CHARACTERIZATION OF INFRARED DETECTORS FOR THE EUCLID NISP INSTRUMENT

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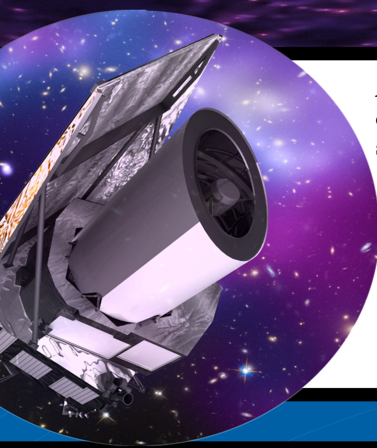
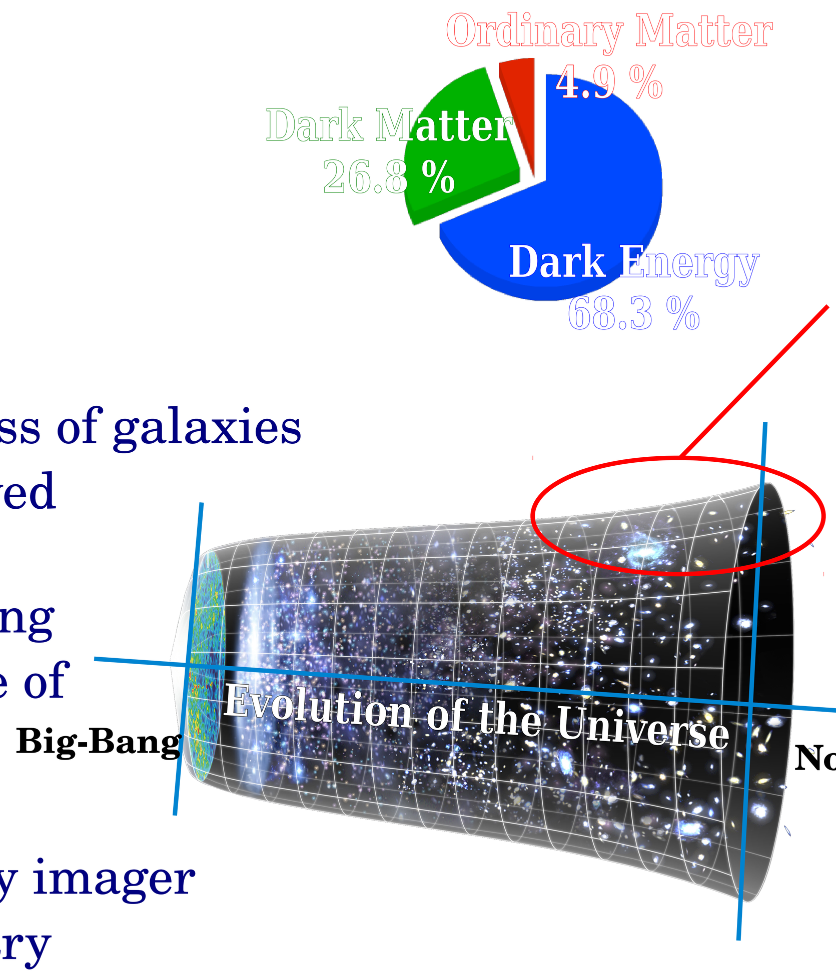


An artist view of the Euclid satellite – © ESA

Euclid is a wide-field mission for the cartography of the dark Universe lead by European Space Agency (ESA) and the Euclid Consortium that is to launch on 2020. This mission was selected within the Cosmic Vision program and aims at bringing more understanding on the nature of the recent acceleration of the expansion of the Universe and the possible related nature of dark matter and dark energy.

Cosmology & Euclid — Observing cosmological probes



Dark Matter

- Heavier mass of galaxies than observed
- Weak Lensing (WL): shape of galaxies
- High quality imager & photometry

Dark Energy

- Present acceleration of the expansion of The Universe
- Baryonic Acoustic Oscillations (BAO): distribution of galaxies
- Spectroscopy: detection of Hα line

Method - Multi cosmological probes

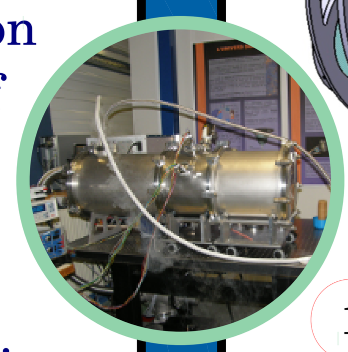
- High precision measurements <1%

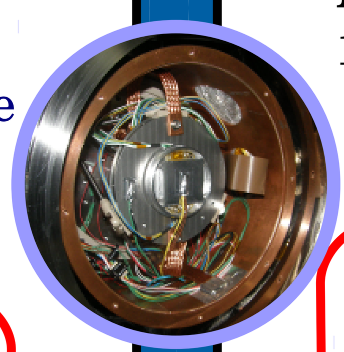
Euclid survey

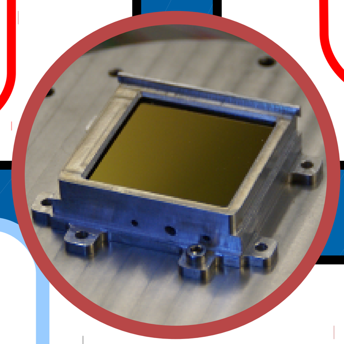
- 15,000 deg² over 6 years
- 10s of millions of galaxies
- z between 0.9 and 2.0

Control of systematics

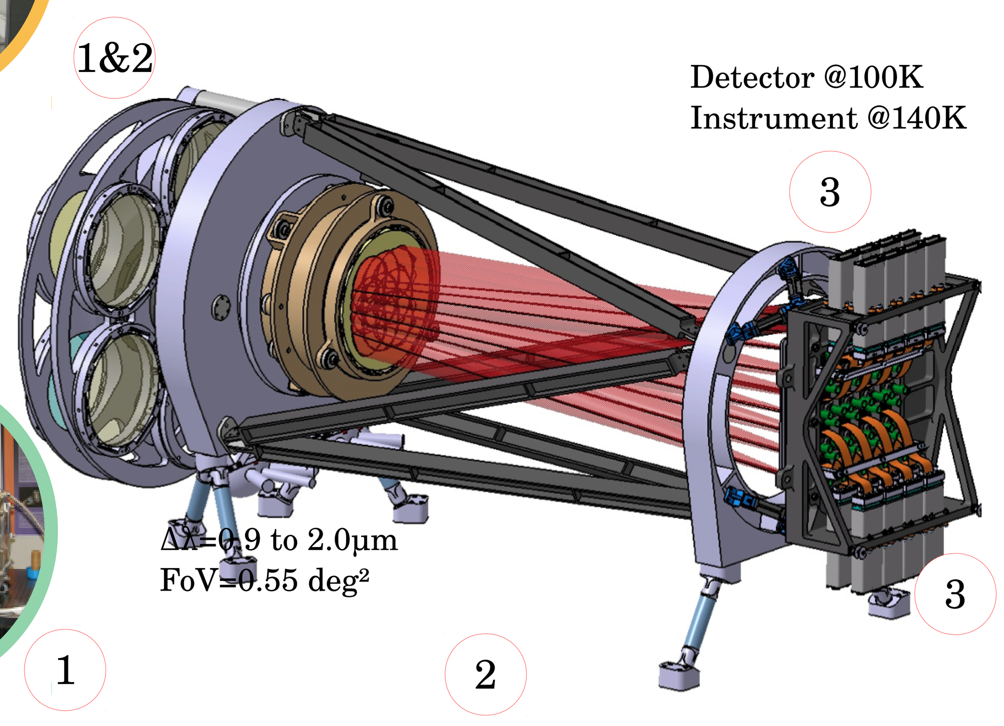
- Frequent calibration
- Detailed *a priori* knowledge of instruments

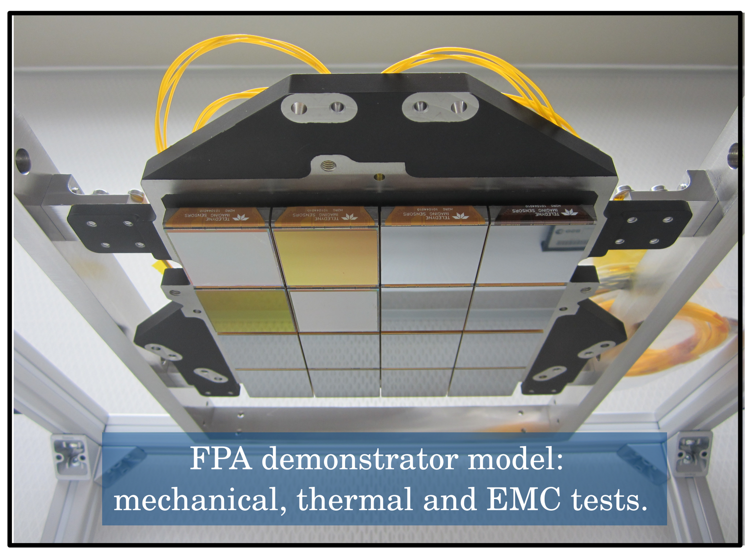






EUCLID-NISP — Near Infrared Spectrometer Photometer





FPA demonstrator model: mechanical, thermal and EMC tests.

1 Photometer

Y, J, H filters
0.3 arcsec/pixel
MACC(3/4,16,xx)
100s exposure

2 Slitless spectrometer

3 red and 1 blue grisms
2.10^{-16} erg/cm²/pix
MACC(15,16,13)
560s exposure

NISP IR H2RG detectors

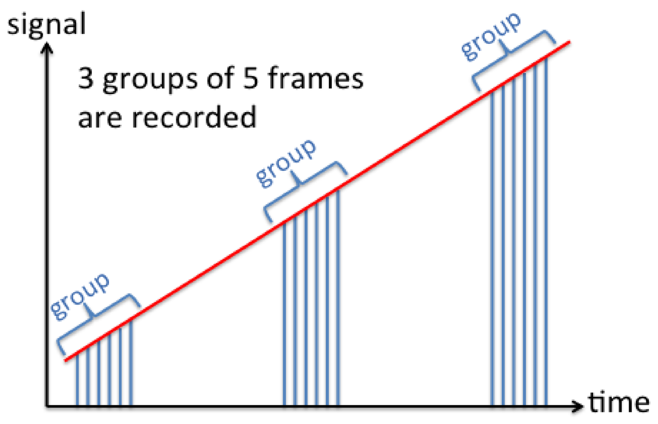
- 16 detectors in the FPA
- 2048x2048 hybrid pixels
- 18µm pitch / 2.3µm cut-off
- Provided by Teledyne Imaging Sensors under ESA/NASA contract

Limited telemetry

- Transfer of slopes and error
- Need for characterization

Readout strategy – Non destructive MACC

- Average down readout noise
- Detection of cosmic rays



H2RG : Hawaii 2kx2k with Reference pixels & Guide mode

The technology for infrared detection that is used for H2RG detectors is 20 years old. With improvement of performances, and feedback from experiences, new effects have been discovered and need to be studied :

Persistence creates an afterglow after bright illuminations (like high energy cosmics of bright stars)

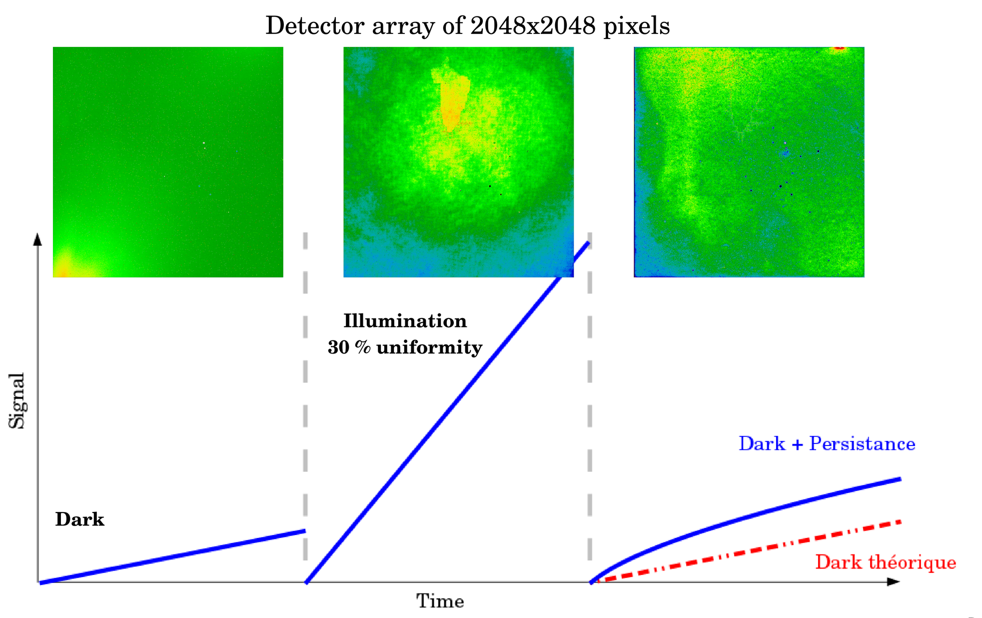
Cosmics induce an offset on the signal. At the L2 point flux of ~5/cm²/s.

The characterization facilities at CPPM are equipped with a test cryostat that has been used to study these effects.

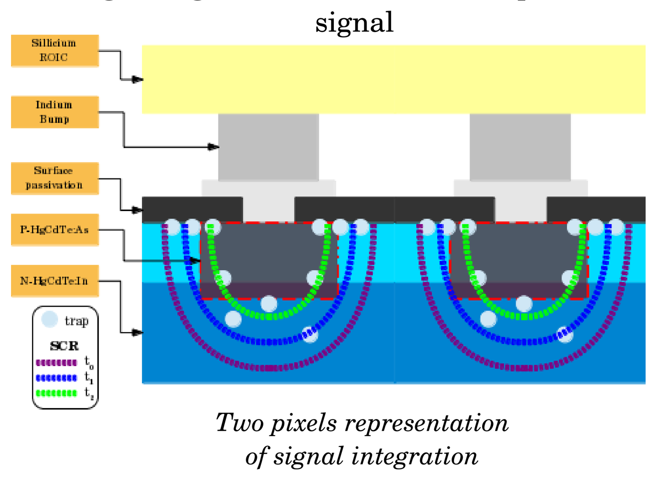
Persistence

Impact on acquisitions

- Charges trapped during acquisition in non-depleted regions
- Charges liberated during next acquisition
- Creation of a persistent pattern that can be seen on following exposures.



Traps below the lines representing the Space Charged Region (SCR) contribute to persistence signal



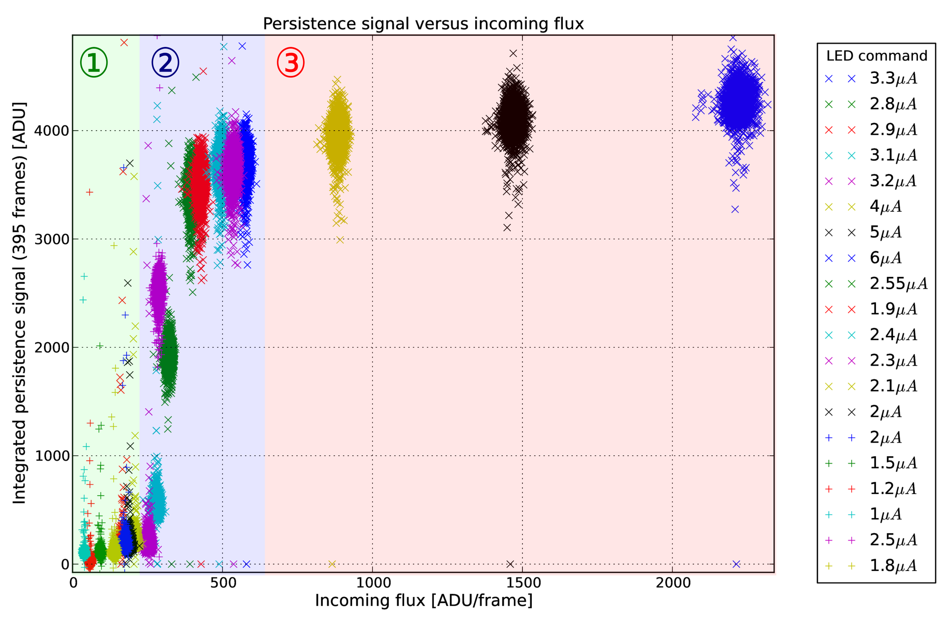
Two pixels representation of signal integration

Conclusions

<u>Bulk & Surface persistence</u>

Persistence signal vs exposure flux shows three regimes:

① Bulk persistence
② Oxyde passivation persistence
③ Saturation of traps within P-N junction

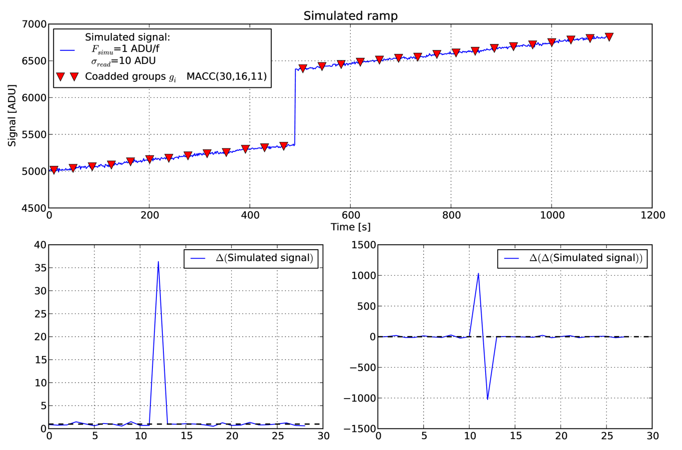


Characterization — knowledge of system behavior

Cosmic rays

Impact on acquisitions

- Creating an offset in the ramp that can saturate the pixel



Impacts	$\%_{detector}$
0	96.75 %
1	3.19 %
2	0.06 %
3	6.10^{-4} %

Number of impacts estimated at the L2 point during spectro. exposure (~560s)

Correction algorithm

- Compute a χ² and P-value

$$\chi^2=\sum_{i=0}^{N_{groups}-1}(g_{i+1}-g_i-F_{fit})^2/(F_{fit}+\frac{2\sigma_{read}^2}{N_{frames}})$$

- Compute a temporary χ² on second derivative of signal (fitting 0 slope), to see deviations caused by cosmics.

Compute the original χ² and P-value without impacted groups

P-value :
Value used to validate an hypothesis to be verified .

<u>In our case :</u>
- Signal can be described with a linear fit
- Readout errors are not Correlated

<u>*A priori* information :</u>
- Estimation of the readout errors for all pixels

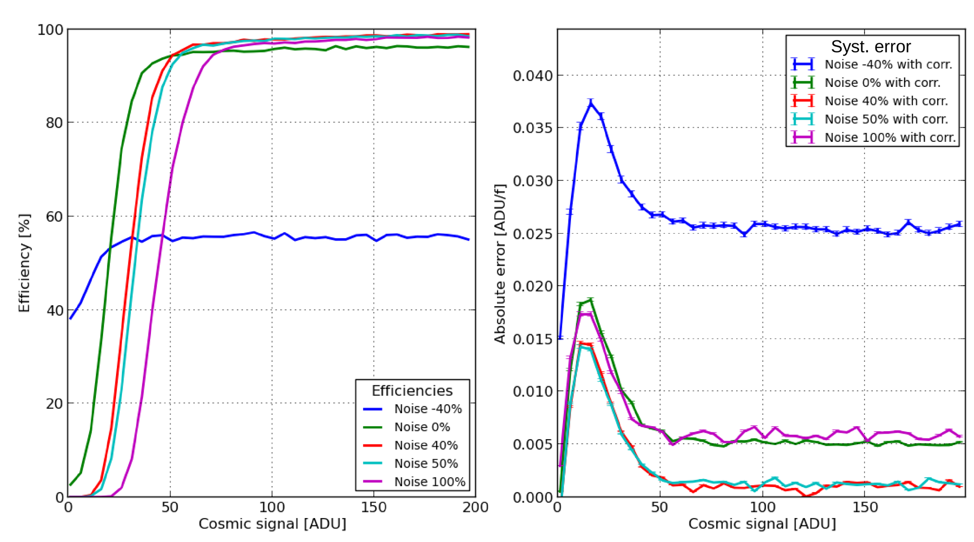
- Cosmic selected with criteria : $\begin{cases} P_{value\ raw}<0.01 \\ P_{value\ corr}>0.01 \end{cases}$

« If a ramp can not be fitted as a linear signal before the correction but can be after, then it is a cosmic »

Conclusions

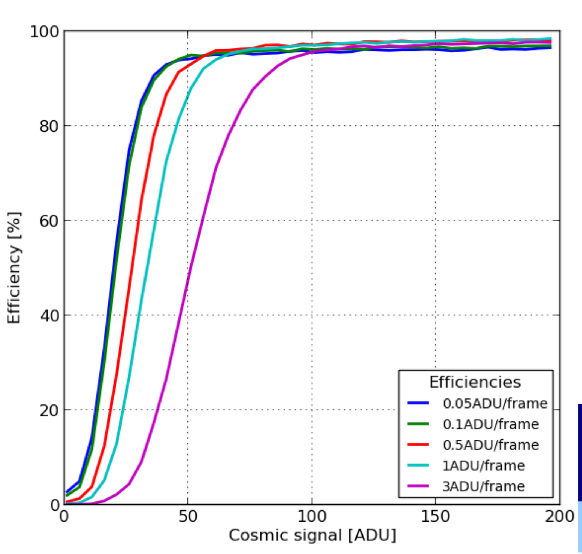
Coadding adds correlation between readout errors.
Adding an error component to the χ² improves the systematic error done on flux recomputation for low fluxes conditions.

σ_{read}	-40 %	0 %	40 %	50 %	100 %
Syst. err	$2,5.10^{-2}$	5.10^{-3}	2.10^{-3}	2.10^{-3}	6.10^{-3}



$$Efficiency=\frac{Nb_{true\ \ detection}}{Nb_{trys}}$$

$$Purity=1-\frac{Nb_{false\ \ detection}}{Nb_{trys}}$$



Algorithm performances

- Detection efficiency up to 94 % for cosmics of 50 ADU and higher.
- Detection purity of 97 % at min.
- Correction syst. error lower than statistical error.

	Dark		Science		Straylight
Flux (e-/s)	0.05	0.1	0.5	1	3
Purity	97.17 %	98.03 %	99.28 %	99.68 %	99.82 %

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