ESPM-16

16th European Solar Physics Meeting

Metis coronagraph aboard Solar Orbiter: instrument performance on the eve of the nominal mission phase

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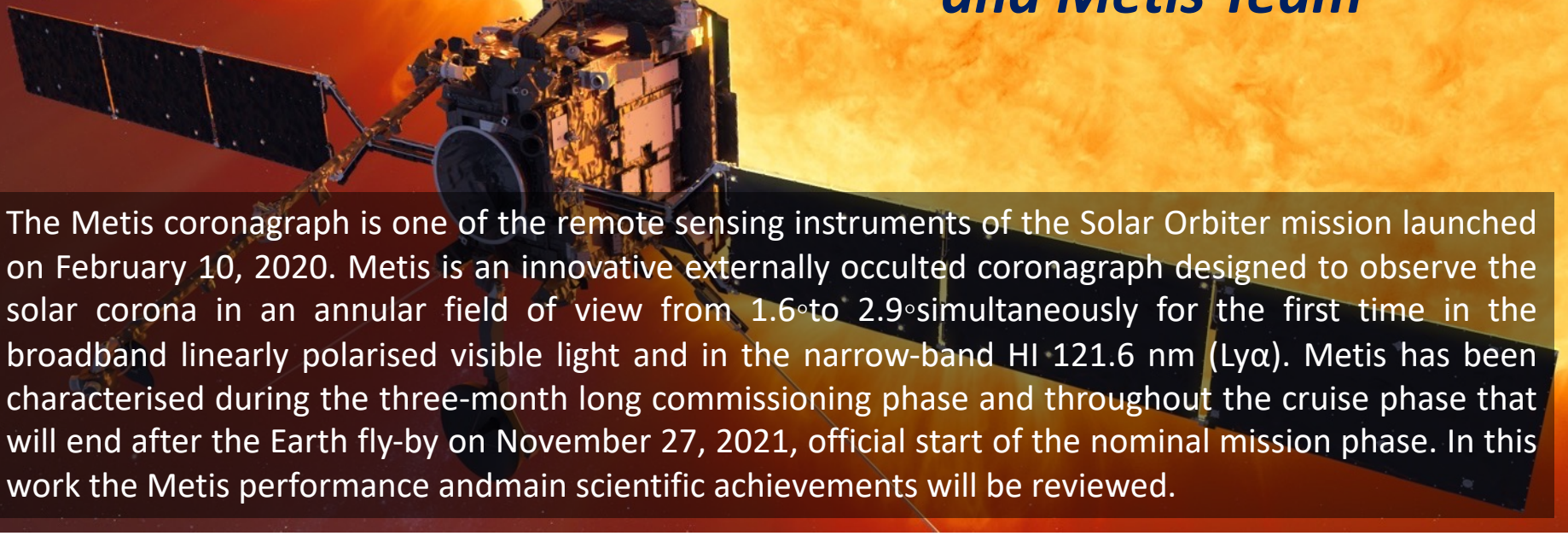
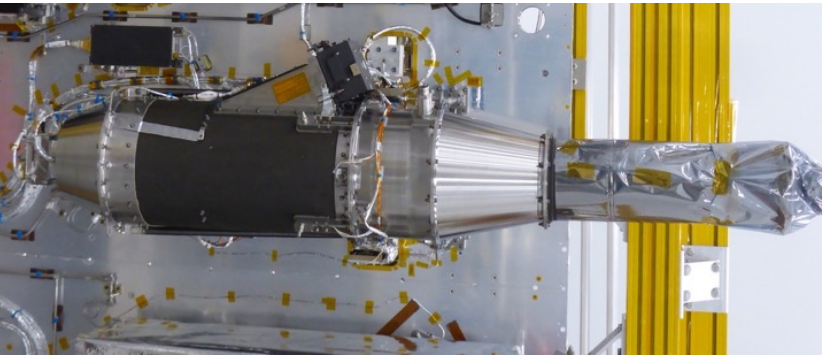
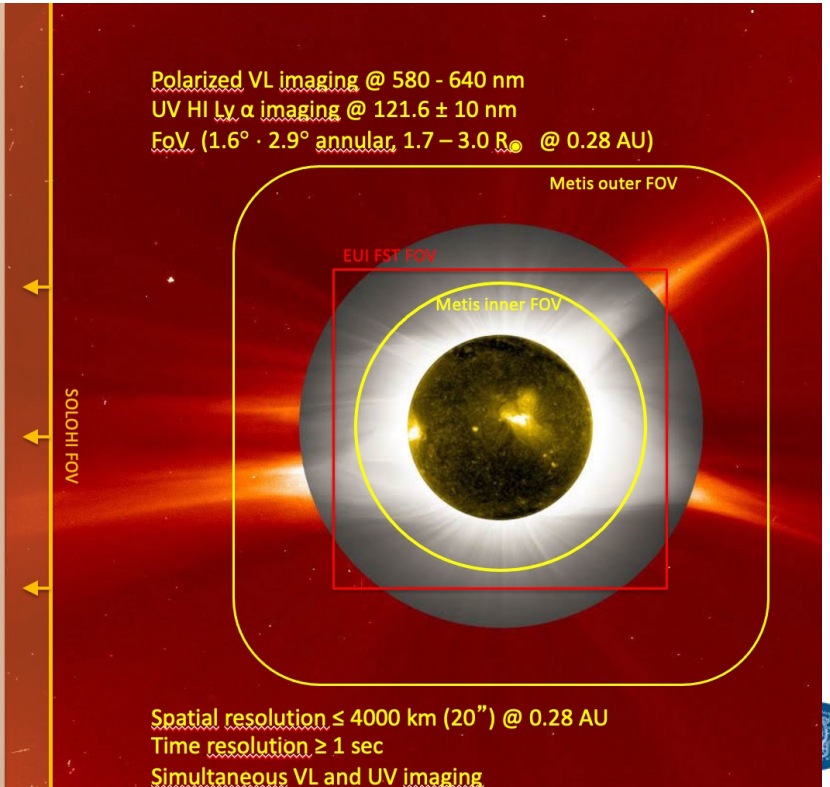
and Metis Team



The Metis coronagraph is one of the remote sensing instruments of the Solar Orbiter mission launched on February 10, 2020. Metis is an innovative externally occulted coronagraph designed to observe the solar corona in an annular field of view from 1.6◦to 2.9◦simultaneously for the first time in the broadband linearly polarised visible light and in the narrow-band HI 121.6 nm (Lyα). Metis has been characterised during the three-month long commissioning phase and throughout the cruise phase that will end after the Earth fly-by on November 27, 2021, official start of the nominal mission phase. In this work the Metis performance andmain scientific achievements will be reviewed.

Metis
coronagraph on-board Solar Orbiter





Metis is an imaging externally occulted all-reflecting coronagraph designed to provide:

- Full Imaging of the extended corona (1.7 - ~9 $R_\odot$) in
  - UV Ly-alpha (121.6±10 nm), and
  - visible light (580-640nm) in total and polarized brightness

- 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

Mission Profile & Metis Coronagraphic Observations

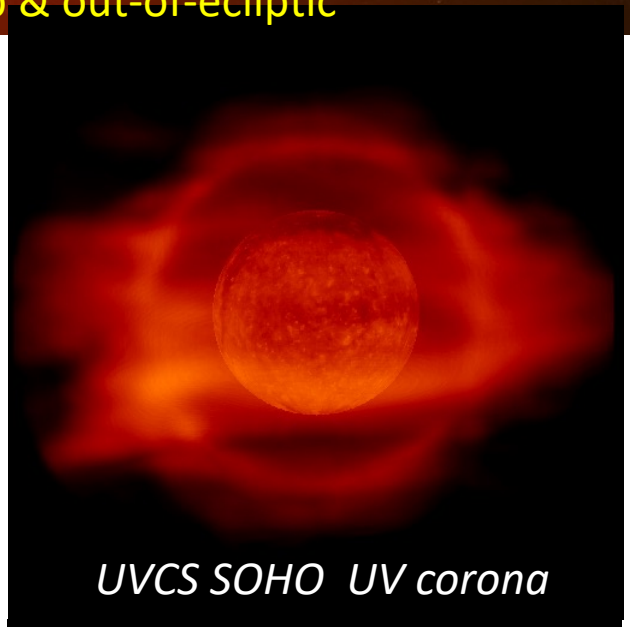
Metis - first coronagraph pointing to the Sun close-up & out-of-ecliptic

Close to the Sun 0.28 AU (min perihelion) fine structure of wind plasma in corona in extended latitude & longitude ranges

Out of the ecliptic ~ 34°
access to longitudinal structure of corona, solar wind and magnetic flux tubes channeling outflows

Reduced rotation relative to the Sun 7.7°/d
intrinsic evolution of solar wind and of coronal density inhomogeneities due to reduced rotation effect at the limb

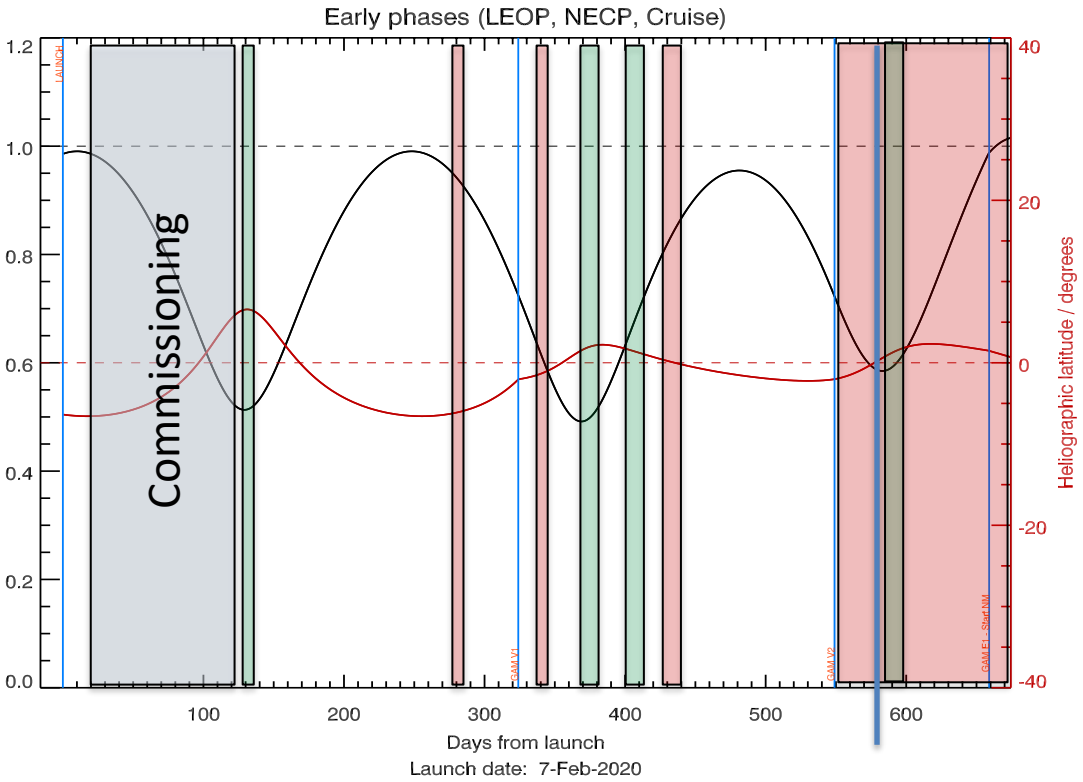
Out of the geocorona
best UV coronal seeing conditions



UVCS SOHO UV corona

Courtesy of A. Panasyuk

Cruise Phase



- Star radiometric calibrations
- Observing modes testing
- Several CMEs observed since January 2021
- Density fluctuation test
- Synoptic program test
- Stray light and polarizer tests with S/C rolls and slews
- Optimization of the internal occulter position

Metis Performance Status

Completed activities:

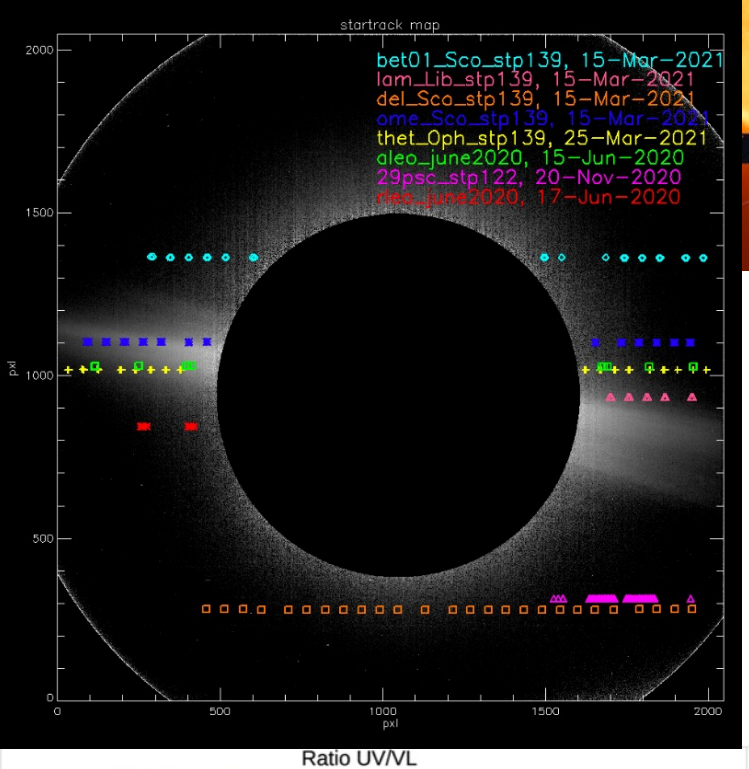
- **IO alignment** (Coarse and fine)
- Dark/Bias subtraction
- **Spatial resolution** (preliminary: need more star observations)
- **Polarimeter characterization**
- **Metis pointing verification**
- **Vignetting function** (Preliminary vignetting function for both VL and UV available)
- **VL radiometric calibration** (preliminary: confirms VL on-ground efficiency within uncertainties)
- **Stray light characterization**

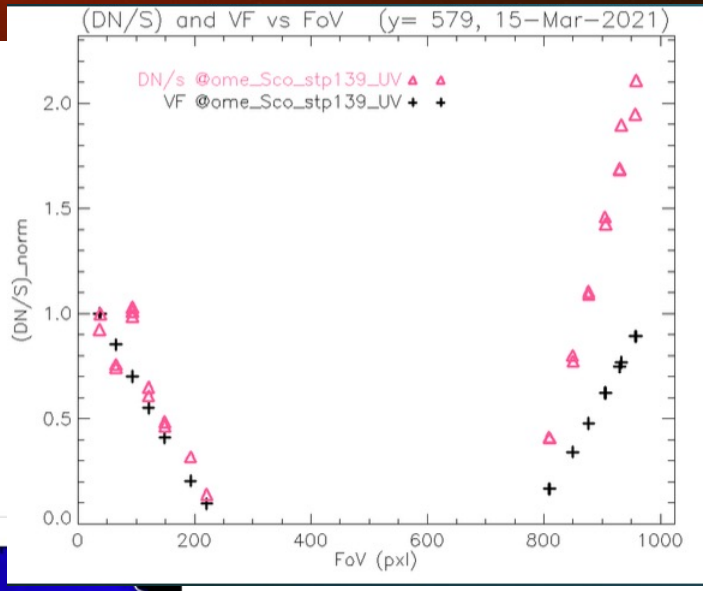
On-going activities:

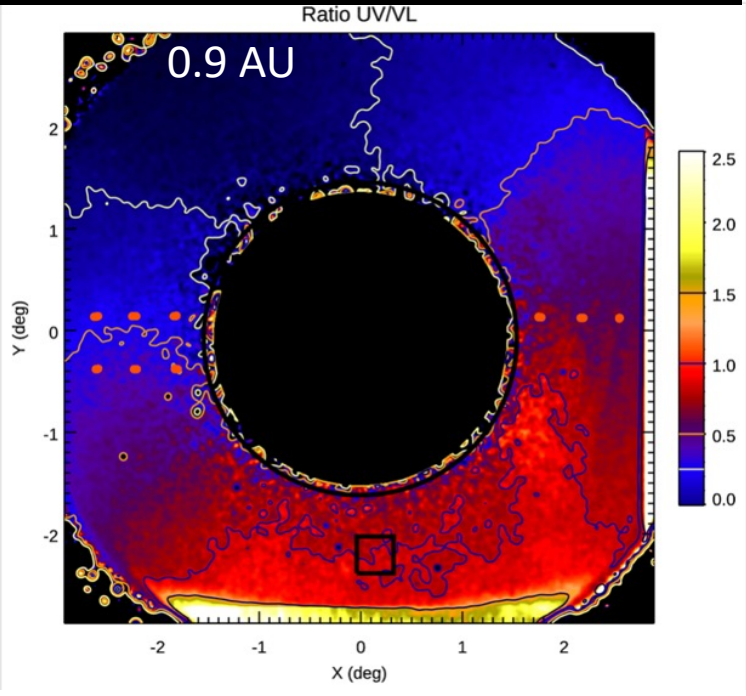
- Perihelion tests on IO alignment and stray light (Feb-Mar 2022)
- Radiometric calibration (UV in progress – On-ground calibration temporarily used)

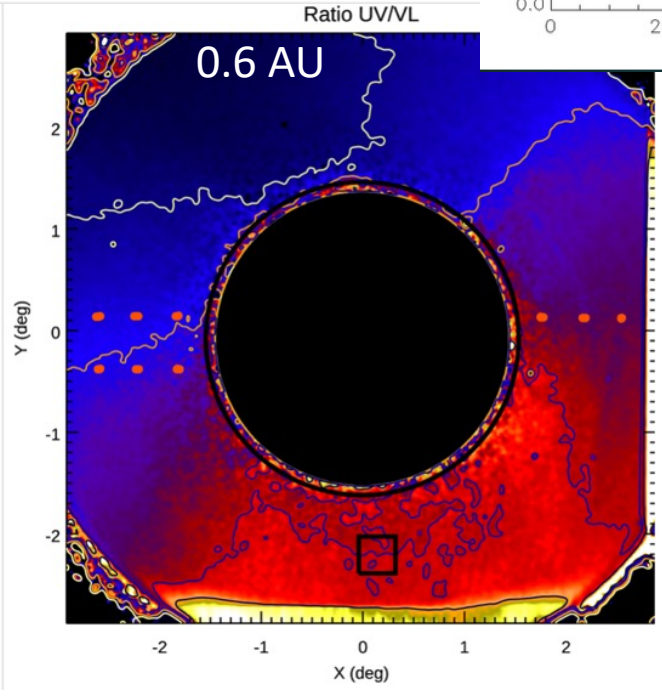
The full analysis is needed to complete the pipeline to L2 (within NMP)

UV radiometric calibration



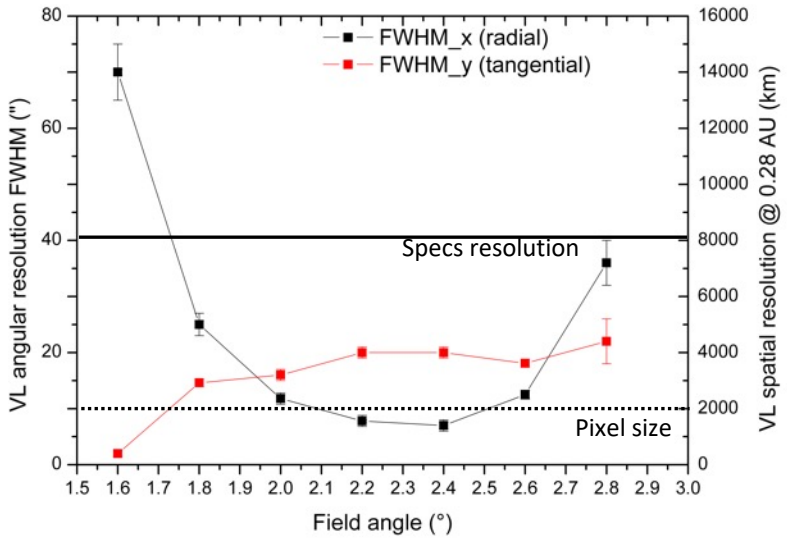




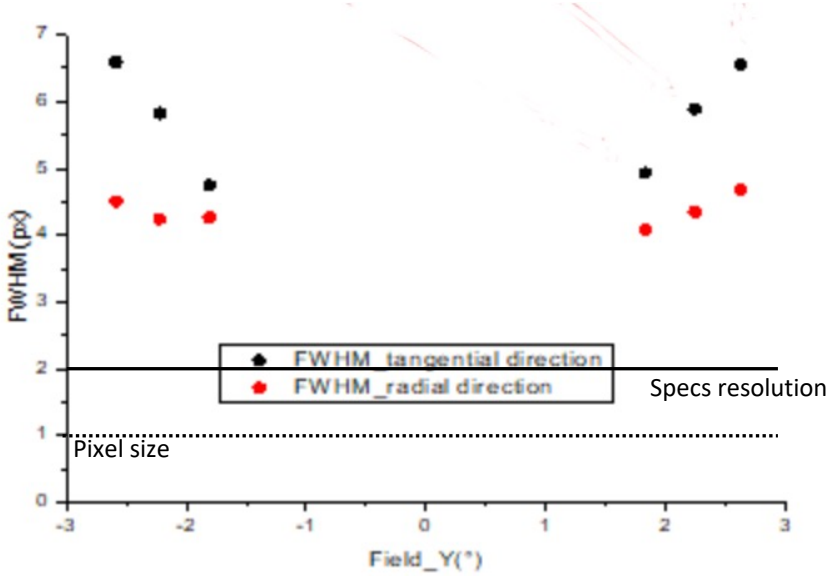


METIS spatial resolution

VL



UV



	Specs
Spatial Plate Scale (detector pixel)	10 arcsec (VL) 2000 km @0.28AU 20 arcsec (UV)
Spatial resolution	40 arcsec (VL and UV analog)

Spatial resolution checked in-flight
With Star observations

Nominal Mission Phase

Starts in December 2021 – Metis will be **continuously** operating with upgraded telemetry:

- **Synoptic programs**
- **Increased Sun center pointing opportunities**
- **CME watch**
- **Targets of opportunity:**
  - Stars observations for radiometric and inter-instrument calibrations;
  - coordinated observations with PSP, SOHO, STEREO A and future solar missions
  - coordinated observations with ground based observatories
- **Density fluctuations**

Nominal Mission Phase

Data will be available 3 months after download and processing as:

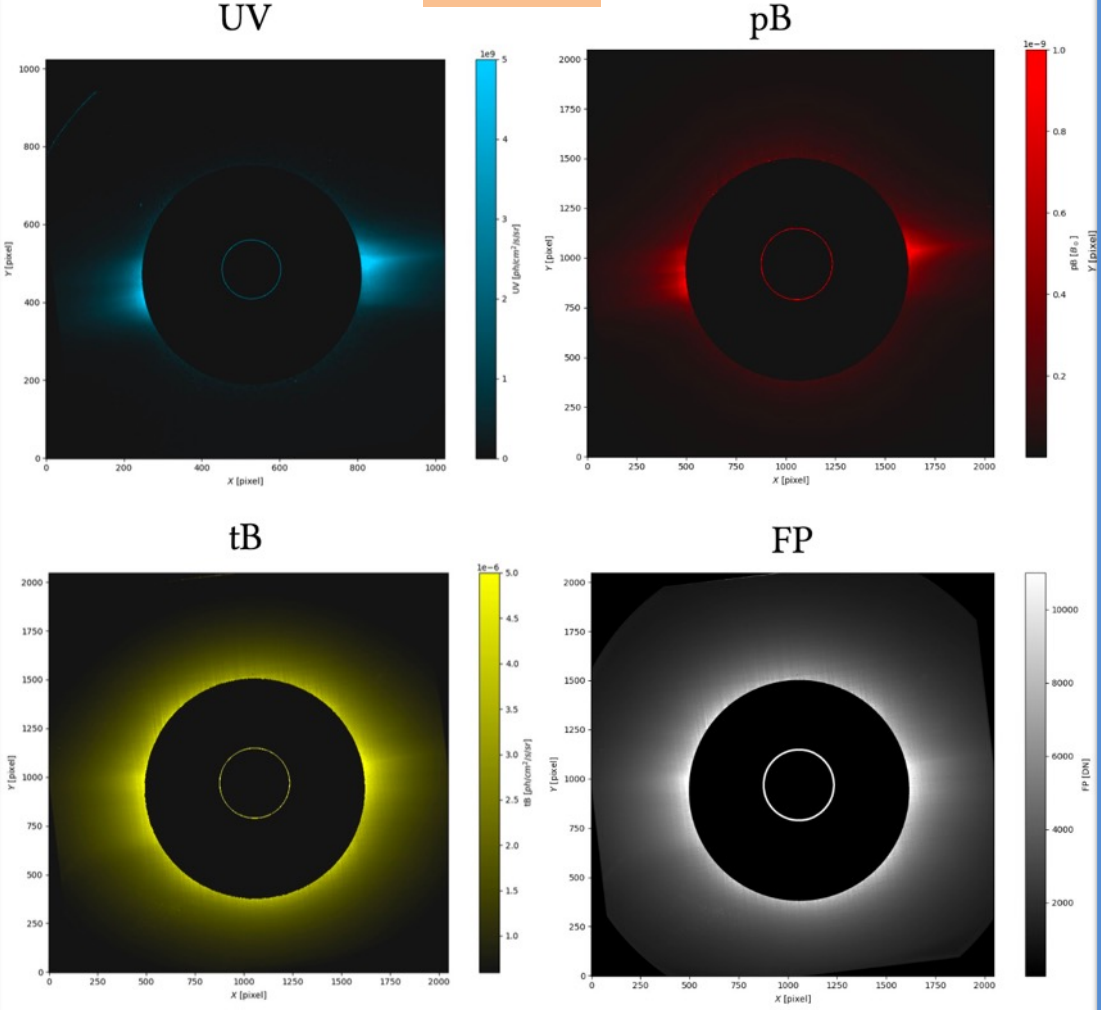
- **Level 2:** calibrated data (physical units).
  Corrections for bias, dark current, flat-field, and vignetting, exposure normalisation, pointing, and radiometric calibration are applied. Stokes paramaters, total/polarised-brightness images, polarisation angle/fraction.
- *All the available orbital and attitude information is used and coordinates expressed in scientific coordinate systems (WCS).*

- **Level 3:** science data derived from L2 data,
  Movies, Carrington maps; and data obtained after scientific analysis, i.e., electron-density maps, solar-wind outflow velocity maps.

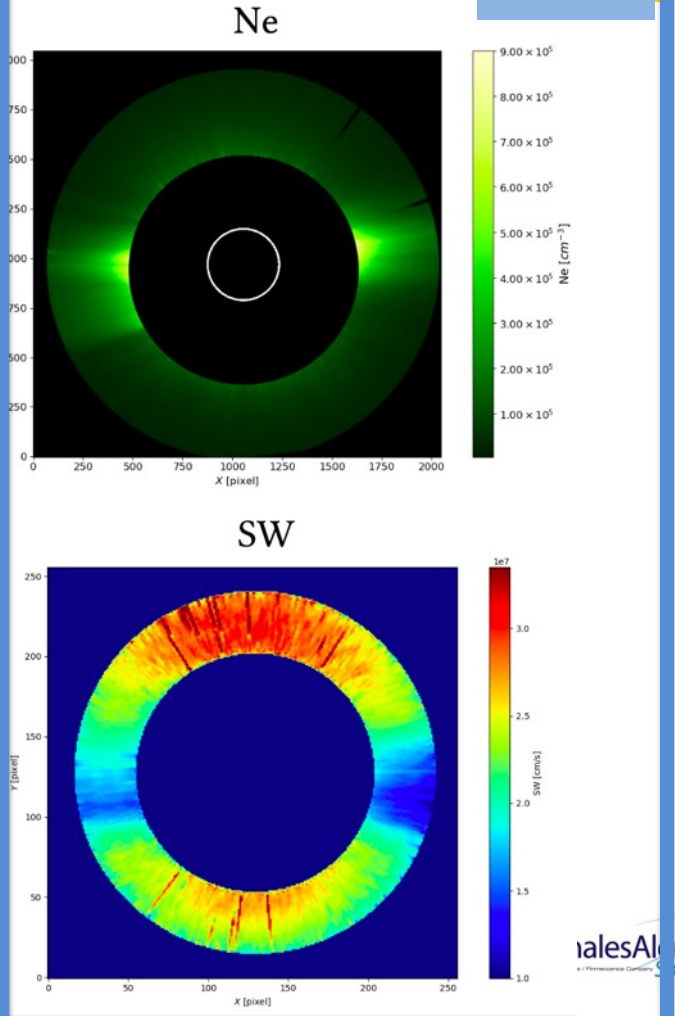
Level 2 data release will start with the Nominal Mission (> Dec 2021)

Metis data

Level 2



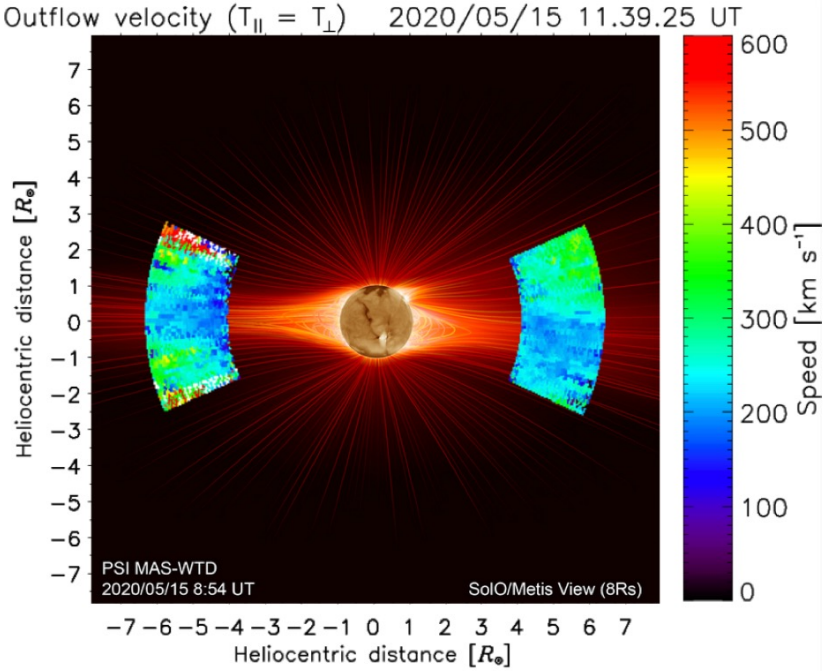
Level 3



Metis Science

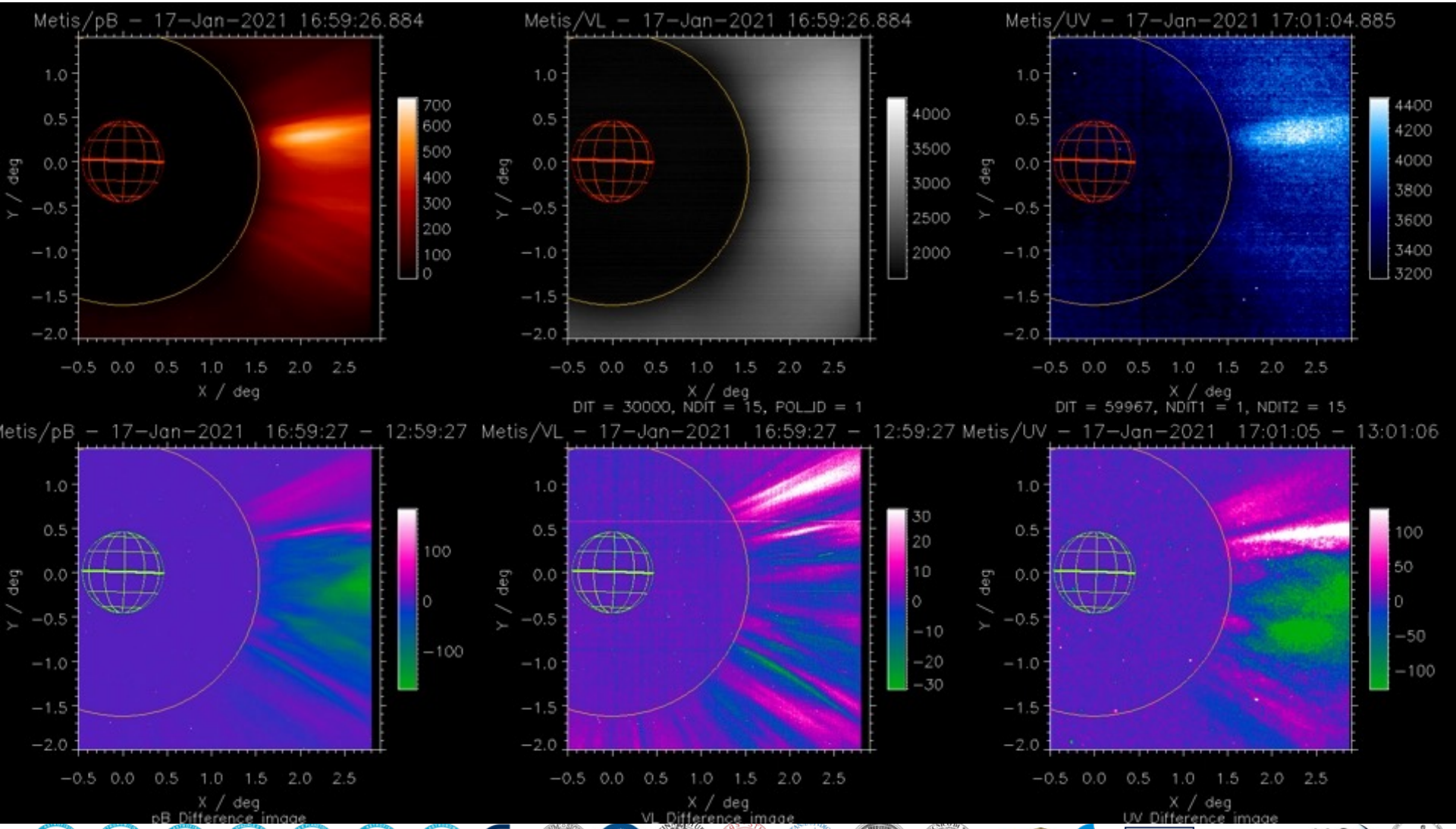
First paper on Metis data:

- Romoli et al., *First light observations of the solar wind in the outer corona with the Metis coronagraph,* A&A 2021
- Grimani et al., *Cosmic-ray flux predictions and observations for and with Metis on board Solar Orbiter*, A&A 2021
- Telloni et al., *Exploring the Solar Wind from its Source on the Corona into the Inner Heliosphere during the First Solar Orbiter – Parker Solar Probe Quadrature*, ApJL ,submitted
- Andretta et al., *The first Coronal Mass Ejection observed in both visible-light and FUV HiLy-α channels of the Metis Coronagraph on-board SolarOrbiter*, A&A, to be submitted



Many contribution from Metis in this ESPM-16 meeting

First CME detection in VL and UV



Science topics working groups

TT1 - Wind diagnostics (R. Susino)
a. **Electron density (and electron temperature)** (S. Fineschi)
b. **Hydrogen density** (J.C. Vial)
c. **Wind velocity with Doppler dimming** (R. Susino)

TT2 - F-corona (F. Landini)

TT3 - Combined synoptics (L. Teriaca)

TT4 - Helium Diagnostics (V. Andretta)

TT5 - Image enhancements (F. Frassetto)

TT6 - Solar Wind (D. Telloni)

TT7 - Large scale magnetic configuration and evolution, Streamers and pseudo-streamers (L. Strachan)

TT8 - CMEs, prominence eruptions and blobs (P. Heinzel)

TT12 - Modelling of CME propagation/evolution in corona and solar wind in connection with space weather (A. Bemporad)

TT9 - Coronal shocks, particle acceleration (G. Zimbardo)

TT10 - Plasma density fluctuations and waves (G. Nisticò)

TT11 - Flux emergence, magnetic field reconnection, coronal heating, flares (F. Reale)

TT13 - Cosmic Rays (C. Grimani)

TT14 - Sun grazing comets and other solar system bodies (V. Da Deppo)

Synergies with several space missions:
SOHO, STEREO, SDO, *PSP, Proba3, ASO-S, Aditya, UVSC, PUNCH, CODEX, Solar C,* and Ground based telescopes

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Thank you

METIS Design Overview