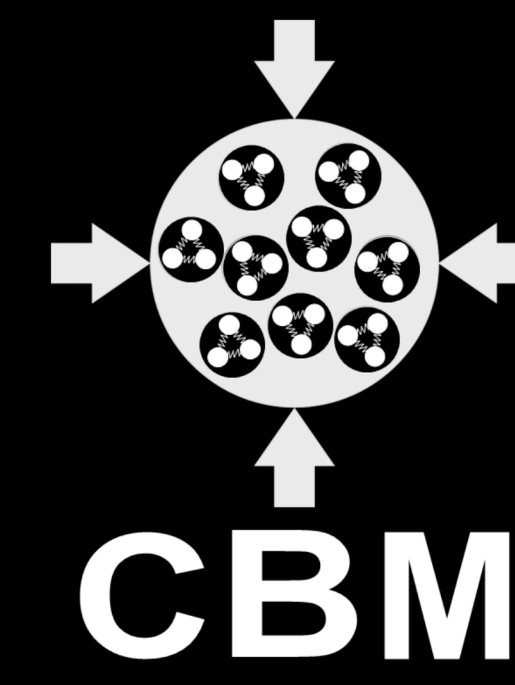


SiPM-based RICH detector at an upgraded Compressed Baryonic Matter experiment

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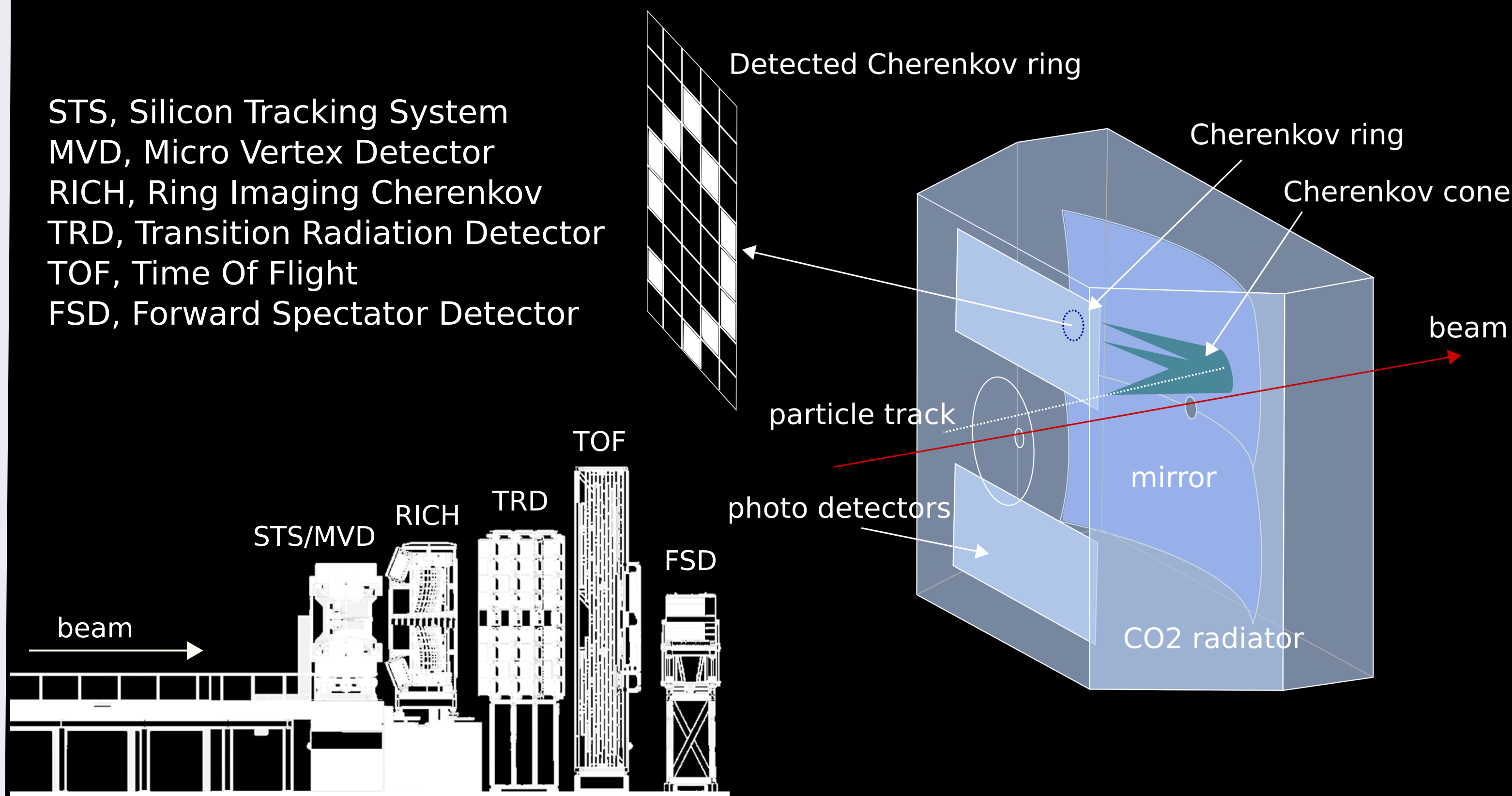


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CBM's Ring Imaging Cherenkov detector

The CBM experiment at FAIR will study the phase diagram of nuclear matter at moderate temperatures and high densities and will search for traces of the critical point. The RICH detector is a central element of CBM and serves to measure dielectrons as a clean probe for the different phases of the collision.

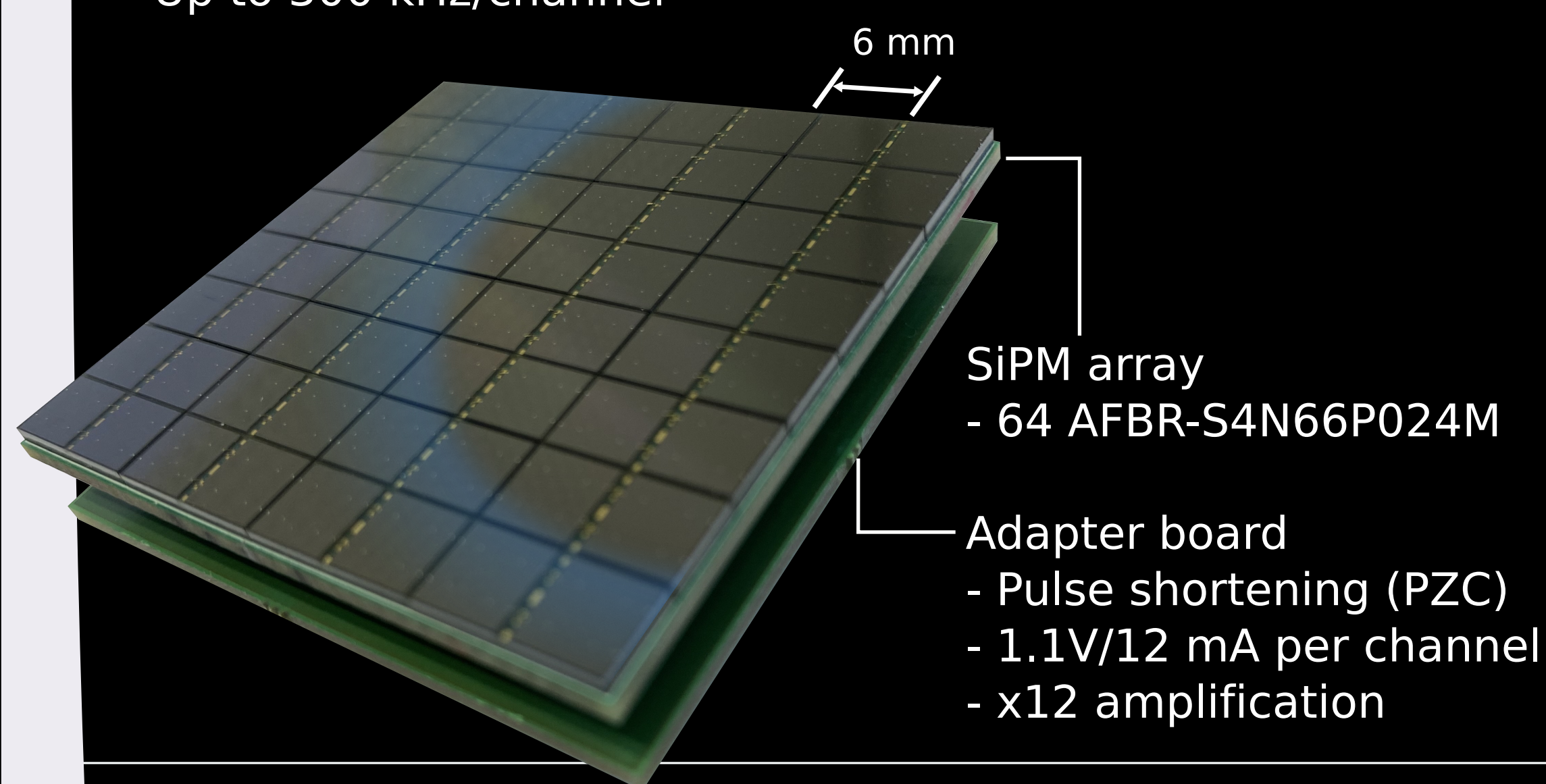
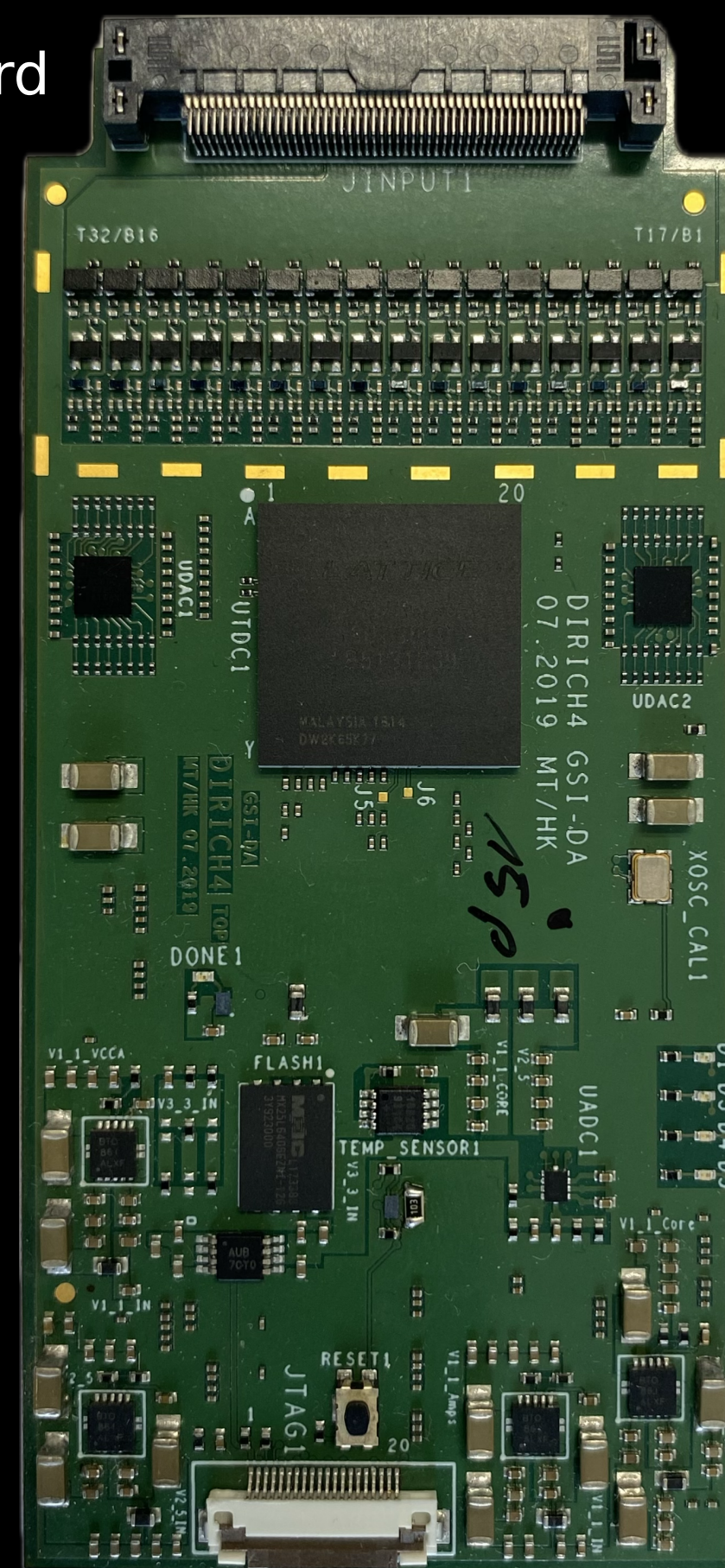
STS, Silicon Tracking System
MVD, Micro Vertex Detector
RICH, Ring Imaging Cherenkov
TRD, Transition Radiation Detector
TOF, Time Of Flight
FSD, Forward Spectator Detector



Frontend Electronics

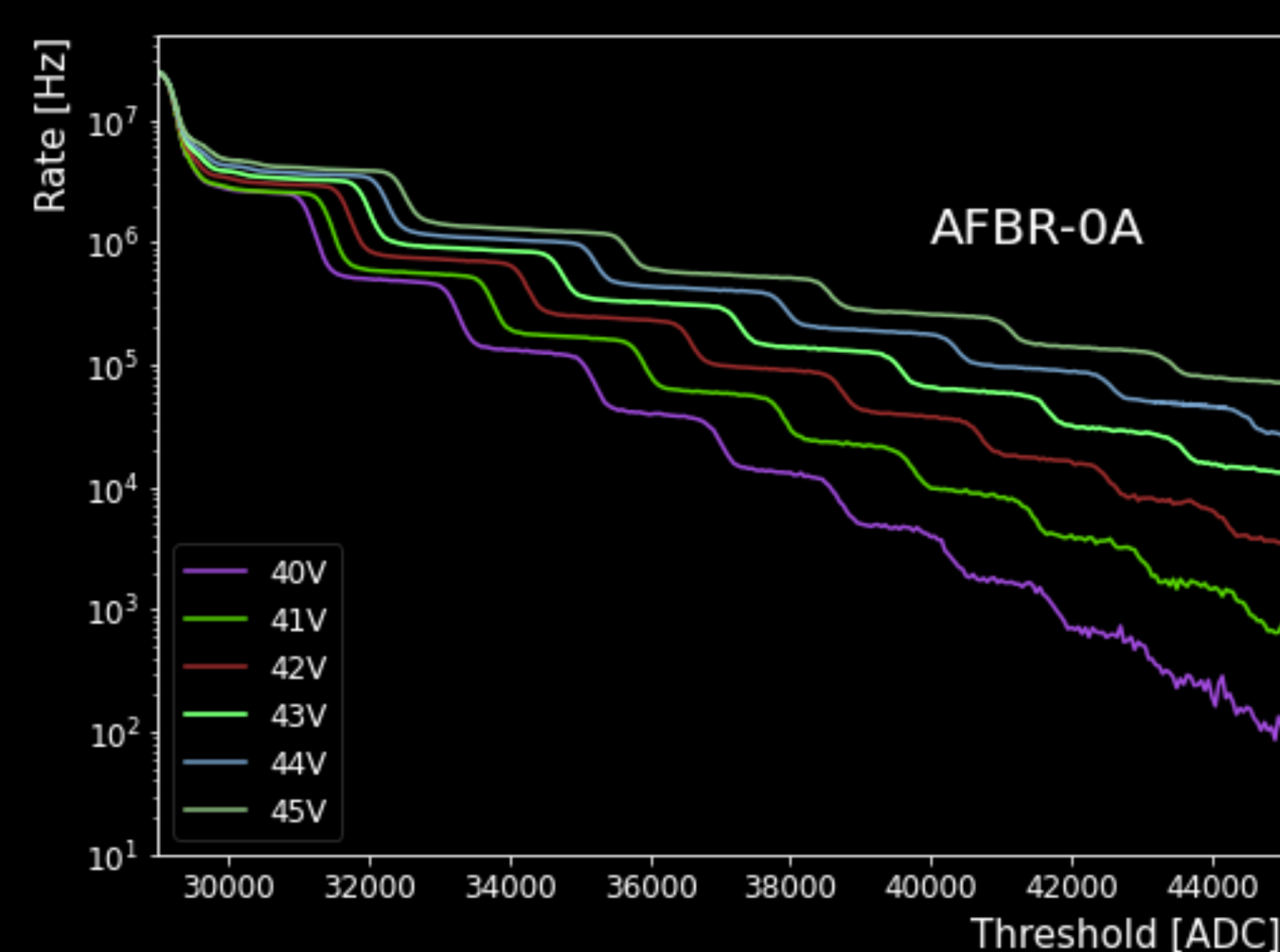
- 32 analog channels
- FPGA Lattice ECP5-85
- Thresholds: Delta-Sigma DAC + Filter
- Discrimination: comparator in LVDS receivers
- Timing precision ~20 ps
- Measurement of both edges in same TDC channel
- Up to 300 kHz/channel

DIRICH card

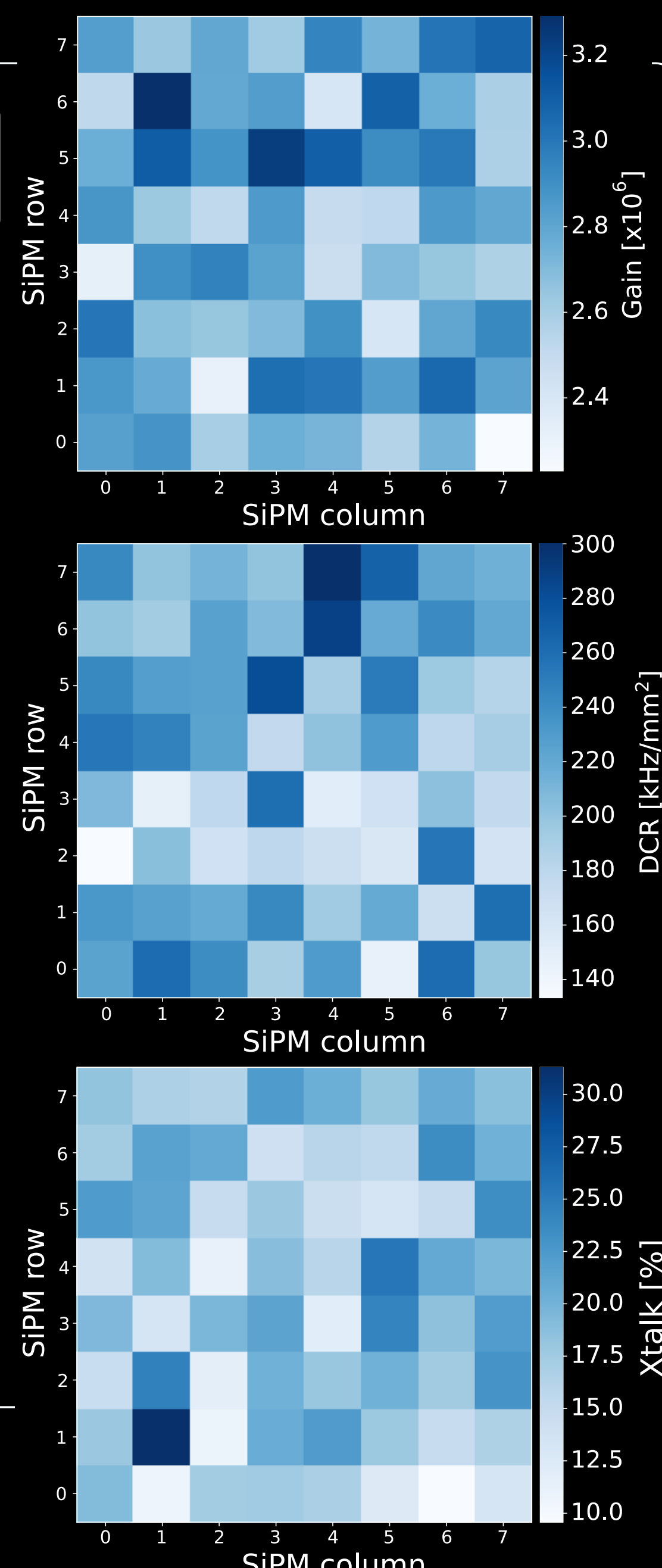


SiPM array
- 64 AFBR-S4N66P024M
Adapter board
- Pulse shortening (PZC)
- 1.1V/12 mA per channel
- x12 amplification

SiPM array characterisation

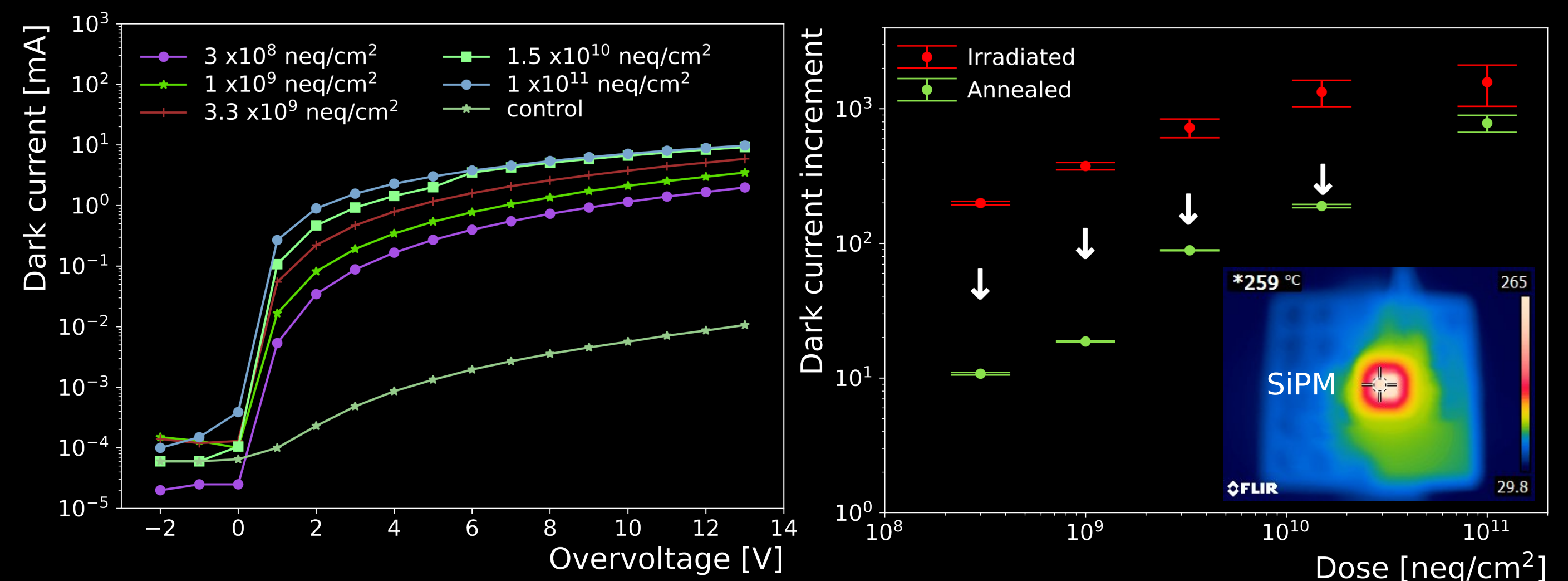


- Bias and temperature dependency
- Gain: 2.3×10^6 - 3.2×10^6
- DCR: 140 kHz/mm² - 300 kHz/mm²
- Crosstalk: 10% - 30%
- Afterpulsing < 1%
- * Temperature: 20°C

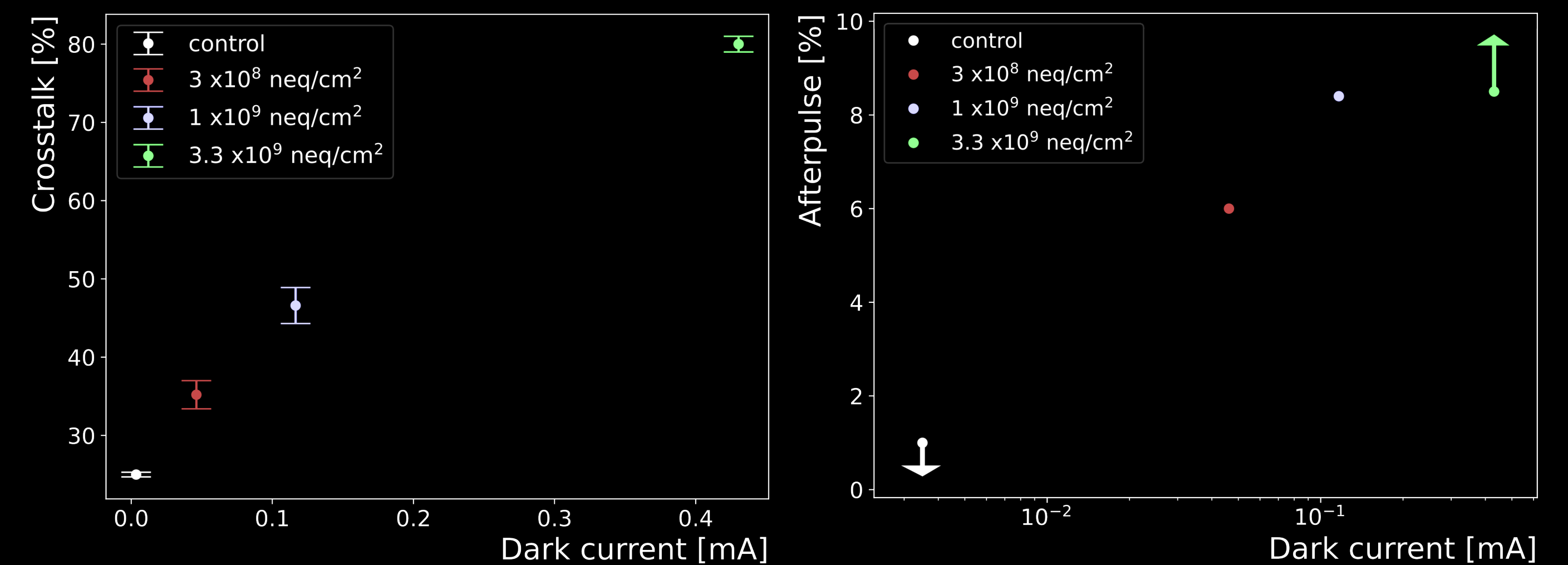


Radiation Hardness: Neutrons

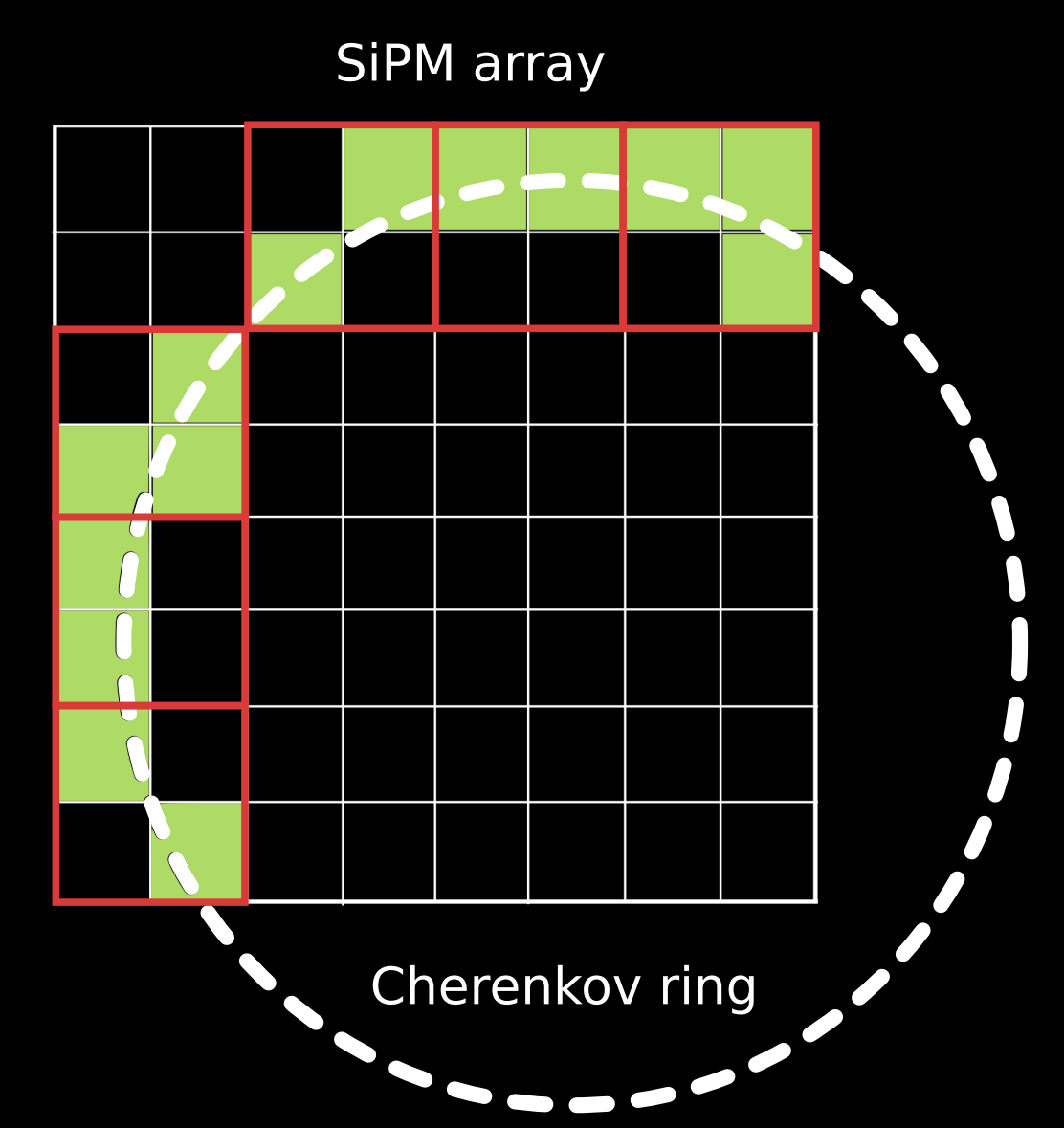
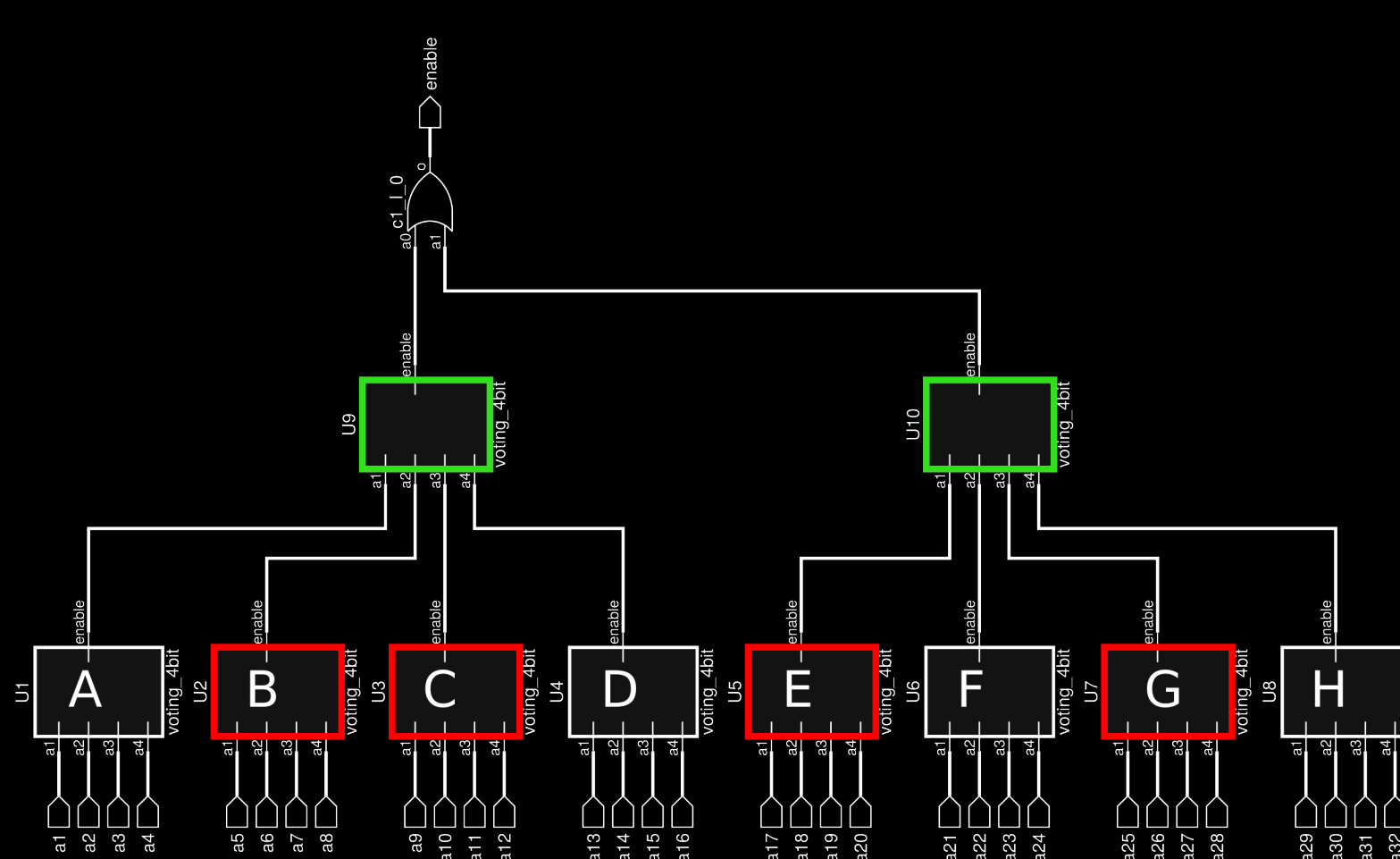
- Measurements at U120M cyclotron, Nuclear Physics Institute, Prague
- Mono-energetic neutron beam ~ 20 MeV
- Irradiation dose: 3×10^8 neq/cm² - 1×10^{11} neq/cm²
- Radiation damage:
 - . Dark current x100 - x1000
 - . DCR x100 and afterpulsing 10%
 - . Degradation of gain and photon resolution



- Electrical annealing: Forward polarization (up to 3 W)
- Temperature: 250°C
- Annealing time: 30 min

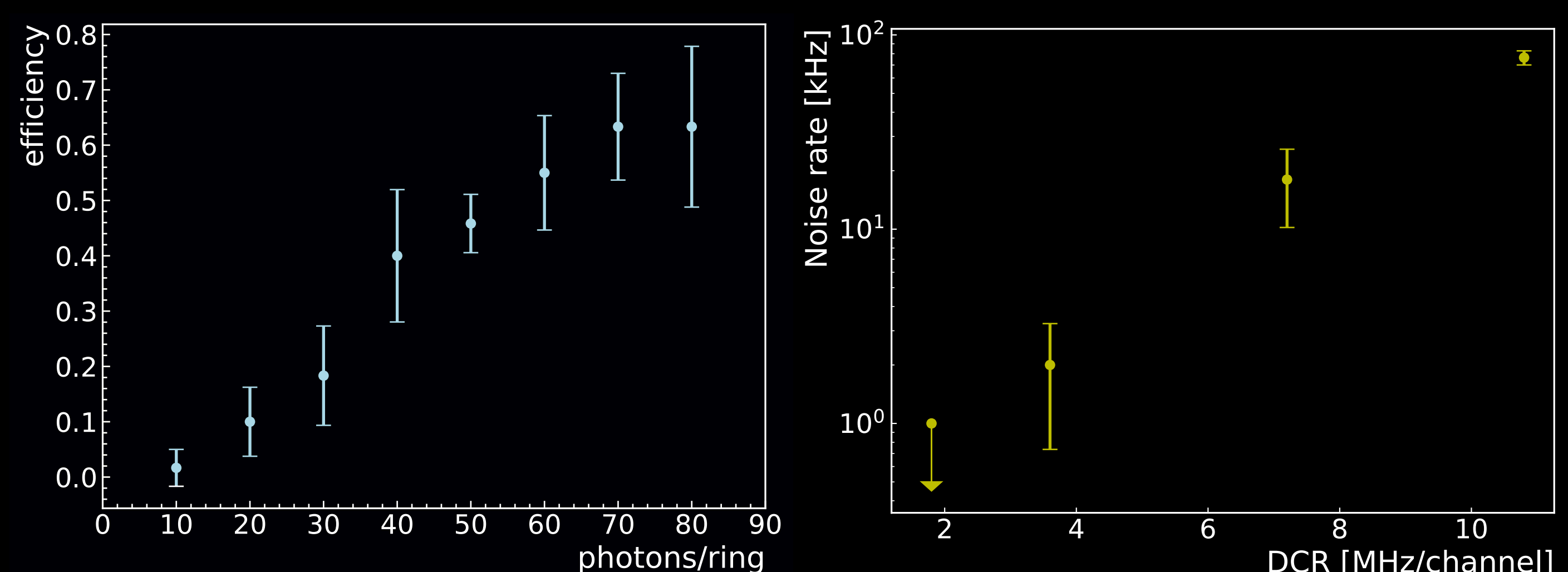


Trigger Concept

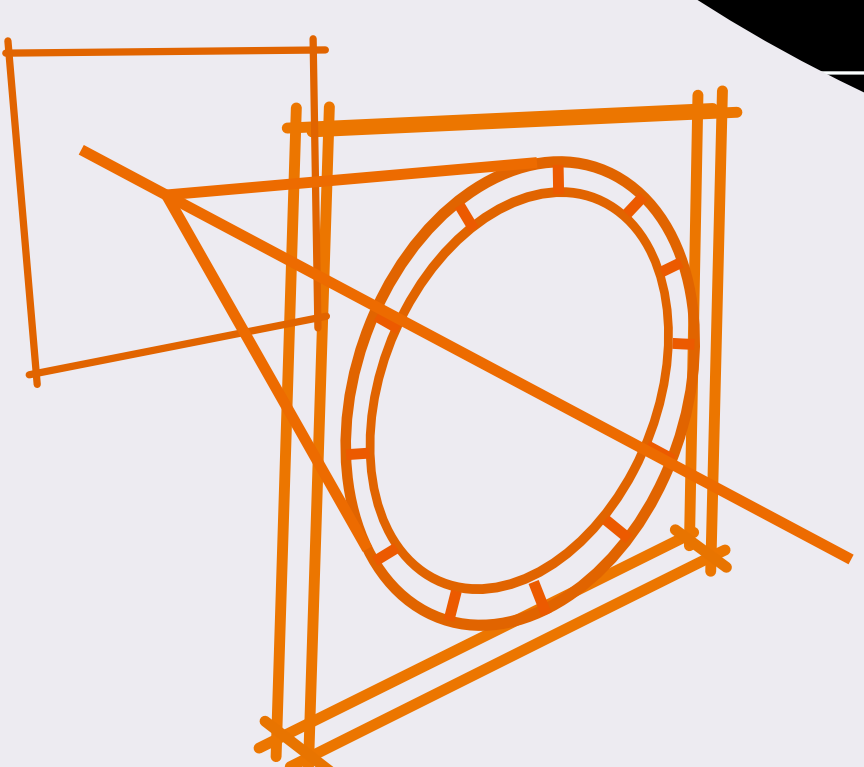


CBM freestreaming DAQ concept requires local coincidence trigger to reduce noise / data rate

- Local clustering and timing correlation
- 4-bit majority voting trigger: ≥ 2 votes
- Layer 1: 4-SiPM subarrays
- Layer 2: 4-subarrays (16 SiPMs)
- Layer 3: OR gate
- Reduction of fake events due to DCR
- Photons per ring > 50
- Ring radius ~ 5 cm
- Coincidence window: 10 ns



- Noise reduction: 2 MHz/ channel x 32 channels to < 1 kHz
- Shortening the signal FWHM decrease the noise rate
- Trigger efficiency depends on the photons/ring



RICH 2025



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