DRD1 H4(PPE134) 2024 Test Beam

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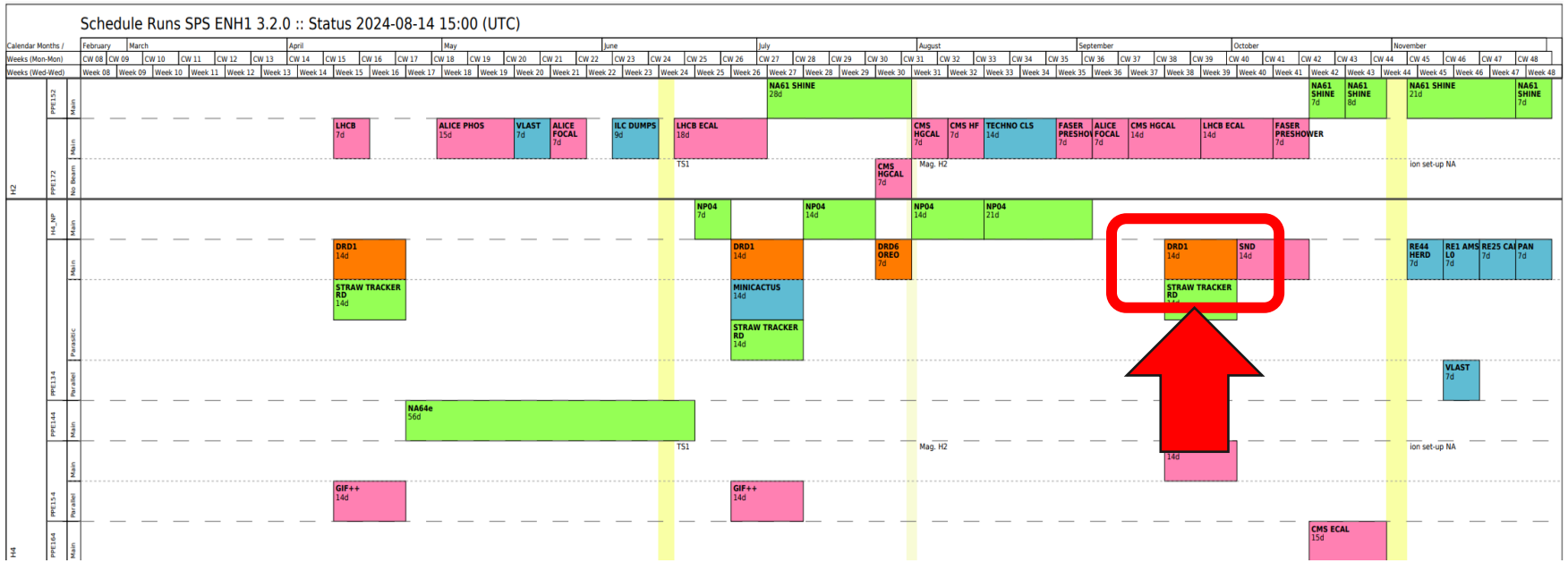
Generic and Application driven R&D

Technologies: Micromegas, uRGroove, GEM
Application: High Rate, Timing, Calorimetry, Tracking in Magnetic Field

FE electronics and DAQ

Tigers, Mu2e, ASD. GEMROC, SAMPIC

Wed. 18/09/2024 – Wed. 02/10/2024



Beam Conditions

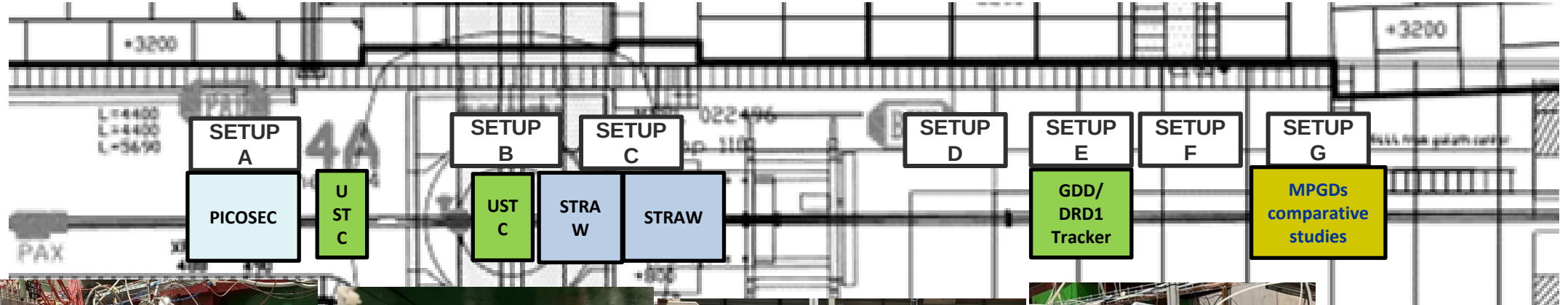
Muon: perfectly satisfying our needs (up to few 1e5 mu/spill)

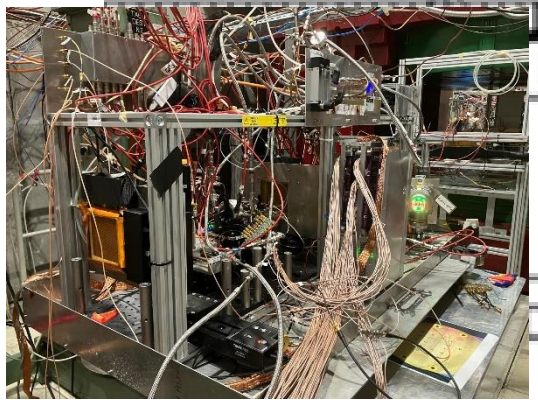
Pion: short run of a few hours, up to ~5e+6 pi/spill

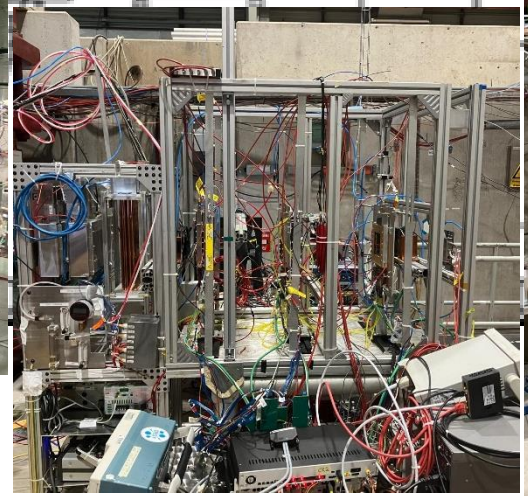
Magnet: three successful night shifts up to 1.5T

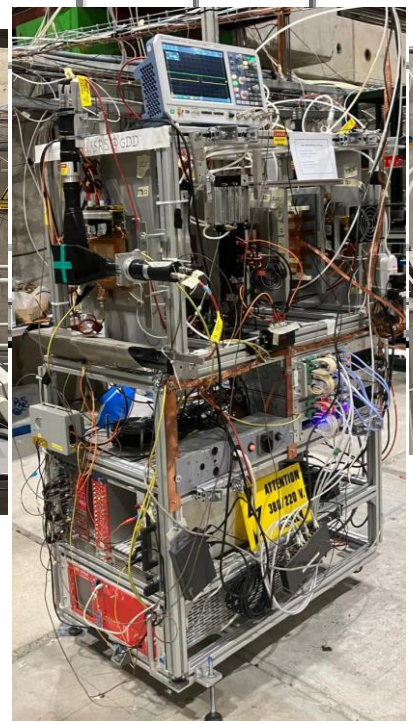
Huge thanks to Nikos and Bastien for helping with the Beam Tuning and the Magnet. Thanks to GIF for the flexible arrangement of Pion and Magnet runs.

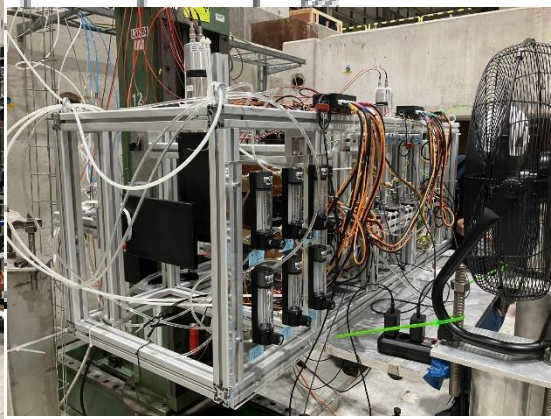
BEAM H4, PPE134 – INSTALLATION (DRD1, Sept 18 – Oct 2)





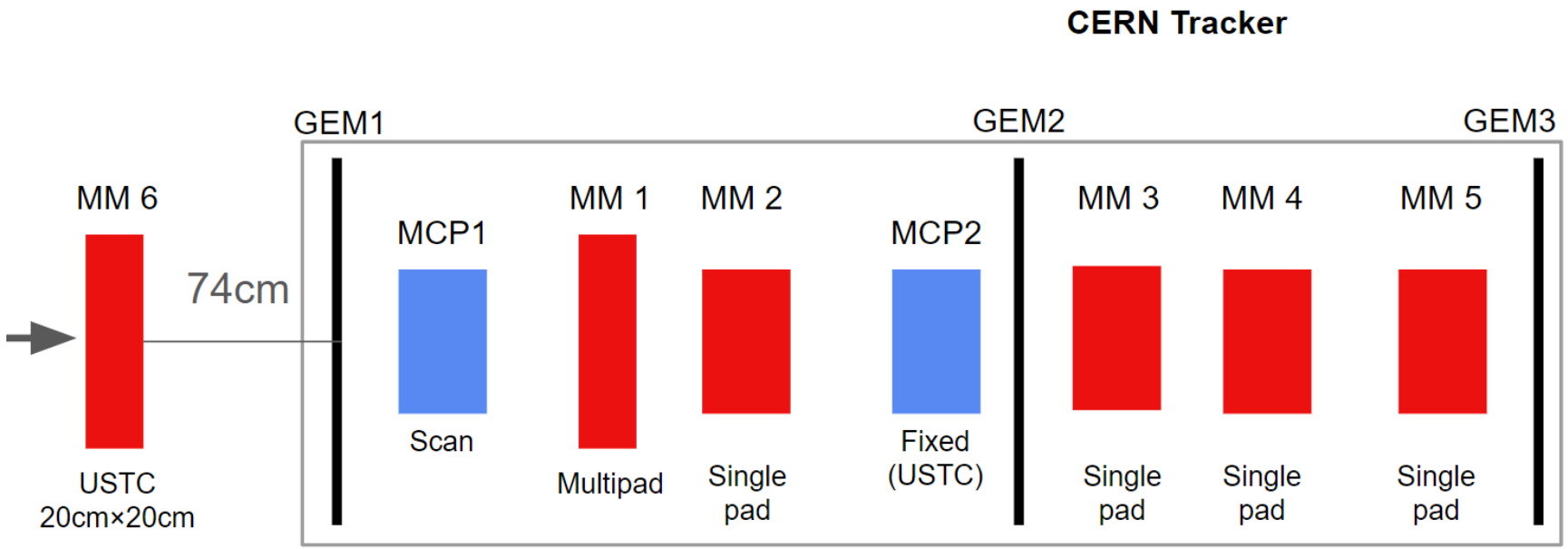






- SETUP A: PICOSEC (F. Brunbauer)
- SETUP B: USTC (Y. Zhou)
- SETUP C: STRAW (T. Enik, K. Kuznetsova)
- ~~SETUP D: Cylindrical TPC - DUT not ready~~ -> plans to come next year
- SETUP E: GDD/RD51 Tracker (L. Scharenberg, K. Floethner)
- ~~SETUP F: Saclay - Did not manage to come ->~~ plans to come next year
- SETUP G: MPGD comp. Studies (Darina Zavazieva)

PICOSEC – Test Beam Setup and Detectors under Test



Telescope layout comprises of :

GEM for tracking
MCP – PMT as time reference device
MMX – Detectors Under Test

Detectors Under Test

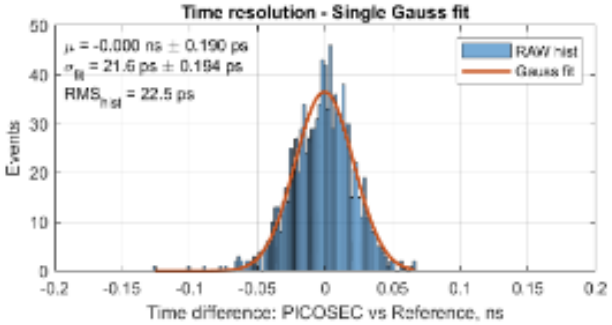
Single Channel prototype → 1cm diameter active zone (circular)
7- Channel prototype → 1cm single cell (hexagons)
96-Channel prototype → 1cm single cell (square)
100-Channel prototype → 1cm single cell (square)
400-Channel prototype → 1cm single cell (square)

COMPASS Gas Mixture (80% Ne – 10%C2H2 – 10% CF4)

PICOSEC - Block of Measurements and Highlight Preliminary Results

Robust & Efficient prototypes

Resistive prototypes ~ 10MO, 20MO, 50MO
DLC single and double layers to explore better charge vertical evacuation
Voltage scans → Stable operation voltage in a high rate
Timing runs on individual pads
Long scan for uniformity map on amplitude and timing



10x10cm2 Double DLC with CsI ~ 21ps at a center of a pad

Spatial Resolution studies

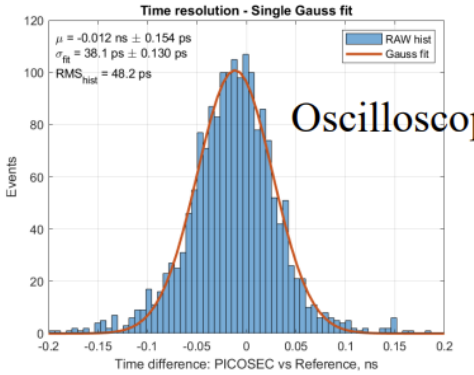
15mm diameter active zone splitted in hexagonal pads (medium and high granularity prototypes)

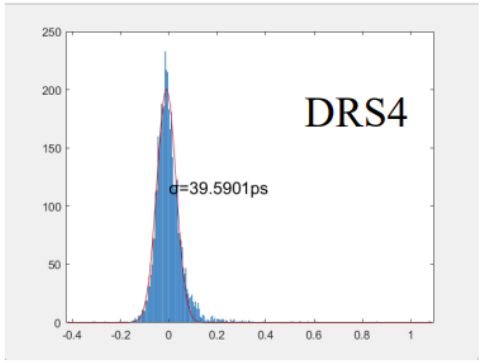
Alternative photocathodes

Graphene single, double and triple layer on a contactive thin layer

Alternative digitizers

SAMPIC and DRS4



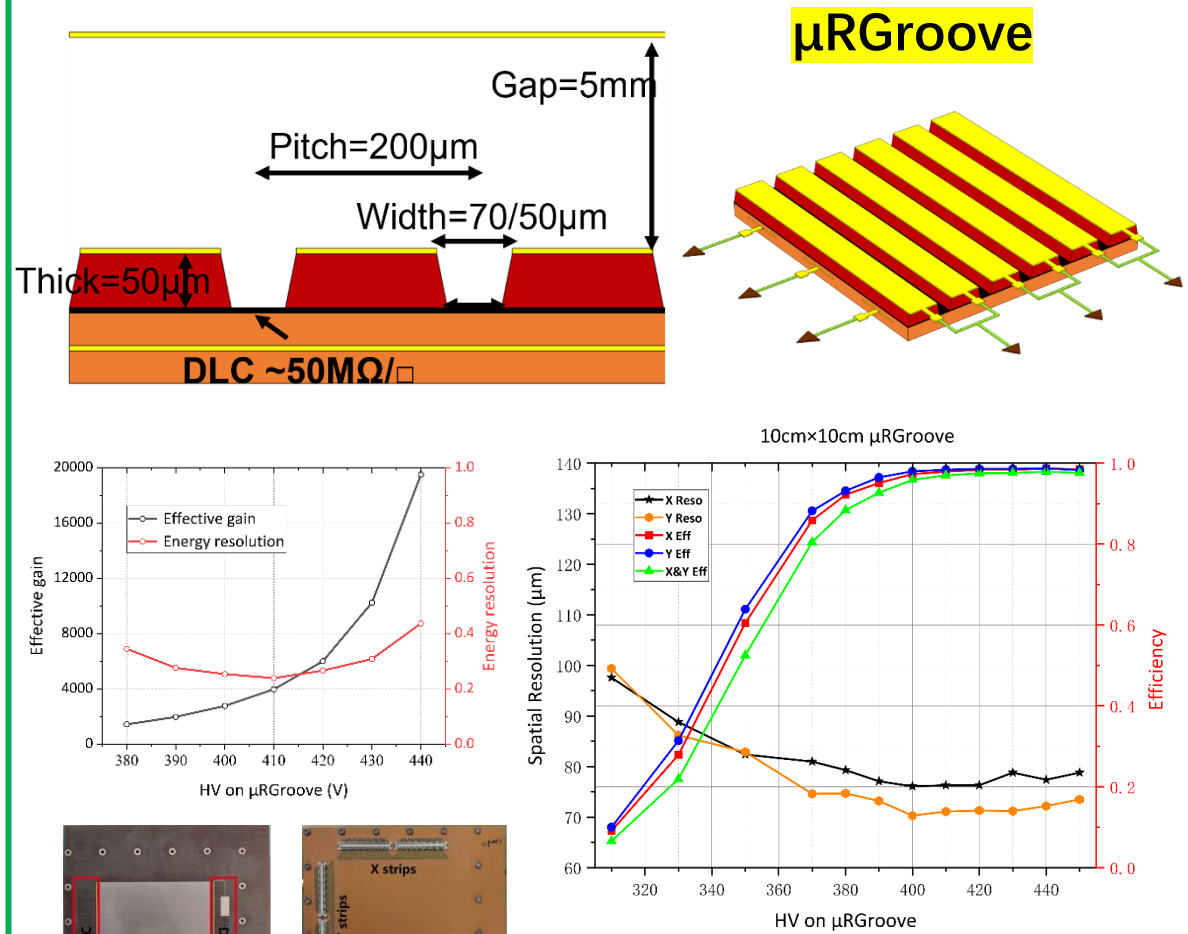


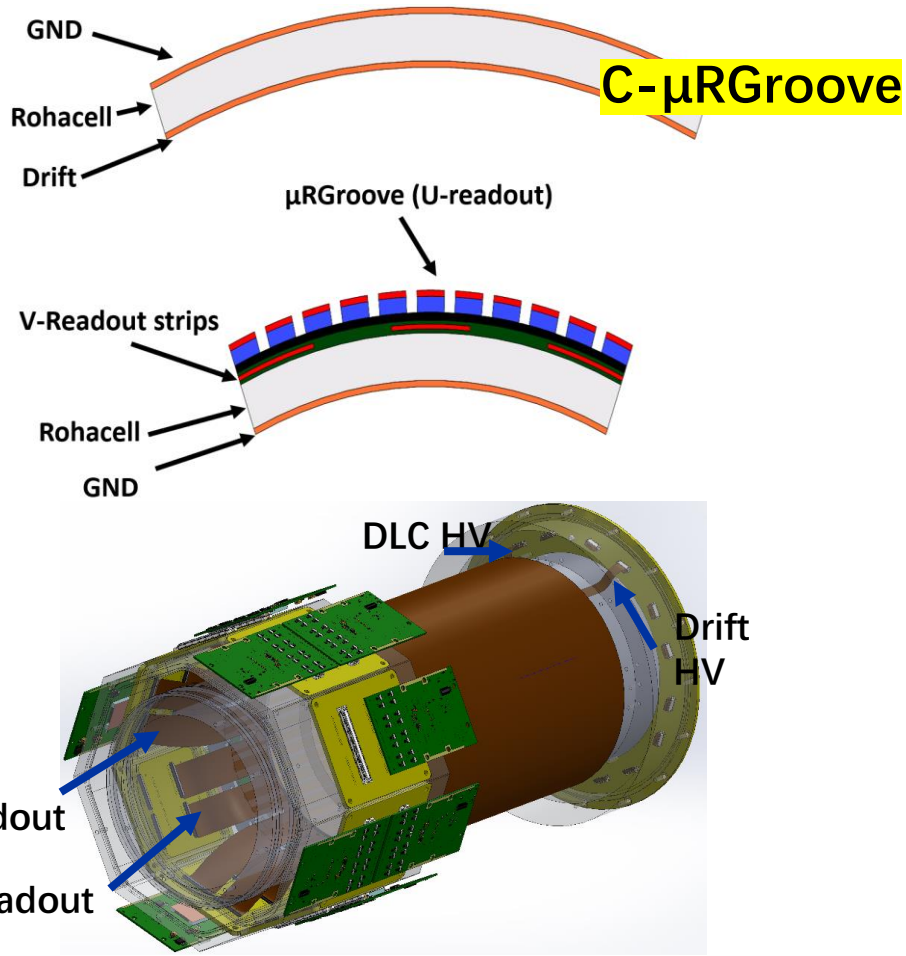
Radiation Hardness

High intensity pion beam (from 8kHz up to 1MHz)
Stable operation through the whole run both for the detector and for the photocathode

20x20 cm2 with DLC ~ 38ps at a center of a pad and agreement with different digitizers

Cylindrical µRGroove

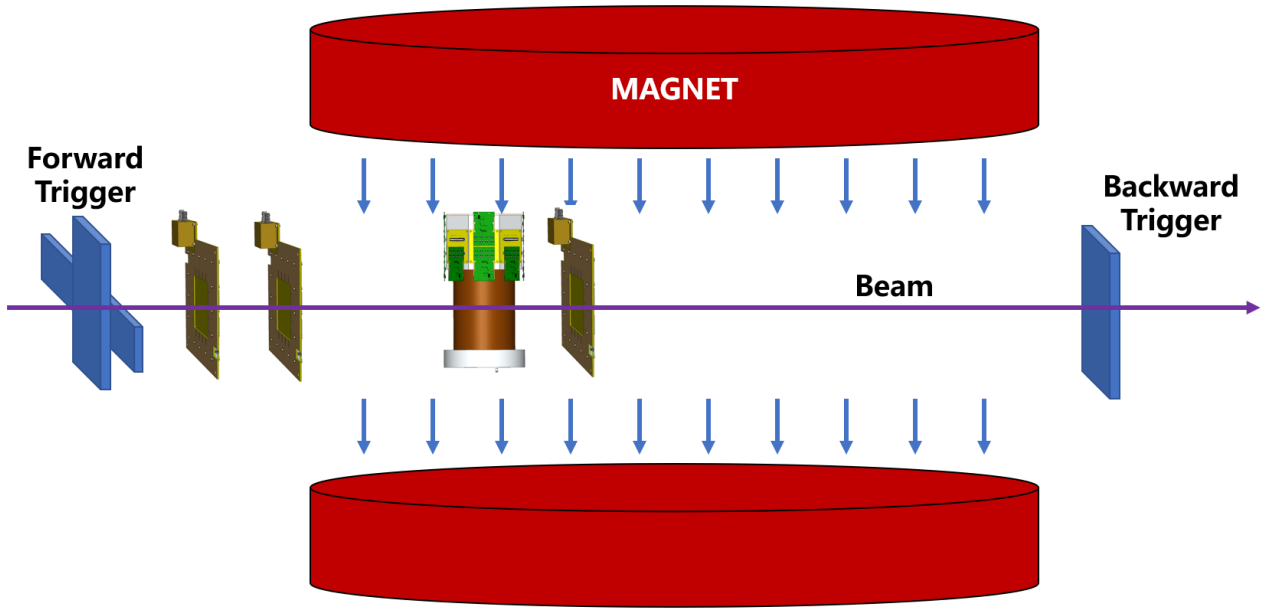




➢Active area: Diameter=131.0mm, Length=100.0mm.

Setup

- Gas: Ar/CF_4/CO_2 (45/40/15)
- Particle: 150GeV/c muon
- X-strip readout; V grounded
- APV25+SRS+mmDAQ
- 3 μRGroove Trackers
- 0.5-1T magnetic field



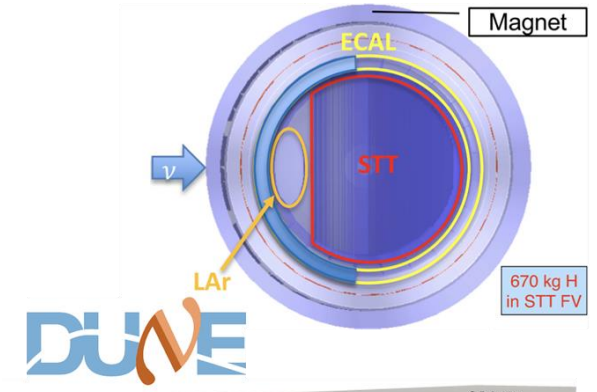
- Spatial resolution without magnet：~100μm；
- Measure the detection and spatial resolution in 1Tesla magnetic field

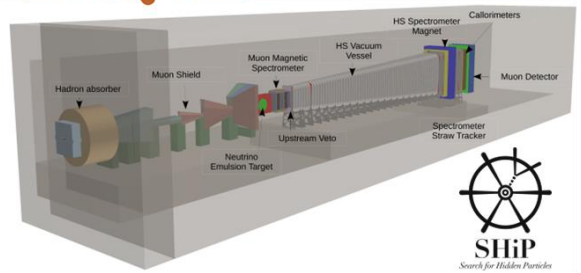
Analysis ongoing (Correction for track bending and Lorentz angle to be applied correctly).
Results looks promising (below 100um spatial resolution at 1T).
Can be repeated in 2025 if final results will not satisfy requirements.

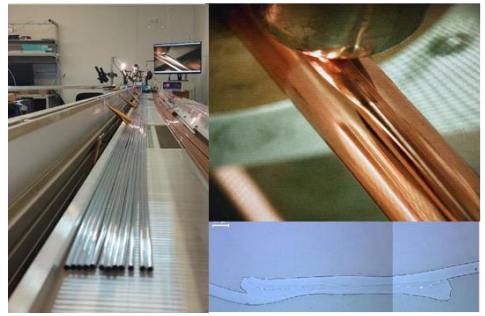
Straws R&D Setups

@H4 September-October 2024

- DUNE near detector SAND for neutrino beam monitoring including flux shape changes [200k+ straws upto 4 m long]
- SHiP Spectrometer Straw Tracker (STT) for track and vertex reconstruction [10k channels]
- As well for DRD1-WP3, SPD NICA, COMET
- Ultrasonic welding technology for the Straws
- Test beam measurements
- Tracker prototyping
- Study of read-out electronics

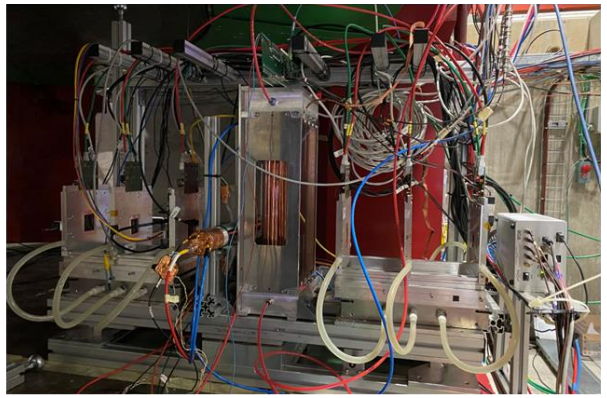






Straw setups

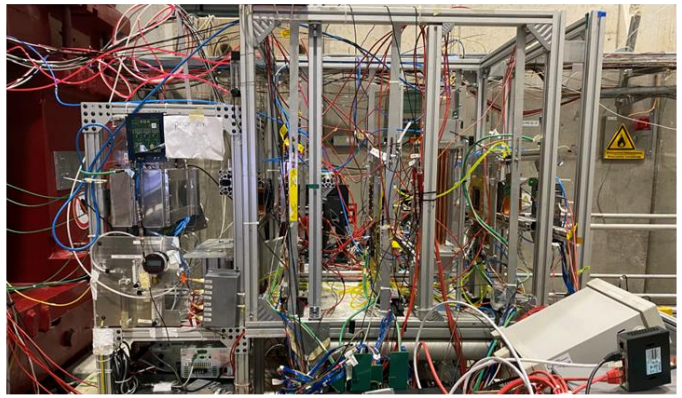
Setup-1



- AZALEA Telescope
- DUT: a new uSPD straw array (10 mm) or individuals tubes (10, 20 mm)
- Elecronics under tests: Sampic, Mu2e, ASD (from sMDT setup)
- Timepix

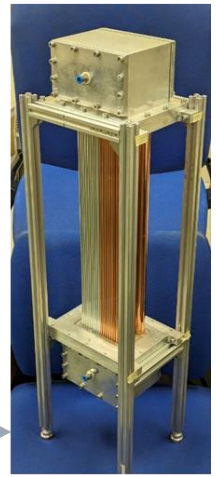
New uSPD prototype

Setup-2



- MM tracker and sMDT
- Old straw array (5, 10, 20 mm) and uSPD
- Electronics: Tigers, Mu2e, ASD
- GEMROCs

Old Combine prototype



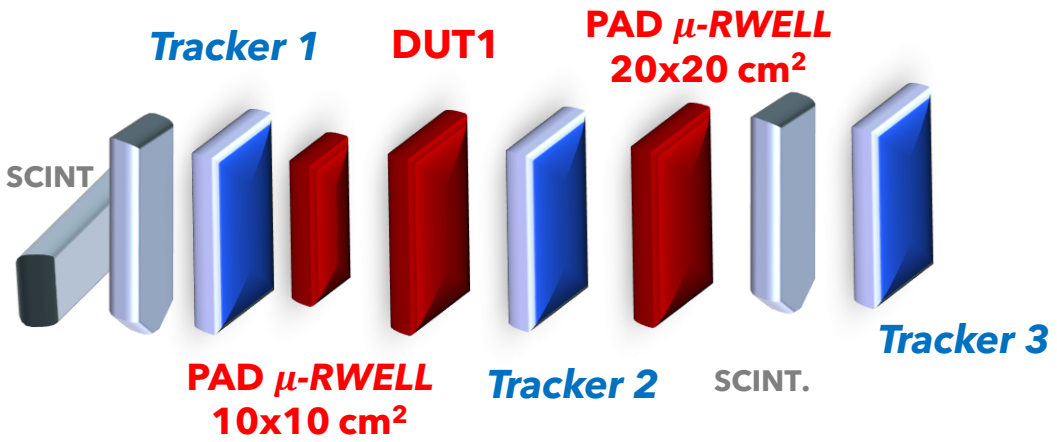
- Operation modes:
  - Large acceptance (sMDT + MM reference tracking 9x9 cm2) – resolution ~100 um
  - Small acceptance (1x2 cm2) high resolution (~5um) – AZALEA telescope
- Straw tracker prototypes and straw
  - Combined 5-10-20 straw (ASD and VMM3 -based readouts) – readout performance studies
  - 10mm with 2degree stereo angles (ASD and VMM3 -based readout) – readout performance and tracking studies
  - Stand-alone 10 and 20 mm straws (custom PA + SAMPIC digitizer)
- Test in magnetic field 1 and 1.5 T with ASD and SAMPIC readouts
- Data analysis ongoing

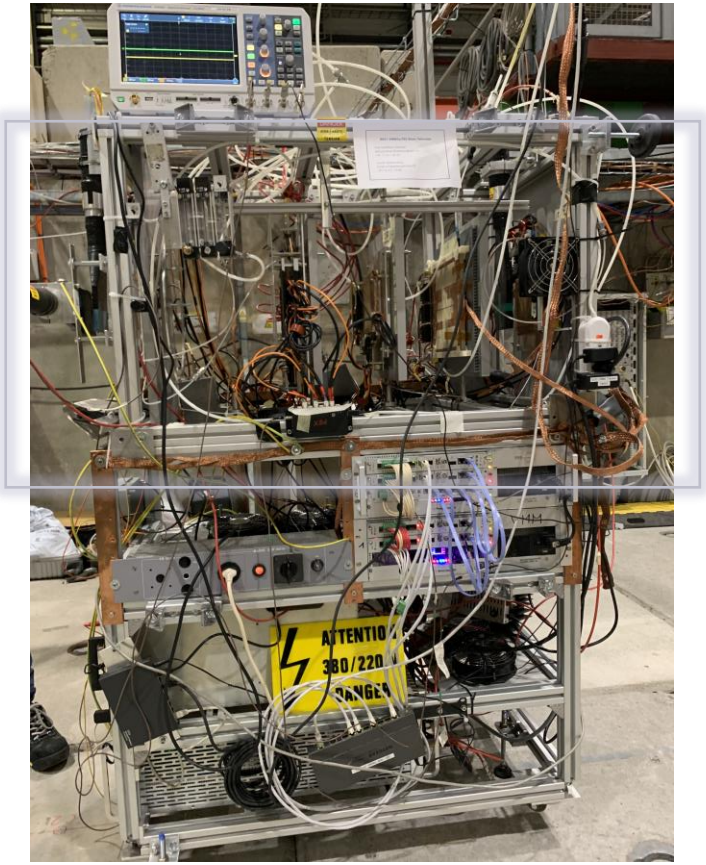
- **Many thanks to DRD1 and GIF++ colleagues for their collaboration and patience, to Nikos Charitonidis for the great beam intensity, and to Andre Rummler for AZALEA support!**

DRD1 VMM3A/SRS TELESCOPE

Set-up

- 3 scintillators in coincidence trigger
- 3 triple GEM trackers for reference
- 3 detectors under test



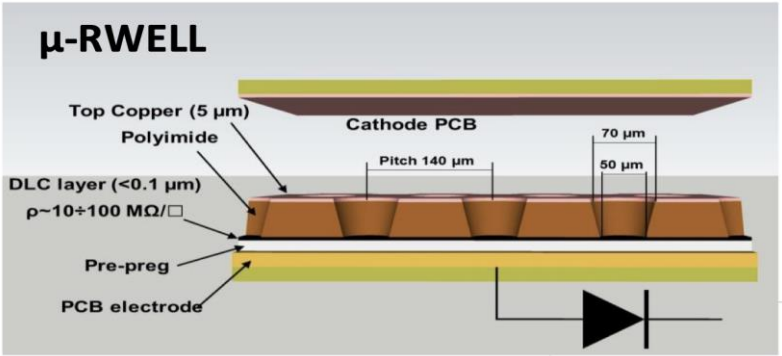


Scope

A) Repeat performance evaluation of recently implemented externally triggered readout mode

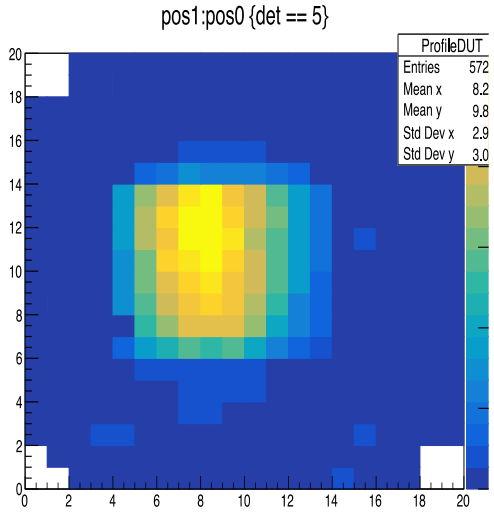
B) Test of VMM3a front-end for MPGD-based DHCAL for future muon colliders and compare with APV25 front-end, reading out 20 x 20 cm² μRWELL prototype detector

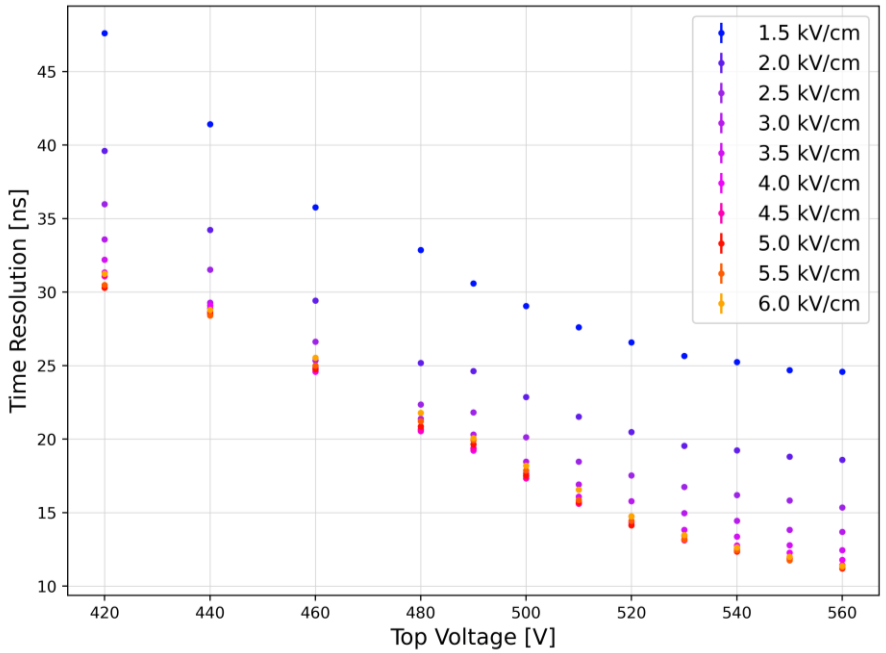
C) Test of 10 x 10 cm² μRWELL detector for studies on alternative, eco-friendly gases

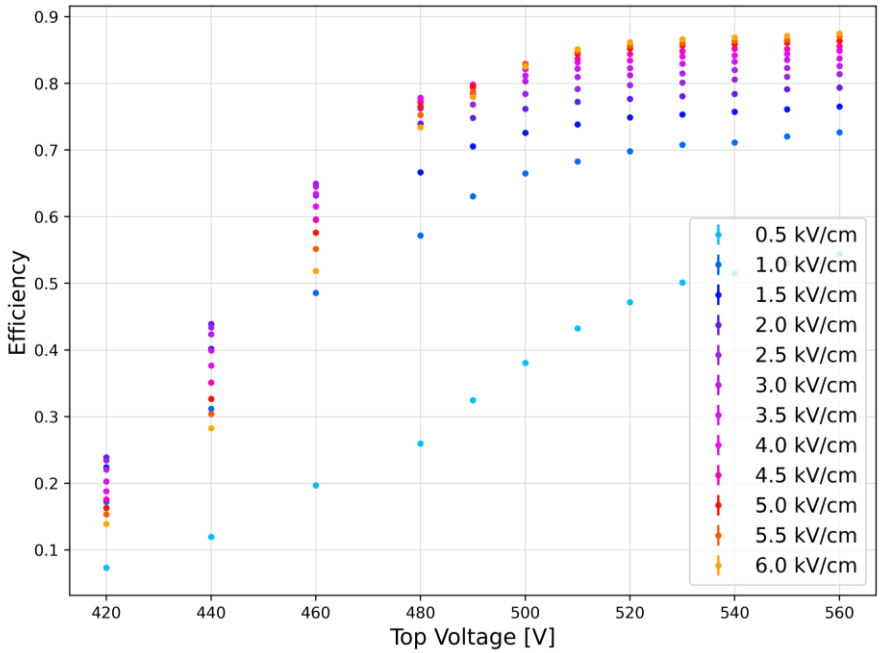


DRD1 VMM3A/SRS TELESCOPE

Results, 20 x 20 cm² μ-RWELL



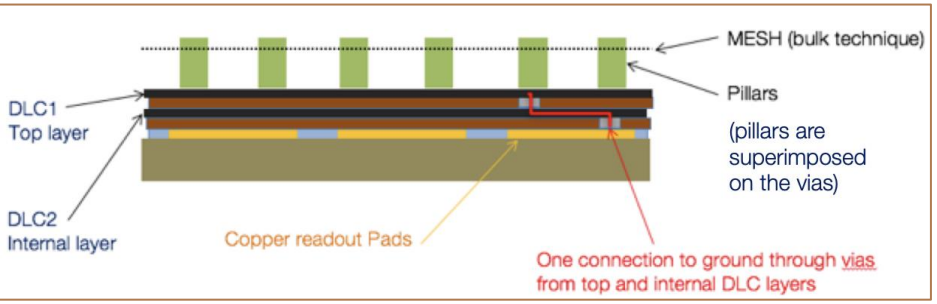




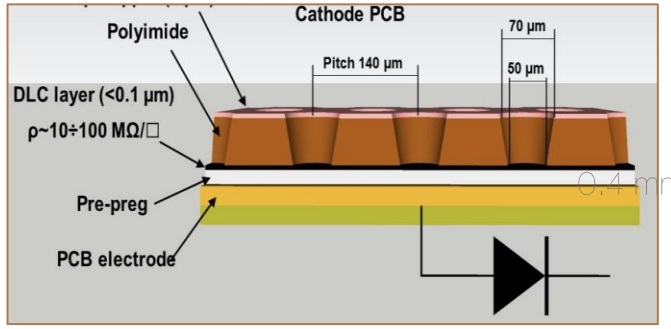
- **1×1 cm² pad area**
- 384 pads → 3 hybrids
- Drift Gap: **5 mm**
- DLC grounded, TOP and DRIFT connected to HV
- Gas Mixture **Ar CO_2 CF_4 45/15/40**

Weizmann Institute of Science setup
Comparative study of resistive MPGD technologies

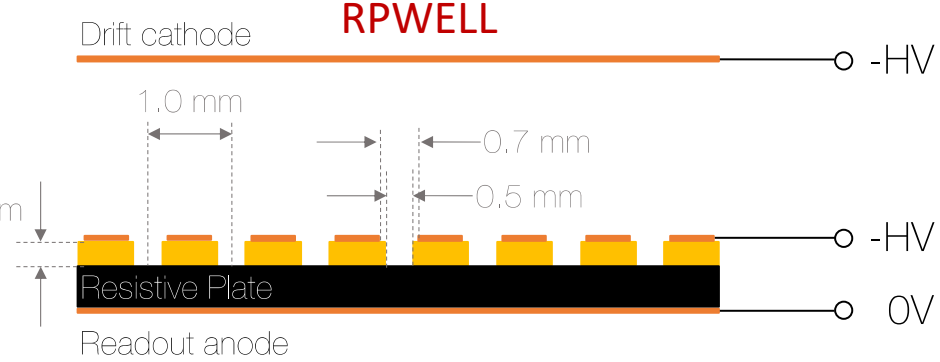
Micromegas, MM



uRWELL

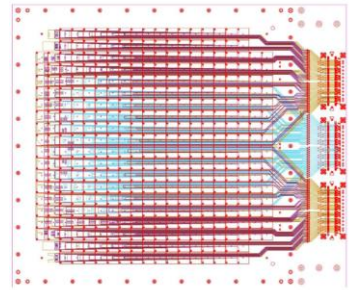


RPWELL

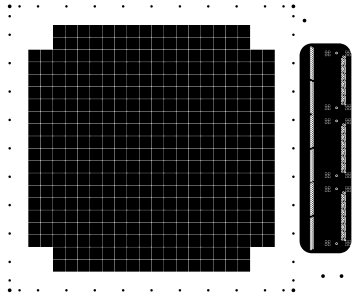


Single stage resistive MPGD:

- Single stage amplification
- Lower material budget
- Simpler power supplying scheme
- Resistive layer/plate to protect the electronics from discharges



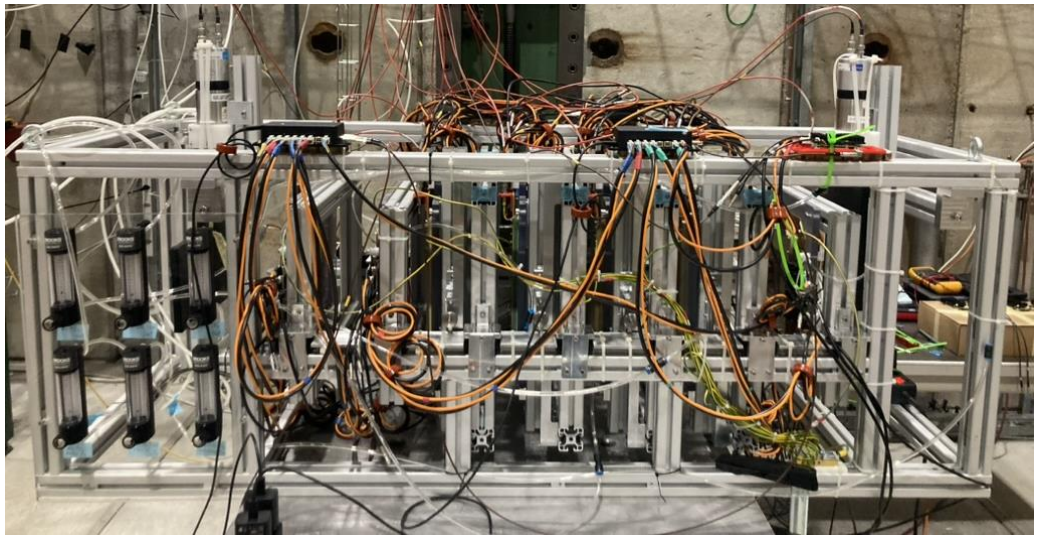
- Potentially a sampling element digital hadronic calorimeters with fine 3D segmentation
  in fact, it is a complementary study to RD51 Common project [1])



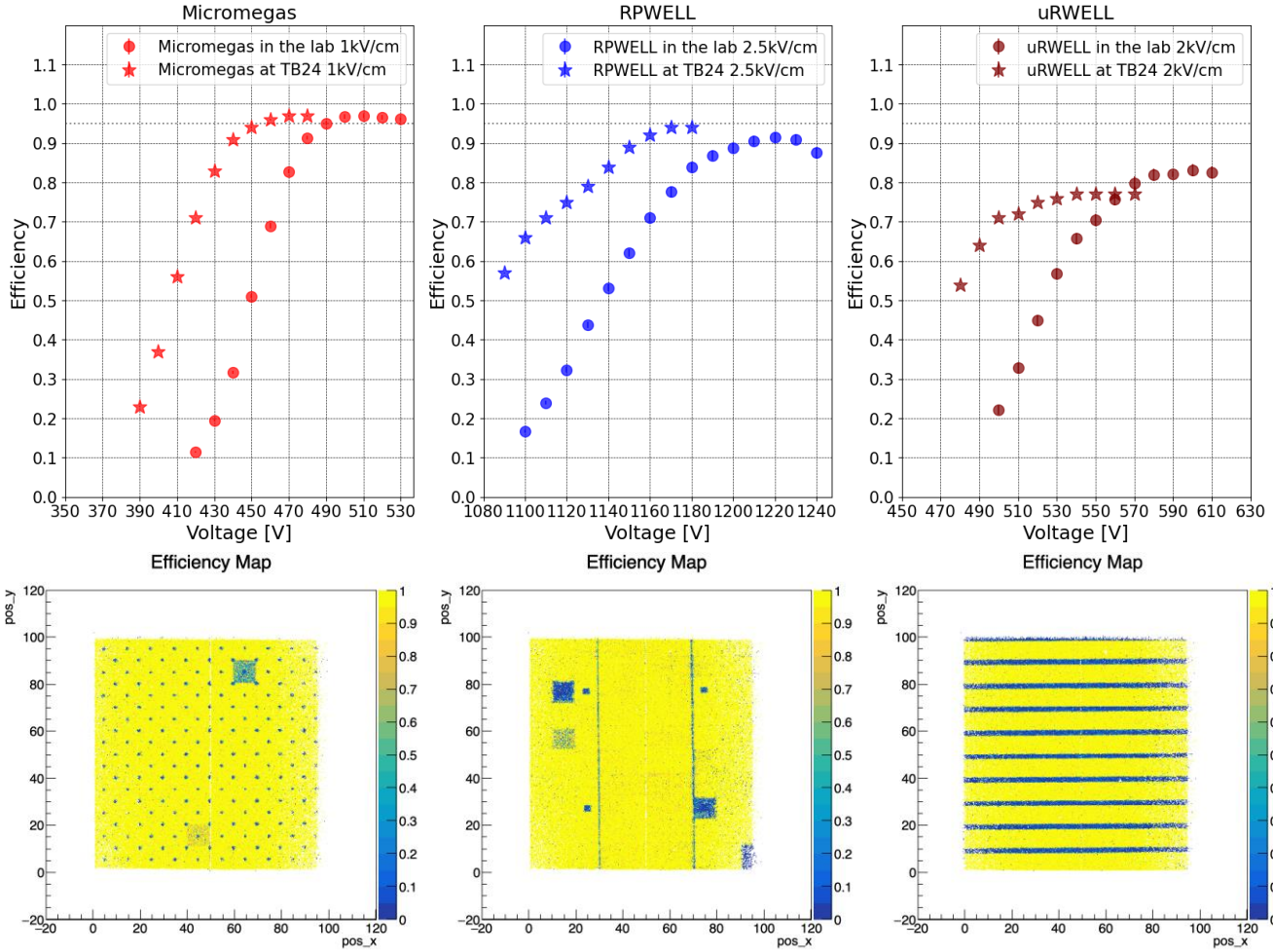
No systematic characterization in controlled environment
→ Goal of the study: to compare the performance of the three technologies with identical readout in similar operational conditions

[1] https://indico.cern.ch/event/1368231/timetable/?view=standard#33-mpgd-hgcal-multipattern-gas

Weizmann Institute of Science setup
Comparative study of resistive MPGD technologies



- Common VMM3a-SRS readout
- DRD1 (triple GEM) tracker
- 2688 total channels
- Mounted on DESY table
- Gas mixtures: ArCO2iC4H10, ArCO2, ArCO2CF4
- Measurements
  - Efficiency scan (vs. amplification voltage, vs drift field) with muons
  - Rate scan with pions
  - Uniformity scan across the area



Setup Removal

- As usual, huge thanks to the RP and Crane teams for their prompt help.
- Some equipment was left in PPE134 (needed for the 2025 TB campaign). It can be removed at any time if needed.
- We hope we did not interfere too much with the SND installation (the area was completely free only before lunch due to the large amount of equipment).

Beam Sharing with GIF++

- Good Sharing as usual (at least on our side… we hope GIF++ will share the comment)
- Optimized collimator settings in case of three spills and GIF access (PAXNA14404 has reduced limit in access)

Special thanks to

Nikolaos Charitonidis (beam), Bastien Rae (magnet), 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, 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 (RP), Alex Schouten (Safety), Martin Jaekel, Paolo Martinengo, Giuseppe Pezzullo (GIF++).... and to everyone we forgot by mistake

Backup

3 Spills + GIF access (PAXNA14404 reduces to 15uSv/h)

-> XCSH.022.068 to –8.5 & 8.5 (beam ref -12/12)

(don't forget to remove the cross for 'update beam ref')