

Draft

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GEM Detectors of Proton Charge Radius (PRad) Experiment at Jefferson Lab

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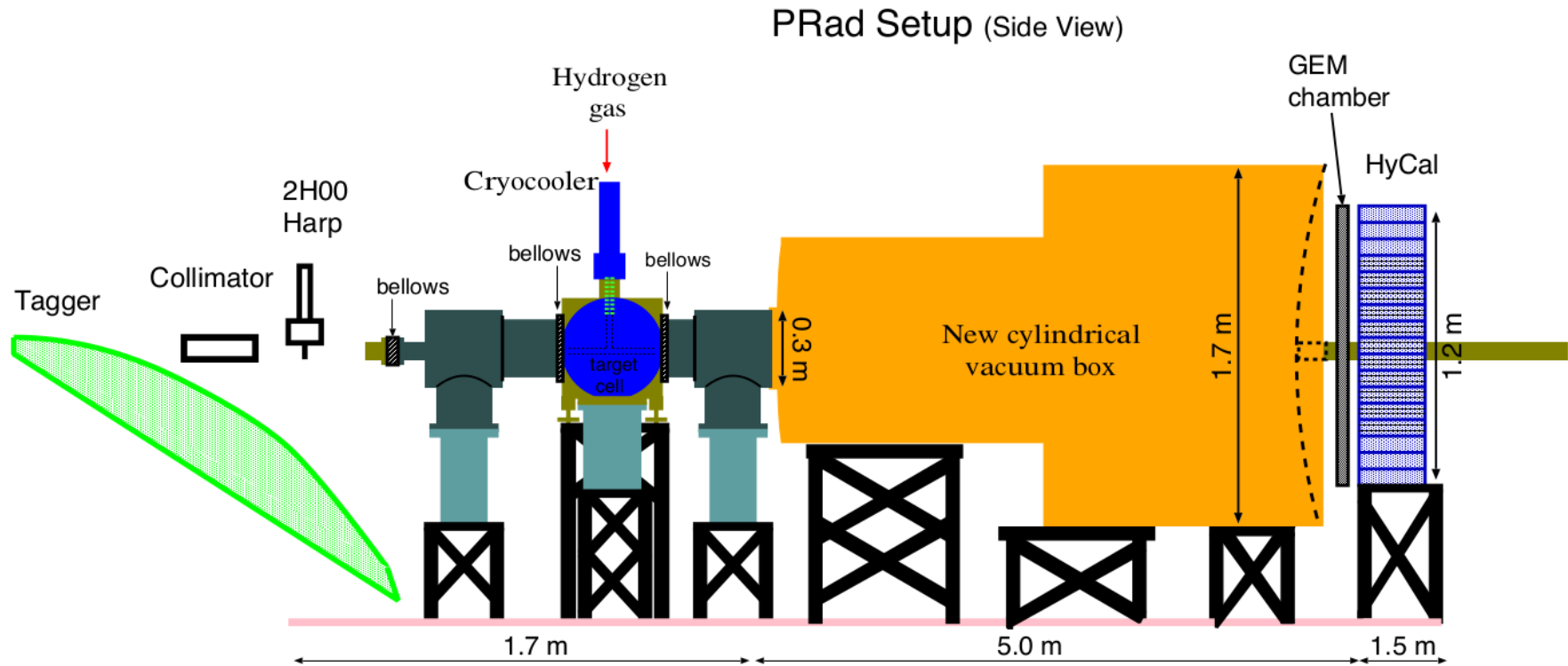
Offset Correction

Spatial Resolution

Efficiency

Performance

Prad Experiment Setup

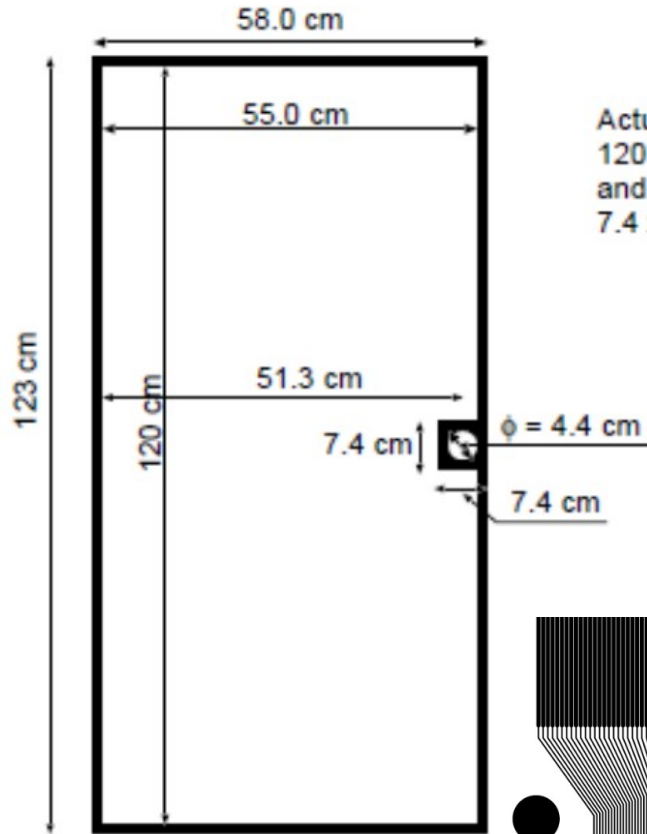


PRad Detector Setup

PRad GEM Design

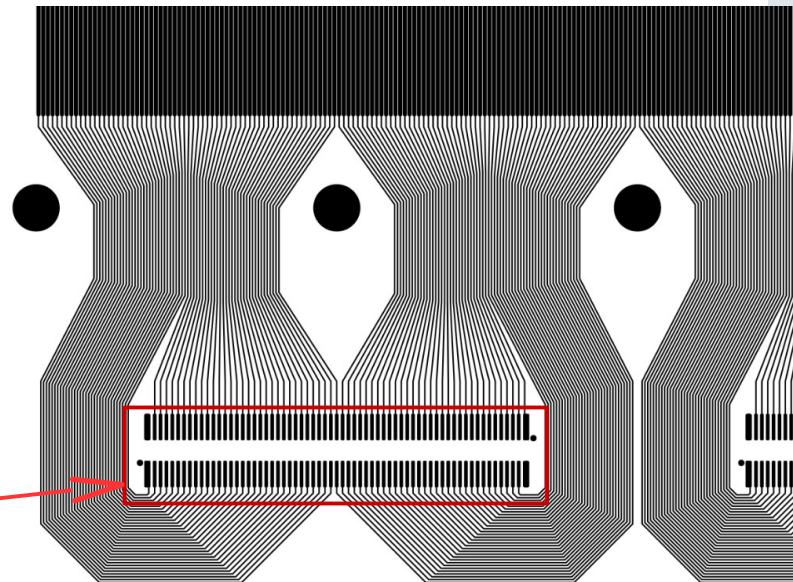
2 COMPASS-like Triple GEM Detector

Desired Sensitive area: $116.4 \times 116.4 \text{ cm}^2$
central hole: diameter 4.4 cm, including the frame max allowed
maximum allowable non-sensitive region $7.8 \times 7.8 \text{ cm}^2$



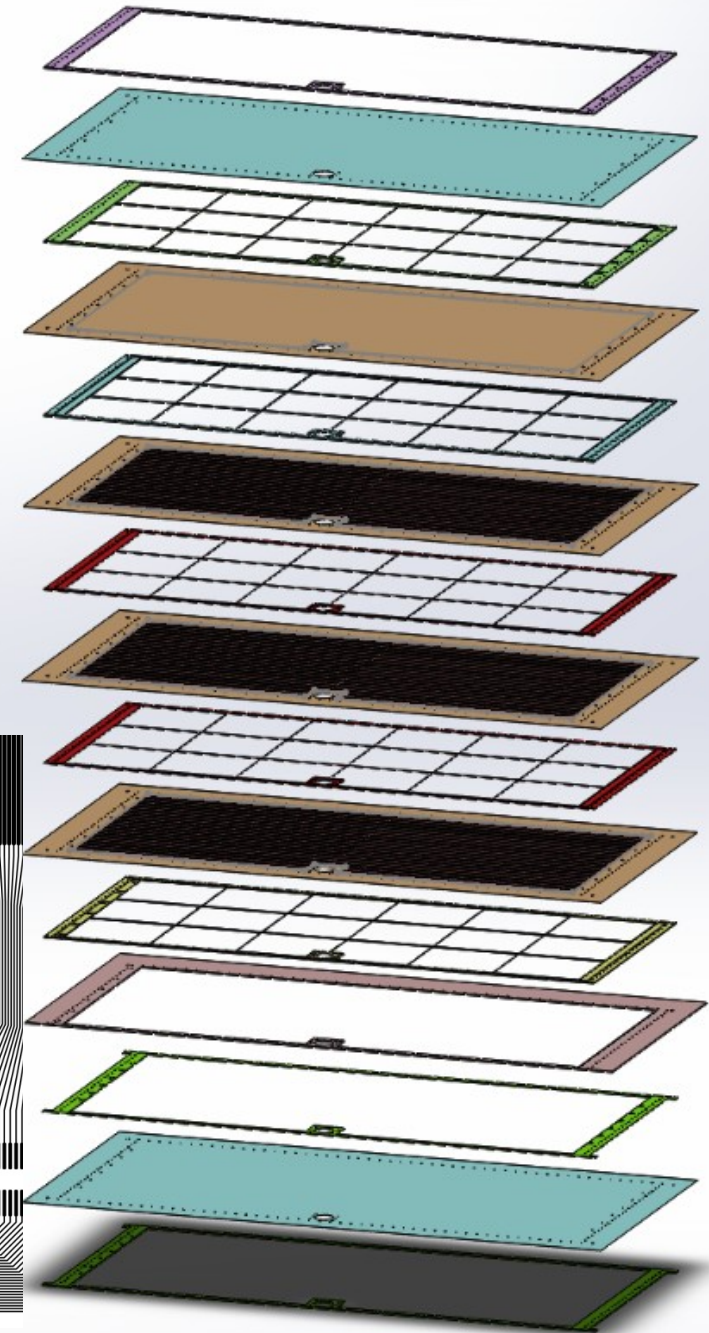
Actual sensitive area:
 $120 \times 102.6 \text{ cm}^2$
and actual non-sensitive area:
 $7.4 \times 7.4 \text{ cm}^2$

Strip Readout

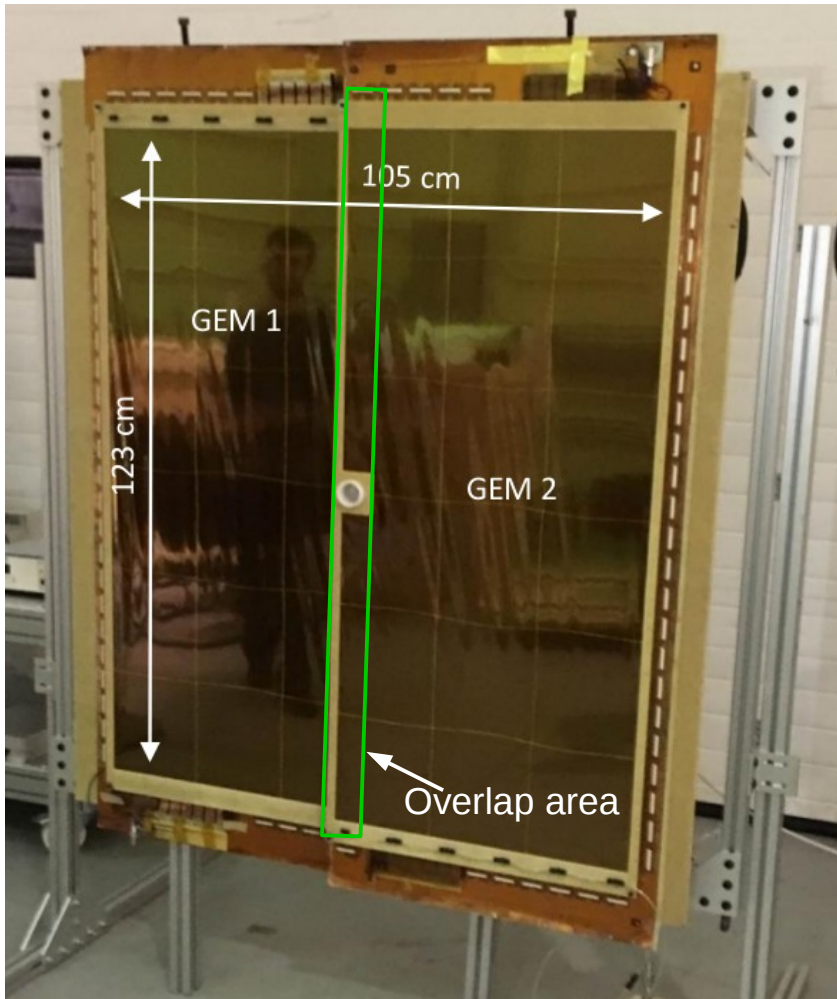


the world largest GEM Chamber

Panasonic Connector
To Front End Electronics



PRad GEM Construction

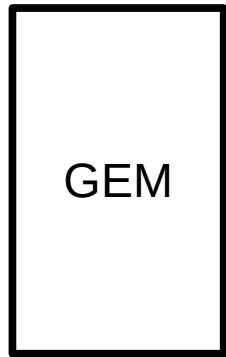


Two chambers, Overlap in the central part. Central opening hole for beam.

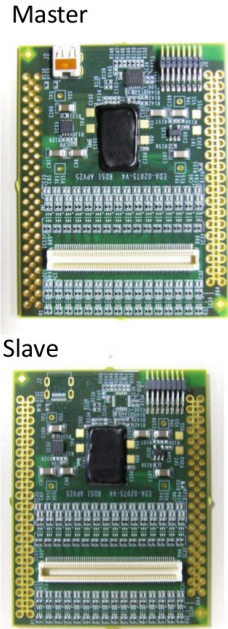


Chamber mounted on HyCal

DAQ



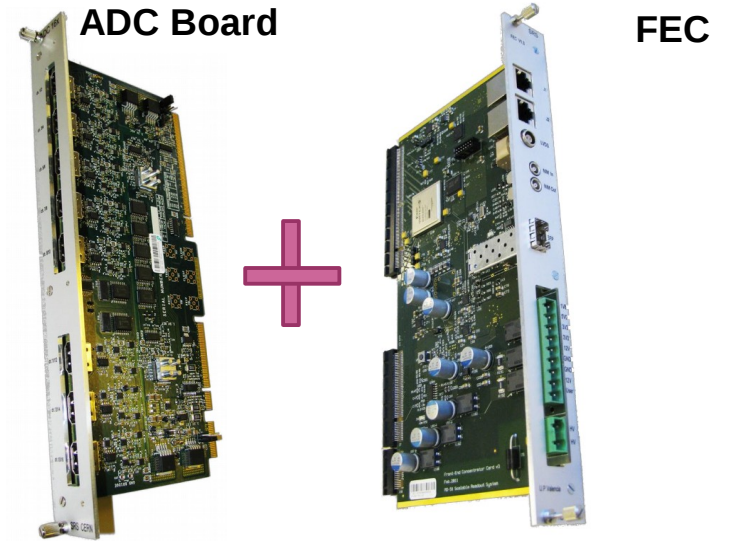
Panasonic Connector



HDMI Connection

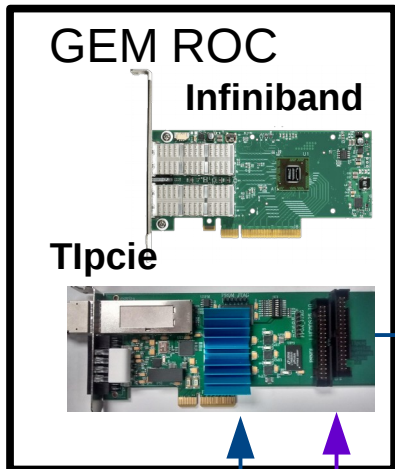


Data Flow



- ✓ Normal Event Rate: ~ 4kHz
- ✓ 2 SRUs
- ✓ 2 GEM Chambers
- ✓ 8 FEC + ADC's
- ✓ 72 APVs (a total of 9216 channels)
- ✓ 3 Time Sample
- ✓ Normal Data Transfer Rate per ROC: 150~250MB/s

DAQ Software: Hall B CODA



10Gbps Fibre



Trigger

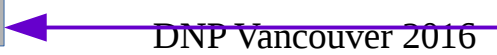


Trigger



Logic & Translator

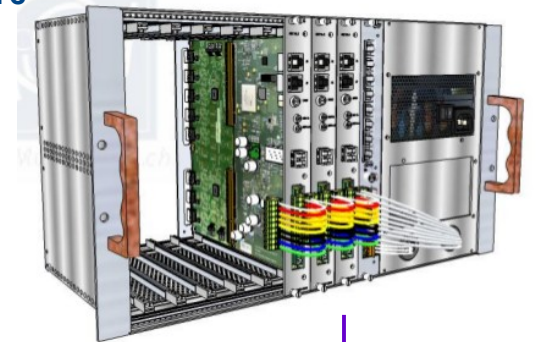
Busy Signal



TCP/UDP CAT6



SRS Crate



Trigger From Master TI

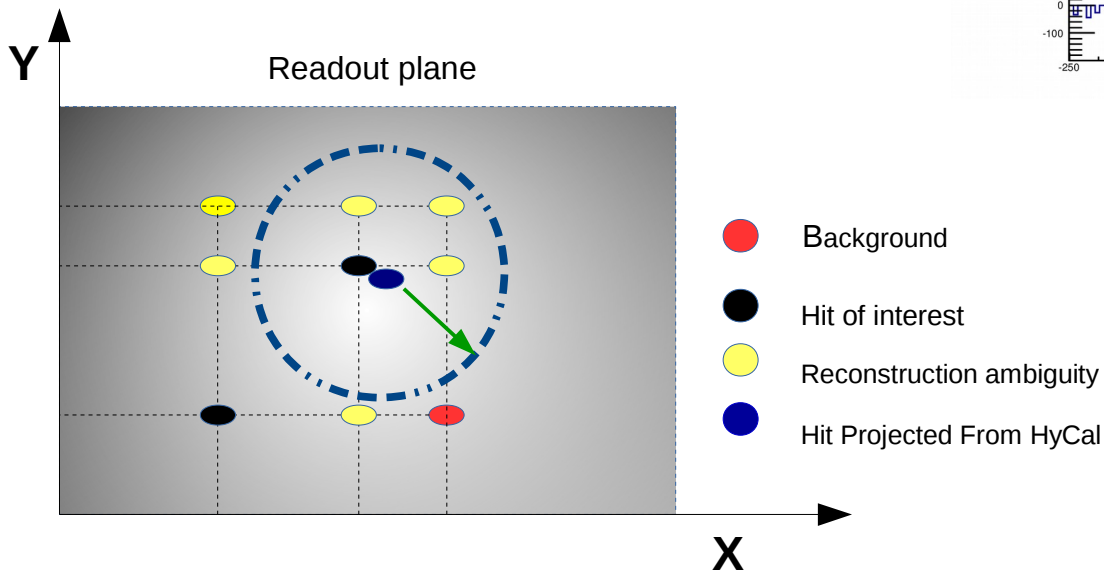
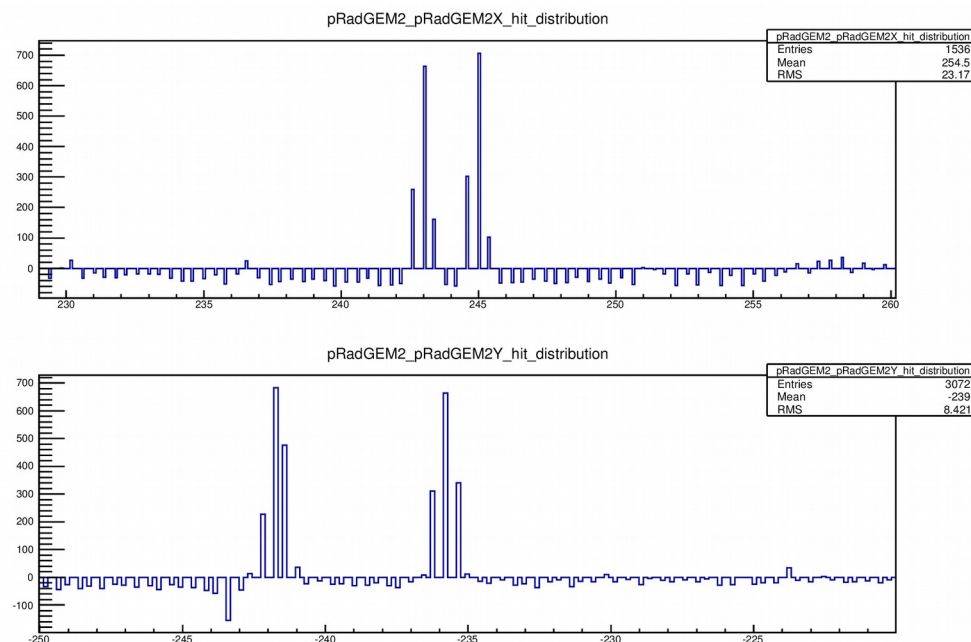


DNP Vancouver 2016

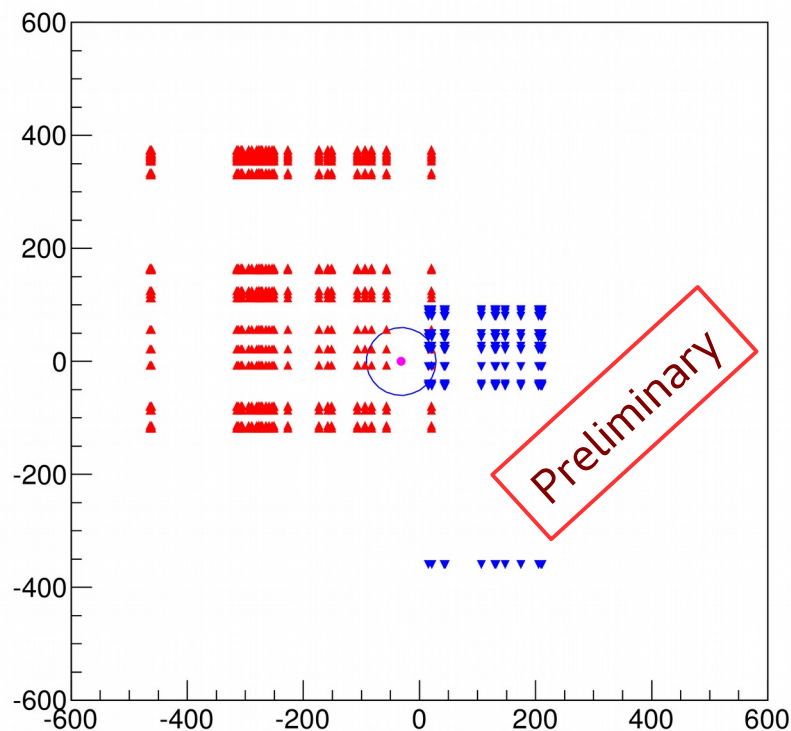
GEM Cluster Reconstruction

- Mostly Relativistic Electrons.
- Minimum Ionization Particles (MIP).
- Only one layer of GEM detectors, no tracking.
- No timing information.
- Challenge to match X-Y clusters.

One typical event from GEM Detector



Use HyCal Information to Filter GEM Clusters



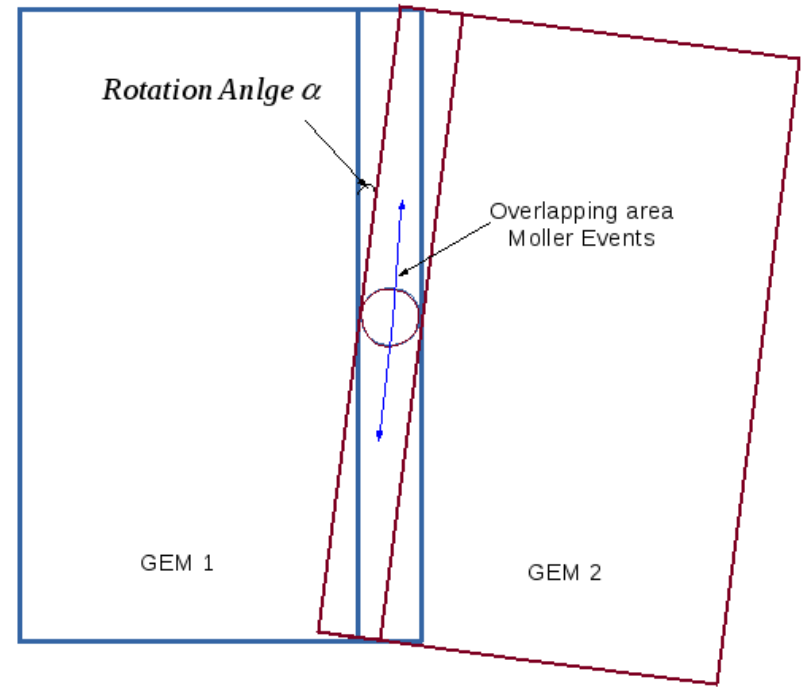
Offset Correction

Two Offsets:

- 1), Relative Rotation Between Two GEM chambers.
- 2), X-Y Offsets Between Two Chambers.

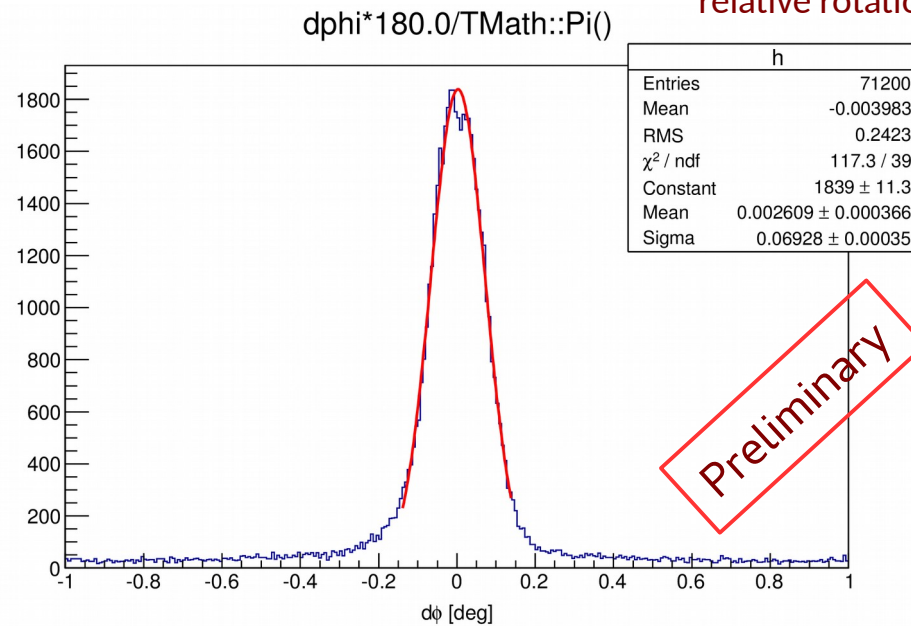
Angular Offset:

- Select moller events in the overlapping area.
- Connect the two electrons.
- On each chamber find the angle between the electron line and GEM axis.
- Get difference for rotation angle.



Using overlapping area moller events to find relative rotation between two gems.

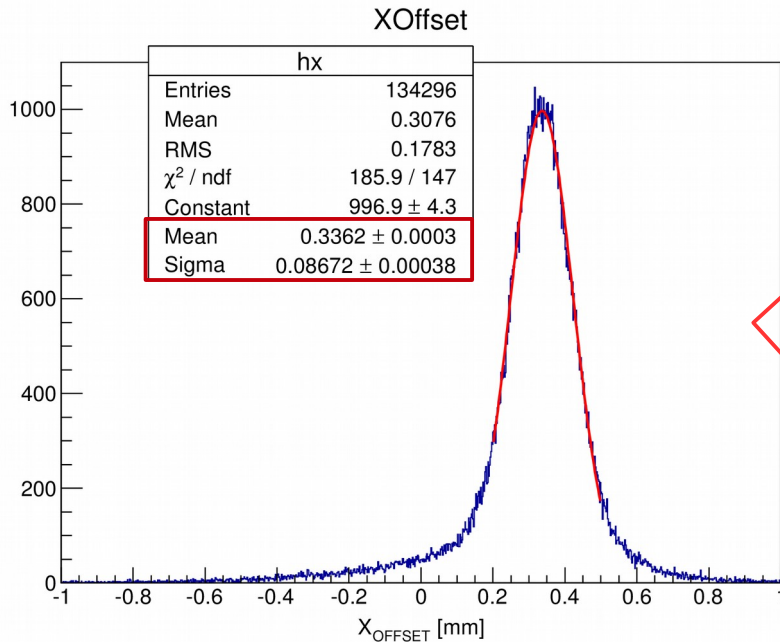
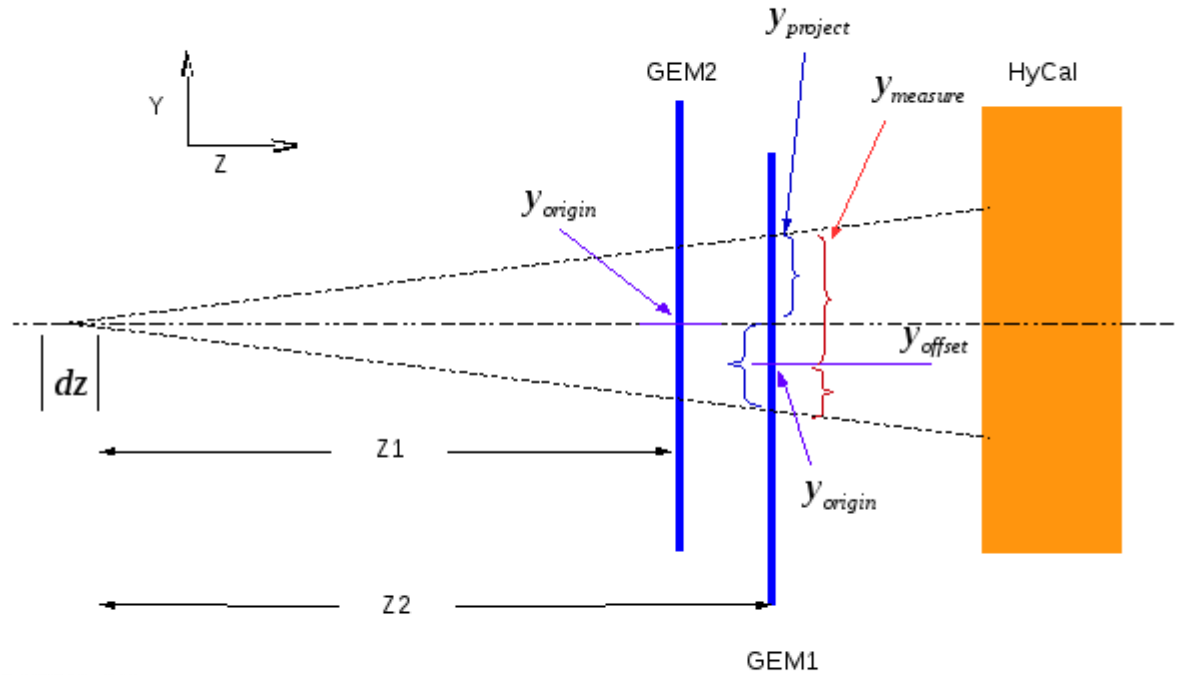
Value: ~ 0.0026 deg.
negligible



Offset Correction

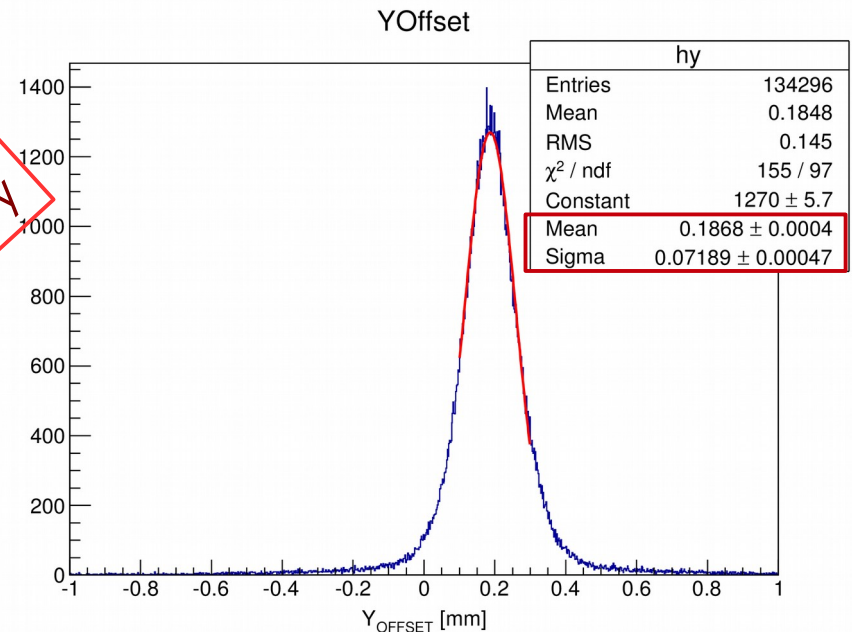
X-Y Offset:

- Using overlapping area events.
- Project GEM1 Coordinates to GEM2.
- Take the difference of projected value and measured value.



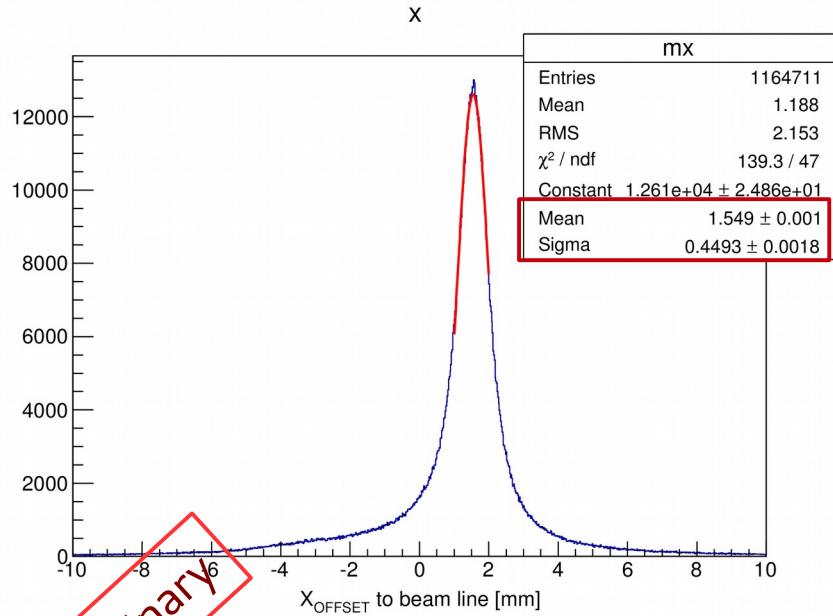
Preliminary

Vanc

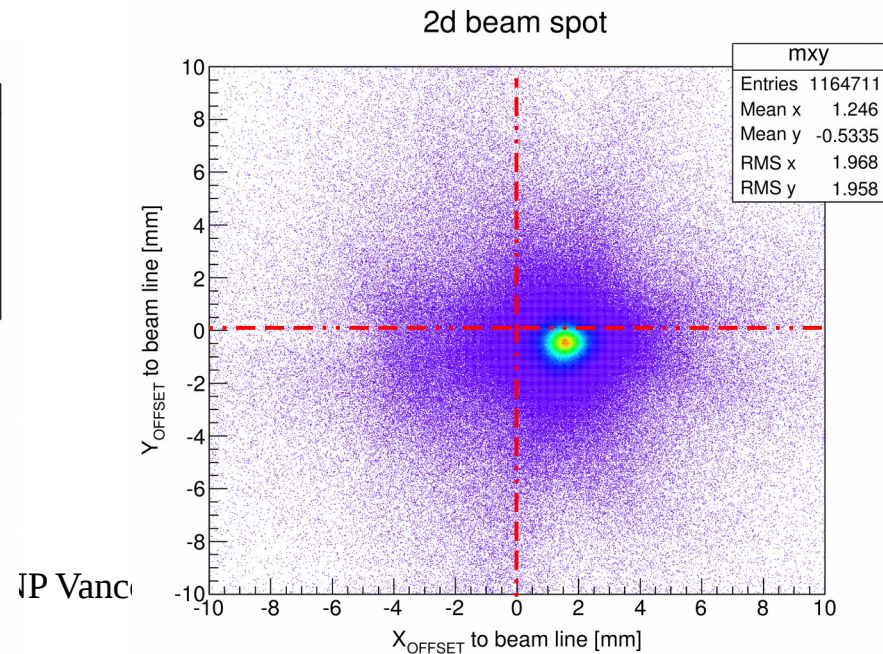
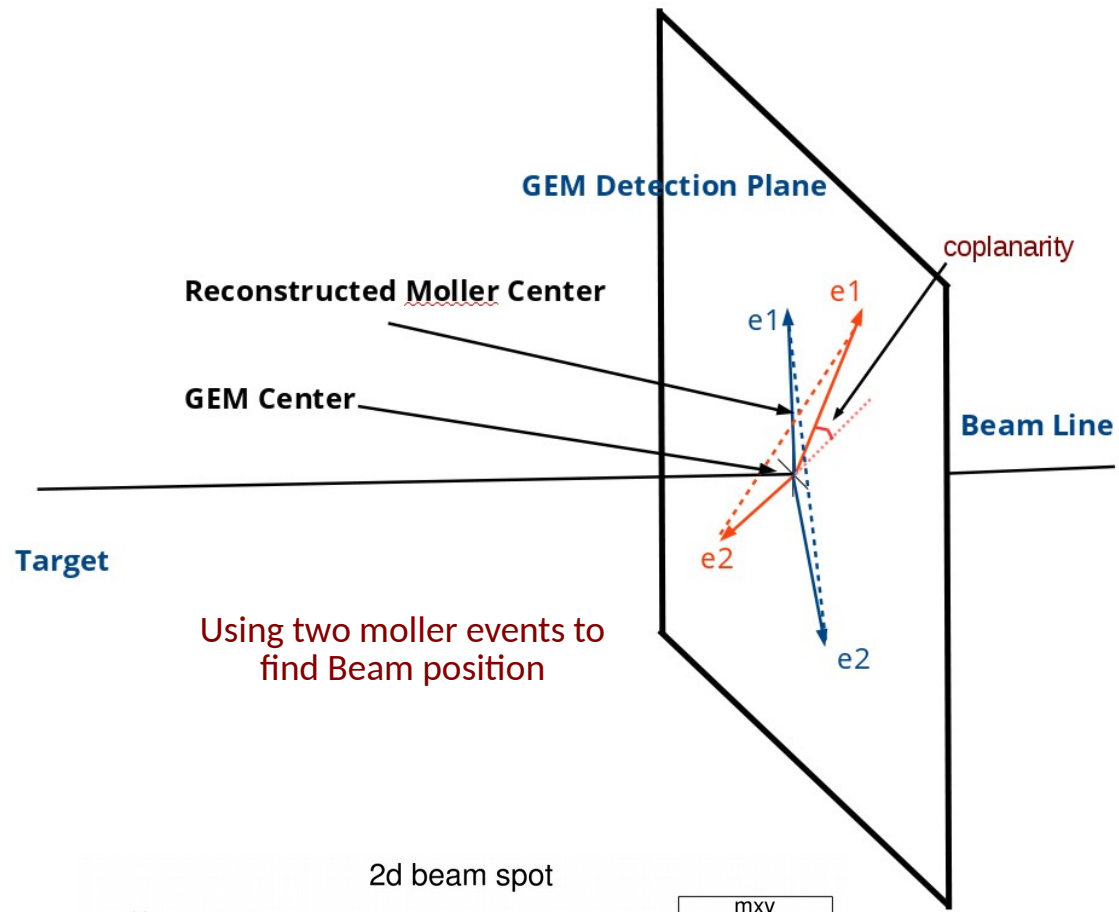
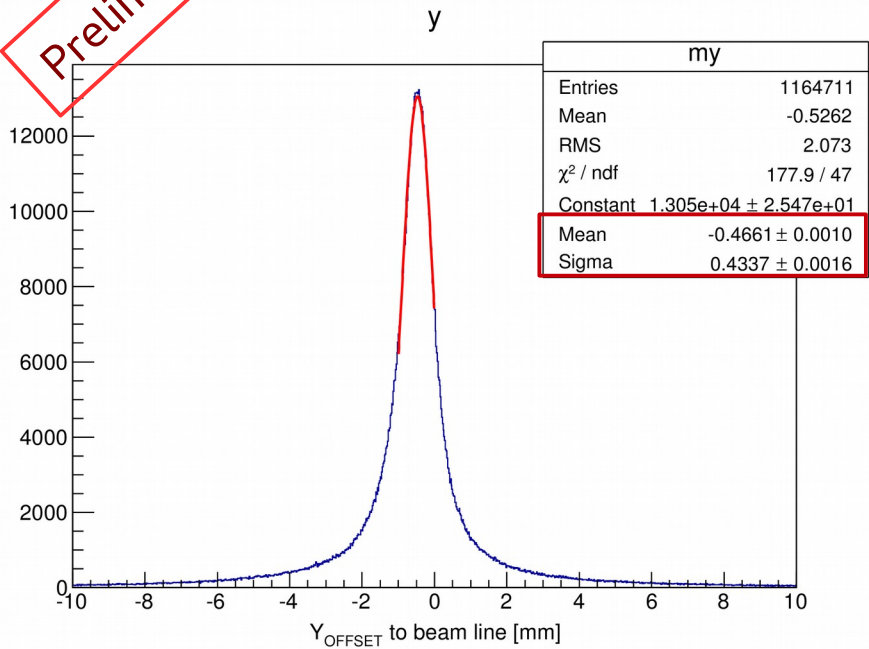


Offset Correction

Reconstructed Beam Spot.



Preliminary



Resolution Check

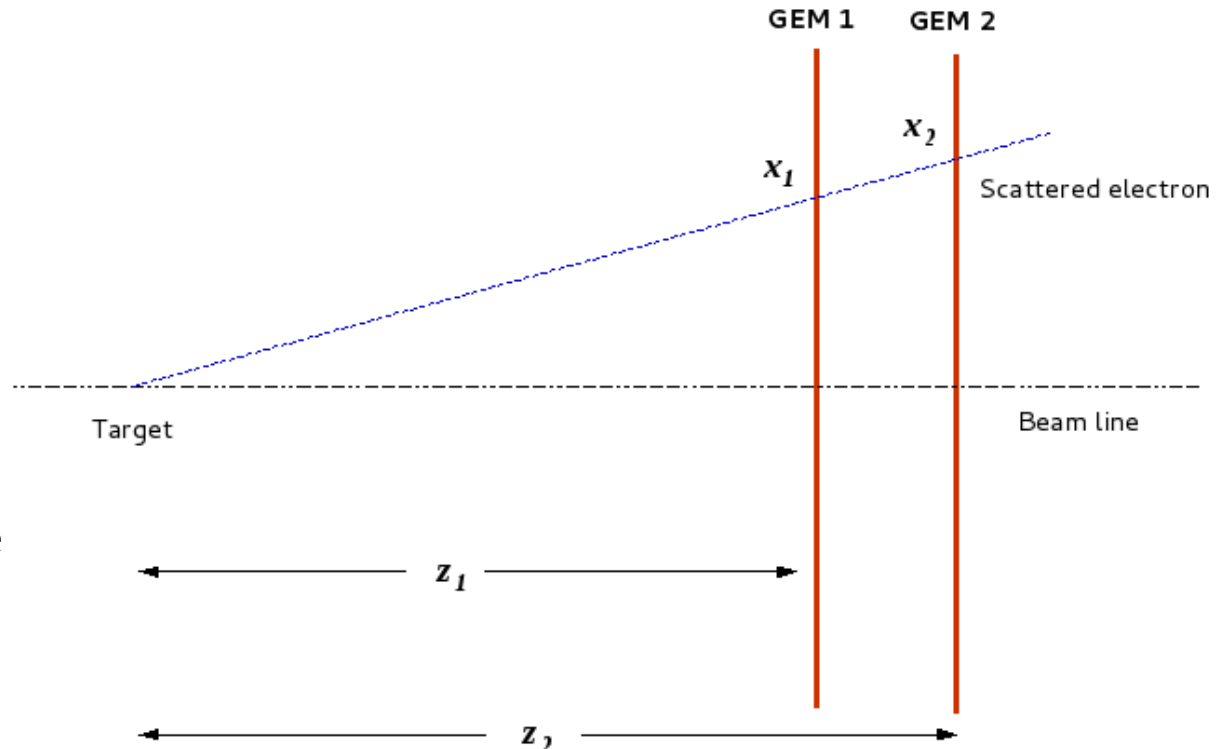
Using overlapping area e-p events to check resolution.

Procedures to Check Spatial Resolution:

- Correct offsets.
- Project GEM1 coordinates to GEM2.
- Find statistical width.
- Suppose two chambers have the same resolution:

$$\sqrt{\sigma_{gem1}^2 + \sigma_{gem2}^2} = \sigma_{stat}$$

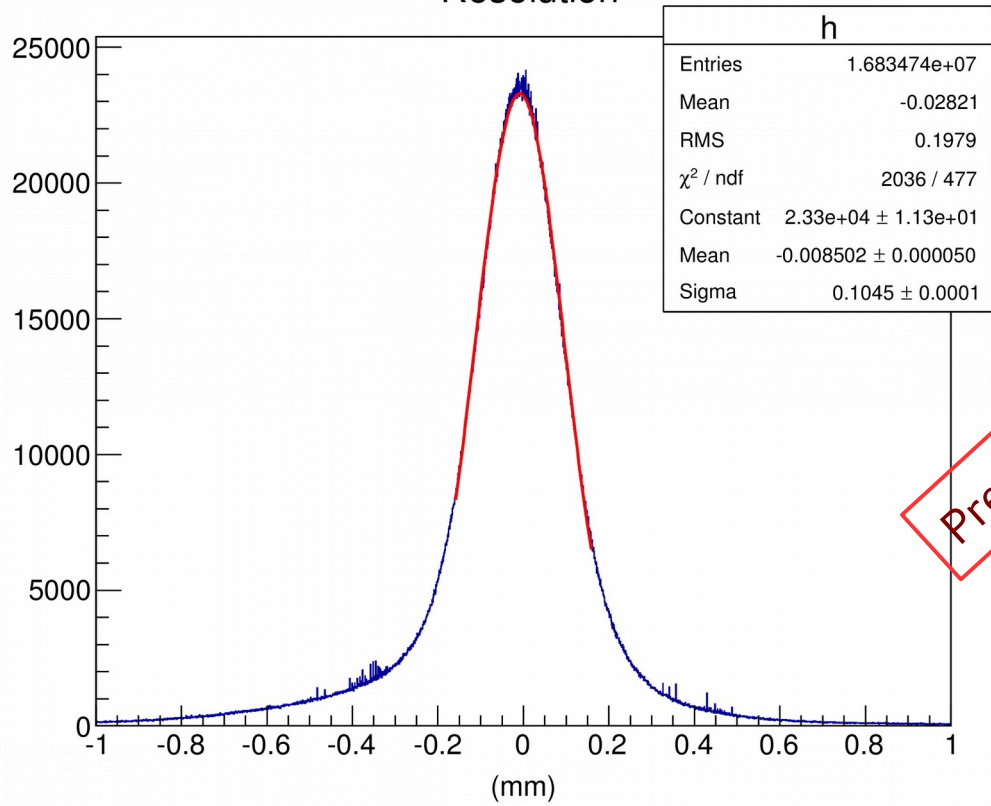
$$\sigma_{gem} = \sigma_{stat} / \sqrt{2}$$



Resolution Check

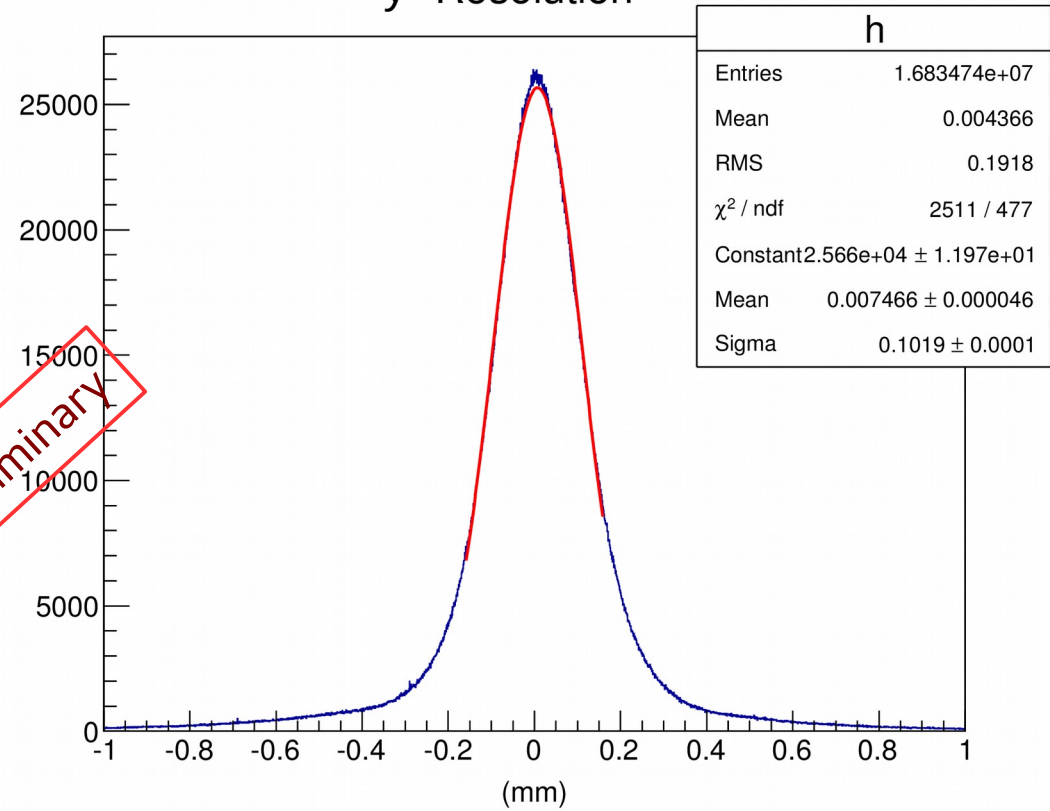
Using overlapping area e-p events to check resolution.

X Resolution



$$\sigma_x = 73.89 \mu\text{m}$$

y Resolution



$$\sigma_y = 72.05 \mu\text{m}$$

Preliminary

GEM Efficiency From Production Runs

Efficiency from e-p events:

- 1), Select e-p events from HyCal.
- 2), Match gem Clusters.
- 3), # GEM cluster / # HyCal cluster.

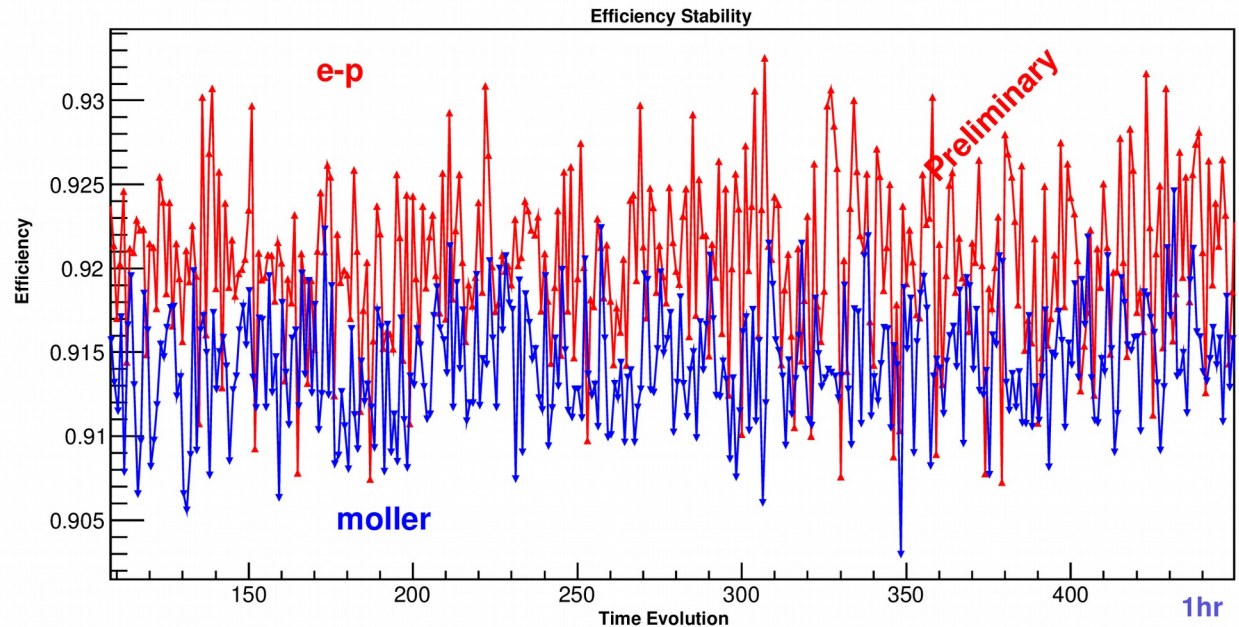
Efficiency from Moller events:

- 1), Select moller events from HyCal.
- 2), Match gem Clusters.
- 3), # GEM cluster / # HyCal cluster.

Efficiency Preliminary Results:

E-p: 92.0% +/- 0.03%

Moller: 91.4% +/- 0.03%

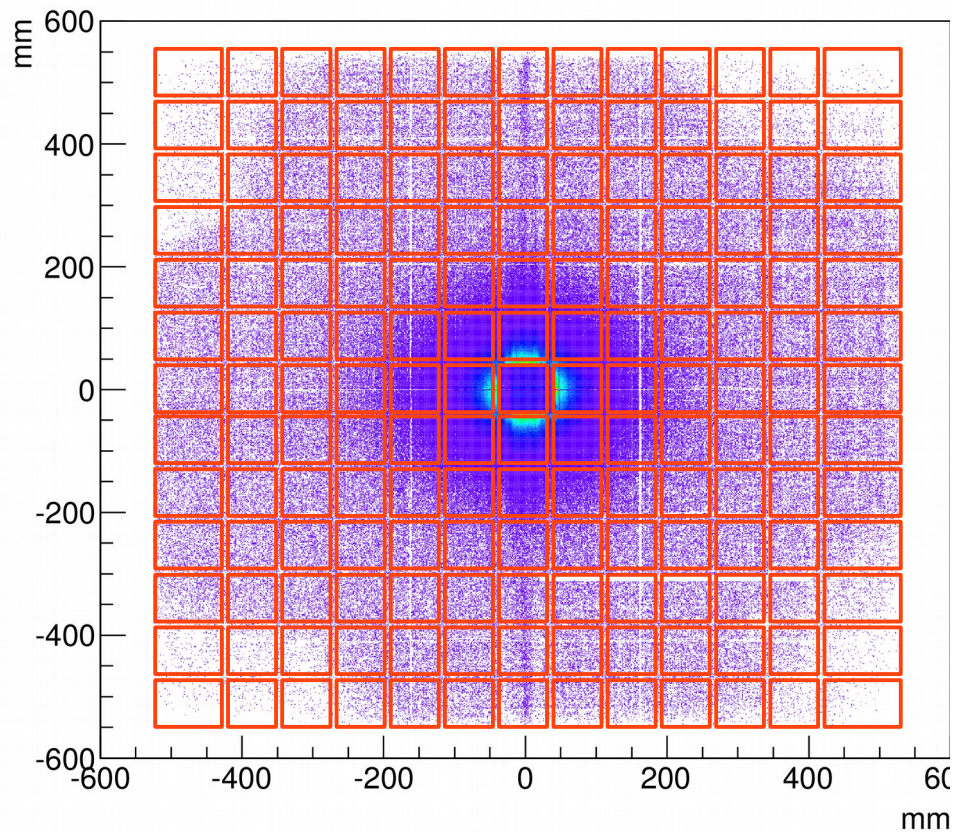


GEM Efficiency By Sectors

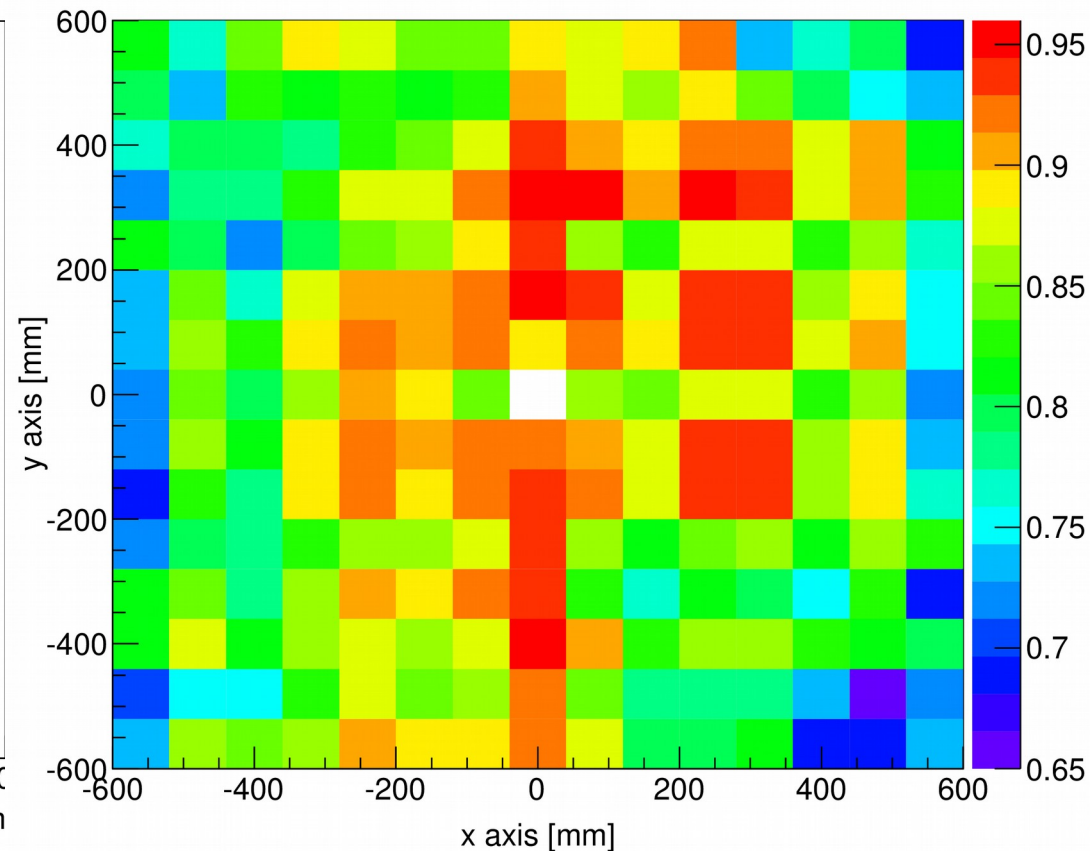
Using preliminary e-p + Moller events. Efficiency relative to hycal. Clusters Filtered by HyCal.

- Divide GEM Plane into 225 sectors (sector size: 72mm by 72mm).
- Estimate Efficiency for each sector.

A Qualitative Plot showing efficiency by sectors.



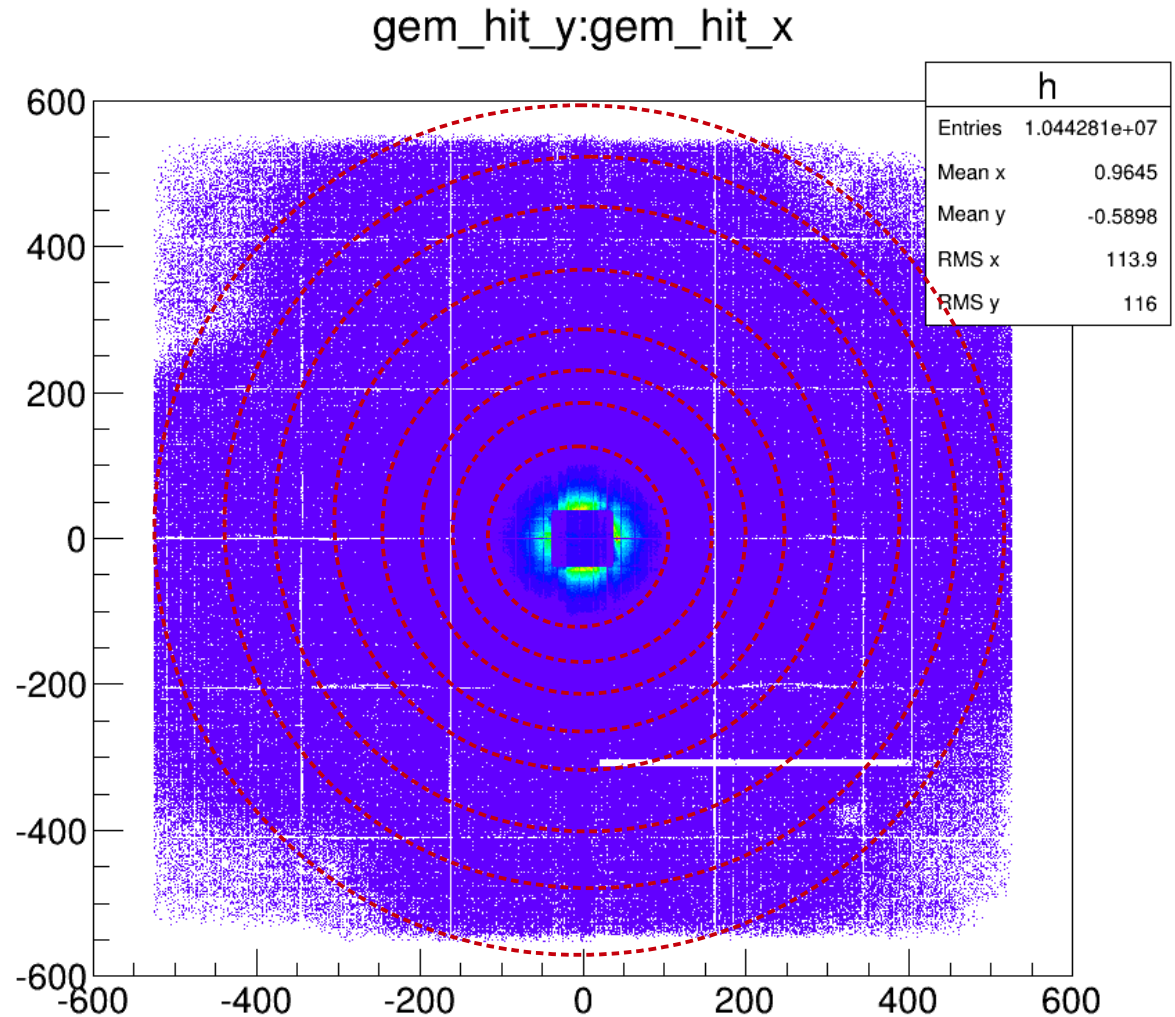
gem efficiency map



GEM Efficiency along Radius

Using preliminary e-p + Moller events. Efficiency relative to hycal. Clusters Filtered by HyCal.

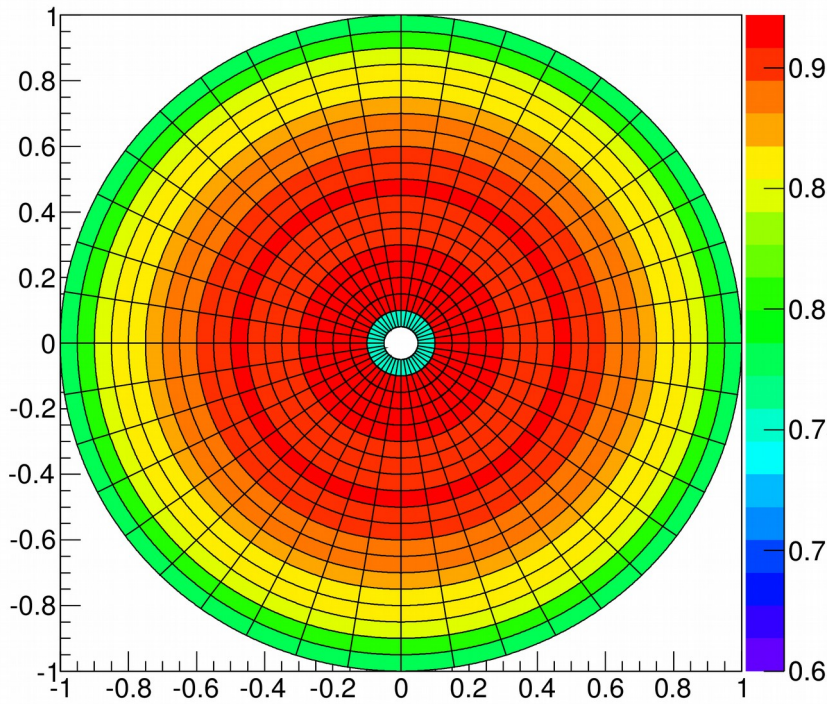
- Divide GEM Plane into 20 rings. (ring radius difference: 30mm).
- Estimate Efficiency for each ring.



A Qualitative Plot showing Efficiency along Radius

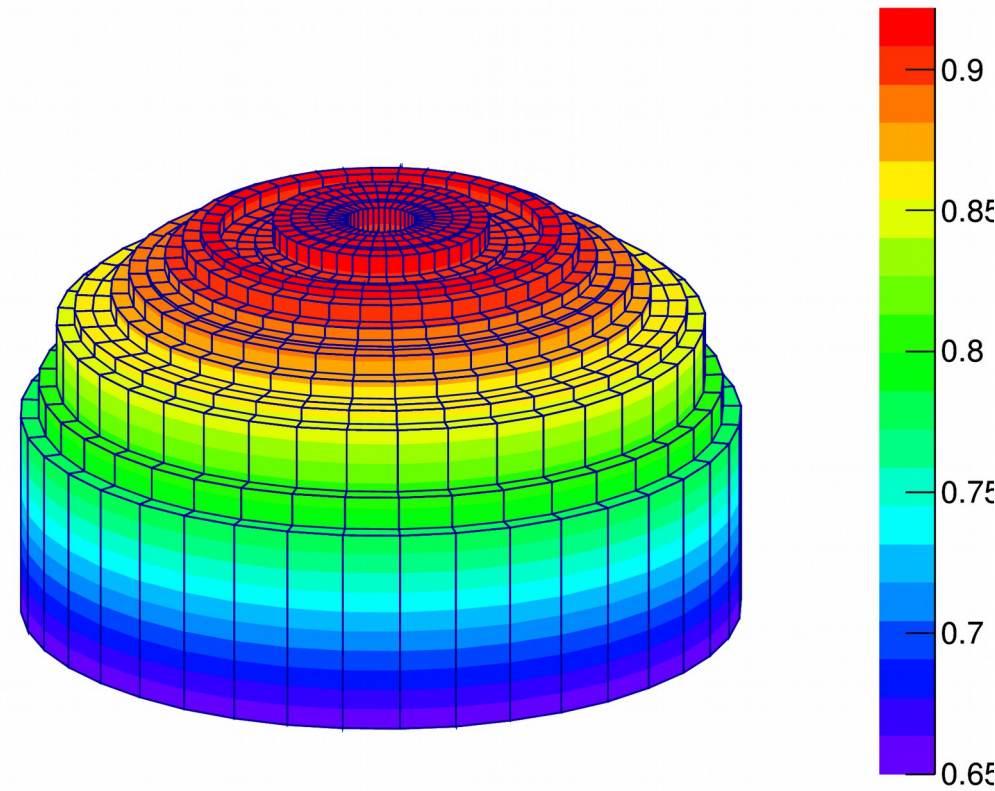
Using preliminary e-p + Moller events. Efficiency relative to hycal. Clusters Filtered by HyCal.

efficiency along radius



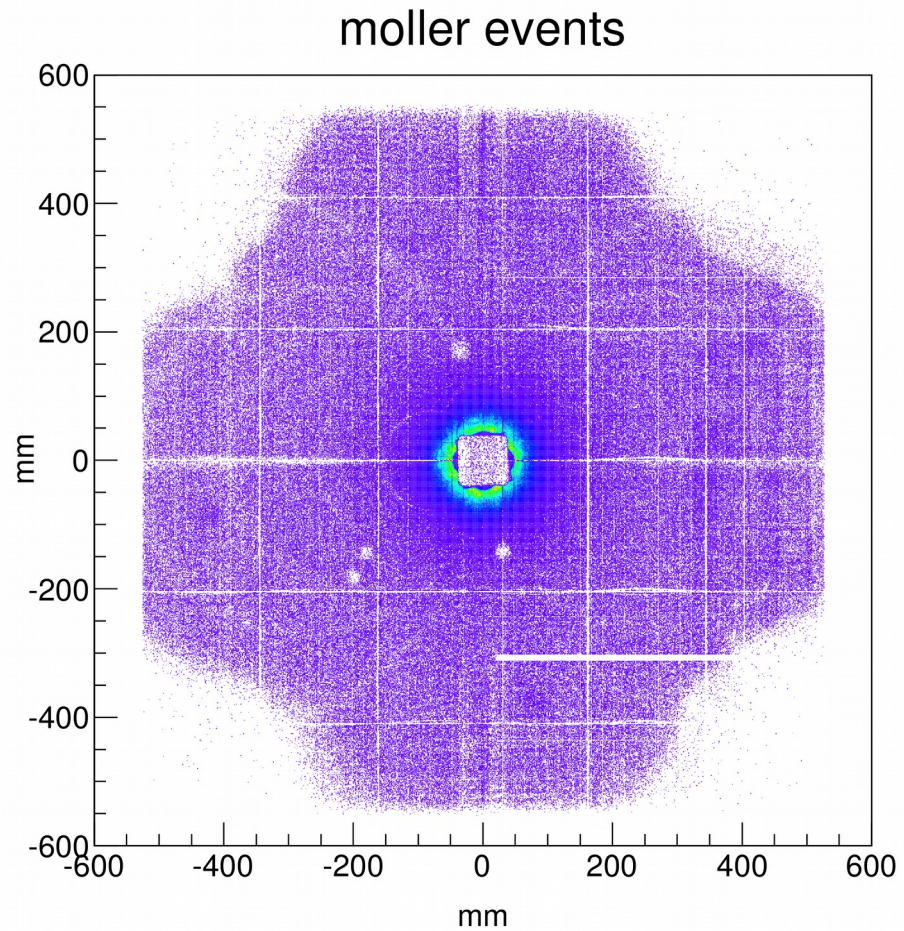
Units R/600mm

efficiency along radius

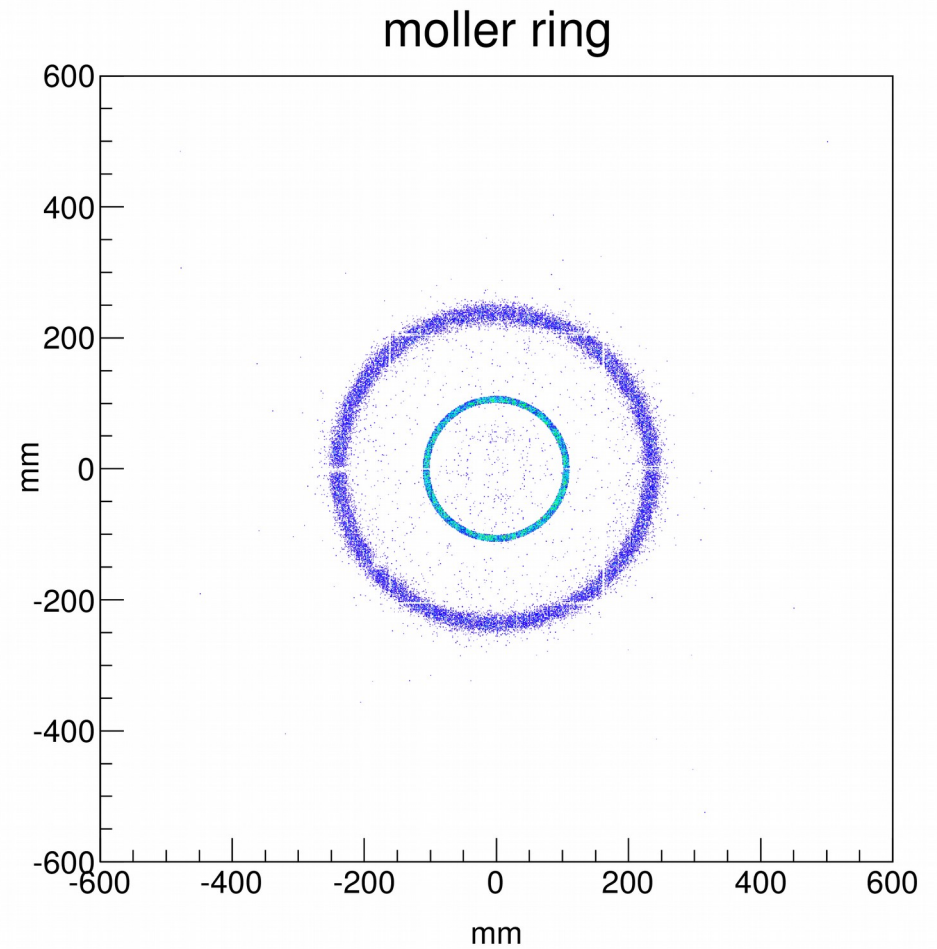


Dead Area Not yet Excluded

Performance



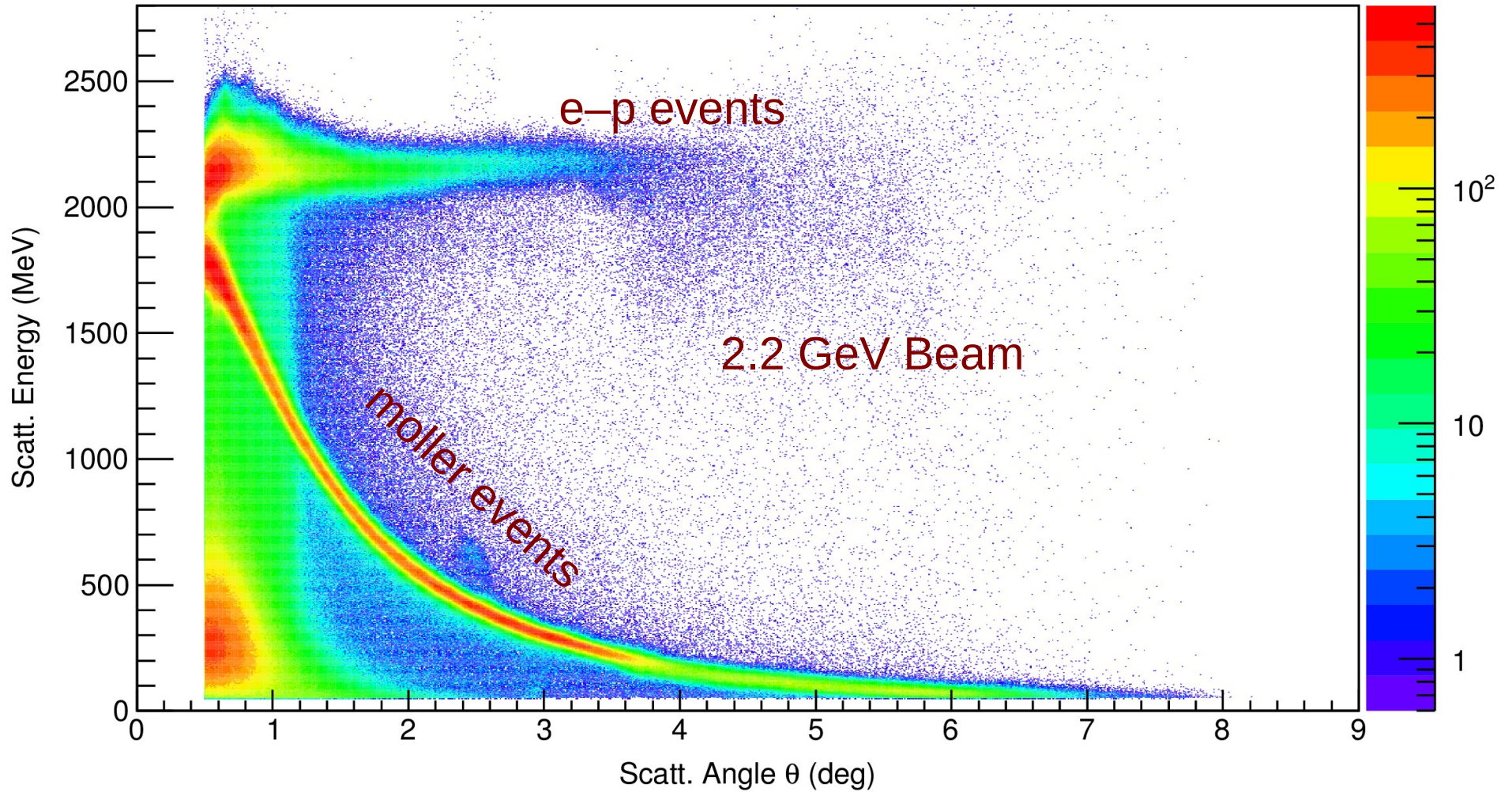
Overall 2-hits events (suspected moller events) 2D position distribution From GEMs.



Moller Ring From GEMs

Performance

Scatt. Energy vs Scatt. Angle



Summary

Very Good Performance GEM detector.

- 1), World-largest GEM Chambers.
- 2), High Spatial Resolution achieved.
- 3), High quality data.

Data Analysis On going...

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