eRD106 (Forward ECal for ePIC) Draft v1
Proponents: BNL, Chinese EIC ECal Consortium (Fudan, Shandong University, Tsinghua and South China Normal University), IUCF, UC EIC Consortium (UCLA, UCR)
Project Coordinators: O. Tsai and H. Z. Huang (UCLA)

- We propose to build a full scale 64 channel forward pECal prototype. With the construction and beam testing of the calorimeter system, we expect to address all technical, performance and cost questions related to the final design of the forward ECal, in preparation for CD2 of the ePIC experiment.
- We expect that the R&D team will develop the construction techniques and facilities that can be used for the pECal detector construction of the ePIC experiment.

ePIC collaboration selected W-powder/Scintillating Fiber (WScFi) technology for the default choice of pECal. This technology was pioneered by the UCLA group, developed via generic EIC detector R&D program and further developed by the sPHENIX collaboration for barrel ECal. This technology now is well established in the EIC community. The WScFi construction technology is particularly well suited for Universities. sPHENIX had major production factories in operation at universities in the US and China.

The proposed FY23 R&D plan will focus on two remaining questions identified previously in our generic EIC R&D program and from sPHENIX barrel EMCal testing:

1. Uniformity of light collection with compact SiPM readout
2. Efficiency of light collection.

The UCLA group developed a few methods in 2015/2016 to address the first question. Prior test runs indicated that light collection efficiency can be improved by increasing size of SiPMs. We estimate to achieve LY ~ 1000 p.e./GeV to meet requirements on minimum energy detection as specified in the YR.

We tried different methods to compensate for non-uniformities in light collection, including compensation filters between fibers and light guides (help with uniformity but decreases efficiency of light collection), or compensated mirror at the far end of the fibers (opposite side of the light guides) which turned out challenging. The last method tried at that time was to introduce a controlled non-uniformity with pre-bunching of fibers – the main idea is to make light path for fibers at the edge of towers somewhat similar to the light path from fibers at the center of towers. Figure 1 shows scans with UV source exiting fibers at far end of the EMcal module for different configurations of light collection performed in 2016. Pre-bunching fibers significantly improved the light collection uniformity (by a factor of 4.5) compare to earlier prototypes (or sPHENIX version). We will use this method to build 64 channels ECal prototype needed for the test run. This method was investigated for only one production block previously and needs to be tested and validated with the full scale production modules and test beam.

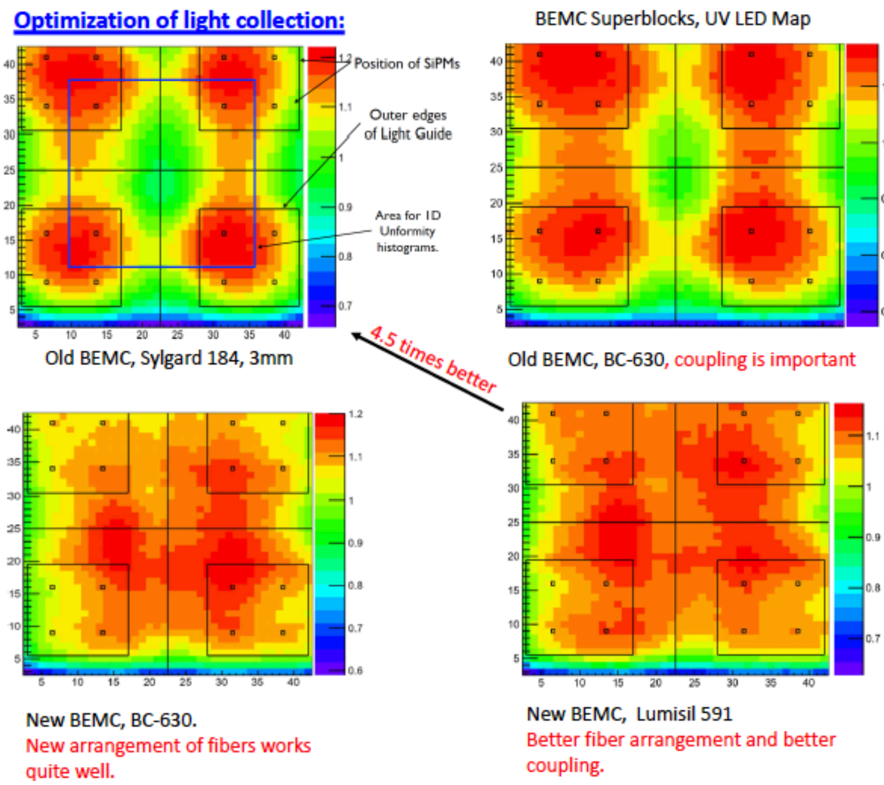

Figure 1. Response uniformity maps. Figure from EIC Generic R&D Project eRD1 2015 report.

An additional improvement of non-uniformities will come from using larger area SiPMs. In previous test runs and bench measurements we used 3 mm x 3 mm SiPMs. For ePIC ECal we plan to use 6 mm x 6 mm SiPMs. The primary reason is to enhance the light collection efficiency. With increased area of photo-sensors by a factor of 4, we should be able to achieve the targeted number 1000 p.e./GeV, compared to present ~390 p.e./GeV.

We will also optimize the light guides to be used for the ePIC pECal.

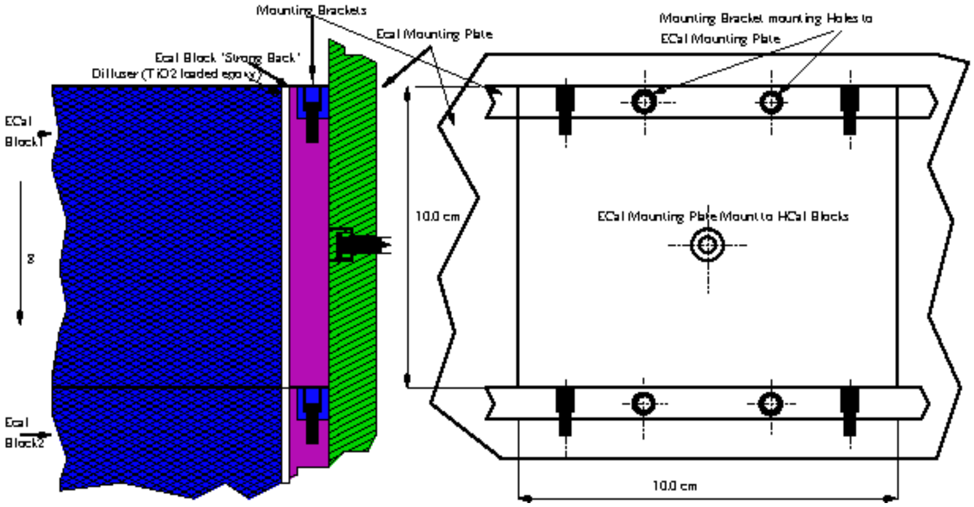

Figure 2 Preliminary integration concept of pECal with HCal

A concept of mechanical integration was discussed with BNL EIC project engineers (R.Sharma, R.Wimmer). A few structural tests were discussed to finalize integration concept. Each ECal installation block will be connected to HCal via strong back as shown in Fig 2. This strong back either fully or partially supports installation block (i.e. no load or reduced load to an adjacent lower EMCal block in the EMCal stack). Strong back interface with the WScFi compound involves optical reflection layer at the backside of the EMCal installation block. This layer can be a polished aluminum mirror (sPHENIX approach) or white diffusive reflector (used in eRD101 tests). In any case interface between optical reflector and WScFi compound and strong back considered as a weakest mechanical link. A series of tests to measure shear load with different optical reflector options had to be performed with an installation block. Additional compression stress tests (short/long term) were also discussed. Tests will be performed at BNL at the STAR Assembly hall with the help from project engineer (R.Sharma) (some of these tests are similar to one performed for STAR FCS EMCal).

A mechanical/optical/electrical integration of readout is part of this proposal. This activity will be closely coordinated with eRD109 project (a separate proposal for development of readout for pECal was submitted to eRD109). G.Visser from IUCF will be leading this efforts.

We communicated with major producers of scintillating fibers (Kuraray and Saint-Gobain) as a potential vendor for the final detector. Saint-Gobain adjusted composition of their standard BCF-12 fibers to increase light yield by about 15-30% at our request to be competitive with Kuraray SCSF-78 fibers. New fibers from Saint-Gobain will be available for comparison with Kuraray fibers in Nov.-Dec. 2022.

We plan to carry out a beam test run in 2023. Per communication with the FNAL FTBF, a test run will be most likely in Nov. 2023. Readout electronics for the test run will be adopted either from STAR FCS or from previous eRD1 test runs. MC and software development for test run will be prepared by the UC EIC consortium.

FY 22 Detailed Schedule.

1.Transfering know-how, old production mold/methods and tooling from UCLA to Fudan. 12/31/22
2. Comparison of new Bicron BCF-12 Fibers with Kuraray SCSF-78. 1/15/23
3. Assembly of one production block in China from leftover materials 1/31/23.
4. Shear tests complete 3/30/23
5. Acquire Sc. Fibers (all fibers delivered to Fudan) 02/27/23
6. Acquire W Powder (all powder delivered to Fudan) 02/27/23
7. Acquire production meshes and tooling (all meshes and some tooling in Fudan) 02/27/23
8. Iteration on production methods and molding forms finished 03/30/23
9. Start production of blocks for test beam prototype 04/01/23
10. Deliver two production blocks to US for inspections 05/01/23
11. QA first production blocks 05/15/23
12. Perform UV scan to check uniformity LY 05/30/23
13. Deliver all production blocks to US 06/30/22
14. QA Production all blocks done 07/15/22
15. Compression tests complete 7/30/23
16. Light guides for prototype produced 8/30/23
17. 64 channel prototype ready for integrating readout. 09/30/23
18. Readout electronics for test run, software, MC complete 10/30/23
19. Test Run at FNAL complete 12/15/23.
