ooty Radio Telescope Figure Courtesy: Manoharan

New Results - Microflares



High Sensitive X-ray spectrometer on Chandrayaan-2 – XSM

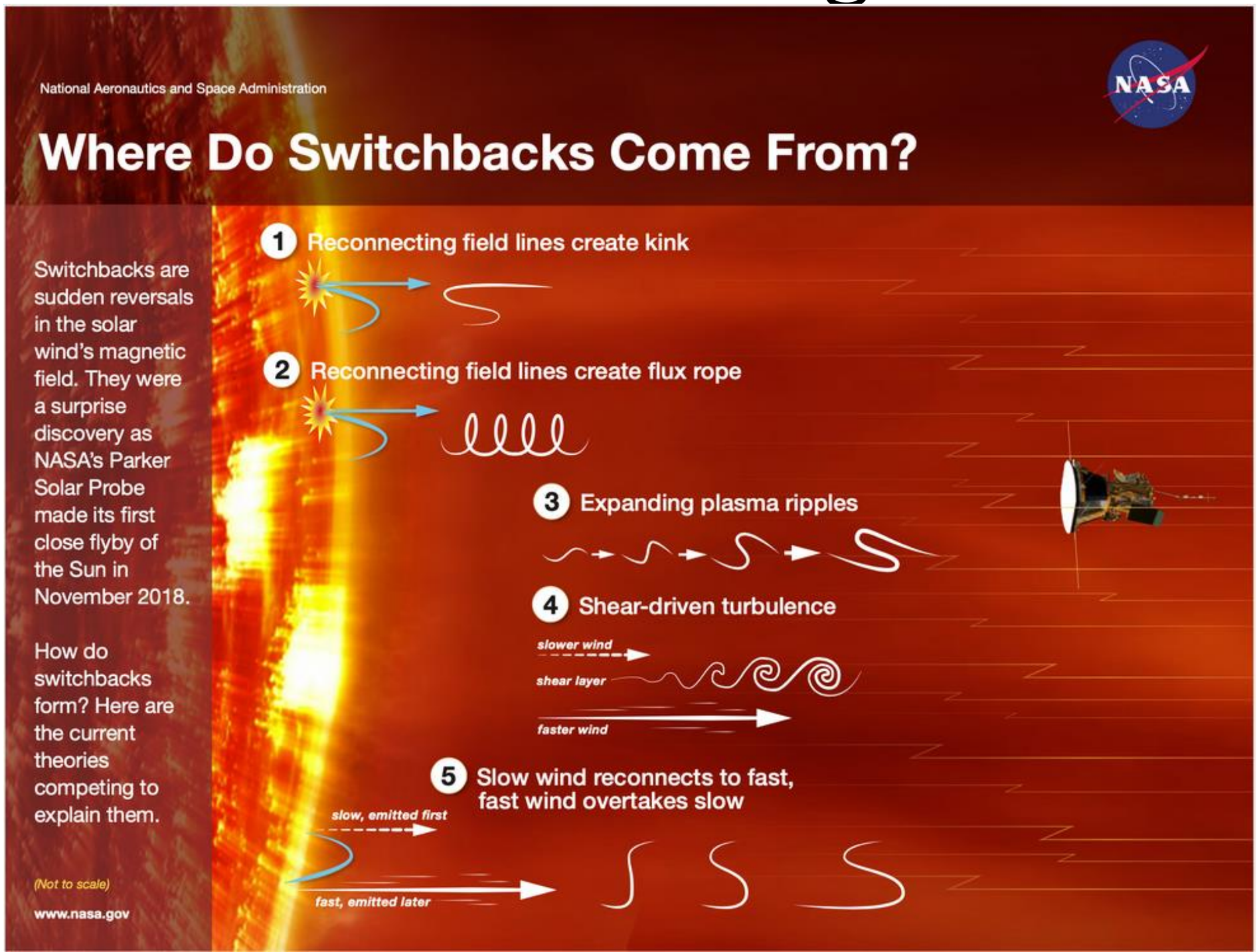
Micro flares

Vadawale et al, 2020

Mithun et al, 2020

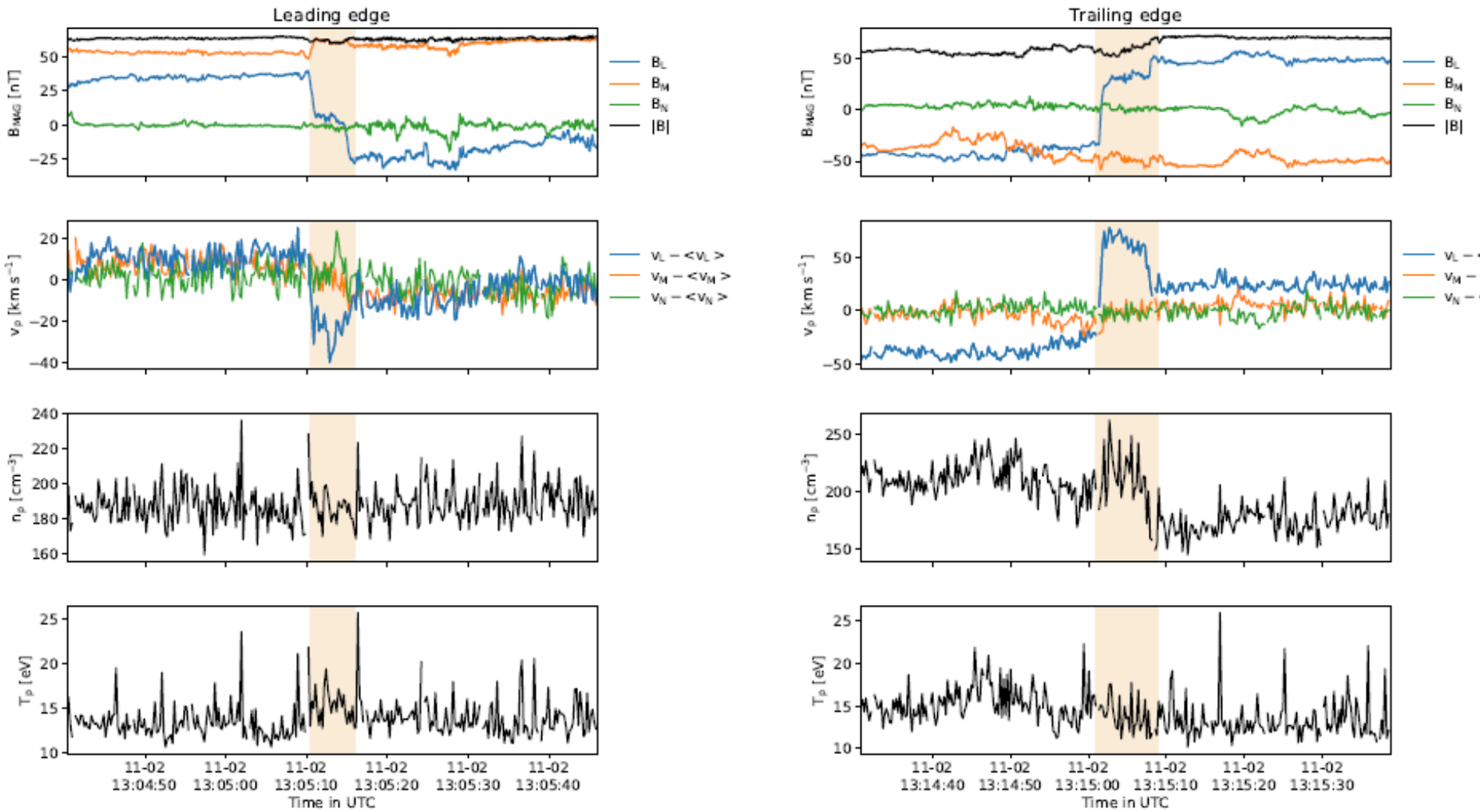
From: isro.gov.in

New Results – Magnetic switchback



Courtesy: NASA/ESA

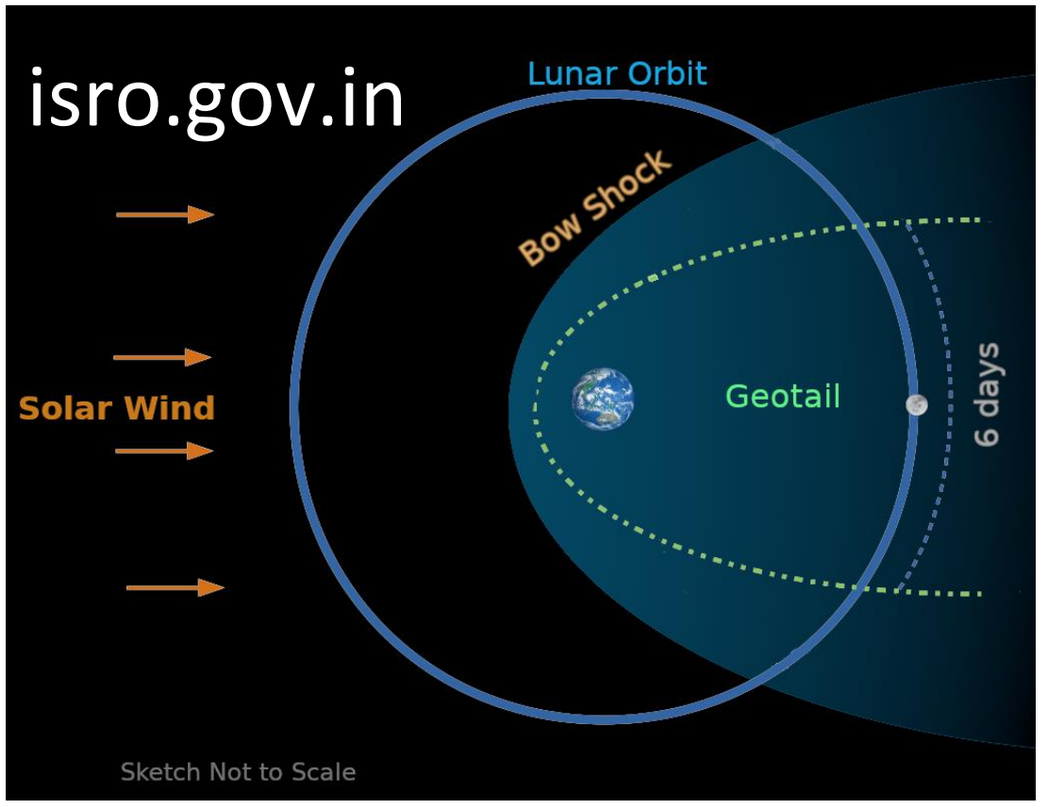
New Results – Magnetic switchback

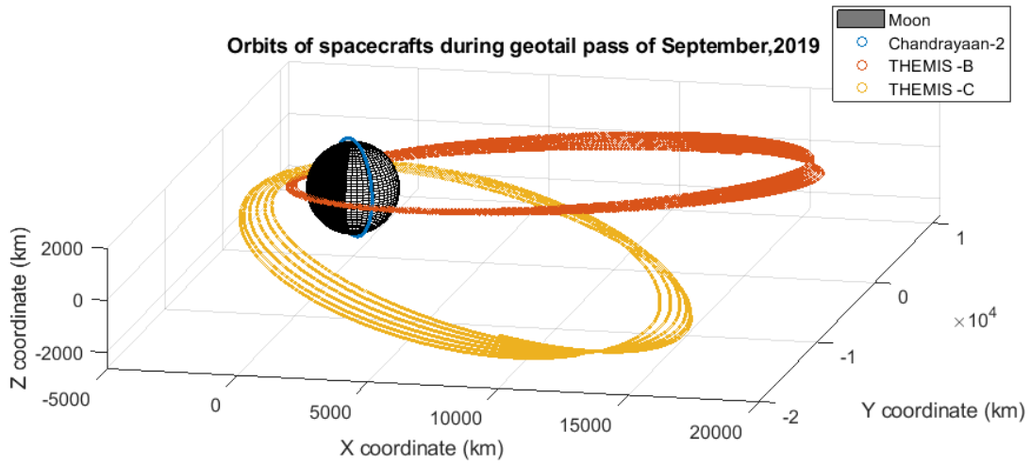


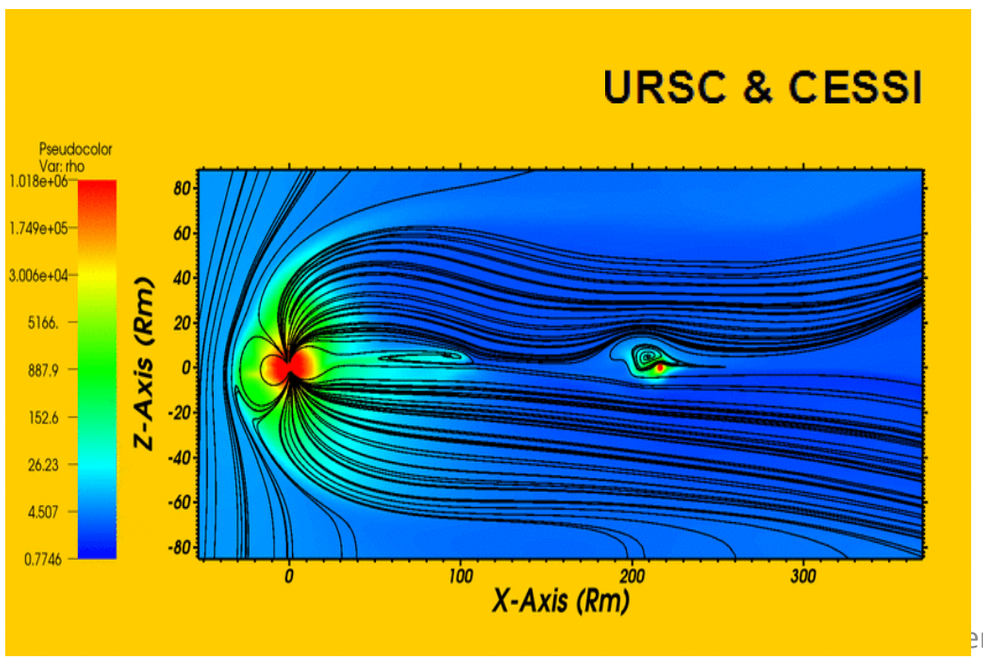
Evidence for magnetic reconnection

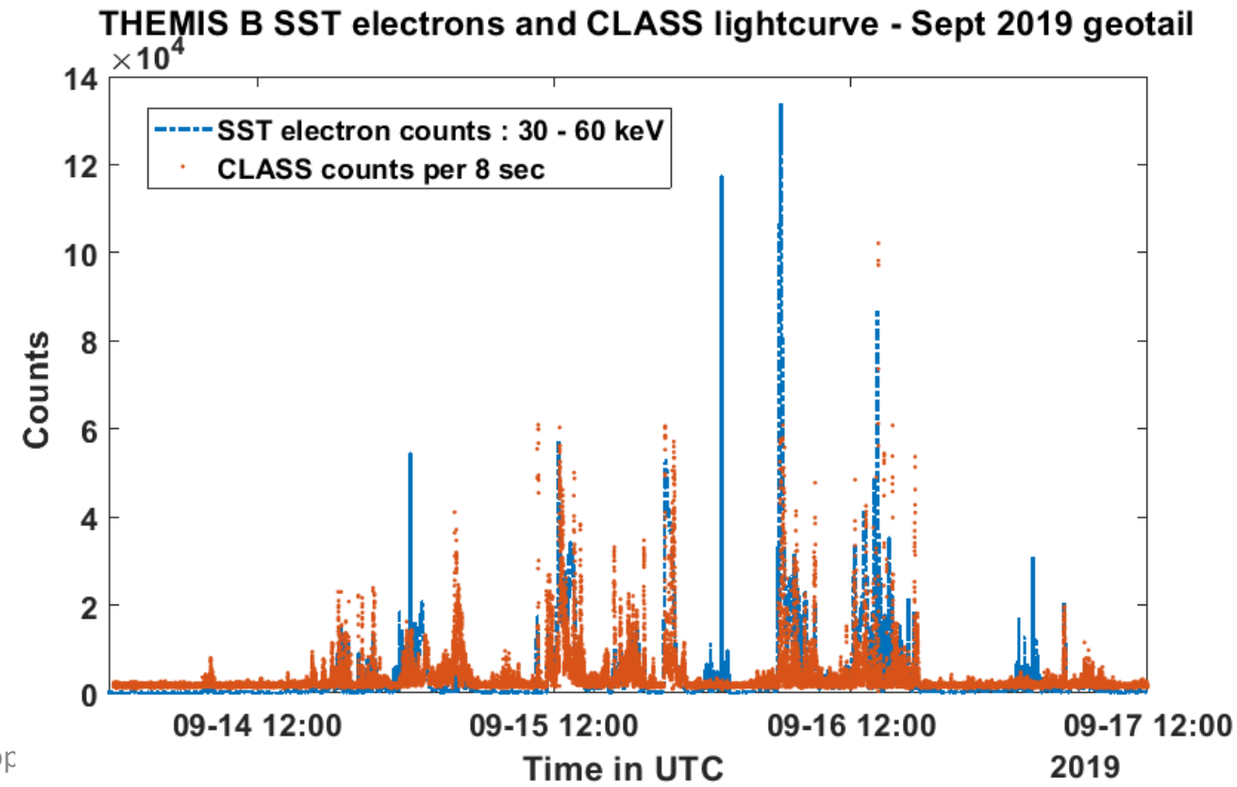
Froment et al., 2021

New Results – Geotail Dynamics









Future Missions

- Aditya-L1 – An observatory class mission for solar events and in-situ measurements

✓ Coronagraph (1.05 to 3Rsun)

✓ Simultaneous spectroscopy (3-channel) & Imaging

✓ Imaging in NUV band for irradiance studi

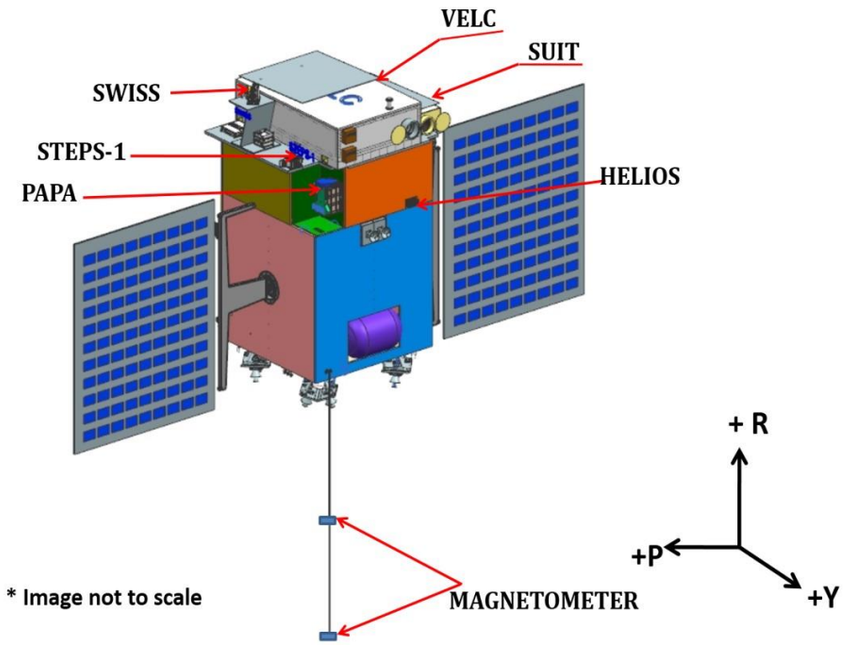
✓ Chromospheric filters for Filaments, Prominences & Flares

✓ X-ray spectroscopy of flares

✓ In-situ particle instrument including direction identification

✓ In-situ magnetic field measurements

isro.gov.in



Deployed view

REMOTE SENSING INSTRUMENTS

* Visible Emission Line Coronagraph (VELC)
* Solar Ultra-violet Imaging Telescope (SUIT)
* Solar Low Energy X-ray spectrometer (SoLEXS)
* Hard X-ray L1 Orbiting Spectrometer (HEL1OS)

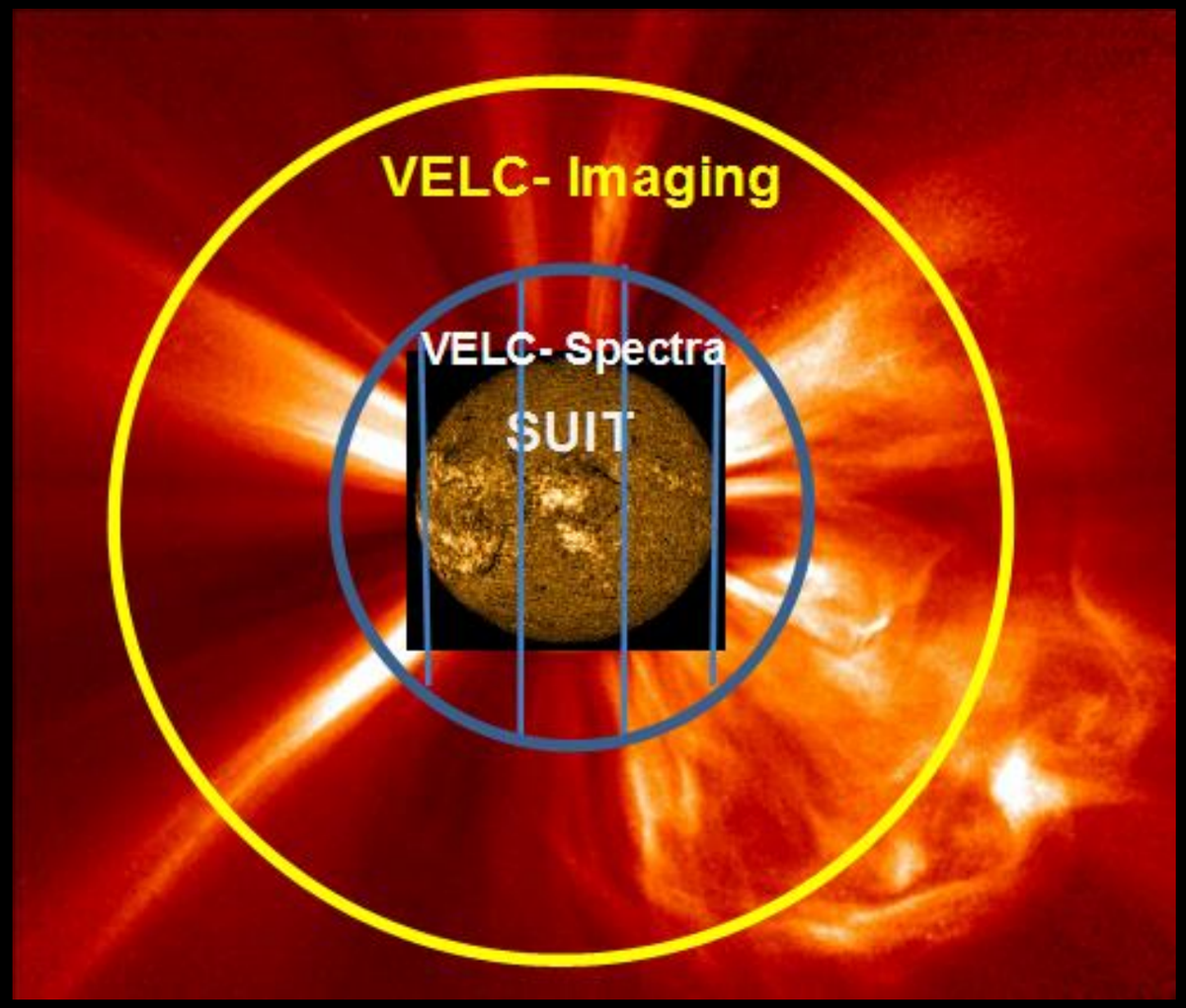


Image Courtesy: STEREO Modified to include FOVs of Aditya-L1

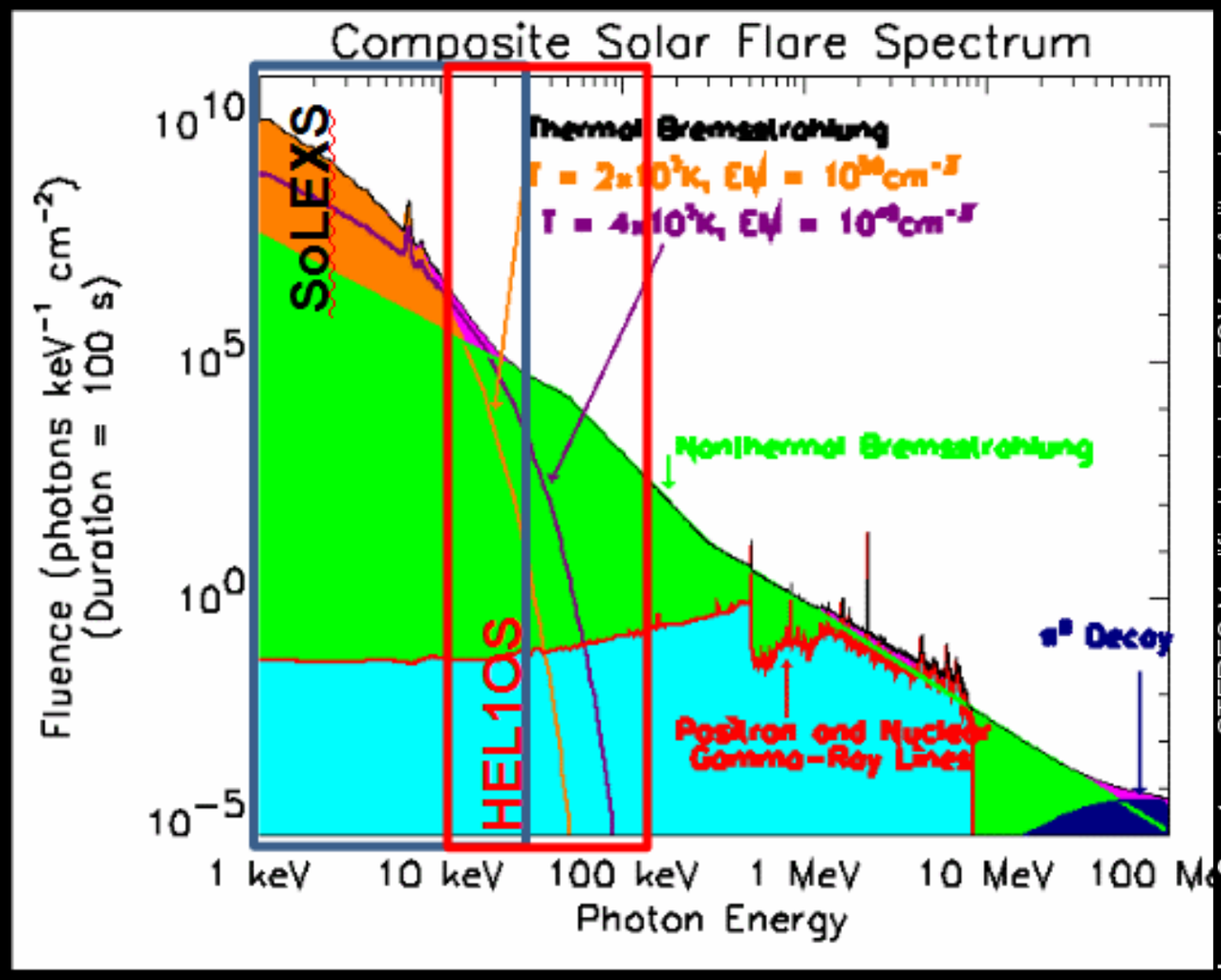
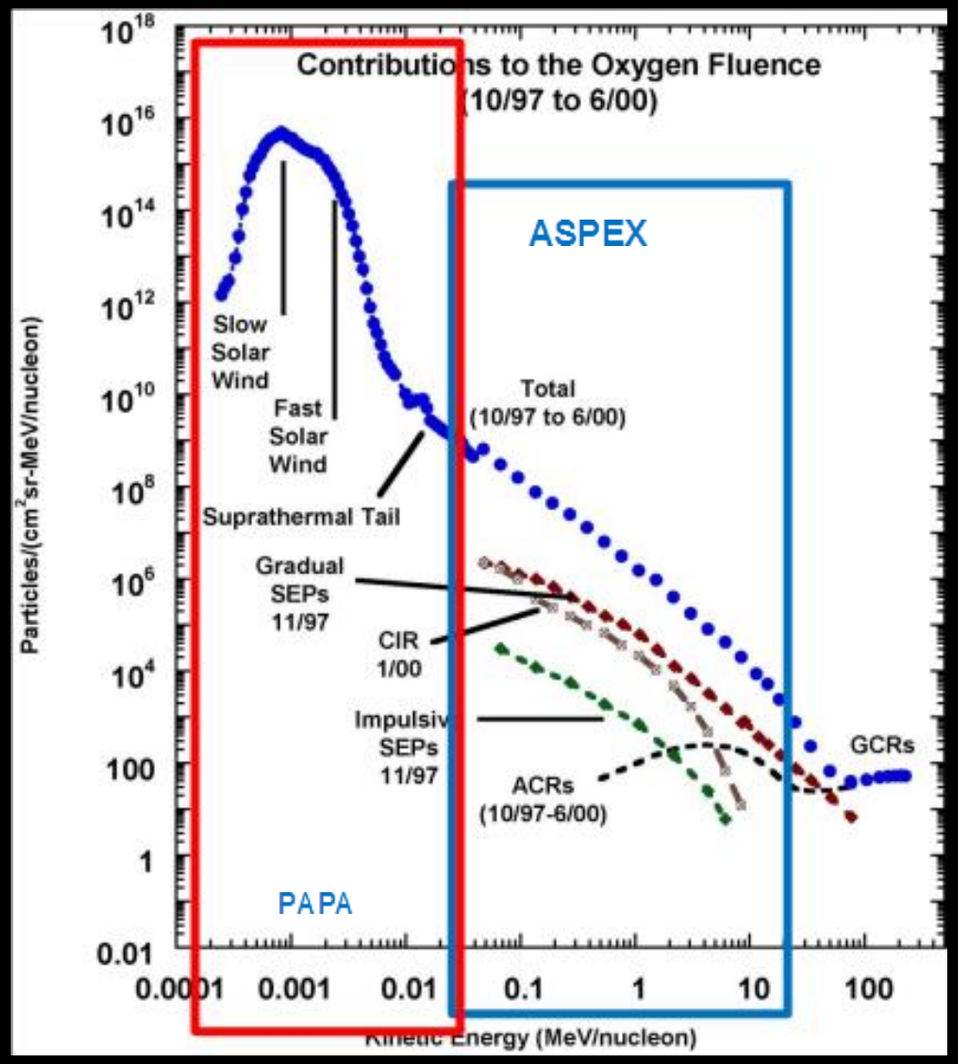


Image Courtesy: STEREO Modified to include FOVs of Aditya-L1

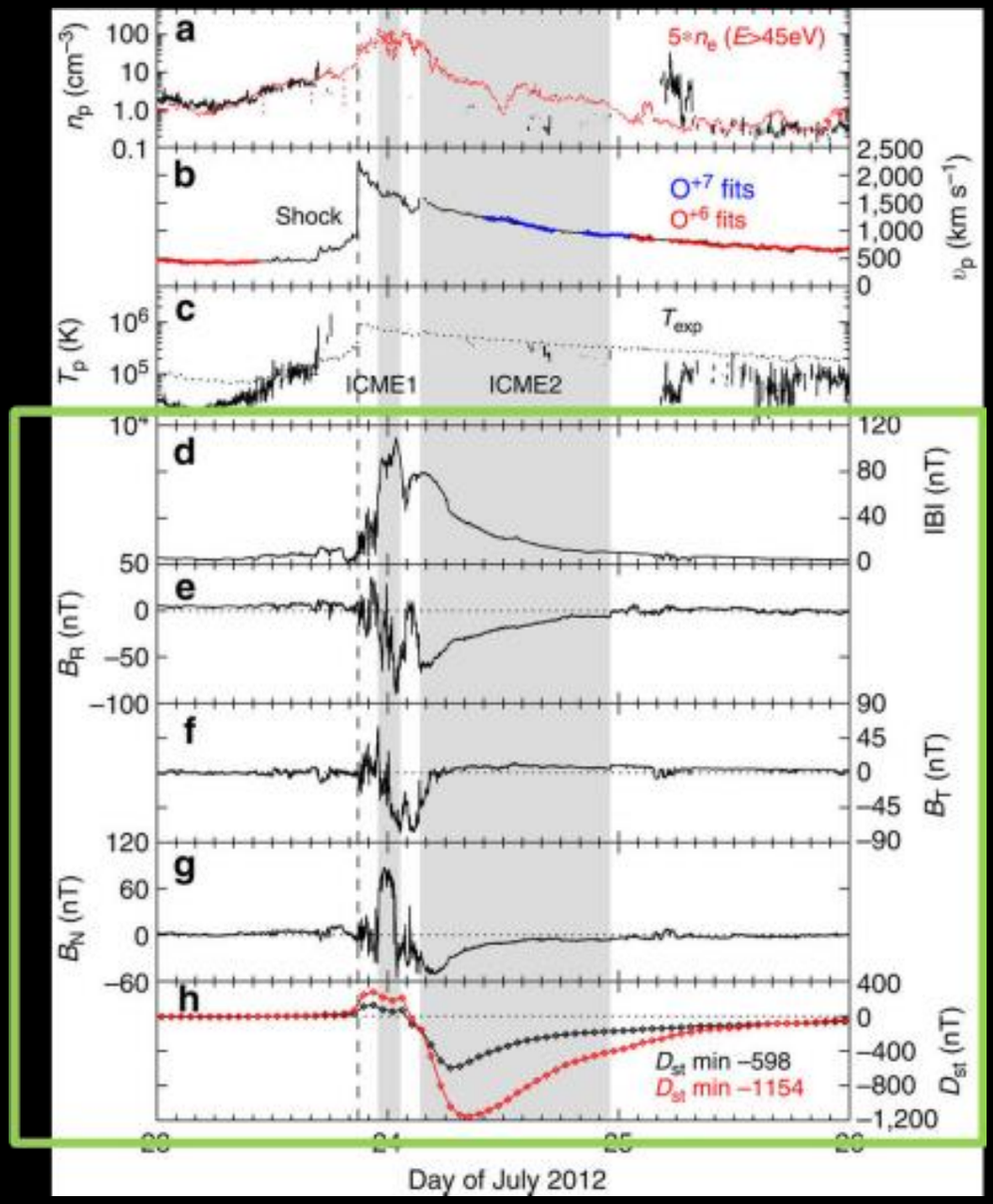
IN-SITU INSTRUMENTS

* Aditya Solar Particle Experiment (ASPEX)

* Plasma Analyser Package for Aditya (PAPA)

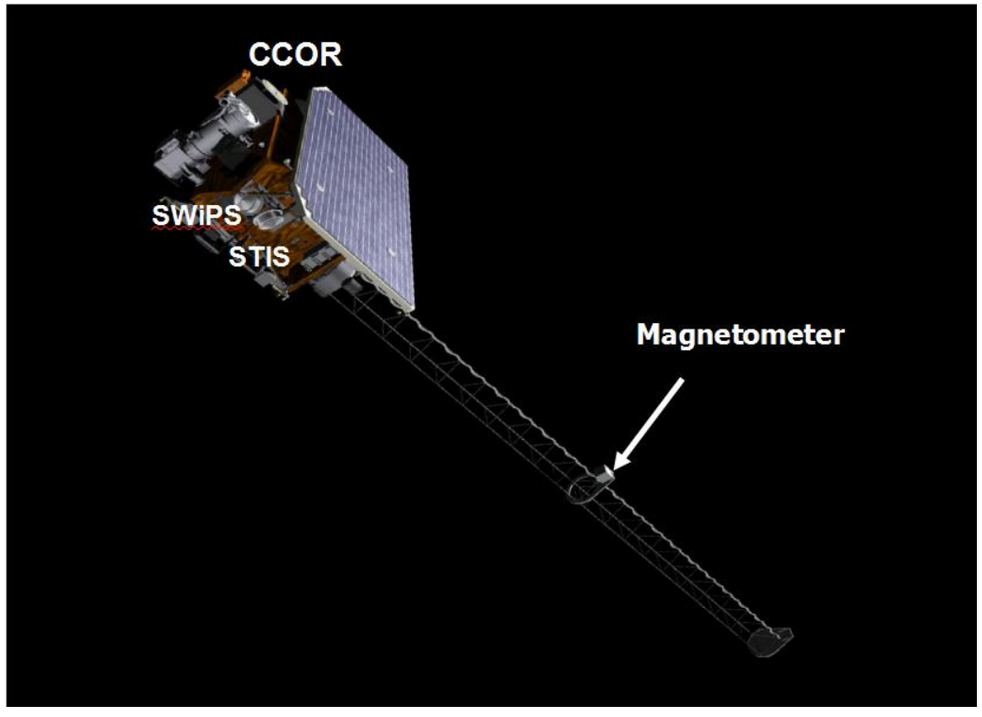


* Magnetometer (Mag)



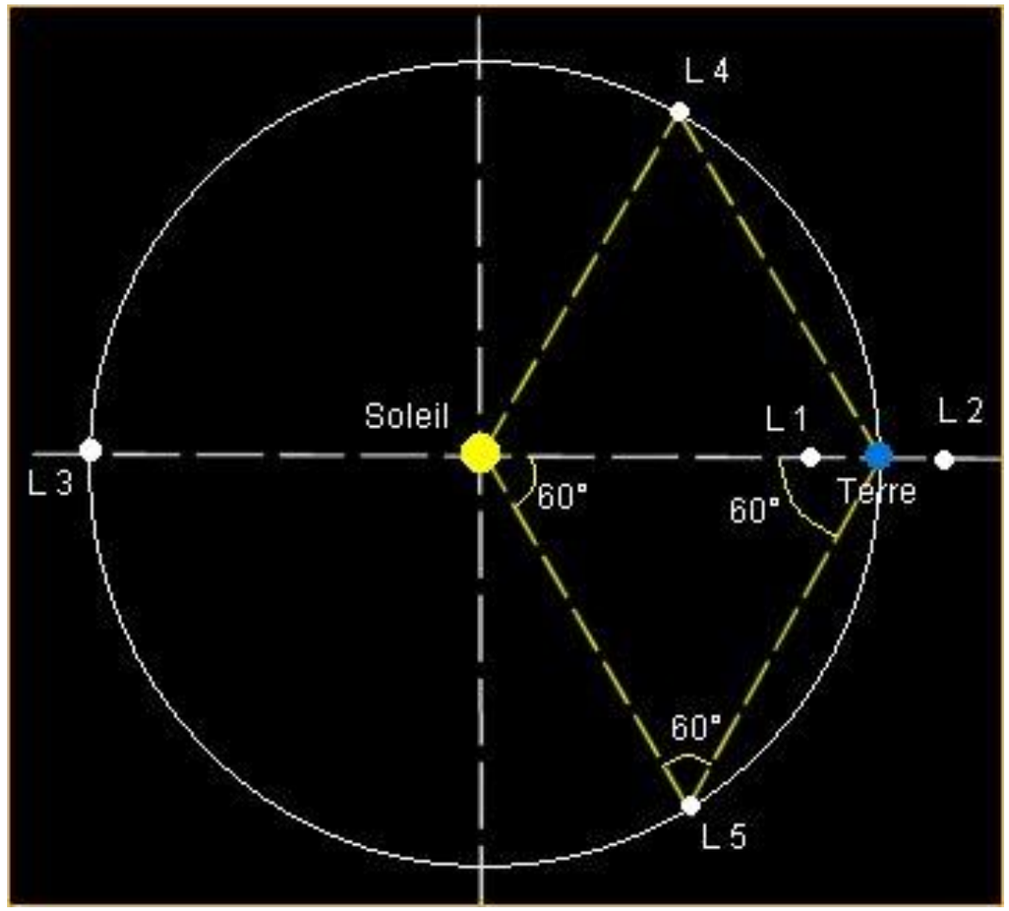
Future Missions

- Proba-3 (2023)
- ✓ Solar corona through refractive optics
- ✓ Imaging in three spectral bands
- ✓ 530.4nm, 587.7nm, and whitelight
- ✓ Formation flying concept
- SWFO-L1 (2025)
- ✓ Space weather specific mission at L1
- ✓ CCOR – 3.75 to 22Rsun
- ✓ Supra-thermal Ion sensor
- ✓ Solar Wind Plasma Sensor
- ✓ Magnetometer



Future Missions

- Lagrange – L5 Mission
- ✓ Coronagraph – 2.7R – 25R
- ✓ Magnetograph
- ✓ EUVI – EUV Imager
- ✓ HI – Heliospheric Imager – 4 to 70deg
- ✓ Magnetograph
- ✓ In-situ particle and magnetometers



Thank you for your attention