Example of a RD51 generic R&D

Optically Read Out GEM-based TPC

F. M. Brunbauer[1,2], C. Bault[1], G. Galgóczi[3], D. Gonzalez Diaz[4], E. Oliveri[1], F. Resnati[1], L. Ropelewski[1], C. Streli[2], P. Thuiner[1,2], M. van Stenis[1]

[1]CERN, Geneva, Switzerland
[2]Technische Universität Wien, Vienna, Austria
[3]Eötvös Loránd University, Budapest, Hungary
[4]Uludag University, Bursa, Turkey

November 9, 2016

Motivation

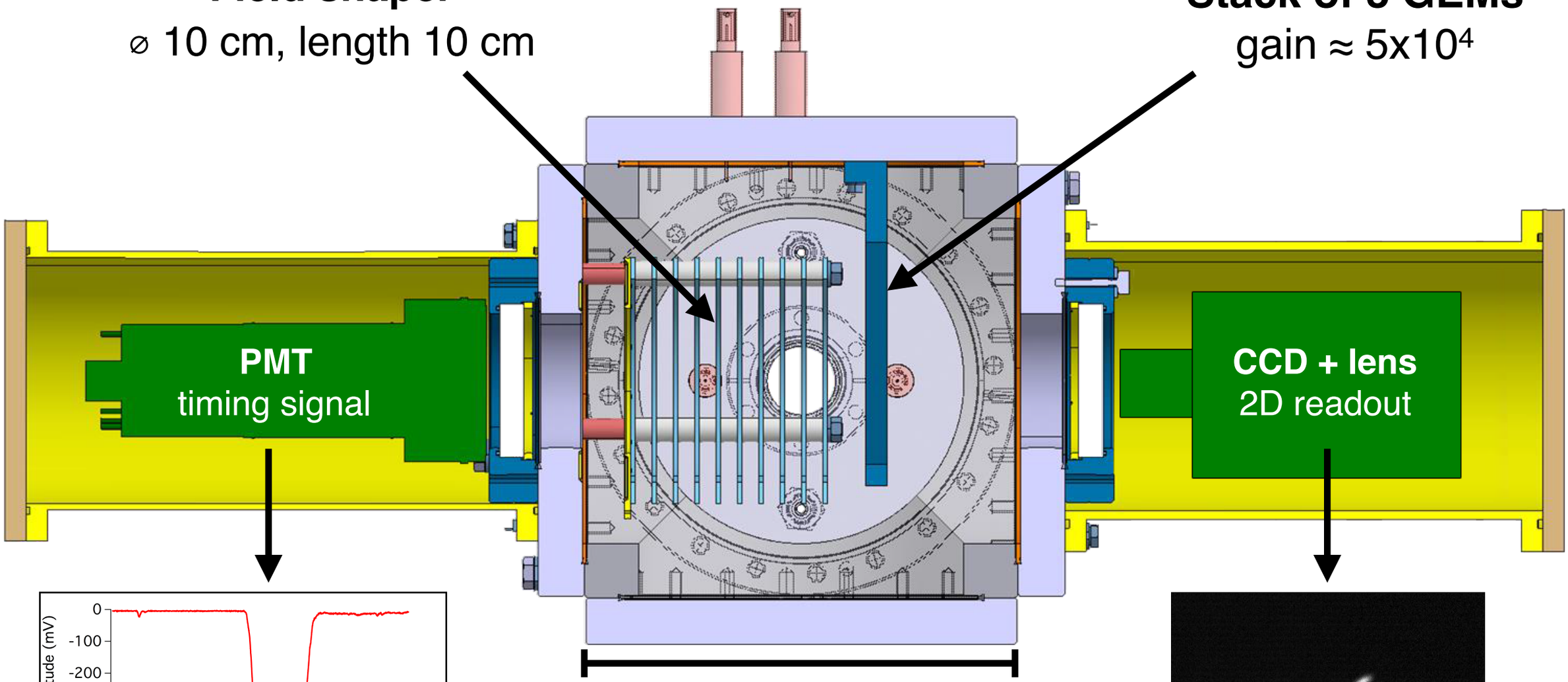
- Studies of gas scintillation properties of gases
    - Primary scintillation
    - Proportional scintillation
    - Avalanche scintillation

- Application-driven optimisation for scintillation-based TPCs

Setup 2D+1D

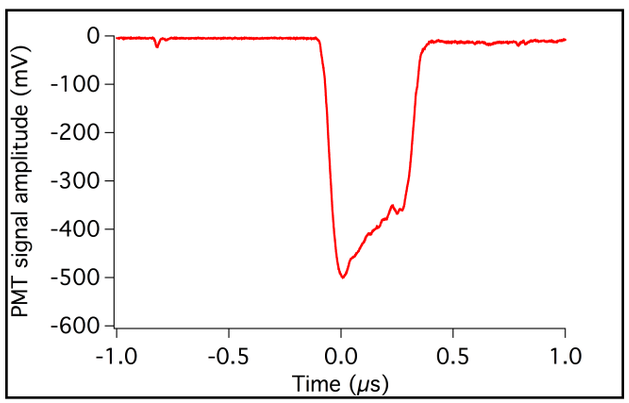
Field shaper
⌀ 10 cm, length 10 cm

Stack of 3 GEMs
gain ≈ 5×10^4



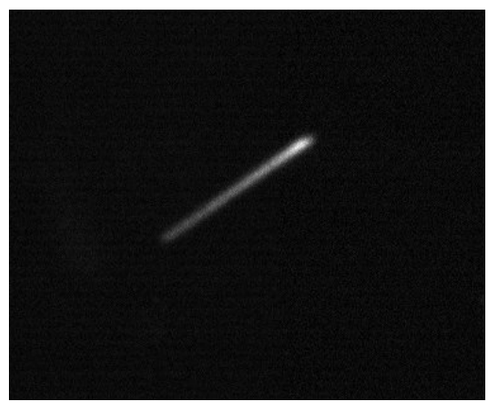
PMT
timing signal

CCD + lens
2D readout



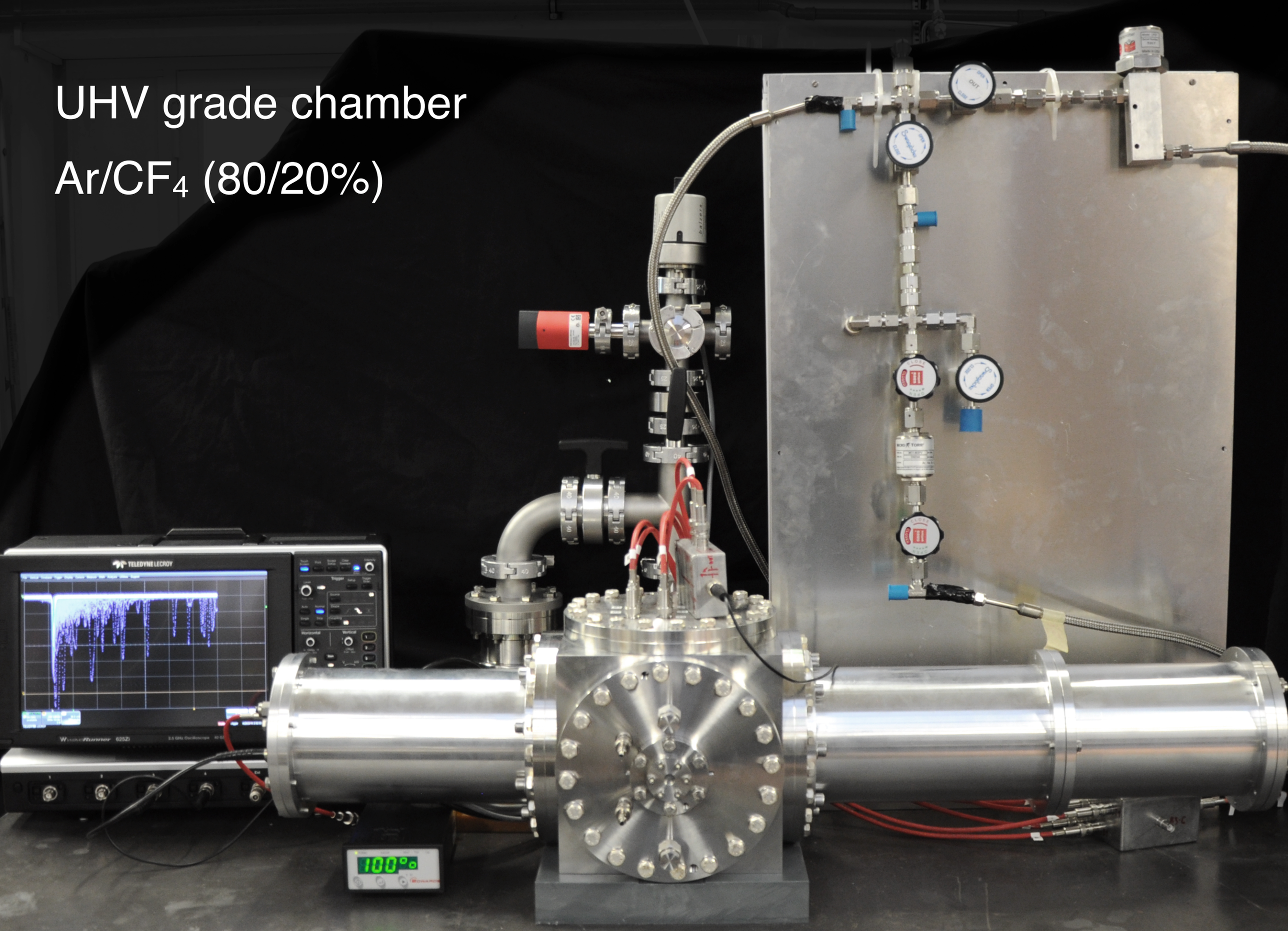
20 cm

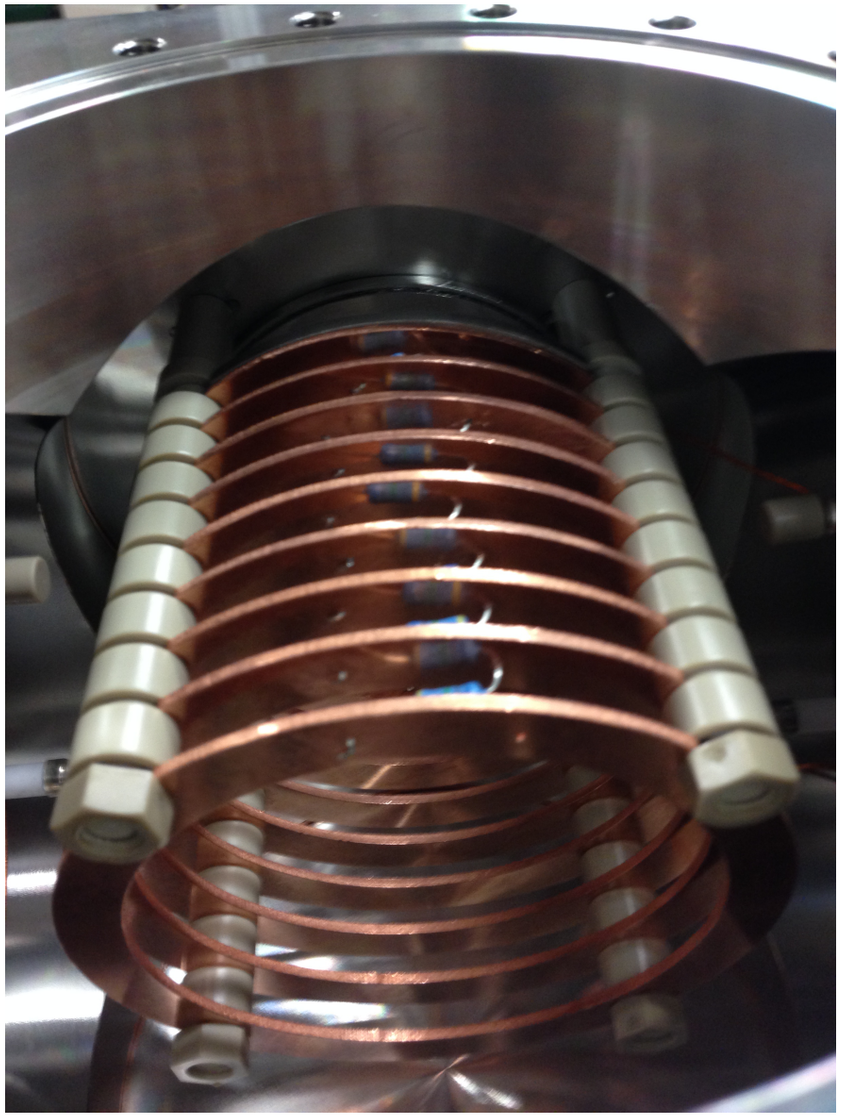
α track



UHV grade chamber

Ar/CF_4 (80/20%)

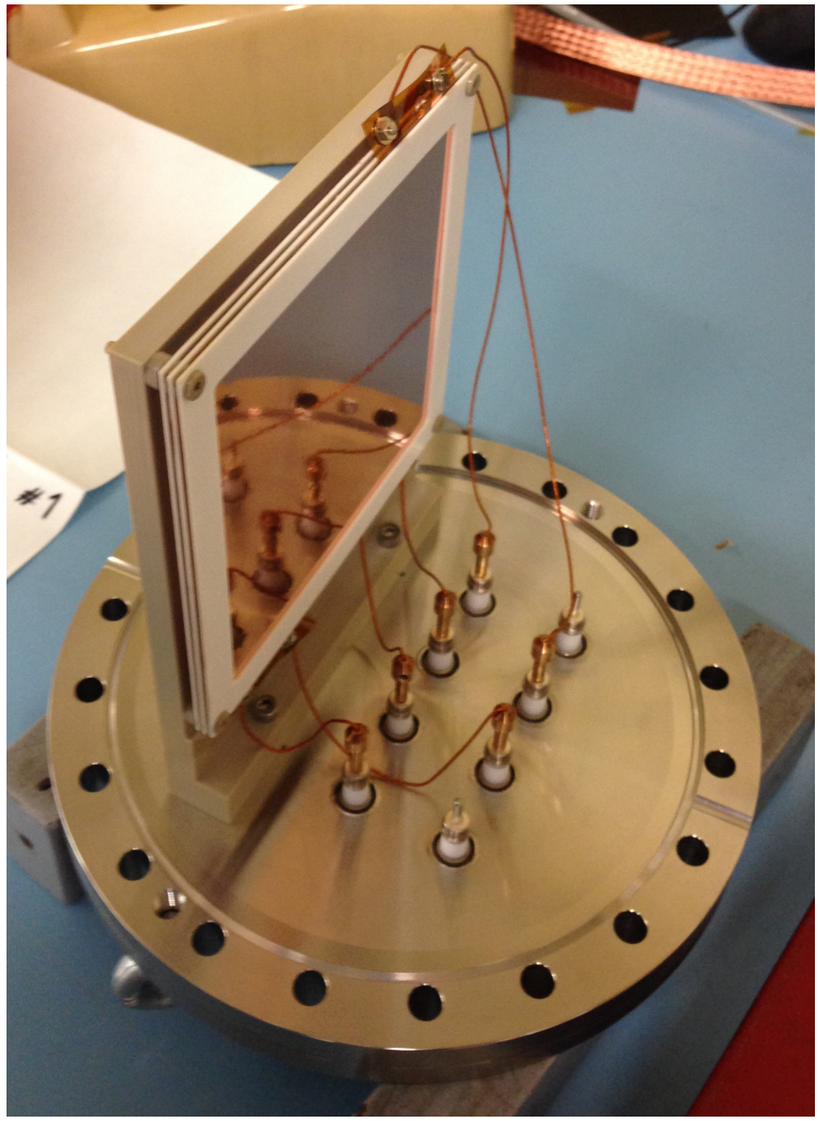




Field shaper

⌀ 10 cm, length 10 cm

Cu rings, PEEK rods



Triple GEM

10 x 10 cm^2

70 μm holes, 140 μm pitch

$^{220}Rn \rightarrow {}^{216}Po \rightarrow {}^{212}Pb$

- Ar/CF_4 (80/20%) flushed through Th cartridge
- α-decays in chamber from Rn and Po
- 6.4 MeV α-tracks from Rn are $\approx$ 4.5 cm long at 1 bar
- α-decay of Po with half life λ = 140 ms

Camera & lens

QImaging Retiga R6

CCD: 2688x2200 4.54x4.54um pixels

ADC: 14bit

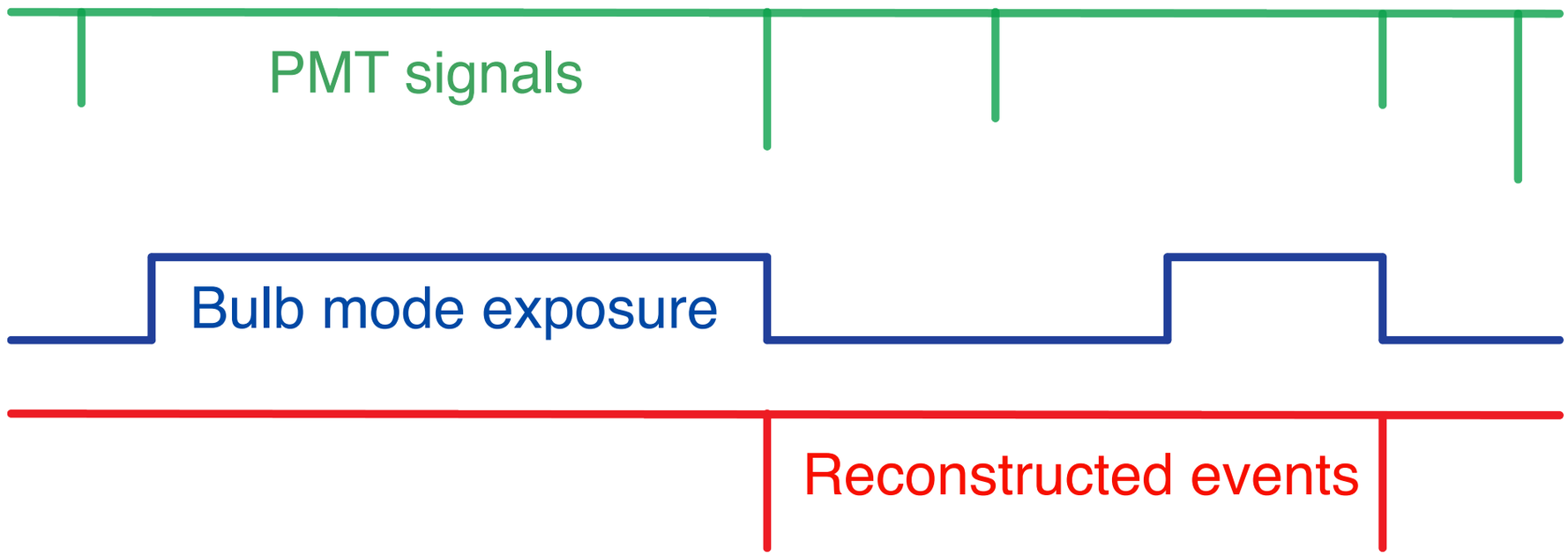
Read noise: 5.7e^- RMS

Dark current: 0.0002e^-/p/s @ -20°C

Navitar

Focal length: 25mm aperture: f/0.95

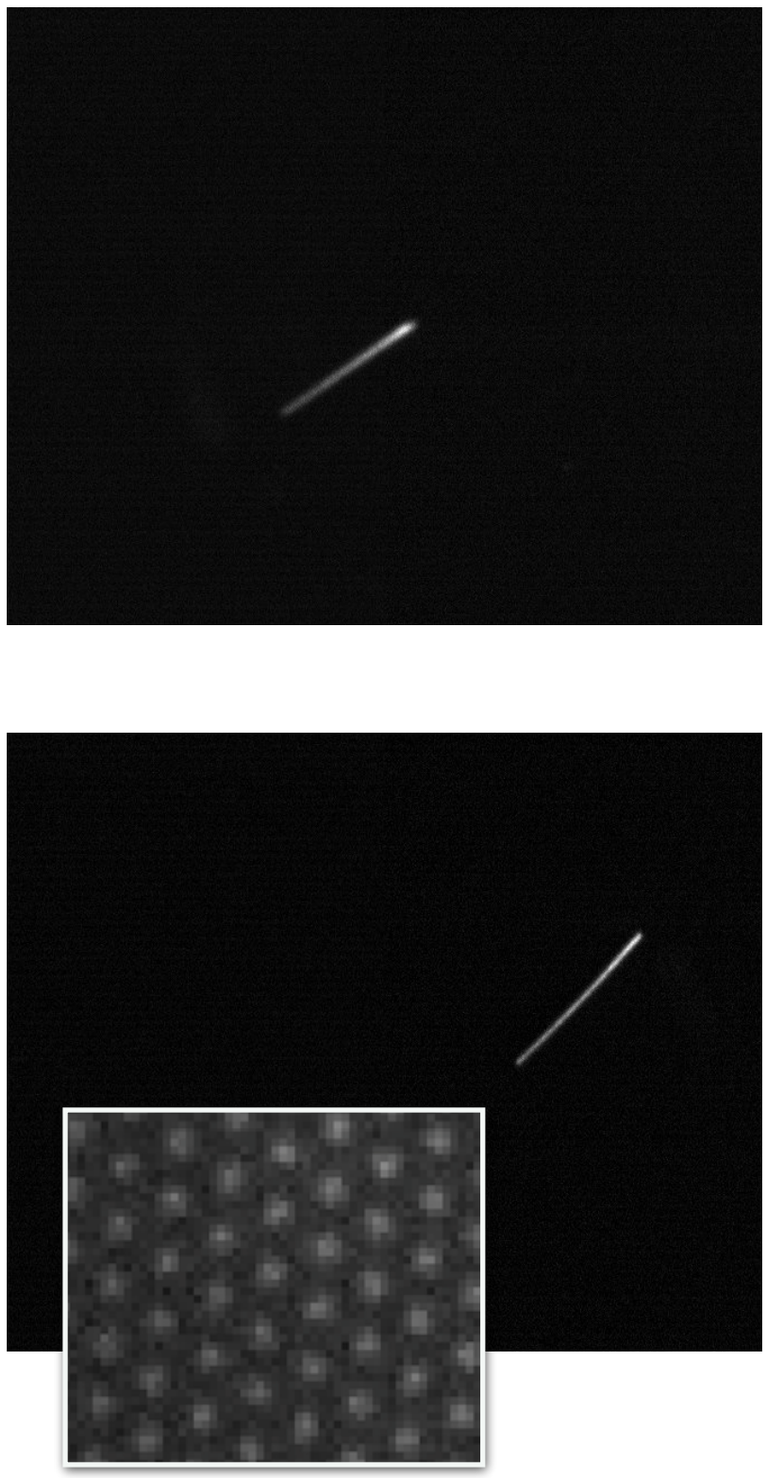
Triggering

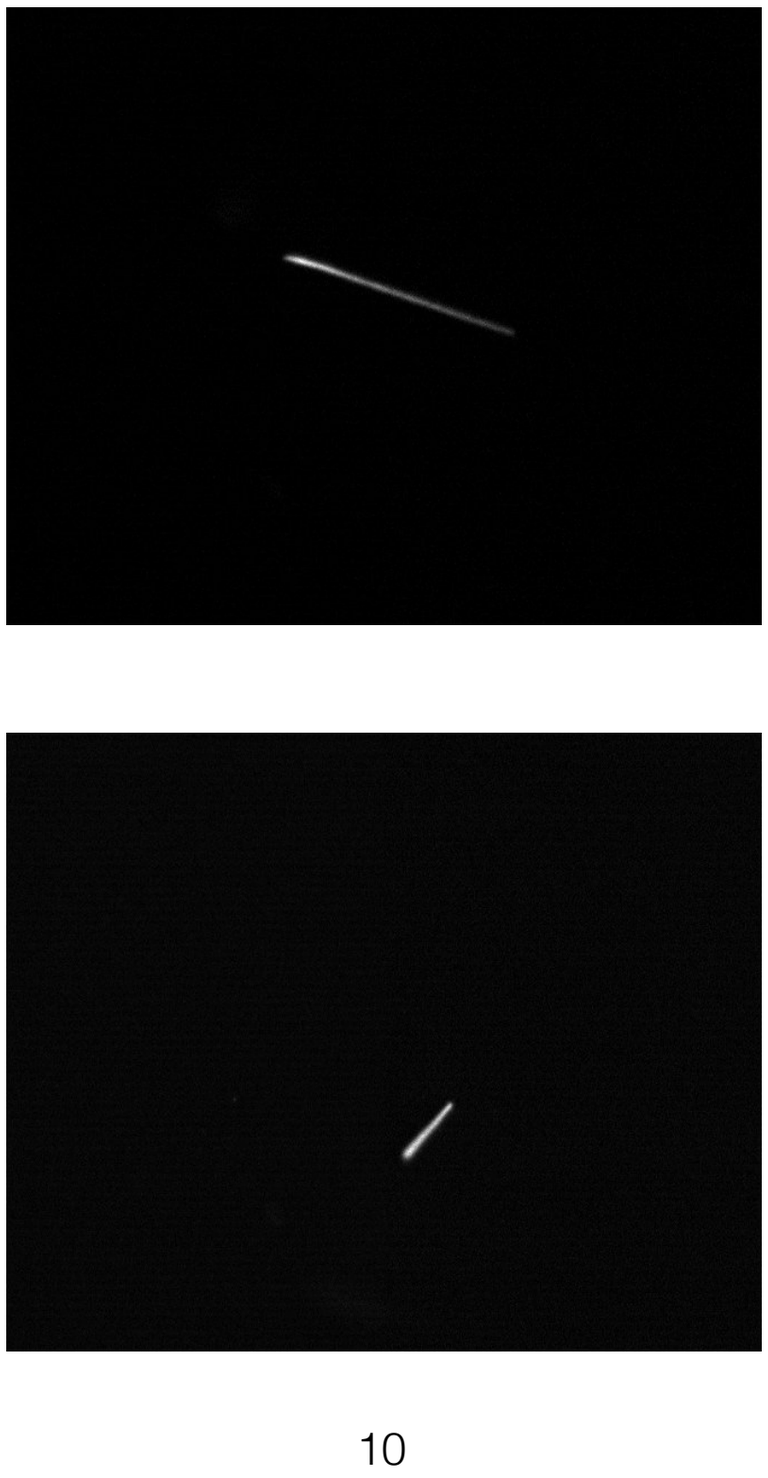


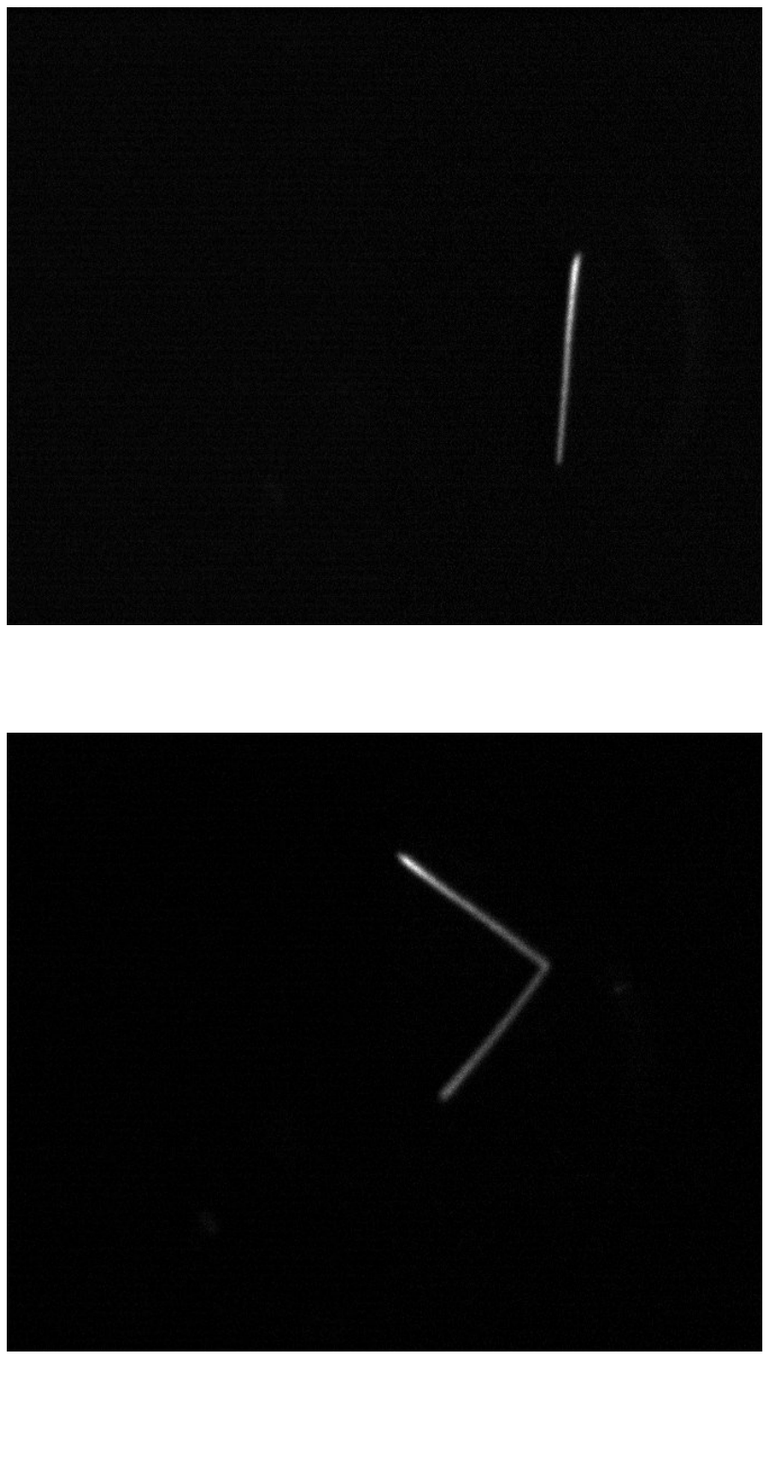
- Bulb mode exposure of CCD stopped by trigger from PMT when system not busy
- Matlab reads PMT waveform and image and displays event after reconstruction
- Event display rate limited by communication

α-track reconstruction

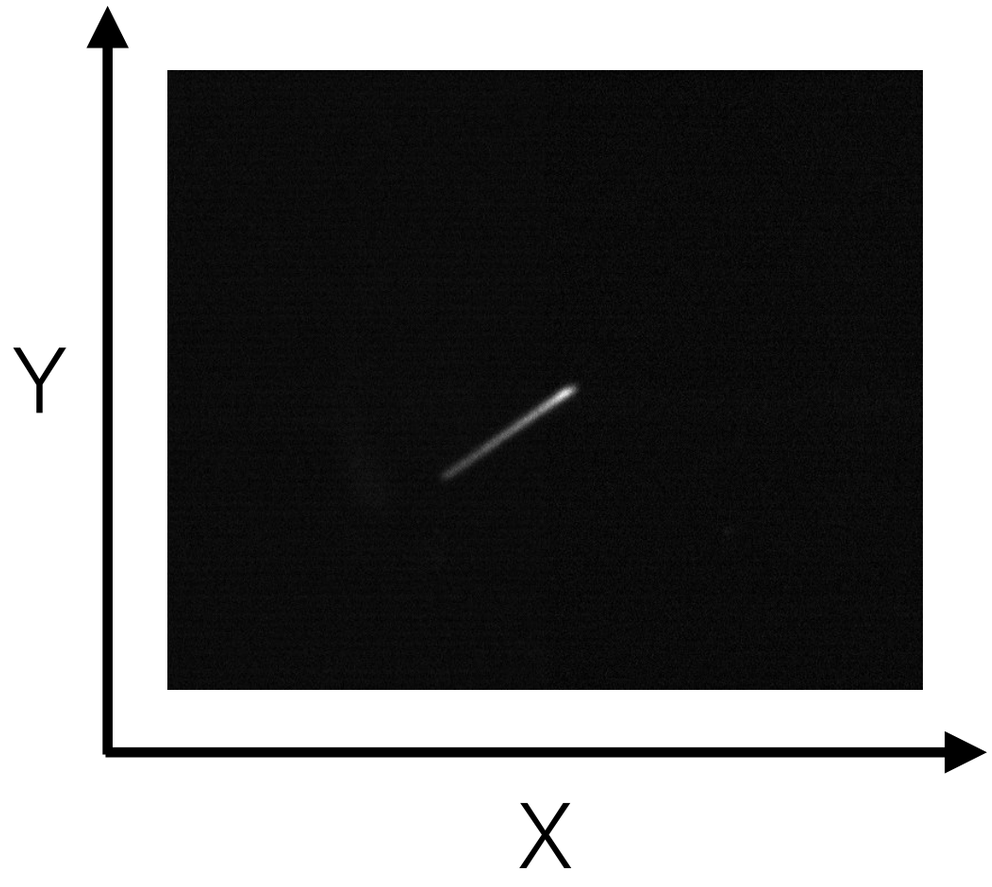
Images of α tracks

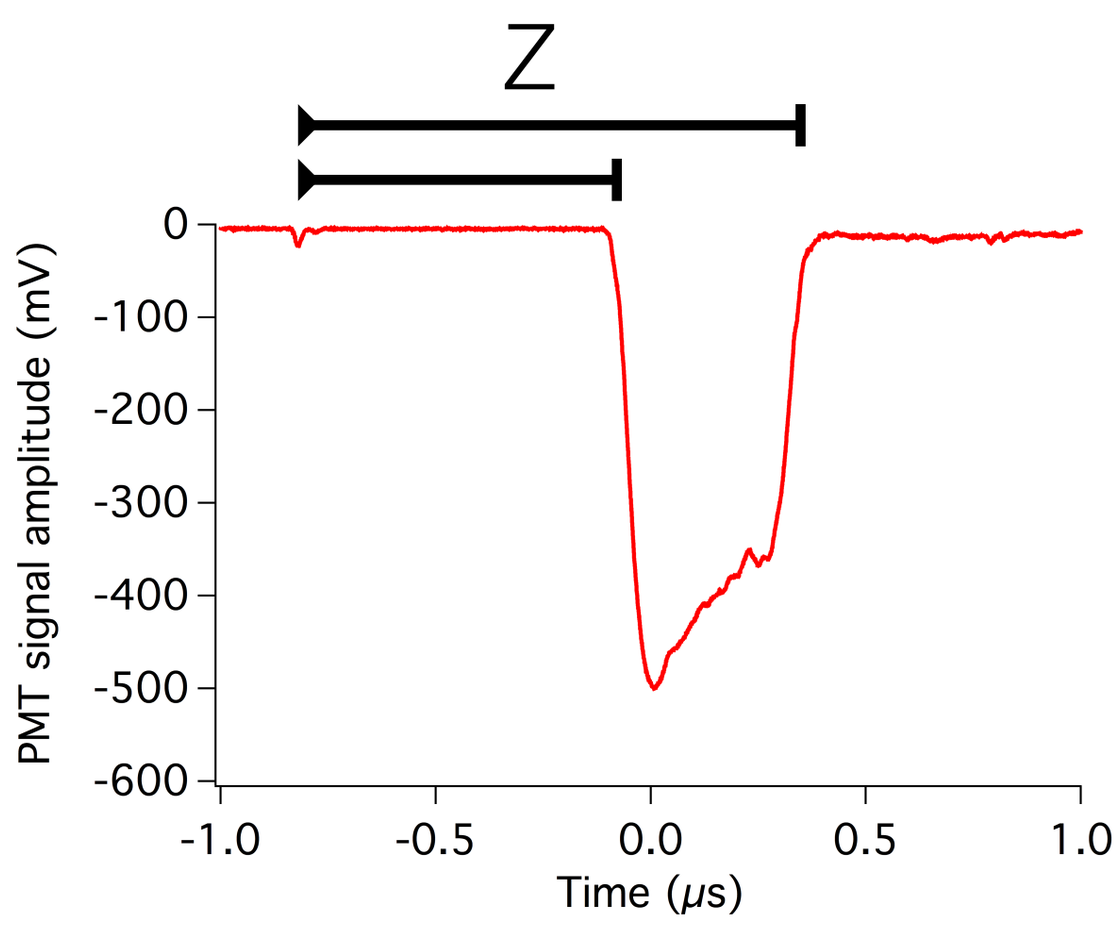






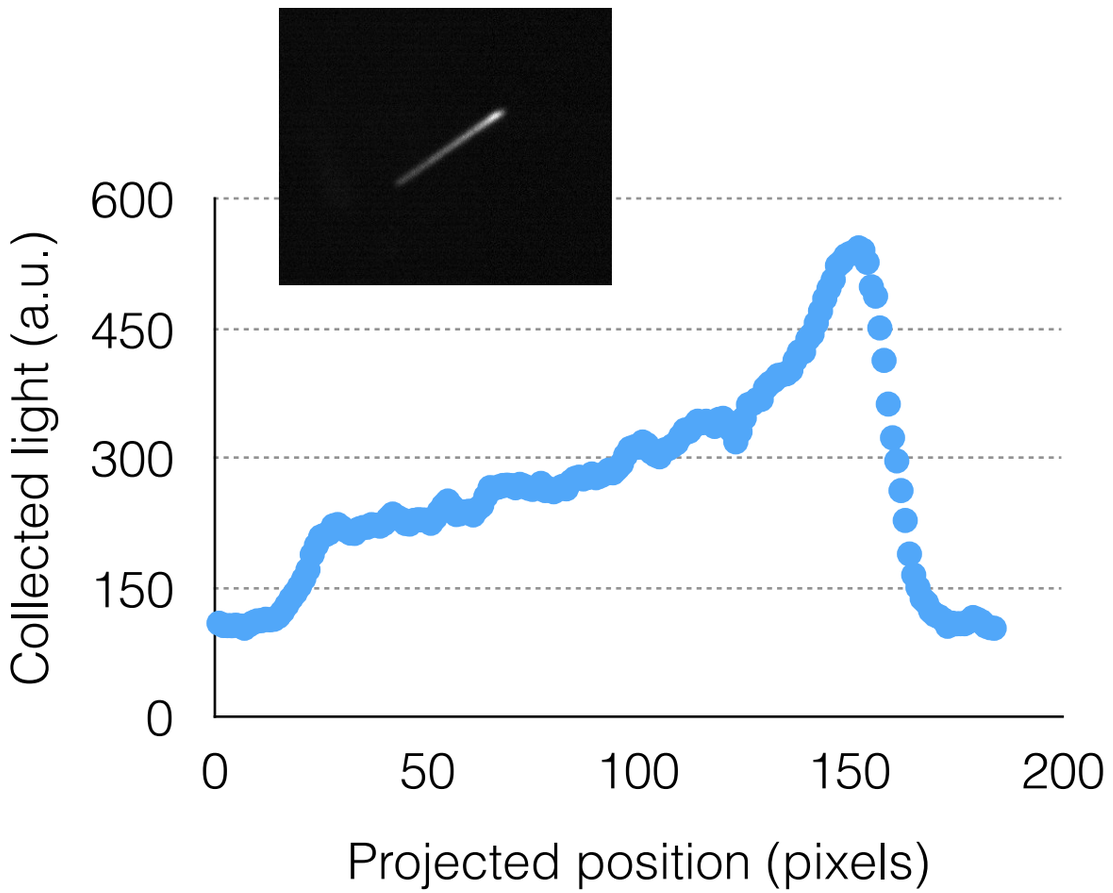
X Y Z



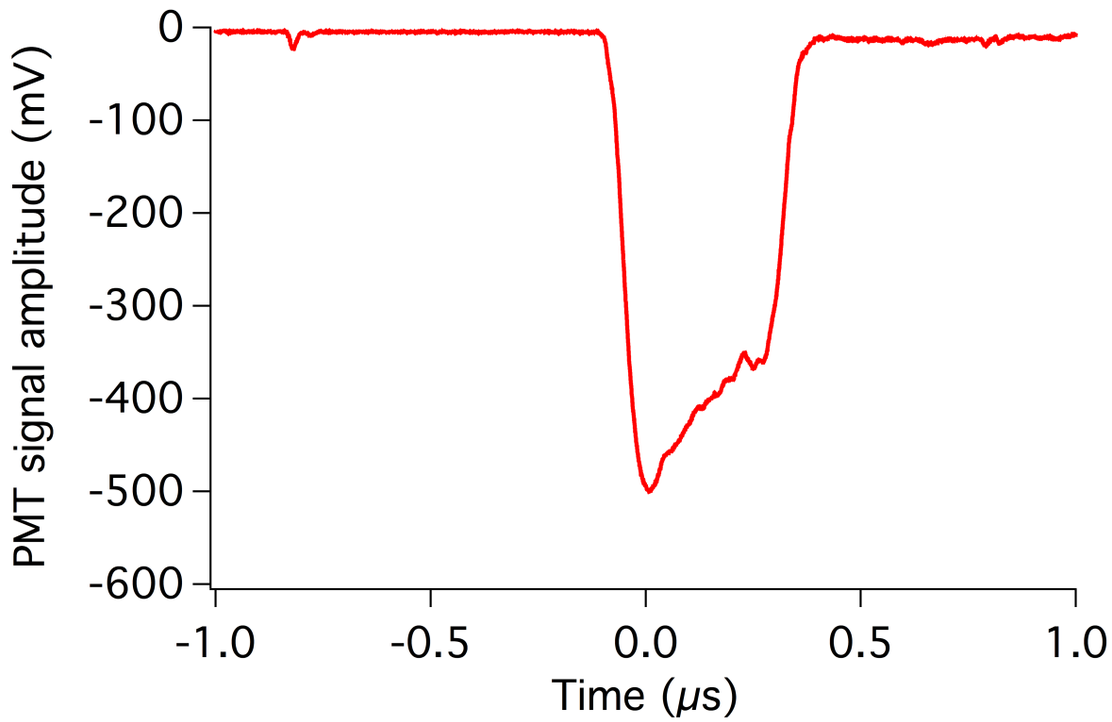


PMT waveform

Orientation by Bragg curve



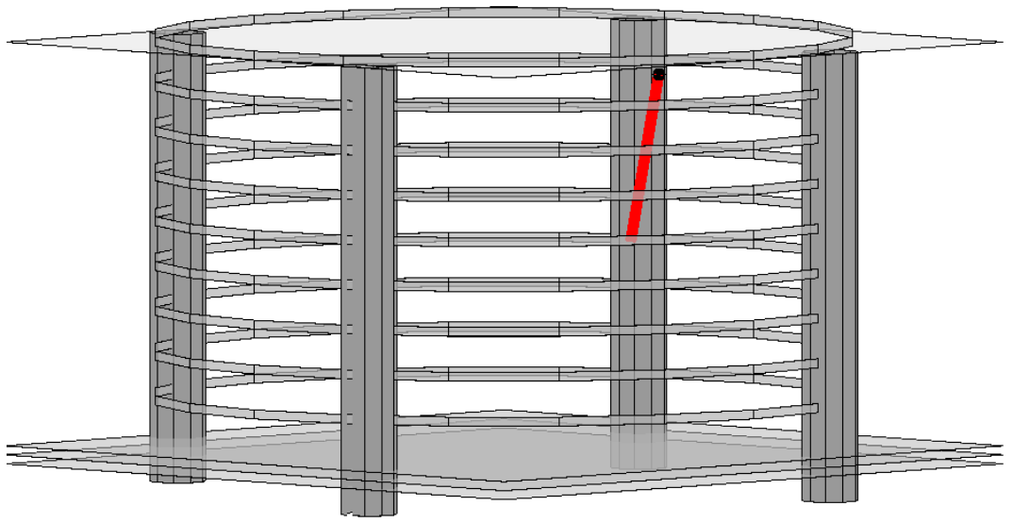
Intensity profile from CCD image

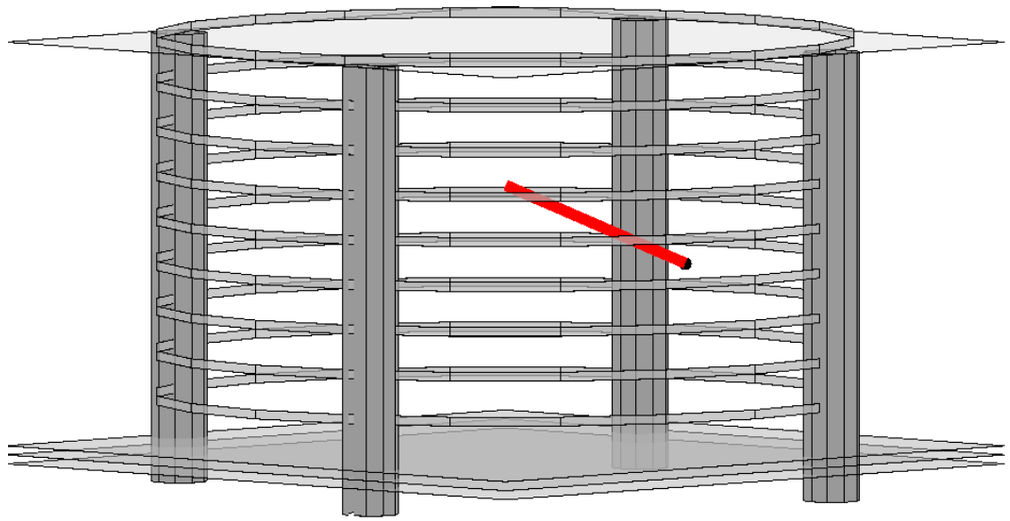


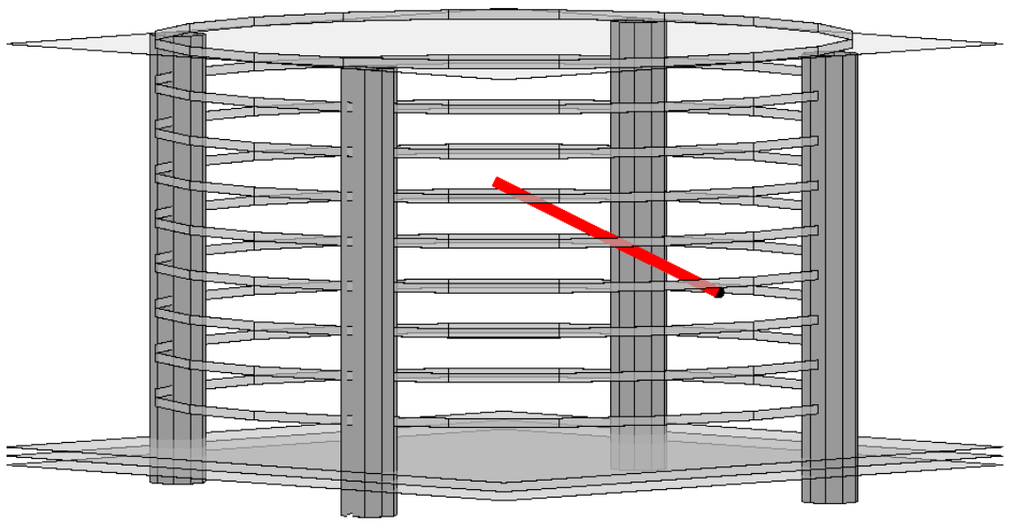
PMT waveform

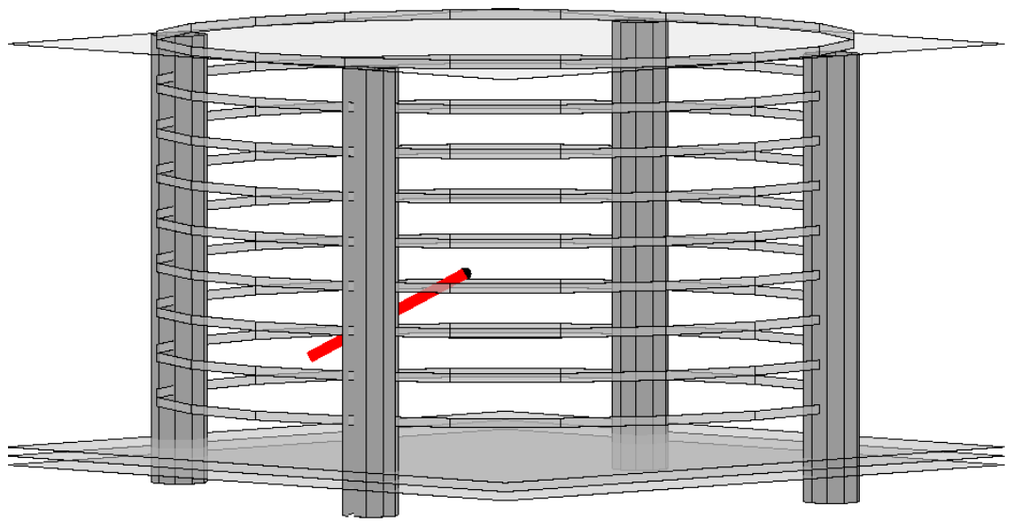
⇒ Track oriented towards GEMs

Reconstructed α tracks

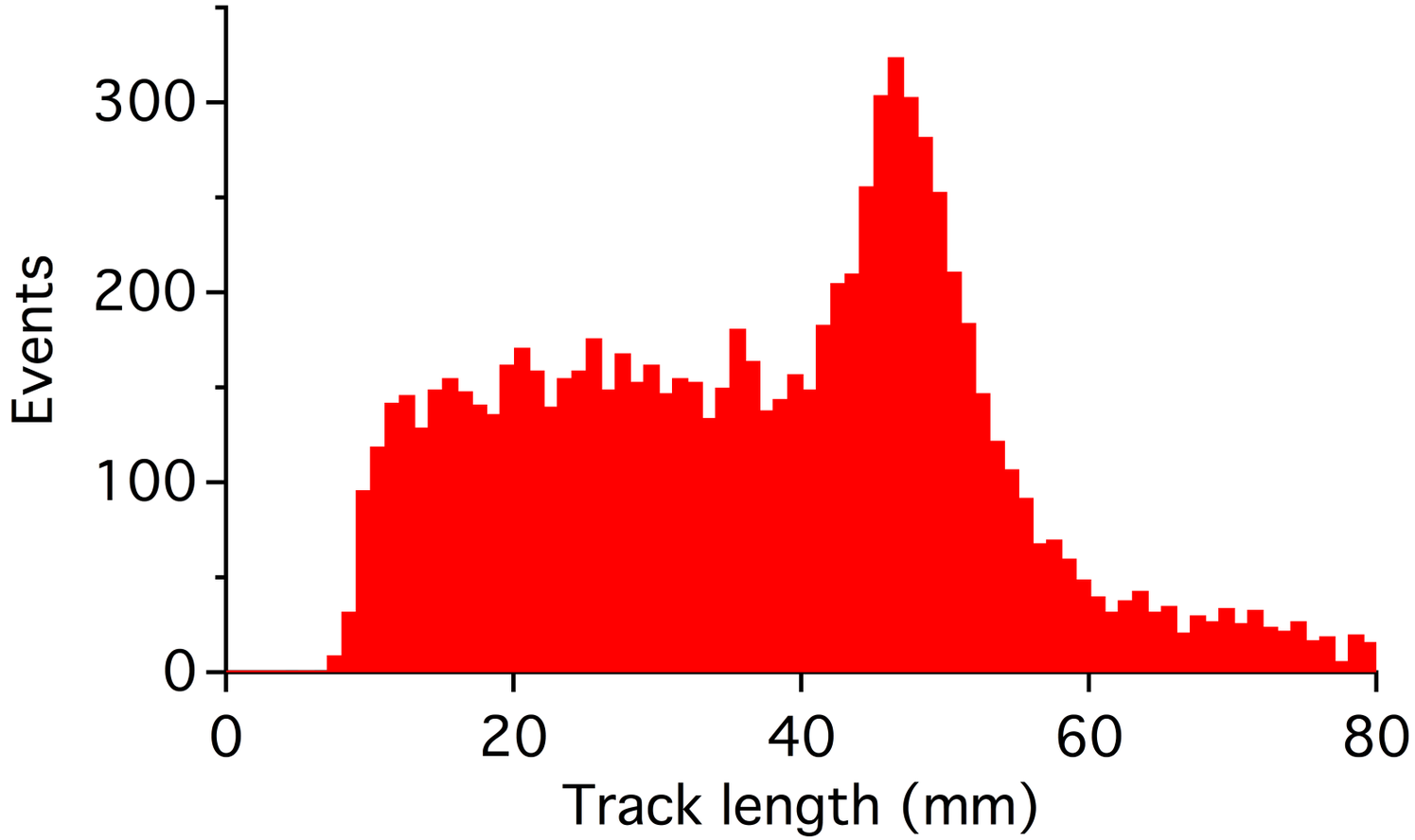








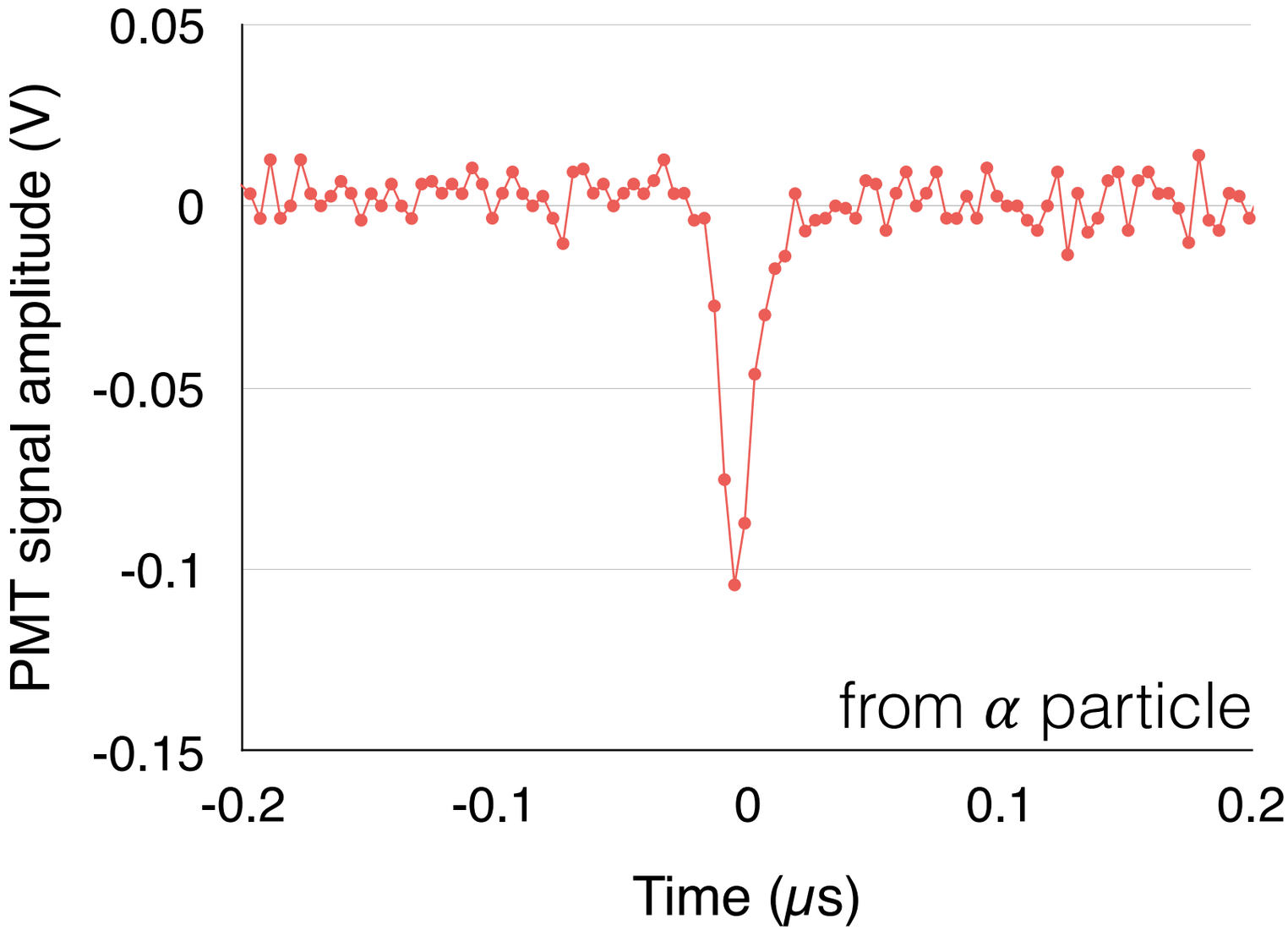
Track length distribution



Partially contained tracks and peak of 6.4 MeV (Rn) and 6.9 MeV (Po) α tracks

45 mm track length of 6.4 MeV alpha particles in agreement with Geant4 simulation

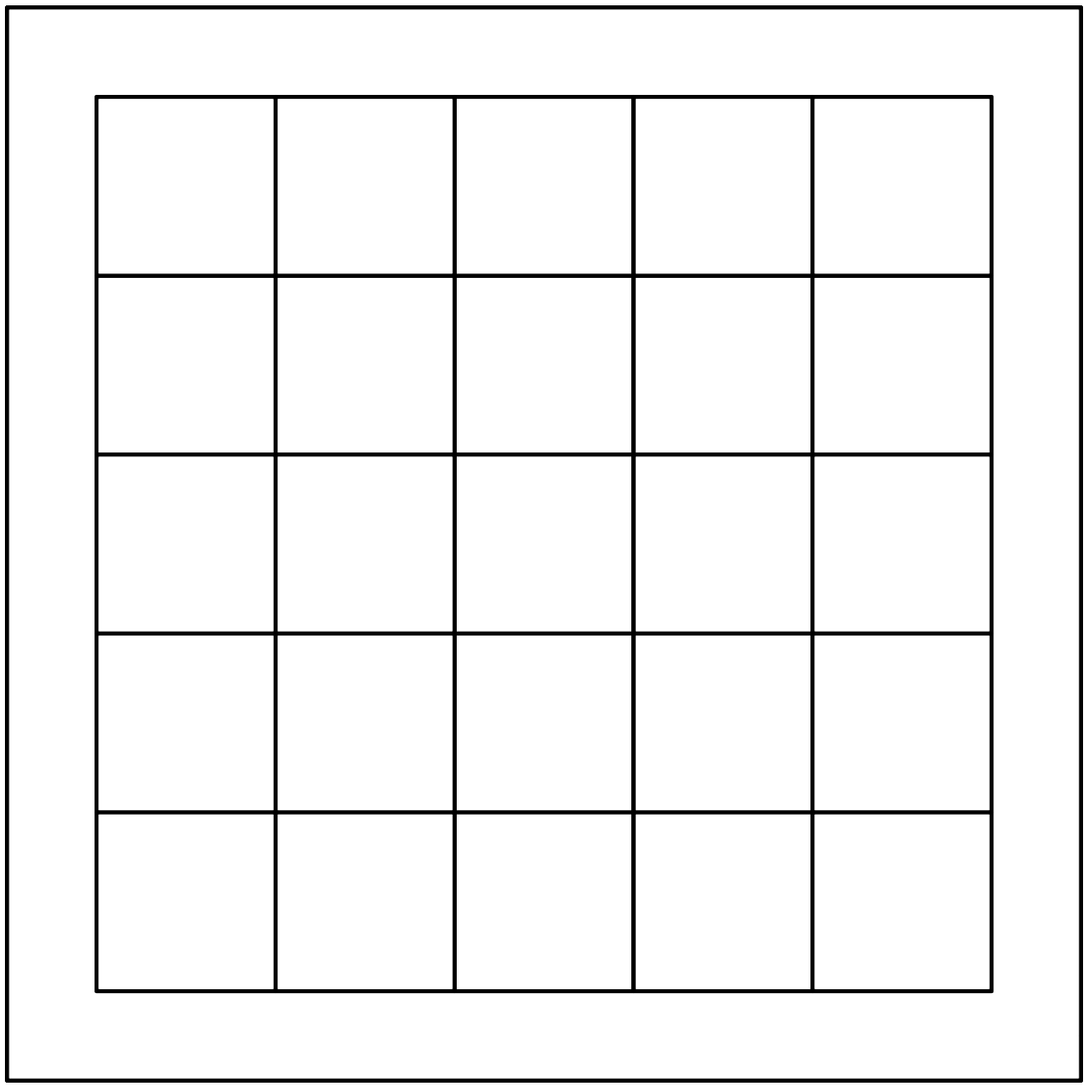
Primary scintillation signals



For studies of primary scintillation dependence on electric fields, pressure and gases

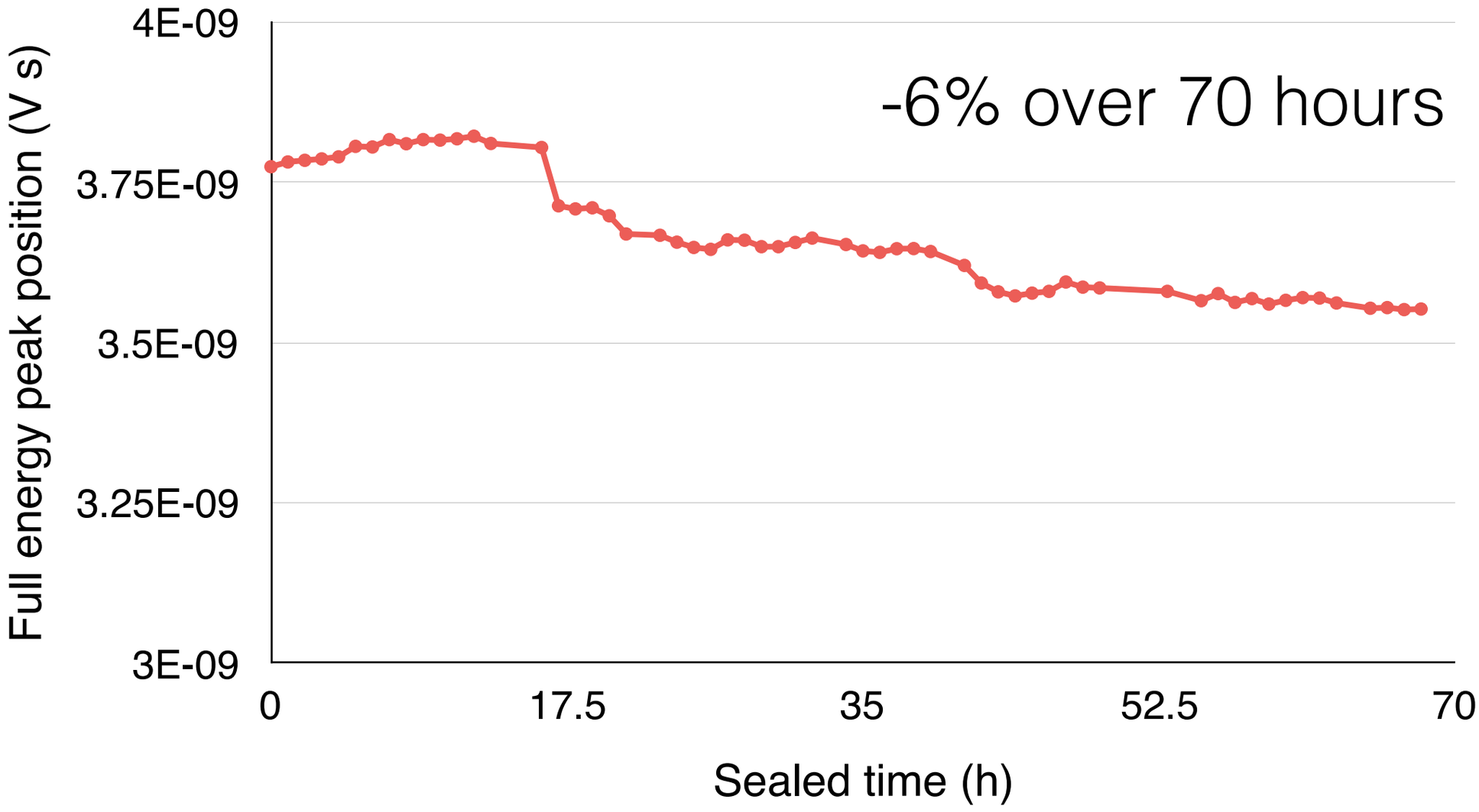
Outlook

Transparent anodes



Electronically read out ITO-based pad-anode for z-coordinates combined with x-y projection from CCD image

Sealed mode operation



Drift field 100 V/cm

Obtained by full energy peak fit of ^{55}Fe spectra from PMT

Future work

High P

- Improved containment
- Enhanced primary scintillation

Gas

- Studying light yield of different gases and mixtures
- Scintillation in sealed mode

Hz

- Increase event reconstruction and display rate by improved algorithms and communication

Summary

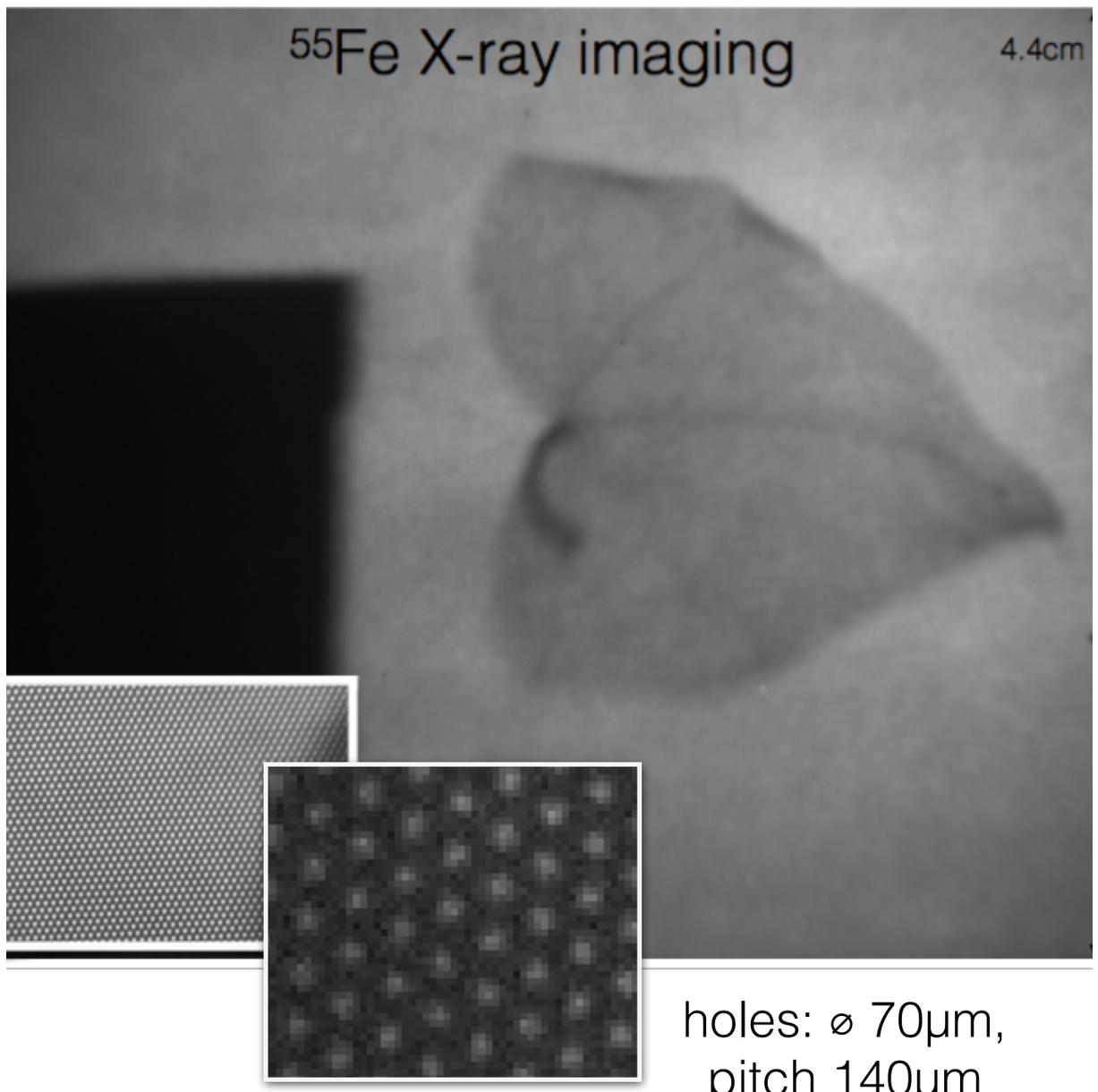
- 3D reconstructed α-tracks from primary and secondary scintillation in GEM-based TPC read out by CCD and PMT

- Ionisation profile in PMT waveform and images allows track orientation

- Minor degradation of scintillation intensity allows sealed mode operation of optically read out GEM-based TPC

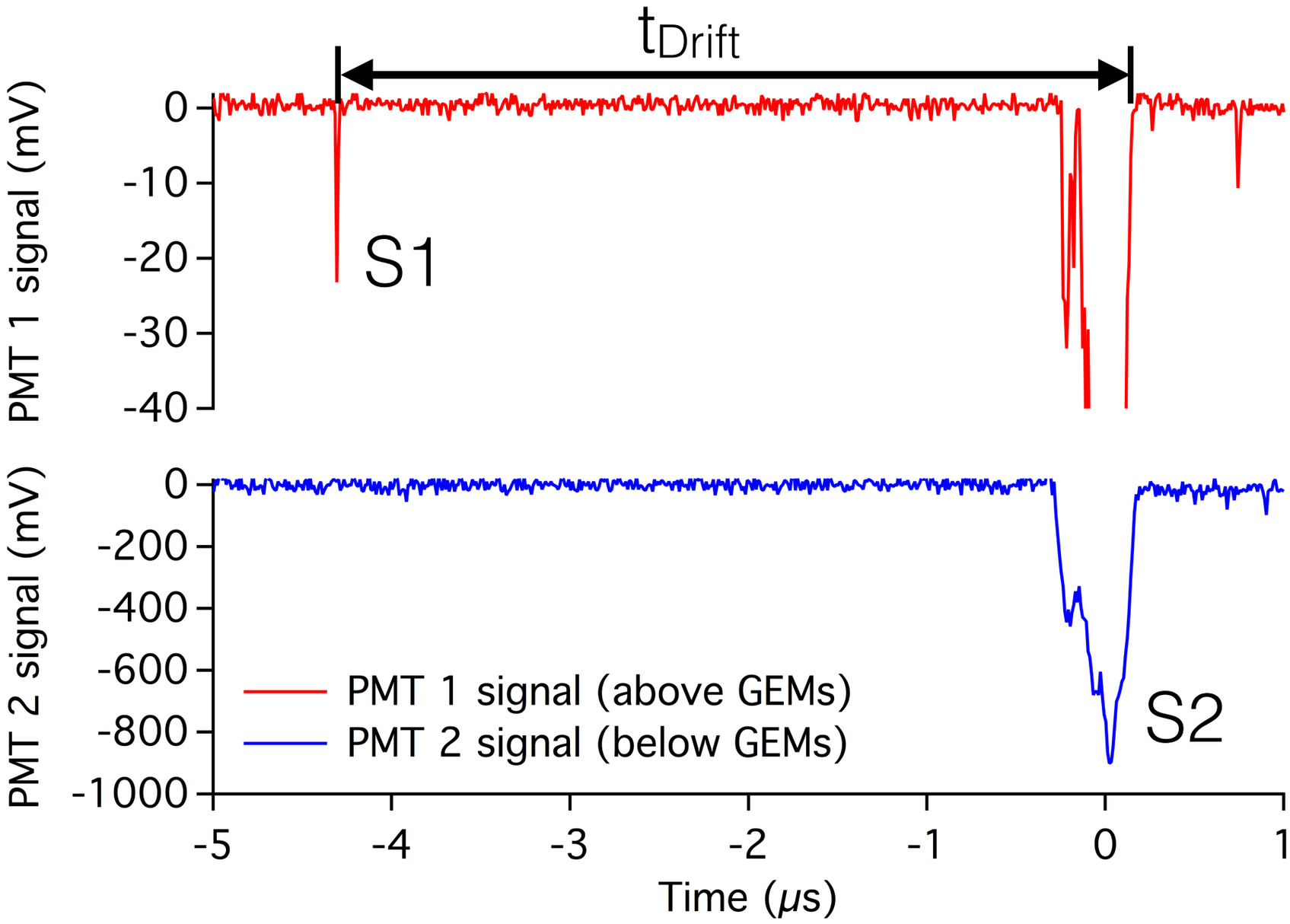
Backup

Imaging



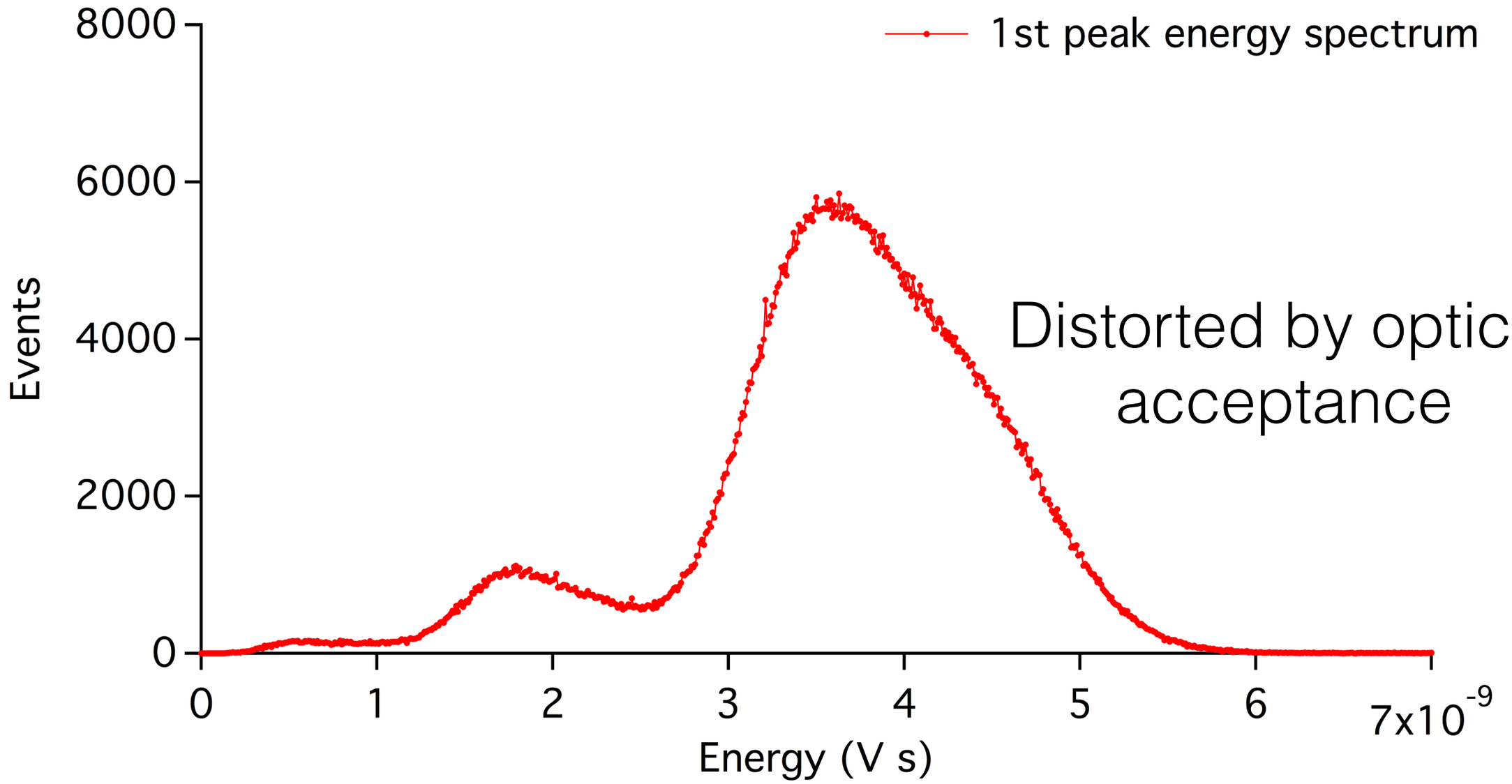
holes: ⌀ 70μm,
pitch 140μm

α signal



Primary (S1) and secondary (S2) scintillation of α-tracks

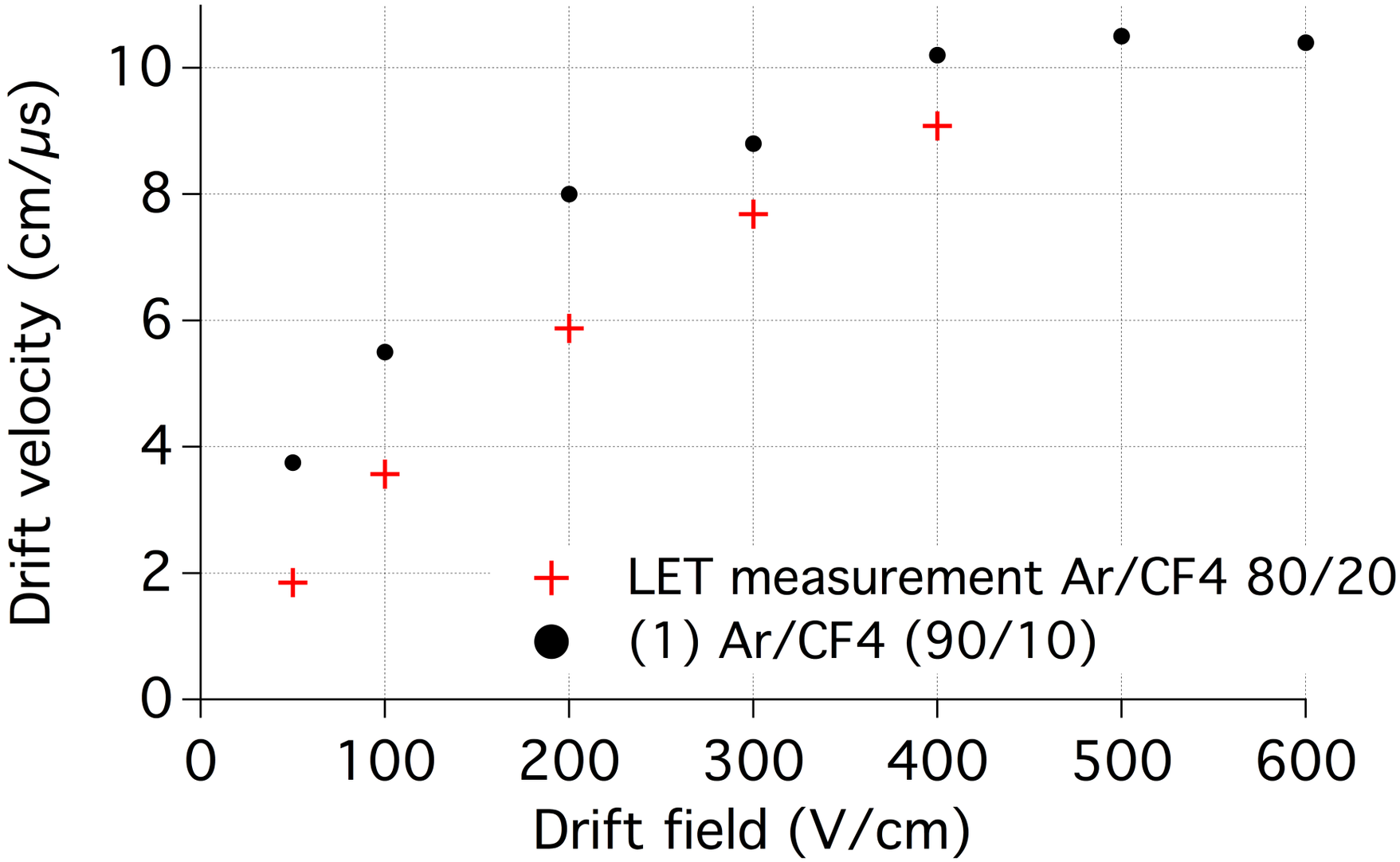
^{55}Fe spectrum



FWHM @ 5.9keV = 39%

Escape peak amplitude 12% of amplitude of full energy peak

Drift velocity



(1) Colas, P. et al. NIM 2002, 478, 215-219.