MPGD as tracker for EIC

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On behalf of
EIC-eRD108 MPGD consortium

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The eRD108 Consortium

Project ID: eRD108

Project Name: Development of EIC ePIC MPGD Trackers.

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CEA Saclay: Francesco Bossù, Maxence Vandenbroucke
Florida Institute of Technology (FIT): Marcus Hohlmann
Istituto Nazionale di Fisica Nucleare (INFN Roma Tor Vergata): Annalisa D'Angelo
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Project Members:

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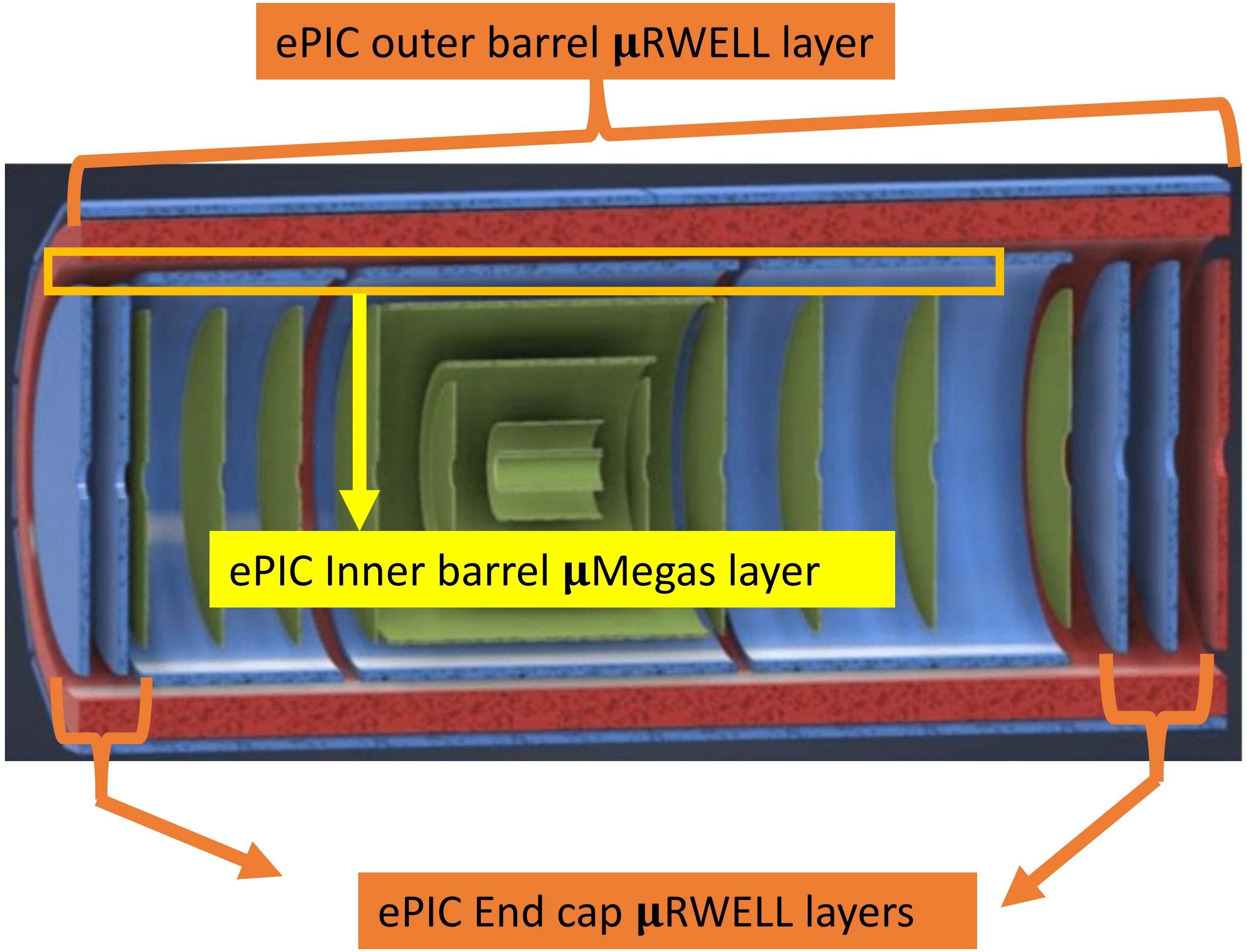
MPGD R&D program for EIC

❑ Goals of MPGD R&D in EIC

- Provide low mass, low channel count tracking detector.
- Address the issue of deterioration of spatial resolution on track angle and EXB effect.

❑ MPGD for ePIC detector in EIC

- **Inner barrel :** Low mass large size cylindrical detector based on µMegas technology .
- **Outer barrel :** Large size, low channel count planar detector based on µRWELL technology to provide additional space point for pattern recognition and to aid DIRC for PID.
- **End caps :** Disc shaped low channel count based on µRWELL technology to compliment Si hits for pattern recognition along with background rejection due to better timing resolution compared to Si MAPS tracker.



R&D on cylindrical Micromegas tracker

Motivation

- Build a full (no acceptance gaps) light-weight modular Micromegas barrel tracker to complement the silicon vertex detector

CLAS12 MM Technology (data taking since 2017)

- Compact cylindrical tracker in a B=5T solenoid, total active area ~4m^2
- Light cylindrical tiles (~0.4% X0 per layer)
- 1D readout per tile (either phi or z coord)

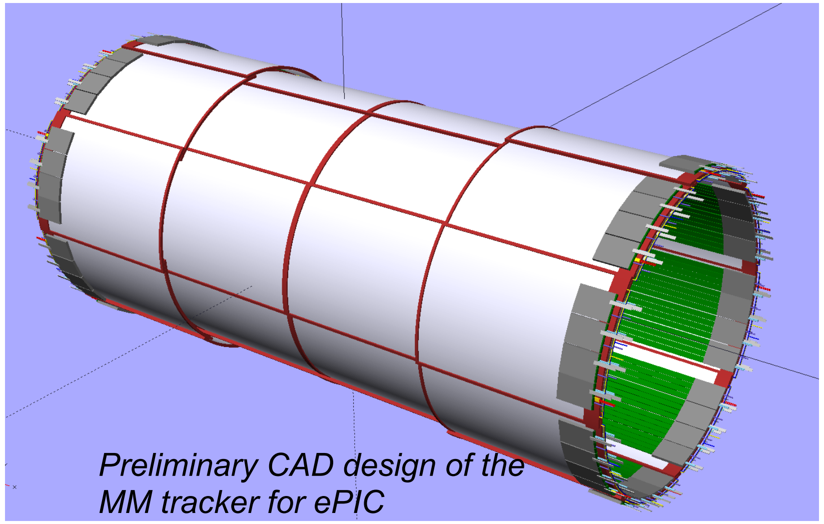
Upgrades to fit the EIC needs:

- **Simpler construction:**
    - about one module size bent at different radii
    - overlap tiles for no acceptance gaps
- **2D readout**
    - Resolutions 50 – 100 µm, on both directions with low channel counts

Objectives

- Optimization of the 2D readout for low number of channels on small prototypes
- CAD design of the full-scale prototype

CLAS12 MVT open for maintenance



Preliminary CAD design of the MM tracker for ePIC

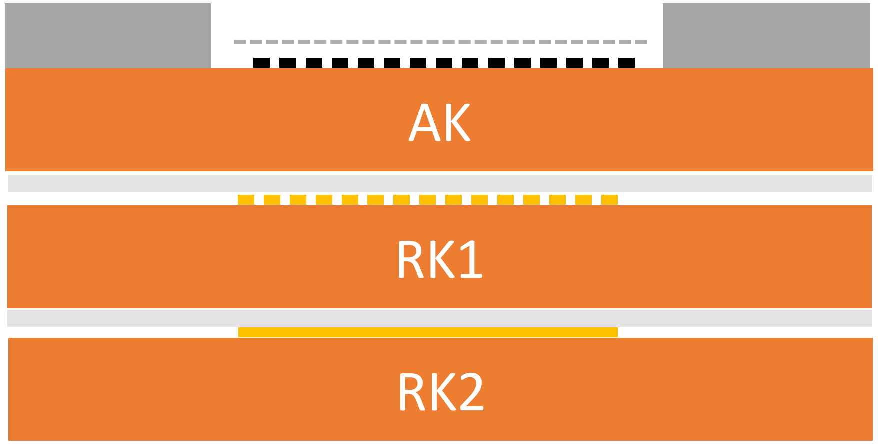
R&D on cylindrical Micromegas tracker

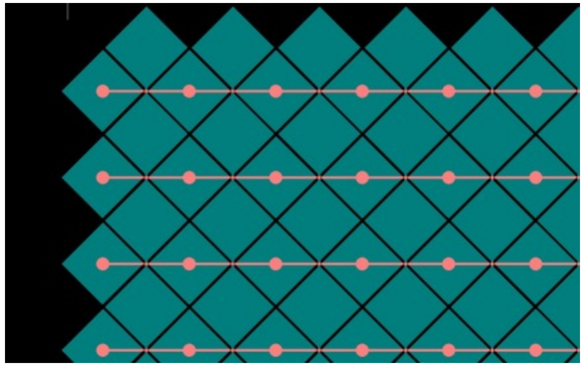
R&D 2D readout

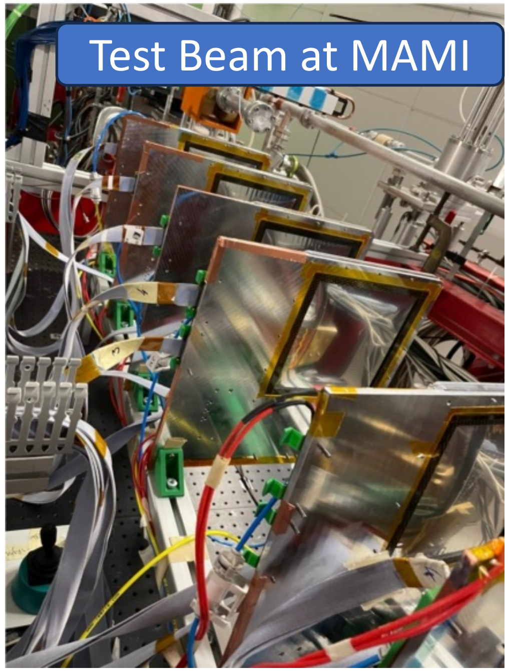
- Several small prototypes ~12x12 cm^2
- Multi stack for easy combination of different options:
  - AK: Amplification Kapton
    - Vary the resistivity, the shape, …
  - RK: Readout Kapton
    - Different strip pitch (1, 1.5, 2 mm)
    - ASACUSA pattern
- Assembly in house
  - Pressing
  - 3D printed mechanics

Testing

- ^{55}Fe Cosmic rays test bench in Saclay
- Beam test in 2023 in MAMI facility using 880 MeV electron beam.

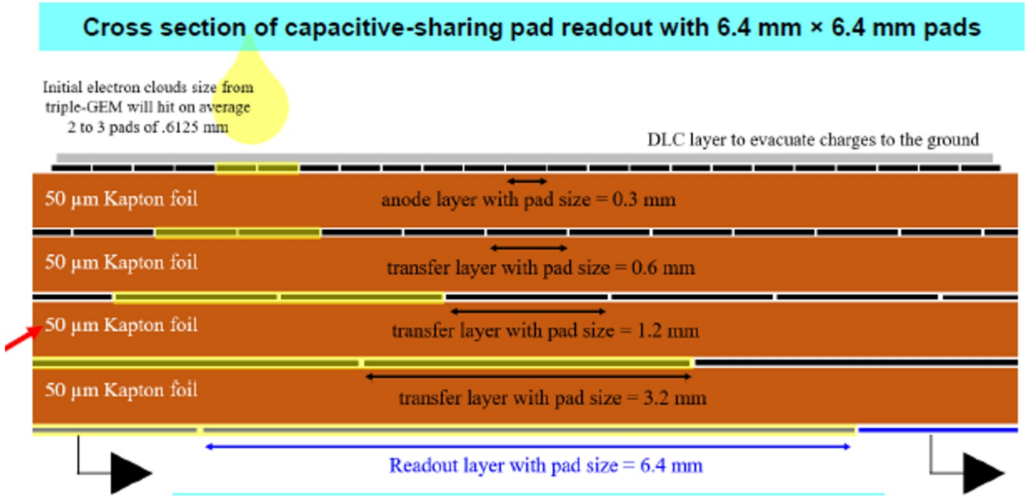




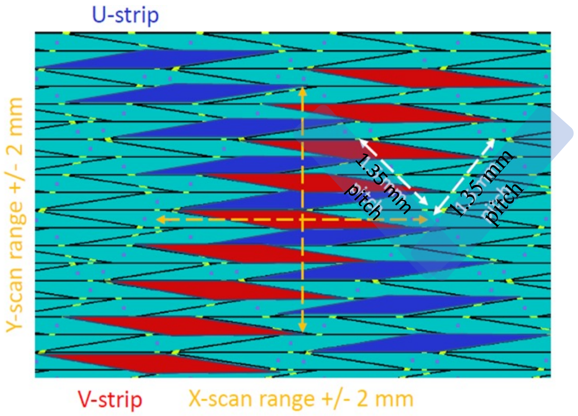


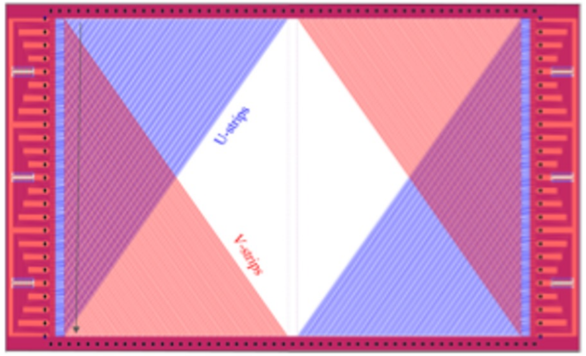
Cylindrical μ-RWELL prototype

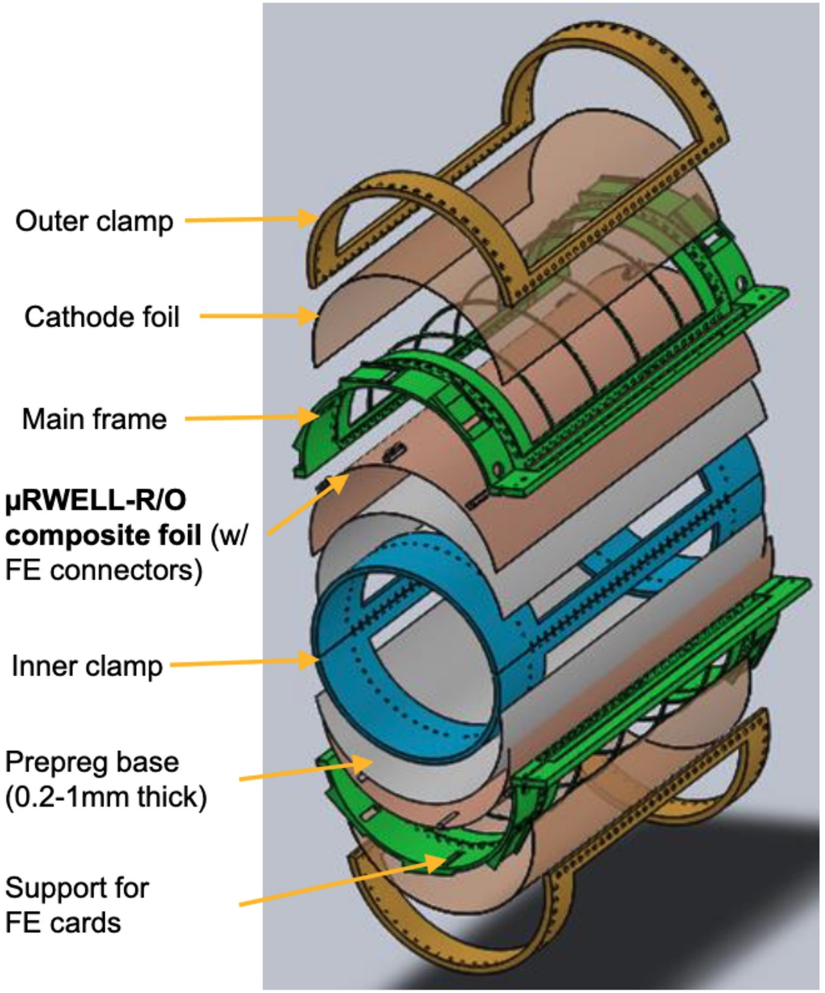
- Each half of prototype were based on capacitive sharing principle with U-V strips readout pattern
  - One half straight capacitive sharing U-V pattern by Jlab
  - Other half 2D zigzag U-V pattern by BNL



Ref: *[K. Gnanvo et al., NIM A, 1047 (2023) 167782]*







Length = 40 cm, diameter = 26 cm

- Design with only foils in the active area. Mechanical support structure was developed by FIT

Cylindrical μ-RWELL prototype

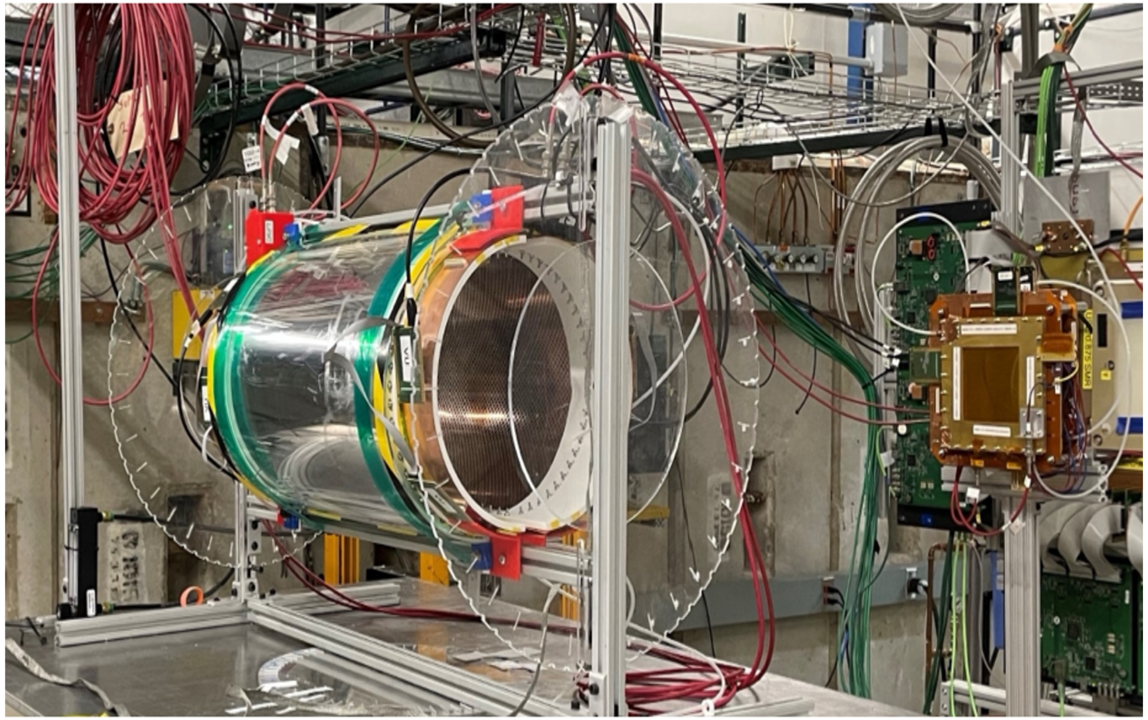
Jefferson Lab | Brookhaven National Laboratory | FLORIDA TECH

❑ June 2023 Fermilab Test beam

- Prototype was installed on rotational mount
- 120 GeV proton beam with the motivation to study spatial resolution along with efficiency and stability of detector.

❑ Unable to collect data

- Use of substantial beam time to address HV stability issue.
- FNAL shut down due to safety/security issue elsewhere onsite.
- Intending to test the prototype at the earliest test beam opportunity at Fermilab test beam facility .



Cylindrical μRWELL in 2023 Fermilab Test Beam Facility

Thin Gap MPGD tracker for EIC

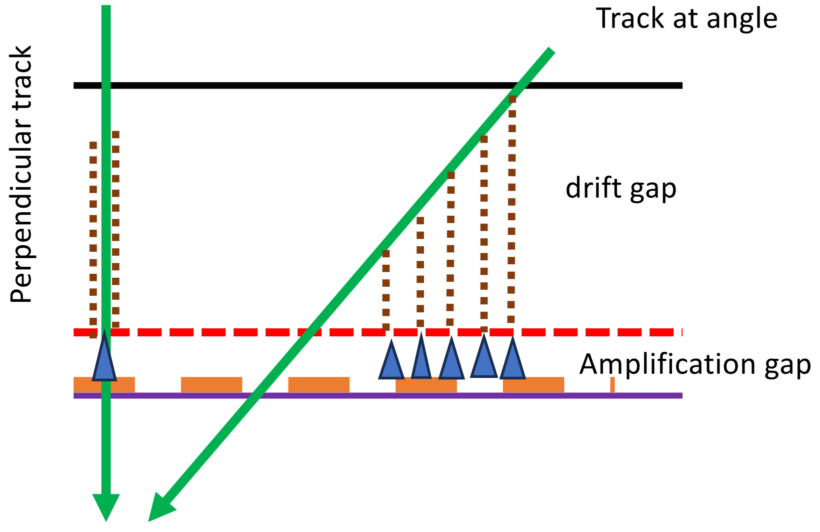
Jefferson Lab · University of Virginia · Vanderbilt University · Yale University · Temple University

❑ Current challenges with MPGD trackers

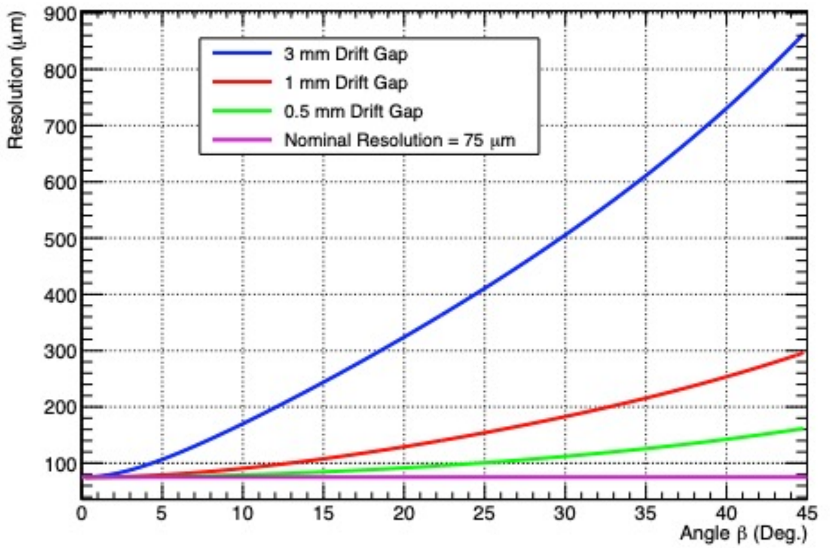
- Deterioration of spatial resolution with track angle .
- Minimization of E x B effect inside magnetic field.

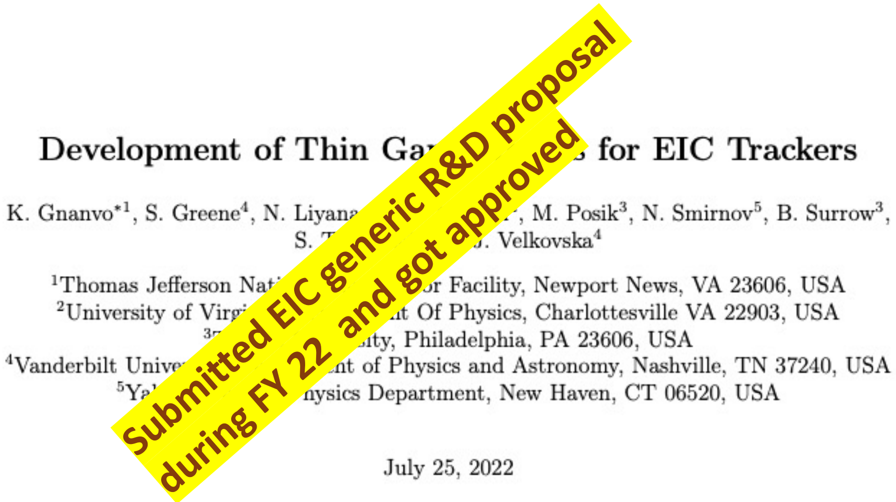
❑ Steps for addressing the above issues

- Reduce drift gap to circumvent dependence of spatial resolution on track angle.
- Use various gas mixtures to optimize the detector performance in terms of stability and efficiency.



Parametrization from *ref: EPJ Web of Conferences 174, 06005 (2018) MPGD 2015*





Development of Thin Ga... for EIC Trackers

K. Gnanvo*[1], S. Greene[4], N. Liyana... M. Posik[3], N. Smirnov[5], B. Surrow[3], S. T... Velkovska[4]

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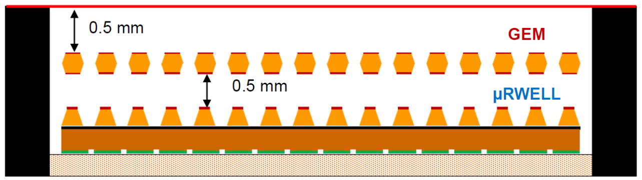
July 25, 2022

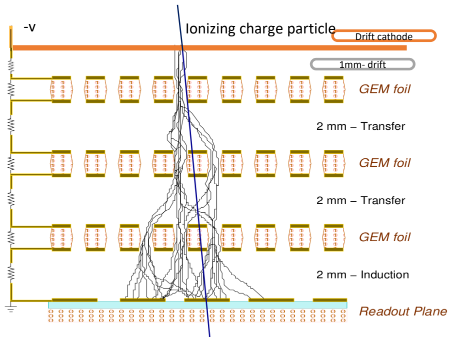
Thin Gap MPGD tracker for EIC

- Recently (June 2023) concluded Fermilab test beam.
- 10 prototypes from Jlab, UVA and VU
  - ✓ Jlab : Hybrid GEM+ **µ**RWELL with capacitive sharing X-Y strip (0.8 mm pitch) R/O board and multiple drift gap (0.5-1 mm).
  - ✓ UVA : Triple GEM with X-Y strip (0.4 mm pitch) R/O with multiple drift gaps (1-3.0 mm) and cathode based on copper-Kapton foil or copper wire mesh.
  - ✓ VU : Hybrid GEM + **µ**RWELL and GEM + **µ**Megas with 2D zigzag (1.6 mm pitch) R/O board with 1 mm drift gap.
- Rotation angle from 0 degree to +/- 45 degrees .
- 2 trackers upstream and 2 trackers downstream on a fixed separate stand.
- Data taken using both $ArCO_2$ (80:20) and $KrCO_2$(80:20) gas mixtures at different track angles.

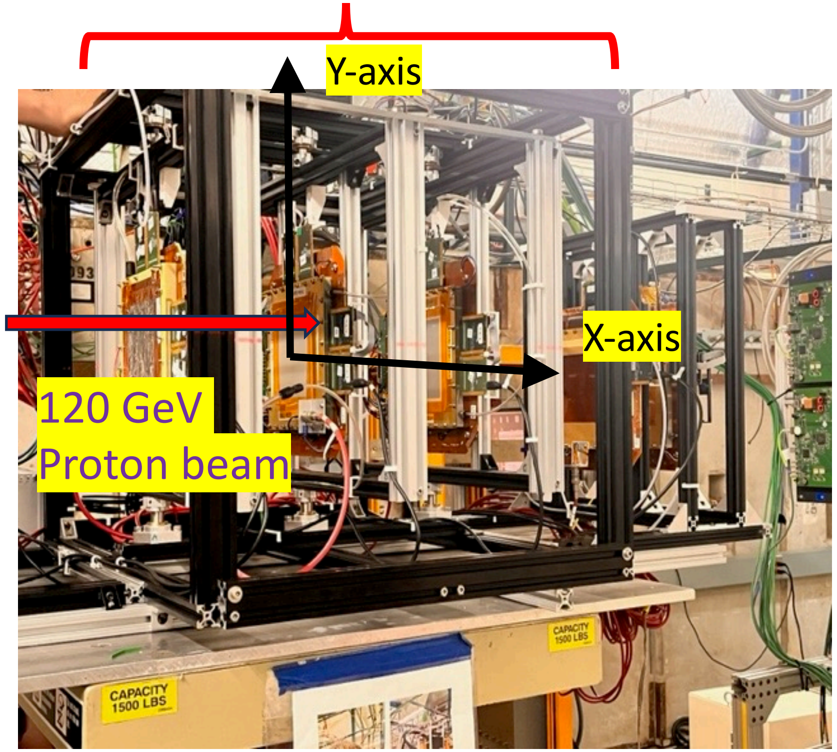
hybrid amplification GEM-µRWELL with 0.5 mm drift gap



Thin gap triple GEM



Prototypes on rotating frame



Thin Gap MPGD tracker for EIC

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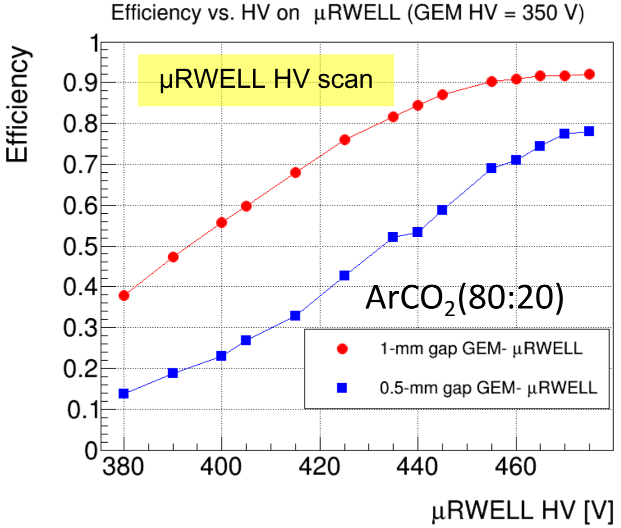
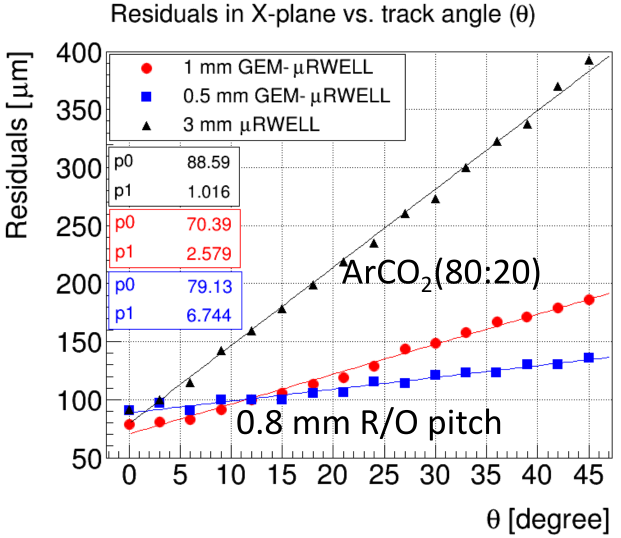
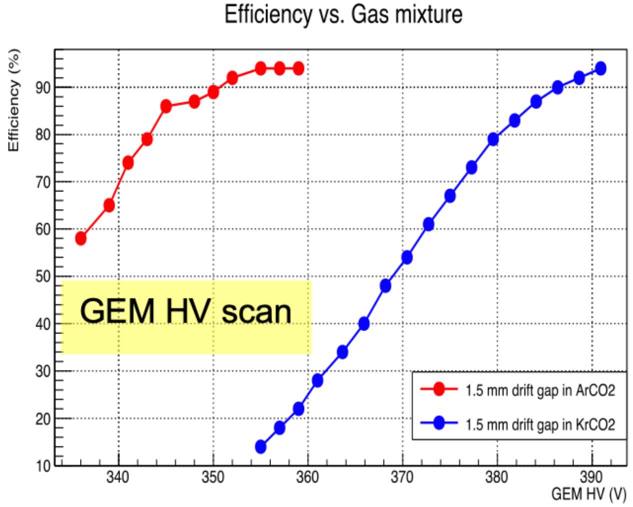
Preliminary results from ongoing analysis of June 2023 Fermilab test beam data

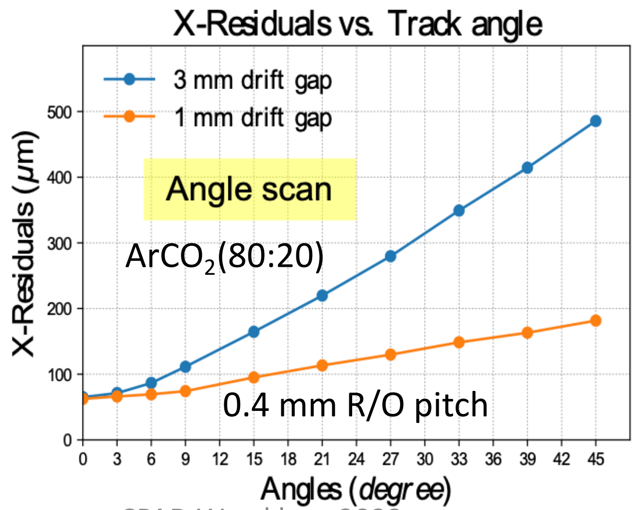
Jlab prototype



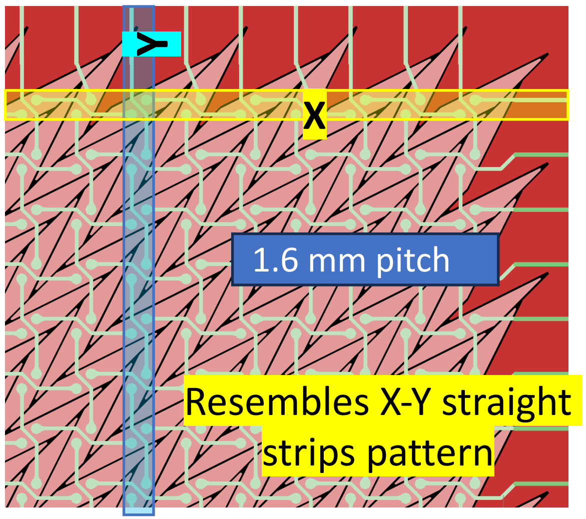


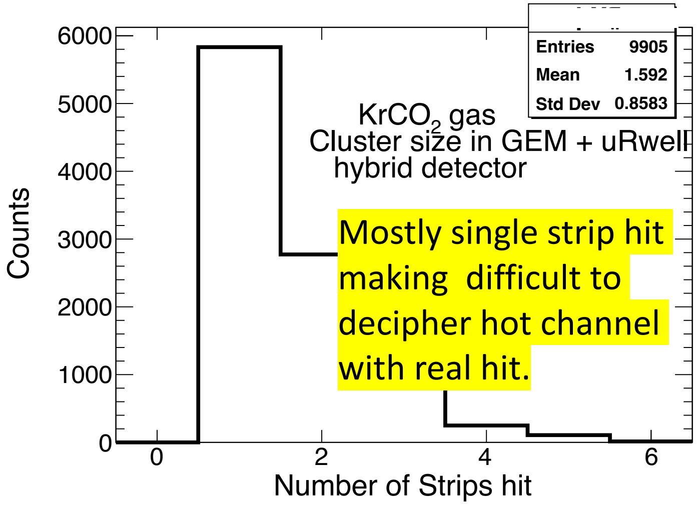
UVA prototype





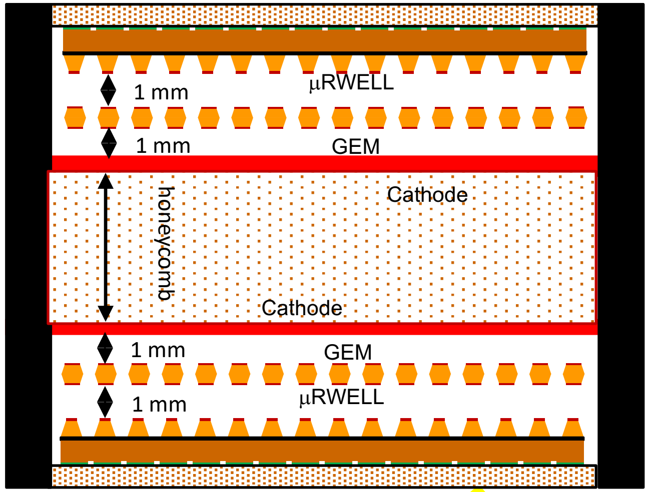
VU prototype

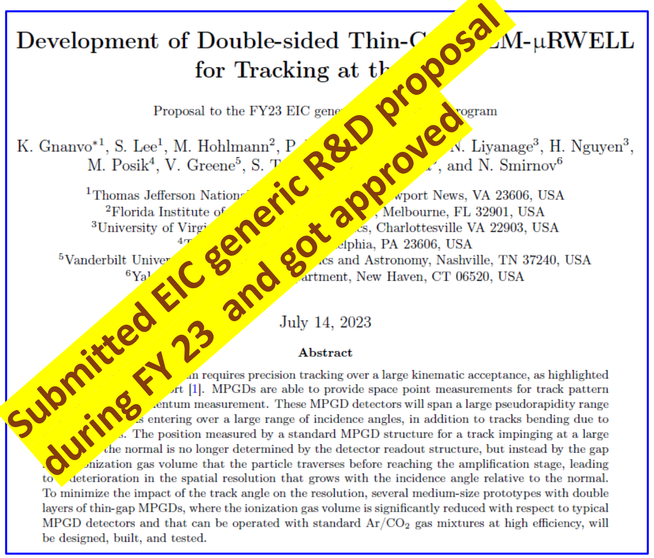




Double-sided Thin-Gap MPGD tracker for EIC-FY23

- **Double-sided thin-gap GEM-µRWELL hybrid**
  - Double amplification with hybrid GEM-µRWELL is the most promising approach for thin-gap MPGD
  - With double-sided, we recover full detector efficiency
- **Operation with Argon based gas mixture**
  - Affordability and availability than Xe / Kr
  - Improved timing resolution (~ 2 ns) for 0.5 mm gap
- **Large-area, low-mass and compact detector modules**
  - Outer tracker layer / disc of EIC central tracker
  - Large acceptance muon chambers
  - High performance trackers in high-η and FF regions





Development of Double-sided Thin-G…M-µRWELL for Tracking at th…

Proposal to the FY23 EIC gene… …rogram

K. Gnanvo*[1], S. Lee[1], M. Hohlmann[2], P. … N. Liyanage[3], H. Nguyen[3], M. Posik[4], V. Greene[5], S. T… and N. Smirnov[6]

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July 14, 2023

Abstract

…n requires precision tracking over a large kinematic acceptance, as highlighted …rt [1]. MPGDs are able to provide space point measurements for track pattern …entum measurement. These MPGD detectors will span a large pseudorapidity range …s entering over a large range of incidence angles, in addition to tracks bending due to … The position measured by a standard MPGD structure for a track impinging at a large … the normal is no longer determined by the detector readout structure, but instead by the gap …nization gas volume that the particle traverses before reaching the amplification stage, leading to deterioration in the spatial resolution that grows with the incidence angle relative to the normal. To minimize the impact of the track angle on the resolution, several medium-size prototypes with double layers of thin-gap MPGDs, where the ionization gas volume is significantly reduced with respect to typical MPGD detectors and that can be operated with standard Ar/CO_2 gas mixtures at high efficiency, will be designed, built, and tested.

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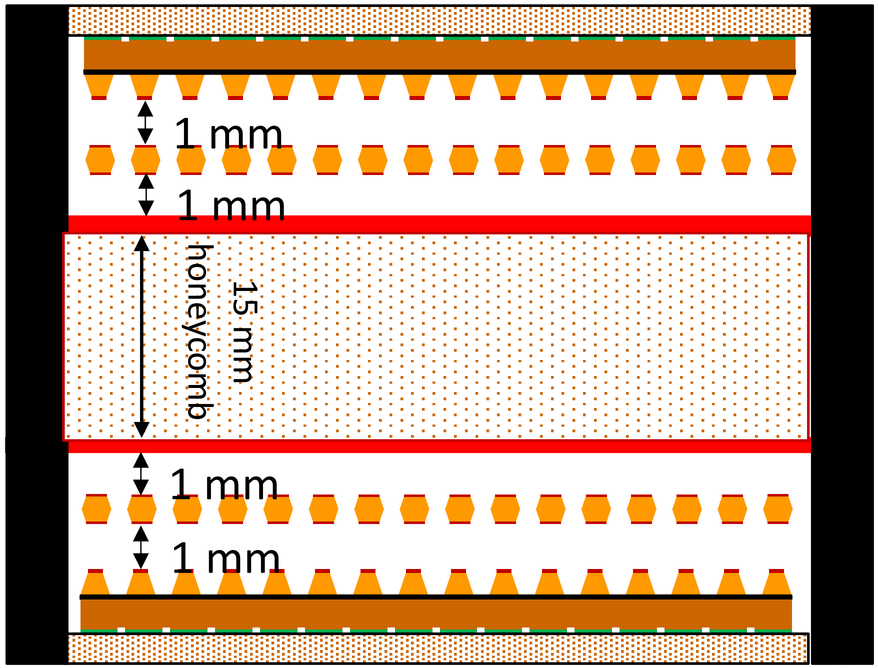
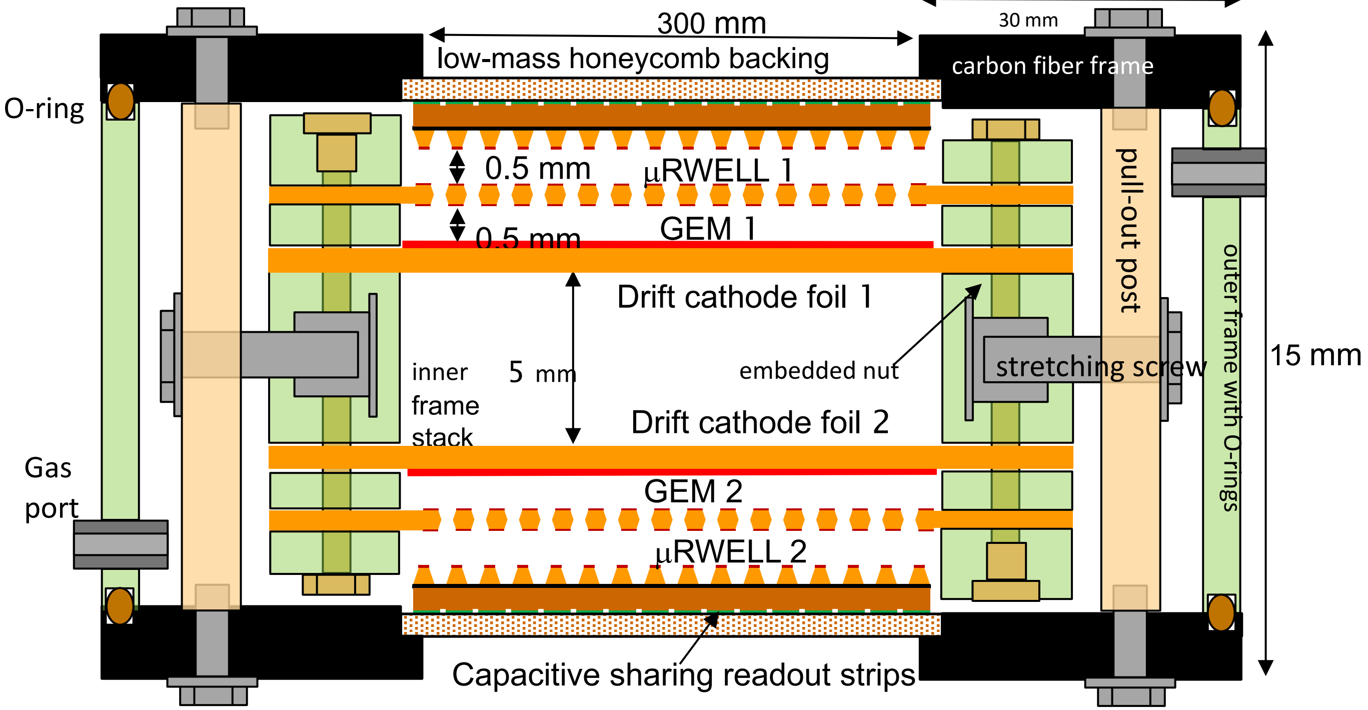
Double sided Thin Gap MPGD tracker for EIC-FY23

- ❑ Development of low mass, low channel count, double sided thin-gap 30 cm x 30 cm active area GEM-µRWELL hybrid trackers.
- ❑ Collaborative effort from multiple Institutions.
  - Design of two capacitive sharing R/O with different pattern (X-Y and UV) : Jlab and VU
  - Design of honeycomb support structure and GEM foil : UVA
  - Design of frame structure for GEM and drift foil stretching allowing to adjust foil tension during assembly of detector : FIT
  - Final assembly at UVA : FIT, Jlab, TU, UVA, VU, YU



Conceptual design by Florida Inst. of Technology



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Conclusions

- Substantial R&D is in progress related to design of mechanical structure of large size cylindrical **μ-RWELL** and planar **μ-RWELL .**
- Promising R&D results from cylindrical large size Micromegas and awaiting results from 2023 test beam.
- Promising preliminary result from June 2023 Fermilab test beam for thin gap hybrid **(GEM + μ-RWELL)** and thin gap triple GEM detector showing effect of track angle on spatial resolution can be mitigated by reducing drift gap of detector (improvement in spatial resolution by a factor of 3 as compared to 3 mm drift gap detector).
- Approved FY23 generic R&D funding for double sided thin gap MPGD tracker will mitigate using expensive heavier gas (Xe/Kr) along with providing tracklet information.
- Future R&D plans on large size thin gap MPGD tracker will provide answers for detector stability (both mechanical and High Voltage).