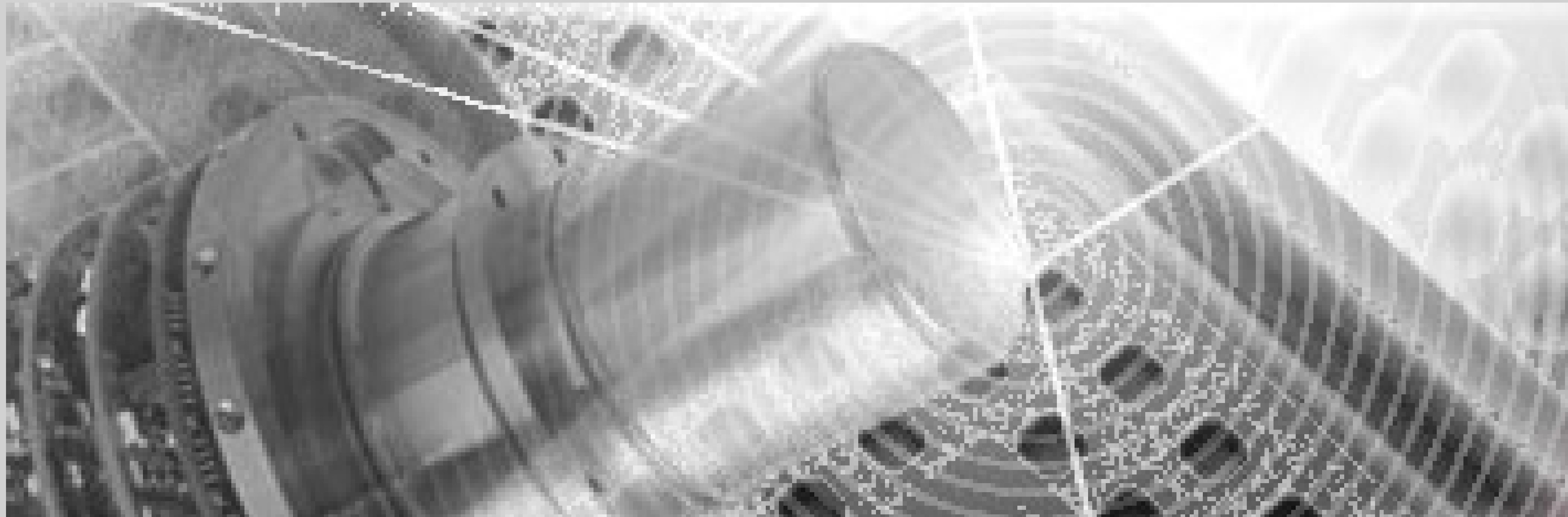


# AIM Infrarot-Module GmbH



## Next Generation of High Performance Detectors for Anthropogenic Gas Detection

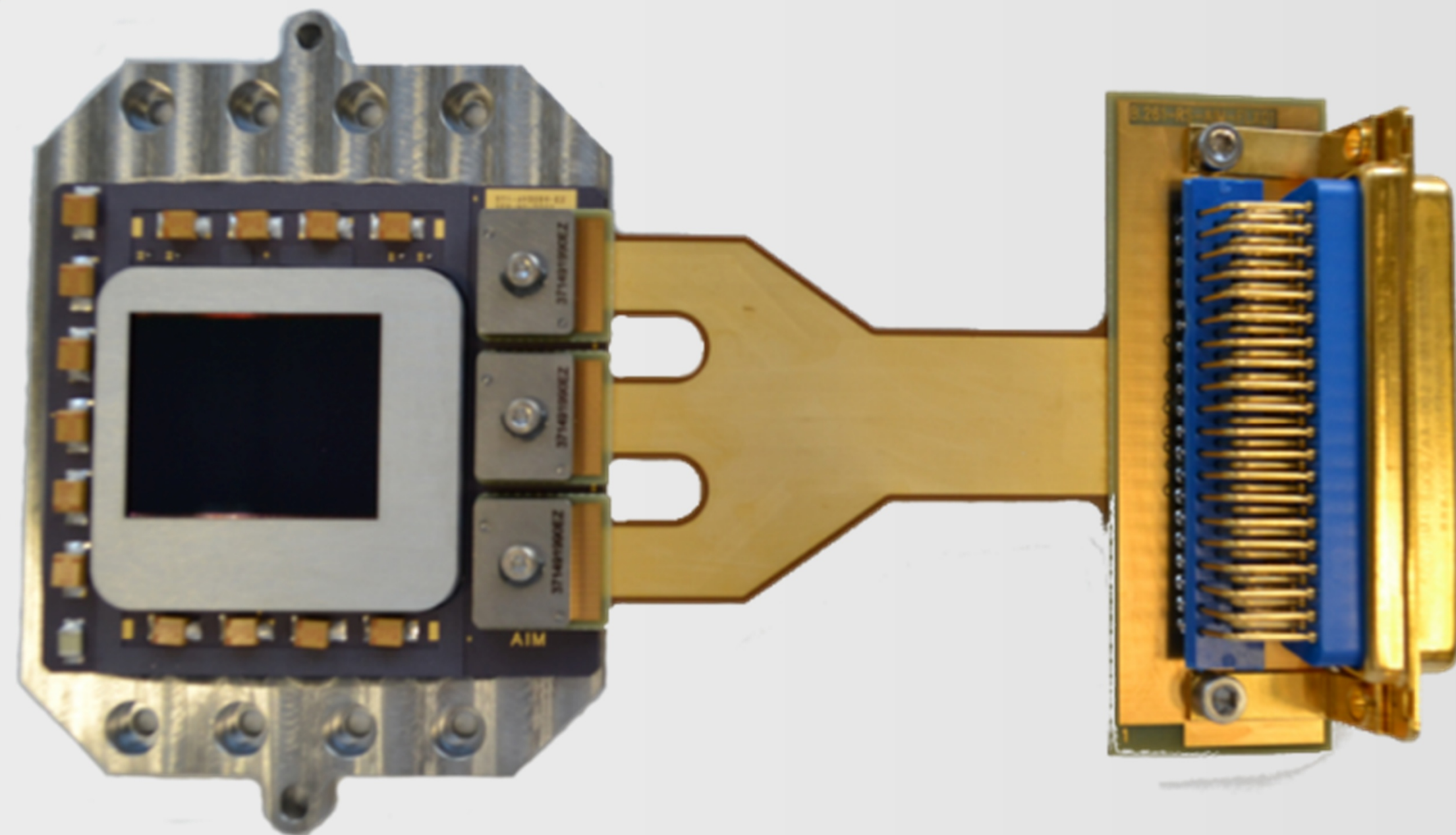
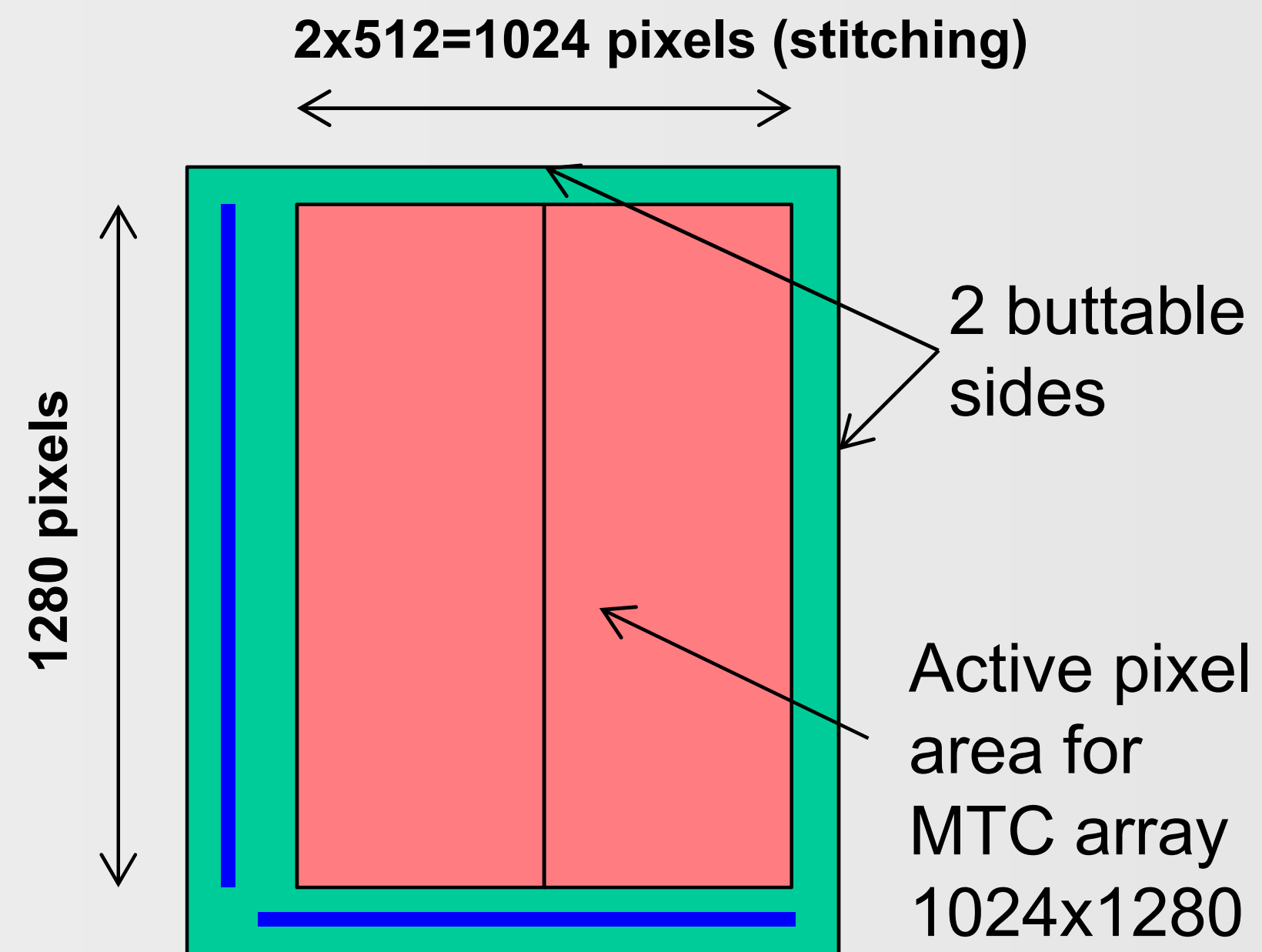
Workshop “Infrared detection for space application”, 08.06.2023, Toulouse

[wolfgang.horn@aim-ir.com](mailto:wolfgang.horn@aim-ir.com)

## Qualification Progress of AGD (Anthropogenic Gas Detector)

- Sensor Overview
- Selection of EO Test Results
- Radiation Tests
- Additional Environmental Tests

# ■ Feature Overview

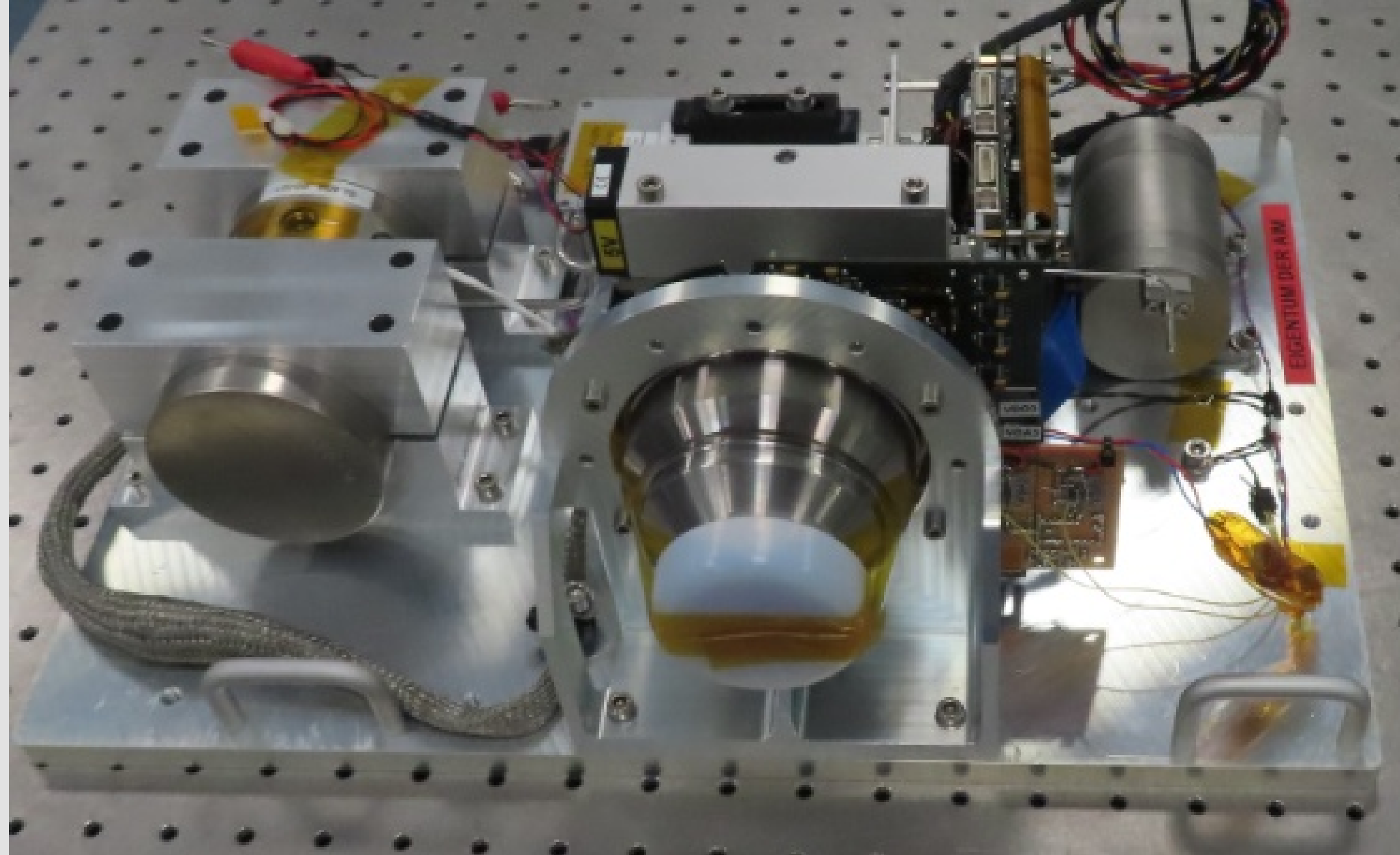
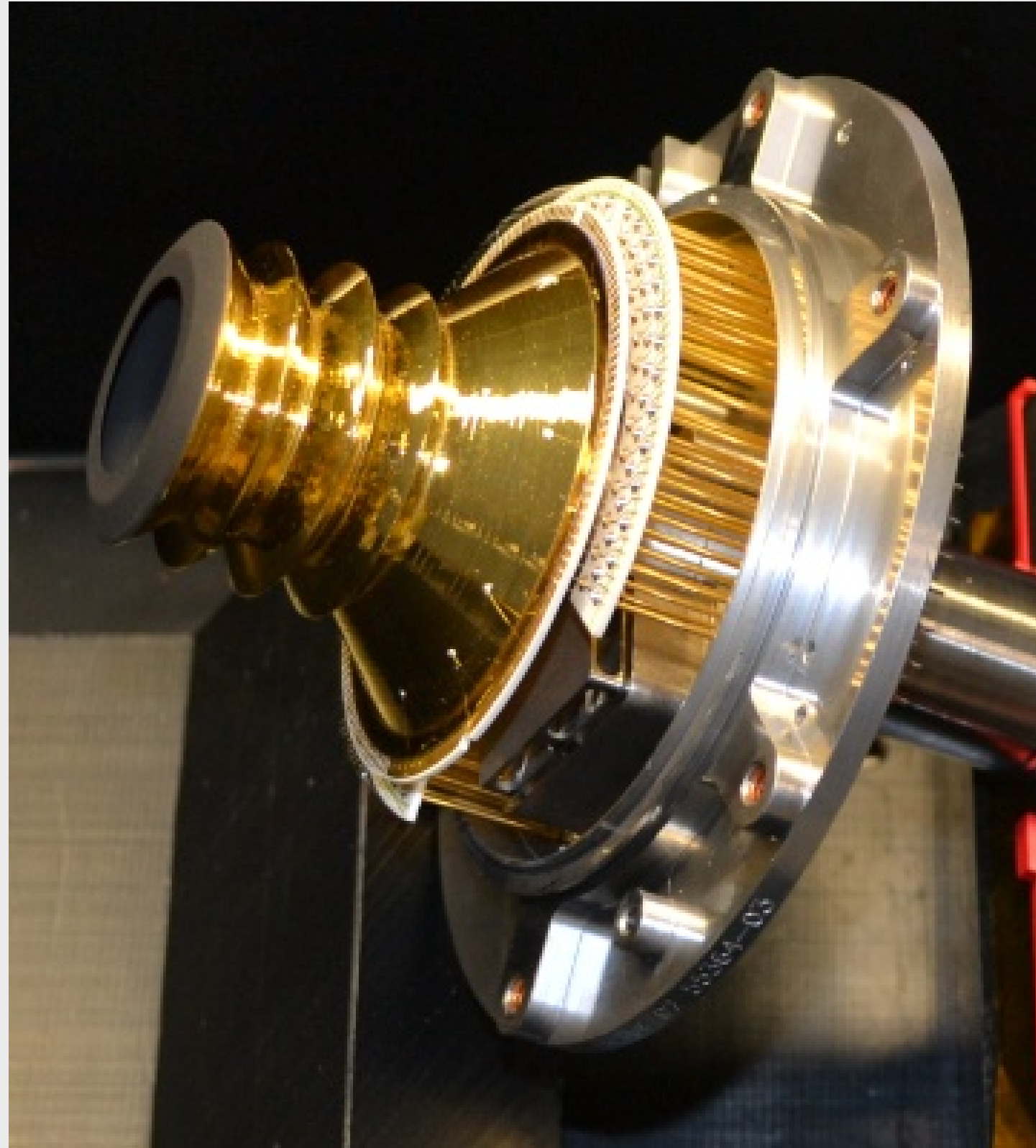


Open package with DCW

- 1024x1280 SWIR 20 $\mu$ m n-on-p MCT
- IWR, ITR, IWR-NDR
- 8 analog video outputs
- 50 Hz in IWR
- CDS for all modes
- Sub-frame windowing
- Gain select in spectral direction
- HG: 397ke-, LG: 1.17Me- (measured)
- Radiation hardening strategy in ROIC

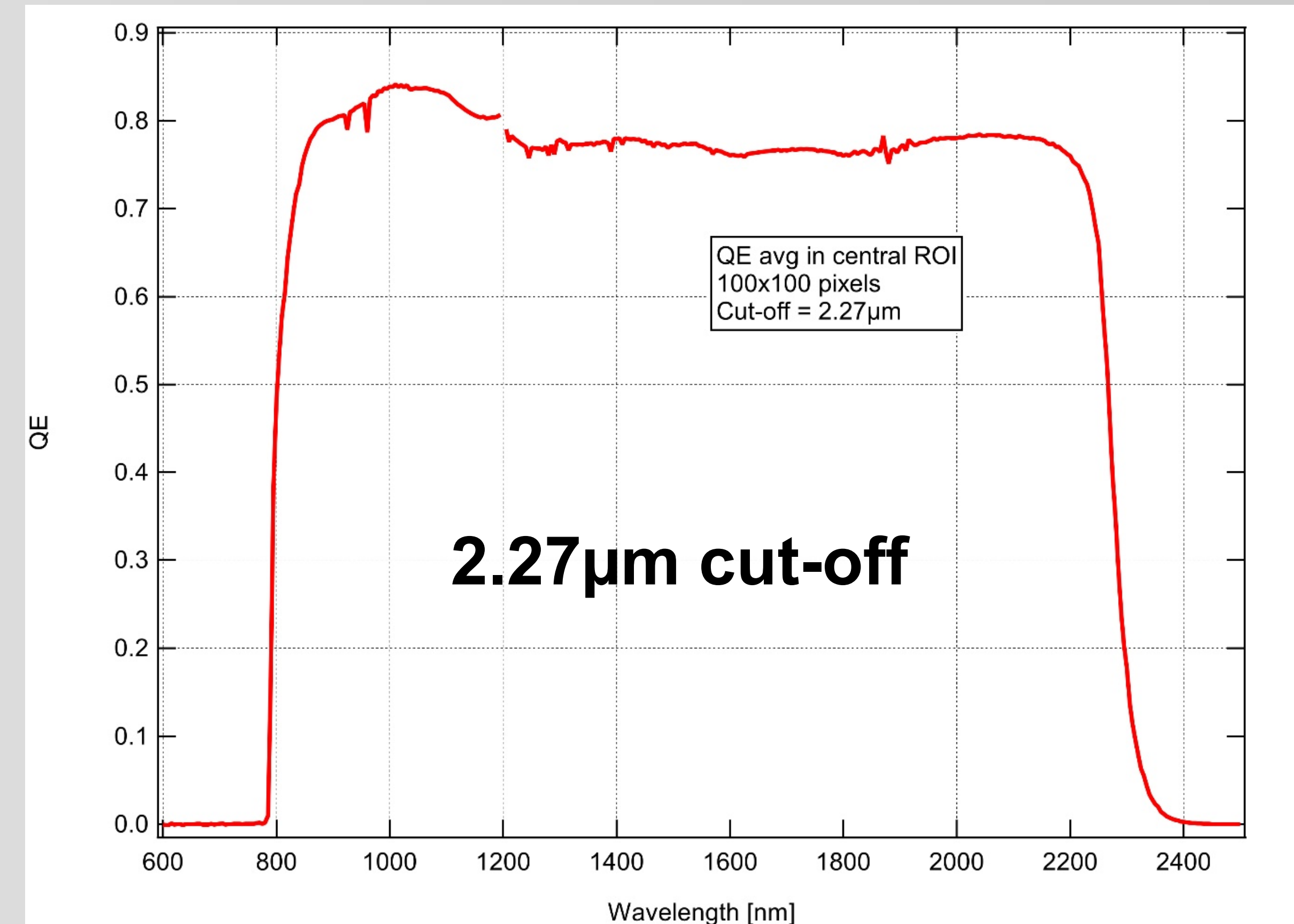
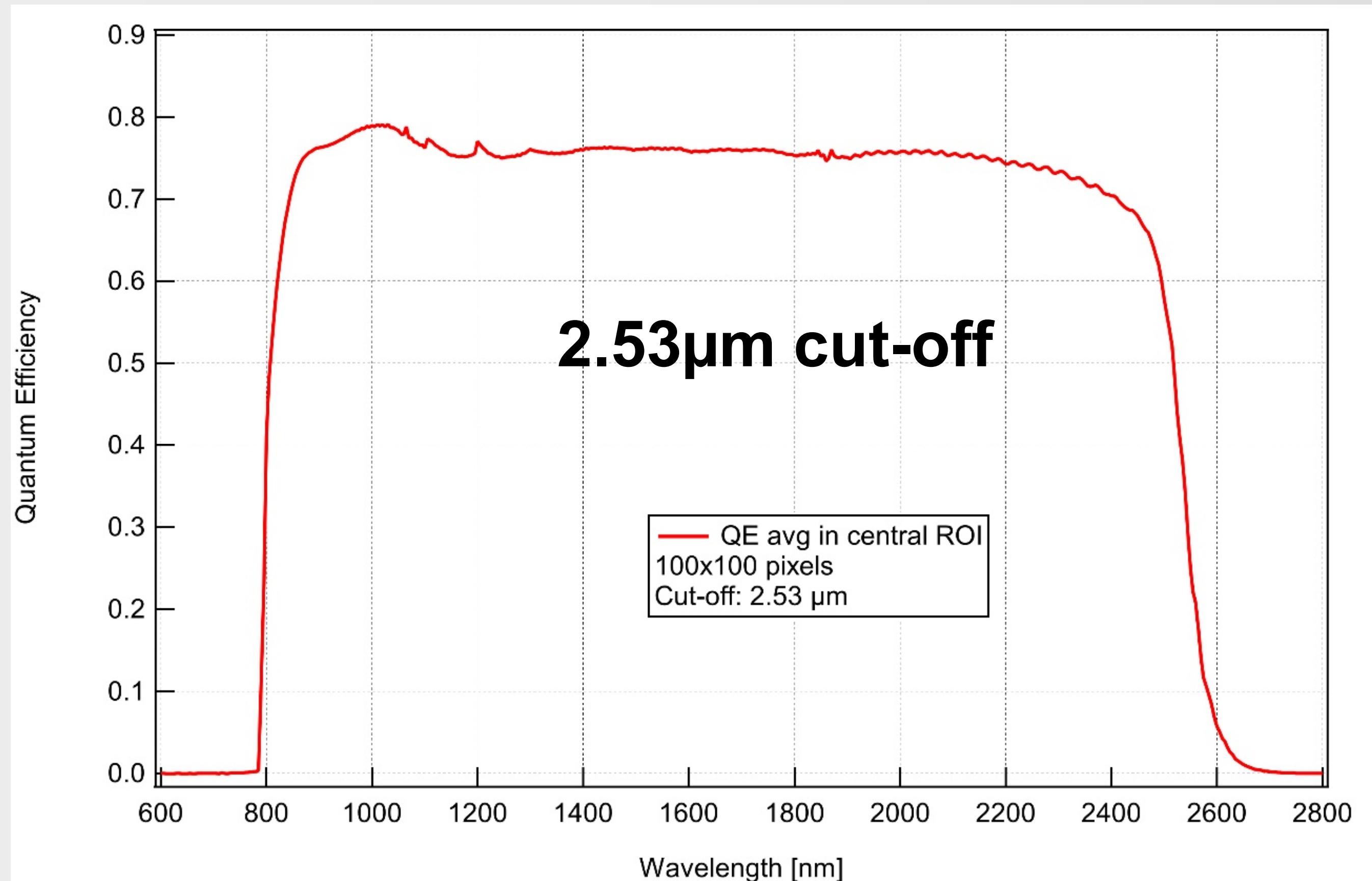


# ■ IDDCA CONFIGURATION



- IDDCA with flight heritage: Dewar XL (f/# 2) with SF400 cryocooler
- Lab testing: FEE, PXE, cooler driving electronics
- Currently in production, testing, and shipment of open package for a flight mission
- Delivered: EM, QM, PFM





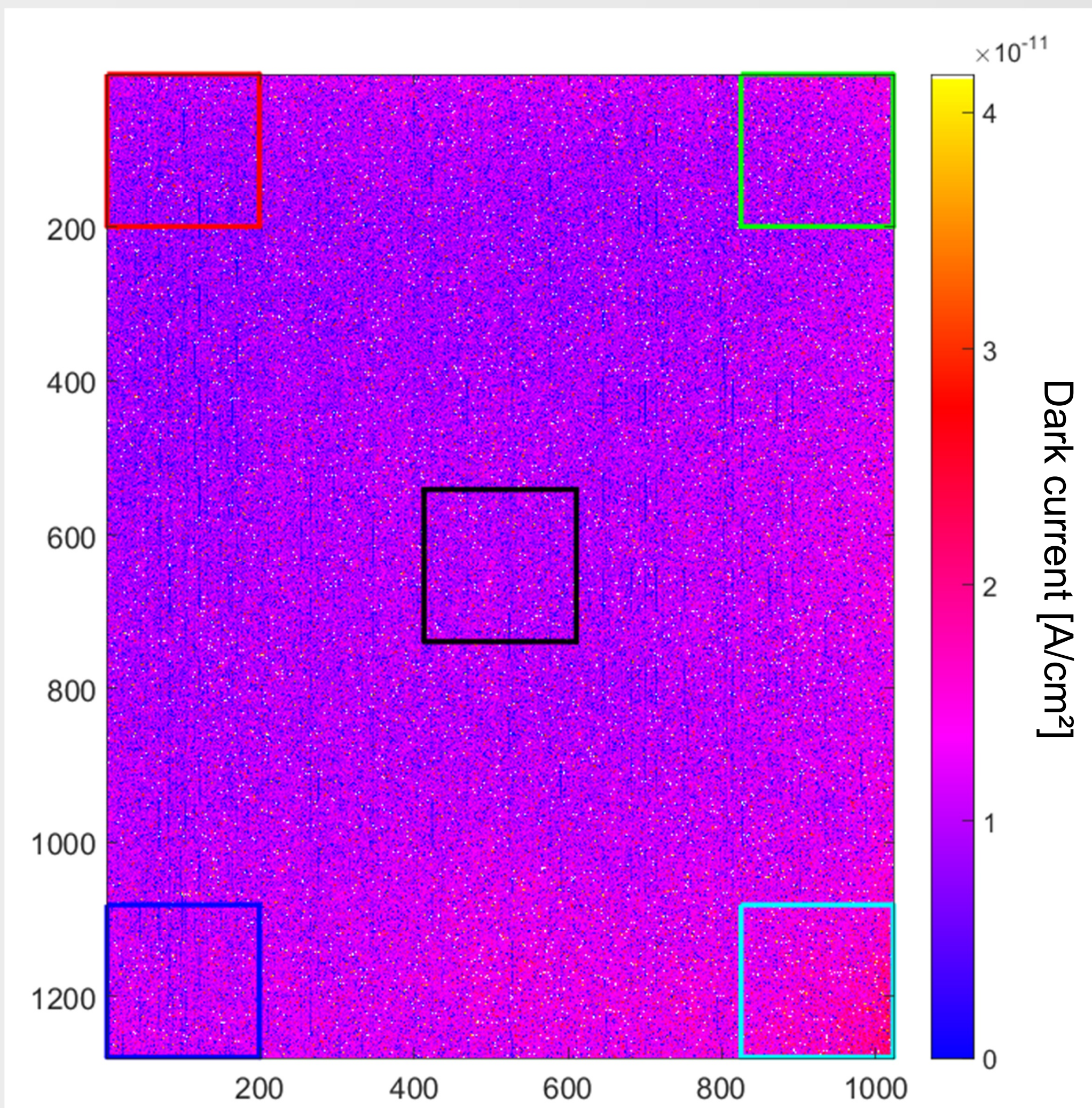
- Quantum efficiency at 150K in IDCA for 2 cut-offs
- Average quantum efficiency > 75% on plateau
- Optimized ARC (VIS-SWIR)
- Custom cut-off can be realized, e.g. 1.8  $\mu$ m
- Sensor substrate can be removed



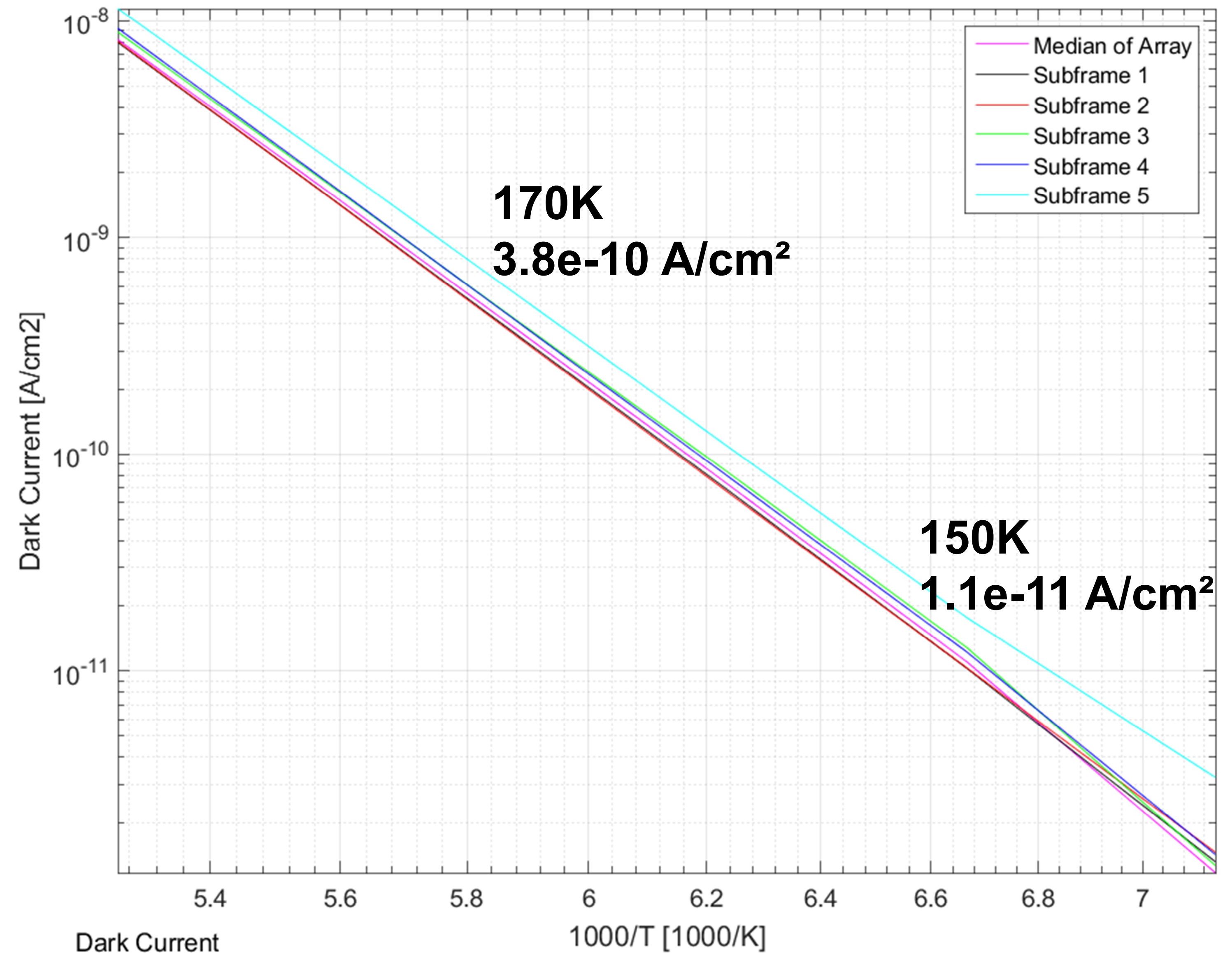
# ■ EO | Dark Current

All sensors

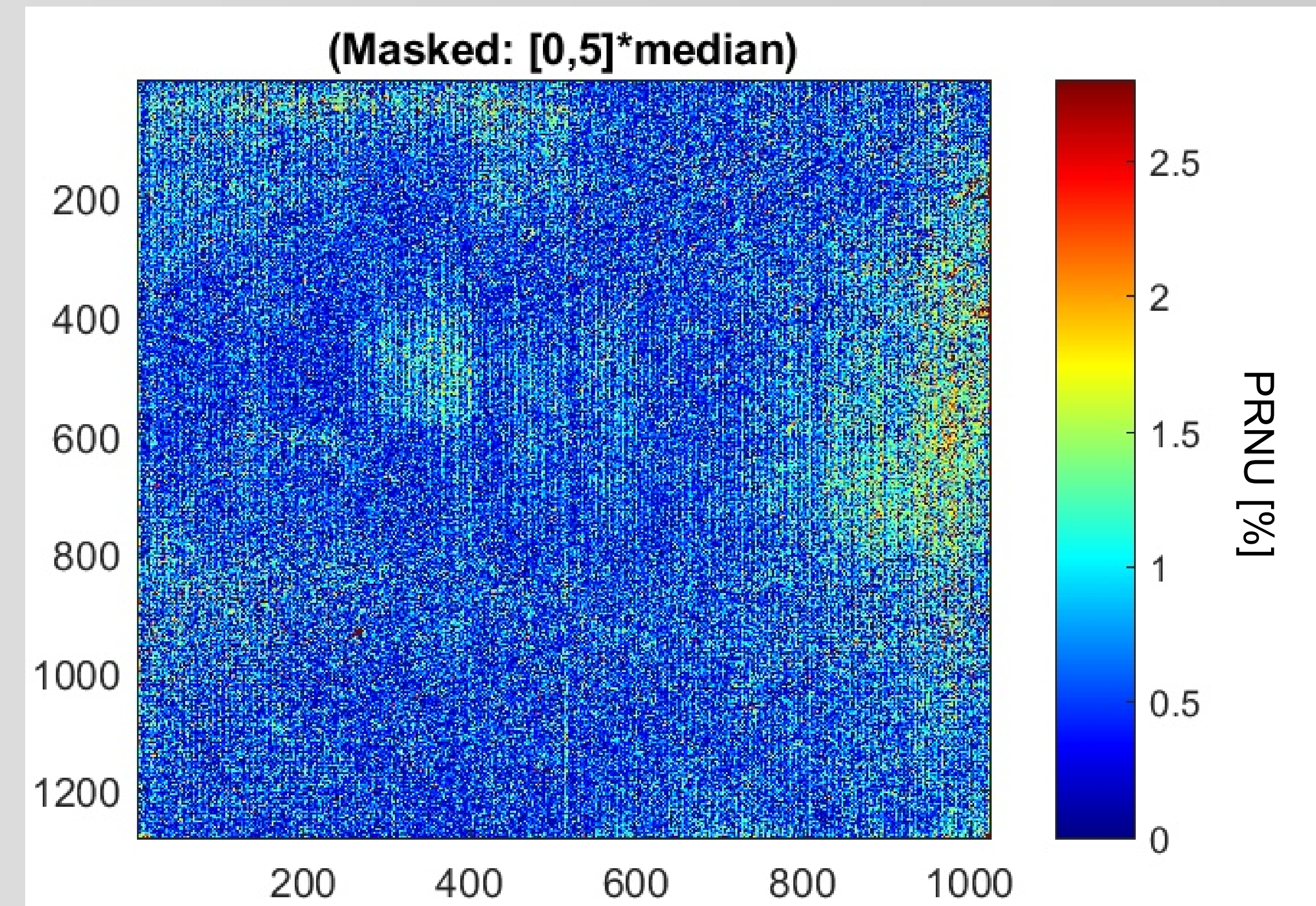
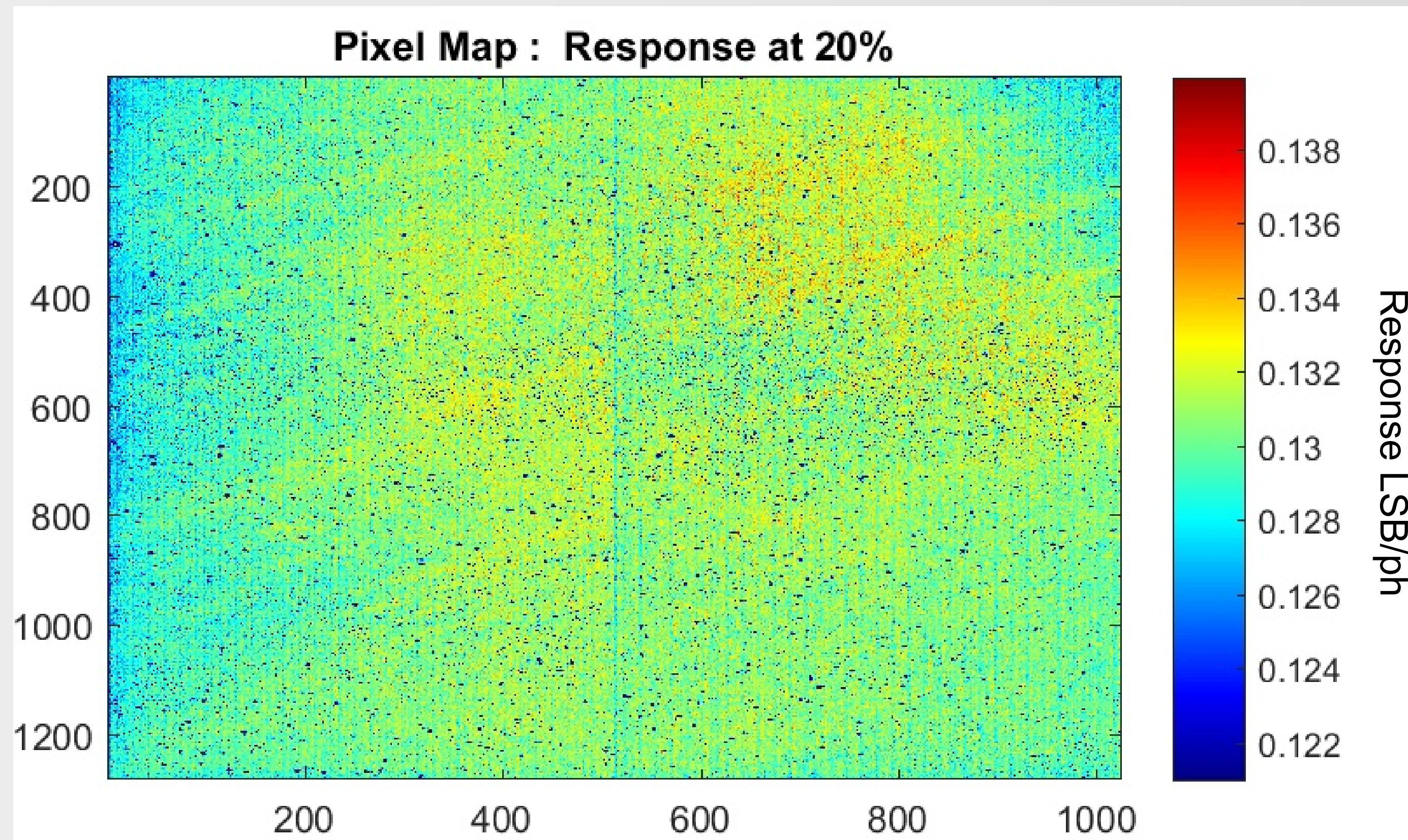
- Median of dark current @150K:  
 $< 0.1 \text{ nA/cm}^2$
- $< 1 \text{ nA/cm}^2$  for OT below 170K



## 2.53 $\mu\text{m}$ cut-off, 0° FOV



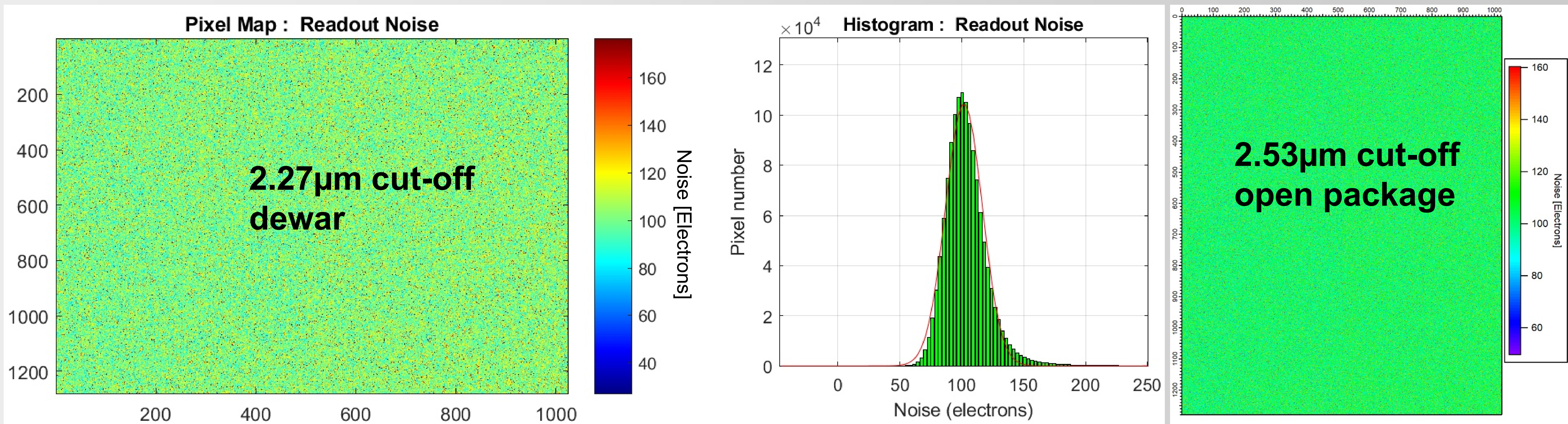




- Response map at 20% WF
- Response non-uniformity <1%
- Stitching is visible but values are no outliers

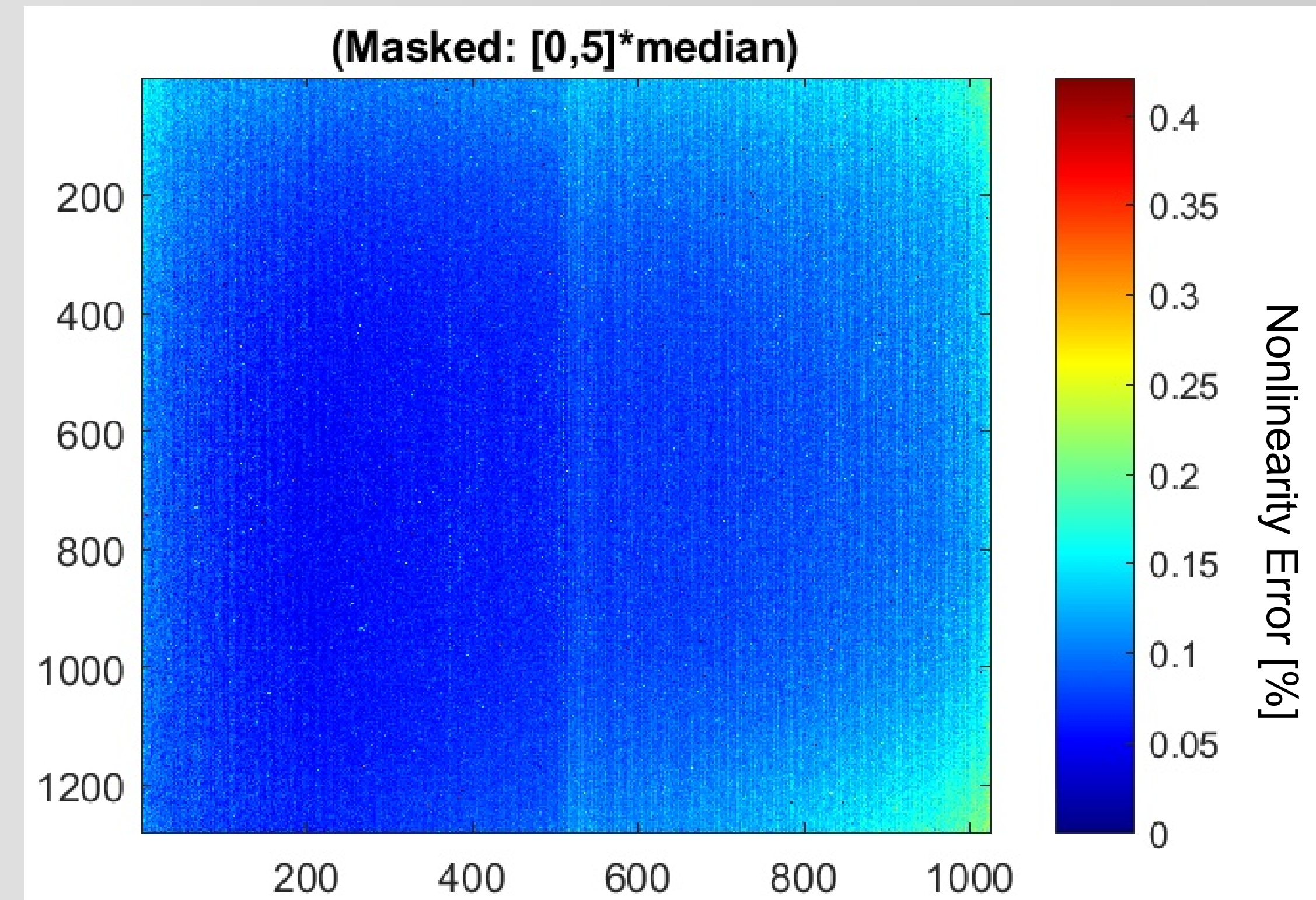
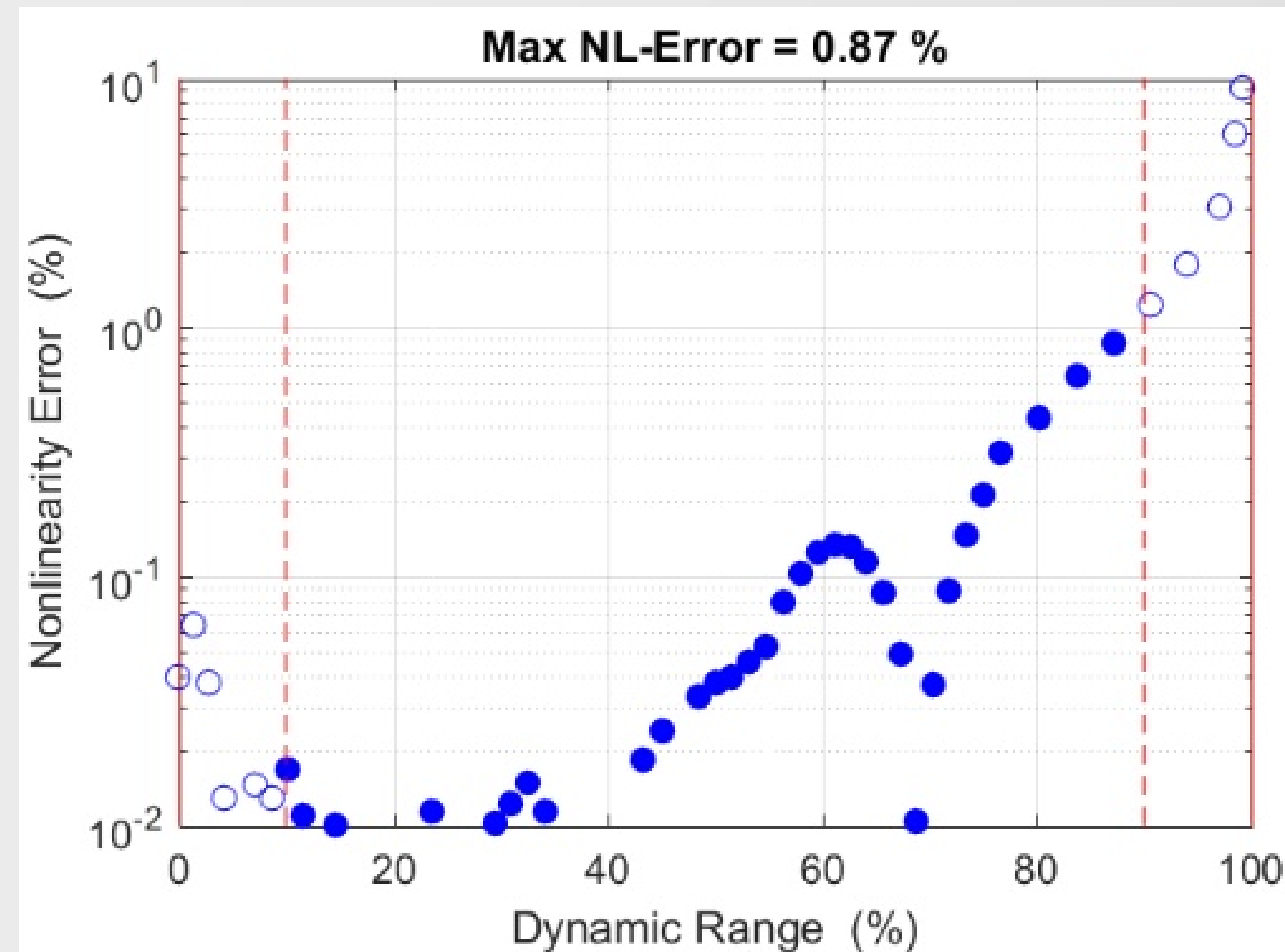


# ■ EO | Read-Out noise

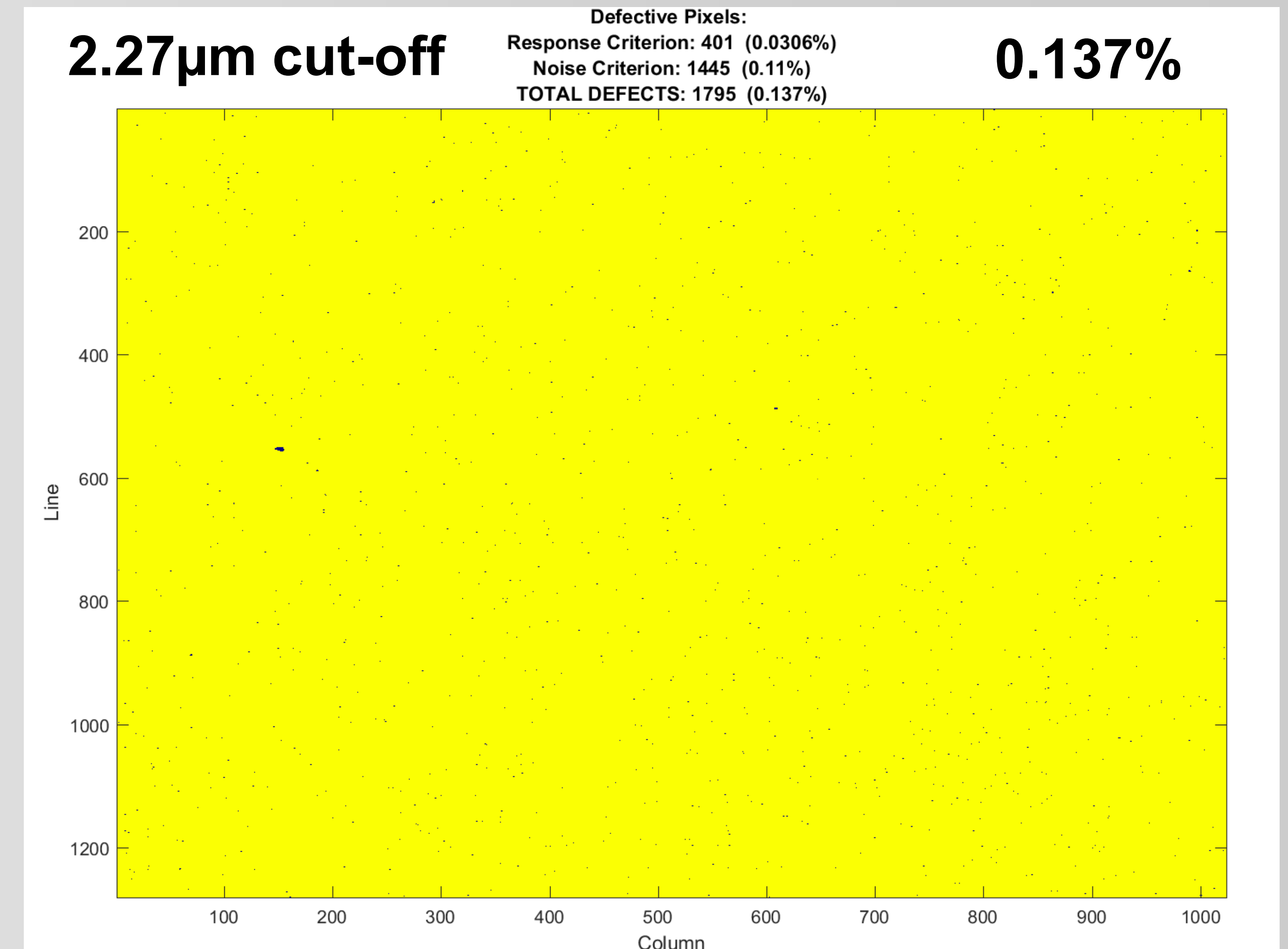
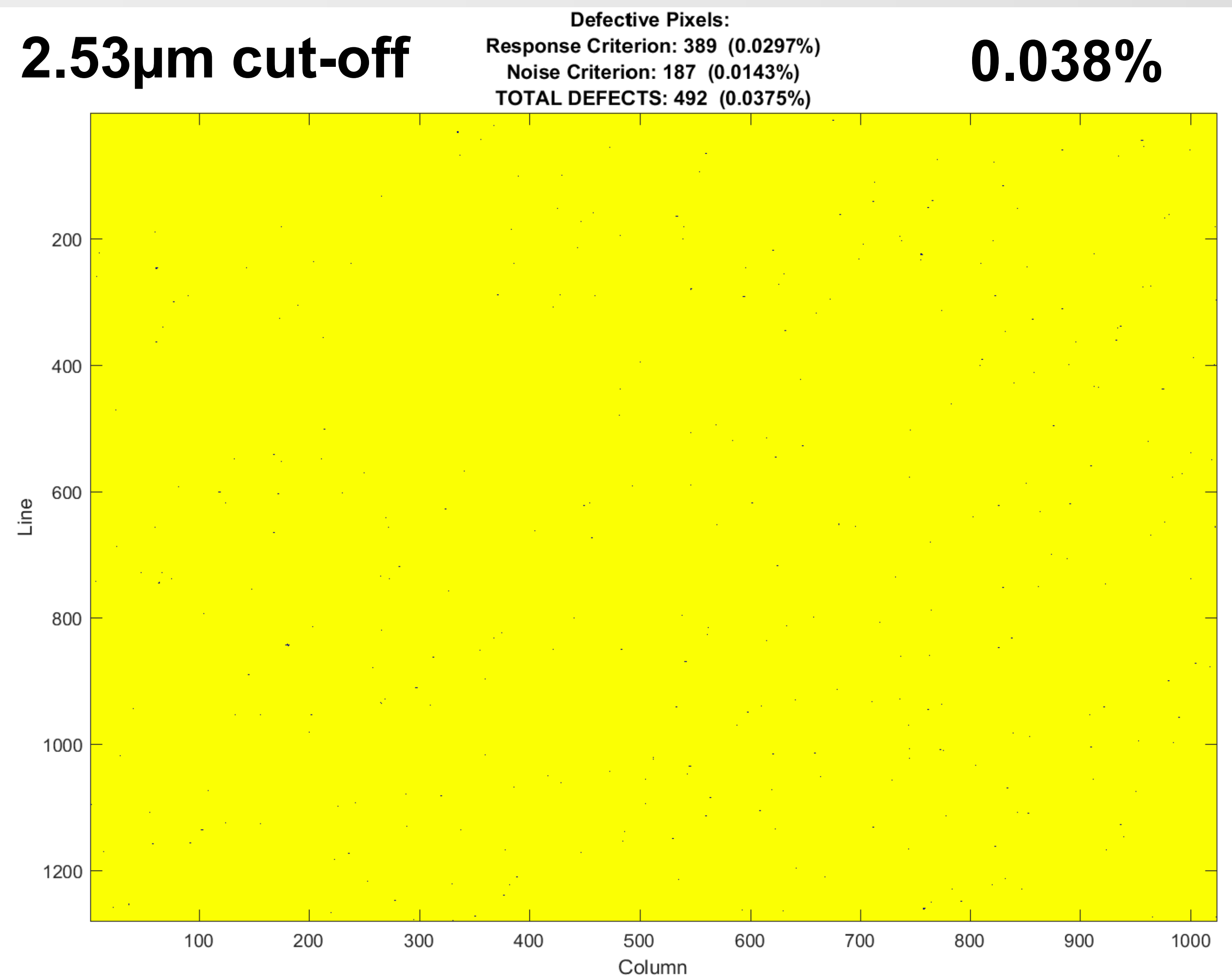


- Design goal was 100e-
- Read-out-noise @ 150K, high gain, 35 frames
- IDDCA mean value: 98.18e-, std: 22.16e-
- Open package mean value: 102e-



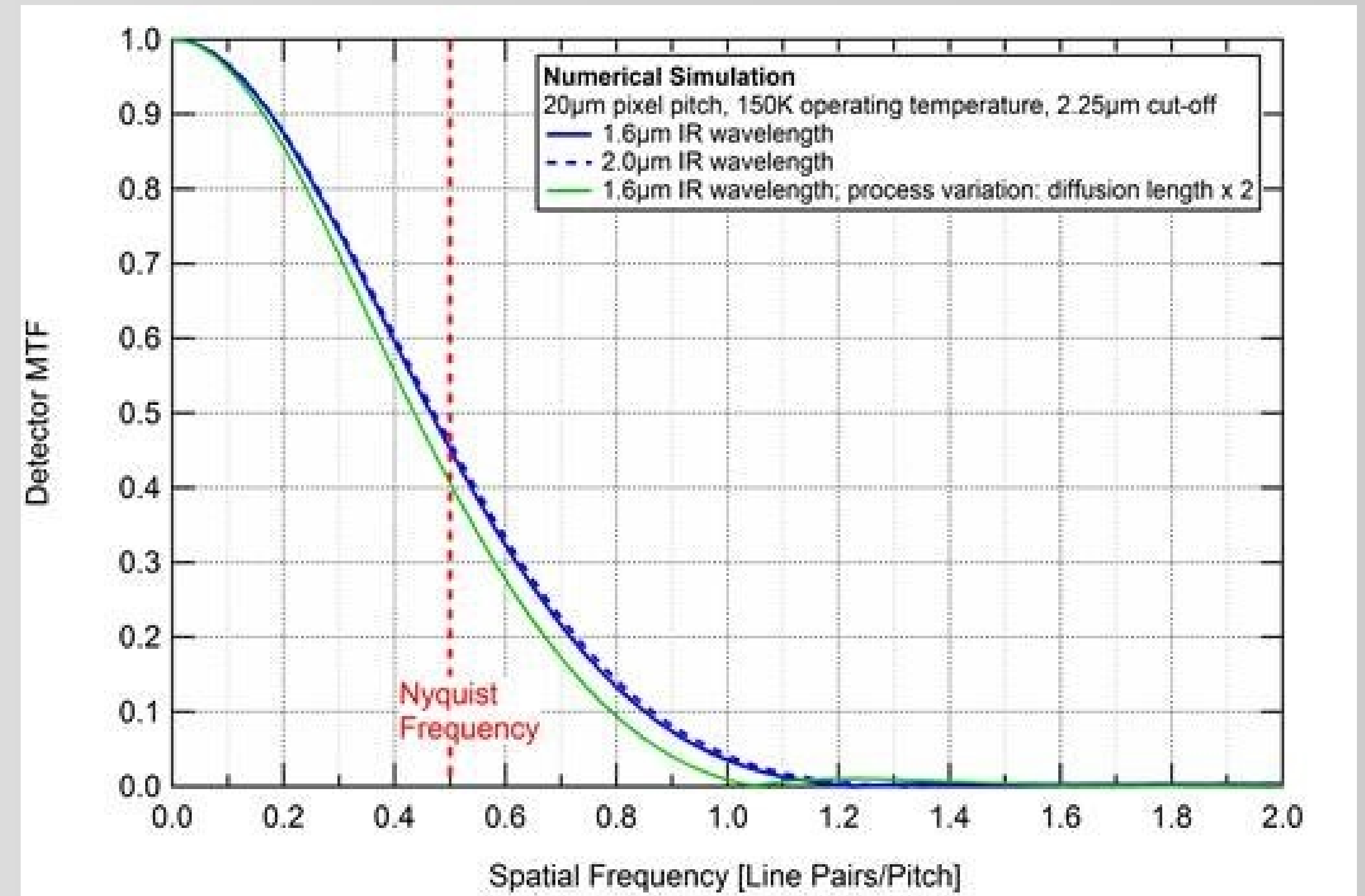
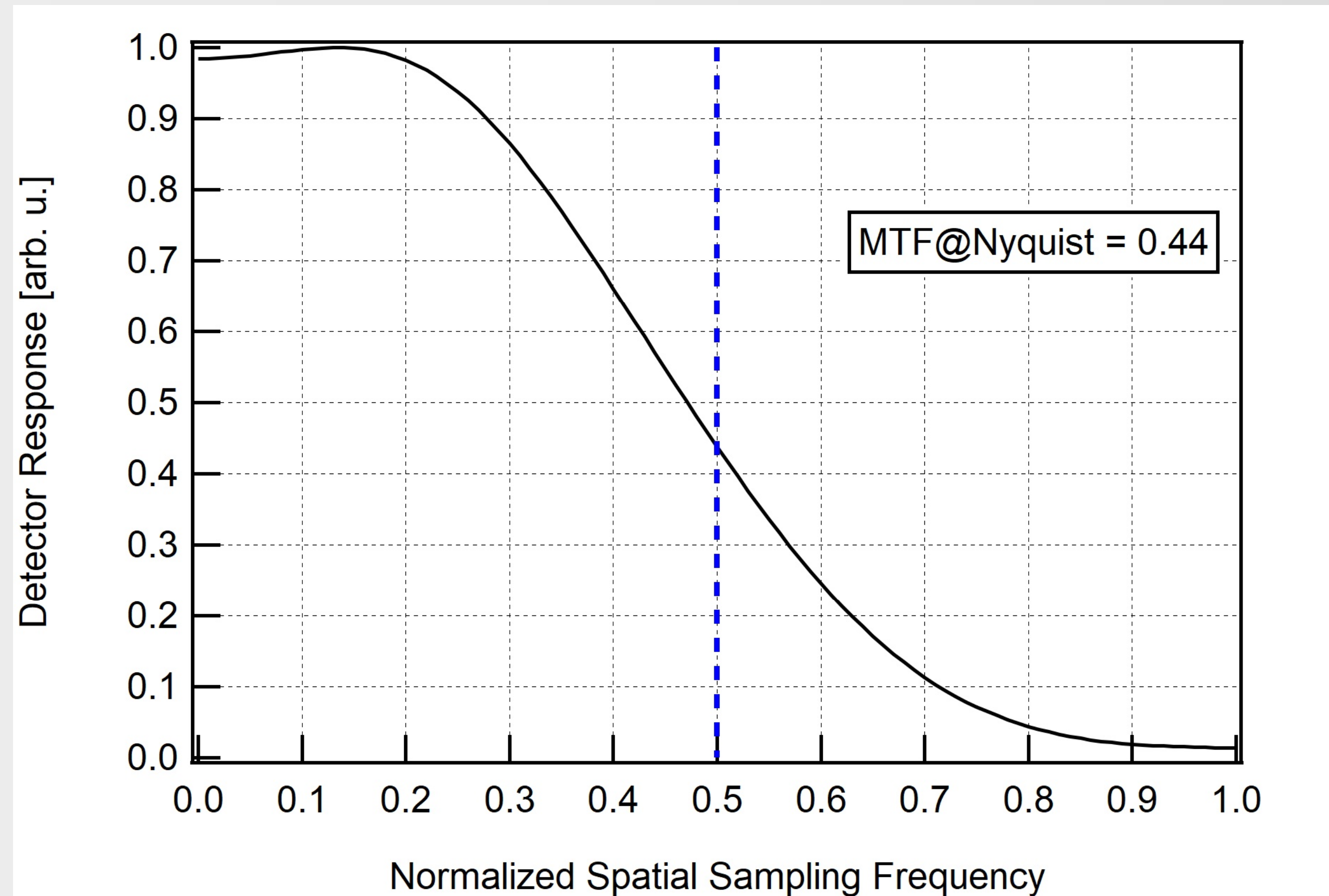


- Design target was 0.5% NL for all gains FW, currently not achieved
- 60% WF median  $<0.1\%$  NL for the current program
- Depending on ROIC configuration, FW around 1% NL



- 2 different hybrids, defects below  $<0.15\%$  @ 150K
- Defect criteria: Read-out-noise  $>3 \times$  mean  
Response  $<0.5 \times$  mean OR  $>2 \times$  mean



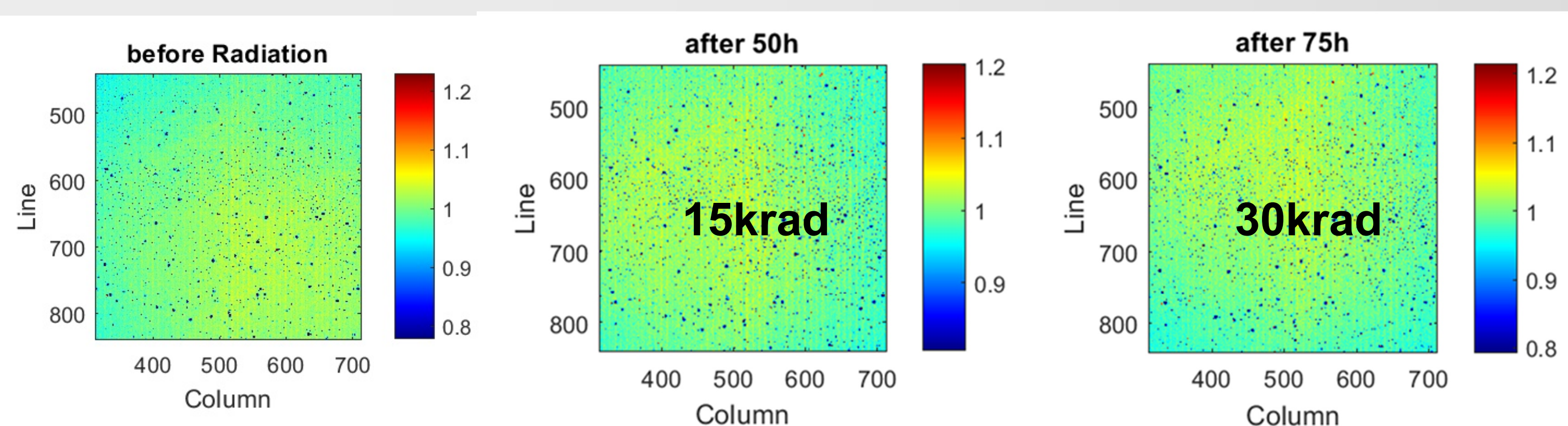
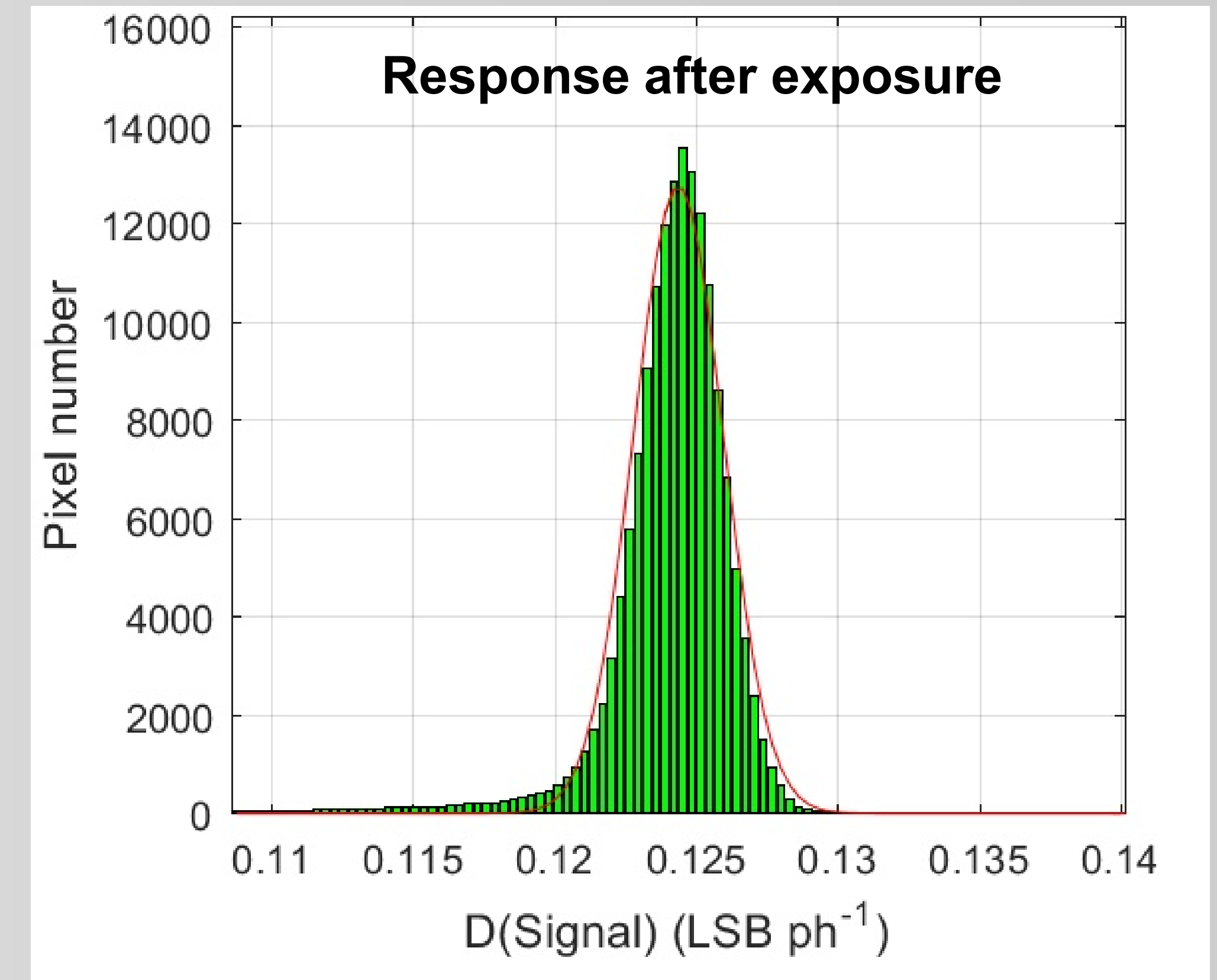
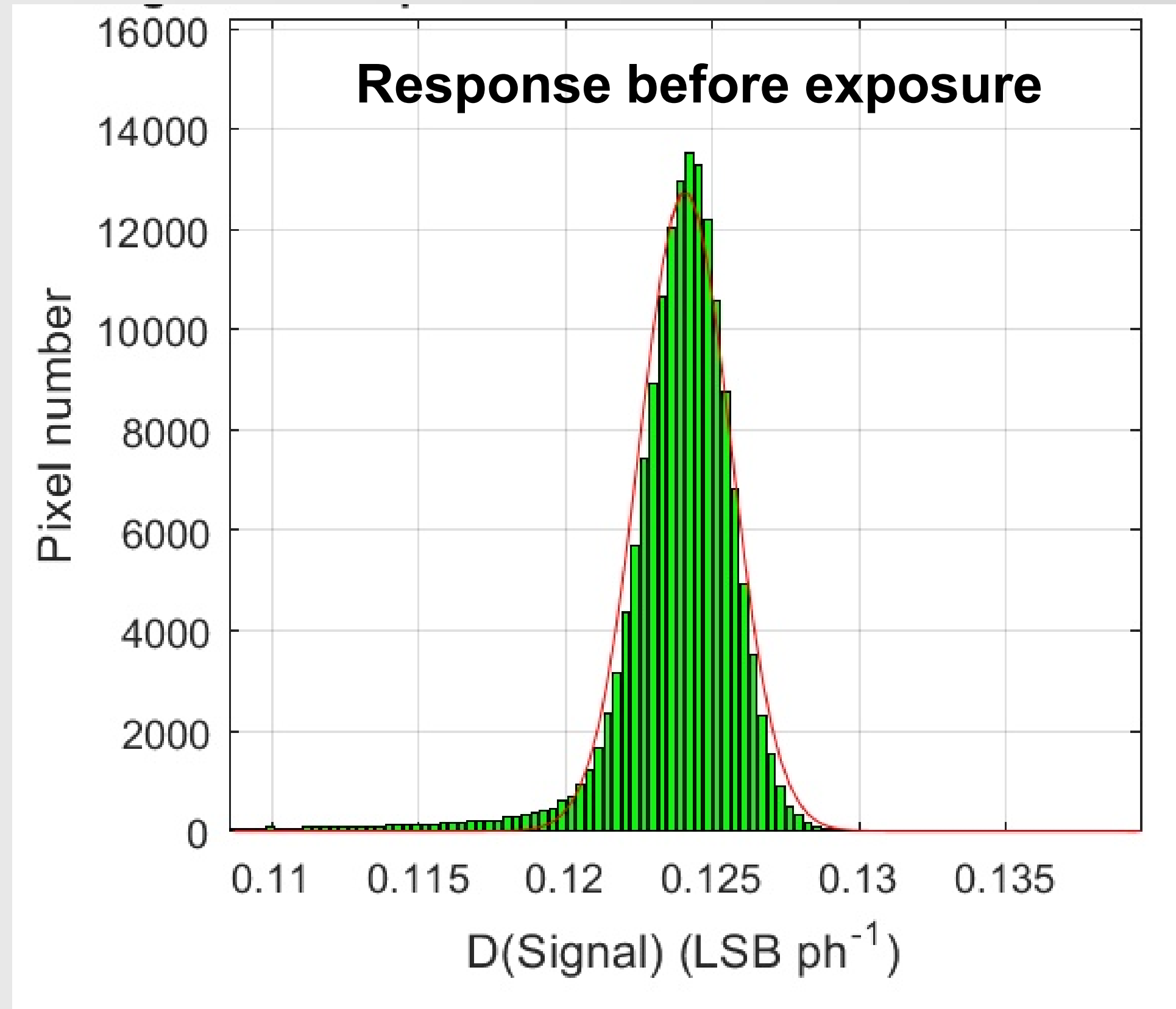


- MTF: 0.44 at Nyquist in spectral direction
- Used spot-scan method
- Impact of microvibrations visible
- Measurement is close to design



# ■ GAMMA RADIATION EXPOSURE

Co60 source at the Fraunhofer INT



- Dose rate 0.3 krad/h to 30 krad total, 4 steps
- Intermediate qualitative response tests: No changes
- EO characterization at AIM: Response and linearity unchanged but increase in read-out noise

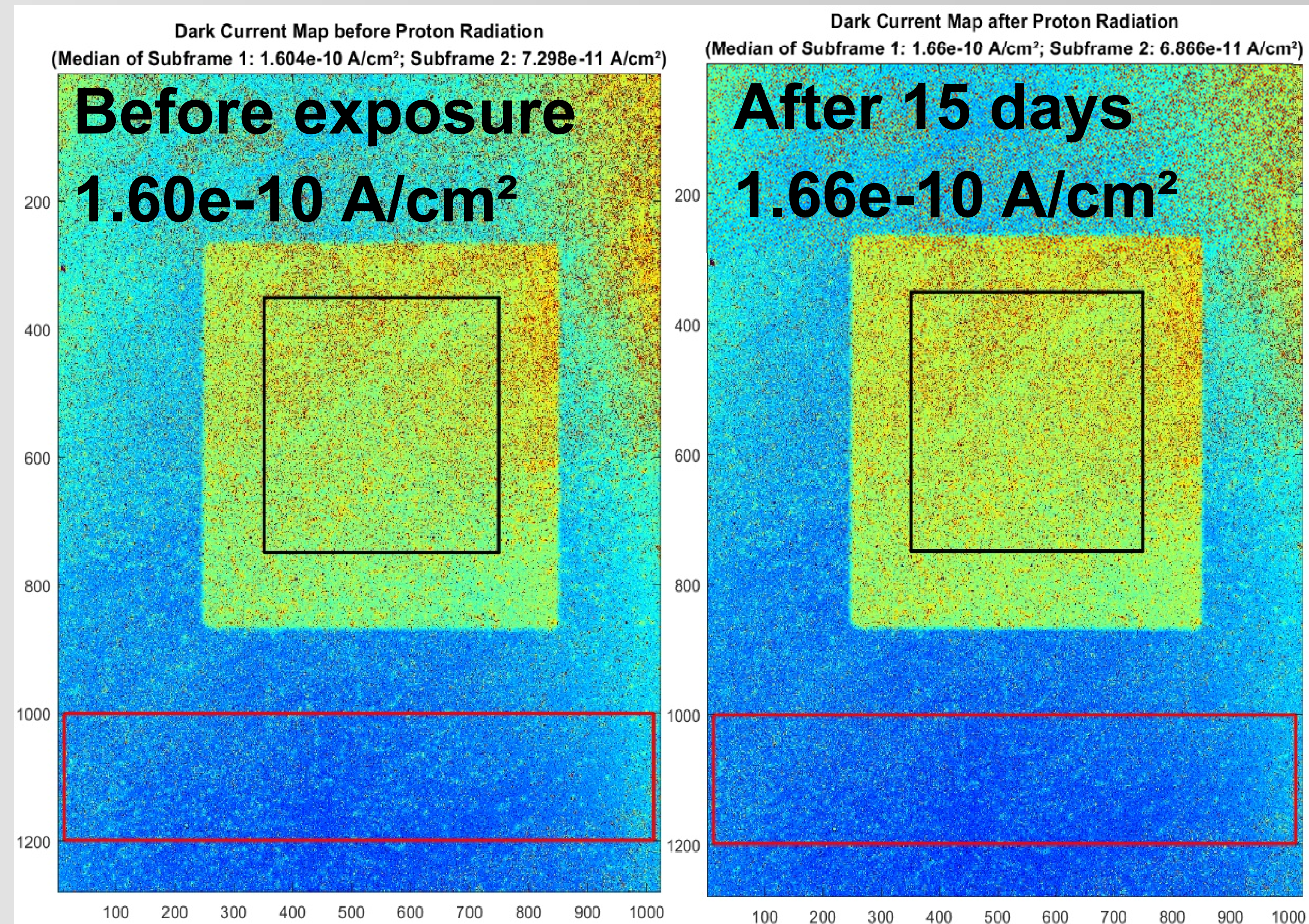


# ■ Proton Exposure

## Cyclotron at UC Louvain

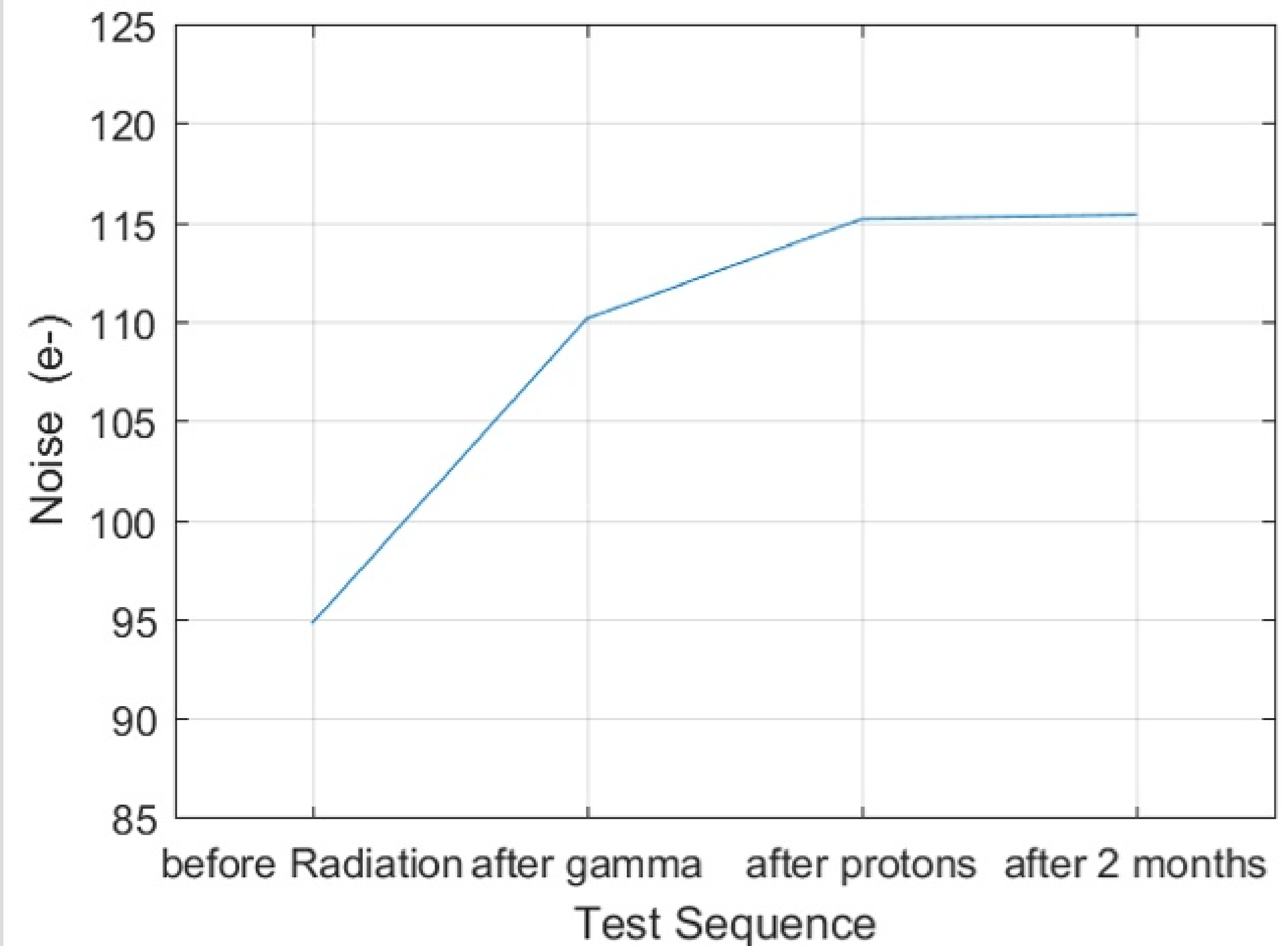
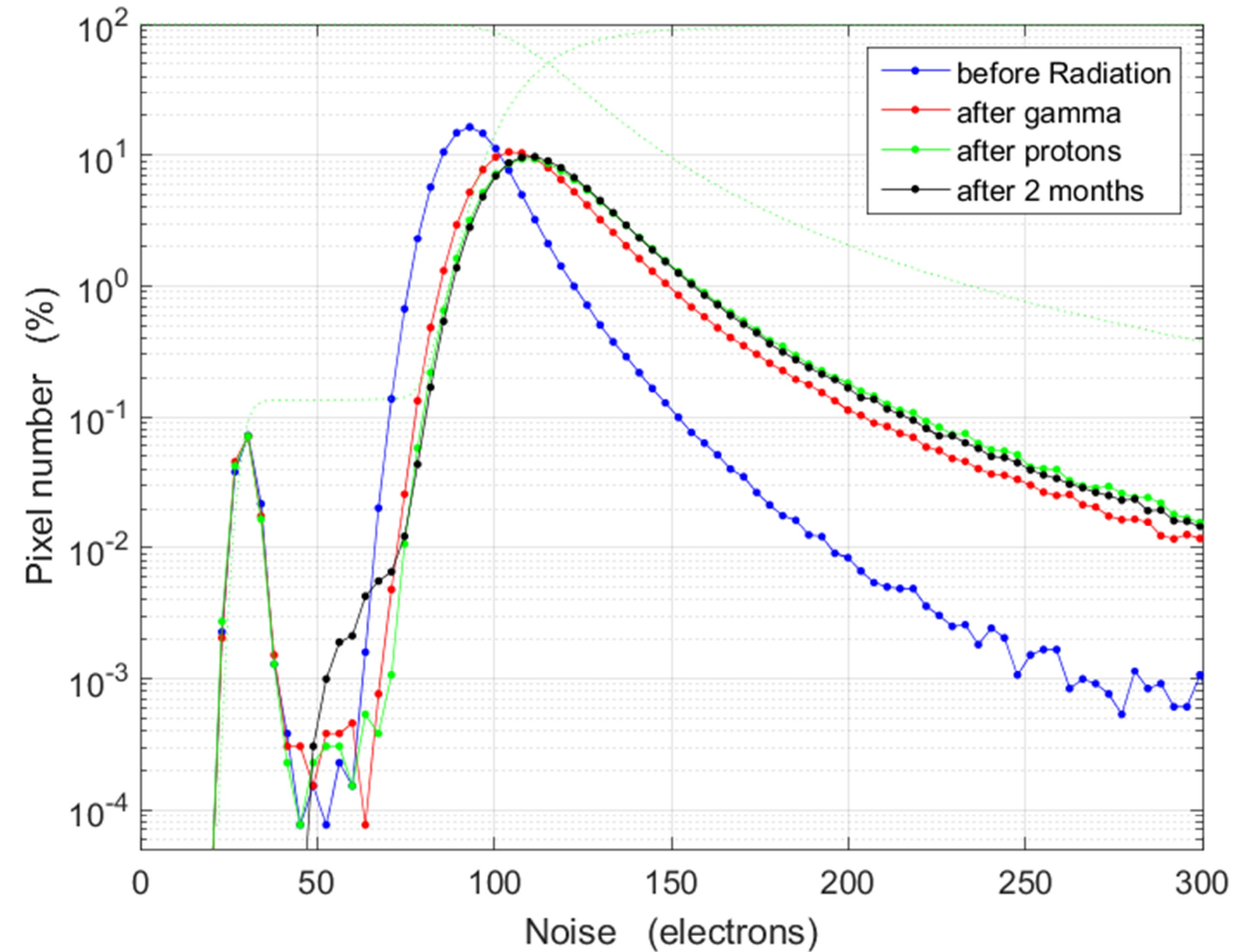


- Total dose  $2 \times 10^{11} \text{ p}^+/\text{cm}^2$
- EO test at AIM pre and post exposure
- 4 steps with response check in between
- No change in response
- Small dark current increase relaxed after 15 days
- No RTS analyses yet





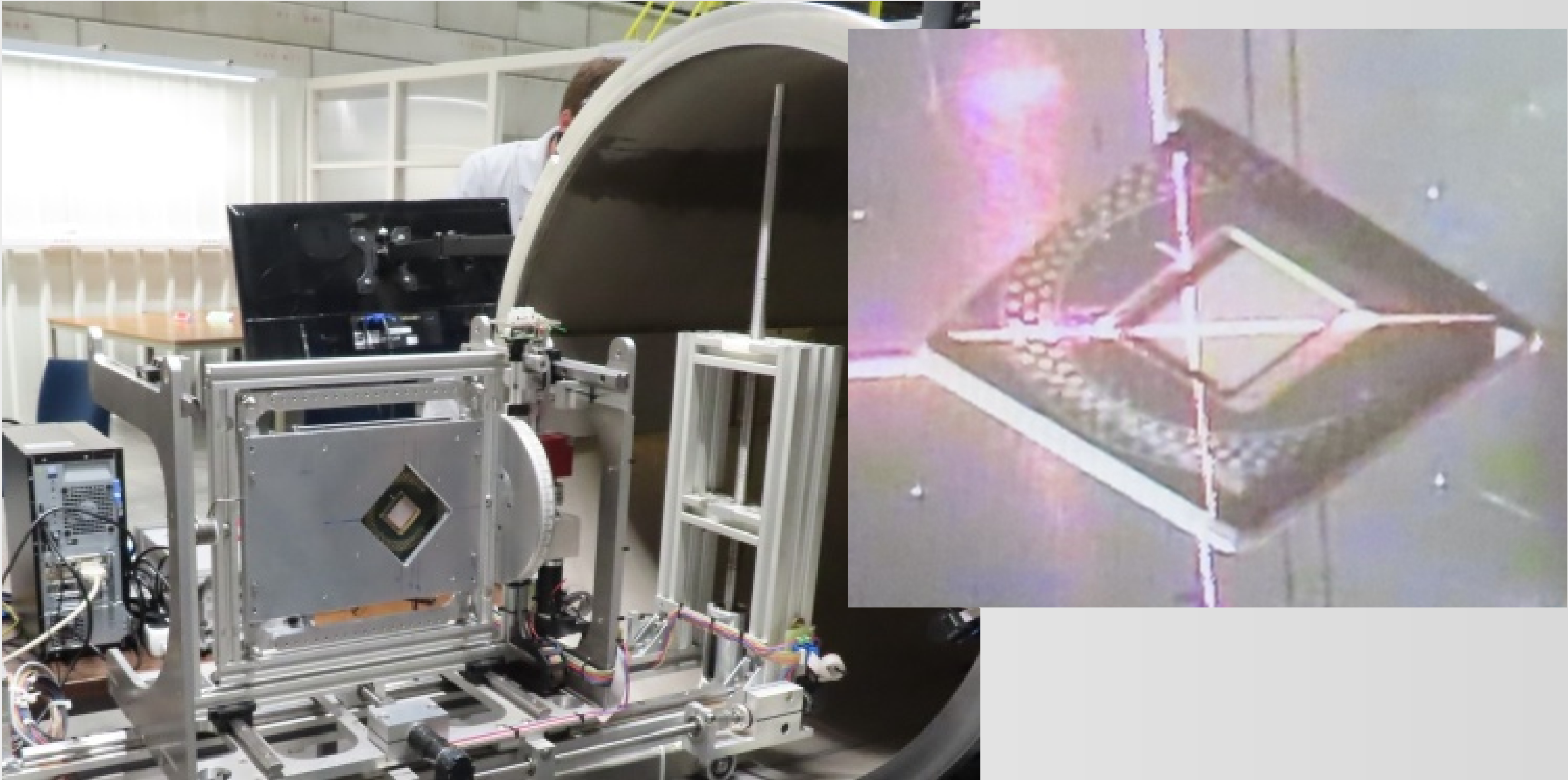
# ■ Radiation Tests Readout Noise



- Increase on the read-out noise after gamma radiation exposure
- This leads to more defects 0.5% -> 1.2% defective pixels
- No significant changes after proton irradiation



# ■ Heavy Ion Testing



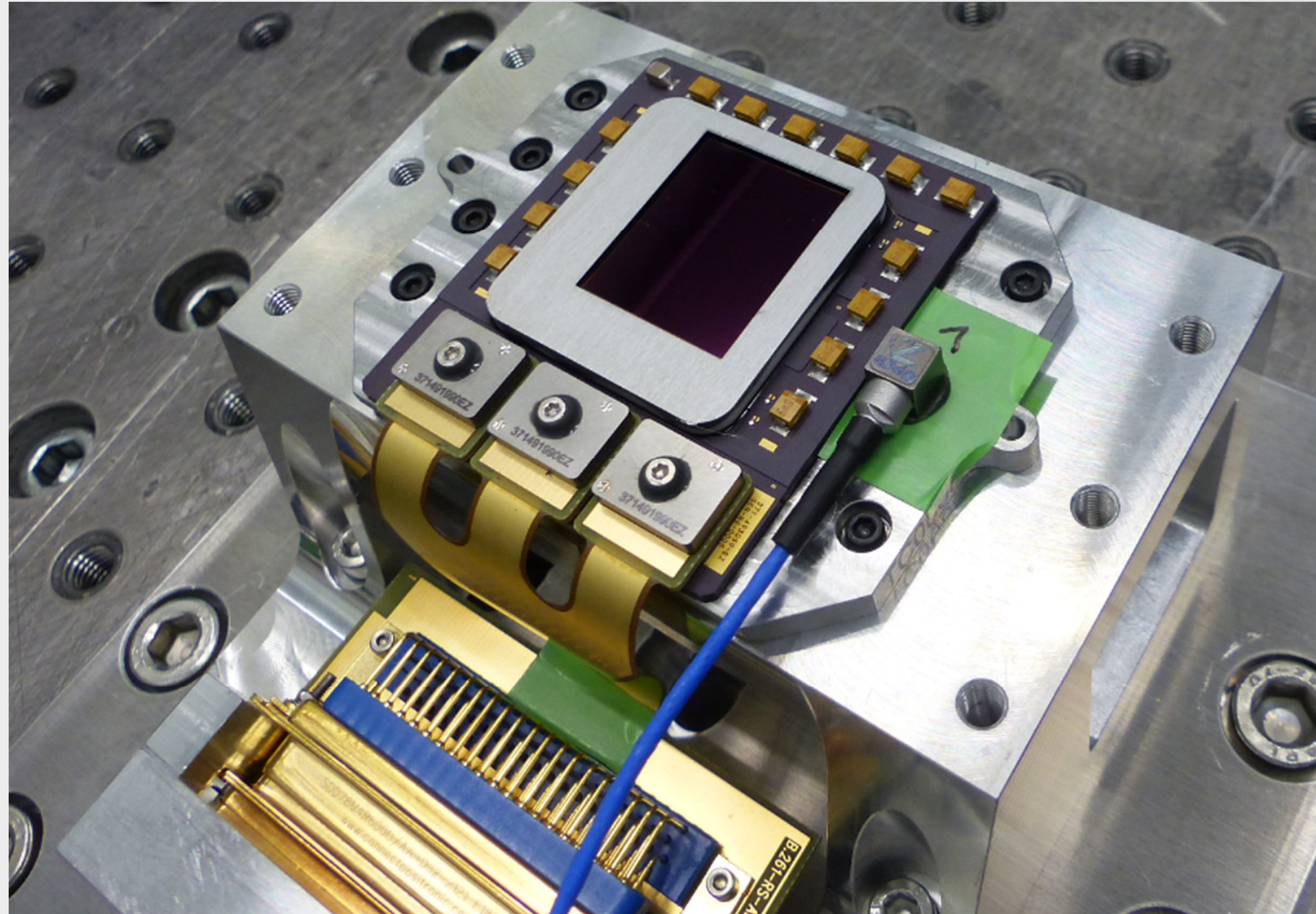
- 2 ROICs, different PXEs, Target fluence: 1e7 part/cm<sup>2</sup>
- Latch-up detection supply currents, register monitoring
- Exposed digital core and partly pixel array
- Maximum effective LET tested 109MeV\*cm<sup>2</sup>/mg
- No latch-up until 65.4 MeV\*cm<sup>2</sup>/mg

ROIC	Ion	Effective LET [MeV*cm <sup>2</sup> /mg (Si)]	ROIC Reset	Bit Flip	Latch Up
A	Ni-582	25.2	0	0	0
A	Kr-769	40.0	1	0	0
A	Kr-769	50.4	1	4	0
A	Xe-995	65.4	3	15	0
A	Xe-995	81.6	1	49	1
A	Xe-995	109.0	4	85	2
B	Xe-995	65.4	2	22	0
B	Xe-995	81.6	6	36	0



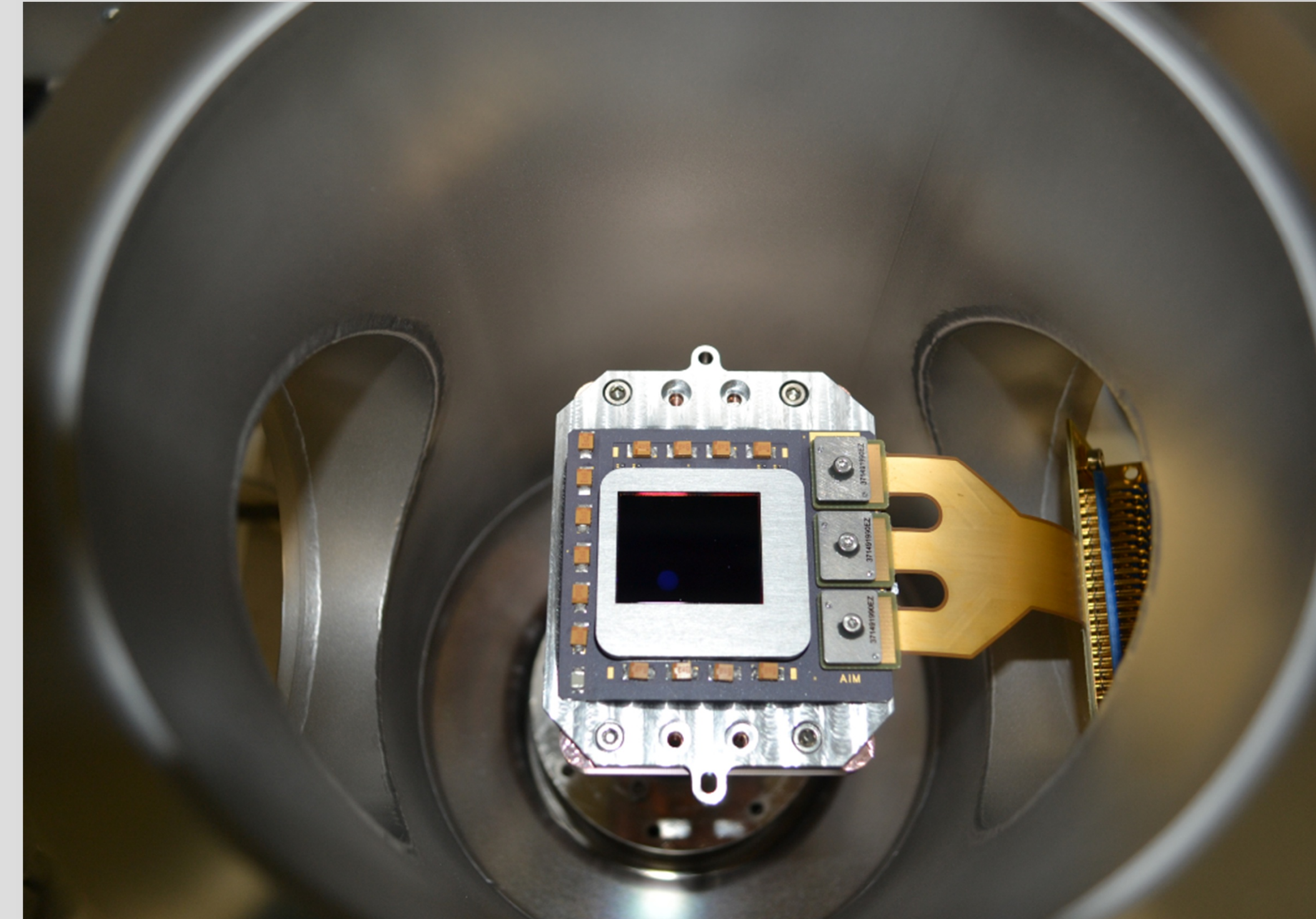
# ■ ENVIRONMENTAL TESTING

## Vibration load testing



- Modal, structural and thermal FEM analysis performed for open package
- Performed sine, random, and shock test on the open package with flex
- Passed EO testing before and after load
- Passed modal survey

## Temperature tests



- Open package cycling to 140K
- HTS 80°C for 240 hours in vacuum
- More than 500 cycles with IDDCA sensors
- No findings



## **Qualification Results of the AGD SWIR sensor**

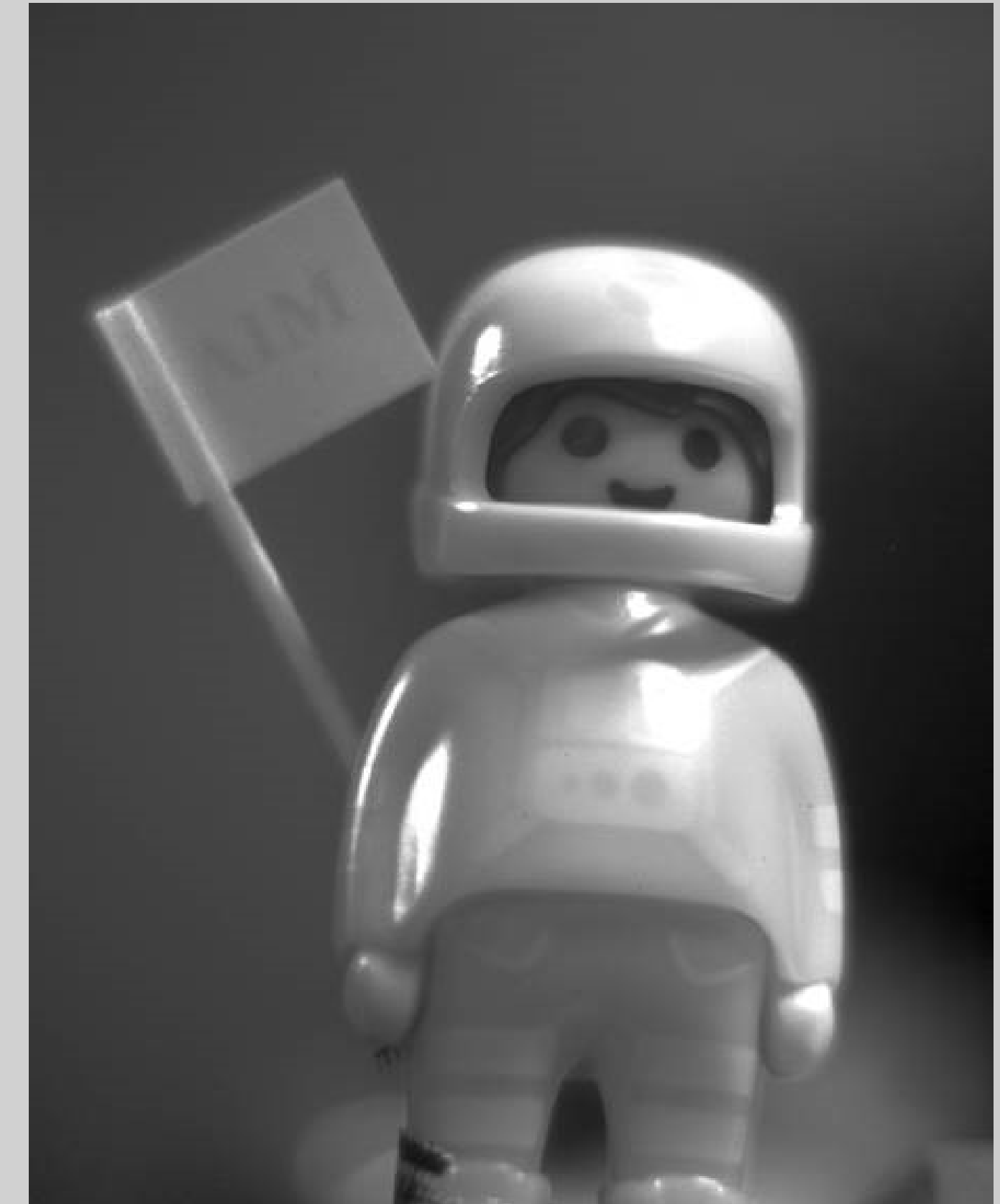
- EO test results: response, noise, dark current, linearity
- Environmental testing: Radiation testing, vibration (open package), temperature tests
- Data available: cross talk, dark signal shift, remanence, power consumption etc.
- Achieved TRL 5-6

## **SWIR sensor layer technology outlook**

- Significantly increased operating temperature of SWIR sensors
- Results expected to be published this year

## **Acknowledgements**

- DLR Funding 50EE1606
- Qualification and testing: Matthias Benecke, Richard Thöt, Marcus Schaaf



Thank you for your attention!