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, Calorimetry
Readout: Capacitive Coupling, Resistive Sharing

Project driven R&D

FCC-muons uRWELL/TIGER

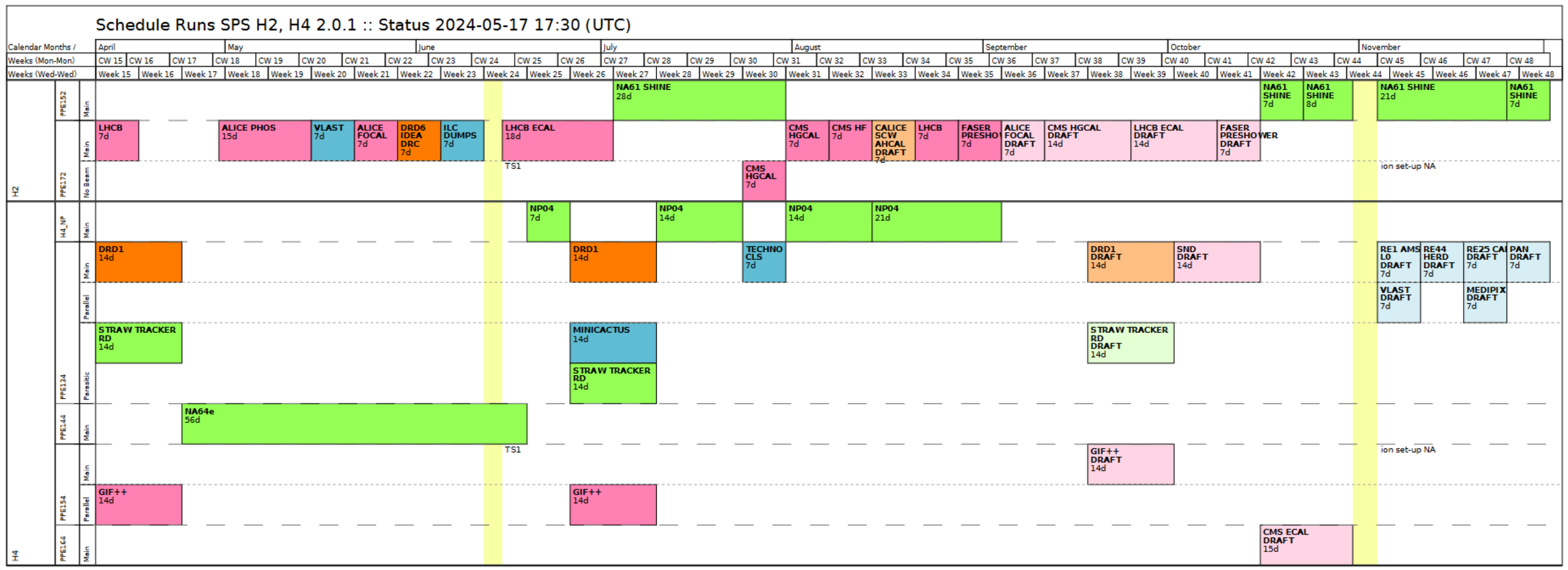
Detector Commissioning

MPGDHCAL

FE electronics and DAQ

Straw, VMM3a and TPC

Wed. 26/06/2024 – Wed. 10/07/2024



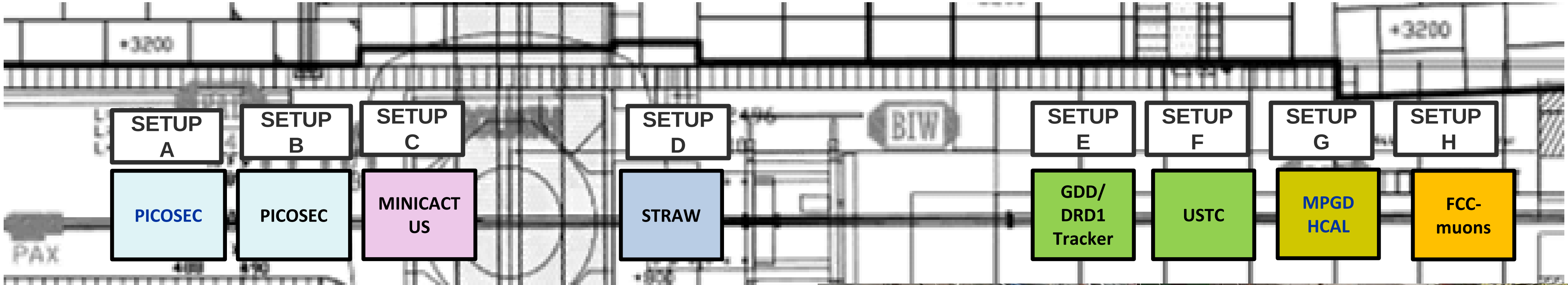
Beam Conditions

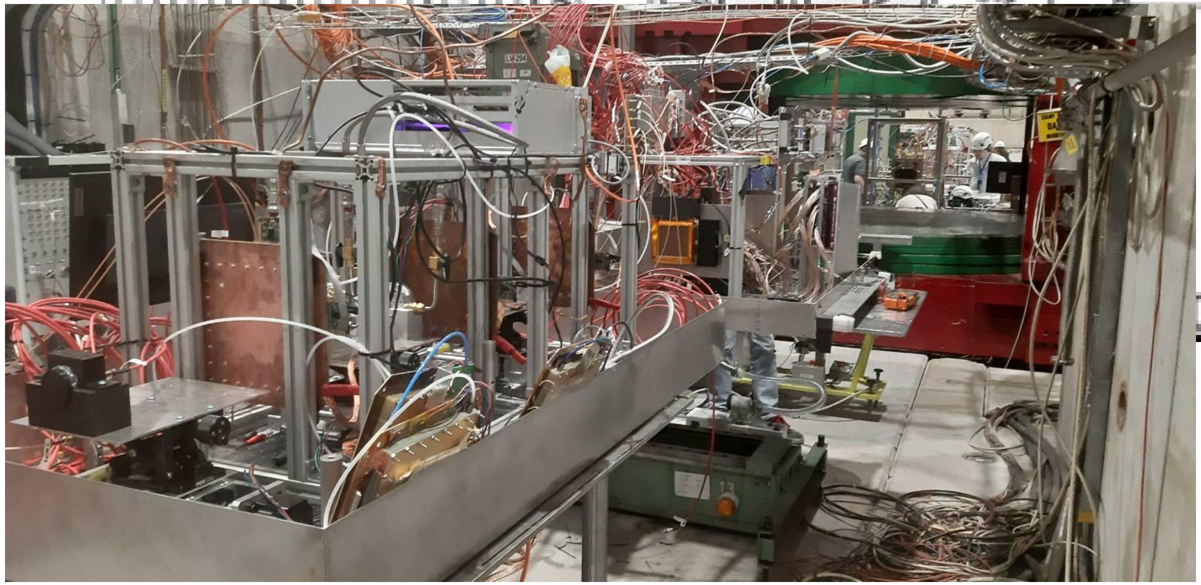
- **Muon Beam Purity: perfectly satisfying our needs (no showers produced by our detectors)**

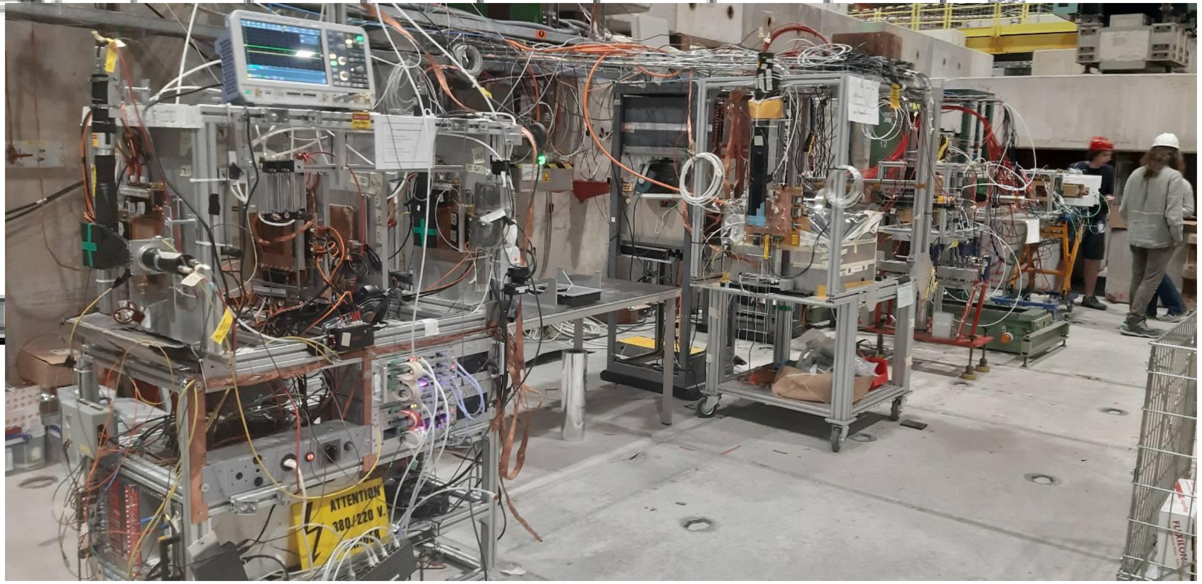
- **Pion: >10e+7/spill**

- **Muon/Pion Rate: Very Satisfied. Huge thanks to Nikos, Bastien 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)


+3200
SETUP A
PICOSEC
SETUP B
PICOSEC
SETUP C
MINICACT US
SETUP D
STRAW
BIW
SETUP E
GDD/ DRD1 Tracker
SETUP F
USTC
SETUP G
MPGD HCAL
SETUP H
FCC- muons
+3200
PAX




ATTENTION
380/220 V

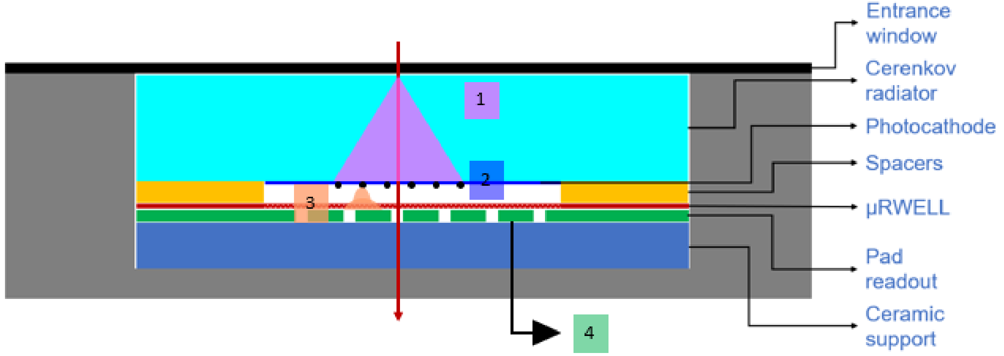
Basic concept of µrPICOSEC detector

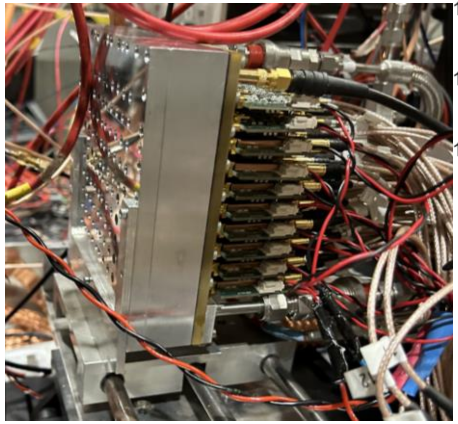
Jefferson Lab
K. Gnanvo, N. Shankman
Stony Brook University

Concept of µrPICOSEC: fast timing gaseous detector using µRWELL amplification ➔ time resolution of ~10 (s) ps

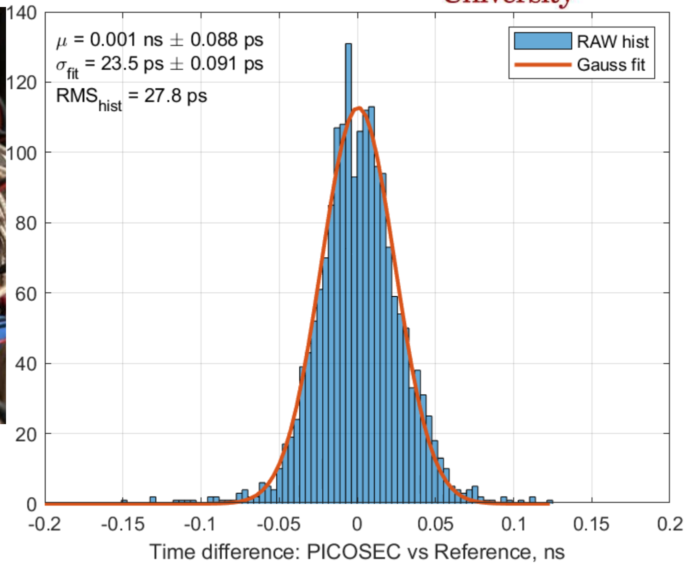
1. Cherenkov photons: relativistic charged particle creates Cerenkov photons ➔ prompt photons i.e. good timing.
2. Photoelectrons: convert the Cerenkov photons into electrons, all created at the location ➔ good timing
3. Pre-amplification: First amplification of electrons ~100 µm gas in high drift field region (~20 kV/cm)
4. Amplification: Final electron amplification in µRWELL gain structure ➔ high electric field (>40 kV/cm)
5. Electronic Signal: Arrival of the amplified electrons to the anode creates a signal.

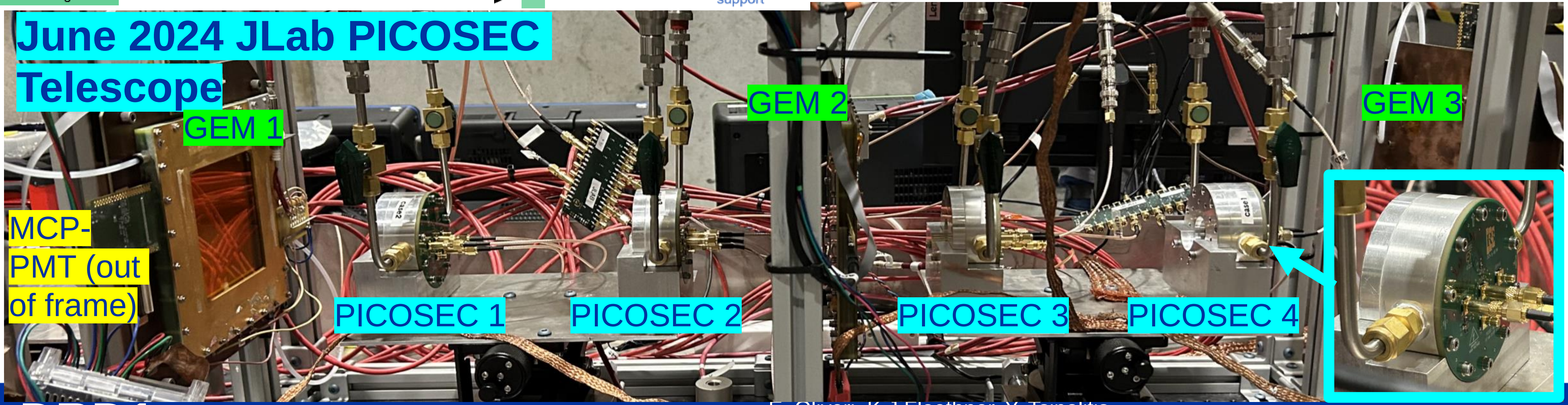
1. Cerenkov photons in radiator
2. Photoelectrons in photocathode
3. Pre-amplification in 200 µm gas
3. uRWELL amplification
4. Collection of electronic signal





10x10-channel μ-RWELL PICOSEC detector prototype

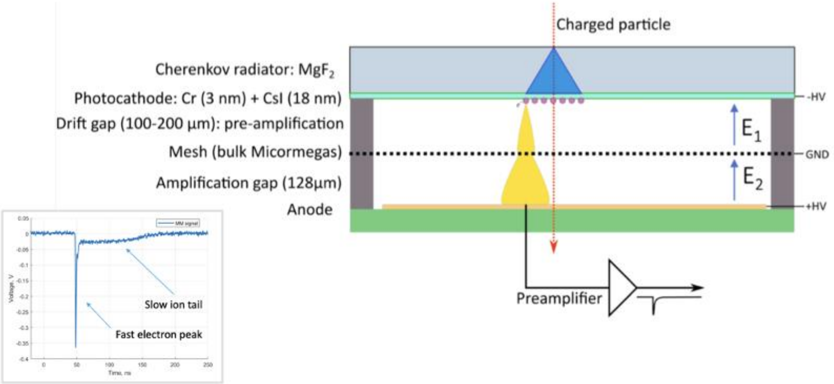




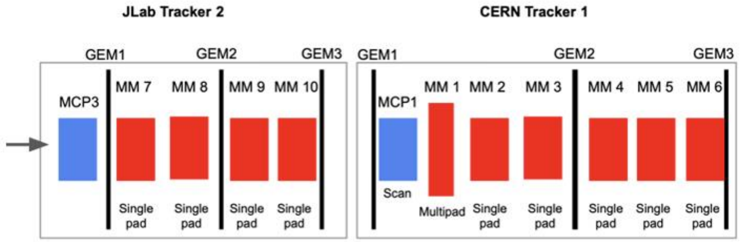
PICOSEC Micromegas precise timing

Precise timing detector concept

Cherenkov radiator coupled to semi-transparent photocathode with two-stage amplification (Micromegas or µRWELL-based)



Testbeam setup: GEM trackers + MCP-PMT time reference detectors + multiple DUTs



June 2024 test beam campaign program

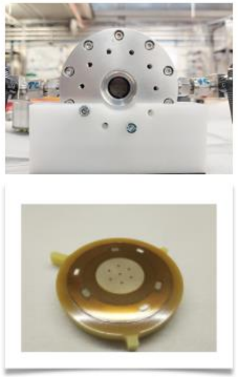
4 teams participating in data taking (CERN GDD, RBI, CEA Saclay, JLAB+SBU)

Performance studies
- Std mesh / fine mesh / electroformed mesh Micromegas performance
- Detailed uniformity maps of 10 and 15mm diameter prototypes
- Spatial resolution evaluation with higher readout granularity
- Readout electronics comparisons (8 bit vs. 12 bit digitisation, TIA, FastIC, SAMPIC)
- DLC photocathodes with graphene layer

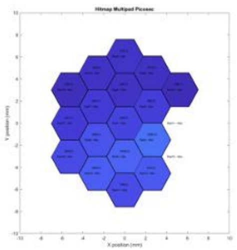
96 pad low-material budget Picosec
- Resistive multipad Micromegas

µRWELL PICOSEC in dedicated JLAB tracker
- Single channel prototypes
- 10x10 multi-channel µRWELL

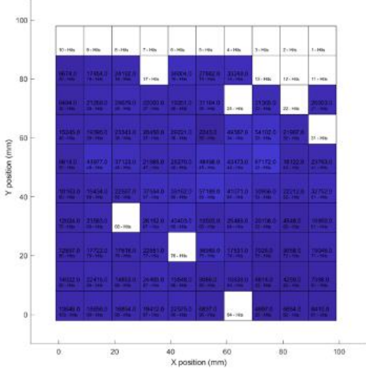
Performance studies on single pad prototypes



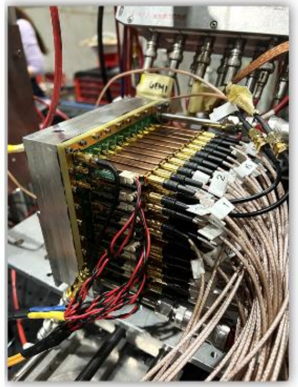
Fine readout pads for evaluation of spatial resolution



10x10 multi pad uniformity map (efficiency / gain / timing resolution)

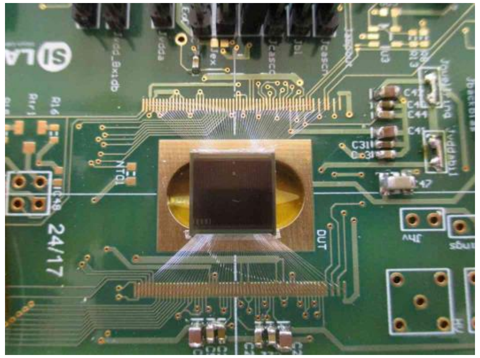


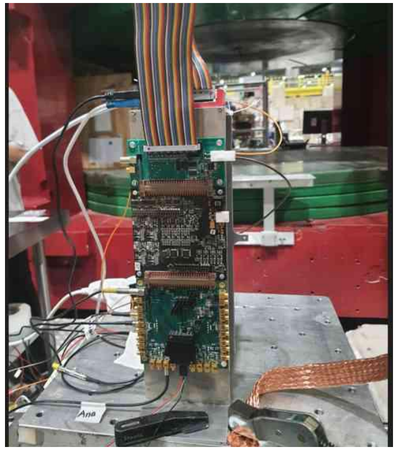
Multi-channel readout
Preamp cards + SAMPIC
FastIC multi-channel



MiniCactus

Monolithic CMOS DMAPS for timing R&D

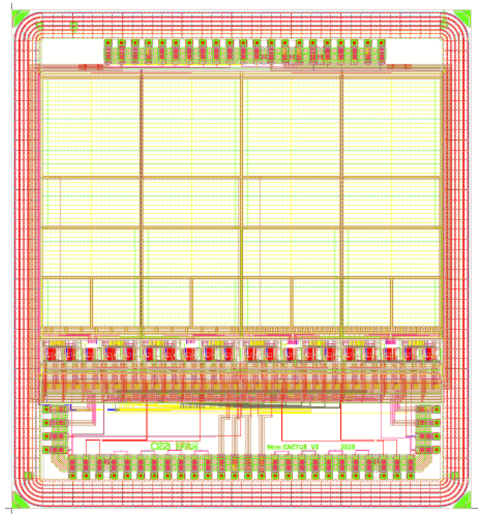


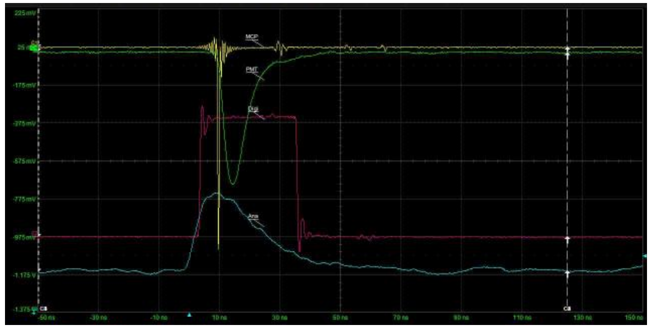


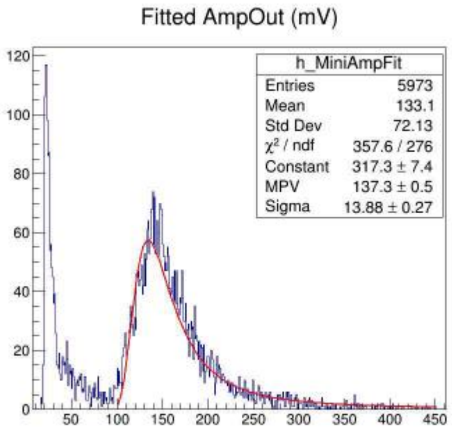
- Charge collecting diode and readout front-end on same silicon substrate
- Pixel sizes :
  0.5 mm x 1 mm , 1 mm x 1 mm and 0.5 mm x 0.5 mm diodes
- 3 different preamps (CSA1, CSA2, VPA)
- New multistage discriminator with **programmable hysteresis**
- Improved layout w.r.t. MiniCactus v1 for better mixed-signal coupling rejection

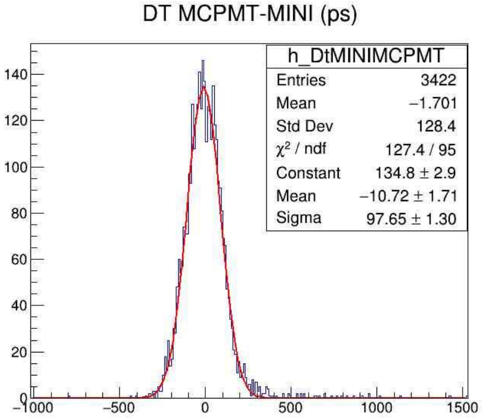
Measurements :

- HV scans (S/N, time resolution vs HV)
- Pixel scans (comparison of FE readout options)
- Three different sensor thickness (200, 175, 150 u)





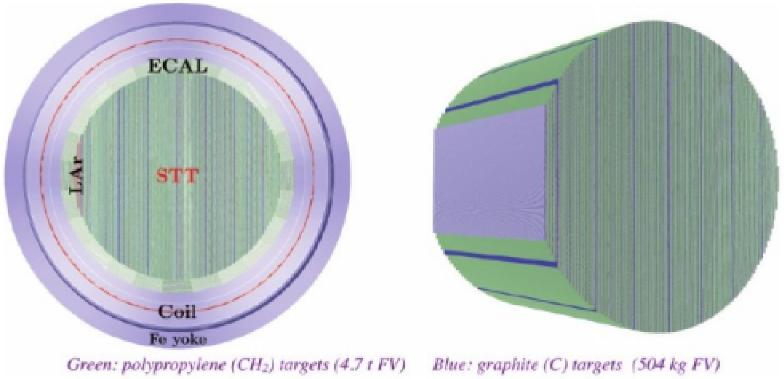




Straw Tracker R&D setup @H4 (Jul 24)

***Motivation*:**

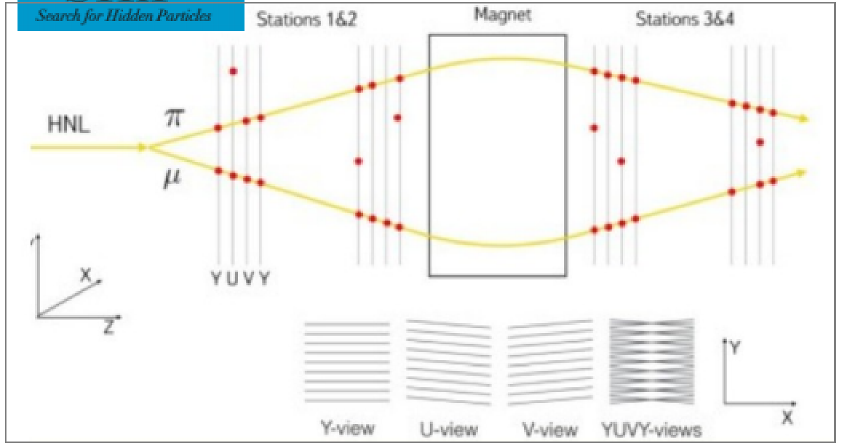
Straw Tube Tracker (STT)



Beam monitoring (with ECAL) and neutrino flux measurements

200k straws in total

Spectrometer Straw Tracker (SST)



Tracking and vertex reconstruction for HiddenSector Detector
10k channels

Also **DRD1-WP3**, COMET, SPD...

The same straw technology (ultra-sonic welding) but different geometry/material

TB measurements supporting

- **Tracker prototyping**
- **Choice of read-out electronics**

The setup:

Reference tracking:

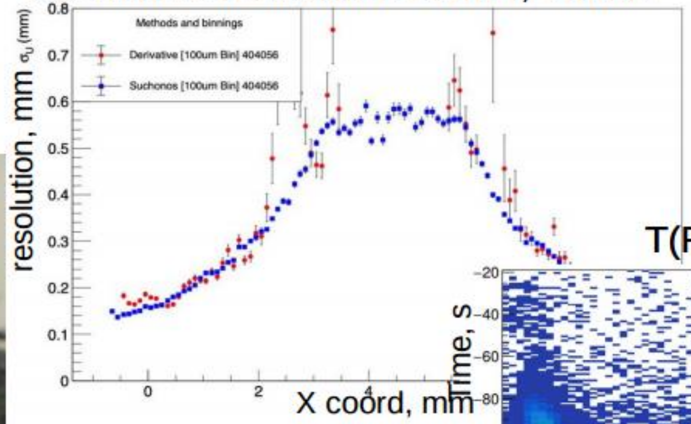
- MM detectors (250 um, 400 um) + Tiger readout (Torino University) + Timepix

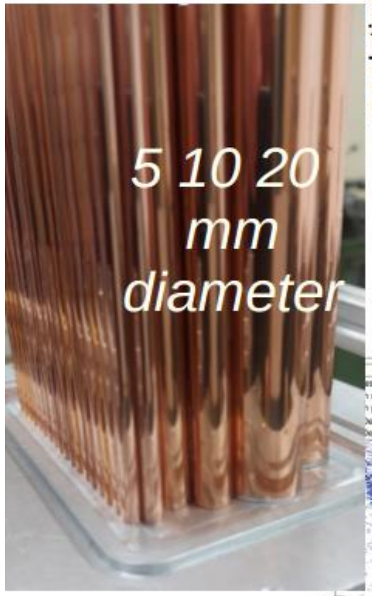
Under test: a **combined straw tracker prototype +** two types of readout: **Tiger and VMM3**

Goals:

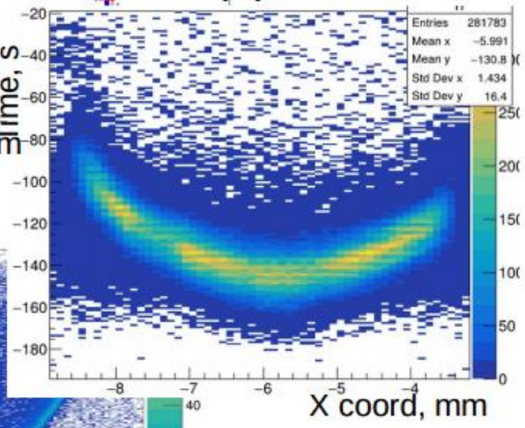
- **Stray array** (currently 2+1 straws :) **with improved geometry**
- **12 Tiger R/O with 6 new FEBs and Guffi2.0**
- New design stand-alone SHiP straw

Coordinate resolution: **10mm**, VMM3

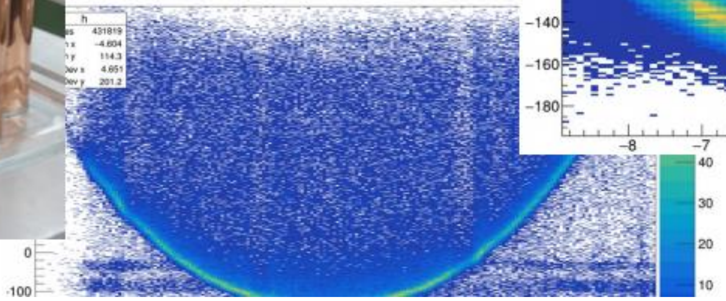


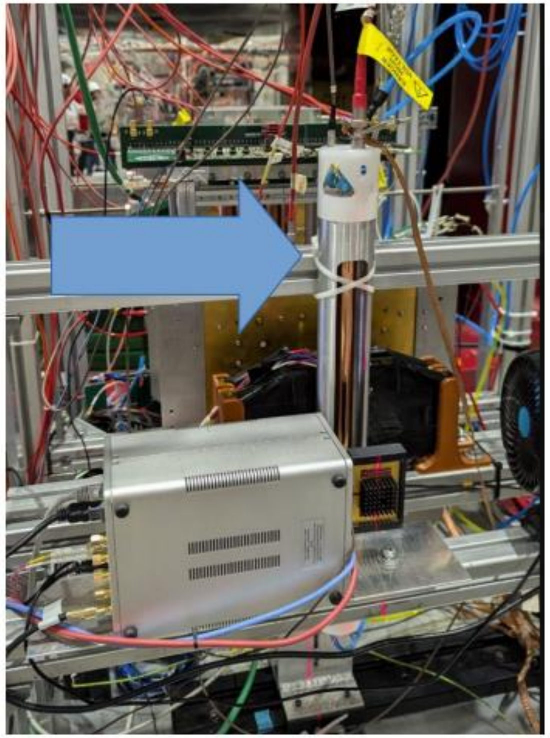


T(R), **5mm**



T(R), **20mm**





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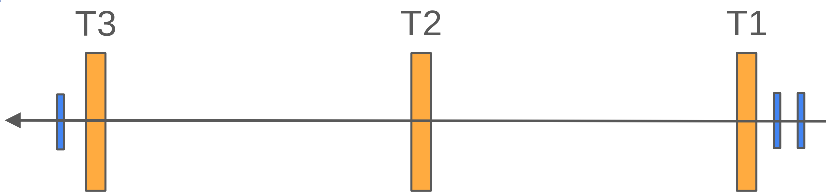
RD51/DRD1 VMM3a/SRS telescope

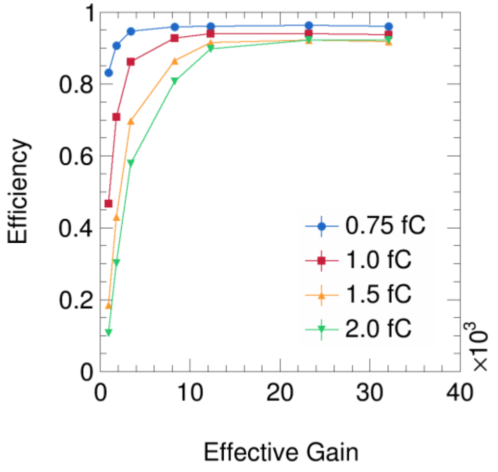


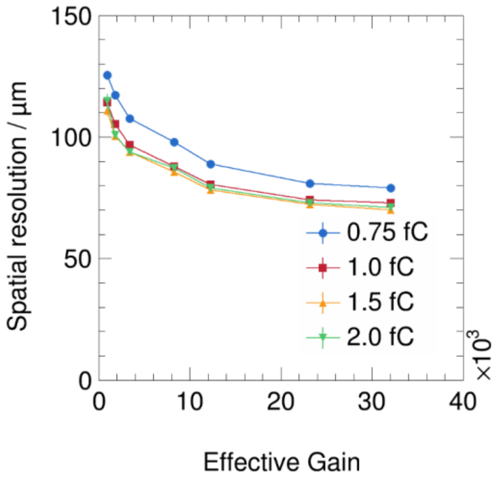
In addition to continuous self-triggered readout mode, VMM3a/SRS now also contains an externally triggered readout mode.

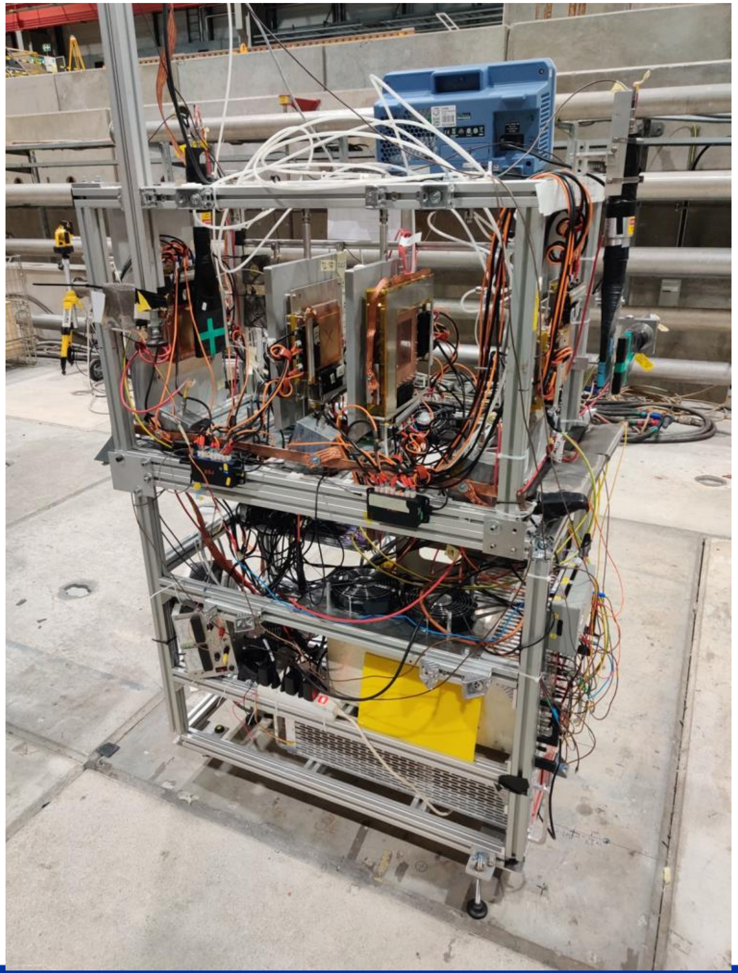
Goal of this test beam: performance characterisation of triggered mode
→ Useful for integration of front-end electronics with other telescopes and experiments

Measurements and results so far:
→ Externally triggered mode allows operation at lower thresholds (1 fC THL instead of typically 1.5 to 2.0 fC in the self-triggered mode)
→ Operation at high rates possible (> 100 kHz trigger rate), but detailed analysis still ongoing.

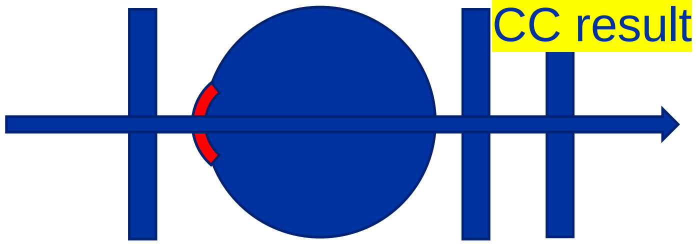
Thanks a lot to Bastien and Nikos for the excellent beam quality, especially the pion beam for the rate tests of the triggered mode





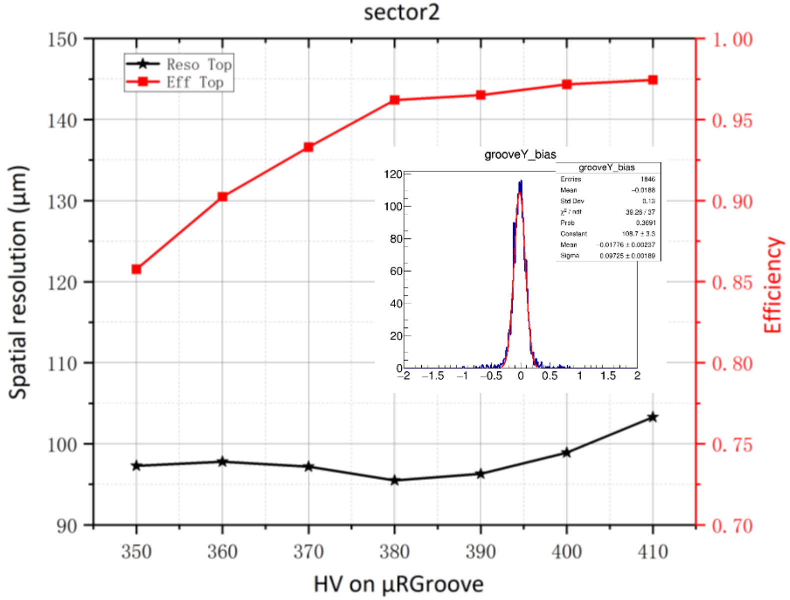


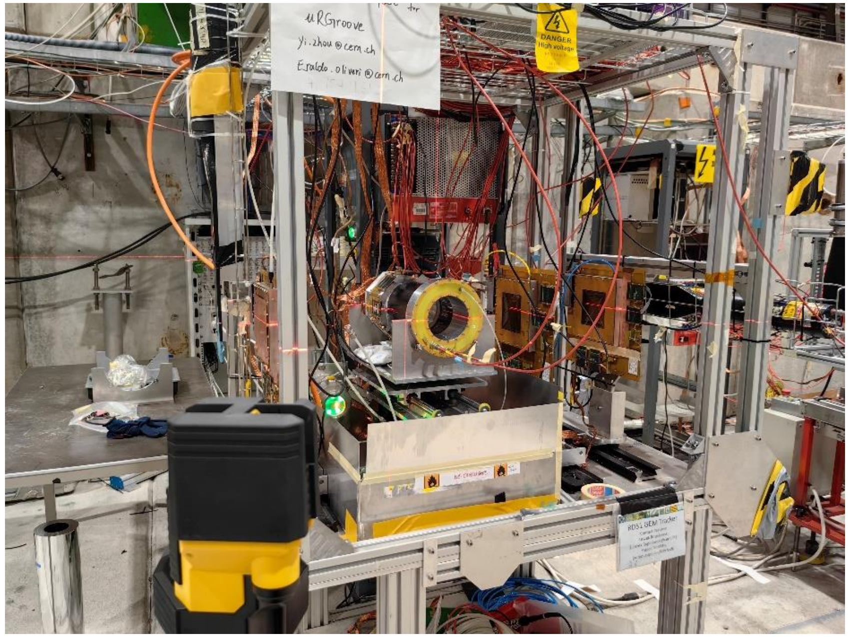
USTC beam test: Cylindrical μRGroove

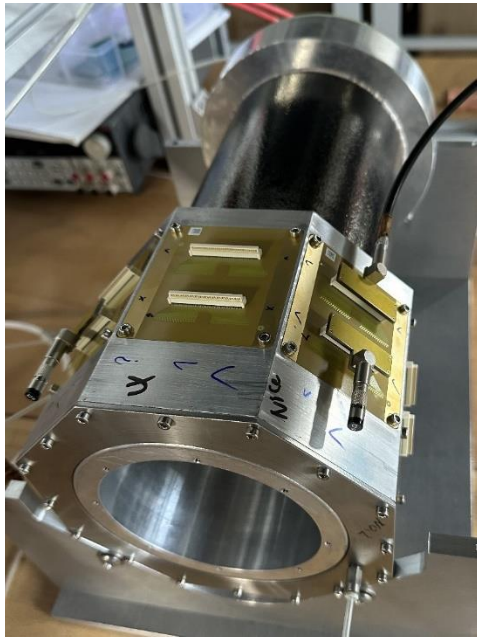


Setup：

- Gas: Ar/iC_4H_{10}(95:5) and $Ar/CO_2/CF_4$(45/15/40)
- Beam: 150GeV/c muon
- Readout from X-strip(top), V-strip grounded
- 3×MM Tracker+APV25+SRS+mmDAQ
- CC for the perpendicular and μTPC for the oblique track

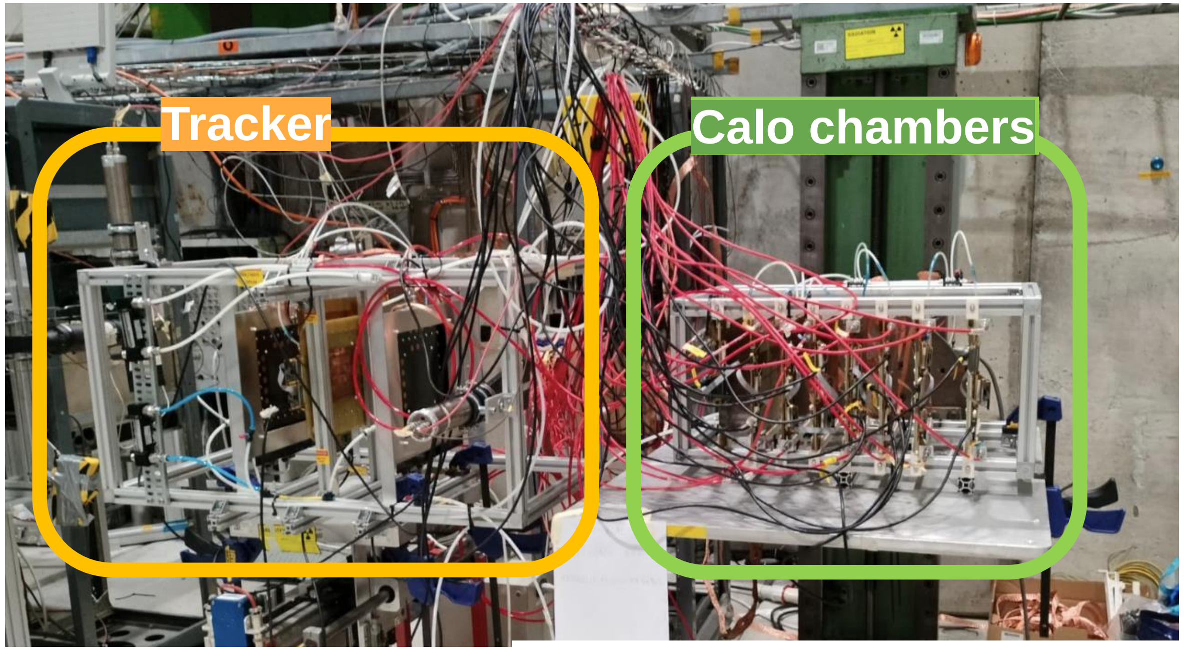






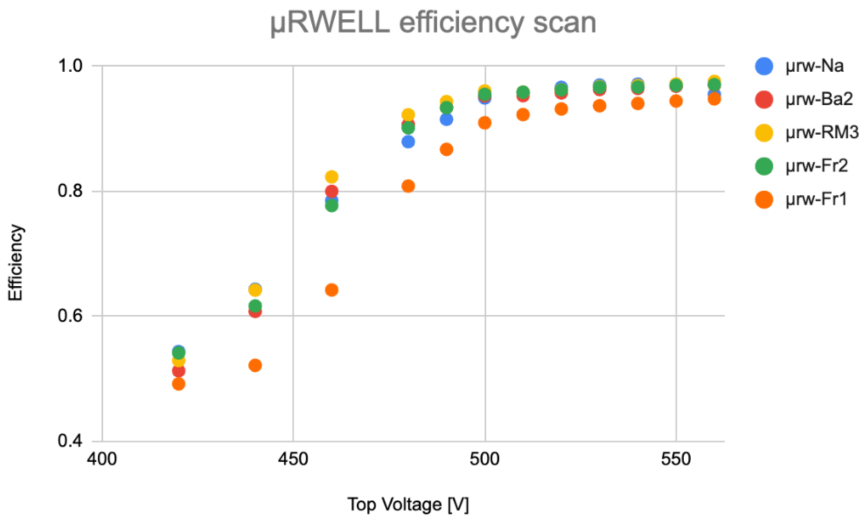
- ☐ USTC Group: Yi Zhou, Siqi He
- ✓ Spatial resolution by CC：90~100μm
- ✓ Detection efficiency >95%;
- ✓ Preliminary results of μTPC：~150μm

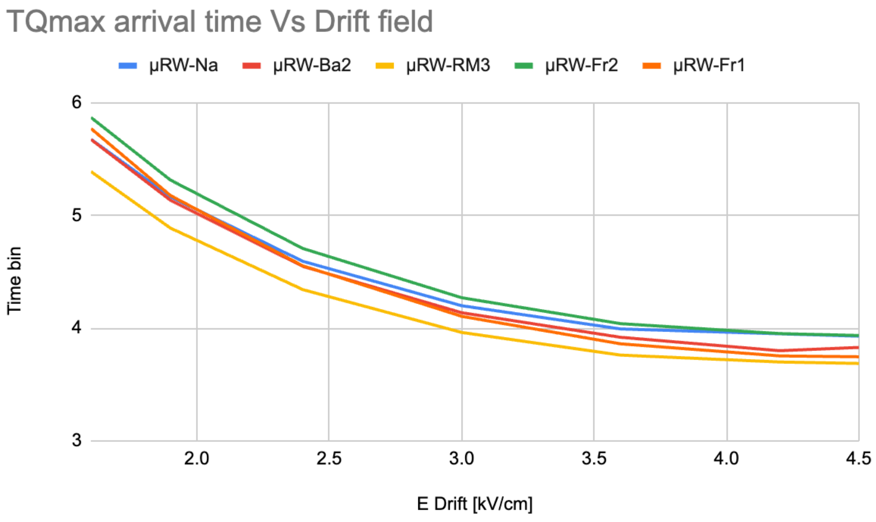
MPGDHCAL



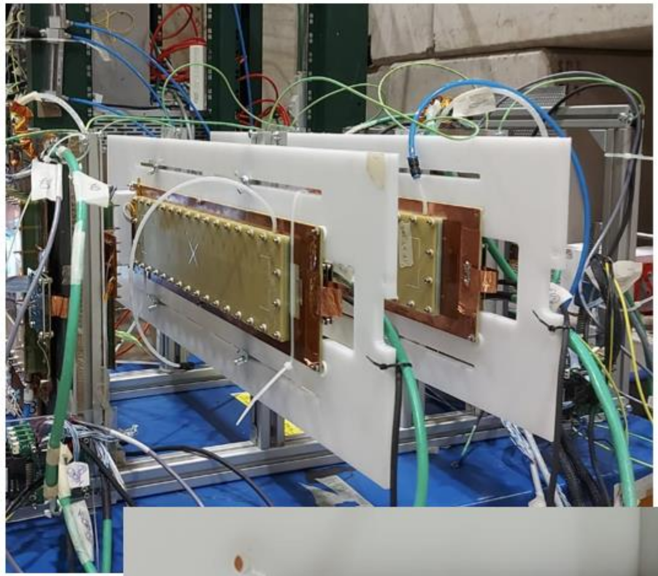
Setup:
- Tracker made of:
  - 2 Micromegas Tmm
  - 1 GEM with double readout
  - 2 Scintillators
- Calo structure:
  - all pad chambers with pad size of 1x1cm2
  - 3 Micromegas
  - 5 µRWELL

Measurements:
- muons beam:
  - HV top/mesh scan
  - Drift scan
  - X&Y scan
- pions beam:
  - rate capability





FCC-ee group testing µRWELL and TIGER electronics



Detector under test:
- 4 µRWELL w/ 40 cm strip length
  1D strip pitch of 0.4/0.8/1.2/1.6 mm

Readout under test:
- TIGER FEE
- GEMROC FPGA

Goals of the testbeam:
- Define the state of art of µRWELL+TIGER for IDEA Muon system optimization studies
- Compare the APV-25 performance studies with TIGER
- Performance in Ar:CO2 and Ar:CO2:CF4 comparison
- Collect data to compare experimental measurement and simulation

Measurements:
- Gain scan to evaluate the amplification/saturation/performance
- Drift scan to evaluate the signal collection
- Threshold scan to optimize S/N