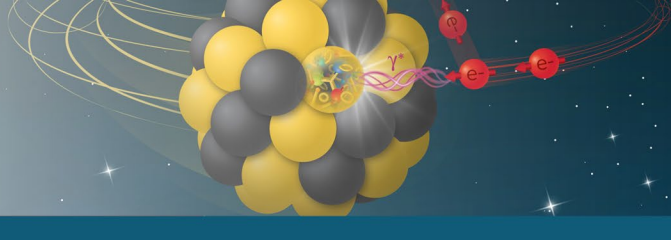

Electron-Ion Collider

Incremental Preliminary Design and Safety Review of the pfRICH, dRICH and hpDIRC

April 1-2, 2025

FINAL

Performed Remotely at Jefferson Lab

Newport News, Virginia

April 1-2, 2025

Table of Contents

1. Executive Summary

We thank the PID detector proponents for the excellent presentations and discussions during the PID Review.

We congratulate the proponents on the significant progress since the last review.

We encourage finalization of designs and beam test with full scale prototypes.

The PID detectors are fully on track for the CD2/3 review on the current project timeline.

2. Responses to Charge Questions

Charge Question 1: Are the technical performance requirements appropriately defined and complete for this stage of the project?

Yes. Detailed assessment in the comments.

Charge Question 2: Are the plans for achieving detector performance and construction sufficiently developed and documented for the present phase of the project?

Yes. Detailed assessment in the comments.

Charge Question 3: Are the current designs and plans for detector and electronics readout likely to achieve the performance requirements with a low risk of cost increases, schedule delays, and technical problems?

Yes. Detailed assessment in the comments.

Charge Question 4: Are the fabrication and assembly plans for the various particle identification detector systems consistent with the overall project and detector schedule?

Yes. Detailed assessment in the comments.

Charge Question 5: Are the plans for detector integration in the EIC detector appropriately developed for the present phase of the project?

Yes. Detailed assessment in the comments.

Charge Question 6: Have ES&H and QA considerations been adequately incorporated into the designs at their present stage?

Yes. All presented projects discussed at a sufficient depth possible ES&H issues and their mitigation. And we expect that the QA plans will become more detailed in time, accompanied by protocols.

Charge Question 7: Have the recommendations from previous reviews been adequately addressed?

Yes, they have been adequately addressed.

3. Comments

Technical performance requirements:

- The interface between the detectors and requirements is now defined through a web interface and easily accessible, addressing a recommendation from the previous review. The requirements on the tracking detectors for the dRICH and hpDIRC are defined and there is progress to demonstrate they are achievable, however more work is needed to demonstrate the required tracking performance is adequate over the full range of polar angles and momenta for individual tracks.

- In the previous review we commented that: "Many studies have been done with standalone simulation and reconstruction; however additional support should be provided for integrating the latest designs and realistic PID performance into the full ePIC simulation." While progress towards this goal was shown during the review, we suggest continued priority be placed on integrated simulations with the full detector to finalize optimizations between detector subsystems

- (pfRICH) The single photon time resolution requirement of ~30-40 ps may be aggressive once the full readout chain is implemented. We suggest to consider if the single photon time resolution requirement can be relaxed, given the complementary information on the t0 provided by the accelerator and primary vertex location.

- (hpDIRC) Simulation and validation should be performed on the potentially relaxed performance requirements for the additional light guide bars, relative to the refurbished BaBar bars.

Detector performance and construction:

- (dRICH) The chromatic error is dominating the overall performance of the aerogel. It is recommended to study the optimization between (a) loss of photon yield and (b) reduction in chromatic error, using a possible optical filter installed after the aerogel tiles.

- Detailed calibration, especially regarding the picosecond single-photon time resolution, will be required. The reviewers would encourage a more detailed breakdown of the calibration procedures in the laboratory and during detector commissioning, including the performance of the optical illumination system.

- (pfRICH) Motivation, possible performance gain, challenges in reconstruction, and installation overheads of funneling mirrors should be carefully examined.

Detector and electronics readout:

- (dRICH/DAQ) High level filtering of interactions through the GTU is being built

into the DAQ design, with the specific example of the dRICH filtering provided. As this is developed the ePIC collaboration should work to understand the dependence between detectors this may introduce and prioritize the external inputs for this online filtering for different detectors.

- (dRICH) In order to optimise the ALCOR time gate, a simulated distribution of the time-of-arrival of the photon signal (and background) on the photon detector plane would be required, together with an evaluation of the main front-end electronics contributions (if any) before the application of the time gate.

- (pfRICH, hpDIRC) It is recommended to perform a more detailed ASIC power simulation, followed by tests as soon as the FCFD or EICROC is delivered, to validate the assigned LV and cooling services.

- (dRICH) Preliminary results from studies of the SiPM array optical window after annealing were shown. A more detailed evaluation of the effect of high-temperature annealing on the shape integrity and optical properties of the resin layer is advised.

Fabrication and assembly plans:

- It was reported that for the dRICH and hpDIRC the full photodetector box will be tested and/or calibrated before installation. For the hpDIRC, quality assurance will be performed on the photodetector modules, sub-vessel and mirrors. It would be encouraged that the hpDIRC explores the possibility to perform a test of the fully cabled and mounted photodetector plane before installation.

Detector integration:

- Global services (cables, cooling, etc.) through the endcaps have been identified, including their impact on the hpDIRC and dRICH positioning. These should continue to be monitored to allow reasonable overhead for packing and inevitable increases as additional services are identified.

4. Recommendations

1. Document the comprehensive test plan for two candidate MCP-PMT photosensors, which are planned to be performed by multiple groups at different locations. This document should evaluate if the complete performance requirements can be met for the pfRICH and hpDIRC, and how to make the final choice.

5. Appendices

5.1 Appendix A: Charge to the Review Committee

Date: March 5, 2025

To: Peter Krizan (U Ljubljana), Floris Keizer (CERN), Ana Amelia Machado (UniCamp), Koji Nakamura (KEK), Justin Stevens (W&M)

From: Elke Aschenauer and Rolf Ent

Subject: Charge for the Incremental Design and Safety Review of the EIC Particle Identification Detectors based on Cerenkov light detection - April 1-2, 2025

The scope of this review includes all aspects of particle identification detectors based on Cherenkov light detection in the central EIC detector, which includes the barrel, the forward endcap, and the backward endcap regions. This includes three detector systems. In particular, a proximity-focusing RICH in the backward region, a high-performance DIRC detector in the barrel region, and a dual RICH detector in the forward region. The review may include design and fabrication choices and their cost-effectiveness, the construction schedule, considerations for safety and quality assurance, levels of redundancy, front-end electronics and interface to the data acquisition system, commissioning and calibration procedures, considerations for materials and labor, operational reliability and longevity, and any other considerations that may influence the construction, maintenance and operation of these particle identification detectors.

Please address the following questions point-by-point:

1. Are the technical performance requirements appropriately defined and complete for this stage of the project?
2. Are the plans for achieving detector performance and construction sufficiently developed and documented for the present phase of the project?
3. Are the current designs and plans for detector and electronics readout likely to achieve the performance requirements with a low risk of cost increases, schedule delays, and technical problems?
4. Are the fabrication and assembly plans for the various particle identification detector systems consistent with the overall project and detector schedule?
5. Are the plans for detector integration in the EIC detector appropriately developed for the present phase of the project?
6. Have ES&H and QA considerations been adequately incorporated into the designs at their present stage?
7. Have the recommendations from previous reviews been adequately addressed?

You will be supplied with the schedule and labor assumptions, copies of presentations and other documentations relevant to this subject material, and the project milestones extracted from the most current EIC resource loaded P6 schedule as part of the pre-brief material.

Note that several aspects of the EIC detector including its electronics, and data acquisition systems have been reviewed previously. Along with your briefing materials, you will also be supplied with the reports from earlier reviews.

cc: Katherine Wilson

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Jefferson Lab is managed by the Jefferson Science Associates, LLC for the U.S. Department of Energy Office of Science

5.2 Appendix B: Review Committee

Peter Križan - Chair	U. Ljubljana	peter.krizan@ijs.si
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Ana Amelia Machado	UniCamp	aameliabm@gmail.com
Koji Nakamura	KEK	koji.nakamura@cern.ch
Justin Stevens	W&M	jrsteven@jlab.org

5.3 Appendix E: Agenda

Incremental Preliminary Design and Safety Review of the pfRICH, dRICH, and hpDIRC

April 1 – 2, 2025

AGENDA

Click here for Zoom (Open Session)

Day 1 – Tuesday, April 1, 2025

Time	Talk	Speaker	Duration
8:00 am	Executive Session	(Closed Session)	20 mins
8:20 am	Welcome and Introduction	Elke Aschenauer / Rolf Ent	20 mins
8:50 am	PID Systems Overview and Requirements	Beni Zihlmann	30 mins
9:30 am	Detector Integration Status and CAD Design	Alex Eslinger	30 mins
10:10 am	Break	All	30 mins
10:40 am	dRICH: Forward PID	Marco Contalbrigo	30 mins
11:25 am	pfRICH: backward Region	Brian Page	30 mins
12:10 pm	hpDIRC: Barrel Region	Grzegorz Kalicy	30 mins
12:55 pm	Quartz Bars: Specifications and Refurbishment	Jochen Schwiening	30 mins
1:35 pm	Lunch	All	25 mins
2:00 pm	Executive session	Closed Session	60 mins

Day 2 – Wednesday, April 2, 2025

Time	Talk	Speaker	Duration
8:00 am	Q&A: dRICH, pfRICH, hpDIRC	All	60 mins
9:00 am	Photo Sensors dRICH	Roberto Preghenella	20 mins
9:25 am	Photo Sensors pfRICH and hpDIRC	Alexander Kiselev	30 mins
10:05 am	DAQ streaming readout Overview	David Abbott	20 mins
10:35 am	Break	All	25 mins
11:00 am	Executive Session	Closed Session	120 mins
1:00 pm	Closeout	All	30 mins