Report of the

Final Design Review of the PbWO4 Crystals for the ePIC Backward EM Calorimeter

Performed Remotely at Brookhaven National Laboratory

Upton, NY

July 21, 2023

Table of Contents

1. Executive Summary

The Electron-Ion Collider (EIC) is a major facility, fully international in character, being designed and built at the U.S. Department of Energy's (DOE) Brookhaven National Laboratory (BNL) in partnership with the Thomas Jefferson National Accelerator Facility (Jefferson Lab). The accelerator and one general purpose detector will be constructed over the next 10 years as a DOE construction project augmented with non-DOE in-kind contributions. The ePIC collaboration in cooperation with the EIC project is designing the detector systems to meet the goals as outlined in the 2015 NSAC Long Range Plan. The detector design work is currently in full swing.

The Backward EM Calorimeter (EEEMCAL) will provide high-precision detection of the scattered electron that is critical to determine event kinematics at the EIC in the range of particle energies of hundreds of MeV to 18 GeV. The EEEMCAL is designed to be in the electron endcap of the EIC detector, at a distance of 175 cm from the EIC interaction point. It is installed around the EIC beamlines in a roughly cylindrical geometry. The particles of interest impinge on the front face of the detector and pass through a PbWO4 radiator with adapted geometrical dimensions to contain the major part of the electromagnetic shower. The produced scintillation photons are detected at the back of the radiator using an array of Silicon Photomultipliers (SiPMs) and readout with back- and front-end electronics. The detector is enclosed in a mechanical frame that provides services like thermal cooling, light, and thermal monitoring.

The EEEMCAL radiator consists of ~3000 PbWO4 crystals. These will be the base of a procurement based on the ongoing EIC EEEMCAL design that includes requirements, specifications, and control drawings. We are ready to proceed with the Final Design Review of the PbWO4 crystals for this ePIC detector subsystem.

2. Reponses to Charge Questions

The scope of this review is an assessment of the readiness to proceed to the procurement phase. The committee is asked to respond to the following charge questions:

Responses to Questions

• **Charge Q#1**: Are the EEMCAL technical performance requirements complete, documented, and understood?

Findings

- The requirements are well documented and complete.

Comments

- The PWO crystals are the only choice that satisfies the requirements.

Recommendations

- The project should proceed with the PWO long lead procurement.

• **Charge Q#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 PbWO4 procurement?)

Findings

- Yes, plans for the crystals are in place and well documented.

Comments

A) Non-pointing (flat) geometry may cause performance degradation at the edges.

B) Although the current solutions seem to be the best available at this time, direct in-beam measurements of pi/e suppression would be beneficial for the whole project.

Recommendations

- The following recommendations do not apply to the LLP and are only for the benefit of the final design optimization.

A) Calculations of the impact of the thermal gradients on detector performance caused by shower fluctuations should be performed.
B) The carbon-fiber mesh (or something similar to the final design) should be used in the prototype being tested for temperature stabilization.

• **Charge Q#3:** Do the present EEEMCAL design and the resulting PbWO4 specifications meet the performance requirements with a low risk of cost increases, schedule delays, and technical problems?

Findings

- It is a well-established technology and the only option available concerning cost increases and schedule delays.

Comments

- To the best of our knowledge the chances of technical problems should be small.

Recommendations

- None

• **Charge Q#4:** Are the fabrication and assembly plans for the EEEMCAL consistent with the overall project and detector schedule and appropriately developed to initiate the PbWO4 procurement?

Findings

- Yes

Comments

- None

Recommendations

- None

• **Charge Q#5:** Are the plans for detector integration in the EIC detector appropriately developed to initiate the PbWO4 procurement?

Findings

- Yes

Comments

- None

Recommendations

- The project should proceed with he PWO long lead procurement.

• **Charge Q#6:** Have previous review recommendations been adequately addressed to initiate the PbWO4 procurement?

Findings

Comments

- Not applicable

Recommendations

- None

• **Charge Q#7:** Have ES&H and QA considerations been adequately incorporated in the PbWO4 procurement planning? (This includes a quality assurance plan for receipt of material meeting specifications.)

Findings

- QA has been developed.

Comments

- No comments about ES&H.

Recommendations

- None

• **Charge Q#8:** Is the procurement approach sound and the procurement schedule credible?

Findings

- Yes

Comments

- No comments.

Recommendations

- None

3. Appendices

3.1 Appendix A: Charge to the Review Committee

Charge to the Committee:

The scope of this review is an assessment of the readiness to proceed to the procurement phase. The committee is asked to respond to the following charge questions:

1. Are the EEMCAL technical performance requirements complete, documented, and understood?
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 PbWO4 procurement?)
3. Do the present EEEMCAL design and the resulting PbWO4 specifications meet the performance requirements with a low risk of cost increases, schedule delays, and technical problems?
4. Are the fabrication and assembly plans for the EEEMCAL consistent with the overall project and detector schedule and appropriately developed to initiate the PbWO4 procurement?
5. Are the plans for detector integration in the EIC detector appropriately developed to initiate the PbWO4 procurement?
6. Have previous review recommendations been adequately addressed to initiate the PbWO4 procurement?
7. Have ES&H and QA considerations been adequately incorporated in the PbWO4 procurement planning? (This includes a quality assurance plan for receipt of material meeting specifications.)
8. Is the procurement approach sound and the procurement schedule credible?

We would appreciate receiving the committee's report within 14 days of the review's conclusion.

You will be supplied with the report from the earlier calorimetry preliminary design review, with the EEMCAL PbWO4 specifications table, with a copy of ongoing similar PbWO4 crystal procurements, and the crystal performance spreadsheet illustrating the quality assurance process of those crystals.

3.2 Appendix B: Review Committee

Eugene Chudakov (JLab), Dipangkar Dutta (MSU)

3.3 Appendix C: Agenda

Electron-Ion Collider
PbWO4 Crystals FDR

July 21, 2023

(July 21, 2023) via Zoom
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PLENARY SESSION (OPEN)

EST	Topic	Presenter	Duration (Min)
8:00-8:20 AM	Introduction: Backward EMCal physics goals, requirements, expected physics performance with PbWO4	Alexander Bazilevsky	20
8:20-8:40 AM	Mechanical Design	Carlos Munoz	20
8:40-9:00 AM	PbWO4 Specs and QA	Tanja Horn	20
9:00-9:20 AM	Discussion	All	20
9:20-9:50 AM	Executive Session	Review Committee	30
9:50-10:00 AM	Close-out	All	10
10:00 AM	Adjourn		

EXECUTIVE SESSION (CLOSED)
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EST	Topic	Presenter	Duration (Min)
9:20-9:50 AM	Executive Session	Review Committee	30