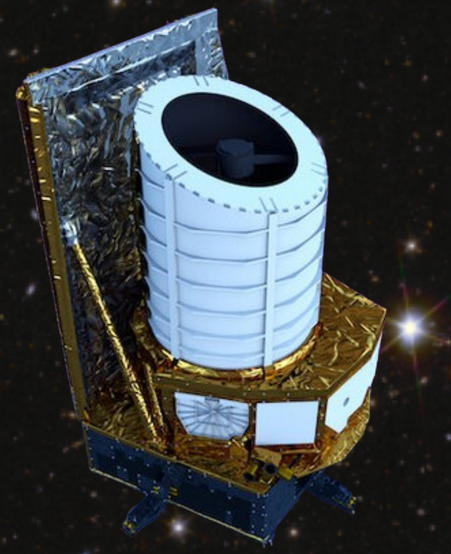
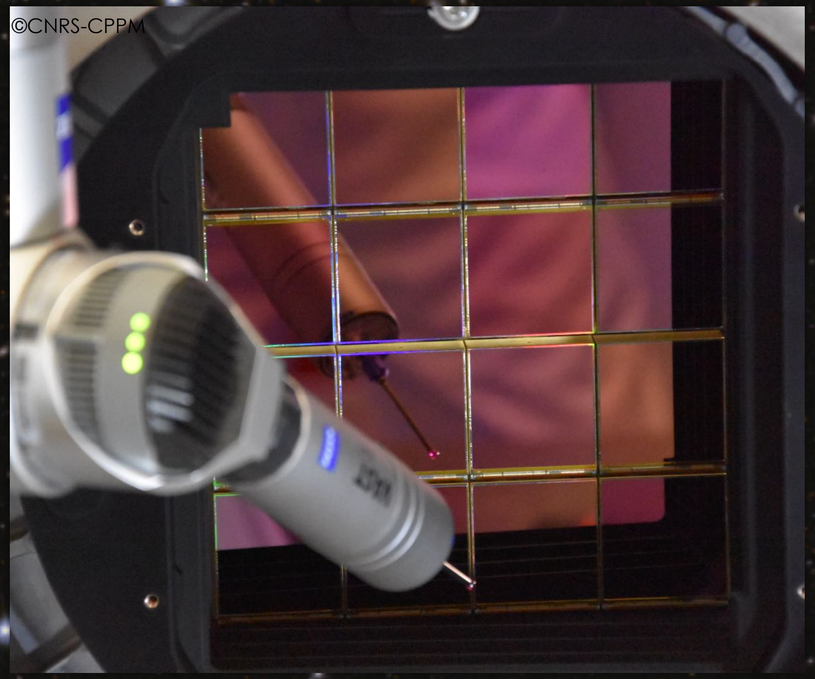
Performance of Euclid H2RG Detectors: IPC and Persistance Contributions

Aurélia Secroun
on behalf of CPPM team



ISIS workshop in Bologna 11/03/2026

NISP H2RG DETECTORS SPECIFICATIONS



FPA = 16 H2RG
2.3μm CUTOFF
32 CHANNELS @ 100KHZ
T_{OP} ~95K IN FLIGHT

SPATIAL CORRELATIONS < 5%

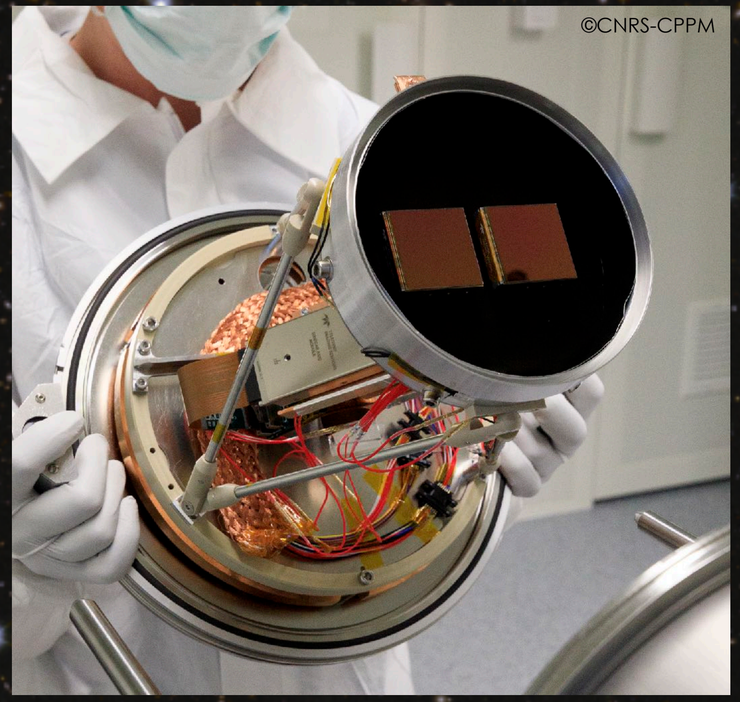
95% OPERABLE PIXELS

NON LINEARITY AFTER CORRECTION < 1%

RELATIVE ERROR ON FLUX AFTER CORRECTION < 1%

PER PIXEL PERFORMANCE

GROUND PERFORMANCE TESTS



3 TYPES OF TESTS

- DARK — baseline, dark current, noise
- ILLUMINATION — conversion gain, non-linearity, persistance, flatness
- ELECTRICAL TESTS — IPC, readout electronics non-linearity

3 TEMPERATURES
FLAT FIELD ILLUMINATION
SCIENCE MODE ACQUISITIONS

80,85 & 90K

Temperature stability < 1 mK

Background < 0.005 e.s

26 fluxes up to 3x full well

Photo 100fr
Spectro 400fr

Homogeneity < 1%

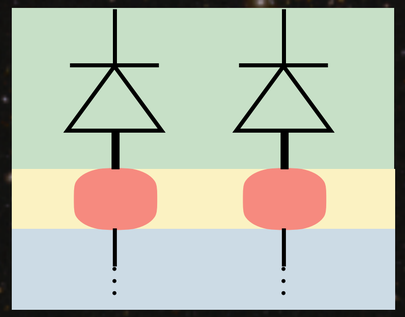
Flux stability < 0.5%

INTERPIXEL CAPACITANCE

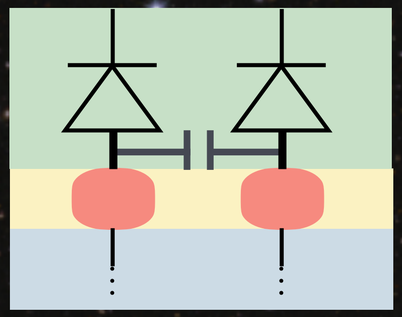
Jean Le Graët's PhD work

For 100 incoming photons

No IPC



IPC



Measured signal

0.0	0.0	0.0
0.0	100.0	0.0
0.0	0.0	0.0

0.057	0.676	0.055
0.623	97.125	0.658
0.050	0.695	0.048

Origin

Very close proximity of pixels (pitch=18μm)

Parasitic capacitance between neighbors

Spreads the signal to those pixels

Characterized by IPC kernel

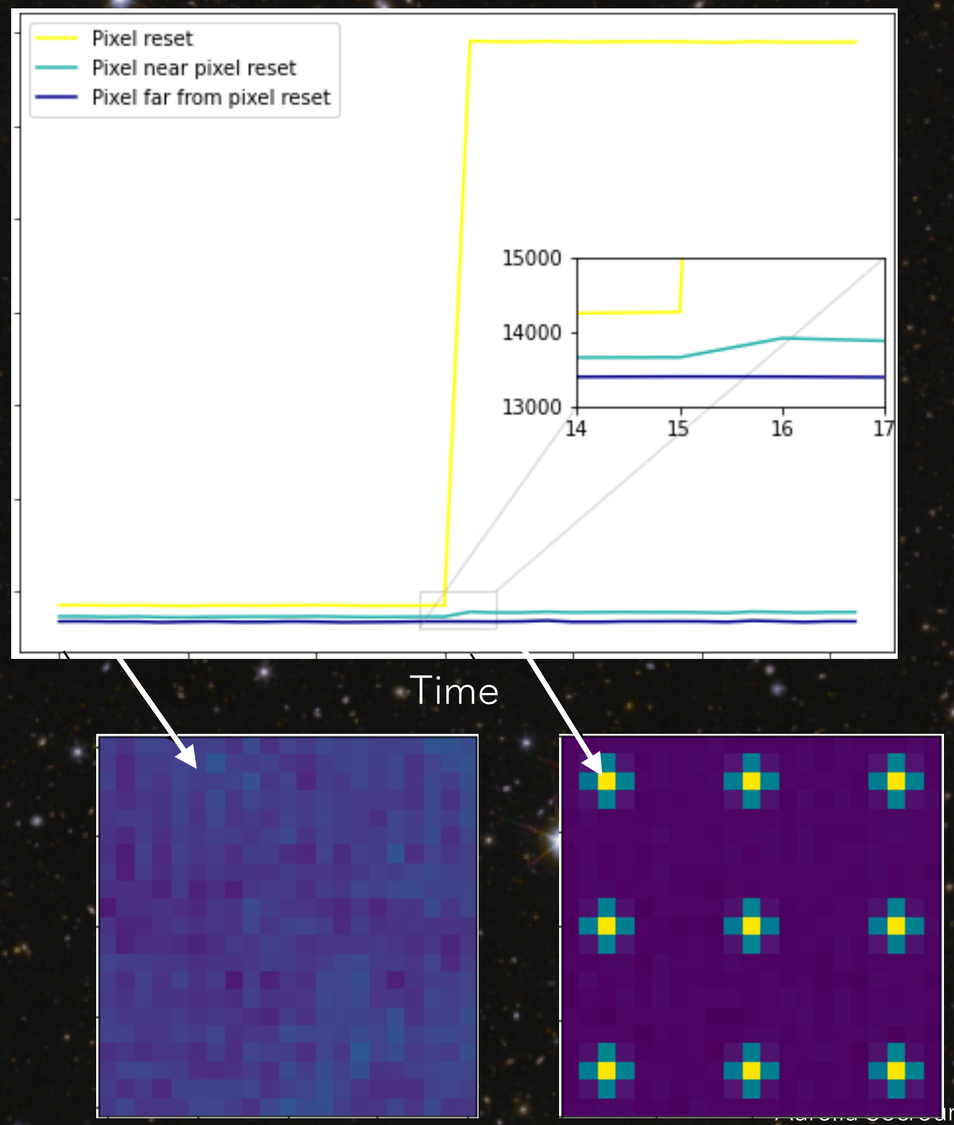
Effect on signal

Measured signal True signal IPC kernel

$$S_{i,j\,\mathrm{bias}} = S_{i,j\,\mathrm{true}} * \begin{bmatrix} \alpha_1 & \alpha_2 & \alpha_3 \\ \alpha_4 & 1-\sum_{i=1}^{8}\alpha_i & \alpha_5 \\ \alpha_6 & \alpha_7 & \alpha_8 \end{bmatrix}$$

INTERPIXEL CAPACITANCE

MEASUREMENT METHOD



Single Pixel Reset (SPR)

- Only method allowing per pixel measurement
- One pixel each 8x8 electrically stimulated
- Measure repeated 16 times for statistics
- 64 different grids to measure all pixels

Kernel calculation

$$D = \frac{1}{16}\sum_{16} S_{base} - \frac{1}{16}\sum_{16} S_{SPR}$$

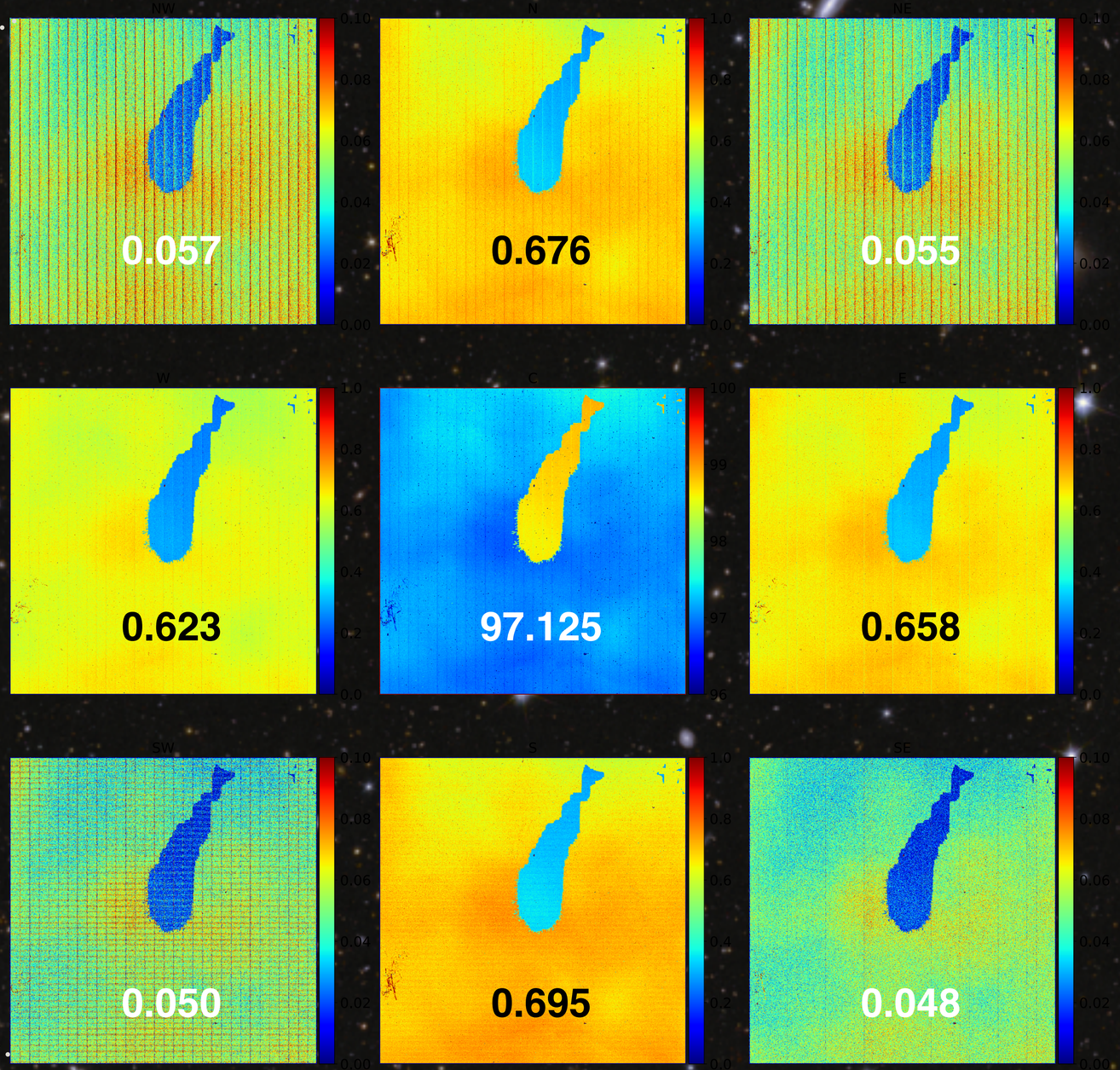
For each resetted pixel:

$$\textbf{IPC kernel} = \begin{bmatrix} D_{-1,-1} & D_{-1,0} & D_{-1,1} \\ D_{0,-1} & D_{0,0} & D_{0,1} \\ D_{1,-1} & D_{1,0} & D_{1,1} \end{bmatrix} \Big/ \sum_{i=-1,j=-1}^{1} D_{i,j}$$

INTERPIXEL CAPACITANCE

IPC KERNEL

0.057	0.676	0.055
0.623	97.125	0.658
0.050	0.695	0.048



Diagonals non negligible

Second ring in noise < 0.04

INTERPIXEL CAPACITANCE

IPC KERNEL

NW	N	NE
W	C	E
SW	S	SE

IPC \ Det	#1	#2	#3	#4	#5	#6
Center	97.22	97.41	97.22	96.80	97.17	97.22
North	0.65	0.65	0.61	0.74	0.65	0.65
South	0.68	0.62	0.67	0.76	0.66	0.68
West	0.61	0.60	0.61	0.70	0.63	0.60
East	0.61	0.61	0.65	0.74	0.67	0.64

S > N (+4%)

E > W (+4%)

Read direction effect

INTERPIXEL CAPACITANCE

IPC KERNEL

NW	N	NE
W	C	E
SW	S	SE

IPC constant with signal

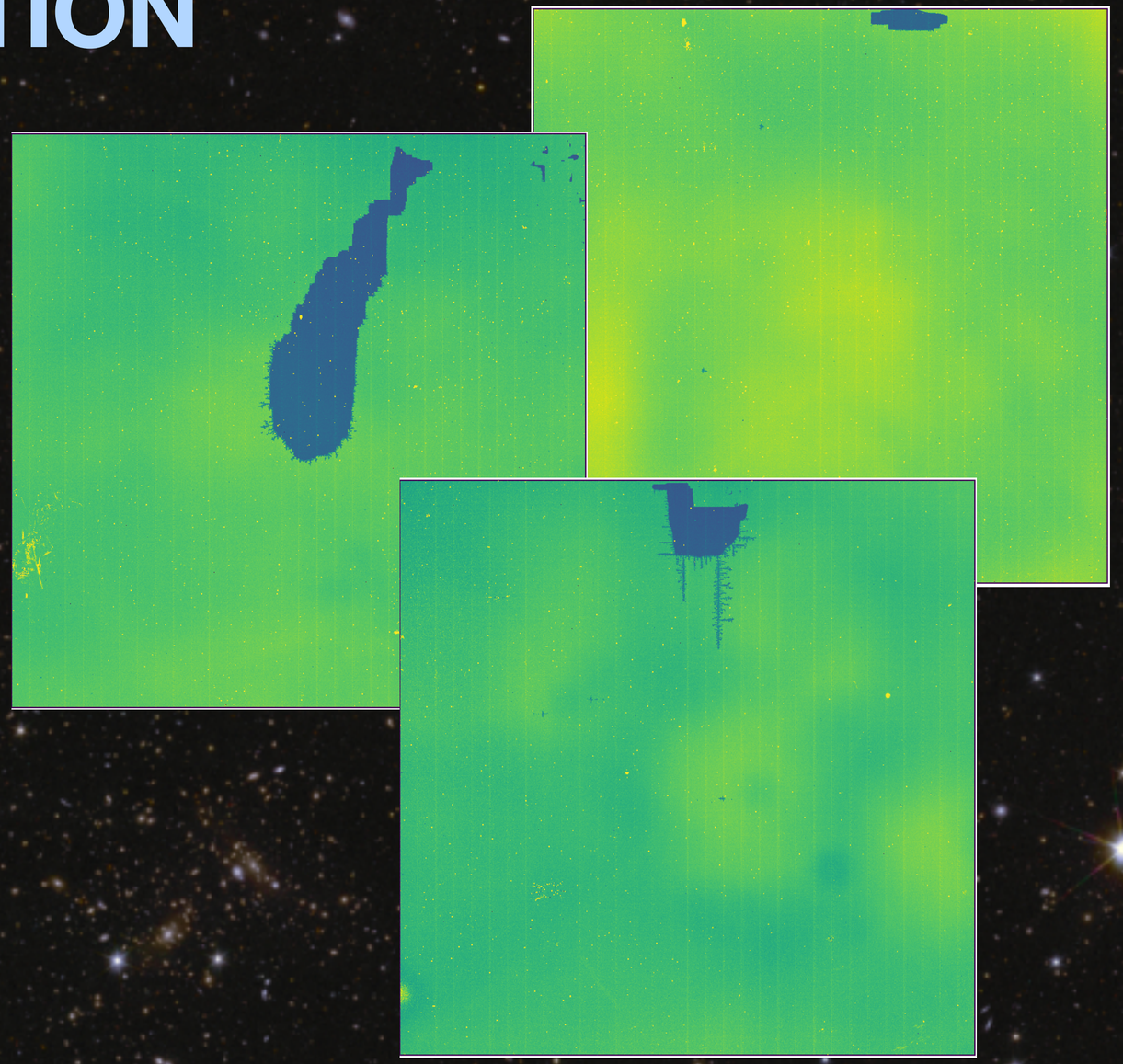
Vreset (mV)	350	500	650
Central pixel (%)	97.21	97.22	97.23

INTERPIXEL CAPACITANCE

SPATIAL DISTRIBUTION

Void = up to 6% of pixels

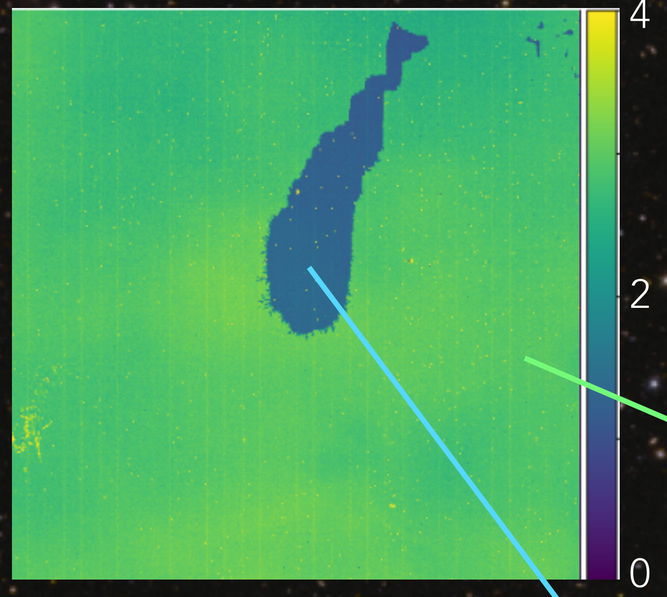
—> Difference in dielectric constant (epoxy)

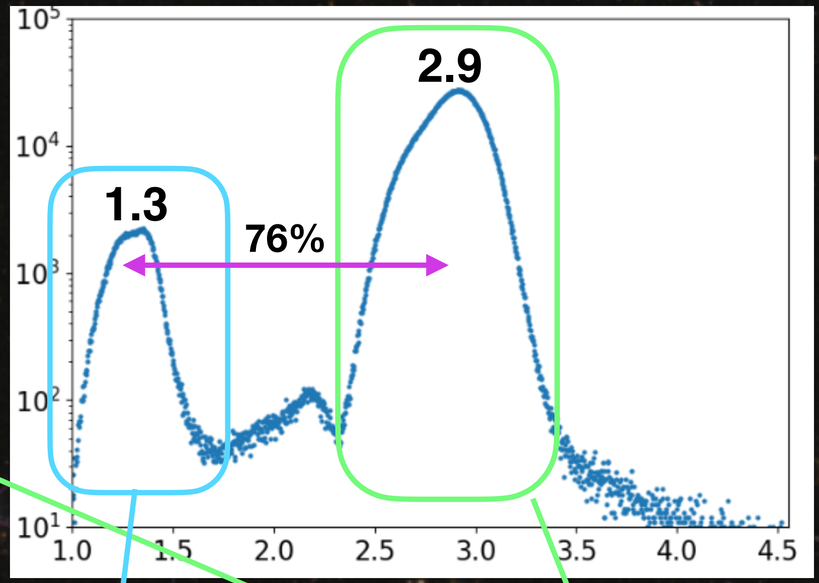


INTERPIXEL CAPACITANCE

SPATIAL DISTRIBUTION

Percentage of signal detected in neighbors





Overall pixels:

Avg IPC ~ 2.97±0.01%

First column larger

Void pixels:

Spatial var. ~10%±2σ

IPC $_{\text{void}}$ 2x < IPC $_{\text{glued}}$

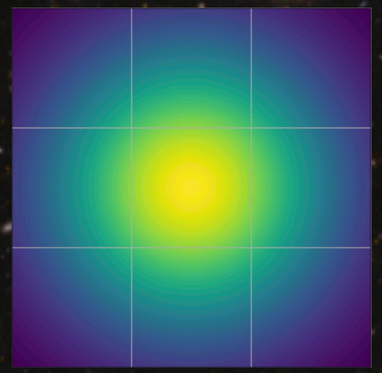
Glued pixels:

Spatial disp. ~ 30%± 3σ

IMPROVING PERFORMANCE THANKS TO DECORRELATION

IPC BIASES FLUX MEASUREMENT

Euclid PSF



8.27	12.01	8.28
12.01	18.85	12.02
8.28	12.02	8.28

*

IPC kernel

5.9e-04	6.4e-03	6.1e-04
6.1e-03	0.972	6.1e-03
5.1e-04	6.8e-03	7.2e-04

=

Measured PSF

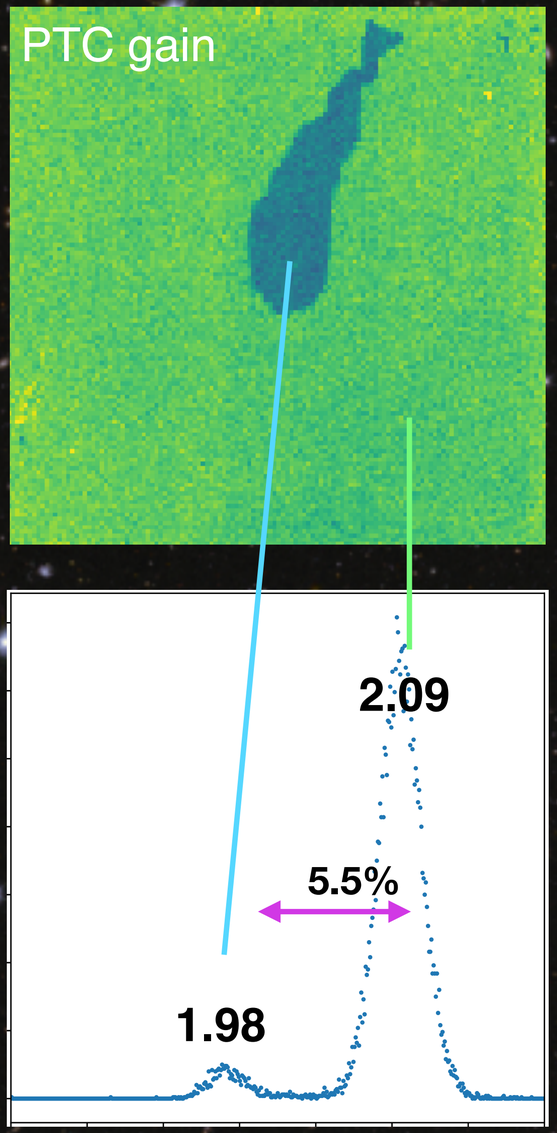
8.30	12.00	8.31
12.00	18.73	12.01
8.31	12.02	8.32

Bias of 0.6% on central pixel

—> slight underestimation of flux

IMPROVING PERFORMANCE THANKS TO DECORRELATION

IPC BIASES CONVERSION GAIN



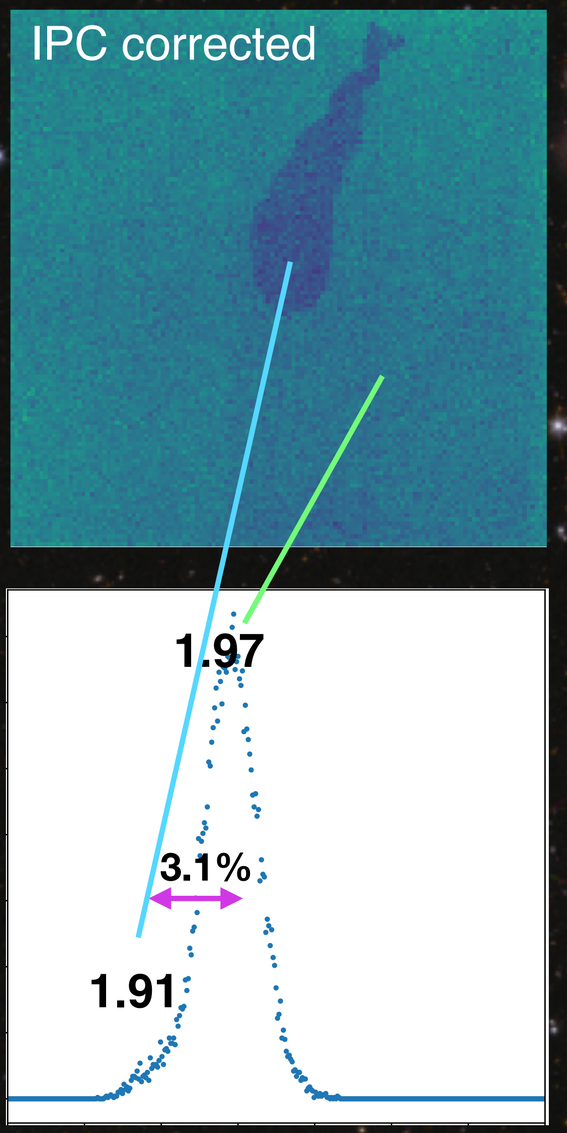
Avg gain ↘ 5% with IPC correction

5% bias corrected on photon flux

Void - Glued difference: 5.5% ↘ 3.1%

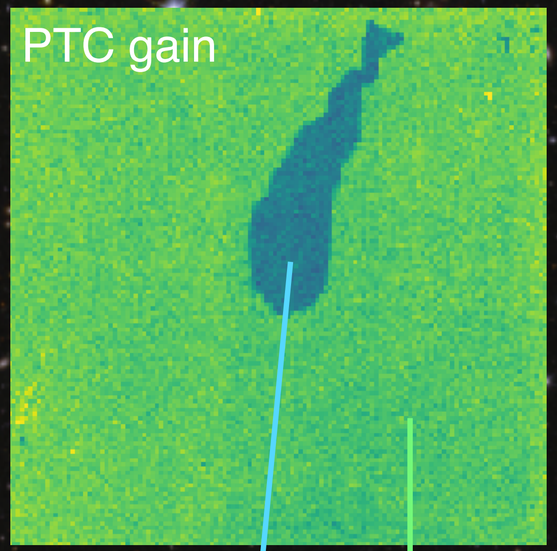
epoxy void affects gain

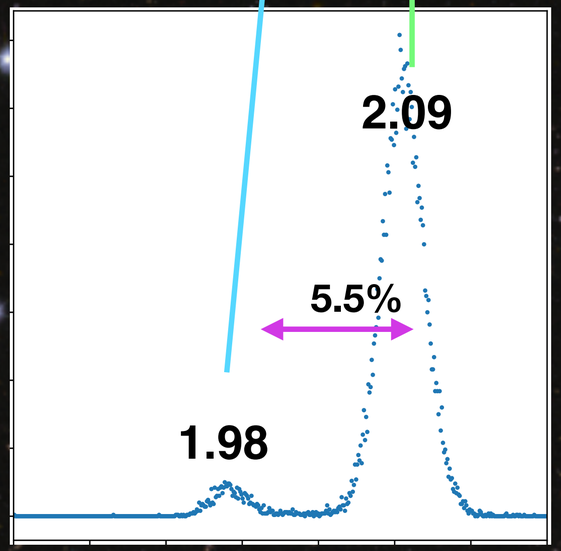
Glued spatial variations ~ 3%



IMPROVING PERFORMANCE THANKS TO DECORRELATION

NON-LINEARITY BIASES CONVERSION GAIN



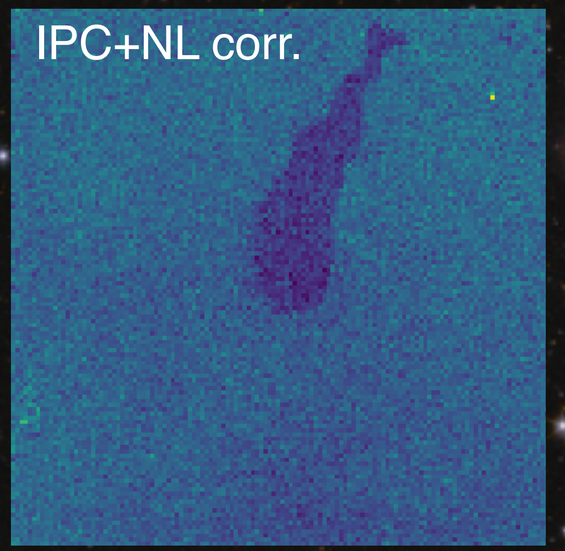


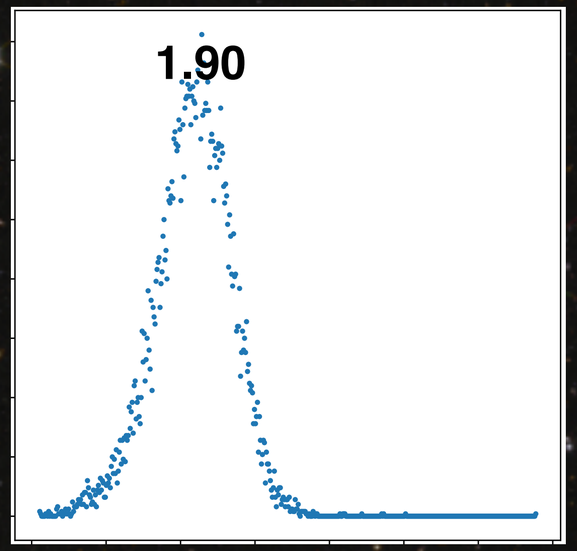
Avg gain ↘ 9.5% with IPC+NL corr.

9.5% bias corrected on flux

= 5.0% from IPC corr.

+ 3.6% from NL corr.





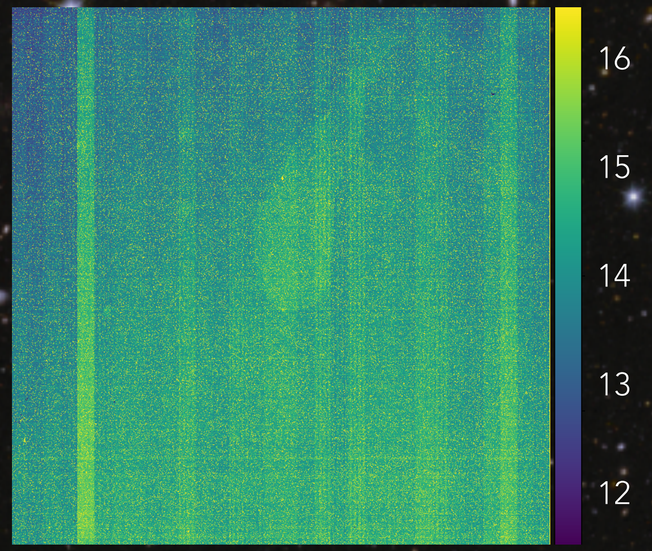
Methodology described in

A&A 705, A138 (2026)

DOI 10.1051/0004-6361/202556173

IMPROVING PERFORMANCE THANKS TO DECORRELATION

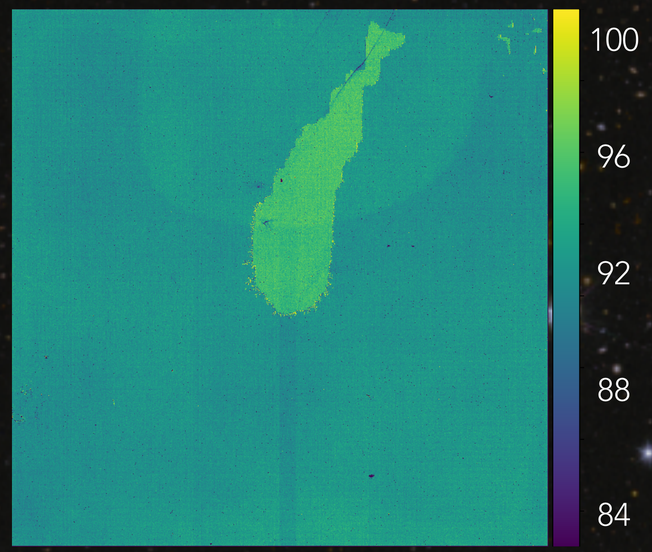
WHEN PERSISTENCE KICKS IN….

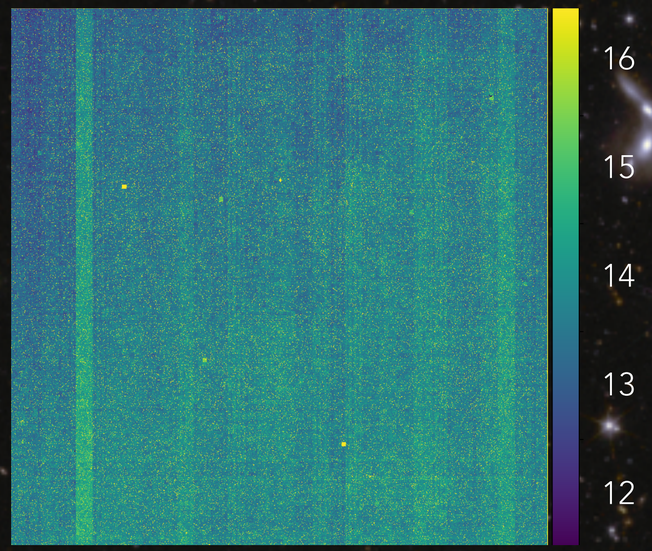


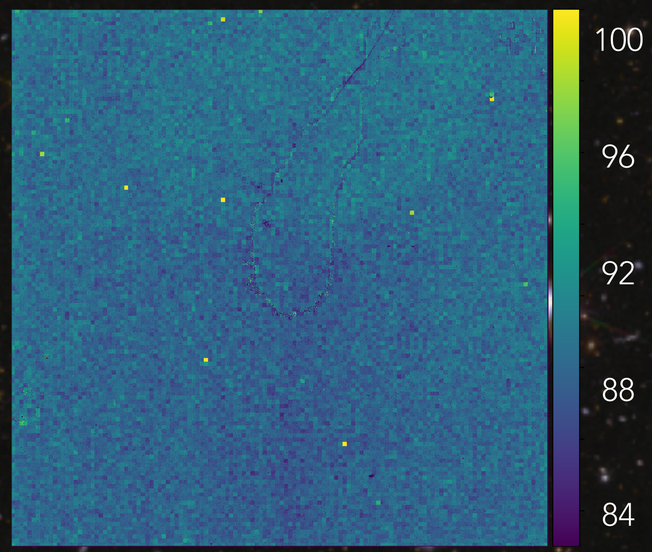
Readout noise (e rms)

Using IPC and gain measured at pixel level corrects most spatial variations

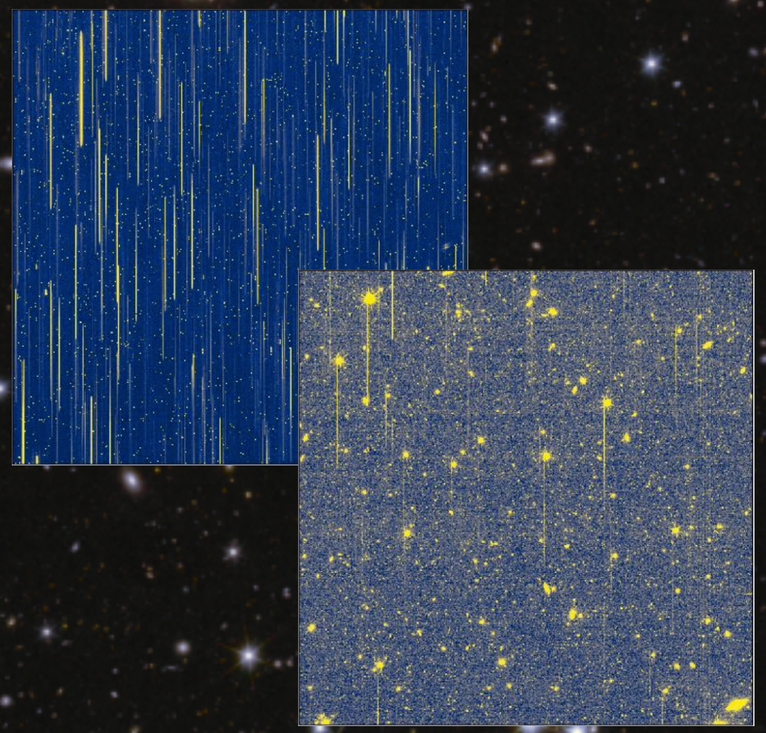
QE (% e/ph)







PERSISTENCE



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EUCLID commissioning

Complex phenomenon

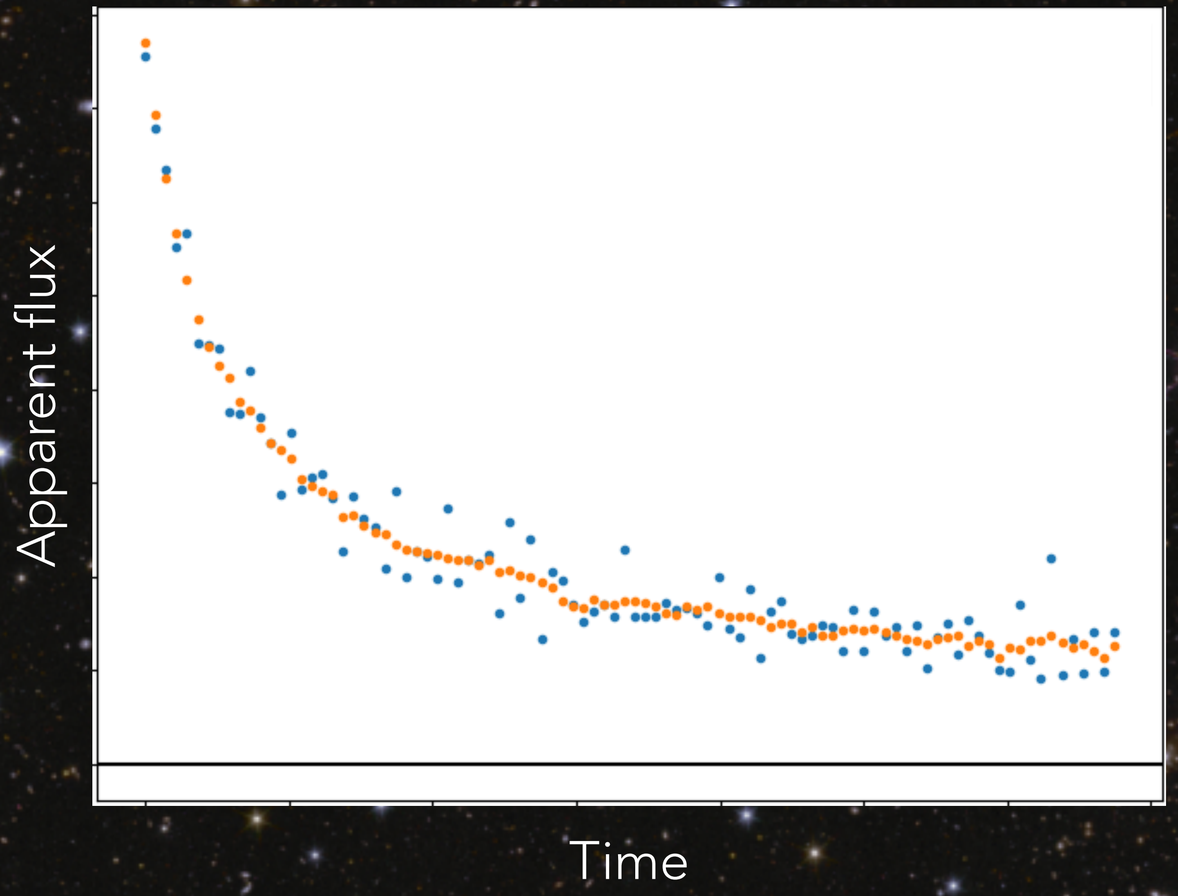
- Remnant signal from previous acquisitions
- Explained as trapping/detrapping of charges
- Both take place simultaneously
- Different types of traps related to defaults within material (dislocations, impurities, etc.)

Major risk for most missions

- Source misidentification, risking false detections
- Spectral misidentification, biased redshift
- Biased photometric measurement

HOW DO WE DEAL WITH PERSISTENCE

Pixel's response under dark after illumination



WG PERS

Persistence behavior

- Fast decrease
- May remain higher than sky for hours
- Adds up to other sources of signal
- Many dependencies: temperature, flux level, history, etc.

Possible strategies

- Masking: Euclid's current strategy
- Flagging for later consideration
- Correcting

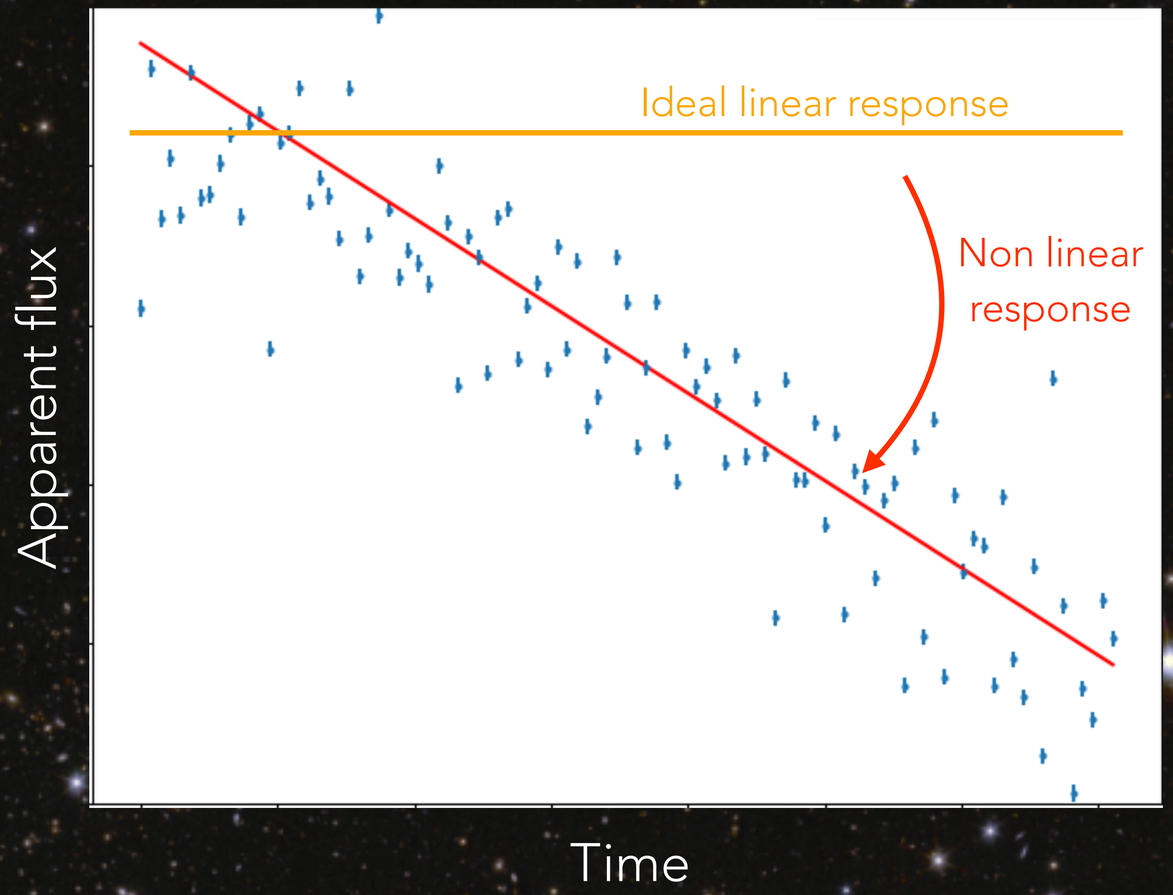
See other Euclid talks

PERSISTENCE

… AND ANTI-PERSISTENCE

Naomie De Araujo's PhD work

Pixel's response under illumination after dark



See results in Naomie's POSTER

PERSISTENCE

… AND ANTI-PERSISTENCE

Naomie De Araujo's PhD work

Anti-persistence behavior

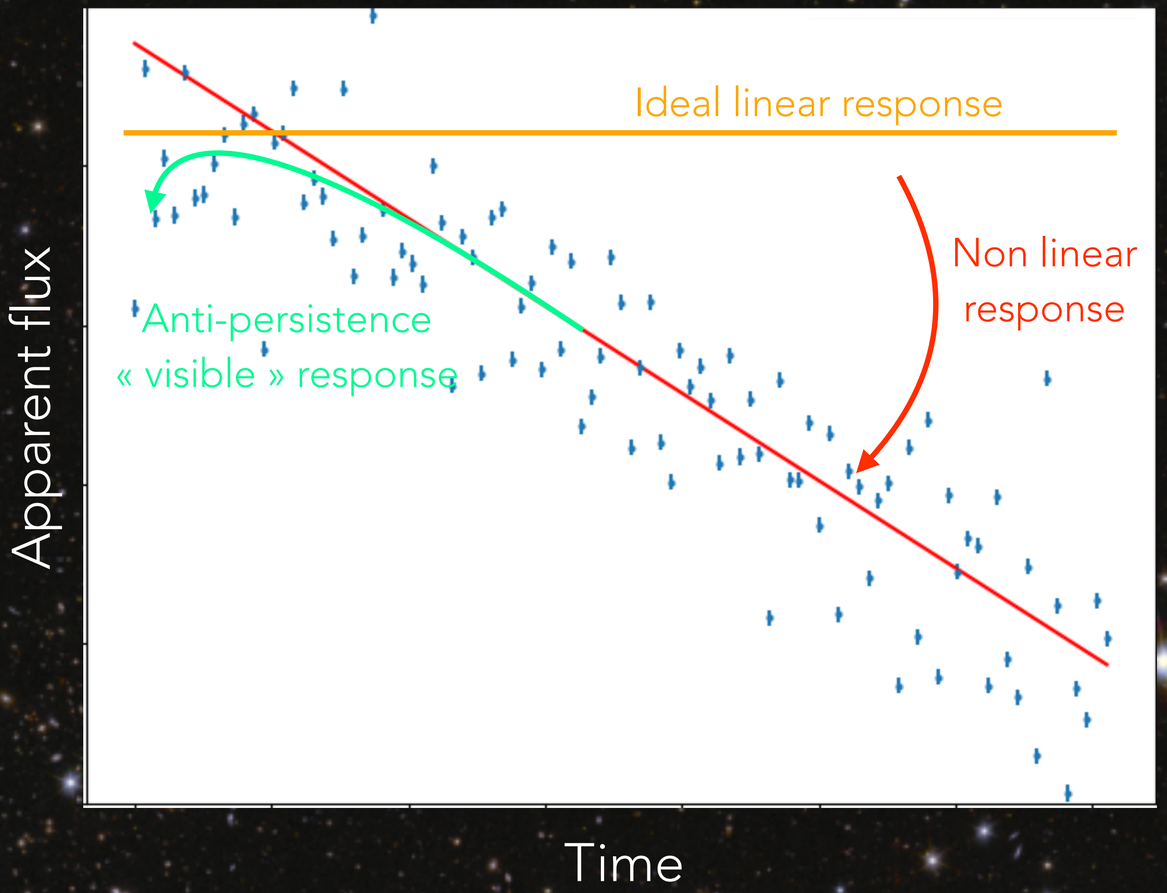
- Persistence counter-part
- Same origin
- Same dependencies

Possible strategies

- Not so simple to characterize
  - Need « perfect » control of environment
  - Need good statistics
- Difficult to decorrelate from other effects

See results in Naomie's POSTER

Pixel's response under illumination after dark



FINAL THOUGHTS

IMPROVING PERFORMANCE REQUIRES DECORRELATION OF VARIOUS EFFECTS:

- Interpixel capacitance
- Non-linearity
- Persistence
- And others

gain decorrelated from IPC and NL
= 9.5% bias corrected on flux

THROUGH MODELING AND CHARACTERIZING INDIVIDUAL PIXELS' RESPONSE

COMING UP NEXT AT CPPM:

- Explore dependencies
- Put together dedicated tests to study anti-persistence
- Propose pixel response model that includes (anti-)persistence