# Final Design Review of the Scintillating Fibers for the EPIC barrel and forward EM Calorimeters

The scope of this review is an assessment of the readiness to proceed to the procurement phase.

**Date of review:** September 13, 2023

**Last update of closeout text**: September 14, 2023, 14:54 EDT

**Reviewers**: Pierluigi Campana (LNF) and Caroline Riedl (UIUC)

**General**: The committee thanks the speakers and team for the complete and very well-prepared presentations and accompanying material; the material and arguments brought forward were convincing. The assembled team is very knowledgeable, expert and mature on the used technologies, since they have been involved in several similar projects at big laboratories.

We reviewed material about the EPIC barrel EMCal and the EPIC hadron-going forward (h-forward) EMCal.

Below follow the answers to the eight charge questions. **None of the recommendations should delay the fiber procurement plans. Some of the recommendations are beyond the scope of this review and they are kept to guide future follow-up work.** The recommendations are also separately summarized at the end of this document.

*1. Are the EMCAL technical performance requirements complete, documented, and understood?*

The performance requirements are overall well understood and the designs match the EPIC P6 requirements. It is advisable to pay attention to redundancy (for example, single vs. double-clad fibers for the barrel to ensure good performance of the system even in harsh conditions, like beam background or noise in the SiPMs).

*2. Are the plans for achieving detector performance and construction sufficiently developed and documented for the present phase of the project? (I.e., are they commensurate with the initiation of the scintillating fiber procurement?)*

We strongly recommend exposing one minimal slice / element of the EPIC barrel EMCal into a testbeam to study its performance and test as a slice of the full system latest before the second purchase order of the scintillating fibers. This would also serve as a test of the assembly procedure at the new production site (ANL).

It would be good to have for both barrel and h-forward a more detailed production chain, the production rates over time, and the required resources to reach the necessary production rate to satisfy the EIC installation schedule. We understand that there will be an elaborate series of production readiness reviews that will address exactly that question.

It would be good to identify an alternative US production site for the h-forward blocks in case collaboration with Fudan University will not be possible.

*3. Do the present EMCAL design and the resulting scintillating fiber specifications meet the performance requirements with a low risk of cost increases, schedule delays, and technical problems?*

The specifications of the chosen fibers look reasonable, a judgment that is based on the previous experience with these fibers (GlueX, sPHENIX, …).

We cannot anticipate a possible increase of fiber costs from the two vendors if the purchase order would be delayed. But if a linear extrapolation was applicable, the fibers ordered from SG for sPHENIX in 2018/2019 will cost about a factor of 2.5 more 6 years later (order 2024/2025).

*4. Are the fabrication and assembly plans for the EMCAL consistent with the overall project and detector schedule and appropriately developed to initiate the scintillating fiber procurement?*

The plans are consistent, but we lack some of the details of production procedure (see Q2) to make a full assessment at this point. As elaborated in Q2, such details will be addressed in future reviews. For the h-forward, in order to build 3,000 blocks over 3 years, on average 20 blocks per (every) week have to be built. The barrel construction appears to be less challenging.

In any case - these considerations and material suggest that fiber procurement should start asap.

Our understanding of the timeline (supporting table):

- July 2024: order fibers
- Summer 2024 - Summer 2028: receive fibers
- ~ Spring 2025 start block factories (after ramp-up curve of 6 months)
- December 2029 - barrel EMCal ready for installation
- June 2030 - barrel EMCal installed
- January 2031 - h-endcap EMCal installed

*5. Are the plans for detector integration in the EIC detector appropriately developed to initiate the scintillating fiber procurement?*

We do not see any showstopper and in this context nothing should hold up the fiber procurement.

*6. Have previous review recommendations been adequately addressed to initiate the scintillating fiber procurement?*

In reference to the closeout of the Review Dec 6-8, 2022: have the simulations been advanced in the meantime? Have simulations of h-forward energy resolution with passive structures been performed? Note added during the closeout: this question has been addressed six months ago, and it was shown that including the passive structure material budget into the simulation does not change the energy resolution of the h-forward modules.

We continue to recommend the beamtest of engineered structures (see also Q2).

*7. Have ES&H and QA considerations been adequately incorporated in the scintillating fiber procurement planning? (This includes a quality assurance plan for receipt of material meeting specifications.)*

We recommend parallelizing the QA efforts, for example, make use of ways to measure attenuation length developed at one lab also at the other site. We recommend making a clear evaluation of the needed margin in fiber length to compensate for bad fibers and production training / losses / accidents. We recommend ordering fibers in canes if possible, to avoid the issue of elastic memory.

*8. Is the procurement approach sound and the procurement schedule credible?*

We recommend considering pre-production of a small amount from both companies to evaluate the different sets of parameters.

Overall, the procurement schedule looks reasonable.

For comparison, we enclose the summary for the sPHENIX barrel EMCal (UIUC portion):

UIUC sPHENIX barrel EMCal

- S1-12, 800km, $385k, ordered 4/2018, received 7-11/2019
- S13-64, 1,800km, $840k, ordered 1/2019, received 4/2019-3/2021 (=2 years - extrapolated to the larger amount for EPIC, 3-4 years of lead time is actually not bad)

EPIC

- EMCal h-endcap, 3,000km, $384k + $980k, receive over 3-4 years after July 2024
- EMCal barrel, 4,500km, $1,275k + $3,390k, receive over 3-4 years after July 2024

## Summary of reviewers' recommendations:

**None of the recommendations should delay the fiber procurement plans. Some of the recommendations are beyond the scope of this review and they are kept to guide future follow-up work.**

- Q2: We strongly recommend exposing one minimal slice / element of the EPIC barrel EMCal into a testbeam to study its performance and test as a slice of the full system latest before the second purchase order of the scintillating fibers.
- Q6: We continue to recommend the beamtest of engineered structures (see also Q2).
- Q7: We recommend parallelizing the QA efforts, for example, make use of ways to measure attenuation length developed at one lab also at the other site.
- Q7: We recommend making a clear evaluation of the needed margin in fiber length to compensate for bad fibers and production training / losses / accidents.
- Q7: We recommend ordering fibers in canes if possible, to avoid the issue of elastic memory.
- Q8: We recommend considering pre-production of a small amount from both companies to evaluate the different sets of parameters.