BNL PAC Recommendations
PAC Meeting Nov. 3-5, 2005

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The PAC heard Beam Use Proposals from BRAHMS, PHENIX and STAR, and interim reports from the RHIC II Science Working Groups. There was a status report about eRHIC, as well.

RHIC Run 6

Because the length of RHIC operations in Run 6 is expected to be 20 weeks, the PAC reluctantly recommends that the run be limited to the study of a single species, in particular polarized protons. This should be run for a long enough time to provide a significant publishable result at 200 GeV. The PAC recommends a short run at 62 GeV. BRAHMS should take data during the run at 62 GeV.

The individual experiments, using their spin rotators, can determine whether they study transversely or longitudinally polarized protons. The PAC believes that the PHENIX and STAR collaborations are best able to decide on the optimal mix of transverse and longitudinal polarizations. It is important to complete the 2-3 week 62 GeV p-p running, both for heavy ion comparison and equally important the single spin asymmetries A_N at lower energy. BRAHMS should definitely run during this time

The PAC strongly recommends that at least one experiment focus on A_{LL} (longitudinal polarization studies), and is pleased that this is the stated preference for the STAR collaboration.

The PAC also notes that the short runs of different proton energies are most efficiently done at the time when that species is already established in RHIC. As a result, we urge that, even in the 20-week run, a short 62 GeV run and a short 500 GeV run for accelerator development be incorporated and, if possible, a short run at 22 GeV.

RHIC Run 7 and Later

The drastic reduction of Run 6 to 20 weeks requires reevaluation of the Run 7 and beyond beam use proposals by STAR and PHENIX. The Run 6 Au+Au beam request could not be accommodated, given the stated higher priority in this circumstance by both experiments for the polarized proton running needed to make a major advance in A_{LL} and A_N measurements. Consequently, the proposed d+Au run in 2007 should be revisited and its physics priority relative to Au+Au clearly justified.

The PAC feels that a “must do" physics case for Au+Au was presented for 2006, but had to be deferred to future runs. The proposals from both STAR and PHENIX for Run 7 and beyond should therefore include detailed discussions of the measurements achievable in and the relative priorities of d+Au and Au+Au collisions. The experiments should quantify what could be achieved with runs of specific duration. What is the best strategy and schedule to achieve them, and what detector must be in place to achieve these goals? This should include options for triggering and specific detector configurations to optimize for each run. For example, PHENIX should discuss how to optimize the low mass dilepton and virtual photon measurements once the HBD is ready, and STAR should consider heavy ion physics running with the SVT in and out. The case made for d+Au forward physics measurements is also compelling science, but the priority of this relative to Au+Au measurements should be spelled out. The PAC noted that STAR did not request Au+Au in either 2006 or 2007. STAR notes that when the upgrades, the TOF, and at least some vertex detector capability are in place, the usefulness and efficiency of Au-Au running will be substantially improved over what STAR could do in 2006 or 2007. Thus, STAR proposes that the 2006 and 2007 runs be devoted to polarization studies and d-Au.

The specific proposals for Run 7 and beyond that were presented by PHENIX and STAR at this meeting should be revisited, taking into account the final choice of systems for Run 6 and the continuing uncertainties in run time duration. The PAC feels that a substantial 200 GeV Au+Au run, of approximately 12-15 weeks duration, generating an increase in recorded luminosity of a factor of 5 or more relative to Run 4, would produce very compelling measurements by both STAR and PHENIX even prior to instrumental upgrades.

- Significant reduction of the currently large statistical errors in identified hadron yields at p_T >10 GeV/c. Such data, together with concurrent theoretical advances, could support or rule out the currently prevailing paradigm of energy loss that is primarily radiative.

- Significant improvement in the measurements of charm quark energy loss and flow.

- Improved measurements of the correlations among hadrons from jet fragmentation, to identify the mechanism of modifications of the away-side jet.

- Improved measurement of intermediate $1<p_T<5$ GeV/c “thermal” real and virtual photon data, to provide a first direct test of our understanding of electric current fluctuations in the medium. Energy momentum fluctuations, as inferred from the observed “perfect fluid” phenomena (via differential elliptic flow of pions, kaons, baryons and most recently heavy quarks) have led to a radical new view of the quark-gluon plasma in terms of minimal quantal viscosity. This was unexpected prior to the experimental results. Electric current fluctuations could be quite different in strongly- and weakly-coupled QGPs.

RHIC II Science

The PAC heard a number of presentations on the development of the science case for RHIC II. The term "RHIC II" has traditionally been used to describe a series of detector upgrades along with an order of magnitude increase in the collider luminosity, to be achieved by electron cooling of the heavy ion beams. The cooling step is also an important component of the development of technology to allow electron-ion collisions at a future electron-ion collider. In considering the science drivers of the various components of the evolution of the BNL Nuclear Physics facility, the PAC finds it advantageous to identify scientific goals and technical developments as a set of steps following a clear timeline. These steps include the near-term future of RHIC (i.e. Runs 6 and 7), the mid-term future following Run 7 and continuing until the luminosity upgrade, and the longer term future once the increased luminosity is available. This third phase leads naturally to the broadening of the laboratory's study of QCD to an electron-ion collider project.

The PAC found that the mid-term plan is in good shape and the RHIC II working groups and writing group have in hand the material required to produce a planning document for transmission to the Department of Energy. The PAC urges the writing group to adopt a style similar to that used in the "Research Plan for Spin Physics at RHIC", which has proven to be very useful. This plan should clearly specify which of the physics goals can be achieved in the mid-term, with the existing RHIC luminosity and upgraded STAR and PHENIX detectors, and which goals require increased luminosity to come within reach.

The PAC believes that the physics goals for the high luminosity era, along with the detector capabilities required to address them, were less clearly presented at the meeting than the mid-term strategy. This is quite natural, as the timescale is longer, and the community is understandably focusing on extracting the physics from recent data. The PAC feels that there is more time to develop ways to articulate the physics driving the luminosity upgrade, as that is driven by the timescale of the next Nuclear Physics Long Range Plan, rather than by the deadlines for defining and carrying out the mid-term strategy. We comment on specific items warranting further development in the sections below, and look forward to additional discussion of physics with higher luminosity at RHIC in future PAC meetings.

Electromagnetic Probes

Experimental study of chiral symmetry restoration at high temperature and density is of fundamental and broad interest. Medium effects on low mass vector mesons can be measured via the mass spectrum of dileptons, whose rate is directly related to the vector current correlator. At present, however, phenomenological models are required to connect the measured modifications of vector mesons (in particular, that of the ρ) to the approach to chiral symmetry. A convincing, model-independent demonstration of chiral symmetry restoration would require observation of the degeneracy of states of opposite chirality, i.e. both vector (ρ) and axial-vector (a_1). The a_1 spectral function may be accessible via the $\pi^{\pm}\gamma$ channel, though this is probably not suitable for studies of in-medium modification because the pion interacts strongly in dense matter and the correlation of interest will be lost.

Dilepton measurements in the region of the low mass vector mesons will be carried out in the near future using the PHENIX Hadron Blind Detector (HBD) starting in 2007 and STAR Time of Flight in 2008. While the committee feels that these measurements will provide valuable new probes of dense matter, the question of chiral symmetry restoration will likely remain unresolved. This is a difficult and long-standing problem, and new theoretical and experimental developments are needed to address it.

The second main point of interest in electromagnetic probes is measurement of the temperature of hot matter at the core of the collision volume. Model calculations indicate that the yield of thermal electromagnetic radiation exceeds that of pQCD sources for $p_T <\sim 4$ GeV/c. The interaction of jets with matter is also expected to generate a significant yield of photons in this interval. PHENIX has reported measurements in Au+Au collisions of both real and low mass virtual photons in this region, with yields in excess of pQCD expectations. These measurements will be improved substantially in the next two to three years via increased statistics and the introduction of the PHENIX HBD. The committee recognizes the great importance and significance of these measurements.

The above processes are not triggerable and the measurements are limited by DAQ bandwidth. They will benefit greatly from near-term detector upgrades (PHENIX HBD, STAR DAQ1000 and TOF) but not directly from the RHIC II luminosity upgrade. Insofar as high luminosity enables efficient scans of systems and energies there will be an indirect benefit from RHIC II luminosity, but we expect that the measurements of low to medium mass dileptons and intermediate pT photons will be substantially complete on the time scale of the luminosity upgrade.

Measurements of $\gamma\gamma$ HBT will offer the possibility of measuring both the temperature and space-time properties of the collisions. However, they will require very large data sets to be achieved on timescales commensurate with the luminosity upgrade. The question of observing Disoriented Chiral Condensates should also be revisited, taking into account the potentially very large data sets (billions of events) that will become available with increased luminosity.

Heavy Flavor

The study of heavy quark systems consists of two broad areas of investigation: a) Studies enabled by individual quark identification that comprise the extension to the heavy quark sector of the various phenomena studied with the light quarks; and b) Studies of quarkonia, which have a long history in heavy ion physics. The goal of observing the "melting" of the different quarkonia presents a challenging and complex experimental - and to an extent – theoretical task. The results will contribute to our understanding of the QGP produced at RHIC and to the production processes involved.

We discuss here some specific goals of heavy quark studies, which represent an important part of the medium term RHIC program, as well as drive the need for higher luminosity.

Individual quark studies:

1) Measurement of the elliptic flow of charm and beauty. This is crucial to determining whether or not the c, b quarks participate in the fast equilibration seen in the light quark systems.

2) Are c, b quark jets suppressed? If so, by how much and with what p_T dependence? The pattern of suppression observed with u,d,s systems is striking: mesons are suppressed, while baryons are not. Understanding c,b will give essential clues to the underlying reasons for this.

3) The study of the nature of the quark jets is part of the general study of correlations of jet fragments, and is a promising, albeit statistically challenging, approach to elucidating the nature of jet propagation in the new medium.

The PAC believes it is crucial to see more complete analyses of the separation between c and b systems. How much can be done just with displaced vertices for electrons? Can triggering on the electron of the second charm allow triggering for the study of $K\pi$ decays of D mesons? In general what is the relation between the fully reconstructed $K\pi$ decays and the charm identified by displaced electron tracks? Useful work can be done before the luminosity upgrade on heavy quark flow and, separately, studying the suppression of mesons containing c and b quarks. However, the full physics potential of heavy quark studies can only be accomplished with the luminosity upgrade, due to the statistical limitations. Detector upgrades are essential, especially the vertex detectors in STAR and PHENIX and the STAR TOF and PHENIX nose cone calorimeter.

Questions regarding the production and suppression of quarkonia include:

1) Study of the different quarkonia states is important to test color screening in the medium. Such screening would cause dissolution of different states at different temperatures, depending on the binding energy or size of the bound states, providing a

QCD thermometer. This simple picture may be complicated by existence of correlations looking like quarkonia bound states above T_c, as suggested by the lattice, however the χ_c state should still melt near Tc.

2) How does the J/ψ suppression depend on system size and possibly also on beam energy? Can the hypothesis of dynamic coalescence or recombination be experimentally falsified?

3) What is the A dependence of quarkonia production? This is a crucial component to quantitatively understanding the formation of quarkonia probes of the plasma, and requires p- or d-nucleus running at RHIC.

4) Are there interesting angular correlations of light hadrons with those containing heavy quarks?

The PAC believes that quarkonium spectroscopy is crucial for answering these questions. Studying the system size and beam energy (i.e. initial temperature) dependence of the different states will allow the melting pattern to be mapped out. First results on the J/ψ are statistics-limited, and disentangling the other states requires yet more data than for J/ψ. Data acquisition speed and triggering capability have limited the results available from STAR to date, and planned upgrades will improve the situation. Access to the Y certainly requires upgraded luminosity and improved detector acceptance. Though current theoretical uncertainties make it unclear to what extent the Y will truly serve as the control, the availability of such data will be very important.

High p_T

In the near-, mid-term and high luminosity eras at RHIC, high p_T observables in A+A will continue to provide essential probes of the bulk QGP matter. Measurements will help to constrain energy loss mechanisms responsible for rapid thermalization.

Jet quenching is one of the new phenomena discovered at RHIC. The nuclear modification of high pt single inclusive observables has been systematically measured in the past 5 runs up to $p_t \sim 20$ GeV/c for pions, 10 GeV/c for direct γs and ηs, and up to 6 GeV/c for hyperons. In addition, major advances have been made in the study of intra-jet and away side jet correlations. This year the first measurements heavy quark jet suppression through non-photonic electrons have produced a major surprising challenge to theory of energy loss based on the assumption of the dominance of radiative energy loss. The upcoming near and mid term detector upgrades will provide very important and more precise constraints on the jet energy loss mechanisms.

Among the most important future high priority measurements that the PAC discussed are

1) γ-tagged jet fragmentation
2) high p_T charm quark quenching through D meson measurement
3) extended intra and away side jet correlations
4) azimuthal dependence of jet quenching vs. (p_T, centrality, hadron id…)
5) high rapidity high p_t multipoles

6) high p_t charmonium and Y
7) Study fixed x_T and ϑ_{cm} scaling behavior of cross sections of high p_T particles, particularly baryons, to test for higher twist effects.

The PAC is convinced that the STAR and PHENIX upgrade proposals will position both experiments to make major advances on these topics. High p_T studies are currently limited by the beam luminosity and the gradual (slow) evolution of the detector. Efficient triggering and higher data recording and transfer rates are necessary, particularly for STAR, as well as acceptance improvements planned by PHENIX.

The PAC did not hear enough at this meeting to determine whether, and what kind of, new detector systems will be required to take full advantage of increased luminosities while remaining realistic given the evolving funding constraints. The R2D study group reports have provided valuable documentation outlining maximal rapidity and p_T coverage. While the cost at present for such a large scale detector is not consistent with projected funding scenarios, the long range plan working groups should make use of this information.

All six areas discussed above are under study by both STAR and PHENIX. There are open questions that hopefully will be better understood in the next few years. For example, considerable uncertainty was expressed during the meeting about the feasibility of p_t>10 GeV/c γ-tagged jet fragmentation function measurements. The working groups are urged to make more quantitative estimates for projected uncertainties anticipated on D(z). Of particular importance is development of algorithms and detector optimization to deal with the admixture of trigger photons from QCD Compton scattering, neutral meson decays, and jet fragmentation.

The PAC believes that correlations of hadrons with jet triggers represent key future measurements. In addition to helping pin down energy loss mechanisms, jets offer a promising probe of the medium response to energy and particles impinging upon it. The measurements require exploration of a huge phase space of η_1, η_2, p_{T1}, p_{T2}, φ_1, φ_2 with different hadron probes as a function of collision centrality. At the moderate and high p_T of interest, the measurements are limited by statistics and low signal to background levels. Luminosity and beam time will be the limiting factor in the differential studies. Three particle correlations have already provided powerful observables to pin down the physics, for example the "Mach Cone"-like away-side two particle correlations. Another example is the proposed octupole twist observable at high rapidity and high p_T which would require the study of large range rapidity correlations ($\Delta y > 4$ and $p_T > 6$ GeV/c), out of reach of the present detectors. Jet correlations should remain a very high priority in the AA physics since this is the main observable sensitive to full 3D tomographic information.

New Directions

The new directions group reported on their studies of the "big picture" for future heavy ion studies at RHIC HI. Three questions were presented as fundamental:
1) Entropy Creation
2) Degrees of Freedom
3) Phase Transition

The PAC regards these questions as very important, and at the core of the RHIC heavy ion physics. The New Directions group, or a follow-on study group, could present a more detailed picture of the current status in addressing the above questions and what experimental observables would be useful to answer them. Furthermore, it would be very useful to show what role the new detector upgrades and luminosity upgrade will play. New avenues both from theoretical analyses that are currently developing, e.g. new CGC signatures, CP-violation bubbles, etc. or further detector upgrades should be studied. The PAC further felt that the New Directions group could enlarge its scope and include a mid-term view in developing the ingredients that will establish RHIC as a QCD lab.

Equation of State

The working group presented very positive connections between long standing fundamental questions on the EOS and newly emerging questions on viscosity, for example. The testing and interplay with developing 3-dimensional viscous hydrodynamic calculations and new experimental data are critical for progress. Defining the necessary rapidity coverage for specific measurements (straw-man example - up to rapidity 3 for π, K, p spectra and v_2) is important in considering new detectors and their priority. In this context, the PAC wondered what level of effort would be required for a BRAHMS measurement with a new reaction plane detector.

The PAC believes that it would also be useful to further elucidate the connection of bulk physics with jet physics. A large amount of energy is dumped into the medium. Does it go into heat or collective modes? Hoe do correlation measurements contribute to our understanding of global dynamics, and what is needed beyond the two-particle correlations and low and rather high p_T that are currently available? Consideration of what observables can best address this physics and the statistics and coverage requirements will be very useful. Mapping the physics via scans to asymmetric species and lower energy requires upgraded luminosity to allow shorter runs. It would be useful to quantify the integrated luminosity needs for specific measurements and trigger/DAQ requirements. The group is proceeding well, and has clearly articulated which of the goals they have studied can be reached in the near, mid, and long terms.

The EOS group is encouraged to document these issues, carefully highlighting the most critical parts.

p-A and Forward Physics

One of the interesting areas of investigation of the RHIC physics program is reactions involving forward particle production. This physics is one of the least explored areas of hadron physics and can constitute an integral part of the proposed future "QCD Laboratory" at BNL. The PAC was very favorably impressed by the program of forward QCD physics laid out by Michael Leitch and his working group.

The forward particle physics program is relevant to p+p, p+d, p+A and A+A collisions. p+A collisions are simpler than d+A so this capability at RHIC would be desirable. With the advent of eRHIC, forward tagging of reactions such as deeply virtual Compton scattering and $ep \rightarrow ep\gamma$ and meson production $\gamma^* p \rightarrow Hp$ will allow measurements of generalized parton distributions and hadron distribution amplitudes. In the case of coherent nuclear reactions, such as $\gamma^* A \rightarrow \rho A$, one can test QCD color transparency predictions.

The forward hadron program at RHIC includes

(a) the study of tagged Drell-Yan reactions, such as $pp \rightarrow e^+e^- nX$. The tagged forward neutron allows the study of hard processes involving a high energy virtual π^+ projectile. This type of forward tagging experiment can be extended to the measurement of kaon structure functions by tagging forward Λs.

(b) the study of hard reactions at forward rapidities in pA collisions where there are hints of saturation phenomena setting in.

(c) The study of surviving hadrons: In the case of heavy-ions collisions one gains information on the underlying physics of the quark-gluon plasma by looking at the fast particles which escape the collision. For example, monojet events are potential signals for the formation of color glass condensate. The diagnostics of these phenomena will benefit from forward tagging.

(d) Exotic diffractive phenomena, such as the doubly diffractive reaction $pp \rightarrow pXp$, where X can be any neutral system produced by gluon fusion such as η_c, η_b, Z^0. One can also look at nuclear-coherent diffractive processes such as $A_1A_2 \rightarrow A_1X$, where one or both nuclei remain intact.

(e) Studies of the production and nuclear dependence of forward heavy hadron production. One of the outstanding anomalies in charmonium physics is the strong nuclear dependence of J/ψ production at large longitudinal momentum fraction, x_F, indicating that charmonium is made at the front surface of a nucleus. Furthermore, the nuclear dependence breaks pQCD factorization: it depends on the longitudinal momentum fraction x_F, not the parton momentum fraction in the nucleus x_2. This exotic phenomenon could be due to anomalous energy loss mechanisms or the intrinsic charm mechanism.

(f) The recent discovery of doubly-charmed baryons such as the χ_{ccd} at SELEX at high x_F shows that charm quarks are produced with a high momentum fraction of the projectile. This observation supports earlier findings of double J/ψ production at high x_F at NA3. The Λ_c and Λ_b were also observed at the ISR in pp collisions at high x_F. All of these findings, including the EMC measurements of the charm structure function at high x_{bj}, are consistent with production mechanisms based on the existence of intrinsic charm and bottom Fock states in the wave function of the incident proton. The RHIC facility could be an important laboratory for studying the production mechanisms for fast charm as well as the new spectroscopy of heavy hadrons.

(g) Resolving the proton's valence quark structure: One can study the diffractive dissociation pA→qqqA of the proton into three forward jets on a nucleus, thus probing the fundamental valence wave function of the proton. QCD color transparency predicts that the incident proton suffers no absorption at high jet transverse momentum: the forward diffractive amplitude is coherent on each nucleon of the nuclear target.

(h) Measuring exclusive reactions such as pA→pA, pp→pp, and pp→γ^*pp, etc., provides new insights into QCD at the amplitude level.

(i) Measuring shadowing and anti-shadowing in Drell-Yan reactions; anti-shadowing is believed to be caused by the constructive interference of Glauber many-step processes involving Reggeon rather than pomeron exchange. It is thus non-universal.

(j) Double parton correlations in the proton and nuclei may be observable in 4-jet, double Drell-Yan and double J/ψ events. Comparisons of these events in pp and nuclear collisions will reveal the underlying physics mechanisms.

(k) Ultra-peripheral collisions allow studies of γ+g-initiated processes. The nuclear target allows a new window into the shadowing of gluon distributions in nuclei.

The polarized proton beams at RHIC, together with forward tagging capability, allow a large array of QCD spin tests and correlations, especially single-spin asymmetries. These T-odd observables are sensitive to initial and final state phases in involving hadron amplitudes with different orbital angular momentum

Spin Physics

Matthias Grosse-Perdekamp presented a well structured and potentially compelling program for spin physics in the high luminosity era. As the CERN (COMPASS) and DESY (HERMES) programs in deep inelastic electron scattering wind down, RHIC II will emerge as the unchallenged center for detailed studies of the quark and gluon substructure of hadrons. The addition of ep and eA capabilities with the advent of eRHIC could transform BNL into a legitimate "QCD-Lab".

By the end of the mid-term spin program, we can expect to have a good measurement of the gluon helicity distribution, $\Delta G(x,Q^2)$ over a range of x from $\sim 10^{-2}$ to $\sim 3 \times 10^{-2}$, complemented by measurements from HERMES and COMPASS at lower energies and over smaller x-ranges. These should have enough precision to distinguish among qualitatively different models of the nucleon's gluon helicity. However, these will fall rather short of the "precision measurements" typical of unpolarized distribution functions. In contrast, the single transverse spin asymmetries, A_N, in pion and jet production should be rather well measured. $W^{\pm}$ production at the highest RHIC energy should allow the first *direct* detection/measurement of the polarization on the non- strange quark sea, if RHIC indeed runs at 500 GeV during the mid-term era.

Increased luminosity will allow higher precision studies of the gluon helicity distribution, capable of observing the Q^2 evolution of ΔG using the γ-hadron and hadron-jet production channels. Spin effects in W^{+-} production should become better known, if RHIC is run at the highest energy. This will open a new era in transverse spin physics: A_N and A_T can be analyzed in detail to distinguish Sivers, Collins, and other sources of single spin asymmetries. The Sivers function gives insight into the correlation of spin and orbital angular momentum in the nucleon, while the Collins function measures the same correlation in the fragmentation process. Both begin to probe the elusive role of orbital angular momentum in the confined bound state.

Perdekamp described two more speculative projects which the PAC found tantalizing: First, the possibility of a (small) dedicated Drell-Yan detector in the present Phobos interaction region. Transverse spin asymmetries in Drell-Yan are the cleanest way to access the quark transversity distributions, which have never been measured and that are, in principle, as fundamental as the well-known helicity distributions. Such a project would require organizing a new collaboration, most likely reaching out to European groups presently engaged in COMPASS and HERMES. This is an exciting prospect. The second project involves charm-associated $W^{\pm}$-production: $p + p\uparrow \rightarrow W^{\pm}$ +cbar c +X. This channel is cleanly sensitive to Δs and Δsbar, the helicity carried by the strange quark sea. This measurement would be complementary to the study of Δs and Δsbar in low energy elastic neutrino scattering, a program under consideration at J-PARC. Probably this project would only be compelling if there were indications that Δs or Δsbar were anomalously large or if Δs(x)-Δsbar(x) might show significant x dependence.

On its own, the spin program would not be sufficient to motivate the luminosity upgrade, though the possibility of a sensitive, dedicated Drell-Yan experiment strengthens the case significantly. When the spin program possible at eRHIC (as presented briefly by Abhay Deshpande and discussed below) is folded in, however, the package looks more impressive. We were not asked to consider that package at the current meeting. As it stands, the RHIC II spin program must be considered along with the RHIC II heavy ion program in making a case for proceeding with the luminosity upgrade.

The spin working group for RHIC II seems to be large, active, and well-organized. The PAC looks forward to hearing further from them.

eRHIC

An electron-ion collider offers a major new direction for QCD studies at BNL. It will be the world's first machine to offer the capabilities of polarized electron scattering at center of mass energies above 30 GeV on 1) polarized protons and polarized light nuclei, and 2) heavy nuclei, providing unique kinematic reach for small-x physics and higher order QCD processes in these reactions. The PAC looks forward to the much more extensive presentation of the scientific case planned for the meeting next spring. It is clear that a number of physics directions are exciting on their own merits and others have direct bearing on the relativistic heavy-ion program at RHIC. In preparation for that meeting, the PAC offers a few comments.

The timescale for a project like e-RHIC is such that it is unlikely to become operational until late in the next decade, and much progress will have been made at RHIC and potentially elsewhere (for example, color glass condensate studies at the LHC or Sivers function measurements at RHIC). It will be important to anticipate what new information is likely to become available and to elucidate how such progress may recast the e-RHIC science directions. In some cases, this may indicate whether the e-RHIC community is separate from the heavy-ion community or could grow from the science thrusts of the heavy-ion community. At RHIC, hadron and heavy-ion physics evolved together by using a suite of common detectors and beams. This will not be so at eRHIC. It also appears that additional attention should be placed on diffractive physics which is known to account for significant fractions of the DIS cross sections on nuclear targets at low-x. Intrinsic heavy flavor in the proton wave function also should be examined. If orbital angular momentum is the critical unknown in hadron structure, what are the key measurements?