sPHENIX Annual MIE Review Cost/Schedule

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July 14-15, 2021

BNL

Outline

1. Program description highlights for Projects with TPC $50M or less
2. sPHENIX MIE Status as of May 31, 2021
3. EVM tools and procedures
4. Summary

sPHENIX Project Performance Measurement Baseline

- WBS is product oriented and is comprehensive, identifying all work scope, including Contributed Labor - separately tracked.
- Activity based resource loaded schedule, logically linked.
- Cost Baseline developed by the L2 and L3 Managers maintained through baseline change control process – Project Change Requests (PCRs) approved through Change Control Board (CCB).
- The resource loaded schedule/cost baseline includes:
  - **All resources estimated using labor hours and material dollars required to execute the work scope.**
  - **The cost element data (labor and non-labor) fully burdened and escalated in P6.**

sPHENIX MIE EVMS Implementation - Tailored

- sPHENIX MIE is following the BNL Project Management procedure for projects with TPC less than or equal to $50M. Posted on website.

- sPHENIX is managed consistent with the **intent** of DOE order 413.3 B with a **tailored** implementation of EVMS:

  - 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 (Cost Performance Report) CPR and scheduling status reports for Lab management and customer reporting.
  - Earned Value based on percent complete.

sPHENIX Project Reporting Thresholds

All thresholds defined in PMP- Project Management Plan

- **Change Controls Thresholds** defined by scope/cost/schedule levels
- **Control Account Level –** Level 2 WBS
  - Cumulative to date $100K and +/- 10%
  - Same for Cost or Schedule Variance
- **Variance Analysis requires explanation of:**
  - Root Cause of the Variance
  - Impact on project/CA due to the variance
  - Corrective Action Plan

Control Thresholds and Authorities:

Change Control Level	**Lab Director**:** Change Control Level 1	**Associate Lab Director for Nuclear and Particle Physics:** Change Control Level 2	**sPHENIX Upgrade Project Director** Change Control Level 3
Scope	Any changes in scope and/or performance that affects the ability to satisfy the mission need or is not in conformance with the current approved Threshold KPPs.	Any changes to scope as described in the PMP, Section 2.1.	Changes in scope affecting the technical performance WBS Level 2 components that do not affect the KPP's or major changes in the technology or approach to Level 2 WBS components.
Cost	Any increase in the Total Project Cost of the Project as stated in the PMP Table 2.	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 (Table 3) or Project Schedule Milestones (Table 4) or use of schedule contingency	Any delay greater than or equal to three months to a Project Technical Milestone (Table 5).

1. Program description highlights for Projects with TPC $50M or less
2. sPHENIX MIE Status as of May 31, 2021
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4. Summary

sPHENIX MIE Status as of May 31, 2021

Current PD:	**2/3**	Date of Current CD/PD approval		September 2019	
Next PD:	**4**	Forecast approval:	**1QFY23**	Baseline:	**1QFY23**
% Complete:	**75.1%**	Planned:		**90.2%**	
ETC:	**$6.20M**	TPC or Cost Range:		**$27.0M**	
Contingency:	**34.6%** on ETC	Float to PD-4 in months:		**10.75**	
Cumulative CPI:	**1.02**	Cumulative SPI:		**0.83**	

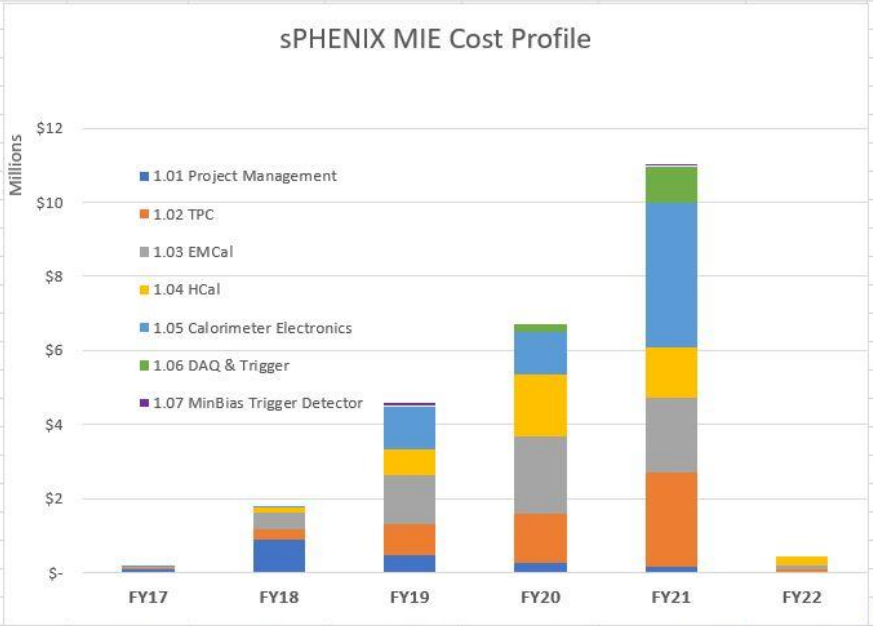
sPHENIX MIE Cost Baseline Change Summary

Cost Baseline K$				
WBS	**Level 2 WBS Description**	**PMB PD2/3 Sep 2019**	**PMB May 2021**	**Delta**
1.01	Project Management	$ 1,952	$ 1,952	$ -
1.02	Time Projection Chamber	$ 4,170	$ 5,027	$ 857
1.03	EM Calorimeter	$ 5,196	$ 6,070	$ 874
1.04	Hadron Calorimeter	$ 4,069	$ 4,100	$ 31
1.05	Calorimeter Electronics	$ 5,373	$ 6,291	$ 918
1.06	DAQ/Trigger	$ 1,240	$ 1,245	$ 5
1.07	Min Bias Trigger Detector	$ 170	$ 170	$ -
	Performance Measurement Baseline	**$ 22,169**	**$ 24,854**	$ 2,685
	Contingency	$ 4,831	$ 2,146	$ (2,685)
	Total Project Cost	**$ 27,000**	**$ 27,000**	$ 0

- Performance Measurement Baseline (PMB) changes of 2,685K total due to:
  - TPC – additional electrical engineers for FEE, more expensive lasers and FEE electronics
  - EM Calorimeter – additional TECH labor for QA and assembly to mitigate COVID delay
  - Hadron Calorimeter – additional cost for Support Rings
  - Cal Electronics - additional cost for EMCal and HCal trunk signal cables
- PMB is under Change Control via Project Change Requests (PCRs)

sPHENIX MIE Baseline Cost Profile

WBS Level 2 is Control Account



BCWR - $6.2M as of May 31, 2021
(commits are not included)

WBS Code and Name						Burdened AY$	Direct FY19 $
1.01A Project Management	107,107	893,953	488,827	272,957	177,474	11,361	1,951,679	1,726,473
1.02A TPC	20,961	274,664	810,740	1,304,574	2,521,078	94,758	5,026,775	4,355,400
1.03A EMCal	45,714	463,282	1,347,324	2,108,747	2,028,955	75,986	6,070,008	5,323,458
1.04A HCal	3,021	142,473	685,258	1,655,786	1,348,096	264,958	4,099,592	3,667,612
1.05A Calorimeter Electronics	33,387	39,193	1,153,817	1,164,890	3,899,335	0	6,290,621	5,503,376
1.06A DAQ & Trigger	0	2,782	23,191	216,042	1,003,076	0	1,245,090	1,077,580
1.07A MinBias Trigger Detector	0	414	98,734	0	71,022	0	170,170	151,053
Grand Total	**210,190**	**1,816,761**	**4,607,890**	**6,722,996**	**11,049,036**	**447,063**	**24,853,936**	**21,804,953**

sPHENIX - Performance Measurement Baseline (PMB)

	Burd/Esc AY$	FY17	FY18	FY19	FY20	FY21	FY22
A - MIE	**24,853,936**	**210,190**	**1,816,761**	**4,607,890**	**6,722,996**	**11,049,036**	**447,063**
1.01 Project Management	**1,951,679**	107,107	893,953	488,827	272,957	177,474	11,361
1.02 TPC	**5,026,775**	20,961	274,664	810,740	1,304,574	2,521,078	94,758
1.03 EMCal	**6,070,008**	45,714	463,282	1,347,324	2,108,747	2,028,955	75,986
1.04 HCal	**4,099,592**	3,021	142,473	685,258	1,655,786	1,348,096	264,958
1.05 Calorimeter Electronics	**6,290,621**	33,387	39,193	1,153,817	1,164,890	3,899,335	0
1.06 DAQ & Trigger	**1,245,090**	0	2,782	23,191	216,042	1,003,076	0
1.07 MinBias Trigger Detector	**170,170**	0	414	98,734	0	71,022	0
B - BNL Contributed Labor	**23,126,193**	**1,592,521**	**4,025,547**	**5,036,518**	**6,103,161**	**6,212,264**	**156,183**
1.01 Project Management	**6,764,350**	498,662	1,146,441	1,608,868	1,695,622	1,743,201	71,555
1.02 TPC	**3,795,420**	234,824	716,473	1,111,251	1,232,564	500,309	0
1.03 EMCal	**4,830,027**	163,723	479,465	588,886	1,288,602	2,224,724	84,628
1.04 HCal	**2,282,018**	260,083	579,301	370,305	329,084	743,245	0
1.05 Calorimeter Electronics	**2,417,787**	273,082	593,810	632,500	608,917	309,479	0
1.06 DAQ & Trigger	**2,798,925**	127,930	428,318	663,954	912,464	666,260	0
1.07 MinBias Trigger Detector	**237,666**	34,217	81,740	60,754	35,908	25,047	0

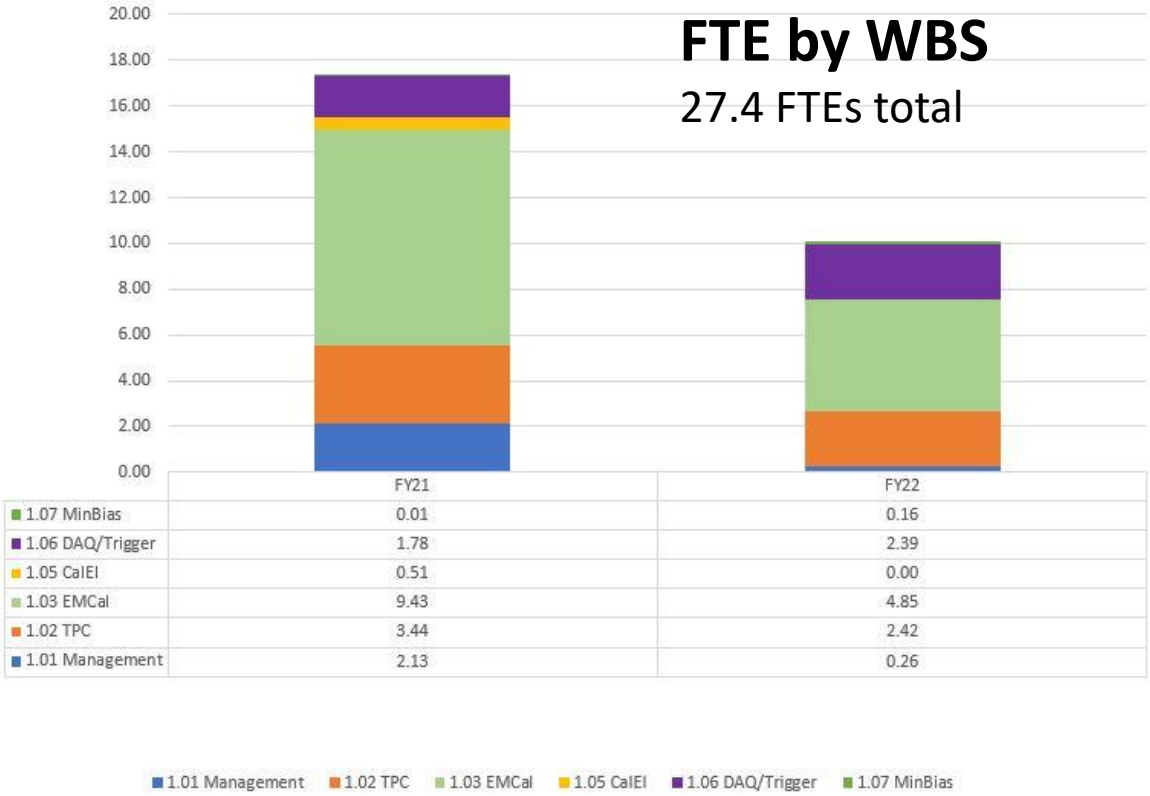
BNL contributed Labor CatB supporting MIE

sPHENIX MIE Cost to Go by WBS

Cost to go = BCWR = BCWS - BCWP

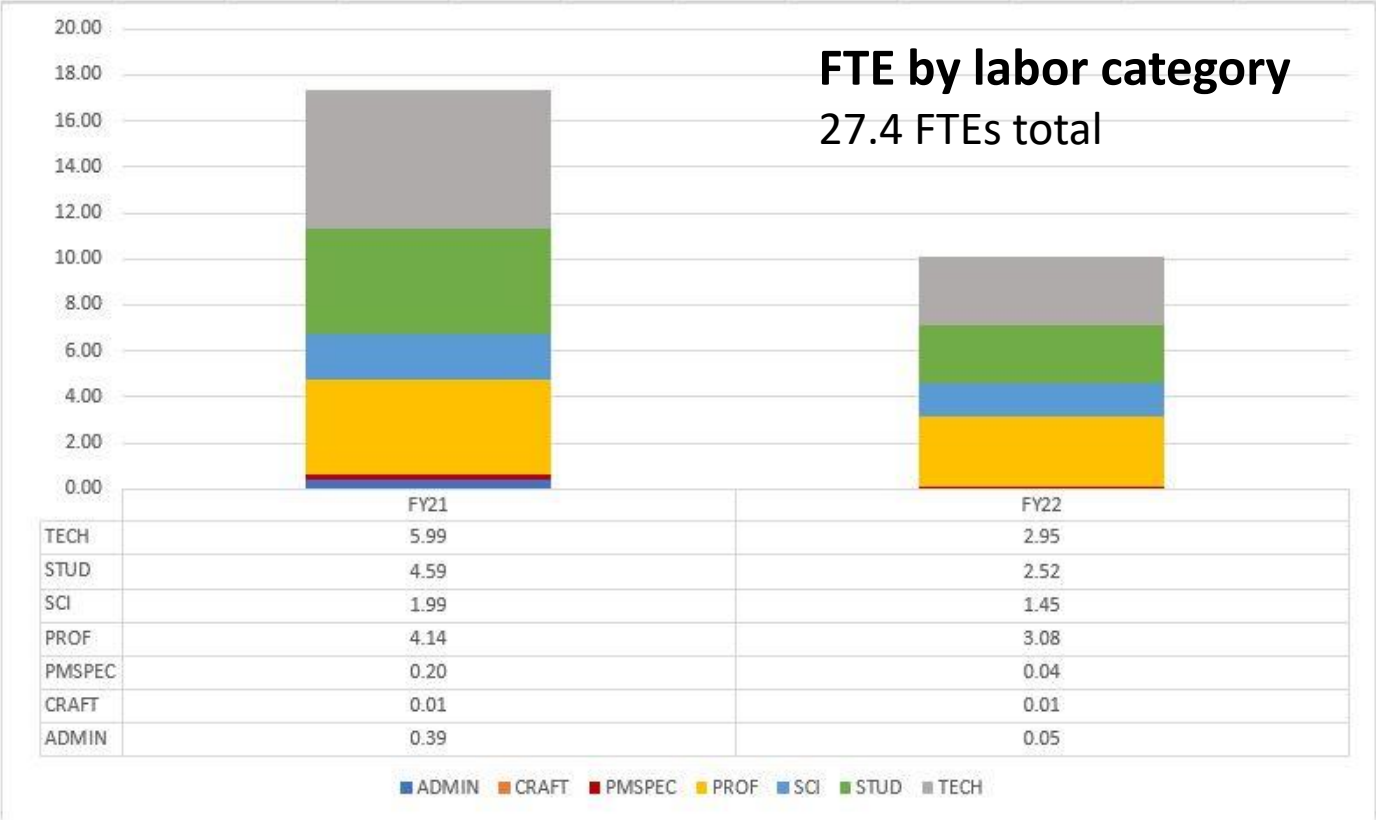
WBS	Cost to go
1.01 Project Management	71,963
1.02 TPC	1,441,587
1.03 EMCal	807,074
1.04 HCal	1,059,833
1.05 Calorimeter Electronics	2,009,810
1.06 DAQ & Trigger	719,312
1.07 MinBias Trigger Detector	71,022
Grand Total	**6,180,601**

Remaining FTEs as of May 31, 2021 – Paid/Contributed



	FY21	FY22
1.07 MinBias	0.01	0.16
1.06 DAQ/Trigger	1.78	2.39
1.05 CalEl	0.51	0.00
1.03 EMCal	9.43	4.85
1.02 TPC	3.44	2.42
1.01 Management	2.13	0.26

Remaining FTEs as of May 31, 2021 – Paid/Contributed



	FY21	FY22
TECH	5.99	2.95
STUD	4.59	2.52
SCI	1.99	1.45
PROF	4.14	3.08
PMSPEC	0.20	0.04
CRAFT	0.01	0.01
ADMIN	0.39	0.05

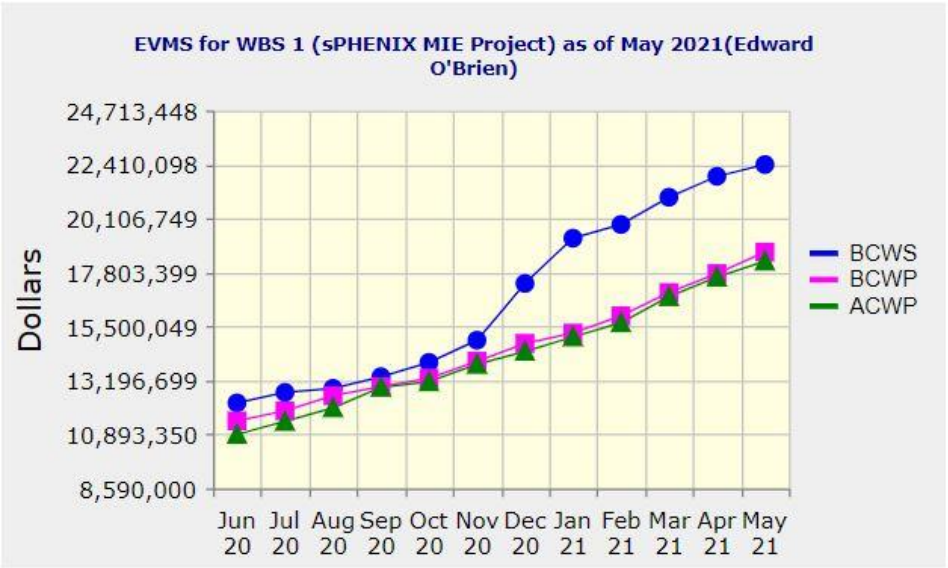
May 2021 Cost Performance Report (CPR) – sPHENIX MIE

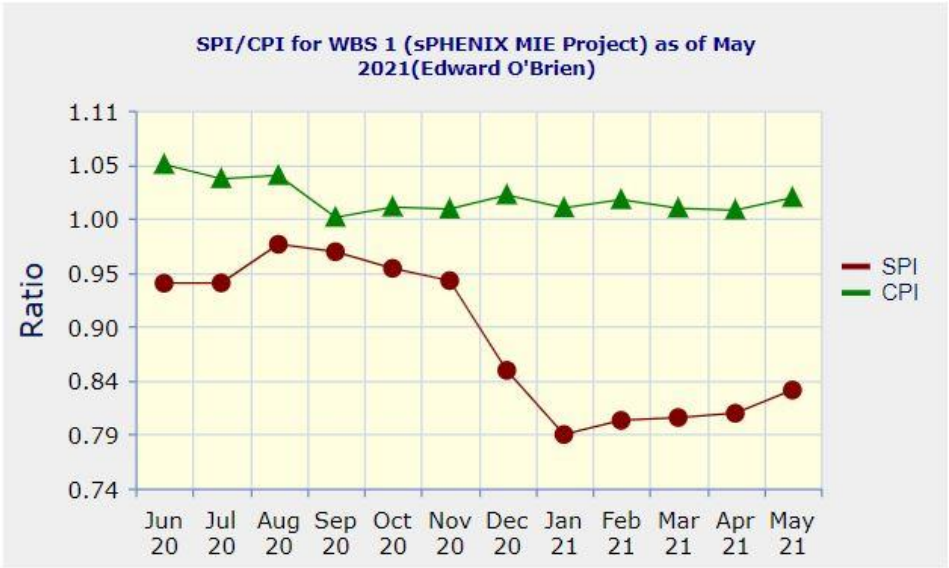
8. PERFORMANCE DATA										
CA (3)	CUMULATIVE TO DATE					AT COMPLETION				
	BUDGETED COST		ACTUAL	VARIANCE		BUDGETED	ESTIMATED	VARIANCE		
ITEM	WORK SCHEDULED	WORK PERFORMED	COST WORK PERFORMED	SCHEDULE	COST					
(1)	(7)	(8)	(9)	(10)	(11)	(14)	(15)	(16)	SPI	CPI
1.01A Project Management	1,879,716	1,879,716	1,731,909	0	147,807	1,951,679	1,803,872	147,807	1.00	1.09
1.02A TPC	4,762,916	3,585,188	3,286,624	-1,177,727	298,564	5,026,775	4,720,538	306,237	0.75	1.09
1.03A EMCal	5,580,536	5,262,935	5,543,989	-317,601	-281,054	6,070,008	6,353,539	-283,531	0.94	0.95
1.04A HCal	2,855,608	3,039,759	3,163,224	184,151	-123,464	4,099,592	4,223,057	-123,464	1.06	0.96
1.05A Calorimeter Electronics	6,053,314	4,280,811	3,879,106	-1,772,503	401,704	6,290,621	5,910,216	380,405	0.71	1.10
1.06A DAQ & Trigger	1,109,290	525,778	599,107	-583,512	-73,329	1,245,090	1,323,005	-77,914	0.47	0.88
1.07A MinBias Trigger Detector	170,170	99,148	87,969	-71,022	11,179	170,170	160,411	9,759	0.58	1.13
b. COST OF MONEY	0	0	0	0	0	0	0	0		
c. GENERAL AND ADMINISTRATIVE	0	0	0	0	0	0	0	0		
d. UNDISTRIBUTED BUDGET						0	0	0		
e. SUBTOTAL	22,411,549	18,673,335	18,291,928	-3,738,214	381,407	24,853,936	24,494,638	359,298	0.83	1.02
f. Contingency						2,146,064				
g. TOTAL	22,411,549	18,673,335	18,291,928	-3,738,214	381,407	27,000,000				
9. RECONCILIATION TO CONTRACT BUDGET BASELINE										
a. VARIANCE ADJUSTMENT				0	0					
b. TOTAL CONTRACT VARIANCE				-3,738,214	381,407	0	0	0		

CLASSIFICATION (When Filled In)

$6,202,710	ETC
$6,180,601	BCWR
34.60 %	% Contingency on ETC
34.72 %	% Contingency on Remaining Work
90.17 %	% Planned
75.13 %	% Complete
73.60 %	% Spent

May 2021 Cost Performance Graph – sPHENIX MIE





BAC: $24,853,936 **EAC:** $24,494,638 **VAC:** $359,298

- Schedule performance is in recovery since pandemic low
- Cost performance remains excellent

MIE Milestone Status based on P6 progress file

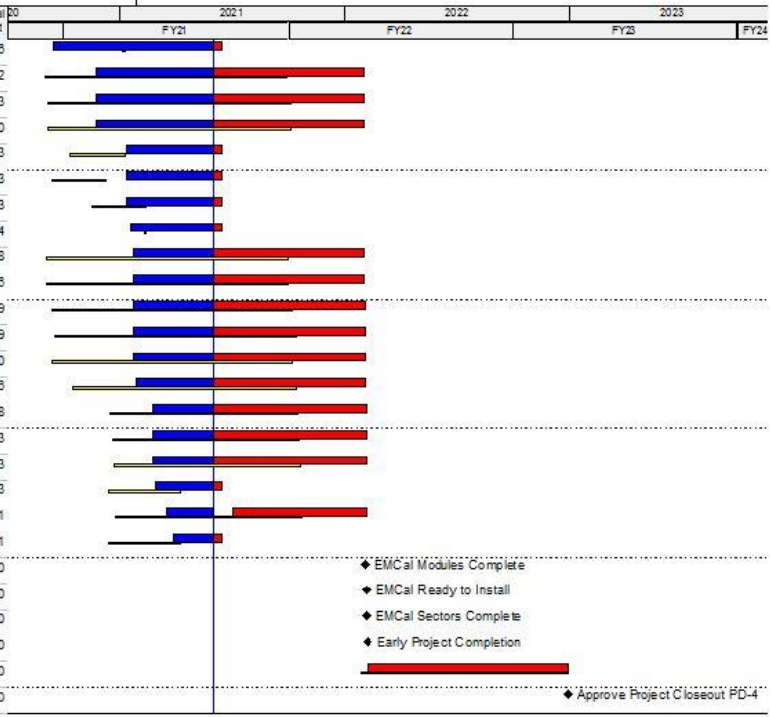
#	WBS	Milestone Name	Target Milestone Date	Forecast	Actual Finish	Variance (in work days)
1	01.01.2001	Approve Project Baseline and Construction PD2/3	30-Sep-19	20-Sep-19 A	20-Sep-19	6
2	01.02.02.02	Production Readiness Review - TPC Module Factories	31-Dec-19	17-Dec-19 A	17-Dec-19	8
3	01.03.02.03.02	EMCal Preproduction Sector 0 Assembled	31-Dec-19	25-Nov-19 A	25-Nov-19	23
4	01.02.06.02	Production Readiness Review - TPC DAM	28-Feb-20	04-Feb-20 A	4-Feb-20	16
5	01.05.02.03	HCal Preproduction FEE Complete	30-Apr-20	22-Jan-20 A	22-Jan-20	70
6	01.05.02.01	EMCal Electronics Preproduction Complete	29-May-20	28-May-20 A	28-May-20	0
7	01.03.01.03.01	EMCal W Powder Acquisition Complete	30-Jun-20	15-Jun-20 A	15-Jun-20	11
8	01.03.02.03.03	EMCal Production Readiness Review Blocks/Modules/Sectors Complete	31-Jul-20	30-Jul-20 A	30-Jul-20	1
9	01.02.05.03	SAMPA ASIC Performance Accepted	30-Sep-20	29-May-20 A	29-May-20	86
10	01.05.2001	EMCal/HCal SiPM Sensor Procurement Complete	30-Oct-20	28-Feb-20 A	28-Feb-20	171
11	01.05.02.04	HCal SiPM Boards Assembly Complete	30-Nov-20	22-Sep-20 A	22-Sep-20	45
12	01.04.04.02	First Outer HCAL Sector and Splice Plates Ready to Install	30-Apr-21	25-Feb-21 A	25-Feb-21	46
13	01.05.02.02	EMCal SiPM Boards Production Complete	27-May-21	30-Apr-21 A	30-Apr-21	19
14	01.02.01.06	GEM Production Complete	31-May-21	17-Apr-21 A	17-Apr-21	30
15	01.03.01.03.01	EMCal Scintillating Fiber Acquisition Complete	31-May-21	25-Feb-21 A	25-Feb-21	67
16	01.06.02.03	Trigger LL1 Preproduction complete	28-Jun-21	29-Jul-21		-23
17	01.05.02.04	HCal Electronics Complete: Production	30-Jun-21	29-Jul-21		-21
18	01.04.2001	Inner HCAL Support Structure Ready for Installation	9-Aug-21	19-Nov-21		-72
19	01.02.06.03	TPC DAM Felix 2.0 Production Complete	31-Aug-21	31-Aug-21		-1
20	01.05.03.02	Calorimeter Electronics Complete	28-Oct-21	28-Jan-22		-61
21	01.05.02.02	EMCal Electronics Complete	28-Oct-21	28-Jan-22		-61
22	01.02.01.08	TPC Ready to Install (Assembly Complete)	29-Oct-21	31-Jan-22		-61
23	01.02.05.04	TPC FEE Production Complete	29-Oct-21	19-Jan-22		-53
24	01.04.04.02	Last Outer HCAL Sector Ready to Install	29-Oct-21	29-Mar-21 A	29-Mar-21	150
25	01.02.06.03	TPC DAM Production Complete	12-Nov-21	2-Feb-22		-54
26	1.07	MinBias Detector Ready to Install	14-Dec-21	21-Dec-21		-6
27	01.06.01.03	DAQ Production: DAQ Ready for Operation	30-Dec-21	28-Jan-22		-20
28	01.06.03.03	GL1 Ready to Operate	24-Jan-22	21-Jan-22		0
29	01.06.02.04	LL1 Trigger Production Complete	25-Jan-22	20-Dec-21		22
30	01.06.02.04	LL1 Ready to Operate	25-Jan-22	20-Dec-21		22
31	01.03.02.03.03	EMCal Ready to Install	4-Feb-22	4-Feb-22		-1
32	01.01.2001	Early Project Completion	7-Feb-22	7-Feb-22		0
33	01.01.2001	Approve Project Closeout PD-4	30-Dec-22	29-Dec-22*		0

- Completed milestones are mostly early
- Early Completion currently projected for February 2022

MIE Critical Path

POM02 sPHENIX WBS 1.x, 2.x May 2021 — IPD - MIE Critical

Activity ID	Activity Name	At Completion Duration	Total Float	Start	Finish	Variance - BL Project Finish Date	Budgeted Labor Units	Budgeted Nonlabor Units	Budgeted Total Cost
S195400	Procure EMCAL Mechanical Parts for Final Sectors - Delivery Acceptan	187	0	14-Sep-20 A	14-Jun-21	-108	0	251357	291,746
S187500	Receive, unpack, log & inspect final blocks	295	0	23-Nov-20 A	31-Jan-22	-82	1384	0	179,682
S187800	Install reflectors on final blocks Labor	295	0	23-Nov-20 A	31-Jan-22	-78	1384	0	179,723
S187900	Install reflectors on final blocks M&S	295	0	23-Nov-20 A	31-Jan-22	-78	0	0	0
S196200	Build mechanical enclosures for final sectors	107	0	12-Jan-21 A	14-Jun-21	-108	720	0	84,633
S196300	Build mechanical fixtures for final sectors	107	0	12-Jan-21 A	14-Jun-21	-129	720	0	84,633
S196400	Build cooling system for final sectors	107	0	12-Jan-21 A	14-Jun-21	-84	180	0	27,303
S196100	Procure EMCAL Cooling System for Final Sectors - Delivery Acceptanc	103	0	18-Jan-21 A	14-Jun-21	-84	0	70893	82,284
S187600	Install lightguides on final blocks Labor	257	0	21-Jan-21 A	31-Jan-22	-80	1384	0	180,018
S187700	Install lightguides on final blocks M&S	257	0	21-Jan-21 A	31-Jan-22	-80	0	1650	1,926
S188000	Install SiPMs daughterboards on final blocks Labor	259	0	22-Jan-21 A	03-Feb-22	-77	1384	0	180,039
S188200	Glue final blocks together into modules	259	0	22-Jan-21 A	03-Feb-22	-75	1384	0	180,039
S188100	Install SiPMs daughterboards on final blocks M&S	259	0	22-Jan-21 A	03-Feb-22	-77	0	300	350
S196500	Install modules in final sectors	257	0	26-Jan-21 A	03-Feb-22	-75	1845	0	234,726
S196700	Install readout electronics on final sectors	240	0	22-Feb-21 A	04-Feb-22	-74	1845	0	235,148
S196800	Install cables & cooling system on final sectors	240	0	22-Feb-21 A	04-Feb-22	-72	3573	0	500,103
S196900	Test final sectors with LEDs & cosmic rays	239	0	23-Feb-21 A	04-Feb-22	-70	5532	0	125,693
S229400	Test EMCal Preamp Boards: Production Sectors 13-64	76	0	26-Feb-21 A	14-Jun-21	-46	384	0	6,313
S197000	Repair or rework any sectors as required	224	0	16-Mar-21 A	04-Feb-22	-69	3921	0	252,651
S229405	Test EMCal Preamp Boards: Production Sectors 13-64 - Contributed Lab	55	0	29-Mar-21 A	14-Jun-21	-46	249	0	31,221
S196600	EMCal Modules Complete	0	0		03-Feb-22	-75	0	0	0
S197300	EMCal Ready to Install	0	0		04-Feb-22	-16	0	0	0
S197100	EMCal Sectors Complete	0	0		04-Feb-22	-69	0	0	0
S101022	Early Project Completion	0	0		07-Feb-22	-7	0	0	0
S101030	WBS 1X Schedule Contingency	225	0	07-Feb-22	29-Dec-22	0	0	0	0
S101040	Approve Project Closeout PD-4	0	0		29-Dec-22*	0	0	0	0



- EMCal long duration activity progress is measured in sector/module count
- ~11mo of schedule contingency

MIE Risks

Risk Identification			Risk Handling Plan (Mitigations)	Residual Risk (Post- Mitigation Assessment)										
Risk ID Numbe	Risk Title	IF/THEN	Risk Handling Plan (Mitigations)	Residual Risk	Low Cost Impa	Likely Cost	High Cost Impa	Low Schedu	Likely Schedu	High Sched	Overall Impact	Expected Valu	Average Expect	Basis of Impact Estimates How were cost and
Mgmt_001	Departure of Key Personnel	If someone critical to the Project informs of his intention to leave sPHENIX, then a replacement	Closely work with sPHENIX collaboration and BNL	10 %	0	0	0	1.0	3.0	6.0	Moderate	0.00	0.00	Impact estimates were approved on Jan 31 2019
Mgmt_002	Safety incident	If safety incident resulting in serious injury and 'Stop Work' protocol initiated at BNL happens,	Carefully plan all work in accordance with BNL SBMS.	2 %	0	0	0	0.1	0.5	1.0	Low	0.00	0.00	Schedule delay will not have a cost impact
Mgmt_003	Funding profile stretches	If funds are not available on time then procurements will be delayed, resulting in	Work closely with the funding agency so any funding profile	10 %	0	213	213	0	0	0	High	21.30	14.20	Cost Impact was assessed for FY20 and
Mgmt_008	COVID-19 delays	If the Project experiences COVID-19 delays, then additioanal labor will be needed and that will	Work with BNL management and implement all COVID safety	50 %	200	300	400	2.0	4.0	6.0	High	150.00	150.00	Cost was estimated based on TECH3 labor
sPH_TPC_013	TPC FEE assembly is late	If TPC FEE assembly rate is lower than planned, then TPC FEE assembly could be behind	Check P6 progress schedule monthly	10 %	0	0	0	1	2	3	Negligible	0.00	0.00	Based on latest experience
sPH_TPC_014	TPC assembly is late	If TPC assembly rate is lower than planned, then TPC assembly could be behind schedule up to 3	Check P6 progress schedule monthly	10 %	0	0	0	1	2	3	Negligible	0.00	0.00	Based on latest experience
sPH_TPC_015	TPC Lasers	If fiberoptic cable has to be 18 m long, then more diffuse lasers will be needed.	Keep track of latest design.	50 %	20	40	80	0	1	1	Low	20.00	23.33	Based on latest experience
sPH_TPC_016	TPC FPGA replacement	If the project needs to change FPGA vendor, the purchase will cost more	Keep track of FPGA procurement.	100 %	100	100	100	0	0	0	Moderate	100.00	100.00	Based on latest experience
sPH_EMCal_004	Delay of EMCal block production at UIUC due to component supplies or	If EMCal Block production rate is not on schedule, then there will be a delay in EMCal	Add shifts or additional production when supplies are	10 %	0	0	0	0.2	0.5	1.0	Low	0.00	0.00	Estimates based on experience with other
sPH_EMCal_005	Delay of EMCal module production or sector assembly rate due to	If EMCal module production/assembly rate is not on schedule, then there will be a delay in	Add shifts or additional production when supplies are	10 %	0	0	0	0.2	0.5	1.0	Low	0.00	0.00	Estimates based on experience with other
sPH_EMCal_009	UIUC students not available for EMCal Fiber Assemblies	If UIUC students are not available for fiber assemblies, then there will be a delay in EMCal	Get a list of participating students from collaboration	5 %	0	100	0	3	6	6	Low	5.00	1.67	Best: move effort to another University
sPH_EMCal_010	UIUC students not available for EMCal Final Block Fabrication	If UIUC students are not available for block fabrication, then there will be a delay in EMCal	Get a list of participating students from collaboration	10 %	0	0	0	3	6	6	Moderate	0.00	0.00	Best: move effort to another University
sPH_EMCal_011	Loss of Students for Sector testing	If UIUC students are not available for sector testing, then there will be a delay in EMCal	Get a list of participating students from collaboration	10 %	0	0	200	1	3	6	Moderate	0.00	6.67	Estimates based on experience with other
sPH_EMCal_013	EMCal Sector Assembly is late due to shortage of TECH labor	If sector assembly rate is low, we will need more TECH labor	Monitor sector assembly rate closely.	30 %	0	100	100	1	2	3	Low	30.00	20.00	Based on latest experience
sPH_EMCal_014	TECH Labor at UIUC for EMCal blocks	If rate of machining blocks is low, we will need another machinist at UIUC	Monitor block machining rate closely.	50 %	0	200	200	1	2	3	High	100.00	66.67	Based on latest experience
sPH_Hcal_005	Delay of Inner HCAL assembly due to technical or component supply issues	If HCal components are not available on time, then the assembly of the inner HCAL barrel and	Carefully plan delivery and availability of all components.	25 %	0	0	0	0.5	1.0	2.0	Negligible	0.00	0.00	Schedule impact estimates made
sPH_CalEl_012	Digitizer component prices go up	If digitizer components cost more, then there will be additional costs	Accept	70 %	117	117	117	0.0	0.0	0.0	High	81.90	81.90	Based on the BOE and remaining work
sPH_CalEl_013	Digitizer components procurement is late	If student labor unavailable for SiPM testing and/or Calorimeter FEE board testing, then	Work with participating University to monitor student availability	10 %	0	0	0	1.0	3.0	6.0	Low	0.00	0.00	Based on most recent experience
sPH_CalEl_015	External cables delivery is delayed	If cables are late, then there will be schedule delays up to 6 mo	Work with BNL procurement, maintain Critical Procurement list	25 %	0	0	0	1.0	3.0	6.0	High	0.00	0.00	Based on most recent experience
sPH_DAQ&Tr_001	DAQ Prototype does not meet specifications	If tests with the various prototype stages reveal problems, then DAQ prototype throughput and	Acquire more or more expensive PCs	5 %	10	35	74	0.0	0.0	0.0	Low	1.75	1.98	Expert estimate
sPH_DAQ&Tr_005	TPC produces higher data rate than we can store	If the TPC or other subsystem cannot meet the envisioned data reduction specifications, then	Invest in more local storage, change compression algorithms	30 %	50	100	150	0.0	1.0	2.0	Low	30.00	30.00	Expert estimate
sPH_DAQ&Tr_007	DAQ DCM boards are late	If Nevis contract is delayed, then board production will be late	Work with BNL procurement, maintain Critical Procurement list	20 %	0	0	0	1.0	2.0	3.0	Low	0.00	0.00	Based on latest experience
MinBias_001	Failure of D/S Board Prototype	If the D/S Board does not meet specifications, then we need to redesign to more conservative	Work with the vendor, Columbia University	10 %	0	0	0	0.0	2.0	3.0	Negligible	0.00	0.00	Based on most recent experience
MinBias_002	Nevis Labor not available	If Nevis labor is not available, then there will be schedule delays.	Work with the vendor, Columbia University	50 %	35	70	105	1.0	3.0	6.0	Low	35.00	35.00	Based on most recent experience

- 24 open risks: 5 High, 4 Moderate, 11 Low, 4 Negligible
- 44 risks retired, 8 risks realized
- EMV = $575K

Contingency Analysis as of May 2021

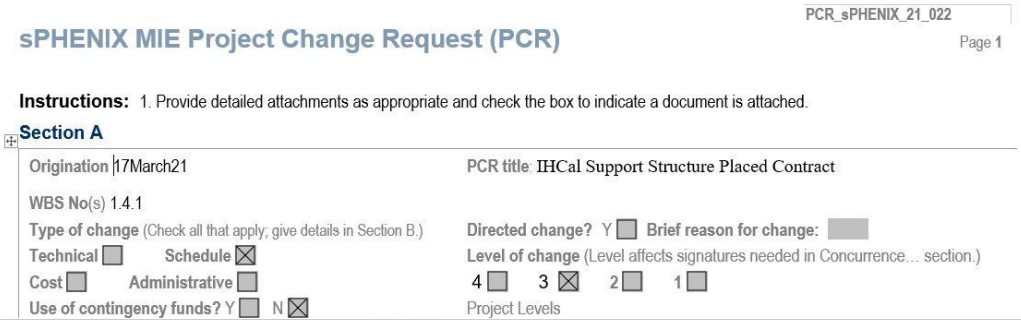
Cost Contingency based on risk event analysis and estimate uncertainty assessment.

- Risk Registry prepared for sPHENIX with mitigation strategies developed.
- Risk Expected Monetary Value is calculated by multiplying risk probability by risk cost impact
- **Estimate Uncertainty** assessed bottom up for unfinished work.
- Cost Contingency is $2.1M (**34.6% on work to go) of $6.2M**.
- Schedule contingency **11 months to PD-4**

Cost Contingency	
	Requested Funds
MIE Project	**$K**
Funding	27,000
Current Baseline	24,854
Current Contingency	2,146
ETC	6,203
% Contingency on ETC	34.60 %
MIE Project	**$K**
Risk Events EMV	575
Bottom up Estimate Uncertainty	764
Tostal Contingency needs	**1,339**
Available Contingency	2,146
Balance Contingency Available	807

Change Control in IPD

- Baseline Change Control in Integrated Project Database (IPDv2)
- Change Control Process
  - Project Change Requests (PCRs) Approvals
  - Change Control and Project Contingency Log



PCR_sPHENIX_21_022

sPHENIX MIE Project Change Request (PCR)

Page 1

Instructions: 1. Provide detailed attachments as appropriate and check the box to indicate a document is attached.

Section A

Origination 17March21

PCR title: IHCal Support Structure Placed Contract

WBS No(s) 1.4.1

Type of change (Check all that apply; give details in Section B.)

Technical ☐ Schedule ☒

Cost ☐ Administrative ☐

Use of contingency funds? Y ☐ N ☒

Directed change? Y ☐ Brief reason for change:

Level of change (Level affects signatures needed in Concurrence... section.)

4 ☐ 3 ☒ 2 ☐ 1 ☐

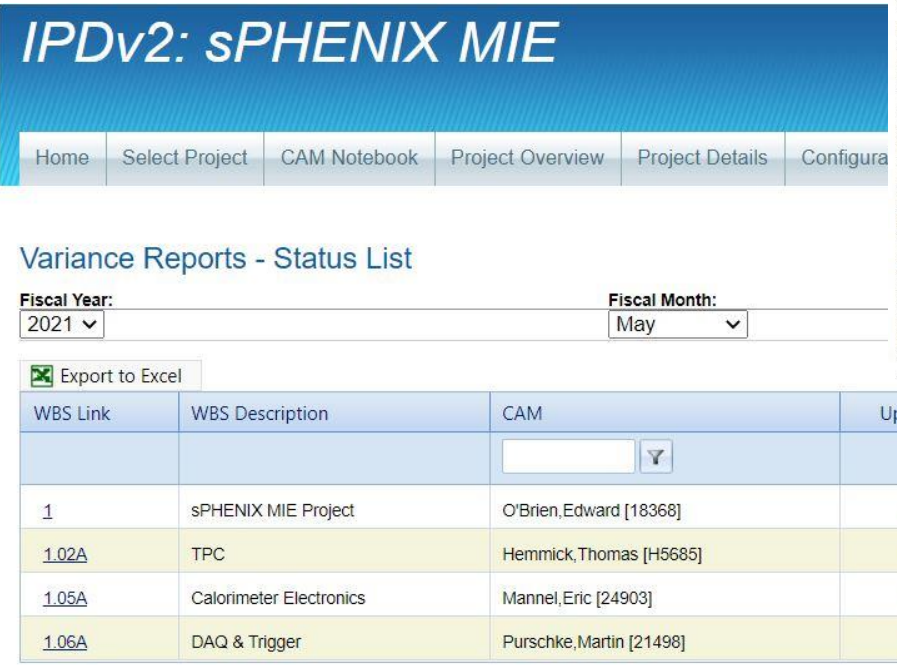
Project Levels

Baseline/Contingency Log - sPHENIX MIE Project

Date	PCR ID	PCR Title	WBS affected	sPHENIX MIE Baseline Cost	PCR Change	Contingency	Total Project Cost
20.09.2019	Approved MIE Baseline	Setting up Baseline	all	$22,169,490		$4,830,510	$27,000,000
24.09.2019	007A	Hcal Scin Tiles placed Contract delivery schedule	1.04 HCal	$22,132,844	($36,646)	$4,867,156	$27,000,000
31.01.2020	008A	OHCal Sci.Tiles delivery schedule update	1.04 HCal	$22,132,943	$100	$4,867,056	$27,000,000
27.02.2020	009A	Extending the lead time for IHCal Support Rings	1.04 HCal	$22,132,943	$0	$4,867,056	$27,000,000
31.03.2020	011A	Added management labor for EMCal block production. EMCal Powder and TPC Sampa Cost and Delivery Schedule update	1.02 TPC and 1.03 EMCal	$22,193,813	$60,870	$4,806,187	$27,000,000
28.04.2020	013A	EMCal Block assembly contract details schedule update	1.03 EMCal	$22,195,549	$ 1,736	$4,804,451	$27,000,000
27.05.2020	014A	EMCal Light guides delivery schedule; EMCal SiPM daughterboards for Sectors 13-64 contract schedule	1.03 EMCal and 1.05 Cal E	$22,176,963	$ (18,586)	$4,823,037	$27,000,000
19.06.2020	105A	COVID-19 Schedule Adjustments	All	$22,198,743	$ 21,780	$4,801,257	$27,000,000
30.10.2020	017A	Risk Reduction and Realization	1.2; 1.3; 1.4; 1.5	$24,309,836	$ 2,111,093	$2,690,164	$27,000,000
31.12.2020	019A	Additional tech labor for EMCal and HCal	1.3; 1.4	$ 24,531,362	$ 221,527	$ 2,468,638	$ 27,000,000
31.01.2021	020A	Move out the Early Project Completion milestone; add tech labor	1.1; 1.2; 1.3; 1.4	$ 24,897,760	$ 366,398	$ 2,102,240	$ 27,000,000
28.02.2021	021A	IHCal Support Rings Placed Contract	1.4.1	$ 24,853,936	$ (43,824)	$ 2,146,064	$ 27,000,000
31.03.2021	022A	IHCal Support Structure Placed Contract	1.4.1	$ 24,853,936	$ -	$ 2,146,064	$ 27,000,000

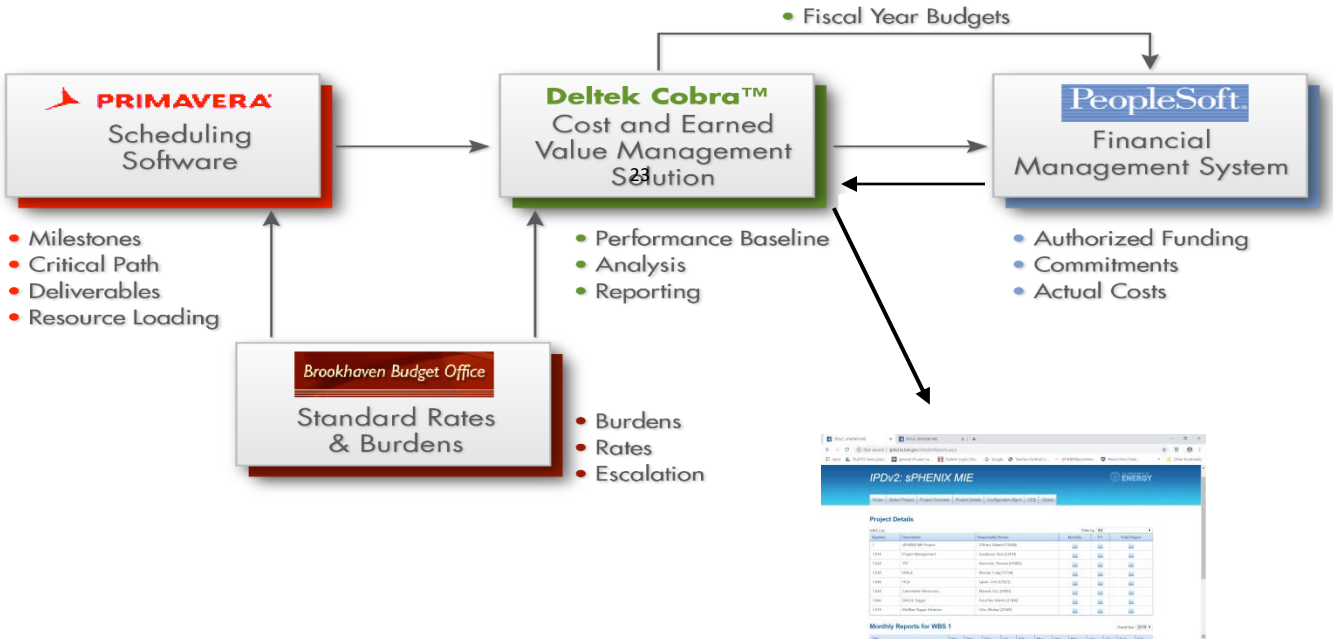
Variance Reporting in IPD

- Variance Analysis
  - Thresholds for reporting variances
  - Analysis, Approval and Reporting



1. Program description highlights for Projects with TPC $50M or less
2. sPHENIX MIE Status as of May 31, 2021
3. EVM tools and procedures
4. Summary

BNL Manages Projects with Proven Systems and Software



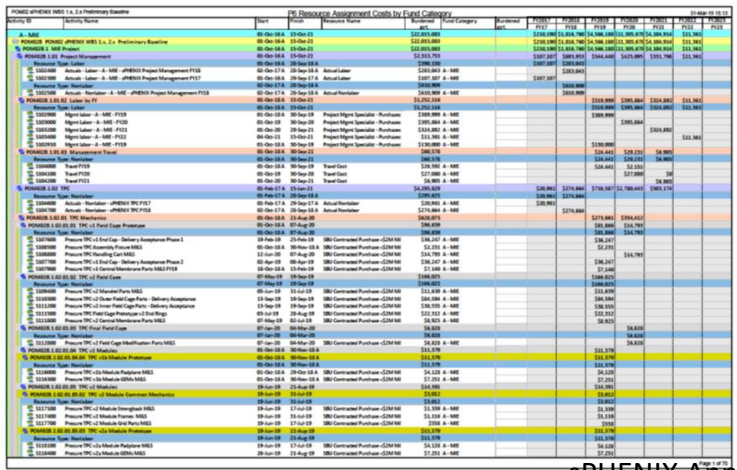
- Integrated Project Database (IPD)
- Monthly Reporting
- Change Control

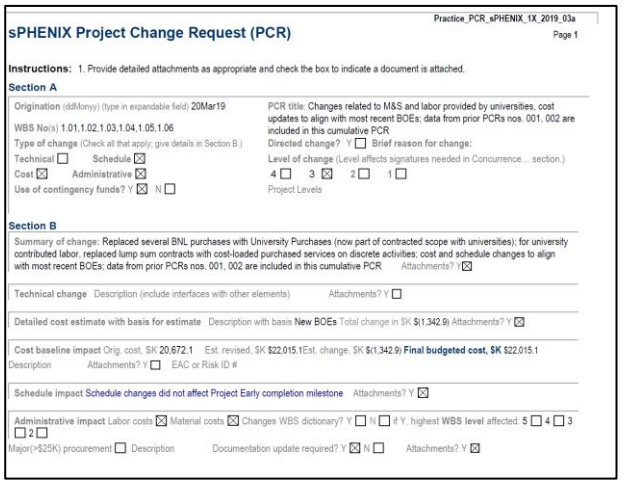
Performance Analysis and Reporting

- **Performance Analysis**
  - **Cost and schedule variance thresholds established by Project in PMP for reporting Variance Analysis**
  - **Variance analysis, schedule milestone and critical path analysis performed**
  - **Supported by project management, project controls, procurement and ES&H professionals**
- **Performance Reporting**
  - **Cost/schedule performance reports and variance analysis reporting conducted monthly**
  - **Monthly cost/schedule status reports generated and posted monthly to IPDv2**
  - **DOE and BNL Management monthly Reporting.**

Resource Loaded Schedule and tailored EVMS Implementation

- **Resource loaded schedule is basis for:**
  - **Time-phased Cost and Obligations Plan to form the Performance Measurement Baseline (PMB*)* to assess project performance**
  - **Tailored EVMS implementation**
  - **CAMs Trained in EVMS**
  - **Baseline Approved Sept 2019 with PD-2 - May 2019 Review**
  - **Processed 11 PCRs changes using P6/Cobra and reporting in IPDv2 (Integrated Project Database).**





sPHENIX Project Change Request (PCR)

Practice_PCR_sPHENIX_1X_2019_03a

Page 1

Instructions: 1. Provide detailed attachments as appropriate and check the box to indicate a document is attached.

Section A

Origination (dd/Monyy)) (type in expandable field) 20Mar19

WBS No(s) 1.01,1.02,1.03,1.04,1.05,1.06

Type of change (Check all that apply; give details in Section B.)

Technical ☐ Schedule ☒

Cost ☒ Administrative ☒

Use of contingency funds? Y ☒ N ☐

PCR title: Changes related to M&S and labor provided by universities, cost updates to align with most recent BOEs; data from prior PCRs nos. 001, 002 are included in this cumulative PCR

Directed change? Y ☐ Brief reason for change:

Level of change (Level affects signatures needed in Concurrence… section.)

4 ☐ 3 ☒ 2 ☐ 1 ☐

Project Levels

Section B

Summary of change: Replaced several BNL purchases with University Purchases (now part of contracted scope with universities); for university contributed labor, replaced lump sum contracts with cost-loaded purchased services on discrete activities; cost and schedule changes to align with most recent BOEs; data from prior PCRs nos. 001, 002 are included in this cumulative PCR Attachments? Y ☒

Technical change Description (include interfaces with other elements) Attachments? Y ☐

Detailed cost estimate with basis for estimate Description with basis New BOEs Total change in $K $(1,342.9) Attachments? Y ☒

Cost baseline impact Orig. cost, $K 20,672.1 Est. revised, $K $22,015.1Est. change, $K $(1,342.9) **Final budgeted cost, $K** $22,015.1

Description Attachments? Y ☐ EAC or Risk ID #

Schedule impact Schedule changes did not affect Project Early completion milestone Attachments? Y ☒

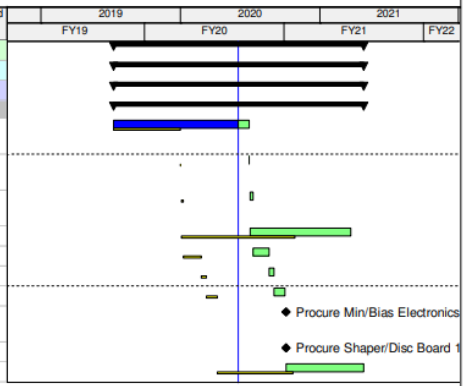
Administrative impact Labor costs ☒ Material costs ☒ Changes WBS dictionary? Y ☐ N ☐ if Y, highest WBS level affected: 5 ☐ 4 ☐ 3 ☐ 2 ☐

Major(>$25K) procurement ☐ Description Documentation update required? Y ☒ N ☐ Attachments? Y ☒

Schedule Lookahead/EV Drilldown

POM02 sPHENIX WBS 1.x, 2.x May 2020 | IPD - MIE 6M Look-ahead | 18-Jun-20 18:54

Activity ID	Activity Name	At Completion Duration	Activity % Complete	Start	Finish	BL Project Start	BL Project Finish	Budgeted Labor Units	Budgeted Nonlabor Units	Budgeted Total Cost	BL Project Total Cost	BNL_Accou Number	BNL_Fund Source
Mickey Chiu (BNL)		451		09-Jul-19 A	27-Apr-21	09-Jul-19	29-Oct-20	372	0	46,170	46,442		
POM02 sPHENIX WBS 1.x, 2.x May 2020		451		09-Jul-19 A	27-Apr-21	09-Jul-19	29-Oct-20	372	0	46,170	46,442		
MIE Project		451		09-Jul-19 A	27-Apr-21	09-Jul-19	29-Oct-20	372	0	46,170	46,442		
Min Bias Trigger Detector		451		09-Jul-19 A	27-Apr-21	09-Jul-19	29-Oct-20	372	0	46,170	46,442		
S272700	Prototype Shaper/Disc Board Testing and evaluation, revisions; Final Design and Procurment Readiness Reviews_50%	246	60%	09-Jul-19 A	30-Jun-20	09-Jul-19	31-Dec-19	216	0	20,874	21,192	16714	B_T
S272701	Final Design Review, Procurement Readiness Review - MBD (Discriminator/Shaper board)	1	0%	01-Jul-20	01-Jul-20	02-Jan-20	02-Jan-20	28	0	3,213	3,213	16714	B_T
S272800	Procure Min/Bias Electronics - Provide Requirements to Procurement	5	0%	02-Jul-20	09-Jul-20	03-Jan-20	09-Jan-20	112	0	19,276	19,276	16714	B
S273700	Oversight of sPHENIX MBD Digitizers Procurement	180	0%	02-Jul-20	24-Mar-21	03-Jan-20	29-Oct-20	16	0	2,807	2,762	16714	B
S272900	Procure Min/Bias Electronics - Prepare & Send Solicitation	30	0%	10-Jul-20	20-Aug-20	10-Jan-20	24-Feb-20	0	0	0	0		
S273000	Procure Min/Bias Electronics - Vendor Responses	10	0%	21-Aug-20	03-Sep-20	25-Feb-20	09-Mar-20	0	0	0	0		
S273100	Procure Min/Bias Electronics - Vendor Selection	20	0%	04-Sep-20	02-Oct-20	10-Mar-20	06-Apr-20	0	0	0	0		
S273200	Procure Min/Bias Electronics - sPHENIX Production Digitizers - Contract Award(s)	0	0%	05-Oct-20		07-Apr-20		0	0	0	0		A-TEC
S273300	Procure Shaper/Disc Board 128 Channels - Contract Award(s)	0	0%	05-Oct-20		07-Apr-20		0	0	0	0		A-TEC
S273400	Procure Min/Bias Electronics - Contract/PO - Leadtime	139	0%	05-Oct-20	27-Apr-21	07-Apr-20	22-Oct-20	0	0	0	0		



Control Account	Work Package.BNL_Accounts	Work Package	Cost Set Actuals	Budget	Progress	SV
1.01A Project Management	16700 sPHENIX OPC - Project Management		$ 1,356,251	$1,421,413	$1,421,413	$ (0)
	16707 sPHENIX OPC - OPC-Reserve		$ -			$ -
	59700 sPHENIX MIE - 1.1 Project Management		$ 176,804	$ 247,907	$ 247,907	$ (0)
1.01A Project Management Total			**$ 1,533,055**	**$1,669,320**	**$1,669,320**	$ (0)
1.02A TPC	16701 sPHENIX OPC - Time Projection Chamber		$ 1,209,748	$1,359,714	$1,348,619	$ (11,095)
	59702 sPHENIX MIE - 1.2 TPC Mechanics		$ 921	$ 68	$ 64,803	$ 64,734
	59703 sPHENIX MIE - 1.2 TPC GEMs (R1, R2, R3)		$ 58,711	$ 310,499	$ 118,418	$ (192,081)
	59704 sPHENIX MIE - 1.2 TPC Front End Electronics		$ 274,484	$ 268,550	$ 132,568	$ (135,982)
	59705 sPHENIX MIE - 1.2 TPC Data Aggregator Modules		$ 23,869			$ -
	59706 sPHENIX MIE - 1.2 TPC Support Systems		$ 15,596	$ 160,922	$ 17,744	$ (143,178)
1.02A TPC Total			**$ 1,583,330**	**$2,099,754**	**$1,682,152**	$ (417,602)
1.03A EMCal	16702 sPHENIX OPC - ElectroMagnetic Calorimeter		$ 1,791,636	$1,814,259	$1,664,711	$ (149,548)
	59708 sPHENIX MIE - 1.3 EMCal Blocks - LLP		$ 1,017,425	$1,192,150	$1,175,645	$ (16,505)
	59709 sPHENIX MIE - 1.3 EMCAl Modules & Sectors		$ 52,052	$ 41,873	$ 41,873	$ -
1.03A EMCal Total			**$ 2,861,113**	**$3,048,282**	**$2,882,230**	$ (166,053)
1.04A HCal	16703 sPHENIX OPC - Hadronic Calorimeter		$ 668,121	$ 626,217	$ 615,099	$ (11,118)
	59711 sPHENIX MIE - 1.4 Outer HCal Sector Mechanics			$ 348,843	$ 45,517	$ (303,325)
	59712 sPHENIX MIE - 1.4 Outer HCal Scintillating Tiles - LL		$ 836,919	$1,014,024	$ 761,442	$ (252,582)
	59713 sPHENIX MIE - 1.4 Outer HCal Sector Assembly and		$ 16,648			$ -
1.04A HCal Total			**$ 1,521,688**	**$1,989,083**	**$1,422,058**	$ (567,025)
1.05A Calorimeter Electronics	16704 sPHENIX OPC - Calorimeter Electronics		$ 847,148	$1,174,231	$1,033,680	$ (140,551)
	59714 sPHENIX MIE - 1.5 CalE SiPMs - LLP		$ 737,421	$ 740,294	$ 742,114	$ 1,820
	59715 sPHENIX MIE - 1.5 CalE Front End Electronics		$ 487,925	$ 312,541	$ 443,054	$ 130,512
1.05A Calorimeter Electronics Total			**$ 2,072,494**	**$2,227,066**	**$2,218,847**	$ (8,219)
1.06A DAQ & Trigger	16705 sPHENIX OPC - DAQ/Trigger		$ 27,831	$ 25,972	$ 25,972	$ 0
	59718 sPHENIX MIE - 1.6 DAQ		$ 102,818		$ 99,994	$ 99,994
	59719 sPHENIX MIE - 1.6 Local Level 1 Trigger		$ 132,085	$ 196,861	$ 196,861	$ -
1.06A DAQ & Trigger Total			**$ 262,733**	**$ 222,833**	**$ 322,827**	$ 99,994
1.07A MinBias Trigger Detector	16706 sPHENIX OPC - Min Bias Trigger Det		$ 78,304	$ 99,148	$ 99,148	$ -
1.07A MinBias Trigger Detector Total			**$ 78,304**	**$ 99,148**	**$ 99,148**	$ -

CAMs provided with Lookahead schedules and detail cost/schedule reports below Control Account.

PM/EVMS Cost Performance Reports posted IPD

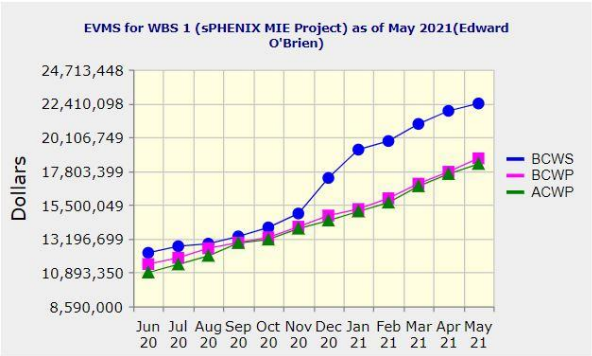
- Generated monthly for project, BNL, and DOE management
- Project and control account level
- Based on PMB from Cobra/Excel

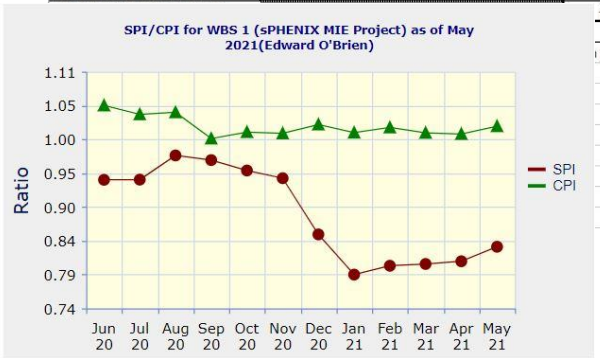
8. PERFORMANCE DATA

CA (3)	CUMULATIVE TO DATE					AT COMPLETION				
	BUDGETED COST		ACTUAL	VARIANCE		BUDGETED	ESTIMATED	VARIANCE		
ITEM	WORK SCHEDULED	WORK PERFORMED	COST WORK PERFORMED	SCHEDULE	COST					
(1)	(7)	(8)	(9)	(10)	(11)	(14)	(15)	(16)	SPI	CPI
1.01A Project Management	1,879,716	1,879,716	1,731,909	0	147,807	1,951,679	1,803,872	147,807	1.00	1.09
1.02A TPC	4,762,916	3,585,188	3,286,624	-1,177,727	298,564	5,026,775	4,720,538	306,237	0.75	1.09
1.03A EMCal	5,580,536	5,262,935	5,543,989	-317,601	-281,054	6,070,008	6,353,539	-283,531	0.94	0.95
1.04A HCal	2,855,608	3,039,759	3,163,224	184,151	-123,464	4,099,592	4,223,057	-123,464	1.06	0.96
1.05A Calorimeter Electronics	6,053,314	4,280,811	3,879,106	-1,772,503	401,704	6,290,621	5,910,216	380,405	0.71	1.10
1.06A DAQ & Trigger	1,109,290	525,778	599,107	-583,512	-73,329	1,245,090	1,323,005	-77,914	0.47	0.88
1.07A MinBias Trigger Detector	170,170	99,148	87,969	-71,022	11,179	170,170	160,411	9,759	0.58	1.13
b. COST OF MONEY	0	0	0	0	0	0	0	0		
c. GENERAL AND ADMINISTRATIVE	0	0	0	0	0	0	0	0		
d. UNDISTRIBUTED BUDGET						0	0	0		
e. SUBTOTAL	22,411,549	18,673,335	18,291,928	-3,738,214	381,407	24,853,936	24,494,638	359,298	0.83	1.02
f. Contingency						2,146,064				
g. TOTAL	22,411,549	18,673,335	18,291,928	-3,738,214	381,407	27,000,000				
9. RECONCILIATION TO CONTRACT BUDGET BASELINE										
a. VARIANCE ADJUSTMENT				0	0					
				-3,738,214	381,407	0	0	0		

Filled In)

$6,202,710	ETC
$6,180,601	BCWR
34.60 %	% Contingency on ETC
34.72 %	% Contingency on Remaining Work
90.17 %	% Planned
75.13 %	% Complete
73.60 %	% Spent





BAC: $24,853,936 **EAC:** $24,494,638 **VAC:** $359,298

1. Program description highlights for Projects with TPC $50M or less
2. sPHENIX MIE Status as of May 31, 2021
3. EVM tools and procedures
4. Summary

Cost/Schedule Charge Questions

- Charge Q. 2: Will the project's remaining cost and schedule resources be sufficient to achieve PD-4? Is contingency usage appropriate for this stage of the project? Is project critical path clearly identified and understood? **Yes,** available cost contingency is $2,146K (~35%) on cost to-go, and schedule contingency is 11 months to PD-4. Cost/Schedule contingency is sufficient to successfully complete project within cost and schedule requirements. The Critical Path and near critical activities are understood and analyzed monthly for changes.

Issues and Concerns

- Increase employees and visitors on BNL site while working under the COVID protocols
- BNL PPM support
- Vendors – schedule, availability, possibly cost

Summary

- The Project is 75.1% complete, work to go is $6.2M, SPI is 0.83, CPI is 1.02
- Performance measurement Baseline (PMB) is in place with sufficient cost/schedule contingencies within approved funding profile.
- The Resource loaded schedule is maintained for effective performance measurement and reporting.
- Risk Registry is updated and maintained by L2 managers.
- EVM system (tools and tailored process) is in place and has been implementing EV and change control since PD-2/3 September 2019.
- Staff is experienced and the **sPHENIX Project is performing per plan with close monitoring of performance. COVID-19 impacts closely monitored and tracked via PCRs.**

Back Up

sPHENIX Cost/Schedule Assumptions

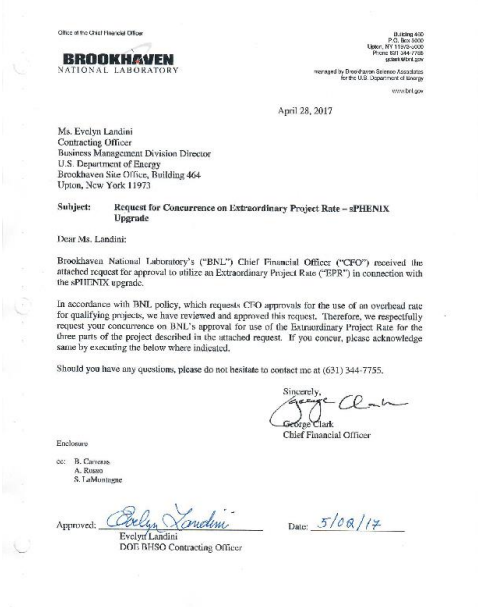
Cost/Schedule Assumptions document describes the assumptions for how the cost estimate, and schedule were developed.

Cost Estimate:

- BNL Labor Bands were used to estimate project labor requirements.
- Contributed labor is included in the estimate.
- FY19 Labor, Burdened Rates are provided by Budget Office as a composite rate in P6.
- **Extraordinary Project Rate was approved for the MIE project.**
- Escalation 3.0% labor, 2% Material

Schedule:

- Schedule resource loaded and planned within funding constraints and critical decision milestones.
- Activities developed based on WBS Dictionary,
- Durations estimated and resources assigned by L2/L3 Managers.



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. Clarenas
A. Rosso
S. LaMontagne

Approved: Evelyn Landini Date: 5/09/17
Evelyn Landini
DOE/BHSO Contracting Officer

- 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.