MWPC Based Muon Trigger At GIF++

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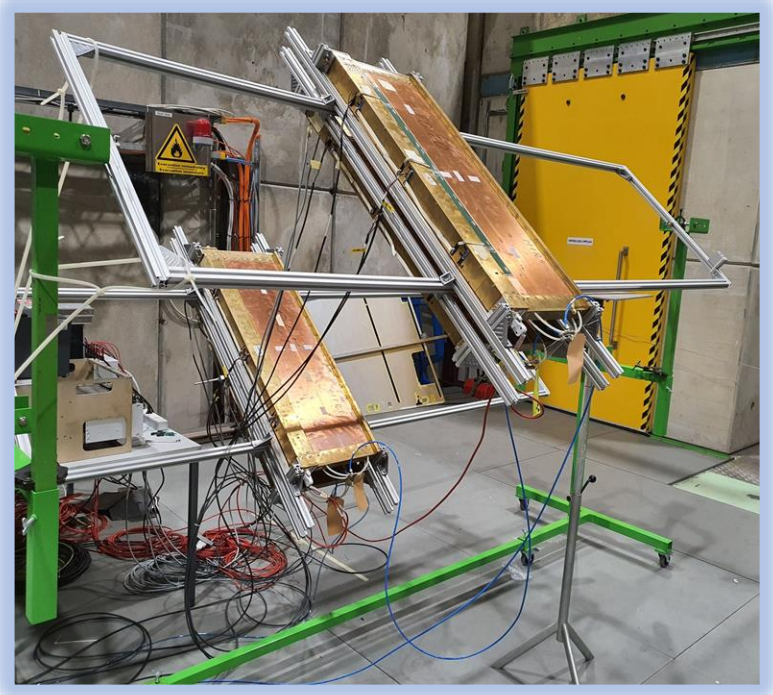
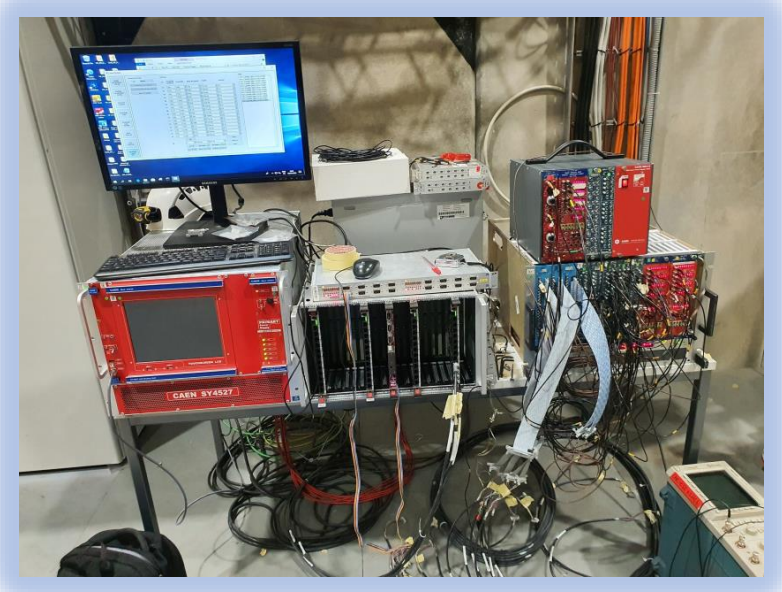
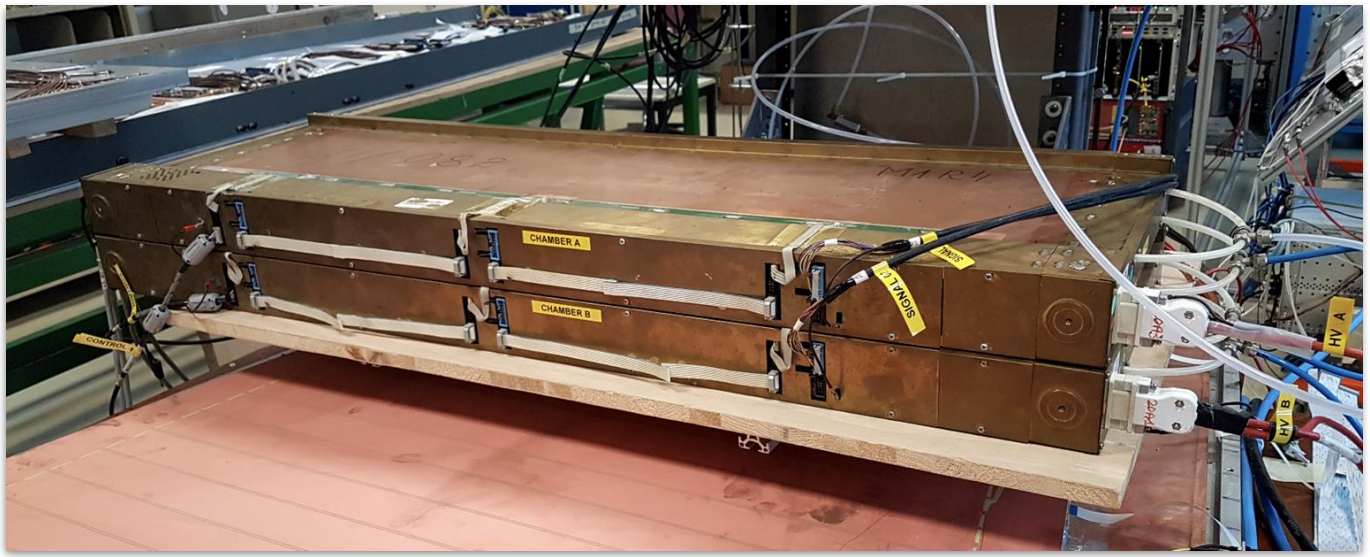
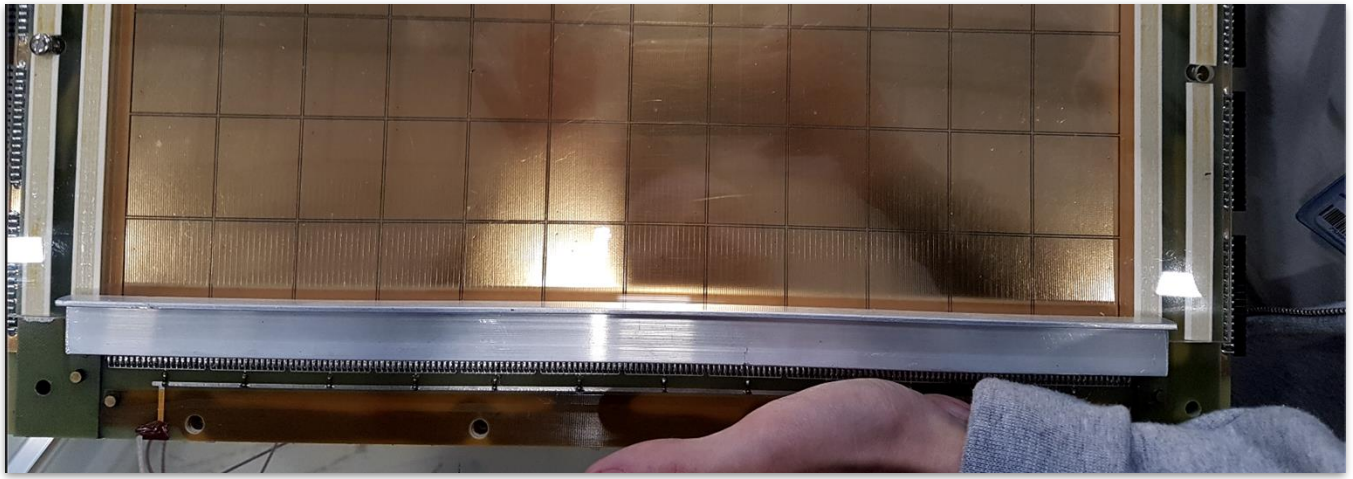
Motivation

- Provide a reliable, flexible cosmic muons trigger for RPC tests in GIF++.
- LHCb MWPC chambers available.
- Low sensitivity for gamma radiation.









- **Two gaps (top/bottom) in one chamber.**
- Gas gap: 5 mm
- Wire: Gold-plated Tungsten, 30 um dia.
- Wire spacing: 2 mm
- Wire length: 210 mm
- Wire mechanical tension: 60 gf

- Charge/mip: ≈ 0.8 pC @ HV ≈ 2.55 - 2.75 kV
- Field on wires: ~262 kV/cm, on cathodes ~6.2 kV/cm

- Gap efficiency: ≥ 95% in 20 ns window (st ≈ 3.9 ns)

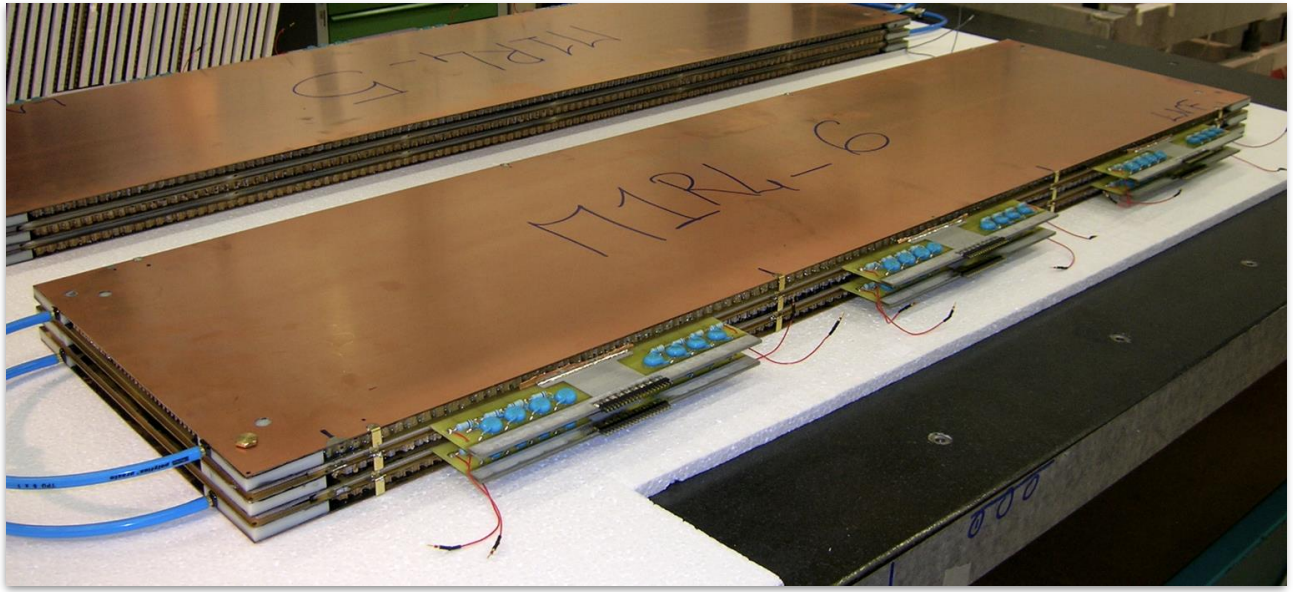
- **Rate/channel: max 1 MHz**

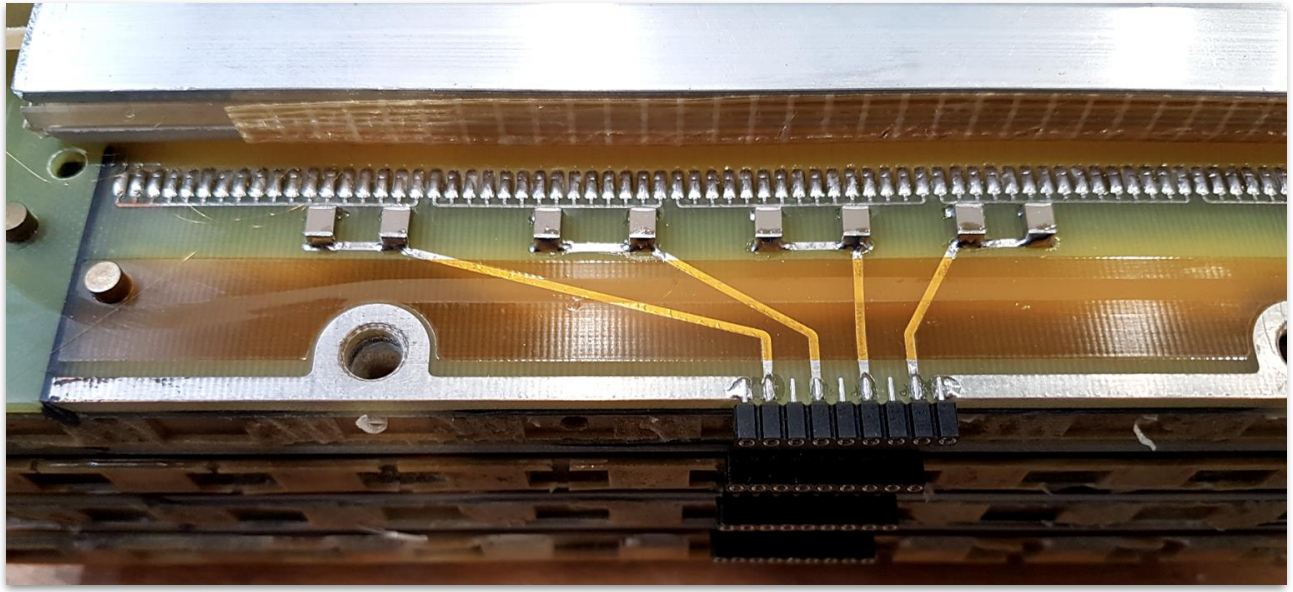
- Max. operating voltage: 2.75 kV, most of chambers tested up to 2.85kV

- **Typical HV 2650V**

- **LV 3.5V,** 1.5 A per chamber. Build-in chamber LV-regulator, tolerance +-100mV

- **Signal output - LVDS**. Readout from anode wires groups.





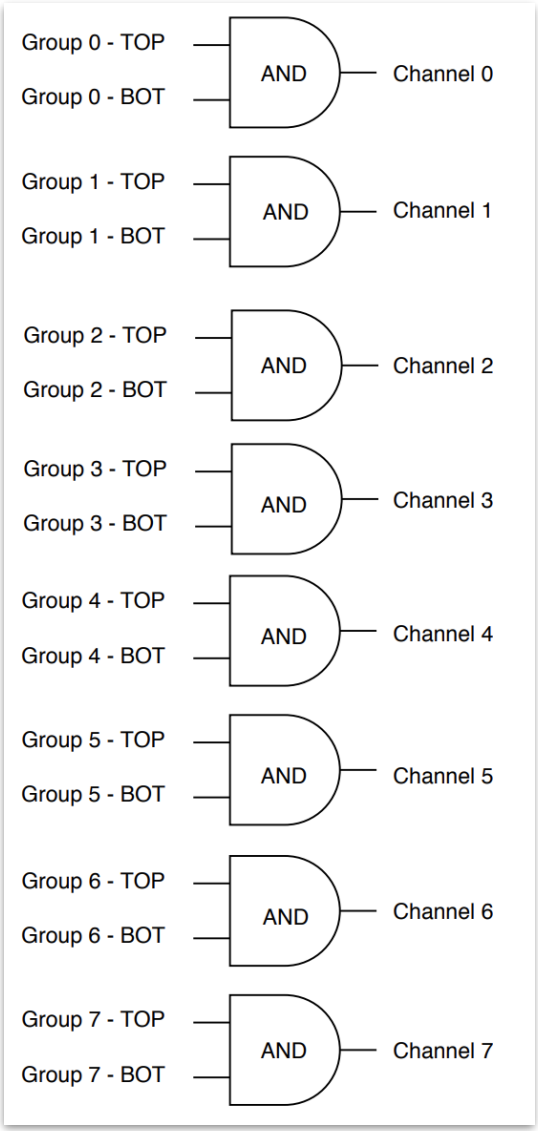
Gas:

- **Gas mixture: Ar/CO2/CF4 (40:55:5)**
- CMS CSC gas (40:50:10) is okay for a first test.
- Gas gain: G ≈ 10^5
- **Gas flow: 2-4 l/h,**
- **Max. overpressure 2 mbar, could be 5-10 chambers in gas chain (max 10)**

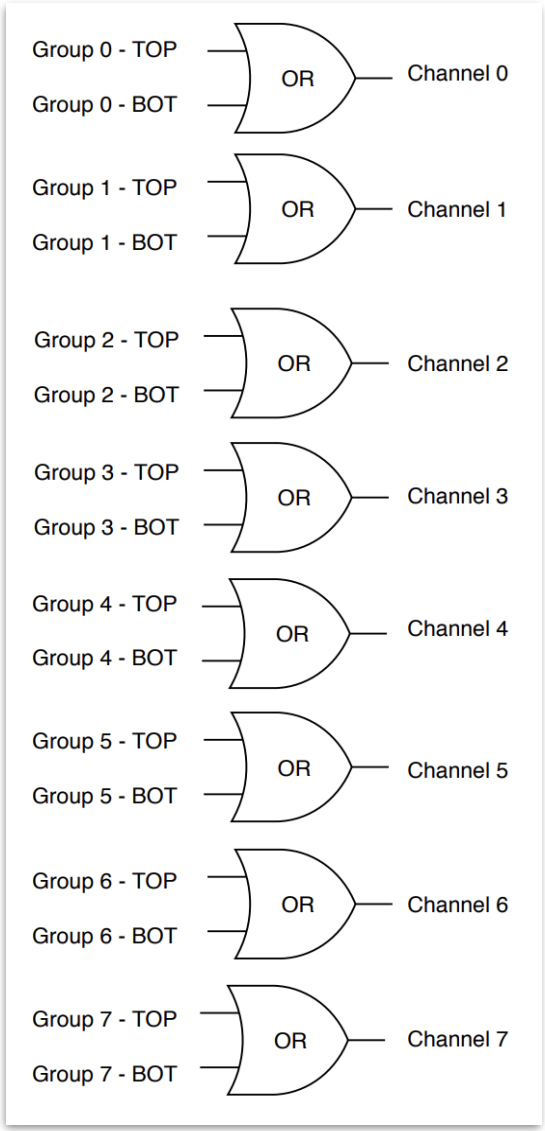
Wire groups:

- A logical combination of 2 groups (from top and bottom gap) is the minimal readout channel.
- Groups are merged by construction.
- **Granularity: 40x200mm**
- **Active area is 968 x 200 mm per chamber**

AND2



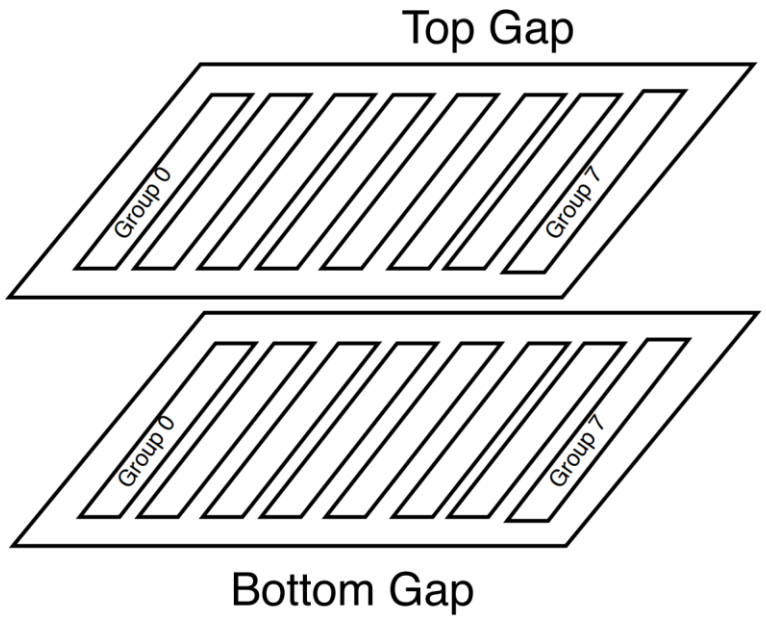
OR2



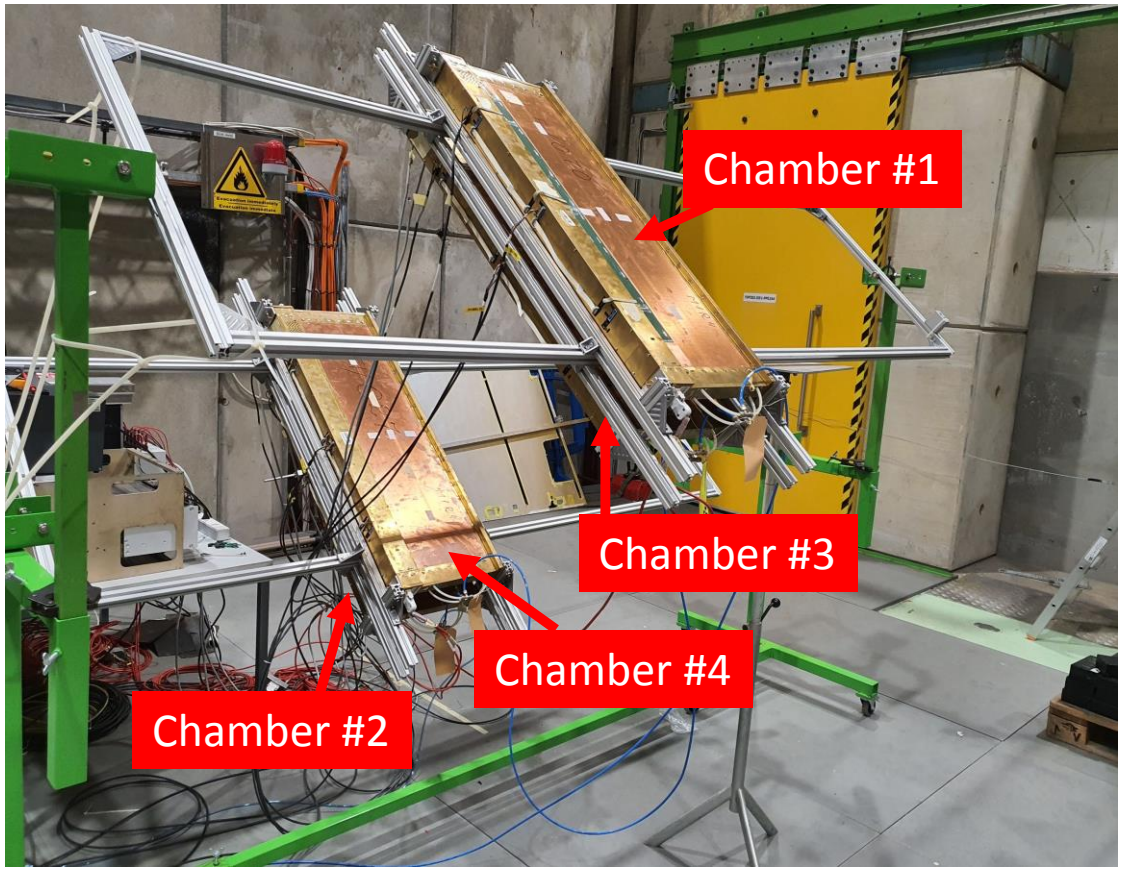
- **Each chamber has 3 FEEs**

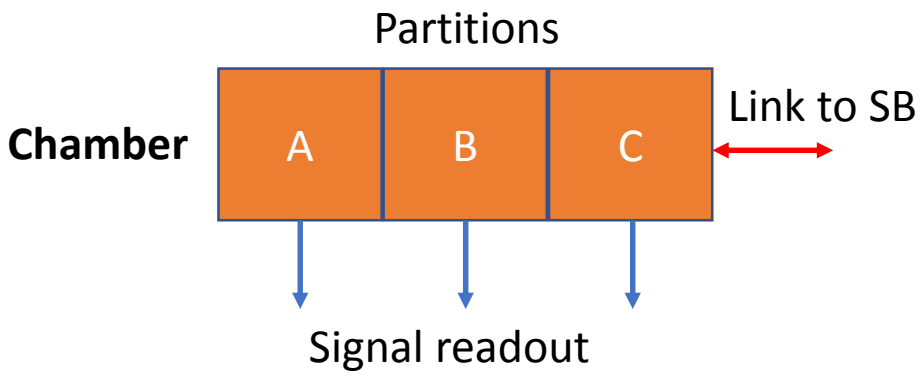
- 8 channels per FEE
- Each channel is composed by a logical combination of Wire Groups.
- The logical combination is configured from control software.

- **Relevant logical combinations:**
  - **AND2**: 8 output channels
    OR2: 8 output channels
  - **OR4AND2**: 2 output channels
  - **OR8:** 2 output channels



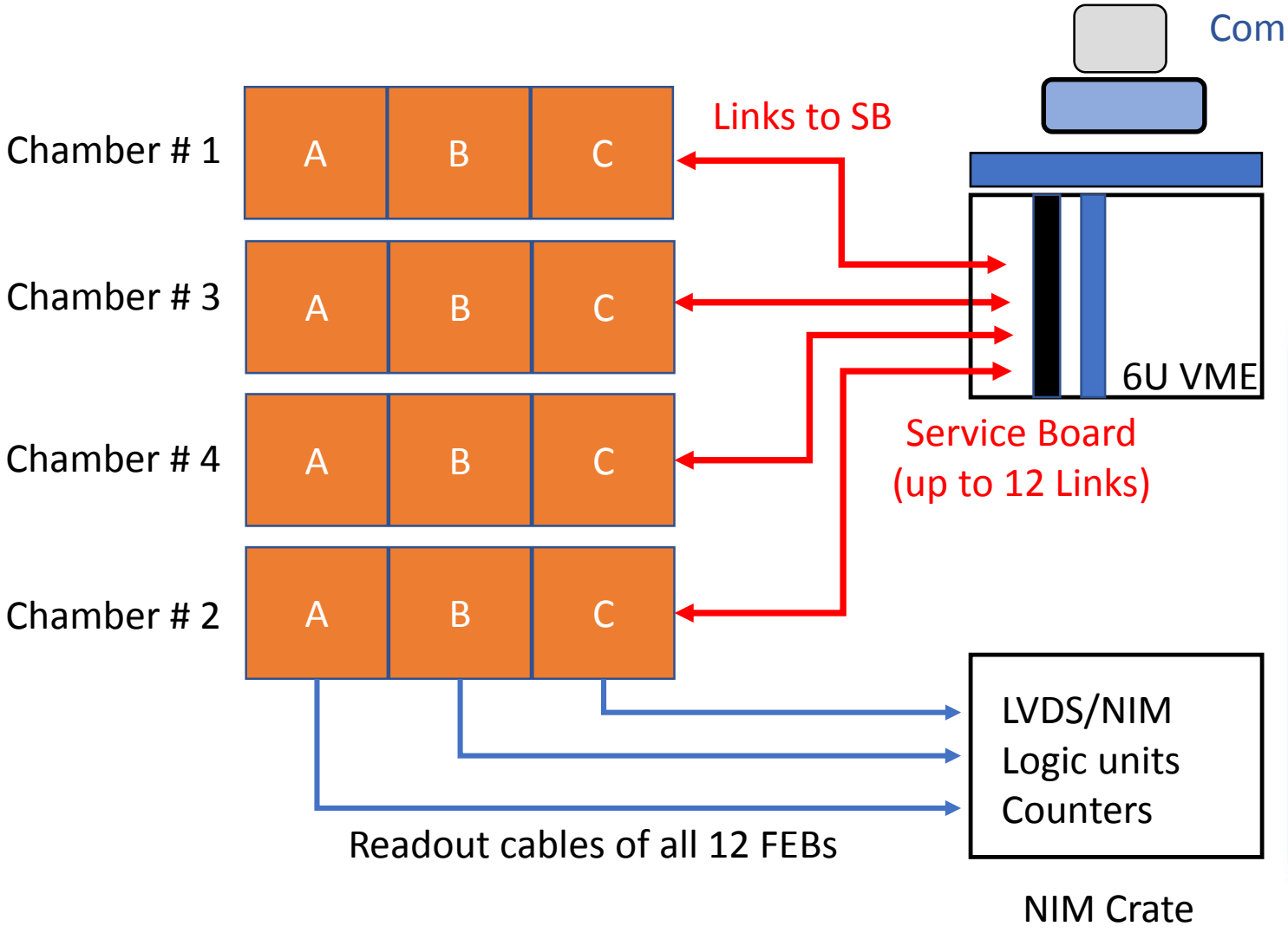
Setup



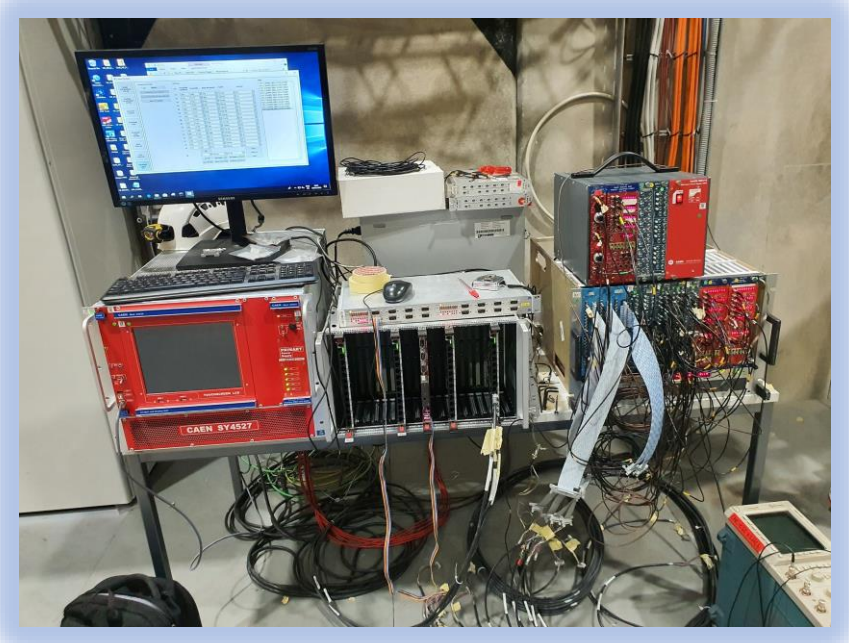


- **Two layers.**
- **Two chambers/layer.**
- **Each chamber:**
  - 2 gaps (top/bottom)
  - 3 FEBs (Partitions A, B, C)
  - 16 channels/FEB – internal
  - Readout of 8 channels/FEB (top/bottom channels combined in And/Or logic)
  - Single channel: 40x200mm^2
  - Active area is 968 x 200 mm^2/chamber

Electronics



To configure discriminators and read internal counters of the FEBs.



Rates Measurements

Inside the bunker, two angles were tested: 45° and 0° wrt horizontal. The last one is more attractive due to the better acceptance to cosmic muons.

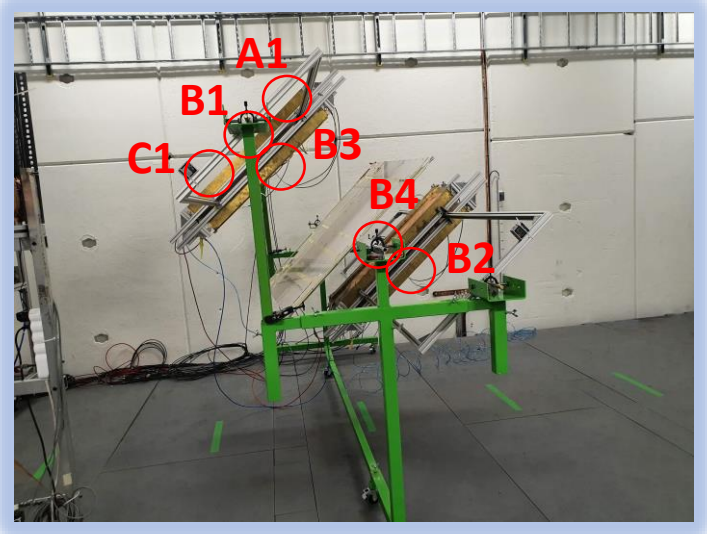
- Intensity of muons at sea level $I \approx 1\ \mathrm{cm}^{-2}\mathrm{min}^{-1} = 0.017\ \mathrm{Hz/cm}^2$.
- Muons angular distribution $I(\theta) \propto \cos^2\theta$.

Partition	Rate (Hz)	Stat Error	Fakes (Hz)	Stat Error
A1	6.975	0.026		
C2	7.784	0.028		
A3	7.393	0.027		
C4	6.447	0.025		
A1&A3&C2	0.148	0.004	6.77369E-12	4.32189E-14
A1&C4&C2	0.121	0.003	5.90731E-12	4.42594E-14
A1&C2	0.214	0.005	8.14451E-06	3.19947E-09
A3&C4	0.333	0.006	7.14943E-06	2.80856E-09

A3 eff	0.69	0.02
C4 eff	0.56	0.02
A3&A4 eff	0.39	0.02

$$\mathrm{A3} \rightarrow 10.71 \pm 0.04 \frac{\mathrm{Hz}}{640\ \mathrm{cm2}} =$$

$0.01674 \pm 0.00006\ \mathrm{Hz/cm2}$

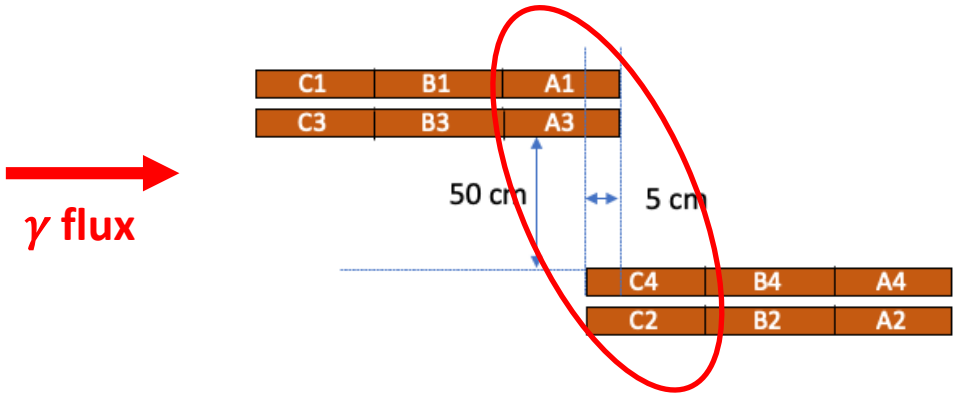


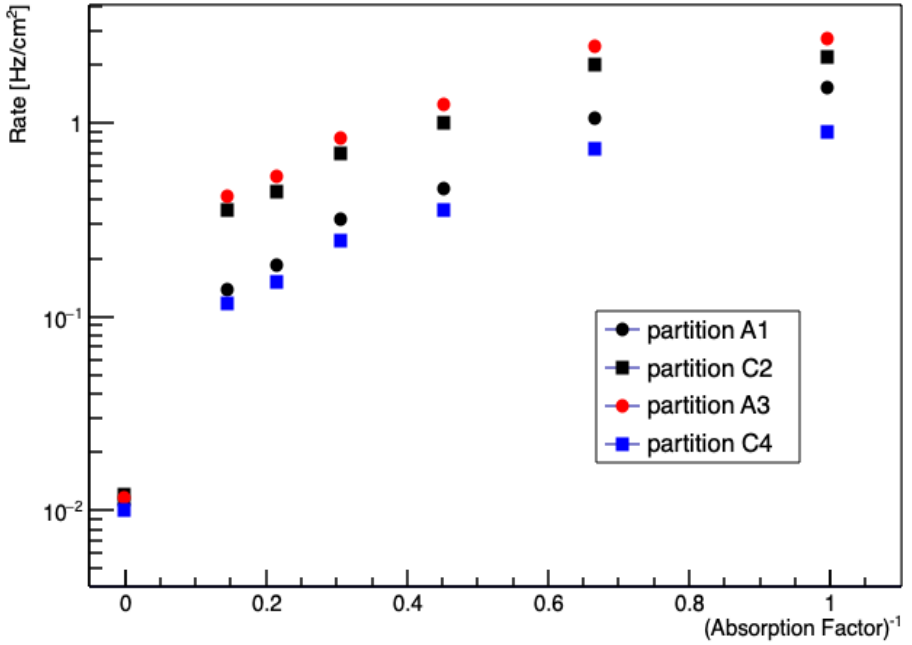
45°

0°

Partition Rates as a Function of the Absorption Factor

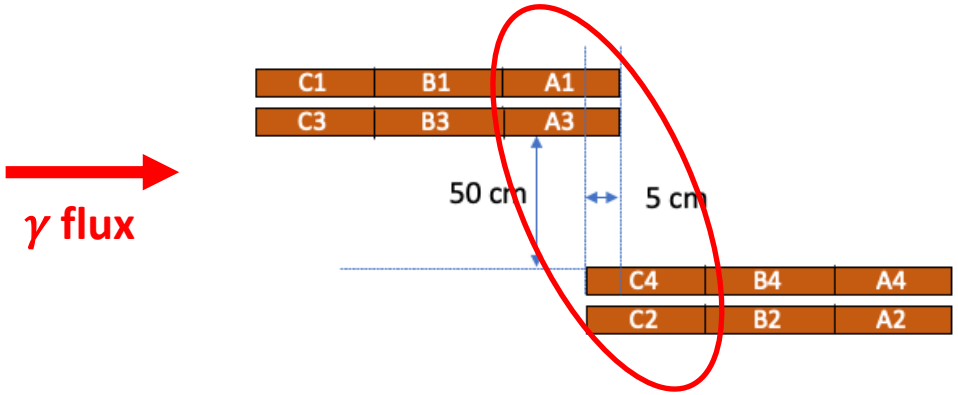
- Partitions A1, A3, C2, C4.
- Absorption Factors: 1.0, 1.5, 2.2, 3.3, 4.6, 6.9, 46000.
- Rates differences are due to the obstacles in front of the measuring partitions.
- AND logic between the “top/bot” gaps.
  - Lower probability to have gamma signals.
  - Most coincidences are statistical (“fakes”).

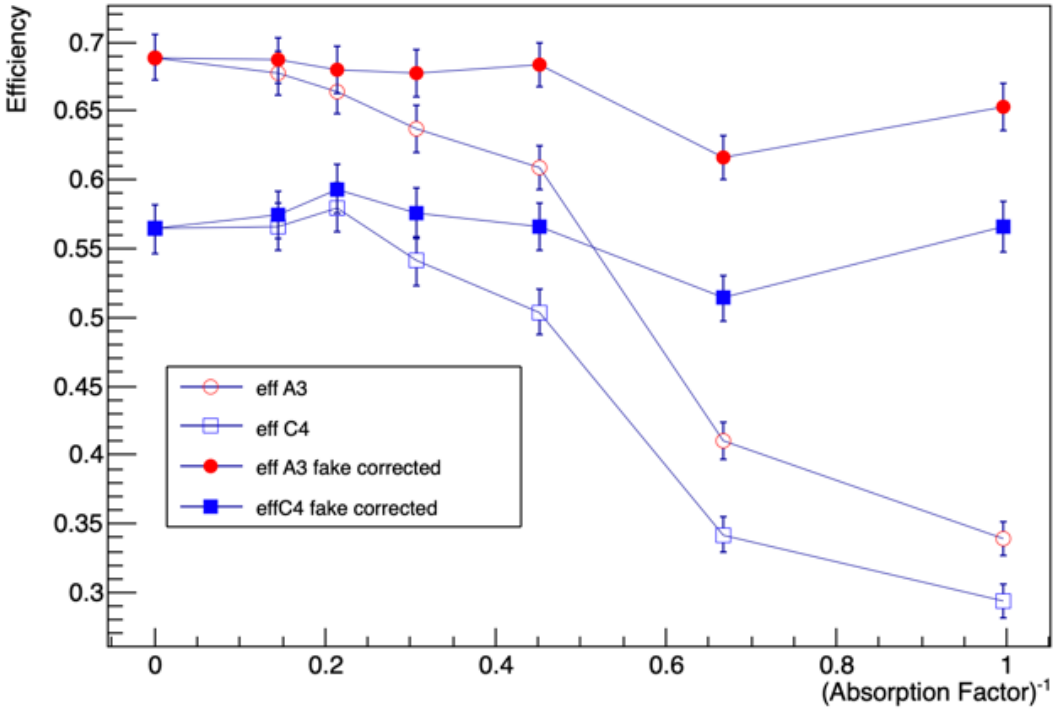




Detection Efficiency

Only internal partitions were evaluated.





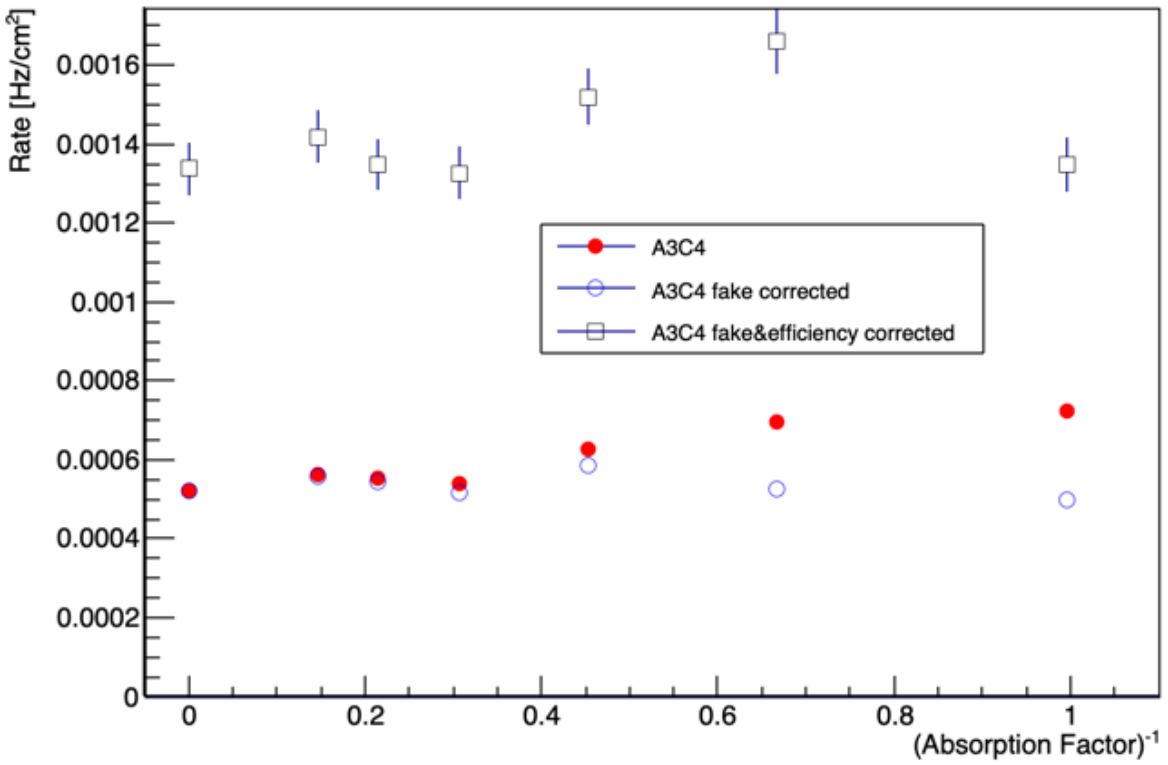
$$\mathcal{E}_{A3} = \frac{N_{A1 \wedge A3 \wedge C2}}{N_{A1 \wedge C2}} \qquad \mathcal{E}_{C4} = \frac{N_{A1 \wedge C4 \wedge C2}}{N_{A1 \wedge C2}}$$

Statistical coincidences (fakes)

$$N^{f}_{A1 \wedge C2} = 2 N_{A1} N_{C2} \tau$$

Muon Trigger Rates Estimation

- Better acceptance using the coincidence of partitions A3 and C4 as trigger.
- For the 4 x 20 cm^2 MWPC cell, the trigger rate is > 2 muons/min for the current topology and partition efficiency.
- If partitions efficiency gets to 100 %, the rate goes up to 6 muons/min.



Next Steps

- The mechanic frame was modified, allowing larger separation between the layers and better alignment. New measurements have to be done with the new configuration.

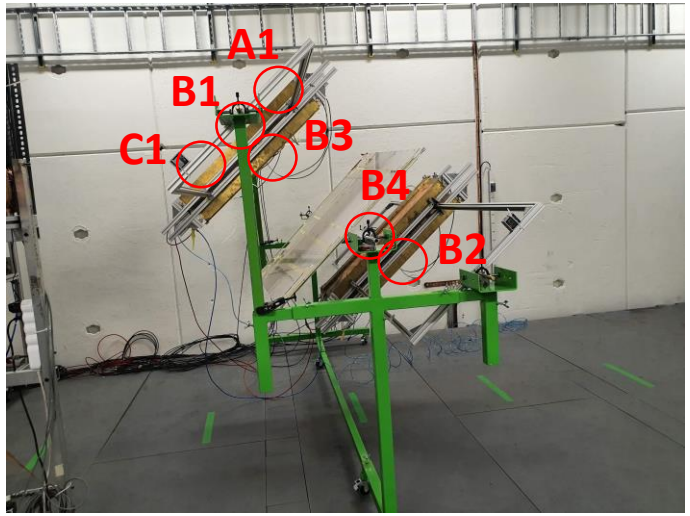
- The setup has to be moved and tested closer to the source, at higher gamma rates.

Backups

LHCb - MWPC Based Cosmic Trigger

8 m from the source

45°



Bunker (Source On – Att: 6.9)

Partition	Average (Hz)	Stat. Error (Hz)
B1	228.916	0.366
B2	110.690	0.100
B3	430.068	0.357
B4	328.314	0.229
B1&B3	6.128	1.301
B2&B4	7.442	1.619
B1&B2	0.090	0.004
B3&B4	0.152	0.007

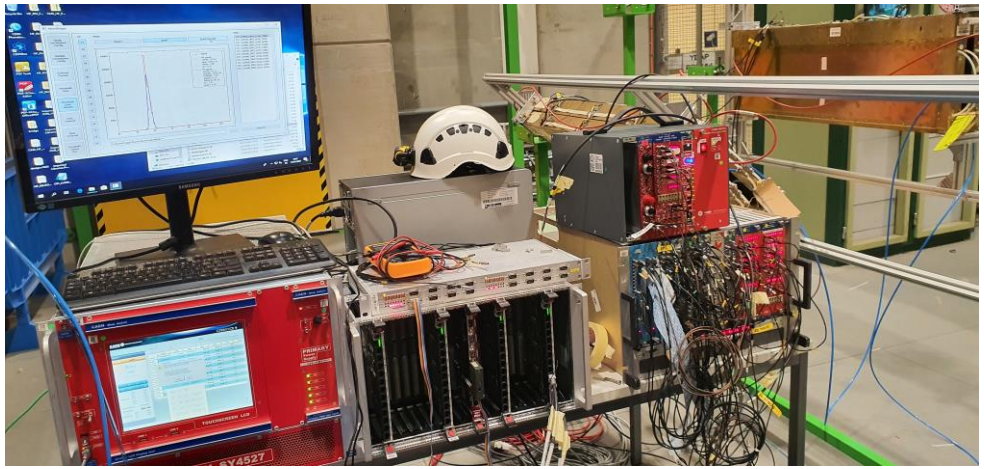
0°

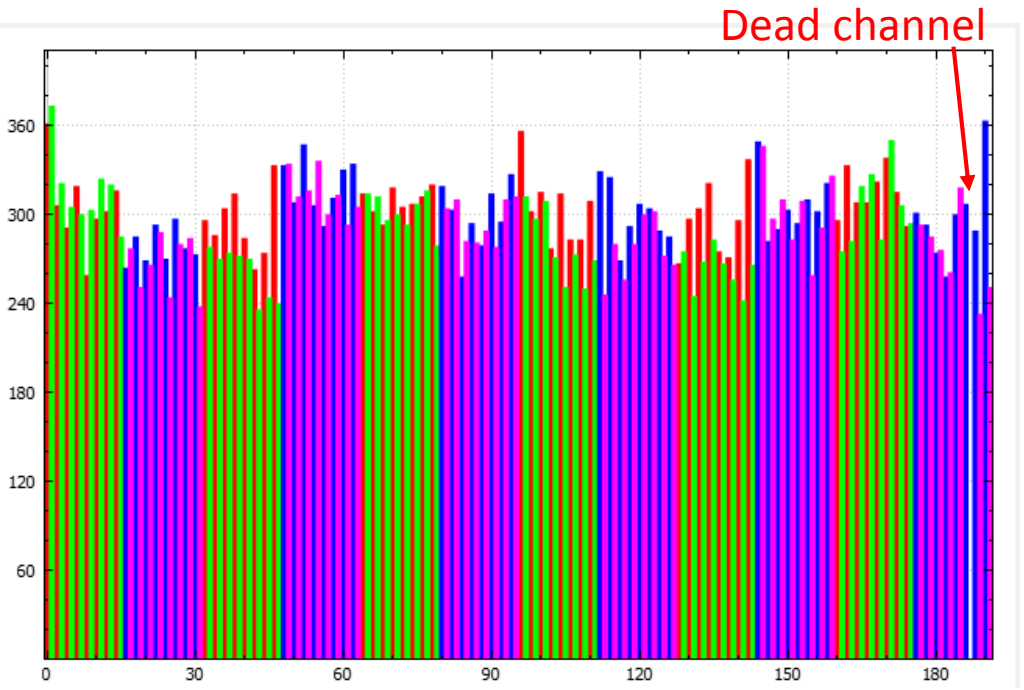
Bunker (Source On – Att: 4.6)

Partition	Average (Hz)	Stat. Error (Hz)
B1	147.186	0.199
B2	132.574	0.164
B3	438.984	0.804
B4	401.294	0.932
A3	386.398	0.475
C4	93.232	0.104
A3&C4	0.328	0.012
B1&B3	2.430	0.041
B2&B4	2.606	0.027

Status

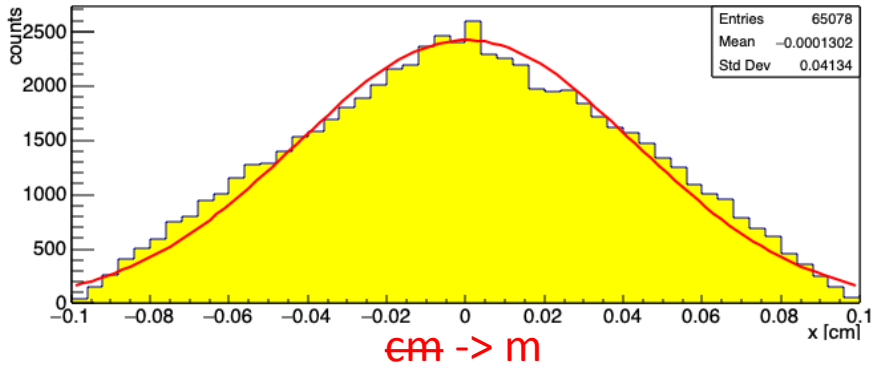
- Configuration software ok.
- Just one dead channel.
- Link cables (slow control) for configuration of the chambers ok.
- Signal cables with wrong connectors. (Should be ready today.)
- Trigger tests with 4 (shorter) cables, 4 partitions.
- Using the same NIM crate used in 904 LHCb setup.



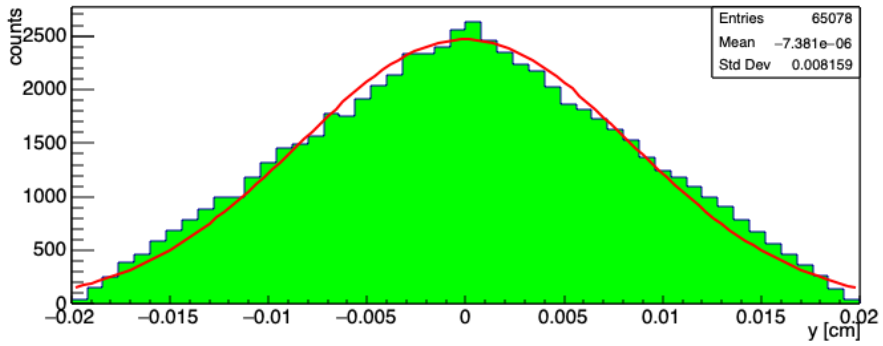


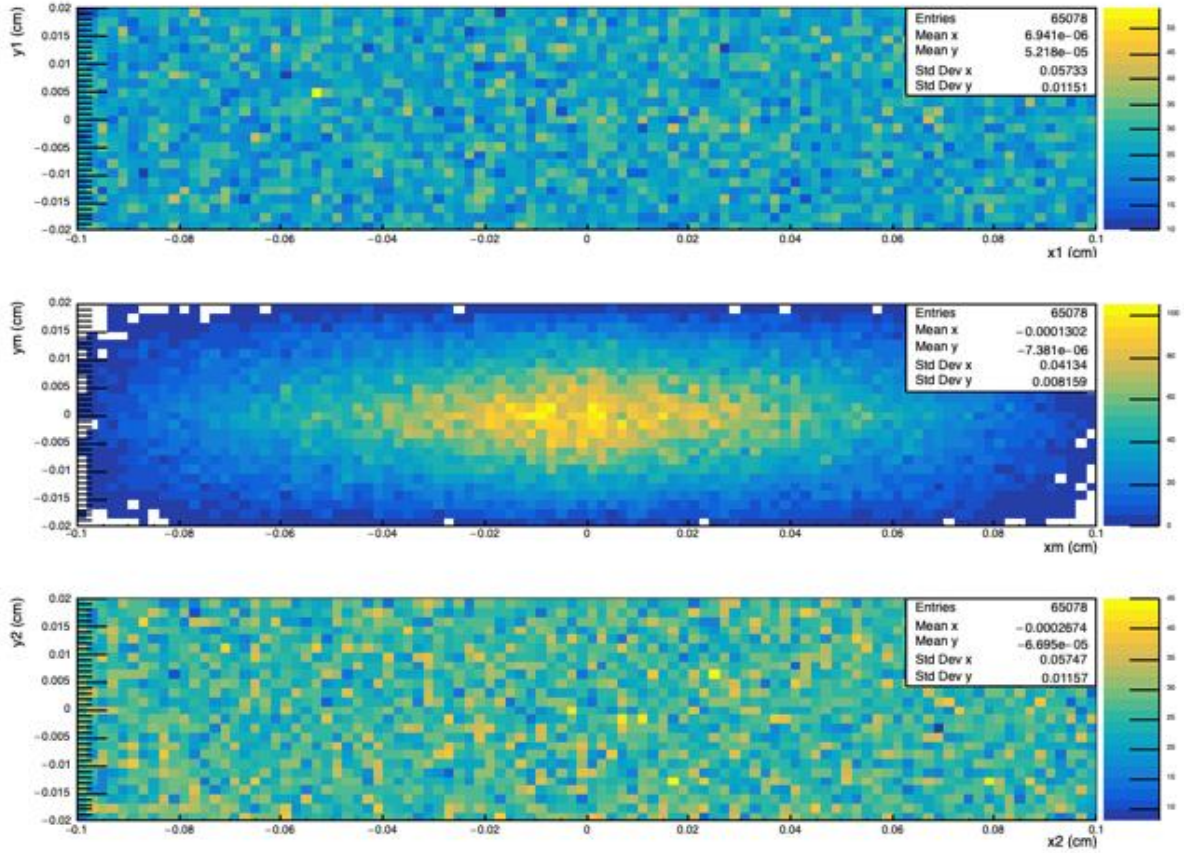
Spatial Resolution

- MC evaluation of the hit area of the triggered muons in the central horizontal plane.



~~cm~~ -> m





~~cm~~ -> m

About 65% of the muons hit an area of 1,6 x 8,2 cm^2, 1/6 of the MWPC cell.