The Euclid mission NISP instrument: performances and data simulations

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on behalf of EC/NISP team

August 25th 2022

Outline

1. Euclid Overview
2. NISP Instrument
3. Performances
4. Simulations

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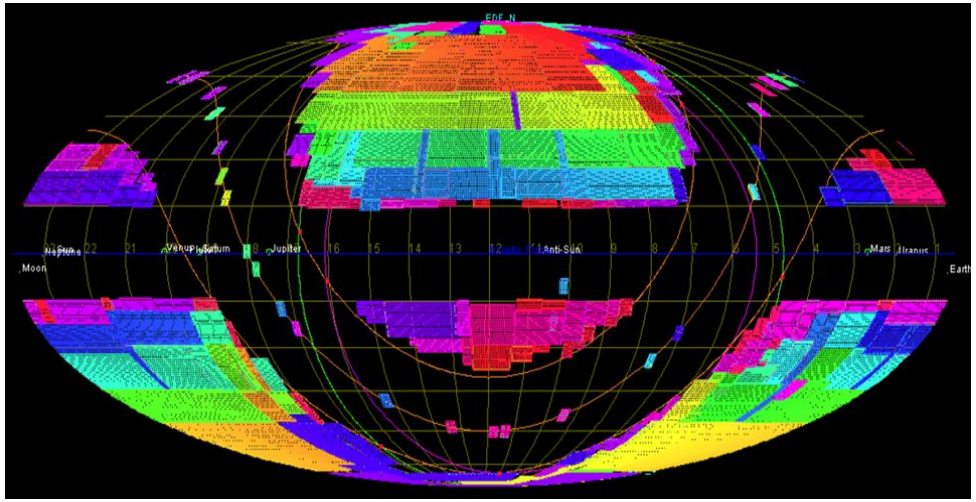
The Euclid mission

Primary science objective: understand the properties and nature of dark matter and dark energy.

Main probes: Weak Lensing, Galaxy Clustering

Area: 15000 deg2 (Wide Survey)

(for more details, see **C. Moretti talk**)



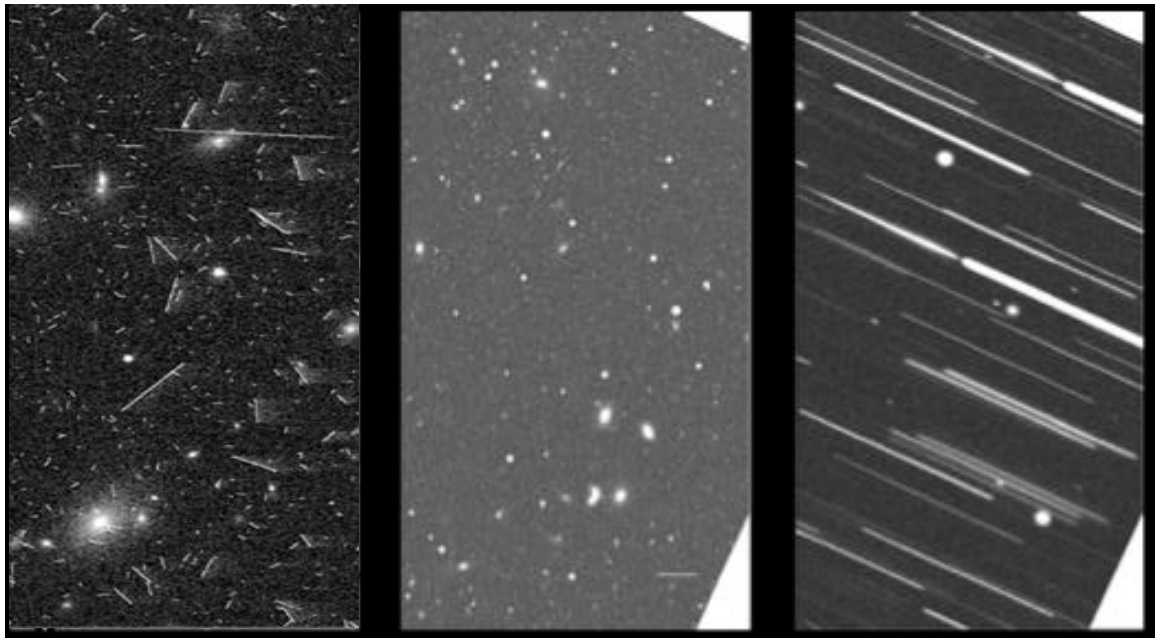
Sky covered by the Euclid mission at completion (6 year) in eclipic coordinates – Courtesy Euclid Consortium/ESA/Science Survey Working Group

Euclid's flight model – Courtesy of Thales Alenia Space - Italy

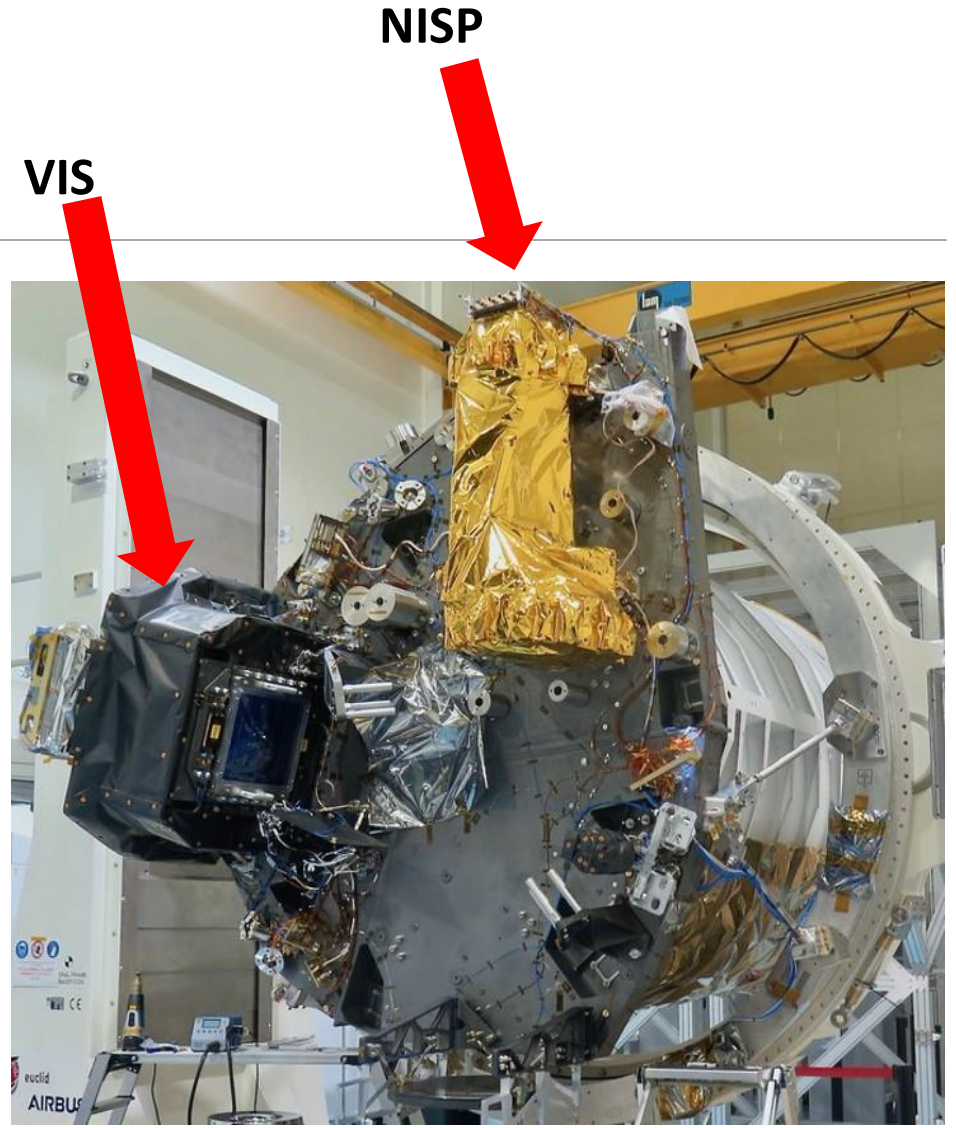
The Payload Module

VIS: High-Quality panoramic visible imager

NISP: Near Infrared Spectrometer and Photometer



SPIE 2022 - E. Medinaceli



PLM baseplate –
Courtesy of Thales Alenia Space - Italy

Data Products

VIS will measure high quality imaging of the shapes of galaxies (resolution 0.1 arcsec).

NISP will provide:

- NIR (between 900 and 2000 nm) photometry of all VIS galaxies (resolution 0.1arcsec);
- NIR low resolution (0.3arcsec) spectra ($\lambda/\Delta\lambda \sim 250$) and redshifts of millions of galaxies.

NIR photometry + VIS data -> 1.5Bil redshifts: $\sigma(z)/(1+z) < 0.05$ $0 < z < 2$

NIR spectrometry (Hα) -> 35Mil redshifts: $\sigma(z)/(1+z) < 0.001$ $0.7 < z < 1.8$

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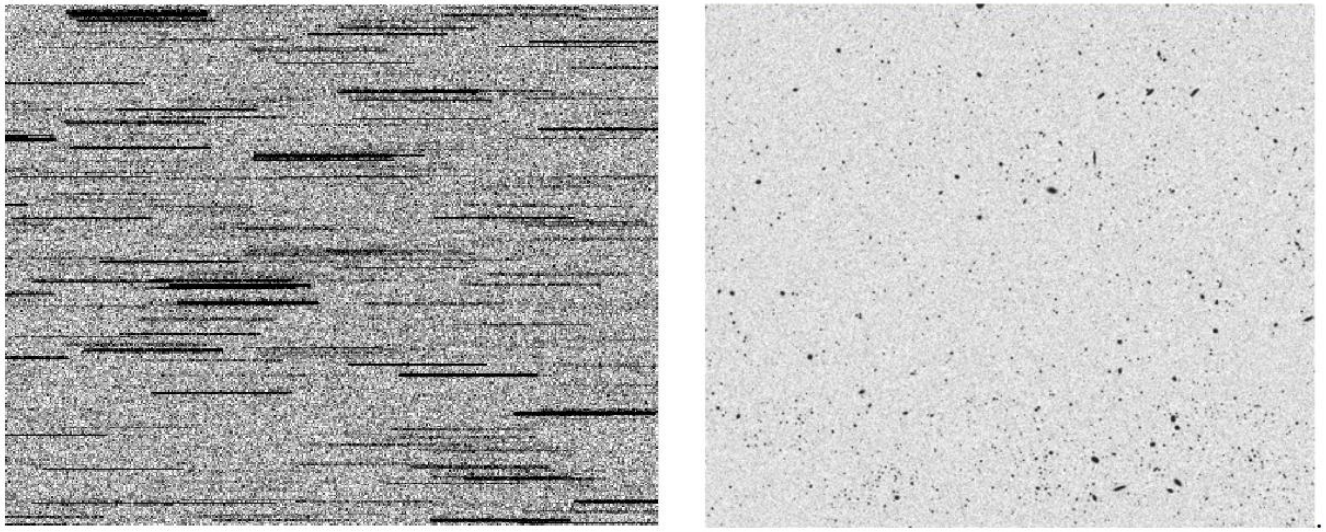
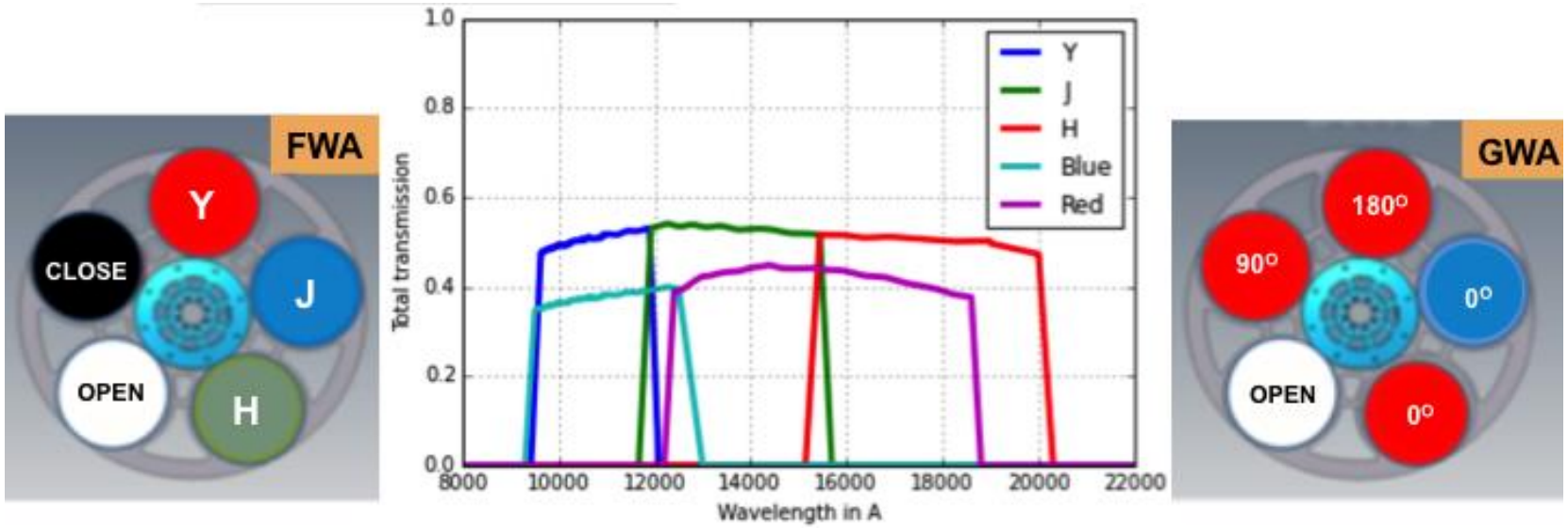
Near Infrared Spectrometer and Photometer (NISP)

- 4×4 2040×2040 18 micron pixel HgCdTe detectors (same as JWST), cooled at ~120K
- FoV 0.55 deg2
- Photometric limiting mag = 24, z res = 5%
- Spectroscopic limiting mag = 19.5, z res = 1%



Simulation of a typical slitless observation (left) and its direct image (right) - Courtesy Euclid Consortium/ESA

Wavelength Coverage



Filter positions (left), grism positions (right) and the tranmsission curves of the Y, J and H filetrs and the blue and red grims. Courtesy Euclid Consortium/NISP team

Wavelength range	550– 900 nm	Y (920-1146nm),	J (1146-1372 nm)	H (1372-2000nm)	1100-2000 nm
Sensitivity	24.5 mag 10σ extended source	24 mag 5σ point source	24 mag 5σ point source	24 mag 5σ point source	$3\ 10^{-16}$ erg cm-2 s-1 3.5σ unresolved line flux
	Shapes + Photo-z of $n = 1.5 \times 10^9$ galaxies			z of $n=5 \times 10^7$ galaxies	

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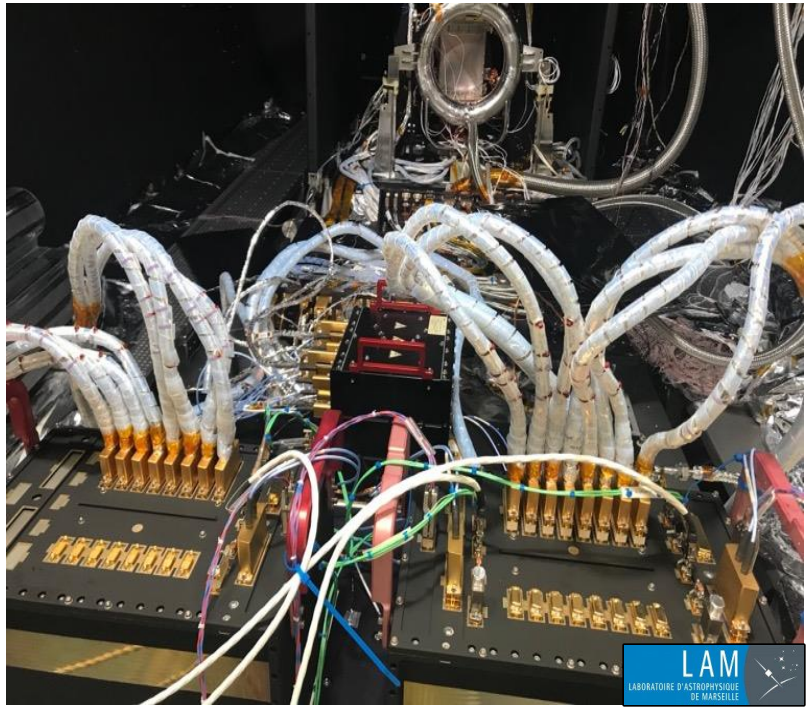
Euclid test Facilities



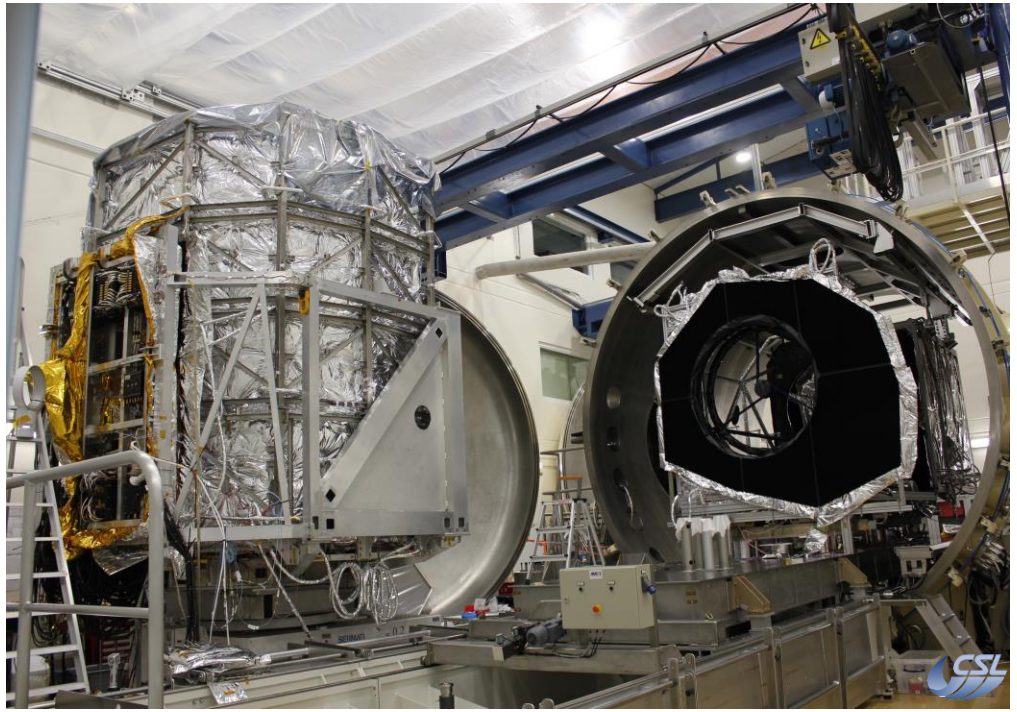
Laboratoire d'Astrophysique di Marseille, France (NISP tests):

- Detector characterization

- Optical system & detector performances (TV3)

~40K commands executed, ~19K images acquired per detector

~300K transferred files, continuous 72h of wide survey



Centre Spatial de Liège, Belgium (end-to-end tests):

- end-to-end Telescope-PLM performances

1 month of nominal continuous operations:

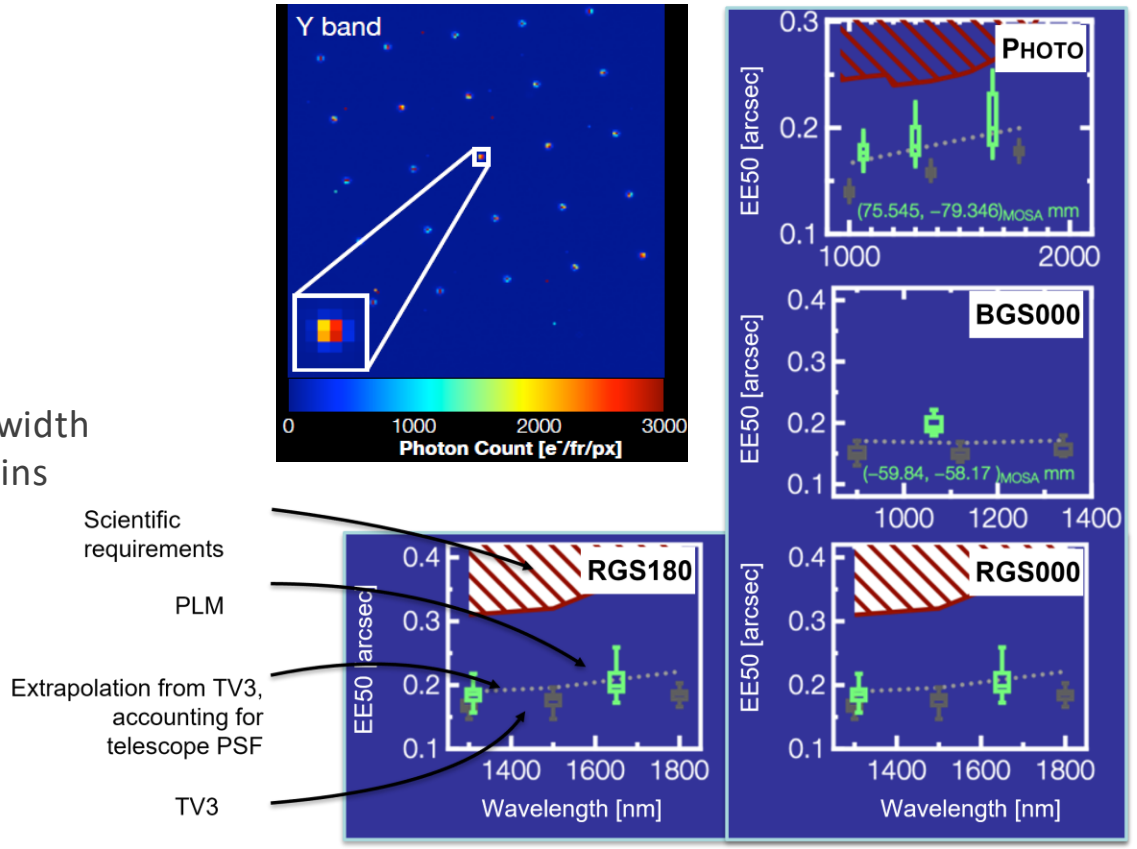
NISP/VIS autocompatibility and common focus

NISP photometric PSF verification and spectrometric dispersion verification

Image quality (PSF)

- 1 long exposure with 25 PSF flashes at different location (monochromatic point-like source)
- NISP well aligned with (M2 mirror is focalized on VIS)
- PSF modelled by 2D asymmetric Erf function (Gaussian px integration)
- 50% Encircling Energy radius (EE50) deduced from the width of the Gaussian (centroid position of the PSF that contains the 50% of the total PSF's energy)

<u>NISP PSF EE50 better than scientific requirement!</u>

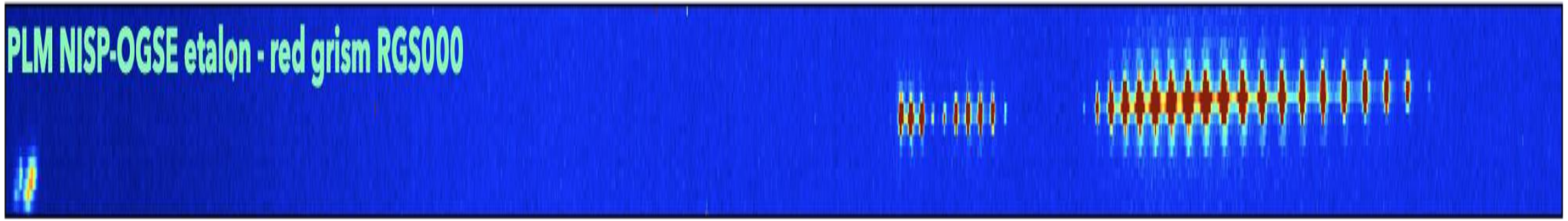


Courtesy of W. Gillard - CPPM

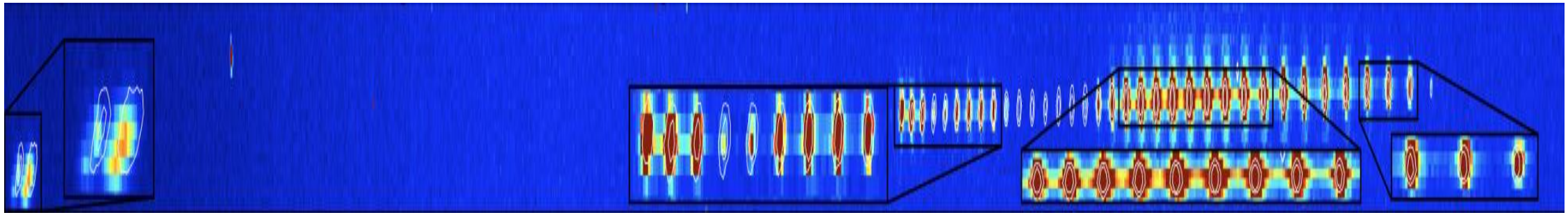
Spectrometric Dispersion Verification

The NISP optical Ground Equipment (OGSE) used during TV3 was used to verify spectral dispersion at PLM level

Same spectral source in both campaigns



Almost perfect matches between RGS000 spectra from TV3 (color) and PLM spectra (contour) when 0th order are manually aligned to each other (translation only)

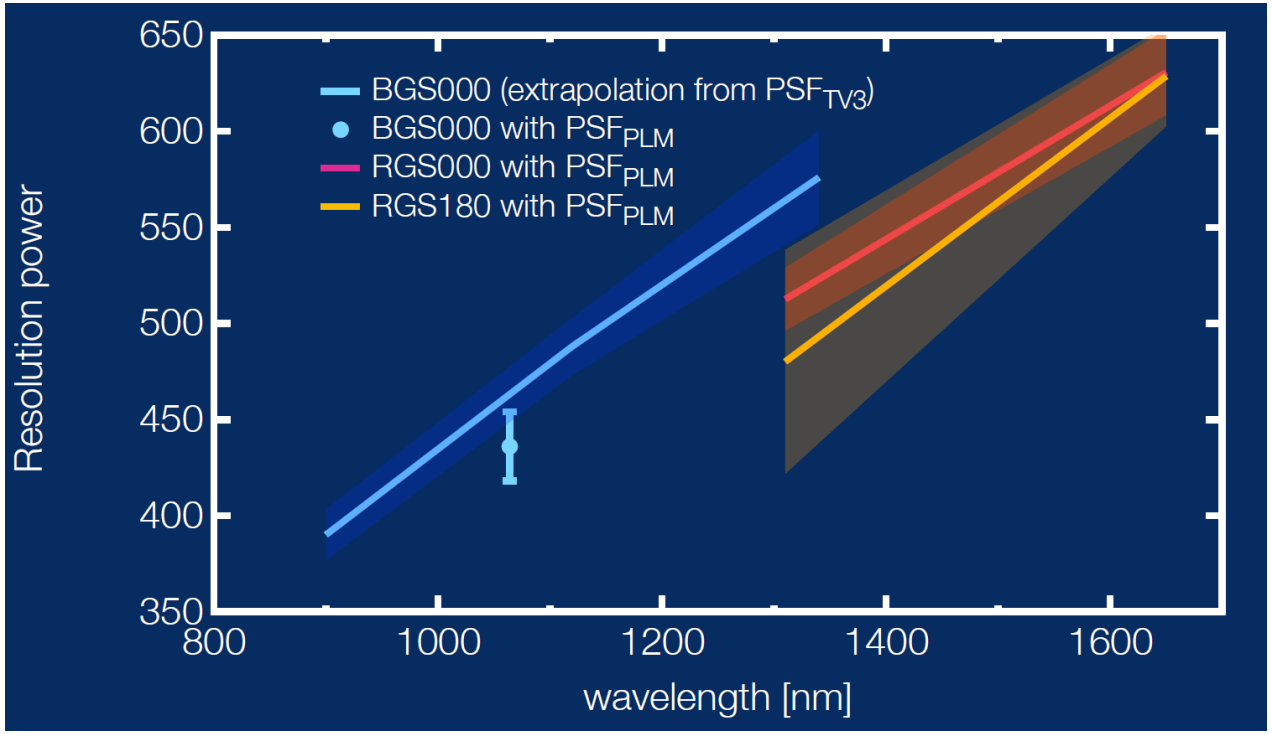


Spectral attenuations are induced by the **fibre** that is used to interface the NISP OGSE with the PLM Cryogenic chamber.

Courtesy of W. Gillard - CPPM

Spectral Resolution

NISP resolution power is better than scientific requirement (R > 380) for the wide survey, 0.5" source diameter



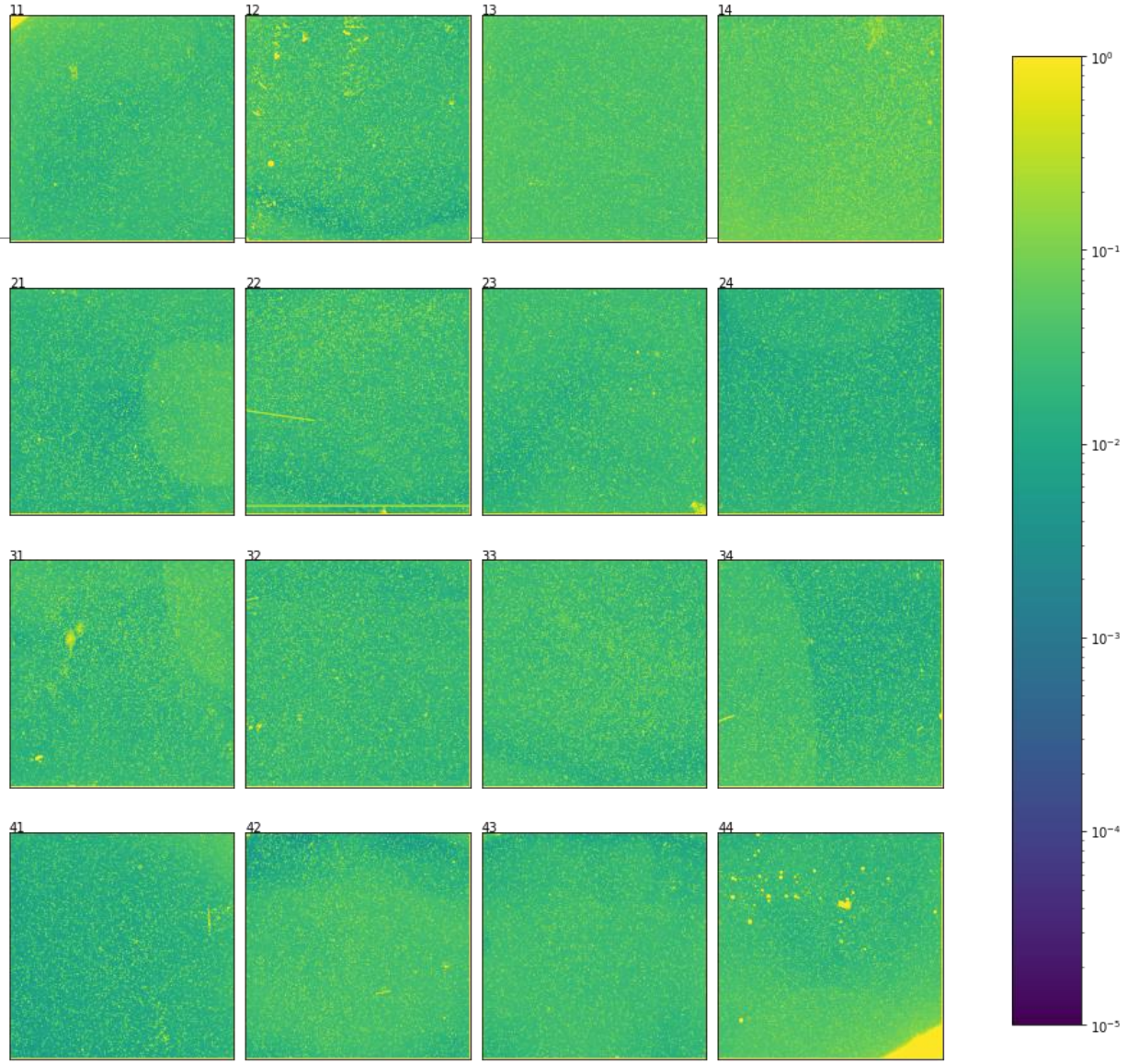
Courtesy of W. Gillard - CPPM

Thermal background characterization

Photometric and Spectroscopic darks were taken in order to study the pixel response to dark current.

Light-leakage effects were found in TV3 and corrected during PLM tests.

Quantity of disconnected pixels below 1%, (requirements < 2%)



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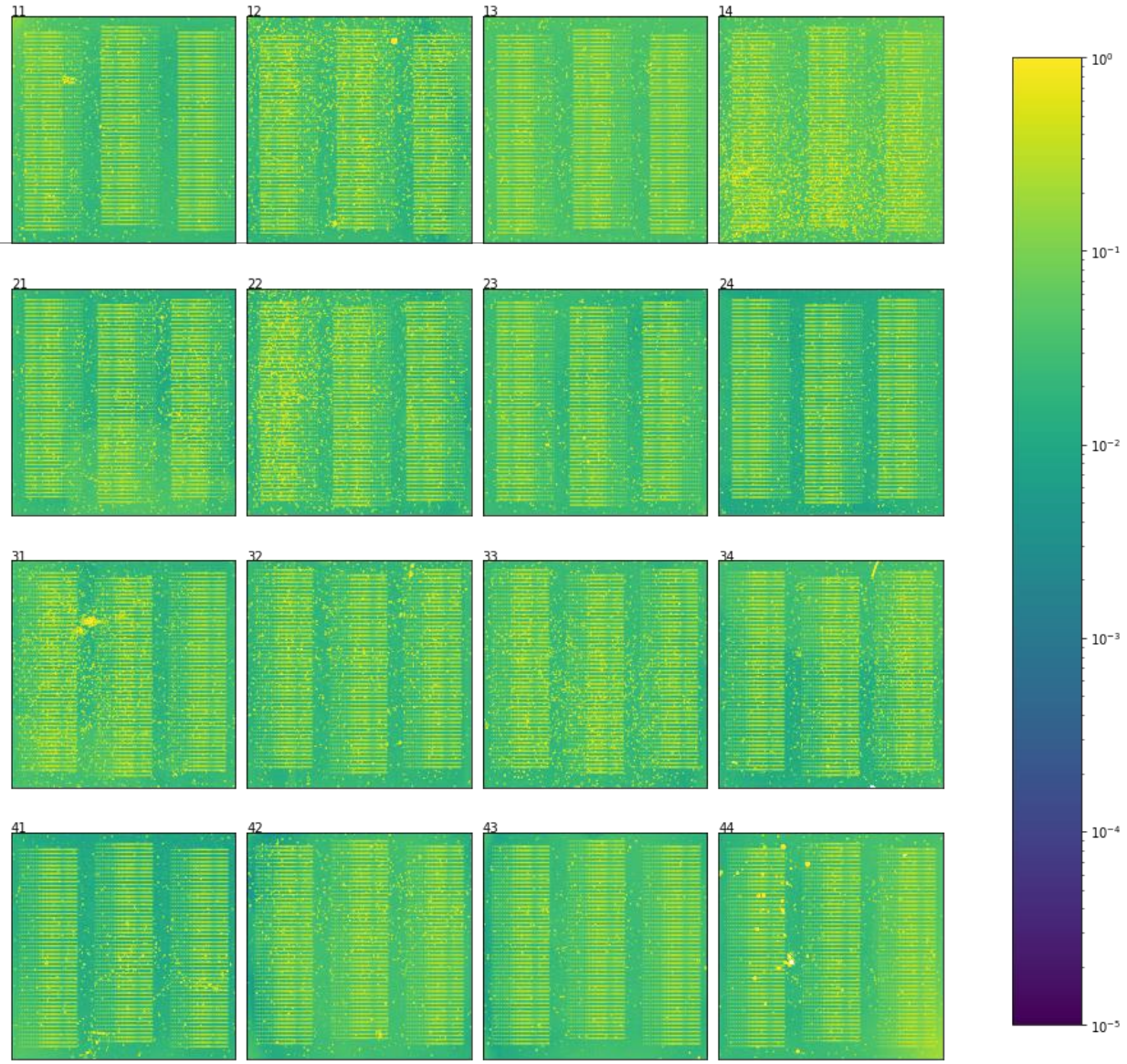
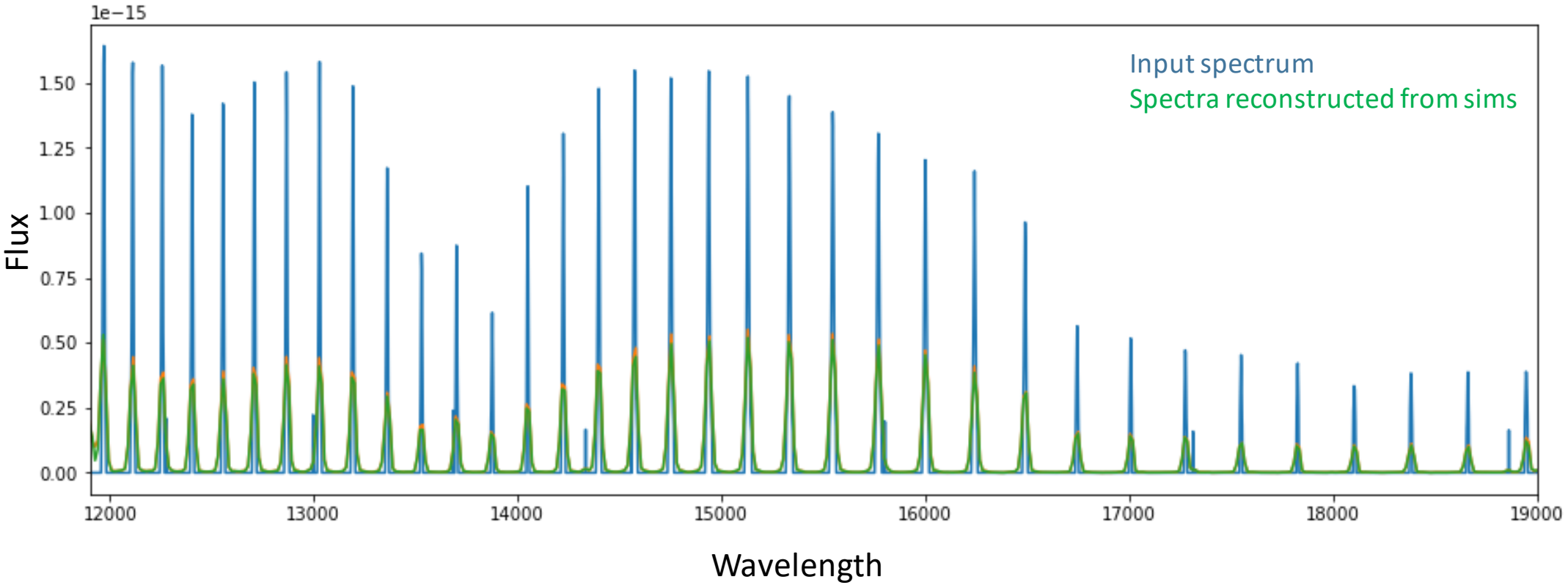
Focal Plane sims

Euclid pipeline allows to simulate the data taken by the detectors and extract spectra from them.

The results of NISP detectors characterization were introduced into the codes in order to get realistic simulations.



Spectra Reconstruction



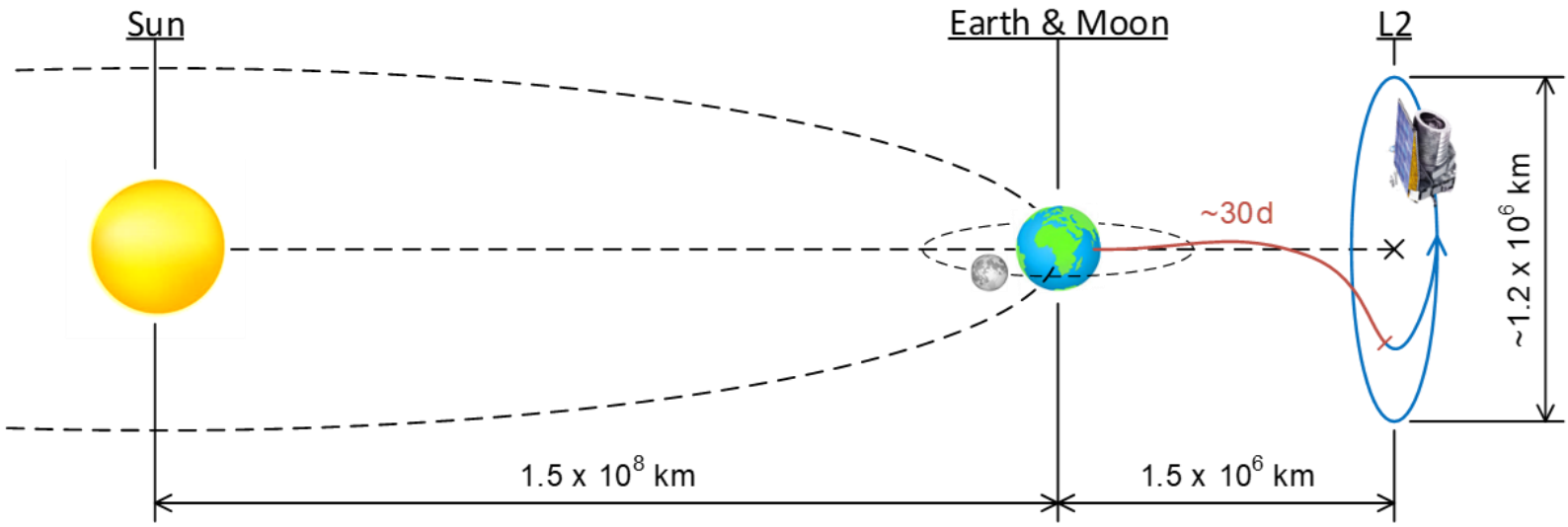
Conclusions and future perspectives

EUCLID is assembled and ready for launch (ext. late 2023)

It will measure a total of

- ~1.5 billion galaxy shapes
- ~35 million galaxy spectra

Performance tests show that NISP is ready and above the expectations.



Stay tuned for the next exciting phase!