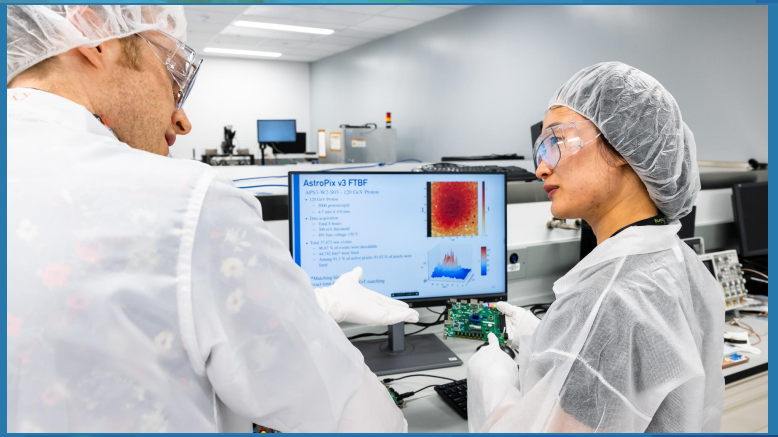
The ePIC Barrel Imaging Calorimeter

System Testing and Simulation



Maria Żurek, Bobae Kim, Minho Kim, Henry Klest
Argonne National Laboratory

BIC General Meeting
March 14, 2025

News Brief

Bench Pb/ScFi testing front

- Fiber testing: First results from ANL, and Discussions at URegina
- SiPM testing (CAEN: 13360-1350CS / URegina: S14161-3050HS-04)

AstroPix testing front

- Any updates worth mentioning? Yes a lot!

Integrations and R&D news

- SFILs (almost) at ANL

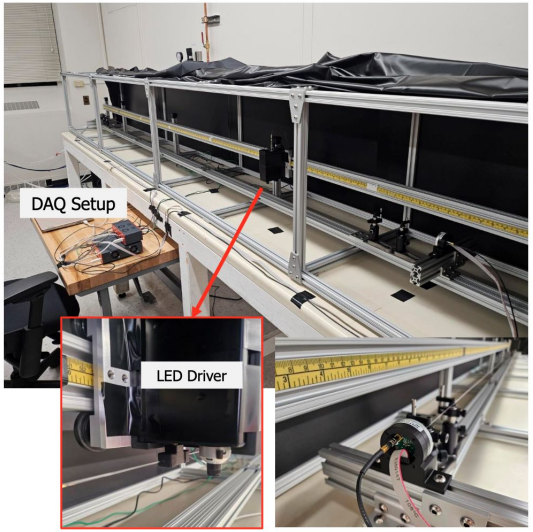
Simulations front

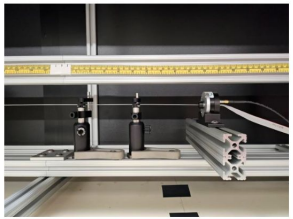
PED Test Articles Deliverables and Planning Sessions

SciFi Testing Plans at ANL

System Testing Meeting: https://indico.bnl.gov/event/26284/ (Seoyun, Bobae)
URegina discusses protocols - done! (Zisis, Tegan, Aram)
Meeting with the project regarding fiber evaluation and decision beginning of April (as of now)

SciFi Measurement
Updated Setup





SiPM on both end
S13360-1350CS

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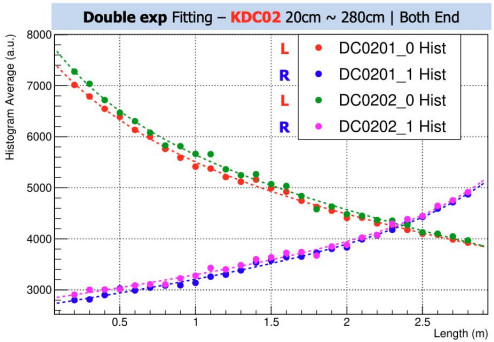
SciFi Measurement
Measuring both end

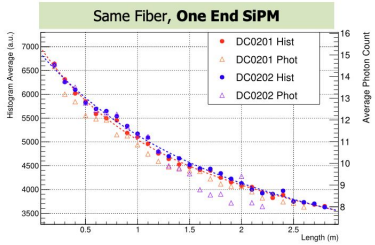
*Only result of **histogram avg.**
**Not proper fitting



$1st\ L: \lambda_{short} = 0.64 \pm 0.18\ m, \lambda_{long} = \mathbf{6.38 \pm 0.84\ m}, ch_{val} = 0.629$
$2nd\ L: \lambda_{short} = 0.50 \pm 0.20 m, \lambda_{long} = \mathbf{5.51 \pm 0.64\ m}, ch_{val} = 0.644$

$1st\ R: \lambda_{short} = 0.52 \pm 0.18\ m, \lambda_{long} = \mathbf{5.94 \pm 0.56\ m}, ch_{val} = 0.616$
$2nd\ R: \lambda_{short} = 0.50 \pm 0.18 m, \lambda_{long} = \mathbf{6.50 \pm 0.73\ m}, ch_{val} = 0.667$

$ch_{val} = (Signal\ at\ 20cm)/(Signal\ at\ 200cm)$



$1st^{**}: \lambda_{short} = 0.78 \pm 0.23\ m, \lambda_{long} = \mathbf{8.22 \pm 2.46\ m}$
$\lambda_{long(o100)} = \mathbf{5.41 \pm 0.19}, ch_{val} = 0.614$
$2nd^{**}: \lambda_{short} = 1.18 \pm 0.12 m, \lambda_{long} = \mathbf{10.00 \pm 15.0\ m}$
$\lambda_{long(o100)} = \mathbf{5.16 \pm 0.19}, ch_{val} = 0.625$

- Similar values of measured points (ch_{val}) with one end SiPM, but large fluctuation on fitting results.

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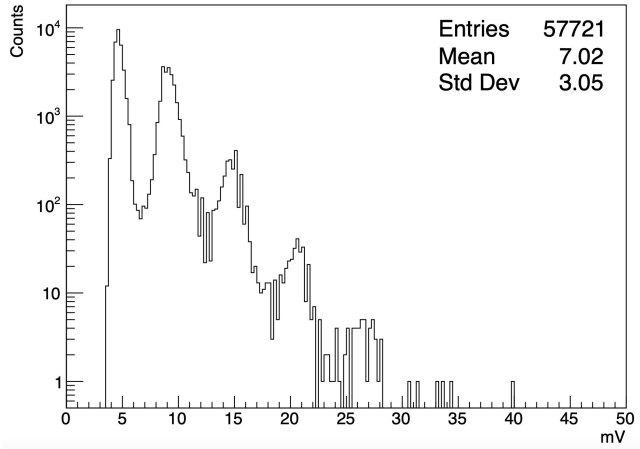
SiPM Testing

CAEN: 13360-1350CS/ URegina: S14161-3050HS-04/ Hamamatsu: new module C13367-6050EA

(Seoyun, Bobae)

Parameter		Symbol	Condition	C13367-6050EA Min.	Typ.	Max.	Unit
Spectral response range		λ		320 to 900			nm
Peak sensitivity wavelength		λp		-	500	-	nm
Temperature stability of output voltage		-	Ta=25 ± 10 °C	-	-	±5	%
Photoelectric sensitivity		-		0.	0.7 x 10⁹	1.0 x 10⁹	1.3 x 10⁹	V/W
Cutoff frequency	High band	fc	-3 dB, sine wave	2.5	3.5	-	MHz
	Low band			DC			-
Noise equivalent power		NEP	Dark state	-	2.3	4.6	fW/Hz$^{1/2}$
Minimum detection limit		-	Dark state	-	4.3	8.6	pW rms
Maximum output voltage		-		-	4.7	-	V

±5 V, 31mA, 13mA



Measurement with oscilloscope; KEYSIGHT DSOS204A
Dark count measurement [ADC]

Results agree with Hamamatsu specs
These SiPMs mostly used for fiber tests

AstroPix Testing Front

Quad chip testing updates

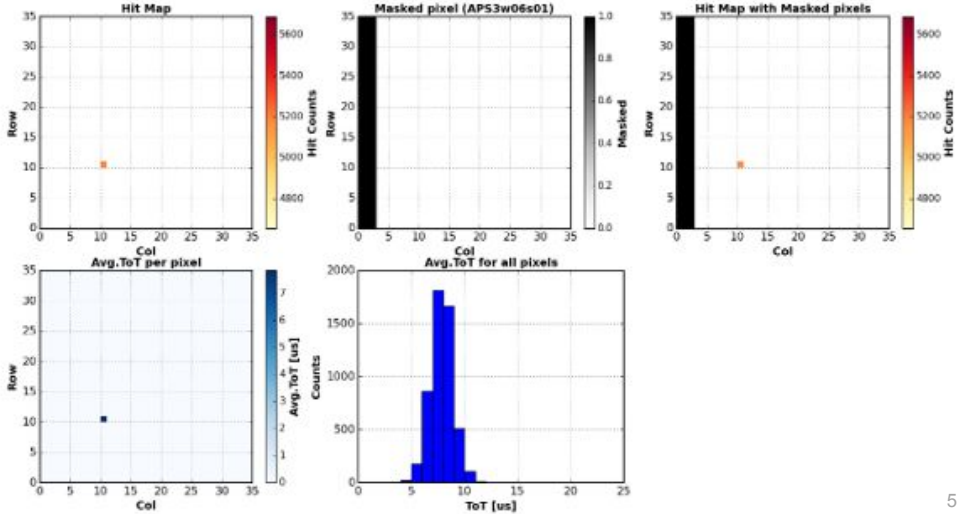
(Bobae)

Available quad chips for testing at ANL

- W112Q07+old carrier board
- W06Q08+old carrier board
- W112Q06+new carrier board
- W08Q09+new carrier board+bus bar
- W101Q12+new carrier board+bus bar

Digital injection and data saving worked:

- ASTEP latest version (updated on Feb 6, 2025)
- W112Q07+old carrier board
- digital injection on [c10, r10]



AstroPix Testing Front

v4 chip testing updates

(Yoonha, Bobae)

v4 testing at ANL

✅ Optimized the configuration for v4 testing

✅ Injection scan (HV = -200 V, threshold = 130 mV)

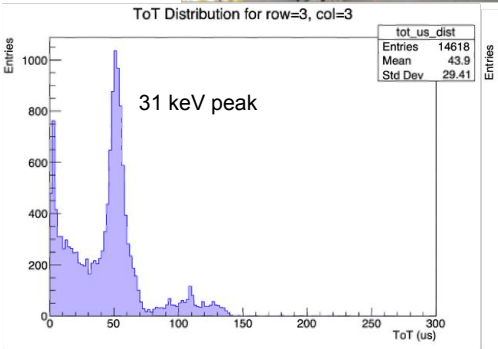
✅ Noise scan

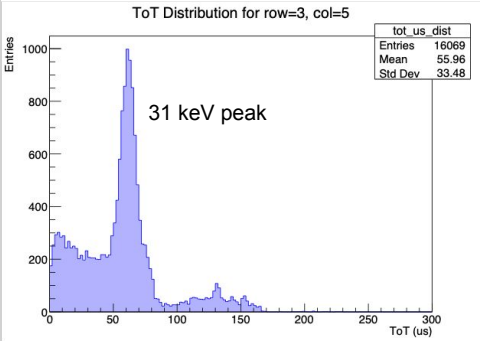
✅ Source test with Ba-133 source

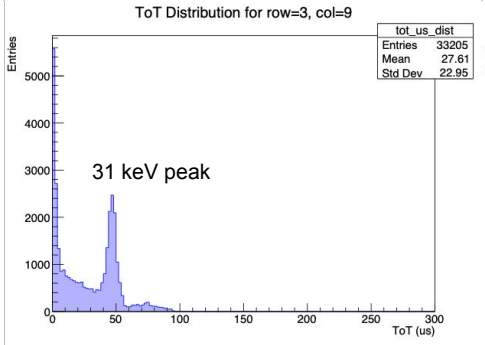
▶️ Source test with Sr90 and Am241 source

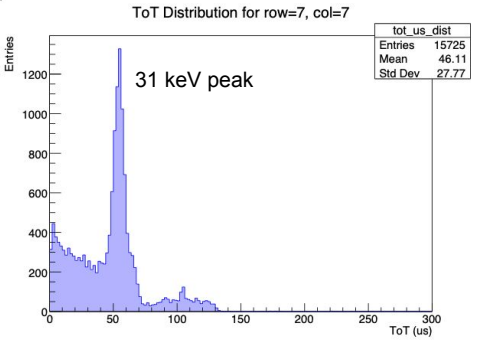
at Busan National University: in progress

- Ba133 result: ToT distributions
  - r3, c3
  - r3, c5
  - r3, c9
  - r7, c7

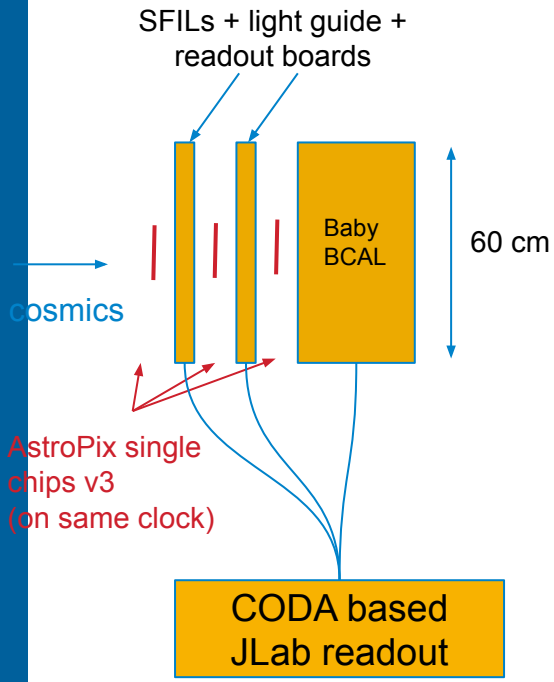








R&D



R&D Goal to be accomplished by April 16

What is needed?

- SFILs x 2 with lightguides and S13 and S14 SiPMs
- SFILs Readout boards (custom, discrete electronics)
- BabyBCAL and SFILs integrated in CODA readout
- AstroPix chips (from layer 1, 2, and 3) read in sync (external clock): may do only with layers 2 and 3
- Sync of CODA clock with AstroPix one

Goal: show integration between AstroPix chips + 2 SFILs (44x10x2.5cm^3 each) + Baby BCAL with cosmics

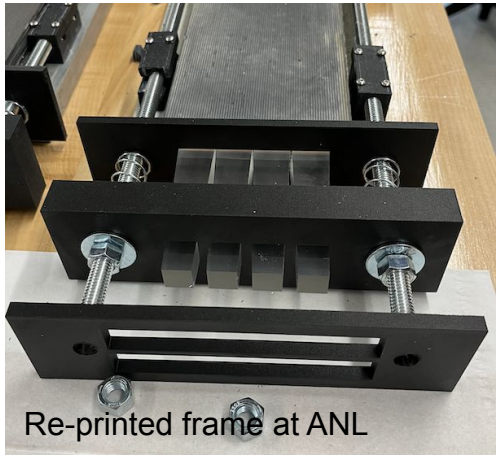
- Note: Review on April 16-17 R&D day

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

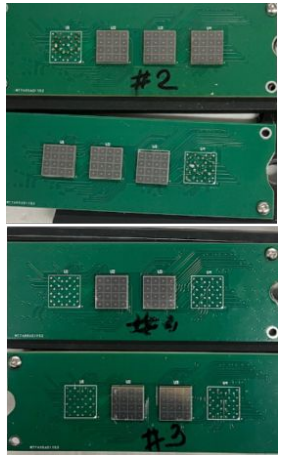
Integrations and R&D news

(Bobae)

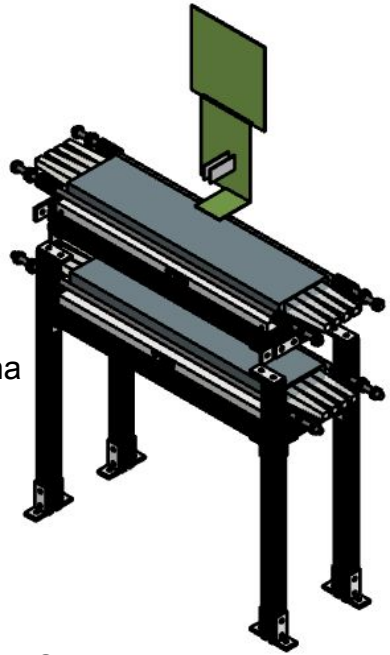
SFILs (almost) at ANL



Re-printed frame at ANL



Re-send to U.Regina



Support structure design in progress by Tom.

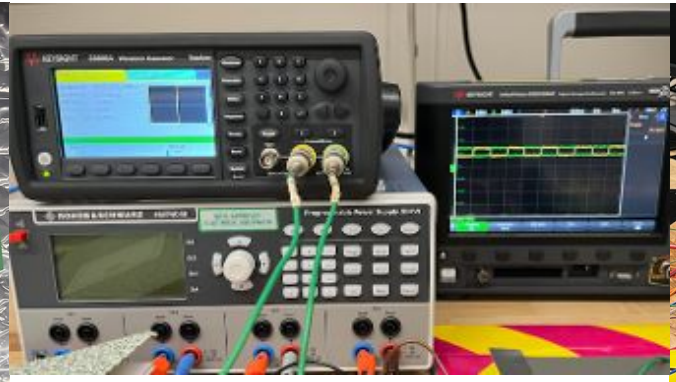
HGCROC is here

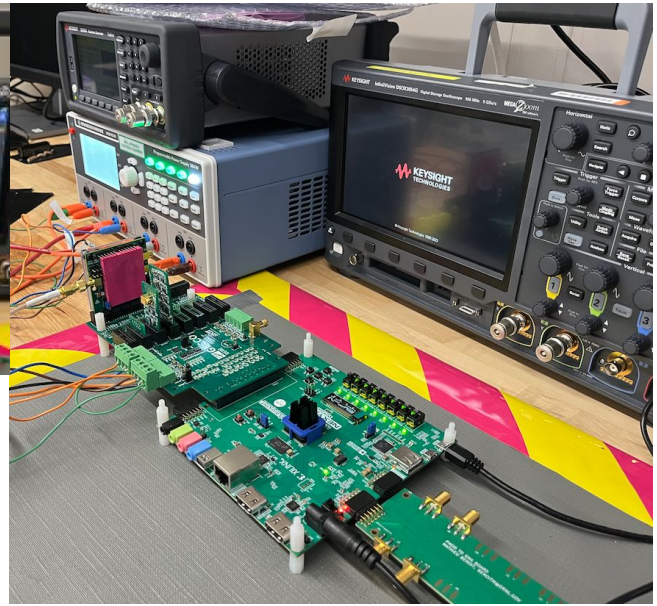
Need KCU105 to test at ANL

Integrations and R&D news

Work on AstroPix Sync

(Bobae)





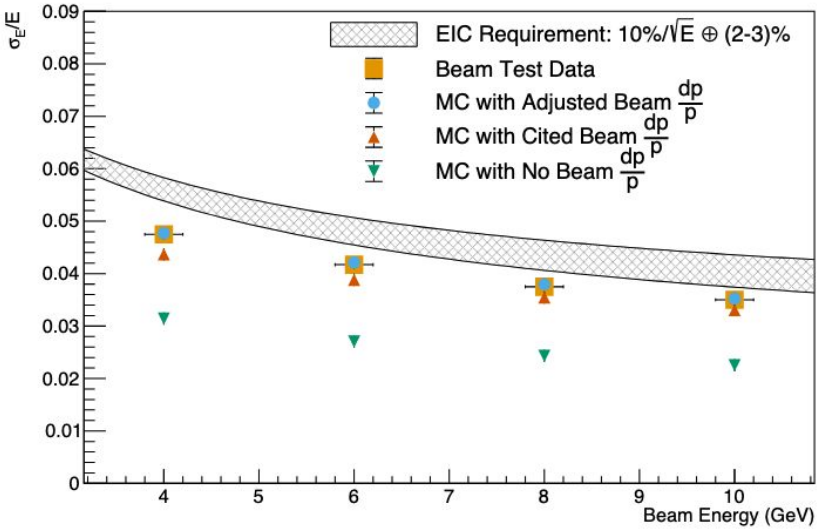
- The arbitrary waveform generator was delivered last week.
- The board from ORNL was also delivered last week; it allows the clock to be connected via SMA connectors instead of a custom cable.
- Successfully reproduced the same LVDS setup at ORNL for external clock testing.

Beam Tests

SciFi/Pb results

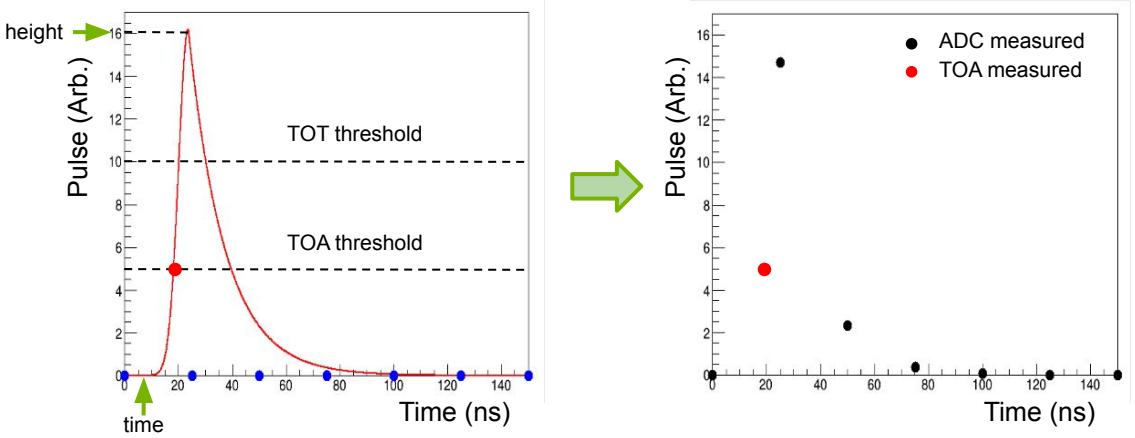
SciFi/Pb results from June 2024 summarized

- Electron and pion response measured
- Energy resolution extracted (measurement limitation: 2-3% dp/p at FTBF)
- Good constrain power over the constant term ~1.5 ± 0.4% (affected by beam dp/p measurement precision)
- Simulations describe the electron and pion data well
- e/pion separation extracted within the full system in the test beam environment



Energy resolution (sigma of the Gaussian core of Crystal Ball fit) from data with past "cited" dp/p (interpolation between 2 values given by FTBF), adjusted to the data dp/p as well as expected resolution with no dp/p.

Analysis and Simulation Front



(Tentative)

edm4hep::**RawTimeSeries**

Members:
- uint64_t cellID
- float height // pulse info
- float time // pulse info
- int32_t toa // h2gcroc info
- int32_t tot // h2gcroc info

VectorMembers:
- int32_t adc // h2gcroc info

Standalone simulation for understanding the digitized hit
- What ADC, TOA, and TOT values are obtained from the pulse has been understood.
- Effect of the TOA threshold on the energy resolution has been studied.

Implementation of the digitized hit into the EICrecon
- What data type will be used and how to implement it are being studied and prepared.
- The detailed procedure and plan will be discussed at the S&C meeting next Wednesday, March 19.

Energy splitting study
- Production of the corresponding PYTHIA sample has been requested.

PED Test Articles and Planning

PED test article plans and timelines discussed at two consecutive System Testing Meetings Feb 25 and Mar 21

- Comments and feedback welcomed: link

Simulation Meetings: Tue 2 PM CT https://indico.bnl.gov/category/551/

Testing Meetings: Tue 8 AM CT https://indico.bnl.gov/category/606/