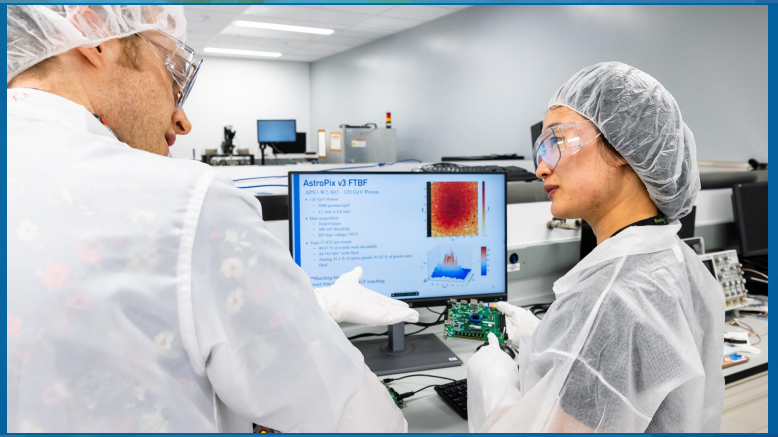
The ePIC Barrel Imaging Calorimeter

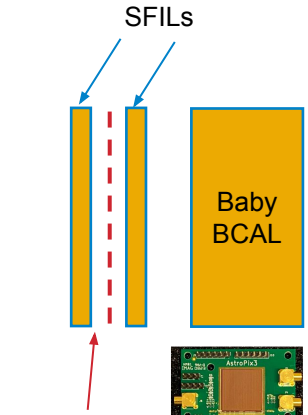
System Testing & ESB Meeting



Maria Żurek
Argonne National Laboratory

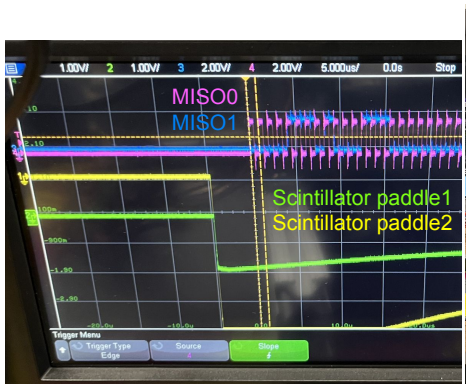
R&D Recap

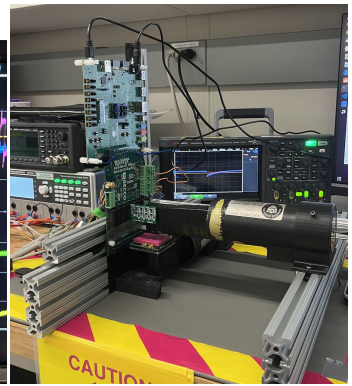
R&D Recap: AstroPix/SFILs Integrations



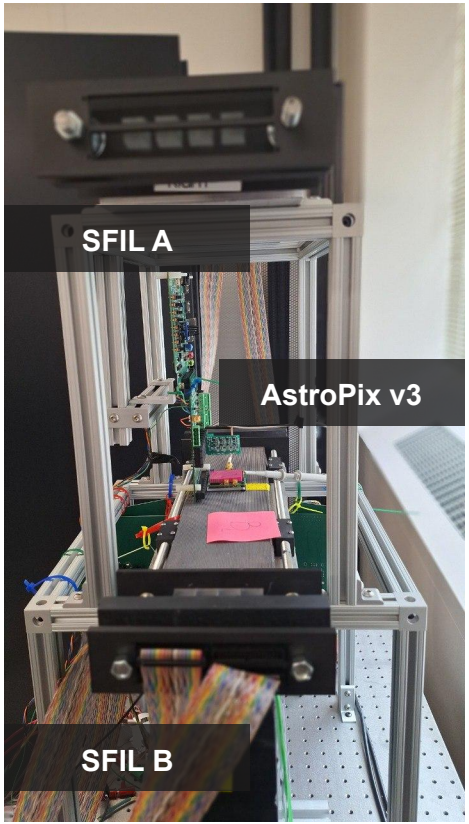
How to synchronize AstroPix w/ SFIL?

- Plan A (for CODA based JLab readout)
  - LVDS MISO0/1 signals that generated from Astropix used as trigger IN for Baby BCAL

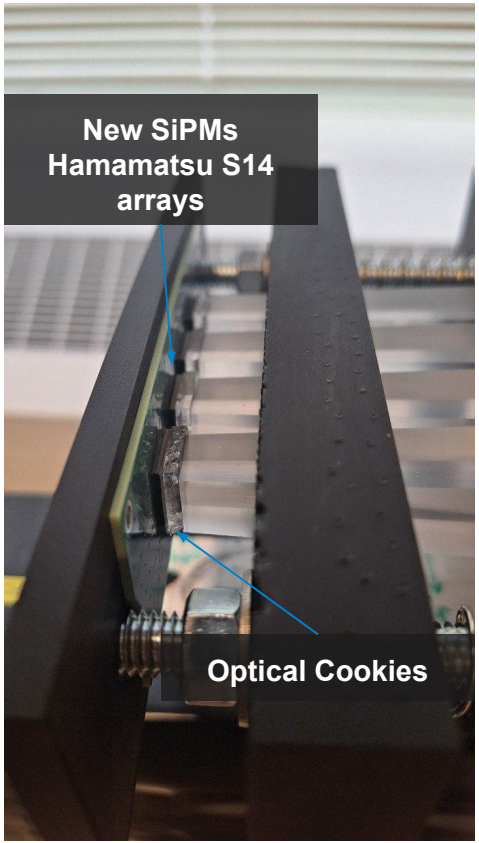




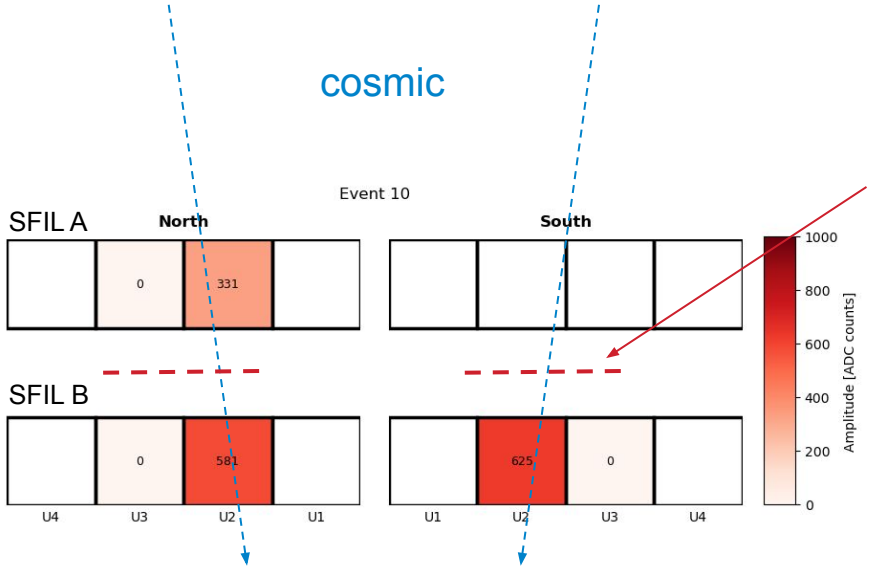
- Plan B (for HGCROC) - for PED phase
  - Provide up to 10 MHz LVDS external clock to Astropix chip via PMOD

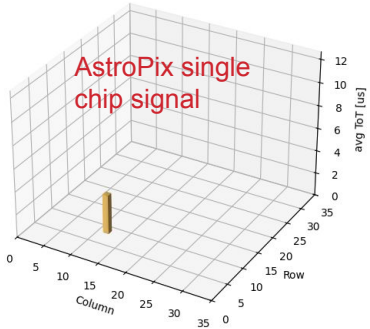


R&D Recap: AstroPix/SFILs Integrations



- SFILs: new S14 SiPM arrays, optical cookies, 8 cm machined light-guides
  - Test station for optical coupling and improvements
- Delays and hiccups delivery to Argonne (broken package, lost SiPM boards)
- Setup successfully commissioned at bench with cosmics



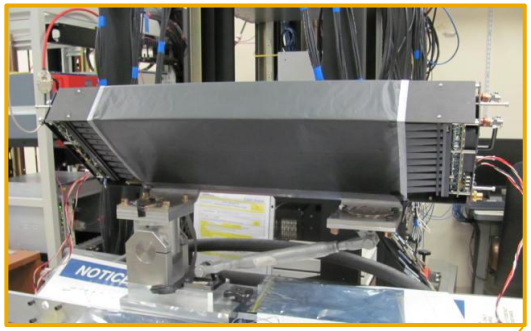


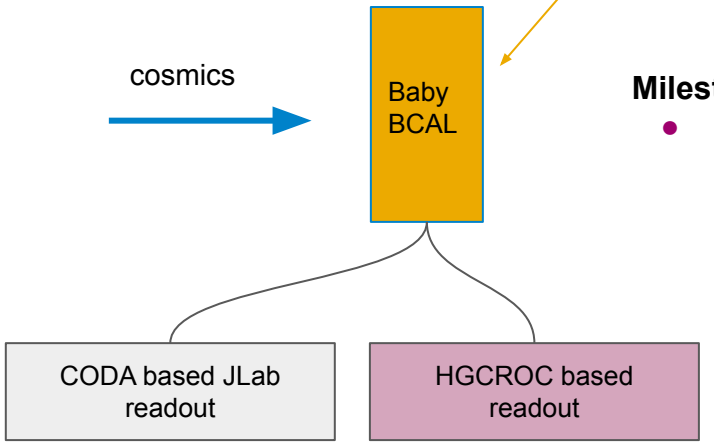
PED - Testing Timeline

Test Article Evolution - PED

What do we test and why?

GlueX Baby BCal





Existing:

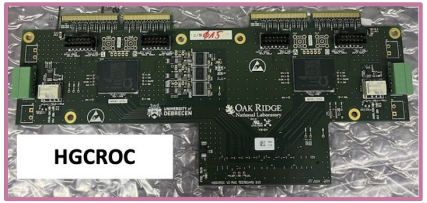
- Baby BCAL: ~60 cm long, 15.5 X_0 deep GlueX BCAL prototype with 40 SiPMs on each side (S12 Hamamatsu)
- CODA Based Readout: 250MHz fADCs, to TDC currently

To be upgraded:

- New SiPM Board with BIC SiPMs (S14 Hamamatsu) and optical cookies
  - Test of new SIPMs with better optical connection
- HGCROC Based readout tested against CODA

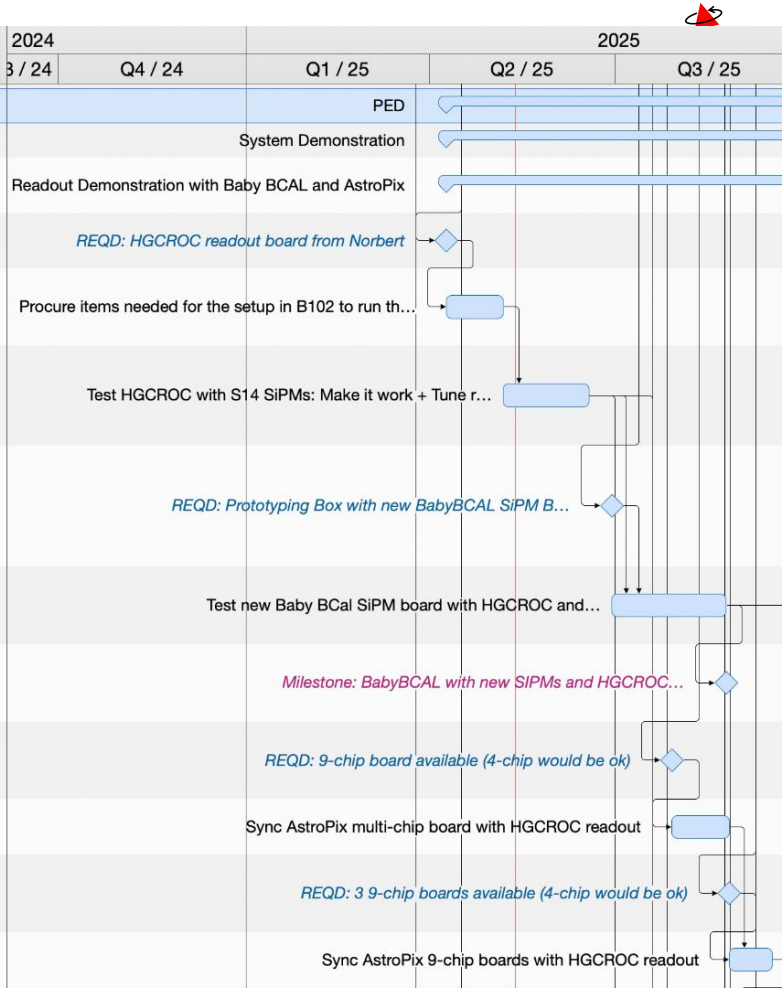
Milestone:

- ***Milestone: BabyBCAL with new SIPMs and HGCROC tested and benchmarked against previous results (August 2025)***

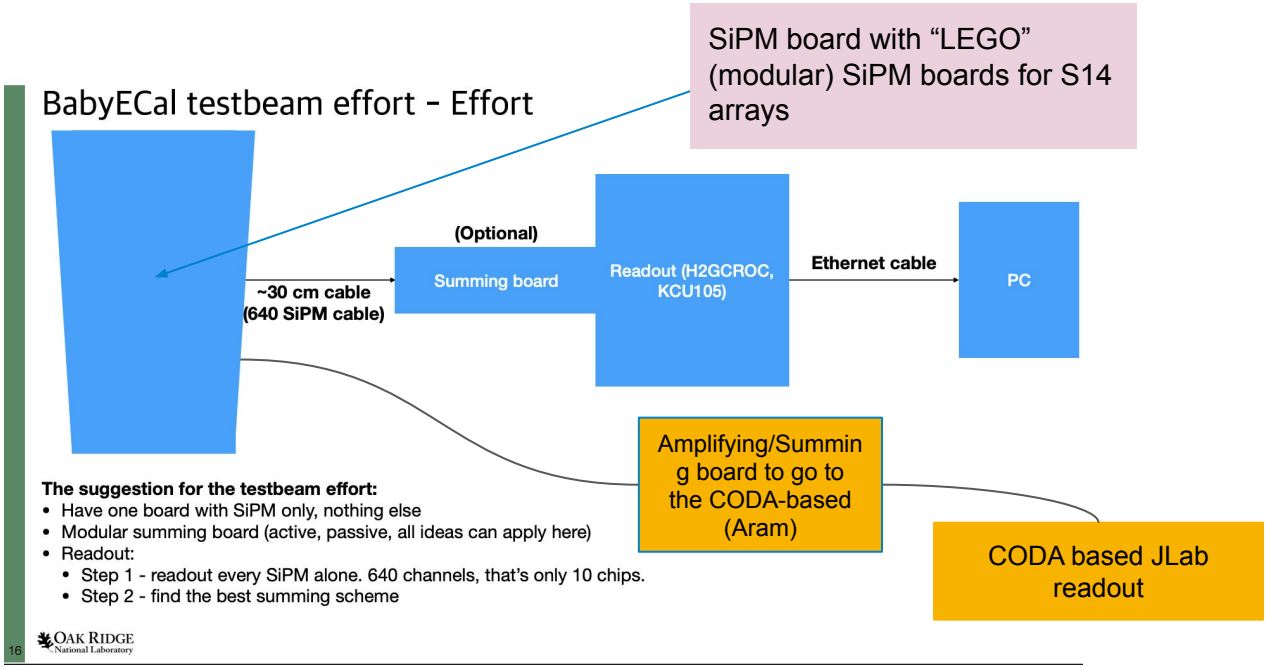


Beam Test Opportunity:
EM (e/ɣ) beam with range of energies up to > 10 GeV (ideally)
Goal: linearity of response

#	Title	Expected Start	Expected End	Given Work	Given Duration	Predecessors
692	**▼ PED**	**Apr 9, 2025**	**Mar 26, 2026**			
693	**▼ System Demonstration**	**Apr 9, 2025**	**Mar 26, 2026**			
694	**▼ Readout Demonstration with Baby BCAL and AstroPix**	**Apr 9, 2025**	**Feb 2, 2026**			
695	***REQD: HGCROC readout board from Norbert***	***Apr 9, 2025***	***April 9, 2025***			***626***
696	Procure items needed for the setup in B102 to run the HGCROC Board	Apr 9, 2025	May 6, 2025	2 weeks	1 month	695
697	Test HGCROC with S14 SiPMs: Make it work + Tune readout parameters for our SiPMs	May 7, 2025	Jun 17, 2025	30 days		696
698	***REQD: Prototyping Box with new BabyBCAL SiPM Board that can connect to HGCROC readout and JLAB Coda***	***6/30/25***	***Jun 30, 2025***			***613***
699	Test new Baby BCal SiPM board with HGCROC and benchmark against JLab Coda	6/30/25	Aug 22, 2025	2 months		697; 698
700	***Milestone: BabyBCAL with new SIPMs and HGCROC tested and benchmarked***	***8/22/25***	***Aug 22, 2025***			***699***
701	***REQD: 9-chip board available (4-chip would be ok)***	***7/28/25***	***July 28, 2025***			***125***
702	Sync AstroPix multi-chip board with HGCROC readout	Jul 29, 2025	Aug 25, 2025	4 weeks		697; 701
703	***REQD: 3 9-chip boards available (4-chip would be ok)***	***8/25/25***	***Aug 25, 2025***			***129***
704	Sync AstroPix 9-chip boards with HGCROC readout	8/26/25	Sep 15, 2025	3 weeks		702; 703



Test Article Evolution - PED



ToA Calibration:

- Crucial for BIC (SiFi/Pb) position resolution.
- EEEMC results suggest phase elimination is possible. PED tests should include ToA calibration efforts. Need direct tests for BIC.

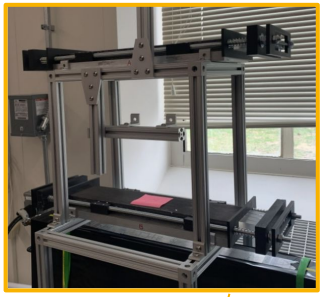
Summing Scheme:

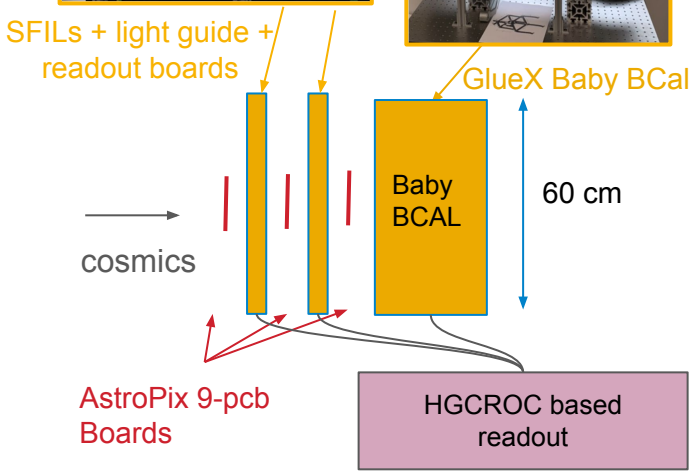
- Impacts signal shape and size.
- EEMCAL example shows risk of long signals: must investigate carefully.

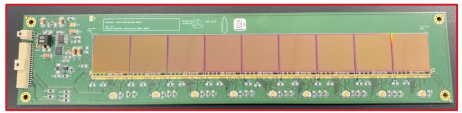
Backup - System Testing Plans

Test Article Evolution - PED

What do we test and why?







To be upgraded:

- 2 SFILs (Scintillating Fiber/Pb Intermediate (thin) Layers) with S14 SiPMs (existing, but to be compatible with the HGCROC readout)
- 9-chip pcb boards (eventually 3 of them, starting from one)

Goals:

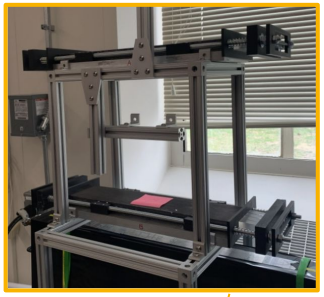
- Show the performance of the Integrated System of AstroPix 9-chip (daisy-chained chips) with SciFi: synchronization is needed
  - Read 3 9-chip PCB boards in sync
  - Read 9-chip PCB board and SciFi (HGCROC) in sync
    - The sync work can start with quad/single chip
- Develop basis for the cross-calibration procedure (position and energy)
- Additionally: Develop basis for the large scale AstroPix energy calibration with sources (AstroPix v4 single chip based)

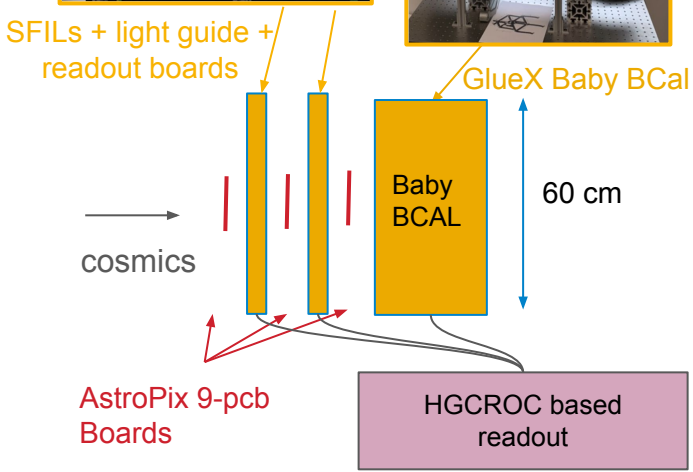
Beam Test Opportunity:

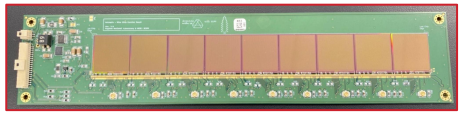
- EM (e/ɣ) beam with range of energies up to > 10 GeV (ideally), **Goal:** linearity of response
- e/π beam with range of energies up to > 10 GeV (ideally), **Goal:** e/π separation

Test Article Evolution - PED

What do we test and why?







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- 2 SFILs (Scintillating Fiber/Pb Intermediate (thin) Layers) with S14 SiPMs (existing, but to be compatible with the HGCROC readout)
- 9-chip pcb boards (eventually 3 of them, starting from one)

Milestones:

- ***AstroPix 9-chip board can be read in sync with SciFi HGCROC readout (Sep 2025)***
- ***3 fully calibrated AstroPix 9-chip boards read in sync with SciFi HGCROC readout (Nov 2025)***
- ***Energy calibration strategy for AstroPix developed (TBD)***

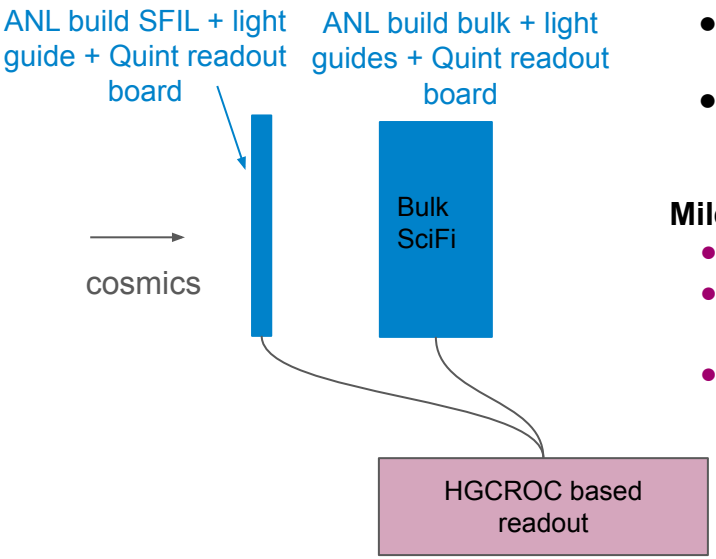
Beam Test Opportunity:

- EM (e/ɣ) beam with range of energies up to > 10 GeV (ideally), **Goal:** linearity of response
- e/π beam with range of energies up to > 10 GeV (ideally), **Goal:** e/π separation

Test Article Evolution - PED

What do we test and why?

GlueX SFIL



To be upgraded:

- SFIL build at ANL
- Bulk SciFi/Pb build at ANL (thicker section)
- New 5 cm lightguides
- Quint board with 5 SiPMs (S14 Hamamatsu)

Goals:

- Test the ANL-build SciFi Matrix with full readout chain and compare light response with MIPs
- Test the uniformity of the Bulk SciFi Matrix with photodiode (based on GlueX QC procedure) and eventually MIPs

Milestones:

- ***First ANL-build SciFi/Pb piece tested at ANL (August 2025)***
- ***ANL-build SciFi/Pb calo bulk response tested electrically and for uniformity (October 2025)***
- ***Optional: And calibrated through several layers with the new SiPM board (January 2026)***

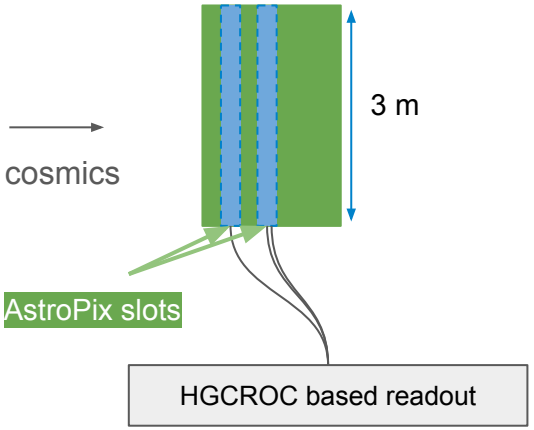
Beam Test Opportunity:

- Can be integrated in previous setups with same goals

Test Article Evolution - PED

What do we test and why?

LankyTeenagerBIC



Beam Test Opportunity:

- Can be integrated in previous setups with same goals + impact of longer sector tested (z-dependent calibration)

To be upgraded:

- LankyTeenagerBIC (3-m long, ANL build test article with slots for AstroPix layers) (AVAIL: Jan 27) + Bulk Section for integration might be separate
- ESB Test Article
- 3 9-chip pcb (AVAIL: Aug 25)
- first QC'ed module (AVAIL: July 25); ½ stave (AVAIL: Mar 26)

Goals:

- Test the long ANL-build SciFi Matrix with full readout chain and compare light response with MIPs
  - measure attenuation length, SciFi position resolution, cross calibration
- Develop the SciFi uniformity QC procedure (most probably with photodiode)
- Test fully integrated system with MIPs: cross calibration for energy and position/timing
- Eventually repeat the procedure with fully integrated first v5 modules

Milestones:

- ***Integration of Lanky with ESB and 9-chip PCB and testing accomplished (Mar 2026)***
- ***Integration with first stave (modules) accomplished (May 2026)***

Test Article Evolution - PREP

What do we test and why?

Test Articles:

- First Tested PREP staves (~ Dec 2026)
- PREP Test with Lightguides + ESB (~Jan 2027)

Goals:

- Tray + ETC Card:
  - Connection
  - Energy Calibration: Test the full chain calibration for the flow tray with tooling (reiterate on tooling if needed)
  - Timing calibration verification/ synchronization and system timing
  - Electrical Stress Test

First Tray fully tested and calibrated ready to be integrated with the Sector (March 27)

- SciFi/Pb Sector
  - Bench test for the full SciFi Sector with ESB (with LMS: Light Monitoring System): Relative calibration with MIPS and temperature dependence with LMS
  - Reception QC procedure development on sector SciFi (check that LMS works on sector, check that SiPMs work, check that readout works)
  - Global tests: light output (nphe), attenuation measurement for full system

All subprocedures developed, all aspects of SciFi/Pb tested (June 2027)

Test Article Evolution - PREP

What do we test and why?

Test Articles:

- First Tested PREP staves (~ Dec 2026)
- All Tested PREP staves (~ May 2027)
- PREP Test with Lightguides + ESB (~Jan 2027)

Goals:

- Full integration with 1 tray
  - Thermal performance in the full system (trays + sector + ESB)
  - Verify full system response with MIPs: Read out both systems in sync
    - Position calibration for AstroPix
    - Cross-calibration between SciFi/Pb and AstroPix (energy, timing, position)

Milestone: Full Sector with 1 tray tested (July/August 27)

- Trays (All 5) + ETC Card (assumed happening in parallel):
  - Repeat the tests for 5 remaining trays
  - Fully develop (reiterate) receiving QC procedures at BNL

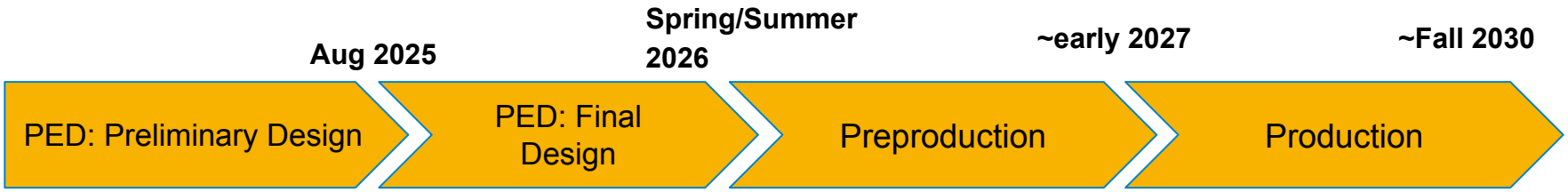
5 trays fully tested and calibrated ready to be integrated with the Sector (Aug 27)

Beam Test Opportunity:

- This would be a fantastic opportunity to perform a full dressed rehearsal of the system integration and reception QC procedure ideally nearby the construction side (FNAL?)
- ***Milestone: Perform full system energy response with beam and expected EIC occupancies. Test full system (sector) assembly procedure and testing.***

PED/preliminary and final design

Milestones



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3 fully calibrated AstroPix

3 9-chip boards read in sync with SciFi HGCROC readout (Nov 2025)

ANL-build SciFi/Pb calo bulk response tested electrically and for uniformity (October 2025)

Optional: And calibrated through several layers with the new SiPM board (January 2026)

Integration of Lanky with ESB and 9-chip PCB and testing accomplished (Mar 2026)

Integration with first stave (modules) accomplished (May 2026)