4th BIC In-person Workshop, Apr 10, 2025

System Testing: R&D Program Accomplishments

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* Updates since Detector Advisory Meeting, August 2024.

- AstroPix v4 single chip
- AstroPix v3 quad chip
- AstroPix v3 single chip
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 - Single AstroPix v3 chip with Baby Bcal
 - Two AstroPix v3 chips daisy-chained
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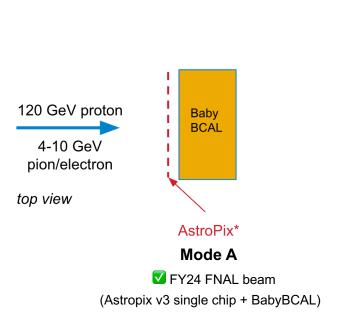


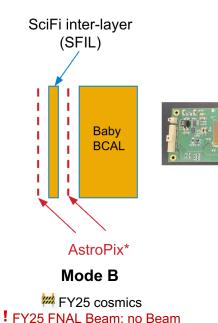
FY24 R&D Goals

Goal: Characterize the integrated AstroPix and SciFi/Pb system with a mixed e/π beam and mips, benchmarking the response to charged pions, benchmarking the electron-pion separation capability, and testing the new generation SiPMs.

Possible options of system integration:

* System flexible for testing single AstroPix chip, quad chip, 9 chip PCB module











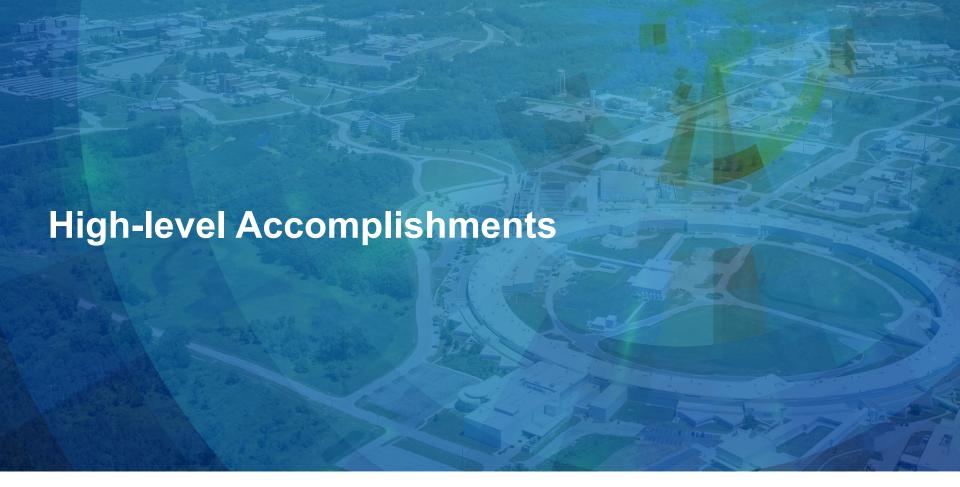


FY24 R&D Milestones Summary

* Updates since Detector Advisory Meeting, August 2024.

| Milestone | Status |
|---|--|
| M1: Integrated setup with Baby BCal and AstroPix chip designed and built at Argonne | Done 🗸 |
| M2: AstroPix chips prepared at the bench for integrated tests with Baby BCal | Done ✓ Astropix v3 single chip Astropix v3 quad chip Astropix v4 single chip |
| M3: Data Acquisition (DAQ) for the integrated system of Baby BCal and AstroPix chip designed and tested | Done Proof-of-concept tested in the beam • Proof-of-concept tested in the beam |
| M4: Integrated prototype system tested at the bench with cosmics and/or source | Done ✓ • Proof-of-concept tested in the beam |
| M5: SciFi Inter-Layer (SFIL) delivered by the University of Regina, integrated, and tested at the bench | In progress (Almost there) |
| M6: Integrated system commissioned at the beam test facility with protons | Done ✓ • Single AstroPix v3 chip with Baby BCal • Two AstroPix v3 chips daisy-chained |
| M7: Response to pions tested in the beam environment and e/pi separation benchmarked in the simulations | Done ✓ → Will be presented in next talk by Henry: "Beam Tests: Accomplishments from FNAL Beam Test FY24" |









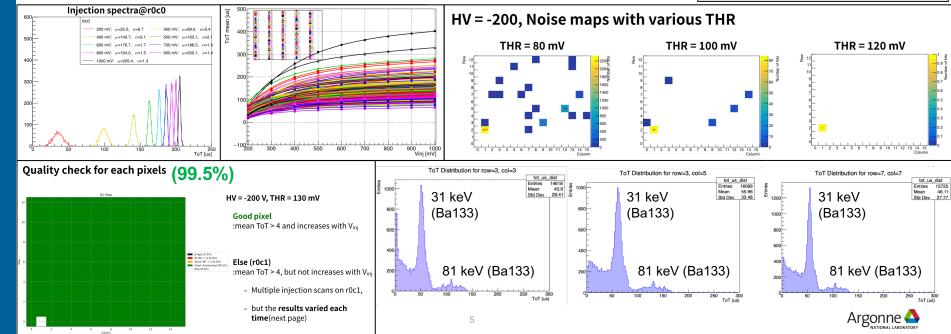
M2: AstroPix v4 chips testing

- Optimized the configuration for v4 testing
- ☑ Injection scan (HV = -200 V, threshold = 130 mV)
- ✓ Noise scan
- Source test for calibration curve at Busan National University: in progress
- Beam test at KEK or CERN: in progress

*Final version for BIC, similar design to v4 spec.

Astropix v4 single chips

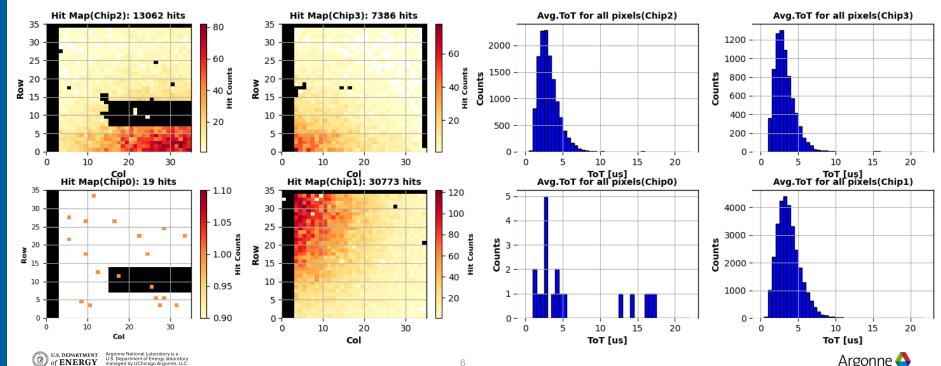
- 1 x 1 cm² -size with 13 × 16 pixel matrix
- 500 µm pixel pitch
- Individual pixel readout
- 3 timestamps, 3.25 ns time resolution
- TuneDAC for pixel-by-pixel thresholds



M2: AstroPix v3 quad chips testing

- Sr90 source test using CMOD board and ASTEP sw/fw → four daisy-chained chips!
- The hit map aligns well with the source position at the center of the quad chip.
- The ToT distribution is well-described by a Landau distribution convoluted with a Gaussian function.

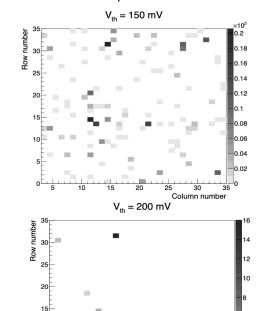




M2: AstroPix v3 single chip testing

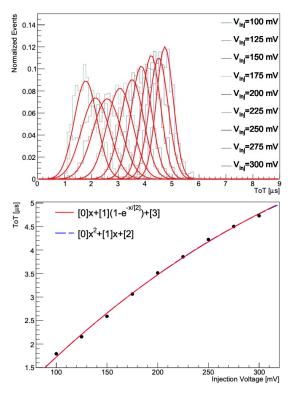
Noise scan, injection scan and source test for FY24 beam test

· Noise map w.r.t threshold

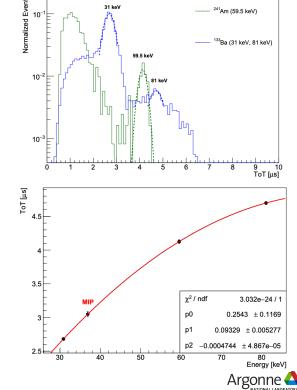


Column number

ToT distribution and injection vol. vs ToT



Calibration curve for beam test result

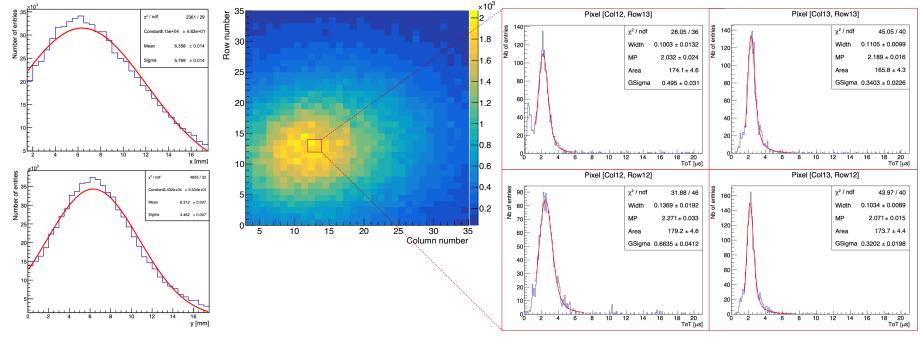




M6: AstroPix v3 single chip with proton

Response of MIP, Align well within dynamic range of requirement (1)

- The hit map reveals the proton beam profile: $\sigma_x \times \sigma_v = 5.8 \text{ mm} \times 4.5 \text{ mm}$
- First 120 GeV proton response: 37.18 keV for MIP which sits well within dynamic range (25 keV 200 keV) in AstroPix v3
- Behaves well in the particle rates of 13 kHz



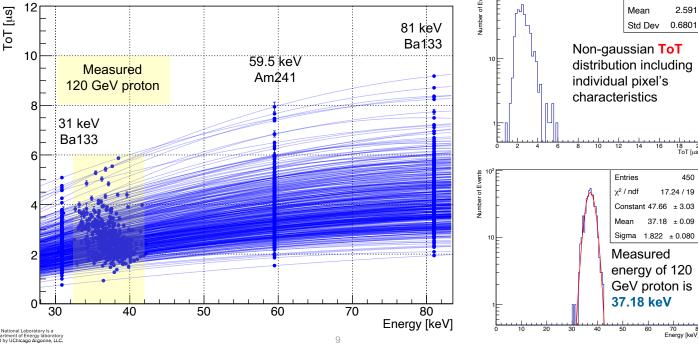




M6: AstroPix v3 single chip with proton

Response of MIP, Align well within dynamic range of requirement (2)

- The hit map reveals the proton beam profile: $\sigma_x \times \sigma_v = 5.8 \text{ mm} \times 4.5 \text{ mm}$
- First 120 GeV proton response: 37.18 keV for MIP which sits well within dynamic range (25 keV 200 keV) in AstroPix v3
- Behaves well in the particle rates of 13 kHz





Entries

450

M6: Integrated system commissioned with proton

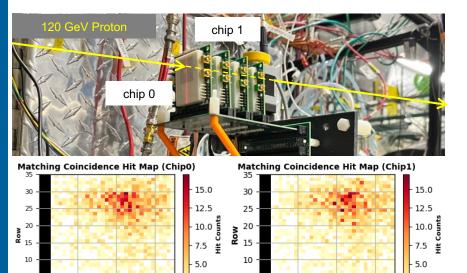
120 GeV proton beam events from the first two single chips, read in coincidence, showing
the position of the hit pixel.: First proof-of-concept demonstration of the integration of
two daisy-chained AstroPix v3 chips in a beam-like environment

Baby BCal events triggered by AstroPix analog signal from 120 GeV proton.

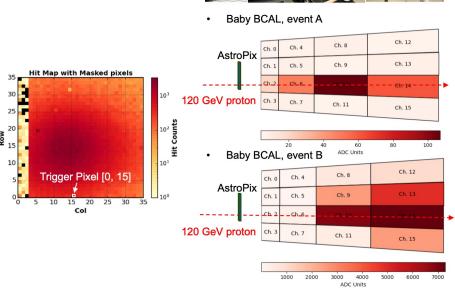
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Preliminary



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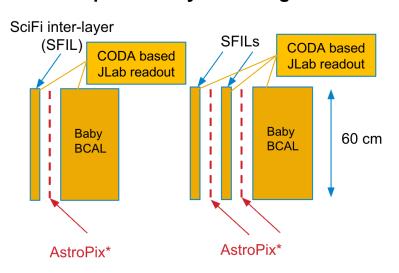






AstroPix-SciFi Integration and Bench Tests

Possible options of system integration:



R&D Goal to be accomplished by **April 16**

What is needed?

- SFILs x 2 with lightguides and S14 SiPMs
- SFILs Readout boards (custom, discrete electronics)
- BabyBCAL and SFILs integrated in CODA readout
- Sync of Pb/SciFis with AstroPix → AstroPix as trigger IN for SFIL+BabyBCAL DAQ
- AstroPix chips read in sync (external clock)

Goal: show integration between AstroPix chips + 2 SFILs (44 x 10 x 2.5 cm³ each) + Baby BCAL with cosmics

Note: Review on April 16-17 R&D day

In summary: 1st level integrated system that can be upgraded with new subcomponents (SFILs, AstroPix modules/FPGAs, bulk section, new SiPMs, etc.) as these became available on March 3 (arrival of SFILs at ANL)



Astropix & Pb/SciFi DAQ

Currently available

- Astropix + GECCO board + ASTEP sw/fw
- ☑ Based on ASTEP sw/fw used in FY24 beam test at FNAI
- Enable external clock since last November
- Astropix + CMOD board + ASTEP sw/fw
- 1 layer of quad chip working Available up to 3 layers: work in progress
- ## 9 chip PCB: work in progress (Aug. 2025 for PDR)

Pb/SciFi + CODA based JLab DAQ

- Used with Baby BCAL in FY24 beam test at FNAL
- Add two SFILs

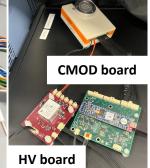
Pb/SciFi + HGCROC/CALOROC (Aug. 2025)

Need one KCU105, two A5205 header adapters

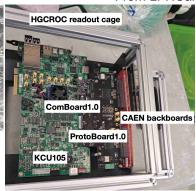


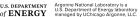
*From LFHCal









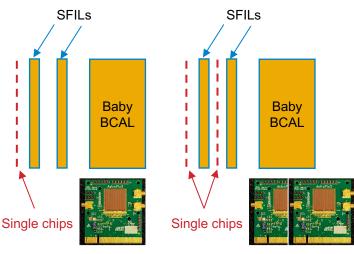




System Testing Plan

Plan for Synchronization

Possible setup of system integration at bench test in ANL:

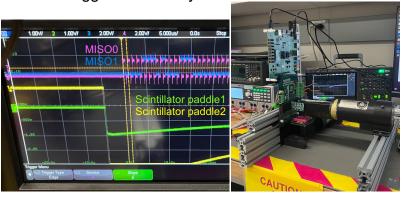






How to synchronize?

- Plan A
 - ## LVDS MISO0/1 signals that generated from Astropix used as trigger IN for baby bcal



- Plan B
 - Provide up to 10 MHz LVDS external clock to Astropix chip via PMOD



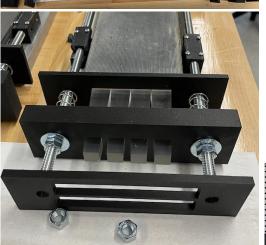


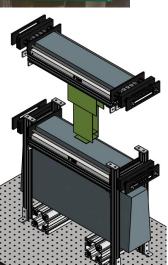
Current status of Bench Test at ANL

SFIL and **Setup**



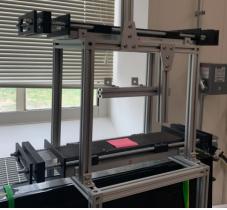


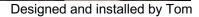




- **☑** Signals from AstroPix and scintillators using cosmic muon
- Testing SiPM board for SFIL
- ## Testing AstroPix and SFILs using cosmic muon
- Image: Data taking using CODA based JLAB DAQ









Summary & Plan

- FY24 R&D Milestones have been completed. ©
- AstroPix-SciFi Integration with SFILs will be done by April 16-17 R&D day.

| Milestone | Original Timeline* | Status |
|--|-------------------------------|---|
| M1: Integrated setup with Baby BCal and AstroPix chip designed and built at Argonne | t0 + 3 months Q1 FY24* | Done 🗹 |
| M2: AstroPix chips prepared at the bench for integrated tests with Baby BCal | t0 + 3 months Q1 FY24* | Done 🗹 |
| M3: Data Acquisition (DAQ) for the integrated system of Baby BCal and AstroPix chip designed and tested | t0 + 5 months Q1-Q2 FY24* | Done V • Proof-of-concept tested in the beam |
| M4: Integrated prototype system tested at the bench with cosmics and/or source | t0 + 6 months Q2 FY24* | Done . Proof-of-concept tested in the beam |
| M5: SciFi Inter-Layer (SFIL) delivered by the University of Regina, integrated, and tested at the bench | t0 + 7 months Q2-Q3 FY 24* | In progress (almost there) 🚧 |
| M6: Integrated system commissioned at the beam test facility with protons | t0 + 9 months Q3 FY24* | Done ✓ • Single AstroPix v3 chip with Baby BCal • Two AstroPix v3 chips daisy-chained |
| M7: Response to pions tested in the beam environment and e/pi separation benchmarked in the simulations | t0 + 12 months Q3-Q4 FY24* | Done (with as much beam as we had available) |

