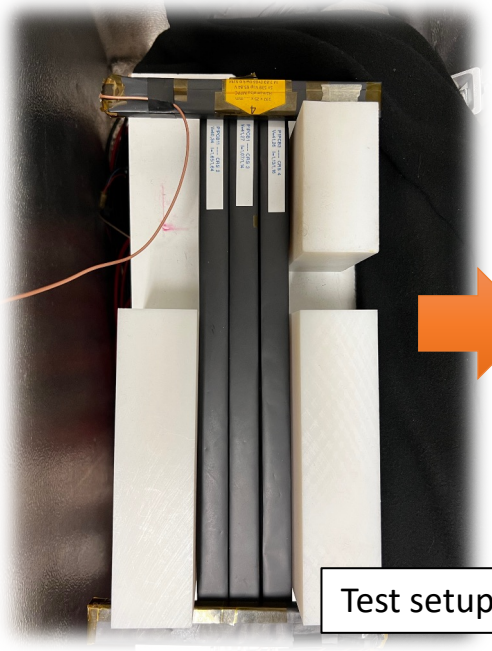
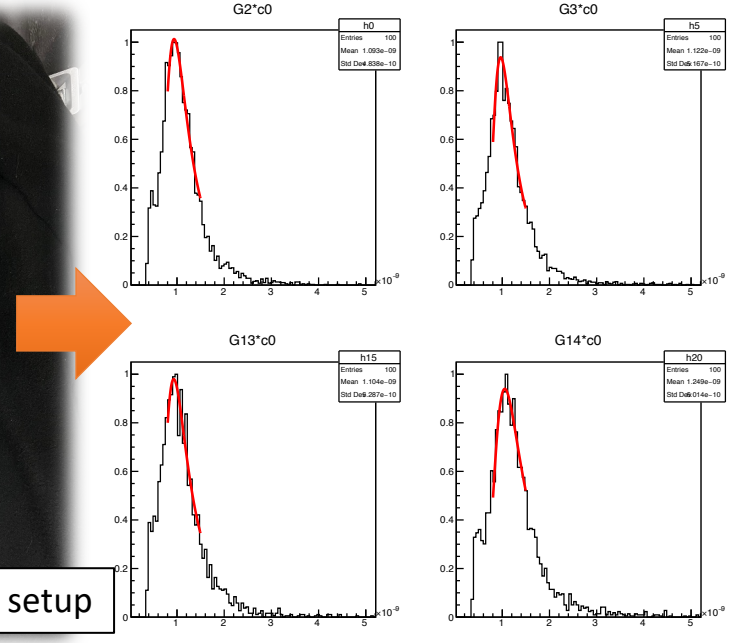
SciGlass characterization

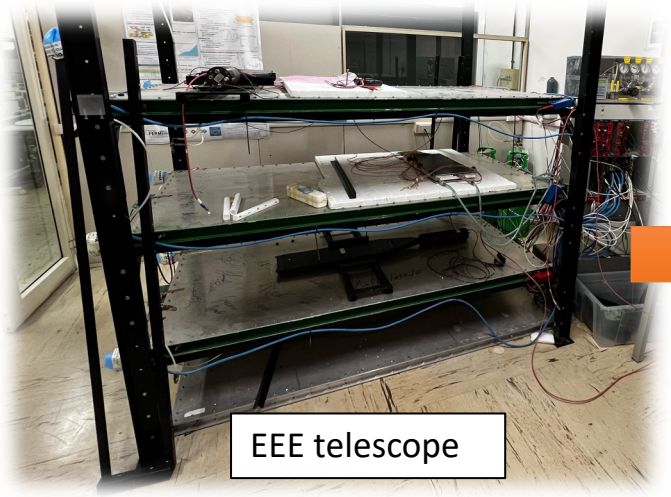
SciGlass characterization performed in Genova:

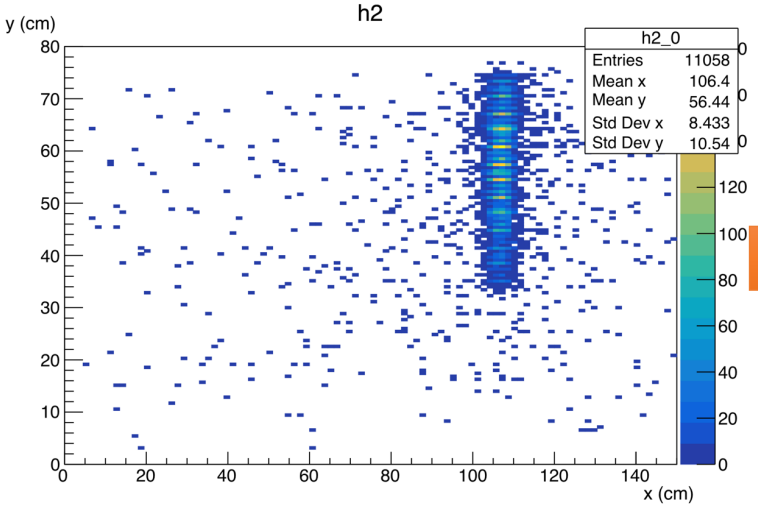
- Light Yield measured using cosmic muons
  - → Fit to cosmic muons spectrum with Landau distribution
  - → Light Yield (LY) ~ 4 phe/MeV (on 2 SiPM)

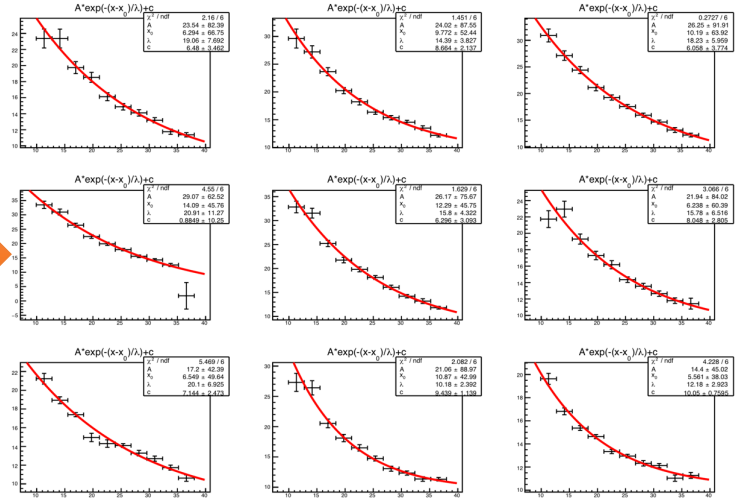
- Attenuation length measured with EEE telescope (cosmic muon tracker)
  - → Tracker used to evaluate dependance of charge measured on the position along crystal
  - → Curve fitted with exponential function
  - → Attenuation length ~ 20 cm







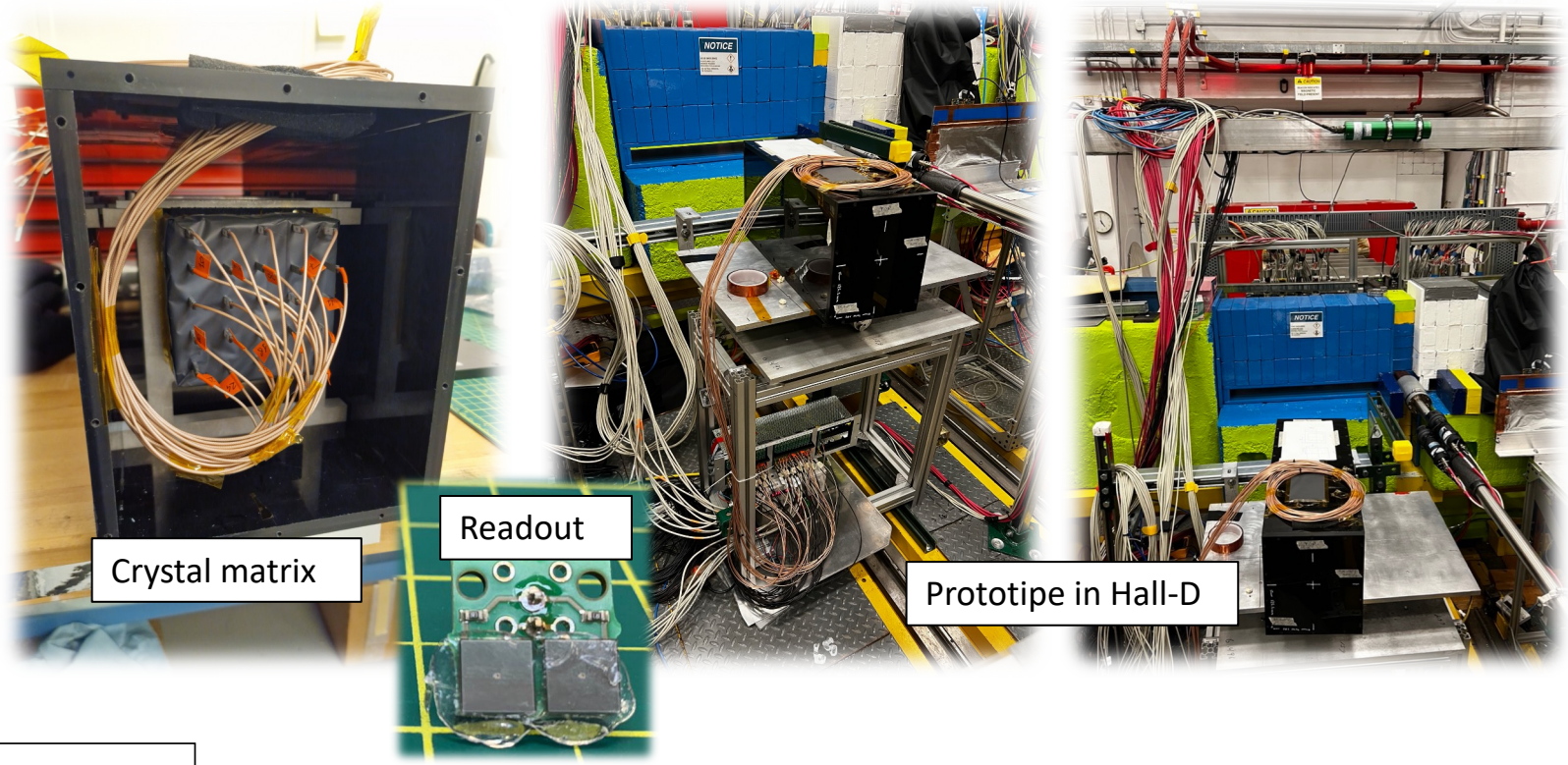


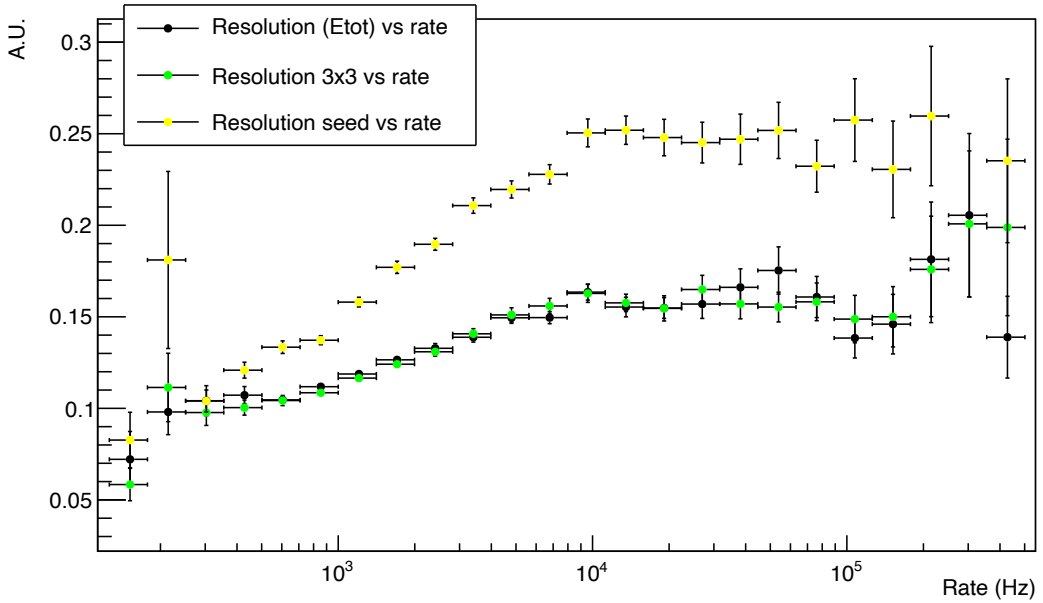


On-beam test

Beam test performed in February-March 2023

- 5x5 prototype with 40 cm long SciGlass crystals read by 2 SiPM in parallel
- Detector positioned in front of JLab Hall-D Pair Spectrometer
- On beam measurement to assess energy resolution





Results:

- Measured resolution as a function of number of crystals used for clustering
- Comparison between Streaming Readout with traditional DAQ

- Observed rate dependency of resolution
  → Resolution deteriorates as signal rate increases
  → SiPM response altered by high charge and high rate

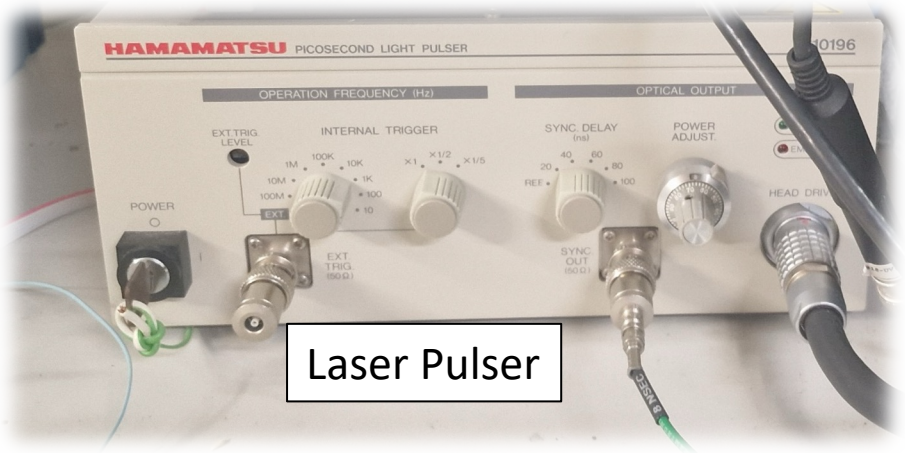
SiPM high rate response

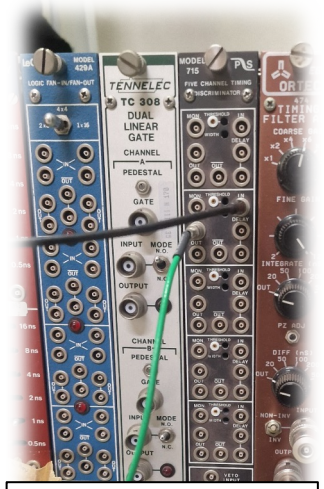
SiPM response at different rate tested with pulsed light source at fixed-intensity (led, laser)

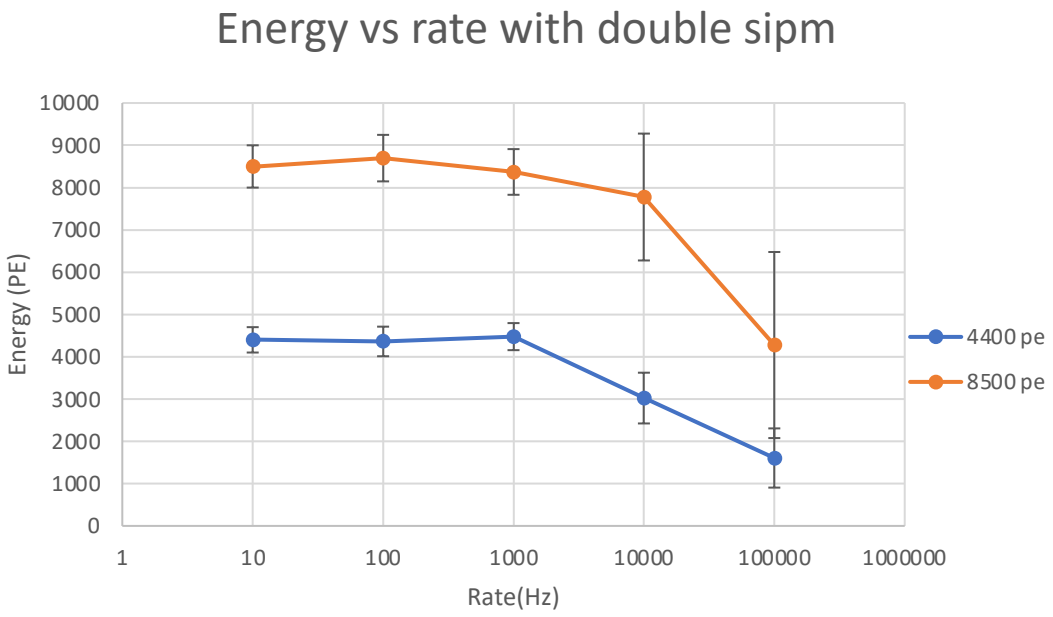
- Conducted test with fixed rate
- Test with stochastic signal (generated using SiPM dark noise passed through a discriminator)

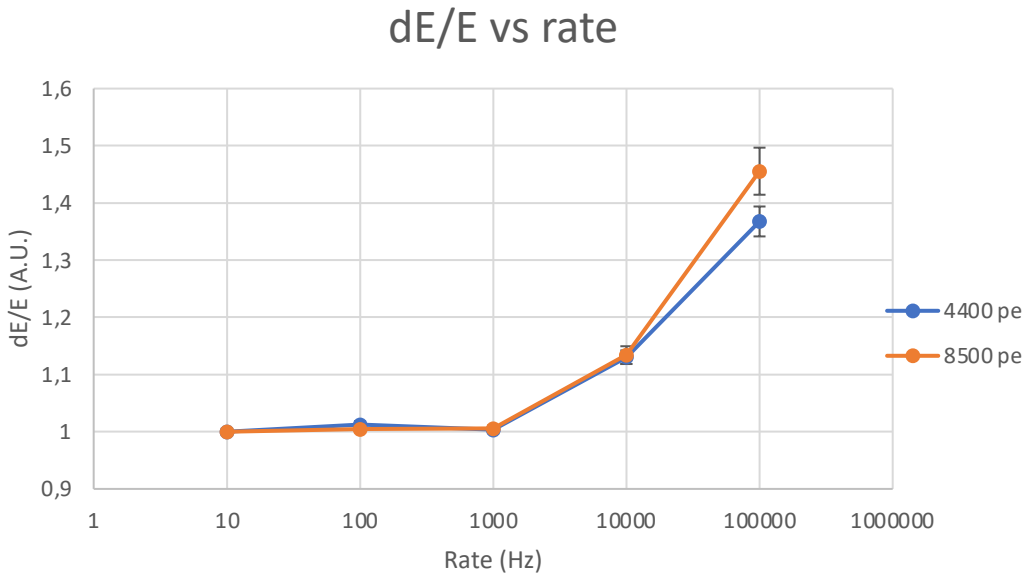
→ Confirmed behavior observed in beam test

- Signal intensity depends on rate
- Resolution deteriorates at higher rates
- Critical rate lower for higher charge





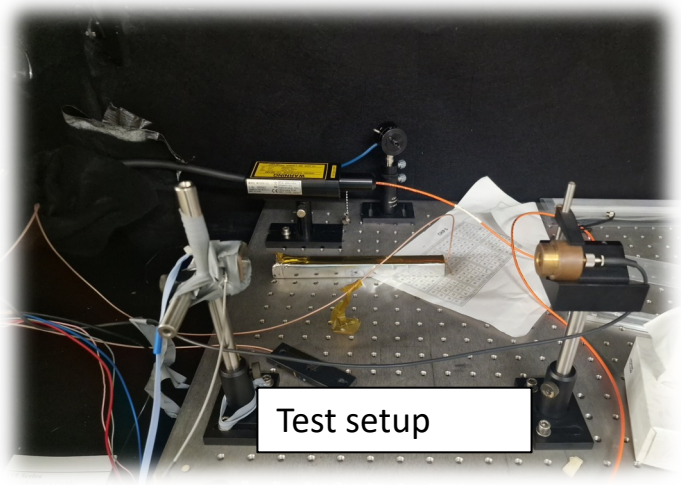


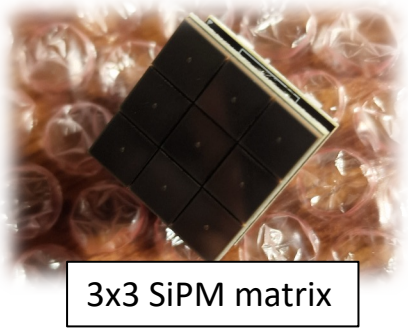


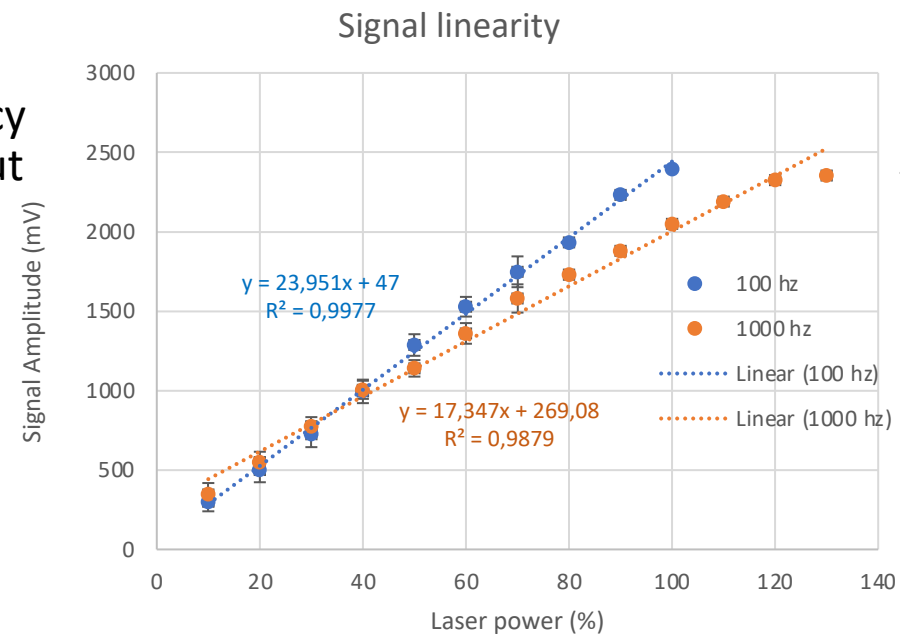
3x3 SiPM matrix test

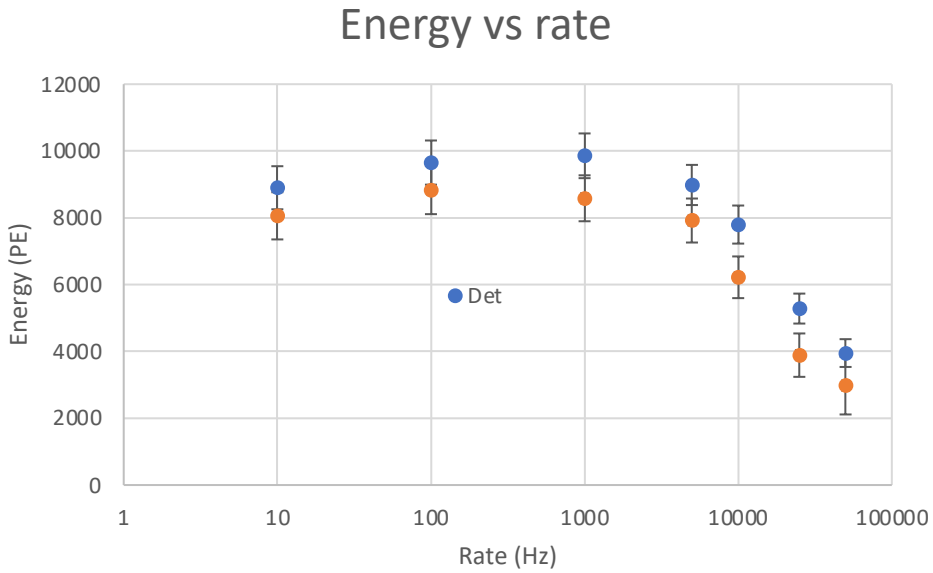
Custom 3x3 SiPM matrix tested:

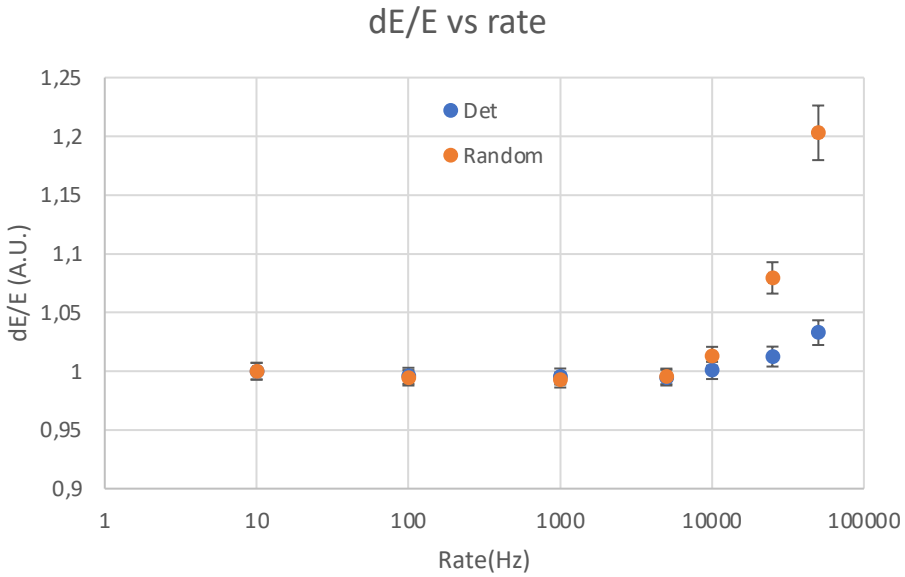
- 8x larger signal compared to single SiPM
- Linear response preserved for large signal
- No saturation up to few GeV
- Higher Dark Noise (single photoelectron measure not feasible)
- Similar energy/rate dependency as the 2 SiPM configuration, but with higher critical rate











Conclusions

SiPM response altered by high charge and high rate signals

→ Systematic deterioration of resolution

Possible source of this issue: power supply is not able to handle current required for SiPM recovery

→ Deploy more stable power supply (Weiner MPV8060I used by POKER experiment, that faced similar issues)

→ Investigate effect of pre-amplifier on SiPM recovery time

3x3 SiPM matrix demonstrates better performances compared to 2 SiPM configuration

- To recover single PE calibration consider reading one SiPM independently to reduce noise
- Low dynamic range
  - → Use differential amplification for low and high energy events
  - → Use matrix and single SiPM for different energy ranges

BK Precision 9185 Power Supply

Weiner MPV8060I Power Supply

Proposal

Requirements:

- Measure signal between 10 MeV (cosmic muons) and 20 GeV (beam) → 1000x dynamic range
- Reasonable resolution at all energies → NPE(10 MeV) $\sim$ 1000
- Stable gain in large charge/rate range

Reference parameters with 6×6 mm^2 SIPM with 25×25 μm^2 cell size ($\sim$ 11k cells at max occupancy) and $PbWO_4$ (LY = 100 photons/MeV)

- Single SiPM light yield: $N_{phe} = 4.4$ phe/MeV
  → For a 9 SiPM matrix $N_{phe}(10\ MeV) \sim 400$ → Reasonable resolution at low energy
  → For a single SiPM $N_{phe}(3\ GeV) \sim 12k$ → single SiPM saturates; amplifier may saturate with 9 SiPM

Proposal for 3x3 matrix: use two different amplification lines

- 8 SiPM (9-1) for low energy signals with a larger area coverage → work range 1 MeV – 1 GeV (350 to 35000 PE - resolution < 3%)
- 1 SiPM to be used for larger signals, with 1/5 PDE → work in range 1 GeV—15 GeV (880 – 13000 PE)

Implementation:

- Two identical preamplifiers for matrix and single SiPM → double number of digitalizer's channels
- Multiplex two signal on same fADC channel (if possible)