

BIC R&D FY24 PLANS

HENRY KLEST et al.



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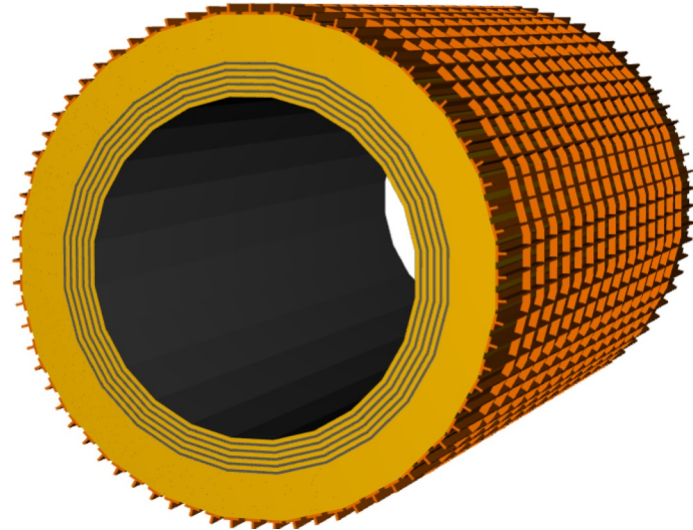
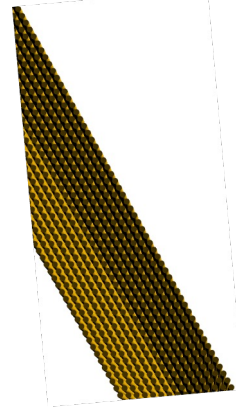
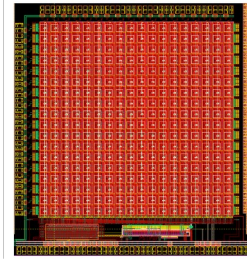


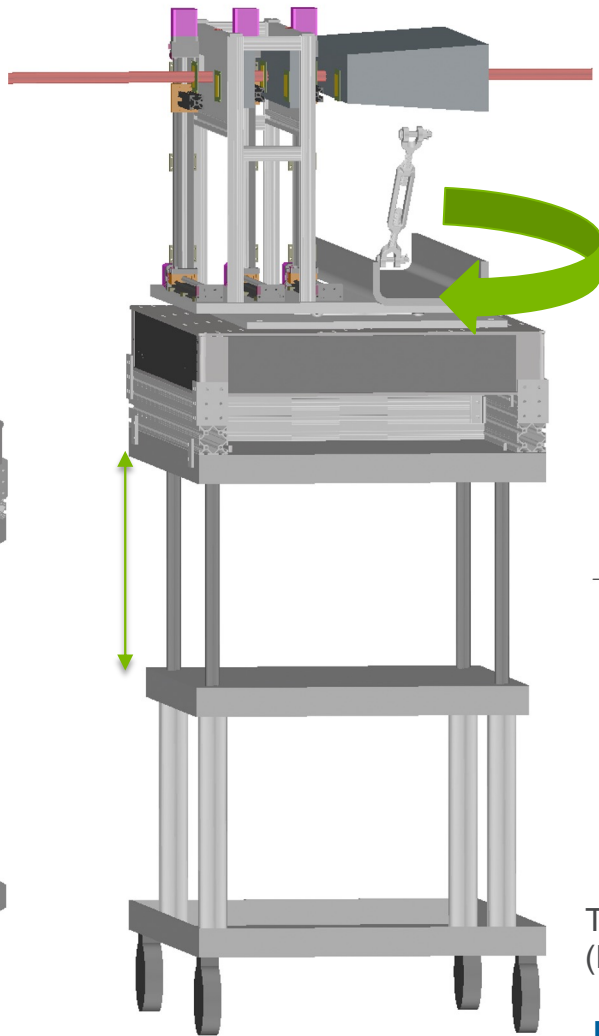
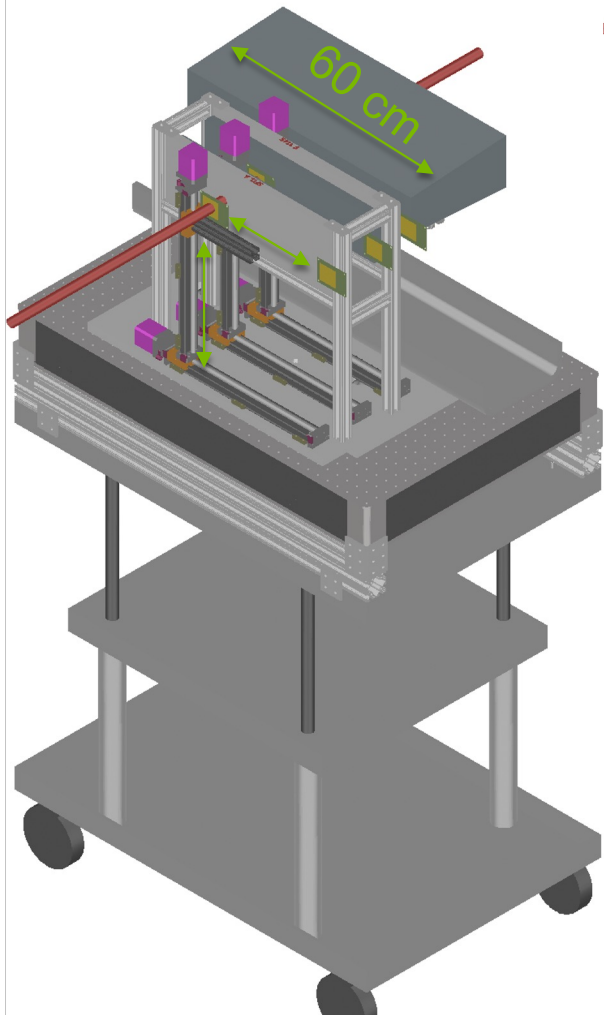
FY24

- Nominal plan as laid out in July 2023 was to take AstroPix & Baby BCal to FTBF and study the e/π capabilities of the combined system
 - Use test beam data to benchmark simulation
- Given uncertainty in Fermilab Test Beam availability, will try to do as much as possible on the bench
 - Building a cosmic test stand to study SciFi & AstroPix with cosmics
 - See what we can do with radioactive sources
 - Continue data analysis of Hall D beam test
 - Once AstroPix and SciFi are integrated on the bench, maybe go back to JLab (CERN?) for beam test
- Immediate goal is to pursue R&D that will allow us to converge on design choices for the TDR
 - More on this in the “choices” discussion sessions tomorrow

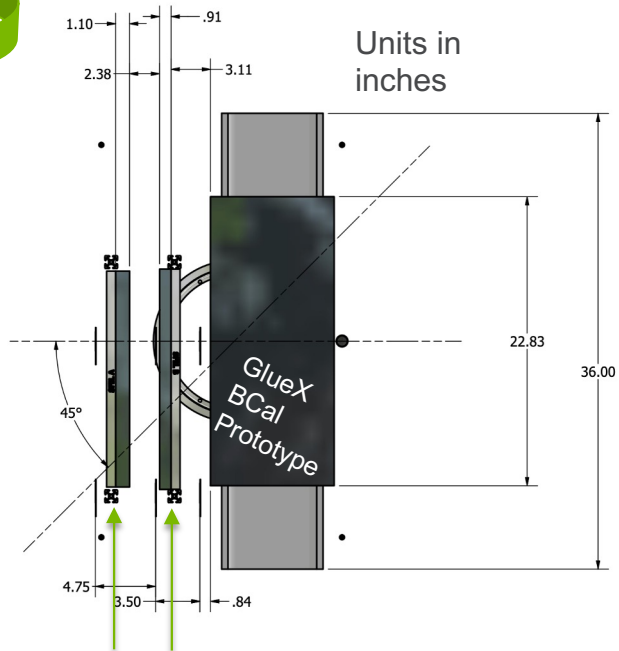
TEST BEAM R&D GOALS

- Benchmark detector performance in as realistic a configuration as possible with different beams at FNAL
 - Demonstrate ability to operate AstroPix & SciFi in tandem
 - Study e/π separation and overall π response
 - Characterize SciFi energy resolution & linearity at higher energy than GlueX
 - Gain operational experience with the specific SiPM options to be used in ePIC BIC





Rotatable
up to 45°!

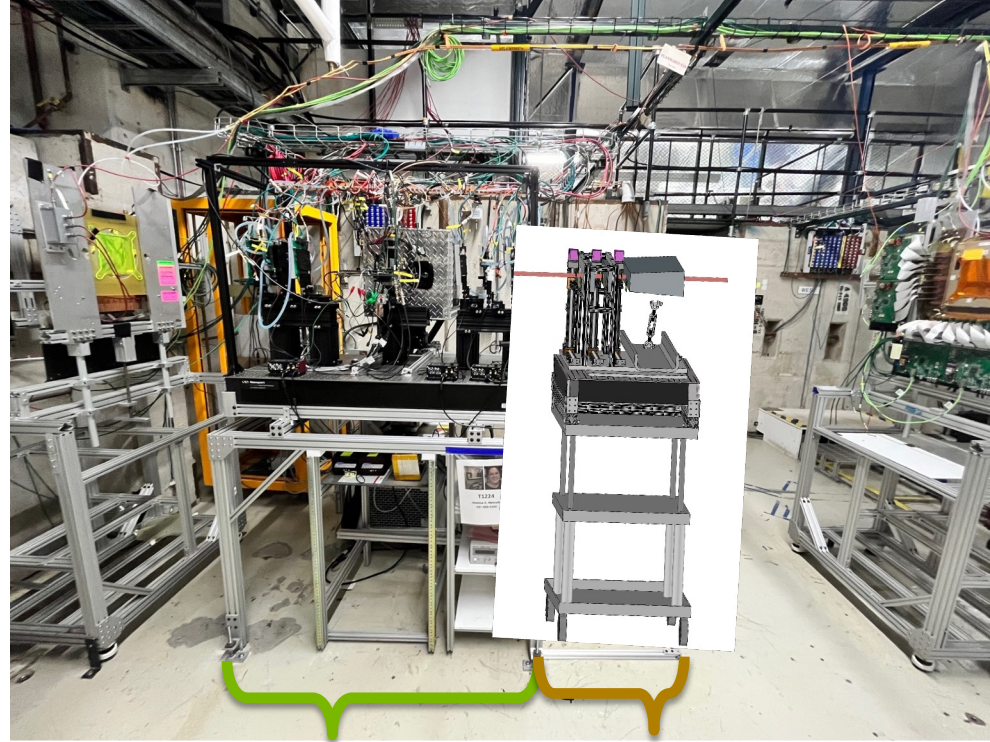


Thin SciFi Insert Layers
(Removable)

Drawings by Tom O'Connor

Fermilab Test Beam Facility Setup

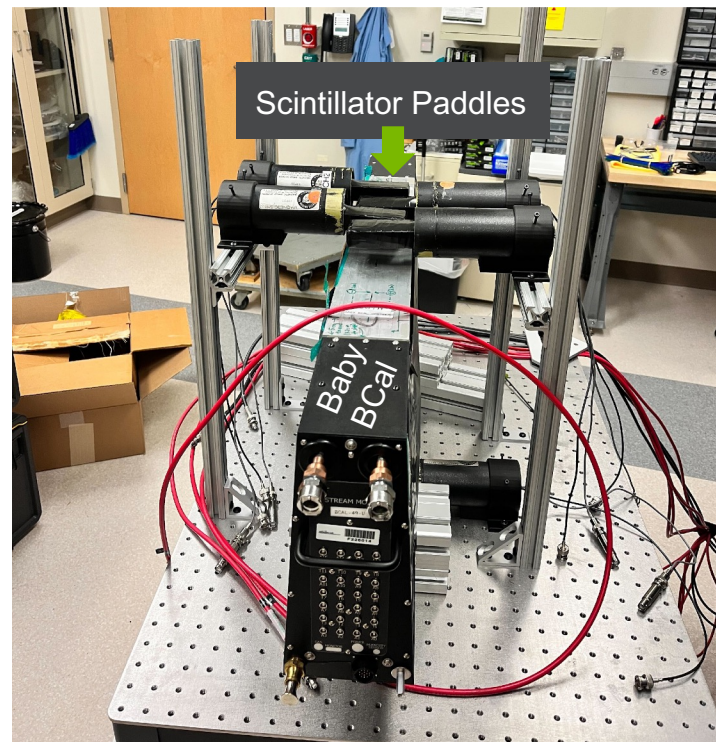
- Add BIC prototype calorimeter behind existing Argonne ATLAS Pixel telescope with AstroPix setup at MTest
- Rotating stage to simulate particles incident at angles up to 45° ($\eta \sim 1$)
- Ability to lower BIC setup out of the beam, no need to uninstall for other experiments to run



Current ANL AstroPix Telescope Setup Planned BIC Setup

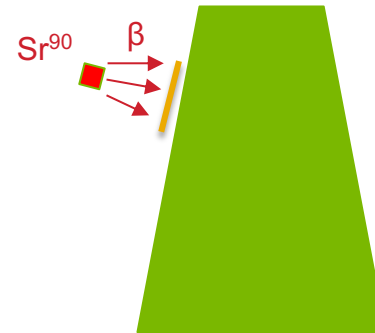
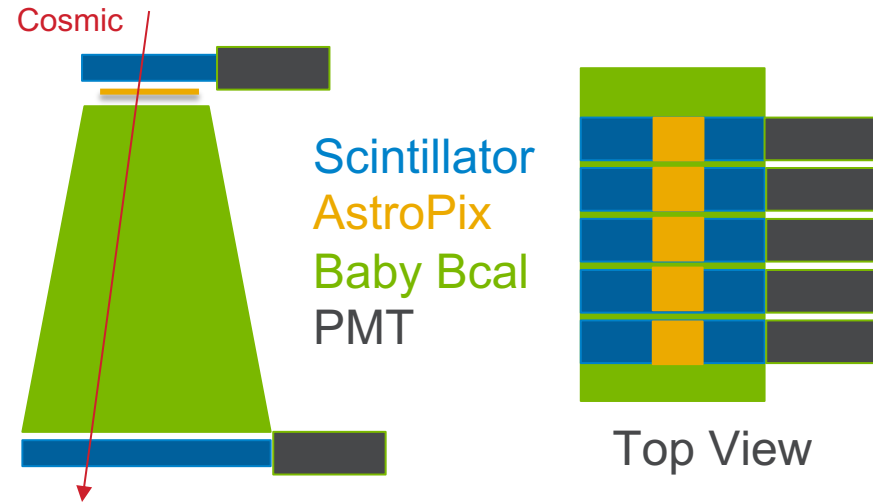
COSMIC TEST STAND

- Have 8 movable trigger scintillator paddles giving control over entry angle to Baby BCal
- Currently GlueX readout box is attached
 - Has HV, LV, Cooling, LED inputs
 - TDC, ADC outputs
- Readout box can be detached, exposing light guides
 - Can test S14160 or S13360 SiPMs standalone with real fiber output signals
- SciFi insert layers can also be integrated
 - Currently at Regina for SiPM testing



ASTROPIX INTEGRATION

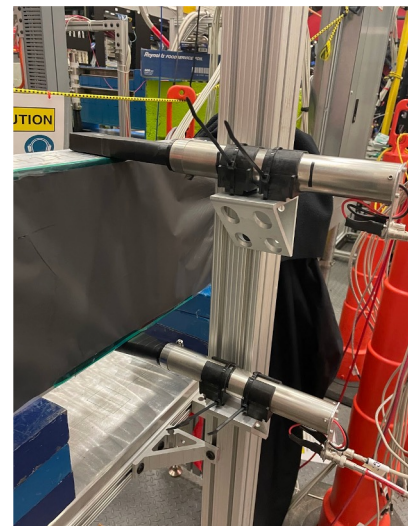
- A steady stream of updated chip versions have been produced and are being tested at ANL
 - Large area V3 chips more useful for combined system testing
 - V4 readout more similar to final design
- Two possible avenues for testing AstroPix + SciFi together
 - Cosmics (inevitably low statistics)
 - High energy β sources that may penetrate the AstroPix chip and make it into the scintillator of the Baby Bcal
- More on this in the following session



Backup

GLUEX BCAL PROTOTYPE

- Thick SciFi portion of BIC approximated by the GlueX prototype
 - Studied in March '23 with positrons in Hall-D PS
 - Cosmic data taken in Hall-D, currently under analysis
 - More cosmics planned at ANL prior to installation at FTBF
- Overall well understood system!

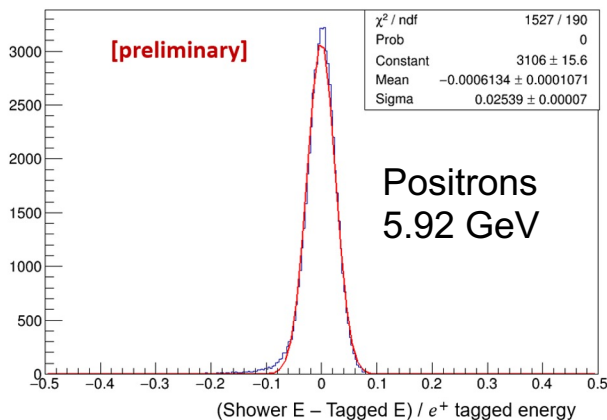


Baby BCAL in Hall D, 2023

- e^+ energy = 5.92 GeV
- Resolution $\approx 2.5\%$

GlueX NIM, extrapolated

- Expect $\approx 4.2\%$

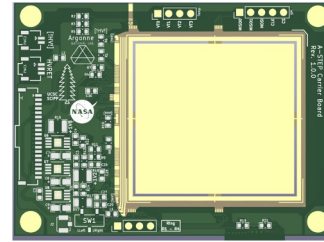


GlueX BCAL: $\frac{5.2\%}{\sqrt{E} \text{ (GeV)}} \oplus 3.6\%$
 NIM A896 24-42 (2018)



PLANNED STAGED SETUP – STAGE 1

- Start with GlueX BCal prototype with one AstroPix v3 quad in front
- Prior to installation at FTBF:
 - Characterize AstroPix v3 Quad sensor on the bench, noise scans, calibration, etc.
 - Take cosmics with GlueX prototype at ANL
 - Gain a good understanding of both systems individually



AstroPix v3 Quad
4x4 cm

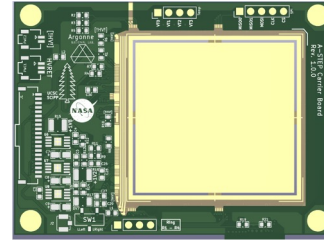


GlueX Prototype

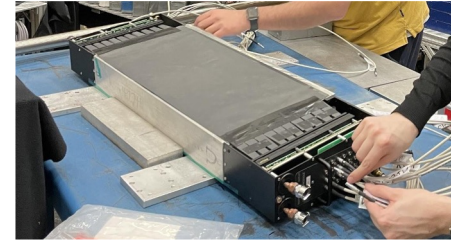


PLANNED STAGED SETUP – STAGE 1

- Once beam is available, work on combining information between the systems
 - Bringing the two detectors into time coincidence
 - Use AstroPix hit position information to seed clusters in the SciFi
- Test response of SciFi at different incidence angles



AstroPix v3 Quad
4x4 cm

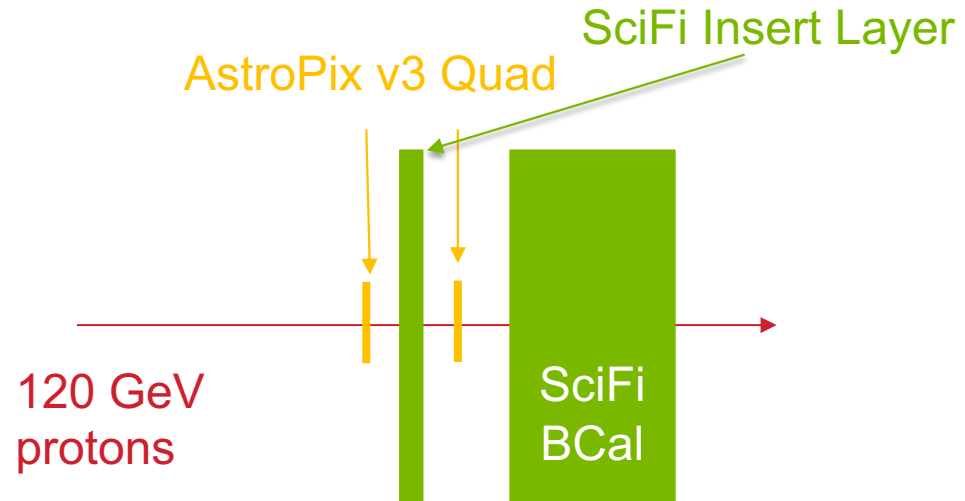
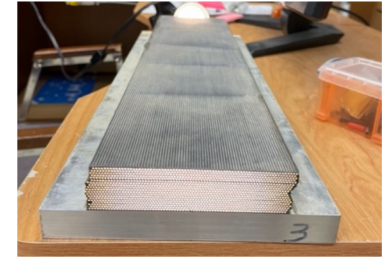


GlueX Prototype



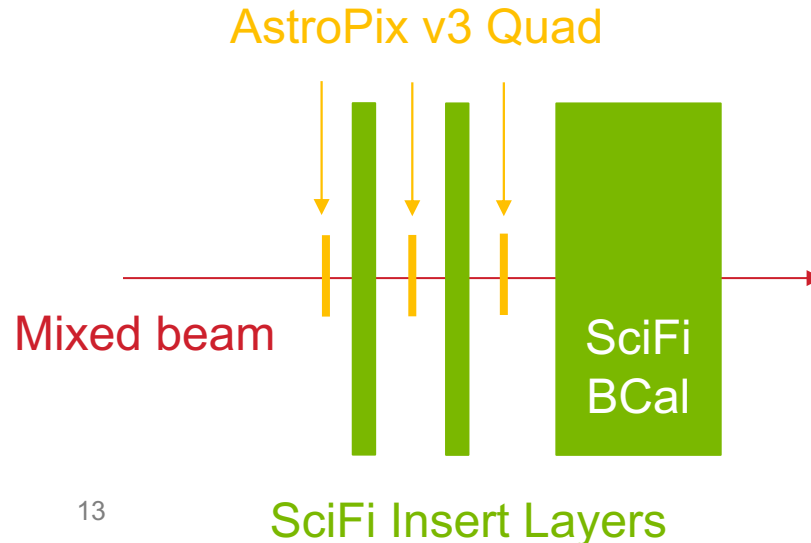
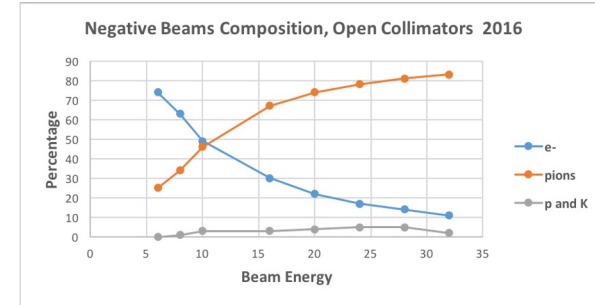
PLANNED STAGED SETUP – STAGE 2

- Add thin layer of SciFi from GlueX
 - Layers of SciFi in thickness similar to ePIC already exist, currently no SiPMs attached
- Opportunity for testing of SiPMs planned for use in the final design
 - Protons to test response to MIPs
 - Measure pulse shape & timing response with fast electronics



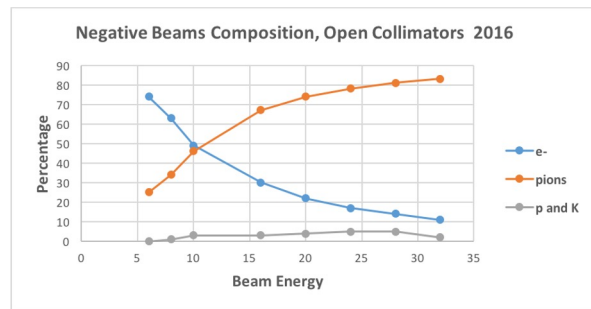
PLANNED STAGED SETUP – STAGE 3

- Add second thin layer of SciFi
 - Approach ePIC design
- Test e/π separation with mixed beam
 - Run at low rates to avoid pile up in SciFi
 - Possibility with AstroPix to tag two-particle events
 - Use FTBF beamline instrumentation to tag electrons
 - Possibly tag hadronic showers with detectors behind BCal

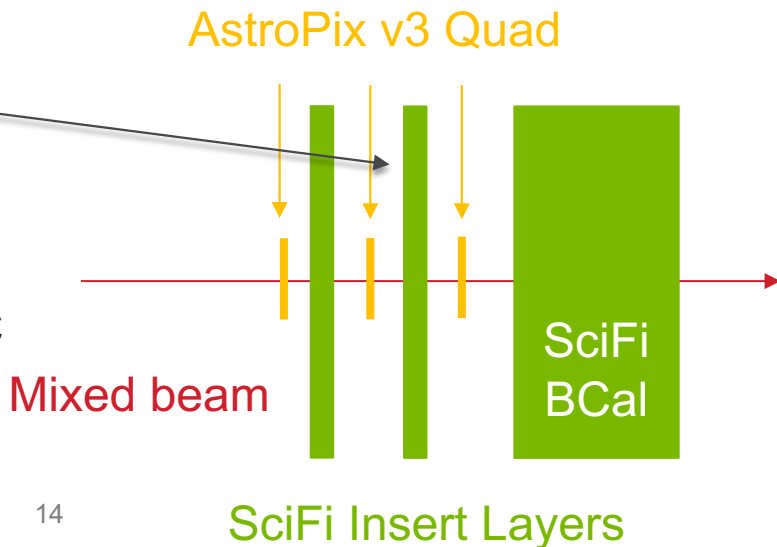


PLANNED STAGED SETUP – STAGE 3

- Test energy resolution & linearity up to 32 GeV
 - Near upper limit of what will be seen at EIC



- Second (downstream) SciFi layer should see significant energy deposits from 32 GeV electrons (especially at large angles)
 - Allow for characterization of ePIC BIC SiPMs with large N_{Ph} .



ANTICIPATED TIMELINE

- FTBF Beam schedule highly uncertain, original estimated schedule:
 - Stage 1: Setup prior to beam, Estimated Winter '23
 - Stage 2: Estimated Spring '24
 - Stage 3: Estimated Summer '24
- If only Spring '24 is available, can try to use cosmics to interleave AstroPix & Bcal information (approximate stage 1), skip stage 2, and go directly to stage 3
- **Any information regarding the FTBF schedule would be helpful, we are meeting to discuss our plans after this meeting**
- Aside from beam test, various construction activities planned for FY24
 - Lab space being acquired at Argonne for testing of SciFi construction equipment

TABLE 1: Barrel Imaging Calorimeter SiPM Specs

Parameter	Specification	Notes
Active Area	3 mm x 3 mm (4 x 4 array)	Preassembled array covering 1.2cm x 1.2cm
Pixel Size	50 μm	
Package Type	Surface Mount	
Peak Sensitivity	450 nm	
PDE	~ 50%	
Gain	$> \sim 2 \times 10^6$	
DCR	Typ.: ~ 500kHz / SiPM Max: < 1.5 MHz / SiPM	DCR applies to each SiPM in the 4 x 4 array
Temperature coefficient of Vop	< 40mV/C	
Direct crosstalk probability	< ~ 7%	
Terminal capacity	~ 500pF / SiPM	Applies to each SiPM in the 4 x 4 array
Packing granularity		
Vop variation within a tray	< 200 mV	
Recharge Time	< 100 ns	
Fill Factor	> 70%	
Protective Layer	Silicone (n ~ 1.5-1.6)	