The Solar Orbiter Metis and EUI Intensified CMOS-APS detectors

- concept, main characteristics and performance -

U. Schühle , L. Teriaca, R. Aznar Cuadrado, K. Heerlein, S. Werner

Max Planck Institute for Solar System Research, 37077 Göttingen, Germany;

Michela Uslenghi

Istituto di Astrofisica Spaziale e Fisica Cosmica-INAF, 20133 Milano, Italy

CONCEPT

Two instruments aboard the Solar Orbiter mission[1], the Extreme Ultraviolet Imager[2] and the Metis coronagraph[3], are using cameras of similar design to obtain images in the Lyman alpha line of hydrogen at 121.6 nm. Each of these cameras is based on an APS sensor used as readout of a single microchannel plate intensifier unit.

Detailed design requirements and specifications

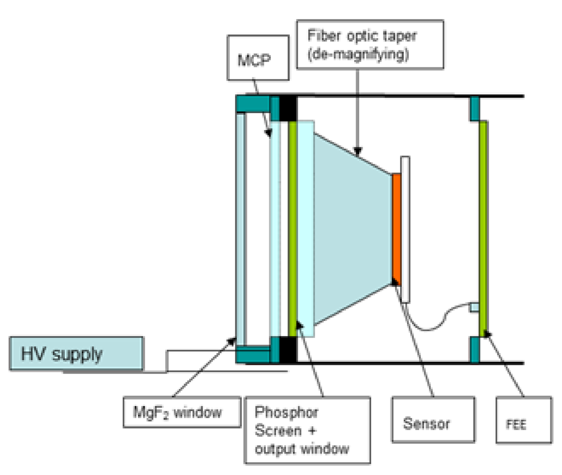

Fig. 1: Schematic representation of the intensifier with a CMOS APS sensor

Component	Material and characteristics	
Entrance window	VUV grade MgF_2 plate	4 mm thickness “c-cut” orientation of the crystal
Intensifier body	Microchannel plate	49 mm diameter 10 μm pores/ 12 μm pitch 40 mm diameter of active area Up to 1 kV
	Photocathode	KBr of > 0.35 μm thickness
Output coupler	Fiber optic plate	6 μm fibers 40 mm diameter of active area
	“P46” phosphor anode	Up to 6 kV
Fiber optic taper	de-magnifying taper	6 μm fibers EUI: 1/1.41 de-magnification Metis: 1:2 de-magnification
HV supply	Stabilized, regulated	1 kV (MCP) + 6 kV (anode)

Table 1: Detailed requirements of the MCP intensifier

All sensors and intensifiers have be characterized and calibrated before being integrated in the EUI and Metis instruments.

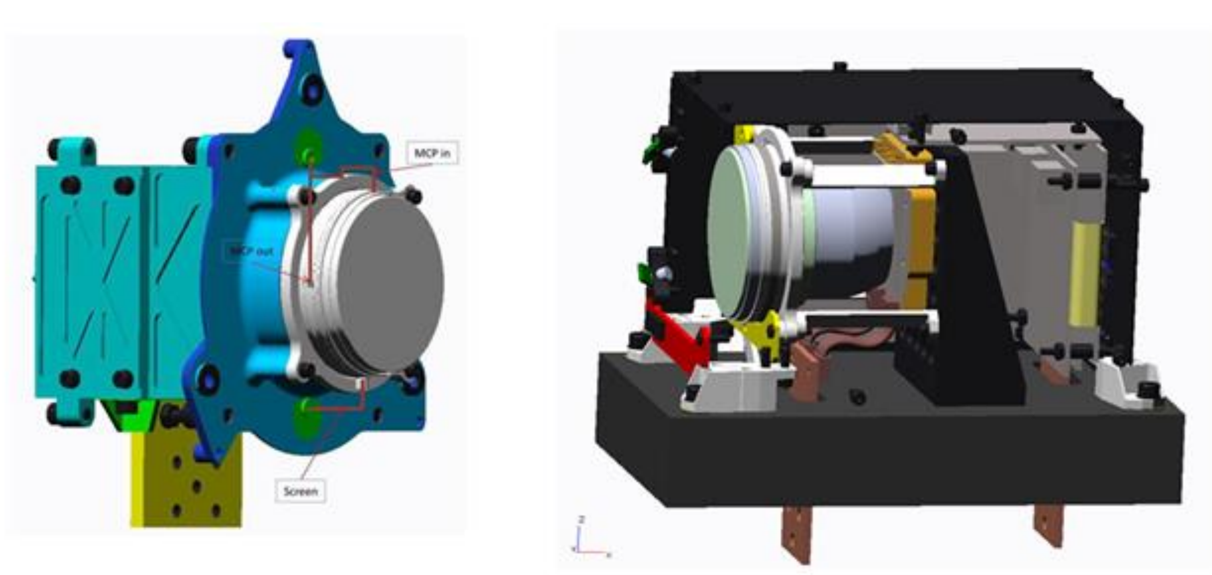

Fig. 2: CAD derived views of the Metis (left panel) and the EUI (right panel) Lyman-alpha cameras showing the mounting inside the cameras.

DESIGN

The two Lyman-Alpha cameras of EUI and Metis use different image sensors: The **EUI** camera is using an APS sensor with **3k × 3k format and a dual readout** electronic system providing a “high gain” and “low gain” channel, specially developed for the Solar Orbiter mission and fabricated by CMOSIS. The **Metis** camera is using a space-qualified **STAR1000 1k × 1k format** imaging chip.

The requirements for a high dynamic range, high resolution, and large active area are leading to a design of an intensifier with a single microchannel plate (MCP) with a potassium bromide (KBr) photo-cathode, providing sufficient amplification for the APS-based detection system. To protect the photocathode, the intensifier tube is closed by a magnesium fluoride entrance window. A high voltage supply unit (HVU) provides the adjustable voltages of up to +1 kV for the MCP and +6 kV with respect to the MCP output for the phosphor screen.

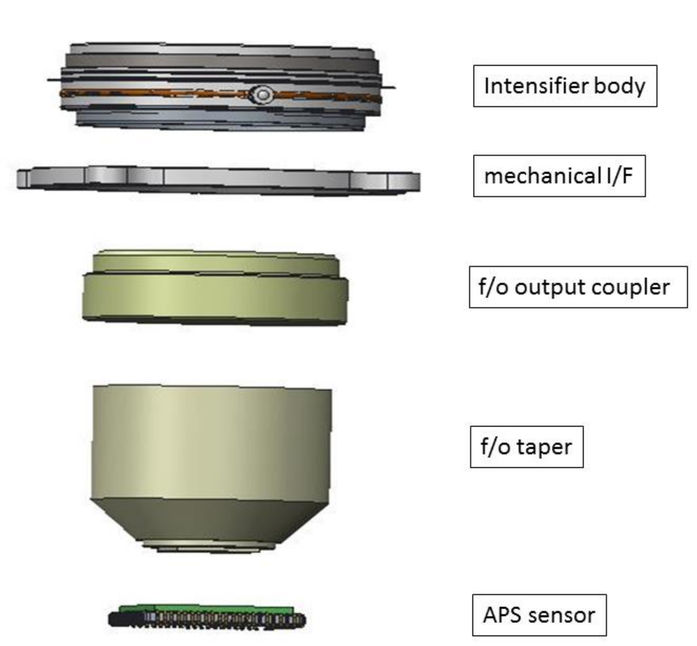

Fig. 3: Design of the intensifier with CMOS APS sensor readout, connected by a fiber optic taper

The mating of the intensifier with the sensor by optical fiber coupling requires a de-magnifying taper to match the size of the sensor. For EUI, a 2k × 2k subfield of the 3k × 3k pixel of this sensor with 10 μm pixel size is used and a fiber optic taper is required for re-scaling the image by a factor 1/1.41 to match the useful size of 20 mm x 20 mm of the sensor. In the case of the Metis camera, a de-magnification of 1/2 is necessary to map the active area over the 1k × 1k sensor with 15 μm pixel size.

PERFORMANCE

For characterization at 121.6 nm the specially designed vacuum chamber was equipped with a Lyman alpha source and a narrow-band interference filter to suppress all longer wavelengths. As a test of resolution, an USAF 1951 target was placed directly on the entrance window of the intensifier which was exactly 7.5 mm in front of the focal plane (i. e., the photocathode on the MCP).

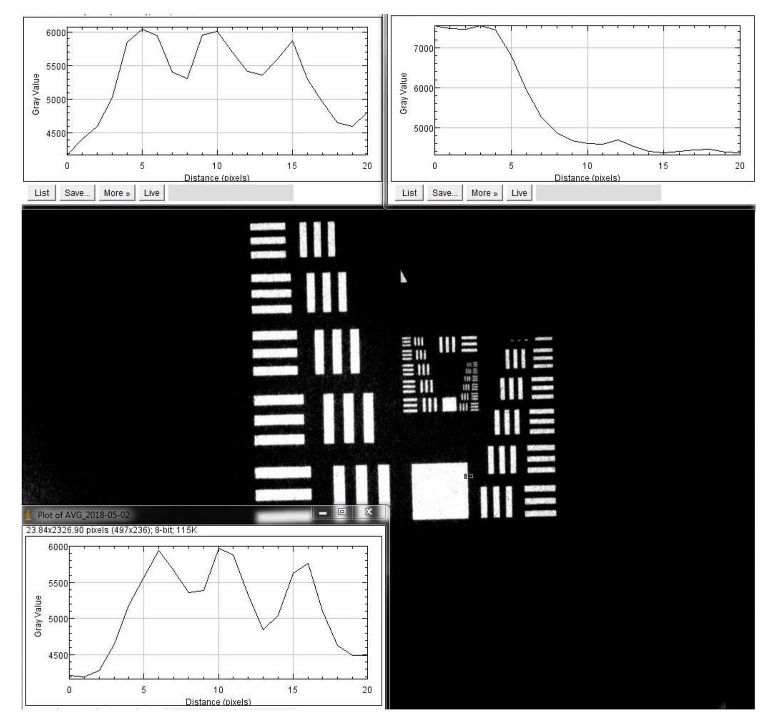

Fig. 4: Results of a resolution test using an USAF 1951 resolution target. The inserts on the left show cuts through the smallest horizontal and vertical features of the target while the insert on the top right shows a cut through the edge of the largest square.

For the spectral radiometric calibration the cameras were carried with the vacuum chamber to the Metrology Light Source (MLS) of the electron storage ring of the Physikalisch-Technische Bundesanstalt (PTB) in Berlin. Fig. 5 shows the spectral response of the two cameras.

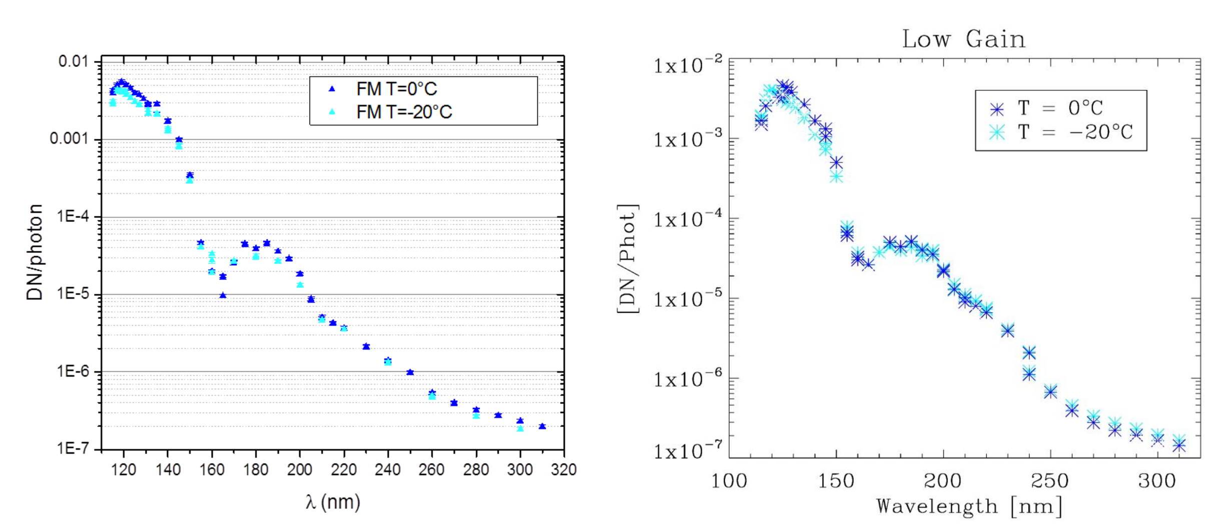

Fig. 5: Spectral response of the Metis UVDA camera (left panel) and the EUI intensifier (right panel) between 110 nm and 310 nm.

REFERENCES

1. ESA Science & Technology Missions: Solar Orbiter, http://sci.esa.int/solar-orbiter
2. Schühle, U., Halain, J.-P., Meining, S., Teriaca, L., “The Lyman-alpha telescope of the extreme ultraviolet imager on Solar Orbiter,” Proc. SPIE, 8148, 81480K (2011).
3. Uslenghi, M., Schühle, U., Teriaca, L., Heerlein, K., Werner, S., "Characterization of the UV detector of Solar Orbiter/Metis,” Proc. SPIE, 10397, 103971K (2017).

Acknowledgements: The development of the EUI intensifier system and the Metis UVDA electronic camera system has been financed by the German Space Agency (Deutsches Zentrum für Luft- und Raumfahrt - DLR). A contribution to the Metis Detection System from the Italian Space Agency (Agenzia Spaziale Italiana - ASI) is gratefully acknowledged.