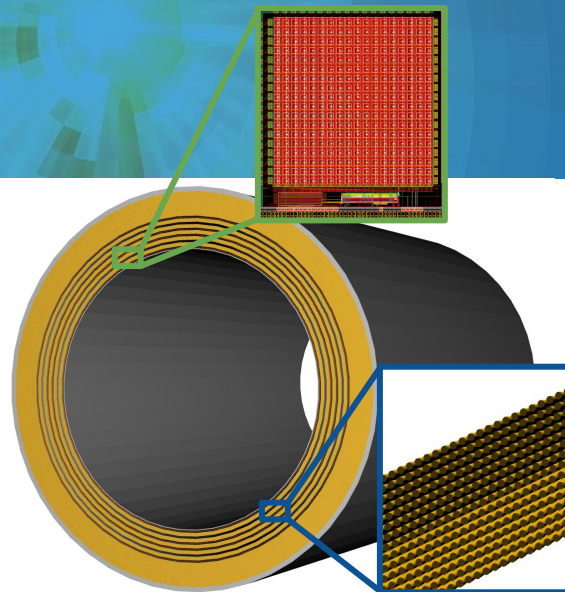


The ePIC Barrel Imaging Calorimeter

Software and Simulation System Testing



Maria Žurek
Argonne National Laboratory

BIC General Meeting
November 22, 2024



System Testing

- New AstroPix bench setup for calibration with Ba133 (made in PHY division at ANL) - results presented on CPAD2024

Performance Test Results (4)

Beam Test of AstroPix_v3 (2)

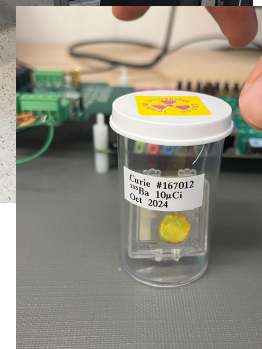
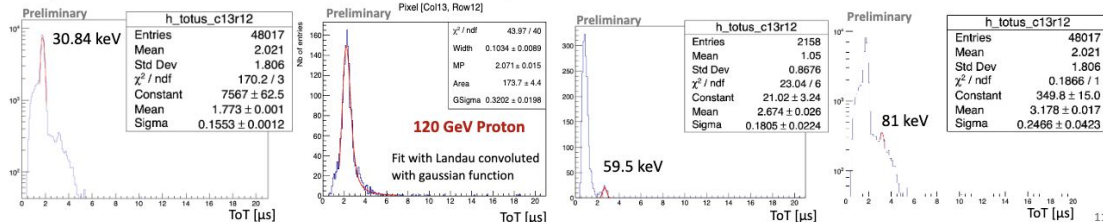
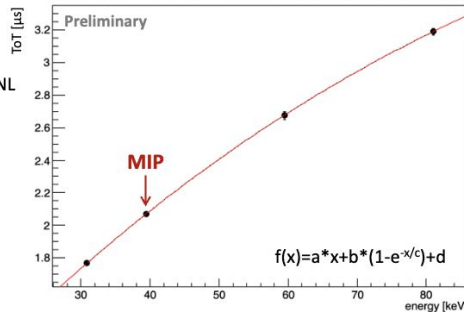
One example pixel [column 13, row 12] in single layer

- ToT Histograms of measuring gamma energies to obtain a calibration curve
 - Ba-133 (30.84 keV and 81 keV), Am-241 (59.5 keV) at bench test in ANL
- Calibration curve fitted using pol2 or linear+exp. decay functions
- MPV of 120 GeV Proton at pixel [c13,r12] ~ **39.41 keV**
- Paper in progress

	Ba133 (30.84 keV)	Proton (120 GeV)	Am241 (59.5 keV)	Ba133 (81 keV)
$\mu \pm \sigma$ [μ s]	1.773 ± 0.1553	2.071 (MPV)	2.674 ± 0.1805	3.178 ± 0.2466
E_{res} (FWHM)	20.6 %	-	15.9 %	18.2 %

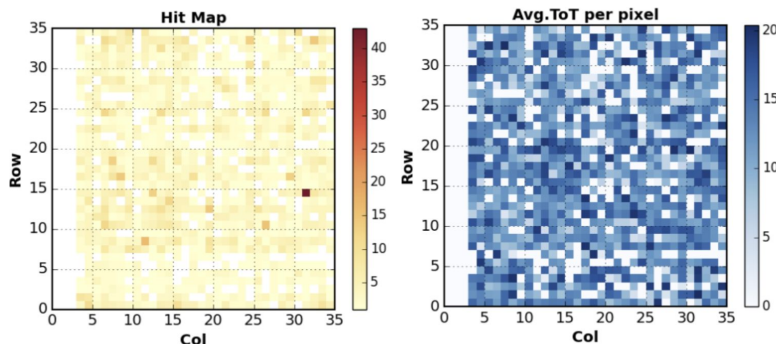
Bobae Kim, CPAD2024

Calibration curve as a function of energies [keV] at [c13, r12]



System Testing

- Concluding analysis of the beam test data with SciFi and AstroPix
- FTBF in FY25 uncertain, definite news in Dec.
 - Tue 26th, 2 PM CT Meeting will discuss that.



Result of w101s07 chip
 HV: -150V
 th: 100 mV
 External Clock
 source Ba133
 10m data taking

- AstroPix with external clock tested for the first time at ORNL (thank you Bobae, and the ORNL team!)

Jared Richards, Henry Klest
 CPAD2024

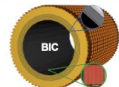
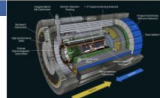


ELECTRON AND PION RESPONSE BENCHMARKS FOR THE EPIC BARREL IMAGING CALORIMETER

Jared Richards, Argonne National Laboratory and University of Connecticut
 For the ePIC Collaboration, [jrichards@ornl.gov](https://arxiv.org/abs/2401.12345)

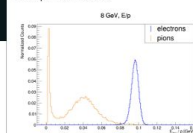
INTRODUCTION

- The Electron-Ion Collider (EIC) will collide electrons with protons and heavy ions at Brookhaven National Laboratory.
- The Electron-Proton Ion Collider Experiment (ePIC) will detect particles created in those collisions.
- The Barrel Imaging EM Calorimeter (BIC), being designed at Argonne National Laboratory, is a sampling calorimeter utilizing two technologies: initiating fibers embedded in lead (PbScFi), interleaved with AstroPix silicon sensors.
- BIC's Baseline Designing: $\sqrt{s} = 10-12$ TeV e^-p @ (1-3)% \sqrt{s} suppression up to $1:10^4$
- The BabyBIC is a small PbScFi calorimeter: prototype, based upon a version of the GlueX Barrel Calorimeter with incorporated AstroPix sensors.



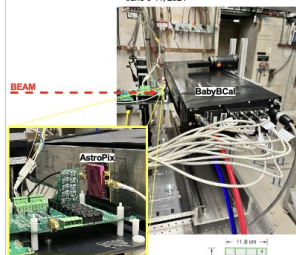
MOTIVATION

- Benchmark the simulated responses to electrons and pions to characterize [Energy Resolution](#) and [Electron ID](#).
- BIC optimization studies



SETUP

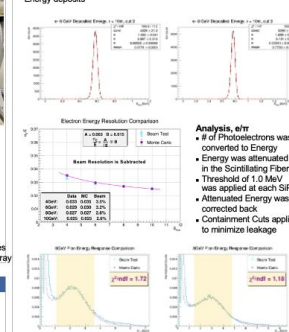
Fermilab Test Beam Facility (FTBF)
 June 5-11, 2024



- MTest Beam Line**
 - Main Injector Beam: 120 GeV Protons
 - Secondary Beam: Main Beam on Aluminum target
 - 4x Beam at 4, 6, 8, and 10 GeV
 - 4x Beam at 10 GeV, inserted lead sheet absorbs electrons
 - 4x Beam: Two FTBF Cherenkov detectors
 - 4x Beam: FTBF Beamline Scintillators
- BabyBIC Readout Scheme**
 16 channels with North/South sides
 4x10 SiPM Array → 4x4 Readout Array

RESULTS

- Realistic Simulation in Official ePIC Framework
- FTBF Beamline Scintillators included in geometry
- Energy dependent \sqrt{s} Beam spread in p, θ , and ϕ
- π Quenching in PbScFi material, BIC's Constant = 0.128 mm/MeV
- Calibration
 - Plot MP peaks by channel in ADC units
 - Convert ADC units to Energy by adjusting MP peaks to simulated Energy deposits



CONCLUSIONS

- Energy response of e^- fulfills the BIC requirements.
- Energy response of π^- matches well with FTBF data at 6 and 8 GeV
- Benchmarking in real data provides confidence in simulating for BIC

This work is supported by Laboratory Directed Research and Development (LDRD) funding, "Tomography at an Electron-Ion Collider: Unraveling the Origin of Mass and Spin" and "Towards Prototyping the Design of a Generic Imaging Barrel Electromagnetic Calorimeter" from Argonne National Laboratory, provided by the Director, Office of Science, of the U.S. Department of Energy under Contract No. DE-AC02-06CH11357

Simulation and Software

- Light Guide Simulation
 - Layer efficiency with single-clad fiber
 - Non-linearity of response from simulations with cross-talk

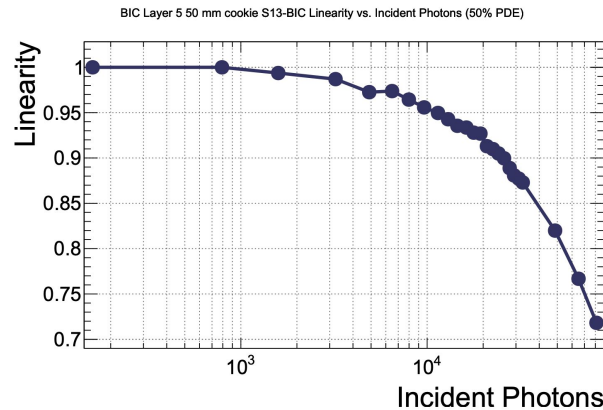
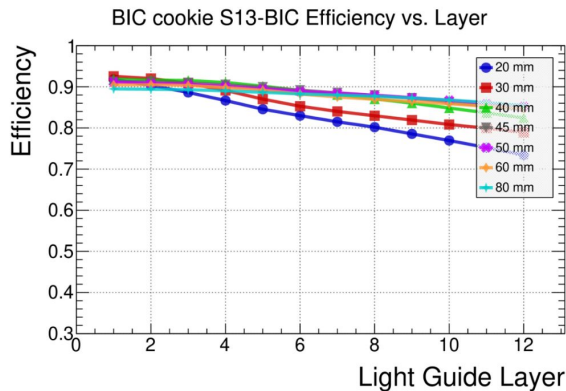
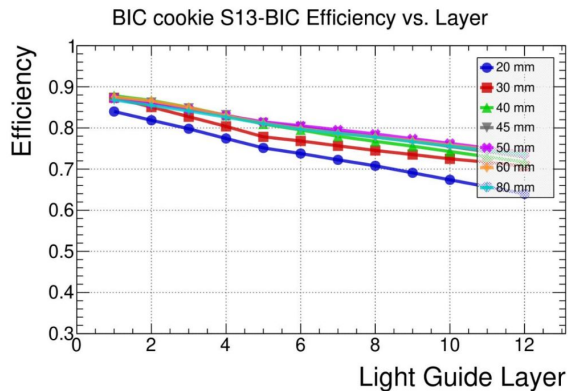
Efficiency

Tegan Beattie, BIC Simulation Meeting,
<https://indico.bnl.gov/event/24751/>

Tegan Beattie, BIC Simulation Meeting,
<https://indico.bnl.gov/event/24753/>

Double-Clad ($\theta_{\max} = 26.7^\circ$)

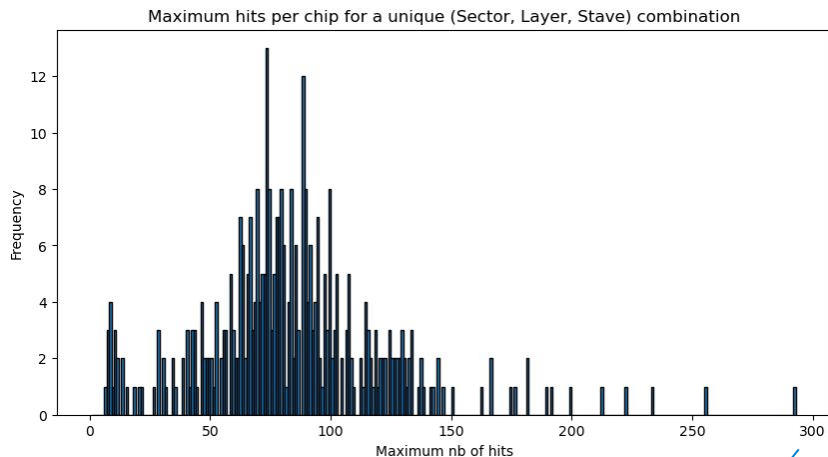
Single-Clad ($\theta_{\max} = 20.4^\circ$)



- AstroPix Occupancies (max buffer size)

Pythia, DIS NC, 18x275, Q2 > 1000

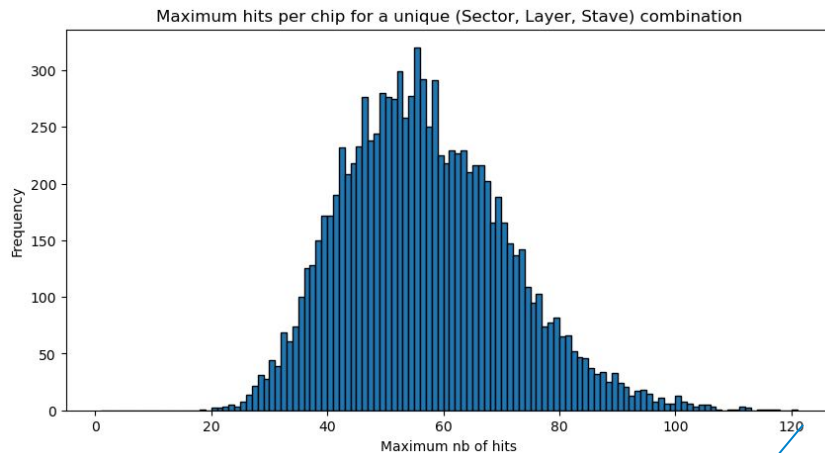
Max nb of pixels fired per chip



up to ~300 hits (extreme)

e at $\eta = -1.4$ (18 GeV)

Max nb of pixels fired per chip



up to 120 hits

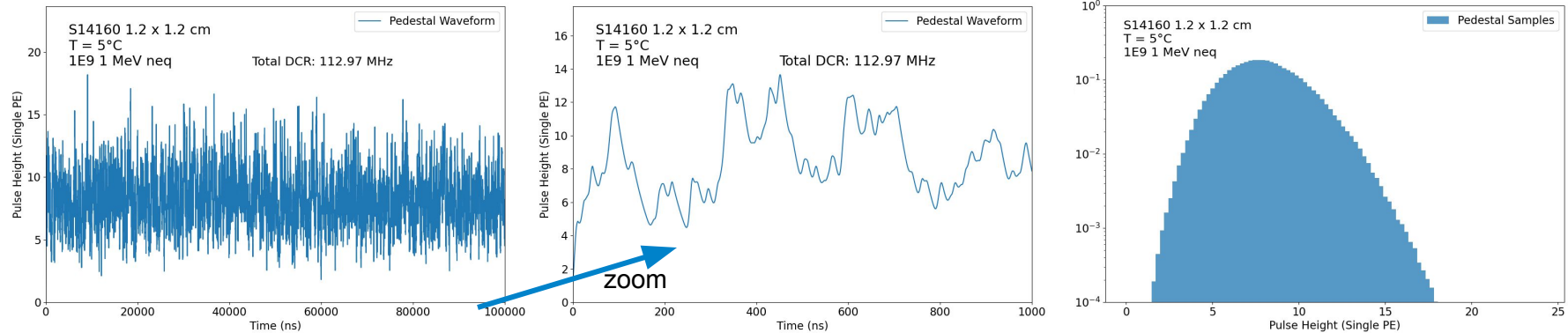
Simulation and Software

SiPM simulations



- Simulations of the expected pedestal position and sigma realistic SiPM DCR and signal shape
- Scenarios for different SiPM families, irradiations and operating temperatures tested
- Based on the pedestal sigma, the threshold (4-sigma) is being placed on a readout cell

Analysis by Henry Klest



Example simulated baseline and pedestal for S14160 SiPMs at 5 °C irradiated 1e+09 1-MeV neutron equivalent dose

1E9 1-MeV neq/cm² irradiation **at 5 °C** (INFN Bologna results): Pedestal sigma = 2 phe

1E9 1-MeV neq/cm² irradiation **at room temperature** (UC Davis results): Pedestal sigma = 5.38 phe

1E10 1-MeV neq/cm² irradiation **at room temperature** (UC Davis results): Pedestal sigma = 9 phe