October RD51 Test Beam: CERN GDD and CMS preliminary data analysis

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On behalf of CERN GDD and CMS groups

Overview

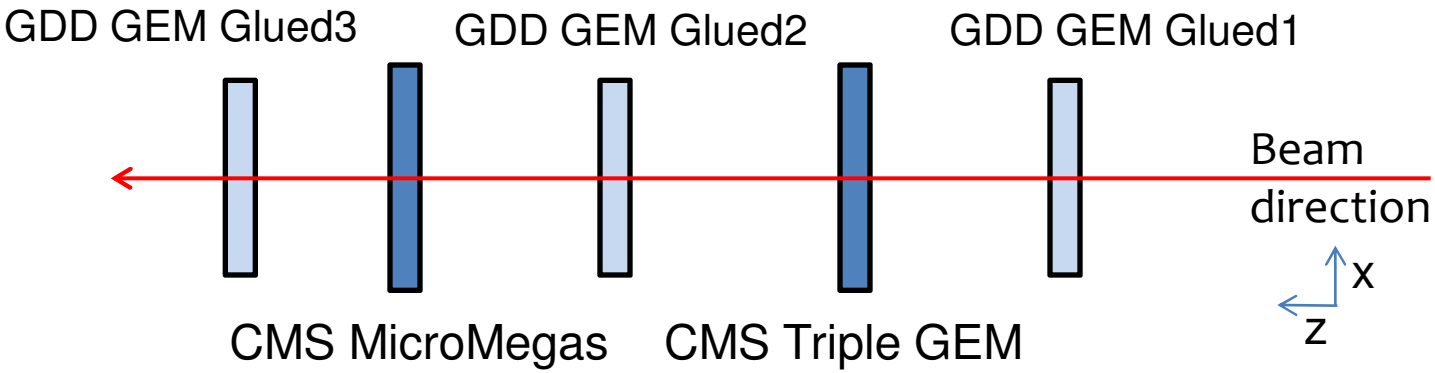
- The CERN GDD and CMS goal for October test beam was:
  - to understand the performance of the GEM telescope equipped with VFAT electronics (see E. Oliveri Presentation)
  - to undestand the performances of CMS Triple GEM and MicroMegas Prototypes with two different gas mixtures (Ar/CO_2 70%/30% and Ar/CO_2 90%/10%)
    - CMS TRIPLE GEM was equipped with VFAT
    - CMS MICROMEGAS was equipped with Gassiplex (but we tried also VFAT)

➢ We have just started to analyse the first datasets

A reminder of the setup

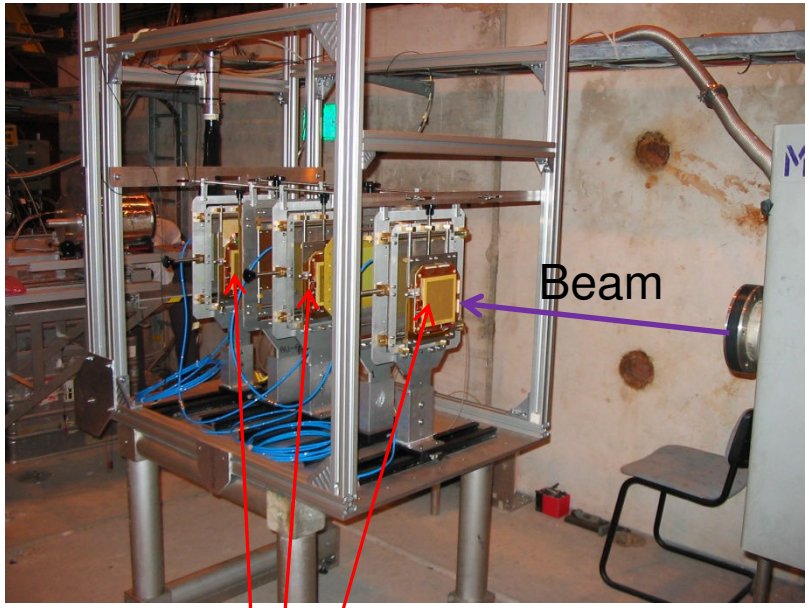
- 3 Triple GEM 2D readout stations to reconstruct the track: Glued Tracking GEMs

- Two devices under test: CMS Triple GEM and MicroMegas



- All GEM detectors were read out with VFAT ; Micromegas was readout by Gassiplex but also VFAT was tried

Pictures of the setup



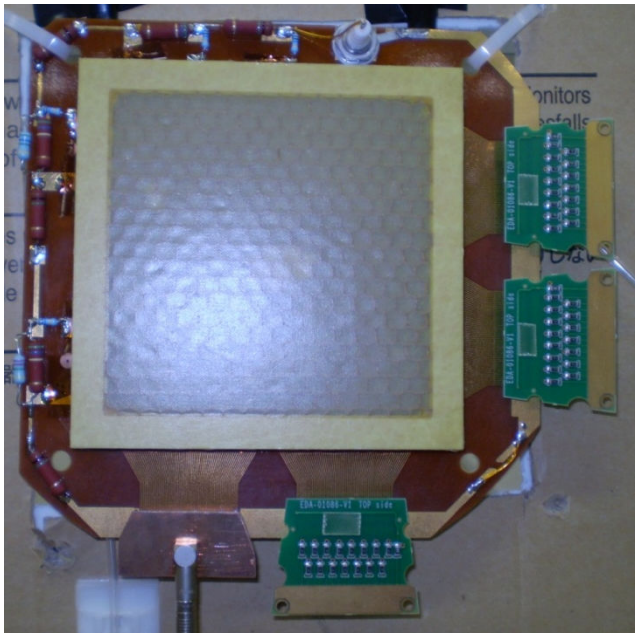
CERN GDD TRACKING GLUED GEM

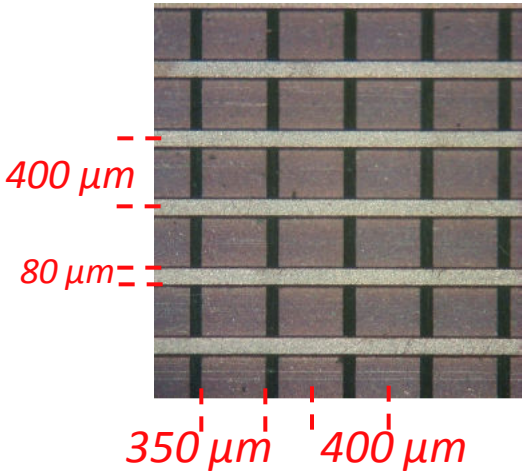
CMS μMegas

CMS Triple GEM

CERN GDD "Glued" GEM

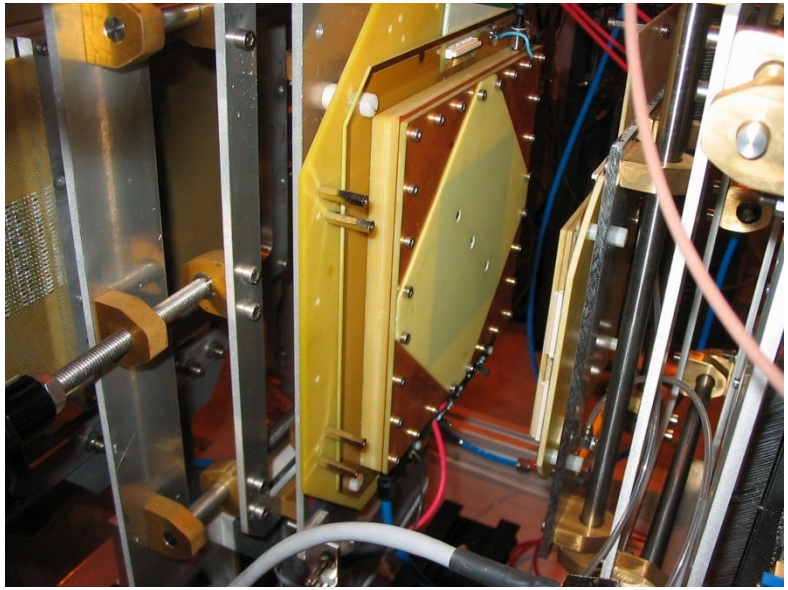
- Triple GEM detector
- 10x10 cm^2 active area
- Gas mixture used Ar/$C0_2$ 70%/30%
- Possibility to have X-Y Readout but only 1 VFAT was connected → We used only X-Strips (1D Readout)
- All the other strips were terminated at 50 Ohm or 1 Mohm
- Strip pitch = 0.4 mm; 1 connector →128 strips
- Always operated at a gain more than 10^4
- Tracking Device





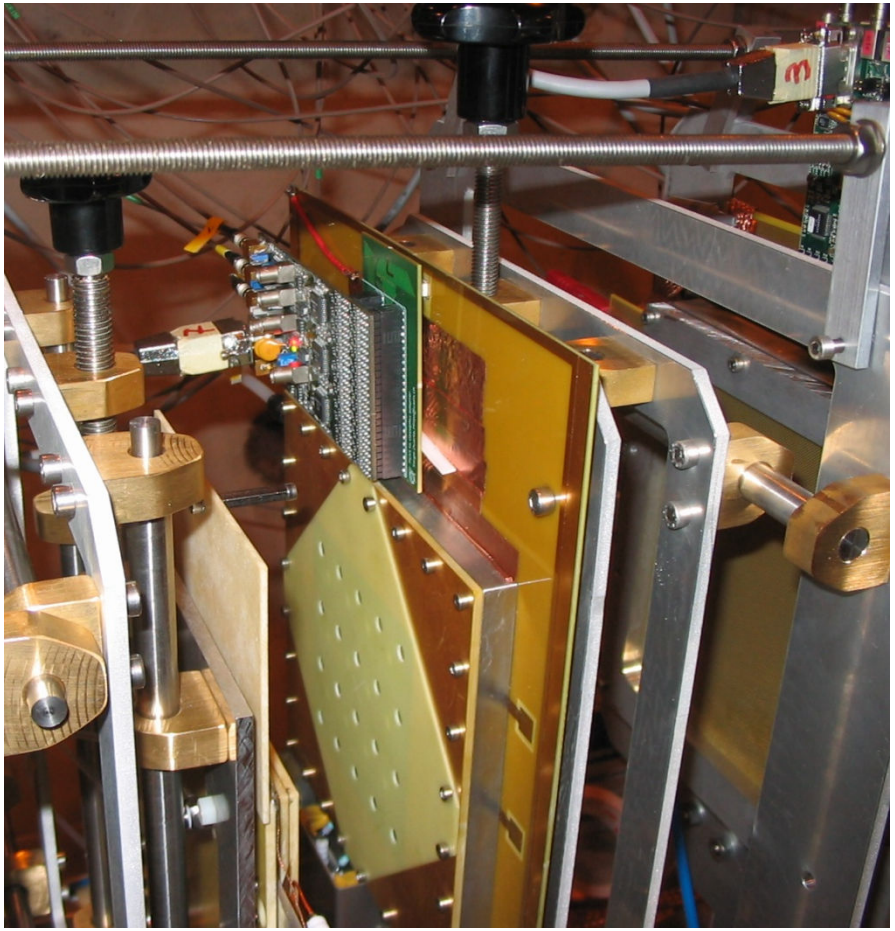
CMS Triple GEM

- Triple GEM Detector
- 10x10 cm^2 active area
- Gas Mixtures used: $Ar/C0_2$ 90%/10% and 70%/30%
- 1D Readout Strip (X-direction) and 1 VFAT connected to the only one connector
- Strip pitch = 0.8 mm;
  1 connector →128 strips
- Device under test



CMS MicroMegas

- MicroMegas Detector
- 10x10 cm^2 active area
- Gas Mixtures used: Ar/$C0_2$ 90%/10% and 70%/30%
- 1D Readout Strip (X-direction) and 1 VFAT connected to the only one connector
- Strip pitch = 0.8 mm;
  1 connector →128 strips
- Device under test



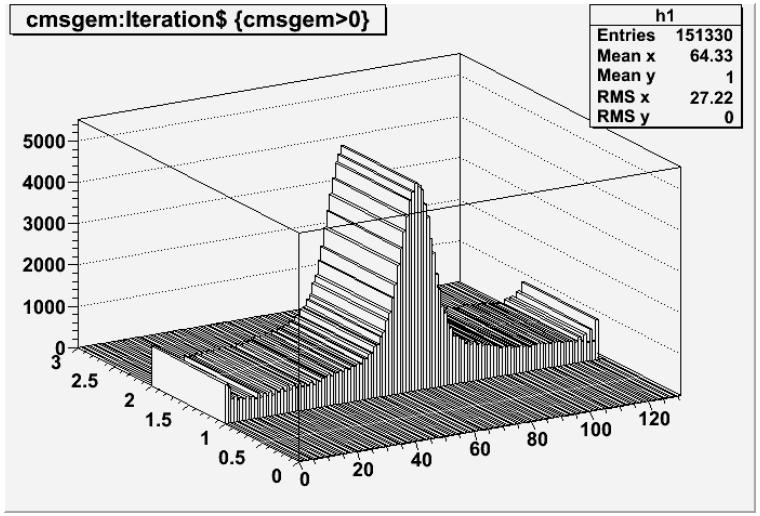
- **Analysis with Gassiplex still on-going!!!**

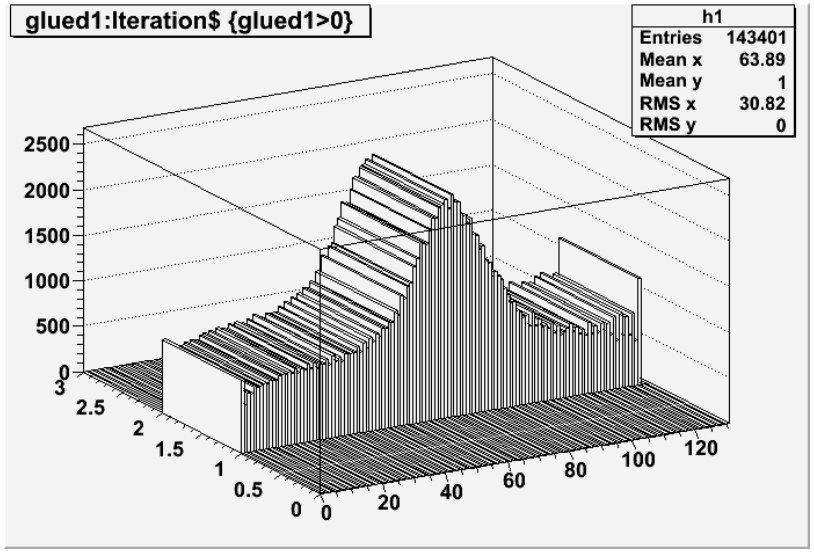
Software implementation

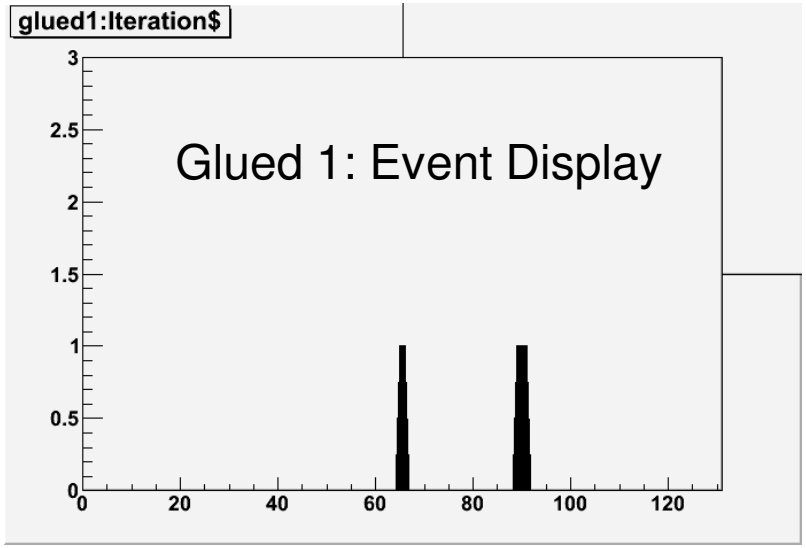
- All the analysis is performed with the ROOT package
- Raw data are converted from the binary DAQ format to a ROOT tree
- Each VFAT data are converted in an array of 128 elements, each giving the presence of a hit (for a fixed threshold) in one channel of the card.

Some examples of raw data..

Beam Profile from Raw Data



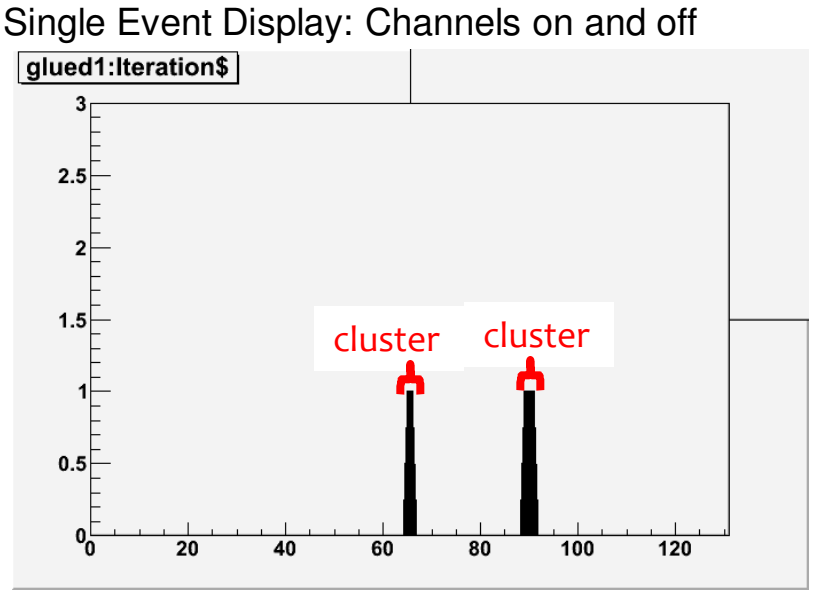




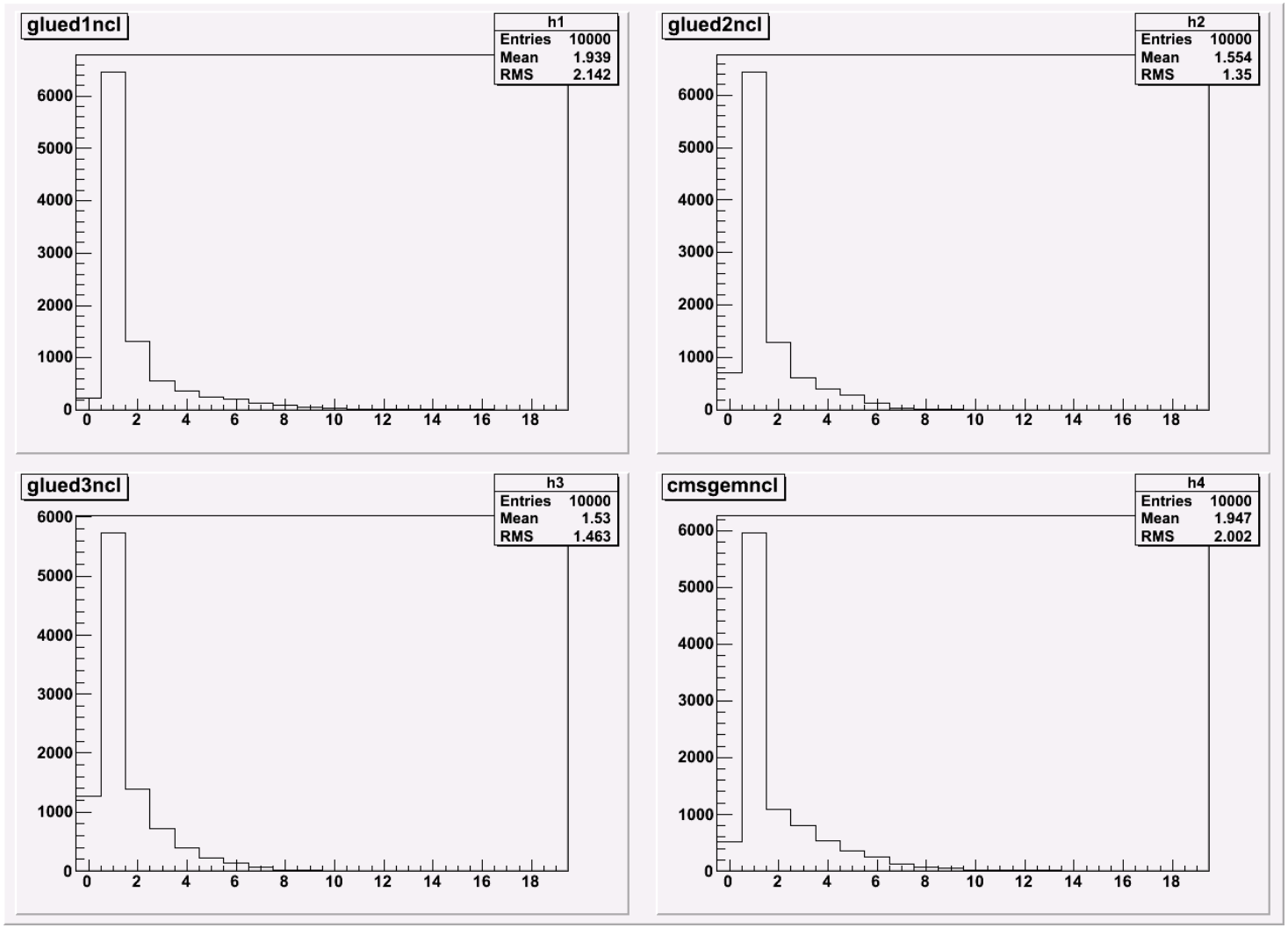
A simple clustering algorithm

- VFAT is a digital FEE, either a channel is on (has value of 1) or is off (has value of zero)
- A cluster is formed by neighbouring hits
- The position of the cluster is calculate using the centre of gravity

- For analogue chips, such as Gassiplex, the algorithm is more complex, see presentation in RD51 mini-week in September by M. Alfonsi

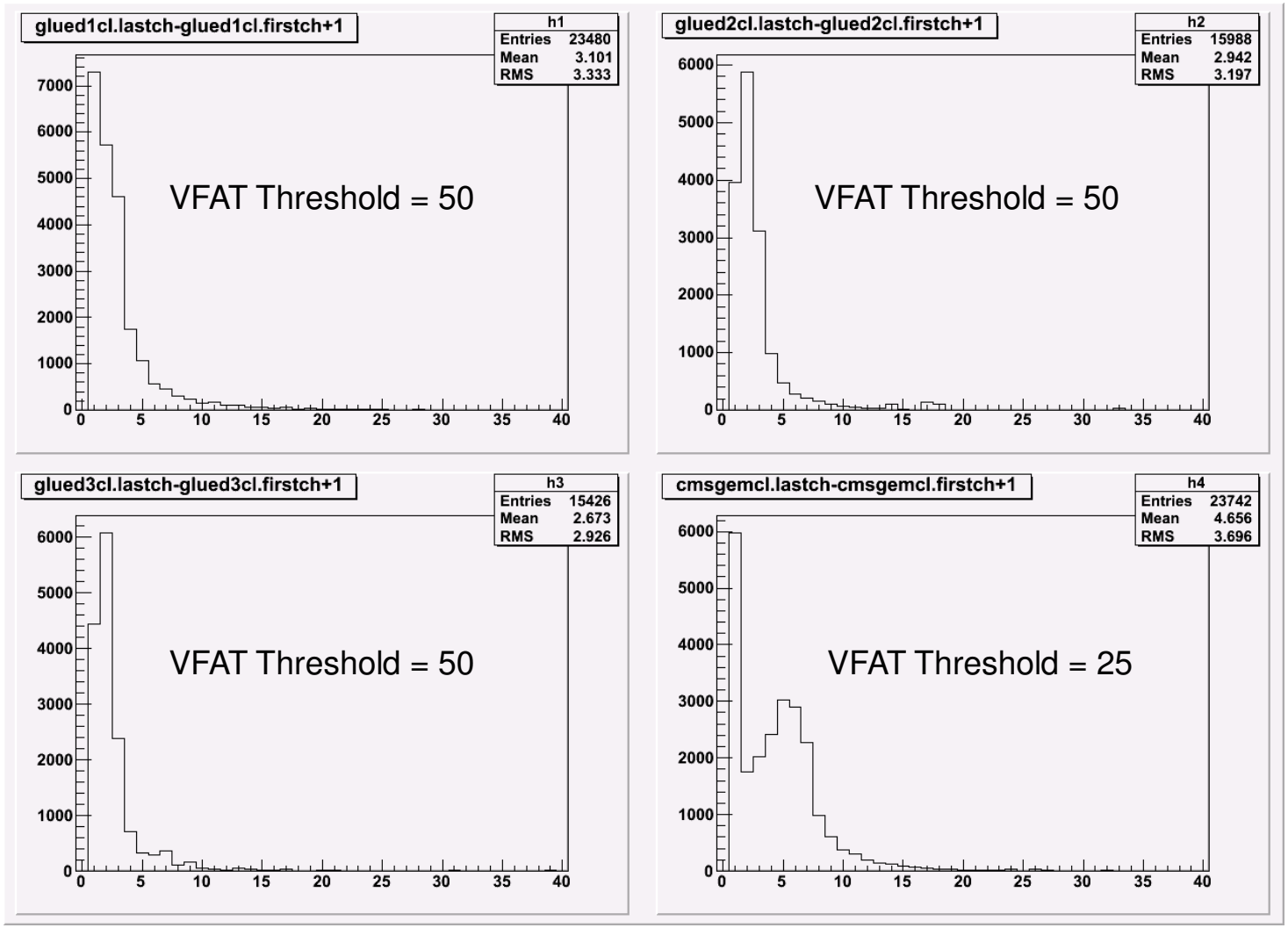


Cluster multiplicity for the four GEM detectors



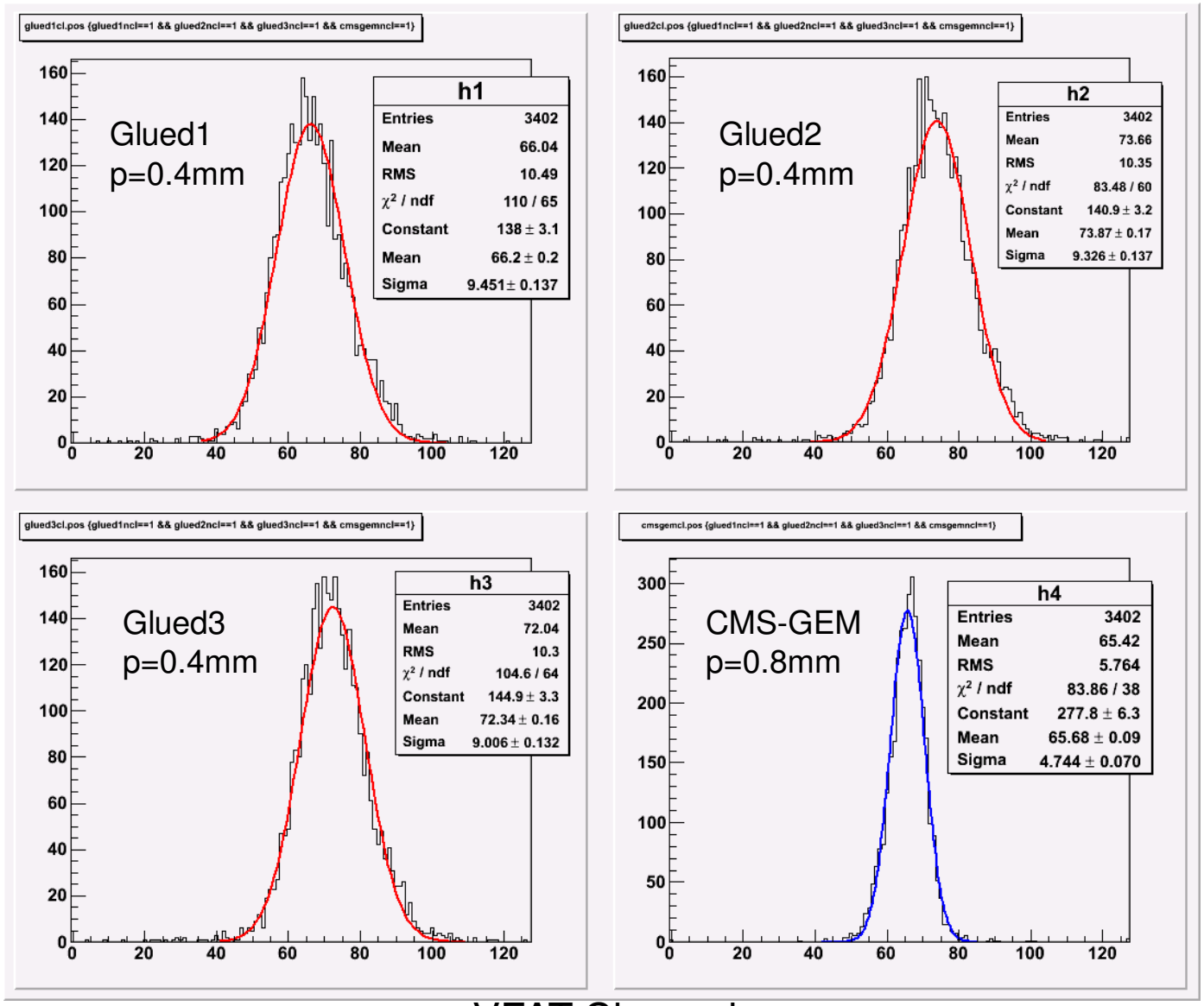
Cluster Multiplicity

Cluster size for the four GEM detectors



Cluster Size

Beam Profile using Cluster positions

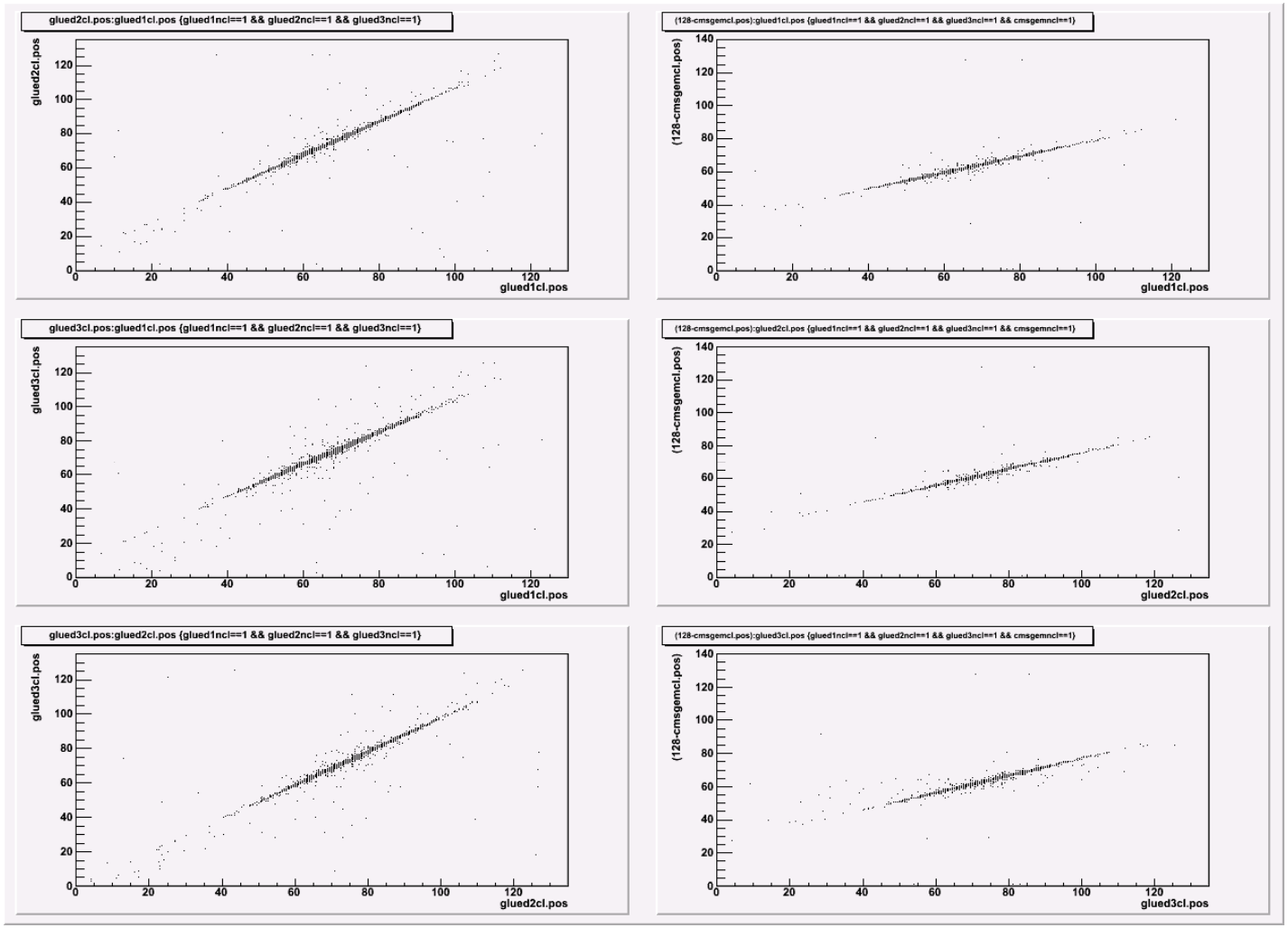


Track reconstruction

- In the following, for this preliminary analysis, tracks are reconstructed only in the events with one and only one cluster per tracking Glued GEM station.
- Tracks are included in the "reconstruction" ROOT tree, to avoid the very long track fitting computational time (standard ROOT Minuit Fit)

Detectors x-x correlations

Cluster correlation plots between glued gems

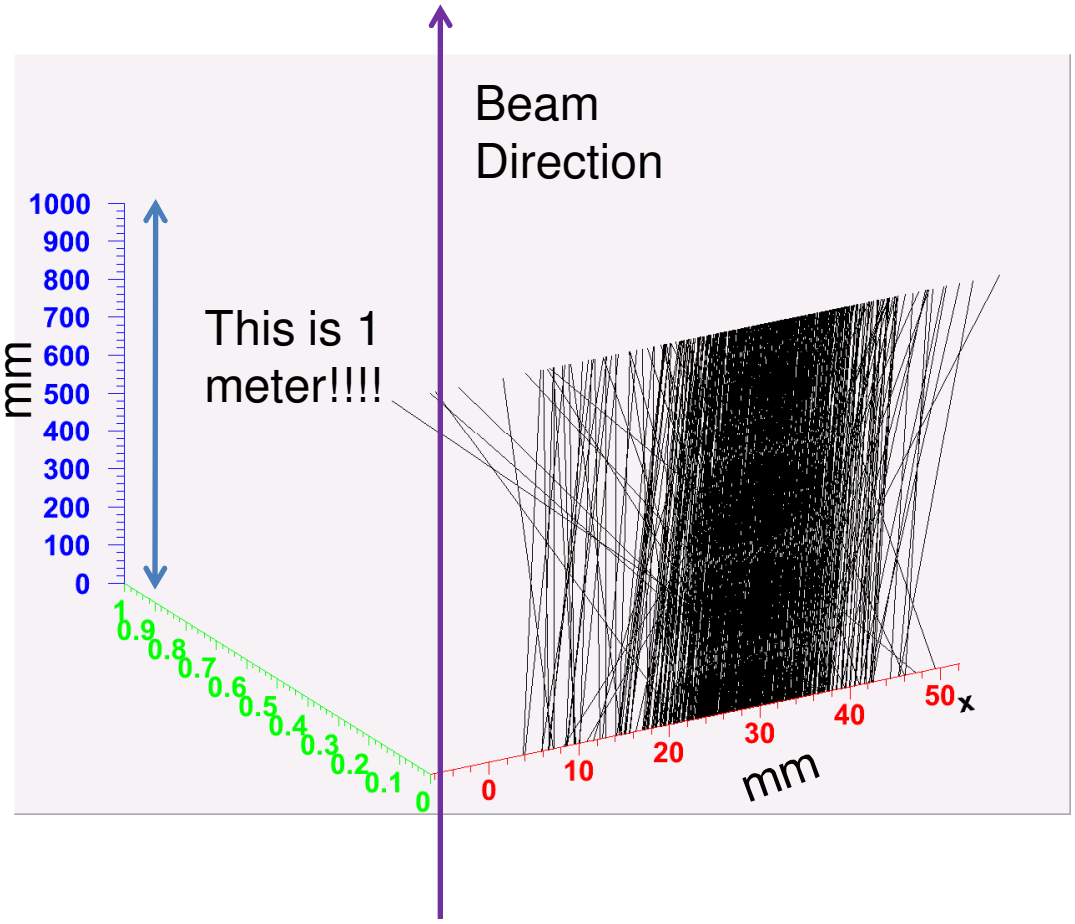


Cluster correlation plots between glued gems and cms gems

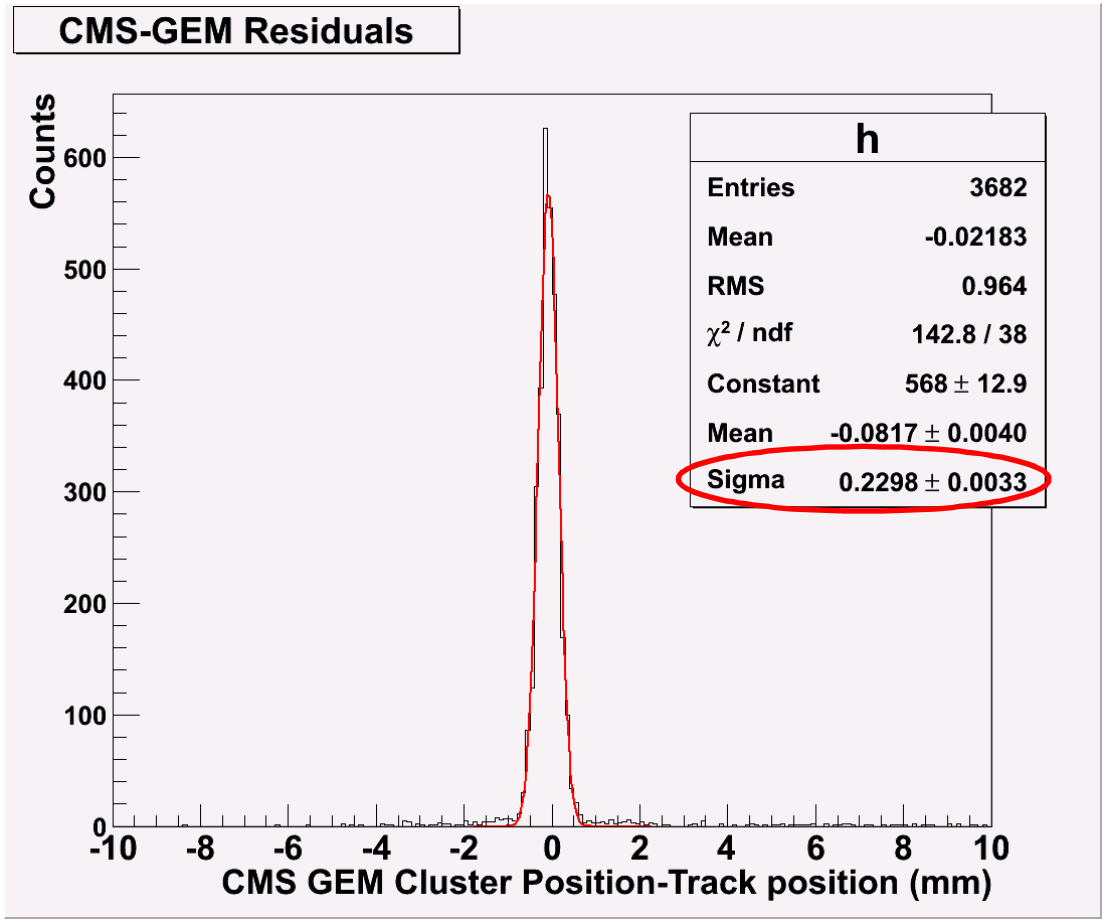
- Angular coefficient CMS-GLUED ~ 0.5 = pitch_GluedGEMs/pitch_CMSGEM = 0.4 mm/0.8 mm
- The small misalignment is corrected before track reconstruction

Reconstructed tracks

- The “reconstruction” ROOT file can be opened again for further analysis or to see the results, like with this simple “track viewer”

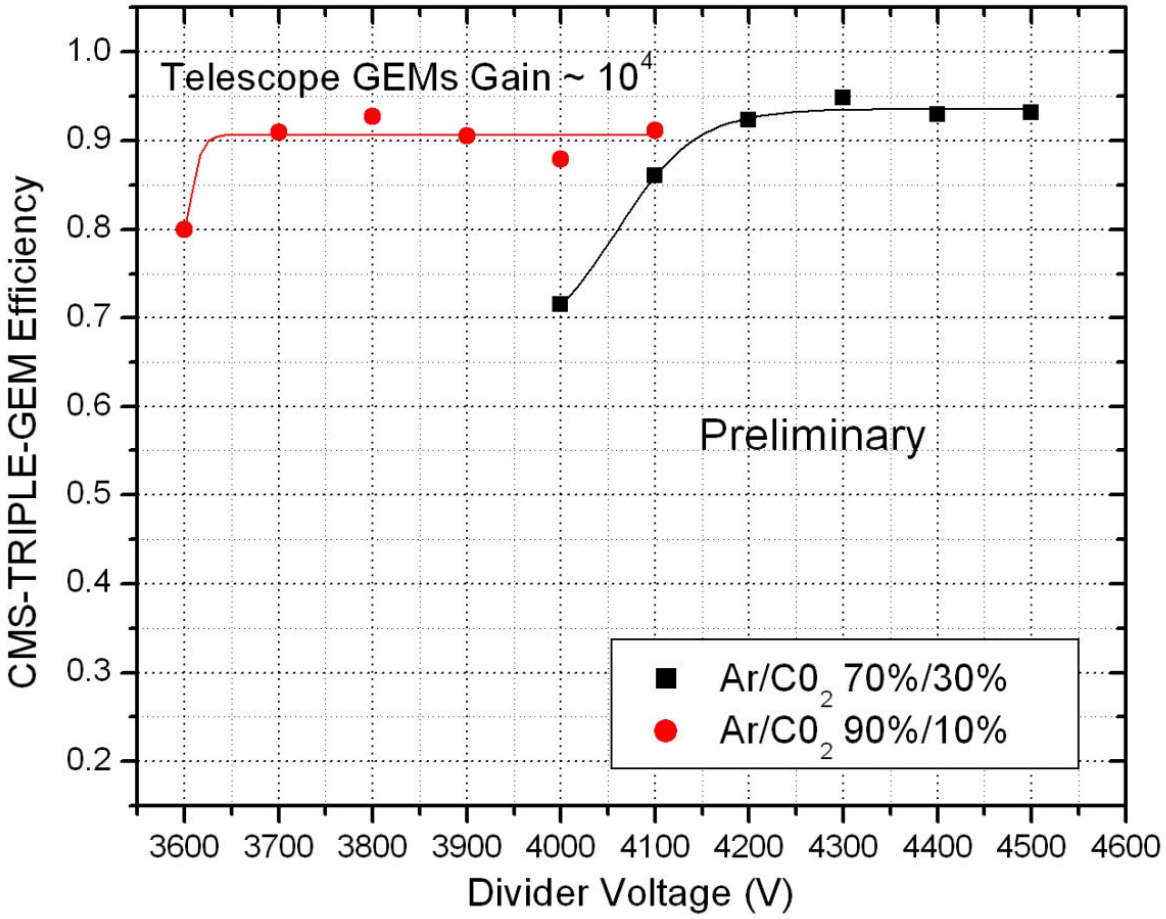


CMS GEM Space Resolution



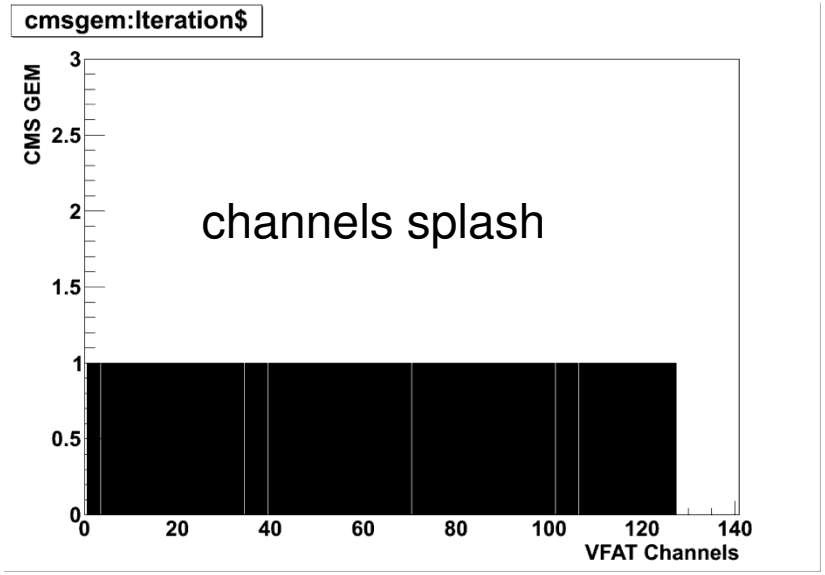
The expected resolution due to a digital readout is pitch/sqrt(12) = 0.8mm/√12 = 230 μm
The measured space resolution is ~ 230 μm
Track position is the position in x direction
Used track with only 1 cluster in each glued gem

CMS GEM Preliminary Efficiency



$$\text{Efficiency} = \frac{\text{Cluster in CMS GEM close to track crossing point}}{\text{number of tracks}}$$

A possible source of inefficiency



Sometimes all the VFAT channels are (almost) all on due to noise bump
If this situation happens in all the three glued tracking chamber, it is possible that a fake track is reconstructed.
If the CMS GEM sees a splash, the position of the cluster is artificially wrong reconstructed

If the rate of channels splashes is high, it can introduce inefficiency.

Future plans

- Complete the analysis
- Improve the algorithms
- Understand better the source of inefficiency
- The telescope is mounted on a table that can rotate and become a cosmic station
- This cosmic station is in our lab and we are continuing the studies with GEMs+VFAT

Spare slides

A “Cluster” class

- “Cluster” objects are able to “Find()” themselves in an array of channels
- Easy to implement more sophisticate algorithms, while keeping the same interface
- .. and all the other advantages of object oriented programming

```
class Cluster
  : private TC
{

public:
  short firstch;
  short lastch;
  short maxpos;
  short maxq;
  float pos;
  float q;

  //Default constructor
  Cluster (short firstch = -1, short lastch = -1,
           short maxpos = -1, short maxq = 0,
           float pos = -1., float q = 0.);

  //Copy constructor
  Cluster (const Cluster& original);

  int Find(const short * arrayofch,
           const short startch, const short maxnumofch,
           const int threshold, const int rangecluster,
           short * lastcheckedch = 0);
  static float CentreOfGravity (const short * arrayofch,
                                const short startch,
                                const short endch,
                                float * totalcharge = 0);
```