

Recent results from the RD51/DRD1 VMM3a/SRS beam telescope

Lucian Scharenberg on behalf of the CERN EP-DT-DD GDD team

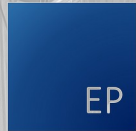
2nd DRD1 collaboration meeting
21 June 2024



UNIVERSITÄT



BONN



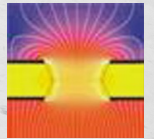
EP R&D



AIDA
innova



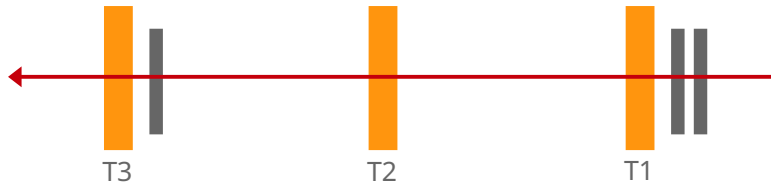
EUROPEAN
SPALLATION
SOURCE



Overview of the beam telescope

COMPASS-like triple-GEM detectors for tracking

- 10 x 10 cm², 256 + 256 X-Y-strips, 400 μm pitch
- **Around 50 μm spatial resolution**



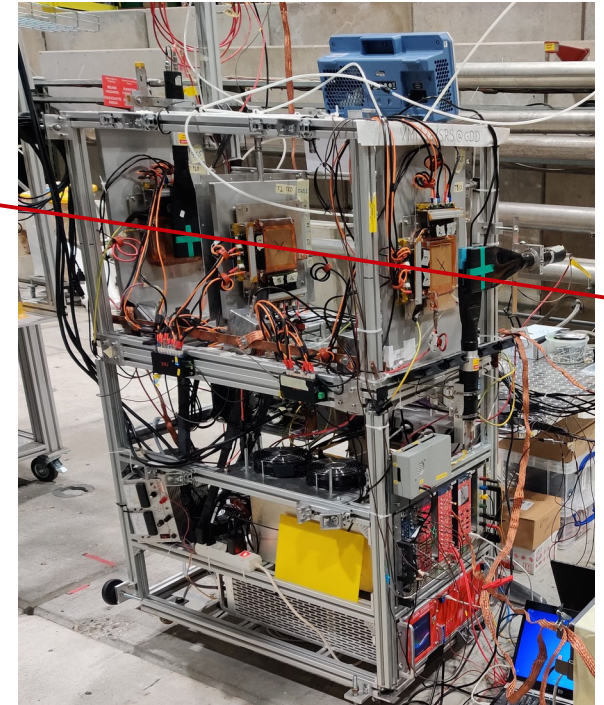
Scintillators with PMTs + NIM coincidence unit for timing

- **Around 1 ns time resolution**

Integrated HV and low voltage power supplies

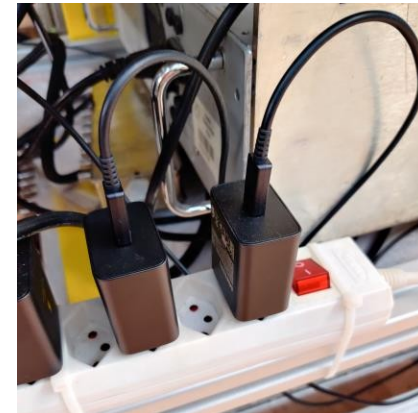
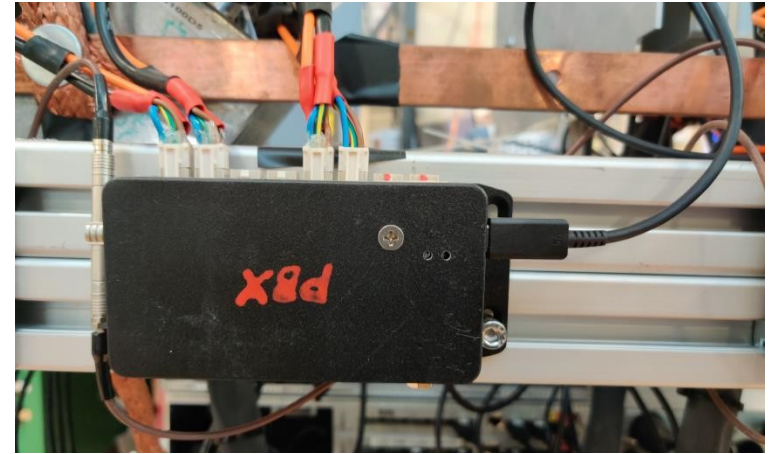
All detectors, including NIM coincidence unit, read out with **VMM3a/SRS**

- Space for 2 to 3 DUTs (depending on availability of RD51 VMM hybrids)



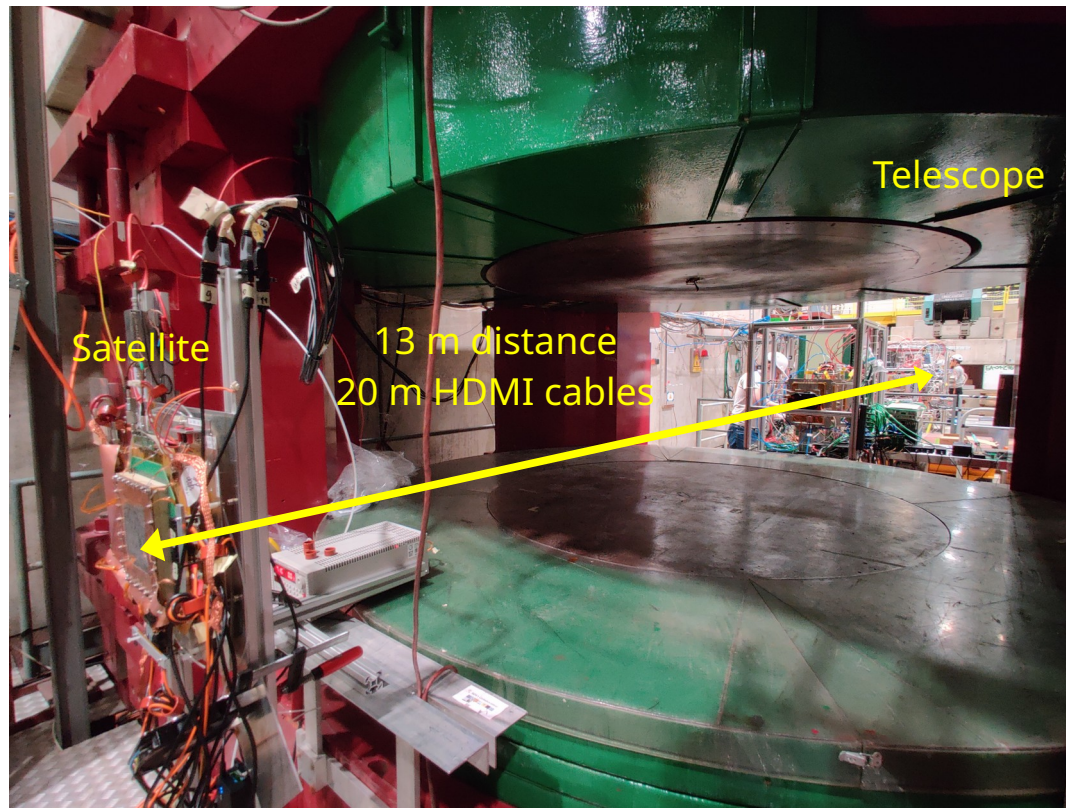
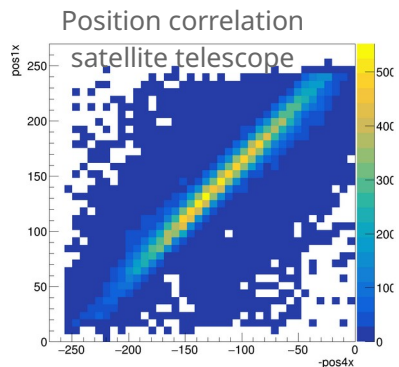
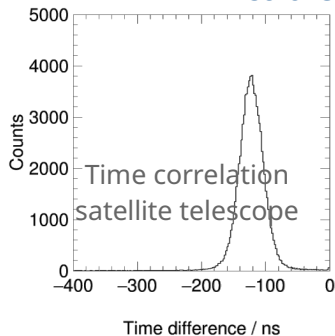
Upgrade: Power Box (PBX)

- **Default** low-voltage powering scheme for front-end electronics: **power-over-HDMI**
 - Limited to 2 m long HDMI cables
- **External PowerBoX (PBX)** as new alternative powering scheme for (geometrically) large systems
 - Introduced in 2023
- Up to 8 hybrids (1k front-end channels) per PBX
 - **Power from standard (30 W) USB-C phone charger**



Upgrade: distributed readout system

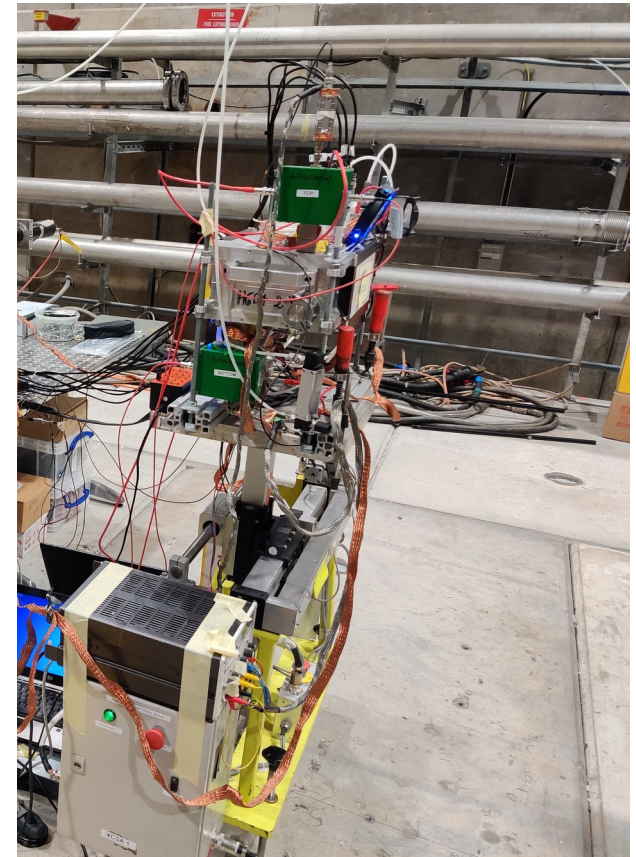
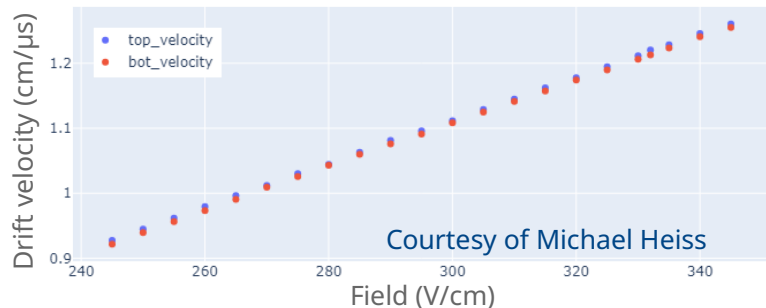
- Use PBX (separate low-voltage power supply) for distributed readout system
 - **Long lever arm telescope (10's of meters length)**
- Initially tested in August 2023, final characterisation in April 2024
 - Satellite tracking detector, separated by 13 m from the telescope (20 m HDMI cables)



Low material budget TPC

PRELIMINARY

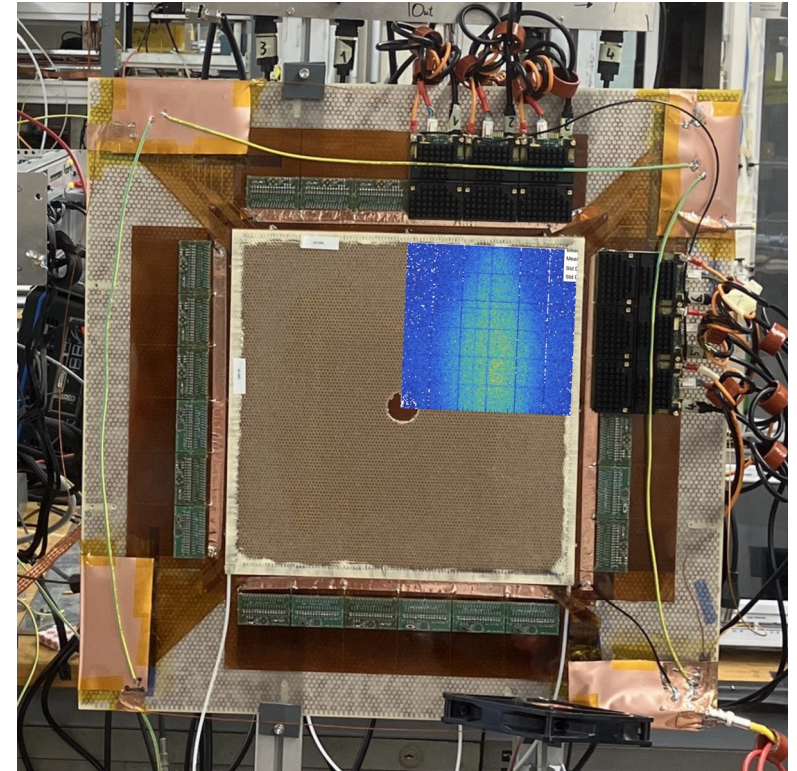
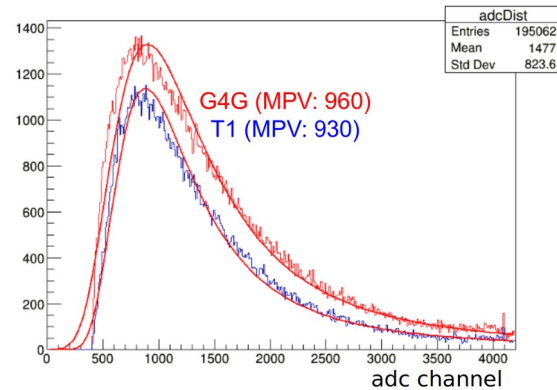
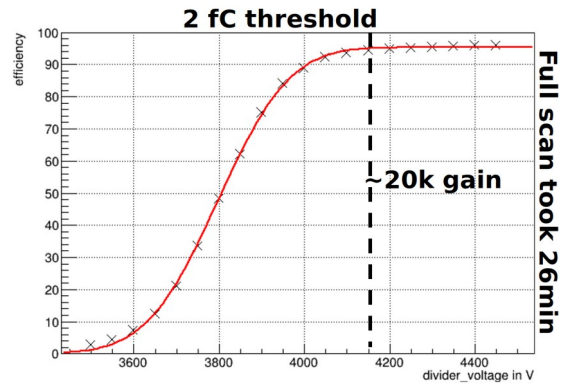
- Beam tracking for **MIXE @ PSI**
 - **Low energetic muons (20 to 60 MeV/c)**
- Also read out with VMM3a/SRS
 - Validation of optimisation for low material budget operated
 - **He/CO₂ (90/10 %)** instead of Ar/CO₂ (70/30 %)
- Spatial resolutions of $\sigma_x \sim 140 \mu\text{m}$ and $\sigma_z \sim 160 \mu\text{m}$



AMBER G4G prototype

PRELIMINARY

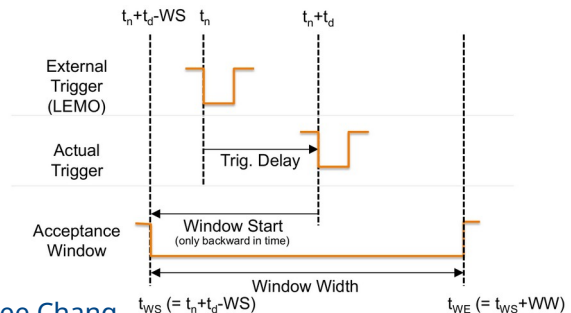
- **30 x 30 cm² triple-GEM** prototype tracking detector for the 4th generation GEM detectors (G4G) of AMBER
- Includes tests of the VMM3a as potential front-end for the experiment



Plans for June/July 2024 beam period

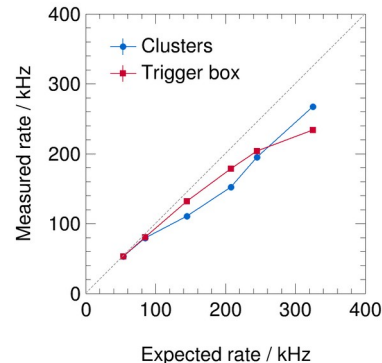
Triggered readout

- VMM3a/SRS operates by **default in self-triggered** mode
- To ease synchronisation with other experiments, colleagues from FRIB @ MSU (J.-H. Chang) implemented triggered mode
 - **Trigger and data selection on FEC level**
 - ATLAS L0 implementation (data selection on VMM) still under development
- Tested end of last year with X-rays, **now move to larger system in beam**



Courtesy of Jin-Hee Chang

Busy depends on the parameters: $t_{busy} = t_d - WS + WW$ ($WS < t_d$) or WW ($WS \geq t_d$)



Corrvreckan

- Study of Corrvreckan tracking software



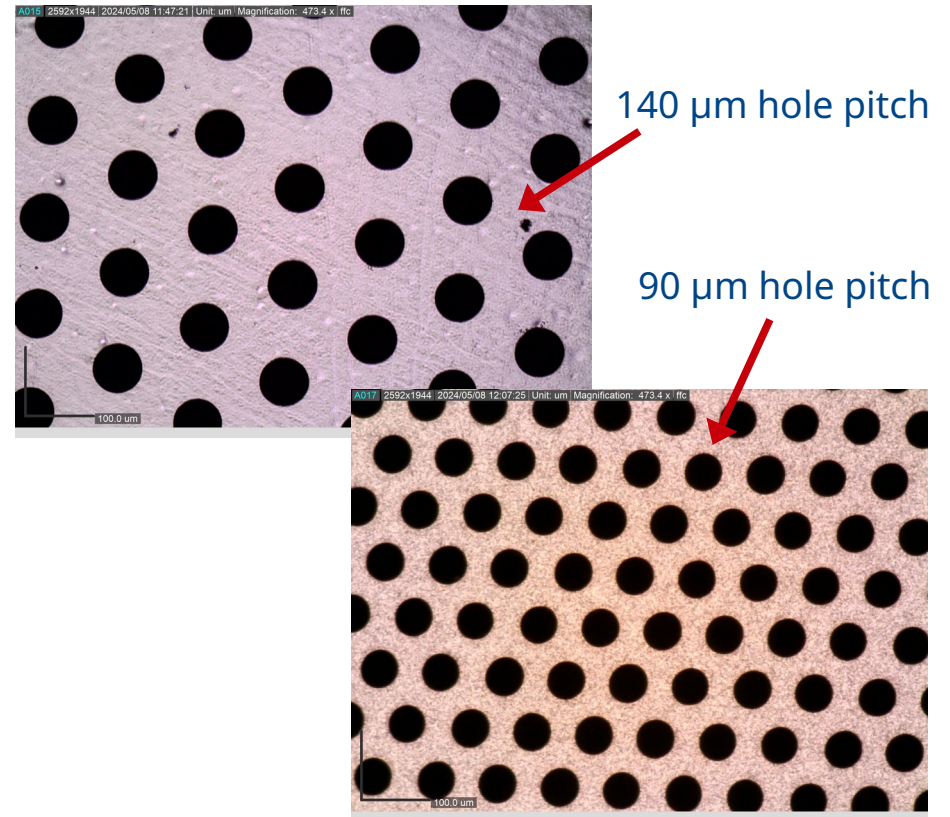
<https://gitlab.cern.ch/corrvreckan/corrvreckan>

- Benchmark with existing anamicom reconstruction
- Summer student from HIP working on this project (A. Lumpio) together with colleagues from TOTEM (F. Garcia and D. Figueiredo)

Finer pitch GEMs: motivation

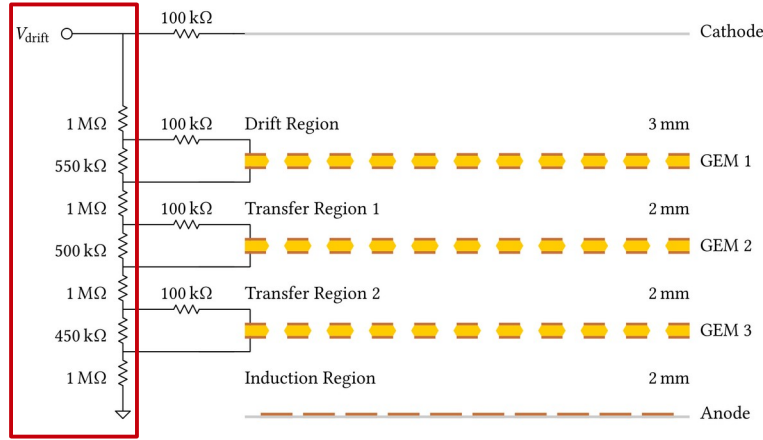
First trials in 2021, final measurements performed in July and August 2023, results presented here:

- 15 primary electrons (MPV) in 3 mm drift gap
- **Sampling of electron cloud** by 140 μm hole pitch structure \rightarrow **loss of position information**
- **Improve sampling** and thus position resolution by finer hole pitch \rightarrow 90 μm pitch structure



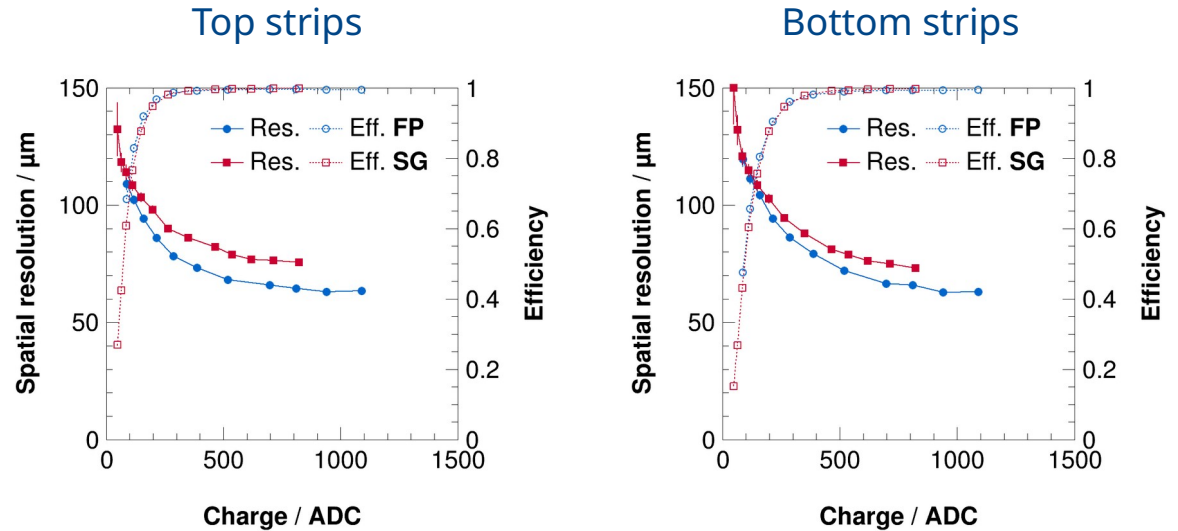
Finer pitch GEMs: results

COMPASS-like triple-GEM detector:



Two configurations:

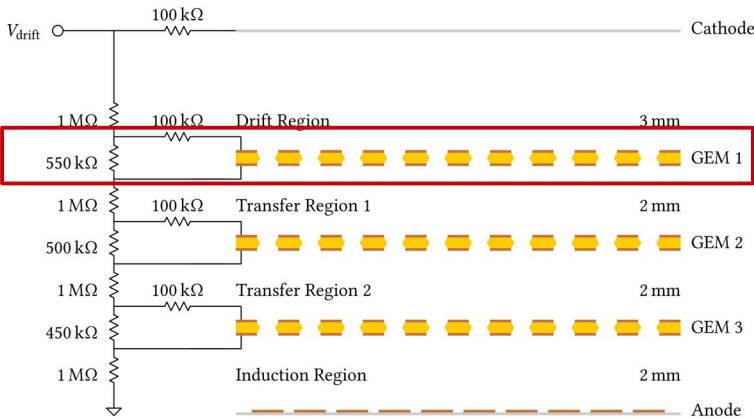
- a) 3 standard GEMs (SG)
- b) 3 finer pitch GEMs (FP)



Charge = most probable energy loss (Landau peak)
1000 ADC ~ 40k effective gain

Finer pitch GEMs: results

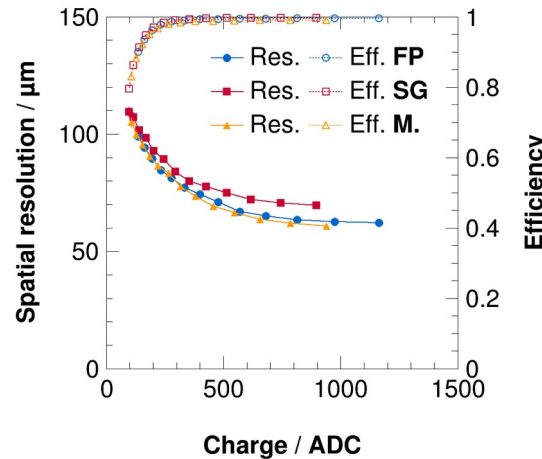
COMPASS-like triple-GEM detector:



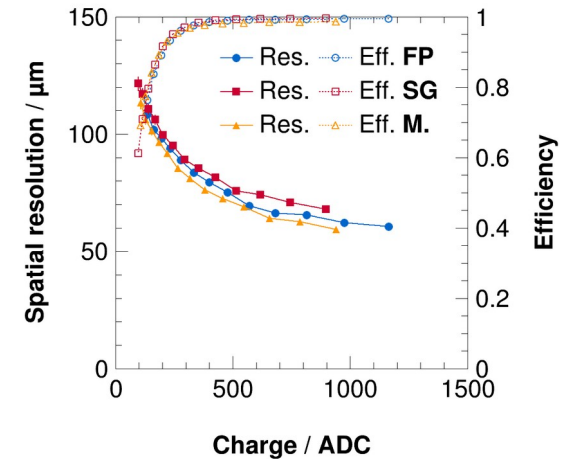
Change voltage only across GEM-1

- a) 3 standard GEMs (SG)
- b) 3 finer pitch GEMs (FP)
- c) 1st GEM = FP, 2nd/3rd GEM = SG (M.)

Top strips



Bottom strips



Charge = most probable energy loss (Landau peak)
1000 ADC ~ 40k effective gain

Summary

- Continuous improvements of the DRD1 VMM3a/SRS beam telescope
 - **New powering scheme** enables distributed readout system (high angular resolution tracking)
 - Integration into **new tracking software (Corryvreckan)**
 - Implementation of **triggered mode on SRS FEC** (to be tested in upcoming beam)
- Move from system tests and improvements to **more detector tests**
 - Low material budget TPC
 - AMBER tracking detector prototype
 - Small pitch GEMs
- Use of GEMs with finer pitch shows 15 % improvement in spatial resolution