First Results from the HV-MAPS Testbeam for the MU3E Experiment

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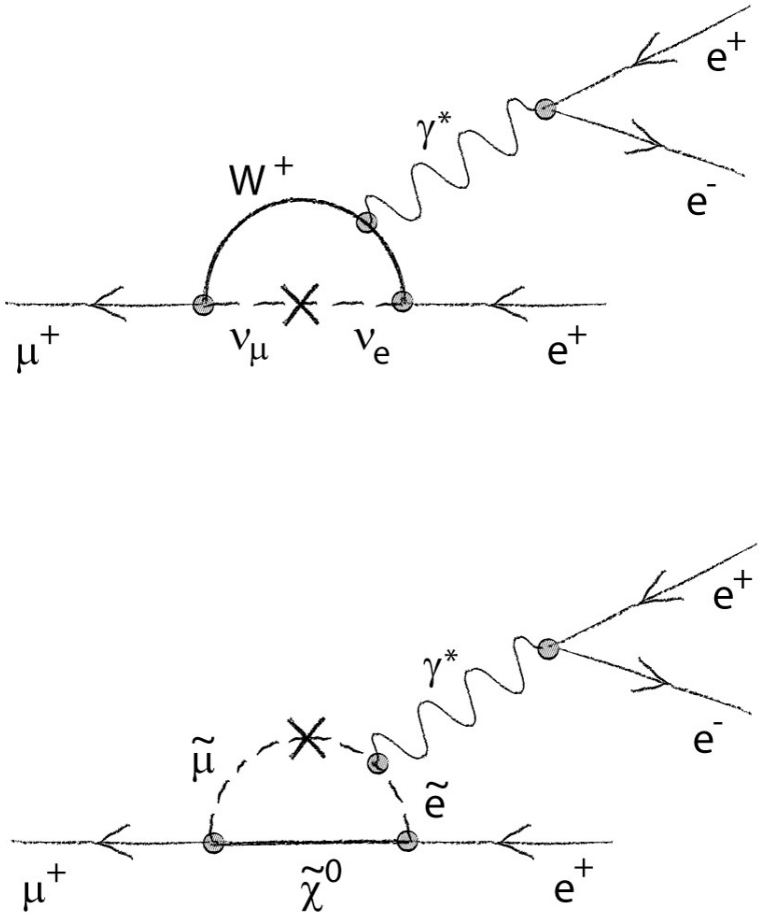
The MU3E Experiment



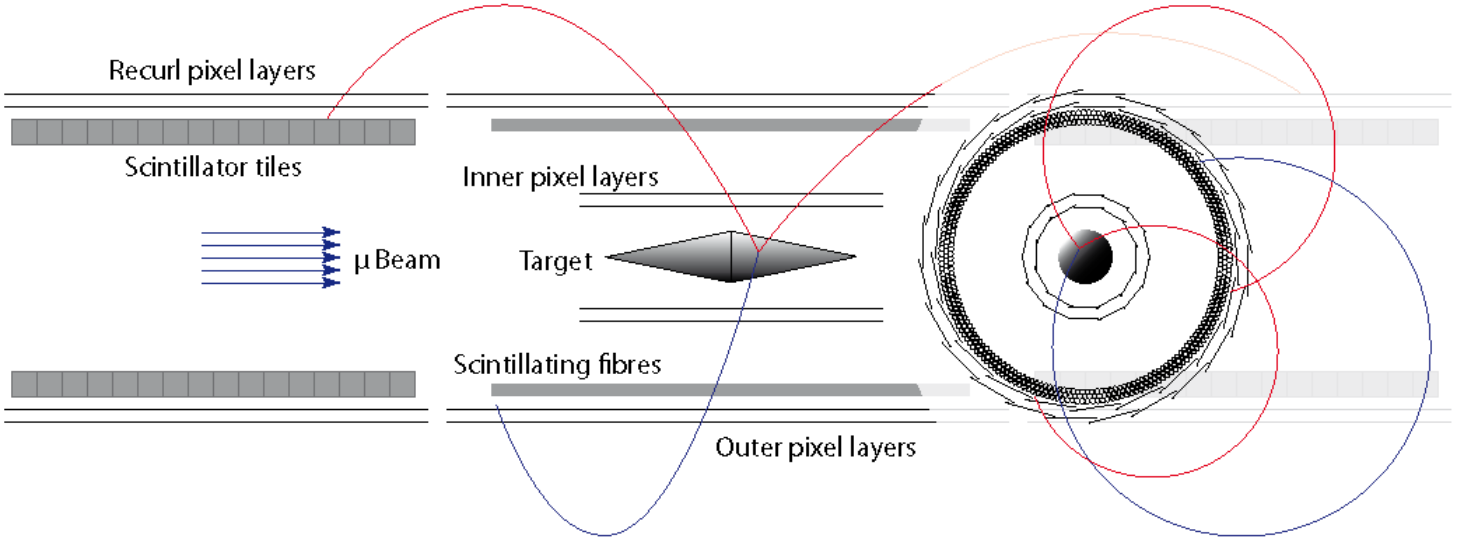
The MU3E Experiment:

- Search for $\mu^+ \rightarrow e^+e^-e^+$
- Charged Lepton Flavor Violation (LFV)
- SM heavily suppressed BR < 10^{-50}
- Current limit BR < 10^{-12}
- Proposed Sensitivity:

  BR < 10^{-16}

- Any observable BR must come from new physics

The MU3E Detector



Challenges:

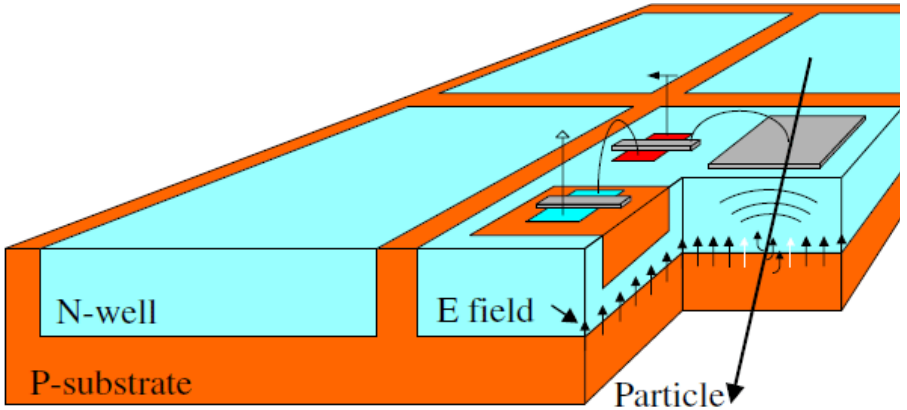
- High rate(PSI muon beam):
  Time resolution
- Background suppression:
  vertex and momentum resolution

→ New detector concept needed

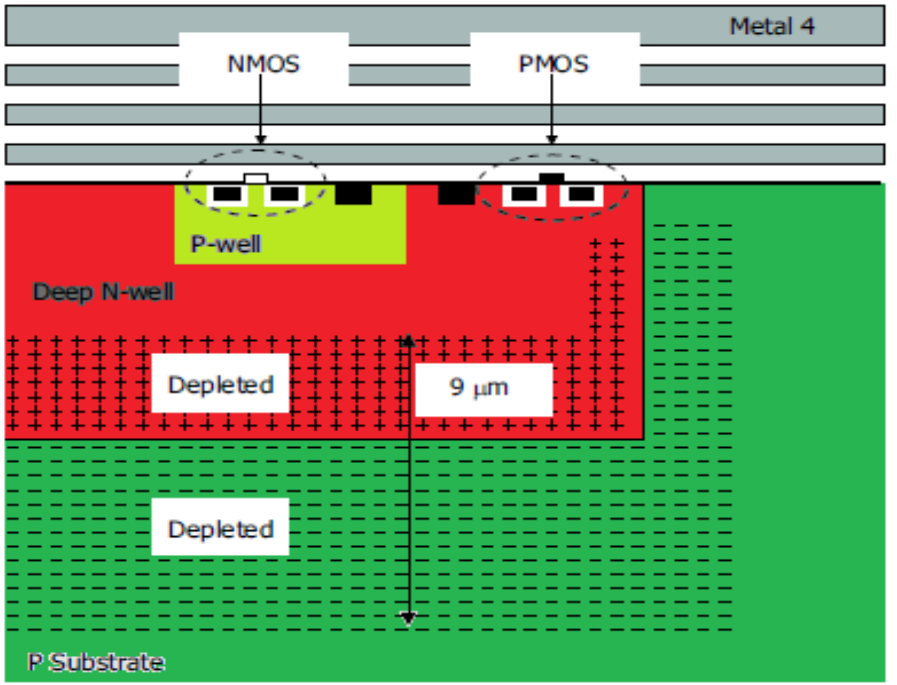
- Multiple scattering:
  low material budget

High Voltage MAPS

top view



cross section



MAPS:

Monolithic

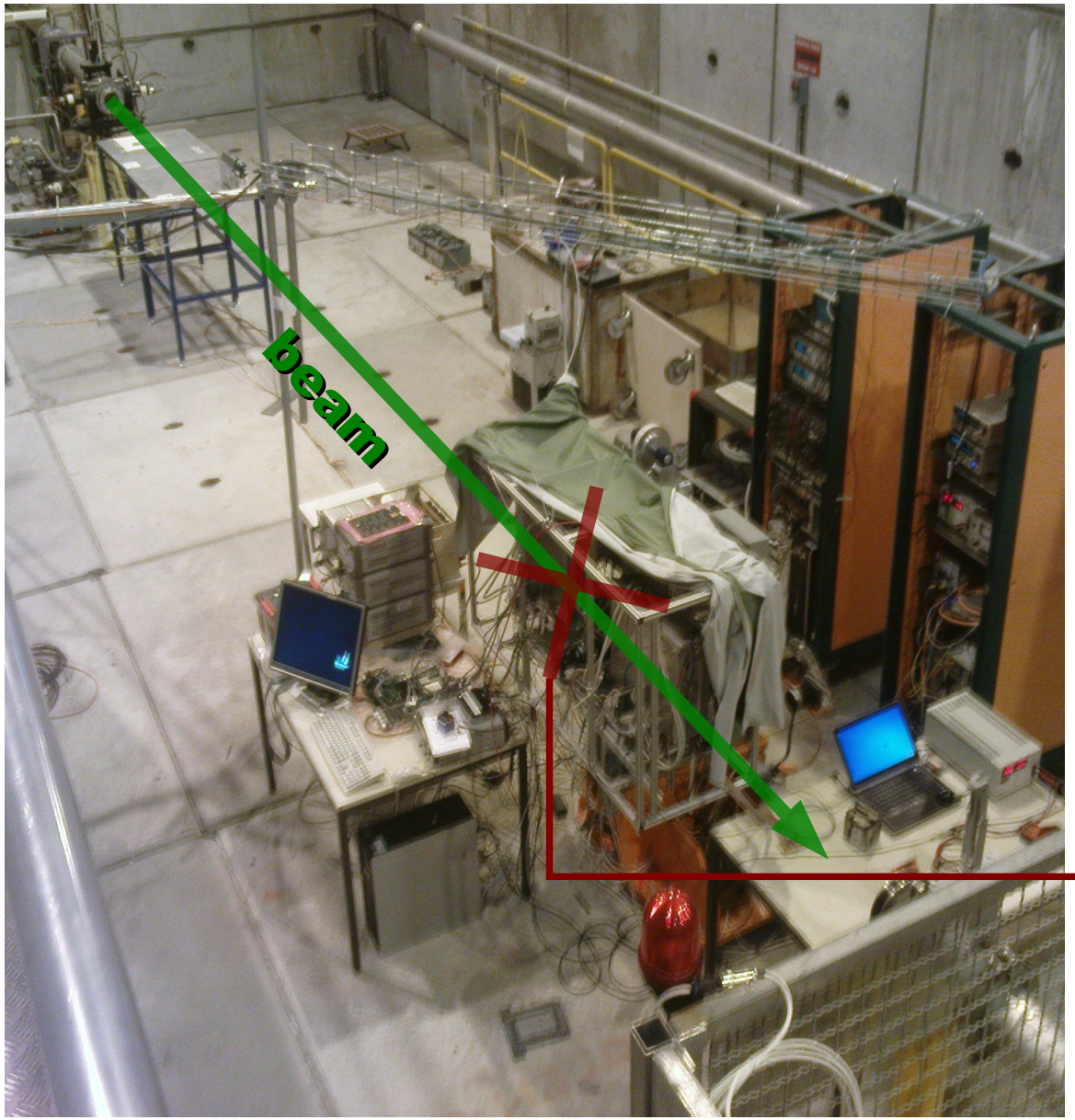
Active

Pixel

Sensors

- integrated readout
- small active detector volume
- charge collection via drift (fast)
- thinable down to <50µm

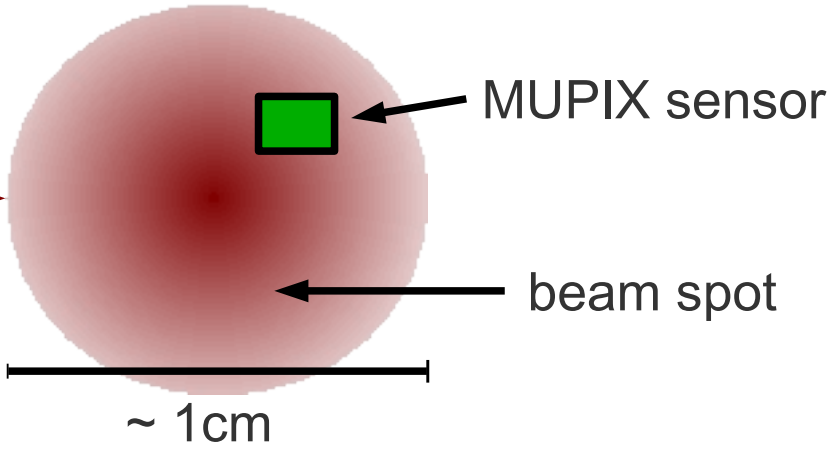
SPS Testbeam at CERN



Testbeam August 2012

- Testbeam Area T4-H8A
- 180 GeV/c pions
- TIMEPIX Beam Telescope

But: ~ few hours of data taking



MUPIX Prototype 2

Prototype

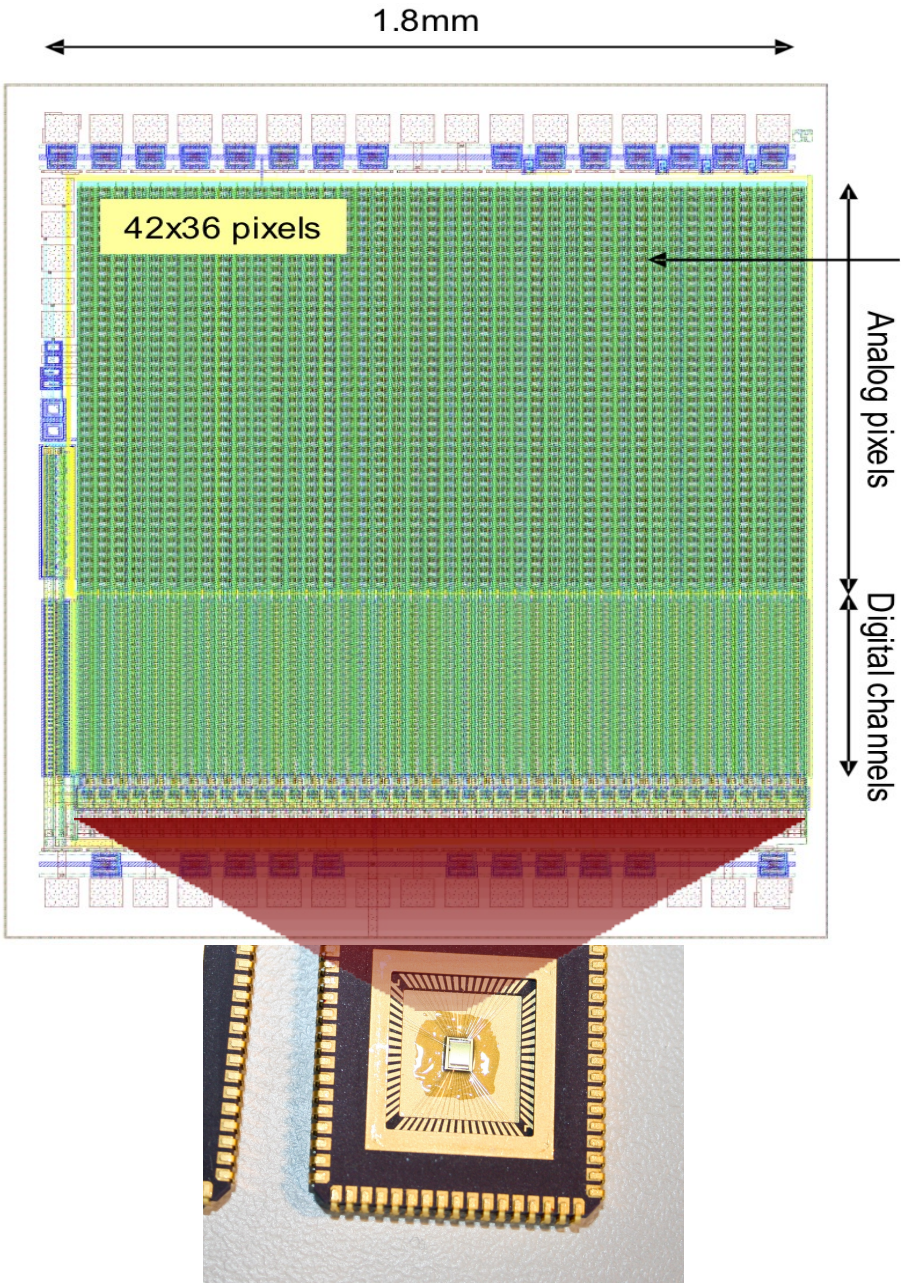
- Developed by Ivan Perić(ZITI)
- 42x36 pixels
- Pixel size 39x30 μm^2

Settings

- Binary readout
- Single (global) threshold:
  0.9 V, 1.0 V, 1.1 V
- No optimisation
- Fixed High Voltage: 56 V

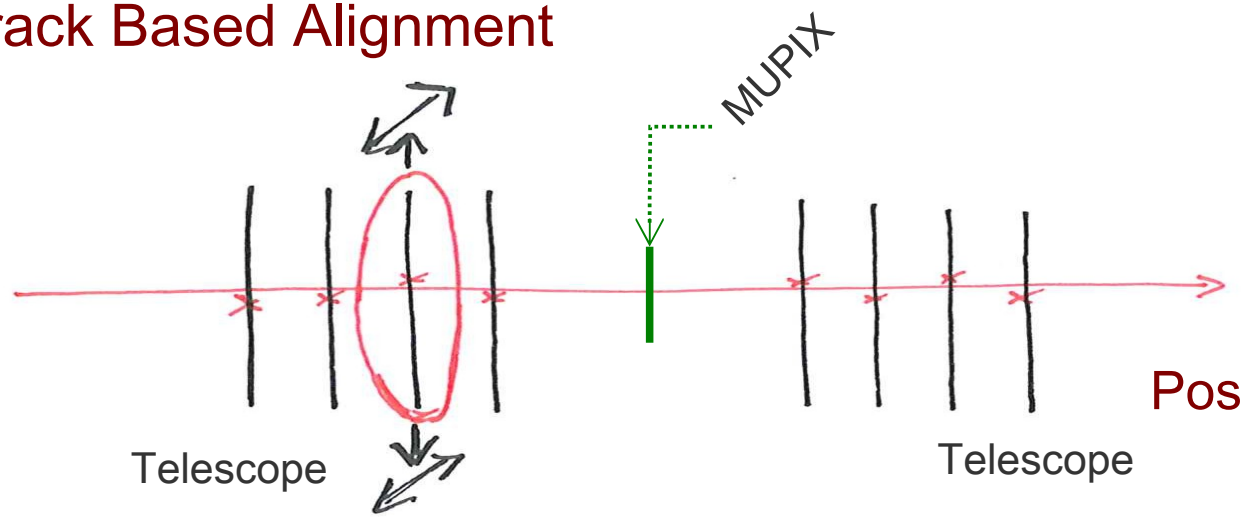
Questions to answer

- Efficiency
- Resolution
- Response to MIPs



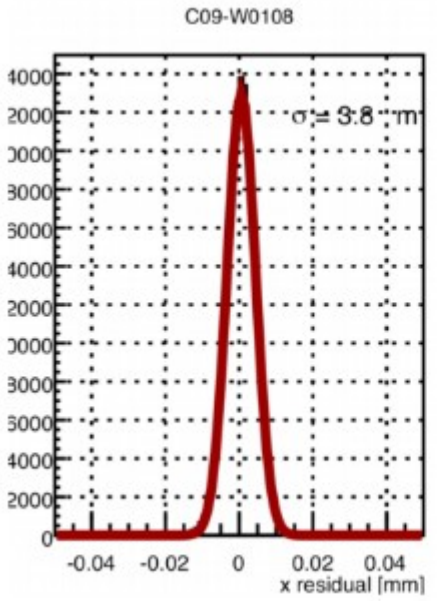
Telescope Alignment

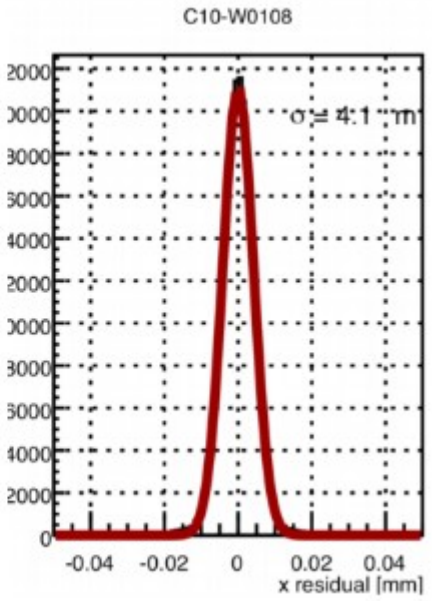
Track Based Alignment

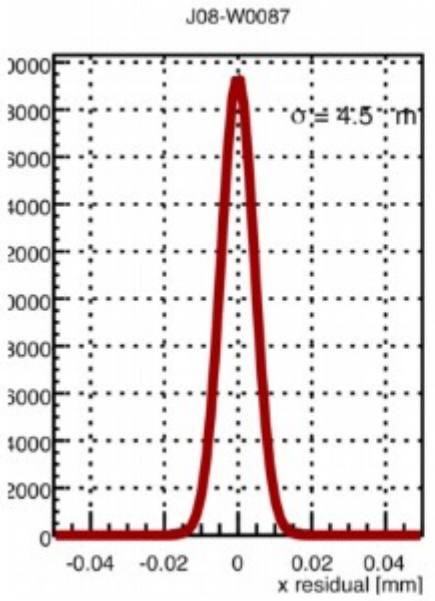


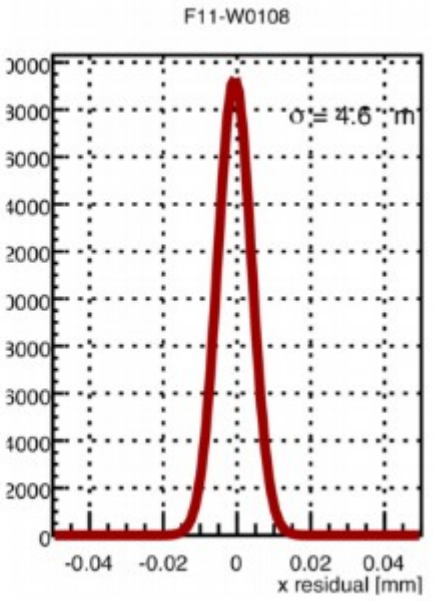
Position Resolution ~ 5-7µm

Track Residuals (First 4 Telescope Layers)

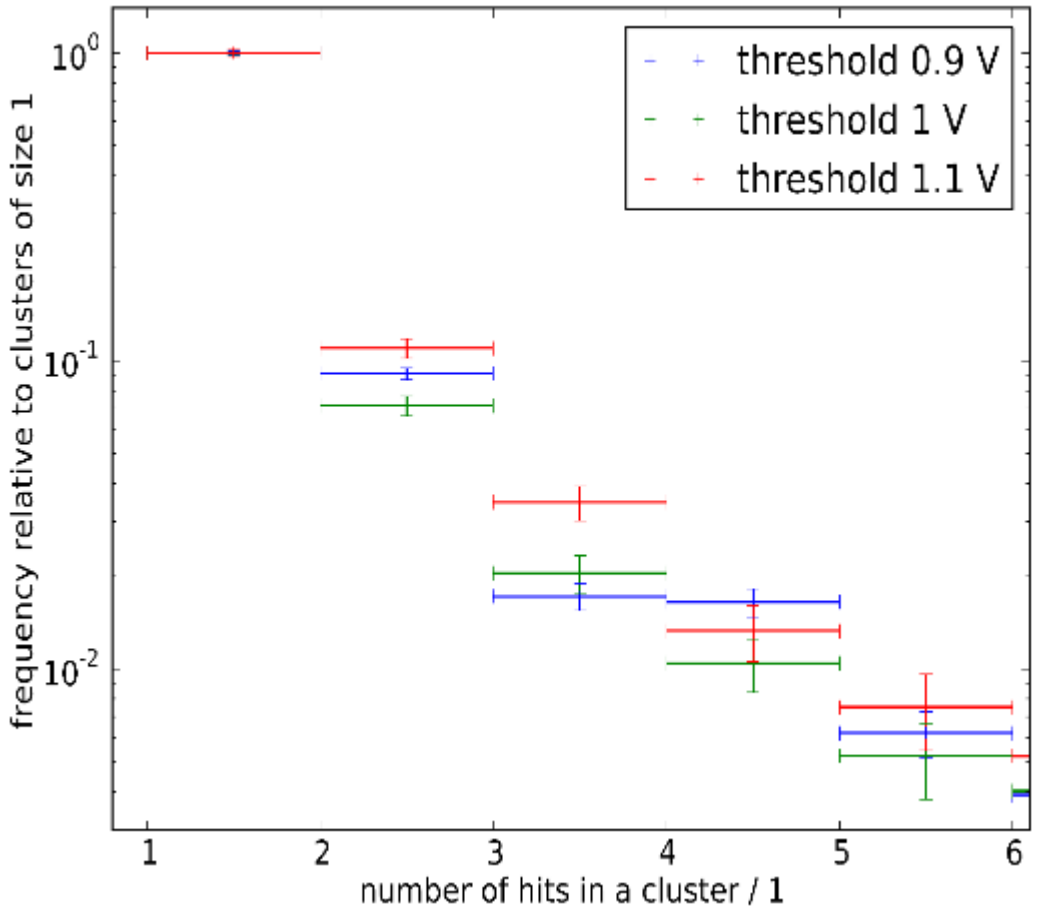






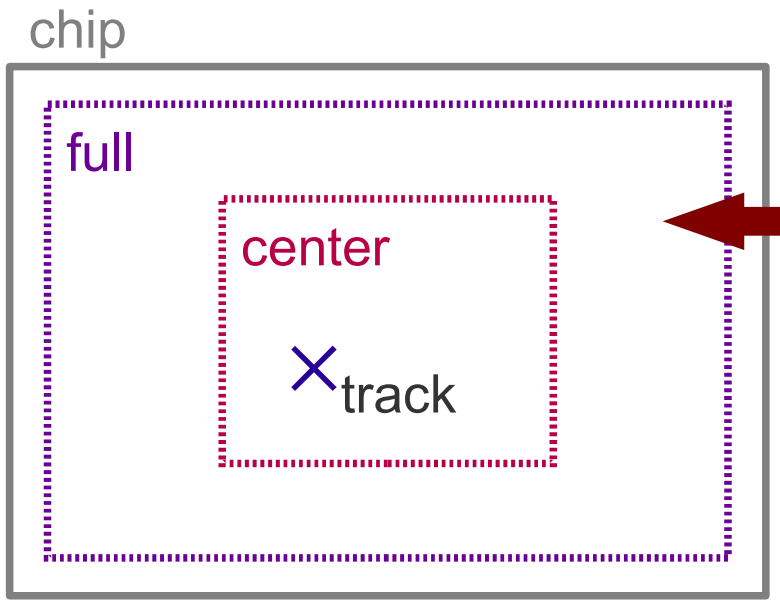


Cluster Size



- Single hit clusters dominate
- No significant difference between thresholds
- Small difference expected
- Low statistic

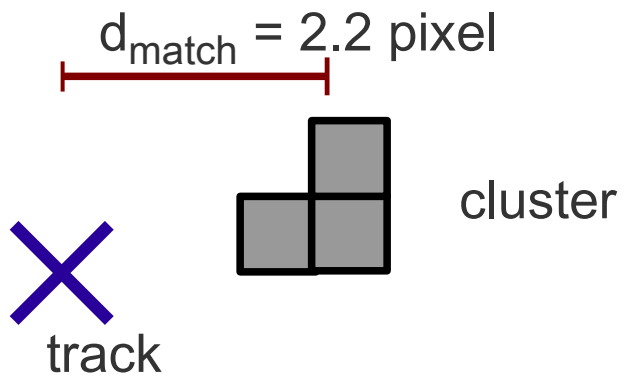
Matching



Procedure:

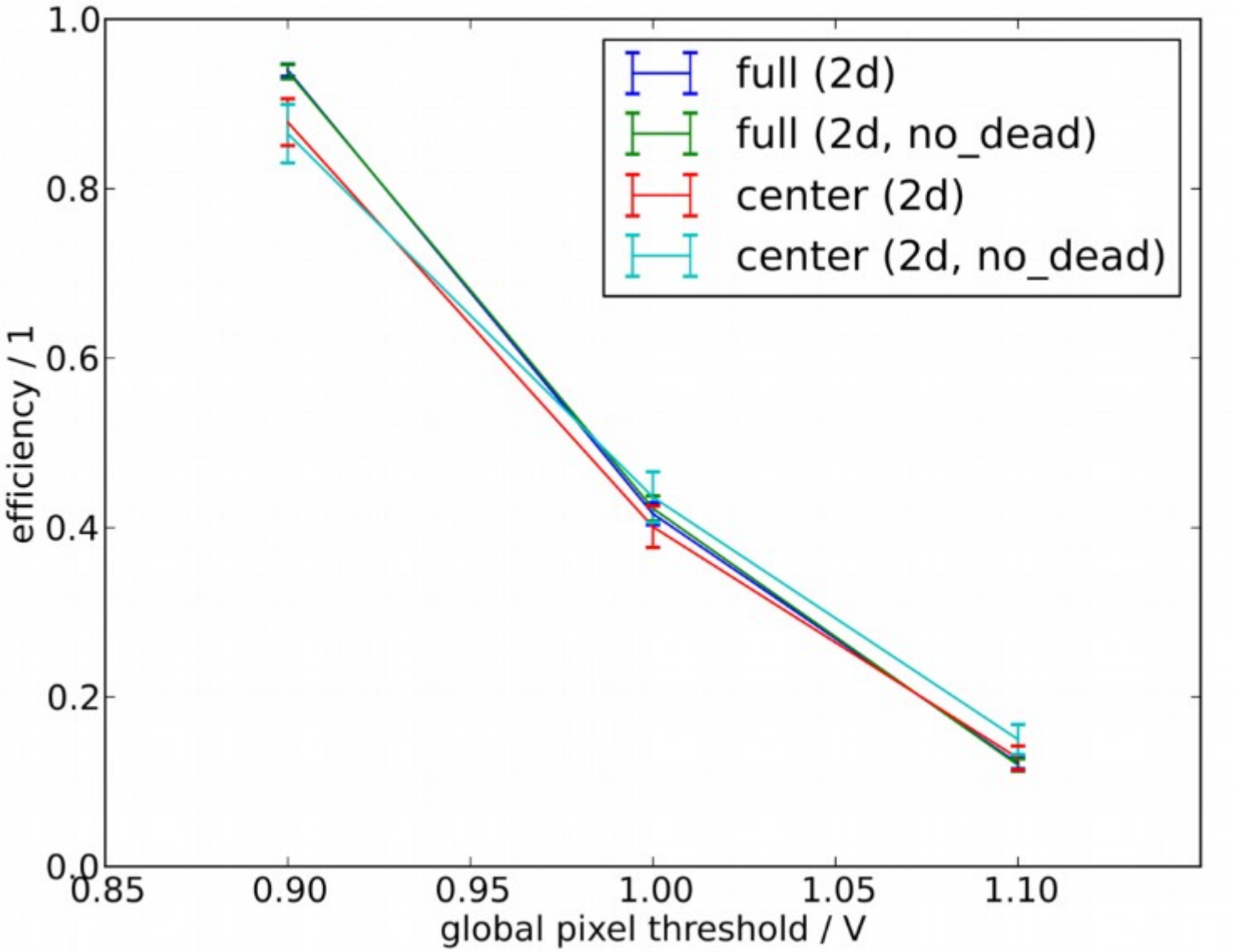
1. Find track intersections on selected area ($N_{selected}$)
2. Select closest cluster ($N_{matched}$)

Efficiency



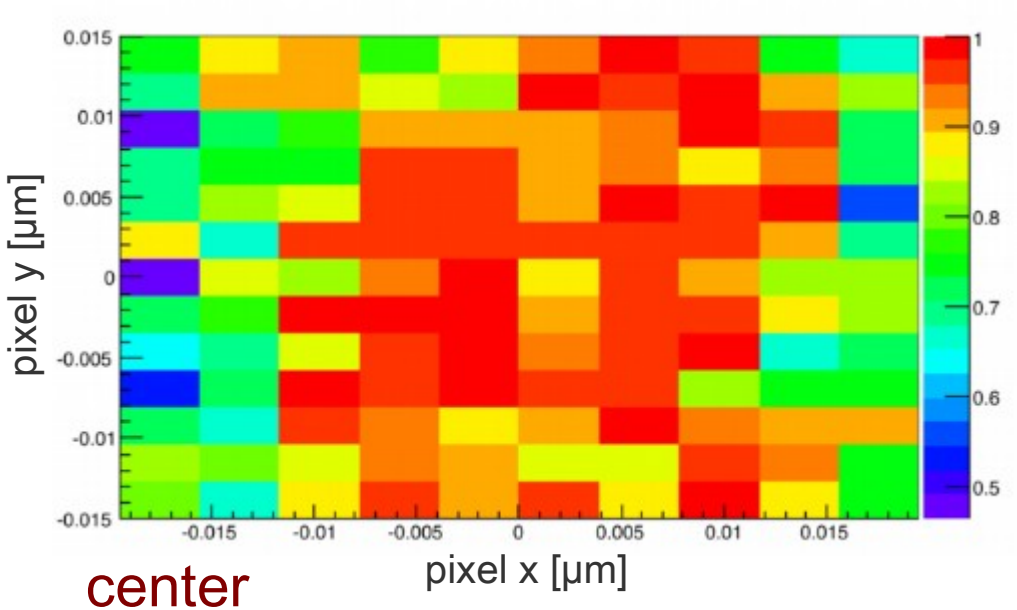
$$\epsilon = \frac{N_{matched}}{N_{selected}}$$

Global Hit Efficiency

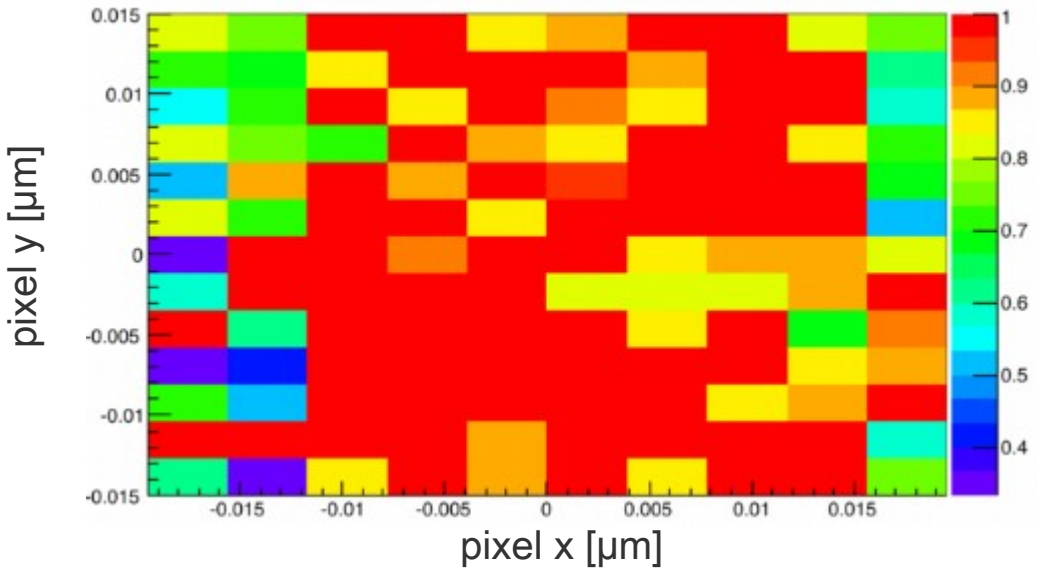


Pixel Hit Efficiency – 0.9 V

full



center

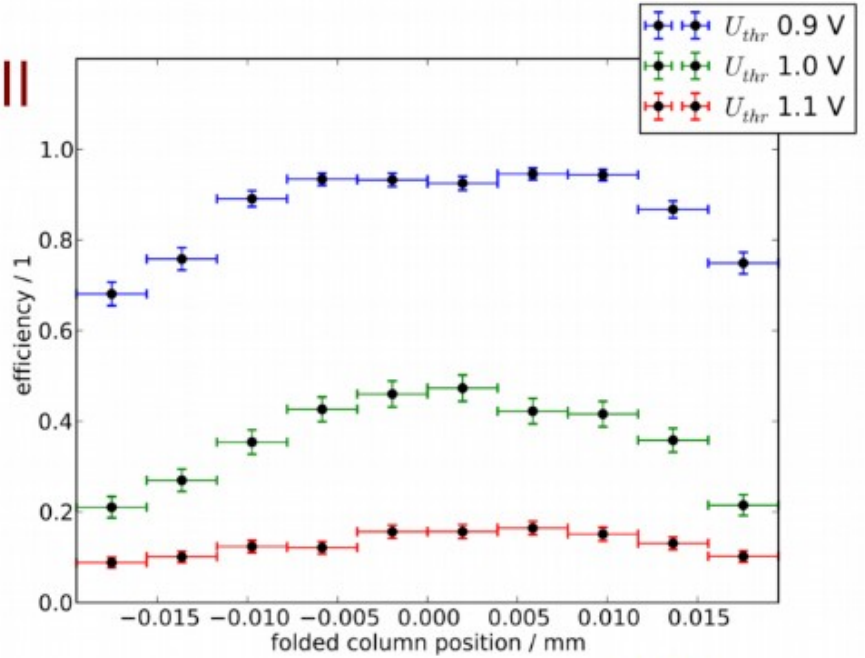


- All matched tracks folded to one pixel
- Unexpected shape
- Expected: symetry in rows and columns

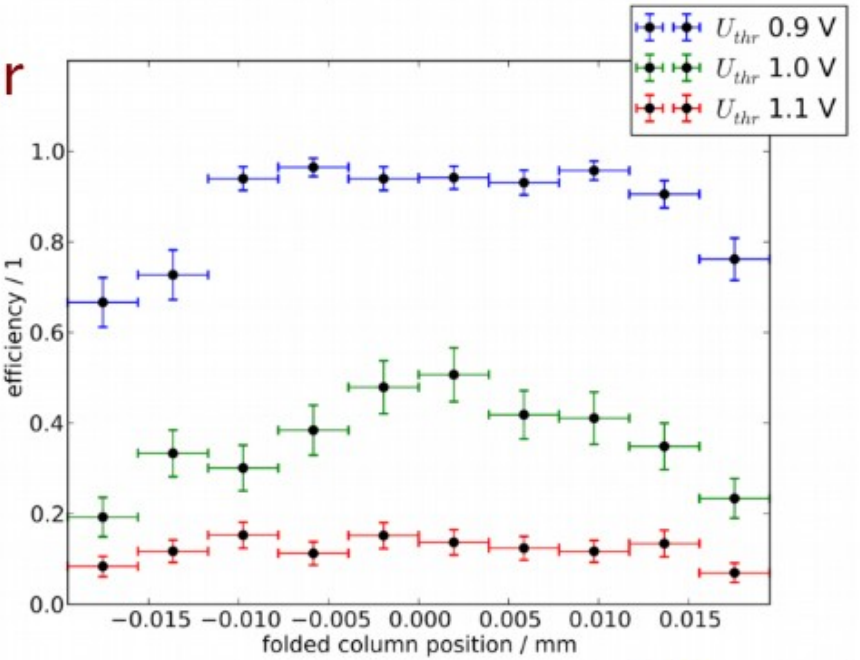
- More obvious in the projection

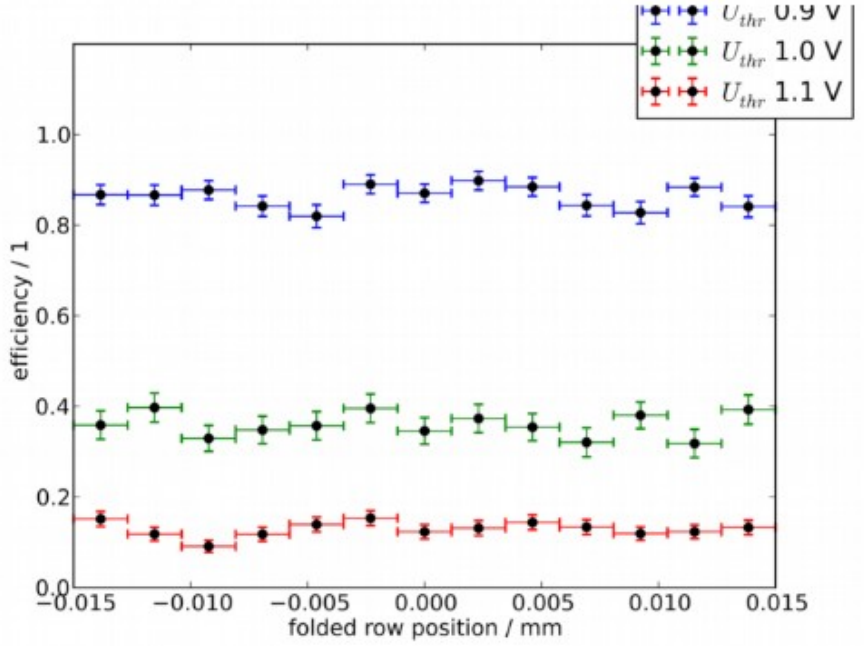
Pixel Hit Efficiency (Projected)

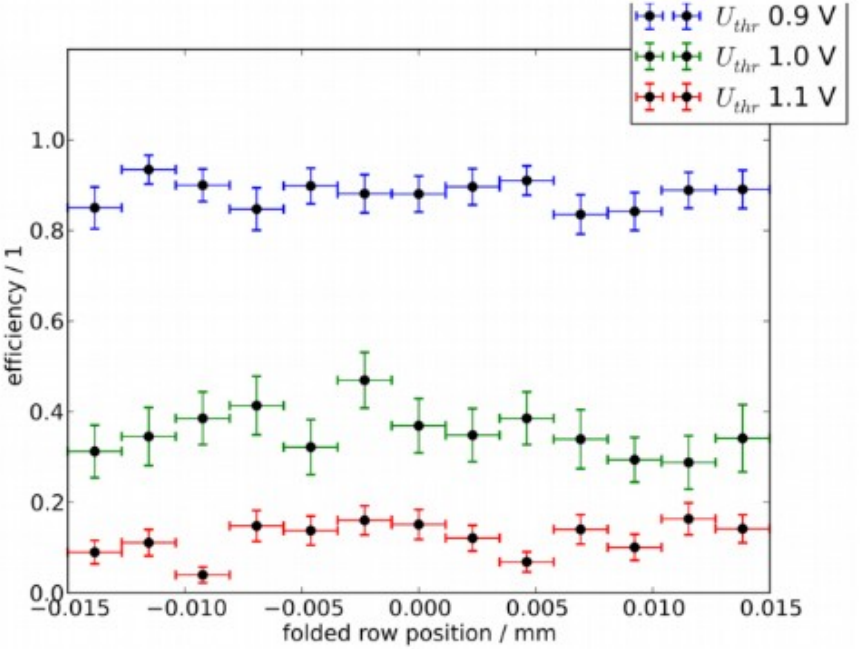
full



center





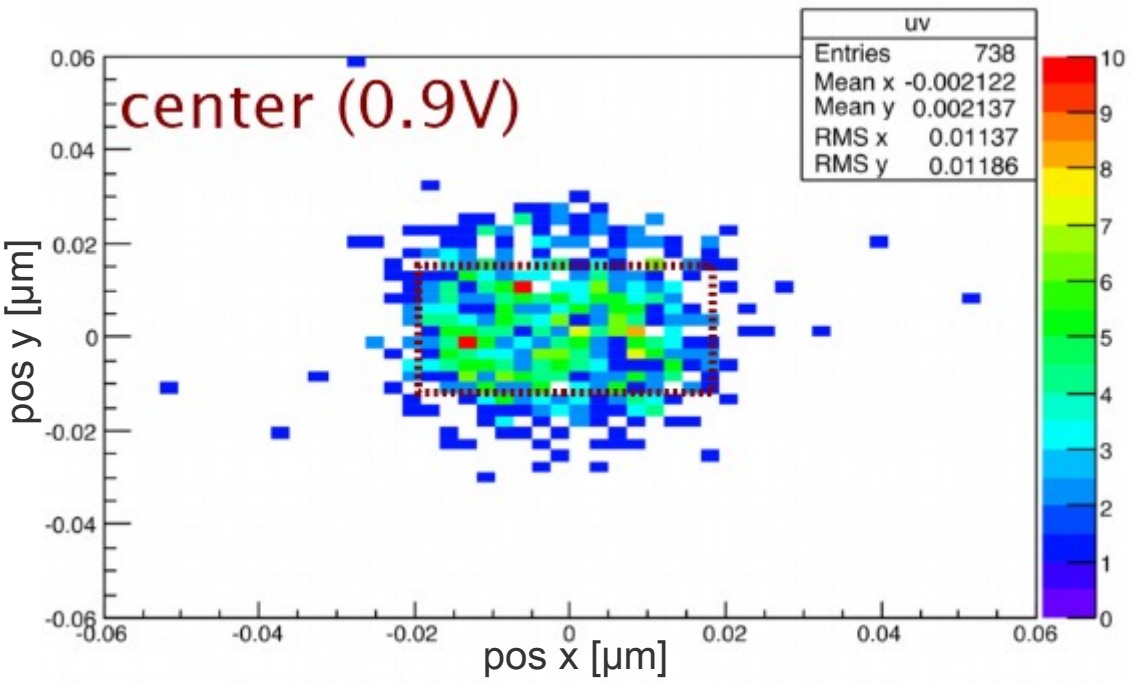


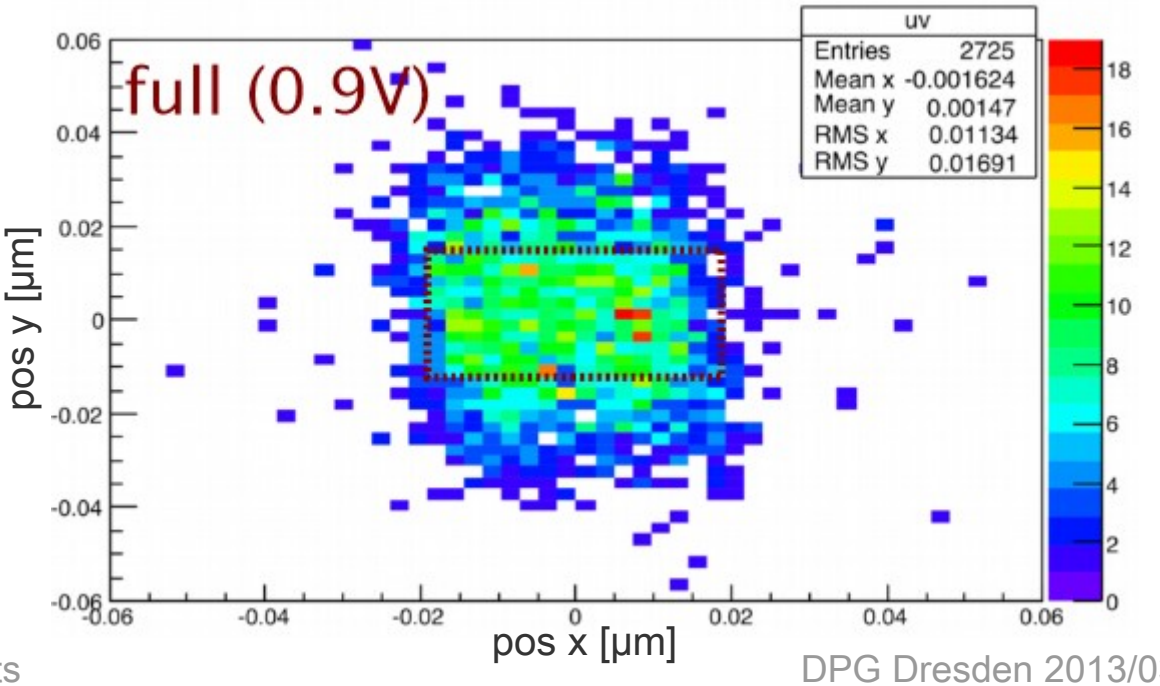
Resolution

- Independent of threshold
- Naively: pixel size and telescope resolution

$$\sigma = \sqrt{\sigma_{Telescope}^2 + \frac{d_{Pixel}^2}{12}}$$

- Expectation: $\sigma_x > \sigma_y$





- $\sigma_x \leq \sigma_y$
- Dependent on fiducial Cut
- Alignment?

Summary & Outlook

Results

- Cluster Size: Ok.
- Efficiency: On the right track.
  Structure?
- Resolution: Not Clear.
  Alignment?

What's Next?

- New Prototype: MUPIX v3
- Next Testbeam Next week
- Higher Statistics

Limitations

- **Statistics**
- Alignment
- High Voltage
- High Thresholds

Thank You!