Department of Energy
Office of Nuclear Physics Report

on the

Annual Science and Technology Review

of the

Relativistic Heavy Ion Collider (RHIC)

July 7-9, 2008

Executive Summary

The Department of Energy (DOE) Office of Nuclear Physics (NP) held an Annual Science and Technology (S&T) Review of the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL) on July 7-9, 2008.

The RHIC Facility is a National User Facility that delivers the world's highest energy heavy ion collisions and colliding polarized proton beams for experimental research in nuclear physics. This facility has two large state-of-the-art detectors operated by the Pioneering High Energy Nuclear Interaction eXperiment (PHENIX) and Solenoidal Tracker at RHIC (STAR) research collaborations. Together, these experiments investigate collisions of heavy ions with the primary goal to discover and study a new state of matter called the Quark-Gluon Plasma, and collisions of polarized protons to study the internal structure of the nucleon. The RHIC facility and research staff also carry out research and development (R&D) of advanced instrumentation, detector upgrades, state-of-the-art accelerator technology and advanced computing.

The new Associate Laboratory Director (ALD) for Nuclear and Particle Physics has clearly taken leadership of the RHIC management including providing a vision for the RHIC physics program.

All recommendations from the previous S&T review have been addressed.

The BNL RHIC experimental and theoretical research programs continue to produce high-quality, original and creative results that advance science and technology. The success of RHIC is again demonstrated by the impressive amount of scientific measurements and publications that have appeared in refereed journals and at conferences. In summary, the RHIC research program is considered to be outstanding.

The reviewers were concerned that support for two of the very strong and essential theory efforts at BNL, notably in perturbative quantum chromo-dynamics (QCD) and in lattice QCD, still needs to be placed on a firmer footing. It will be important for Laboratory management to take steps to insure that the strength in these areas is not lost.

As in the previous 2007 S&T review, this review panel reaffirms the merits of the BNL updated mid-term strategic plan for future detector upgrades and the new research opportunities afforded by the planned RHIC luminosity upgrades and the development of low-energy heavy-ion beams. The panel believes a plan for the low-energy beams should be developed based upon the identification of experimental observables which are crucial for the understanding the science and that these observables be evaluated against the measurement potential of the PHENIX and STAR detectors.

An important STAR upgrade, DAQ 1000, will equip the Time Projection Chamber (TPC) for high speed operation that is needed under high luminosity conditions. A concern is the potential effects of possible aging and space charge in the TPC. The

STAR collaboration is encouraged to develop a program to study the possible consequences of operating the TPC under higher luminosity conditions.

The PHENIX and STAR local groups asserted that they faced an increased burden in the form of operational tasks. The STAR experiment's local maintenance and operational support of subsystems was presented as being particularly stressed. A STAR workshop has been planned to address this issue. Both experiments and RHIC management need to ensure that there is adequate staff for operations and maintenance.

The observation and utilization of W decays in the RHIC spin program is at its nascent stage. The reviewers endorse the planned early commissioning run in FY 2010 which could address backgrounds and determine whether the W measurements are feasible. The feasibility of this program is of continuing interest from the previous 2007 S&T review.

The RHIC Collider-Accelerator Division's (C-AD) performance in delivering heavy ion beam has significantly exceeded expectations. The C-AD has demonstrated the retention of proton beam polarization at the maximum acceleration energy of 250 GeV and for the first time collided Au+Au at $\sqrt{s_{NN}}$= 9.2 GeV. The Division's pursuit of innovative accelerator R&D is recognized in recent awards to its staff. The C-AD staff is commended for its outstanding performance.

The reviewers concur with C-AD/RHIC management to implement stochastic cooling on a rapid schedule. The RHIC-II performance upgrade is no longer planned to be accomplished by electron cooling but instead to use stochastic cooling and a 56 MHz RF system to achieve similar luminosity gains. The goal is to have the cooling installed by 2012, providing RHIC-II capabilities five years earlier and at a fraction of the cost.

With higher beam luminosities anticipated, the experiments have responsibility for its efficient utilization. The PHENIX and STAR experiments have reported their findings on factors that contributed to their ratios of recorded-to-delivered integrated luminosity. The panel believes further modest improvements should be achievable.

The safety record of the C-AD and RHIC has continued to improve over the past ten years according to the data on performance and backward-looking indicators. The C-AD has the lowest DART (~0.3) and TRC (~0.9) rates at BNL. The reportable occurrences are declining towards zero.

BNL management is appropriately maintaining and developing core competencies in support of the DOE Nuclear Physics Program goals.

The Phase I plan developed by the ALD to maintain RHIC science impact during the Large Hadron Collider (LHC) heavy ion era is sound. The need for a vision beyond 2014 (Phase II) was expressed but a plan for this period leading up to the possible Electron-Ion Collider (EIC) in the early 2020s was not presented and should be

developed. Any staging options of the EIC would need to be supported by compelling, stand-alone scientific justification.

The effective management of detector upgrade projects, both below and above the Major Item of Equipment (MIE) threshold, was the principal concern at this review. Capital equipment (CE) projects near the MIE threshold are initiated prior to robust cost and schedule determination. This practice could jeopardize the credibility of the Laboratory and Agency should issues arise with the capital projects. BNL management should scrutinize their management practices regarding the implementation of small-scale initiatives.

DOE Recommendations

- The STAR collaboration should develop a program to study possible consequences (e.g., aging) of operating the TPC in a high luminosity environment. Progress should be documented and presented at the 2009 RHIC S&T review.

- BNL should strengthen collaboration management with experienced technical and project management expertise in order to implement the planned suite of detector upgrade projects. BNL should present progress at the 2009 RHIC S&T review.

- BNL should adopt a methodology to improve monitoring and consulting on detector upgrade projects sufficient to ensure progress on the needed aggressive timelines. BNL should document the methodology and present the same at the 2009 RHIC S&T review.

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Introduction

On July 7-9, 2008, the Office of Science for Nuclear Physics (NP) performed a Science and Technology (S&T) Review of the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL) in Upton, New York.

The review committee consisted of eight external consultants: Dr. Rodney Gerig (Argonne National Laboratory), Dr. Roy Whitney (Thomas Jefferson National Accelerator Facility), Dr. Michael Church (Fermi National Accelerator Laboratory), Dr. Harold Jackson (Argonne National Laboratory), Dr. David Richards (Thomas Jefferson National Laboratory), Professor Berndt Mueller (Duke University), Dr. George Ginther (Fermi National Accelerator Laboratory) and Dr. Peter Braun-Munzinger (GSI, Gesellschaft fuer Schwerionenforschung, Germany). The review was chaired by Dr. Gulshan Rai, Program Manager for Heavy Ion Nuclear Physics, Office of Nuclear Physics. Dr. Jehanne Gillo, Facilities and Project Management Division Director for the Office of Nuclear Physics (ONP); Dr. Brad Tippens, Program manager for Medium Energy Nuclear Physics for ONP; Dr. Helmut Marsiske, Program Manager for Instrumentation for ONP; Dr. Manouchehr Farkhondeh, Program Manager for Advanced Technology Research and Development for ONP; and Dr. Ted Barnes of the ONP attended as well.

The primary purpose of the annual S&T review is to evaluate the quality, performance, and significance of the ongoing and planned RHIC programs, in the context of the Nuclear Science Advisory Committee (NSAC) Long Range Plan for Nuclear Science and the national nuclear physics program. In order to perform the review, each consultant was asked to evaluate and comment on any relevant aspect of the science and technology at the RHIC, facility operations and strategic planning. Specifically, the focus of the Science and Technology Review was on understanding:

- The quality, productivity, and significance of the laboratory's scientific and technical accomplishments and the merit, feasibility and impact of its future planned physics program;

- The effectiveness and appropriateness of facility operations and the planning for future facility upgrades in support of the research program;

- The effectiveness of management in strategic planning, developing appropriate core competencies, implementing a prioritized and optimized program, and promoting and implementing a safe work environment;

- The leadership, creativity, and productivity of the facility's scientific and technical staff in carrying out the above activities; and

- The quality and appropriateness of the laboratory's interactions with, and nurturing of, its scientific community.

In addressing these charge elements, the reviewers were also asked to comment on what progress had been made towards addressing action items from the previous S&T Review, and on the facility's computing capabilities, both current and planned. Prior to the review, BNL had provided background material to the panel reviewers, including copies of the 2007 RHIC S&T Report, the Response from BNL/RHIC management regarding the 2007 S&T DOE Recommendations, and an updated Mid-Term Strategic Plan.

The review was based on formal presentations given by the RHIC operations and research staff, detailed discussions with the staff, and the panel members' extensive experience. The first day covered plenary presentations on scientific progress, facility and experiment operations, planned upgrade projects for both instrumentation and the accelerator, and an update on the status of the RHIC Mid-Term Plan. The second day commenced with breakout sessions that focused on RHIC accelerator performance and operations, progress on RHIC beam stochastic cooling, accelerator research and development (R&D), plans to improve experiment data taking efficiency, status of Major Item of Equipment (MIE) and Capital Equipment projects, the RHIC Computing Facility (RCF) operations and the BNL Theory and Lattice groups' contributions to the RHIC scientific program. Question and Answer (Q&A) sessions and executive sessions were held throughout the review. A verbal briefing of preliminary findings, comments and recommendations was presented to Dr. Steven Vigdor, Associate Laboratory Director for Nuclear and Particle Physics, and other BNL staff upon the conclusion of the review on the third day. The panel members were asked to submit their individual evaluations and findings in a "letter report" covering all aspects of the RHIC program. The executive summary and the accompanying recommendations are based largely on the information contained in these letters reports. Appendix A lists the recommendations from the 2007 RHIC S&T Report and their current status. A copy of the charge letter and the agenda are included in Appendix B and Appendix C, respectively.

Scientific Program

Heavy-Ion Research Program and Productivity

Findings:

The Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL) is the world's premier heavy-ion and polarized proton collider facility, which has now operated for eight years. The latest research studies of the strongly interacting Quark Gluon Plasma (sQGP) continue to stimulate strong worldwide interest. The RHIC experiments have published 29 refereed papers (~200 papers to date) in scientific journals since the last review and awarded 51 Ph.D. degrees since 2007.

Scientific achievements during the last year included:

- The observation of low mass di-electron excess in Au-Au collisions, the first measurement of low p_t photons via the virtual photon technique and the delineation of the magnitude of viscosity/entropy from flow analysis. These measurements could help determine the initial temperature of the collision; provide a window to study chiral symmetry restoration; and provide an upper bound for the viscosity for the strongly coupled quark-gluon plasma (Pioneering High Energy Nuclear Interaction eXperiment, PHENIX collaboration).
- The measurement of heavy quark energy loss, the separation of b (beauty) and c (charm) quark contributions to single lepton spectra and the first reconstruction of ψ (Upsilon) and of jets in Au-Au collisions. These results suggest that heavy quarks lose as much energy as light quarks and thus provide important constraints on theories of parton energy loss. (Solenoidal Tracker at RHIC, STAR collaboration).
- Confirmation of the existence of the nearside "Ridge" and demonstration that it extends more that four units of pseudo-rapidity. This implies that the Ridge phenomena is not confined to the mid-rapidity and indicates that the Ridge is created in the earliest moments of the collisions. (PHOBOS collaboration).
- Evidence for longitudinal scaling for net protons in nucleus-nucleus collisions thereby shedding new light on the energy dependence of the baryon stopping process (The Broad Range Hadron Magnetic Spectrometers Experiment at RHIC, BRAHMS collaboration).

Notable technical achievements by the PHENIX experiment included:

- Efficient running and data analysis in 2008 achieved data throughputs of up to 20 TB/day.
- A fix has been developed for the high voltage problems encountered with the Hadron Blind Detector (HBD) detector and the full detector is now again nearly ready for installation in the experiment.

- Start of construction of the Forward Vertex Tracker detector (FVTX).

Notable technical achievements by the STAR experiment included:

- The installation of the Forward Meson Spectrometer (FMS) detector and successful operation for its 1st physics run.
- The Data Acquisition 1000 (DAQ1000) upgrade nearing completion. The Time Projection Chamber (TPC) detector will be ready for low dead-time running in 2009.
- Progress made in the commissioning and installation of the new Time-of-Flight (ToF) detector, with 90 out of 120 ToF trays expected to be installed for Run 9 and the full detector in place for Run 10.

Comments:

The overall RHIC scientific research program and productivity is considered by all the reviewers to be outstanding.

The science program of the two remaining large experiments at RHIC, PHENIX and STAR, is regarded as being vigorous and spectacularly productive. Also the PHENIX and STAR groups at BNL have been extraordinarily successful in producing forefront physics while taking leading roles in the development of detector hardware.

New measurements made by the PHENIX and STAR collaborations continue to have significant impact world-wide and stimulate many new theoretical investigations that go beyond nuclear physics into areas such as string theory and plasma physics.

As in the previous 2007 S&T review, this review panel reaffirms the merits of the BNL updated mid-term strategic plan for future detector upgrades and the new research opportunities afforded by the planned RHIC luminosity upgrades and the development of low energy heavy ion beams.

The panel believes the search for the critical point on the quantum chromo dynamics (QCD) phase transition diagram using low energy heavy ion beams is an important scientific opportunity that should be pursued. However, several reviewers commented that a plan for the low-energy beams should be developed based upon the identification of experimental observables which are crucial for the understanding the science and that these observables be evaluated against the measurement potential of the PHENIX and STAR detectors in the low luminosity, relatively poor beam quality regime. While the achievement of adequate beam luminosity will be difficult, it seemed to some reviewers that no definitive goals for the luminosity have been defined by the scientific needs. In this context, the panel noted the plans for the low-energy scan presented by the STAR collaboration. As the Program Advisory Committee (PAC) pointed out in its last report, the science program for a low-energy scan is not sufficiently robust yet to justify an extended run at beam energies below standard injection energy. The science case and the feasibility of measurements to search for the QCD critical point with the RHIC detectors, especially STAR, should be developed with high priority.

An important STAR upgrade concerns the effort to prepare the Time Projection Chamber (TPC) for high luminosity running. A major part of this plan is the ongoing "DAQ1000" data acquisition system upgrade which should allow the TPC to operate at near kHz rates. This high-speed operation of the TPC is a new regime of operation where the effects of possible aging and space charge need careful monitoring. The review panel encourages the STAR collaboration to further develop and implement a strategy that will permit precision corrections for space charge effects. This effort might require a dedicated team of experienced detector experts who could measure the sensitivity of the existing detector to the effects of a large amount of charge accumulated in the TPC. Since the detailed aging behavior depends on the materials used in the TPC construction, aging tests should be made as realistic as possible.

The reviewers noted STAR management's concern that the team of available experts to support operations, and the TPC in particular, was shrinking. The collaboration has scheduled an Operations Workshop in response to this situation. The reviewers stress STAR and BNL/RHIC managements need to ensure that there is adequate staff to address the operations and maintenance of the STAR TPC.

Recommendations:

- The STAR collaboration should develop a program to study possible consequences (e.g., aging) of operating the TPC in a high luminosity environment. Progress should be documented and presented at the 2009 RHIC S&T review.

Spin Research Program and Productivity

Findings:

RHIC is the world's first and only polarized proton collider dedicated to understanding the origin of the nucleon's intrinsic spin. Reductions in the omnibus funding bill in December 2007 had shortened the 2008 RHIC "Run 8" from 30 cryogenic weeks to 19. This resulted in a nine week run of 100x100 GeV/nucleon d-Au and a 3.5 week run of 100x100 GeV pp collisions. Despite the shortened run, RHIC researchers have continued to make significant accomplishments.

Latest data from both PHENIX and STAR on the A_{LL} observable in polarized pp collisions show that the RHIC measurements will be competitive on a world-wide scale and, when given sufficient luminosity, should be able to determine the gluon polarization in the $0.02 < x < 0.3$ range. With a combination of comprehensive measurements of observables sensitive to the gluon spin ΔG and a careful global theoretical analysis of all the available data, the RHIC program is evolving the most promising option for the determination of the contribution of gluon polarization to the nucleon spin.

BNL/RHIC management has responded to the recommendation from the 2007 S&T review to develop and document a detailed plan with milestones that demonstrates the experimental sensitivity for the proposed proton spin measurements between 2008 and 2013 using the anticipated accelerator design capabilities and detector performance as a planning base. A report on an updated RHIC Spin plan was submitted on June 13, 2008 to DOE.

Comments:

The reviewers believe the measurement of the polarization of gluons in the proton over the accessible kinematic range remains the most important near term goal of the RHIC spin program. The best fit to existing data on $\Delta G(x)$ suggests a zero crossing in the current region of measurements. Consequently, measurements covering differing ranges of x (the bjorken x variable) could allow discrimination among the range of possible distributions for $\Delta g(x)$. For this reason measurements of di-jets (STAR) with their ability to probe varying ranges of x are now important to resolving this problem. Di-jet measurements are planned to be made in the 2009. However, measurements at forward angles combined with direct photon measurements remain a long term goal if it could be demonstrated that these forward measurements are feasible and could probe the polarization to very low values of x.

The Sivers effect could play an important role in accounting for Single-transverse Spin Asymmetries (SSA) observed in hard scattering. A sign change is predicted by the gauge link formalism of QCD for the Sivers function between Drell-Yan and Semi-Inclusive Deep Inelastic Scattering (SIDIS). Experimental confirmation of this sign change will represent a major advance in understanding the QCD processes which underlie the physics of hadrons. Its detection has become a DOE milestone for 2015. RHIC plans to test the predicted sign change by measuring SSAs (specifically A_T) in Dell-Yan events starting in 2015, but a possible new option as an experimental test for this sign change has emerged in the measurement of SSAs in γ+jet events. Its observation will be of wide interest.

Proton beam operation at 500 GeV with an integrated recorded luminosity of 300 pb^{-1} and a polarization of 70% is essential to ensuring the eventual success of the W program to be completed in the out years with the planned detector upgrades. Partial polarization survival to 250 GeV maximum beam energy has been demonstrated and the presence of a depolarizing resonance at 135 GeV is the likely cause of the polarization loss which could be eliminated with proper tuning.

The observation and utilization of W decay for measurement of Δqbar is at its nascent stage. The reviewers endorse the planned early commissioning run in FY 2010 which will address backgrounds and determine whether the W measurements are feasible. The latter is an issue of continuing concern. Without additional information on the resolution in x-bj, it is difficult to assess the sensitivity of the measurements to the details of the shape of the helicity distributions of the antiquarks.

As presented, the updated RHIC running plan for operations through 2014 does incorporate anticipated accelerator and detector performances. It addresses appropriately the scientific opportunities for spin measurements with milestones which should be attainable with the presently projected accelerator performance. However, some of the projected detector sensitivities, while plausible, remain to be demonstrated experimentally. The issue of the achievability of the goals of the spin program hinges on these tests.

Recommendations:

- None

Theory Program

Findings:

The RHIC theory program comprises the BNL Nuclear Theory Group and the BNL Lattice Gauge Theory Group (LGTG). Both groups work in close collaboration with the theory group of the RIKEN-BNL Research Center (RBRC).

The Nuclear Theory Group has 7 senior members and 2 post doctoral researchers; the group is mostly supported by DOE program funds, except for one post doctoral researcher who is supported by Laboratory Directed Research and Development (LDRD) funds. The Lattice Gauge Theory Group has 1 senior and 2 junior staff members as well as 4 post doctoral researchers. This group is primarily supported by LDRD and other short-term funds, and its staff will decrease slightly next year, to 0.5 senior and 2 junior staff members and 3 post doctoral researchers.

The principal areas of concentration of the theory program are in the theory of QCD at finite temperature and baryon density, parton saturation at small x, and spin physics in QCD.

Achievements during the past year include:

- The first global fit of spin-dependent parton distribution functions to the world data set that includes the RHIC spin data. This fit has uncovered indications of a surprising sign change of the longitudinal gluon polarization at small x; this is an important contribution to resolving the "spin crisis."
- Theoretical predictions of monojets at forward rapidity in d+Au collisions and of a QCD-anomaly-driven charge asymmetry have inspired dedicated experimental searches by STAR, which are ongoing. This is helping to reveal the possible role of instantons in the QCD vacuum.
- First calculations of two-particle correlations in the color glass condensate model have been made, indicating a possible role of gluon flux tubes in the formation of the quark-gluon plasma.

- An improved calculation of the QCD equation of state for $N_t = 8$ and almost realistic quark masses, corresponding to $m_\pi = 220$ MeV, as part of a new effort with the hot QCD Collaboration. This is important input to the phenomenology of relativistic heavy-ion collisions.
- A collaborative effort between members of the Nuclear Theory and Lattice Gauge Groups has employed the new lattice QCD results above to perform a first calculation of the bulk viscosity with light dynamical quarks as a function of temperature.

The Nuclear Theory Group, working with the RBRC Theory Group, organized a three-week workshop on viscous hydrodynamics; this helped to initiate a sustained collaboration between all U.S. groups working on the application of viscous relativistic hydrodynamics to nuclear collisions. The group has also initiated a new Center for Analysis and Theory of Heavy Ion Experiments (CATHIE), aimed at coordinating and supporting ongoing efforts in the wider community.

In response to a recommendation of the 2007 S&T Review, the Lattice Gauge Group has described its involvement in the strategic planning of the U.S. national effort in lattice QCD. This included the appointment of F. Karsch to membership in the US-QCD Scientific Program Committee, and his contribution as a leading author of the whitepaper on thermal QCD. This whitepaper was an important step towards the Lattice QCD-II (LQCD-II) proposal of US-QCD, which was submitted to DOE in January 2008. The contribution of the lattice group to the LQCD-II proposal for a computational facility in 2010-2014 was described; this program proposes the use of an optimized balance of dedicated hardware (clusters) and leadership class computing. The thermal QCD effort would use approximately 40% of the available run time on the dedicated hardware.

Beginning next year, the leader of the Lattice Gauge Theory Group [F. Karsch] will be at BNL for only half of each year; there will be no permanent member of the group in full-time residence at BNL.

Comments:

The RHIC theory groups are recognized by the reviewers as being world class.

The perturbative QCD / Spin effort is closely aligned with the experimental RHIC spin program, and is essential for its success. This crucial effort within the Theory Group is carried by only one senior full-time equivalent (FTE), and is thus fragile. There would be significant negative consequences for the RHIC spin program and for an electron-proton program at a future Electron-Ion Collider (EIC) were this effort to be jeopardized.

The Nuclear Theory Group has made continued progress in aligning its research focus with the experimental RHIC heavy ion program; several new results address specific problems of interest to the ongoing experiments. The group has increased its activities

in support of the broader community efforts directed at meeting the theory-related DOE program milestones.

The Lattice Gauge Theory Group has been effectively involved in the strategic planning for the national US-QCD Lattice-QCD effort, making essential contributions to the thermal QCD part of the program.

Acquiring additional dedicated hardware for lattice QCD calculations as proposed in LQCD-II is necessary to assure the future vitality of the U.S. effort in thermal QCD. These calculations form an essential basis for most theory efforts directed toward RHIC heavy ion phenomenology. Lattice calculations are similarly important to ensure the greatest impact of the RHIC-spin program.

The reviewers were concerned that two of the very strong and essential theory efforts at BNL, perturbative QCD and lattice QCD, still need to be placed on a firmer footing. Access to competitive hardware resources and stable on-site leadership are important for the continued viability of this group.

Some weaknesses were also noted in the areas of global modeling of heavy ion collisions and the use of hard probes. The group had presented tentative plans for engaging broader community efforts directed at these core areas of relativistic heavy ion theory, mainly by playing a coordinating role. The panel encourages the theory group to implement these promising ideas.

Recommendations:

- None

Facility Operations and Planning for Future Facility Upgrades

Accelerator Operations

Findings:

The omnibus funding bill in December 2007 shortened the 2008 "Run 8" from 30 cryo weeks to 19. This resulted in a nine week run of 100x100 GeV/nucleon d+Au operations and a 3.5 week run of 100x100 GeV polarized p+p collisions. The p+p luminosity at 100 GeV is still three times below enhanced design goal. An overall beam polarization of 60% (goal is 70%) was achieved in Run 6. However, during the short p+p run in 2008 the polarization was about 10% lower. The survival of beam polarization at the maximum beam energy of 250 GeV has now been demonstrated.

Successful collisions of Au+Au at $\sqrt{s_{NN}}$= 9.2 GeV was conducted in 2008. RHIC operation was also tested at $\sqrt{s_{NN}}$= 5 GeV with the "yellow" beam only. These tests are in preparation for critical point search. The remainder of the time was spent in machine setup and luminosity ramp-up.

The Integrated luminosity in each run has met design goals. The average luminosity of the stores in the 2007 high energy Au-Au run was $12x10^{26}$ which exceeded the design goal for RHIC. The RHIC goal for "Time in Store" is 60% of calendar time. Both Run 8 runs were very close to this goal.

Progress has been made on reducing the number of failure hours. The percentage of "time in failure" was reduced from 29% in Run 7 to 16% in Run 8. Power supply failures continue to be the largest contributor to failure hours.

The Electron Beam Ion Source (EBIS) project is nearing completion and is expected to be operational near the end of FY 2010. EBIS will obviate RHIC's need for the aging tandems and provide new capabilities. A six month rebaselining was done due to the recent continuing resolution (CR).

The RHIC-II performance upgrade is no longer planned to be accomplished by electron cooling. The plan now is to use stochastic cooling and a 56 MHz rf system to achieve similar luminosity gains. The goal is to have the cooling installed by 2012, providing RHIC-II capabilities five years earlier and at a fraction of the cost ($10 million vs. $100 million).

The electricity needed to operate the RHIC cryogenic system has been lowered from 9.2 MW in 2002 to below 5 MW, saving the Lab as much as $1.5 million per year. This achievement has been the result of a sustained improvement program including incorporating the "Ganni Cycle" developed at Jefferson Lab.

The Collider-Accelerator Department (C-AD) is focusing on five high level accelerator initiatives with respect to RHIC operation, including reliability; high energy heavy ion luminosity increases; low energy heavy ion luminosity increases; proton on proton luminosity increases; and increases in polarization while maintaining high luminosity. RHIC management viewed 25 cryoweeks as an effective minimum to permit running substantial periods for two different beam species in a given year and allow progress on accelerator development initiatives (25 cryoweeks correspond to about 9 physics production weeks for each beam species).

Comments:

The reviewers are impressed by the C-AD's efficient operation of the RHIC facility, technical accomplishments, world-class leadership and the productivity of the C-AD staff. The C-AD continues to produce innovative accelerator technology advances which are bringing great benefit to RHIC science. The reviewers commend the C-AD on the reliable operation and numerous enhancements to RHIC facility performance. Most notable is the change in the heavy ion cooling strategy to stochastic cooling which advances RHIC-II performance years earlier at a fraction of the cost. The C-AD and BNL management is also commended for effective management of the EBIS construction project during budget constraints.

The reviewers have identified five significant challenges where RHIC staff has demonstrated exceptional expertise in addressing them to meet the science needs:

- **Reliability:** RHIC efforts to improve availability have been successful with a significant improvement in the metric "time in failure." C-AD is commended for effectively addressing the power supply reliability issue. After discussions with RHIC staff, the review panel understands the motivation for the present goal of 60% of "Time in Store." The panel noted that improvements in reliability would achieve a higher number (74% Time in Store with no failure hours). C-AD is encouraged, consistent with its ongoing reliability program, to reduce failure hours. The panel concurs with the emphasis and overall approach being taken by C-AD.
- **High Energy Heavy Ion Luminosity:** Improvements in heavy ion luminosity have already exceeded RHIC goals, contributing to the decision to address RHIC-II goals without the major electron cooling upgrade.
- **Low Energy Heavy Ion Luminosity:** RHIC has begun to explore, during study time, low energy (below normal injection energy) collisions of heavy ions, at which the incoming beam is very large. RHIC is not ramped and remains at a constant energy. The achievement of adequate luminosity is difficult. C-AD has assumed average luminosity goals for this mode and has credible plans to achieve them. However, better definition of the luminosity goals from the science community would greatly benefit this program.
- **Proton on Proton Luminosity:** Plans are to achieve pp luminosity goals by reducing β^* and by increasing bunch current. The latter will require better control of the beam-beam effect, for which C-AD has credible plans.

- **Increases in polarization:** Credible plans are in place to achieve polarization goals. However, it was noted that as the pp luminosity is increased, preservation of polarization becomes more challenging. The reviewers concur with RHIC management that the success of this program hinges on runs of sufficient length to make progress on the issues.

Recommendations:

- None

Future Facility Upgrades and R&D

Findings:

The RHC/C-AD management has responded to the recommendation from the 2007 S&T review to develop a plan with an aggressive schedule to demonstrate feasibility of transverse and longitudinal cooling with bunched beams. This plan was submitted to DOE on December 31, 2007.

A comprehensive plan for luminosity upgrades in the next 5 years was presented to the review panel for both Au+Au and p+p collisions. These upgrades include the installation of stochastic cooling, a 9 MHz RF cavity for more efficient Alternating Gradient Synchrotron-RHIC (AGS-RHIC) beam capture, a 56 MHz SRF cavity for more efficient rebunching in RHIC, reduction of β^*, lattice modifications to reduce Inter Beam Scattering (IBS), and increased beam intensities.

RHIC staff has successfully commissioned a longitudinal cooling system in one ring and has documented an improvement of ~15% in integrated luminosity in Au+Au collisions. An identical system is now installed in the other ring, and two transverse cooling systems are being developed to be installed in both rings by 2011. Cooling system measurements and calculations show close agreement.

RHIC staff is designing a 56 MHz SRF cavity for the purpose of implementing more efficient rebunching of ions. A room temperature copper prototype is currently under test, with good results to date.

The head of the Superconducting Accelerator and Electron Cooling Group presented an overview of the group and current hardware and calculational projects. These include construction of a 20 MeV Energy Recovery Linac (ERL), which requires construction of a high current superconducting radio frequency (SRF) cavity and high current SRF electron gun.

The concept and design of a Coherent Electron Cooling (CEC) experiment was presented. The proposed CEC will be driven by the above-mentioned ERL.

Preliminary designs for a staged approach to a future EIC were presented. The design utilizes the above-mentioned ERL for the electron beam, and the above-mentioned CEC to cool the ion beam.

Comments:

The overall high energy luminosity upgrade plan for the next 5 years is well-defined and well-thought out. These plans are backed up by extensive operational experience and extensive calculations.

RHIC staff has gained an impressive amount of expertise in stochastic cooling hardware and calculations. The review panel expressed high confidence that the planned stochastic cooling systems will provide the projected luminosity increases. This plan fulfills the recommendation of the 2007 S&T DOE Review Panel.

The panel agrees the 56 MHz SRF project is very likely to produce the projected increase in luminosity for Au+Au collisions. This system is critically important once the PHENIX VTX, FVTX and the proposed STAR Heavy Flavor Tracker (HFT) detectors with reduced longitudinal acceptance are installed. The reviewers also observed the efforts of the SRF group have thus far not led to direct benefits for RHIC science. The 56 MHz cavity will be the first deliverable from this group to benefit RHIC. The development of local SRF expertise related to RHIC and eRHIC is deemed appropriate.

For p-p operation, the primary luminosity limitation is the beam-beam tune shift. The plan is to increase the bunch intensity to where the beam-beam tune shift parameter is ~0.015 and decrease β^* to 0.50m. Luminosity gains made at 100 GeV beam energy should be transferable to 250 GeV beam energy. Some reviewers thought it unrealistic to expect that electron cooling or an electron lens could be implemented in the next 5 years. The luminosity projections for p-p operation were deemed realistic, but harder to attain than for Au-Au operation.

The C-AD ERL program is a one-of-a-kind R&D program in the Office of Science (no one else is exploring ERLs at 800 MHz, no one in the U.S. is exploring SRF gun technology, and diamond amplified photocathode development) and is making progress. As a long term R&D project, the reviewers thought it was well-motivated, as it can potentially provide an electron beam for a test of the CEC experiment and also the basis for an electron beam for a future EIC. If successful, the CEC will represent a major advance in beam cooling technology. However, some reviewers thought that demonstrating proof-of-principle for the CEC before 2016 is a challenge.

While previously proposed for RHIC-II science, the ERL is now envisioned as a driver for either a Medium Energy Electron-Ion collider (MEIC) or for the CEC. The former is an emerging concept and the latter is speculative; thus the interest in testing CEC as soon as possible in RHIC. Because the CEC is unprecedented in its innovation, the reviewers remarked that many major R&D issues need to be addressed.

Establishing the viability of an EIC will require demonstration of technical feasibility of key R&D activities, including the CEC, a high current polarized electron gun, compact recirculation magnets, and high power ERL in a multi-pass linac. The reviewers support continuing R&D with as much resources as is consistent with ongoing operations.

The concept presented for a future EIC appears plausible. The review panel feels such a machine is far in the future, but encourages continued conceptual work at this time.

Recommendations:

- None

PHENIX and STAR Experiment Detector Efficiency

Findings:

The RHIC management has responded to the recommendation from the 2007 S&T review for the Pioneering High Energy Nuclear Interaction eXperiment (PHENIX) and Solenoidal Tracker at RHIC (STAR) collaborations to perform an evaluation to improve the ratio of data recorded with respect to delivered beam luminosity. A written report was submitted to DOE by June 11, 2008 and presented at this review.

Several facts had emerged from this study:

- The longitudinal dimension of the beam interaction region (the so called "interaction diamond") is large compared to the current detector/trigger acceptances resulting in an efficiency factor ~0.5.
- Prior to stochastic cooling, 50% of delivered luminosity is currently within +-30cm of the nominal interaction vertex. Stochastic cooling, beta* changes, and the 56 MHz system are projected to enhance the average luminosities and decrease the interaction diamond.
- The acceptance of the silicon vertex detector upgrades for STAR and PHENIX experiments will be shortened to a region +-10 cm of the nominal interaction vertex. After various machine luminosity upgrades, projections indicate that 40-50% of delivered luminosity will still be accessible in the narrower acceptance. It was noted that the stochastic beam cooling is not expected to help with the low-energy heavy ion collisions or the pp program.

- The PHENIX response to the recommendation included plots of recent uptime and livetime. The collaboration emphasized the need for trigger/DAQ upgrades to maintain livetime with increasing beam luminosity. A potential ~$2 million electron/photon trigger electronics upgrade is currently in the R&D phase.
- PHENIX reported detector uptimes of 65 to 80% and livetimes of ~90%. The collaboration does not anticipate luminosity related longevity complications and measurements are in progress to help insure appropriate longevity.
- The STAR response to the recommendation emphasized the substantial improvement in the TPC readout time, which is essential to maintain and/or improve livetime with increasing beam luminosity. STAR provided an upper value for an uptime of ~76% and a livetime ~50%.
- STAR reported their detector efficiency is about 40%, with the inefficiency currently dominated by the TPC readout deadtime. STAR reported making good progress on the implementation of the TPC electronics readout upgrade (DAQ 1000) which will permit running the TPC with rates up to 1 kHz. STAR does not currently track daily operation efficiencies.

Comments:

The reviewers found the overall efficiency depended on each experiment's unique mode of operations. In general, the panel agreed that stable accelerator operations facilitated efficient detector operations. The C-AD's plan to decrease the longitudinal size of the interaction regions was applauded by the panel. This is offset by the narrower acceptances of the new silicon detector upgrades. Both experiments have plans that aim to make modest improvements in detector uptime.

The reviewers thought the two experiments were clear on the details of the efficiency accounting procedures. As an example, the definition of delivered luminosity to exclude luminosity during times of large losses merits further discussion between the experimental groups and accelerator staff.

STAR provided an upper value for the uptime of 76% based upon estimated times for beginning of store activities, and calibration and commissioning activities. STAR reported that they nominally operate with roughly 50% livetime fraction, due to the current readout time of the TPC. The product of the uptime and livetime was reported to be between 30% and 70%, for the average choice of triggering conditions. STAR did not provide evidence of readily available daily record keeping of uptime and/or livetime. While no detailed day-to-day tracking of the causes of inefficiencies were provided, detector livetime is currently a serious concern for STAR. The experiment is in the process of implementing an important upgrade (DAQ1000) to significantly improve the readout time for the TPC from 10 ms per event to 50 μs per event. There was an indication that other readout systems will require attention to reap the full benefits from this improvement.

Given the various RHIC operating modes and long shutdowns each year, the panel believes the upper end of the reported detector uptime fractions ~80% for the RHIC

experiments probably represents reasonable performance. A comparison to the Tevatron collider was made where detectors achieved uptime fractions of ~90% for long running periods in a single mode of operation. The reviewers noted, however, that the uptime reported for PHENIX covered a range from 64% to 77% and that STAR's uptime report is an estimate, without any indication of the range actually achieved. Some reviewers thought the uptime performance of both experiments could be improved if this was a high priority for the experiments, but, such improvements would likely come at a cost to other aspects of the program in a resource limited program. While modest improvements in uptime will not make large changes in the statistical precision of results, a 10% improvement in uptime corresponds in some sense to a cost value of ~$1M per year for a nominal RHIC run.

Not all the reviewers were persuaded the experimenters had made a convincing effort to understand the source of their inefficiencies. One reviewer foresaw no improvement in experimental efficiency until the problem was studied with more discipline.

The review panel encourages the experiments to continue the developments of triggering and DAQ capabilities that will help the experiments effectively utilize increasing instantaneous luminosities. The collaborations should continue to optimize the uptime, in the context of competing priorities and carefully plan the commissioning of the various upgrades to minimize the downtime generated by the nearly yearly introduction of substantial improvements of the detectors. RHIC management and the experiments are encouraged to continue the scrutiny, accounting and monitoring of the sources of inefficiencies in order to isolate and minimizing sources of detector downtime. An analysis of efficiency performance should become part of the experiment's end-of-the-run critique similar to the approach adopted by the C-AD. A summary of findings should be routinely reported at the annual RHIC S&T reviews.

Recommendations:

- None

RHIC Computing

Findings:

The issue of idle Computer Processing Units (CPUs) from a previous review has been resolved and on average farm CPUs now are in excess of 90% utilization. The RHIC Computing Facility (RCF) has moved data from old tapes to LTO-3 at no cost for tapes. Redundant 10 Gbps links have been installed for Wide Area Network (WAN) connectivity.

The combination of detector upgrades, e.g. DAQ1000 for STAR, and luminosity upgrades from the anticipated stochastic cooling will increase the annual data from PHENIX by a factor of 2-3 and from STAR by a factor of ~5 over the next several years. RCF stated about 25% of the CPUs and 33% of the disks will have to be

replaced each year. Fiscal year 2008 funding will just meet the requirements outlined in the mid-term plan. A short fall of 0.8 MSI2k[1] (~12%) in computing performance and 200TB of distributed disk space (~11%) is projected. The historical annual replacement of RCF equipment at the level ~ $2 million/year has not been possible in the past two years (actual ~$1.7 million per year).

PHENIX reported that their data was reconstructed within a year of the time it has been recorded. STAR had not fully reconstructed all data acquired over the past two years and only processed 10% of their 2007 data. Concern was expressed that once a significant backlog develops in an ongoing STAR operations, it may be a substantial challenge to overcome the backlog.

Several investments are planned to address power and cooling infrastructure needed for computing:

- 8,400 SF of space will be become available in two stages in 2008 and 2009.
- An additional $1.25 million has been committed in 2009 for power and cooling.
- In 2010-2012 $4.1 million will need to be invested in infrastructure to support RCF and A Toroidal LHC Apparatus (ATLAS) computing. The RHIC fraction and the source(s) of these funds are to be determined.

RCF stated that the support and operations of NY Blue supercomputer are separate from NP funding.

Comments:

The reviewers agree combining the RHIC and ATLAS computing resources is beneficial for RHIC computing and the physical infrastructure requires immediate attention.

The issue of idle CPUs has been resolved. It is clear to the review panel that RCF is on the right track for keeping the utilization up. Although, a follow-up on this issue was not a recommendation of this review, BNL should continue to monitor RCF utilization and routinely provide a summary of RCF performance at the annual RHIC S&T reviews.

While the challenge of providing adequate computational resources was recognized, plans were not presented in sufficient detail to determine whether the DAQ/trigger capabilities, RCF capacity and distributed computing resources will be sufficient to keep up with planned luminosity increases. For example, in a parallel session, RCF stated that they need ~2 additional full time equivalents (FTEs) and the PHENIX and STAR collaboration both need ~2 additional FTEs each to be able to acquire and analyze the anticipated increased data rates. The reviewers noted the 4 FTEs requested

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[1] SPECINT2000 (1 unit = SI2k, 10^6 SI2k = MSI2k) is a computer benchmark specification for CPU's (Central Processing Unit), integer processing power. It is maintained by the Standard Performance Evaluation Corporation (SPEC).

by the collaborations were not in the plans presented by BNL. In a post review remark to DOE NP, BNL management stated its position was reflected in the presentation given by the RCF group which indicated an increase of 1 FTE.

In light of the projected experimental needs, the annual replacement of hardware at the 25% level at RCF appeared to be reasonable to the reviewers. However, the RCF mid-term plan should be updated annually to reflect the changing RHIC run schedule, timing of the detector upgrades, off-site resources and the technology performance advancements.

The increasing demand on RCF resources anticipated from the STAR DAQ1000 upgrade has prompted the STAR collaboration and RCF to reconsider its data model. Among the options under review are Quasi-online event reconstruction and moving offsite simulations and analysis using Grid technology. However, the discussions during the computing breakout session provided little insight as to why STAR only processed 10% of their 2007 data. The issue may not be entirely the availability of hardware resources. As in the previous 2007 S&T review, a comprehensive approach is necessary to determine the needs of the STAR experiment. The DOE has encouraged the STAR collaboration to develop such a plan that would put into context its offsite needs at NERSC/PDSF and elsewhere.

Recommendations:

- None

Scientific and Technical Staff

Findings:

The RHIC heavy-ion program has published 29 refereed research papers since the last S&T review and has the award of 51 Ph.D.s since 2007. Several APS and AAAS fellowships have been awarded to the C-AD staff. Particularly noteworthy are those related to the ERL R&D and Dr. Ben-Zvi. There are presently seven graduate students in C-AD.

The BNL Theory Group has published 71 papers in FY 2007, of which 50 were in refereed journals; a senior member was elected an APS Fellow. One of the lattice theory group's papers is in the top five cited papers in LQCD in 2005-2008.

Comments:

The reviewers unanimously commend the high quality of the BNL researchers and C-AD staff. The publication record of the scientists, in particular the impressive number of publication citations, is a measure of the surpassing excellence of their research.

The innovation, creativity and leadership of the C-AD staff continue to be prominent as demonstrated by C-AD's world-leading technical accomplishments in accelerator operations, design and R&D.

Both the Nuclear Theory and Lattice Gauge Groups continue to be highly productive, as reflected in an impressive number of refereed publications.

Recommendations:

- None

Scientific Community

Findings:

The RHIC management maintains a relationship with its user community through the activities of the RHIC/AGS program advisory committee (PAC) and the RHIC/AGS user group organization. The RHIC user community numbers about 1000 and maintains an active schedule of quarterly meetings each year which focus on scientific, technical and administrative matters (e.g. quality of life issues at BNL) which are important to the users.

The major concerns of the RHIC user community presently are funding for science, quality of life at BNL, and visa and site access issues.

RHIC currently has over 350 students and 60 post-docs involved in the research program. The total number of Ph.D. theses completed at RHIC is 182. The CA-D has a strong training and development program with 7 graduate students and 5 post-docs.

Comments:

The RHIC User Group appears well organized and expresses general satisfaction with the receptiveness of BNL management

It is important for Laboratory management to strike the right balance between the desire by users to have access to affordable accommodations and the need to assure adequate quality of on-site housing facilities.

Recommendations:

- None

Management

Findings:

BNL management has satisfactorily responded to all the DOE recommendations of the 2007 RHIC S&T review.

The new Associate Laboratory Directory (ALD) for Nuclear and Particle Physics (NNP) outlined a series of steps for the future, including implementation of the RHIC II science program, a staged approach to the EIC or AGS precision experiments to be conducted in parallel to the RHIC II science program, and the implementation of an EIC.

The review panel was presented with a long term strategic view for RHIC which has re-scoped the RHIC-II upgrades by employing stochastic cooling rather than electron cooling providing a pathway to RHIC-II science nearly five years earlier and at a fraction of the cost. BNL management plans to make a scientific case and technical feasibility argument for an Electron Ion Collider by 2012, with implementation by the early 2020's.

In response to a RHIC/AGS Program Advisory Committee recommendation, a run plan has been laid out through 2014. RHIC milestones have been mapped to run time planning through 2018.

RHIC is pursuing a suite of experimental upgrades, including a range of smaller capital projects that are supported from with RHIC capital equipment funds. Management is concerned about project management glitches on detector projects.

The review panel with was presented with the status report on integrating safety at RHIC. The C-AD has a Days Away, Restricted or Transferred (DART) of 0.30 and a Total Reportable Cases (TRC) of 0.89. Other areas of BNL have DART and TRC rates ranging from a factor of 1.5 to 20 higher. RHIC management has taken a multiyear approach with a 15 step process for enhancing Environment, Safety, Health, and Quality (ESH&Q).

The panel noted there have been several BNL and RHIC senior leadership changes over the past year.

Comments:

The new ALD for Nuclear and Particle Physics has clearly taken leadership of the RHIC management including providing a vision for the RHIC physics program.

Management is commended for exploiting the opportunities offered by stochastic cooling and integrating these opportunities into the RHIC strategic plan.

The Phase I plan developed by the ALD to maintain RHIC science impact during the LHC heavy ion era seems sound, in particular concerning the strategic importance of the PHENIX and STAR upgrade plans. An important component of this plan is the provision for sufficient running in polarized pp to make a significant impact on proton spin issues.

The need for a vision beyond 2014 (Phase II) was expressed but a plan for this period leading up to the possible EIC in the early 2020s was not presented and should be developed. Any staging options of the EIC would need to be supported by compelling, standalone scientific justification.

There is a concern about the loss of experienced staff and users in the collaborations for support of the development and operations of the PHENIX and STAR detectors. More of the load is being pushed off to BNL/RHIC staff. University based technical support is diminishing.

The reviewers stated the management of detector upgrade projects is the principal concern raised during this review. There is concern that capital equipment (CE) projects near the Major Item of Equipment (MIE) threshold are initiated prior to robust cost and schedule determination. This practice could jeopardize the credibility of the Laboratory and Agency should issues arise with the capital projects. BNL management should scrutinize their management practices regarding the implementation of small-scale initiatives from within their capital support.

PHENIX and STAR collaborations have 5 major Items of Equipment (MIE) projects and several capital projects for detector upgrades.

- The majority of these projects had or is having substantial issues with meeting technical, cost and/or schedule goals. There does not appear to be effective project management methodology or reporting mechanisms to senior collaboration and RHIC management.
- Plans were not presented on how to improve monitoring and consulting on detector upgrade projects sufficient to ensure progress on the needed aggressive timelines. What was presented indicated that such plans would prove very useful.
- Indications are that these projects do not seem to have sufficient experienced technical and project management resources appropriate for the current MIE and capital projects.
- The collaboration management expertise seems currently focused on science core competencies as opposed to technical and management core competencies.

In the context of workforce development, the RHIC collaborations, together with BNL management should develop a plan for mentoring junior scientists in Project Management.

The RHIC DART and TRC rates as an indication of ESH&Q performance are commendable both for their improvements over the last several years and their values.

Recommendations:

- BNL should strengthen collaboration management with experienced technical and project management expertise in order to implement the planned suite of detector upgrade projects. BNL should present progress at the 2009 RHIC S&T review.

- BNL should adopt a methodology to improve monitoring and consulting on detector upgrade projects sufficient to ensure progress on the needed aggressive timelines. BNL should document the methodology and present the same at the 2009 RHIC S&T review.

Appendix A: Action Items from 2007 Science and Technology Review

- The Pioneering High Energy Nuclear Interaction eXperiment (PHENIX) and Solenoidal Tracker at RHIC (STAR) collaborations should perform an evaluation to improve the ratio of data recorded with respect to delivered beam luminosity. All factors should be analyzed, including the efficiency of detector operations. This evaluation and planned actions should be documented in a report submitted to DOE by May 31, 2008 and presented at the 2008 Relativistic Heavy Ion Collider (RHIC) Science and Technology (S&T) review.

Status: Report on the assessment of the PHENIX and STAR experiments' data taking efficiency and planned improvements was submitted on June 11, 2008 to DOE NP.

- Brookhaven National Laboratory (BNL) should develop and document a detailed plan with milestones that demonstrates the experimental sensitivity for the proposed proton spin measurements between 2008 and 2013 using the anticipated accelerator design capabilities and detector performance as a planning base. This plan should be submitted to DOE NP by May 31, 2008 and presented at the 2008 RHIC S&T Review.

Status: A detailed report on an updated RHIC Spin plan was submitted on June 13, 2008 to DOE NP

- Considering the magnitude of the resources required for the lattice gauge calculations envisioned by the Lattice Gauge Theory (LGT) group, RHIC should develop a plan for obtaining the computational capabilities to realize the scientific goals. This plan should be developed in the context of the National Lattice Gauge Program of the U.S. Quantum Chromo Dynamics (USQCD) collaboration, submitted to the Department of Energy (DOE) Office of Nuclear Physics (NP) by May 31, 2008 and presented at the 2008 RHIC S&T review.

Status: This brief report was submitted on June 11, 2008 to DOE NP.

- BNL should develop a plan with an aggressive schedule to demonstrate feasibility of transverse and longitudinal cooling with bunched beams. This plan should be submitted to DOE by December 31, 2007.

Status: A plan to implement stochastic cooling was submitted on December 31, 2007 to DOE NP.

Appendix B: Charge Memorandum

Thank you for agreeing to participate as a panel member for the annual Science and Technology (S&T) Review of the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL), July 7-9, 2008. A list of the members of the review panel and anticipated DOE participants is enclosed.

The RHIC facility plays an essential role in two major scientific thrusts of the U.S nuclear physics program, the national heavy-ion program and spin physics program. As the primary sponsor of U.S. nuclear physics research and the operations of RHIC, it is important for the Office of Nuclear Physics to understand the progress and future potential of these two research programs, the effectiveness of RHIC operations and whether resources and planning are being directed optimally to achieve the scientific goals of the Nation's nuclear physics program.

In carrying out this charge, each panel member is asked to evaluate and comment on:

- The quality, productivity, and significance of the laboratory's scientific and technical accomplishments and the merit, feasibility and impact of its future planned physics program;

- The effectiveness and appropriateness of facility operations and the planning for future facility upgrades in support of the research program;

- The effectiveness of management in strategic planning, developing appropriate core competencies, implementing a prioritized and optimized program, and promoting and implementing a safe work environment;

- The leadership, creativity, and productivity of the facility's scientific and technical staff in carrying out the above activities; and

- The quality and appropriateness of the laboratory's interactions with, and nurturing of, its scientific community.

The review should comment on what progress has been made towards addressing action items from the previous Science and Technology Review.

The first two days will consist of presentations by the laboratory, and executive sessions. The third morning will be used for an executive session and preliminary report writing; a brief close-out will take place in the early afternoon. Preliminary findings, comments and recommendations will be presented at the close-out.

You will be asked to write individual "letter reports" on your findings. Your "letter report" will be held in strictest confidence, so please be candid in your written remarks. The review will be chaired by Dr. Gulshan Rai, Program Manager for Heavy Ion Nuclear Physics, Office of Nuclear Physics. We will accumulate your "letter reports"

and compose a summary report based on the information in the letters. The "letter reports" will be due at DOE two weeks after the conclusion of the review.

An agenda and background material, as well as travel and housing information, will be sent to you directly from BNL. The laboratory will make word processing and secretarial assistance available during the review. If you have any questions about the review please contact me at (301) 903-1455, or Email: Jehanne.Simon-Gillo@science.doe.gov or Dr. Gulshan Rai at (301) 903-4702, or E-mail: Gulshan.Rai@science.doe.gov. For logistics questions, contact Elaine Zukowski at RHIC at (631)-344-3830 or E-mail: zukowski@bnl.gov.

I greatly appreciate your willingness to assist us in this review. This is a very important process, and it helps to insure the highest quality scientific program at BNL. I look forward to a very informative and stimulating visit.

Sincerely,

Jehanne Simon-Gillo
Acting Associate Director of the
Office of Science for Nuclear Physics

Appendix C: Agenda and List of Reviewers

Monday, July 7 (Berkner B)

08:30	DOE Executive session	
09:00	Welcome	D. Gibbs
09:10	ALD Overview ·1 Vision & strategic plans ·2 Overview of RHIC ops: science; projections ·3 Response to previous S&T ·4 Focus and issues for this review	S. Vigdor (30+10)
09:50	PHENIX ·1 Accomplishments & status ·2 Detector efficiency ·3 Plans and issues	B. Jacak (25+15)
10:30	Break	
10:50	STAR ·1 Accomplishments & status ·2 Detector efficiency ·3 Plans & issues	N. Xu (25+15)
11:30	RHIC Spin ·1 Accomplishments & status ·2 The updated Spin Plan	G. Bunce (25+15)
12:10	Lunch and DOE Executive Session	
13:40	C-AD operations overview ·1 Status & performance of RHIC ·2 Plans & performance projections	D. Lowenstein (30+10)

	·3 Planned infrastructure improvements ·4 Issues	
14:20	RHIC performance evolution ·1 Prospects and plans for luminosity upgrade ·2 Polarization; 500 GeV running ·3 Critical point energy scan ·4 EBIS project status ·5 R&D issues	T. Roser (30+10)
15:00	Break	
15:20	Experiment operations ·1 Mid-Term Plan status	T. Ludlam (30+10)
16:00	DOE Executive Session	
18:00	Questions for BNL: Homework	

Tuesday, July 8

Breakout Sessions 09:00 – 12:30

DOE Lunch and Executive Session 12:30- 14:00

Plenary Session 14:00

Breakout Session A: Accelerator Operations, Upgrades and R&D

09:00	Accelerator performance analysis	F. Pilat (20+10)
09:30	Stochastic cooling status and plans	M. Brennan (20+10)
10:00	56 MHz SRF upgrade	E. Choi (20+10)
10:30	Panel discussion	(20)
10:50	Break	

11:10	Status of ERL and e-cooling R&D (including coherent electron cooling)	I. Ben-Zvi (20+10)
11:40	Accelerator development for eRHIC	V. Litvinenko (20+10)
12:10	Panel Discussion	(20)

Breakout Session B: Detectors and RCF

09:00	Plans to improve PHENIX data-taking efficiency	J. Nagle (15+10)
09:25	Plans to improve STAR data-taking efficiency	W. Christie (15+10)
09:50	Panel Discussion	(20)
10:10	Status of BRAHMS + PHOBOS analyses	M. Baker + F. Videbaek (20+10)
10:40	Break	
11:00	Detector upgrades ·1 Status of MIEs and Cap Equip Projects ·2 Plans to improve BNL oversight of projects	E. O'Brien (30+10)
11:40	RCF Operations and Plans ·3 Status and performance of RCF ·4 Present manpower & equipment resources ·5 Breakout of funding of RCF activities and capital equipment turnover ·6 Integration with ATLAS Tier 1 ·7 Projected needs, in context of BNL plans	M. Ernst (25+5)
12:10	Panel Discussion	(20)

Breakout Session C: Theory Program

09:00	Lattice Gauge Theory ·1 BNL role in USQCD LQCD-II proposal	F. Karsch (20+5)
09:25	Achieving RHIC science goals: theory perspective	D. Kharzeev (25+5)
09:55	Panel Discussion	(45)
10:40	Break: panel re-joins session A or B	

12:30 – 14:00 DOE lunch and executive session

Plenary Session 14:00

14:00	BNL response to homework questions	(30)
14:30	Update on science studies for Electron Ion Collider	T. Ullrich (20+5)
14:55	Integrating safety management in the RHIC program	E. Lessard (15+5)
15:15	RHIC users presentation	A. Deshpande (15+5)
15:35	Break	
15:55	Discussion on the new "Plans for the RHIC Spin Physics Program"	(30)
16:25	DOE Executive Session	
18:00	Questions for BNL	

Wednesday, July 9 (Berkner B)

08:30 Questions and answers with Laboratory Management

09:30 DOE executive session and report writing

14:00 Closeout

14:30 Adjourn

Relativistic Heavy Ion Collider Science & Technology Review
July 7-9, 2008

Review Panel

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