solar orbiter

metis

Metis Instrument Overview and Status

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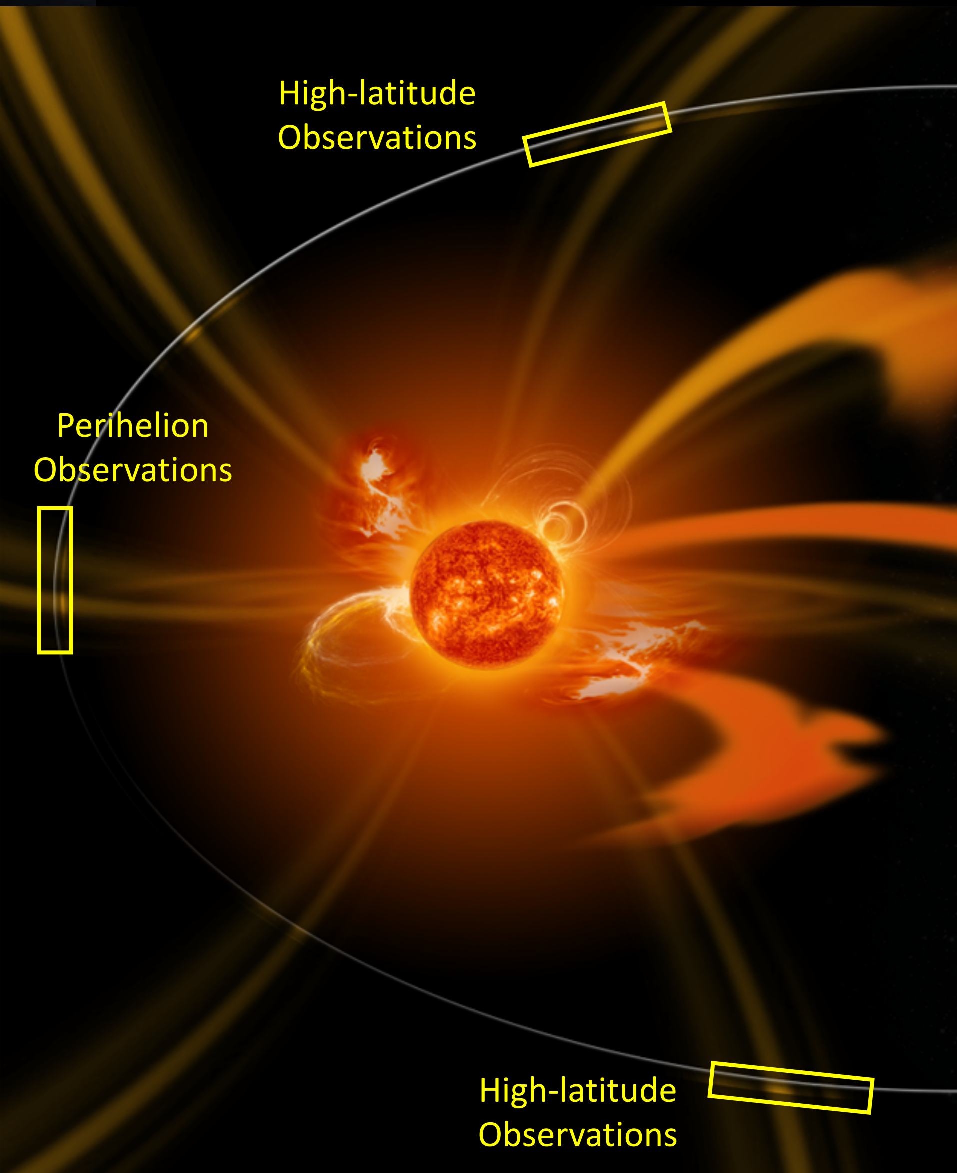
Univ. di Firenze, Italy

6th Metis Workshop *MPS, Göttingen, 21 November 2018*

OHB CGS ThalesAlenia Space

IFN IASF ifsi OAC OACt CAPA OATs Osservatorio Astronomico Torino UNIVERSITÀ DEGLI STUDI FIRENZE MPS LAM



M1 of Cosmic Vision 2015-2025

Launch date: February 2020

Cruise phase: 1.8 years (till 1/12/2021)

Nominal mission: 5 years

Extended mission: 3.7 years

Orbit:

0.28 – 0.32 AU (perihelion)

0.74 -- 0.91 AU (aphelion)

Out-of-ecliptic view:
Multiple gravity assists with Venus to increase inclination out of the ecliptic to >24° (nominal mission), >34° (extended mission)

Reduced relative rotation:
Continuous observation of evolving structures on the solar surface and heliosphere for almost a complete solar rotation

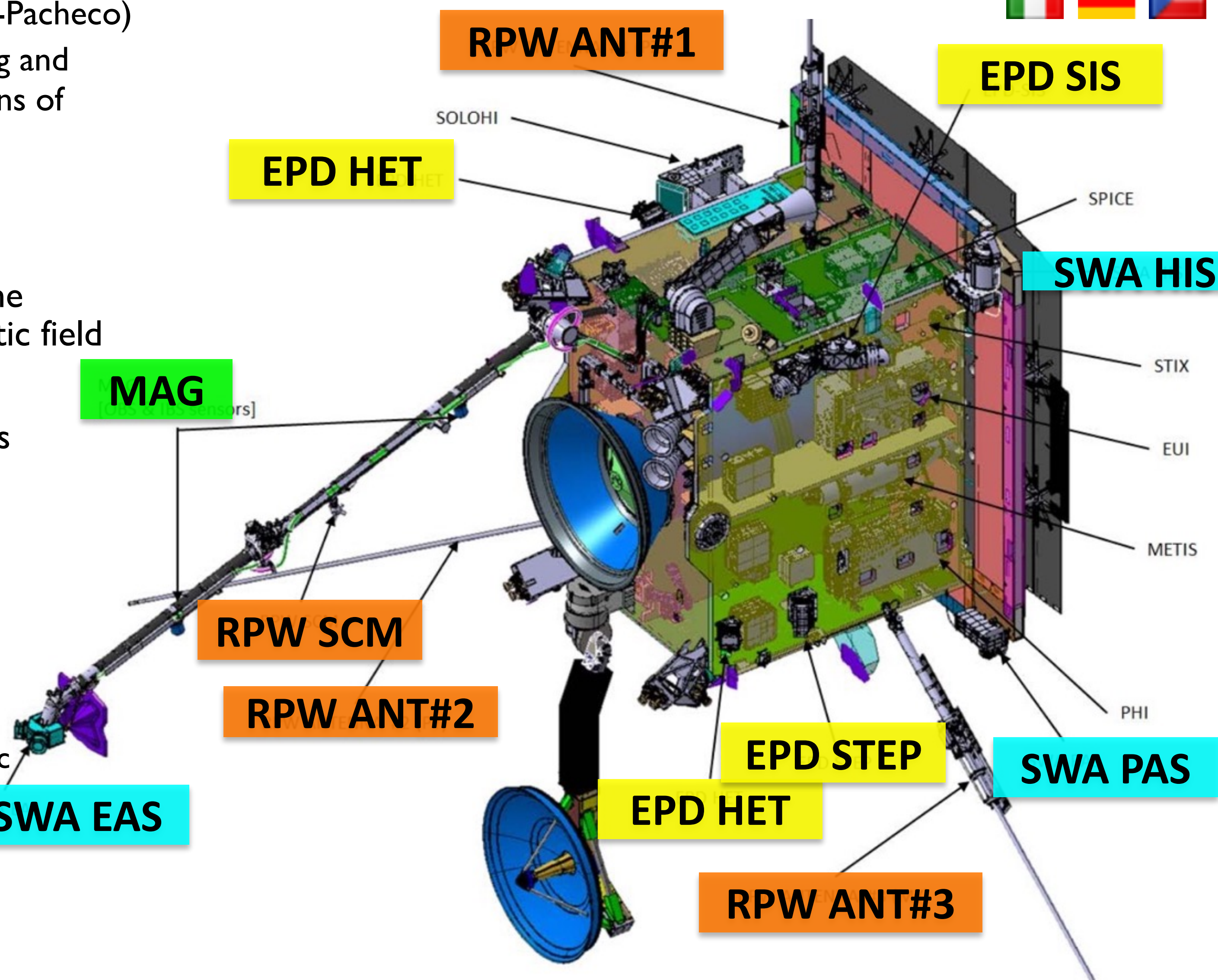
In situ Instruments

EPD (J. Rodriguez-Pacheco)
Composition, timing and distribution functions of energetic particles

MAG (T. Horbury)
High-precision measurements of the heliospheric magnetic field

SWA (C. Owen)
Sampling protons, electrons and heavy ions in the solar wind.

RPW (M. Maksimovic)
Electromagnetic and electrostatic waves, magnetic and electric fields at high time resolution



Remote Sensing Instruments

EUI (P. Rochus)
High-resolution and full-disk EUV imaging of the on-disk solar corona. HRI 17.4 and 121.6nm FSI 17.4 and 30.4nm

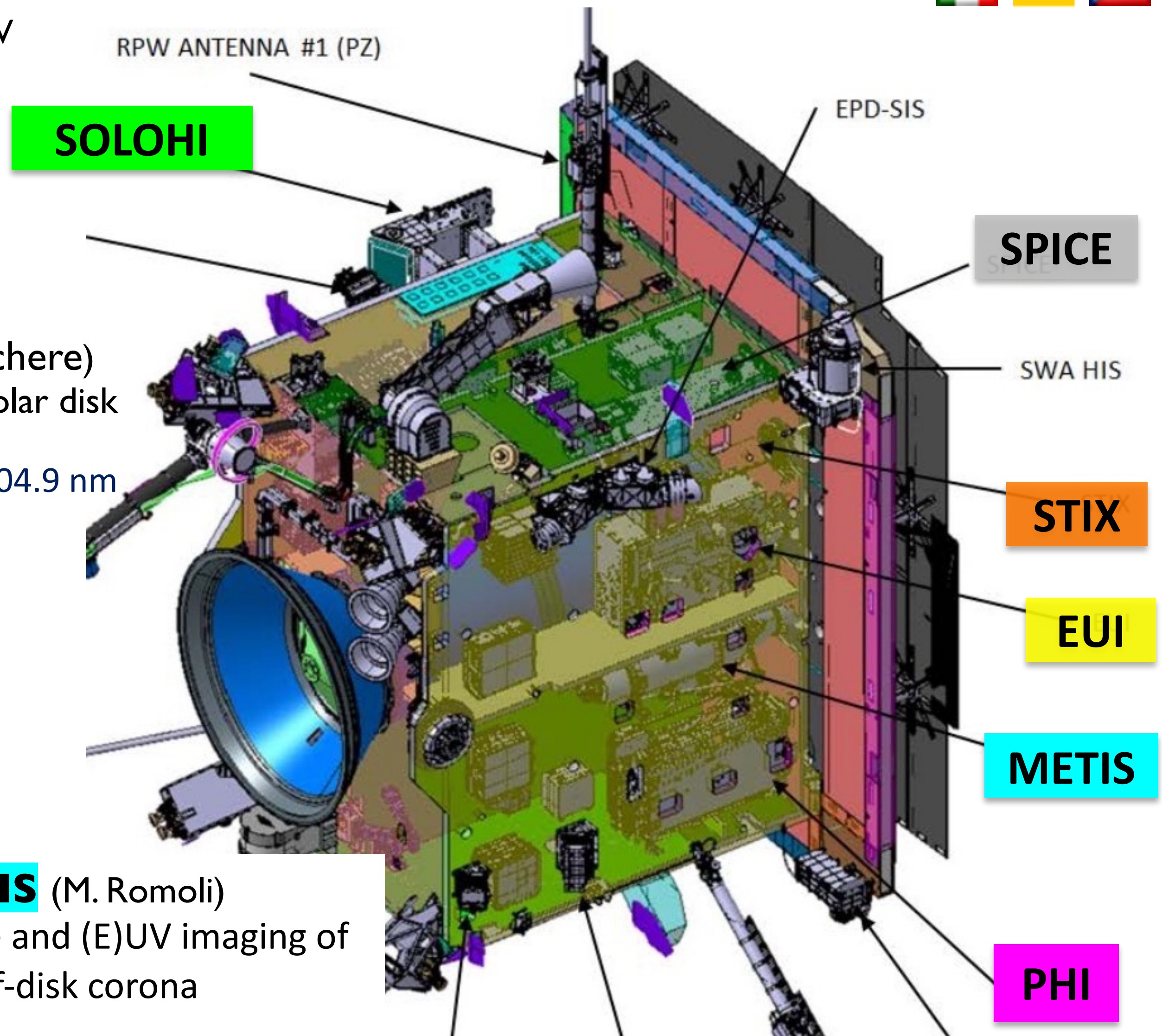
SOLOHI (R. Howard)
Wide-field visible imaging of the solar corona and wind

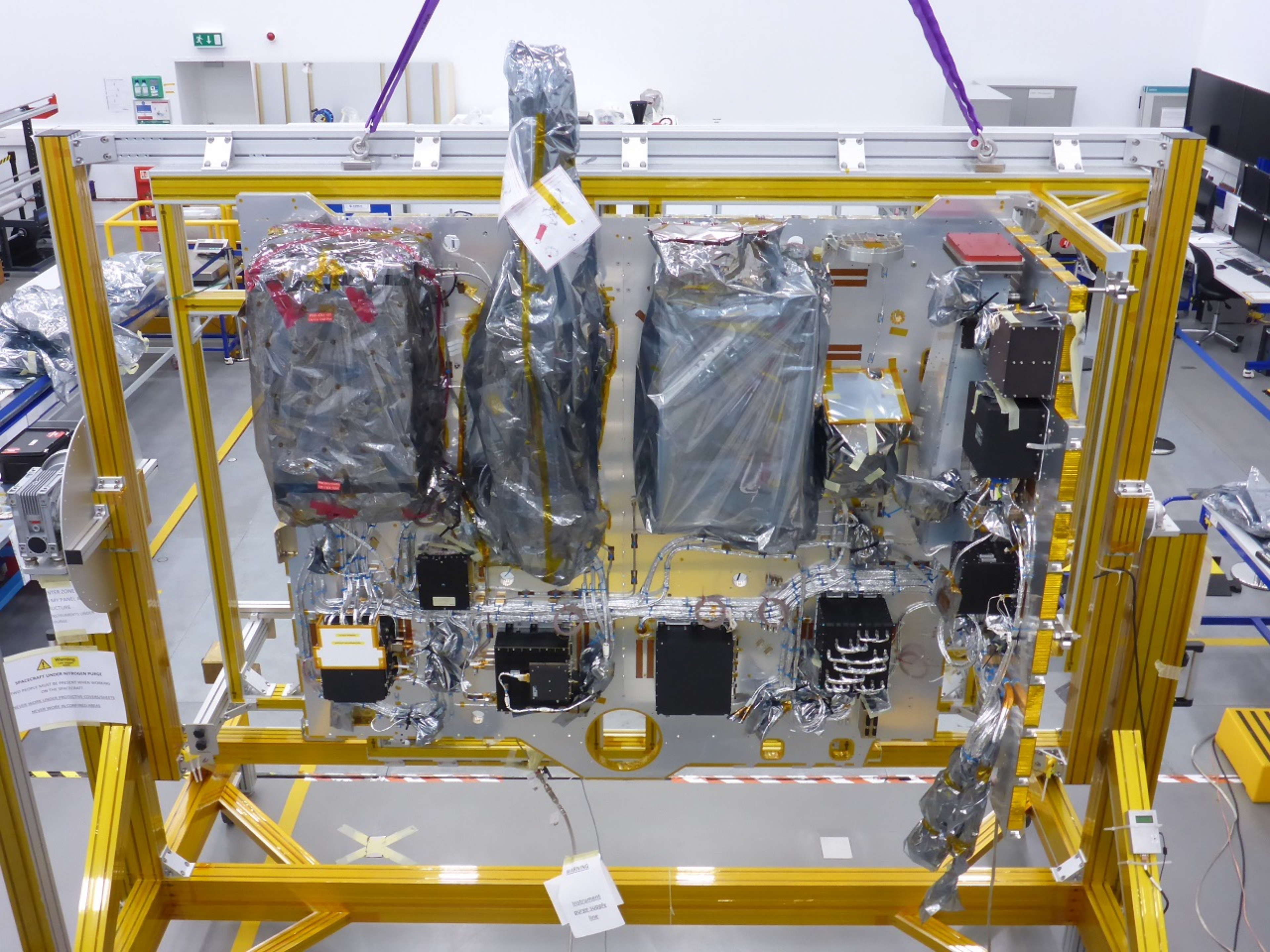
SPICE (A. Fludra/F. Auchere)
EUV spectroscopy of the solar disk and near-Sun solar corona.
70.4 - 79.0 nm and 97.3 - 104.9 nm

STIX (S. Krucker)
Imaging spectroscopy of solar X-ray emission

PHI (S. Solanki)
High-resolution vector magnetic field, line-of-sight velocity in photosphere, visible imaging

METIS (M. Romoli)
Visible and (E)UV imaging of the off-disk corona

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SPACECRAFT UNDER NITROGEN PURGE
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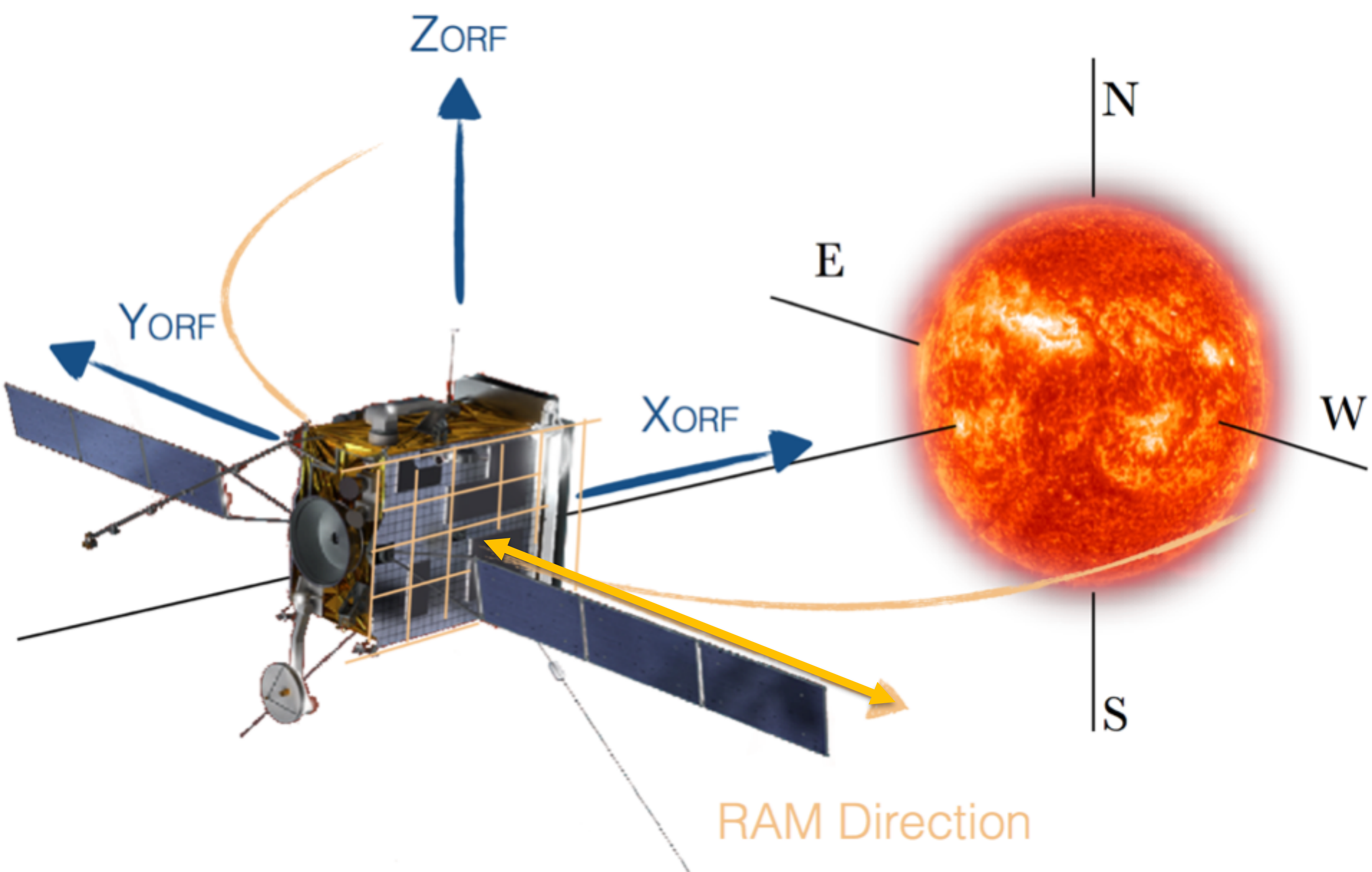

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RAM Direction

Metis scientific objectives

- Gives a unique contribution to address the core science objectives of Solar Orbiter
- Provides observations needed to understand the region linking the Sun to the heliosphere
- A key instrument to investigate how the Sun creates and controls the heliosphere (primary objective of the Solar Orbiter mission)

Solar Orbiter Top-level Science Questions	**Unique METIS contribution** The only Solar Orbiter instrument observing the:
How and where do the *solar wind plasma* and *magnetic field* originate in the corona	region where the solar wind is accelerated from ≈100 km/sec to near its asymptotic value
How do *solar transients* drive heliospheric variability	region where the first, most dramatic phase of the propagation of coronal mass ejections occurs
How do solar eruptions produce *energetic particle radiation* that fills the heliosphere	path of the shock front accelerating particles in the solar corona
How does the *solar dynamo* work and drive *connections between the Sun and the heliosphere*	overall magnetic configuration (closed and open magnetic field regions of the corona)

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Metis

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METIS is an imaging all-reflecting coronagraph designed to provide::

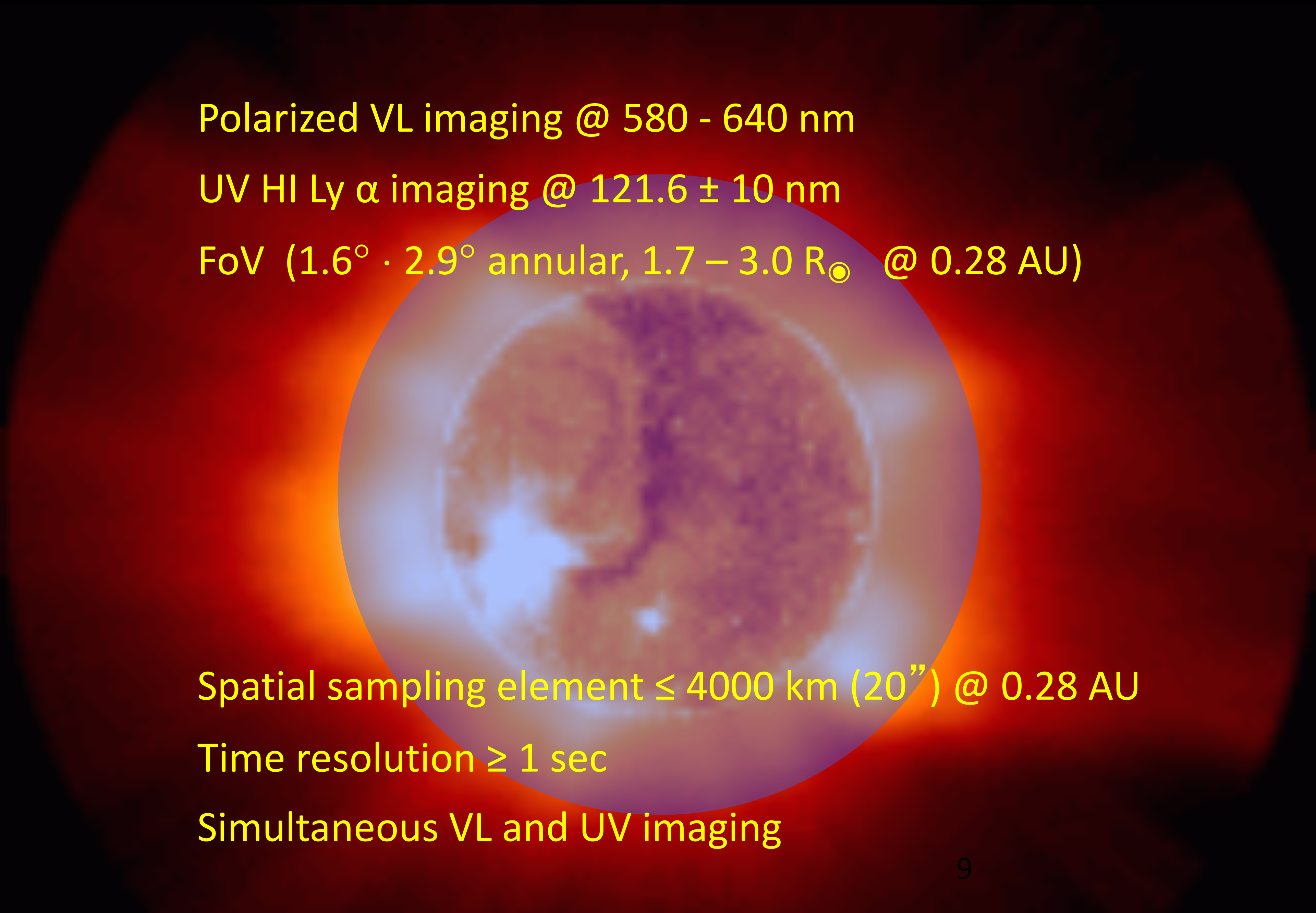
✓ Full Imaging of the extended corona (1.5 - 12 Ro) UV (121.6 nm), and visible light

✓ Density distribution in corona of H^0, and e^-

✓ Global Maps of solar wind outflow (H^0)

✓ Large scale dynamics of H^0, and e^- in CMEs

Metis: near-Sun coronagraphy



Polarized VL imaging @ 580 - 640 nm

UV HI Ly α imaging @ 121.6 ± 10 nm

FoV (1.6° · 2.9° annular, 1.7 – 3.0 $R_\odot$ @ 0.28 AU)

Spatial sampling element ≤ 4000 km (20”) @ 0.28 AU

Time resolution ≥ 1 sec

Simultaneous VL and UV imaging

METIS instrument requirements

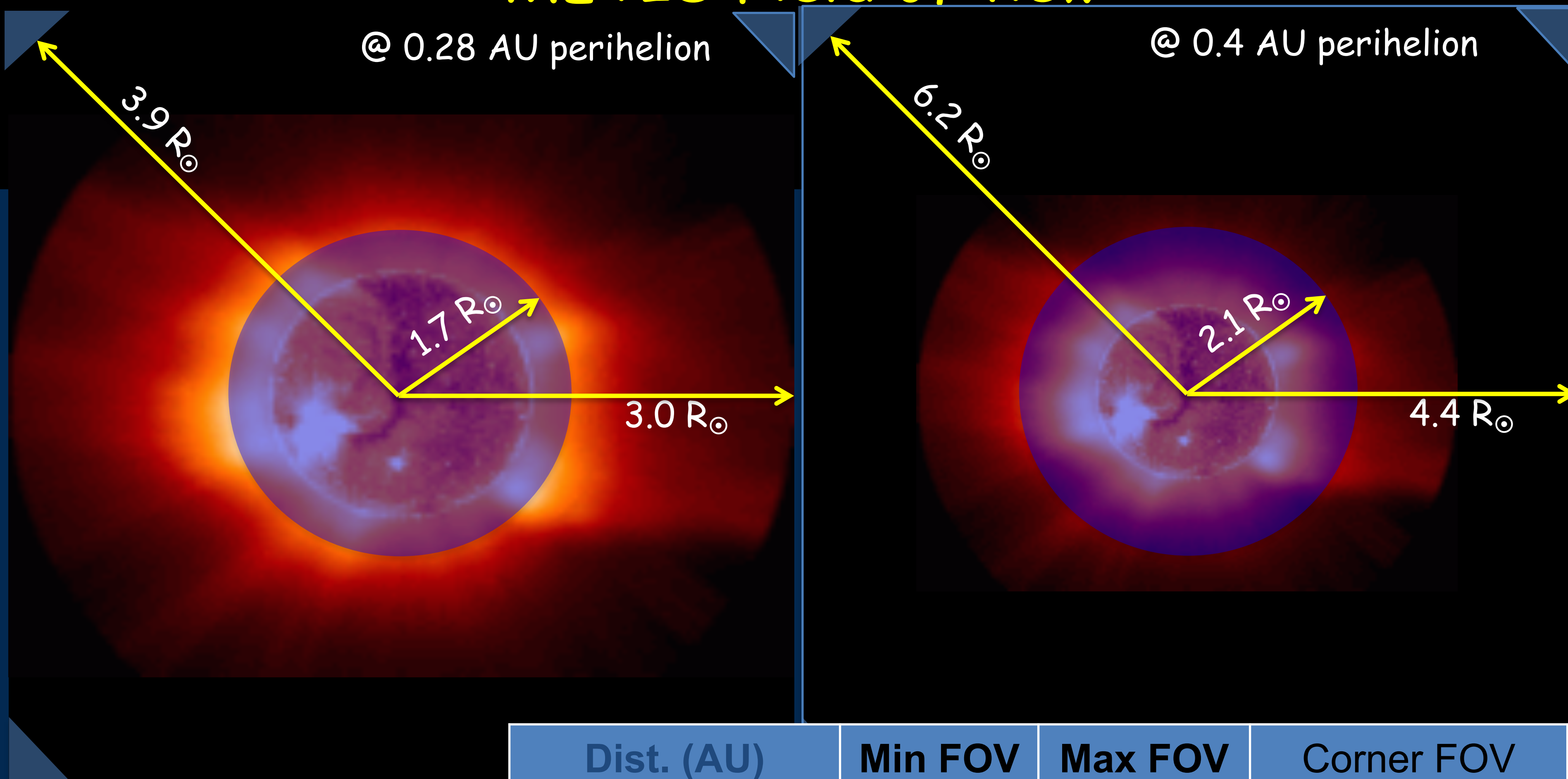
METIS instrument is an externally occulted coronagraph off-axis gregorian (with inverted occultation) with imaging capabilities.

Polarimetry with liquid crystal retarder

Inverted Coronagraph instrument requirements

Wavelength range:	Visible light: 580 – 640 nm UV: HI 121.6 ± 10 nm	
Field-of-view (square)	1.6° - 2.9°	0.28 AU: 1.7 – 3.0 $R_\odot$ 0.4 AU: 2.2 – 4.5 $R_\odot$
Spatial Plate Scale	10 arcsec (VL) 20 arcsec (UV)	
Spatial resolution	40 arcsec (VL and UV analog)	
Instrumental Stray Light	VL < 10^{-9} UV < 10^{-7}	
Mass	24.55 kg	
Average power consumption	15.5 W (stand-by) 26.07 W (operational)	

METIS Field of view



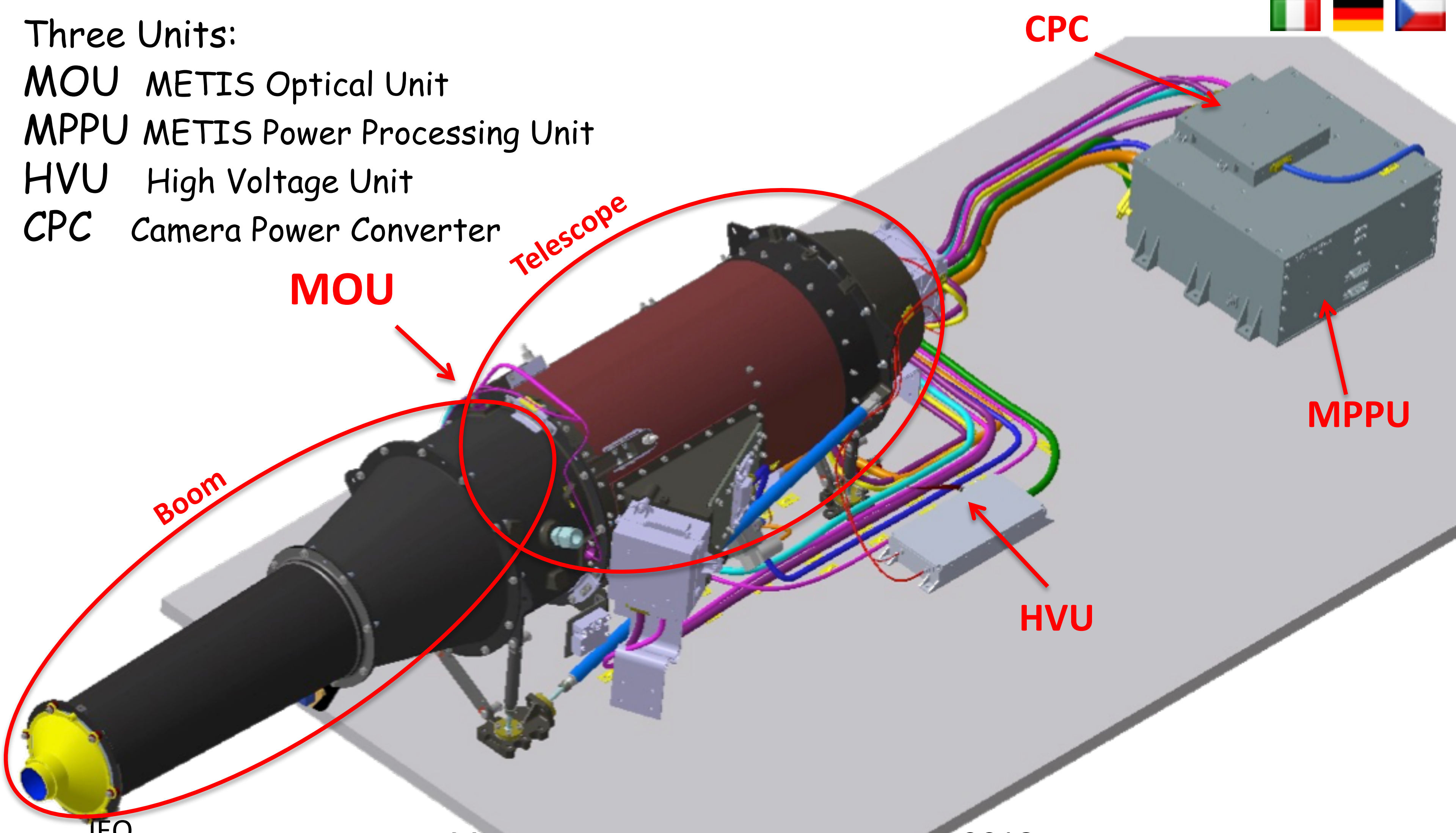
Dist. (AU)	Min FOV	Max FOV	Corner FOV
0.28	1.7 R⊙	3.0 R⊙	3.9 R⊙
0.3	1.75 R⊙	3.3 R⊙	4.0 R⊙
0.4	2.2 R⊙	4.4 R⊙	6.2 R⊙
0.5	2.8 R⊙	5.4 R⊙	7.7 R⊙
0.8	4.3 R⊙	12 R⊙	17 R⊙

Zooming effect in the FOV due to the orbit's eccentricity offers the chance of observing interplanetary H around the Sun

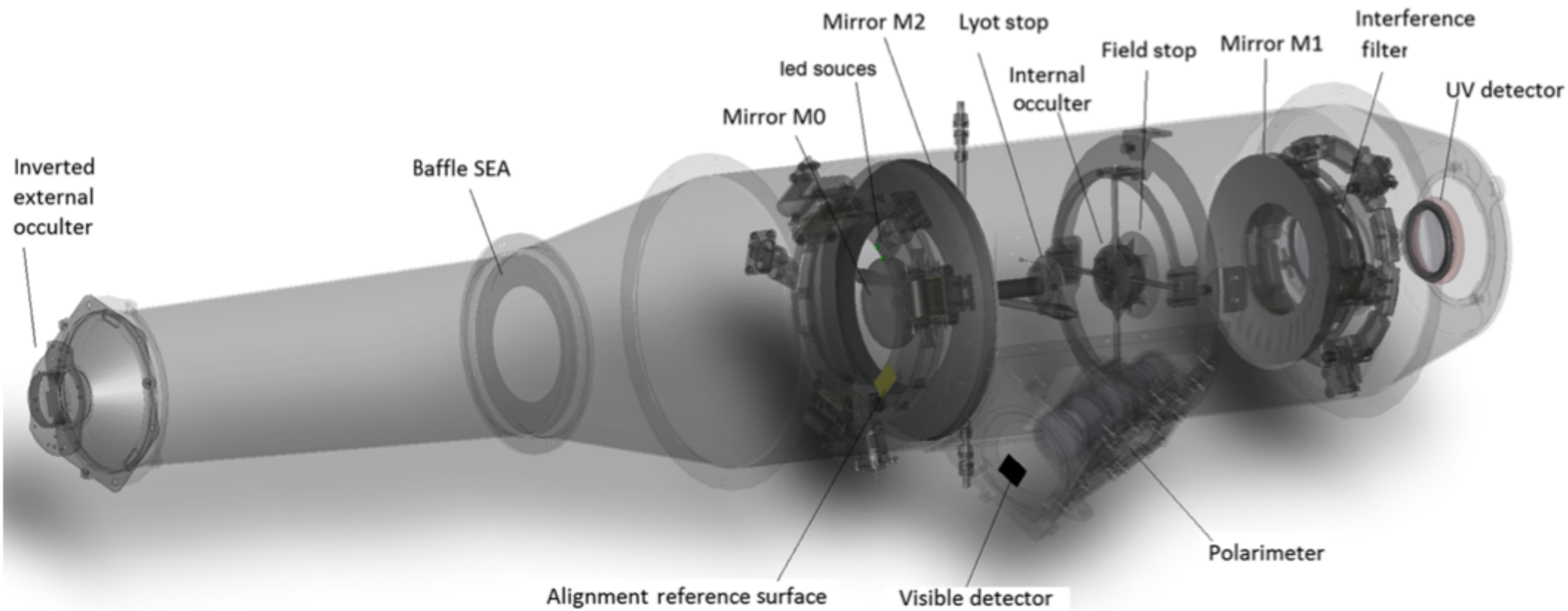
METIS Design Overview

Three Units:

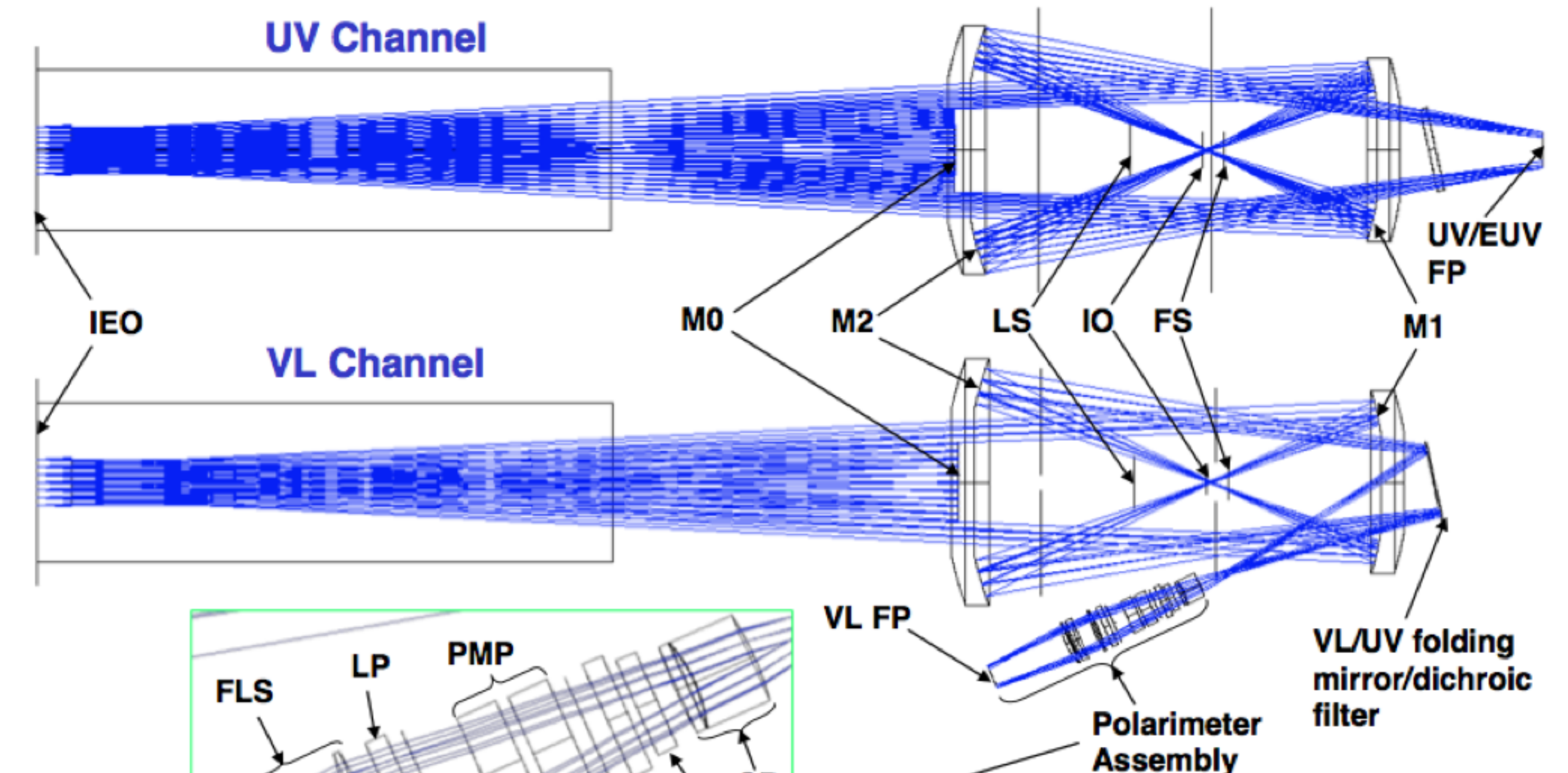
MOU METIS Optical Unit
MPPU METIS Power Processing Unit
HVU High Voltage Unit
CPC Camera Power Converter

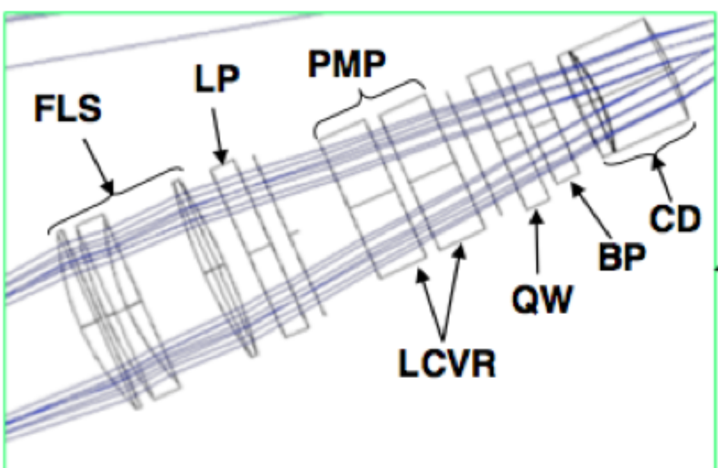


METIS Design Overview



METIS Optical Design



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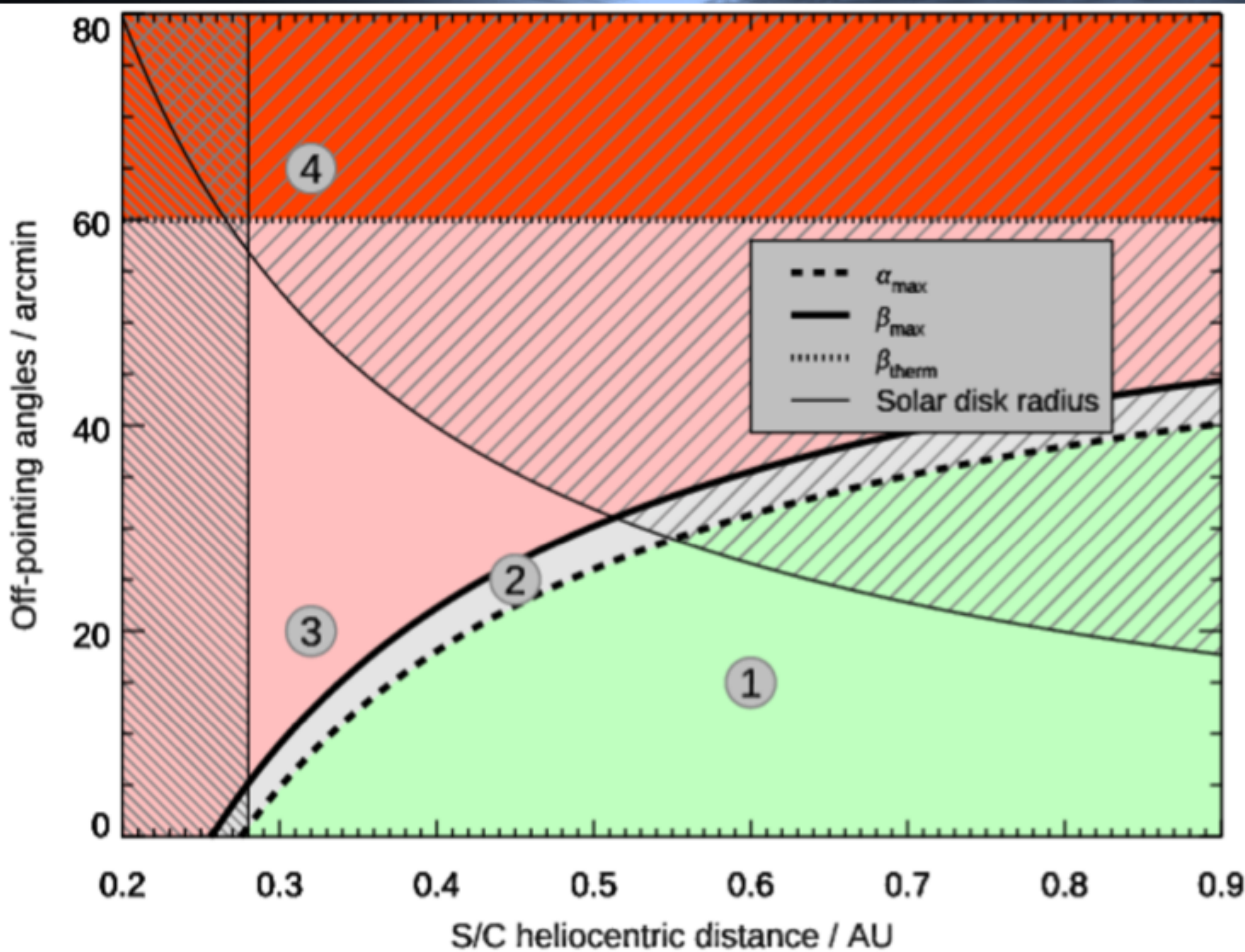
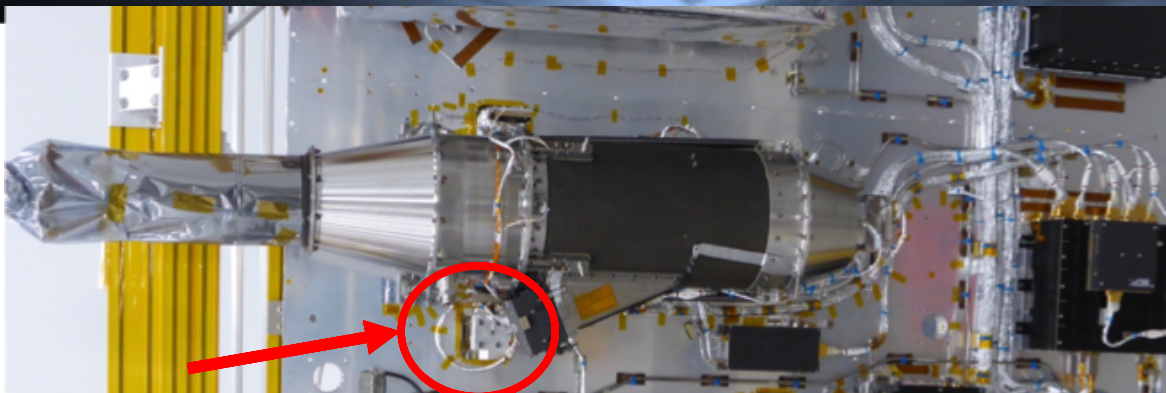
METIS in-flight off-pointing

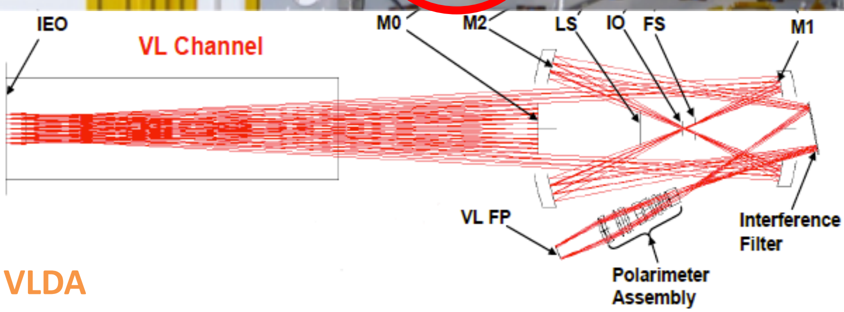


1. Metis nominal science operations
2. Scientific observations can be degraded by excessive stray-light
3. Metis internal components can be exposed to direct sunlight for a limited time
4. HS door should be closed in all circumstances

Metis Detectors - VLDA



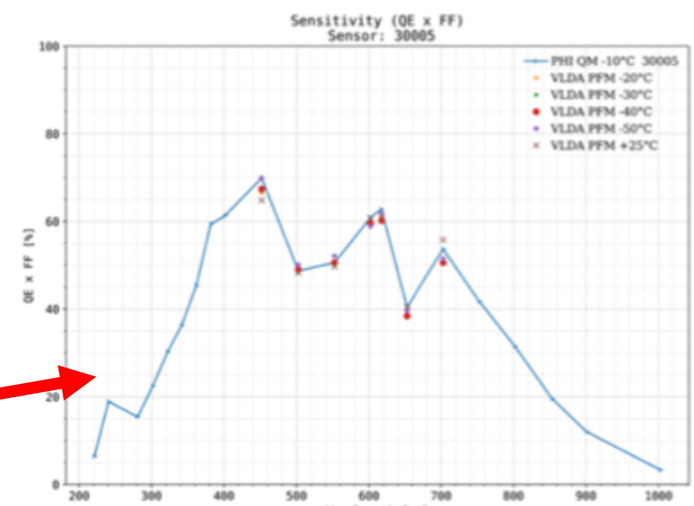
The METIS Visible Light Detector Assembly (VLDA) is a 2k x2k APS with a 10 um pixel size @14 bits and it is based on the same sensor adopted by the Solar Orbiter Polarimetric and Helioseismic Imager (PHI) instrument and developed by CMOSIS and MPS.



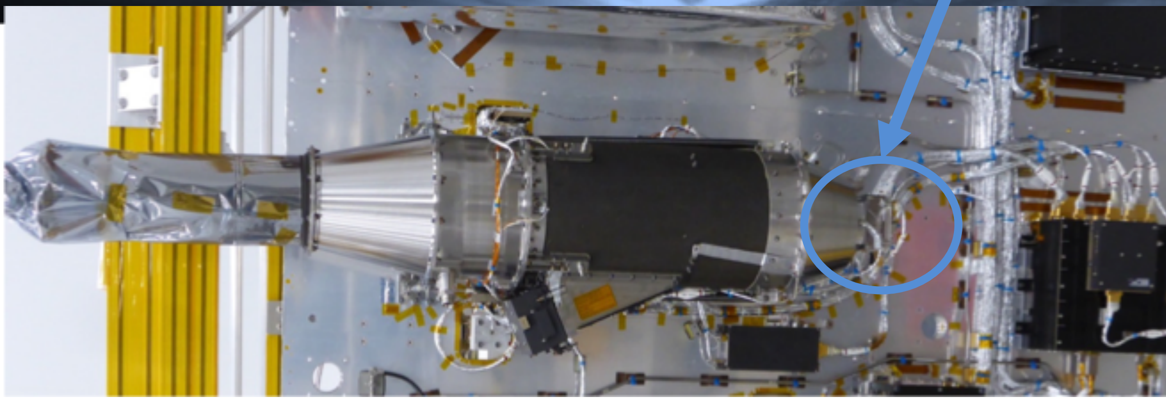
VLDA

Broad band images of the Sun corona @ 580-640 nm

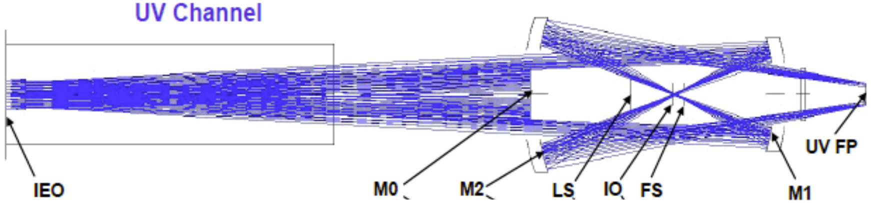
- APS 2Kx2K, 10 µm pixel (PHI replica)
- Scale factor 10.7 arcsec/pixel
- dark signal of about 25 e-/s below -10 °C
- average quantum effciency (QE + FF) of about 55%
- Full Well Capacity >70 ke$^-$ (90 ke$^-$ with low gain)
- Dynamic Range > 60 dB

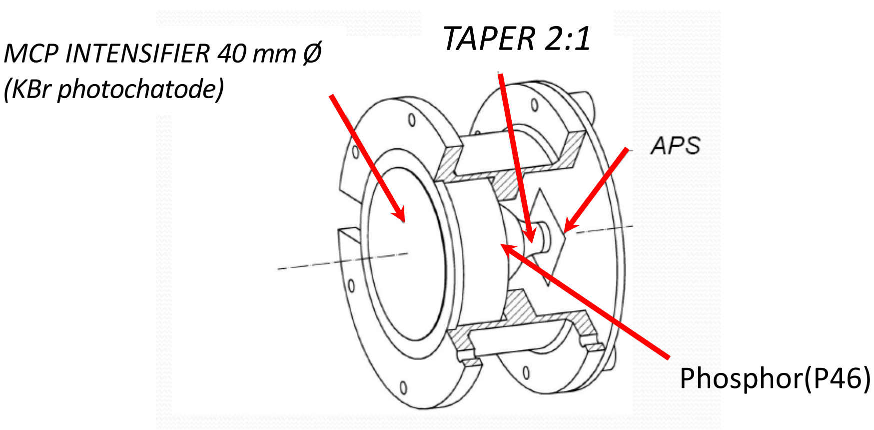


Metis Detectors - UVDA



The UV detector assembly (UVDA) is based on an Intensified Active Pixel Sensor (IAPS), consisting of a microchannel plate (MCP) intensifier with phosphor screen output, optically coupled via fiber optic taper to a 1k × 1k APS sensor.





Intensified UV light detector

- **Intensifier** (-> window-photocathode- MCP-phosphor screen)
  - Sealed
  - entrance window of UV-grade MgF2 to optimize the transmission @ 121.6 nm.
  - KBr deposited on the entrance face of the MCP to optimize in-band sensitivity and out-of-band rejection
  - Single stage MCP
- **FO taper** (de-magnification 2:1)
- **APS**
  - Star1000 based
  - **1024x1024 pixels (30 µm at the focal plane)**
  - Max pixel rate 12 MHz
  - **Scale factor 20 arcsec/pixel**
  - Dark current 840 e-/p/s @20° C 370° e-/p/s@-20° C
  - Full well **135 ke-**

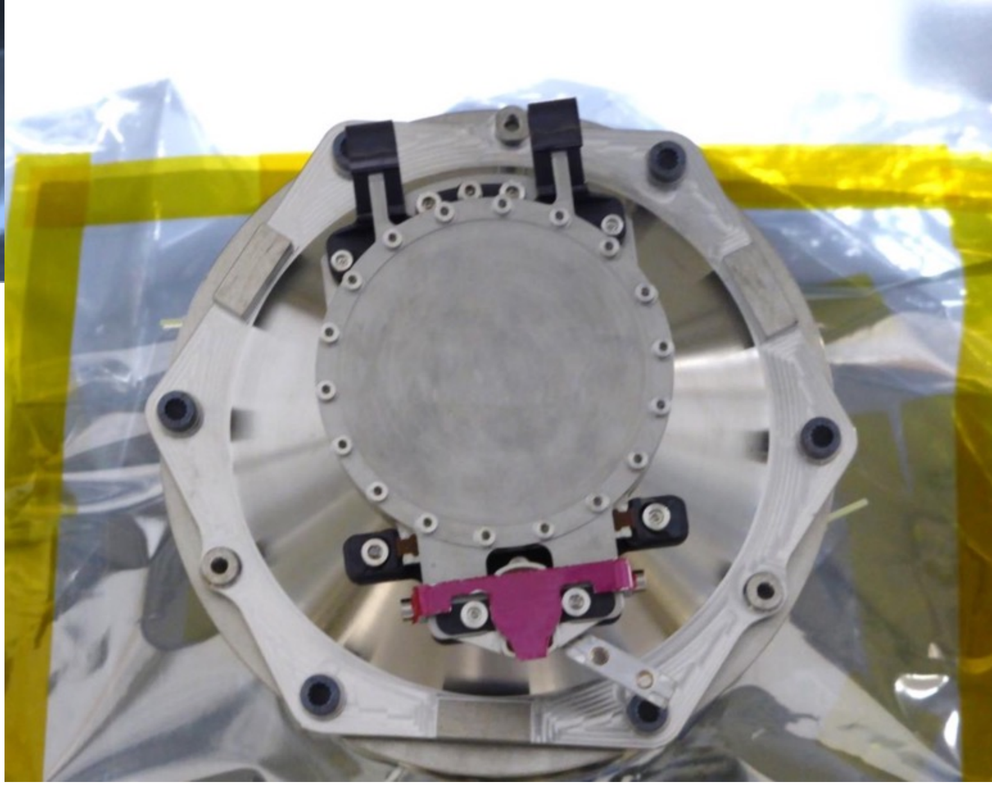
Metis AIV activity on S/C

S/C AIV at IABG, München

- MCAP mechanism installation
  28 October

- *SFT + Tvac (Nov/Dec) and verification of thermal model (Jan)*

- *Ejection Cap Test + protection cap removal (under definition – planned after Vibe Test Mar.2019)*



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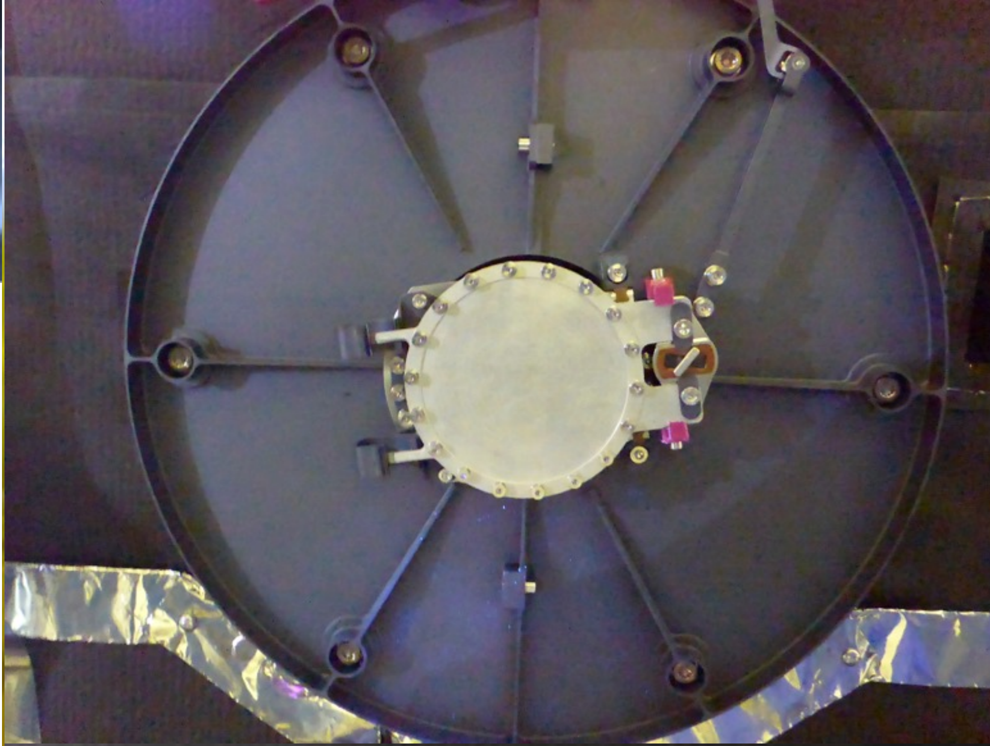


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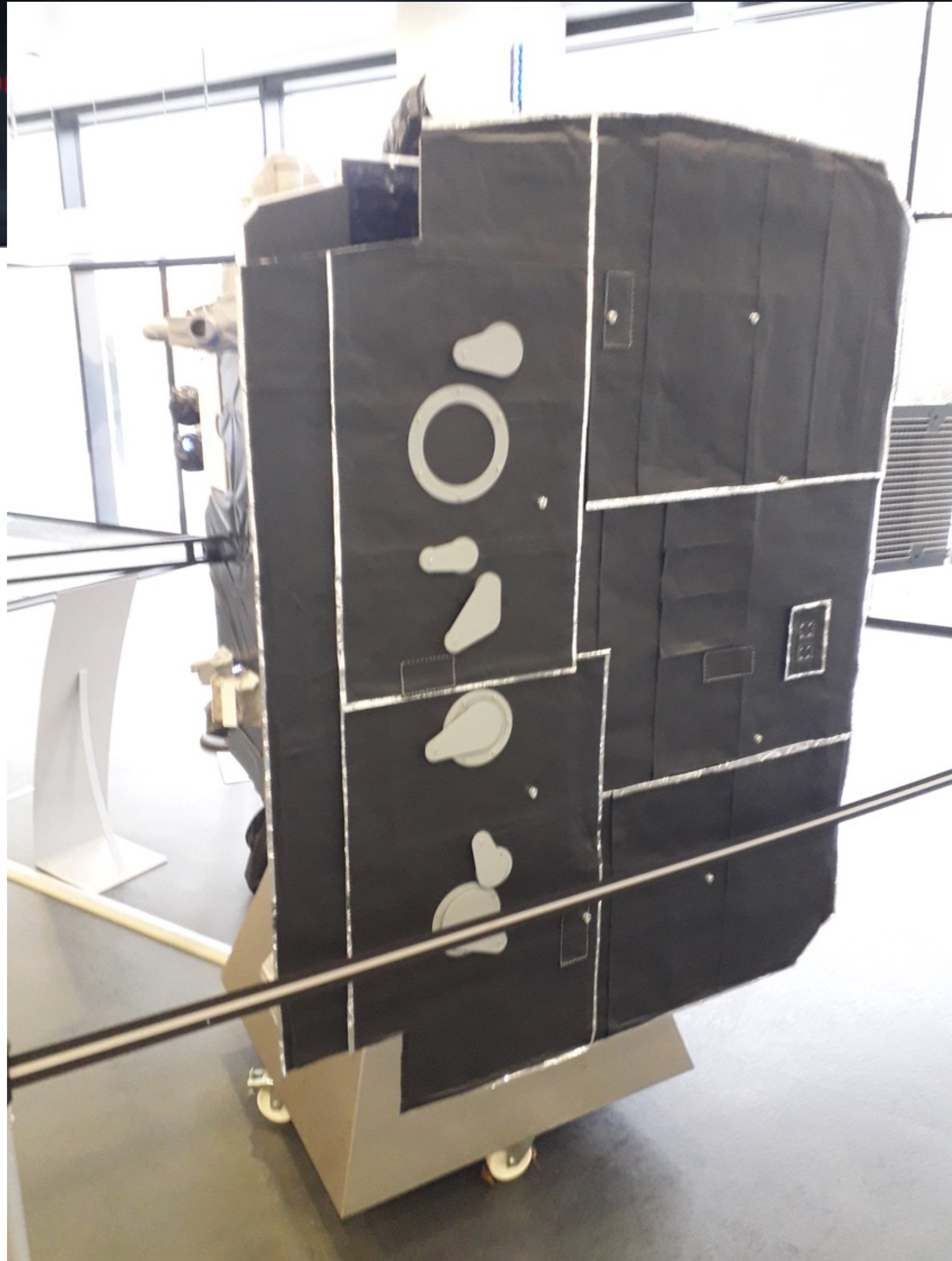

Metis OBSW

Present configuration:
- OBSW 2.0.7 + IDB 4.0 are stable and suitable for ground testing but not for flight (due to some minor defects and non conformances: revise the HK organisation and routing)
- Not all features of OBSW 2.0.7 have been functionally tested and verified (e.g. CME monitoring, Sun Disk flag, UV-Photon Counting)

Future plan:
- Metis Reference model
- Test planned at IABG: I-SFT (11-12/2018), I-FFT (8/2019), IIC (8/2019)
- Test planned at ESOC: SVT-1 (7/2019), IIC

- OBSW optimization, functional testing, and validation is in continuous progress at home on FUMO and EM, and, when ready, on the Metis Reference Model.
- Metis plan to release and upload a revised OBSW (+IDB) version shortly before or at the **beginning of the launch campaign.**
- Metis are prepared to support a further/backup OBSW upload activity at the first **Earth fly-by** if either in-flight activity will evidence any not proper functional behaviour or if the on-ground patch slot is missed.

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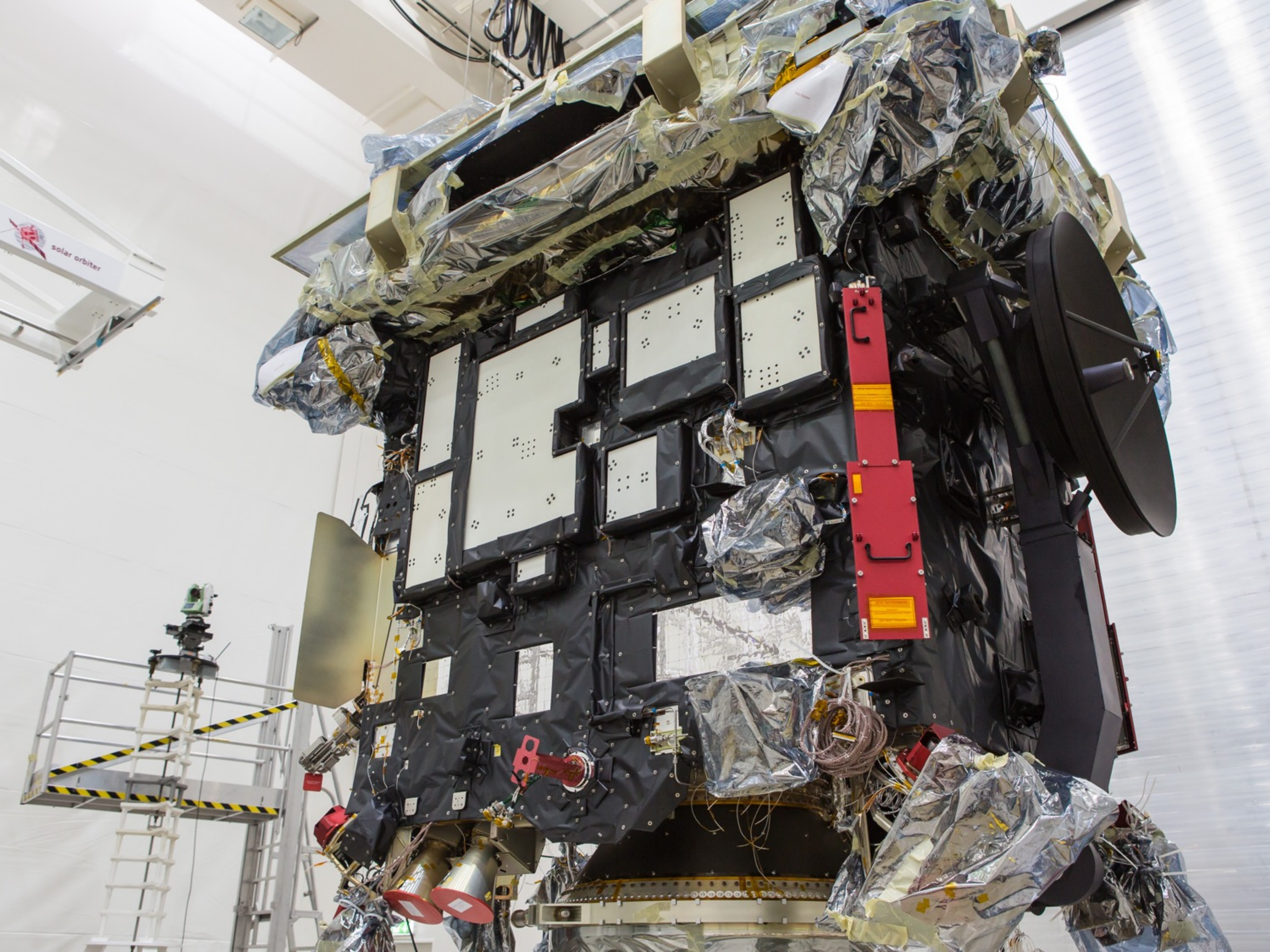
CHAMP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Metis Team

- Metis Team coordinated and funded by the Italia Space Agency (ASI)

- Industrial Team:
  - OHB Italia, Milan
  - Thales Alenia Space – Turin

- Scientific Team
  - University of Florence (PI: Marco Romoli)
  - INAF – Turin Astrophysical Observatory
  - University of Padua
  - CNR-IFN Padua
  - INAF – Capodimonte Astrophysical Observatory, Naples
  - INAF – Catania Astrophysical Observatory
  - INAF –IASF, Milan
  - INAF – Trieste Astrophysical Observatory
  - University of Urbino

- Institute of Astronomy, Czech Academy of Science and Toptec
- Max Planck Institut für Sonnensystemforschung (MPS)
- Naval Research Laboratory, Washington DC, USA