



GEMROC family ASICs

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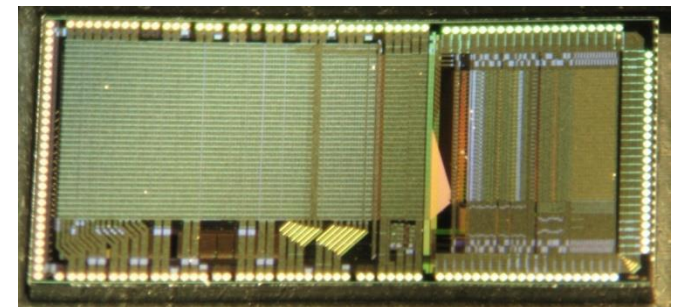
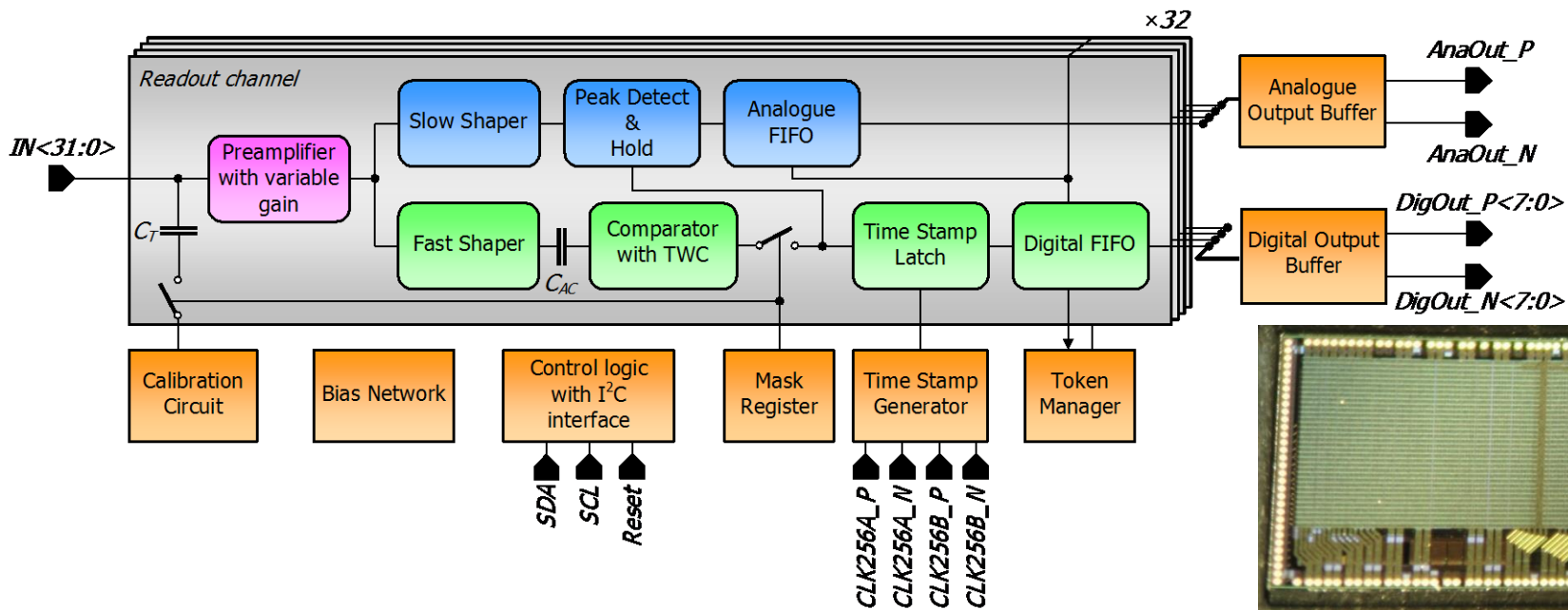
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Faculty of Physics and Applied Computer Science*

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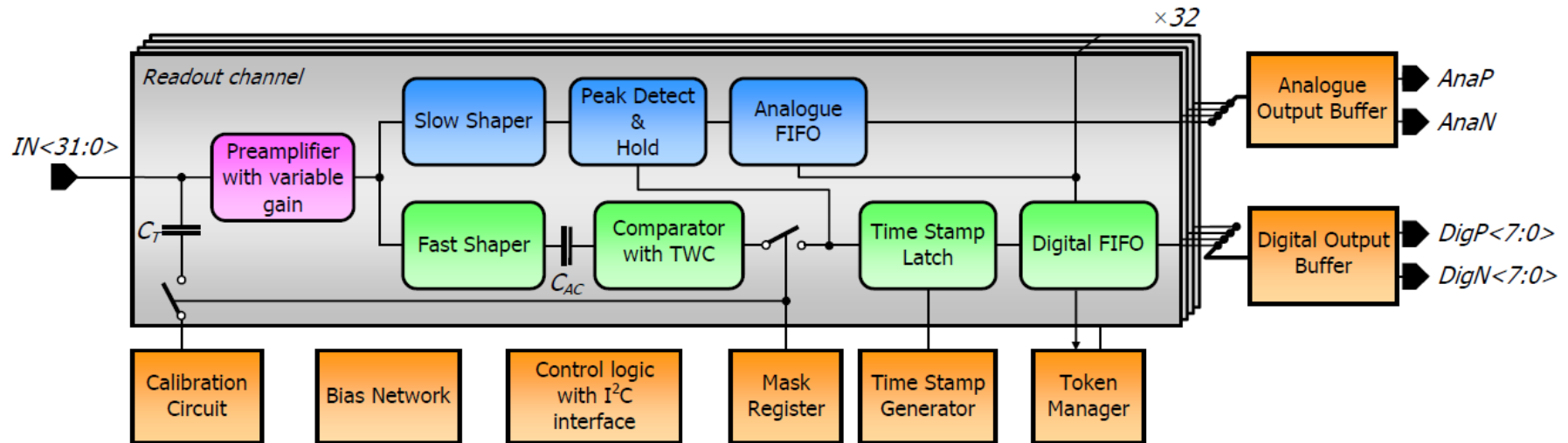
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- Parameters to be measured: $X/Y, T, E_x/E_y$
- Detector strip capacitance: ~ 23 pF
- Strip multiplicity per event: ~ 3.5 (c.o.g.)
- Hit rate per strip: $\sim 9 \cdot 10^5$ /s
- Input signal charge: $2 \cdot 10^5 e^- - 5 \cdot 10^6 e^-$ (depending on gas gain)
- ENC required for E (5σ threshold): $\sim 2000 e^-$ rms

- X/Y coincidence window 2 ns + ($E_x = E_y$)
- Discriminator: time walk < 2 ns, jitter < 1 ns FWHM.
- The preamp-shaper circuits must handle both polarities of the input signal and deliver signals of one polarity to the discriminator and peak detector circuit.
- Variable gain to cope with different detector gas gains

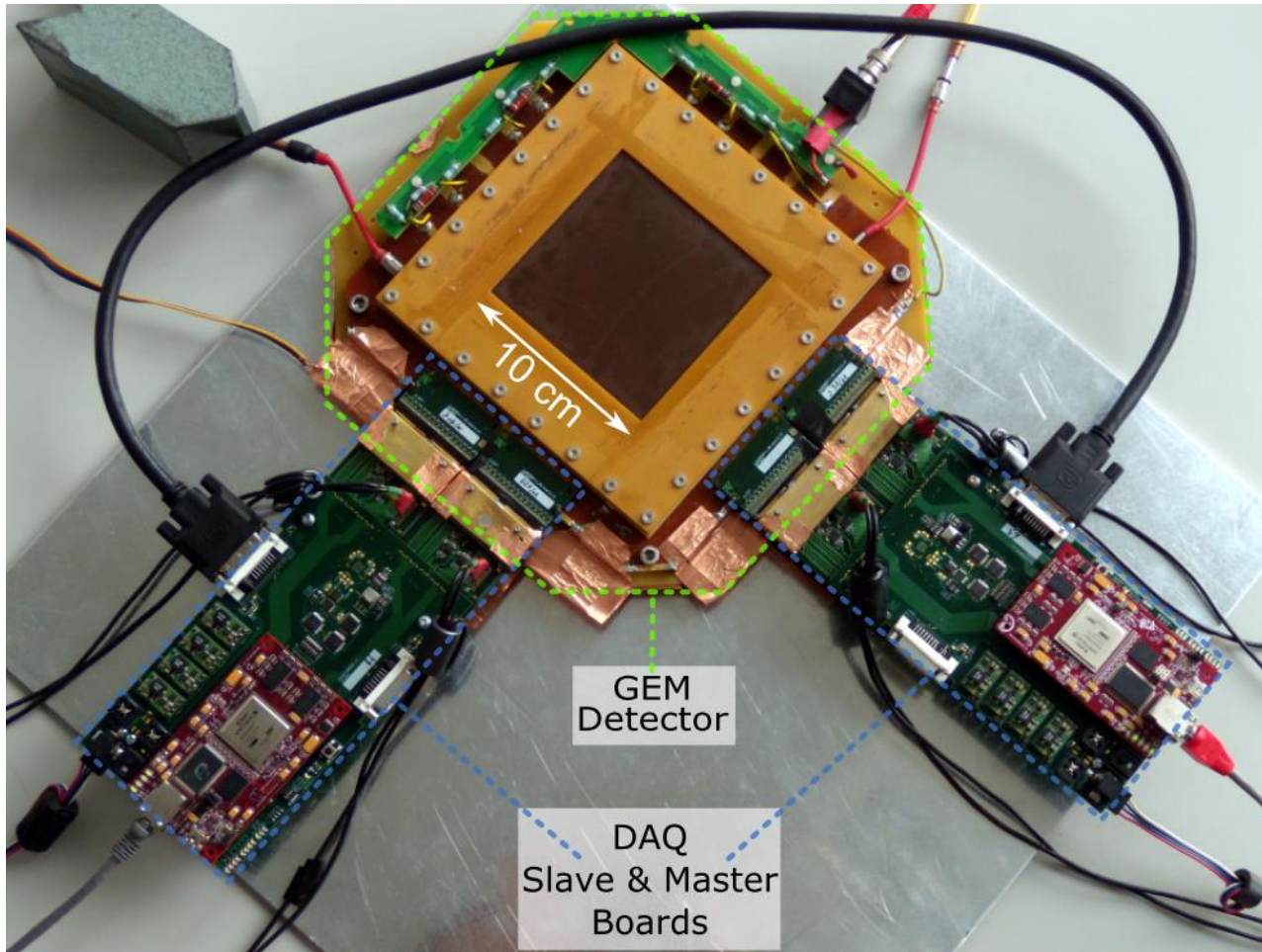


GEMROC architecture



- each channel is split into: slow (energy) and fast (timing) sub-channels
- switchable gain (2 modes) and signal polarity selection
- signal range: 300 fC (low gain mode), 150 fC (high gain mode)
- hit rate per strip: ~ 1 M/s
- ENC < 0.5 fC
- derandomization of data and zero suppression in the token-based readout
- self triggering mode – readout initiated by the input signal
- internal testability functions
- 32 channels per ASIC
- 0.35 μ m CMOS process

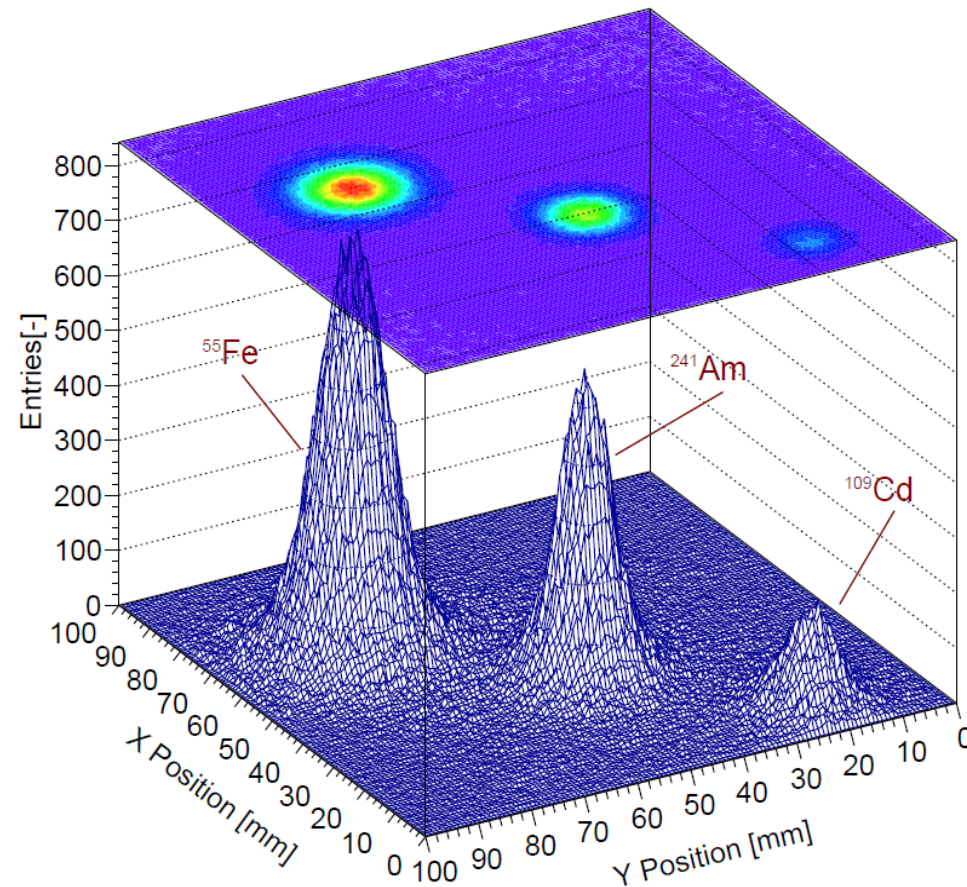
Detection system with triple-GEM (GEMROC ASIC)



- Custom designed DAQ board with Ethernet based communication protocol
- Four 32-channel GEMROCs for each coordinate (one channel per two readout strips)
- Triple-GEM with 256×256 readout strips (pitch of readout strips is $800 \mu\text{m}$)

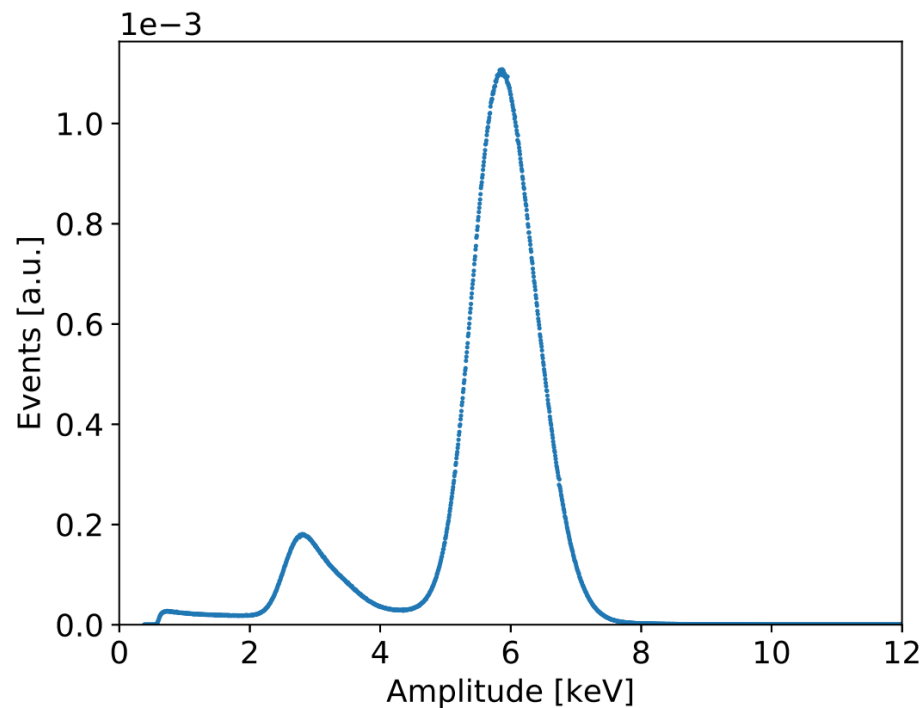
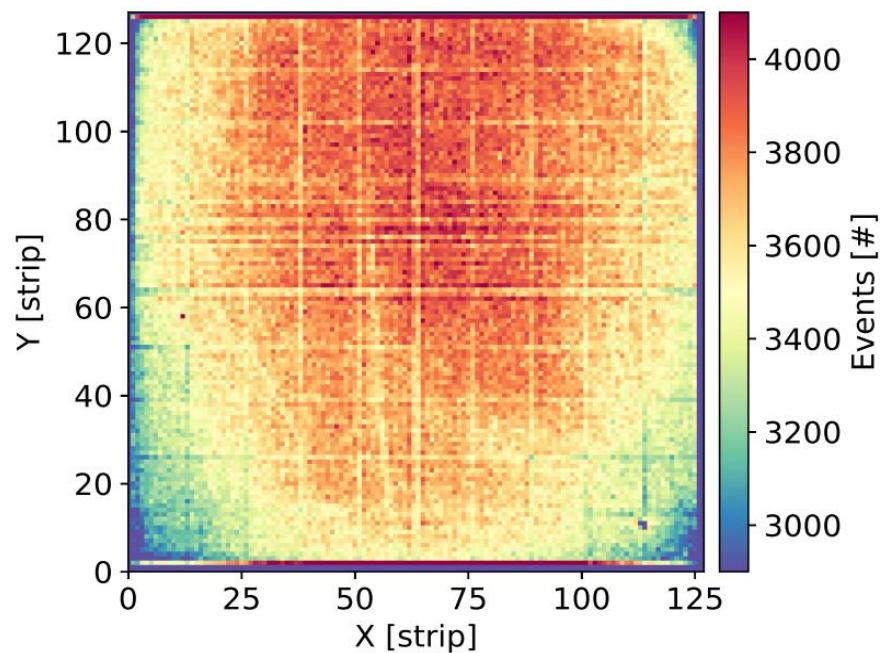
Count rate measurements

Simultaneous measurement with Fe-55, Am-241, and Cd-109 X-ray sources



Reconstructed events count rate ~ 1.5 Me/s
Hits count rate ~ 5.6 Mh/s (~ 9 kh/s/mm²)

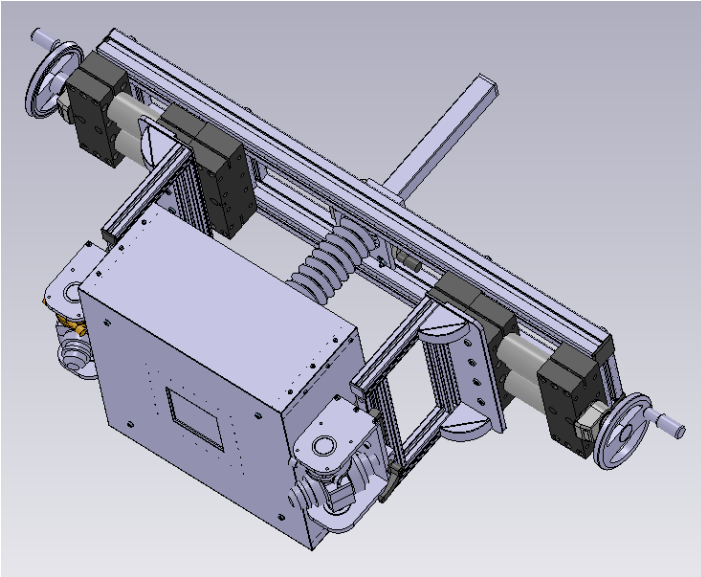
Energy resolution



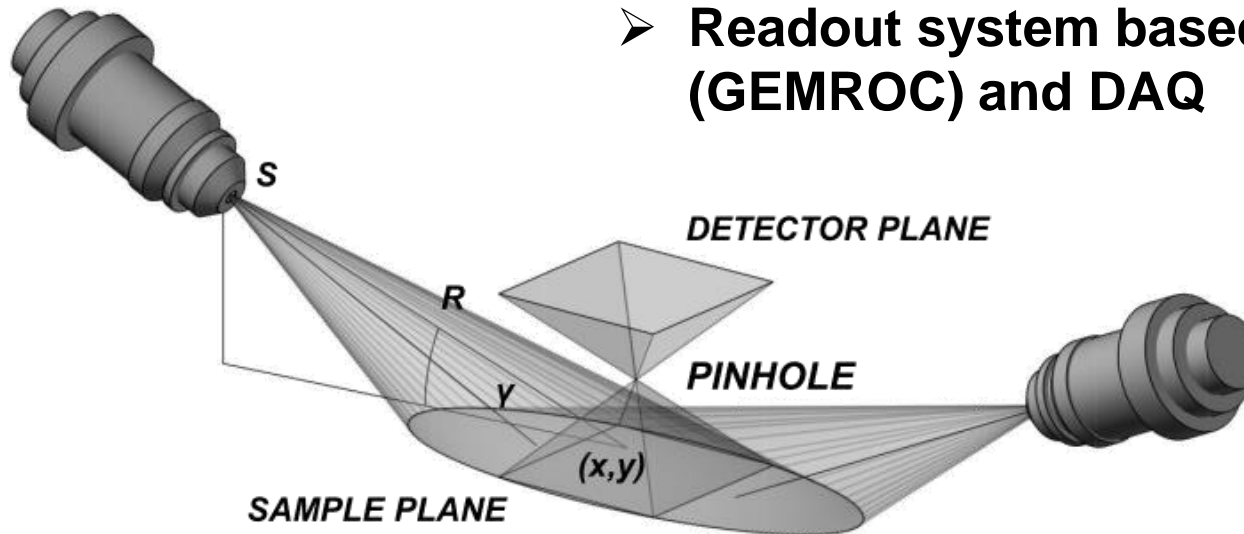
Energy resolution Fe-55 (FWHM) - **19.8%** @ 3860V Ar/CO₂ (70/30)

GEMROC upgrade motivation

GEM-based Full-field XRF imaging system



- Two 50 W Mo air-cooled X-ray tubes
- Excitation geometry optimized to obtain homogeneous illumination of 10×10 cm area
- Projection by a pinhole camera
- Fixed magnification $M=1$
- **10×10 cm triple-GEM detector**
- **2-dimensional Cartesian readout structure with a strip pitch of 0.8 mm**
- **Readout system based on full custom ASIC (GEMROC) and DAQ**



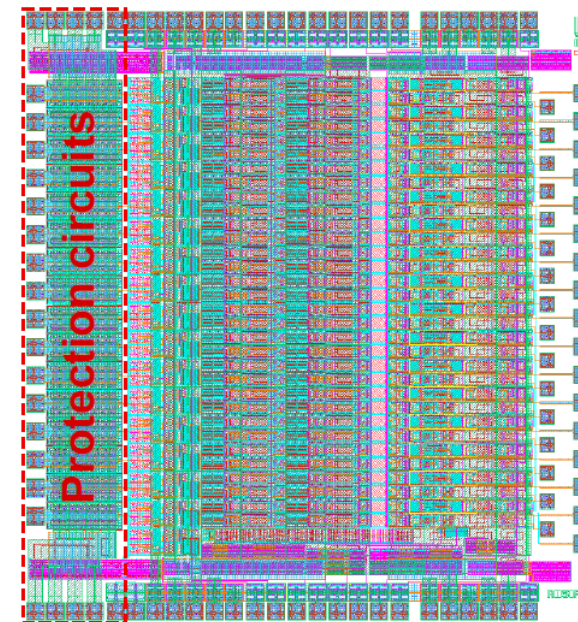
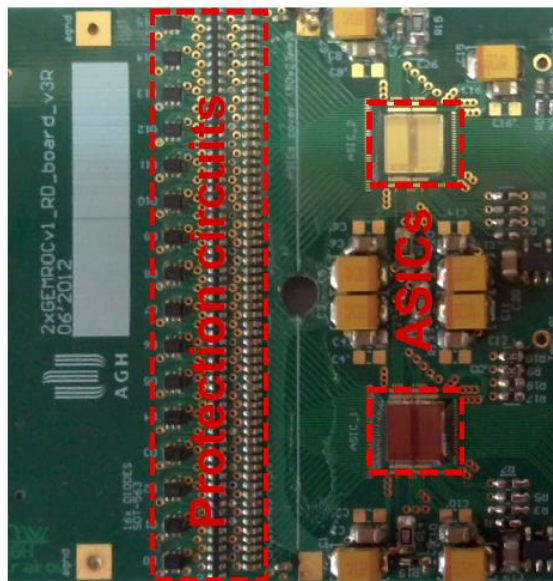
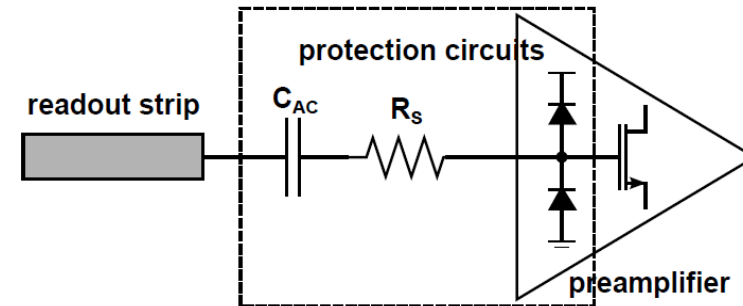
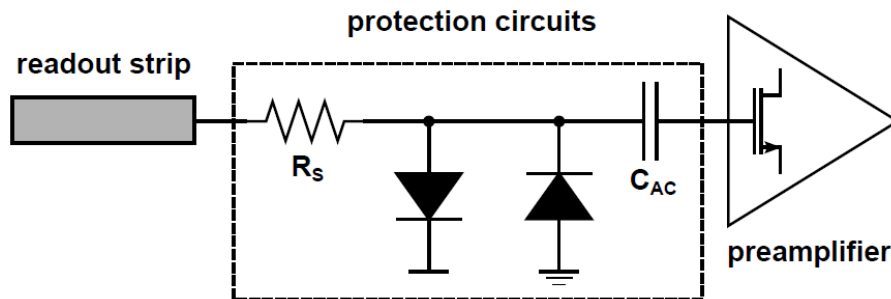
GEMROC upgrade motivation

- » Much simpler assembling
 - Higher number of channels in one ASIC
 - two ASICs per detector plane (800 μm readout pitch)
 - four ASICs per detector plane (400 μm readout pitch)
 - Integrated input protection against discharges

- » Optimization of the system energy resolution
 - Higher dynamic range
 - Lower electronic noise level (slower readout)
 - Higher front-end gain

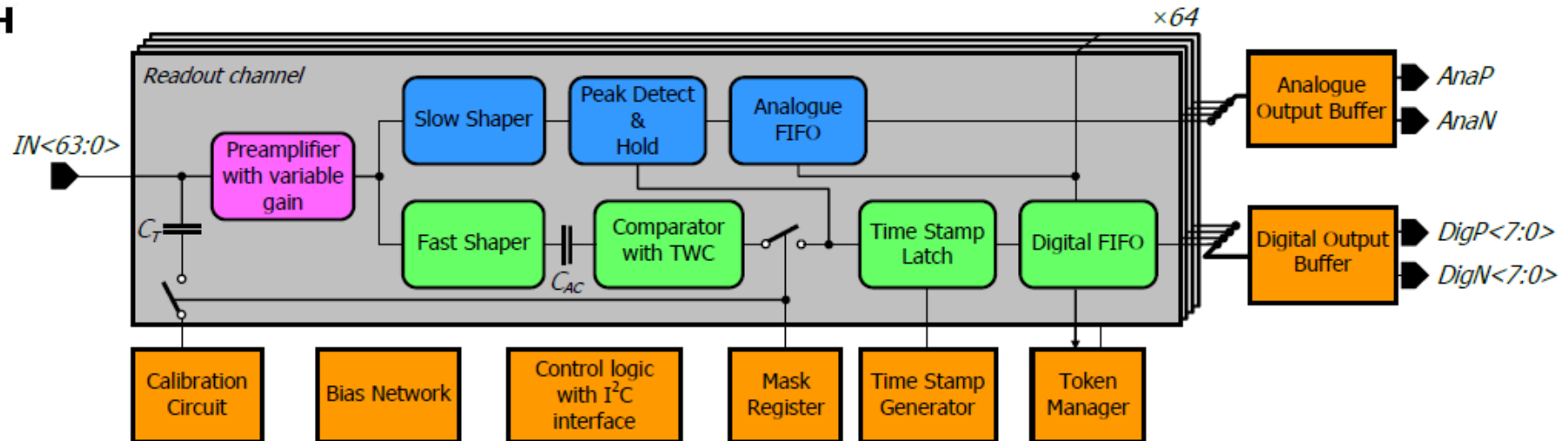
Protection against discharges

External SMD components vs. integrated structures



- T. Fiutowski et al., *Front-end electronics for Micro Pattern Gas Detectors with integrated input protection against discharges*, JINST 11 C01036 (2016)
- T. Fiutowski et al., *Integrated input protection against discharges for Micro Pattern Gas Detectors readout ASICs*, JINST 12 C02021 (2017)

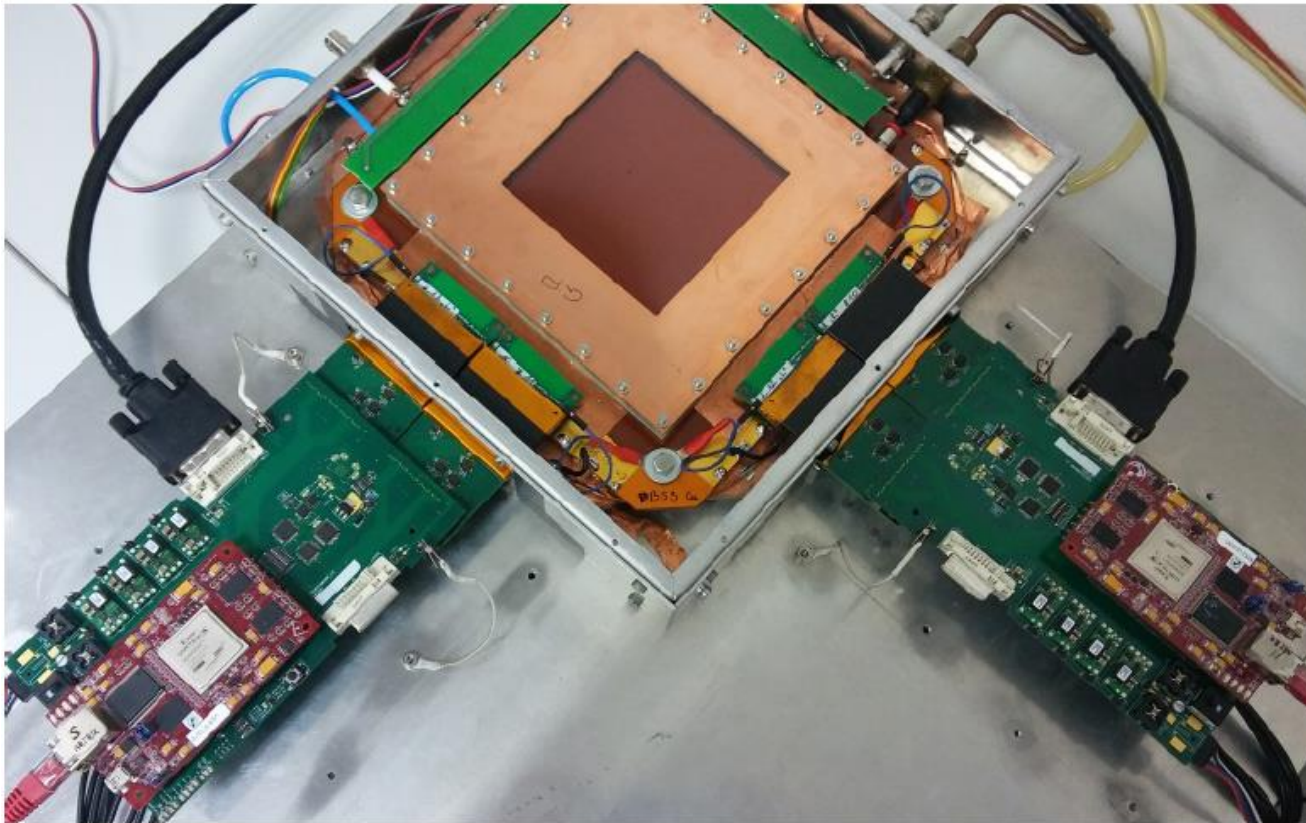
ARTROC/GEMROC2 architecture



- each channel is split into: slow (energy) and fast (timing) sub-channels
- switchable gain (6 modes) and signal polarity selection
- derandomization of data and zero suppression in the token-based readout
- **hit rate per strip: ~ 200 k/s**
- **ENC < 0.2 fC**
- self triggering mode – readout initiated by the input signal
- internal testability functions
- **64 channels per ASIC**
- **integrated input protection against discharges**
- 0.35μm CMOS process

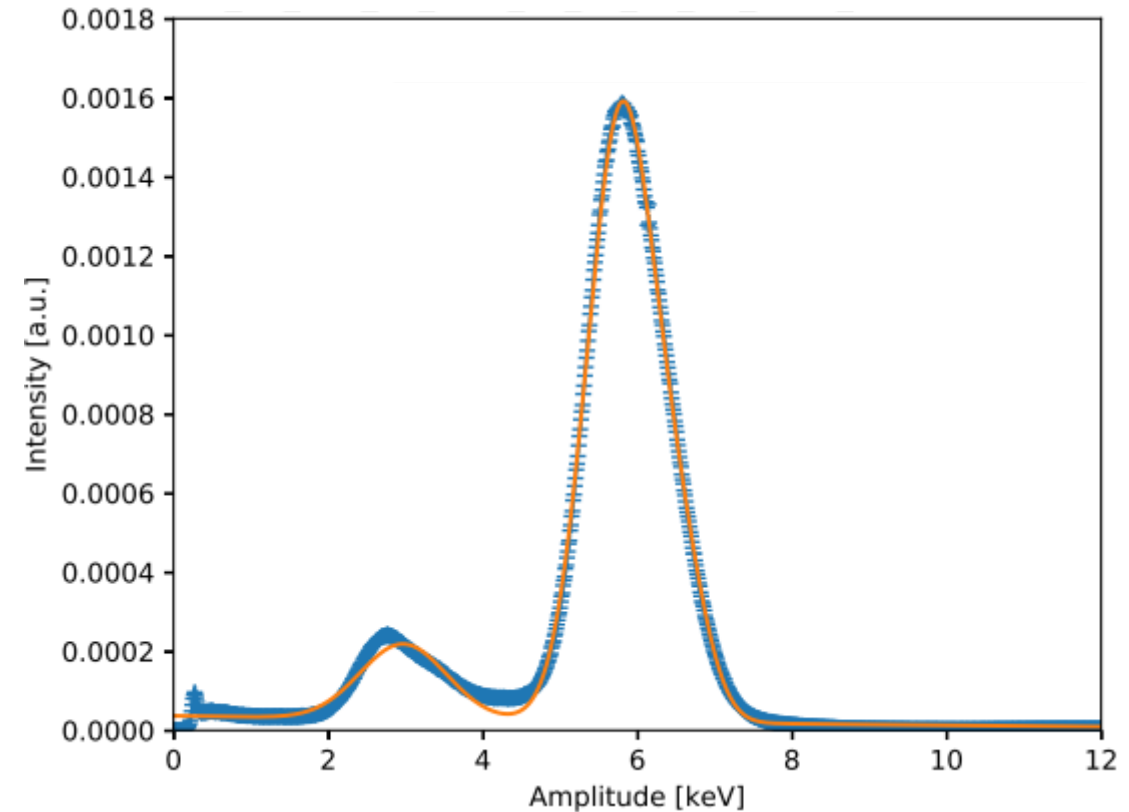
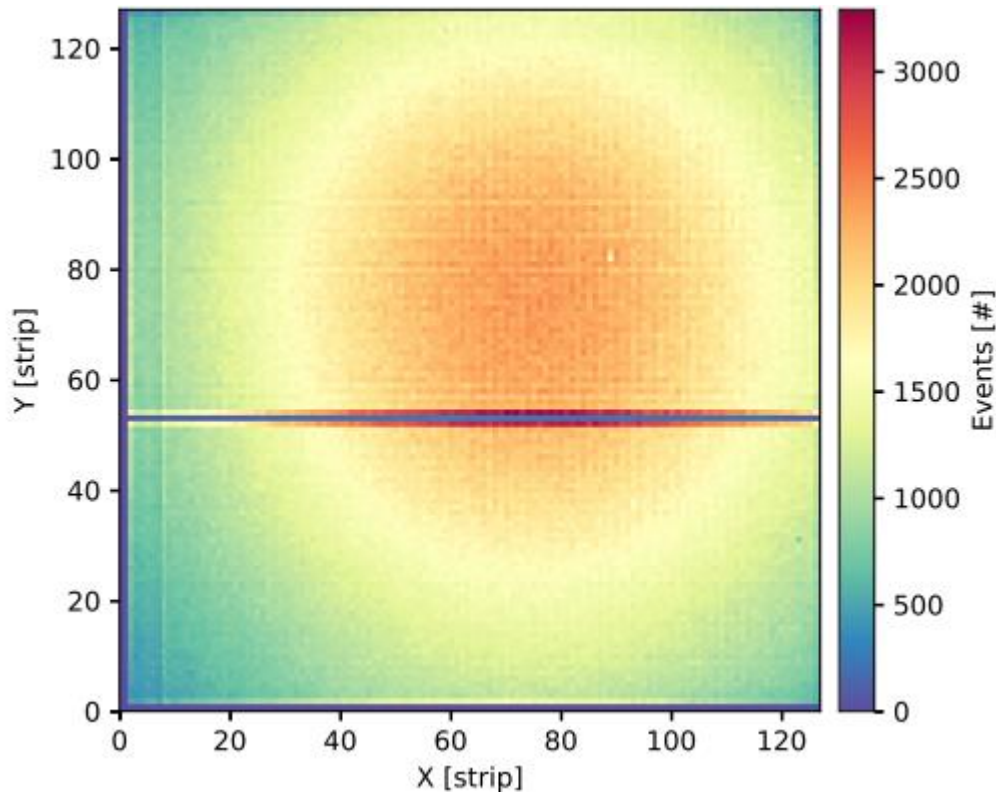


Detection system with triple-GEM (ARTROC/GEMROC2 ASIC)



- Custom designed DAQ board with Ethernet based communication protocol
- Two (four) 64-channel GEMROC2 for each coordinate (one channel per two (one) readout strips)
- Triple-GEM with 256×256 readout strips (pitch of readout strips is 800 (400) μm)

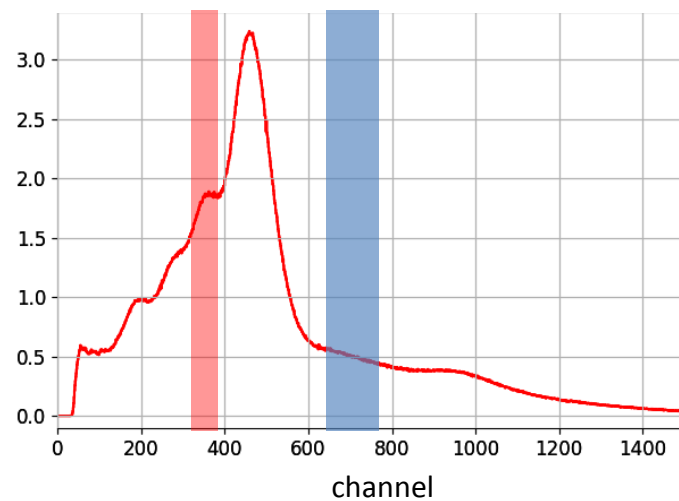
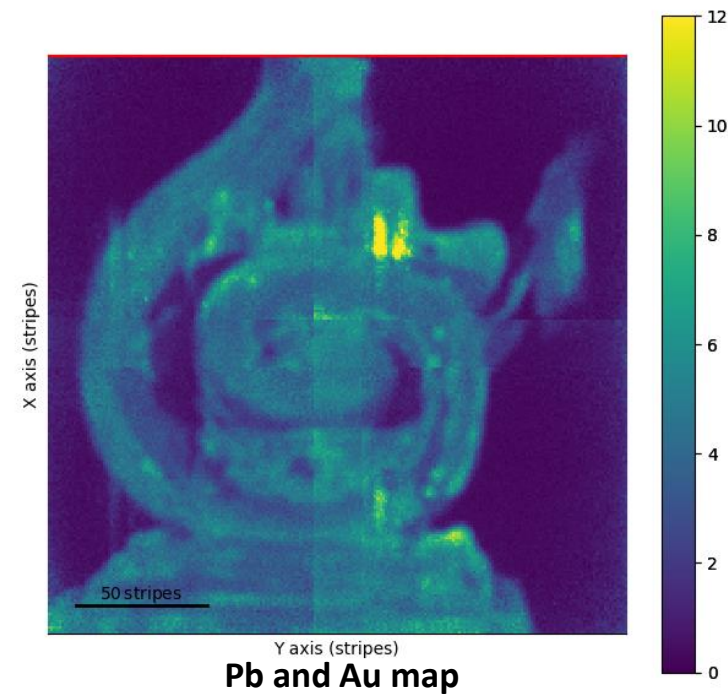
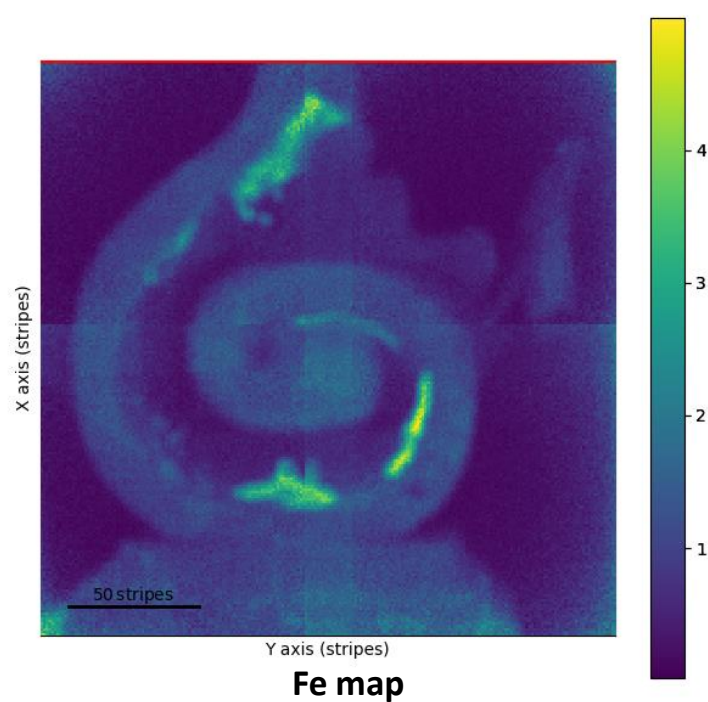
2-D imaging (800 μm readout pitch)



Energy resolution Fe-55 (FWHM) - **17.6%** @ 3470V Ar/CO₂ (80/20)

Instead of a summary ...

Example of XRF imaging

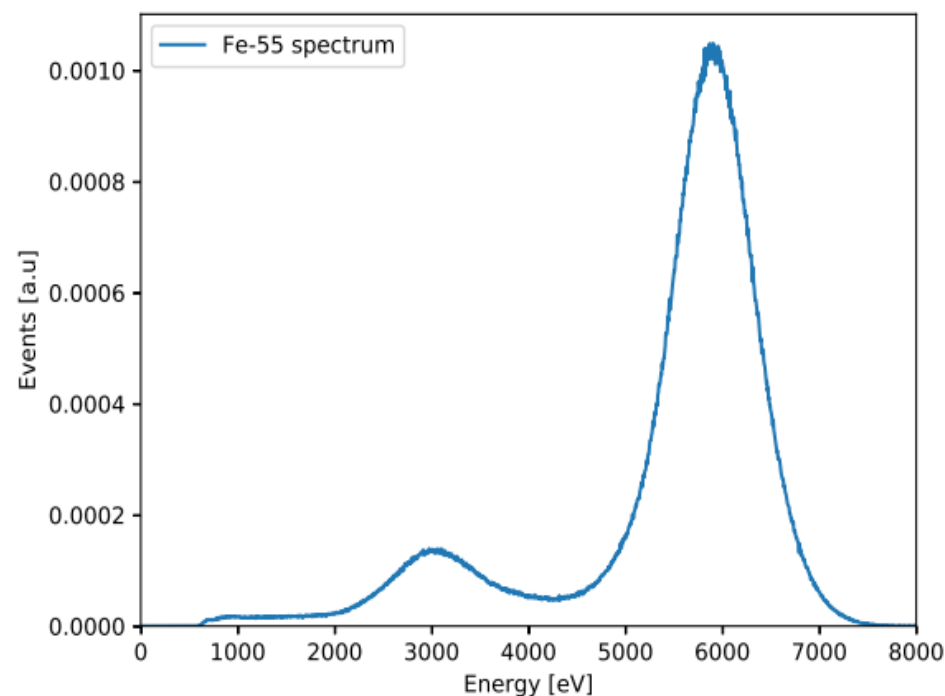
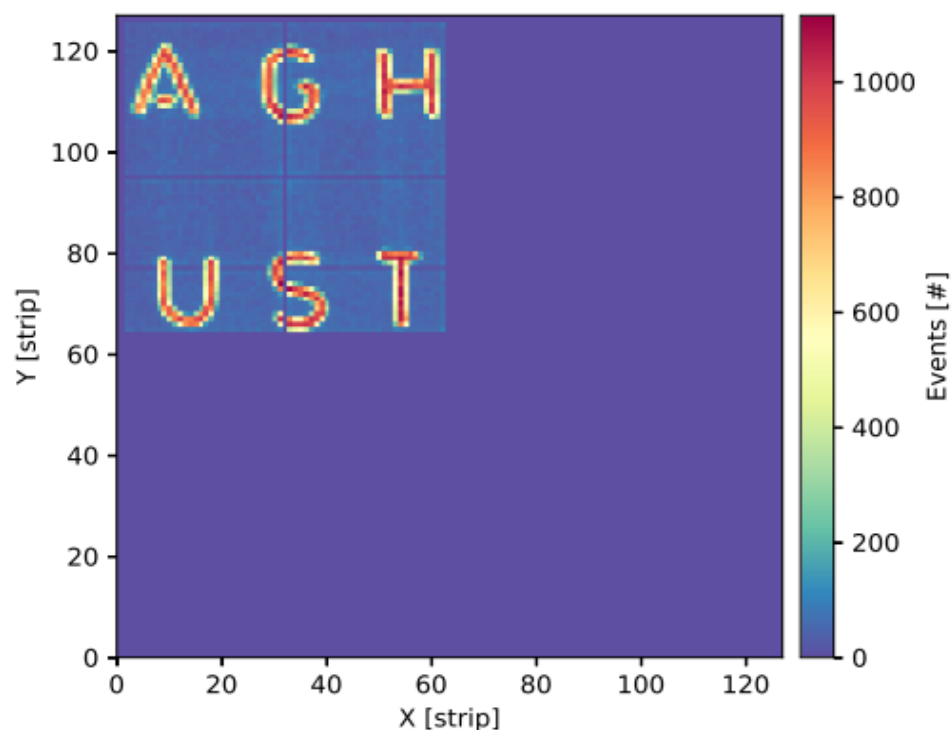




Thank you for your attention

2-D imaging (800 μm readout pitch)

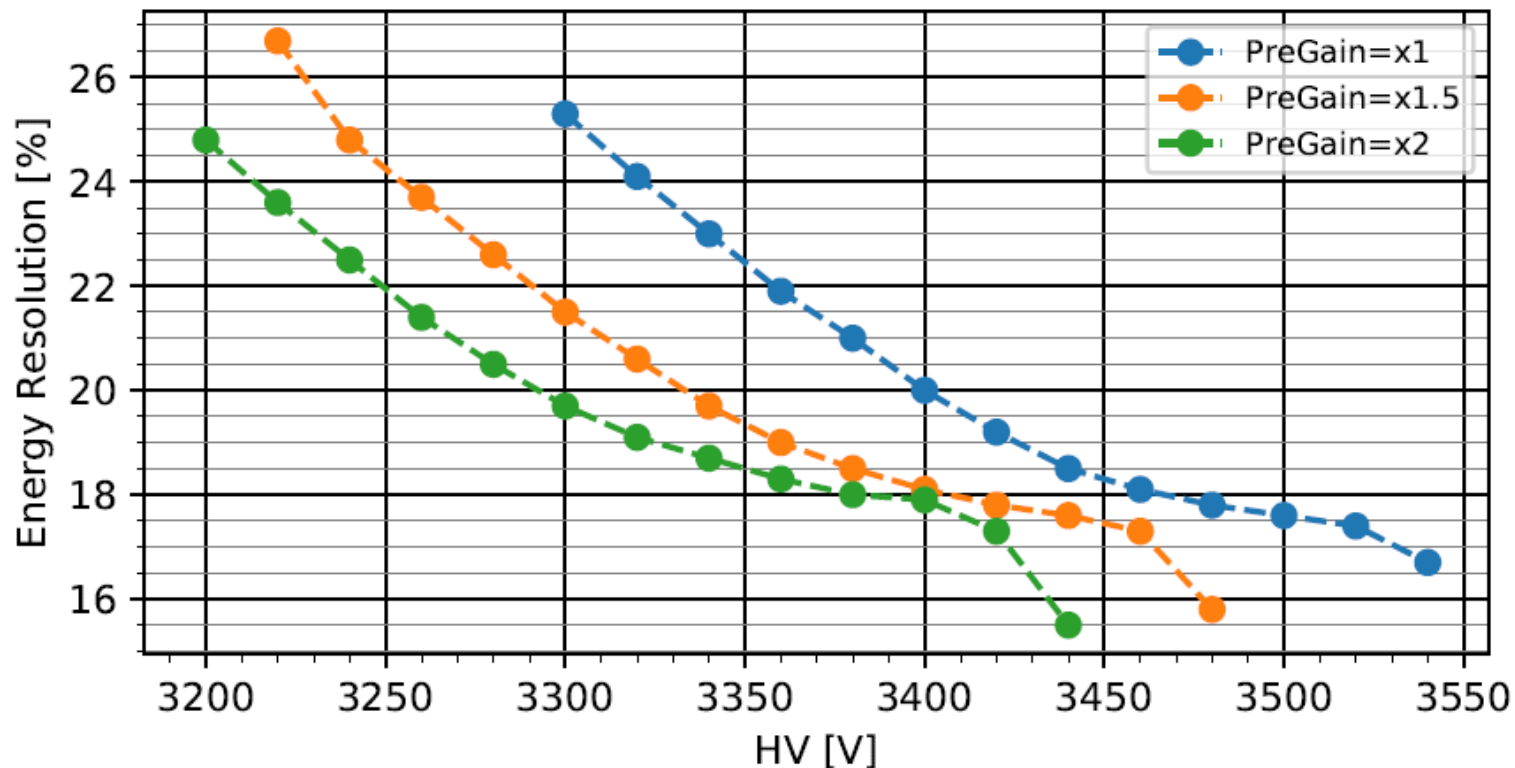
One ASIC board per plane is used (one fourth of the detector is read out)



Energy resolution Fe-55 (FWHM) - **15.7%** @ 3600V Ar/CO₂ (80/20)

Energy resolution vs. system gain

Energy resolution Fe-55 (FWHM) for Ar/CO₂ (80/20)



Theoretical intrinsic energy resolution of the GEM detector ~17%

$$R_{FWHM} = \sqrt{8 \ln(2) \frac{1}{n_0} \left(F + \frac{\bar{A} - 1}{A} \right)}$$

