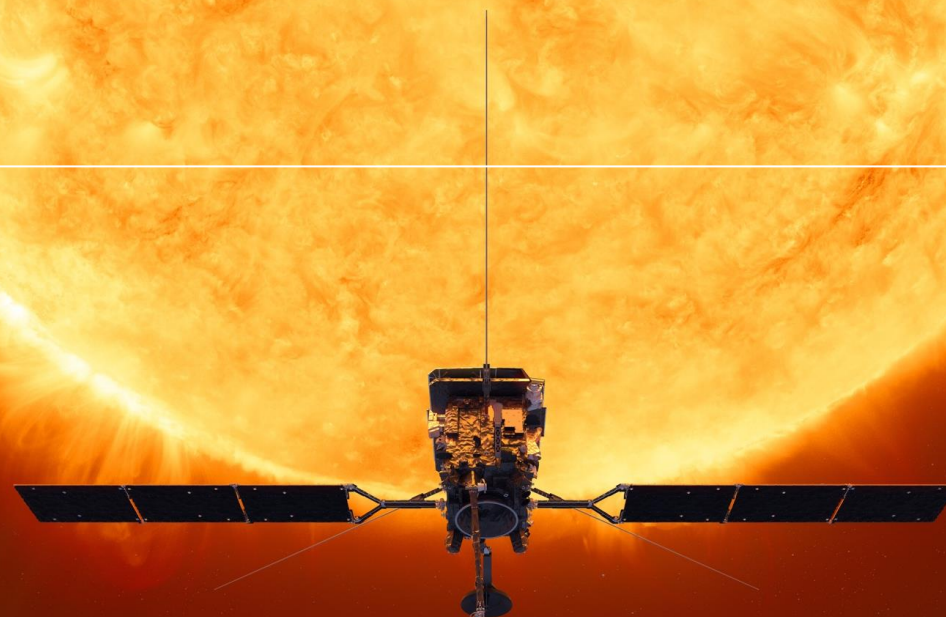


# SOLAR ORBITER

Anik De Groof  
Science Operations Scientist  
ESAC Madrid



BELSPO Space Talks

7 July 2022



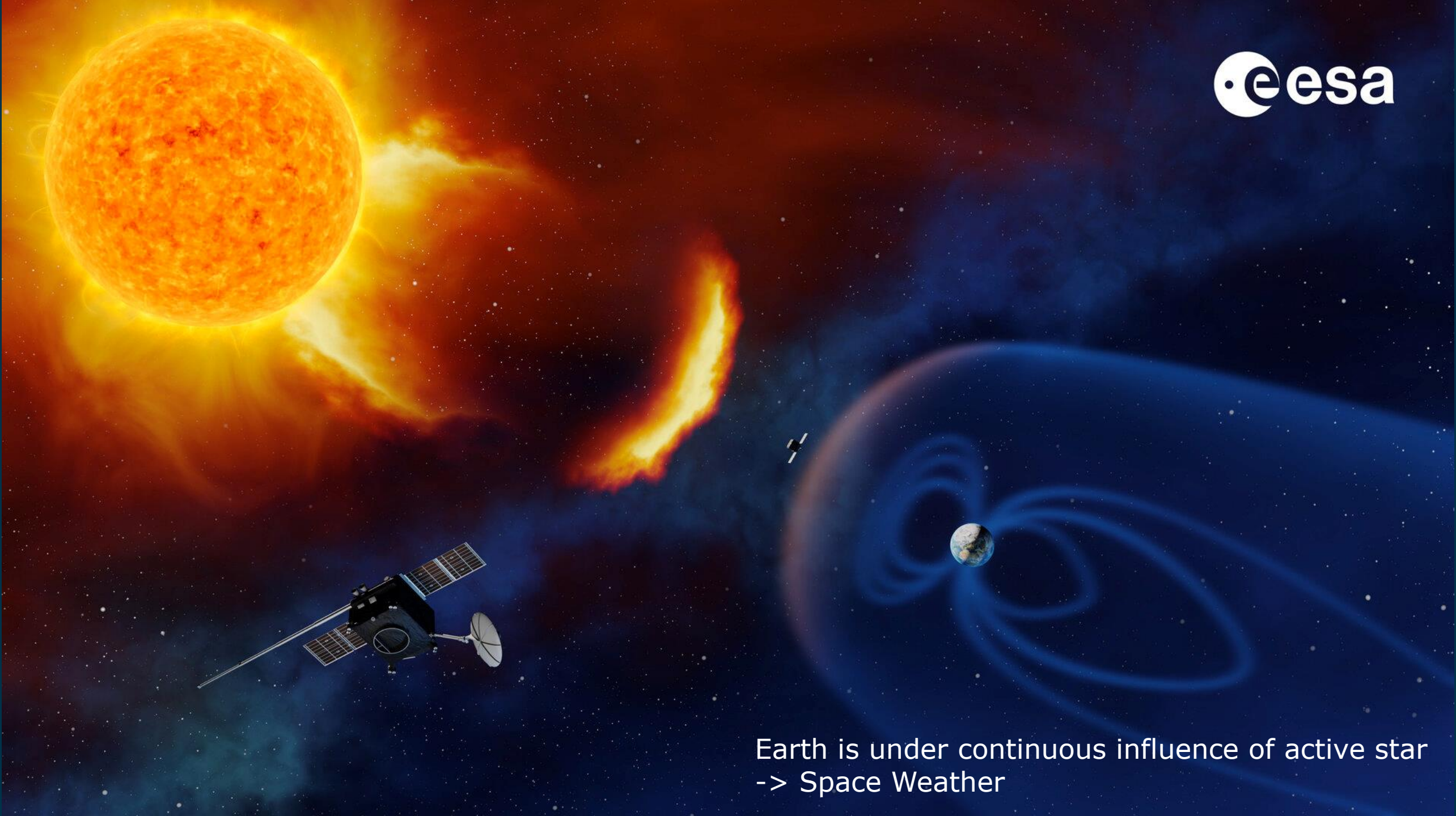
# Solar Orbiter: Exploring Sun & Heliosphere



- First medium-class mission of ESA's Cosmic Vision 2015-25, implemented jointly with NASA
- Comprehensive payload:
  - 10 remote-sensing and in-situ instruments
  - measuring from Sun's surface into the solar wind
- Launched on 10 Feb 2020 in highly elliptical orbit around the Sun

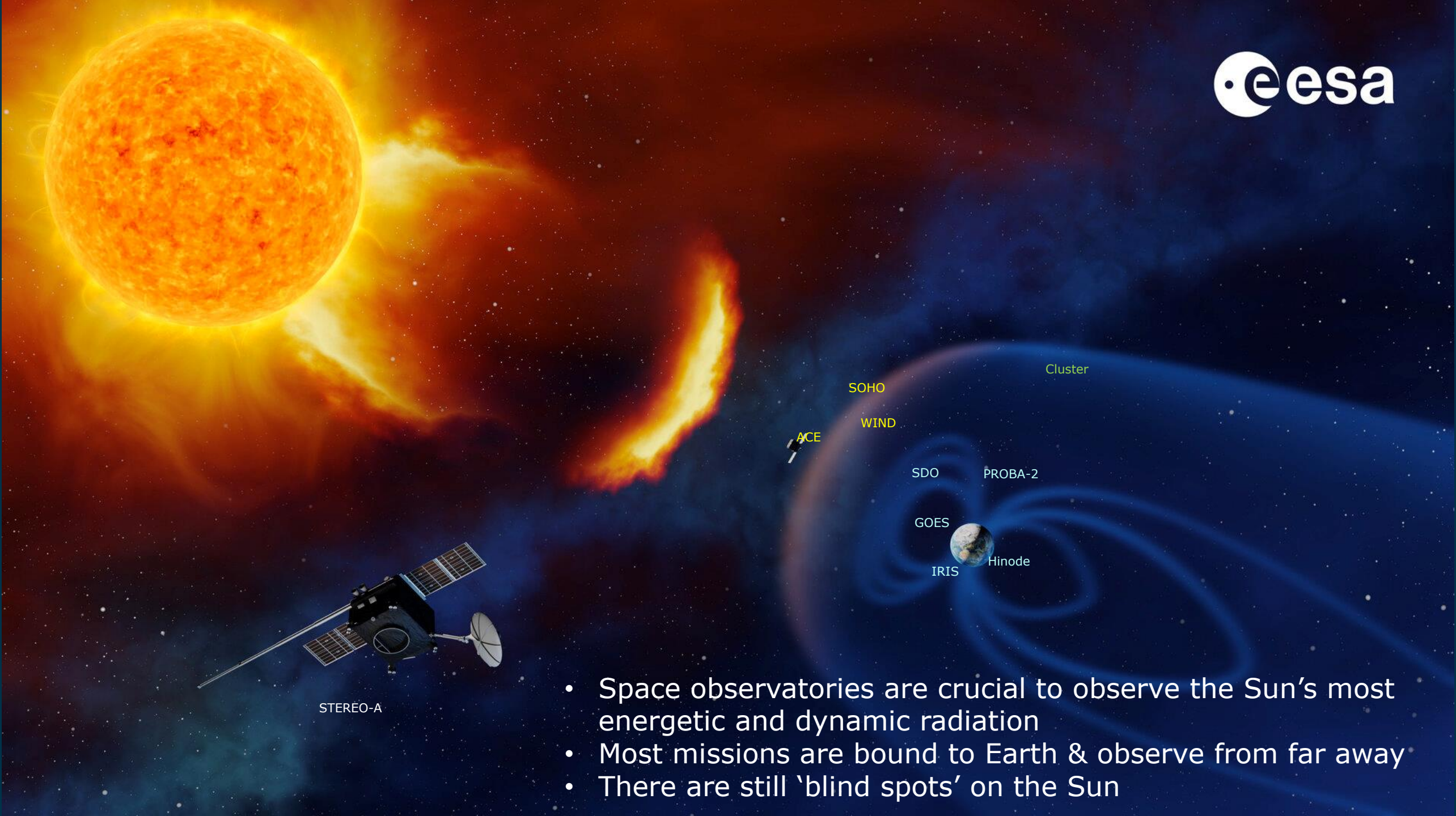






Earth is under continuous influence of active star  
-> Space Weather

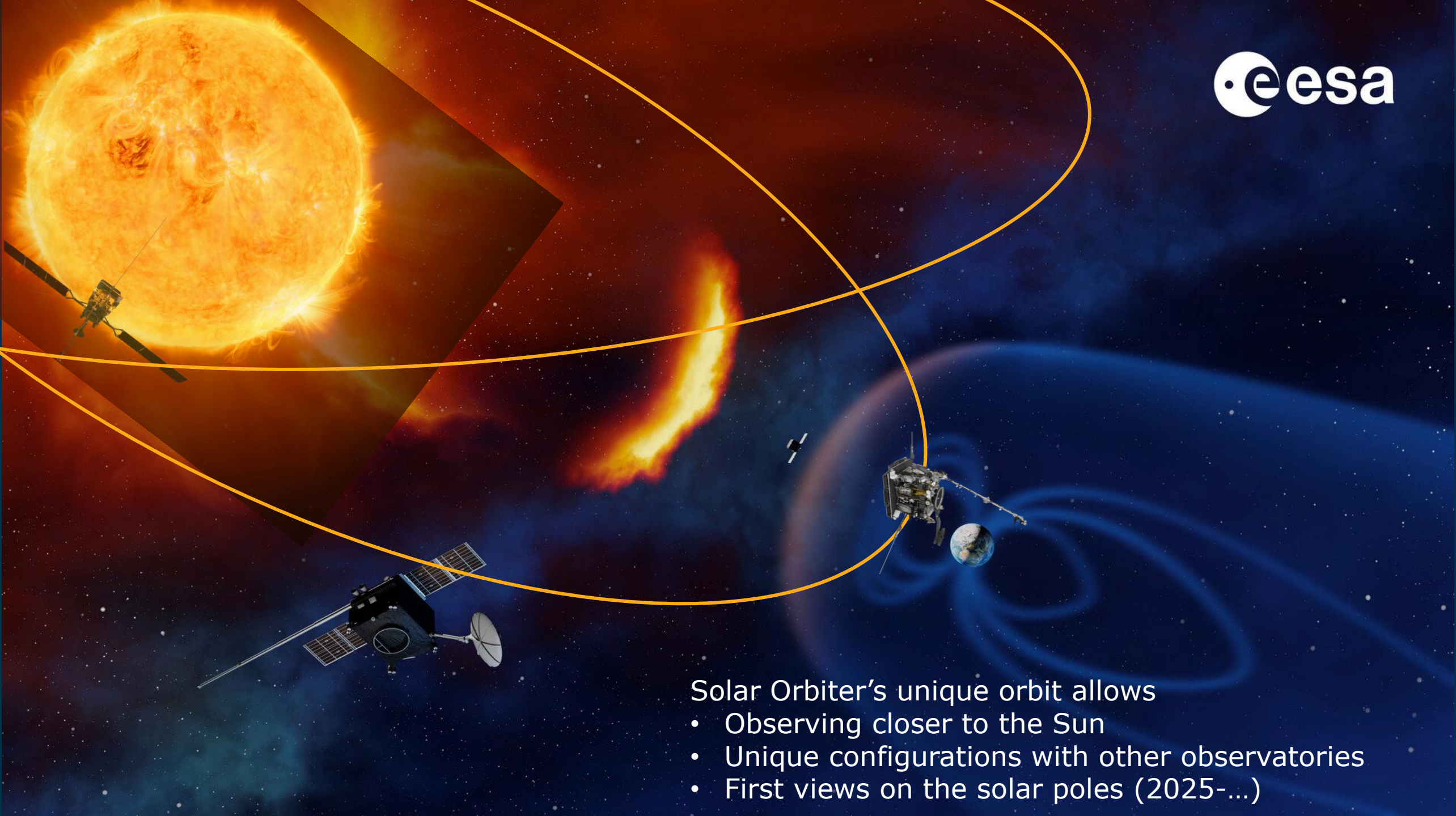




STEREO-A

- Space observatories are crucial to observe the Sun's most energetic and dynamic radiation
- Most missions are bound to Earth & observe from far away
- There are still 'blind spots' on the Sun





Solar Orbiter's unique orbit allows

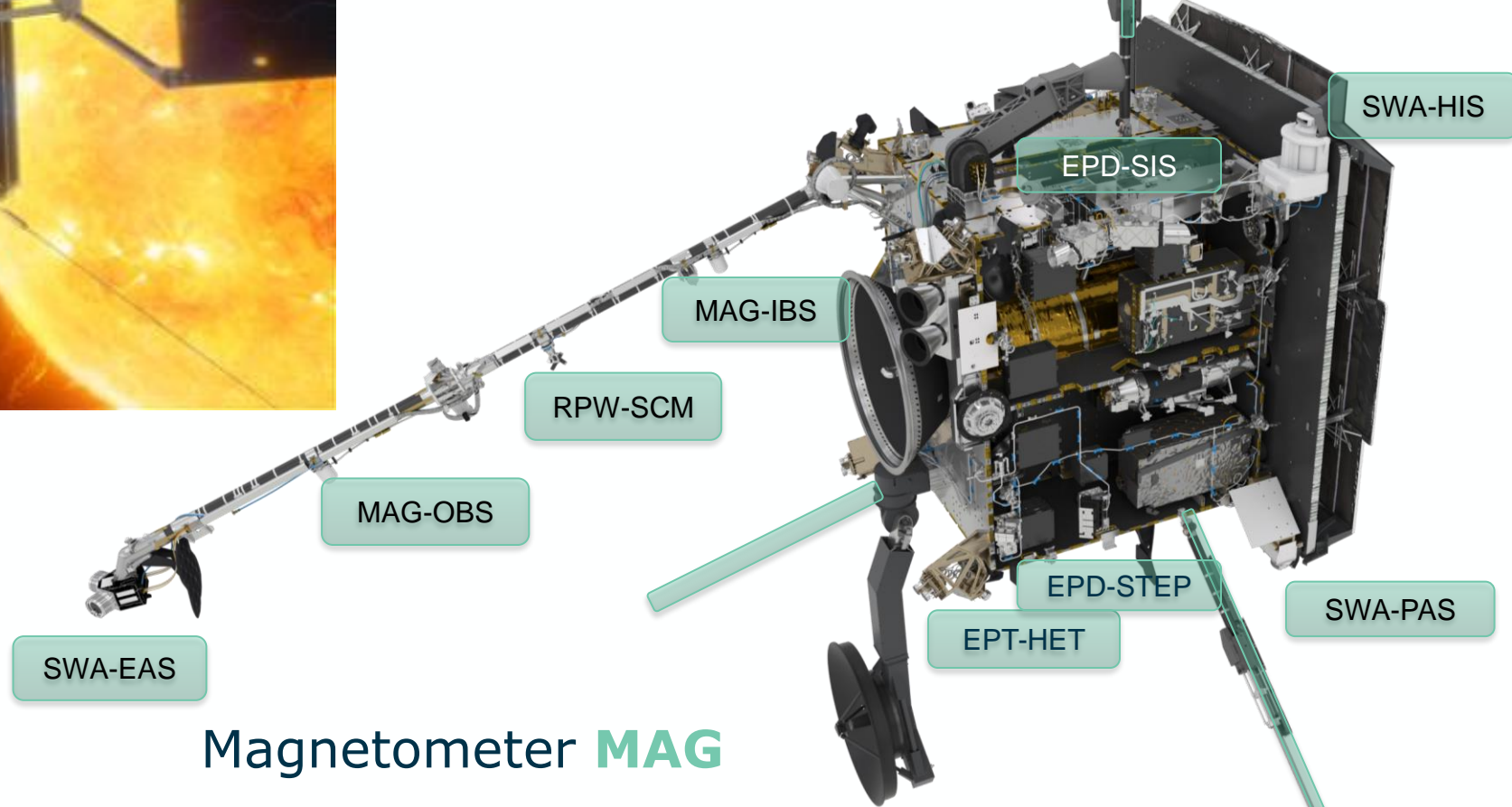
- Observing closer to the Sun
- Unique configurations with other observatories
- First views on the solar poles (2025-...)





Radio and Plasma Waves  
Energetic Particle Detector

RPW  
EPD



In-Situ  
Payload

Magnetometer **MAG**

Solar Wind Analyser **SWA**

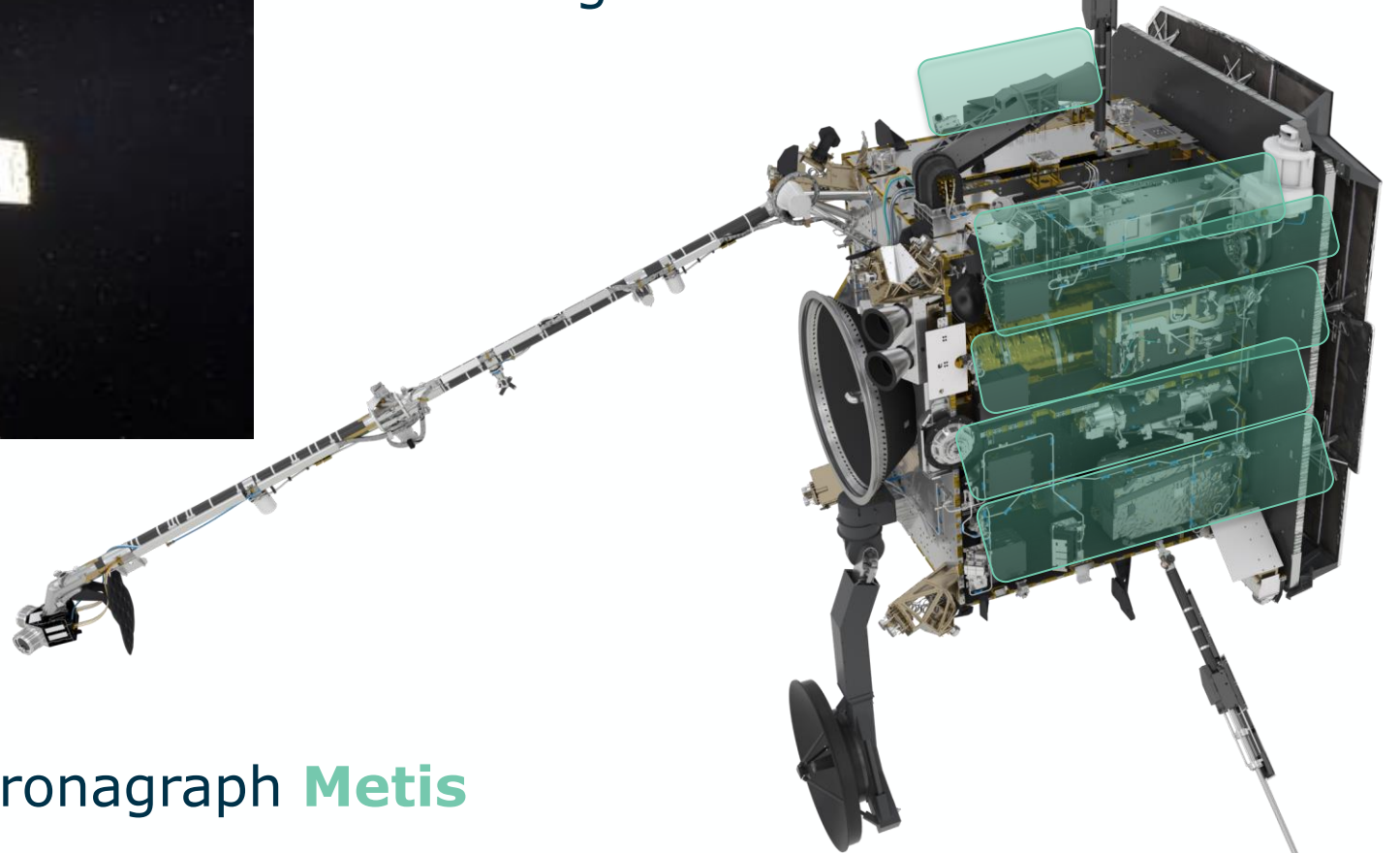




Imaging Spectrometer **SPICE**

X-ray imager/spectrometer **STIX**

EUV Imager **EUI**



## Remote-Sensing Payload

Coronagraph **Metis**

Polarimetric & Helioseismic Imager **PHI**

Heliospheric Imager **SoloHI**





# Engineering challenges: Taking the heat

Heat shield:

- SolarBlack coating
- 40 cm thick (high-temperature MLI, star brackets, low-temperature MLI)
- Surface temperature between  $-200\text{ }^{\circ}\text{C}$  and  $+520\text{ }^{\circ}\text{C}$



Thermal tests at ESTEC, May 2014 (Photo: ESA)



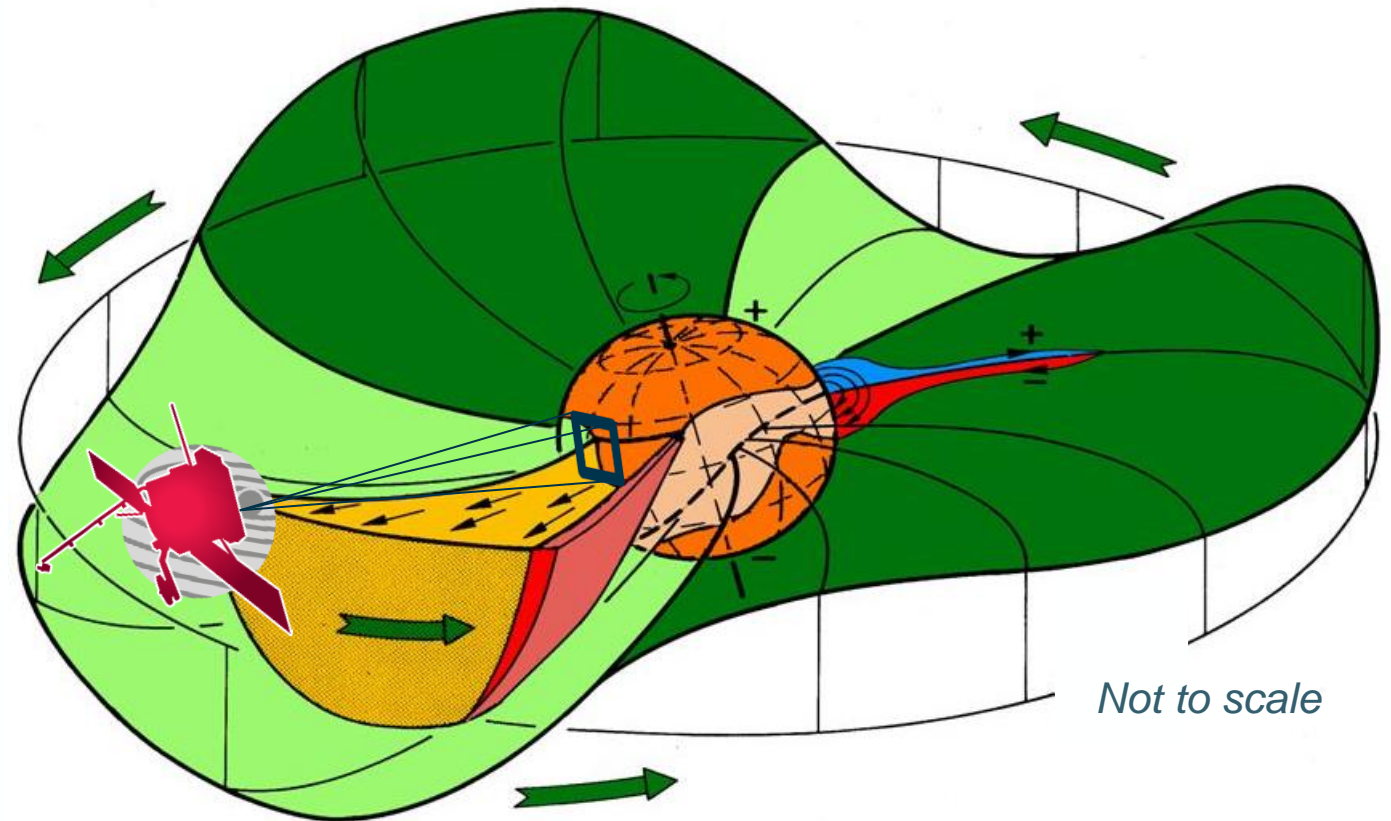
Solar Orbiter at IABG, Oct 2019 (Photo: ESA)



# Solar Orbiter's operational challenges

Solar Orbiter is quite different from previous solar missions, due to its unique orbit:

- Changing **distance to Sun and Earth**, changing viewpoint
- Changing **science opportunities**
- **Limited resources** force us to
  - Limit remote sensing observations
  - Plan long time ahead
  - Store data onboard
- Linking Sun and Heliosphere requires in-situ and remote-sensing payload to be **coordinated**
- Science planning and coordination happens at ESAC in Madrid





# Where is Solar Orbiter now? What has been done so far?

SOLAR ORBITER TO SUN  
**52,011,924 KM (0.35 AU)**

SOLAR ORBITER TO MERCURY  
**104,459,880 KM (0.70 AU)**

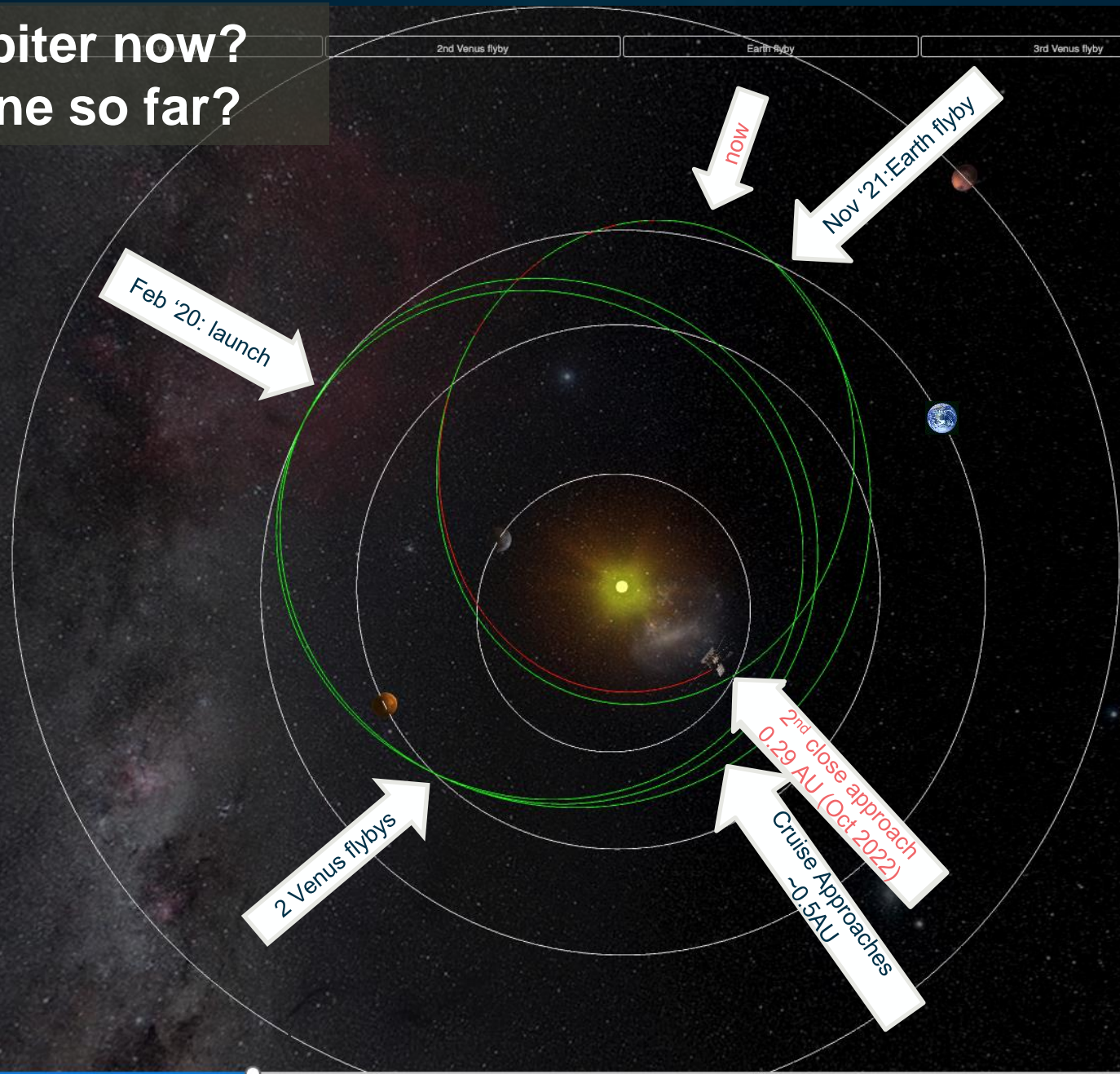
SOLAR ORBITER TO VENUS  
**138,180,475 KM (0.92 AU)**

SOLAR ORBITER TO EARTH  
**136,543,738 KM (0.91 AU)**

ONE-WAY SIGNAL TRAVEL TIME  
**455.15 SECONDS**

SUN INCLINATION  
**1.82 DEGREES**

ACCUMULATED DISTANCE  
**2,882,205,512 KM**



- [2020-02-10] Launch
- [2020-12-27] 1st Venus flyby
- [2021-08-09] 2nd Venus flyby
- [2021-11-27] Earth flyby
- [2022-09-04] 3rd Venus flyby
- [2025-02-18] 4th Venus flyby
- [2026-12-24] 5th Venus flyby
- [2028-03-18] 6th Venus flyby
- [2029-06-10] 7th Venus flyby

2022-10-21

Solar Orbiter Full mission

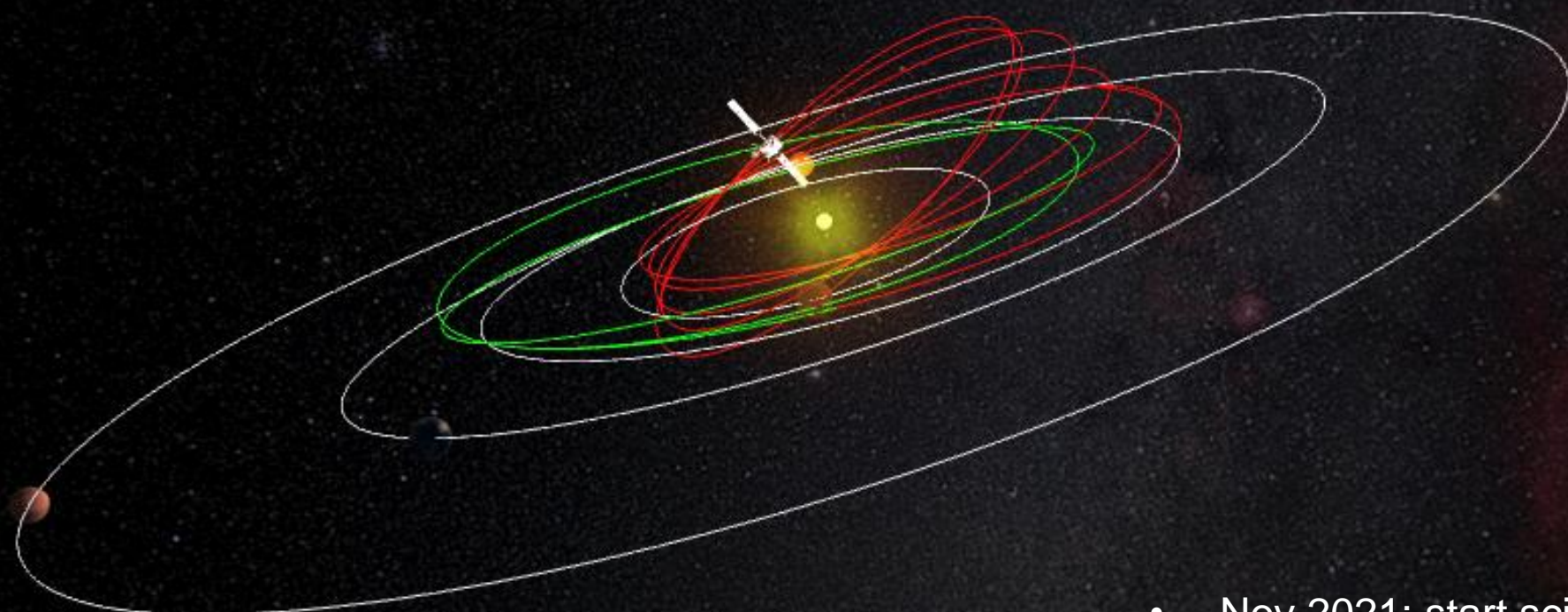


Simple path Hide Milestones



<https://solarorbiter.esac.esa.int/where/>

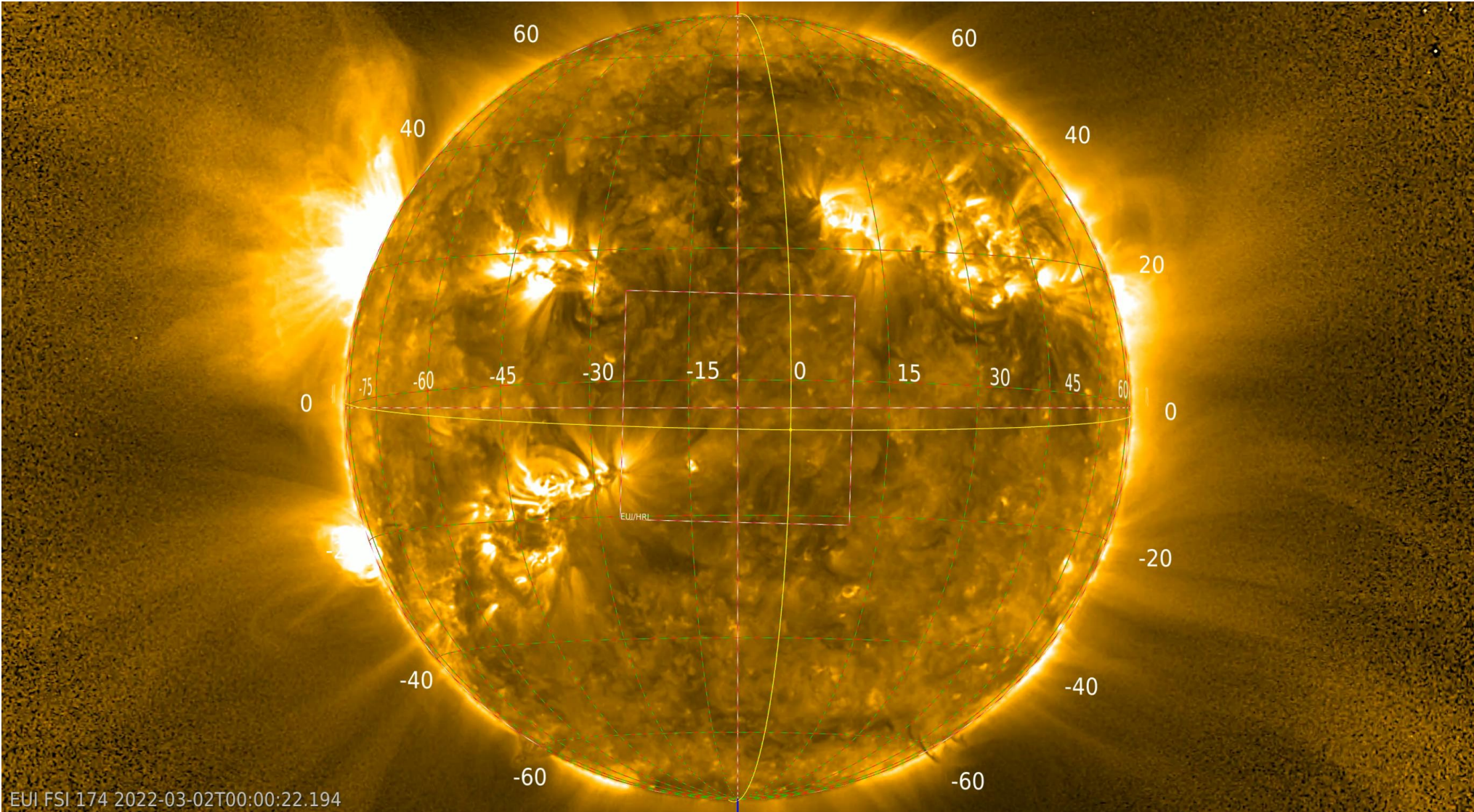




- Nov 2021: start science phase
- Mar 2022: first perihelion at 0.32AU (then every ~6 months)
- 2025: better view on both poles

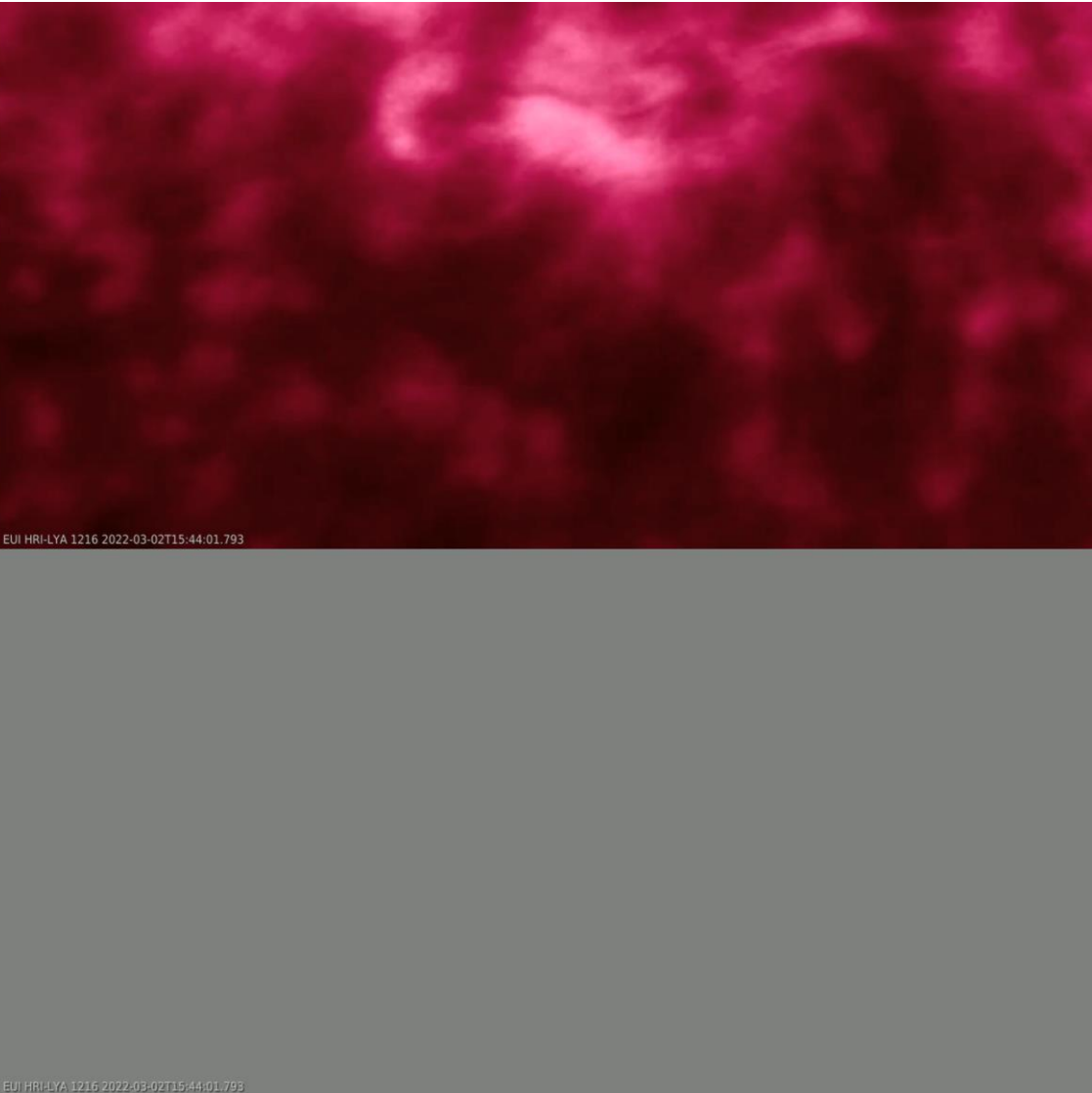
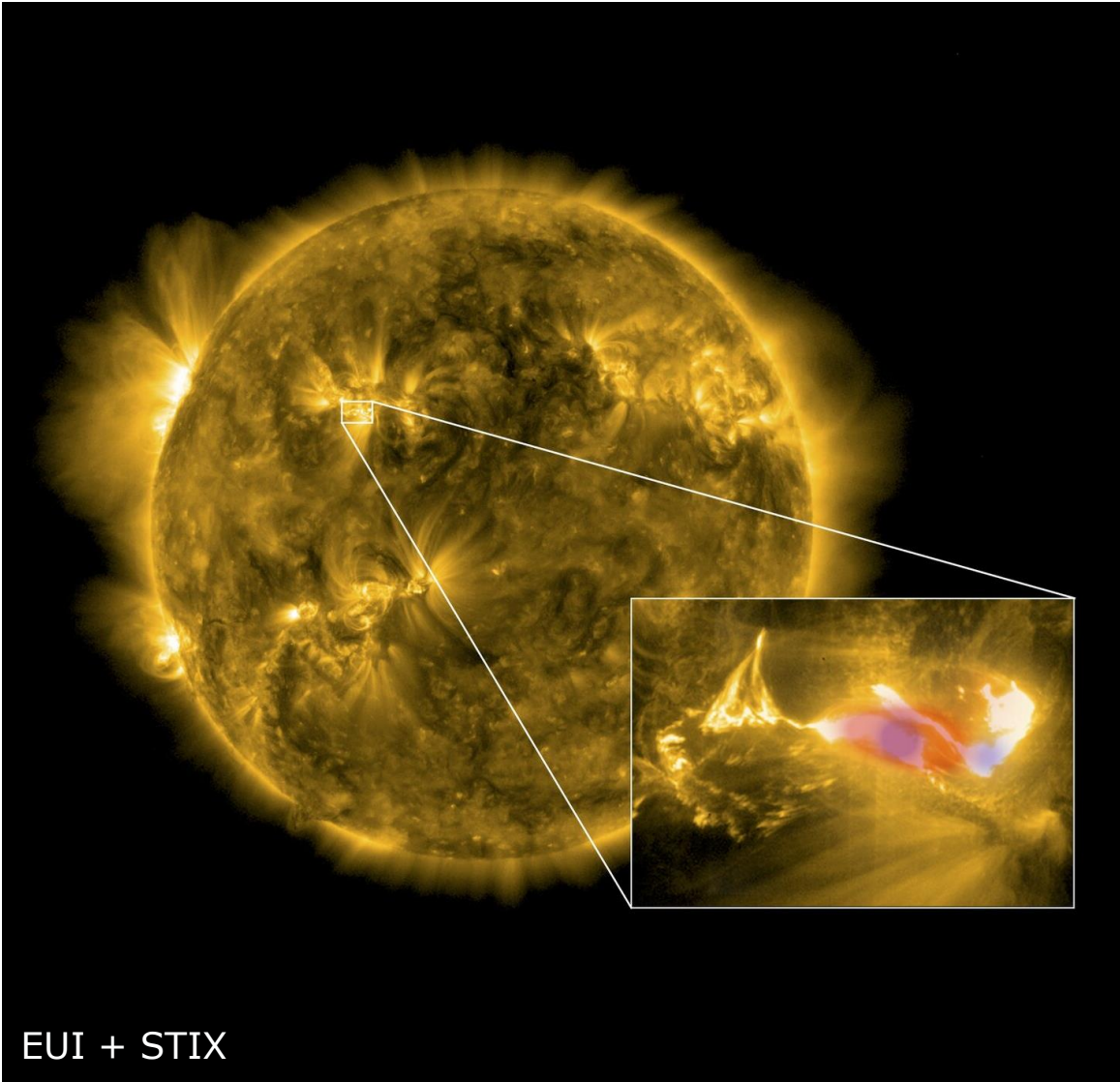


# EUI's observations from first close approach Mar 2022



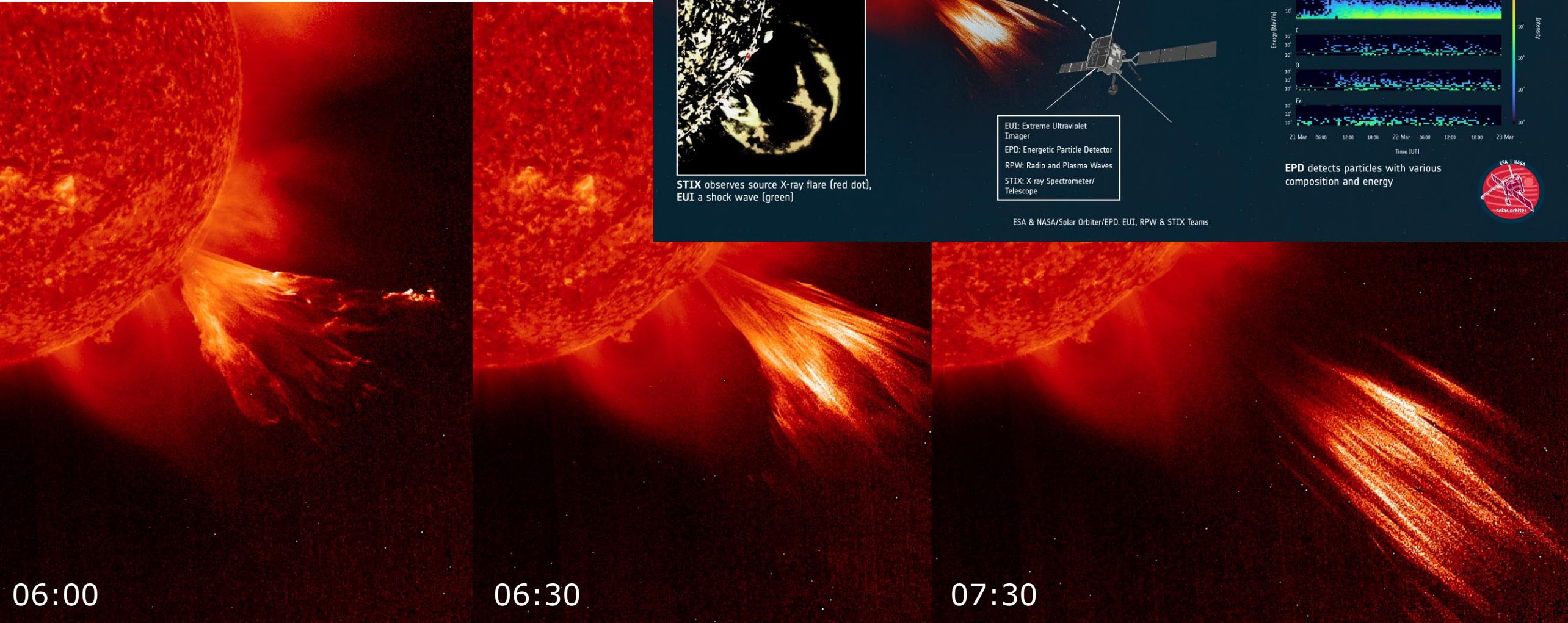


# Solar flare 2022-03-02





# EUI coronal mass ejection 2022-03-21 @ 0.34au



## JOINING THE DOTS

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

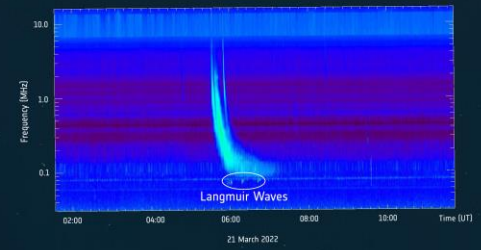


STIX observes source X-ray flare (red dot), EUI a shock wave (green)

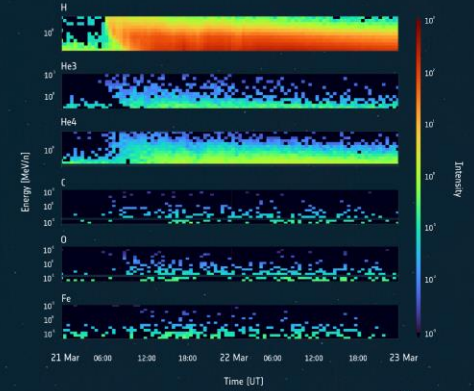
Particles spiraling out on Sun's magnetic field lines reach Solar Orbiter

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

ESA & NASA/Solar Orbiter/EPD, EUI, RPW & STIX Teams



RPW detects radio signals of accelerated particles and plasma oscillations



EPD detects particles with various composition and energy





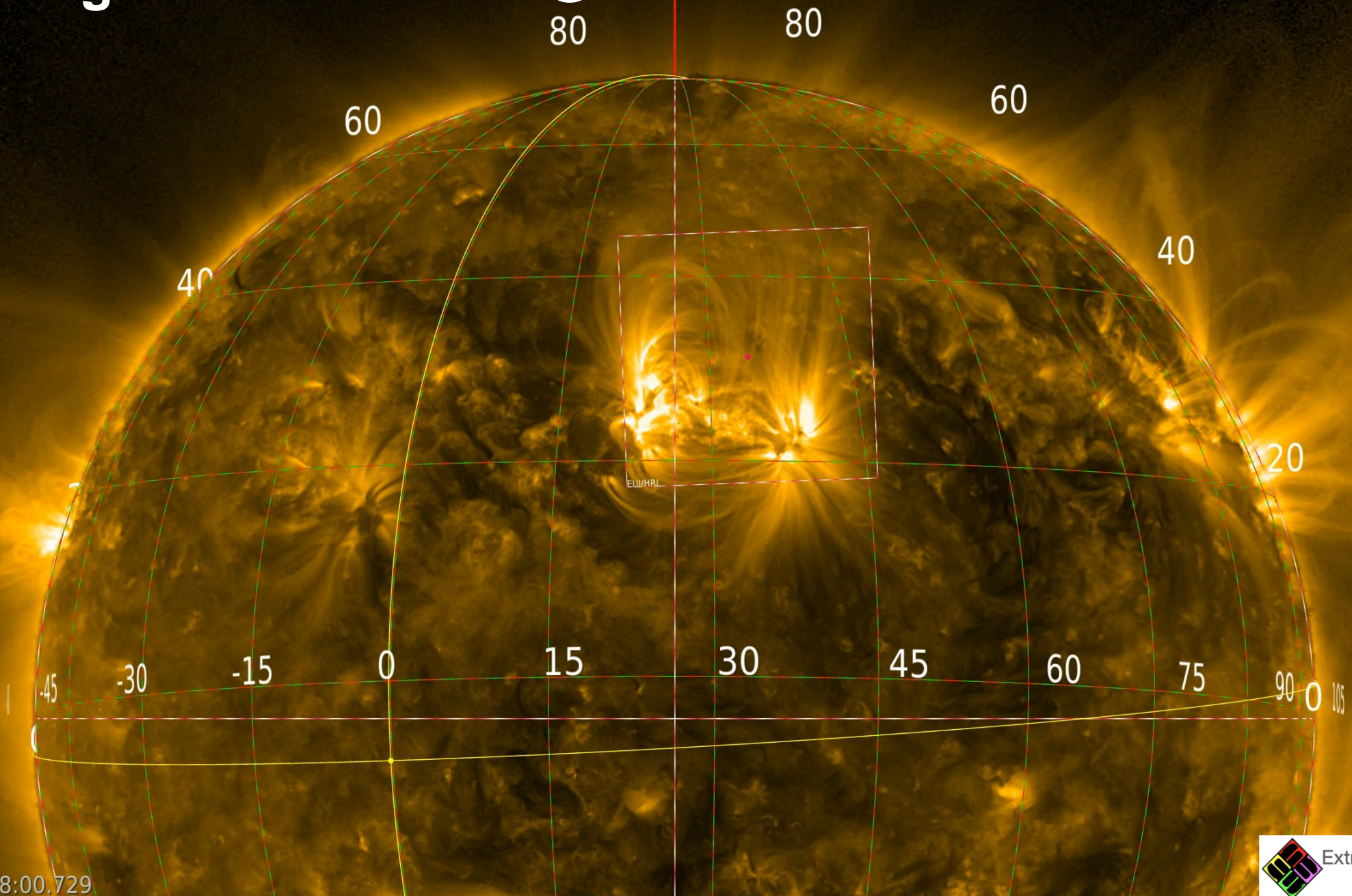
# Solar south pole - 2022-03-30 @ 0.33au



Earth to scale



# Active Region - 2022-03-17 @ 0.38au



2022-03-17T03:18:00.729



# 5x5 Mosaic image made by HRI/EUV telescope of EUI on 2022 March 7 Solar Orbiter was halfway the Earth-Sun line

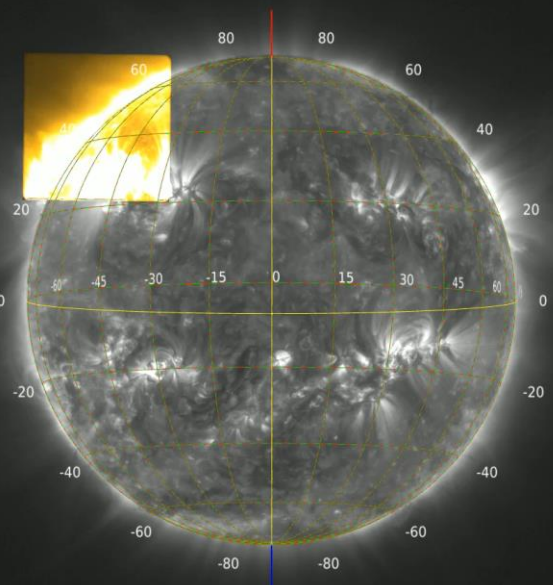


Image processing by Emil Kraaikamp (ROB)  
ESA&NASA/Solar Orbiter/EUI team

Forbes

SCIENCE

## See The Jaw-Dropping New 83 Megapixel Photo Of The Sun Sent Back From A Spacecraft Halfway There

Jamie Carter Senior Contributor ©  
*I inspire people to go stargazing, watch the Moon, enjoy the night sky* [Follow](#)

Apr 2, 2022, 04:51am EDT

[Listen to article](#) 3 minutes

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The European Space Agency's Solar Orbiter has returned an incredible 83 megapixel image of the Sun.  
ESA/ATG MEDIALAB

Cookies on Forbes

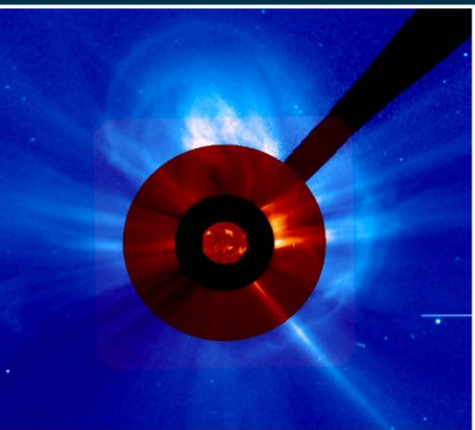
If you only look at one "space photo" this year then this one *has* to be it.

If you only look at one "space photo" this year then this one *has* to be it.



# TRACKING SPACE WEATHER

Solar Orbiter felt a coronal mass ejection (CME) wash over it on 11 March 2022, predicting when it would hit Earth and allowing astronomers to capture its impact as aurora



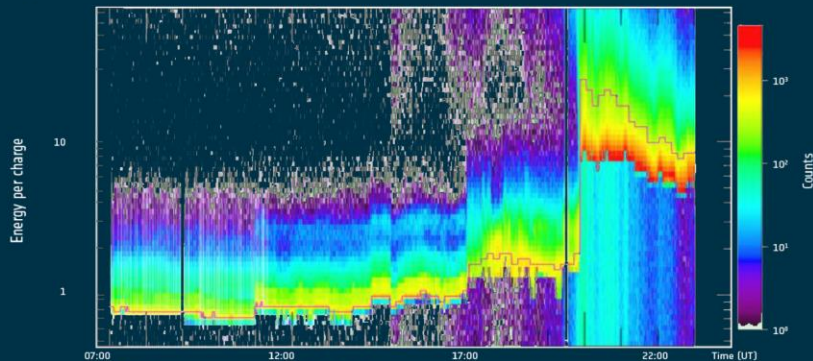
**10 March:** CME observed on Sun by Solar Orbiter and Soho



**Solar Orbiter**  
67 million km from Sun

**EUI:** Extreme Ultraviolet Imager  
**MAG:** Magnetometer  
**SWA:** Solar Wind Analyser

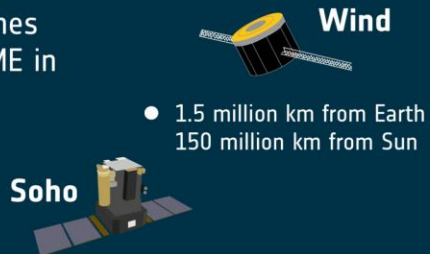
**11 March:** Solar Orbiter SWA detects CME as a change in properties of the solar wind



**11 March:** Solar Orbiter MAG detects CME in magnetic field



**13 March:** CME reaches Earth; Wind detects CME in magnetic field



**13 March:**  
Aurora triggered in Earth's atmosphere





# Stay tuned! Solar Orbiter has only yet started!

[https://www.esa.int/Science\\_Exploration/Space\\_Science/Solar\\_Orbiter](https://www.esa.int/Science_Exploration/Space_Science/Solar_Orbiter)  
<https://solarorbiter.esac.esa.int/where/>

