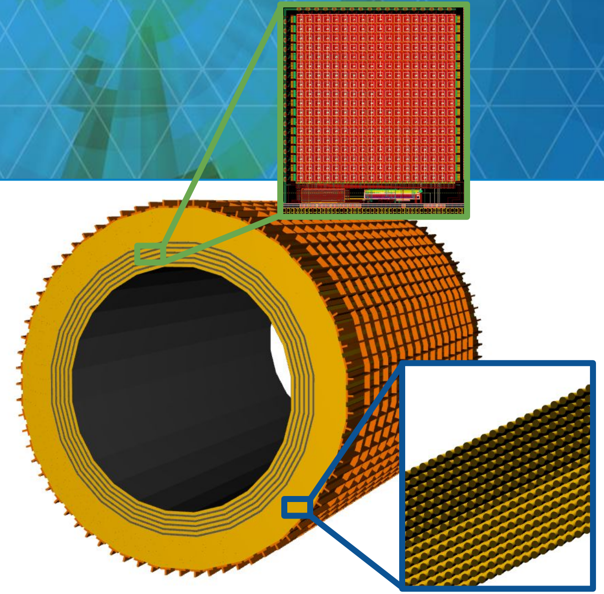
ePIC TIC Meeting

October 2, 2023

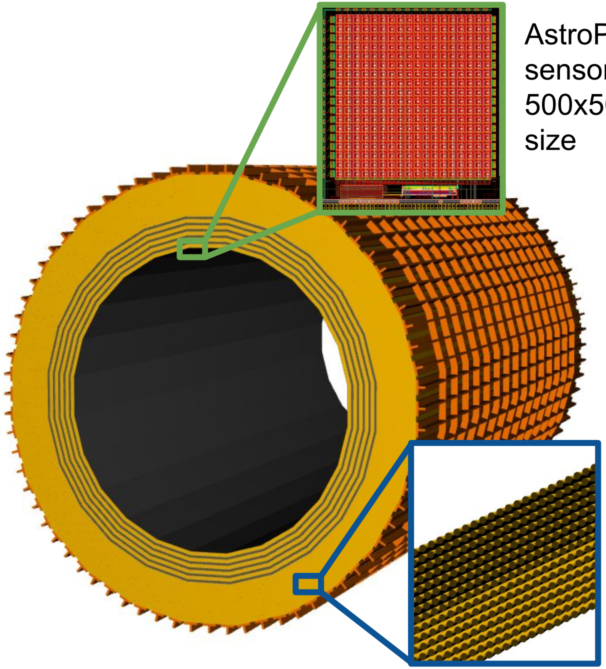


Barrel Imaging Calorimeter (BIC)
INTRO AND STATUS

Sylvester Joosten
Argonne National Laboratory

General Overview

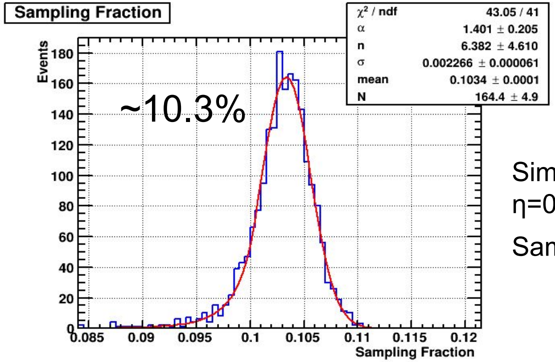
BARREL IMAGING CALORIMETER (BIC)



AstroPix: silicon sensor with $500 \times 500 \mu m^2$ pixel size

ScFi Layers with two-sided SiPM readout

- **4(+2) layers of imaging Si sensors** interleaved with **5 Pb/ScFi layers**
- Followed by a **large section of Pb/ScFi section**
- Total radiation thickness > 17.1 X_0
- Sampling fraction ~ 10%



Simulation of **single photons** at η=0 (~17.1 X_0)

Sampling fraction = $\Sigma E_{fibers} / E_{thrown}$

Energy resolution - Primarily from Pb/ScFi layers (+ Imaging pixels energy information)
Position resolution - Primarily from Imaging Layers (+ 2-side Pb/ScFi readout)

Detector Structure

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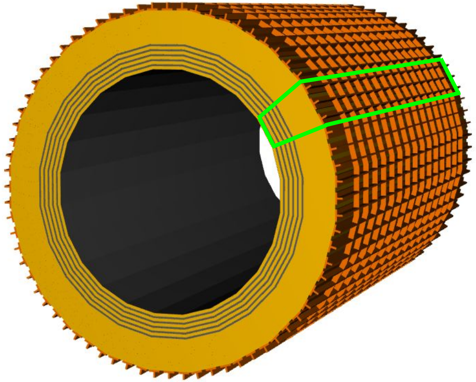
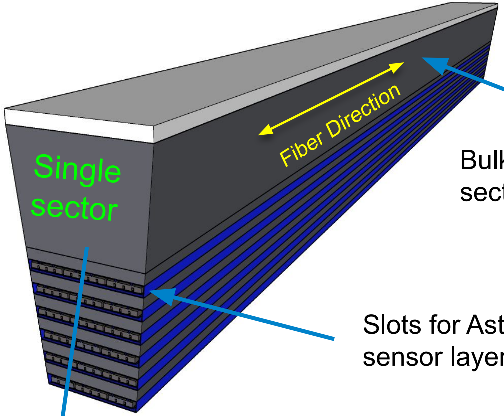


Length: 432.5 cm

Radius: ~ 80 cm radius,

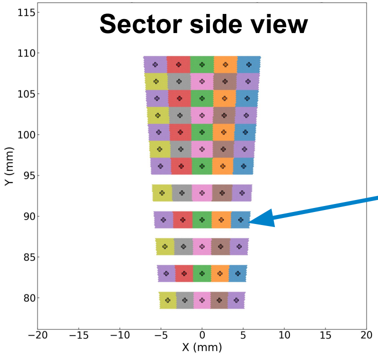
Structure: 48 sectors

η Range: -1.71 < η < 1.31



Bulk Pb/SciFi section

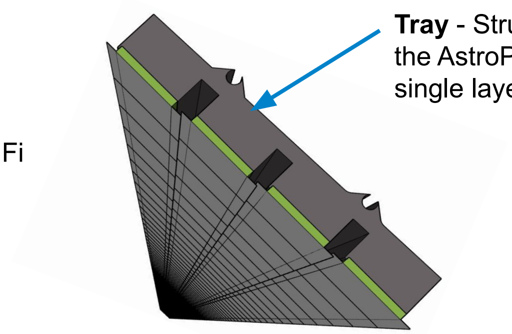
Slots for AstroPix sensor layers



Pb/SciFi **Layer** - 12 layers per sector

Structure: 5 readout cells (one light-guide per readout cell)

Construction: 17 rows of fiber

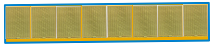


Tray - Structure holding the AstroPix staves for a single layer

Length: ~ 200 cm (half length)

Structure: 6-7 “turbofanned” staves per tray

Stave Structure: ~ 13 **Modules** per stave



Module - Several AstroPix chips daisy-chained together on Flex PCB

Length: ~ 16 cm

Width: ~ 2 cm

Gaps: < 200 μm

Structure: ~ 8 chips/module

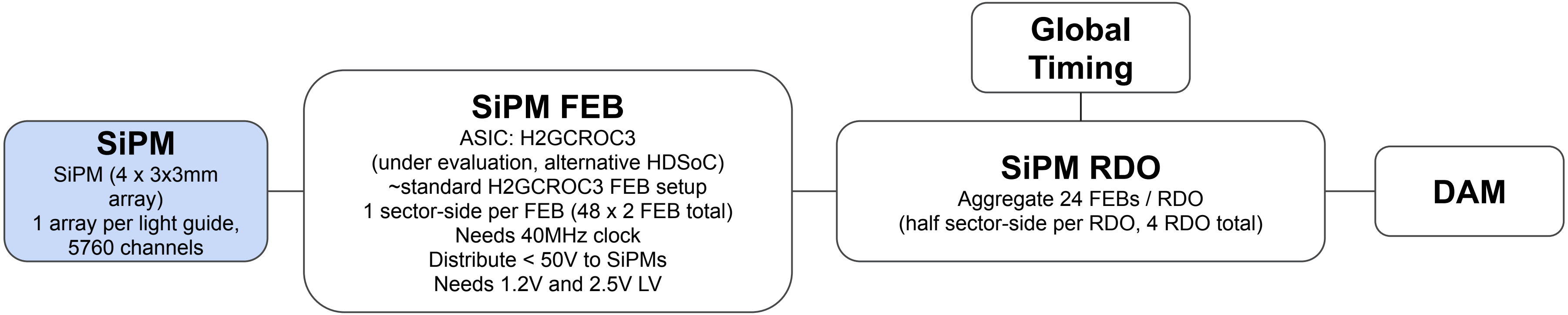
UPDATES

What happened over the Summer?

- Main focus in DSC:
  - Pb/SciFi CD3a preparation
    - High-priority fiber testing to come to final design → **See Zisis' talk**
    - Finalize SiPM specs for final design / CD3a
  - Cosmics test with Baby BCAL Pb/SciFi prototype at JLab
  - Simulation studies to support readout ASIC choice for SiPM readout
  - Global engineering and integration with Project engineers
  - Received AstroPix v4 chip → **See Manoj's talk**
  - Preparation for R&D tests → **See Amanda's and Henry's talks**
  - Preparation to start PED work
  - Organize and mobilize DSC → **See Maria's talk**
- Latest News:
  - SiPM FDR and SciFi FDR went very well
  - Notice of Decision for BIC formally signed and posted on September 18

SiPM READOUT CHAIN

Similar to other calorimeters, leverage H2GCROC3 if possible



Ongoing studies:

- Data rate with realistic thresholds depending on fiber light yield to accommodate required dynamic range? (see Zisis' talk)
- Ability to disentangle energies for multiple hits in a readout cell when using the H2GCROC3 instead of a waveform digitizer?

ASTROPIX READOUT STRATEGY

AstroPix v5
HV-MAPS (Monolithic CMOS)
2x2cm sensor, 500 µm pixel pitch
~ 250k chips, ~ 350M pixels
Needs 200-400V bias voltage
Needs 1.8V (x2) + 1.2V LV
Needs 2.5MHz “slow” clock

AstroPix module
Group of ~ 8 AstroPix chips
Chips within a module are daisy-chained together
Distribute HV and LV to chips
Distribute clock from FEB to chips
Each module connected through bus-tape to end-of-stave card

AstroPix stave
Group of ~ 13 AstroPix modules
~ 104 AstroPix chips per stave
LV: 1.8V (x2) + 1.2V LV
HV: 200-400V
HV and LV distributed from the stave level to the modules (*)

(*) Could be handled through end-of-stave card instead if needed to reduce service volume (requires engineering)

End-of-tray Card (FEB)
FPGA-based aggregator connected to all modules in a tray
Controls all AstroPix chips
One “end-of-tray card” per layer (reads out 6-7 staves)
Optical output
PLL to translate 100MHz EIC clock to a 2.5MHz “slow” clock

Ongoing efforts:

- FY24 PED: Finalize module-stave design, design end-of-tray card and bus tape (see Maria’s talk)
- Work with DAQ group to identify role and scope of RDOs

Global Timing

DAM

RDO
Aggregate 384 end-of-tray cards into a smaller number of RDOs

INTEGRATION

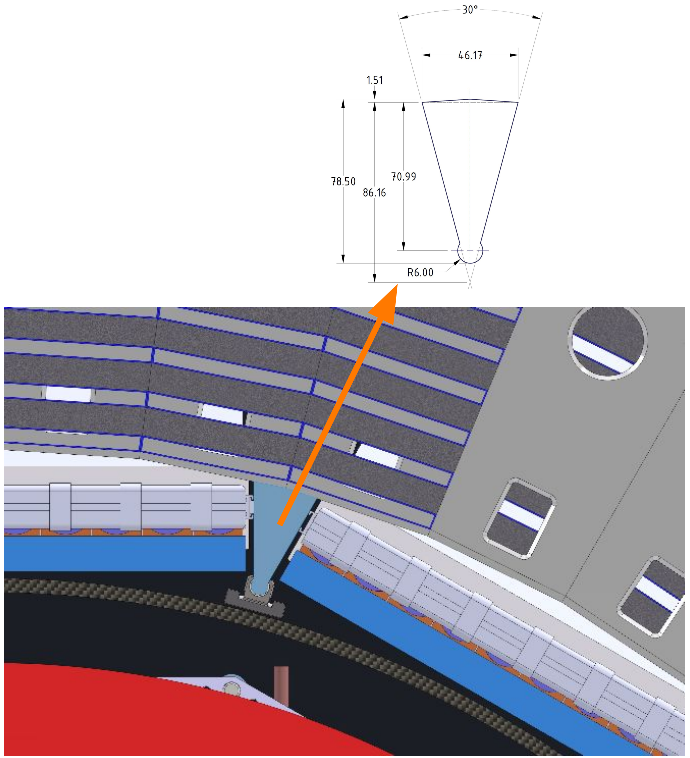
Newest Engineering Design:
outward shift and integrated support rail

Newest CAD design of detector imposes a 3cm outer shift to accommodate the inner detector support and services.

- Will assess impact on hermetic coverage in future simulation campaign.

New integrated support structure attaches inner detector rails directly to the BIC

- Pro: No support frame needed: less material in front; minimize outward shift
- Pro: Simpler structure at end of sectors
- Con: Discontinuities in inner layer may impact DIRC?
- Con: Extra material for support rail (can be optimized)
- Alternative (extra inner detector support frame) less desirable:
  - requires more space (outward shift → more cost and weight)
  - adds more material at larger distances from the calorimeter.



- Supporting the inner detector off the BIC puts extra constraints on the structural properties of the shelves for the imaging layers.
- This impacts the final mechanical sector design (see Maria’s talk).

SIMULATION AND RECONSTRUCTION

Status and needs

- **New:**
  - Implemented realistic AstroPix chips and staves in simulation
  - better estimation of support and service material
- **Ongoing**:
  - (high-priority) treat light propagation in digitization and reconstruction, needed for final SciFi choice
  - Implement inner detector mounting rail and assess impact of material
- **Todo**:
  - Outward shift of calorimeter and identify possible gaps in acceptance caused by shift
    - Related: potential dip in coverage between BIC (full depth up to $\eta \sim 1.31$) and forward calorimeter (starts at $\eta \sim 1.4$)
  - Include first AstroPix layer as tracking detector in ACTS geometry
    - Assess impact on the pointing resolution for the DIRC
    - Assess impact of 2-3 mm gaps between imaging layers in neighboring sectors on DIRC
    - Assess impact on track finding

SUMMARY

- Lots happened over the Summer
- The Barrel Imaging Calorimeter is now formally part of the Project
- Global integration and support seems to be converging, but in need of engineering tests
- Remaining open questions about the readout chain to be addressed in the next months
- DSC ready to start PED work and define the final design!

Following talks will directly addressing recent DAC comments!

09:00 → 09:05 **Communications**
Speaker: Silvia Dalla Torre (INFN, Trieste)

09:10 → 09:20 **Introduction and Status**
Speaker: Sylvester Joosten (Argonne National Laboratory)

09:25 → 09:35 **Astropix**
Speaker: Manoj Bhanudas Jadhav (Argonne National Laboratory)

09:40 → 09:50 **SciFi and SiPM**
Speaker: Zisis Papandreou (University of Regina)

09:55 → 10:05 **AstroPix v3 Bench Test**
Speaker: Amanda Steinhebel

10:10 → 10:20 **R&D Status and FY24 plans**
Speaker: Henry Klest

10:25 → 10:35 **Timeline and schedule**
Speaker: Maria Zurek (Argonne National Laboratory)

BACKUP

Selected DAC comments - R&D

- Several technologies still **require significant further R&D, prototyping/production cycles** in order to confirm that they will provide the required performance
  (also with reference to test beam difficulties in the next years)
  - *Silicon Tracker*
  - *μRWELL tracker*
  - *Imaging Sci/Fi tracking calorimeter*
  - *AC-LGAD Tracker*
  - *pfRICH prototype*
- **less advanced systems**, which we nonetheless feel can be ready for CD2/3 are:
  - *the electron polarimeters*
  - *the dual RICH*
  - *the far forward and backward detectors*
  - *the TOF detectors.*

Warnings for ePIC

Selected DAC comments - Holistic

General, cont.

- There **remains concern** that **radiation hardness and background rate** issues may still affect detector performance (and design), with time-dependent rate and noise dependences. We urge the incorporation of the machine background expectations into the detector simulations as well as attempting to provide conservatively large safety margins.
- **Component failure rate requirements incorporated in evaluation of performance** would be useful for evaluating detector technology
- A comprehensive description of the **survey/alignment/monitoring and calibration strategy** for the hardware components of all detector systems is needed.
- Many of the components are already in advanced stages of design, nearly ready for a CD2/3 review (a part what already mentioned concerning design and R&d/prortotyping)
- The **overall schedule appears realistic given that the schedule does not have added contingency**, and in many cases is based on actual experience at RHIC and Jlab. It is nonetheless quite aggressive and ambitious, and will require careful monitoring of critical milestones.
- **Development of contingency plans** would be useful for understanding the effects of delays which occur in the schedule. Flexibility in the schedule should be maintained as much as possible to minimize risk to the project.

Several indication of sector where
ur activity should be increased or started

Selected DAC comments - LLP

LLP items

- Magnet
  - The magnet design is nearly completed and seemed ready to advance to procurement within a few months. The specifications are clear and the design appears quite mature, with good cooling system redundancy.
- SiPMs for use in the PID/CAL detectors
  - the background conditions are varied within the detector so that close attention to the specifications are needed
  - A summary of the different types of SiPM being planned for long procurement would be useful for evaluating whether they are optimal in pixel size and environmental sensitivity *[such a table then presented at SiPM review]*
- PbWO4 crystals for the electron endcap calorimeter
- scintillating fibers for the calorimeters
- the absorber (W and steel) for the forward HCAL/insert
  - Design of the forward HCALs is quite advanced

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Warnings for ePIC

Addressed for FDR but never presented to ePIC

Addressed for FDR and ongoing right now, needs to be presented

Selected DAC comments - BIC

Barrel ECal

- require **significant further R&D** in order to confirm the required performance
- prototype needs validation with **beam test**

- The recent choice of the imaging calorimeter technology made this **design less mature**; however, as it is based on the existing GLUE-X calorimeter, the long lead purchase of the scintillating fiber and SiPMs are specified sufficiently well.
- It was not mentioned **how long** it would take to **procure** sufficient **astropix** detectors and **what services/conditions they require** for reliable operation.

Need to directly address these (many we already covered directly with the Project)