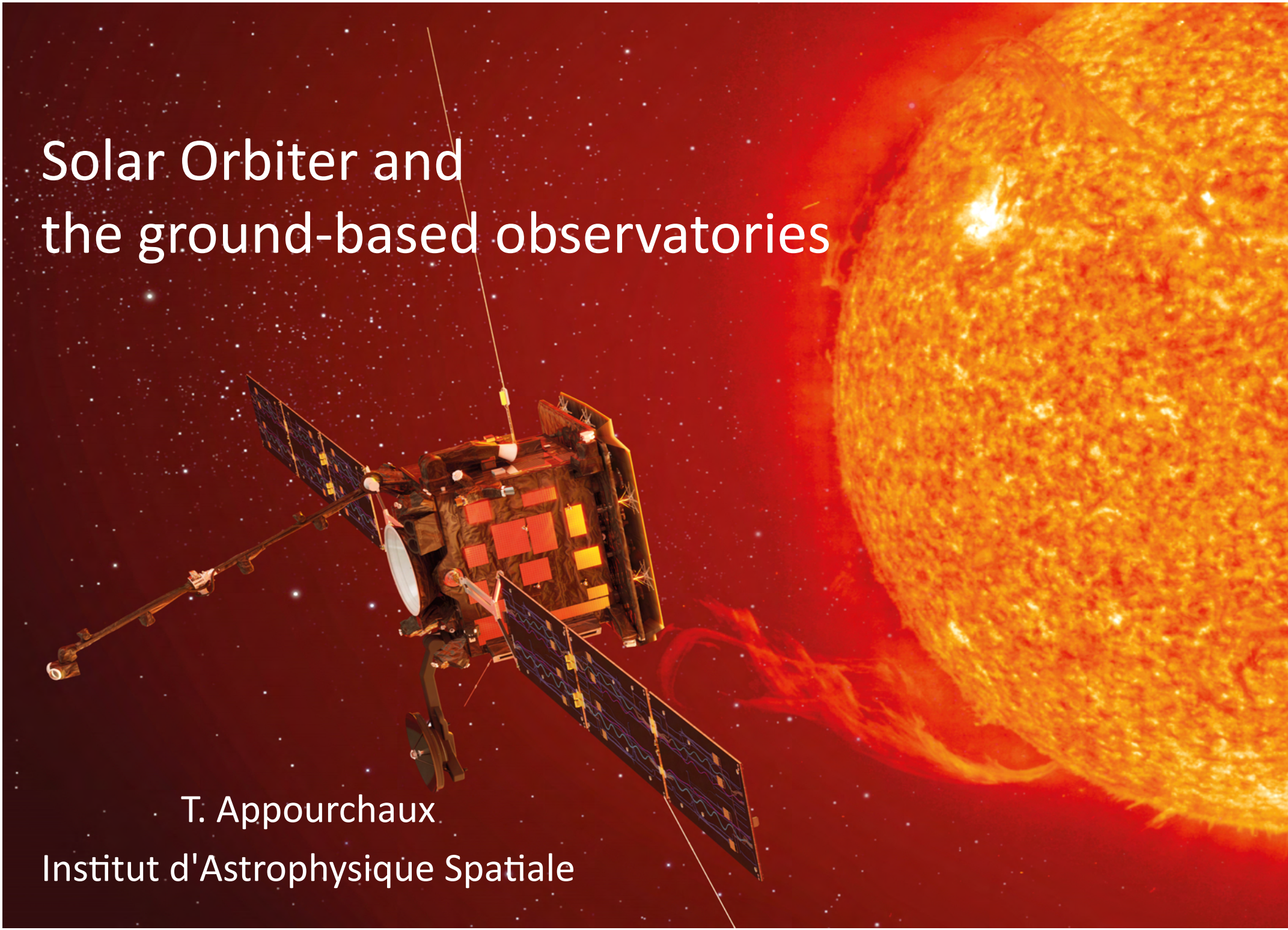
# Solar Orbiter and the ground-based observatories



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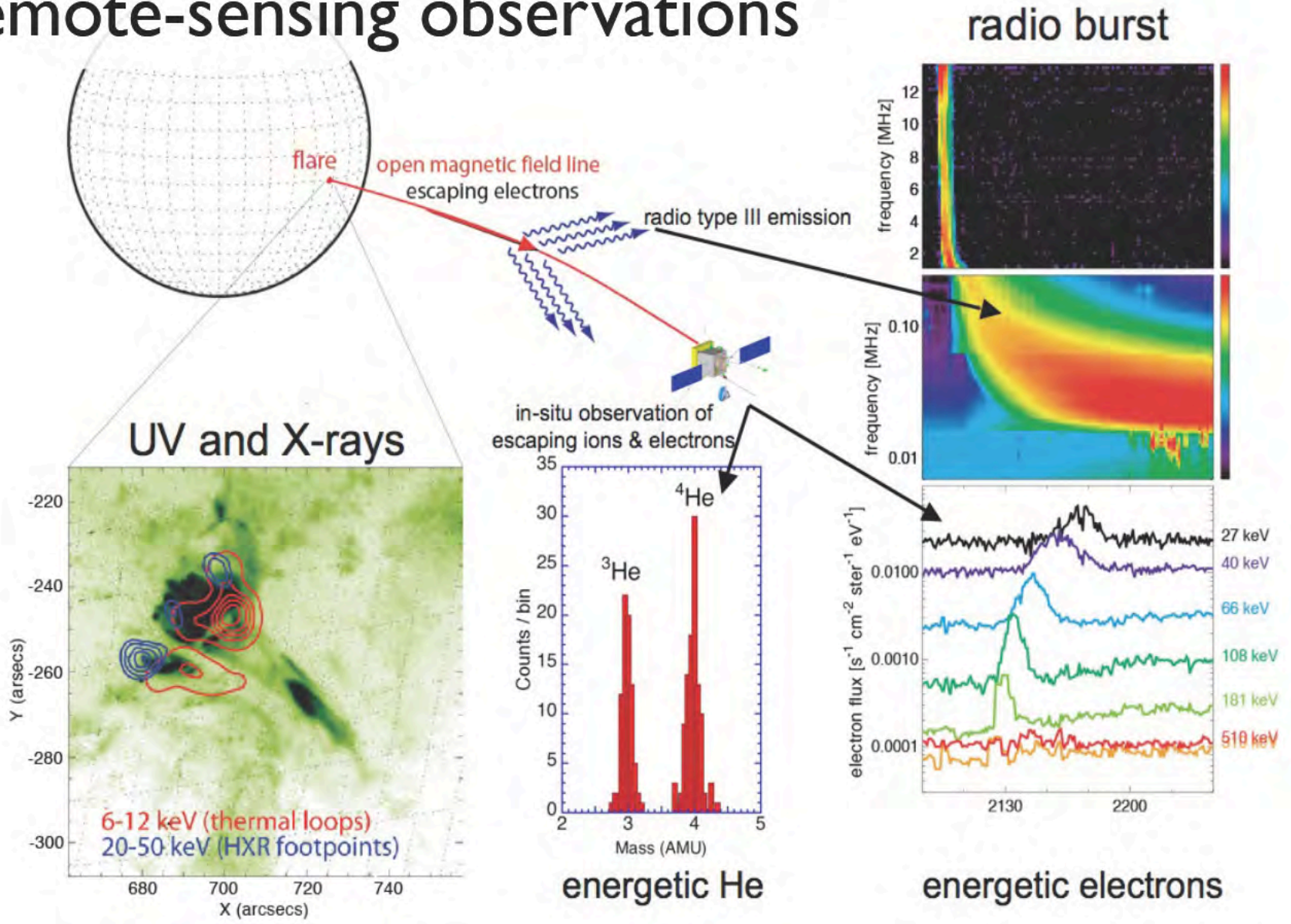
# Solar Orbiter
# Exploring the Sun-Heliosphere connection

- Joint ESA / NASA mission
- Launch in October 2018
- Three-axis stabilized
- Perihelie at 0.28 AU, inclined orbit up 33$^{o}$ solar latitude
- 10 remote-sensing and in-situ instruments
- Mission of 6.5 years + 2.5 years extension
- Scientific objectives

# Solar Orbiter
# Science objectives

- How does the Sun create and control the Heliosphere – and why does solar activity change with time ?
  - What drives the solar wind and where does the coronal magnetic field originate?
  - How do solar transients drive heliospheric variability?
  - How do solar eruptions produce energetic particle radiation that fills the heliosphere?
  - How does the solar dynamo work and drive connections between the Sun and the heliosphere?

# Solar Orbiter = Linking in-situ and remote-sensing observations



# Solar Orbiter: Payload

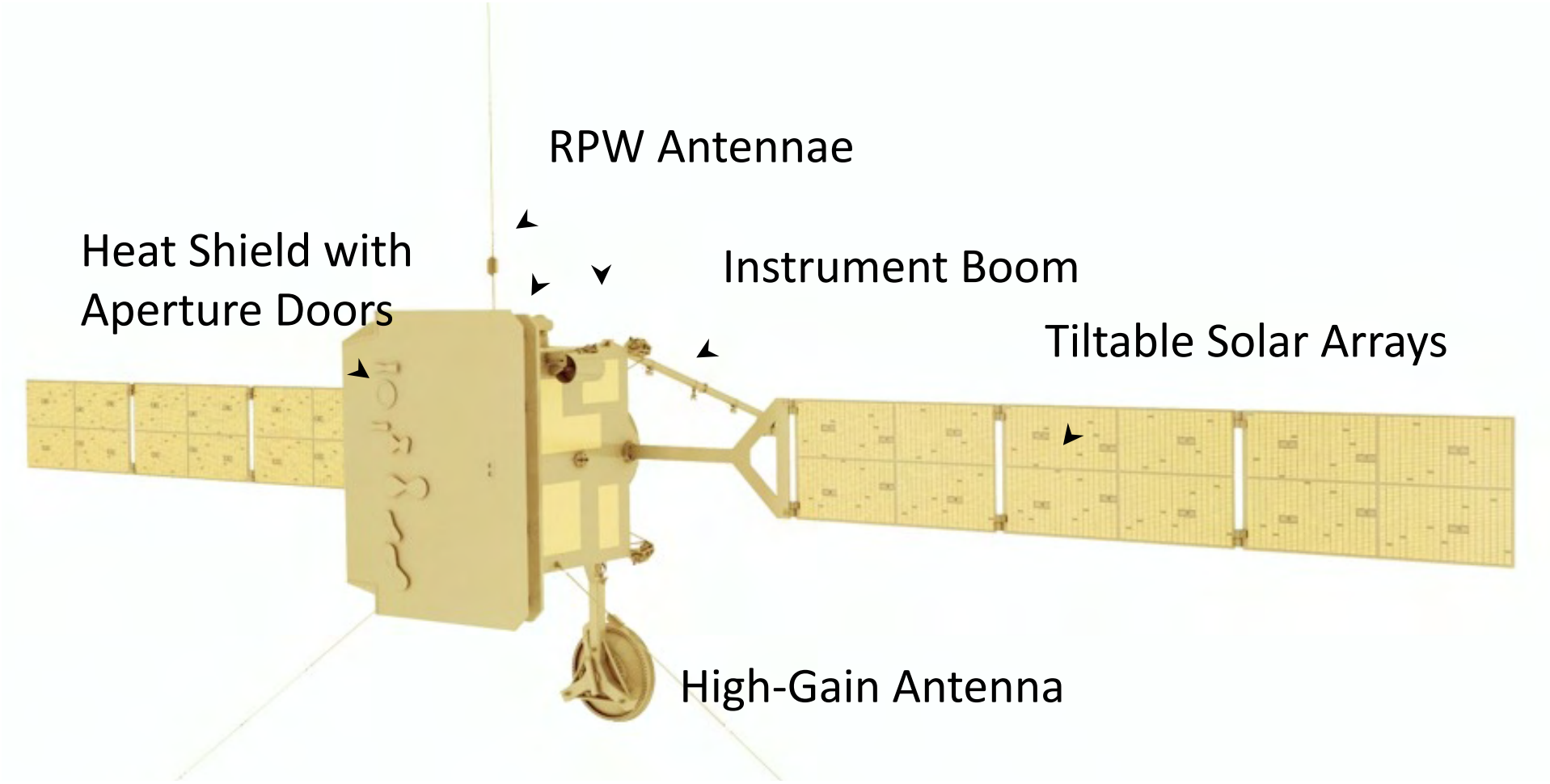
## In situ

| | | |
|---|---|---|
| EPD | Energetic Particle Detector | Composition, timing and distribution functions of energetic particles |
| MAG | Magnetometer | High-precision measurements of the heliospheric magnetic field |
| RPW | Radio & Plasma Waves | Electromagnetic and electrostatic waves, magnetic and electric fields at high time resolution |
| SWA | Solar Wind Analyser | Sampling protons, electrons and heavy ions in the solar wind |

## Remote sensing

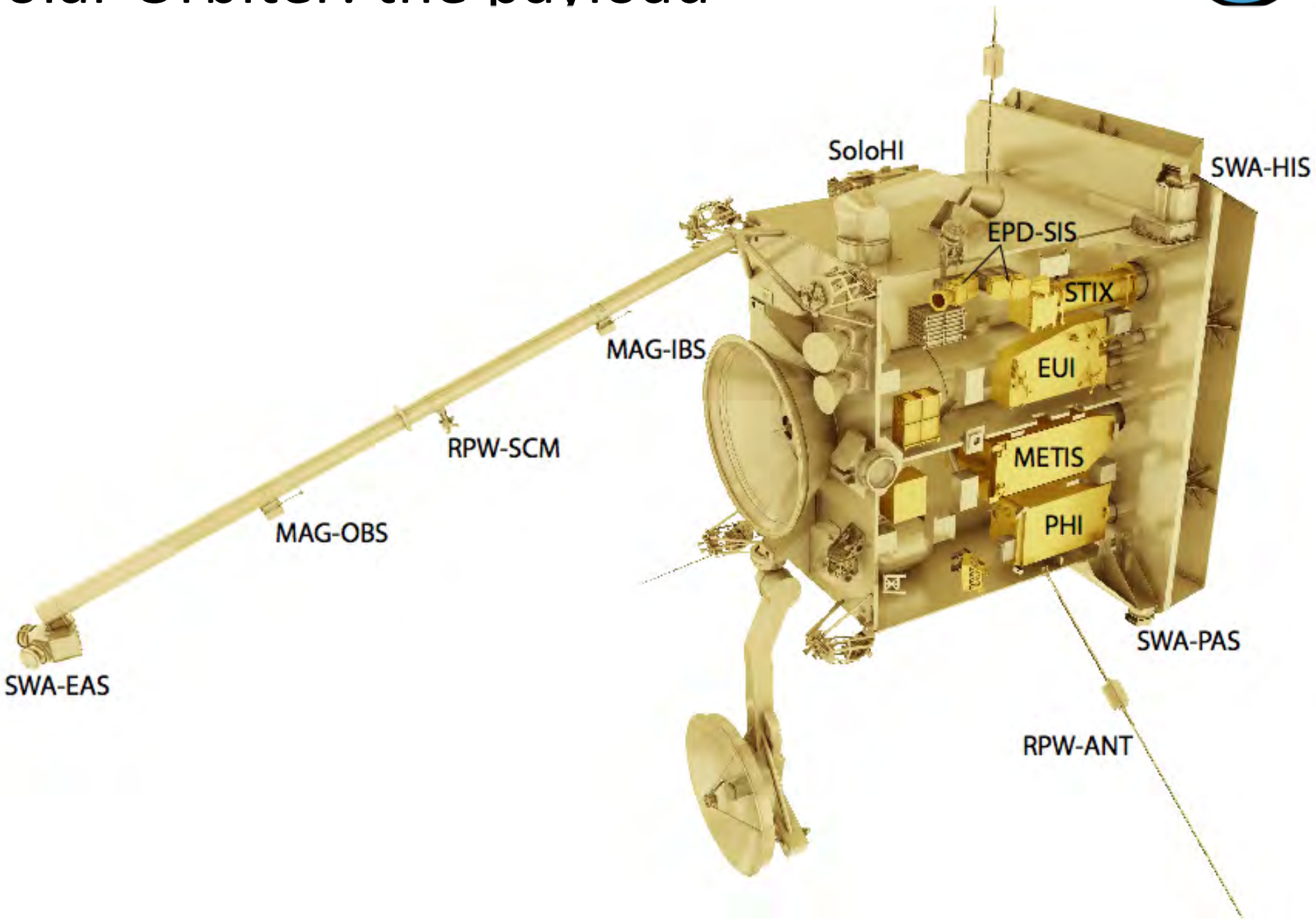
| | | |
|---|---|---|
| EUI | Extreme Ultraviolet Imager | High-resolution and full-disk EUV imaging of the on-disk corona |
| METIS | Coronagraph | Visible and (E)UV Imaging of the off-disk corona |
| PHI | Polarimetric & Helioseismic Imager | High-resolution vector magnetic field, line-of-sight velocity in photosphere, visible imaging |
| SoloHI | Heliospheric Imager | Wide-field visible imaging of the solar off-disk corona |
| SPICE | Spectral Imaging of the Coronal Environment | EUV spectroscopy of the solar disk and near-Sun corona |
| STIX | Spectrometer/Telescope for Imaging X-rays | Imaging spectroscopy of solar X-ray emission |

# Solar Orbiter: the platform




Picture courtesy DM / ESA

# Solar Orbiter: the payload



# Needs for ground-based support: The example of Solar Probe plus

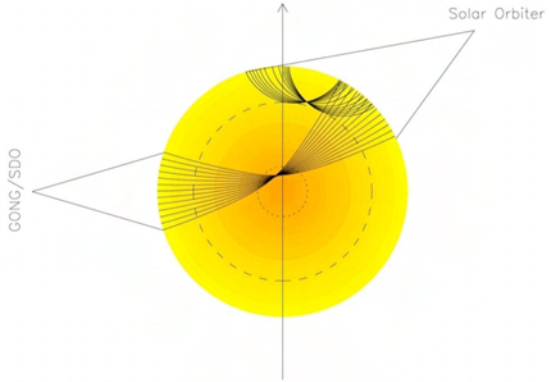
- How do the corona and inner heliosphere magnetically connect to the Sun?
  - What is the global context for in situ structures measured by SPP
  - How do transient structures (CMEs) from the Sun affect the corona and inner heliosphere?
- How are solar energetic particles accelerated and transported to SPP, SO and other space missions?
  - What are the sources of energetic particle suprathermal seed populations?
  - What role do flares and CME-driven shocks play in the acceleration of solar energetic particles?

# Needs for ground-based support: Observatories for SPP

- Meridional circulations, differential rotation
  - Solar radial velocity / magnetic field / helioseismology
- Localized energy release (flares, CMEs,...)
  - H$\alpha$ monitors + the above
- Large-scale magnetic structures
  - Stokes polarimetry / magnetograms
- Magnetic corona
  - Radio observations

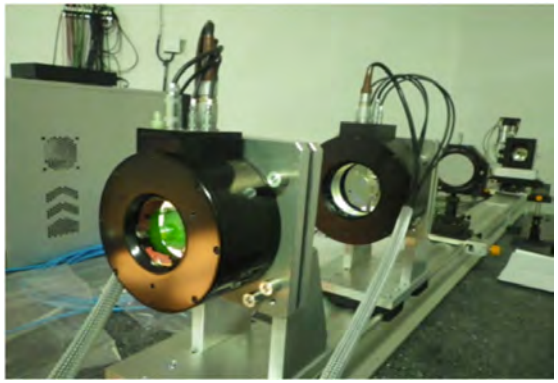
# Observatories for Solar Orbiter
# Radial velocity

- Full disk at 617.3 nm:
  - Global Oscillations Network Group (+H$\alpha$)



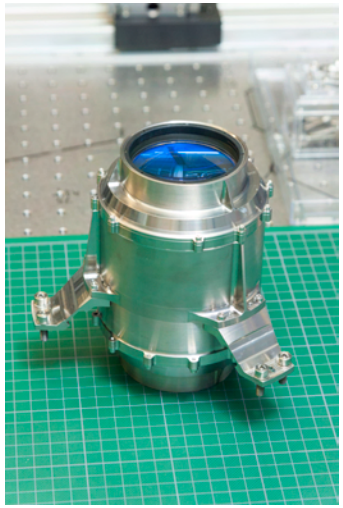


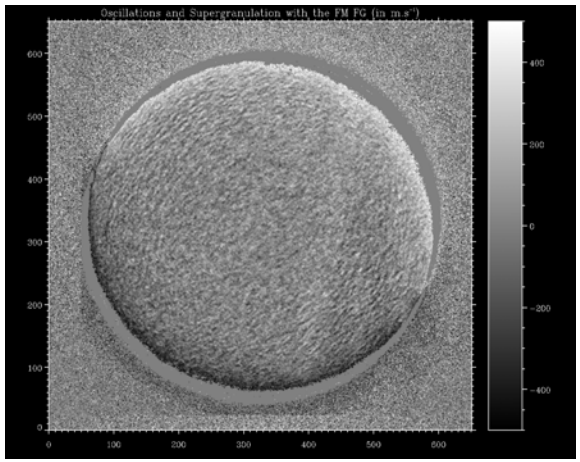
- Hi res at many lines
  - HELLRIDE

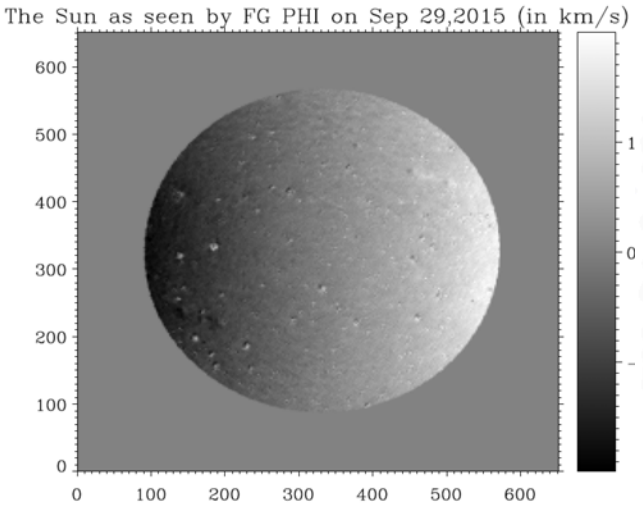


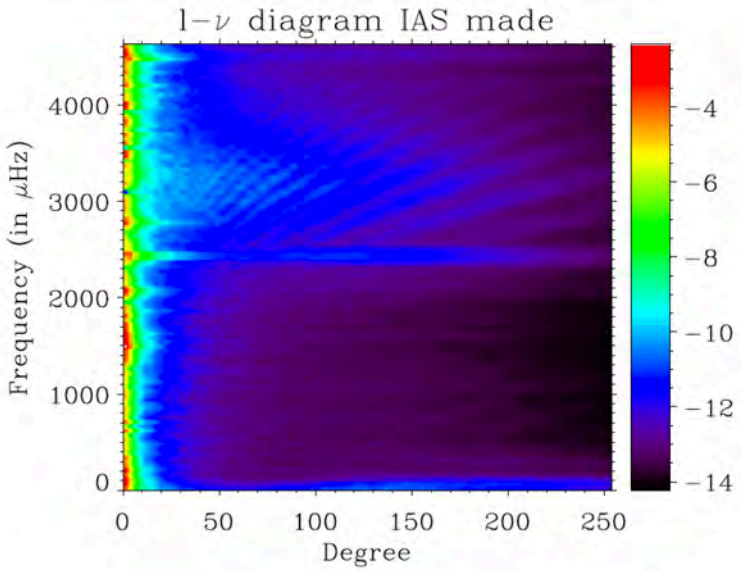
# Observatories for Solar Orbiter
# Radial velocity

- Full disk at 617.3 nm:
  - Filtergraph of PHI at the Meudon Solar Tower



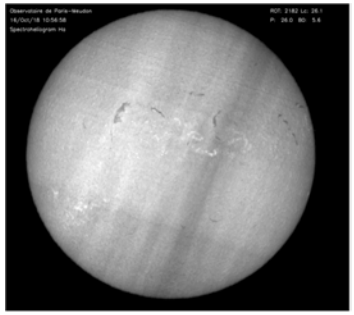


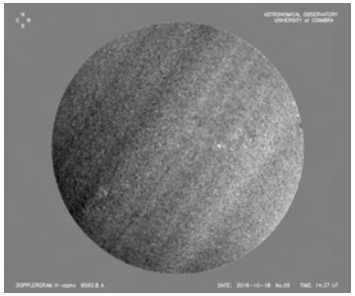



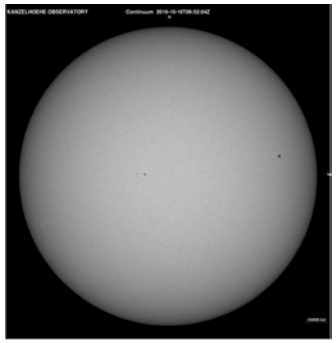



# Observatories for Solar Orbiter: Images and radial velocity

- Meudon observatory:
  - Full disk Hα, Ca II images / Full disk radial velocity Hα
- Pic du midi:
  - Coronal images in Hα / Full disk Hα, Ca II images
- Coimbra
  - Full disk Hα, Ca II images / Full disk radial velocity Hα
- Kanzelhöhe
  - Full disk Hα, Ca II images, White light
- Dutch Optical Telescope:
  - High res. Hα, Ca II
- Tamanrasset:
  - Hα, Ca II, Helium D3

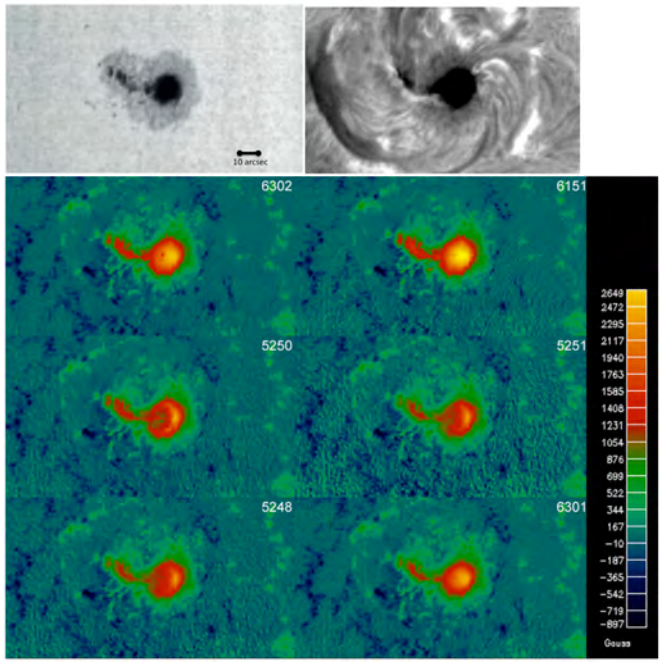




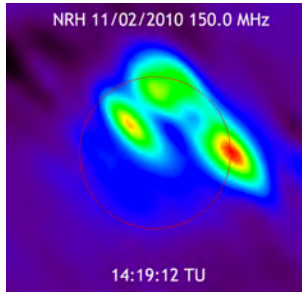
# Observatories for Solar Orbiter Polarimetry

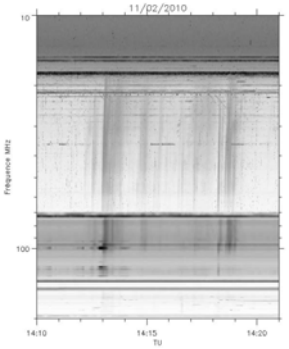
- THEMIS / Tenerife: restart in 2018 with AO
  - Multi line mode / Multichannel Subtractive Double Pass mode
- TRIPPEL at the Swedish Solar Telescope / Tenerife
  - Many line mode (one at a time?)
- GREGOR / Tenerife
  - From Visible to IR
- VTT / Tenerife
  - From Visible to IR
- DKIST / Hawaii: start late 2019
  - From Visible to IR
- EST / Tenerife: commissioned in 2026
  - From Visible to IR



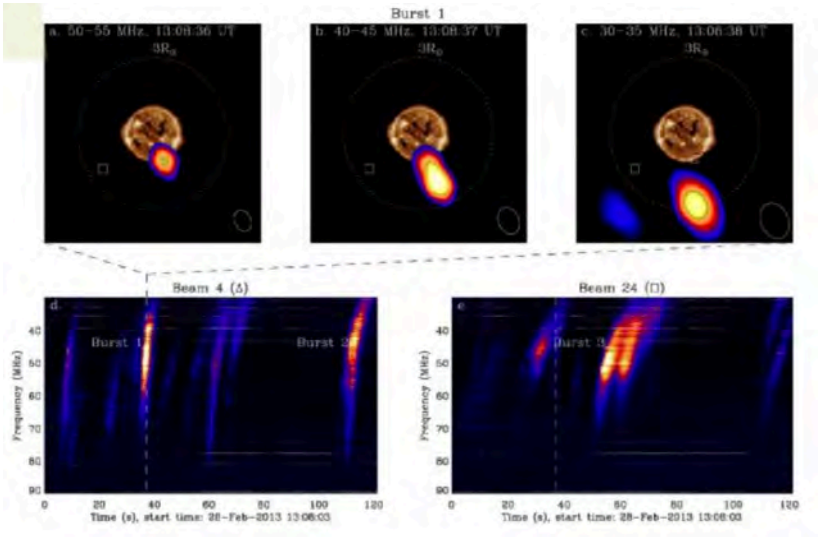
# Observatories for Solar Orbiter: Radio observatories

- Nancay Radioheliograph (150-450 MHz)
- Nancay total radio flux
- Nancay decametric array (10-100 MHz)




- LOFAR (10-270 MHz)
- ORFEES (Flare detection)



# Conclusion

- Current focus is on payload delivery
- Need for a White Paper for Solar Orbiter
- Needs are H$\alpha$ images, velocity, polarimetry and radiotelescopes
- Coordination of observatories yet to be put in place
- Coordination for preparing and supporting the encounters