The GEMPix, a Timepix-based gas detector

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ARDENT

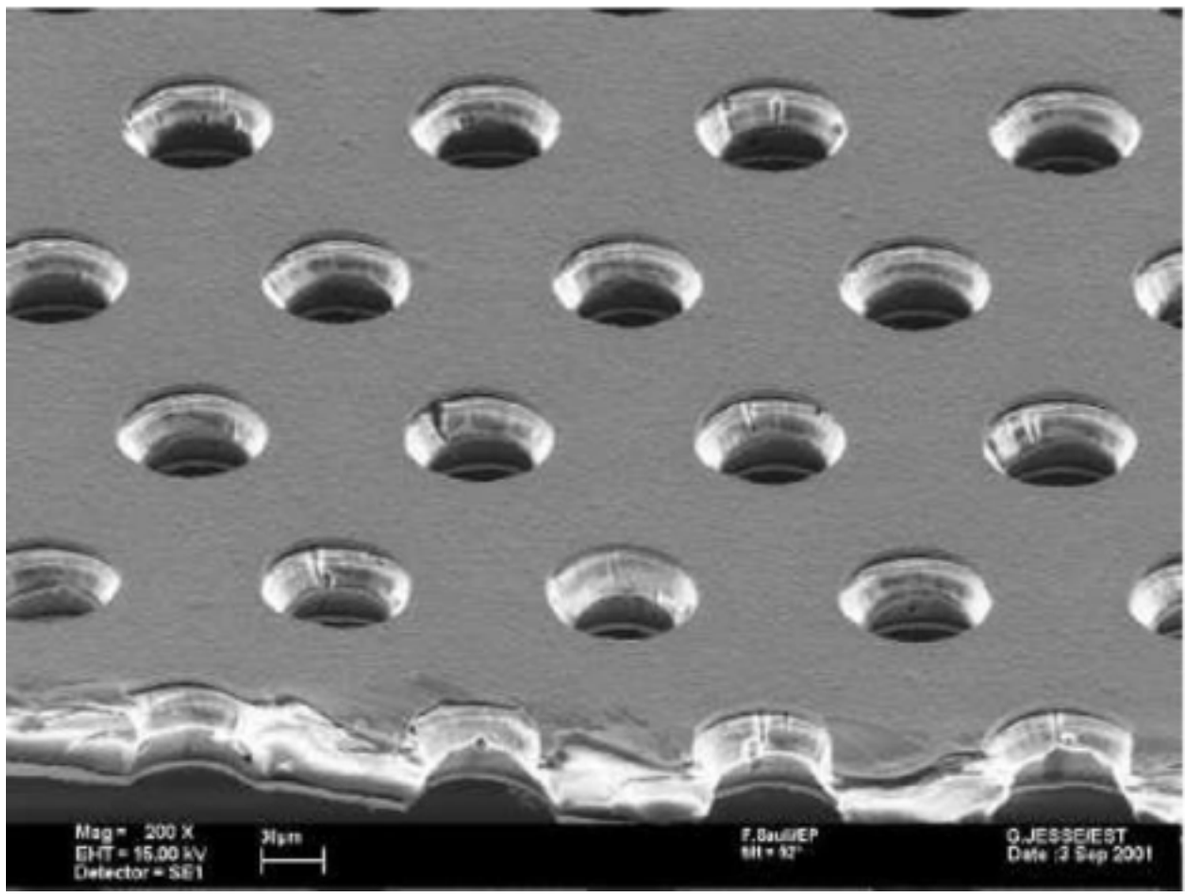
Advanced Radiation Dosimetry European Network Training

The Gempix - Introduction

- The GEM is a micro pattern gas detector, thin holes are etched in a kapton foil and a potential is placed across it

- Very large electric field around the holes which creates an electron avalanche

- Couple a timepix asic for readout of a triple Gas Electron Multipler (GEM) detector



CERN GDD Group (http://gdd.web.cern.ch/GDD/)

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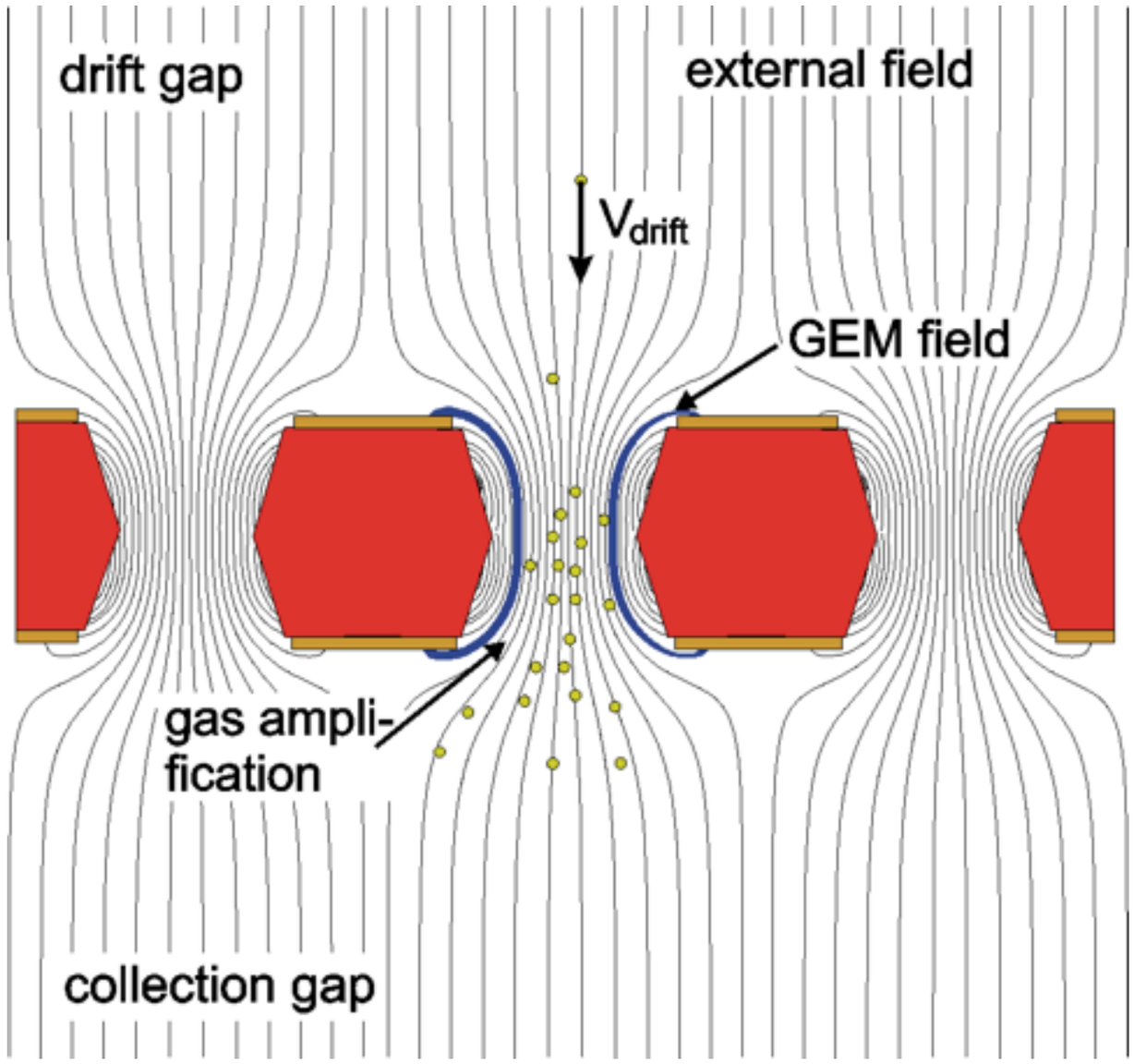

Ziegler and Straumann, Development of a triple GEM detector for particle tracking, IEEE NSS Conference Record 2005, Vol 2

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Quad Timepix ASIC

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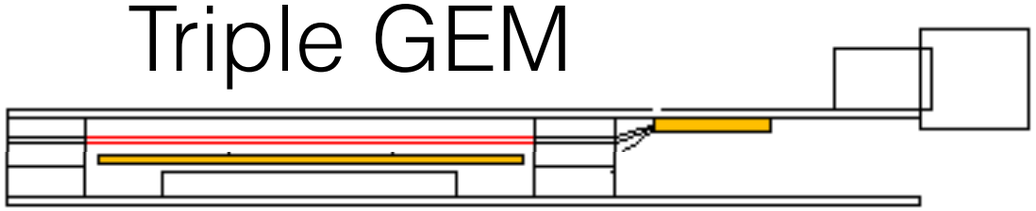
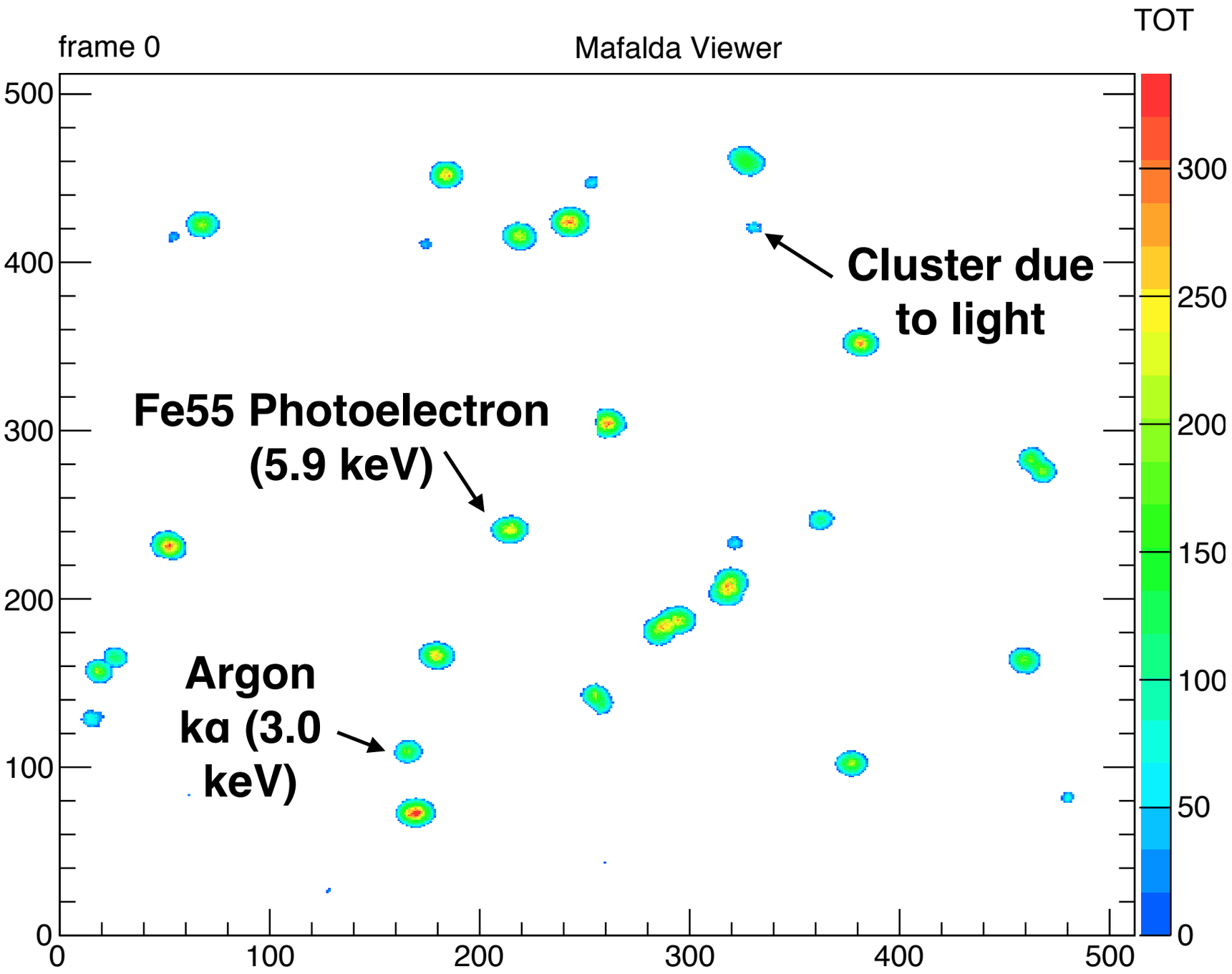
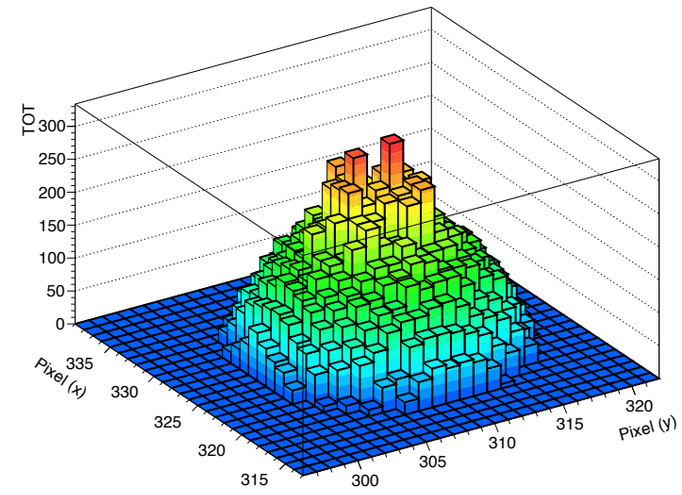
Triple GEM

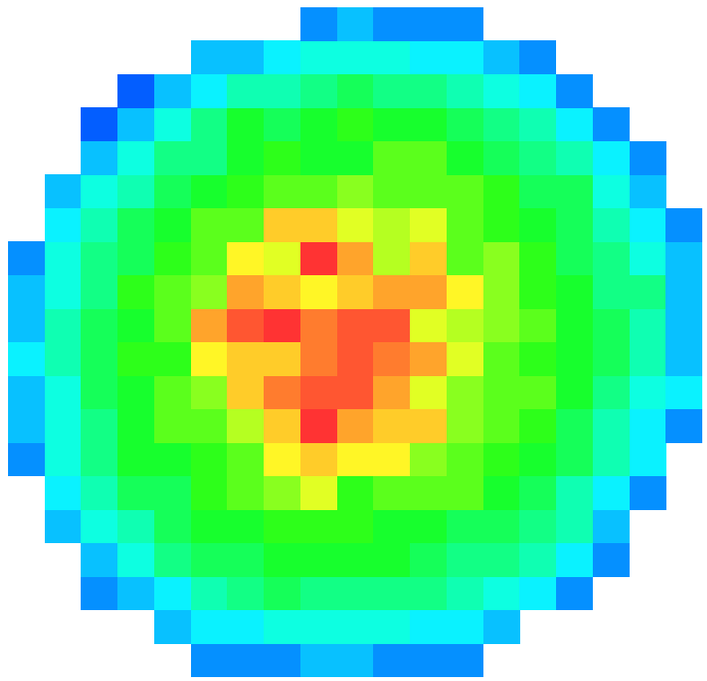


Quad Timepix ASIC

Typical Frame - Fe55



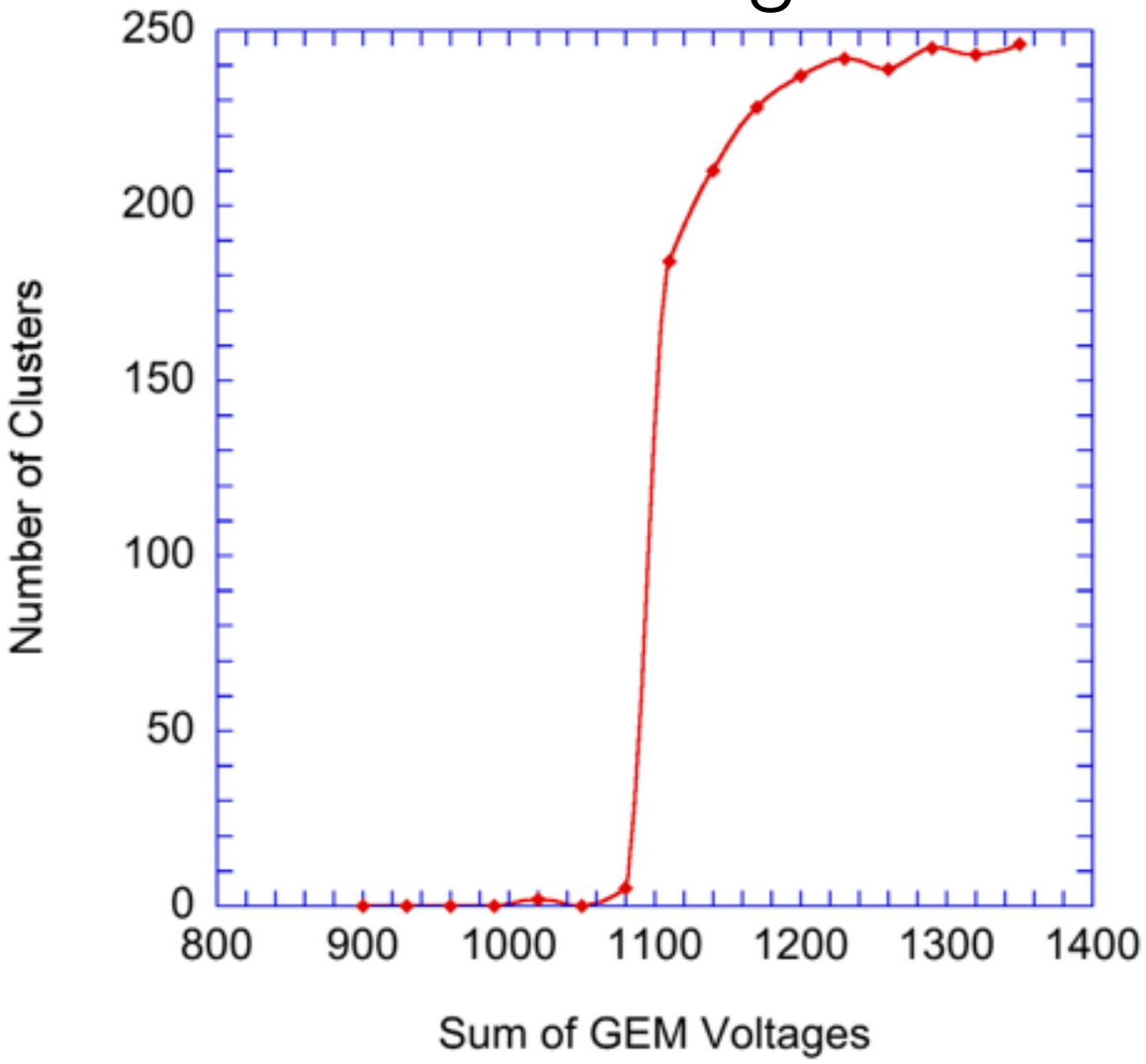




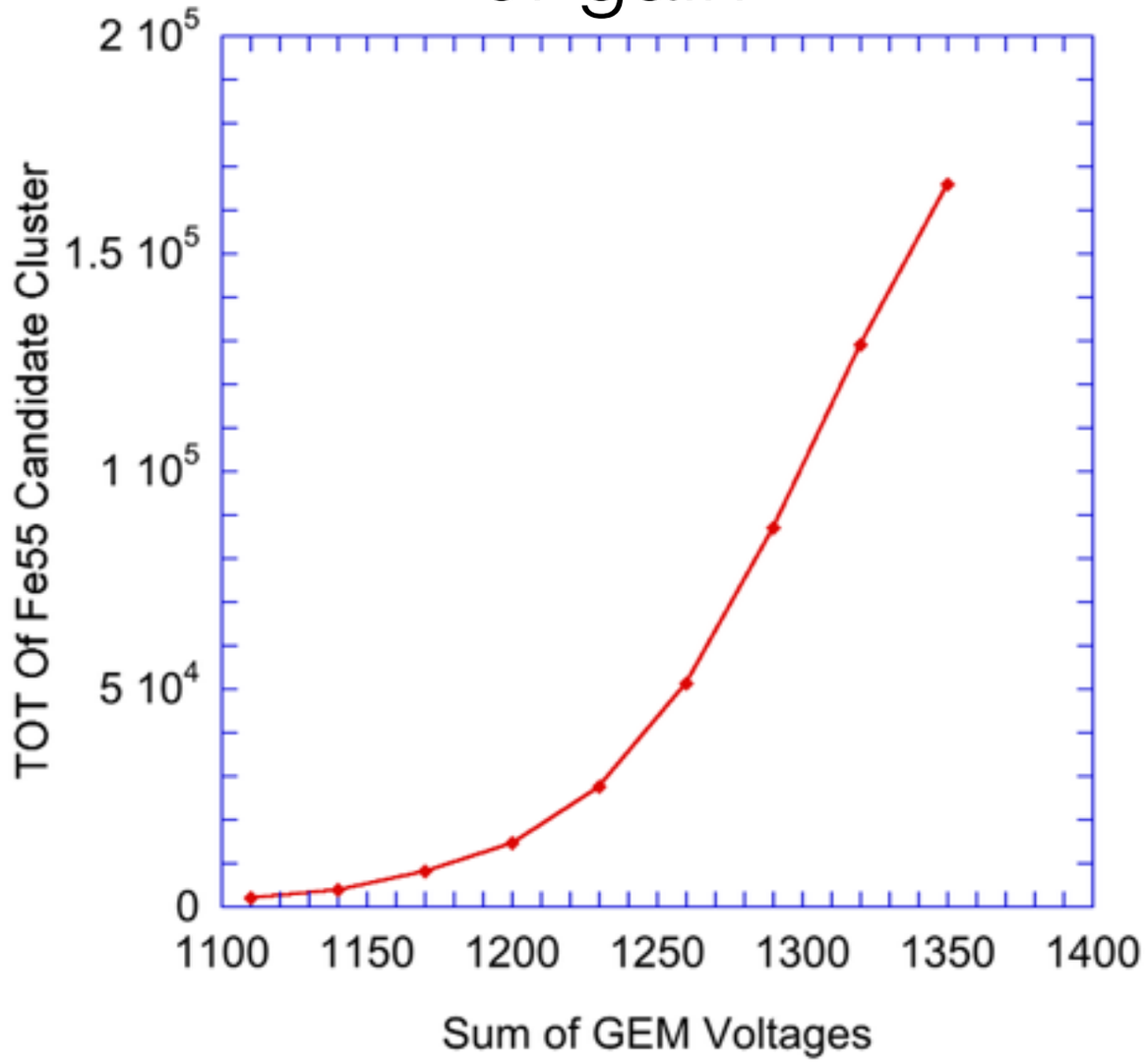
2.5 × 10^4 TOT
(9.6 Mhz)

Gain Scan with Fe55

Number of Clusters as a function of gain

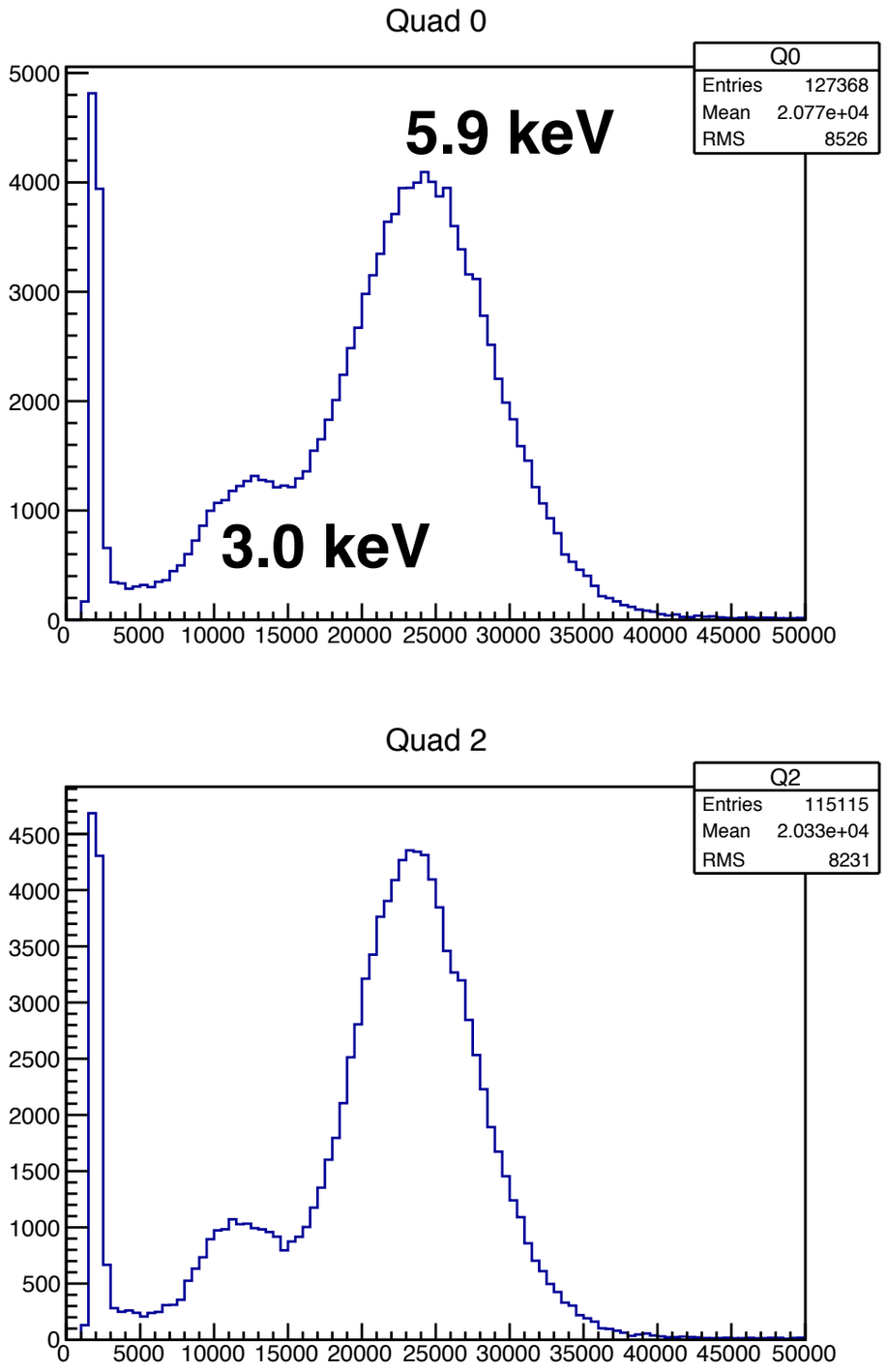


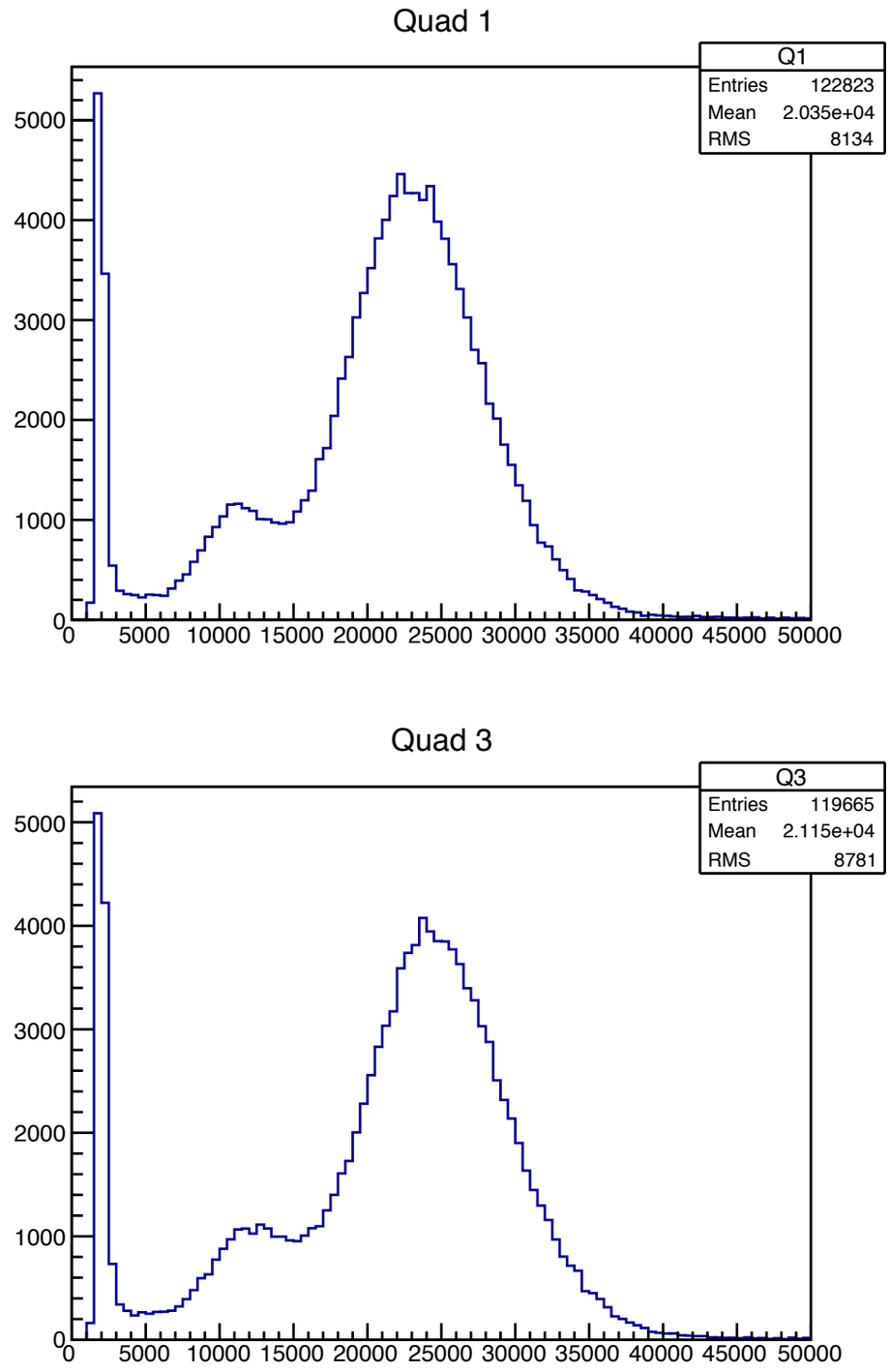
Cluster TOT as a function of gain



Working point at 1230 V

Spectral Features - Fe55

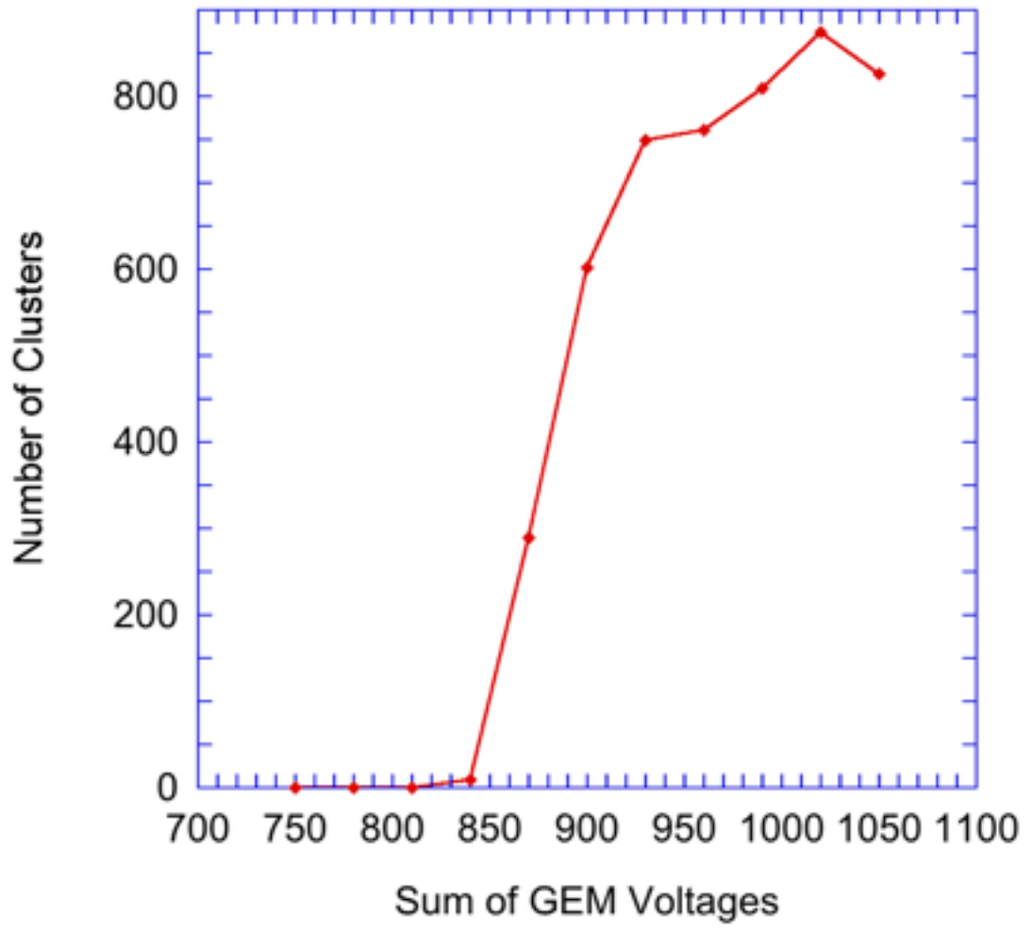




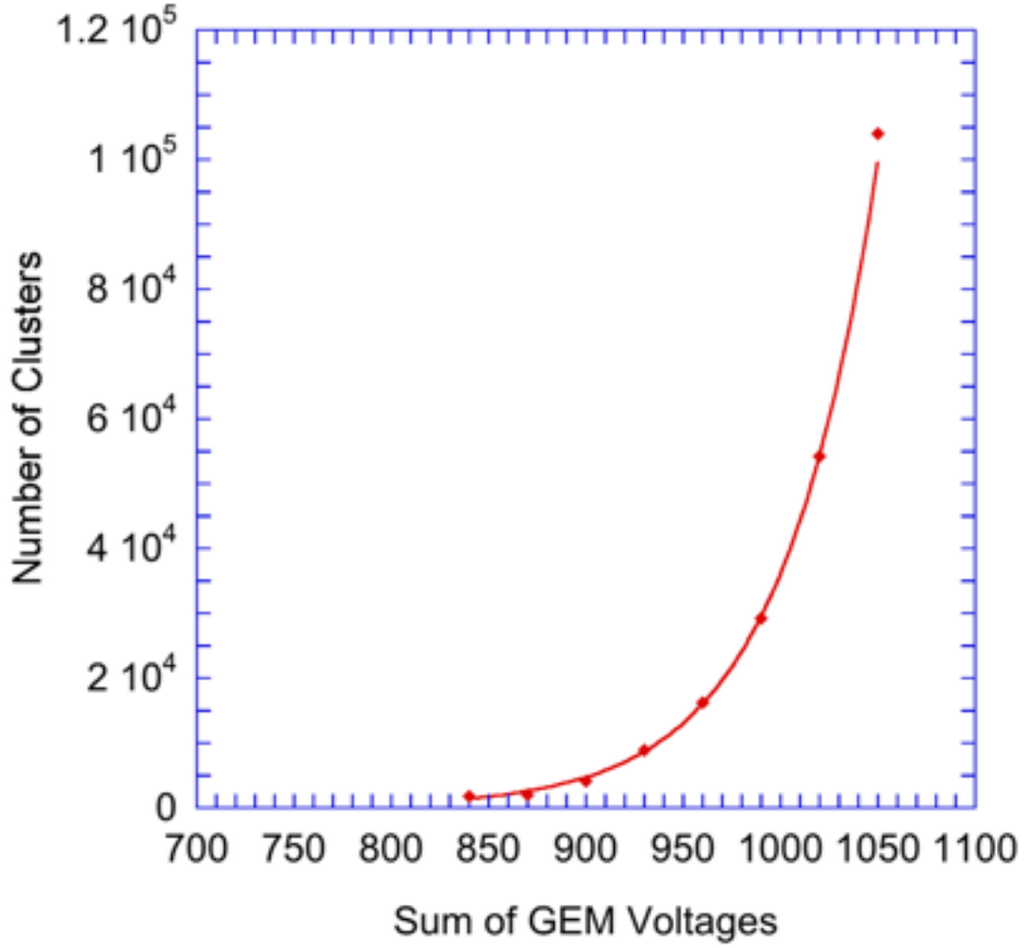
A (very) naive calibration gives an energy resolution of 2.3 keV at 6 keV

Alpha Particles (~6 MeV Am241)

Number of Clusters as a function of gain

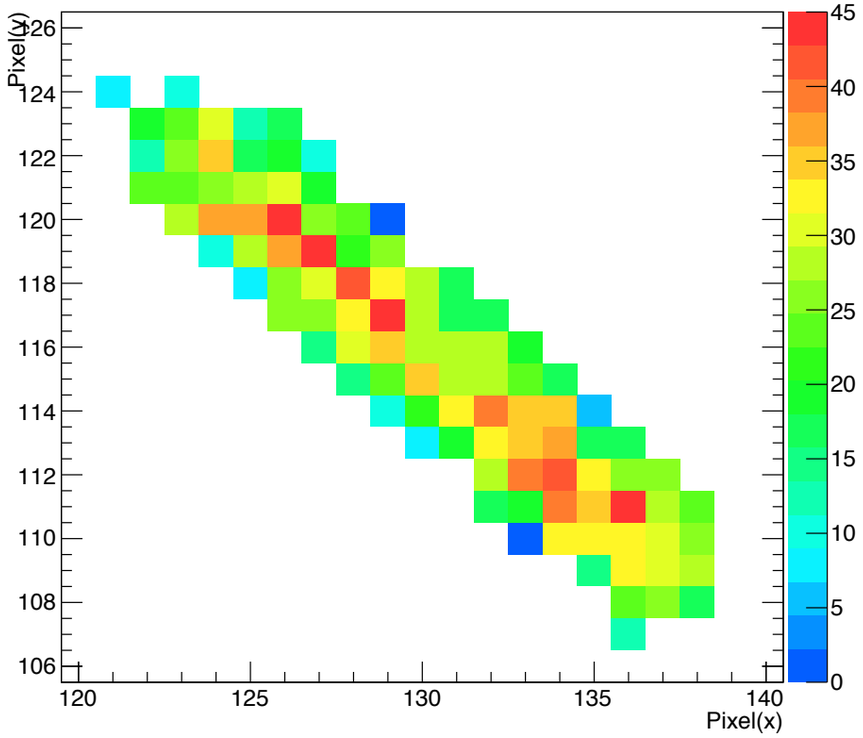


Cluster TOT as a function of gain



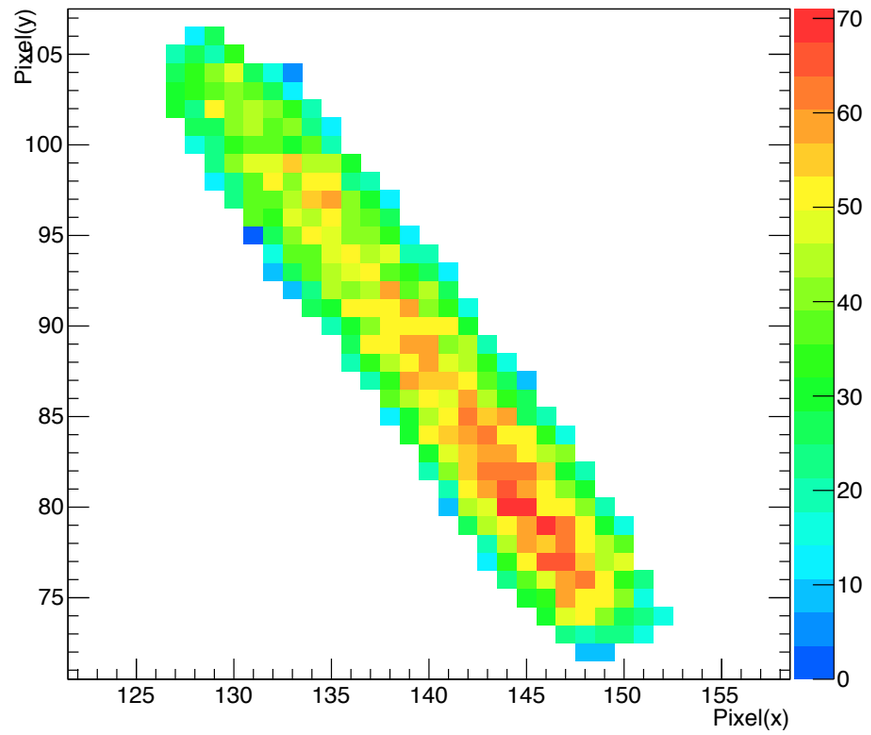
Working point at Gain ~950V, compare with 1230V for Fe55

870 V



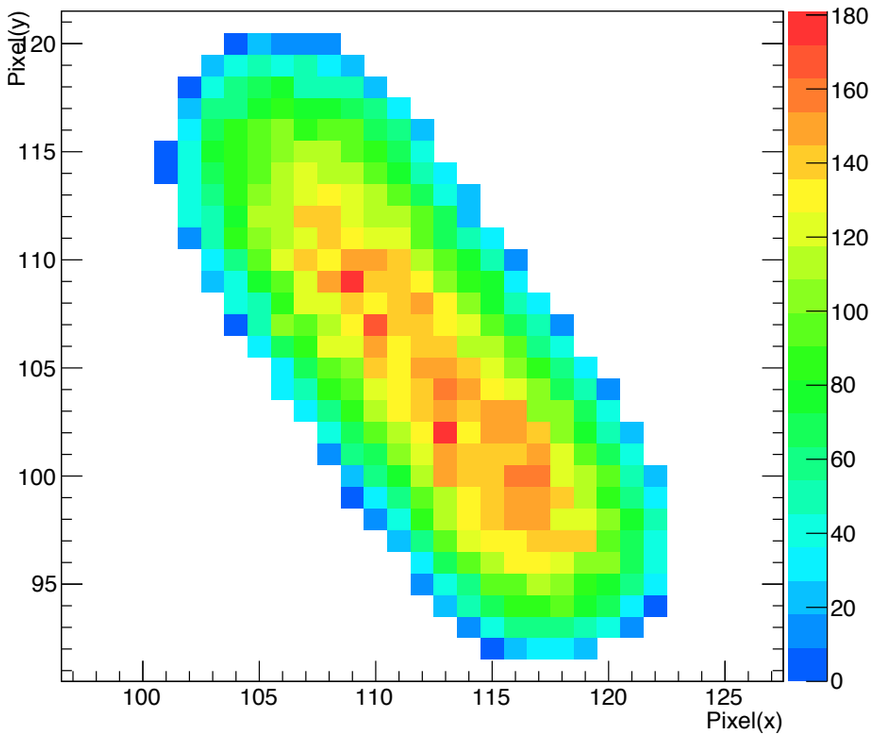
Length ~ 1 mm, vol ~70 px

930 V



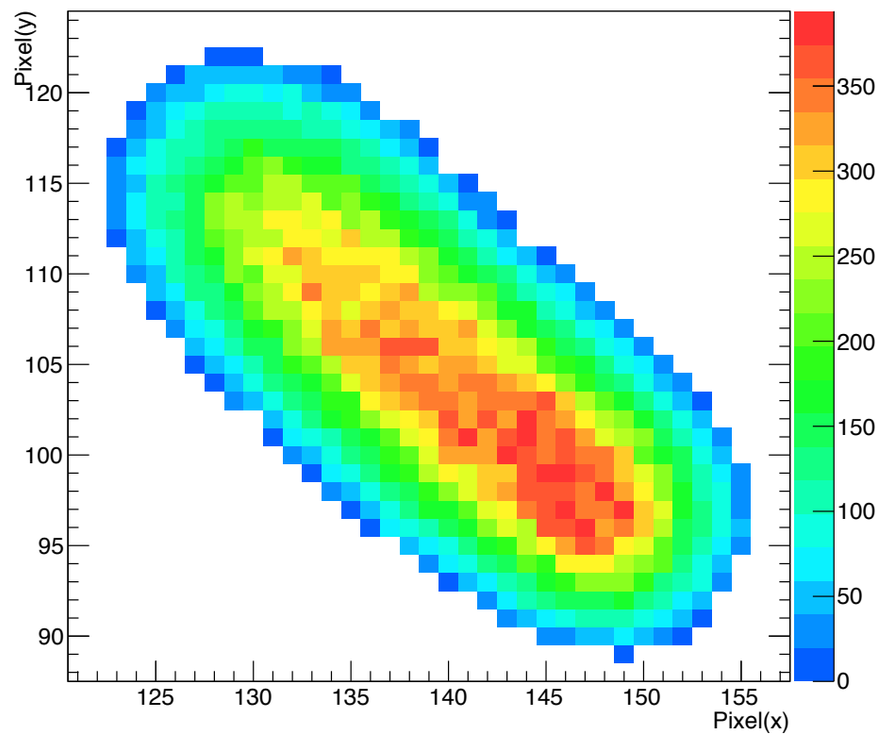
Length ~ 1.7 mm, vol ~200 px

990 V



Length ~ 1.8 mm, vol ~350 px

1050 V



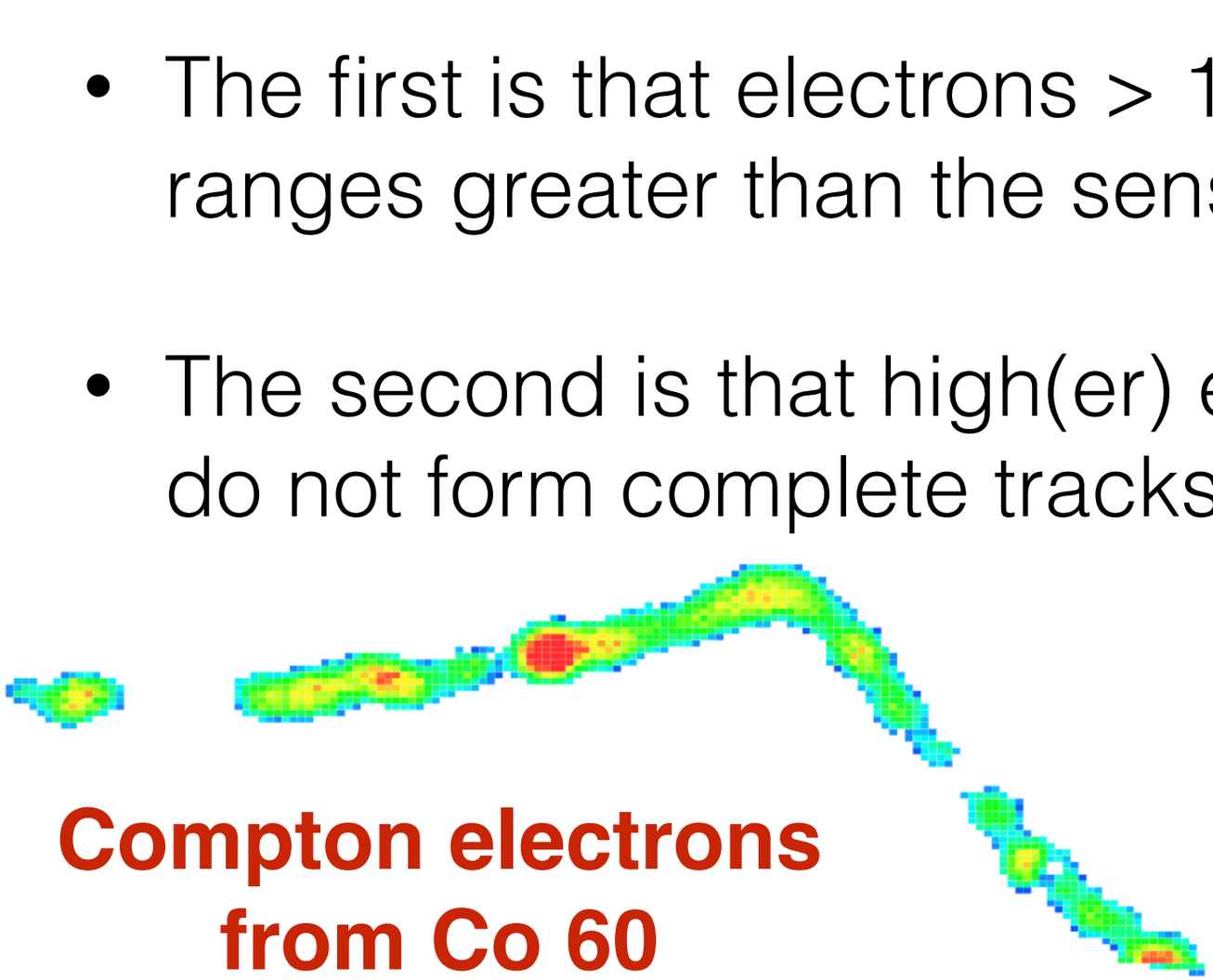
Length ~ 1.9 mm, vol ~600 px

Higher Energy Electrons

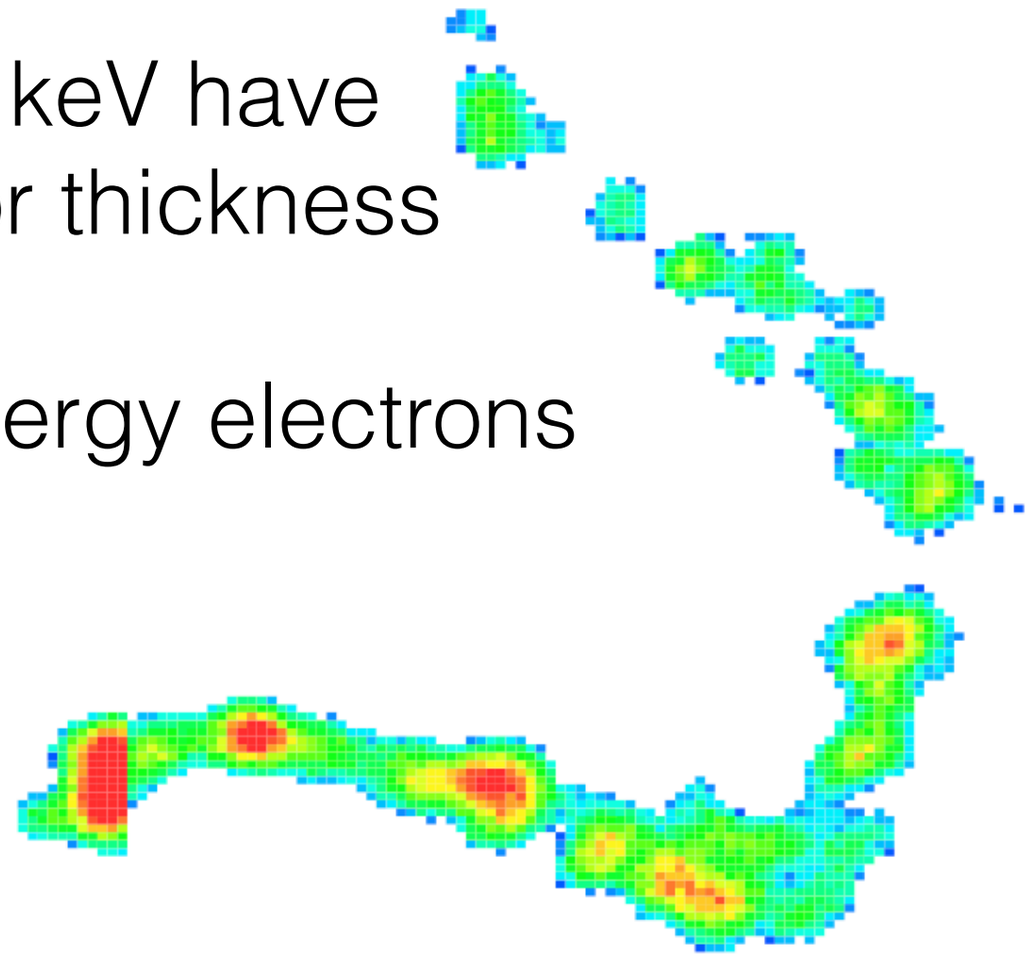
- Higher energy photons suffer a poor energy resolution because of two issues.

- The first is that electrons > 10 keV have ranges greater than the sensor thickness

- The second is that high(er) energy electrons do not form complete tracks



Compton electrons from Co 60



Time Based Clustering

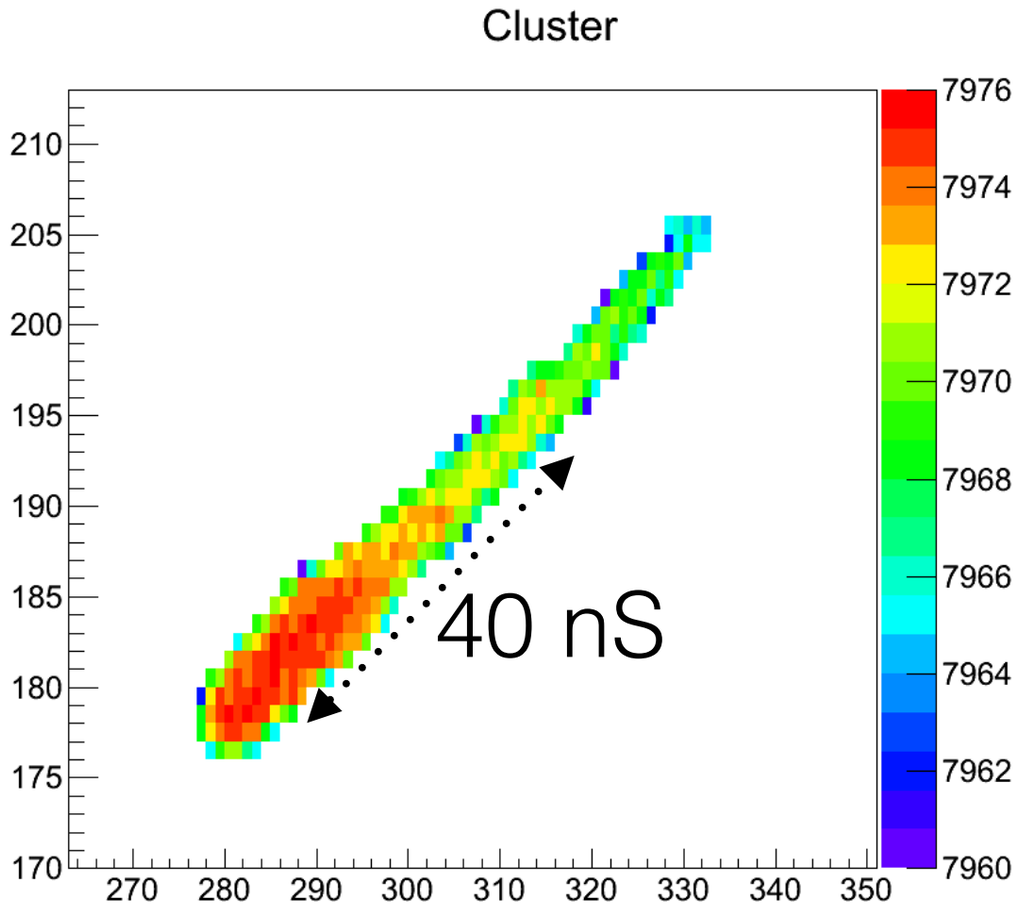
- Geometrical clustering
- Load mode mask, and average time pixels to get a TOA value
- Reconstruct TOT in TOA clusters based on weighted average of nearest neighbours (needs validation)
- Gather clusters with similar time values into a “Track” object

Time Based Z Reconstruction

- The gas drift time is long in comparison to the particle traversal time.

- We want to use the timepix in mixed mode to measure the drift time and construct the Z coordinate.

- The main issue is the timewalk effect



96 Mhz, IKrum = 1
Timepix Mode

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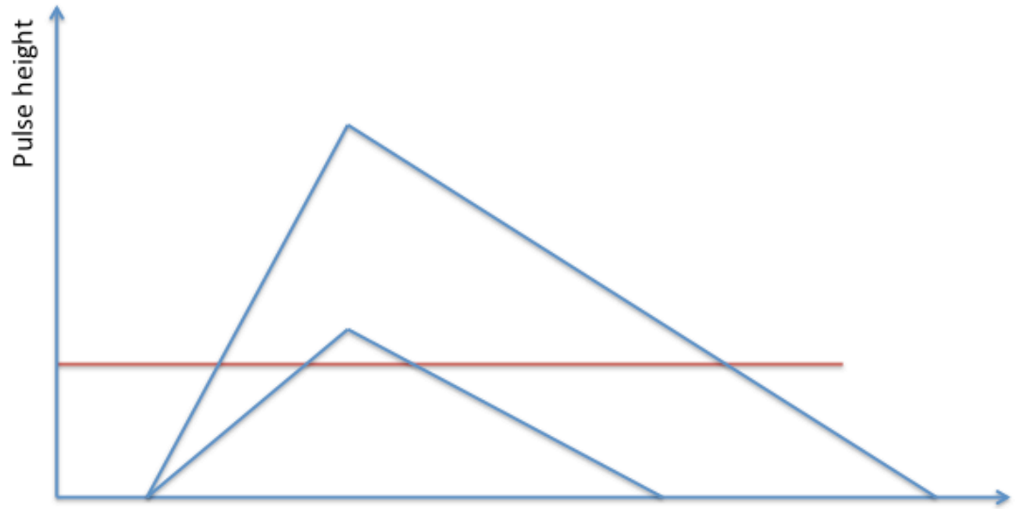
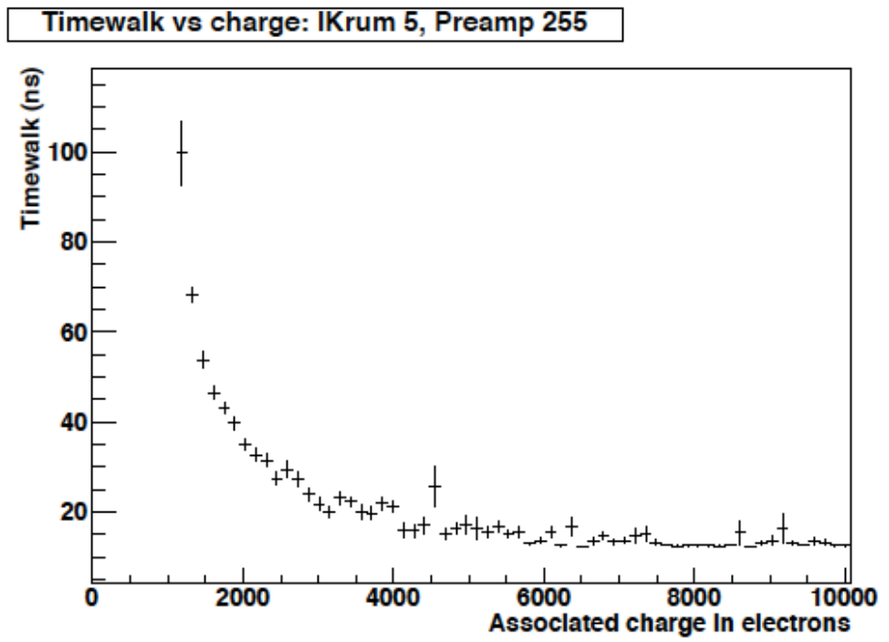
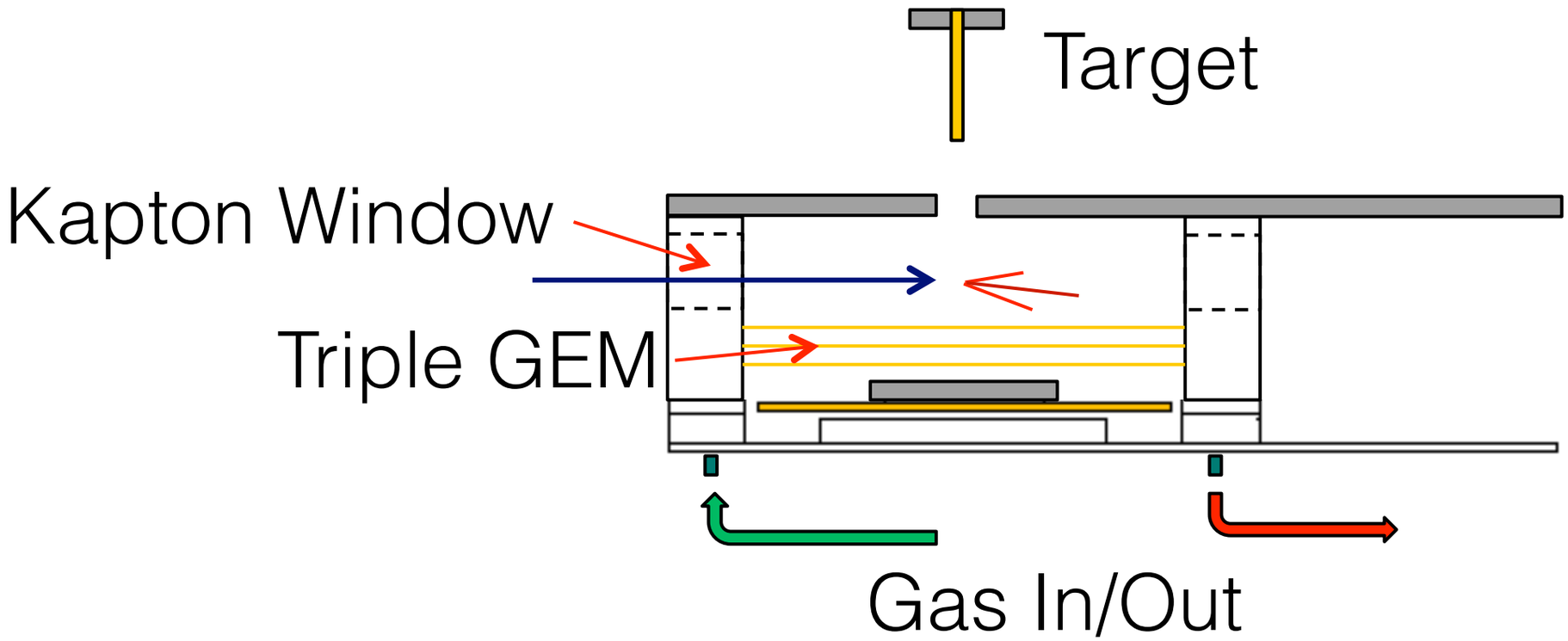




H.Gordon, http://indico.cern.ch/getFile.py/access?contribId=2&resId=0&materialId=slides&confId=174865

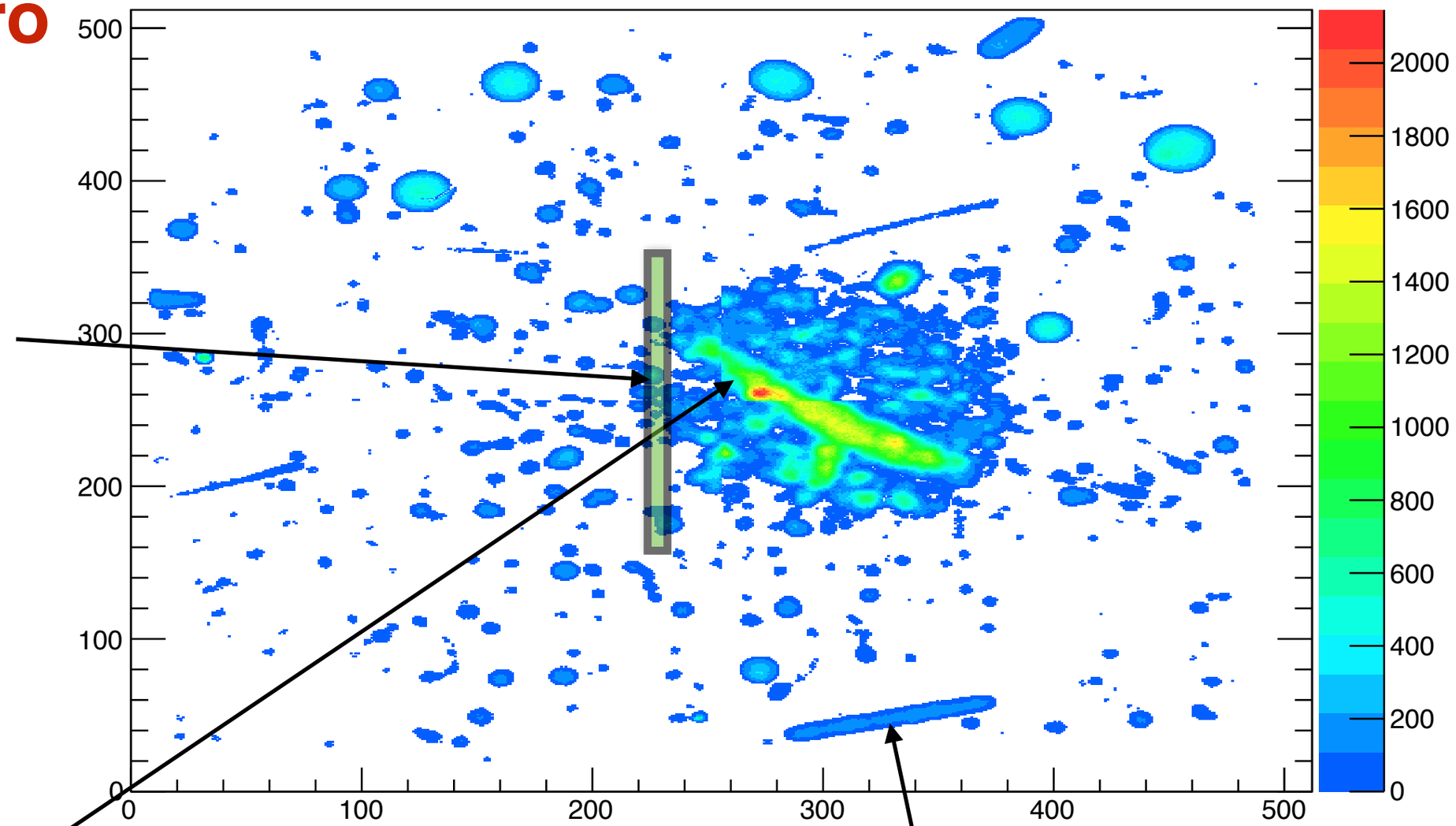
Towards Microdosimitery

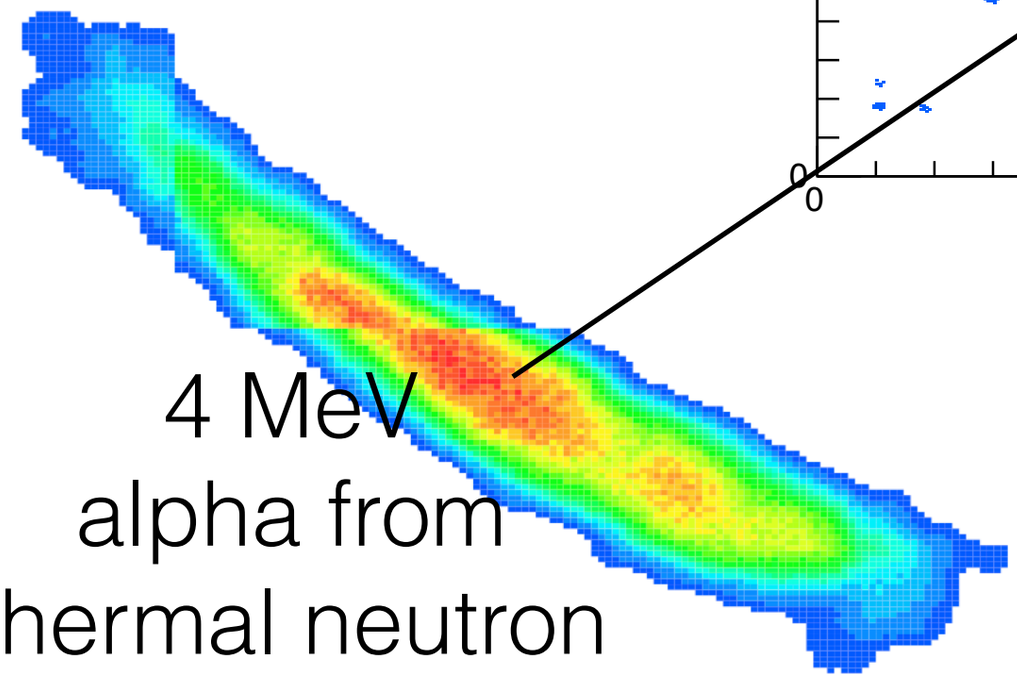
- A microdosimiter measures energy transfer over a site size of biological interest
- Typically a cellular volume = 1um
- For a propane tissue equivalent gas at STP 1 site ~ 10 pixels
- How do we get a relevant field?



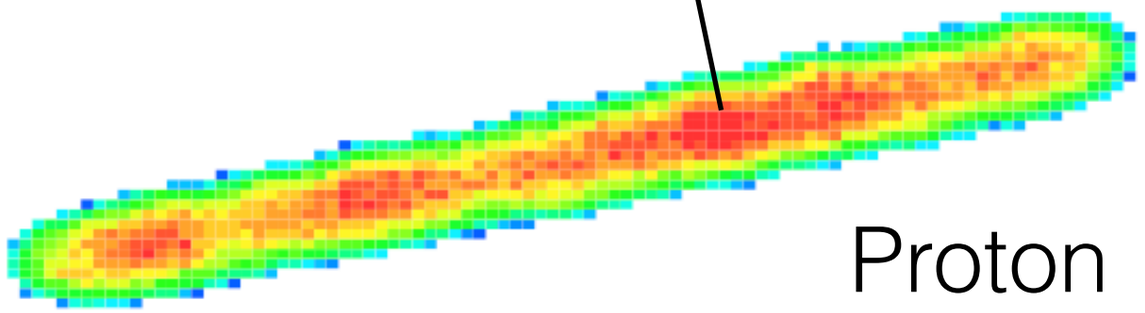
Measurement with mixed neutron field at INFN Legnaro

Enriched Boron 10 Target





4 MeV alpha from thermal neutron capture in target



Proton Candidate

To Do

- Per Pixel test pulse calibration to electrons
- Detailed characterisation with quite a few x-ray fluorescence lines
- Beamtime at CNAO with protons and carbon ions
- 3D Track Reconstruction for TPC configurations
- Microdosimetric spectra (…)

Acknowledgements

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Electrical Field Issues