METIS
Science Performance

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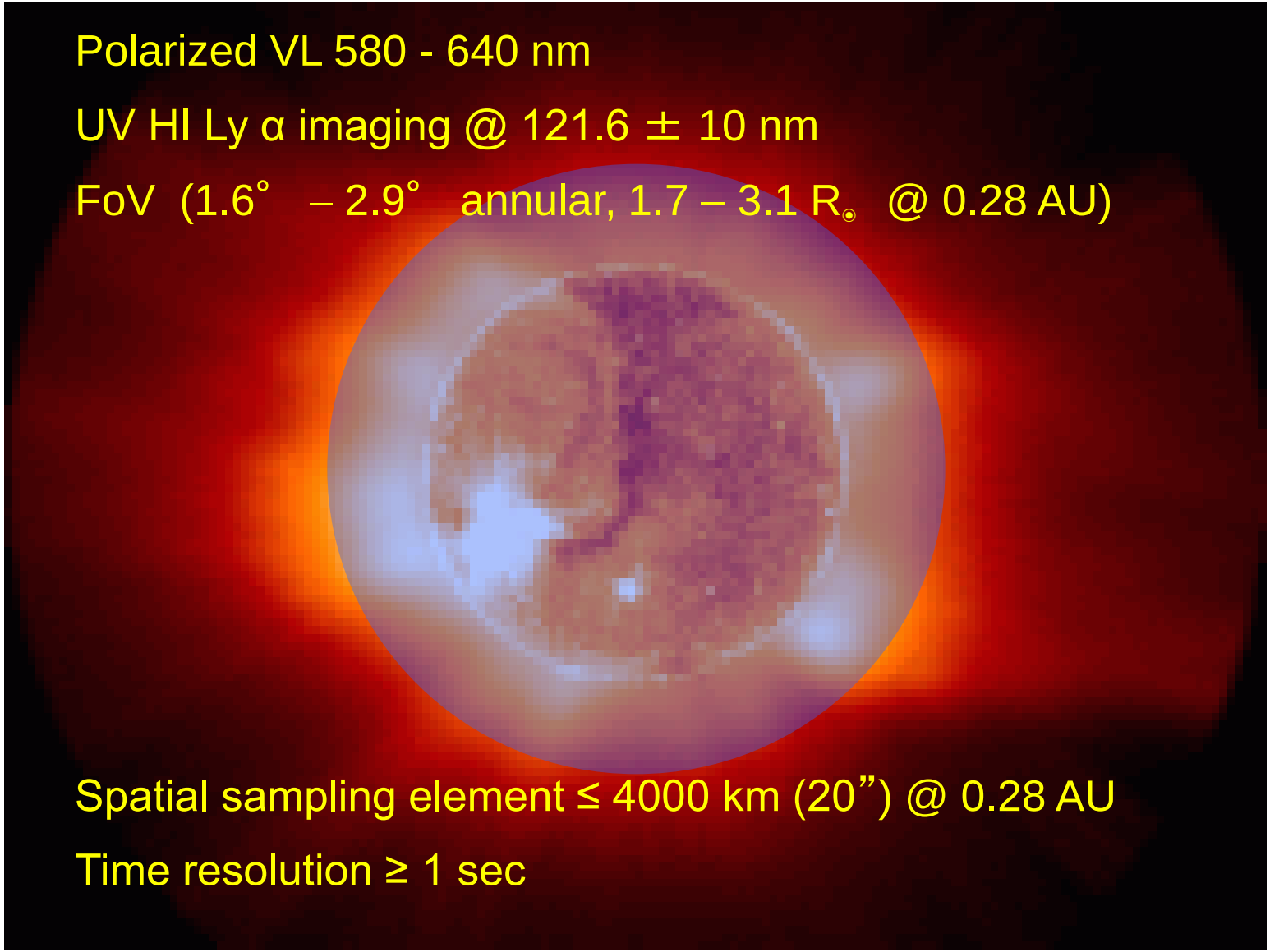
Metis coronal imaging



- METIS -

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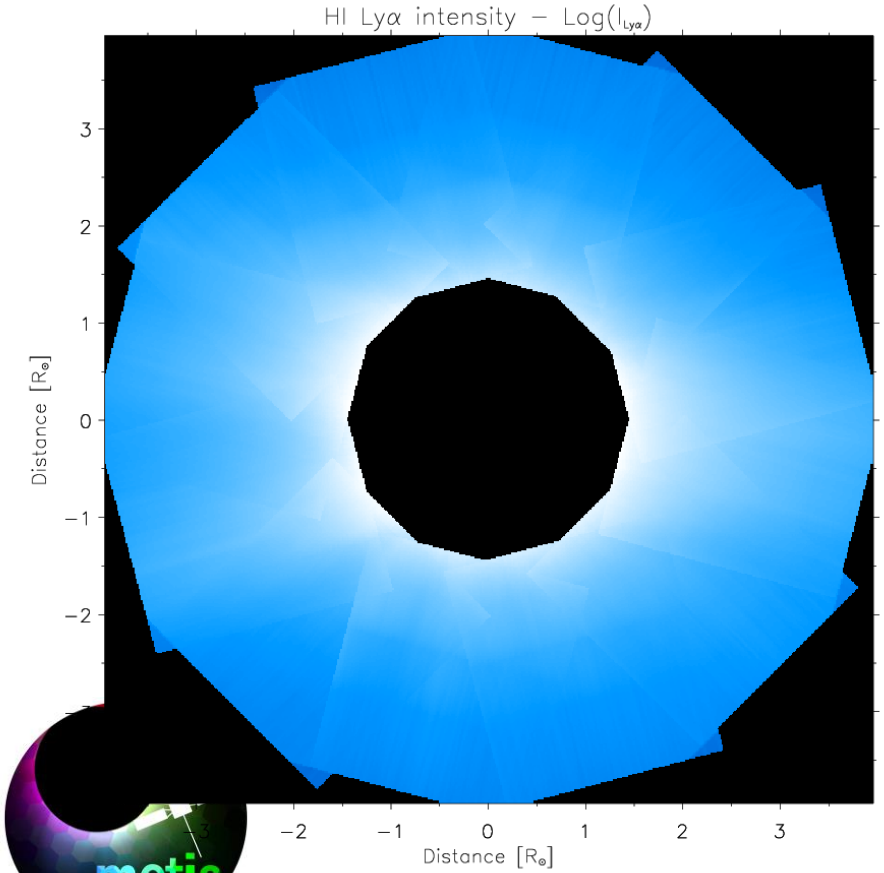
Off-limb and near-Sun coronagraphy

For the first time:

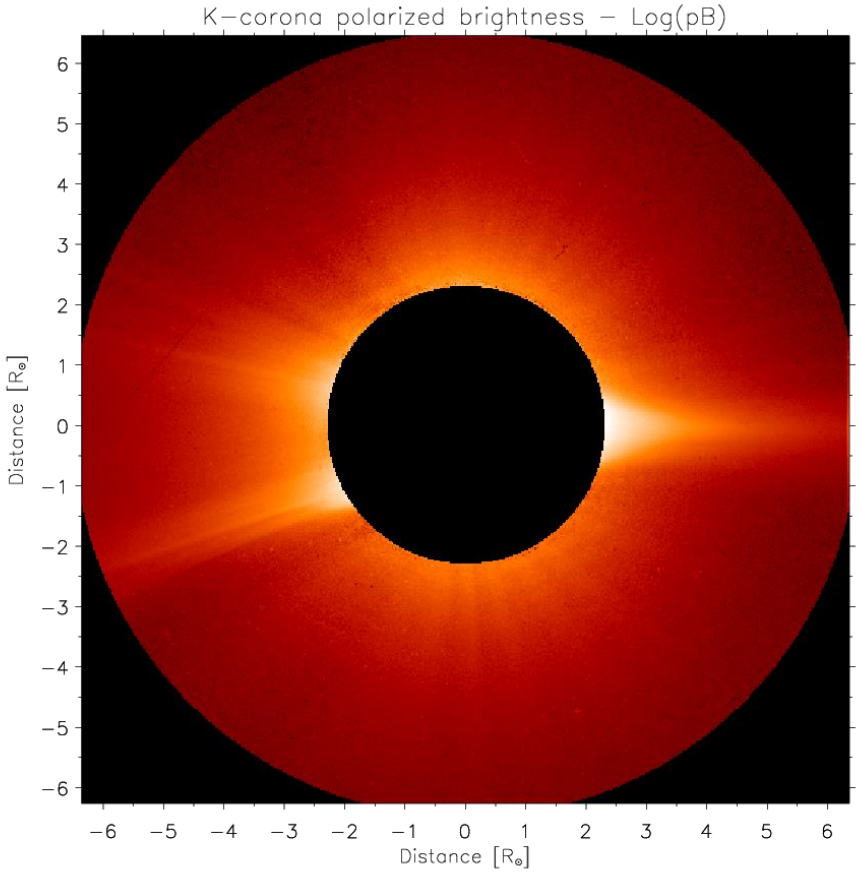
- **simultaneous imaging of the full corona in polarized visible light (580-640 nm) and narrow-band ultraviolet H I Ly α (121.6 nm) - Global maps of coronal emission -**

Complete characterization of the most important plasma components of the corona and the solar wind, i.e., electrons and protons: ==> density (polarized VL), outflow velocity (Doppler dimming of Ly α), …

UV and VL coronal images

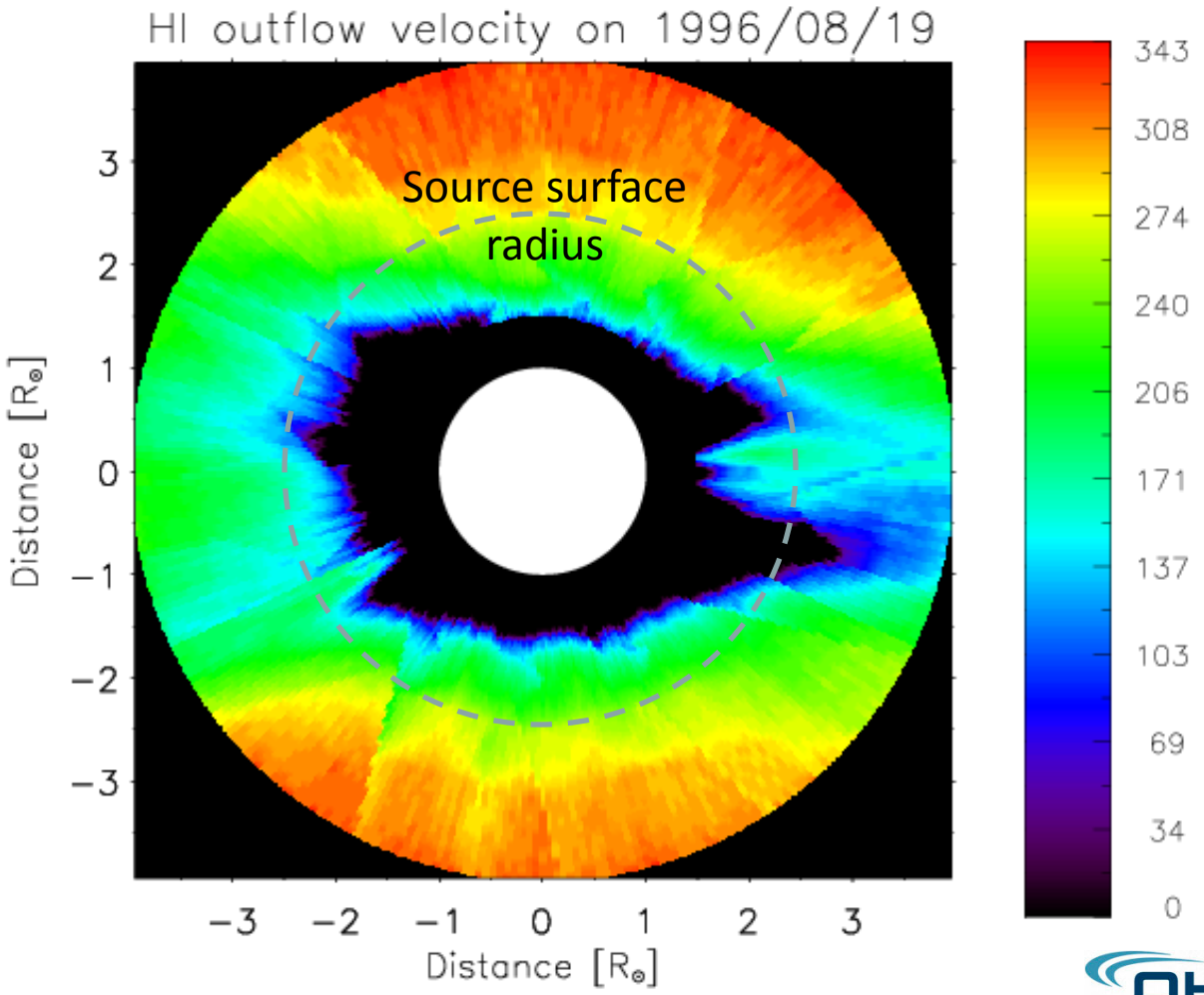


UVCS/SOHO Supersynoptic during Whole Sun Month 1996, 19th August – 1st September



LASCO-C2/SOHO pB image on 1996, 20th August at 20:05 UT

Full inversion output



-Scientific Objectives –

(see the doc METIS-OACT-RPT-001 – METIS Scientific Performances Report)

1. - Origins and acceleration of the solar wind streams

2. - Sources of the solar energetic particles (SEP)

3. - Origin and early propagation of coronal mass ejections (CME)

* Crucial questions in the field of coronal and solar wind physics *

4. - Study of Sun-grazing comets (in addition)

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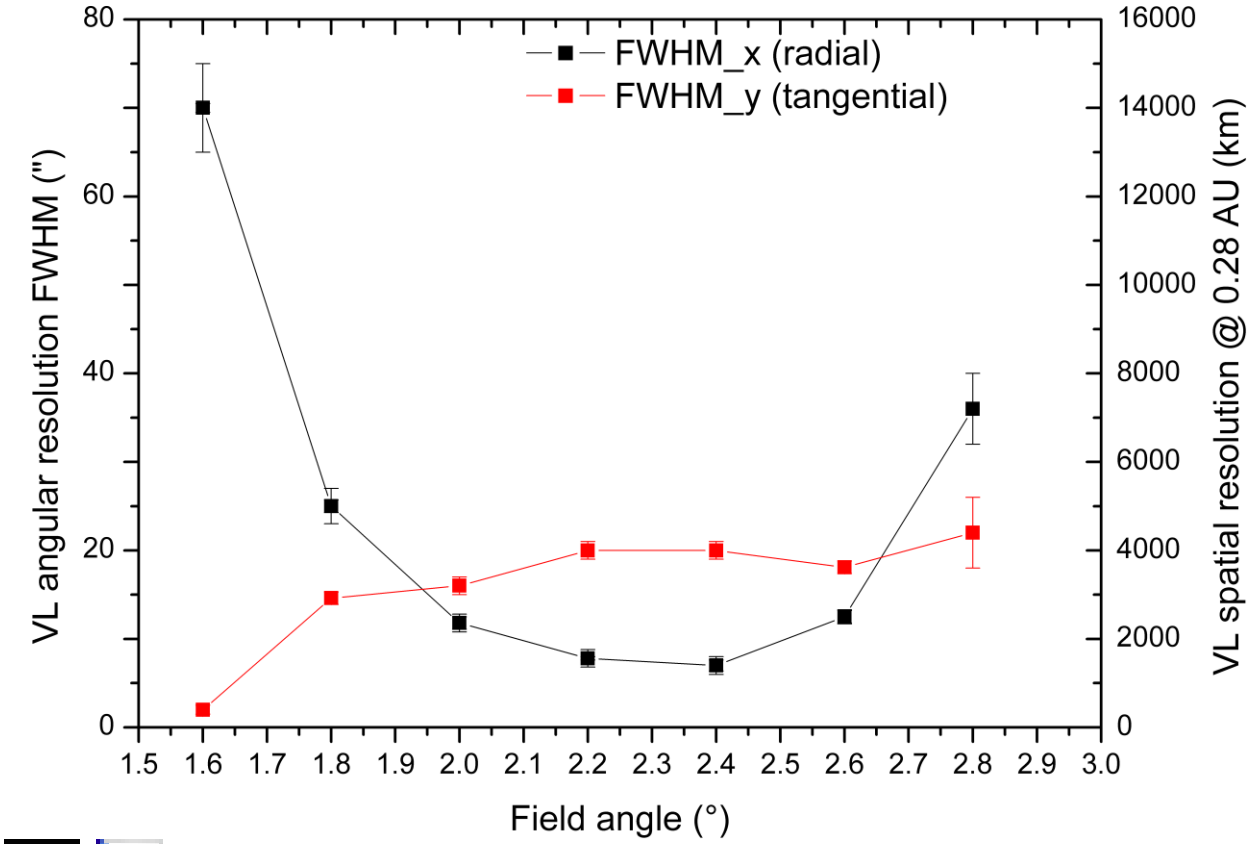
- **The scientific objectives define the observational requirements that will be satisfied by the performances of the instrument**

Metis Instrument Performance	
CORONAL IMAGING	
Avg. Instrumental Stray Light (B_{stray}/B_{disk})	VL<10^{-9} UV<10^{-7}
Wavelength range:	VL: 580-640 nm UV: 121.6±10 nm
Detector pixel	10 arcsec (VL), 20 arcsec (UV)
Sampling element	20 arcsec (VL), 40 arcsec (UV)
Field of view (FoV)	1.5°-2.9°annular, off-limb corona

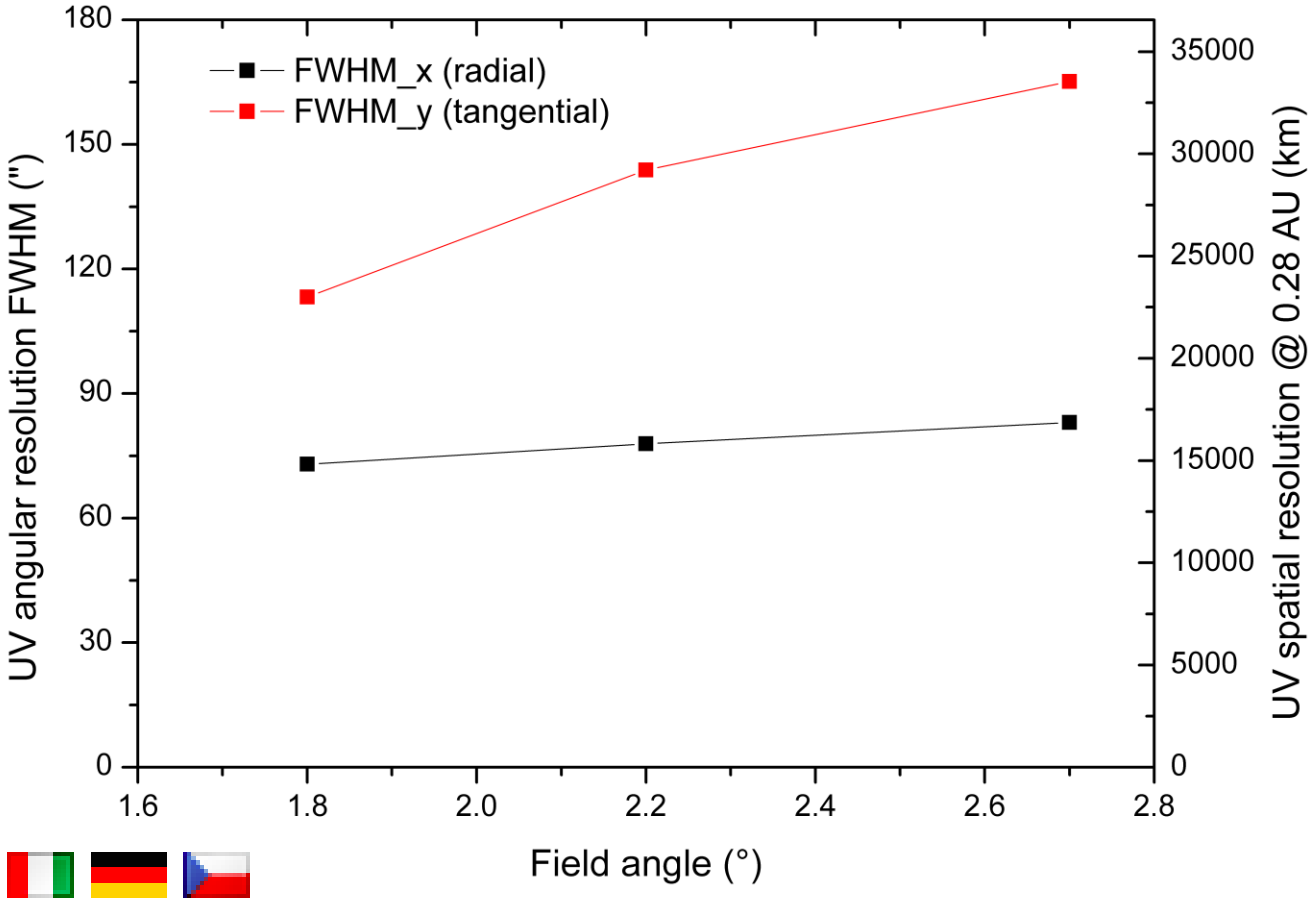
3.4° at the corners of the square detectors vignetted by the round field stop

VL Imaging Performances vs Field-of-View



VL Imaging Performances ⇓ well within requirements

UV-analog Imaging Performances vs Field-of-View



UV worse:

$FWHM_X \leq$: 90 [arcsec] (≅80)

$FWHM_Y \leq$: 180 [arcsec] (≅135)

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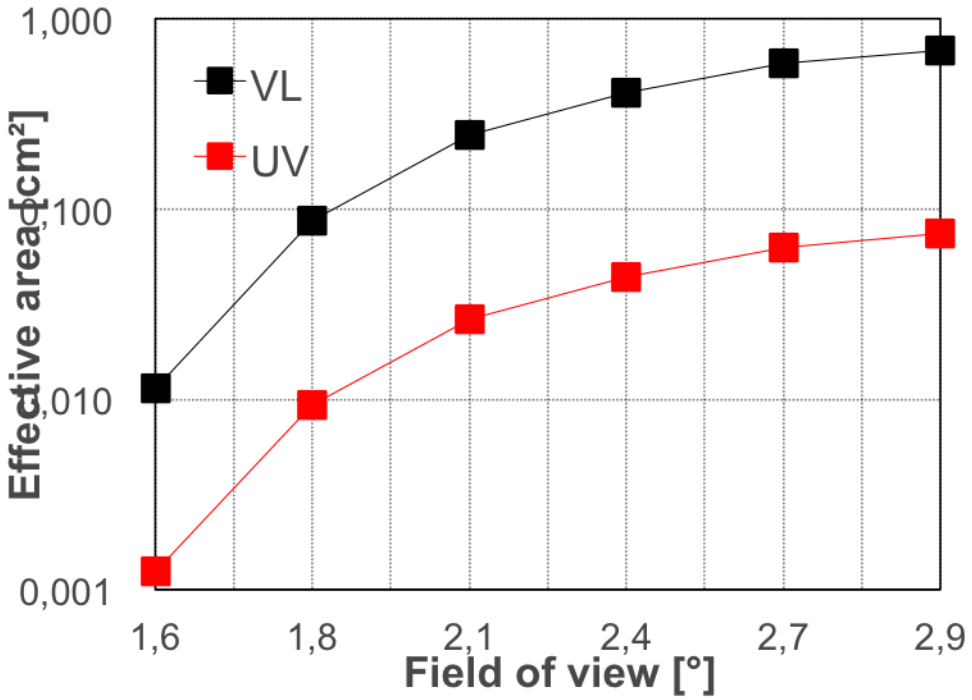
Field of view [°]	Effective areas [cm²]	
	VL	UV
1.6	1.14×10^{-2}	1.24×10^{-3}
1.8	8.62×10^{-2}	9.34×10^{-3}
2.1	2.43×10^{-1}	2.63×10^{-2}
2.4	4.06×10^{-1}	4.40×10^{-2}
2.7	5.80×10^{-1}	6.28×10^{-2}
2.9	6.84×10^{-1}	7.41×10^{-2}

The effective areas are obtained from the overall instrument throughput, inclusive of the vignetting, times the geometrical area of the entrance aperture (Ø 40 mm).

Instrument response



Expected countrates (*i.e., CR, counts-of-detected photons/s/pixel*) in the two wavelength bands of Metis from typical coronal radiances at minimum solar activity (I_C, *photons/s/cm^2/sr*) – see METIS-OACT-TNO-004

S/C @ 0.28 AU perihelion
VL path: 500-5000 counts/s/pixel for a typical streamer (100-2000) (coronal hole)
UV path: more than 2 orders of magnitude lower

S/C @ 0.5 AU
VL path: 25-800 counts/s/pixel for a typical streamer (15-450) (coronal hole)
UV path: about 3 orders of magnitude lower

S/C @ 0.65 AU
VL path: 15-500 counts/s/pixel for a typical streamer (5-300) (coronal hole)
UV path: more than 3 orders of magnitude lower

Signal-to-noise (S/N) ratio and required exposure times

Exposure times required [s]				
S/C @	VL		UV	
	min (S/N ≥ 10)	2/3 DFWC	CH (S/N ≥ 10)	STR (S/N ≥ 10)
0.28 AU	7	16	2401	120
0.50 AU	90	56	18002	900[1]
0.65 AU	210	80	-	9003

1 Binning 2x2
2 Binning 4x4, below 3.5 $R_{\odot}$
3 Binning 4x4

Note: In the case of maximum activity, the expected countrates are higher by a factor ranging from 3 to 6, depending on the height.

In the case of CMEs, the expected countrates are about 20%-30% higher than those corresponding to the streamer belt.

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- ✓ Polarimetric Calibration

Current voltage-quadruplet:

Voltage [V]	14.00	5.59	3.56	2.83
Retardance [°]	60.8	137.9	257.5	369.4

Optimized voltage-quadruplet (max polarimetric efficiency ΔRetardance= 90°):

Voltage [V]	8.96	4.60	3.45	2.89
Retardance [°]	90	180	270	360

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- **Flow-down from mission-level key science questions to METIS scientific objectives, and to measurement requirements, which correspond to specific observing modes of METIS**

Traceability matrix (see METIS-OACT-RPT-001)

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SOLAR ORBITER Key Science Question	Metis Science Question	Metis Objective	Metis Observation	Field of View (FoV)	Metis Measurement	Cadence	Required Exposure Time (S/N≥10)	VL Sampling element	Observing Mode	Data Volume
How and where do the solar wind plasma and magnetic field originate in corona	Origin and acceleration of solar wind streams	Identify coronal wind flows: slow and fast streams	**VL polarized (580-640 nm) UV (HI Ly α) imaging**	**Annular FoV** 1.5°-2.9° Off-limb corona Out to 5 $R_\odot$	Global maps of ***electron density outflow velocities*** of neutral hydrogen	VL 5-30 min UV 5-30 min	VL 7-210 s UV 10-30 min	20”-40” (4000 km – 8000 km)	WIND	14 Mb
		Locate energy deposition in wind streams	**VL polarized (580-640 nm) UV (HI Ly α) imaging**	**Annular FoV** 1.5°-2.9° Off-limb corona Out to 5 $R_\odot$	Global maps of ***outflow velocity gradients*** of neutral hydrogen	VL 5-30 min UV 5-30 min	VL 7-210 s UV 10-30 min	20”-40” (4000 km – 8000 km)	WIND	14 Mb
		Assess role of coronal fluctuations in heating and accelerating solar wind	**VL (580-640 nm) imaging only**	**Annular FoV** 1.5°-2.9° Off-limb corona Out to 3 $R_\odot$	***High spatial and temporal resolution time series*** of visible coronal brightness to derive fluctuation spectra *best near perihelion*	VL 1-20 s	VL 1-20 s (S/N 2-28)	20” (4000 km)	FLUCTS TBF	5 Mb
		Asses role of coronal magnetic topology vs. wind outflow velocity	**VL polarized (580-640 nm) UV (HI Ly α) imaging**	**Annular FoV** 1.5°-2.9° Off-limb corona Out to 5 $R_\odot$	Global maps of ***electron density outflow velocities*** of neutral hydrogen *best near perihelion*	VL 5-20 min UV 5-20 min	VL 7-90 s UV 10 min	20” (4000 km)	MAGTOP	23 Mb
		Identify sources of the slow solar wind	**VL polarized (580-640 nm) UV (HI Ly α) imaging**	**Annular FoV** 1.5°-2.9° Off-limb corona Out to 5 $R_\odot$	Global maps of ***electron density outflow velocities*** of neutral hydrogen streamer/hole interfaces, above streamer cusp *best near perihelion*	VL 5-30 min UV 5-30 min	VL 7-210 s UV 10-30 min	20”-40” (4000 km – 8000 km)	WIND	14 Mb

SOLAR ORBITER Key Science Question	Metis Science Question	Metis Objective	Metis Observation	Field of View (FoV)	Metis Measurement	Cadence	Required Exposure Time (S/N≥10)	VL Sampling element	Observing Mode	Data Volume
How do solar eruptions produce energetic particle radiation that fills the heliosphere	Coronal sources of solar energetic particles	Identify SEPs produced by CMEs and their associated shocks	**VL polarized (580-640 nm) UV (HI Ly α) imaging**	**Annular FoV** 1.5°-2.9° Off-limb corona Out to 7.5 $R_\odot$	Global maps of ***e⁻ density outflow & tracer velocities*** to identify the path of the shock in coronal ambient	VL 1-5 min UV 1-5 min	VL 7-90 s UV 1-5 min	20” (4000 km)	CMEOBS	23 Mb
How do solar transient drive heliospheric variability	Origin and early propagation of coronal mass ejections	Identify the mechanism driving the eruption of CMEs	**VL polarized (580-640 nm) UV (HI Ly α) imaging**	**Annular FoV** 1.5°-2.9° Off-limb corona Out to 7.5 $R_\odot$	Global maps of ***electron density outflow velocity*** of neutral H to monitor CME pre-eruption, eruption and reconfiguration states of ambient corona *best near perihelion, out of ecliptic*	VL 1-5 min UV 1-5 min	VL 7-90 s UV 1-5 min	20” (4000 km)	CMEOBS	23 Mb
		Understand the evolution of the global corona	**VL polarized (580-640 nm) UV (HI Ly α) imaging**	**Annular FoV** 1.5°-2.9° Off-limb corona Out to 7.5 $R_\odot$	Global maps of ***e⁻ density outflow & tracer velocities*** to follow evolution of CMEs with UV and visible-light imaging from the coronal base (1.6 Ro at 0.28 AU) out to 7 Ro *best near perihelion, out of ecliptic*	VL 5-30 min UV 5-30 min	VL 7-210 s UV 10-30 min	20”- 40” (4000 km – 8000 km)	GLOBAL	8-12 Mb
How does the solar dynamo work and drive connections between the Sun and heliosphere	Observe the evolution of the global magnetic field shaping the global corona (indirect inference)	Observe the overall magnetic structure of the corona	**VL polarized (580-640 nm) UV (HI Ly α) imaging**	**Annular FoV** 1.5°-2.9° Off-limb corona Out to 5 $R_\odot$	Global maps of ***electron density outflow velocities*** of neutral hydrogen	VL 5-20 min UV 5-20 min	VL 7-90 s UV 10 min	20” (4000 km)	MAGTOP	23 Mb