MPGD Trackers in the ePIC Detector @ the EIC

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On behalf of the ePIC collaboration

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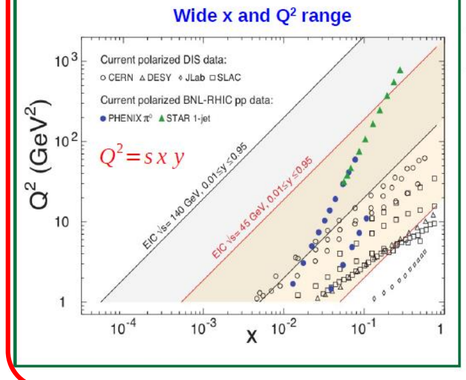
ePIC Experiment @ the Electron Ion Collider (EIC)

- Why ePIC Experiment ?
  - Electrons mainly interacts with electroweak interaction using Deep Inelastic Scattering (DIS): high precision
  - Polarized protons and light ions to study spin/structure physics
  - Collider to achieve wide x and Q^2 range to probe extreme gluon density regime

Wide x and Q^2 range

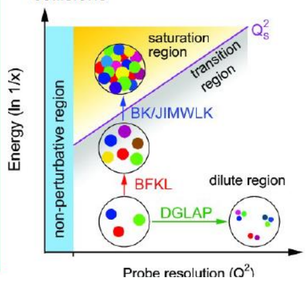


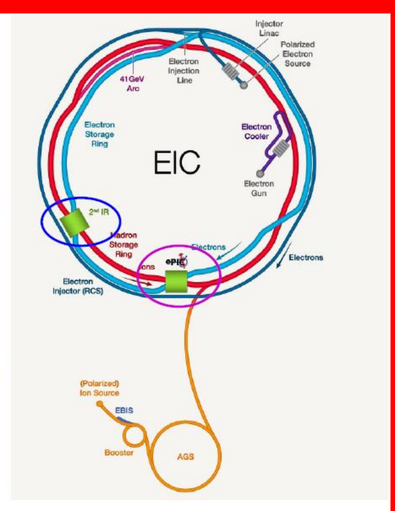
For e-N collisions at the EIC:

- ~70% polarized beams: e, p, d/^{3}He
- Electron beam (5-18 GeV)
- $\sqrt{s_{ep}}$ = 20-140 GeV (Variable)
- L_{ep} ~10^{33}-10^{34} cm^{-2}sec^{-1} ~100-1000 times higher than HERA using crab cavities

For e-A collisions at the EIC:

- Wide range of nuclei
- Variable center-of-mass energy
- Luminosity per nucleon same as ep collisions





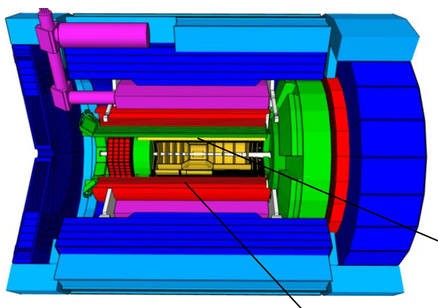
ePIC (electron-Proton/Ion Collider) experiment at Brookhaven National Laboratory (BNL), USA

More than one interaction region

Detector II (not yet scheduled in time)

Overview of ePIC Tracking Detector

ePIC Detector@ EIC



Vertex detector → Identify primary and secondary vertices,

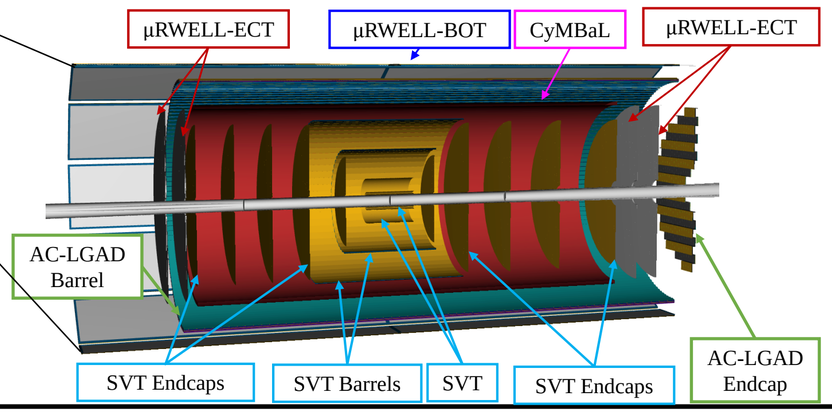
Low material budget: 0.05% X/X_0 per layer;

High spatial resolution: 20 mm pitch CMOS Monolithic Active Pixel Sensor

Central tracker → Measure charged track momenta

MAPS – tracking layers in combination with micro pattern gas detectors

MPGD: µRWELL and Micromegas technologies



µRWELL-BOT: µRWELL Barrel Outer Tracker

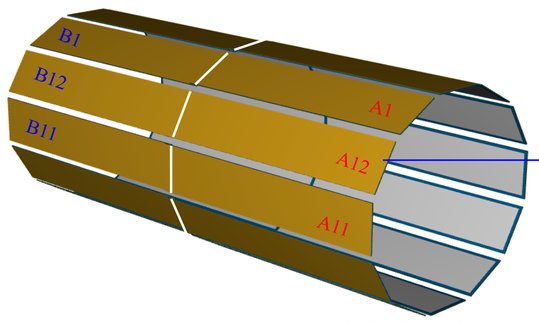
ePIC Barrel Outer Tracker (µRWELL-BOT)

- ❖ Tracking layer close to hpDIRC detector
- ❖ improved and angular & space point resolution for the DIRC
- ❖ Acceptance matching with hpDIRC bars
- ❖ Spatial resolution: better than150 µm on average over the full eta range in barrel region

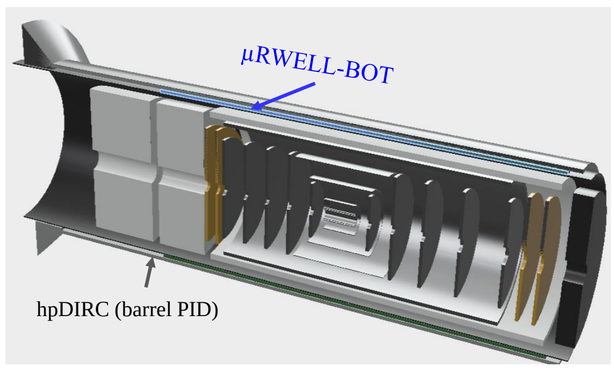
µRWELL-BOT specifications

- L = 340 cm (−165 cm ≤ Z ≤ 175 cm), R = 72.5 cm

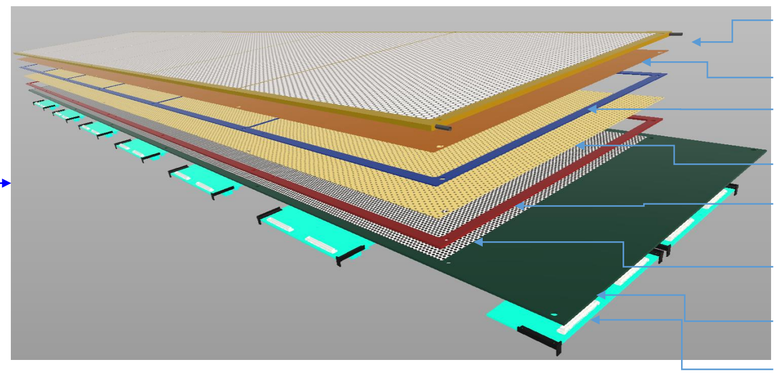
- ❖ Thin-gap & hybrid amplification (GEM & µRWELL)
- ❖ 2D U/V strip readout ➔ spatial resolution = 150 µm
- ❖ Fast timing layer ~ 10 ns
- ❖ Radiation length < 2% in active area



2 × µRWELL-BOT modules in 12-sided polygon shape



ePIC µRWELL Barrel Outer Tracker in front of hpDIRC in the central detector

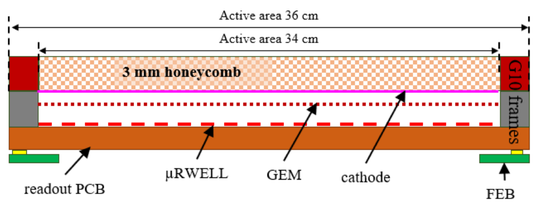


µRWELL-BOT module: Thin-gap & hybrid amplification (GEM & µRWELL)

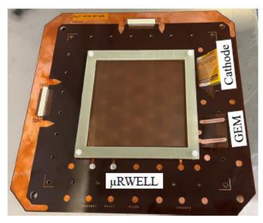
Thin-gap GEM-µRWELL Hybrid Detector

Thin-gap GEM-µRWELL detector concept

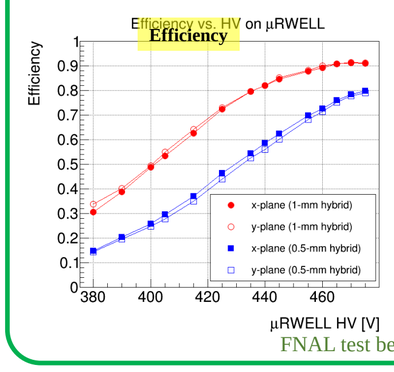
- ❖ Small drift gap ~ 1mm ➔ better spatial resolution, timing resolution, smaller E×B effect
- ❖ hybrid amplification MPGD:
  - GEM foil for preamplification and µRWELL for main amplification
  - Allow large detector gain and stable operating HV
- ❖ Readout layer: 3-layer capacitive-sharing U-V strip readout
  - Achieve excellent spatial resolution with thin gap detector

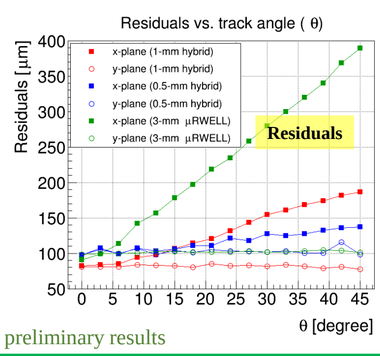


cross-section view of thin-gap GEM-µRWELL detector



https://wiki.bnl.gov/eic/upload/ERD_tgMPGD_FY22_endOfYearReport_final.pdf





FNAL test beam 2023 preliminary results

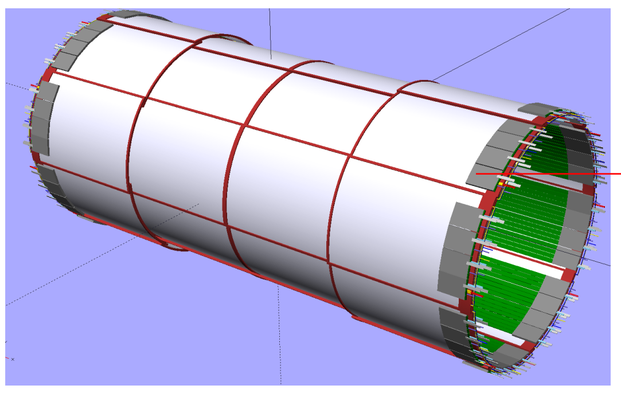
CyMBAL: Cylindrical Micromegas Barrel Inner Layer

Cylindrical Micromegas Barrel Inner Layer: **(CyMBaL)**

- ❖ The inner MPGD layer wraps around the SVT
- ❖ Provides additional hit points for pattern recognition

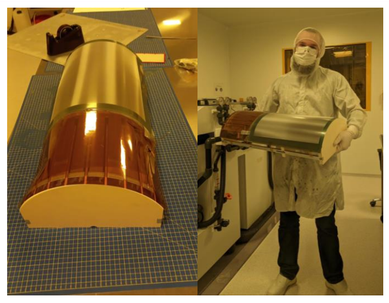
Keeping zones:

- ❖ Z = [-105, 135.5] cm
- ❖ R = [50, 55]cm

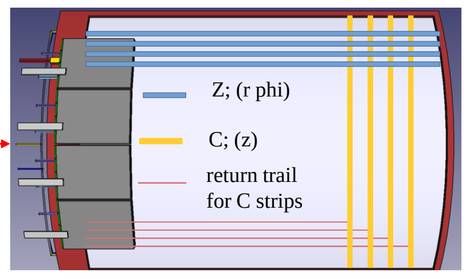


Some numbers:

- ❖ 32 modules : 8 modules in phi × 4 modules in z
- ❖ 1024 readout channels/module
- ❖ 32K readout channels



Upgrade CLAS12 Micromegas technology from 1D → 2D readout



CyMBaL module Dimensions:

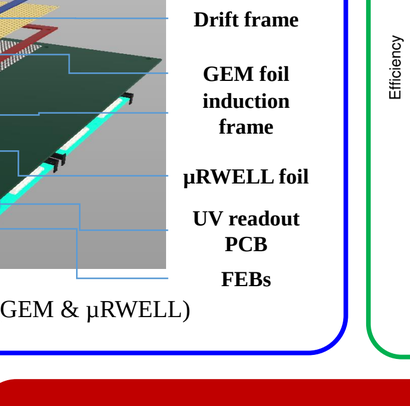
- ❖ Size: 65 x 46 cm^2 with active area: 59x44 cm^2
- ❖ r/o strips: ~1 mm pitch in both directions
- ❖ Readout strips per module: 1024
- ❖ 32 channels per connector → 32 connectors

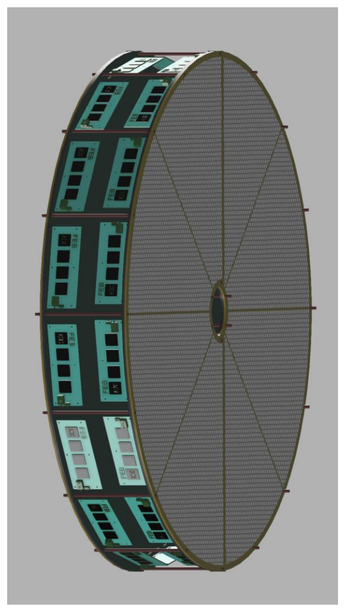
µRWELL-ECT: µRWELL End Cap Trackers

ePIC End Cap Tracker (µRWELL-ECT)

- ❖ Provides additional hit points for pattern recognition
- ❖ Two discs in each end cap: hadron (HD) and electron (LD)
- ❖ Time resolution 10 ns time to provide tracking timing
- ❖ Low material budget: ~ 2% X0
- ❖ Spatial resolution: 150 μm or better

Component	Z (cm)	Inner Active Reg. Radius (cm)	$\lvert\theta\rvert$ min (deg)	$\lvert\eta\rvert$ max	Outer Active Reg. Radius (cm)	$\lvert\theta\rvert$ max	$\lvert\eta\rvert$ min
HD MPGD 2	162	10.5	3.35	**3.43**	45	15.52	1.99
HD MPGD 1	148	10.5	4.06	**3.34**	45	16.91	1.9
LD MPGD 1	-111	6	3.09	3.61	45	22.07	1.63
LD MPGD 2	-121	6	2.83	3.69	45	20.40	1.72





µRWELL-ECT disc design

µRWELL-ECT strip readout choice:

- (X, Y) readout is preferred vs (R,φ)
- 500 µm pitch → better than 150 μm intrinsic position resolution

µRWELL-ECT disc: Hybrid amplification (GEM & µRWELL)

Conclusion

MPGD trackers in ePIC detector @ the EIC

- ❖ Pattern recognition layers in support to the Silicon trackers in the barrel and end cap central tracker ➔ spatial resolution **< 150 µm** and timing resolution **~10 ns**
- ❖ Three MPGD subsystems: Barrel Inner Tracker (CyMBaL), Barrel Outer Tracker (µRWELL-BOT) and end cap discs (µRWELL-ECTs)
- ❖ Two MPGD technologies: Cylindrical Micromegas a la CLAS12 MVT for inner barrel ; Planar GEM-µRWELL detectors (novel hybrid MPGD approach) for outer barrel & end cap discs
- ❖ Intense ongoing R&D effort to achieve the performance requirements ➔ large consortium of international universities and labs involved

Acknowledgement

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