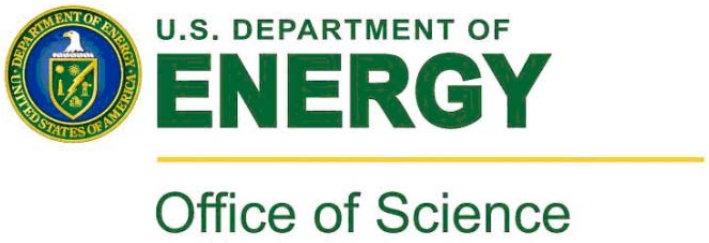

Department of Energy
Office of Nuclear Physics Report

on the

Science and Technology Review

of the

Thomas Jefferson National Accelerator Facility (TJNAF)

July 28-30, 2015

Executive Summary

The Department of Energy (DOE) Office of Nuclear Physics (NP) held a biennial Science and Technology (S&T) Review of the Thomas Jefferson National Accelerator Facility (TJNAF or JLab) at TJNAF on July 28-30, 2015. The Laboratory is a DOE facility operated under contract with the Jefferson Science Associates, LLC (JSA). The primary purpose of the review was to evaluate the quality, performance, and significance of the ongoing and planned TJNAF program, in the context of the 2007 Nuclear Science Advisory Committee (NSAC) Long Range Plan for Nuclear Science and the national Nuclear Physics Program. The review was also used to assess the activities of TJNAF as required under the JSA/TJNAF Performance-Based Contract with the DOE. The S&T review examines all supported research and development activities carried out by the Laboratory as well as the facility operations that support those activities.

The primary mission of TJNAF is to explore the fundamental nature of confined states of quarks and gluons, including the nucleons that comprise the mass of the visible universe. The Laboratory has core competencies in nuclear physics, accelerator and applied nuclear science and technology, large scale user facilities and advanced instrumentation. The laboratory operates the Continuous Electron Beam Accelerator Facility (CEBAF), an Office of Science (SC) Scientific User Facility which is currently being upgraded with the 12 GeV CEBAF Upgrade project. Four experimental halls, Halls A, B C and newly constructed Hall D, house detector experiments operated by JLab staff in collaboration with the user community. TJNAF also is a world-leader in the development of the superconducting radio-frequency (SRF) technology. A local theory group is associated with the facility and carries out research with a principal interest in topics relevant to the experimental program.

A day-one physics program in the field of strong quantum chromodynamics (QCD) was presented. Highlighted were studies of gluonic meson excitations, the nucleon spin puzzle, the 3D nucleon structure, parity-violating experiments, precision nuclear structure studies, tests of the standard model and a limited search for dark photon candidates. Overall, the planned 12 GeV physics program was judged by the panel as outstanding and highly competitive in the context of international activities. There is a well formulated and prepared series of physics experiments which should yield high impact, visible results in the first few years.

The majority of the research topics of the Theory Center are in support of the experimental program at CEBAF. A fruitful collaboration exists between experiment and theory from the proposal stage up to data analysis. The international outreach and expansion of the role of the Theory Center is commendable. Development of milestones for amplitude construction relevant to spectroscopy experiments, extraction of Generalized Parton Distributions (GPDs) and Transverse Momentum dependent Distributions (TMDs) from experiments, and for lattice gauge computations concerning the production of hybrid mesons relevant to Hall D is strongly encouraged.

Accelerator performance continues to be world class. The CEBAF delivered 10.5 GeV beam to Hall D for commissioning and simultaneously to Halls A and B. Beam performance at 10.5 GeV is generally better than required. A well-planned transition to operation following completion of the 12 GeV upgrade project is essential for JLab's early physics programs to succeed. Construction and eventual installation of a spare C100 cryomodule was identified as a means to mitigate risk and ensure machine reliability. A proposed capability to deliver beam to all 4 halls simultaneously is an important improvement to provide more beam time to the users.

JLab is engaged in a number of high profile and important DOE projects which commit a substantial fraction of the staff. The cryogenic design and engineering team is the premier group in the U.S. and is doing an impressive job covering multiple projects (Linac Coherent Light Source II, FRIB, and 12 GeV) with lean staff. Management should work to develop new talent to maintain this important skill set for the U.S. and provide expertise for other DOE laboratories. The injector group was viewed as being at the top of the field for producing parity-quality polarized electron beams. The Laboratory was encouraged to continue to search for opportunities to develop new missions for the Low Energy Recirculating Facility. The laboratory was also encouraged to search for more external collaborators to help with the development of the Medium energy Electron-Ion Collider (MEIC) design.

JLab staff demonstrates leadership and creativity in proposing and shaping the physics program for JLab. The leadership role JLab staff play in the community is evident from the numerous appointments of their staff to important committees that help guide the national program in nuclear science. The user community seems strongly engaged in contributing to both the near- and long-term health of the Laboratory. The Users' Group seems reasonably content with the level of communications from the Laboratory regarding scheduling and priorities.

JLab management has effectively developed an early physics plan which addresses the challenging multi-dimensional balancing of priorities and early capabilities. Significant risks in development of the HDIce polarized target for the CEBAF Large Acceptance Spectrometer (CLAS12) detector were identified and Laboratory management should consider a decision point at which backup plans are developed. The Laboratory maintains an impressively broad expertise in accelerator design, construction and operation as well as cryogenic engineering. It will be important to have a well thought out succession plan to maintain these standards. It may be prudent for management to take a new look at the relative priorities and timelines of Accelerator Improvement Projects (AIPs) to mitigate of risks associated with maintaining full-energy performance. The JLab commitment to the Linac Coherent Light Source (LCLS-II) cryomodule fabrication involves a significant fraction of available SRF and cryogenic workforce and management will have to carefully monitor and manage the impact of possible delays on 12 GeV operations. The Laboratory's safety record has improved since the peak years of 12 GeV construction. Management is commended for implementing a student safety mentorship program.

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Introduction

On July 28-30, 2015, the Office of Science for Nuclear Physics performed a biennial Science and Technology (S&T) Review of the Thomas Jefferson National Accelerator Facility (TJNAF or JLab) in Newport News, Virginia. The review panel consisted of seven external peer review experts: Professor Bruce Dunham (Cornell University), Professor Frank Maas (GSI), Professor Ulrich Wiedner (Bochum University), Professor Steven Vigdor (Indiana University), Professor Amanda Cooper-Sarkar (Oxford University), Professor Eric Swanson (University of Pittsburgh), and Dr. Norbert Holtkamp (SLAC National Accelerator Facility). Dr. Gulshan Rai, Program Manager for the Medium Energy Nuclear Physics Program chaired the review. Dr. Jehanne Gillo, Director of the Facilities and Project Management Division was responsible for the review. Dr. Timothy Hallman, Associate Director of the Office of Science for Nuclear Physics; Mr. James Hawkins, Program Manager for Major Initiatives; Dr. James Sowinski, Acting Program Manager for Heavy Ion Nuclear Physics; Dr. Manouchehr Farkhondeh, Program Manager for Advanced Technology Research and Development; Dr. Ted Barnes, Program Manager for Nuclear Data; Dr. George Fai, Program Manager for Nuclear Theory; Dr. Elizabeth Bartosz, Program Manager for Nuclear Physics Instrumentation; and Dr. Kyungseon Joo of the Office of Nuclear Physics also attended the review.

The primary purpose of the review is to evaluate the quality, performance, and significance of the ongoing and planned TJNAF program, in the context of the 2007 Nuclear Science Advisory Committee (NSAC) Long Range Plan for Nuclear Science and the national nuclear physics program. In order to perform the review, each panel member was asked to evaluate and comment on any relevant aspect of the science and technology at the TJNAF, facility operations and strategic planning. Specifically, the focus of the S&T Review was on understanding:

- The quality 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 assess what progress had been made towards addressing action items from the previous Science and Technology Review.

The review was based on formal presentations given by the TJNAF staff, reports from the Program Advisory Committee (PAC) and the Users' Group, breakout sessions between the panel and TJNAF staff, as well as discussions with TJNAF users and staff. These activities over the first two days provided an overview and formal response to the charge letter. The third day included a question and answer session with staff management, and panel deliberations. The panel discussed the results of the review with Director Hugh Montgomery, TJNAF staff, and Jefferson Science Associates, LLC (JSA) representatives in a closeout briefing on Thursday, July 30, 2015. The panel members were asked to submit their individual evaluations and findings in a "letter report" covering all aspects of the TJNAF program. The executive summary and the accompanying recommendations are based largely on the information contained in these letter reports. A copy of the charge letter and the agenda are included in Appendix A and Appendix B, respectively.

DOE Recommendations

- None

Scientific Program

Experimental Program

Findings:

Highlights of the planned 12 GeV strong quantum chromodynamics (QCD) physics program include studies of gluonic meson excitations, the nucleon spin puzzle, the 3D nucleon structure, parity-violating experiments, precision nuclear structure studies, tests of the standard model and limited search for dark photon candidates. A day one physics program in the field of strong QCD was presented for the experimental halls up to 2019.

The GlueX detector performs as expected within available beam-time as far as tracking performance, time of flight (TOF), and calorimetry are concerned. The availability of 19 days of beam time in 2014 and the 10 days of commissioning in the spring of 2015 has enabled early physics results from GlueX.

The hardware for Continuous Electron Beam Accelerator Facility (CEBAF) Large Acceptance Spectrometer 12 (CLAS12) is partially installed. The CLAS12 collaboration believes that it is advanced in its software development and well organized for Day 1 physics analysis. The Collaboration has been developing common tools that are useful for a diverse array of CLAS12 experiments.

The measurements of electromagnetic form factors are planned for the Super BigBite Spectrometer (SBS) detector. They explore new territory and allow for flavor separation of u- and d-quark contributions. The nucleon structure experiments for the determination of Generalized Parton Distributions (GPDs), and Transverse Momentum dependent Distributions (TMDs) explore a variety of complementary measurements with different polarized and unpolarized targets.

There is a series of parity violation experiments on nuclear targets (PREX and CREX) aiming for a clean determination of the neutron distribution in nuclei. These measurements have direct impact on the understanding of neutron stars through the nuclear equation of state and address an important puzzle concerning observed neutron star masses.

The previous 6 GeV Qweak experiment aims at a measurement of the weak charge of the proton and its data is presently being analyzed. The Laboratory is developing plans for two proposed experiments, the Measurement of Lepton-Lepton Electroweak Interaction (MOLLER) experiment for a high precision determination of the weak charge of the electron, and SoLID (Solenoidal Large Intensity Device), which aims for a determination of the weak charge of the quarks. These could allow for a high precision determination of the weak coupling constant $\sin^2 \theta_W$. A timeline for implementing these experiments has not yet been agreed upon by the Department of Energy (DOE) and the Laboratory.

Comments:

The JLab physics program and the science impact of the 12 GeV upgrade very much relies on providing the maximum energy (11 GeV for Halls A, B, and C and 12 GeV for Hall D). Overall, the planned 12 GeV physics program is outstanding and highly competitive in the context of international activities. There is a well formulated and prepared series of physics experiments which will yield high impact, visible physics results in the first few years. The spectroscopy program at GlueX would benefit from early beam time since it has the potential to provide the first papers from the 12 GeV science program.

The determination of the contribution to the nucleon spin from the angular momentum of valence quarks represents an important contribution to the nucleon spin puzzle. Different experimental Halls explore different aspects of nucleonic structure based on exclusive, semi-inclusive, and inclusive hard scattering, striving for a determination of electromagnetic form factors (EM-FF), GPDs, and TMDs. It would be desirable to develop an integrated picture of what measurements are necessary and will be conducted in determining the GPDs and TMDs.

CLAS12 seems to be well on track in regards to software readiness for data-taking. The measurement of the nucleon form factors at high momentum transfer will constrain the integral of the independent determination of GPDs. The CLAS12 program and the determination of some of the GPDs and TMDs depend strongly on the reliable operation of the hydrogen-deuterium (HD)-ice target. While the reliable operation of this target has been successfully demonstrated with photon beam, this has not yet been proven with an electron beam.

Qweak's results are eagerly awaited by the community.

While the initial parity violation experiments can use the presently achieved beam parameters, a major improvement of parity violation beam parameters is necessary for the proposed experiments, MOLLER and SoLID. The proposed MOLLER and SoLID parity experiments open a possibility for a test of the standard model complementary to the present direct Large Hadron Collider (LHC)-search up to a mass scale of about 50 TeV. In addition these experiments are sensitive to low mass scales down to several 10's of MeV. The Proton Radius (PRad) experiment aims at a measurement of the proton form factors at very low momentum transfer. This measurement could potentially resolve the proton radius puzzle. It is desirable to realize the PRad experiment in the window of opportunity that exists before the CLAS12 upgrade is fully installed.

A fruitful collaboration exists between experiments and theory on several issues. The theory support for the experimental program from the proposal stage up to data analysis is vital.

Recommendations:

- None

Theory Program

Findings:

The Theory Center has seventeen senior staff and joint faculty plus four associate faculty members, nine postdocs and ten graduate students. The Theory Center is conducting research in a wide variety of topics, most of which are of direct interest to the Laboratory's experimental mission. The topics covered, as presented by the Center director, are broadly:

- Understanding short range N-N correlations as a step to understanding the nuclear force
- Calculation of nucleon, pion and meson electromagnetic form factors, coupled channel scattering on the lattice, partial wave analysis and amplitude analysis;
- Parton Distribution Functions (PDFs) for both protons and neutrons, in the polarized and unpolarized sectors
- Multi-dimensional extensions of the PDFs into GPDs and TMDs.
- The evolution of the gluon TMD from small-x to high-x, beyond the conventional QCD evolution in the Dokshitzer–Gribov–Lipatov–Altarelli–Parisi (DGLAP) formalism.
- Lattice QCD calculations of the meson spectrum including gluon excitations which produce exotic states beyond the simple quark model and how this may shed light on quark confinement
- A formulation for computing hadronic transitions on the lattice has been implemented.

The Theory Center has implemented links with several external groups, chiefly in Europe. The Theory Center has initiated a Joint Physics Analysis Center (JPAC) with international collaborators. JPAC has two strands: the well-established Spectroscopy in which JLab takes the lead, and the more recently established Tomography. Both of these have weekly phone conferences and regular workshops. In support of the experimental program the Theory Center contributes to Technical Advisory Committee (TAC) reports that are used by the PAC.

Comments:

There was a recommendation from the previous review to 'Develop a plan for the Theory Group which identifies the theoretical needs of the 12 GeV science program, articulates the role that the Theory Group will play in addressing those needs, and defines goals for how to implement the plan, within constrained budgets'. They have made good progress in implementing the plan.

The majority of the research topics of the Theory Center are in close connection with and in support of the experimental program at CEBAF, both the previous 6 GeV and the future 12 GeV programs. This is reflected in a number of jointly funded theory/experimental positions. Examples of how theory is interfacing with the experimental programs include:

- The work on proton PDFs has benefitted from the CTEQ (Coordinated Theoretical-Experimental Project on QCD)-JLAB collaboration which has

experimentalists as members and uses the BoNuS (Bound Nucleon Structure Experiment) data; the result on the d/u PDF ratio is a world leading result. The work on neutron PDFs relates to the Medium energy Electron-Ion Collider (MEIC) experimental program.
  - The work on Generalized Parton Distributions relates directly to the forthcoming experiments on Deeply Virtual Compton Scattering (DVCS) and the work on TMDs to the Semi-inclusive Deep Inelastic Scattering (SIDIS) experiments.
  - The work on the meson spectrum and spectroscopy within JPAC relates directly to the GlueX program.

It is not clear what new methods are being brought to the longstanding and important issue of creating analytic and unitary model amplitudes. It is strongly encouraged to develop milestones for amplitude construction relevant to spectroscopy experiments, extraction of GPDs and TMDs from experiment, and for lattice gauge computations concerning the production of hybrid mesons relevant to Hall D.

The lattice implementation of coupled channel scattering problems is an important advance that, coupled with the extraction of scattering amplitudes, will provide significant guidance to experiment. Given that the Agency funding for lattice QCD (LQCD) is currently projected to decline, it is important to evaluate the computing hardware requirements needed for the theory group's planned lattice gauge theory calculations.

The demonstration of the feasibility of measuring neutron spin asymmetries at the MEIC is welcome and useful. Theory TAC reports are a vital contribution to implementing the experimental program and this effort is to be commended.

The international outreach and expansion of the role of the Theory Center is commendable. It is notable that the Theory Center sees the work of other groups such as those at Mainz and Istituto Nazionale di Fisica Nucleare (INFN) in terms of a fruitful cooperation and collaboration rather than in terms of competition.

Recommendations:

- None

Facility Operations and Planning for Future Facility Upgrades

Findings:

The accelerator group consists of 154 people and 14 graduate students. Several accelerator staff members also teach classes at Old Dominion University (ODU). The group concentrates on 12 GeV performance and operations, MEIC, core competencies, work for others, and education.

With Critical Decision-4A (CD-4A) achieved for the 12GeV upgrade in July 2014, five months ahead of schedule, CEBAF is transitioning towards user operations. The CEBAF delivered 10.5 GeV beam to Hall D for commissioning and simultaneously to Halls A and B. A plan for an upgrade to deliver beam to all 4 halls simultaneously was presented. Beam energy management, as well as low trip rates, requires high performance cryomodules and a continuous improvement program. Failure of a C100 cryomodule will reduce the available beam energy to below 12 GeV.

Projected operations budgets corrected for inflation do not allow full utilization of the CEBAF facility.

Accelerator Improvement Projects (AIPs) and investments funded from the operations budget are used to maintain or improve accelerator performance in several areas (injector upgrade, parity priorities, energy stability etc). A new ¼ cryomodule for the injector will reduce x-y coupling and allow lowering the emittance and improving helicity dependent effects, and an increase to the gun energy will similarly improve performance. The injector group continues to make excellent progress on developing DC high voltage, polarized electron sources. Electron beam diagnostics, particularly with wide dynamic range, are actively pursued by the accelerator group.

MEIC is becoming a cornerstone of JLab's strategic plan. A modest research and development (R&D) program is underway. The MEIC design plan was updated in 2014, and a preliminary cost estimate was reviewed by the Nuclear Science Advisory Committee (NSAC). An internal MEIC laboratory organization was formed in 2014.

The Laboratory has undertaken a number of 'work for others' contracts, including building half of the cryomodules for Linac Coherent Light Source II (LCLS II) and 2 full cryoplants, as well as a cryoplant for the Facility for Rare Isotope Beams (FRIB). The superconducting radio frequency (SRF) group is engaged in a wide variety of projects across the world, with work at Helmholtz-Zentrum Berlin (HZB), CERN, FRIB, LCLSII, to name a few.

The former Free Electron Laser (FEL) facility has been renamed the Low Energy Recirculating Facility (LERF), and a new mission for the facility is being developed, including nuclear physics, isotope production and accelerator physics research.

Comments:

Accelerator performance continues to be world class at JLab. A well-planned transition to operation following completion of the 12GeV upgrade project is essential for JLab's early physics programs to succeed. Reliable operation with a minimum number of interruptions (trips, failures) is essential to maximize the beam availability. A risk assessment for the facility should be redone and funding priorities (AIP, GPP, operations funds) be re-evaluated. It seems prudent to build a spare cryomodule (C100) to ensure 12 GeV capability, and eventually put it online to reduce the number of trips per hour.

Beam performance at 10.5 GeV is generally better than required. Performance requirements should be proven as soon as possible at the design energy of 12 GeV. By switching to a new laser frequency and adding different RF separators, beam could be delivered to 4 halls simultaneously. This is an important improvement that will provide more beam time to the users.

Being engaged in a number of high profile DOE projects which commit a substantial fraction of the staff, it is crucial for JLab's reputation to deliver on them.

The cryogenic design and engineering team is the premier group in the U.S. They should work towards developing new engineering talent so as to maintain this important skill set for the U.S., and to provide expertise for other DOE laboratories. The cryogenic group is doing an impressive job covering a number of large projects (LCLSII, FRIB, and 12 GeV). They have barely enough staff, and challenges in meeting the commitments in any one of these projects will impact progress on the others. This should be tracked carefully.
The injector group continues to study vacuum and high voltage technologies necessary to improve performance and reliability for polarized sources. They are clearly at the top of the field for producing parity-quality polarized electron beams.
The MEIC design evolves as alternatives are investigated. The team would benefit from more early R&D money to continue the research they have started. They are encouraged to search for more external collaborators to help with these important efforts.

The LERF facility is a one-of-a-kind machine with potential for advanced accelerator R&D studies. The Laboratory should continue to search for opportunities to develop new missions for this facility.

The Laboratory should consider increasing university involvement in accelerator science by expanding the use of bridge and joint appointments, particularly for universities without accelerator science programs.

Recommendations:

- None

Scientific and Technical Staff

Findings:

The Laboratory supports 673 full-time equivalents (FTEs). The Laboratory Director stated that the Laboratory produces ~1/3 of U.S. PhD's in Nuclear Physics, with 504 PhDs completed to-date and 200 in progress.

JLab staff members are co-spokesperson in the majority of the experimental proposals. Based on JLab's key competencies in SRF and Cryogenics, the staff is engaged in a number of high profile construction projects (e.g. LCLS II, FRIB, LARP) within the DOE complex. JLab staff plays leadership roles on committees important to the national program in nuclear science, including NSAC and the American Physical Society. The Laboratory hosts major international workshops and conferences.

Laboratory staff has won a suite of awards, including Early Career Awards, American Physical Society (APS) Fellows, and DOE Secretarial Awards. The Laboratory scores in the DOE NP Comparative Reviews in Theory and Experimental Physics were well above average.

Comments:

JLab staff demonstrates leadership and creativity in proposing and shaping the physics program for JLab. The leadership role that JLab staff plays in the community is evident from the numerous appointments of their staff to important committees which help guide the national program in nuclear science. JLab has a highly competent, effective, and well-balanced management team. The Hall staff provides an important and effective role in leading the experiments. The number of publications has been maintained at a constant level during the 12 GeV preparation phase. The development of detector technologies for nuclear physics has led to spin-offs and new applications. Several innovations appear in connection with the research done at JLab. The Laboratory's training mission for junior scientists is commendable.

JLab has strong accelerator leadership engaged in all aspects of the Laboratory's programs. The technical staff is excellent at all levels. The recent hosting of International Particle Accelerator Conference 2015 (IPAC2015) and International Committee for Future Accelerators (ICFA) Workshop on Future Light Sources, demonstrates JLab's leadership in the international accelerator physics community. The SRF developments, MEIC studies and polarized source R&D illustrate the scientific creativity and productivity of the JLab staff.

The responsiveness of the staff to questions during the review is very impressive and extremely effective, generally answering with the required level of detail.

Recommendations:

- None

Interactions with the Scientific Community

Findings:

JLab management charged a special Program Advisory Committee (PAC) meeting in 2014 with selecting about 600 PAC-days of the highest-impact science proposals among a nearly decade-long suite of already approved experiments for the 12 GeV era. At other PAC meetings, the Laboratory has not provided the PAC with explicit guidelines regarding how much 12 GeV beam time should be approved. The Laboratory has initiated a change regarding the need for explicit PAC approval of new proposals that fit within already approved Run Groups and require no new beam time or significant equipment modifications. The Run Group participants have not yet absorbed this message.

The Laboratory noted that scheduling of experiments is a difficult multi-parameter issue that involves the readiness of the experiments and other constraints. Early science and more detailed 18-24 month beam schedules are developed with major input from the experimental hall leaders, who serve as intermediaries to the broader user community. The Laboratory requires each experiment to undergo a rigorous Experimental Readiness Review before it can be scheduled for beam time.

The Users' Group expressed strong appreciation of Laboratory efforts to solicit user opinion and provide updates on Laboratory policies. A specific example is the recent inclusion of a user representative on the Director's Safety Council. A Jefferson Science Associates (JSA) Initiative fund of roughly $400,000/year is judged by the Users' Group Board of Directors to provide critical support for Users' Group activities. A series of workshops for JLab user community members has served to increase user involvement in EIC science and detector planning. A number of talks and international discussions within the past two years have been used in attempts to grow international participation in development of MEIC.

The Laboratory makes extensive use of bridge and joint faculty positions at universities to grow and nurture their scientific community, as well as to enhance JLab science productivity.

Comments:

The user community seems strongly engaged in contributing to both the near- and long-term health of the Laboratory. The Users' Group seems reasonably content with the level of communications from the Laboratory regarding scheduling and priorities.

The decade-long backlog of approved experiments for the 12 GeV era is more than the optimal amount needed to provide sufficient flexibility in scheduling. It will likely require the PAC "jeopardy" review program to be reinstituted a few years into 12 GeV operations, with the potential for introducing some tension among users. However, the Users' Group seems to understand the necessity of such reviews. The Laboratory should consider establishing a running five year schedule, which could be informed by a

"jeopardy" review program. As the Laboratory approaches steady-state 12 GeV operations, it will be useful for them to provide the PAC with more explicit guidelines regarding the number of beam hours to approve at each meeting, in order to maintain scheduling flexibility and high science impact.

It may be useful for the Laboratory to consider encouraging the Collaborations – especially those associated with large general-purpose detector facilities such as CLAS12, SoLID and GlueX – to more strongly set internal priorities for beam proposals prior to submission of collaboration proposals for PAC approval. The change in policies for Run Group experiments is an initial step in this direction.

Laboratory management should increase involvement of the PAC Chairperson in developing the PAC agenda.

Recommendations:

- None

Management

Findings:

JLab management has developed a sketch of an early 11-12 GeV physics program for each experimental hall during FY 2015-2019. Management continues to nurture the Laboratory's core technical competencies in superconducting RF, lattice QCD computation, and advanced detector development. The superconducting expertise, in particular, is being exploited in JLab projects that are part of the LCLS-II (SLAC) and FRIB (Michigan State University) construction projects. JLab management has very recently instituted efforts to do more quantitative risk analysis for single points of failure affecting accelerator operations.

JLab's safety record has improved in FY2014-2015 following a slight deterioration during the peak years of 12 GeV construction, with Total Reportable Cases (TRC) and Days Away, Restricted or Transferred (DART) rates now well below the goals set. The Safety Awareness Training for the experimental halls has been significantly revised.

An R&D program supporting EIC science and technology has been put in place, using a newly established Laboratory-Directed R&D (LDRD) program in addition to operations funds and competitive accelerator R&D funds from the Office of Nuclear Physics.

JLab management is providing oversight of 22 modest detector and target upgrade projects being funded in FY2013-2019 by Capital Equipment and non-DOE sources, in addition to preparing major items of equipment (MIE) cases for the proposed major MOLLER and SoLID detectors. A new external software and computing review team has been established, and has met three times to date, to ensure that detector data acquisition, simulation and analysis software will be ready for 12 GeV science and facilitate timely reporting of early physics results.

A Science Laboratories Infrastructure (SLI) proposal has been submitted to address an identified risk and operational efficiency issue associated with the End Station Refrigerator system.

The Laboratory continues to make extensive use of joint and bridge appointments with universities to support both the experimental and theoretical research programs.

Comments:

The early physics plan effectively addresses the challenging multi-dimensional balancing of science impact and timeliness, technical risk and readiness, suitability for early beam performance characteristics, compatibility with completion of 12 GeV upgrade construction in the halls, and involvement of junior scientists. With so many small target and detector upgrades required, coupled with operations funding uncertainties, the 12 GeV schedule for the next several years will need to be kept flexible to accommodate unanticipated delays. The experimental hall leaders play key roles in drafting early science schedules, communicating them to the users and gathering user feedback.

On a slightly longer time scale, a significant portion of the CLAS12 science program relies on overcoming significant risks inherent in the HDIce development for transverse polarization operation. Laboratory management should consider a decision point at which backup plans are developed.

The Laboratory maintains an impressively broad expertise in accelerator design, construction and operation as well as cryogenic engineering. It will be important to have a well thought out succession plan to maintain these standards.

It may be prudent for management to take a new look at the relative priorities and timelines of AIP projects associated with providing parity-quality beam vis-à-vis mitigations of single-point failure risks and reliability issues associated with maintaining full-energy performance, given the likely scheduling of experiments that require the associated machine performance characteristics.

The JLab commitment to LCLS-II cryomodule fabrication involves a significant fraction of available SRF and cryogenic workforce, especially with regard to process engineers. Management will have to carefully monitor and manage the impact of possible delays in LCLS-II fabrications on 12 GeV operations.

Substantial progress has been made over the past two years on MEIC design and costing estimates. The management has also worked to increase involvement of the JLab user community in developments of the EIC science case and detector requirements.

The Laboratory is commended for implementing a student safety mentorship program.

The JLab strategy behind choices of joint and bridge faculty appointments was not made clear. In particular, it was not clear how proactive the Laboratory is in stimulating appointments aligned with the Laboratory's strategic planning. It would be useful to create an overall strategy for the creation and pursuit of bridge and joint positions.

Recommendations:

- None

Appendix A: Charge Memorandum

Thank you for agreeing to participate as a panel member for the biennial Science and Technology (S&T) Review of the Thomas Jefferson National Accelerator Facility (TJNAF) that will take place at TJNAF on July 28-30, 2015. A list of the members of the review panel and anticipated Department of Energy (DOE) participants is enclosed.

The TJNAF research program, based around the Continuous Electron Beam Accelerator Facility (CEBAF), plays a major role in the Nation's nuclear physics program. As the primary sponsor of U.S. nuclear physics research and the operations of TJNAF, it is important for the Office of Nuclear Physics to understand the progress and future potential of the research program, the effectiveness of its 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 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 also 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.

Each panel member is asked to review these aspects of TJNAF and write an individual "letter report" on his/her findings. These "letter reports" will be due at DOE two weeks after conclusion of the review. The review will be chaired by Dr. Gulshan Rai, Program Manager for Medium Energy Nuclear Physics, Office of Nuclear Physics. As Chair, he will collate the comments and recommendations from these "letter reports" and compose a final summary report based on the information in the letters. We take care to keep the identity of the reviewers confidential in the summary report. It would be convenient if you would prepare your response in a form suitable for transmittal to the proponents devoid of

potentially identifying information. The cover letter may include other remarks you wish to add.

An agenda and background material, as well as travel and housing information, will be sent to you directly from TJNAF. 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 E-mail: Jehanne.Gillo@science.doe.gov or Dr. Gulshan Rai at (301) 903-4802, or E-mail: Gulshan.Rai@science.doe.gov. For logistics questions, contact Ms. Pat Stroop at TJNAF at (757) 269-7553 or E-mail: stroop@jlab.org.

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

Sincerely,

Jehanne Gillo
Director
Facilities and Project Management Division
Office of Nuclear Physics

Enclosure

Appendix B: Agenda

Science & Technology Review
Thomas Jefferson National Accelerator Facility
Jul 28th–30th, 2015
Agenda

Tuesday Jul 28th (F113)

8:00	**Executive Session/Continental Breakfast**	
8:45	DOE Introduction	T. Hallman/J. Gillo
8:50	JSA Welcome	J. Draayer
9:00	Laboratory Overview	H. Montgomery
9:15	Science Overview	R. McKeown
10:00	Experimental Nuclear Physics Progress	R. Ent
10:45	**Break**	
11:00	Accelerator Overview	A. Hutton
11:45	Theoretical Physics	M. Pennington
12:30	**Lunch (B207) / Executive Session (F113)**	
1:45	LDRD Program	L. Cardman
2:00	The 12 GeV Project – Status and Schedule	A. Lung
2:30	Accelerator Commissioning and Operations	A. Freyberger
3:15	Early Physics Program	R. Ent
3:45	**Break**	
4:00	Users Group Report	J. Arrington
4:30	PAC Report	J. Napolitano
5:00	**Executive Session**	
7:00	Reception - CEBAF Center	

Wednesday, Jul 29th (F113)

8:00	Homework Q&A	
9:00	Report on Experimental Facilities and Operations Metrics	J. Gomez
9:30	SBS, MOLLER, SoLID	C. Keppel
10:00	Other Physics CE Projects	P. Rossi
10:45	**Break**	
11:00	MEIC Physics and Design	R. Ent
11:15	Tour	
12:45	**Lunch (B207) /Executive Session (F113)**	
	Break-out sessions 2:00pm-3:30pm (Rooms F113, L102/104, B207)	
	Breakout Session I: Accelerator S&T (L102/104)	
2:00	LCLS-II	G. Neil
2:15	FRIB Cryogenic Plant	K. Dixon
2:30	Beam Diagnostics R&D	P. Evtushenko
2:45	Kicker R&D for MEIC	A. Kimber
3:00	SRF R&D for MEIC	S. Wang
3:15	Plans for Low Energy Recirculator Facility (LERF)	S. Benson

Breakout Session II: Experimental Nuclear Physics Research (F113)

2:00	GlueX Progress and Plans	J. Stevens
2:30	CLAS12 Simulation and Analysis Plans	V. Ziegler
3:00	Detector Technology and Applications	D. Weisenberger

Breakout Session III: Theory and Computation (B207)

2:00	LQCD Campaigns	R. Edwards
2:30	Calculating transitions on the lattice	R. Briceno
2:50	MEIC polarized deuteron R&D	C. Weiss
3:10	TMDs	T. Rogers
3:30	**Executive Session and report writing**	

Thursday Jul 30th (F113)

8:00	Homework
9:00	Executive Session
12:30	Working Lunch
2:00	Closeout