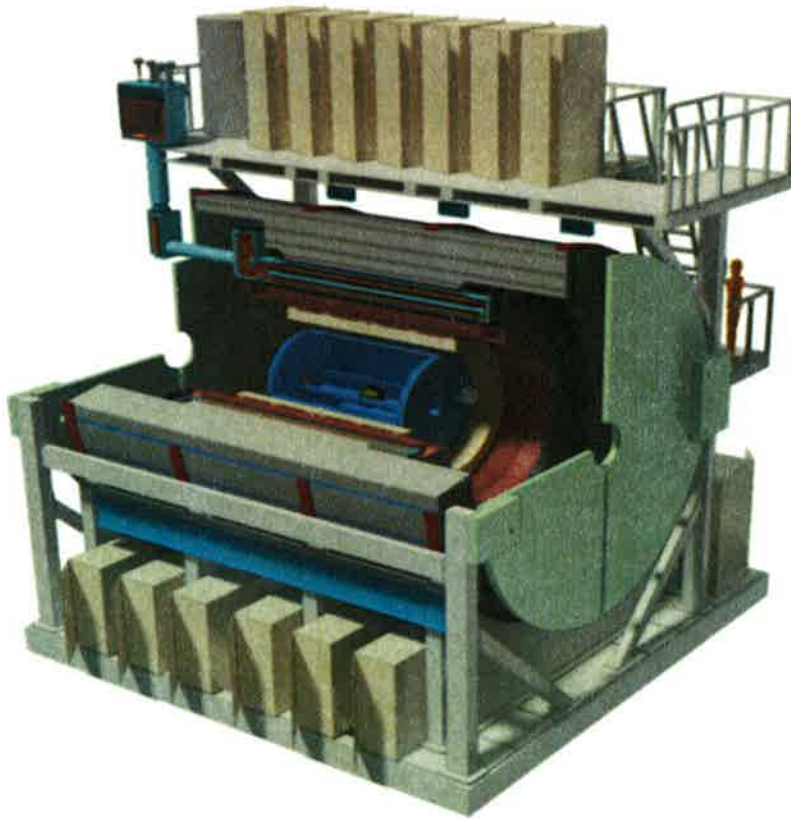


**sPHENIX Project
Project Assumptions**

for the

Scope, Cost and Schedule

May 2019



Version History Log

Version	Effective Date	Summary of Change
0	March 2018	Establish Assumptions Document
1	April 2019	Revise Assumptions Document for Director's Review
2	May 2019	Revise Assumptions Document for PD2/3 Review

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for the
Scope, Cost and Schedule

APPROVALS:

Submitted 
Cathleen Lavelle

Approved 
Ed O'Brien

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1 SCOPE ASSUMPTIONS

Scope that is included in the sPHENIX Project is defined in detail in the WBS Dictionary.

- sPHENIX MIE scope includes conceptual design, R&D, procurement, fabrication and subsystem testing, but does not include Magnet, infrastructure, sPHENIX integration, installation and commissioning.
- The sPHENIX MIE Project deliverables:
 - WBS 1.02 TPC – Time Projection Chamber
 - WBS 1.03 EMCAL – Electro Magnetic Calorimeter
 - WBS 1.04 HCAL – Hadronic Calorimeter
 - WBS 1.05 Calorimeter Electronics
 - WBS 1.06 Data Acquisition and Trigger System
 - WBS 1.07 Minimum Bias Trigger Detector
- Based on the project risk analysis and to follow the good practice learned from similar DOE projects, estimate uncertainty and analysis of risk events are used to determine project contingency. As risks are retired with good cost performance, the sPHENIX Project management will request, via the established change request process, that appropriate activities in the scope contingency be included in the project baseline scope.
- The long lead procurements for sPHENIX Project MIE include:

Hadronic Calorimeter Scintillating Tiles
Silicon Photomultipliers (SiPM)
EMCal Scintillating Fibers
Tungsten Heavy Powder for EMCal Blocks

The EMCAL Tungsten Heavy Powder will be placed as two orders one in FY19 and one for FY20 contract award. APP (Advanced procurement Plans) have been approved for each of these Long lead Procurements.

- Based on the project bottom up estimate uncertainty calculation and Monte Carlo project risk analysis at 90% confidence level, approximately 25% of the to-go estimate will be allocated to project contingency. As risks are retired with good cost performance, the sPHENIX Project management will request, via the established change request process, that appropriate activities in the scope contingency be included in the project baseline scope.

2 COST ASSUMPTIONS

2.1 Key Assumptions for Estimating Cost

The following key assumptions were used to establish the cost estimate for the sPHENIX projects:

- This project is being funded by existing funds allocated by DOE for KB0202012 RHIC Operations.
- The funding for the project is redirected funds from RHIC Operations and is categorized into three distinct types:
 - Category A – MIE funded Project Total Project Costs includes (TEC+OPC). This category includes all MIE Project Management Labor and all Non-Labor M&S, Travel costs.
 - Category B – BNL Contributed Labor in support of the MIE. Hours only are included in the MIE Cost Estimate. The labor costs are not included in the MIE Project. The labor costs have been estimated for the project.
 - Category T – Collaborator Contributed Labor in support of the MIE. Hours only are included in the MIE Cost Estimate. The labor costs are not included in the MIE Project.
- All costs are estimated in FY2019 dollars for work planned from October 1, 2018 through completion of the project.
- Work planned and performed in FY17 and FY18 is represented in the baseline as Actual Costs .
- Base estimates do not include contingency, escalation, or burdens.
- Materials and travel are estimated in US dollars.
- Quotes and budgetary estimates received in foreign currency are estimated in US dollars at the exchange rate that was in effect at the time of the quote or estimate is received by the estimator. See later discussion on exchange rates.
- Extraordinary Project Rate (EPR) was approved by the CFO for sPHENIX and is applied to all MIE project costs and contributed labor. (See Letter below). The EPR is applied to large single procurements that are charged overhead on the first \$2M. Exception: The value of large procurements over \$2M is exempt from all overheads except 2.3% LDRD.
- There is a 7.5% material handling burden applied to all procurements in all years.
- Key laboratory support functions are co-located with and charged directly to the project. Service Level Agreements and Memorandum of Agreements have been approved and the planned labor requirements are provided by the NPP Directorate and appropriate laboratory support organizations.
- For FY19 & beyond, BNL will charge Overheads utilizing a Value-Added-Base (VAB) method, which includes Organizational Burden, Procurement Burden, Common Support Burden, G&A Burden, and LDRD Burden. All Overhead rates were provided by the BNL Budget Office .

- Rates are approved by BNL and DOE Site Office and published yearly.
- Salary estimates that were used for development of the baseline are determined based on labor bands (*which include fringe and paid absence burden for the NPP directorate*).
- Labor is estimated in hours.
- FTEs are derived using a productive person-year of 1,760 hours.
- Brookhaven National Laboratory fringe and paid absence are included in the direct labor rate.

Office of the Chief Financial Officer

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April 28, 2017

Ms. Evelyn Landini
Contracting Officer
Business Management Division Director
U.S. Department of Energy
Brookhaven Site Office, Building 464
Upton, New York 11973**Subject: Request for Concurrence on Extraordinary Project Rate – sPHENIX Upgrade**

Dear Ms. Landini:

Brookhaven National Laboratory's ("BNL") Chief Financial Officer ("CFO") received the attached request for approval to utilize an Extraordinary Project Rate ("EPR") in connection with the sPHENIX upgrade.

In accordance with BNL policy, which requests CFO approvals for the use of an overhead rate for qualifying projects, we have reviewed and approved this request. Therefore, we respectfully request your concurrence on BNL's approval for use of the Extraordinary Project Rate for the three parts of the project described in the attached request. If you concur, please acknowledge same by executing the below where indicated.

Should you have any questions, please do not hesitate to contact me at (631) 344-7755.

Sincerely,

George Clark
Chief Financial Officer

Enclosure

cc: B. Carreras
A. Russo
S. LaMontagne

Approved: _____

Evelyn Landini
DOE BHSO Contracting Officer

Date: _____

5/02/17

2.2 Contracting Assumptions

The contracting approach will utilize one of the following procurement strategies based on the complexity and risk of the item or system being procured:

- Request for Quote (RFQ)
 - Definable requirements
 - Commercial off the shelf equipment
 - Award criterion: Lowest price
- Request for Proposal “Best Value” (RFP) Method
 - Specifications are supported by functional requirements.
 - Schedule and supplier’s past performance are an integral part of the proposal evaluation criteria.
 - Evaluation criteria are developed through close coordination with Control Account Managers.
 - Performance and technical specifications are detailed.
 - Suppliers’ proposals are evaluated based on overall compliance with specification requirements.
 - Award criteria include: Highest technical score, Competitive Range, Best value.
- There are four long lead procurements the MIE project submitted for CD-3A procurement approval. The long lead procurement approval for these procurements was authorized in August 2018. These procurements include 30% of cost contingency.

APP #	WBS/Description	Procurement	Direct Material K\$ Estimate	PO Value LLP	L2 Manager	Contract Award	Vendor	Delivery Date	PO #
33267	1.04.02.03 Outer HCAL Scintillating Tiles	Hadronic Calorimeter Scintillating Tiles	\$1,327	\$1,550	J. Lajoie	3/8/19 (A)	GSU	3/7/2021	361122
33270	1.05.01 Calorimeter Electronics - Optical Sensors	Silicon Photomultipliers (SiPM)	\$655	\$669	E. Mannel	10/5/2018 (A)	Hamamatsu	3/1/2020	347787
33268	1.03.01.03 EMCAL Final Block Production	EMCal Scintillating Fibers	\$742	\$840	C. Woody	1/15/2019 (A)	St Gobain	3/1/2021	359217
33269	1.03.01.03 EMCAL Final Block Production	Tungsten powder for EMCAL Block	\$1,290	\$951	C. Woody	Pre-award	UIUC	TBD	362913
	Total Dollars		\$4,014	\$4,010					

2.3 Escalation

Escalation factors used for the cost estimate include 2.0% for non-labor and 3.0% for labor. These escalation factors are published by the Budget Office based on BNL experience.

2.4 Foreign Exchange Rates

Estimators have been asked to use current exchange rates when estimating for quotations that were received in foreign currency.

2.5 Basis of sPHENIX Labor and Material Cost Estimate

The cost estimates were prepared by the Project team, L2, L3 managers and cognizant engineers. The cost estimating process follows best practice and is consistent with the GAO 12 step Cost Estimating Guidelines. The estimate has been continuously improved and updated over the last 2.5 years. The numbers are based on experience from not only PHENIX but also consultation with experts from ATLAS, STAR, and ALICE.

This estimate included the design, R&D, procurement, fabrication, assembly and testing of each subsystem as well as project management and support. The Cost Estimators provided a detailed cost estimate by labor band (Scientist, Assistant Scientist, Mechanical Engineer, Electrical Engineer, Designer, Mechanical Technician, Electrical Technician, Riggers), basing the direct costs on FY19 Labor Band Rates provided by the Business Operations Office through the Project Office. This cost estimating effort provided the basis and starting point for the sPHENIX project Level 2 managers (Control Account Managers, CAMs) to prepare their detailed cost estimates for the project scope.

The basis of estimate (BOE) used for labor and material cost estimate is defined in the sPHENIX project BOEs for each resource estimated. The tables attached at the end of this document are the codes used by the L2 and L3 managers to characterize the estimate uncertainty by resource for labor and material.

It is assumed that the sPHENIX Project will have the following BNL space available in order to carry out detector component production, assembly, staging and prep for installation:

- 2000 sq. ft. for EMCal module and sector assembly, testing and installation preparation in the Physics Dept. High Bay Building 510.
- Eight labs currently occupied by sPHENIX in Building 510.
- 10,000 sq. ft. for HCal sector assembly, testing, staging, and installation prep in the Building 912 High Bay.

It is also assumed that the project will have full access to the space in the 1008 complex including the Assembly Hall, IR, Rack room, Control room, 1008B, Gas Mixing Hut, Gas Pad, Test/Staging room, Trailers.

It is assumed that the BNL office space occupied by sPHENIX group members and visitors will at a minimum be maintained at the current level, and increased as appropriate.

3 SCHEDULE ASSUMPTIONS

3.1 Key Schedule Assumptions

The sPHENIX schedule is developed for the sPHENIX project. The schedule assumptions are as follows:

- The schedule is integrated and used as a management tool by the Project Director, Project Manager, Level 2 Managers, and other project staff. The schedule will be used

to evaluate the impact of “what-if” scenarios, measure progress, and evaluate the effect of current progress on future work.

- The schedule is resource-loaded with cost estimates prepared by the Level 2 Managers/Control Account Managers.
- To develop the schedule, management has evaluated risk magnitude, absolute cost magnitude, and technical complexity. Analysis of project activities by the management team identifies the following phases of work, as detailed in the project schedule:
 - Phase 1 – Conceptual Design and R&D of the subsystems
 - Phase 2 – Long lead-time procurement packages
 - Phase 3 – Remaining procurement packages
 - Phase 4 – Fabrication and testing of the subsystems, and components

3.2 Critical Path Methodology

The Critical Path and near critical paths are developed based on the logically linked activities and durations developed by the CAMs for the resource-loaded schedule.

- The resource-loaded schedule is the tool used to time phase the project costs. It ensures that cost and obligation profiles are within the anticipated annual funding profile constraints.
- The activities in the schedule are logically tied to each other with predecessor and successor relationships.
- The project schedule, once baselined, will be placed under change control.
- Constraint dates are minimally used. The early project completion milestone is constrained, as well as a few reference milestones established by the management team. Constrained milestones are established in a way that allows activity total float to be calculated through the early project completion date.
- The last milestone of the MIE schedule, Critical Decision CD-4, is constrained one day prior to the planned end of the project, to create a Total Float value of 0 on the Critical Path. This method easily identifies work on the Critical Path.
- Schedule Contingency for the MIE project is developed based on an assessment by the Project Director. The schedule contingency is 14 months from the Early Finish milestone to CD-4 Project Completion.
- There are Interproject Links between the MIE Schedule and the Infrastructure and Facility Upgrade Project.

3.3 Advanced Procurement Plans (APPs) for Long Lead Procurements

The APP process will utilize either a Request for Quote (RFQ) or Request for Proposal (RFP) procurement strategy depending on the complexity and risk of the component or system

being procured. Based upon guidance from BNL Procurement and Property Management (PPM), the following durations are planned:

- The standard duration for the activity string utilizing an RFQ/RFP procurement strategy consists of 60 working days.

The standard RFQ and RFP activity strings can be adjusted, as necessary and by agreement between the sPHENIX Project and PPM, for a given procurement.

4 PROCESS FOR COST/SCHEDULE FORMULATION AND RISK ASSESSMENT

4.1 Cost and Schedule Formulation

A task force comprised of sPHENIX Level 2 managers assembled an initial labor estimate in hours and material and travel estimate for each SPHENIX subsystem based on PHENIX Project experience and the Conceptual Design for each subsystem. The labor estimates were refined and validated for each subsystem by the sPHENIX Project Manager and sPHENIX Project Level 2 and Level 3 Managers. The subsystem material estimates were based on the design proposed for each system

4.2 Formulation of Resource-Loaded Schedule

The sPHENIX Level 2/Control Account Managers and the sPHENIX Project Controls Specialist met to decide how labor would be applied (resource-loaded) to activities in the schedule for each subsystem. Each labor resource was reviewed based on the activities defined in the WBS for each subsystem. The activities included Procurement, Fabrication, Assembly, and Testing for each of the standard WBS elements within the project.

The MIE WBS is structured as follows:

Level 2:

- 1.01 Project Management
- 1.02 Time Projection Chamber (TPC)
- 1.03 Electro Magnetic Calorimeter (EMCal)
- 1.04 Hadronic Calorimeter (HCal)
- 1.05 Calorimeter Electronics
- 1.06 DAQ/Trigger
- 1.07 Minimum Bias Trigger Detector (MBD)

4.3 Risk Assessment and Contingency Analysis

The project has conducted a risk and contingency assessment to determine the contingency needs of the project:

- 1) Risk Assessment of the project risks and the expected risk mitigation cost.
A risk assessment was prepared by the project L2 managers based on a review of the scope, cost and schedule at the WBS Level 2 elements. Technical, cost, and schedule risks were identified and an assessment of the risk cost, schedule impact and probability were determined. This risk assessment resulted in an expected value captured in the risk registry for all risks identified on the project. The Risk Registry contains the assessment of all project risks.
- 2) A bottom-up estimate uncertainty was assessed by the Level 2 managers as they prepared their cost estimates. The estimate uncertainty is assessed at the activity and resource level. The estimate uncertainty was determined by the L2 manager's assessment of the basis of the cost estimates (vendor quotes, professional judgement, catalog prices, design maturity, etc.). The tables used to determine this assessment are attached.

Code	Type of Estimate	Estimate Uncertainty Value	Description
L1	Actual	0%	Actual costs incurred on activities completed to date.
L2	Level of Effort Tasks	5%	Support type activities that must be done to support other work activities or the entire project effort, where estimated effort is based on the duration of the activities it is supporting.
L3	Advanced	10%	Based on experience with documented identical or nearly identical work. Development of activities, resource requirements, and schedule constraints are highly mature. Technical requirements are very straightforward to achieve.
L4	Preliminary	25%	Base on direct experience with similar work. Development of activities, resource requirements, and schedule constraints are defined as preliminary (beyond conceptual) design level. Technical requirements are

			achievable and with some precedent.
L5	Conceptual	40%	Base on expert judgment using some experience as a reference. Development of activities, resource requirements, and schedule constraints are defined at a conceptual level. Technical requirements are moderately challenging.
L6	Pre-conceptual	60%	Base on expert judgment without similar experience. Development of activities, resource requirements, and schedule constraints are defined at a pre-conceptual level. Technical requirements are moderately challenging.
L7	Pre-conceptual – Uncommon Work	80%	Base on expert judgment without similar experience. Development of activities, resource requirements, and schedule constraints is largely incomplete. Technical requirements are challenging.
L8	Beyond state of the art	100%	No experience available for reference. Activities, resource requirements, and schedule constraints are completely undeveloped. Technical requirements are beyond state of the art.

Code	Type of Estimate	Estimate Uncertainty Value	Description
M1	Existing Purchase order (Actual)	0%	Items have been completed or obligated. (Note: Contract Change Orders are considered a Risk and should not be included)

M2	LOE, Travel, supplies, software	5%	LOE M&S items such as travel, software purchases and upgrades, computers, etc. estimated to support LOE efforts and other work activities.
M3	Quote or Catalog Price	10%	Items for which there is a catalog price or recent vendor quote based on a completed or nearly completed design or an existing design with little or no modifications and for which the costs are documented.
M4	Analogous Design	25%	Items that can be readily estimated from a reasonably detailed but not completed design; items adapted from existing designs but with moderate modifications, which have documented costs from past projects. A recent vendor survey (e.g., budgetary quote, vendor RFI response) based on a preliminary design.
M5	Professional Judgement	40%	Items with a documented conceptual level of design; items adapted from existing designs but with extensive modifications, which have documented costs from past projects.
M6	Pre-conceptual	60%	Items that do not have a documented conceptual design, but do have documented costs from past projects. Use of this estimate type indicates little confidence in the estimate. Its use should be minimized when completing the final estimate.
M7	Pre-conceptual - Uncommon work	80%	Items that do not have a documented conceptual design, and have no documented costs from past projects. Its use should be minimized when completing the final estimate.
M8	Beyond state of the art	100%	Items that do not have a documented conceptual design, and have no documented costs from past projects. Technical

			requirements are beyond the state of the art.
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- 3) A Monte Carlo Risk Analysis was performed on the Risks in the risk registry and the baseline schedule. The results indicated that the MIE project would complete with cost and schedule parameters and contingency allocated with a 90% confidence level.

The Risk assessment, a Monte Carlo analysis at 90% confidence level and Estimate Uncertainty analysis resulted in a determination that the project level contingency of approximately 26% on work to go is sufficient for the project to successfully deliver the scope within cost and schedule objectives.