Double Thin gap GEM-μRWELL Hybrid (DTGH) Prototypes

CERN DRD1 20206 Test Beam

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Development of Double Thin-Gap GEM-µRWELL Hybrid (DTGH) Detectors

Development of Double-sided Thin-Gap GEM-µRWELL for Tracking at the EIC

Proposal to the FY23 EIC generic detector R&D program

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Abstract

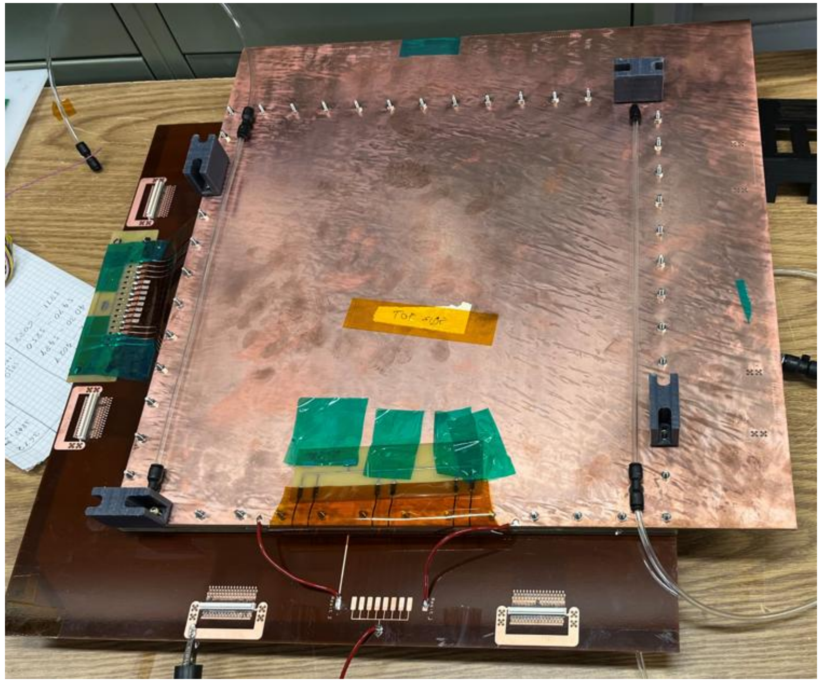
The EIC physics program requires precision tracking over a large kinematic acceptance, as highlighted in the EIC Yellow Report [1]. MPGDs are able to provide space point measurements for track pattern recognition and momentum measurement. These MPGD detectors will span a large pseudorapidity range and will see tracks entering over a large range of incidence angles, in addition to tracks bending due to magnetic fields. The position measured by a standard MPGD structure for a track impinging at a large angle from the normal is no longer determined by the detector readout structure, but instead by the gap in the ionization gas volume that the particle traverses before reaching the amplification stage, leading to a 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.

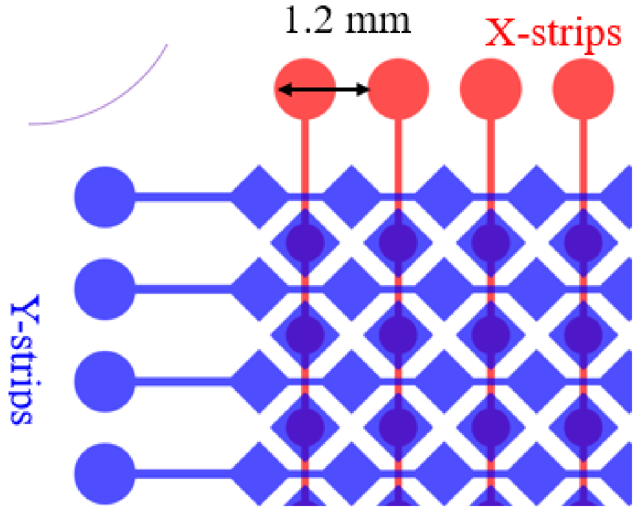
- **Double-sided thin-gap GEM-µRWELL hybrid**
  - Continuation of FY22 Thin Gap MPGD development
  - Double amplification with hybrid GEM-µRWELL is a promising approach for thin-gap MPGD
  - Double-sided allows full detector efficiency
  - Minimize Lorentz angle effect on resolution in B field
- **Operation with Argon based gas mixture**
  - Affordability and availability than Xe / Kr
  - Reduction of background rate in the detector
  - Better 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

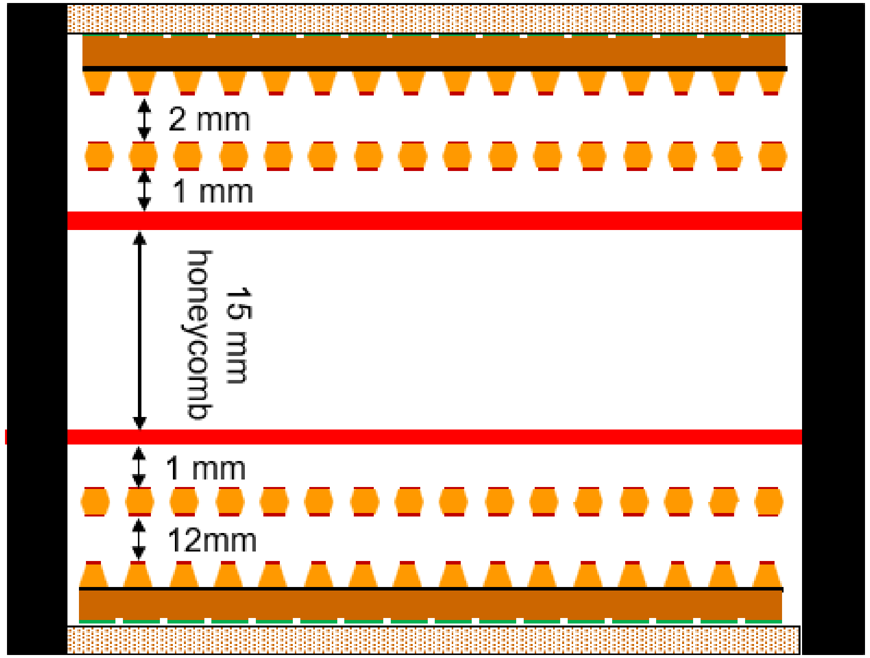
https://wiki.bnl.gov/eic/index.php?title=File:20230714_eRD_tgMPGD_Proposal_FY23_Final.pdf

Medium size (30 cm × 30 cm) DTGH prototype with X-Y strip readout

- Double Thin-Gap GEM-µRWELL Hybrid detectors (DTGH) with capacitive-sharing readout.
- One side of the DTFH is labelled DTGH1 and the second DTGH2
- 1.2 mm pitch X-Y strip with ASACUSA pattern with 3 capacitive sharing layer
- Applications: Large area muon tracking detector, EIC Barrel Outer Tracker (BOT)



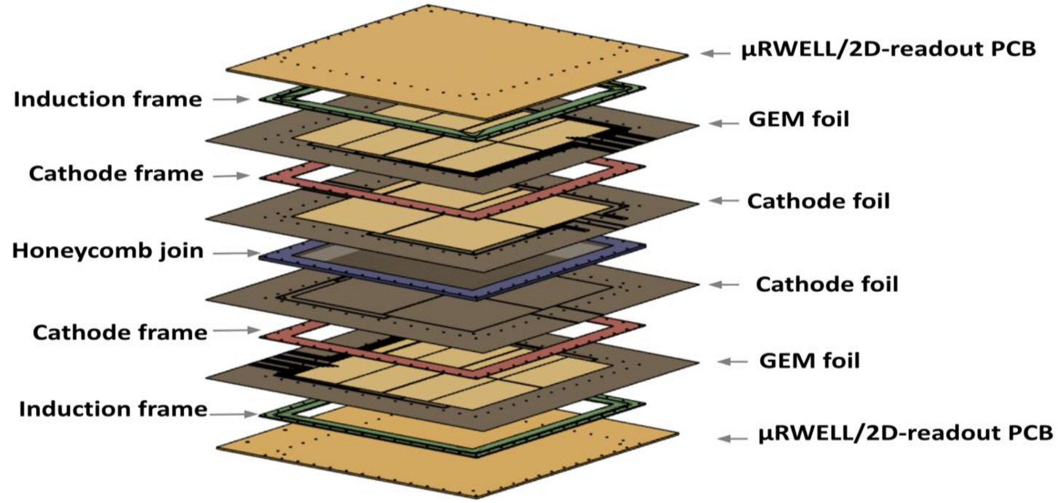


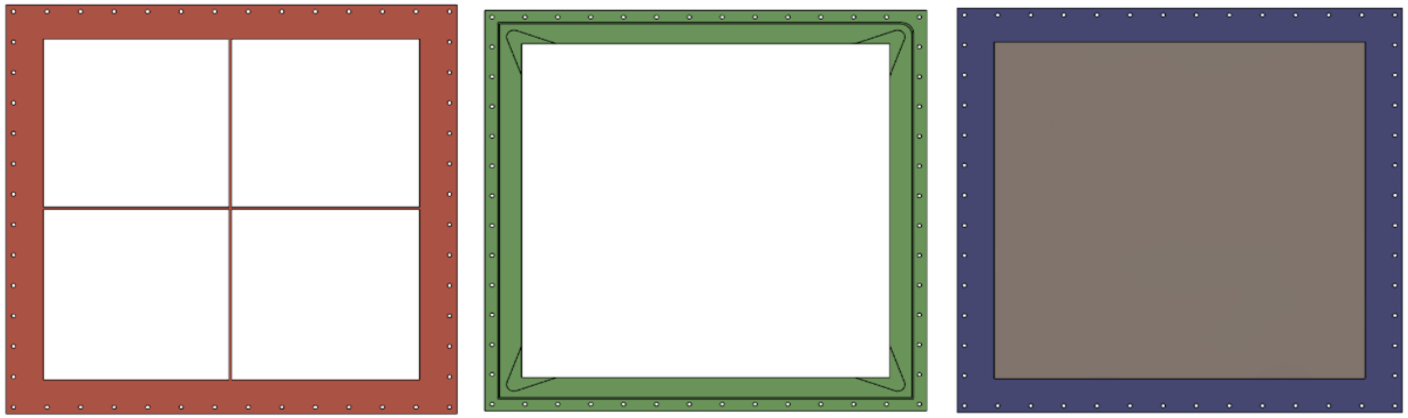


- Design of GEM, cathode & mechanical done @ UVa
- Design of µRWELL PCB + capaSh readout @ JLab
- Assembly of prototype @ UVa (2025)
- HV tests @ UVa (2025 / 2026)
- Plan tests in beam at JLab and at CERN

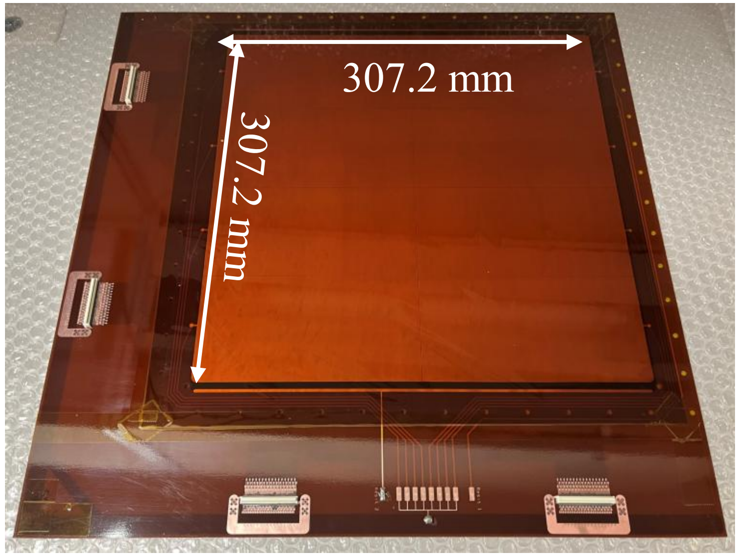
https://www.jlab.org/sites/default/files/eic_rd_prgm/files/2023_Proposals/20230714_eRD_tgMPGD_Proposal_FY23_Final_EICGENRandD2023_16.pdf

Medium size (30 cm × 30 cm) DTGH prototype with X-Y strip readout

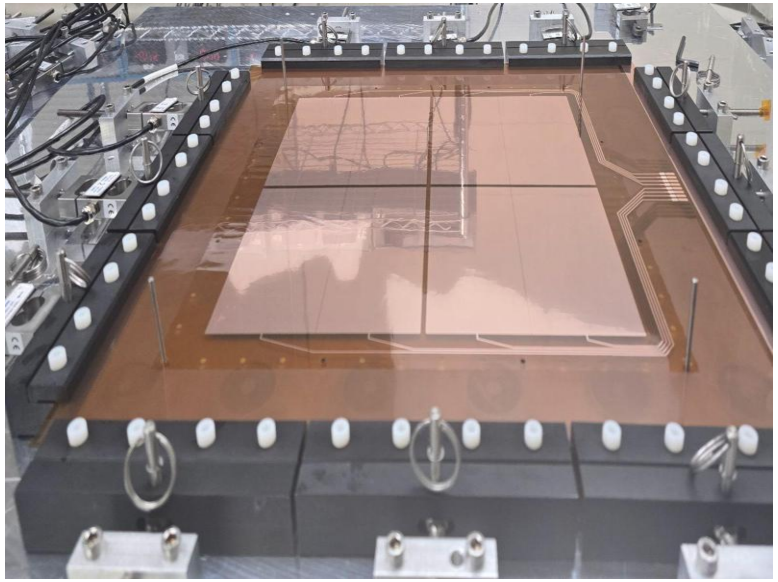




: CAD designs of drift frame (*left*), induction frame (*middle*) and honeycomb-join frame



µRWELL + capaSh RO PCB



GEM foil on mechanichal stretcher

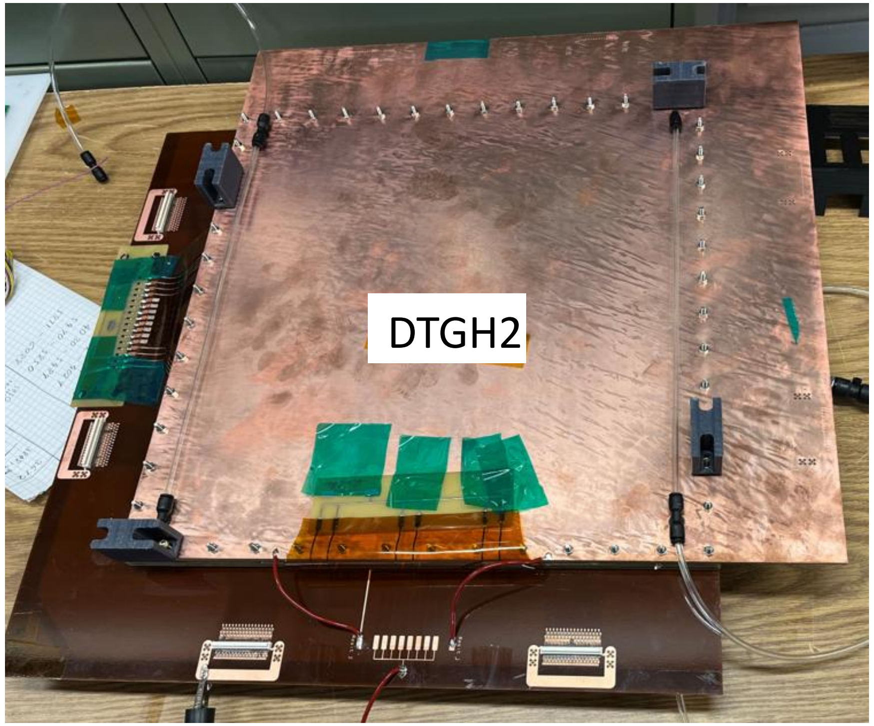
µRWELL parameters the DTGH prototype

- We purchased 3 µRWELL / RO PCBs from CERN each with a sligly different parameters
- PCB #3 used for DTGH1 has a higher DLC surface resistivity while and PCB #2 used for DTGH2 has lower resistivity
- Observe a big difference in detector signal amplitudes for the two sides of the prototypes
  - indicating a big impact of the DLC resistivity on signal amplitude
  - This also impact the maximum voltage before leakage current starts increasing

<u>DTGH1</u> <u>with PCB #3</u>

µRWELL

- DLC = 70 - 95 MOhm
- Hole parameters
  - Pitch = 100 µm
  - Outer Diam. = 70 µm
  - Inner Diam. = 40-50 µm



<u>DTGH2</u> <u>with PCB #2</u>

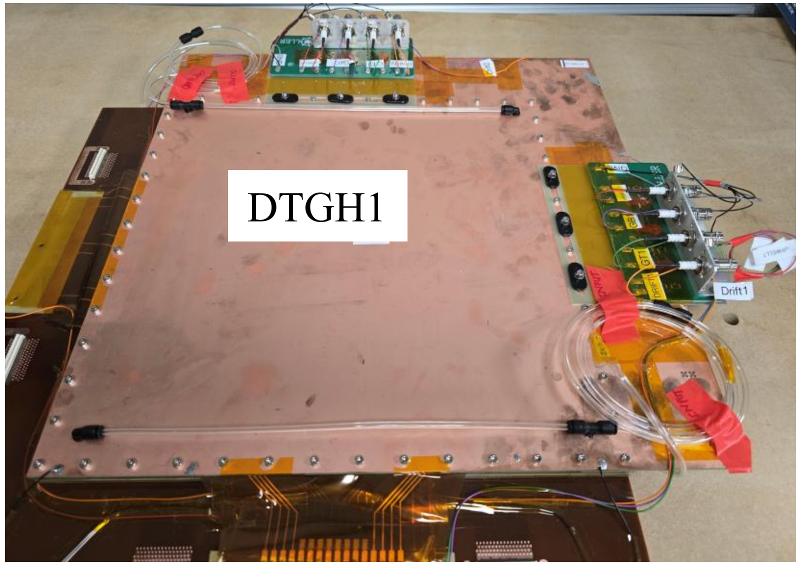
µRWELL:

- DLC = 40 - 55 MOhm
- Hole parameters
  - Pitch = 100 µm
  - Outer Diam. = 70 µm
  - Inner Diam,= 40-50 µm

HV test in N2 @ UVa of the µRWELLs

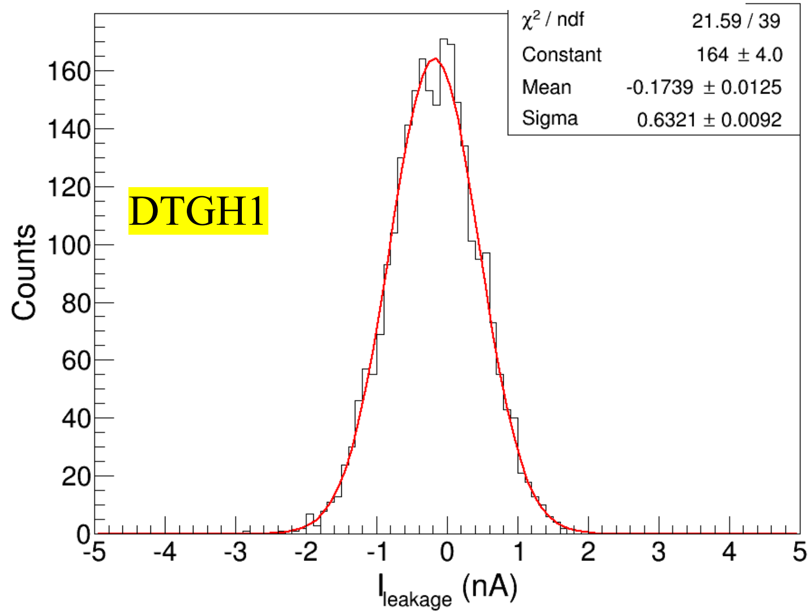
HV test performed with Nitrogen gas flowing through the detector

- µRWELL voltage scan with HV from 0 to 600 V by step of 10 or 20 V
- Leakage current measured with picoammeter connected to the LabView DAQ program ➔ 2 min for each HV setting
- Average leakage current @ 600 V between 0.5 and 1 nA at each HV setting well below our acceptance criteria of a few nA
  - DTGH1 with higher DLC resistivity has a larger leakage current (~0.6 nA) than DTGH (~0.5 nA)
  - DTGH1 also developed one spark at 600V (lower DLC resistivity?) ➔ current spike then slowly goes down to baseline

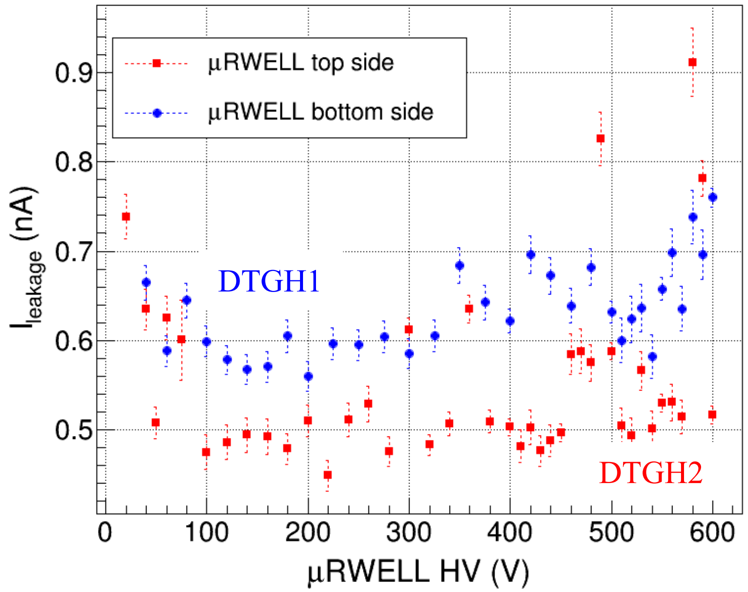


DTGH prototype under test @ UVa

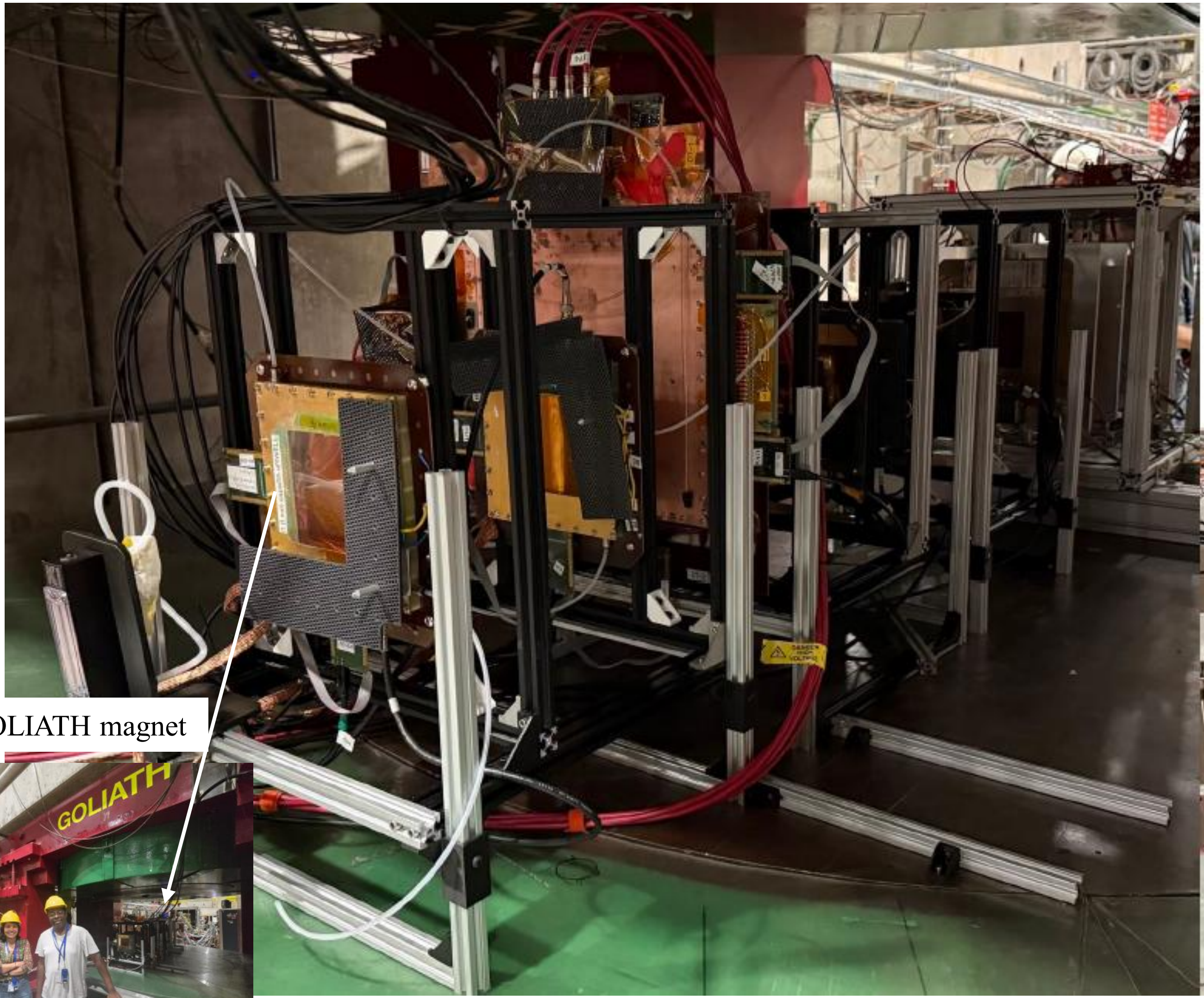
Leakage current distribution @ 500 V



Average leakage current vs. µRWELL HV



DTGH Setup @ CERN Test Beam



Inside GOLIATH magnet

Std µRWELL
Tracker 2

Triple GEM
Tracker 1

DTGH
DUT 1/2

Thin gap hybrid
Tracker 3

Thin gap hybrid
Tracker 4

Test plans

150 GeV/c Muon beam runs with $ArCO_2$ and $ArCO_2iC_4H_{10}$

- µRWELL voltage scan
- GEM voltage scan
- Transfer field scan in the gap between GEM and µRWELL
- Drift field in the gap between the cathode and the GEM

Pion beam with $ArCO_2iC_4H_{10}$

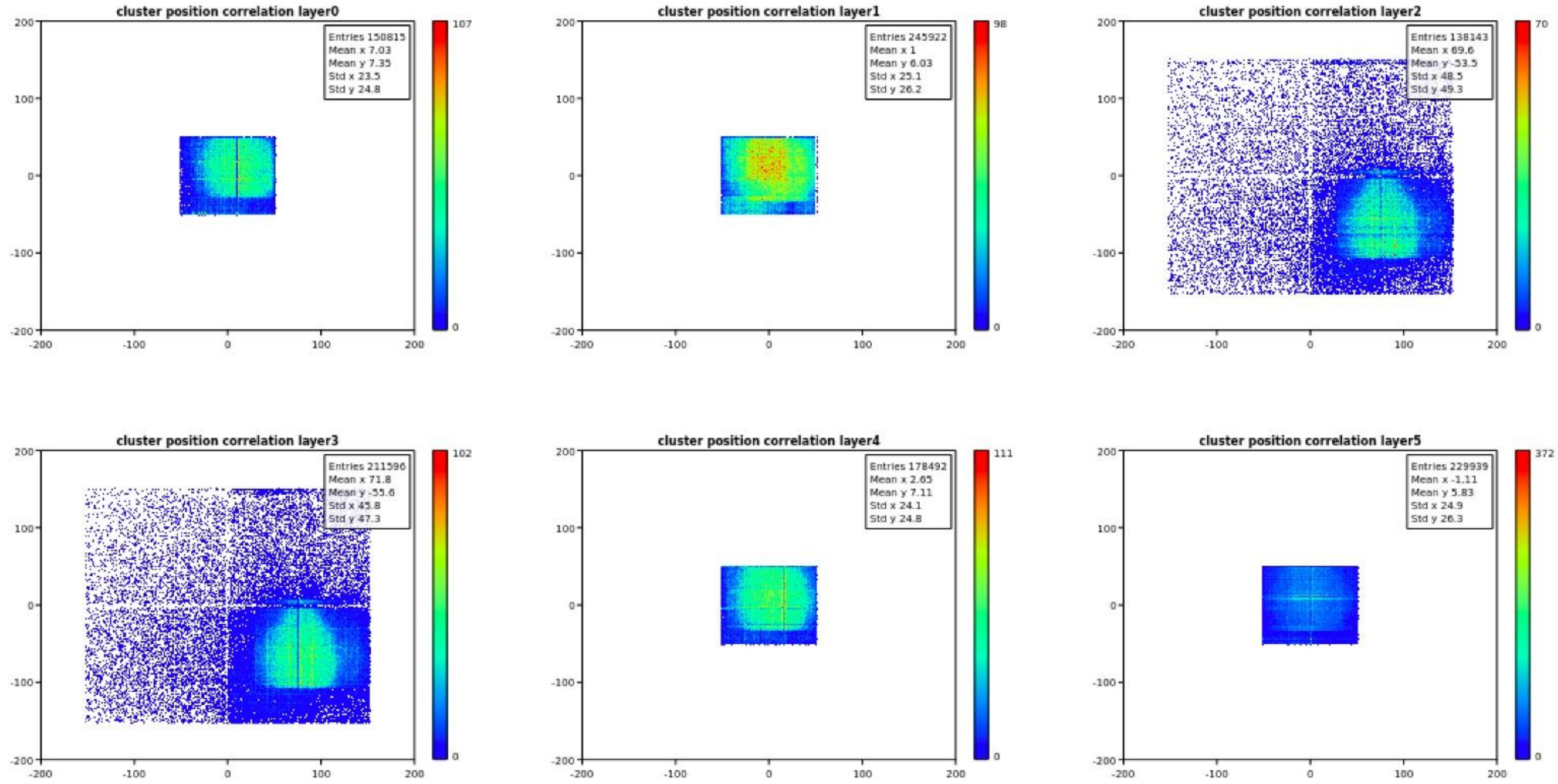
- Magnetic field scan from 0 – 1.5T

Data

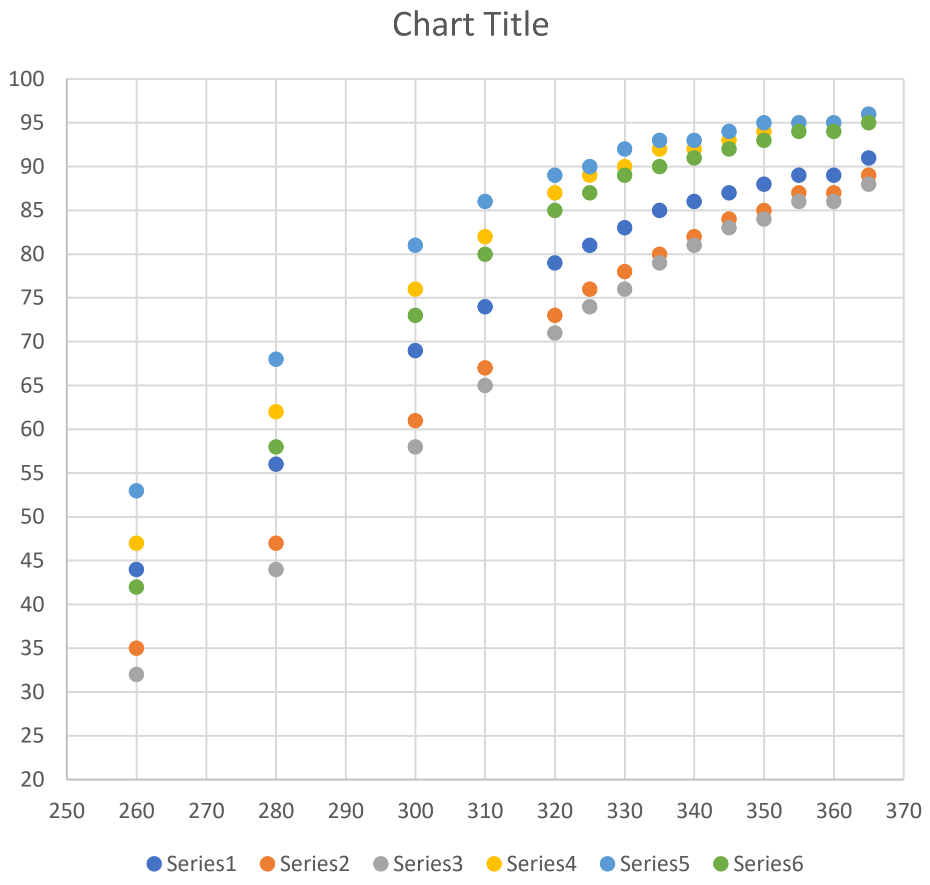
- APV25-SRS with CODA (DAQ) and GemView monitoring and analysis package (by Xinxhan)
- ~200kEvts / run
- Run spreadsheet:

https://docs.google.com/spreadsheets/d/18fzHT8VrBVvGst_2utNJ0KWm9WRms5FTCQ0ZwbAe5EM/edit?gid=2045953215#gid=2045953215

Some very preliminary results – 2D hitmap



Some very preliminary results – Efficiency with $ArCO_2iC_4H_{10}$



https://docs.google.com/spreadsheets/d/1CbhjHm4Ae9ynYv3LMR6JuiAnT-lbELVk5oWoDs_gkd4/edit?gid=852965765#gid=852965765

HV test in N2 of the two µRWELL @ UVa (January 28-29, 2026)