Space-based Astronomy and Space Weather

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Space-based Astronomy and Space Weather

Objectives:

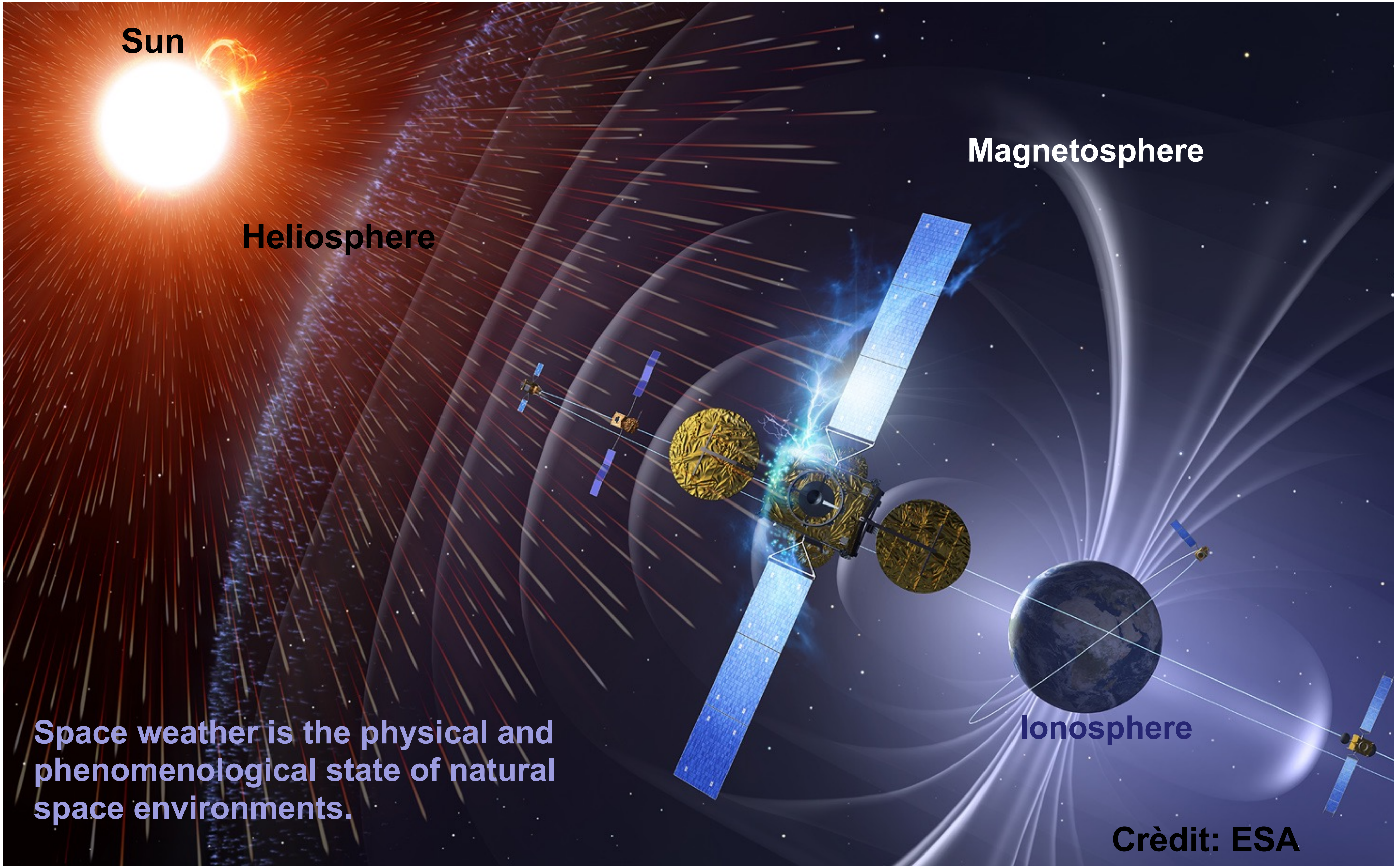
I. To acquire the basic concepts of scientific space missions.

- Technological aspects, scientific drivers, management, requirements and limitations that play a role in the design of a scientific mission.
- Astronomical observations: review of the results of various recent Missions of ESA and NASA, at different wavelengths (and of future missions scheduled).

II. To understand what Space weather and heliophysics are.

- Relevant solar and heliospheric physics phenomena.
- Effects of solar storms in spacecraft and at Earth. Prediction and forecasting.
- Review of the results of recent solar and heliospheric missions of ESA and NASA.

Space Weather



Program. Part I

Space-based Astronomy

1. Elements of a mission

Orbits. Launch windows. Payloads

Subsystems. Launchers

2. Space mission analysis and design

Development phases

Analysis.

Selection and implementation

The main agencies: ESA and NASA

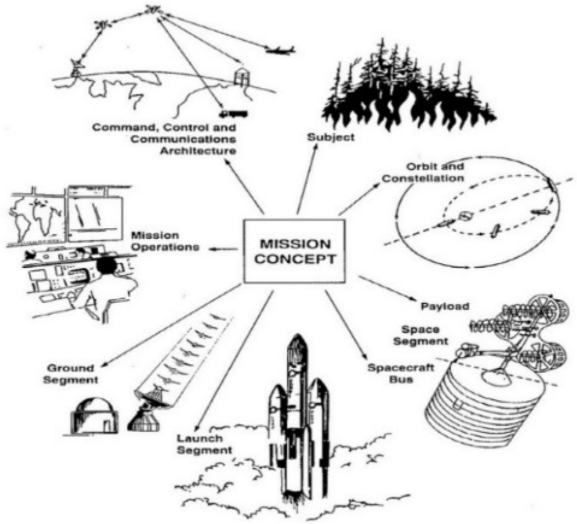
ESA’s Cosmic Vision 2015−2025

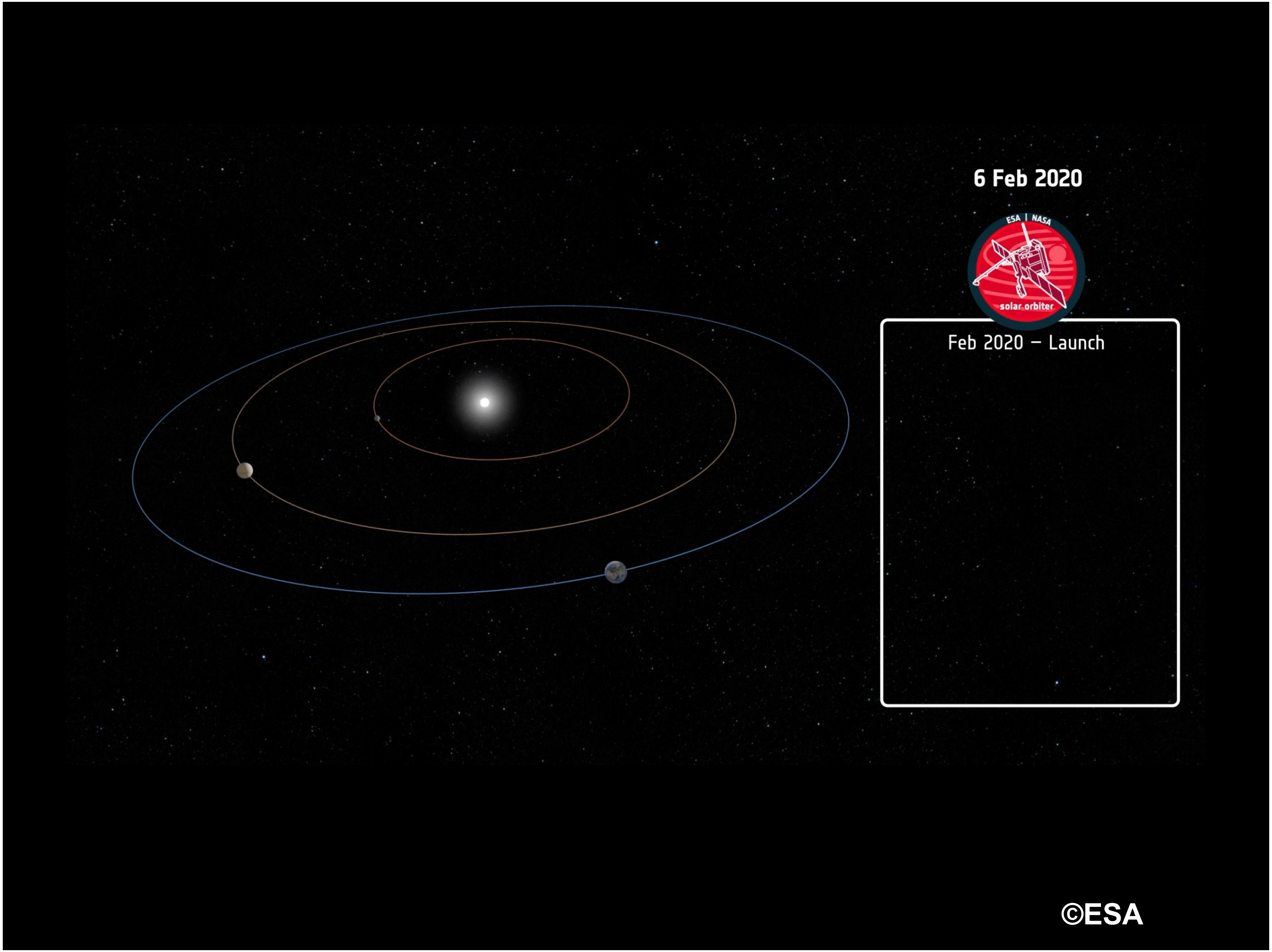
3. Astronomy from the space

Scientific goals.

Missions: Types and Payloads

Data bases and exploitation




6 Feb 2020
ESA | NASA
solar orbiter
Feb 2020 – Launch
©ESA

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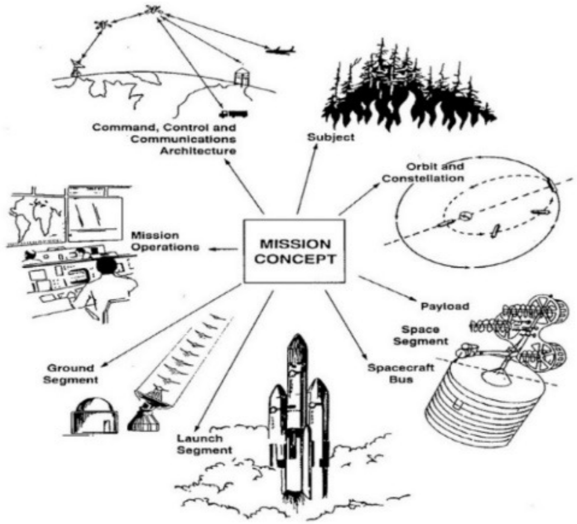
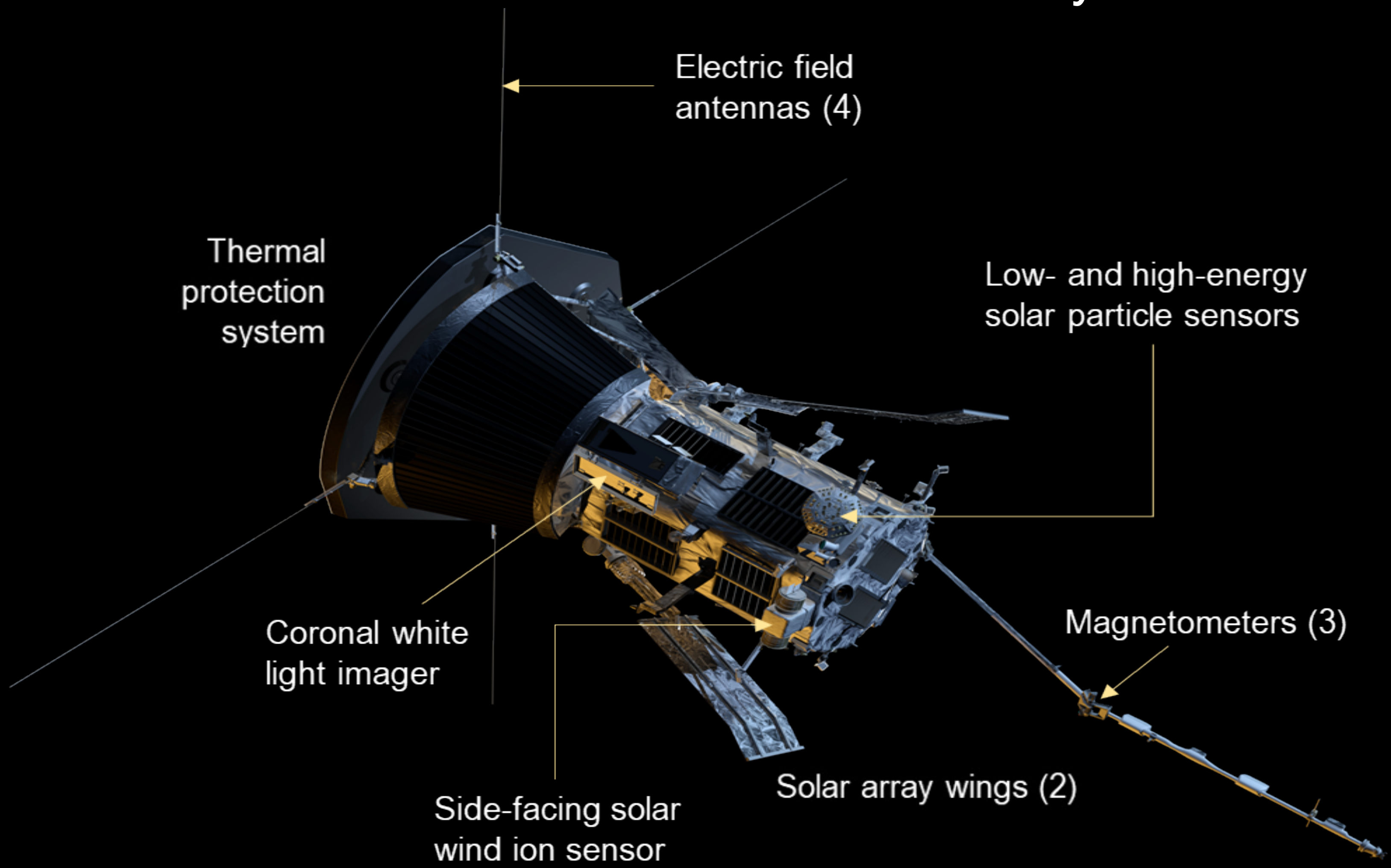


Parker Solar Probe: Anatomy



Program. Part II

Space Weather

1. Space Weather

Effects of solar storms in spacecraft and at Earth. Extreme stormy events

Prediction. Radiation risks

ESA/EU and US programmes

2. Heliospheric physics

Solar wind plasma and interplanetary magnetic field. Earth magnetosphere

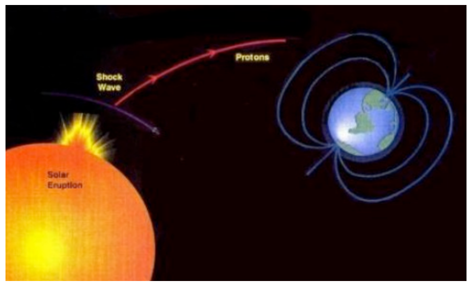
Solar activity: Flares, Coronal mass ejections and CIRs. Solar activity cycle

Solar energetic particles.

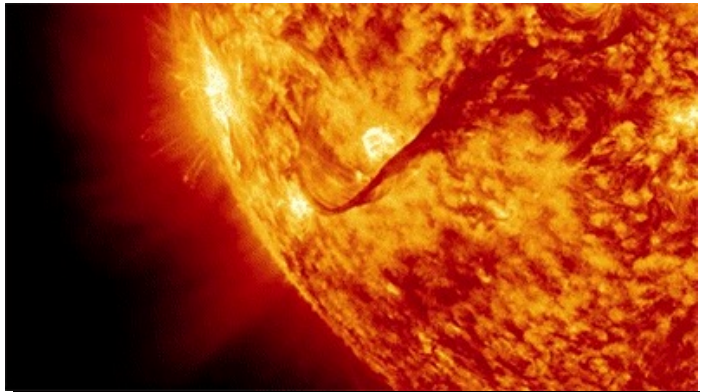
3. Heliophysics and space weather missions

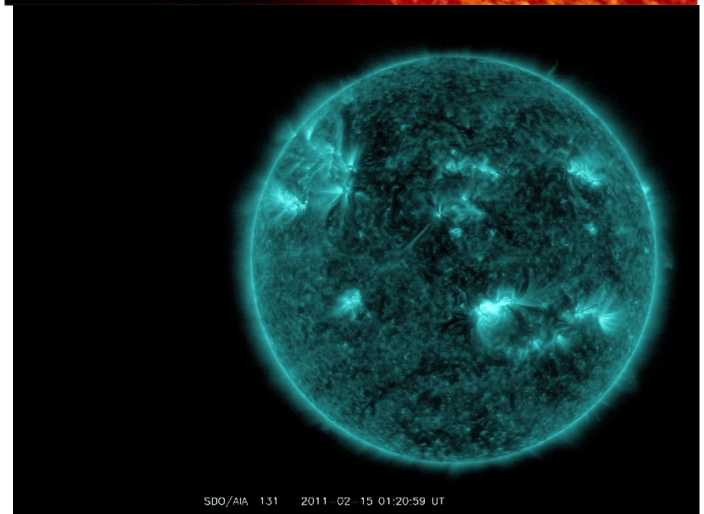
STEREO, ACE, SDO, PSP , SOHO and Solar Orbiter.

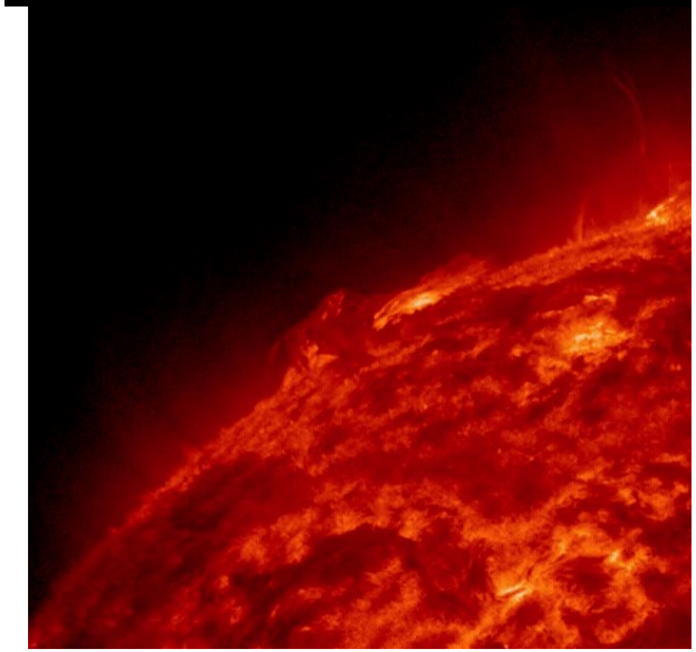
Data bases and exploitation. In-situ instrumentation



A typical Solar Storm





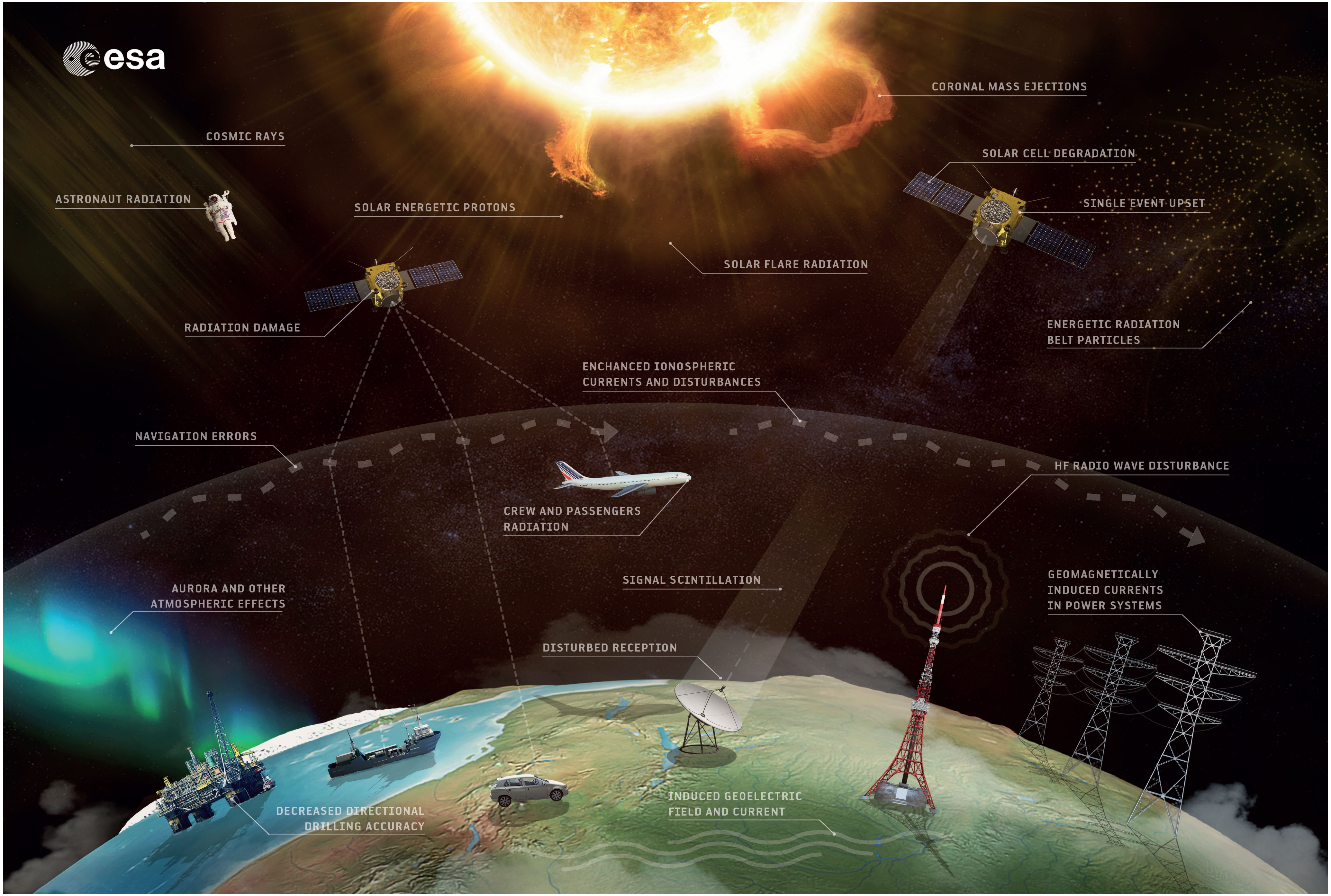


Solar eruptive phenomena:

- Flares
- Coronal mass ejections (CMEs)

Timeline to Earth:

- 8 minutes: EUV, X-ray emission reach earth.
- 20 min. - 1 hour: solar energetic particle onset
- 1- 4 days: CME arrives at earth and causes a geomagnetic storm


esa
CORONAL MASS EJECTIONS
COSMIC RAYS
SOLAR CELL DEGRADATION
ASTRONAUT RADIATION
SOLAR ENERGETIC PROTONS
SINGLE EVENT UPSET
SOLAR FLARE RADIATION
RADIATION DAMAGE
ENERGETIC RADIATION BELT PARTICLES
ENCHANCED IONOSPHERIC CURRENTS AND DISTURBANCES
NAVIGATION ERRORS
HF RADIO WAVE DISTURBANCE
CREW AND PASSENGERS RADIATION
SIGNAL SCINTILLATION
AURORA AND OTHER ATMOSPHERIC EFFECTS
GEOMAGNETICALLY INDUCED CURRENTS IN POWER SYSTEMS
DISTURBED RECEPTION
INDUCED GEOELECTRIC FIELD AND CURRENT
DECREASED DIRECTIONAL DRILLING ACCURACY

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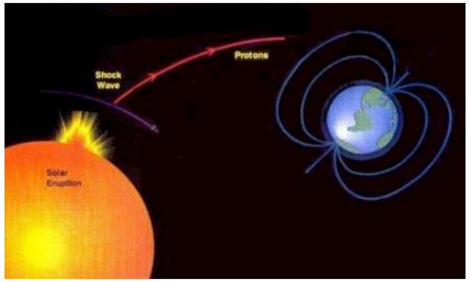
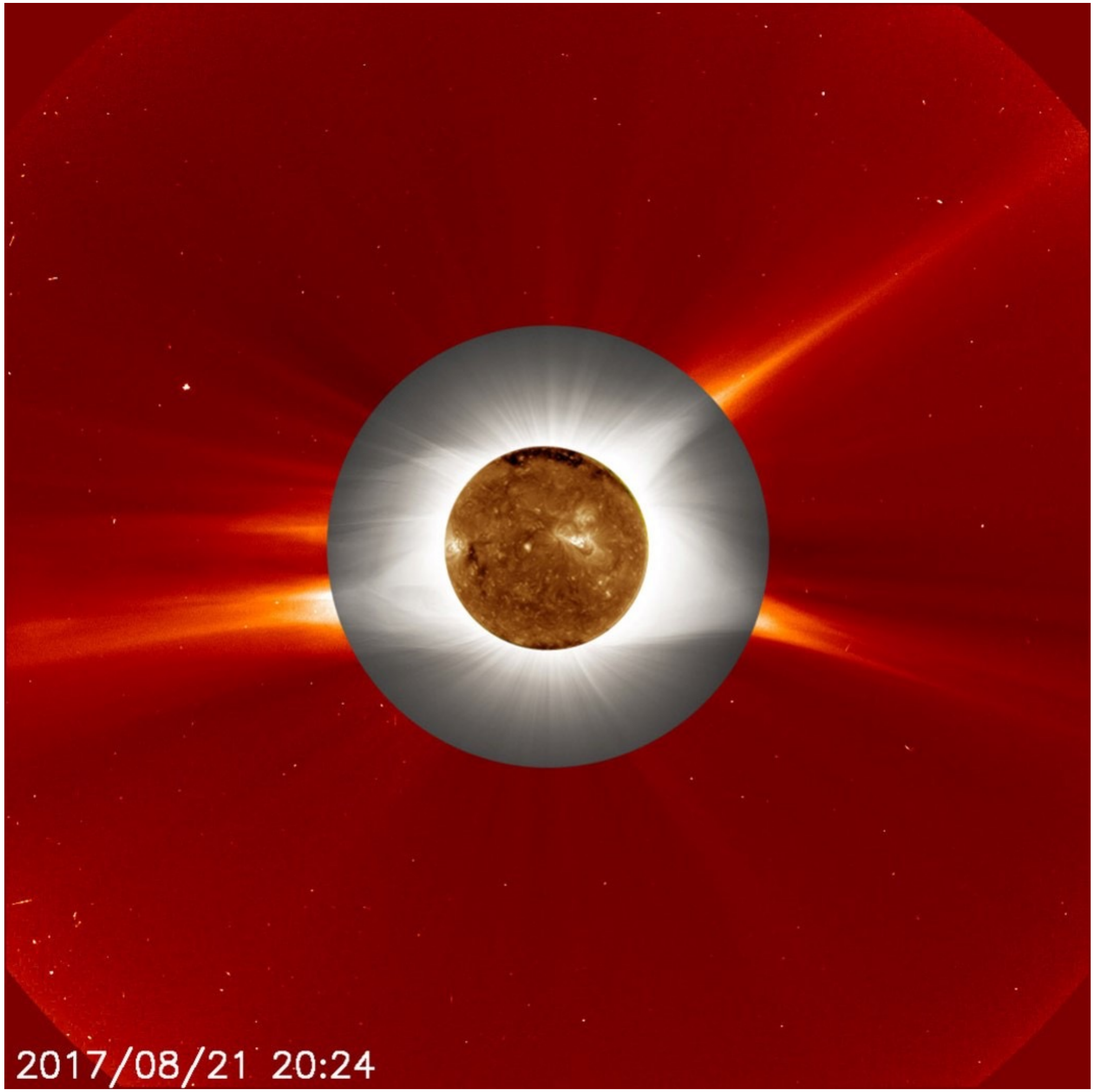
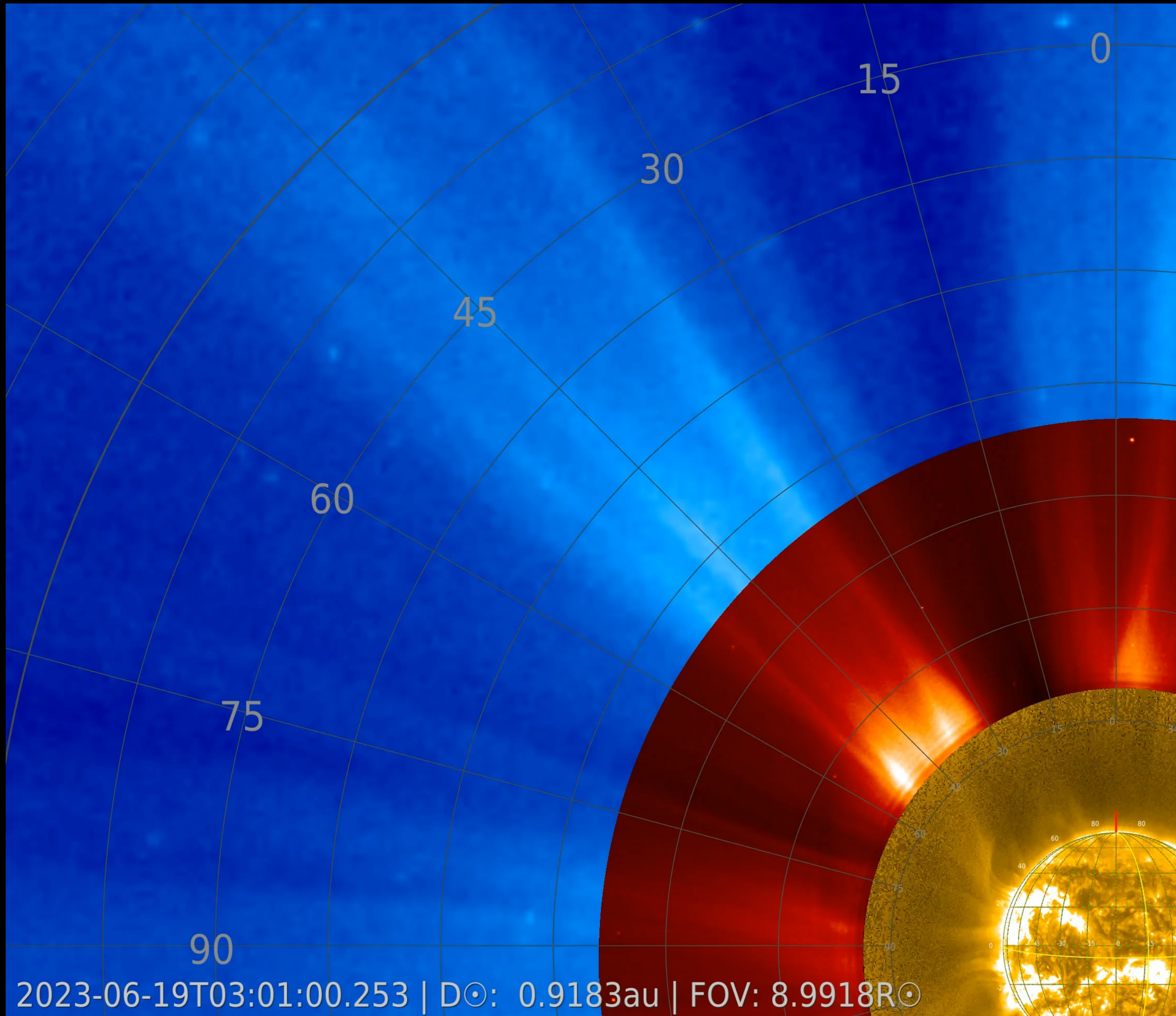




NASA/ESA Solar and Heliospheric Observatory (SOHO). At center is an image of the sun's surface as seen by the Solar Dynamics Observatory in extreme UV light.



Solar Orbiter

Program. Part II

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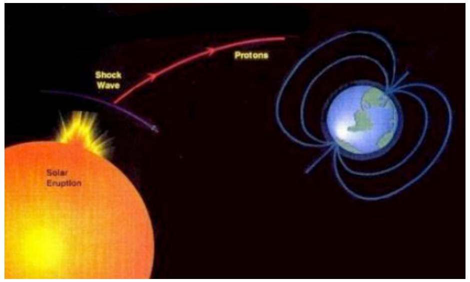
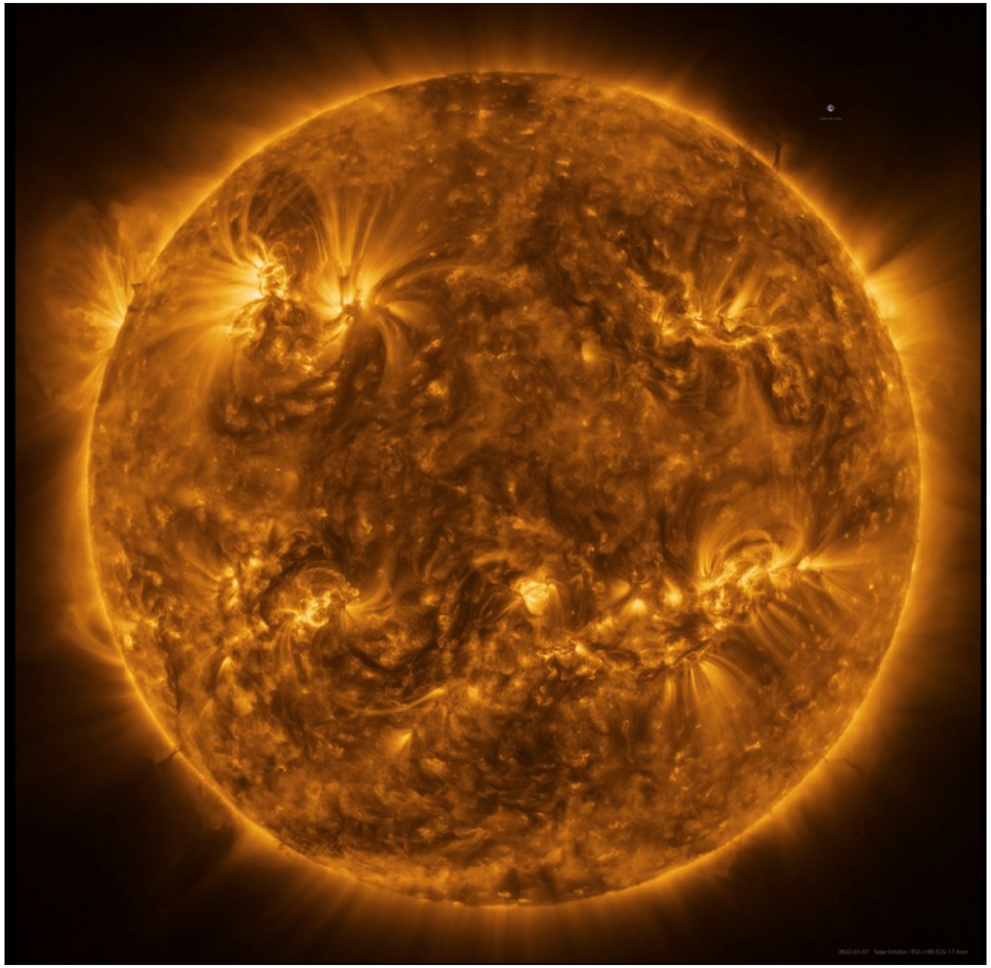


The Sun in EUV – Solar Orbiter

Composition of 25 images taken on March 7, 2022 by EUI the Extreme Ultraviolet Imager of Solar Orbiter, at 75 million km (~0,5 au) from the Sun. Wavelength: 17,4 nm, which corresponds to emission lines of Fe IX and Fe X, in the region of the solar corona at ~1 mlilion K

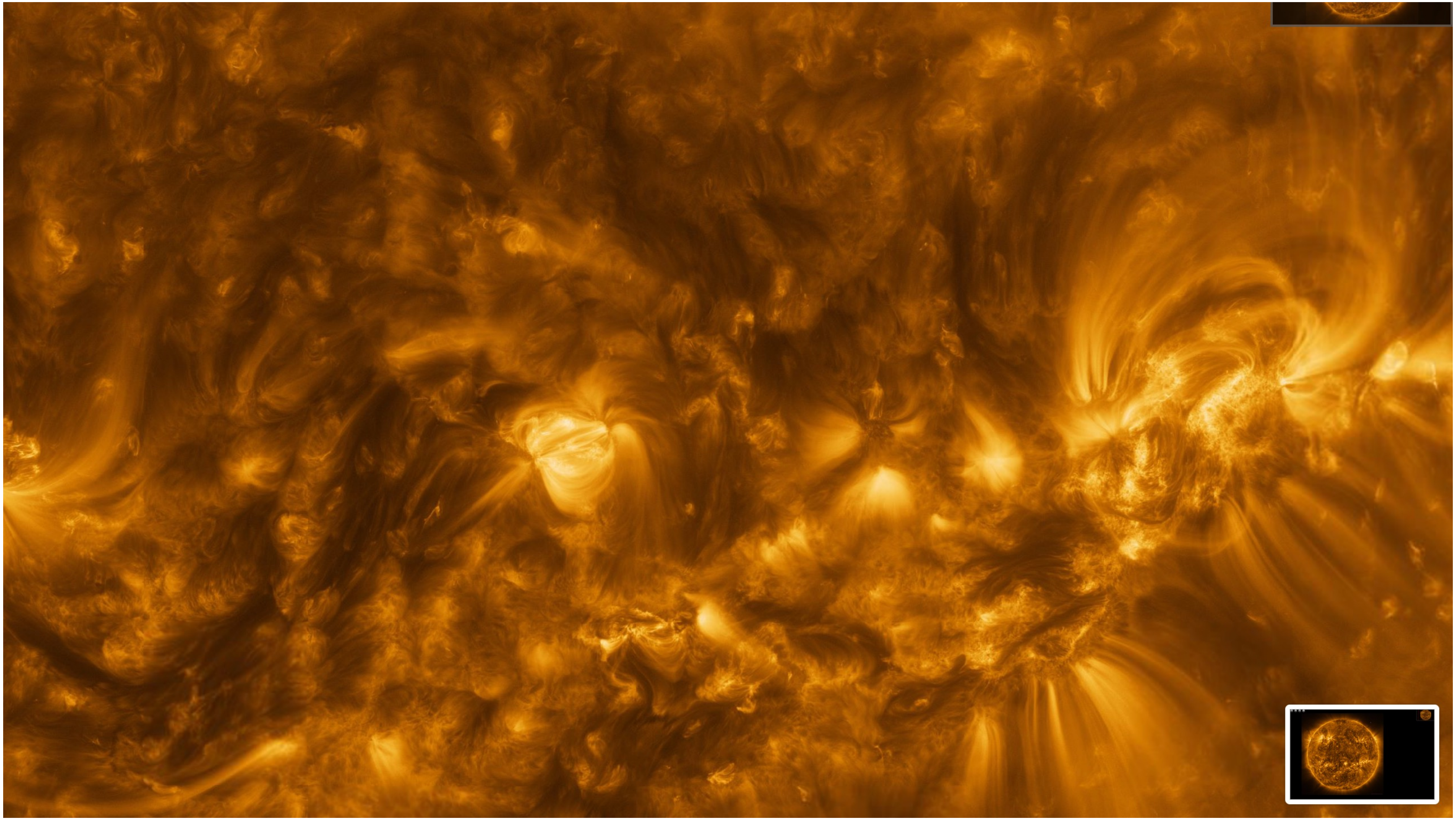
This is the highest resolution image of the solar disc up to date (83 million pixels).
Each image: 10 minutes, total: 4 hours

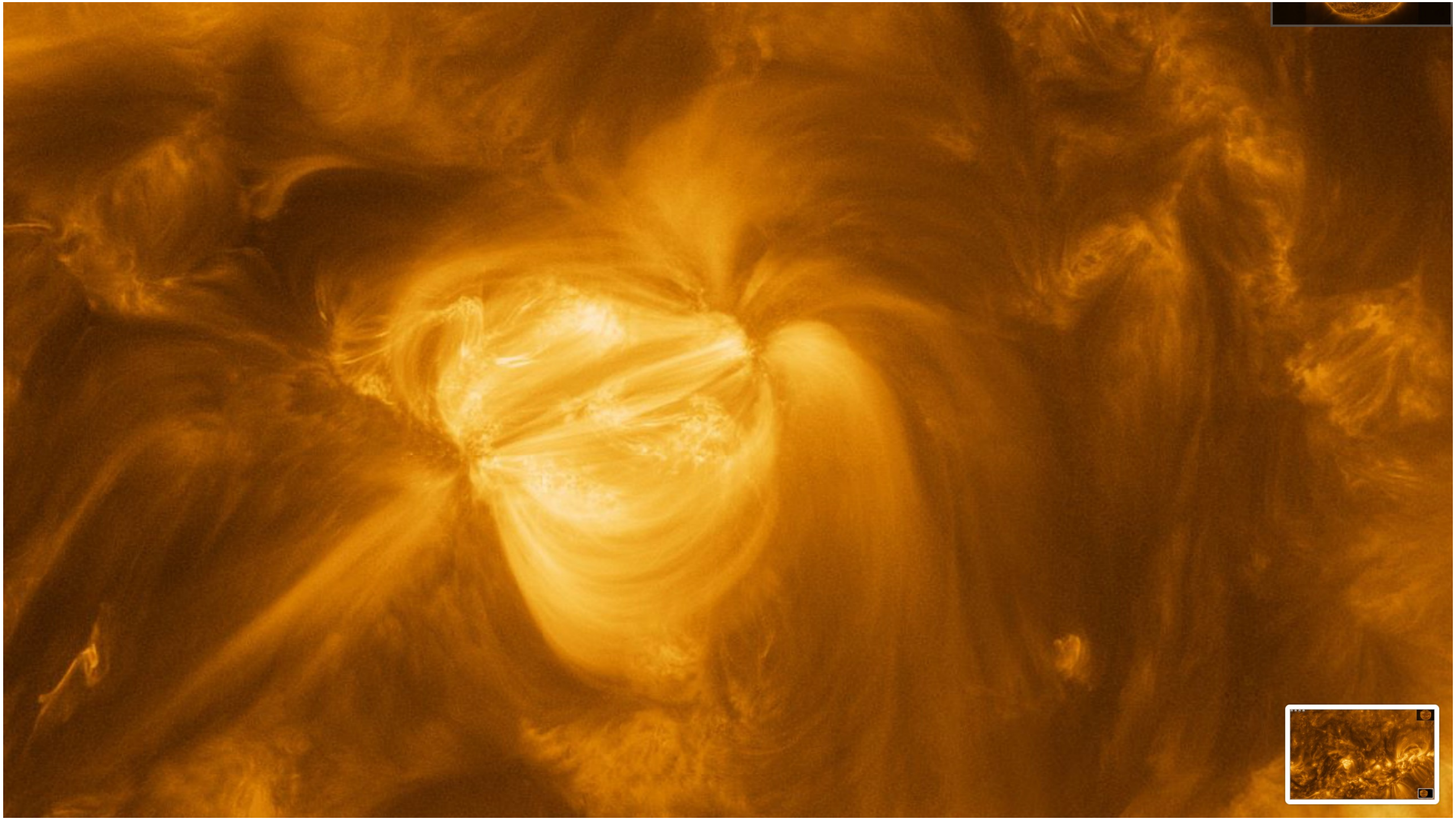


[ESA & NASA/Solar Orbiter/EUI team; Data processing: E. Kraaikamp, ROB]

https://www.esa.int/Science_Exploration/Space_Science/Solar_Orbiter/Zooming_into_the_Sun_with_Solar_Orbiter

https://www.esa.int/Science_Exploration/Space_Science/Solar_Orbiter/Giant_solar_eruption_seen_by_Solar_Orbiter
https://www.esa.int/Science_Exploration/Space_Science/Solar_Orbiter/The_Sun_as_you_ve_never_seen_it_before



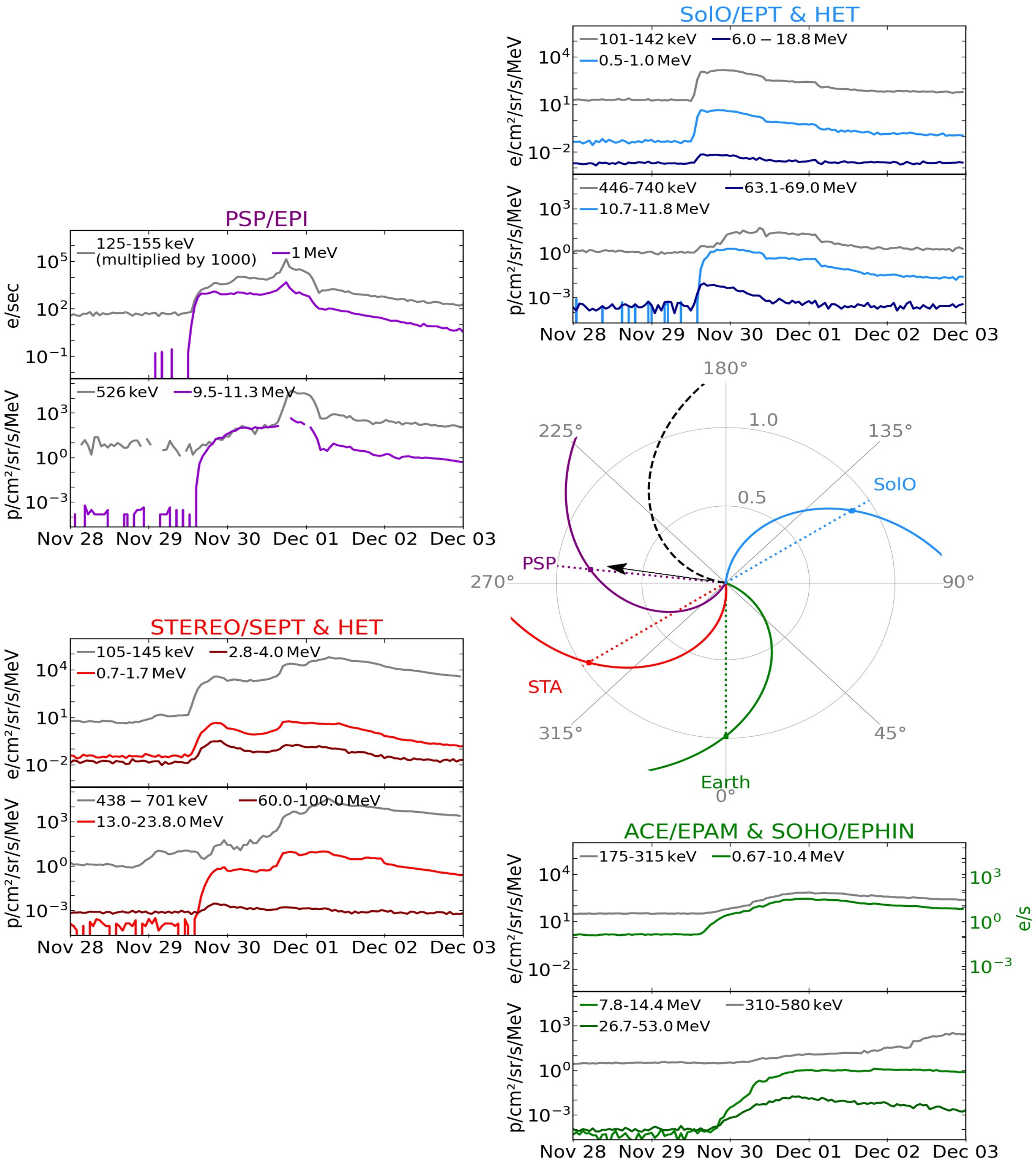


Observation of a large SEP event event

This one, on 29 November 2020, was the first large event detected both by Parker Solar Probe and Solar Orbiter.

SolO and PSP add as unique vantage points to observe large Solar Energetic Particle events.

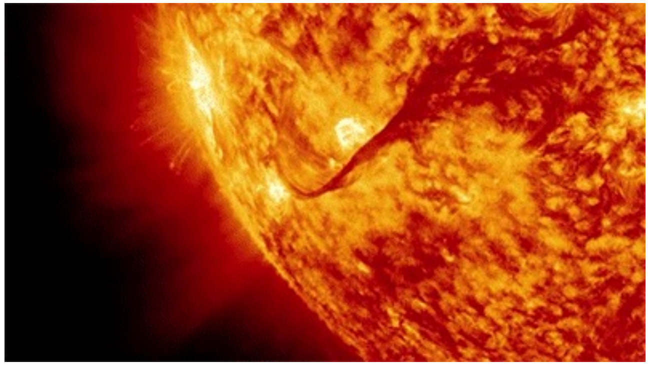
Kollhoff + A&A (2021)



Evaluation

3 ECTS
From 31st October to 21st December
Compulsory attendance

1st Part:
Design an astronomical satellite, simulate a cubesat proposal for a Space Agency
- Oral presentation



2nd Part:
a) Oral Presentation on a selected topic
b) Daily questions
c) Hands-on study on a real Solar Energetic Particle event
-Paper Presentation (< 8 pages)

BIBLIOGRAPHY

1st Part:

- “Space mission analysis and design”, Wiley J. Larson & James R. Wertz, Ed. Kluwer, 1992
- “Spacecraft systems engineering”, Peter Fortescue & John Stark, Ed. Wiley, 1991
- “Orbital motion”, A.E. Roy, Ed. Hilger, 1978

2nd Part:

- Introduction to Space Physics. M.G. Kivelson and C.T. Russell (Cambridge University Press, 1995)
- Solar Particle Radiation Storms Forecasting and Analysis, Eds. Malandraki, O.E. & Crosby, N.B., Astrophysics and Space Science Library, 444, Springer, 2018, ISBN 978-3-319-60051-2 (eBook)
- Heliophysics. Space Storms and radiation: causes and Effects. C.J Schrijver and G.L. Siscoe (Cambridge University Press 2010)
- Kallenrode, May-Britt. *Space physics : an introduction to plasmas and particles in the heliosphere and magnetospheres*. 3rd ed. Berlin : Springer, 2004
- Physics of Space Storms. From the Solar Surface to the Earth. H. E. J. Koskinen (Springer Praxis, 2011). ISBN 978-3-6-00310-3