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Efficiency and noise measurements on irradiated samples of H2M Monolithic Active Pixel Sensors

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Motivation: Why MAPS?

- **Monolithic Active Pixel Sensors (MAPS)**
- Detection volume and readout logic are integrated into a single silicon layer
- Eliminates the complex and difficult process of connecting two chips through bump-bonding
- Enables smaller pixel pitches for improved spatial resolution
- Reduces material budget
- Targeted for application in future lepton colliders

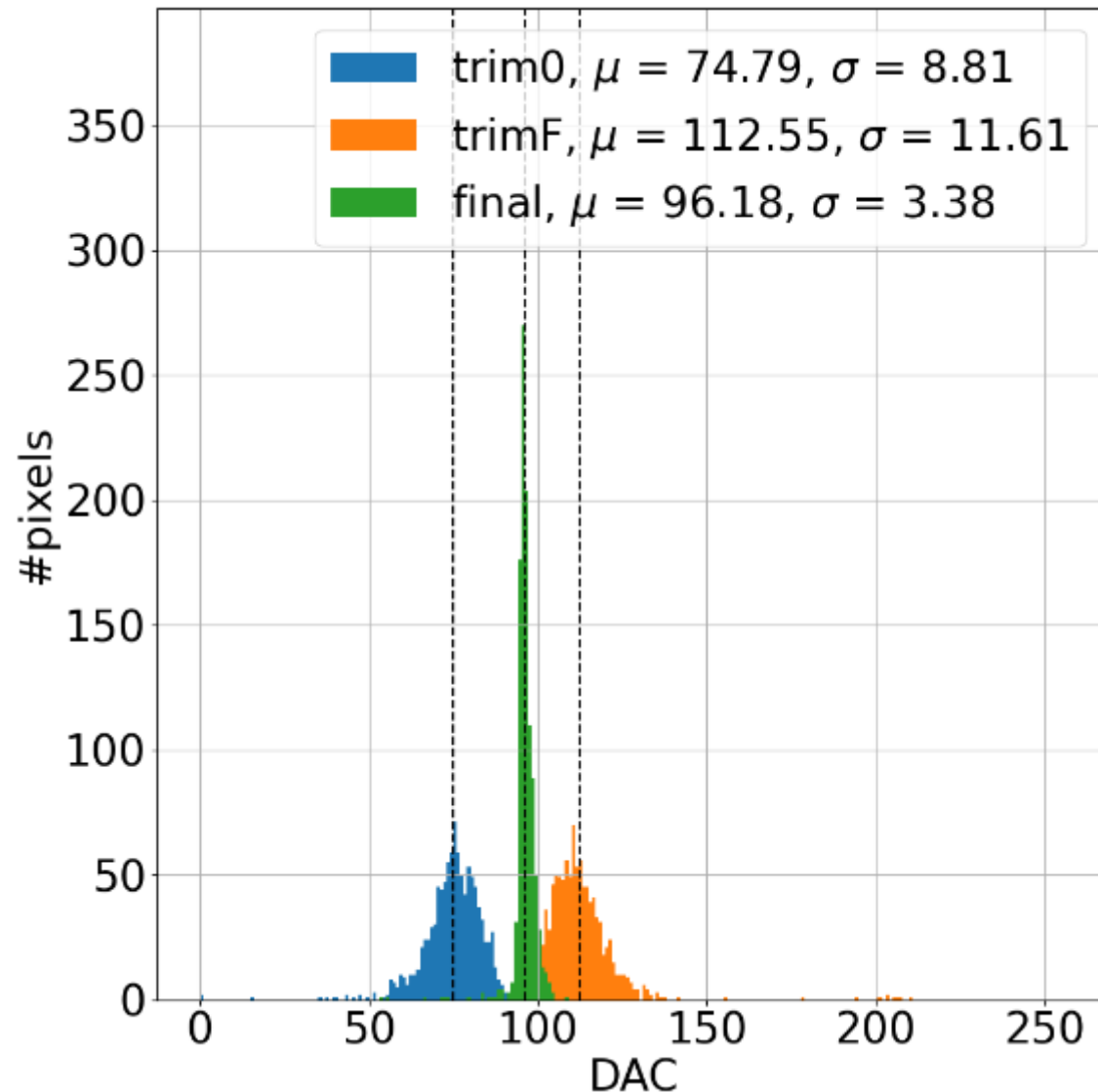
The H2M prototype

- MAPS manufactured in 65 nm CMOS process
- **Pixel matrix:** 64 x 16 pixels with a pitch of 35 μm and an overall detection surface of 2.24 x 0.56 mm²
- Detector functions are primarily controlled by six detector-level DACs (e.g., detection threshold setting)
- Each pixel contains its own integrated electronics (e.g., fine threshold tuning at the pixel level)

Trimming

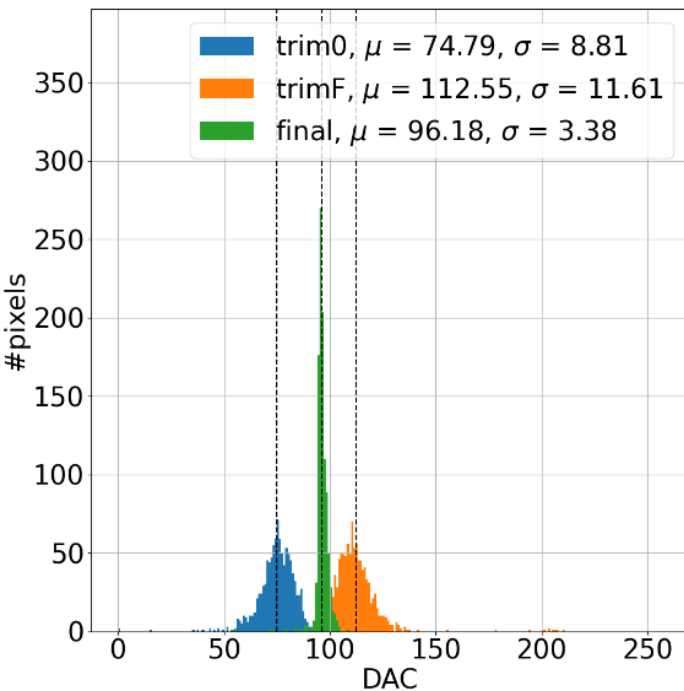
- **Problem:** Due to microscopic imperfections, each pixel exhibits a slightly different baseline detection threshold, eventually leading to a loss of uniformity across the detector if left uncorrected
- **Solution:** The H2M chip contains local 4-bit tuning_DAC inside every single pixel. By scanning thresholds for each pixel at each tuning_DAC value, we can assign specific 4-bit values to all of them, forcing their individual threshold to a globally targeted mean

Trimming results

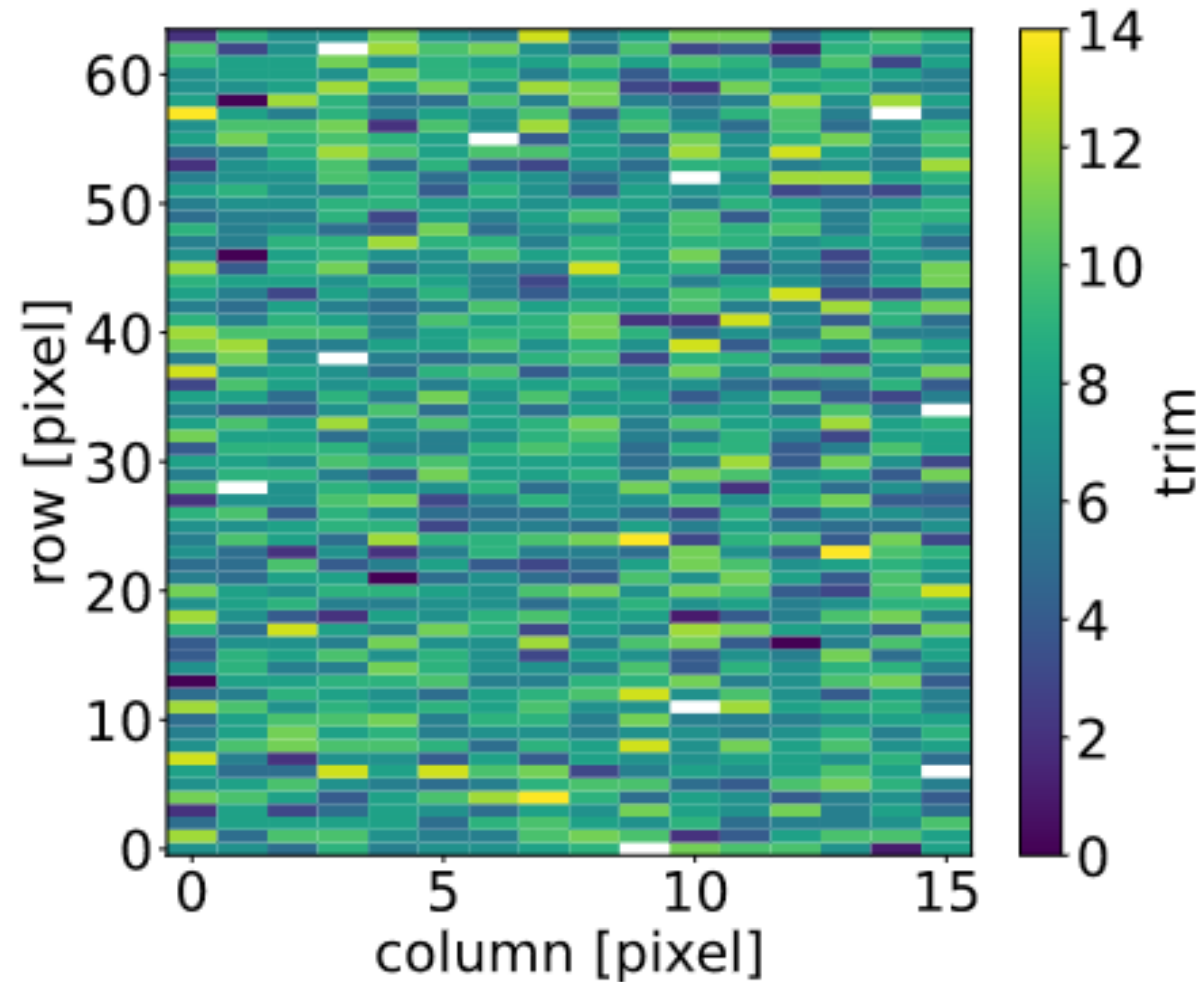


- Number of pixels as a function of their detection threshold before and after trimming

Trimming results

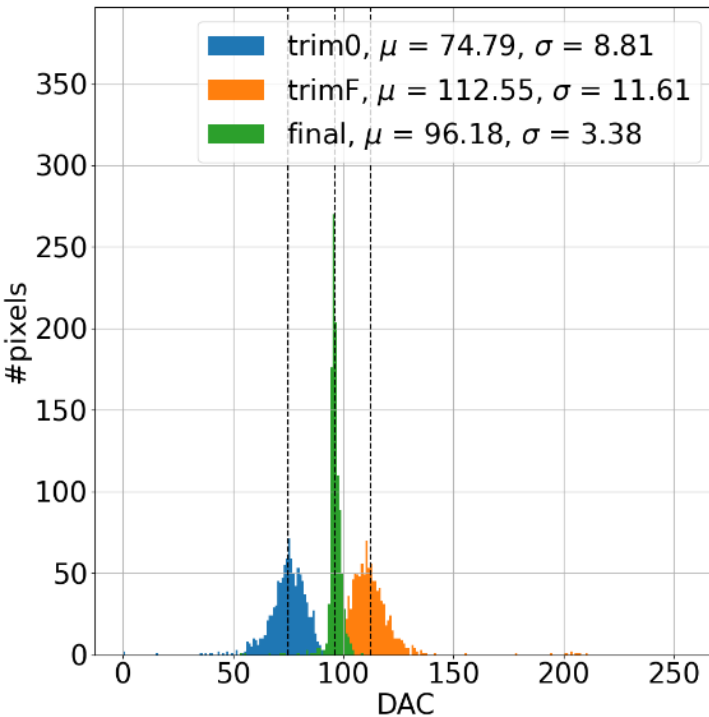


- Number of pixels as a function of their detection threshold before and after trimming

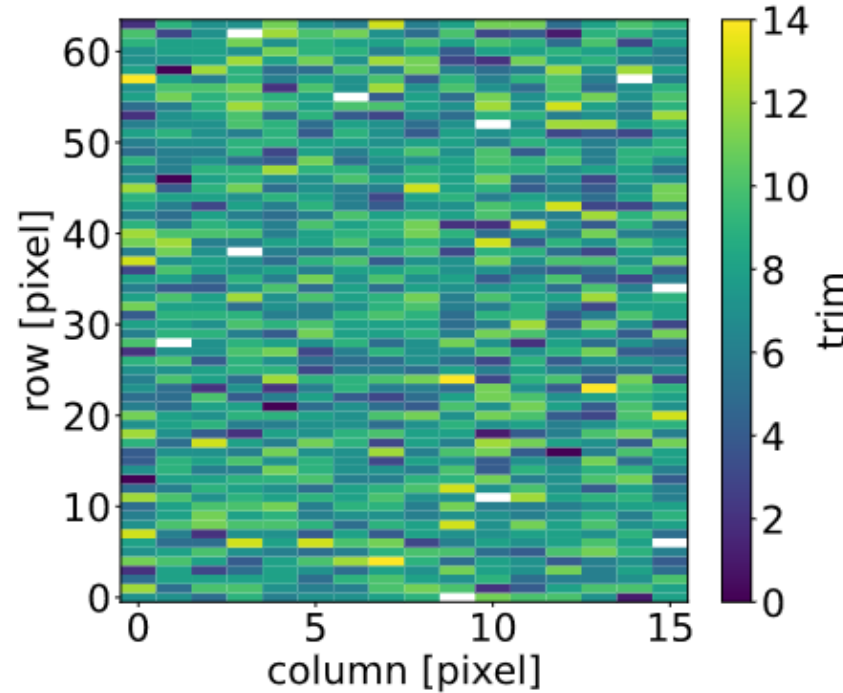


- Values of tuning_DAC for specific pixels

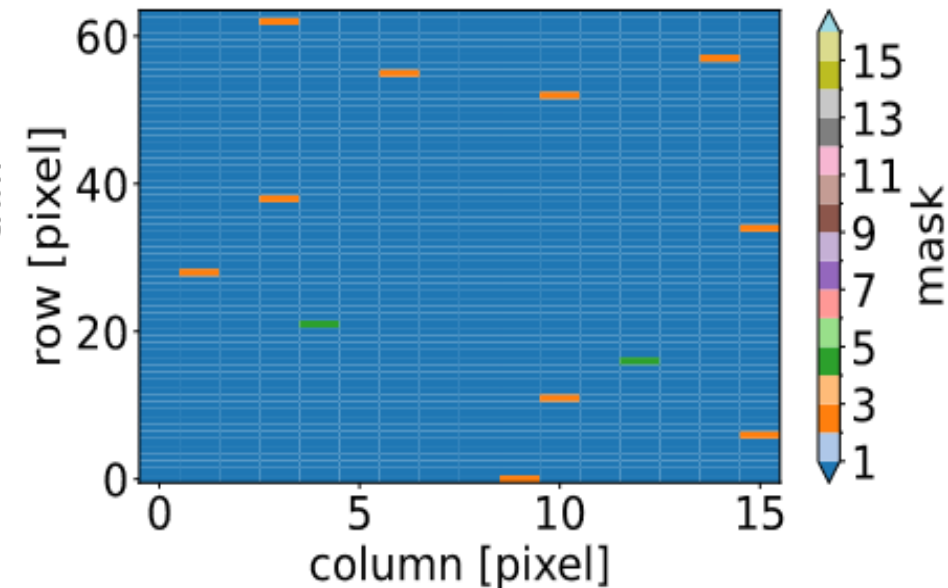
Trimming results



- Number of pixels as a function of their detection threshold before and after trimming



- Values of tuning_DAC for specific pixels



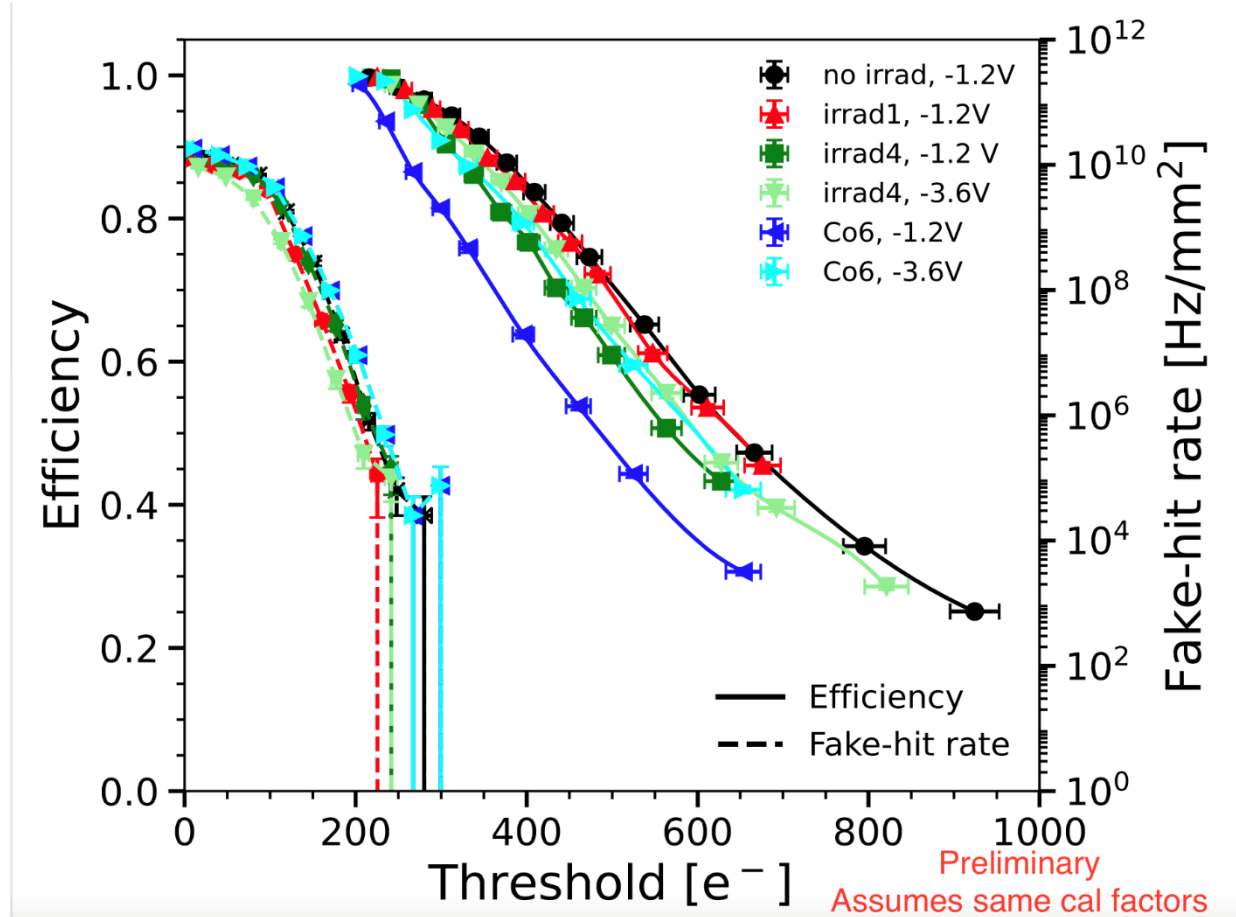
- Masked pixels

Trimming results

Sample / Irradiation Level	Standard Deviation (σ) [# DAC_vthr]	Number of Masked Pixels
Reference	3.38	12
Gamma 30 kGy	1.41	7
Gamma 100 kGy	1.61	11
Gamma 300 kGy	1.88	7
Protons 5×10^{12} p/cm ²	2.30	14
Protons 1×10^{13} p/cm ²	4.30	10
Protons 1×10^{14} p/cm ²	2.70	22
Protons 5×10^{14} p/cm ²	2.54	18

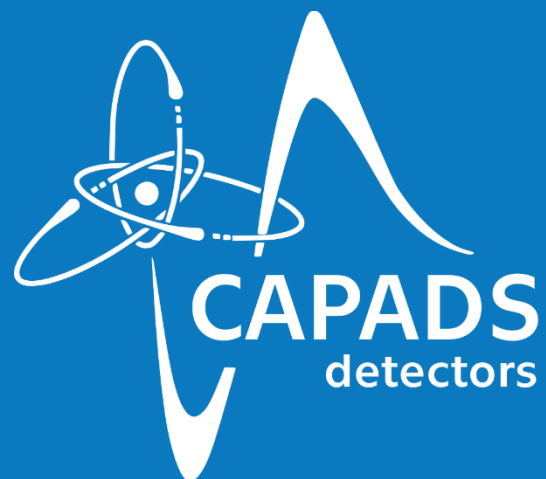
(Total number of pixels is 1024)

Summary and future outlook

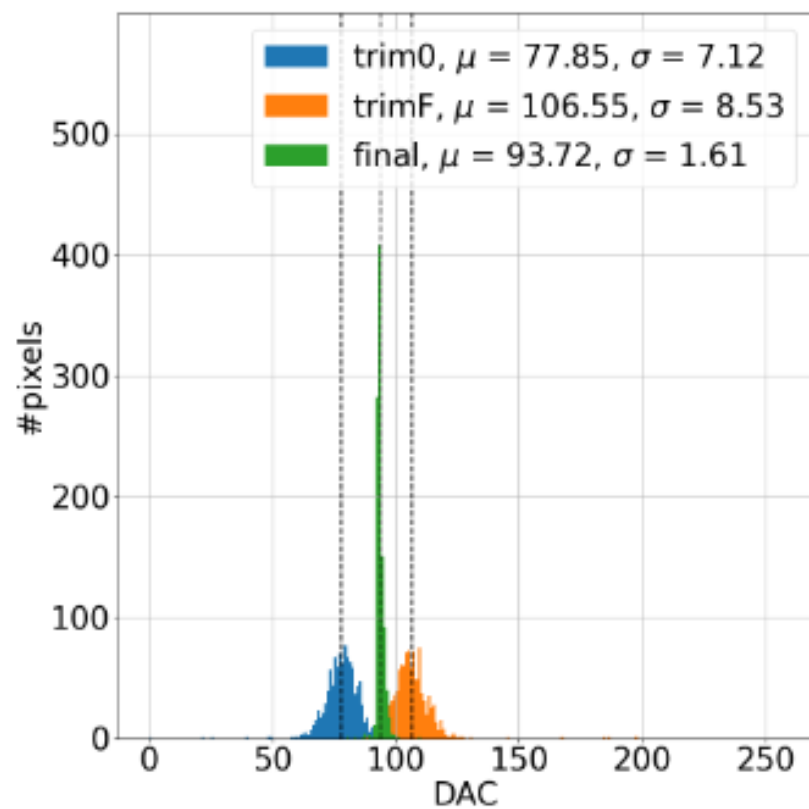


- **Project OCTOPUS:** This work contributes to the broader R&D effort developing monolithic detectors for application in future lepton colliders
- **Laboratory characterization:** The functionality and radiation hardness of various H2M samples were successfully tested
- **Next steps:** The efficiency measurements of the samples were carried out at DESY. The analysis of acquired data is currently ongoing

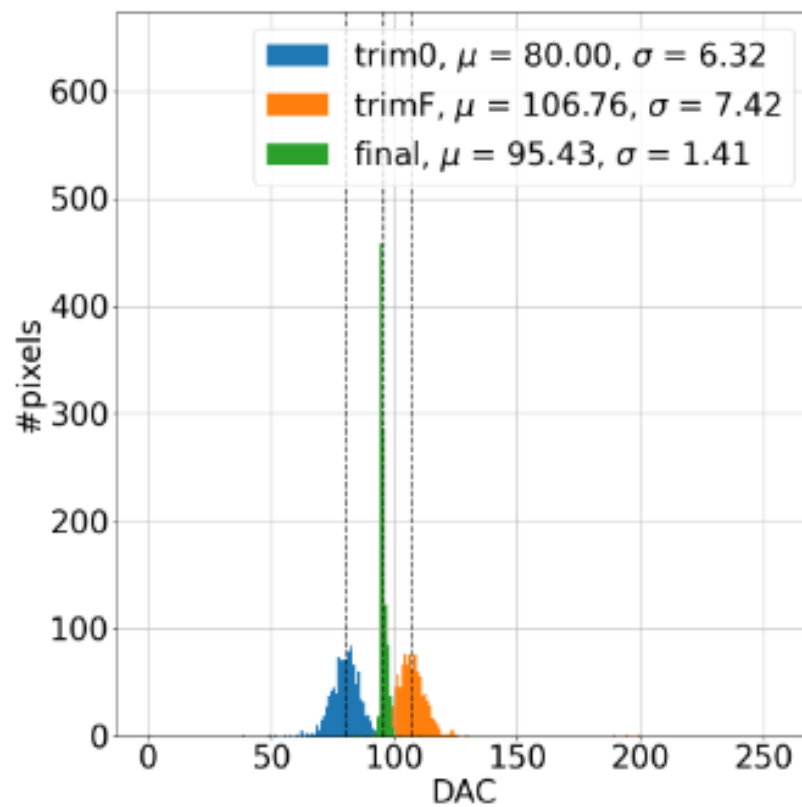
Thank you for your attention!



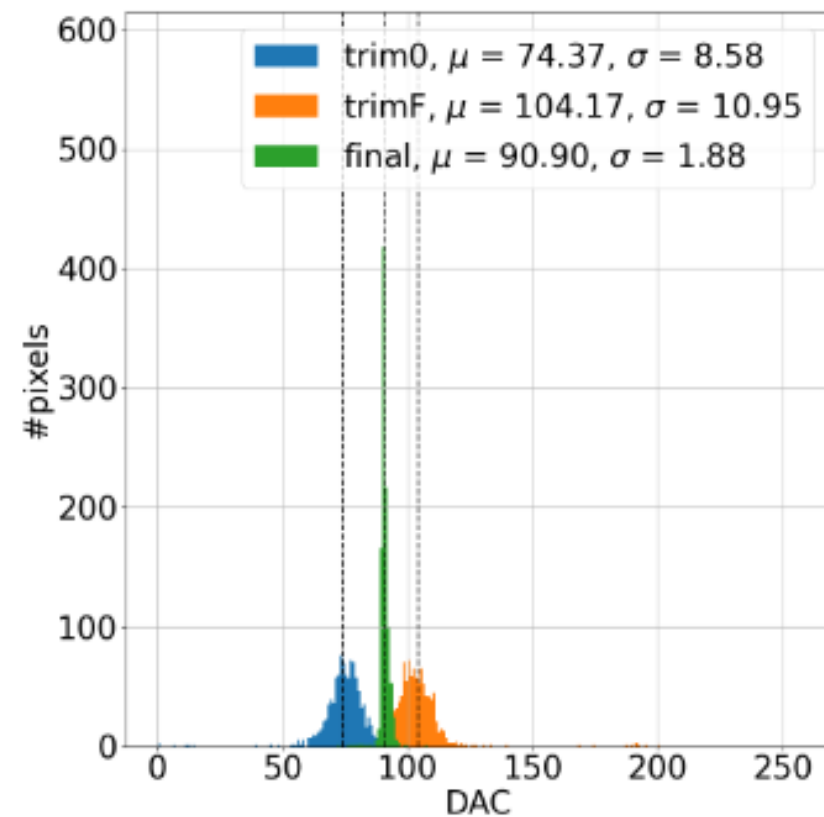
<https://capads.fjfi.cvut.cz>



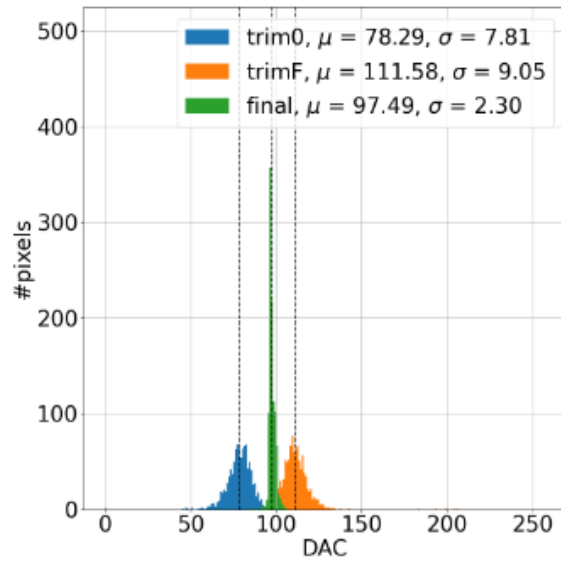
(b) Dávka 100 kGy



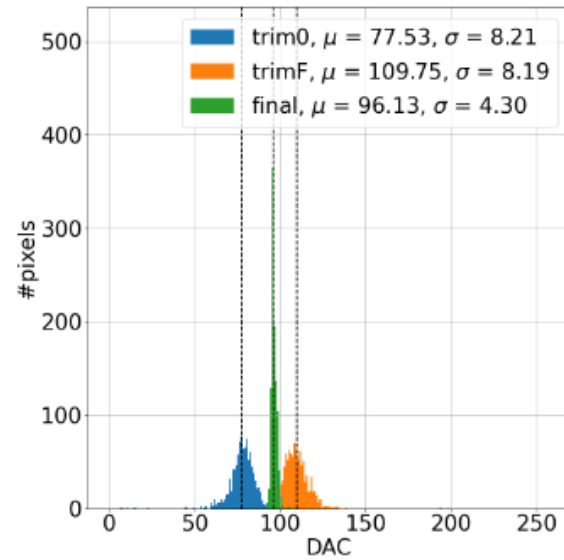
(a) Dávka 30 kGy



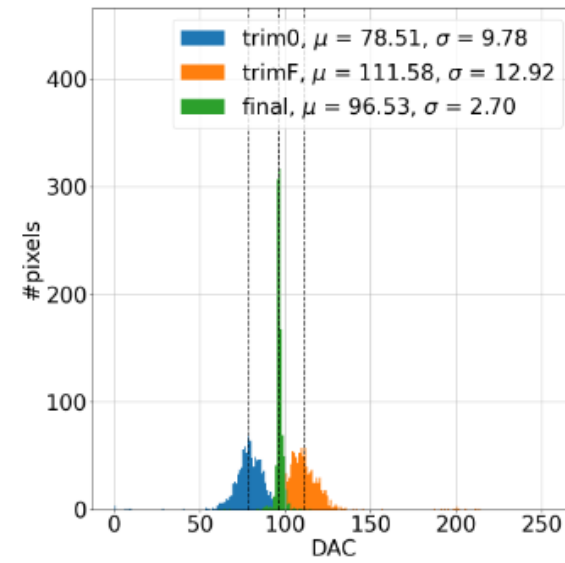
(c) Dávka 300 kGy



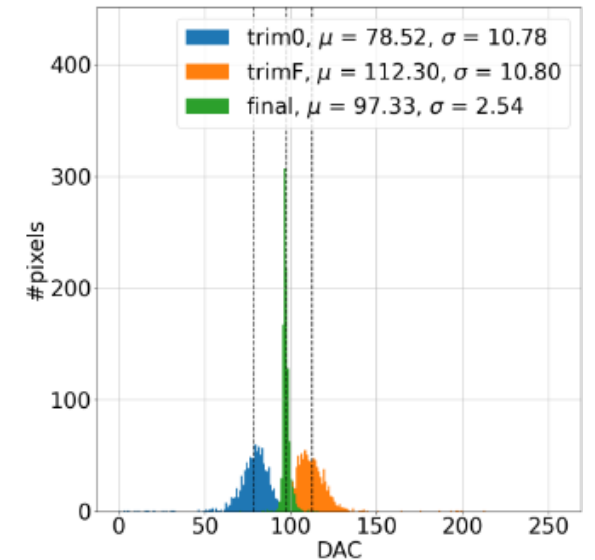
(a) Fluencia 5×10^{12} p/cm²



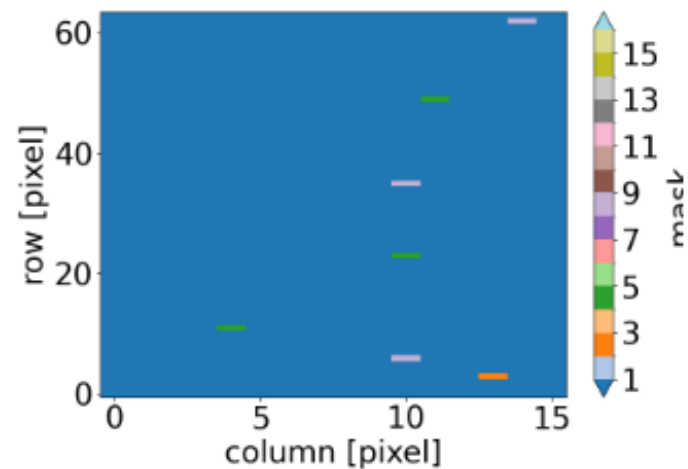
(b) Fluencia 1×10^{13} p/cm²



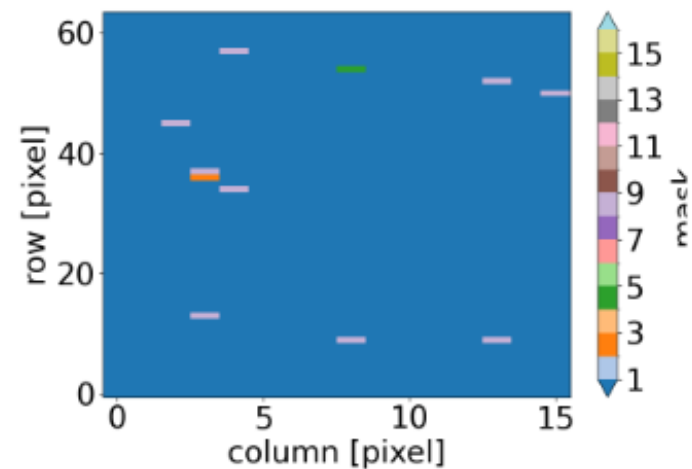
(c) Fluencia 1×10^{14} p/cm²



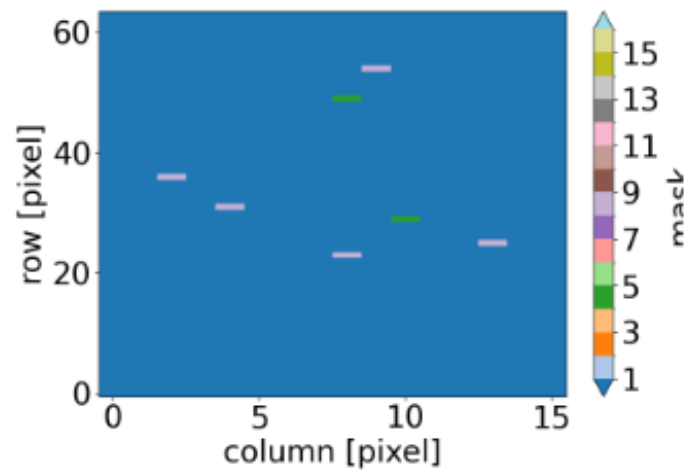
(d) Fluencia 5×10^{14} p/cm²



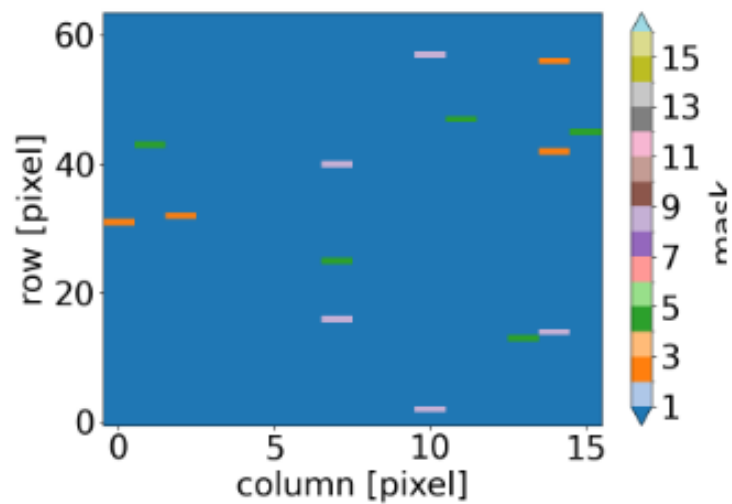
(a) Dávka 30 kGy



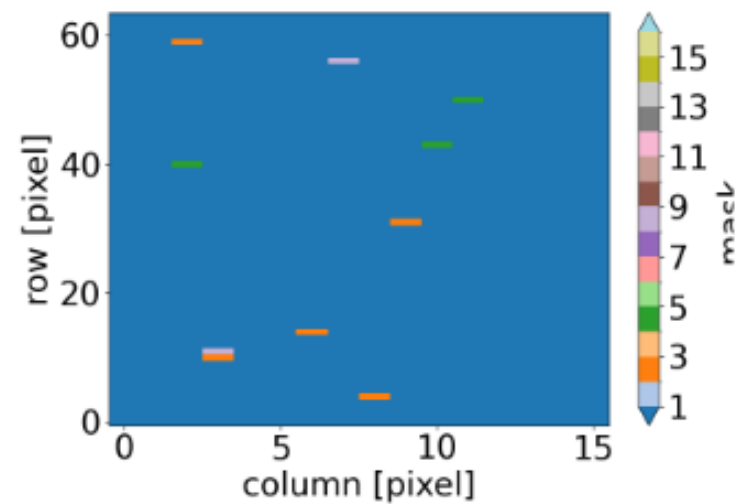
(b) Dávka 100 kGy



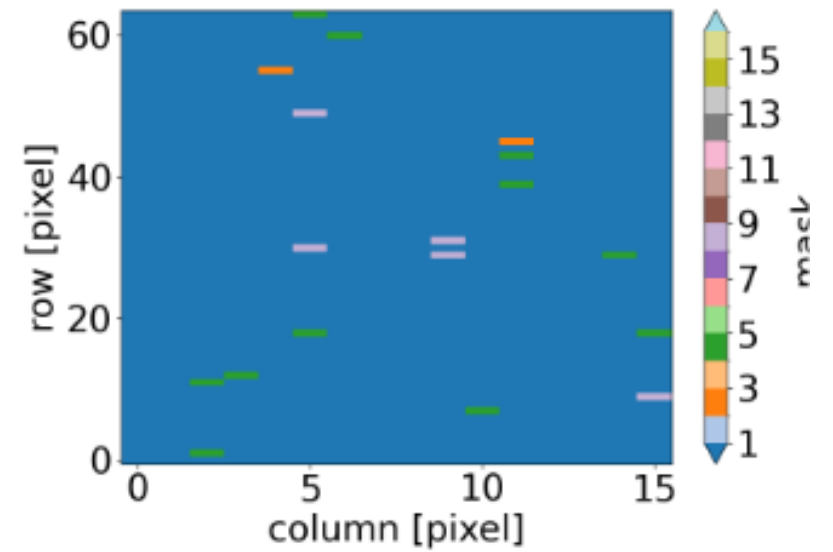
(c) Dávka 300 kGy



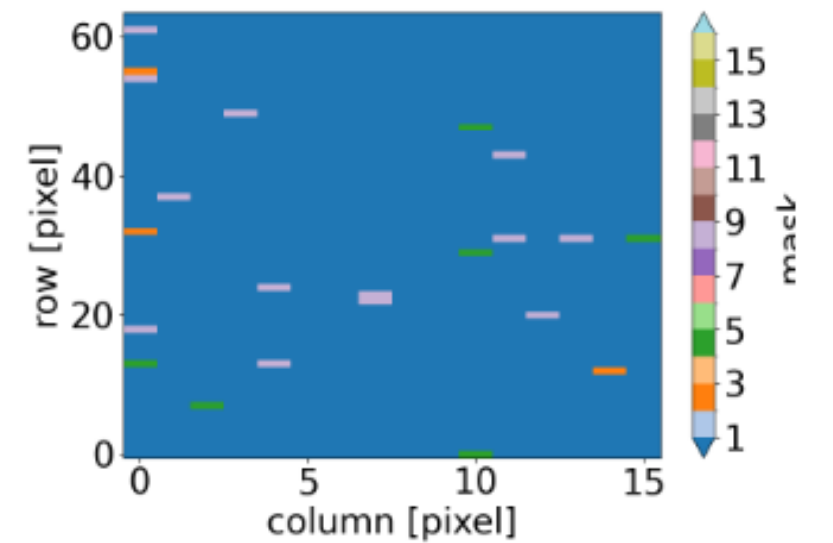
(a) Fluencia 5×10^{12} p/cm²



(b) Fluencia 1×10^{13} p/cm²



(d) Fluencia 5×10^{14} p/cm²



(c) Fluencia 1×10^{14} p/cm²