GEM in a double phase liquid xenon detector

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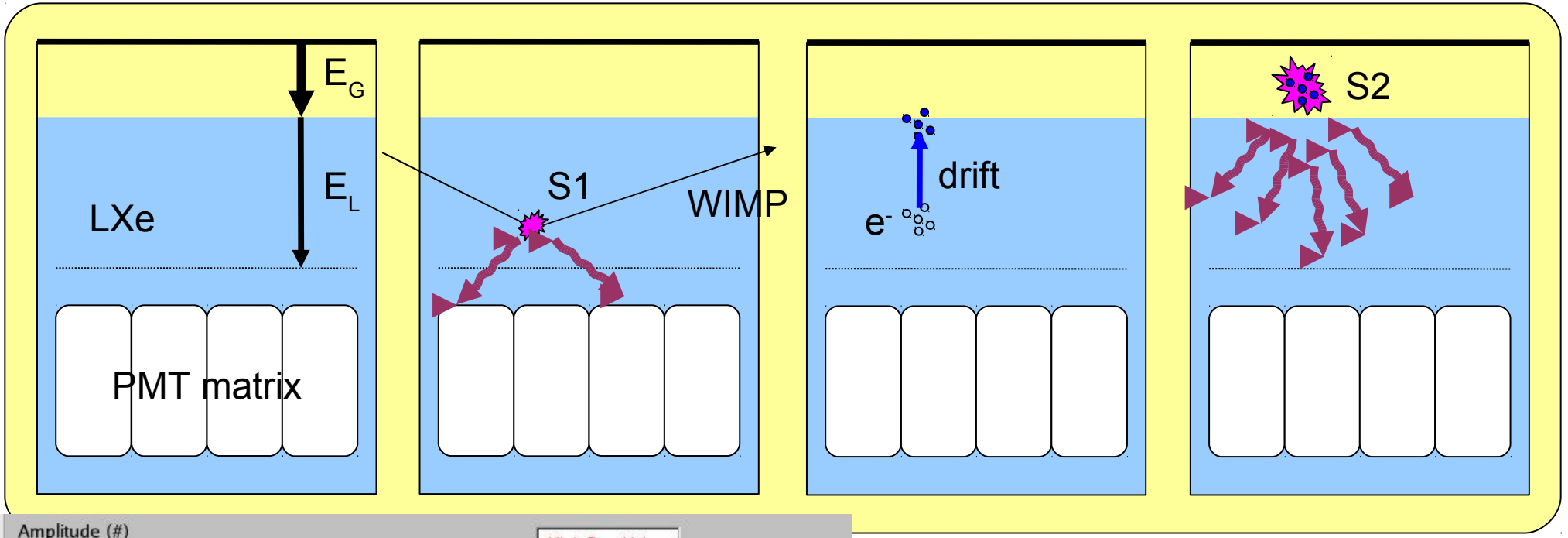
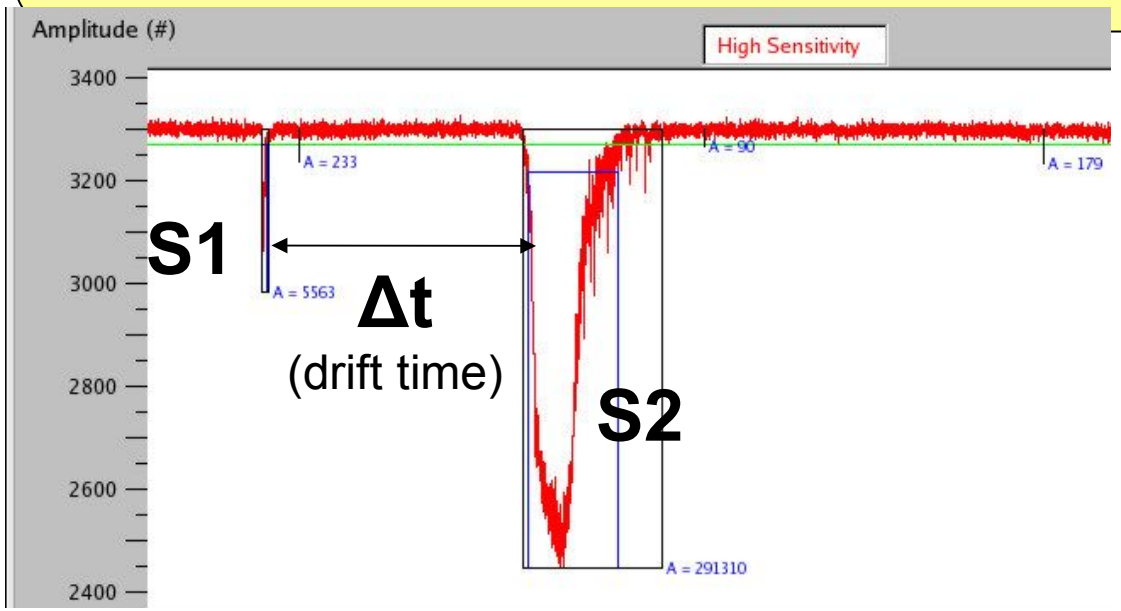
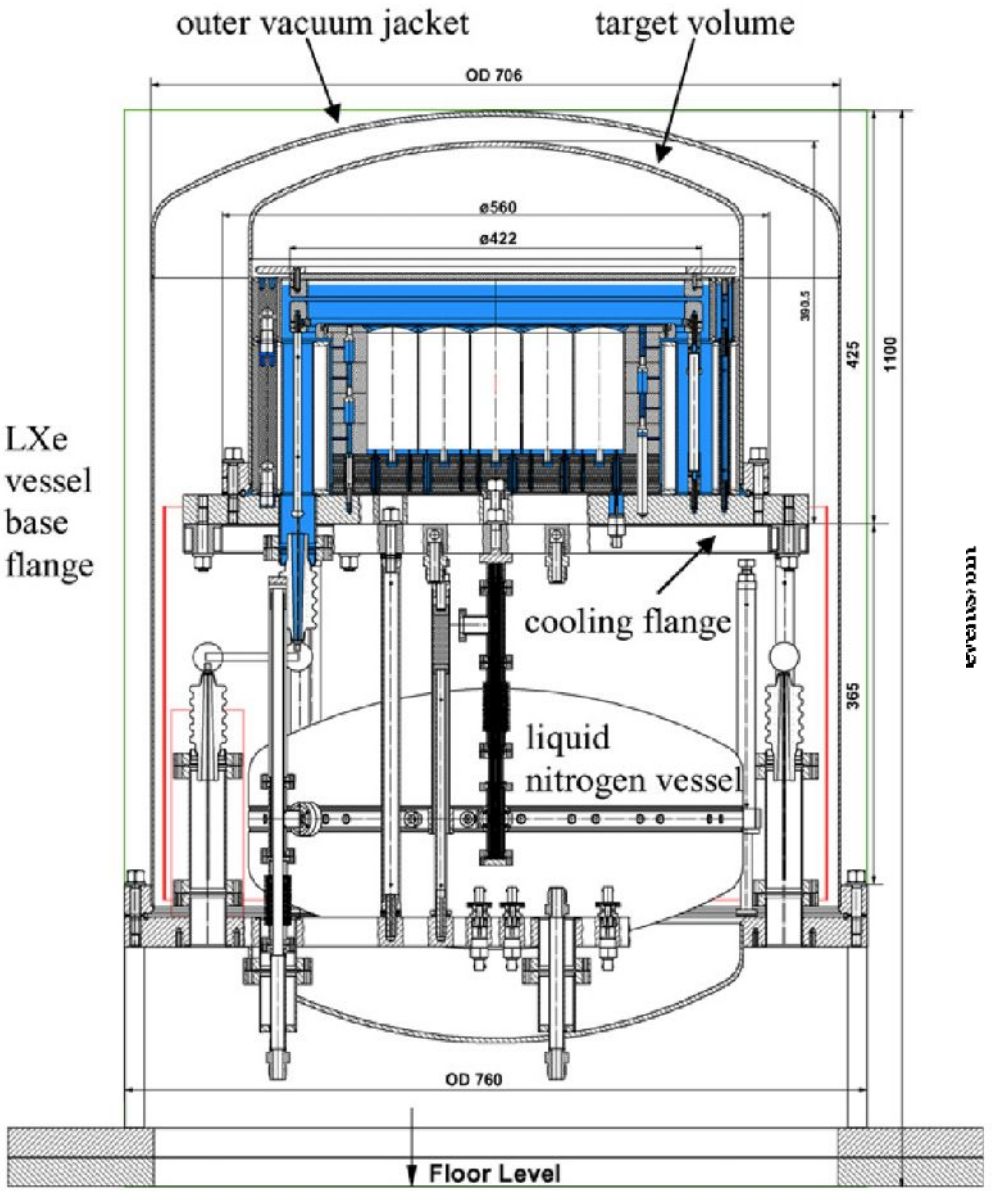
Double phase detector



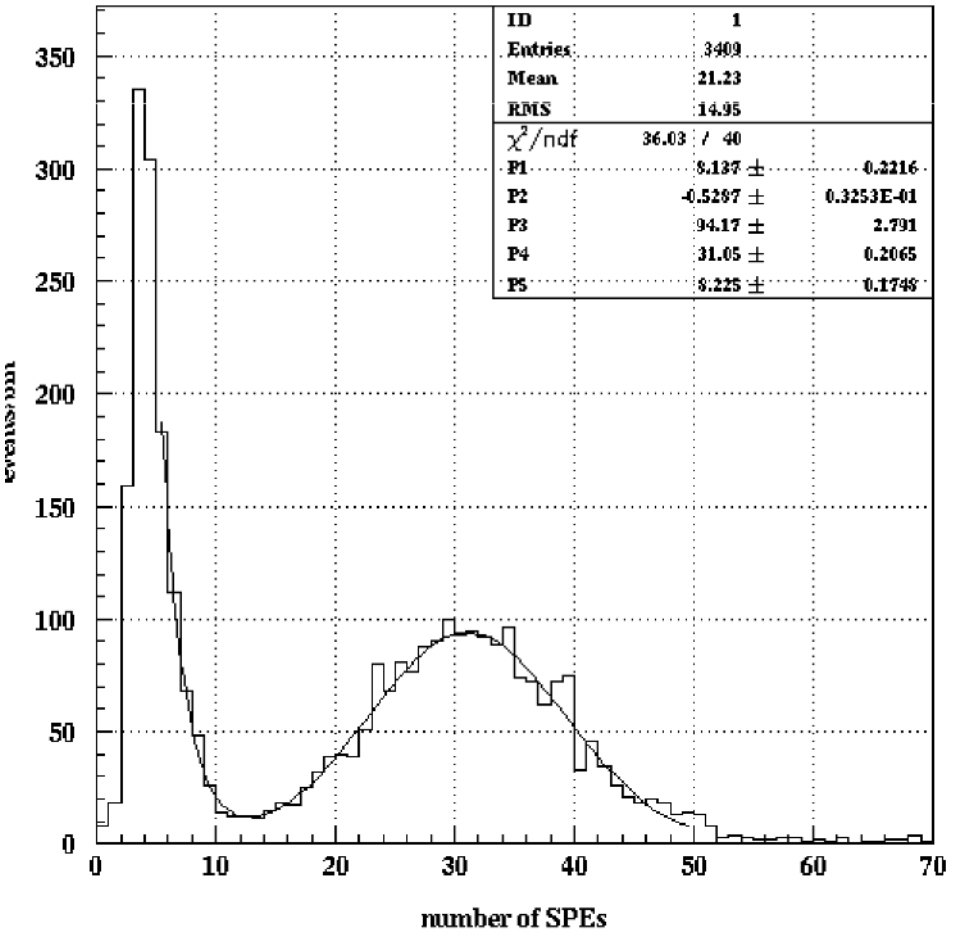


S1 ~ scintillation
S2 ~ charge
Depth ~ drift time
S2/S1 depends on ionizing particle (electron/recoil)
Very high gain in S2

Example: ZEPLIN III



S2 from single electron

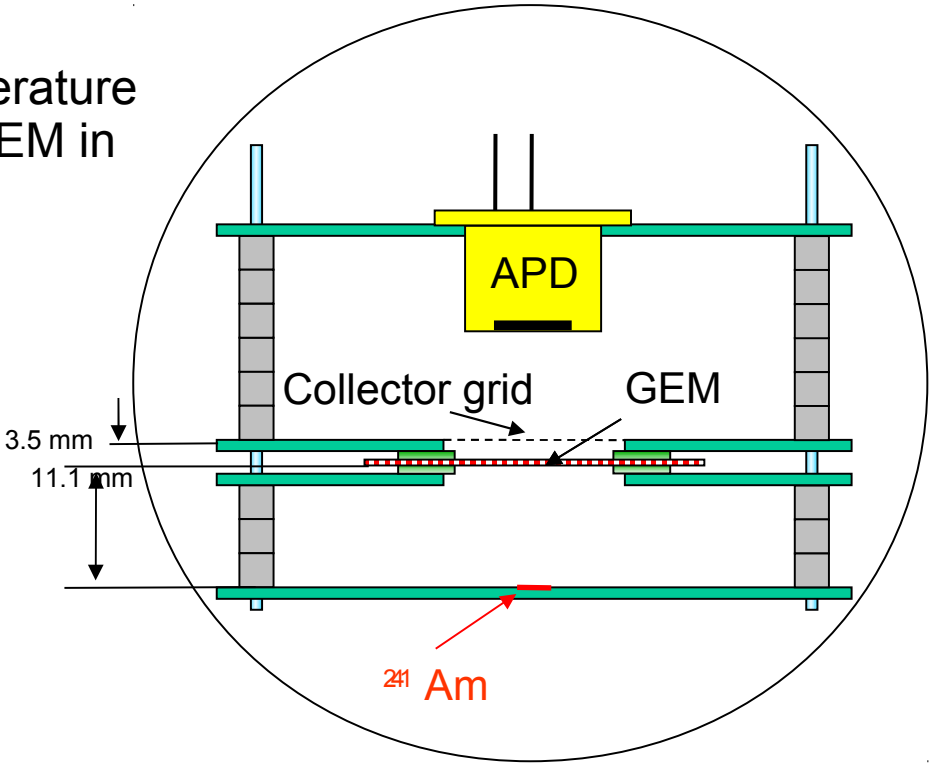


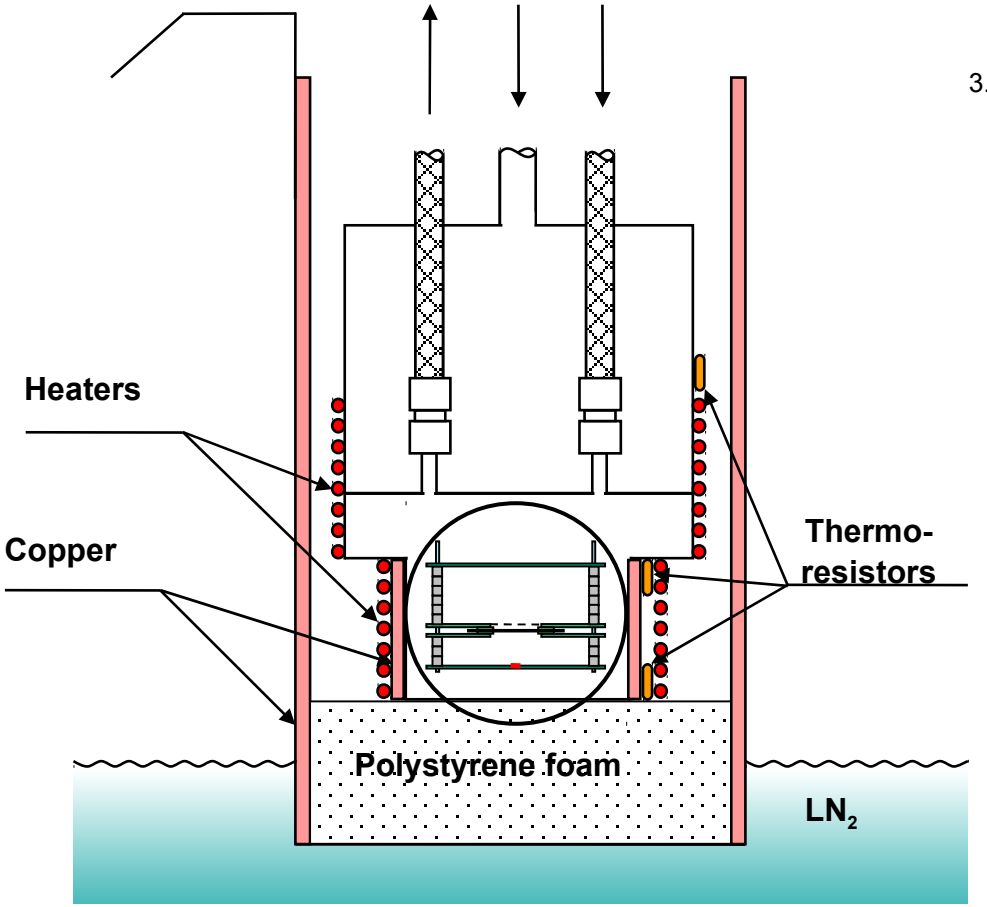
Motivation

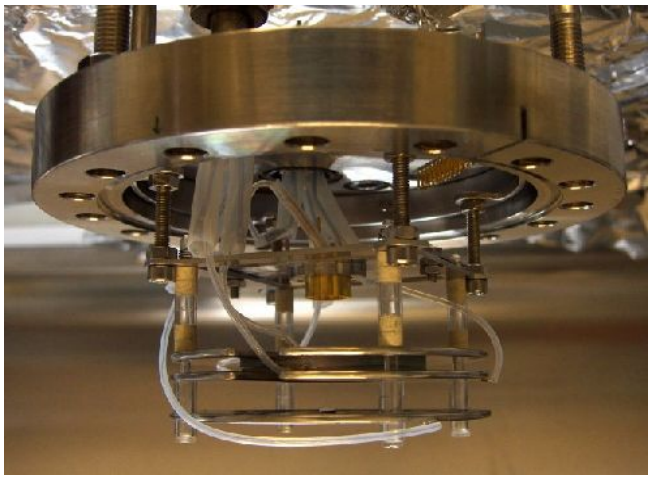
- PMTs remain the main source of intrinsic radioactivity
- How can we do a cleaner readout with comparable characteristics?
  - APD
  - SiPM
  - GEM + APD
  - CsI + GEM + APD

Experimental Set-Up

- Good thermostabilization plus a slight temperature gradient is the key to stable operation of a GEM in double phase Xe
- An authomatic temperature conrol highly increases realability



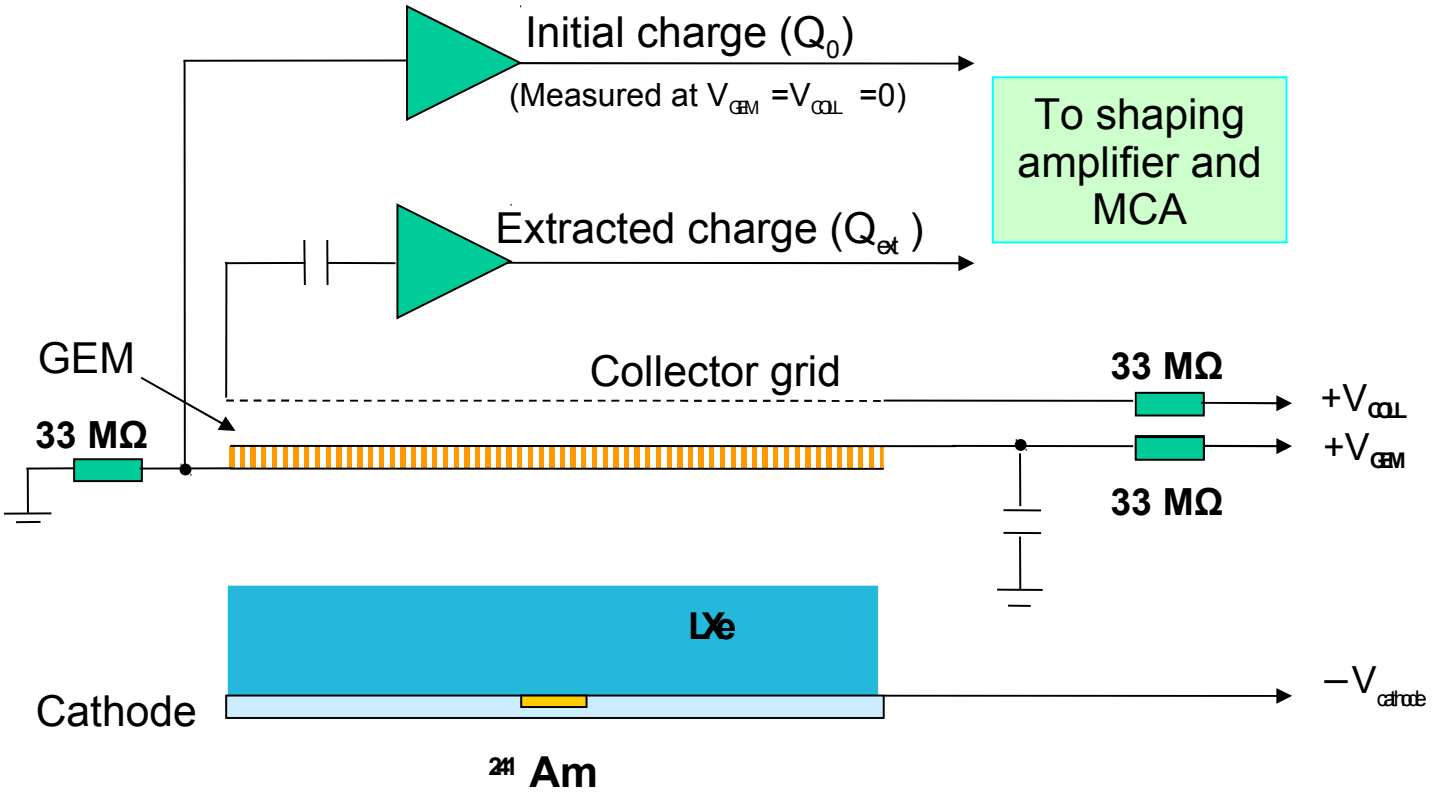




HV and Electronics

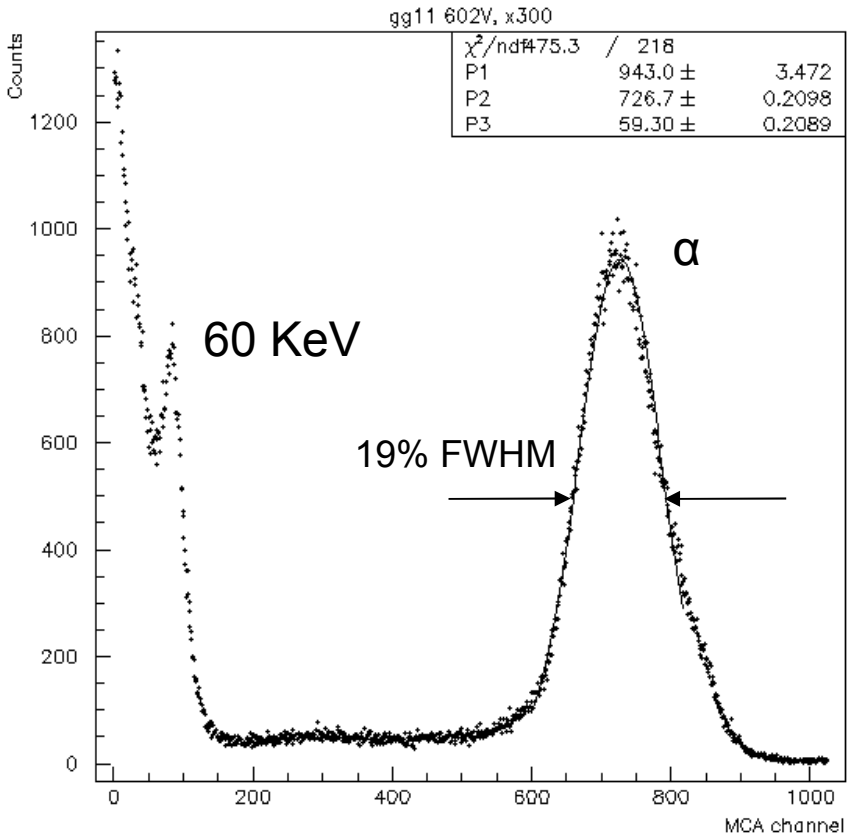
- Typical Voltages:
  - V_{CATH} = -6000V
  - V_{GEM+} = +300..600V
  - V_{COLL} = +2000V
- Bottom side of the GEM is grounded
- E_L = 3..6 kV/cm depending on the liquid level

- Charge-sensitive preamps (Cremat)
- 6 and 12 μs Semi-gaussian shaping
- Calibration circuit (not shown)
- Initial charge extracted from liquid (Q_0) is typically 3 fC
- Effective Gain = Q_{ext} /Q_0



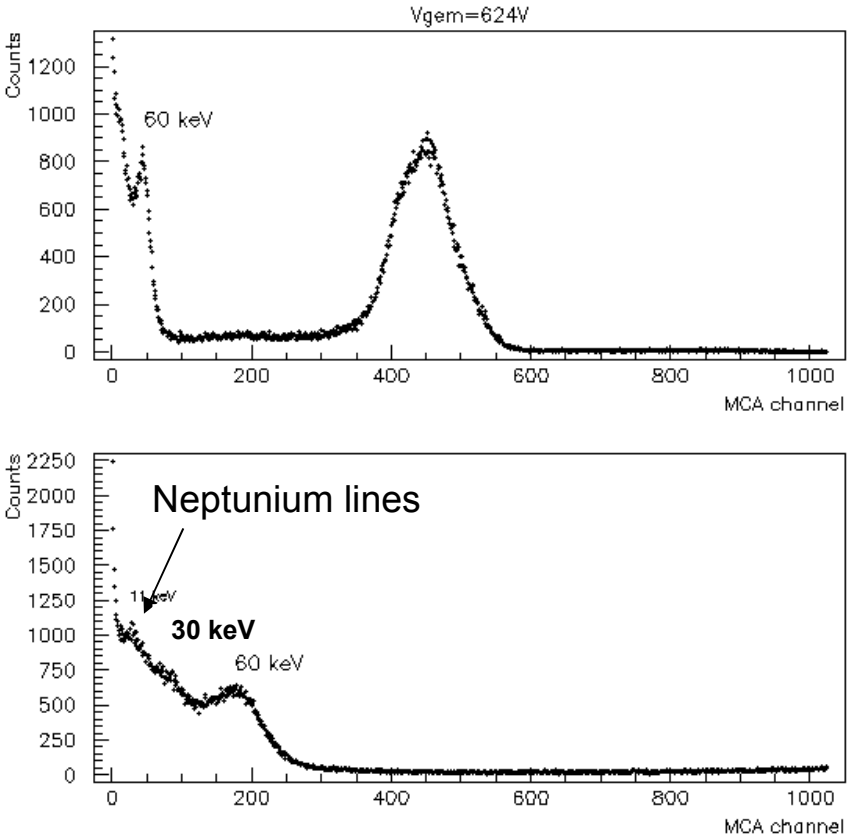
Charge spectra

VGEM = 600V



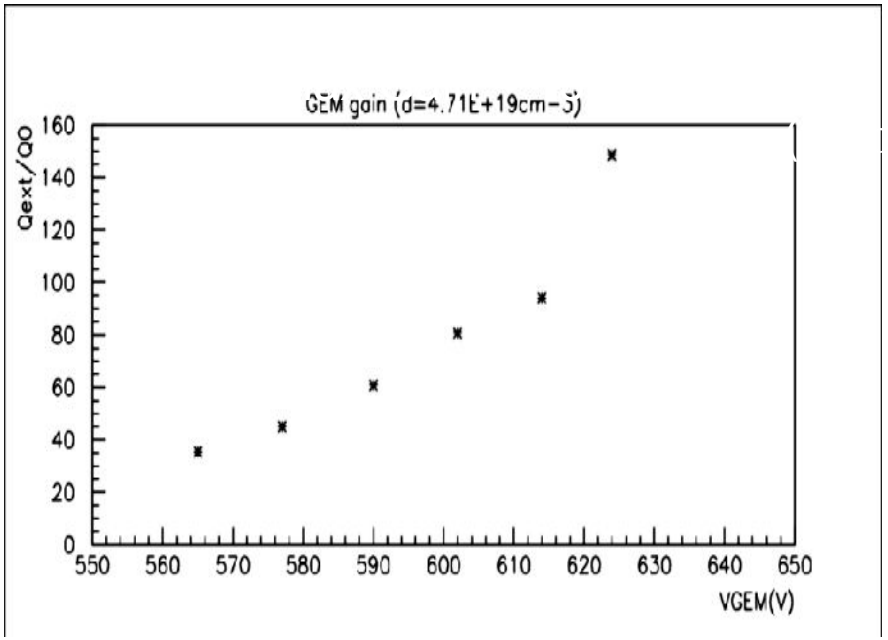
Gain = 80

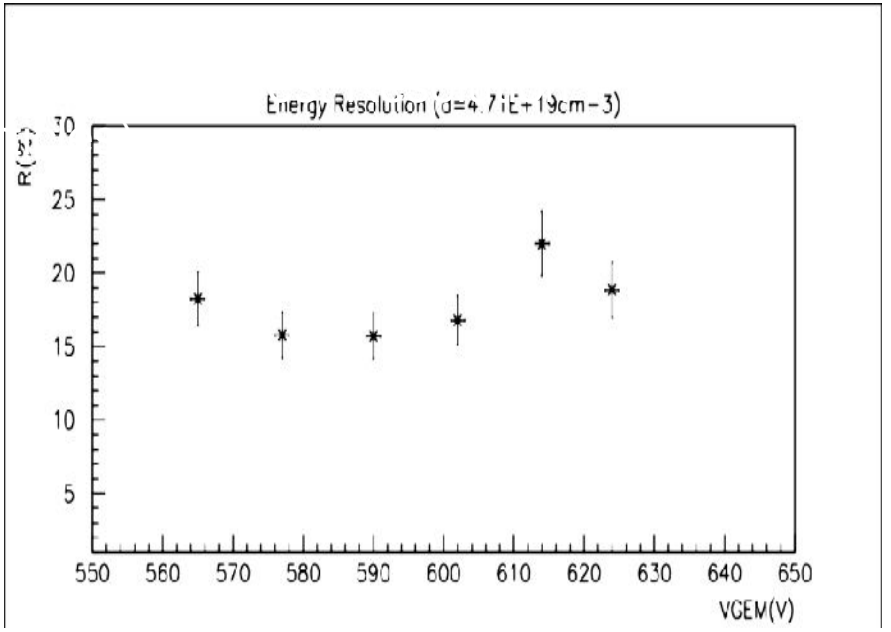
VGEM = 625V



Gain = 140

Charge: Gain and resolution

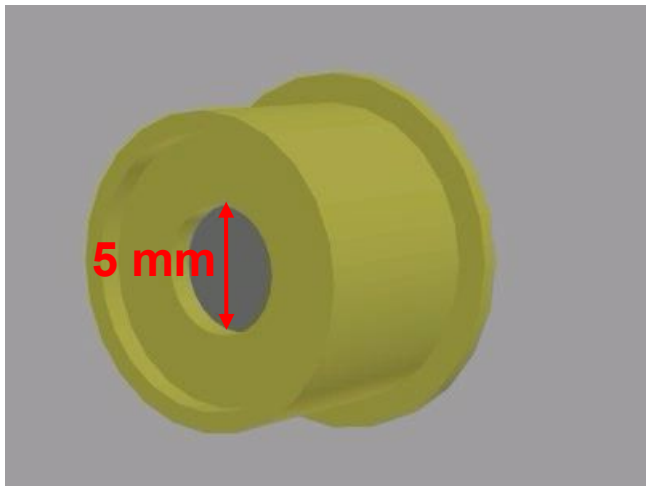




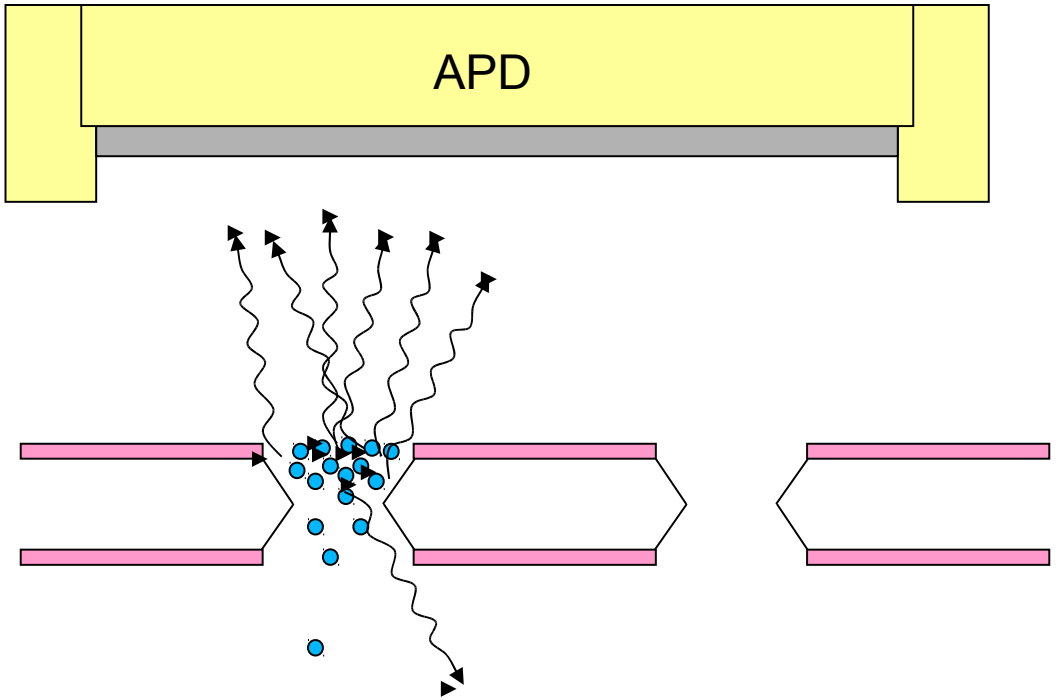
The reason for poor resolution is very strong electric field in the gas gap (~6 kV/cm)
Most of the driftig electrons do not make it to the GEM holes

GEM + APD

Advanced Photonix LAAPD



- Sensitive area: 0.2 cm^2
- Dark current:
  - 50 nA typical @ 25 °C
  - <1nA @ –100 °C
- Maximal gain:
  - 250 @ 25 °C
  - >1000 @ –100 °C
- QE ~ 1 @ 175 nm

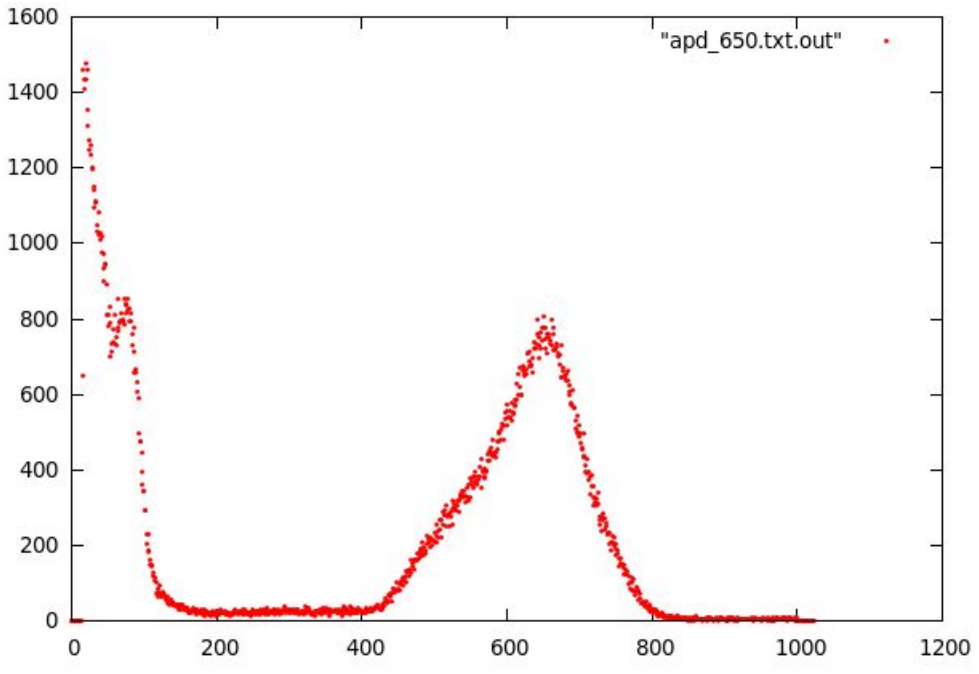


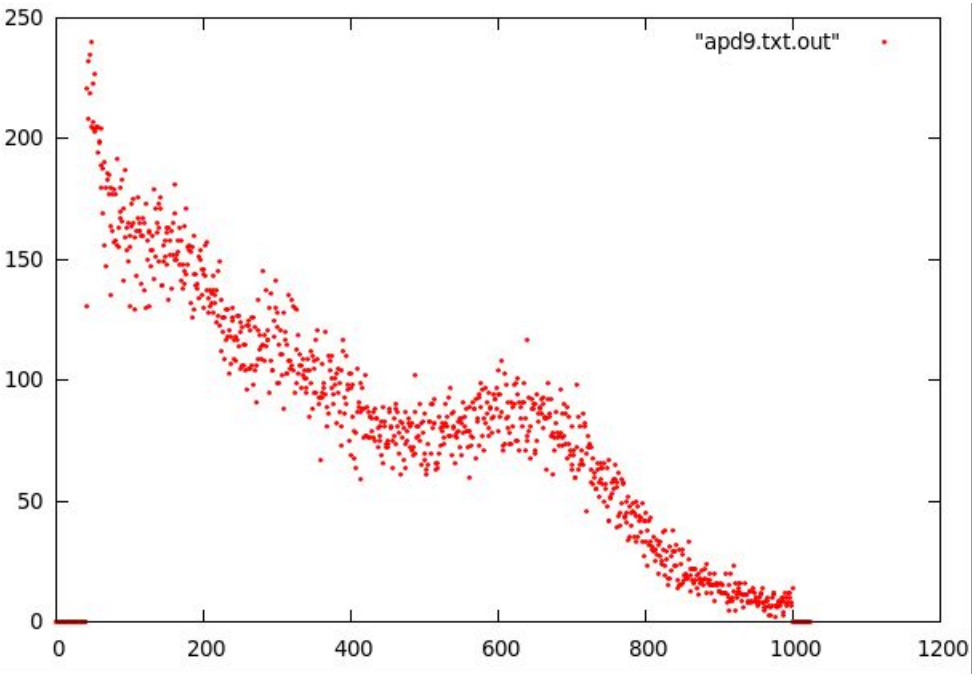
•GEM gain can be lower → less discharging
•Higher overall gain → single electron detection should be possible
•Less capacitance, less microphonic → better signal-to-noise ratio
•Less channels for position-sensitive readout

Light mode

What we see:

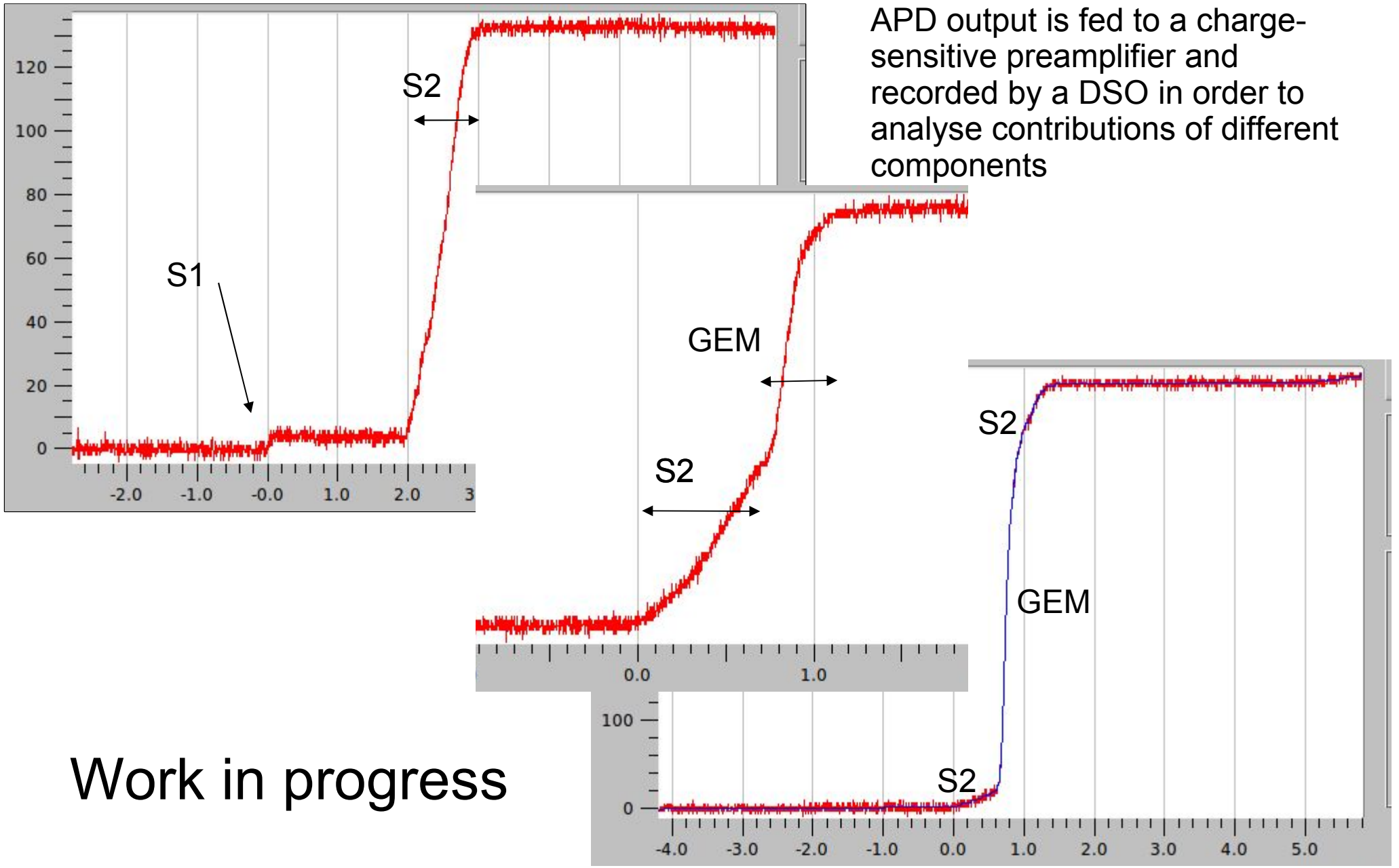
- Higher gain, up to ~3000 electrons per primary electron
- Lower resolution, maybe because we are multiplying two avalanche processes
- The tail to the left is probably due to partial shadowing for off-center events





Waveform analysis

APD output is fed to a charge-sensitive preamplifier and recorded by a DSO in order to analyse contributions of different components



Work in progress