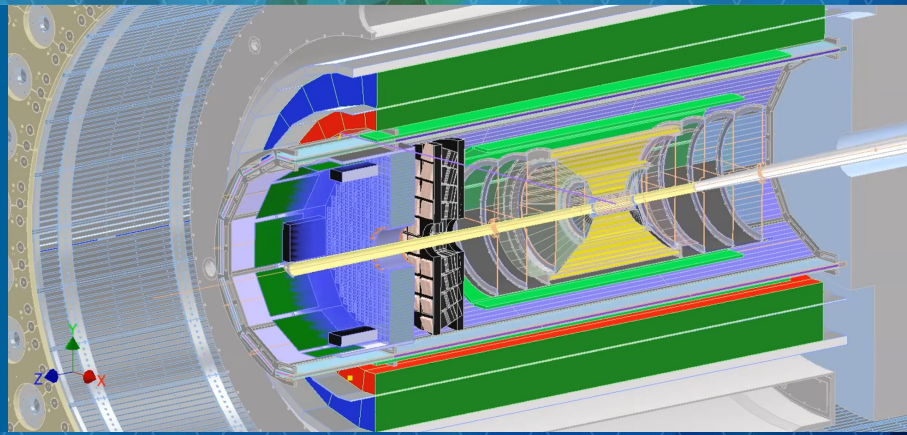
BECal Meeting

Barrel Electromagnetic Calorimeter

Towards Change Control



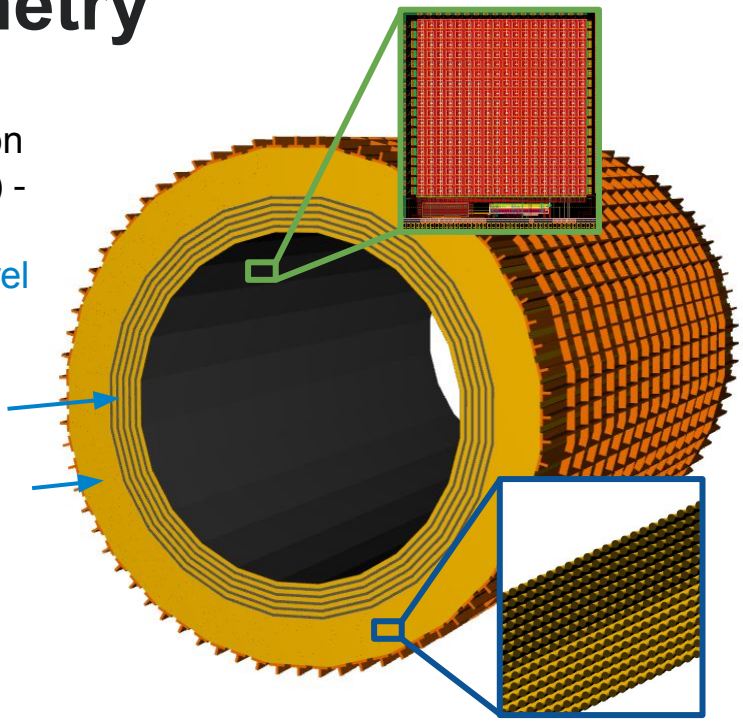
05/02/2023

Imaging Barrel EM Calorimetry

- **Hybrid concept**
  - Imaging calorimetry based on monolithic silicon sensors AstroPix (NASA's AMEGO-X mission) - 500 μm x 500 μm pixels NIM, A 1019 (2021) 165795
  - Scintillating fibers in Pb (Similar to GlueX Barrel ECal, 2-side readout w/ SiPMs) NIM, A 896 (2018) 24-42

- **6 layers of imaging Si sensors** interleaved with **5 SciFi/Pb layers** (starting with 4 layers)
- Followed by a **large section of SciFi/Pb section** (can serve as inner HCAL)

- Total radiation thickness for EMCAL of ~21 X_0 (only ~40 cm deep)



Energy resolution - SciFi/Pb Layers: $5.2\% / \sqrt{E} \oplus 1.0\%$
Position resolution - Imaging Layers (+ 2-side SciFi readout): with 1st layer hit information ~ pixel size for γ

Detector System Collaboration

Detector Subsystem Technical Contact
Si Layers: Jessica Metcalfe (jmetcalfe@anl.gov)
Pb/ScFi: Zisis Papandreou (zisis@uregina.ca)

Detector Subsystem Lead: Maria Zurek *interim* (zurek@anl.gov)

Collaborators:

Argonne National Laboratory
University of California Santa Cruz
University of Connecticut
Duquesne University
Gangreung-Wonju National University
Kyungpook National University
Pusan National University
University of Seoul
Sejong University
Sungkyunkwan University
Yonsei University
Korea University
Hanyang University
University of Giessen
University of Manitoba
University of Regina
Mount Allison University

https://eic.cloud.mattermost.com/main/channels/det-cal-barrel-imaging

Towards Change Control (and beyond)

- **CD-3: April 2025**
- **CD-3a reviews start in August**

- **Budget and Timeline**
  - Identifying Long-Lead Procurement Items: **SiPMs and Scintillating Fibers**
    - Specification needed till August(!)

- **Mechanical and Readout Design**
  - Integration meetings with Engineering and DAQ teams

- **Defining Internal Collaboration Structure**

Backup

SciFi/Pb layers technology

SciFi/Pb layers follow the **GlueX Barrel Calorimeter**
Energy resolution: $\sigma = 5.2\% / \sqrt{E} \oplus 3.6\%$ [1)]

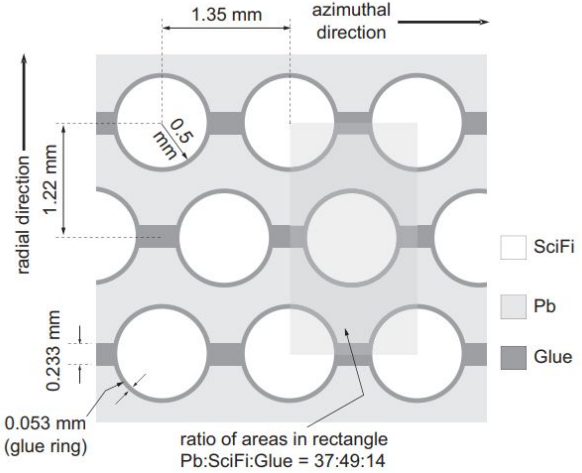
- 15.5 X_0, extracted for low energy photons < ~1 GeV

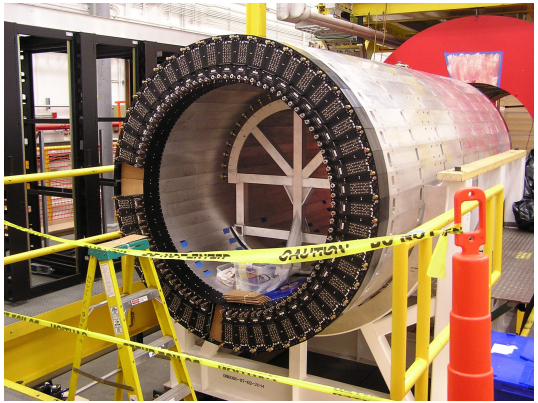
Position resolution in z: $1.1\text{cm}/\sqrt{E}$ [2)]

- 2-side SiPM readout, Δt measurement

Mature technology used in Barrel ECALs (GlueX, KLOE)

- Detailed studies on **calorimetry performance**, including the light collection uniformity in fibers, light collection efficiencies, etc.
- **Module construction** (lead handling, swaging, SciFi/Pb layers assembly, module machining) fully developed for GlueX
  Z. Papandreou, https://halldweb.jlab.org/DocDB/0031/003164/
  - Previously used equipment still available (swager machine, presses)
- Assembly and installation of self-supporting barrel based on GlueX experience





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

Imaging layers technology

Imaging layers based on AstroPix sensors

- Developed for AMEGOX NASA mission
- CMOS sensor based on ATLASpix3
  arXiv:2109.13409 [astro-ph.IM]

Key features:

- Very low power dissipation
- Good energy resolution
- 500 μm pixel size

AstroPix chip R&D:

v1 (4.5×4.5 mm^2, 200 μm pixel)

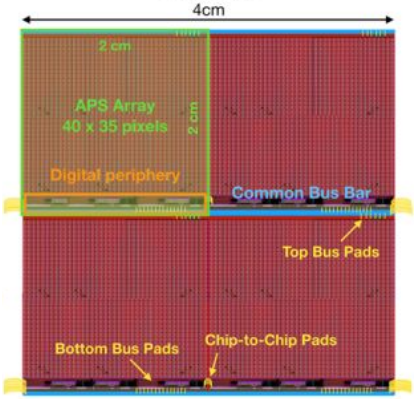
v2 (1×1 cm^2, 250 μm pixel)

- Both chips tested with ɣ,β sources and in 120 GeV proton beam
- See results in arXiv:2209.02631 [astro-ph.IM]

v3a (2×2 cm^2, 500 μm pixel, **quad chip**)

- Expected ready for tests in **January 2023**

Quad chip v3a



v2 carrier board

arXiv:2208.04990 **[astro-ph.IM]**

Targeted AstroPix performance goals

Pixel size	$500\,\mu m \times 500\,\mu m$
Power usage	< 1 mW/cm^2
Energy resolution	10% @ 60 keV (based on the noise floor of 5 keV)
Dynamic range	~ 700 keV
Passive material	$< 5\%$ on the active area of Si
Time resolution	25 ns
Si Thickness	$500\,\mu m$

Planned choice of the foundry TSI (v1-v3). With a large production order, AMS as a backup.

Simulation plans

Next priorities for simulations (rough timeline)

1. Detailed simulation with light propagation in the ScFi (can be standalone)
2. Background studies
3. More complete implementation of the silicon sensor staves and Si drawers
4. Impact of non-sensitive areas around AstroPix chips
5. 2-sided readout for the Pb/ScFi
6. Optimization studies on the readout scheme
7. Iteration between simulation and the mechanical model of the calorimeter
8. Reconstruction studies (cluster matching, full event reconstruction, clustering algorithms, cluster merging, …)
9. Benchmark simulation against R&D tests
10. Performance impact of the imaging calorimeter on the hadronic calorimetry
11. Realistic calibration (collaboration-wide)

Q3 FY23

Q4 FY23