The Scientific Conference
of Young Scientists and Specialists

Performance of a new fast timing generation of RPC detector of the high eta CMS muon stations

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Alushta'19

Outline

Motivation and Goals

- **Motivation and Goals of Research & Development**
  - CERN CMS Resistive Plate Chamber (RPC) upgrade project
  - Scheme of Resistive Plate Chambe and Readout system

Protypype of RPC

- **Improve RPC (iRPC): RETURN and COAX prototypes**
  - RETURN and COAX prototypes
  - Front-End Board with Petiroc 2A
  - Printed Circuit Board (strips)
- **Electronic PETIROC2A: Pedestal, Injection, Noise**
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  - Calibration with injection signal form generator
- **Description of the stand for tests of the prototype**
  - Scintilators setup
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Test of RPC

- **H2 line: Study of time resolution**
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- **GIF++: Study of rate capability**
  - Stand Description, Results

Motivation and Goals of Research & Development

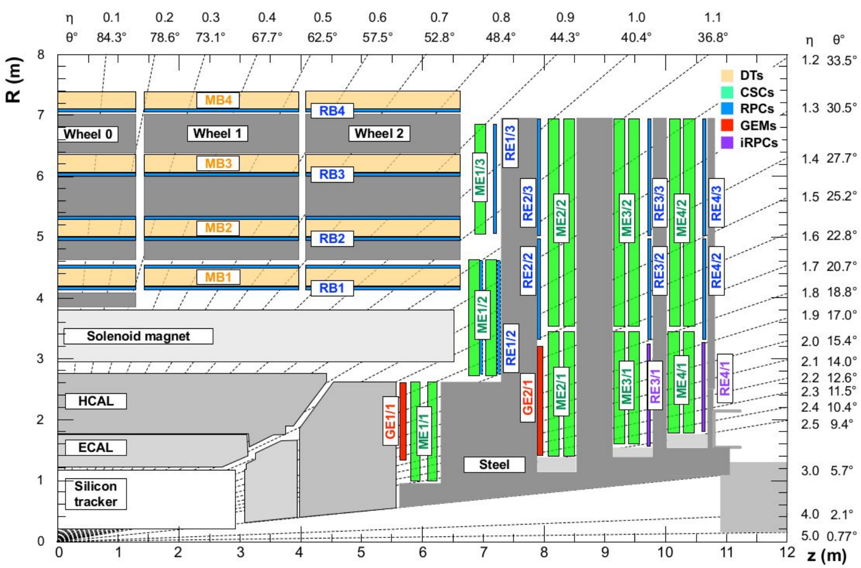
High η CMS RPC upgrade project

RE3/1-RE4/1 muon stations motivation:

- To improve on the muon detector performance.
- Heavy Stable Charged Particle search.
- To improve on the muon trigger efficiency at high η

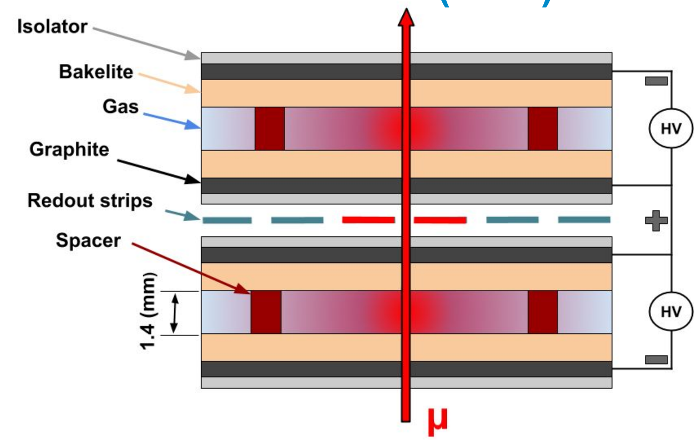
$$1.8 < |\eta| < 2.4$$

- Detectors should be able to withstand high particle rates: $2\ kHz \cdot cm^{-2}$



Layout of one quadrant of CMS.
The slots RE3/1 and RE4/1 are to be instrumented by RPC chambers for HL-LHC upgrade [1]

Resistive Plate Chamber (RPC) and Readout

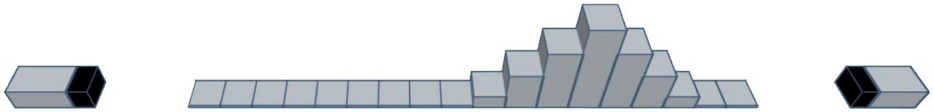


Thinner gap in the double gap RPC detector [2]
95.2% $C_2H_2F_4$, 4.5% i-C_4H_{10}, and 0.3% SF_6

lower charge → less aging → needs more sensitive electronics
higher rate → more combinatory → needs better space resolution

Standard Readout

Time of Arrival (Proposal Solution)



Determine position along a strip of the hit with resolution given essentially by the readout.

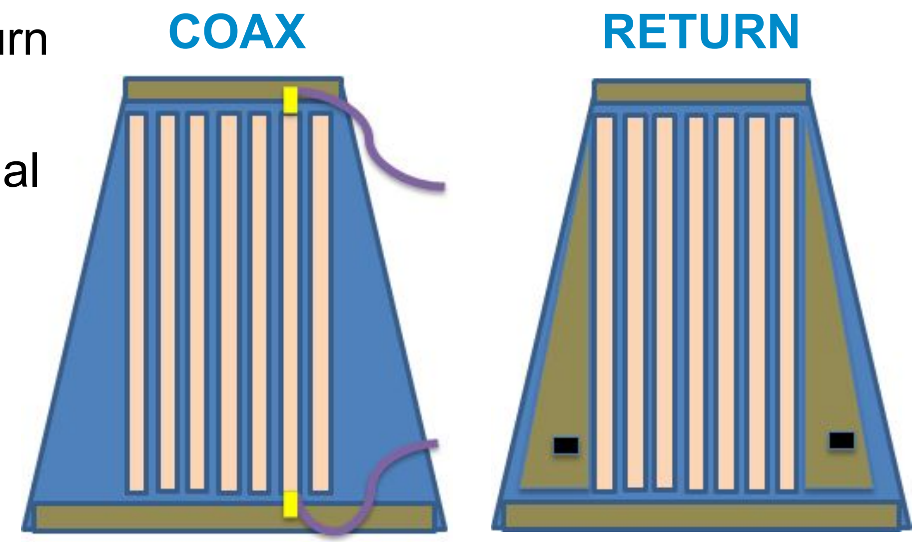
Improve RPC (iRPC): RETURN and COAX prototypes

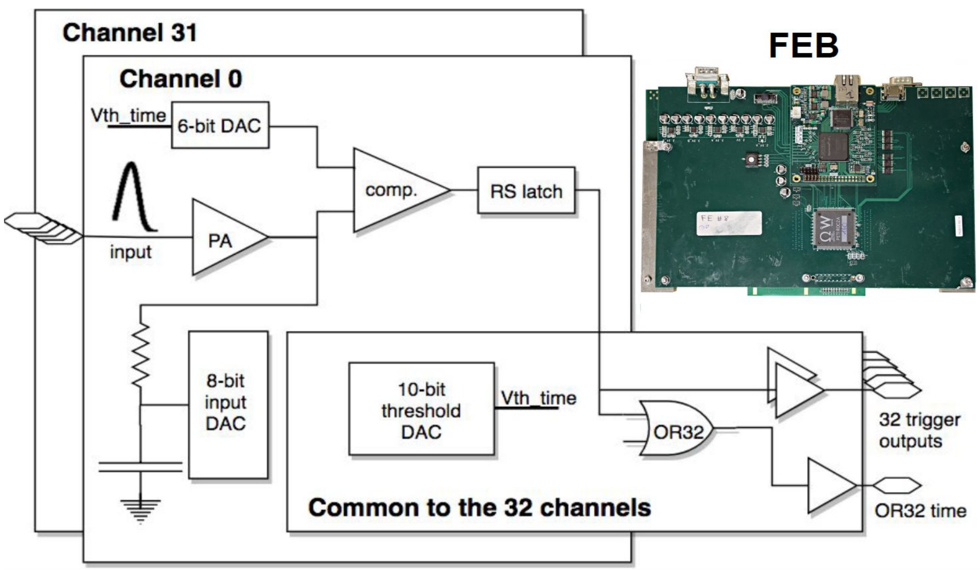
<u>Solution RETURN</u> Connect with a return line within PCB (same impedance 45 Ω).

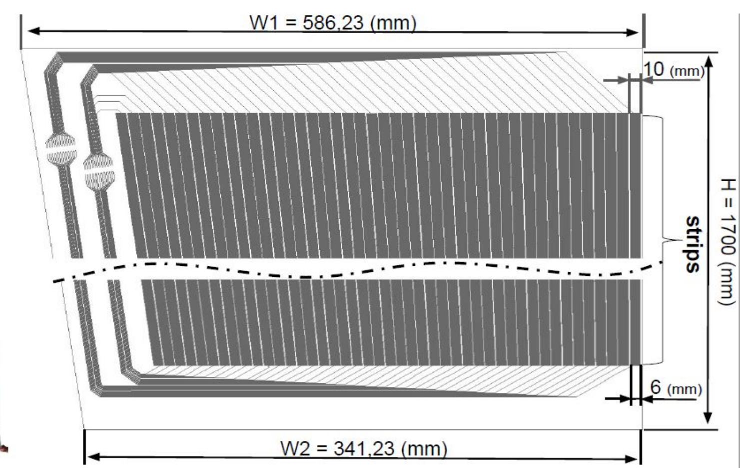
<u>Solution COAX</u> Connect with coaxial cables. Cable impedance = 50 Ω.

RETURN prototype better than COAX.

- more noise protection;
- less complicated construction process.



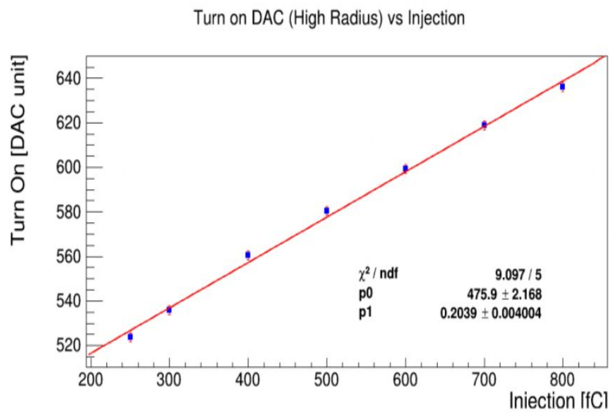




The Front-End Electronics Board (FEB) that hosts one PETIROC ASIC and the FPGA that includes the TDC and the schematics of the PETIROC ASIC [3]. (left) Photograph and dimensions of a prototype pickup-strip PCB. (right)

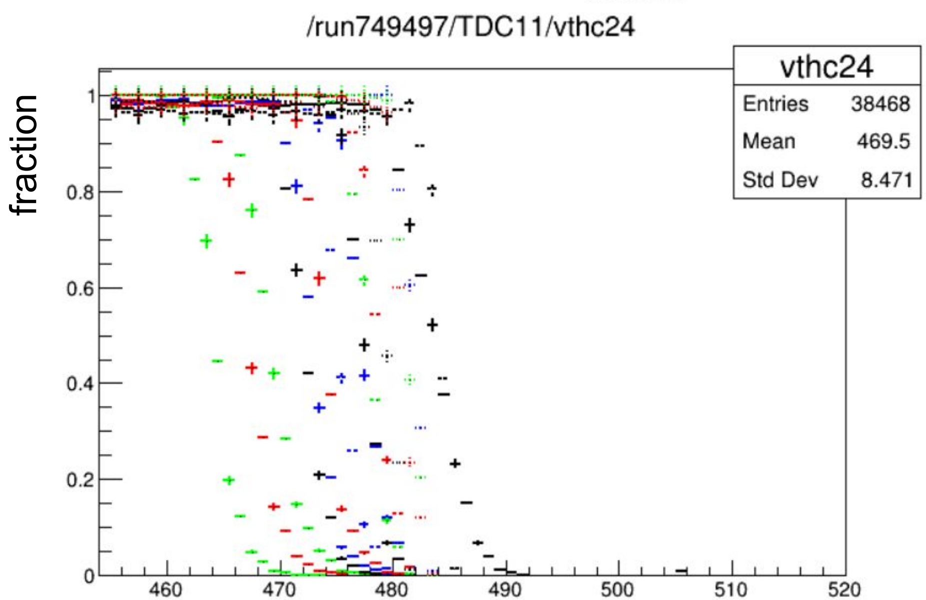
Electronic PETIROC2A: Pedestal, Injection, Noise

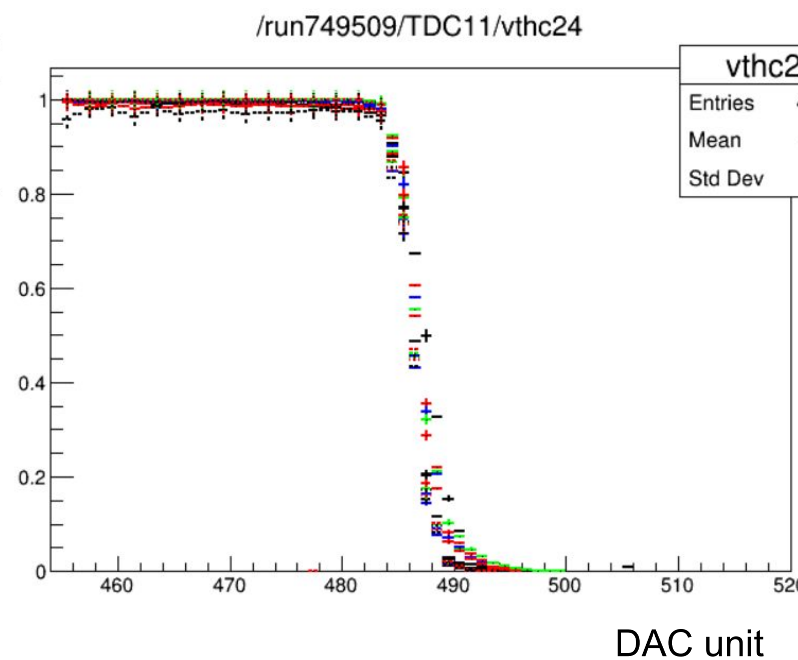
The parameters of each channel (6-bit DAC) is adjusted so the pedestal S-curves of all channels are similar.



- This allows a uniform esponse of the 32 chs.
- Easy control threshold with 10-bit DAC

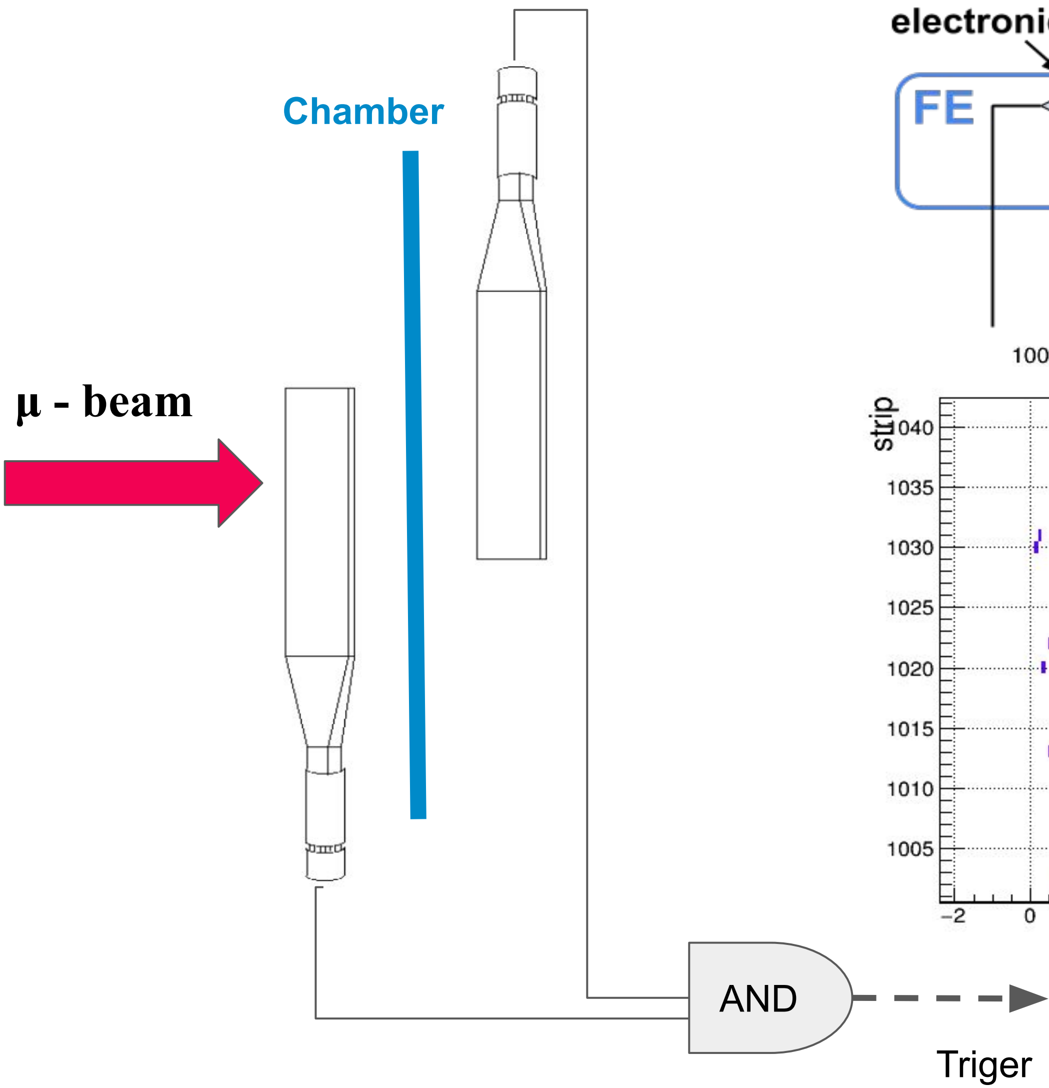
1DACunit = 4.90fC per strip
1DACunit = 2.45fC per DAQch

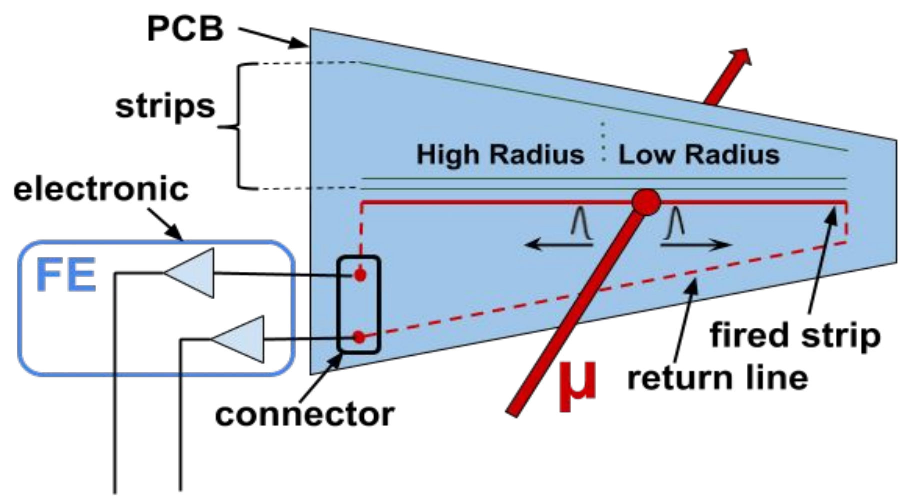


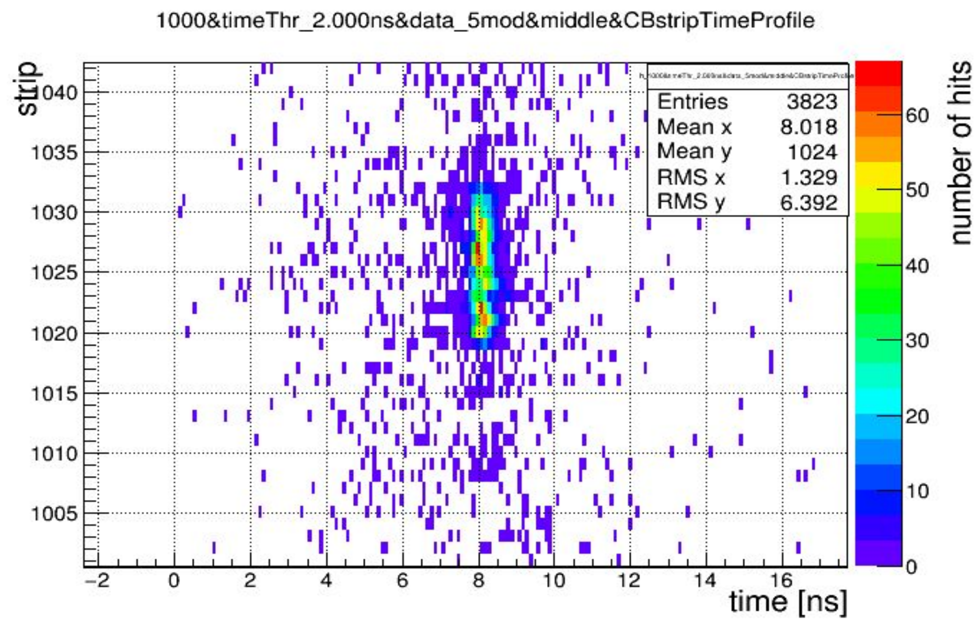


Description of the stand for tests of the prototype

Setup of scintilators

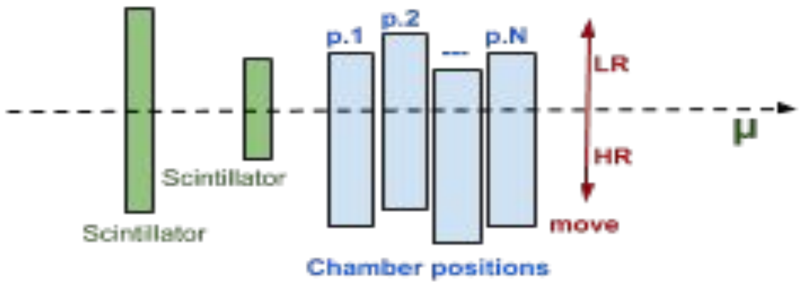


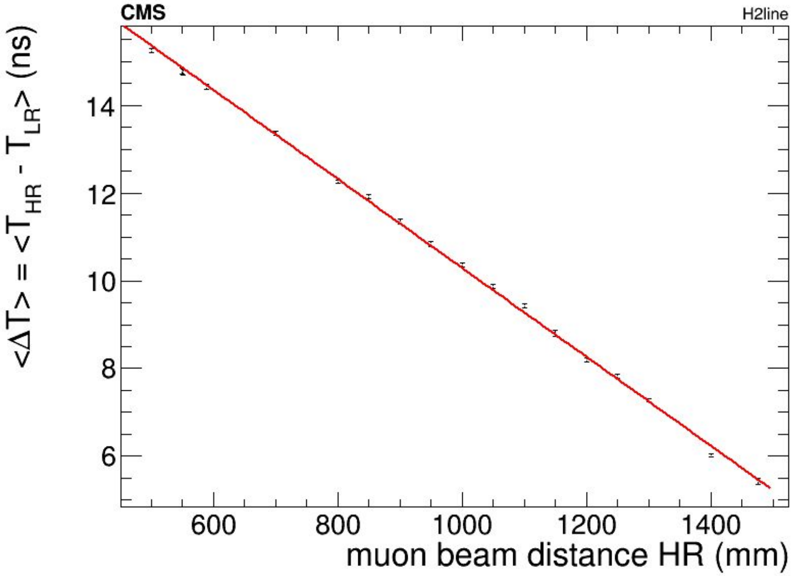


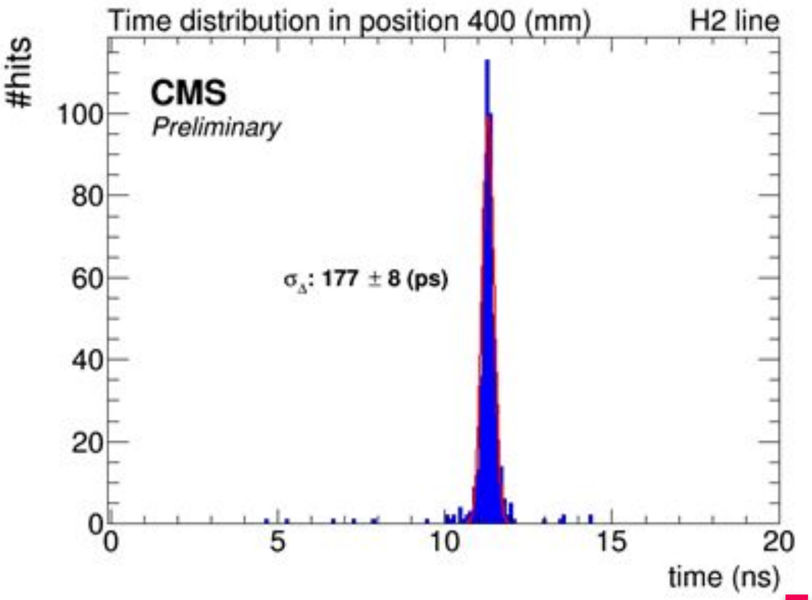


Time profile with offset ATT22;
HVeff=7500; THR=510; dead 20ns

H2 line: Study of time resolution



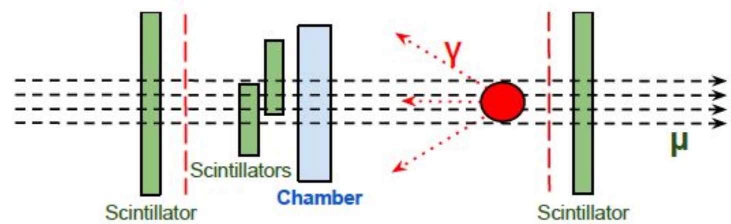




GIF++: Study of rate capability

14 TBq 137Cesium is used in GIF++ with different attenuation coefficient is used to obtain different gamma irradiation levels.

To test our chambers up to **2 kHz·cm^{-2}** rate needs to be **seen** in our chamber.



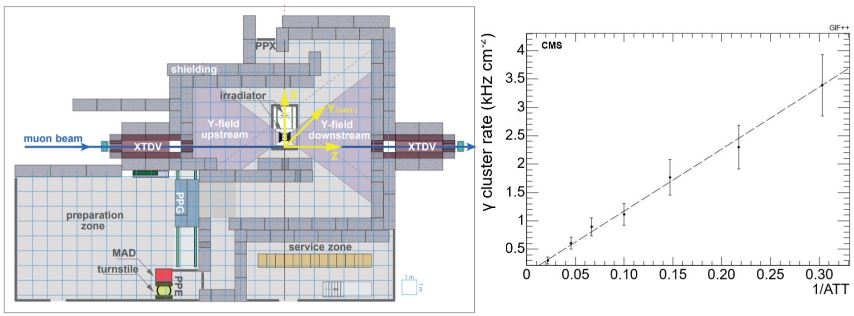
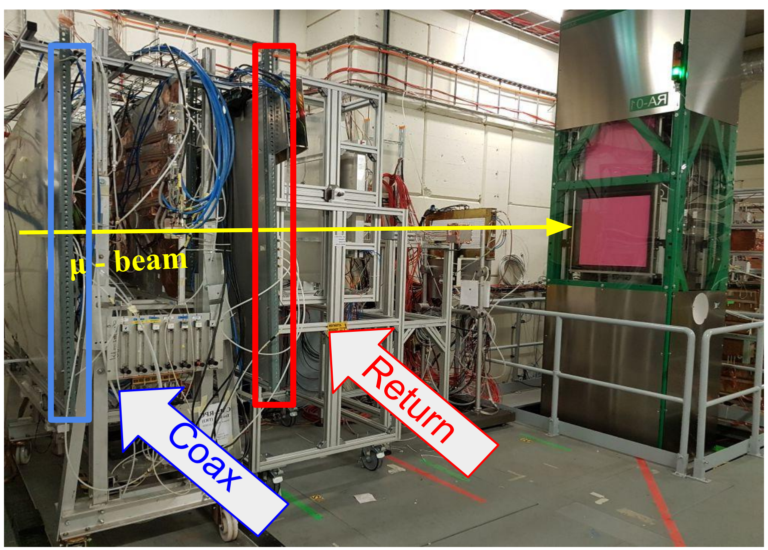
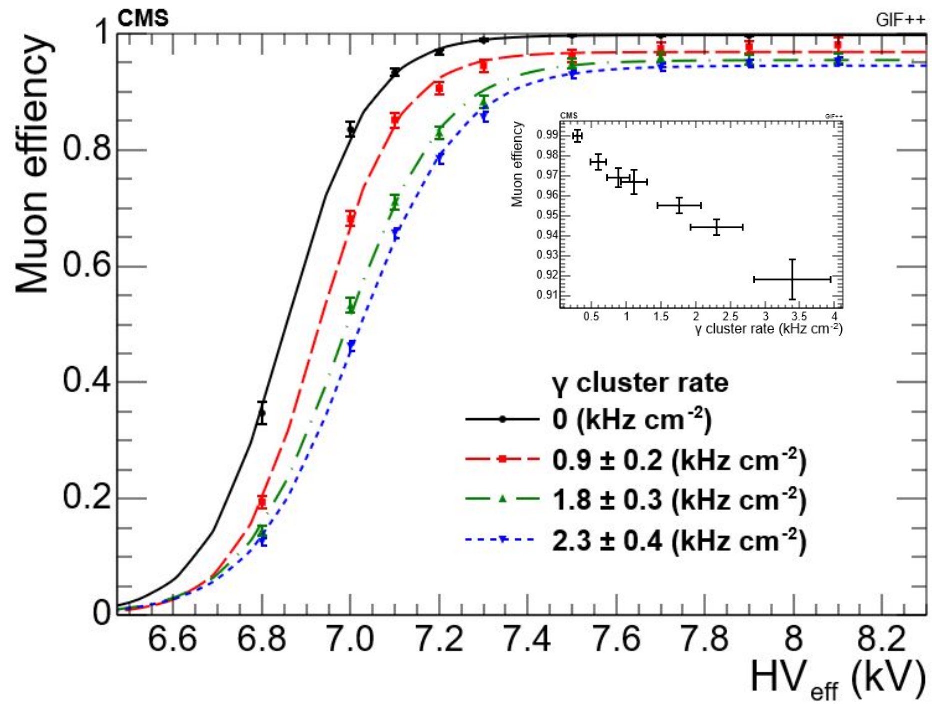


Fig.4 Floor plan of the GIF++ facility [4]





Loss of efficiency at a high rate is due partially to the DAQ dead time used to reload FEB channels after triggered by the noise.

Summary

- The linearity of the TOA time measurements and the time resolution of the TOA are verified on H2 line tests. Along strip resolution ~180ps.

- Measurements of the detector characteristics were carried out at the required noise on GIF tests 95% on 2kHz of background.

Reference

1. CMS Collaboration, The Phase-2 Upgrade of the CMS Muon Detectors, 145 Tech. Rep. CERN-LHCC-2017-012. CMS-TDR-016, CERN, 2017.
2. K. S. Lee, et al. Study of Thin Double-Gap RPCs for the CMS Muon 147 System. Journal of the Korean Physical Society 73 1080 (2018).
3. J. Fleury et al., Petiroc, a new front-end asic for time of fight application, 149 2013 IEEE Nuclear Science Symposium and Medical Imaging Conference, 150 conference record pp. 15, October 2013
4. D. Pfeiffer, et al., The radiation field in the gamma irradiation facility gif++ at cern. Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, 866:91 – 103, 2017. ISSN 0168-900.

Thank for Your Attention!

Any questions:

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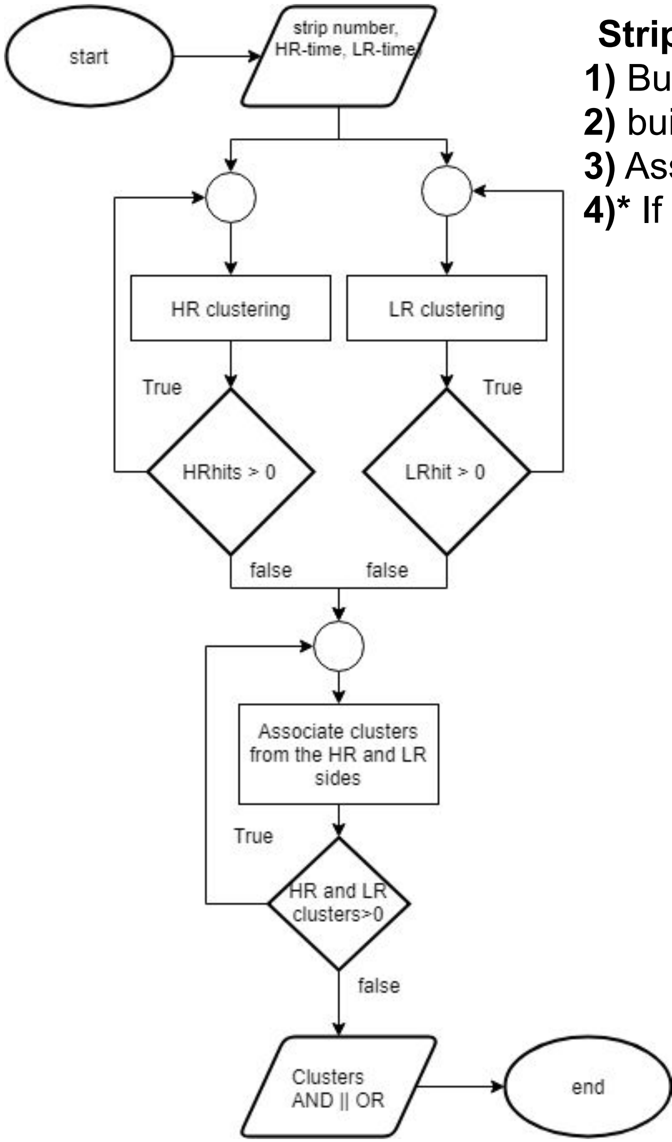
New Clustering algorithm



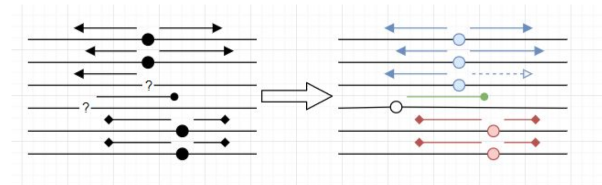
Strip (strip Number, HR-time, LR-time).

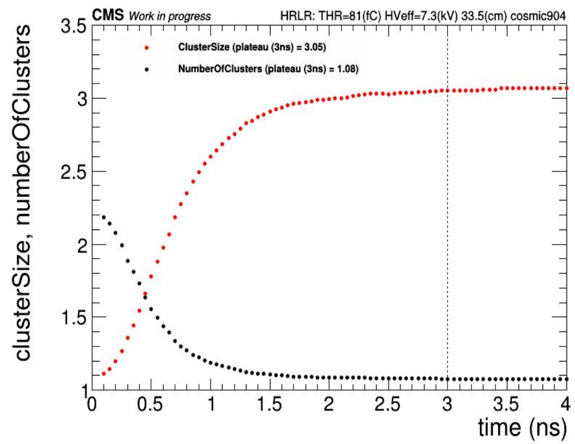
1) Build clusters for HR (Space and TIme);

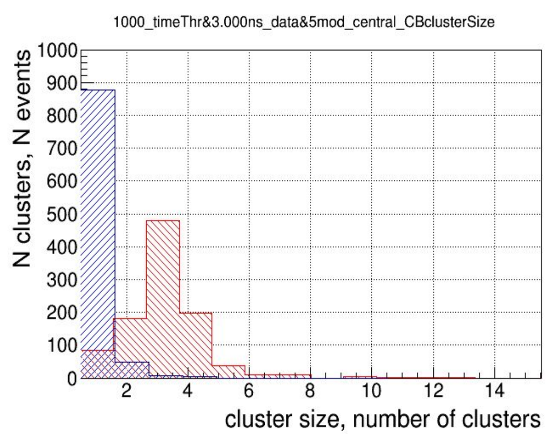
2) build Clusters for LR (Space and TIme);

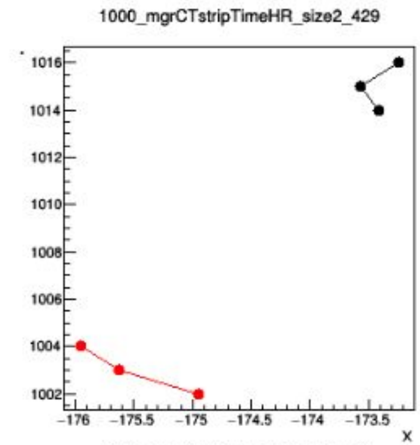
3) Associate clusters HR and LR sides;

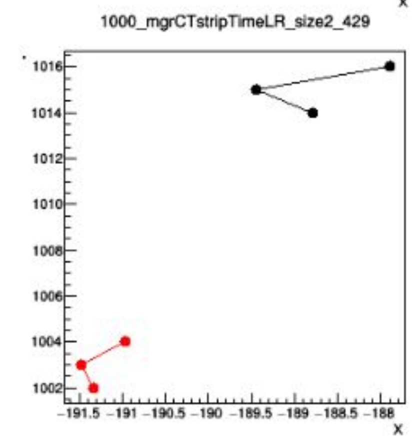
4)* If OR add clusters without association.



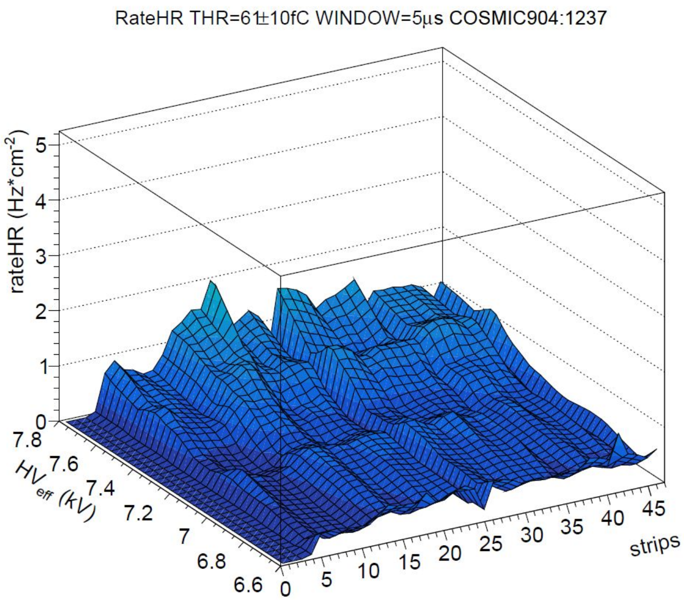








Noise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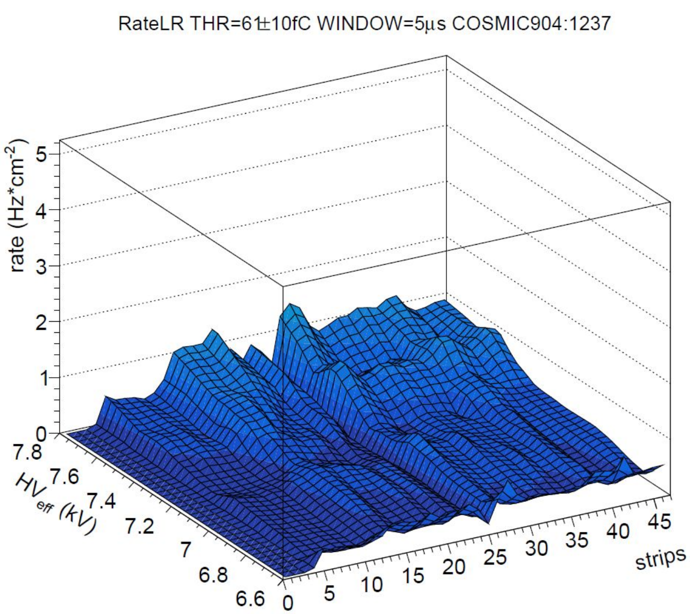
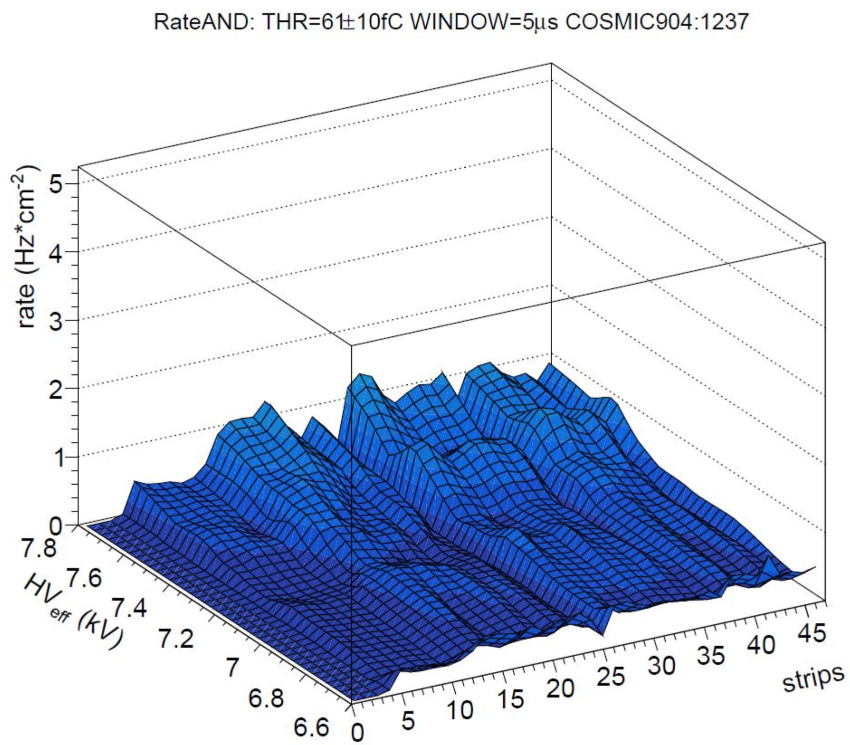
rateHR (Hz*cm^-2)
HV_eff (kV)
strips


RateLR THR=61±10fC WINDOW=5µs COSMIC904:1237
rate (Hz*cm^-2)
HV_eff (kV)
strips


RateAND: THR=61±10fC WINDOW=5µs COSMIC904:1237
rate (Hz*cm^-2)
HV_eff (kV)
strips