A study of MuCh digitization parameters on omega reconstruction efficiency

Ajit Kumar
VECC

Date: 10-09-2021

Digitization parameters and observables

Digitization parameters:

- Spot size (0.025 cm - 0.100 cm)
- Gas gain (1k – 10k)
- Dynamic range
- Noise threshold

Variables of study:

- **Residuals**
- **Omega reconstruction**
  - **efficiency**
  - **S/B**
  - **Significance**

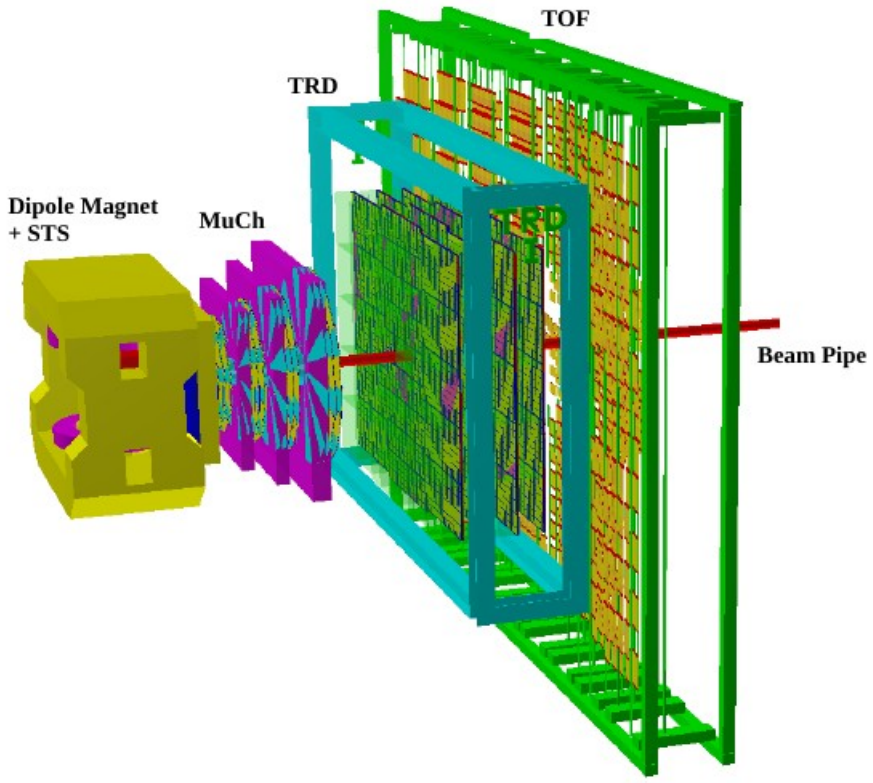
Geometry and Input

CBMROOT Version: APR20

Background:
UrQMD, Au+Au, Central, 8A GeV

Signal:
Pluto, Au+Au, 8A GeV

```
Magnet      = "v18b";
Pipe        = "v20a_1m";
Sts         = "v19a";
Much        = "v20c_sis100_1m_lmvm";
Trd         = "v17n_1m";
Tof         = "v16d_1m";
Plate       = "v13a";
```



SIS100 LMVM

v20c ==> Realistic module geometry
-> 2 GEM station + 2 RPC station

Analysis Steps

I have used scripts prepared by Anna Senger

a. batch_run_bg.sh
b. batch_run_sgn.sh
c. run_batch_jobs.sh

Standard macros:

a. run_trnasport.C
b. run_digi.C
c. run_reco.C
d. run_ana.C
e. Optimization.C -- Invariant mass analysis

Spot radius

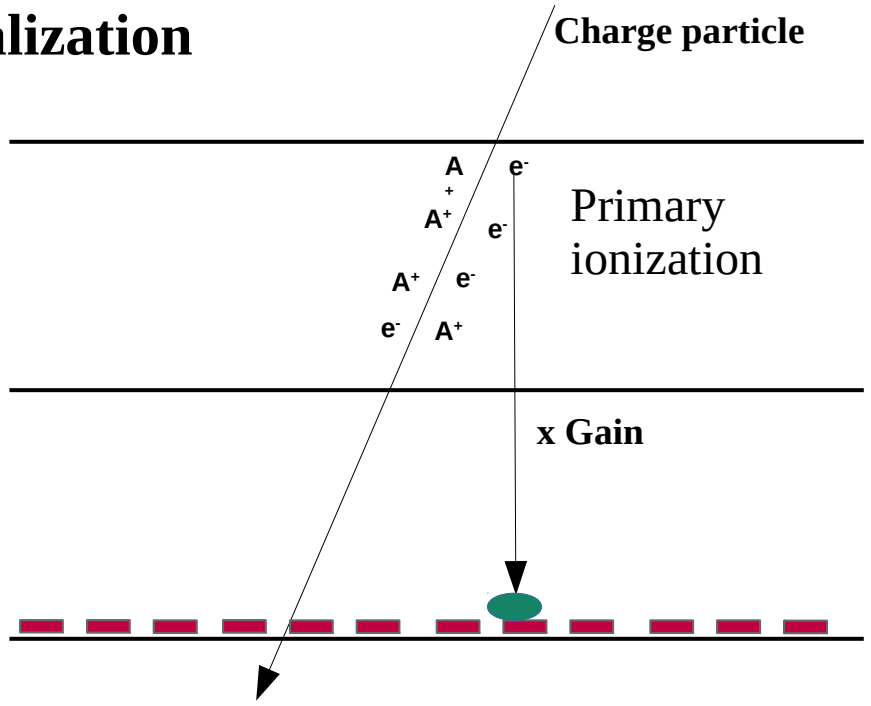
Cluster size: Number of fired pads per incident particles (cumulative effect of all primary e)

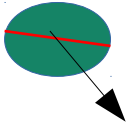
-- Each incident particle creates certain number of primary ionization

-- Each electrons in the primary ionization affected by E. Field – hence the fired pads

-- The number of fired pads will certainly depend on the pad size

Visualization





Diameter (d) = 2R

Spot radius = d/2 = R

Effect of Gas Gain and Spot Size on Omega Reconstruction

Invariant mass distribution of Omega

Gain = 3000

Number of events: 10^5

Cuts:

N of STS hits ≥ 7

N of MUCH hits ≥ 11

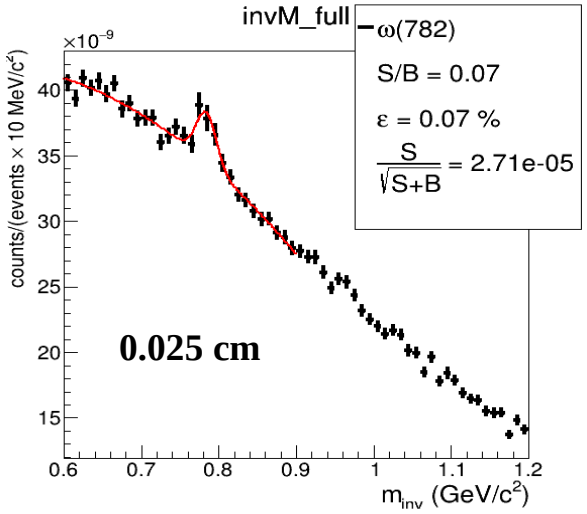
N of TRD hits ≥ 1

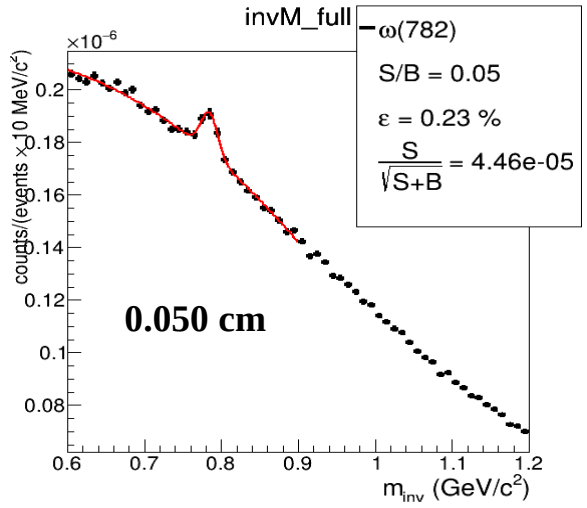
$\chi^2_{vertex} \leq 2.0$

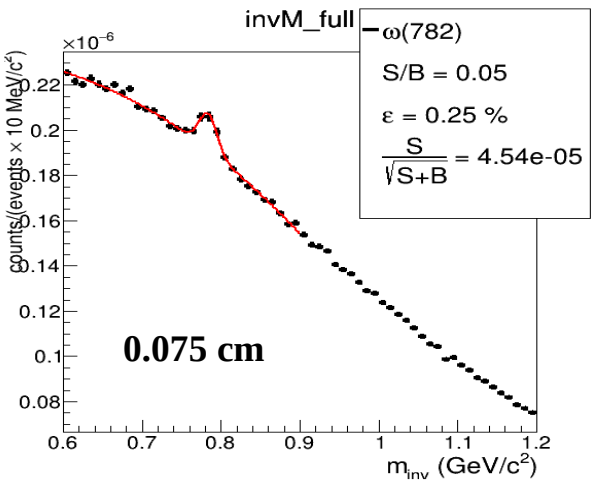
$\chi^2_{STS} \leq 2.0$

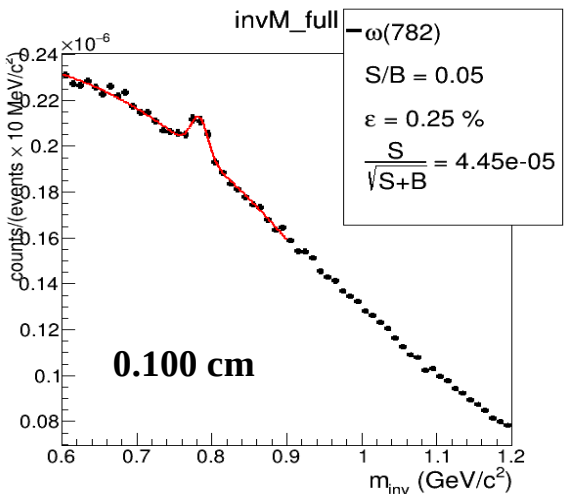
$\chi^2_{MUCH} \leq 2.0$

2σ cut in TOF



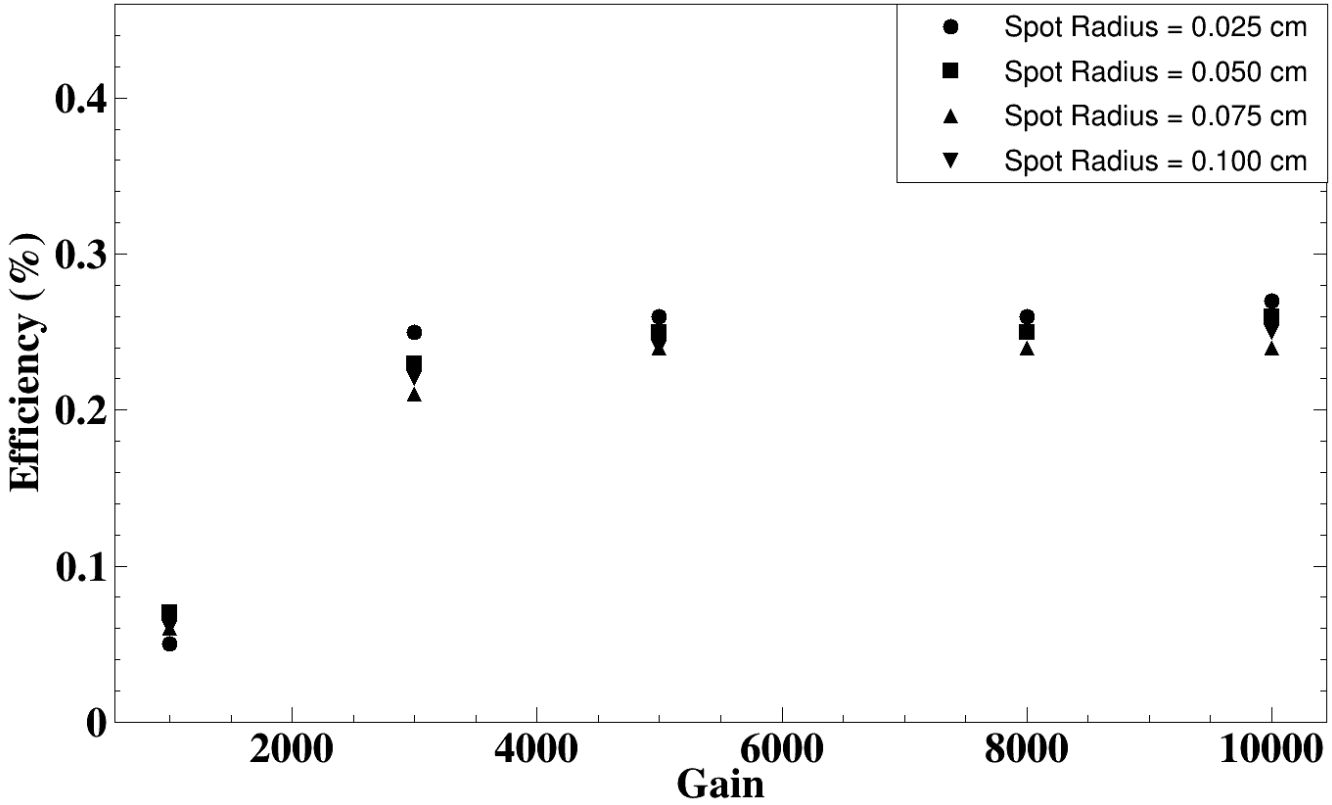






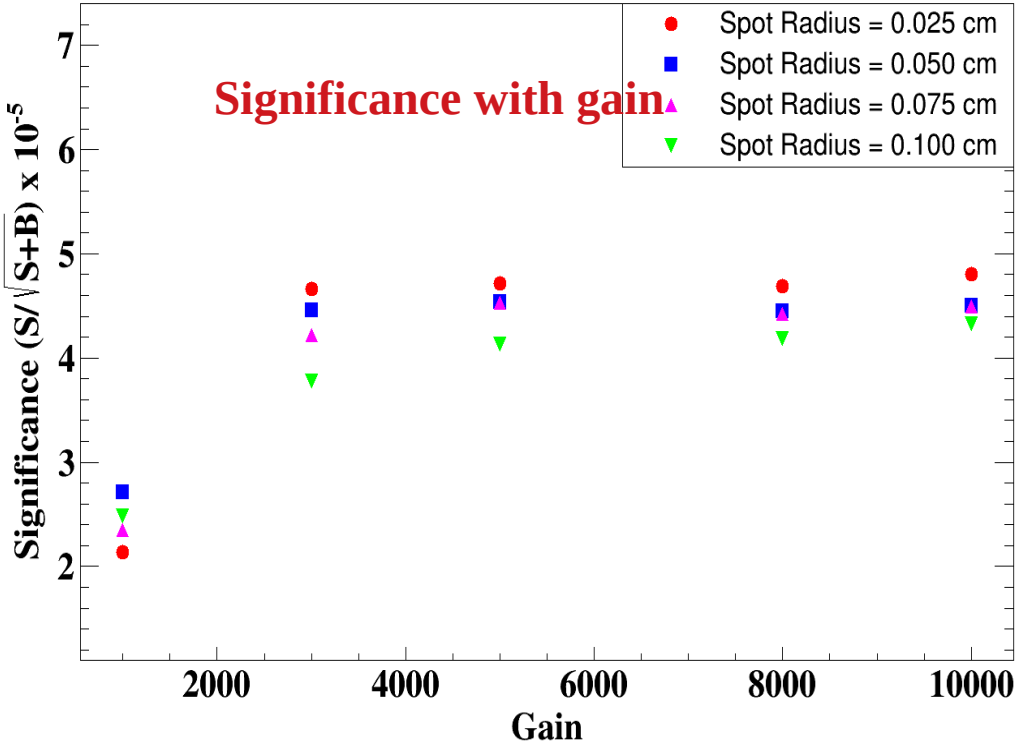
Efficiency with Gain

- Efficiency increase with gain and saturates after ~3k.
- At a given gain, it does not vary much due to spot radius as can be seen from figure.

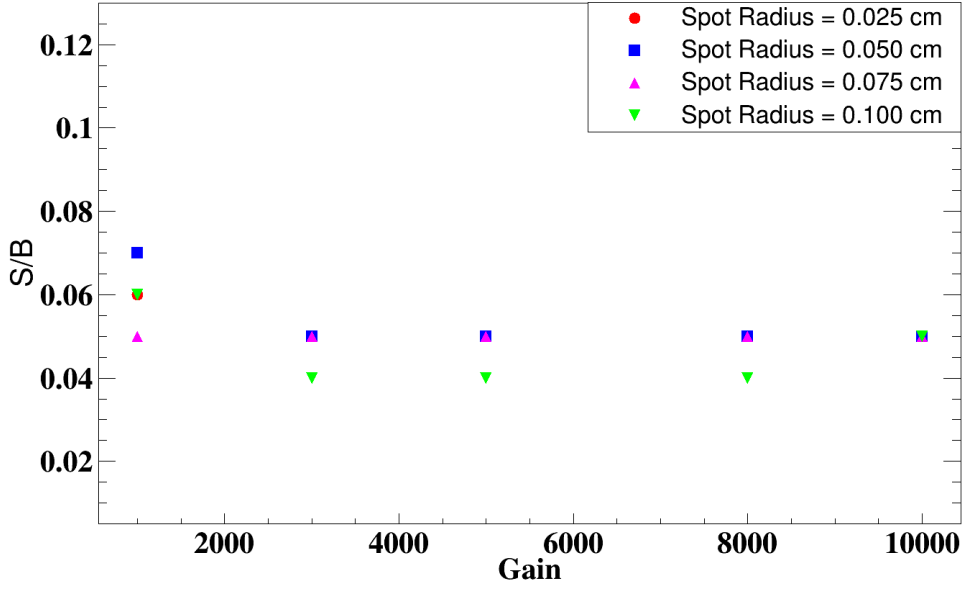


https://indico.gsi.de/event/1118/contributions/1437/attachments/1146/1491/2_Kryshen-2011-04-04-cbm-much-issues.pdf

S/B and Significance



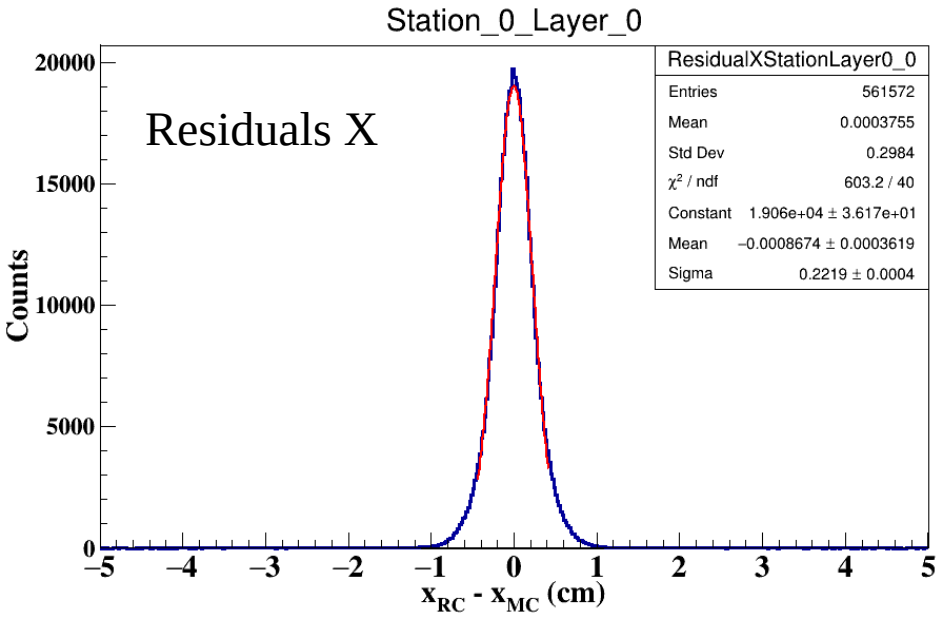
- **Significance** increase with gain and **saturates** after **~3k**.
- At a given gain, it does not vary **much** due to spot radius as can be seen from figure.

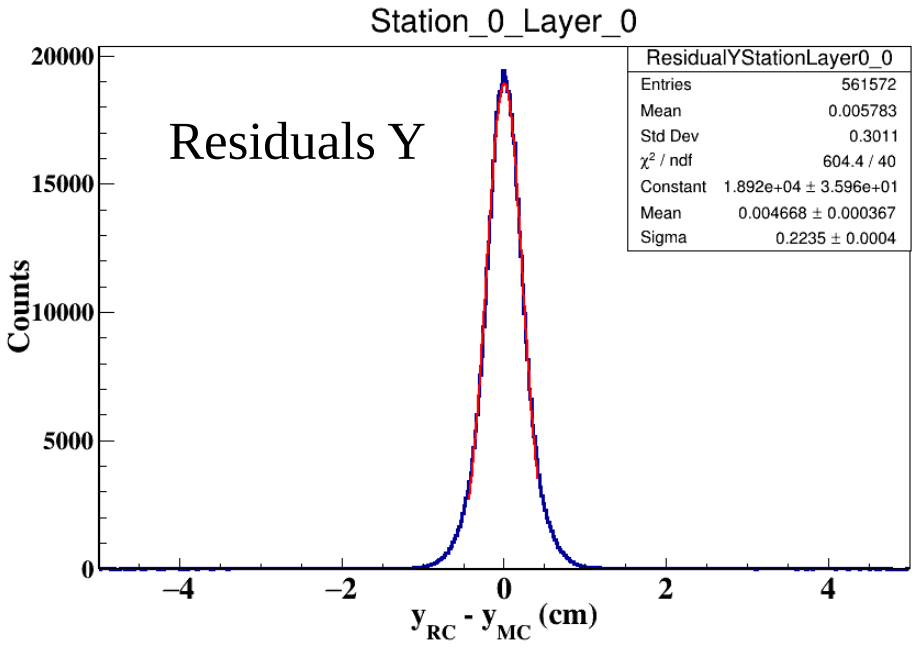


Effect of Gas Gain and Spot Size on Residuals

Residuals

Background (URQMD)



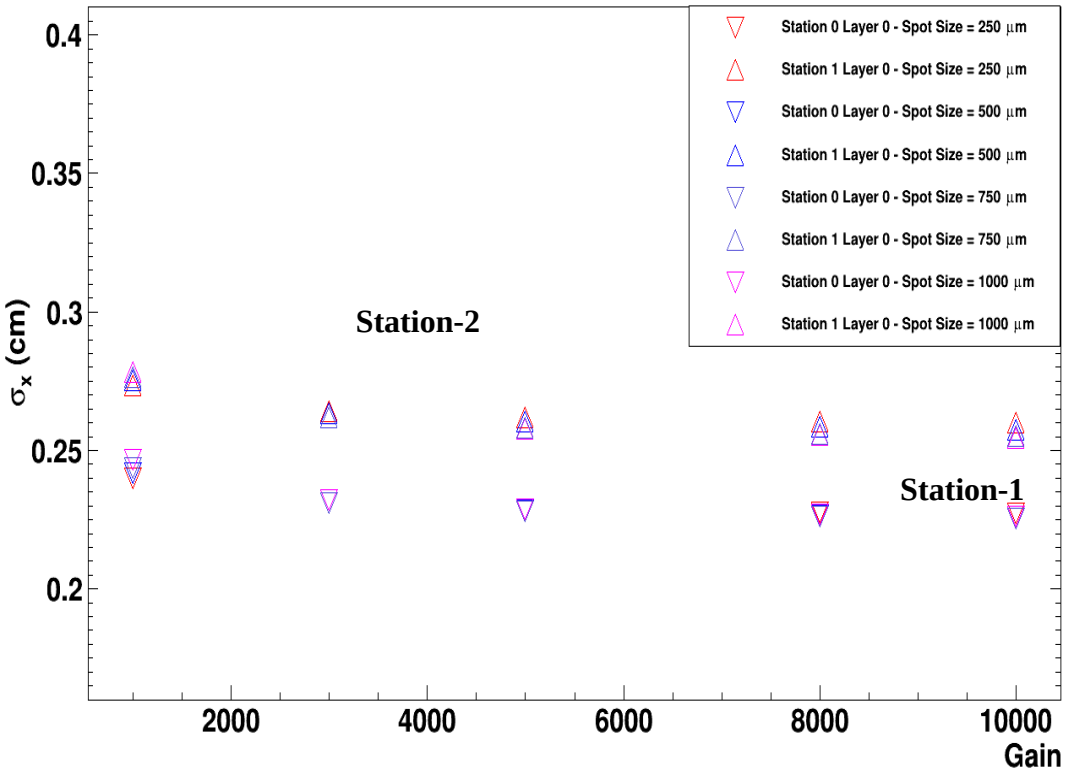


1000 events

Residuals with gain

UrQMD particles (2000 events)

- At a given gain, sigma of the residuals does not depend on the spot size
- the resolution improves slightly with gain and is observed to saturate after ~3k
- First station module has smaller value compare to 2nd station – due to multiple scattering
- At a given gain, ~12% increase in sigma at 2nd station compare to 1st station

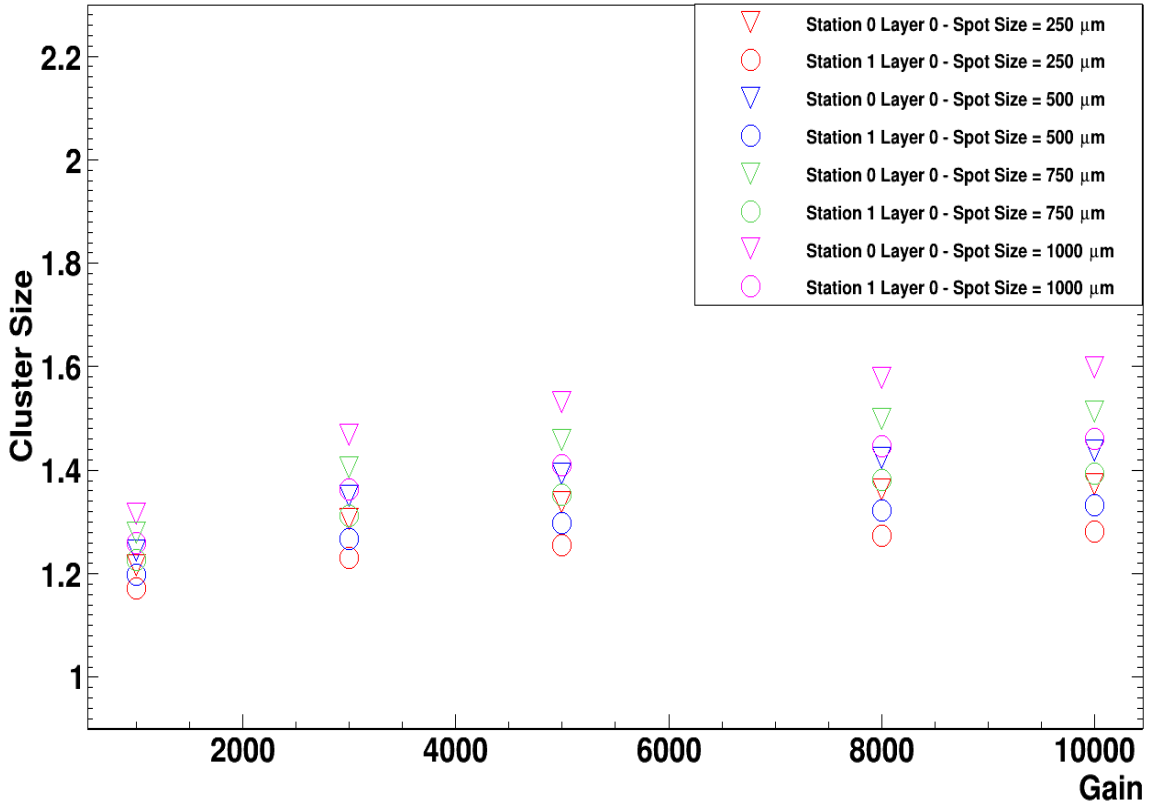


$$\theta_0 = \frac{13.6MeV}{p\beta c} z_c \sqrt{\frac{s}{X_L}} \left[1 + 0.038\ ln\left(\frac{s}{X_L}\right)\right]$$

σ_y looks similar to σ_x

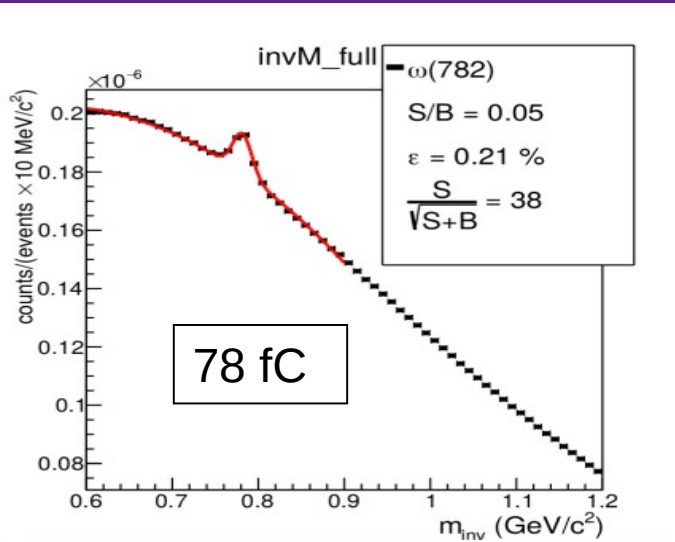
Cluster size with gain

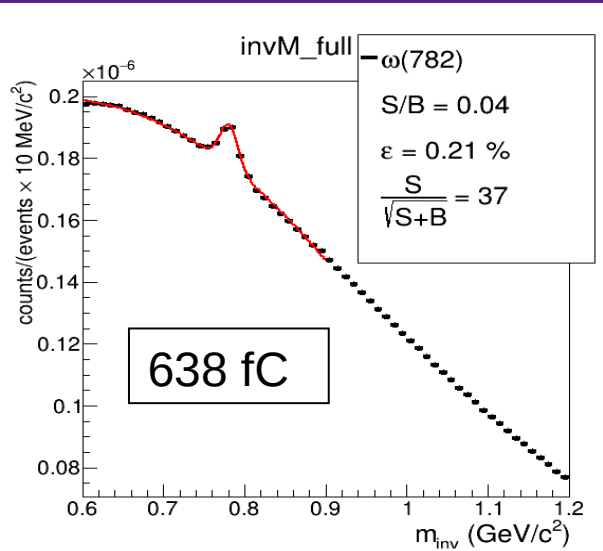
- At a given gain, cluster size increases with increase in spot radius – % increase in cluster size increases with gain
- At a given spot radius, cluster size increases with increase in gain - % increase in cluster size increases with spot radius
- First station module has smaller value compare to 2nd station

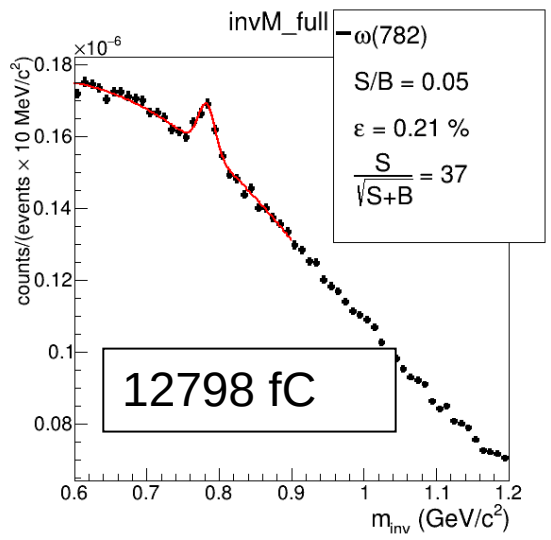


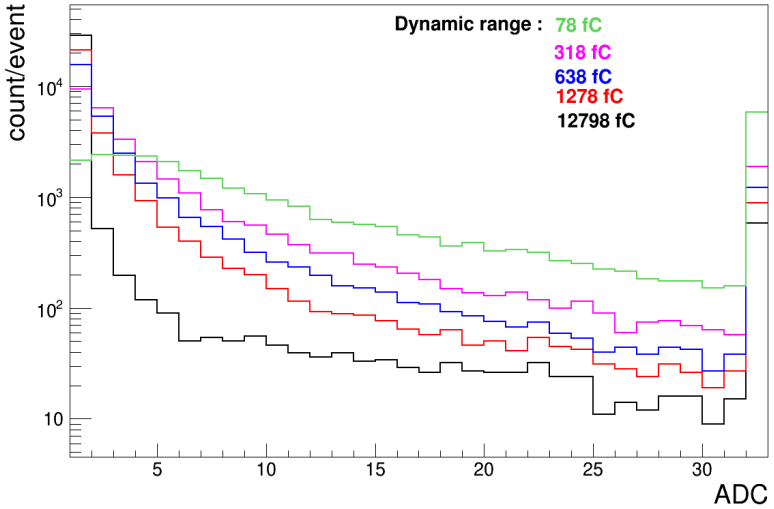
Dynamic Range Study

Dynamic Range Study









Cuts:

N of STS hits ≥7

N of MUCH hits ≥11

N of TRD hits ≥1

N of TOF hits ≥1

χ^2_{vertex} **≤2.0**

χ^2_{STS} **≤2.0**

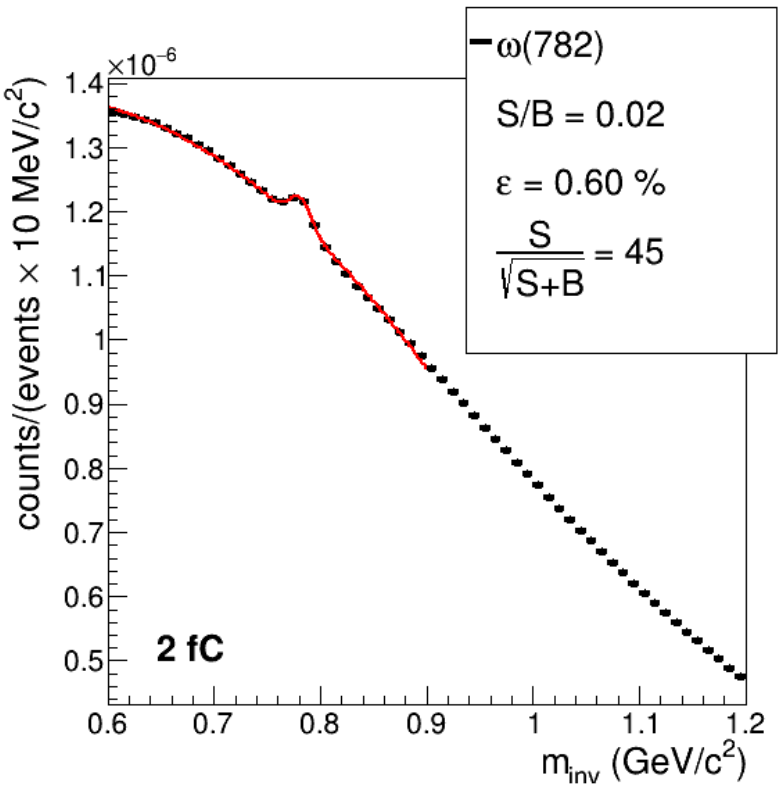
χ^2_{MUCH} **≤2.0**

2σ cut in TOF

S. Chatterjee, BI, Kolkata

Noise Threshold Study

Noise Threshold Study



Cuts:

N of STS hits ≥ 7

N of MUCH hits ≥ 11

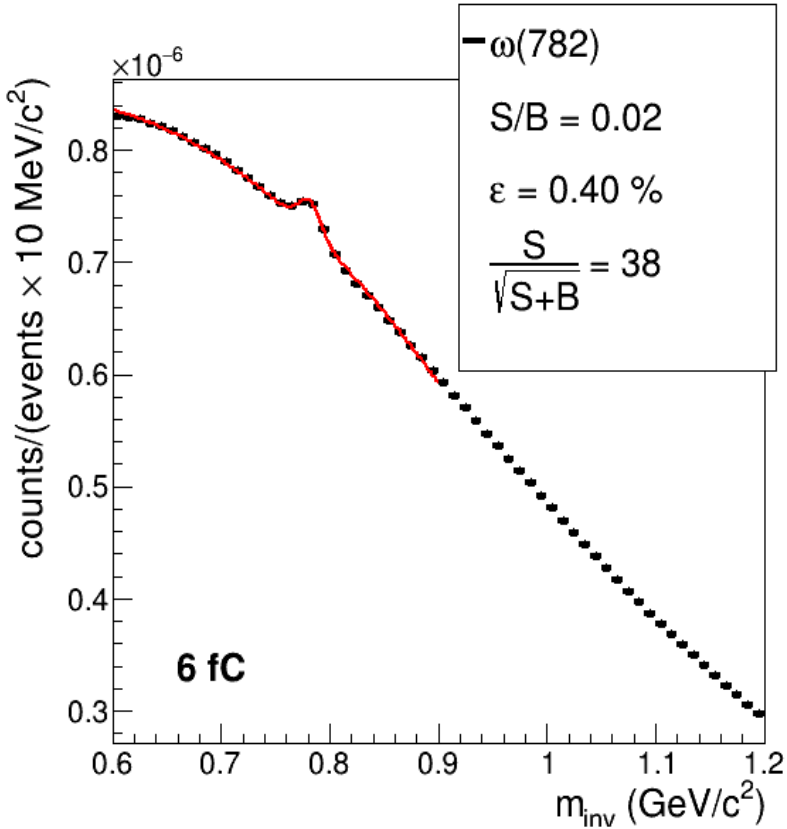
N of TRD hits ≥ 1

$\chi^2_{vertex} \leq 3.0$

$\chi^2_{STS} \leq 2.0$

$\chi^2_{MUCH} \leq 3.0$

2σ cut in TOF



Significant reduction is observed in Omega reconstruction efficiency

S. Chatterjee, BI, Kolkata

Summary

- Effect of spot size and gain on **sigma of the residuals** has been studied
- Effect of spot size and gain on **omega reconstruction** has been studied
- Effect of **dynamic range** and **noise threshold** on **omega reconstruction** has been studied
- Observed **insignificant** effect of spot radius on **reconstruction efficiency**
- **Reconstruction Efficiency** increases with increasing gain as expected and saturates after 3**k**
- **No effect** of **spot radius** on sigma of the **residuals**
- Second station modules observed slightly higher sigma – due to multiple scattering
- **No effect** of **dynamic rang** on omega reconstruction
- Change in noise thresholds from 2fC (default setting) to 6fC **significantly** affect the omega reconstruction.

Next Steps

- Vary randomly the detector gain (either station wise or module wise) and see the effect on reconstruction. As would be case in main experiment- different modules may have different gain

- Systematic study of threshold effect

Thank you for your kind attention!

I would like to thank **O. Singh** and **S. Chatterjee** for the help

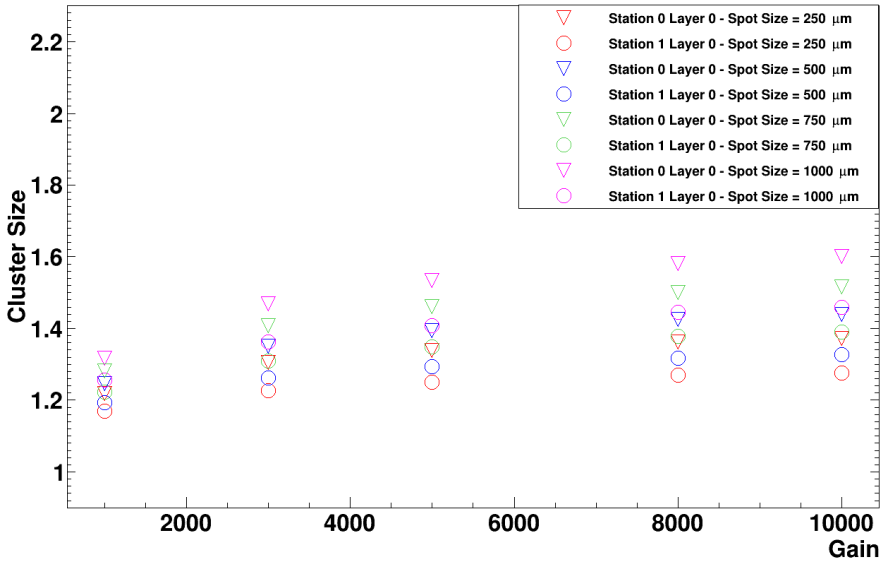
Backup

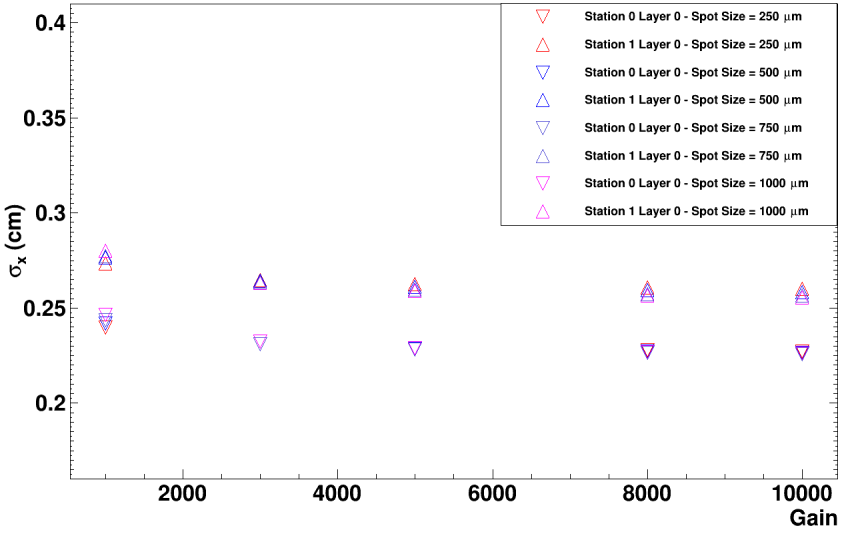
https://indico.gsi.de/event/1118/contributions/1437/attachments/1146/1491/2_Kryshen-2011-04-04-cbm-much-issues.pdf

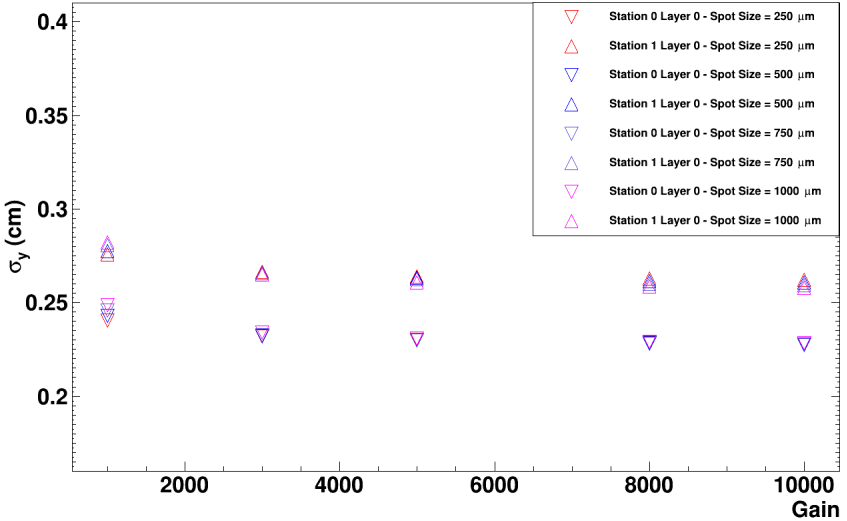
Results2

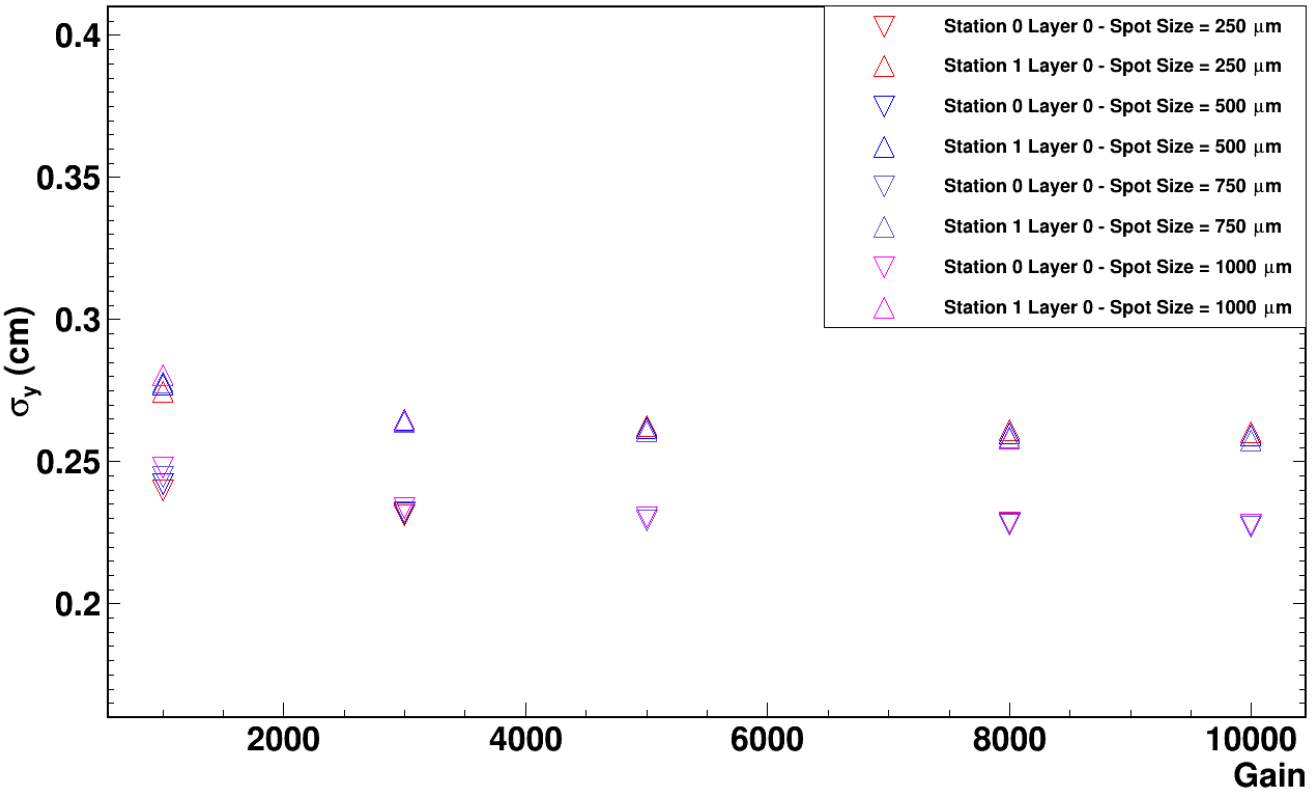
Omega
2000 events

- Sigma of the residuals does not depend on the spot size
- It decrease with gain and it saturates after 4k – large gain means more charge – fluctuation is less
- First station module has smaller value compare to 2nd station – due to multiple scattering



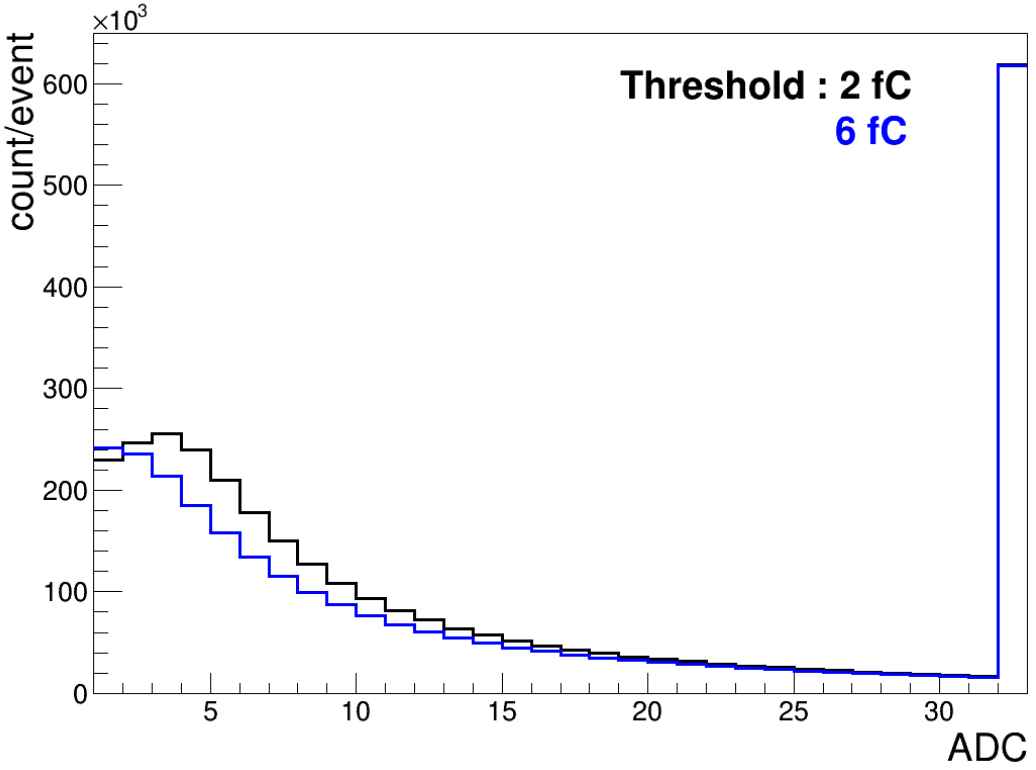


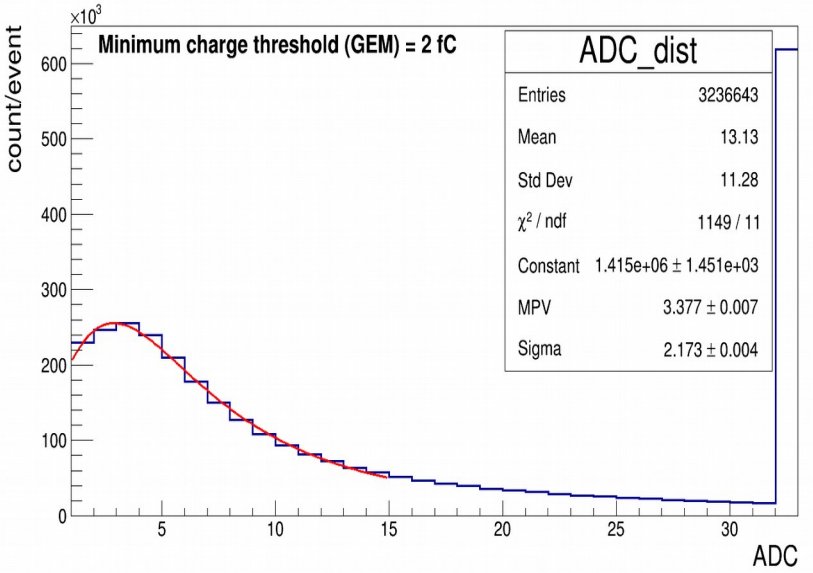


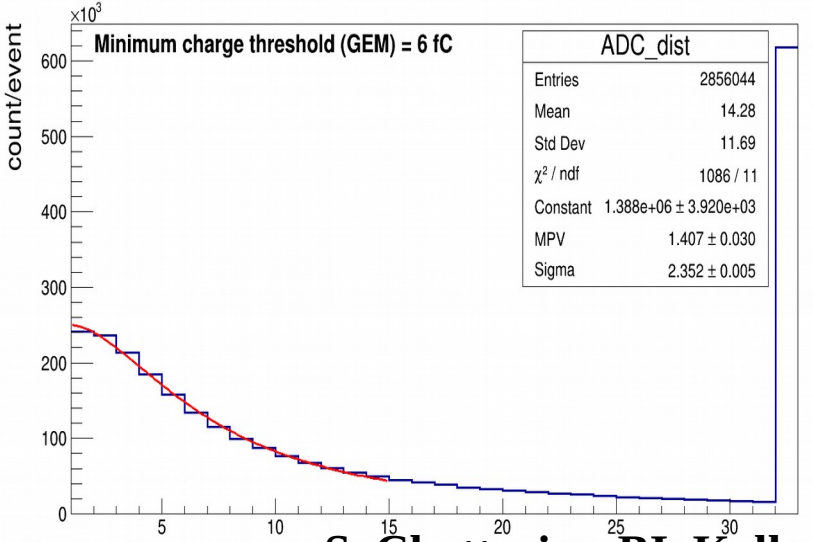

Station 0 Layer 0 - Spot Size = 250 μm
Station 1 Layer 0 - Spot Size = 250 μm
Station 0 Layer 0 - Spot Size = 500 μm
Station 1 Layer 0 - Spot Size = 500 μm
Station 0 Layer 0 - Spot Size = 750 μm
Station 1 Layer 0 - Spot Size = 750 μm
Station 0 Layer 0 - Spot Size = 1000 μm
Station 1 Layer 0 - Spot Size = 1000 μm
σy (cm)
0.4
0.35
0.3
0.25
0.2
2000
4000
6000
8000
10000
Gain

Results

fQMax=80 fC

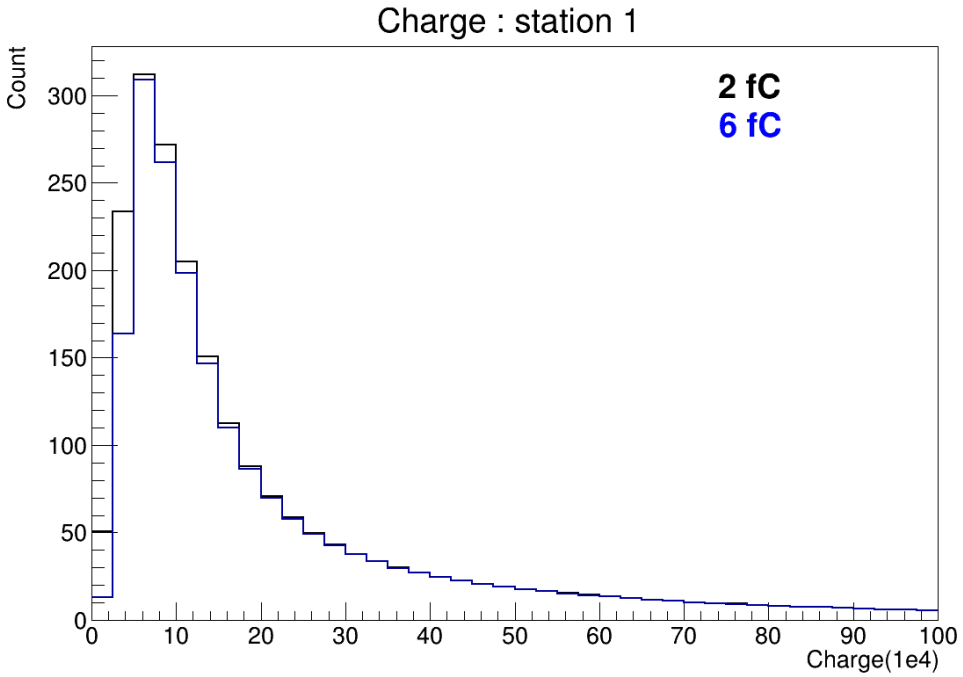


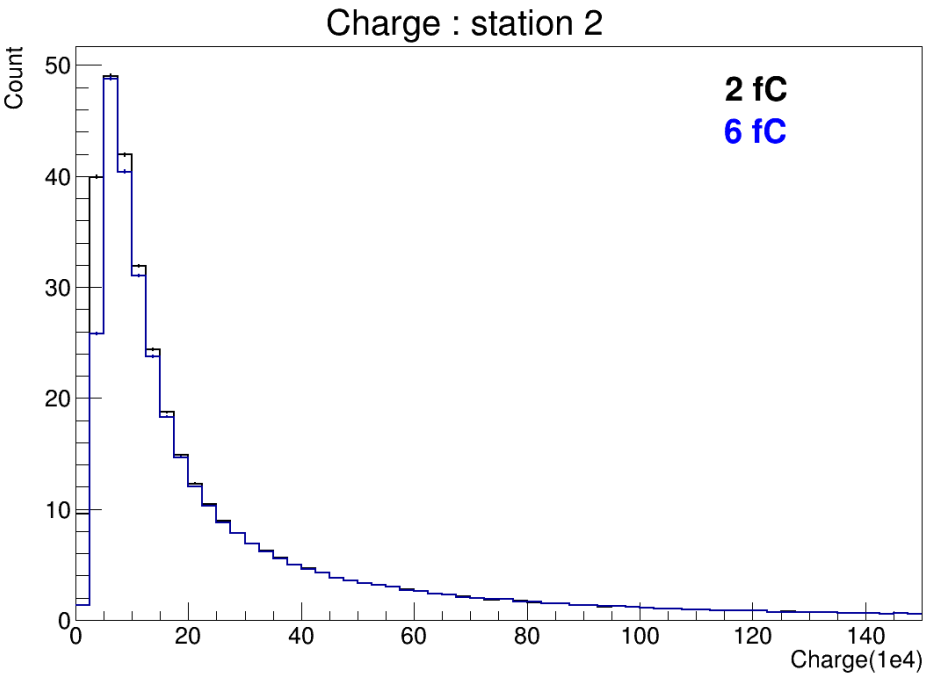




Results

fQMax=80 fC

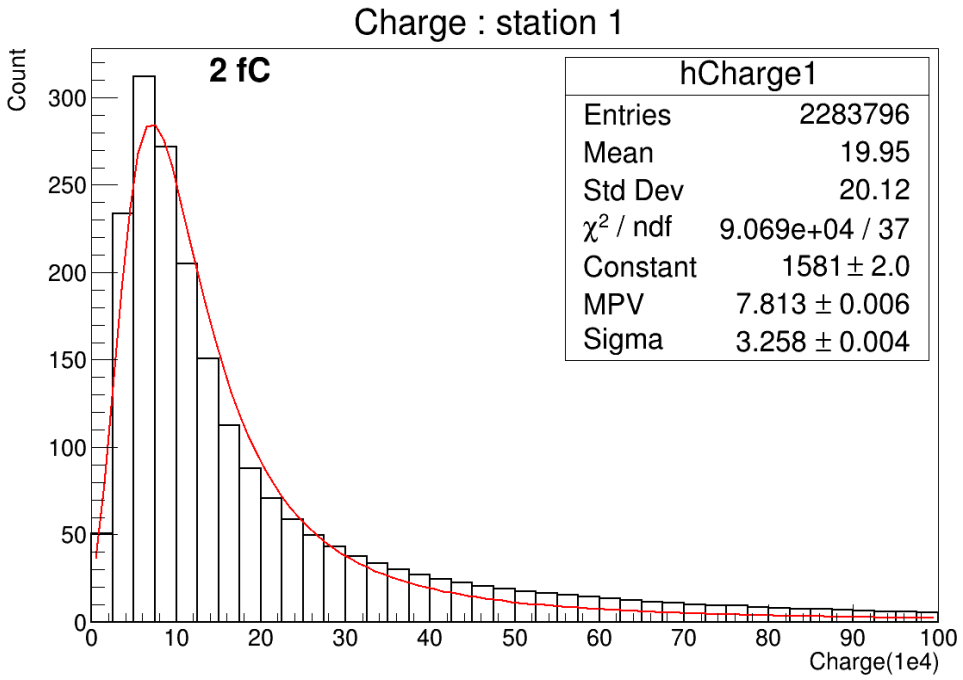


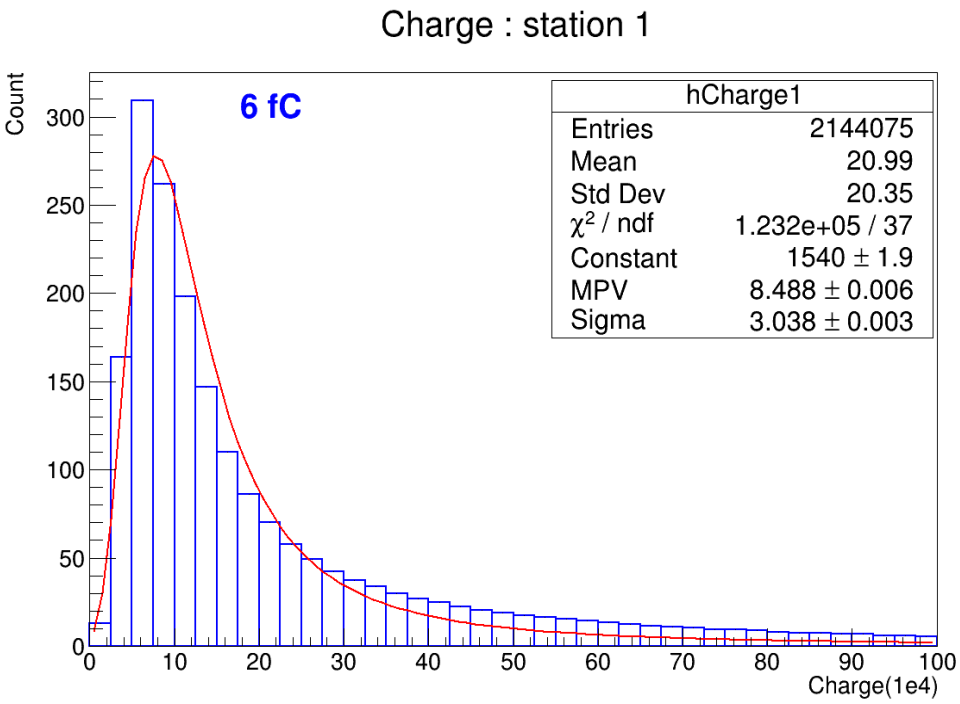


S. Chatterjee, BI, Kolkata

Results

fQMax=80 fC

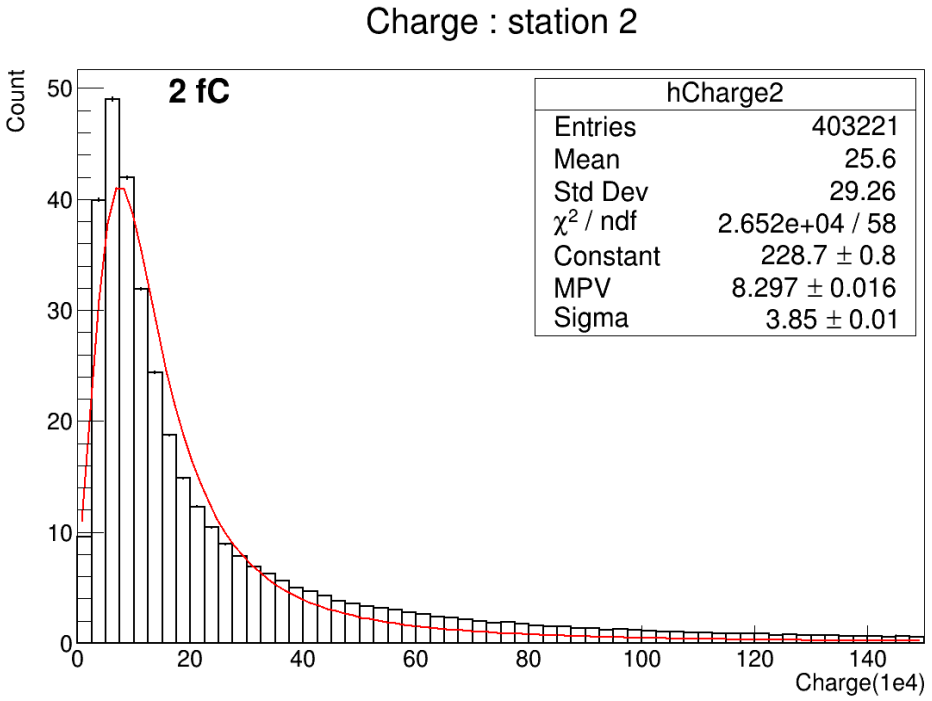


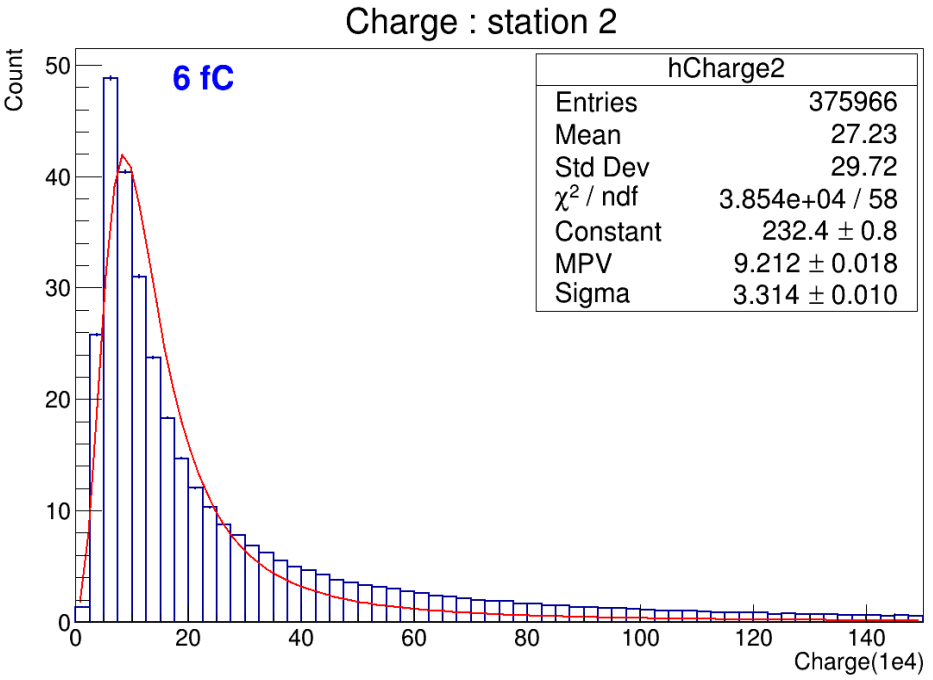


S. Chatterjee, BI, Kolkata

Results

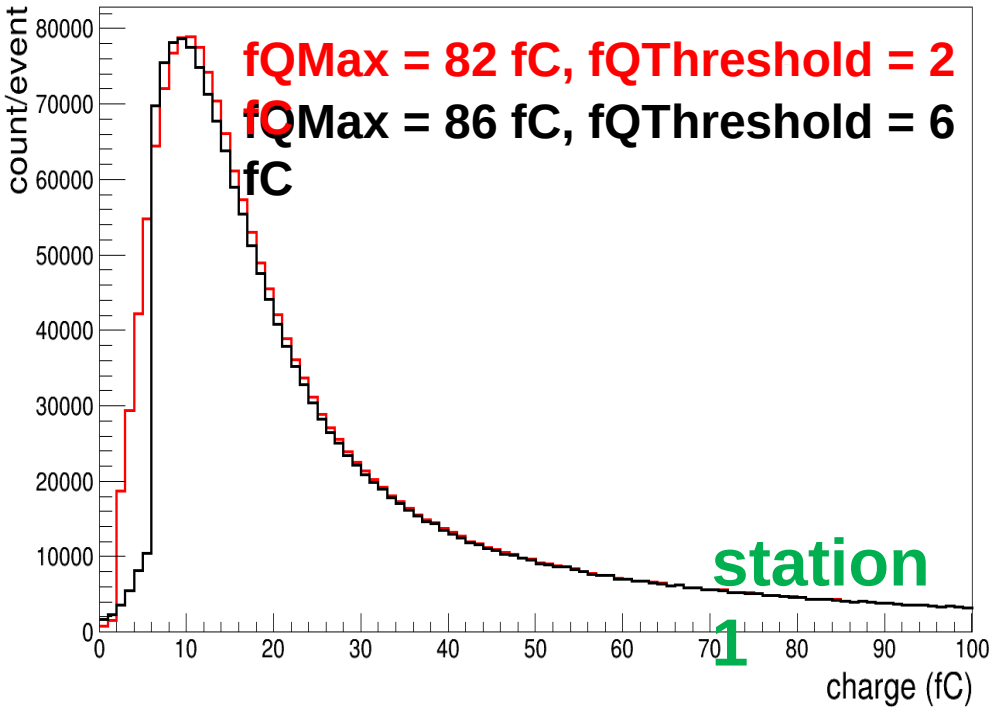
fQMax=80 fC

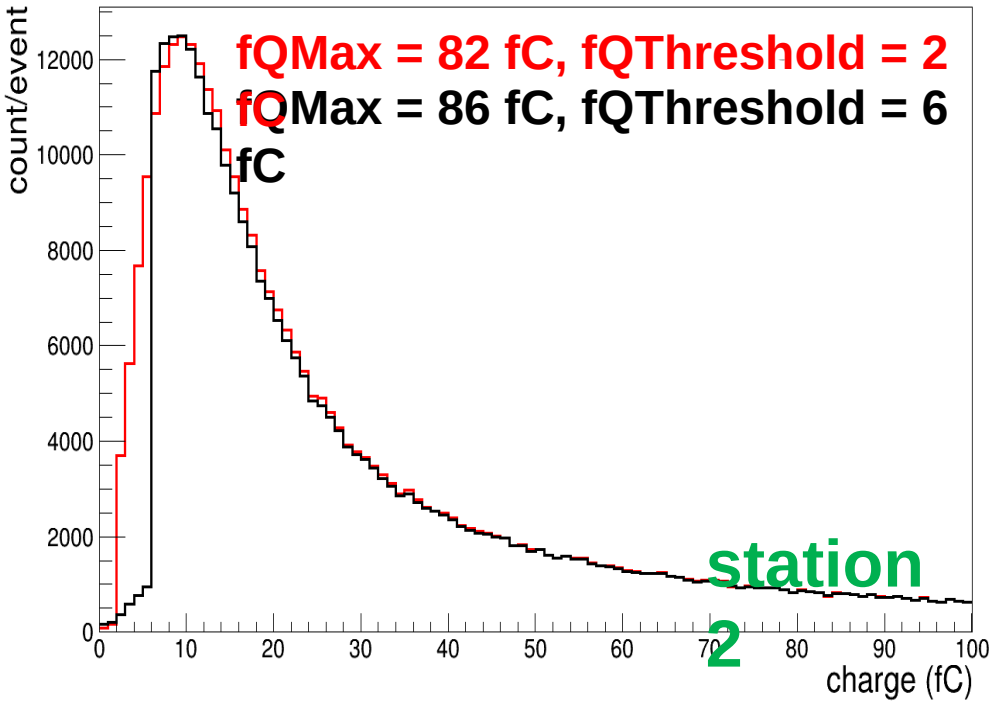




S. Chatterjee, BI, Kolkata

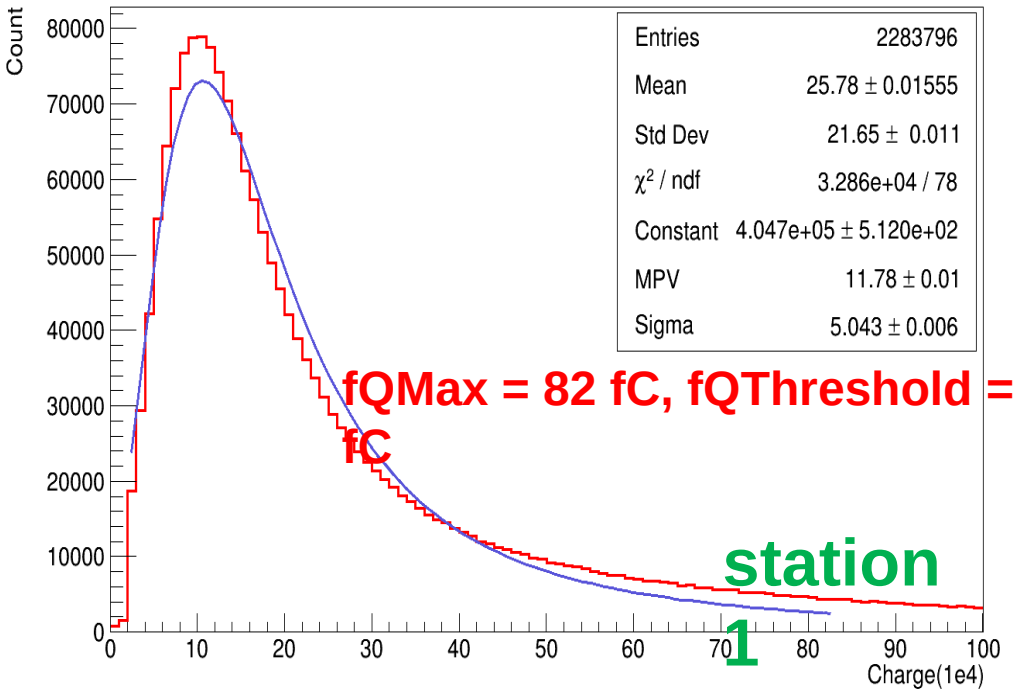
Results

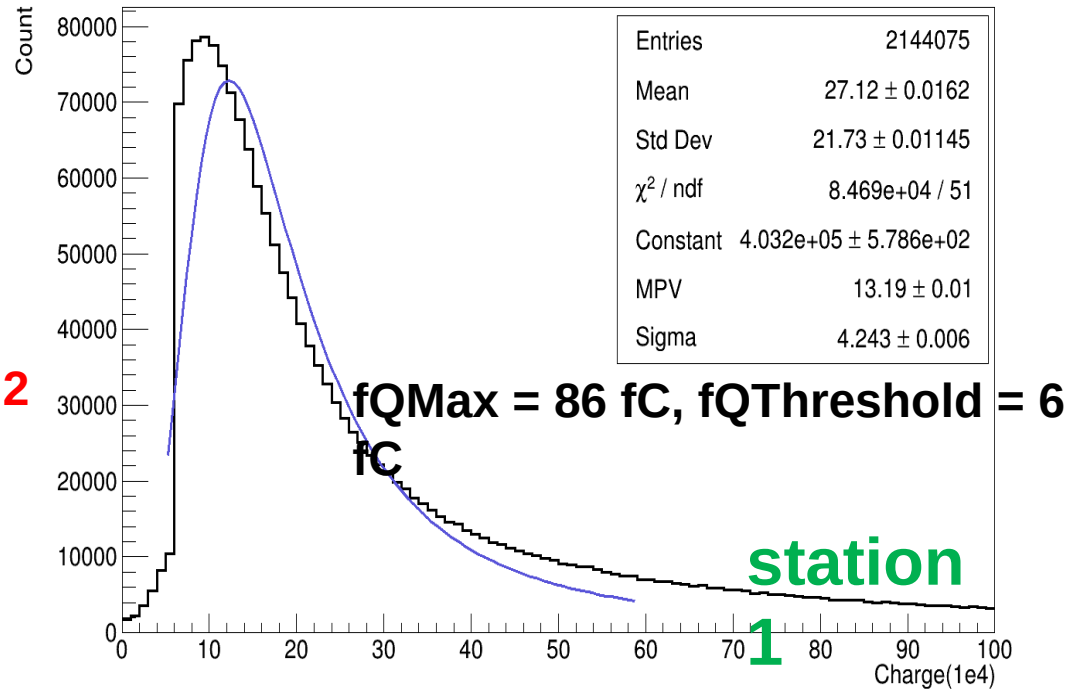




S. Chatterjee, BI, Kolkata

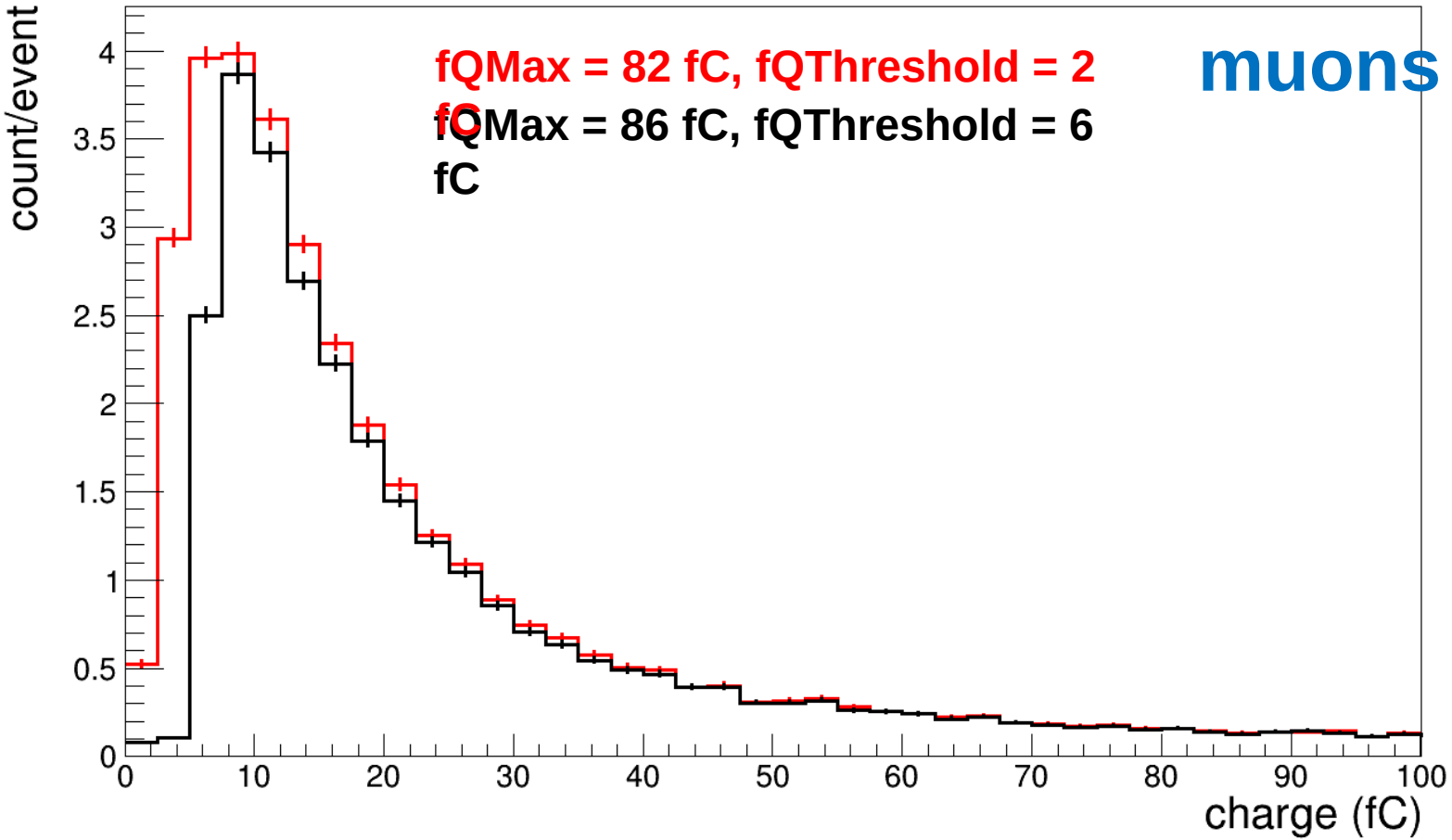
Results





S. Chatterjee, BI, Kolkata

Results



S. Chatterjee, BI, Kolkata