Quality control for large volume production GEM detectors

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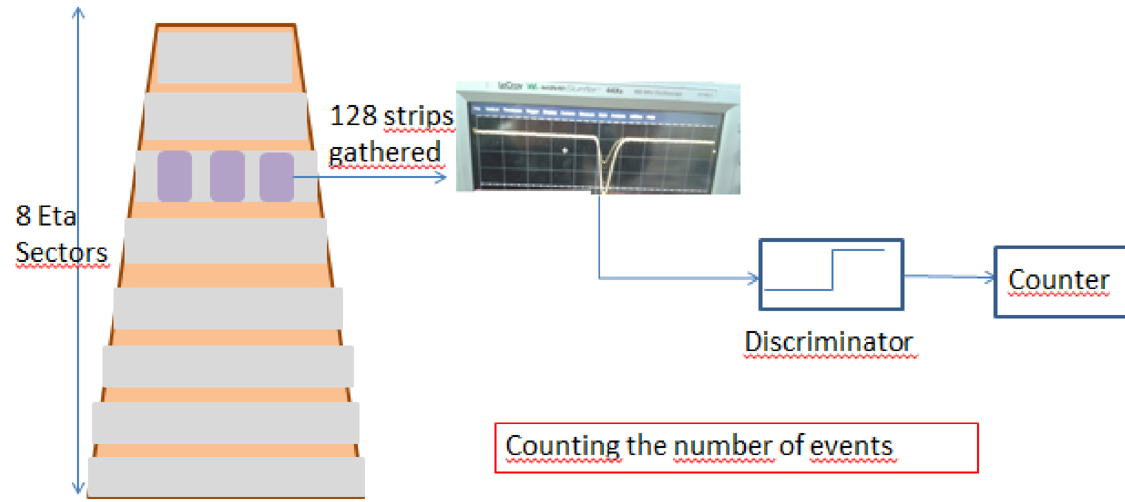
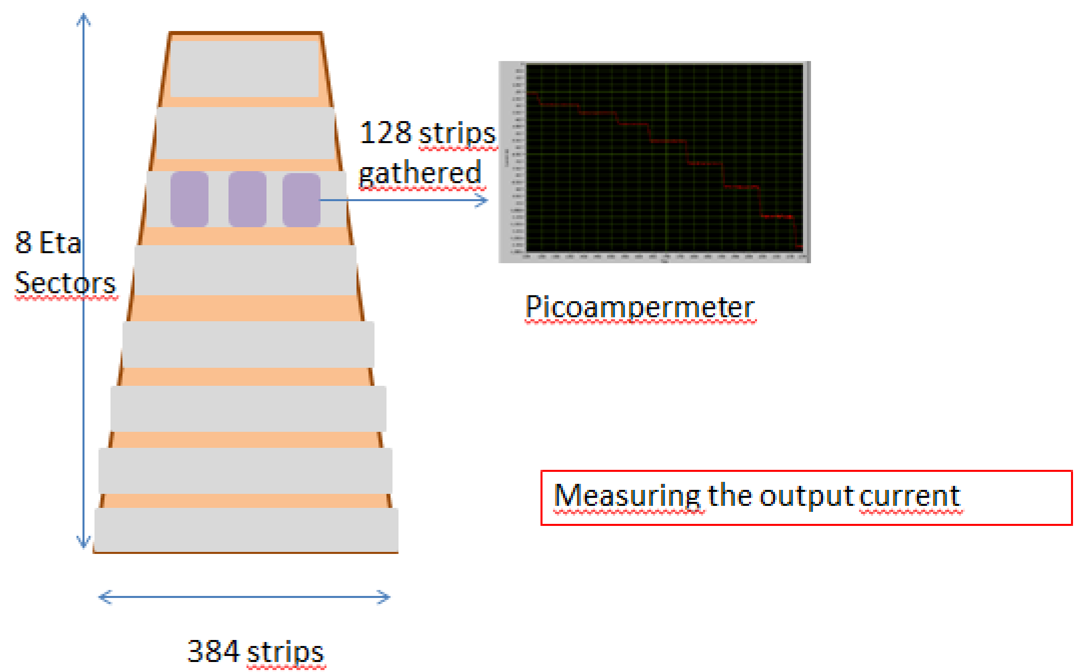
On behalf of the collaboration GEMs for CMS

Gain calculation

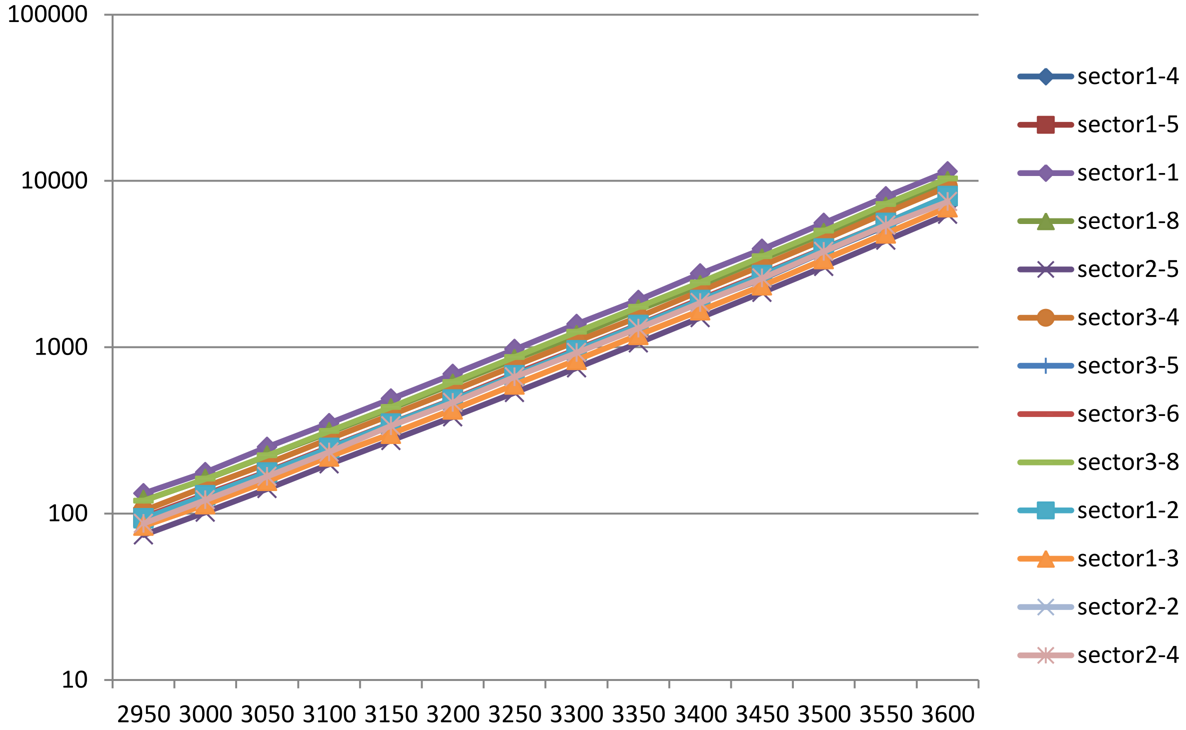
$$gain = \frac{\boldsymbol{I}}{primaries\ \times \boldsymbol{rate}\ \times e}$$

$$primaries = \ E_{\gamma}\ \times (\frac{70\%}{w(Ar)} + \frac{30\%}{w(CO_2)})$$





- Counting the number of events with amplifier-Discriminator-counter
- Measuring the current with a picoampermeter



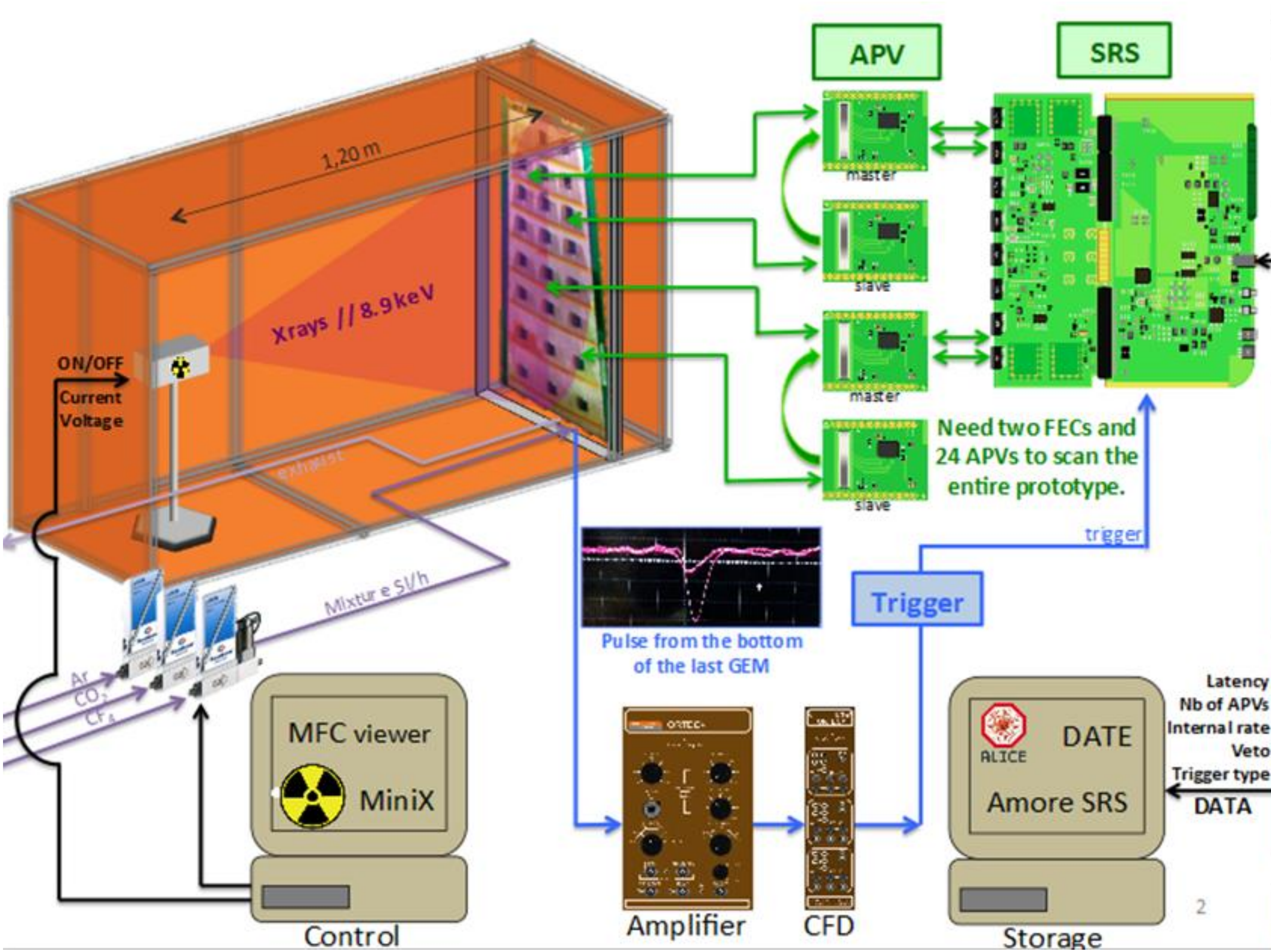
Argon/CO2 (70/30)

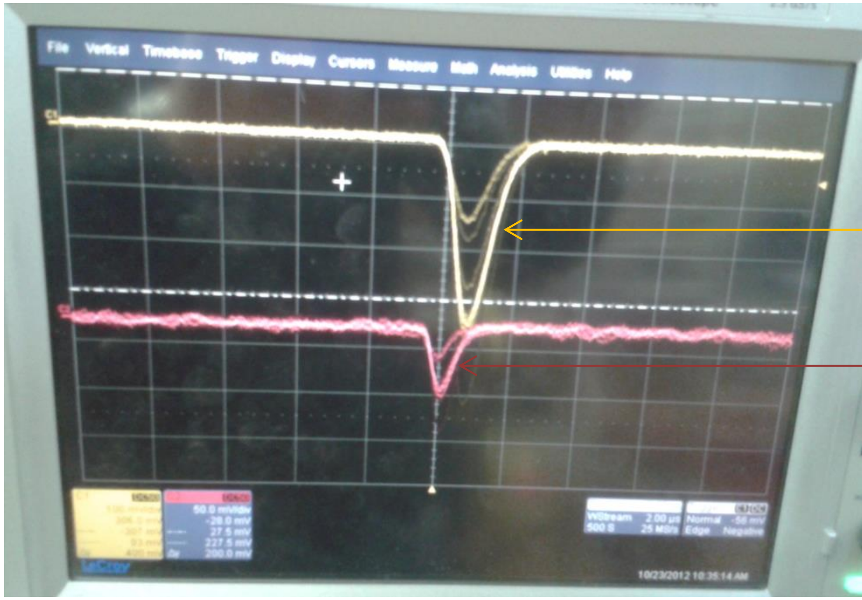
NS2 chamberII

Computing the gain for every **24** sectors

Comments:
About 2 weeks needed to measure one single chamber.
Many manipulation needed.
External conditions change during the measure.

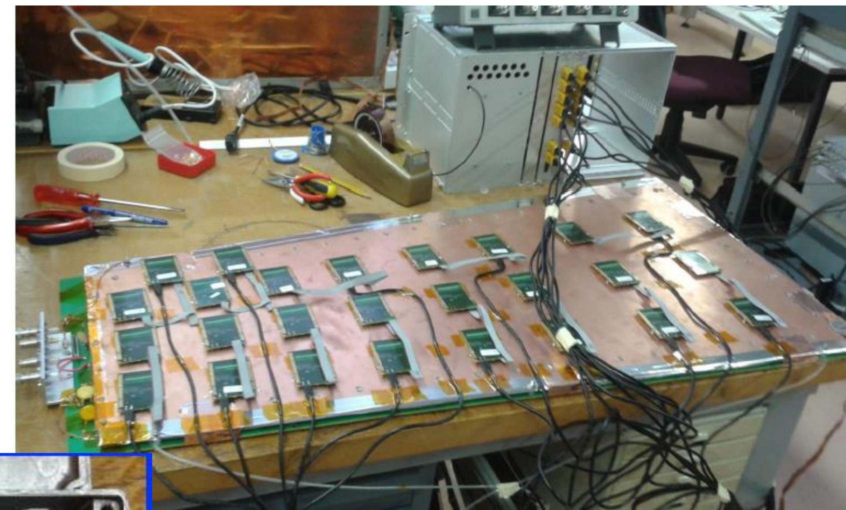
Gain Uniformity using SRS system





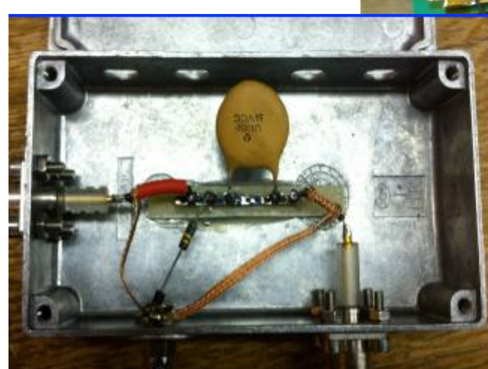
Signal on the readout

Signal on the GEM
used as a trigger



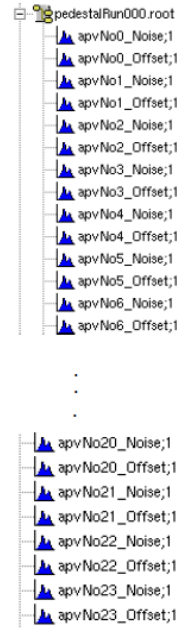
Difficulty of the measurement :

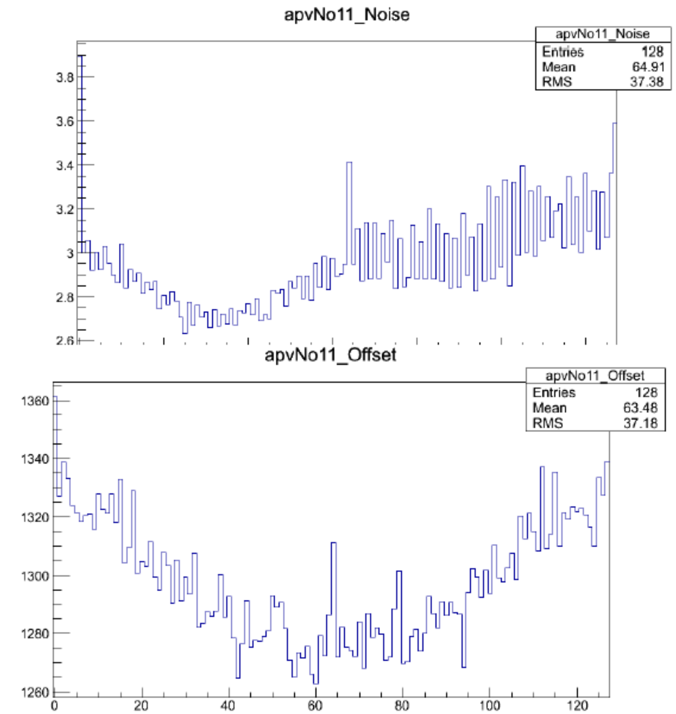
- The noise of the signal on the GEM is high because of the size of the GEM.
- APV needs very low input charge, we have to run the detector with low gain.



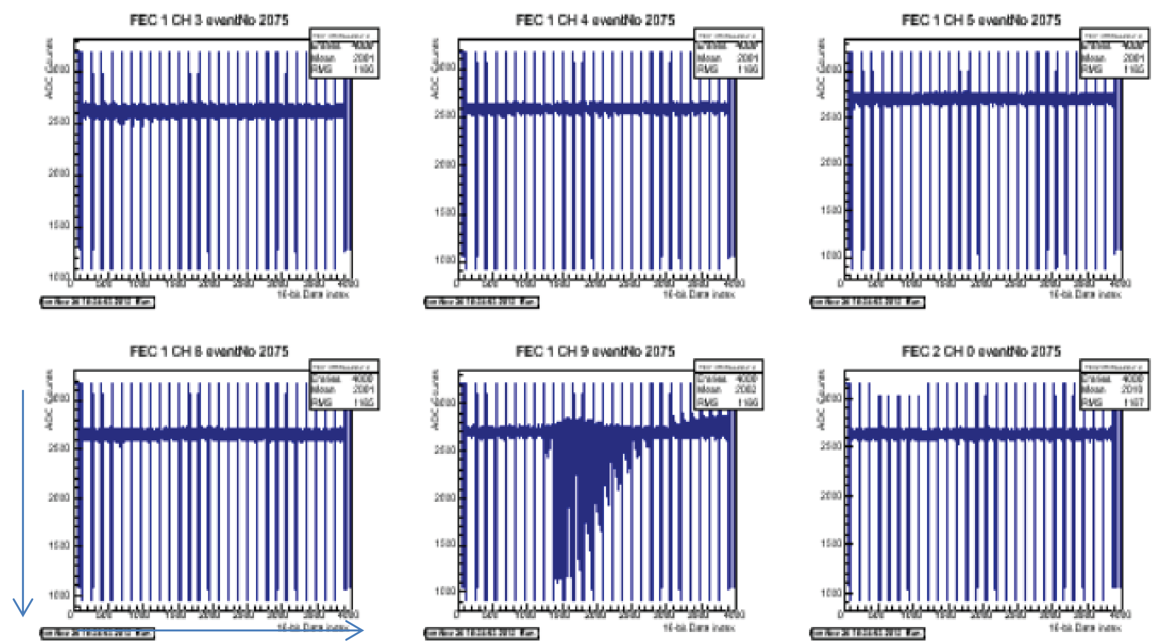
Reducing the noise with a large copper plate grounded and a filter to cut low frequency signals

Pedestal run to determine the level of the noise and offset for each APV



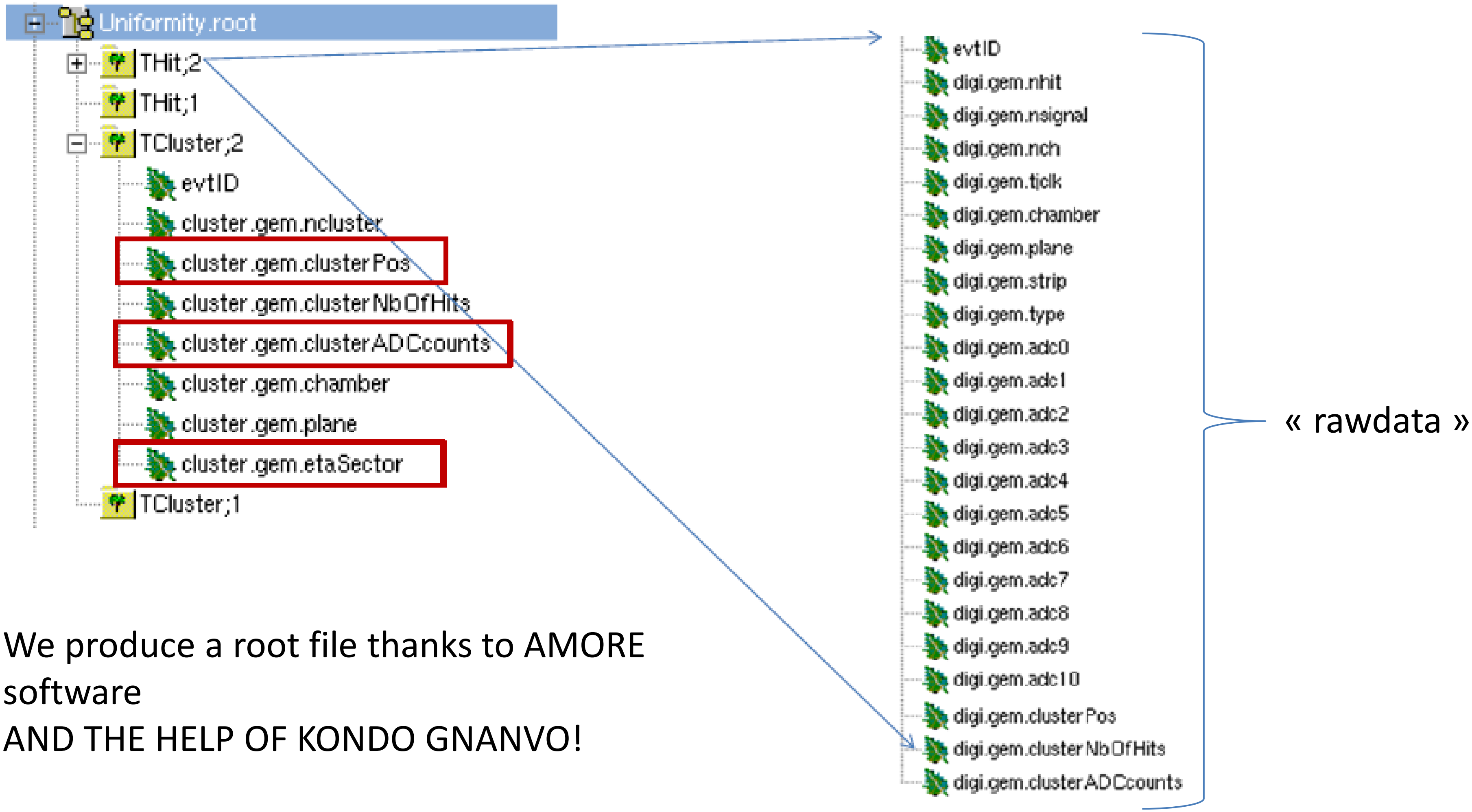


Raw data from each APV.



Charge collected

Time frames

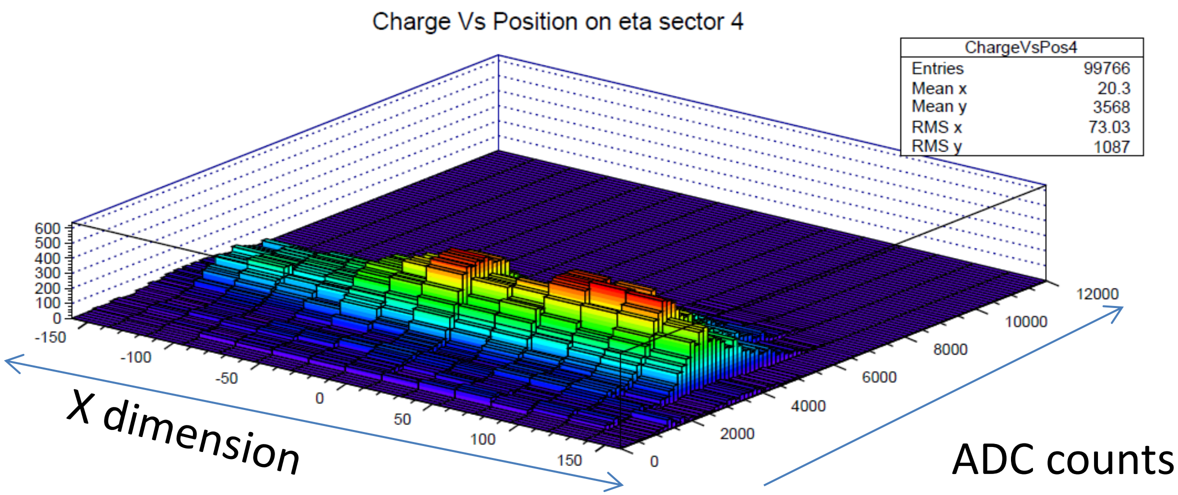


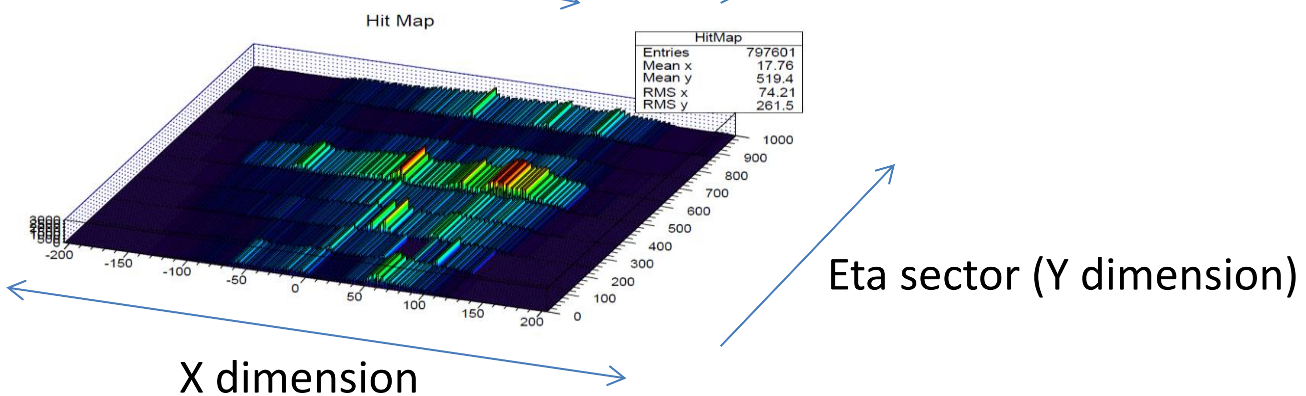
We produce a root file thanks to AMORE software
AND THE HELP OF KONDO GNANVO!

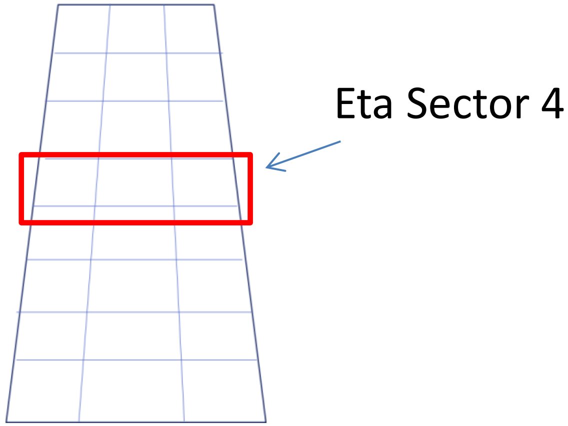
And we get the clusters informations

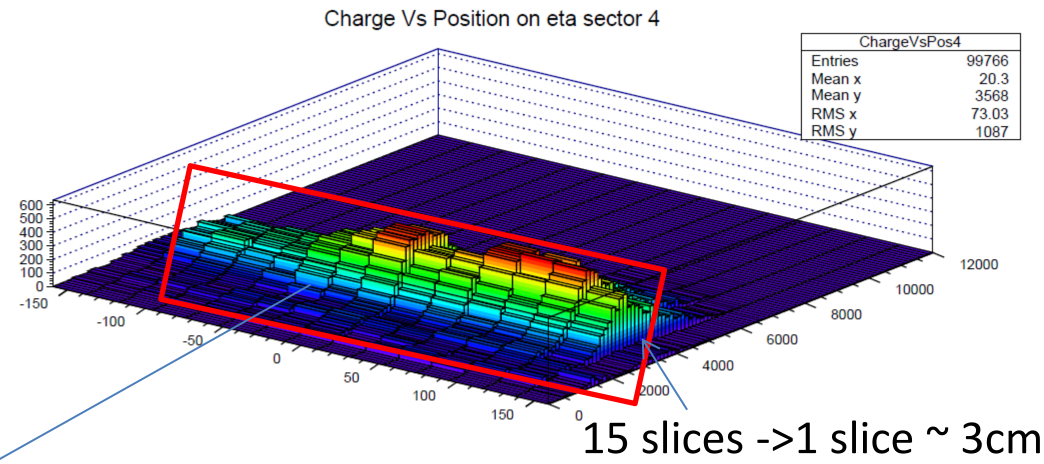
With these three objects and a root macro we can have everything

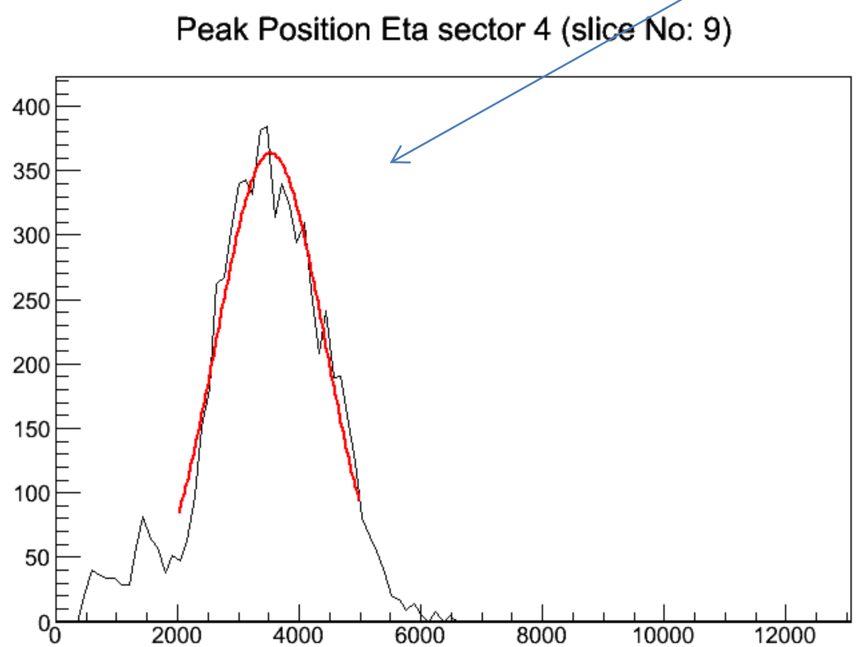
cluster.gem.etaSector | cluster.gem.clusterPos | cluster.gem.clusterADCcounts



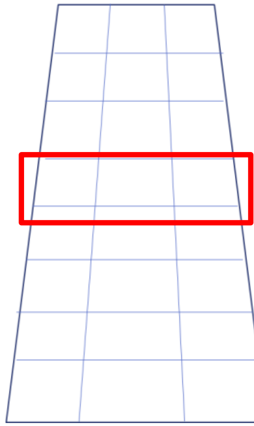




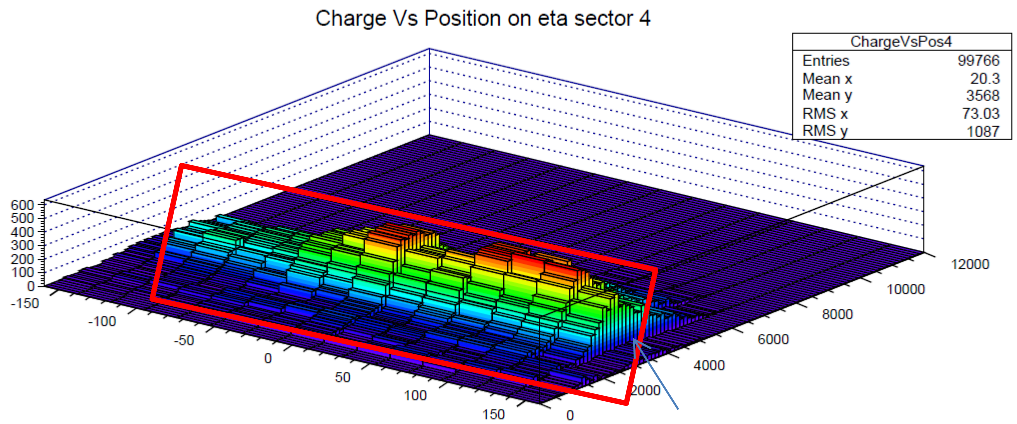




- For each event we compute the charge per cluster, and we reconstruct the spectrum of the X-Ray source

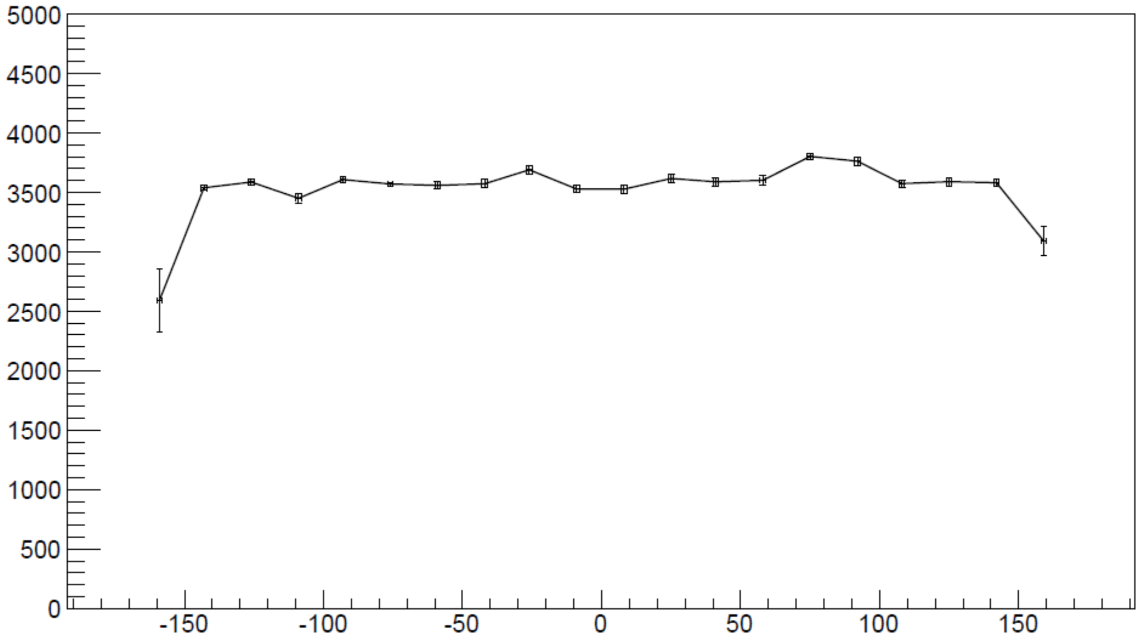


Eta Sector 4

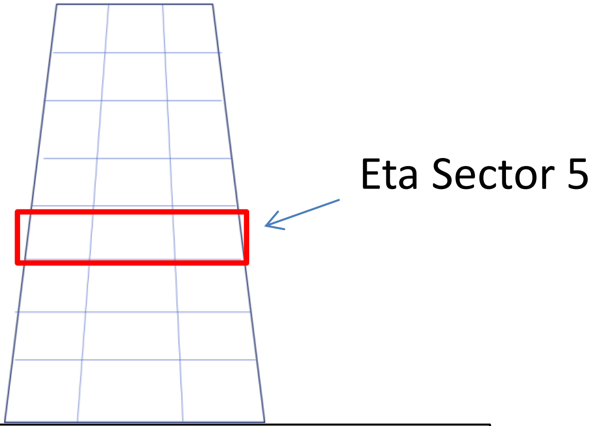


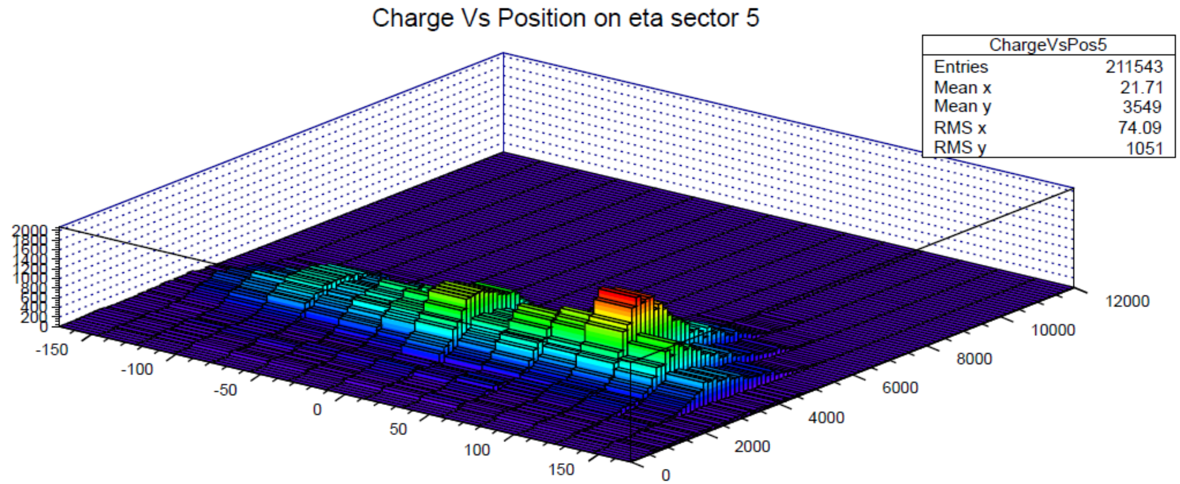
- We follow the peak position of the spectrum along the chamber

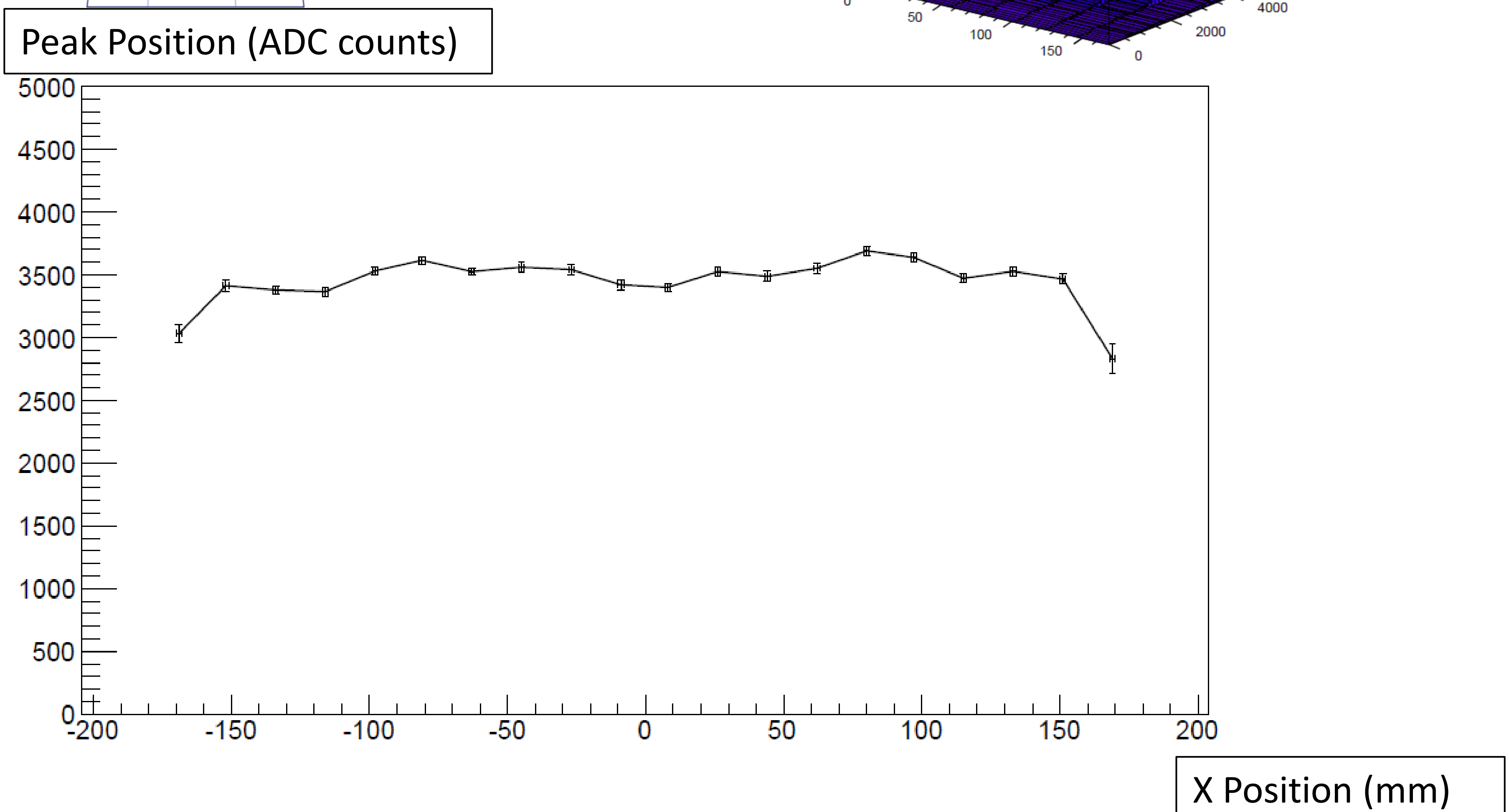
Peak Position (ADC counts)

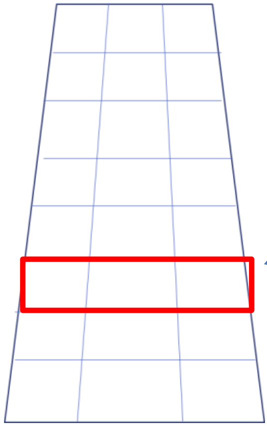


X Position (mm)

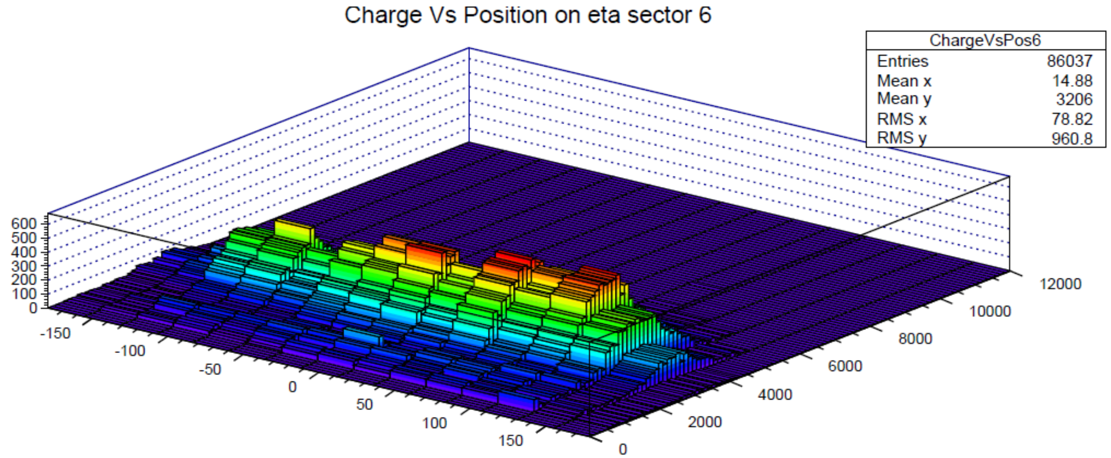

Eta Sector 5


Charge Vs Position on eta sector 5
ChargeVsPos5
Entries 211543
Mean x 21.71
Mean y 3549
RMS x 74.09
RMS y 1051
-150
-100
-50
0
50
100
150
0
2000
4000
6000
8000
10000
12000

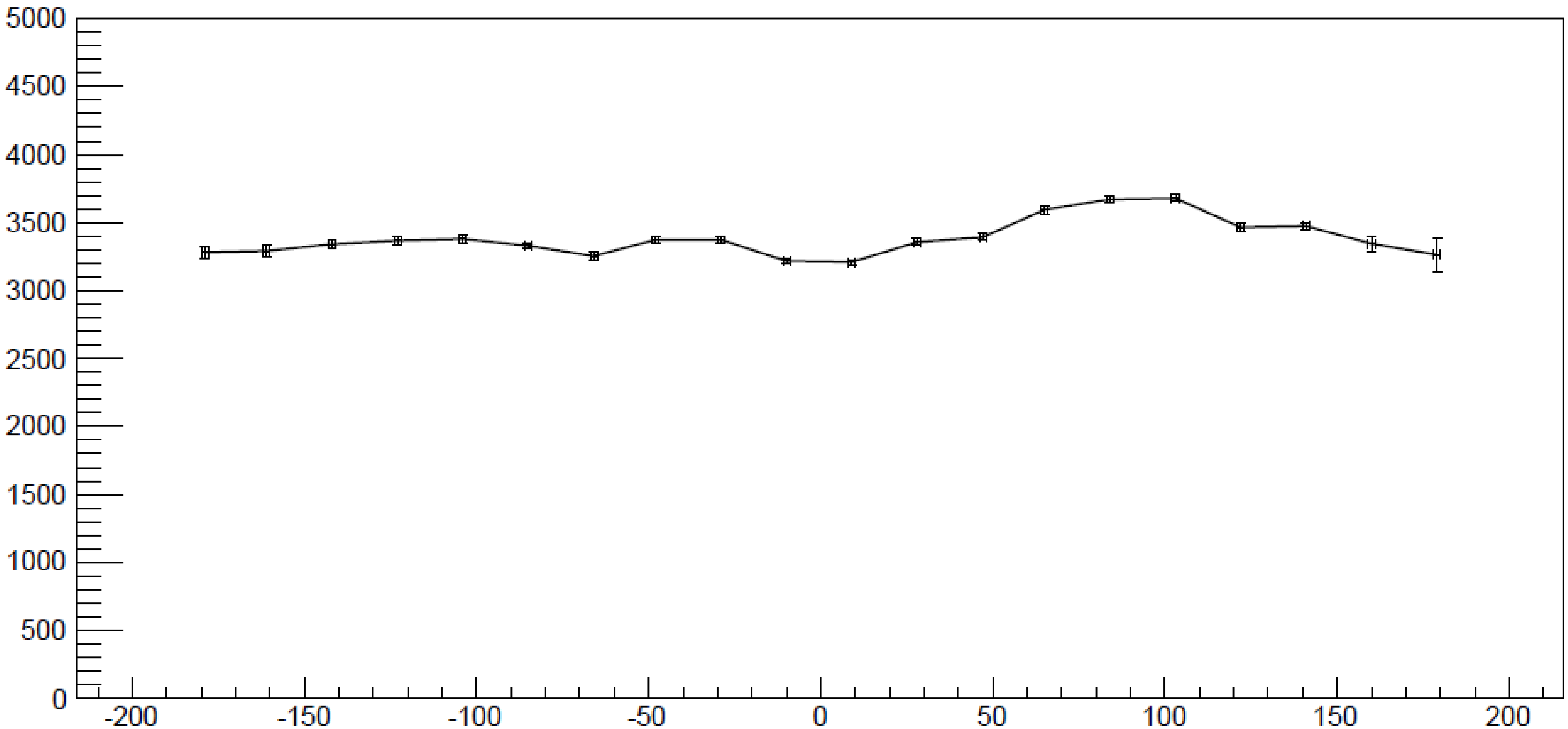

Peak Position (ADC counts)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-200
-150
-100
-50
0
50
100
150
200
X Position (mm)



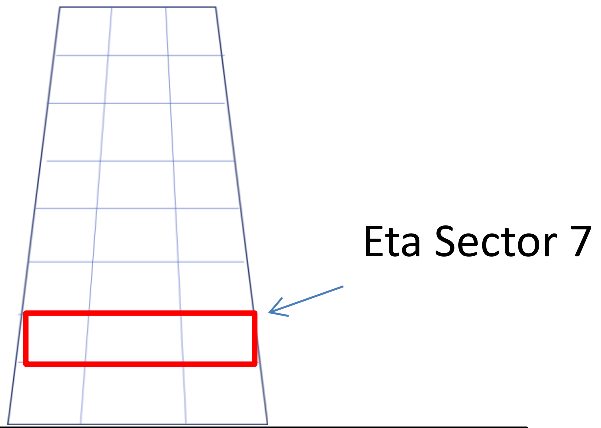
Eta Sector 6

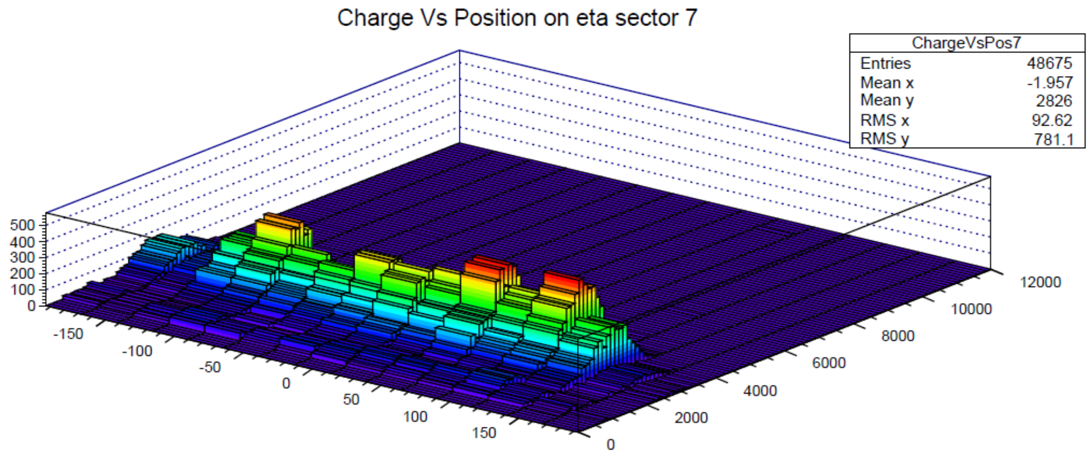


Peak Position (ADC counts)

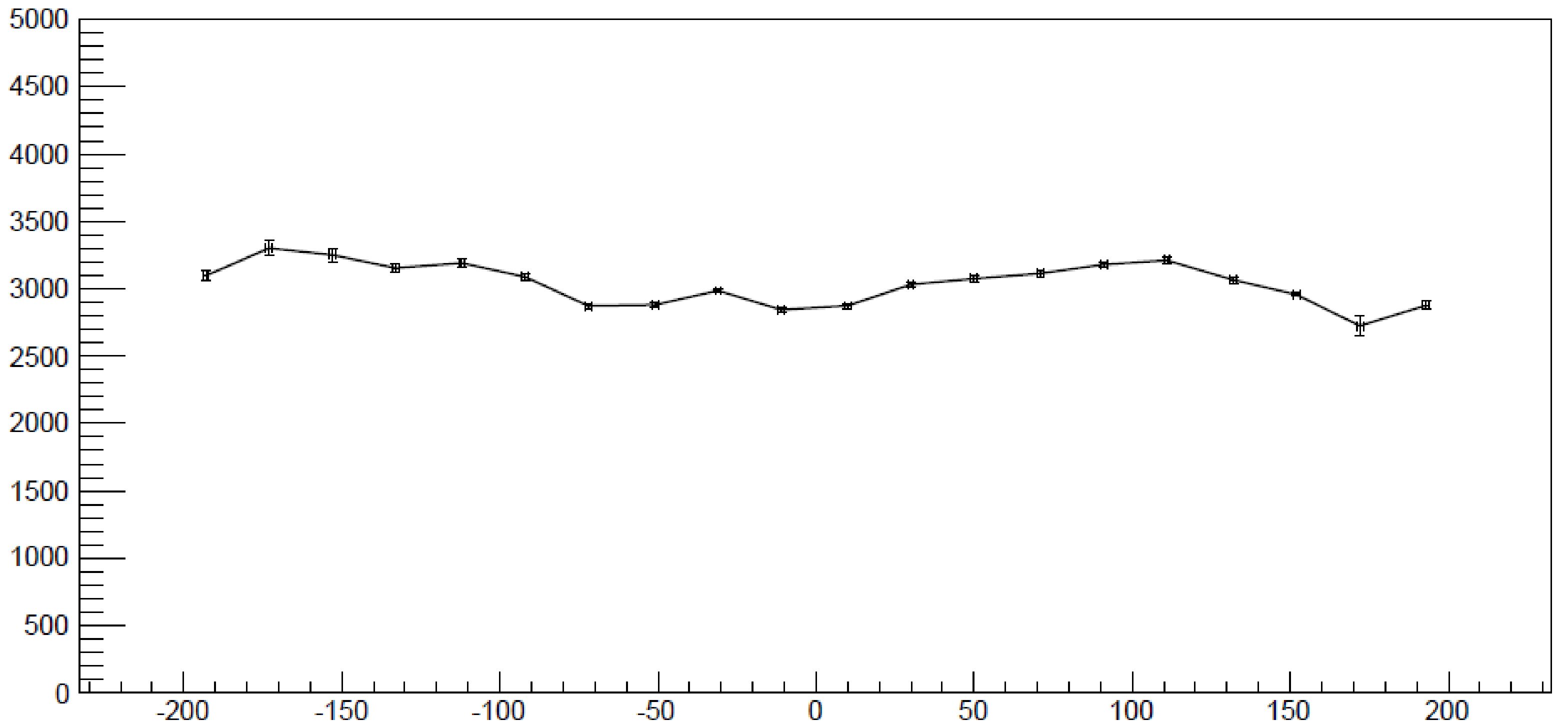


X Position (mm)

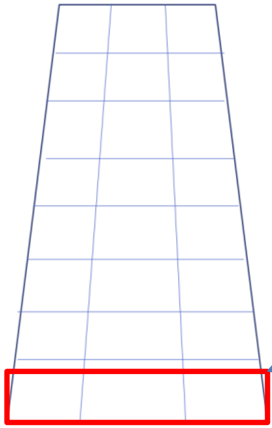




Peak Position (ADC counts)

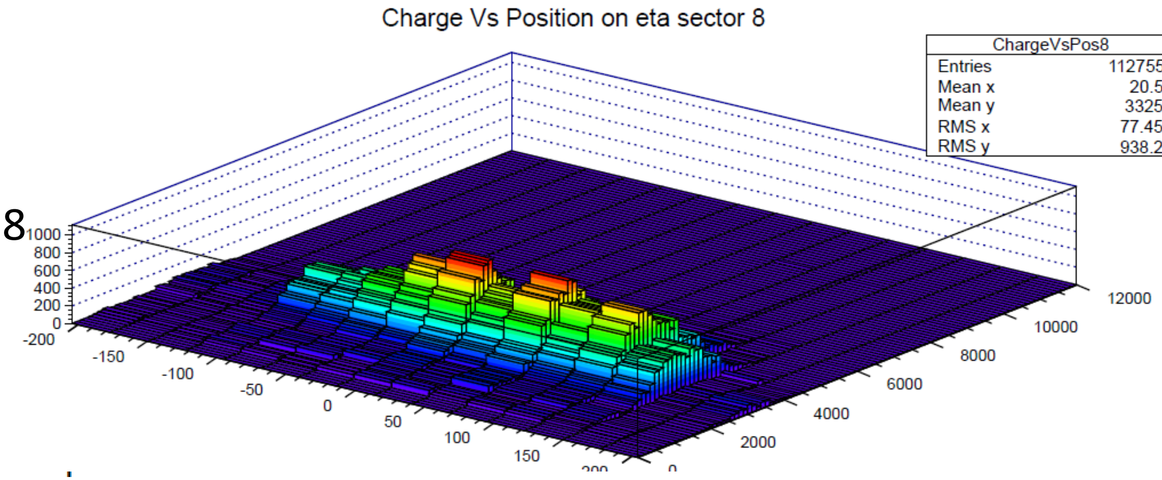


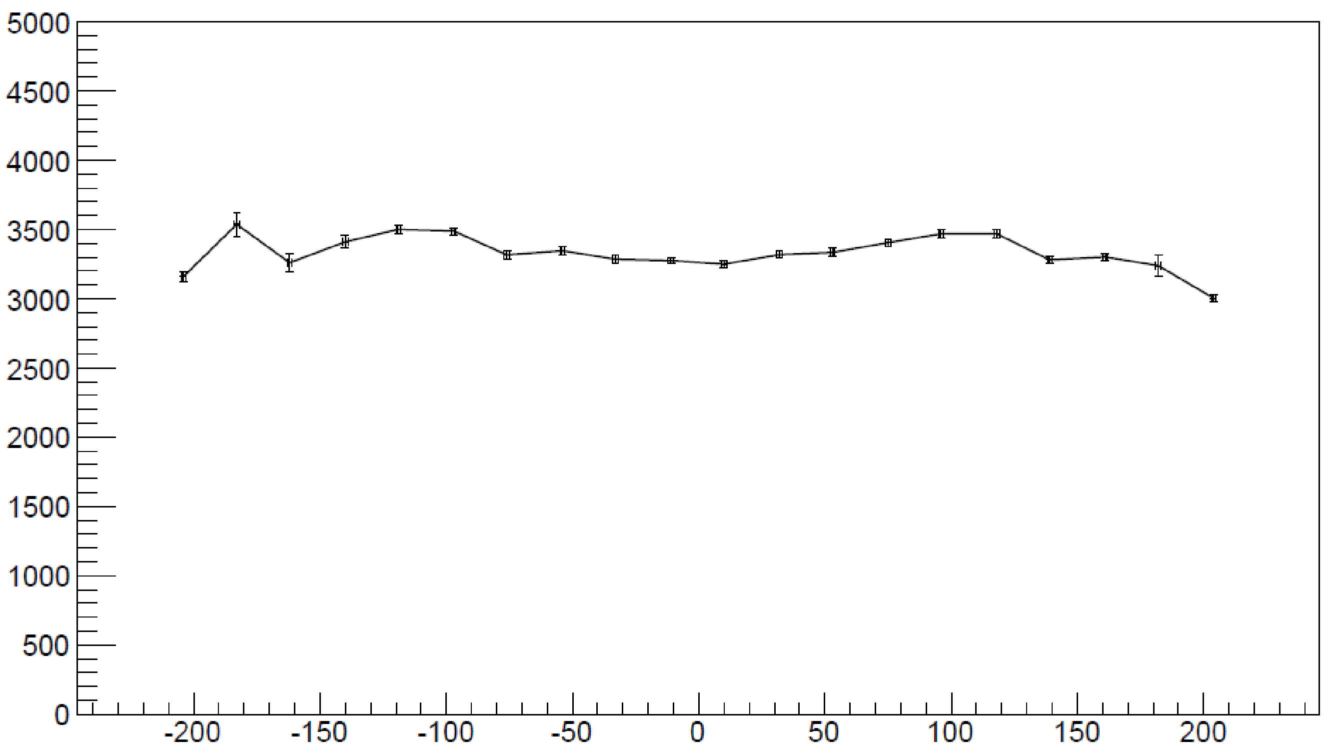
X Position (mm)



Eta Sector 8

Peak Position (ADC counts)

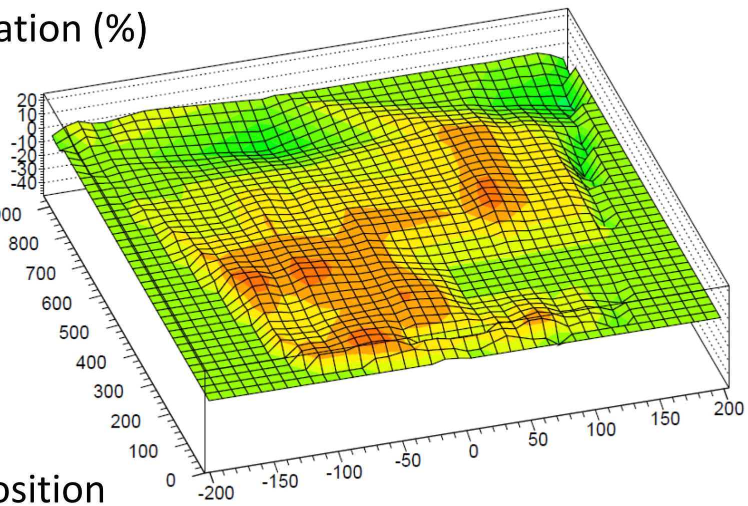




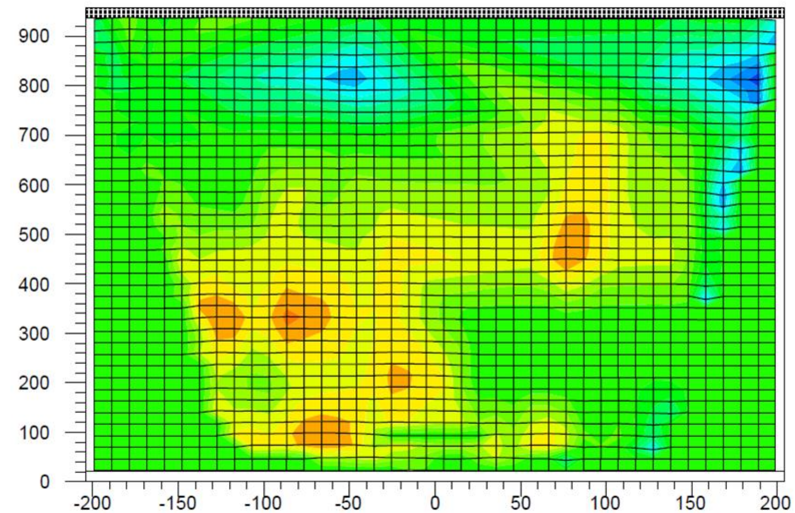
X Position (mm)

Uniformity Plot

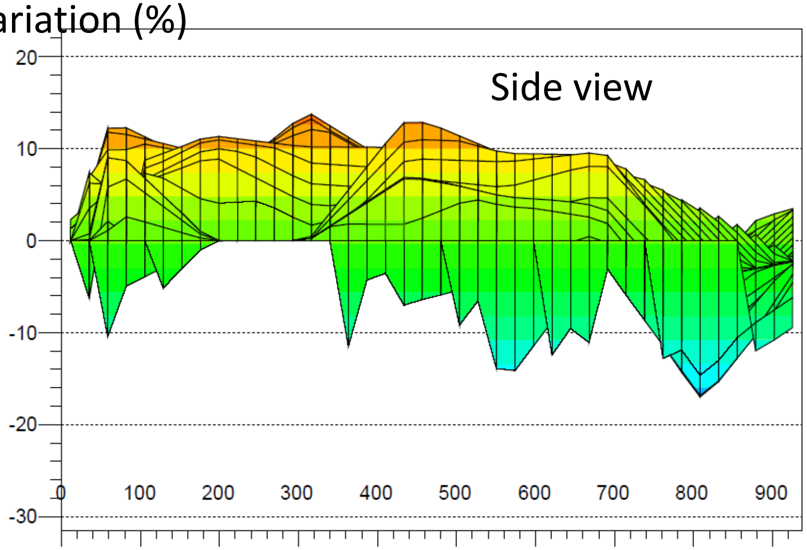
PeakPosition
Variation (%)



Top view



PeakPosition
Variation (%)



Eta Sector

Time estimation with APV

- Install the chamber at the end of the day and leave flushing with gas all night
- 2h data taking
- ½ day data analysis
- 2 days are enough to install and test one chamber
- This reduces enormously the QC/repair and validation of production chambers

CONCLUSION:

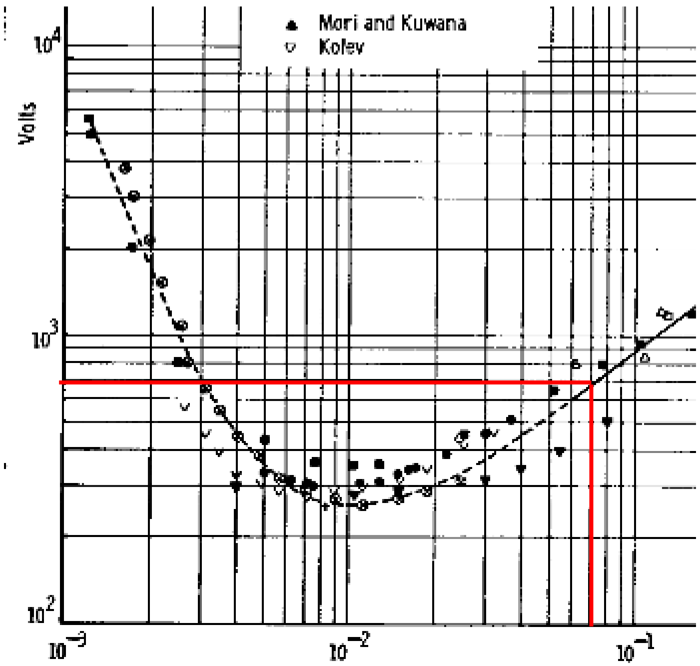
Compare two weeks to two days !!

GEM foil quality control

Paschen's law, experienced in nitrogen

(http://www3.nd.edu/~dgo/teaching/AME60637/reading/1974_E_Dakin_Luxa_Oppermann_paschen_curves.pdf)

Breakdown voltage (V)



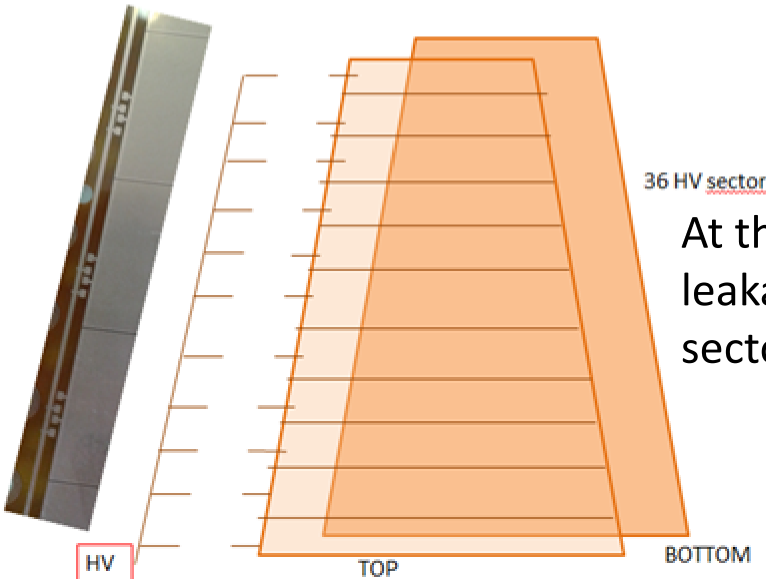
Product pressure x distance (bar.mm)

For a GEM foil, under atmospheric pressure 1,013Bar
60µm thickness, in nitrogen

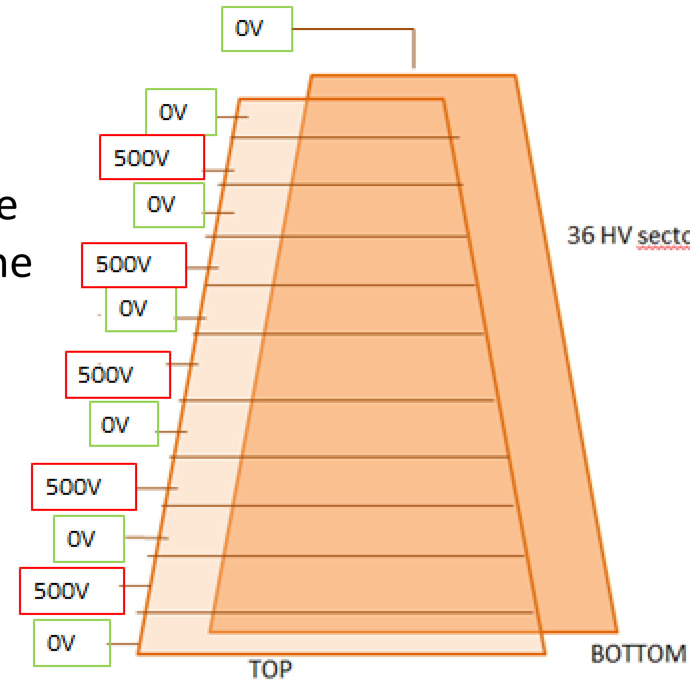
P.d = 6.10^{-2} bar.mm

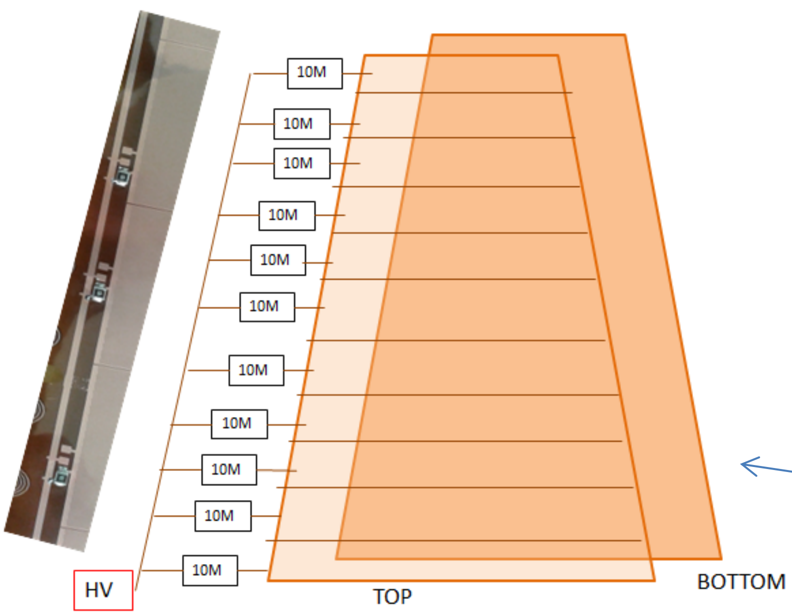
$V_{breakdown}$ = 600V (±50V)

GEM foil preparation



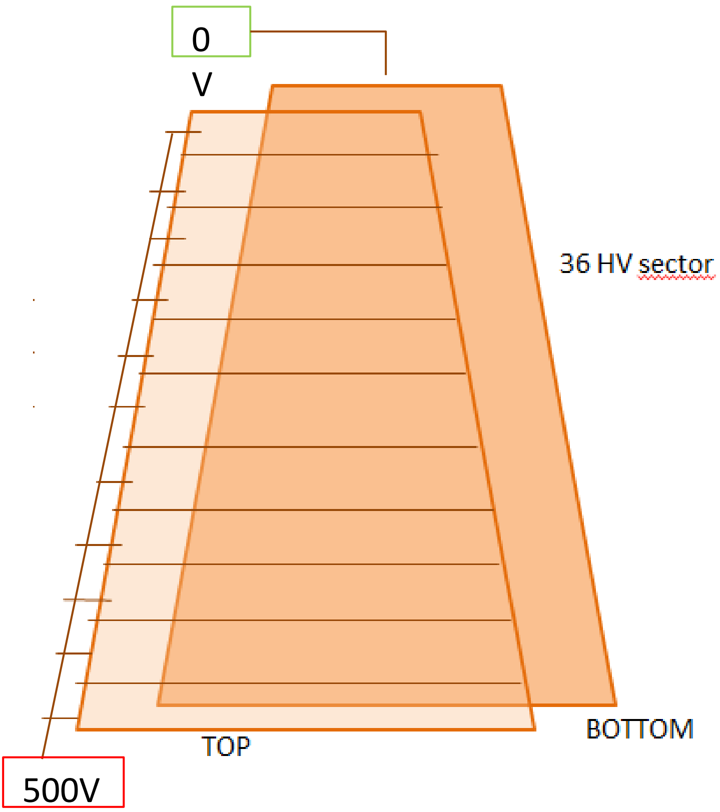
At this point we can test the leakage current between the sectors.





Soldering the protective resistors

Carefull leakage measurement of the foil

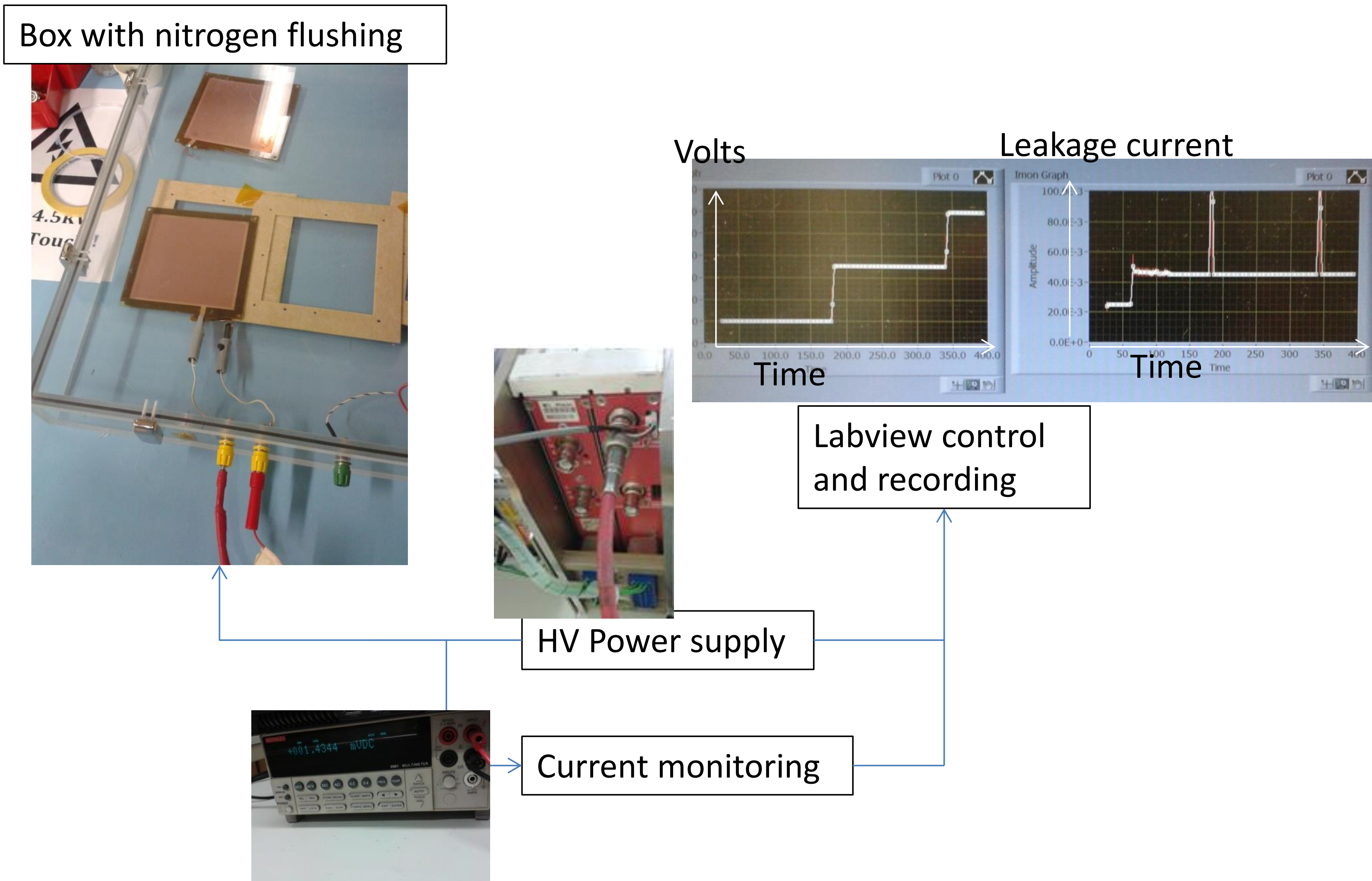


Under Nitrogen, atmospheric pressure.

From 0V to 500V we should not see sparks.

And we should measure a small leakage current.

Set up already in place at RD51
Made by Eraldo.



Further develeoppement possible

N1471HB

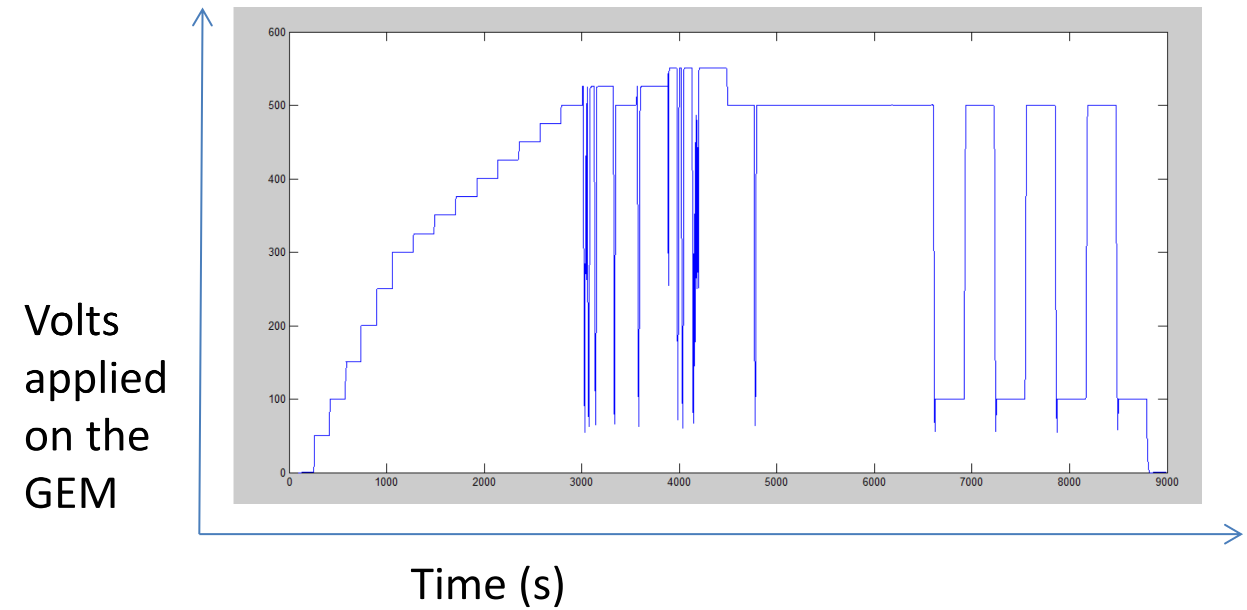
1 Channel 5.5 kV Programmable HV Power Supply

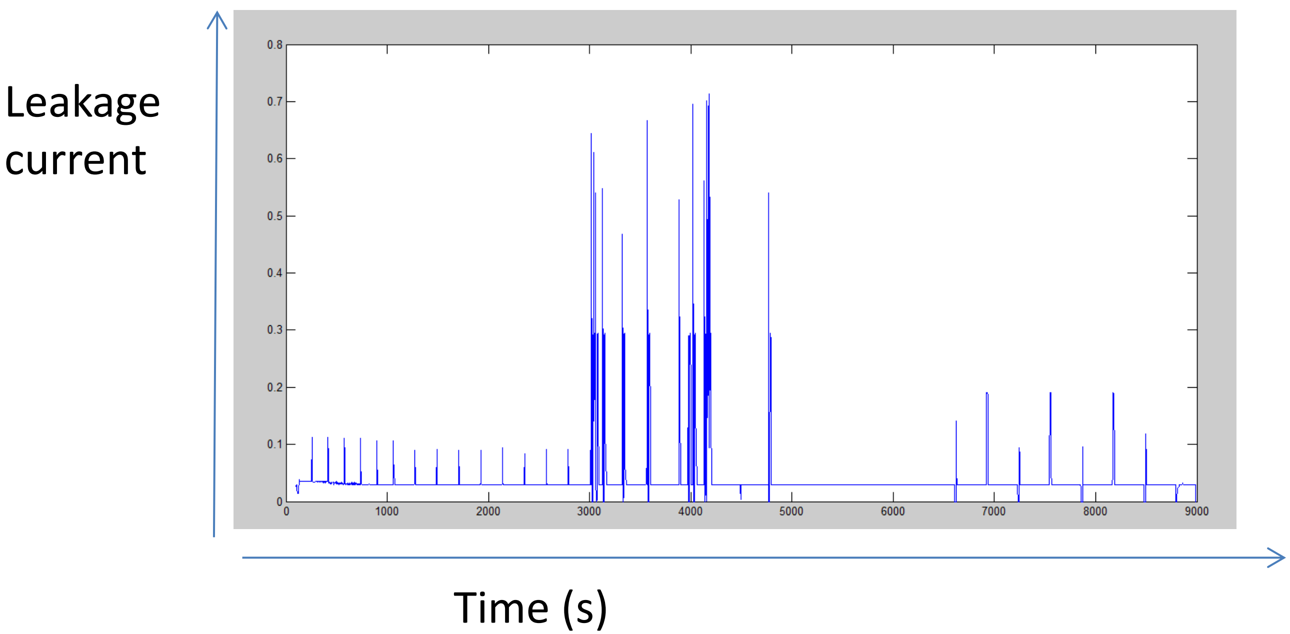
- 1 channels in 1U NIM module available)
- 5.5 kV / 20 μA output ranges
- Channels with individually selectable positive or negative polarity
- SHV coaxial output connectors
- Common floating return
- Low Ripple (Typ: < 5mVpp)
- 100 mV Vset resolution
- 1 nA Iset resolution (Imon-Zoom: 50 pA)

More

Setting HV and measuring the leakage current with 50pA resolution with the same device.

Result example





From 0 to 500V by steps of 50V, waiting 120s at each value.

If there is a high current recorded, one step back in the voltage, if there are more than 3 steps back switch off.

On this 10x10 we saw some high leakage current, but then it stabilized.

Future plans

- About the gain uniformity: several other runs foreseen when the 6 large scale prototypes will be ready.

- A cosmic stand needs to be designed to validate the final electronic and check chambers efficiency.

THANK YOU