DRD1 H4(PPE134) 2024 Test Beam

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Generic and Application driven R&D

Technologies: Micromegas, uRWELL, uRGroove, GEM
Application: High Rate, Timing, Large Area
Readout: Capacitive Coupling, Resistive Sharing

Project driven R&D

CMS ME0

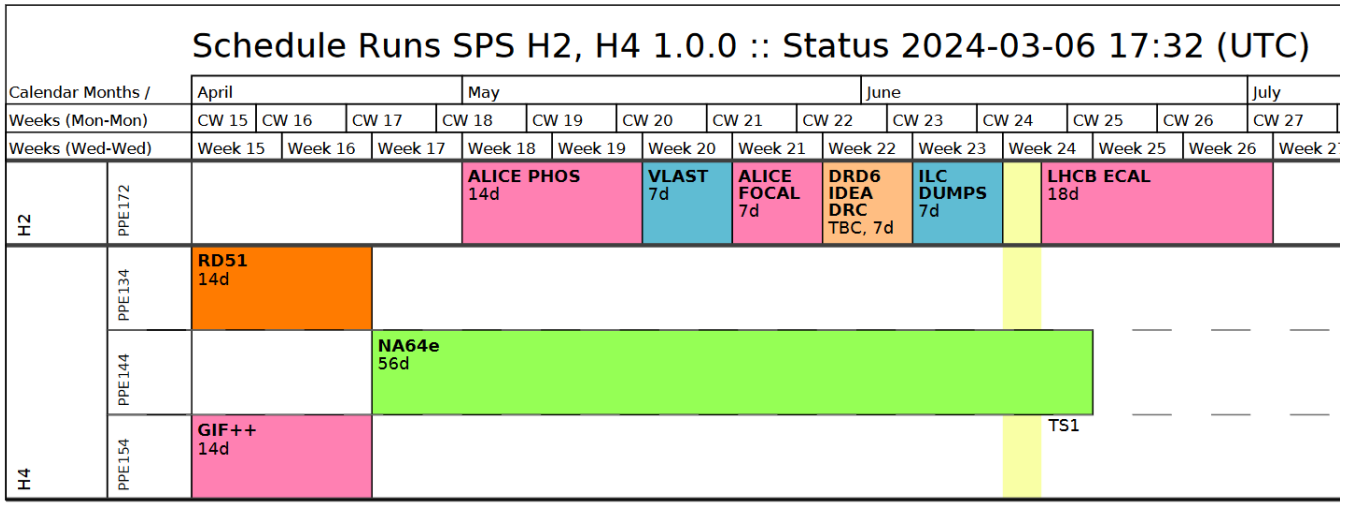
Detector Commissioning

Twin TPC for MIXE, G4G (AMBER)

FE electronics and DAQ

Straw, VMM3a and TPC

Wed. 10/04/2024 – Wed. 24/04/2024



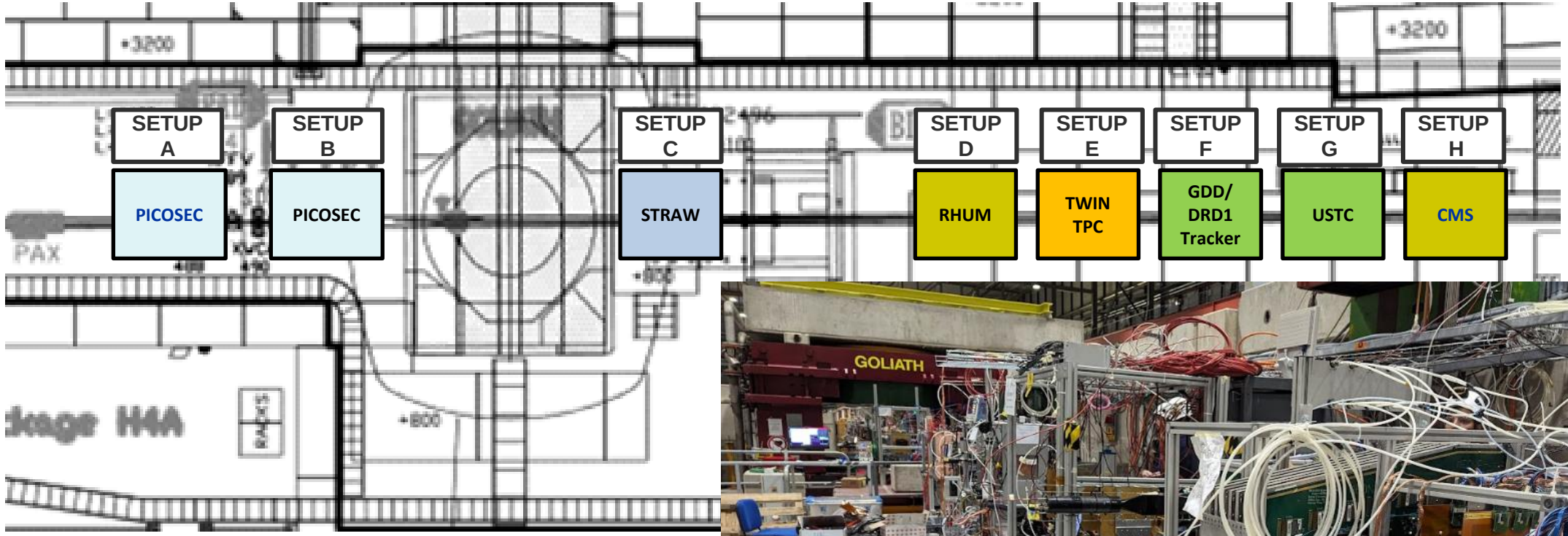
Beam Conditions

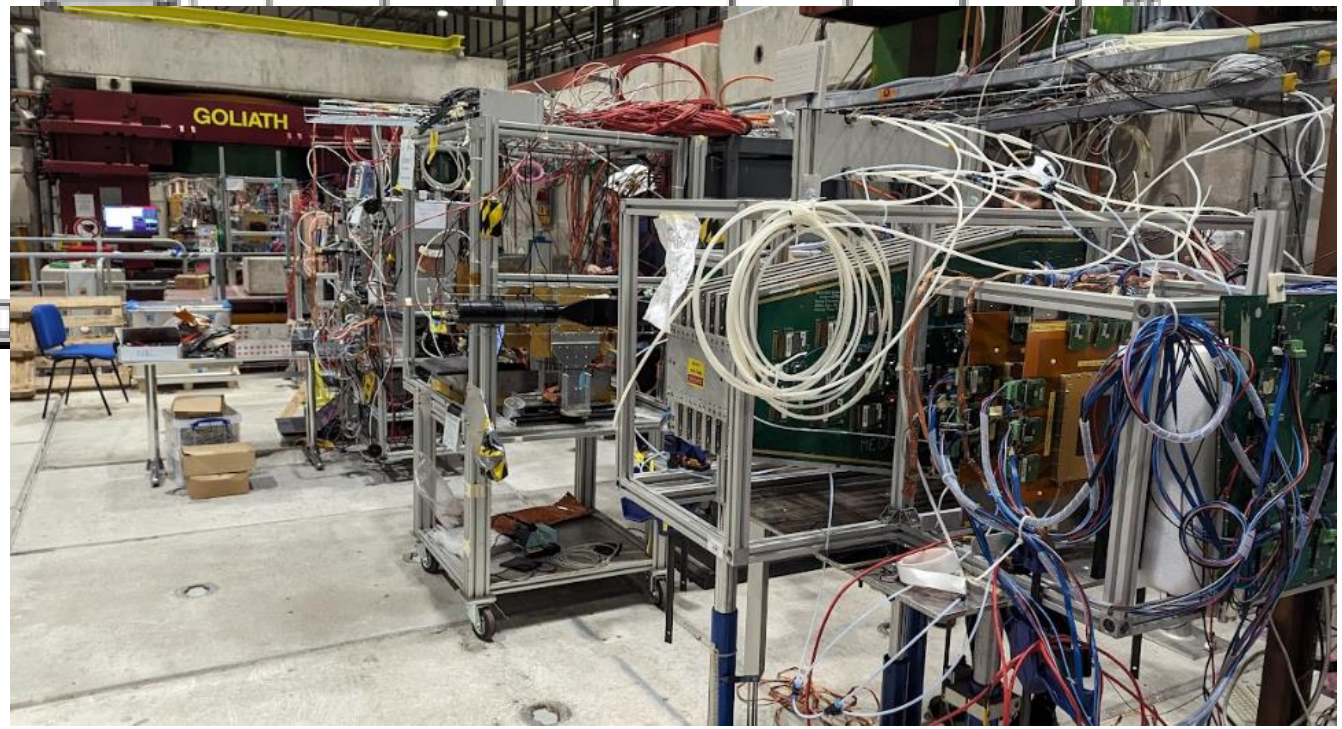
- **Muon Beam Purity: perfectly satisfying our needs (no showers produced by our detectors)**

- **Pion: >10e+7/spill (good for the test on the GEM TWIN TPC)**

- **Muon/Pion Rate: Very Satisfied. Huge thanks to Nikos and Frederic (Aberle, RP) for helping optimize beam intensity and RP alarms. DAQ rate doubled in some setup. Very important and really appreciated.**

Setups (8)

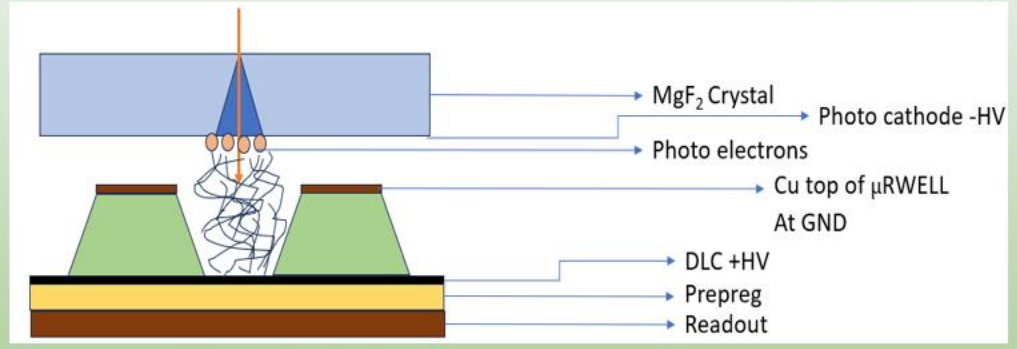




- SETUP A, B: PICOSEC (F. Brunbauer, M. Lisowska)
- SETUP C: STRAW (T. Enik, K. Kuznetsova)
- SETUP D: RHUM (M. Iodice, G. Sekhniaidze)
- SETUP E: TWIN TPC (F. Garcia Fuentes)
- SETUP F: GDD/RD51 Tracker (K. Floethner)
- SETUP G: USTC (Y. Zhou)
- SETUP H: CMS ME0 (A. Pellecchia, P. Everaerts)

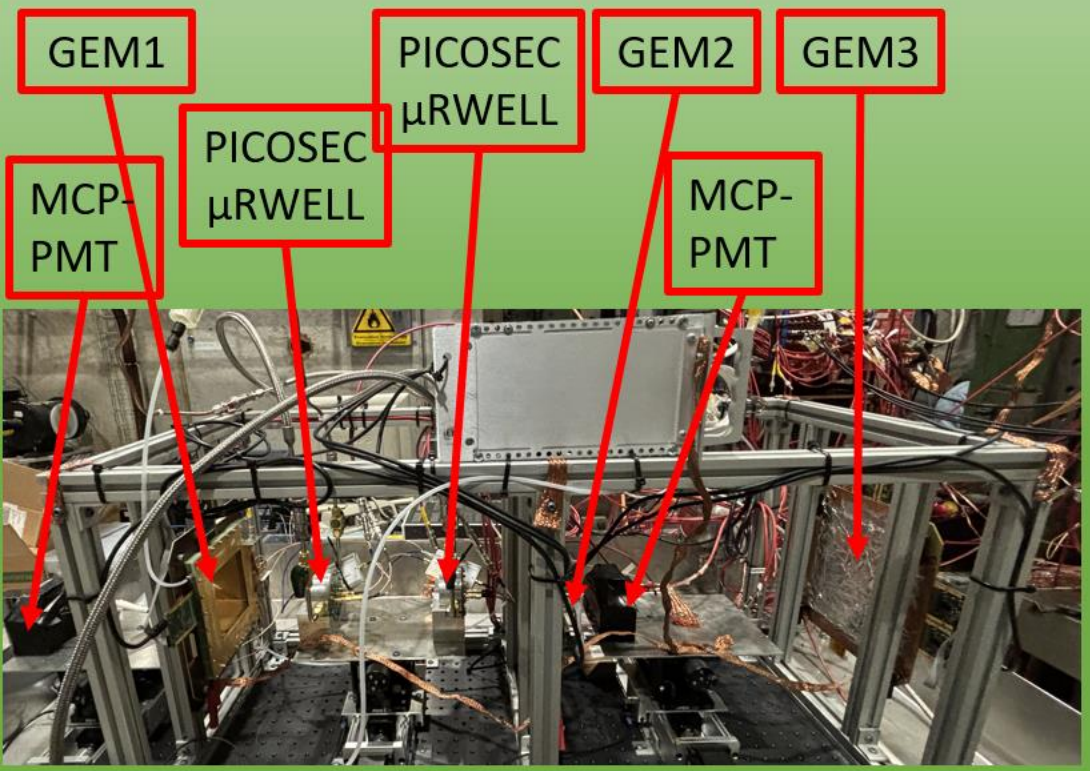
Preliminary test beam results of µRWELL-PICOSEC (JLab LDRD)

K. Gnanvo PI (JLab), A. Pandey (JLab), J.Datta (SBU)

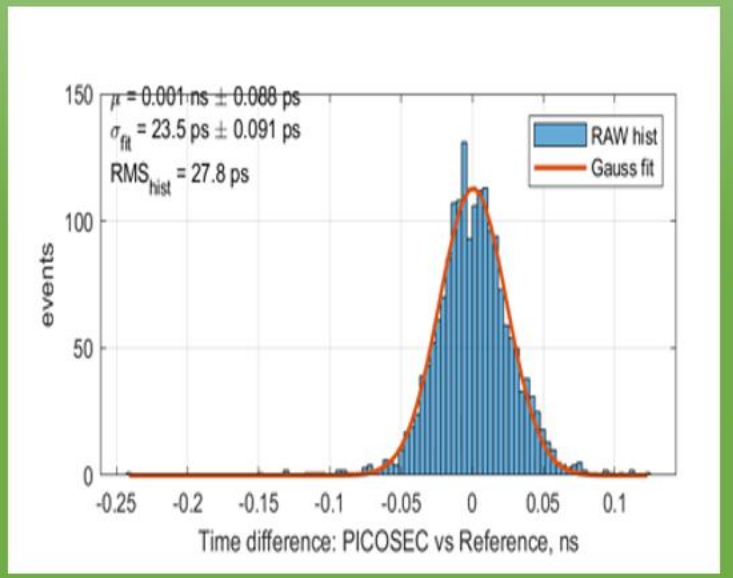


Working principle of µRWELL PICOSEC

- Optimization of µRWELL technology and achieving tens of picosecond time resolution
- Testing different combination of pitch, outer diameter and inner diameter of the wells.
- Different shape of the wells (square and round)
- Different readout pad (plain and strip)
- Different drift gaps to be measured
- Assembled and tested µRWELL with plain and grided readout pad, round shaped hole
  - 120 um pitch, 100 um OD and 80 um ID
  - 100 um pitch, 80 um OD and 60 um ID
- Fused silica window, MgF_2 as crystal and CsI photo cathode
- Gas mixture of Neon: C_2H_6 : CF_4 = 80: 10:10 and drift gap of 170 um
- CIVIDEC and customized pre-amp board has been used



Test beam set up



- A time resolution of 23.5 ps has been achieved with µRWELL PICOSEC prototype
- The result has been obtained for the prototype with 120 um pitch, 100 um OD and 80 um ID and plain pad
- Analysis of other prototypes are ongoing

PICOSEC Micromegas

- **PICOSEC Micromegas** – a gaseous detector that aims at reaching a time resolution of **tens of picoseconds**
- **Objective:** Robust multi-channel detector modules for large-area detection systems requiring good time resolution
- **Experimental setup:** tracking/timing/triggering telescope: GEMs + MCP PMT + PICOSEC MM detectors
- **Test beam campaign April 2024 measurements**:

→ Single-pad resistive MM (CERN,RB): 20 MΩ/□, 10 + 15 mm dia. → **10 mm MM + CsI time resolution σ ~ 12 ps**

→ Single-pad photocathodes studies (CERN,CEA,Bari): CsI with Cr/Ti, DLC, nanodiamonds → DLC σ < 30 ps

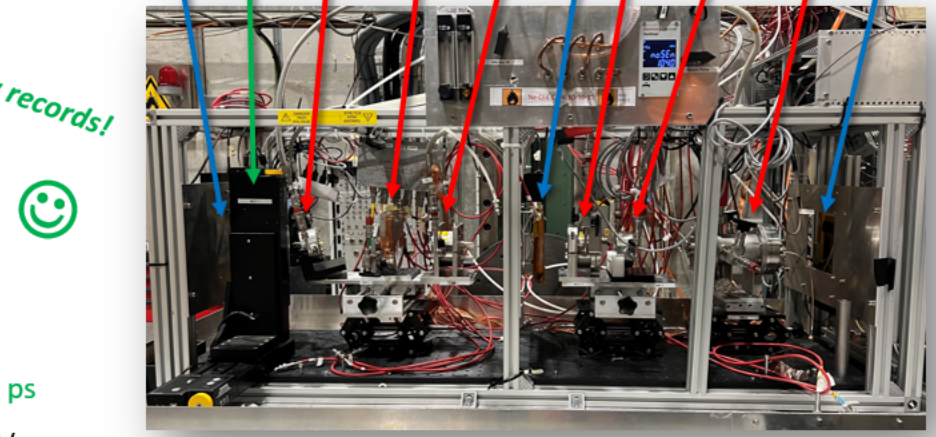
→ Single-pad uRWELL (JLAB): 7 different prototype geometries tested with CsI photocathodes → σ ~ 23 ps

→ Large area detector (USTC): 20x20 cm^2 MM with different photocathodes: DLC, B_4C, CsI → with CsI σ ~ 25 ps

→ Gas studies: Ne/Iso mixture at different ratios as an alternative to the std gas Ne:CF_4:C_2H_6 (80:10:10) → σ ~ 17 ps

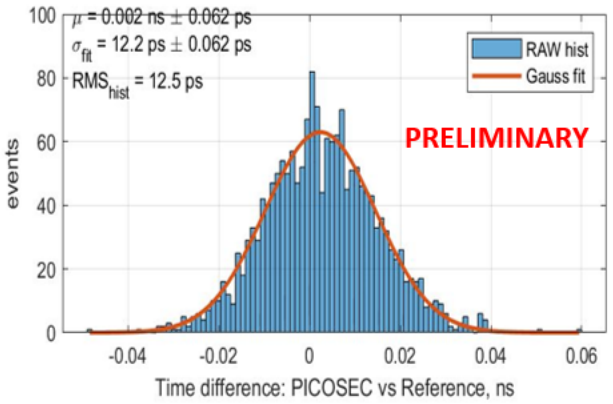
→ New readout electronics(CERN,RB,SBU): integrated preamp on the outer PCB → σ ~ 13 ps , DRS4 v5 12bit, 5GS/s

New records!

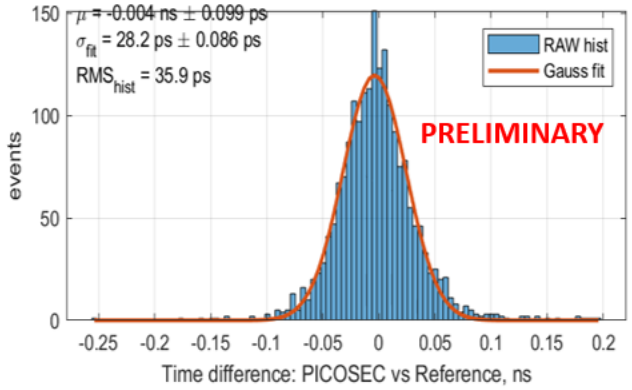


Clean (wireless) setup (before connecting cables ☺)

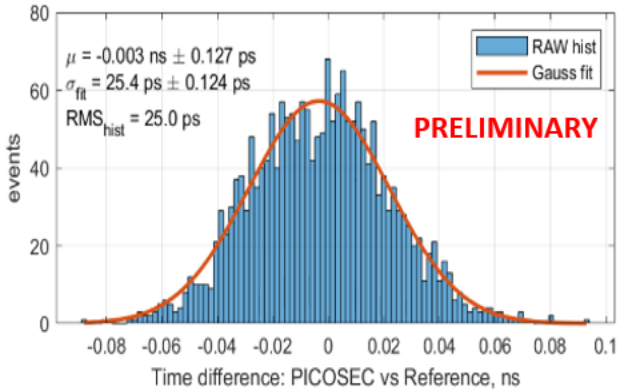
Single-pad resistive MM 20 MΩ + CsI **σ ~ 12 ps**



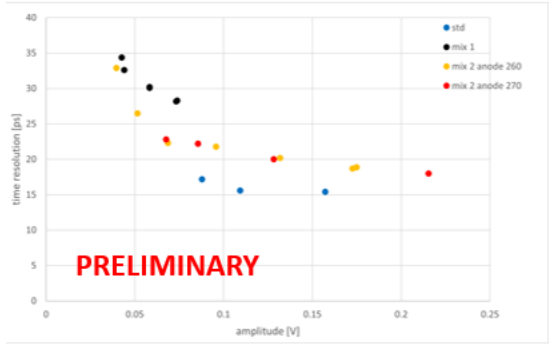
Single-pad + DLC photocathode **σ < 30 ps**



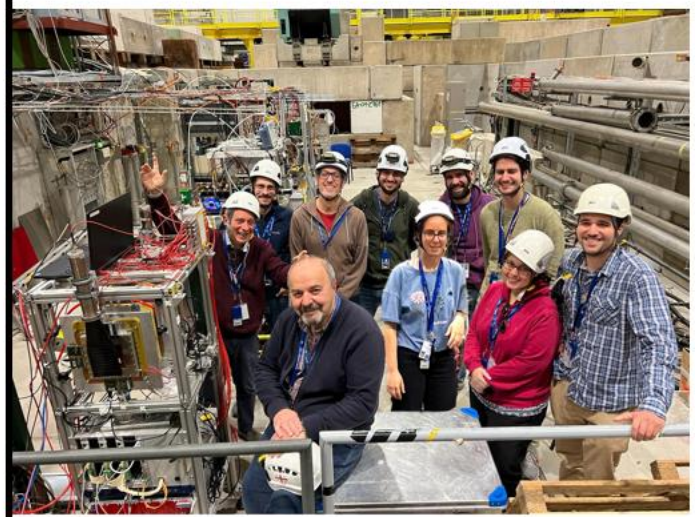
20x20 cm^2 MM with + CsI **σ ~ 25 ps**

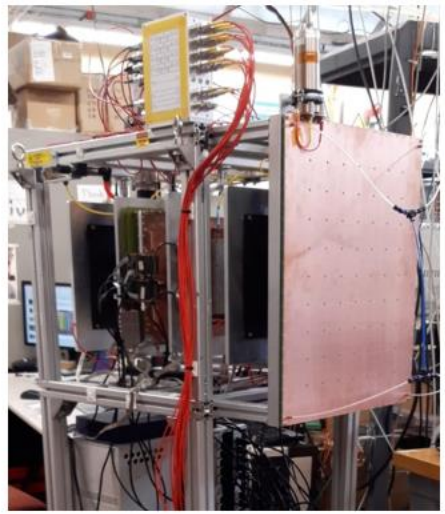


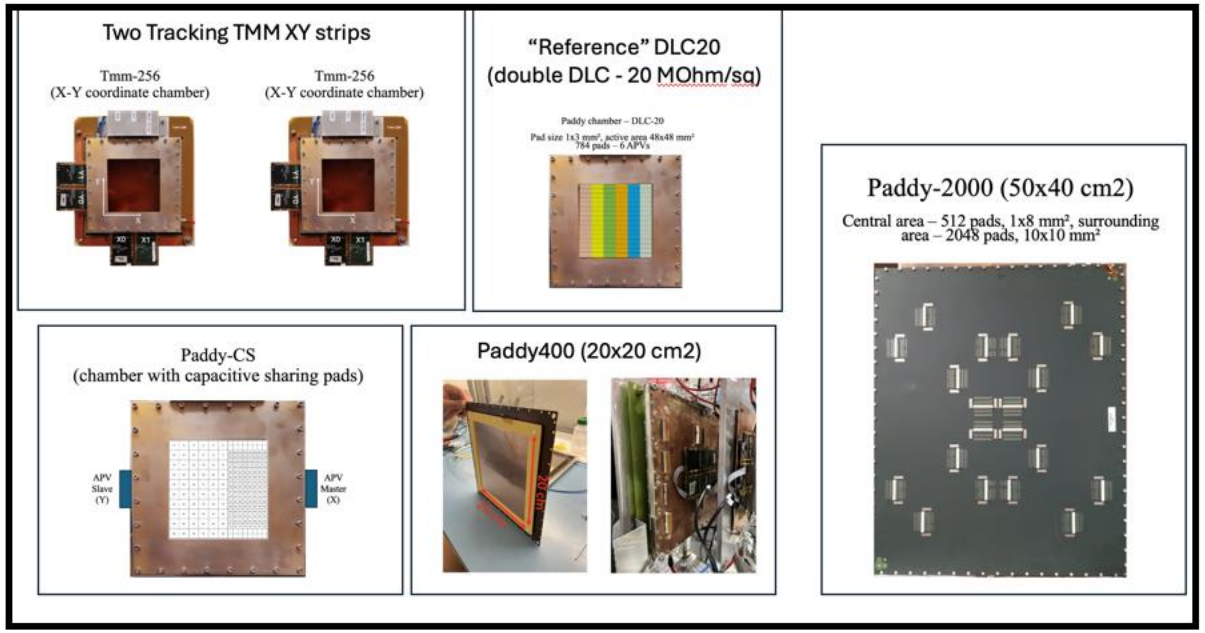
Gas studies **σ ~ 17 ps**



RHUM test-beam – April/2024



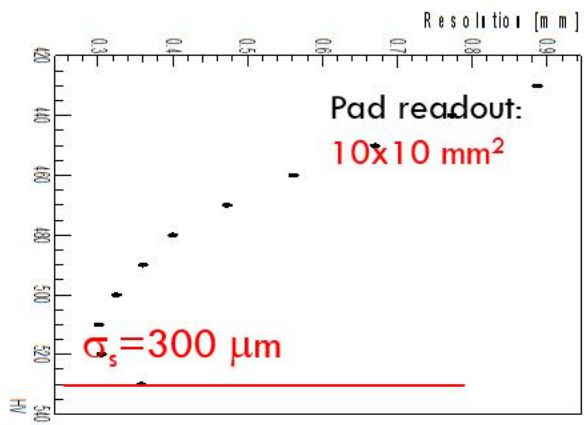




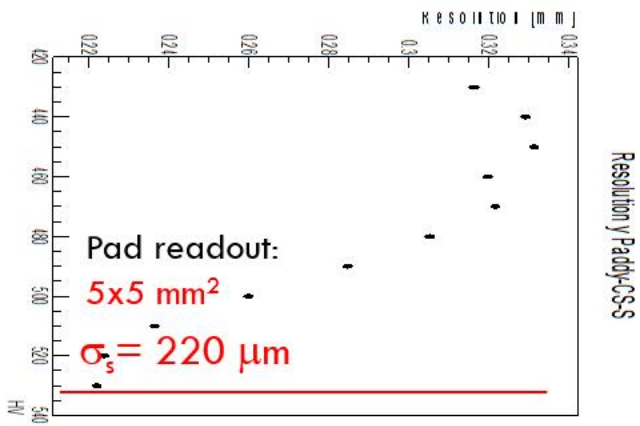
MAIN OBJECTIVES

- Test of the **Capacitive Sharing Principle**
- First tests of the NEW BigONE Double DLC Micromegas -pad readout (**50x40 cm²** – Aka Paddy2000)
- Further tests on **2 x Paddy400 (20x20 cm2):** Two detectors coupled sandwiched – sharing the same volume and one cathode

FIRST RESULTS ON SPATIAL RESOLUTION WITH CAPACITIVE SHARING

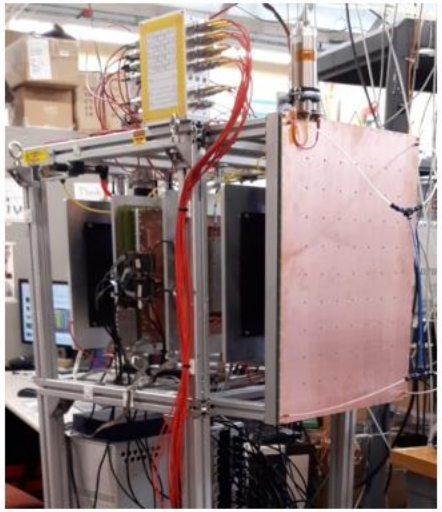


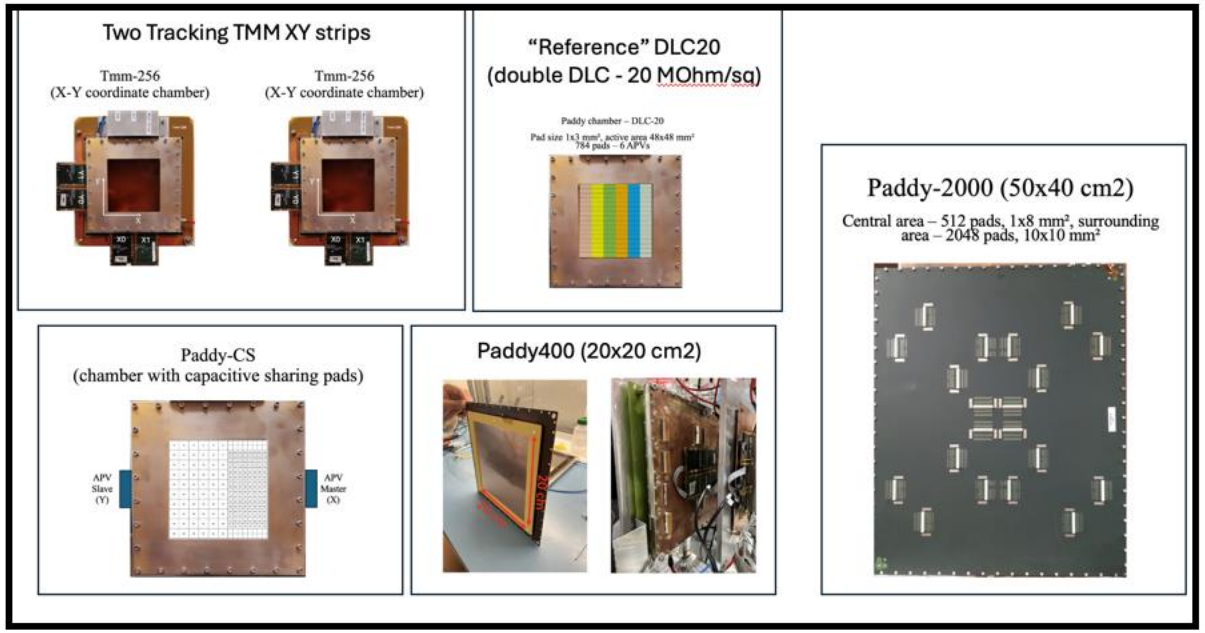
Spatial Resolution
~1/30 of the pad size



Spatial Resolution
~1/20 of the pad size

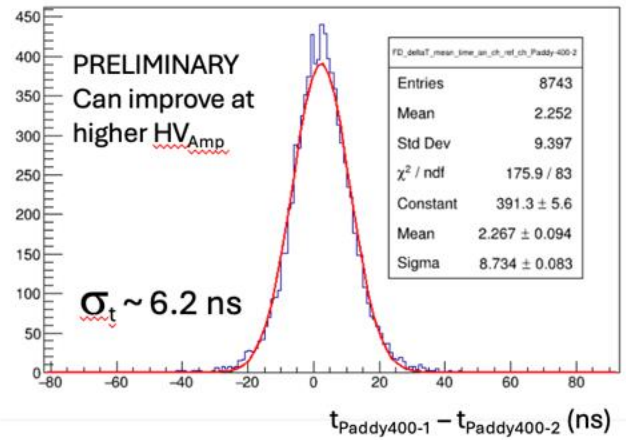
RHUM test-beam – April/2024



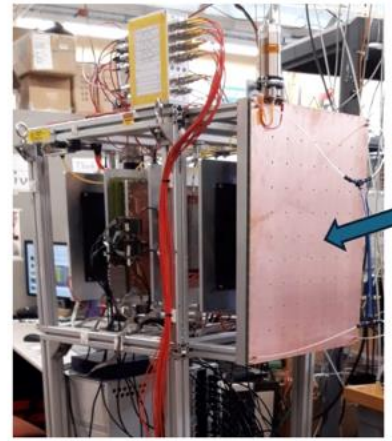


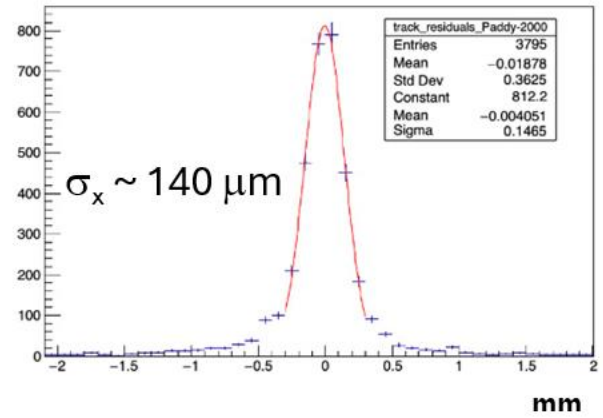
FIRST RESULTS ON TIME RESOLUTION WITH SANDWICHED Paddy400 (two 20x20 cm2)

Very first result at Vdrift ~ 10 cm/μs



FIRST RESULTS ON SPATIAL RESOLUTION on BigONE – Paddy2000 (50x40 cm2)



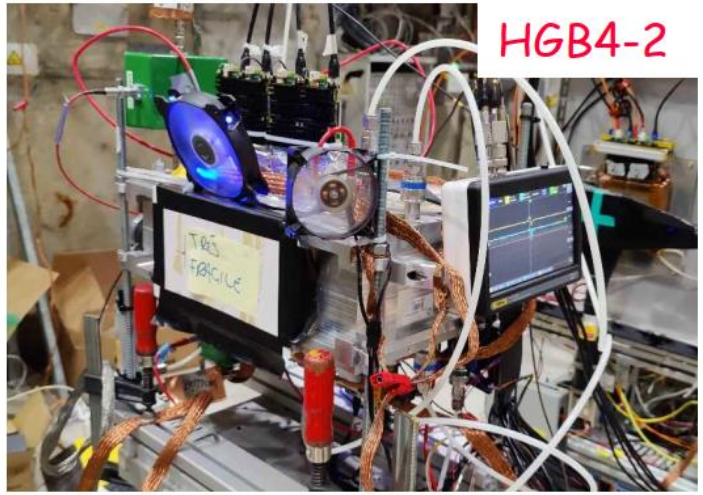


The Ultra-low Material Budget GEM-TPC in Twin

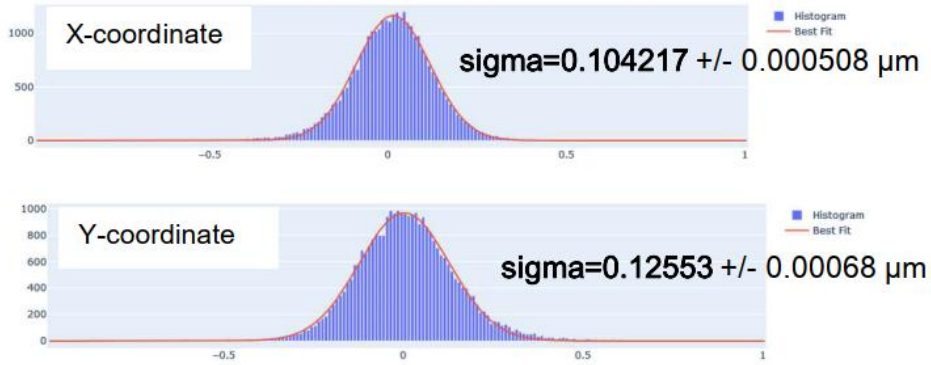
F. García, K. Floethner, M. Heiss, M. Meurer, E. Oliveri, L. Scharenberg, B.Zeh, X. Zhao

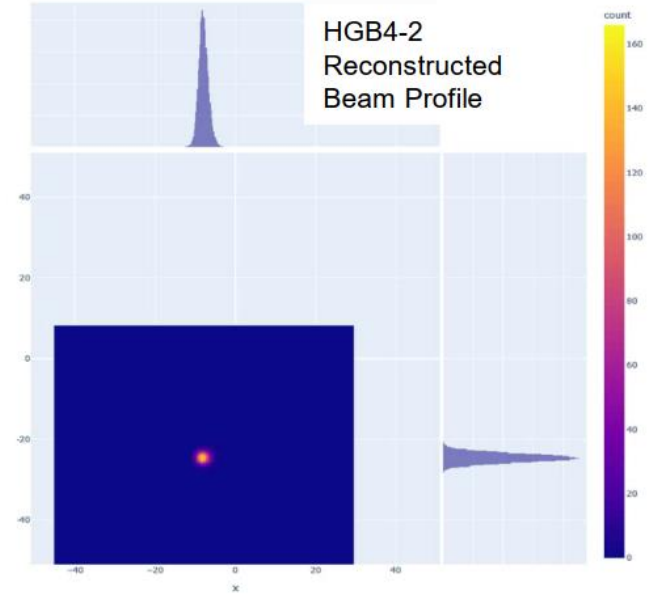
PHYSICS PROGRAM

$ArCO_2$(70/30)	$HeCO_2$(90/10)	$HeCO_2$(70/30)
-	Field scans 240 – 345V/cm	-
Muons	Muons	Muons
Pions	Pions	Pions
Rate scans ~100k – 10M per spill	Rate scans ~100k – 10M per spill	Rate scans ~100k – 10M per spill
Entrance window beam scan	Entrance window beam scan	Entrance window beam scan



Pion beam @ 370k per spill in $HeCO_2$ (90/10)





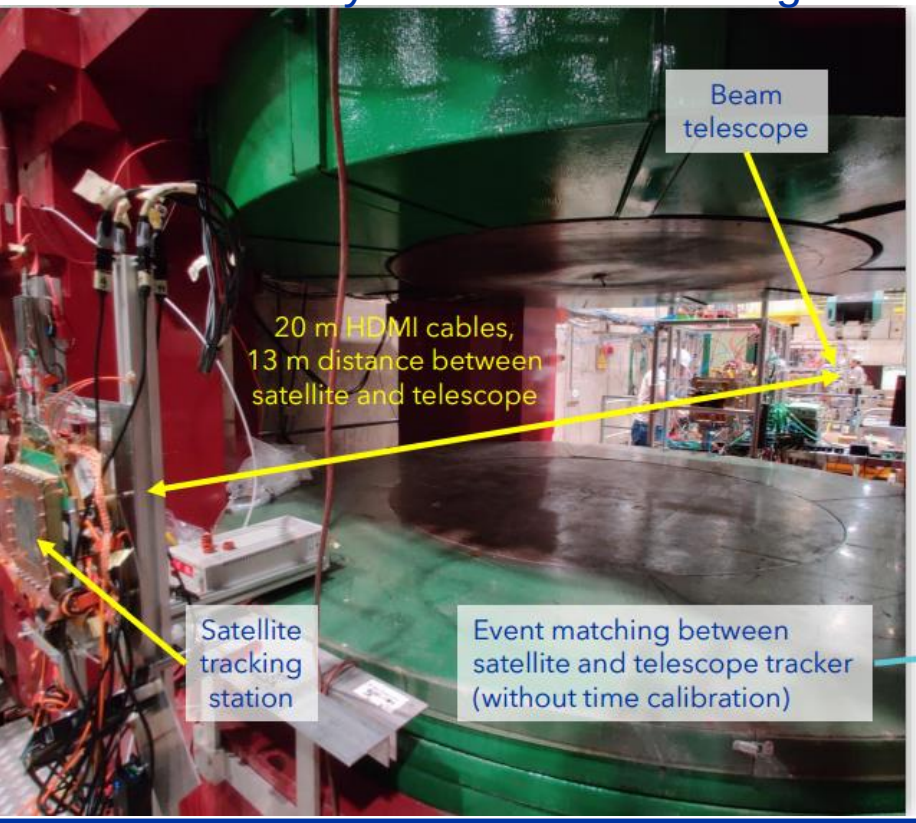
GDD/DRD1 Telescope

(compass-like triple GEM detectors with Ar/CO2 70/30)

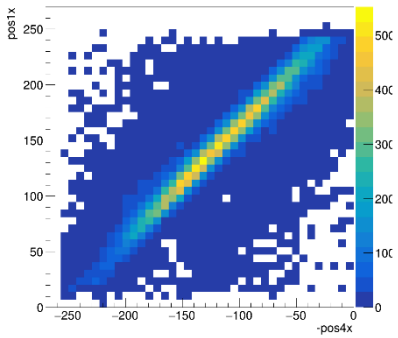
Karl Jonathan Flöthner, Max Meurer, Lucian Scharenberg with special thanks to Hans, Doro and Jerome

Extended Telescope with Satellite @13m distance

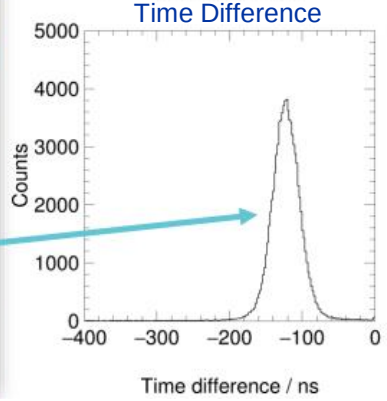
- Enabled due to PBX
  (external power of front-end elctronics)
- Clear correlations in time/position
- Could directly be used for tracking reference for DUT

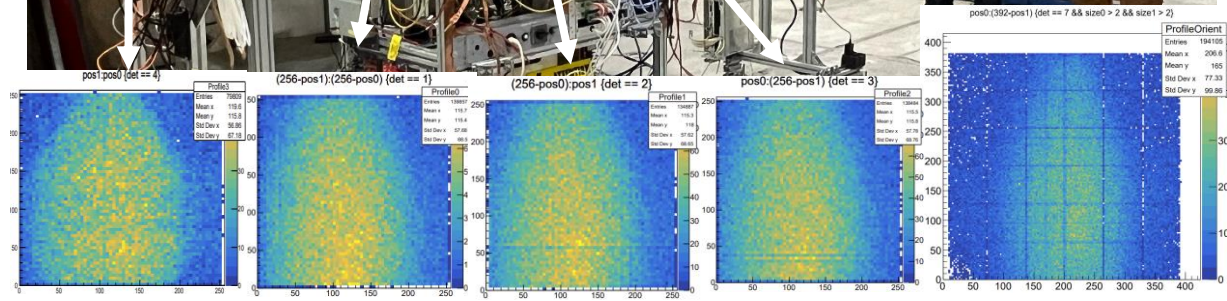


Correlation in X



Time Difference

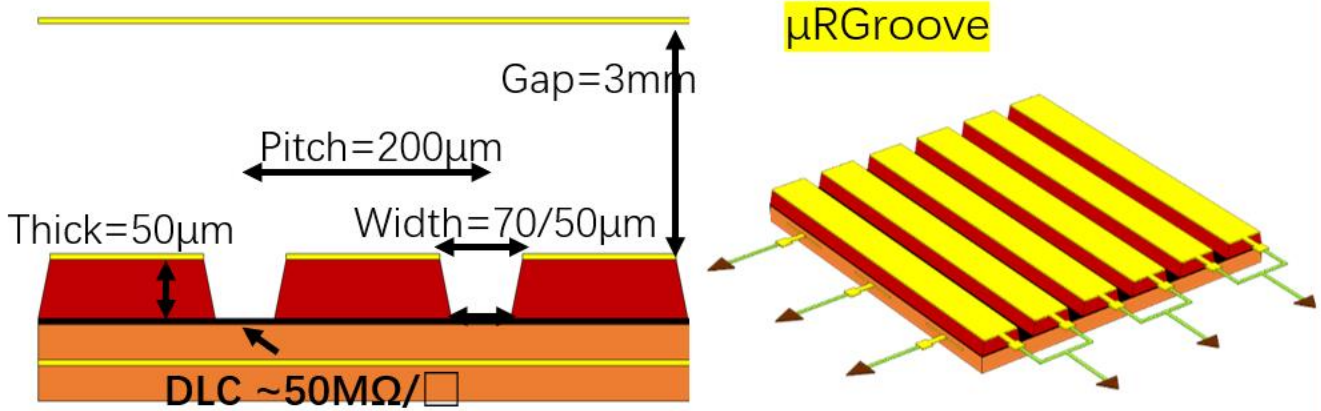




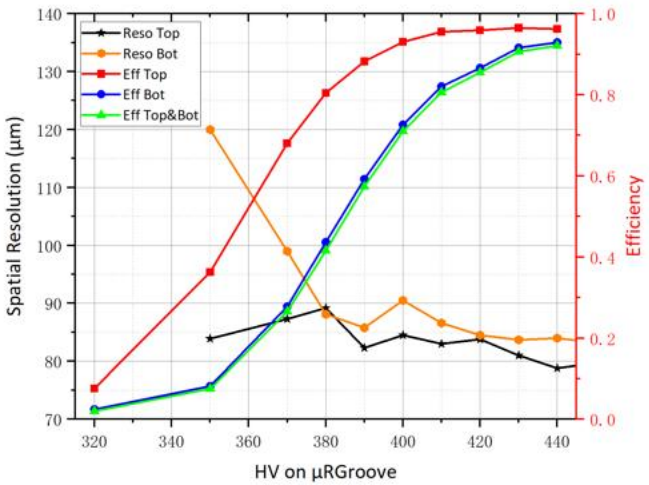
Triple GEM Tracking Detector for AMBER (G4G)

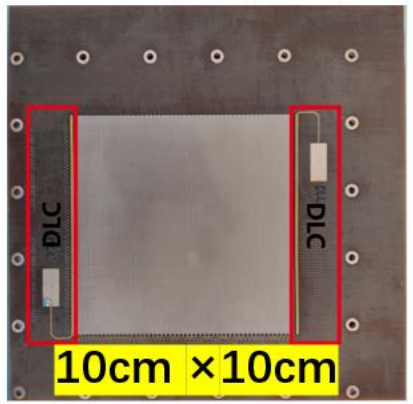
- Trigger-less readout with the VMM3a
- Stable operation with 1.5 fC THL
- One quatrant was measured of the 30cm x 30cm active area

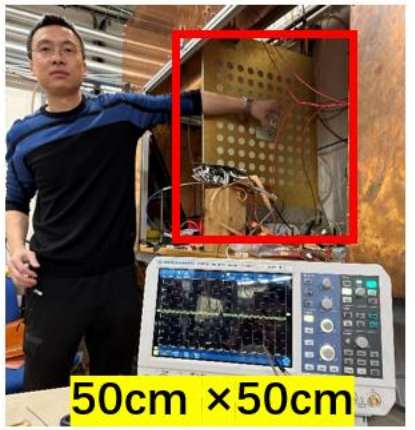
µRGroove studies



Siqi He, RD51 Mini-Week, 02/27/2023







➢ **USTC-µRGroove group: Yi Zhou, Siqi He**

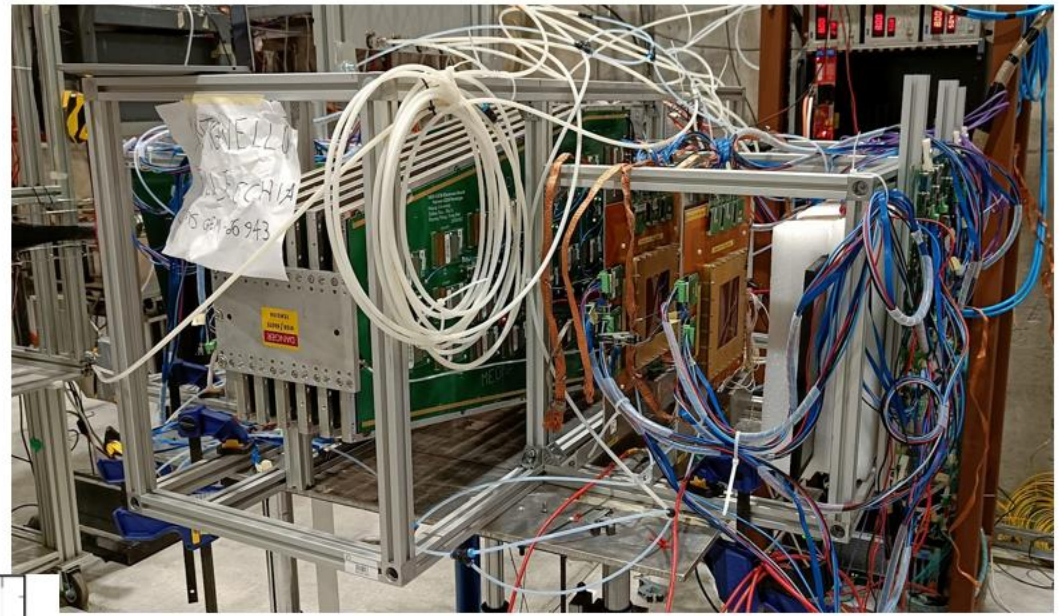
- **Decoupled X&Y readout strips, no charge sharing problem**
- **Compatible with all the techniques developed for the µRWELL manufacture and easy to produce with lower cost**
- **Easier to clean**

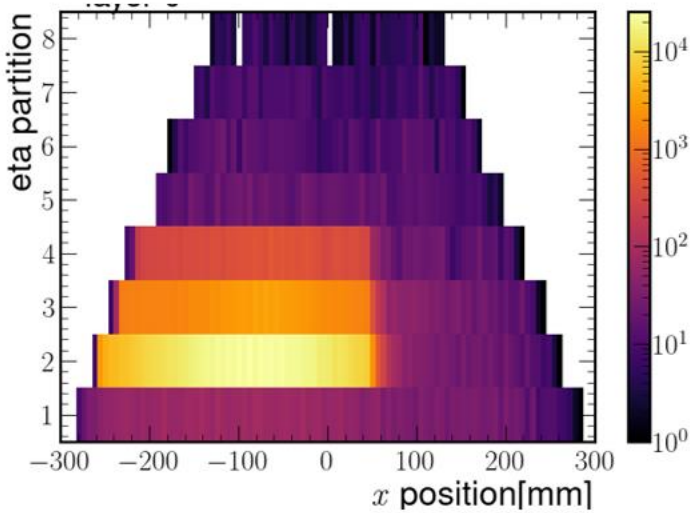
For 10cm×10cm XYV-version prototype:

- Gas: Ar/iC4H10 (90/10).
- Spatial resolution: ~80 microns.
- Efficiency: 96% for cathode, 93% for readout strips

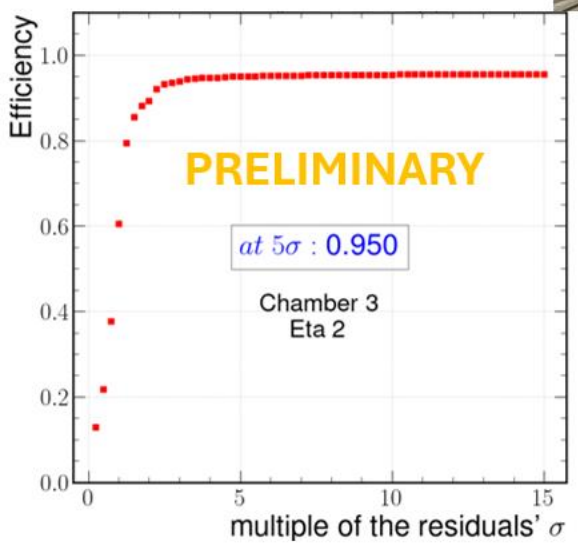
CMS GEM: stack for the ME0 station

- ME0 station for the CMS Phase-2 upgrade:
  - 36 stacks of six triple-GEM detectors (18 per endcap) instrumenting a total surface of 22 m^2
  - Physics goal: high-eta muon tagger for CMS endcap muon spectrometer ($|\eta| \leq 2.8$)
- Testing first full prototype of ME0 stack. Measuring:
  - Muon segment efficiency vs external tracker (> 99%)
  - Single layer time resolution (~ 12 ns)
  - Segment time resolution combining multiple layers

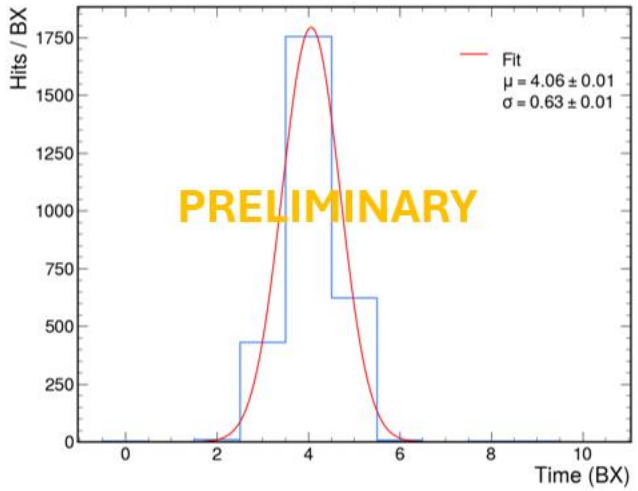




Beam occupancy (30x30 cm^2 scintillators)



Detector efficiency with standalone muon segment reconstruction



Detector time resolution

Beam Sharing with GIF++

Good Sharing (at least on our side… we hope GIF++ will share the comment)

Special thanks to

Nikolaos Charitonidis (beam), Michael Lazzaroni, Sylvain Girod, Vincent Marchand, Francois Grenouilleau et l'equipe, Silvia Schuh-Erhard (Installation and infrastructure), Alexandre Beynel, Jakub Michal Polak(Survey), David Jaillet, Anastazja Sedzicka, Thierry Erisay, Lionel Degasparis (Gas Support), Letizia Di Giulio, Henric Wilkens, Nicolas Broca, Romain Bonnard, (Flammable Gases and safety) Frederic Lionel Aberle, Yann Pierre Pira, Valerie Tromel, Antoine Zeder (RP), Alex Schouten (Safety), Martin Jaekel, Paolo Martinengo, Giuseppe Pezzullo (GIF++).... and to everyone we forgot by mistake