Report of the EIC Detector Advisory Committee
2nd meeting, December 11-12 2011

BNL 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.

On December 11-12, 2011 the EIC Detector Advisory Committee met at BNL to review nine proposals received in response to the second solicitation. The Committee members are: M. Demarteau (ANL), R. Klanner (Hamburg), I. Shipsey (Purdue, Chair), R. Van Berg (U. Pennsylvania), J. Va'vra (SLAC), G. Young (JLab). M. Demarteau and J. Va'vra were unable to be at the December meeting.

General Remarks on the Program

Microstructure gas detectors feature in many of the proposals. Opportunities for synergy clearly exist and should be encouraged and developed. Calorimetry is underrepresented. We are pleased to note an increased focus on simulation, but much more is urgently needed to prepare for the DOE/NSF long range planning exercise for Nuclear Physics expected in 2012-2013. At our last meeting we encouraged studies of benchmark golden modes where we have seen considerable progress. We also encouraged studies of machine backgrounds that we have not seen. In addition we have not seen proposals on small angle tracking and electron tagging at zero degrees.

At our next meeting we would like to see presentations from the proponents of both machines with emphasis on differences between them, with a focus on the IR and how model detectors are incorporated, the machine related backgrounds and the radiation dose in the different regions of the detectors.

We encourage management to develop a common set of e-p/A beam energies to facilitate the development of proposals that begin from a common set of assumptions. Proponents of a given detector technology should include a discussion of how well it performs for these specific reference cases.

The Committee suggests an instrumentation workshop be held in the next six months or so that brings together the EIC community with their colleagues in other areas of nuclear physics, and particle physics to explore and develop ideas leading to proposals for instrumentation relevant to the EIC.

2012-1 Improved energy loss calculations for GEANT4 simulations

H.Bichsel (Washington)

The aim of the proposal is to improve/correct the straggling functions presently used in GEANT4.

The Committee notes that

- Hans Bichsel is a world-expert on issues related to energy loss of charged particles in matter,

- the proposal as presented does not meet the formal standards with respect to quality of presentation and deliverables,

- the differences between the present implementation and the correct one are expected to be minor for most EIC detectors,

- implementing the proposed changes to GEANT4 is highly desirable, however in view of the limited resources available, not of the highest priority

To summarize: The Committee acknowledges the high quality of the proposed work but, in view of limited resources available, does not recommend it for funding at present.

2012-2 Proposal for Very Forward Tracking in STAR (up to eta=5)

D. Underwood, H. Spinka, S. Gliske (ANL)

The proposal involves using thick GEM detectors in the very forward region of STAR in the expectation that similar detectors will be useful in the high eta regions of any EIC detector. The proponents note that this could be especially useful for tuning the spin precession snakes at STAR at higher and higher rates. The proponents request funds to instrument a number of thick GEM detectors including additional STAR circuit boards and readout electronics and postdoc, EE, and mechanical technician effort to complete the assembly.

The proposal is, as written, quite STAR-centric, the argument for EIC utility did not come across strongly and, at the same time, no new detector technology is planned. The Committee appreciates that there may well be a crisp argument for needing such devices for polarization measurements at some future EIC detector, but suggests that that argument needs to be further developed and supported in order to be compelling. It is possible that some of the ideas put forward in this proposal would fit within a larger consortium of R&D efforts.

The Committee does not recommend funding this proposal. The Committee suggests that STAR is probably the best funding source for the work as presented.

2012-3 Design and assembly of fast and lightweight barrel and forward tracking prototype systems for an EIC

S. Aune, E. Delagnes , M. Garcon, I. Mandjavidze, S. Procureur, F. Sabatie (CEA Saclay-Irfu) B. Surrow (MIT/Temple) D. Hasell, R. Milner, B. Redwine, G. van Nieuwenhuizen (MIT, Laboratory of Nuclear Science) B. Buck, J. Bessuille (MIT, Bates Laboratory)

The proposal involves a collaboration between a SACLAY group and an MIT/Temple group to work on MicroMEGAS and GEM detectors for intermediate tracking at a future EIC detector. The effort is directed at demonstrating constructability of both types of detectors as very large area devices and includes attempts at encouraging commercial vendors of the critical foils. The MicroMEGAS work would be centered at SACLAY building on their successful CLAS12 work (including the DREAM readout chip). The MicroMEGAS in this work would be configured as a very large cylindrical structure in the barrel. The North American effort will be directed toward achieving flat end cap triple GEM detectors using foils of very large size produced by a commercial company. The characterization effort over the two year period for both detector types will be largely limited to optical inspection of foils for uniformity and measurement of leakage currents at various stages of assembly and stress. The team is experienced in such trackers and the proposal is aimed at questions that must be answered before any new EIC detector can be confidently designed. The work plan seems aggressive but focused and the planned budget is well justified and relatively modest.

The Committee recommends funding this proposal in full.

2012-4 Endcap TOF and TRD for Identifying Electrons at EIC

Tonko Ljubicic, Bob Scheetz, Gene van Buren, Lijuan Ruan, Zhangbu Xu (BNL) Gerard Visser, (Indiana CEEM) Geary Eppley, Frank Geurts, Bill Llope (Rice) Jerry Hoffmann, Jo Schambach (UT-Austin) Cheng Li, Hongfang Chen, Ming Shao (USTC) Subhasis Chattopadhyay (VECC) Richard Majka, Nikolai Smirnov (Yale) Bernd Surrow (MIT)

The Committee is interested in the concept of identifying electrons at an EIC via a combination of tracking, TOF and detection of TR photons. The Committee would like to understand better over what range of pseudorapidity a TPC/TR could work, from the standpoint of required momentum resolution, hit areal density and overall hit rate, and whether space charge poses any problems in particular at forward angles.

It was not clear whether this technique is proposed to operate in isolation or in conjunction with further detectors such as EM Calorimeters or Cerenkov detectors, or in a different range of pseudorapidity. More generally, the direction of the overall R&D effort and development of detector reference design for an EIC would benefit from an exposition of electron detection strategies to be deployed in various regions and how well they are expected to identify electrons and reject hadrons.

The authors propose to develop a GEM which can operate with Xe in combination with another gas such as CO2, then to measure the position and energy resolution achieved with the GEM, identify and prepare appropriate electronics, and in future years study emission and detection of TR photons.

The Committee encourages the authors to delineate more thoroughly the requirements on the electronics. Such electronics were developed at BNL for the PHENIX Time Expansion Chamber and include a preamp with wide dynamic range coupled to a planar TPC and a non-linear FADC. The FADC combined a linear lower range with a non-linear upper range to accommodate the

large difference in energy deposition in a unit gas volume between normal ionization by a minimum-ionizing charged particle and a TR photon of keV energy. A revised proposal should note improvements required beyond the performance achieved above to meet the needs of an EIC.

The Committee recommends that this group return in 6 months with a revised proposal that includes elements of the above studies to place the proposed device in the broader context of electron detection at an EIC. The Committee does not recommend funding at this time.

2012-5 Physics Simulations to Establish and Refine Detector Requirements and Detector Design for the EIC

T. Ullrich (BNL)

The aim of the proposal is to compile a suite of eA event generators for EIC physics simulations. In a first step it is proposed to finish the ongoing work on event generators for diffractive physics in ep and eA interactions, then to assemble an eA event generator for electro- and photo-production including the details of nuclear break-up, and finally use the event generator to optimize the design of an EIC detector and study its physics performance.

This program is very ambitious and essential for the success of the EIC physics program. The Committee strongly supports the proposal, including the idea to invite Monte Carlo experts to visit and establish collaborations.

However, the Committee is of the opinion that this effort has to be organized in a more strategic and prioritized way. With the resources allocated, it doubts that the program as presented can be completed in the years 2012-2014. It therefore requests that the PI present in the first quarterly report and at the next EIC-RD meeting a prioritized plan. This is also in the interest of the post-doc assigned to this work. The committee also stresses that complete documentation is also essential: only if the work is documented in sufficient detail will it be useful for the entire EIC community and beyond.

The Committee is also of the opinion that the EIC simulation effort has to be further strengthened in order to have the tools for detector optimization available in time for the development of experiment LoIs and proposals. These studies may have an impact on the IR and machine parameters.

The Committee recommends funding this proposal in full.

2012-6 Development of a Spin Light Polarimeter for the EIC

Dipangkar Dutta (PI), James Dunne, Edward Leggett, Mitra Shabestari (Mississippi State), Wouter Deconinck (Co-PI), Valerie Gray (William and Mary), Abhay Deshpande (Stony Brook), Frank Maas (Johannes Gutenberg) Kent Paschke (Virginia), Paul Reimer (ANL),

It is proposed to develop a continuous non-invasive polarimeter based on the spin dependence of synchrotron radiation (SR), "spin-light", to measure the electron beam polarization at the EIC. The polarimeter consists of a pair of position sensitive hard X-ray detectors based on split-plane ionization chambers and a wiggler magnet. It is proposed to test the polarimeter using the chicane magnets of the Compton polarimeters at JLab. It is also proposed to reuse wiggler magnets from ANL to build a prototype 3-pole wiggler magnet as the SR source.

Polarized electron and ion beams are an essential part of the EIC physics program. Some of the physics measurements they permit include: (a) the gluon contribution to the spin structure of the nucleon; (b) parity violating structure functions mediated by the electroweak gauge bosons; (c) precision tests of the Bjorken sum rule and precision measurements of the strong coupling constant; (d) 3-D mapping of the proton's internal structure.

The determination of the polarization of the electron beam is one of the dominant systematic uncertainties for this program. In order to achieve the desired high precision, it is expected that the polarization of the electron beam must be monitored continuously with an uncertainty of <1%.

The technique proposed here relies on a spin dependent asymmetry between the power radiated above and below the orbital plane of the electron beam. The asymmetry is easiest to measure in the hard tail of the synchrotron radiation above 500 KeV but is small, 10E-4. The photon flux is sufficient to permit a measurement with 1% statistical uncertainty in tens of seconds. The technique is suitable for 4 – 20 GeV electron beams.

Two position sensitive differential ionization chambers using 1atm Ar/Xe operated in current mode would be used to measure the SR asymmetry. The design of the ionization chamber was not clear.

The major sources of systematic uncertainties are expected to be background asymmetries from processes such as Bremsstrahlung and false asymmetry due to vertical beam motion, differences in chamber efficiency and magnetic field non-uniformity between adjacent poles of the wiggler. The main advantage of operating the ionization chambers as differential detectors is that false asymmetries are expected to cancel to first order. In addition the visible portion of the synchrotron light, imaged with CCDs, can be used to align the ionization chambers.

This proposal describes a very interesting approach to a very important task. The proposal would benefit from a back-of–the envelope calculation to demonstrate that the systematic uncertainty of 0.5% can be reached. Supplementary information was provided to the committee after the presentation but it was difficult to assess. The proposal would benefit from a detailed explanation of the ionization chamber readout electronics and the calibration scheme of the polarimeter including the null measurement. The proposal should address beam/bunch structure and the suitability of the technique for both versions of the EIC.

The budget contains 25K$ for a CCD alignment system. This is a considerable sum. The committee is unclear what this alignment system consists of. The budget contains 10K$ for HV power supplies and 10K$ for a VME crate. One would expect such items, and others requested,

could be borrowed from the equipment lending pool of a national lab or otherwise obtained on loan.

The Committee encourages the proponents to further develop this very interesting proposal and consider resubmission in response to a future call.

2012-7 DIRC-based PID for the EIC Central Detector

T. Horn (Catholic University of America), C. Hyde, H. Seraydaryan (Old Dominion) T. Cao Y. Ilieva (South Carolina) P. Nadel-Turonski, W. Xi, C. Zorn (TJNAF), K. Peters, C. Schwarz, J. Schwiening (GSI).

This proposal is currently in its first year of funding. The proponents have adopted this Committee's recommendations from our earlier review. In particular they have extended the scope of the sensor-testing program and are proposing to take advantage of a new, high-B-field dedicated test facility at JLab.

The central detector at the EIC must provide particle identification (e/π, π/K, K/p) over a wide momentum range. A Detector of Internally Reflected Cherenkov light (DIRC) is a radially-compact attractive option. An EIC DIRC will need to deal with the higher momenta particles than the DIRCs for BelleII /SuperB and PANDA.

The proposal is broad and well-written encompassing the following activities: (a) development of a compact readout "camera" that can operate in the high magnetic field of the central solenoid, (b) a study of the possibility to extend the momentum coverage for or π/K identification by improving the θc resolution, (c) a study of the integration of a DIRC into the EIC full-acceptance detector with and without a supplementary gas Cherenkov detector, and (d) the option of using extended DIRC bars that would allow the expansion volume and readout to be located outside the magnetic field.

Extending the momentum range over which it is possible to identify particle species is useful beyond an EIC and for this reason alone the proposal is worthy of support. The proposal discusses semi-inclusive DIS and Transverse Momentum Distributions but does not provide requirements for DIRC performance. The proponents should *quantify* the degree to which extending the momentum range of particle identification impacts specific physics measurements at the EIC.

For all three years of this proposal there is an appropriate emphasis placed on design and simulation both to determine the performance requirements and to develop a DIRC that can meet them. In year one simulation of pion backgrounds in the EIC central detector will determine the need for supplementary e/π discrimination capabilities (beyond the DIRC and Electromagnetic Calorimeter) in the central detector. Studies will be carried out of the performance of different expansion volume sizes, shapes, focusing designs, and radiator shapes, in terms of single photon resolution and light yield. This will inform the design of a prototype compact expansion volume with multi-pixel readout, the set up of a DAQ system and the test of an expansion volume

imaging and sensors. Deliverables will include electron/pion identification requirements, a simulation and reconstruction framework for the DIRC prototype, DIRC resolution studies and initial prototype design. The plan of work and budget are both clearly presented and well-justified for all three years. However the committee would like to see a detailed strategy to achieve a θ_c resolution improvement by a factor that exceeds two.

The Committee recommends funding this proposal in full.

2012-8 Crystal R&D for a forward calorimeter at EIC

Y. Zhang, H. Chen, C. Li, Z. Tang (USTC), H. Huang (UCLA), F. Liu (CCNU), Y. Ma (SINAP), Y. Wang (TSU), Q. Xu (SDU), H. Yuan (SICCAS)

The Committee supports a well-defined effort by the community to develop high-resolution EM calorimeters for use at an EIC. The cost of crystalline calorimeters has limited but not precluded their deployment at other colliders. The Committee believes some further delineation of the likely pseudorapidity range over which such a device would be deployed should be provided, as part of a larger discussion of appropriate techniques for electron identification and tagging at an EIC. This study should note any dependence of how EM calorimeters would be deployed on the choice of machine collision energy and parameters.

The authors propose a range of possible studies. Particularly interesting for these initial efforts are the measurement of basic properties such as light output and timing performance, and the temperature dependence thereof, for doped lead tungstate, PWO, and a comparison to published values for BGO and un-doped PWO.

The Committee is interested in a future proposal for example concerning measurement of properties of BSO and comparison to those of BGO and PWO. This future proposal would need to be more specific than the present one about specific goals and deliverables. Further development could focus on measurements of energy and position resolution for a small matrix of towers and choice of appropriate photo-sensor, although this would need to be done in the broader context of a decision to move forward with crystal calorimetry over some part of an EIC detector's acceptance.

The Committee supports partially funding this proposal to enable the characterization of the crystals to commence and recommends funding at $60K.

2012-9 LOI for Detector R&D towards an EIC detector

E. Aschenauer, B. Azmoun, T. Burton, B. Christie, S. Fazio, A. Franz, M. Lamont, R. PaK, R. Pisani, S. Stoll, T. Ullrich, C. Woody (BNL) M. Hohlmann, M. Staib (FIT) A. Lebedev, M. Rosati (Iowa State), E. Sichtermann (LBNL) B. Surrow (MIT), A. Deshpande (Riken-BNL & Stony Brook) K. Dehmelt, A. Drees , C. Gal, H. Ge, T.K. Hemmick, B. Lewis (Stony Brook) Z-E. Meziani, T. Videbaek, S. Yalcin (Temple), K. Gnanvo, N. Liyanage (Virginia)), H. Caines, J. W. Harris, R. Majka, N. Smirnov (Yale)

The progress towards a “Proposal for Detector R&D Towards an EIC Detector” was reported and the funding of a post-doc for detector simulation and some support for a test beam experiment at JLAB has been requested.

The progress in hardware work and in the planning of the simulation efforts has been presented. The committee was impressed by the progress towards forming collaborations, in particular in the field of hardware. With respect to simulations, the committee strongly supports the decision to use FairROOT and initial detector studies based on a simplified, fast simulation. It however sees the need to further strengthen the simulation efforts.

To summarize: the funding of the postdoc position and the 10 k$ requested for the beam test at JLAB is recommended. The Committee looks forward to a proposal in spring 2012.