Stony Brook University

Construction of the Vessel for the Proximity-Focusing RICH for the ePIC Experiment

Julian Driebeek

APS 2025

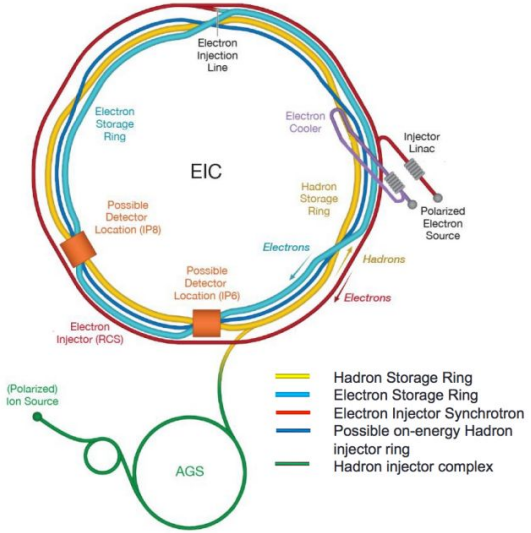
March 2025

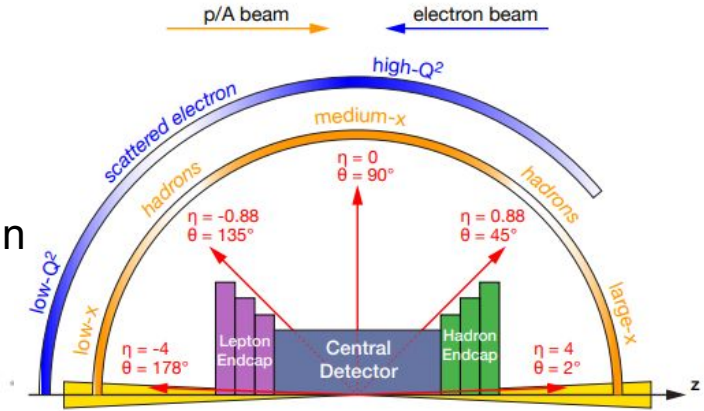
FAR BEYOND

The Electron-Ion-Collider (EIC)

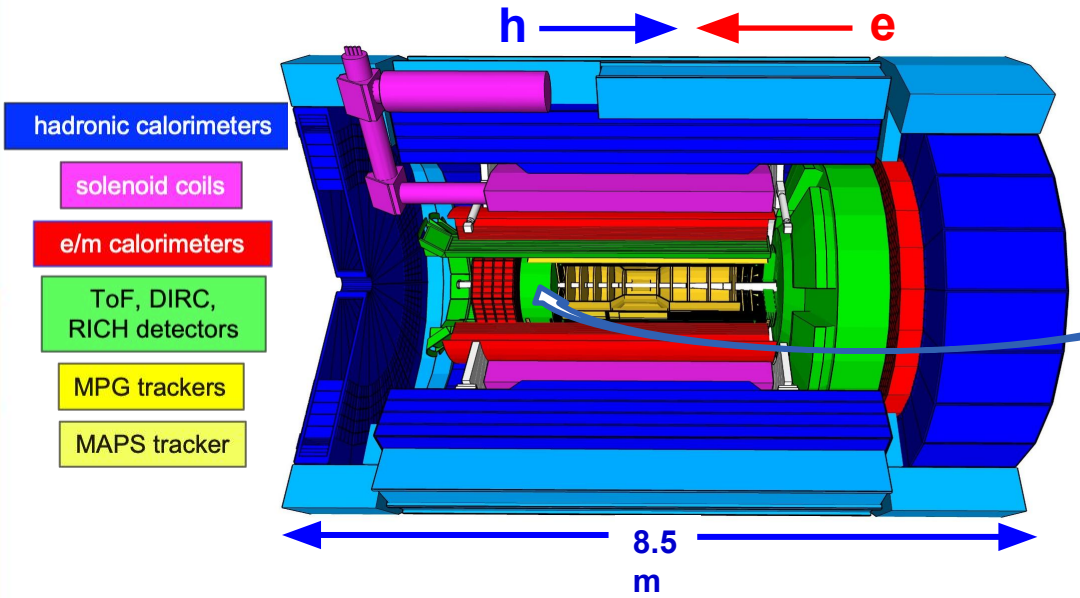
- Will be built at Brookhaven National Laboratory (BNL)
- Will collide relativistic electrons with protons and ions
- Both beams can be spin polarized
- Some topics it will investigate are:
  - **The origin of the mass of hadrons**
  - **The dynamics of quark-gluon interactions**
  - **The origin of the spin of hadrons and nuclei**

- **ePIC will be the first detector** built at EIC
- The **Proximity-Focusing RICH** will identify hadrons in the backwards direction **Rapidity range**: $-3.5 \leq \eta \leq -1.5$





ePIC: EIC general purpose detector @ IP6



Tracking:
- New 1.7 T solenoid magnet
- Si MAPS Tracker
- MPGDs (μRWELL/μMegas)

PID:
- hpDIRC
- pfRICH
- dRICH
- AC-LGAD (~30ps TOF)

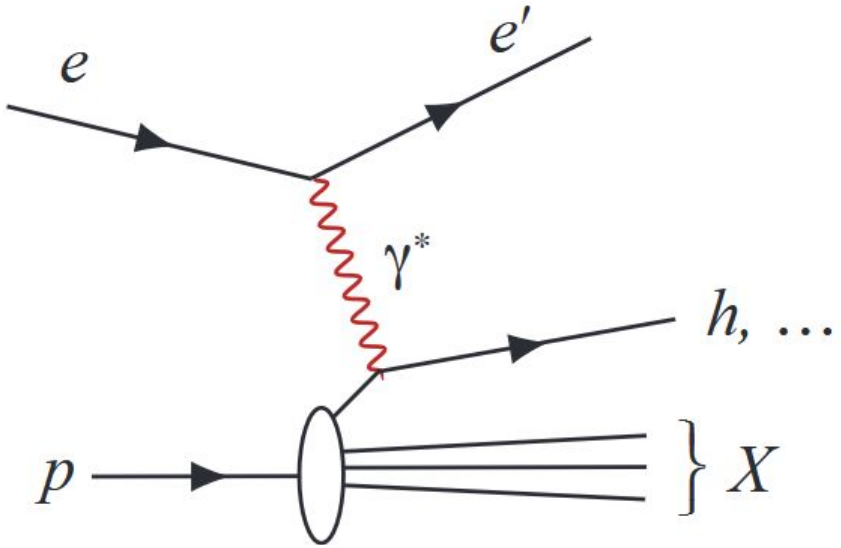
Calorimetry:
- Imaging Barrel EMCal
- PbWO4 EMCal in backward direction
- Finely segmented EMCal + HCal in forward direction
- Outer HCal (sPHENIX re-use)
- Backwards HCal (tail-catcher)

- A compact central detector with several subsystems
  - (Almost) hermetic coverage in tracking, calorimetry & PID $-3.5 < \eta < +3.5$

See B.Page, ePIC Users Meeting 2023
A. Kiselev, CPAD 2024

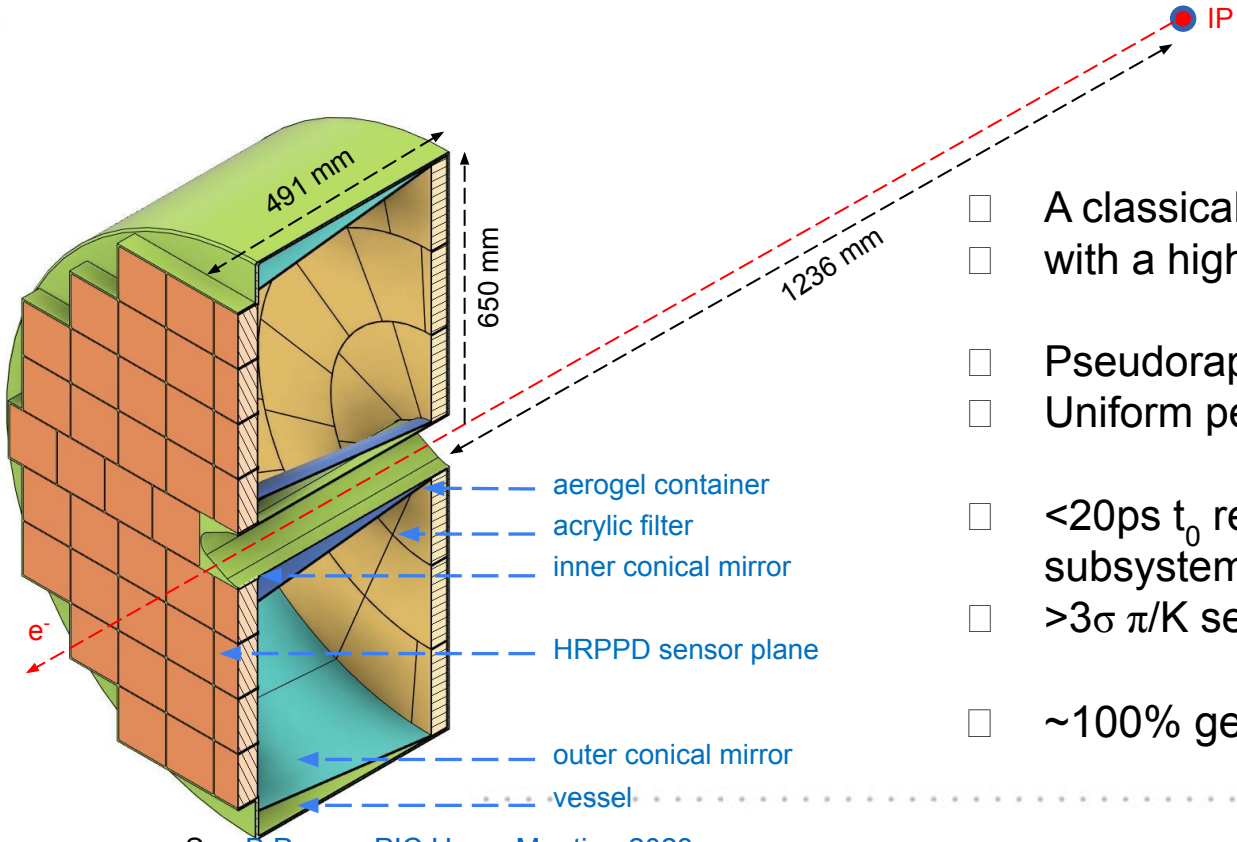
Semi-inclusive Deep Inelastic Scattering SIDIS

The pfRICH serves as a particle identification (PID) detector, playing a crucial role in distinguishing hadrons in SIDIS



Observing SIDIS “requires measurement of at least one identified hadron in coincidence with the scattered electron.” EIC Yellow Report

pfRICH for ePIC detector electron-going endcap



- A classical proximity focusing RICH
- with a high-resolution timing capability

- Pseudorapidity coverage: $-3.5 < \eta < -1.5$
- Uniform performance in this $\{\eta,\varphi\}$ range

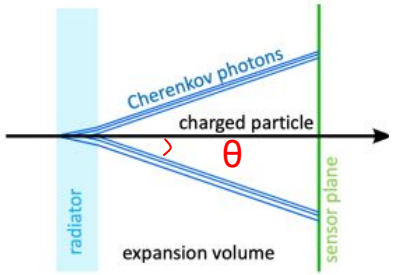
- <20ps t_0 reference for the ToF subsystems
- >3σ π/K separation up to ~ 7.0 GeV/c

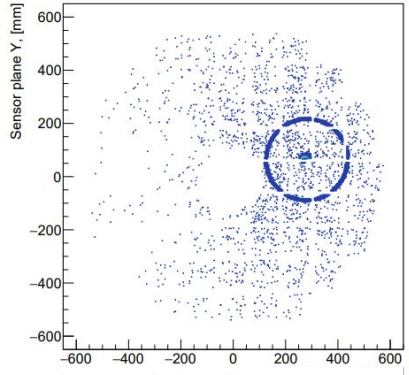
- ~100% geometric efficiency

See B.Page, ePIC Users Meeting 2023
A. Kiselev, CPAD 2024

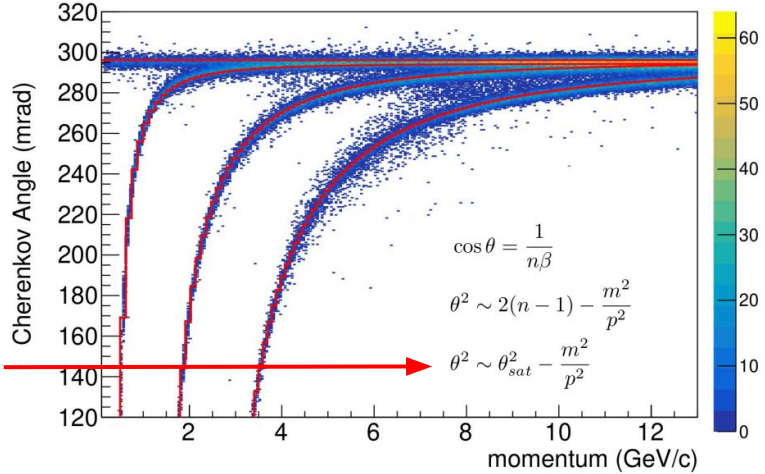
Operation of the pfRICH

- When charged particles exceed the speed of light in a medium, they emit **Cherenkov Radiation** as they travel, resulting in a cone
- In the pfRICH the aerogel radiator is thin relative to the readout distance, so these cones appear as rings
- The Cherenkov angle depends on the particle's **velocity** and the medium's refractive index:
- θ→p(m): provides access to the **particle mass**





Momentum Vs Cherenkov angle (track)

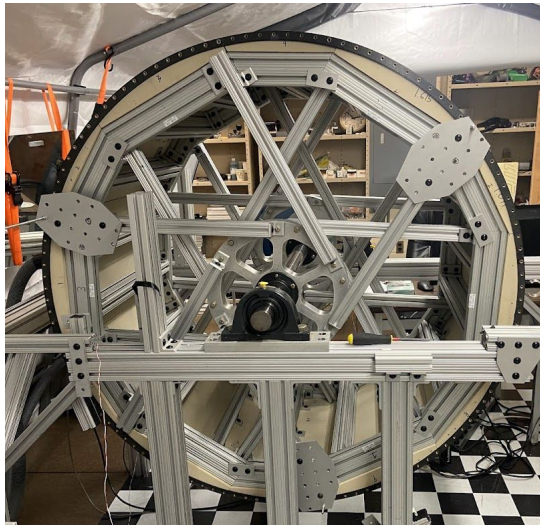


e/π/K/p response integrated over the whole η acceptance

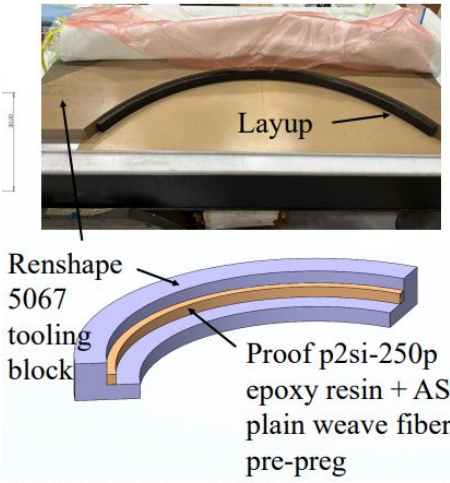
B.Page, ePIC Users Meeting 2023

End-rings production at Purdue University

- End rings are created by **laying carbon fiber strips into a mold**, followed by machining them to the required dimensions
- Holes are drilled, and brass threaded inserts are installed

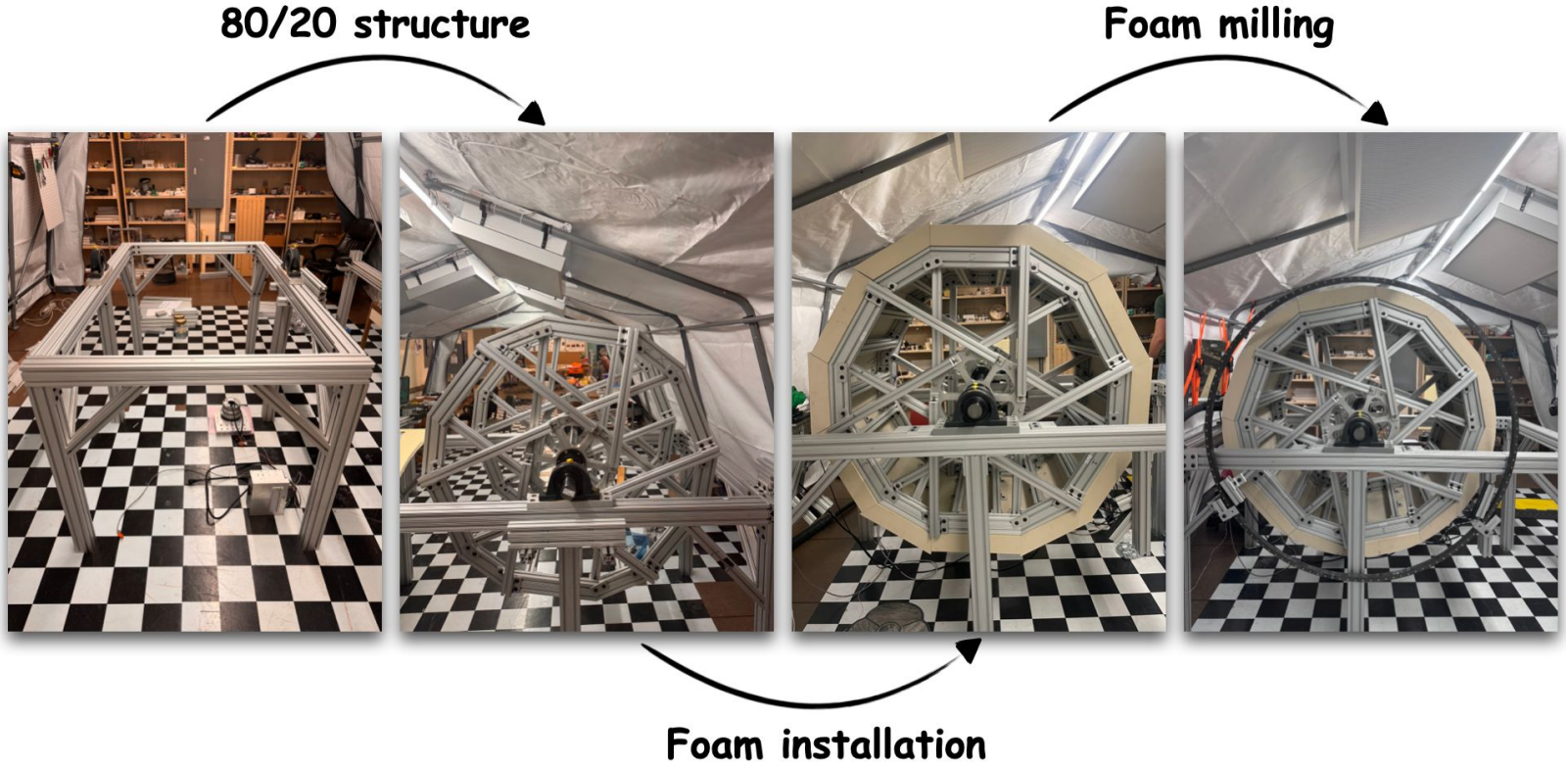


Endring mounted to the mandrel



[Purdue CSMC]

Assembly of the Mandrel for the Vessel



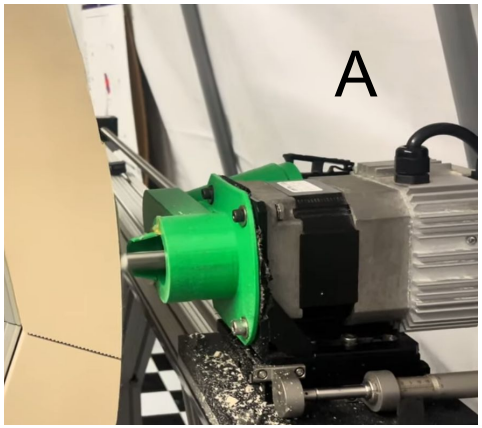
Mandrel Machining

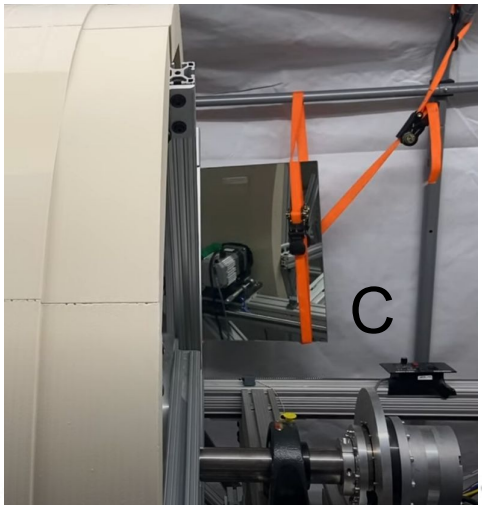
- The foam is cut by a system similar to a lathe but with a rotating bit
  - This involves 3 motors

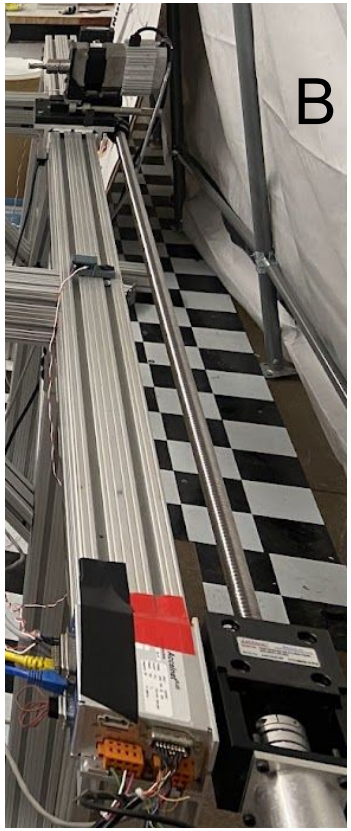
A. An endmill is mounted to a motor on a micrometer stage
   a. The stage allows for precise depth control

B. The stage is moved horizontally by a motor which turns a lead screw

C. The foam mandrel is rotated by a third motor

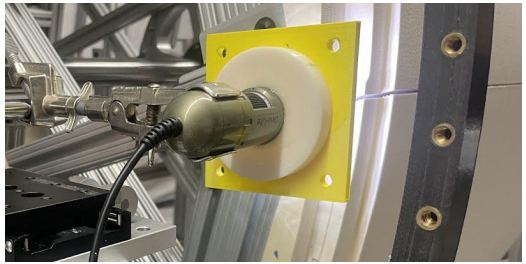


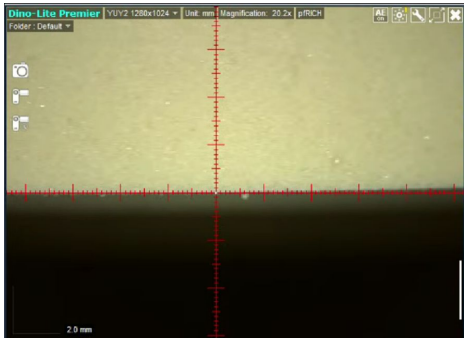




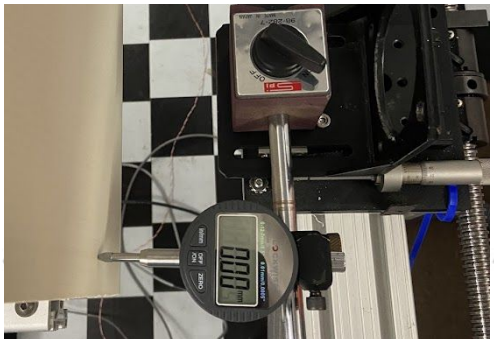
Mandrel Evaluation

- A digital microscope checks uniformity of **r** in **φ** at the edges





- A digital dial indicator scans the surface to assess uniformity of **r** in **z** and **φ**

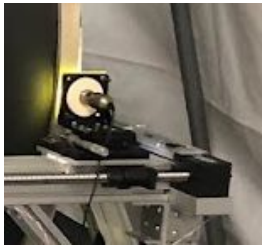


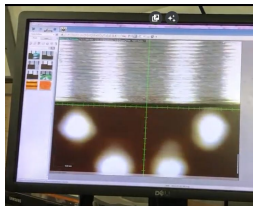
pfRICH Vessel Assembly

(See analogous process for sPHENIX TPC on right)

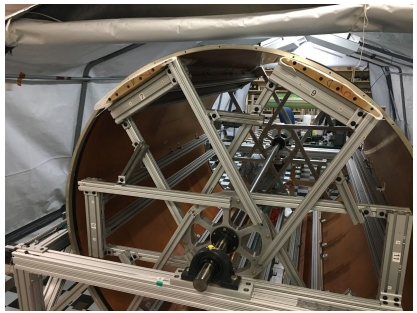
- The foam mandrel **is not** part of the pfRICH
  - It provides a mold for flat panels to be formed into a cylinder
- The pfRICH outer vessel will be built around the mandrel as a sandwich of **carbon fiber composite plastic** (CFRP) with **an aramid honeycomb core**
- End rings will be aligned in **z** and **φ** using a digital microscope mounted on the cutter stage
- Once the vessel is complete the 80-20 frame can collapse for removal of the foam.

Honeycomb and inner carbon fiber layer of sPHENIX TPC during construction
Photo Credit: Thomas Hemmick





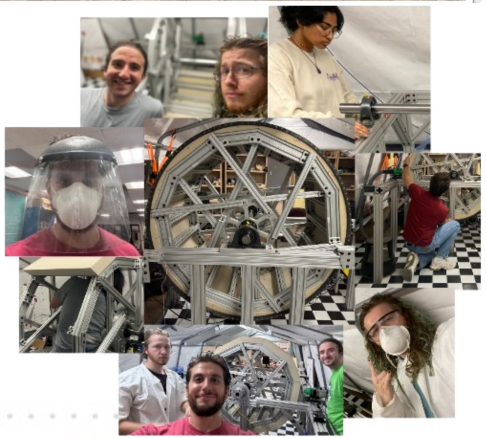
TPC endring alignment
Photo Credits: Thomas Hemmick



Removal of foam mandrel after completion of the TPC outer vessel
Photo Credit: Julian Driebeek

Summary

- The pfRICH will be **a critical PID detector in the backwards region** of ePIC detector at EIC
- **Outer vessel construction is ongoing**
  - The mandrel is near the final diameter
- **The final end-ring has been delivered**
- **Vessel construction will begin soon**



Backup

pfRICH Components

- The pfRICH outer vessel will be built as a sandwich of **carbon fiber composite plastic** (CFRP) with **an aramid honeycomb core**
- Mirrors expand the acceptance
- 25 mm thick aerogel radiator with **<n> = 1.040**
- HRPPDs by Incom Inc **detect the Cherenkov photons**
  See A. Kiselev, CPAD 2024