College of Science and Technology
TEMPLE UNIVERSITY

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ATHENA

ATHENA's MPGD Tracking Detectors for the Electron-Ion Collider

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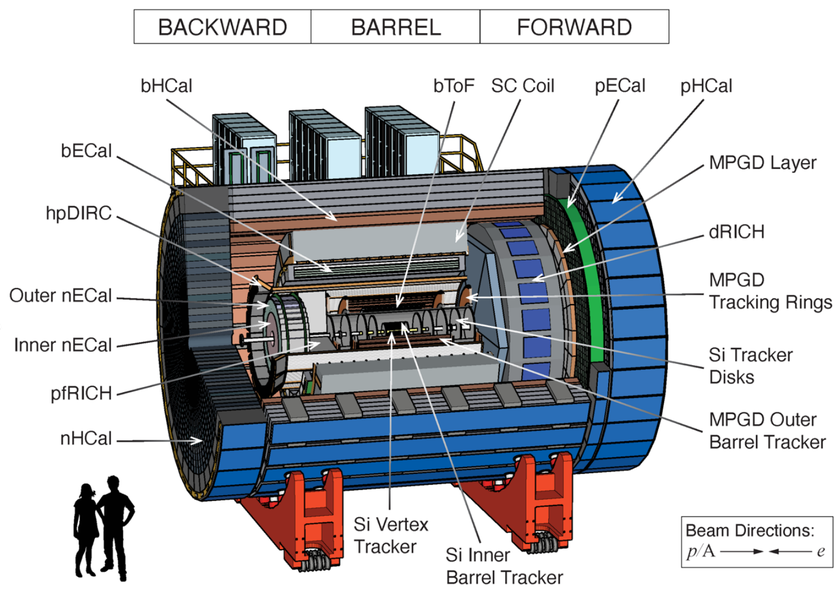
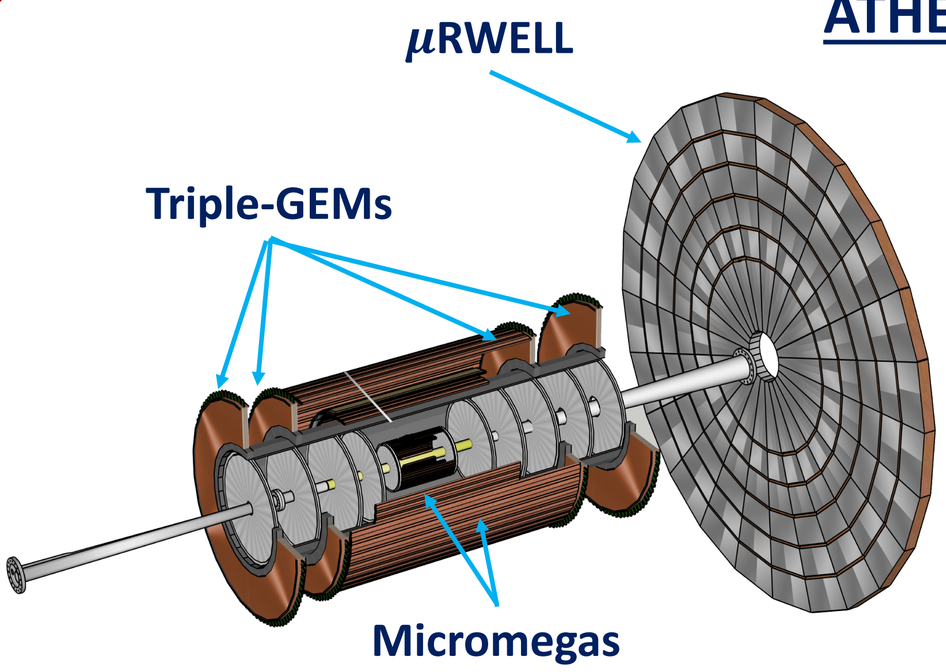
A Totally Hermetic Electron-Nucleus Apparatus (ATHENA)

- Brookhaven National Laboratory will host a new collider, the Electron-Ion Collider (EIC), capable of colliding polarized electrons with polarized protons and nuclei.
- This unique environment places stringent requirements on the tracking system needed for the measurement of the scattered electron and charged particles in the collisions. A low material budget to reduce multiple scattering, large tracking lever arm, and high magnetic field are critical for excellent momentum resolution.
- **A T**otally **H**ermetic **E**lectron-**N**ucleus **A**pparatus (ATHENA) was designed around a 3 T solenoid magnet and was proposed as a potential EIC detector.



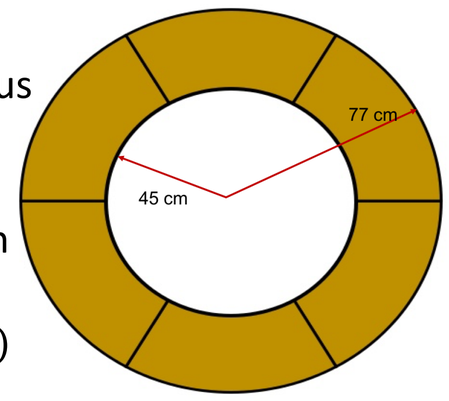
ATHENA Tracker and MPGDs



- ATHENA Tracking system consists of silicon at small radii complimented by Micro-Pattern Gas Detectors (MPGDs) at larger radii.
- MPGDs are gaseous ionization detectors consisting of microelectronic structures with a small drift gap between the anode and cathode electrodes.
- Different MPGD technologies have different electron amplifications.
- ATHENA implemented 3 MPGD technologies: triple-GEM, Micromegas (MM), and micro-resistive well (μRWELL).

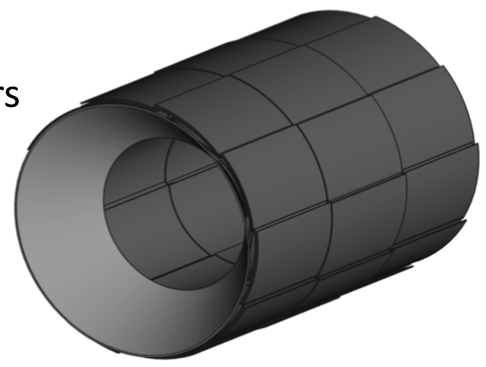
Triple-GEM Rings

- Module size: inner radius $\sim 45cm,$ outer radius $\sim 77\ cm$
- Material budget $\sim 0.4\%\ X/X_0$ per module
- Provide additional hits for track reconstruction
- Covers $\sim 1.1 < |\eta| < 2.0$
- Simulated resolution $50\ \mu m(r\phi) \times 250\ \mu m(r)$



Micromegas Barrel

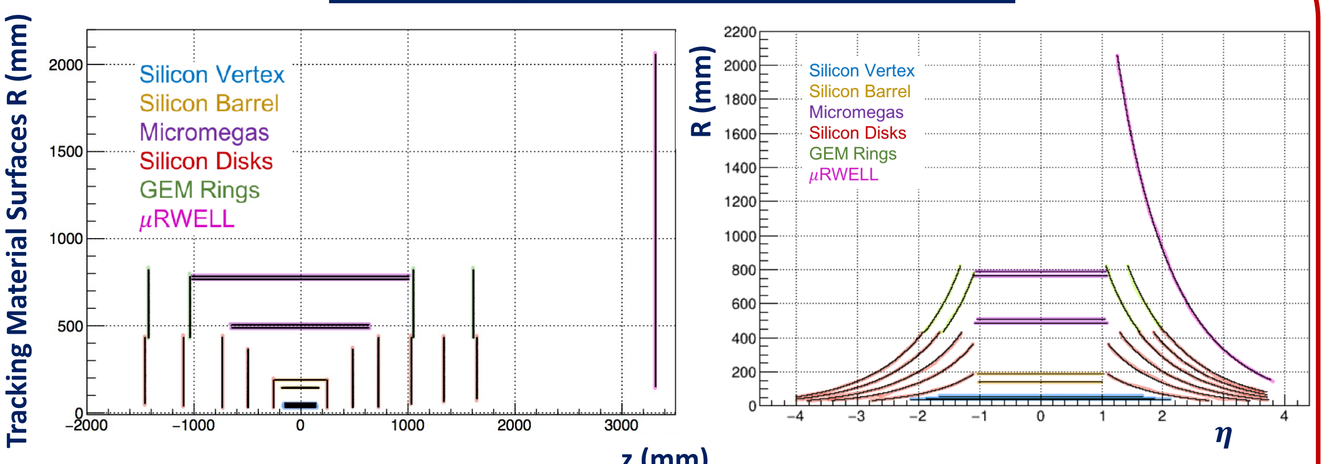
- Module size $\sim 50\times70\ cm^2$
- Material budget $\sim 0.4\%\ X/X_0$ per module
- 2 inner layers ($r \sim 50\ cm$) and 2 outer layers ($r \sim 70\ cm$)
- Covers $|\eta| <\sim 1.1$
- Extends lever arm in barrel region for track reconstruction.
- Simulated resolution $150\ \mu m$



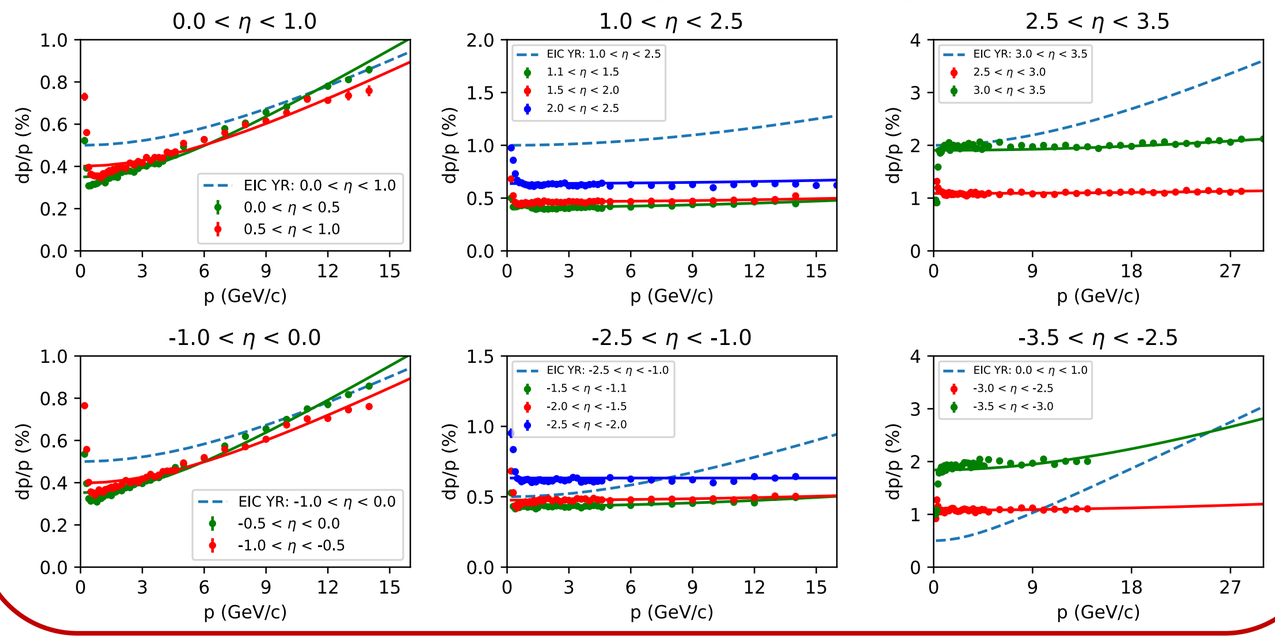
μRWELL

- Located behind dRICH to aid PID
- Needs to cover large area with a radius of $\sim 196\ cm$ and pseudorapidity $\sim 1.5 < \eta < 3.75.$
- Material budget can be more relaxed ($\sim 1\%\ X/X_0$)
- Simulated resolution $50\ \mu m(r\phi) \times 250\ \mu m(r)$

Coverage and Performance



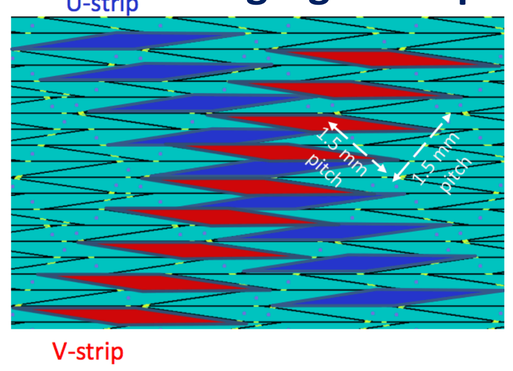
Momentum Resolution Performance



Main EIC MPGD R&D Areas

- EIC MPGD R&D supported by DOE is being carried out by eRD-108 and addresses several areas of R&D:
  - ➢ Further reduction of material budget
  - ➢ Development of large area μRWELL detectors
  - ➢ Reducing readout channel count without sacrificing spatial resolution via 2D zigzag and capacitive charge sharing readouts
  - ➢ 3 coordinate readout structures

2D Zigzag Concept



Capacitive Sharing – 2D Strip Concept