EPIC MPGD Tracker Update

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GD / I WG meeting

07 September 2022

Charges from GD / I WG conveners for today's meeting

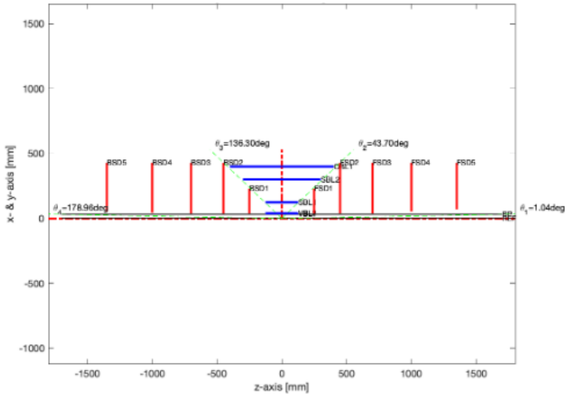
- Presentation of your recommendation including the motivations
- The list of pros and cons
- The R&D outcomes
- The expected performance from simulations
- The potential construction model (who, what, where?)

Current EPIC central tracker configuration

Silicon Tracker configuration

Barrel:

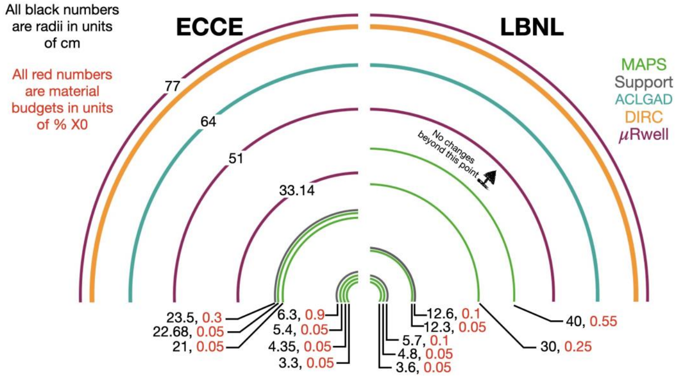
	r [mm]	l [mm]	X/X0 %
Layer 1	36	270	0.05
Layer 2	48	270	0.05
Layer 3	120	270	0.05
Layer 4	270	540	0.25
Layer 5	420	840	0.55



Disks:
- Suggested |z| = 250, 450, 700, 1000, 1350* mm.
- r_{out} = 430mm** at |z| > 430mm, ~230 mm at |z| = 250mm
- X/X0 ~ 0.24% per disk
- r_{in} ~ 5mm away from beam pipe
- Outer support / service cylinders for 450 < |z| < 1350* mm

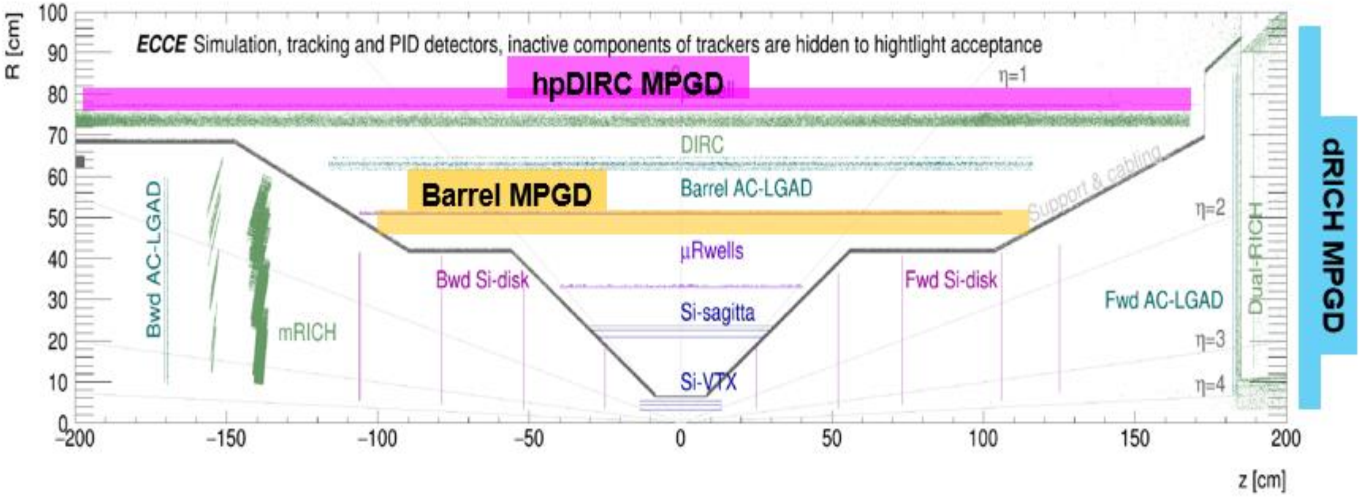
* z=1350 mm would put the last disk right against the mRICH in the e- direction; TBC pending checks with project engineers/up-to-date CAD drawing.

See Laura's talk @ GD/I WG - https://indico.bnl.gov/event/16587



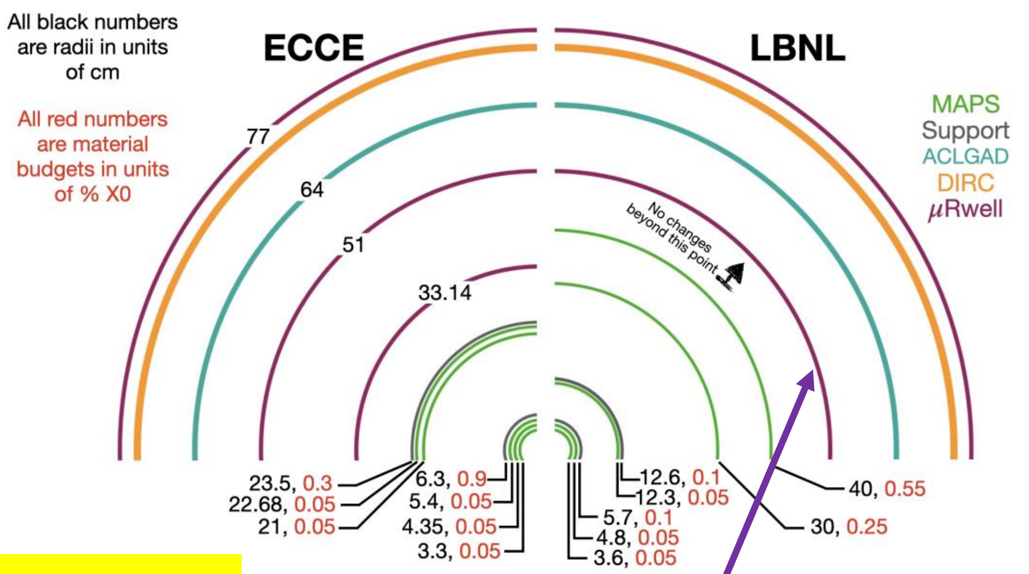
MPGD Layers under consideration

- Barrel MPGD: Cylindrical layers
  - Full cylindrical / Curved or planar tiles in cylindrical arrangement?
  - Challenges: Low mass, large area resolution at large track angle
- hpDIRC MPGD: Planar rectangular module (~400 cm × 36 cm)
  - Challenges: resolution at large track angle and high B field
  - Not needed if Imaging calorimeter chosen for EPIC EM cal
- dRICH MPGD: Planar trapezoidal module
  - Challenges: resolution at large track angle and high B field
  - Tracking performance simulation of dRICH will decide on this layer



MPGD layer(s) to complement Si-tracker in barrel region

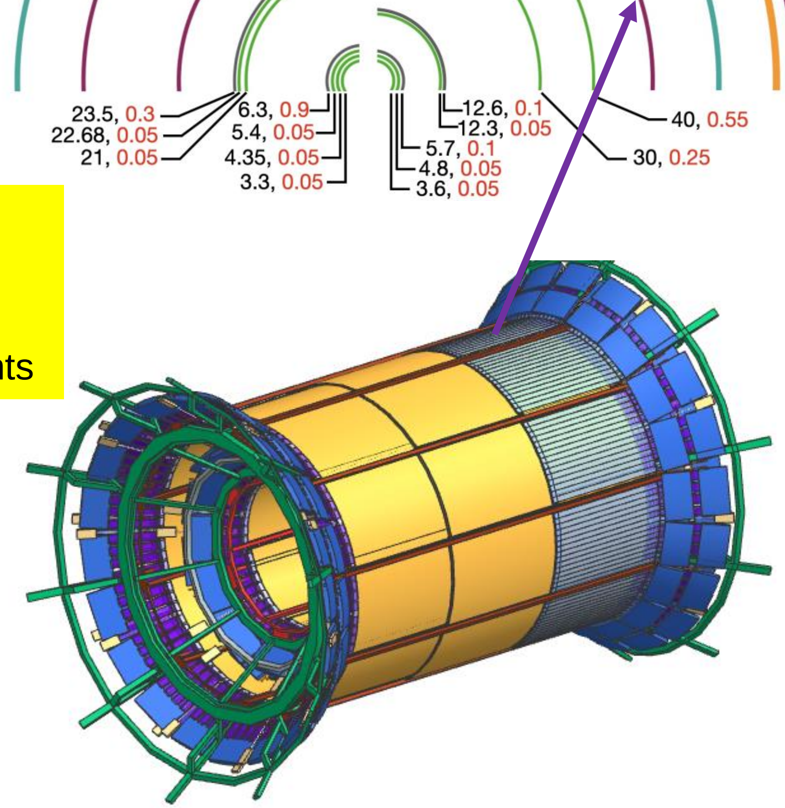
- ❖ Provide hit for the tracking pattern recognition in barrel region
- ❖ Provide additional track hit and lever arm for tracking in both end caps
    - ❖ Need to be careful regarding spatial resolution requirement
- ❖ Total number of Cyl MPGD layers not finalized
    - ❖ Driven by requirement from simulation for pattern recognition
- ❖ Low mass < 0.5% X0 per layer for all barrel MPGD layer(s)
- ❖ Spatial resolution (100 µm – 150 µm) in both phi and z directions?
- ❖ Full coverage in eta and phi ➔ minimization of dead area



- ❖ We will have to revisit some of these expectations and relax the constraints
- ❖ This should come from tracking simulation results and physics requirements
- ❖ Technologies are known (MM or µRWELL) but actual design strongly depends on requirements

Some challenges ➔ No showstopper

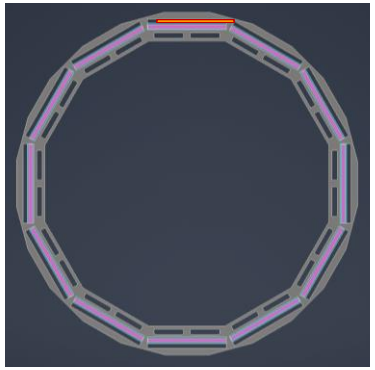
- ❖ **Large area & low mass:** < 0.5% X_0 will be very challenging
- ❖ **Low mass & 2D readout:** at this level of low mass, material budget of readout is a major contribution to the overall thickness regardless the MPGD technology
- ❖ **Spatial resolution:** degradation of resolution with incoming track angle
    - Main concern is spatial resolution requirements at large angle in z direction

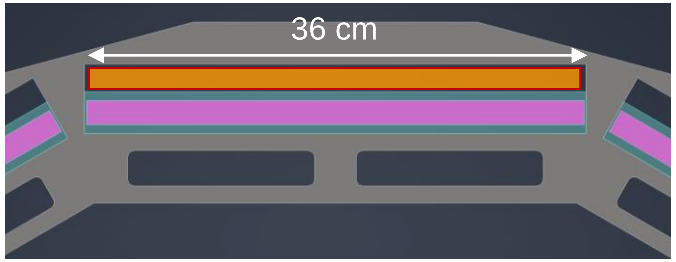


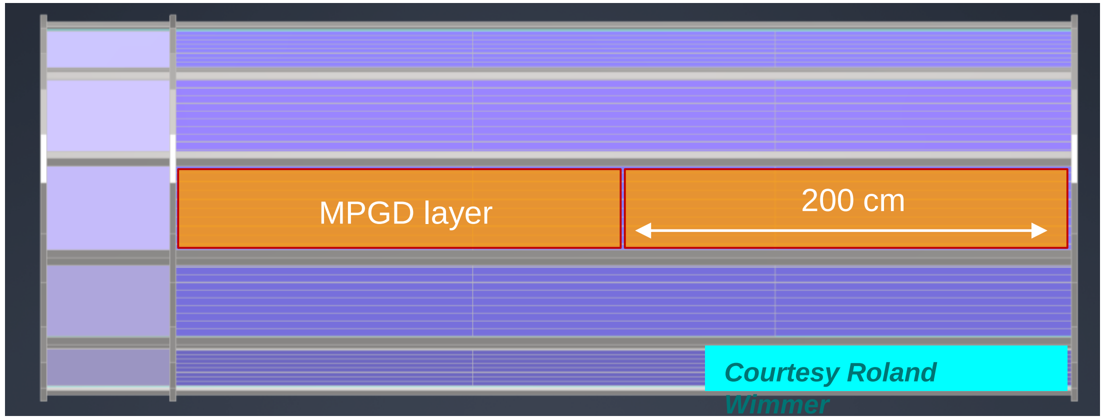
Preliminary sketch of Cyl. MPGD

MPGD support layers for PIDs

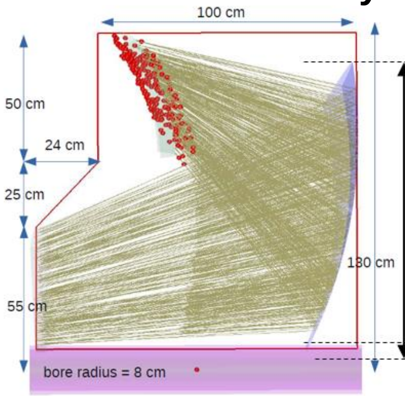
MPGD layer behind hpDIRC: Ring reco. Seeding



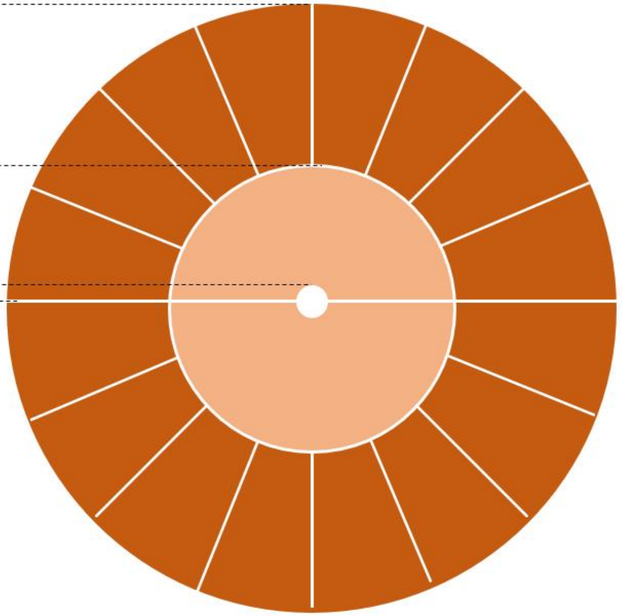




MPGD layer behind dRICH: Ring reco. seeding



µRWELL layer in CORE proposal



- ❖ Same argument overall on requirements & expectations
- ❖ Planar configuration & "no-low mass" requirements makes layers less challenging

- ❖ Need for hpDIRC MPGDs depends on the chosen EPIC EM Cal technology:
  - ❖ an Imaging Calorimeter will provide the required tracking information for the hpDIRC without an additional MPGD tracking layer behind hpDIRC
- ❖ Need for the MPGD layer behind dRICH will determined by simulation results of the tracking requirement for Cerenkov ring reconstruction
- ❖ Low mass **is not** required for this layers ➔ **1% to 2% X_0** MPGD layer right in front of EM Calorimeters is not an issue
- ❖ Spatial resolution of 100 µm – 150 µm for MPGD layers in r, phi and z directions will be challenging at large angle ➔ more on that on following slides

Services & Integration considerations

Services and integration

- Material on the essential service cylinders is being worked out (Shujie) to be added soon to the geometry description.
- Explore different routing scenarios.
- Justify/revisit the double cone and step structure for the service in the current design.
  - Explore the ATHENA's solution: only one "services exit cone at eta~1.1", routing of disk services towards the cone

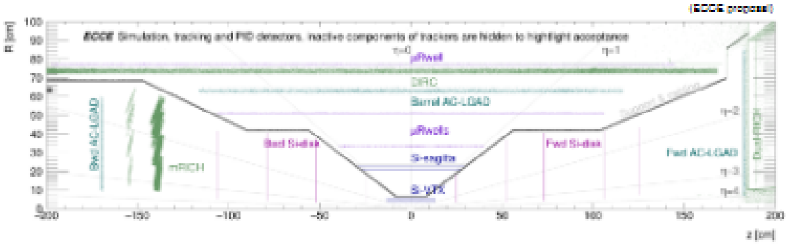
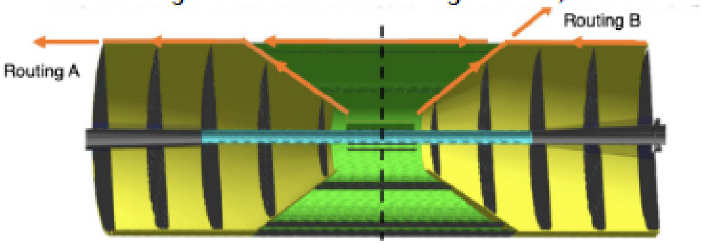
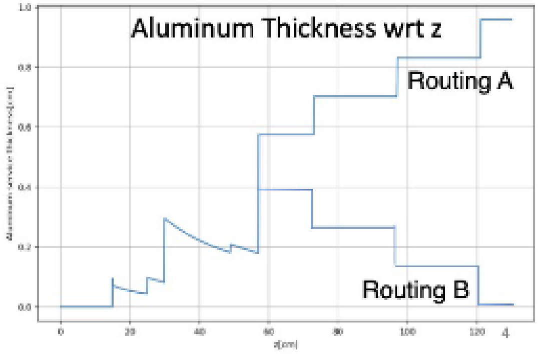


Figure 2.5: Schematic view of the ECCE tracker, including silicon, μRWELL, AC-LGAD, DIRC, mRICH and dRICH detector systems.

Services routing scheme (drawn on top of the original all-silicon configuration)





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[Fom Laura's talk @ GD/I WG - https://indico.bnl.gov/event/16587](https://indico.bnl.gov/event/16587)

- ❖ Discussion regarding the optimization of the Si-tracker support cone structure ➔ double cone vs. single cone @ eta 1.1 ➔ will have an impact on the length of cylindrical MPGD layers
- ❖ We would need to revisit the whole configuration and maybe come back to the ATHENA solution with MPGD rings in the endcap region to complement the Si-discs

"Presentation of your recommendation including the motivations:"

MPGD technologies choice for EPIC gaseous trackers:

- The tracking WG conveners recommend both Micromegas and µRWELL technologies for the EPIC detector
  - We will continue referring EIC gaseous trackers as MPGD layers because the expected performances of the two technologies are similar
  - The remaining R&Ds and the risk level for either technology to be ready for EIC are of similar nature
    - The real challenges that we should concentrate on are the development of large and low mass detector modules,
    - High performance and low channel count 2D readout structures (resolution, capacitance noise, RF shielding …)
    - The amplification structure (Micromegas or uRWELL) is the easy part
- **Micromegas** for the cylindrical layers in the barrel to complement the Si-tracker
  - Micromegas is a more mature technology, so it makes more sense to chose this technology for the most challenging EIC MPGD layer
  - CLAS12 MVT (curved & light-weight micromegas) as starting point
- **µRWELL** for the planar layers behind dRICH and hpDIRC detectors
  - More recent technology but very promising and development of technology is making fast progress
  - Large planar µRWELL will be ready and proven technology within EPIC detector timeline
- Readout electronics:
  - Same readout electronics for the two technologies SALSA chip is the likely candidate for the FE electronics
- Services & mechanical structures: Detector design, services and integration considerations are interchangeable between the two technologies
  - Again: operation and performance for the two technologies are expected to be very similar
  - So, one technology is a perfect fallback solution for the other

Motivations to keep the two MPGD technologies

1. Micromegas and µRWELL will both be **fallback option** to each other and that is the healthier approach
   - ❖ As we keep parallel and complementary R&D effort for the two technologies, we will consolidate each technology and performance
   - ❖ Only after the R&D is completed, we will feel comfortable making a final and definitive decision on the technology readiness for EIC
2. Cost and production consideration:
   - ❖ 2 or 3 EPIC gaseous subdetectors systems (Cylindrical barrel tracker, hpDIRC MPGD layer and dRICH MPGD layer)
   - ❖ Whether we consider same technologies or both uRWELL and Micromegas ➔ different R&D needs, design, production sites etc …
   - ❖ Cost figures likely to be similar in either case ➔ will be driven by specific detector requirements and design constraints rather than technology
3. Large MPGD community (in the US, Europe and Asia) involved in MPGD R&D for the EIC EPIC detector.
   - ❖ Institutions with different level of expertise and experience in the development and deployment in experiments of either technology
   - ❖ Unlikely that all the institutions will coalesce around one technology once chosen
     - ❖ Risk is to cut out half of the available expertise so early in the process ➔ will not benefit EPIC detecor in the long run
     - ❖ This expertise and experience will not be available from scratch later in time when EIC is ready to start
4. Not clear to us what will be the benefit of down-selecting one technology today
   - ❖ Other than the illusion of risk mitigation and cost saving
   - ❖ In our opinion, it is actual the opposite result that we will get by choosing a single technology for EIC
5. Our view is that we are **too early (premature)** in the process for a down-selection of one technology over the other because:
   - ❖ Still a lot of R&Ds required to fully validate the technologies for EIC tracker.
   - ❖ Only after the R&D is completed that we can feel comfortable making a firm decision on the technology readiness for EIC

Ongoing R&D efforts – Timeline & expected outcome

Development of Cylindrical Micromegas with 2D readout structures – eRD108

Existing technology:

- CLAS12 MVT:
  - cyl. tiles ~50x50 cm2 active region
  - 1D readout with ~0.5mm strips
  - Material budget per tile ~0.4X0
- ASACUSA: 2D tiles

CLAS12 MVT open for maintenance

Goal

- cyl. tiles
  - Active region 50x70cm2 (or 50x100cm2)
  - 2D readout with ~1mm pitch
  - Material budget per tile ~0.5X0

FY22 (ongoing)

- Optimization of 2D readout pattern
  - Choice of the strip motif
  - Choice of the resistive layer
  - Tests with cosmics and beam tests

FY23

- Full scale prototype
  - Reuse/refurbish MVT mechanics
  - Beam test

CD3

- Ready for production

R&D timeline as detailed in eRD108 proposal

Remarks:

- 2D micromegas exist already (Asacusa, ScanPyramid,…): not starting from scratch
- CAD models for CLAS12 tiles (detectors and tooling) are the starting point: minimizing reinventing the wheel
- Detailed plans for prototyping, pre-production, production, integration and installation were prepared during Athena’s proposal

Ongoing R&D efforts – Timeline & expected outcome

Development of Cylindrical µRWELL with 2D readout structures – eRD108 effort for FY22

EIC Detector R&D Proprosal

The eRD108 Consortium

September 18, 2021

The eRD108 Consortium

Project ID: eRD108

Project Name: R&D on cylindrical and planar MPGDs towards an EIC detector

Brookhaven National Laboratory (BNL): Craig Woody
Florida Institute of Technology (FIT): Marcus Hohlmann
CEA Saclay: Francesco Bossù, Maxence Vandenbroucke
Temple University (TU): Matt Posik, Bernd Surrow
University of Virginia (UVa): Kondo Gnanvo

Project Members:

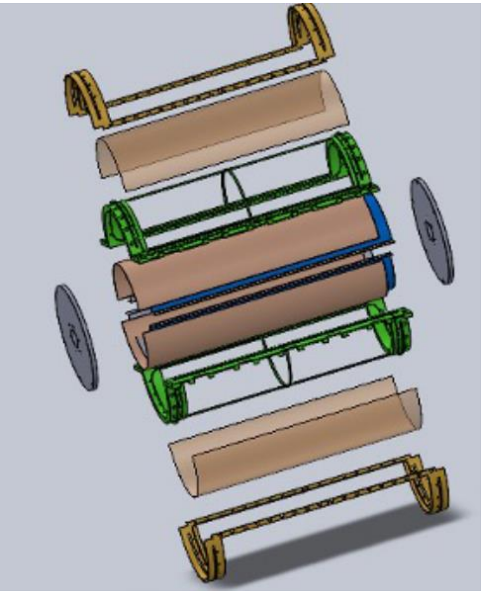
BNL: B. Azmoun, A. Kiselev, M. Purschke, C. Woody
FIT: M. Hohlmann, P. Iapozzuto, M. Lavinsky
CEA Saclay: S. Aune, F. Bossù, M. Revolle, F. Sabatié, M. Vandenbroucke
TU: M. Posik, B. Surrow
UVa: S. Ali, K. Gnanvo, N. Liyanage

Contact Person: Kondo Gnanvo; kgnanvo@virginia.edu

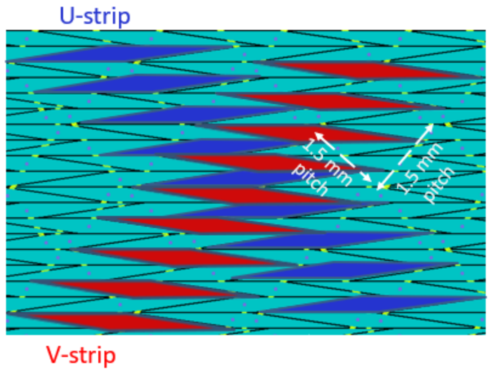
https://wiki.bnl.gov/conferences/images/c/c9/ERD108_Proposal_update20210918.pdf

- ❖ **Cylindrical µRWELL prototype with 2D readout**
  - 2 half cylindrical chambers with different type of 2D strip R/O structures each (U-V zigzag, U-V capacitive-sharing)
  - Design of the prototypes is ongoing
- ❖ **Goals and timeline:**
  - Design of the two-halves prototypes – October 2022
  - Prototype ready for test in beam at FNAL - Spring 2023
  - Study the spatial resolution in a cylindrical detector configuration
- ❖ **Outcome of this R&D will benefit both Micromgas or µRWELL**

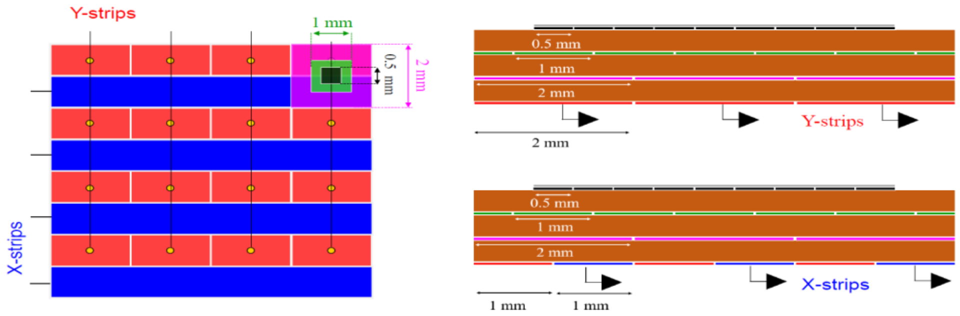
CAD drawings



2D Zigzag readout



Capacitive-sharing 2D strip readout



Ongoing R&D efforts – Timeline & expected outcome

Development of Thin Gap MPGDs (tg-MPGD) – proposal for FY22 EIC Generic Detector R&D call for proposals

Development of Thin Gap MPGDs for EIC Trackers

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July 25, 2022

Abstract

The EIC physics program requires precision tracking and PID over a large kinematic acceptance, as highlighted in the Yellow Report [1]. MPGDs are able to provide space point measurements to aid in both tracking and PID. These MPGD detectors will span a large pseudorapidity range (e.g. angular acceptance) and will see tracks entering over a large angular range, in addition to tracks bending due to the EIC's magnetic field. The position measured by an MPGD structure for a track impinging at a large angle is no longer determined by the detector structure (e.g. readout structure) but 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 angle. To minimize the impact of the track angle on the resolution, several prototype thin gap MPGDs (tg-MPGDs), where the ionization gas volume is significantly reduced with respect to typical MPGD detectors, will be built and tested in beam. In addition various gas mixtures will be studied within simulation to identify optimal mixtures for future use.

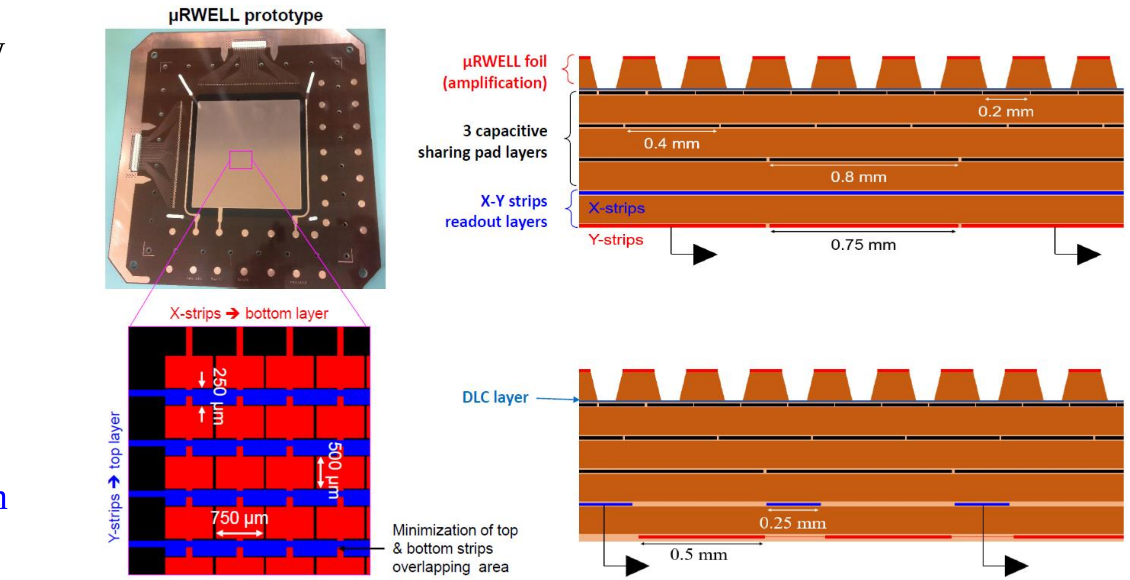
https://www.jlab.org/sites/default/files/eic_rd_prgm/files/2022_Proposals/20220725_eRD_tgMPGD_Proposal_final_EICGENRandD2022_23.pdf

- **R&D program: Development & test of small tg-MPGD prototypes**
  - Thin Gap µRWELL prototypes with 2D readout (JLab & Vanderbilt U.)
  - Thin Gap hybrid (µRWELL + GEM) prototype (JLab & Vanderbilt U.)
  - Thin Gap Micromegas prototype (Yale U.)
  - Thin Gap triple-GEM with mesh cathode (UVa)
  - Study of different gas mixture options (Xe-CO2, Kr-CO2)
- **Goals and timeline:**
  - All prototypes ready for test in beam at FNAL - Spring 2023
  - Demonstrate resolution and efficiency performance of tg-MPGDs
  - **If successful ➔ develop large tg-MPGDs ➔ FY23 funding cycle**
- **Should reach to a definitive conclusion by summer 2023**
- **Should solve the spatial resolution issue for large incoming angle**

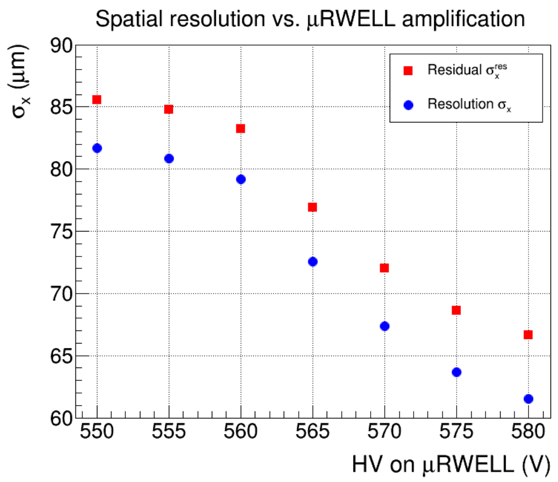
Ongoing R&D efforts – Timeline & expected outcome

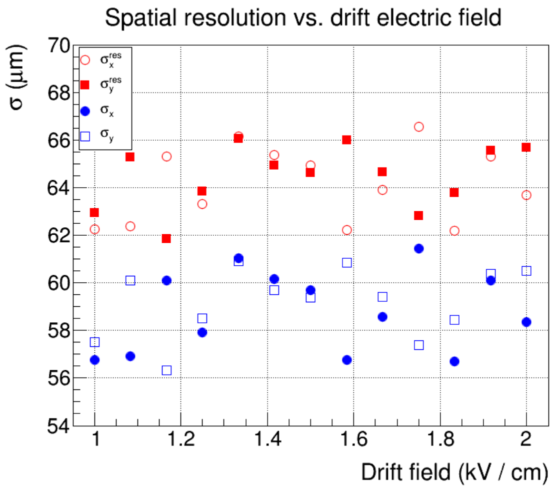
Performance of µRWELL with capacitive-sharing 2D readout in beam test in JLab Hall D - Sept 2021

- 3-layer stack capacitive sharing strip readout ➔ black pads on the cross-section view
- Signal on top & bottom strip through capacitive coupling: strip pitch = 800 µm
- Beam test in Hall D @ JLab with 3 – 6 GeV electron beam
- Spatial resolution performances
  - Red : widths $\sigma^{res}_{X(Y)}$ of residuals **before** track fit correction. $\sigma^{res}_{X(Y)}$ = ~64 µm
  - Blue: resolution **after** fit corrections. Average resolution in x and y $\sigma_{X(Y)}$ = ~59 µm

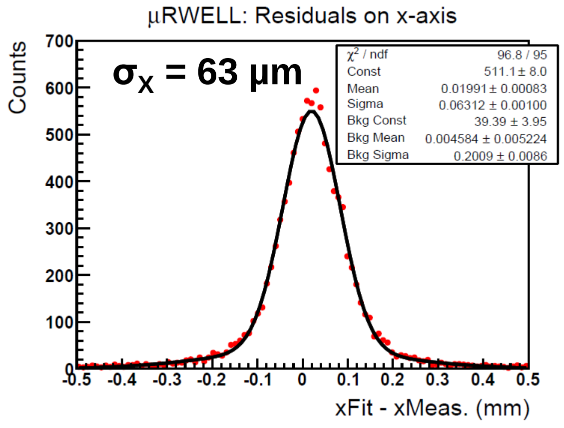


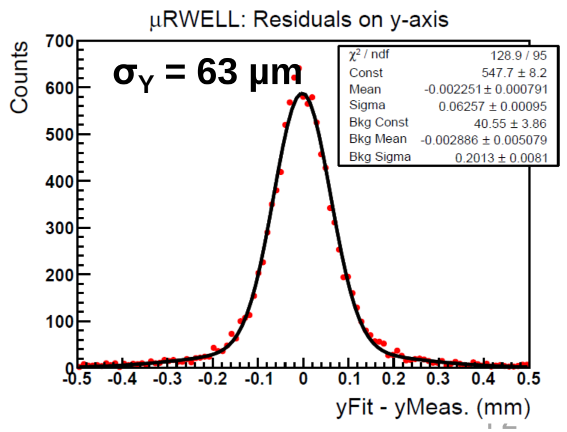
Residuals (red) & resolutions (blue) in x (open) and y (full)





Tracking residual distribution in x and y before track fit correction

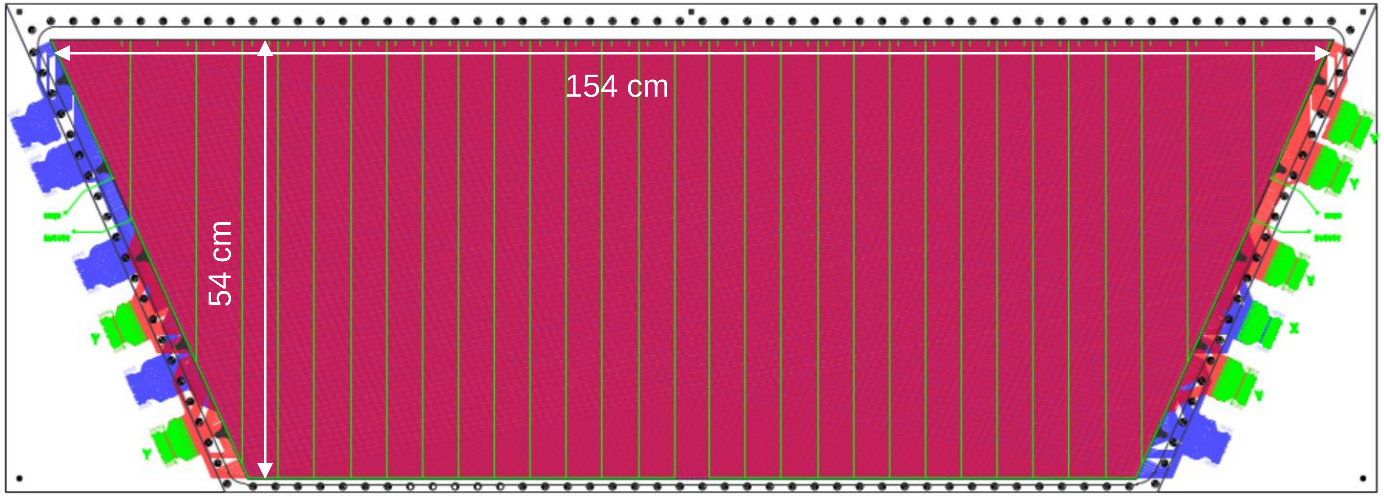




Ongoing R&D efforts – Timeline & expected outcome

Synergetic effort – development of large planar µRWELL tracker – CLAS12 High Luminosity Forward Tracker upgrade

Gerber view of CLAS12 High-Lumi FT µRWELL prototype



- First large µRWELL prototype is under development
- [150 cm – 100 cm] x 50 cm similar in size to largest EPIC hpDIRC MPGD module
- Design completed and detector part in fabrication at CERN
- Testing 2D capacitive-sharing R/O over large area
- Testing segmented uRWELL foil ➔ for high-rate capability

- **Goals and timeline:**
  - The prototype is expected to be assembled **– December 2022**
  - Plans to test it in beam Hall B @J Lab Spring run 2023
- **Should demonstrate the viability of large area µRWELL tracking detector**
- **Input on 2D capacitive-sharing R/O performance for large chambers**

Expected performance from simulation

Performance of the whole tracking system presented last week in Laura https://indico.bnl.gov/event/16587

Simulation as input for design choices:

- ❖ MPGD layers will help in track finding
- ❖ How many layers we need depends on:
  - Background levels
  - Track finding algorithm

Design choices as input for simulation:

- ❖ Choice of Barrel Emcal:
  - If the imaging calorimeter is chosen:
    - Is the MPGD layer at the DIRC still needed
  - If SciGlass:
    - Define the position resolution needed for PID goal
- ❖ Routing of services
  - Single cone vs double cone
  - Are there enough hit points everywhere?

Ongoing implementation in ePIC framework:

- ❖ Matt Posik is the tracking WG liaison
- ❖ Currently:
  - MPGD are cylindrical layers
  - 0.5%X0 for the barrel layer
  - 1%X0 for the DIRC layer
  - Resolutions set at 150µm

TODOs:

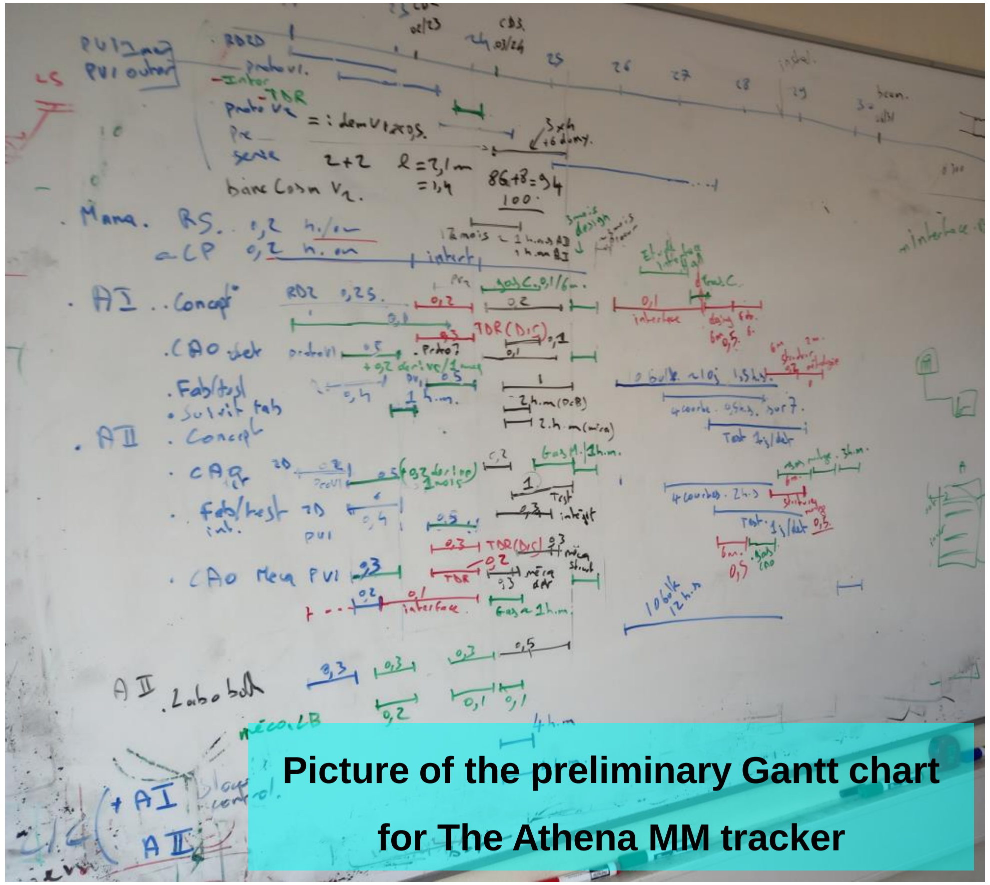
- ❖ Match geometry with the actual design:
  - Barrel layer made out of overlapping cylindrical tiles
  - DIRC MPGD layer to match the DIRC box geometry, i.e. flat tiles
  - Add FEE cards and services as passive materials
- ❖ Switch to 2D strips readout
- ❖ Inject detector noise
- ❖ Include B field effect (Lorentz angle)

We are identifying person power for these tasks

Potential construction model

MicroMegas construction model

- Main idea: only one module type, curved at different radii
- Detail preliminary planning developed during Athena's proposal.
  - Prepared for a system with about 100 tiles
  - Include all phases until installation
  - Services, support and integration tasks included
- The number of tracking MPGD layers in EPIC not yet defined. Currently only 1 layer (likely 2)
- For a module size of 50x70cm2, EPIC will have ~28 (56) tiles
- Considering 50x100cm2 tiles (this will reduce the amount of services)
- CEA Saclay will be leading and major site
- **Production**:
  - From the experience of large projects such ATLAS NSW
  - PCB from external companies (Elvia, CERN,…)
  - Resitive layer (Saclay, or industrial partner)
  - Bulk (Saclay, but it can be done with industrial partners)
  - Mechanics, integration, testing: Saclay and partner institutes



Picture of the preliminary Gantt chart for The Athena MM tracker

Adopt similar construction model & Production for µRWELL

- PCB production from external companies (CERN, ELTOS, …)
- Resistive layer (CERN or industrial partner in US or Asia)
- µRWELL foil (CERN or potentially industrial partner in US
- Mechanics, Integration testing. EPIC institutions

Summary

- Current EPIC Gaseous trackers
  - 1 or 2 cylindrical MPGD layers in the barrel region to provide track hit capability for pattern recognition to the Si-trackers in high background
  - Planar layer behind the hpDIRC detector to provide tracking information for the DIRC ring seeding
  - Planar MPGD disc behind dRICH for in tracking information for the dRICH ring seeding
  - Possibility for additional MPGD ring in endcap regions to complement the Si-disc at lower eta (eta > 1.1)
  - Simulation performances will settle for the final MPGD tracker configuration
- Tracking WG conveners recommend to adopt both Micromegas and µRWELL for EPIC MPGD subdetectors
  - Micromegas for barrel MPGD trackers
  - Large planar µRWELL for the PID-MPGD support layers (dRICH & hpDIRC)
  - Both technologies will serve as fallback solution to each other
  - Same readout electronics for the two technologies SALSA chip is the likely candidate for the FE electronics
- Intensive ongoing R&D effort:
  - Outcome and timeline are laid out to reach some definitive answer on technologies readiness for the CD3 timeline
- First draft of construction model and production of the EPIC MPGD modules has been developed

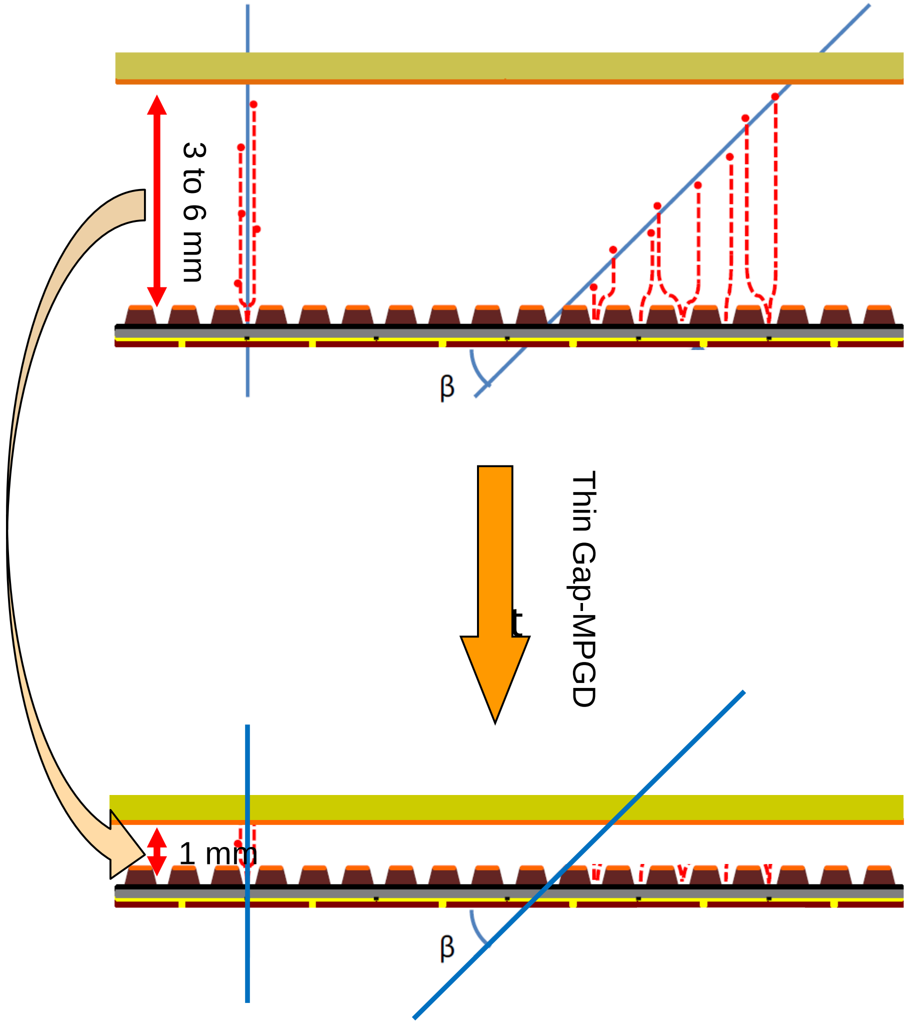
Back up slides

Ongoing R&D efforts – Timeline & expected outcome

Development of Thin Gap MPGD – proposal for FY22 EIC Generic Detector R&D call for proposals

- Nominal resolution is calculated for hits from tracks perpendicular to detector plane
- Resolution degrades for large angle tracks due to large ionization trail in the drift gap
- **One solution to address the issue:**
  - Narrow drift gap from couples of mm (3 to 6) to sub mm level
  - Spatial resolution still angle dependent but expected to be reasonable at large angle

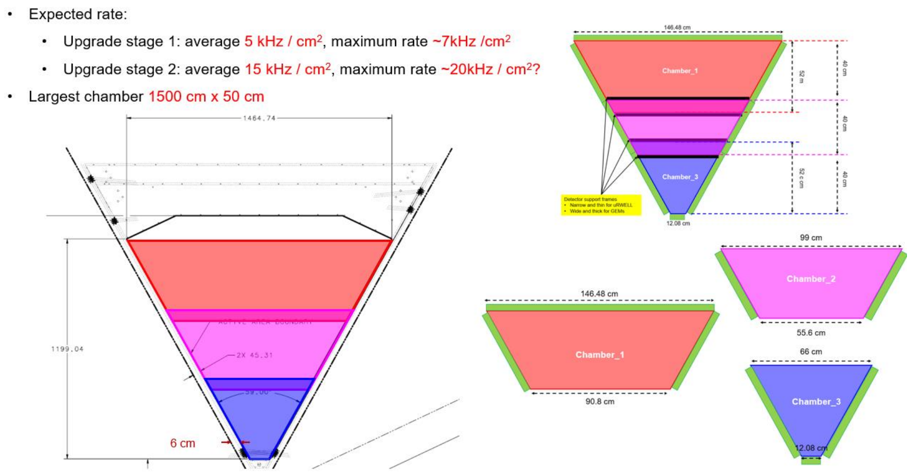
    ➔ < 150 um for 30 º tracks with 1 mm drift gap
- **advantages:**
  - Twin TG-MPGD configuration ➔ Good angular resolution in large eta range
  - Performance improvement in large B field ➔ to be demonstrated
  - Should work with capacitive-sharing readout structures
- **Cons / challenges**
  - Will require high density gas like Xe ➔ cost
  - Not ideal solution for low mass Cyl. layer

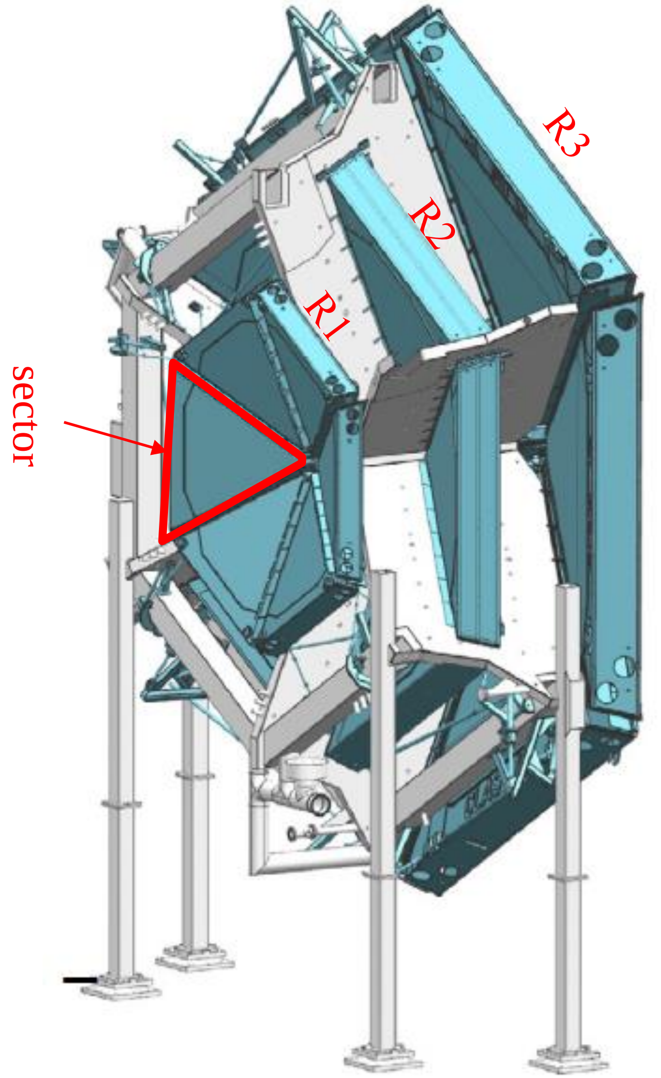


Ongoing R&D efforts – Timeline & expected outcome

Synergetic effort – development of large planar μRWELL tracker – CLAS12 High Luminosity Forward Tracker upgrade

- Forward drift chambers is the limiting factor for full luminosity runs
  - At half luminosity ➔ single track efficiency = 80%, double track = 64% and three track = 50%
- Add or replace new tracking layer in front of region 1 R1 forward drift tracker
  - Provide good timing response (< 10 ns) ➔ improve multiple hit detection ➔ track efficiency
  - Improve tracking capabilities ➔ precision tracking with < 100 μm space point resolution
- Phase 1 of CLAS12 Luminosity forward tracker upgrade
  - Add one layer to region drift chambers (R1 DC) ➔ six triangular DC sectors (151 cm × 146 cm)
  - MPGD only technology for fast response, excellent spatial resolution and large area capability
- μRWELL has been chosen as MPGD technology for CLAS12 High-Luminosity forward tracker upgrade
  - Low mass and compactness
  - easy assembly, easy powering
  - Intrinsic spark quenching
  - Gas gain → 10^4
  - Rate capability HR version → 10 MHz/cm^2
  - Spatial resolution → < 100 μm
  - Time resolution → < 10 ns





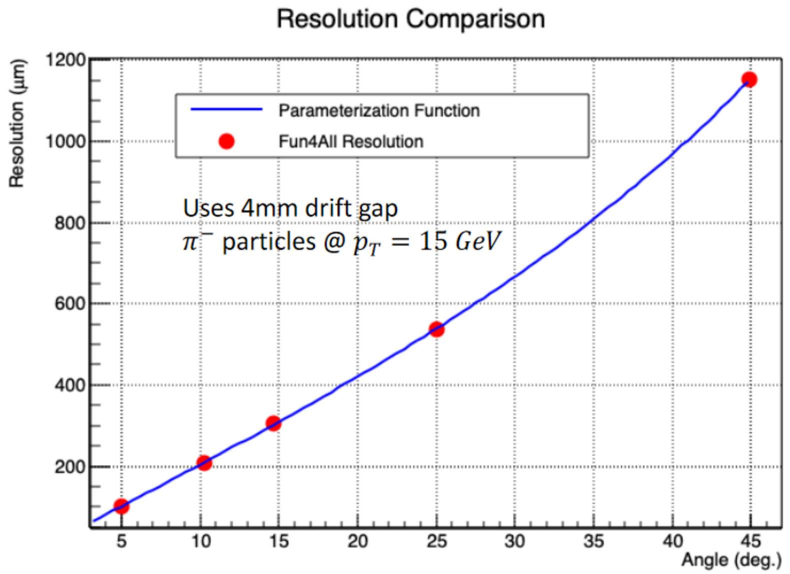
Spatial resolution: issues to address

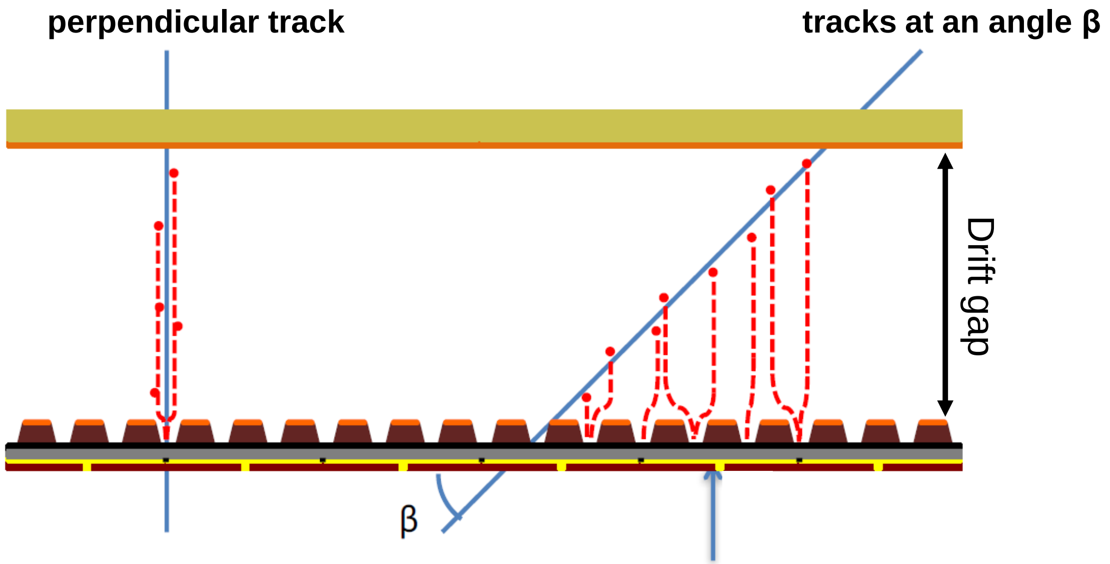
❖ **Nominal position resolution:** hits from **tracks perpendicular to detector** plane.

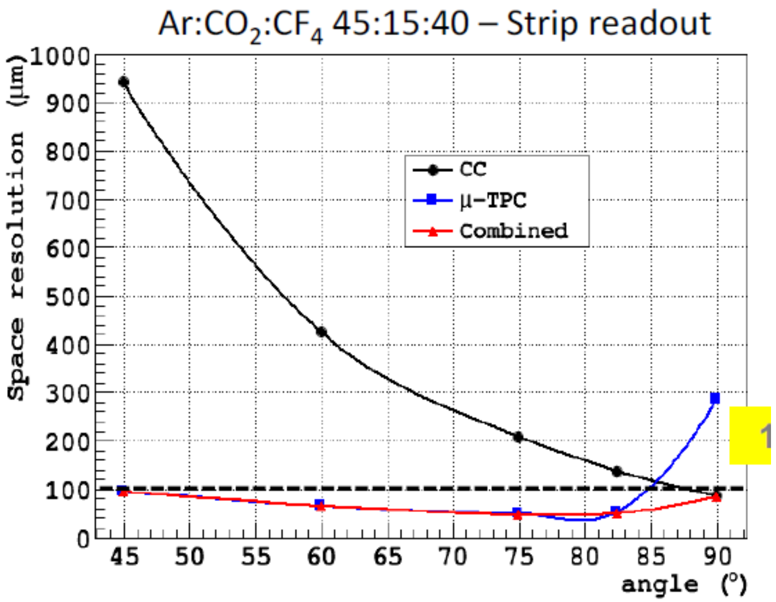
- Depends on technologies, readout structures & pitch (strips, pads, ZZ…), gas properties
- Ranging between 50 µm – 100 µm for MPGD trackers

❖ **Incoming track at large angle**

- Ionization in drift generates signal **on too many strips** Nb of strips increases linearly drift gap
- COG no longer valid way, spatial resolution **~ d/$\sqrt{12}$** ➔ determined by drift gap
- **Two approaches to recover spatial resolution performance under consideration**
    - Micro-TPC (µTPC) ➔ increasing the drift gap (from 3 mm to 10, 20 mm)
    - Thin gap MPGDs ➔ reducing the drift gap (**from 3 mm to 1 mm or less**)





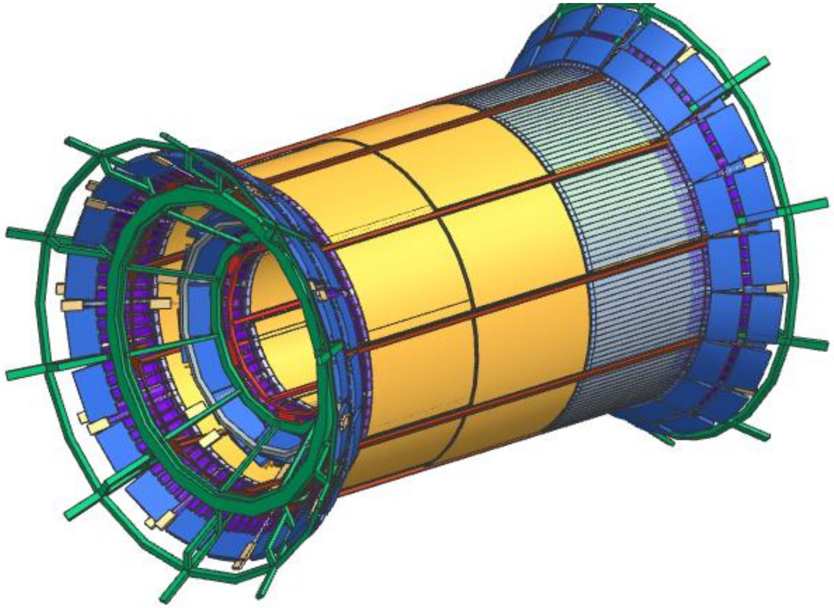


Barrel MPGD trackers: Cylindrical design

Requirements & expectations from YR & various detector proposals:

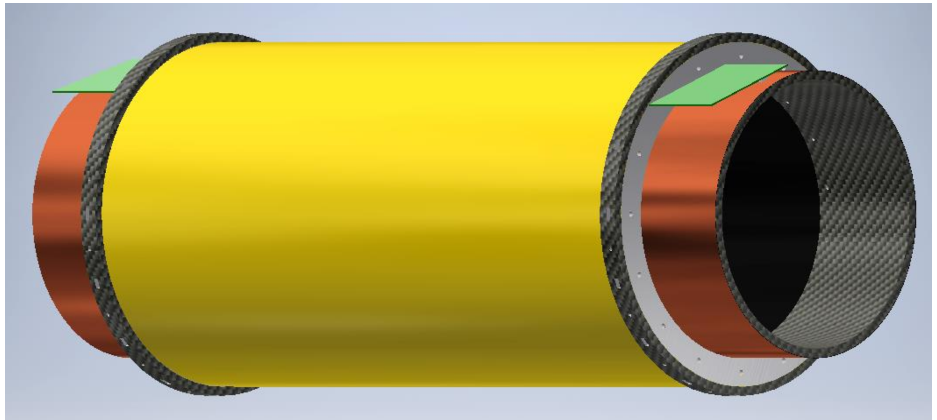
- Low mass < 0.5% X0 / layer for all barrel MPGD layers
- Spatial resolution (50 µm – 100 µm) for all barrel MPGD layers in both phi and z directions
- Full coverage in eta and phi ➔ no dead area

Preliminary design of micromegas tracker for ATHENA proposal



- We will have to revisit some of these expectations and relax the constraints where we can
- This should come from tracking simulation results and "updated" physics requirements
- The technologies are known (micromegas or µRWELL)
- Actual design strongly depends on requirements

Ongoing R&D for cylindrical µRWELL (eRD108)



Challenges:

- **Large area & low mass ➔** < 0.5% X0 will be very challenging
- **Low mass & 2D readout ➔** at this level of low mass, material budget of readout is a major contribution to the overall thickness regardless the MPGD technology
- **Spatial resolution ➔** degradation of resolution with incoming track angle
  - Main concern is the spatial resolution requirements at large angle in z direction
  - 50 µm–100 µm will be extremely challenging at ➔ more on following slides
  - excellent spatial resolution (50 µm–100 µm) uniform across the range in phi direction

EIC detector 1: MPGD technologies - μRWELL

Technology:

- Leading institutions in eRD108 and Tracking WG: **BNL, Florida Tech, JLab, Temple U, UVa.**
- More recent technology ➔ never deployed in an HEP or NP experiment yet
  - Simpler fabrication, low cost, flexibility, robustness
- Planar and tiles modules for cylindrical trackers, full cylindrical module for smaller radius possible

CLAS12 High Luminosity Upgrade Forward Tracker: Large-area μRWELL prototype:

- Large-area (150 cm x 50 cm) & light-weight (0.7% X0)
- Prototype completion by end 2022 and in test in Hall B in 2023
- A lot to learn from the test this prototype in early 2023

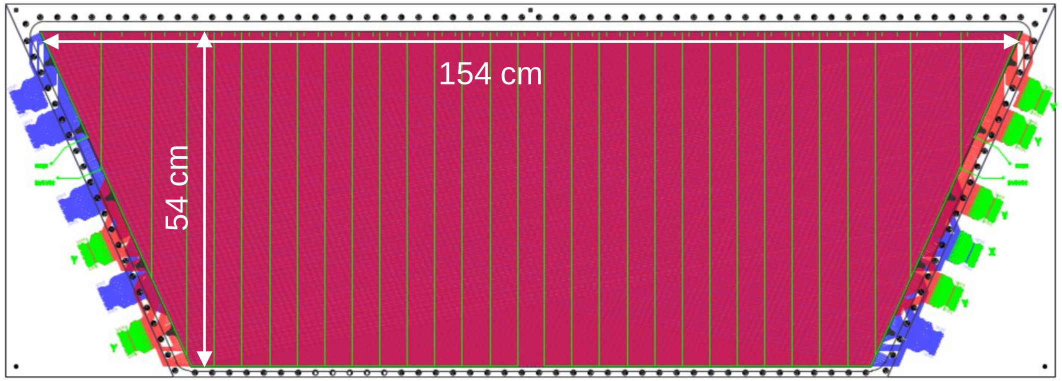
EIC detector 1 needs:

- Cylindrical tracking layers (full cylinder for most inner barrel layer & modular tiles option ala Micromegas all under consideration
- Large planar module (200 cm x 34 cm)) capability for DIRC MPGD layer
- 2D readout with **nominal resolutions 50 – 100 μm** in both directions & low channel count

Ongoing R&D efforts with eRD108:

- FY22:
  - Develop small radius (2 cm diam) cylindrical μRWELL prototype
  - Develop 2D readout for low number of channels on small prototypes
- FY23:
  - Prototype tests in beam ➔ FNAL Summer 2023 (contingent R&D funding continuation)
  - Explore options optimization of track angle dependence of the spatial resolution

Gerber view of CLAS12 High-Lumi FT μRWELL prototype



Pros & cons list - table