MULLARD SPACE SCIENCE LABORATORY

UCL

# Synergies between in-situ and remote-sensing science with Solar Orbiter


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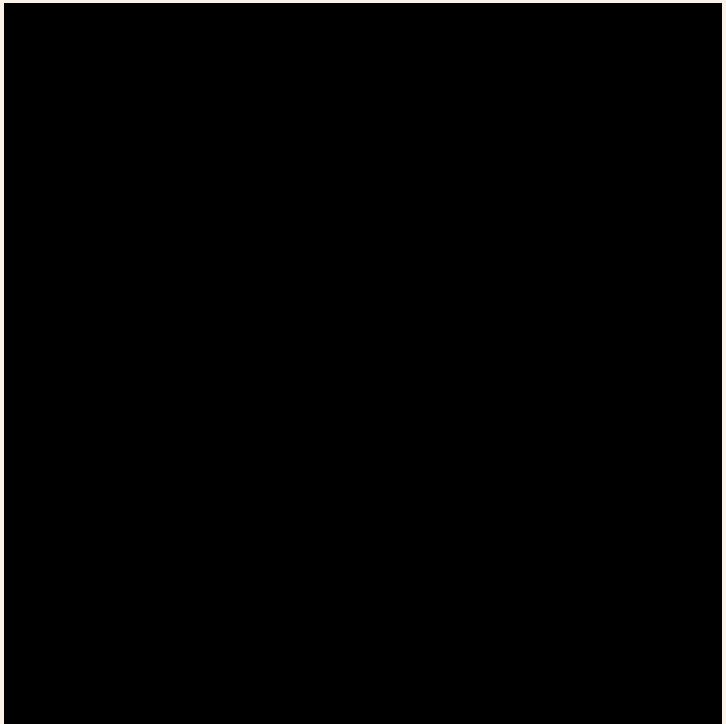
# Solar Orbiter science questions

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



(ESA, EUI Team, 2022)

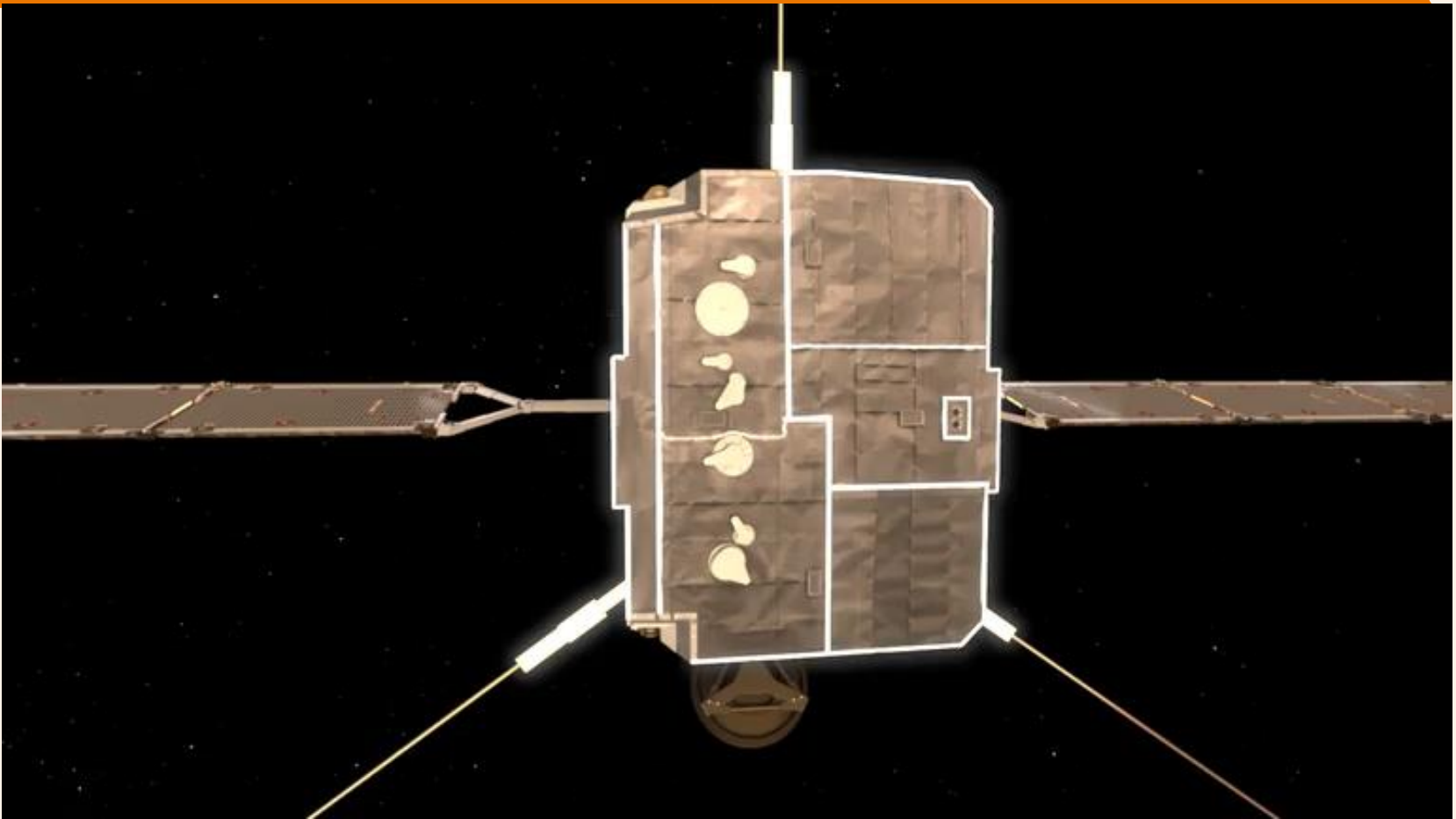
*Top-level scientific questions:*

1) What drives the solar wind, and where does the coronal magnetic field originate?
2) How do solar transients drive heliospheric variability?
3) How do solar eruptions produce energetic particle radiation that fills the heliosphere?
4) How does the solar dynamo work and drive connections between the Sun and the heliosphere?

# Solar Orbiter launched successfully in February 2020

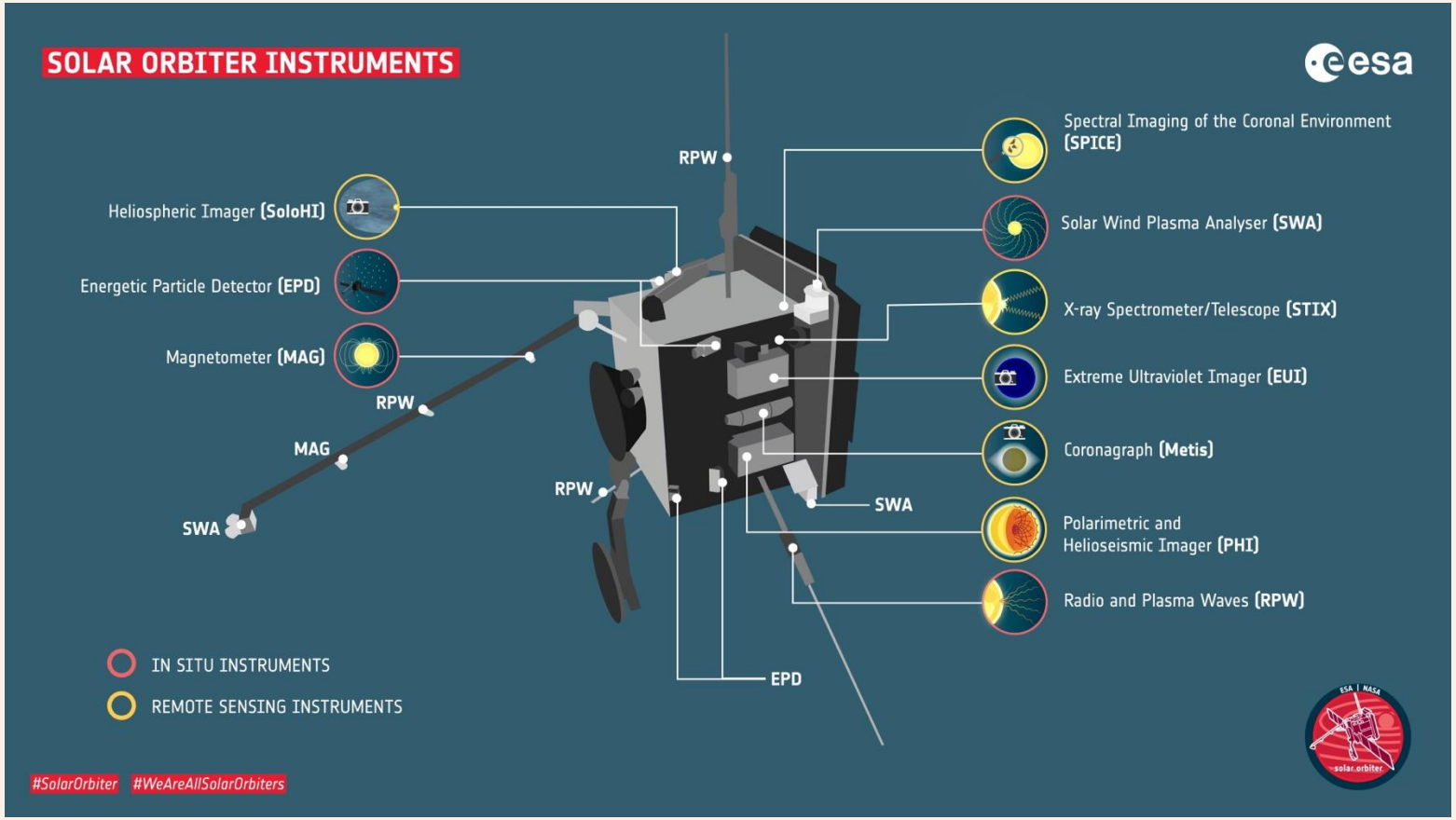
(ESA)

# Solar Orbiter – combining remote-sensing and in-situ measurements

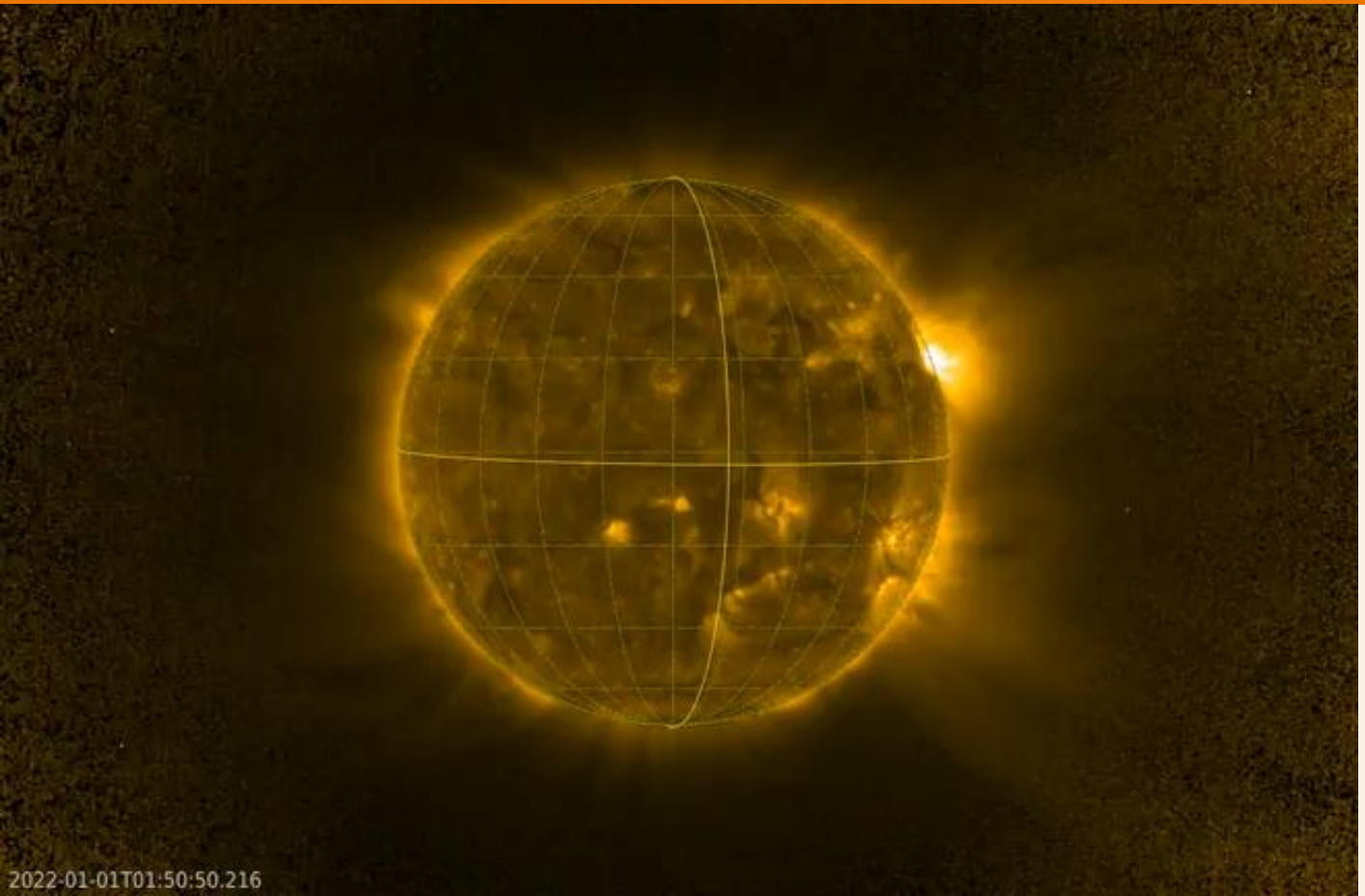


(ESA)

# Solar Orbiter – combining remote-sensing and in-situ measurements

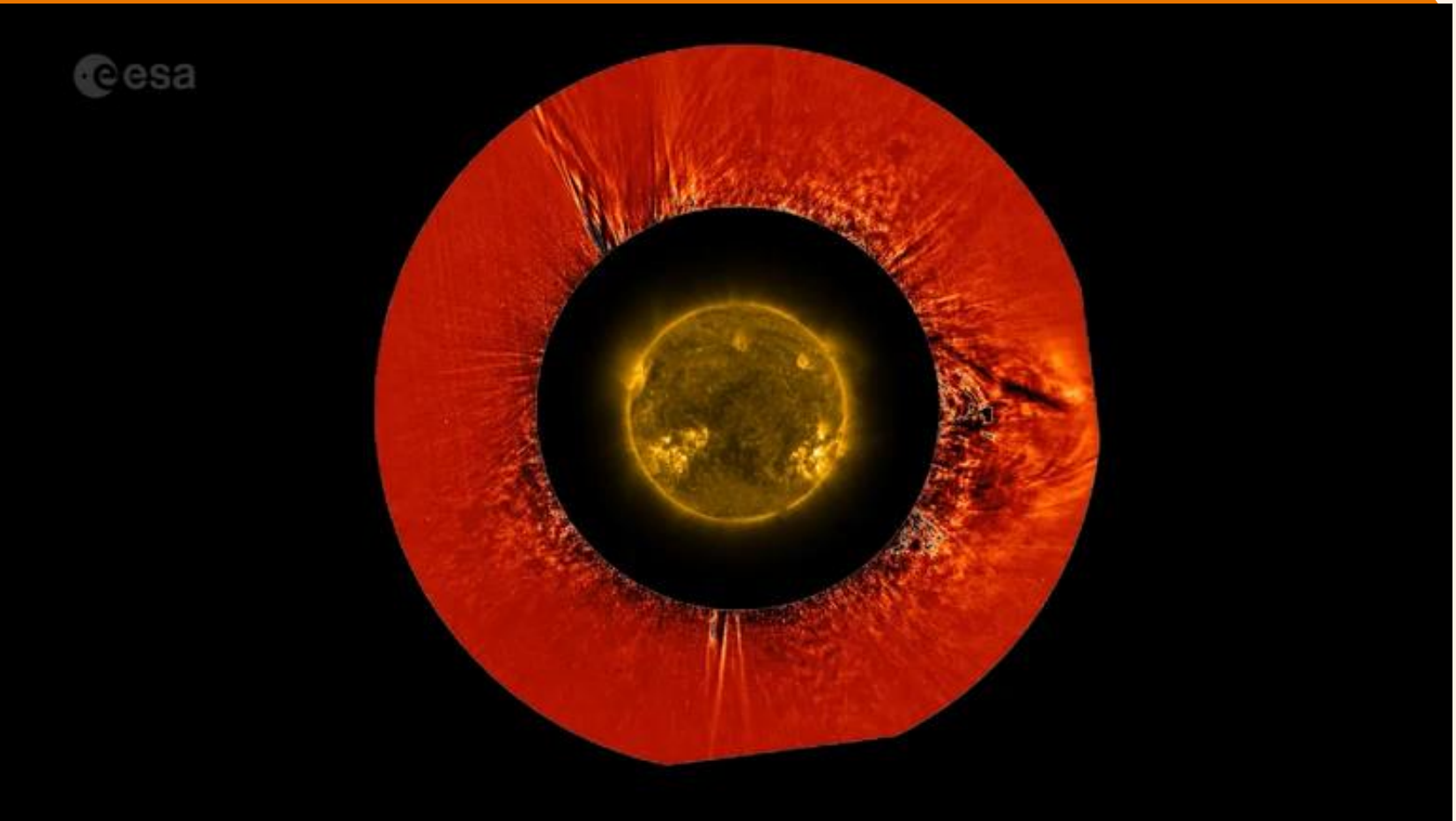


# Solar Orbiter – unprecedented remote-sensing observations



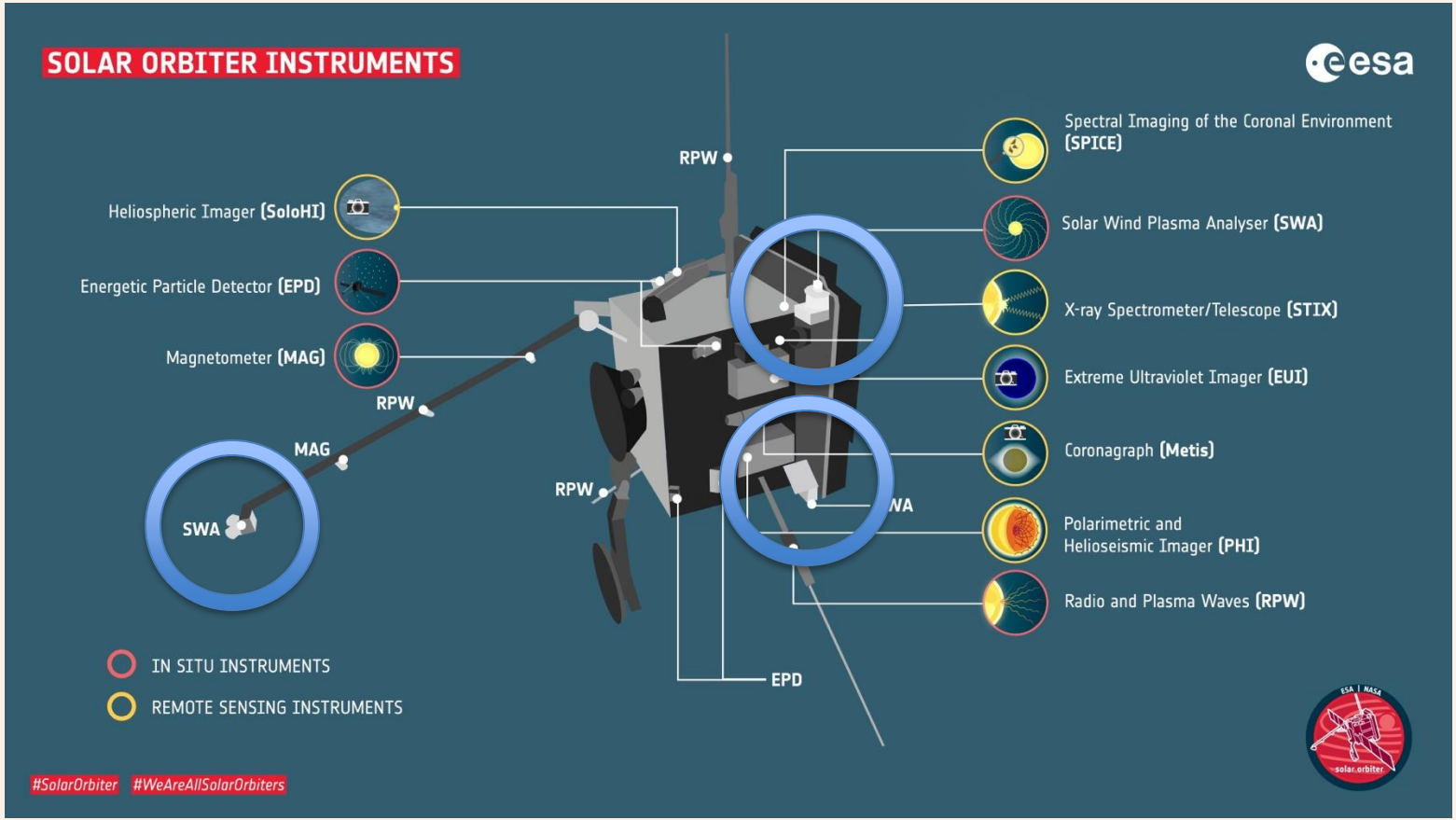

(ESA, EUI Team, 2022)

# Combining remote-sensing instruments: turbulence in the corona



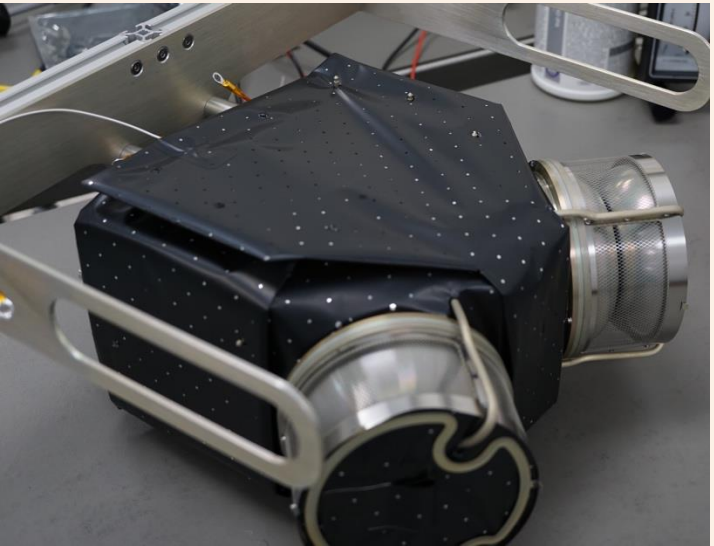

(ESA, Metis & EUI Teams, 2024)

# SWA – Solar Wind Plasma Analyser (led by UCL/MSSL)



# SWA – Solar Wind Plasma Analyser (led by UCL/MSSL)

Electron Analyser System
(built at UCL/MSSL)



Proton-Alpha Sensor

Heavy Ion Sensor
(provided by NASA)

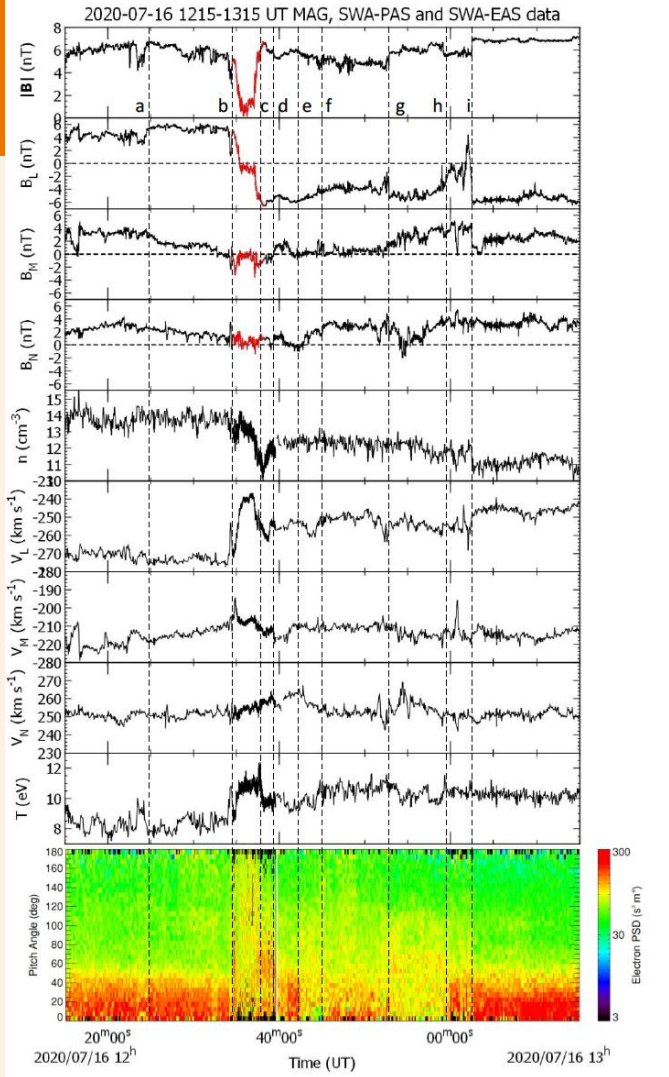
# In-situ measurements at the spacecraft

The in-situ instruments provide high-resolution measurements of

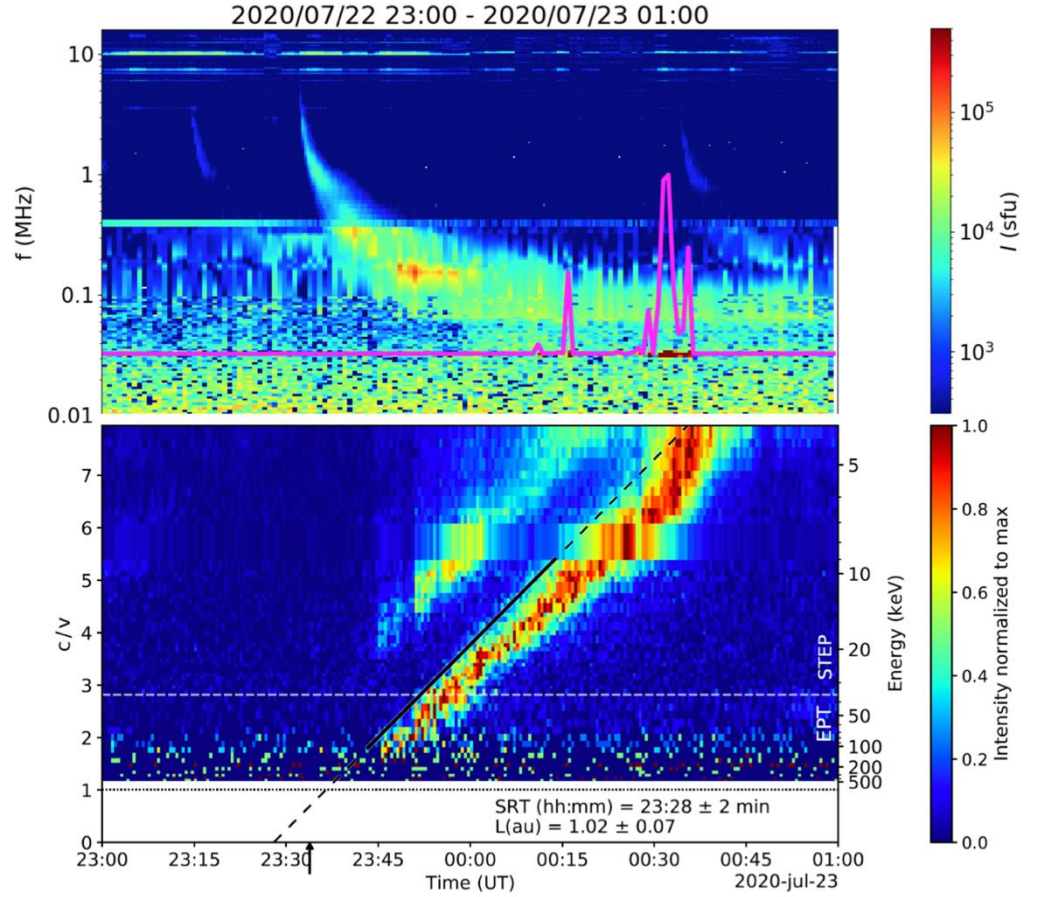
- the ions and electrons of the solar wind,
- energetic particles,
- electric fields,
- magnetic fields, and
- radio waves.

*The key challenge is the connection of these local measurements with the global heliospheric environment and the source regions in the solar corona.*

(Owen, …, DV, et al., 2021)



# Near-relativistic electron events and high-frequency waves




Type III radio bursts are generated by energetic electron beams.

RPW radio spectrum observed in association with an electron event.

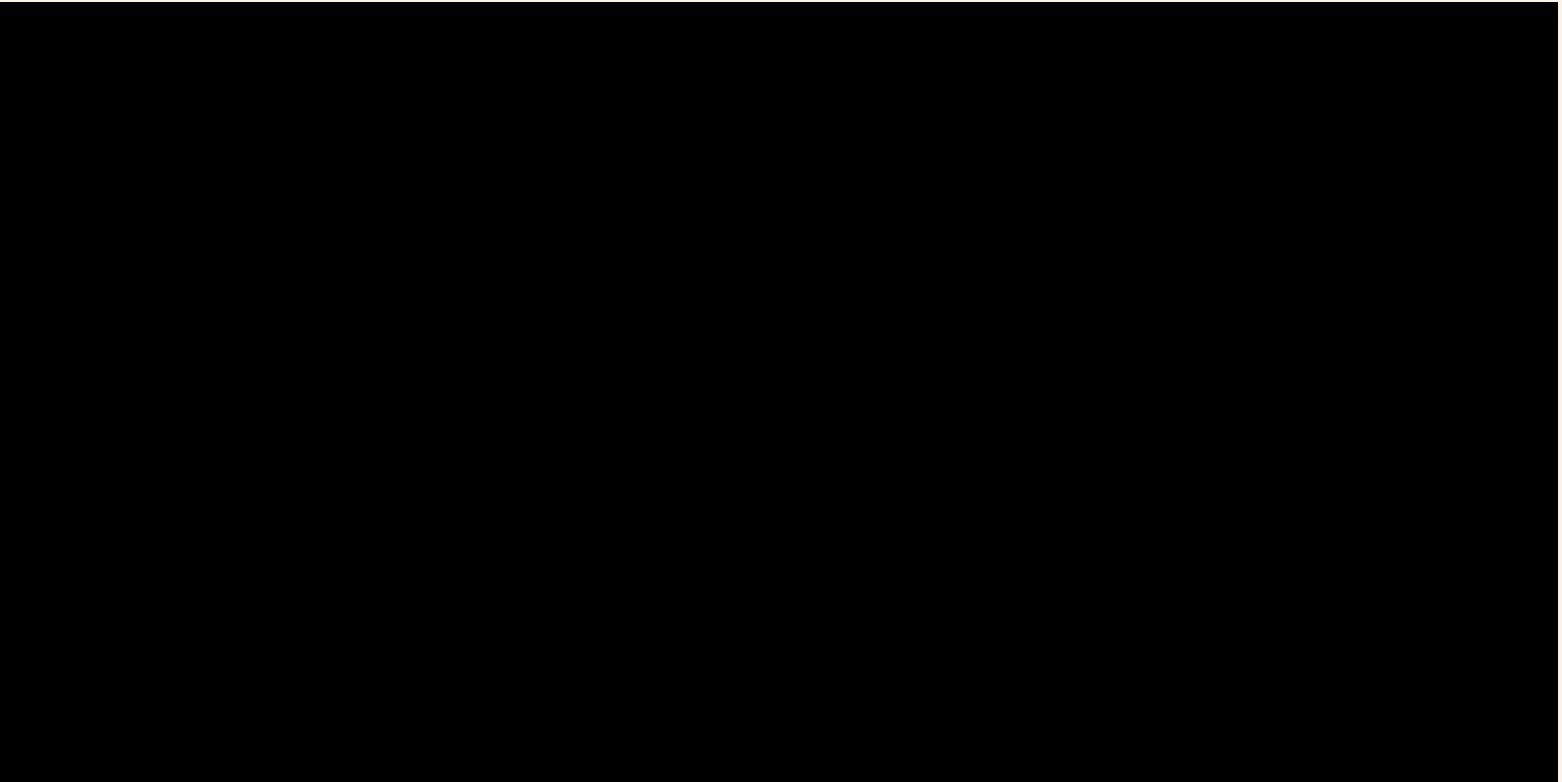
Magenta line: spectral flux at plasma frequency -> locally generated Langmuir waves!

Electron dispersion plot shows arrival of accelerated electrons in situ, while the radio waves show the remote action of these electrons.

(Gómez Herrero et al., 2021)

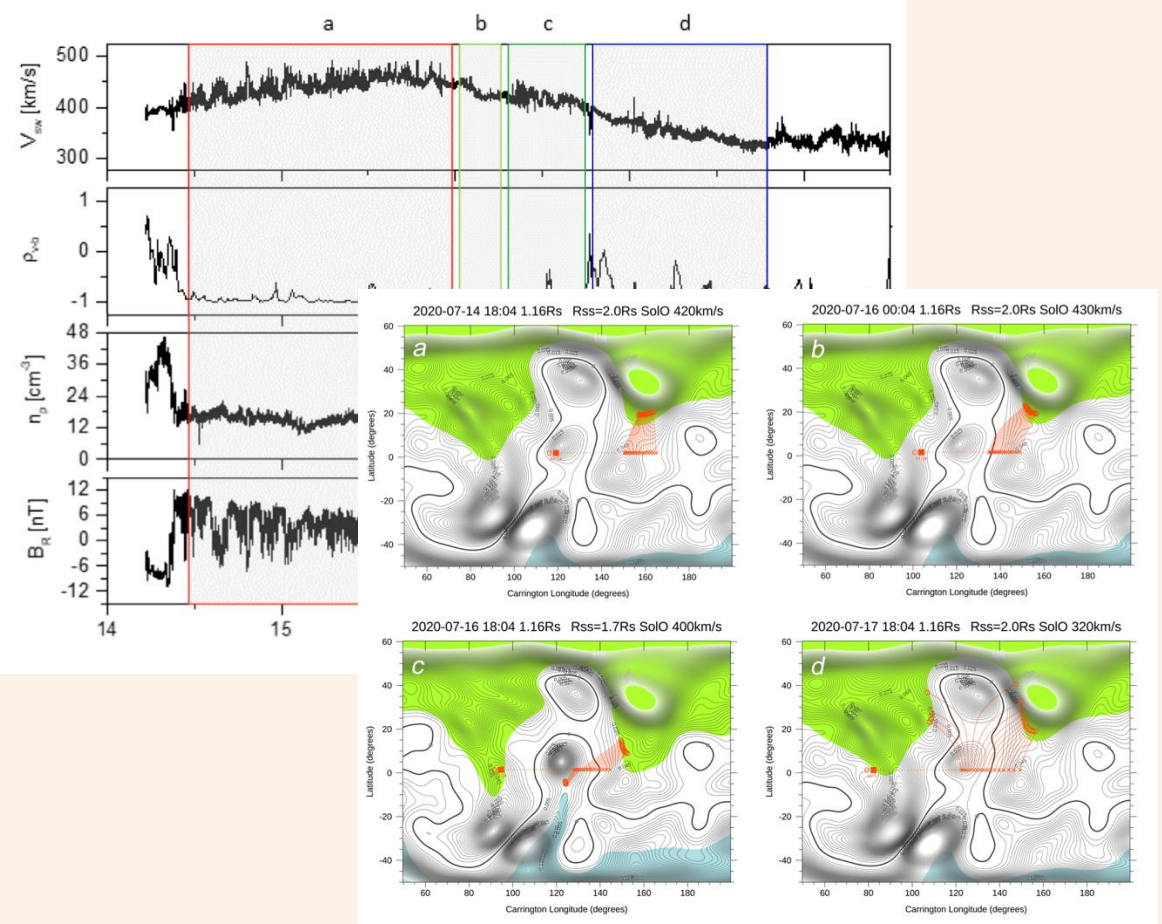
# Connecting observations in the corona with the solar wind

The SPICE instrument measures the elemental composition of the plasma in the corona. The composition can be compared with in-situ measurements from SWA/HIS.



(ESA, SPICE Team, 2022)

# Connection science: slow Alfvénic solar wind and its source regions

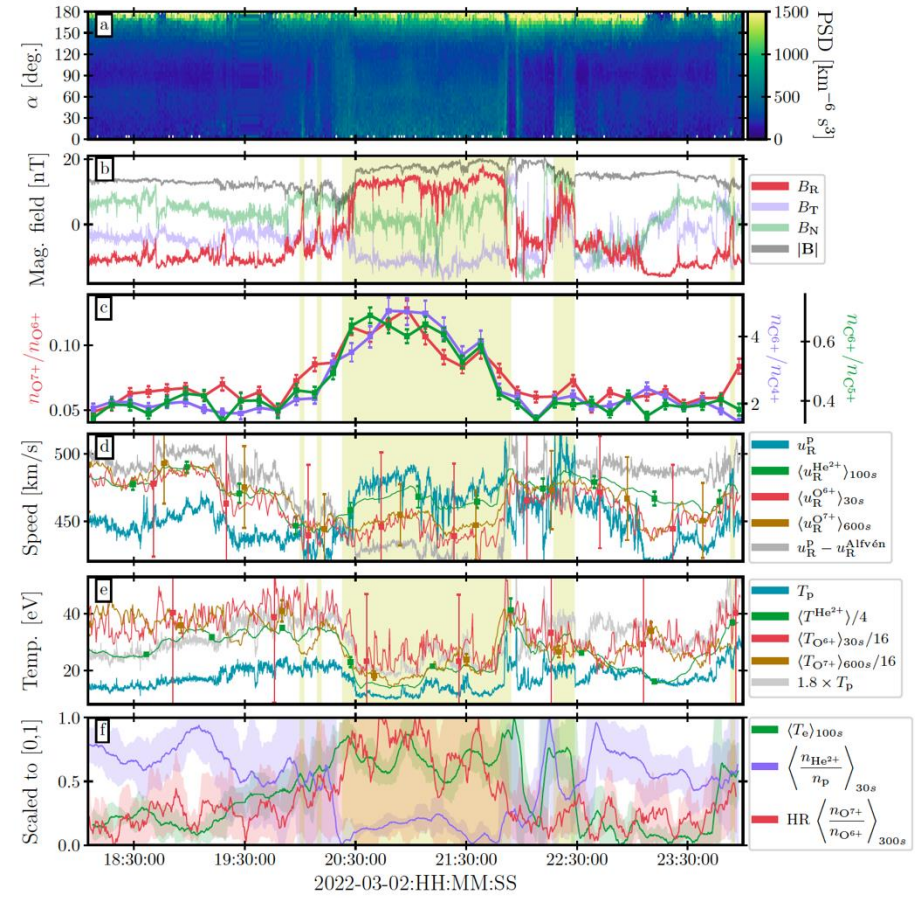


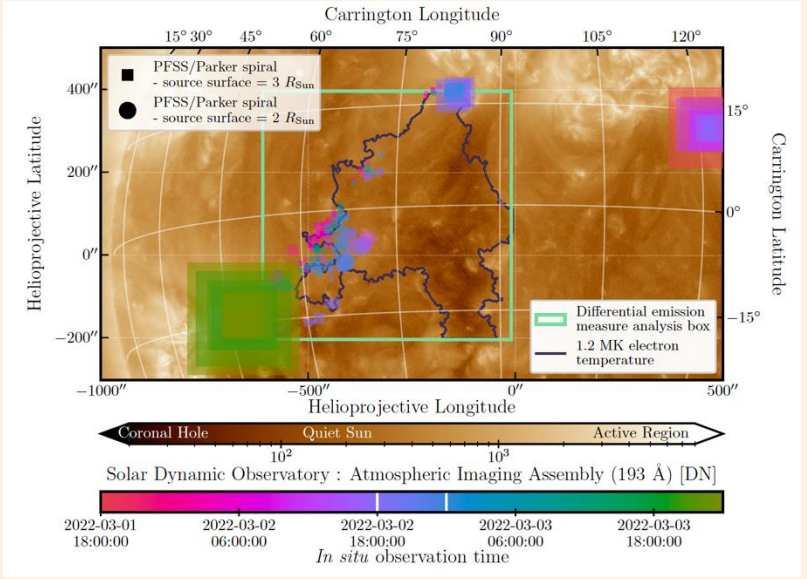

In-situ measurements of the solar wind and Alfvénic fluctuations are combined with connectivity model (PFSS model).

Transitions between coronal holes, helmet streamers, and pseudostreamers are identified in the source regions.

(D'Amicis, …, DV, et al., 2021)

# Connection science: investigating the sources of solar-wind structures



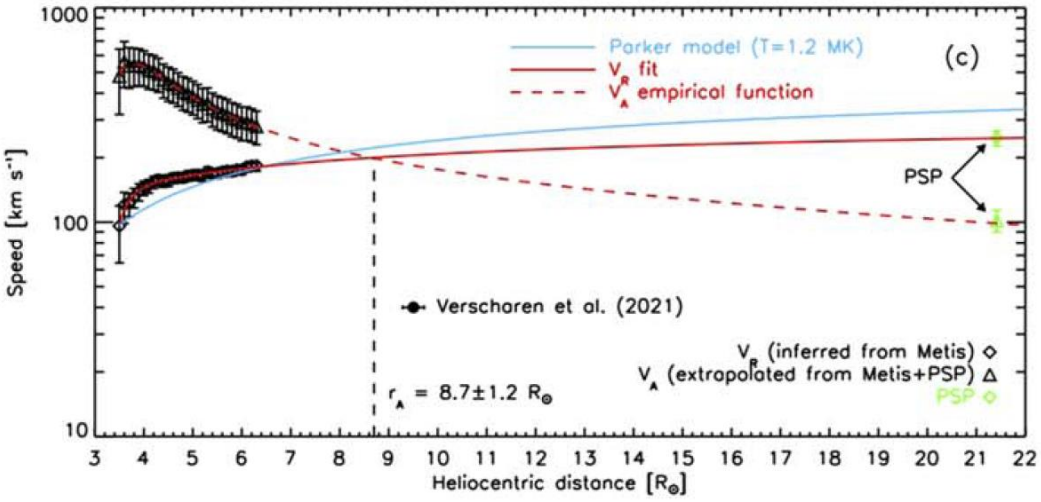



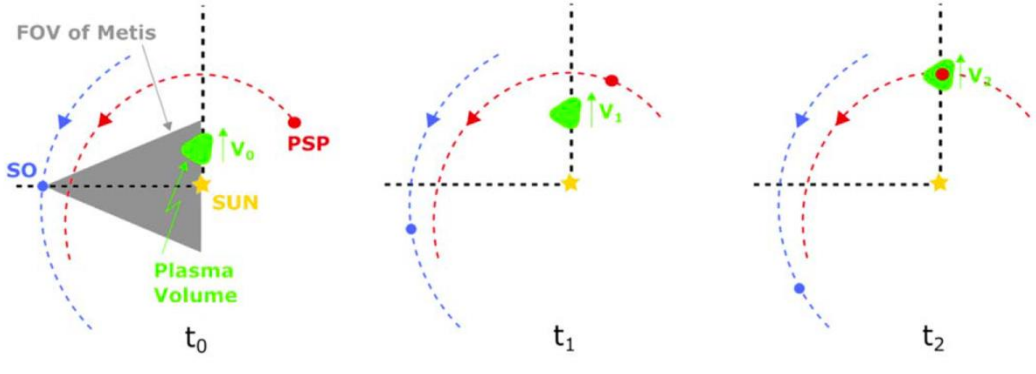

Foot-point predictions of the magnetic field that connects the Sun with Solar Orbiter.

In-situ measurements during a local magnetic-field reversal.

(Coburn, …, DV, et al., 2025)

# Combining Solar Orbiter with Parker Solar Probe (and others)



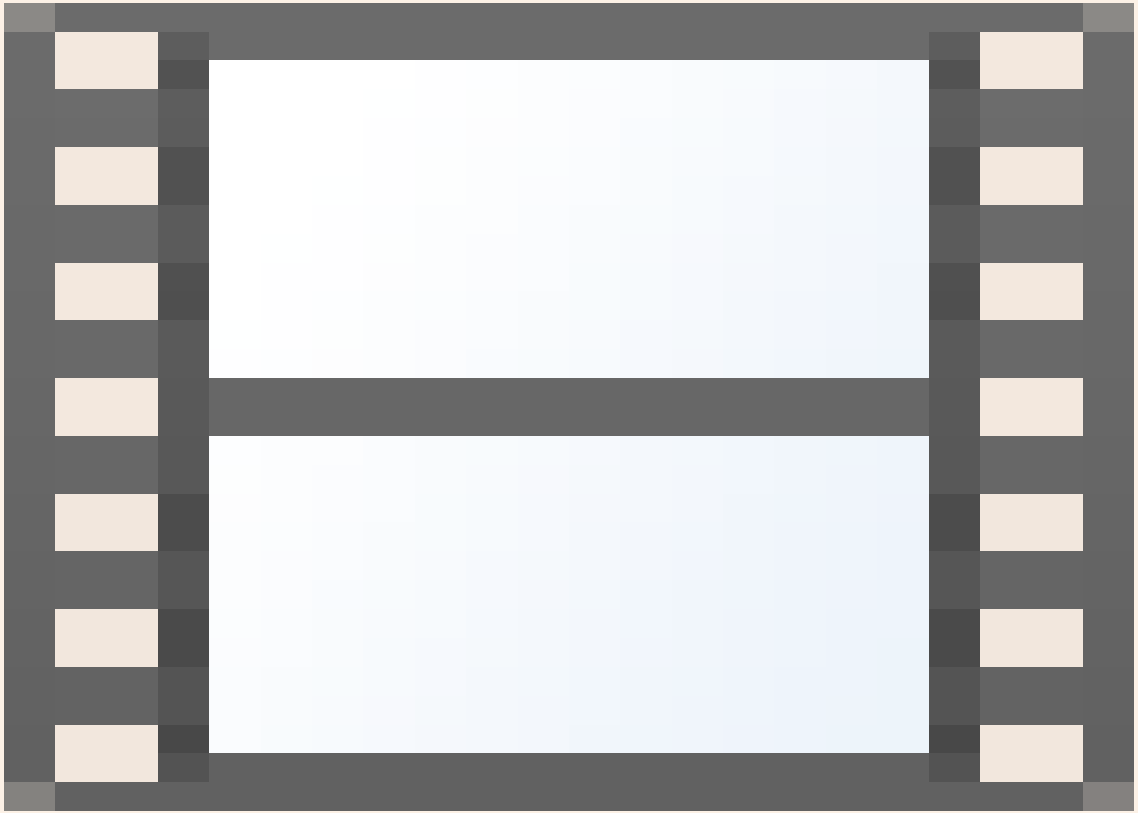

Parker Solar Probe and Solar Orbiter are often in conjunction or quadrature, allowing combined observations.

This work combines Solar Orbiter Metis coronagraph observations with Parker Solar Probe in-situ data.

Constrained fits allow new determination of Alfvén critical point.

(Telloni, …, DV, et al., 2021)

# Solar Orbiter will leave the plane of the ecliptic soon



(ESA)

# The Solar Orbiter Science Working Groups

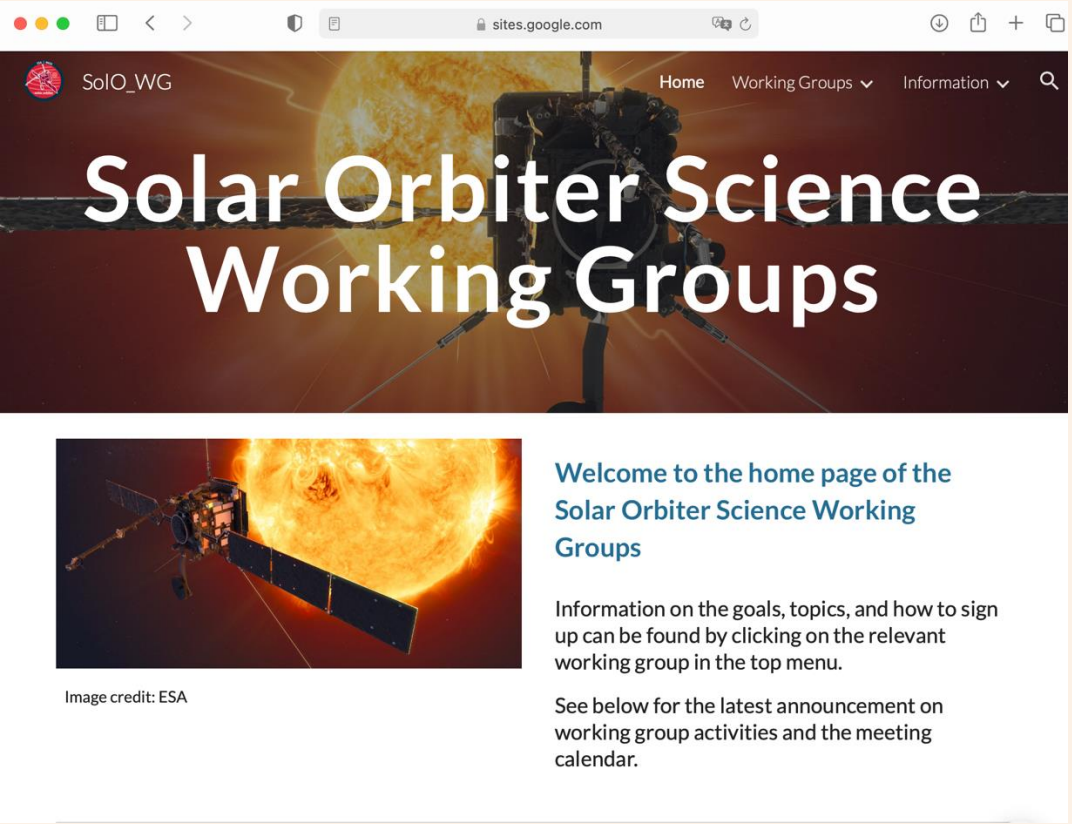



Image credit: ESA

https://sites.google.com/view/solo-wg/

The goals of the Science Working Groups are:

- Form collaborations
- Avoid overlap
- Make community aware of ongoing work
- Deliver on Science Activity Plan

Membership is open and without restrictions. All career levels are welcome.

JOIN US!

# Synergies between in-situ and remote-sensing science with Solar Orbiter


(ESA)

Solar Orbiter's unique strength is its combination of in-situ and remote-sensing instrumentation.

Connecting these measurements is crucial for our understanding of the Sun's interactions with the heliosphere.

The coming years are especially exciting for solar and heliospheric physics (Solar Orbiter's out-of-ecliptic orbit and synergies with other assets).

𝕏 @DVerscharen