Jefferson Lab

U.S. DEPARTMENT of ENERGY | Office of Science

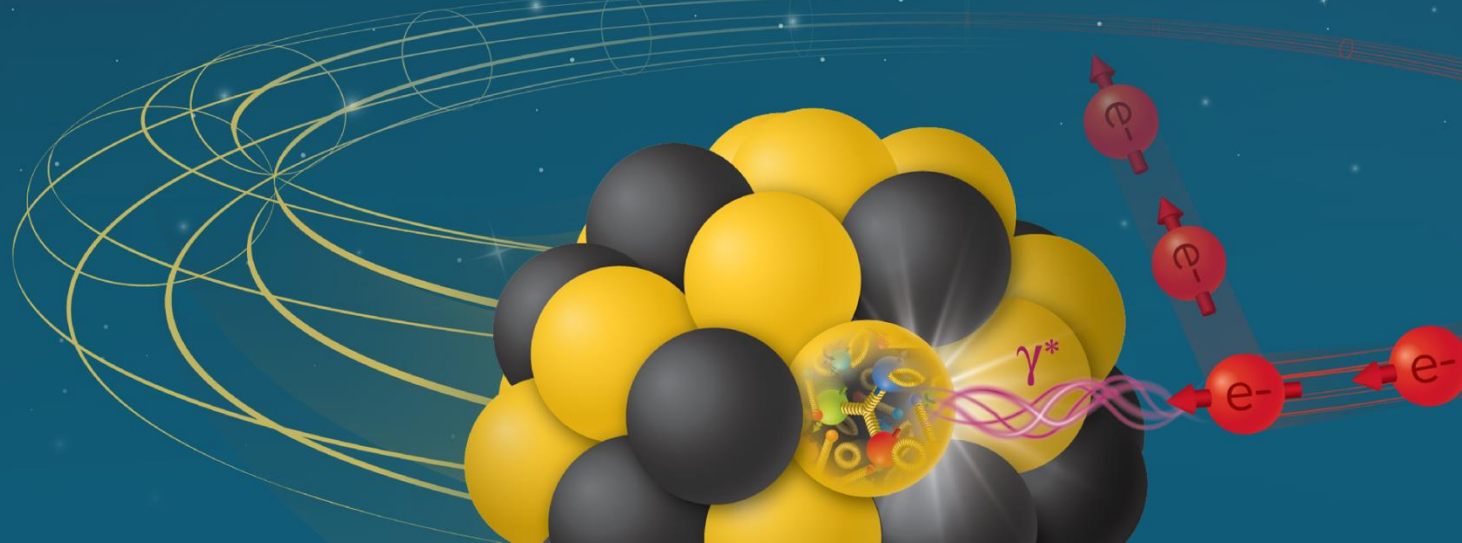
# MPGD Updates on Outer $\mu$RWELL-BOT Test Article

Xinzhan Bai, Kondo Gnanvo, Seungjoon Lee, Brian Kross, Sourav Tarafdar, Andrew Lumanog, Evan Emerson, Caleb Graham, Drew Weisenberger, Eric Christy

JLab EIC Weekly Meeting

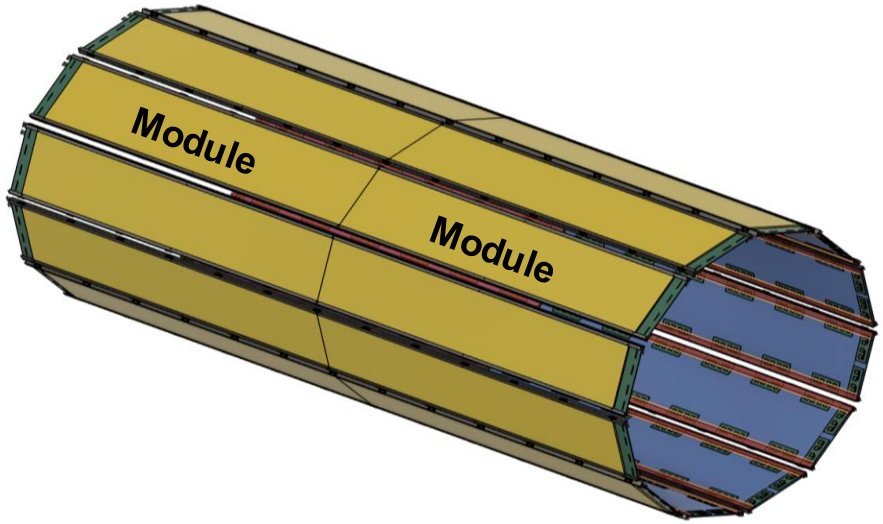
October 24th, 2025

Electron-Ion Collider

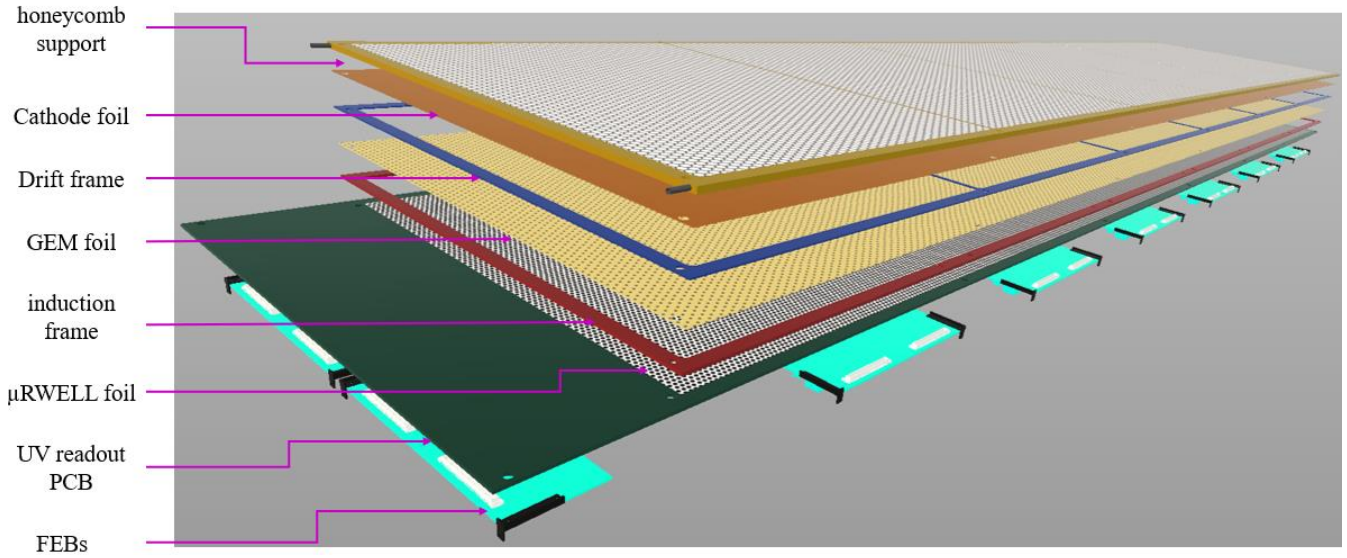


# $\mu$RWELL –BOT : ePIC MPGD Barrel Outer Tracker

## µRWELL-BOT layout




## Module design




- **24 module: 12 modules in ϕ × 2 modules in z**
- No overlaps in ϕ and in z ~ 10% dead area
- 7,168 readout channels / module
- **86K readout channels**
- $R_{min}$ = 72.5 cm; $R_{max}$ = 75 cm

**Module dimensions**

Z = 180 cm

R*phi = 36 cm

**Active zone dimensions**

Z = 170 cm

R*phi = 33 cm

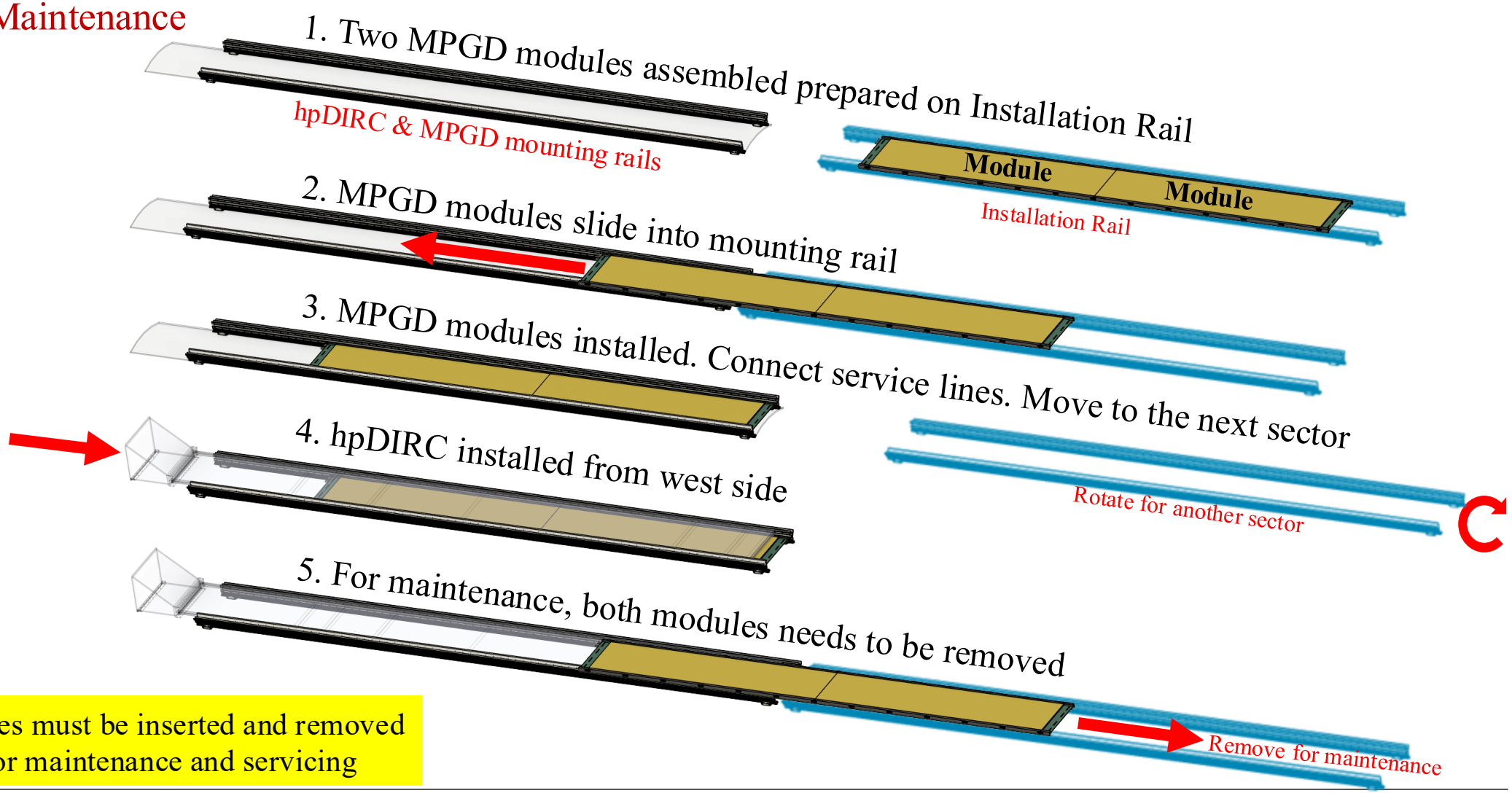
**Expected performance**

- Spatial resolution: < 100 (250) µm in Z (rphi)
- Time resolution ~10ns
- Efficiency ≥ 95%
- Material budget ~2% X0

https://eic.jlab.org/Geometry/Detector/Detector-20240515102931.html

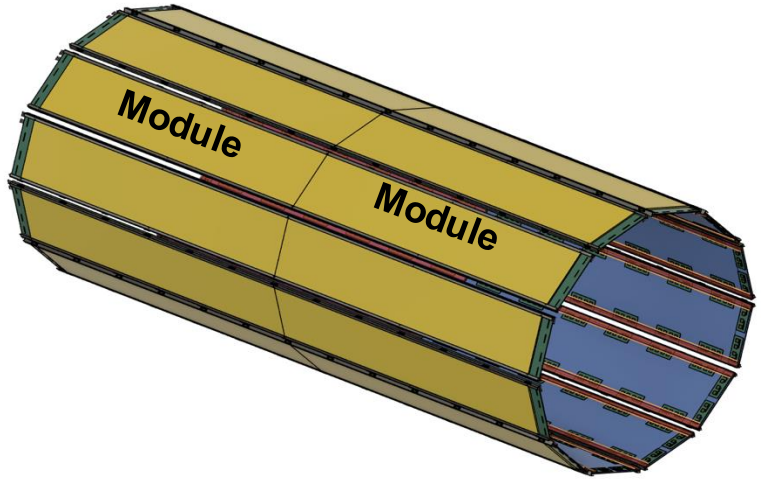
# Integration in ePIC

## Installation & Maintenance

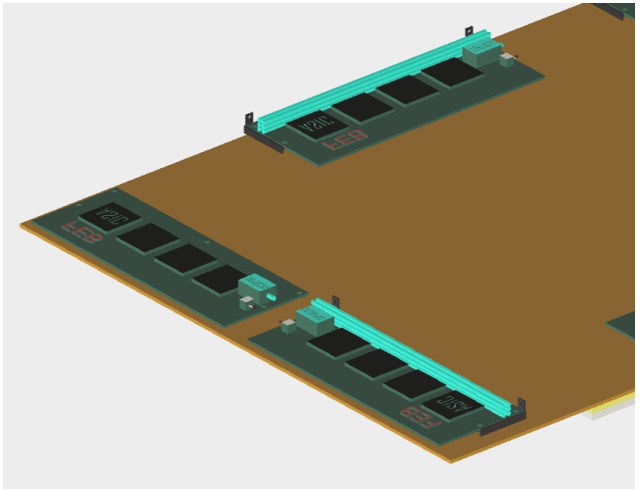



Both MPGD modules must be inserted and removed from the east side for maintenance and servicing

# μRWELL-BOT: Service Requirement




| Type | Size (OD,mm) | Model | Qty/Module |
|---|---|---|---|
| Data cable (optical) | 3 | OM3/OM4 | 14 |
| High Voltage | 3.2 | HTC-50-1-1 (CEH50) | 4 |
| Low Voltage | 5 | Alpha Wire 3464C | 14 |
| Gas | 5 | PTFE | 2 |
| Cooling | 6 | Copper/Stainless steel tubing | 2 |
| Env. Sensor (temp, humid) | 1 | -- | 3 |
| Ground | | | 1 |



- The volume and diameter of each service line are subject to change as the FEB design progresses.
- The cooling requirement has not yet been finalized.
- The current cooling approach utilizes water cooling with a heatsink.
- Three subsystems—BOT, ECT, and CyMBaL—will collaborate on the cooling system design.

# $\mu$RWELL –BOT : Module Structure

honeycomb support

Cathode foil

Drift frame

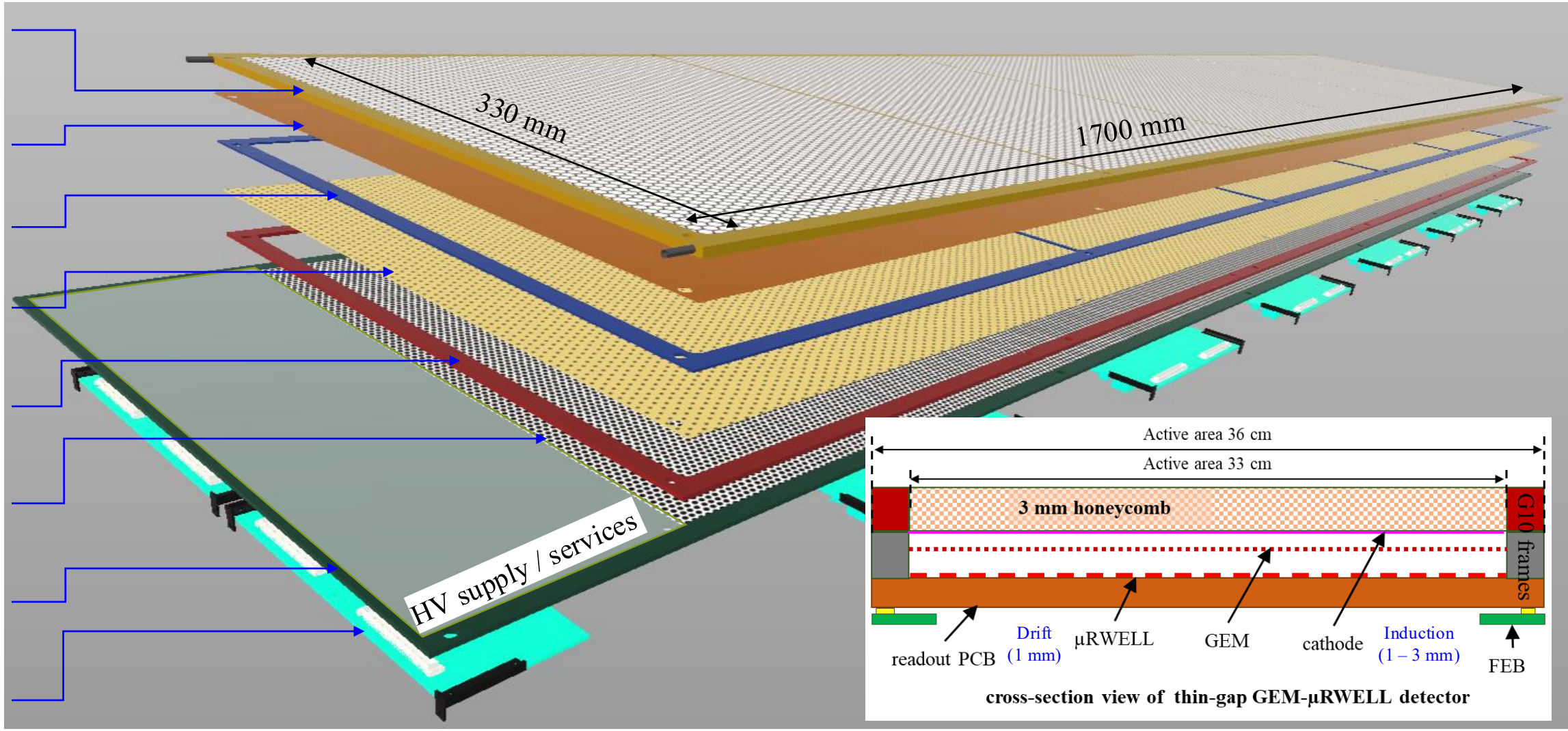
GEM foil

induction frame

µRWELL foil

UV readout PCB

FEBs



# Thin-gap GEM-µRWELL: Performance Studies in Test Beam

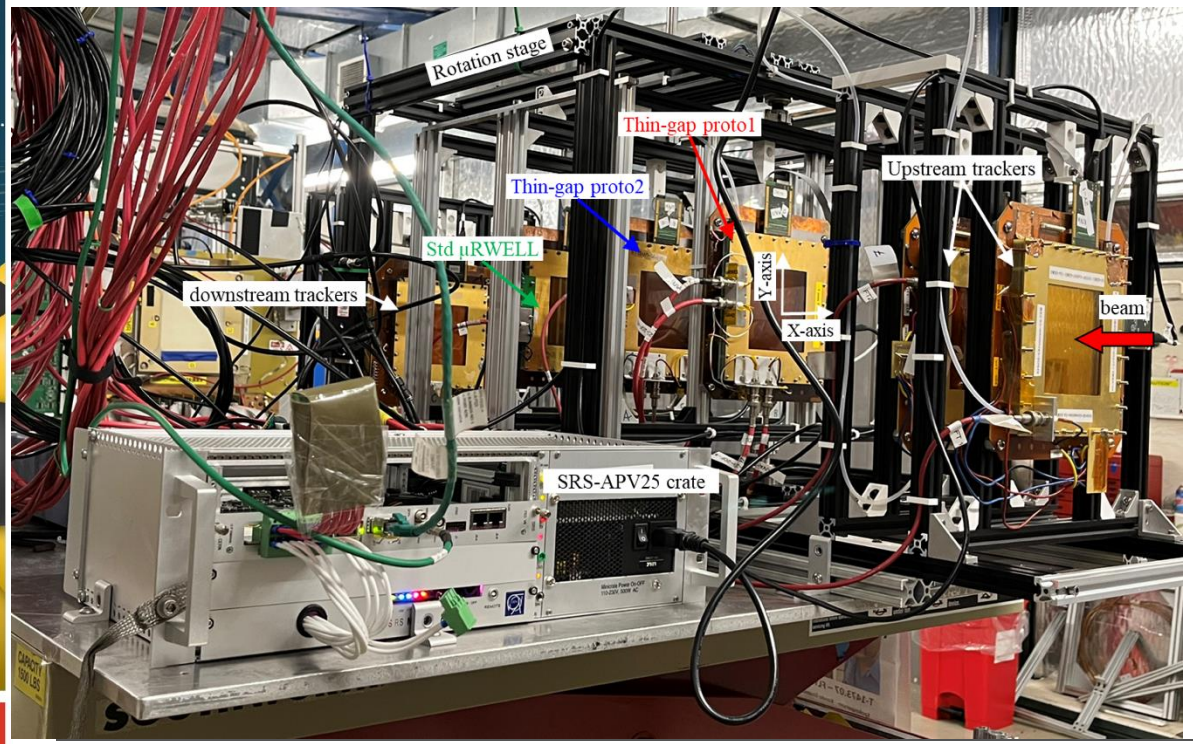
**Test beam campaigns @ FNAL (2023) and @ JLab (2025) for performance study and optimization of thin-gap GEM-µRWELL prototypes**

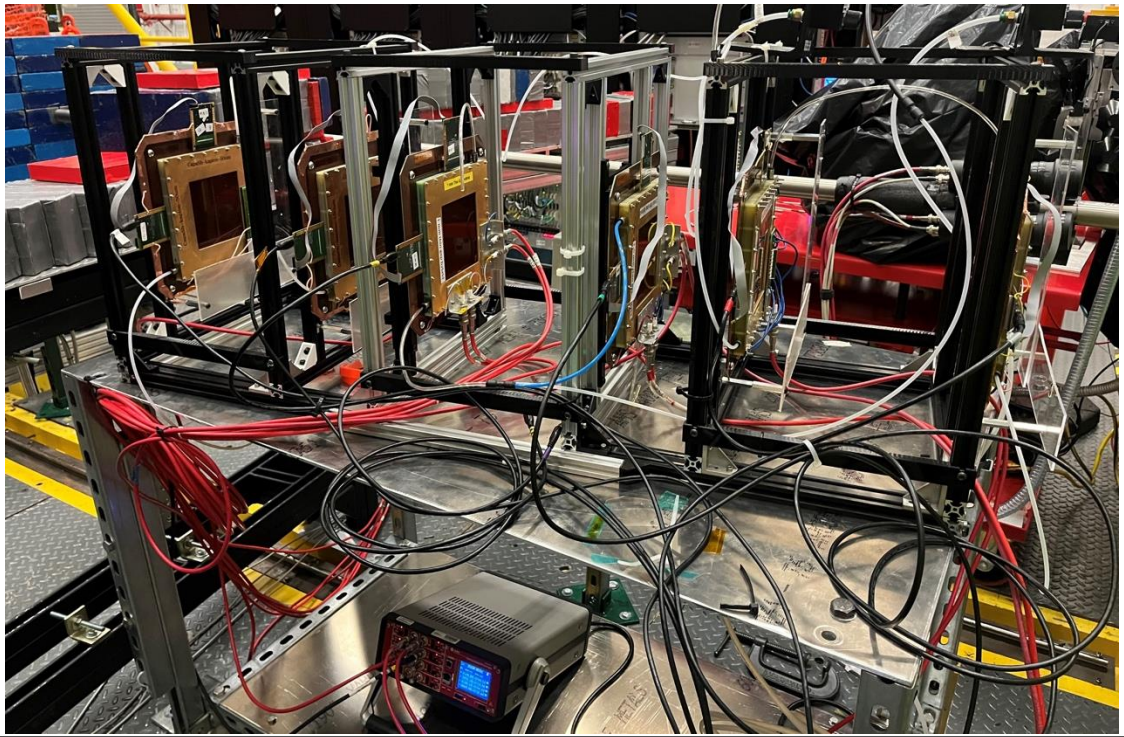
**FNAL test beam (06/2023): Position resolution vs. track angle**

- **3 protos**: 0.5 & 1 mm thin-gap GEM-µRWELL, 3-mm std µRWELL
- 4 HV scans for efficiency study with Ar:CO2 (80:20) gas mixture
- Track angle scan (0 – 45$^{O}$) for position resolution comparison studies

**JLab Hall D test beam (06/2025): - Efficiency vs. gas mixtures**

- **2 protos**: 1-mm and 1.5-mm thin-gap GEM-µRWELLs
- HV scan for efficiency study various Ar-based mixtures
- Argon gas mixture: (Ar/CO2 & Ar/CO2/Iso)



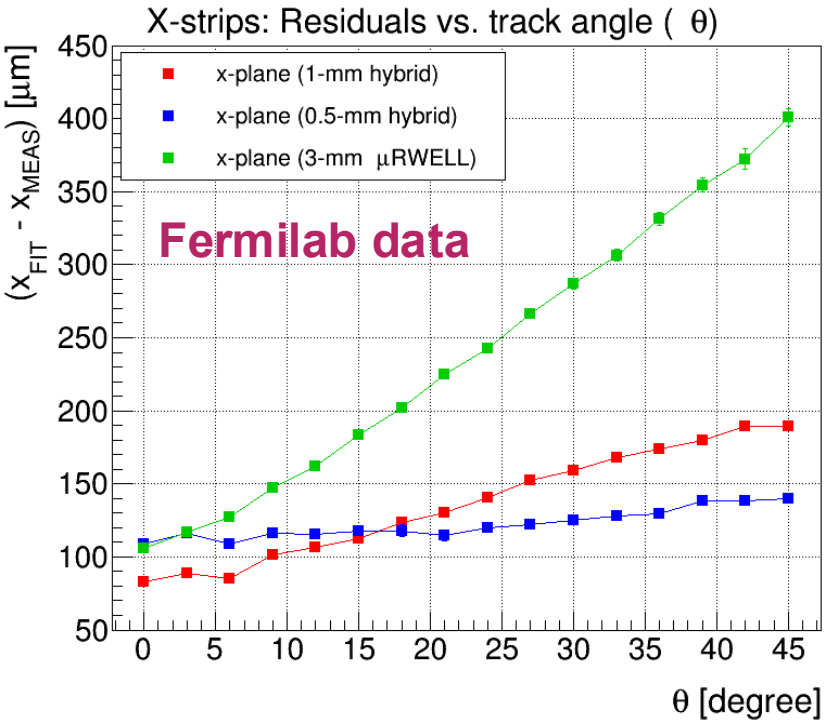



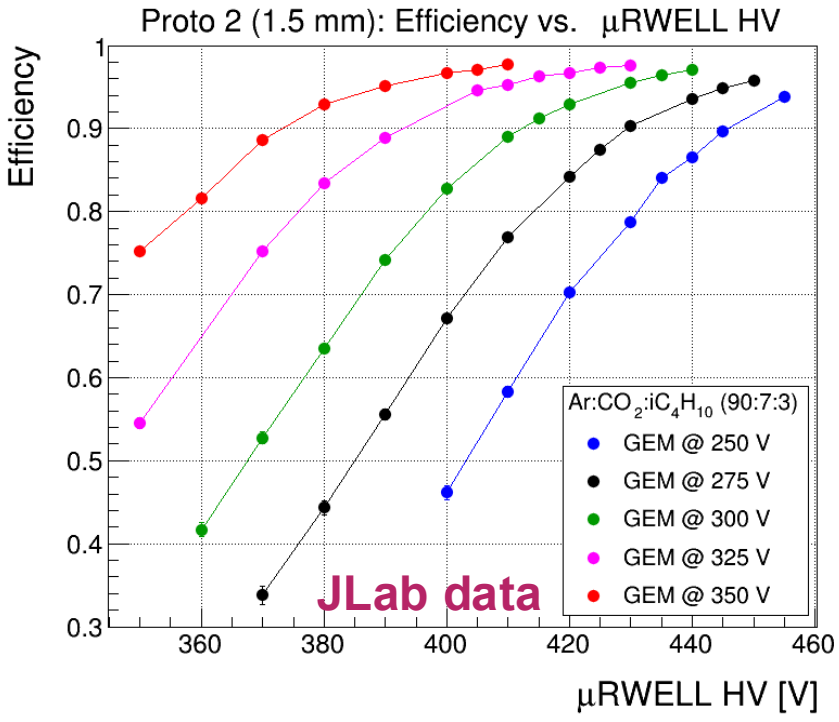
Preparation for the third campaign to study performance in 1.5T field in the GOLIATH magnet

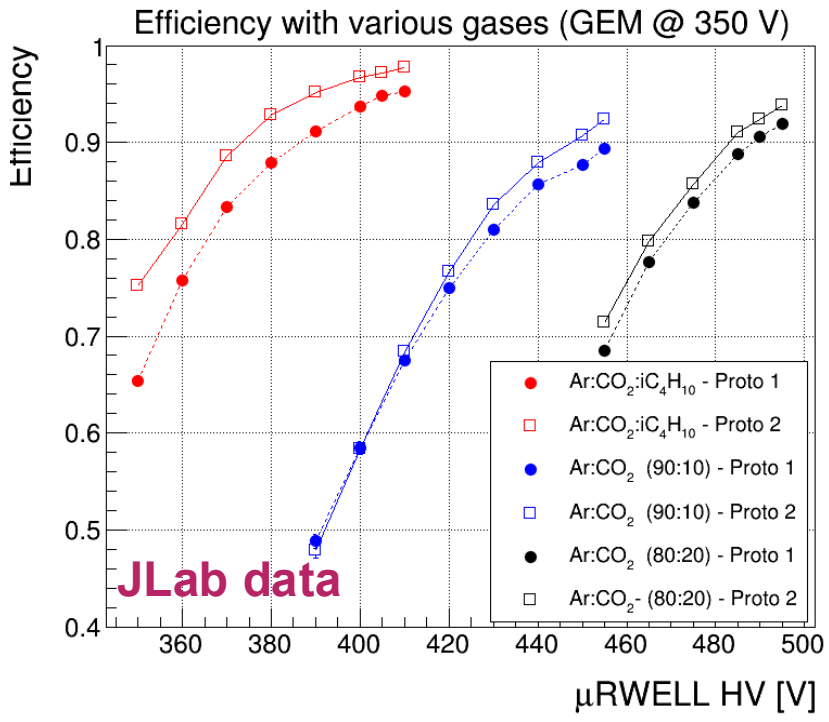
in Spring 2026 at the CERN SPS H4 line

# Thin-Gap GEM-µRWELL: Performance Studies in Test Beam

- Efficiency : 95%
- Thin-Gap leads to significant position resolution improvements without degrading efficiency



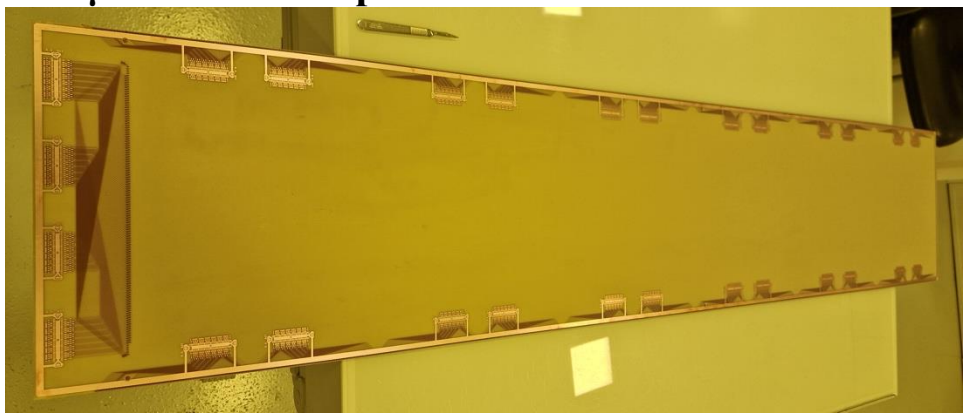



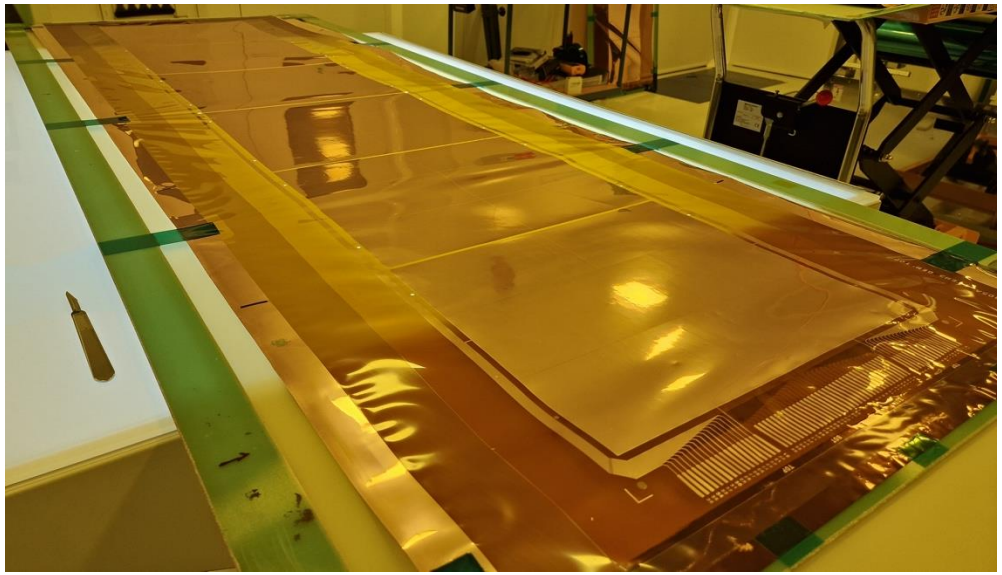
# Engineering Test Article – Foils & Frames

**µRWELL / CapaSh readout PCB: Front view**

**µRWELL / CapaSh readout PCB: back view**



**GEM foil**



**Support frames**

# Engineering Test Article – Assembly Workflow

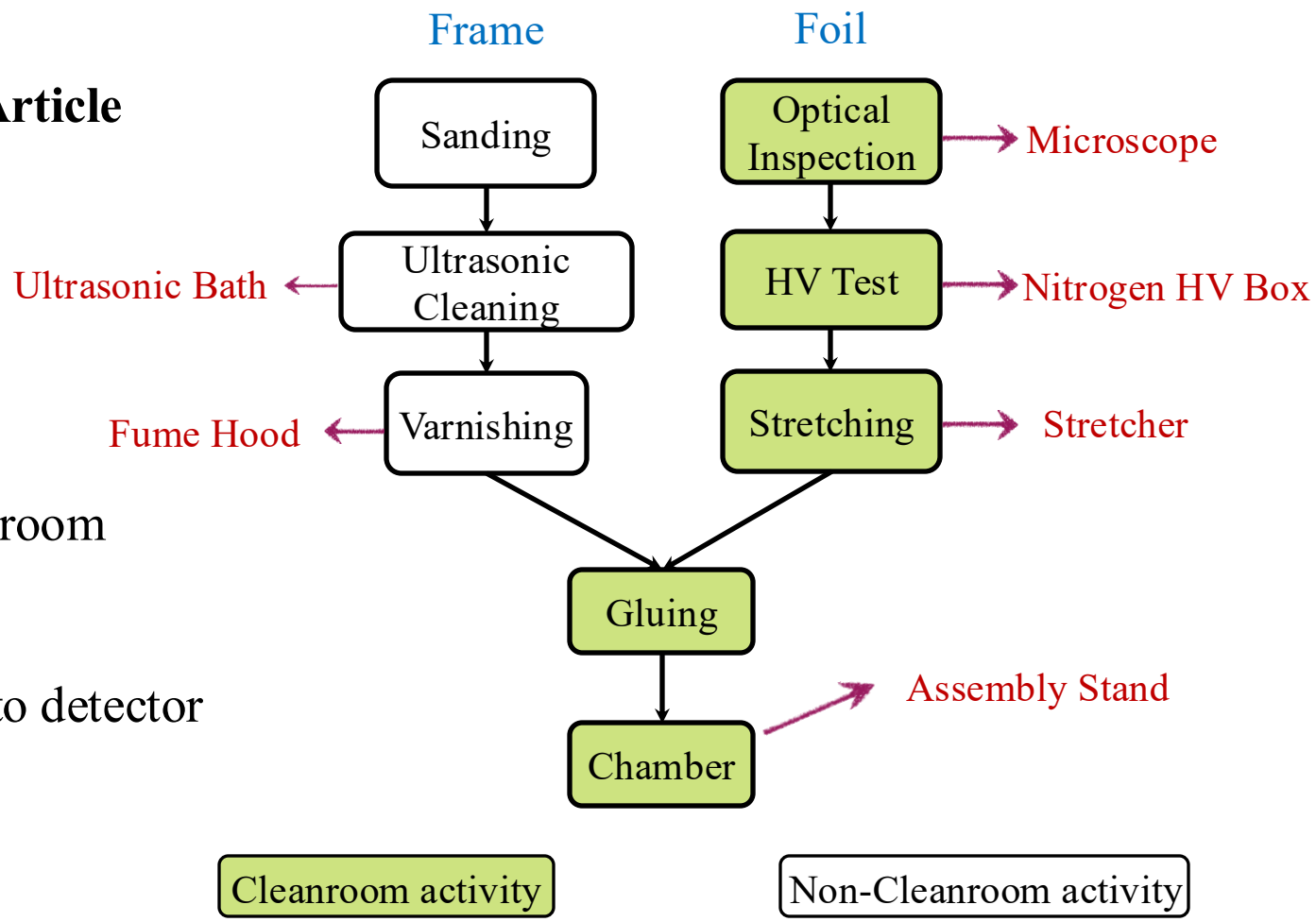
**Workflow for the Assembly of the Test Article**

Components:

- Detector Frame
- GEM Foil
- $\mu$RWELL Foil

Includes cleanroom activity and non-cleanroom activity

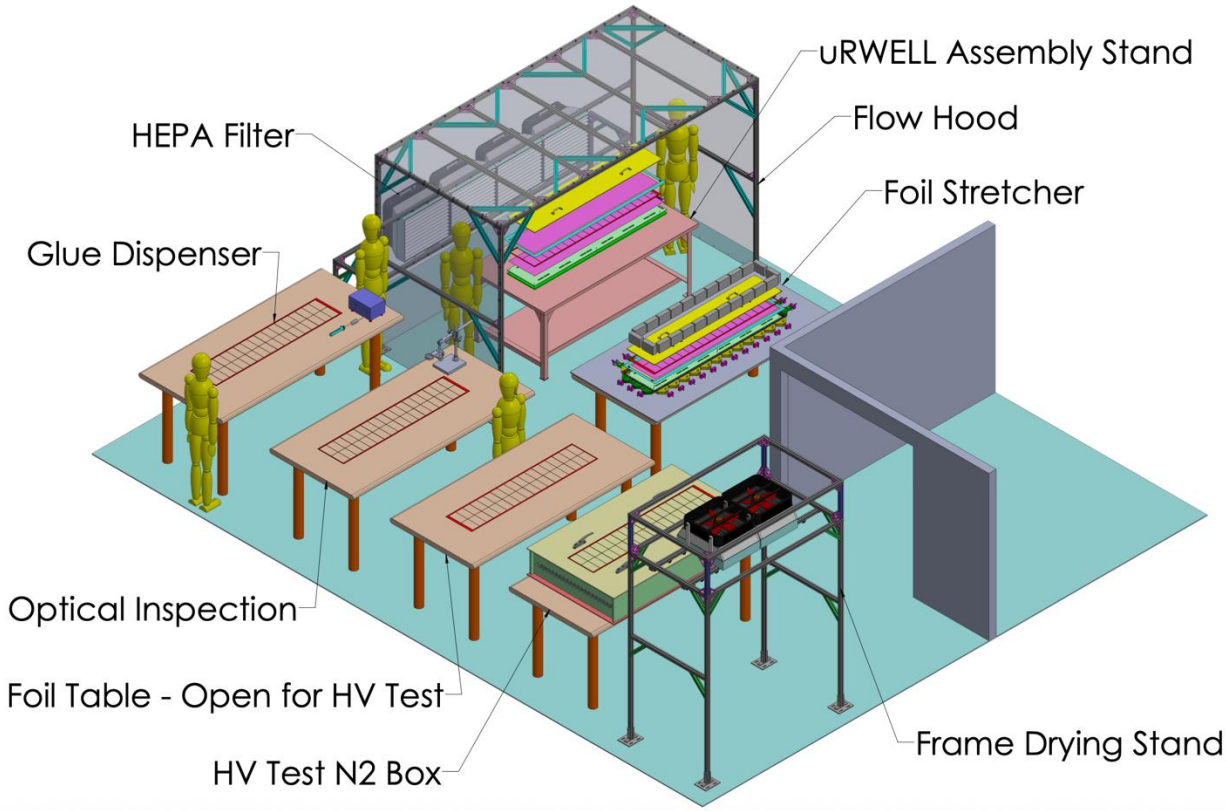
Highly customized instruments – tailored to detector size and shape



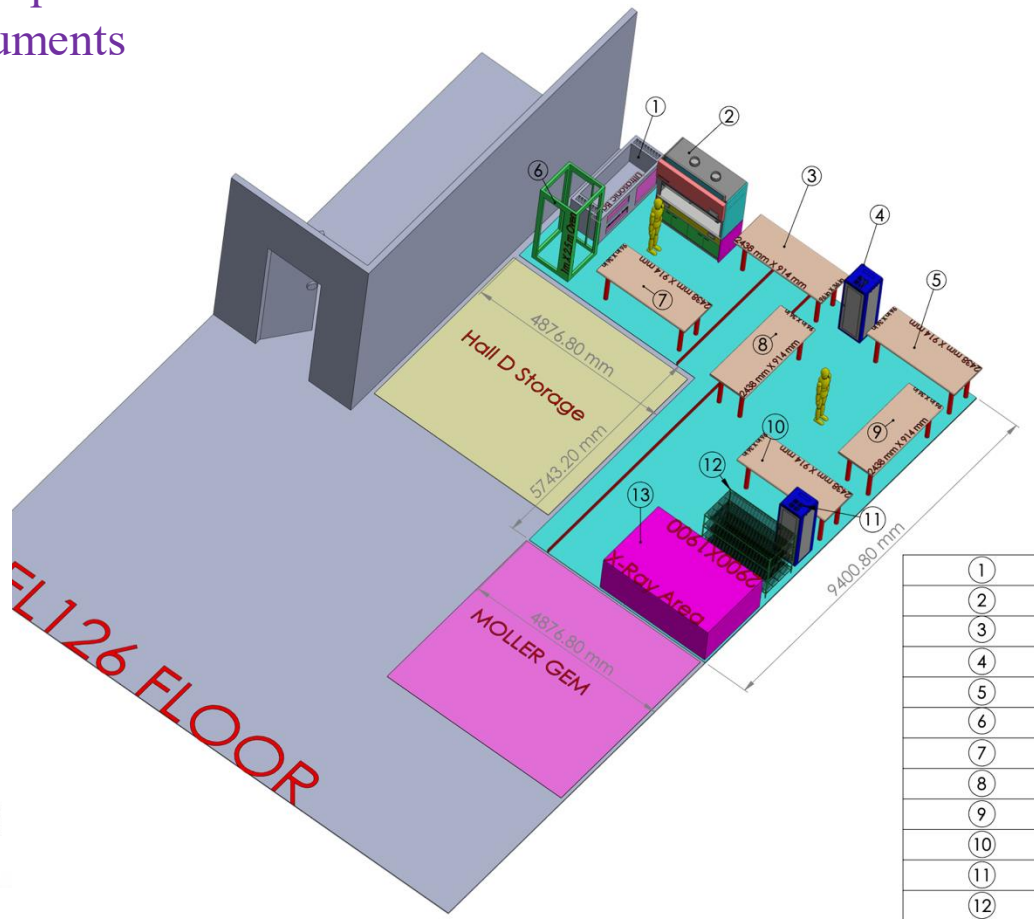
# Two Labs : Cleanroom and EEL126 (RD&I Group MPGD Lab) Layout

## EEL-121 Cleanroom Layout

Both labs are packed with instruments



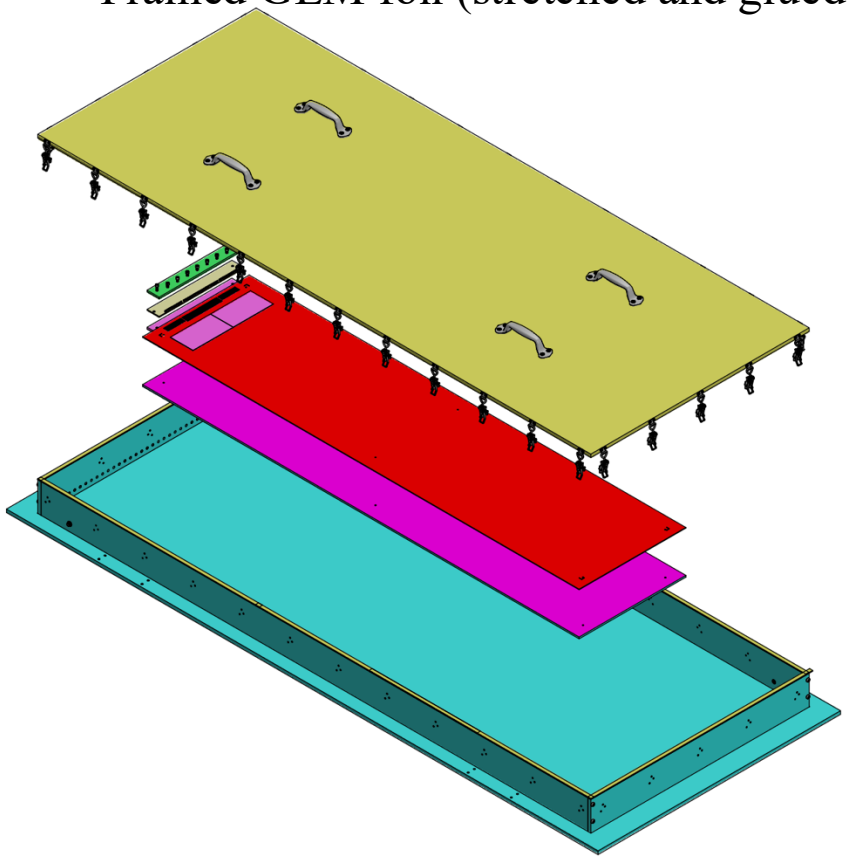

## RD&I Group MPGD Lab (EEL-126)




| | |
|---|---|
| 1 | Ultrasonic Bath |
| 2 | Fume Hood |
| 3 | Sanding Stand |
| 4 | Electronics Rack |
| 5 | Eric's Test Stand |
| 6 | Oven Space |
| 7 | Clean Hood |
| 8 | Workbench |
| 9 | PICOSEC |
| 10 | Flow Hood |
| 11 | Electronics Rack |
| 12 | Cosmic Stand |
| 13 | X-Ray Area |

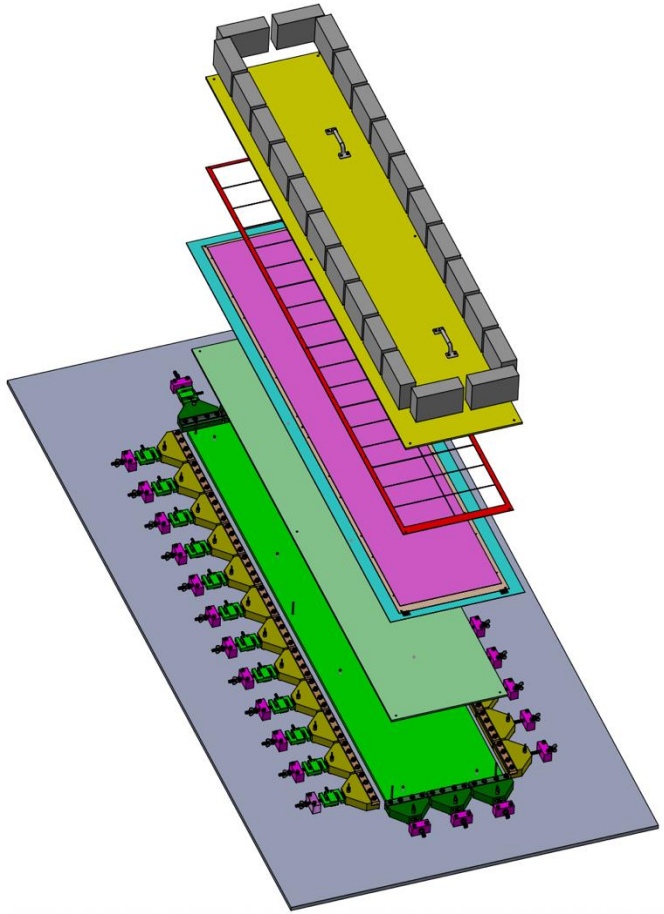
# Cleanroom Instruments – HV Nitrogen Box

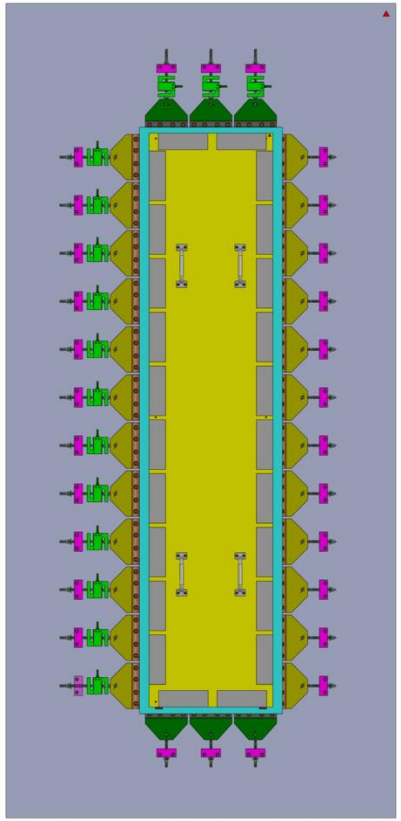
- GEM Foil High Voltage Test (GEM Foil HV Cleaning)
- Includes two steps:
  - Raw GEM foil
  - Framed GEM foil (stretched and glued to detector frame)

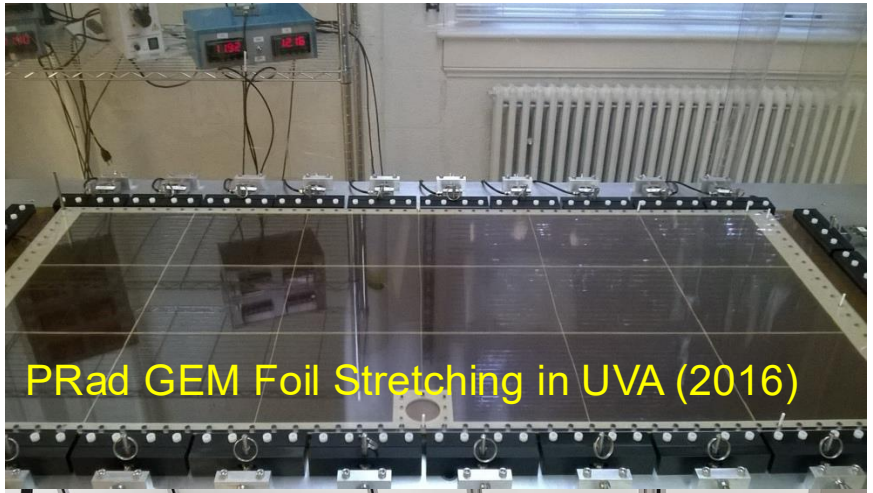


# Cleanroom Instruments – GEM Foil Stretcher

- Stretch GEM Foil
- Glue detector frame to the foil after stretching

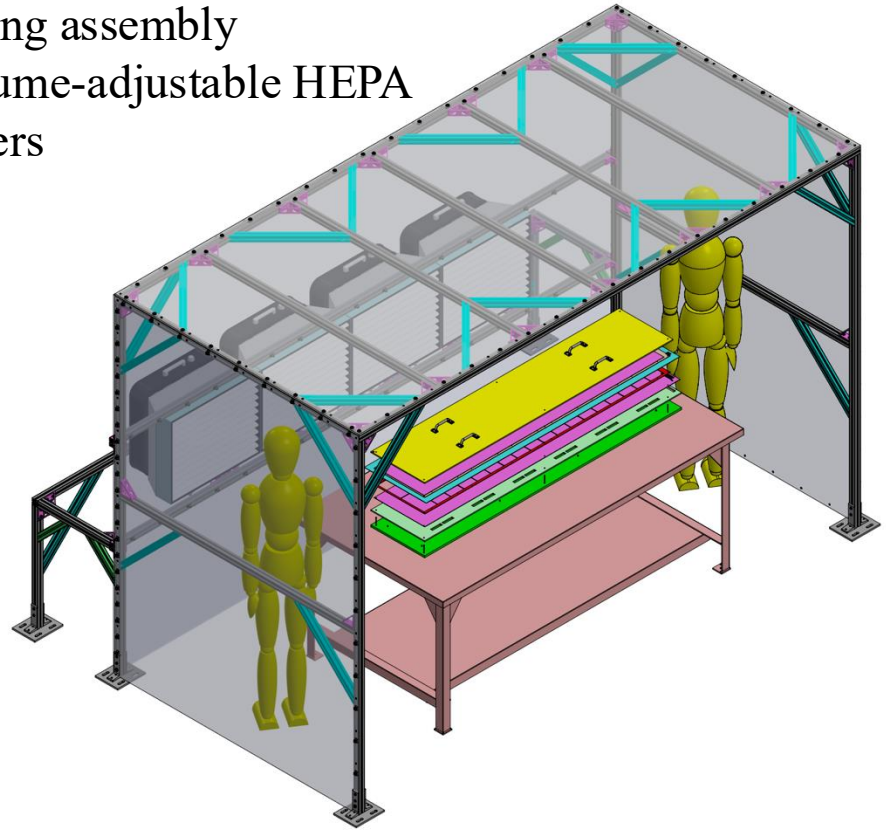


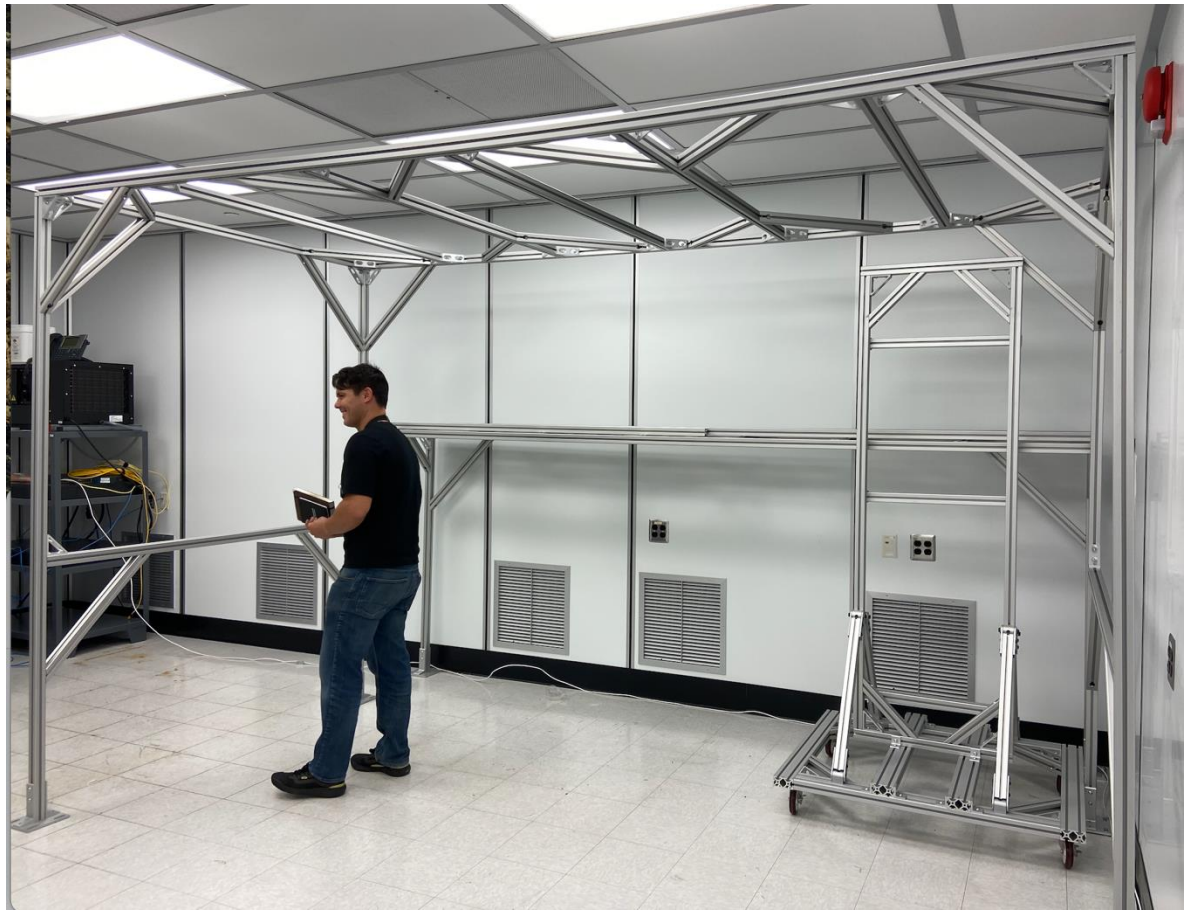





# Cleanroom Instruments – $\mu$RWELL Assembly Stand

- For final detector chamber assembly ($\mu$RWELL assembly)
- Advised by CERN : class-10 cleanroom (hard to get at JLab)
- A customized flow hood (placed inside the cleanroom)
  - Keep a laminar flow over the $\mu$RWELL board surface during assembly
  - Volume-adjustable HEPA Filters

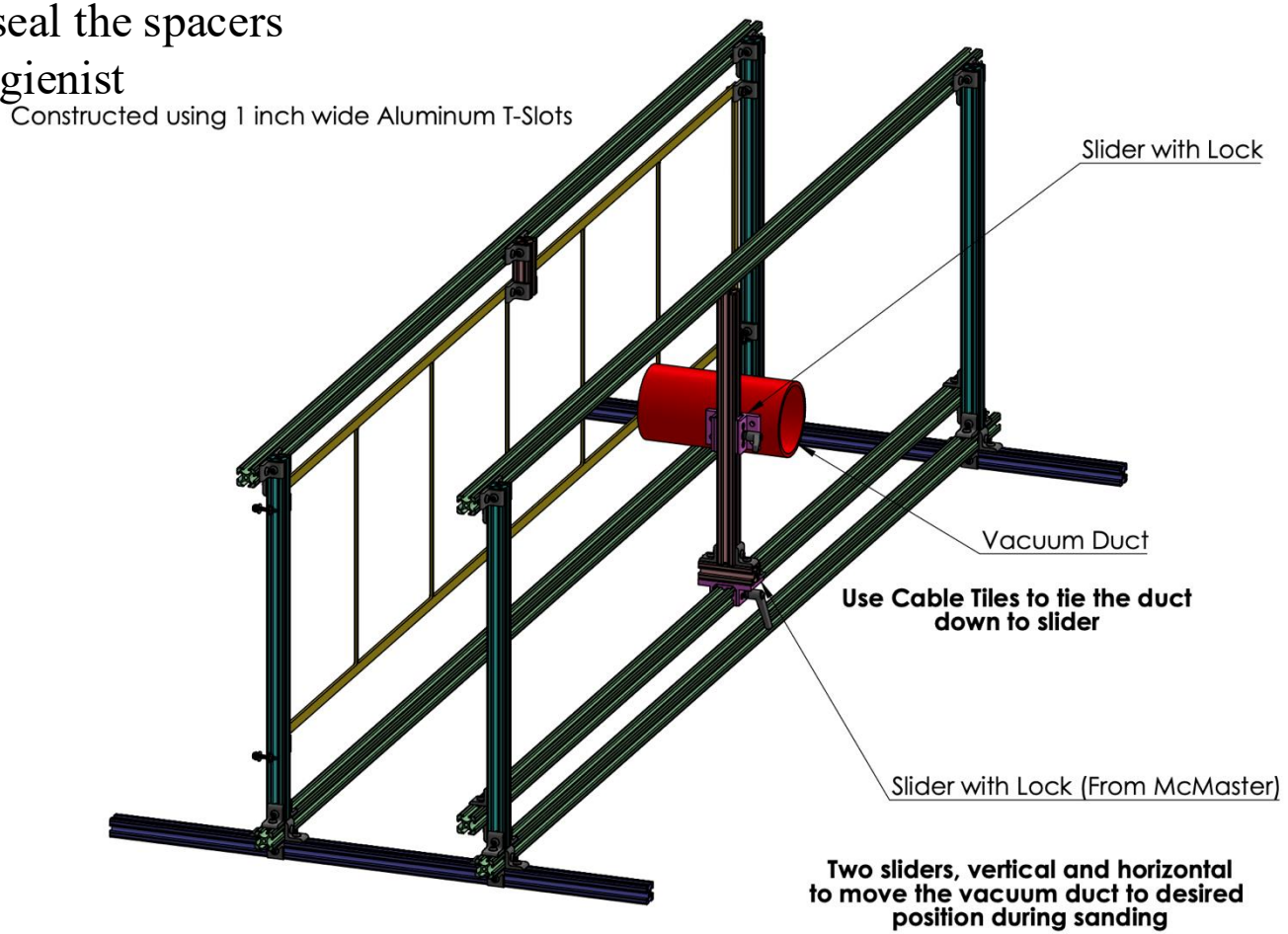




Flow Hood with **Andrew Lumanog** standing inside

# RD&I Group MPGD Lab Instruments – Sanding Stand

- Detector frame grids – 0.4 mm thick spacers to support GEM foil from sagging
- Inside the detector volume
- Sanding to reach a smooth surface and varnishing to seal the spacers
- Sanding stand design suggested by JLab industrial hygienist



# RD&I Group MPGD Lab Instruments – Ultrasonic Bath

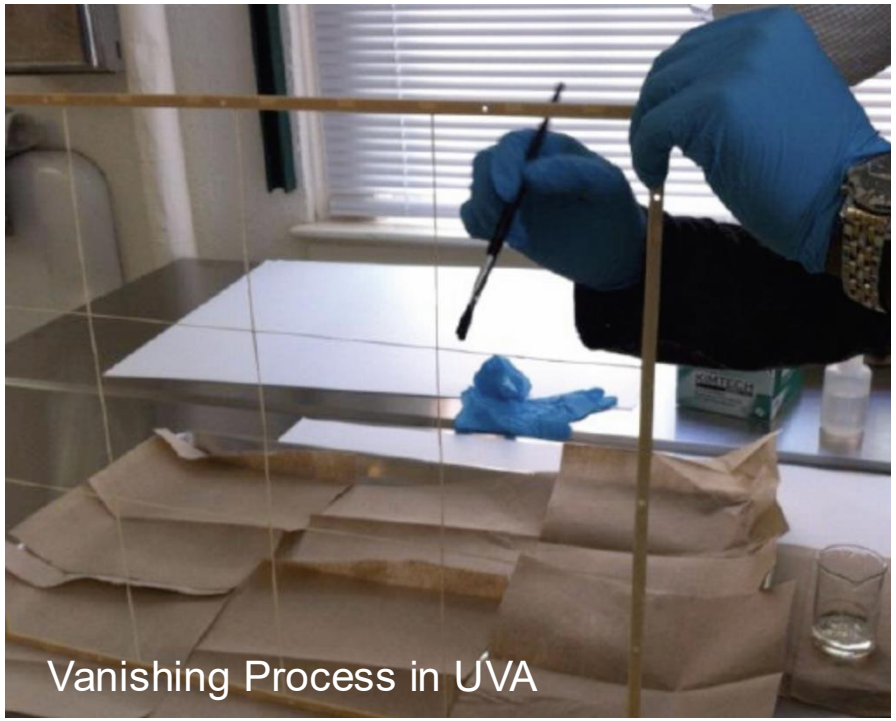
- Ultrasonic bath to clean the frame
- Fill with de-ionized water
- Purchased a large volume ultrasonic bath
- Pending installation in EEL-126

SBS Frame Ultrasonic Bathing in UVA

Ultrasonic Bath for outer-Barrel Tracker

# RD&I Group MPGD Lab Instruments – Fume Hood

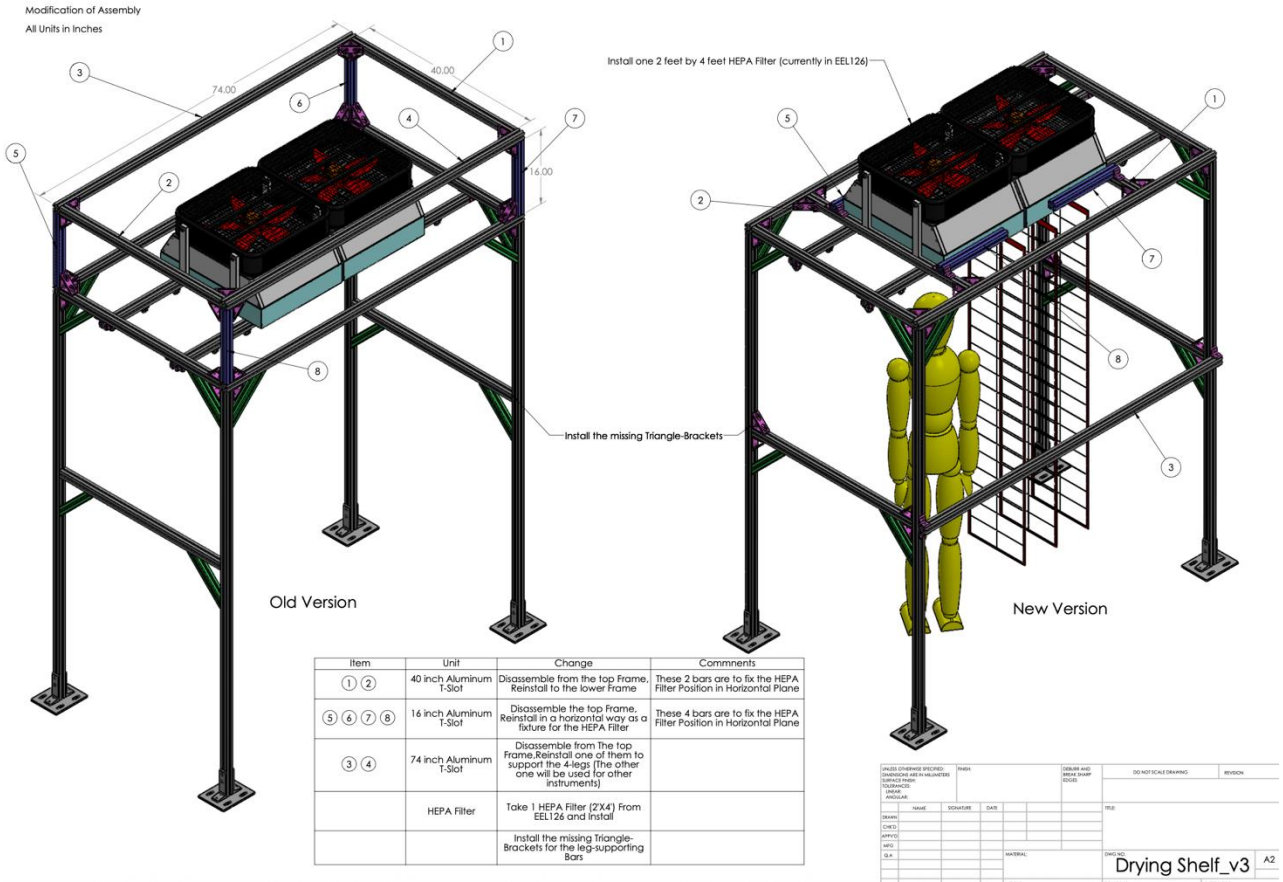
- Apply a thin film of Varnish to seal the spacers after sanding and ultrasonic bath cleaning
- Varnish work requires a Fume Hood
- Pending installation in EEL-126


Vanishing Process in UVA


Fume Hood to be installed

# Cleanroom Instruments – Frame Drying Stand

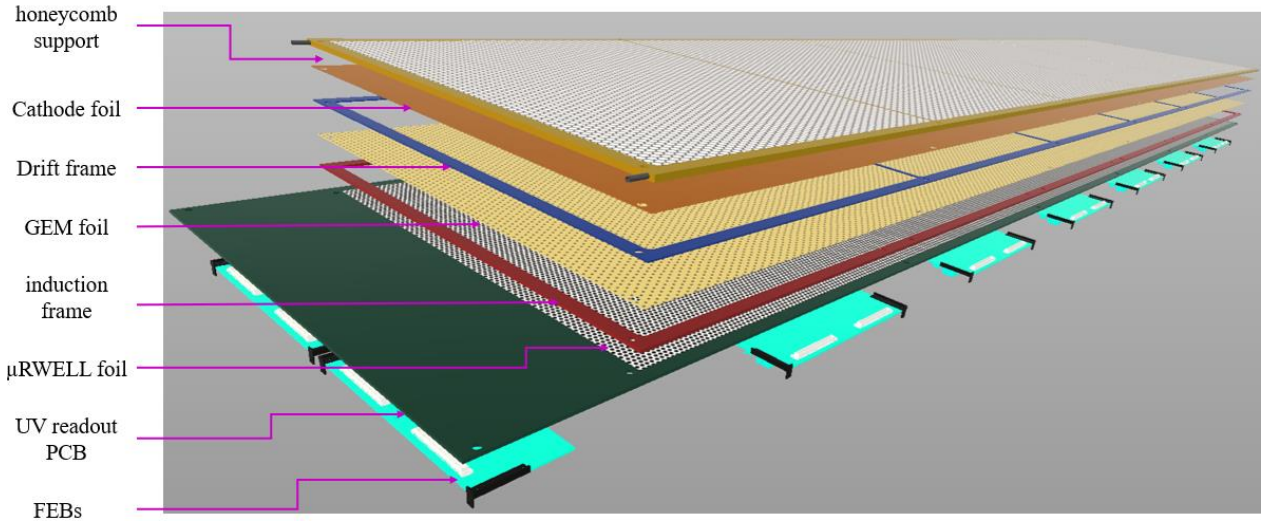
- Dry the frames after cleaning in ultrasonic bath
- Process needs ~24 hours in cleanroom

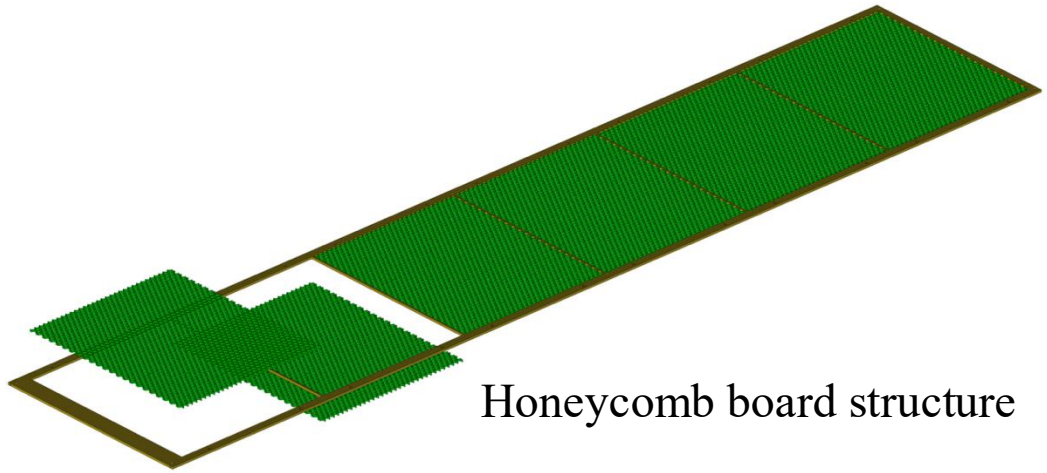



| Item | Unit | Change | Commnents |
|---|---|---|---|
| ① ② | 40 inch Aluminum T-Slot | Disassemble from the top Frame, Reinstall to the lower Frame | These 2 bars are to fix the HEPA Filter Position in Horizontal Plane |
| ⑤ ⑥ ⑦ ⑧ | 16 inch Aluminum T-Slot | Disassemble the top Frame, Reinstall in a horizontal way as a fixture for the HEPA Filter | These 4 bars are to fix the HEPA Filter Position in Horizontal Plane |
| ③ ④ | 74 inch Aluminum T-Slot | Disassemble from The top Frame,Reinstall one of them to support the 4-legs (The other one will be used for other instruments) | |
| | HEPA Filter | Take 1 HEPA Filter (2'X4') From EEL126 and Install | |
| | | Install the missing Triangle-Brackets for the leg-supporting Bars | |

# Detector Assembly – Honeycomb Supporting Board

- Nomex honeycomb core material (Axiom)
- Light rigid material
- Material come in as a whole piece
- Cut into correct size

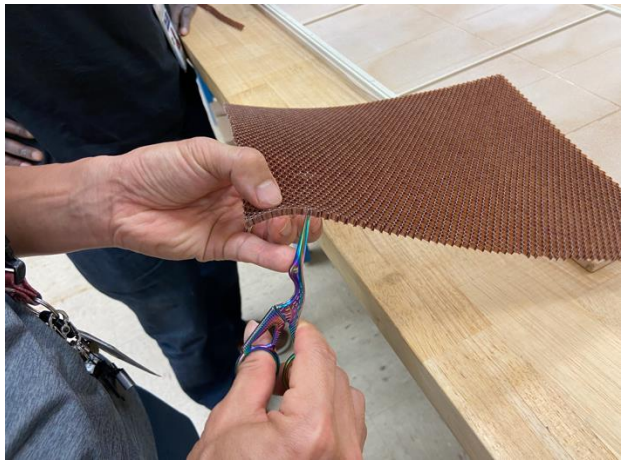


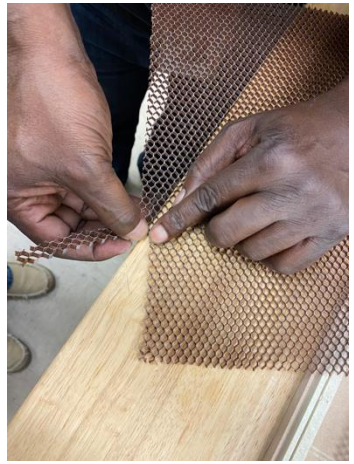



Honeycomb board structure

# Honeycomb Board Assembly – Honeycomb Preparation

- Glued with 125 micrometer thick G10 skin – vacuum bagging process

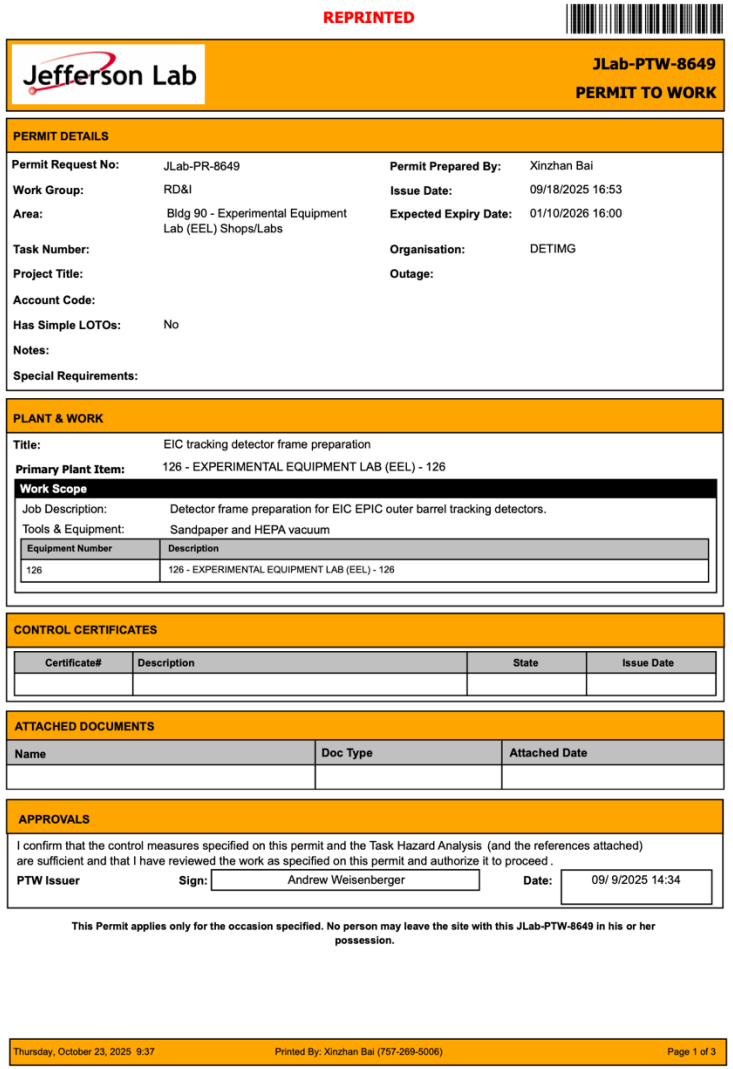







# Honeycomb Board Assembly – Status

- Frame Preparation (sanding, honeycomb preparation) completed
- Vacuum bagging pending safety review
  - Safety requirement
  - Review expected to be completed this Friday



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Jefferson Lab

JLab-PTW-8649
PERMIT TO WORK

**PERMIT DETAILS**

| | | | |
|---|---|---|---|
| Permit Request No: | JLab-PR-8649 | Permit Prepared By: | Xinzhan Bai |
| Work Group: | RD&I | Issue Date: | 09/18/2025 16:53 |
| Area: | Bldg 90 - Experimental Equipment Lab (EEL) Shops/Labs | Expected Expiry Date: | 01/10/2026 16:00 |
| Task Number: | | Organisation: | DETIMG |
| Project Title: | | Outage: | |
| Account Code: | | | |
| Has Simple LOTOs: | No | | |
| Notes: | | | |
| Special Requirements: | | | |

**PLANT & WORK**

Title: EIC tracking detector frame preparation

Primary Plant Item: 126 - EXPERIMENTAL EQUIPMENT LAB (EEL) - 126

**Work Scope**

Job Description: Detector frame preparation for EIC EPIC outer barrel tracking detectors.

Tools & Equipment: Sandpaper and HEPA vacuum

| Equipment Number | Description |
|---|---|
| 126 | 126 - EXPERIMENTAL EQUIPMENT LAB (EEL) - 126 |

**CONTROL CERTIFICATES**

| Certificate# | Description | State | Issue Date |
|---|---|---|---|
| | | | |

**ATTACHED DOCUMENTS**

| Name | Doc Type | Attached Date |
|---|---|---|
| | | |

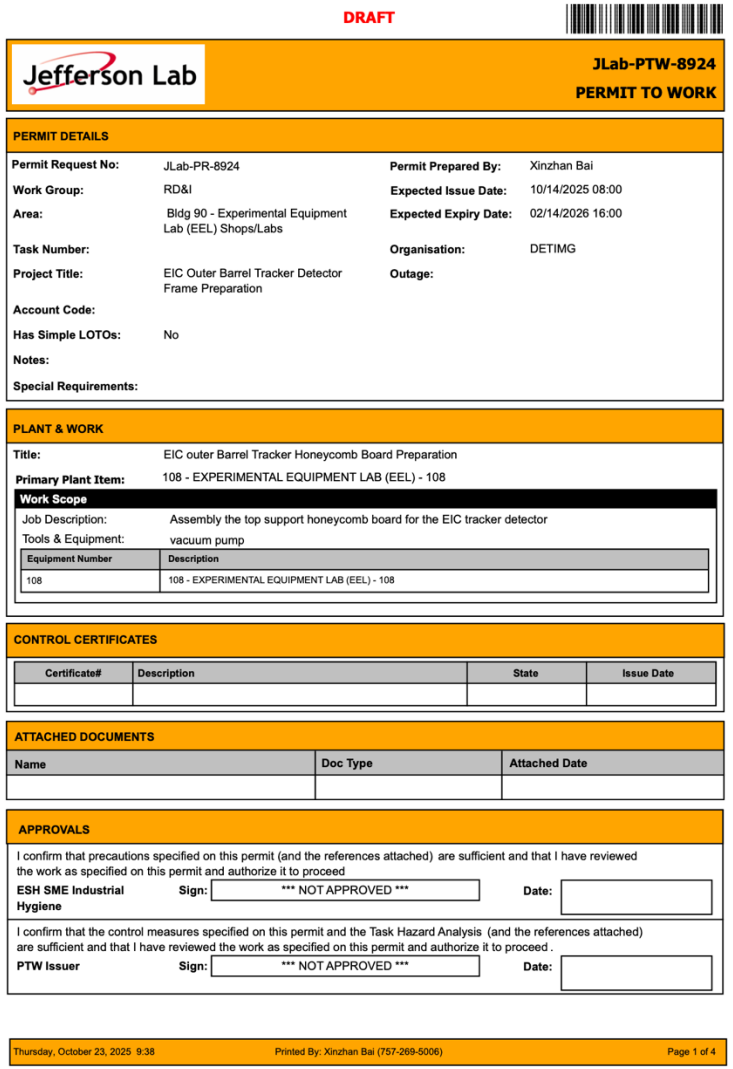
**APPROVALS**

I confirm that the control measures specified on this permit and the Task Hazard Analysis (and the references attached) are sufficient and that I have reviewed the work as specified on this permit and authorize it to proceed .

PTW Issuer Sign: Andrew Weisenberger Date: 09/ 9/2025 14:34

**This Permit applies only for the occasion specified. No person may leave the site with this JLab-PTW-8649 in his or her possession.**

Thursday, October 23, 2025 9:37 Printed By: Xinzhan Bai (757-269-5006) Page 1 of 3



DRAFT

Jefferson Lab

JLab-PTW-8924
PERMIT TO WORK

**PERMIT DETAILS**

| | | | |
|---|---|---|---|
| Permit Request No: | JLab-PR-8924 | Permit Prepared By: | Xinzhan Bai |
| Work Group: | RD&I | Expected Issue Date: | 10/14/2025 08:00 |
| Area: | Bldg 90 - Experimental Equipment Lab (EEL) Shops/Labs | Expected Expiry Date: | 02/14/2026 16:00 |
| Task Number: | | Organisation: | DETIMG |
| Project Title: | EIC Outer Barrel Tracker Detector Frame Preparation | Outage: | |
| Account Code: | | | |
| Has Simple LOTOs: | No | | |
| Notes: | | | |
| Special Requirements: | | | |

**PLANT & WORK**

Title: EIC outer Barrel Tracker Honeycomb Board Preparation

Primary Plant Item: 108 - EXPERIMENTAL EQUIPMENT LAB (EEL) - 108

**Work Scope**

Job Description: Assembly the top support honeycomb board for the EIC tracker detector

Tools & Equipment: vacuum pump

| Equipment Number | Description |
|---|---|
| 108 | 108 - EXPERIMENTAL EQUIPMENT LAB (EEL) - 108 |

**CONTROL CERTIFICATES**

| Certificate# | Description | State | Issue Date |
|---|---|---|---|
| | | | |

**ATTACHED DOCUMENTS**

| Name | Doc Type | Attached Date |
|---|---|---|
| | | |

**APPROVALS**

I confirm that precautions specified on this permit (and the references attached) are sufficient and that I have reviewed the work as specified on this permit and authorize it to proceed

ESH SME Industrial Hygiene Sign: *** NOT APPROVED *** Date:

I confirm that the control measures specified on this permit and the Task Hazard Analysis (and the references attached) are sufficient and that I have reviewed the work as specified on this permit and authorize it to proceed .

PTW Issuer Sign: *** NOT APPROVED *** Date:

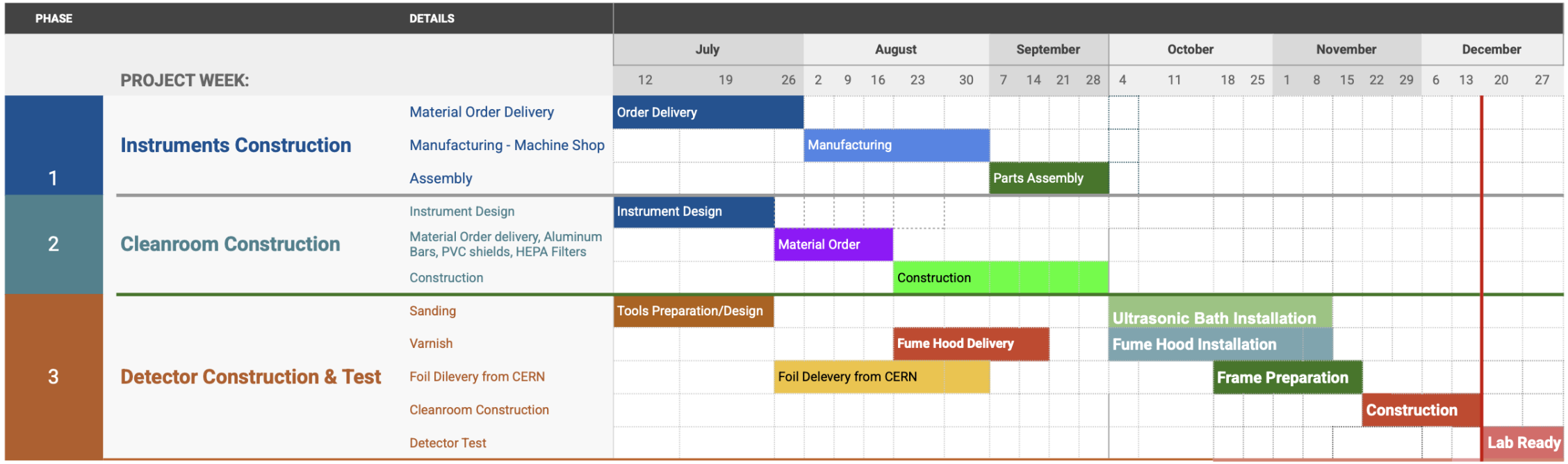
Thursday, October 23, 2025 9:38 Printed By: Xinzhan Bai (757-269-5006) Page 1 of 4

# RD&I MPGD Lab Installation Status

- Detector frame preparation in EEL-126 (RD&I Group MPGD Lab)
  - Sanding
  - Varnishing – Flow hood
  - Cleaning – Ultrasonic bath
- EEL-126 Installation (JLab Facility)
  - Ultrasonic bath
  - Fume hood
- Delay to be expected (Government shutdown)

# Engineering Test Article – Timeline

- Detector frames (RESARM), GEM Foil, µRWELL (CERN) Received
- Major instruments delivered, installation in progress
  - Infrastructure ready for construction – November
  - Detector ready for benchmarking – December (before Christmas)
- Preliminary cosmic test – early January
- Planned beam test at CERN – spring 2026
- Contingent on Lab operation schedule (government shutdown)



# Summary

- All major instruments, detector frames, detector foils on-hand
- Cleanroom preparation complete
  - All major instruments in place
- EEL-126 MPGD Lab installation – (JLab Facility is taking charge of)
  - Fume Hood installation
  - Ultrasonic bath installation
- Detector fabrication to begin upon EEL-126 installation completion

# Backup Slides

# Honeycomb Board Assembly – Vacuum Gluing

- Vacuum bagging process – performed on a Granite table – ensure flatness
- Process under safety review by JLab industrial Hygienist