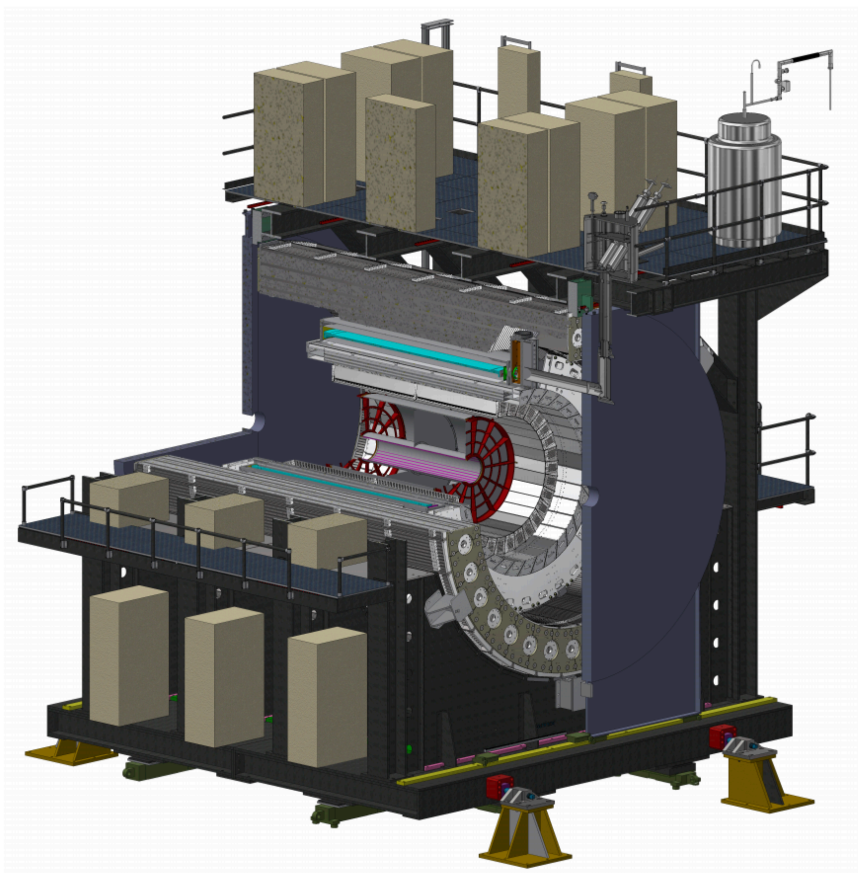
Project Decision 2/3 Review of Super Pioneering High Energy Nuclear Interaction Experiment (sPHENIX) Project

at Brookhaven National Laboratory
May 2019



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Brookhaven National Laboratory

May 28 – 30, 2019

i Introduction and Executive Summary

Introduction

The scientific goals of the sPHENIX MIE have been endorsed by the 2010 National Academy Study: Nuclear Physics, Exploring the Heart of Matter, in the 2015 Long Range Plan for Nuclear Science, and in a science review of the sPHENIX detector conducted by the Office of Nuclear Physics.

In a February 1, 2018 memorandum, Dr. Timothy J. Hallman, Associate Director of the Office of Science for Nuclear Physics, requested that Stephen W. Meador, Director, Office of Project Assessment (OPA), Office of Science (SC), conduct a review of the sPHENIX project on May 23-25, 2018, at BNL. Ethan Merrill, OPA, chaired the Review Committee. The purpose of this review was to determine if the project had fulfilled the requirements for Critical Decision (CD) 1, "Approve Alternative Selection and Cost Range" and was positioned to execute CD-3a, "Approve Long-lead Procurements". As a result of this review, sPHENIX was granted CD-1 and CD-3a for those elements of technical scope where advance procurements were advisable.

On August 2, 2018, a Department of Energy (DOE) Memo from Steve Binkley, Deputy Director of Science Programs, Office of Science (SC), changed project review and approval procedures by exempting projects with a Total Project Cost (TPC) Equal to or Less than $50 Million from DOE Order (O) 413.3B Project Management requirements. This Memo delegates the responsibility for managing these projects to the Laboratory Directors.

Thus, at the request of the Director of Brookhaven National Laboratory (BNL), an external committee of detector, electronics, management, cost and schedule and ES&H experts was assembled and met at BNL on May 28 through May 30, 2019 to review the baseline status and execution readiness of the sPHENIX project. Explicitly, the committee was asked to determine if the sPHENIX project had fulfilled the requirements of PD-2, "approve performance baseline" and PD-3, "approve start of construction/execution". The full charge letter to the committee is appended to this report in appendix B. These levels of project readiness are analogous to the critical decisions CD-2/3 familiar from DOE Order 413.3b but tailored by the BNL Laboratory Director as appropriate to the projects in the $10M to $50M range. Appended to this report as appendix C is the guidance document "BNL Guidance for Project Management for Office of Science Projects with a Total Project Cost Equal to or Less than $50 Million and Greater than $10 Million" in which this tailoring strategy is detailed. The review committee followed this tailoring strategy in making its recommendations and conclusions concerning PD-2/3 for sPHENIX.

Committee members for this review were chosen based on their technical and/or project management expertise, and experience with building large scientific research facilities, as well as their independence from the project. The full review committee is listed in Appendix A. The Chairperson organized the Committee into five subcommittees, each assigned to evaluate a particular aspect of the project corresponding to members' areas of expertise. The 5 subcommittees dealt with (1) the Detectors, (2) Data Acquisition, Triggers, and Electronics, (3) Environment, Safety and Health (4) Cost and Schedule and (5) Project Management.
The sPHENIX Project Office developed the agenda (Appendix E). This final report is also organized into these 5 main areas. The experience of review committee members with past similar projects was relied on heavily for assessing technical requirements, cost estimates, schedules, and adequacy of the management structure.

Executive Summary

The Committee finds that very substantial progress has been made on all project fronts in the intervening year since the CD-1/3a review. The committee finds that most elements of the project are ready to proceed to PD-2/3. There are a few key recommendations coming from this review, however, for specific subsystems, which should be addressed prior to proceeding to PD-2 and/or PD-3. We list all recommendations here as part of this executive summary before proceeding to the detailed report.

Recommendations:

WBS 1.01 – Project Management

- There should be a dedicated ES&H Manager for the project..
- ES&H should periodically visit universities and/or collaborators, possible look at Office of Quality Management frequency of visits.
- The committee recommends PD2/3 after a clean up, review and status of the project schedule, cost estimate and risk register.

WBS 1.02 - TPC

- The review committee recommends PD-2 for the TPC. Before PD-3, however, the TPC group needs to establish credible production readiness. The review committee is convinced that the TPC Team is very capable; is very close to proving production readiness and that an appropriate focus in the coming weeks could see it done. To this end, we recommend that this be accomplished using their first set of pre-production chambers to simultaneously study the actual IBF, energy resolution and discharge stability for their proposed gas mixture as a function of possible operating point settings for the full range of GEM voltages and transfer fields. This is to be done with the front mesh in place (if that continues as a design option) to confirm that an operating point exists that meets all sPHENIX requirements with their proposed gas mixture. Once the above is completed to the satisfaction of the sPHENIX Project Director and reported to the Review Committee, the TPC can proceed to PD-3.

WBS 1.02.05 TPC FEE

- As indicated in last year's review, all components on the TPC FEE board need to be radiation-qualified; this has been largely achieved but some tests remain. Demonstrate the performance of (two) full TPC FEE boards with SAMPA V4 ASICs versus dose up to a TID of at least 100 kRad. Once available, repeat this demonstration using full TPC FEE boards with SAMPA V5 ASICs. The Committee then recommends proceeding to PD-2/3.

WBS 1.03 EMCal

- Re-evaluate the contingency associated with large procurements such as the W powder, in view of the recent cost increase in this material and possible pending tariff situation. Once the above is satisfactorily completed, to the satisfaction of the sPHENIX Project Director and reported to the Review Committee, the EMCal can proceed to PD-2/3.

WBS 1.04 HCal

- Proceed to PD-2/3

WBS 1.05 Calorimeter Electronics

- Proceed to PD-2/3

CONTENTS

Appendices

1. Detector Systems

Sub-Committee 1

Giorgio Apollinari, FNAL Chair
Tom Cormier, ORNL
Paul Grannis, SBU

1.1 Time Projection Chamber

1.1.1. TPC (WBS 1.02) - Findings

sPHENIX is proposing Project Decision Level 2 and 3 (PD-2/3) to establish performance and cost base line and authorize construction start for a compact TPC central-tracker.

In sPHENIX, the TPC provides charged particle tracking needed for momentum measurements for upsilon physics and jet physics. These are two of the key elements of the sPHENIX physics program and thus the TPC plays a central role in the sPHENIX physics mission.

Four layers of GEM, micro-pattern gas detectors, will be used as the primary electron gain elements at the ends of the TPC providing the required signal gain while at the same time maintaining low positive ion feedback into the TPC drift volume. The sPHENIX TPC design utilizes 3 radial and 12 azimuthal modules on two planes in z for a total 72 modules. The TPC team plans to use a chamber operating point that emphasizes lowest positive Ion backflow

For charge readout, the pad planes, which receive the charge output from the GEM stack, are designed with pads in the "chevron" or "zig-zag" pattern to create better charge sharing for improved spatial resolution with a low diffusion gas.

The TPC will use the SAMPA ASIC revised to a version 5 from the version 4 chip used in ALICE. A readout card prototype using the version 4 chip has been tested but SAMPA V5 is still in early stages of development. A Multi Project Wafer (MPW) including the revised pre-amp and modified ADC has been produced. SAMPA v5 development, production and testing now drive the readout card schedule.

Prototype field cages are being built. TPC HV isolation at the central membrane is provided by layers of insulating material as distinct from the insulating gas volume approach used in ALICE or STAR. One advantage claimed by STAR and ALICE of insulating gas is the reduction of multiple scattering and secondary particle production. The second obvious advantage is that the HV insulator is not susceptible to permanent damage which is conceivable with any solid material.

Stony Brook University continues as the principal TPC fabrication/assembly site receiving materials and subcomponents from collaborating institutions.

The GEM foil production rate at CERN drives the overall sPHENIX GEM Module schedule. A purchase contract is now in place with the GEM shop at CERN. GEM QA and framing will be done in separate factories at Vanderbilt, Wayne State and Weizmann Institute. Each institute handles one of the three module sizes. Framed GEMs will be shipped to Stony Brook for final module assembly and test. GEM factories will follow procedures transferred from ALICE IROC experience at Wayne State. Stony Brook will closely follow assembly procedures developed at Yale for the ALICE IROC project.

The required TPC support subsystems including gas, cooling and laser calibration are all included in the project scope and at an advanced state.

Almost all TPC project labor is contributed. Project cost is thus dominated by M&S; 56% of which is catalog or quote and 35% is analogous design. The project spending profile is sharply peaked in FY20

The TPC project globally continues to benefit from the many years of R&D invested by the ALICE collaboration in the upgrade of their TPC from traditional gated MWPC readout to GEM readout.

1.1.2. TPC (WBS 1.02) - Comments

The TPC team is commended for the outstanding technical progress made since the last review. All aspects of the TPC project are now at or very near pre-production status.

The final design uses four layers of GEM, micro-pattern detectors as the primary electron gain elements to provide the required signal gain at low positive ion feedback into the TPC drift volume. From ALICE and other R&D on similar detectors, this is likely to be a successful approach for the sPHENIX TPC. However, the TPC group plans to choose a module operating point with the best Ion Back Flow settings (IBF~0.3%) and deteriorated energy resolution arguing that ALICE chose IBF closer to 1% because they had to keep good E-res for PID. This is only partially correct, however, because it overlooks that the IBF=0.3% settings in ALICE chambers reduced the HV stability of the system quite significantly. ALICE found at least one order of magnitude worse discharge probability measured with alpha particles (ALICE TDR Addendum) at the very lowest IBF settings. Does a similar situation apply in the sPHENIX chambers and operating gas? It would be good to know but measurements were not shown.

At the verge of production readiness, which of course is implied by PD-3, the sPHENIX TPC team has not finalized all possible issues related to the the operating gas, the corresponding electronics sampling frequency and the related pulse shaping time. Things can always be improved and each of these can presumably be adjusted in that direction for better sPHENIX physics performance. But every project comes to a point where it must weigh the magnitude of further improvements in physics performance versus schedule risk and other project realities. ALICE, for example, spent a lot of R&D effort and time on precisely these choices but they were all closed out prior to production readiness approval.

Similarly, SAMPA V5 is still in early stages of development. Some tests at the MPW level look promising based on the first basic, on-wafer measurements in Sao Paulo but the chip has yet to be completely integrated and packaged so that it can be fully evaluated including understanding such basic performance issues as noise, digital non-linearity and cross-talk. Also, what will be the final yield of acceptable chips. None of this impacts the overall readiness for production of the TPC itself, of course, but it represents a series of possible schedule risks going forward.

The GEM production rate at CERN drives the overall sPHENIX GEM Module schedule. An upcoming anticipated lull in demand for GEM foils from the CERN shop suggests that they should easily meet sPHENIX needs.

Almost all TPC project labor is contributed. This is a major cost savings, but it also creates a potential significant schedule risk if not properly managed. The TPC team and project will watch this.

1.1.3. TPC (WBS 1.02) - Recommendations

The review committee recommends PD-2 for the TPC. Before PD-3, however, the TPC group needs to establish credible production readiness. The review committee is convinced that the TPC Team is very capable; is very close to proving production readiness and that an appropriate focus in the coming weeks could see it done. To this end, we recommend that this be accomplished using their first set of pre-production chambers to simultaneously study the actual IBF, energy resolution and discharge stability for their proposed gas mixture as a function of possible operating point settings for the full range of GEM voltages and transfer fields. This is to be done with the front mesh in place (if that continues as a design option) to confirm that an operating point exists that meets all sPHENIX requirements with their proposed gas mixture. Once the above is completed to the satisfaction of the sPHENIX Project Director and reported to the Review Committee, the TPC can proceed to PD-3.

1.2 EMCal

1.2.1 EMCal (WBS 1.3) – Findings

The UPP calls for an energy resolution of $\sigma_E/E < 16\%/\sqrt{E} \oplus 5\%$ and an e/h separation of 100:1 at 4 GeV with complete azimuthal coverage. The KPP for the initial precision of the pre-calibration is 35% with greater than 90% of all channels live.

sPHENIX plans for an EM calorimeter with complete azimuthal coverage and a +/- 0.85 η coverage, segmented in 2(η) x 32 (ϕ) for a *total deliverable of 64 sectors ready for installation*. Each sector is composed of 72 blocks with 4 towers each (288 towers) approximately projective to the vertex in η and ϕ. Each tower corresponds to an independent EM energy readout channel (18,432 total) fed by 4 SiPM/tower (73,728 SiPM). The design, procurement and construction of the external support structures are not part of WBS 1.3 scope.

The EMCal blocks are fabricated from a tungsten powder epoxy matrix with an embedded square array of 0.47mm diameter scintillating fibers on a 1mm x 1mm pitch. The tungsten epoxy matrix provides both the basic mechanical unit of the EMCal and functions as the shower absorber material. The towers are approximately projecting back to the interaction vertex in both η and ϕ. Blocks are manufactured in up to 22 unique two-dimensional tapered shapes. Light from each tower is collected by light guides into four silicon photo multipliers.

The EMCal team includes members from UIUC, BNL and Fudan/Peking Universities (China). Possible contributions from China would extend the η coverage to 1.1.

The EMCal has an external dependence on the delivery of SiPM daughter boards for the assembly of blocks into modules and sectors.

The EMCal team includes members from UIUC, BNL and Fudan/Peking Universities (China). Possible contributions from China would extend the η coverage to 1.1.

The EMCal schedule driver is the filling of fiber assemblies and blocks construction at UIUC and Fudon/Peking. The first cost driver is the W powder (20 Metric Tons) followed by the scintillating fiber (~2600 km). Both elements received CD-3a approval for early procurement. The WBS Total estimate is 5,162k$ (burdened) with a total effort of 42.4 FTEs (MIE supported + Contributed). The production steps for modules are well understood but must be scaled up for mass production. The overall EMCal BOE relies on quotes and catalog for approximately 73% of the cost and analogous design experience for 26%. The project has identified 15 risks, with the highest Likely Cost Impact (145k$) coming from "EMCal block production requires more labor resources".

The EMCal collaboration has been working to bring in possible new collaborators (China) to extend EMCal η coverage from 0.85 to 1.1. Even though not part of MIE project, the usefulness of coordinating this potential contribution into the overall P6 schedule was clear.

An opportunity to provide a potential second EMCal Blocks factory was presented to alleviate the very labor-intensive assembly effort and address the main EMCal risk ("EMCal Block Production requires more labor resources").

QA procedures are written and approved for all major components. The EMCal has gone through 4 rounds of prototyping achieving in TB data, an energy resolution of $\sigma_E/E < 13.3\%/\sqrt{E} \oplus 3.5\%$, exceeding the UPP requirements.

Module and sector assembly will be performed onsite at BNL. The EMCal schedule is on or near the critical path throughout the entire project. Procurement of Tungsten powder and scintillating fibers under CD-3a allowed schedule to be preserved.

The EMCal block will have a light-injecting fiber to calibrate the Silicon Photomultipliers (SiPMs). No other beam-off detector calibration mechanism (cosmic muons, radioactive source) is considered at this time.

1.2.2 EMCal (WBS 1.3) – Comments

We commend the EMCal collaboration for the continued effort in building prototypes (Module-0) to address all aspects of the EMCal production. The performance of the calorimeter in stand-alone mode, as measured in the TB, gives a better energy resolution than the UPP requirements.

All the scintillating fibers needed for EMCal are under contract but the W powder is under contract only for ~5% of the production. The contingency on the cost is set at ~15%, which is roughly the amount W cost increased recently. The uncertainty on the final contract cost and the possibility of tariff-related expenses suggest a higher contingency level than the ~15% presently quoted by the Project.

Timing studies for the assembly of Blocks and Module needs to continue in earnest. Although much of the labor is contributed, early knowledge about production timing will better inform the P6 schedule.

A production yield of ~90% was assumed in the procurement/production of Blocks. Observation in Module-0 is a yield of approximately ~80%. On the other end, Test Beam results are extremely good in terms of UPP performance. It would appear some of the tolerances might be released.

We note that no additional risk associated a possible FY20 CR is needed at this time.

1.2.3 EMCal (WBS 1.3)- Recommendations

Before PD2/3, re-evaluate the contingency associated to large procurements such as the W powder, in view of the recent cost increase and pending tariff situation.

Proceed to PD2/3

1.3 HCal

1.3.1 HCal (WBS 1.4)- Findings

sPHENIX will have a Hadron Calorimeter (HCal). The project scope for the HCal allows complete azimuthal coverage with longitudinal acceptance extending from η = -1.1 to +1.1 to allow uniform coverage in the -1.0 to 1.0 region.

The HCal design should permit absorption of more than 95% of the energy of a 30 GeV jet and result in a Gaussian-like energy resolution of approximately 150%/sqrt(E) in central Au+Au collisions.

The outer HCal sector structure is built up from tapered low carbon steel absorber plates oriented in a slightly off axis radial direction (a tilted plate calorimeter). The HCal mechanical structure functions as the magnet return yoke. Scintillator tiles are placed between the steel plates and are divided into 48 towers per sector. The tower dimensions are $\Delta\eta \times \Delta\phi \sim 0.1 \times 0.1$ in a projective geometry. The scintillators are read-out by a SiPM and there are 7,680 scintillators arranged in 1,536 towers.

The scintillator tiles have gone through several rounds of prototyping with the anticipated Russian provider (Uniplast) and have demonstrated performance at Test Beam measurements. Each HCal scintillator tile is readout by a single wavelength shifting fiber coupled to a single SiPM.

The inner HCal is interior to the superconducting magnet and thus uses non-magnetic material as the absorber medium. At the present time, scintillators and readout instrumentation for the inner HCal is not included in the project scope.

Scintillator/fiber tile assemblies for outer HCal are under procurement following the CD-3a approval. The QC results of delivered tiles satisfy the technical requirements. A yield of 90% is assumed in the BOE.

Project cost is dominated by M&S, by the Tile Procurement (under execution) and the Inner HCal structure. The Outer HCal structure is already available. The project spending profile is sharply peaked in FY20. The largest risk is a default of the tile manufacturing company.

1.3.2 HCal (WBS 1.4)- Comments

The current schedule incorporates the bare HCal-inner frame, but if a real HCal-inner detector is approved, one might worry that assembling it and then installing could delay EMCAL, which is now on the critical path.

Mechanical structure analysis needs be finalized and reviewed for HCal load-bearing features, such as the Splice plate, before Production

1.3.3 HCal (WBS 1.4)- Recommendations

Proceed to PD2/3.

2. Data Acquisition, Triggers, Electronics

Sub-Committee 2

Myron Campbell, U of Michigan
Rainer Bartoldus, SLAC
Ken Read, ORNL

2.1 DAQ, Triggers, Electronics (WBS 1.05 – 1.07) Introduction

This committee reviewed: Electronics, WBS 1.05, which includes the optical sensors, EMCal electronics and HCal electronics; and DAQ & Trigger, WBS 1.06, which includes the DAQ, Trigger, GL1 and Timing systems. The electronics for the TPC FEE, WBS 1.02.05, and TPC DAM, WBS 1.02.06 are included in this subcommittee review.

2.1.1 Data Acquisition, Triggers, Electronics Findings

The proposed DAQ, Trigger and Electronics are designed to meet the Scientific Objectives and Performance goals of the sPHENIX experiment. Details of the flow-down from the science objectives to the requirements for the electronics, DAQ and trigger were presented. The proponents have creatively capitalized on technologies and equipment developed elsewhere, for example by ATLAS, ALICE, and NSLS II. The subsystem managers have extensive and relevant experience ranging up to over 30 years, often on PHENIX. This experience is used to guide the reuse of equipment from PHENIX, equipment used elsewhere, and where needed, new designs. The proponents are using the final hardware and software in test stands and in detector prototype testing. This avoids development of additional systems and provides tests and early integration of the final electronics. The system is well designed to be able to scale to increased bandwidth and storage, should that become necessary.

The TPC FEE requires noise of < 1000 e per channel to achieve the necessary Upsilon mass resolution and momentum resolution. A value of < 800 e is measured using prototype electronics. A peaking time of 80 ns is required to avoid pileup issues for efficiency and purity. Additionally, an ADC sampling time of 20 MHz is required. This has led to a development of the SAMPA V5 MPW ASIC based on the ALICE SAMPA V4 ASIC. The preamp/shaper, ADC, and digital parts of the SAMPA V5 will be integrated into a full chip layout and submitted for assembly in August 2019. The performance of the full SAMPA V5 chip will be measured in December 2019. The risk associated with a failure of this SAMPA V5 engineering run is listed as 5% in the Risk Register. The front-end capacitance of the TPC detector will vary from 15 to 23 pF. All commercial semiconductor devices for TPC FEE were radiation qualified to a TID of 50 kRad. One KPP sets the requirement of the TPC FEE cross talk to be less than 2% per channel for every channel.

The Calorimeter Electronics Interface Board development, production, and testing drives much of the critical path for sPHENIX, with no schedule float specifically called out before the early project completion date of October 2021. The radiation tolerance of a whole Calorimeter electronics readout board has been demonstrated up to TID of at least 100 kRad. The Local Level-1 board is still at an advanced conceptual design stage.

2.1.2 Data Acquisition, Triggers, Electronics (WBS 1.05 – 1.07) - Comments

The overall design is well matched to meeting the challenge of collecting data from sPHENIX and meeting the design goals derived from the Scientific Objectives. The committee recognizes the experience, competence, and professionalism of the team working on the DAQ, Trigger and Electronics. The presentations were very well-structured and provided the committee with the information needed to assess the project. The committee recognizes the significance of the solid demonstration achieved since the last review of the complete TPC FEE chain via a cosmic ray test using the SAMPA V4, the FELIX card, and the RCDAQ system.

We commend that the first batch of production SiPMs has been successfully tested using an automated robot. The committee finds it is wise and beneficial that final DAQ software and data format are used for testing all subsystems. The committee recognizes and appreciates the importance of the OSI.

The quoted sPHENIX TPC FEE TID requirement of 50 kRad exceeds the level explored by ALICE for SAMPA V4, and has not been otherwise demonstrated by sPHENIX. It would be prudent to test the performance of an entire TPC FEE board with SAMPA V4 versus dose up to a TID of at least 100 kRad. (This is feasible using a Co-60 source with 10 kRad/hr.)

If the SAMPA V5 Engineering Run production does not satisfy performance requirements, an unknown number of weeks would be required to identify and correct the problem, followed by another 4 months Engineering Run at a cost of $200k. The committee considers the risk associated with the SAMPA V5 Engineering Run to be significantly greater than the assigned value of 5%. The TPC FEE KPP of less than 2% cross talk for every channel has not yet been demonstrated as achieved or certain to be achieved on average, or for every channel.

The Calorimeter interface board production has some internal built-in float, and has the potential contingency of extra testing time per day if needed to maintain the planned readiness by October 2021. However, this requires that the first boards arrive on schedule.

2.1.3 Data Acquisition, Triggers, Electronics (WBS 1.05 – 1.07) - Recommendations

As indicated in last year's review, all components on the TPC FEE board need to be radiation-qualified; this has been largely achieved but some tests remain. Demonstrate the performance of (two) full TPC FEE boards with SAMPA V4 ASICs versus dose up to a TID of at least 100 kRad. Once available, repeat this demonstration using full TPC FEE boards with SAMPA V5 ASICs.

The Committee recommends proceeding to PD-2/3.

3. ES&H and QA

3.1 ES&H and QA

Sub-Committee 3
James Niehoff

3.1.1 ES&H and QA Findings

The sPHENIX upgrade detector is comprised of distinct activities, the major items of equipment which include infrastructure and facility upgrades. There is an Environment, Safety and Health (ES&H) plan for sPHENIX detector that is based on DOE's Integrated Safety Management System (ISMS). The ES&H Plan references the Hazard Analysis Report (HAR) which describes an updated list of the hazards present related to the detector and mitigating controls to be used.

The hazards posed by operation of the sPHENIX are covered in the BNL's Collider/Accelerator Division's Safety Assessment Document. Furthermore, the sPHENIX HAR will be retired and incorporated into the Final Safety Assessment Document prior to operation. The hazards associated with the decommissioning of the existing PHENIX detector are addressed in a separate Hazards Analysis Report and is not part of this review. In addition, the Fire Hazard Analysis and the Safety Assessment Documents are not part of this review.

Assembly and testing of the BNL built components will be done in BNL Buildings 510, 912, and 1008. There are parts of the detector that are being built by universities and other DOE national laboratories. The sPHENIX detector will be located and operated in BNL Building 1008

In general, the operations of sPHENIX detector are expected to be similar to those found in the previous Safety Assessment Document, with the exception of the helium cooled superconducting magnet.

The sPHENIX project has adopted in its entirety, the BNL's institutional Quality Assurance Program. This program is documented and delivered through BNL's Standards-Based Management System (SBMS). The sPHENIX Quality Assurance Program uses an integrated management systems approach. It describes the various BNL management system processes and functions to provide a sound approach that conforms to the basic ten criteria defined in DOE Order 414.1D titled "Quality Assurance".

The purpose of the specific sPHENIX Project's Quality Assurance Plan is to outline how the project aligns with the BNL's institutional Quality Assurance requirements and any supplemental project-specific requirements. The Project's Quality Assurance Plan unifies the projects quality assurance activities, which are spread across multiple universities and laboratories, and is implemented through documented processes that address specific quality requirements.

3.1.2 ES&H and QA Comments

The Preliminary Hazard Analysis Report (PHAR) has been combined with the Hazard Analysis Report (HAR). This is documented in the May 19, 2019 ES&H Plan for sPHENIX.

The HAR will eventually be incorporated into the Safety Assessment Document (SAD) and that in turn will be finalized once operational.

BNL's Work Planning Controls (WPC) are in place to assure worker safety and health to their employees, collaborators (users) and contractors when on-site. A summary of some of the WPC planning and processes that are in place, see table below.

Work Planning Controls		
Planning	**Processes**	
Employees/Users/ Contractors	**Controls**	**Commissioning/ Operational**
• ID Badging • Job Risk Analysis (JRA) • Job Training Analysis (JTA) • Service Level Agreement (SLA) • Design Review Questionnaire (DRQ) • Experiment Safety Review (ESR) • Health and Safety Plan (HASP) • Green sheets Work Permits • Fire Hazard Analysis (FHA) • Safety Assessment Document (SAD)	• Job Hazard Analysis (JHA) • Standard Operating Procedure (SOP) • Worker Planning Work (WPW) • Area Specific Training Briefing for Students (ASTBS) • Pre-Job briefings	• Subsystem Readiness Review (SRR) • Final Safety Assessment Document (FSAD)

There are beam pipes that will connect to the sPHENIX detector, specifically, Beryllium pipe; however, this is outside the scope of the sPHENIX project and is the responsibility of BNL's Collider/Accelerator Division.

HAR identities Fire as "High" probable risk; however, this is based on the existing PHENIX experiment that used flammable gases. At this point, there are no plans to use flammable gases in sPHENIX.

BNL has a Standards-Based Management System (SBMS) which is flowed down in part to universities through Supplier Quality Assurance Technical Specification.

BNL has a graded approach to quality; however, the graded approach is not allowed on sPHENIX internal or external collaborators.

Office of Quality Management conducts quarterly surveillance of detector components being manufactured by universities and other DOE National Laboratories. In addition, the Office of Quality Management also performs annual assessments of universities and other DOE national laboratories.

There is a controlled procedure guidelines document as well as documents related to document controls (drawings) etc.

3.1.3 ES&H and QA Recommendations

- There should be a dedicated ES&H Manager for the project.
- ES&H should periodically visit universities and/or collaborators, possible look at Office of Quality Management frequency of visits.
- The Quality Assurance document should have version "DRAFT-B" removed from footer and cover sheet.

4. Cost and Schedule

4.1 Subcommittee 4

Greg Capps
Garrett Meek

4.1.1 Findings:

The project presented a Total Project Cost (TPC) of $27M, which is an increase of $450K from the CD-1 point-estimate. The TPC is composed of the Budget at Complete (BAC) of $22.015M and $4.985M in cost contingency. T he cost contingency is 26% of the Estimate to Complete (ETC) and ~40% of the uncommitted ETC. The detailed resource loaded schedule (RLS) was last updated in Jan 2019 and the project is 18.9% complete based upon actual costs of $4.15M through Apr 2019.

The project schedule early finish date is Oct 2021 and the PD-4 date is Dec 2022; which allows for 14 months of schedule contingency (float). The schedule is logic driven and resource loaded with material costs and labor hours, and it has over 1800 activities, including 319 milestones. The schedule scores a 94 using the FUSE analysis. The schedule is seamlessly integrated with the RHIC supporting activities with over 190 physical logic ties between the schedules. The project critical path runs through the Calorimeter Electronics' EMCal electronics preproduction and production into the EMCAL module fabrication and sector assembly.

During drilldowns, there were several instances of activities completing after their expected finish dates; even a few on the project critical path.

The baseline cost estimate was developed bottom-up by L2 and L3 managers within the last 6 months. Nearly 80% of the estimate is supported by vendor quotes and estimates or by existing procurement purchase orders. The project estimate is 90% materials and 10% labor. Most of the labor to support the project execution is funded via contributed, off-project sources, and the primary off-project sources are BNL RHIC staff and University staff/students funded via the DOE NP program.

The project risk register has 66 active risks, with 8 High, 23 Moderate and 35 Low, and 1 opportunity. Risks are analyzed using both cost and schedule Monte Carlo simulations, and risks are reviewed monthly by the project management and CAMs. The project has $2.99M of estimate uncertainty and a Monte Carlo analysis of the project risk register at 90% confidence calls for additional cost contingency of $1.6M. This is a total potential call on cost contingency of $4.66M leaving the project with $325k of unencumbered contingency.

The project will use a tailored implementation of the BNL Earned Value Management System (EVMS) and the CAMs have all received training on the EVMS.

4.1.2 Comments:

The project has a proficient project controls team, and the systems and tools to monitor and control the project appear to be ready for project execution. Additionally, the CAMs were knowledgeable about their scope, schedule, cost, and risks, and appear to be ready for project execution. The estimate and schedule drilldowns were acceptable and demonstrated CAM knowledge of their control accounts

The MIE WBS appears to contain the complete project scope of work required to achieve the threshold and objective KPPs. Project is very well integrated within RHIC activities and the collocated schedule is a best practice and the project obligation and spending profiles are supported by the approved funding and while tight in FY19, they appear reasonable.

The schedule is very well organized and constructed. Multiple risk-based Monte Carlo calculations were performed that confirmed the 14 months of schedule contingency is reasonable and the schedule activities and durations appeared appropriate and optimistically reasonable. The project schedule should be updated as soon as possible to confirm the physical % complete and the 14 months of schedule contingency remains available.

The cost estimates were adequately supported with backup data. The project should consider a scrub of the estimate uncertainty keeping in mind comments from the technical subcommittees. There were several minor flaws discovered in the estimate and schedule (i.e. project review activities in 1.02 & resources on short duration activities) that should be cleaned up before a baseline is established.

The project risk methodology appears well developed and comprehensive. While some of the risk mitigations appear to be optimistic, the overall risk register appears to be complete and accurate. The cost contingency of 26% of the ETC initially appeared to be low. However, the contingency is also ~40% of the uncommitted ETC, therefore this seems palatable. Due to the numerous international procurements, the project should consider reviewing the risks associated with tariffs and update the register.

There is a significant amount of contributed labor on the project, and the BNL contributed effort appears well managed and sufficient to support the project. The project fully understands the risks surrounding the ~60,000 hours of non-BNL contributed effort and has a reasonable approach for managing this work; examples of currently used performance tracking tools for these scopes were provided.

The project intends to use a tailored application of EVMS to monitor the project and the approach seems reasonable. Due to the large amount of contributed effort and the potential difficulty obtaining Actual Cost data, the project may want to consider additional metrics (milestones, BEI, QBD) to augment EVMS.

4.1.3 Recommendations:

Before PD2/3, clean up, review and status the project schedule, cost estimate and risk register.

5 Project Management

5.1 Project Management- Sub-Committee 3

Ron Ray
Vincent Riot

5.1.1 Project Management (WBS 1.01) – Findings

The Committee was welcomed by the Laboratory Director and the Deputy Director for Science and Technology. Both expressed a strong commitment to the successful completion of the sPHENIX Project.

sPHENIX is a major upgrade to the PHENIX detector. It is a large-acceptance, high-rate detector for Heavy Ion physics that repurposes >$20M in existing PHENIX equipment, infrastructure and support facilities. The Project is supported by a large international collaboration of 77 institutions

To reduce cost, the Project went through a scope reduction exercise in Oct 2017 that reduced the calorimeter eta coverage by 23%. It was stated that further reductions would compromise the jet program. Coverage was later restored thanks to contributions from international partners. The KPPs do not rely on the contributed coverage.

FY20 is the Project's peak funding year and is nearly twice the funding in FY19.

The Project includes a significant amount of contributed funding and effort from BNL and other institutions. About 2/3 of the overall labor is contributed. M&S is 90% of the TPC. All major vendors have been identified.

The Project's Risk Registry is updated monthly. A Monte Carlo simulation of Project risks using the Primavera Risk Management Tool has been performed and reported at the 90% confidence level.

All Long Lead Procurements approved at CD-3a have been placed. The overall cost was said to be within the budgeted amount.

The Project has set up a program of Design and Procurement Reviews for major systems. The cost weighted design maturity for the overall Project is 91%.

The Project has established an Office of System Integration to ensure fidelity across subsystems and to arbitrate disputes. The group meets monthly with representatives from each subsystem. Installation and commissioning are not part of the Project scope.

Deputy L2 Managers exist but are not identified in the WBS.
A Contract Specialist has been assigned to the Project. Procurement durations, provided by the Procurement Department, are included in the P6 schedule.

The Project's critical path runs through electronics and the EMCal and is technically limited.

5.1.2. Project Management (WBS 1.01)- Comments

The Project is managed by a strong, experienced team. The project appears well structured and organized.

The Project has very limited scope contingency. A small amount of contingency was available in the form of angular coverage, which was cut back, though it was restored by an in-kind contribution. There is very little savings available by backing off from Objective to Threshold KPPs.

The contingency of 26% is a bit low by conventional standards. However, because of the large amount of contributed labor, the Project cost is dominated by material purchases (90%), so the standard labor costs associated with schedule delays is largely non-existent. Virtually all of the vendors have been identified and many are under contract. The contingency relative to the amount of uncommitted funds is about 40%, a more comfortable number.

The availability of significant contributed effort is a major benefit to the Project and reduces the standard army risk in the case of delays, but there are also risks if all of the effort cannot be provided or if the contributed effort is not adequate to achieve the contributed scope. It is important that the Project properly tracks the contributed effort and appropriately captures the associated risks.

FY20 is the peak funding year for the Project, requiring almost twice the funding provided in FY19. An extended continuing resolution in FY20 would impact the project significantly. The Project could survive for some number of months, depending on the nature of the CR, but eventually a significant delay would result.

Many risks have a most likely residual cost impact of $0 under the assumption that schedule delays don't have a cost associated with them because the labor is contributed. This may not be fully realistic as some labor is not contributed and labor may have to be purchased in the event of shortfalls or immediate need. This could skew the Monte Carlo to the low side.

According to the Organizational Chart, the collaboration spokespersons provide advice directly to the BNL ALD and not the Project Director. This seems to be operating successfully.

The project is planning to execute Memorandums of Agreement with Universities for in-kind contributions. The committee believes that this will be an important item to complete to reduce risks of in-kind support being lost over time.
Contracts to Universities do not seem to include a section addressing the need to report monthly into the EVMS framework. Clearly defining the required information in future contracts should be considered.

The Project has set up a complete set of Design and Production Readiness Reviews that follows best practices. The reviews are primarily staffed by personnel internal to sPHENIX with one or two external experts. While it can be difficult to obtain outside participants for a large number of reviews, it is worth the effort to have fresh eyes and input from experts outside the Project circle.

System Interfaces seem to be mature and are reviewed by the Office of System Integration, but it does not appear that the Project has plans for a system level review. It may benefit the project to conduct a system level final design review with external reviewers.

The verification and validation process for level 2 deliverables should clearly define how compliance with the technical specifications will be determined, how interfaces will be validated, how non-conformance issues will be handled and how ES&H compliance will be determined. It was not obvious to the committee what the formal process would be and who would be required to sign off.

Test and acceptance plans should take care to capture equipment safety, handling and assembly procedures. The current drafts of QA documentation does not appear to address all of these issues.

The Project meets weekly with representatives from the Procurement Department to review ongoing and upcoming procurements. Project Management was aware of the potential for delays associated with procurements and appears to be proactive in mitigating these potential delays.

A status update of the project schedule has not been performed in several months. Since then, several critical path or near critical path items have been delayed, potentially eating into the Project's 14 months of schedule float. Prior to baselining, the project should status it's schedule and any necessary baseline changes should be implemented to recover the lost schedule, if possible.

The Project's travel budget is $45K and appears low to support vendor and partner oversight. It may be worth assessing whether more travel may be needed to adequately support QA.

5.1.3. Project Management (WBS 1.01) - Recommendations

1. Perform a comprehensive status update prior to PD-2/3
2. Proceed to PD-2/3

sPHENIX PD-/3 2Review Committee BNL May 28 – 30, 2019

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Appendix B – Charge to the PD-2/3 Review Committee. BNL May 28-30, 2019

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May 6, 2019

sPHENIX Review Committee

***SUBJECT*:** **Brookhaven National Lab Independent Project Review for Project Decision 2&3 (PD-2&3). Approval for sPHENIX Major Item of Equipment (MIE) Project**

I request that you organize and conduct a Project Decision 2/3 (PD2/3) Independent Project Review of the sPHENIX project at the Brookhaven National Laboratory on May 28-30, 2019. The purpose of this review is to determine if the sPHENIX project has fulfilled the requirements for PD 2 "Approve Performance Baseline" and PD-3, "Approve Start of Execution, and that the project is ready for PD-2/3 approval. The PD-2 and PD-3 approvals are similar in nature to the CD-2 (Approve Performance Baseline) and CD-3 (Approve Start of Construction/Execution) and support the expectations and requirements as stated in the memo from Steve Binkley dated August 2, 2018 on (Project Management of SC Projects with TPC of $50M or less).

The performance baseline for sPHENIX (CD1/3A) was approved August 2018 with a Project Cost Range of $22-35M and a CD-4 date along with authorization for Long Lead Procurements (CD-3A) in the amount of $5M. The sPHENIX MIE is a major upgrade to the PHENIX experiment that will enable precision characterization of jets produced in nucleus+nucleus (AA), proton+nucleus (pA) and proton+proton (pp) collisions at the Relativistic Heavy Ion Collider (RHIC) located at BNL.

In carrying out its charge, the review committee should respond to the following questions:

1. Project Scope: Do the proposed technical design and associated implementation approach satisfy the performance requirements? Are the technical designs sound and sufficiently mature to support the performance expectations for PD2/3?

2. Management: Is the project being properly managed at this stage? Is there a capable team in place, and required resources identified, to effectively manage the production phase including all the procurements, major interfaces, technical issues, and risks to ensure successful delivery of the project? Is the Project ready for PD 2/3?

3. Cost and Schedule:_Are the cost and schedule estimates complete, adequate, and reasonable to support the performance baseline?

4. Risk and contingency: Are the project risks properly identified and appropriate mitigation strategies in place? Do the cost and schedule estimates include adequate contingency based on a sound and reasonable risk analysis?

5. Environment, Safety & Health and Quality Assurance (ES&H/QA): Are the ES&H/QA requirements being properly addressed given the project's current stage of development?

6. Prerequisites: Have all the prerequisite activities and documents (see attached definition) necessary to support PD 2/3 approval been completed?

7. Recommendations: Have the recommendations from past reviews been appropriately addressed?

Robert Tribble, Deputy Director for Science and Technology, will serve as the point of contact for this review. I would appreciate receiving your committee's report within 14 days of the review's conclusion.

Sincerely,

Doon Gibbs
Laboratory Director

cc: J. Gillo, DOE
J. Hawkins, DOE
R. Gordon, BHSO/DOE
L. Nelson, BHSO/DOE
B. Mueller, BNL

BNL Guidance for Project Management for Office of Science Projects with a Total Project Cost Equal to or Less than $50 Million and Greater than $10 Million

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Background

Department of Energy (DOE) Memo from Steve Binkley, Deputy Director of Science Programs, Office of Science (SC), dated August 2, 2018, exempted projects with a Total Project Cost (TPC) Equal to or Less than $50 Million from DOE Order (O) 413.3B Project Management requirements. This Memo delegates the responsibility for managing these projects to the Laboratory Director.

Purpose and Applicability

1. The purpose of this procedure is to describe the project management process Brookhaven National Laboratory (BNL) will implement to manage SC projects with a TPC equal to or less than $50 million (50M) and greater than $10 million (10M). All SC projects with TPC equal to or less than $50M or greater than $10M will follow this procedure unless specifically exempted by DOE. The BNL procedure will follow the principles of good project management and the intent of DOE O 413.3B, which include: Line management accountability.
2. Sound, disciplined, up-front planning.
3. Well-defined and documented project requirements.
4. Corporate effective risk handling mechanisms.
5. Well-defined and managed project scope and risk-based performance baselines and stable funding profile that support original baseline execution.
6. Development of reliable and accurate cost estimates using appropriate cost methodologies and databases.
7. Properly resourced and appropriately skilled project staffs.
8. Effective implementation of management systems supporting the project (e.g., quality assurance, integrated safety management, risk management, change control, performance management and contract management systems).
9. Early integration of safety into the design process.

10. Effective communication among all project stakeholders.
11. Utilization of peer reviews throughout the life of a project to appropriately assess and

    make course corrections.

Tailoring Strategy

BNL's Project Management process allows for the development of a tailoring strategy for each project, based on the risk, complexity, visibility, cost, safety, security, and schedule. The requirements of BNL are to be applied on a tailored basis as appropriate to the project. Tailoring is subject to the Laboratory Director's approval and DOE concurrence and is identified prior to the impacted significant project decisions/approvals (e.g., Approve Project Performance Baseline, Approve Project Production, and Approve Project Completion). These reviews will be conducted as independent reviews with invitations to the respective DOE Program Offices and the DOE BHSO Manager to observe. The projects will follow all federal regulations and Executive Orders.

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Roles and Responsibilities **BNL Laboratory Director**

The BNL Laboratory Director has full responsibility for project planning and execution, and for establishing broad policies and requirements for achieving project goals. The Laboratory Director is accountable to DOE for BNL Project Performance and has the following responsibilities:

- Approves the Project Management Plan.

- Approves the appointment of the Project Director

- Approves Level 1 baseline changes.

- Approves Project Decisions (PD) through BNL Independent Project Reviews (IPRs)

  including:
  - PD-1 Approve Conceptual Design and Cost Range
  - PD-2 Approve Project Performance Baseline
  - PD-3 Approve Project Execution
  - PD-4 Approve Project Completion
  - The responsibility for CD-0 Mission Need is the responsibility of DOE

- Concurs with funding requests to DOE. **BNL Associate Laboratory Director (ALD)**

The BNL Associate Laboratory Director, as delegated by the BNL Laboratory Director, has the following responsibilities:

- Ensures BNL Lead Laboratory commitments are met in executing the project within scope, cost, and schedule in a safe and responsible manner.

- With the Laboratory Director's concurrence, appoints the Project Director and ensures the Project Director is qualified and has appropriate communication and leadership skills prior to designation.

- Initiates objectives of the project.

- Initiates and successfully executes BNL Independent Project Reviews (IPRs) for Project

Decisions (PDs) and status reviews:

- PD-1 Approve Conceptual Design and Cost Range
- PD-2 Approve Project Performance Baseline
- PD-3 Approve Project Construction/Execution/Production
- PD-4 Approve Project Completion
- Annual Project Status Reviews after approval of the Project Performance Baseline

(PD-2)
- PDs can be tailored to request LLP, site prep, or other tailoring requests

- Ensures access to Laboratory/contractor resources, systems, and capabilities required to execute the project.

- Accepts changes to the funding profile as directed by DOE.

1.0/PMSC_PD.docx 3 (05/2019)

- Approves KPPs (Key Performance Parameters) with DOE concurrence.

- Approves major subcontracts in accordance with federal regulations and BNL policy.

Project Management Executive

The Project Management Executive has the following responsibilities:

- Supports the request for the federal appropriation necessary to support this project.

- May concur on the PMP .

- May concur on KPPs.

- May attend and concur on BNL's Independent Project Reviews and Project

Decisions.

- Will assign a Performance Evaluation Measurement Plan (PEMP) goal to the

Laboratory.

Federal Program Manager (FPM)

Serves as the primary DOE Program Office point of contact for the project and is charged to fulfill program responsibilities for project funding, coordination, oversight, and communication with other DOE Headquarters (HQ) offices. The DOE FPM has the following responsibilities:

- Functions as DOE HQ point of contact for project matters.

- Serves as the representative in communicating the interests of the SC program.

- Coordinates with Laboratory Director, DOE BHSO Manager, SC Staff offices, and DOE

HQ program offices, as needed, to execute the project.

- Assists with budget formulation.

- Reviews and concurs with Level 1 baseline changes.

- Attends monthly meetings.

- Reviews and concurs with the PMP .

- Reviews project progress reports and deliverables.

The DOE FPM is consulted in the charge, agenda and schedule of formal periodic reviews of the project, including BNL Independent Project Reviews (IPRs) and is invited to attend the reviews.

Brookhaven Site Office Manager

The Brookhaven Site Office (BHSO) supports the Program Office in their oversight of their respective BNL Projects. The DOE BHSO Manager has the following responsibilities:

- Assigns a Contracting Officer to oversee performance in accordance with contract requirements.

- Appoints a BHSO Project point of contact.
- Reviews and concurs on Project Decisions PD-1 PD-2, PD-3, and PD-4.
- Reviews development and implementation of key project documentation.
- Reviews project cost, schedule, performance, and scope progress to baseline plans.

1.0/PMSC_PD.docx 4 (05/2019)

- Ensures design, construction, environmental, safety, security, health, and quality efforts performed comply with the M&O Contract, public law, regulations, and Executive Orders.
- Concurs with the PMP .

CD-0 (Mission Need) is still the responsibility of DOE and the remaining critical decision equivalent, called Project Decisions, will be the responsibility of the Laboratory to initiate and execute. The respective Program Office and BHSO will be invited to participate in the Project Decisions.

Project Director/Project Manager

The Project Director leads the Project Management team. The Project Director/Project Manager is appointed by and reports directly to the BNL ALD. The Project Director/Project Manager is responsible for ensuring that adequate direct, indirect, and support resources are available for the successful execution of the project. The Project Director's/Project Manager's responsibilities include the following:

- Approves the project organization in consultation with the ALD.
- Represents the project in interactions with the DOE.
- Collaborates with the responsible Project Scientist to provide overall direction to the project.
- Establishes clear and achievable project objectives (KPPs) in consultation with the FPM.
- Successfully executes the project scope.
- Assembles the staff and resources necessary to complete the project.
- Appoints Level 2 Managers, Level 3 Managers and Control Account Managers (CAMs)

for the project whom will be responsible for managing bid package(s), overseeing daily technical and managerial oversight of specific assigned WBS tasks from design through construction, and for preparing change requests in conformance with Baseline Change control.

- Manages the completion of Project deliverables as defined in the PMP.

- Ensures that the project deliverables meet functional requirements.

- Ensures timely resolution of critical issues within Project Director's control.

- Identifies risks to scientific and technical performance; works with the CAMs to control

project risks.

- Defines areas of collaboration and relationship between the project and other BNL

departments and divisions, and other institutions participating in the project. Develops appropriate Memoranda of Agreements (MoAs), Memorandum of Understandings (MOUs) and other collaborative agreements as applicable.

- Works with the Project team to define the WBS structure and to establish intermediate milestones.

- Allocates contingency funds according to the procedure defined in the Baseline Change Controls.

- Provides monthly financial reports to BNL and DOE.

- Approves major subcontracts.

- Implements a tailored Earned Value Management System (EVMS) in accordance with the DOE-approved EVMS system at BNL.

- Maintains change control log and documentation.

- Assures that work is performed in compliance with the BNL Environmental, Safety and

Health requirements and Worker Safety Regulations.

Project Management Plan (PMP)

Projects will develop a Project Management Plan (PMP) which will describe the elements and process for planning and executing a successful project. The PMP will be approved by the Laboratory Director and BNL will obtain concurrence from BHSO and the responsible Program Office.

The PMP will include the following elements:

1. Introduction, Background, Mission Need
2. Project Baseline (Including scope, cost, schedule baseline)
    1. Scope Baseline
        1. Key Performance Parameters (KPP)
        2. WBS Dictionary
    2. Schedule Baseline
        1. Summary Schedule
        2. Project Milestones (L1-L4)
        3. Detailed Resource Loaded Schedule
        4. Critical Path
        5. Schedule Contingency/Float
    3. Cost Baseline
        1. Cost Estimate by WBS, Labor and Material
        2. Obligations Profile
        3. Estimate Uncertainty and Cost Contingency
        4. Time phased Plan by month
    4. Funding Profile
        1. TEC (Total Estimated Cost), OPC Other Project Costs
        2. TPC -Total Project Cost (TEC+OPC)
        3. Time-phased by Fiscal Year
3. Risk Management
    1. Risk Management Plan
    2. Risk Register
4. ES&H
5. Procurement
6. Tailoring Strategy
7. Management Organization
8. Roles and Responsibilities
9. PM Oversight
10. Change Control
11. Project Controls Systems/EVMS
12. Project Reviews

13. Project Reporting
14. Transition to Operations 15. Project Closeout

Projects will maintain all project documentation in a shared site accessible by DOE and the project team.

Key Performance Parameters (KPPs)

The project will define Key Performance Parameters (KPPs) with which DOE concurs. KPPs will be developed similar to larger projects, with threshold, objective, and if required, Ultimate PPs. The Laboratory Director and ALD must approve all KPPs. The responsible Program Office must concur on all KPPs.

Project Phases/Reviews

Reviews will be conducted for each phase in the project lifecycle (Conceptual Design – TDR, PDR-Preliminary Design, FDR-Final Design, procurement phase, start of construction, execution or production and project closeout) Project Decisions (PD) will be defined in a procedure which will follow a similar but tailored review process. Experienced external reviewers will chair the PD reviews to ensure independence. Projects will conduct external Independent Project Reviews at these critical points, based on guidance from the Program Office in the project lifecycle at least annually and during the Project Decision phases. DOE will be asked to concur with the review team members and will be invited to attend the reviews.

1. The Conceptual Design will be finalized and approved as part of PD-1 (Project Decision 1) (similar to CD-1). The Cost Range and Conceptual Design is approved.

   Project Decision 1 - The Conceptual Design and Cost Range will be developed and approved as part of PD-1 (Project Decision 1). A successful PD-1 Review will be attained when an approach to meet the gap in mission capability has been identified, selected, and a nominal cost range established. This is an indication that the project team and the sponsor have agreed on path forward for meeting the mission need defined by DOE CD-0. To achieve PD-1 the project team should meet the following requirements and produce the following documentation:

   - Conduct Conceptual Design Review
   - Complete Conceptual Design Report
   - Approve Preliminary Project Management Plan (PPMP)
   - Develop a Risk Management Plan (RMP)
   - Develop a project cost range, initial cost estimate and schedule.
   - Develop NEPA Determination
   - Prepare a Preliminary Hazard Analysis Report
   - Develop a preliminary Integrated Safety Management Plan, and
   - Develop a preliminary Quality Assurance Plan
   - Conduct a Safeguards and Security Vulnerability Assessment, if required
   - Begin reporting monthly progress to BNL Project Oversight Board
2. The Preliminary Design will be finalized and approved as part of PD-2 (Project Decision 2) (similar to CD-2). The project Performance Measurement Baseline is

approved.

Project Decision 2 - The Preliminary Design and Project Baseline will be finalized and approved as part of PD-2 (Project Decision 2). A successful PD-2 Review will

be attained when the project team has estimated and time-phased the resources required to execute the project against an integrated project schedule, and a risk analysis is conducted to help determine the potential variability in scope, schedule and/or cost which might be encountered in the course of executing the project. To achieve PD-2 the project team should meet the following requirements and produce the following documentation:

- Conduct Preliminary/Technical Design Review
- Complete Preliminary/Technical Design Report
- Update and approve Project Management Plan (PMP)
- Develop a Performance Baseline including Resource-loaded schedule
- Finalize Hazards Analysis Plan
- Finalize Quality Assurance Program
- Update and approve funding changes
- Continue Monthly Reporting include Cost Performance Report
- Implement tailored Earned Value Management System (EVMS) and change

  control

- Review Project Risk Registry and assess Contingency
- Initiate Annual Status Review and EVMS Reporting after PD-2 approval.

3. The Final Design will be finalized and approved as part of PD-3 (Project Decision 3) (similar to CD-3). Procurement Execution authorization is approved.

   Project Decision 3 (PD-3) includes Approval of the Project Final Design requirements and specifications and Authorization to start Execution of the Project. A successful PD-3 Review will be attained when it is determined that the state of the development of the project planning is adequately defined to execute the project plan for successful delivery of the project scope with effective management, resource planning, scheduling, risk assessment, and progress tracking at a level that ensures project delivery that addresses the expectations of the stakeholders. To achieve PD-3 the project team should meet the following requirements and produce the following documentation:

   - Conduct Design Review of the final design requirements and specifications.
   - Update Project Management Plan (PMP)
   - Generate a preliminary Transition to Operations Plan
   - Update Hazard Analysis Plan
   - Continue Quality Assurance Program
   - Update Project Integrated Safety Management Plan

- Continue Monthly Reporting include Cost Performance Report
- Implement tailored EVMS and change control
- Monitor Project Risks and Contingency
- Continue Annual Status Reviews

4. The Project Closeout will ensure all scope has been completed and approved as part of PD-4 (Project Decision 4) (similar to CD-4) and will be submitted to BHSO and the responsible DOE Program Office for concurrence after the PD-4 review has been held

and all open items have been addressed. The Laboratory Director will inform BHSO and the responsible DOE Program Office in writing that BNL has successfully completed all deliverables and KPPs and will request DOE concurrence on PD-4.

Project Decision 4 (PD-4) includes approval for Completion of the project or Start of Operations. A successful PD-4 Review will be attained when it is determined that the project has met the technical, cost, and schedule deliverables consistent with the approved project plan/objectives. To achieve PD-4 the project team should meet the following requirements and produce the following documentation:

- V erify KPPs are met
- V erify Scope completed, close accounts
- Finalize Hazard Analysis Plan
- Finalize Transition to Operations Plan
- Complete Project Closeout Report
- Document Lessons Learned

Qualifications for Project Director or Project Manager

The Project Director or Project Manager must be approved by the Laboratory Director or his designee. The Project Director or Project Manager must meet the following minimum requirements:

5. Either the Project Director or Project Manager on the project must have successfully completed BNL's Project Management Comprehensive Training Course, a similar course elsewhere, or have demonstrated experience managing projects.
6. The Project Director or Project Manager must have experience in delivering successful projects on time within budget.
7. The Laboratory Director must approve the Project Director or Project Manager

Independent High-Quality Cost Estimates:

BNL will follow the characteristics of a good estimate, the BNL Cost Estimating checklist and the BNL Standards-Based Management System (SBMS); best practice guidelines will be followed and documented in the Project Management Subject Area.

Project Controls Systems/Earned Value Management System

Projects over $20M will develop a tailored Earned Value Management System (EVMS) implementation which will meet the following EVMS principles:

- **Objectively assess accomplishments** at the work performance level
- **Plan all work scope** for the program from inception to completion
- **Break down the program work scope into finite pieces** that can be assigned to

  a responsible person or organization for control of technical, schedule, and cost

  objectives
- **Integrate program work scope, schedule, and cost objectives into a performance measurement baseline** plan against which accomplishments may be measured
- **Use actual costs incurred** and recorded in accomplishing the work performed

1.0/PMSC_PD.docx 9 (05/2019)

- **Analyze significant variances** from the plan, forecast impacts, and prepare an estimate at completion based on performance to date and work to be performed
- **Control changes to the baseline** and maintain the baseline throughout contract execution
- **Use EVMS information** in the organization's management processes with tailoring defined in the PMP.

These projects will use the standard project controls tools that are used on most BNL projects including: Primavera for scheduling, Cobra for Earned Value Reporting, PeopleSoft for Actual Costs and Procurement, and Integrated Project Database for reporting.

After PD-2 approval, the project will generate a monthly Cost Performance Report (CPR) each month by WBS that provides BCWS (planned value), BCWP (earned value) and ACWP (actual costs) for current month and cumulative to date. The cost and schedule variances and SPI and CPI indices will be calculated and reported each month along with the running SPI and CPI trends for the past six months. The calculated remaining contingency on the ETC will be calculated and reported each month. Variance analysis will be written for each Control Account when the cumulative cost and schedule variances exceed the thresholds to be determined by the Laboratory Director.

Some examples of EVMS tailoring include:

- Perform monthly cumulative variance analysis only

- Simplify change control thresholds and reduce change control documentation

requirements

- Simplify or eliminate the Work Authorization process to minimize excessive

documentation.

- Eliminate PARSII reporting for EVMS, prepare monthly reports CPR and scheduling

status reports for Laboratory management and customer reporting.

- Simplify or eliminate earned value assessment on contributed effort.

For projects less than $20M, EVMS is not required, however there is an expectation that the projects will develop a budget and schedule to measure performance against. Monthly reporting will be required to assess and report performance against the cost/schedule plan. Milestones will be established (one to two per quarter) for reporting schedule performance.

Project Oversight

The Project Oversight Board (POB) has been established by the Laboratory Director and chaired by the Deputy Director for Science and Technology to review monthly project performance, risk assessment, share lessons learned, ensure acceptable trends of performance on Laboratory large/critical projects and to provide assistance if needed, to line and project managers to resolve issues that may threaten budgets, schedules or key performance requirements. POB meetings will also serve as an opportunity to share common experiences between Project and Laboratory managers and chartered by the Deputy Director for Science and Technology. DOE is invited and may be in attendance at the POB reviews.

The Project Oversight Board Subpanels (POB-S) are established by the Deputy Director for Science and Technology to serve as dedicated review teams tasked with assisting the Project Oversight Board (POB) in providing oversight to the Project Decision process to ensure project performance and improve overall project success at BNL. If the Laboratory Director identifies issues that require additional management attention, he can call on the POB to provide oversight and, if necessary, will convene a POB sub-panel review to assess the project performance in more detail. A charge will be developed for the review team by the Deputy Director for Science and Technology who will oversee the review process.

The project will report regularly to the ALD through the department Project Management Group (PMG) or equivalent, chaired by the ALD or their delegate, where project issues will be raised in a timely manner.

Baseline Change Control Thresholds

The project will establish a formal change control process that requires all baseline changes to be managed in a controlled manner. Changes are addressed with PCRs (Project Change Requests) that clearly describe the type of change (scope, cost, schedule or administrative) and the cause, impact and corrective action for the change. A baseline log will be maintained and approvals will follow the change control thresholds below:

Change Control Level	**Laboratory Director **:** Change Control Level 1	**Associate Laboratory Director** Change Control Level 2	**Project Director/ Project Manager** Change Control Level 3
Scope	Any changes in scope and/or performance that affect the ability to satisfy the mission need or that are not in conformance with the current approved Threshold KPPs	Any changes to scope/technical performance as described in the PMP	Changes in scope affecting the technical performance WBS Level 2 elements that do not affect the KPP’s
Cost	Any increase in the Total Project Cost of the Project as stated in the PMP	Cumulative allocation of $50% of Contingency or Management Reserve*	Any Contingency or Management Reserve usage
Schedule	Any delay in PD-4, Approve Project Completion.	Any delay to a Project Decision Level 1 Milestone except PD-4 or Project Level 2 Milestones or use of schedule contingency	Any delay greater than or equal to three months to all Project Milestones to Level 3.

: Baseline Change Control Thresholds and Authorities

*After the cumulative threshold has been reached and the associated change approved, the cumulative cost thresholds will be reset. ** Level 1 changes will require review and concurrence by the Federal Program Manager and the BHSO Manager or his point of contact.

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Project Reporting

The project will generate a monthly project performance/status report submitted to and reviewed by the Laboratory Director, DOE BHSO Manager, and the Program Office. Upon approval of the project baseline (PD-2), with DOE concurrence, a monthly cost/schedule performance report will be provided. Milestone status will be assessed on a monthly basis.

The project will conduct weekly meetings with the project team.

The project will define and manage the project progress with project milestones assigned at increasing authority levels which will be defined in the PMP:

- L1 Milestones – Laboratory Director and BNL Deputy Director for Science and Technology

- L2 Milestones –Associate Laboratory Director
- L3 Milestones – Project Director/Project Manager
- L4 Milestones – L2 WBS Manager/CAM

The responsible DOE Program Office will assign an annual PEMP goal to the Laboratory and hold the Laboratory accountable for successful execution of these projects under $50M.

Cost Savings Reporting

The BNL Project Management Center (PMC) will track, maintain and report all documented cost savings from implementation of this procedure. Types of cost savings include:

- Cost savings from DOE and Lab personnel travel for CD Reviews will be part of the cost savings reporting.

- Reducing the number of documents required for the CD Review process.

- Tailoring of EVMS implementation and reduced requirements for oversight and surveillance of EVMS guidelines.

- Labor saved from elimination of PARSII monthly EVMS reporting.

- A more streamlined review process will reduce time required for review preparation.

- Additional costs to BNL for the organization of the independent reviews.

Cost Savings reporting will be provided to Laboratory management upon request and will be reported annually to the DOE BHSO Manager and the responsible DOE Program Office.

Answers to questions included in the Charge to the Review Committee

Charge Question #1a: Do the proposed technical design and associated implementation approach satisfy the performance requirements?
Yes for HCal and EMCal.
Yes, for TPC and TPC Electronics; however, see recommendations and comments.
Yes, for Electronics and DAQ subcommittee; however, see comments.

Charge Question #1b: Is the technical design sound and sufficiently mature to support the performance expectations of PD2/3?
Yes, amply demonstrated at Test Beam for ECal/HCal. See above for TPC.

Charge Question #1c: Is the technical design sound and sufficiently mature to support the performance expectations of PD2/3?
Yes for TPC and Electronics and DAQ, contingent on addressing the recommendation.

Charge Question #2. Is the project being properly managed at this stage? Is there a capable team in place, and required resources identified, to effectively manage the production phase including all the: **Yes**

Charge Question #3. Cost and Schedule: Are the cost and schedule estimates complete, adequate, and reasonable to support the performance baseline? **Yes**

Charge Question #4 Risk and contingency: Are the project risks properly identified and appropriate mitigation strategies in place? Do the cost and schedule estimates include adequate contingency based on a sound and reasonable risk analysis? **Yes, Yes**

Question #5: Environment, Safety & Health and Quality Assurance (ES&H/QA): Are the ES&H/QA requirements being properly addressed given the project's current state of development? **Yes**

Question #6 Prerequisites: Have all the prerequisite activities and documents necessary to support PD 2/3 approval been completed? **Yes**

Question #7 Have all the recommendations from past reviews been appropriately addressed?
Yes

BNL PD-2/3 Review of the
Super Pioneering High Energy Nuclear Interaction Experiment (sPHENIX) Project at BNL
May 28-30, 2019

Revised AGENDA

Plenary Sessions

Tuesday, May 28, 2019— Berkner B Conference Room (Plenary)

1:00 pm	Full Committee Executive Session(40)	Chair
1:40 pm	Welcome(10)	D. Gibbs/B. Mueller
1:50 pm	Project Overview(30+15)	E. O'Brien
2:35 pm	Science Mission(20+10)	D. Morrison
3:05 pm	Project Management and Status(20+10)	G. Young
3:35 pm	Break(10)	
3:45 pm	Cost and Schedule(20+10)	C. Lavelle
4:15 pm	Technical Status(20+10)	J. Haggerty
4:45 pm	ES&H(15+5)	L. Stiegler
5:05 pm	Full Committee Executive Session(30)	
5:35 pm	Dinner	

Thursday, May 30, 2019 – Berkner B (Plenary)

8:00 am	Full Committee Executive Session and Report Writing(120)
10:00 am	Dry Run(60)
11:00 am	Closeout Presentation(60)
noon	Adjourn

Parallel Sessions

Wednesday, May 29, 2019 – Level 2 Breakout Session* - Berkner B

8:00 am	System Integration(15+5)	M. Chi
8:20 am	Time Projection Chamber(20+10)	T. Hemmick
8:50 am	Electromagnetic Calorimeter(20+10)	C. Woody
9:20 am	Hadronic Calorimeter(20+10)	J. Lajoie
9:50 am	Calorimeter Electronics(20+10)	E. Mannel
10:20 am	Break(20)	
10:40 am	DAQ/Trigger(20+10)	M. Purschke
11:10 am	Minimum Bias Detector(15+5)	M. Chiu
11:30 am	Tour of sPHENIX areas	
12:30 pm	Lunch/Executive Session(60)	

Wednesday, May 29, 2019 – Management Breakout Session* – (Project Management, Cost/Schedule, ES&H/QA Berkner C

8:00 am	Project Management Plan/Recommendations Tracker(20+10)	E. O'Brien
8:30 am	WBS Dictionary and Basis of Estimate(20+10)	G. Young
9:00 am	Risk Management/Registry(20+10)	I. Sourikov
9:30 am	Quality Assurance(20+10)	C. Gortakowski
10:00 am	Break(15)	
10:15 am	Procurement(15+5)	P Bernath
10:35 am	Resource-Loaded Schedule in P6(15+5)	E. Menter
10:55 am	EVMS Implementation(15+5)	C. Lavelle
11:30 am	Tour of sPHENIX areas	

BNL PD-2/3 Review of the
Super Pioneering High Energy Nuclear Interaction Experiment (sPHENIX) Project at BNL
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BREAKOUT AGENDA

Wednesday, May 29, 2019 – Technical Breakout Session* – Calorimeter Berkner C

1:30 pm	Calorimetry Simulations(20+10)	D. Perepelitsa
2:00 pm	EMCal Blocks(20+10)	C. Riedl
2:30 pm	EMCal Modules/Sectors(20+10)	S. Stoll
3:00 pm	HCal Scintillating Tiles(20+10)	M. Connors
3:30 pm	Break(10)	
3:40 pm	HCal Sector Mechanics(15+5)	C. Pontieri
4:00 pm	HCal Sector Assembly and Testing(15+5)	S. Bathe
4:30 pm	Full Committee Executive Session (Berkner B)	

Wednesday, May 29, 2019 – Technical Breakout Session* – Tracking Berkner D

1:30 pm	Tracking Simulation(20+10)	A. Frawley
2:00 pm	Time Projection Chamber (TPC) Mechanics(20+10)	K. Dehmelt
2:30 pm	TPC Gas Electron Multiplier (GEM) Modules(20+10)	V. Greene
3:00 pm	Break(15)	
3:15 pm	TPC Ancillary Systems (Gas/Cooling)(15+5)	R. Pisani
3:35 pm	TPC Laser Calibration(10+5)	B. Azmoun
4:30 pm	Full Committee Executive Session (Berkner B)	

Wednesday, May 29, 2019 – Technical Breakout Session* – Electronics/DAQ/Trigger, Berkner A

1:30 pm	Silicon Photomultipliers(15+5)	C. Aidala
1:50 pm	Calorimeter Electronics Front End Boards(15+5)	S. Boose

2:10 pm Calorimeter Digitizers(15+5) .... C.Y. Chi
2:30 pm TPC Front End Electronics(15+5) ....T. Sakaguchi
2:50 pm Break(10)
3:00 pm TPC Data Aggregator Modules(15+5) ....J. Huang
3:20 pm Data Acquisition(15+5) ....E. Desmond
3:40 pm Trigger(15+5) ....J. Nagle
4:00 pm Global Level-1/Timing System(15+5) ....M. Purschke

4:30 pm Full Committee Executive Session (Berkner B)

Wednesday, May 29, 2019 – Management Breakout Session* – Drill Downs - Berkner B

1:30 pm Cost Drill-down Session 1(90)……………………..………E. Menter/I. Sourikova
3:00 pm Break(15)
3:15 pm Cost Drill-down Session 2(60)..……………………………E. Menter/I. Sourikova
4:30 pm Full Committee Executive Session (Berkner B)

***Answers to homework will be incorporated as necessary in the breakout session schedules.**