BNL HENP PAC Recommendations
Meeting of 23-24 March 2006

19 April 2006

The HENP Program Advisory Committee met on March 23-24, 2006 to review and give input on the neutrino and eRHIC programs at Brookhaven National Laboratory. The exact charge given to the PAC is included at the end of this document as Appendix A.

We first comment on the proposed neutrino program (section 1), then on the eRHIC program (section 2), and a brief comment on integration with RHIC II and the heavy ion program (section 3).

Section 1: Neutrino Physics

The status of the BNL neutrino program was presented at this meeting. The committee members noted that BNL has a long tradition in neutrino physics and has made significant intellectual contributions to that area of physics. The three-component neutrino program, as presented, addresses the most pressing questions in neutrino physics, builds on the strengths of BNL achievements in neutrino physics, and is a nice balance of near and far term projects.

The plan as presented is to continue the significant participation in the MINOS experiment in the near term, continue involvement in the Daya Bay reactor experiment beyond this, and grow involvement in the farther term in the very long baseline neutrino oscillation program.

The MINOS experiment, with first results expected very soon, will produce the next accelerator based neutrino physics results. On MINOS, BNL is responsible for beam stability studies, monitoring and data processing, as well as data analysis. The BNL group's analysis focus is on ν_e appearance and π^0 background rejection. While this analysis is unlikely to produce early conclusive results, it is an important component of the MINOS analysis and has a very natural connection to ν_e appearance issues relevant to the long baseline component of the BNL program.

The next generation accelerator and reactor neutrino physics experiments will focus on measurement of the least well known mixing angle in the MNS matrix, θ_{13}. The present limit set from the Chooz reactor experiment on $\sin^2(2\theta_{13})$ is ~ 0.12. The Daya Bay reactor experiment anticipates a sensitivity down to $\sin^2(2\theta_{13}) > 0.01$ beyond which new techniques, like a neutrino factory, will be needed to improve sensitivity. While the Double Chooz experiment, expected to run before Daya Bay, may be able to reach a sensitivity of 0.02, the committee appreciated the importance of Daya Bay in pushing the sensitivity down to the best possible at reactors, or in performing precision measurements should Double Chooz see a signal. The BNL neutrino group's presentation of the Daya Bay experiment and their involvement in it was very well received. In particular, the committee noted the crucial role BNL plays in R&D work for the Daya Bay experiment. In conjunction with the BNL Chemistry department, the group studies solubility of Gd in scintillator, and attenuation of light in the Gd doped scintillator. These R&D issues are at the heart of the potential success of both the Daya Bay and Braidwood reactor efforts. The committee recognizes and encourages the great synergy between the BNL physicists and chemists in the reactor program.

The very long baseline neutrino oscillation concept employs a wide-band neutrino beam to simultaneously measure θ_{13}, search for CP violation and understand matter effects. This unique proposal was conceived of and developed at Brookhaven; it is the only proposal, world wide, to consider wide-band beams. The idea was recently expanded to include neutrino beams from Fermilab as well as BNL. The committee recognizes the importance of the wide band beam concept for the longer term neutrino oscillations physics program, and the role the BNL group has played in promoting this concept. The next six months will prove pivotal in the future of this concept with the completion of the BNL/FNAL long baseline physics study, and the conclusions of the NuSAG committee charged in addressing the US long baseline neutrino physics program beyond NOvA. BNL should continue to play a leading role in the interactions with NuSAG and the BNL/FNAL long baseline study. In particular they should continue to explore the background estimation, physics reach, and cost and detector issues for the long baseline program. Because of the BNL contributions to the wide-band neutrino program and the timeliness of the NuSAG committee decisions, the committee recommends that the BNL neutrino program's highest priority in the next 6 months be to focus on development of this program. Evaluation of this program in light of the conclusions from NuSAG will define BNL's future role in the long baseline neutrino oscillation program. At that time, Brookhaven may have to consider how large a role it can have with a limited size group or may consider strengthening the group.

Section 2: eRHIC

The PAC is very supportive of the proposed electron-proton/ion collider as a definitive machine for probing and testing QCD. The proponents have made a strong case for studying the collisions of polarized electrons/positrons with protons and ions of sufficient energy to cover a broad range of x and Q^2. Such a machine has the potential of significantly advancing fundamental aspects of hadron and nuclear physics. A strong proposal for such an electron-ion collider was presented utilizing the existing RHIC ring at Brookhaven and termed eRHIC.

An electron-ion collider in conjunction with polarized electron, proton and light ion capabilities at eRHIC will provide a unique new world class facility for investigating QCD nuclear physics in as yet uncharted domains of high density at small $x \sim 0.0001$ and coherence at large x over a wide range in scales $Q^2 \sim 1\text{-}10^4$ GeV^2, and with nuclei across the whole periodic table. The fundamental theory, QCD, of the structure of strongly interacting matter will be tested with new levels of precision and novel nonlinear QCD phenomena will almost certainly be discovered. Therefore, the PAC strongly supports the eRHIC initiative of BNL.

The PAC includes below three subsections with comments on the organization of the eRHIC effort, input on accelerator and experimental design considerations, and feedback on a wide range of physics topics.

Subsection 2a: Strategy and Organization

The physics case for construction of the eRHIC collider facility and associated experimental program are very compelling. The next 6 to 12 months are a critical time where the project will either be included as a high priority in the next NSAC long range plan or it will not. The PAC felt that there was not enough focus and organization to support this project during this critical early stage. Internally Brookhaven management best understands its resources and possible options, so these suggestions are meant to be only general guidance.

The formation of a specific eRHIC group at Brookhaven with some administrative assistance help would be viewed in a positive light. The upcoming workshop in July is a good example of a critical gathering, and yet insufficient coordination could reduce its effectiveness. The planned QCD Workshop in July 2006 gives little lead time to build broad based consensus in support of eRHIC. This consensus building and thus communication is crucial both within the eRHIC group and also to people outside the group in the RHIC, DESY DIS, and JLAB communities.

The local BNL group could then push on coordinating efforts including updates on the web page (www.bnl.gov/eic), trying to have a large email list of upcoming meetings and events, and a larger contact group of people. Bi-weekly meetings, not just with accelerator people, but on physics focus and long range planning politicking are needed. A Steering committee exists, but meets way too infrequently. The activity level needs to be raised significantly to have a buzz in the field that this is the key next desired large scale facility.

From the presentations heard by the PAC the main strategic problem at this stage appears to be the building of a substantially broader support base for this project within the US nuclear physics community as well as the internationally particle physics community while at the same time gaining the support of the large international heavy ion community. There is urgency to this process because of the rather short time remaining before the NSAC LRP commences this year. The PAC feels that it will be critical for BNL management and scientists to work more closely with the JLab community to formulate a coherent, unified vision for a future nuclear “QCD Lab” that centers on eRHIC with center of mass energy reach 10-100 GeV. However, the QCD Lab concept should also encompass hadron-nucleus as well as nucleus-nucleus capabilities. A united vision and effort toward the formulation of the QCD Lab construction project is essential.

There is also a need to formulate a more inclusive approach to the eRHIC manpower with international support of both high energy experimentalists and nuclear (RHIC and JLAB) experimentalists. The July workshop is a good starting point but even a higher management level coordination and accommodation would be useful to prepare for the NSAC LRP. Involving other groups in a formal collaboration would be extremely useful. For example, direct contact with the DESY directorate to set up a formal collaboration with DESY accelerator physicists is critically different than having one name and a set of verbal interest statements.

It was also felt that in pushing a $650 M project, the involvement of some key senior people is needed on a short time scale. Perhaps one or two people (some mentioned in discussions) could be convinced to take a sabbatical to Brookhaven over the next year to work near full time to push the project. The focus may not necessarily be on specific accelerator and detector design, but rather in developing the physics program and including a broader group of interested physicists.

In the talks it was mentioned that the community might be of order 300-400 people. For a project of this scale and the possibility of multiple experiments and such a rich variety of physics channels, the PAC felt that a larger community is needed and this must be cultivated.

Subsection 2b: Accelerator and Experiment Input

For the eRHIC project to succeed, the PAC feels that the proposal at BNL should keep all options open and not commit too early to one intersection point limited to one detector. On the envisioned >2016 startup time scale, physics directions and detector needs will most likely evolve from present preliminary concepts to adapt to new knowledge gained over the intervening decade as already noted in the previous PAC report: "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." The "flexibility/adaptivity" aspect of the eRHIC planning was not emphasized enough in the talks presented.

The presentation that PAC heard about the Ring-Ring option has only one intersection region and one detector, and the PAC regards that as too inflexible at this stage to be able to attract broad support from the outside community. Multiple intersections options are possible with a Linac-Ring configuration and the PAC favors that approach since it leaves open the widest set of physics opportunities. The LINAC-ring is not a requirement, but is one option that keeps open the physics opportunities. Other options should also be considered that do the same. Additionally the possibility of an order of magnitude increase in luminosity is important for attracting the JLab contingent. Clearly the issue of not being able to run with positrons in the LINAC configuration is a major issue that needs to be addressed. A staged approach was presented with the smaller MPI experiment being run first for 1-2 years and then removed. This was not viewed as a viable option and was too limiting.

The cost of a LINAC design with multiple IR and then an additional ring for positrons at lower luminosity should be examined in detail.

a) How would the ring-ring design be modified to have more than one possible interaction region? To be used only one at a time, not simultaneously.
b) What would the modification above cost?
c) How would the ring-ring design be modified so that at a later date it would be possible to have two interaction regions?
d) What is the cost of a stages two LINAC solution with a second stage ring-ring for positrons – perhaps at lower luminosity?

The presenters suggested that there might be significant cost savings in obtaining the PEP-II ring (9 GeV) and then developing the LINAC for higher luminosity in the future. This is potentially very appealing as it maintains the needed flexibility to make this a major program. The question was also raised about obtaining the 3 GeV ring as well for other focused studies at higher x.

Subsection 2c: Physics Input

The PAC was very impressed with the physics possibilities at eRHIC. However, the PAC feels that the discussions of the underlying physics potential of eRHIC need considerable broadening to show how fundamental aspects of hadron dynamics and structure will be significantly advanced, and why such physics topics will be compelling to the entire QCD community. For example, deeply virtual Compton scattering $\gamma^*(q)p \to \gamma(k)p'$ (DVCS) provides a remarkable way to study the fundamental structure of the proton at the amplitude level. Measurements of the DVCS cross sections with specific proton and photon polarizations provide comprehensive probes of the spin as well as spatial structure of the proton at the most fundamental level of QCD.

In the following we will briefly discuss a number of important eRHIC physics topics which probe aspects of hadron structure and which are interesting to the hadron and nuclear QCD community. The proponents should demonstrate in detail how the capabilities of eRHIC and its proposed detectors will probe such QCD phenomena, especially its novel aspects.

Many important physics studies of deep inelastic lepton scattering require measurements at high x over a significant range of Q^2 as well as electron-positron comparisons. The proponents need to show that their choice of the $e^\pm$ energy range has been optimized for high x as well as low x studies.

Also, in presenting to people outside this subfield, a physical picture (e.g. spatial structure of the proton) needs to be included so that physics does not appear as minutia of measurements that can and therefore must be done. The argument that we have pushed lower in x every decade and now can go further does not carry much weight in the broader community.

Below we include comments on a rather long list of topics. The length of this section highlights the excitement of many of the PAC members.

Low-x Physics: An electron-ion collider of the sort being discussed at Brookhaven is an excellent machine for studying small-x physics and, in conjunction with results from heavy ion collisions, for doing first principles calculations of pre-equilibrium dense QCD matter.

As a small-x machine studying the dynamics of high-density wavefunctions eRHIC sits in the same domain as HERA. The HERA collider has significantly smaller values of x but this is compensated by the added gluon densities coming from large nuclei. One of the main problems in effectively using HERA data to study the idea of gluon saturation (Color Glass Condensate) at small x is the difficulty in separating regions of dense gluons in the proton at small impact parameters from more dilute regions at larger impact parameters. This problem is less severe in scattering off nuclei and, as well, the impact parameter dependence should be easier to determine in electron-ion collisions. Details on this impact parameter determination of what detector configuration is needed should be spelled out. In addition, the original HERA program was not focused on small-x physics and the detectors were badly designed to do that physics. Detectors at eRHIC should be able to make sharper measurements.

By the time an electron-ion collider would begin to operate theoretical control over the dynamics turning high-density wavefunctions into high density QCD matter in heavy ion collisions should have improved considerably. One can expect that precise data coming from electron-nucleus scattering can be used to calculate, from first principles, the pre-equilibrium time evolution of dense QCD matter and follow that evolution to the time of equilibration and the appearance of the equilibrated quark gluon plasma. RHIC and the LHC will be the only facilities ever to have produced systems that allow one to study the properties of a non-equilibrium field theory (QCD), and data coming from electron ion collisions will be the only precise information that will be available concerning the initial conditions of that system.

DVCS at eRHIC: Deeply virtual Compton scattering $\gamma^*(q)p \to \gamma(k)p'$ provides a remarkable way to study the fundamental structure of the proton at the amplitude level. When the incoming photon is highly virtual $Q^2 = -q^2 >> \Lambda^2_{QCD}$, the underlying scattering process measures Compton scattering on bound quarks, convoluted with the fundamental microscopic wavefunctions of the initial and final state proton. In addition, the photons can scatter and annihilate virtual quarks pairs in the initial state, thus probing quantum fluctuations of hadron wavefunctions predicted by relativistic quantum field theory. Thus DVCS provides direct and unique information on the proton's light-front wavefunctions.

The DVCS amplitude is complex, so one must have the capability of measuring both its real and imaginary part. Measuring the electron-positron asymmetry allows the measurement of the real part of the DVCS amplitude from its interference with the Bethe-Heitler bremsstrahlung amplitude. One can thus test for the presence of a constant in energy J=0 fixed pole characteristic of quark Compton scattering. Single proton-spin asymmetries provide the interfering imaginary part related to the generalized parton distributions.

The Fourier transform of the DVCS amplitude with respect to the momentum transfer and the skewness parameter can provide a three-dimensional spatial picture of the proton at fixed light-front time. Measurements of the DVCS cross sections with specific proton and photon polarizations can thus provide comprehensive probes of the spin as well as spatial structure of the proton at the most fundamental level of QCD.

The sum rules of DVCS, such as Ji's sum rule for angular momentum and the integral relations to electromagnetic and gravitational form factors are all explicitly satisfied in the LF formalism. The generalized parton distributions derived from DVCS are not probability distributions; they are predicted to obey unique evolution equations for hard exclusive in Q^2.

The proponents need to demonstrate the capabilities of eRHIC in carrying out comprehensive measurements of the DVCS amplitudes.

Structure functions of protons and nuclei: The strange and anti-strange distributions of the proton need not be $s(x,Q^2) \neq \bar{s}(x,Q^2)$; this asymmetry reflects fundamental nonperturbative aspects of the proton's structure.

QCD predicts that the charm and bottom quark distributions $c(x,Q^2)$, $b(x,Q^2)$ measured in DIS have support at large x; these contributions arise from diagrams in which the heavy quarks are multi-connected to the valence quarks of the proton. These intrinsic contributions are addition to those derived from gluon splitting and DGLAP evolution. The probability for intrinsic heavy quarks scales as $1/m_{Q2}$ due to the non-Abelian interactions of QCD. The presence of intrinsic charm and bottom fluctuations leads to the production of heavy mesons, baryons, and quarkonia at high x_F in the proton fragmentation region.

Studies of the gluon distribution utilize subprocesses such as $\gamma^* g \to c\bar{c}$. The presence of intrinsic charm complicates using the charm tag to determine the gluon distribution at high x. This effect can be reduced by requiring that c and $\bar{c}$ jets balance in transverse momenta since the associated charm quark appears in the proton fragmentation region in the case of the intrinsic contributions.

It has been predicted that the anti-shadowing of nuclear structure functions is not universal, but rather is quark- flavor specific. This phenomenon may be related to the

NuTeV anomaly. It can be tested in semi-inclusive DIS in nuclei where the quark flavor can be tagged.

DGLAP evolution of the proton structure breaks down as one enters the large x fixed W^2 domain since the struck quark is far off shell at $x \to 1$. This phenomenon is essential in order to preserve exclusive-inclusive duality even at large Q^2. The structure functions of nuclei at $x \to 1$ reflect fundamental features of the nuclear wavefunction in QCD, including hidden color dynamics.

The electron-positron asymmetry in DIS tests the electroweak neutral current as well the presence of two-photon exchange contributions, which in the case of exclusive amplitudes, are believed to cause a breakdown of the Rosenbluth separation method.

Diffractive DIS: Diffractive DIS $ep \to epX$ where there is a large rapidity gap and the target nucleon remains intact probes the final state interaction of the scattered quark with the spectator system via gluon exchange.

Diffractive DIS on nuclei $eA \to e'AX$ and hard diffractive reactions such as $\gamma^* A \to VA$ can occur coherently leaving the nucleus intact.

Single-Spin Asymmetries: Single-spin asymmetries measuring the $\overline{S} \cdot \vec{p} \times \vec{q}$ correlation in DIS arise from the final-state interactions of the struck quark in DIS; the Wilson line of the quark propagator cannot be neglected in any gauge. Here $\vec{S}$ can be the electron or proton spin and $\overrightarrow{p'}$ is the quark momentum as determined by a jet measure such as thrust, or it can be the momentum $\vec{p}_H$ of a hadron from the jet fragmentation. The SSA for jets in DIS is free of the Collins asymmetry from jet fragmentation. It has never been measured.

Forward Fragmentation: When the electron strikes a quark in DIS, the remnant part of the proton emerges along the proton direction. The remnant system for DIS on nuclei such as the deuteron and ^3He targets do not always leave the spectator nucleons intact, because of QCD hidden-color degrees of freedom in the nuclear wavefunction as well as the final-state interactions of the quarks.

When the electron interacts with the intrinsic charm or bottom quark, heavy hadrons such as the Λ_b and even doubly charmed baryons such as the $\xi(ccd)$ are created with high momentum fractions and Lorenz-dilated lifetimes.

One of the novel aspects of eRHIC is its capability for studying the forward fragmentation products of the struck proton in DIS. The proponents should discuss how a detector with forward hadron capability can illuminate this fundamental proton physics.

Search for the Odderon: A fundamental prediction of QCD is the existence of the Odderon exchange with odd charge conjugation in the t-channel reflecting three-gluon exchange. The measurement of the asymmetry in the fractional energy distribution of charm versus anti-charm jets produced in high energy diffractive photoproduction $\gamma p \to c\bar{c} + p$ at eRHIC would provide a sensitive test of the interference of the Odderon and Pomeron exchange amplitudes in QCD. Another possible test is to measure the energy dependence of exclusive process such as $\gamma p \to \pi^0 p$.

Coulomb Excitation of the Proton into Quark Jets: The diffractive dissociation of the pion into di-jets was measured by E791 at Fermilab, thus determining the pion light-front $q\bar{q}$ wavefunction. An analogous measurement of the proton's wavefunction via diffractive dissociation of the proton into three jets can be carried out using Coulomb excitation $ep \to e' qqq$.

Inclusive DVCS: The inclusive reaction $e^{\pm} p \to e^{\pm'} + \gamma + X$ at high photon transverse momentum measures Compton scattering on quarks. The electron-positron asymmetry from the interference with Bethe-Heitler bremsstrahlung measures the cube of the quark charges.

Exclusive Reactions and QCD Color Transparency: The hard exclusive reactions $\gamma^* p \to Mp$ and $\gamma^* A \to VA$ which keep the nucleon or nucleus intact provide important tests of hadron structure and QCD color transparency, The connection of these processes with exclusive reactions at fixed angle could be explored at eRHIC.

Sum Rules: The Bjorken sum rule requires the integration of the spin-dependent structure function over all x. According to Regge theory, the energy dependence of the cross section has a fixed power determined by Reggeon exchange independent of the photon virtuality Q^2. The same energy dependence enters the integrand of the DHG sum rule. Is this prediction correct even in QCD?

The Generalized Crewther Relation of QCD makes the remarkable prediction that the leading-twist radiative corrections to the product of the Bjorken sum rule and $R_{e^+e^- \to x}(s)$ at commensurate values of s and Q^2 cancel to all orders in perturbation theory, thus providing a fundamental test of QCD devoid of theoretical ambiguities.

Section 3: RHIC II Additional Comments

The status of the long term (2012 and beyond) eRHIC strategic initiative was presented at this meeting in the context of a newly reformulated midterm (2006-2011) RHIC operation and high luminosity construction plan.

At the previous PAC meeting in November 2005 the scope of the planning RHIC II versus eRHIC versus a more generic "QCD lab" was still not well formulated. At this meeting the PAC saw a major clarification in the planning process, as documented by the BNL report on "Mid-Term Strategic Plan: 2006-2011" for RHIC, and presented by Tom Ludlam at the request of the PAC. The new report discusses thoroughly and convincingly the rich physics program that will be possible to pusue up to the construction of eRHIC. A series of STAR and PHENIX upgrades and an increase of a factor of 10 in the luminosity will enable these experiments to address many of the open problems posed by the discoveries in the first five years of operations up to about 2012. The major change since the last PAC has been to redefining the scope of the RHIC II Project (p.53 of that report) to be strictly a luminosity upgrade for the machine. The expectation is that the STAR(FMS, DAQ1000, TOF, HFT, InTrack) and PHENIX(HBD, VTX, FVTX, NCC, DAQ) array of major detector upgrades to be completed by 2011 will be enable those detectors to address quantitatively compelling physics questions related to (1) the bulk QCD equation of state , (2) the transport properties of strongly coupled quark gluon plasmas, as well as (3) explore nuclear parton structure, such as gluon saturation and the spin structure of nucleons. A strong case was presented in the report that the RHIC II heavy ion program beyond 2012 will compete well and complement the then running (1 month/year) LHC heavy ion program even without a major new detector (e.g. R2D discussed last year). For example, the important heavy quark production and nuclear modification physics observables can be addressed with similar yields per year when the luminosity and detector upgrades are completed.

The sacrifice of the previously discussed major new heavy ion detector option (like R2D) is regarded by the PAC strategically essential to enable BNL to go forward in a timely manner with a proposal to place eRHIC as the top priority next construction project in the upcoming NSAC Long Range Plan.

One concern is the current lack of an identified >2016 concurrent heavy ion program that could be compatible with the eRHIC running demands of e+p and e+A. Such a program is desirable for the QCD Lab RHIC II capabilities to remain on the cutting edge of QCD matter physics studies after four years of high luminosity operations at RHIC II and eight years of LHC heavy ion studies. Of course, no one knows today which questions will drive the physics ten years from now and what new detector capabilities (like R2D or beyond) will be required to answer them in the post 2016 time frame. However, the lack of any planned new heavy ion detector to complement the eRHIC program could decrease the interest and support of the current pp, pA and AA community at RHIC and LHC. Future workshops should reach out to that community for ideas to emphasize that while eRHIC is a vital new direction, the QCD Lab that can continue to serve to address their interests as well.

Appendix A: Charge to the PAC

Charge to the PAC for the March 2006 Meeting

This meeting will be devoted to discussions of presentations to the PAC on two topics – eRHIC and neutrino physics. Pointers to some reading material are provided with this note. We've tried to focus your attention on relatively brief documents in hopes you'll find it useful in the short time between now and the PAC meeting. The agenda for the meeting is attached.

There will be no proposals for new experiments at this meeting. The PAC is asked to provide advice of a more strategic nature on both topics, as requested below. The next meeting of the PAC – at a time in late summer to be decided at the March meeting – will be devoted to Beam Use Proposals from STAR and PHENIX for Run 7 and other proposals that may be received.

eRHIC

The future of the RHIC program is based on the RHIC II luminosity upgrade, which we discussed at the November meeting in the content of the RHIC Mid-term Strategic Plan, and on eRHIC. We touched on this subject briefly at our November 2005 meeting. This time we will hear a number of presentations on the physics of eRHIC and the eRHIC project. eRHIC is a substantially larger project and the Laboratory intends to realize it in the next decade, along with another large project – NSLS II. For this to happen, eRHIC must, along with RHIC II, become part of the Nuclear Physics community's vision of NP in the next NSAC Long Range Plan. We can expect NSAC to be charged to develop that plan starting later this year.

To help us position eRHIC appropriately in the Long Range Plan, the PAC can help by providing advice on this effort, starting with the March meeting. I would like you to provide advice on the following issues:

- Physics – is the case for pursing this program compelling? Does it mesh well with the national (and international) NP program? Are we making the case properly (i.e., is it complete)?
- Program – do RHIC and eRHIC complement one another (and other high energy nuclear physics facilities) in an effective way?
- Project – do the planning for and effort on the project concept and R&D (detector and accelerator) look appropriate? This is not expected to be an in-depth technical assessment, but more of a reality check.

Neutrinos

The Laboratory is embarking on an ambitious program of neutrino physics, in all likelihood not based on BNL neutrino beams. This includes present work on MINOS at

Fermilab, planned near-term future work on a reactor-based neutrino oscillation experiment and longer-term efforts to develop a national program in long baseline oscillations, together with Fermilab and other laboratories, including DUSEL. Advice from the PAC on the scope and direction would be most helpful at this stage.

- Do the elements of the BNL neutrino physics program make sense as a package? Are we working on the right topics with the right level of effort?
- Does the planned BNL effort contribute effectively to a high quality national and international program in neutrino physics?
- Is the R&D effort appropriate? What components, if any, should be getting more attention?

I want to thank you in advance for your input on these programs. They form the basis (together with US-ATLAS) for the BNL HENP effort in the future. External guidance at this stage will be very useful and much appreciated.