Solar Orbiter: Unlocking the Secrets of our Star

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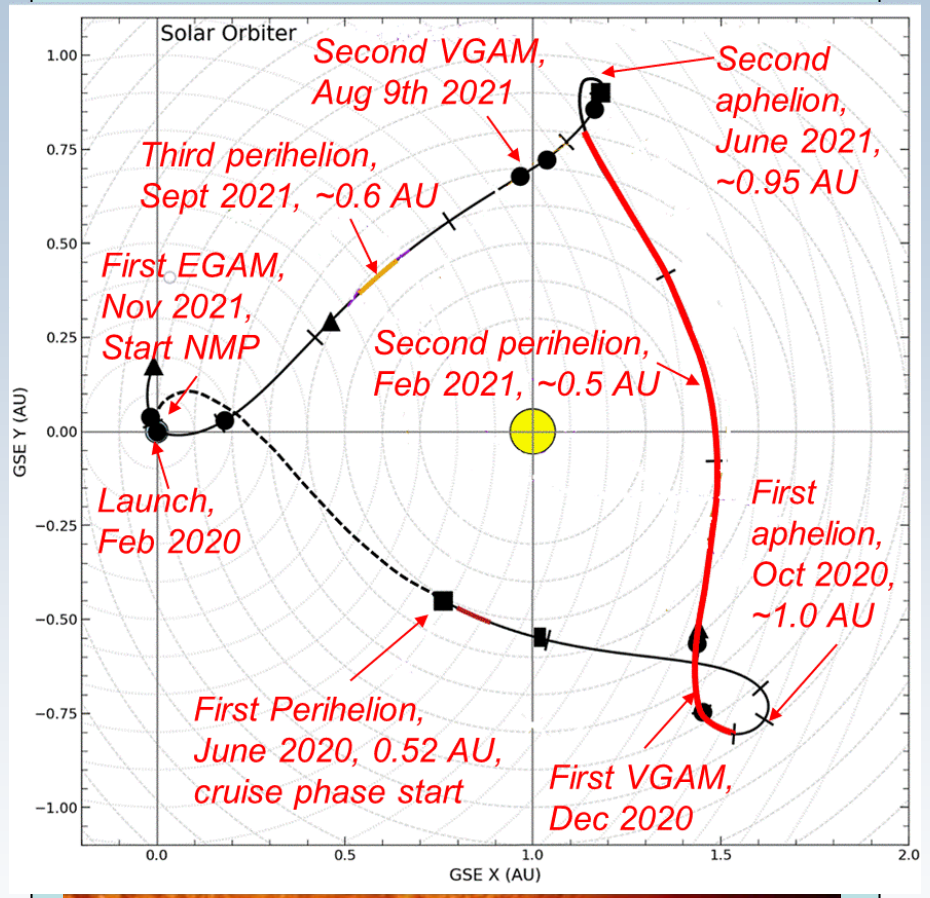
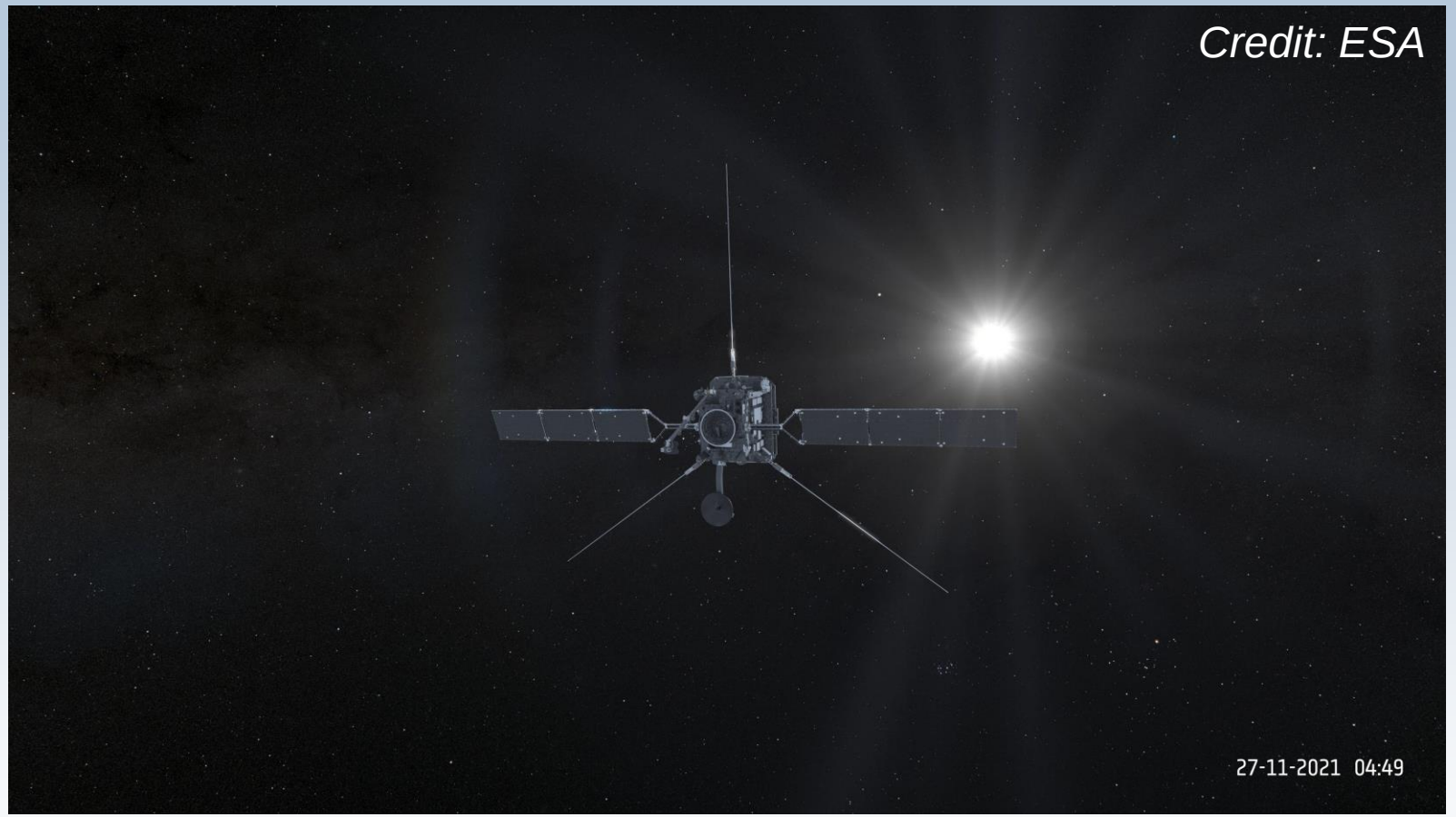
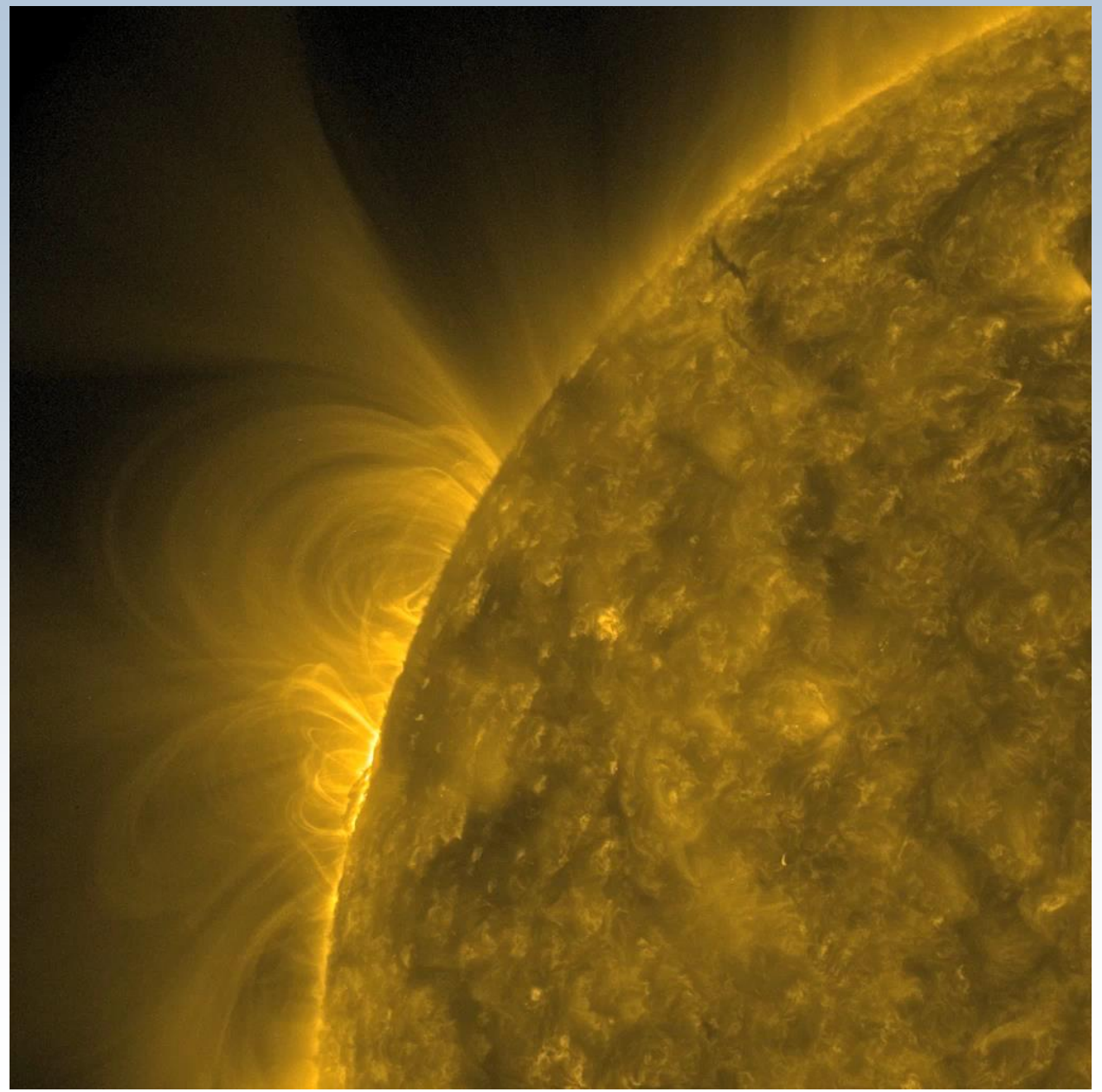
Principal Investigator SWA Team on Solar Orbiter



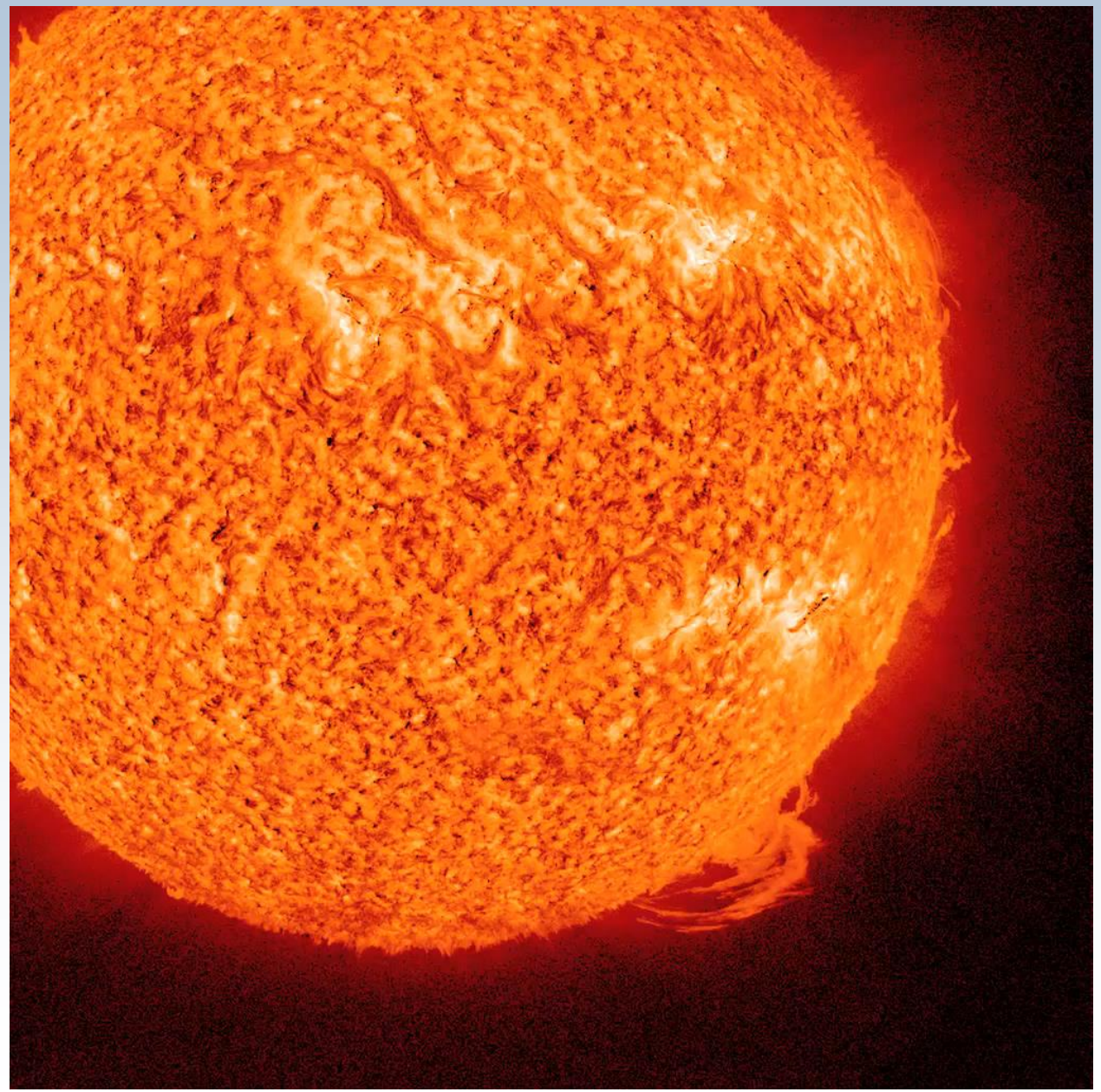
Submitted January 10th 2008



Solar Orbiter ‘nominal’ mission phase begins with the Earth swingby at end of this month.



NASA/SDO/AIA



NASA/SDO/AIA

The Wider View – Heliospheric Imaging

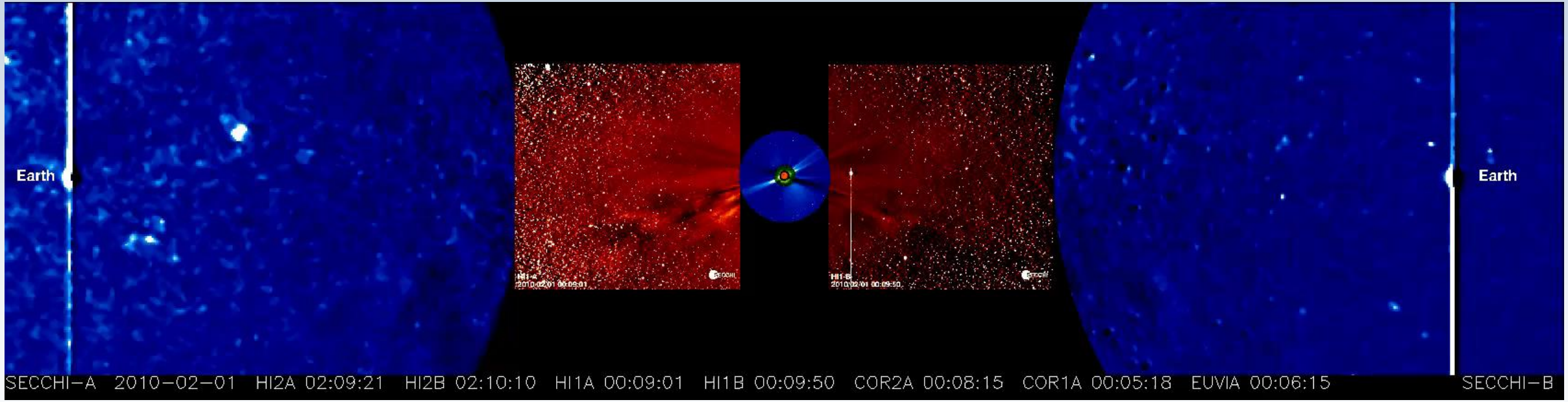
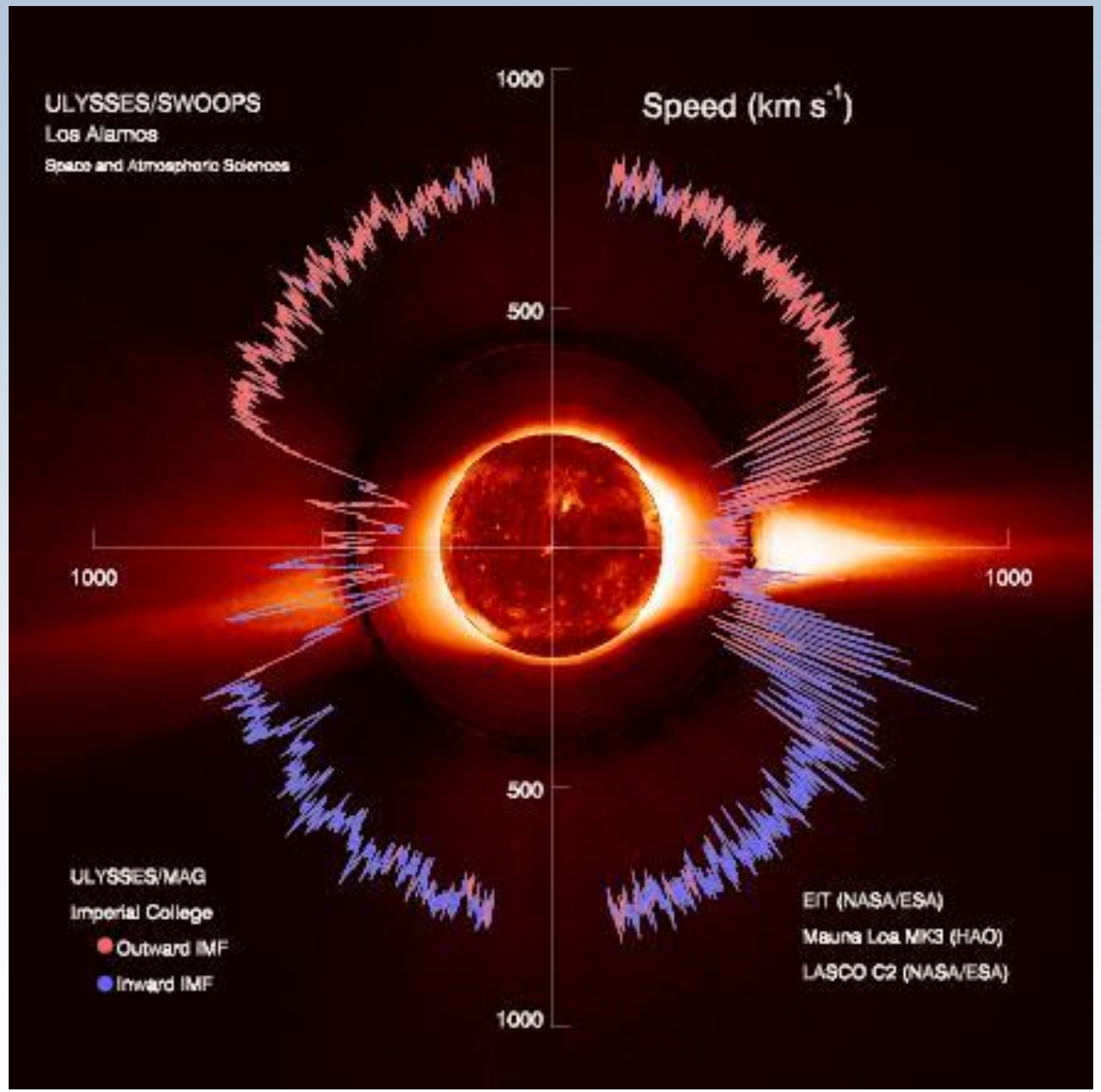


Image composite of NASA/Stereo images
https://stereo.gsfc.nasa.gov/gallery/item.php?id=selects&iid=117

The Solar Wind

- Extension of solar corona, and the activity / variability, into interplanetary space;
- Note the major variability occurs near the ecliptic plane – thus the Earth is immersed in this fluctuating environment;
- The goal of Solar Orbiter is to understand the origins and drivers of this variability.

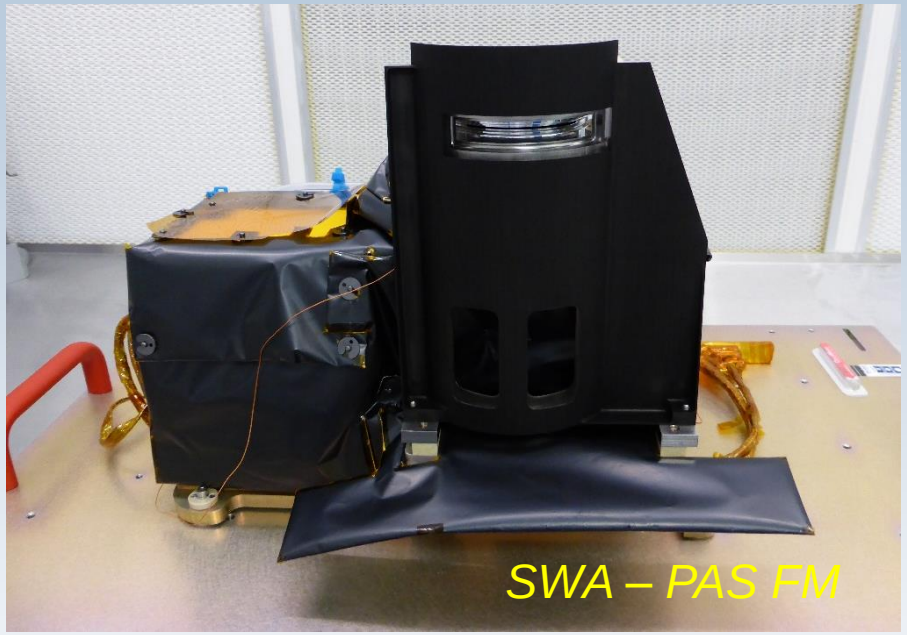


Instruments and Measurements

	Investigation	Measurements
In Situ Group	Solar Wind Analyzer (SWA)	Solar wind ion and electron bulk properties, ion composition (1eV- 5 keV electrons; 0.2 - 100 keV/q ions)
	Energetic Particle Detector (EPD)	Composition, timing, and distribution functions of suprathermal and energetic particles (8 keV/n – 200 MeV/n ions; 20-700 keV electrons)
	Magnetometer (MAG)	DC vector magnetic fields (0 – 64 Hz)
	Radio & Plasma Waves (RPW)	AC electric and magnetic fields (~DC – 20 MHz)
Remote Sensing Group	Polarimetric and Helioseismic Imager (PHI)	Vector magnetic field and line-of-sight velocity in the photosphere
	EUV Imager (EUI)	Full-disk EUV and high-resolution EUV and Lyman-α imaging of the solar atmosphere
	Spectral Imaging of the Coronal Environment (SPICE)	EUV spectroscopy of the solar disk and corona
	X-ray Spectrometer Telescope (STIX)	Solar thermal and non-thermal X-ray emission (4 – 150 keV)
	Coronagraph (METIS/COR)	Visible, UV and EUV imaging of the solar corona
	Heliospheric Imager (SolOHI)	White-light imaging of the extended corona

- *The science goals can only be achieved with both in situ measurements of the plasma conditions local to the spacecraft TOGETHER with relevant remote observations of the source(s) of that plasma in near-Sun environment.*
- *Thus a key challenge is to be able to make the connection between the 2 sets of observations.*

Solar Orbiter - Solar Wind Analysers (SWA)



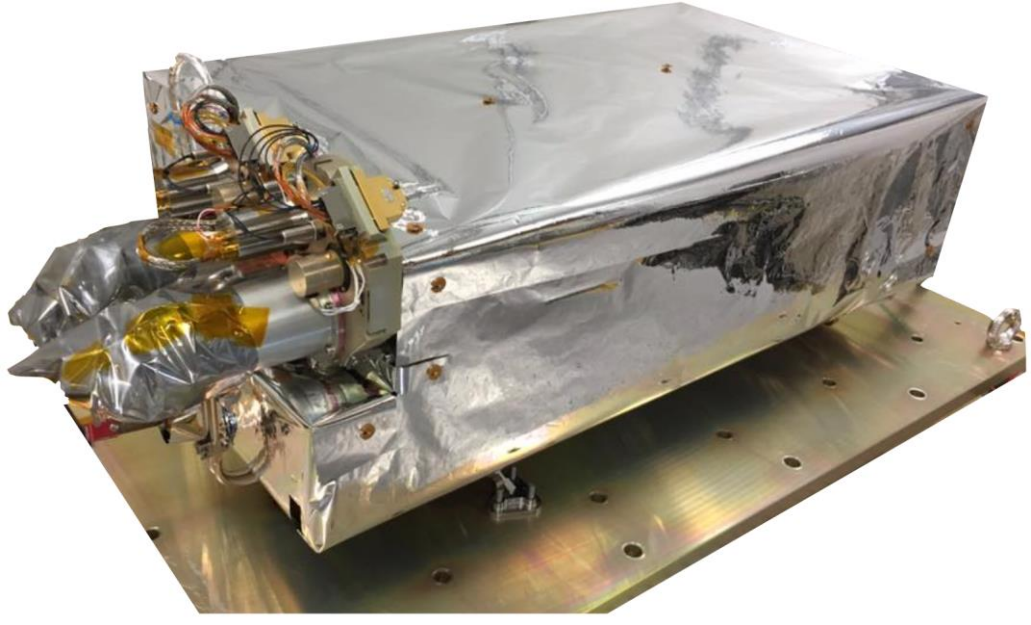
- Electron Analyser System (EAS):
  - Electrons
  - < 5 keV,
  - quasi- 4π sr FoV;
- Build led by UCL/MSSL, UK

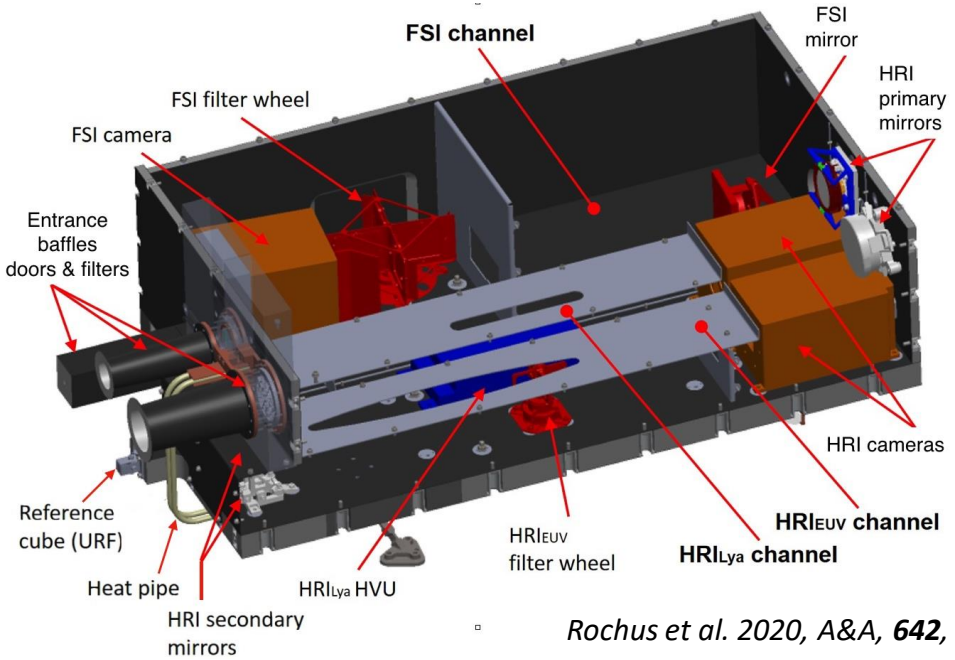
- Proton-Alpha Sensor (PAS):
  - Protons/Alphas,
  - 0.2 - 20 keV/q,
  - 60° × 40° FoV around SW flow direction;
- Build led by IRAP, Toulouse, Fr

- Heavy Ion Sensor (HIS):
  - He – Fe,
  - < 0.5 – 100 keV/q,
  - 96° × 34° FoV centred on SW flow;
- Build led by SWRI (US) and IRAP (Fr)

Extreme Ultraviolet Imager (EUI)

- PI group is Royal Observatory Brussels (Belgium) and UCL/MSSL designed and built the Central Electronics Box;
- 2 instruments, 3 telescopes:
  - Full Sun Imager (FSI):
    - 17.4 & 30.4nm, 3072 x 3072 pixels
    - FoV: 2 R_{sun} at perihelion
  - High Resolution Imager (HRI); 2 telescopes:
    - 17.4nm & Lyman-alpha, 2048 x 2048 pixels
    - FoV: 1000 arcsec^2

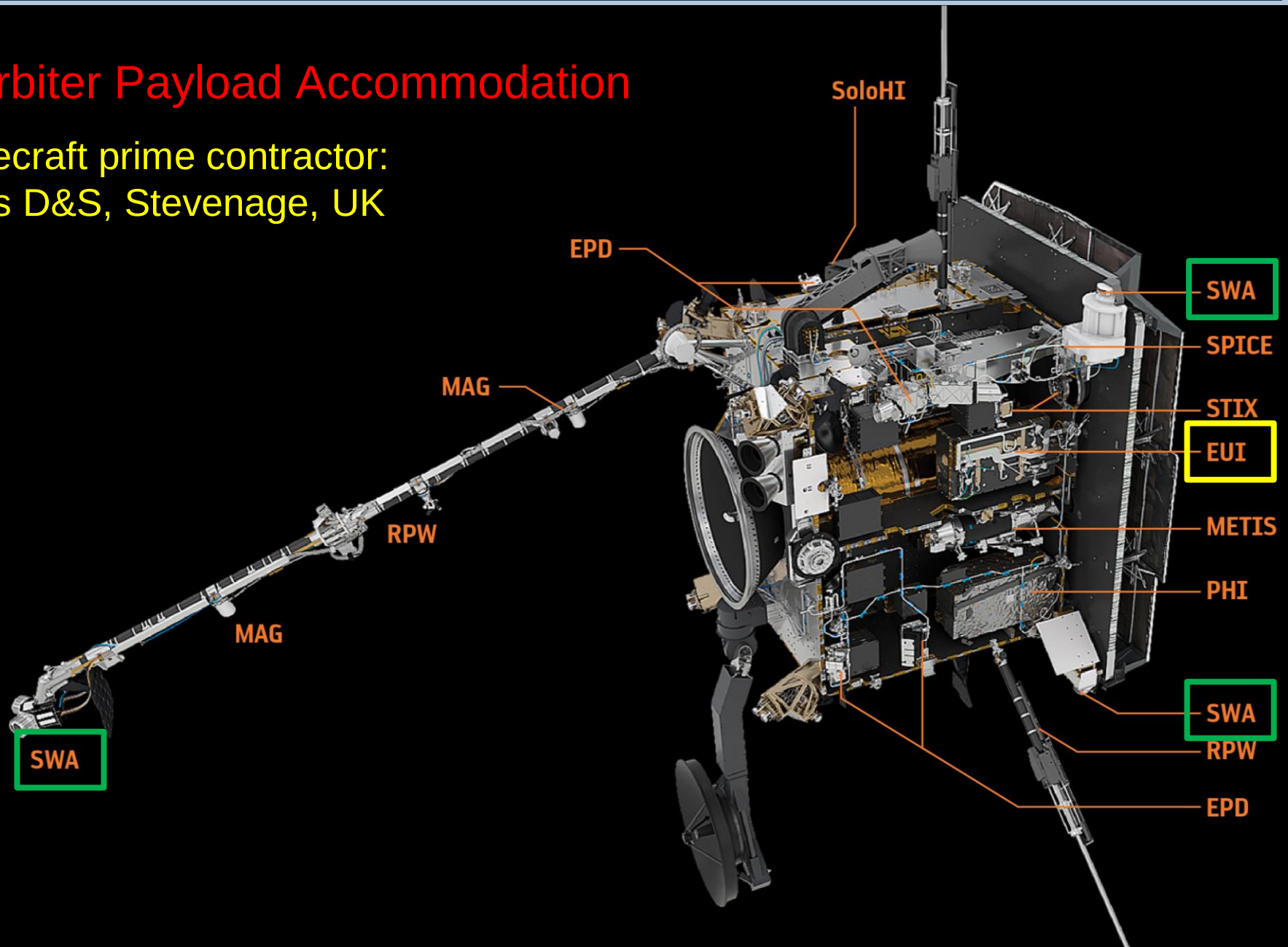




*Rochus et al. 2020, A&A, **642**, A8*

Solar Orbiter Payload Accommodation

- Spacecraft prime contractor:
  Airbus D&S, Stevenage, UK



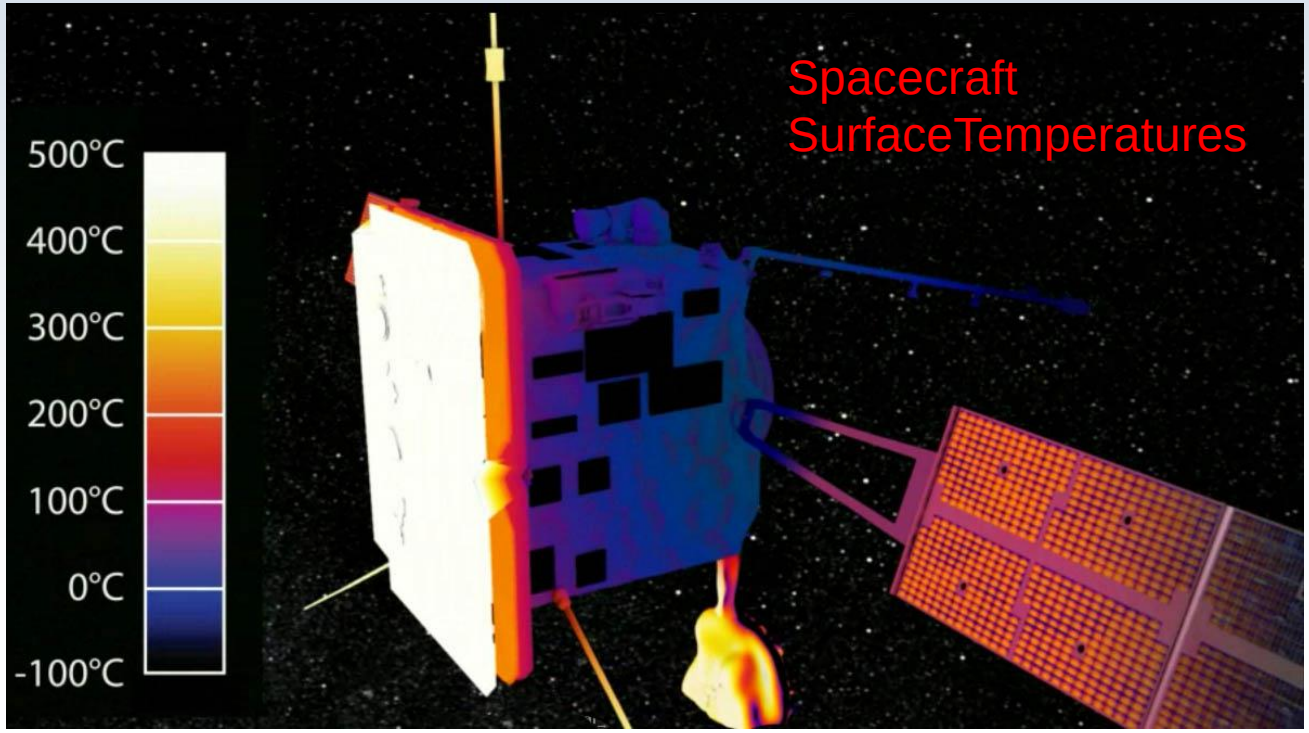
To Sun

Credit: ESA

The Thermal Challenge

The majority of the spacecraft and subsystems reside behide a bespoke heat shield:

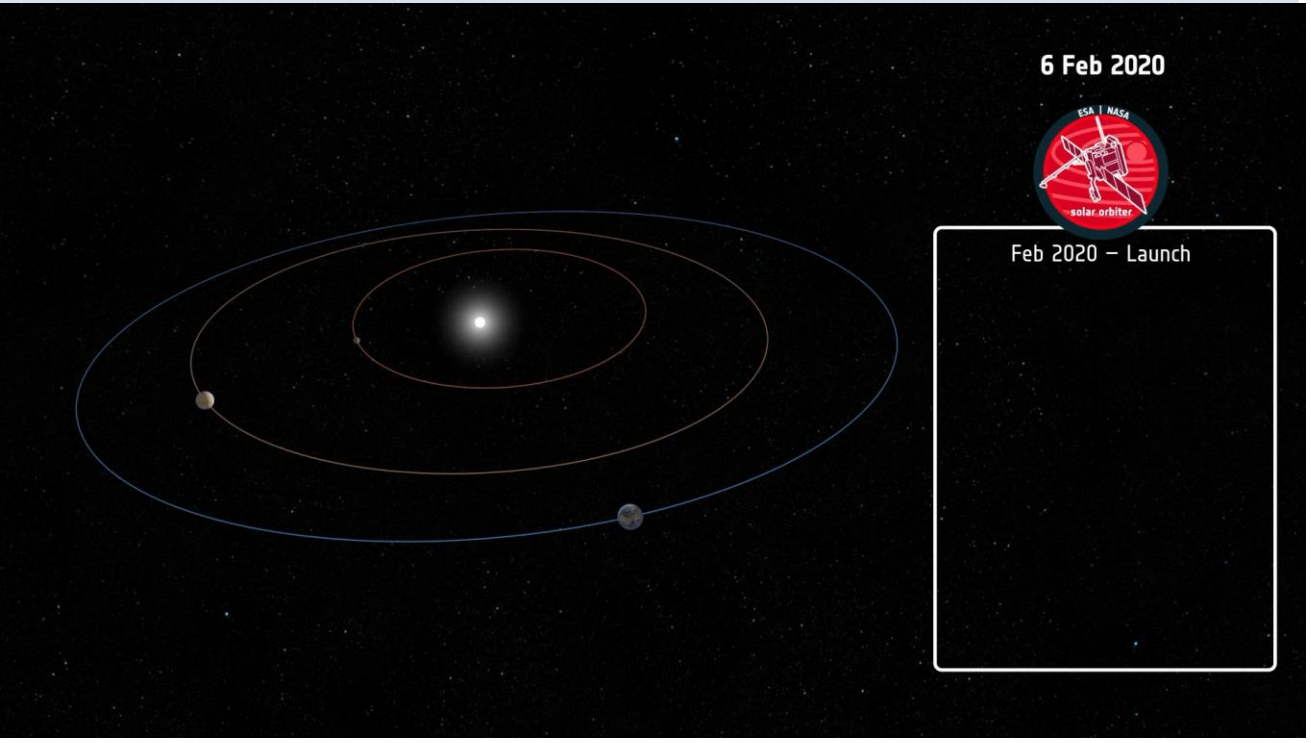
- SolarBlack coating
- 40 cm thick (high-temperature MLI, star brackets, low-temperature MLI)
- surface temperature between -200°C and +520°C

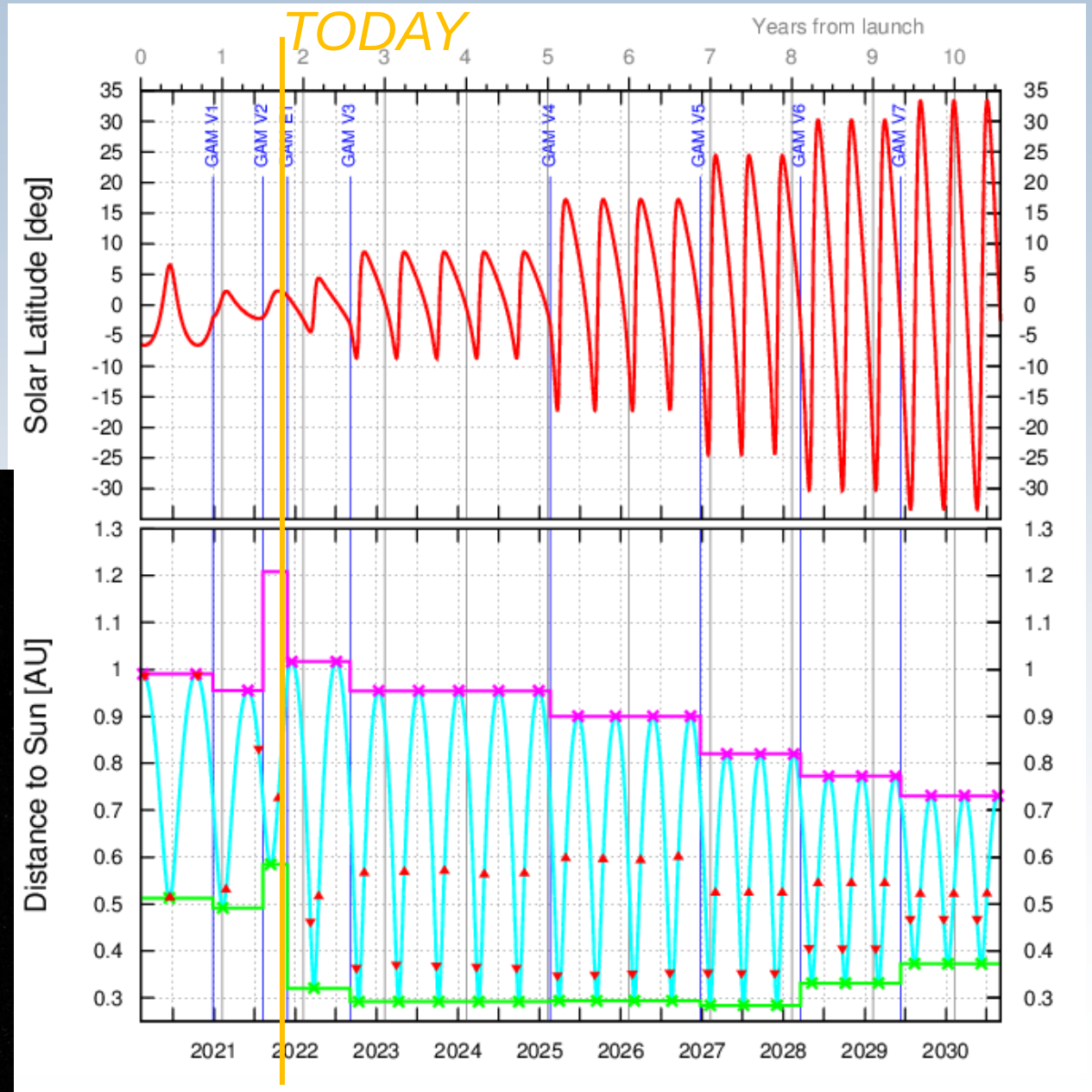


Solar Orbiter at IABG, Oct 2019 (Photo: ESA)

Mission Profile

- Spacecraft makes multiple Earth and Venus gravity assist manoeuvres;
- Mission duration >10 years, reaching minimum perihelion distance: ~60 solar radii (0.28 AU) and maximum solar latitude ~35° .

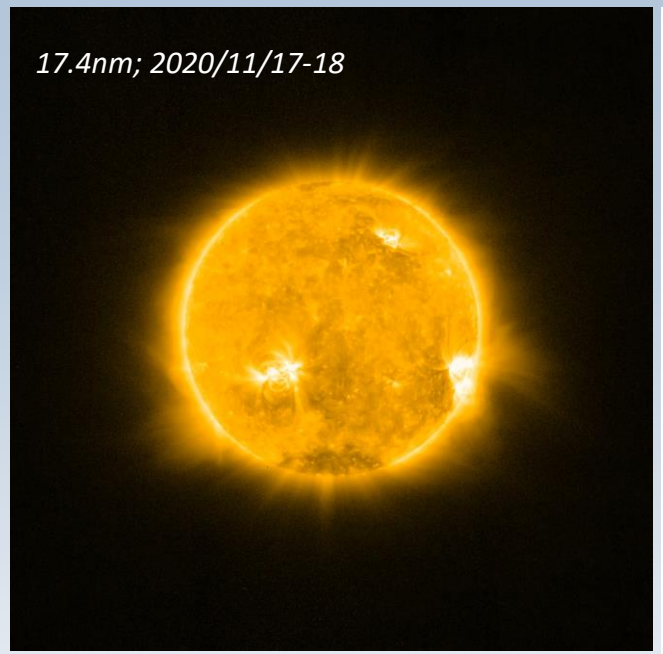


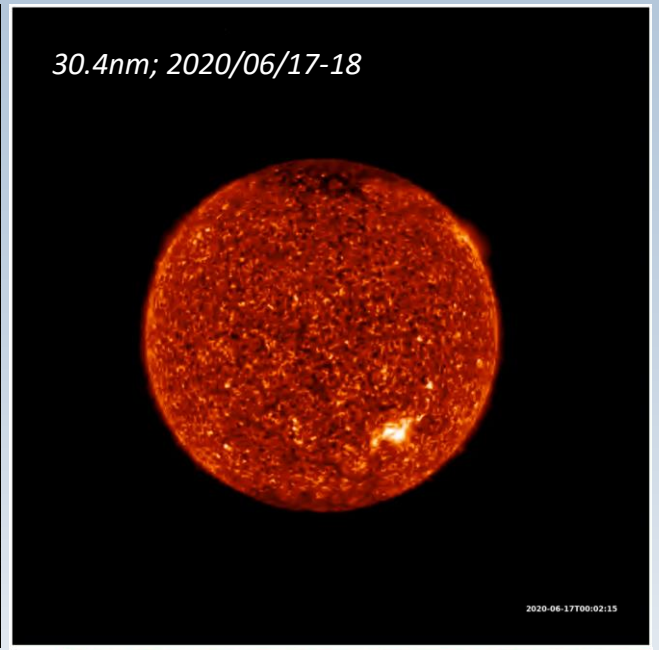


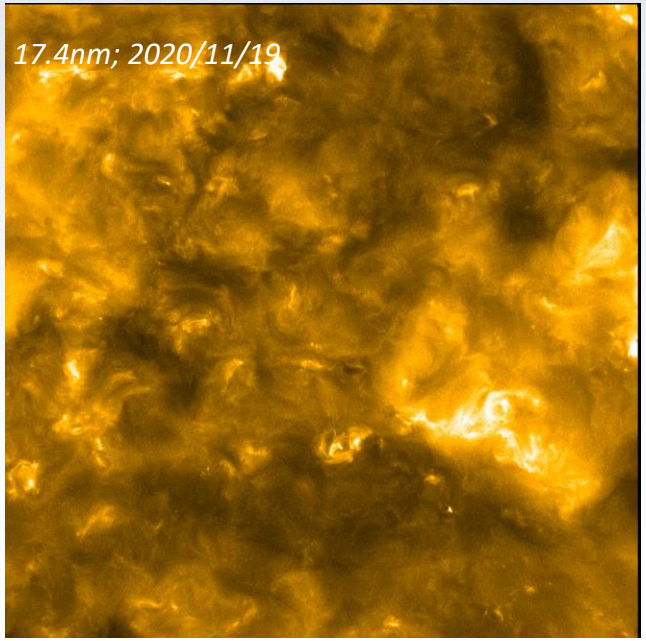
EUI Early Observations from the Cruise (check-out) Phase)

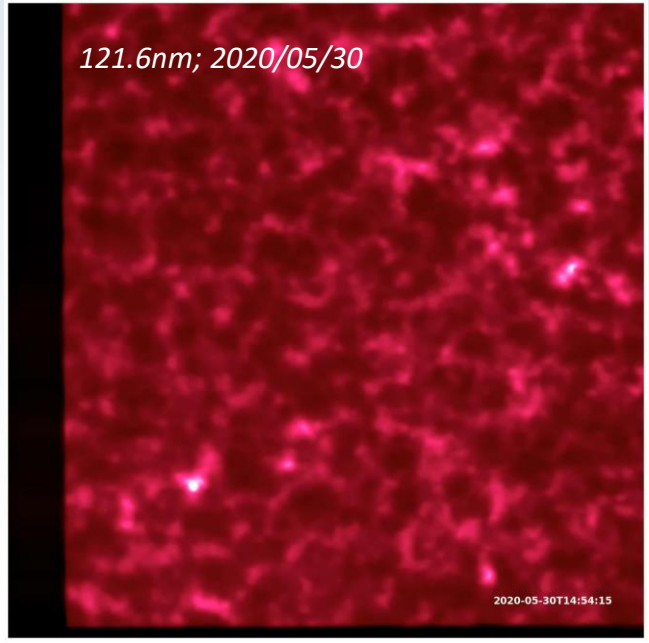
- Full Sun Imager (FSI), tuned to access:
  - Low corona (17.4 nm)
  - Transition region (30.4 nm)

- High Resolution Imagers:
  - EUI (17.4 nm)
  - Lyman-α (121.6 nm)
  - Co-aligned with high resolution imagers of the other remote sensing instruments to support science goals;

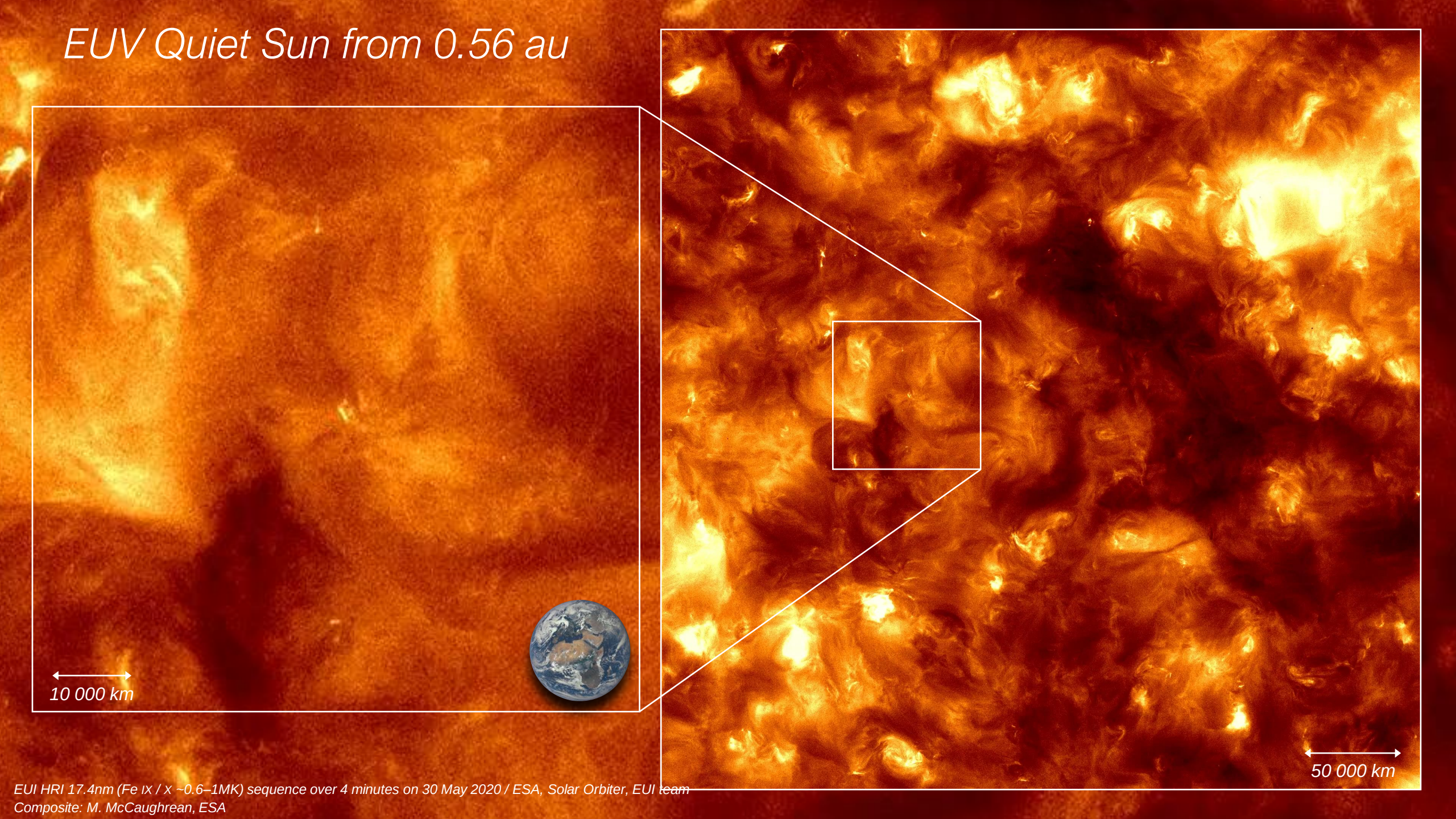






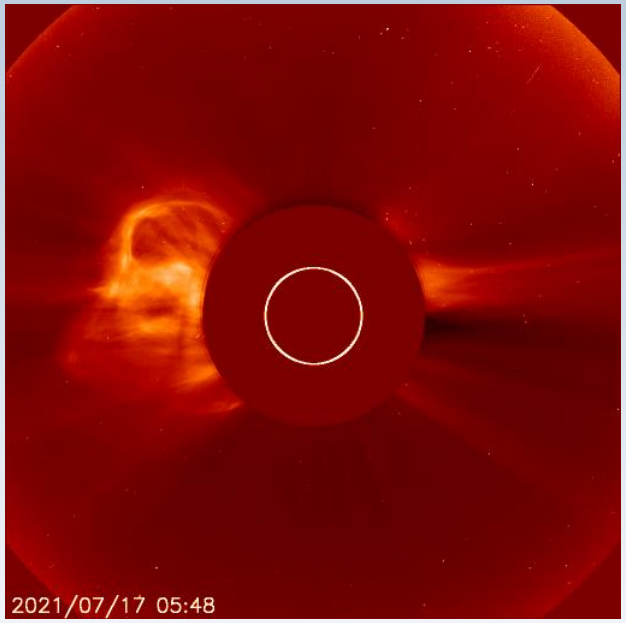


EUV Quiet Sun from 0.56 au

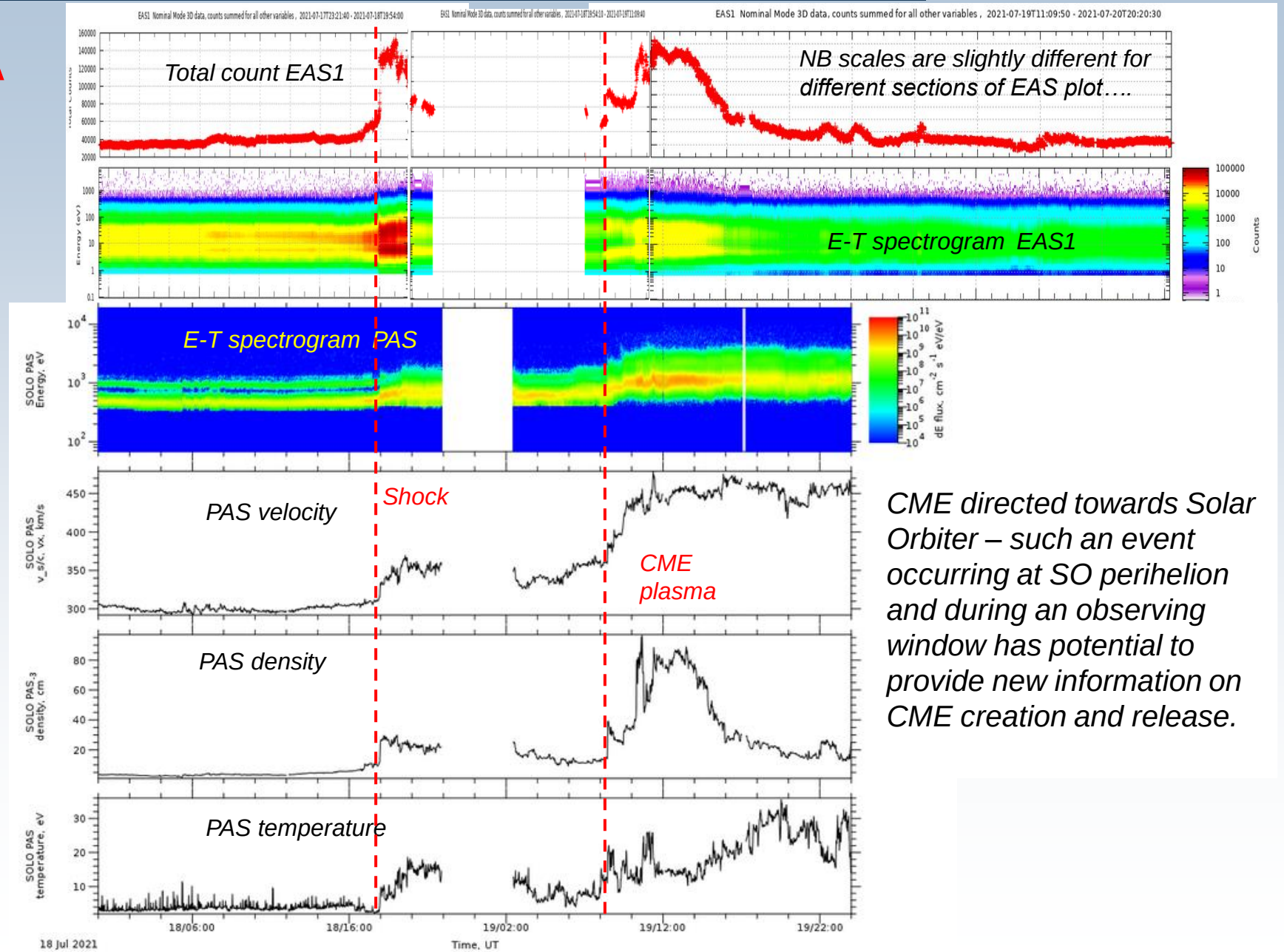


EUI HRI 17.4nm (Fe IX / X ~0.6–1MK) sequence over 4 minutes on 30 May 2020 / ESA, Solar Orbiter, EUI team
Composite: M. McCaughrean, ESA

CME observed by SWA on 18/19 July 2021



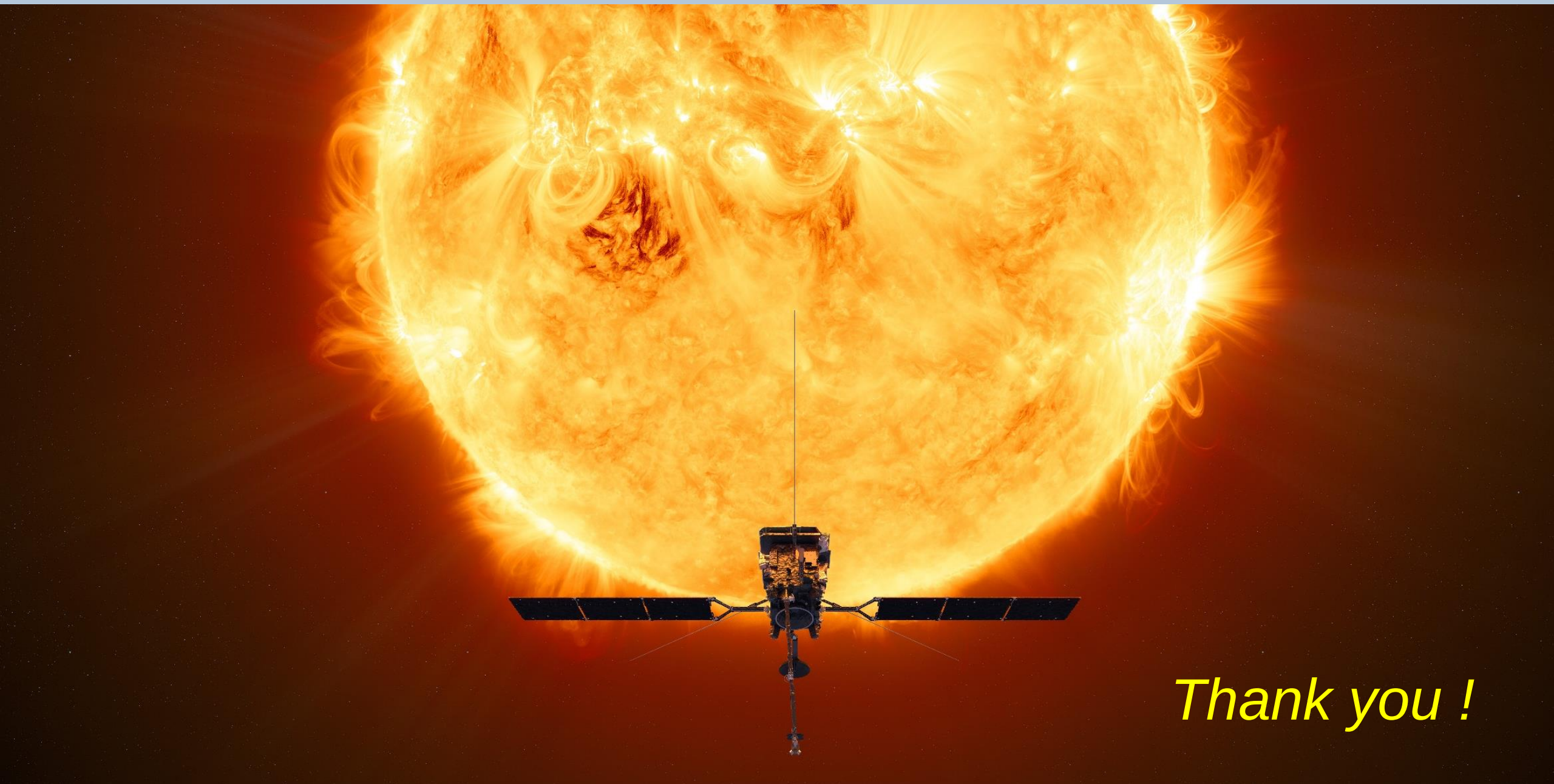
SOHO/LASCO showed a CME on 17th July 2021 at 0540 UT. PAS and EAS show shock arrival 36 hours later and denser, faster plasma arrived ~50 hours after the CME was observed



CME directed towards Solar Orbiter – such an event occurring at SO perihelion and during an observing window has potential to provide new information on CME creation and release.

Summary

- Hopefully I have managed to convey some of the motivations for building and launching the Solar Orbiter mission;
- We are nearing the end of the cruise phase, at which point the full payload complement will start regularly coordinating observations by which to address the mission science goals of understanding the dynamic outer atmosphere of a star and the physical processes that control of our local space environment;
- Even so, data from the cruise/check-out operations have already yielded discoveries, interesting new viewpoints and new science results, so there is promise for lots more once the nominal mission starts at the end of the month;
- [Even more so when Solar Orbiter observations are considered in context of other assets (e.g. Parker Solar Probe, Hinode, Solar Dynamics Observatory) which for time reasons I have barely touched on in passing];
- Stay tuned……



Thank you !