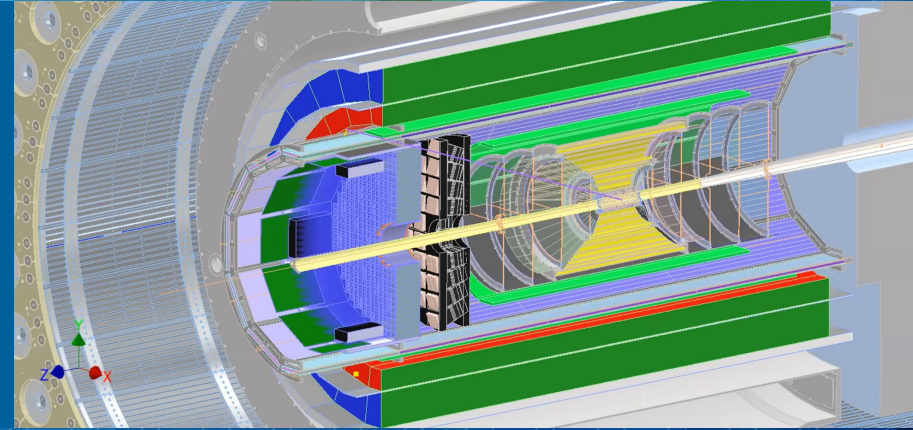


ePIC Calorimetry Meeting

# Barrel Imaging Calorimeter ePIC TDR Planning



07/03/2024



# TDR Structure

- ✓ ready to write
- ⚠ partially ready to write
- ✗ lots of to do

## Design

- Overview ✓
- Detector Requirements ✓

## Performance

- Performance with *most up to date geometry/envelopes* ⚠
  - Energy resolution, Position resolution,
  - e/pi separation, gamma/pi0 separation
- Beam test benchmarking (e resolution) ⚠
- Literature benchmarking (pion response) ⚠
- Backgrounds ✗

## Sector Design, Mechanics and Integration

- Sector design and construction ⚠
- Tracker mechanics ✗
- End-of-sector box mechanics ⚠
- Deflection studies ✗
- Barrel assembly and integration tooling ⚠

## AstroPix Wafers & Modules

- AstroPix characteristics and readiness ✓/⚠
- Automated wafer testing ⚠
- Module & stave design ⚠
- Stave bus design ✗
- Module assembly and scalability ✗

## End-of-sector Box and Readout

- SiPMs characteristics ✓/⚠
- SiPM boards and FEB ⚠/✗
- LED system ✓/⚠
- Tracker End-of-tray card (RDO) ✗
- Slow controls (temperature, humidity) ⚠

## Cooling

- Cooling system design ⚠
- Global heat load simulations ✗

## System Testing

- System Calibration ✗
- System QC ✗
- System Demonstration ⚠/✗

# High-level timeline

# Performance

## Performance

1. Performance with *most up to date geometry/envelopes* 🚧
  - a. Energy resolution, Position resolution,
  - b. e/pi separation, gamma/pi0 separation
2. Beam test benchmarking (e resolution) 🚧
3. Literature benchmarking (pion response) 🚧
4. Backgrounds ✖

Tasks	Time	Missing Workforce/Resources
1a and 1b	July 2024 (repeated depending on implementation of design)	FTEs on reconstruction algorithms implementation and validation.
2	August 2024	
3	October 2024 (depending on beam test success)	
4	November 2024	Requires input from background task-force and work on reconstruction algorithms.

# System Testing

1. System Calibration ✕
2. System QC ✕
3. System Demonstration 🚧/✕










Tasks	Time	Missing Workforce/Resources
1, 2	July 2024 Internal preliminary design review Sep 2024 Preliminary design review May 2025 Internal final design review	
3	<del>May 2024 FTBF Beamtest (Commissioning, e/pion response)</del> ✓ September 2024 First Integrated Mechanical Test Article Nov/Dec 2024 FTBF Beamtest (Integrations, e/pion response) July 2025 Large Integrated Test Article	

# Sector Design, Mechanics and Integration

1. Sector design and construction 🚧
2. Tracker mechanics ✖
3. End-of-sector box mechanics 🚧
4. Deflection studies ✖
5. Barrel assembly and integration tooling 🚧

Tasks	Time	Missing Workforce/Resources
1,2,3	July 2024 Internal preliminary design Sep 2024 Preliminary design review Jan 2025 Internal final design review	
4	July 2024 Sector-scale FEA Dec 2024 Full system FEA	
5	<del>May 2024 Assembly Strategy Decision (w/ Project)</del> ✓ Dec 2024 Assembly and tooling design	

# End-of-sector Box and Readout

1. SiPMs characteristics  
2. SiPM boards and FEB   
3. LED system  
4. Tracker End-of-tray card (RDO) 
5. Slow controls (temperature, humidity) 

Tasks	Time	Missing Workforce/Resources
1	July 2024 Irradiation Studies (FBTF tests) Sep 2024 Start Bidding/Procurement	
2, 3, 4, 5	July 2024 Internal preliminary design Sep 2024 Preliminary design review Mar 2025 Internal final design review	Formal FEB expert (Norbert has been helping us)







# Cooling

1. Cooling system design 🚧
2. Global heat load simulations ✖

Tasks	Time	Missing Workforce/Resources
1, 2	July 2024 Internal preliminary design Sep 2024 Preliminary design review Jan 2025 Internal final design review	TBD: FEA expert to conduct simulations (can recruit from BIC DSC or maybe get help from Project)



# AstroPix Wafers & Modules

1. AstroPix characteristics and readiness  
2. Automated wafer testing 
3. Module & stave design 
4. Stave bus design 
5. Module assembly and scalability 

Tasks	Time	Missing Workforce/Resources
1	Nov 2024 AstroPix v5 characterization June 2025 AstroPix v6 characterization (production chip)	
2	July 2024 chip-level QC testing for AstroPix v3 Nov 2024 chip-level QC testing for AstroPix v5 Jan 2025 transition from chip to wafer-level QC testing	
3,4,5	July 2024 Internal preliminary design Sep 2024 Preliminary design review Apr 2025 Internal final design review	

# Progress Report

# Performance and System Testing

June beam test at Fermilab Test Beam Facility

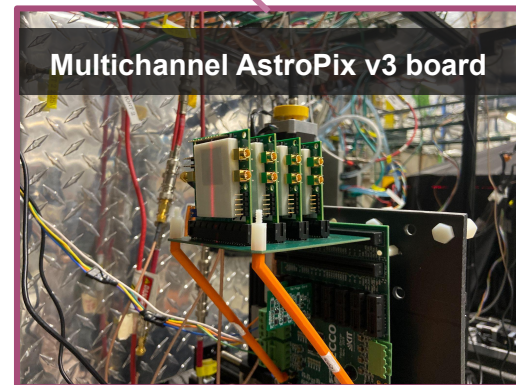
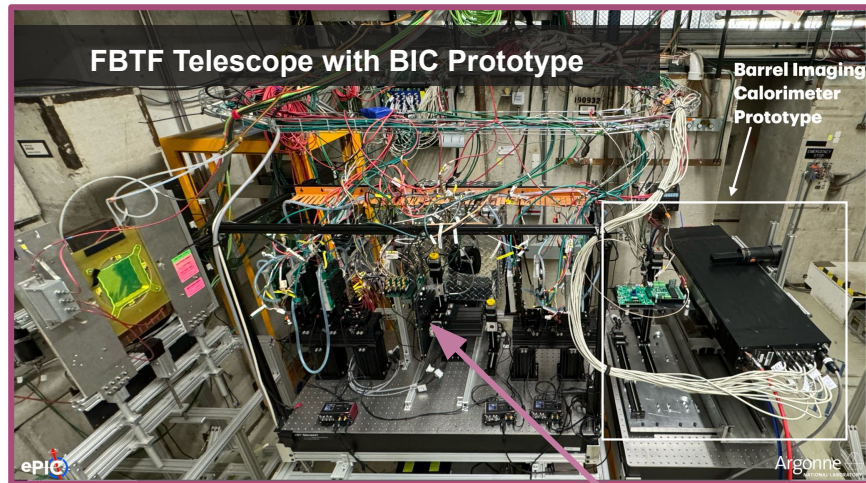
Prototypes and test articles:

- **Setup 1:** Baby BCal (ScFi/Pb prototype) shipped from JLab to Argonne/FBTF integrated with single AstroPix v3 chip
- **Setup 2:** AstroPix multi-channel board with successful daisy chain readout of v3

Beam Test goal:

- **Commission** both setups in the beam including the first test of the integration between AstroPix and SciFi/Pb
- Benchmark **response to pions**

**~30 hours of beam out of promised 6 days** because of the heat wave in Chicago area (no enough cooling capability for FTBF beam magnets)

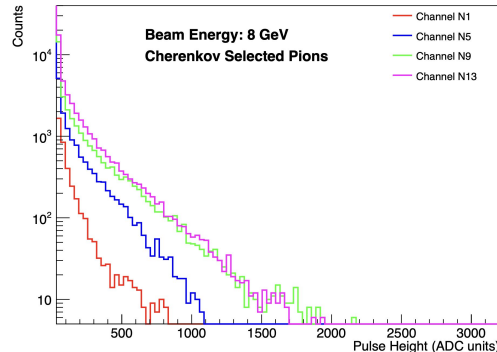
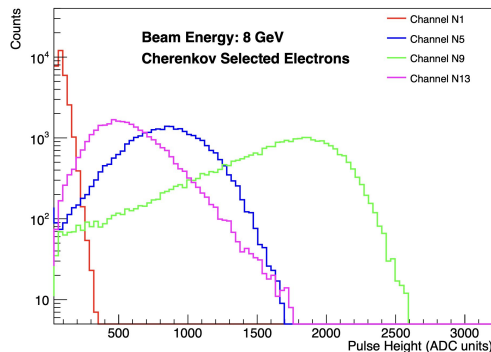


# Performance and System Testing

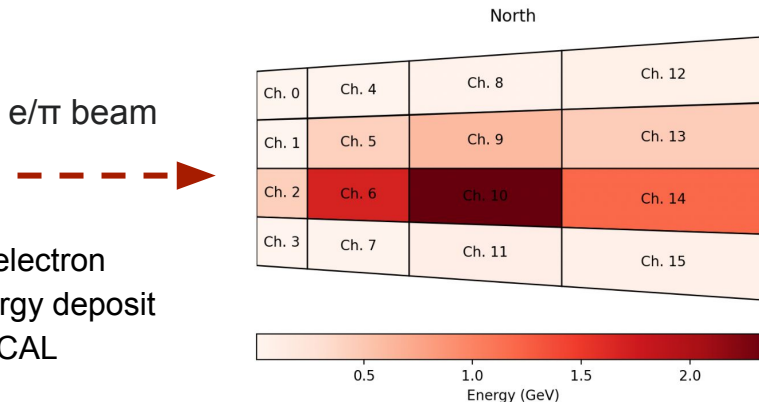
## June beam test at Fermilab Test Beam Facility

Despite extremely challenging conditions:

- Successfully **commissioned the DAQ** system for the Baby BCAL
- Tuned and included **Cherenkov counter information** for electron/pion particle identification in our data stream
- Performed a **proof-of-concept integration between the AstroPix** layer and Baby BCAL using the AstroPix analog signal
- Collected sets of **electron/pion data at 4, 6, 8, and 10 GeV**, as well as sets of muon/pion and proton data for calibration purposes
  - After initial assessment data seems analysis-quality
  - Data analysis in progress



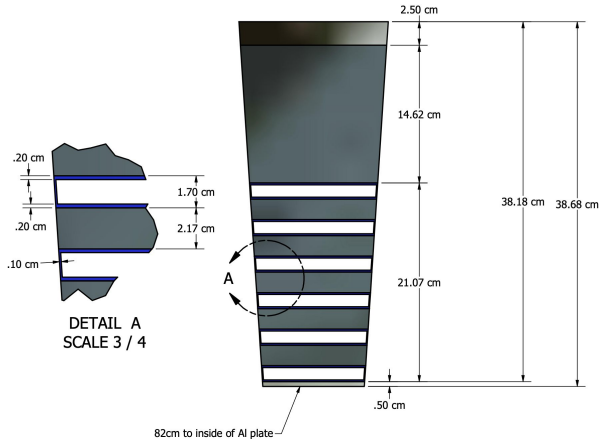
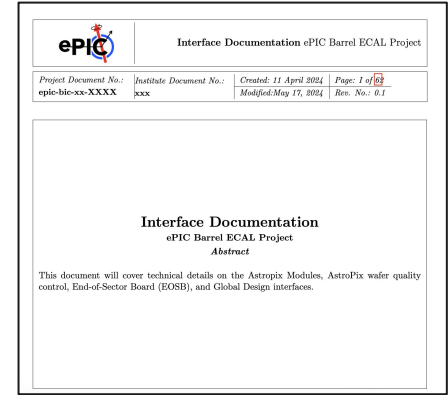
Collected **energy response** in selected Baby BCAL channels at different depths in the calorimeter prototype for a sample of pions (bottom) and electrons (top) identified with the Cherenkov counters.



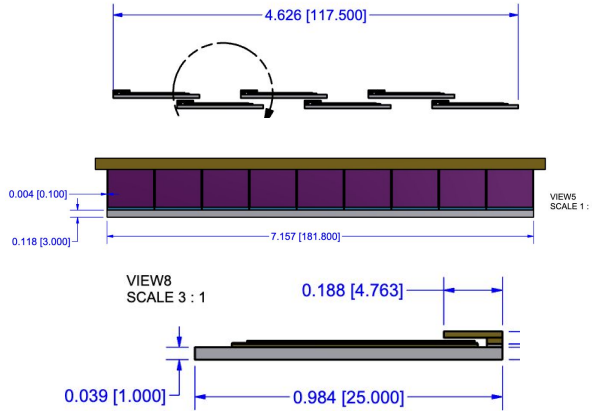
Example electron event energy deposit in Baby BCAL

# Sector Design, Mechanics and Integration

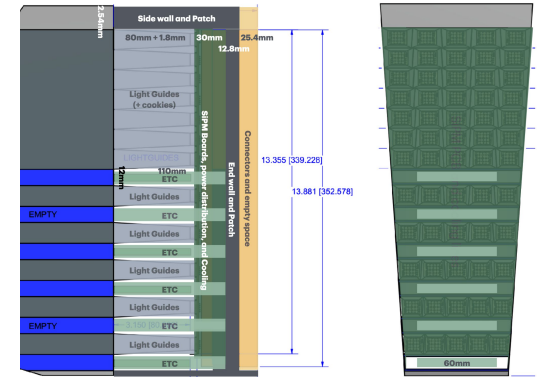
- Extensive work on finalizing **revision 1 of the BIC Interface Control Document** over the last few months, with a series of topical meetings and writing sessions during the in-person BIC Workshop (May 14-17, 2024)
- **Freezing interfaces**, as PED funds start becoming available, will allow teams to **focus on sub-component designs** with clearly defined envelopes and conditions



BIC Sector Design



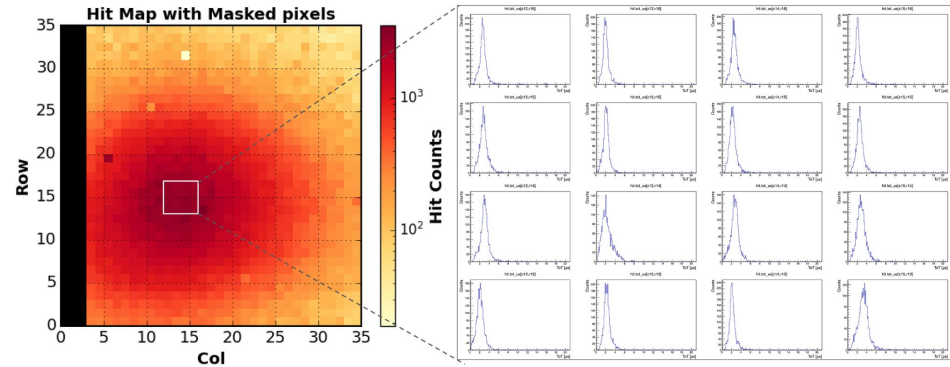
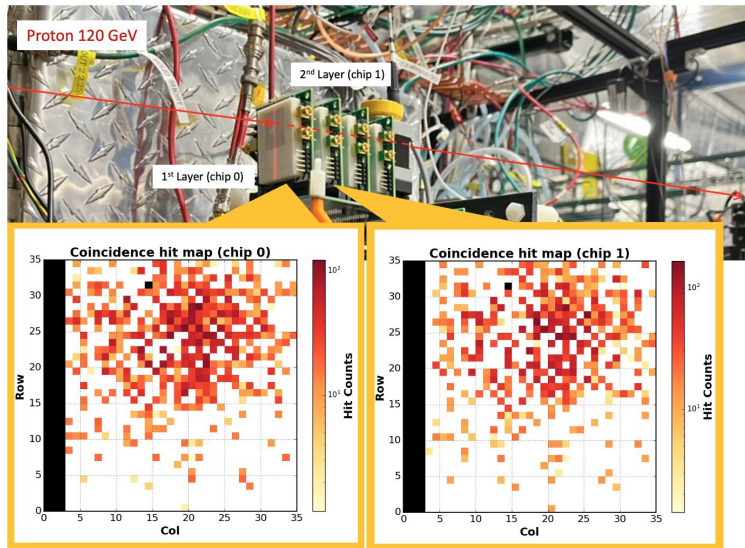
AstroPix Module Designs



End of Sector Box Envelopes

# AstroPix Wafers & Modules

1. AstroPix v3 integration tests at FTBF, first proof-of-concept demonstration of the integration of two daisy-chained AstroPix layers in a beam-like environment.
2. AstroPix v5 design review (to be submitted for an engineering run in July)



The multilayer AstroPix v3 setup which has been tested at FTBF with example of the recorded 120 GeV proton beam events from the first two layers, read in coincidence

Example AstroPix data collected with a 120 GeV proton beam. The hit map reveals the proton beam profile. The collected ToT values for the marked pixels are presented in the matrix of plots on the right