CMS GEM test beam - ME0 stack

RD51 collaboration meeting - June 21st, 2023

Antonello Pellecchia[1], Piet Verwilligen[1], Pieter Everaerts[2] for the CMS GEM group

[1]*INFN Bari,* [2]*University of Wisconsin-Madison*

Overview

The CMS GEM team participated to the last test beam campaign as part of the final design validation of the GEM detectors for ME0

In the 12 months we had three GEM test beams:

→ **SPS North Area** (muons): **ME0** detector performance

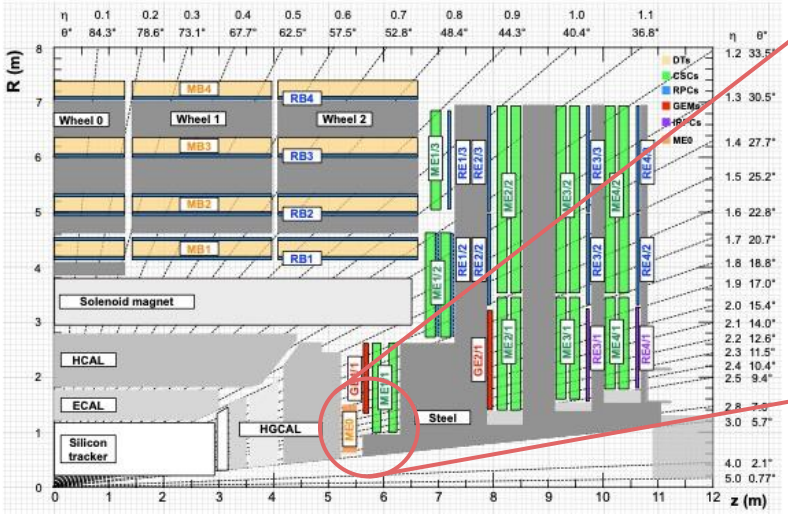
→ **GIF++** (muons + source): ME0 performance in **high background**

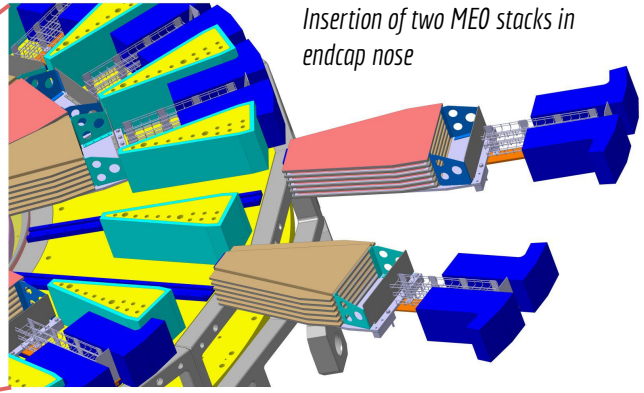
→ **SPS North Area** (muons, pions): performance of **ME0 stack** with four layers

→ **Next: GIF++** with ME0 stack in July 2023

Warning: I cannot show preliminary results not approved by CMS Muon group

ME0 project in CMS





Insertion of two ME0 stacks in endcap nose

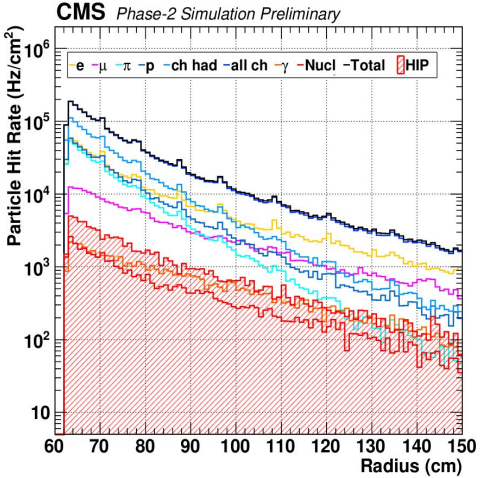
In CMS, ME0 will be the closest muon station to the beam line: 2 < |η| < 2.8

Complementing other GEM and CSC stations and extending muon system coverage

→ Each ME0 stack is made of **six triple-GEM** detectors

→ Background particle rate up to **200 kHz/cm²**

→ Highly uneven background flux distribution in R



ME0 stack test beam

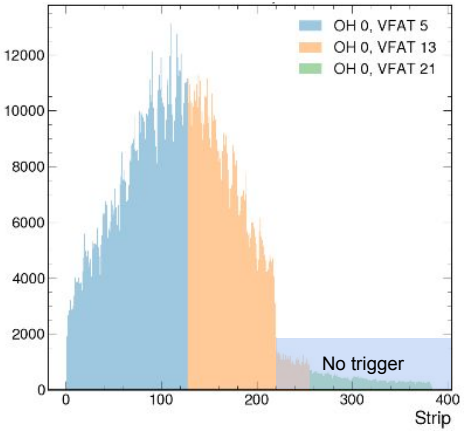
Goal: **testing stack integration** with 4 detector layers with particle beam

→ Setup tested in 904 laboratory (optimized grounding, tested cooling) and run with cosmics

→ SPS North Area, H4 line, April 24th - May 16th

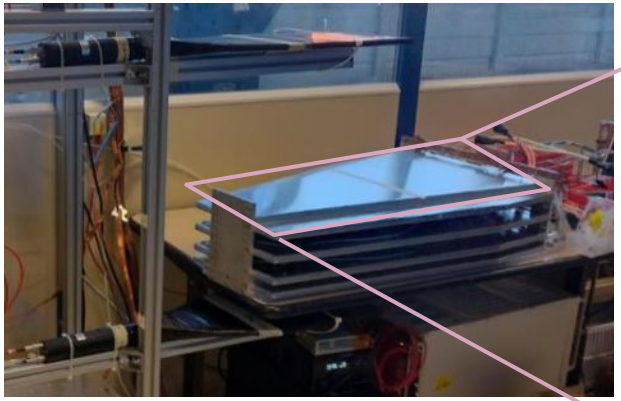
→ 4-layer ME0 stack (wide GEB only), all with radial segmentation
2 detectors with "blank" segmentation, 2 with "random hole" segmentation"

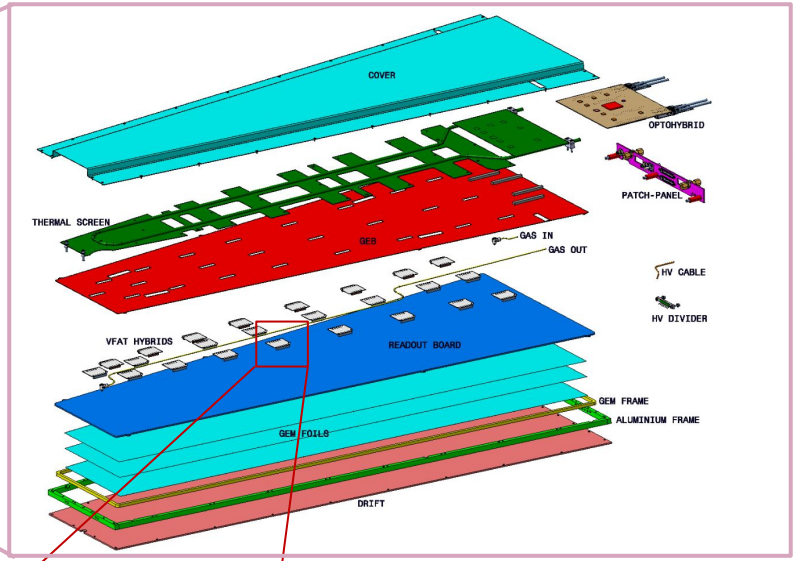
→ 30x30 cm^2 trigger scintillators (beam core + beam halo)



Stack setup and electronics

* This is actually the scheme of a GE1/1 detector, but the components are almost the same





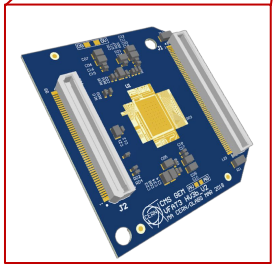
Electronics

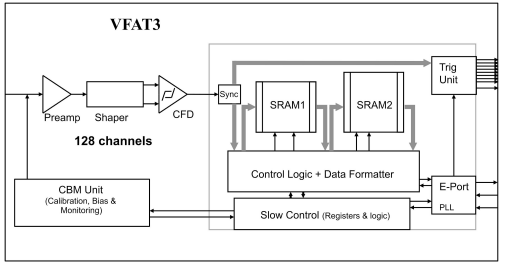
→ Readout chips: *VFAT3* 128-channel digital readout (preamplifier + shaper + comparator + CFD)

→ Front-end communication using GBT protocol

→ Back-end communication using VTRX+

→ Total of 6144 readout strips





Preliminary stack performance

Analysis with tracking:

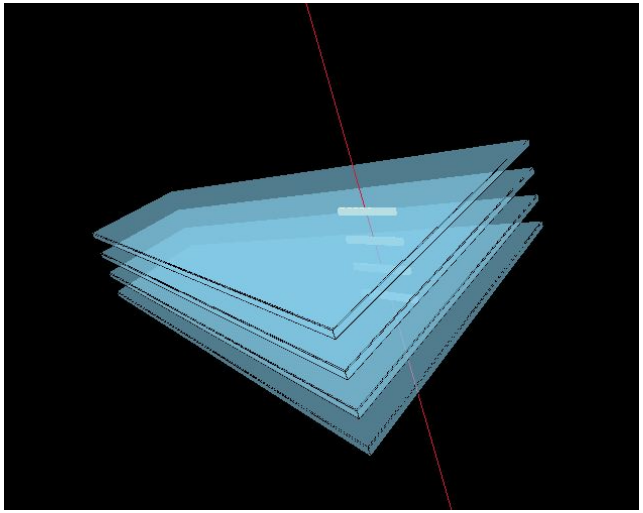
→ Segment **reconstruction with three layers** + extrapolation on 4th layer

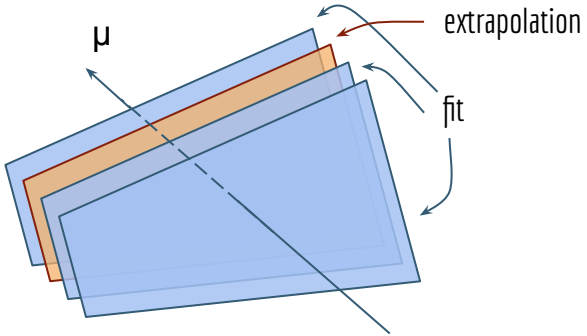
→ **Efficiency and space resolution** in line with expectations

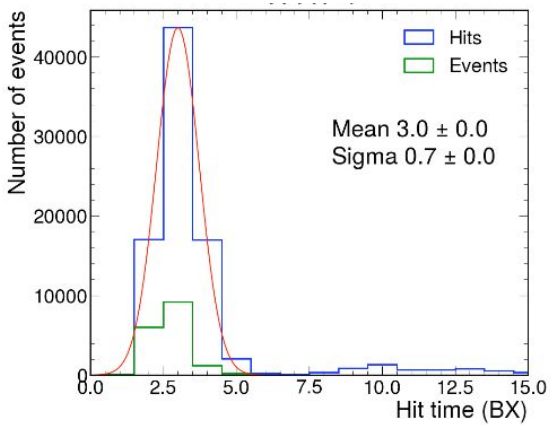
To be verified: stack alignment, segment extrapolation uncertainty

→ **Time resolution 0.6 - 0.7** BX on entire detector

Running with CFD disabled, because it is not well designed with GEM signals







Performance with muons

Main findings on **ME0 detector performance**:

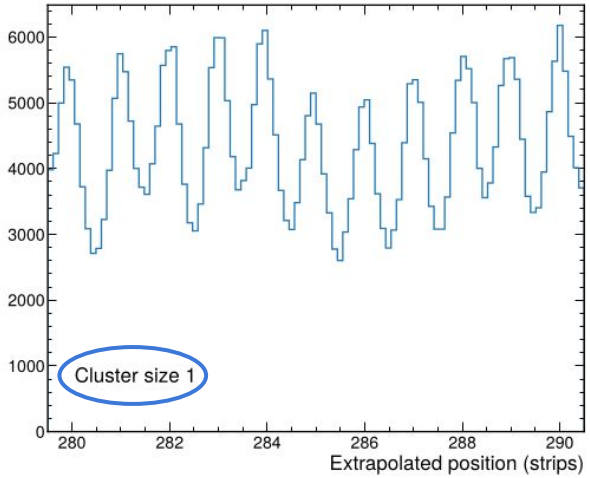
→ Cluster size is determined by position of **track with respect to the strip** pattern

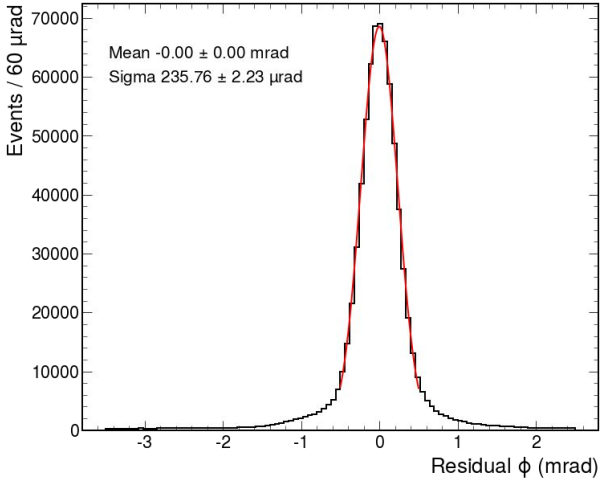
→ **Space resolution** in agreement with **design value**

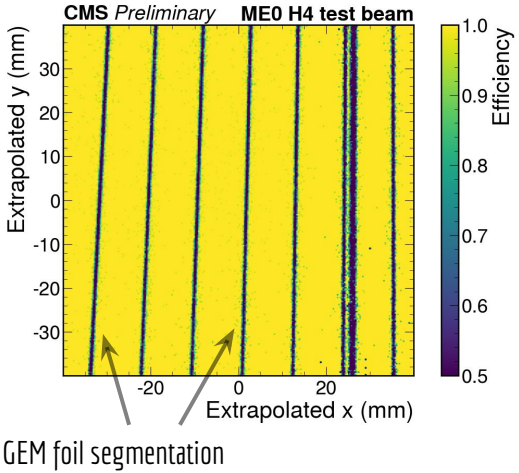
- Long tails due to higher cluster-size events

→ Very **high local efficiency** + dead areas due to **segmentation**

- Average detector efficiency 95-98%







Experience with pions

Several 100M events with pions:

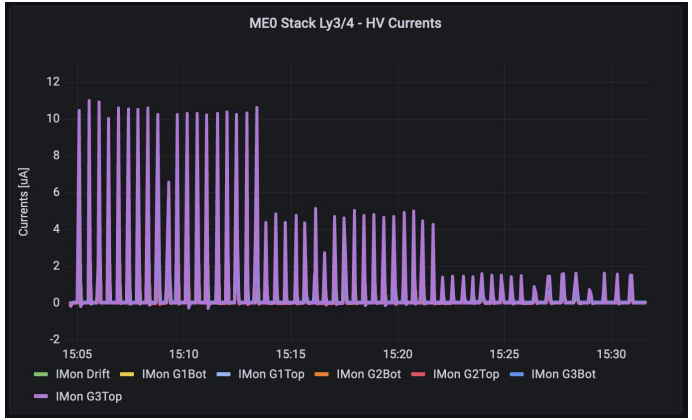
→ Rate scan: 28k - 8.7M events per spill

- At one instance we even **run at 20M events per spill** due to beam user error
- Reached rate up to O(100 kHz/strip)

→ **No instabilities** in detectors

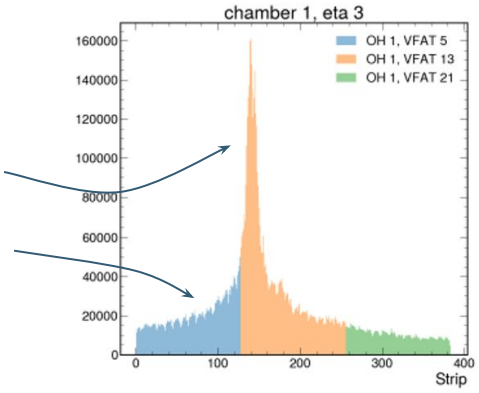
- A few trips only due to baseline current
- (We only needed to increase trigger dead time in DAQ)

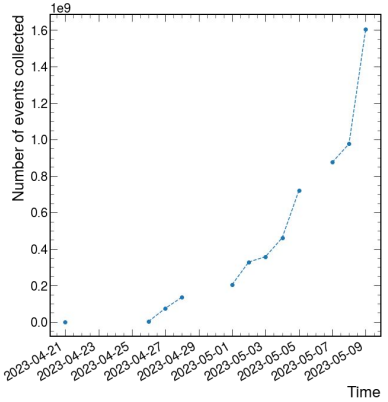
Rates: 8.5M 3.7M 1.2M



Up to ~ 400 kHz/strip

GEM foil segmentation





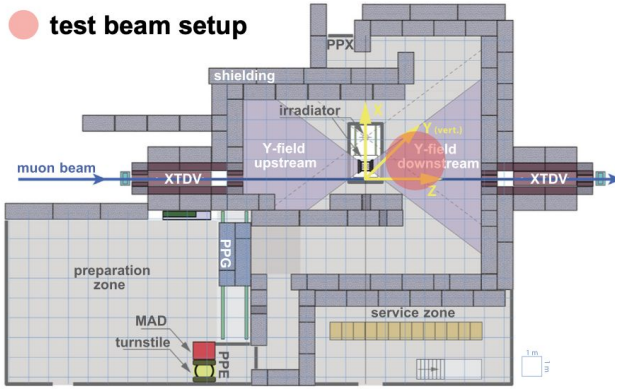
Towards GIF++ test beam with stack

We already had a test beam at GIF++, however we did not reach the **P5 background rates**

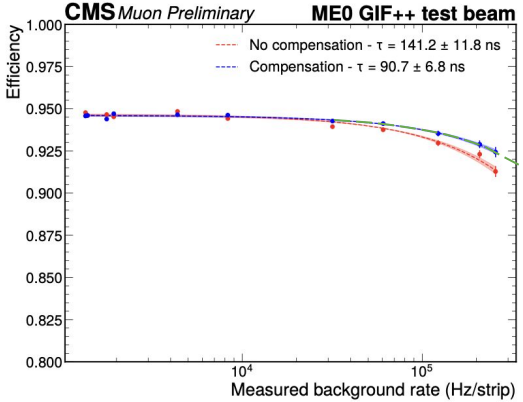
→ We can reach a higher rate by placing the ME0 stack closer to the source

Next beam time July 5-21

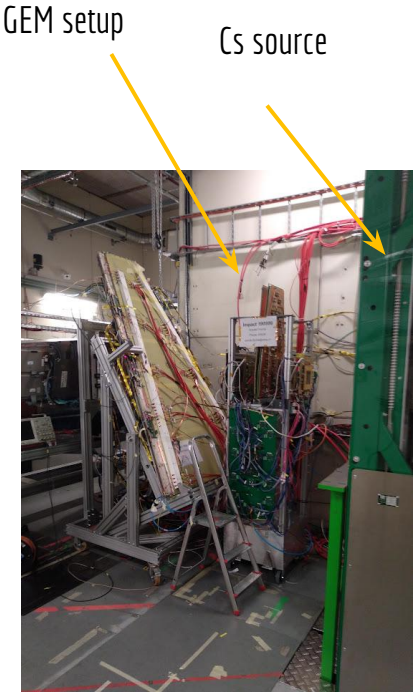
→ Goal: measure **stack segment efficiency** with 4 layers at rates up to 300 kHz/strip



Position of ME0 stack in GIF++ bunker



We want to extend this result up to 300 kHz/strip



Setup of GIF++ test beam with ME0 in July 2022

Conclusions

In the last 12 months we had three GEM test beams:

→ **SPS North Area** (muons): **GE2/1 and ME0** detector performance

→ **GIF++** (muons + source): ME0 performance in **high background**

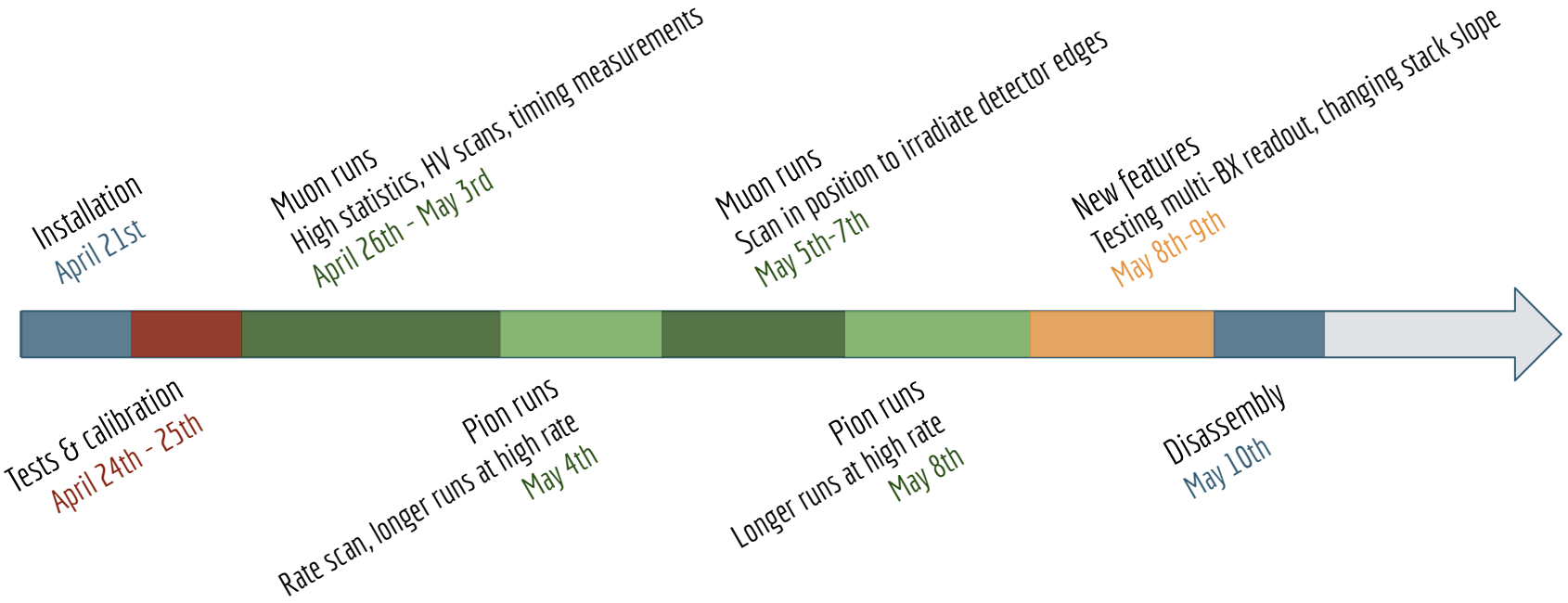
→ **SPS North Area** (muons, pions): performance of **ME0 stack** with four layers

- Tested ME0 stack segment reconstruction
- "Standard" performance + time resolution, timing uniformity, high-rate pion runs. Ongoing analysis

Next test beam planned at GIF++ with ME0 stack

Backup

Summary of data taking



Noise levels