# Characterization and calibration of VIS camera for space applications - JANUS and HYPSOS systems


Livio Agostini - 35th Cycle

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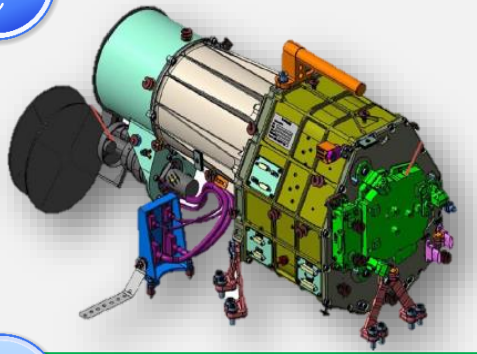
Co-supervisors: Dr. Alice Lucchetti, Prof. Giampiero Naletto


Admission to 3° year - 09/09/2021

# JANUS

## GENERAL INFORMATIONS

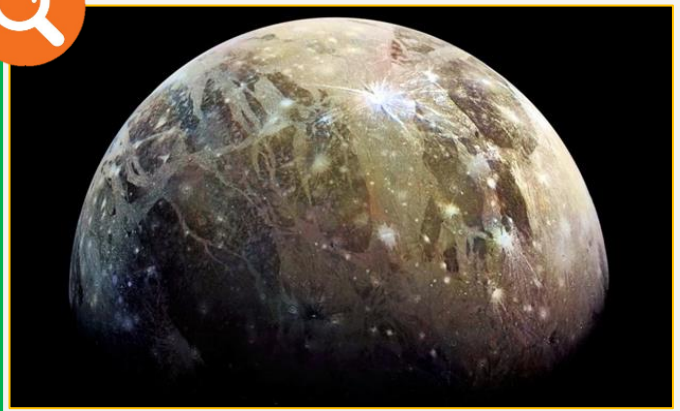


**PI :** ***Prof. P. Palumbo***
**Deputy-PI:** ***Dr. G. Cremonese***
**Prime Contractor:** ***Leonardo SpA***
***Partners:*** ***DLR, Open University, IAA Granada***

## MAIN FACTS

- On board of ESA JUICE mission
- Launch date: August/September 2022
- 9 years of cruise, 4 years of mission
- High resolution camera with modified Ritchie-Chretien design. 5/10 m/pix @ 500km
- Optical Head + PEU + MEU
- Multispectral capabilities

## SCIENTIFIC OBJECTIVES



- study of magmatic, tectonic and impact features of surfaces (icy moons)
- cryovolcanism
- constrain surfaces composition
- Ganymede rotation and libration
- jovian system object observation
- investigation of Io's tidal heating
- Jupiter troposphere: clouds, vortices and lighting
- stratospheric variations
- aurora activity
- plumes, torus and exosphere

# JANUS Calibration activity

IMAGE

TEXT

# JUICE/JANUS Targets of opportunity

IMAGE

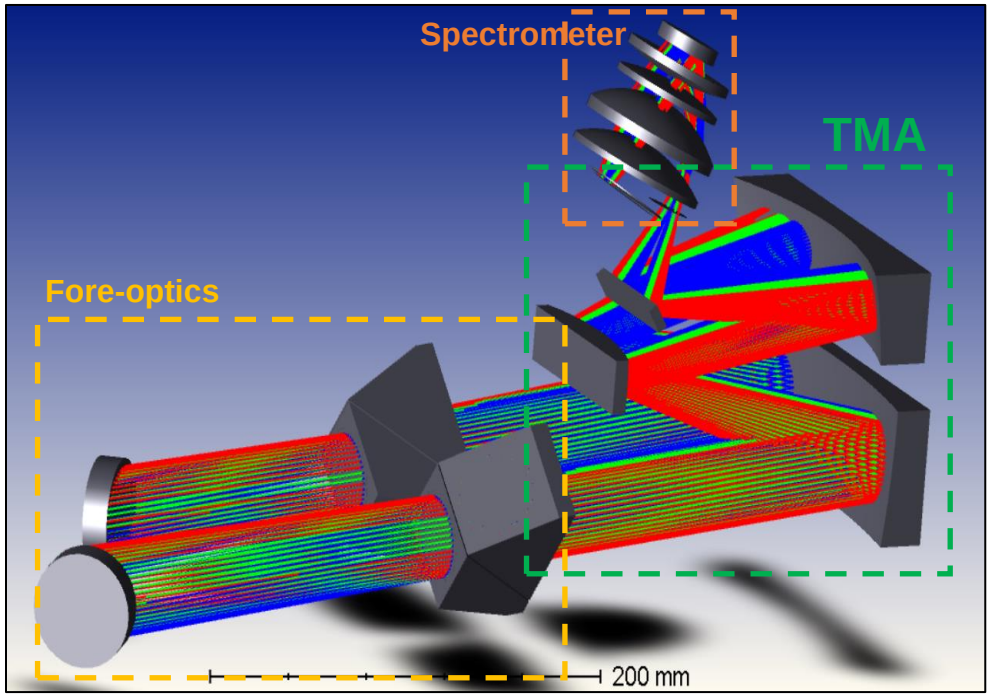
The very long cruise of JUICE drove the question: “Is it possible to observe minor bodies with the remote sensing instrument on board the JUICE spacecraft?”

In order to answer the question we have developed a tool able to perform a preliminary research of possible targets of opportunity for JUICE (and JANUS in particular).
The tool perform a download of the trajectory SPICE kernel from the NASA’s HORIZONS System for each body selected and evaluate the relative position between JUICE and the target.

Currently more then 140000 asteroids has been analysed and 3700 comets.

TEXT

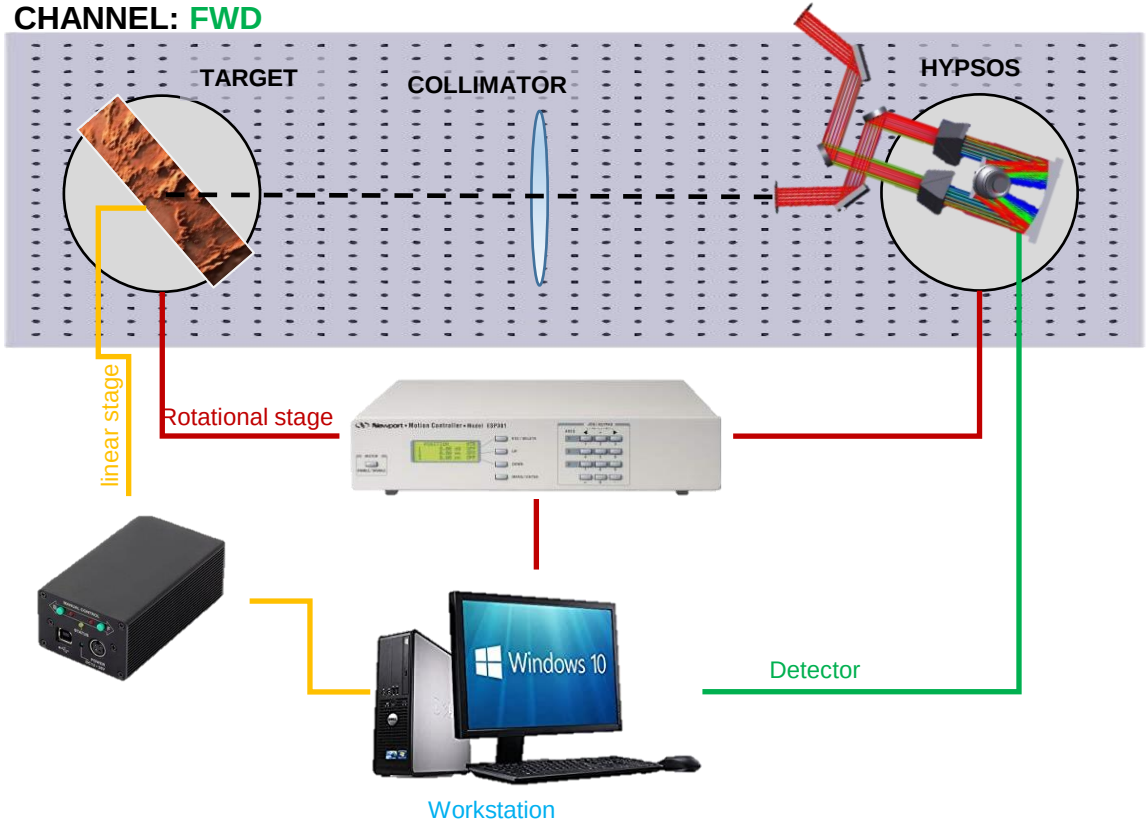
# HYPSOS – The instrument




**HYPSOS** (HYPerspectral Stereo Observing System) is an innovative optical instrument for the study of planetary surfaces. Its design allows to potentially use it also for civilian applications.
As the name said, HYPSOS can provide at the same time 3D spatial (stereo capability) and spectral (hyperspectral capability) within more than 100 spectral bands.
It will generate an Hyperspectral DTM (4D data)

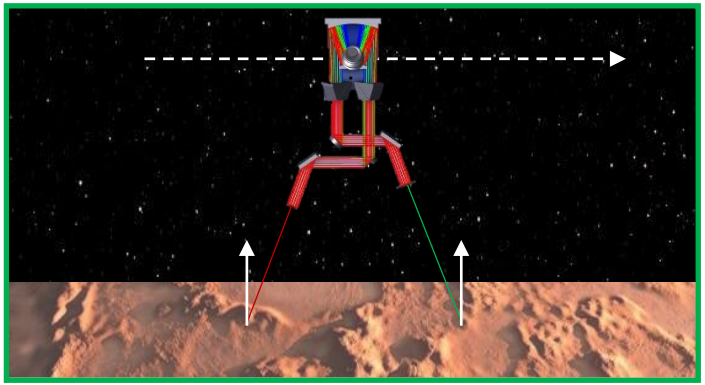
The instrument is a combination of a **TMA** (Three Mirrors Anastigmat) telescope with a modified **Dyson spectrometer** in a **pushbroom configuration**

# Optical bench implementation



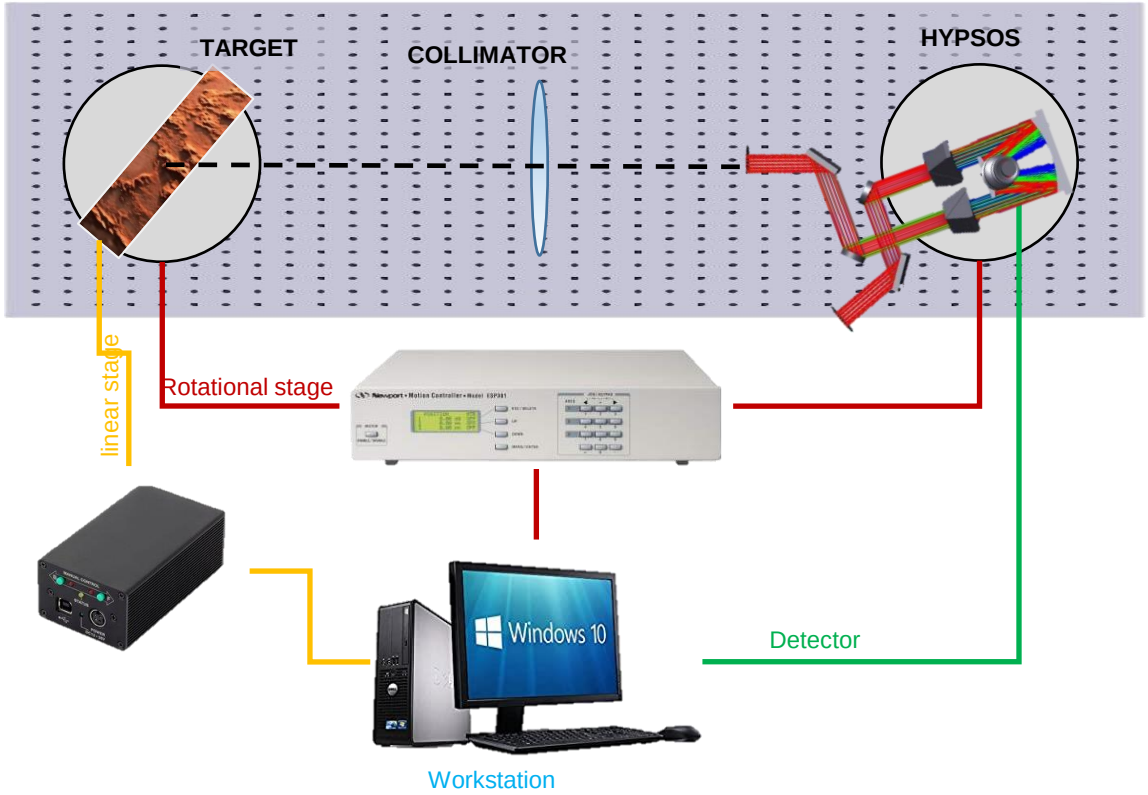

The implementation on optical bench should assure a good representation of a possible planetary observation configuration.
This is performed thanks to a modified configuration of the setup used for SIMBIO-SYS/STC.
The main elements of the setup are:

- Rotational stage for instrument (Channel selection)
- Rotational stage for target (Stereo angle selection)
- Collimator (finite-to-infinite transformation of target position)
- Linear stage (satellite motion and pushbroom simulation)
- Halogen lamp (continuous spectrum simulation, like sun)
- Rock samples



# Optical bench implementation

**CHANNEL: BKG**

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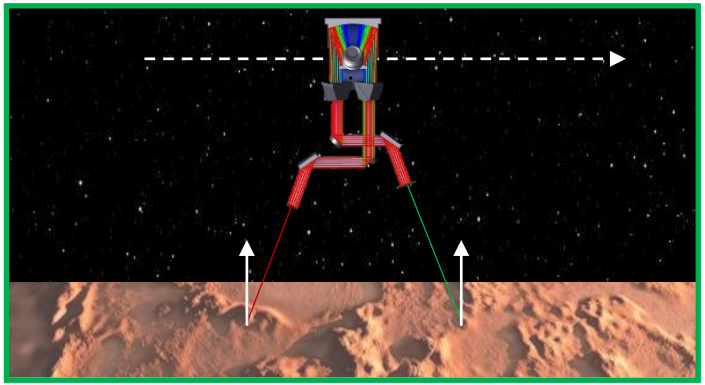
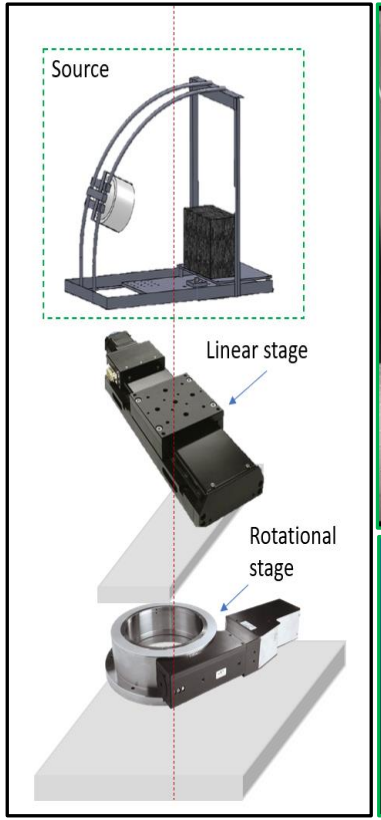
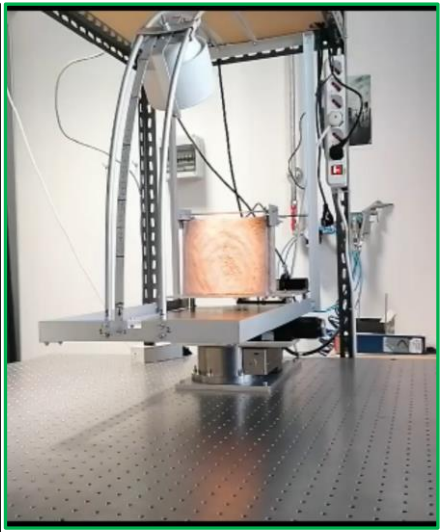
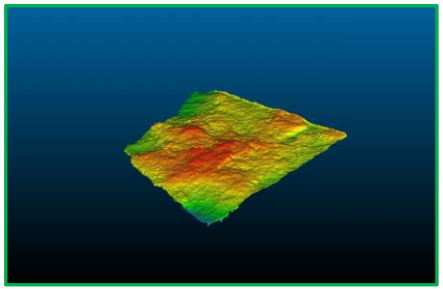


# Optical bench implementation (target)





The target side of the setup has been prepared. The setup already used for SIMBIO-SYS/STC has been modified adding a linear stage to perform the simulation of the pushbroom configuration.

The selection criteria include an appropriate range (about 100mm, to generate the image), appropriate speed (to simulate the relative scaled speed between target and satellite, up to 10mm/s) and appropriate axial load capability (to sustain the weight of structure and rocks).

Thank to Heritage Department of UniPD some targets have been characterize with a range camera using structured light (3D map).

**Acquisition system**

Both rotational and linear stage are compatible with Python, which has been chosen as program language for the acquisition setup of HYPSOS. These elements are almost integrated in the code project.

# Optical bench implementation (TMA)

## ASSEMBLY

M1 during the assembly in its support

## INTEGRATION

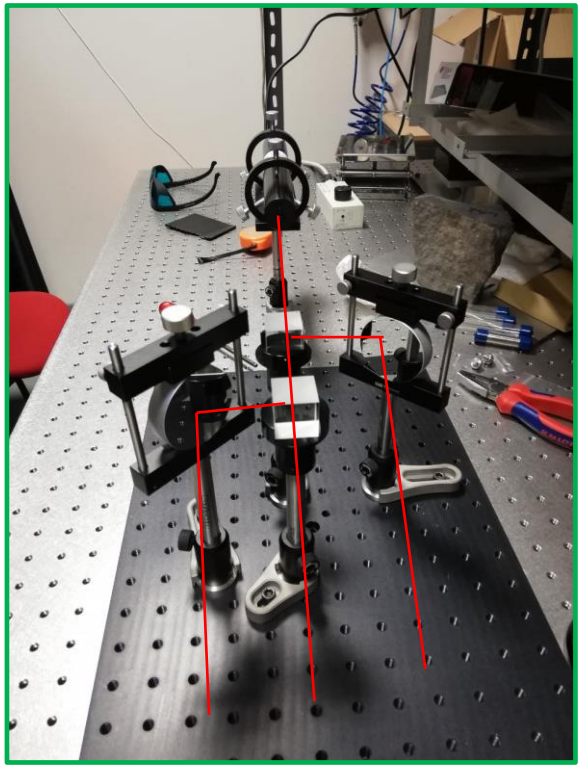
Left: M2, right: Mirrors mounted on the mechanical structure. M1 is observable.

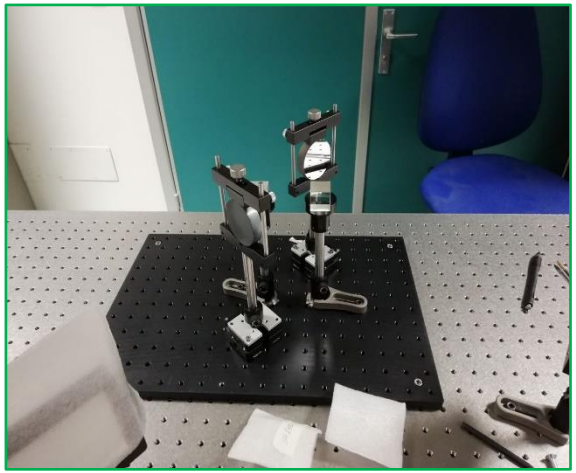
## ALIGNMENT


We have started an intense activity on the telescope.

1. ASSEMBLY: each mirror has been located in its support, springs correctly located and front mask locked in position
2. INTEGRATION: Each support has been located in the mechanical structure specifically designed
3. Currently we are performing the alignment of the TMA and optimization of the mechanical structure position. For the alignment a specific setup has been developed.

# Optical bench implementation (TMA)

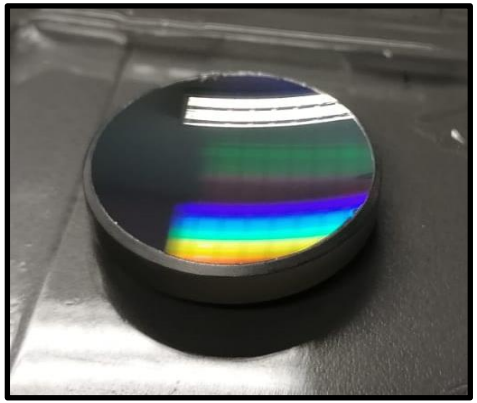




The alignment tool has been developed and assembled. Its purpose is to ease the alignment of the TMA.
The main idea is to generate three parallel rays which the telescope will focalise in a unique point (the telescope focus) if the alignment is correct.
The three ray system allows to evaluate the two channel in the same time.

We have assembled and aligned the components. Each channel (including the central channel) has been aligned using an external mirror in autocollimation. The correct orientation has been retrieved using both the main ray and the back-reflections from the beam splitters. The deviation from the parallelism has been checked measuring the spots deviations in a plane located a different distances. The position of the central spot has been also checked before and after the insertion of the beam splitters in the light path.

# Optical bench implementation (Diffraction Grating)

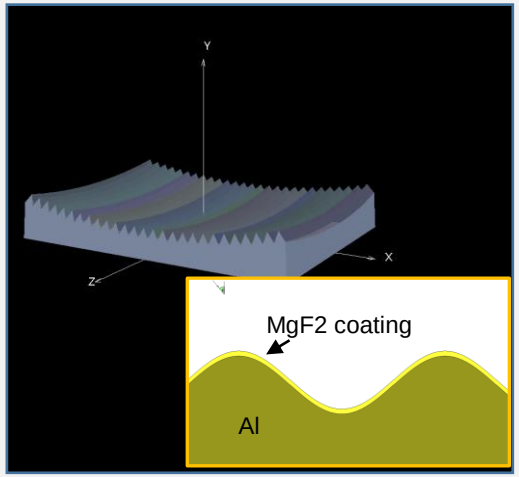


| General information | |
|---|---|
| ***Type*** | Concave Rowland circle |
| ***Producer*** | Richardson Gratings |
| ***Technology*** | Holographic |
| ***Grooves/mm*** | 678 |
| ***Shape*** | Spherical |
| ***Curvature radius*** | 83.7 |
| ***Ruled area*** | 32 mm (diameter) |
| ***Substrate*** | BK7 |
| ***Coating*** | Al + MgF2 |

On the component there is a characterization activity ongoing, both theoretical (simulations) and experimental.

## Simulation

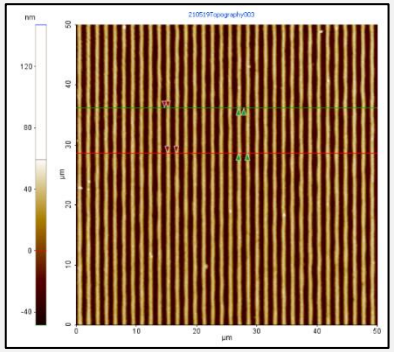
PCGrate Demo 6.7.1

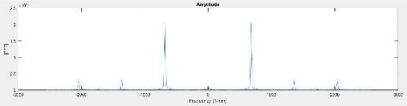



Diffraction efficiency @ different angles

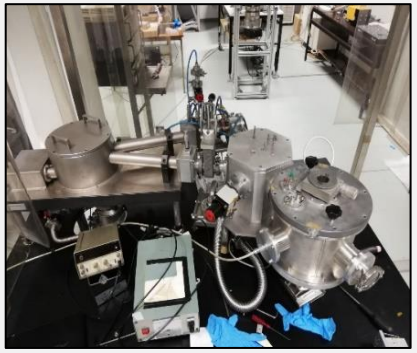
## Experimental

Atomic Force Microscope (AFM)

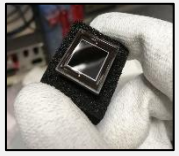


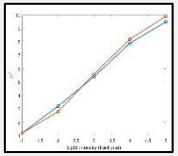


Diffraction efficiency measurement



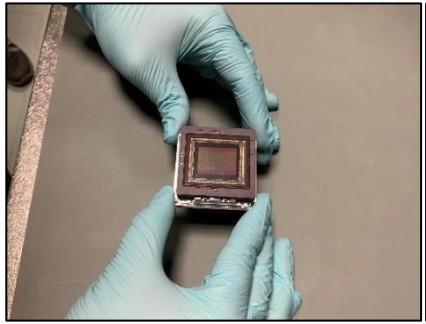
The Johnson-Onaka monochromator will be used to evaluate the diffraction efficiency.





# Optical bench implementation (Detector)

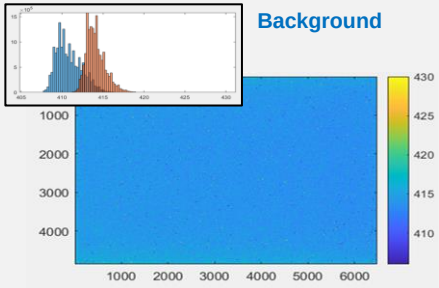
## GENERAL INFORMATION

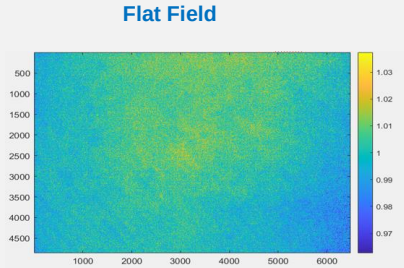


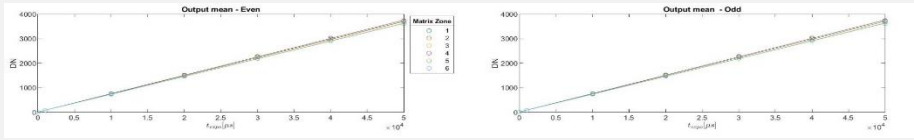
| | |
|---|---|
| ***Produces*** | **MatrixVision** |
| ***Technology*** | CMOS |
| ***Pixel size*** | 3.45µm |
| ***Image size*** | 6480 x 4856 (22.36 mm x 16.75 mm) |
| ***Frame rate*** | 12 (streaming)/14.4 (burst) [full frame] |
| ***ADC*** | 12 bit |
| ***Output*** | Mono8, Mono12, Mono12p |
| ***Comm. Protocol*** | USB3 |
| ***Feature*** | Triggering (several types: internal, software, hardware), Binning 2/2,4/4,8/8,16/16 (software), ROI, Partially remotable, Binning compatible with ROI |

## PRELIMINARY CHARACTERIZATION

**SETUP**



# Thanks for the attention

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