Forward EMCal Update.

O. Tsai. (UCLA/BNL)

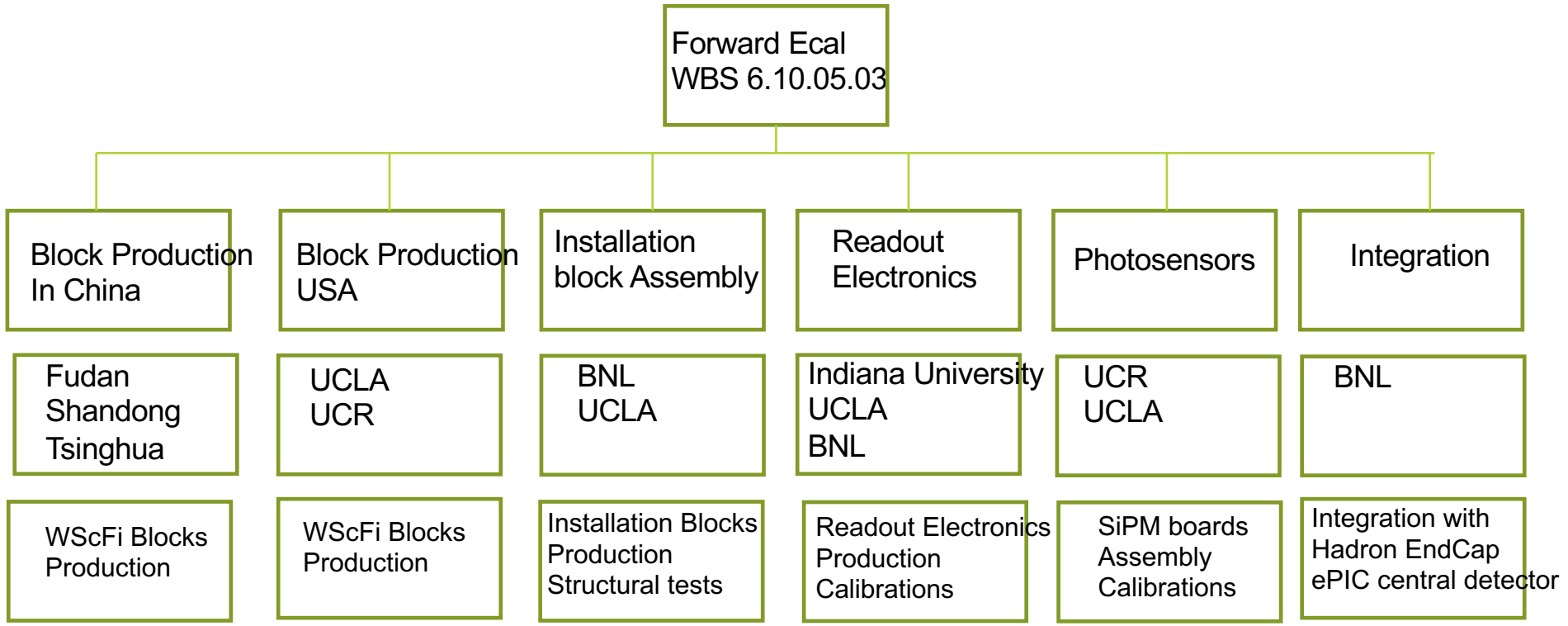
Summary/Outlook. R&D meeting 08/28/24

- Production of fEMCal blocks at UCLA completed.
- Production of fEMCal blocks at Fudan completed.
- Light Guide for ePIC prototype produced, tested.
- Mechanical and installation tests at BNL completed.
- Integration of SiPM/FEEs were iterated and converging to a final scheme.
- Short Test Run at FNAL completed. Data analysis in progress.
- Remaining production ‘tweaks’ is moved to PD.

Remaining R&D Milestones:
“eRD106 (Fwd EM Cal) Done.
R&D to validate production readiness is complete.”

All recent developments were made under PED.

Forward ECal WBS, Workforce

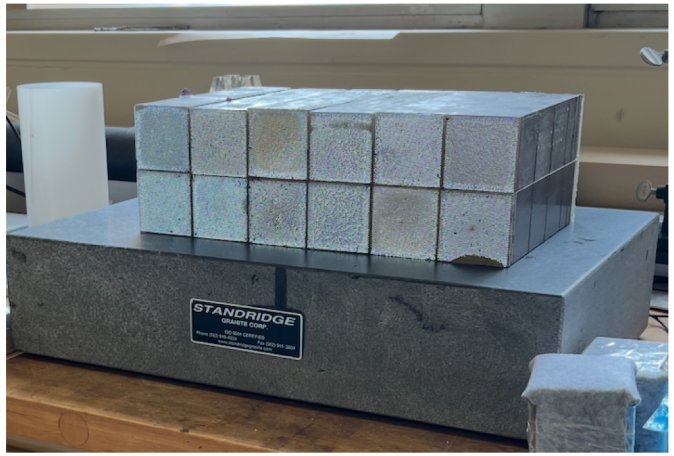


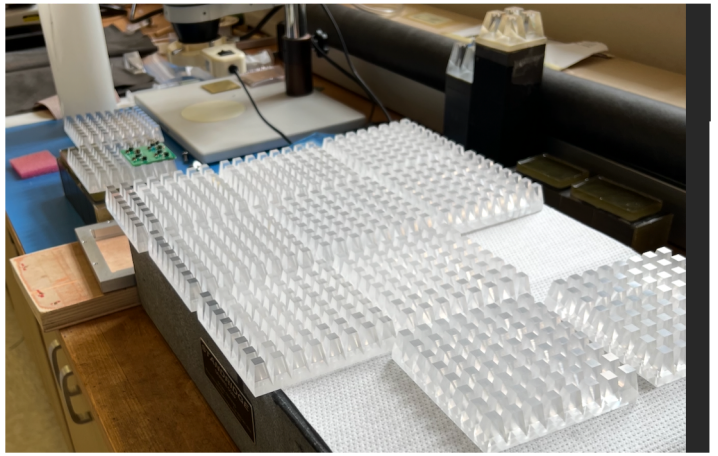
Continuing under PED ->

- Block production in India.
- Production Protocols
- Luxium Sc Fibers QA
- SiPM boards, final design.
- SiPM boards production at UCLA
- SiPM boards tests at Indiana University
- Design detailing

Goal is to advance design of part of the system to FDR level.

Updates from eRD106 since last R&D meeting.

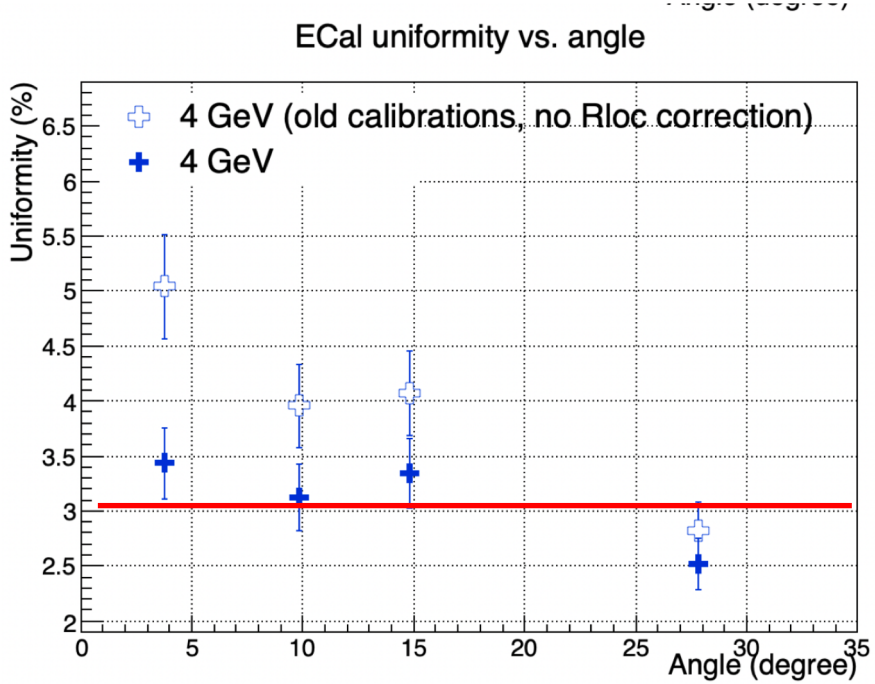




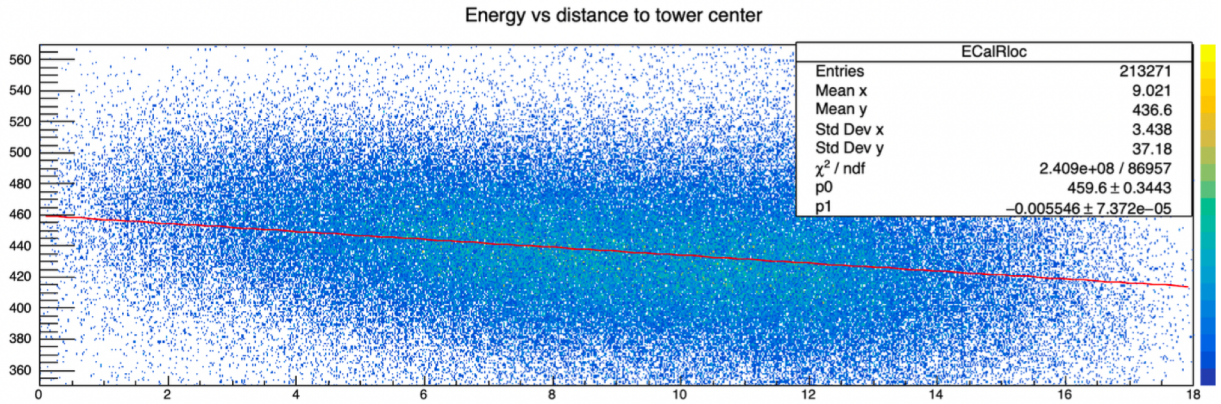
Fudan produced blocks at UCLA Lab. Contribution to fEMCal development from Chinese groups was very valuable to advance **production protocol**.

Thank you !

- Indiana University produced LG, final design.
- Process is well documented.
- Meeting with Chapman Lakes as a potential vendor sometime this month.

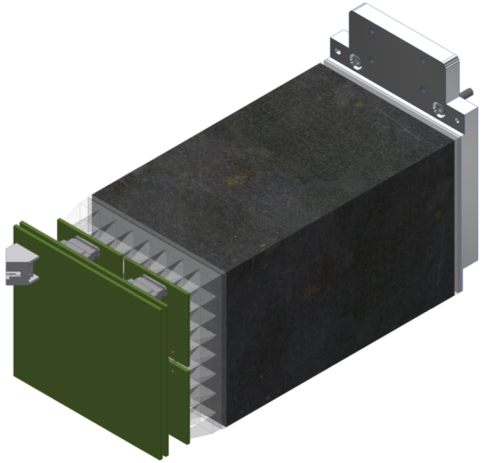


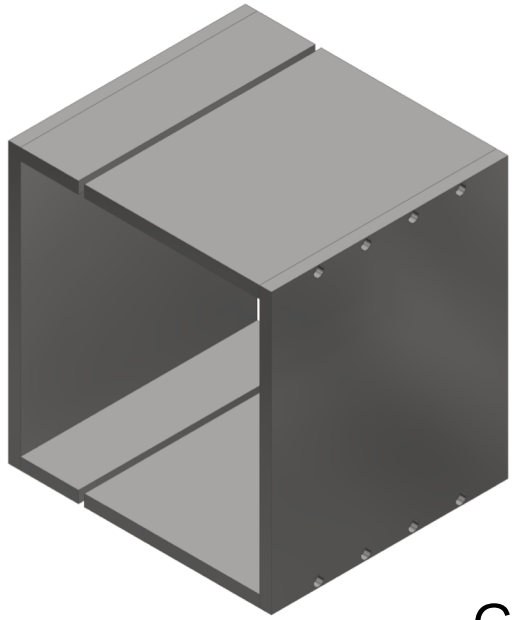
Y.Cheng (UCLA)

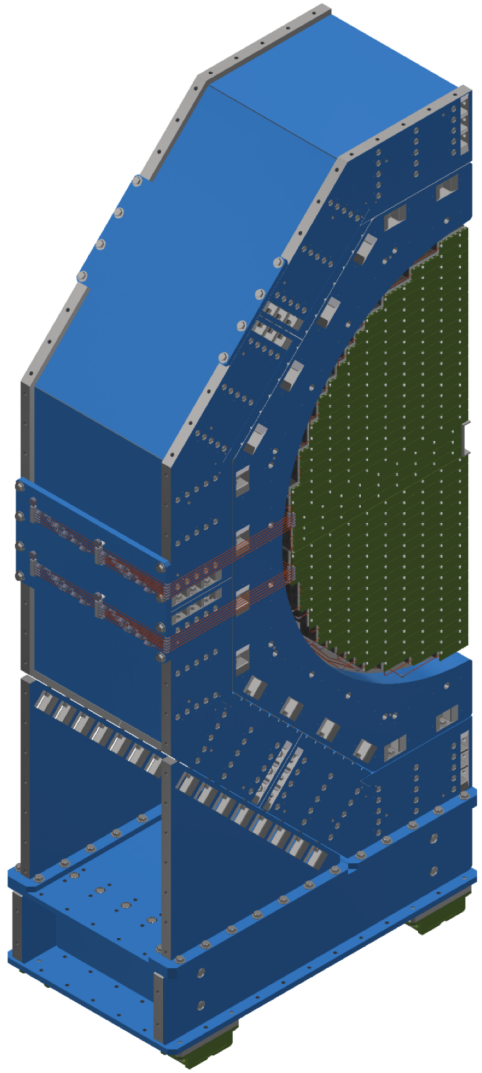


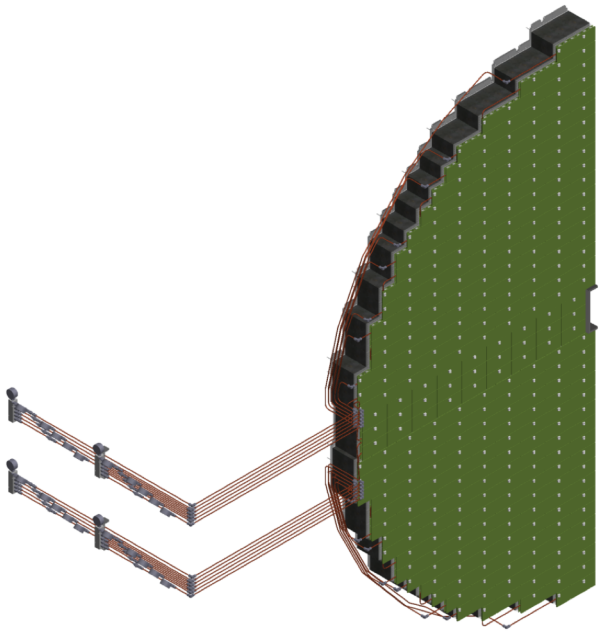
- Improved calibrations.
- A simple correction on energy deposition as a function of hit position to tower center.
- Hit position reconstructed using EMcal information only.

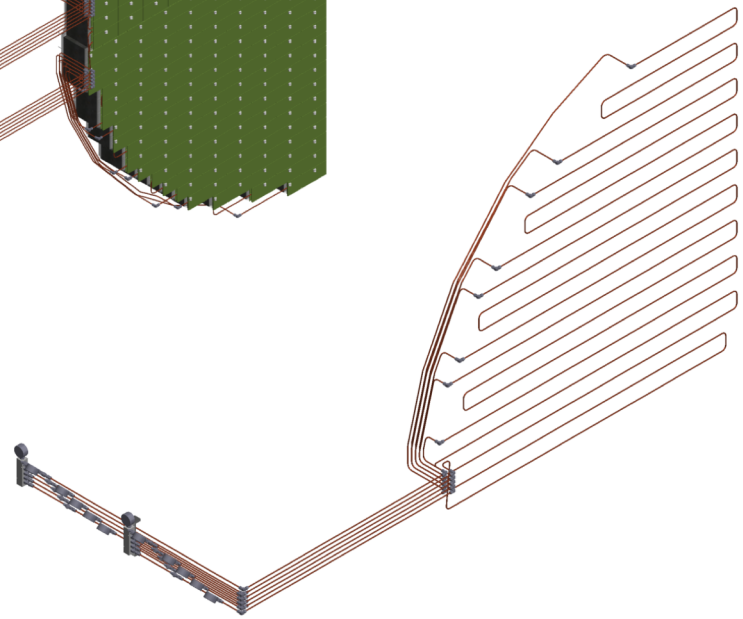
Assembly Overview. Design Detailing.











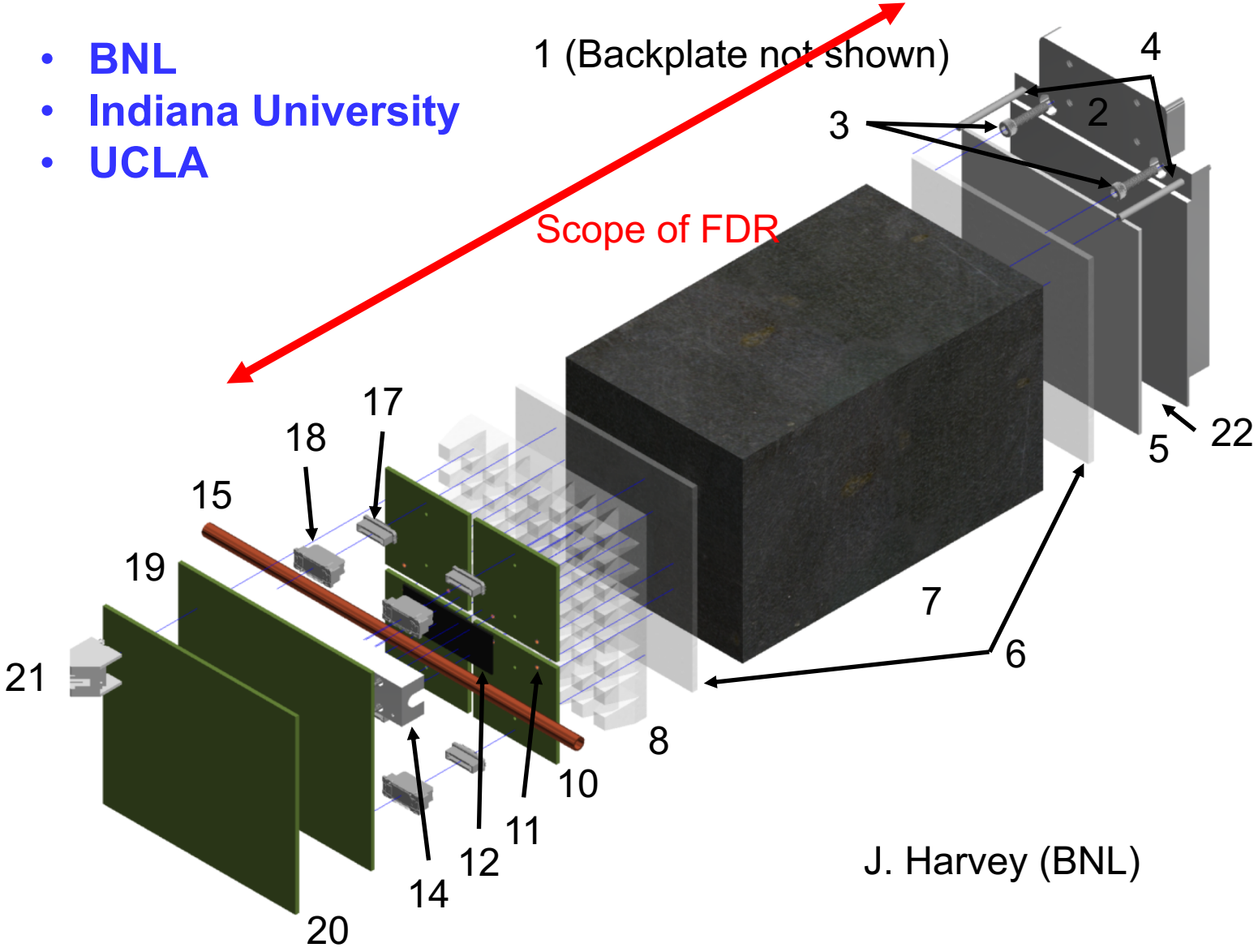
- BNL
- Indiana University
- UCLA

Good support from project engineers at BNL.

Module Exploded View

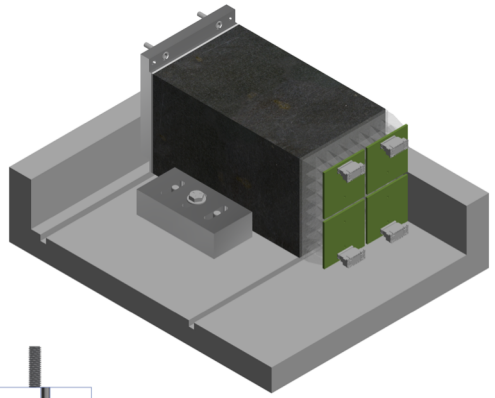
- **BNL**
- **Indiana University**
- **UCLA**

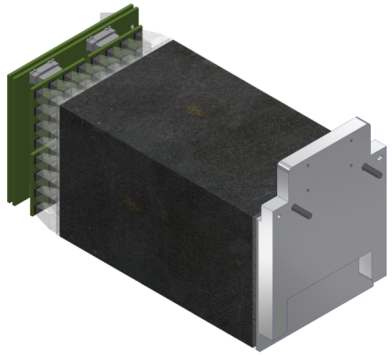
Part Number	Component
1	Backplate
2	Mounting Plate
3	8-36 UNC Socket Head Screws
4	1/8” Dowels
5	Titanium Dioxide Epoxy
6	Epoxy (Part of Tungsten Mold) (Epotek 301-1)
7	Tungsten Sci-Fi Block
8	Light Guide (Acrylic)
9	SiPM
10	SiPM Board
11	U-164-0 PEM Nut
12	Thermal Pad
13	1-64 UNC Socket Head Screw
14	Aluminum Heat Sink
15	Copper Tube Heat Sink
16	4-40 UNC Socket Head Screw
17	Connector MA01F030VABBR300
18	Connector MA01R030VABBR600
19	Pre-Amp Board
20	Bias Board
21	Ethernet 615008145121
22	Epoxy Glued Connection

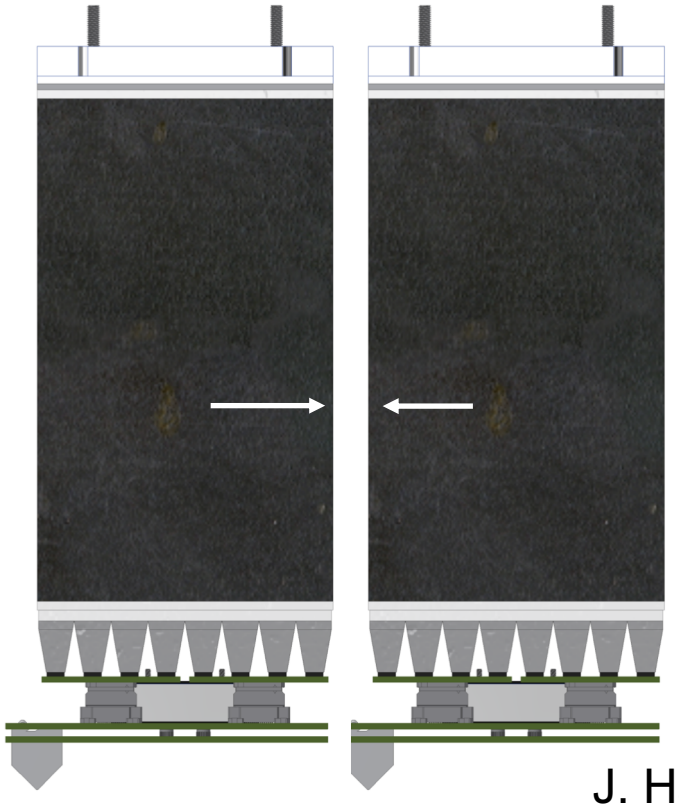


Scenario 1 Tolerance Stack-Up

- Non-conservatively assume that the bottom and right side of the Mounting Plate, Titanium Dioxide and Tungsten Block are flush against the side and bottom of some jig.
- Source of tolerance stack up is the dowel holes in the Backplate, Mounting Plate, and Tungsten Block.
- It is possible for the hole diameters and positions on the left module to stack-up in the positive x-axis and the hole diameters, positions, and Tungsten Block profile to stack-up in the negative x-axis direction.



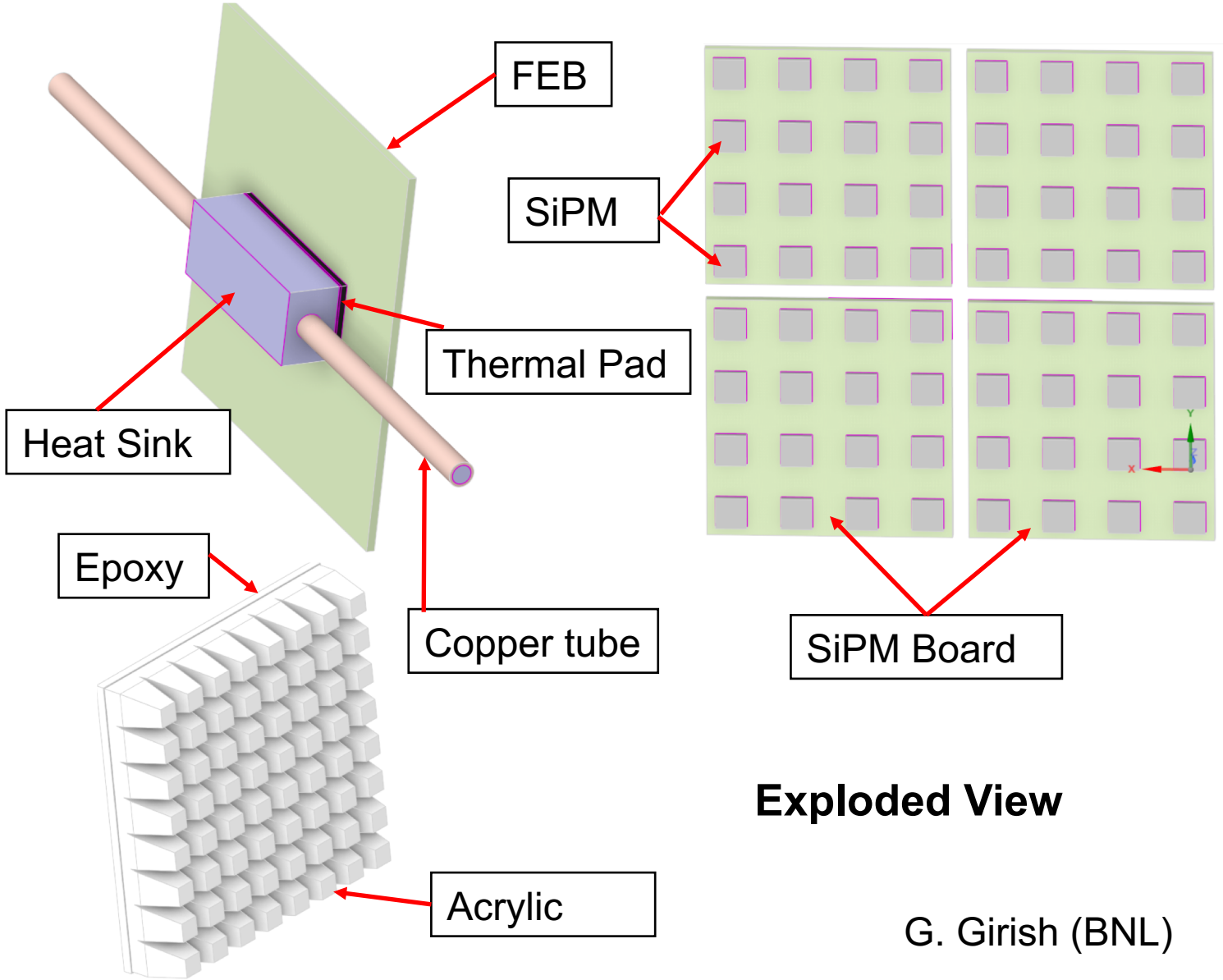




Increased gap from .1mm to 1mm to keep mechanical engineers happy

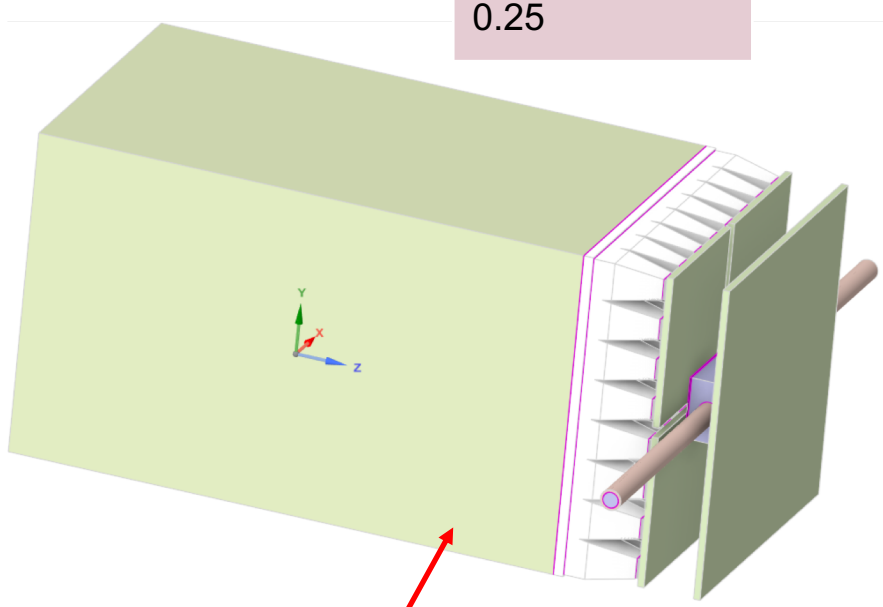
J. Harvey (BNL) et.al.

Forward EMCAL



Exploded View

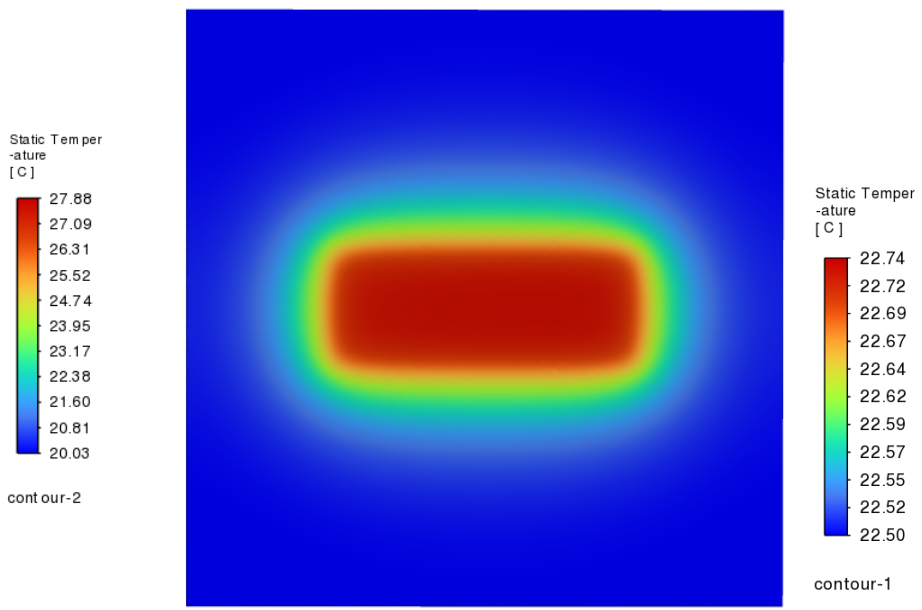
Copper tube (inch)
0.25



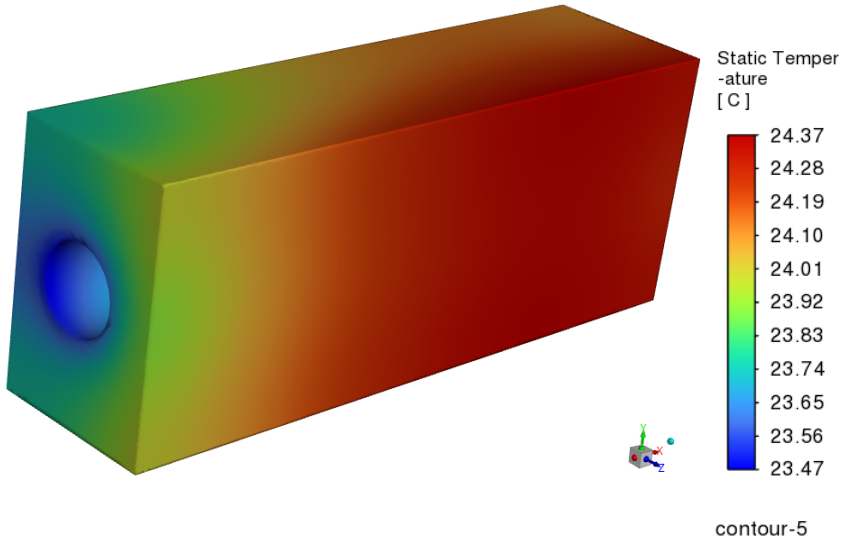
Sector Geometry

G. Girish (BNL)

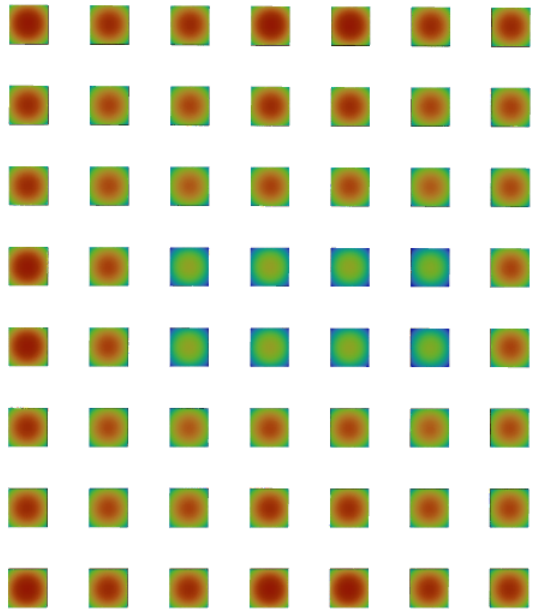
Forward EMCAL – CFD Simulation



FEB Temperature



Heat Sink Temperature



SiPM Temperature

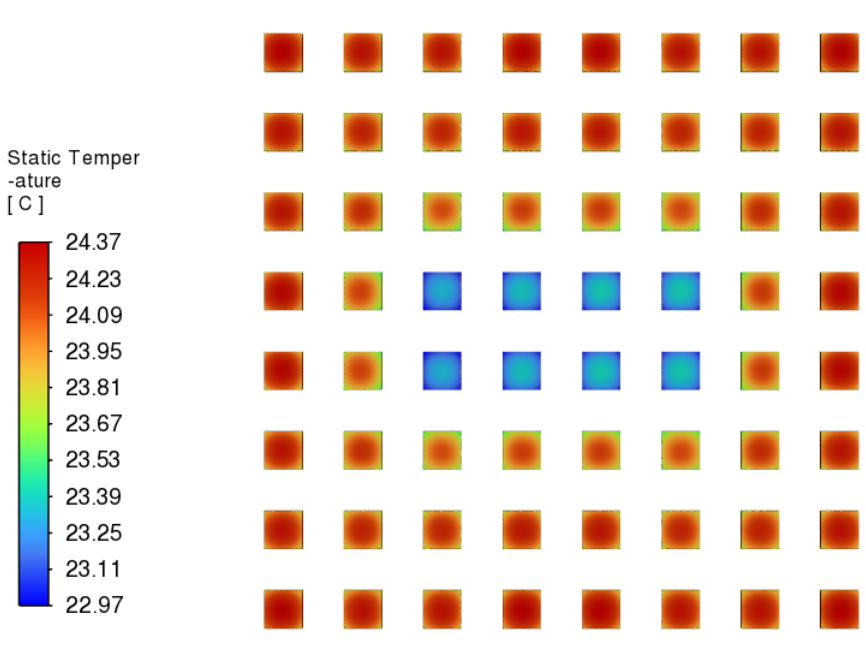
Ambient Temperature (C)	Flow velocity (m/s)	Half FEB Heat load (W)	SiPM Heat load (W)
20	0.76	2.25	0.17

Relative Humidity (%)	Dew Point Temperature (C)	Water Inlet Temperature (C)	FEB Temperature (C)	SiPM Temperature (C)
100	20	22	27.88	24.37

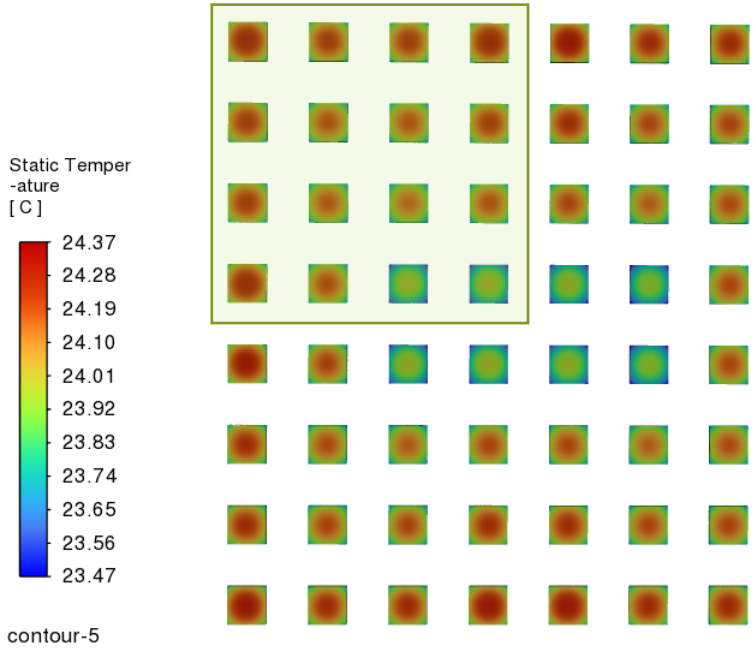
G. Girish (BNL)

Forward EMCAL – CFD Simulation

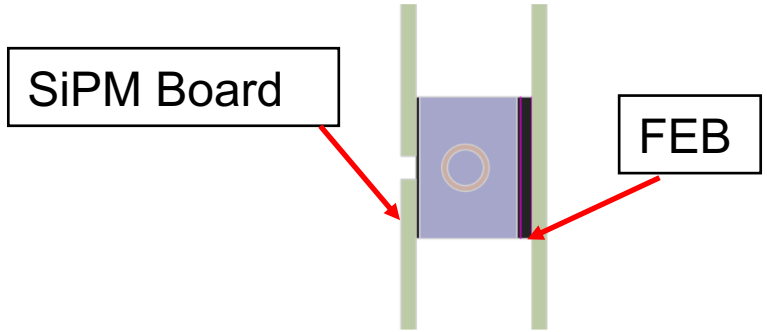
Design :



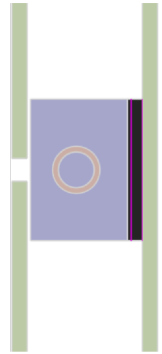
FEB Temperature



SiPM Temperature



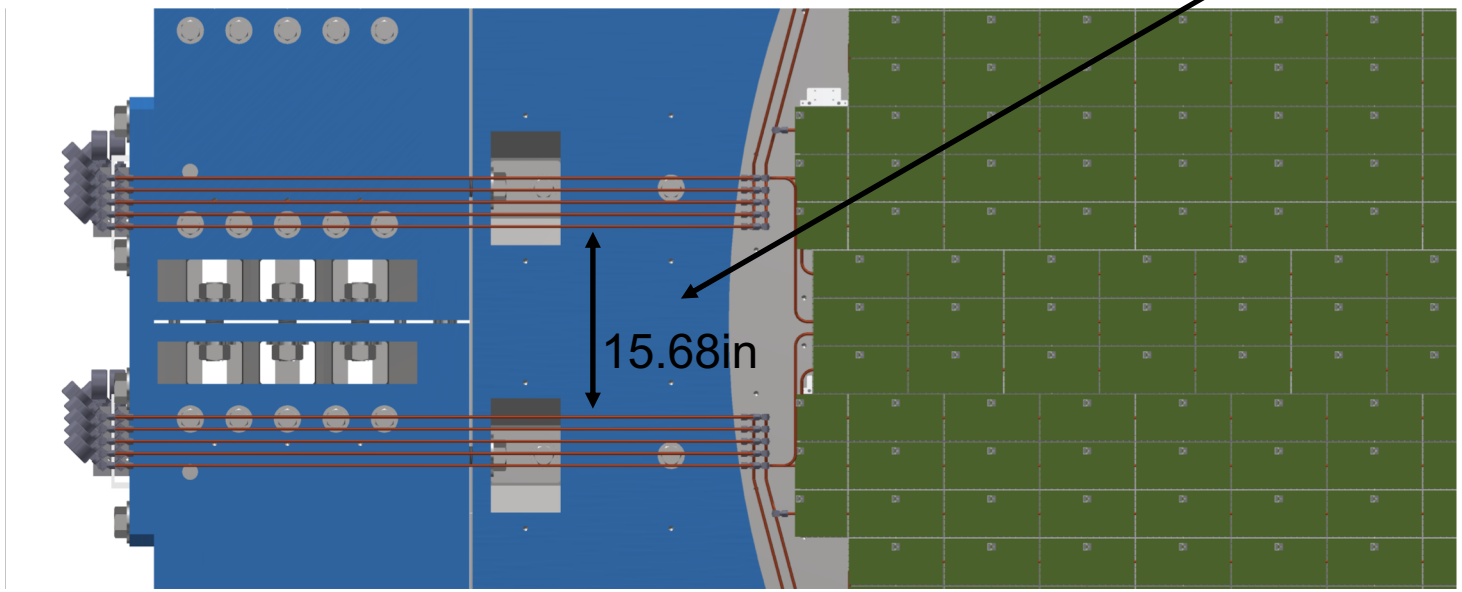
Requirement:
T variation on SiPM boards
+- 0.6 C

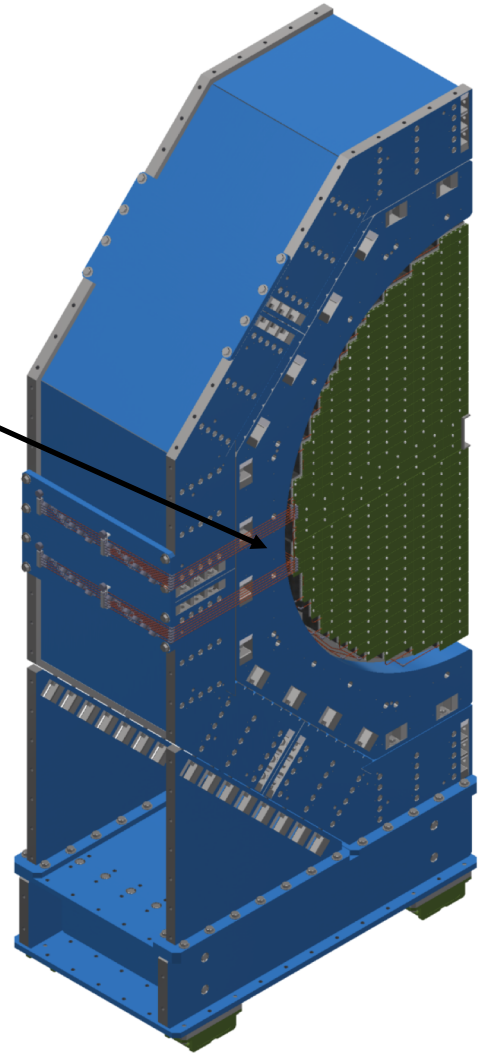


G. Girish (BNL)

Cooling & Cabling

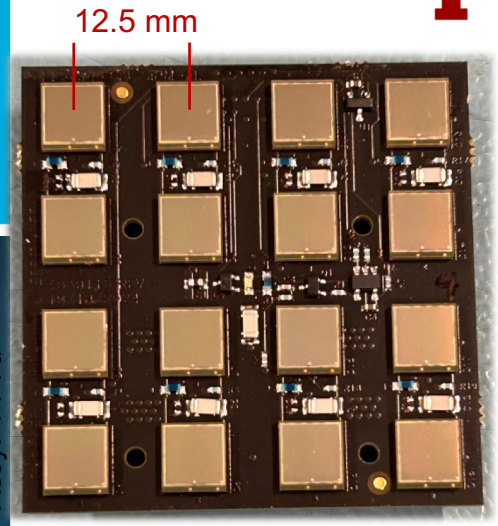
- After discussion with Roland in January this seemed to be the best orientation for cabling.
- Approximately 15.68 in of space between top and bottom cooling assemblies.
- Need to consider whether magnet links affect chosen locations.

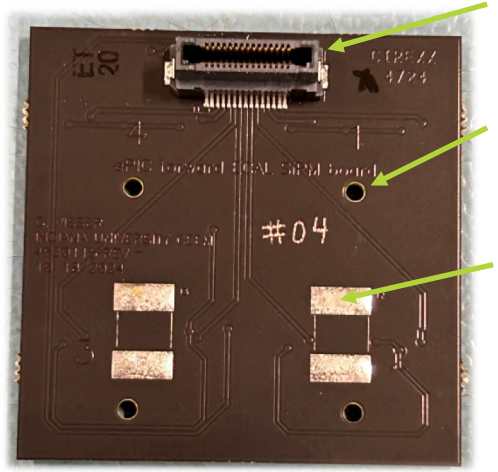




SiPM board

have 5 fully assembled boards, plus ~27 bare PCB



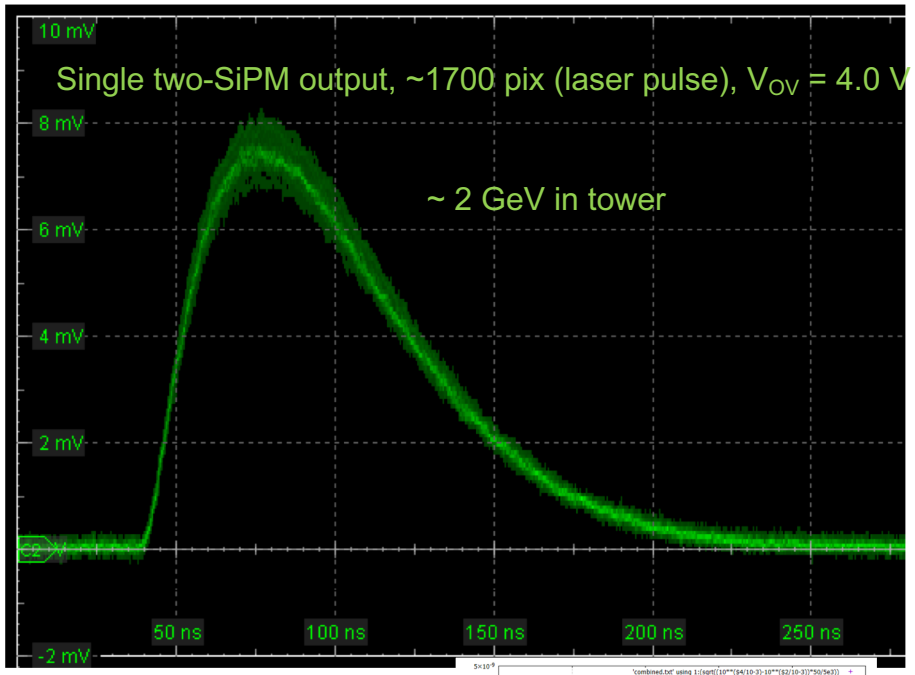


Connector to FEB

Holes for gluing fixture & for removal tool (rivets)

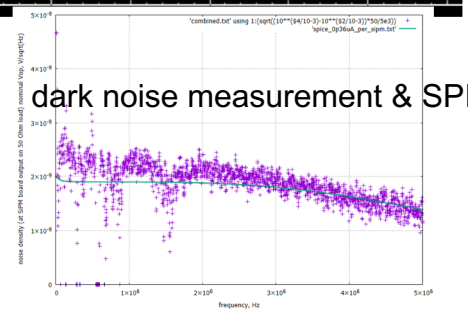
Cooling tab solder pads

Use is under study (not baseline)

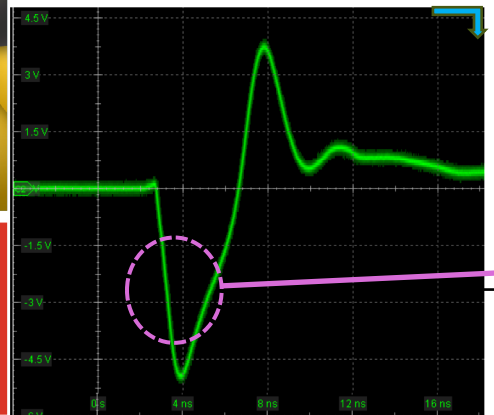


- 2×2 calo. towers
- 8× (2×6×6 mm^2 SiPM channels), 2 ch. combined on FEB
- Passive shaping, no amplifier on SiPM board
- LED and driver circuit
- Thermistor
- E-Serial number

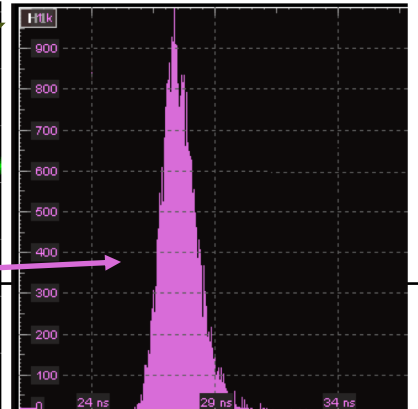
SiPM's in new package **w/ thermal connection!**



LED drive [1.5 V/div 4 ns/div]



1.8 ns FWHM optical pulse



Next steps:

- Optimize 2nd stage of shaping (on FEB)
- Measure thermal resistance SiPM to board
- Measure thermal gradients on board
- Temperature of SiPM's in a mock-up system (w/ DC LED simulating rad. damage
  - w/o cooling
  - same with cooling (which is not baseline plan)
- DCR vs. temperature
- Mechanical fit of blocks/lightguides/SiPM board to FEB w/ floating connectors
- Test removal of glued SiPM board (UCLA/BNL)
  - meaning w/o damage to neighbors or lightguide!
- Evaluation of LED uniformity / need to adjust amplitude in system

Assy: P. Yu

Software.

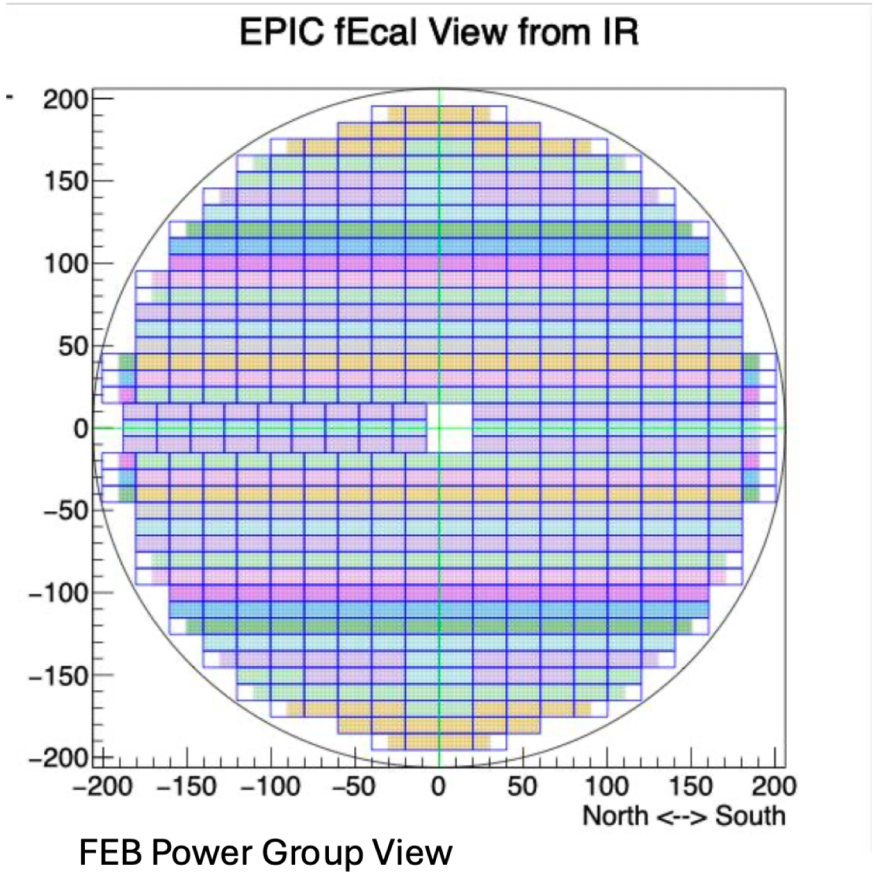
Akio Ogawa (BNL) is new fEMCal software coordinator.

- Expert in calorimetry software at STAR (FMS, FCS).

- Stability
- Structured Approach
- Documented

Map and Numbering

https://www.star.bnl.gov/~akio/epic/map/index.html
https://github.com/eic/epic/blob/fEcal_update/src/forwardEcalMap.h



Simple C++ class to convert between :

- Human readable Id (north/south, row, column)
- Human readable Id (north/south, block, tower)
- Local XY
- Global XYZ
- CellID in MC
- DAQ Id (ROC, FEB, SiPMBd, Ch…)
- Slow Control Id (Power Group, FEB Addr, SiPMBd…)

This also help to provide basic constants and functions for

- Drawings
- MC geometry
- Reconstruction
- QA plots

Summary.

- The eRD106 project has been successfully completed.
- There has been a smooth transition to projects funded under the PED.
- Collaboration and communication with BNL project engineers have significantly improved.
- The forward EMCal is on track for the FDR, currently anticipated in 2025, as per the defined scope.

P.S.

Production is projected to begin in a few years; however, there are currently significant uncertainties regarding the construction approach for the forward EMCal. At present, two scenarios are under active consideration.

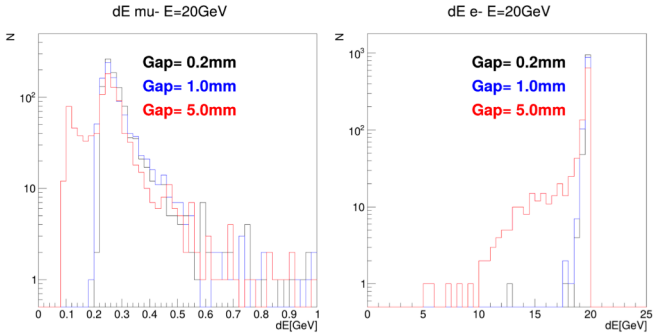
Thanks !

Backup

Software.

Block Gap Study

Shooting Muon/Electron towards +- 2cm of nearest to beam gap where gap effect is worst



From simple geometry :

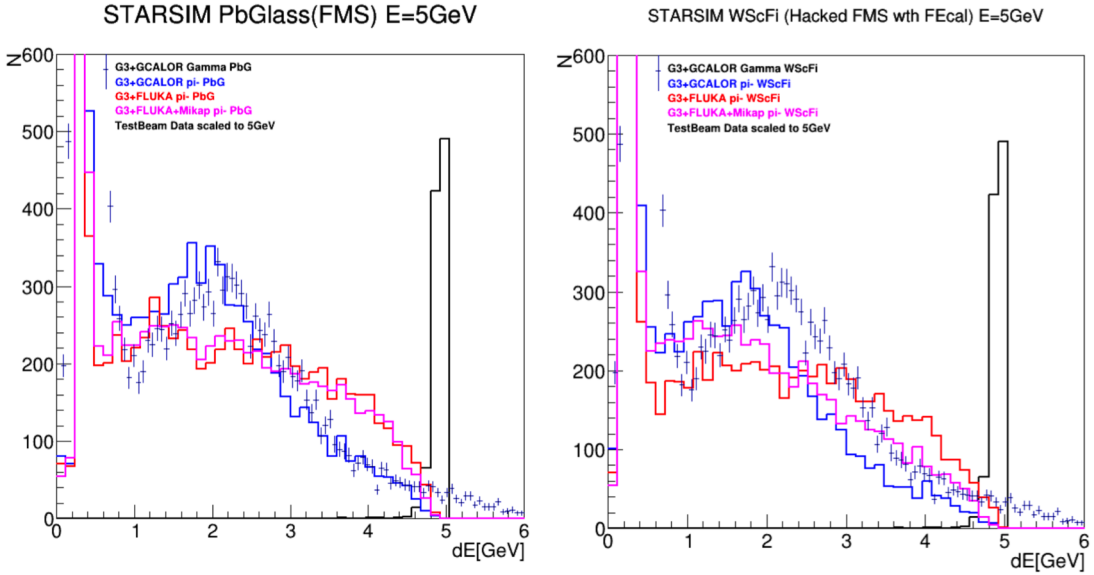
10mm gap make a region for a particle to miss up to 100% material

5mm gap make a region for a particle to miss up to 50% material

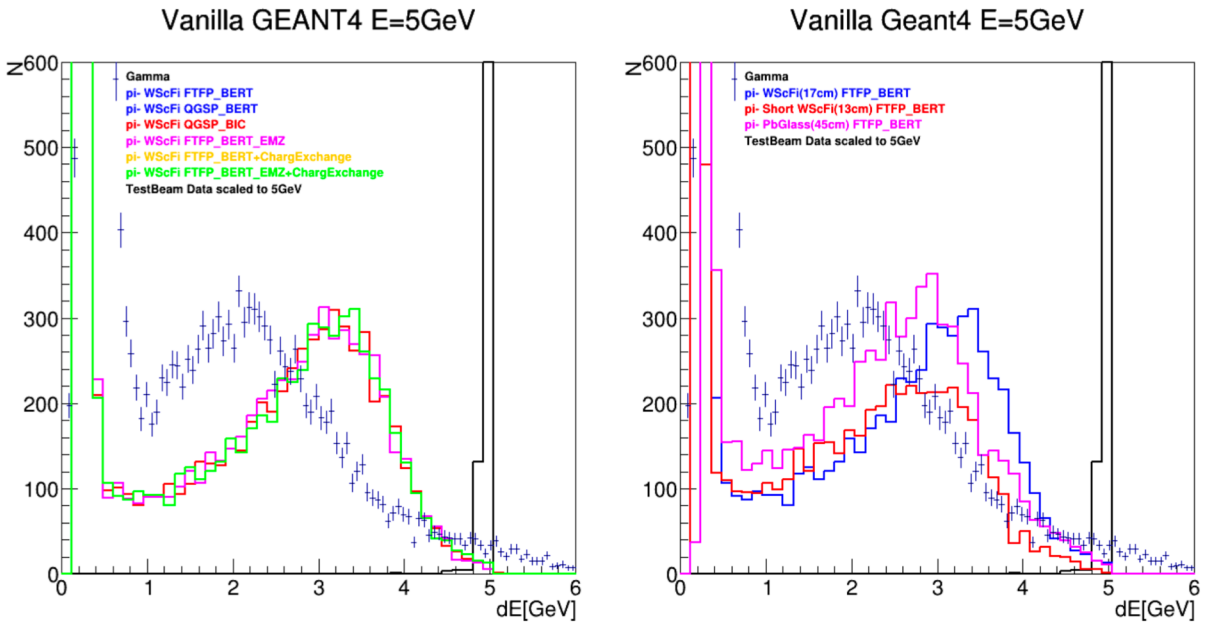
1mm gap make a region for a particle to miss up to 10% material

Increase gap between blocks from 0.6mm to 1mm

Geant3 (STARSim)



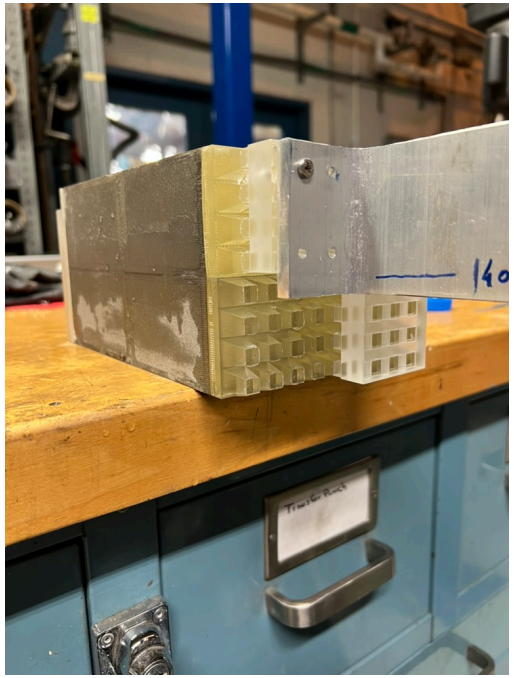
Vanilla Geant4 with different Physics List and Materials



- Response to hadrons in dd4hep for fEMCal was overlooked. Can't reproduce FNAL Test Beam data.
- Next week ePIC Calo WG meeting dedicated to validations…

Tests removal of SiPM boards at BNL

Long term shear test
~ 6 months, no issues.



Removal of SiPM boards
No damages to LG

Static peel tests,
Safety factor ~ 100