

MuCH RPC Test Results and Status

Zubayer Ahammed

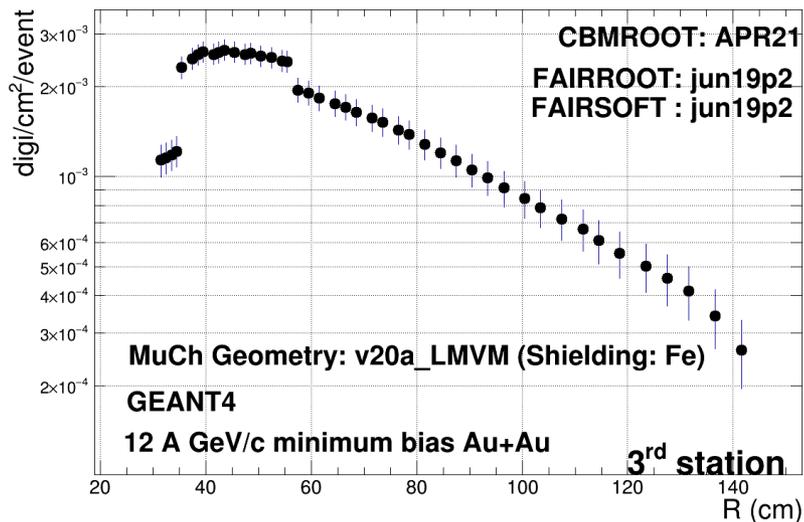
(For the MuCH Team@CBM)

VECC, Kolkata

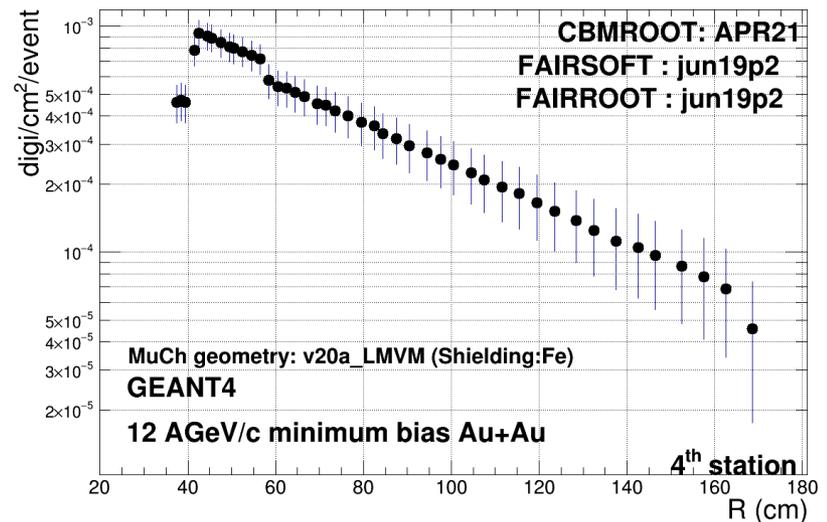
Outline:

- **Expected particle rate at 3rd and 4th stations of MuCH**
- **RPC design parameters**
- **Test Results:**
 - @ GIF++**
- **Observations & Summary**
- **Future plan**

Expected rate



Digi density for 3rd station



Digi density for 4th station

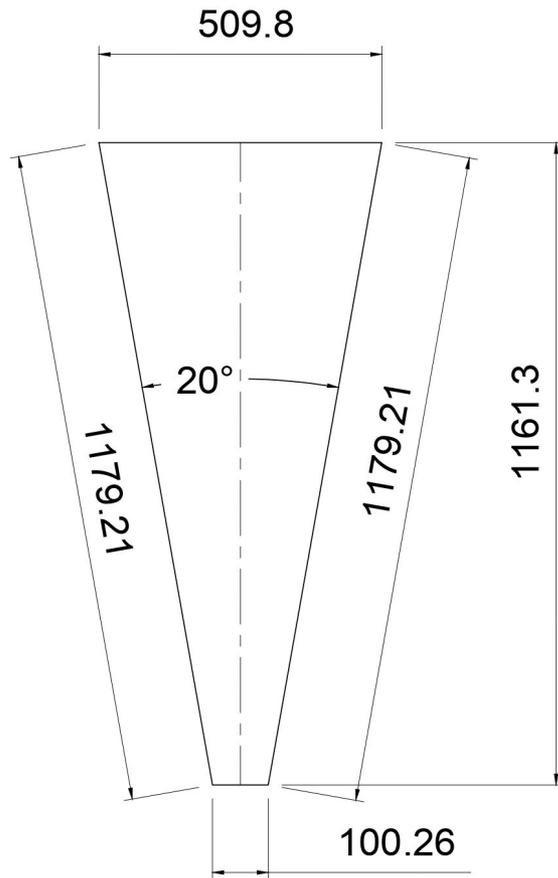
The numbers on the Y-axis when multiplied with the interaction rate (**~10 MHz**) gives the expected particle rate on the detectors.

■ 3rd station → ~30 kHz/cm²

■ 4th station → ~10 kHz/cm²

Chamber Design Parameters

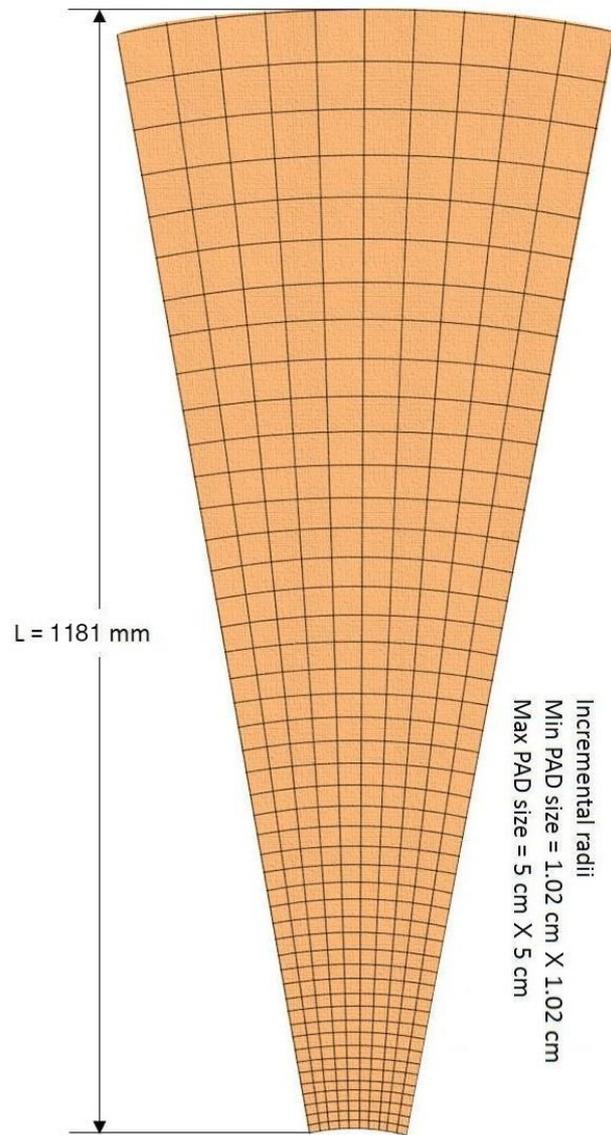
One real size detector (**Bakelite RPC**) was developed, clubbed with specially designed PCB, integrated with MuCh-XYTER, tested rigorously in local laboratory with cosmic rays and then tested at GIF++, CERN, Switzerland.



- Shape: **Trapezoidal.**
- Segmentation: **20°.**
- Each electrode thickness: **1.2 mm.**
- Bulk resistivity of electrodes: **$\sim(3 \times 10^9 - 1 \times 10^{10}) \Omega\text{cm}.$**
- Gas gap thickness: **2 mm.**

Detector dimensions for 3rd station (mm).

Readout PCB

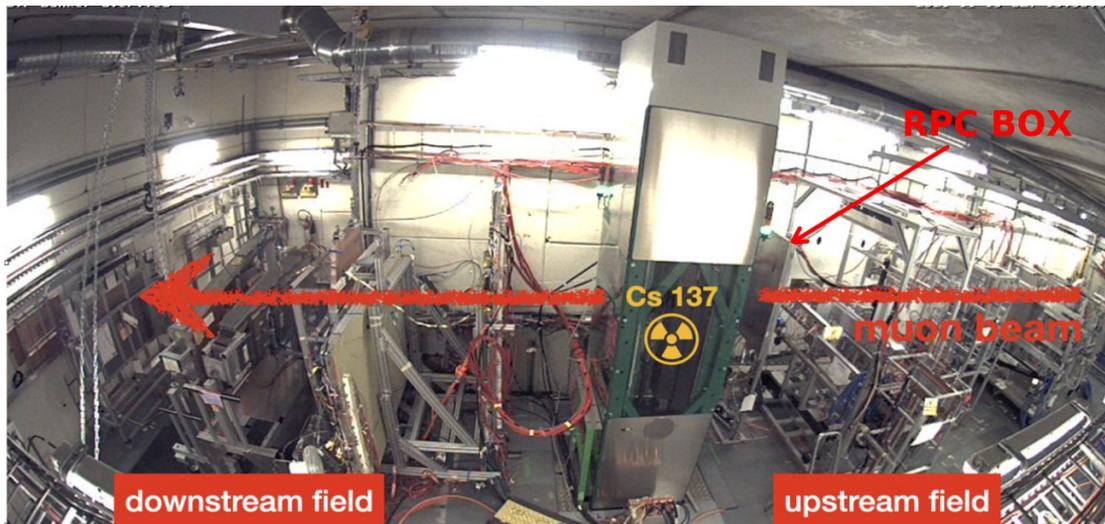


*Schematic design of readout
PCB for 3rd Station*

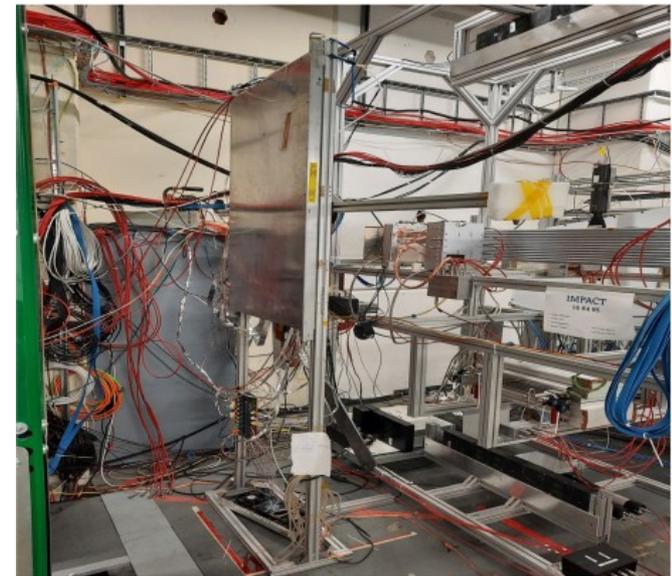
- The PCB is of **1181 mm** in length, and 2.4 mm thick.
- The trapezoidal shaped signal pickup PCB contains trapezoidal **pads** of progressive dimensions.
- There are **46 rows** and **10 columns** of pads \Rightarrow 460 pads in total.
- Each column segmentation \rightarrow **2°**.
- The size of the smallest trapezoidal pad is \sim **(1.01 cm \times 1.01 cm)**.
- The size of the largest trapezoidal pad is \sim **(5.0 cm \times 5.0 cm)**.
- The dimensions of all the pads in each row are exactly the same.

GIF++ Setup(2021)

- GIF++ is located on the H4 beamline which provides high-energy muon beam (≤ 150 GeV/c) in EHN1 North Area of CERN.
- It houses Cs-137 gamma source.
- Our RPC detector was tested in GIF++ **during November-2021** beamtime.
- The RPC was positioned at ~ 84 cm away from the Cs-137 source in the **upstream** region.



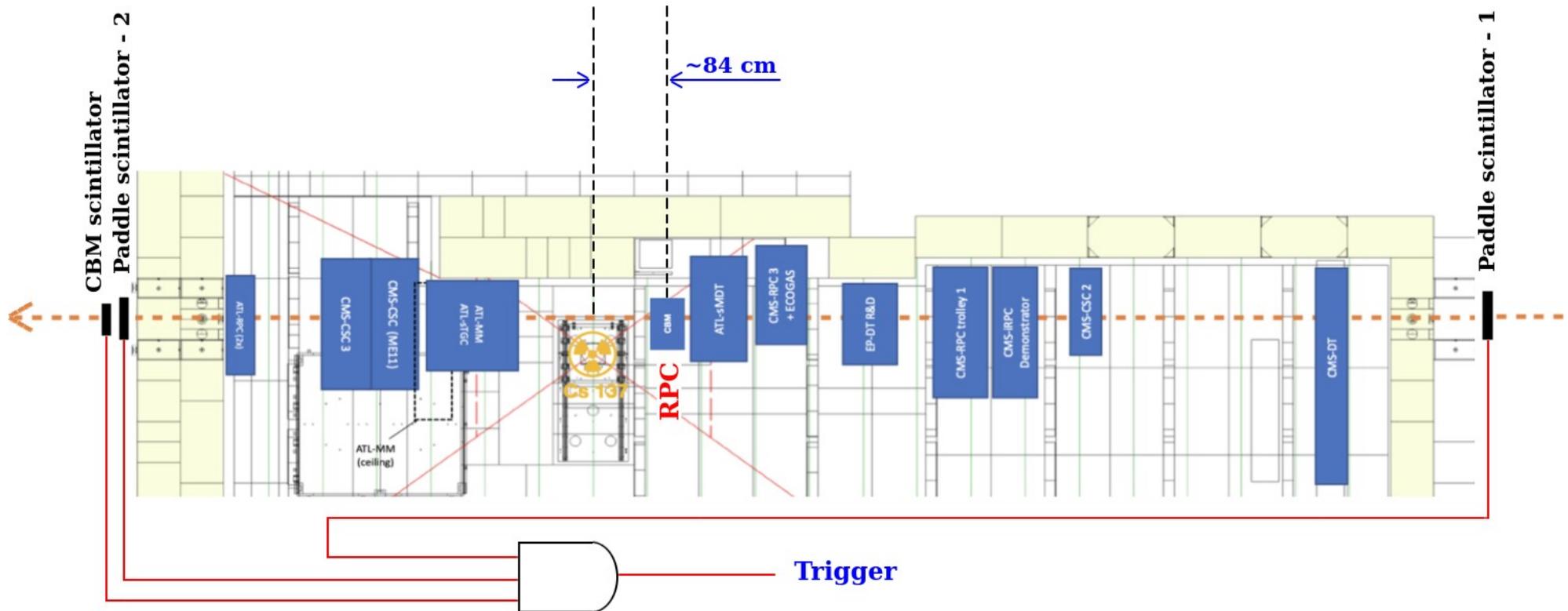
Experimental facility site at GIF++.



*The RPC box in the upstream region
Used CMS RPC Gas.*

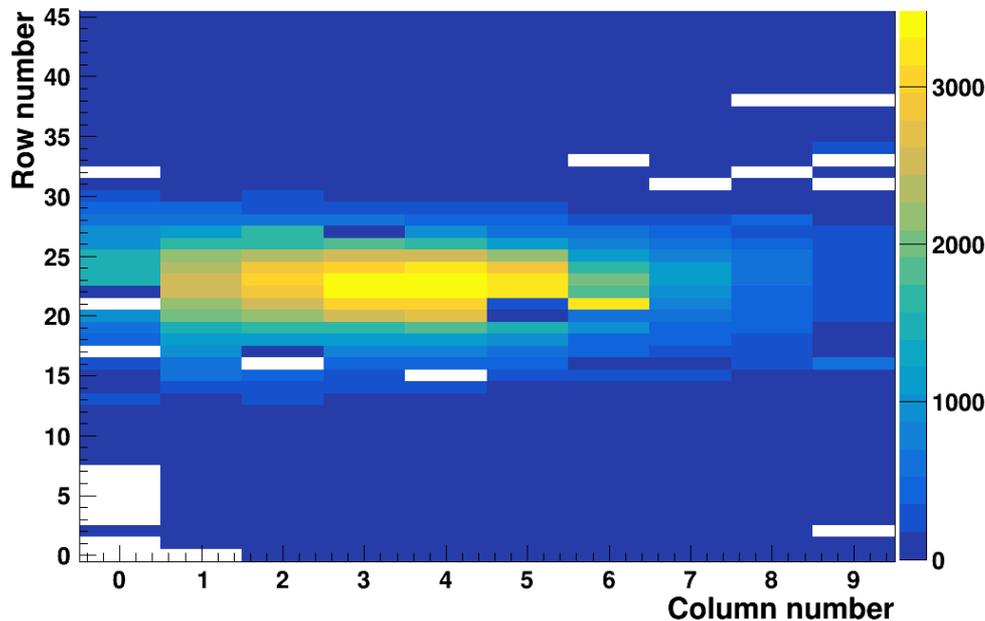
Trigger Scheme

- Coincidence signals from three different scintillators were used:
 - Paddle scintillator -1 and 2 (At the beginning and end of the hall).
 - CBM scintillator $\rightarrow \sim(45 \text{ mm} \times 50 \text{ mm})$ positioned behind the second paddle scintillator.

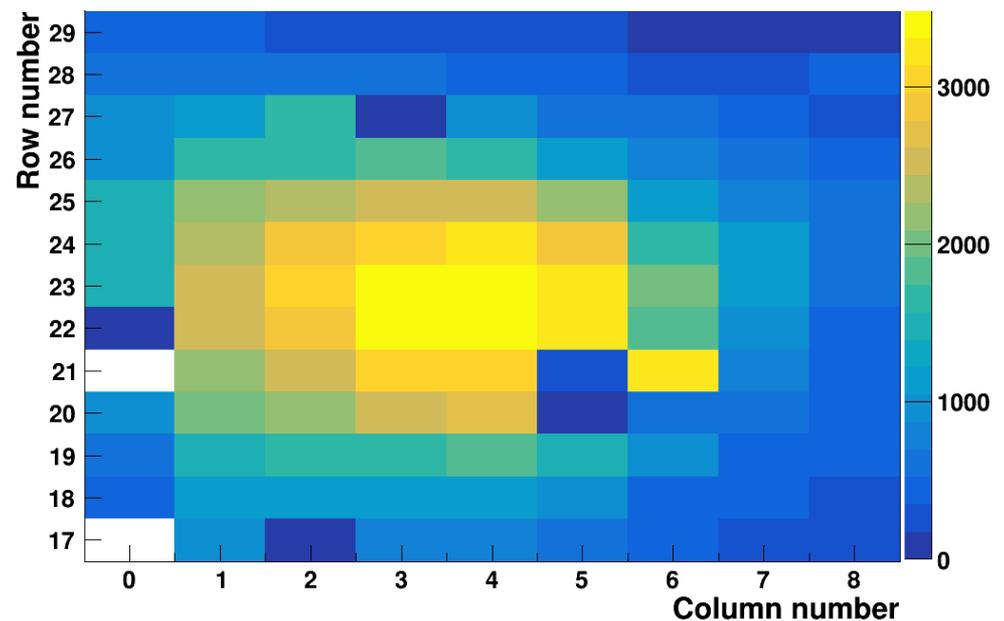


A schematic representation of the experimental site along with the generated trigger scheme. The figure is not to scale.

Hit distribution



Hit distribution of the pads throughout the whole detector.

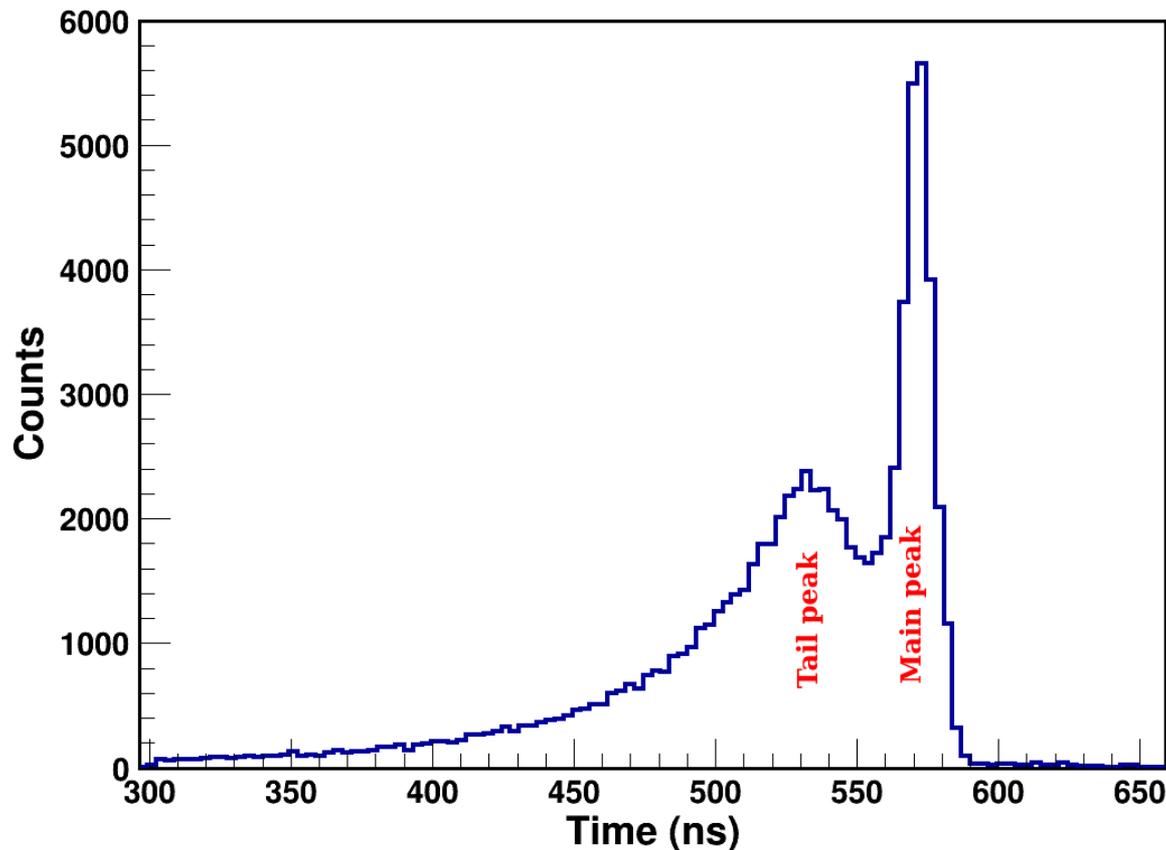


Hit distribution of the pads in and around the beam spot region.

- The detector has been positioned in such a way the beam hit around the middle region.
- The approximate pad dimension \rightarrow **23 mm \times 23 mm.**
- The most intense region of the muon beam has an area of \sim **(92.6 mm \times 92.6 mm)**

Timing Spectra

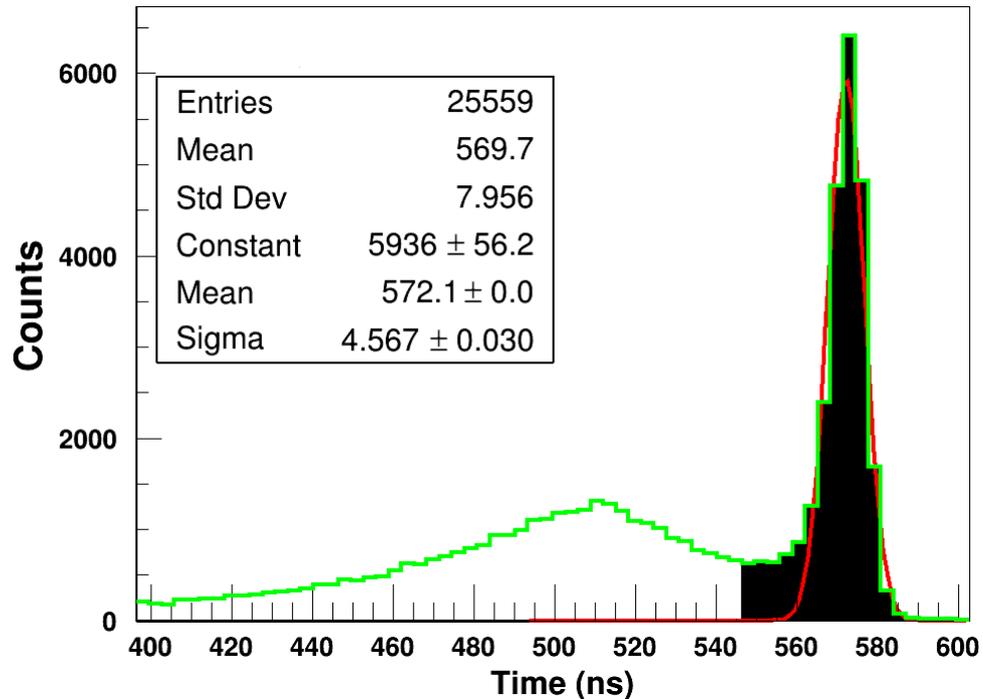
- The timing information of the hits have been measured w.r.t to the trigger time.



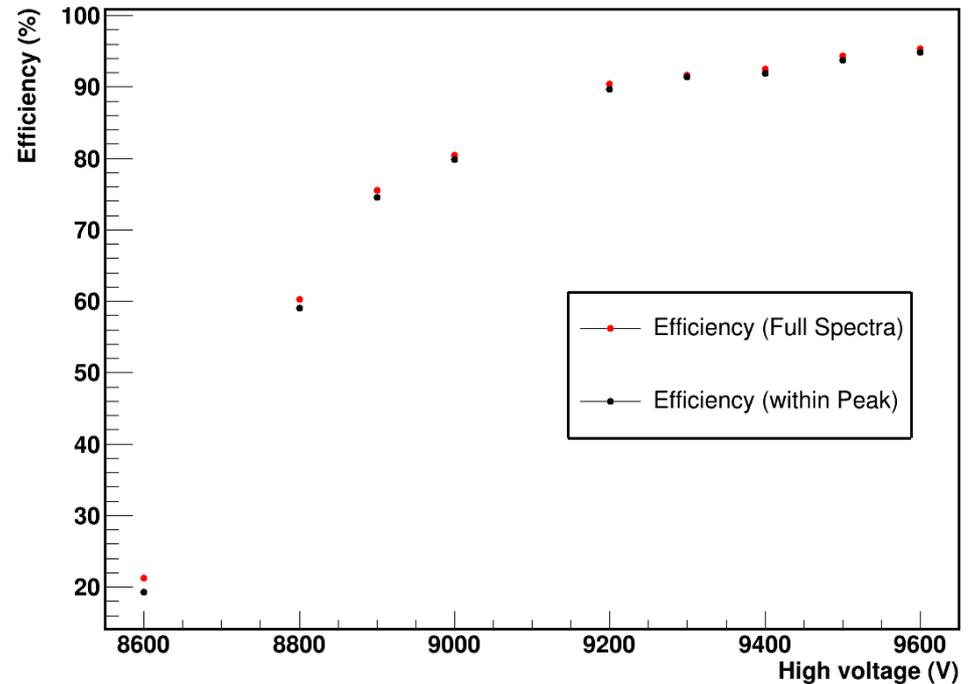
*Time correlation spectra at 9200 V
in absence of photon flux.*

- The single channel resolution of MuCh-XYTER is ~ 3.125 ns.
- **Observation:** Two peaks in the time correlation spectra v.i.z "Main peak" and "Tail peak".

Timing Spectra and efficiency



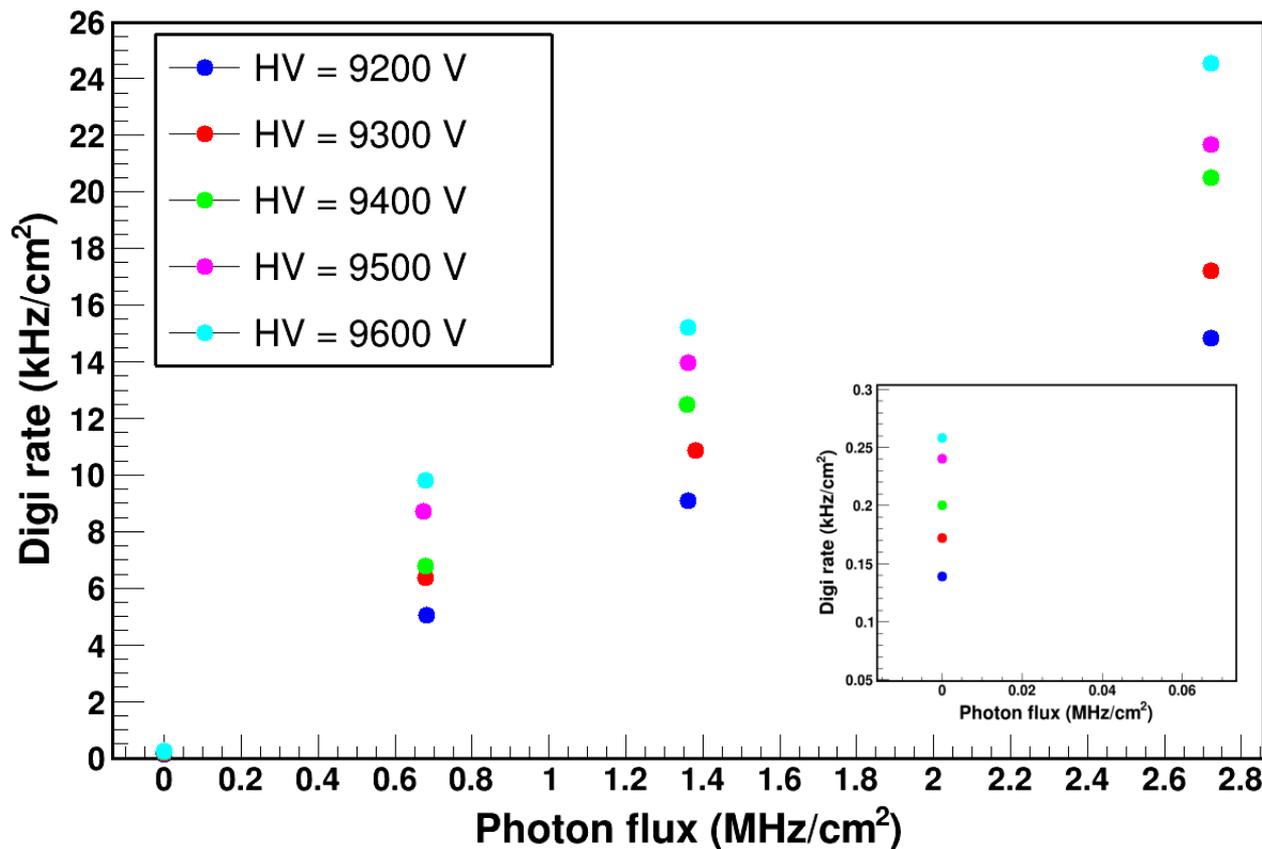
A typical measured time spectra at 9300 V



Comparison of efficiency correlation for different regions of the photon spectra

- **Observation:** No significant change in the efficiency values.
- For further efficiency calculations, the hit(s) lying within the "Main peak" have been considered.

Measured Digi Rate



Variation of digi rate as a function of incident photon flux at different applied high voltages. The photo in the inset shows the variation during source OFF condition.

Observations:

- At any particular voltage the digi rate increases as the number of incident photon increases.
- At any particular photon flux the digi rate increases as the applied voltage increases.
- Maximum digi rate of $\sim 24.56 \text{ kHz/cm}^2$, @ 9600 V with γ -flux of $\sim 2.72 \text{ MHz/cm}^2$.

Plan for 2023

To take part in the test beam in GIF++ for CBM RPC and GEM

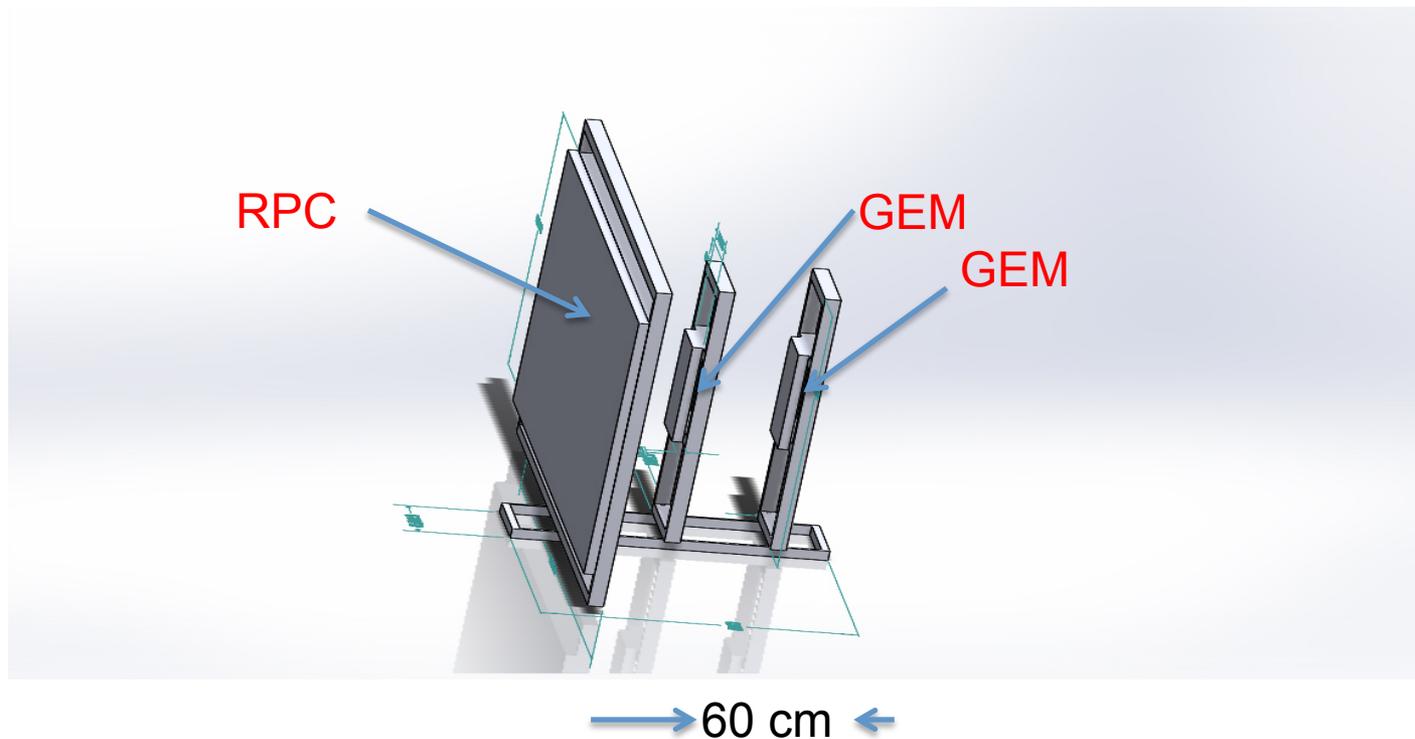
3 Detectors:

- (1) 2 GEM, 30cm X 30 cm
- (1) 1 RPC, 80 cm X 150 cm

Space required : Upstream position, 60 cm in Z- direction along Muon beam axis (**Nearest to Source**)

Support required:

For RPC, CMS humid gas mixture, flow rate 6 lt/hr
For GEM Ar:CO₂ (70:30), premixed cylinder will be fine



Conclusion from GIF++ test

- A real-size single gas RPC along with **paded structure read-out PCB** (**different from standard strip read-out technique**) and dedicated self triggered electronics chain has been successfully tested for its muon detection efficiency in absence and presence of intense photon flux at GIF++ with an idea to study its performance and determine the optimum operating voltage at a high photon environment.
- The detector has shown muon detection efficiency of **> 90% and maximum digi rate 25 kHz/cm²** (in presence of $\sim 2.72\text{MHz/cm}^2$ photon flux as background) at an operating voltage of **9600 V** with a threshold of **$\sim 15\text{ fC}$** .
- We need further tests at GIF++ for optimizing various detector parameters.

Thank you