Department of Energy
Review Committee Report

for the

Technical, Cost, Schedule, and
Management Review

of the

12 GeV CEBAF UPGRADE PROJECT

April 2010

EXECUTIVE SUMMARY

A Department of Energy (DOE) Office of Science (SC) status review of the 12 GeV Continuous Electron Beam Accelerator Facility (CEBAF) Upgrade project at the Thomas Jefferson National Accelerator Facility (TJNAF) in Newport News, Virginia, was conducted April 27-28, 2010 at the request of Timothy J. Hallman, Associate Director of Science for Nuclear Physics. The purpose of this review was to assess all aspects of the 12 GeV CEBAF Upgrade project—technical, cost, schedule, management, and environment, safety, and health — as the project proceeds with construction under the requirements of DOE Order 413.3A. The Committee found that the project is progressing well and that the project is being properly managed. However, there are concerns with the Hall D solenoid. The Committee recommended that design of a back-up replacement solenoid should be initiated now, and that an external peer review should be convened to review the risk mitigation plans for the existing solenoid and to advise the project regarding possible implementation of a replacement solenoid. The Committee had a total of ten recommendations. There were no action items.

TJNAF is proposing to upgrade the maximum electron energy of the main accelerator from 6 GeV to 12 GeV, build a new experimental area (Hall D) dedicated to the study of gluonic excitations, and upgrade capabilities in the three existing experimental halls. The 12 GeV Upgrade will allow broad advances in four key areas of nuclear physics: the understanding of quark confinement, how nuclear building blocks are made from quarks and gluons, the physics of nuclei, and tests of the Standard Model.

The 12 GeV Total Project Cost for the performance baseline is $310 million. Remaining contingency is $66.2 million or 52 percent contingency based on estimate to complete, obligations (approximately 33 percent based on costs). The project’s CD-4b date is June 2015, with six months schedule contingency for Halls B and C.

Concerning the Superconducting Radio Frequency (SRF) cryomodules and cryogenics, the Committee concurred that timely testing of full prototype SRF cryomodules is important to success. No technical issues on either the cryoplant or cryomodules were observed since the September 2009 DOE/SC review. However, the impact of the Technology Engineering Development Facility (TEDF) project on the test laboratory and testing schedule has been rightly identified as a potential problem and needs to be managed and coordinated carefully.

In reviewing the Accelerator and Accelerator Physics, the Committee was satisfied with the approach taken to off-load work from the twelve-month shutdown. This approach moves work forward rather than planning for a longer shutdown.

Progress has been made on detector work. There were no major issues with Hall B and C detectors. The Hall D detector work (WBS 1.5) includes installation and infrastructure related to using an existing solenoid as part of the GlueX Detector system. The refurbishment of that solenoid is a Laboratory effort whose schedule is linked to the 12 GeV Upgrade project schedule. The Committee was concerned that the solenoid is prone to shorts. Because it will be operated under different conditions than in the past, and its coils will be exposed to larger mechanical forces, there is risk of new shorts that could compromise operation or permanently damage the solenoid during a quick discharge. The Committee also commented that means should be pursued to shorten the projected schedule for producing a replacement solenoid.

The Committee recommended that design of a back-up or replacement solenoid should be initiated now, that an external peer review should be convened to review risk mitigation plans, to advise regarding implementation of a replacement solenoid, and that the outcome of the review should be reported at the next DOE/SC review.

The Civil Construction is 19.2 percent complete and approximately two months behind schedule (SPI 0.84) but has recovered significantly in recent months. The Hall D Contractor has improved two months on forecast schedule in the last three months. Approximately 70 percent of the civil construction contracts has been awarded. The project is commended for its decision to increase Agent Construction Manager efforts on Hall D construction providing additional oversight and responsiveness and thereby aiding schedule recovery.

Project ESH&Q issues are being properly addressed, and ESH&Q concepts are thoroughly integrated throughout the project. Performance and results are above average.

The Committee noted that the priority of the project within the laboratory seems to be well understood and appropriately high. Still, focus will be required to ensure that shorter-term priorities do not jeopardize progress on the 12 GeV Upgrade project. The current baseline schedule includes approximately six months of schedule contingency to CD-4b for Halls B and C due to funding limitations. The Committee judged that it is appropriate to start planning for the use of cost contingency now and recommended that a contingency usage plan be drafted for the next DOE/SC review. Major recommendations resulting from the review include:

- Initiate design now of a back-up or replacement solenoid for Hall D. Convene an external peer review to assess risk mitigation plans for the existing Hall D superconducting solenoid and to advise regarding implementation of a replacement solenoid. Report on the outcome at the next DOE review.

- Make detailed estimates of the specific uses of ‘contingency labor’ and include it as a part of project baseline plan, via baseline change request, in timely manner (six months before planned execution date).

- Schedule the next DOE/SC progress review of the 12 GeV project in six months.

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1. INTRODUCTION

The Continuous Electron Beam Accelerator Facility (CEBAF) at the Thomas Jefferson National Accelerator Facility (TJNAF) is the world-leading facility in the experimental study of hadronic matter. TJNAF is located on 162 acres in Newport News, Virginia and was constructed over the period FY 1987-1995 for a Total Project Cost (TPC) of $513 million. CEBAF began operations in FY 1995 and is currently managed by the Jefferson Science Associates (JSA). Activities are now underway to upgrade the CEBAF through the 12 GeV Upgrade project.

The scope of the project includes upgrading the electron energy capability of the main accelerator from 6 GeV to 12 GeV, constructing a new experimental area (Hall D) and associated beam-line, and expanding the capabilities of the existing halls to support the most compelling nuclear physics research. The current 6 GeV accelerator is comprised of an inter-connected pair of anti-parallel linacs, each with 20 cryomodules, with each cryomodule in turn containing eight superconducting radio frequency accelerating cavities. The 12 GeV CEBAF Upgrade project makes use of the existing CEBAF tunnel ‘footprint’ and infrastructure in order to optimize project costs (Figure 1-1).

The Upgrade will enable CEBAF’s world-wide user community to expand its research horizons, and allows breakthrough programs to be launched in three key areas:

- The experimental verification of the existence of powerful force fields (‘flux tubes’) believed to be responsible for quark confinement; understanding confinement is essential for understanding the structure of nuclear matter;
- The measurement of the quark and gluon structure of the proton, the neutron, and other nuclear building blocks at the most basic quantum level; and
- New research domains in key areas already under investigation.

The project received Critical Decision (CD) 0, Approve Mission Need, in March 2004; CD-1, Approve Alternative Selection and Cost Range, in February 2006; CD-2, Approve Performance Baseline, in November 2007; and CD-3, Approve Start of Construction, in September 2008.

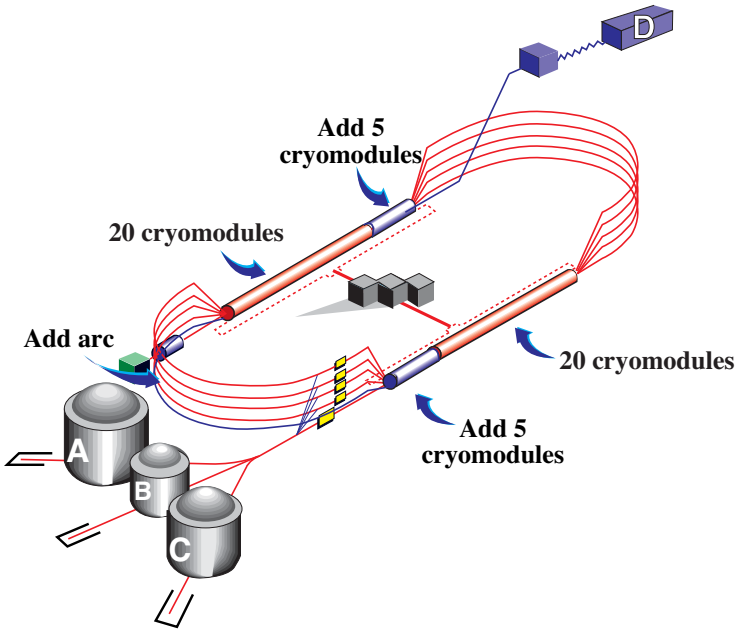

Figure 1-1. Diagram of the 12 GeV CEBAF Upgrade

In a February 4, 2010, memorandum (Appendix A), Dr. Timothy J. Hallman, Associate Director of the Office of Science (SC) for Nuclear Physics (NP), requested that Daniel R. Lehman, Director for the Office of Project Assessment, SC, conduct a Project Mini-Review to assess the project's progress since the September 2009 DOE/SC review. The Review Committee (Appendix B) was chaired by Daniel R. Lehman. Members were chosen on the basis of their technical and/or project management expertise, and experience with building large scientific research facilities, as well as their independence from the project. The Committee was organized into six subcommittees, each assigned to evaluate a particular aspect of the project corresponding to members' areas of expertise. The review was conducted on April 27-28, 2010, at TJNAF in Newport News, Virginia. The agenda (Appendix C) was developed with the cooperation of the CEBAF 12 GeV Upgrade Project Office, Department of Energy (DOE)/SC Headquarters, and DOE/Thomas Jefferson Site Office (TJSO) staff. Comparison with past experience on similar projects was the primary method for assessing technical requirements, cost estimates, schedules, and adequacy of the management structure. Although the project requires some technical extrapolations, similar accelerator projects in the United States and abroad provide a relevant basis for comparison.

2. TECHNICAL SYSTEMS EVALUATION

2.1 SRF Cryomodules and Cryogenics (WBS 1.3.1/1.3.3)

2.1.1 Findings

The Central Helium Liquefier (CHL) procurement is well underway. The CHL building will be completed this week (April 26-30) and all the major equipment orders have been placed. The preliminary design reviews for the coldbox and warm compressor were held at the vendor. The heat exchangers were ordered. There is very little remaining cost risk.

The cost of the 4.5 K cold box was $2.4 million over the estimate due mainly to a rise in the cost of materials, competition for manufacturing resources with the natural gas industry, and an unfavorable foreign exchange rate.

Overall, the cryoplant shows a $0.1 million cost variance and a $1.2 million schedule variance. They are slightly undercost and have a significant amount of internal schedule contingency.

Large numbers of component parts of the cryomodules have been ordered and have started to arrive. Cavity fabrication costs came in $2.4 million over the estimate due to Nb costs and foreign exchange issues.

The cryomodules have a -$0.7 million schedule variance and a -$1.0 million cost variance. The project should still have one cryomodule ready for tunnel installation one to two months before the six-month shutdown. The first cryomodule completes testing in March 2011.

The Technology and Engineering Development Facility (TEDF) project involves remodeling the test lab building and this may slow down cryomodule assembly. They are working hard to coordinate with this project, are adding people to speed up the cryomodule assemblies and training additional testing operators.

2.1.2 Comments

Timely testing of full prototype cryomodules is important to success. The impact of the TEDF project on the test laboratory building and cryomodule assembly schedule has been rightly

identified as a potential problem and needs to be managed carefully. No technical issues on either the cryoplant or cryomodules were seen.

2.1.3 Recommendation

None.

2.2 Accelerator (WBS 1.3.2/1.3.4/1.3.5/1.3.6/1.8.1) and Accelerator Physics

2.2.1 Findings

This review is taking place seven months after the September 2009 DOE/SC review. Although there has not been a lot of time since the last review, much has taken place, particularly in the delivery of procurements and planning for installation.

Accelerator Physics

Very little was presented on accelerator physics at this review, which is to be expected as physics requirements should not be changing at this point in the project. The project did note continuing progress on an earlier recommendation that the project "Implement improvements to the existing 6 GeV machine which will be also helpful in the commissioning of the 12 GeV machine". The Committee was pleased to see this activity continue.

Accelerator Systems

This section deals with WBS 1.3.2, Power Systems—including the radio frequency (rf) and magnet power systems); WBS 1.3.4, Beam Transport—a major set of systems including the injection line, upgrading of all arcs, installation of a tenth arc, modifications to the transport lines to Halls A, B and C, and construction of the transport line to Hall D; WBS 1.3.5, Extraction Systems—primarily the rf separators that allow interleaved bunches to be delivered to Halls A, B, C, and D; and WBS 1.3.6, Instrumentation, Controls and Safety Systems. Overall, the Committee found that the project continues to make good progress in these areas.

Cost

The Committee was presented with a comparison of the project's best understanding of the ultimate cost in these areas; the estimate at completion (EAC). This takes into account

changes made to the baseline and changes that are anticipated, and will be made to the baseline. The summed EAC in these four "Level 3" WBS areas is $39.4 million, up approximately $3 million from the current baseline budget at complete (BAC). This is approximately an eight percent increase, and accounts for both increases and decreases in various areas. Significantly, it accounts for an area where the Committee had previously expressed concern, namely insufficient effort in installation. This has now been increased.

As of this review, the Committee did not see any high-risk items threatening the cost in these areas. As mentioned in the past, monitoring the effort costs of the installation activities will be important.

Schedule

Scheduling issues for these WBS elements continue to focus on two accelerator shutdowns; one of six months duration beginning in May, 2011 and a year-long shutdown beginning in May, 2012. Between these two shutdowns CEBAF will run the 6 GeV program. Work done during the six-month shutdown is planned to not impact subsequent 6 GeV operations. Following the twelve-month shutdown the accelerator complex will begin commissioning with beam. At the September 2009 DOE/SC review, the Committee recommended that the project prepare a plan to lengthen the twelve-month shutdown; primarily to deal with smoothing the effort profile and to address tunnel working conditions. The project chose not to do this, but presented (at this review) a plan to move work forward from the twelve-month shutdown to the six-month shutdown and into the shutdowns in 2009 and 2010. The Committee addressed this strategy in the comment section.

Although the work in these shutdowns is very schedule constrained, the Committee continues to believe that this work in these WBS elements will not jeopardize the project high-level schedule since CD-4a is in December 2014.

P***ower Systems (1.3.2)***

This WBS includes all power supplies for magnets, and the rf power systems (including low level rf (LLRF), high voltage rf power supplies, klystrons, etc.). The rf power systems need to provide higher power to the upgrade C100 cryomodules than what is presently used at CEBAF. Magnet power supplies are similar to what is used in the present CEBAF machine; supplies and their associated control cards are being reused and refurbished where appropriate. New power supplies and their controls are based on existing designs and commercially available equipment.

The klystron first article is expected next month; production deliveries start in FY 2011. The high-power rf systems consist of 80 klystrons powered by 10 high voltage supplies and 80 associated waveguide systems. Eighty new LLRF systems use modern digital architecture designed at TJNAF and will be build-to-print by outside vendors.

Contracts have been awarded for the large power supplies. The costs have come in lower than projected. First article tests are complete on: field control digital board, field control rf board, stepper motor controls, piezotuner board, and the high power amplifier controller. The project is presently working on procurements for magnet trim supplies.

The south linac surface-to-tunnel rf waveguide has already been installed. This work supports the earlier installation activities scheduled for the six month shutdown.

One moderate risk item was identified in this WBS element, namely the possibility that the second harmonic power produced by the klystron might exceed the capacity of the planned High Order Mode (HOM) dampers. To this end, HOM filters in the waveguides are being added to the scope of 1.3.2 as a risk reduction. Forty are being acquired for initial testing, and 40 additional filters will be acquired if testing is successful, and indicates they are needed.

Beam Transport (1.3.4)

Equipment orders have resulted in delivered hardware: for example, the first article 4-meter dipole magnet and production deliveries of the quadrupole magnets (66 of 114). Additional dipole magnets are in transit from the vendor. Production Quality Assurance (QA) including magnetic measurement (11 completed) of the quadrupole magnets is well underway. It is expected that all of the quadrupole magnets will be delivered by August 2010 and QA will be completed well before the six-month shutdown. This will free-up manpower and equipment for other production magnets and for both shutdown efforts.

After the September 2009 DOE/SC review, the order was placed for the 161 dipole corrector magnets. A first article corrector has been delivered. American Reinvestment and Recovery Act (ARRA) funding brought the procurement for the ‘H iron’ for upgrading the field strength of 317 existing arc dipoles forward. ARRA funds also eliminated the need to stage other equipment orders over two fiscal years simplifying the contract management and probably saving cost by reducing material price uncertainties for the vendors.

Extraction (1.3.5)

The extraction system provides equipment necessary to upgrade extraction hardware for 2.2 GeV per pass. Since the September review, magnetic elements have been moved to WBS 1.3.4, leaving primarily the deflecting cavities.

Instrumentation and Controls and Safety Systems (1.3.6)

Little work in this WBS was scheduled during the last seven months. However, the project is planning on providing the necessary controls and instrumentation to support the rf /cryomodule test during the six-month shutdown (ahead of the baseline schedule).

Accelerator Commissioning (1.8.1)

No presentation on commissioning was planned for this review, following the very detailed plan presented at the September review. The Committee asked about this, and was told that little has been done in the area of commissioning except for some additional details added. The commissioning team is also aware of the changes to the shutdown work that would impact start-ups.

2.2.2 Comments

Accelerator Systems

As noted in the findings section, the Committee judged that this work scope is on schedule. However, the Committee remained concerned that the shutdowns will be very challenging periods to manage. The recommendation from the September review, to lengthen the twelve-month shutdown, was not followed. The project did however, deal with the sentiment of the recommendation by moving work from the twelve-month shutdown into the six-month shutdown, and other work earlier into 2009 and 2010 shutdown periods. The Committee was satisfied with the response; some of the effects are positive, and some are challenging.

- The manpower spike has been leveled somewhat, however the six-month shutdown becomes more critical, and exhibits the severest need for effort.

- Moving work earlier allows lessons learned to be applied earlier; for instance, work already performed in the 2009/2010 winter shutdown has shown that installation activities needed to be better staffed.

- The Committee was concerned with the statement that present operation of CEBAF may need to be extended which could shorten or eliminate the 2010 summer shutdown. If so, planned work would be pushed into the six-month shutdown.

- Staffing up for the future is challenging and requires good planning with Human Resources to be successful. Significant additional manpower is required to accomplish the work planned for the six-month shutdown. Moving and re-scheduling work for the six-month shutdown is complicated and still requires more planning. There are many integration issues that still have to be coordinated with 'off project' work planned during the six-month shutdown.

- This work will need to be carefully monitored, but bringing the critical installation activities earlier allows for downstream remediation, if needed.

Power Systems (1.3.2)

Good progress is being made in this area.

Beam Transport (1.3.4)

The recent short shutdown in the winter of 2009/2010 was used to stage some of the magnet stand installation work and to characterize the survey and radiation issues for rework of the existing arc dipoles. The results of the radiation study indicate that the dipoles can be safely modified. Also, offsite machine shops can be used to supplement the in house shops to maintain schedule during the six-month and twelve-month shutdown if necessary. This work was helpful in clarifying installation estimates, and verifying installation procedures.

There was concern expressed by the TJNAF team about the vendor for the septum magnets. The vendor has wound the first coil and that coil failed the pre-epoxy potting high pot test. Upon further review, TJNAF found that the vendor also failed to follow the requirements of the specification. TJNAF is aggressively dealing with this problem; but, another concern is that the same vendor has contracts for the experimental area super-conducting magnets (see the Recommendations Section related to this comment).

Extraction (1.3.5)

The Committee has no comments in this area.

Instrumentation and Controls and Safety Systems (1.3.6)

The Committee has no comments in this area.

2.2.3 Recommendation

1. Maintain strong vendor oversight for vendors, which have exhibited problems.

2.3 Detector (WBS 1.4/1.5/1.8.2)

The detector systems are progressing satisfactorily since the September 2009 DOESC project review. The project is appropriately addressing the recommendations from the prior review; however, please refer to comments and new recommendations concerning the Hall D superconducting solenoid magnet.

2.3.1 Findings

Hall B

The CLAS12 spectrometer that will instrument Hall B will incorporate a new superconducting solenoid and a new superconducting torus. Design-build contracts for both magnets were awarded in fall 2009 as firm, fixed prices close to estimated costs. The torus passed its preliminary design review in December 2009. The preliminary design review of the solenoid will be held in May 2010. A tight collaboration, including close supervision, has been established with the magnet vendor in order to ensure timely delivery. The magnet schedule includes three months schedule contingency with respect to the baseline magnet schedule (in addition to the 23 months schedule contingency for the torus and 13 months schedule contingency for the solenoid in the Hall B schedule).

CLAS12 will incorporate a silicon strip detector (SVT), which is a new technology at TJNAF, for charged particle tracking. TJNAF has continued to develop local expertise in silicon strip detectors for the SVT to complement expertise of external CLAS12 collaborators.

Hall C

The Super High Resolution Spectrometer (SHMS) to be assembled in Hall C incorporates two new superconducting dipole magnets (Dipole and HB) and three new superconducting

quadrupole magnets (Q1, Q2, Q3). Q1 is progressing well. The contract process with Michigan State University for Hall B is nearly complete. No technical issues have been discovered. The Dipole and Q2 and Q3 magnets were bid as a package last year; however, few bids were received, and they were significantly higher in cost than expected. The bid package for the dipole and the quadrupoles have now been split in two for rebid in order to attract more vendors and better prices. New bids are due May 12, 2010 (dipole) and June 12, 2010 (quadrupoles). The magnet support systems are proceeding well.

Hall D GlueX

A strengthened Hall D management structure has been established. The management team now consists of the Hall D Leader/Assistant Project Manager, Deputy Hall D Leader, Hall D Chief Mechanical Engineer, and Hall D Chief Electrical Engineer. The respective responsibilities have been defined, and the positions have been filled.

Selection of the photosensors for the Barrel Calorimeter (BCAL) was completed on schedule in January 2010. Silicon photomultipliers were selected, and the procurement process has been initiated. Fine-mesh photomultiplier tubes (PMT) are retained as a back-up solution.

The Memorandum of Understanding (MOU) process for Hall D detectors, including university labor for detector construction, is progressing well.

Hall D Solenoid

The magnetic field of the GlueX spectrometer in Hall D will be provided by a superconducting solenoid magnet that was originally designed for and used by the LASS spectrometer at SLAC National Accelerator Laboratory in the 1970s and subsequently used by the MEGA experiment at Los Alamos National Laboratory. A review of the superconducting solenoid was conducted in November 2009. The principal conclusions of the review were: 1) design, procurement, and production of a replacement solenoid would cost $3.6-6 million and would require approximately five years, thus delaying CD-4 by approximately two years; and 2) refurbishment of the existing solenoid should continue, given that the solenoid operated satisfactorily in the past despite known shorts.

The detailed recommendations of the solenoid review were not presented at the current review. The presentations from the solenoid review were provided. They included photographs of the shorts in the exposed portion of the top coil pancake and metallic debris discovered in the

cryostat. No quantitative analysis of possible over-currents in the shorted turns was presented. Several examples of acceptable performance of the coils with shorts were referenced as a hint that performance of the solenoid for the Hall D may be acceptable also.

Refurbishment of the solenoid is in progress. Leaks and shorts to ground are being repaired; however, shorts to the supporting strip, which cannot be repaired, will remain after refurbishment. Following refurbishment, the four individual coils, and eventually the assembled solenoid, will be tested. Sequential individual coil tests will require one year total, completing in May 2011. Full solenoid tests, the first with realistic operating conditions, will not complete until late September 2012.

2.3.2 Comments

Hall B

Hall B superconducting magnet development is proceeding satisfactorily. Close collaboration with the supplier, Wang NMR, and supervision of the magnet design and progress should continue.

A full chain test of the Hall B SVT, from prototype silicon sensors through prototype readout electronics to data acquisition, should be performed prior to full sensor and electronics production. (This comment is a reiteration of a comment from the September 2009 DOE/SC review.)

Hall C

The final cost of the Hall C superconducting dipole magnet may be significantly larger than budgeted despite re-bidding. The delay in contracts for the Dipole and Q2/Q3 is not yet a schedule concern; however, the acquisition plan should be revised as necessary after the new bids are received. The Hall C magnet engineers have a preliminary contingency plan of action.

Hall D GlueX

The three actions described above under Findings for Hall D GlueX address three of the recommendations of the September review concerning Hall D. The fourth recommendation concerned the Hall D superconducting solenoid (see below).

Hall D Solenoid

The superconducting solenoid is prone to shorts; moreover, metal shavings and slivers have been found in the winding pack and on the floor of the cryostat. Irreparable shorts between the coil conductor and supporting strip pose a particular hazard, in that a new short to the supporting strip would result in shorted windings. In GlueX, the solenoid will be operated under different conditions than in the past. It will operate with higher current, and it will be exposed to higher mechanical forces and electrical fields. Consequently, there is a risk of new shorts that could compromise the operation or permanently damage the solenoid during a quick discharge.

In order to fully assess the risk of additional shorts, quantitative analysis of the impact of shorts and resulting over-currents and high voltages should be extended to worst case situations, such as multiple-turn shorts and low-resistance shorts.

Means should be developed to reduce risk of permanent damage from possible future shorts. For instance, means to decrease the induced voltage in shorted turns should be examined, e.g., by reducing the protective discharge voltage. It may be beneficial to allow somewhat higher hot spot temperature in order to lower the voltage across the turns. Means to improve the evacuation of stored energy from the solenoid should also be considered, e.g., by using additional low-heat-load current leads and cold diodes to reduce inductive voltage at quench. The design and structural analysis of the coil supports against axial forces should also be completed. Refurbishment and testing of the solenoid should continue expeditiously, in order to determine in the most timely fashion possible if there are any as-yet undetected problems in the existing coils. The analysis and studies discussed above should proceed in parallel with refurbishment and testing.

The superconducting solenoid is a critical component of the GlueX spectrometer, which is the centerpiece of the 12 GeV Upgrade Project. Consequently, every effort should be made to develop a plan that delivers a solenoid that will meet the project timeline and that will provide the needed magnetic field throughout the significant lifetime of the experimental program. The refurbishment and testing program will require another two-and-a-half years. Therefore, consideration of a back-up or replacement solenoid should continue in parallel with analysis, refurbishment, risk mitigation, and testing of the existing solenoid. In particular, at this time, design of a replacement solenoid should be initiated, using external engineering if necessary, and means should be pursued to shorten the projected schedule for producing a replacement solenoid.

2.3.3 Recommendations

2. Initiate design now of a back-up or replacement superconducting solenoid for Hall D.

3. Convene an external peer review to appraise risk mitigation plans for the existing Hall D superconducting solenoid and to advise regarding implementation of a replacement solenoid. Report outcome at the next DOE/SC review.

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3. CONVENTIONAL FACILITIES (WBS 1.6)

The conventional facilities (CF) construction (also called civil construction) of the CEBAF 12 GeV Upgrade project represents only 15.6 percent of the total work of the CEBAF 12 GeV Upgrade project. It is currently estimated at $30.2 million (FY 2010, direct). This work is organized into three WBS elements: 1.6.1, Accelerator; 1.6.2, CHL; and 1.6.3, Hall D.

The WBS 1.6.1, Accelerator scope consists of modifications to existing Accelerator Service buildings and utility distribution systems to support the Accelerator operations at 12 GeV. The scope of work includes the addition of two tunnel access structures, upgrades to the tunnel access utilities (such as low conductivity water (LCW)), a beam switchyard services building addition, tunnel air conditioning and revisions to the electrical distribution at the north and south linac services buildings.

The WBS 1.6.2, CHL scope is modifications to the existing CHL facilities to provide additional space and utilities to support the CHL plant at double the capacity. The building scope includes an approximate 4,800 square foot (SF) steel frame, metal clad addition to the CHL building complex fit out with basic utilities. All cryogenic equipment is to be provided as part of the WBS 1.3 Accelerator Systems portion of the project. The CHL utility upgrades include the industrial cooling water, two new 5 MVA substations, and new cooling towers.

The WBS 1.6.3, Hall D scope is the construction of new facilities and distribution systems to support the operations of a new experimental hall to carry out the GlueX experimental program. The scope includes the construction of approximately 28,000 SF of new facilities and the extension of an existing below grade tunnel stub. The facilities include an experimental hall (Hall D), an associated counting house, a small cryo plant, a service building, an electron dump, a photon dump, and necessary radiation shielding berms. Also included in the Hall D area are associated site utilities and roads for a previously undeveloped section of the CEBAF site.

3.1 Findings

Civil construction is approximately 19.2 percent complete and is approximately two months behind the baseline schedule for Hall D ‘Ready for Equipment’ (SPI 0.84). The project has, however, made significant schedule improvements in the last few months, with the Hall D contractor improving two months in their forecast completion in the last three months.

Approximately 70 percent of all CF construction is currently under contract, including all three phases Hall D, the building portion of the CHL construction, the north and south access buildings, the north and south Linac Power and the Civil Construction Management. All three phases of Hall D construction are funded with ARRA funding. The project provided an **NTP** for Phase 2 in January 2010 and plans to award Phase 3 two months before the six-month shutdown.

Approximately $6.8 million of contract funds have yet to be committed, however $2.4 million for the CHL Utilities Upgrades is expected to be awarded in May 2010. The project plans to bid and award the remaining contracts in FY 2011 and FY 2013.

Construction of the Hall D complex was awarded to S.B. Ballard for a fixed-price contract of $14.6 million and an NTP for Phase 1 in February 2009. Ballard's failure to submit an acceptable safety plan, as well as disagreement on the dewatering and treatment scope of work, led to a late start for this work. An error in the design of the base slab led to an agreement to extend the contract duration by 59 calendar days and an addition to the contract sum of approximately $800K. The Architect Engineer (A/E) also verbally agreed to approximately $400K liability for the design change. Phase 1 of the Hall D construction is currently 43 percent complete. The contractor is currently two months late on the baseline for Hall D Ready For Equipment (RFE) milestone forecasting completion in December 2010. Ballard has been working some weekends to make up lost days.

Ballard submitted a Request for Equitable Adjustment (REA) for the groundwater dewatering and treatment system. The project has hired a dewatering expert and outside counsel to help evaluate the REA and mediation on this claim is expected in the near future. Ballard has elected to proceed with this work with the groundwater dewatering and treatment system for the Hall D building now installed and functioning well. Ballard proposed an alternate discharge location that would allow elimination of the treatment, which is a significant portion of the dewatering costs. In February 2010, they gained approval to discharge to a sanitary sewer eliminating treatment costs but adding a sewer discharge fee. In April 2010, the Department of Environmental Quality granted approval to discharge to the Newport News Storm Sewer system.

A firm fixed-price contract was awarded for the CHL Building construction to Ritchie Curbo for a price of $1.6 million and a NTP in January 2009. The construction was 92 percent complete as of the end of March 2010, and should be ready for equipment in April 2010, five months ahead of the Level 2 milestone.

The staffing for the construction management activities is provided from a combination of TJNAF staff (dedicated and matrixed 12 Gev project staff, Facilities, EHS&Q), the project architect for Hall D, the project architect for the CHL Building and from an indefinite delivery task order contract with an agent construction management company (Alpha). TJNAF has approved the fiscal year Annual Work Plan staffing and provided a MOU confirming agreement to provide staffing for FY 2011, FY 2012 and FY 2013.

The project has prepared a draft Transition to Operations Plan that will be finalized after input from this review.

S.B. Ballard appears to be taking a proactive approach to safety. This has included removal of several subcontractors when unsafe work practices became apparent, focused employee safety training, and dedicated corporate safety oversight on the project.

3.2 Comments

The Committee provided suggestions for changes to Transition to Operations Plan. Specifically, the Committee recommended that this plan be updated to include inspection and approval by the Conventional Transition Team (CTT) and a definition of what the approval allows. The plan should specify that a MOU be developed that transfers safety and maintenance responsibilities of the spaces that are transitioned.

The Agent Construction Manager has been evaluating schedule improvement opportunities with the goal of meeting the Hall D RFE milestone. The Committee suggested sharing these with Ballard prior to settling the REA for groundwater, as appropriate.

A change to the CHL cooling tower strategy resulted in redesign to centralize the towers. This resulted in a delay in bidding and awarding this work, and also a Level 3 milestone date. This date should be revised with a baseline change at the time of contract award.

The Committee recommended that the project work with DOE/TJSO to confirm the process for approval of the Buy American Act waivers on ARRA funding. This should be done proactively to reduce the impacts of processing any last minute waiver requests.

The project has been working to accelerate shutdown work into earlier shutdowns. This resulted in moving the LCW Header installations in West Arc from the six-month down to the accelerator maintenance down in summer 2010. This is aggressive and may still result in some of

this work slipping into the six month down. This presents a minor cost risk to the civil work that is justified by the schedule benefit to the entire project. If possible, the project should work with TJNAF management to confirm the details of the schedule for the summer 2010 maintenance shutdown prior to awarding the LCW Header contract.

The current Hall D construction site is not inside the TJNAF security boundary and is open to passersby creating a possible safety hazard. The project should provide some barriers on the main access road to the site to discourage cars and pedestrians from entering the project site during off hours.

Critical path for the project includes turnover of Hall D for equipment installation at the end of October 2010. S.B. Ballard's current contract is for completion in October 2010; however their current forecast shows December 2010. The milestone date for Hall D RFE is November 2010. The S.B. Ballard REA for the dewatering claim is expected to be mediated between the contractor and TJNF in May. Until this claim is settled, it will be difficult to develop a full recovery schedule with the contractor, and know whether the Hall D RFE milestone date can be achieved. There is a need to settle this claim soon to establish a clear schedule and to not allow this issue to negatively impact relations with the contractor going forward.

The Associate Project Manager (APM) recently recognized that the Hall D contract required additional oversight and support in order to better track progress and provide quicker response to contractor communications. The APM is commended for her decision to increase Agent Construction Manager efforts providing additional oversight and responsiveness and thereby improving the schedule.

The 12 GeV Upgrade ESH&Q Manager described efforts in the project and at TJNAF to increase communications between TJNAF organizations and with contractors regarding safety lessons learned. The Committee noted the good practice of sharing Lessons Learned from other DOE Laboratories with construction contractors, as well as sharing experiences at Subcontracting Officer Technical Representative (SOTR) monthly meetings.

Staffing levels should be evaluated as each additional significant contract is awarded and as labor intensive issues arise.

3.3 Recommendations

None.

4. COST ESTIMATE

4.1 Findings

A summary of the project scope, cost estimate, and contingency profile were provided by the project team. The 12 GeV Upgrade Total Estimated Cost (TEC) is $287.5 million, Other Project Costs (OPC) are $22.5 million, for a TPC of $310 million. A breakdown of the current baseline cost estimate can be found in Appendix D.

As of March 31, 2010, the contingency/management reserve is $66.2 million or approximately 50 percent of the estimate-to-complete (ETC) work to go (based on obligations). The contingency/management reserve percentage of the ETC (based on costs to go) is 32.6 percent. The projected funding profile for the 12 GeV project is contained in Appendix F.

As of March 31, 2010, scheduled work is at 23.5 percent, performed work is at 22.8 percent and actual costs are at 24.4 percent. The Cost Performance Index (CPI) is at 0.93 and Schedule Performance Index (SPI) is at 0.97.

ARRA funds have been integrated into the project plan and ARRA milestones have been established. ARRA funds totaling $65 million are being used to advance work in WBS 1.3 (Accelerator) and WBS 1.6 (Civil).

The project responded appropriately to the recommendations from the September 2009 DOE/SC review.

The labor availability issue mentioned in prior reviews remains a concern.

4.2 Comments

The Committee felt that the management team is effectively managing the project budget and schedule. One particular area noted was the new Integration Engineer employed to oversee the FY 2011 Installation Planning. The Committee judged that this engineer is a definite resource to the project.

The Committee also noted that the TJNAF has a practice of adding five percent of funding to all civil contracts to be held as management reserve for accommodating field modifications in a timely manner.

The Committee was comfortable that the $66.2 million in contingency was sufficient to address the risks inherent in the remaining work and that there is a risk management system in place to adequately track and monitor those risks. The project is presently tracking two high risk, six moderate risks, and 43 low risks.

The high-risk activities being monitored are related to the civil construction of the Hall D complex. Moderate risks include technical issues associated with superconducting magnets, detector cost overruns, potential schedule delays due to labor shortages during assembly and installation, power system hardware for HOM damping, and cost risks of an FY 2012 Continuing Resolution greater than three months. Risks are reviewed and managed regularly and are formally reassessed at least every six months.

Labor availability was noted in prior reviews as a possible issue and it remains a major concern because the project competes with other TJNAF priorities for the availability of its workforce. In FY 2010, over 200 partially dedicated staff contributed to about 90 Full time Equivalents (FTEs) of effort, but the labor shortages equal 25 FTEs since CD-2. As project staffing requirements continue to ramp up to an FY 2012 peak of 130 FTEs, this issue will become more critical. In addition, 60 FTEs of university labor, which are planned for FY 2012, will add more complexity as their work will be handled through MOUs with other institutions.

An updated EAC was presented to the Committee. It will be done at least annually for each subsystem and presented again at the next DOE/SC review.

The opinion of the Committee is that the project can be completed within the cost and schedule performance baseline provided that the labor availability issue is addressed.

4.3 Recommendations

4. Project should revisit the staffing profiles to ensure current staffing contingency is realistic and appropriate prior to the next DOE/SC Review.

5. Project should ensure the process for implementing practice for the five percent of management reserve added to civil contracts is documented.

6. The project should develop a contingency usage plan that can be implemented should contingency be available. This should be completed prior to the next DOE/SC Review.

5. SCHEDULING AND FUNDING

5.1 Findings

A summary schedule and list of milestones were presented by the project team. The proposed Level 1 milestones are shown in Table 5-1. A copy of the summary schedule is included in Appendix E.

Table 5-1. Level 1 Milestones

CD-0 Mission Need	MAR-2004 (A)
CD-1 Preliminary Baseline Range	FEB-2006 (A)
CD-2 Performance Baseline	NOV-2007 (A)
CD-3 Start of Construction	SEP-2008 (A)
CD-4A Accelerator Project Completion and Start of Operations	DEC-2014
CD-4B Experimental Equipment Project Completion and Start of Operations	JUN-2015

The project is currently 22.8 percent complete. Overall, the schedule performance index (SPI) is 0.97, four weeks behind schedule. Civil construction delays were experienced in the first and second quarter of FY 2011, but have been resolved and the project is recovering. Additionally, the project developed a 13-point schedule recovery plan that is being implemented and should continue to improve the overall performance.

The project schedule currently has three accelerator shutdowns identified. They are as follows: July 2010 for one month, May 2011 for six months, and May 2012 for 12 months. As previously noted, the project is utilizing an integration engineer to coordinate these activities.

The current baseline includes approximately six months of schedule contingency to CD-4b for Halls B and C. This is primarily due to funding constraints in FY 2011.

There were no outstanding recommendations from the September 2009 DOE/SC review.

5.2 Comments

The Committee judged that the management team is effectively managing the project funding and schedule. The Project Manager is managing to the early finish dates. Additionally, the project team is evaluating how much work can be advanced into earlier shutdowns.

The Committee suggested that if contingency funding is available, the commissioning of Halls B and C should be brought forward in the schedule to the extent possible.

Lastly, the Committee noted that the ARRA funding has supported some earlier procurements, however some vendors have avoided work tied to ARRA funding due to the burdensome reporting requirements.

5.3 Recommendations

None.

6. MANAGEMENT

6.1 Findings

The 12 GeV Upgrade project is overall progressing satisfactorily since the September 2009 DOE/SC review. The SPI, now at 0.97, has largely recovered but the project remains about four weeks behind the schedule. The CPI, now at 0.93, continues to degrade slowly, with modestly negative cost variances each month for the past half year. The negative CPI is mainly due to the project being slow to make baseline changes based on up-to-date knowledge where the expected costs are higher than baseline.

The project reports overall cost contingency, including a management reserve of $66 million, that accounts for 52 percent of remaining obligations, and 35 percent of costs to go. The schedule contingency of 12 months for accelerator, civil construction and Hall D Equipment remains unchanged. The schedule contingency for Halls B and C was reported as six months, limited by the funding profile.

Project staffing is receiving appropriate management's attention and the project is nearly hitting the goal of ramp-up of four FTEs per month. However, there has still been a 5.5 FTE-year shortfall over the last six months and a 25 FTE-year cumulated shortfall since CD-2.

The staffing goal includes a substantial 'labor contingency' totaling 312 FTE-years, or $31 million, concentrated particularly in FY 2013-FY 2015. In FY 2013 and beyond, this labor contingency exceeds 100 percent of planned labor in the current baseline.

Risks are being effectively managed. Presently, there are 51 risks being tracked in the risk registry (two high; six moderate; and 43 low risks).

Procurement has had excellent performance awarding contracts against internal budgets. The 33 major contracts were awarded within three percent of plan ($67 million planned vs. $69 million actual).

In general, the project is addressing the recommendations from the September review. Nine of fifteen recommendations from the September review and one from an earlier review remain open. However, the project is addressing these recommendations appropriately.

6.2 Comments

There is strong and dedicated leadership from the Laboratory Director and the Project Management Team. Communication between project leadership and DOE appears to be working effectively. The priority of project within the laboratory seems to be well understood and appropriately high. Still continued focus will be required to ensure that shorter-term priorities do not jeopardize progress on the 12 GeV Upgrade project.

The past year has been a successful year for the project. Significant progress has been made in all areas of the project and the staffing situation is under reasonable control. However, identifying and securing matrixed labor from TJNAF will continue to be one of the major challenges for meeting the project schedule. In addition, university contributed labor is particularly important for detector installation during the FY 2012 long shutdown.

Project Management processes, although mostly well implemented and being executed, could benefit from a few adjustments.

Project Change Requests should be submitted and implemented in a timely manner so that performance parameters being tracked (CPI, SPI, remaining work to go, remaining contingency, critical path, schedule float etc) can have meaningful values.

The percentage contingency as presented in this review, which is based only on obligation might be misleading. Contingency should be clearly reported relative to remaining cost, as well as relative to remaining obligations (as it is in the CPR table in the monthly reports).

Bottoms-up staffing requirements should be reviewed and any necessary increase should be captured into the project baseline plan before the start of the specific activity.

The risk management program is being effectively executed and risks are routinely assessed and updated as necessary. Contingency and management reserve are being appropriately managed.

ARRA funds have been incorporated into the project, and are being appropriately managed and reporting is being performed in a timely manner.

Six of the 15 recommendations from the September review were identified as closed out; however, the Committee remains concerned about the Hall D solenoid, although the project has proposed that the recommendation be closed.

6.3 Recommendations

7. Make detailed estimates of the specific uses of ‘contingency labor’ and include it as a part of project baseline plan, via baseline change request, in timely manner, at least six months before planned execution date.

8. Process change requests promptly to ensure CPI and SPI can be meaningful indicators.

9. Review each university construction MOU, which specifies labor that they will contribute, within approximately one year of the need date for that labor.

10. Schedule the next DOE/SC review of the 12 GeV project for September 2010.

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APPENDIX A

CHARGE MEMORANDUM

DOE F 1325.8
(08-93)

United States Government **Department of Energy**

memorandum

DATE: February 4, 2010

REPLY TO ATTN OF: Office of Nuclear Physics, SC-26

SUBJECT: Project Mini-Review of the 12 GeV CEBAF Upgrade Project

TO: Daniel R. Lehman, Director
Office of Project Assessment, SC-28

I request that your office organize and conduct an Office of Science (SC) Project Mini-Review of the 12 GeV Continuous Electron Beam Accelerator Facility (CEBAF) Upgrade Project at Thomas Jefferson National Accelerator Facility (TJNAF) on April 27-28, 2010. The purpose of this review is to assess project's progress since the September 2009 Lehman review. The next full DOE/SC review is anticipated in the September 2010 timeframe.

In carrying out its charge, the review panel is requested to consider the following questions:

1. Is the overall project progressing satisfactorily since the last review?
2. Is the project responding appropriately to recent challenges encountered in conventional construction?
3. Is the project addressing appropriately the recommendations from the prior DOE/SC project review?

The 12 GeV CEBAF Upgrade Program Manager, James Hawkins, will work closely with you as necessary to plan and carry out this review. I would appreciate receiving your Panel's report within 60 days of the review's conclusion.

Timothy J. Hallman
Associate Director of the
Office of Science for Nuclear Physics

cc:
K. Fisher, SC-28
J. Hawkins, SC-26.2
J. Gillo, SC-26.2
E. Henry, SC-26.1
J. May, TJSO
J. Turi, TJSO
C. Rode, TJNAF
A. Lung, TJNAF
H. Montgomery, TJNAF

APPENDIX B

REVIEW PARTICIPANTS

Department of Energy Review of the
12 GeV CEBAF Upgrade Project
April 27-28, 2010

Daniel R. Lehman, DOE/SC, Chairperson

SC1
SRF Cryomodules and Cryogenics
(WBS 1.3.1/1.3.3)

* John Weisend, MSU

SC2
Accelerator and Accelerator Physics
(WBS 1.3.2/1.3.4/1.3.5/1.8.1)

* Rod Gerig, ANL
Geoff Pile, ANL
Joe Tuozzolo, BNL

SC3

Detector
(WBS 1.4/1.5/1.8.2)

* Andy Lankford, UCI
Nicolai Martovetsky, ORNL

SC4
Conventional Facilities
(WBS 1.6)

* Joe Harkins, LBNL
Elaine McCluskey, FNAL

SC5

Cost and Schedule

* Kurt Fisher, DOE/SC
John Tapia, DOE/SC

SC6
Project Management
(WBS 1.7)

* Aesook Byon, BNL
Jim Strait, FNAL

Observers

Timothy Hallman, DOE/SC
Jehanne Gillo, DOE/SC
Manouchehr Farkhondeh, DOE/SC
Jim Hawkins, DOE/SC
Helmut Marsiske, DOE/SC
Joe May, DOE/TJSO
Michael Epps, DOE/TJSO
Paul Bosco, OECM

LEGEND

SC Subcommittee
* Chairperson

Count: 13 (excluding observers)

APPENDIX C

REVIEW AGENDA

Department of Energy Review of the
12 GeV CEBAF Upgrade Project
April 27-28, 2010

AGENDA

Tuesday, April 27, 2010—CEBAF Center, Conference Room F113

8:00 am	DOE Executive Session ..... D. Lehman
9:00 am	Project Status ..... C. Rode
9:45 am	Accelerator Technical Overview (WBS 1.3) ..... L. Harwood
10:15 am	Break
10:30 am	Physics (Experimental Equipment) Technical Overview (WBS 1.4, 1.5) ..... G. Young
11:00 am	FY11 Installation Plans ..... D. Napier
11:30 am	Civil Construction Technical Overview (WBS 1.6) ..... R. Yasky
12:00 pm	Lunch
1:00 pm	Technical Breakout Sessions: 1. Accelerator —**Room F326/377** 2. Physics —**Room L102/104** 3. Conventional Facilities & ESH&Q—**Room F324/325** 4. Project Management**—Room F324/325**
3:00 pm	Breakout
3:15 pm	DOE Executive Session—**Room F113** ..... D. Lehman
6:00 pm	Adjourn

Wednesday, April 28, 2010

8:00 am	Subcommittee Executive Sessions—**Subcommittee Meeting Rooms**
9:30 am	Closeout Dry Run—**Meeting Room F113**
11:00 pm	Closeout Presentation to 12 GeV Management— **Meeting Room F113**
12:00 pm	Adjourn

SUBCOMMITTEE EXECUTIVE SESSION MEETING ROOMS

DOE Executive Session	**F113**
Accelerator and Accelerator	**F326/327**
Physics	**L102/104**
Conventional Facilities & ESH&Q	**F224/225**
Project Management	**F324/325**

APPENDIX D

COST TABLE

12GeV—Baseline Cost Estimate ($K)

12 GeV Cost/Schedule Status Report												31-Mar-10
	Cumulative to Date ($K)											
	Budgeted Cost		Actual Cost	Variance		Performance Indices		Budget At	Estimate At	Independent Estimate At	Contn. & MR	
WBS	Work Scheduled	Work Performed	Work Performed	Schedule	Cost	SPI	CPI	Complete ($K)	Completion ($K)	Completion ($K)	% ($/ETC$_{cb}$)	% Complete
1.2 PED	20,141	20,141	20,992	0	(851)	1.00	0.96	20,141	21,000	20,992		100%
1.3 Construction Accelerator Systems	10,663	10,772	12,181	109	(1,409)	1.01	0.88	62,536	62,556	93,335		13%
1.4 Construction Upgrade Halls A, B & C	3,426	3,007	3,367	(419)	(360)	0.88	0.89	53,209	53,221	53,209		6%
1.5 Construction Hall D	3,468	3,259	3,598	(209)	(339)	0.94	0.91	30,421	30,425	33,587		11%
1.6 Construction Conventional Facilities	6,891	5,788	6,754	(1,104)	(967)	0.84	0.86	30,196	30,206	35,239		19%
1.7 Construction Project Management	1,965	1,965	1,908	0	57	1.00	1.03	8,222	8,268	7,983		24%
12 GeV Total Estimated Base Cost	**46,553**	**44,931**	**48,801**	**(1,622)**	**(3,869)**	**0.97**	**0.92**	**224,727**	**225,677**	**244,345**		**20%**
				Management Reserve					**5,531**	**5,531**	5%	
				IEAC Projected Variance					**0**	**(18,668)**	0%	
				DOE Held Contingency					**56,292**	**56,292**	47%	
				12 GeV Total Estimated Cost					**287,500**	**287,500**		
1.0 ACD/CDR	3,497	3,497	3,445	0	52	1.00	1.02	3,497	3,445	3,445		100%
1.1 R&D	6,878	6,878	7,051	0	(173)	1.00	0.98	6,878	7,052	7,051		100%
1.8 Construction Pre-Ops	0	0	0	0	0	0	0	7,654	7,654	7,654		0%
12 GeV Total Other Project Base Cost	**10,375**	**10,375**	**10,496**	**0**	**(121)**	**1.00**	**0.99**	**18,029**	**18,151**	**18,150**		**58%**
				Management Reserve					-	-	0%	
				IEAC Projected Variance					(0)	1	0%	
				DOE Held Contingency					**4,349**	**4,349**	57%	
				12 GeV Other Project Cost					**22,500**	**22,500**		
12 GeV Total Project Cost	**56,929**	**55,307**	**59,297**	**(1,622)**	**(3,990)**	**0.97**	**0.93**	**242,756**	**310,000**	**310,000**	**51.9%**	**22.8%**
										Contingency	**47.6%**	
					187,449.09					Mgmt Reserve	**4.3%**	
					127,499.90					Contingency Based on Actual Costs	**32.4%**	
										Mgmt Reserve Based on Actual Costs	**3.0%**	

Monthly EVMS Data	BCWS	BCWP	ACWP
12 GeV Total Estimated Cost	1,228	4,429	4,957
12 GeV Other Project Cost	-	-	-
12 GeV Total Project Cost	1,228	4,429	4,957

Assigned ~ $1.26M Mgmt Reserve for Civil contracts.

Contingency and MR % calculation includes out-year phased contracts: **7,197**

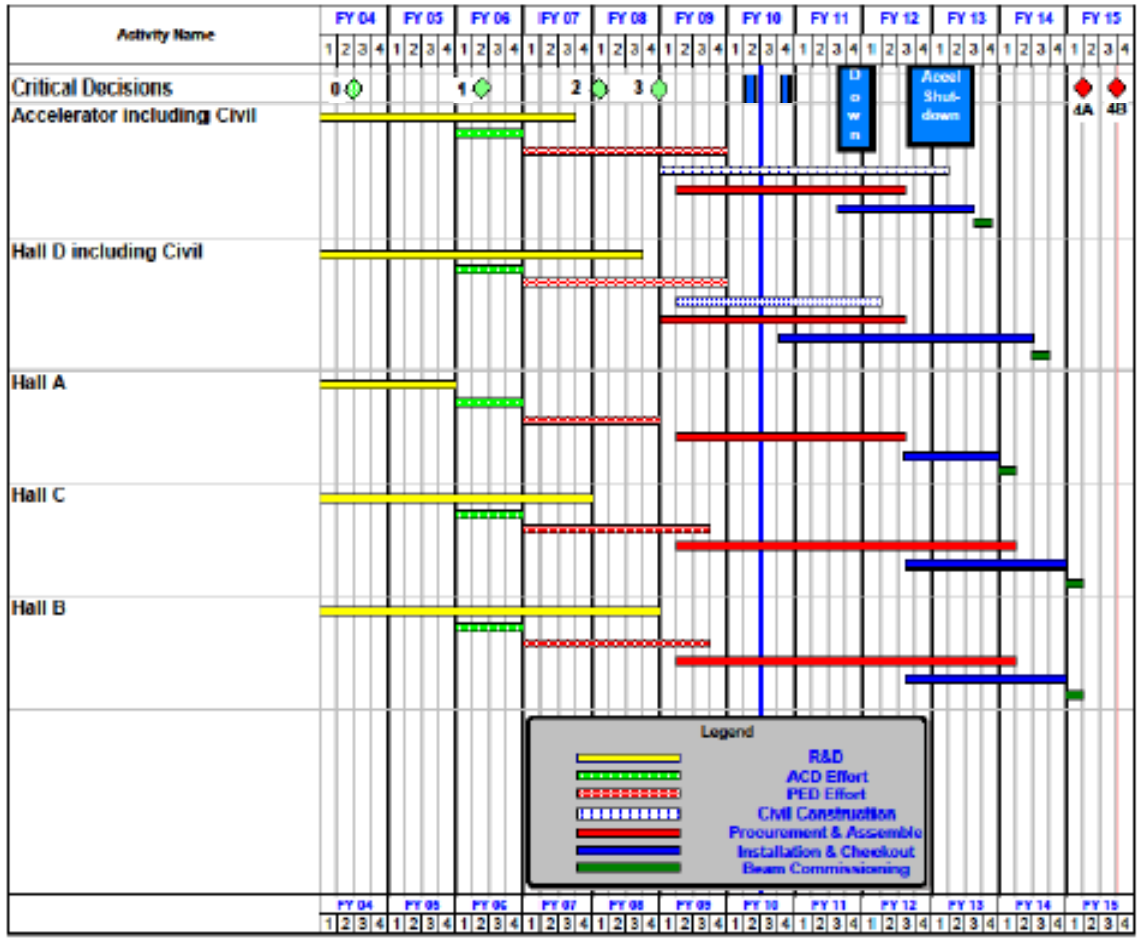
Contingency and MR % calculation includes contract vendor notifications.

Non-DOE	BCWS	BCWP	ACWP	Sv	Cv	SPI	CPI	BAC	EAC	IEAC	Cont/MR %	% Complete
1.9 VA Funding	11	9	0	(2)	9	0.82	#DIV/0!	3,641	3,641	#DIV/0!	21%	0%
1.10 NSF Funding	0	346	N/A	346		#DIV/0!		484	484			71%

APPENDIX E

SCHEDULE CHART

12GeV—Schedule



- Two short parasitic installation periods in FY10
- 6-month installation May-Oct 2011
- 12-month installation May 2012-May 2013
- Hall A commissioning start October 2013
- Hall D commissioning start April 2014
- Halls B and C commissioning start October 2014
- Project Completion June 2015

APPENDIX F

FUNDING TABLE

12 GeV Funding Table

12 GeV Upgrade	CDR/ACD	Mar-10 R&D	FY10 $20M PED	FY10 $20M Construction	FY10 $20M ARRA	Pre-Ops	Total	TEC	OPC
FY04	200	500					700	-	700
FY05	800	1,500					2,300	-	2,300
FY06	2,500	1,500	500				4,500	500	4,000
FY07		2,500	7,000				9,500	7,000	2,500
FY08		1,000	13,377				14,377	13,377	1,000
FY09			123	28,500	65,000		93,623	28,623	-
FY10				20,000			20,000	20,000	-
FY11				36,000			36,000	36,000	-
FY12				66,000			66,000	66,000	-
FY13				40,500		2,500	43,000	40,500	2,500
FY14				10,500		7,500	18,000	10,500	7,500
FY15						2,000	2,000	-	2,000
	3,500	7,000	21,000	201,500	65,000	12,000	310,000	222,500	22,500

APPENDIX G

MANAGEMENT TABLE

12 GeV Organization Chart