Outer MPGD Tracker: µRWELL-BOT

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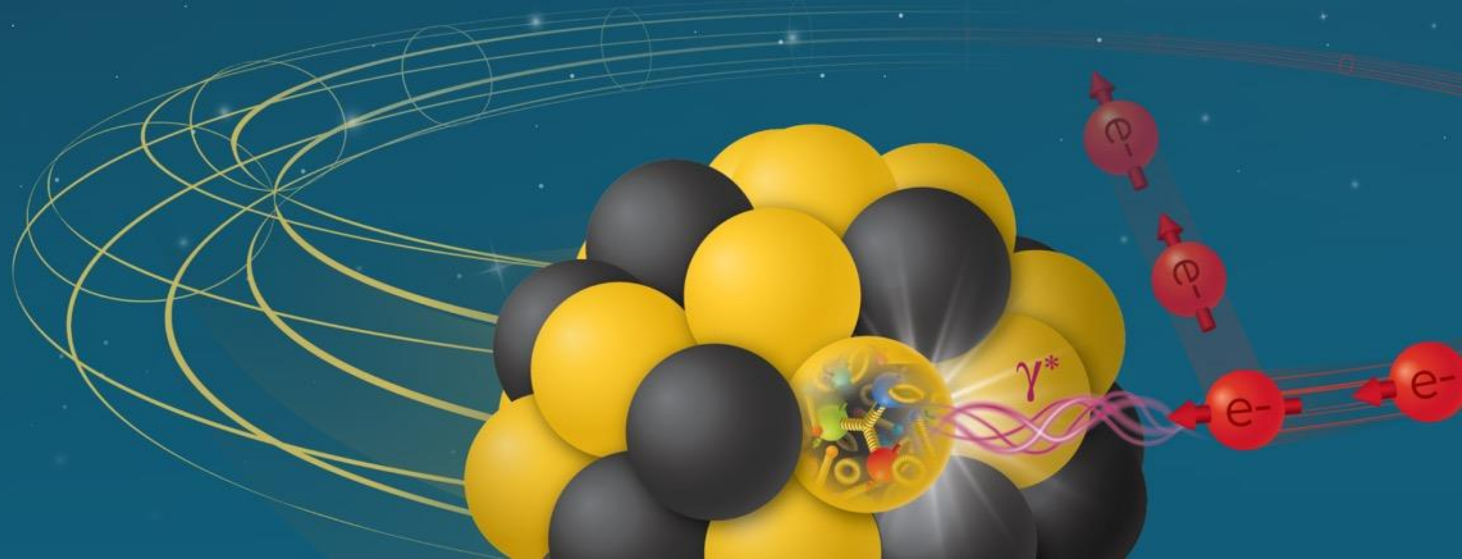
Incremental Design and Safety Review
of the EIC Tracking Detectors
March 20-21, 2024

Electron-Ion Collider



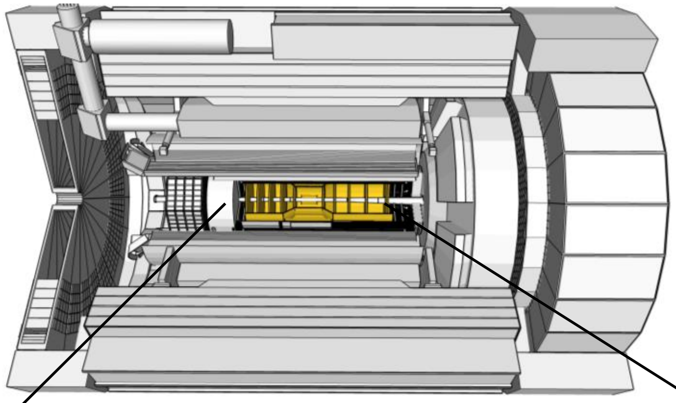
Outline

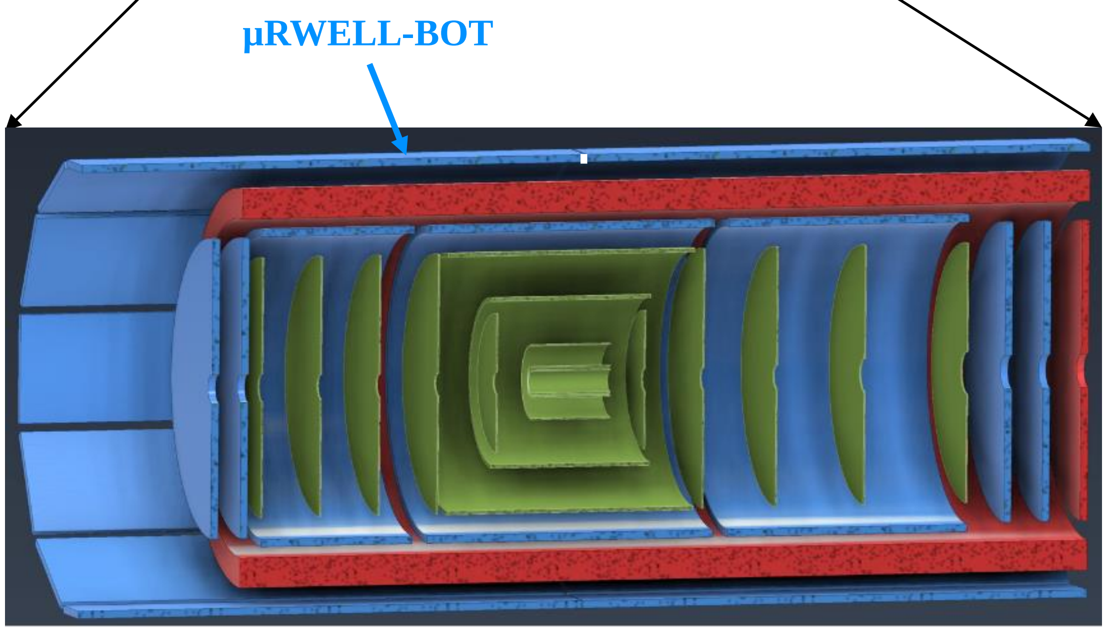
- Requirements — Charge 1
- µRWELL-BOT Detector Layout — Charge 2,3
- Technology Choice & Design Considerations — Charge 2,3
- PED & Prototyping for FY24 - FY25 — Charge 2,3
- MPGD Detector Subsystem Collaboration — Charge 5
- Assembly Schedule, ES&H & QA — Charge 5,7
- Summary

Requirements

µRWELL-BOT Detector Layout

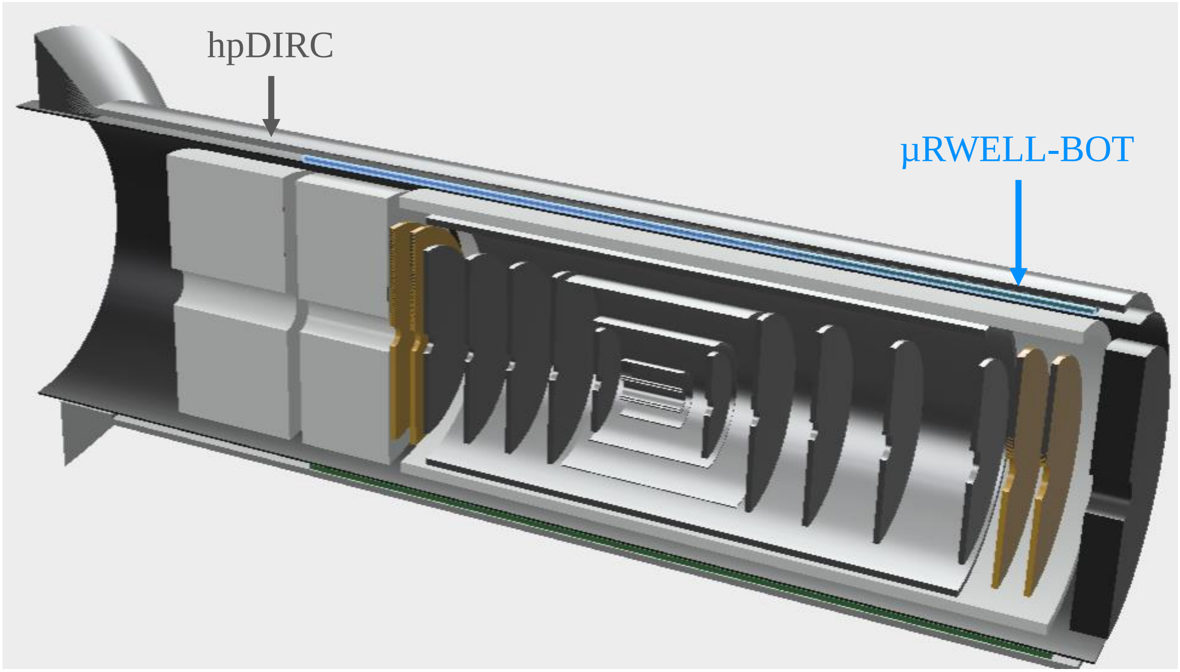
ePIC µRWELL Barrel Outer Tracker (µRWELL-BOT)



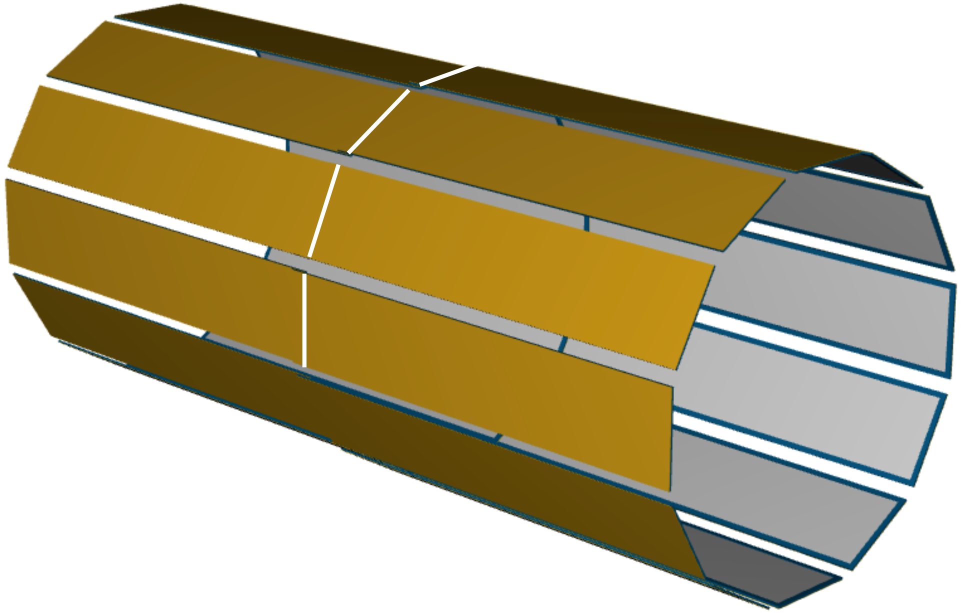


µRWELL-BOT

- Outer most tracking layer of ePIC central tracker the barrel region
- Pattern recognition layer (together with CyMBaL) in the barrel region
  - Fast timing with time resolution better than 10 ns for pattern recognition
- Provide additional hit position capability to the main tracker for redundancy
- Acceptance matching with hpDIRC bars to provide hit information to the PID in the barrel



μRWELL-BOT Layout



Layout

❖ 24 planar modules arrange in 12-sided polygon shape around IP

❖ Segmented into 12 modules in the azimuthal direction

❖ And two sectors in the z direction along the beam

μRWELL-BOT specifications

❖ Double amplification GEM & μRWELL and 2D strip readout

❖ Space point resolution:

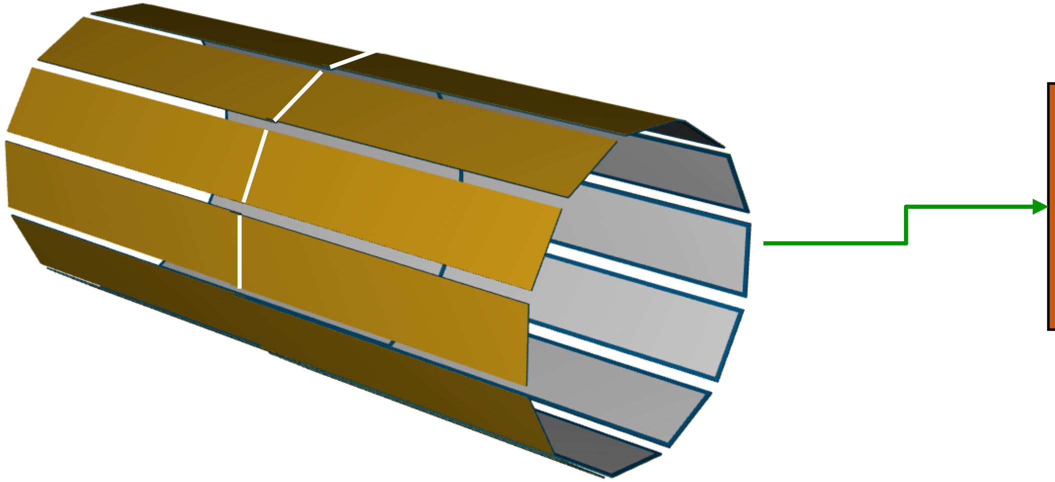
- Nominal **70 μm** (perpendicular tracks i.@ angle = 0 degree)
- **150 μm** on average for track angle range of [0, 45 degrees]

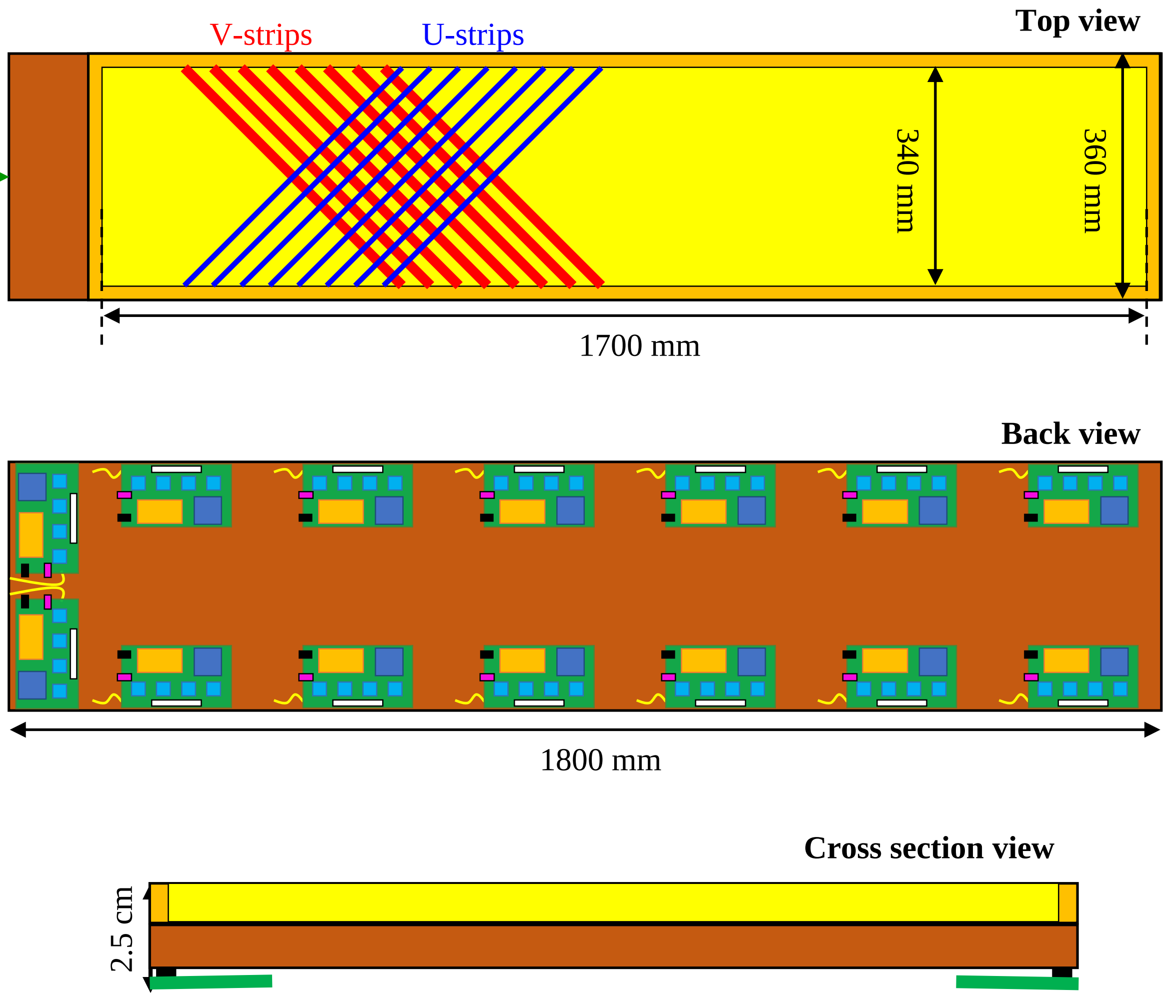
❖ Fast timing layer ~ 10 ns

❖ Radiation length < 2%

µRWELL-BOT Module:

Charge 2,3





24 uRWELL-BOT modules

- Thin-gap (1-mm drift) hybrid amplification GEM-µRWELL detector
- Pitch: ~1.14 mm (1792 U-strips and 1792 V-strips per modules)

On-detector Front End Boards (FEBs) based on SALSA chips

- Capacitive-sharing U-V strips readout layers(45^{O} stereo angle)
- 14 FEB / modules (assuming 4 SALSA chips i.e 256 e-ch / FEB)
- Direct connection on the back of the modules (no need for flex cables)

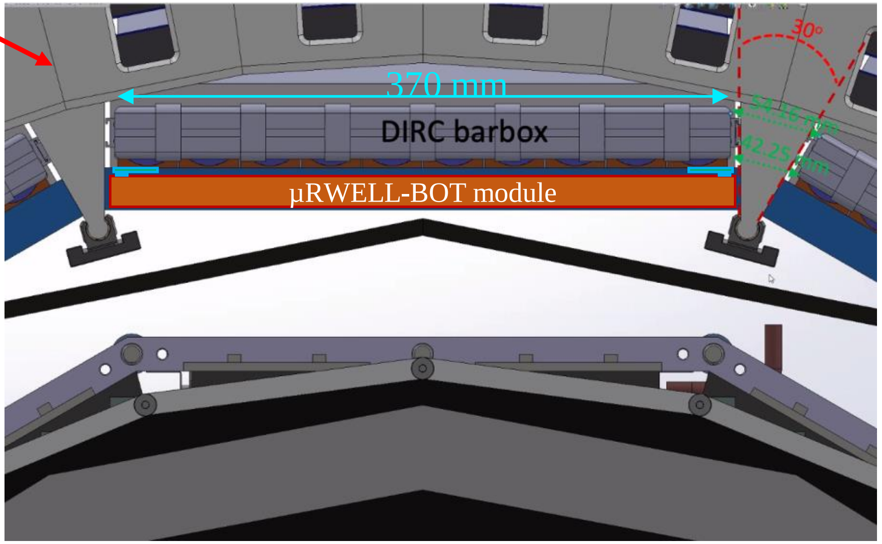
µRWELL-BOT Module: Integration into ePIC Detector

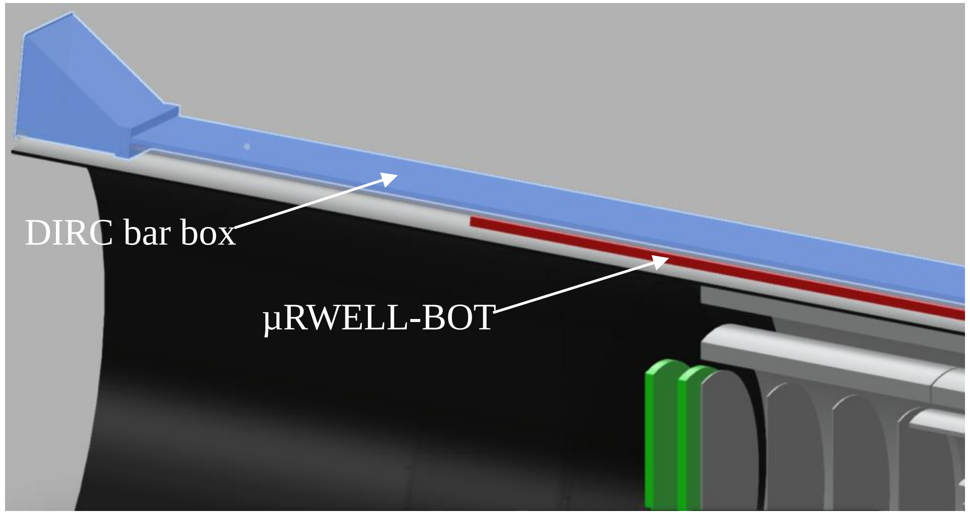
Charge 2,3

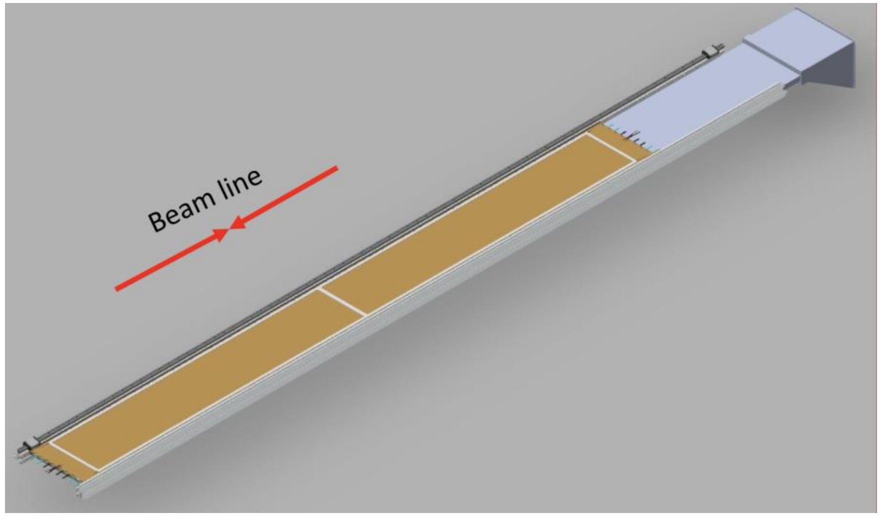
Main integration challenges: Space limitation in ePIC detector environment

- Integrated in barrel ECAL support structure in front (from IP) of hpDIRC bar
- µRWELL-BOT detector envelop in ePIC
  - In radial direction: 2.5 cm
  - Azimuthal direction: 37 cm
- Implication in the design of the µRWELL-BOT module
  - FEB cards on the back of the modules ➔ material budget
  - Carefully consider how services, cables choices affect maintenance in the future

Barrel ECAL support structure







Technology Choice & Design Considerations

Technology choice – Thin-gap GEM-µRWELL Hybrid Detector

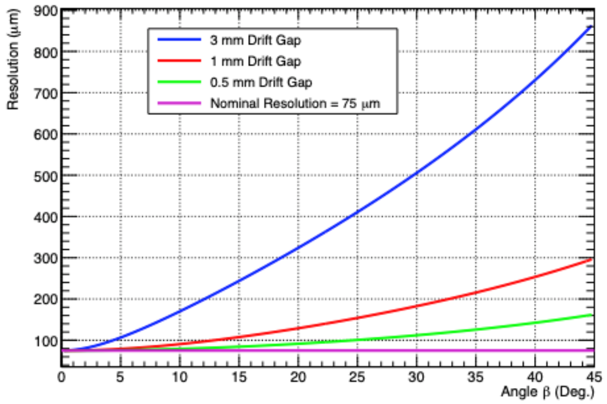
Charge 2,3

Challenges with standard (> 3-mm drift gap) MPGD

- Degradation of the spatial resolution with track angle .
- E × B in magnetic field negatively impact resolution

Development of Thin-gap MPGDs:

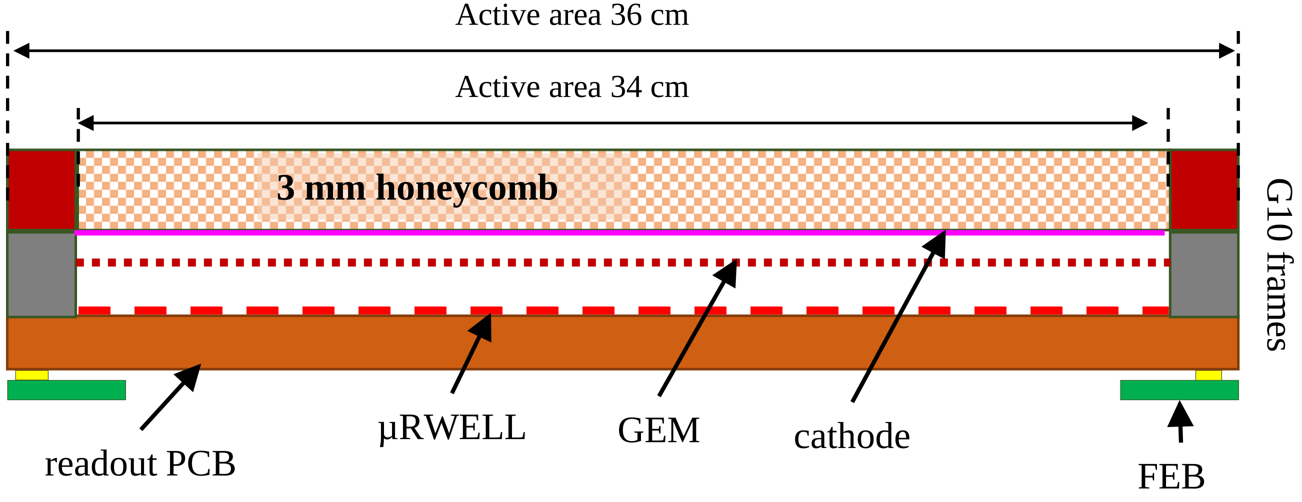
- Small drift gap improve spatial resolution at large angle
- Small gap ➔ minimize E × B effect in magnetic field
- Improve the detector timing performance



parametrization from *EPJ Web of Conferences* ***174****, 06005 (2018)*

Thin-gap GEM-µRWELL detector concept

- Double & hybrid amplification MPGD:
  - GEM (preamplification) and µRWELL (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



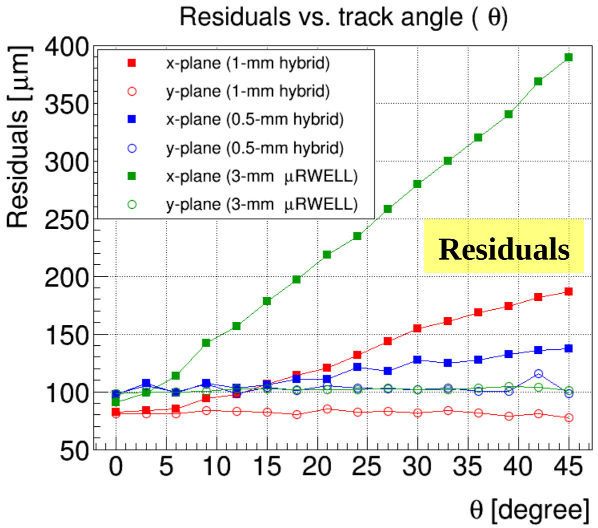
cross-section view of thin-gap GEM-µRWELL detector

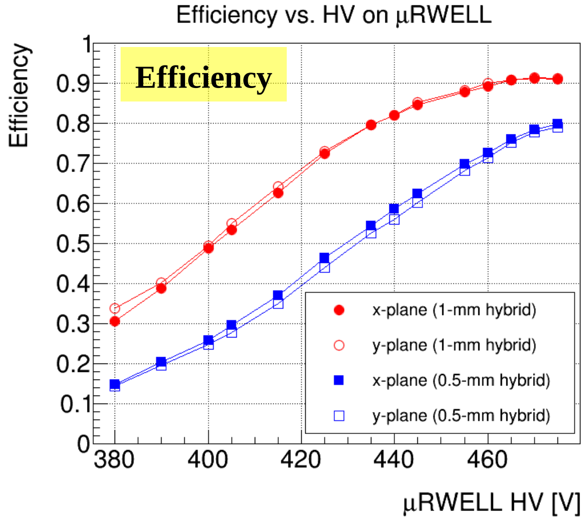
Technology choice: Thin-gap GEM-µRWELL Hybrid Detector

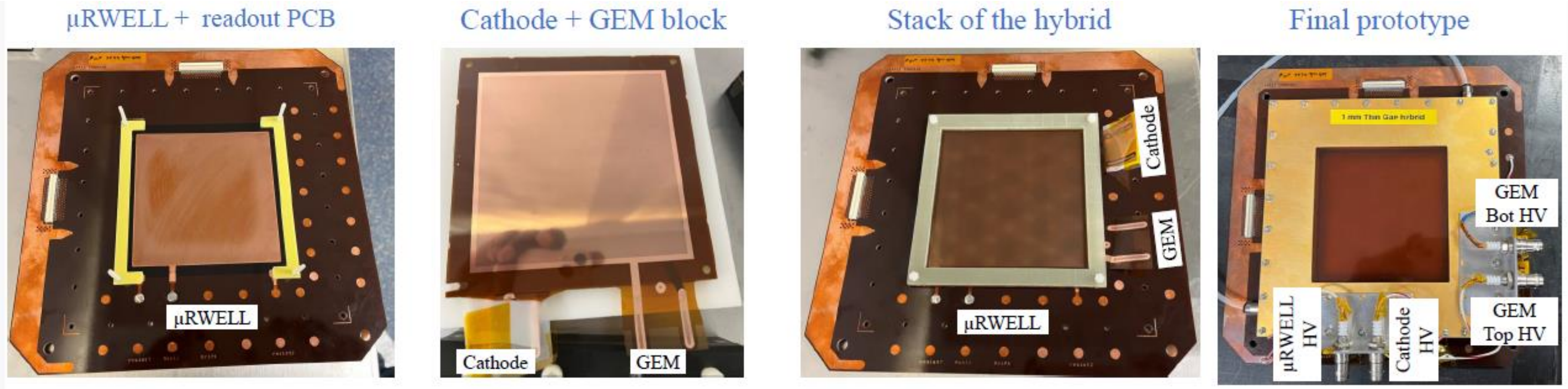
Charge 2,3

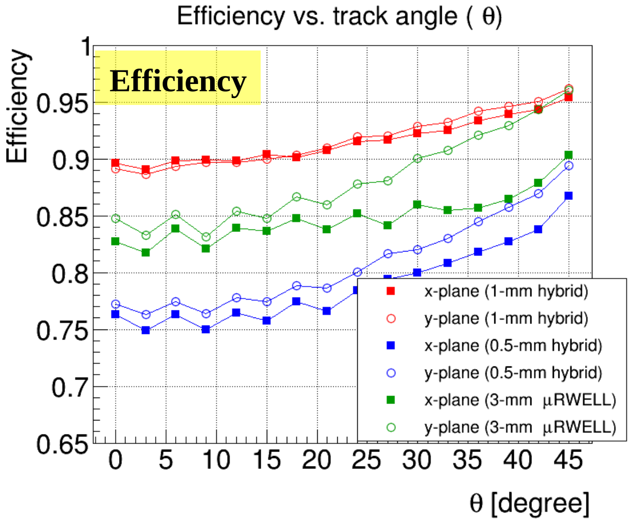
Proof of concept

- Concept of thin-gap GEM-µRWELL hybrid prototype demonstrated in beam test at the Fermilab Test beam Facility in Summer 2023 (red plots)
- Space resolution < 150 µm and efficiency of 92% on average for 1-mm thin-gap GEM-µRWELL prototype (red dots) and for track in an angle range between 0 – 45 degrees.
- **Baseline technology for ePIC outer MPGD tracker**









R&D funded by JLab administered DOE EIC Generic R&D Program as EICGENRandD_2022_23

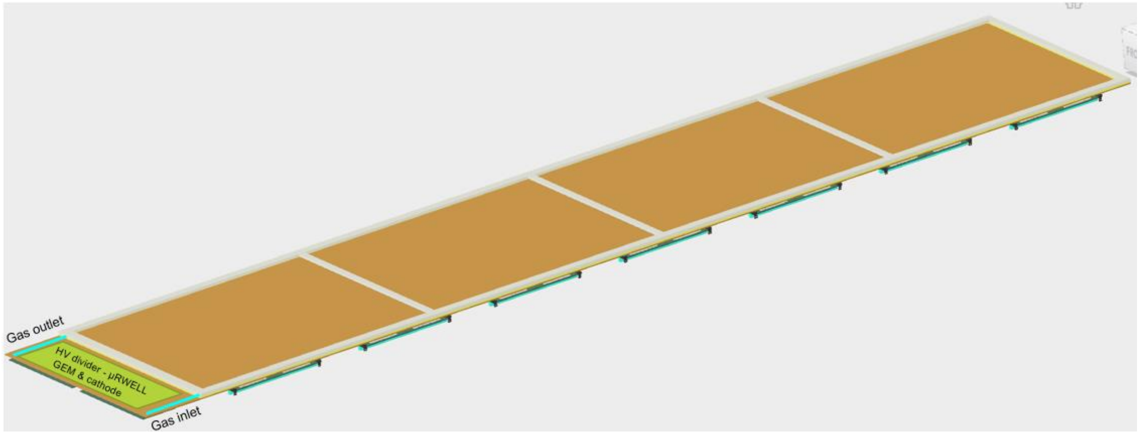
PED ~~& Prototyping~~ for FY24 - FY25

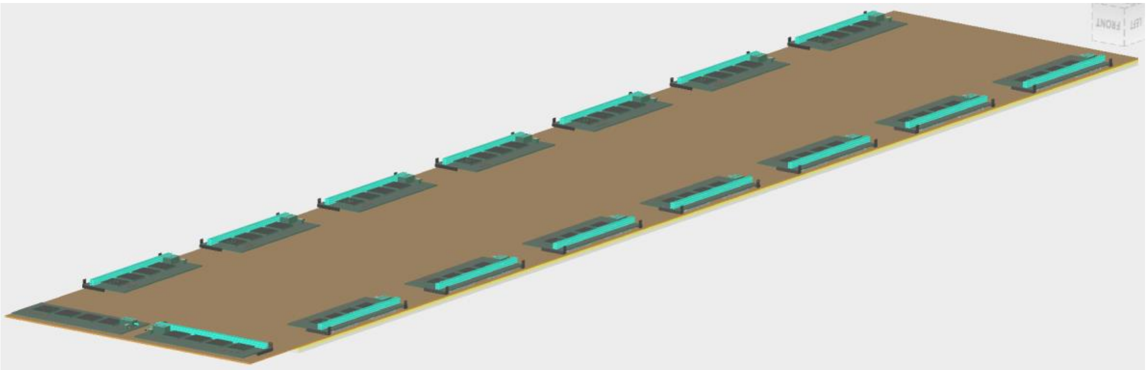
Design consideration – µRWELL-BOT module

Charge 2,3

PED funding 2024 to develop full scale µRWELL-BOT module

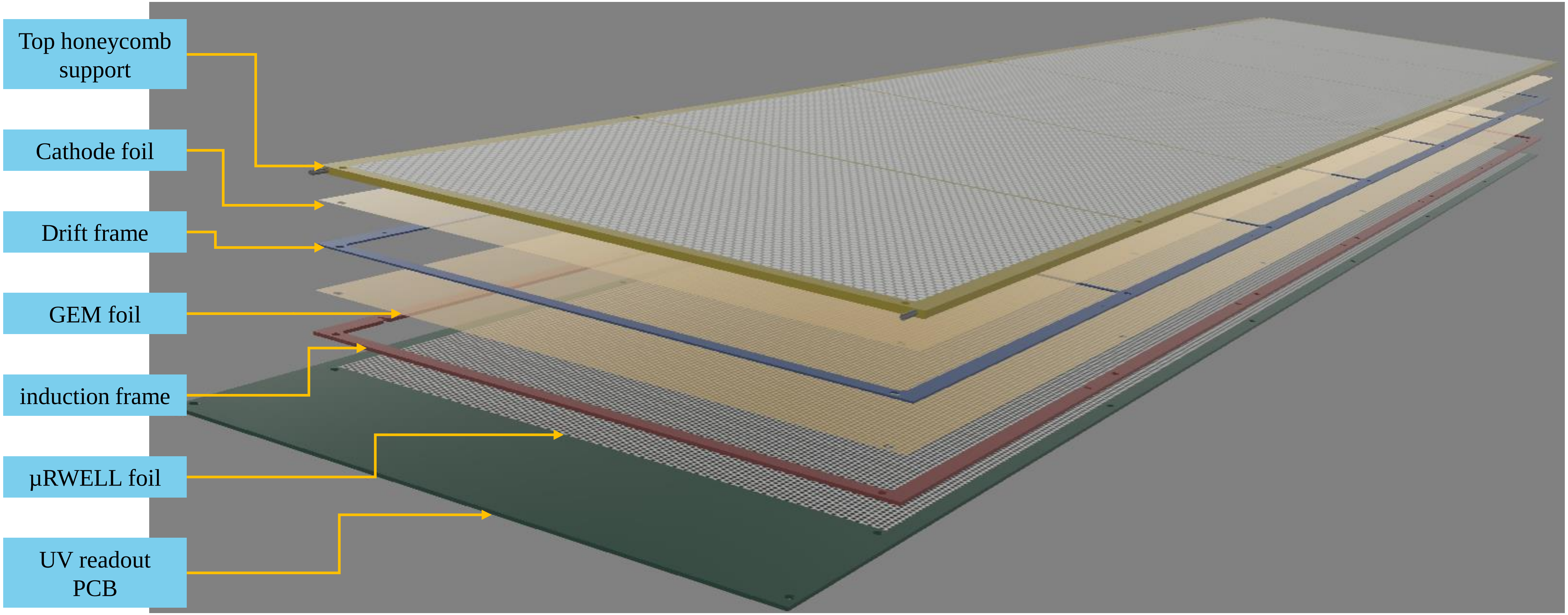
- ❖ Based on the 1-mm thin-gap GEM-µRWELL prototype tested at FNAL
- ❖ Full scale to validate the technology for ePIC
- ❖ Address specific challenges to the ePIC detector
- ❖ Design at JLab (K. Gnanvo & Seung Joon Lee) ➔ FY24
- ❖ Pre-production module completed ➔ end FY24 – early 25
- ❖ Test in beam at FNAL summer 2025





Design consideration – µRWELL-BOT module design

Charge 2,3

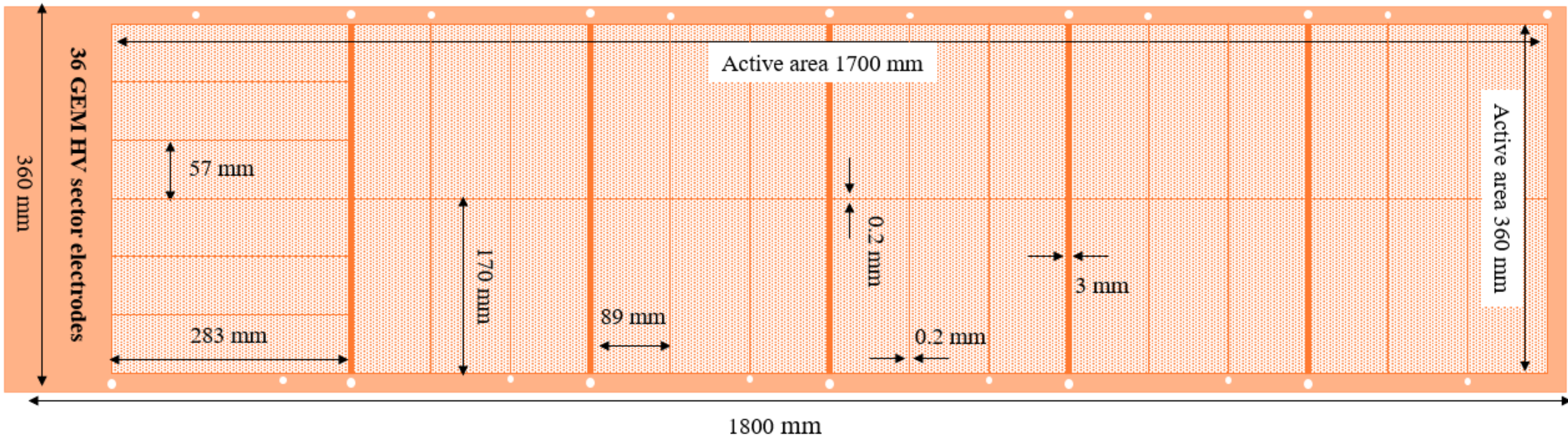


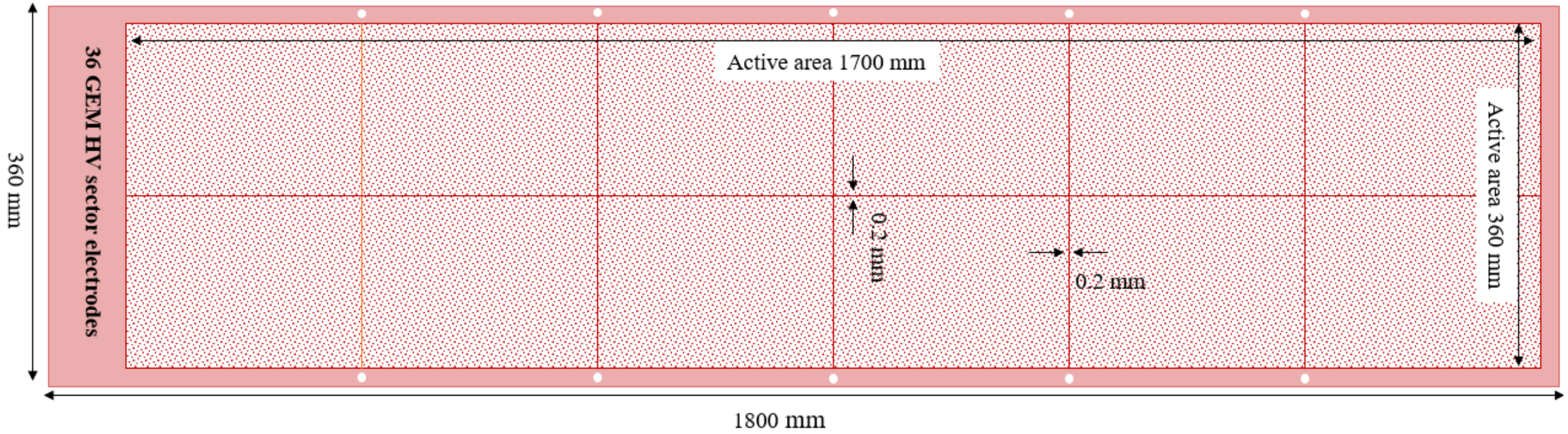
Design consideration – µRWELL and GEM foil design

Charge 2,3

GEM foil design

- ❖ Conceptual foil design: foil divided into 36 HV sector ~ 150 cm^2
- ❖ Trade-off optimization between active-to-dead area ratio and GEM – cathode gap uniformity
- ❖ Final design with input from GEM experts at CERN MPT workshop - 04/24
- ❖ Procurement by 12/24





µRWELL foil design

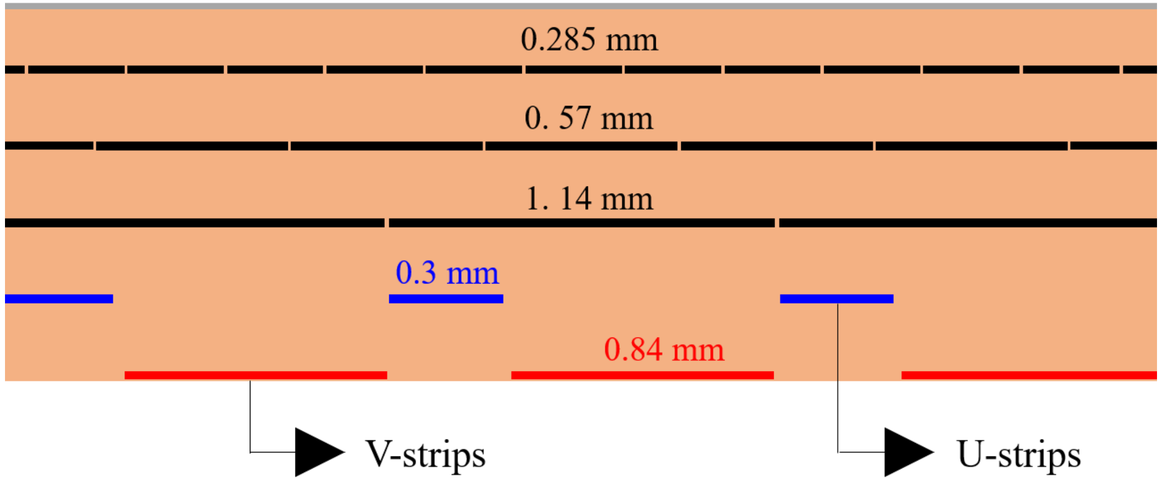
- ❖ Conceptual foil design: foil divided into 12 HV sector ~ 450 cm^2
- ❖ Final design with input from GEM experts at CERN MPT workshop - 04/24
- ❖ Procurement by 12/24

Design consideration: 2D (U-V)-strip readout layer

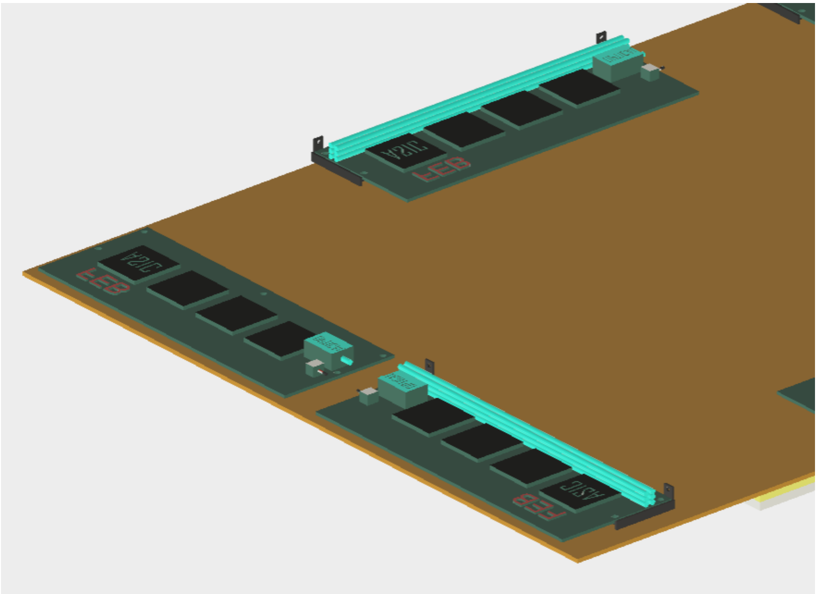
Charge 2,3

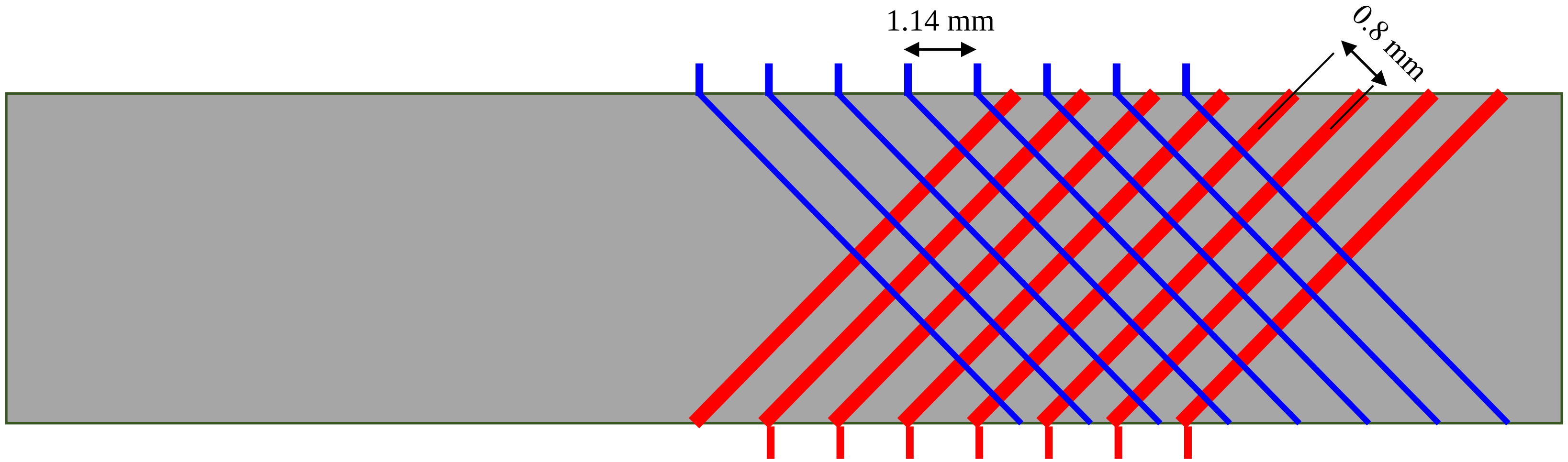
Readout strip layers

- ❖ 3-layer capacitive-sharing U-V strip readout
  - Strip pitch: 0.8 mm (along U and V axis)
  - Trace pitch: 1.14 mm along horizontal axis (traces)
- ❖ Connectors on the back of the rigid PCB detector ➔ vias connected strips to connectors



cross-section view of 3-layers U-V strip capacitive-sharing readout



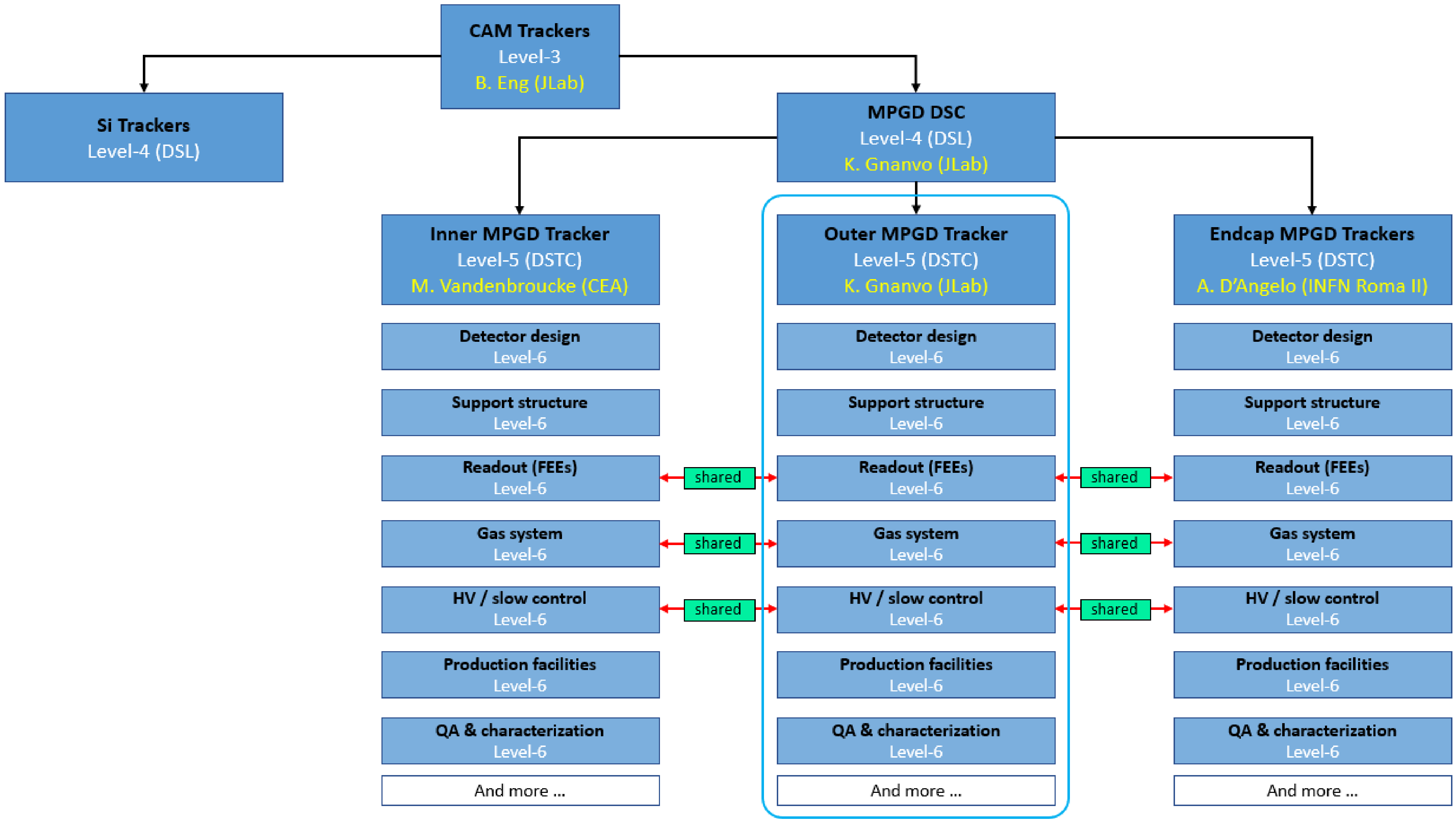


U-V strip configuration

MPGD Detector Subsystem Collaboration

MPGD-DSC Organization – & Barrel Outer MPGD subsystem

Charge 5



MPGD-DSC Organization – & Barrel Outer MPGD subsystem

Institutions	Contacts	Expressed interest	Anticipated contribution (Here, I am speculating)	Past and present experience in MPGD for NP and HEP experiments
University of Virginia	N. Liyanage, H. Nguyen …	Barrel Outer Trackers	Design, assembly site & characterization	SBS GEMs, PRad GEMs, MOLLER GEMs, CLAS12 µRWELL, EIC R&Ds
Jefferson Lab	K. Gnanvo, Seung Joon Lee,, S. Tarafdar	Barrel Outer Trackers & Hadron end cap discs	Design, assembly site, characterization & Installation at BNL	SBS GEMs, PRad GEMs, CLAS12 µRWELL, EIC R&Ds
Florida Tech	M. Hohlmann ..	Barrel Outer Trackers & Hadron end cap discs	Design, assembly site & characterization	CMS GEMs, EIC R&Ds
BNL	C. Woody, A. Kiselev, B Azmoon	Electron end cap µRWELL discs	Design, commissioning & Installation at BNL	PHENIX HBD, sPHENIX TPC, EIC R&Ds …
INFN & University Roma Tor Vergata	A. D'Angelo	end cap µRWELL discs	Design, assembly site, characterization	CLAS12 µRWELL, EIC R&Ds
Temple U.	M. Posik, B. Surrow	end cap µRWELL discs Barrel Outer µRWELL		STAR FGT, sPHENIX TPC GEM readout, EIC R&Ds
CEA Saclay	F. Bossu, Damien Neyret, I. Mandjavidze	Barrel Inner Tracker (CyMBaL & readout electronics	SALSA chips SALSA FEB for CyMBaL	CLAS12 MVT, ATLAS Micromegas Muon detectors… EIC R&Ds
Korean Institutions contribution	I. Yoon	Production of GEM and µRWELL foils	In kind contribution (GEM foils and µRWELL PCBs)?	CMS GEMs foil production

Assembly Schedule, ES&H & QA

Summary

Backup

Charge Questions Addressed

Grey out charge text not being addressed.
GRY RGB HEX CODE: #BFBFBF

1. Are the technical performance requirements appropriately defined and complete for this stage of the project?
2. Are the plans for achieving detector performance and construction sufficiently developed and documented for the present phase of the project?
3. Are the current designs and plans for detector, electronics readout, and services sufficiently developed to achieve the performance requirements?
4. Are plans in place to mitigate risk of cost increases, schedule delays, and technical problems?
5. Are the fabrication and assembly plans for the various tracking detector systems consistent with the overall project and detector schedule?
6. Are the plans for detector integration in the EIC detector appropriately developed for the present phase of the project?
7. Have ES&H and QA considerations been adequately incorporated into the designs at their present stage?