Performance study of mini MuCh (Muon Chamber) detectors in mini CBM experiment at FAIR

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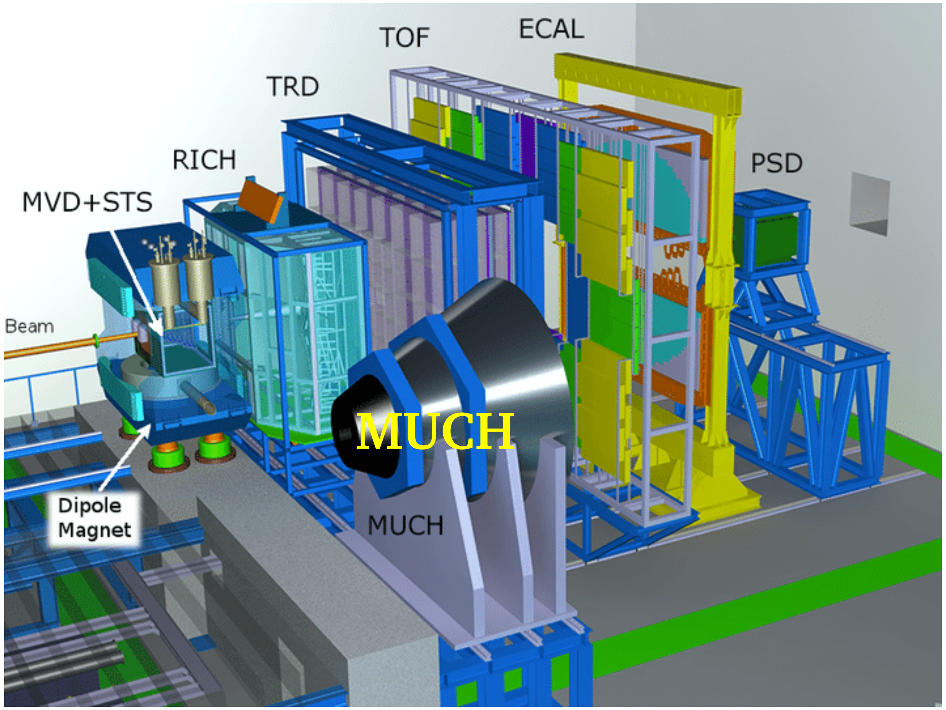
DAE HEP Symposium 2022, IISER Mohali

Outline

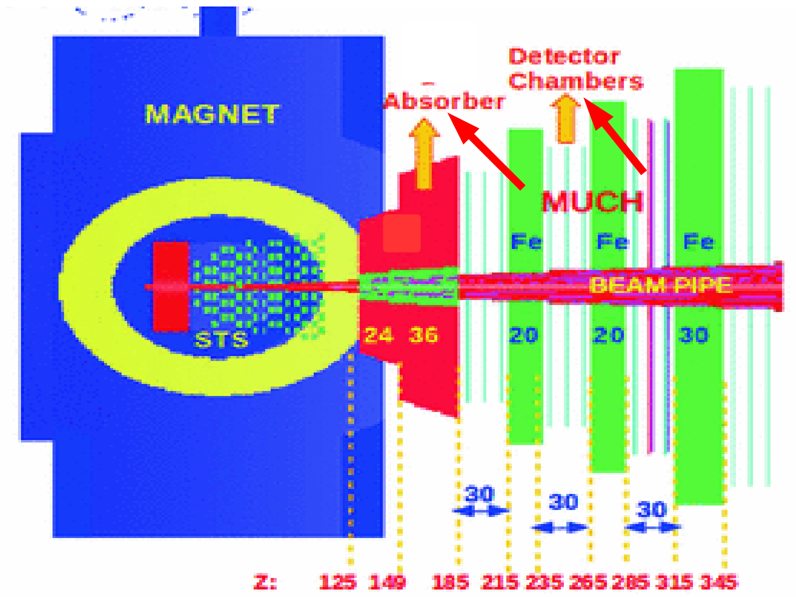
- MUCH @ CBM
- mCBM Campaign @SIS18 (2020)
- mMUCH performance
  - mMUCH performance at low & high intensity
  - Correlations (time & spatial) study
  - mMUCH Efficiency determination
  - Efficiency w.r.t particle velocity (β)
  - Efficiency w.r.t MUCH HV

- Summary

MUCH @ CBM



Schematic of CBM setup



Schematic of Muon Chamber

Muon Chamber → **LMVM(ρ,ω,ϕ,η)** → $\mu^+ \mu^-$

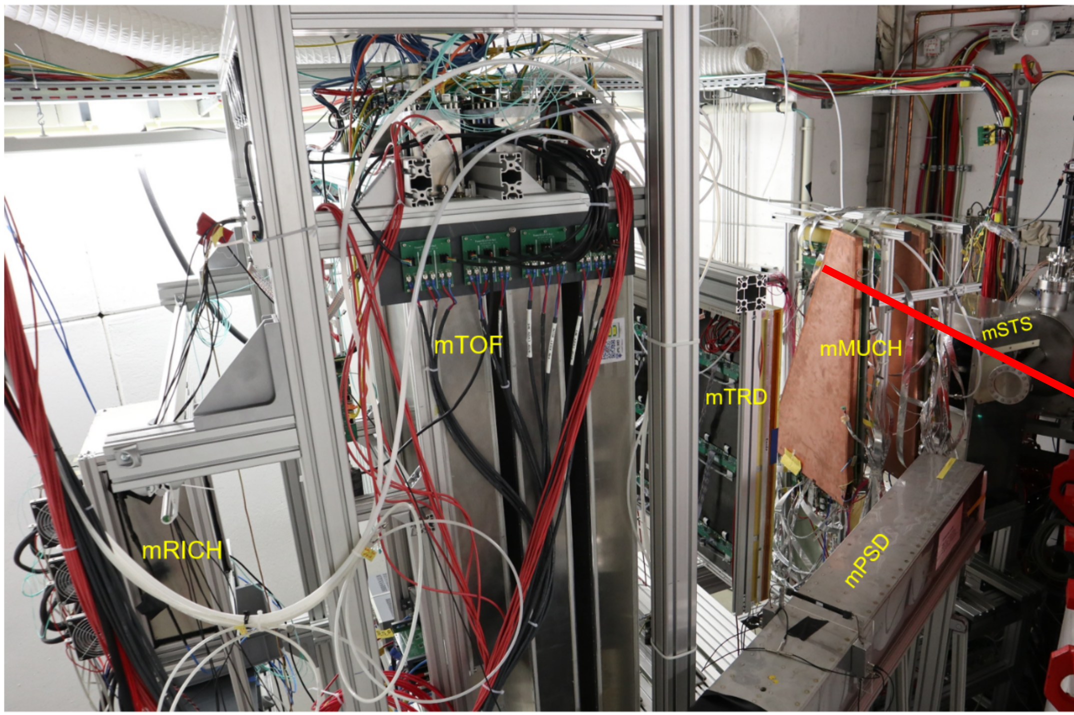
Muon Chamber → **J/Ψ** → $\mu^+ \mu^-$

- MUCH consists of segmented absorbers & detectors. Absorbers will absorb the background particles.
- First 2 stations will be Gas Electron Multiplier (GEM) detectors & Resistive Plate Chambers (RPCs) are proposed for the last 2 stations.

mCBM Campaign @SIS18 (2020)

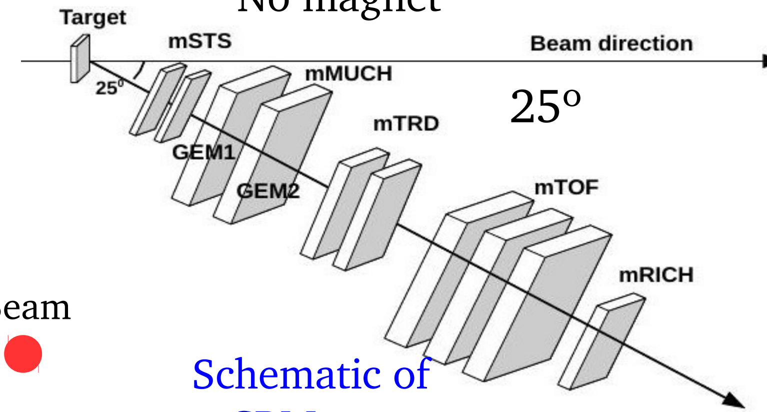
mCBM experiment

A preseries production of CBM full system test setup



Actual photograph of mCBM 2020 setup

No magnet



Beam

25°

Schematic of mCBM setup

2 Real size trapezoidal GEM modules for the first station of MUCH have been installed

Triple GEM with 3:2:2:2 gas gap & with Ar+CO_2 (70:30) gas mixture

Major objectives

- to comission, test & optimize detector prototypes & triggerless DAQ
- validate event & track reconstruction at high rate
- control software packages

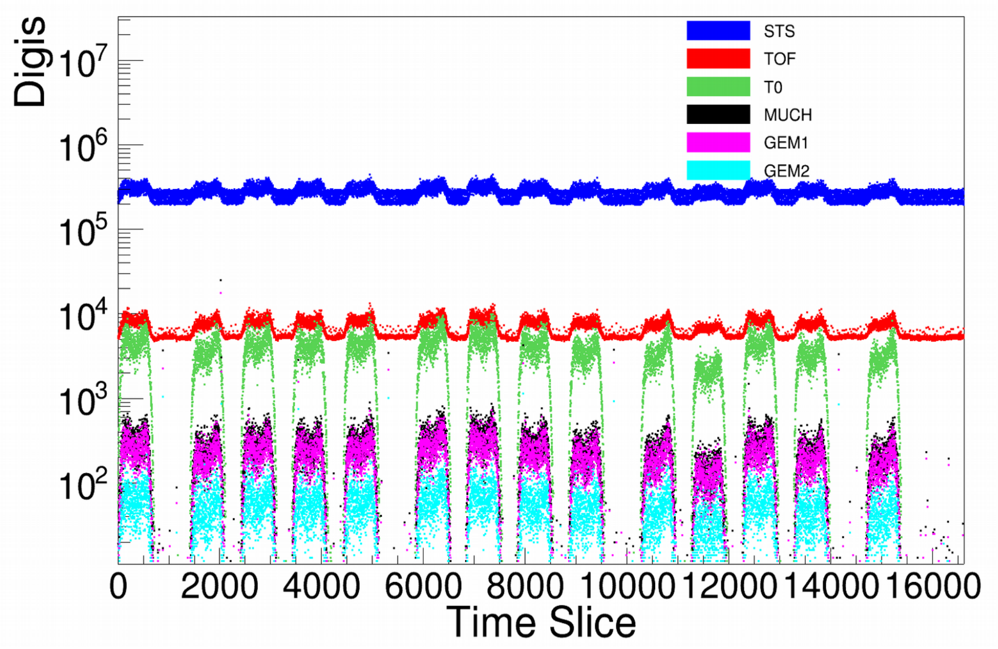
mCBM 2020 run details

Energy -- 1.06 AGeV
Beam – $^{208}Pb_{67+}$
Target – ^{197}Au

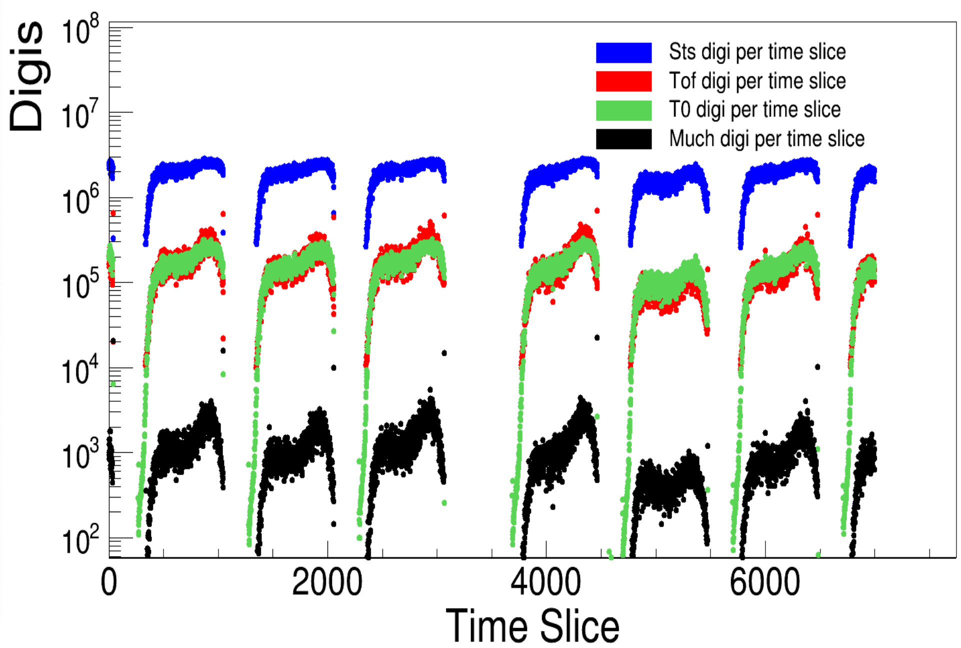
Intensity	Target thickness	Run numbers
2×10^6 per 9s spill	0.25 mm	812 - 815, 819, 821, 822, 827, 828
	2.5 mm	831
2×10^7 per 9s spill	0.25 mm	834, 836
	2.5 mm	846, 849-852
1×10^8 per 9s spill	0.25 mm	854 - 855
	2.5 mm	856, 859
1×10^8 per 3s spill	2.5 mm	861, 865

First check with the data : Spill structure

Low intensity 2 x10^6 /9s spill , thin target



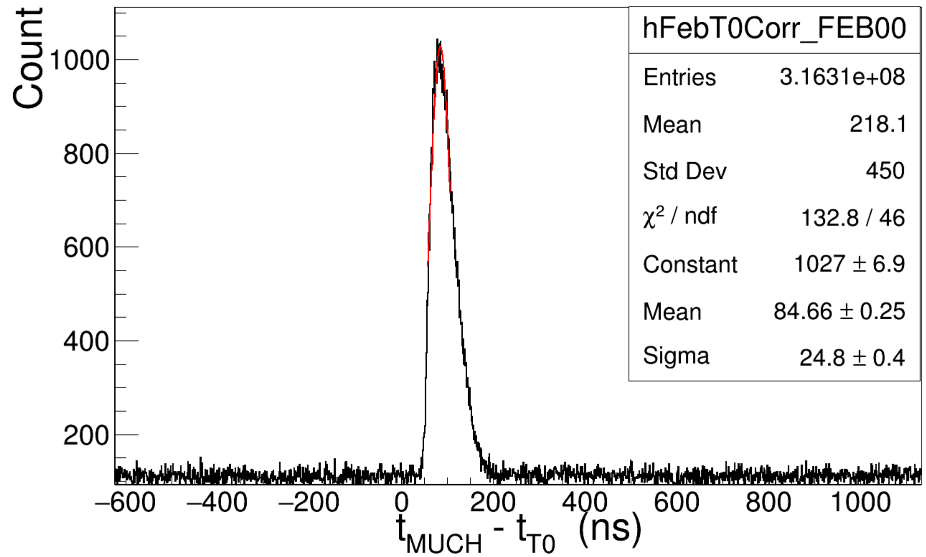
High intensity, 1 x10^8 /9s spill, thin target

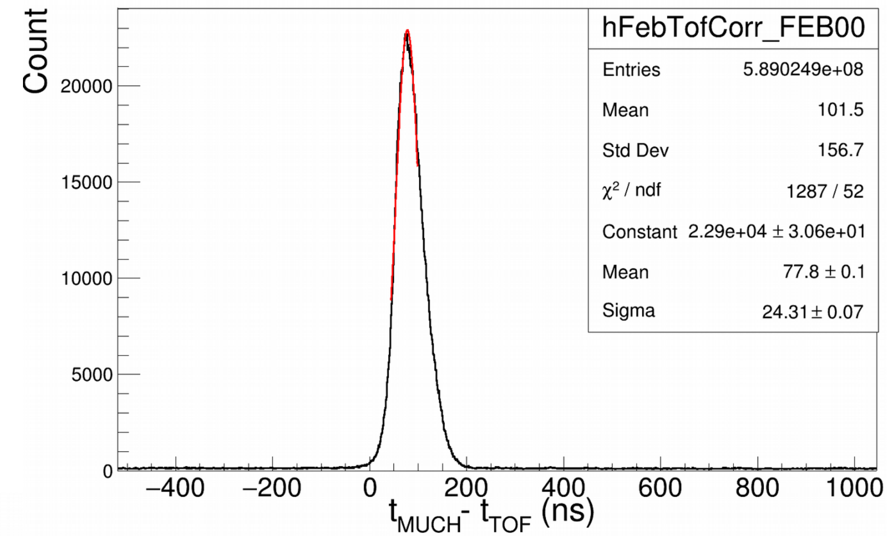


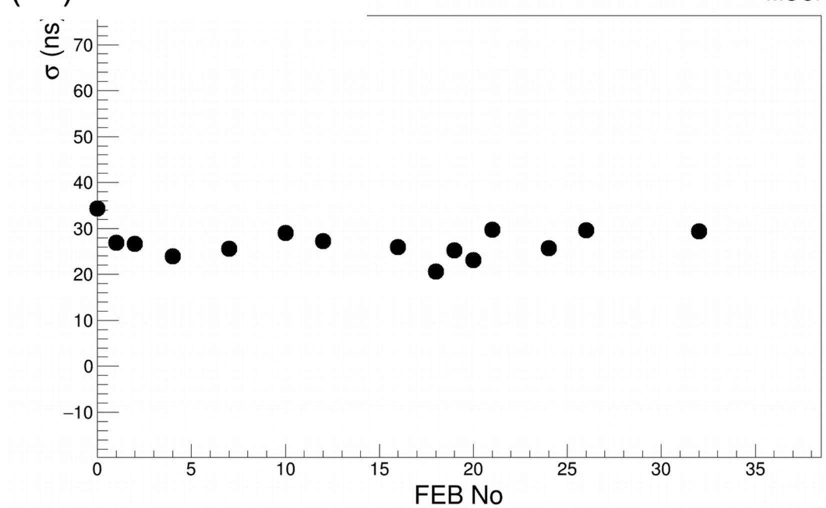
Spills are clearly visible for all subsystems in low intensity & high intensity

Time correlations

Run-822 - 2 $x10^6$ /9s spill intensity , thin target







Good time correlations observed

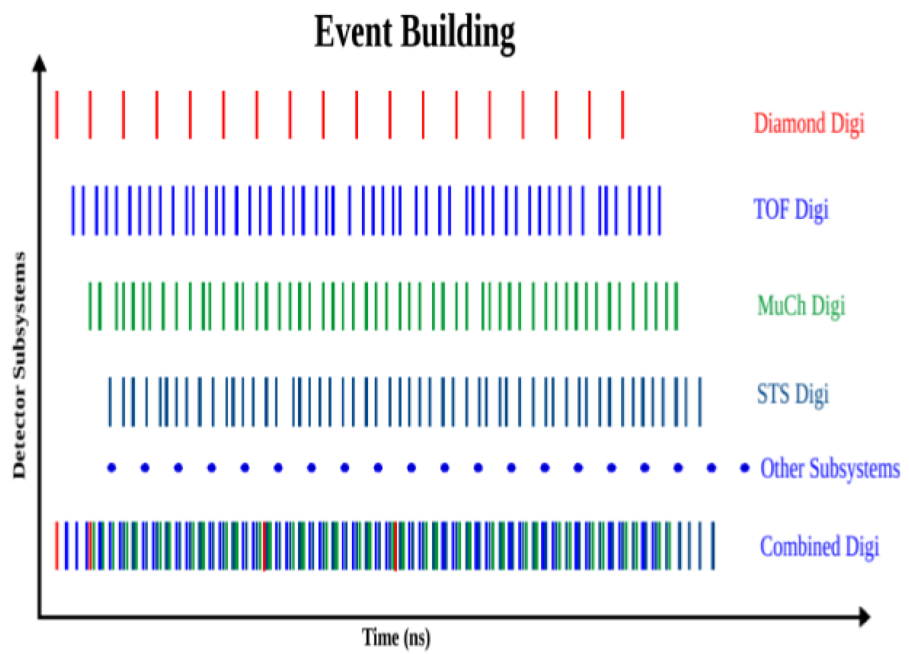
Time correlation width is uniform across different FEBs in MUCH.

Gives the spatial uniformity of time correlation across GEM

Event building & hit reconstruction

Event building algorithm – Fixed Time Window
200ns time window with 1 T0 & 10 TOF digi

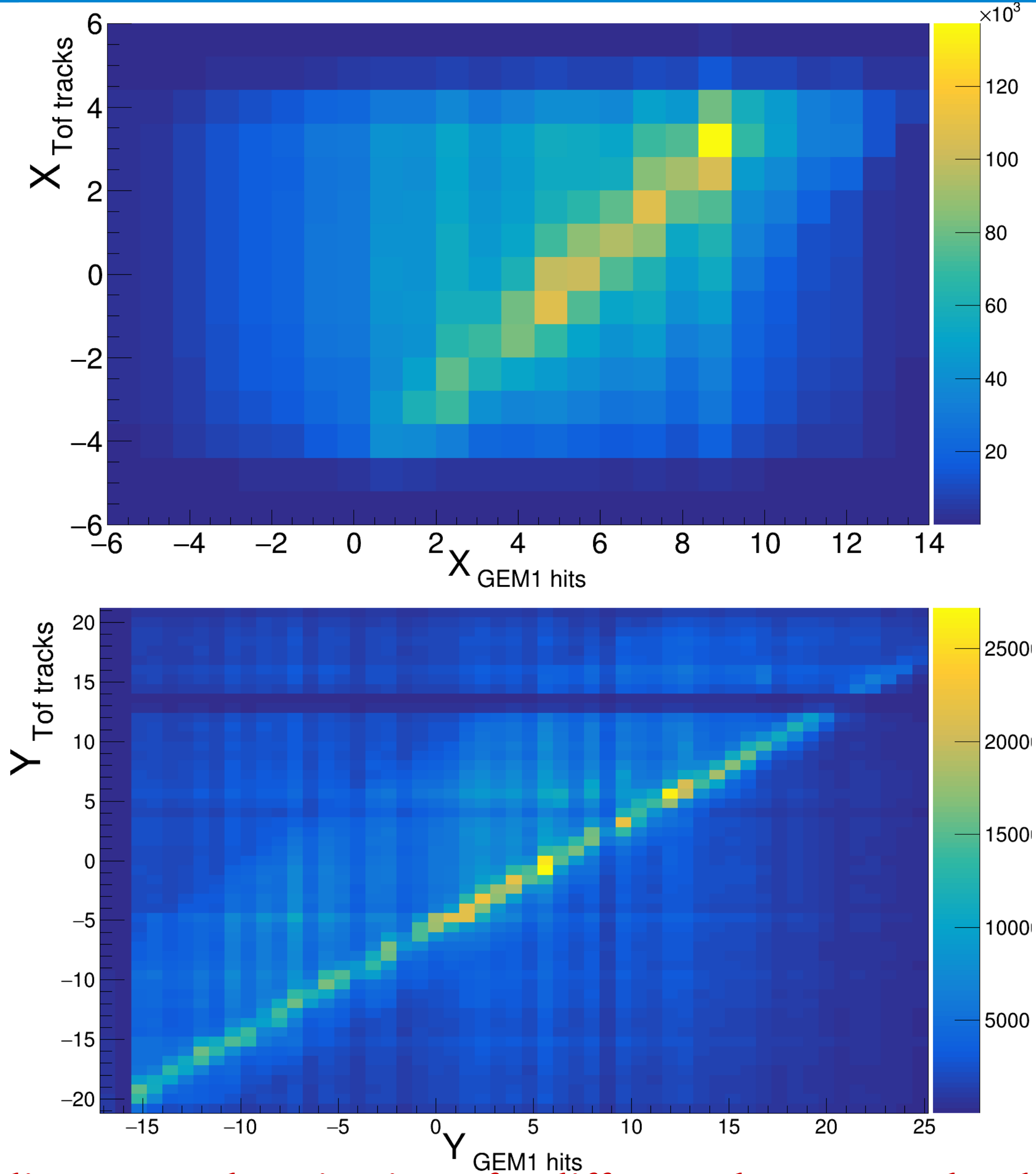
- In this algorithm all the digis are first sorted in time then grouped in a bins of 200ns wrt first digi
- All the digis within this window defined as an event



Schematic representation of event building

TOF tracking : Tracking done by using hit information from 3 layers of TOF detector & T0 detector

Spatial correlations using tracking



Indicates synchronization of 2 different detector technology
Proof of free streaming data aquisition

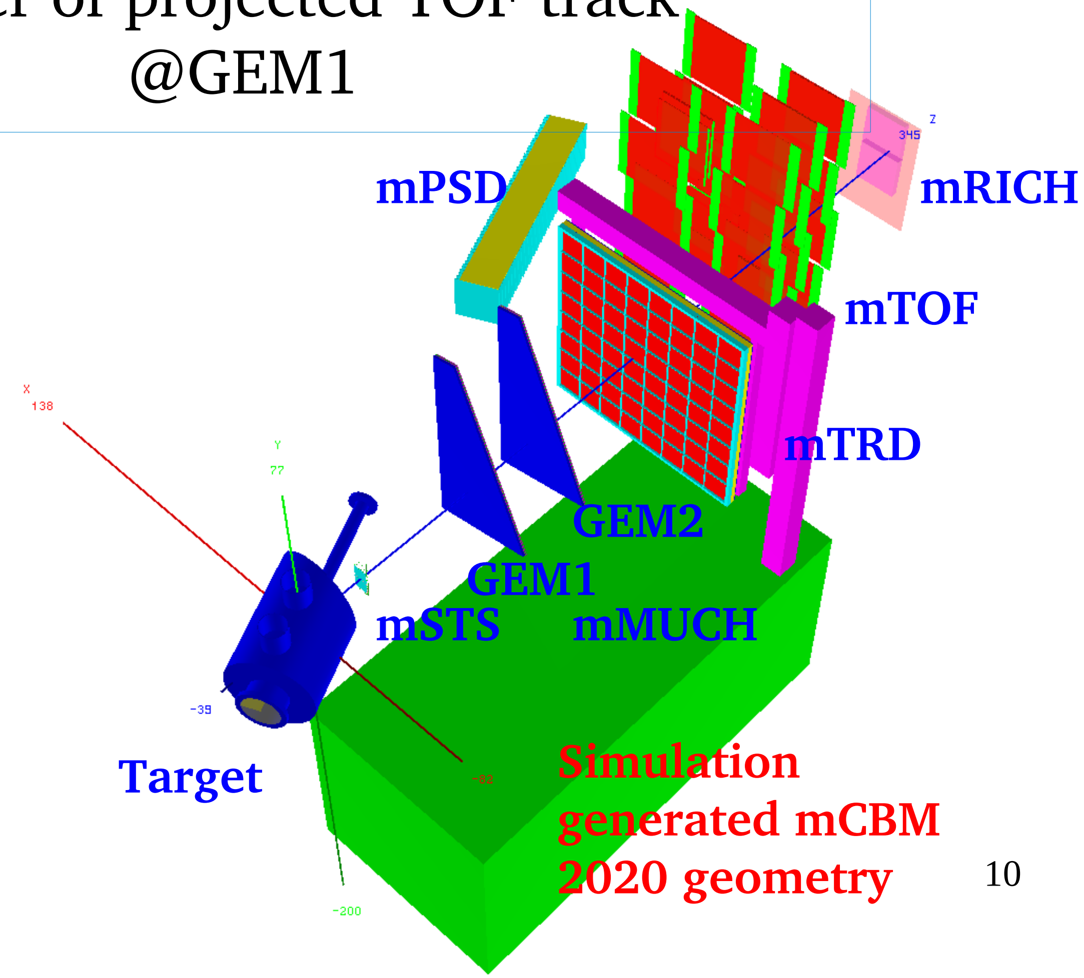
Attempt to calculate GEM Efficiency using tracking

Efficiency definition

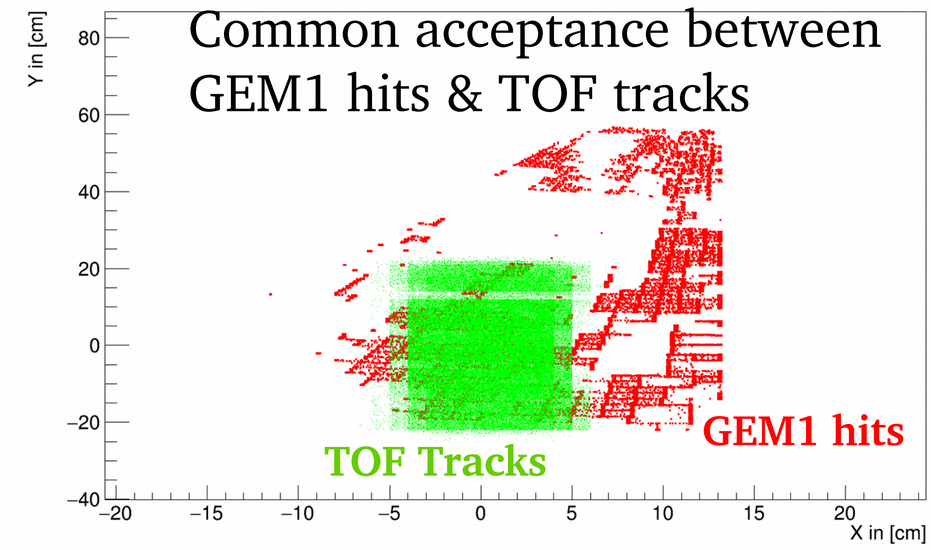
Efficiency (within common GEM1 acceptance) = $\frac{\text{Number of TOF tracks having atleast 1 associated GEM1 hit @GEM1}}{\text{Number of projected TOF track @GEM1}}$

TOF tracks selection criteria -

- TOF tracks within 5cm radial cut around origin
- Time Correlated (3 sigma)TOF tracks with GEM hits are selected
- Associated hits with TOF tracks >=4



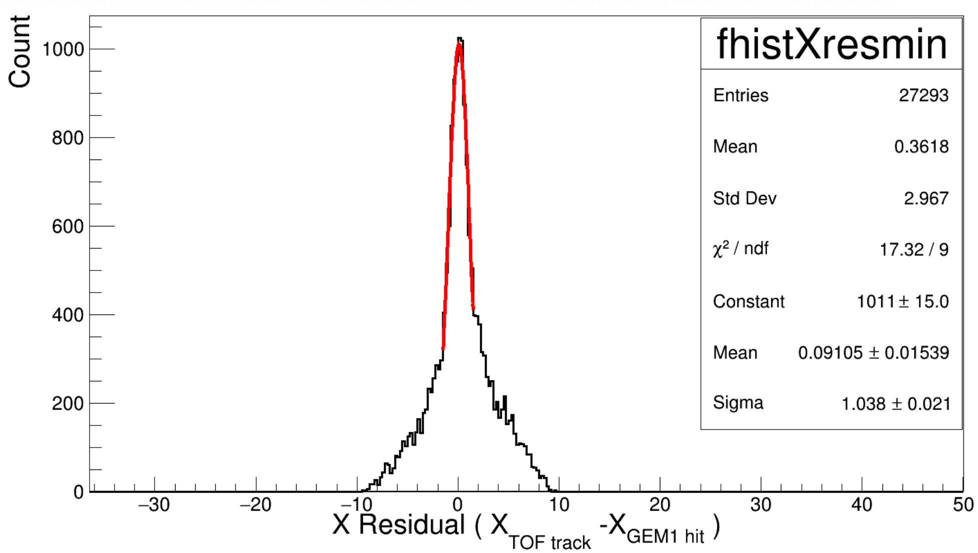
Residuals of TOF tracks wrt GEM1 hits

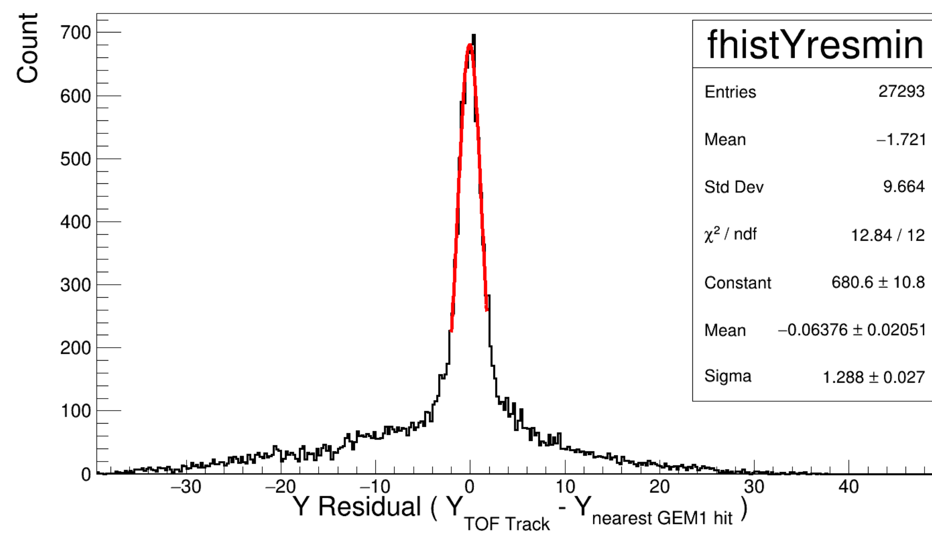


Efficiency definition

Efficiency (within common GEM1 acceptance) = Number of GEM1 hits (around track projected at GEM1) / Number of projected TOF track @GEM1

X residual =X (TOF track at GEM1) – X(nearest GEM1 hit)
Y residual = Y (TOF track at GEM1) – Y(nearest GEM1 hit)

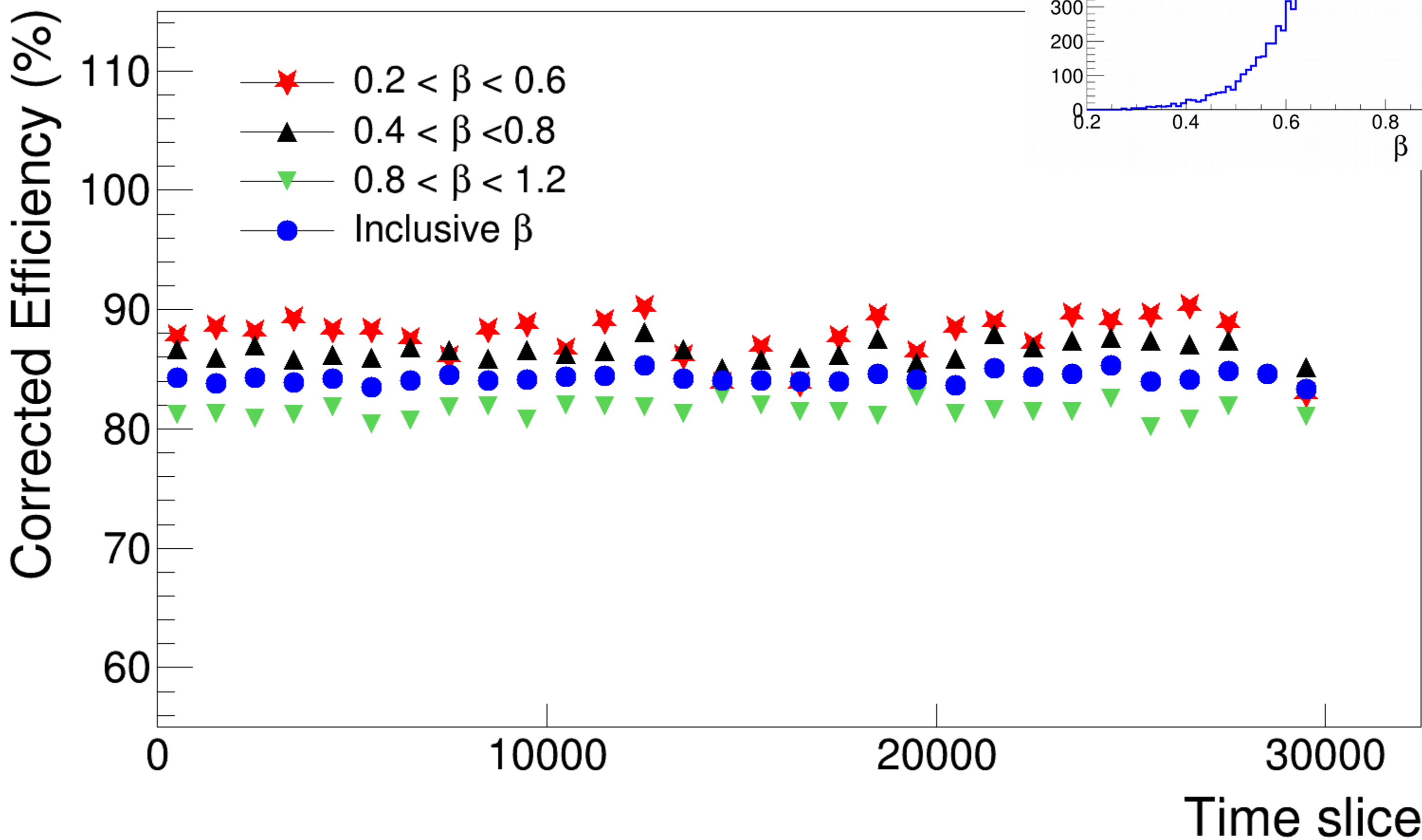


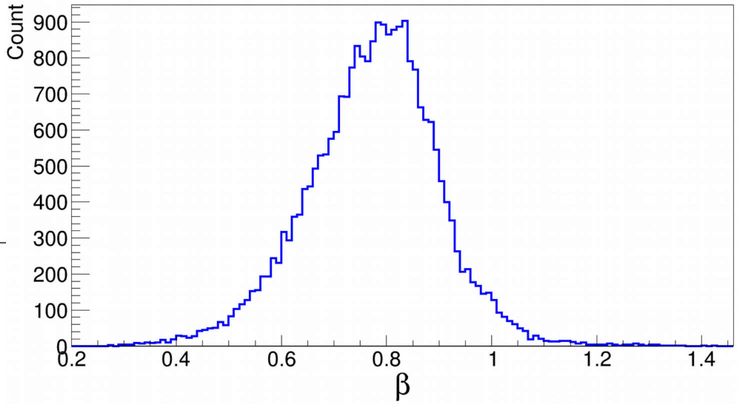


X &Y Residual distributions of TOF tracks wrt nearest GEM1 hit after correcting the shift due to mutual mis-alignment between GEM1 & TOF detector

Efficiency with time & particle's β

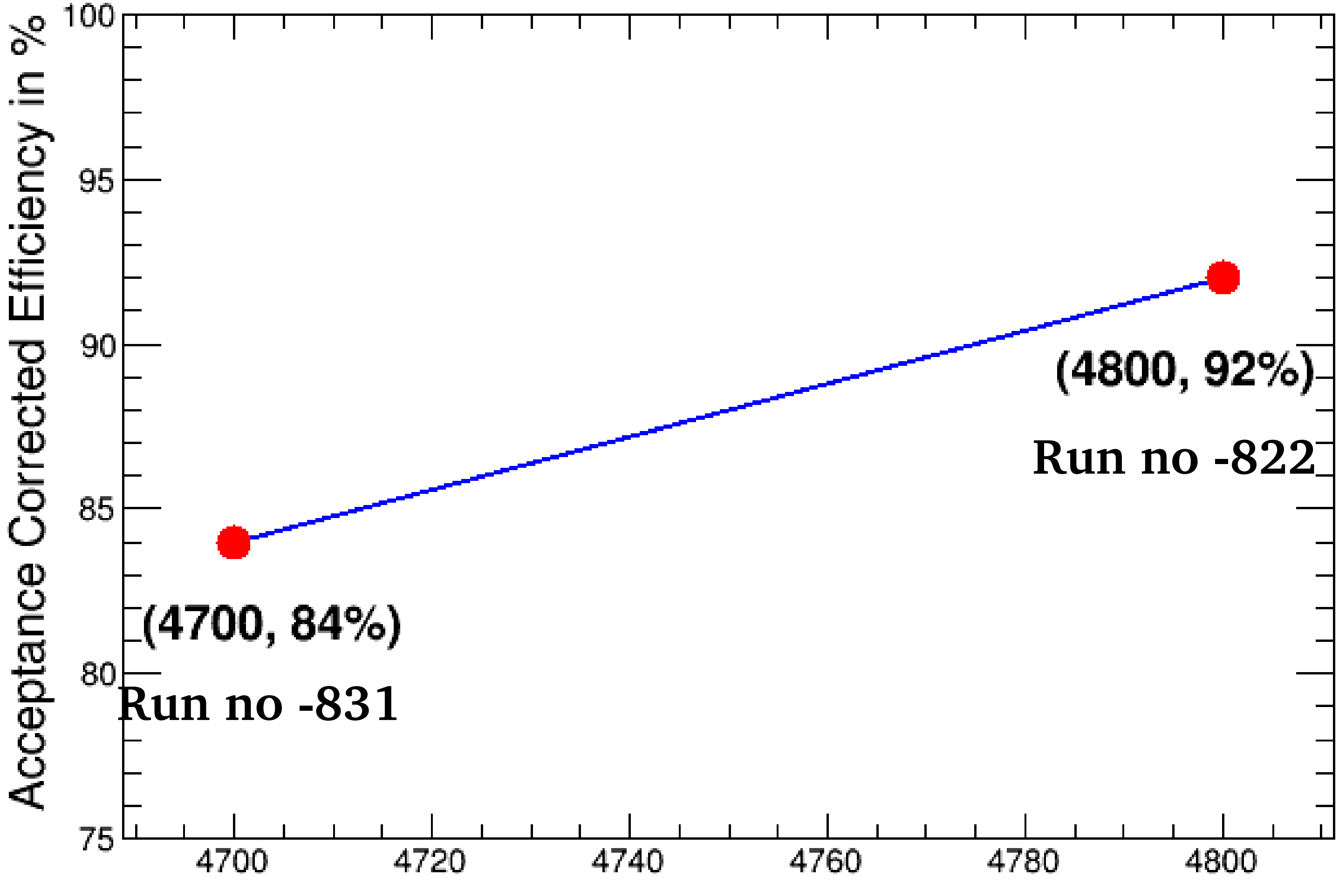
Run-831 : GEM HV 4700 V
Low intensity 2 x 10^6/9s spill,
thick target





- Efficiency is uniform over time
- At lower β efficiency increases due to higher charge deposition of hits according to dE/dx ~1/β

Efficiency vs GEM Voltage



GEM Voltage (V)

Around 8% increase in GEM efficiency observed with increase of 100 V in GEM HV

Summary

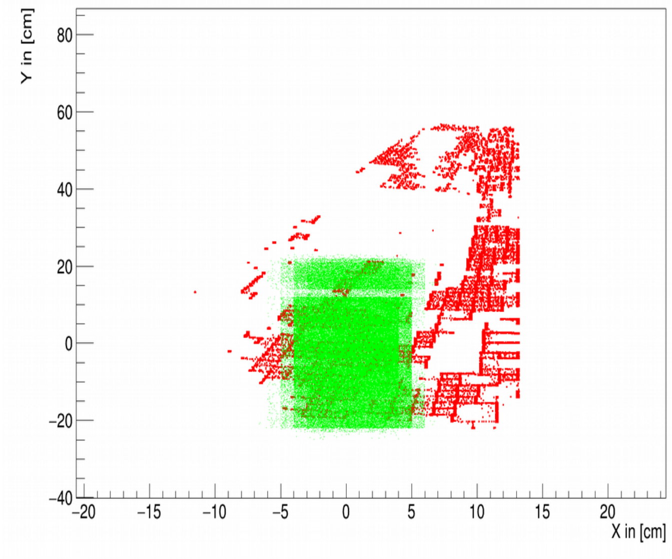
- Good spill structure observed in MUCH at low and high intensity.
- Good Time correlations and spatial correlations of MUCH with other detectors demonstrate coherent working of the detectors.
- First attempt on GEM efficiency determination using TOF tracks from mCBM data
- Systematics of GEM efficiency with time, tracks β, GEM HV have been studied.

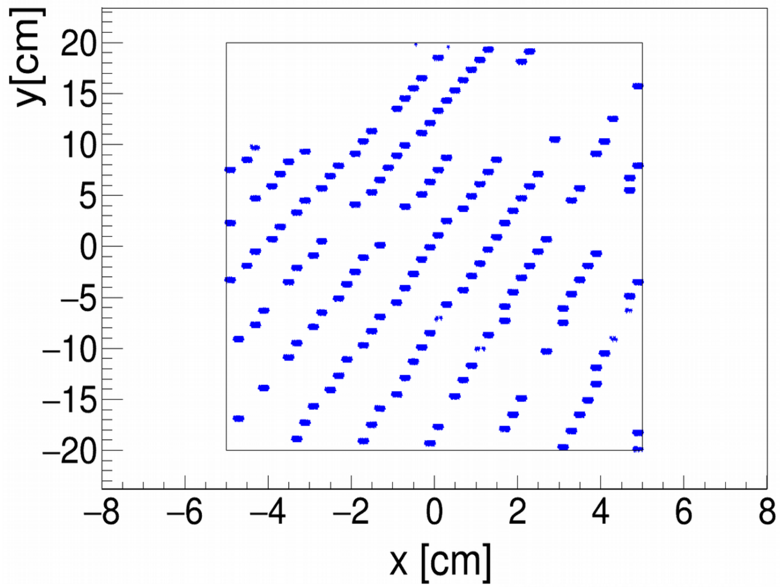
Thank You

Back up

GEM dead area calculations

Run -822, Intensity 2 x 10^6/9s spill , Thin target

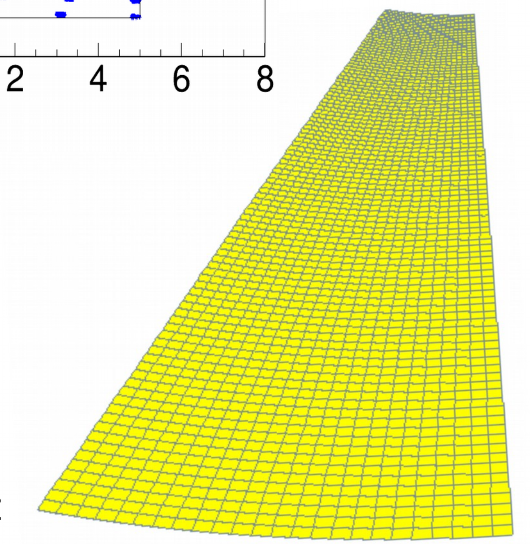


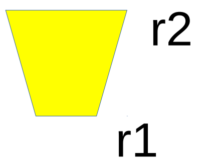


Dead area – No fired pad signal from digi

Steps to calculate dead area from digi information

- Digi ->Digi address -> Fired pad information
- Pads are not purely trapezium shaped but sides are arc shaped with pad segmentation of 1^0 in azimuthal.
- Pad Area = π ($r2^2$ – $r1^2$) / 360^0.
- Dead area = Total common area – total fired pads area

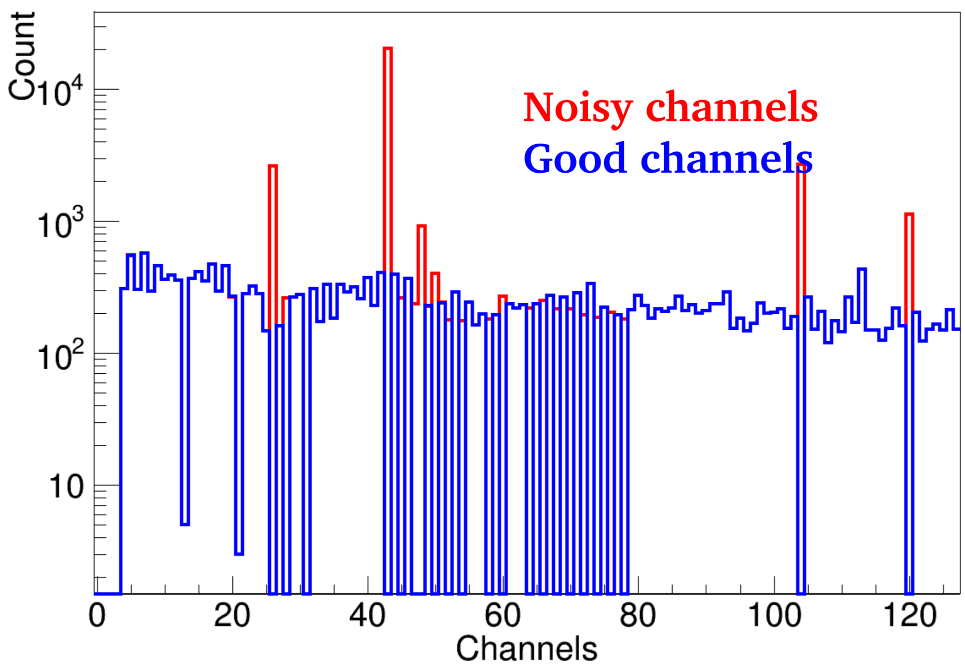




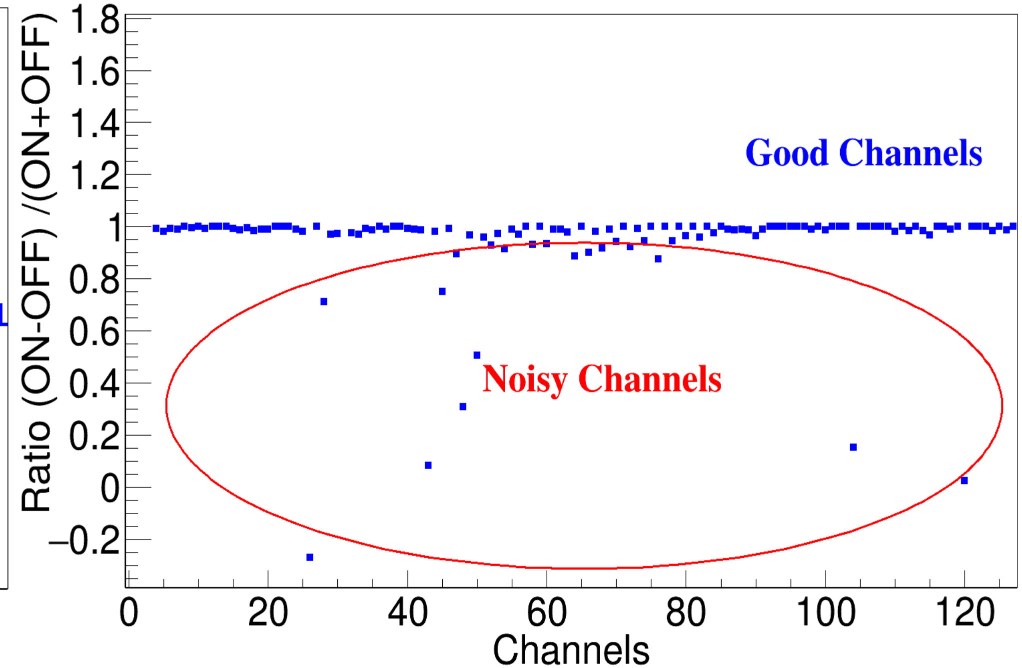
Noisy channels detection

Noisy channel detection method

$$\text{Ratio} = \frac{\text{(ON spill} - \text{OFF spill) count rate}}{\text{(ON spill + OFF spill) count rate}} \quad \sim 1\text{, for good channels}$$



Channel distribution before and after noisy channels



Well separated noisy channels