eRD106. Forward ECal. Progress Report

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BNL, Chinese EIC ECal Consortium (Fudan, Shandong, Tsinghua and South China Normal Universities), Indiana University, UC EIC Consortium (University of California at Los Angeles, University of California Riverside)

ePIC/EIC Project R&D Day – 3/25/ 2024

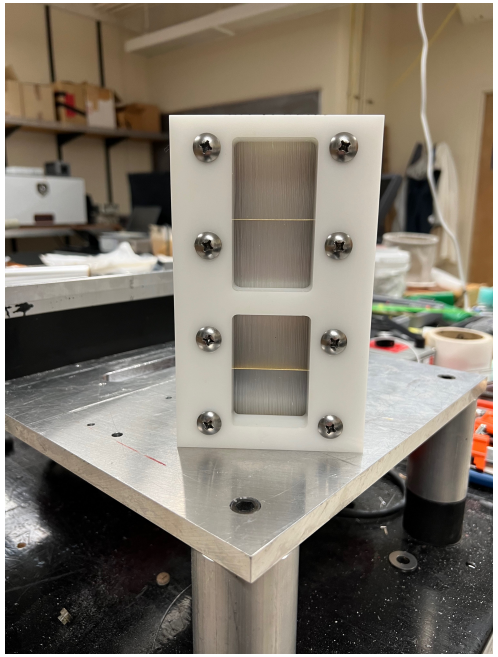
Milestones for FY23 (FY24):

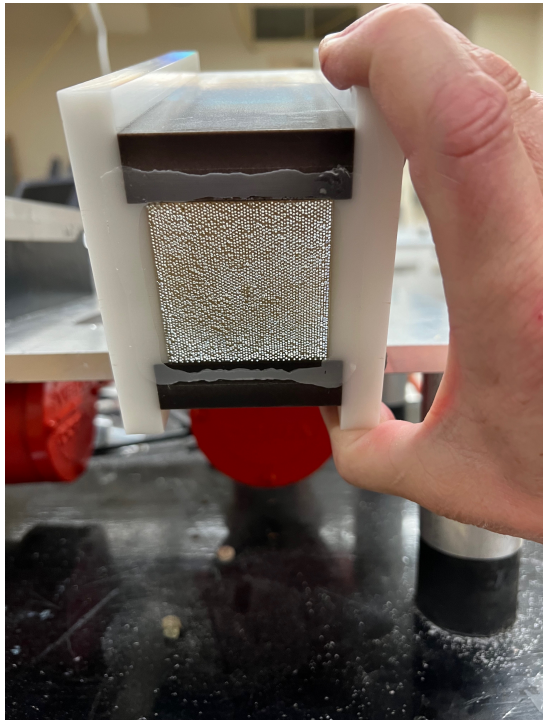
To address the remaining technological questions:

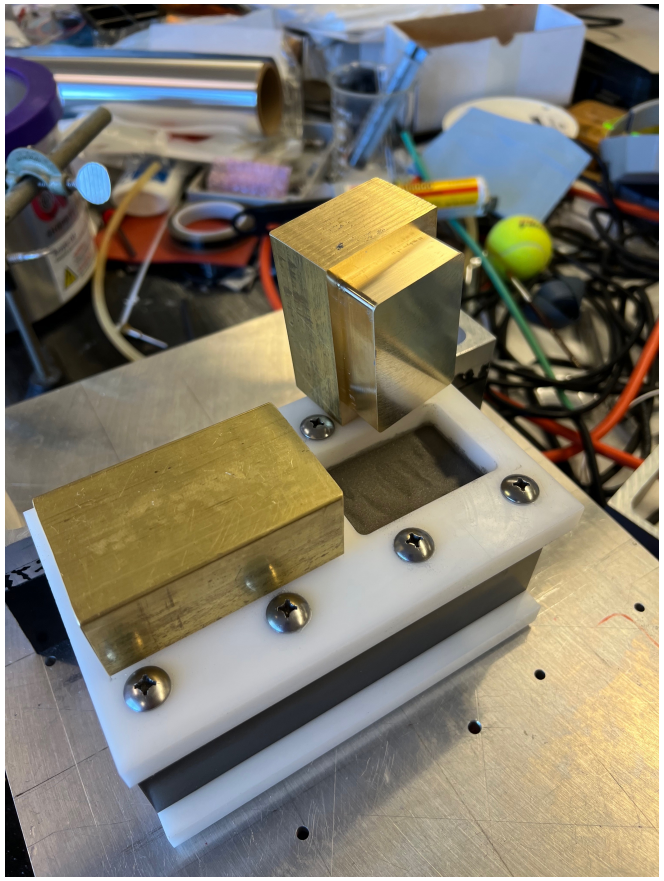
- Construct 64 channel ECal prototype, using latest method developed by eRD1.
- Optimize light guides.
    1. Uniformity of light collection
    2. Efficiency of light collection
- Test detector at FNAL.

Moving toward CD2/3A:

- Mechanical integration of ECal into ePIC.
- Structural tests (sheer and compressions).
- Comparison of 'EIC specs' Saint Gobain and Kuraray fibers.
- Optical/mechanical/electrical integration of readout (with eRD109)
- SiPM testing (with eRD110) was not funded – resumed now.







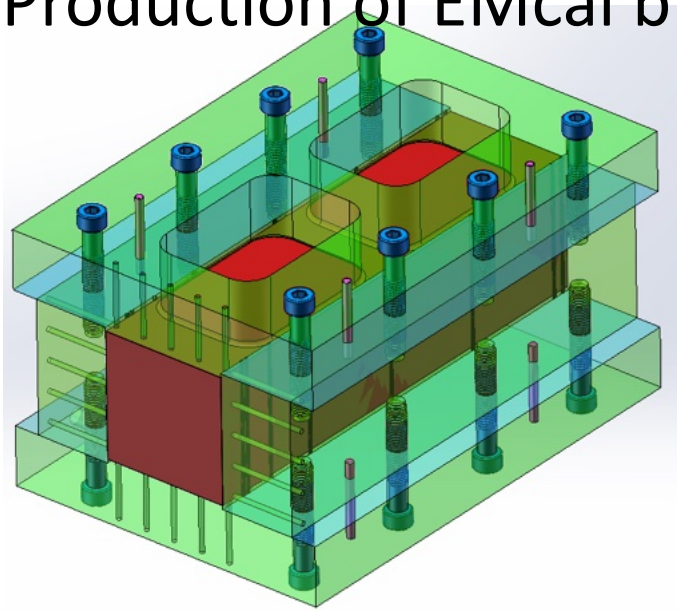
UCLA production of EMcal blocks

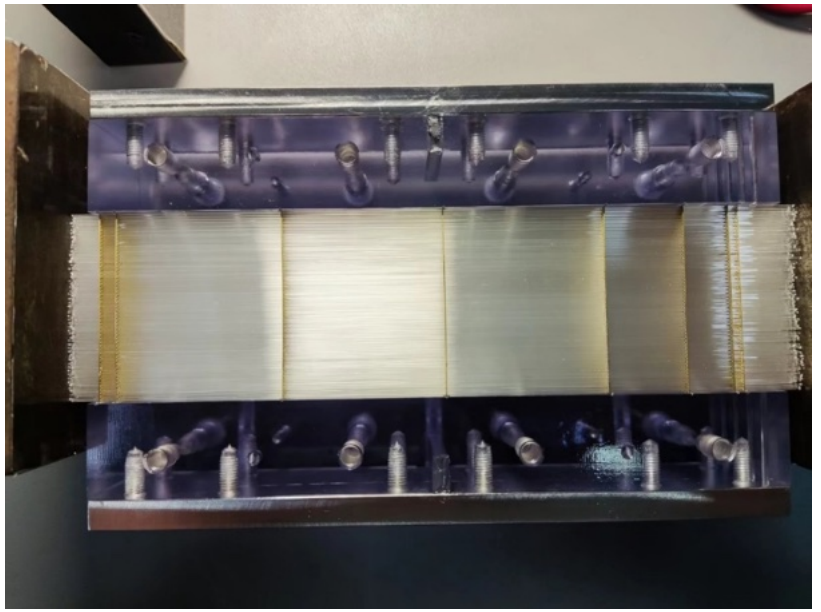
- Mold similar to Fudan's molds (next slide)
- Simplified
- Five blocks made. Four used for mechanical tests at BNL

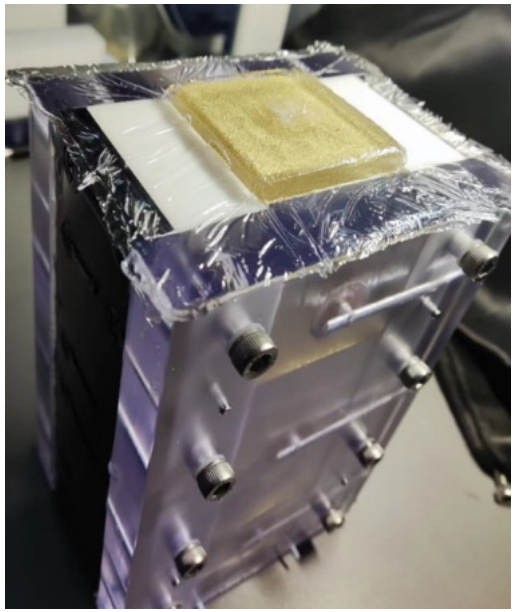
Readiness : Mold

Fudan, Production of EMcal blocks

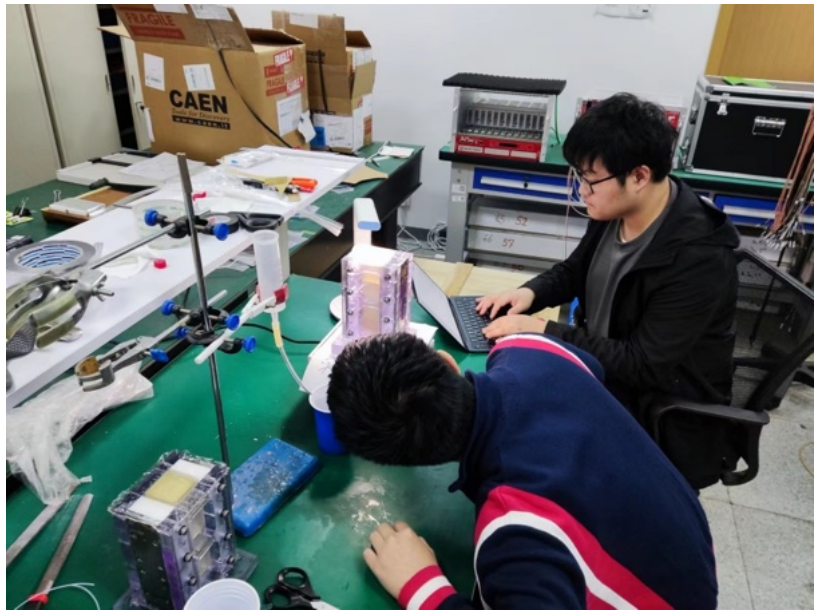
- Fiber filling works smoothly
- New molds are ready

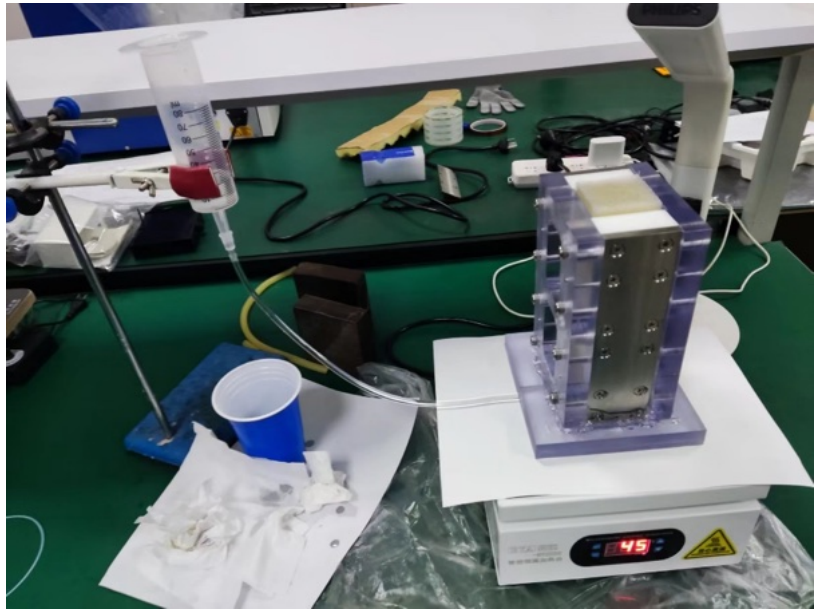


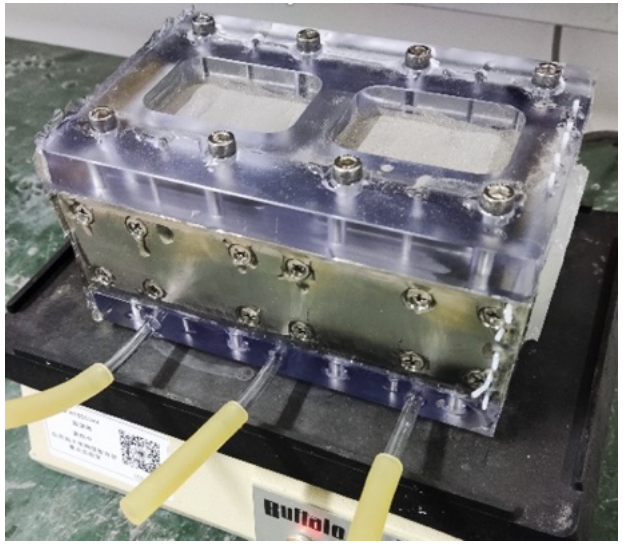


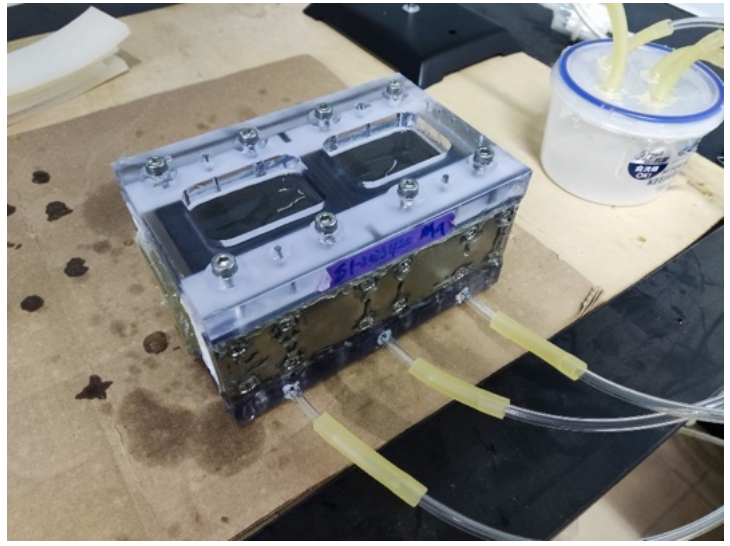


Protype Production at Fudan



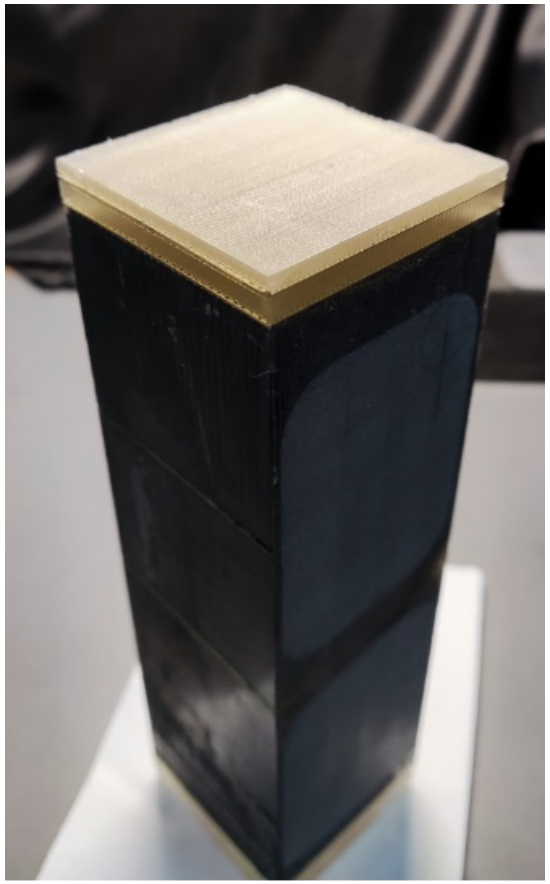


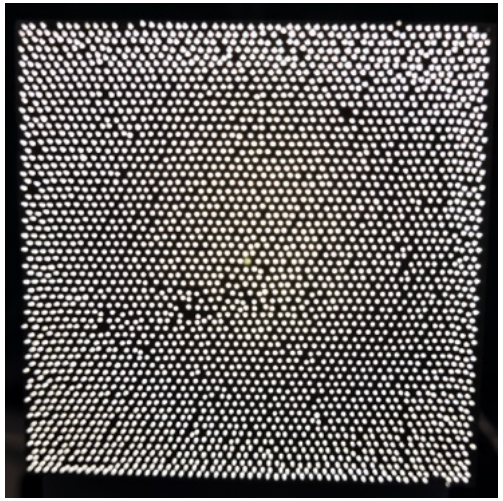


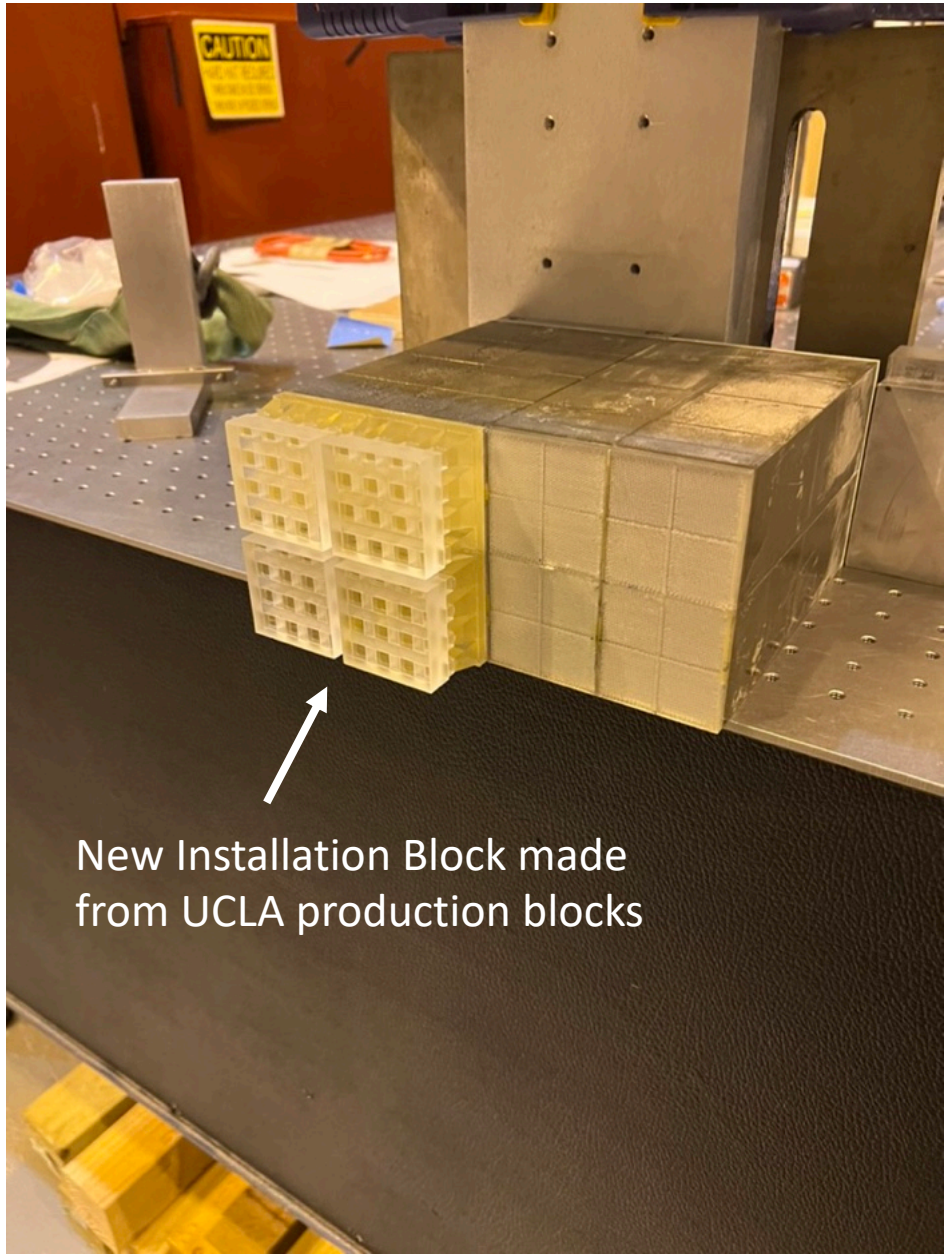


First block

- The first block looks good
- We are running the prototype production flow
- Get manpower from Tsinghua and Shandong Uni.
- Engineers and students are trained
- We plan to get 12 blocks ready in April





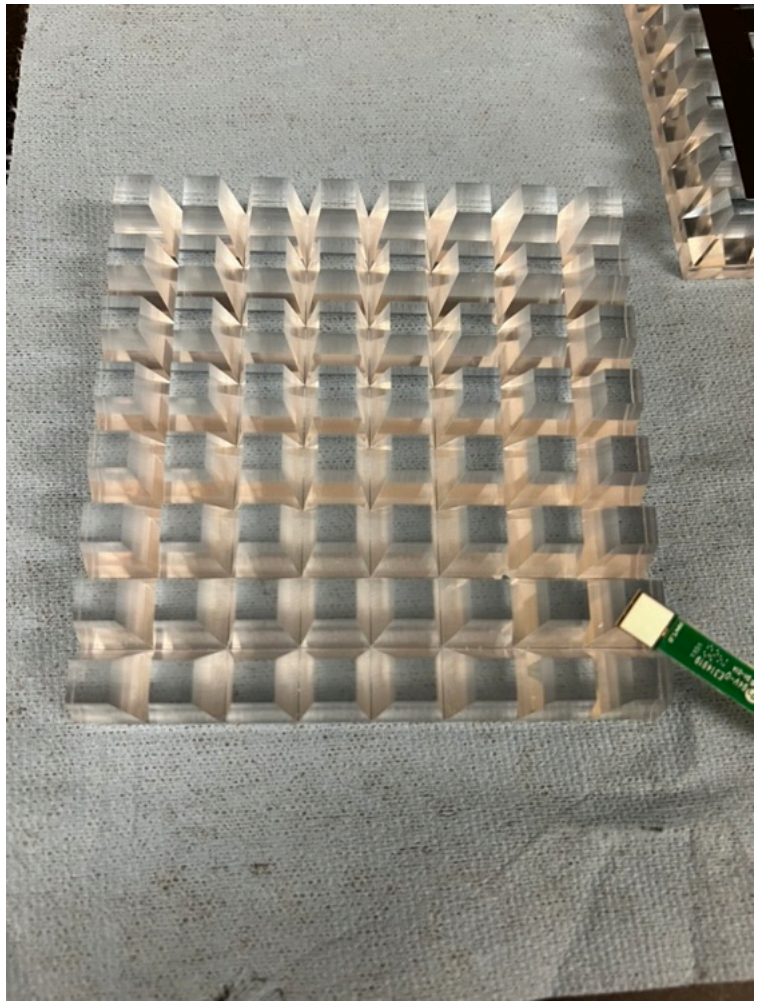


Structural and other mechanical tests at BNL.

Installation test was needed to:

1. Finalize design of lightguides
2. SiPM currying boards
3. Integration with FEEs
4. Assembly sequence of the installation block

- Initially Injection moulding (IM) and machining were considered for LG. IM was dropped as unpractical.
- Eight different light guides were produced at UCLA, BNL, Indiana machine shops using different methods.
- Best method were developed by Indian shop.



Result: Efficiency

- **Efficiency was measured with HPK 6x6 mm SiPM. Light source 1mm diameter plastic optical fiber, 35 cm away from SiPM. 2% light lost in 19 mm Acrylic (PMMA) and Sylgard coupling.**

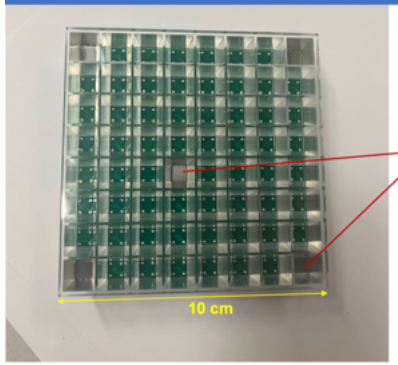
- **Two versions of light guide were tested. One straight after machining (M), another with additional polishing after machining (P).**

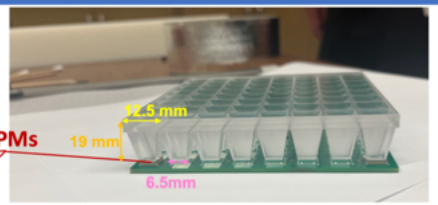
Type of Light Guide	LG efficiency	Light Collection Efficiency (transmittance and geometrical efficiency added)
Machined	84%	70%
Machined + Polished	95%	80%

- **FNAL test run measures light yield ~ 400 pixels/GeV with efficiency at ~ 21%. Scaling this for ePIC gives about 1600 pixels/GeV light yield for forward EMCal.**
- **This will be verified in another test run.**

- First results from light guide scanner at UCLA.
- Setup is being improved now to reduce PMT photocathode non-uniformities.

Prototype of lightguide for ePIC Forward EMCal





- A single lightguide per installation block. It has 64 pyramids to collect light from 10 cm x 10 cm area of W/ScFi block to 64 SiPMs 6 mm x 6 mm.
- Thickness of light guide is 19 mm, reduction area is 12.5 mm x 12.5 mm to 6.5 mm x 6.5 mm.
- Optical coupling between SiPMs and lightguide is Sylgard 3145 RTV.
- Not enough calibrated SiPM chips for now.

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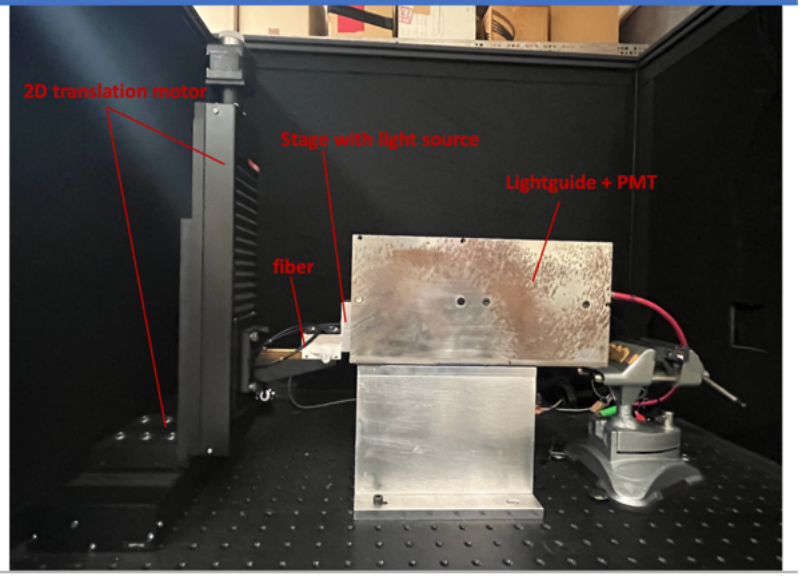
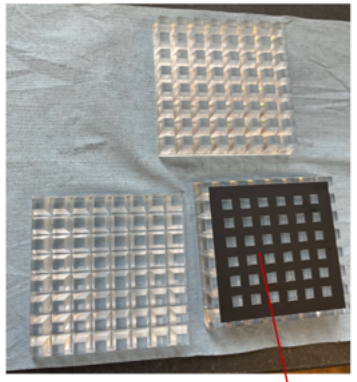
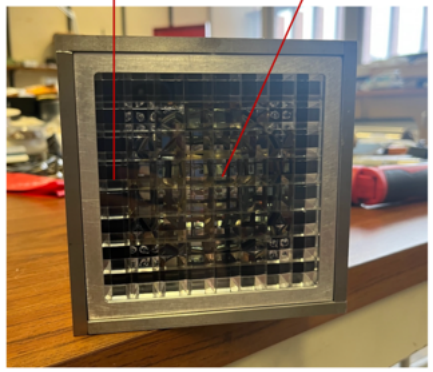
2D scan setup for uniformity test



PMT + lightguide for uniformity test





Mask edges between grids

- PMT + Masked lightguide to mimic the SiPM detection
  - A SiPM is smaller than the transverse area of each grid (trapozoid shape).
  - Incident light that hits the edge (black masked area) won't be detected by PMT.
- Lightguide and PMT are glued to ensure optical contact.

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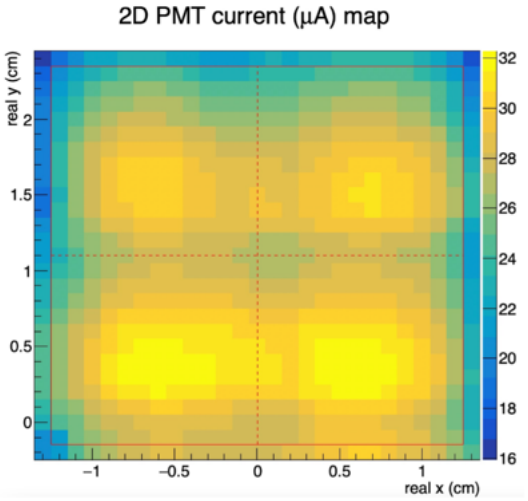
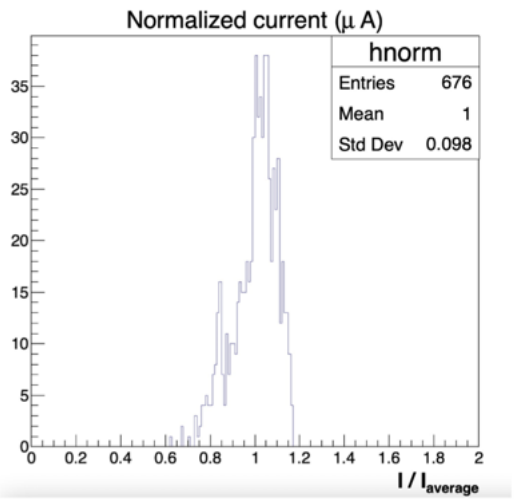
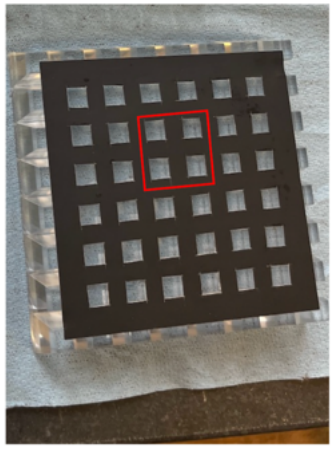
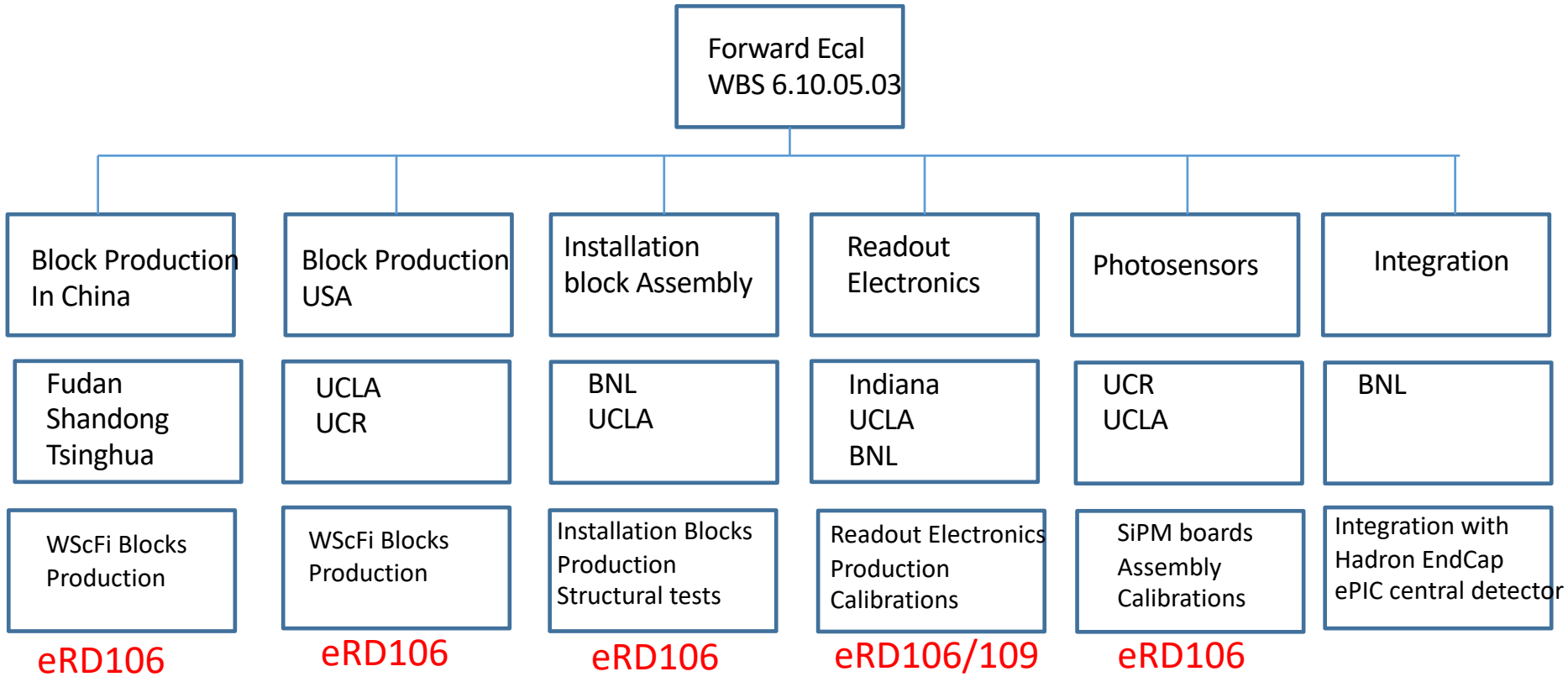






Forward ECal WBS, Workforce



- N.B. SiPMs/SiPM board assemblies are for the test run only to match existing DAQ.
- A single 16 towers readout block, which can be swapped for WSc/Fi installation blocks.
- All HPK SiPMs for the test run received by UCR.
- A second version 4x4 SiPM currying board produced at UCLA, tests next week. Then final board will be assembled during April.

Original Detailed Schedule.

1. Discussion with Fudan group personnel on production mold/methods and tooling.
2. Comparison of new Bicron BCF-12 Fibers with Kuraray SCSF-78.
3. Assembly of one production block in China from leftover materials.
4. Shear tests complete
5. Acquire Sc. Fibers (all fibers delivered to Fudan)
6. Acquire W Powder (all powder delivered to Fudan and some were shipped to UCLA)
7. Acquire production meshes and tooling (all meshes and some tooling in Fudan)
8. Iteration on production methods and molding forms finished
9. Start production of blocks for test beam prototype
10. Deliver two production blocks to US for inspections
11. QA first production blocks
12. Perform UV scan to check uniformity LY
13. Deliver all production blocks to US <- End of April
14. QA Production all blocks done
15. Compression tests complete
16. Mechanical/optical/electrical integration with readout complete
17. Light guides for prototype produced
18. 64 channel prototype ready for integrating readout.
19. Readout electronics for test run, software, MC complete. <- End of April
20. Test Run at FNAL complete - TBD

Test run at FNAL. End of May 2024? (6 x 12 hours beam time). Got notice ~1 week ago.

- Tight schedule and lots of risk.
- Complications with RHIC startup, which is happen at about same time.
- In best case we may be able to test only one installation block (energy scans at different angles, uniformity maps).
- We are still discussing if we want to take this chance (deadline April 1’st to confirm with FNAL) or wait until Fall.
- There are lots of reasons to go there now (one is to train new team of students from UCLA and UCR, last test run was five years ago at FNAL for STAR FCS). But with such short notice colleagues from China who expressed strong interest to participate in this test run will not be able to join.

Summary/Outlook

- Production of EMCal blocks at UCLA completed.
- Production at Fudan is projected to be completed in April.
- Light Guide for ePIC prototype produced, tested.
- Mechanical tests at BNL mostly completed.
- Integration of SiPM/FEEs were iterated and converging to a final scheme.
- Test Run at FNAL – TBD <- completion of eRD106.
- Remaining production ‘tweaks’ is/will be moved to PD.

Thanks!