SWAP as a Pathfinder to the EUVI Instrument on the SSA Lagrange Mission

Matthew J West

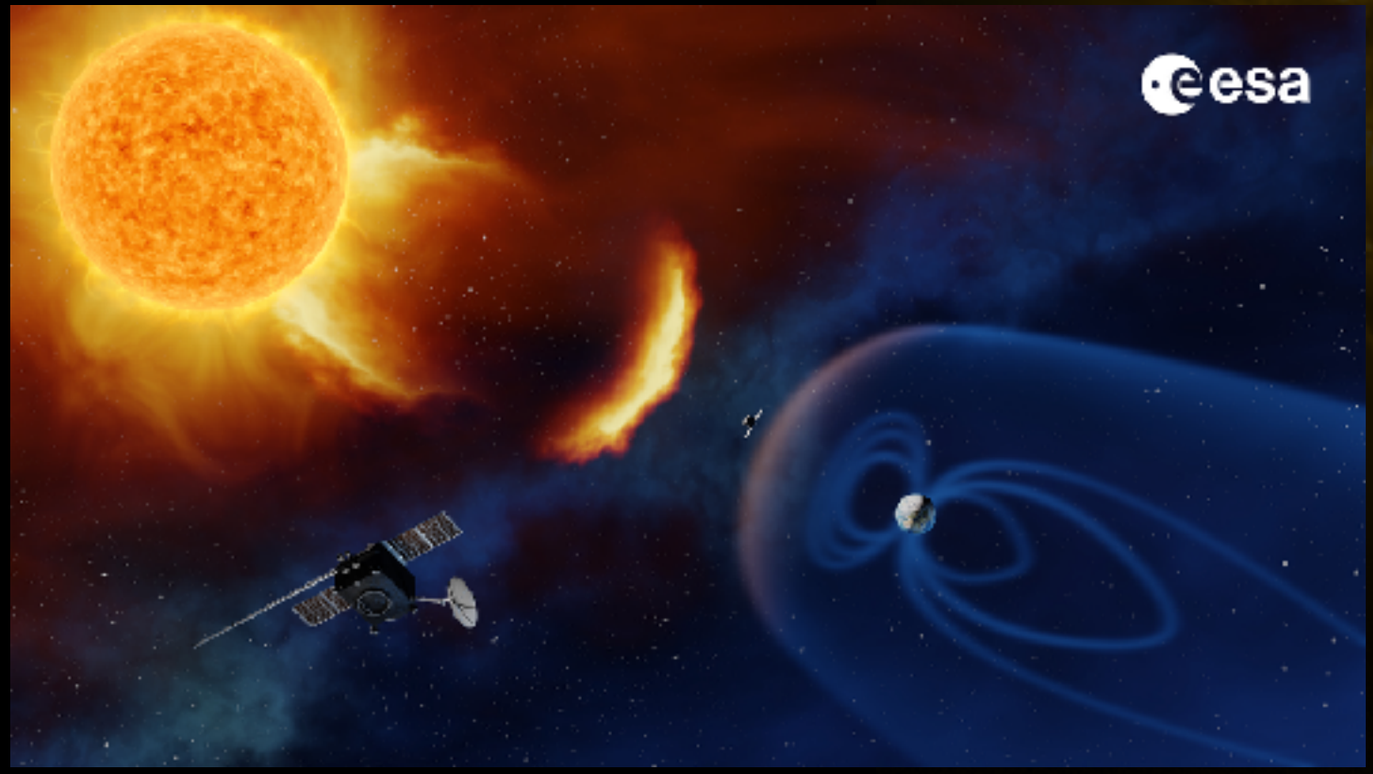
08-Feb-2019

What is the Lagrange Mission?

What Is The Lagrange Mission?

Lagrange is an ESA Phase A/B study for a space weather mission.

Designed for monitoring space weather from the L5 Lagrangian point.



What Is The Lagrange Mission?

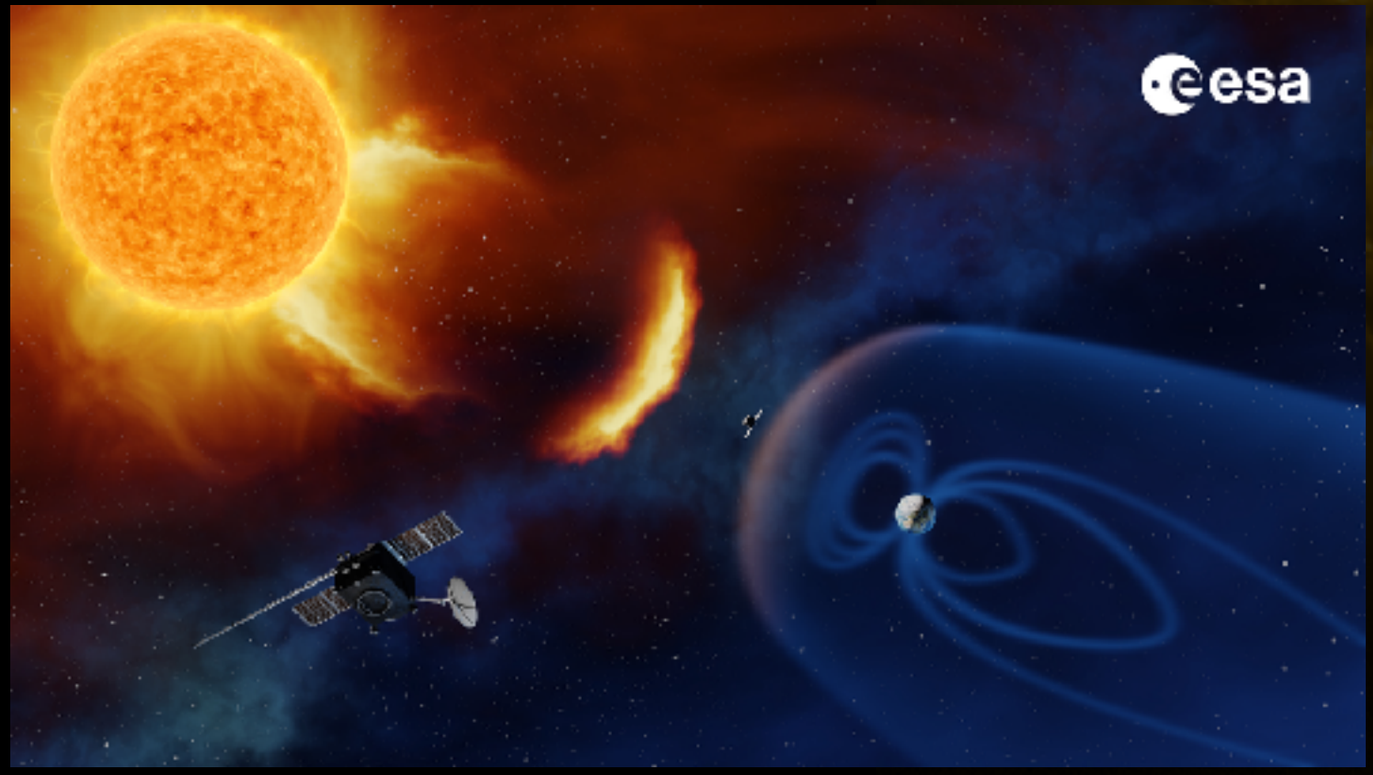
Payload:

Remote Sensing Instruments

Coronagraph
Heliospheric imager (HI)
Magnetograph
EUV imager
X-ray flux monitor

In-situ Instruments

Magnetometer
Plasma analyser
Radiation monitor
particle spectrometer



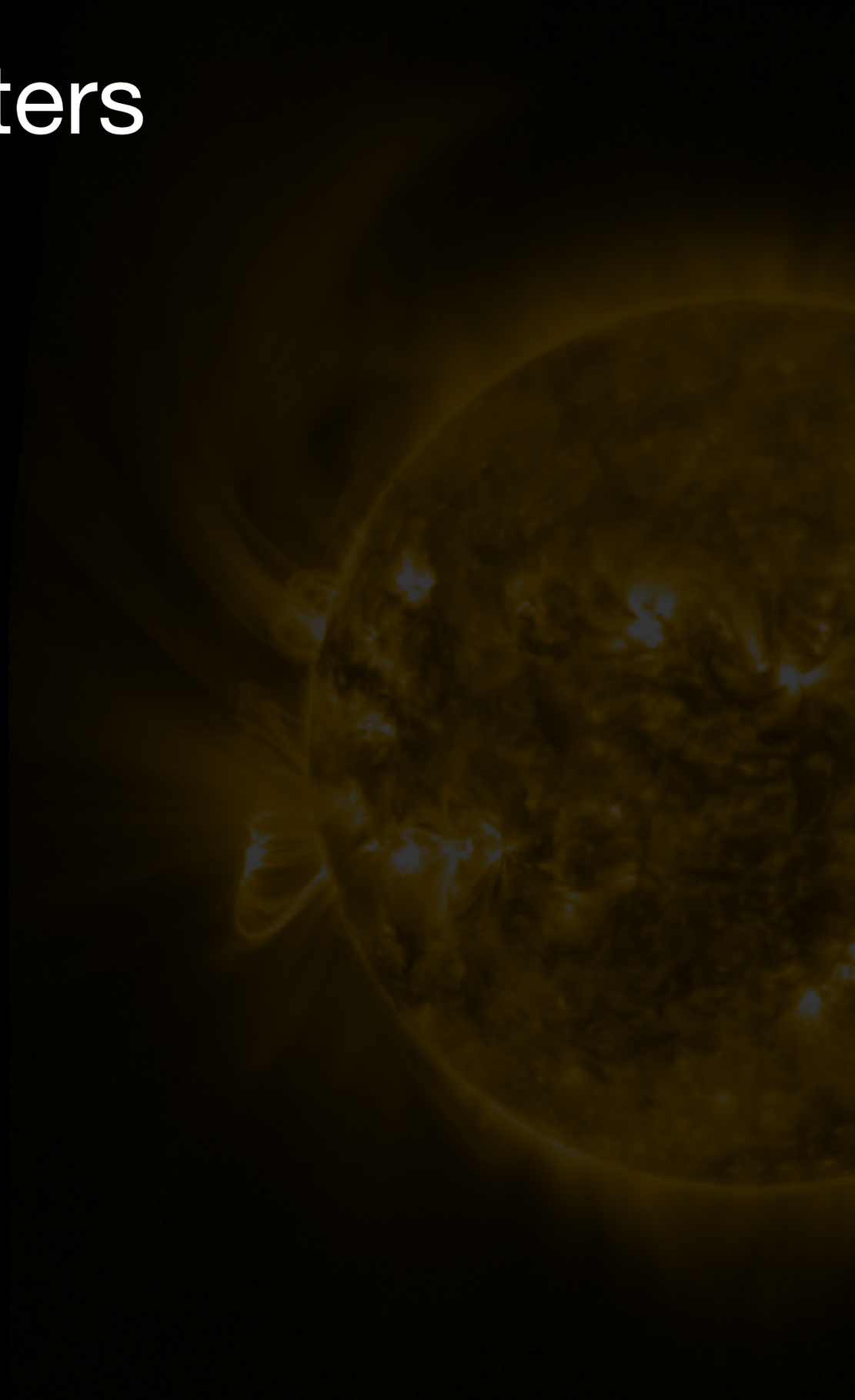
EUV Interests for Forecasters

Semi-Static Structures

Filaments/Prominences
Active Regions
Coronal Holes

Dynamic structures

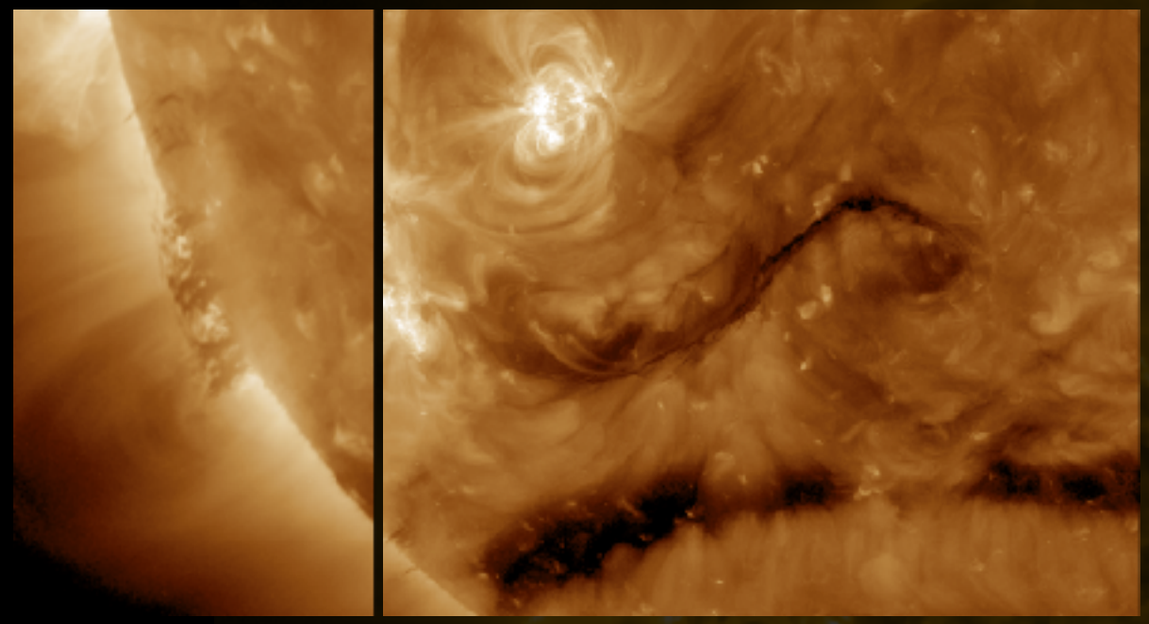
Flares
Eruptions
EUV Waves
Dimmings



Forecaster EUV Interests

Semi-Static Structures - Filaments/Prominences

Typical Temp: 10^3 -10^4 K
Typical Size: up to 1 R_{solar}
3×10^4 -1.1×10^5 km
(Parenti, 2014, LRSP)



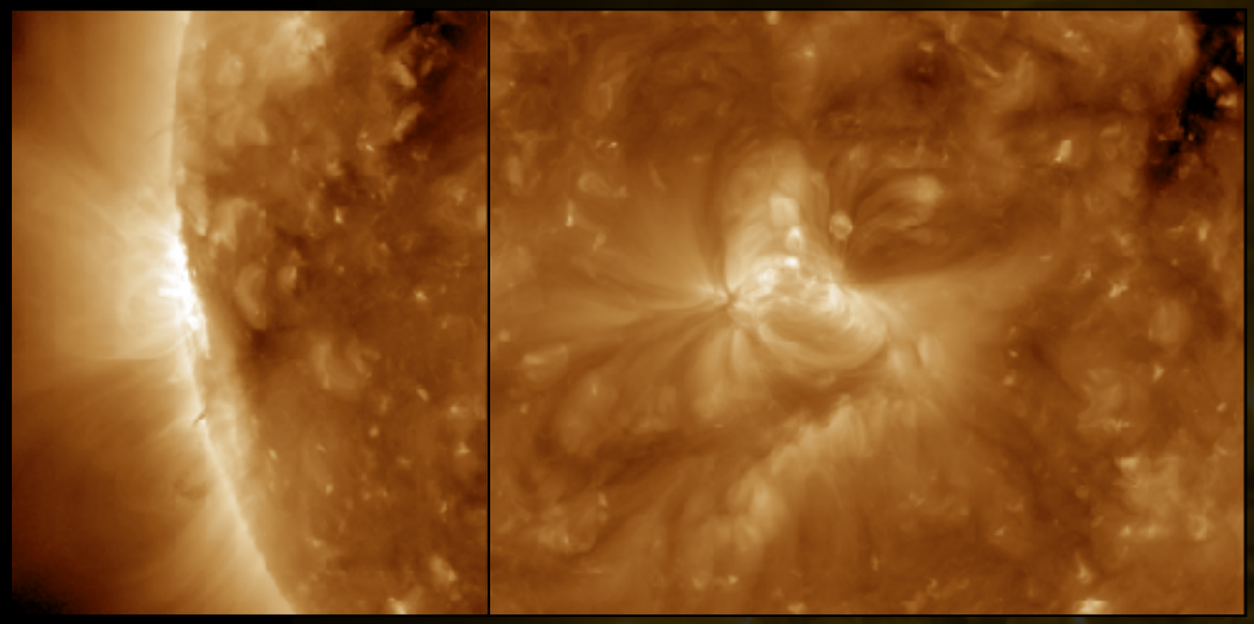
Interest to forecasting community: Filaments destabilise creating "slower" CMEs with a classic three part structure:
Bright Core - Cavity- Leading Edge.

They are denser structures seen bright in white light observations.

Forecaster EUV Interests

Semi-Static Structures - Active Regions

Typical Temp: up to ~10^7 K
Typical Size: up to 0.25^2
R_{solar}



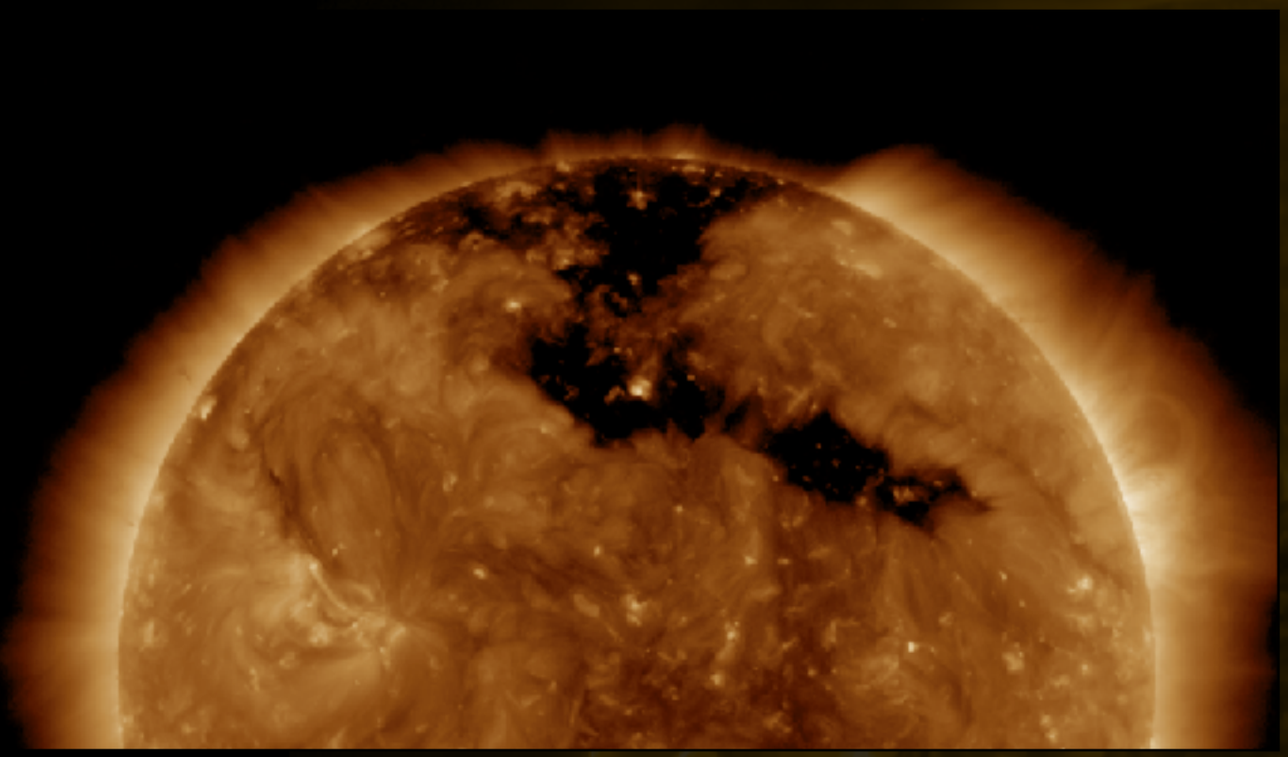
Interest to forecasting community: Active regions produce the largest flares and eruptions.

It's important to track the growth of ARs combined with magnetograph observations, often used to identify the sources of flares and eruptions, and the potential for further activity.

Forecaster EUV Interests

Semi-Static Structures - Coronal Holes

Typical Temp: ~$10^{4\text{-}5}$ K
Typical Size: up to 0.33 Solar Disk

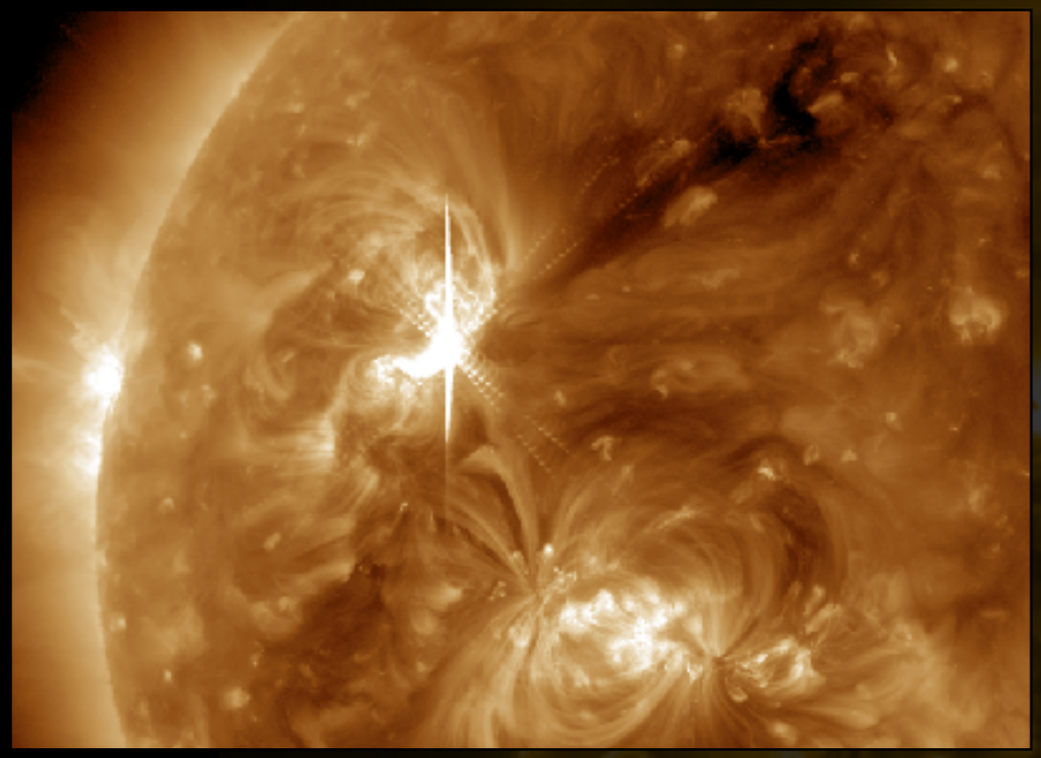


Interest to forecasting community: Polar and transient coronal holes are the source of high speed solar wind, and consequently Co-rotating interaction regions.

Forecaster EUV Interests

Dynamic Structures - Flares

Typical Temp: ~$10^{4\text{-}5}$ K
Typical Size: up to 0.01 R_{solar}

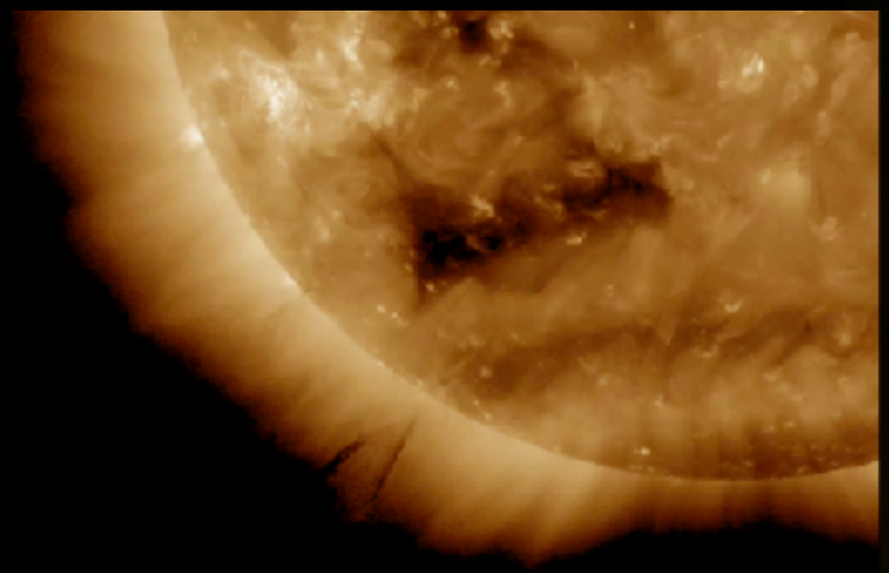


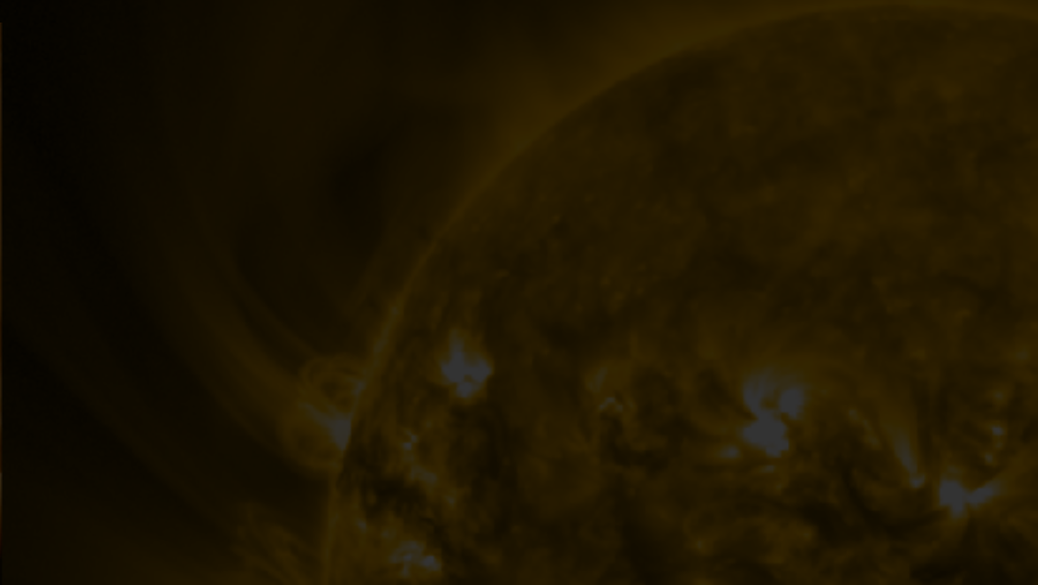
Interest to forecasting community: A solar flare is a sudden release of energy through radiation and particles. These can interfere with sensitive electrical systems.

Often forecasted through legacy

Forecaster EUV Interests

Dynamic Structures - Eruptions



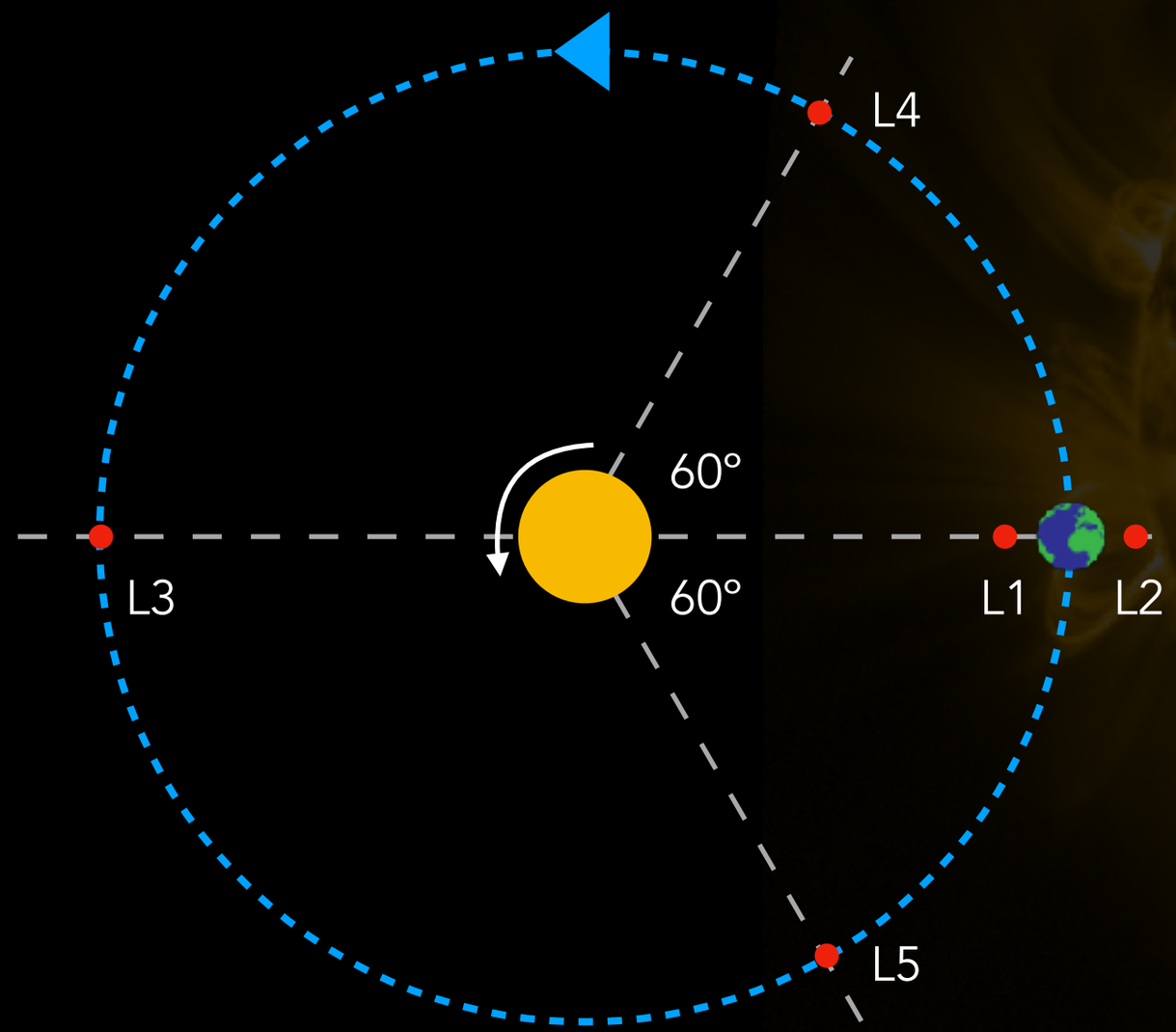


Interest to forecasting community: Eruptions are generally observed further out in white light observations. However, the acceleration and deceleration occurs closer to the Surface.

EUV observations near the limb offer the opportunity to track this growth, especially from an L5 vantage point.

What is the Lagrange Mission?

An important location for future space weather monitoring is the L5 Lagrange point of the Sun-Earth system.



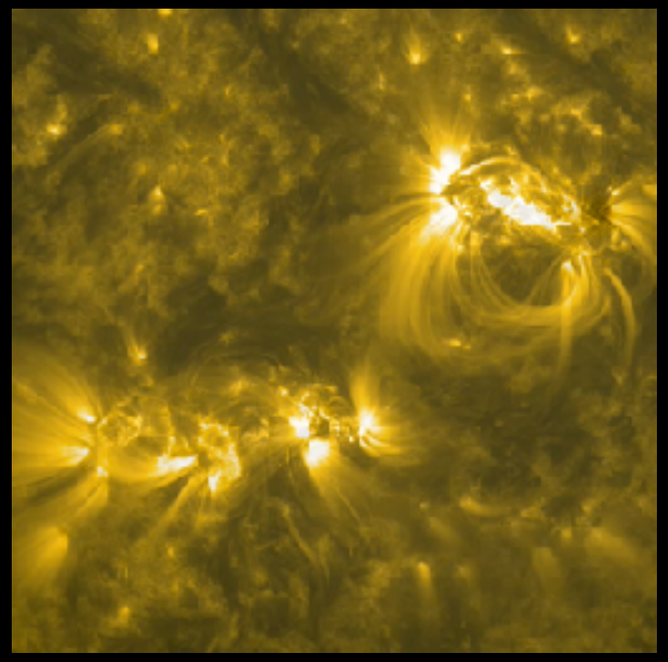
Why Go To L5?

Flares

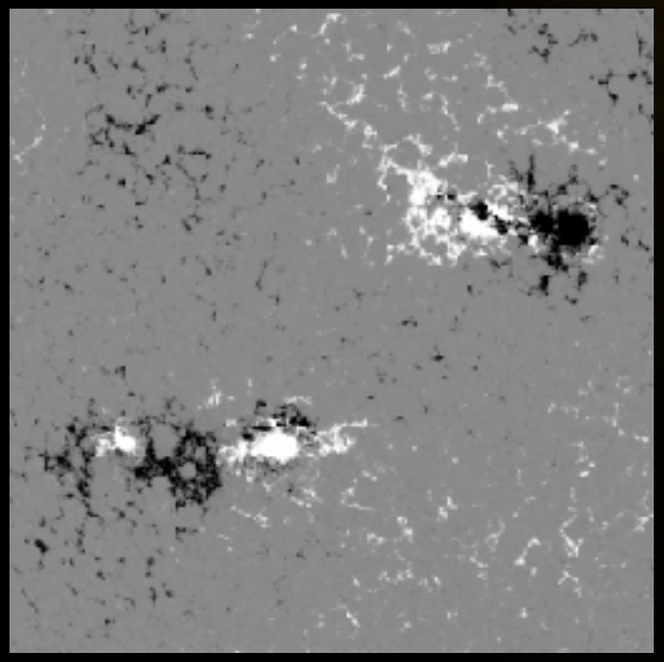
A solar flare is a sudden release of magnetic energy

Releasing up to 10^{25} Joules of energy.

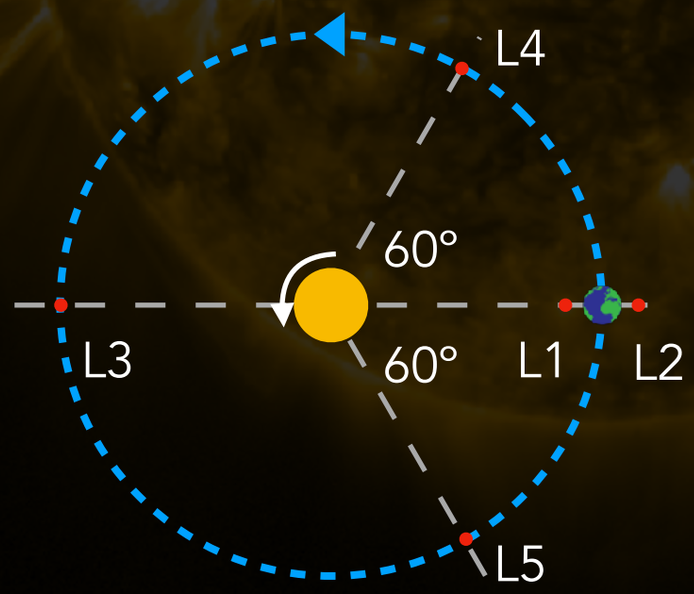
Flares are intrinsically related to the magnetic fields permeating the solar atmosphere. These get reorganised through magnetic reconnection and energy is released.



17.1 nm 6.3x10^5 K



HMI Magnetogram



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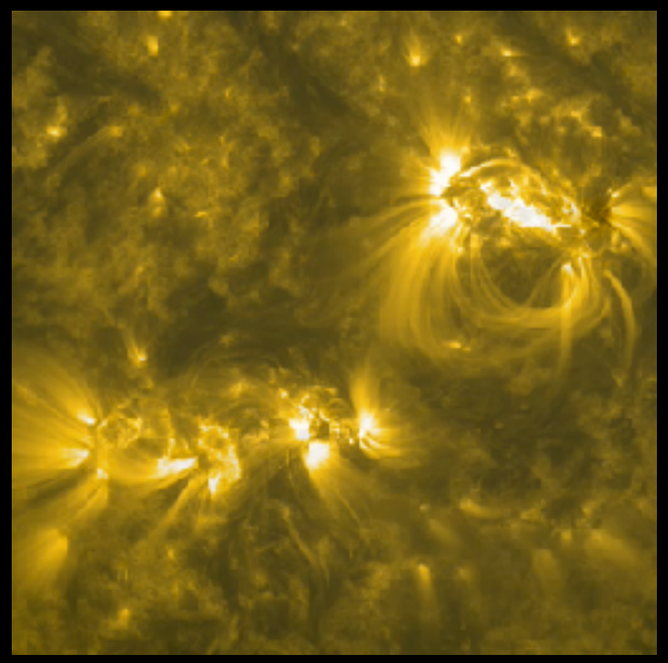
Why Go To L5?

Flares

A lot of flare forecasting is based on how active an Active Region was previously and how the field has evolved.

The L5 perspective, allows us to see how the field is evolving and to see what is coming!



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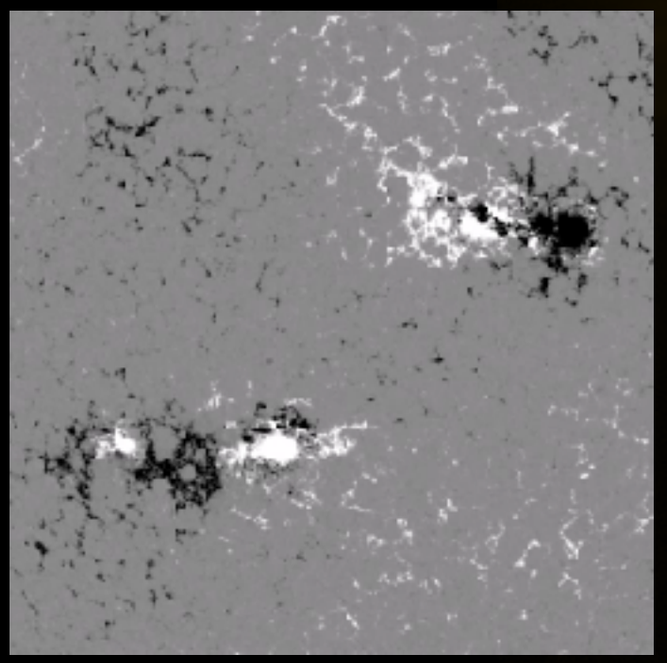
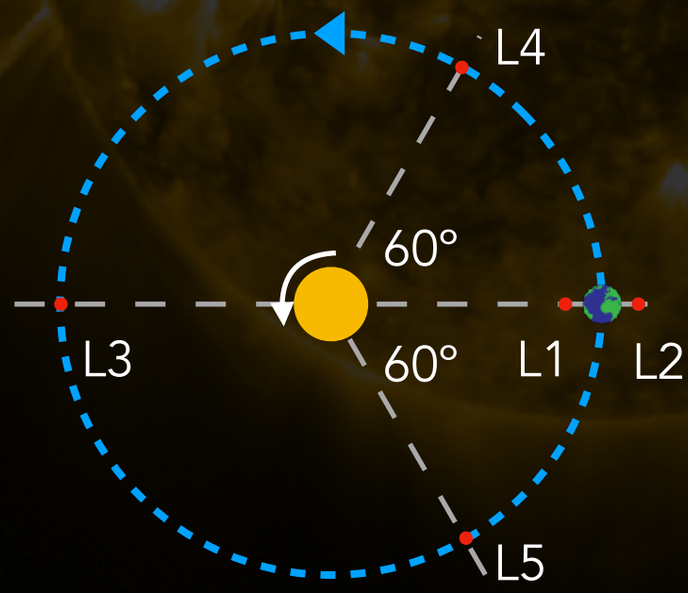


HMI Magnetogram



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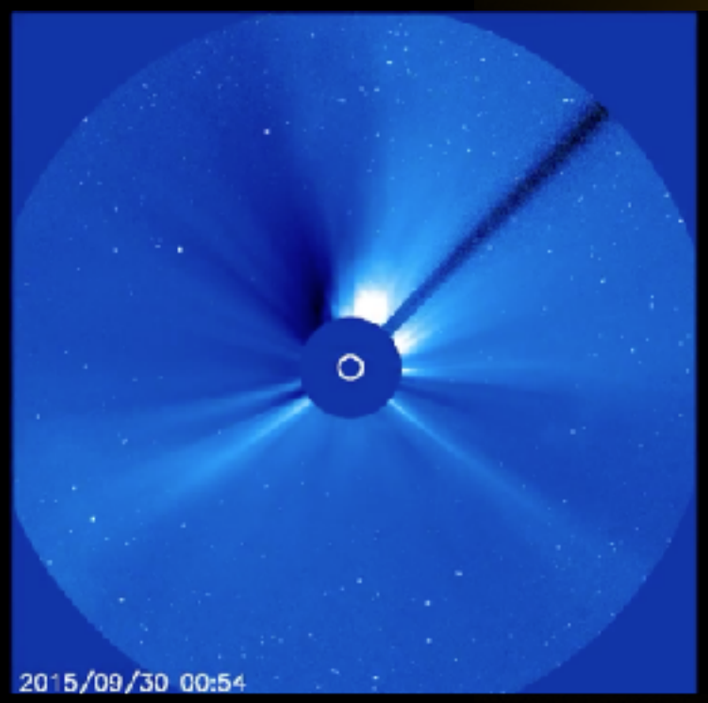
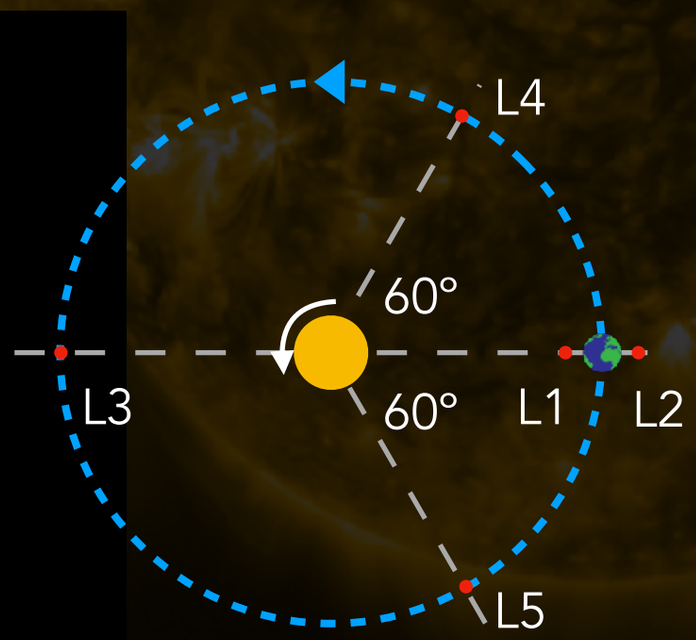
Why Go To L5?

Coronal Mass Ejections (CMEs)

CMEs we're interested in Forecasting are often coming straight towards us - Halo CMEs.



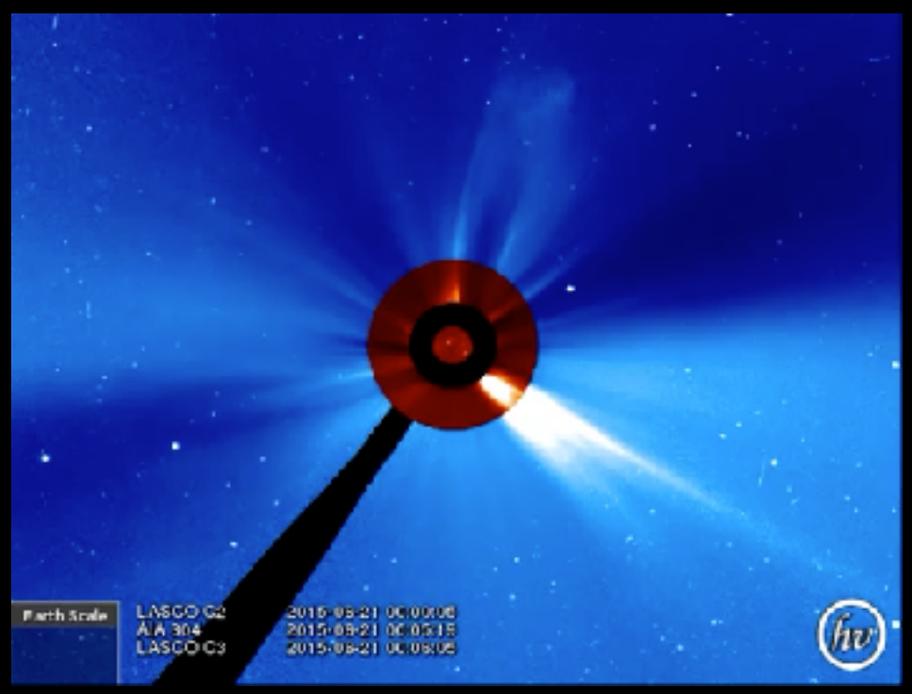


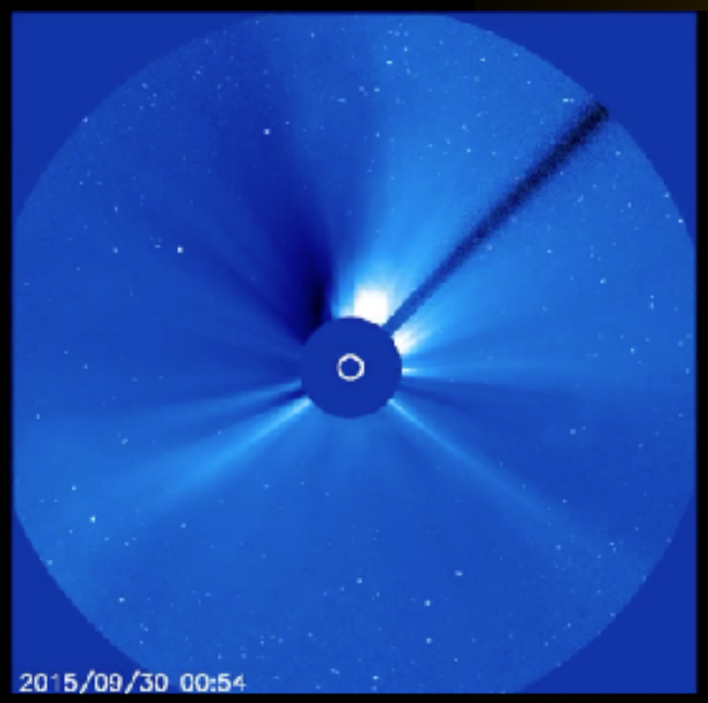
Why Go To L5?

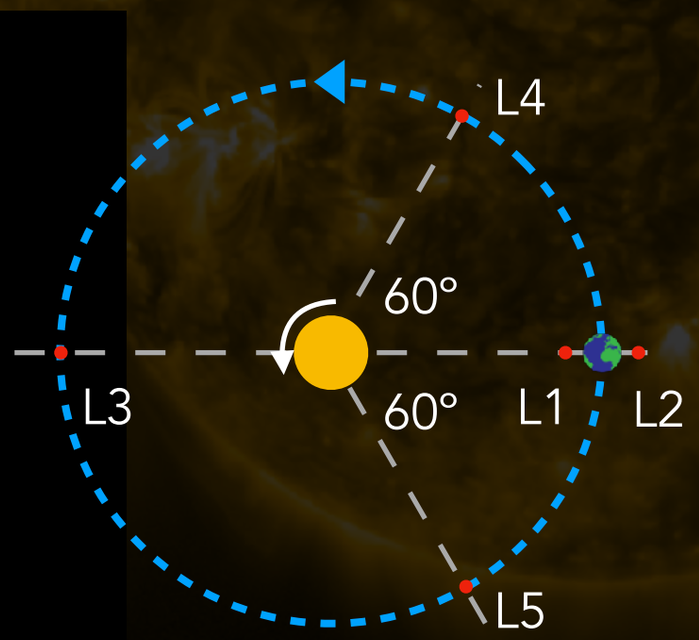
Coronal Mass Ejections (CMEs)

Problems with forecasting Halo CMEs

- Front Sided or backsided (need an EUV imager to confirm)
- Is the expanding CME narrow with high speed or wide with low speed
- Is the majority of the CME mass along the Sun Earth line



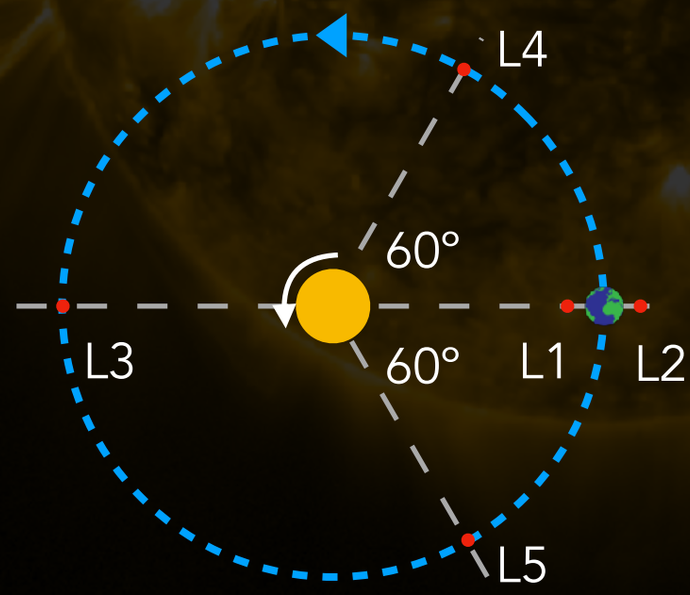




Why Go To L5?

Solar Wind Streams & CMEs

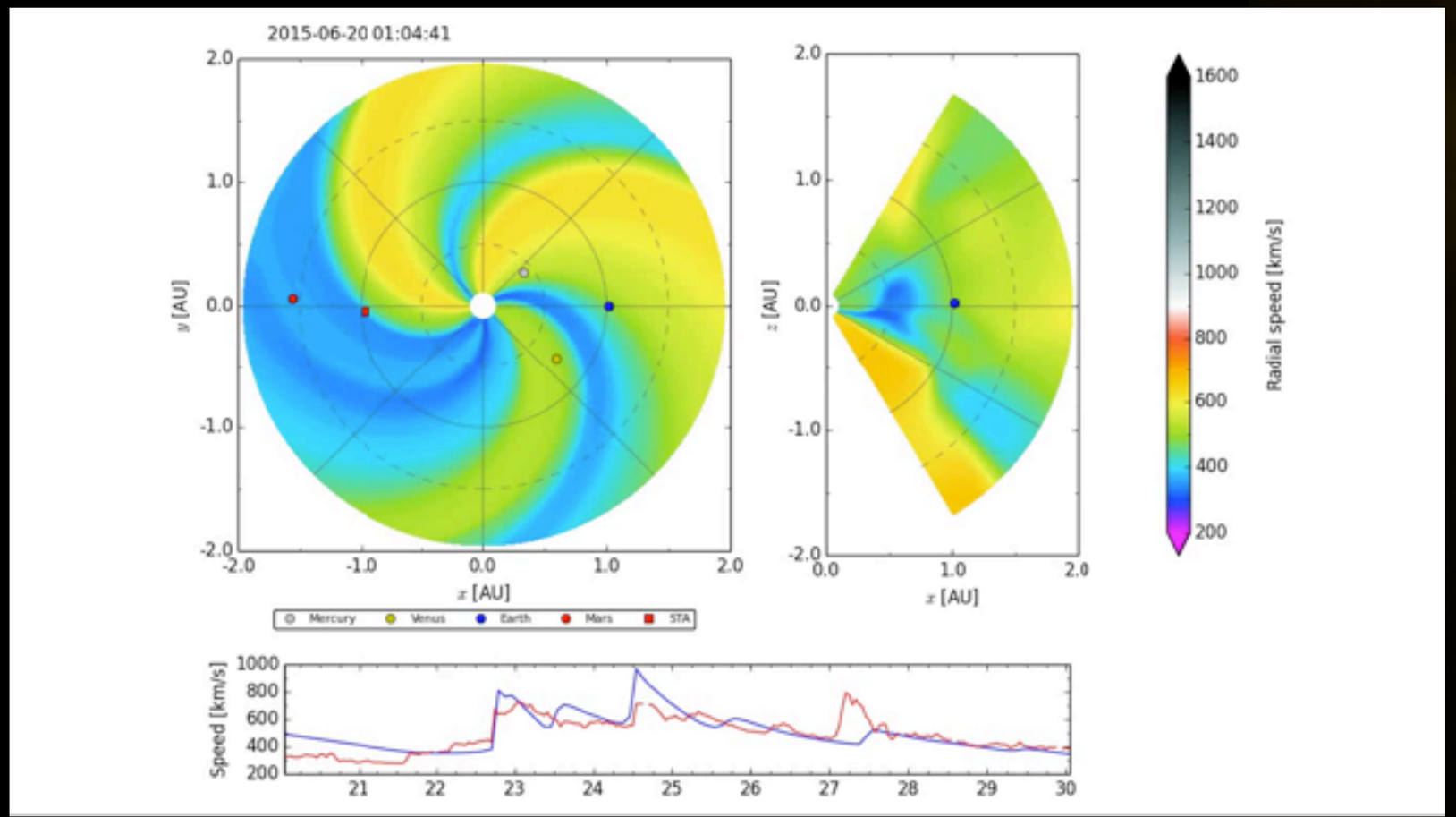
High speed solar wind streams and CMEs can interact with the Earth's Magnetosphere



Why Go To L5?

Solar Wind Streams & CMEs

Euhforia (EUropean Heliospheric FORecasting Information Asset) is a physical model of the inner heliosphere (from 0.1 AU up to ~ 2 AU) developed at the KU Leuven, University of Helsinki, and tested at the Royal Observatory of Belgium.

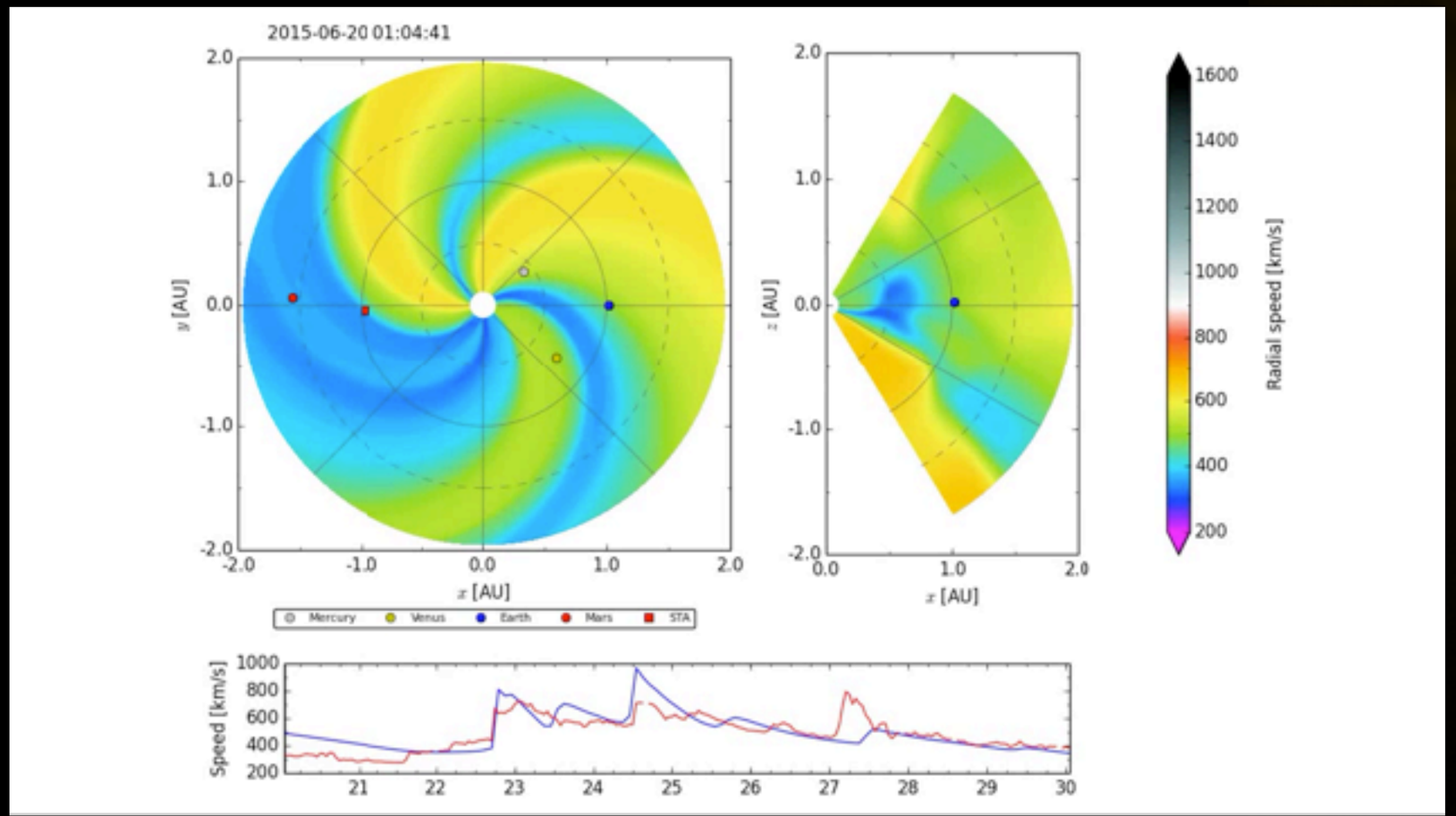


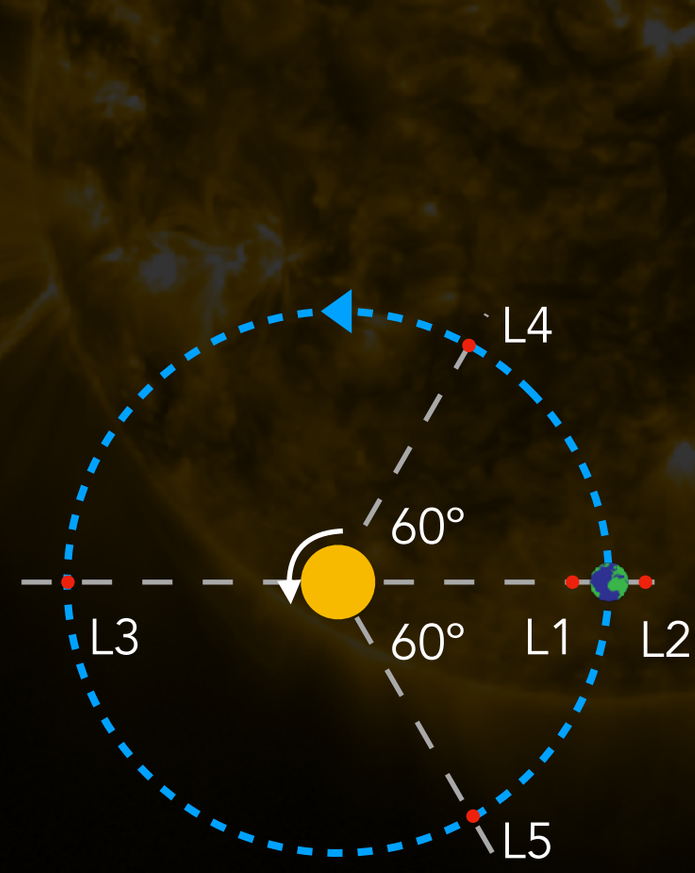
Why Go To L5?

Solar Wind Streams & CMEs

The movie above shows time-evolution of the inner-heliospheric plasma which is dominated by the solar wind and CMEs.

The bottom panel shows the radial speed at Earth as given by the model (blue curve) and spacecraft observations (red curve).

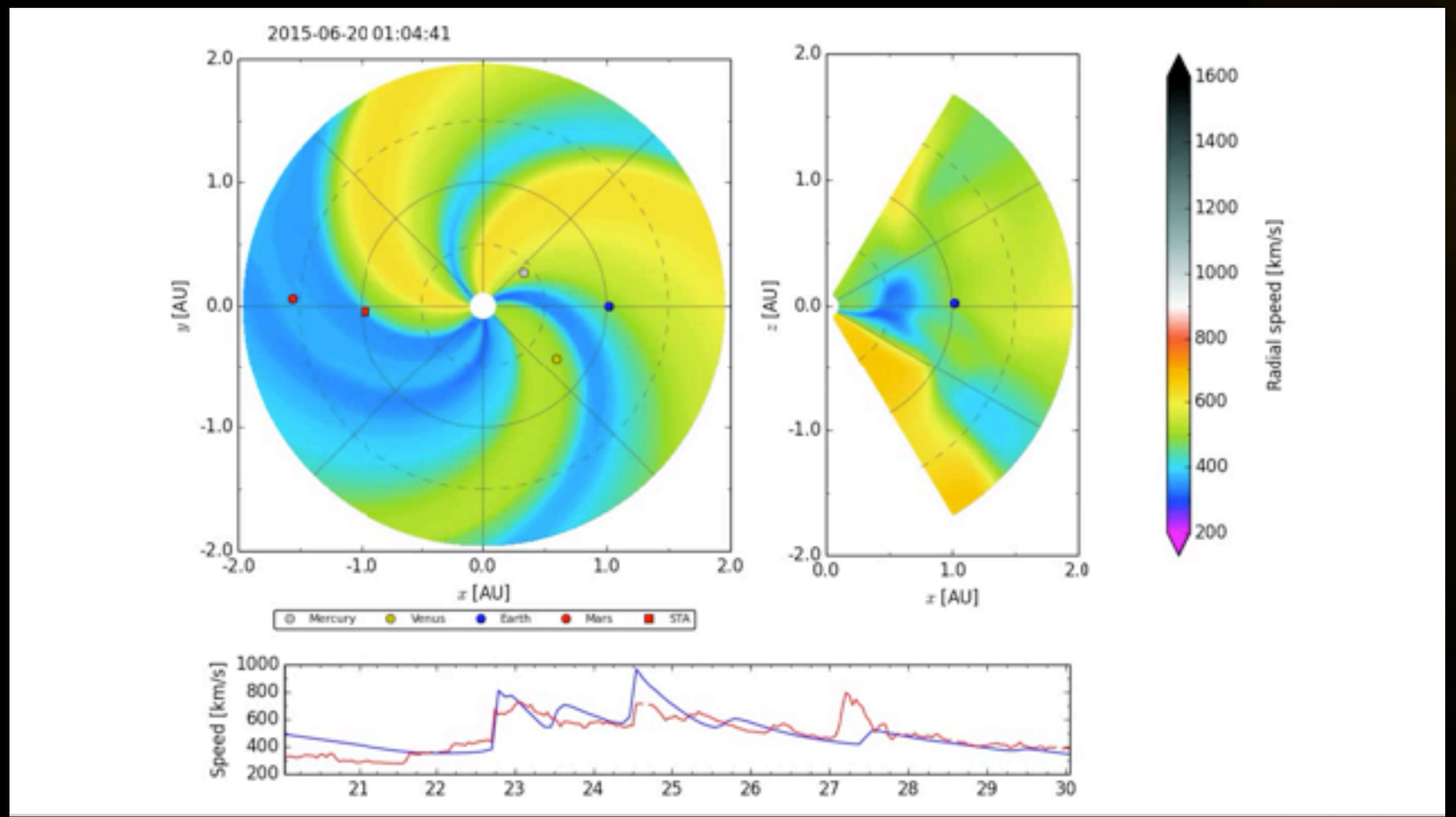


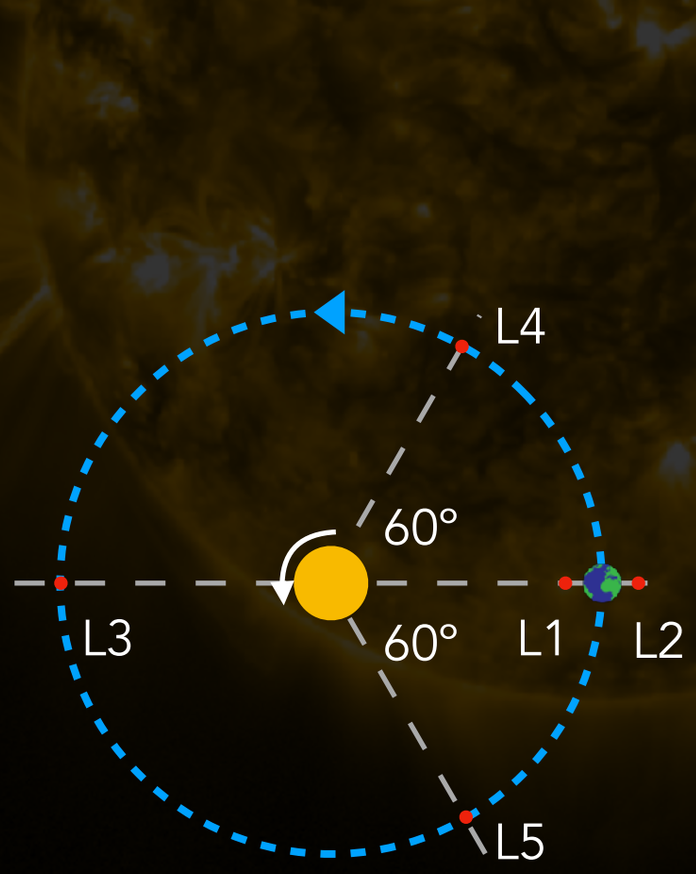


Why Go To L5?

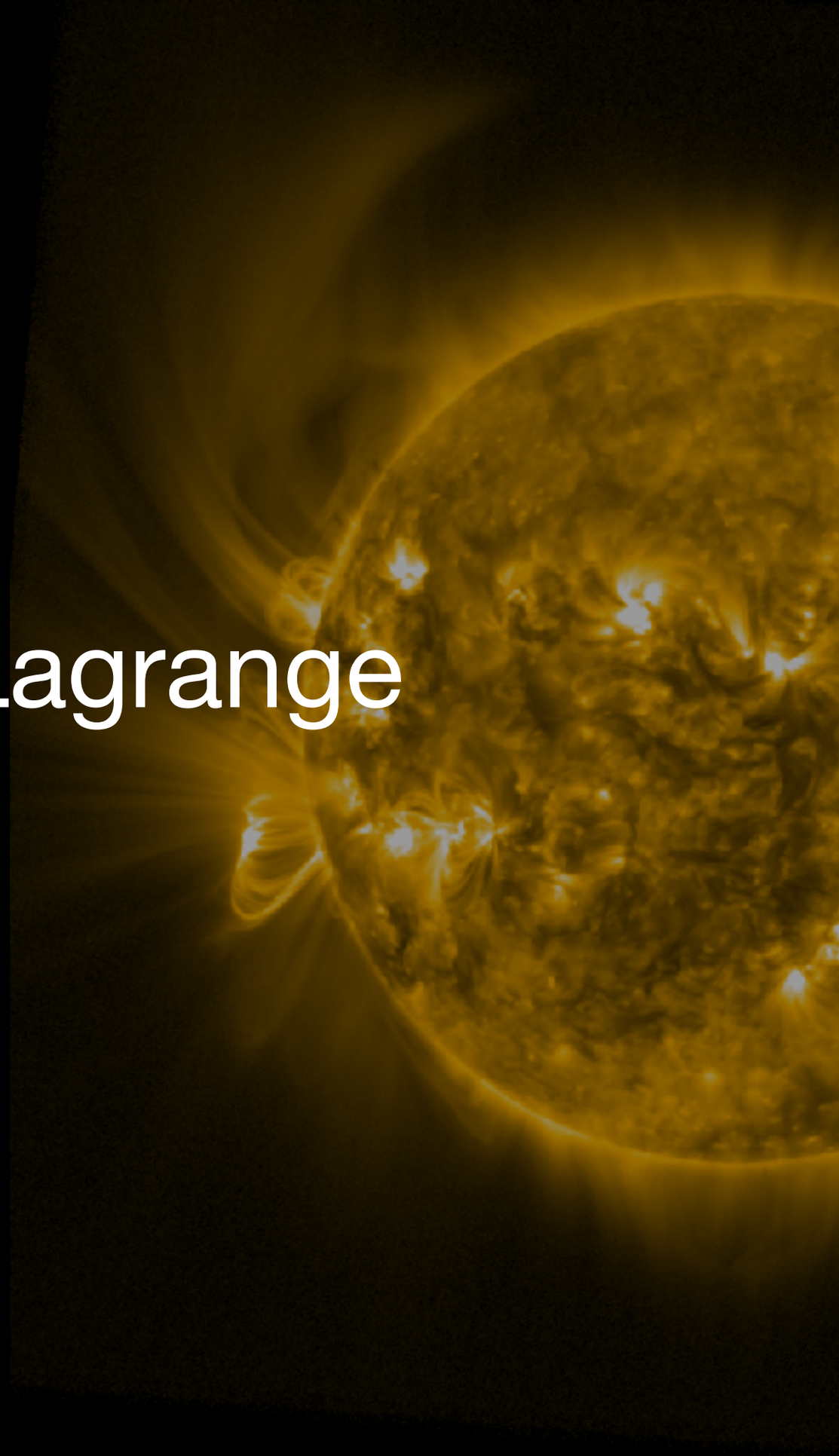
Solar Wind Streams & CMEs

These Streams will sweep over Lagrange first before interacting with the Earth.





PROBA2 to EUVI Lagrange



Why The PROBA2 SWAP EUV Imager?

PROBA (Project for On-Board Autonomy)

1k x 1k

Why The PROBA2 SWAP EUV Imager?

PROBA (Project for On-Board Autonomy)
1k x 1k

Solar Orbiter EUI
3k x 3k

Why The PROBA2 SWAP EUV Imager?

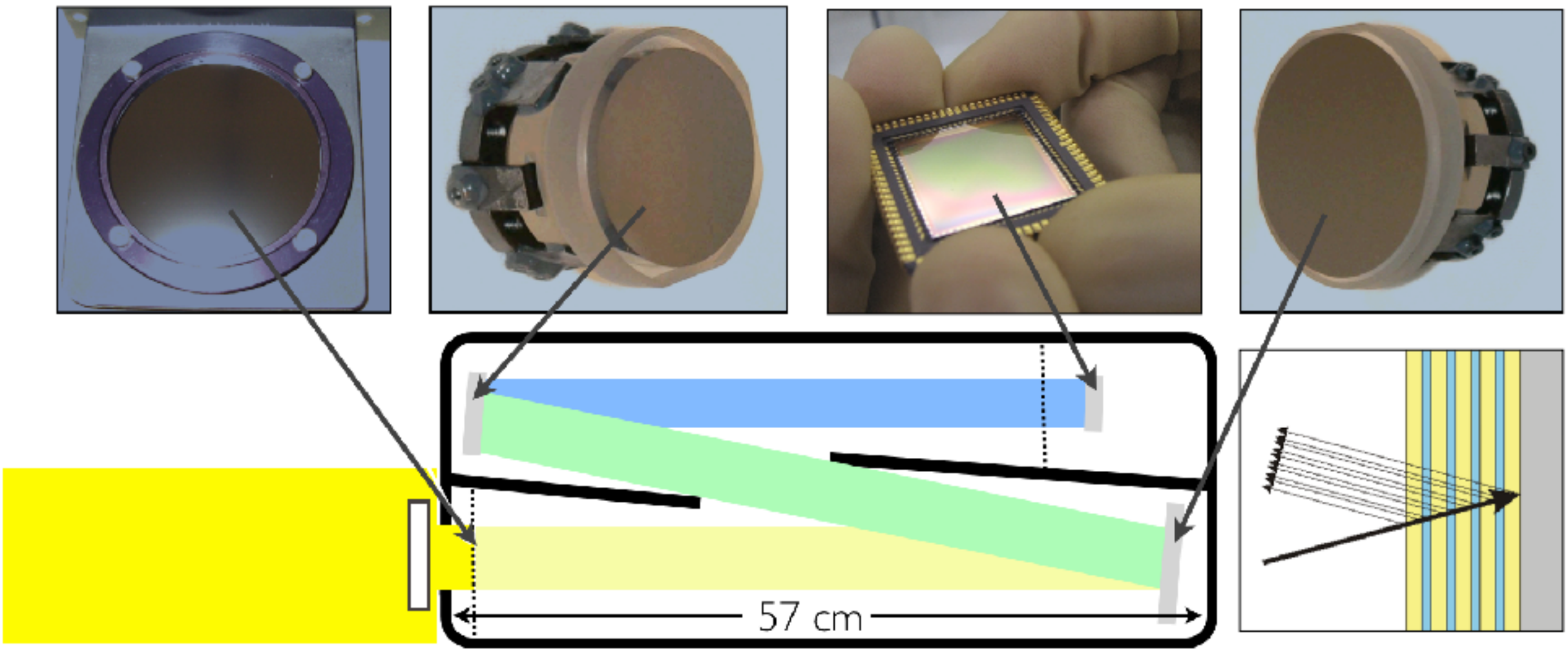
PROBA (Project for On-Board Autonomy)
1k x 1k

Solar Orbiter EUI
3k x 3k

Lagrange EUVI
3k x 3k (sub field 1600 x 2300)

Why The PROBA2 SWAP EUV Imager?

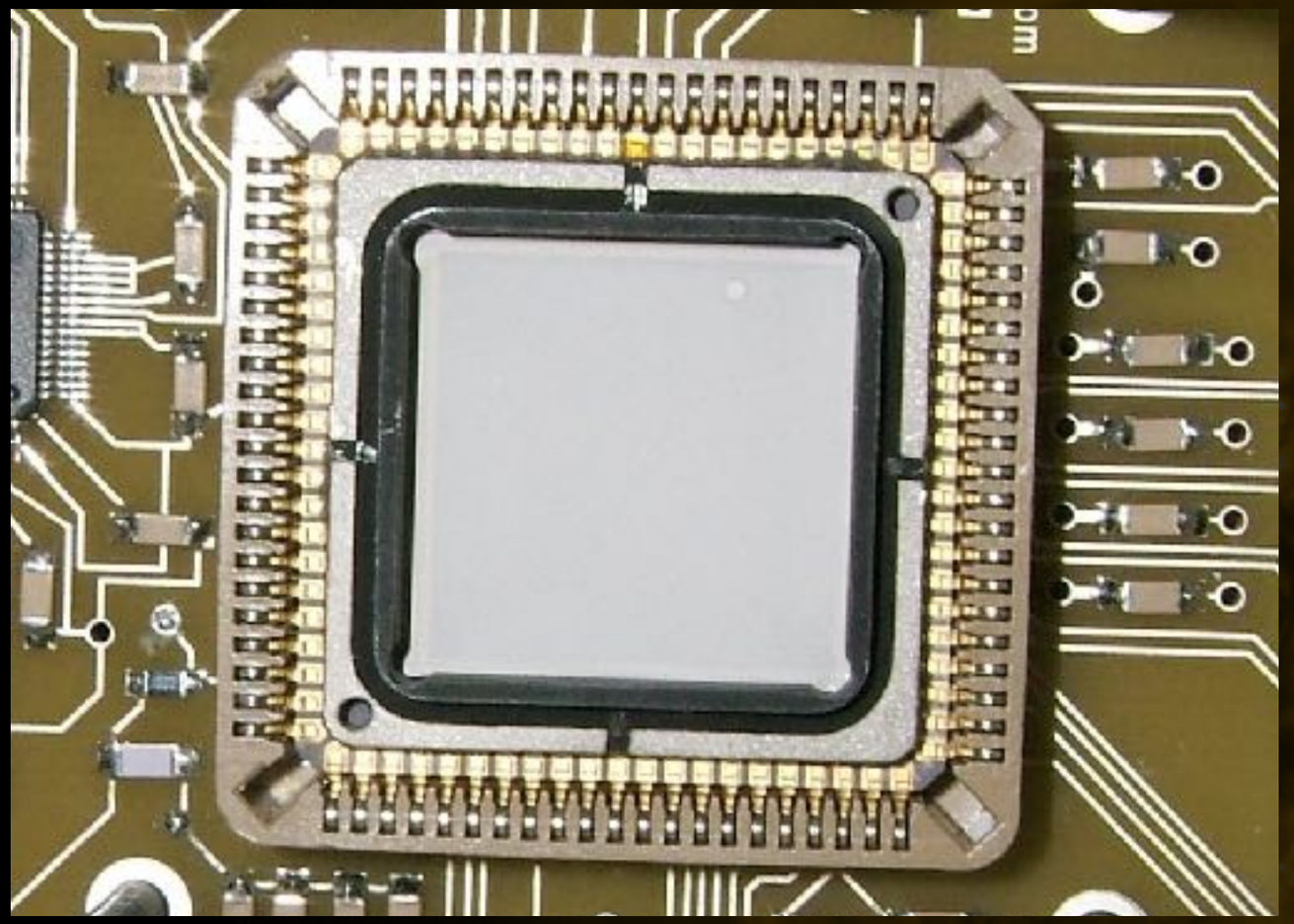
SWAP is a compact EUV Imager



Off-Axis Ritchey-Chrétien Scheme

Why The PROBA2 SWAP EUV Imager?

CMOS APS Detector



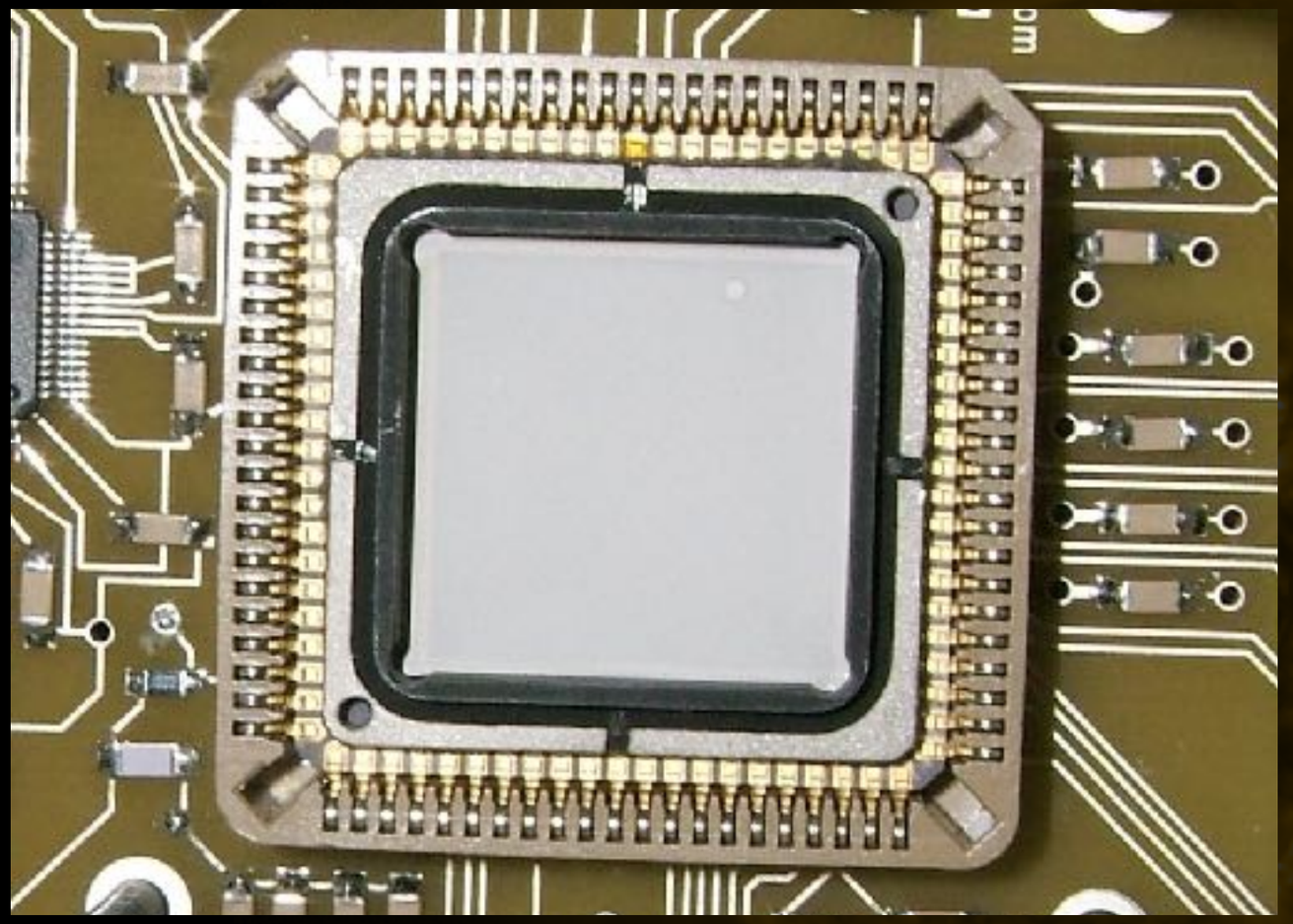
First CMOS for solar physics in orbit

Seaton et al. Sol Phys 2013 :"The SWAP EUV Imaging Telescope Part I: Instrument Overview and Pre-Flight Testing".

Halain et al. Sol Phys 2013:"The SWAP EUV Imaging Telescope. Part II: In-flight Performance and Calibration"

Why The PROBA2 SWAP EUV Imager?

CMOS APS Detector



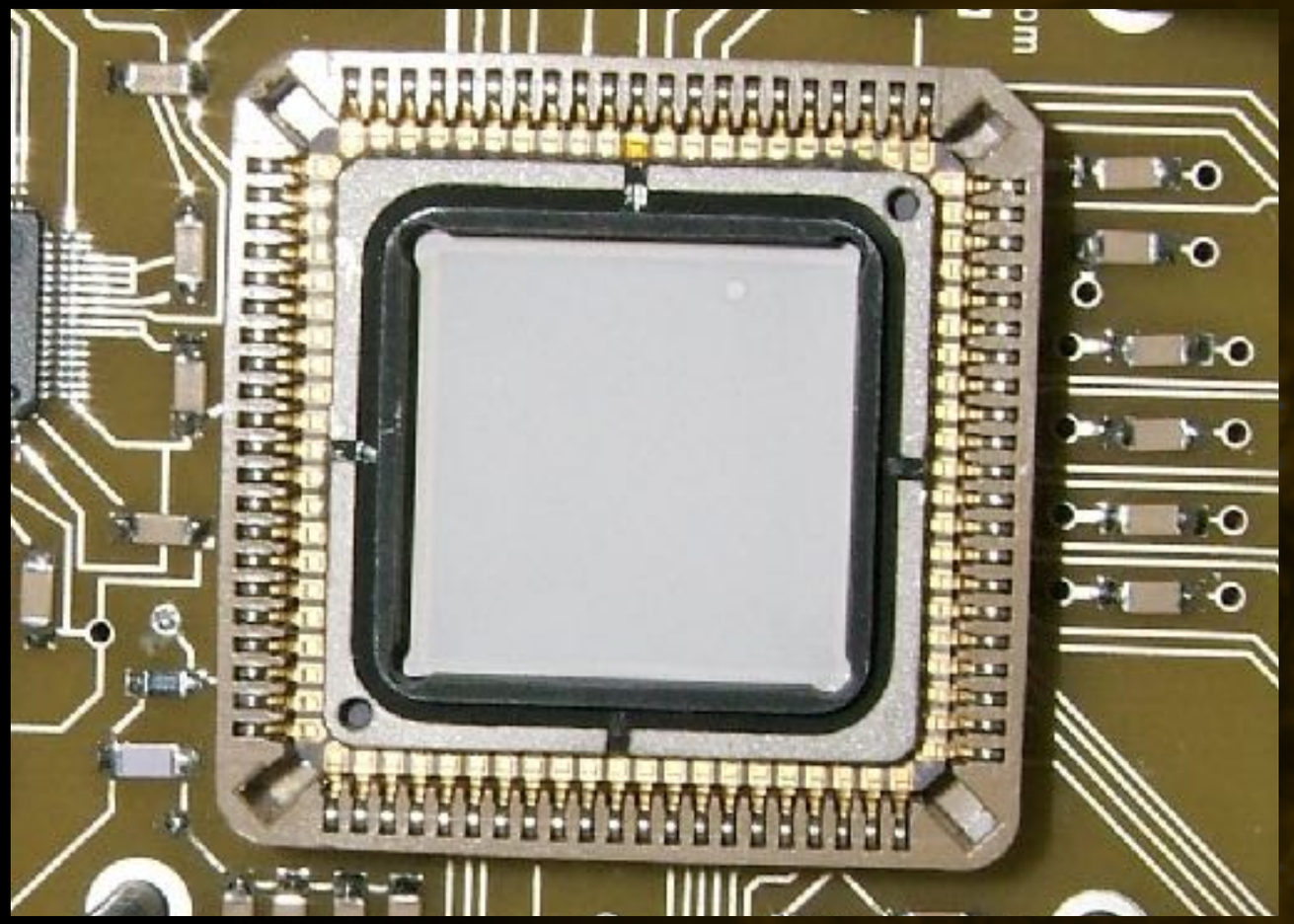
Low power consumption

< 5 Watts

Why The PROBA2 SWAP EUV Imager?

CMOS APS Detector

No charge transfer as in CCD

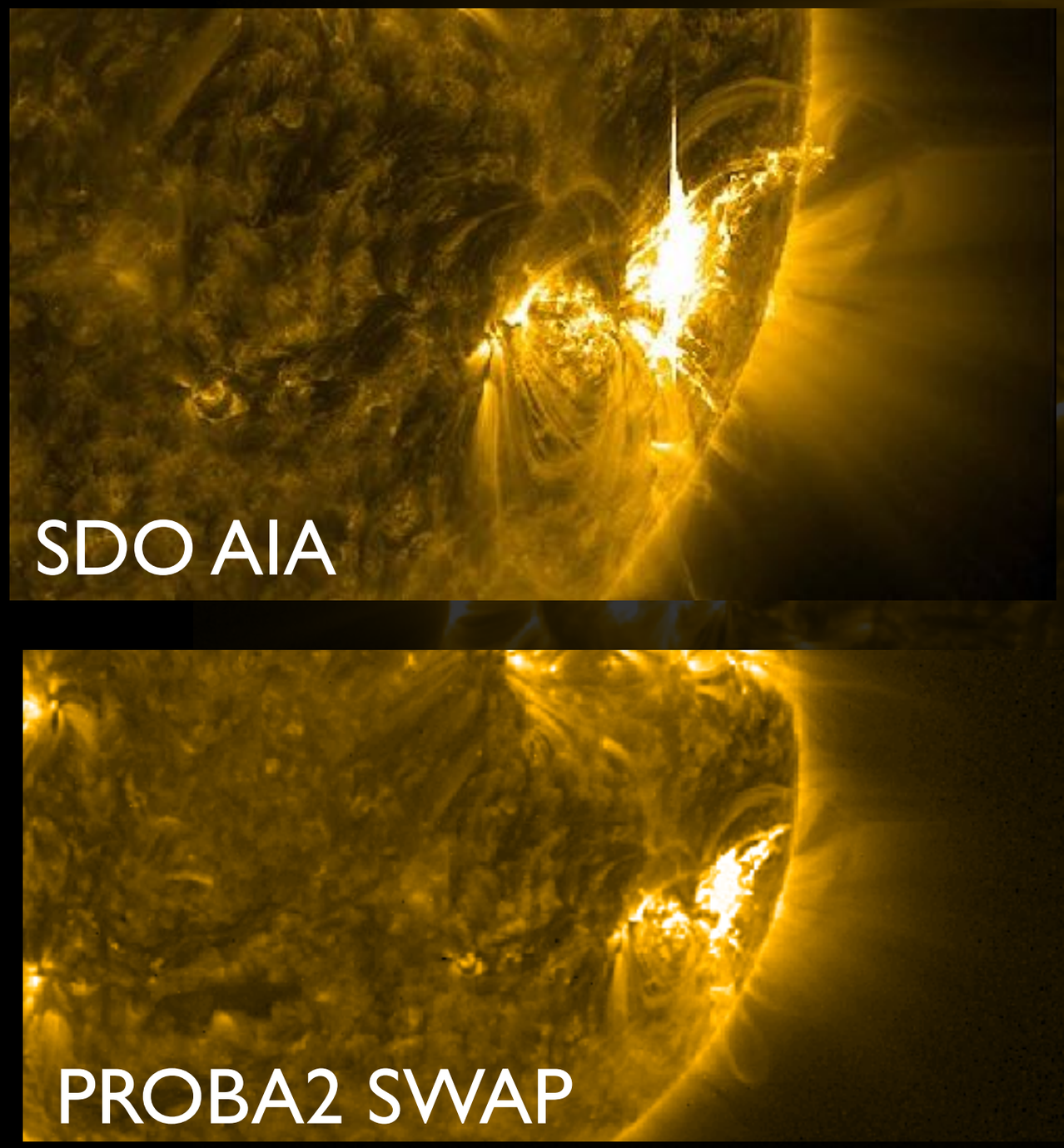


Why The PROBA2 SWAP EUV Imager?

CMOS APS Detector

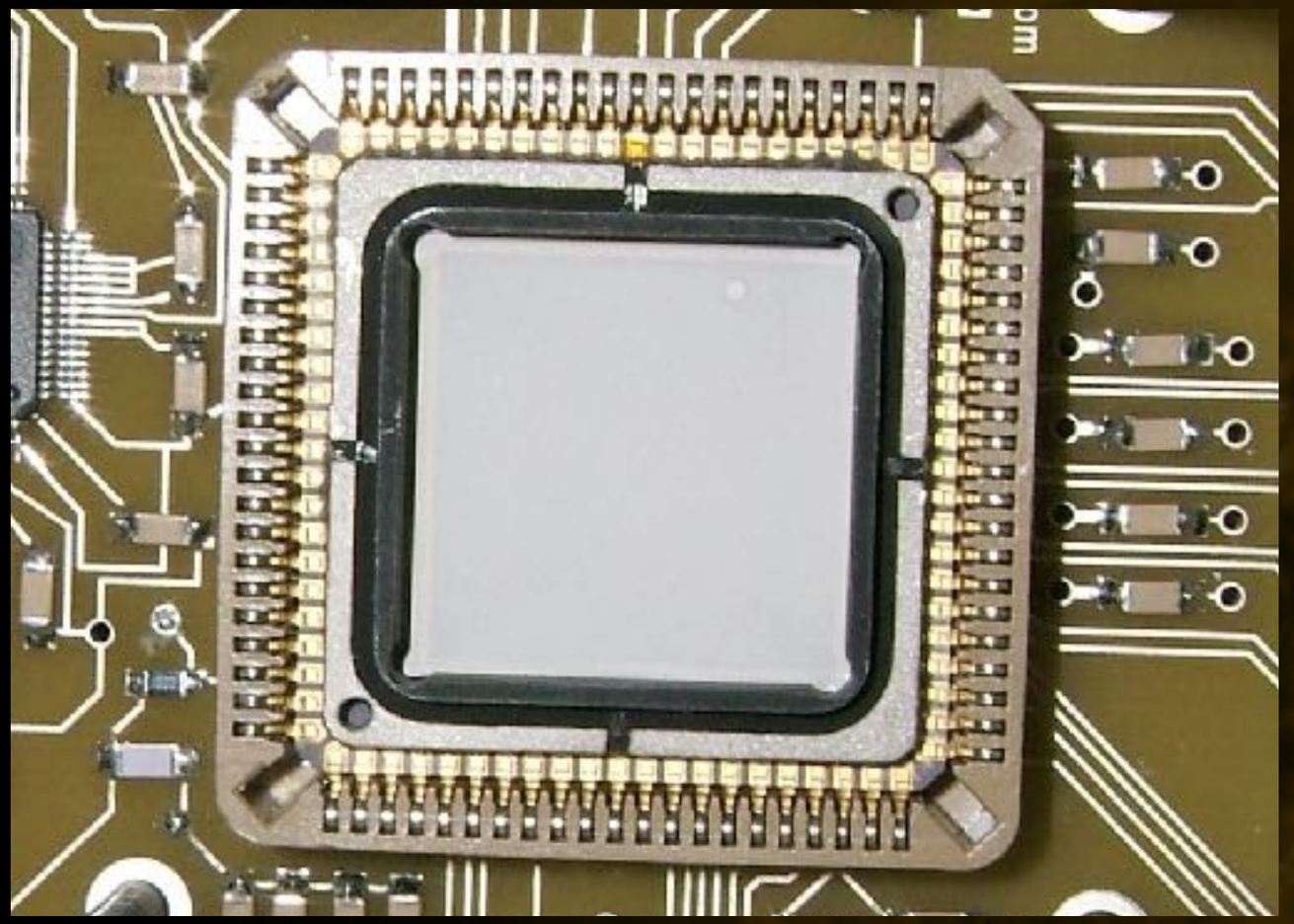
No charge transfer as in CCD

No blooming



Why The PROBA2 SWAP EUV Imager?

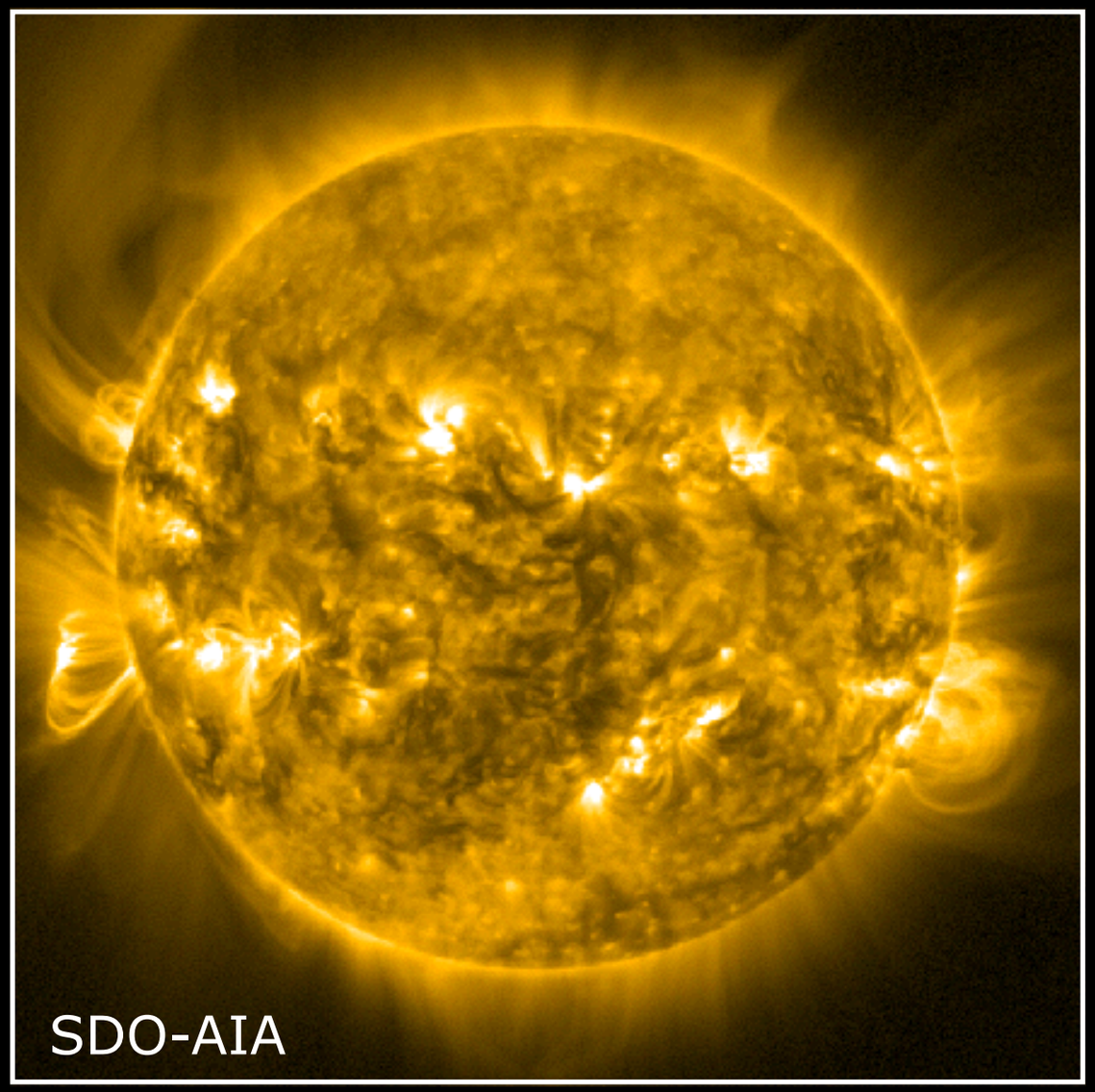
CMOS APS Detector



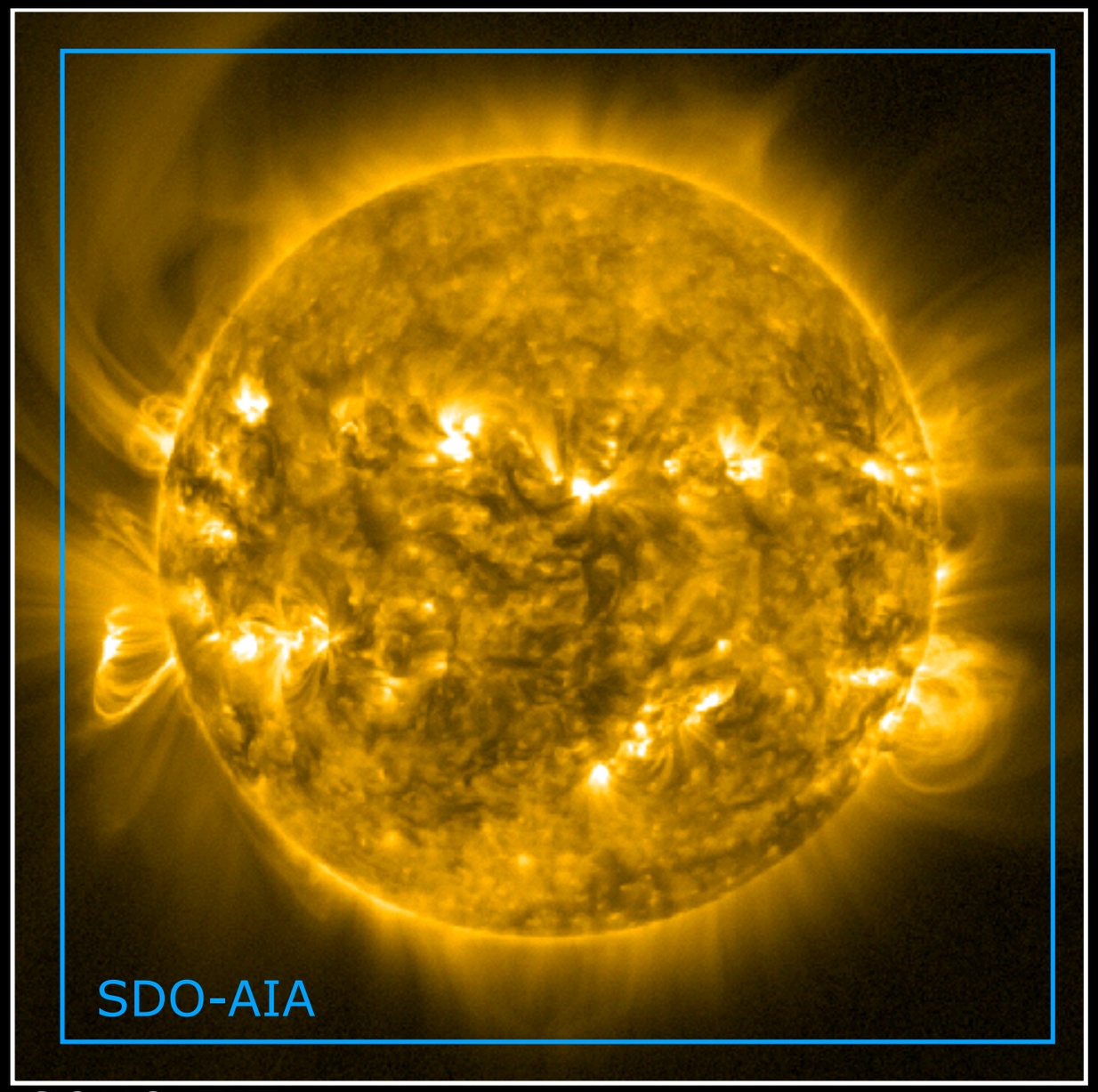
No need for shutter

(reduce chance of mechanical failure)

The Large Field Of View (FOV)

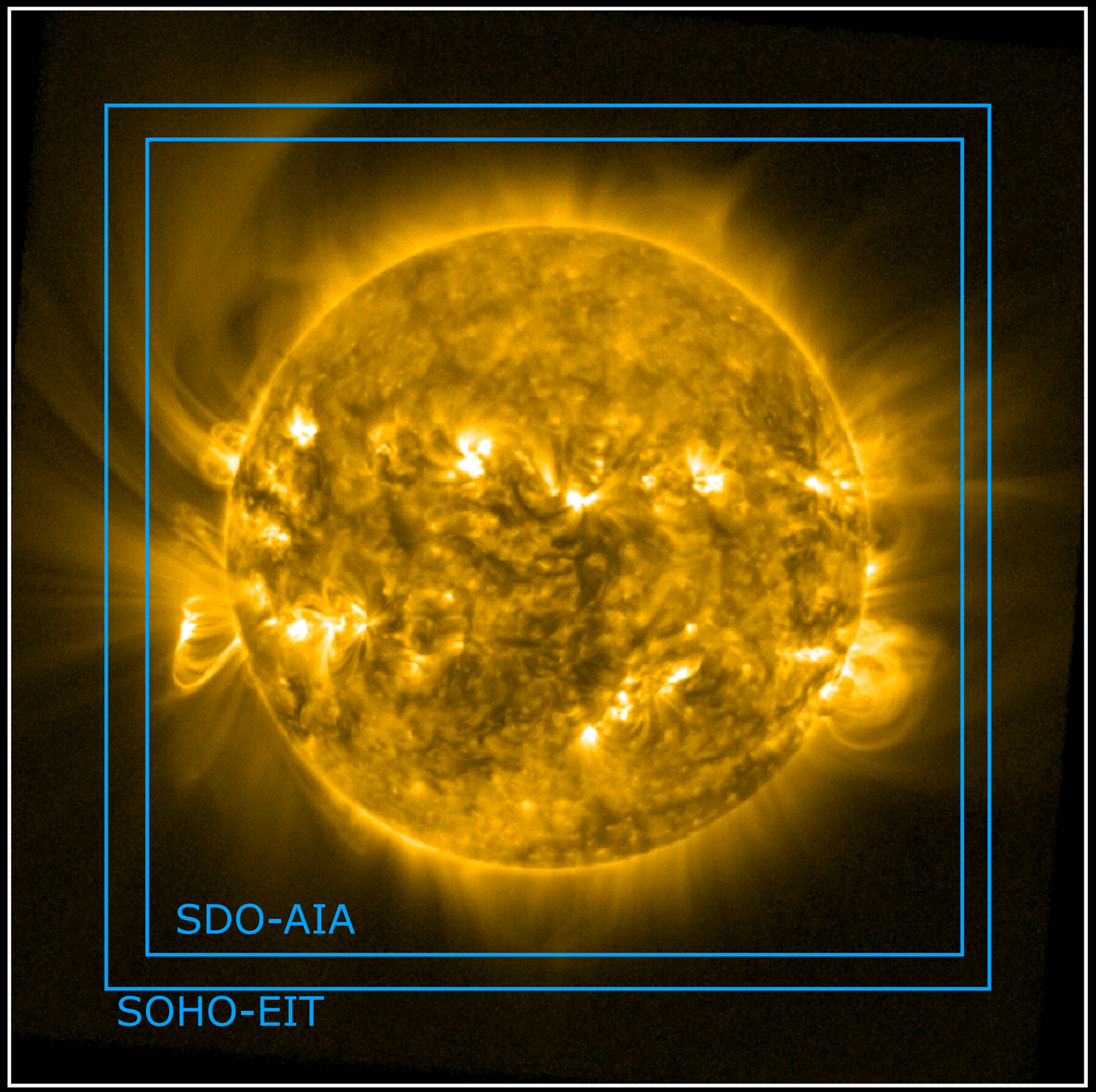


The Large Field Of View (FOV)



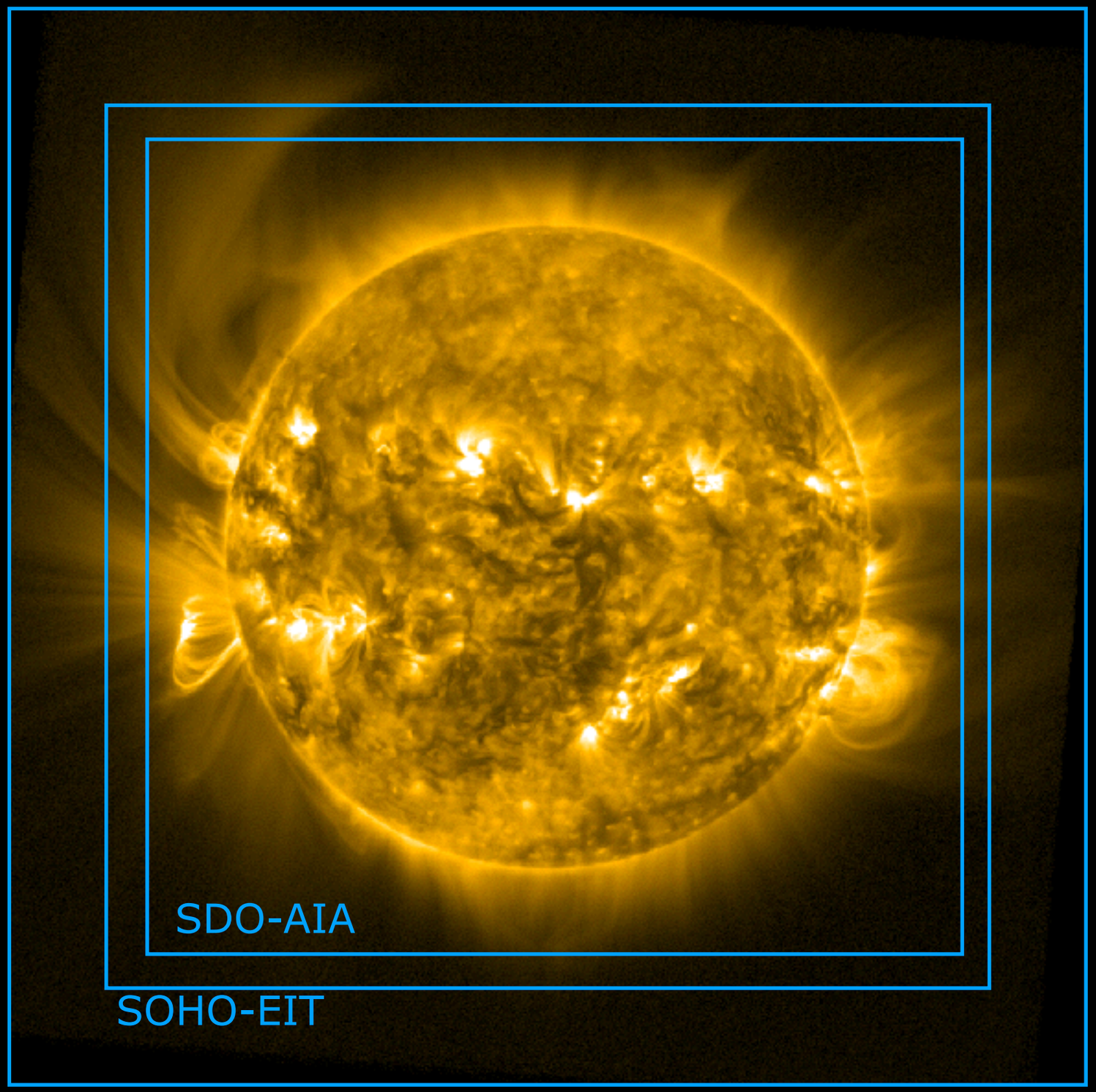
SOHO-EIT

The Large Field Of View (FOV)



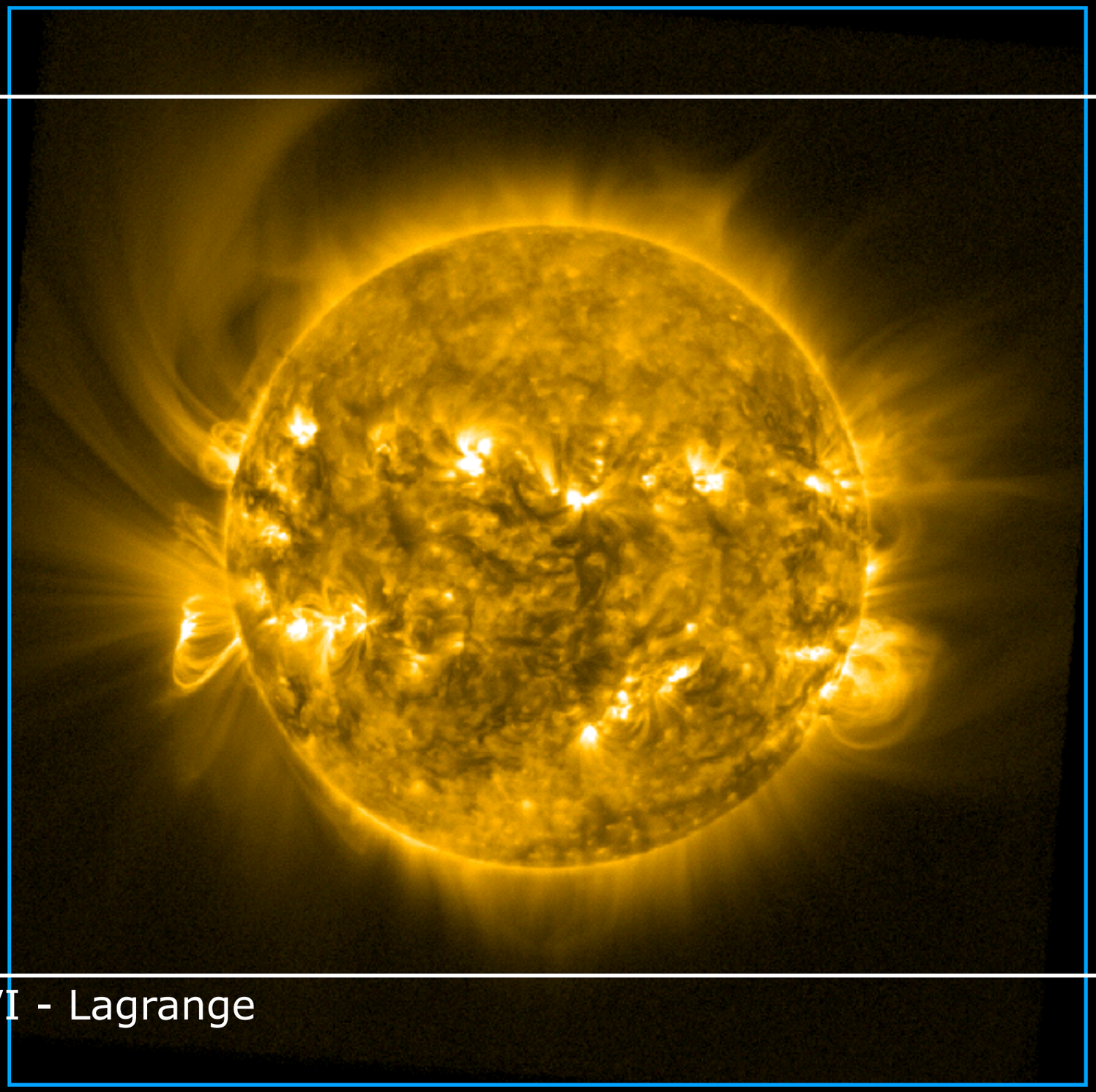
PROBA2 - SWAP

The Large Field Of View (FOV)



Solar Orbiter – FSI (Potential at perihelion)

The Large Field Of View (FOV)



EUVI - Lagrange

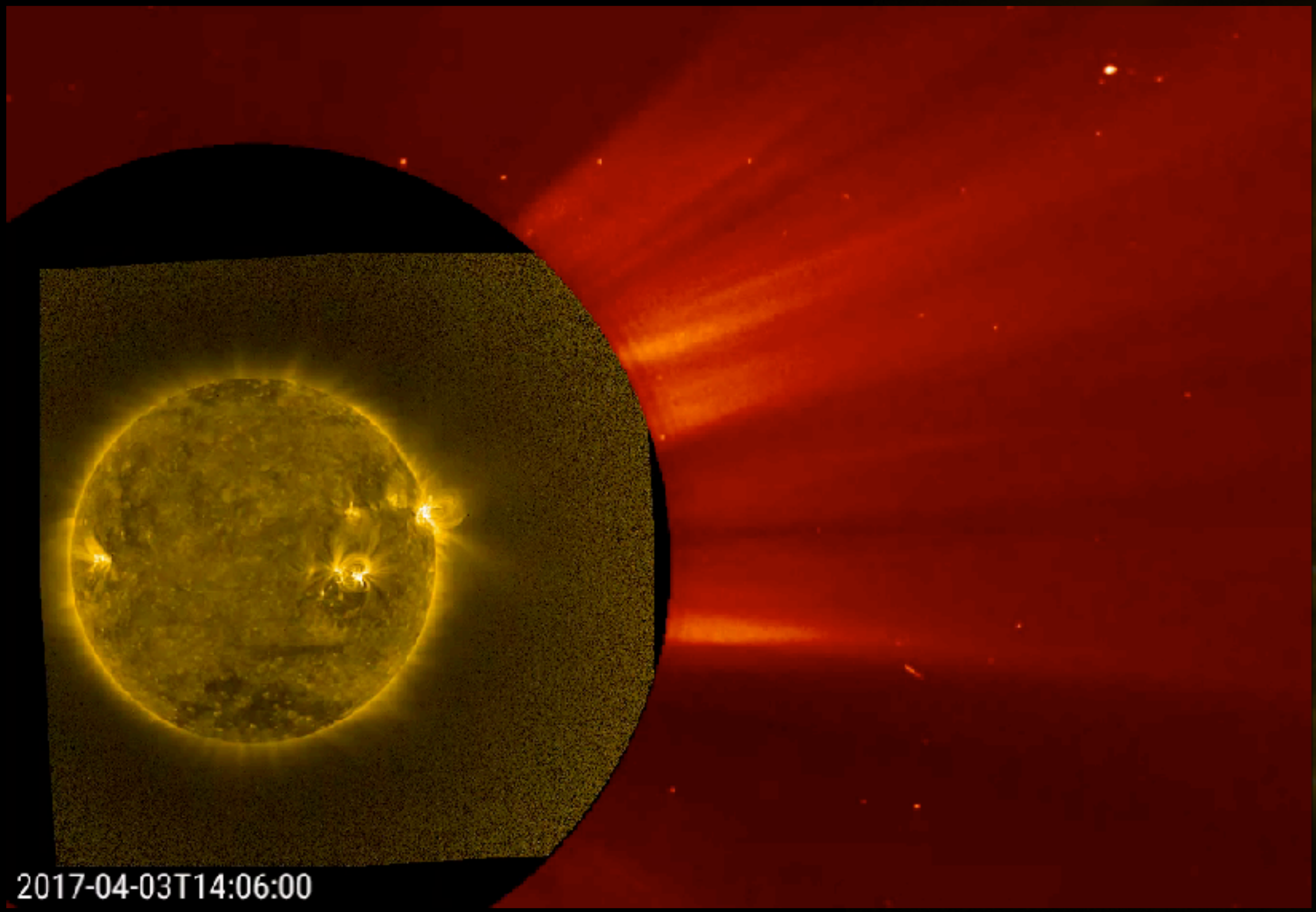
PROBA2 - SWAP

The Large Field Of View (FOV)

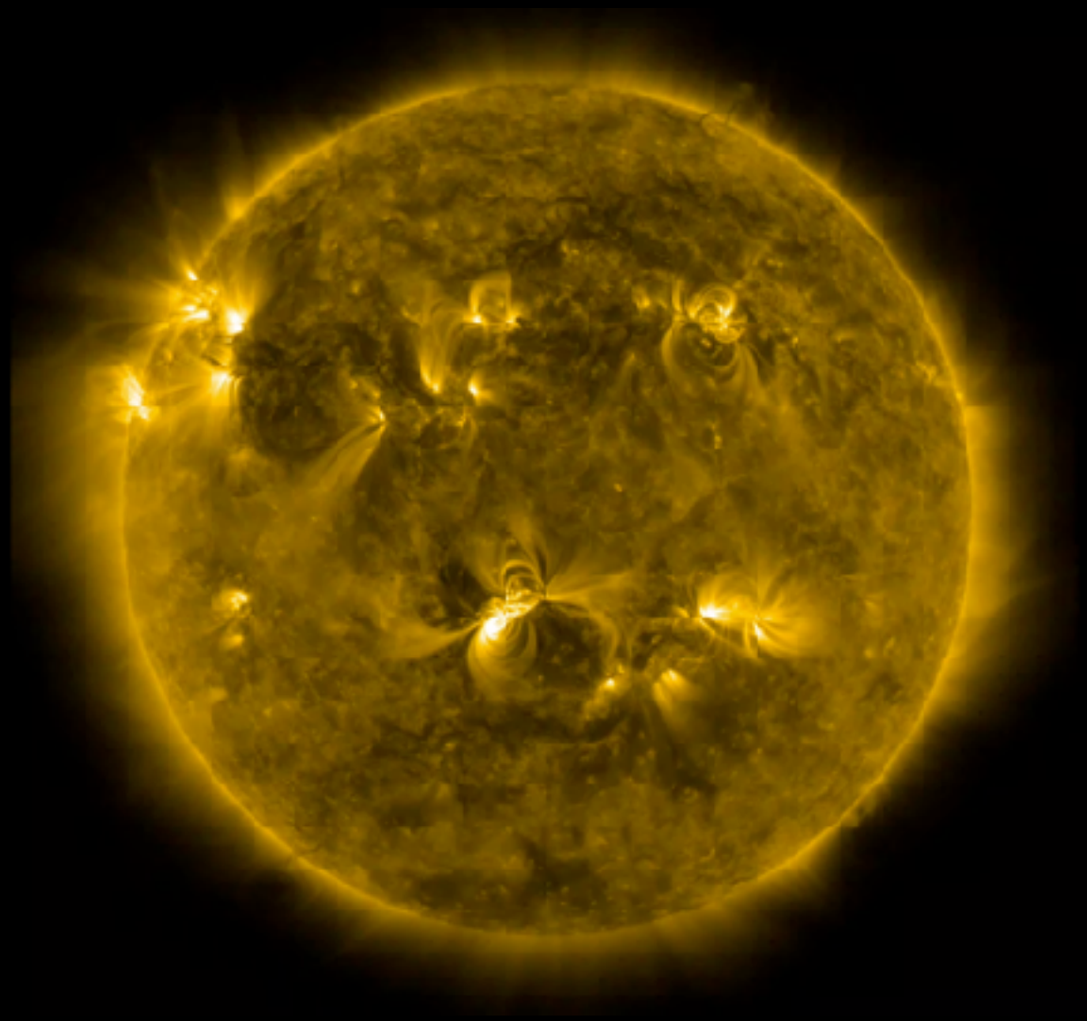
EUVI - Lagrange

PROBA2 - SWAP

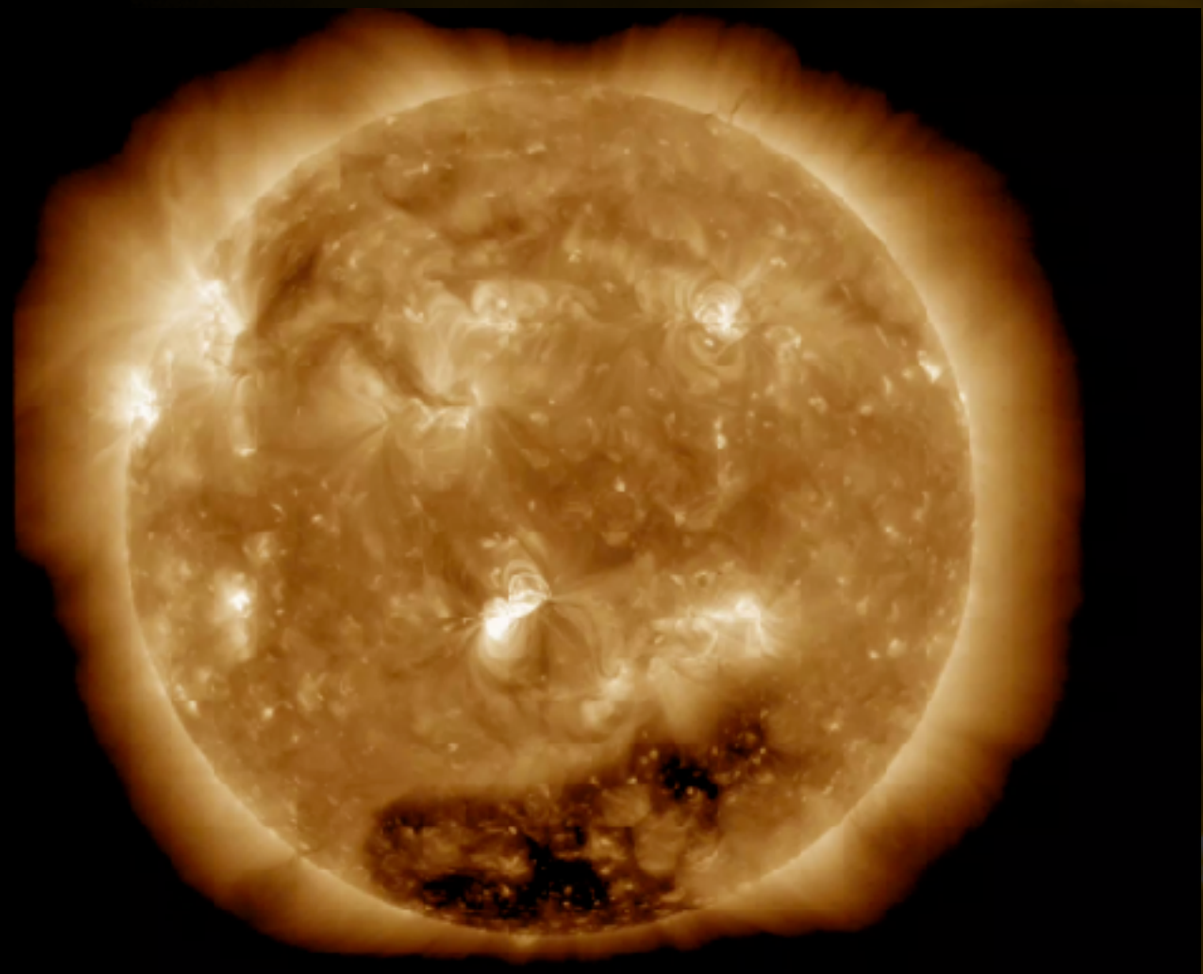
The Large Field Of View (FOV)



Change of Wavelength



17.4 nm

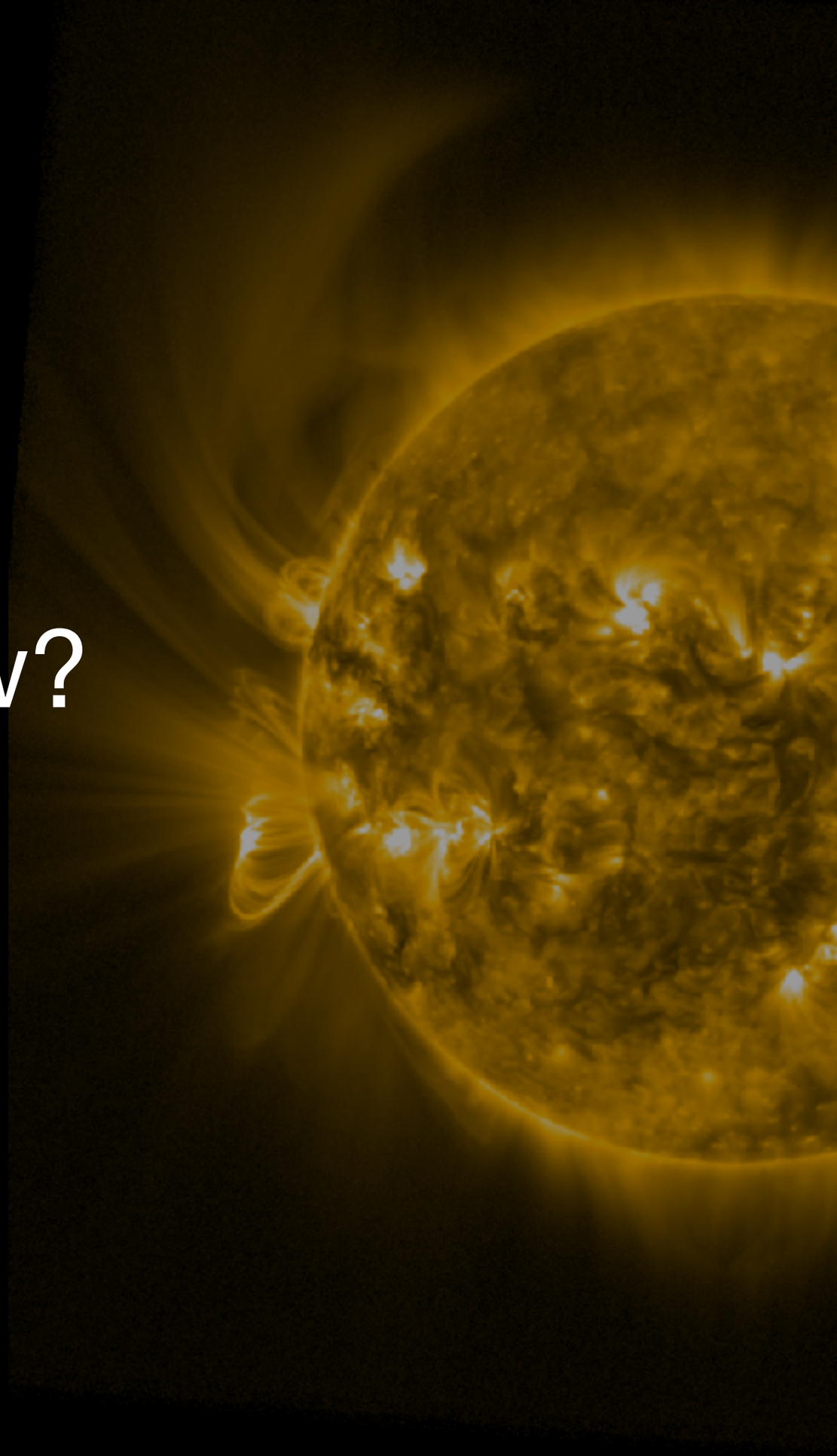


19.5 nm

SWAP next to EUVI

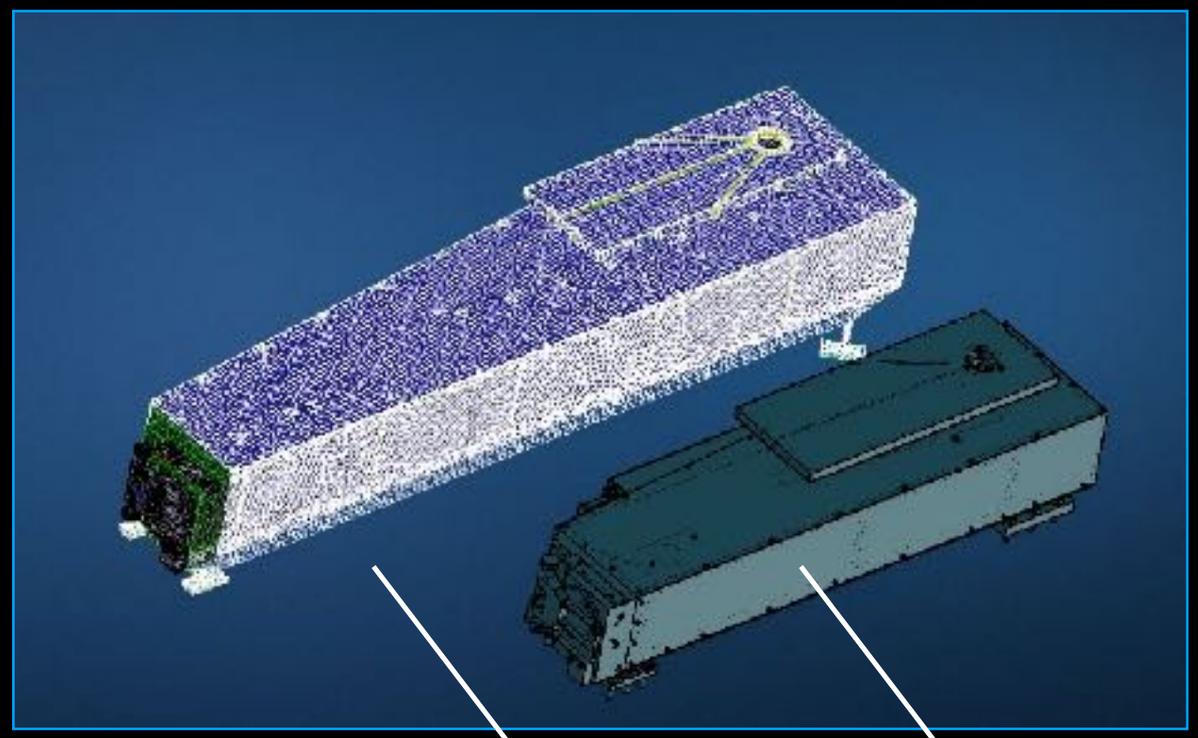
	SWAP	EUVI
Power	<5 W	Similar
Length	565 mm	800 mm ish
weight	11kg	15-20kg ish
resolution	1024x1024 3.2 arcsec / pixel	2300x1600 1.6 arcsec / pixel
FoV	54 x 54 arcmin	63 x 44 arcmin
Wavelength channels	17.4 nm	19.5 nm

Where Are We Now?



Where Are We Now?

Boring Engineering Slides - unless you're into that sort of thing ;)



CAD model EUVI SWAP

SWAP-like EUVI design

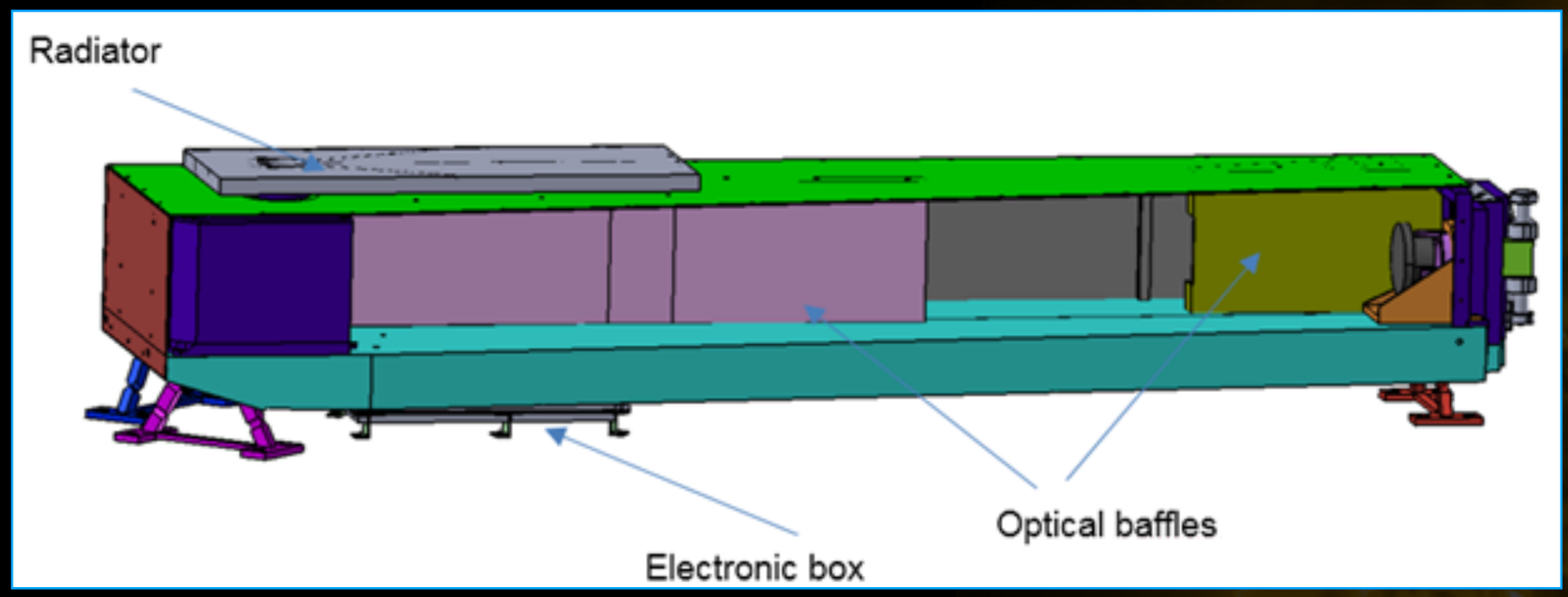
Extend optical bench to new focal length

Extend FPA Module to EUI Detector (in work)

Update housing to fit with bench and FPA extension Radiator

Where Are We Now?

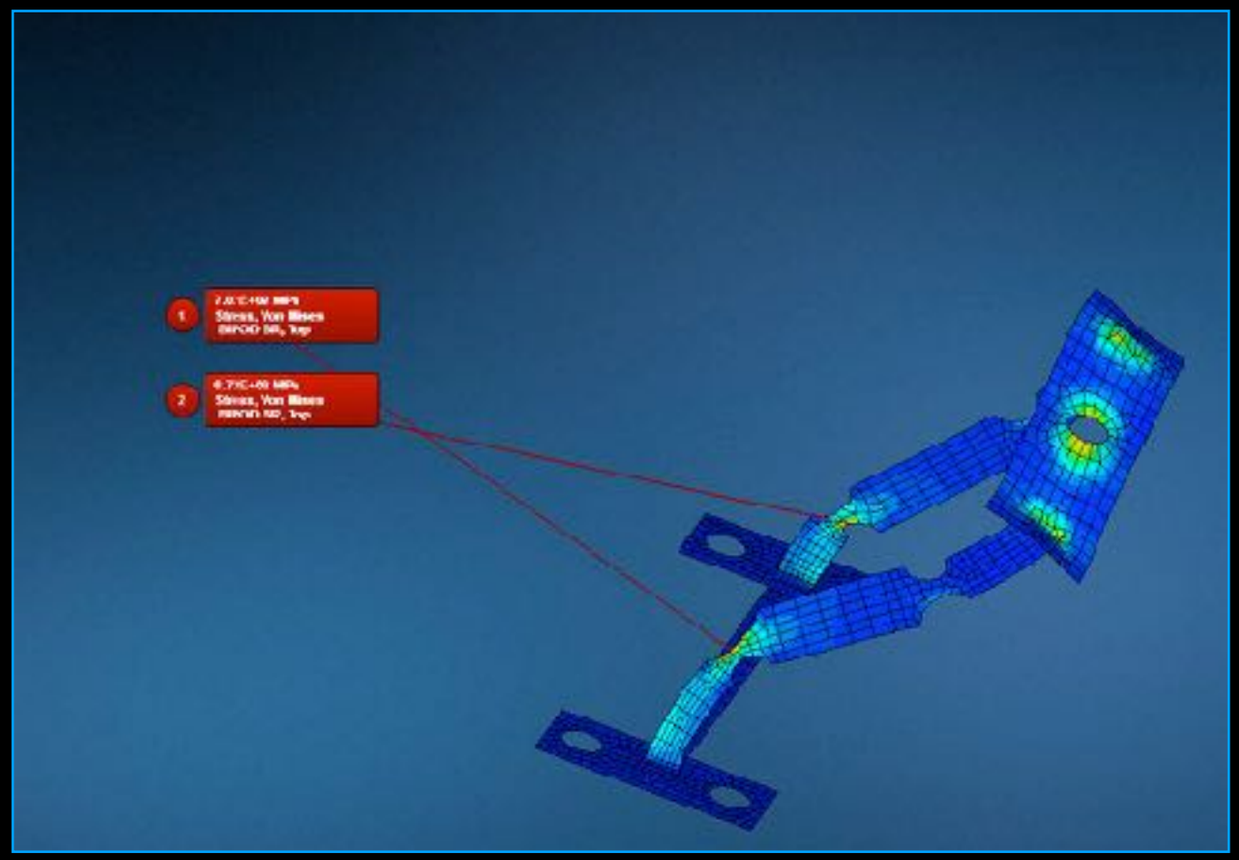
Mechanical Configuration

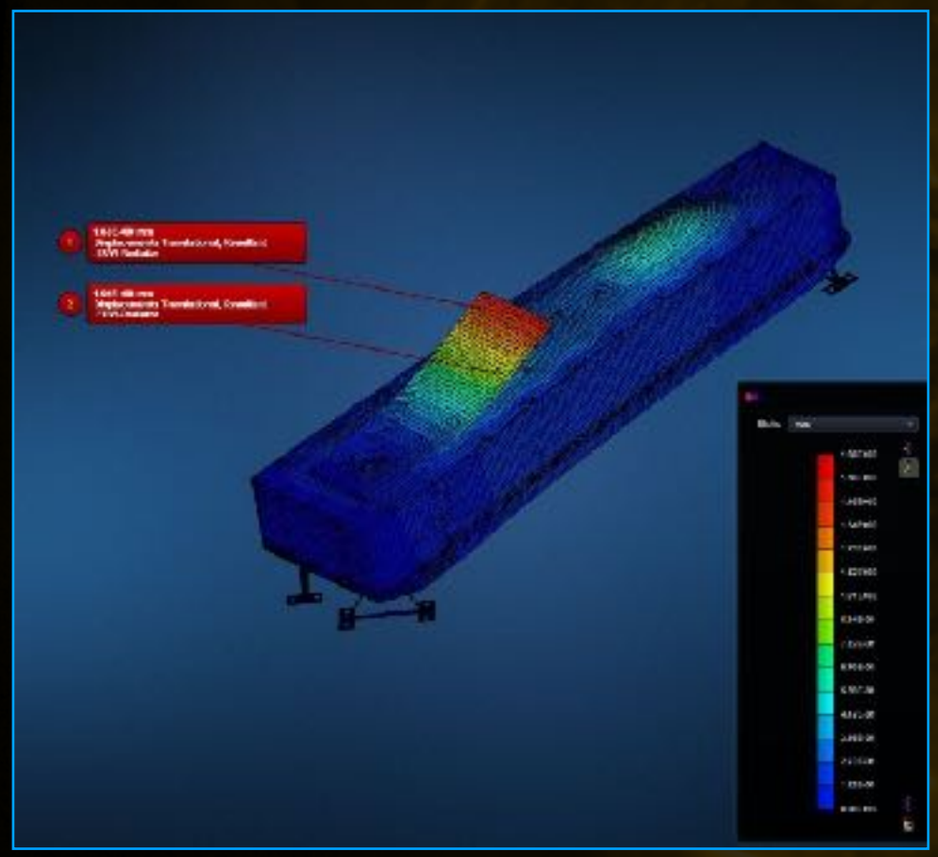


SWAP-like design
Monochromatic
Optical bench-like structure
Typical mounts to hold optics
Invar bench
Radiator dedicated to single detector

Where Are We Now?

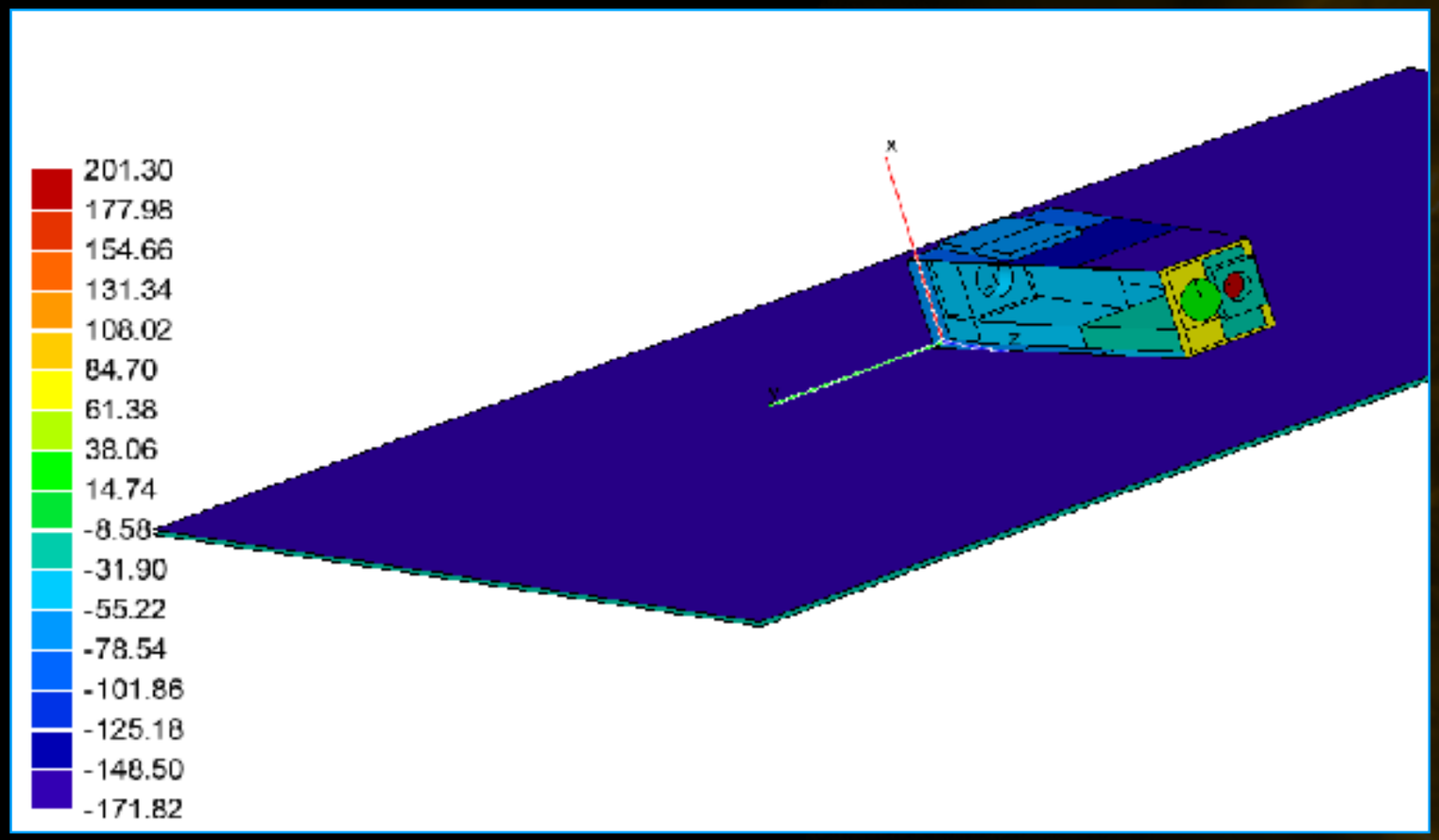
Stress & Displacement Simulations





Where Are We Now?

Thermal Analysis



Thanks For Listening