

Solar Orbiter

Mission Overview and Science Highlights

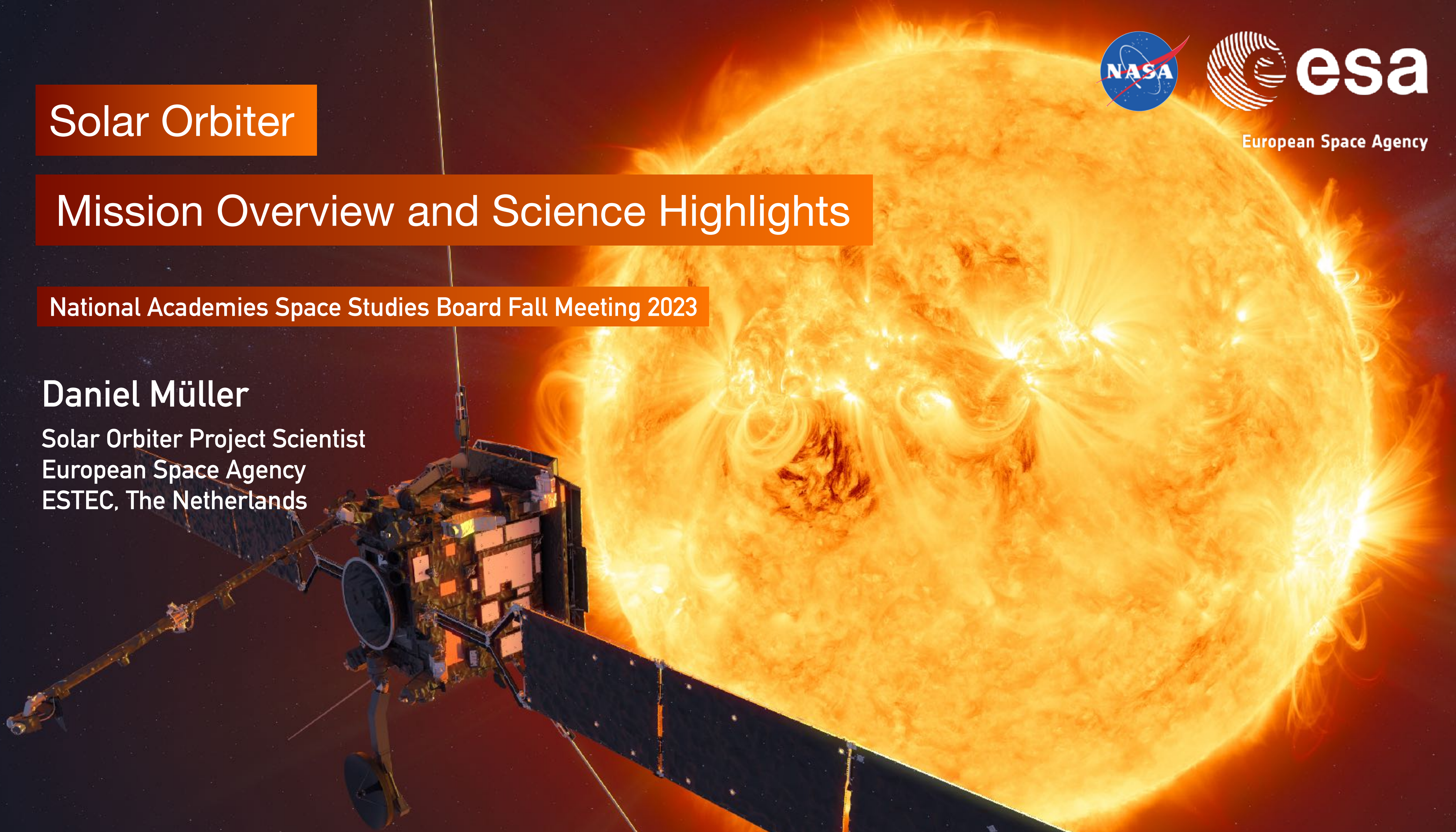
National Academies Space Studies Board Fall Meeting 2023

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Solar Orbiter: Exploring the Sun and heliosphere

How does the Sun create and control the heliosphere – and why does solar activity change with time?

Observations

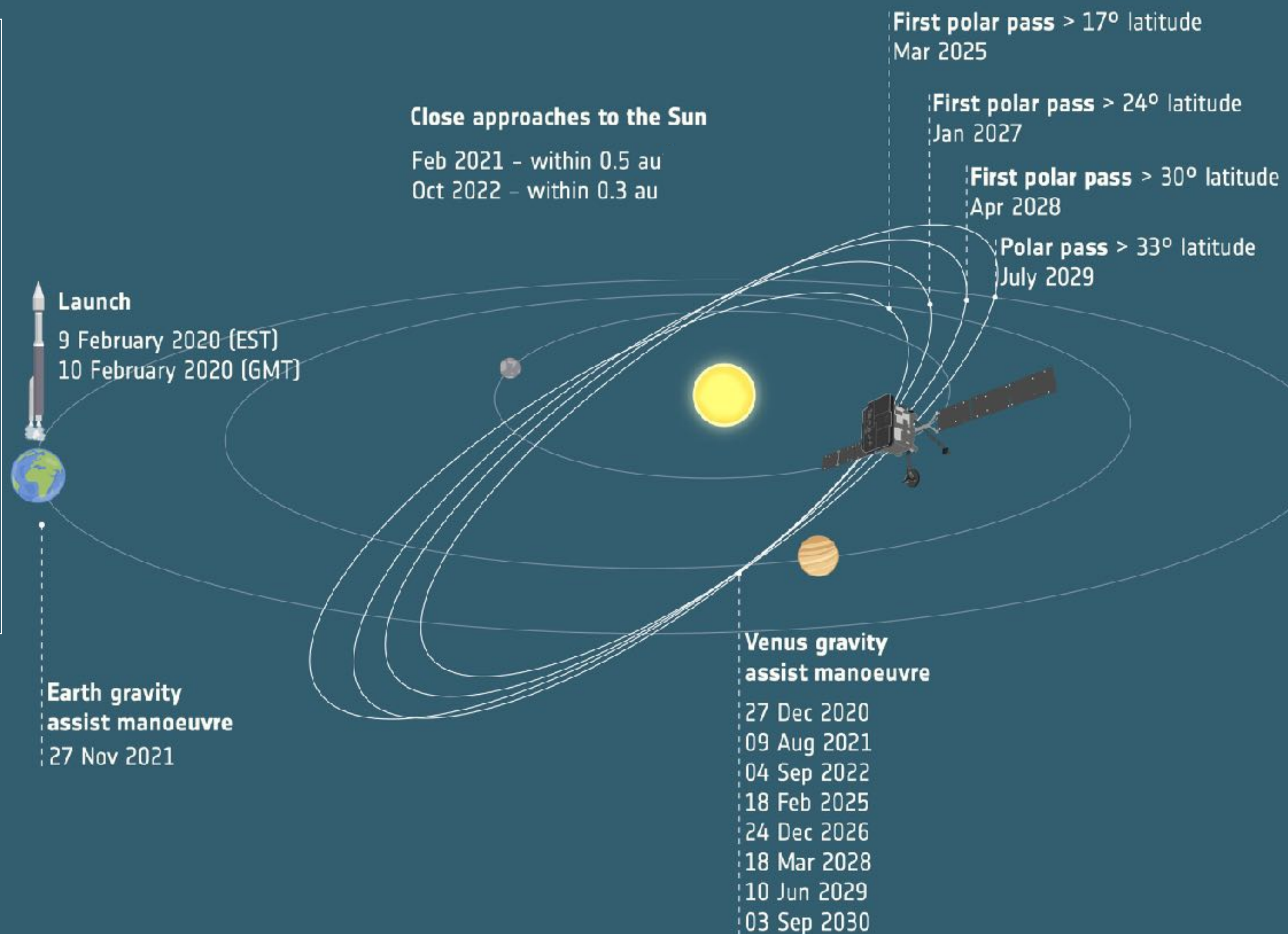
- In situ: Measurements of the solar wind plasma, fields, waves and energetic particles as close as 0.28 au
- Remote-sensing:
 - Observe the entire Sun in visible light, UV, X-rays, including (later in the mission) its uncharted polar regions
 - Simultaneous high-resolution imaging and spectroscopy
 - Vector magnetic field of solar photosphere
 - Image the corona and heliosphere





Mission Summary

- Launch: Feb 2020
- Nominal Mission Phase: Dec 2021-Dec 2026
- Orbit: 0.28-0.91 au (period: 150-180 days)
- Four close perihelia so far, latest one on 7 October 2023 @0.29 au
- Polar views: Venus GAMs will increase inclination w.r.t. solar equator:
24° in Jan 2027 (start of extended mission),
33° in July 2029





Mission Timeline



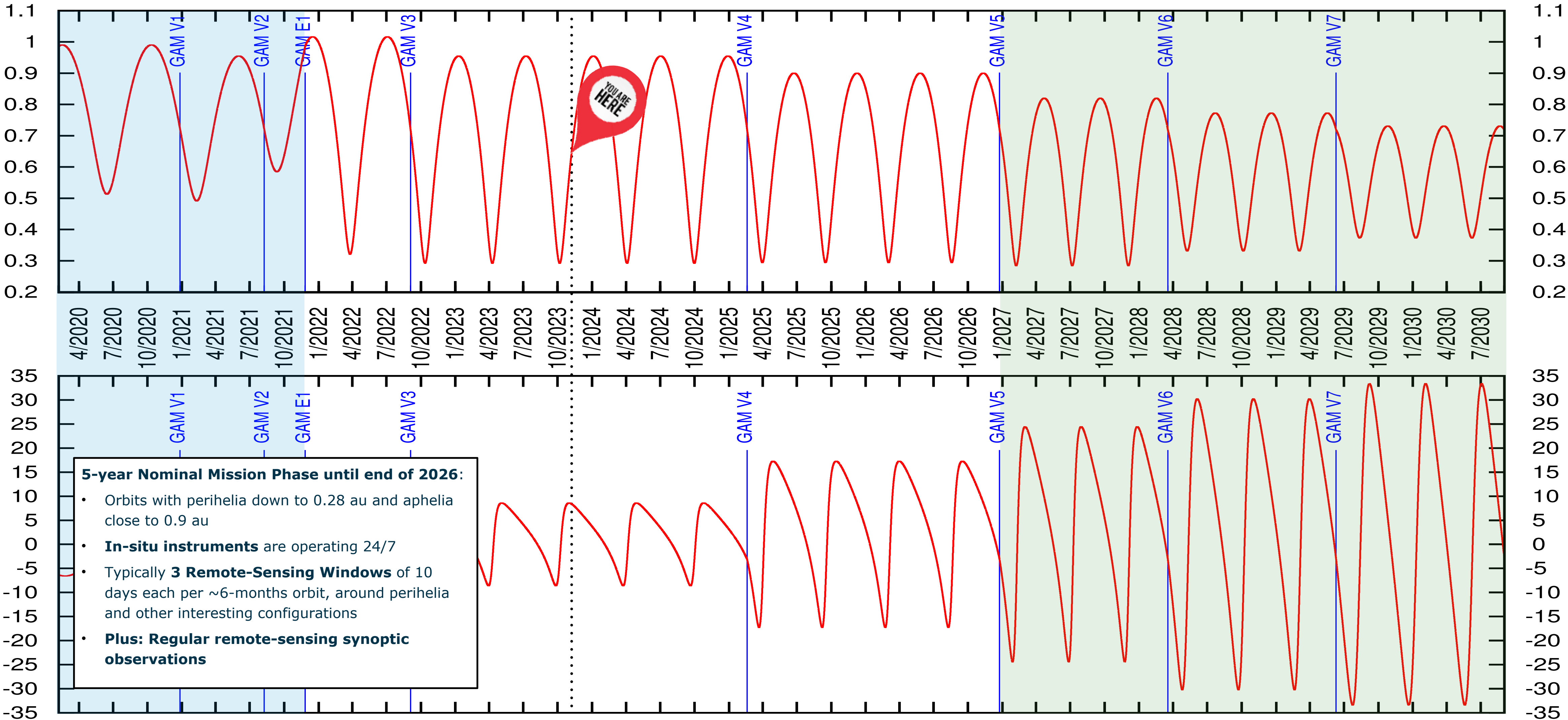
Distance to Sun [AU]

Cruise

Nominal Mission

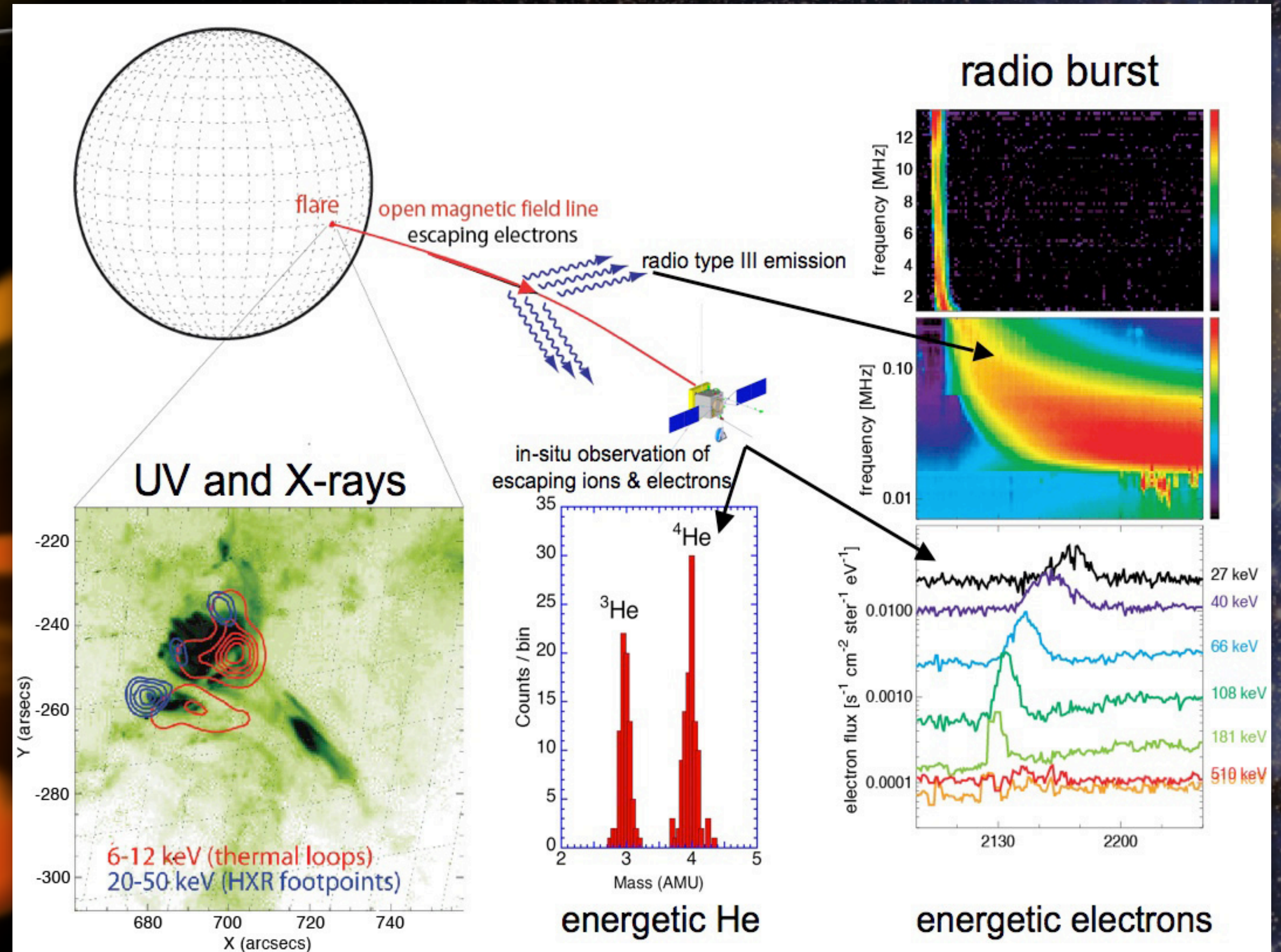
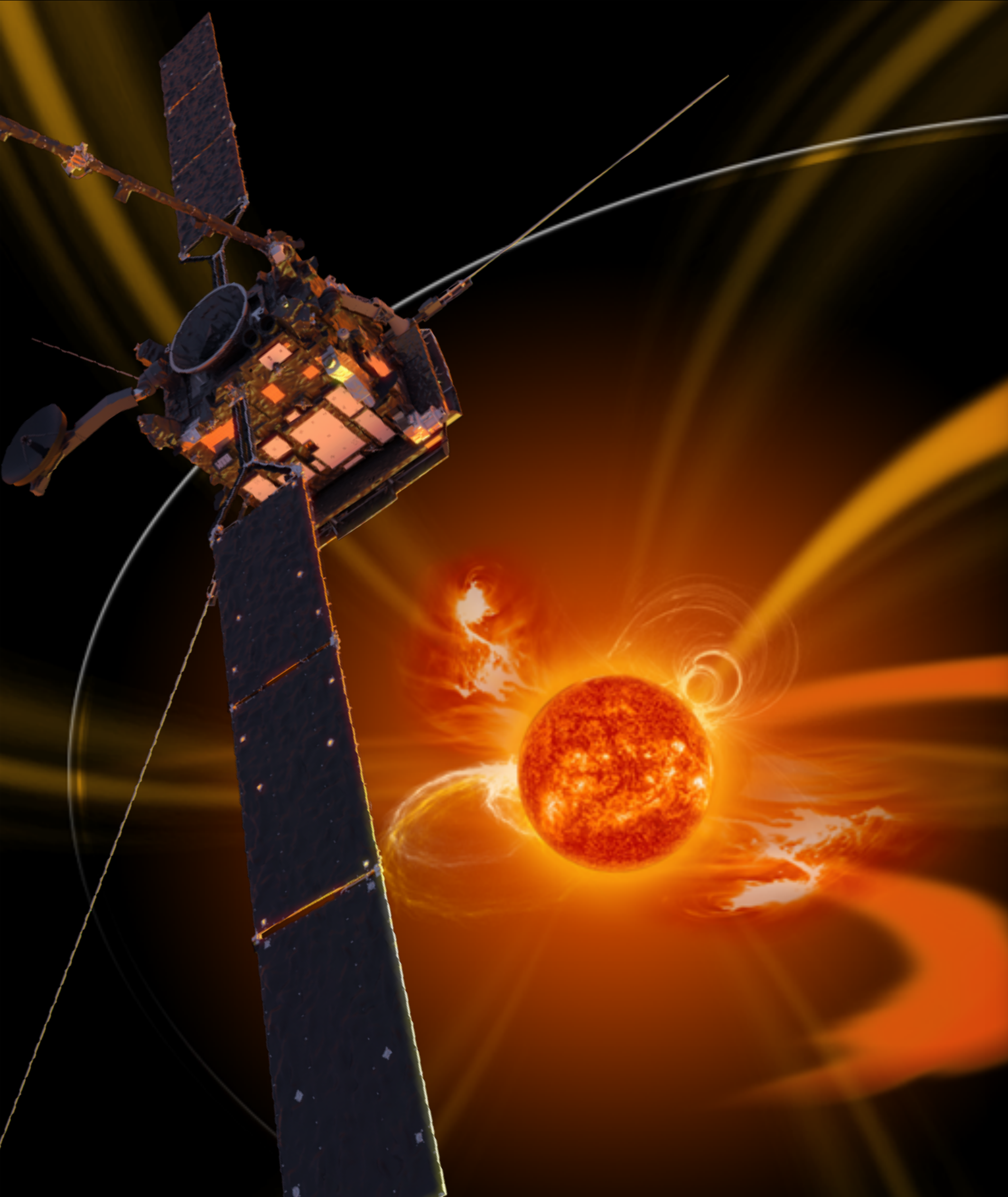
Extended Mission

Solar Latitude [deg]





Goal: Linking the Sun to the heliosphere



Goal: Linking the Sun to the heliosphere ✓

JOINING THE DOTS

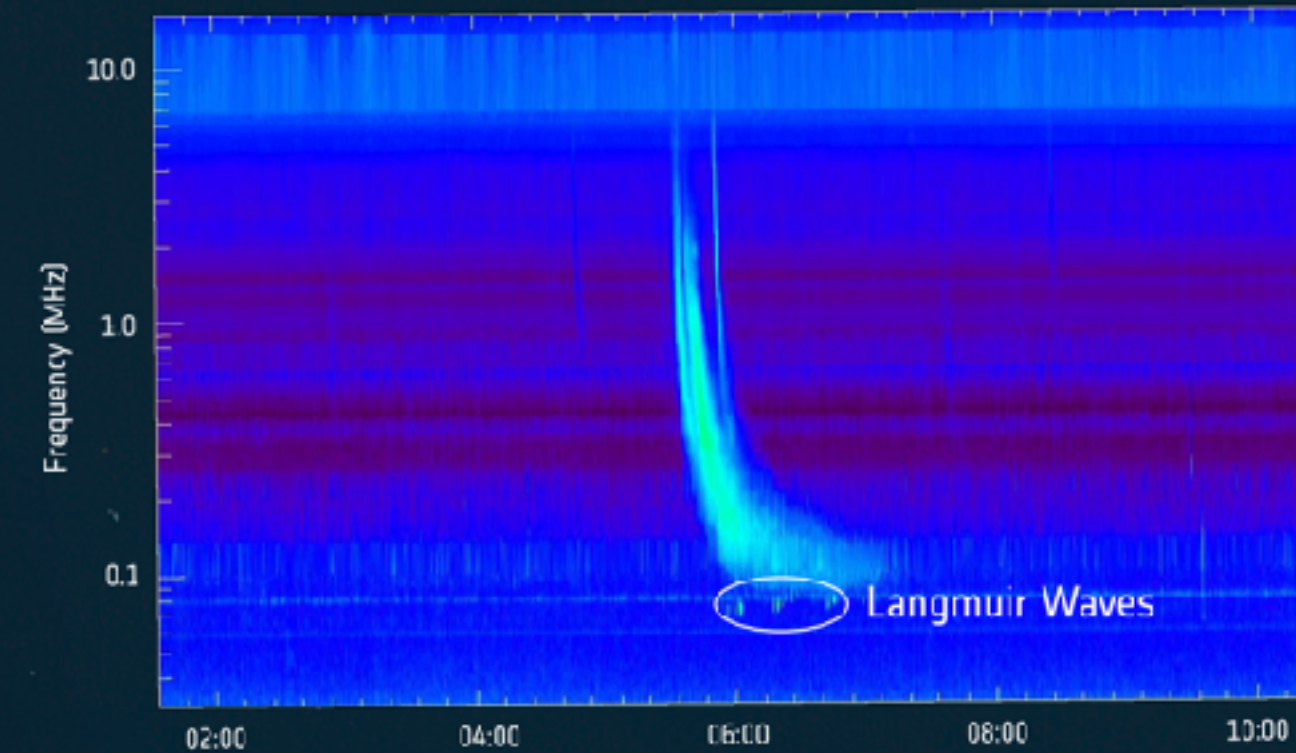
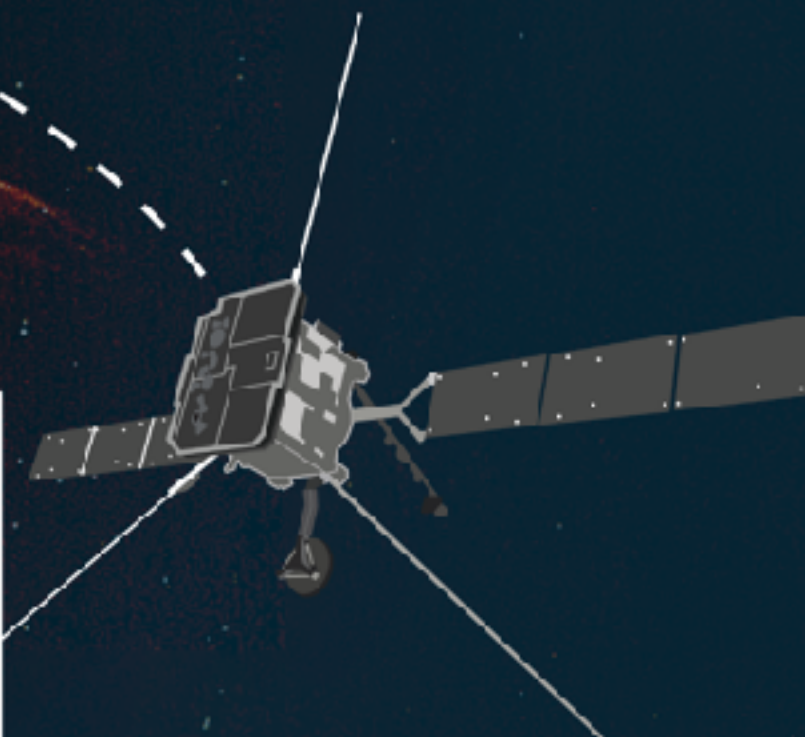
Solar Orbiter traced an energetic particle event on 21 March 2022 from the Sun through the solar wind



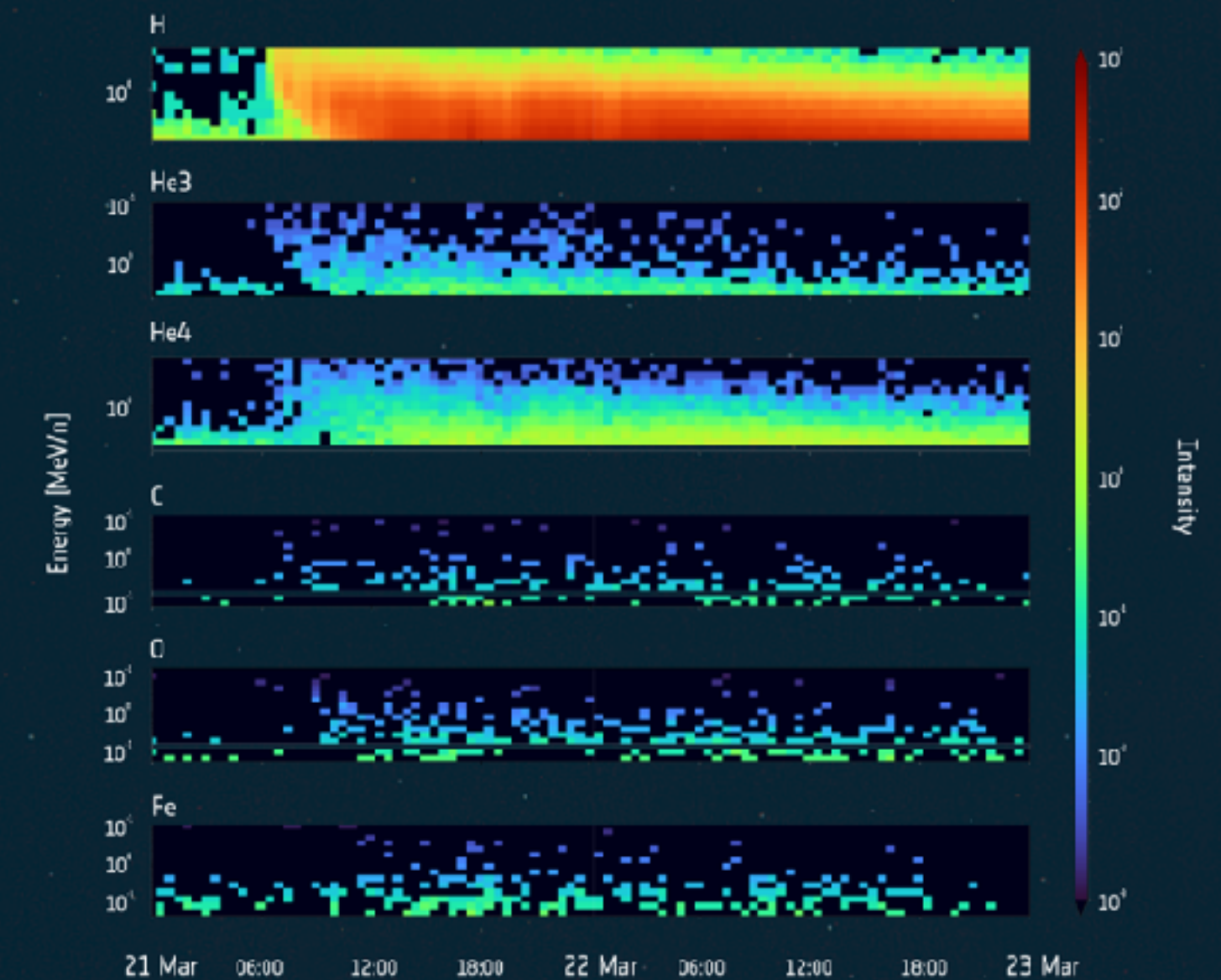
EUI & STIX observe eruption rising over solar limb in extreme ultraviolet and X-rays

Particles spiraling out on Sun's magnetic field lines reach Solar Orbiter

EUI: Extreme Ultraviolet Imager
EPD: Energetic Particle Detector
RPW: Radio and Plasma Waves
STIX: X-ray Spectrometer/Telescope



RPW detects radio signals of accelerated particles and plasma oscillations

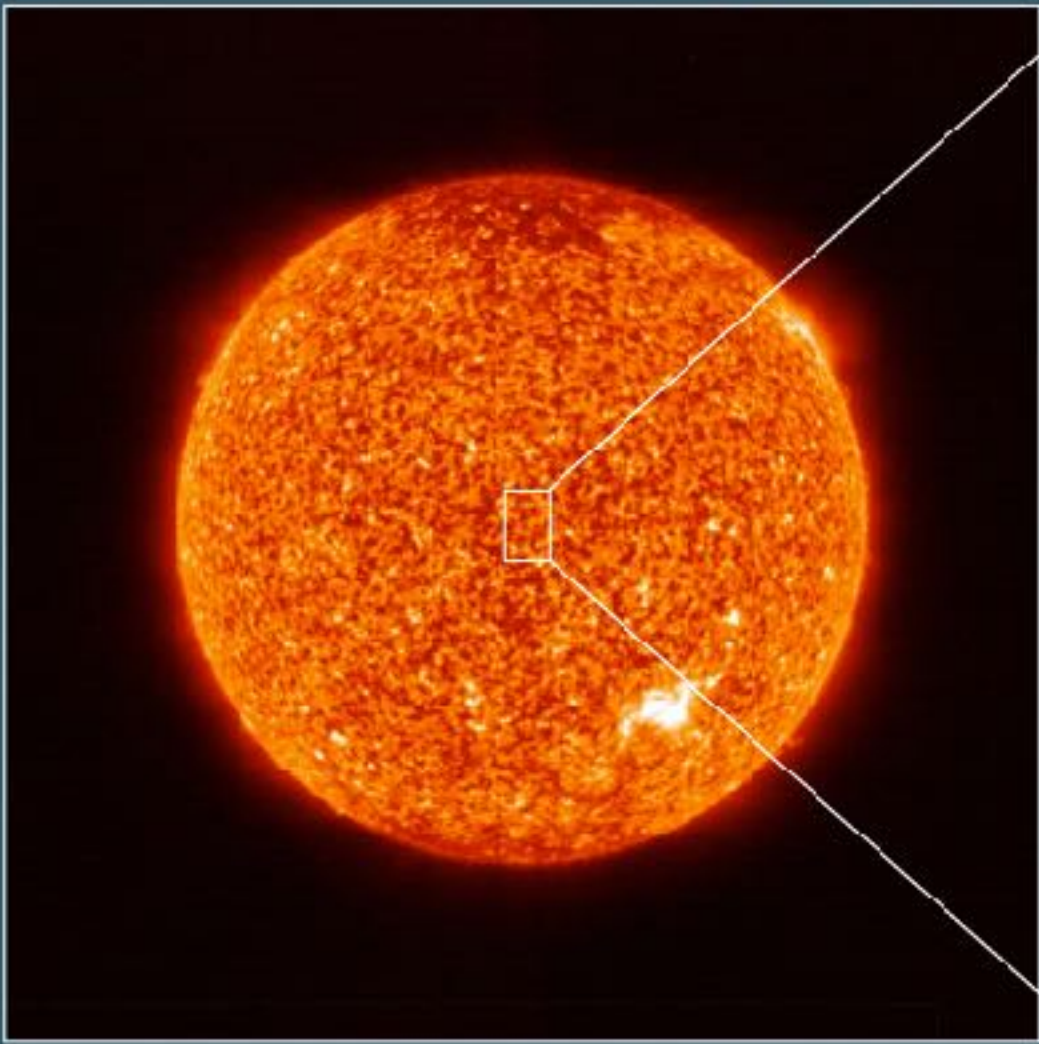


EPD detects particles with various composition and energy

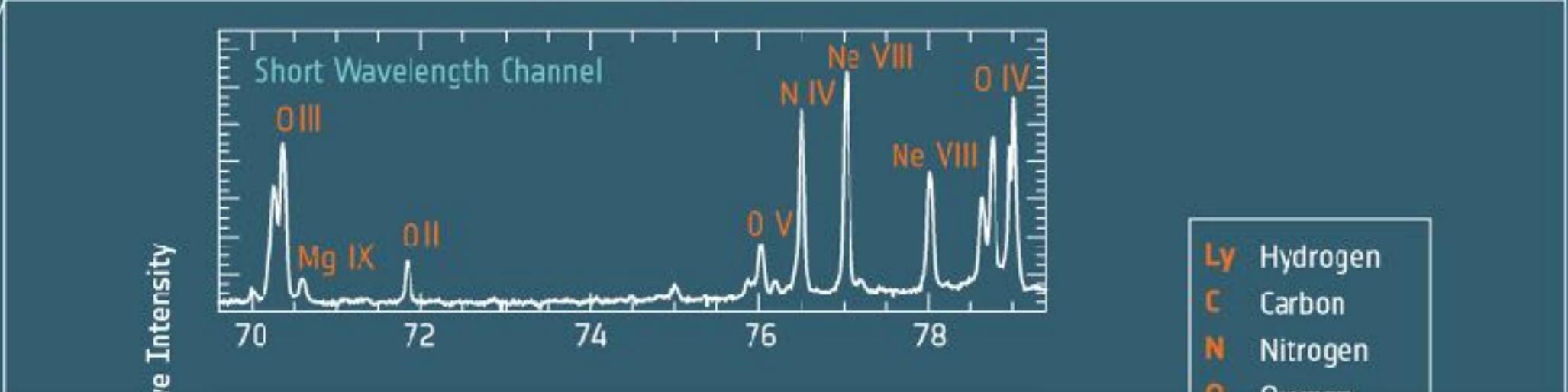
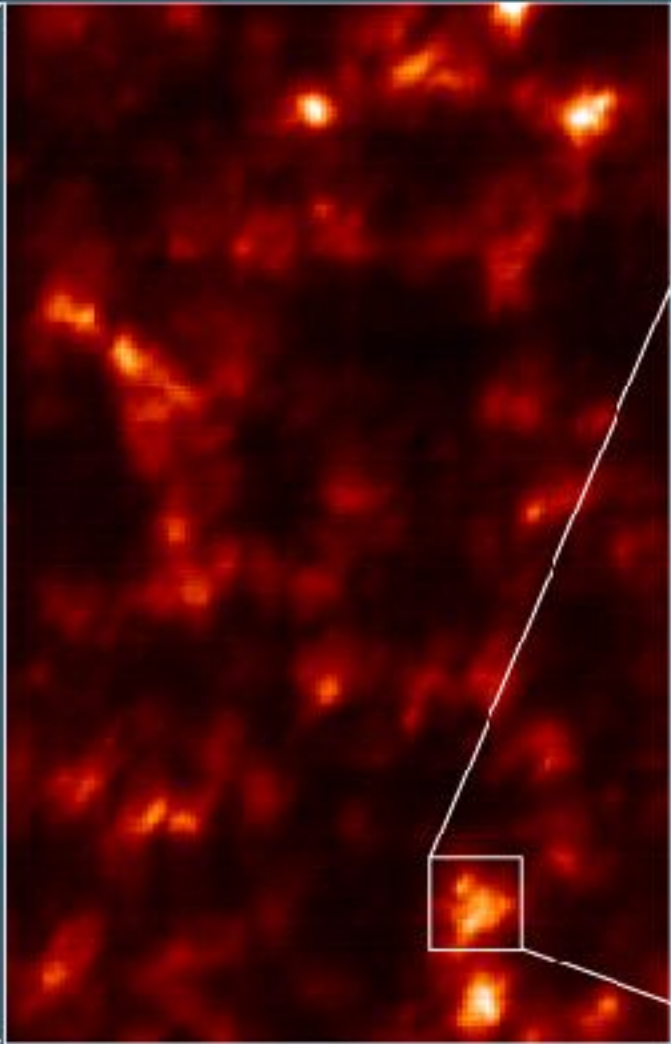


Both sets of data are used to piece together a more complete picture of what is happening on the Sun and in the solar wind, the flow of electrically charged particles that is continuously released by our star.

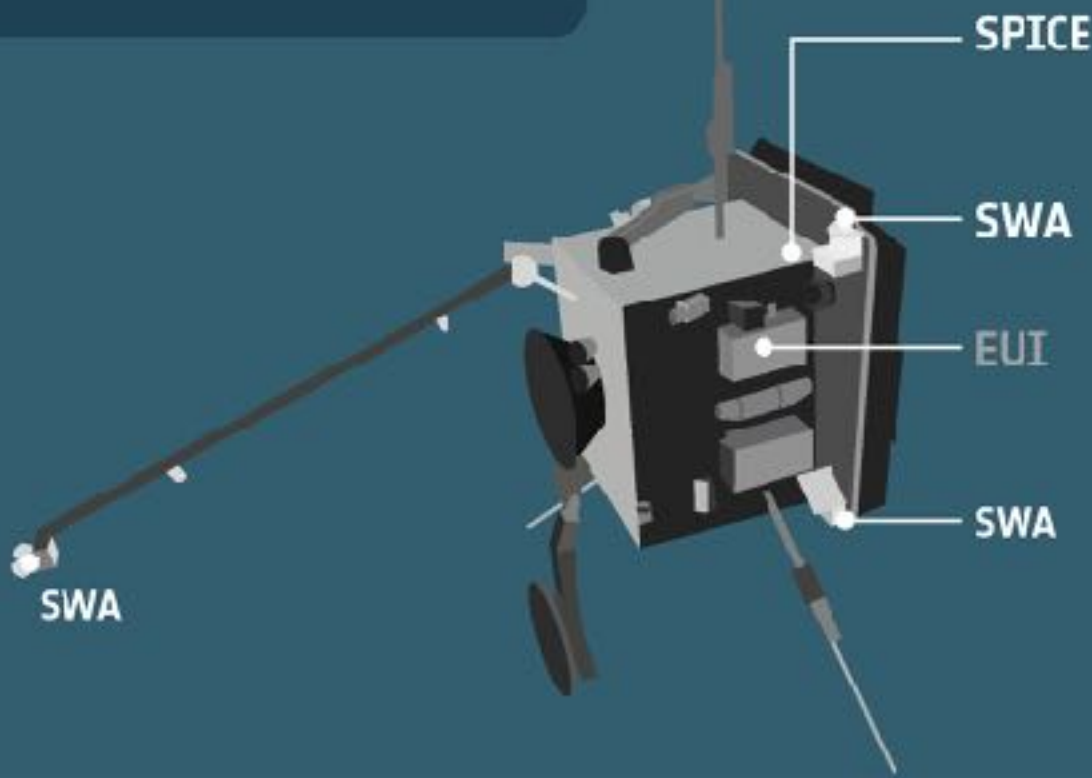
Extreme Ultraviolet Imager (EUI)



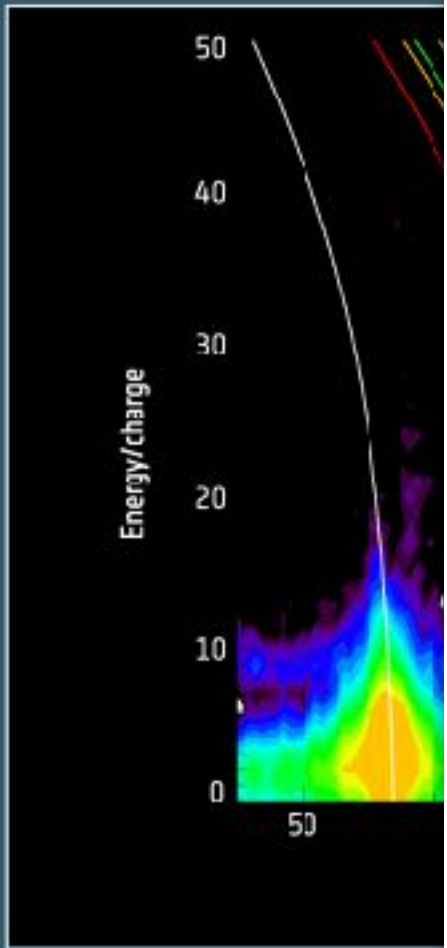
Spectral Imaging of the Coronal Environment (SPICE)



The **remote-sensing instruments** (such as EUI and SPICE) observe the Sun from afar



The **in situ instruments** (such as SWA) measure the electric and magnetic fields, and the particles near the spacecraft



First paper on slow-wind connection science: Yardley et al. (ApJ 2023)

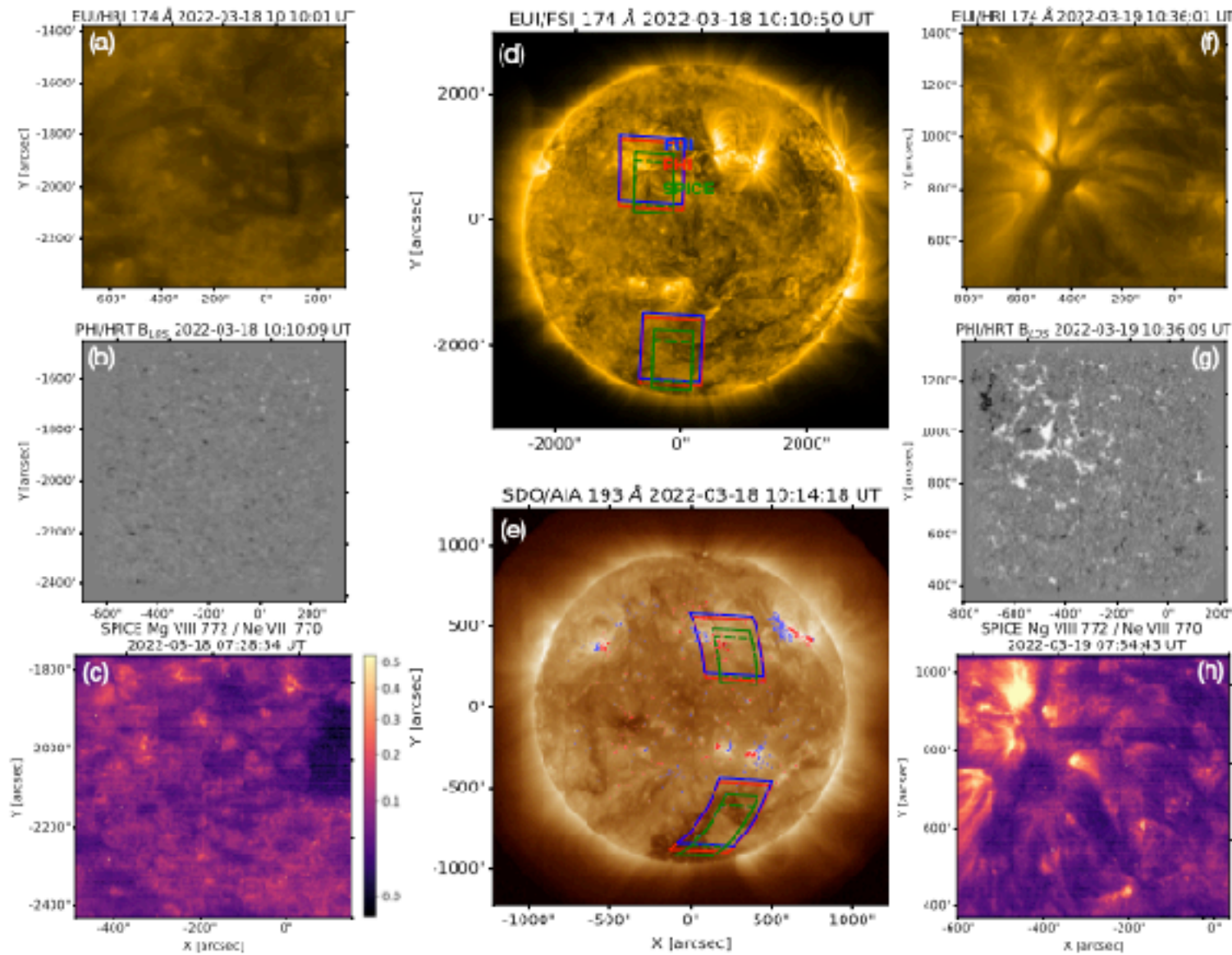
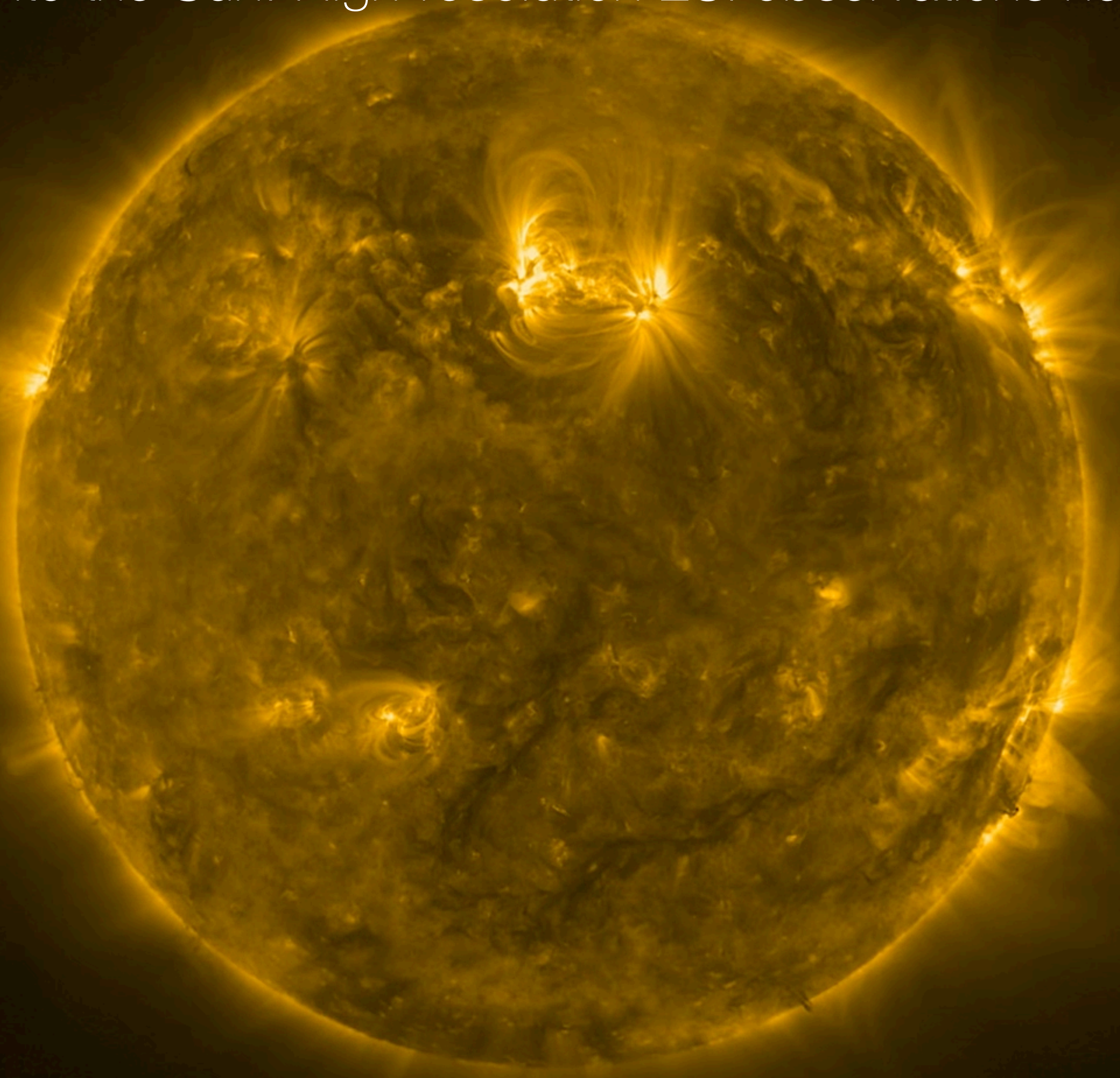


Figure 6. High-resolution data taken during RSW2 of the Slow Wind SOOP on 2022 March 18 (panels a–c) and 2022 March 19 (panels f–h). The FOVs of EUI/HRI, PHI/HRT and SPICE are shown in blue, green, and red on EUI/FSI 174 Å and SDO/AIA 193 Å data, similar to Figure 5.



Zooming into the Sun: High-resolution EUV observations near perihelion

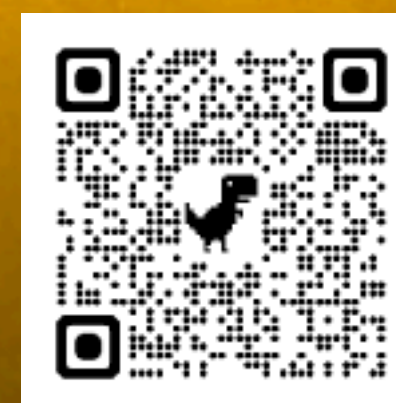




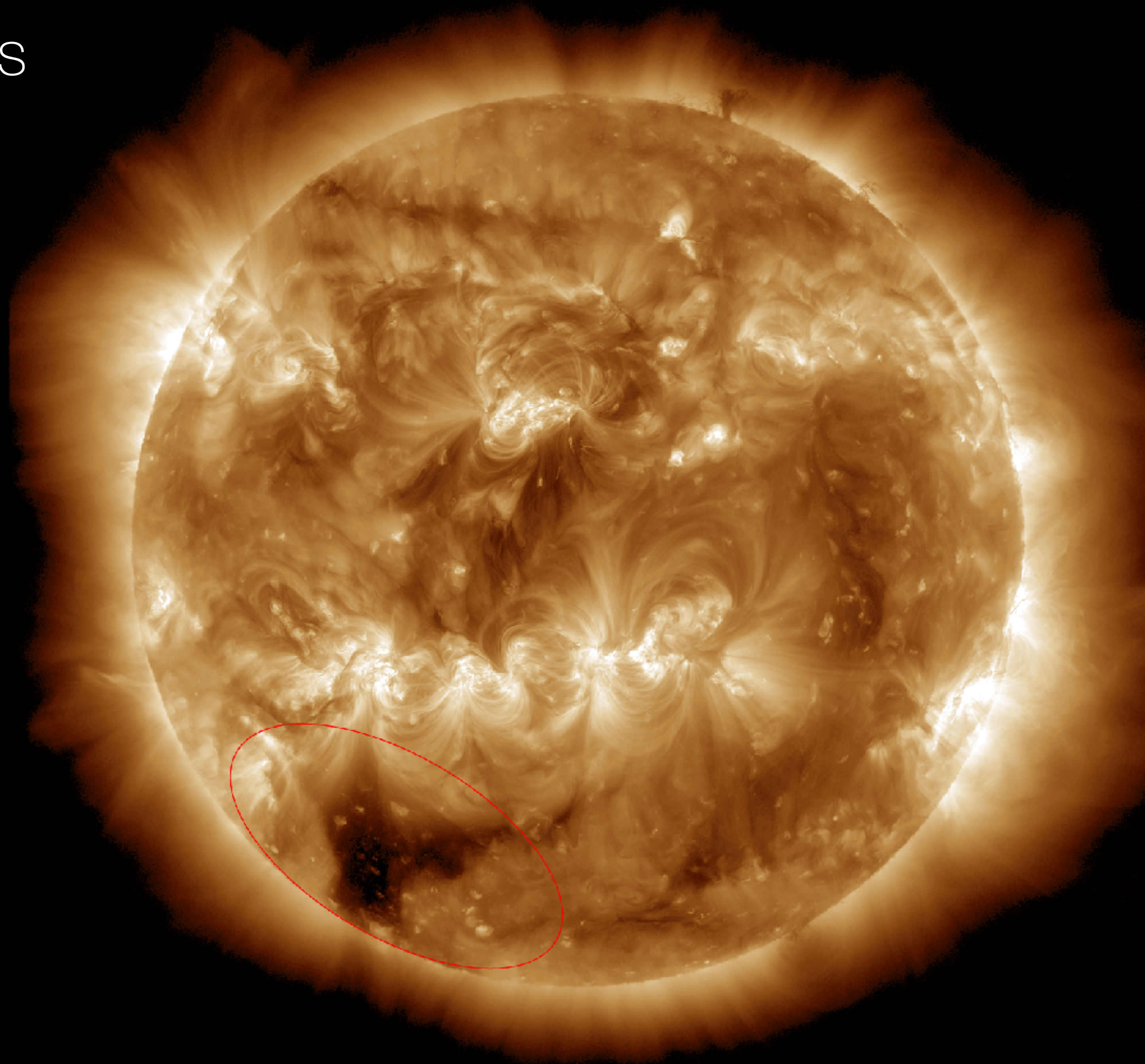
Picoflare jets power the solar wind emerging from a coronal hole on the Sun
Recent results by Chitta et al. (*Science* 2023)



Earth to scale



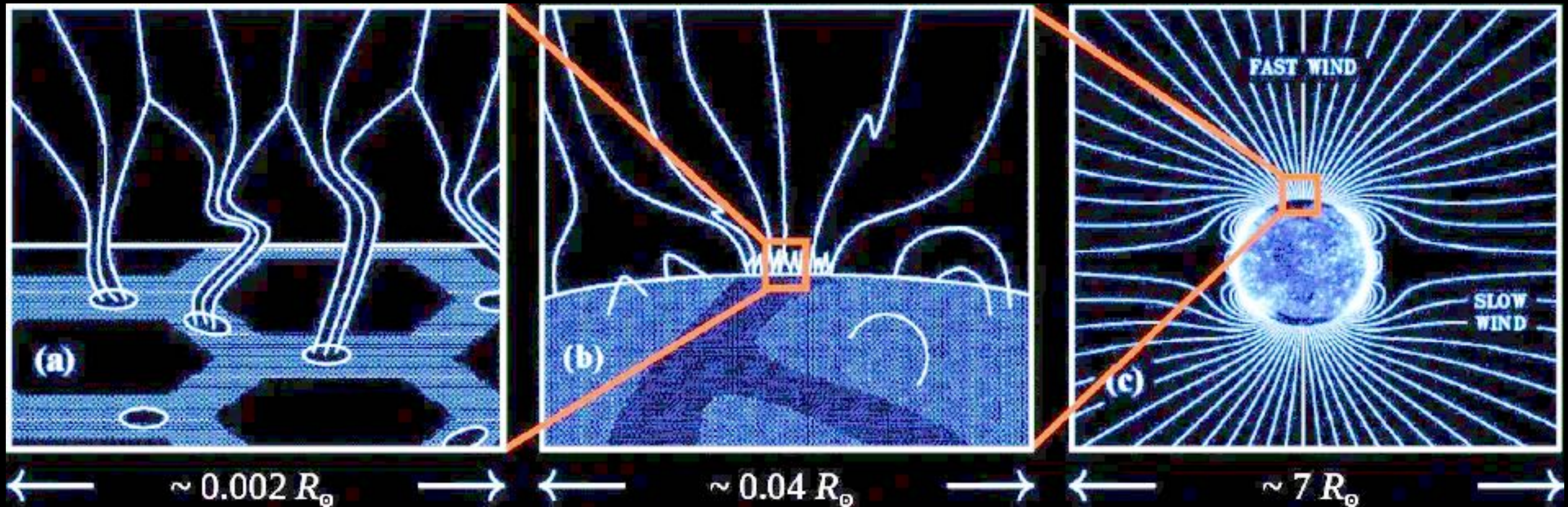
Coronal Holes



2023-04-18T06:47:52.843

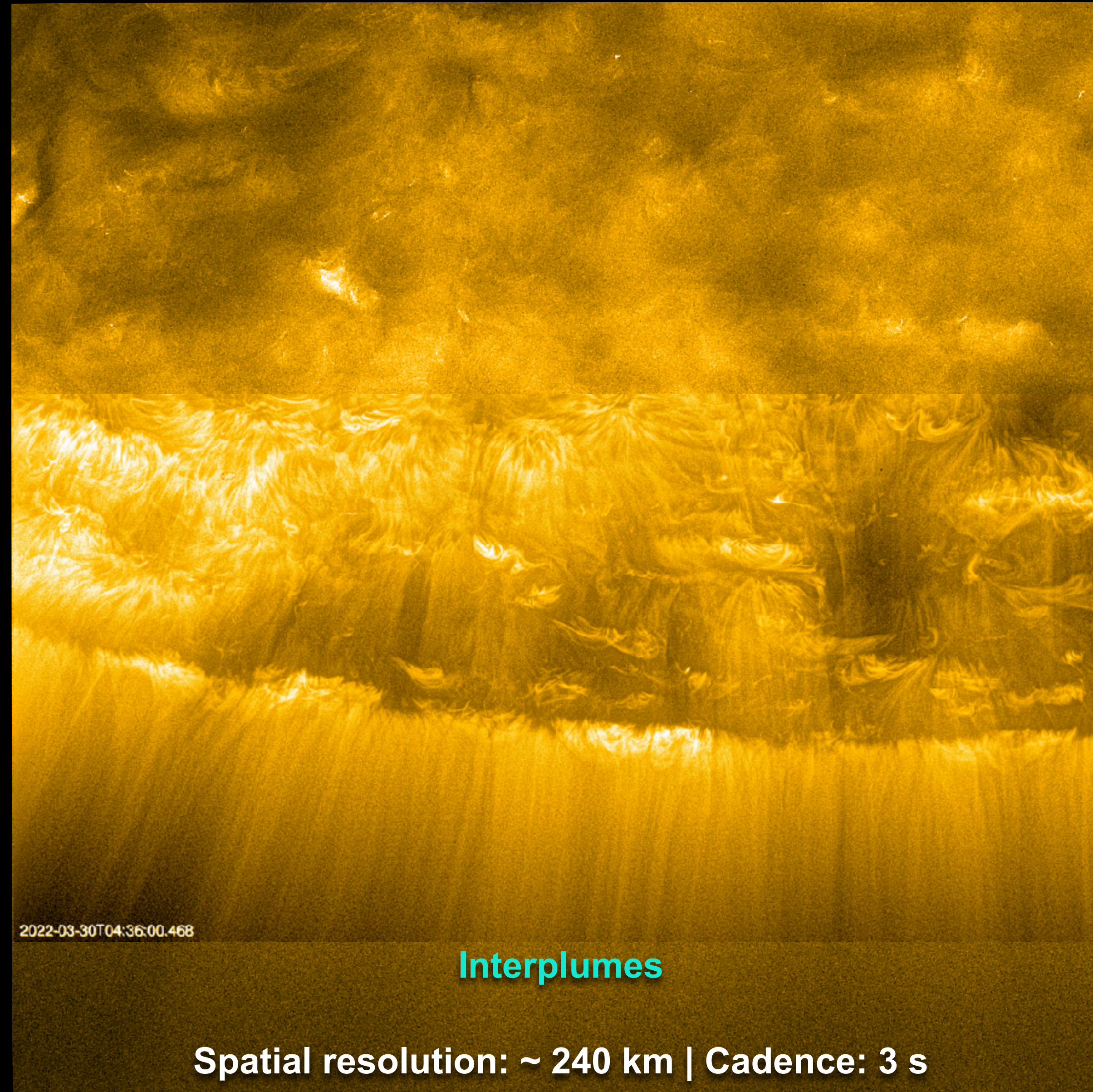
“Coronal holes are the darkest and least active regions of the Sun, as observed both on the solar disk and above the solar limb”

Cranmer, S. R. Coronal Holes. Living Rev. Sol. Phys. 6, 3 (2009)



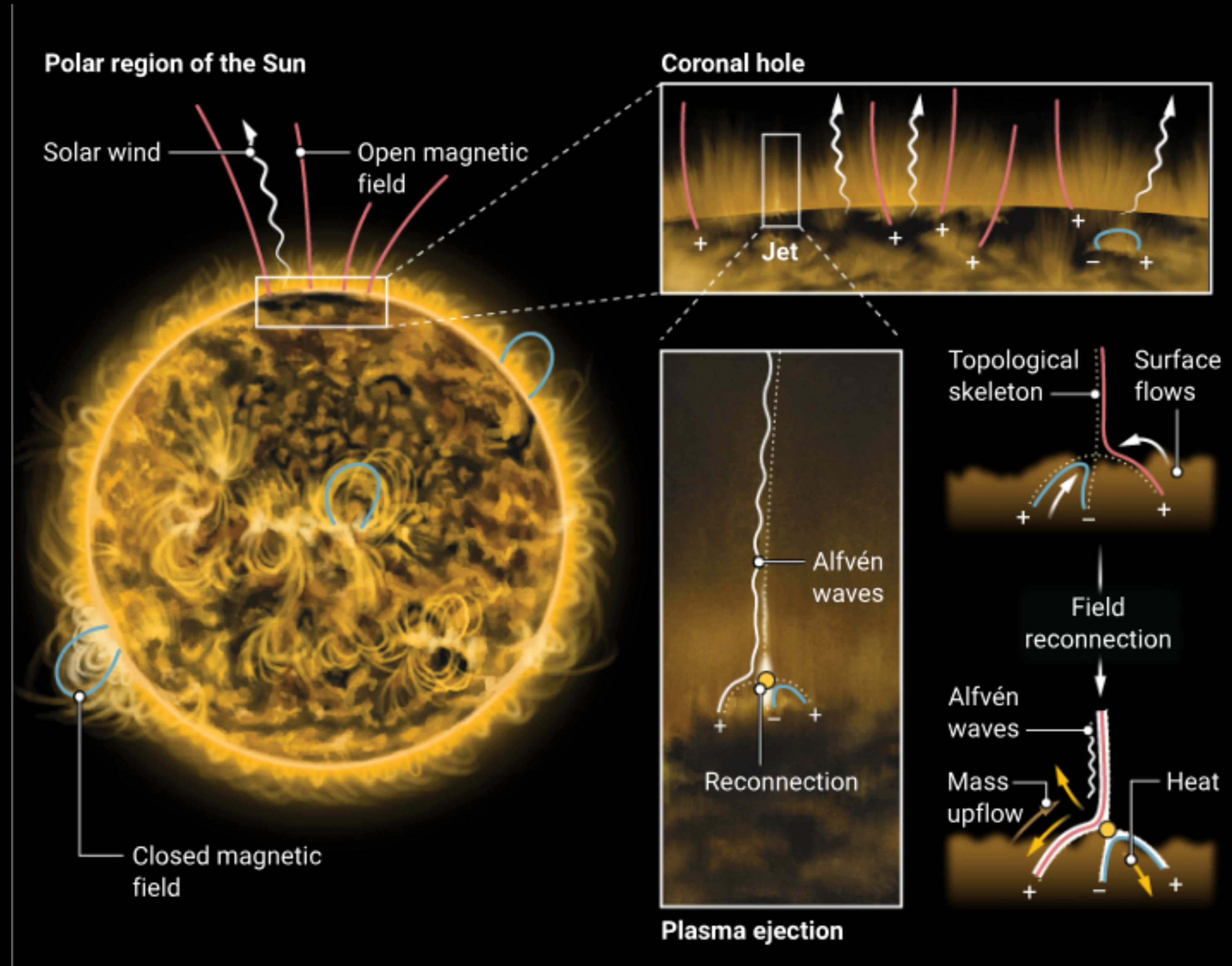
“The extended corona and solar wind connected with coronal holes tends to exist in an ambient time-steady state, at least in comparison with other regions.”

Coronal hole structures observed with EUV – a closer look



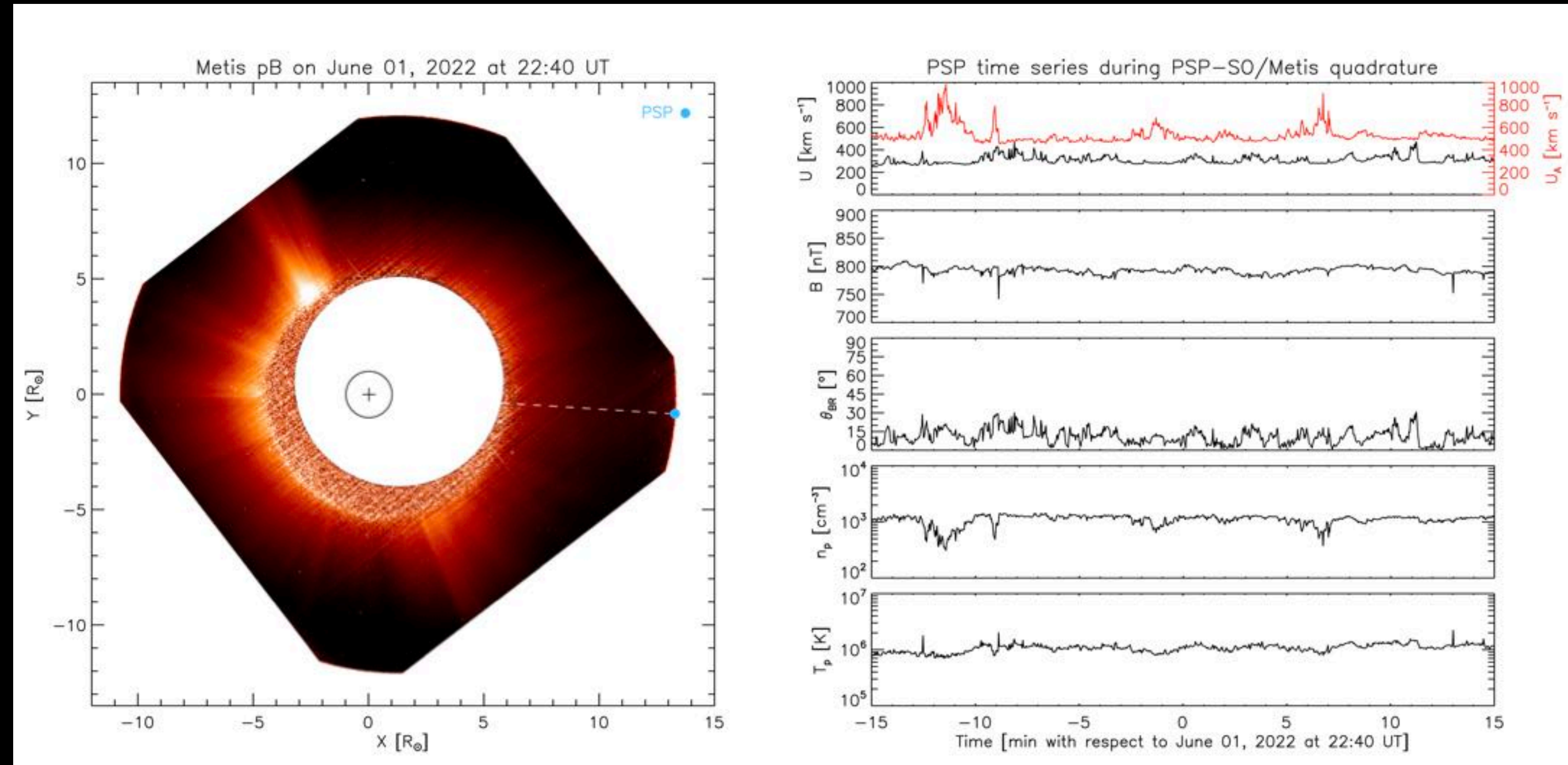
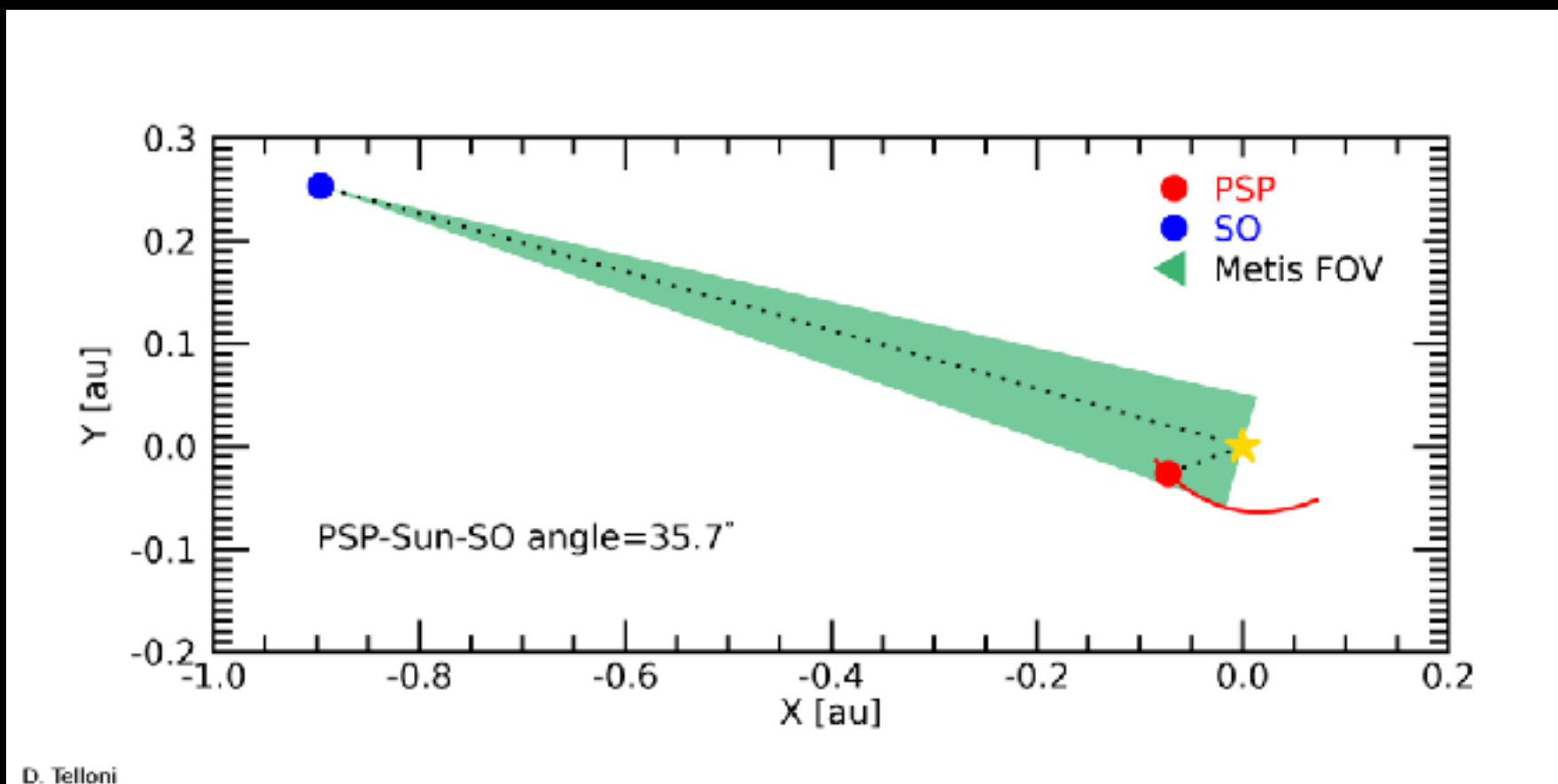
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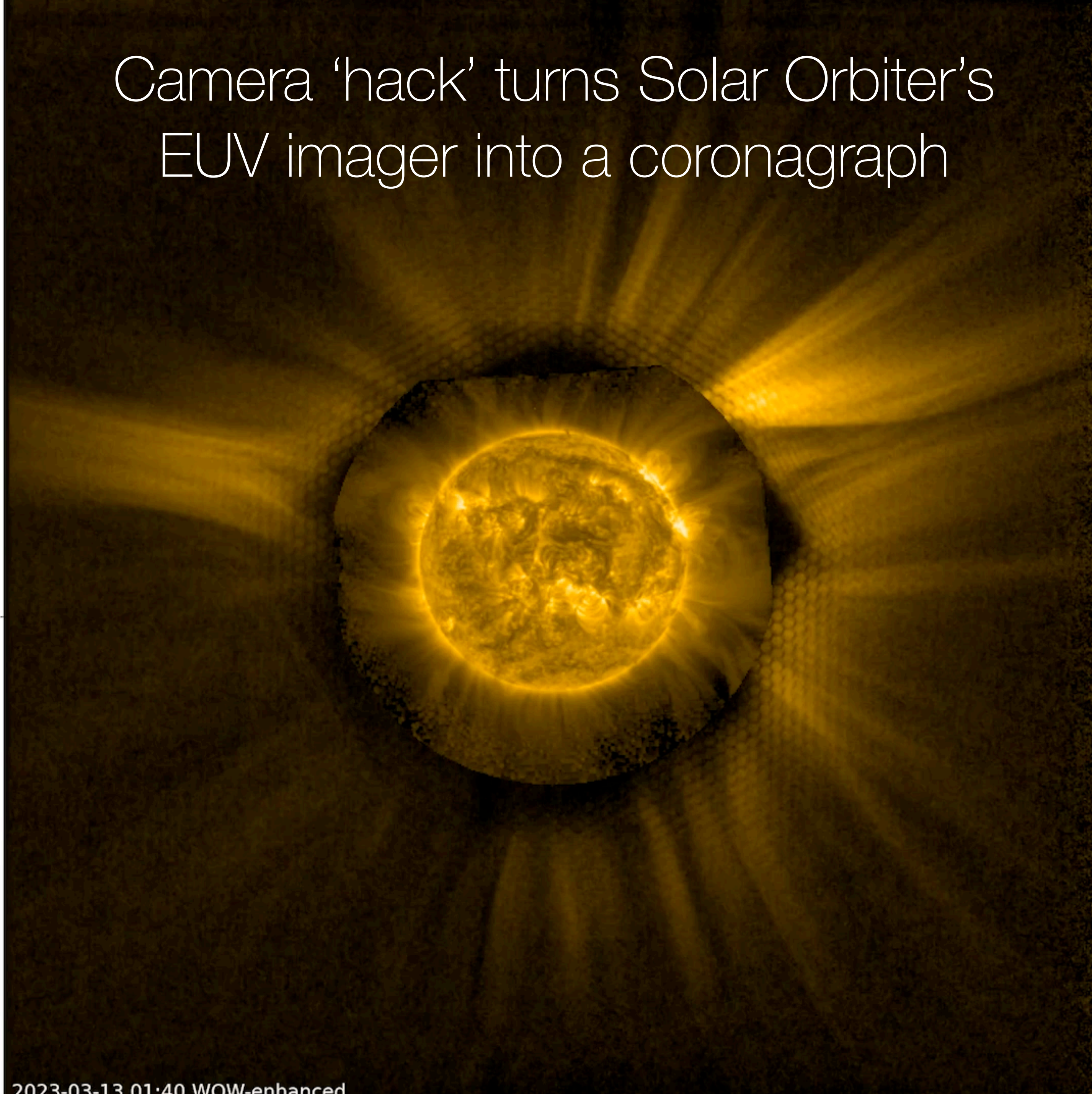


Thin jets underlie the solar wind
(Ugarte-Urra & Wang, *Science*, Sep 2023)

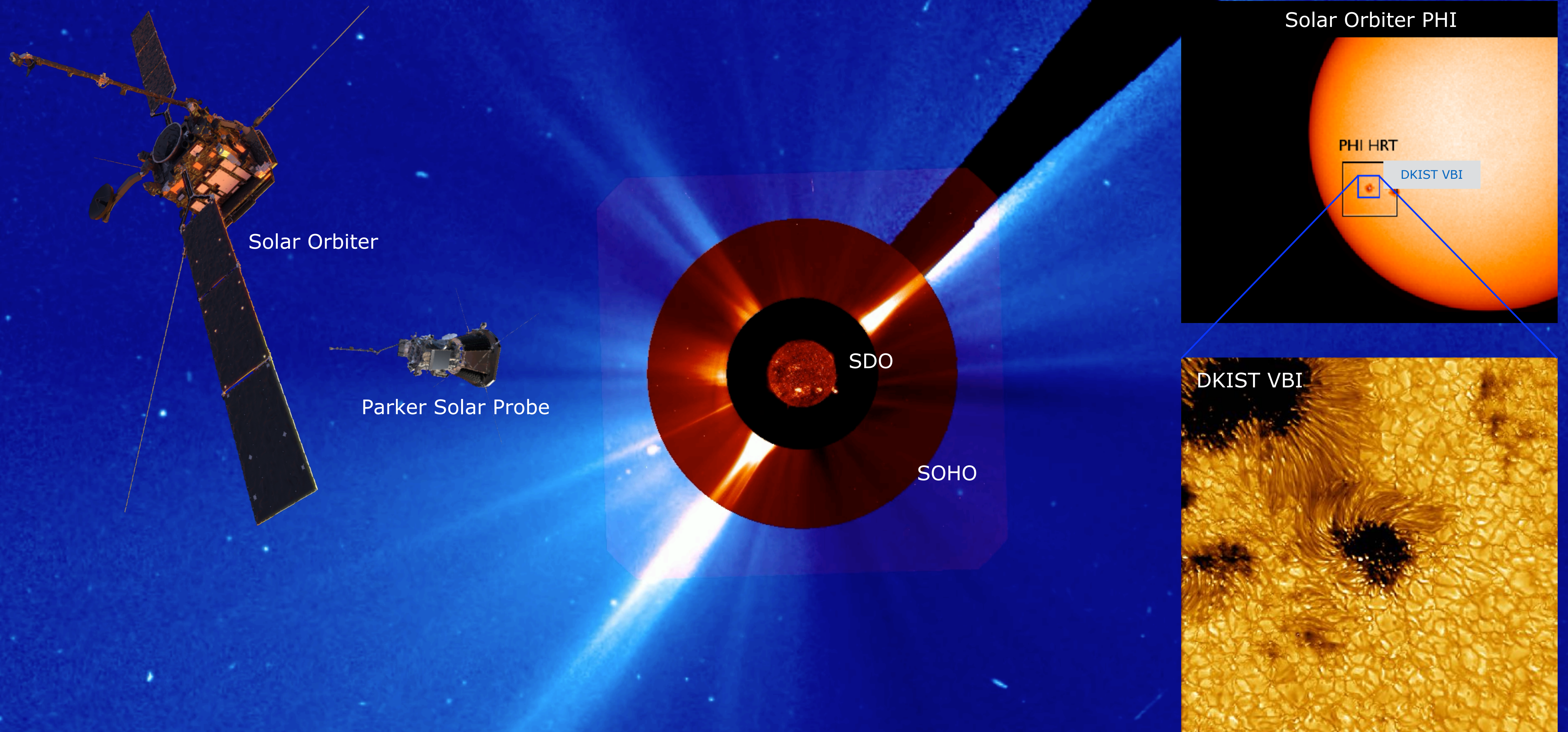
Teamwork in the heliosphere: Parker Solar Probe and Solar Orbiter join forces to measure coronal heating rate



Camera 'hack' turns Solar Orbiter's EUV imager into a coronagraph

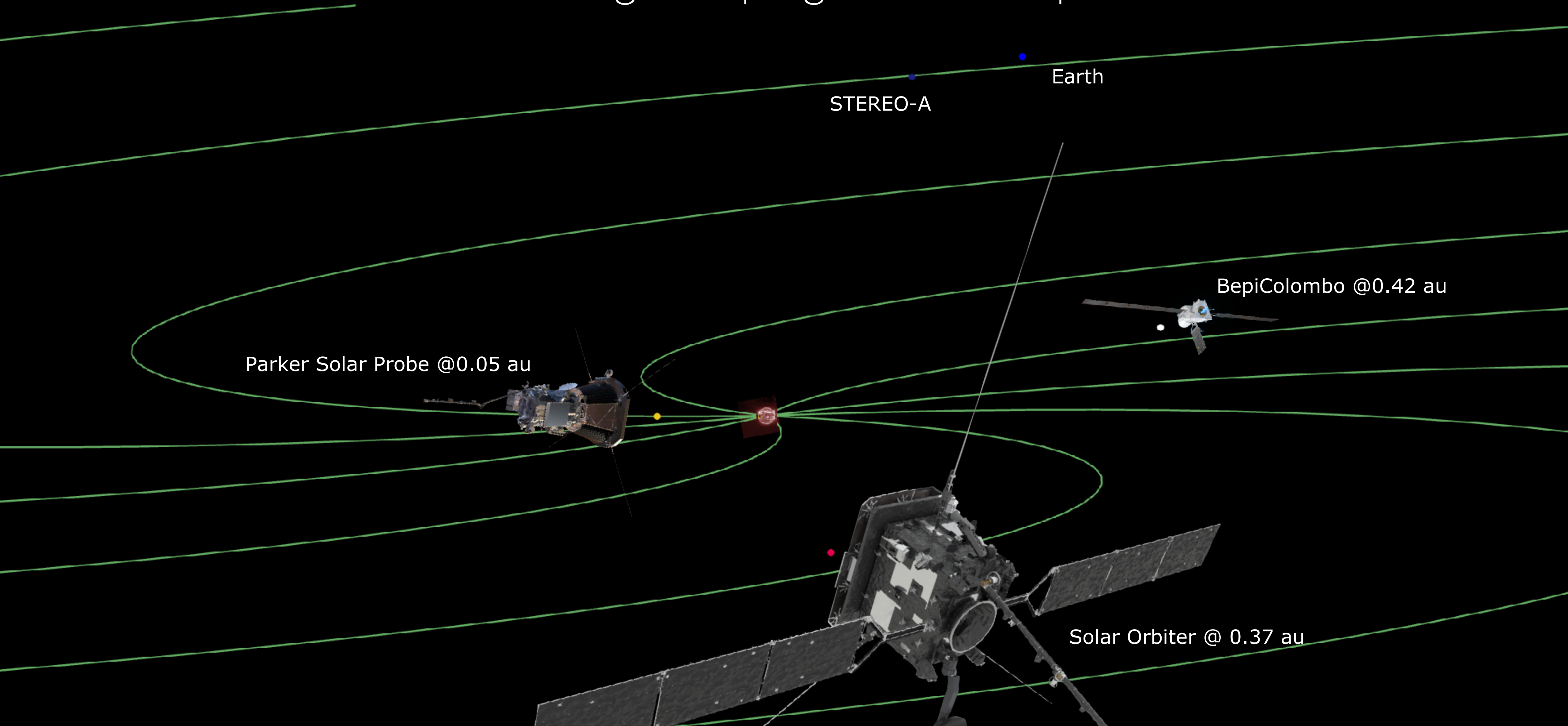


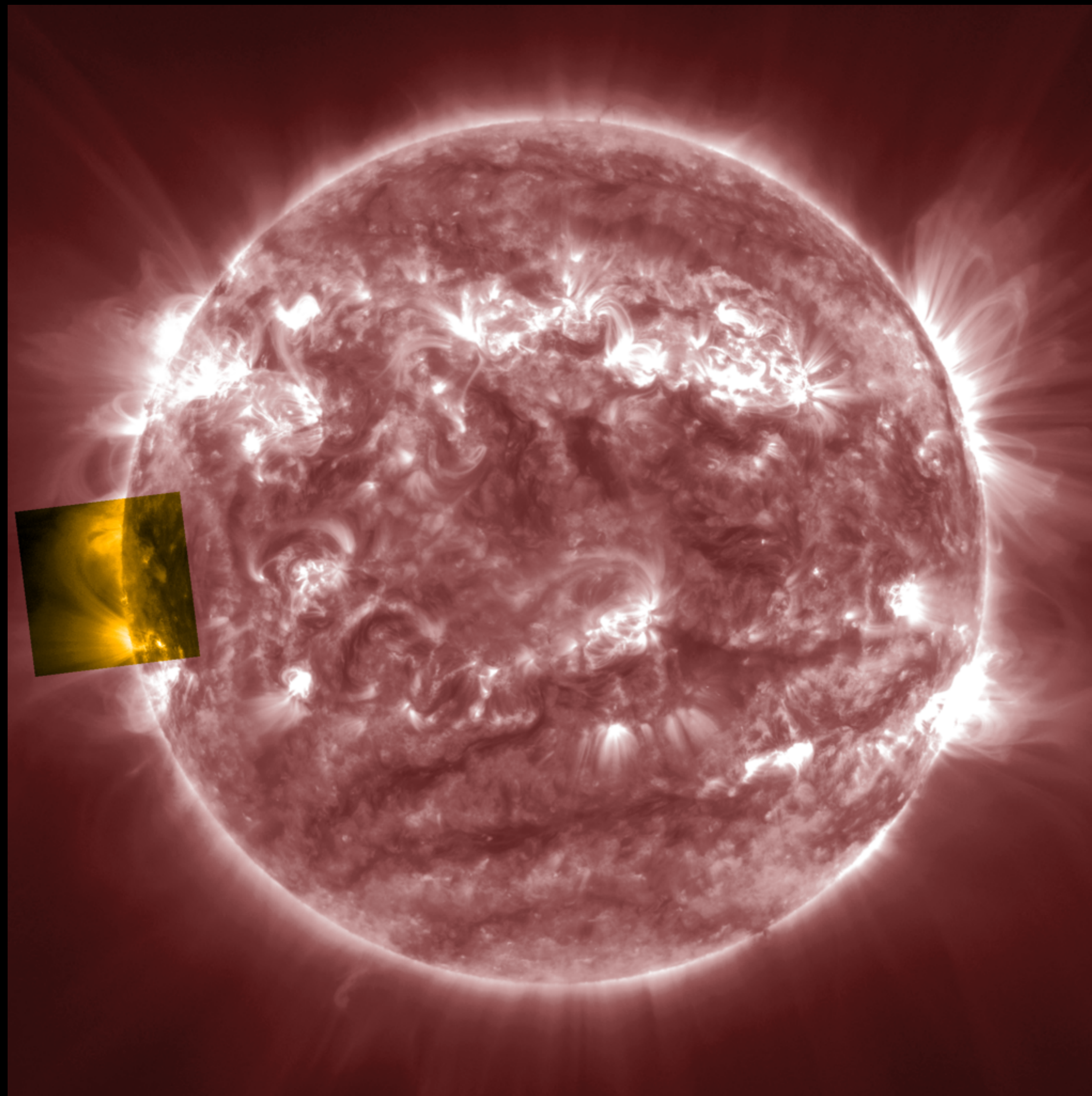
Teamwork in the heliosphere

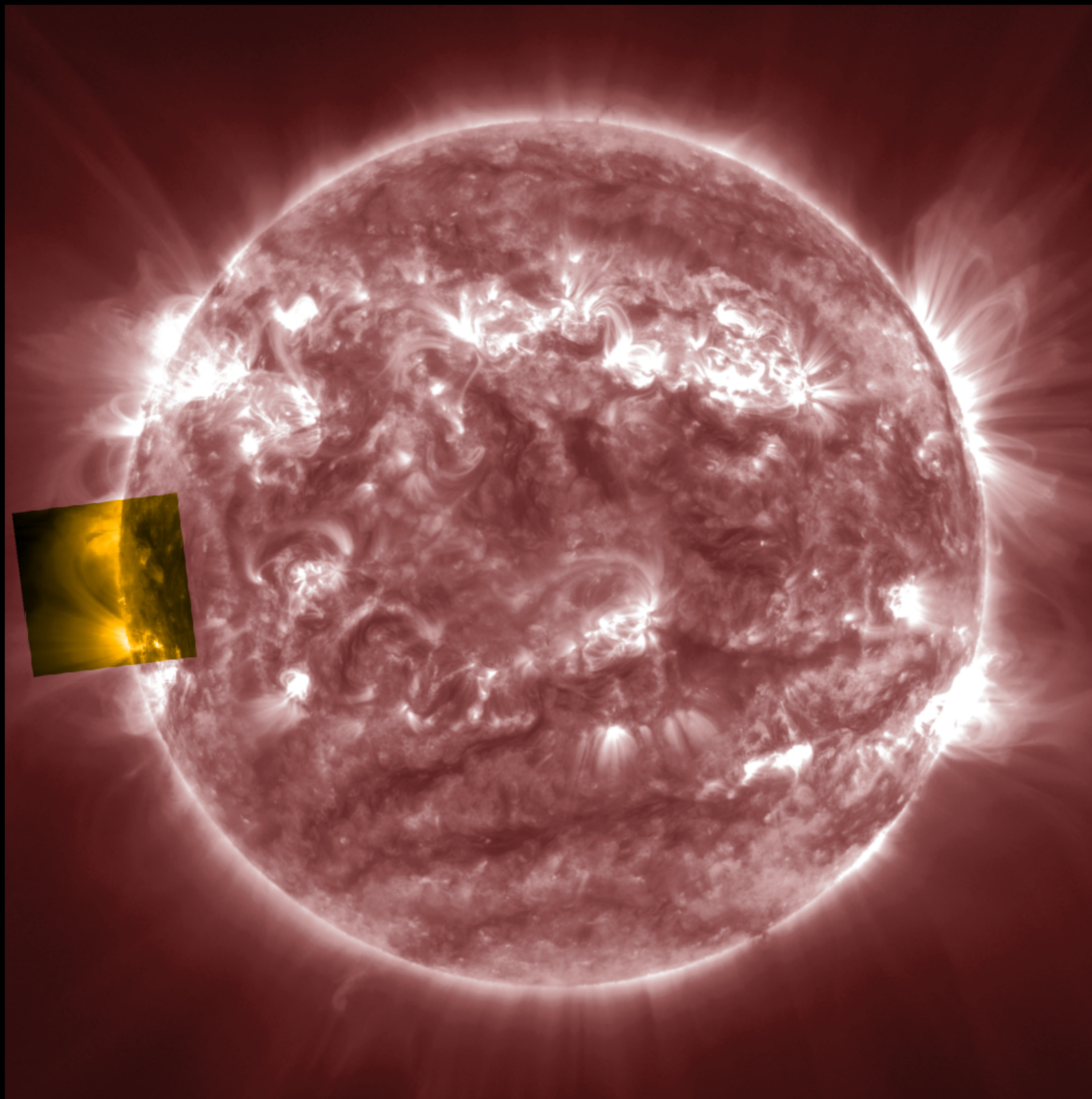


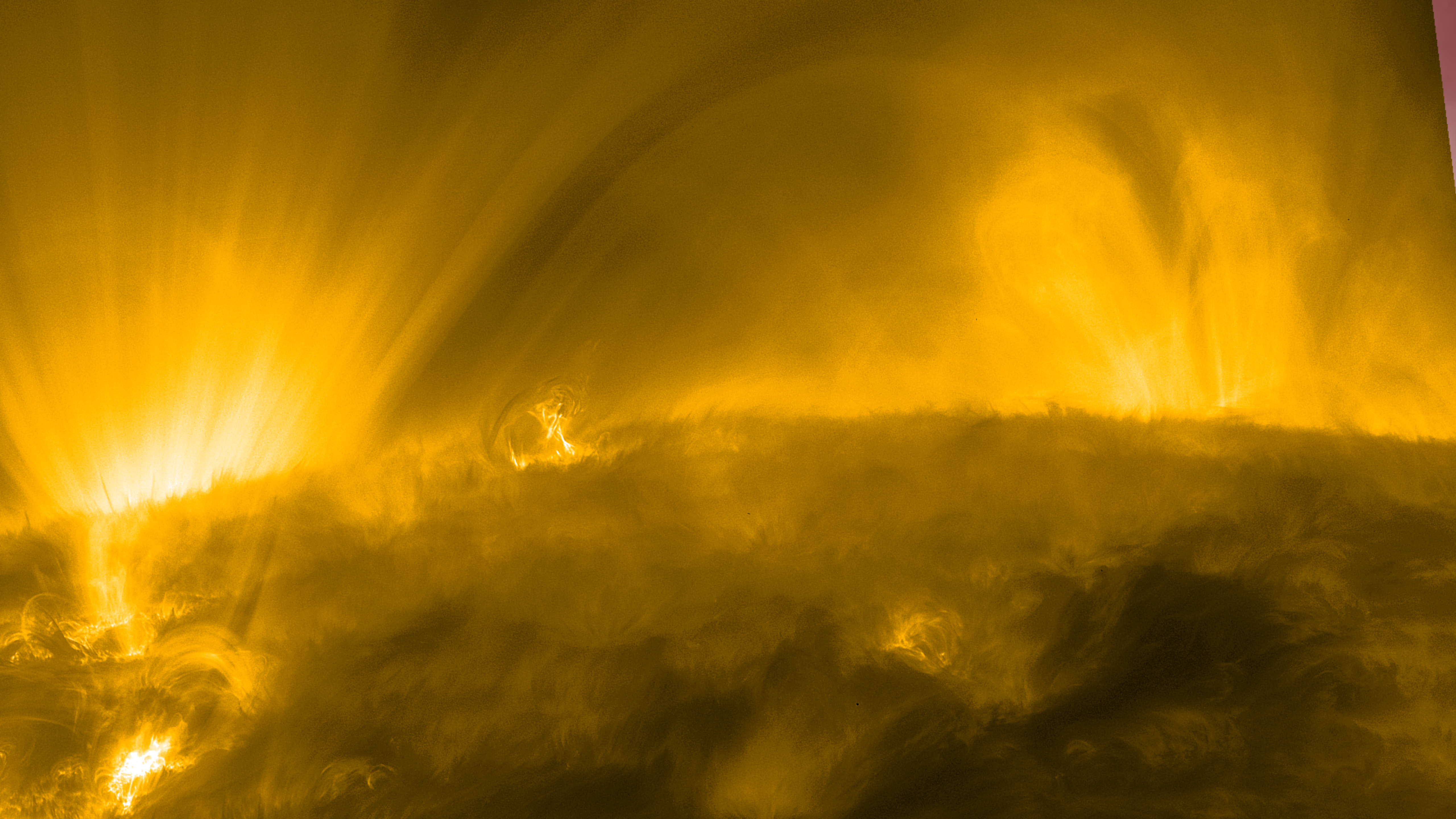
Parker Solar Probe - Solar Orbiter

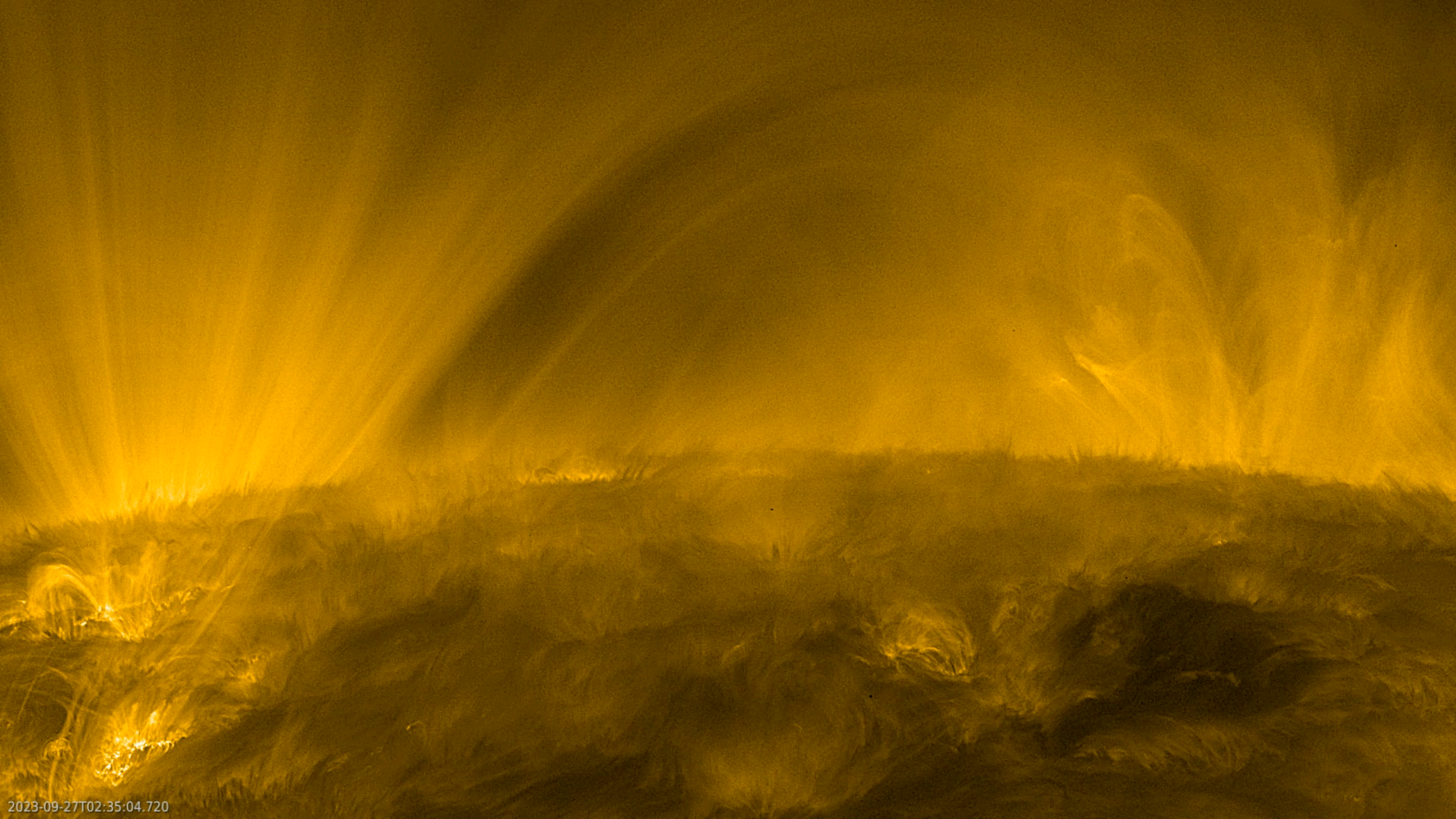
Co-observing campaign on 27 Sep 2023











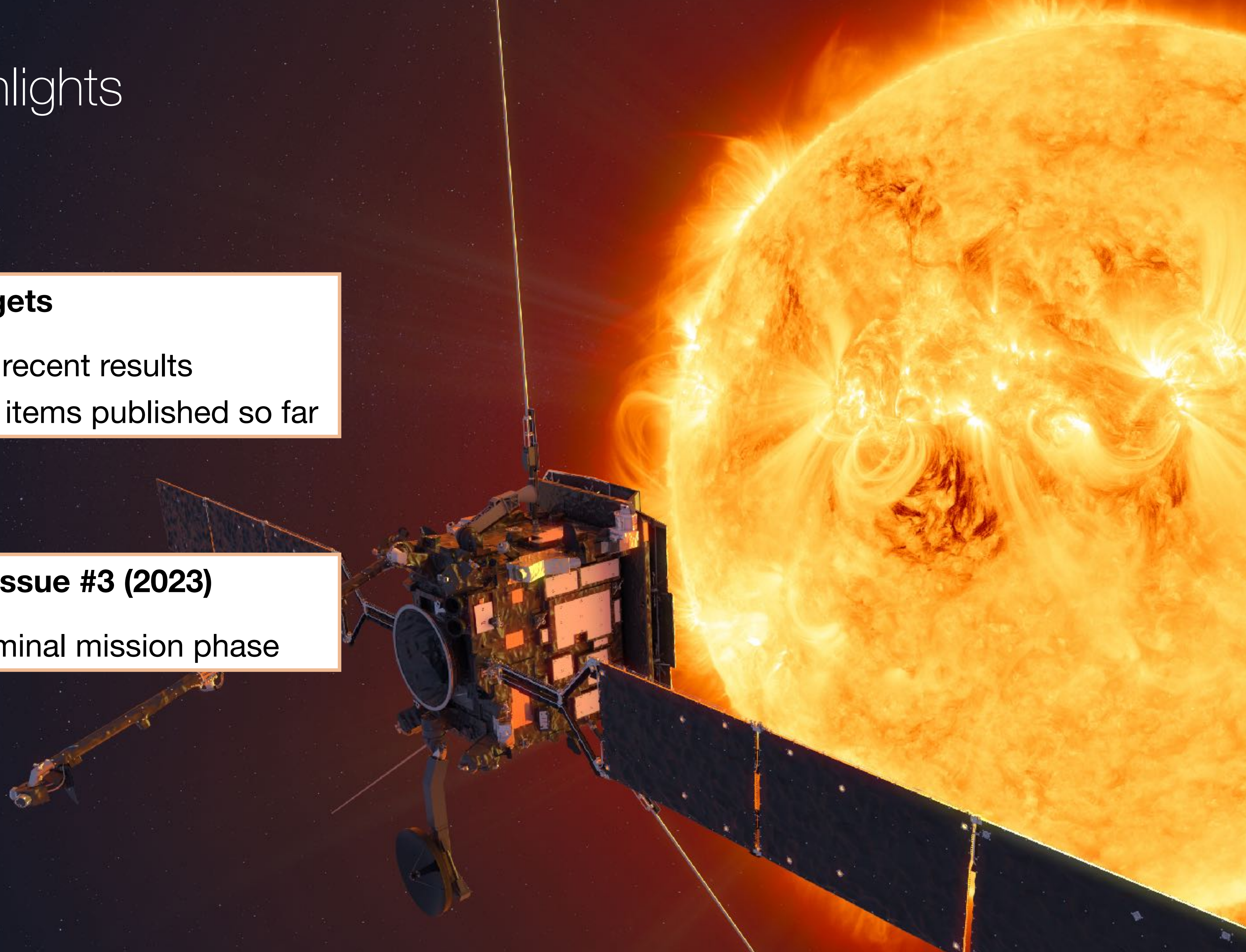
More science highlights

Solar Orbiter Science Nuggets

- Short articles showcasing recent results
- Started in March 2023; 19 items published so far

Solar Orbiter A&A Special Issue #3 (2023)

- First science results of nominal mission phase



Solar Orbiter: Here comes the Sun

Summary

- First four 'hot' perihelia successfully completed
- Exciting science results!
- Successful multi-mission coordination

A vibrant science community:

- Solar Orbiter's topical science WGs:
Open to everyone



Open data policy:

- Instrument teams have 3 months for data calibration & validation
- After submission to ESA, all data is publicly accessible from the Solar Orbiter Archive

