Report of the Detector Advisory Committee on EIC Detector R&D Progress and Proposals

Performed Remotely at Brookhaven National Laboratory

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1. Executive Summary

The detector advisory committee met on August 28 and 31, 2023 to hear reports on R&D proposals for the EIC project. As this review is only a few months before the planned CD-3a review and roughly a year before the CD-2/3 review, the timelines for the various efforts are quite constrained. Overall, the committee found that the proposals focused on important remaining questions for technology choices in the detector.

The report below is organized by the individual proposals presented to the committee.

2. Reponses to Individual Proposals

2.1 Proposal eRD101 – Modular RICH (mRICH)

Findings:

During the past year test beam data from a prototype in Jefferson Lab beam has been analyzed to determine the single photon resolution; multiple ring discrimination studies have now been initiated. Further optimization of the Fresnel lens focal length and detector geometry are under further study.

As the mRICH is no longer a baseline technology for the ePIC detector, there is no funding request for FY24, and the research group has reorganized its efforts to use the mRICH prototype as a tool to characterize aerogel and photosensors performance.

Comments:

The committee was impressed with the comparison of experimental single photon resolution with simulation, which suggests that the prototype detector response is well understood. We encourage this group to join other detectors groups using aerogel and photosensors to allow the use of the mRICH prototype in testing.

Recommendations:

No specific recommendations

2.2 Proposal eRD102 – Dual Radiator RICH (dRICH)

Findings:

The dRICH detector is a RICH with two radiators, aerogel with refractive index ~1.02 and gas C_2F_6, using SiPMs for photon detection. The detector is in an advanced design stage. The collaboration has decided on the SiPM type and has tested it for radiation damage. At present, the collaboration is planning to control the dark count rate by cooling the SiPM to -30°C.

Test beam data and simulations shows that the design meets the overall performance requirements, however the current aerogel quality (from test samples) does not meet the requirements for the detector. We also note that the EIC PID detectors had a review in July 2023 that resulted in certain recommendations.

Comments:

We note that the chosen gas radiator has significant global warming potential, and is likely to have significant use restrictions. The design of a leak tight vessel and gas circulation system to reduce leaks of any gas while also maintaining the required gas purity may impact the infrastructure interfaces and is likely to be non-trivial. Government restrictions are likely to be even more restrictive in the future, so a conservative design is warranted.

There was concern that multiple close tracks could affect the particle ID determination as association between photons and radiator becomes difficult, especially since the space for the photon detectors is very limited and the geometry of the focal surface is complicated. We also note that condensation from the coolant needs to be taken into account in the design of the services infrastructure, especially around electrical connectors.

Recommendations:

1) We encourage the dRICH group to follow the recommendations from the July 2023 PID review.
2) The SiPM studies for the Long Lead Procurement should be finalized as soon as possible. The procurement should be carried out with a close relationship with the manufacturer to monitor fabrication progress and quality.
3) It is important to understand the aerogel quality issues and give feedback to this manufacturer in order to allow time for the production of aerogel which meets the requirements of the detector.
4) We recommend that a detailed design of the gas box and circulation system be given high priority.
5) To address concerns with multiple track PID, we recommend the implementation in the simulation of the expected backgrounds from the accelerator and study performance in the presence of overlapping tracks.
6) We recommend the development of a detailed design of the mechanical support of the photon detectors, as the arrangement seems complex.
7) We support the development and testing of the full-scale prototype.
8) The parameters of the annealing of the SiPMs should be studied to ensure they don't affect neighbouring systems.

2.3 Proposal eRD103 – High Performance DIRC (hpDIRC)

Findings:

The goals expressed in the proposal are to achieve the required performance, minimize any technical risks and to realize opportunities from other DIRC groups. Progress over the last year includes transferring prototype DIRC components from the GSI laboratory (Darmstadt) to Stony Brook University (SBU), completing the simulation and mechanical design of the cosmic ray telescope (CRT), and advancing facility construction at Jefferson Lab and SBU. The CRT will be used to perform three functions. It will enable prompt testing of radiator bars from the disassembly of the BaBar DIRC bar boxes at Jefferson Lab. Secondly, it will be used to test the readout chain as photosensors and readout electronics become available. Finally, quality control (QC) of the completed hpDIRC bar boxes during production will be carried out. The CRT needs to be commissioned during FY24. The accepted event rates in the CRT for different trigger conditions will be determined during commissioning of the system.

The bar boxes from SLAC will be transported to Jefferson Lab in fall 2023, where they will be disassembled. At that time the bars will be cleaned, inspected and evaluated for optical quality.

Travel funds are requested for experts from Catholic University of America (CUA) and GSI to support the prototype installation and commissioning. Also, existing photosensors for the CRT no longer show sufficient single-photon sensitivity and need to be replaced. Funding is requested for a new set of phototubes.

Comments:

The setup of the CRT at SBU is well underway. A 3D stage has been purchased and the prototype DIRC from GSI will be installed there later this summer/fall. The Geant4 simulation of the entire setup has been completed, including the integration into the full EIC simulation packages. Once the prototype DIRC assembly has been completed, it will be installed in the CRT together with the readout electronics. This will allow to exercise the DAQ system, which we strongly encourage.

The committee would like to understand what will be planned in the case that not all the Babar bars are of sufficient quality.

Recommendations:

1) Continue to ensure sufficient funding, communication, and collaboration with the various DIRC experts in the group as well as experts from the original SLAC bars in order to facilitate a smooth and time efficient installation and commissioning phase.

2.4 Proposal eRD104 – Silicon Services Reduction

Findings:

The community proposes R&D towards a serial-powering scheme to reduce the material contribution from power-cabling. They have studied this, based on their experience of a similar approach in ATLAS, and have started the design of an integrated shunt-LDO circuit together with architectural studies. They have also studied a standalone alternative for the shunt-LDO.

They also propose an electrical-optical conversion on detector to reduce the material contribution from data cabling and have identified options for the electrical and optical parts. Funding/procurements delays hindered the progress so far. They have also studied the readout implementation for ALICE-ITS3.

Comments:

The committee would like to understand how the shunt-LDO prototyping is planned and funded. The 'standalone' option allows flexibility to use MPW submission on TJ180 (or similar) while the integrated shunt-LDO is a large deviation from the 'baseline' ITS3 design. We note therefore that the standalone shunt-LDO is a more promising route for the R&D.

Two of the options for readout (PolarFire FPGA and Firefly Transceiver) are off-the-shelf and would likely require radiation testing. If not already included, we strongly encourage that this be part of the planned characterization, and that radiation facilities and funding be identified.

Recommendations:

1) The switch to serial-powering is a significant change and is a large R&D effort requiring both ASIC and system design. Hardware prototyping is essential to prove its viability and the community should strive to advance with this as quickly as possible. The planned submission of the LAS v1 chip in Q1-2025 requires rapid closure of the R&D in 2024.
2) There is potential synergy with ALICE-ITS3 on the readout links and this should be investigated thoroughly for the ePIC case. The ALICE system will use radiation-proven parts so requirements on radiation testing would be minimized. Access to these parts would likely require a request to CERN.

2.5 Proposal eRD105 – Scintillating Glass (SciGlass)

Findings:

We congratulate the SciGlass group on the successful production of large size SciGlass blocks (40cm). Light transmittance of the blocks has been studied along the length of blocks. Readout from the blocks using SiPM photosensors was successfully implemented. Beam tests using 3x3 and 5x5 arrays were performed at Jefferson Lab using electron test beam. Analysis of the data from the 3x3 array suggests transverse leakage of the shower. Results from the 5x5 array were less clear, and it is expected that further readout optimization is necessary in order to understand the performance of the SciGlass.

Comments:

Although no longer a baseline technology for the detector, the committee considers this is a very interesting material which should be studied further in order to understand intrinsic performance, details of light transmittance and effects of irradiation.

Recommendations:

1) The committee recommends proposing continued study in the EIC Generic R&D program.

2.6 Proposal eRD106 - Forward EM Calorimeter

Findings:

The forward EM calorimeter is based on molded Tungsten/Scintillating Fibers components. Delays in the arrangement of the funding from the FY23 grant only allowed the start of work on in August 2023. The group has further developed the mechanical design and has performed a support (shear) test. The molding facilities at Fudan have been developed and supplies for an initial prototype have been delivered. Optimization of the light guide design is on-going, focusing on more uniform illumination of the photosensor. In-beam tests of a prototype at Fermilab are planned in late 2023, although there is apparently some uncertainty in the beam schedule. Going forward into FY24, this effort is expected to be supported by PED funds.

Comments:

We note that the late funding allowed little time to complete necessary R&D in time for CD2/3. This resulted in delay of production runs at Fudan with concomitant testing. The goals of the Fermilab beam tests were not described and would have been useful.

Recommendations:

1) We recommend that the group focus on remaining open questions and produce a final design for the rapidly approaching CD2/3 review.

2.7 Proposal eRD107 – Forward Hadron Calorimeter (hCAL)

Findings:

The previous design of the hCAL has been changed to an iron/scintillating tile readout with SiPM's mounted on the tiles (instead of a fiber readout). The SiPM design is based on CALICE and shared with CMS HGCAL upgrade. Substantial work has been done on developing fabrication techniques. The detectors will not be accessible for long periods, hence they need to be radiation tolerant.

Present design consists of two parts: an outer part with 5 cm segmentation and 7 longitudinal sections, and an inner part 'insert' not yet fully specified as optimization studies need to be done.

Beam tests at CERN are planned in 2023 and 2024. The tests in 2023 will be with individual tiles and absorbers while those in 2024 will test modules manufactured in two different ways.

Comments:

More detail on the 2023 test status would be useful, especially specific goals and results. Fabrication testing is well underway and there is a strong team to perform the physical design/fabrication studies. Full optimization of the design, in particular the insert granularity, depends on simulation and was not yet complete as of July 23. The presentation at this meeting provided an update that the only remaining issue was the segmentation of the insert readout, which does not affect the mechanical design. We encourage the test beam runs at CERN as they are important for final design/integration decisions. Overall, the technology seems to be well demonstrated and the design is well advanced but with some optimization/fabrication/system tests still needing to be performed.

Recommendations:

1) Ensure sufficient funding/staffing/lead time to support CERN beam tests.

2.8 Proposal eRD108 – Micro-Pattern Gas Detectors R&D

2.8.1 Micromegas Barrel Tracker

Findings:

Beam testing of several configurations of small prototypes, with varying resistive layer and readout patterns, was carried out. No results are shown from the beam testing. A full-scale prototype section with the selected readout patterns is under design. A new configuration of the MPGD systems for ePIC evolved in mid-2023 with an inner barrel layer consisting of three cylindrical sections.

Comments:

The committee would like to know the results of the beam tests at MAMI and how these results impact the new inner barrel layer design. The new design indicates a close interaction of the services (power, cooling, readout) between SVT and the MM inner barrel layer. A conceptual design for these services and their impact the tracking coverage is needed. We note that the timeline and milestones indicated for FY24 seem to stretch well into FY25 and probably impact readiness for CD2/CD3 review.

Recommendations:

1) Resolve issues between DAQ systems for MM prototype and beam telescope. Produce beam test results from MAMI.
2) Continue with full scale prototyping, focusing on critical issues to prepare for CD2/3.
3) Complete thin-gap design studies as soon as possible.

2.8.2 Cylindrical μRWELL Prototype

Findings:

A prototype was constructed to investigate this technology as a backup for the baseline cylindrical MM approach. Due to interruption of operations for safety issues at the lab no data was taken with the prototype. Modifications to the drift foil and its support are planned followed by lab testing with cosmics and sources. No further funding is requested for FY24.

Comments:

The committee questions whether further development of this technology for the inner barrel layer is still prudent as risk mitigation for the MM technology approach, particularly in view of the effort needed for the endcap detectors (discussed below).

Recommendations:

1) Recommend test beam studies of existing prototype as soon as possible as a backup in case thin-gap MM solution is not viable.

2.8.3 Endcap μRWELL layers

Findings:

To provide additional tracking hits in the endcap regions of ePIC two planar MPGD disks at each end were added to the baseline design. An additional benefit would be providing fast hit points for background rejection.

Comments:

The committee is concerned that one year is a very short time to accomplish the design and development of new large-area μRWELL chambers particularly given the issue of charge-up and chamber integrity using light-weight materials. Given this short time, reliance on students for design tasks poses a risk.

The anticipated one-year needed for the CERN workshop to design, develop, and fabricate large-area μRWELL foils pushes chamber construction and testing well into FY25. The possibility of no beam testing of large area μRWELL chambers poses a significant risk. A plan for the proposed strategy and a study of the impact of the services for the forward disks is needed.

Recommendations:

1) Explore the possibility of employing professional design engineers.
2) Accelerate the design and development of a prototype.
3) Plan for earliest possible beam tests of a prototype as this is a new technology employed on a large scale.

2.8.4 Outer Barrel μRWELL Layer

Findings:

A layer of planar μRWELL chambers, using a hybrid GEM-μRWELL technology, arranged around a circle is proposed for the outer barrel tracking layer in front of the hpDIRC. These chambers will provide fast timing hits as an aid to pattern recognition and improve the determination of the angles of charged particles entering the hpDIRC. A full-size prototype is planned to address stability issues albeit with a mock μRWELL foil.

Comments:

The committee is concerned that many technical challenges (foil stretching, low mass materials, HV stability) must be overcome in a short time period to create a reliable final design. Again, there is a risk posed by using a Ph.D. student to design and fabricate the prototype.

Recommendations:

1) Explore the possibility of employing professional design engineers.
2) Plan for construction and testing of a full-scale prototype with actual μRWELL foil.

2.9 Proposal eRD109 – ASICS and Readout Electronics

Findings:

A total of 5 distinct proposals for FY24 funding were submitted in July 2023 to the eRD109 R&D project in support for R&D efforts related to ASIC and electronics R&D needs, and which consist in continuation of previous work.

The duration of the needed R&D efforts, driven by ASICs development timescale, will continue well beyond CD-2/3, and requires continued careful monitoring.

It is noted that contract awards for FY23 Project R&D funding, for some proposals, took longer than expected to get setup impacting progress on some of the originally planned FY23 activities. Nevertheless, several milestones in each of the proposals were achieved in this past one year.

We note an increase in the scope of the work submitted in FY24 for Proposal B (Calorimeter SiPMs readout based on the H2GCROC ASIC). Based on recent discussions with designers at the OMEGA/IN2P3 lab, instead of employing the H2GCROCv3 ASIC as is, it is now proposed to modify the H2GCROCv3 design into a new chip variant (ePIROC) that will have a simplified backend adapted to the streaming readout needs of the EIC. We note that the re-design of the H2GCROCv3 backend is already in progress. The impact of this modification in the scope of the proposed efforts on the overall schedule should be small, and the benefits of providing an EIC-tailored readout solution far outweigh the risk associated with the proposed R&D activities.

Comments:

The committee asks that, for future reviews, written progress reports for R&D activities in the eRD109 project be made available to the committee ahead of the open meeting presentations.

The committee recognizes the blurry line that exists between activities deemed as belonging to Project R&D and to Project Engineering Design (PED), but nevertheless notes that several of the activities described in the scope of Proposal A (Calorimeter SiPMs readout based on Discrete/COTS components) could also belong to engineering development activities rather than addressing technical risk milestones that remain.

It is important for all the proposed R&D efforts to develop and test a full readout system (e.g. from detector to electronics hut).

Recommendations:

1) The proposed R&D activities are high priority and continued funding is recommended.
2) Given the tight development timeline of the proposed activities, we recommend that special attention be given to minimize any possible future administrative delays that could impact schedule (e.g. contract awards).
3) There is an extensive list of non-ASIC details that need consideration in the development of a full readout solution for the different subdetector systems that should be addressed by board-level R&D. It is essential that all the different research groups maintain good communication with each other so that experience is quickly disseminated, and common solutions adopted.
4) Close monitoring of ASIC development timelines and testing is recommended given the tight overall EIC project schedule and the fact that these ASIC development timelines are often underestimated.
5) We recommend continuing to move forward as quickly as possible to integrate readout solutions, developed as part of the eRD109 efforts, to the various relevant subdetector integration tests.
6) Proposals related to ASIC development activities are encouraged to make sure to consider potential additional cost of chip packaging in future years budget requests

2.10 Proposal eRD110 – Photosensors and HRPPD

Findings:

Good progress overall has been achieved from the eRD110 project. In particular, important measurements have been performed (*e.g.*, preliminary magnetic field tolerance and timing studies) and ingenious concepts developed (*e.g.,* development of a DC-coupled HRPPD interface).

The FY24 proposal clearly addresses technical risk related to the baseline readout sensors of the EIC electron-side and barrel Cherenkov detectors, the Incom HRPPDs, and it is essential that the proposed activities be pursued.

Comments:

A large effort must be maintained in the near future in order to understand if this is a viable technology for the baseline detector. The EIC-Incom PED contract recently signed by Incom and JLAB includes the production of 5 HRPPDs in March 2024 for thorough evaluation by the EIC groups. The committee suggests exploring the possibility of producing more than 5 HRPPDs in order to ensure that studies of these photosensors by different groups can take place in parallel while accounting for the risk associated with a yet unknown device yield. Additional photosensors could also be used in initial detector integration tests.

The committee also sees the need to compare expected ageing effects between HRPPDs and MCP-PMTs under expected operational environmental conditions and over the typical detector lifetime.

Recommendations:

1) The proposed R&D activities are high priority and continued funding is recommended.
2) The longevity of the proposed photosensor as a result of their operation with increased MCP voltage that may be necessary to maintain the desirable gain when operated under high magnetic field environment should be studied.
3) While good progress has been made to date, the development of new vacuum photosensors is challenging and R&D activities may well extend beyond the currently planned schedule and should be monitored closely. These activities must also ensure the viability and availability of the backup option(s) in case of failure of the baseline.

2.11 Proposal eRD111 – Silicon Tracker Modules, Mechanics, Cooling and Integration

Findings:

The community has made good use of the close contacts to the ALICE community, in particular in the successful demonstration of bending dummy-ALPIDE chips to the ITS3 innermost radius and connecting them with FPCs. This has allowed the construction of a prototype tracker layer using dummy components.

Air-cooling studies have advanced with carbon fibre + foam structures. The benchmark of a DT of 10C has been achieved with conducting carbon foam, which is encouraging for the prospect of air cooling. Simulations have been made to evaluate the presence of the air-flow on the beam-pipe bakeout, indicating that further study is required. The restrictions on the sensor-length variations imposed by the foundry triggered new layout considerations and CAD modelling.

Comments:

The committee encourages investigating the possibility of accessing prototype parts from ER1 in order to carry out integration tests. We also encourage the R&D concepts from eRD104 to be included in the integration modelling here. For example, the use of the concept of the 'Data Management Board' borrowed from ALICE and the FPC.

Recommendations

1) We recommend the group to proceed as fast as possible to prototyping bent structures using active ALPIDE parts or, even better, parts from ER1.
2) We encourage this group to build strong communication with the eRD104 group for FPC and readout concept and design.

2.12 Proposal eRD112 – AC-LGADs

Findings:

This project is dedicated to advancing the AC-LGAD technology, intended for implementation in multiple crucial subdetectors: the main detector of TOF, as well as in the far-forward and far-backward instrumentation along the beam line adjacent to the main detector. Large efforts are proposed to be made on not only the fabrication of AC-LGADs but also the readout electronics including ASICs. Many institutions are involved in the project and made good progress due to a well-organized R&D proposal.

By FY23, both BNL and commercial vendors have produced prototypes of the sensor, substantially reducing risks. The beam testing at Fermilab on these sensors are ongoing, and have achieved some positive results. The timing resolution and position resolution of the pixel sensors produced by HPK have reached 20ps and 20um respectively. The development of the first prototype of the low-mass mechanical support structure has been completed. There are plans to continue further testing of sensor prototypes and to develop multiple versions of the mechanical support structure. Additionally, the possibility of introducing another vender, FBK, will be considered.

Comments:

Compared to FY22, significant progress has been made in this project, especially in the development of the sensor. So far, the results look promising and are in line with the project timeline. Clearly, continuing the research on sensor production options is still crucial, whether at BNL or with commercial venders. The current US-Japan collaboration may benefit by scheduling the mass production at HPK. This will mitigate risks.

According to simulations based on the latest simulation framework, the material budget requirements for the forward TOF and the spatial resolution requirements for the B0 tracker have both been significantly changed to be stricter. The timing resolution requirement of the barrel TOF has been slightly relaxes as well as the material budget for the B0 tracker. The

research team plans to continue the study of a common design to reduce costs and risks. At the same time, attention should also be given to whether the original design can meet the significantly more demanding performance requirements of these individual detectors. More detailed checks are suggested to see if there are other requirement changes.

Since there are several commercial vendors involved, ensuring enough funding contingency is something that needs to be considered due to the fluctuations in the international supply chain prices.

Recommendations:

1) Continue the study on sensor fabrications options in various vendors.
2) Using the latest simulation frame, further check if there are crucial performance requirements that have changed in related individual detectors to meet the goals of EIC physics program.
3) Continue the material budget study based on whole system including sensor, bounding base, supporting structure and other integration materials.

2.13 Proposal eRD113 – Silicon Tracker Sensor Development and Characterization

Findings:

Together with the ALICE community, there has been significant progress on the validation of the TJ65 process with MLR1, then ER1. Multiple building blocks were submitted and many from MLR1 have been tested, including some radiation testing. Designs of other blocks customized for the EIC application were delayed waiting for funding approval and are carried forward to FY24. First discussions on a collaboration agreement with ALICE were held, paving the way for contact between designers. EIC institutes became more and more active in testing of structures from TJ65, including calibration with radioactive sources. A telescope was developed for test beam activities and is available for EIC use.

Comments:

The committee is pleased to hear that more direct connection has been established with the ALICE collaboration. It is important that the EIC group be granted access to the ALICE designs with a formal collaboration agreement in place. This is vital for an EIC outer-barrel design submission targeted for Q1-2025.

The detector construction relies on stitching. We recommend a study on what yield is acceptable, if not already available.

Recommendations:

1) We recommend that this group advance as quickly as possible to finalize the collaboration agreement with ALICE and integrate designers in the team at CERN.
2) We also encourage this group to foster strong ties with eRD104 to ensure the correct consideration in the MAPS design of the systems aspects of both serial-powering and readout links.

2.14 Proposal eRD114 – Proximity Focusing RICH (pfRICH)

Findings:

The proximity focusing RICH (pfRICH) is the new baseline endcap RICH detector replacing the mRICH. The design uses aerogel (refractive index ~1.04) with HRPPDs as the baseline for the photon detectors. Low mass mirrors on the outer and inner edge of the vessel improve light collection.

Simulations of the current design show that it meets the specifications for particle ID. We note that the pfRICH provides "t_0" for other subsystems with a 20 ps time resolution for each track. Five HRPPDs are expected from Incom by March 2024; no details were presented of a backup plan using different photosensors if the HRPPDs fail to meet the specifications. A "60 degree" prototype is planned to be constructed in order to verify all production components.

Comments:

The overall design is similar to the Belle II aerogel RICH, a detector that has been working as expected. Although the design is in its early stages, the concept is based on existing experience. There is significant risk for the photon detectors not meeting the requirements of the experiment, however. Experience from the "60 degree" prototype should provide proof of the performance of the detector. We also note that this detector was reviewed by a PID panel in July 2023.

Recommendations:

1) We endorse and support the recommendations of the July 2023 PID review.
2) We recommend the implementation of expected accelerator backgrounds in the detector simulation and the study of the effect of multiple overlapping tracks on performance.
3) We recommend establishing the ability of the photon detectors to provide a precise t_0 for the TOF detectors.
4) We encourage the group to establish a good relationship with Incom and follow up on HRPPD developments.
5) We strongly support the development of the "60 degree" prototype and the verification that the aerogel properties meet the design requirements.

2.15 Proposal eRD115 – Imaging Barrel EM Calorimeter (bECAL)

Findings:

This is a new FY24 R&D proposal related to the final technology choice for the EM Barrel (bECAL) calorimeter. The new selected option, adopted after FDR of March 2023, replaced the Sci glass option with a new Imaging Calorimeter concept. This Imaging Calorimeter combines the well-established Pb/SciFi technology (Kloe and Gluex with SiPM readout) with a well performing position detector developed for AstroParticles, ASTROPIX.
The design shows a pre-shower region with 4 (baseline) to 6 (optional) layers of ASTROPIX interleaved with short Pb/SciFi sections (SFIL) followed by a traditional EM section.

From simulation, this calorimeter can achieve an energy resolution like that of the GlueX EMCal (5%/sqrt(E)) while dramatically improving the position and angular resolution, from O(cm) to better than 0.5 mm arising from the chosen pixel size. The design with 6 ASTROPIX/SFIL layers matches/surpasses the required bECAL performance for e/π and π^0/γ separation in all required energy ranges.

This R&D group proposes to assemble, operate, and characterize a small-scale hybrid detector realized with different combinations of ASTROPIX and SFIL sections, followed by a small size Pb/SciFi Gluex prototype (baby BCAL). The baby BCAL is identical in composition and cross-section dimension to the GlueX calorimeter but is shorter longitudinally. Goals of the R&D proposal are to benchmark the combined performance, validate the simulation and test integration by exposing the prototypes (FNAL test beam) to e/π beams from 5 to 30 GeV. A long list of tasks/milestones is presented. Three different aspects are considered:

a) A practical organization for integrating the different mechanical structure configurations, the readout and triggering.
b) Extract experimental results on energy, position resolution and e/π separation for different configurations of the hybrid detector.
c) Perform a detailed data-simulation comparison. This work will feed the general simulation to improve fidelity on the e/π shower profiles and the achievable e/π separation.

Comments:

The proposed R&D plan is detailed and ambitious, but it is important for the evaluation of the final detector performance and for its realization, due to the difficulty to integrate such different technologies in such a short time. The test beam plan is crucial to demonstrate that there are not unwanted problems and can provide a first test bed for integration.
We commend the team for the rapid organization of this program from the earlier Athena proposal and provide our support to the proposed plan.

The team demonstrated a lot of expertise on the Pb/SciFi and ASTROPIX sides. There are many upcoming changes on the usable layouts and on the ASTROPIX versions (from 2x2 cc to quad 2x2 cc to other layouts, to ASTROPIX-V4). The R&D program outlined is only one year long and some of the ASTROPIX changes look as if they are coming late in the game. We suggest the proponents to not sacrifice any available beam time for running and understanding the data; these will speed-up design of further configurations that can be carried out also without beam.

Characterization of the high energy side and determination of the detector's linearity in response for the electrons is very relevant for this detector. The dynamic range of the GlueX apparatus has been changed from few GeV up to 50 GeV (for the electrons) and it is not immediately evident that the selected SiPM pixel size (50 um as used in GlueX) will not suffer non-linearity at the highest energy points.

Recommendations:

1) The test beam should be used for testing the readout section with SiPMs of different pixel size to be sure that linearity is proven before starting the SiPM LLP. Test of different sensors is already foreseen in Milestone N.9 and our request can be accommodated in this framework.
2) In case it is needed, we recommend the prioritization of the efforts related to testing the e/π response with respect to more advanced integration efforts (mechanics, DAQ, triggering) since many of those can be carried out, independently from the FNAL test beam, also with cosmic ray data acquired at a later time at a parallel stage of development.

3. General Comments and Recommendations

1) The committee wishes to applaud and congratulate the various R&D groups on their enormous recent progress in the face of the CD 2/3 review in roughly a year from now.
2) Many of these efforts are crucial to a final design, especially those from recently chosen technologies, e.g. the pfRICH and the bECAL.
3) We encourage those groups whose efforts will extend past FY24 to maintain expertise and manpower as they transition to the final detector design, assembly, installation and commissioning.
4) We encourage all R&D groups to incorporate the planned ASIC/readout electronics in their tests as soon as possible in order to gain experience and uncover any needed changes.

4. Appendices

4.1 Appendix A: Charge to the Review Committee

Charge to EIC Detector Advisory Committee – 7th Meeting August 28 & 31, 2023

The EIC Detector Advisory Committee (DAC) provides advice to the EIC project managed by BNL in partnership with Thomas Jefferson National Accelerator Facility (TJNAF) on the experimental equipment and on overall matters with respect to the scientific collaboration, ePIC. This includes advice on the suitability of the experimental equipment for the EIC science, on cost, schedule and technical risk of detector components and design choices, and relative importance of technical tasks, on evaluation of complementary EIC detector technologies and the sub-detector integration, detector-interaction region integration, and detector commissioning, and on the EIC-related detector R&D.

Critical Decision-One (CD-1) for the EIC was awarded on June 29, 2021, and allowed for release of Project Engineering and Design (PED) funds. This initiated the next phases of design of accelerator and detector. The 2022 EIC funding from the Inflation Reduction Act allowed the EIC project to stay on pace, with the EIC project aiming for receiving CD-3A (start of long-lead procurements) early 2024 and CD-2/CD-3 (baseline approval and start of construction) roughly one year later.

The March 2021 DAC meeting concentrated on the transition from the successful 2011-2021 EIC-related generic detector R&D program (https://wiki.bnl.gov/conferences/index.php/EIC_R%25D) to the Project detector R&D program, and on giving advice for opportunities and priorities for a generic EIC detector R&D program. Since that time:

- In late 2021 and early 2022, the DAC provided advice to an ad-hoc Detector Proposal Advisory Panel for the EIC detector proposal and selection process. This has now evolved in the formal ePIC detector collaboration.
- The EIC Project started the project detector R&D late Summer 2022 with FY22 awards.
- The October 2022 DAC meeting provided advice on FY23 project detector R&D priorities.
- Jefferson Lab, in association with Brookhaven National Lab and the DOE Office of Nuclear Physics, has restarted a generic detector R&D program to address the scientific requirements for measurements at the future Electron Ion Collider. This program is overseen by a dedicated advisory panel.

The 6th and 7th DAC meeting will occur in the same week, where two days will be dedicated to a comprehensive design review of the ePIC detector where you will also hear the overall progress and status of the EIC Project, and two days dedicated to the review of the ongoing EIC project detector R&D and possible continuations.

For the August 2023 DAC meeting dedicated to R&D we welcome your guidance and advice on:

- The status and progress from all ongoing projects eRD101 to eRD113. What milestones were achieved. How did our understanding improve. What is left to do?
- If applicable, the plans for remaining EIC project detector R&D for eRD102, eRD103, eRD104, eRD106, eRD107, eRD108, eRD109, eRD110, eRD111, eRD112, and eRD113. These may submit continuation proposals if and only if technical risk milestones remain.
  eRD101 and eRD105 are concluded as the ePIC collaboration has recently made the decision for a technology change for the backward RICH and the barrel ECal.
- The request for EIC project detector R&D for eRD114 and eRD115 that follow these two final detector technology selections for the ePIC detector.
- Further planning for the outyears of the EIC Project detector R&D as documented in the "Assessment of R&D Needs for an EIC Detector" (EIC Detector R&D) document.
- What do you see as priorities?

References:
DAC Meeting Agenda 19th – 21st 2022: https://indico.bnl.gov/event/17159/
FY23 detector R&D proposals: https://wiki.bnl.gov/conferences/index.php/ProjectRandDFY23
FY22 detector R&D: https://wiki.bnl.gov/conferences/index.php/ProjectRandDFY22

EIC Detector R&D plan:
https://brookhavenlab.sharepoint.com/:b:/s/eRHIC/dac/EbW5yq6lSvhNnWEqTNC-xNEB4hiKMzYW93almUKXdJWlBw?e=t2xa88

Generic EIC-related Detector R&D Program: https://www.jlab.org/research/eic_rd_prgm
Received proposals: https://www.jlab.org/research/eic_rd_prgm/receivedproposals

4.2 Appendix B: Review Committee

E. Auffray, E. Kinney, P. Križan, A. Machado, P. Merkel, S. Miscetti, A. Papanestis, H. Schellman, B. Vachon, A. White, K. Wyllie, C. Yang

4.3 Appendix E: Agenda

EIC Project R&D - DAC Meeting (Aug 2023) - Aug 28, 2023 - Aug 31, 2023
Daily Program: Monday, August 28, 2023

Contribution: eRD104/eRD111/eRD113: Si Tracker/MAPS/Serv. Reduction
Time and Place: (Aug 28, 2023 - Aug 28, 2023)
Presenter: : Ernst Sichtermann

Contribution: eRD108: MPGDs
Time and Place: (Aug 28, 2023 - Aug 28, 2023)
Presenters: : Francesco Bossu; Matt Posik

Contribution: Break
Time and Place: (Aug 28, 2023 - Aug 28, 2023)

Contribution: eRD105: SciGlass
Time and Place: (Aug 28, 2023 - Aug 28, 2023)
Presenter: : Joshua Crafts

Contribution: eRD106: Fwd EMCAL
Time and Place: (Aug 28, 2023 - Aug 28, 2023)
Presenter: : oleg tsai

Contribution: eRD107: Fwd HCAL
Time and Place: (Aug 28, 2023 - Aug 28, 2023)
Presenter: : Friederike Bock

Contribution: eRD115: Imaging Cal
Time and Place: (Aug 28, 2023 - Aug 28, 2023)
Presenter: : Maria Zurek

Contribution: Break
Time and Place: (Aug 28, 2023 - Aug 28, 2023)

Contribution: eRD112: AC-LGAD
Time and Place: (Aug 28, 2023 - Aug 28, 2023)
Presenter: : Zhenyu Ye

Contribution: DAC Meeting/Discussion
Time and Place: (Aug 28, 2023 - Aug 28, 2023)

EIC Project R&D - DAC Meeting (Aug 2023) - Aug 28, 2023 - Aug 31, 2023
Daily Program: Thursday, August 31, 2023

Contribution: eRD101: mRICH
Time and Place: (Aug 31, 2023 - Aug 31, 2023)
Presenter: : Murad Sarsour

Contribution: eRD102: dRICH
Time and Place: (Aug 31, 2023 - Aug 31, 2023)
Presenter: : Marco Contalbrigo

Contribution: eRD103: hpDIRC
Time and Place: (Aug 31, 2023 - Aug 31, 2023)
Presenter: : Grzegorz Kalicy

Contribution: Break
Time and Place: (Aug 31, 2023 - Aug 31, 2023)

Contribution: eRD110: Photosensors/HRPPD
Time and Place: (Aug 31, 2023 - Aug 31, 2023)
Presenters: : Alexander Kiselev; Pietro Antonioli

Contribution: eRD114: pfRICH
Time and Place: (Aug 31, 2023 - Aug 31, 2023)
Presenter: : Alexander Kiselev

Contribution: Break
Time and Place: (Aug 31, 2023 - Aug 31, 2023)

Contribution: eRD109: ASICs/Electronic
Time and Place: (Aug 31, 2023 - Aug 31, 2023)
Presenter: : Fernando Barbosa

Contribution: DAC Meeting/Discussion
Time and Place: (Aug 31, 2023 - Aug 31, 2023)

Contribution: Close-Out
Time and Place: (Aug 31, 2023 - Aug 31, 2023)