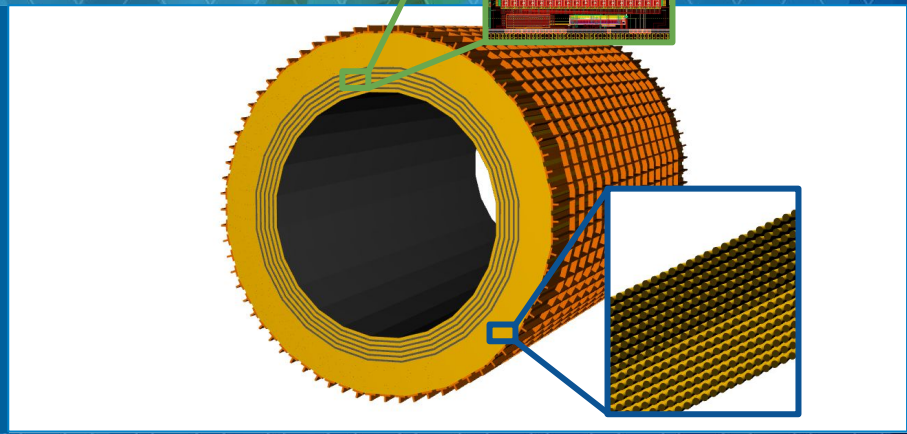
In-person ePIC Barrel Imaging Calorimeter Workshop



The Imaging Calorimeter for ePIC
Introduction

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Why electromagnetic calorimetry at EIC is hard

From the EIC Yellow Report: stringent barrel ECal requirements

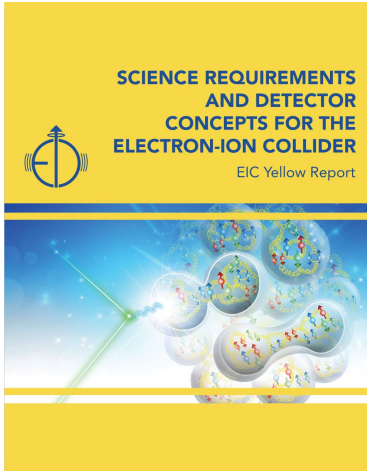
EIC is an **electron scattering** machine and identifying scattered electrons mainly depends on the electromagnetic calorimetry.

The electromagnetic calorimeter is the main detector for **electron-pion separation**. The inclusive physics program requires up to 10^4 pion suppression at low momenta in the barrel.

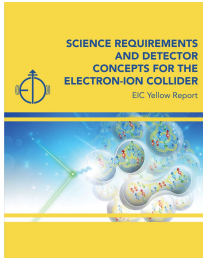
The exclusive program requires **decent energy resolution** ($< 7\%/\sqrt{E} \oplus 1\%$) **for photon energy reconstruction, and also the fine granularity for good** π^0-ɣ separation up to 10 GeV.

The bECal should be capable of measuring **low energy photons** down to 100 MeV, while having the range to measure energies well above 10 GeV

The system is space-constrained to very **limited space** inside the solenoid.



ECal Technologies in the Yellow Report



None of the discussed technologies meet all requirements for the barrel

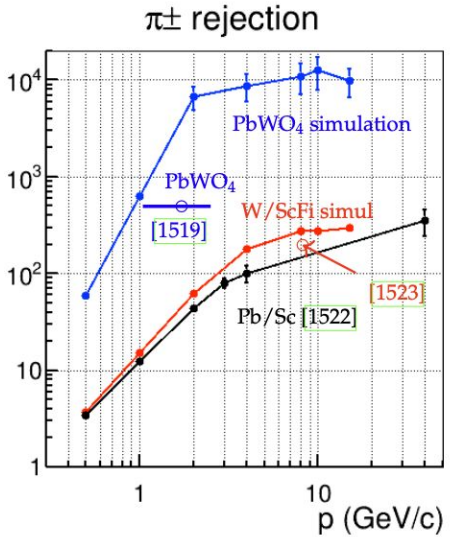
$PbWO_4$ crystal: could hit the marks, impossible to procure enough material (barrel too large), prohibitively expensive, needs precise temperature control.

SciGlass: Larger ratio of radiation length to hadronic interaction length X_0/λ_I leads to suboptimal electron-pion separation, long radiation length in limited space leads to energy leakage, large block size hinders position resolution.

W/ScFi (spacal): Too low electron-pion separation for barrel, even at low efficiencies, energy resolution too low.

Pb/Sc Shashlyk: Cannot meet stringent electron-pion separation requirement

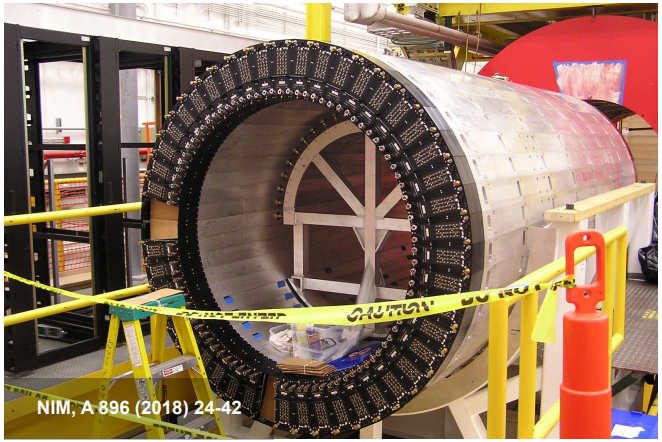
As of YR: No good solution that checks all the boxes. Electron-pion separation requirement in the barrel missed by almost two orders of magnitude risking important parts of the EIC scientific program



Standalone simulations (no field/material) and bench test results from YR.

We can do better!

Let's boost a high-performance sampling calorimeter with inexpensive silicon sensors for shower profiling



Start from mature layered Pb/ScFi technology with side-readout (same as the GlueX calorimeter) for state-of-the-art sampling calorimeter performance

Insert layers of monolithic AstroPix sensors (inexpensive ultra-low-power silicon sensor developed for NASA) in the first half of the calorimeter to capture a 3-D image of the developing shower

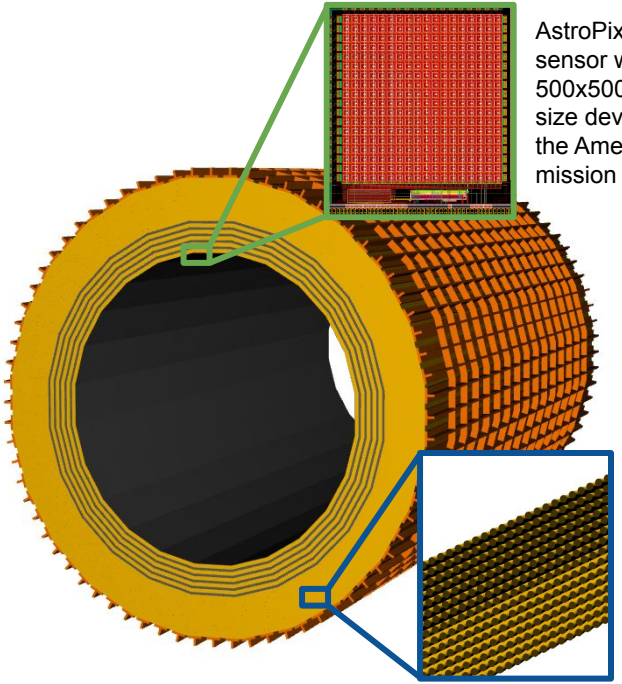
Introducing the ePIC Imaging Barrel ECal

Addressing the unique challenges for the barrel region in ePIC

Hybrid concept: ~~6 layers~~ 4(+2) layers of Astropix sensors interleaved with the first 5 Pb/ScFi layers, followed by a large volume of bulk Pb/ScFi layers

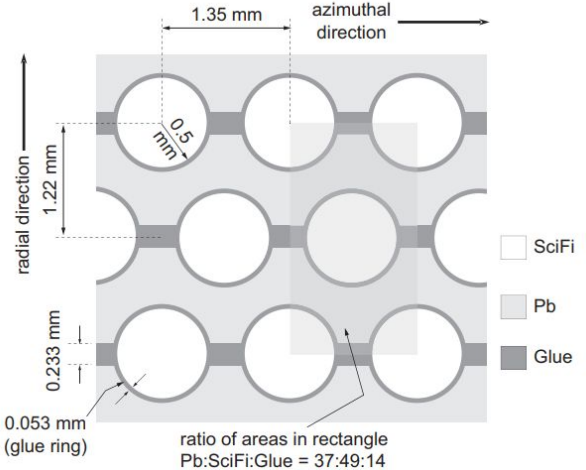
- ☑ Deep calorimeter but still very compact at ~ 40 cm
- ☑ Excellent energy resolution (5.2% /$\sqrt{E}$ ⊕ 1.0%)
- ☑ Unrivaled low-energy electron-pion separation by combining the energy measurement with shower imaging
- ☑ Unrivaled position resolution due to the silicon layers
- ☑ Longitudinal shower profile from the Pb/ScFi layers
- ☑ Deep enough to serve as inner HCal
- ☑ Very good low-energy performance
- ☑ Wealth of information enables new measurements, ideally suited for particle-flow

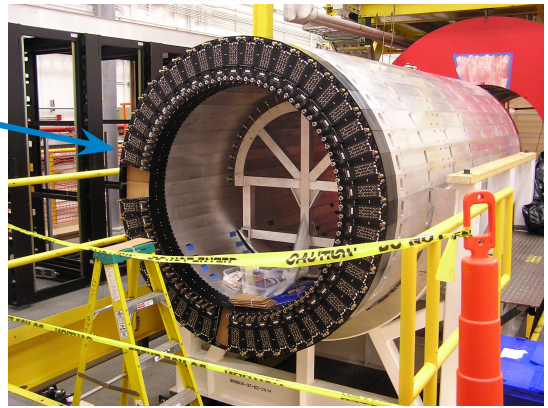
Checks all the boxes!



Pb/ScFi layer technology

Our Pb/ScFi layers follow the GlueX Design





Energy resolution at GlueX: $\sigma = 5.2\% / \sqrt{E} \oplus 3.6\%$ [1)]

- GlueX has 15.5 X_0, and could not constrain the constant term (due to low energies)

Position resolution in z: $1.1\text{cm}/\sqrt{E}$ [2)]

- 2-side SiPM readout, Δt measurement

Mature technology used in Barrel ECals (GlueX, KLOE)

1) Nucl. Instrum. Meth. A, vol. 896, pp. 24–42, 2018
2) Nucl. Instrum. Meth. A, vol. 596, pp. 327–337, 2008

Summary

The detector requirements for the Barrel ECal, driven by the EIC physics program, are **extremely stringent.**

The Imaging Barrel ECal promises **unmatched performance for electron-pion separation and position resolution**, fits in the limited space without compromising on performance, and exceeds all other requirements to enable the EIC physics program.

The detector combines **two mature technologies**, Pb/ScFi and HV-MAPS silicon sensors, to enable full (3+1)-D shower imaging.

Our team has proven expertise in calorimetry, silicon sensors, and large detector systems.

We were selected by the ePIC collaboration after a comparative review in April 2023 as the new baseline technology for the ePIC detector (pending EIC CCB review)