

GEM Efficiency Preliminary Results and Data Analysis

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13th July 2016

PRad Collaboration Meeting

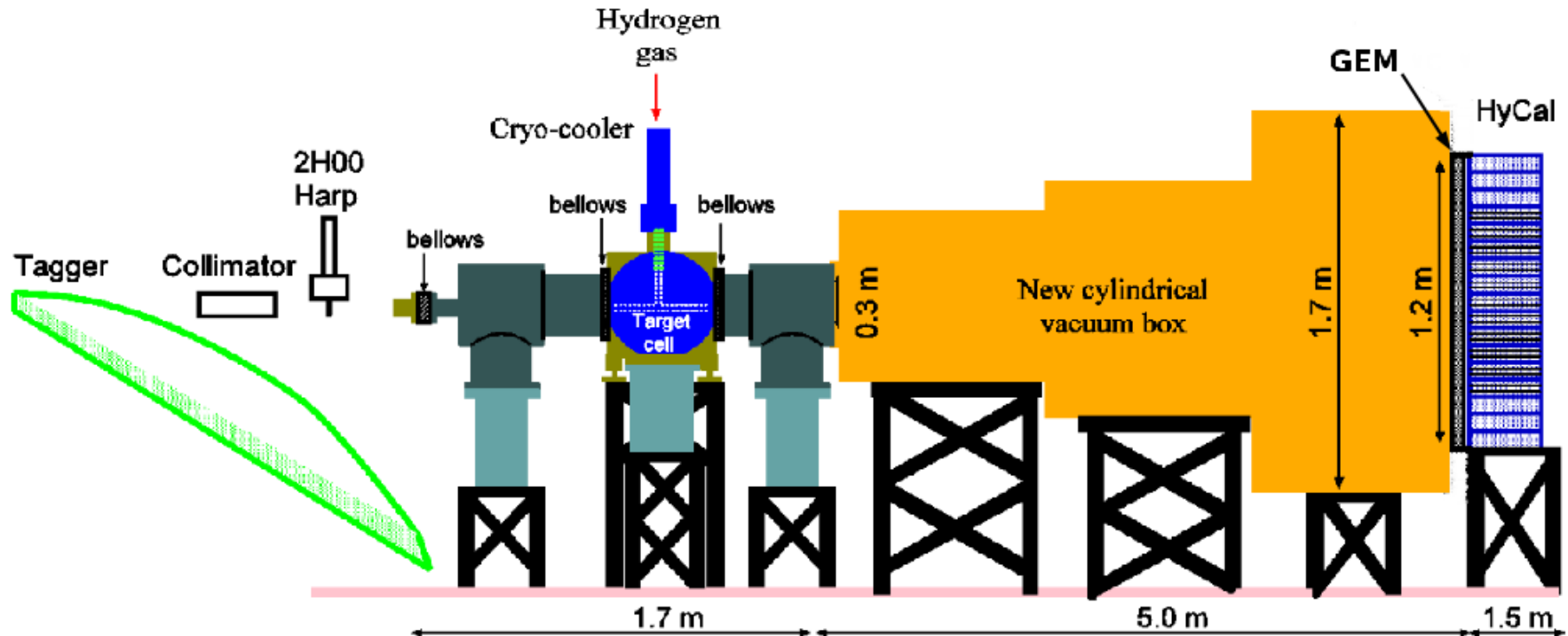
Contents

- 1, Detector Setup
- 2, GEM Efficiency
 - 1), GEM and HyCal Match
 - 2), Calibration
 - 3), Production
- 3, Data Analysis
 - 1), Geometry Calibration
 - 2), other results
- 4, Summary and Next

Detector Setup

Production:

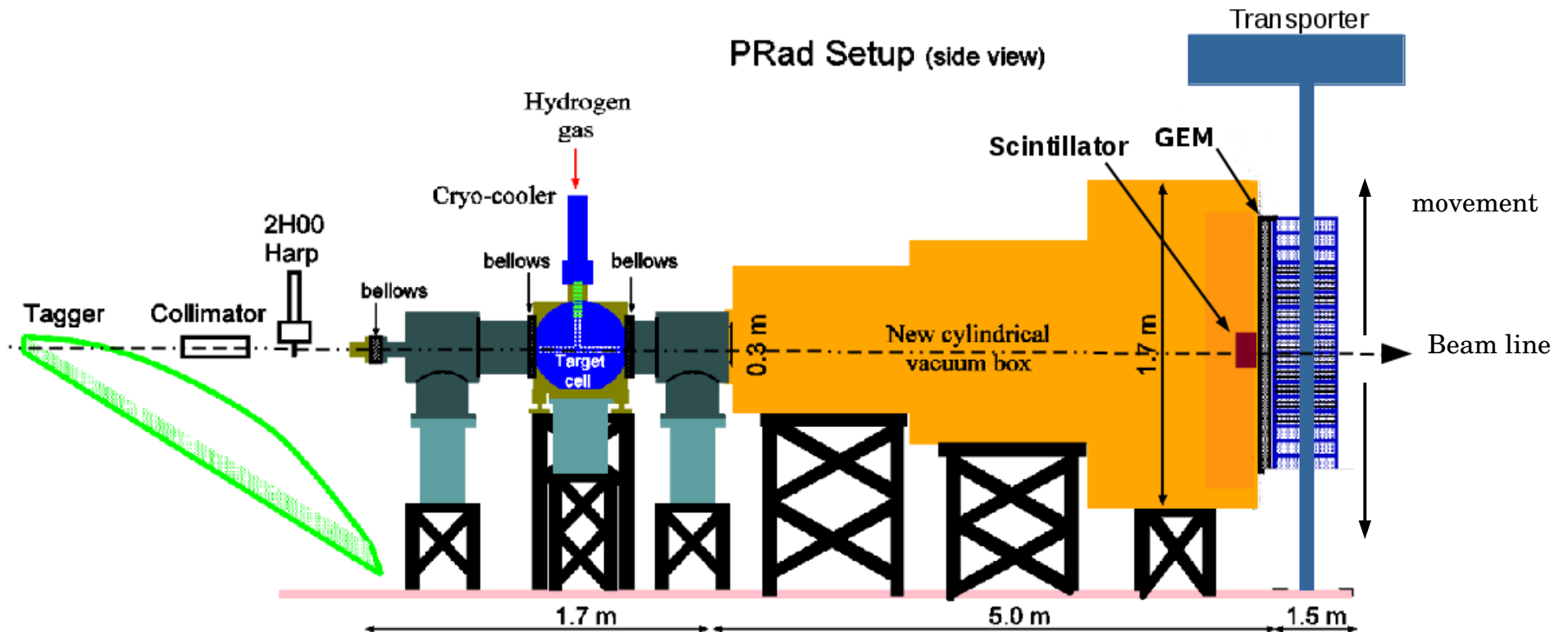
PRad Setup (side view)



Production Setup, GEM mounted on HyCal, which sits on a shelf.
Efficiency measurement from production Runs.

Detector Setup

Calibration:



Calibration Setup, GEM mounted on HyCal, which is mounted on a transporter. Can move upward and downward, leftward and rightward. Using Tagger, photon beam.

GEM and HyCal Match

The way to construct clusters on GEM

Restrictions:

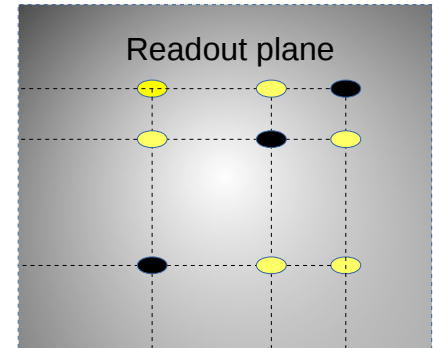
- 1), Only one layer of GEM.
- 2), no timing information on GEM clusters
- 3), A large part of events have two particles hitting GEM at the same time (moller, pair production ...)
- 4), both of the two particles have minimum Ionization deposit energy
- 5), have to match x and y

Usually match them by:

- 1), construct the right track from multiple GEM layers.
- 2), match according to ADC values.

But in our case, the two clusters on x side have about the same adc value as on y side, and we have only one GEM layer.

High likely mismatch between X and Y.



GEM and HyCal Match

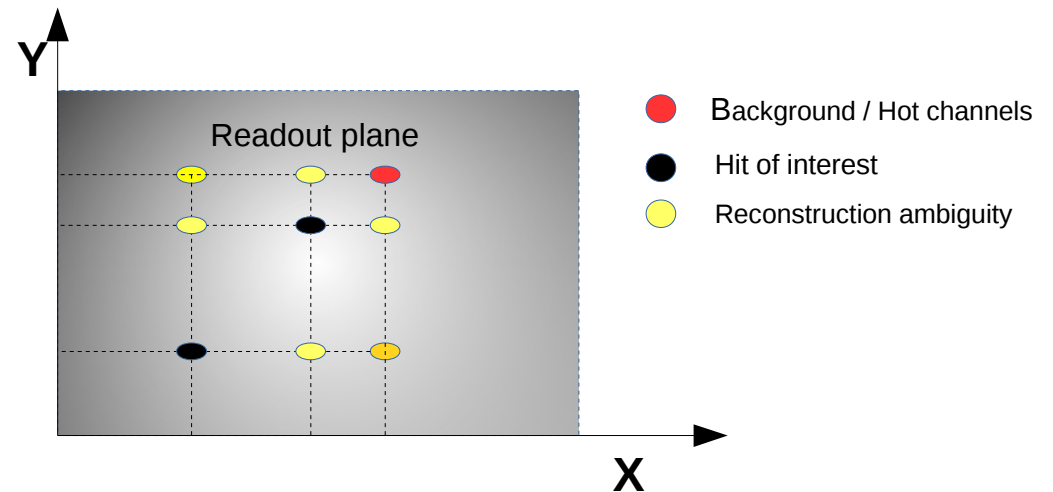
Benefits:

Use HyCal hits to filter out GEM Hits.

HyCal has no matching problem.

Obsolete the old matching way

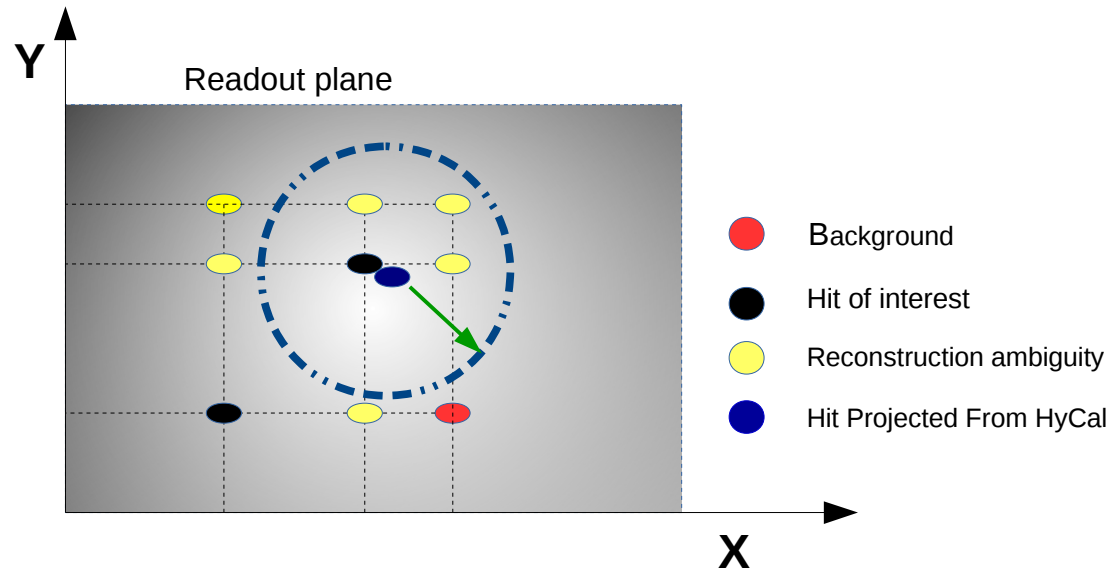
Construct all possible hits on gem
e.g. : 2 clusters on X, 2 clusters
On Y => 4 constructed hits.



GEM and HyCal Match

The matching method*:

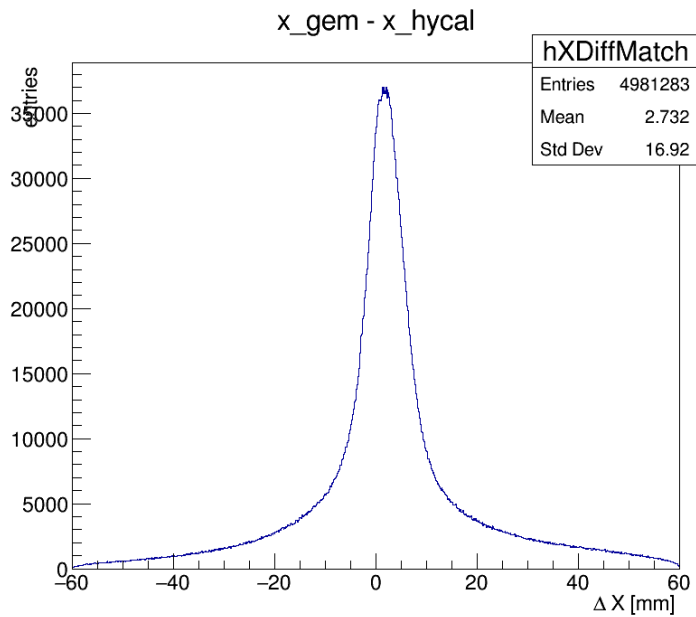
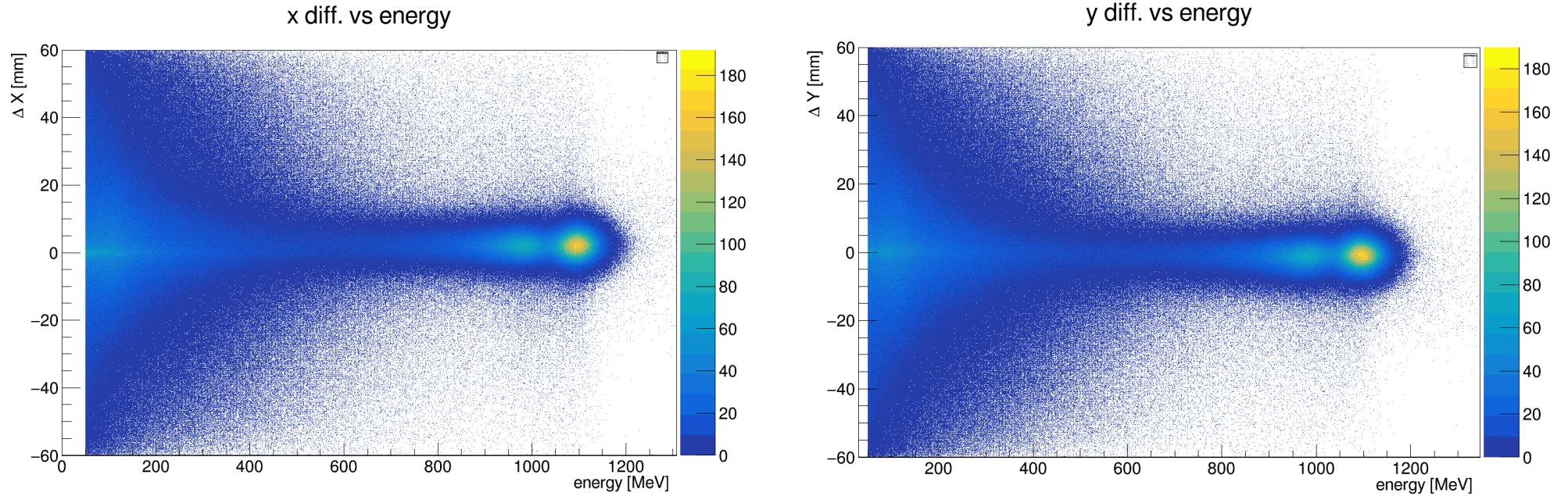
For each cluster on hycal, search the closest one on GEM, within a certain area.



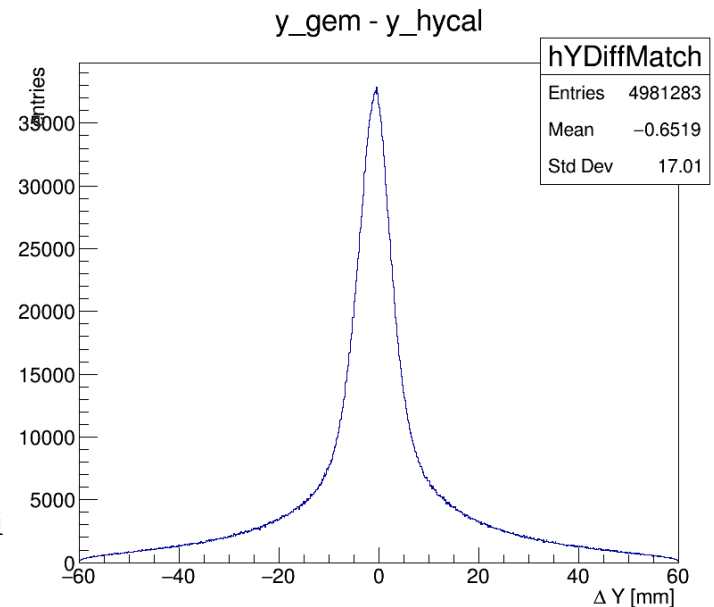
* : Given that for each real cluster on gem, we need to go back to HyCal and get its energy, so if hycal does not have the one, we need to discard this cluster anyway.

GEM and HyCal Match

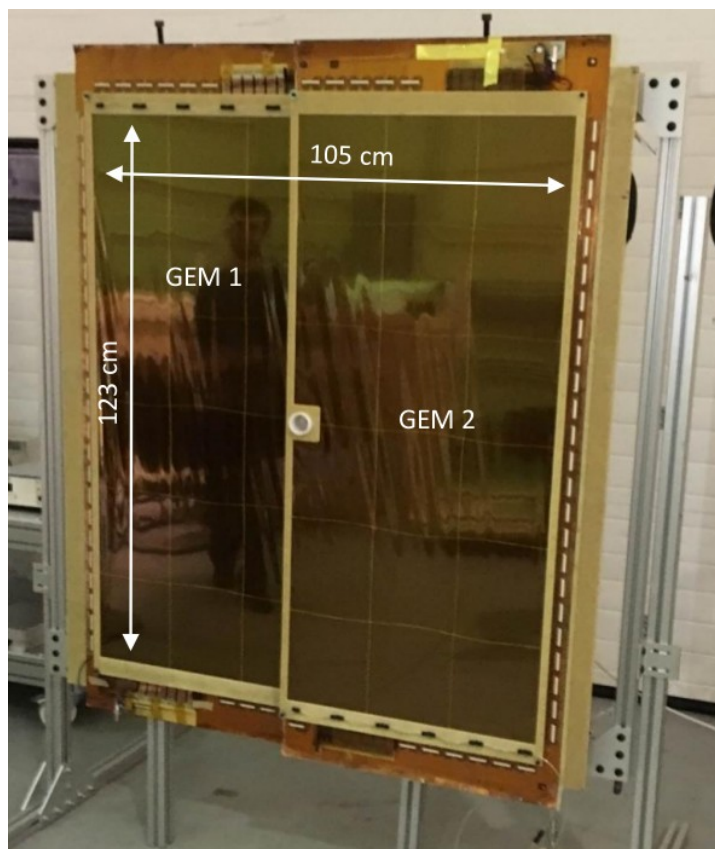
For a quick impression about the matching:



Electron beam
1.1 GeV data



GEM Efficiency from calibration runs



GEM Setup Before mounted on HyCal

Analysis Status :

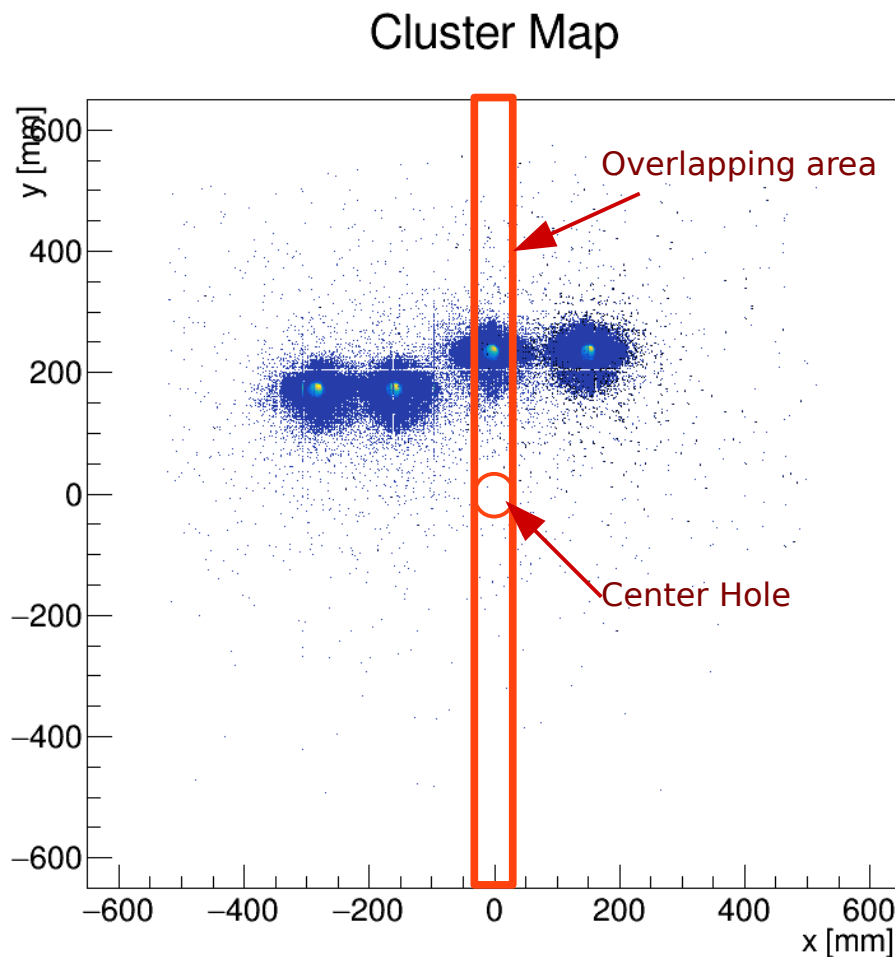
~50% percent data finished
analyzing...

4 spots

Results very preliminary.

PRad Coll

- 1), Two World largest GEM Detectors
- 2), 44mm overlapping area in the middle

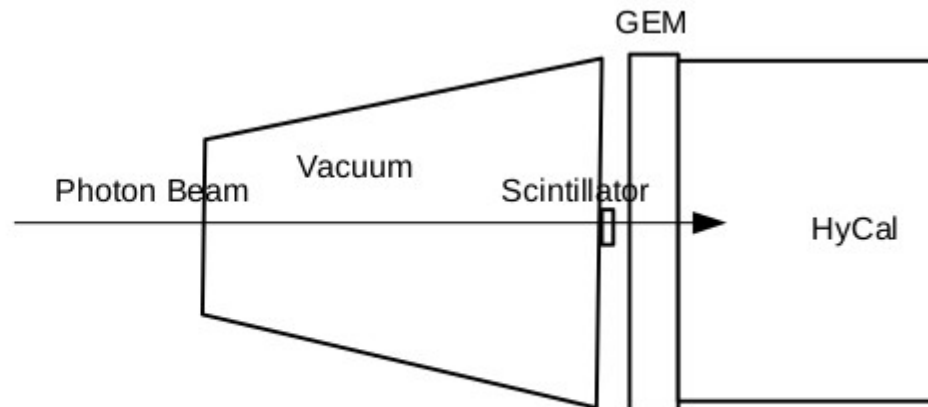


GEM Efficiency from calibration runs

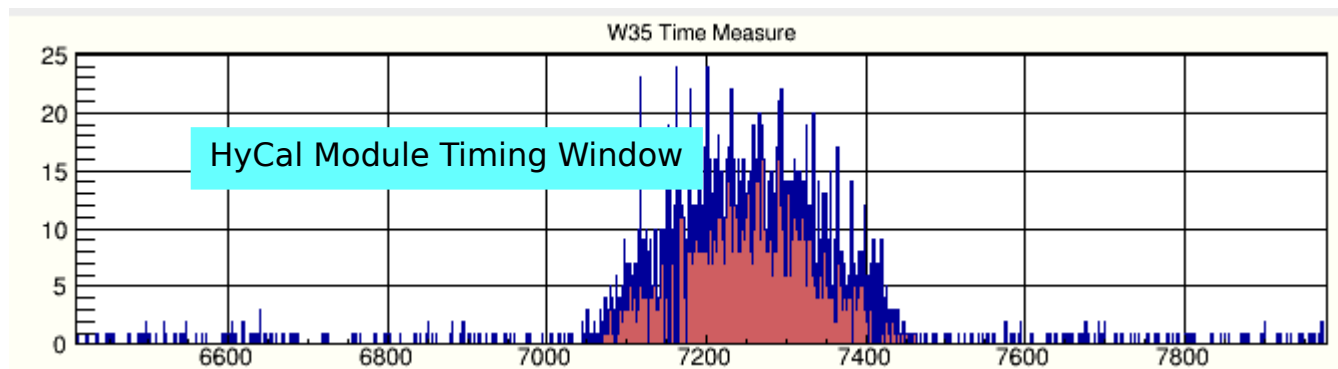
$$\text{Efficiency} = N_{\text{gem}} / N_{\text{tot}}$$

N_{gem} : hits on GEM

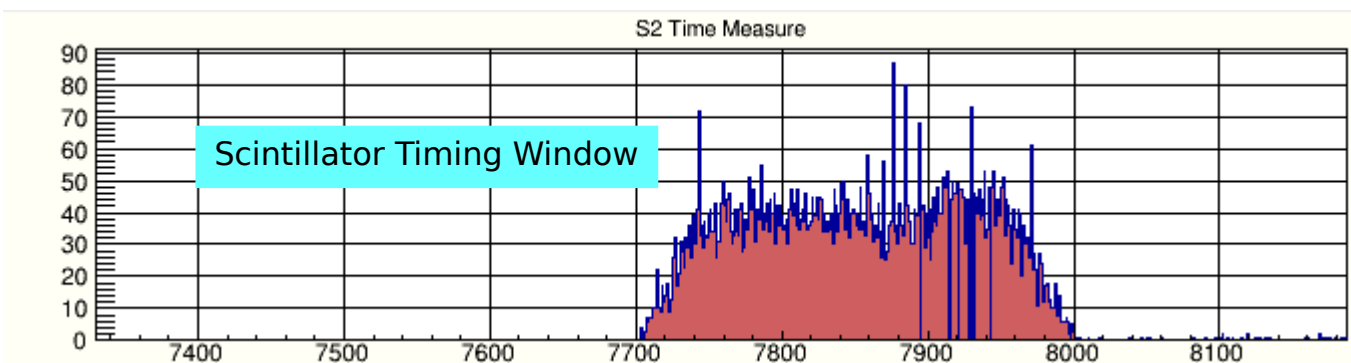
N_{tot} : hits on both scintillator and HyCal.



Use Timing Cut to select hits from Scintillator and HyCal.



N_{tot} :
Software Trigger
Using Timing AND Between
Scintillator and HyCal.



N_{gem} :
GEM detector sees hits.

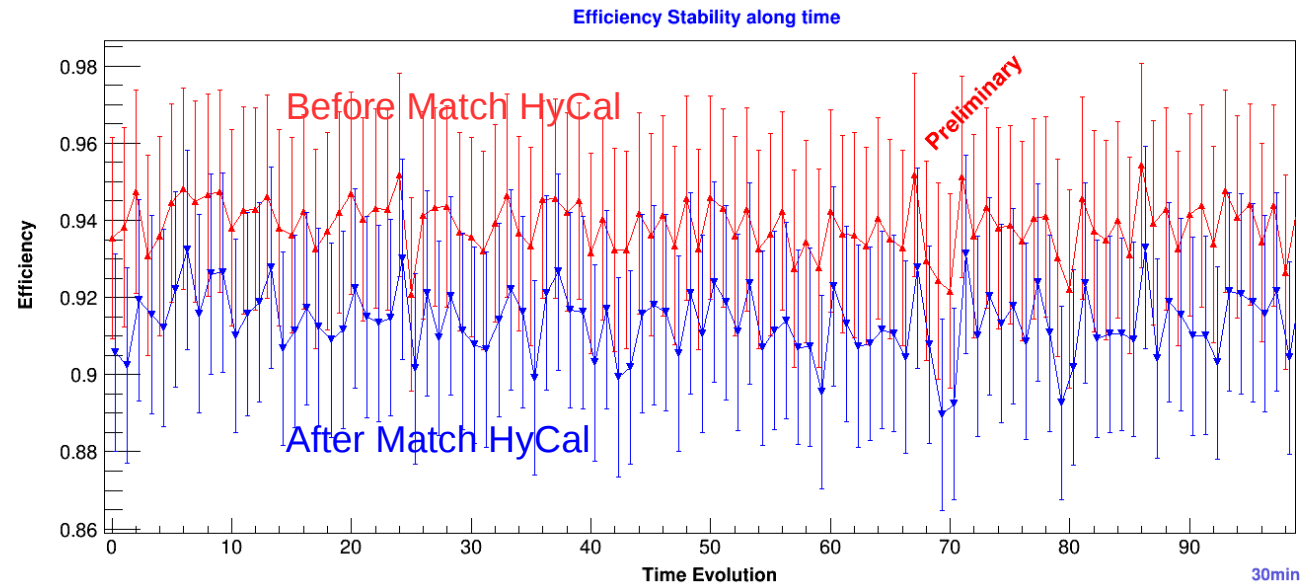
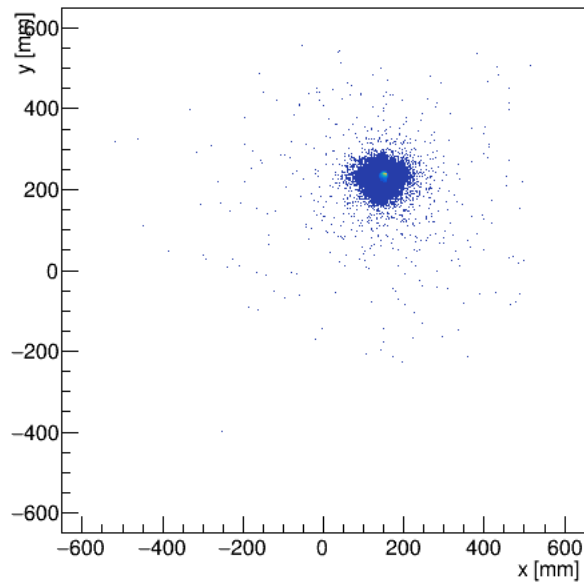
GEM Efficiency From Calibration Runs

Spot 1

Table of efficiency results

Run 982	Beam Spot	Total Events After timing cut	Efficiency	Statistical Uncertainty	Final uncertainty that can reach from experimental data
Before match	W977	130582/139096	93.9%	0.259%	< 0.15%
After Match	W977	127071/139096	91.3%	0.255%	< 0.15%

Cluster Map



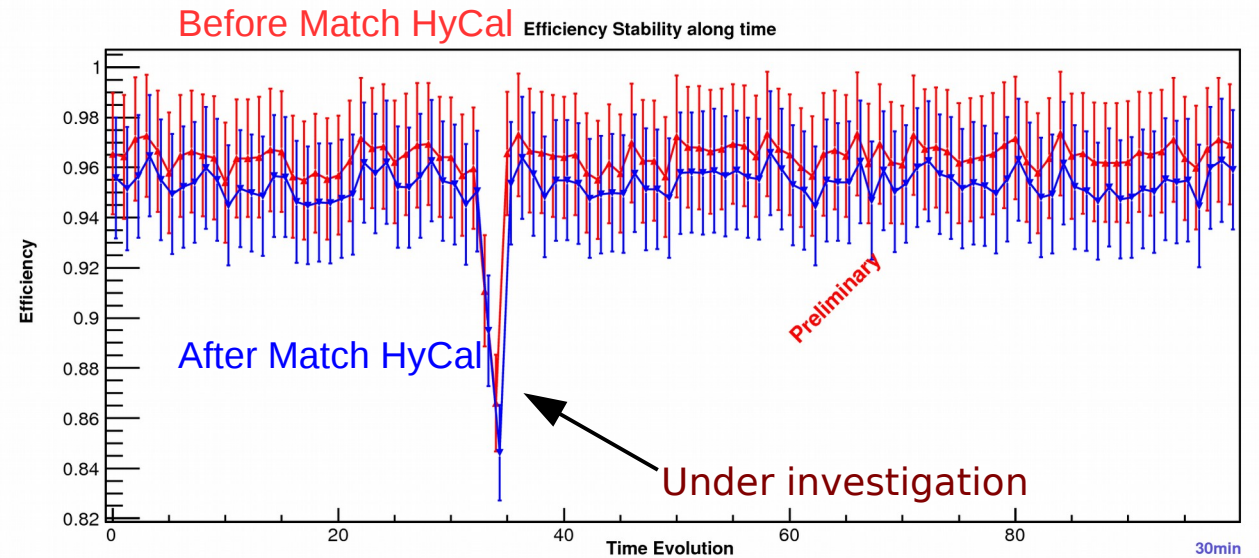
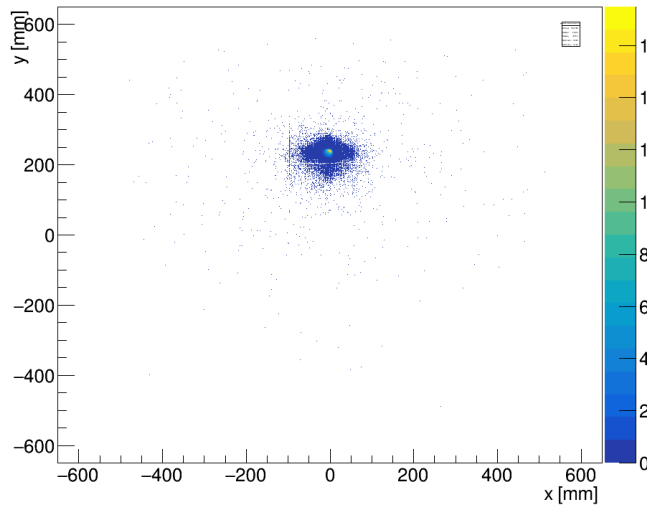
GEM Efficiency From Calibration Runs

Spot 2

Table of efficiency results

Run 983	Beam Spot	Total Events After timing cut	Efficiency	Statistical Uncertainty	Final uncertainty that can reach from experimental data
Before match	W969 + W970	159388/165553	96.3%	0.241%	< 0.14%
After Match	W969 + W970	157548/165553	95.2%	0.240%	< 0.14%

Cluster Map



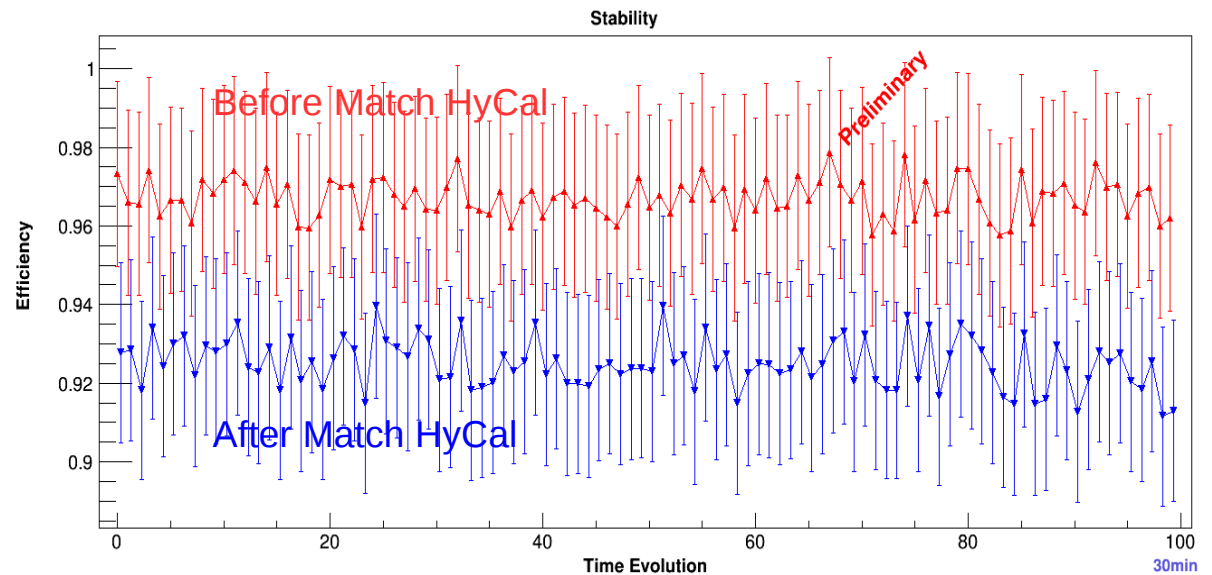
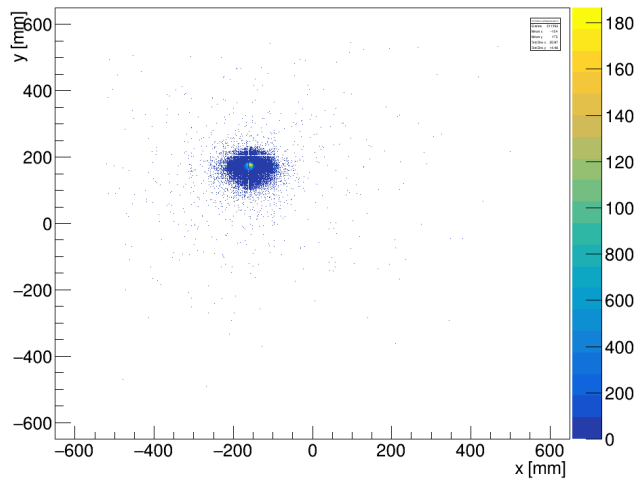
GEM Efficiency From Calibration Runs

Spot 3

Table of efficiency results

Run 987	Beam Spot	Total Events After timing cut	Efficiency	Statistical Uncertainty	Final uncertainty that can reach from experimental data
Before match	W854	166656/172319	96.7%	0.237%	< 0.14%
After Match	W854	159385/172319	92.4%	0.231%	< 0.13%

Cluster Map



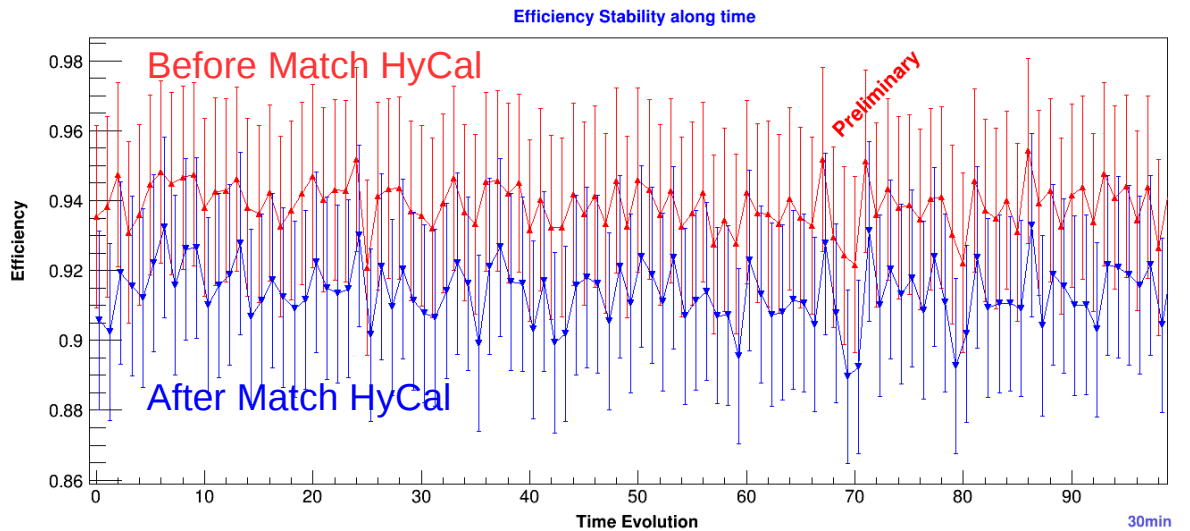
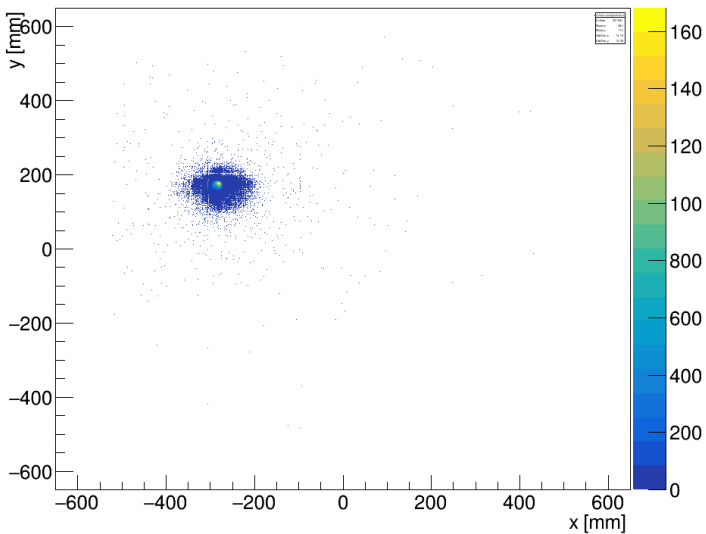
GEM Efficiency From Calibration Runs

Spot 4

Table of efficiency results

Run 988	Beam Spot	Total Events After timing cut	Efficiency	Statistical Uncertainty	Final uncertainty that can reach from experimental data
Before match	W977	130582/139096	93.9%	0.259%	0.15%
After Match	W977	127071/139096	91.3%	0.255%	0.15%

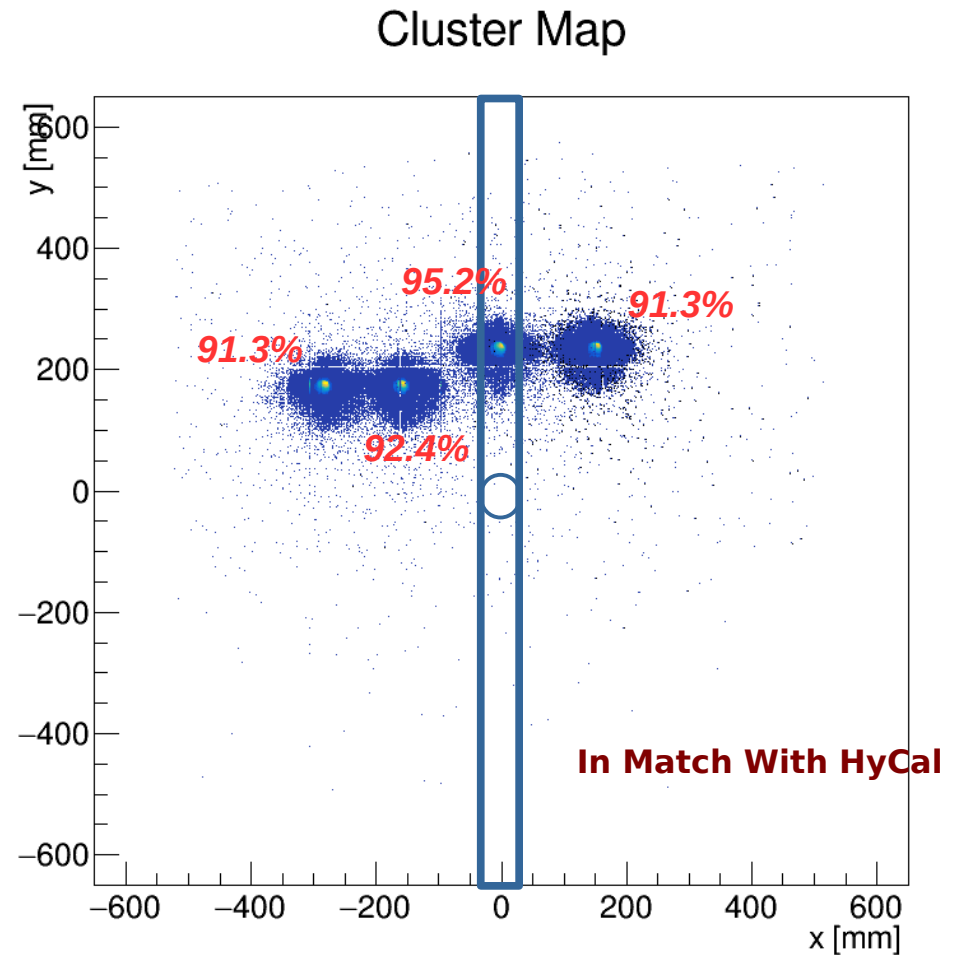
Cluster Map



GEM Efficiency From Calibration Run

Preliminary Conclusion:

- Even.
- The overlapping area higher efficiency.
- Near-Spacer area efficiency drops by 1 – 2 percent.



GEM Efficiency From Production Run

Efficiency from ep(suspected) events:

Requirement:

- 1) HyCal one cluster (preliminary, will change to after match one cluster left)
- 2) cluster energy > beam_energy - 5 sigma
- 2) match with GEM

Efficiency = number of clusters after match / number of clusters before match

Efficiency from moller(suspected) events:

Requirement:

- 1) HyCal two cluster (preliminary)
- 2) two cluster total energy > beam_energy - 5 sigma
- 2) match with GEM

Efficiency = number of clusters after match / number of clusters before match

Using quantity of clusters, instead of number of events.

Relative to HyCal

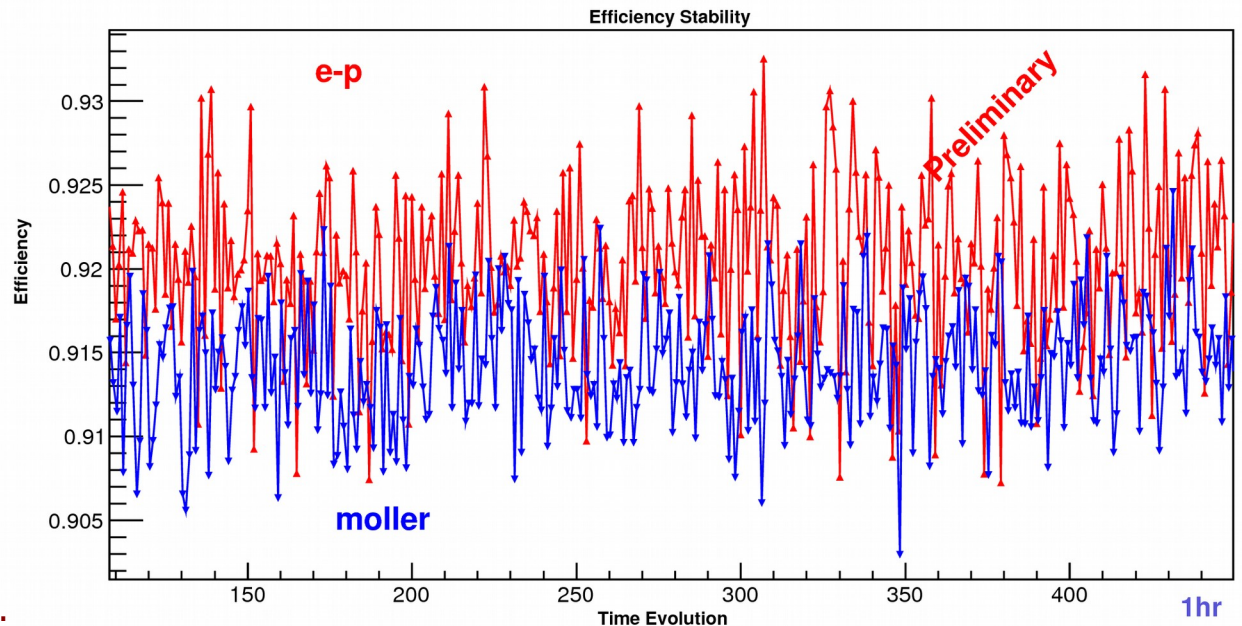
Efficiency Results:

E-p: 92.0% +/- 0.03%

Moller: 91.4% +/- 0.03%

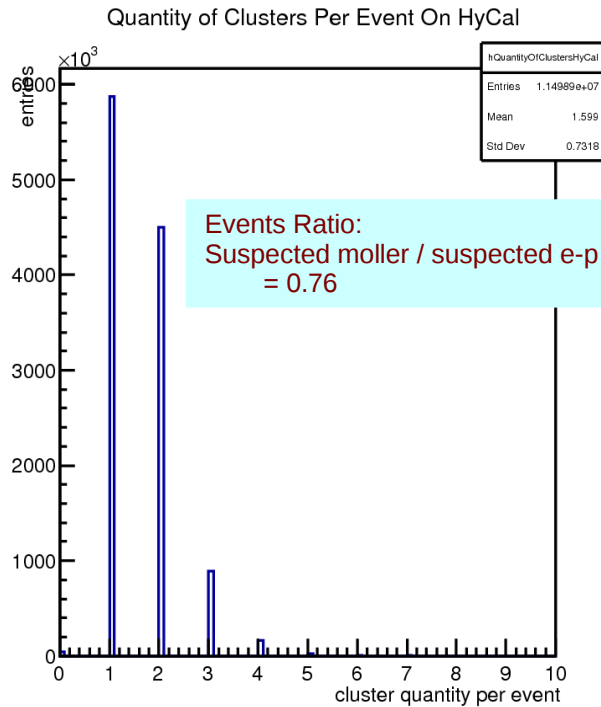
Covering nearly the whole
Active area of GEMs!!!
spacer, dead area,

Results Preliminary:
According to design, HyCal has a
Larger acceptance at smaller angle.

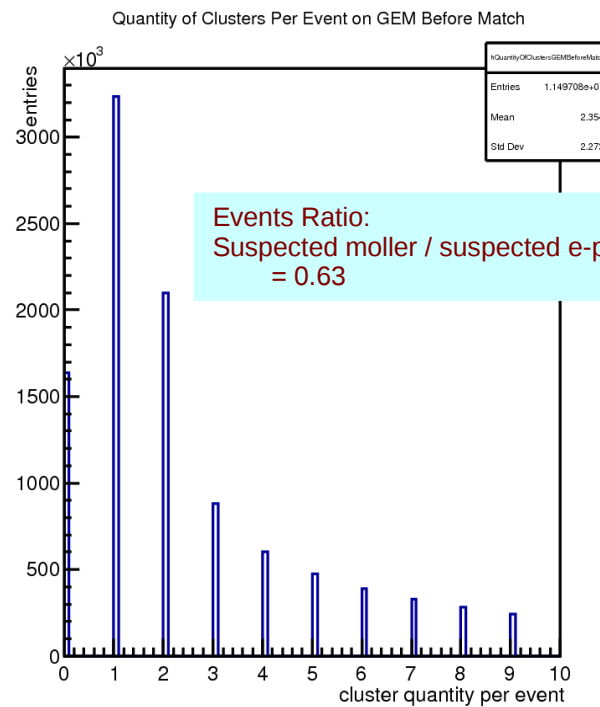


GEM Efficiency From Production Run

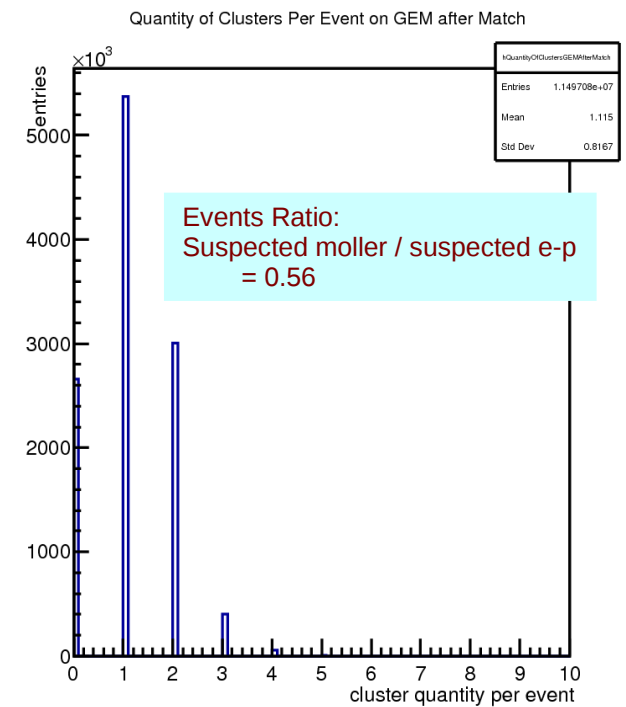
2.2 GeV Data



HyCal Cluster Multiplicity
Before Match



GEM Cluster Multiplicity
Before Match



Cluster Multiplicity
Before Match

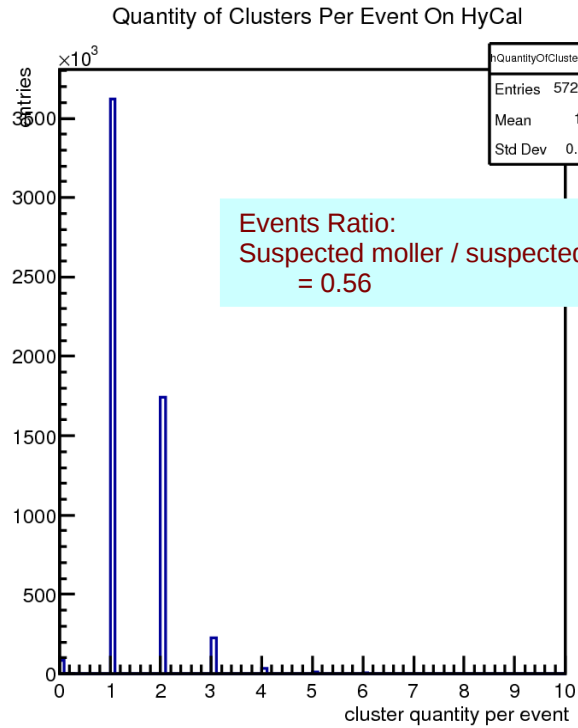
What's happening here?

Not throwing away any events.

e.g. : One event has 4 clusters, after matching, two left, then it will be added up to 2-cluster events

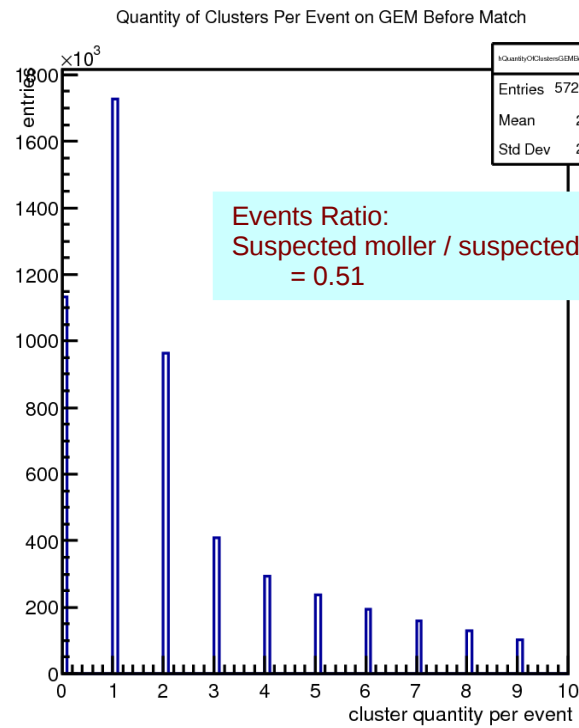
GEM Efficiency From Production Run

1.1 GeV Data



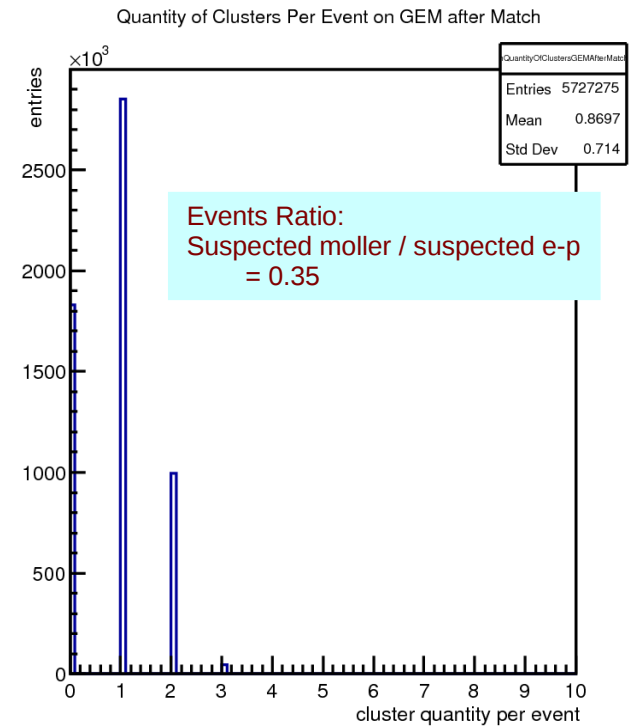
Events Ratio:
Suspected moller / suspected e-p
= 0.56

HyCal Cluster Multiplicity
Before Match



Events Ratio:
Suspected moller / suspected e-p
= 0.51

GEM Cluster Multiplicity
Before Match



Events Ratio:
Suspected moller / suspected e-p
= 0.35

Cluster Multiplicity
Before Match

What's happening here?

Not throwing away any events.

e.g. : One event has 4 clusters, after matching, two left, then it will be added up to 2-cluster events

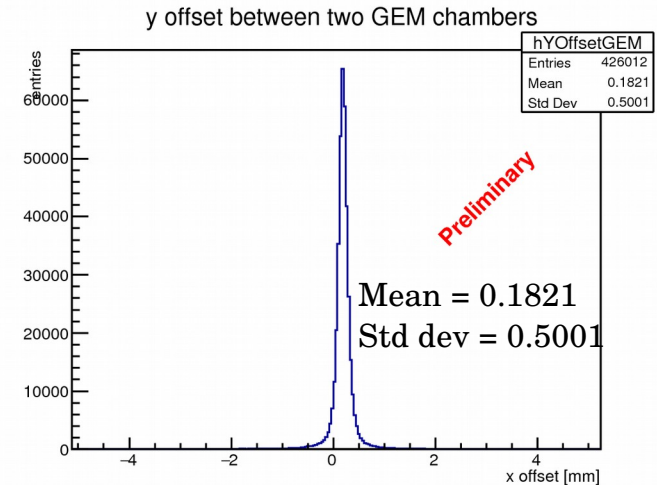
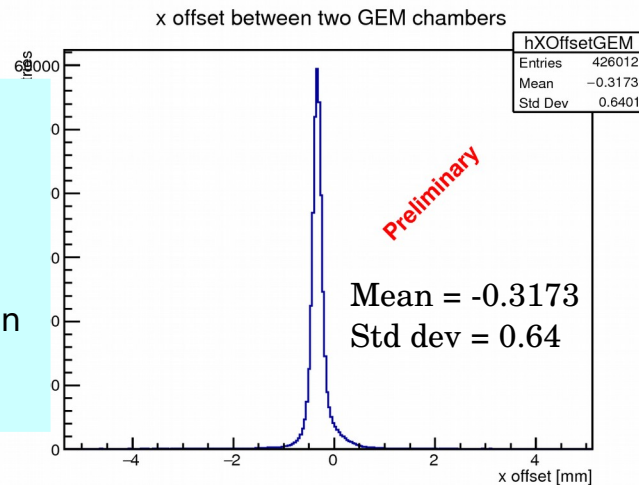
Geometry calibration

Procedure:

- 1), find X-Y offsets between two GEM chambers.
- 2), After the alignment between two chambers
- 3), find X-Y offsets between the detector center and beam line

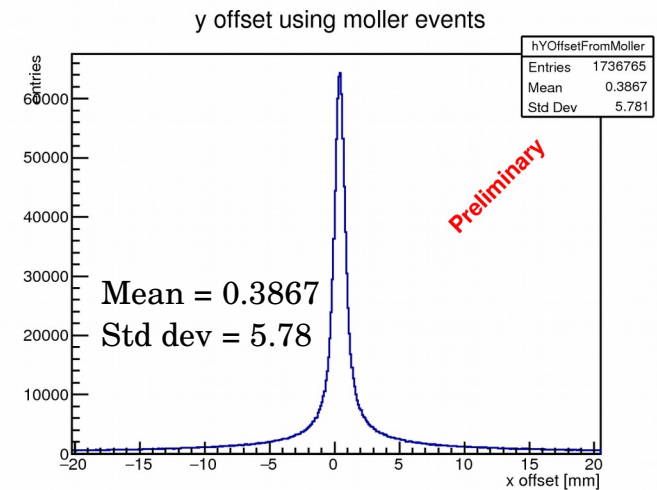
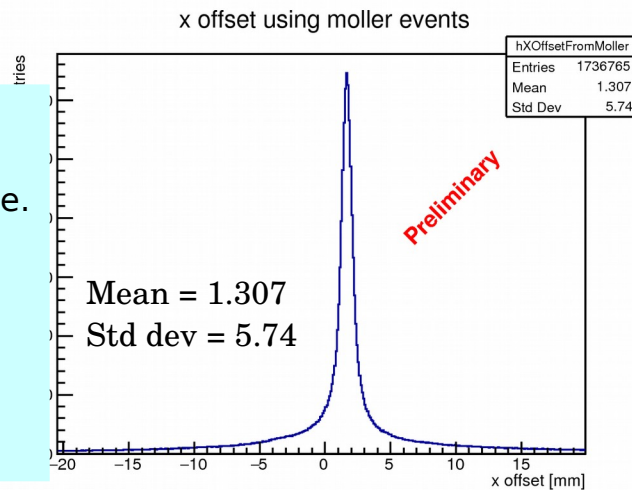
Top Two:
Offsets between
Two GEM chambers.

Procedure:
align the hole center on
Two GEM chambers.

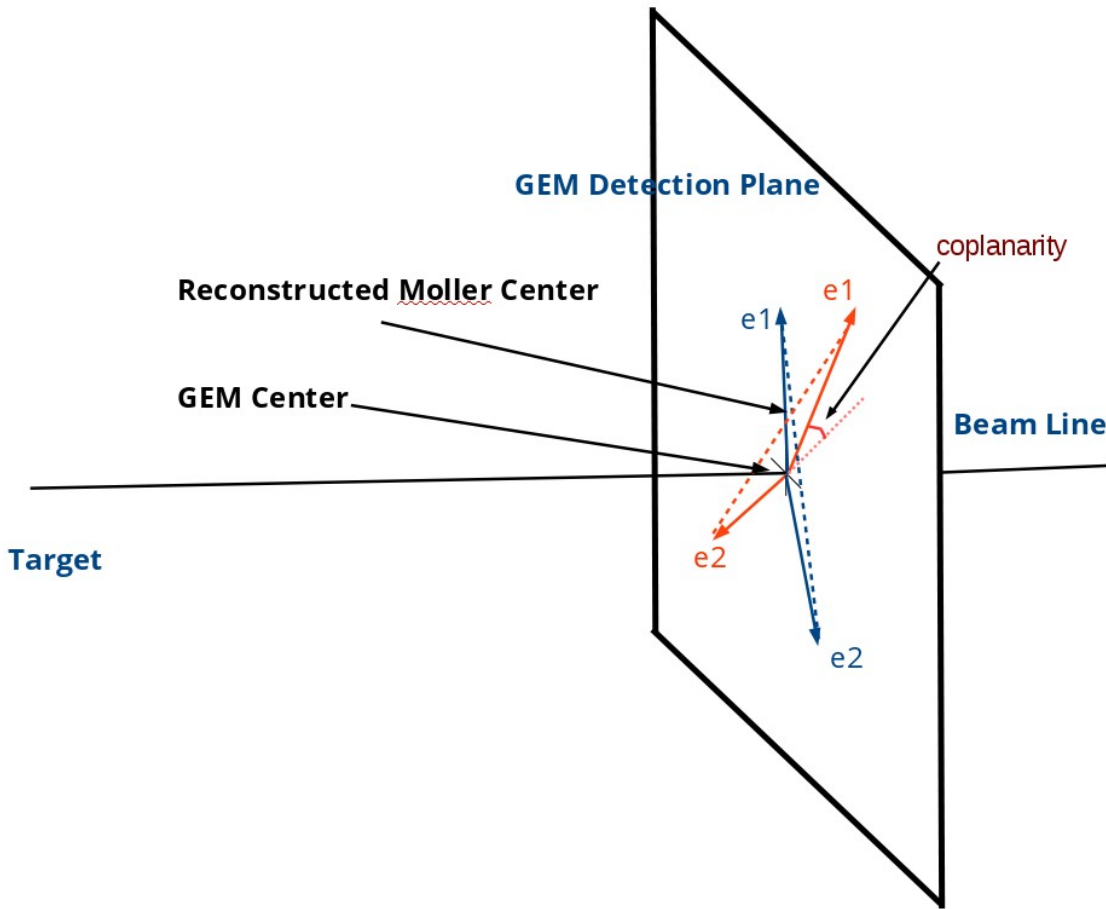


Bottom Two:
Offsets between
GEM Hole center and beam line.

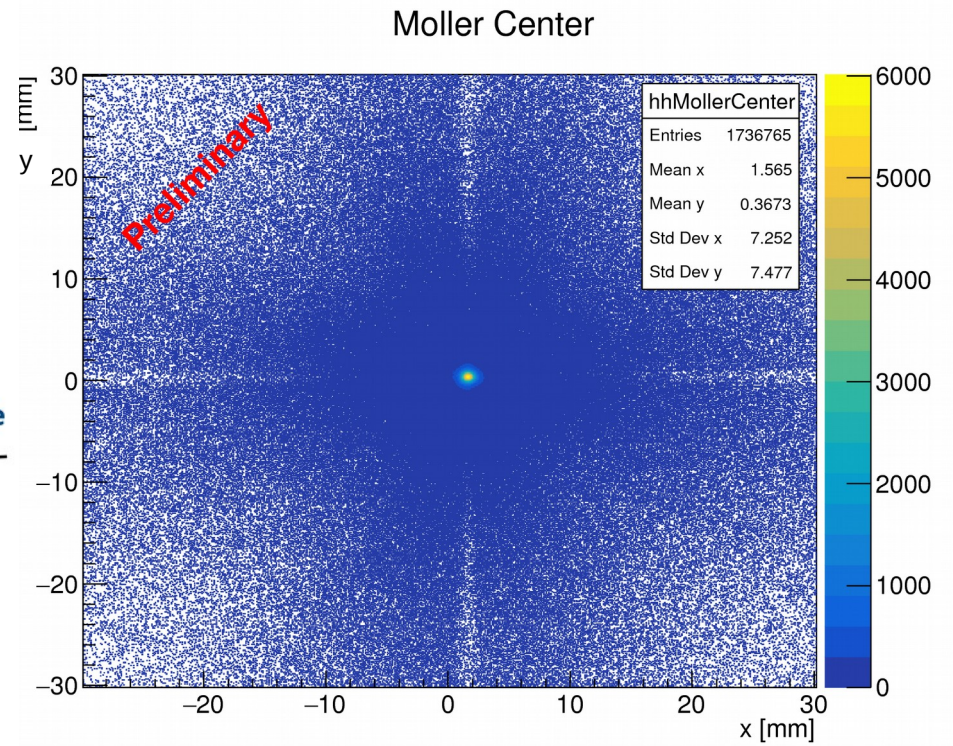
Procedure:
align the hole center on
GEM plane with beam line.
Use moller events



Geometry Calibration



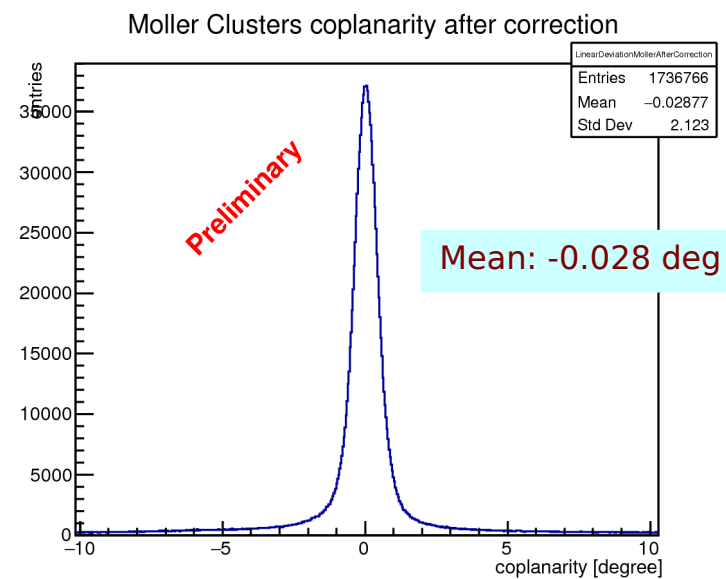
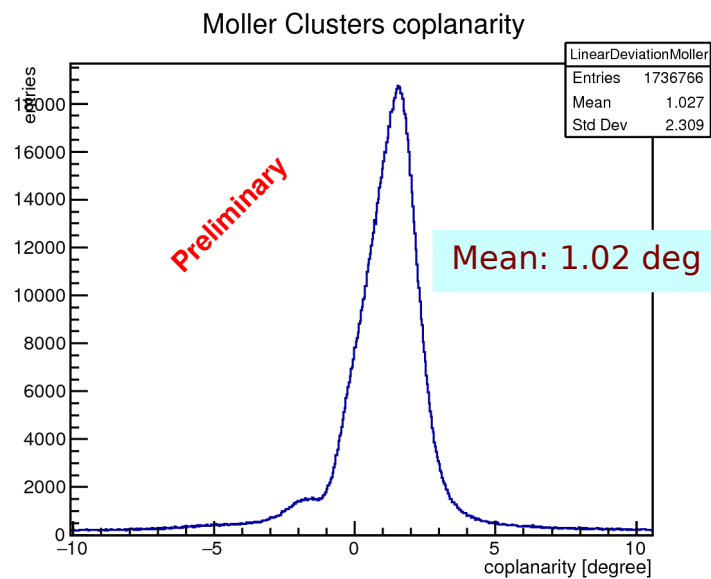
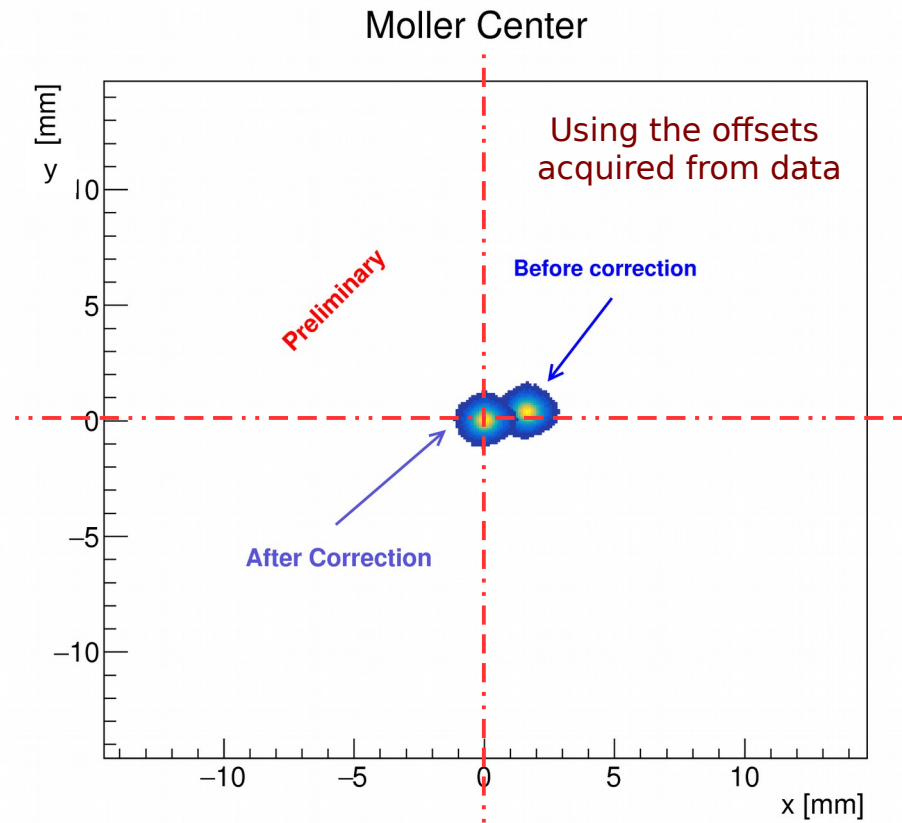
Moller Geometry



Reconstructed Moller Center

Geometry Calibration

Moller center shifts
with offset correction.

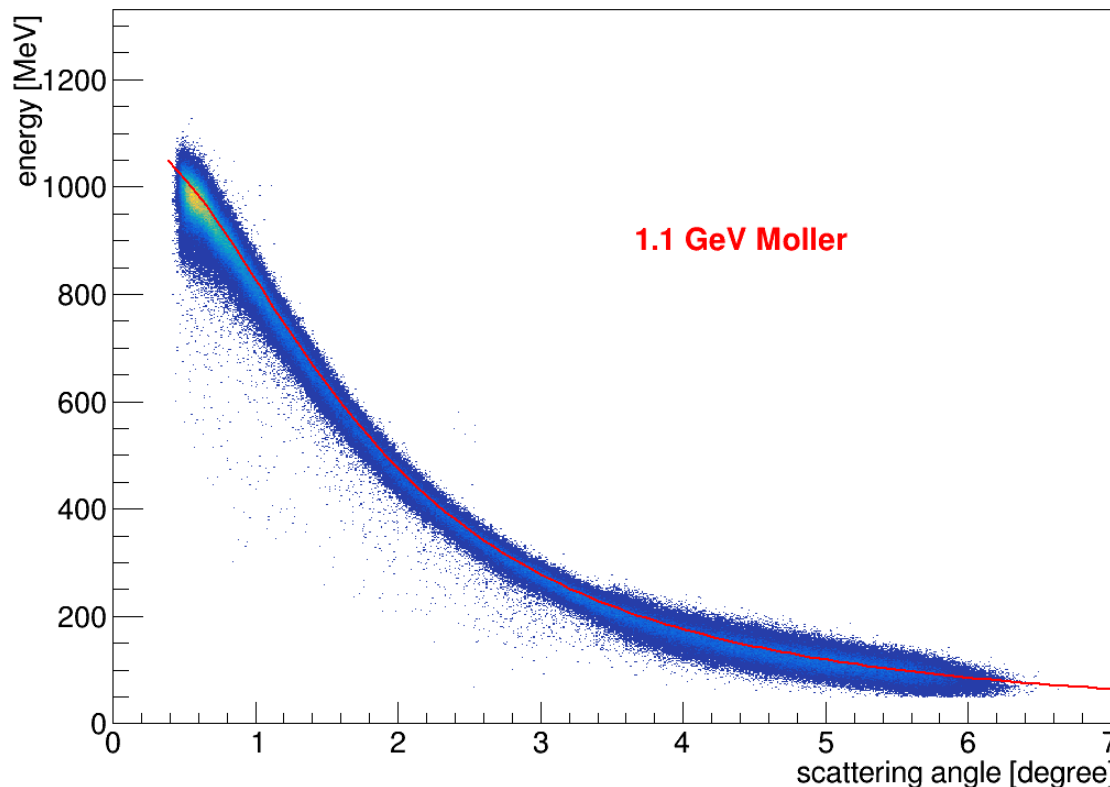


Energy angle distribution

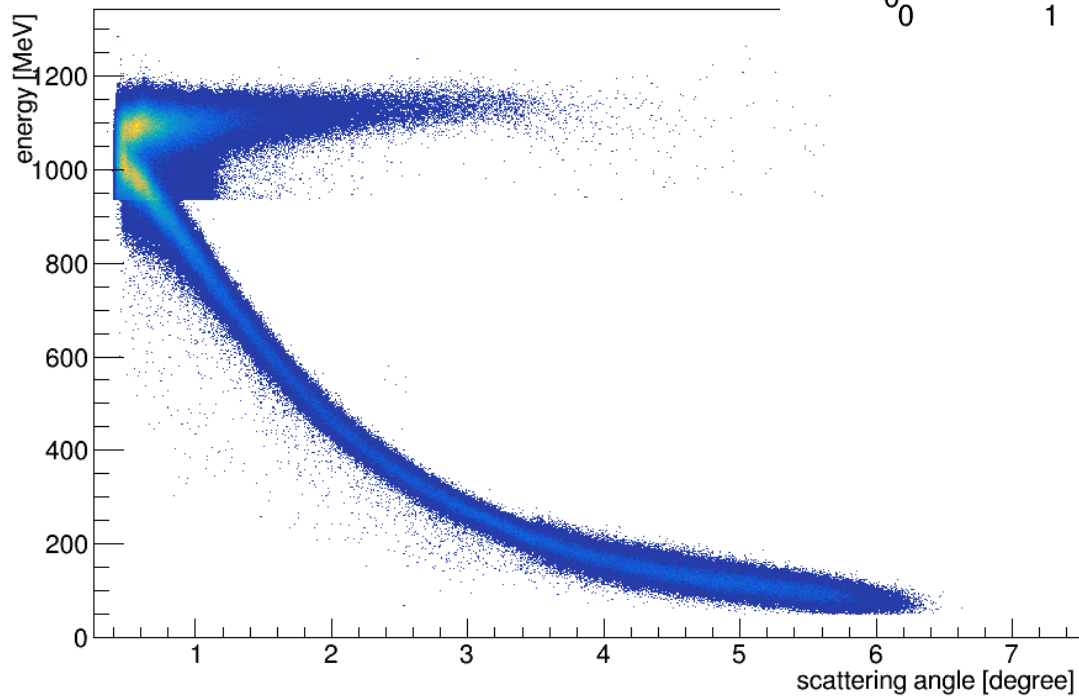
1.1 GeV

Red line: From Calculation

E [MeV] vs Scatt. θ [deg]



Energy Angle



Energy From HyCal

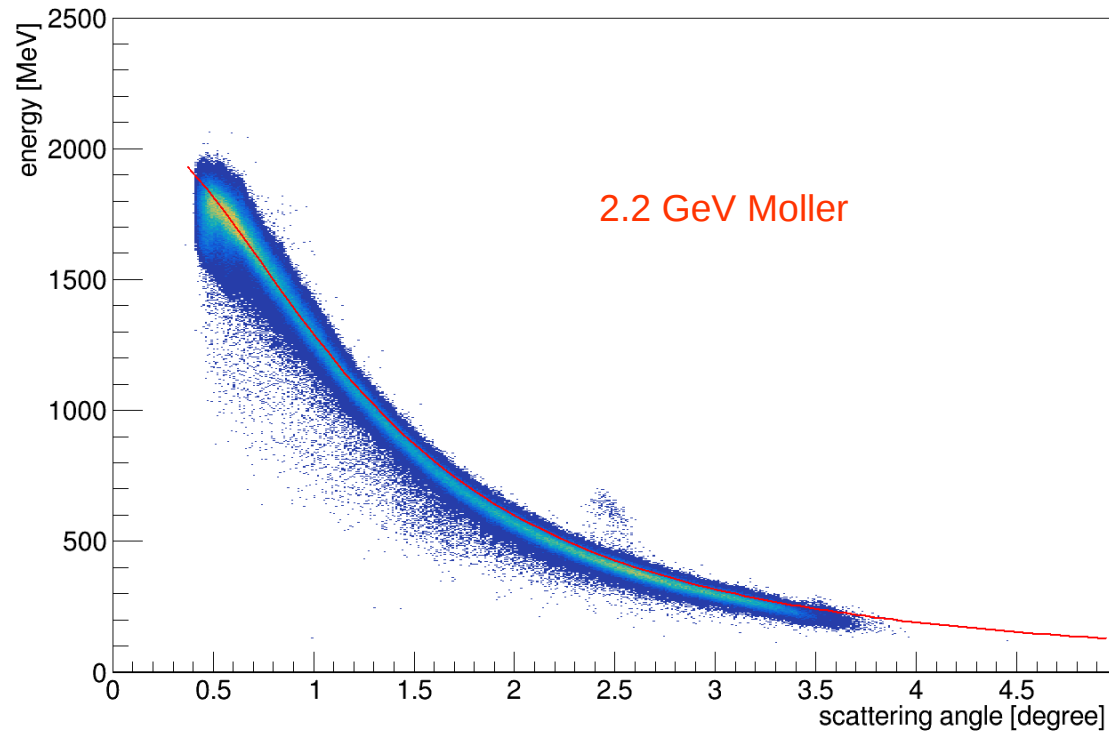
Coordinates from
GEM

Energy angle distribution

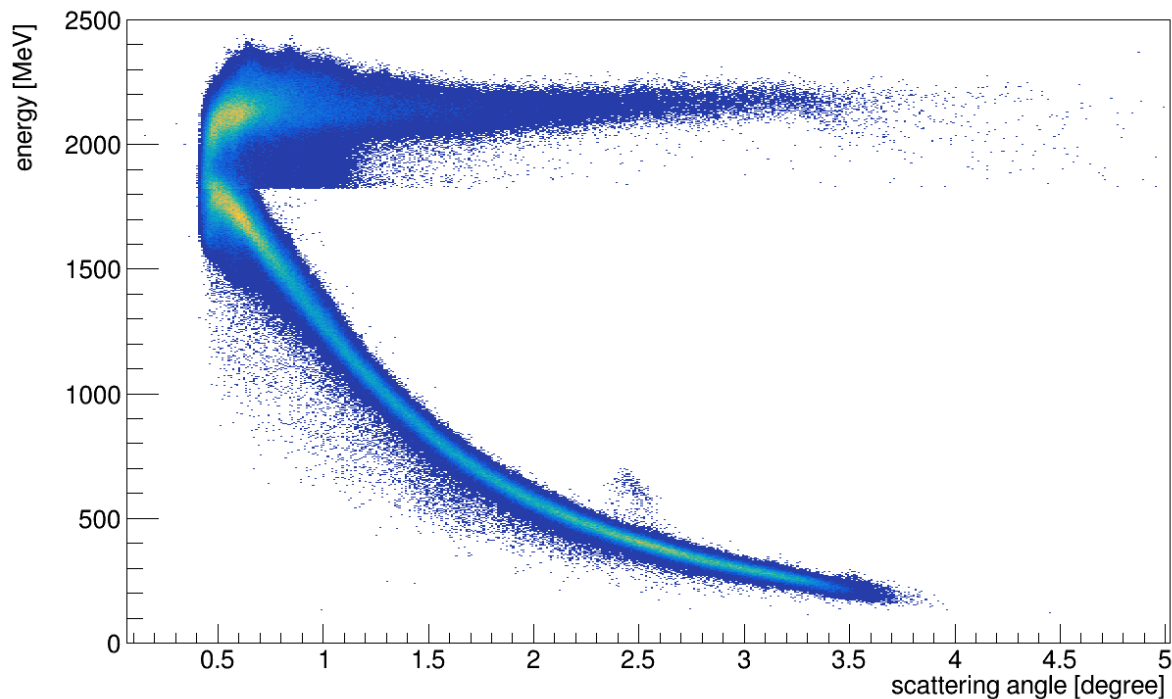
2.2 GeV

Red Line: From Calculation.

E [MeV] vs Scatt. θ [deg]



Energy Angle



Energy From HyCal

Coordinates from GEM

Summary & What's next...

1, Reliable GEM Data.

2, Using moller events to get GEM spatial resolution.

3, analysis refine.