iThemba Labs Instrumentation School 2023

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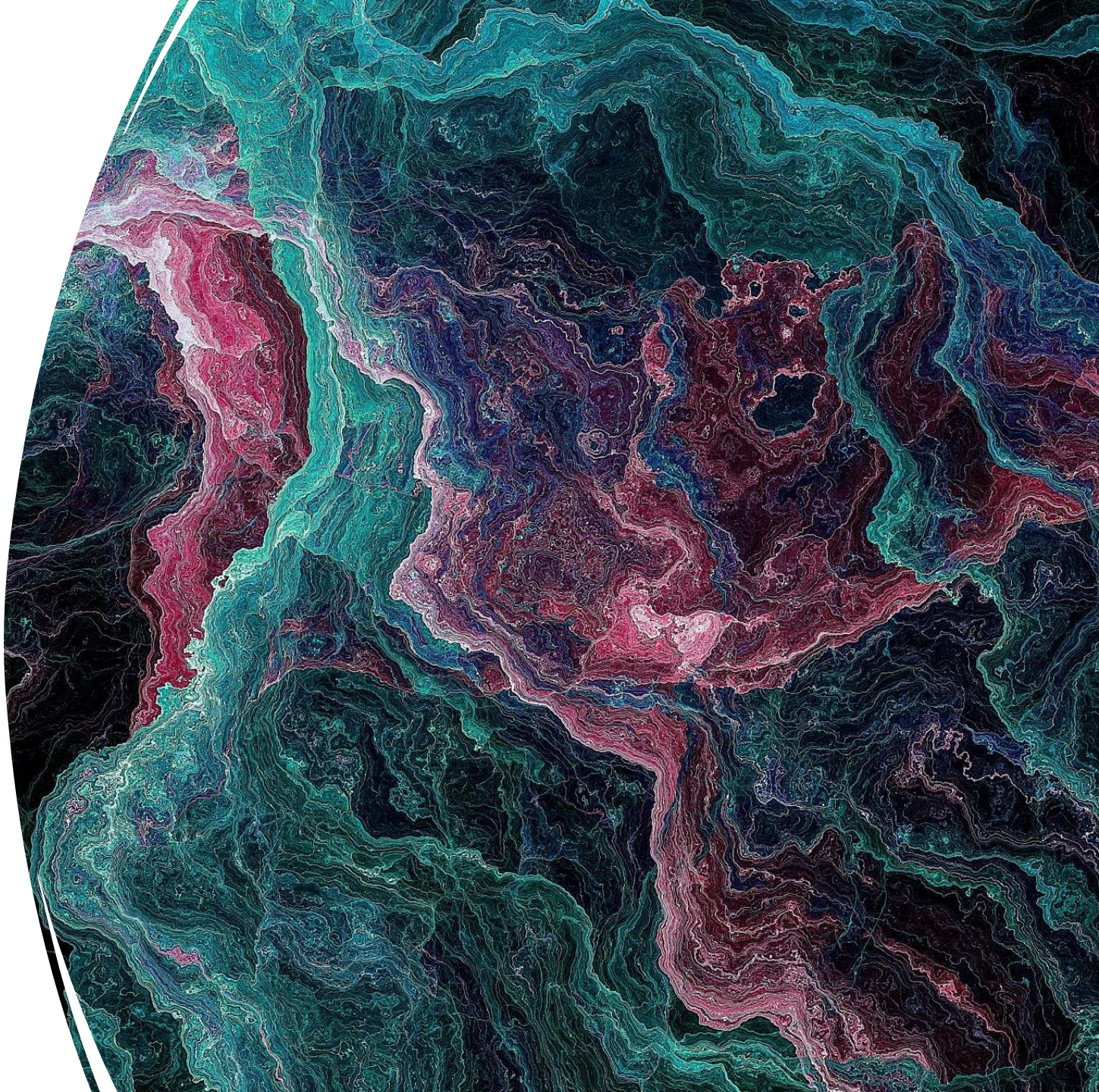
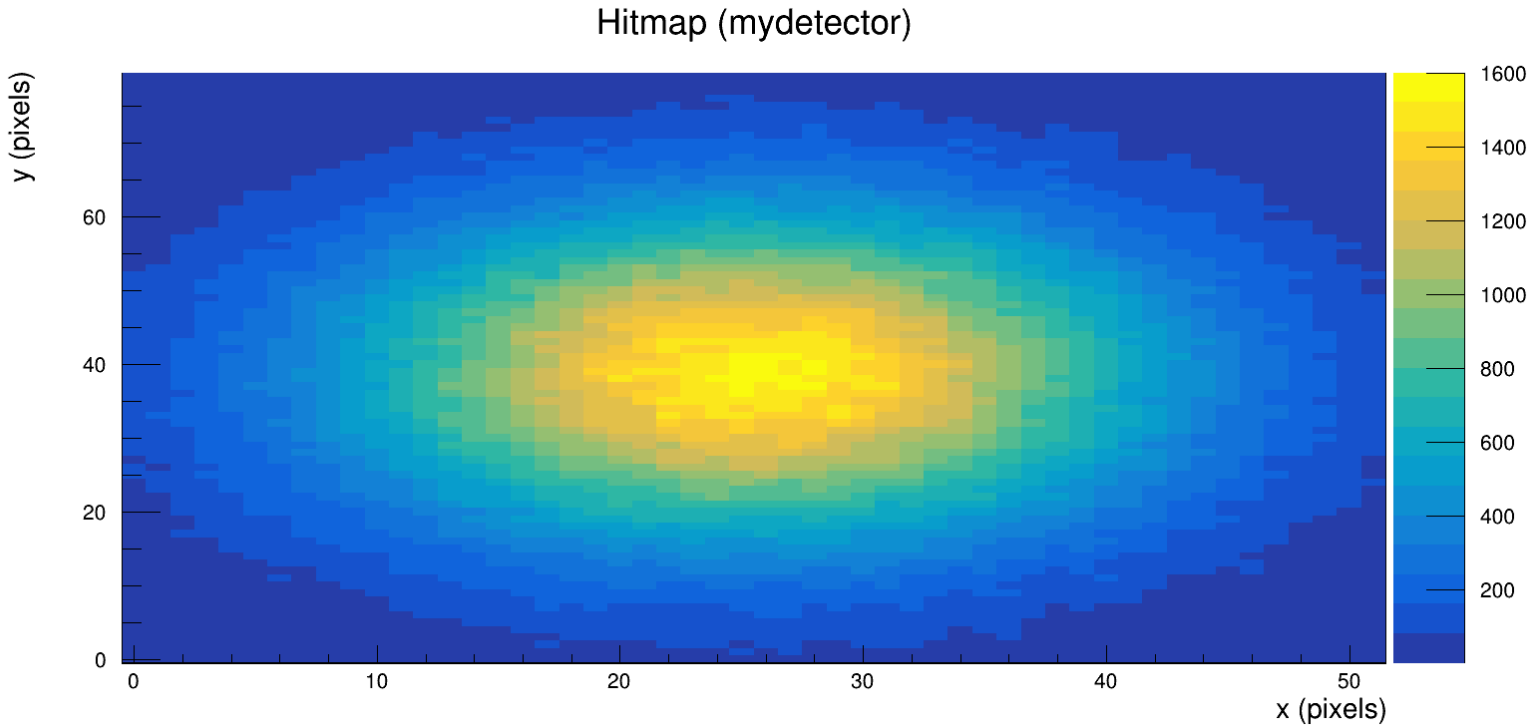
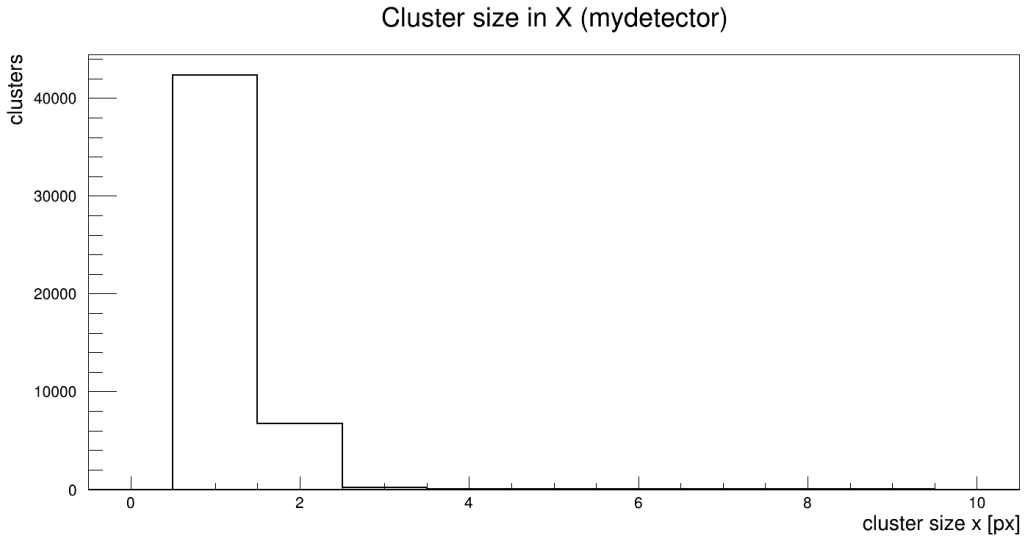


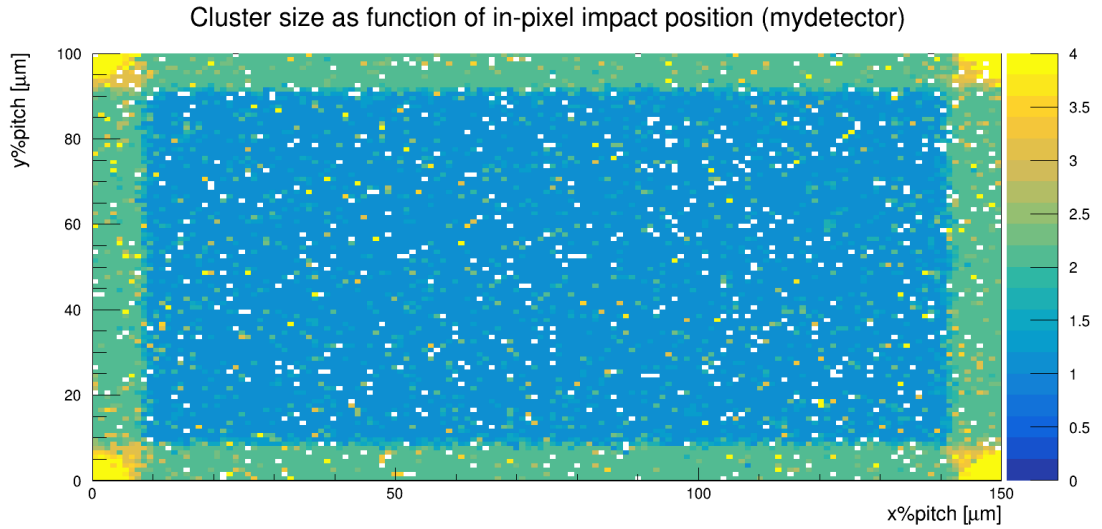
Resolution of a Silicon Pixel Detector

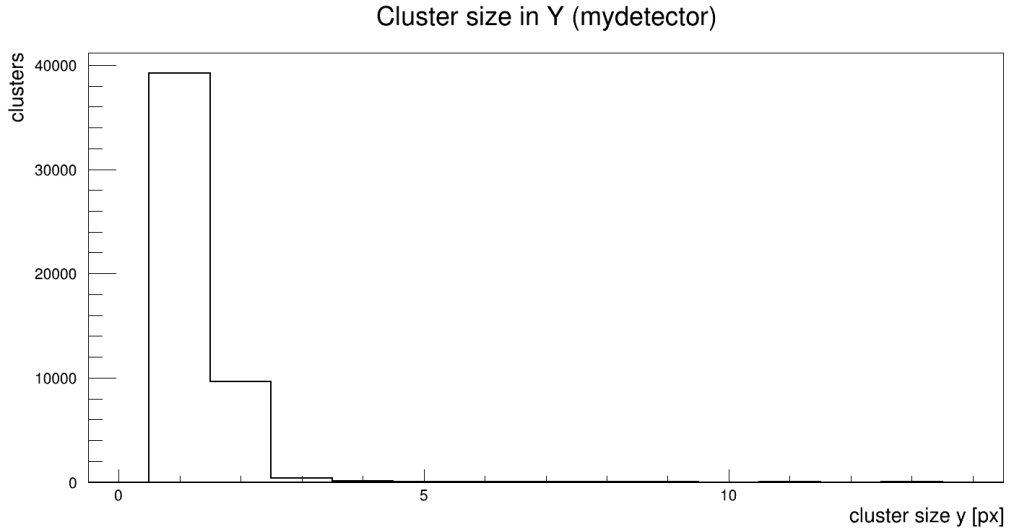


- Incident electron beam, of energy 5 GeV
- Hit map of silicon pixel hits for 500 000 events

Detector incident with electron beam, with no magnetic field applied & no angular rotation

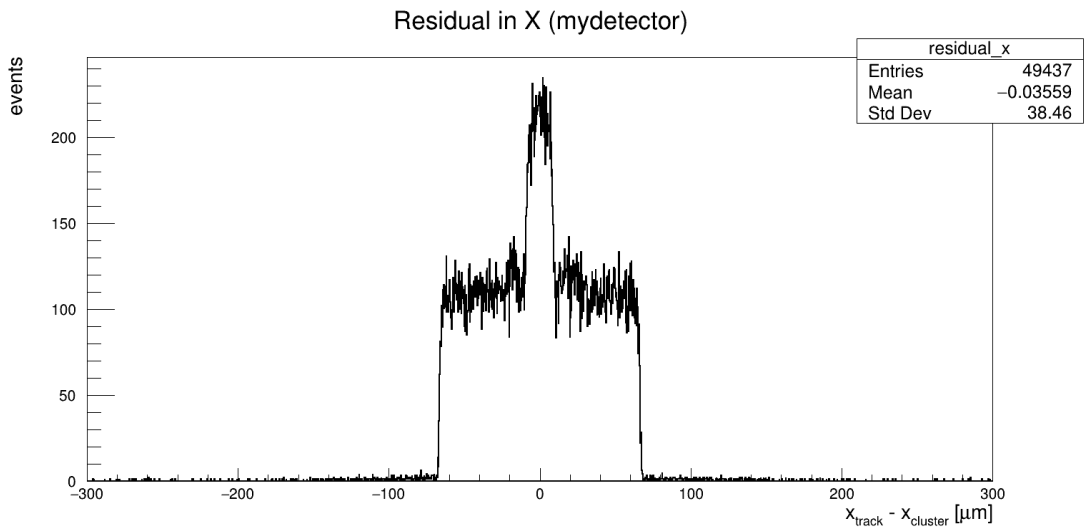


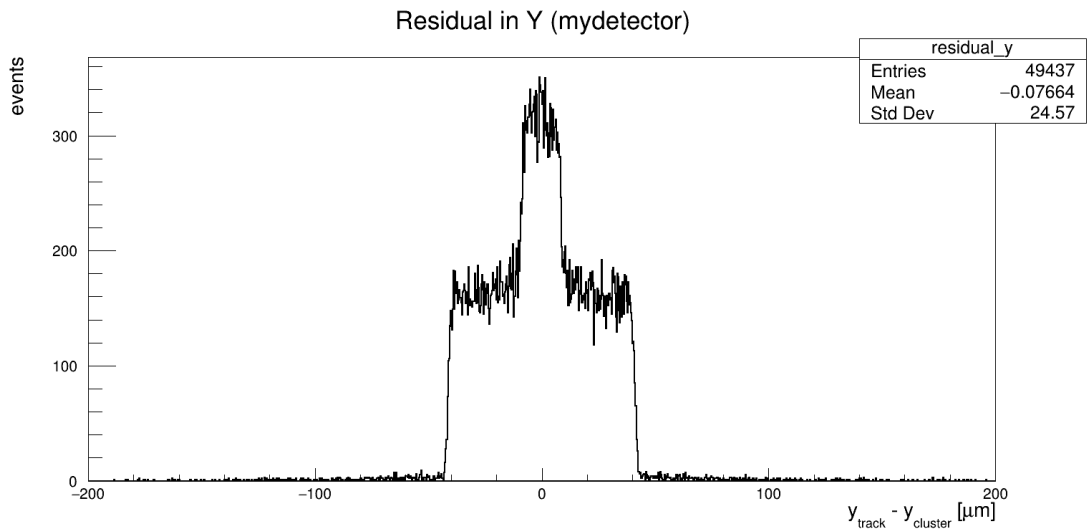




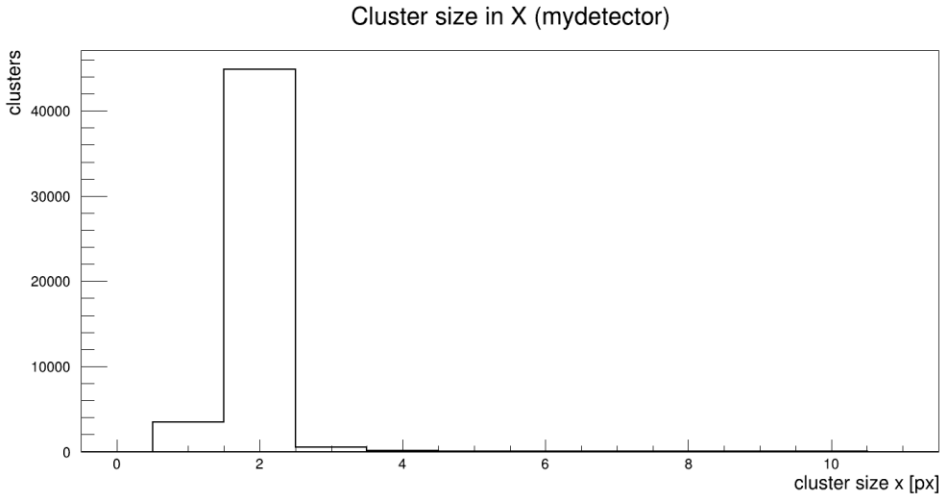
- Majority of hits have a cluster size of 1 pixel, for both X and Y
- Geometrically hits for these parameters show cluster size of 1 in the center of the pixel and 2 – 4 on the edges

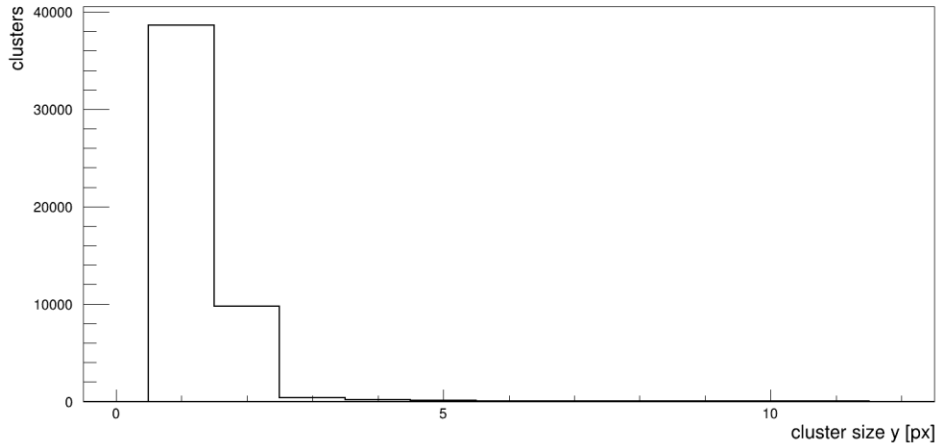
- Residual is given by the difference between the true Monte Carlo position and the reconstructed position from the detector clusters
- Detector resolution is obtained from the RMS of the residuals in each direction, given here by the Std Dev
- This will form as the basis for resolution comparisons to come

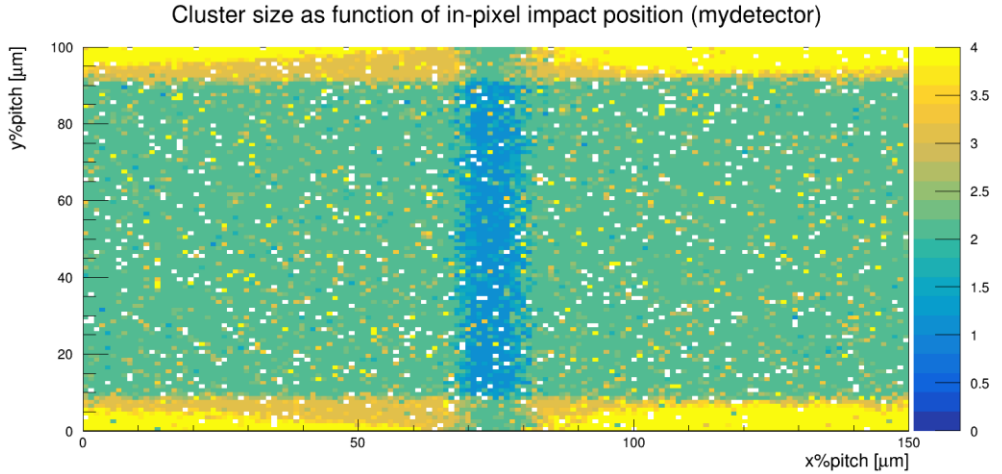




Detector incident with electron beam, with no magnetic field applied & 27-degree rotation of the detector wrt the y-axis

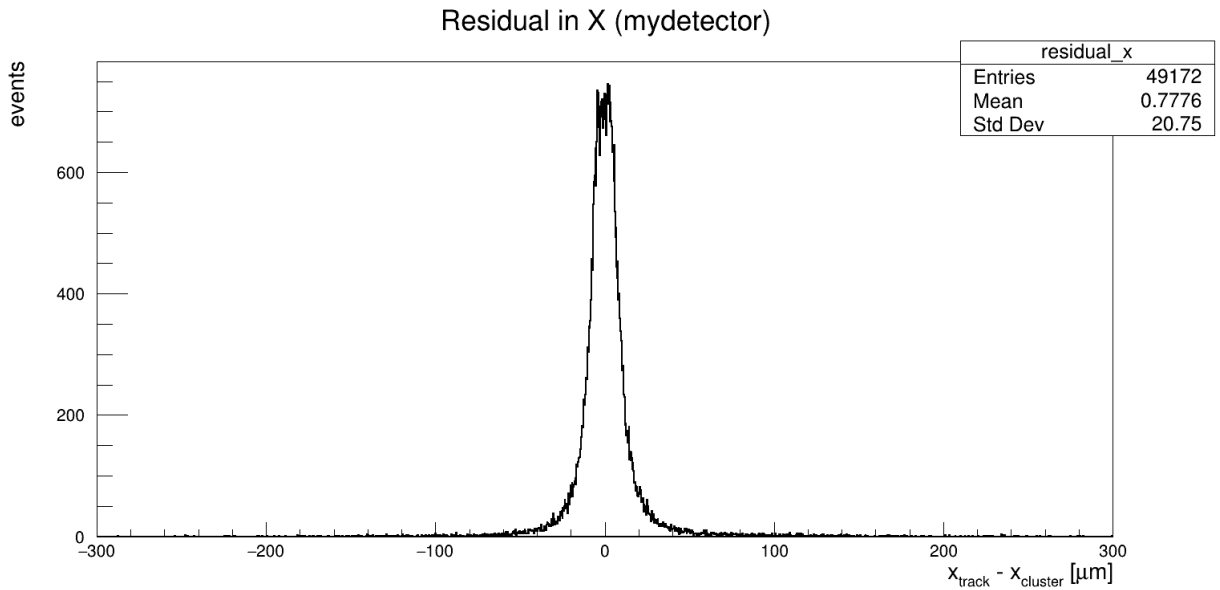


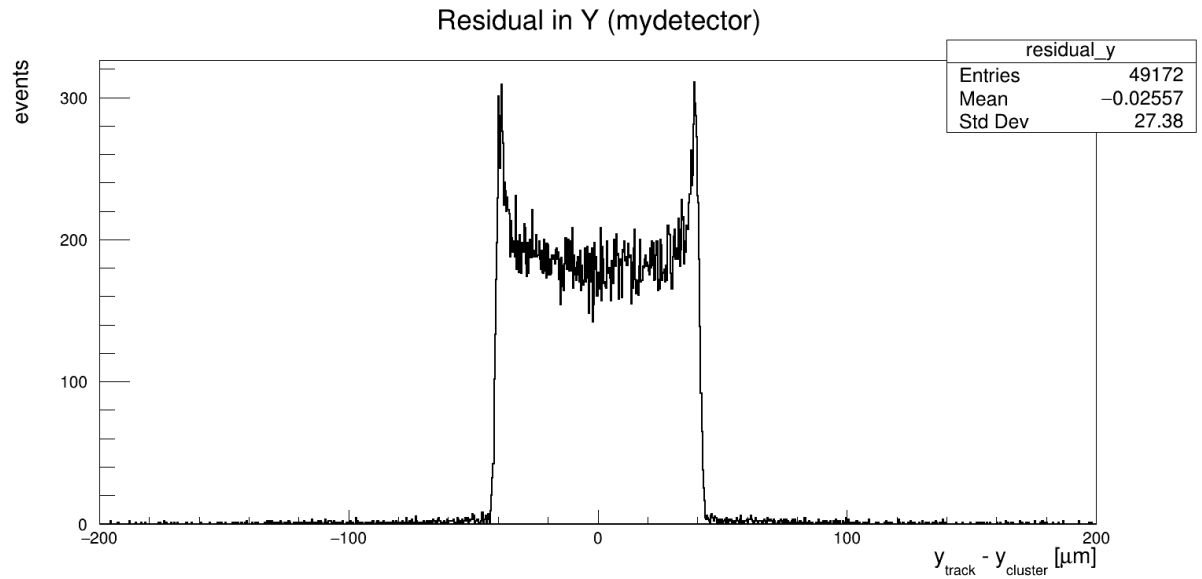




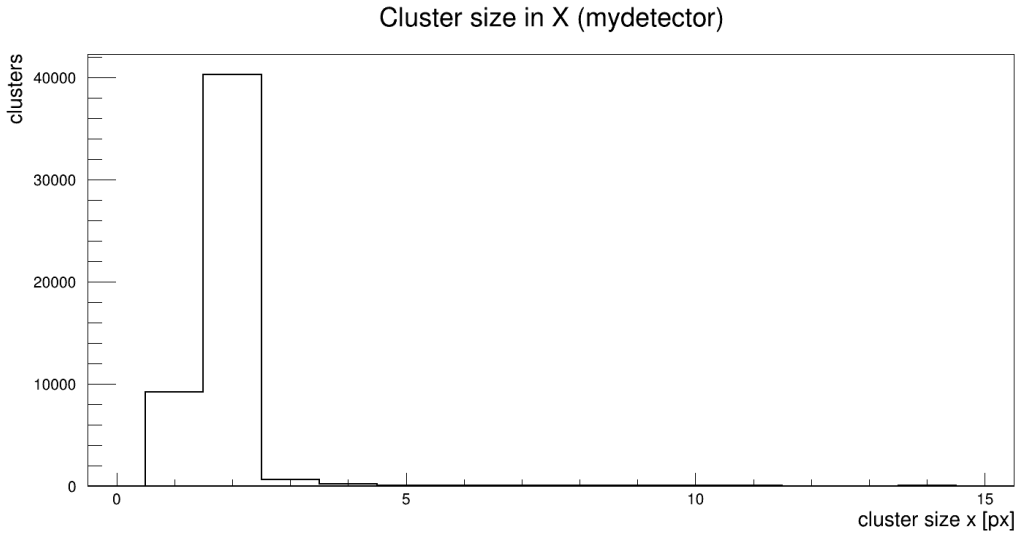
- Majority cluster size in X is 2 pixels, where Y stays unaffected as expected
- Geometrically hits for these parameters show increased cluster size to 2 in the center of the pixel and to 3 – 4 on the edges

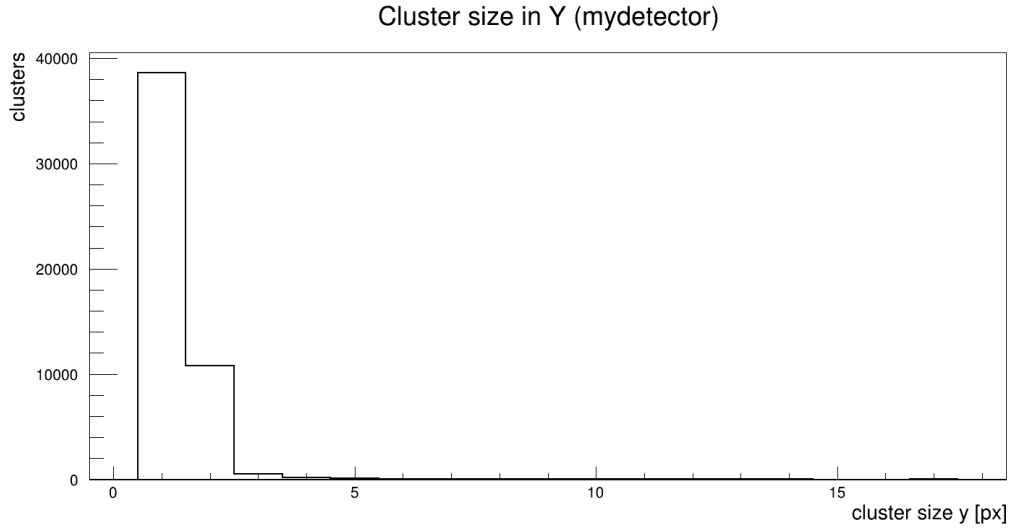
- As a result of the rotation the detector resolution has improved in the X direction as can be expected
- The residual appears to follow a more Gaussian trend with a narrower peak

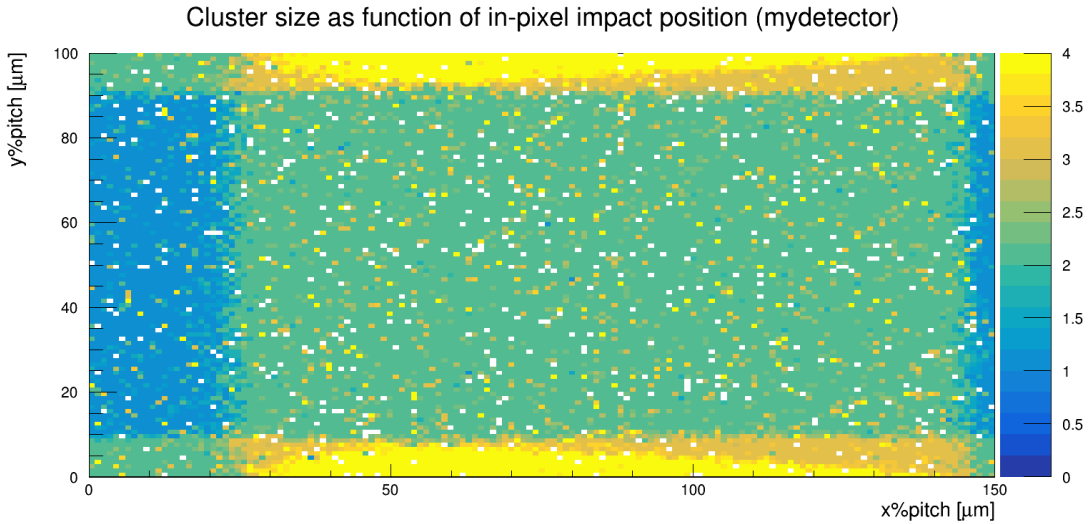




Detector incident with electron beam, with a 4T magnetic field applied & no rotation of the detector wrt the y-axis

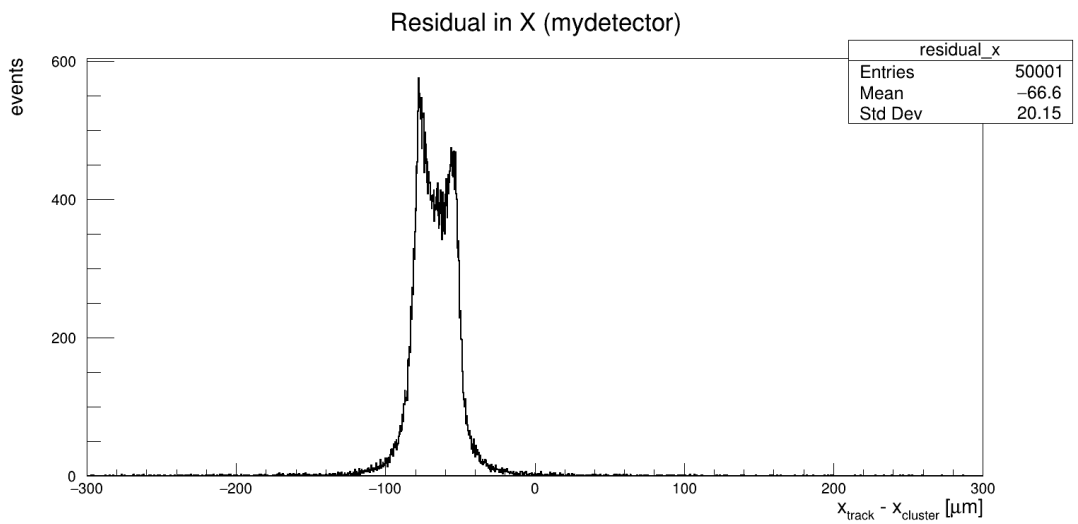


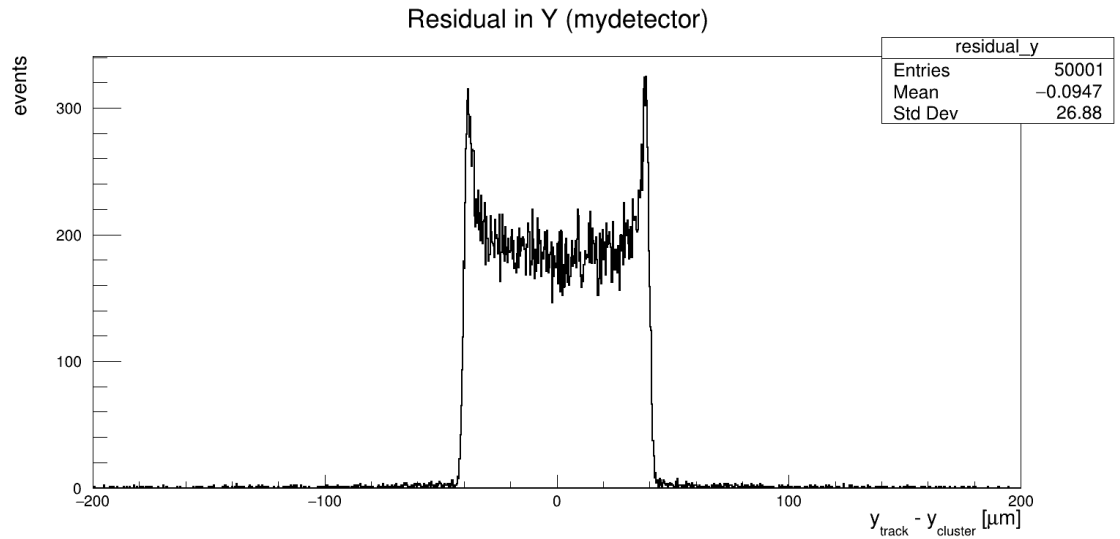




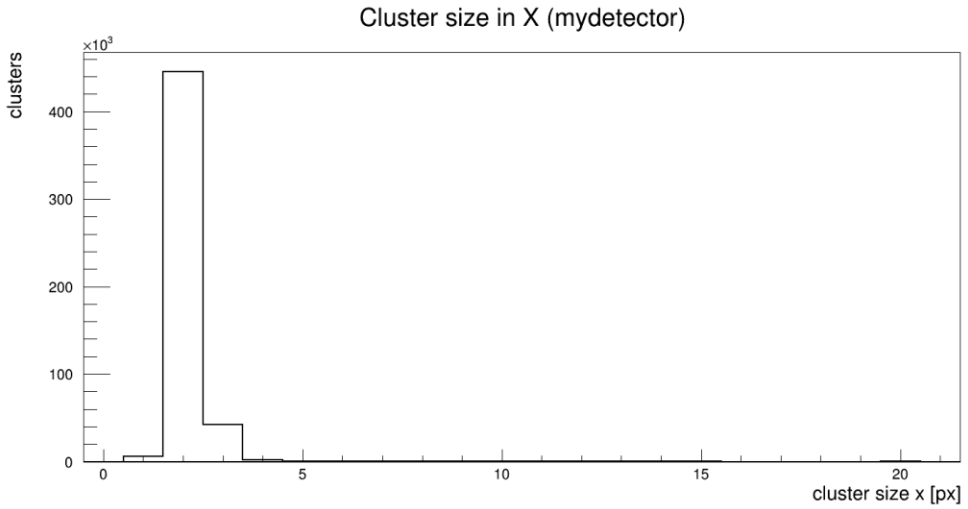
- Majority cluster size in X is 2 pixels, where Y stays unaffected as expected
- Geometrically hits for these parameters show again an increased cluster size to 2 in the center of the pixel and to 3 – 4 on the edges, this time due to the drift electron track curvature caused by the magnetic field

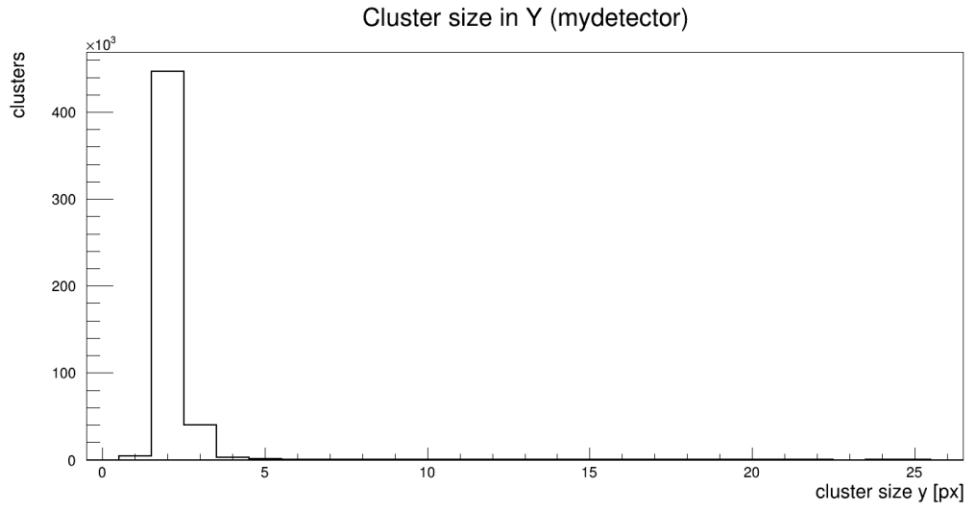
- As a result of the applied magnetic field the resolution has improved in the X direction as can be expected, showing a similar result to that seen when rotating the detector
- The residual appears to follow a more Gaussian trend with a narrower peak
- Eta correction can still be applied to more accurately determine the resolution (ask Håkan)

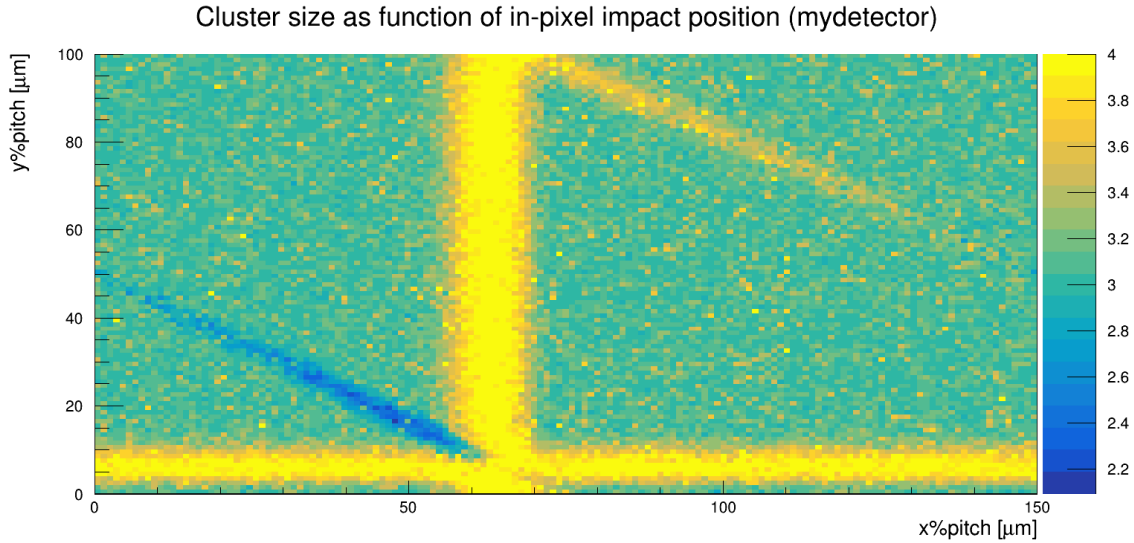




Detector incident with electron beam, with a 4T magnetic field applied & 27-degree rotation of the detector wrt the x-axis (a combination of the previous 2 results)

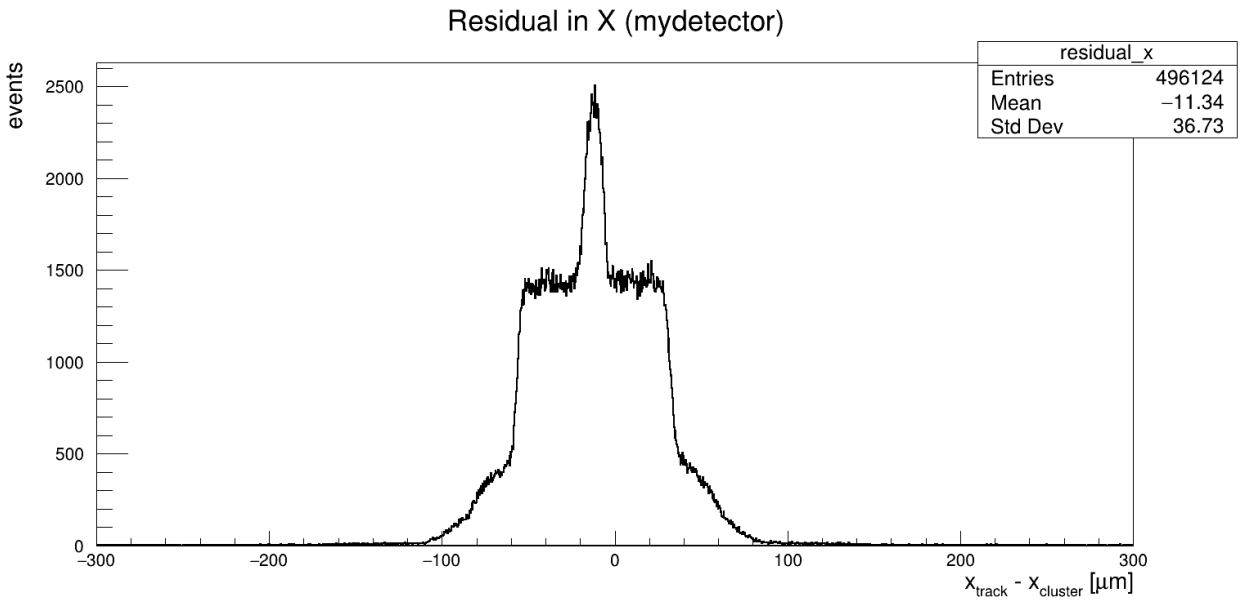


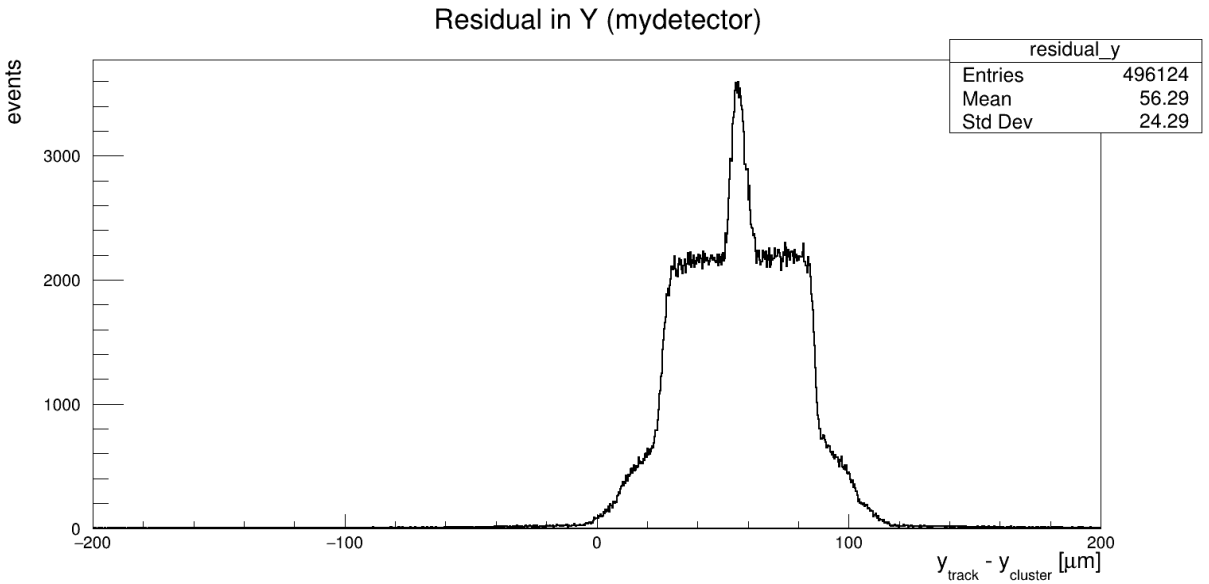




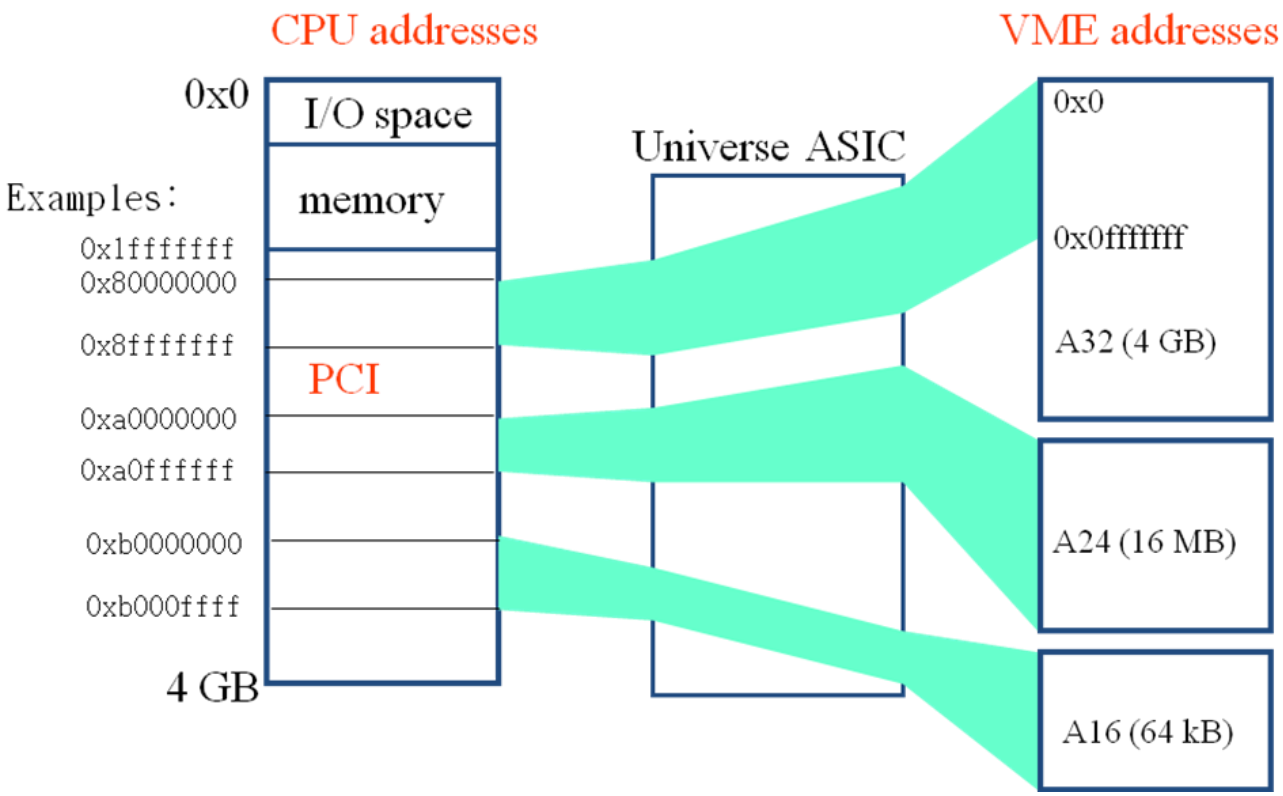
- Majority cluster size in X is 2 pixels as well as 2 pixels in Y (change of B field orientation)
- Choice of angle and magnetic field can be optimized to obtain a more isotropic cluster size in the pixel

- As can be seen from the below residuals the resolution in X has been minorly improved from the having no B field and no rotation, resolution in Y has been improved minorly as well
- Eta correction may be necessary to obtain accurate resolution values



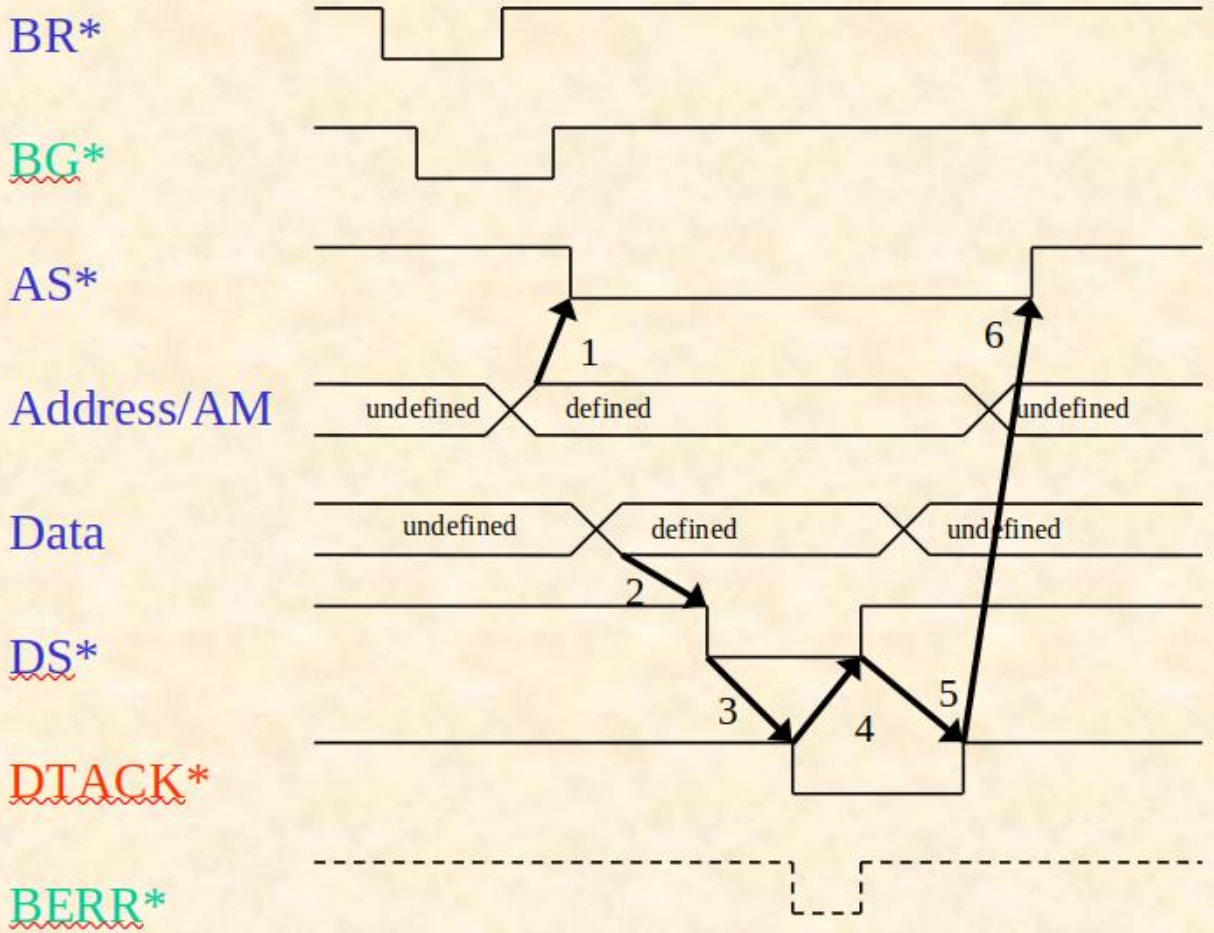


VMEbus Write/Read Transfer Programming



- Virtual vs. Physical memory address – mapping required.
- First implemented single cycle (CPU) write/read transfer in both 'safe' and 'fast' modes.
- Secondly implemented block transfer (DMA) write/read transfer of a single block.
- Comparison and scaling of transfer speed as a function of the size of data.
- Importance of byte ordering, Little vs. Big endian – master with automatic byte swapping.
- Usefulness of analyzer for debugging and investigating master/slave communication.

Example: (Simplified) write cycle



Arbitration

1: Master drives address and AM code. Then it asserts AS
2: Master puts data on the bus. Then it asserts DS
3: Slave latches data and drives DTACK
4: Master removes DS
5: Slave removes DTACK
6: Master releases Address, AM and data lines. Then it releases AS

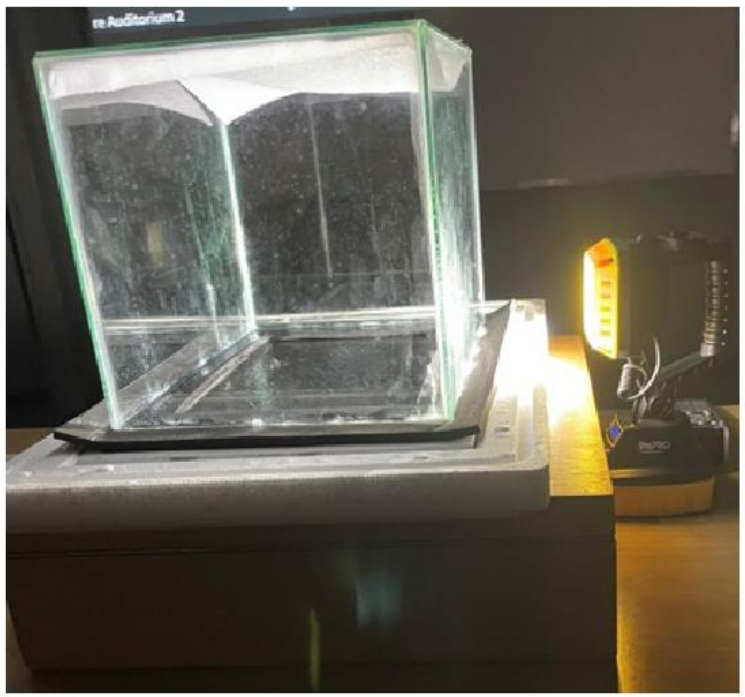
Color code: Master - Slave - Arbiter

Cloud Chamber Exercise

Particle visualization:

Cloud chambers allow to observe the paths of charged particles as they pass through the chamber.

By creating a supersaturated vapor environment, the particles ionize the vapor molecules, creating a visible trail of tiny droplets or clouds.



Aquariums:
Ferplast Geo Plast

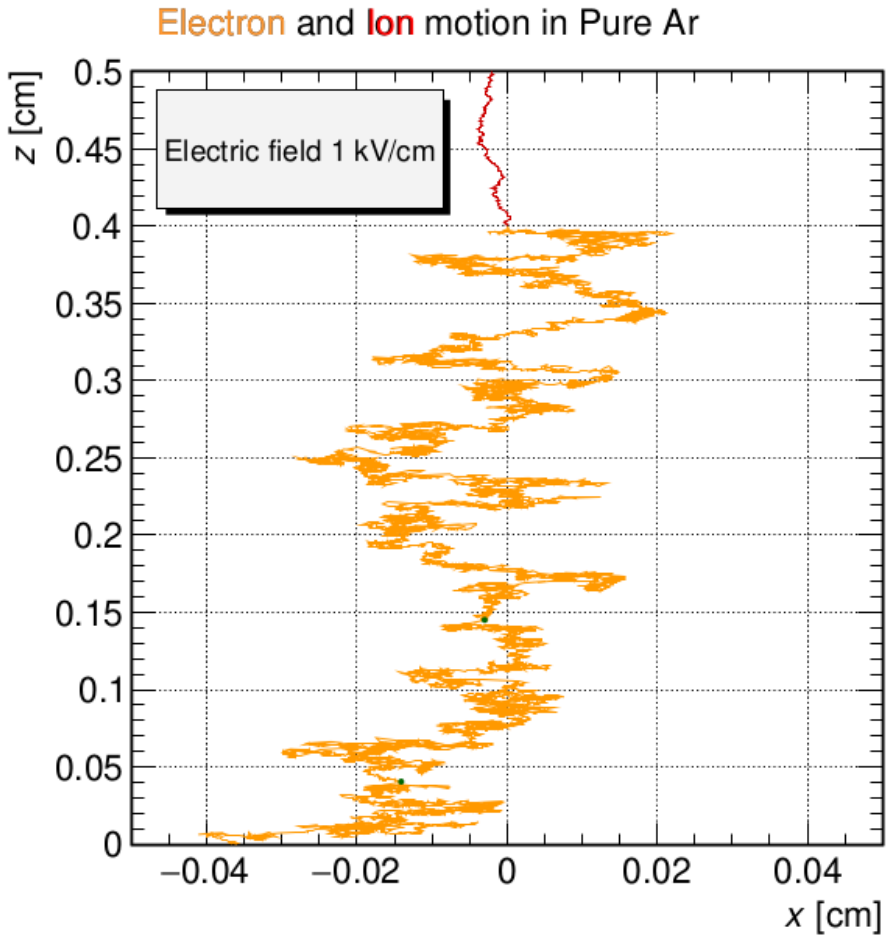
Felt: approx. 3-5 mm thick ideally:
industrial wool felt attach to bottom of aquarium

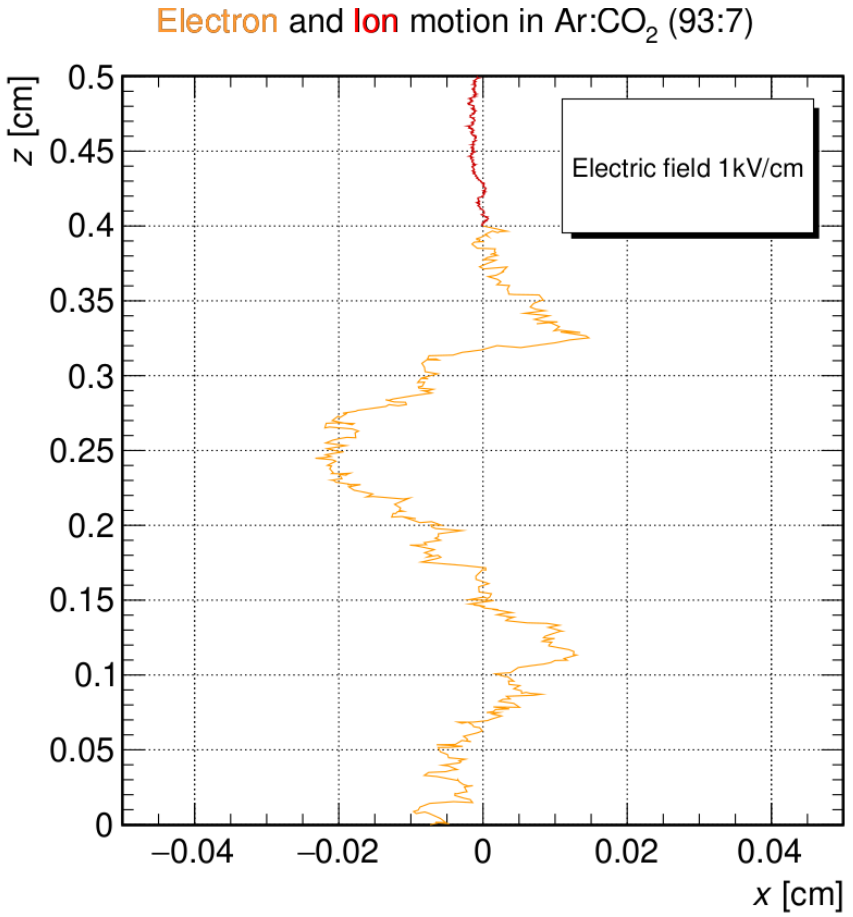
Anodized aluminium plates

Trays: to store dry ice, to place metal plate on top, should have some thermal insulation

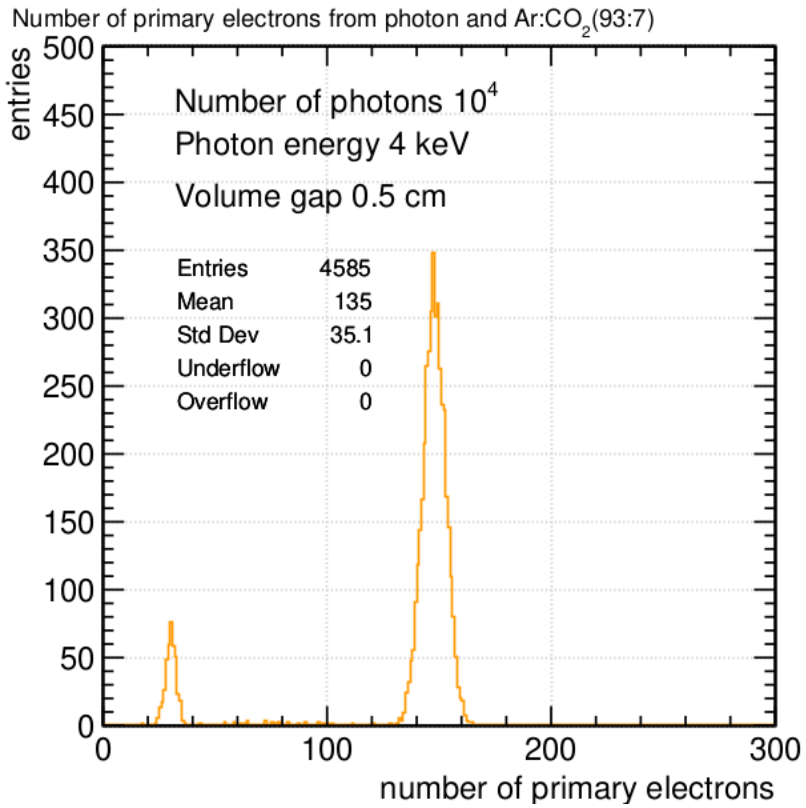
Micro Pattern Gas Detector

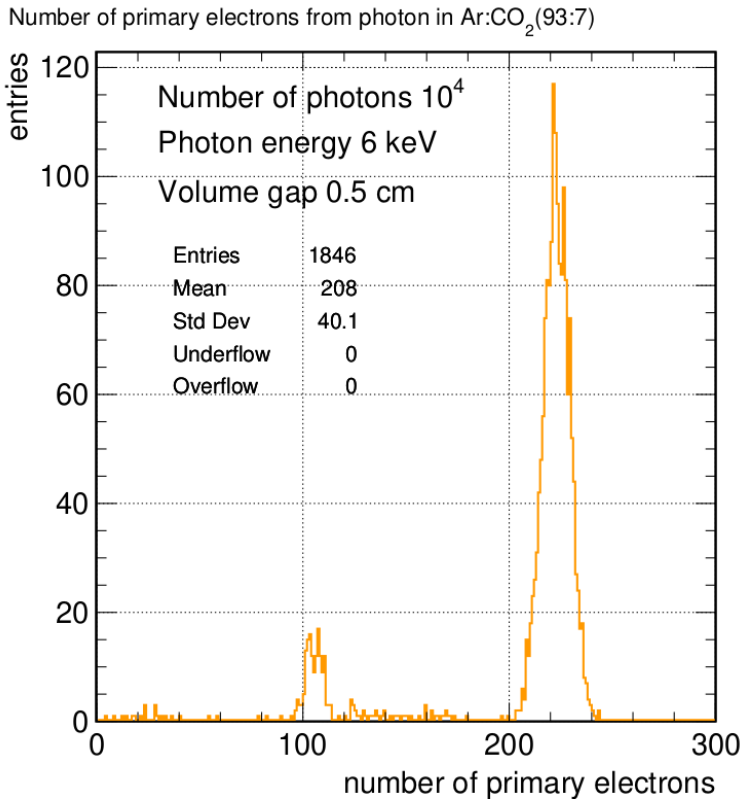
- Ionized pair motion, in applied electric field drift chamber
- Looking at effect of applied E field strength & gas composition

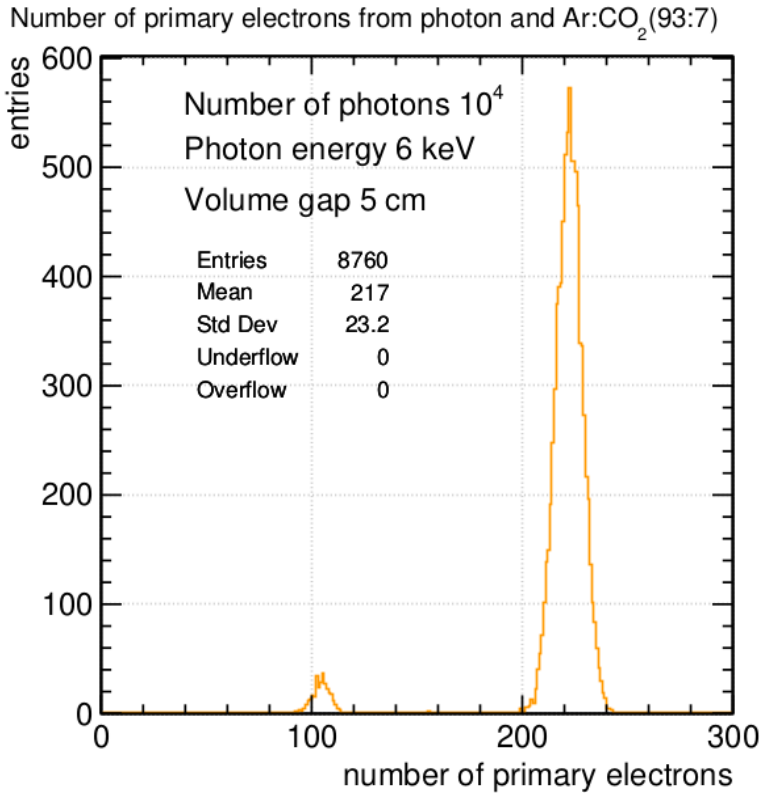




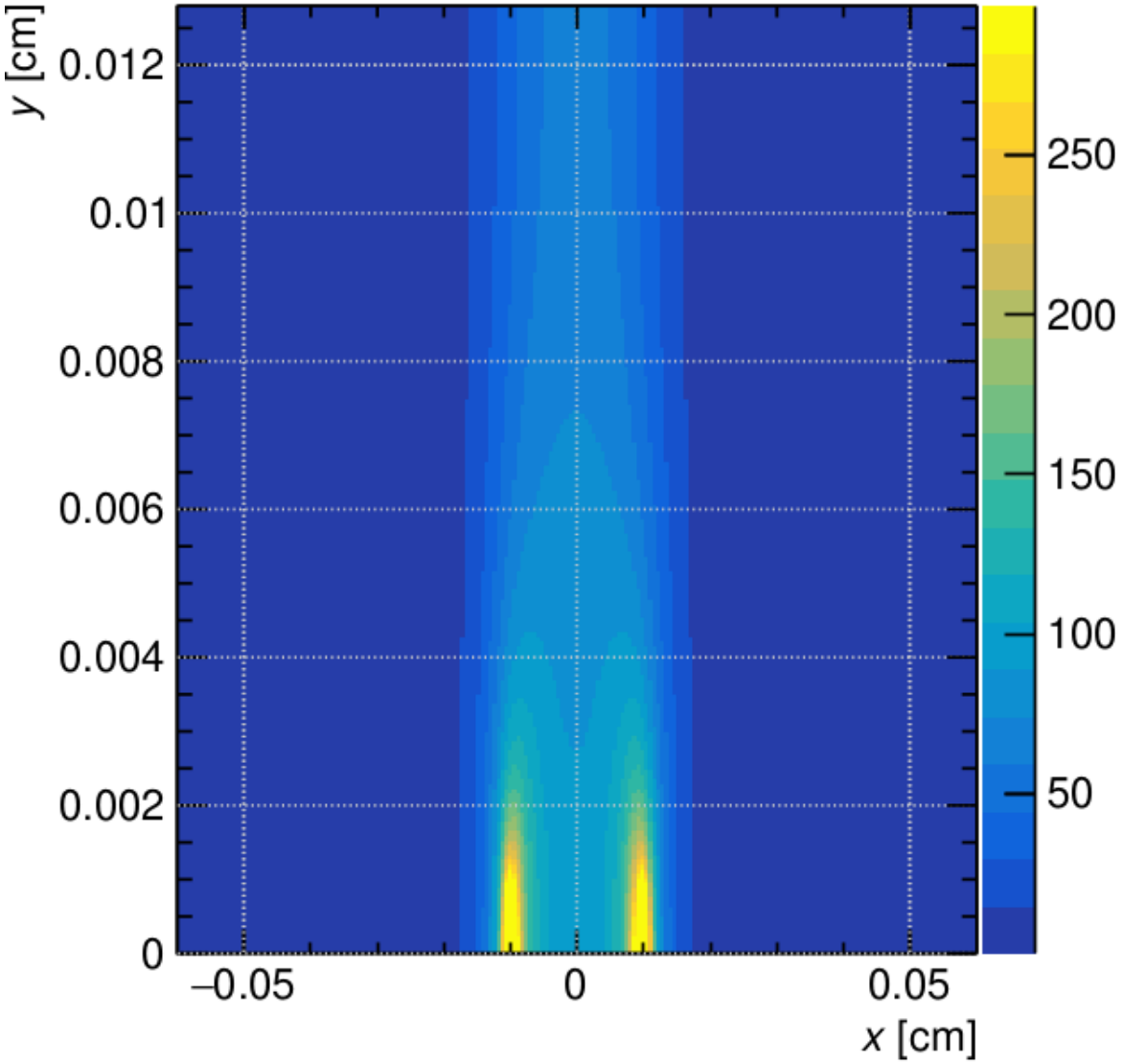
- Number of primary electrons from incident photon as a function of photon energy and volume drift gap

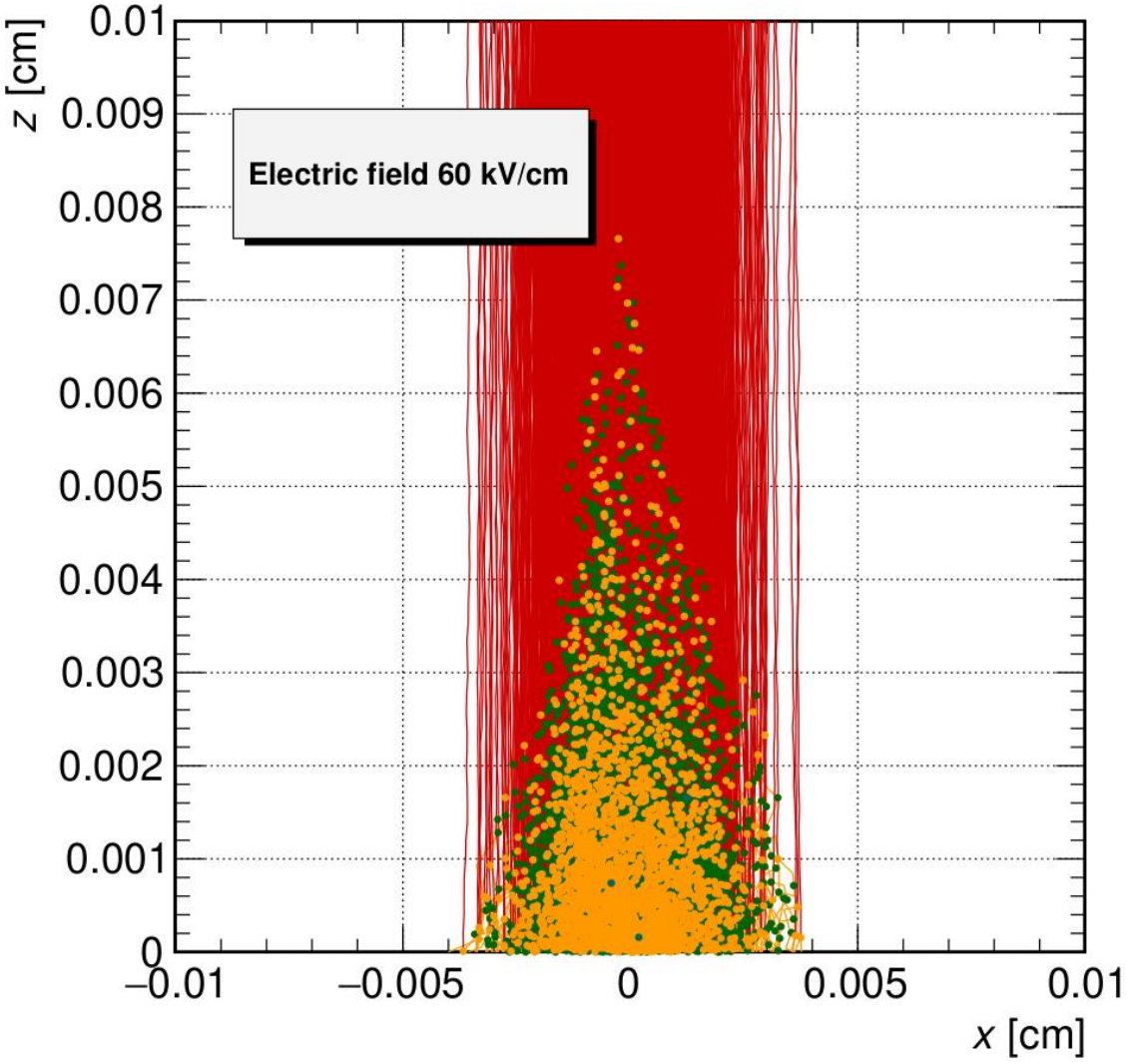




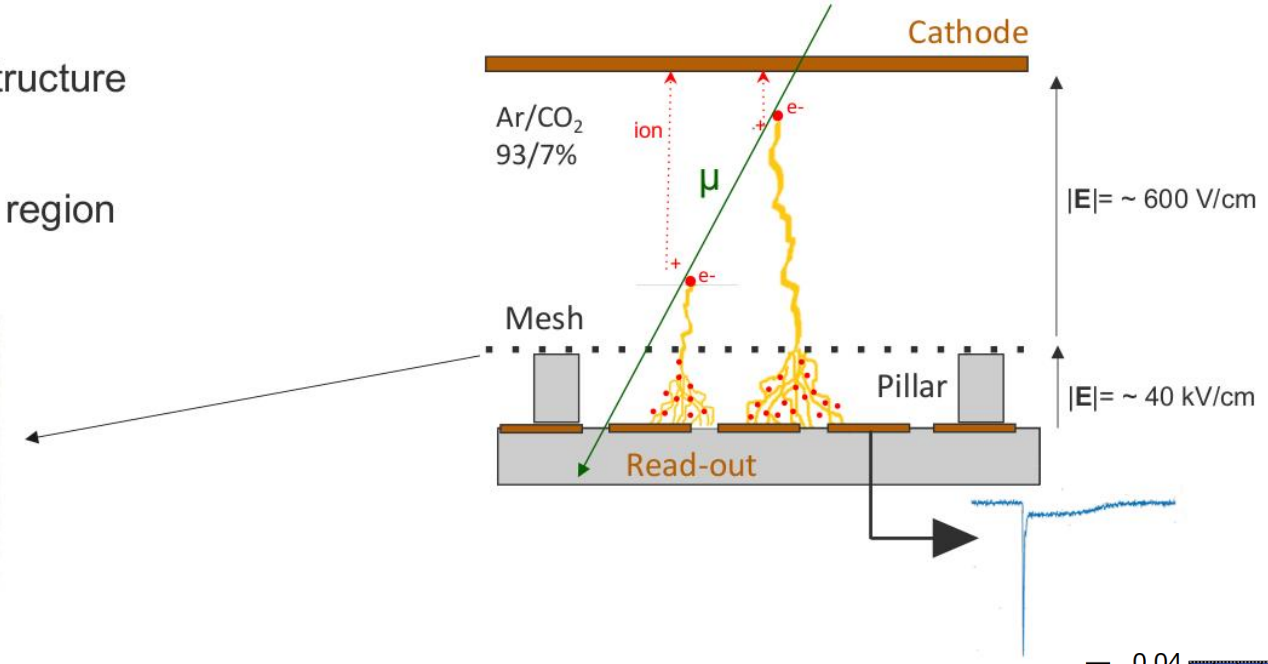


- Looking at avalanche of charges collected on a single plate

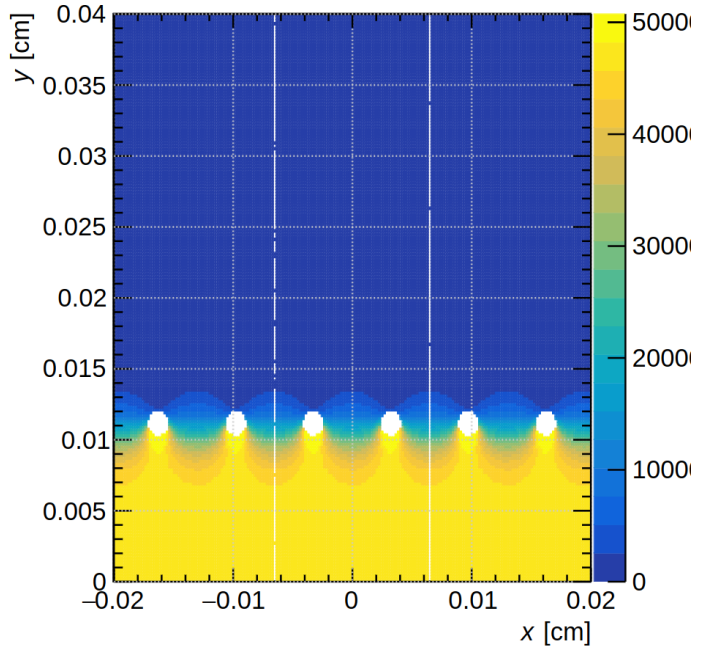




1. Primary ionization
2. Drift of electrons to amplification structure
3. Amplification through high fields
4. Induction of signal in the induction region



- Amplification region & mesh for electric field isolation
- Designed to mitigate too wide of a spread of amplification 'cloud'



- Signals generated in 5 adjacent plates from muon traversing drift chamber
- Charge density induced in plate conductor from both positive and negative ionized charges