ELECTRON-ION COLLIDER DETECTOR ADVISORY COMMITTEE

Report of the 11^{th} Meeting held on Wednesday and Thursday, 6 – 7 July, 2016

BNL, in association with Jefferson Laboratory and the DOE Office of Nuclear Physics, has established a generic detector R&D program to address the scientific requirements for measurements at a future Electron Ion Collider (EIC). The primary goals of this program are to develop detector concepts and technologies that are suited to experiments in an EIC environment, and to help ensure that the techniques and resources for implementing these technologies are well established within the EIC user community.

The EIC Detector Advisory Committee meets twice a year, typically in January and in June. During the January meeting progress reports are reviewed and feedback provided to the proponents. During the June meeting both progress reports and new proposals are reviewed. Funding recommendations for continuation of existing and for new proposals are provided to the program manager in advance of the fiscal year funding cycle.

The EIC Detector Advisory Committee met at Argonne on July 6 and 7, 2016. The meeting was immediately followed by the EIC User Meeting, which was also held at Argonne. The meetings were coordinated to allow maximum participation of the community in both meetings. The Committee members are: M. Demarteau (ANL/Chair), C. Haber (LBNL), P. Krizan (Hamburg), I. Shipsey (Purdue/Oxford), R. Van Berg (U. Pennsylvania), J. Va'vra (SLAC), G. Young (JLab). Peter Krizan was unable to attend the meeting due to prior commitments to the Belle experiment in Japan. Progress reports and new proposals were submitted before the meeting and were evaluated by the committee.

This meeting was the first meeting of the EIC Detector Advisory Committee after the release of the long-range plan of the Nuclear Physics Science Advisory Committee in October of last year. The interest in the program has increased substantially since the release of the report. A large number of new proposals was evaluated. The committee especially appreciates the international interest in the EIC with participation from INFN, Trieste, the University of Birmingham, Birmingham and the Weizmann Institute of Science, Rehovot, in addition to the existing international participation of CEA Saclay, GSI Darmstadt, INFN Rome and Ferrara, IPN, Orsay, the University of Science and Technology of China, Hefei, the Universidad Técnica Federico Santa María, Valparaiso, and the Yerevan Physics Institute, Yerevan. A science assessment of the EIC is now being carried out by the National Academy with a resolution expected by the end of 2017.

The DOE has initiated a $7M program for accelerator R&D shared between various national laboratories. It is recognized in the long-range report that U.S. leadership in nuclear physics requires tools and techniques that are state-of-the-art or beyond. Although vigorous targeted detector R&D for the Electron Ion Collider is recommended to ensure that this exciting scientific opportunity can be fully realized, regretfully no commitment to support detector R&D has been realized yet. Although many of the proposals received target valuable detector research for the EIC, the program remains heavily oversubscribed. A total of 17 proposals were received, of which eight were new proposals. One project, eRD12 studying polarimetry, luminosity measurement and a low Q^2 tagger for the EIC has successfully completed its research program. The committee would like to applaud the eRD12 for completing the proposed research program on budget and on schedule and providing valuable research tools for the community.

General Remarks

The meeting benefited from having the Detector Advisory Committee Meeting and the EIC Users Meeting sequentially. Nearly all attendees participated in both meetings. EIC physics overview talks were given at the opening of the detector advisory meeting that gave an overview of the detector requirements and R&D needs required to reach the EIC physics goals.

The proponents are to be congratulated on the generally good quality of the talks, the focus of the work reported, and on the efforts to obtain the many results presented. The progress reports demonstrated in most cases responsiveness to prior charges and comments as well as ongoing dialogue among proponents of similar technical solutions. The committee would like to thank the proponents in their efforts to make the review process effective and for following the advice given in the previous report. The increase in the number of publications is especially welcomed and all proponents are strongly encouraged to continue to publish their results preferably in peer-reviewed journals, but at a minimum on the archives.

The committee anticipated that, with the endorsement of the EIC as the next highest priority construction project for the nuclear physics community and the support for advanced technology R&D, there would be a substantial increase in the number of proposals to be considered while the funding was not expected to increase. This prediction has come true and the situation is not expected to change in the near future. All existing R&D groups and new proposals are therefore requested to meet the following requirements. The research proposal should crisply articulate the R&D program with achievable milestones for key performance parameters. Secondly, the proposal should clearly indicate how the EIC science will benefit from the R&D and what physics channels will be enabled by the research proposal. All proposals, new and continuing, are also required to submit a research plan under two additional funding scenarios, or a budget 25% lower or 25% higher than the nominal budget. The committee has noticed that many of the existing proposals are moving in the direction of preconstruction engineering design (PED). We would like to reiterate that the intent of this R&D program is to provide seed funding for promising research ideas that after a couple of years will migrate to base support funding and as such should focus more on the research aspects rather than the development aspect.

This review was particularly challenging because the funding request exceeded the available funding by more than a factor of 2.5, exacerbated by the fact that part of the allocated money is not available due to prior hiring commitments. Very cognizant of the funding constraints, new international participation, and the desire to keep the emphasis of this program on the research rather than development, the committee took a purposeful approach with respect to the funding recommendation. The approach taken to address the significant shortfall in funding was to subdivide the proposals. The committee then ranked the various components of the proposals as high, medium and low priority and appropriately adjusted the recommended allocation of funding to fit within the budget. Funding requests for postdocs were not considered if the term of the postdoc support would extend beyond three years of full support on this program. The committee iterates its position that extended postdoc terms are not a good career path. Furthermore, postdoc support does not automatically transfer from one postdoc to a new postdoc, since support of a new postdoc would constitute a new long-term obligation. As noted in several previous reports, this program should be regarded as initiation funding for research that is able to obtain independent base funding. If there exist extenuating circumstances we expect the PIs to contact the program manager, Thomas Ullrich, well in advance to discuss possible transition and mitigation strategies. If the committee felt a research proposal was too vague and did not clearly articulate the value of the research proposal to the EIC physics program, decision was deferred and, funding permitting, review at the next meeting is suggested. The overall funding priorities are given in Table 1 at the end of this report. Summaries of the presentations with corresponding recommendations are given in the next section.

eRD1: Calorimetry for the EIC

O. Tsai and T. Horn reporting

The report addresses continuing work on the tungsten powder-fiber calorimeter development at UCLA and at BNL with various collaborators to be used at most rapidities at an EIC, as well as on the development of a source of PbWO crystals from different sources for homogeneous calorimeters to be used at very forward (electron-direction) rapidities where energy resolution and spatial resolution are at a premium.

Tungsten-Fiber EMCal (C. Woody (BNL) et al.)

A key activity for the W/SciFi work was the test in the FNAL Test Beam of W/SciFi EMCal modules and two Fe/SciFi Hadron Calorimeters, the latter being prototypes for the sPHENIX inner and outer Hadron Calorimeters. The two HCal modules were separated by a metal-only mock-up of the planned magnet coil and cryostat (the re-purposed BaBar magnet). Half of the EMCal modules were prepared at UIUC using a vibration table while half were prepared at the company Tungsten Heavy Powder (THP) using a centrifuge to compact the powder. Non-trivial non-uniformities in density were measured; the densities achieved by THP were on average 6% higher but the dispersion in density ranged from 8.5 to 10.5 g/cm^3 vs. 9.2 to 9.6 g/cm^3 for the UIUC method, which might favor the UIUC method. This non-uniformity will need attention to produce a uniform and easily calibrated final product. The test beam runs were thorough with all planned running achieved. A “m.i.p.” scan was made for all towers and the resolution for the EMCal determined using both the m.i.p. calibration and an electron-beam shower calibration. The linearity results are quite good and the energy resolution results for the electron calibration show a stochastic term of 12.7% and a constant term of 3.2%, close to the estimates from the simulation work of 11.8% and 2.4% respectively.

It is noted that the sources of non-uniformity and resolution loss would benefit from further study to develop a better understanding whether they result from density non-uniformity, fiber-diameter non-uniformity, fiber light-yield and the pitch of the fibers achieved in actual construction.

This work is now supported by Stony Brook and by internal BNL LDRD funding.

Recommendations:

The Committee remains very interested to learn of further progress on the topics being studied and the planned effort to come back to the design of 2D projective towers now that the beam tests are complete. The proponents are encouraged to pursue these vigorously. No funding has been requested.

Tungsten-Fiber EMCal (O. Tsai (UCLA) et al.)

The parallel effort centered at UCLA prepared prototypes of high-resolution EM Calorimeters using both round fibers as well as new ones with square cross section, which were also tested in the FNAL test beam. There was a focus on uniformity of the production units and of using beam time to scan for non-uniformities and sources of resolution degradation. The authors note the need to keep dead areas to a few hundred microns thickness, and the Committee notes in passing that other segmented calorimeters such as the WA98/PHENIX lead-glass and the L3 BGO calorimeter had to keep dead zones to 100-200 microns maximum to achieve 6% and 2% stochastic and constant terms in the energy resolution, respectively. The effort on controlling and minimizing dead areas is a good point of focus for this collaboration for an EM calorimeter to be used at forward angles. The energy resolution results for electrons are encouraging, reaching a 7% stochastic term.

The Committee would like to see energy resolution plotted vs 1/sqrt(E) in the next report to better understand the various observed constant terms; a histogram of measured non-uniformity in response would also be instructive. The collaboration is encouraged to locate test calorimeters for long-term exposure next to the STAR experiment and use the information collected to inform future consideration of radiation damage and possible readout schemes.

An area of proposed future focus is the readout, including light collection, uniformity, immunity to magnetic fields, and long-term radiation damage, including but not limited to neutron damage. PMTs remain problematic due to susceptibility to the magnetic fields considered for an EIC detector. The nuclear counter effect in APDs likely rules them out, unless a “paired” solution is pursued, with two APDs stacked such that the first sees both the light and penetrating particles from the tower and the second sees only the particles, and thus is used to correct the signal in the first. The use of SiPMs is attractive, but given their known susceptibility to neutron damage, it becomes important both to test proposed radiation-hardened new devices and to understand better the soft neutron environment expected at the EIC. Scintillating fibers contain significant hydrogen, which produces secondary neutrons, which will hit the SiPMs. It is also important to consider the shape of any light-guides to be employed and the coupling of the fibers in a manner to match both surface area and angle-of-emission of the light exiting the fibers. Contact to the GlueX/Hall D group at JLab is encouraged, since they have deployed and now operated for 2 years in-beam a barrel SciFi EMCal with shaped light guides and some 4000 SiPMs in the readout.

Recommendations:
The proposed research is targeted and, given the budget constraints, the Committee recommends support at about half the requested level with a focus on the readout devices and system, light levels and fibers as discussed above.

Crystal Calorimeters (T. Horn (Catholic University) et al.)
The collaboration set up a crystal testing infrastructure at two institutions and carried out measurements of light uniformity for both transverse and longitudinal position variation, measurements of light output (p.e./MeV) from $PbWO_4$ crystals and first studies toward measuring and understanding crystal-to-crystal variation of light output. Three first full-sized crystals were procured from a newer vendor. First results of making similar measurements at different collaborating labs were also reported, which established key crosschecks.

Collaboration has been established with the Vitreous State Laboratory at CUA, which will be advantageous to obtain detailed chemical characterization of candidate crystals, all the more important to be sure the stoichiometry of the crystals is acceptable. Contact via IPN-Orsay with a group having access to an irradiation facility that can produce dose rates from 6-5000 Gy/hr of ^{60}Co gammas has been made, which will enable the necessary radiation-exposure measurements to qualify crystals from potential vendors. The IPN-Orsay group can also provide access to electron beams and light hadron beams, enabling further radiation damage studies. Finally a portable fiber-based spectrometer, with necessary mechanical mounting fixtures to yield reproducible positioning of crystals, has been acquired and is being commissioned. This is foreseen to be an important device for characterizing production crystals, characterizing crystals soon after radiation exposure, and providing rapid feedback to a vendor producing batches of crystals.

The group took advantage of its membership in the Neutral Photon Spectrometer project (JLab) to test several crystals procured earlier from SIC in 2014 and 2015 and observed significant crystal-to-crystal variation in radiation hardness when exposed to 30 Gy. The authors note that the SIC crystals would not meet the radiation resistance standards for PANDA and NPS. Preliminary measurements for a crystal obtained from Crytur show an absorption coefficient as a function of wavelength that is lower than that for the best SIC crystal. It meets the specifications for NPS and most likely the specifications for an EIC forward EMCal, which is encouraging. It, however, was not clear from the report if the radiation exposure had been similar to the 30Gy given the earlier SIC crystals.

The authors have made progress to establish crystal testing methods and obtain testing results that are reproducible between the various laboratories involved. The light yield, photoelectrons/MeV, needed for NPS is quoted. A similar specification should be developed for the EIC as part of the future effort to develop a readout system; it is not à priori clear that it must be as demanding as for the NPS, and it is a driver for crystal acceptance. The Committee takes note of the feedback to crystal vendors such as Crytur concerning light yields and the influence of doping levels used in crystal manufacture on the light yield. The Committee would be interested in future reports to learn of material assay and purity standards used by the vendor as well as dimensional precision achieved for the final products. The Committee notes that L3 BGO required significant attention to final crystal polishing steps to obtain necessary dimensional tolerances. Contact to groups at Princeton University and LAPP/Annecy on this point might be of interest.

The authors note an interest in SiPM readout for its stability, insensitivity to magnetic field and matching to the light yield. This readout does require attention to light coupling, temperature stabilization and possibly temperature reduction, thus it is suggested the authors make contact with the GlueX and other groups where a few years operating experience with a few thousand SiPMs has been gained and use that to develop their proposed future work in this area. The groups developing W/SciFi calorimeters should be party to these discussions. A discussion of the radiation dose to be expected for the very forward EMCal would be a useful addition to a future proposal to guide selection of possible readout technologies and also to inform the crystal purity requirements.

The Committee encourages the links to the PANDA group and the efforts to compare results to develop a qualified crystal vendor. The efforts at Crytur appear to be progressing but still seem to be developing and driven by PANDA, which argues for a measured pace of acquiring new crystals, to give time for measurements of optical properties, perform radiation exposure tests and study any possible annealing, and provide feedback to the company. Plans for beam tests, including tests of position response as well as energy response, are of interest.

Recommendations:
The Committee recommends limited support for the crystal procurements for FY16 with attention to the above remarks about feedback to the vendor, and support for the radiation studies proposed, including continuation of the optical measurement program underway.

eRD2: Magnetic Field Cloaking Device

N. Feege reporting

The collaboration reported further work on magnetic shielding measurements using the high-Tc tape wound devices reported at the previous meeting. The capability to shield a forward dipole field, that is used to enable tracking at very forward angles without creating momentum dispersion for the primary collider beam, remains compelling.

The proponents have demonstrated shielding performance for a one-layer shield made of high-temperature superconductor from AMSC operating in liquid nitrogen both with and without overlap at the edge of the wire, observing the expected lower shielding performance for the case of abutting edges and thus demonstrating the need for good geometrical control of the shield in particular at boundaries. This is still a low-field test, only fully shielding 10 mT, but in line with results from last year of shielding by multi-layer shields. Calculations show a 46-layer shield of high-Tc superconductor should be able to shield 0.5T, which is now inside the lower end of the range of dipole fields of interest for forward physics experiments. The prediction was also made in the last report that a 10-layer version of such a design could shield 0.5T if operated at liquid helium temperatures. The simpler cryostat needed for liquid nitrogen motivates testing the shields with larger layer counts.

The authors have designed and built a die and mandrel which enables manufacturing with good geometry control (achieved by careful trimming of shield sections after layering) of multi-layer shields of the 46mm high-Tc superconductor. First manufacturing results for this die set have been demonstrated, including limits on epoxy curing time at elevated temperature. This technique holds promise for larger shield manufacture.

The authors have prepared a larger 60" (152cm) long 2-layer shield on a 1" diameter stainless steel tube using high-Tc superconductor and arranged to place this in a Styrofoam insulated aluminum box that can hold liquid nitrogen. The steel tube can connect to an existing vacuum beamline at a tandem accelerator (at Stony Brook or BNL), thread a steering dipole magnet and transport a particle beam. They have made a first demonstration of better than 95% shielding of a 22 mT field. This geometry is more amenable to large scale testing than that offered by the solenoid magnets investigated to date due to the limited transverse size in any solenoid bore. A setup has been designed to test up to 68cm long prototypes inside a large bore MRI magnet available at ANL, which could apply up to a 4T field. Continued and extended tests with higher fields and multi-layer prototypes are being proposed.

The effort remains of high interest and the authors are encouraged to explore with the groups designing detectors how such a device would integrate with a proposed forward spectrometer and how this might simplify integration of such a spectrometer with the machine lattice. The Committee notes that even very large solenoid magnets not associated with running physics experiments are rare, thus it is either not possible to test meter-scale samples or very difficult to obtain testing time. The Committee encourages exploring the use of a dipole available at SLAC for tests of large prototypes since the geometry is a natural match to the problem at hand

and conventional steel dipoles can reach 1.5T, a field now well inside the range interest for forward spectrometer. The Committee remains interested to see test results for magnetic fields above 0.5T for this device.

Recommendation:
The Committee recommends funding at the full requested level, and urges the authors to investigate the SLAC dipole as a test magnet.

eRD3: Fast and lightweight EIC integrated tracking system

B. Surrow reporting

The group is working on intermediate tracking in the barrel (curved micromegas) and forward (large area triple GEM) regions of a future EIC detector. The curved micromegas work is centered at Saclay, building on the CLAS12 effort, and the large area triple Gem work is centered at Temple University.

The curved barrel one-D micromegas have been shown to work well using sources and cosmics and the consortium plans to advance to a 2-D barrel segment in the near future. In addition, Saclay has fabricated an adapter to allow the use of the DREAM chip readout in place of the outdated APV readout system. The consortium also plans to expend effort to produce additional readout channels based on the DREAM chip to serve for testing of either micromegas or GEM detectors.

On the large area triple GEM side, the consortium has acquired most of the pieces and tooling to assemble a 40x40cm triple GEM, but is awaiting delivery of spacers. The plan is to have a chamber undergoing cosmic ray testing in the spring of next year. In addition they have acquired most of the parts to assemble a larger 2D optical scanning system for foil QC testing and much of the apparatus needed for X-ray testing but do not yet have an approved safety enclosure in which to operate the X-ray tube.

The consortium requests funds for a postdoc, travel and material for the 2D micromegas design and X-ray enclosure materials. The request for postdoc support is motivated by the fact that the current postdoc has been promoted. The committee congratulates the consortium on having been successful at using this program to advance the research in this area and obtain a research faculty position. This is one of its goals. This success, however, does not automatically translate in continuing postdoc support, since support of a new postdoc would constitute a new long-term obligation.

Recommendation:
The committee is encouraged by the progress in many areas and supports the completion of the cosmic ray studies on the barrel micromegas detector and assembly and testing of the 40x40cm triple GEM detector. Postdoc support for the originally envisioned term is supported, that is, support until the end of this calendar year.

eRD6: Tracking Consortium for the EIC

T. Hemmick reporting

eRD6 is working on a variety of tracking solutions for an EIC detector, which is central to the EIC physics program. The collaboration has aggressively pursued a successful test beam program and has a good record of publication and training. The group will complete the promised generic R&D as originally proposed this year. Targeted R&D will then be the complete focus of the group, which will be a merger between eRD3 and eRD6 enhanced with international participation. The latter is referred to as eRD3/eRD6.

Good progress has been reported on the TPC/Cherenkov prototype beam test at Fermilab. The overall objective was to demonstrate proof of principle behind the concept of electron ID and tracking within a common detector volume. The performance of the TPC and Cherenkov light yield were measured and meet expectations. The committee notes the challenges of the TPC/Cerenkov project and is very pleased with the results obtained.

The zig-zag structures for the readout planes, with better interleaving of zigs and zags, has been completed with the goal to reduce non-linear response and achieve better than 100 µm spatial resolution. The new design shows very little bias in the residual distribution. The prototyping of the GEM chambers with large zigzag foils is proceeding well and the CAD design has been completed. R&D has also been ongoing on chromium GEM foils, which have been exposed to a uniform high intensity x-ray source. At an exposure of about 0.7 C over the full area of 100 cm^2 of the chamber half of the active area becomes inactive. These studies will be continued.

The committee noted earlier the design of a "Common GEM Foil" that can be used by the different groups at Florida, Temple and University of Virginia in different configurations to study various issues such as frame design and assembly techniques. As reported at this meeting, these foils have been fabricated at CERN and have been received.

The analysis of the 3-Coordinate GEM data is nearing completion. The final pad response functions are being extracted to develop the required corrections. A study has been carried out on the hybrid gain structure for TPC readout, including two GEMs and a Micromegas. It was determined that the high intensity corona-like discharges seen in the resistive layer MMGs are a problem with the manufacture of the resistive layers for the particular chambers.

The committee recognizes that focused R&D efforts may sometimes rely critically on the contributions of one or a few key people. In this case we understand the request of the Florida Tech group for continued support for Dr. A. Zhang, who started work at Florida Tech. on June 1, 2013. The originally agreed upon term for support for Dr. Zhang on this program has thus come to an end. The committee states again its position that this source of funding should be seen as seed funding to transition to base funding.

The consortium requests support for tests of the next generation of chevron patterns at the

level of $15k for board production to close-out the generic detector R&D.
Recommendation:
The request for funding to close-out the generic R&D plan of the consortium at the level of $15k is strongly supported. Postdoc support at the Florida Institute of Technology is recommended until the end of the 2016 calendar year to provide for a transition period.

eRD12: Polarimetry, Luminosity and low Q^2 tagger for the EIC

R. Petti reporting

RD12 is a simulation driven effort to optimize the Intersection Region (IR) design to include, in a fairly natural and integrated fashion, a luminosity monitor, a lepton polarimeter and a low Q^2 tagger. By developing Monte Carlo code that included Bremsstrahlung, including the polarization dependence, it is possible to study the impact of luminosity and define the accuracy requirements for polarization measurements. The project also has integrated an IR layout into the EicRoot simulation package and developed an integrated simulation package for the polarimeter. In addition, the simulations address machine generated beam backgrounds. Significant progress has also been made on expanding the general-purpose simulation package in various other areas. The simulations have become not only quite detailed as in, for instance, the design and placement of Roman Pots in the beam line, but now is also clearly a tool used from both the physics and machine side to develop an optimal design. This is a very powerful and timely outcome and the final EIC design will clearly benefit from this work. The optimization of the IR is, of course, not yet finished, but most of the tools are now in place to understand and react to the engineering decisions that will follow as the design advances.

The RD12 collaboration is to be congratulated on a job well done. The collaboration has no request for funding and the committee fully expects that by the end of this year, at the termination of the project, much more will be realized and a valuable tool set will be in place for the community to use for the machine/IR design and optimization work to come. This collaboration is the first to finish their research program and deliver as scheduled. The committee hopes that many consortia will follow the exemplary execution of the research plan by eRD12.

Recommendation:
None.

eRD14: Integrated particle identification for a future EIC

P. Nadel-Turonski reporting

The eRD14 consortium studies particle identification for the EIC in four focus areas: a dual-radiator RICH (dRICH) for the hadron endcap, a high-performance DIRC for the barrel, a modular aerogel RICH (mRICH) for the electron endcap, and a high-resolution mRPC TOF system. The R&D is separated into seven different thrusts. There are in addition three technical areas of R&D being the study of large-area photodetectors, performance of photodetectors in high magnetic fields and the development of electronics

At the last review, the committee expressed a desire to better understand the technical challenges in particle identification for the EIC, how the R&D carried out within the consortium moves the state of the art forward and what physics topics the specific R&D is targeting. A good attempt at addressing these requests and what R&D carries the most weight within the consortium was made. The committee appreciates a further discussion of these points at the next meeting and hopes to see that reflected in a more coherent, focused proposal next time. Also a better description of the organizational structure of the consortium would be appreciated. The committee also notes with pleasure the increase in publications, though many are associated with conference proceedings. Detailed NIM papers by the next meeting of the particle identification system for an EIC detector by the time of the next meeting would be welcomed.

<u>Dual-radiator RICH</u>

The Dual-radiator RICH may be a good concept for particle identification in the forward direction and the physics justification is clear. The committee notes significant accomplishments simulating the optics of this detector. Tuning of many parameters, such as geometry of mirrors, gas choice and Aerogel tile's refraction index, is essential to understand this type of detector within an EIC context. The proposal for next year is to add a simulation of real background, including the addition of a detector. We agree that it is important to specify the required pixelization and time response. The committee would like to see a definition of the type of detector that is planned on being used. We would add that the optical part could benefit from many detectors of this type already running. A difficult part is a detector running at 3T. The committee believes that the postdoc is already in his third year and the comments from the introduction apply.

Recommendation:
It is recommended that the background studies be finished and the specifications for photon detector be defined within the next half a year. The committee does not recommend support for the experimental effort until this effort is defined in more detail.

<u>DIRC</u>

The committee sees important progress in both the simulation and experimental effort. The observed Cherenkov angle resolution looks good and is close to MC simulation. DIRC has now experimental data from the beam test to tune many variables. This includes a comparison of pixel-based and time-based PID performance.

The question is if the beam test reached the optimum number of photoelectrons, and the S/N ratio. We have not seen a distribution of the dTOP = TOP_expected – TOP_measured variable, which is very important in any DIRC data and MC analysis. A present cut dTOP < 2ns is too wide for modern DIRC, leaving ambiguities, background and a relative poor S/N ratio.

The committee is pleased to see that detailed studies of the optical performance and radiation damage tests of 3-lens optics have started. The radiation study of the lens material and the optical study of the 3-lens system are extremely important issues for this DIRC and the committee gives this work high priority. The committee is also pleased to see that DIRC practical tests are planned for FY18. We would like to see more detailed plans what the expected achievements are with this device. It is noted that the travel request is very high.

Recommendation:
It is recommended to continue to optimize DIRC optics, analyze existing DIRC data and compare it to MC simulation. Furthermore, it is highly recommended to finish the optical and irradiation tests of the 3-lens optics. Budget permitting, it is recommended that the effort be supported at the requested level but with a reduced travel budget.

<u>Aerogel RICH</u>
The physics justification for this type of detector for an EIC is very clear. The EIC needs a very compact aerogel RICH that can cover a momentum range up to 10 GeV/c. Judging from the Belle-II ARICH performance, this is not easy to achieve. The first prototype was successfully tested in the Fermilab test beam. However, there is no plot showing the measured Cherenkov angle resolution, average number of photoelectrons achieved, comparison with MC simulations, and if you have achieved your goal. The committee would like to see a simulation showing how 3mm pixels will help you achieve the goal set for an EIC detector.

At this stage, it would be appropriate to discuss other options for Aerogel RICH, such as multiple Aerogel layers with different refraction indices to achieve focusing, thus avoiding photon losses in the Fresnel lens. A simulation of this problem would be welcomed for the next meeting.

As mentioned in our last report, there is no detector working at 3T, except an HAPD. We would like to see a transmission of the Fresnel lens before and after irradiation.

Recommendation:

The committee would like to see a clear conclusion from the Fermilab test beam data in view of its applicability for EIC physics and a better-written proposal justifying your future steps. At this point in time only modest support is recommended pending budget availability.

<u>TOF Detectors</u>

At the last meeting results on the TOF performance and rate capabilities in the CERN test beam were presented. A timing resolution of 25.4ps was achieved with a 36-gap RPC. At this meeting, no new experimental results were presented. Last time the committee expressed a concern about a lack of fundamental understanding of mRPCs, and that the 3D printing should not carry any priority and be postponed. The stated goal to reach 5-10 ps resolution seems unrealistic at present to the committee. The ALICE mRPC TOF is not limited by the detector resolution, which was ~22ps in the test beam; instead, they quote ~85ps resolution, and this number depends on t0, which is sensitive to the number of tracks in the event. For example, for events with 5-10 tracks only, t0 is close to ~100ps. This needs to be understood for an EIC environment. Anti-static mylar and 48 gaps might be an interesting idea to follow in the future, but the committee kindly asks the proponents to provide a better proposal how it should work theoretically.

Recommendation:

Given the budgetary constraints, the committee cannot recommend support for this effort at this point until a better proposal is obtained.

<u>LAPPD MCP-PMTs</u>

The research on LAPPD MCP-PMTs for an EIC has seen significant achievements. Initial studies indicate that replacing the Borosilicate window by a UV Fused silica window will increase the pe yield by a factor of two. A measurement of the QE, as well as the TTS, will be done vs. wavelength down to 170 nm. Working with UV sensitive Fused silica windows will enhance the detector performance for DIRC, RICH or TOF applications.

Argonne will produce a modified MCP-PMT with much smaller MCP-to-MCP gap to allow higher B-field operation. This may not help beyond 2T B-field, unless one goes for 6 μm MCP holes.

Argonne will produce a version of the MCP-PMT with a pixilated readout (3mm pixels) and Incom will produce 20 cm x 20 cm MCP-PMT, hopefully, allowing new studies of this device.

Recommendation:

Since this development has very high priority and is very critical for many applications within the EIC, the committee recommends full support.

<u>Sensors in high B field</u>

Research on Photosensors in High-B fields at an EIC is being proposed. The committee notes that tests with 3 and 6 μm MCP-PMTs have been published and indicate a reasonable performance up to 2T; the upper limit depends on the sensor, its orientation relative to the B-field and the HV. High B-field forces one to run at relatively high HV, which could be a concern. The committee notes Lehmann's conclusion about the Burle 10 and 25 μm MCPs: the main reason for the gain drop at a certain B-field is that the avalanche electrons with lower energies start curling inside the pores. The Larmor radius of a 50 eV electron is only 24 μm. For this reason the gain for a tube with 25 μm pores collapses almost completely at around 1 Tesla, and a 10 μm tube is just sufficient for 2 Tesla.

The committee agrees with the proposal to proceed with MCP-PMT simulation studies to see the gain dependence on B-field, HV, and angles θ and ϕ. We would argue that one can compare this simulation to Lehmann's results at high B-field, and to JLAB results with 3 & 6 μm MCP-PMTs. One could also simulate future MCP candidates.

Recommendation:
The committee supports the simulation effort of all older tubes and also tubes the consortium intends to buy. It would like to see the results of the simulation, though, before new tubes are being bought.

<u>Electronics</u>
Research on electronics for photodetector readout at an EIC is being proposed and a request is made for the purchase of a MaPMT. This type of detector has a completely different BW response than a MCP-PMT and will require a different amplifier. A highly pixilated MCP-PMT is not a trivial device to deal with from a BW point of view; it is not easy to obtain a good timing resolution and small cross-talk. It will require an effort, including a Spice simulation, to chose the appropriate BW, as FDIRC and Panda DIRC experiences indicate.

The committee would like to know more about the electronics development being proposed, since the present proposal is not fully clear on many aspects. It took a long time, many years in fact, to develop the IRS-waveform digitizing electronics, developed by G. Varner for the Belle-II TOP counter, which uses MCP-PMTs. It would make sense to collaborate with Gary Varner or Stefan Ritt on the future electronics to avoid mistakes; or at least take their advice.

Recommendation:
The committee recommends waiting with funding this proposal until the effort is described more clearly and is looking forward to an update at the next meeting.

eRD15: Compton Polarimetry

A. Camsonne reporting

The proponents report simulation results on electron and photon rates and signal-to-background rates from Compton events studied both for a case of single pass CW 10-W laser and from a laser coupled to a Fabry-Perot cavity (1kW power). A beam of 5 GeV and 1 Ampere was assumed – a representative choice – and a background pressure of 10^{-9} Torr to set a level for background events, again a representative choice for the machine designs discussed. Rates are given for both laser arrangements for 3, 5 and 10 GeV, with the observation that even for a single pass measurement a measurement time of 1/3 second or less is possible, (and 1/10 of that is possible for the Fabry-Perot case). This is important information considering radiation dose for a detector. The space for a Fabry-Perot cavity was evaluated and a solution for a 2m long cavity with ±4cm aperture to avoid beam halo problems and 2.6^{o} crossing angle was discussed. The counter rates approach 30 MHz for a single-pass laser and exceed 300 MHz for the Fabry-Perot case studied. This would put a premium on speed of detector response, in particular return to baseline. The simulations have been used to extract an asymmetry from the simulated data, and have included a 500 µm thin window to start the modeling of a realistic detector setup.

The authors have implemented a beamline geometry in their simulation that could be implemented in the EIC. They note that tuning the beam may require more transverse aperture than desirable for operation of the Compton Detector, leading to the consideration of Roman Pots to have a means of moving a detector closer to the beam axis after stable collisions are established. This will require investigation of the wakefields induced in the case of a short-bunch-length electron beam. Accordingly, the authors have made contact with accelerator groups at SLAC, notably those with PEP experience, and JLab. This will be an area of future study.

The authors have also made preliminary dose estimates. These are non-trivial, reaching 10 MRad/hr for a 3 Ampère stored beam. These dose rates motivate both considerations of short measurement periods followed by either retracted detectors and/or turning off the laser. The rates also motivate considerations of radiation hard detectors, such as diamond, or of fast silicon of e.g. 50 µm thickness.

The rate studies and test asymmetry extraction, the machine geometry and timing studies, and bench tests of potential detector types and their response are timely topics to help further determine the design of a suitable Compton detector to be used for measuring beam polarization. Although the contact with the TOTEM group is informative, it is not obvious at this point that detailed engineering of the detector housing is warranted until the machine interaction area is further developed. Contact with the machine groups on this point is highly encouraged to ensure that the needs of the Compton polarimeter are folded in to the design of the machine lattice from the outset.

Recommendation:
The Committee recommends funding at half the requested level, and at this time does not support the work on advanced electronics or chamber mechanical design.

eRD16: MAPS for the EIC

E. Sichtermann reporting

As noted in our previous report, the committee was pleased to see an area of study, in the EIC detector development community, emerge, with a focus on silicon-based tracking. This proposal continues the development and studies aimed at forward/backward silicon tracking. The Committee is pleased to see the ongoing development of this important technology and the general growth in interest in silicon tracking within EIC. Future potential for collaboration is strongly encouraged. For example, it would be natural to see a collaboration develop between this effort and the new proposals from ANL and Birmingham, if these new groups decide to proceed further.

Progress is reported on aluminum cables but some questions arise here:

1. With regard to Figures 3 and 5 – there are differences between the slopes and the resistance for a given conductor path length – are these significant or not important? No real conclusion is given.
2. Clearly, interconnection reliability is of great importance here. For the Kharkov cables there is a statement "The tabs….appear to provide robust and reliable connection" – what is the basis of this? If this would not be the case, it would clearly be a show-stopper so the committee would have expected a test program explained and documented. What was done?
3. Again, the "cable structure appears generally more fragile than the Hughes samples" – this calls for evidence and data to back it up. Did both cables get some sort of a stress test?

Concerning the simulation program:

4. There is a reference to the ALPIDE sensors – it would be best to include some sort of description or appendix about this. I do not think there is even a reference here.

Concerning the progress report:

5. With regard to Figure 9, again the committee would have liked more detail: how do b) and c) manage a consistent geometry? Is there a handed-ness here, which would respond differently to tracks with opposite curvature?

In spite of these questions, progress has been good and the Committee sees excellent potential in this work.

Recommendation:

The committee deems the funding request fair and recommends that this work continue to receive support close to the requested level if the budget permits.

eRD17: DPMJETHybrid 2.0

M. Baker reporting (by video connection)

In order to ensure that the detectors designed for the EIC fully address the physics program it is important to incorporate models that include all relevant physics in the Monte Carlo simulation. Nuclear shadowing / parton saturation effects are currently not included in the suite of eA DIS event generators available for EIC physics simulations, because they were not the focus of previous eA experiments. The eA event generator DPMJetHybrid is being extended to include these effects.

The low-x region, where these effects really become important, was first explored at HERA (ep) and other eA efforts – such as Jefferson lab – and are not in this kinematic regime. The EIC will explore this kinematic regime and some of the tools necessary are not yet developed. Knowledge of the relevant effects has come from RHIC and the proponents have a plausible approach to get around knowledge of the exact details of the virtual photon-heavy nucleus cross-section. Unless the community can model these effects in this new kinematic regime for eA, one cannot optimize the detectors.

This project was proposed to be completed in two steps. The first step has been successfully completed on schedule. The second part of the work is scheduled to be accomplished in this Phase II for which funding is requested.

Liang Zhang post doc (for whom no funds are requested) will be at BNL first part of 2017 and so support at this time for this project rather than delaying support is important.

Recommendation:

Very good progress has been made to date in the first phase of the project and the committee has full confidence that the proponents will deliver the Monte Carlo code during the second phase. Full funding is recommended.

New Proposal: Detailed Simulations of Machine Background Sources and the Impact to Detector Operations

E. Aschenauer reporting

This proposal seeks to study accelerator produced background sources in EIC detectors. The proponents want to identify the dominant background sources, quantify the impact on the detectors and physics, and devise schemes to mitigate the backgrounds in the eRHIC designs. These studies are essential and should be developed in parallel to the interaction region design for the machine, as the backgrounds are dependent on the details of the machine lattice and beam optics. The knowledge obtained will help to optimize the machine and detector designs. For the work carried out within the eRD12 collaboration, the interaction between the experimental physicists and the machine design team was crucial to develop the polarimetry, luminosity measurement and a low Q^2 tagger for the EIC. The same approach is used here. Funding is sought for one post doc. It is noted that the same team has a strong track record and has been very successful in providing the deliverables on schedule for the eRD12 collaboration.

Recommendation

The proposal is well motivated and it is recommended that it be fully funded.

New Proposal: Developing Analysis Tools and Techniques for the EIC

Markus Diefenthaler reporting

This proposal builds on the Letter of Intent submitted for the January 2016 review for setting up an EIC consortium to develop a suite of analysis tools and techniques for the EIC. The scope of the consortium is relatively broad and encompasses the initiation of the development of a library for simulating radiative effects, validation of critical Geant4 physics in the EIC energy regime, the development of a universal event display for MC events, promotion of open-data developments for efficient data-MC comparisons. The consortium also proposes to work towards a common geometry and detector interface and a unified track reconstruction. Interfaces would be developed to forward compatible, self-descriptive file formats. All tools would be organized within a software repositories dedicated to the EIC that would be embedded in an EIC-wide community website. The proponents will organize regular meetings of the consortium. Funding is requested for travel and for undergraduate students.

The committee welcomes this timely initiative and agrees that a robust software environment, compatible with the existing software frameworks, is very important for the development of the physics case for the EIC. The areas of focus are relevant to fully establish the physics reach of the EIC and enable accurate and complete detector optimization studies. The deliverables provide long-term value to the community and could ultimately become the analysis framework used in the experiments at an EIC. It is noted that there is synergy between this proposal and the proposal put forward by S. Chekanov on “Performance characteristics of the SiD detector for deep inelastic events at the electron-ion collider”.

Recommendation:
This proposal is well motivated and timely. The committee recommends that it be funded in full. Given the synergy with the proposal put forward by S. Chekanov on the “Performance characteristics of the SiD detector for deep inelastic events at the electron-ion collider”, it is recommended that the funding be increased modestly to allow the proposal of S. Chekanov to be integrated in the scope of this proposal.

New Proposal: Performance characteristics of the SiD detector for deep inelastic events at the electron-ion collider

J. Repond reporting for S. Chekanov

This proposal seeks to perform a characterization of the SiD detector for the ILC in terms of its response to scattered electrons in deep-inelastic scattering events. The deliverable will be a comprehensive mapping of the SiD detector in terms of resolution, efficiency, purity and misidentification rates of Q^2 and x_{BJ}, in bins of these variables. The performance results of the SiD detector will guide the design of a new detector, which will be better optimized for ep (eA) collisions and less expensive compared to the original SiD detector. The intent is to guide the design of future EIC detectors. Benchmark characteristics will be used for comparisons with other detector designs under consideration. This will help to identify the most promising detector geometry and readout technology. The proponents plan to participate in planning a future EIC detector based on the knowledge obtained by running the realistic SiD detector simulation for the ep (eA) collision environment. Support for one postdoc is requested. The scope of the proposed work seems to consist solely of the proponent and the requested postdoc.

This is an attractive proposal that is very well suited for LDRD funding within ANL as it would allow entry for ANL into EIC R&D. We encourage the proponent and ANL to pursue this route.

Recommendation:

Although the proposal is engaging, the committee does not recommend the proposal to be funded with EIC Instrumentation R&D funds at this time. The proponent is, however, encouraged to explore collaborative opportunities with the proposal on “Developing Analysis Tools and Techniques for the EIC” as proposed by Diefenthaler. Modest funding should be made available in the budget of the Diefenthaler proposal to support characterization of the SiD detector.

New Proposal: Developing Imaging Hadron Calorimetry

José Repond reporting

This proposal looks at the DHCAL work already done for the ILC and lists many of the advantages of this approach including very fine granularity, the cost of which is compensated to some extent by a much lower dynamic range requirement per channel. The proponents showed many impressive results for prototype DHCAL devices. Unfortunately, it is not obvious, at least from the proposal, that the advantages of a DHCAL approach are well matched to an EIC detector. For instance being able to cover six orders of magnitude in hit density may not be very helpful if the total number of particles is very small as expected for an EIC. Very high rates are certainly not expected in the EIC environment.

The detector instrument examined for this work is the Resistive Plate Chamber (RPC) and the proposal requests funds to look at long term tests of glass RPCs, long term tests of fast RPCs with even higher rate capabilities, a gas recycling system for RPCs and a HV distribution system for RPCs.

The committee believes that much of the proposed detailed work on RPCs, as requested, lies in the realm of PED and does not fit with the mission of this R&D program. Furthermore, the proposal is premature without a compelling case being made for the advantages of such devices for at least some EIC detector. It is not à priori clear where such a highly segmented calorimeter would be used to advantage at an EIC. Studies showing the applicability of DHCAL ideas to an EIC environment would seem to be a prerequisite to detailed work on high rate RPCs or other DHCAL oriented devices.

Recommendation:

No funding is recommended for this proposal at this time. The proponents are encouraged to demonstrate how such a device would benefit the EIC physics program and develop a case for its usage at an EIC.

New Proposal: Realizing Radiation Tolerant Magnetic Immune Radiation Detector Readout Using Optical Phase-modulation-based Electro-optical Coupling

Wenze Xi reporting

This proposal focuses on the study and development of optical modulators for low mass data transmission. It is an elegant idea and was studied, but then dropped, as part of the early R&D for the SSC (Willis and Radeka). That was many years ago and much has happened in electro-optics since then. The committee felt that the project could have been presented better in the proposal. In particular the actual use case is not discussed at all except in a generally vague way. This issue was raised during the presentations and the proponents responded by showing an example of X-ray spectra measured and read-out through an EOM system as compared to a direct readout. The spectra were similar. While illustrative, this example did not address some relevant question, namely, what part of a presumptive EIC detector would benefit by being read out in this way? What is an example of a system implementation, which would be useful here? How many channels are required? What specifications are being targeted? In past proposed implementations, the emphasis was on reduced power and reduced mass, typically in an inner tracking application.

It is recommended that this proposal be more strongly connected to the readout of a specific part of an EIC detector.

Recommendation:
Given the current funding constraints, it is recommended that this proposal not be funded at this time. The proponents are strongly encouraged to resubmit next time with a clear use case and specifications.

New Proposal: Precision Central Silicon Tracking & Vertexing for the EIC

Laura Gonella and Peter Jones reporting

The Committee is very pleased to see interest from European colleagues in the area of silicon tracking. This is an area, which is relatively new to the EIC R&D program and is growing quickly. We envision some new collaborations emerging and with hopefully a good focus and coordination of efforts.

WP1 seems mostly like synergy and leveraging of existing efforts for ALICE or ATLAS. While the technology is interesting and potentially brings value, it not clear what is unique here for the EIC. If this work will be done in any case, it would be interesting to know the additional cost to relate it to the EIC. Also, it is not specifically detailed what for EIC would the proposed 1 FTE of postdoc would actually be doing?

In WP1 there is a discussion of radiation hardness for the CMOS sensors relative to the recently observed "TID bump" at ATLAS. This is a phenomenon, so far, just in the Global Foundries 130 nm CMOS process, as used in the ATLAS pixel and ABC130 chips, which leads to a transient current increase in certain circuit elements. A modified set of design rules could circumvent this or one could move to a different foundry. It is puzzling why this is also being related to the CMOS active pixel devices, which are targeting completely different processes. This point should be clarified.

The proposal is carried a high cost, but there are clear synergies with other efforts. In fact, the present submission appears to be a hybrid proposal – half the people are silicon detector and electronics experts while the others are interested in nuclear physics/QCD. The former bring expertise, involvement, and interest in CMOS sensors and electronics (WP1). This suggests a potentially natural linkup with the eRD16 effort. For the layout and design side (WP2) a linkup with ANL and Chekanov, or others, would potentially be a natural alliance, as well. Finally the physics effort (WP3), while also of great interest, is too far afield of the detector R&D mission of this funding process.

The Committee would certainly like to see the interest of the Birmingham group grow and supports their participation. We look forward to the increasing engagement of the senior members of the group in the EIC community, spanning all three work-packages. If some focus could be found for example, within WP1, we would be inclined to support participation in specific R&D hardware costs, foundry runs, software licenses, etc.

Recommendation:

It is recommended that this proposal be funded at approximately half the request for EIC targeted R&D and that the consortium explores collaboration with eRD16 on the MAPS development and the new proposal by Diefenthaler on simulations.

New Proposal: Precision Timing at the Electron Ion Collider

Michael Murray reporting

This proposal is motivated by the need to identify particles, in particular protons, emitted at very forward angles at an EIC. Precision timing, approaching 10 ps resolution, is proposed as a key element of a particle identification scheme to be deployed at far forward angles, perhaps in Roman Pots and/or as part of a spectrometer quite close to the ion beamline. The authors have experience with the hardware used for the CMS-TOTEM Precision Proton Spectrometer (CT-PPS), which includes silicon detectors, notably Low Gain Avalanche Diodes, high bandwidth preamplifiers and a relatively new time-to-digital convertor ASIC, specifically the SAMPIC ASIC. This chips allows recording a waveform at 6.4 Gsa/sec, which can in turn be analyzed to interpolate time information with resolutions less than 10ps.The authors included measured waveforms from a thin fast silicon detector exhibiting a risetime of less than 7ns, exhibited a signal simulation from a posited 50 μm thick silicon detector which exhibited a risetime of order 0.5ns, and noted plans for radiation damage studies reaching to 10^{16} n/cm^2, which is likely relevant at forward angles. Finally the authors propose simulation work to study the range of useful timing resolution at an EIC and how such excellent timing resolution as noted above might benefit the physics program.

Contact with the groups developing designs for forward spectrometers would inform this proposal by producing specific information on planned momentum measurement and particle-identification schemes, the range of particle momenta relevant, the likely detector rates, and radiation doses to be encountered at an EIC. This would also yield information on a range of useful channel counts, pixel sizes and thus power densities that could be considered for any readout option, and what resolutions would be useful in identifying reaction channels of interest and removing backgrounds. At present the complexity, cost and power consumption of the relevant electronics may limit the deployment of such very fast timing detectors to usage in forward spectrometers with limited channel counts. The Committee notes beam test results of relevant devices are expected over the next six months, which would also inform this proposal.

The authors are encouraged to contact in particular the eRD12 group on the simulation tools and use them to develop their concept further and establish where fast timing would be of use at an EIC. The testing discussed is so far not specific to the needs of an EIC. The authors are encouraged to contact one or more groups developing EIC detector concepts and refine their proposed tests to address EIC-specific physics needs. This might best be done in the context of a specific physics measurement, perhaps the Deeply Virtual Compton Scattering mentioned by the authors, or other related measurement.

Recommendation:
It is recommended that this proposal not be funded at this time. The authors are encouraged to develop a clear use case for the EIC.

New Proposal: 4D Tracking Detectors: Monolithic Fast Timing Silicon Detectors

Jessica Metcalfe reporting

This is a proposal to develop monolithic detectors with high-speed readout (~30 ps). This general topic is very much a present area of interest in semiconductor detector R&D. For example, ATLAS and CMS are both performing R&D on fast timing detectors for application to the HL-LHC. A scheme in that experimental environment is to deploy a forward and backward plane, in front of the calorimeter, of relatively large pixels (1x1 – 3x3 mm^2) to help disentangle multiple interactions along the beamline and improve jet identification and separation. The state of the art is single sensors read with fast custom discrete electronics. Schemes and designs are underway for custom ASICs aimed at this application, to be used in the simple hybrid approach (sensor + chip), with a small number of channels (~4). This matches the large pixel size.

There are significant issues with this specific proposal because it leaps over the present developments and proposes a high resolution, monolithic approach, applied to a full tracking system. At the moment, Low Gain Avalanche Diode detectors have reached ~44 ps resolution (this number is not divided by √2) at a gain of 15, using a fast scope with 2 channels as a readout method. If the gain is pushed to 50 a resolution of ~31ps can be obtained. Currently there is no multichannel ASIC (like APV25 or FEI4), which offers a preamp with this response time nor a sampling pipeline in a small pixel configuration. The proposal refers to a "monolithic" solution, which implies something like a MAPS or HV/HR-CMOS implementation – and that goes even further beyond the state-of-the-art. No path was provided for scaling to larger systems, which can only be accomplished within a broad collaboration with deep expertise. Furthermore, the quoted specs for radiation dose at EIC are off, they correspond to HL-LHC pixel layers so are too high by something like a factor of 1000-10,000. The proposal lacks an EIC specific case study and gives the impression that an HL-LHC R&D proposal for a "4D" tracker was adopted for this EIC call.

Recommendation:
It is recommended that this proposal not be funded. The proponents are encouraged to revisit this technology, realign with what is feasible, and focus on a specific and practical EIC application.

New Proposal: eRD3/eRD6 Targeted R&D

The eRD3 and eRD6 consortia proposed to merge their efforts and move into so-called "targeted R&D", which was submitted as the eRD3/eRD6 proposal. The targeted R&D areas are TPCs (Brookhaven, Stony Brook, Weizmann, Yale), forward planar GEMs (Florida Institute of Technology, Saclay, University of Virginia) and hybrid MPGDs (INFN Trieste).

For the TPC, a new and improved readout structures will be studied. BNL LDRD is currently funding the development of the field cage. Stony Brook plans to work on the understanding of the magnitude of ion back flow in the TPC. The committee notes that it has not been shown that ion backflow will be a problem at the EIC and suggest a more thorough study on ion backflow issues at the next meeting.

The R&D on forward GEMs focuses on the construction of a larger 30-degree triple-GEM sector with a 2D readout foil with multi-pin connectors and a DREAM-chip readout system. The performance of a fine-pitch 2D flexible stereo-angle strip readout will be studied. Many studies to explore the parameter space of the GEM stack-up are being proposed.

The R&D program on the hybrid MPGDs is devoted to further development for single photon detection. The proposed hybrid detector architecture consists of three multiplication stages: two thick GEM layers, the first one coated with a CsI film and acting as photocathode, followed by a MicroMegas multiplication stage. This configuration is expected to reduce the Ion BackFlow and to increase the maximum gain at which the detector can be operated exhibiting full electrical stability. The main goal of the proposed R&D is to fully develop the concept of a gaseous detector of single photons for the challenging requirements of a high-momentum RICH counter in a collider environment. The committee feels that the scope of this works tends to fall more under PED and would like to see more emphasis on the research aspects of forward tracking detectors and the physics it enables.

Gaseous sensors with very low IBF and high granularity are also an option to read-out TPCs. The hybrid MPGD program developed for a high-momentum RICH counter for colliders is a good match for the EIC R&D program. In addition, this application allows preservation of a good dE/dx measurement. The group proposing this R&D has a strong track record in the development of this technology and the committee strongly supports the proposed research program.

Recommendations:
The proposed research program on hybrid MPGDs by INFN Trieste addresses critical needs for the EIC physics program and the committee recommends full support at the requested level. The research on the TPC seems a good match to the BNL LDRD program and, given the budget constraints, it is recommended that this work be supported from the LDRD budget. The forward GEM research is moving in the direction of project engineering design. The proponent of both the TPC and forward GEM R&D are encouraged to present a combined, coherent proposal at

the next meeting that addressed the needed critical technology improvements for the EIC physics goals.

Funding Summary

Table 1 summarizes the requests for funding and the recommendations by the committee. Regretfully hard choices had to be made to fit within the budget authority. The R&D program to be executed within this budget remains highly effective and targeted and ensures that the required R&D is carried out to enable the EIC physics program. It reinforces the notion that transition to base funding should be part of the planning from the inception of the proposals.

EIC Detector R&D FY2017	PI	Proposal Name	Sub-proposals	Funding Request	Priority
eRD1	Huan Huang Craig Woody	Status Report and Proposal For EIC Calorimeter Development		**$214,250**	
			M&S	$49,550	Medium
			UCLA shops	$16,100	Medium
			Student Support	$15,600	Medium
			Kuraray Fibers	$12,000	Medium
			Electronics Engineering	$26,000	Low
			Travel	$25,000	Medium
	Tanja Horn		PWO	$70,000	Medium+
eRD2	Abhay Deshpande	A Compact Magnetic Field Cloaking Device		**$20,000**	
			Shielding tests	$20,000	High
eRD3	Bernd Surrow	Design and assembly of fast and lightweight barrel and forward tracking prototype systems for an EIC		**$161,732**	
			Postdoc (50%)	$114,226	High (*)
			Travel	$21,606	Medium
			Materials (foils)	$3,900	High
			Equipment (2D + X-ray)	$34,320	High
eRD6	Klaus Dehmelt	RD6 Tracking/PID Consortium: Progress Report & Funding Request		**$413,200**	
			Close-out eRD6 generic	$15,000	High
		Targeted R&D	TPC	$111,000	Low
		Targeted R&D	Forward Planar GEM	$197,200	Low
		Targeted R&D	Cherenkov / RICH (Trieste)	$90,000	High
eRD12	Elke Aschenauer	Polarimeter, Luminosity Monitor and Low Q2-Tagger for Electron Beam	No Funding request	**$0**	
eRD14	P.NadelTuronski, M.Chiu, H.van Hecke, Carl Zorn	Integrated program of Particle Identification (PID)		**$444,000**	
			dRICH	$55,000	Medium
			mRICH	$85,000	Low
			DIRC	$98,000	High
			TOF	$40,000	Low
			High-B	$55,000	High
			LAPPDs	$90,000	High
			Electronics	$21,000	Low
eRD15	Alexandre Camsonne	A proposal for Compton Electron Detector R&D		**$181,230**	
			Postdoc and Travel	$57,165	High
			Electronics	$42,951	Medium
			Detectors (Si, diamond)	$15,450	High
			Discriminator	$30,900	Low
			Chamber construction / electronics	$34,763	Low
eRD16	Barbara Jacak Ernst Sichtermann	Forward/Backward Tracking at EIC using MAPS Detectors		**$104,814**	
			Postdoc (50%), Travel, student support	$91,892	High
			M&S	$12,922	High
eRD17	Mark Baker	DPMJetHybrid 2.0: A Tool to Refine Detector Requirements for eA Collisions in the Nuclear Shadowing / Saturation Regime		**$33,000**	
			Full model and testing	$33,000	High
New	José Repond	Proposal to Develop Imaging Hadron Calorimetry		**$175,000**	
			Long-Term Tests 1-glass RPC		Low
			Long-Term Test Fast RPC		Low
			Development Gas Recycling System		Low
			Development HV Distribution		Low
New	Sergei Chekanov	Performance characteristics of the SiD detector for deep inelastic events at the electron-ion collider		**$150,000**	
			Simulations	$120,000	Low (**)
			M&S	$30,000	Low (**)
New	Wenze Xi	Proposal to Realize Radiation Tolerant Magnetic Immune Radiation Detector Readout Using Optical Phase-modulation-based Electro-optical Coupling		**$20,000**	Low
New	Peter Jones	Precision Central Silicon Tracking & Vertexing for the EIC		**$163,000**	
			Sensor Development		Medium
			Detector Layout		Medium
			Physics Simulations		High (***)
New	Christophe Royon	Precision Timing at the Electron Ion Collider		**$53,752**	Low
New	Jessica Metcalfe	4D Tracking Detectors: Monolithic Fast Timing Silicon Detectors		**$160,000**	
			Detector Simulation		Low
			Sensor Simulation		Low
			Sensor Design and Testing		Low
New	Elke Aschenauer Richard Petti	R&D Proposal for Detailed Simulations of Machine Background Sources and the Impact to Detector Operations	eRD12 Follow-up	**$110,000**	High
New	Markus Diefenthaler	Developing Analysis Tools and Techniques for the EIC		**$50,000**	
			Travel Budget	$30,000	High
			Undergraduate Student Support	$20,000	High

Table 1: Summary of the funding recommendations.

(*) Supported until the end of the calendar year
(**) Collaboration with the Diefenthaler proposal encouraged, which has received a funding recommendation above its request
(***) Collaboration with eRD16 and the Diefenthaler proposal encouraged