

Solar Orbiter is ready to start Nominal Mission

More about when, how and who

ESPM-16

Anik De Groof, Andrew Walsh, David Williams,
Yannis Zouganelis, Daniel Müller

10/09/2021

ESA UNCLASSIFIED – For ESA Official Use Only



→ THE EUROPEAN SPACE AGENCY

Introduction



- Over the last few days, we have seen several results of Solar Orbiter already
- Still, the mission is yet in its initial phase, cruising towards the Science Phase starting Nov 2021
- What does that mean?
What will change?
- In general, how does the Solar Orbiter science planning and data distribution work?

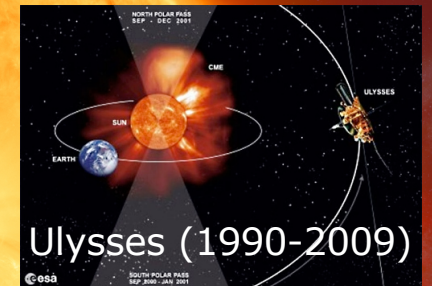


Solar Orbiter: Exploring Sun & Heliosphere

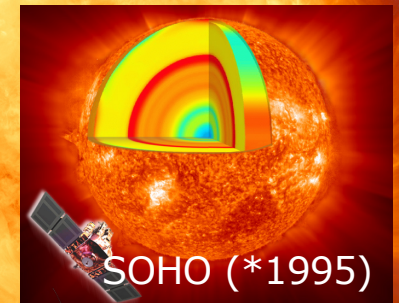


European Space Agency

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

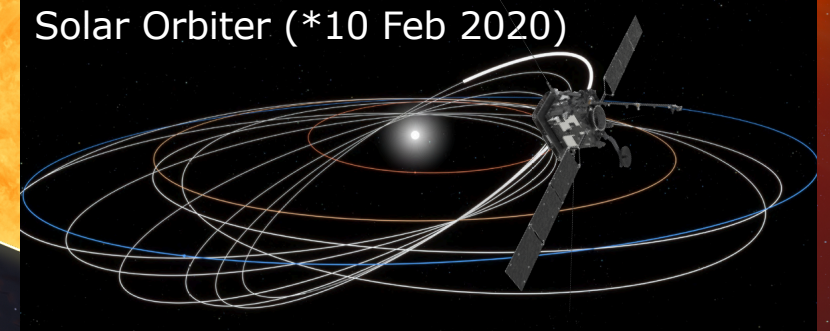


Ulysses (1990-2009)



SOHO (*1995)

Solar Orbiter (*10 Feb 2020)



Mission overview: Müller et al., A&A Special Issue, 2020

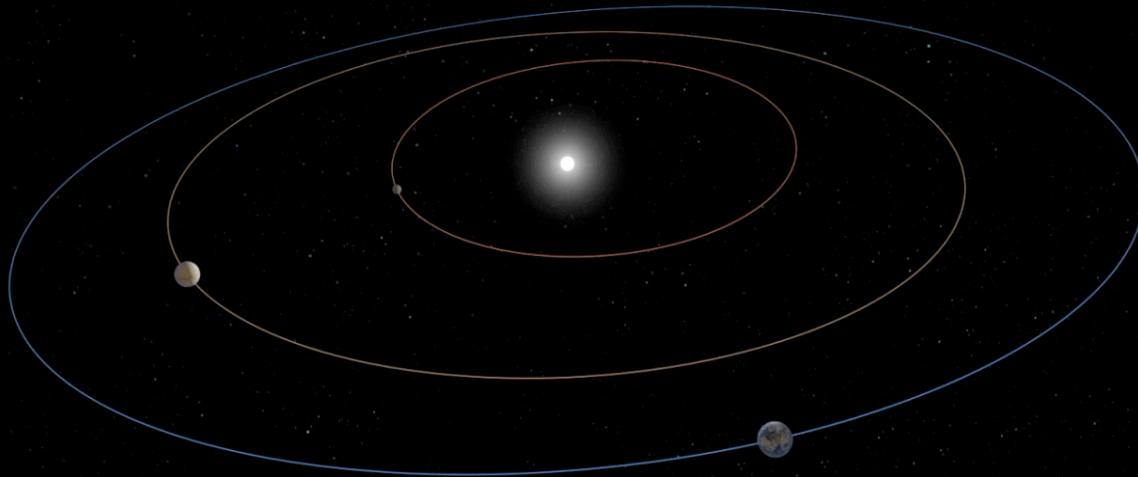
Solar Orbiter's 10-year journey



6 Feb 2020

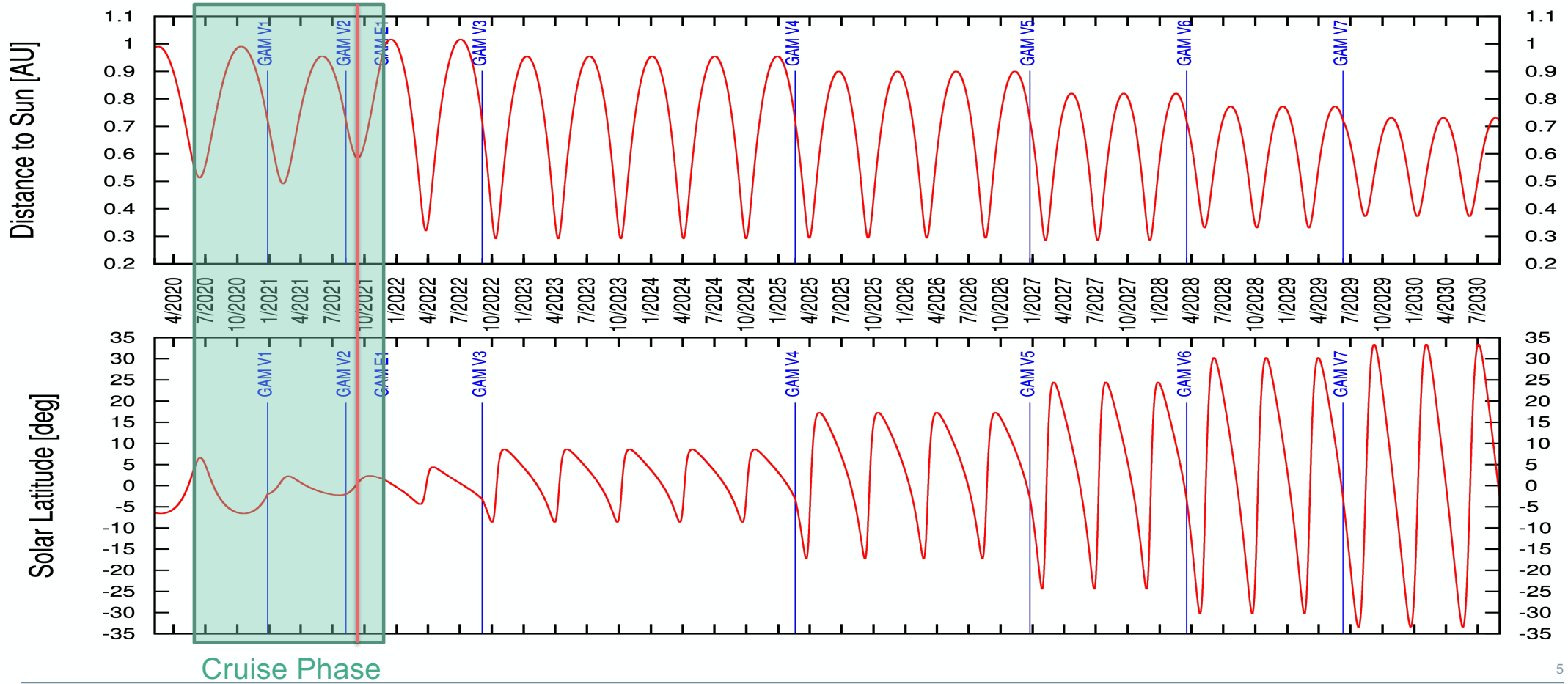


Feb 2020 – Launch



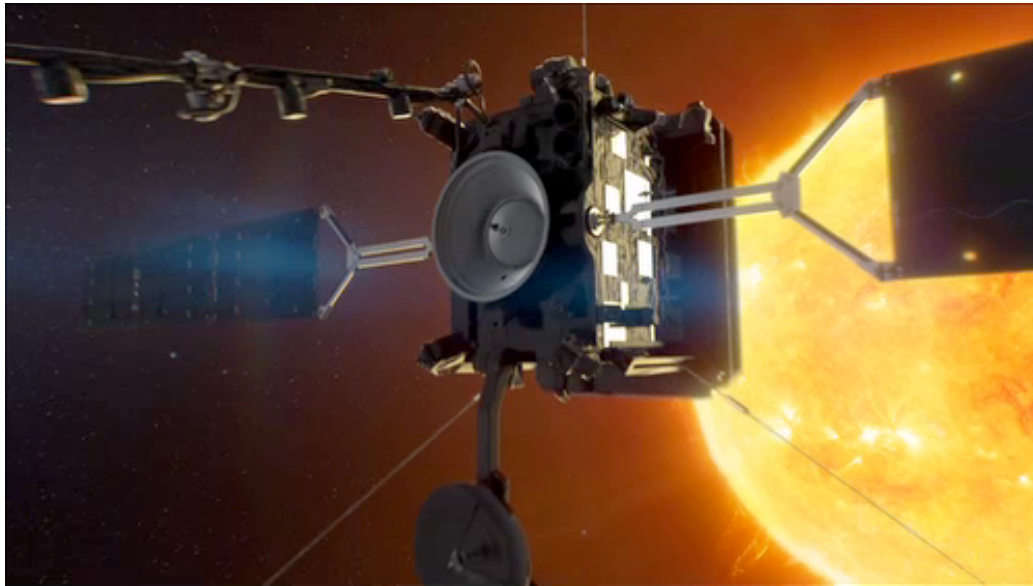
→ THE EUROPEAN SPACE AGENCY

Evolution Sun Distance and Solar Latitude



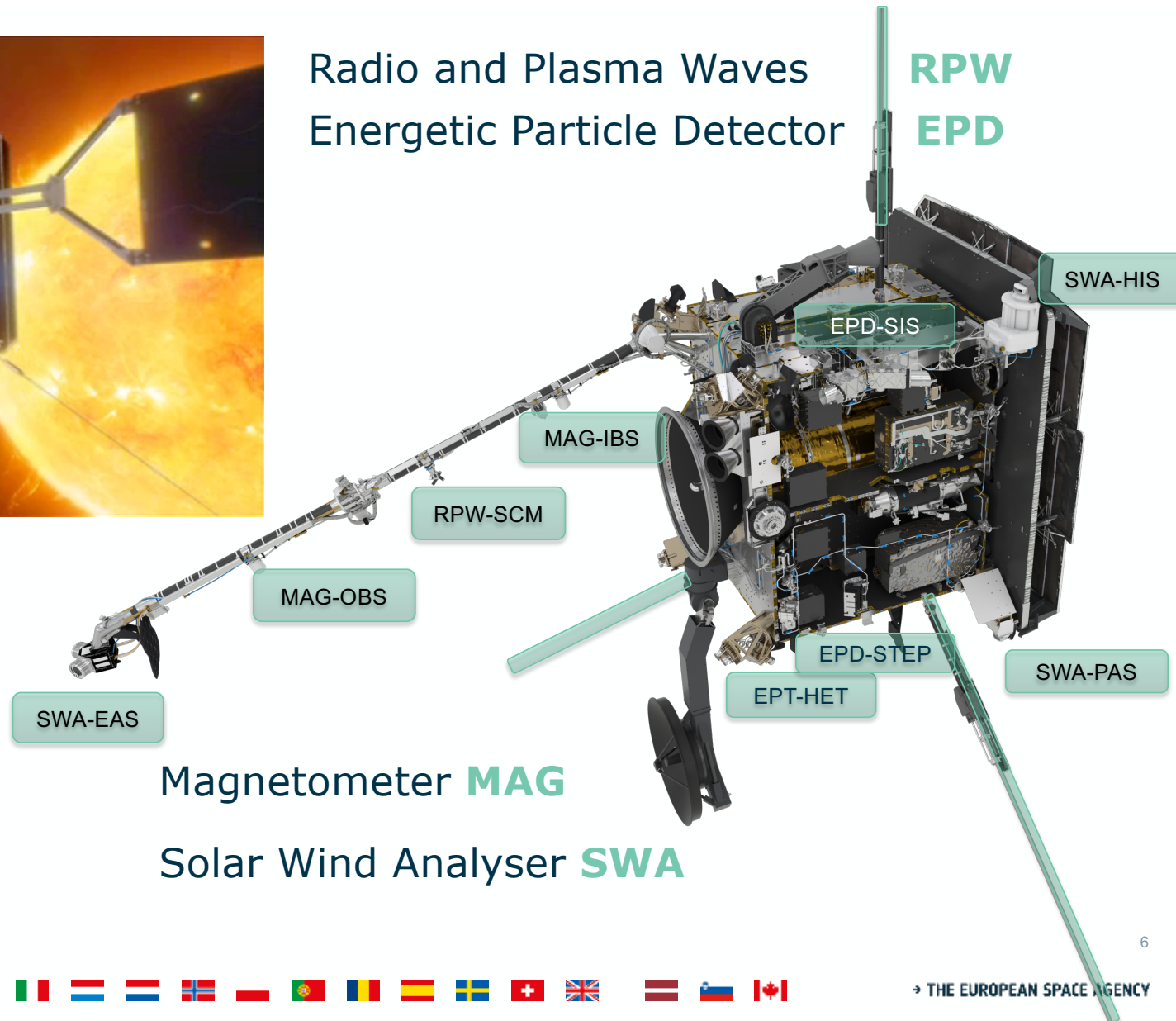
5





Radio and Plasma Waves
Energetic Particle Detector

RPW
EPD



In-Situ
Payload

Magnetometer **MAG**

Solar Wind Analyser **SWA**



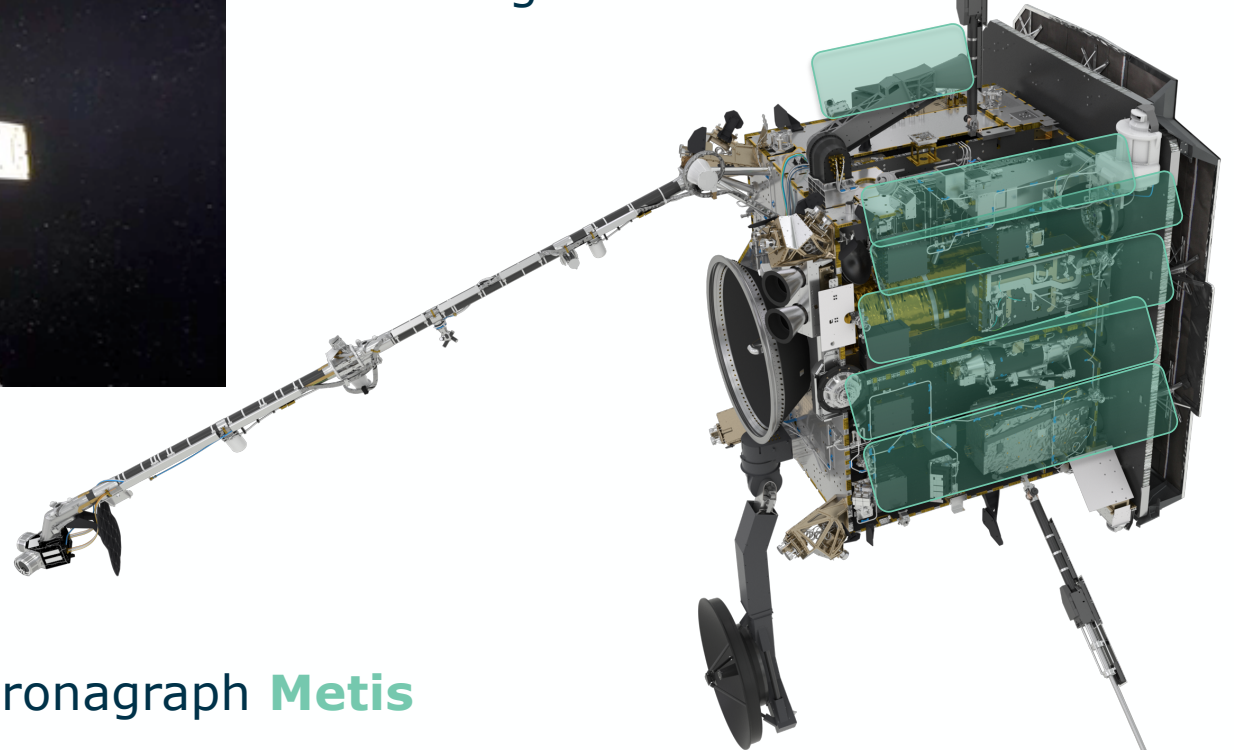
→ THE EUROPEAN SPACE AGENCY



Imaging Spectrometer **SPICE**

X-ray imager/spectrometer **STIX**

EUV Imager **EUI**



Remote-Sensing Payload

Coronagraph **Metis**

Polarimetric & Helioseismic Imager **PHI**

Heliospheric Imager **SoloHI**

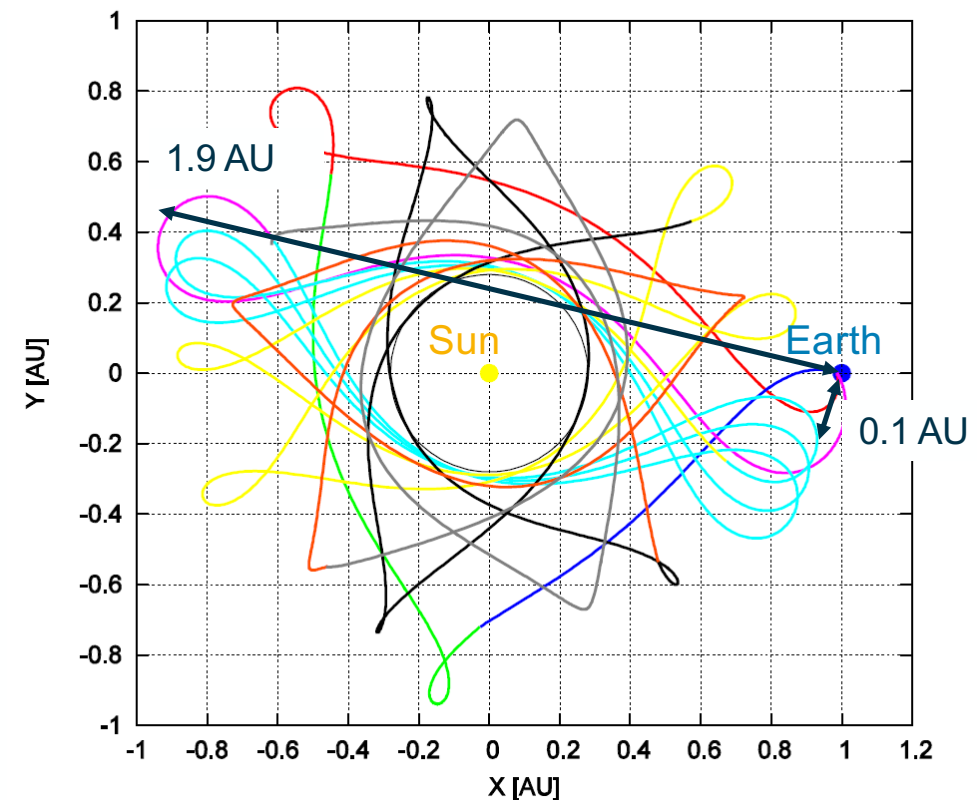


Solar Orbiter's complement to other solar observatories



Solar Orbiter is quite different from previous solar missions

- Unique **orbit** around the Sun: changing viewpoint wrt Earth, changing solar distance & latitude
- Changing **science opportunities**
- **Limited resources** force us to
 - Concentrate RS observations in RS windows
 - Plan long time ahead
 - Store data onboard during low downlink



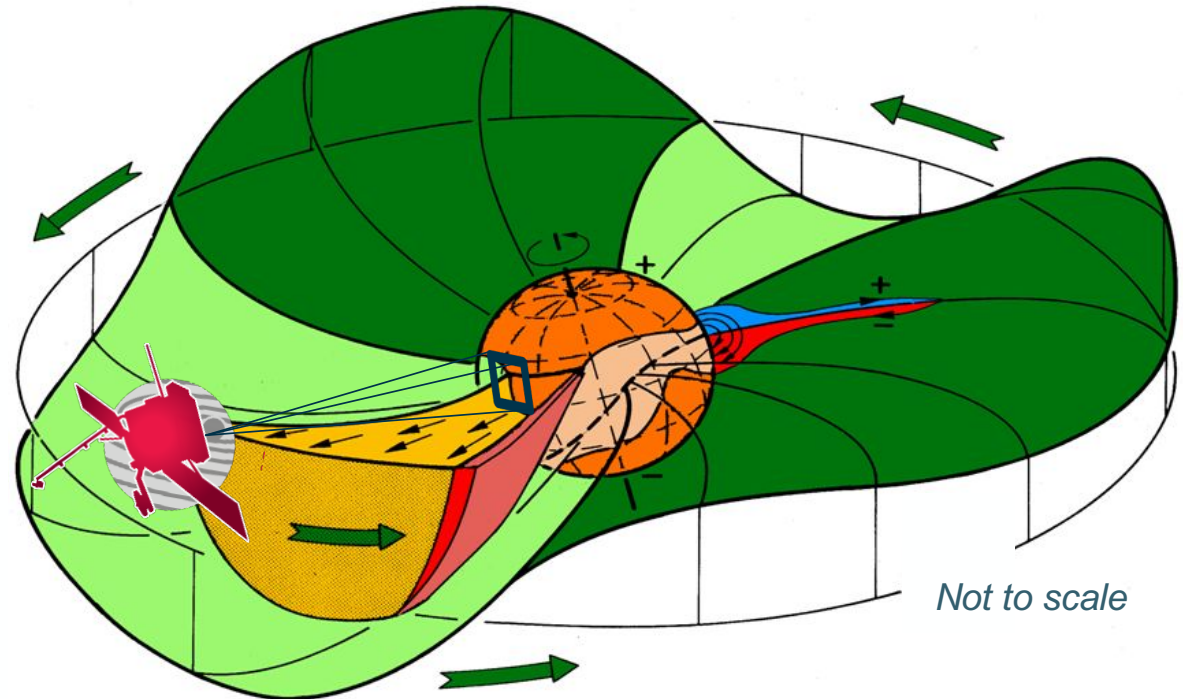
→ THE EUROPEAN SPACE AGENCY

Solar Orbiter's complement to other solar observatories



Solar Orbiter is quite different from previous solar missions

- Unique **orbit** around the Sun: changing viewpoint wrt Earth, changing solar distance & latitude
- Changing **science opportunities**
- **Limited resources** force us to
 - Concentrate RS observations in
 - Plan long time ahead
 - Store data onboard
- Linking Sun and Heliosphere requires in-situ and remote-sensing payload to be **coordinated**
- Coordinated payload observations: **Solar Orbiter Observation Plans (SOOPs)**



9



→ THE EUROPEAN SPACE AGENCY

Where are we now? What have we done so far?



→ THE EUROPEAN SPACE AGENCY

Full mission 1st Venus flyby 2nd Venus flyby Earth flyby 3rd Venus flyby 4th Venus flyby

SOLAR ORBITER TO SUN
87,852,421 KM (0.59 AU)

SOLAR ORBITER TO MERCURY
38,392,695 KM (0.26 AU)

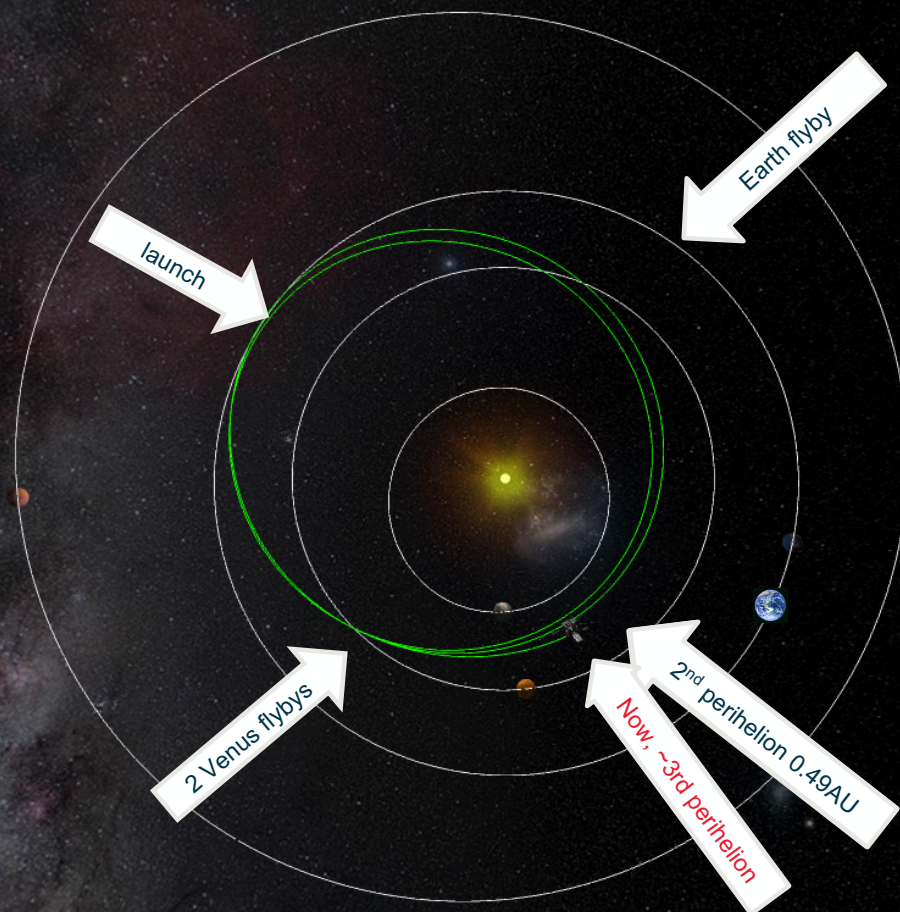
SOLAR ORBITER TO VENUS
37,668,584 KM (0.25 AU)

SOLAR ORBITER TO EARTH
121,362,699 KM (0.81 AU)

ONE-WAY SIGNAL TRAVEL TIME
404.54 SECONDS

SUN INCLINATION
3.92 DEGREES

ACCUMULATED DISTANCE
1,669,640,641 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

2021-09-10

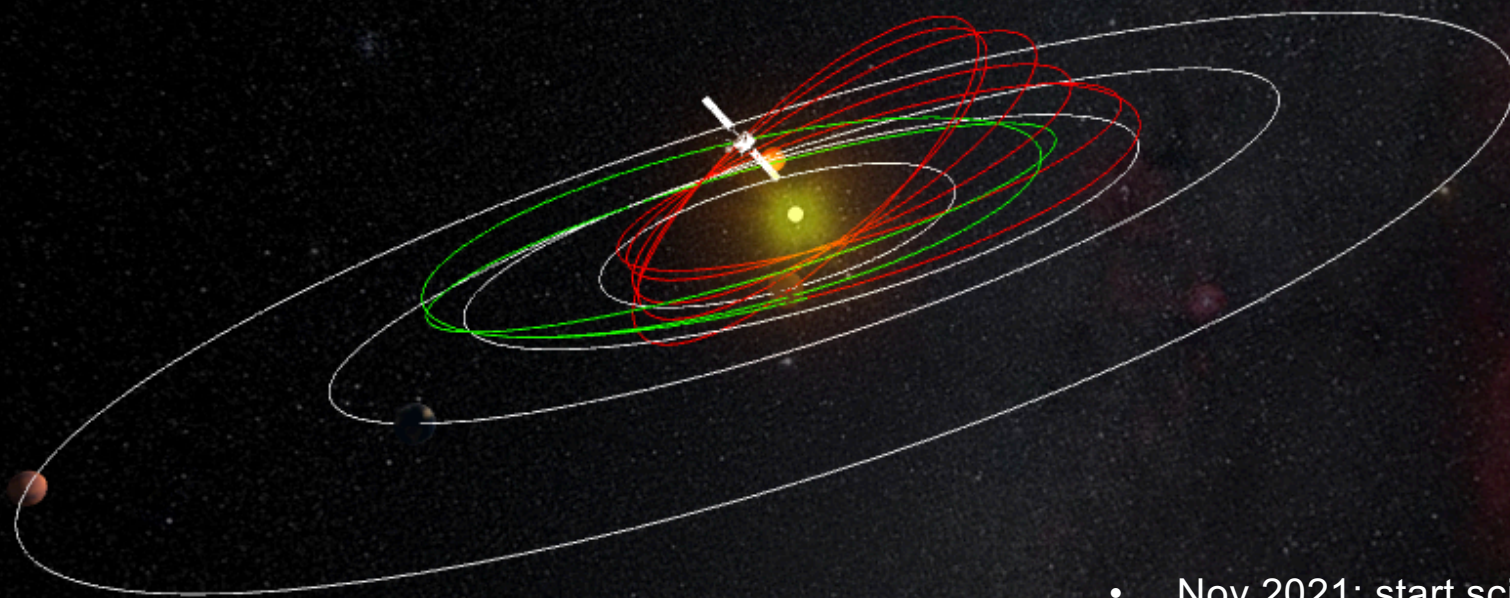
Solar Orbiter Full mission



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

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

What have we done so far?



During Cruise Phase (June 2020 – Nov 2021):

- In-Situ payload started regular science ~~at reduced cadence~~
at higher data rates than anticipated
- Remote-Sensing payload got characterised and calibrated, during checkout windows ~~only~~
and started some regular science campaigns already + some synoptics in between
- Instrument software has been updated to get ready for science phase
- Tests were run for
 - Parallel observation, commanding all payload at once
 - Pre-planned off-pointings and spacecraft rolls
 - Ongoing now: 'Last minute' off-pointings based on target + instrument reconfigurations

Some coordinated campaigns with PSP and ground-based observatories

First data already led to new science results

13



→ THE EUROPEAN SPACE AGENCY

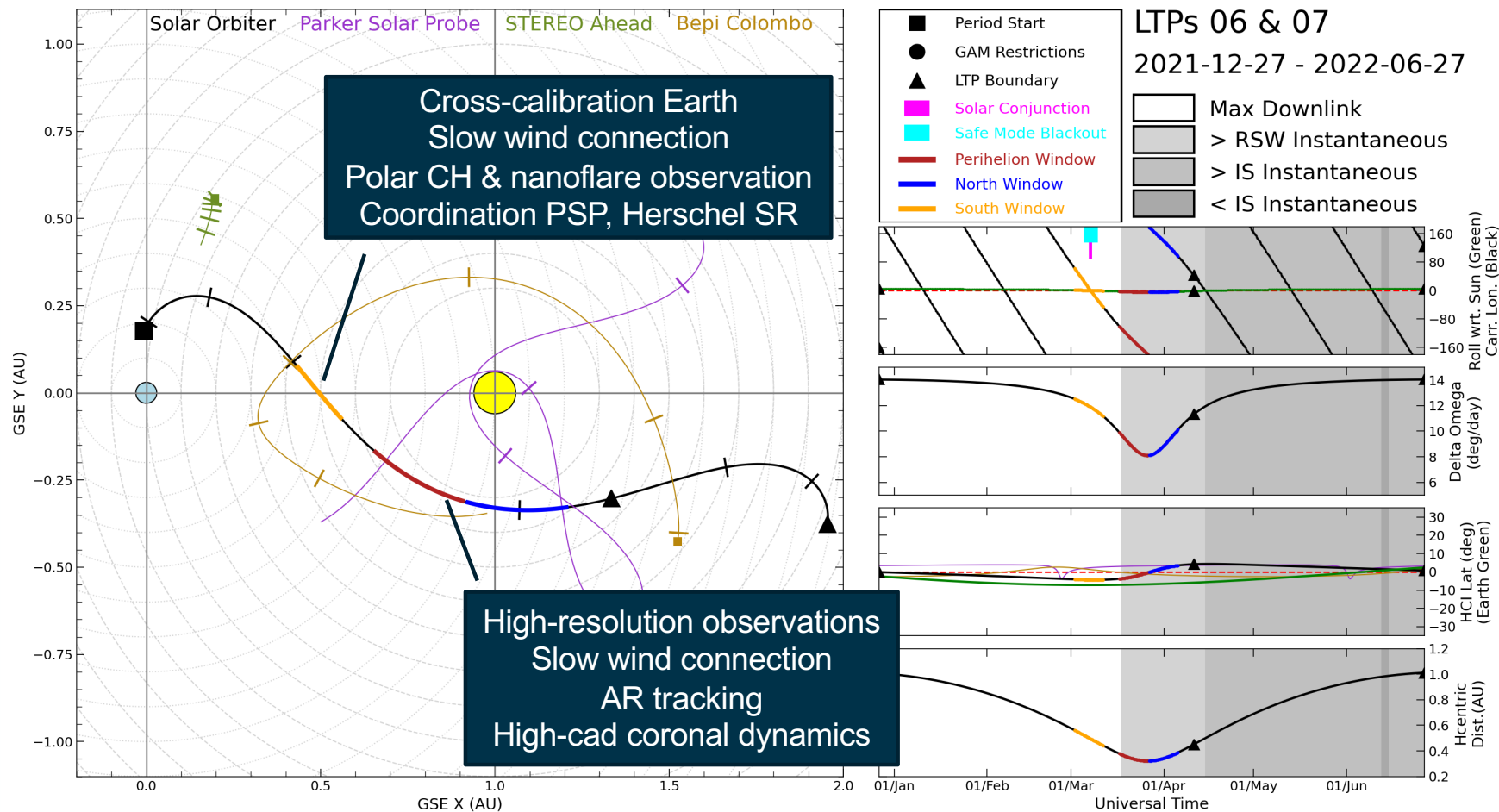
What can you expect next?



Nominal Science Phase starts end November with

- Science orbits with perihelia close to 0.3AU (0.28AU) and aphelia close to 0.9AU
- Daily spacecraft contacts
- Better calibrated instruments (will continue in next years)
- Typically **3 Remote-Sensing windows** of 10 days along 6-months-long orbit, at perihelia and other interesting configurations (e.g. higher latitude windows)
- More regular **RS synoptics** in between
- Extra commanding tools, e.g. **pointing updates** up to 3 days in advance for target tracking

Plan first half 2022



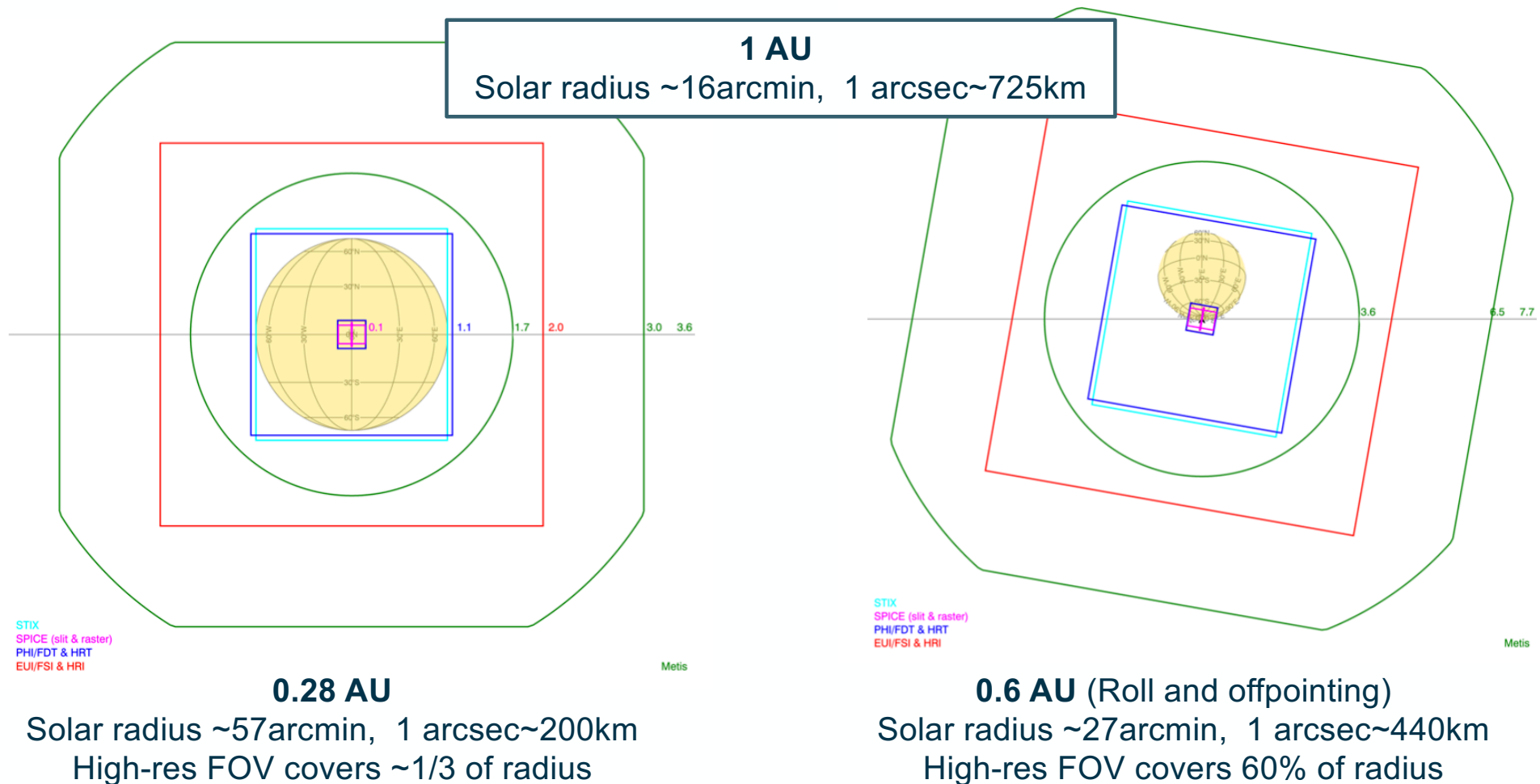
Be aware



- Solar Orbiter is **not a monitoring mission**. Instrument modes change, coordinated in SOOPs, to address varied science goals, according to varying opportunities.
- Unique orbit causes **changes in viewpoint, fields-of-view and RS resolution**
- **Delays in data download**: when Solar Orbiter is at far side, data may be stuck onboard for several months!
- **Low-Latency (LL) Data** = a kind of beacon data, low resolution but downlinked daily
- **Science data policy**: published in data archive 3 months after arrival on Earth



Remote Sensing Fields-of-View and Resolution



How to get involved in planning?



- Science planning is done well in advance, to exploit the scientific opportunities while respecting mission limitations
- **Mission Level Planning** (locate RS windows, define main science goals) is done by the Science Working Team and plans 6 months, at T-9months
 - In Nov 2021 we plan for 2nd half 2022 (=LTP 8+9)
- **Long Term Planning** (define the instrument modes in more detail, optimize resources) is done in Science Operations Working Group meetings, every 3 months
 - End Oct 2021 we plan LTP6 = Q1-2022, based on already decided science goals
- Commands (**Short Term Planning**) are uploaded 1-2 weeks in advance

For campaign coordination:
Contact project scientists at this point

Planning roadmap : <https://tinyurl.com/cby8f254>

18



→ THE EUROPEAN SPACE AGENCY

More information



- Data Archive: <http://soar.esac.esa.int/soar/> (mainly IS data for now)
- ESA mission page: http://www.esa.int/Science_Exploration/Space_Science/Solar_Orbiter
- Solar Orbiter First data release: http://www.esa.int/Science_Exploration/Space_Science/Solar_Orbiter/Solar_Orbiter_releases_first_data_to_the_public
- A&A special issue on the mission: <https://www.aanda.org/component/toc/?task=topic&id=1082>
- First Results A&A issue: <https://www.aanda.org/component/toc/?task=topic&id=1340>
- Public Science Operations pages (incl. long term plans and SOOP definitions):
<https://issues.cosmos.esa.int/solarorbiterwiki/display/SOSP/Solar+Orbiter+SOC+Public>