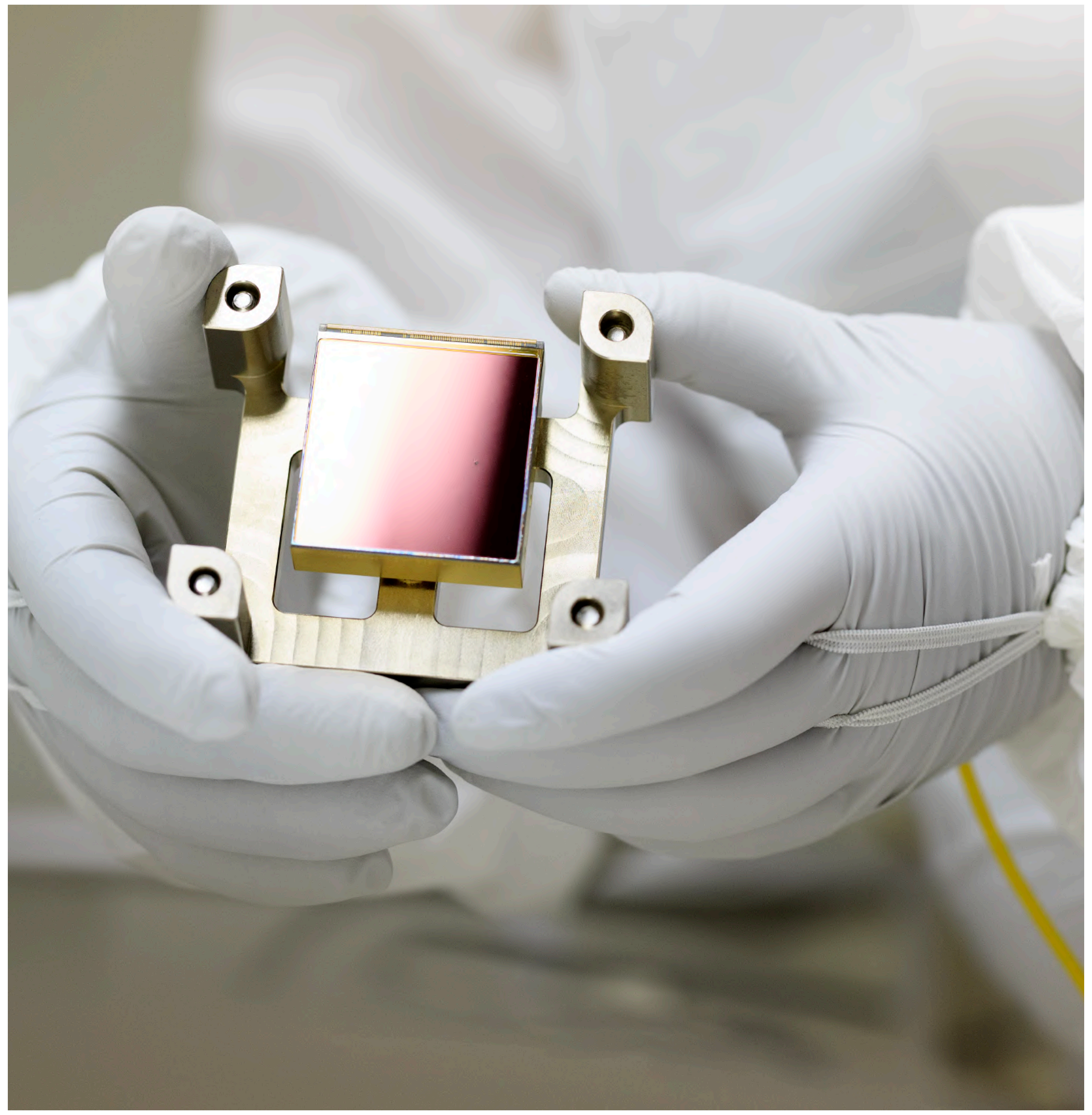
# Euclid NISP H2RGs: spatial insight into their performance from ground characterization



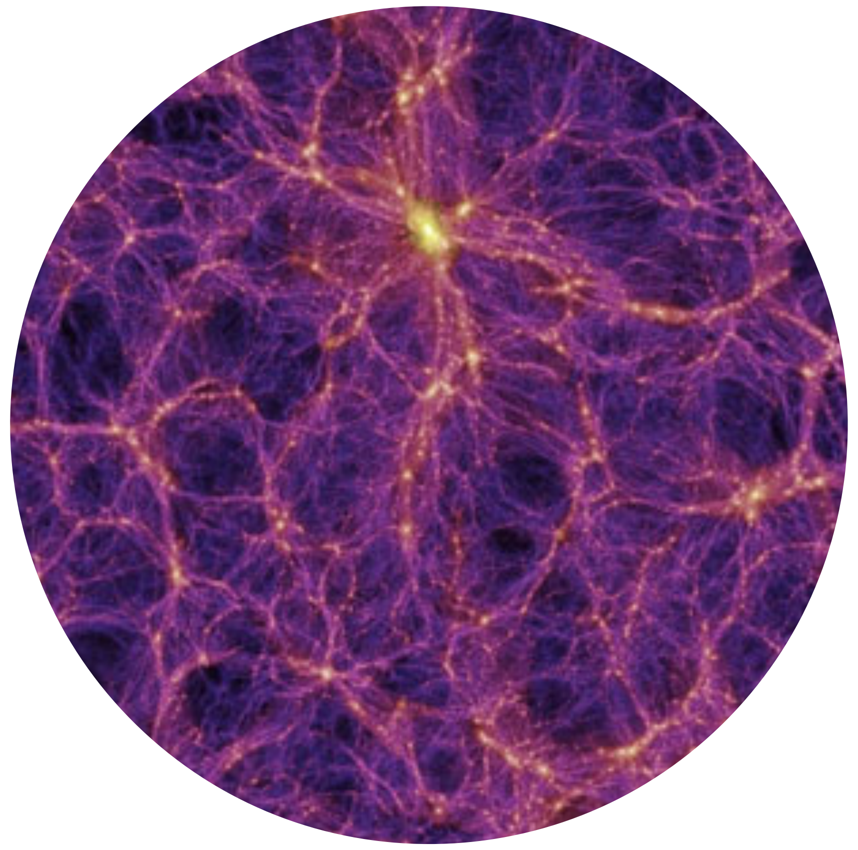
*Jean Le Graët - CNRS/IN2P3 - CPPM - CNES*

*On behalf of the Euclid NISP detector team*

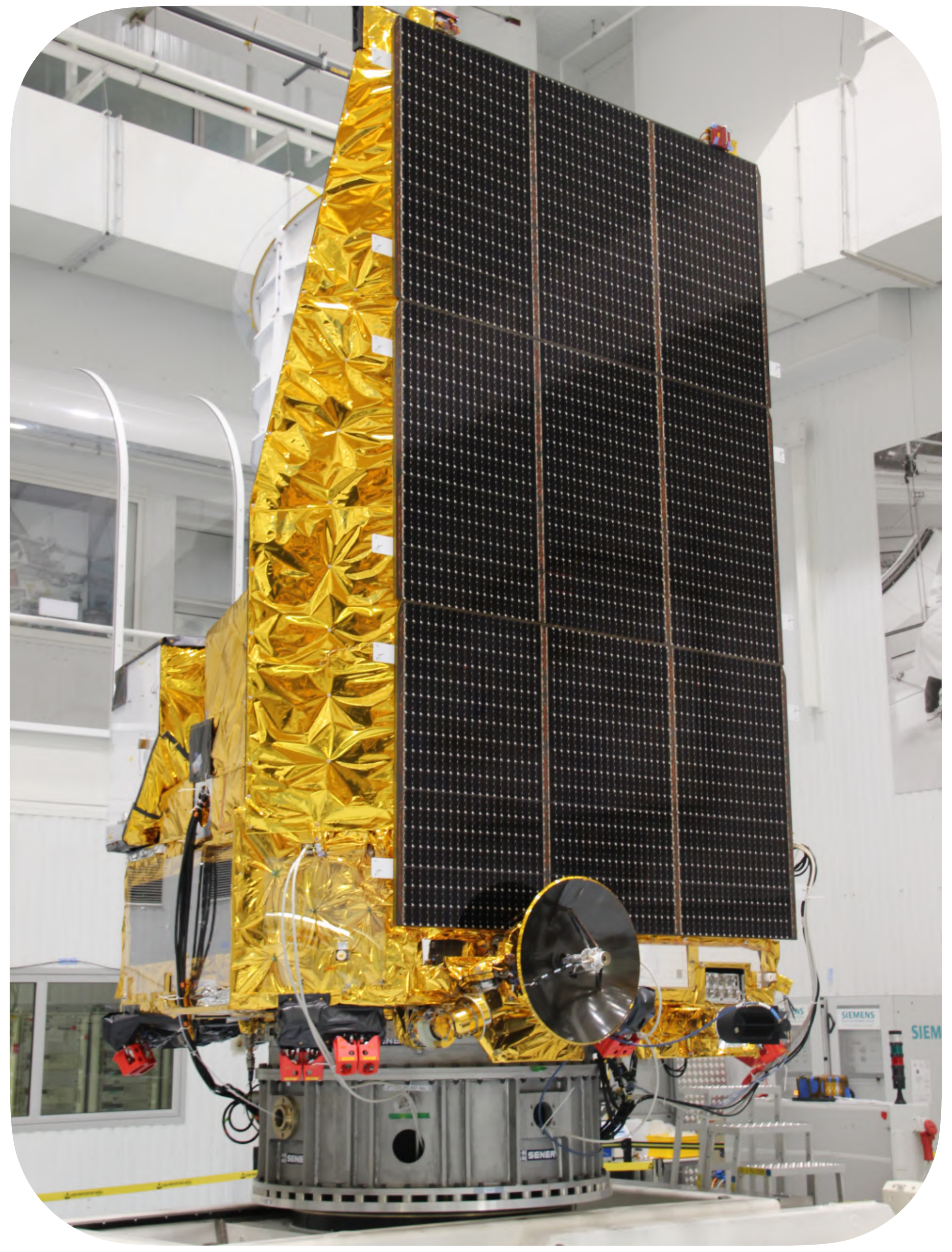
*Phd Thesis funded by CNES/CNRS*

*Contact :*
**legraet@cppm.in2p3.fr**
**secroun@cppm.in2p3.fr**

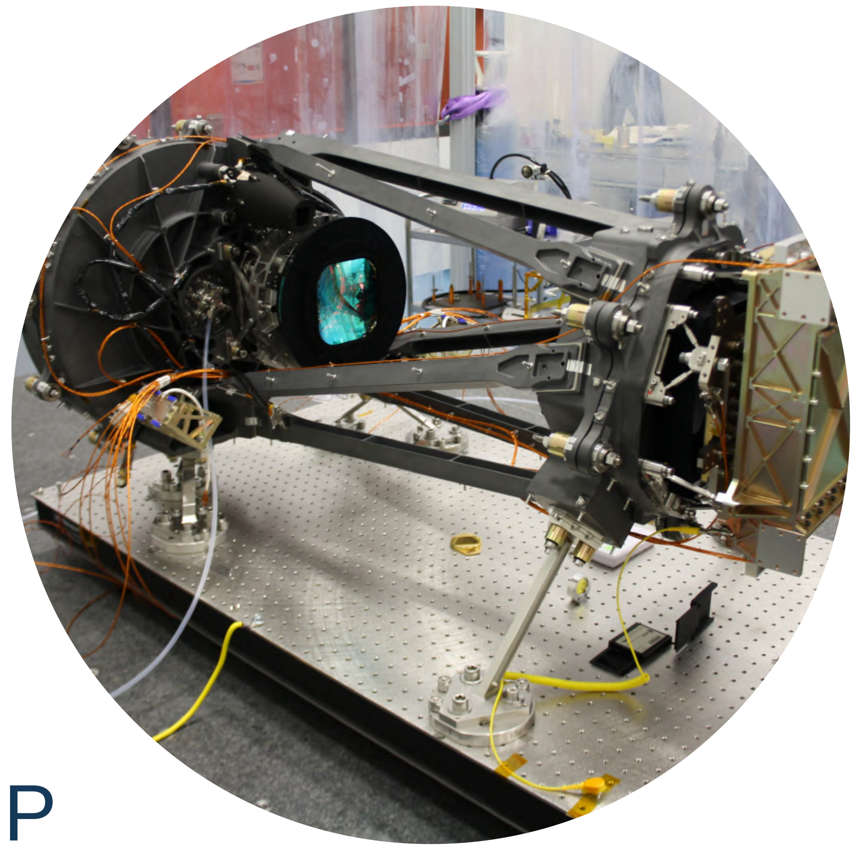
# Euclid mission and NISP Instrument



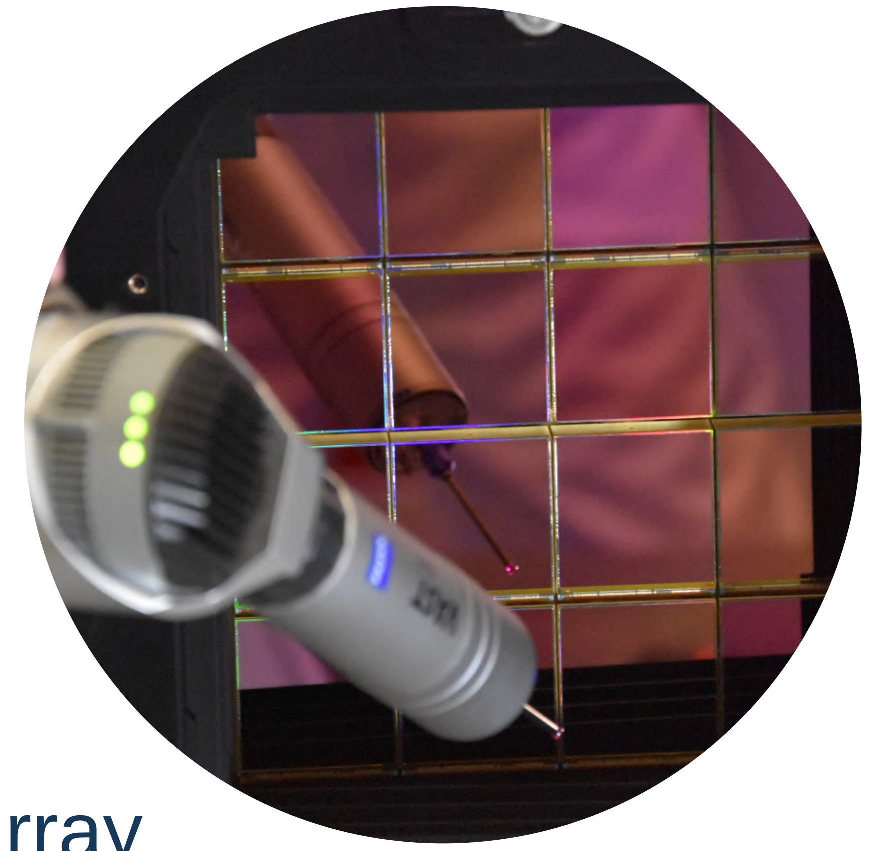
Large scale structure



Euclid



NISP



Focal plane array

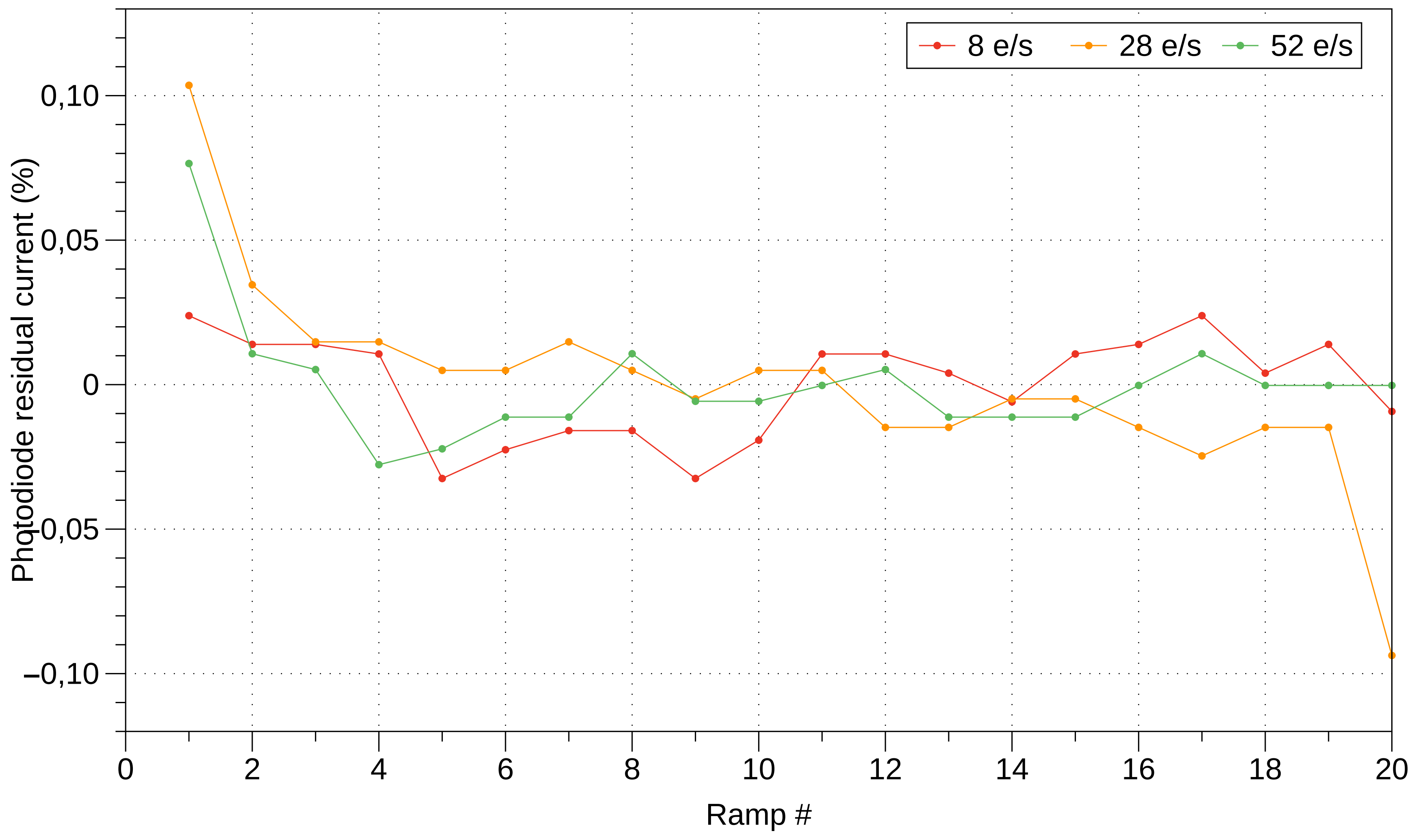
## Euclid scientific goal :

- Dark matter and dark energy distribution
- Survey of 15000 sq deg
- Weak lensing with VIS (Visible imager)
- Galaxy clustering with NISP

## Near-infrared spectro-photometer (NISP)

- 16 x H2RG 2.3 µm cutoff (2k x 2k)
- 32 channels readout at 100 kHz
- Operating temperature ~ 100K
- Measurements of 40 millions galaxies' redshifts
  - 95% operable pixels
  - Relative error on flux <1% after correction

# Characterization at CPPM




## Strategy

- 45 days of acquisitions per detector
- Varying environment (Flux, illumination history, T)
- Electrical tests
- 500 Tb of data produced

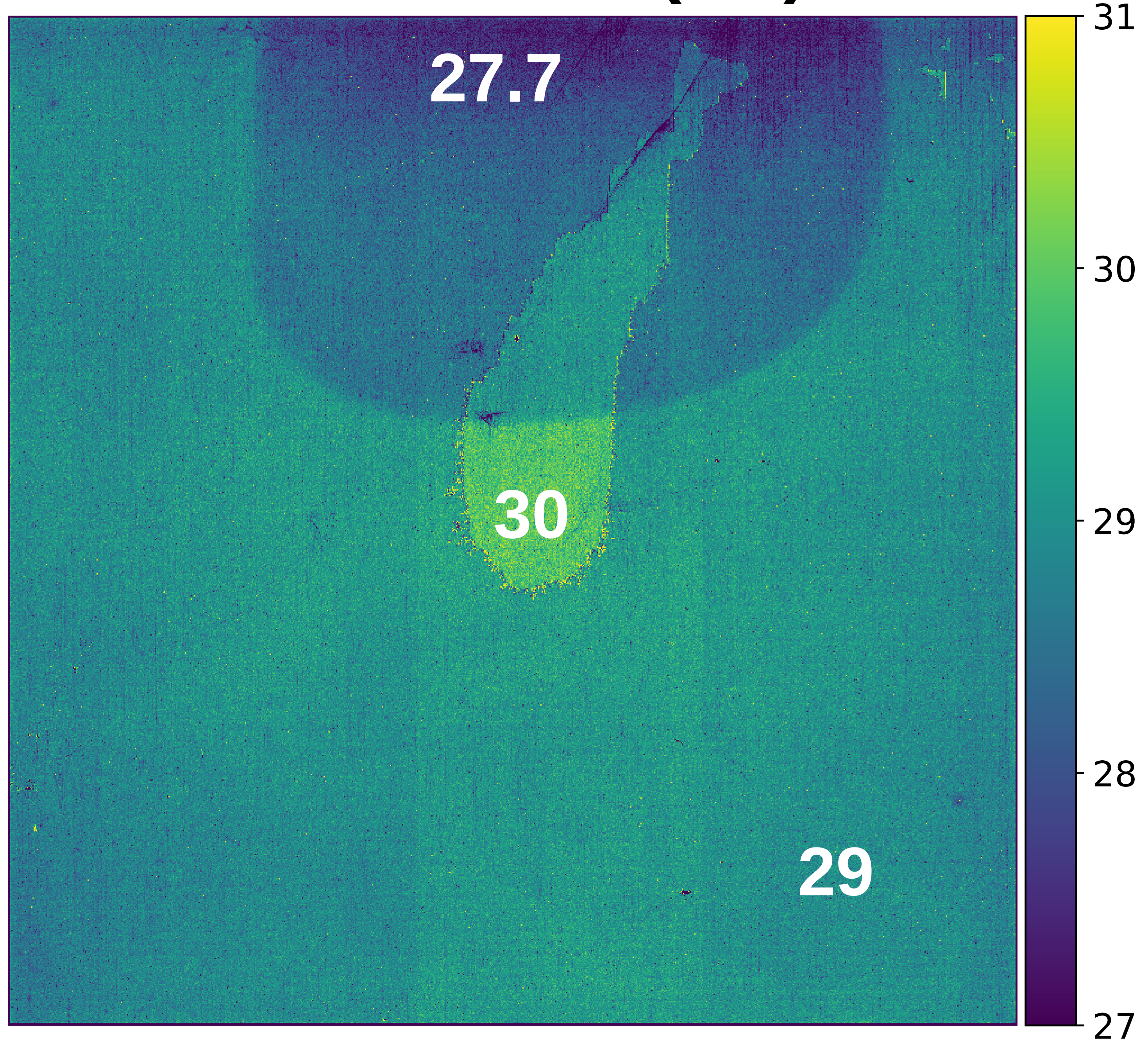
## Bench performance

- FPA thermal stability < 2mK
- Dark ~ 1e-3 e/s
- Flux variations < 0.1 % for 15h

  < 0.5% for 45 days
- FPA homogeneity < 1%

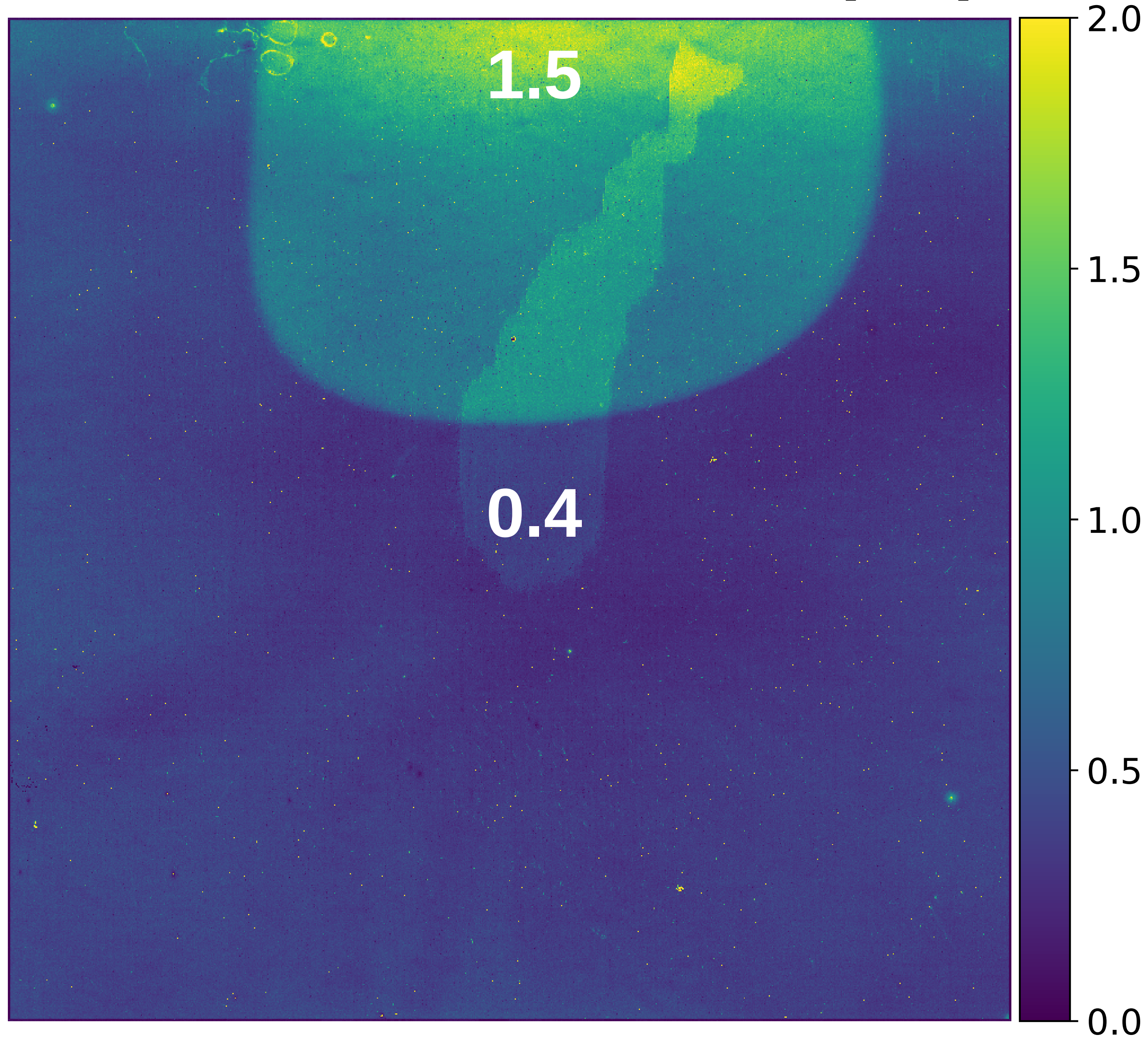
Flux (e/s) = gain*Flux (ADU/s)
Mean gain is used

### Flat field (e/s)



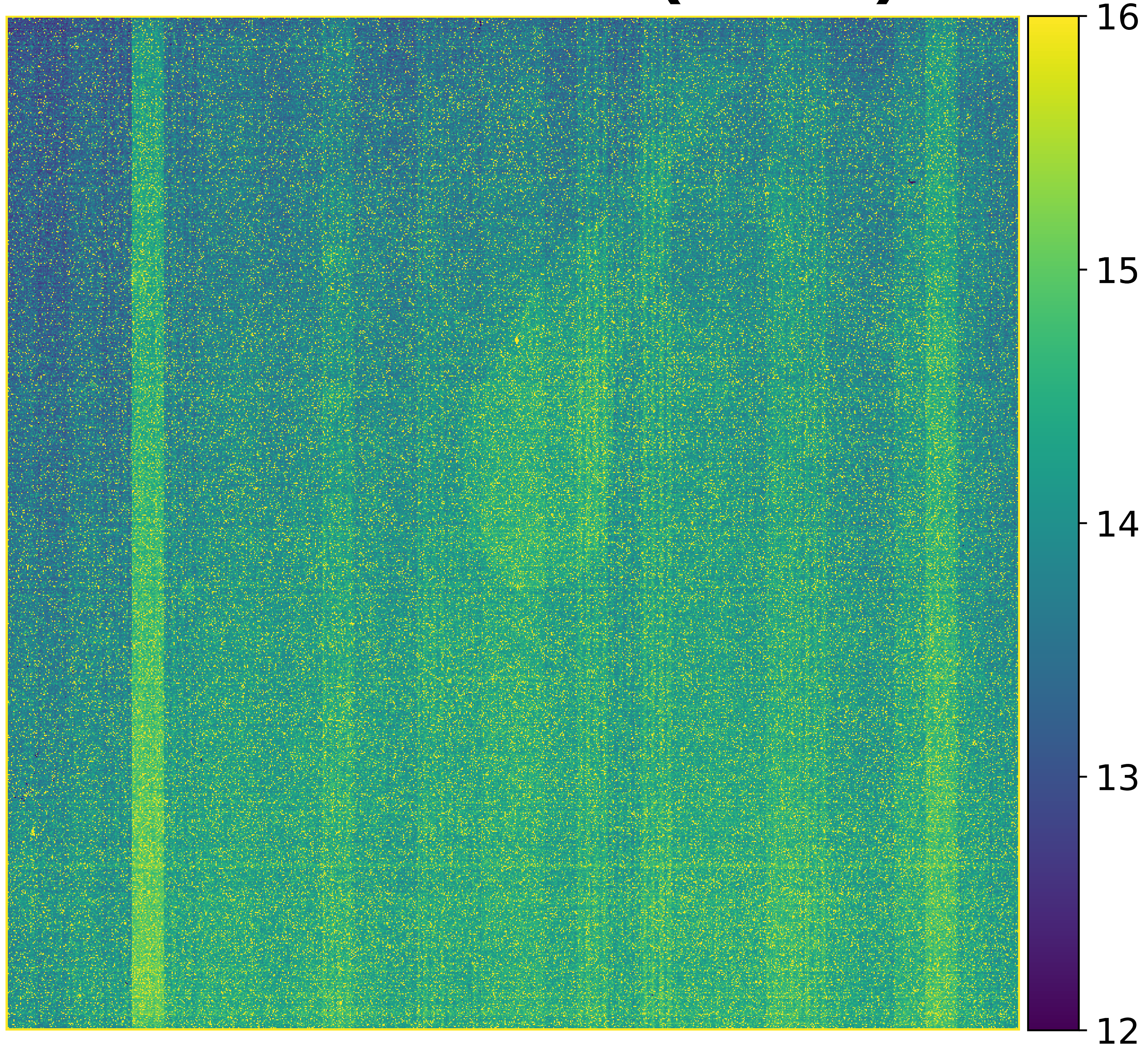

- Spatial variations ~ 8%
- Not coming from setup
- Where from?

### Dark after flat field (e/s)




- Spatial variations > 100%
- Flux higher in "Lake"
- Suggests "Lake" due to latency

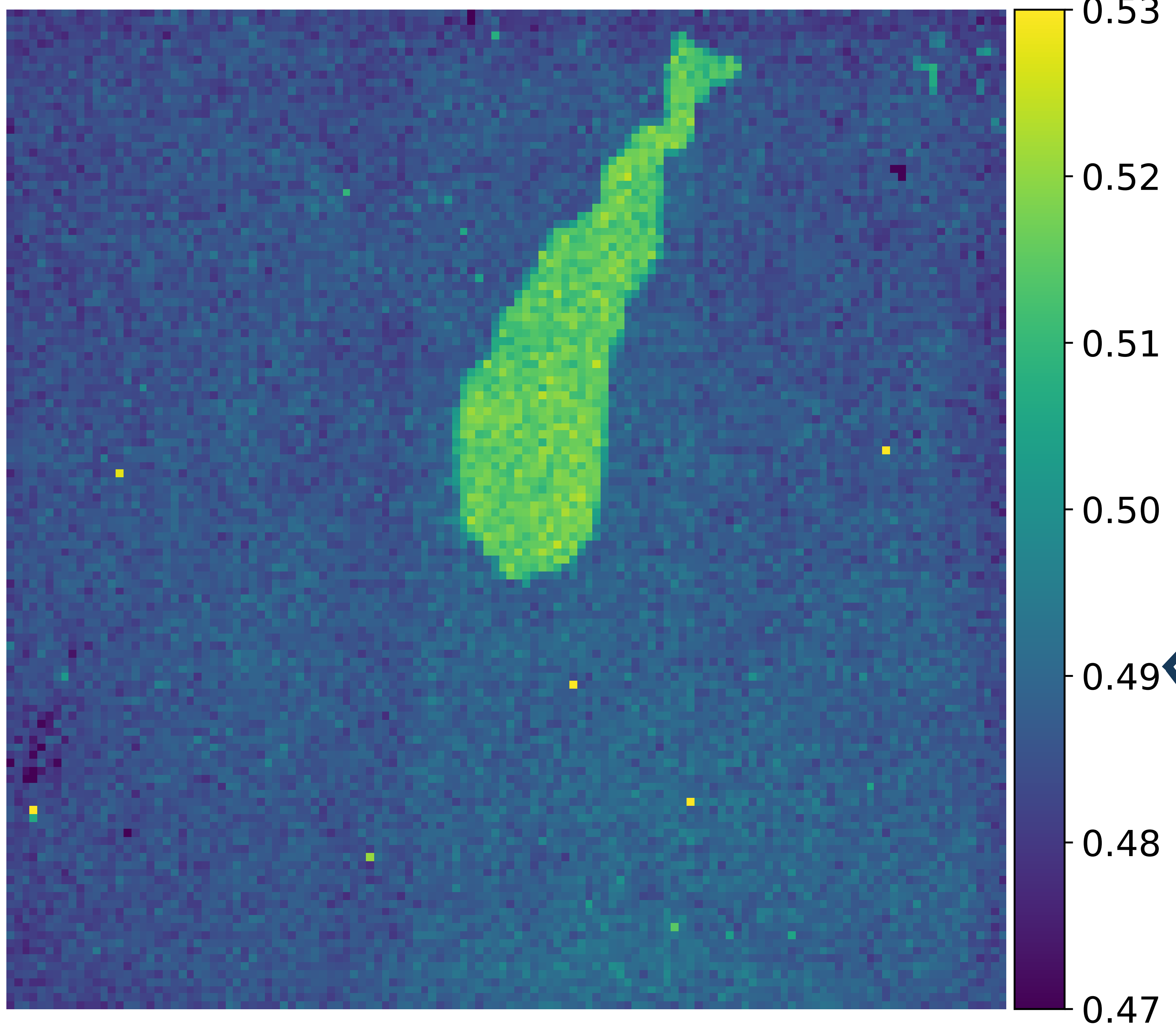
### Read noise (e rms)




- Channel amplifier induces variations
- "Fish" visible

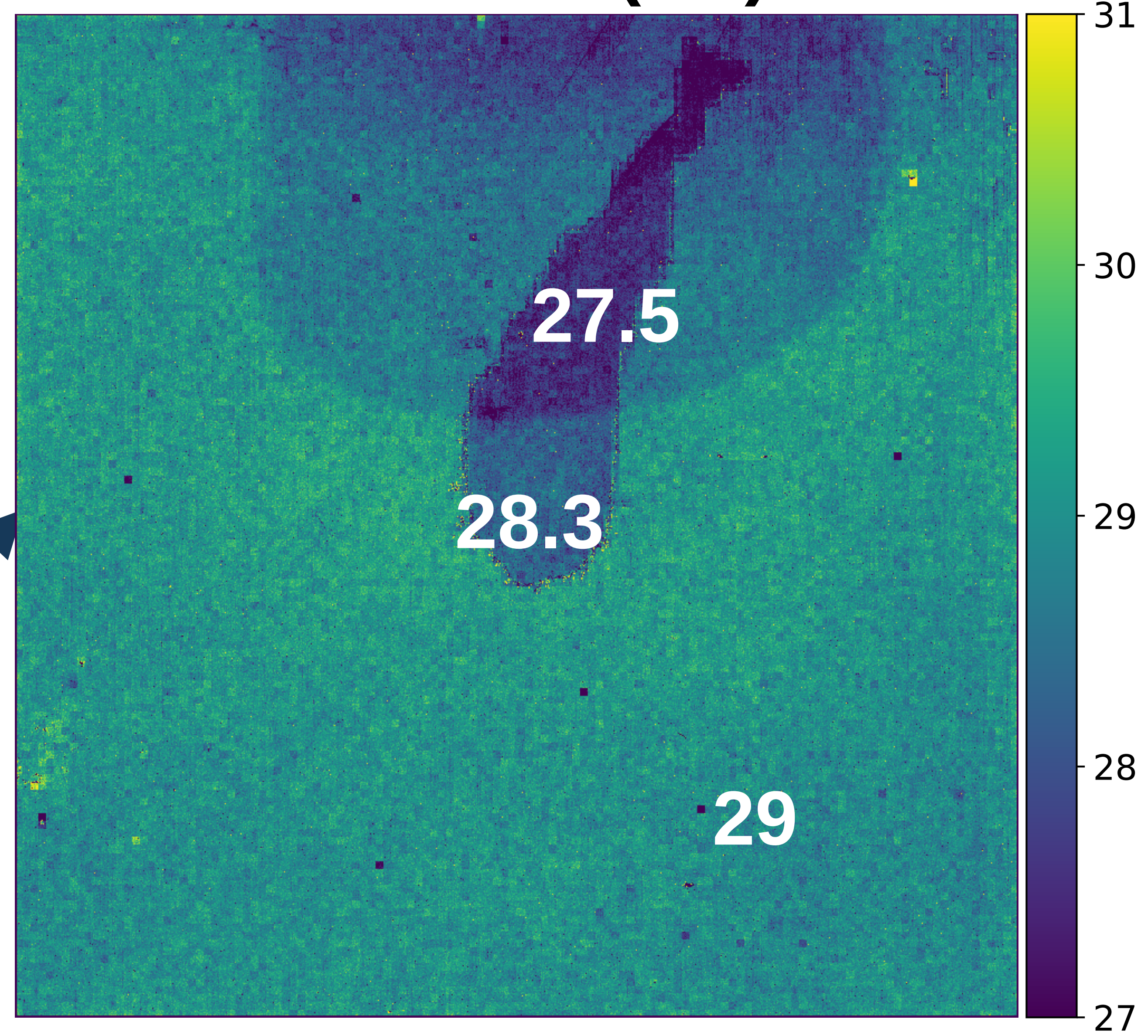
→ **We need to apply spatial flux correction**

## Conversion gain (ADU/e)

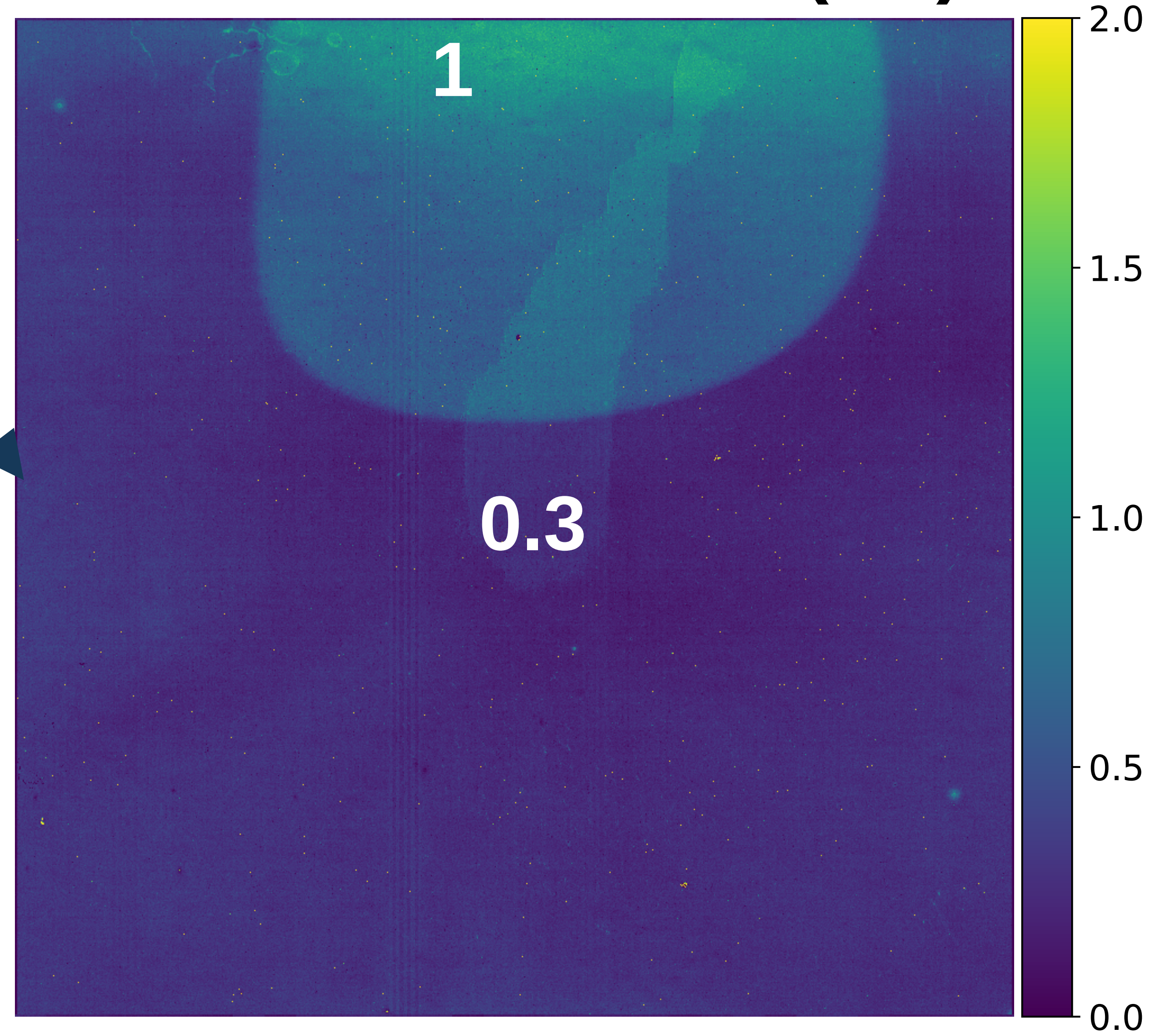



- Per superpixel gain
- Measure by mean variance curve
- First 100 frames cut to limit latency
- Used to spatially correct flux

## Flat field (e/s)




## Dark after flat field (e/s)




- Using per superpx gain spatial variations ~ 5%
- Aside latency variations Fish - Back ~ 2.4 %
- Originates elsewhere

**First assumption:**

**Inter Pixel Capacitance**

# Inter Pixel Capacitance

### Photons

| | | |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 100 | 0 |
| 0 | 0 | 0 |

### Without IPC

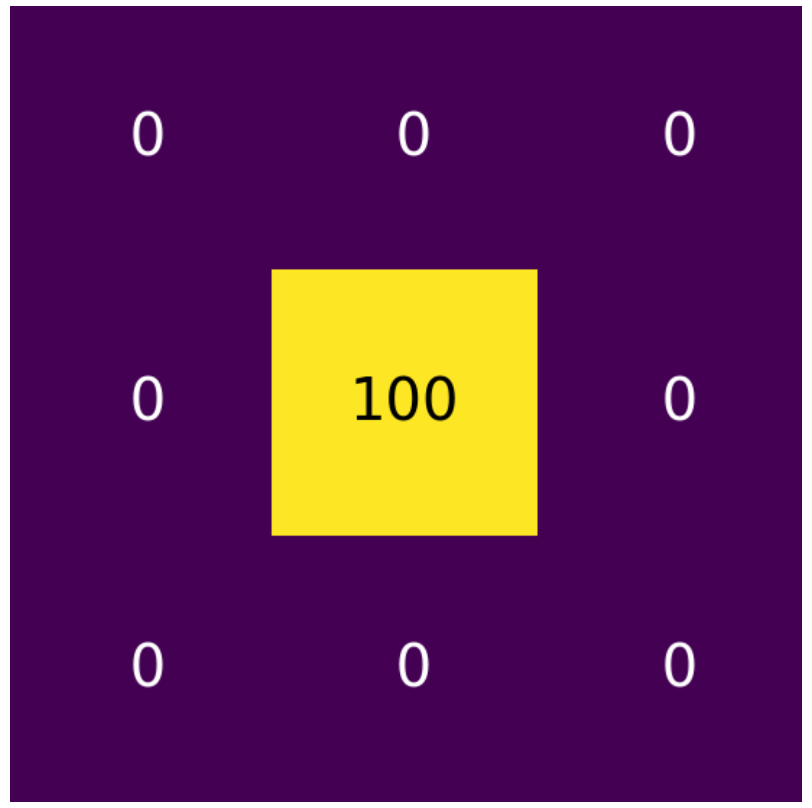
| | | |
|---|---|---|
| 0.0 | 0.0 | 0.0 |
| 0.0 | 100.0 | 0.0 |
| 0.0 | 0.0 | 0.0 |

### With IPC

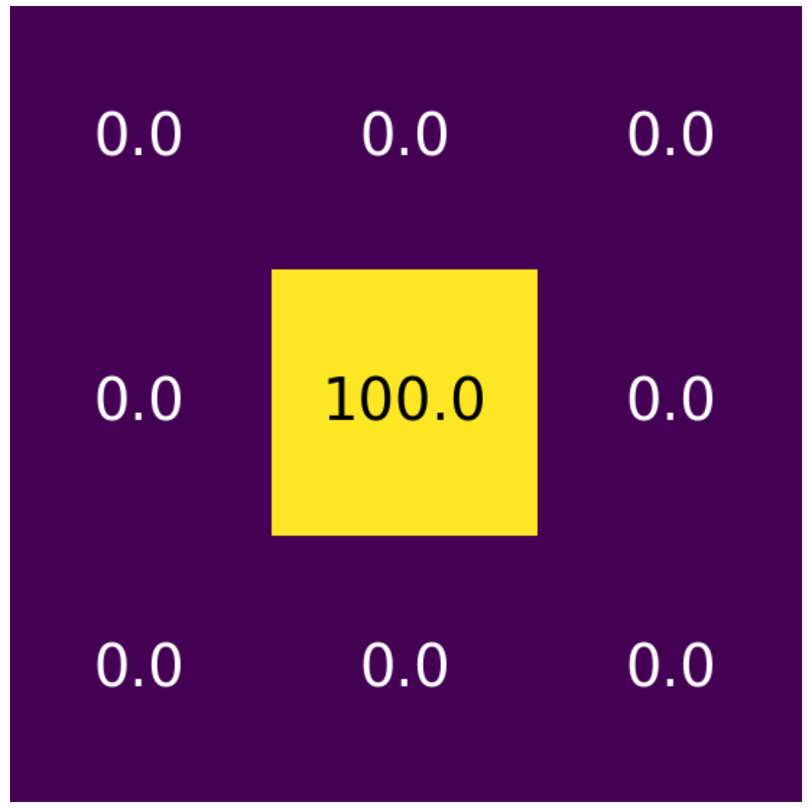
| | | |
|---|---|---|
| 0.057 | 0.676 | 0.055 |
| 0.623 | 97.125 | 0.658 |
| 0.050 | 0.695 | 0.048 |

**Detected signal (V)**

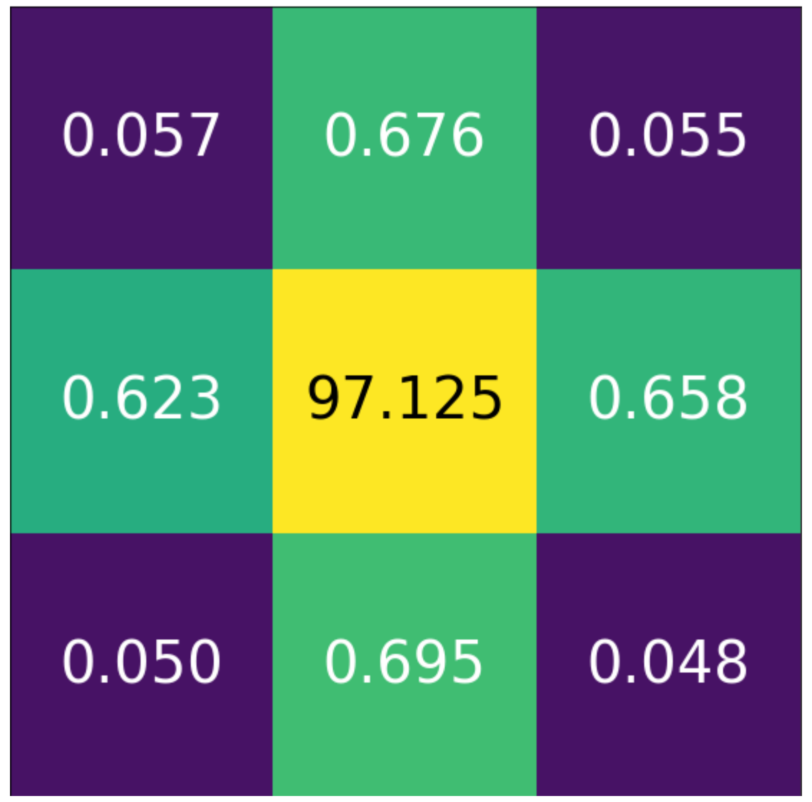
## Photons




## Without IPC




## With IPC




**Detected signal (V)**

Autocorrelation method biased our measure

### Photons

| | | |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 100 | 0 |
| 0 | 0 | 0 |

### Without IPC

| | | |
|---|---|---|
| 0.0 | 0.0 | 0.0 |
| 0.0 | 100.0 | 0.0 |
| 0.0 | 0.0 | 0.0 |

### With IPC

| | | |
|---|---|---|
| 0.057 | 0.676 | 0.055 |
| 0.623 | 97.125 | 0.658 |
| 0.050 | 0.695 | 0.048 |

**Detected signal (V)**

IPC have to be decorrelate from charge diffusion

Autocorrelation method biased our measure

# Inter Pixel Capacitance measurement

**Photons**

| | | |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 100 | 0 |
| 0 | 0 | 0 |

**Without IPC**

| | | |
|---|---|---|
| 0.0 | 0.0 | 0.0 |
| 0.0 | 100.0 | 0.0 |
| 0.0 | 0.0 | 0.0 |

**With IPC**

| | | |
|---|---|---|
| 0.057 | 0.676 | 0.055 |
| 0.623 | 97.125 | 0.658 |
| 0.050 | 0.695 | 0.048 |

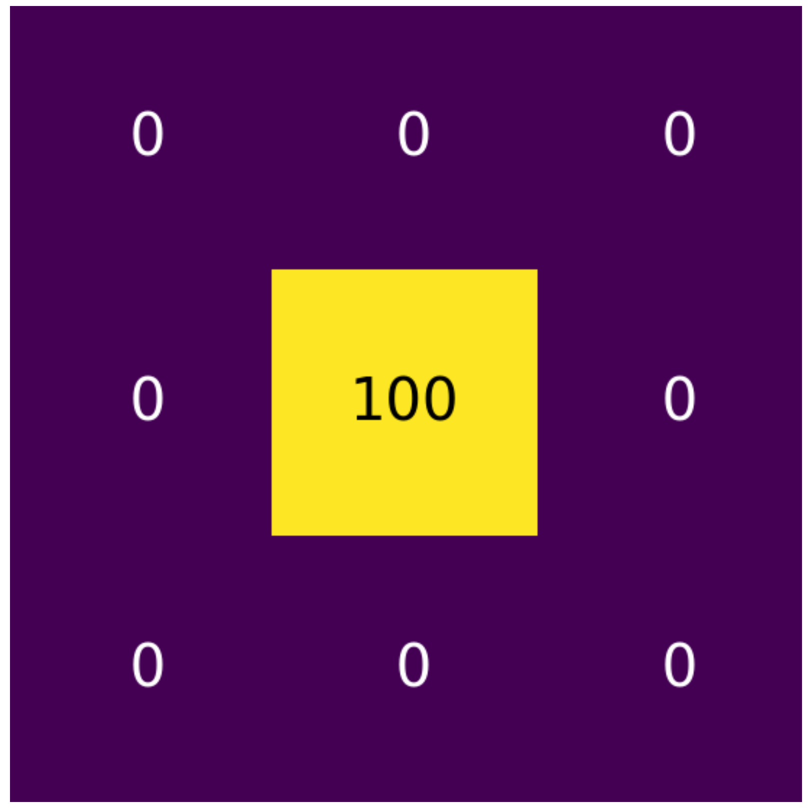
**Detected signal (V)**

IPC have to be decorrelate from charge diffusion

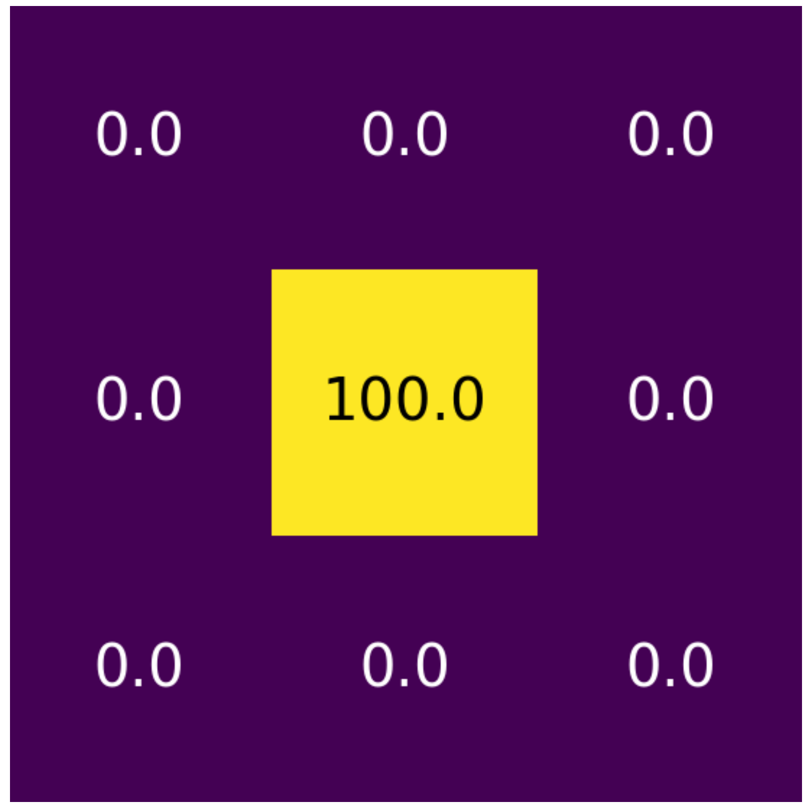
Autocorrelation method biased our measure

Per pixel IPC coefficients are needed

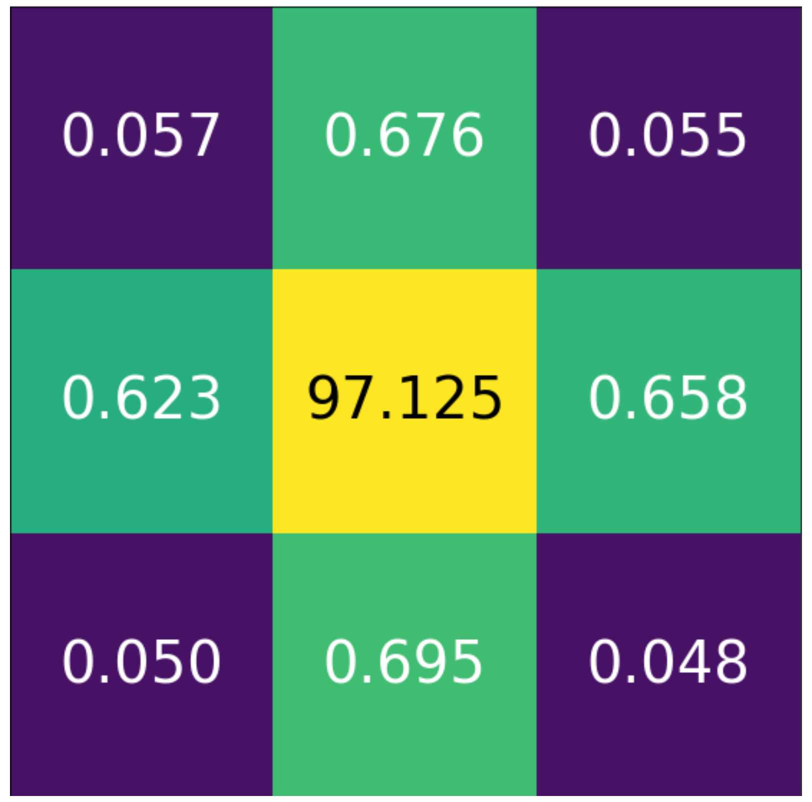
## Photons



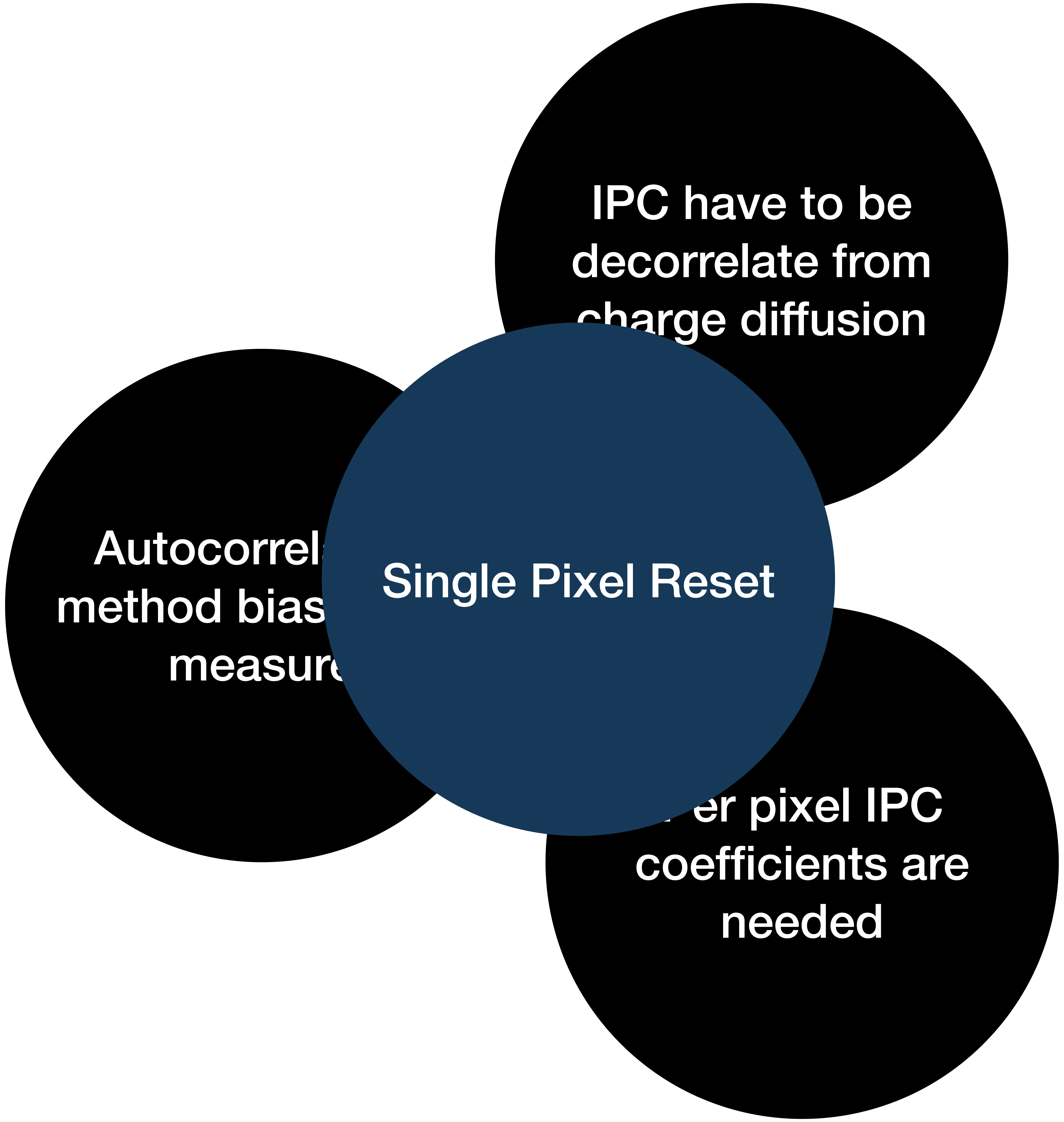

## Without IPC




## With IPC

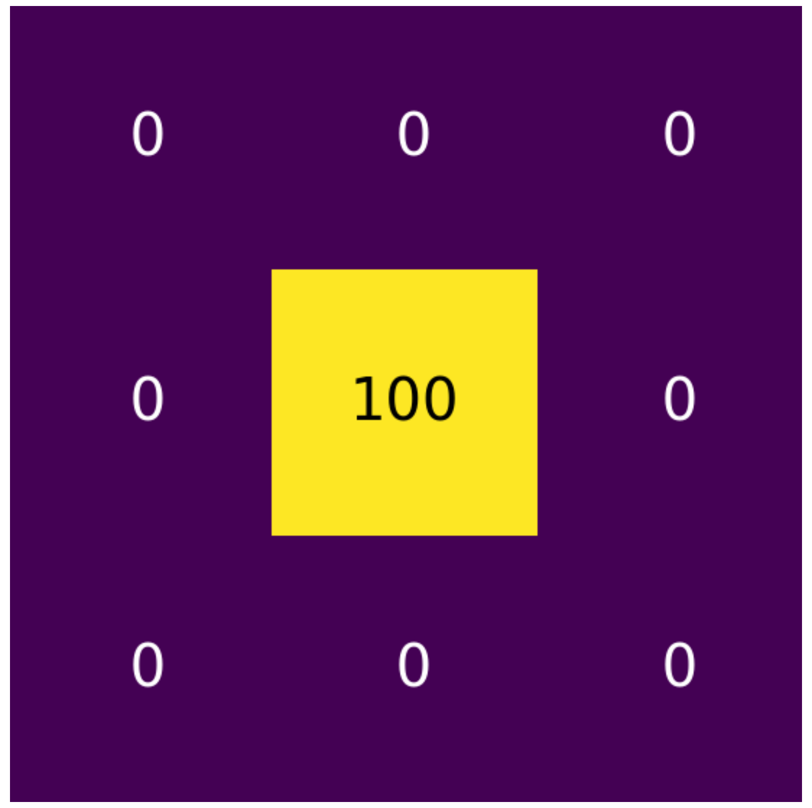



**Detected signal (V)**

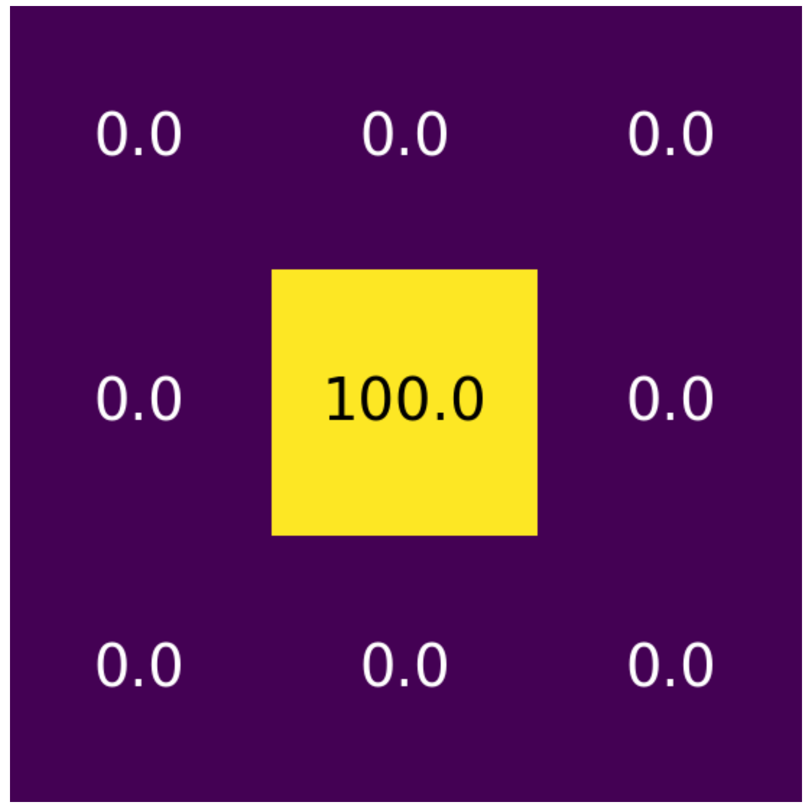


# Single Pixel Reset method

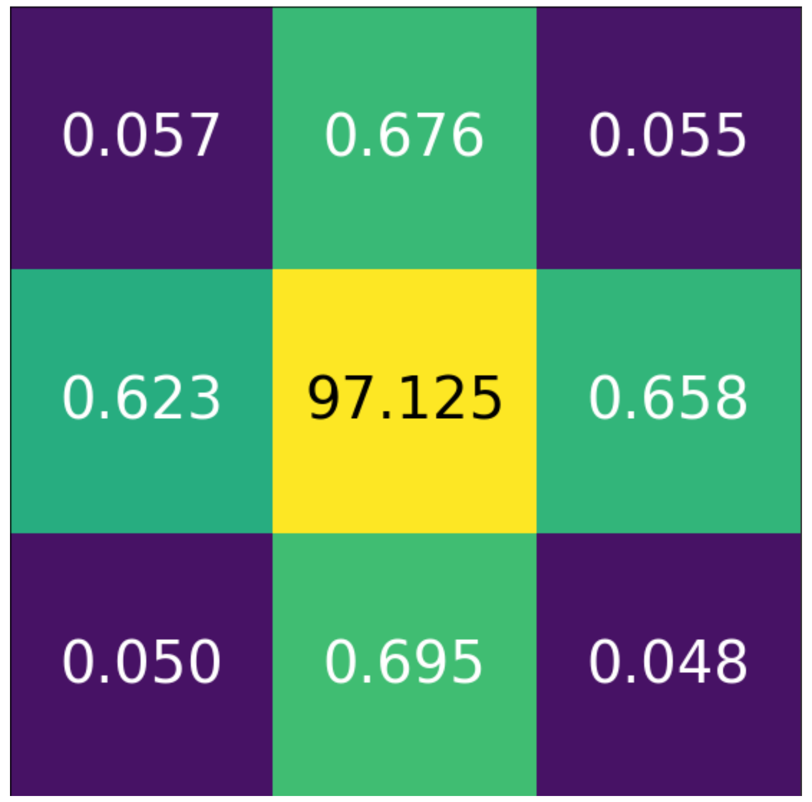
## Photons



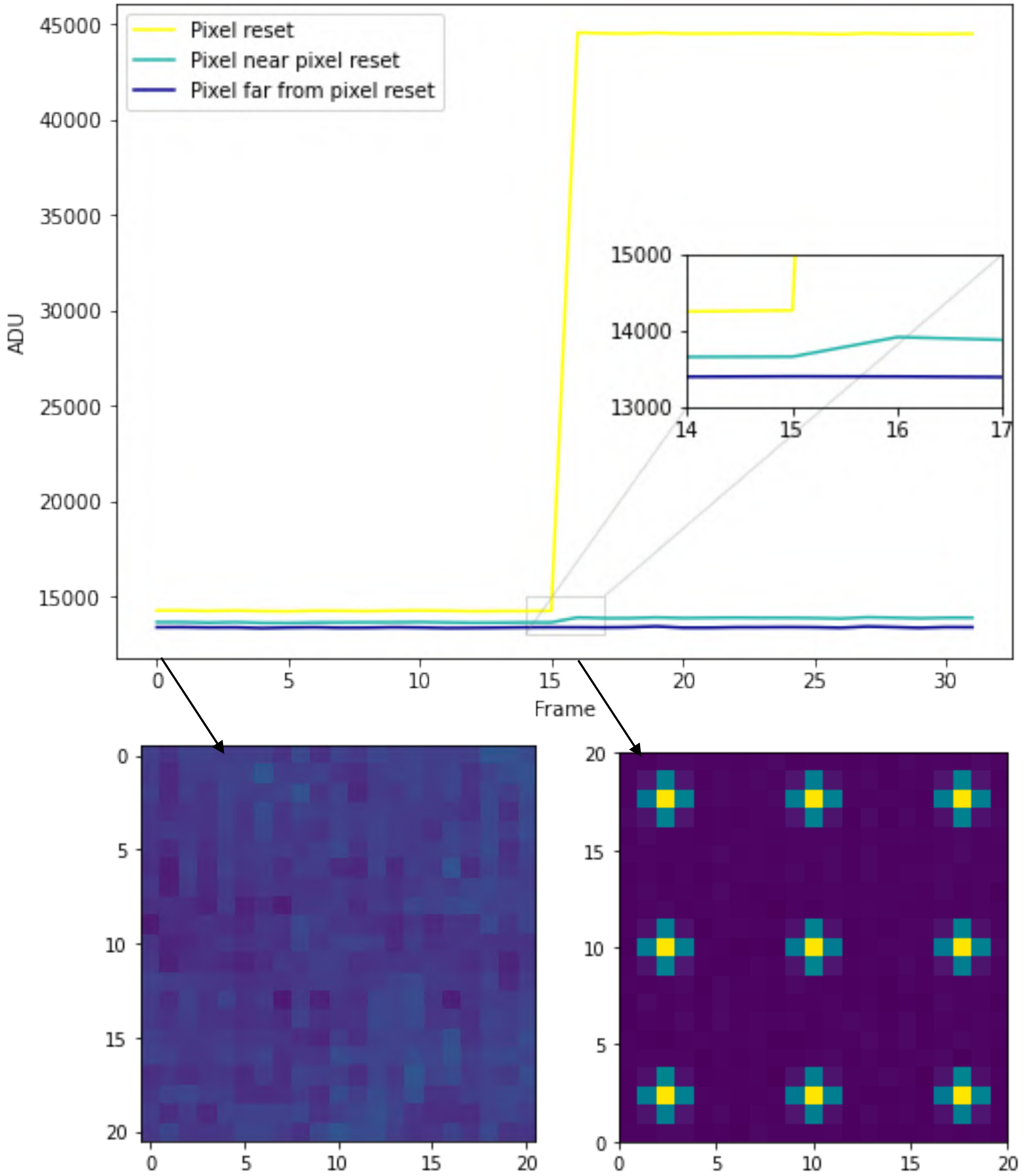

## Without IPC




## With IPC



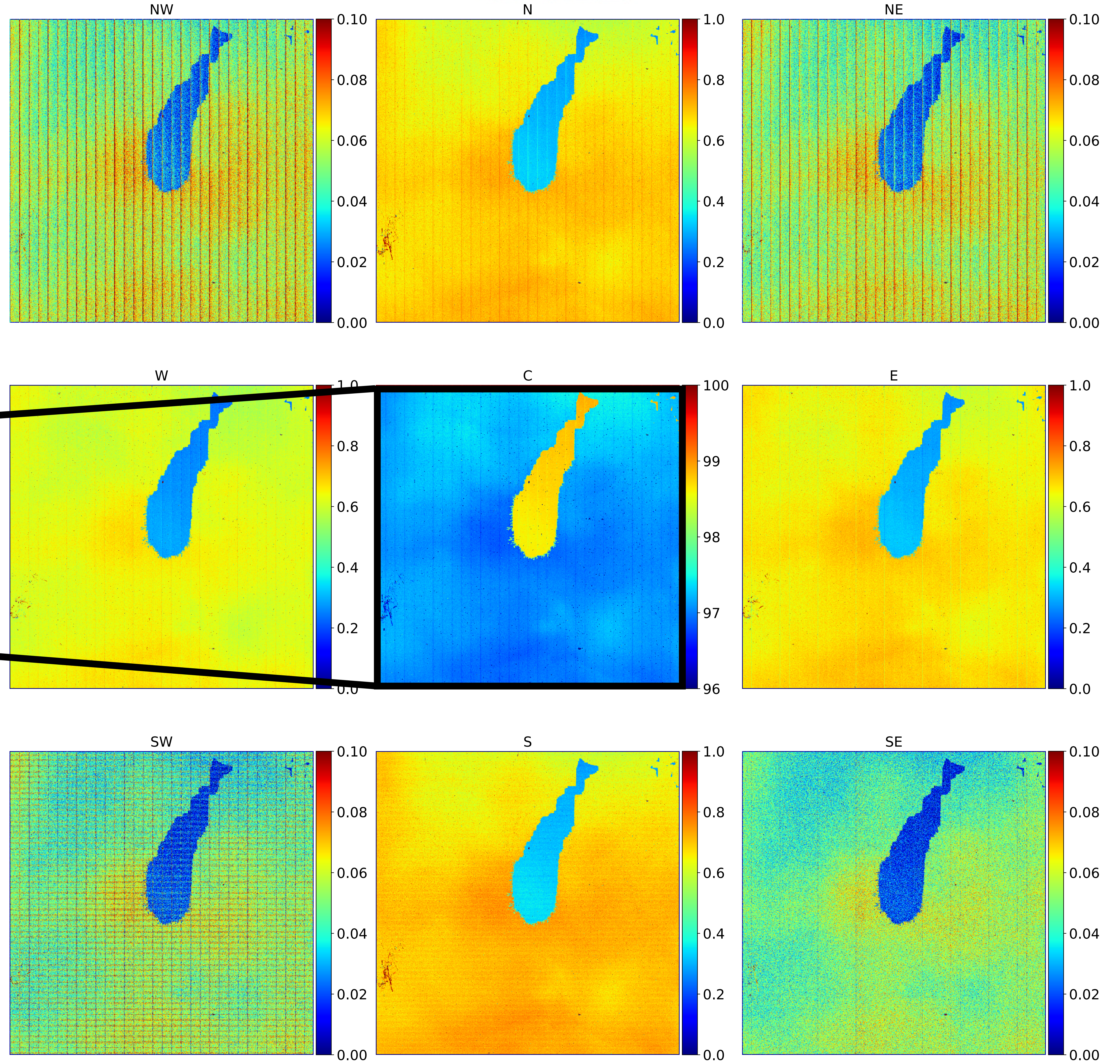

**Detected signal (V)**



# IPC Coefficient

| | | |
|---|---|---|
| 0.057 | 0.676 | 0.055 |
| 0.623 | 97.125 | 0.658 |
| 0.050 | 0.695 | 0.048 |

**For all the pixels**



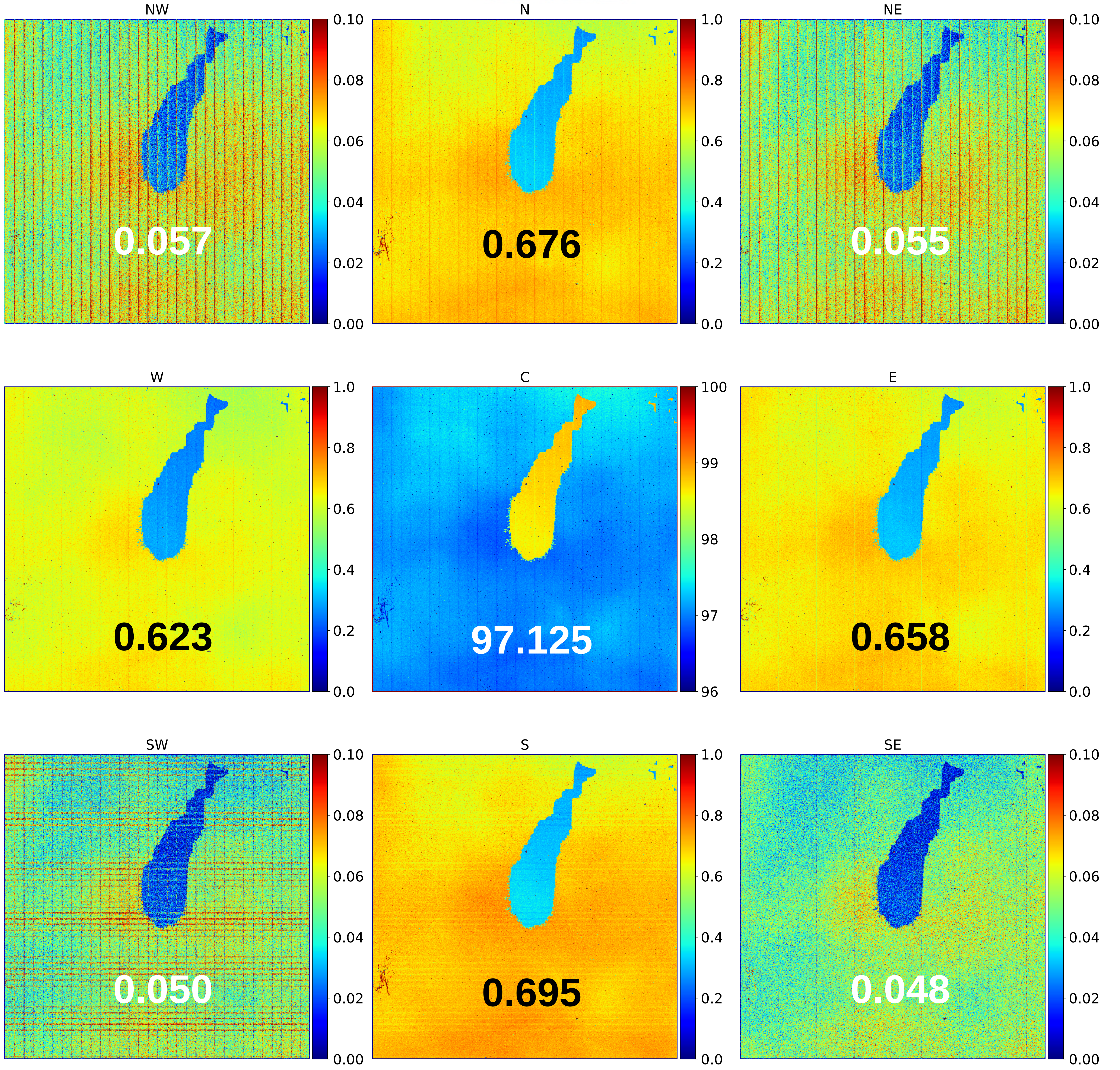
- Central pixel looses 2.87 % of signal (median)

- Difference between cross coefficient ~11%

  **Cross coefficients needs to be different**

- Diagonals coefficient >> uncertainty

  **May not be neglected**



- Fish IPC 120% < Back IPC

  **Originates from epoxy void**

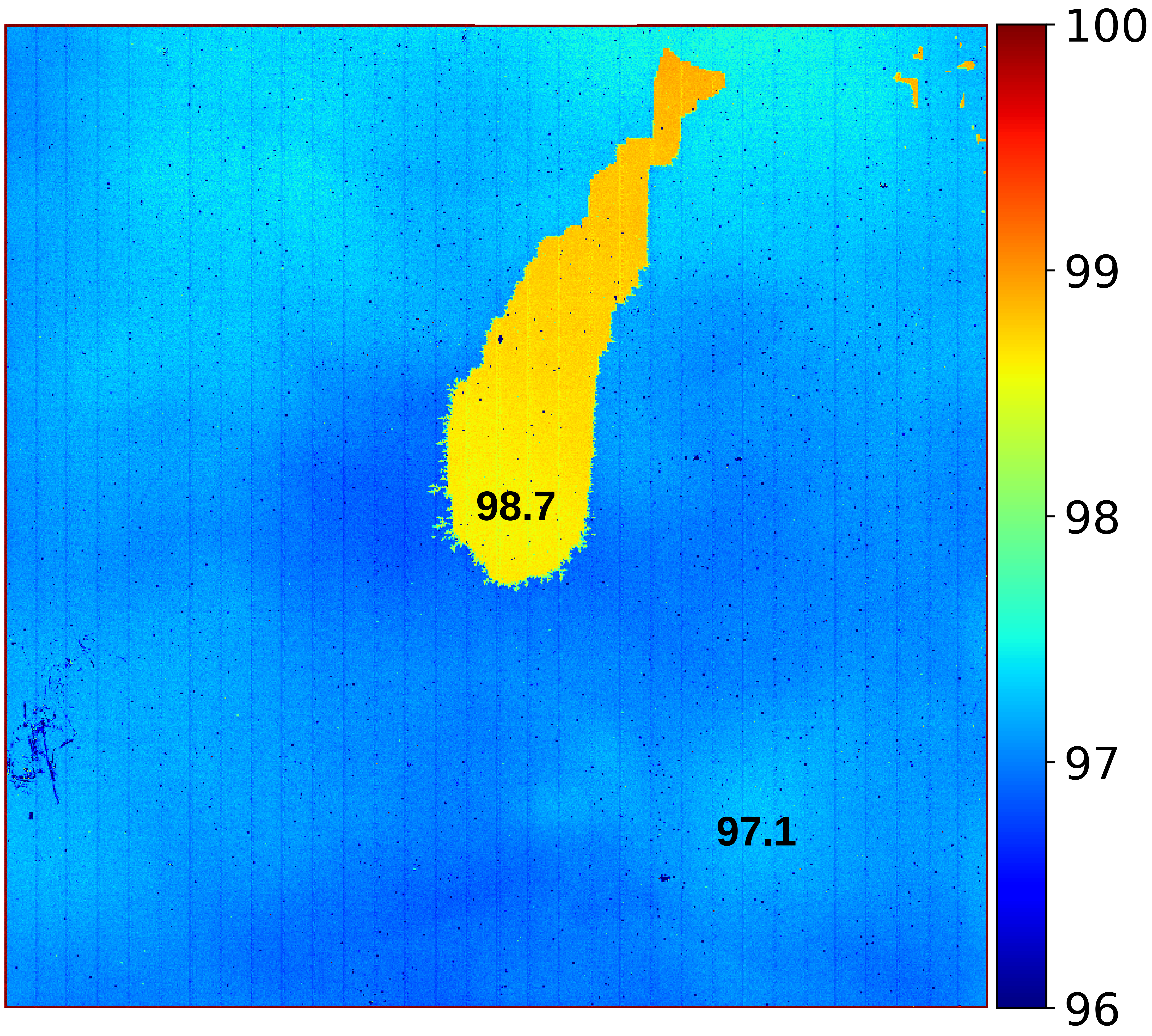
- Epoxy filled IPC variations > 20%

  **Per pixel coefficient mandatory**

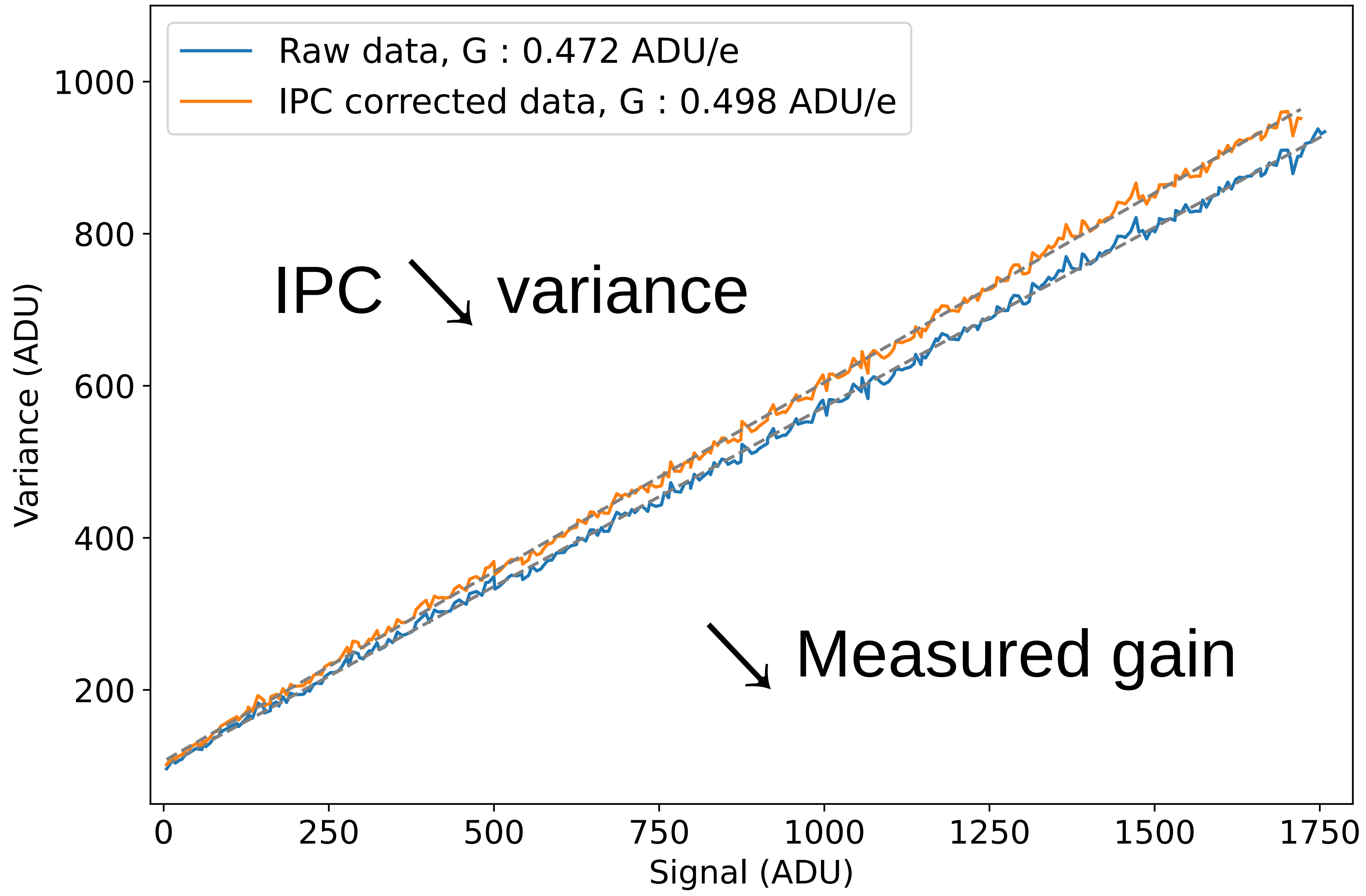
- First column of channels have larger IPC

Difference Fish - Back seems to come from IPC

**How does it affect flat field?**



# Decorrelate CG — IPC




## Original correction :

3x3 IPC coefficient

+

Moore formalism

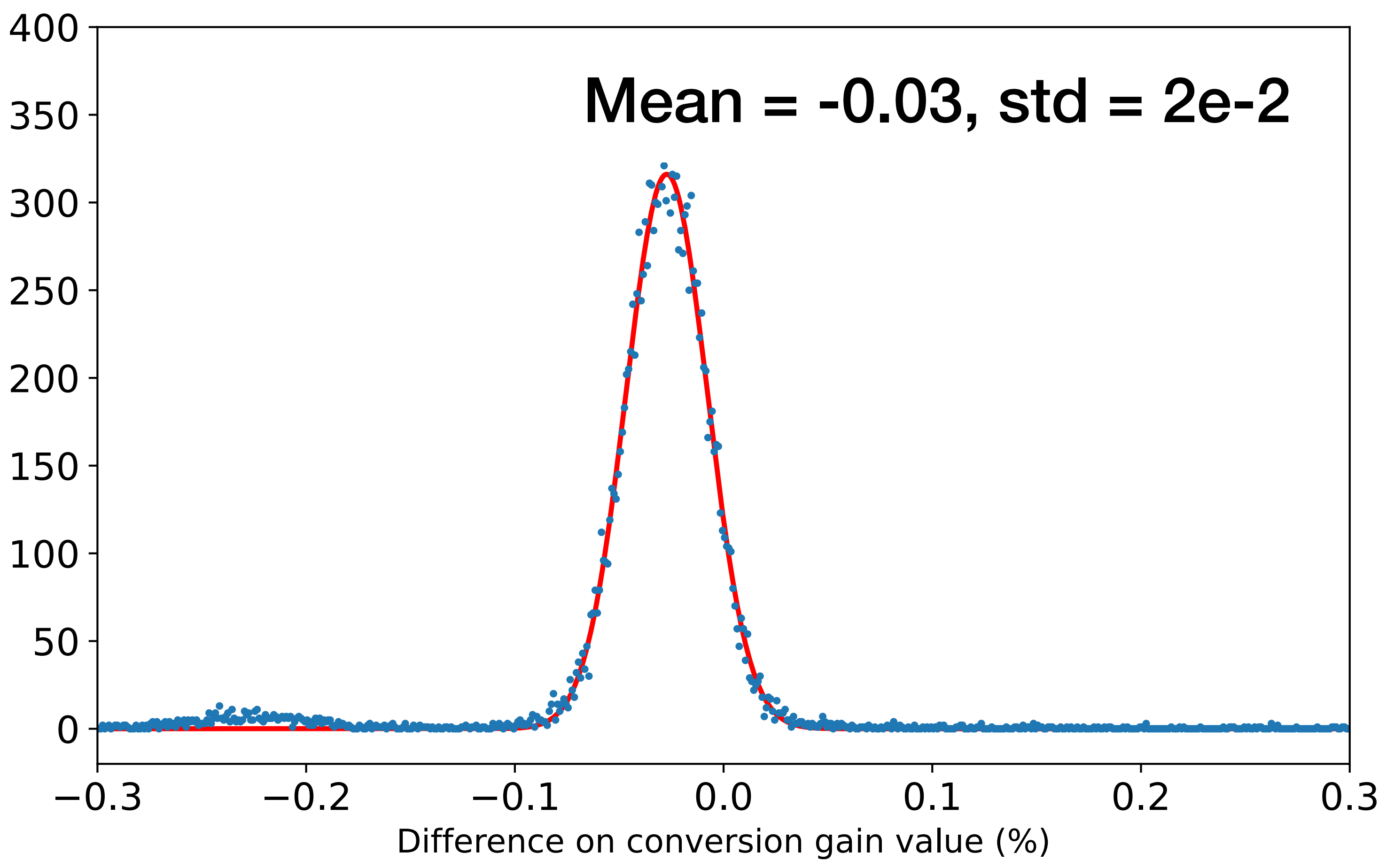
=

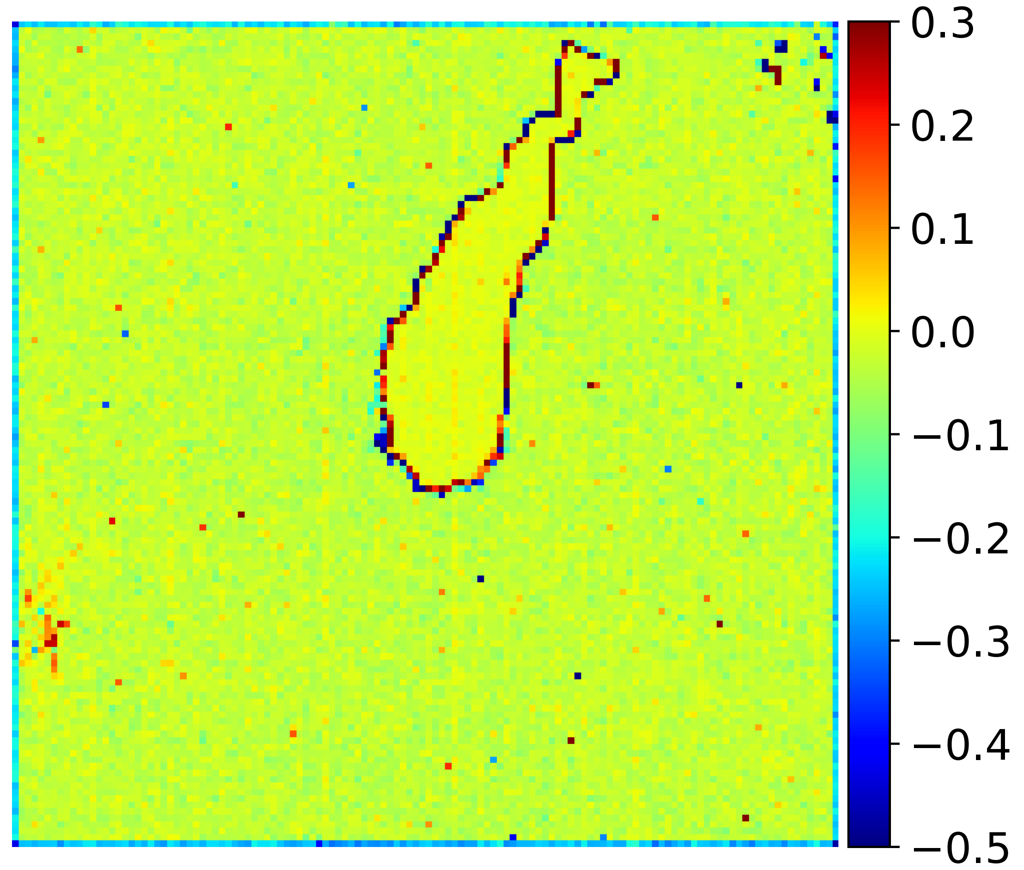
One gain correction coefficient per pixel

## Validation

- Use data IPC corrected by per pixel deconvolution [arXiv:2209.01831]
- Measure gain from this IPC free data
- Compare to gain corrected by coefficient

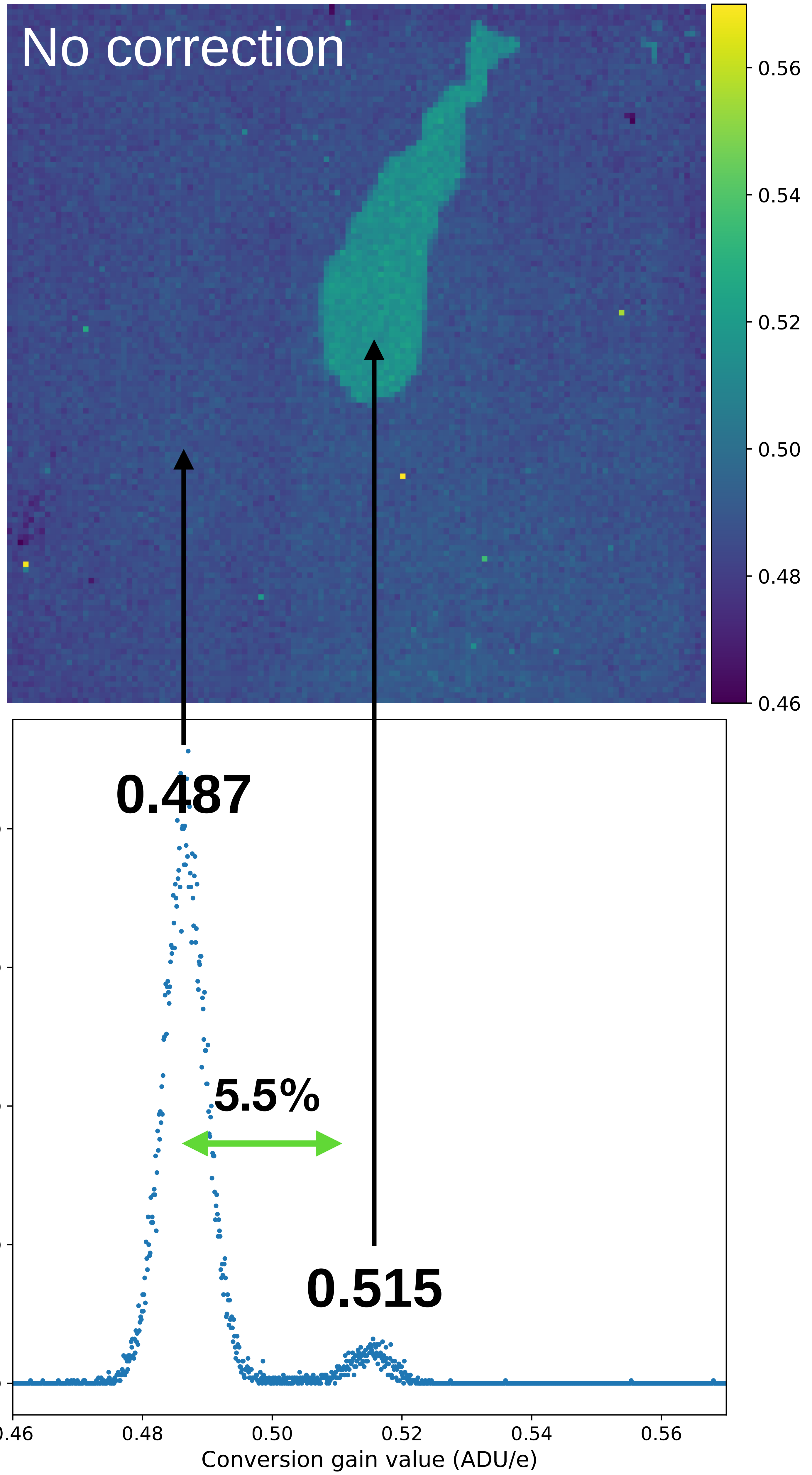
➡ **Difference in gains < 0.1% (excluding boundaries)**



# Decorrelate CG — IPC

Conversion gain (ADU/e)




- Mean gain ↗ 5.5%

  **5.5% bias on corrected flux**

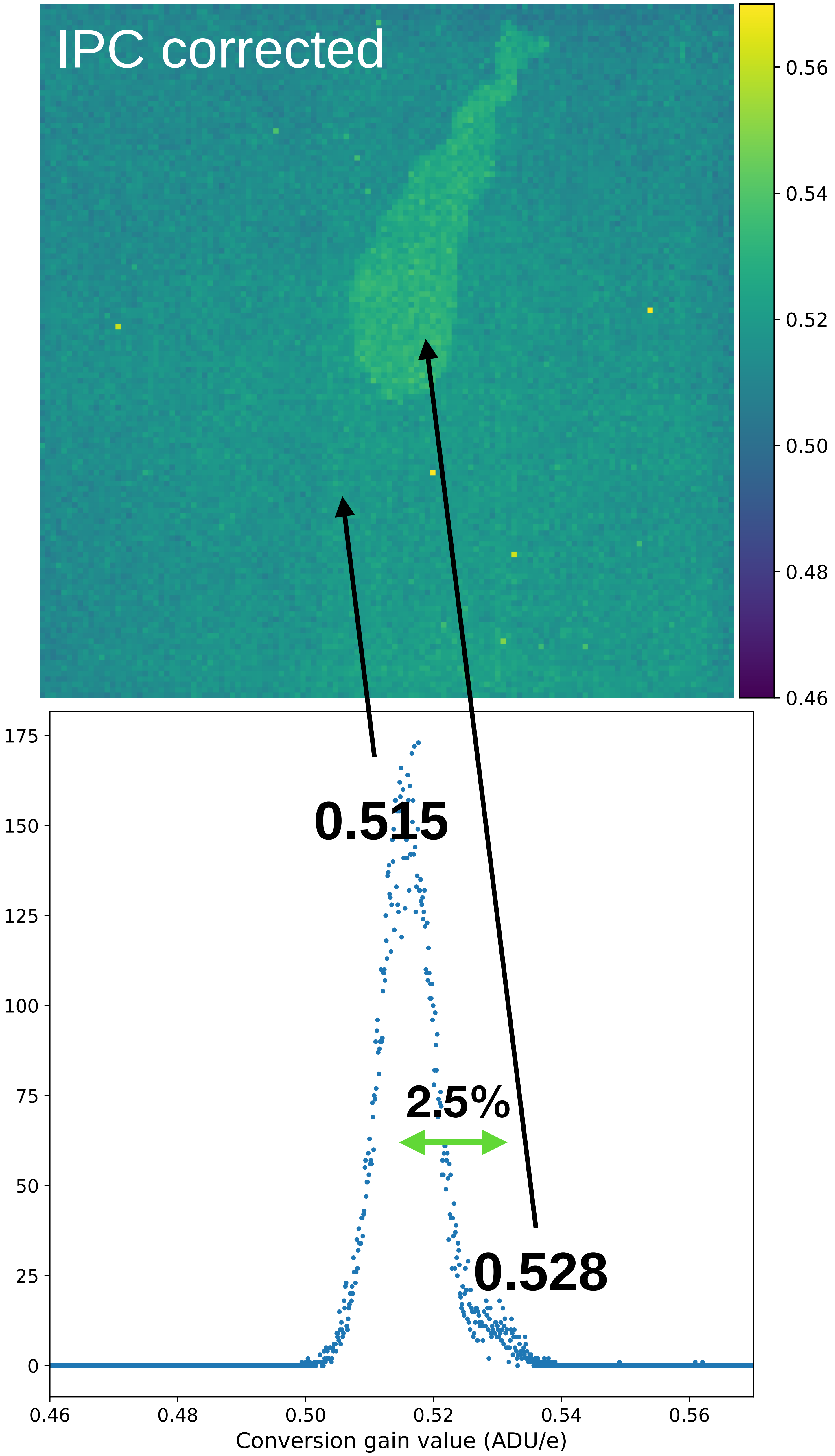
- Fish - back difference:

  5.5 % —> 2.5 %

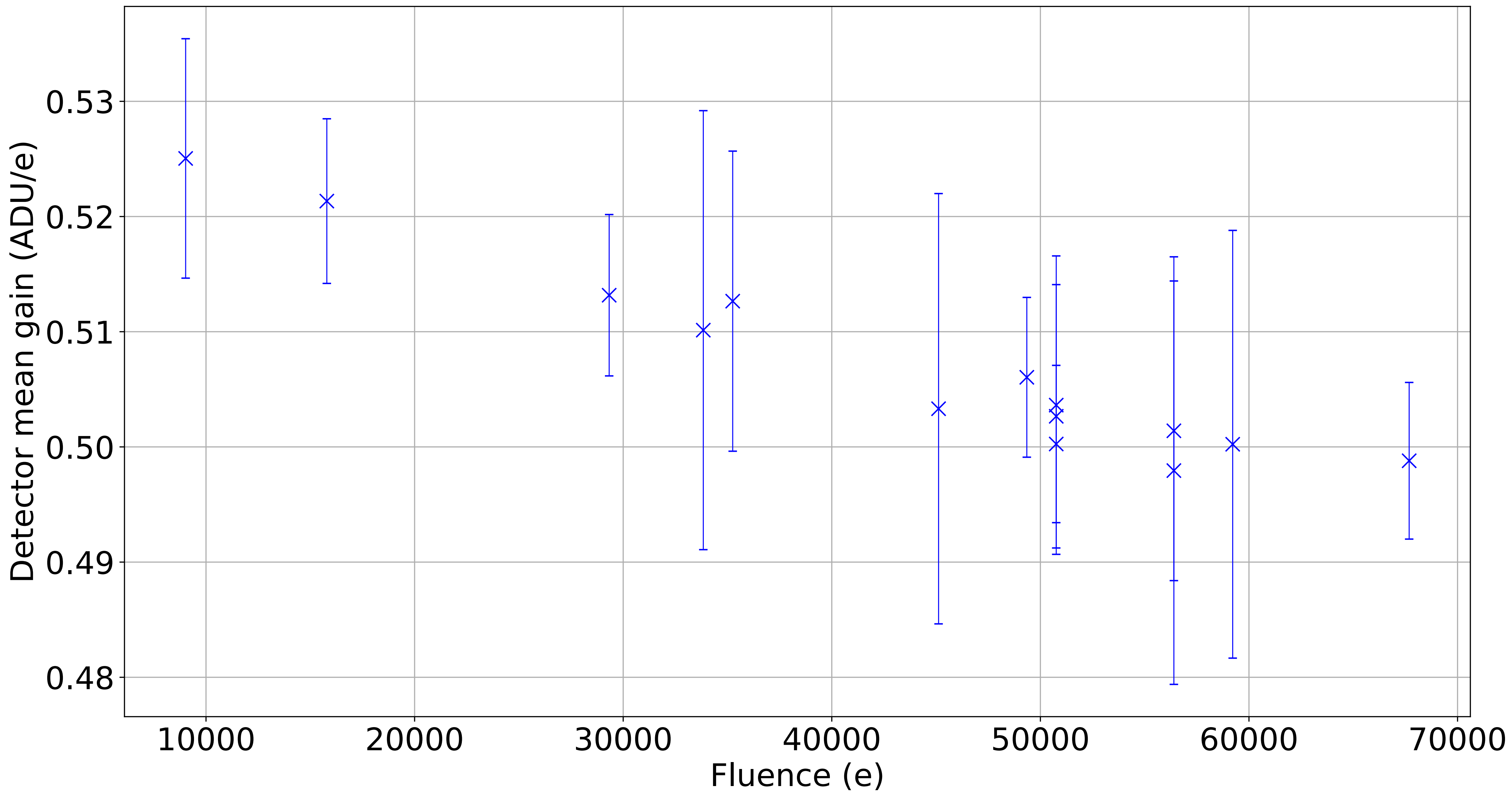
  **Epoxy void affects gain**

- Back spatial variations ~ 3%

  **Per superpx gain mandatory**



CHC ~130ke

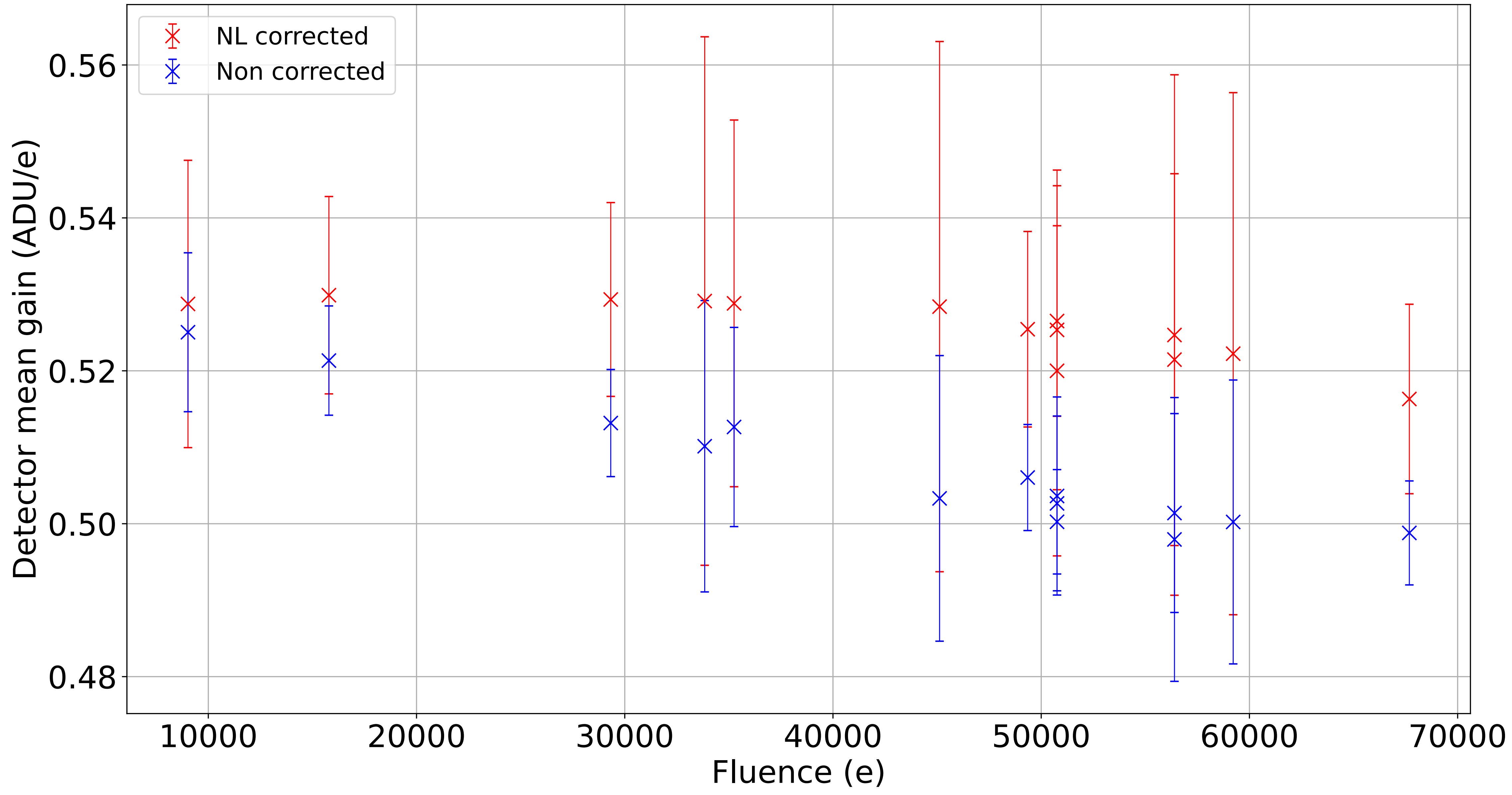



- Gain ↘ when fluence ↗
- Original correction:
  - mean variance curve fit by polynomial
  - Linear part is the true gain

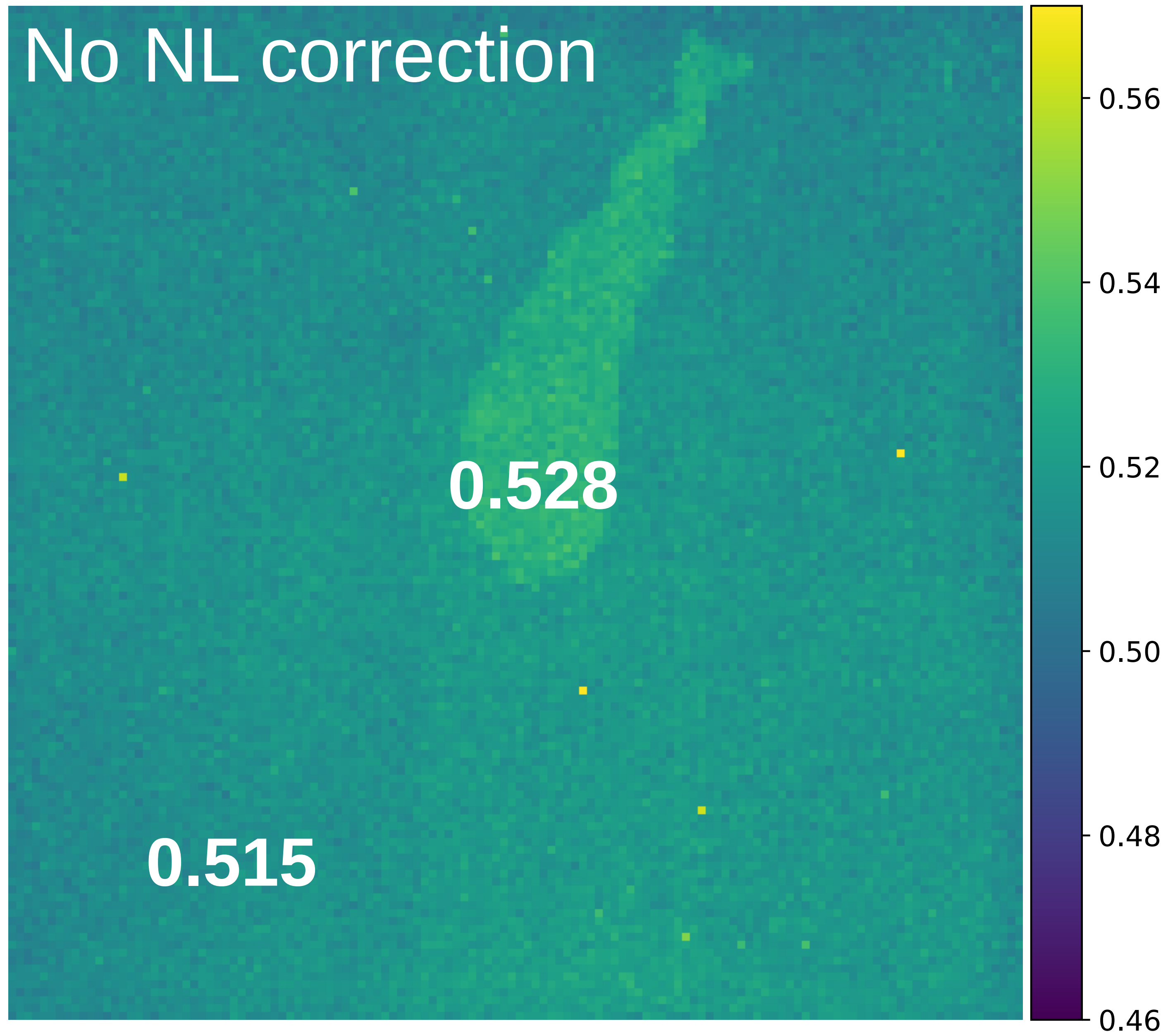
# Decorrelate CG — NL



CHC ~130ke

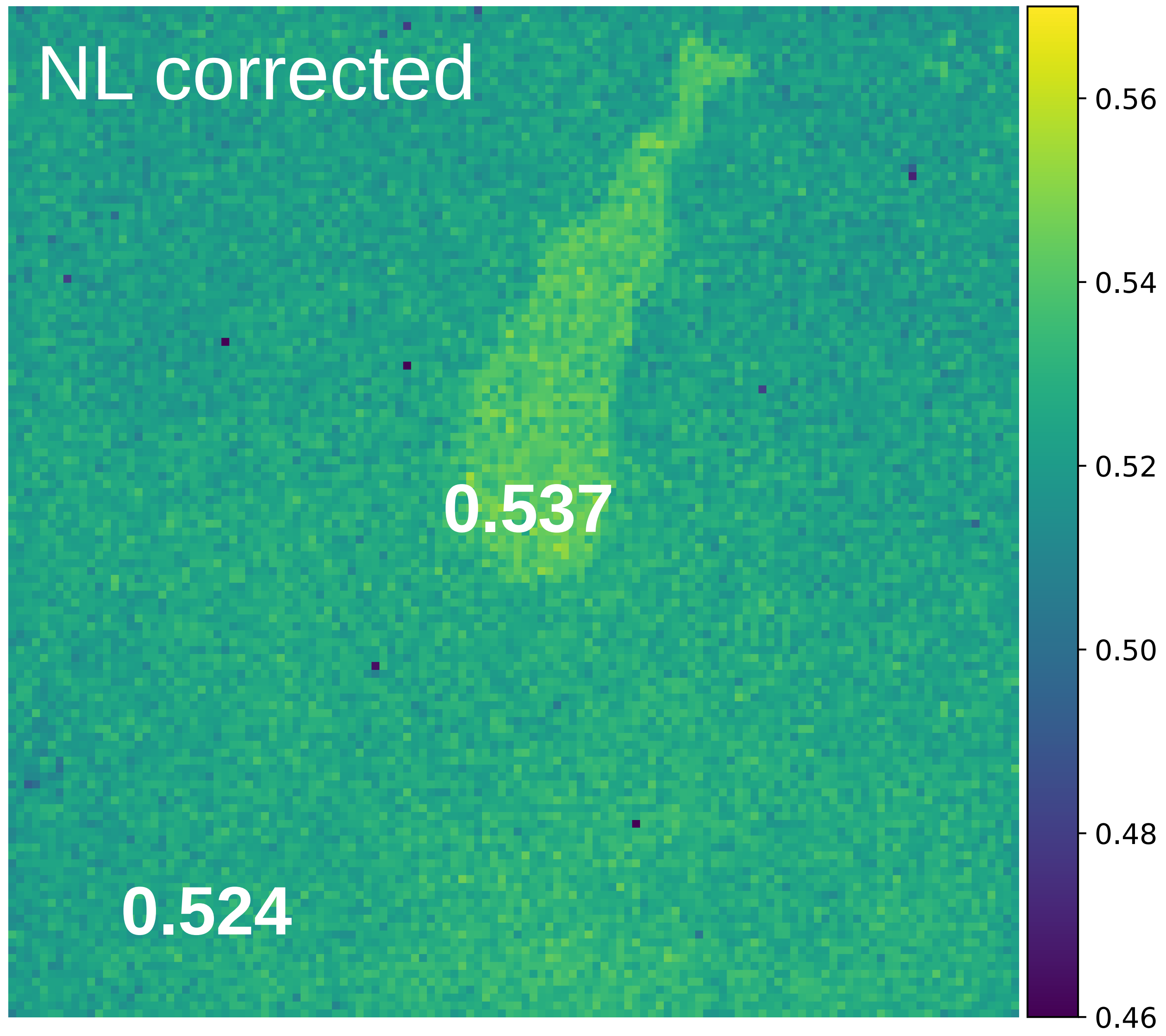



- Gain ↘ when fluence ↗
- Original correction:
  - mean variance curve fit by polynomial
  - Linear part is the true gain




- Fluence effect corrected except at high fluence
- Mean gain ↗ 1.8%

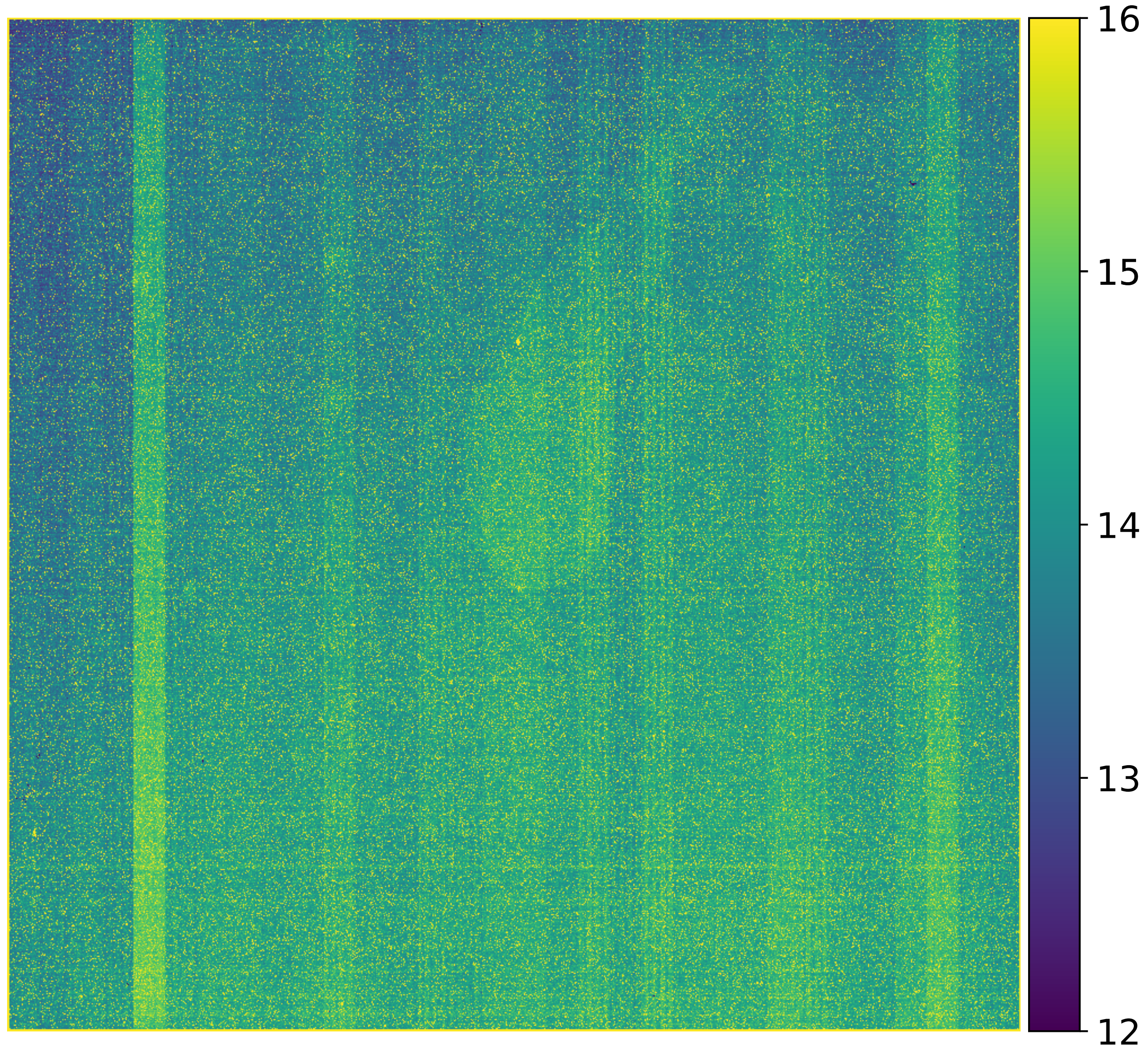
  **1.8% bias on corrected flux**
- No spatial effect



# Corrected performance map

Read noise

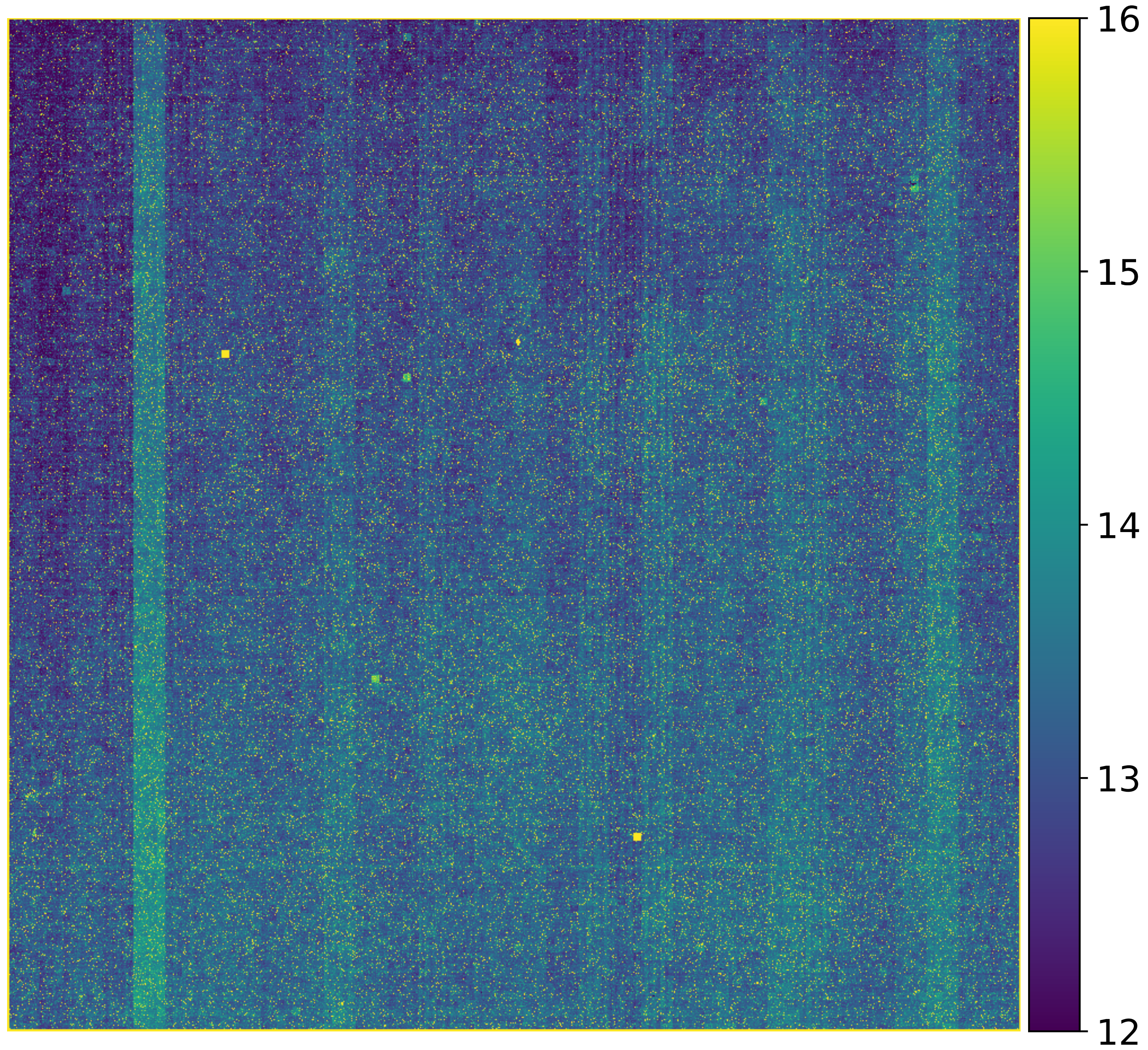
(e rms)




Epoxy void totally corrected

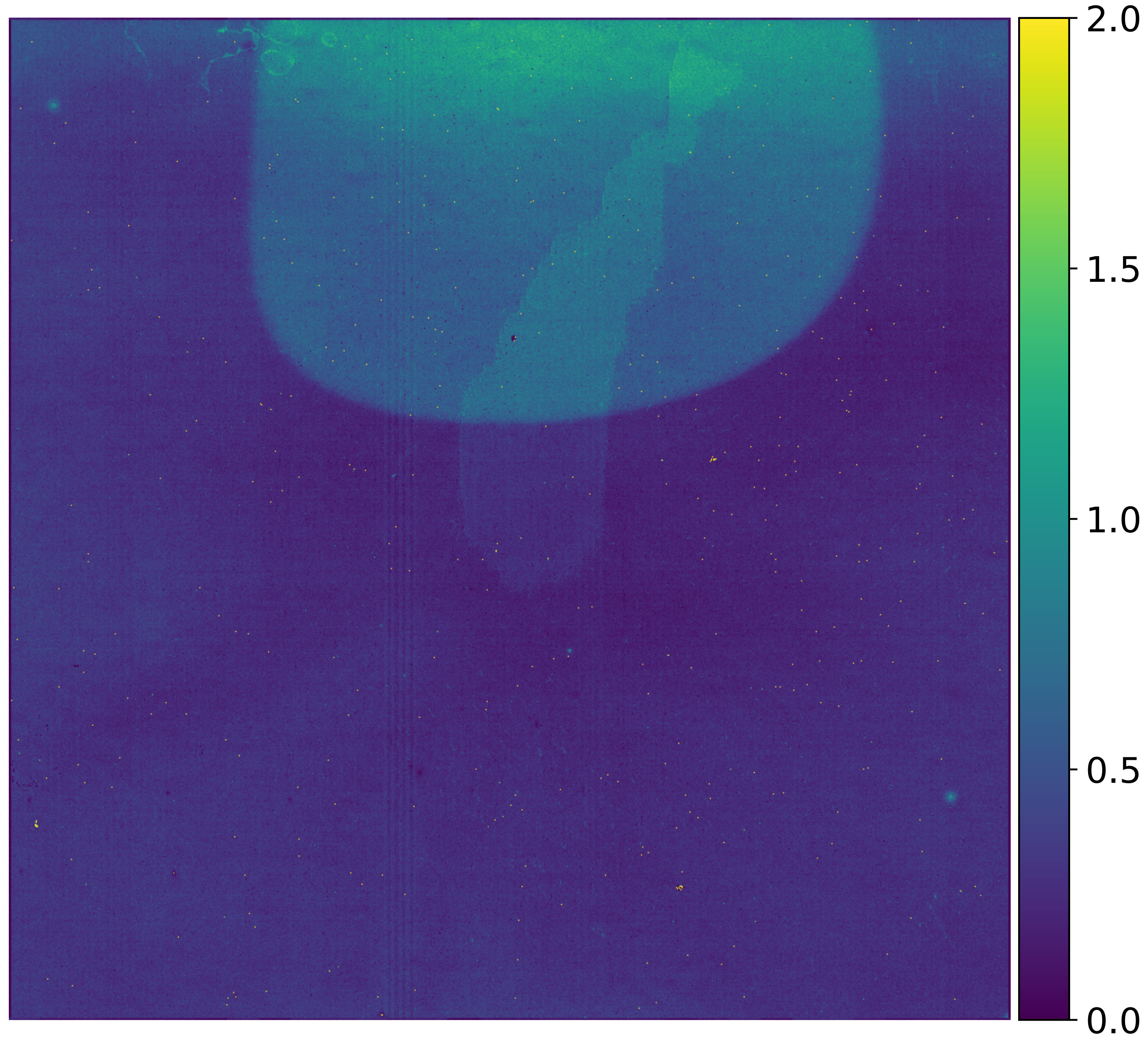
↓

Epoxy does not affect read noise




Dark after flux

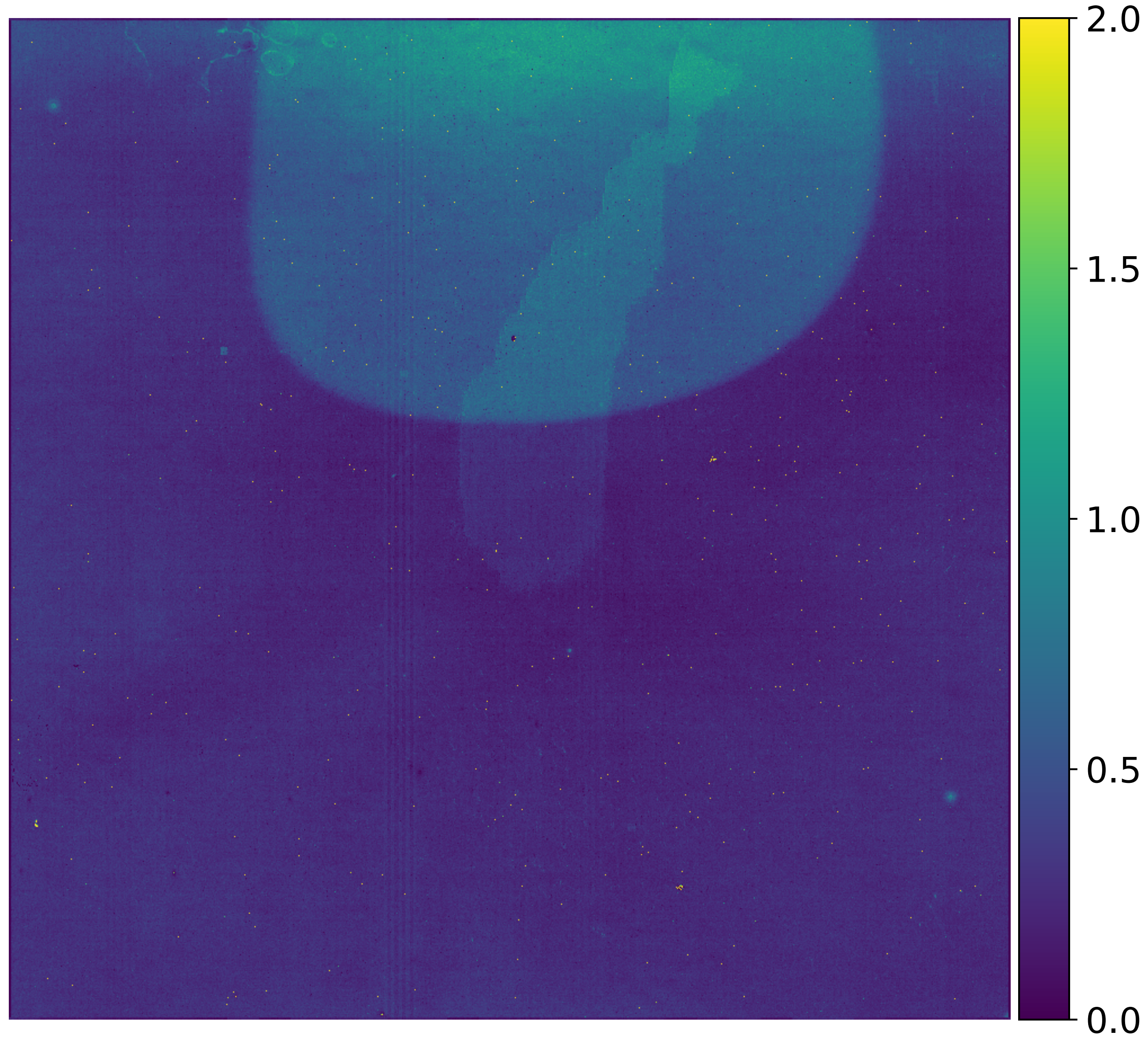
(e/s)




Gain correction does not affect dark

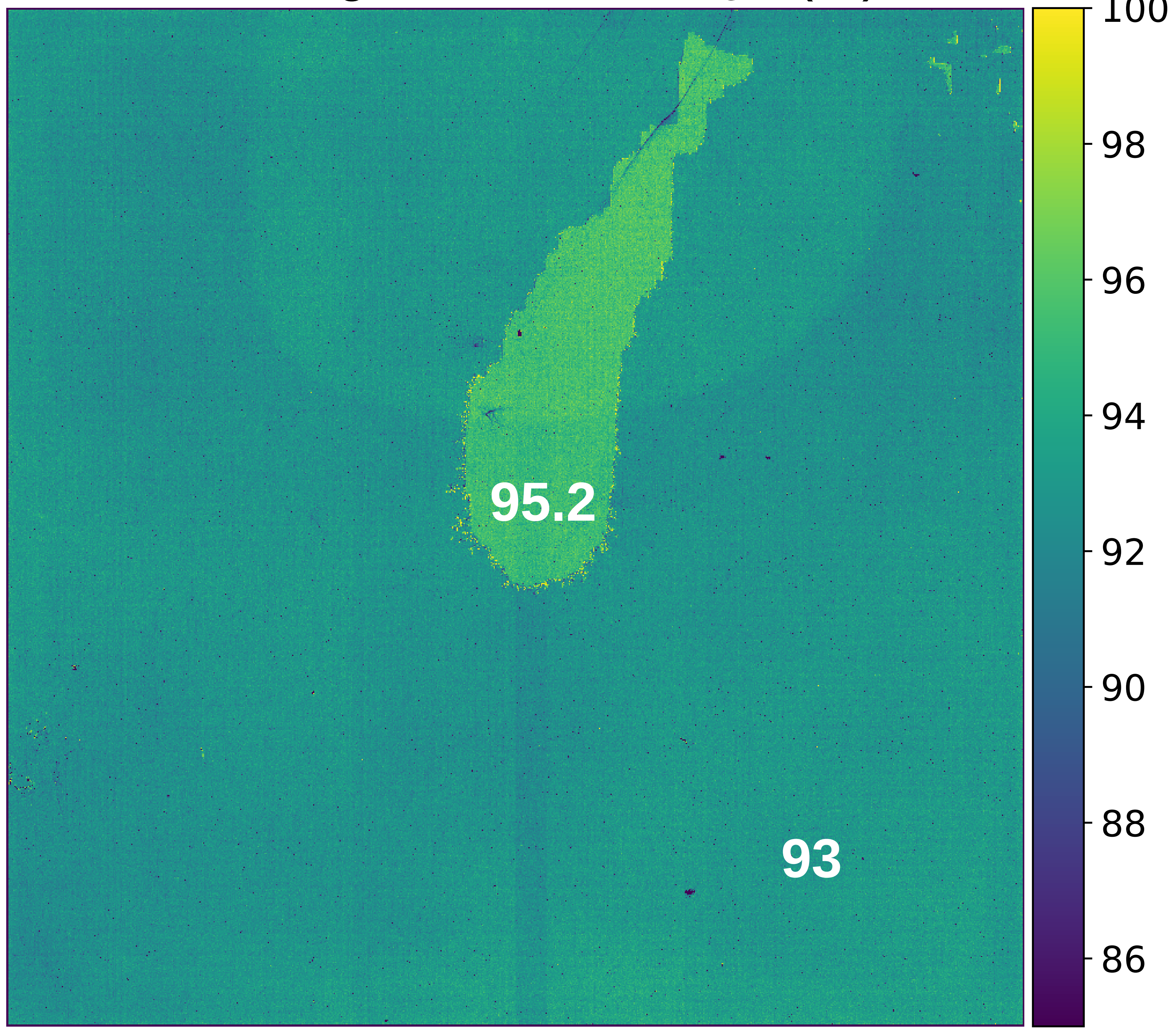
↓

Epoxy seems to affect charge trapping

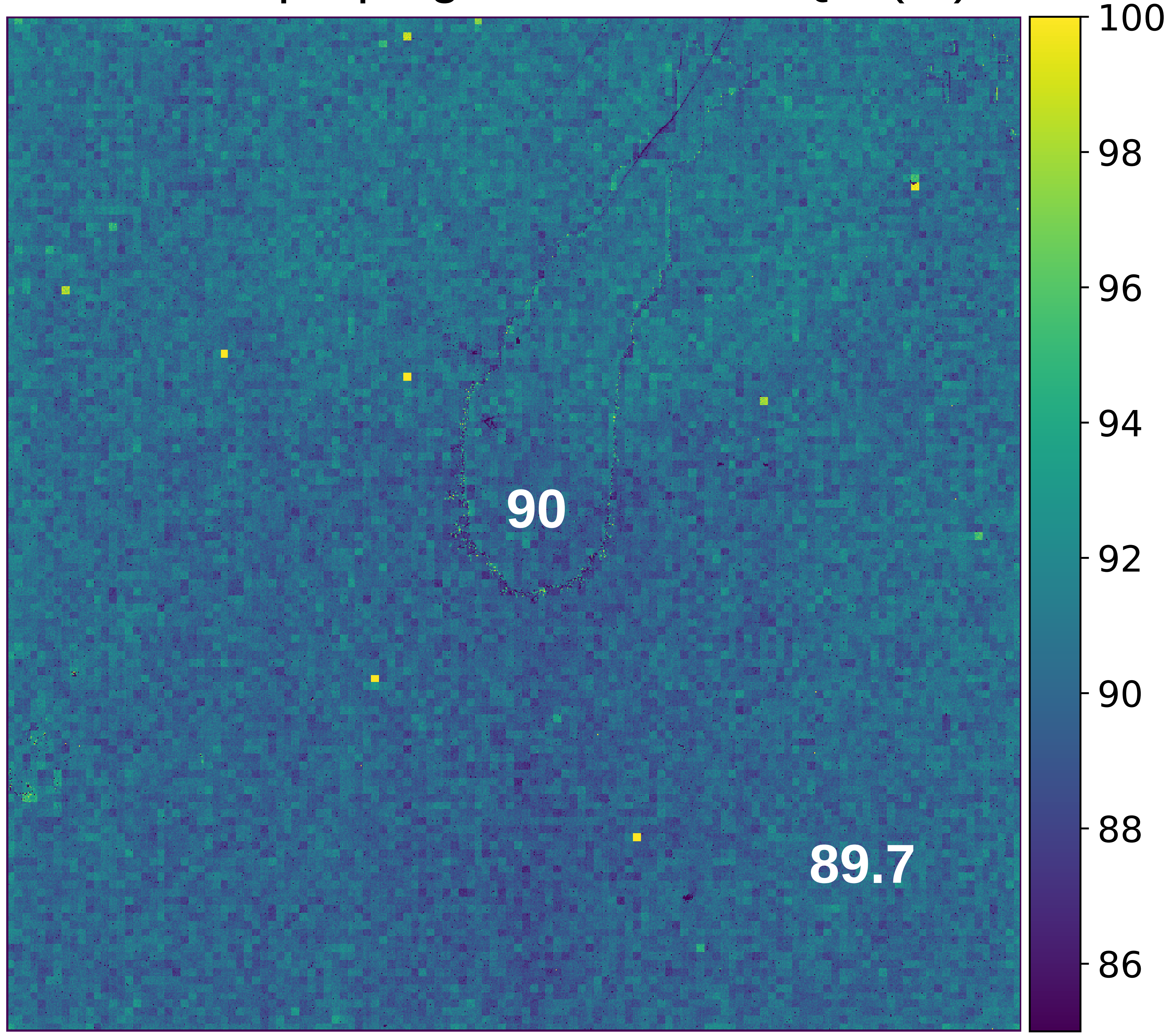


**QE measurement —> (QE x Gain) measurement + Gain correction** ★

Mean gain corrected QE (%)




Per superpx gain corrected QE (%)




- Median QE 92.8% —> 90.2%
- Spatial variations from 1.2 % to 0.17%

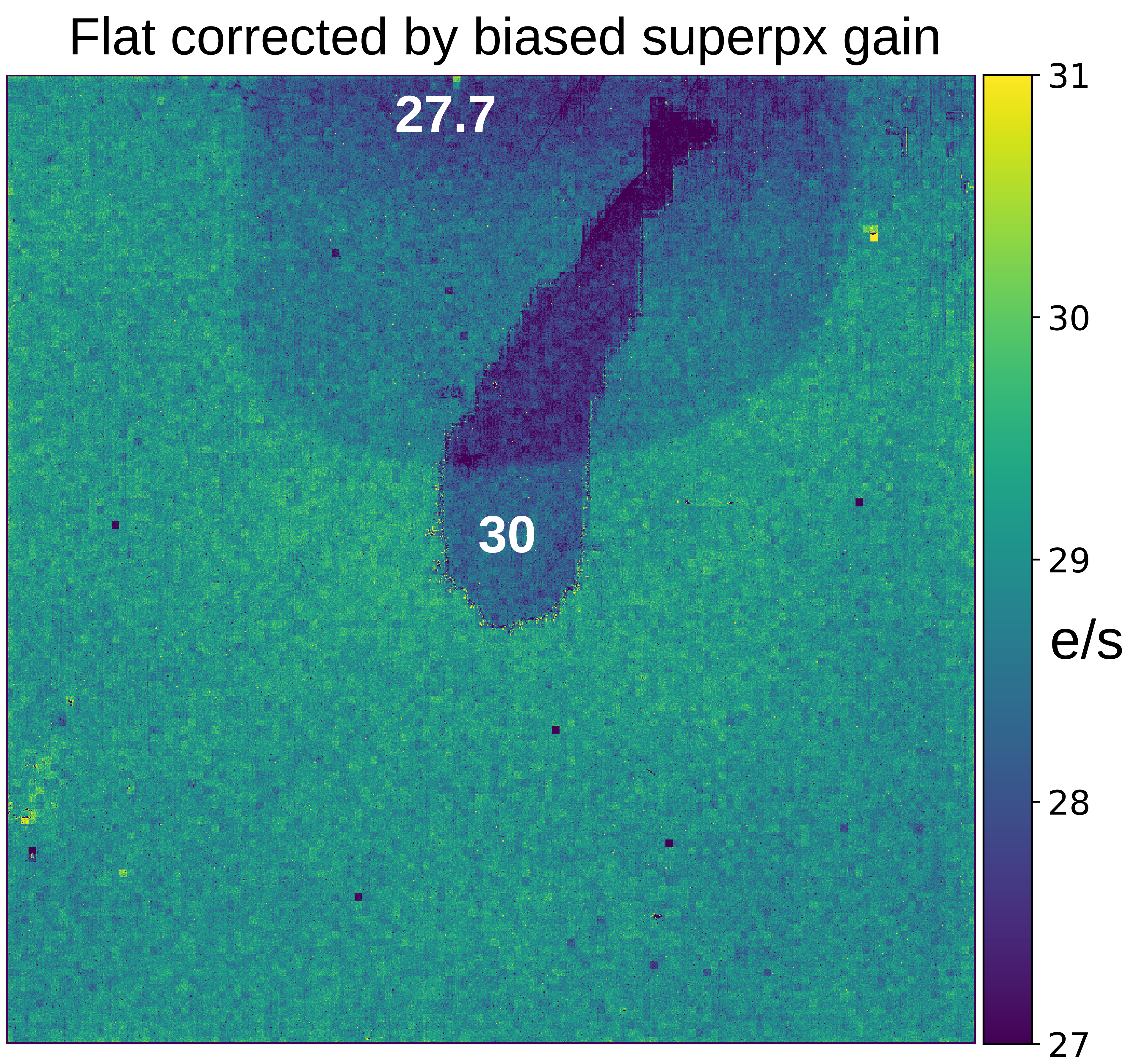
**QE not affected by channels**

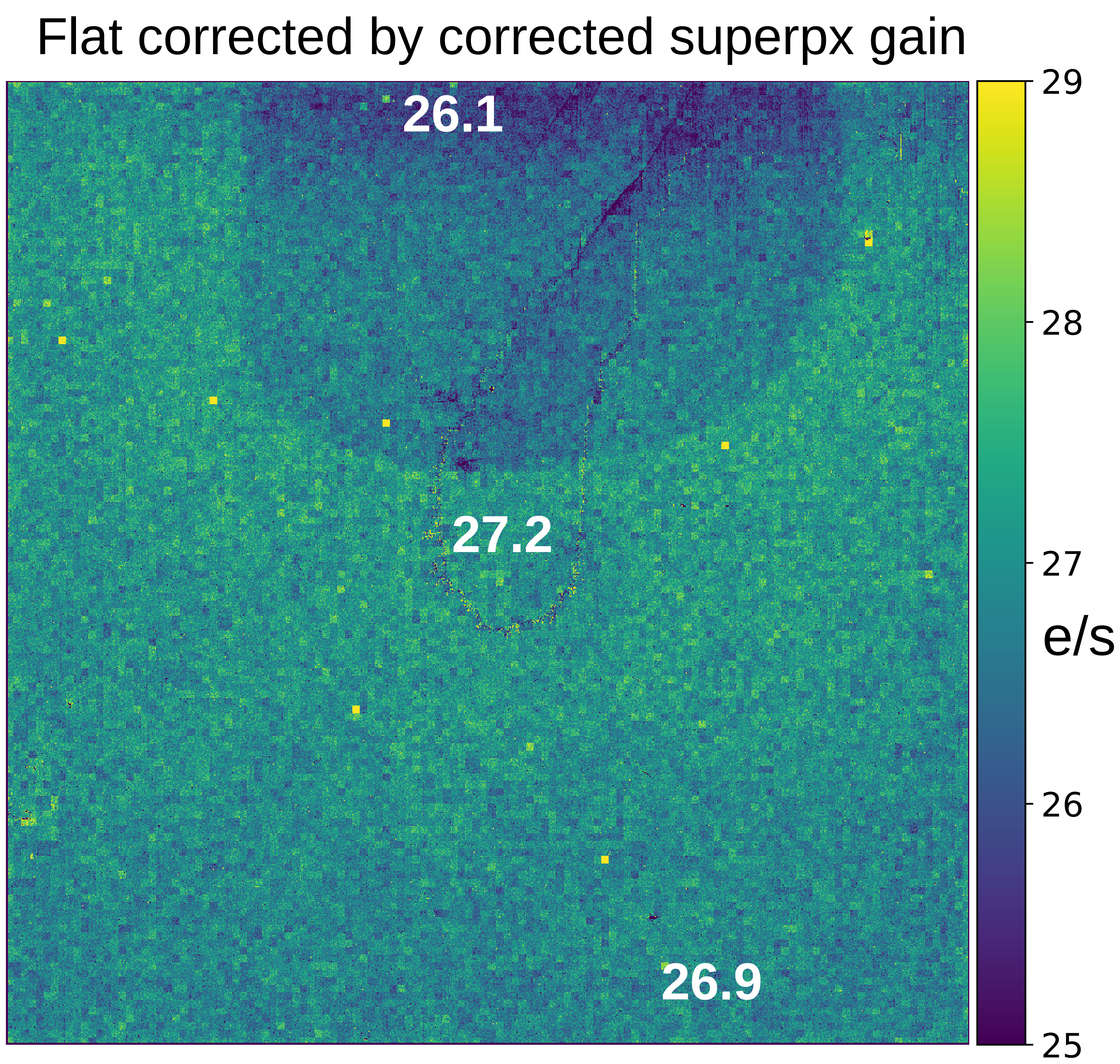
**and epoxy void**

★ by DCL

# Flat field






- Outside Lake-latency, spatial variations < 1%
- Epoxy void region well corrected except in Lake-latency region

→ **Latency needs to be corrected**

IP2I (Lyon) working on a model