sPHENIX Project Status Report – June 2020

HOST LABORATORY: BROOKHAVEN NATIONAL LAB

FEDERAL PROGRAM MANAGER: ELIZABETH BARTOSZ

BHSO POINT OF CONTACT: ROBERT CARADONNA

CONTRACTOR PROJECT DIRECTOR: EDWARD O'BRIEN

1. **SCORECARD AS OF JUNE 30, 2020**

Current PD:	**2/3**	Date of Current CD/PD approval		September 2019	
Next PD:	**4**	Forecast approval:	**1QFY23**	Baseline:	**1QFY23**
% Complete:	**51.7%**	Planned:		**55.1%**	
ETC:	**$12.0M**	TPC or Cost Range:		**$27.0M**	
Contingency:	**44.8%** on BCWR **39.4%**on ETC	Float to PD-4 in months:		**12**	
Cumulative CPI:	**1.05**	Cumulative SPI:		**0.94**	

2. **NEAR TERM MILESTONES**

In the near term the sPHENIX Project team will continue the monthly EVMS process, Change Control, and the monthly updating of the ETC. We continue to place orders for parts approved at PD-3. We are developing plans to mitigate COVID-19 related delays including allowing certain collaborating universities the host sPHENIX fabrication and testing activities to hire additional technicians to replace a shortfall in student labor. We will continue to hire replacement personnel for our recently retired staff members.

R&D for most subsystems components is nearing completion and most of the recent project activities are associated with production of final detector components. GEM foil production will start at CERN. Review of the design for the TPC gas system, TPC Laser System, and TPC carriage-level cooling system will be performed. Fabrication of SAMPA v5 Production ASICs will continue. Testing of over 4000 SAMPA v5 chips produced as part of the SAMPA engineering run will be completed at Lund. Preproduction TPC Fee boards will be ordered and produced. The TPC DAM preproduction module testing will be completed at BNL.

We expect all of the Sector 1-12 blocks to be completed and delivered to BNL by the end of August. Production of blocks for Sectors 13-64 will then begin. BNL will complete the assembly and testing of Sector 1 and then proceed to Sector 2. This will test all the components and assembly procedures for both a north and south sector, which will then allow us to have a Production Readiness Review that will allow us to proceed with the production of all the remaining sectors.

Inner HCal Sector and End Rings structural components will have their drawings finalized, procurement documentation will be prepared and contracts will be in place to procure the IHCAL sectors within the next few months. OHCal assembly will continue at BNL once the OHCal sector production facility reopens at BNL in early July. Tile testing will continue at GSU, with the last shipment of OHCAL tiles expected from the vendor by the end of July.

Work on the Calorimeter Electronics over the next three months will be focused on the continued testing of preproduction sectors and procurement of production electronics. This work includes placing orders for the remaining HCal electronics, placing orders for the remaining EMCal electronics, continued testing of the EMCal SiPM daughter cards, the resumption of testing of EMCal Sector 0 and HCal Sector 1, testing of the instrumented EMCal sectors as they are assembled at BNL, continued system chain test of the calorimeter digitizer ½ crate system and collaboration with the sPHENIX infrastructure and installation group to finalize cable lengths and the rack designs.

The DAQ/Trigger group will finish the various PCIe-related performance tests for the FELIX and JSEB-II cards and proceed with the procurement of the EBDC and SEB machines.

The MBD group expects the fully assembled Discriminator/Shaper board to be available in August for testing. We will continue developing the trigger algorithm and how to best implement it. We will continue discussions on the details of what is needed for integration into sPHENIX (cabling, power, electronics racks, etc).

3. **STATUS HIGHLIGHTS**

The EVMS process is ongoing as the MIE continues to show good cost performance. The June SPI shows impact of COVID-19 related delays across al MIE elements. EVMS processing for June is complete. The schedule contingency decreased from 13 to 12 months while the cost performance remained excellent. Cobra and P6 monthly reports uploaded to IPD. May variance reports have been approved. Estimate Uncertainty and Risks were updated and the bottom-up contingency estimate was revised.

All GEM frames for TPC GEM module fabrication have been delivered to the GEM factories and are undergoing QA inspection. The “first article” R3 pad planes passed detailed inspection and full production is ongoing. R2 pad plane design is complete and awaiting a quotation prior to procurement. The GEM foil order has been placed with CERN. To combat COVID-related delays, we have gone forward with the plan to pay for extra CERN technician training/work to help restore the GEM production schedule. The TPC DC power distribution plan, both HV and LV, was reviewed by the CAD Experimental Safety Committee. LV power supplies are common across systems in sPHENIX and will be ordered by BNL. The HV supplies are unique to the TPC and have been ordered through SBU. The TPC FEE procurement is submitted to BNL Procurement. A final layout of the laser calibration system has been made with dramatic simplification over the original conceptual design. The FEE cooling prototype test is under way at BNL. Approximately 4400 SAMPA V5 chips have been delivered to CERN and sent to Lund for QA testing. A final Design review for the TPC transportation and installation fixtures was held in June.

The Nuclear Physics Lab at UIUC continued to make excellent progress despite having to reduce their operations due to COVID restrictions on the number of students and techs that are allowed to work in

the NPL at any given time. An additional 96 blocks were shipped to BNL bringing the total at BNL to 5 sectors worth of blocks. Approximately 70% of the total fiber order has been delivered and approximately 40% of the fiber assemblies for Sectors 13-64 have been completed. The second batch of tungsten powder was delivered to UIUC in early June completing the tungsten powder long led procurement. There has been no further evidence of dark fibers with the new blocks that have been produced. The use of the block freezing technique before machining and the new screen tab removal tool solved the problem. BNL entered Phase 1 of reopening in early June with only a very limited number of personnel allowed on site. It was still possible to partially resume EMCal module production and to begin to make arrangements for EMCal sector assembly under the new COVID restrictions. Sector 1 is nearing completion and the blocks for Sector 2 have also been preassembled and test fit onto their sawtooth support. The EMCal sector assembly facility was reorganized to enable additional separation between those working in the EMCal factory by adding lab space and additional work set-ups.

Inner HCal sector mechanics and End Rings continue to have their drawings finalized. The fifth of six shipments of OHCal tiles arrived at GSU in June. The final shipment is expected at the end of July. That will complete the long lead procurement of OHCal tiles. Tile testing at GSU has been halted for COVID-19 mitigation, but laboratory operations at GSU resumed June 15th. The GSU lab has been reconfigured to operate in a manner that observes social distancing requirements, and undergraduate workers will be able to return to the lab. Tile testing is continuing with the goal of shipping two pallets of tested tiles to BNL each week.

The first 3,420 EMCal SiPM daughter boards have been assembled and delivered to BNL. Assembly of the OHCal SiPM boards continues and the assembler has completed and delivered 1,500 boards with a projection of completing the balance at a rate of 500 per week. Work on getting the EMCal SiPM board tester running started at the end of June, with a goal of having regular SiPM daughter card testing start in July. The Lehigh group continues preamp testing and pre-assembly for installation into the EMCal sectors with 96 board assemblies shipped back to BNL at the end of the June. Deliveries will continue on a regular basis. The PCB order for the XMIT boards for the 7-Crate production has gone out from Columbia University with a mid-July delivery date. The assembly of the digitizer boards for the 7-Crate production has started with partial deliveries scheduled starting in July and final delivery in August. The Columbia engineering team continues to work on FPGA code development and prepare documentation for assembly of the full digitizer system for the EMCal and HCal. An internal safety review of the AC and DC power distribution was conducted. No significant recommendations were made, and a review with the BNL Experimental Safety Review Committee has been scheduled for July 15th.

The sPHENIX DAQ/Trigger group is planning the procurement of the first rack of machines to be in used in sPHENIX. The computers will be the TPC “Event Builder and Data Compression” (EBDC) machines and will each host one or more FELIX cards. We did a comparison test between AMD and Intel server performance and found significantly better performance of the AMD-based computer in reading out the FELIX card. A second test will be conducted to establish that the other flavor of custom PCIe cards, the JSEB-II, used for the readout of the HCal, EMCal and MBD also works with AMD server. The network infrastructure was upgraded in 1008 as part of the sPHENIX upgrade.

Nevis has received the 2nd prototype of the MDB Disc/Shaper printed circuit board. The prototype D/S board will be assembled and testing will begin at Nevis in August. Work continues with the infrastructure and integration engineers to design the mechanical support and cable routing for the MBD. We have recruited two new university groups, Howard Univ. and Florida A&M Univ., to help with MBD electronics testing, particularly with the production testing of the final D/S boards.

WBS 1.1 Project Management (L2 Manager: Irina Sourikova)

Current Status:

- June SPI shows COVID-19 related delays, CPI is above 1.

Highlights:

- PCR for COVID-19 related delays across all WBS elements approved, adding $21.8 K to contingency.
- EVMS processing complete; schedule contingency decreased from 13 to 12 months while cost performance remained excellent.
- Cobra and P6 monthly reports uploaded to IPD.
- May variance reports approved.
- Estimate Uncertainty and Risks updated bottom up.

Plans for the next 2-3 month:

- Develop a plan to mitigate COVID-19 related delays.
- Continue monthly EVMS process and Change Control.
- Place TEC orders and monitor procurements.
- Hire replacements for retired personnel.

Issues:

- Worldwide COVID-19 pandemic continued to delay MIE schedule though the DP-4 date is still on track.

WBS 1.2 Time Projection Chamber (L2 Manager: Tom Hemmick, SBU)

Current Status:

All frames are delivered to the GEM factories and undergoing QA inspection. The “first article” R3 pad planes passed detailed inspection and full production is ongoing. R2 pad plane design is finished and undergoing bid from the company that made R3. R2 is similar but smaller and so the company should be able to produce the board.

The GEM foil order is placed with CERN. To combat COVID-related delays, we have gone forward with the plan (previously thought unnecessary) to pay for extra technician training/work to help restore the GEM production schedule.

The DC power plan meeting was held successfully. Orders for LV power supplies are common across systems in sPHENIX and are handled at BNL. The HV supplies are unique to the TPC and are already ordered through SBU.

The FEE procurement is working its way through BNL purchasing.

A final layout of the laser calibration system has been made with dramatic simplification over the original conceptual design. Prototype parts for the laser transport mechanics (piezo-electric motors, gas-tight and light-tight beam transport optics) have all been delivered allowing bench tests prior to an August design review..

The FEE cooling prototype test is under way at BNL. We are collecting quotations for the parts in advance of an anticipated successful design review.

~4400 SAMPA V5 chips have been delivered to CERN and sent to Lund for QA testing.

A final Design review for the TPC transportation and installation fixtures was held.

Work Anticipated 2-3 Months

Reviews of the TPC gas system, TPC Laser System, and TPC carriage-level cooling system will be performed.

Issues:

SBU labs and BNL labs are just initiating a staged re-entry of personnel. The level of work approved will become a driving factor in determining the overall impact of the COVID pandemic. SBU plans include availability of undergraduate personnel and we anticipate hiring technician help (as described in the TPC risk registry) to mitigate the impact.

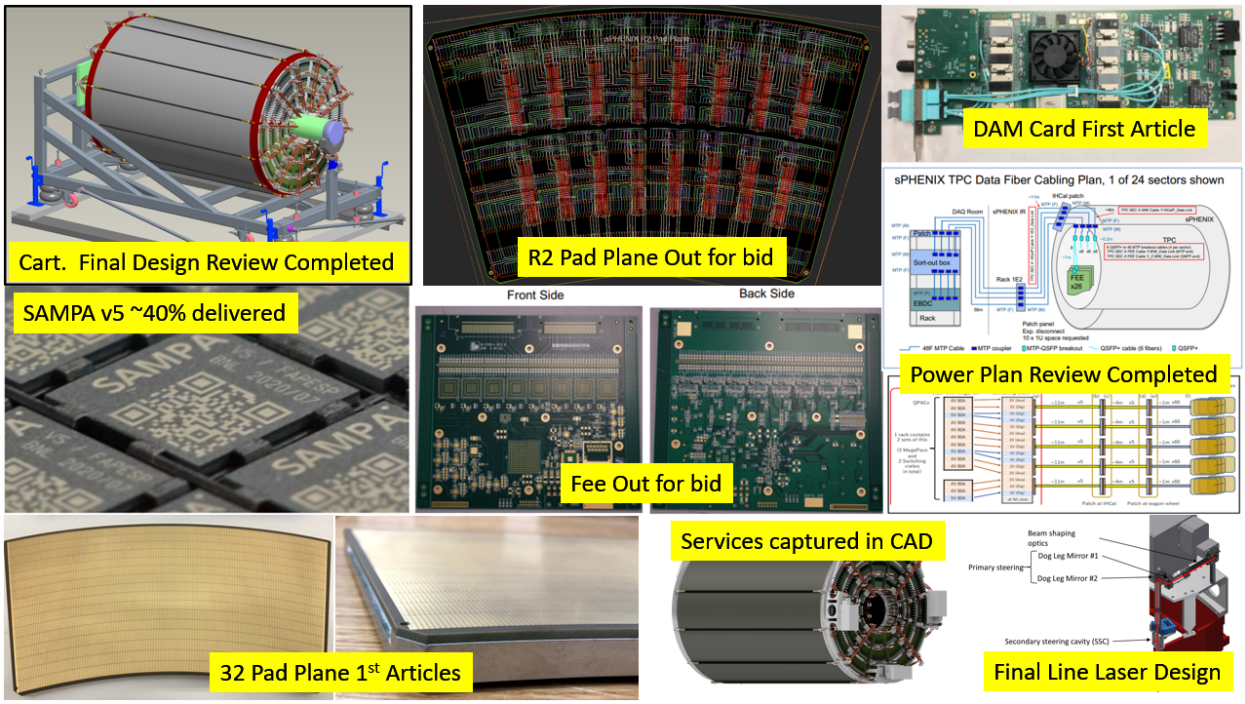


Figure 1. Clockwise from upper left: 3D model of TPC transport cart. Layout of R2 pad plane. Assembled TPC DAM card. TPC fiber/cabling plan, TPC power distribution schematic. Design of calibration laser system. TPC service location on the end of the detector. TPC preproduction Fee board w/o components. First article of R3 pad plane. SAMPA v5 chips.

WBS 1.3 Electromagnetic Calorimeter (L2 Manager: Craig Woody, BNL)

Current Status:

The Nuclear Physics Lab at UIUC continued to make excellent progress despite having to reduce their operations due to COVID restrictions on the number of students and techs that are allowed to work in the NPL at any given time. Figure 2 shows their progress on block production for Sectors 1-12, filling of fiber assemblies for Sectors 13-64, fiber delivery and shipment of finished and tested blocks to BNL through the end of June. An additional 96 blocks were shipped to BNL bringing the total there to 5 sectors. Approximately 70% of the total fiber order has been delivered and approximately 40% of the fiber assemblies for Sectors 13-64 have been completed. In addition, the second batch of tungsten powder was delivered to UIUC in early June, completing the delivery of all the tungsten powder for remaining block production.

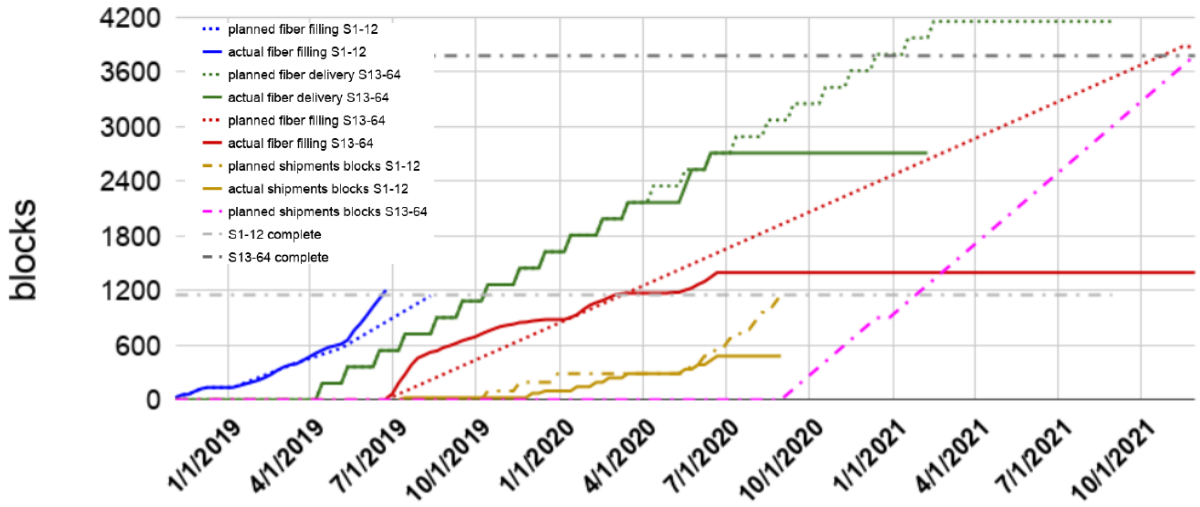
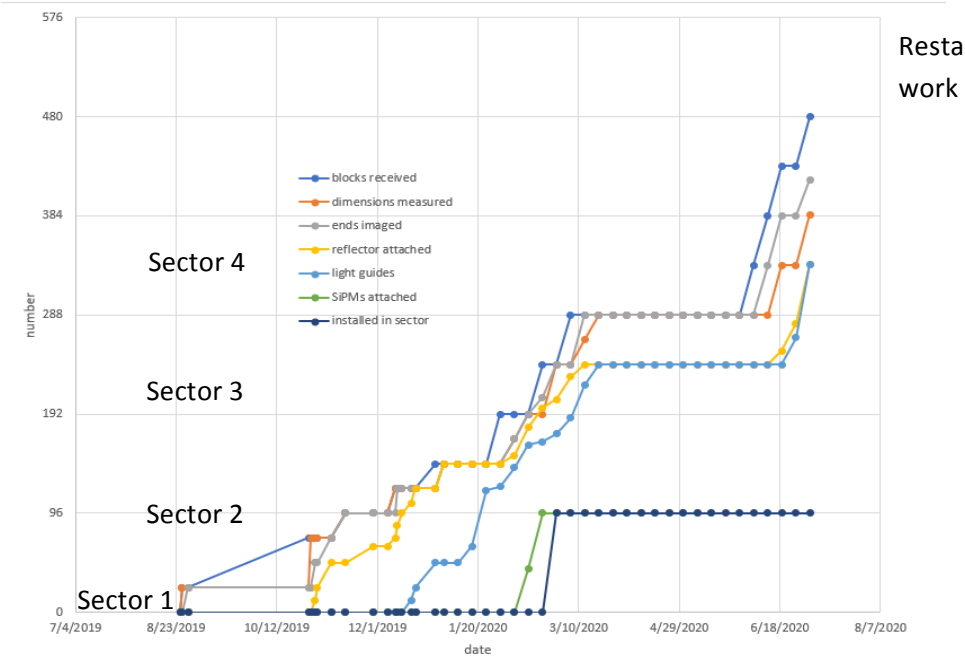


Figure 2. Progress at UIUC on block production, fiber filling and block shipment through the end of June 2020.

There has been no further evidence of dark fibers with the new blocks that have been produced using the freezing technique before machining and the new screen tab removal tool. We believe this problem has now been solved.

Block production at Fudan University has also continued and progress is being made despite still having limitations due to COVID restrictions. They are in close communication with UIUC to ensure that while the details of the block fabrication process may be slightly different at the two locations, the final blocks that are produced go through the same QA procedure and meet the same performance specifications for the final detector.



Restart factory work at BNL

Figure 3. Progress at BNL on module production through the end of June. The flat lines indicate the delay due to the COVID-19 shutdown.

BNL entered Phase 1 of reopening in early June with only a very limited number of personnel allowed on site. However, it was still possible to partially resume module production and to begin to make arrangements for sector assembly under the new COVID restrictions. Figure 3 shows the status and progress at BNL through the end of June. The new blocks that were received from UIUC were unpacked and inspected and installation began of some of the module components. The blocks for Sector 2 have also been preassembled and test fit onto their sawtooth support as shown in Fig. 4 on the left. Figure 4 on the right shows some of the preparations being made to start up the sector assembly area in the Physics High Bay.

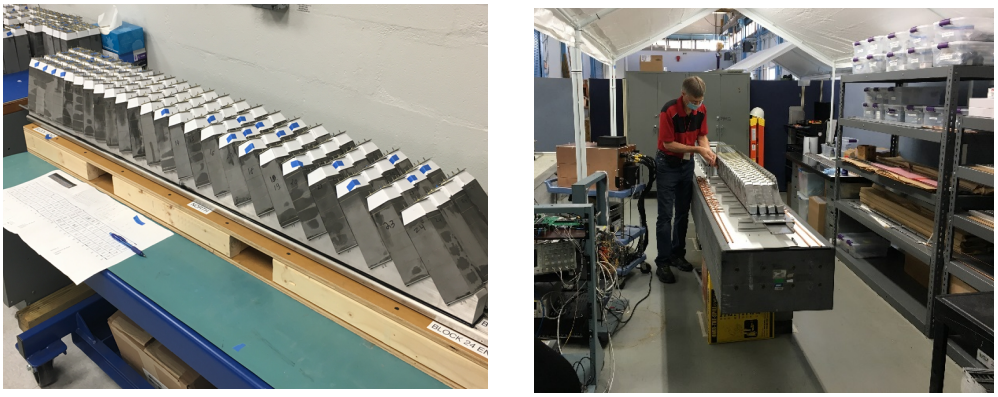


Figure 4. Left: Test fit of Sector 2 blocks. Right: Preparations being made for starting up the sector assembly area in the Physics High Bay.

Work For the Next 2-3 Months:

Progress on block production for Sectors 1-12 and fiber filling for Sectors 13-64 will continue at UIUC. We expect all of the Sector 1-12 blocks to be completed and delivered to BNL by the end of August. Production of blocks for Sectors 13-64 will then begin.

BNL plans to enter Phase 2 of reopening in early July, which will allow more personnel on site and more technical work to be done on module production and sector assembly. However, due to the backlog of blocks to process, we do not expect to be able to produce sectors as rapidly as the blocks come in. The first priority will be to complete the assembly and testing of Sector 1 and then proceed to Sector 2. This will test all the components and assembly procedures for both a north and south sector, which will then allow us to have a Production Readiness Review that will allow us to proceed with the production of all the remaining sectors.

We also expect that the first sector's worth of high rapidity blocks from Fudan will be sent to UIUC by the end of August which will allow a cross check of the test results obtained at Fudan with those obtained at UIUC. Once confirmed, this will allow future shipments of blocks from Fudan to be sent directly to BNL.

Issues:

- The main issue of concern is that BNL continues with its reopening plan as scheduled. More personnel will be needed on site in order to fully resume module production and sector assembly for Sectors 1-12 and eventually Sectors 13-64.
- The vendor for the light guides is still behind in its delivery schedule. While we have enough light guides to complete several more sectors, we will need more parts soon in order to proceed with the remaining sectors.
- We continue to face a manpower shortage for testing completed sectors. It has always been assumed that this would be done by postdocs and graduate students provided by our collaborators and we will need to get more people involved in the testing procedure very soon if we are going to maintain our schedule for the installation of tested and working sectors into sPHENIX in 2021

WBS 1.4 Hadronic Calorimeter (L2 Manager: John Lajoie, Iowa State University)

WBS 1.4.1 Inner Hadronic Calorimeter Frame

Current Status:

An engineering design for a cooling solution for the inner HCAL has been developed. This is important as initial thermal calculations show that temperatures could be uncomfortably high between the inner HCAL and the magnet cryostat. The solution involved Cu cooling tubes with fingers attached to the preamplifier boards and a radiator in the electronics bays. Minor modifications were required to the sector endplates and end rings.

Work for the Next 2-3 Months:

Documentation required for the procurement process for the sectors and end ring is being prepared, and contracts should be in place to procure the iHCAL sectors in several months.

Issues:

The current mitigation efforts for COVID-19 will have a negative schedule impact on the inner HCAL assembly schedule. More will be known when we have a sector production schedule from the manufacturer.

WBS 1.4.2/3/4 Outer Hadronic Calorimeter

Current Status:

Shipment #5 (of a total of 6) of outer HCAL tiles from the vendor was received at Georgia State University on June 12th. The final shipment is expected at the end of July.

Tile testing at GSU was been halted for COVID-19 mitigation, but laboratory operations at GSU resumed June 15th. The GSU lab has been reconfigured to operate in a manner that observes social distancing requirements, and undergraduate workers will be able to return to the lab. Tile testing is continuing

with the goal of shipping two pallets of tested tiles to BNL each week. Ideally, if there are no additional delays, this should complete testing by the end of November.

Factory operations at BNL are resuming with technician labor. One pre-production sector has been fully assembled and we are finalizing the cosmic ray test procedures, and scripting the operation so that it can be performed by undergraduates. A second sector is ready to be cabled with electronics, and the remaining pre-production sectors have been loaded with scintillating tiles. Technician labor is being used to sort incoming tiles, attach SiPMs, load tiles into production sectors, and cable pre-production sectors and install electronics. The electronics boxes for the remaining pre-production sectors have ben received at BNL, and the remaining light-tight skins are expected at the beginning of August. All cables and electronics for the pre-production sectors are in-hand.

The contract between BNL and ISU is complete and PO's have been issued for all parts of the contract. Delivery of the first set of 10 electronics boxes for the oHCAL has been made to BNL, with the remainder of the skins and boxes by August 1st. The three-sector test stand has been shipped to BNL July 17th and are expected at BNL the week of July 20th. The high-strength endplates, splice plates, pucks and pins are expected before November 2020.

Work for the Next 2-3 Months:

Over the next six months work on the outer HCAL will center on production sector assembly in the HCAL factory once work at BNL resumes. Tile testing will continue at GSU, with the last shipment of oHCAL tiles expected from the vendor by the end of July.

Issues:

The plan for oHCAL sector assembly relied on undergraduate and graduate labor from collaborating institutions. Commitments for sufficient labor for summer 2020 have been made by collaborating institutions, but with the ongoing COVID-19 this plan will not be feasible in summer 2020. We are planning work in the summer will make use of technician labor, but this will have schedule impacts based on availability. We are hoping that we will be able to supplement oHCAL factory labor with graduate students and postdocs in the fall of 2020.

WBS 1.5 Calorimeter Electronics (L2 Manager: Eric Mannel, BNL)

Current Status:

The first 3,420 EMCal SiPM daughter boards have been assembled and delivered to BNL. A preliminary visual inspection shows that the boards are properly assembled. Assembly of the oHCal SiPM boards continues and the assembler has completed and delivered 1,500 boards with a projection of completing the balance at a rate of 500 per week. Work on getting the EMCal SiPM board tester running started at the end of June, with a goal of having regular testing start in July. The tester will be used to verify that the SiPM boards are fully functional by illuminating the LEDs, reading back the thermistors, and measuring the current of the SiPMs as they are illuminated with a light source in the scanning head. A

picture of the tester is shown in Fig 5 showing both the panel tester and the single board tester with the LEDs turned on.

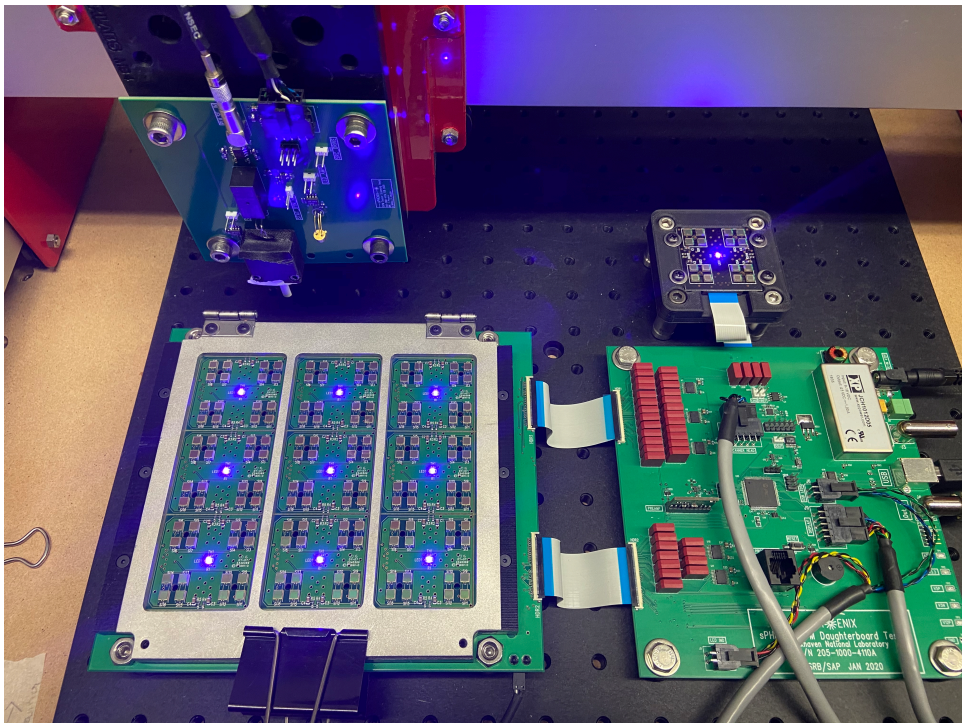


Figure **5**: EMCal SiPM Board tester with a full panel of boards. The tester allows for fast verification that all aspects of the SiPM boards function. In this picture, the LEDs are light up to provide a visual confirmation that they are functional.

The Lehigh group continues preamp testing and pre-assembly for installation into the EMCal sectors with 96 board assemblies shipped back to BNL at the end of the June. Deliveries will continue on a regular basis. Orders went out for the prototype Test Pulse Driver board that will be used to verify the redesign. Design work continues on the digitizer and control racks for the EMCal. Orders for the EMCal and HCal interface boards, and the HCal preamps for the full production run have been submitted, with deliveries schedule for September. The HCal LED Driver Board order was received by the assembler and they expect to be able to make full delivery by mid-August.

The PCB order for the XMIT boards for the 7-Crate production has gone out with a mid-July delivery date. The assembly of the digitizer boards for the 7-Crate production has started with partial deliveries scheduled starting in July and final delivery in August. The Columbia engineering team continues to work on FPGA code development and prepare documentation for assembly of the full digitizer system for the EMCal and HCal.

Work with the sPHENIX Integration and Installation team continues to finalize the cable routing for the EMCal and HCal. This will allow cable lengths to be determined which are needed for ordering the signal and power cables. An internal safety review of the AC and DC power distribution was conducted. No significant recommendations were made, and a review with the BNL ESRC has been scheduled for July 15th.

Work for the next 2-3 months:

Work over the next 3 months will be focused on the continued testing of preproduction sectors and procurement of production electronics. This work includes:

1. Place orders for remaining HCal production electronics
2. Place orders for remaining EMCal production electronics
3. Continued testing of EMCal SiPM boards
4. Resume testing of the EMCal Sector 0 and HCal Module 1
5. Testing of EMCal Sector 1 when it is fully assembled
6. System chain test of the Digitizer ½-Crate system at BNL
7. Work with the Integration and Installation group to finalize cable lengths and rack design

Issues:

- COVID-19 travel and work restrictions will impact the short-term schedule for testing of delivered electronics.

WBS 1.6 DAQ/Trigger (L2 Manager: Martin Purschke, BNL)

Current Status:

As the cautious re-opening of Brookhaven National Laboratory continues, we had intermittent access to our hardware, and have been able to make progress.

One area of investigation is the choice of the PC processor that we will use with the FELIX card. We are planning the procurement of the first rack of machines to be in use in sPHENIX. These computers will be the TPC "Event Builder and Data Compression" (EBDC) machines, which will host one or more of the FELIX cards. Recently, new CPUs produced by AMD have a significantly better performance than the best CPUs by Intel at roughly the same price point. We have recently been able to demonstrate that the FELIX card works as advertised in the AMD server by making a number of changes to the firmware on the FELIX card. We have yet to determine if those changes will still allow the card to work on the Intel system. We would like to avoid the need for architecture-dependent firmware versions at all costs. The theory is that the FELIX firmware needed a revision in order to work with the AMD server because the earlier version of the FELIX firmware marginally met the PCIe requirements, which the Intel architecture tolerated but the AMD did not.

A second test needs to be made to establish that the other flavor of custom PCIe cards, the JSEB-II, used for the readout of the HCal, EMCal and MBD also works with AMD server. A successful demonstration would clear the path for a procurement of identical machines to act as both EBDCs (for the FELIX cards) and Sub-Event Buffers (SEB) for the JSEB-II cards.

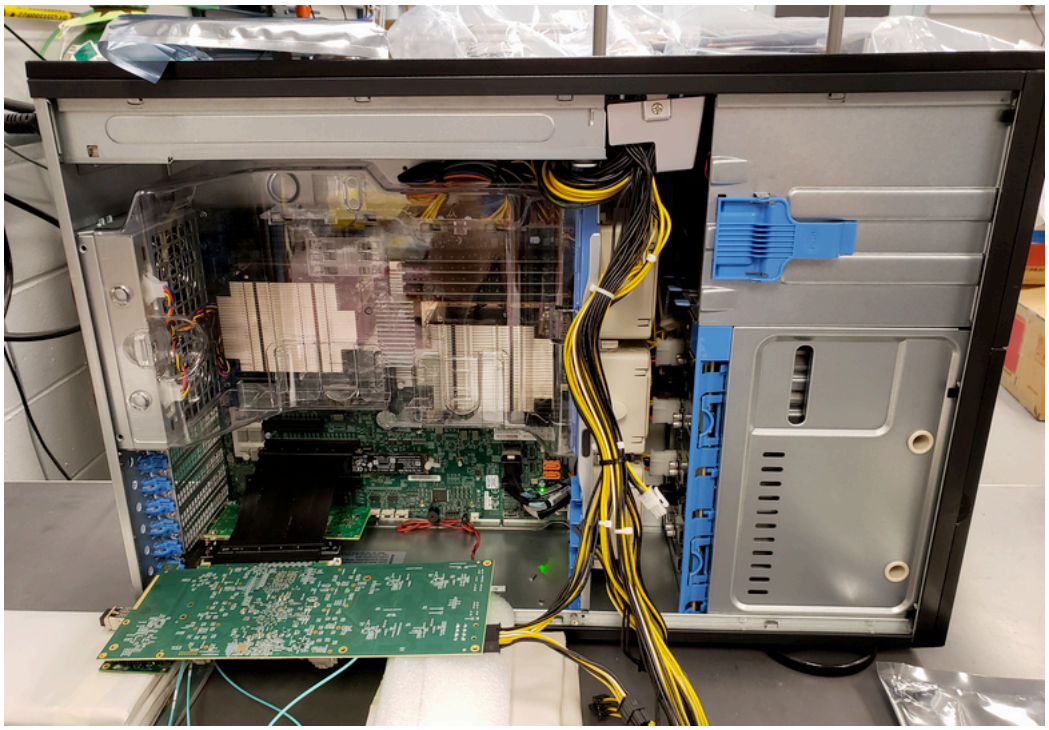


Fig. 6: The AMD “pilot” machine that we use to test if the FELIX and JSEB-II cards will work with AMD CPUs. All tests so far used an Intel architecture. We have succeeded with a demonstration that the card indeed works. In the picture, a FELIX card is mounted with a PCIe extension.

At the experimental site, work has been going on to upgrade the network infrastructure. As most computers have been decommissioned and disruptions will be minimal, the main network switches that provide our connectivity to the BNL campus network have been mostly disconnected and are awaiting the installation of their replacements. At the same time, our high-speed switch that will carry the main data flow of the experiment has been received and unboxed (Fig. 7). The machine shown in Fig. 6 will initially be used to connect to the switch and perform performance and throughput tests, and other tests of various network parameters.

Fig. 7: The high-end network switch that will enable the data flow in the experiment.

Work for the next 2-3 months :

We will finish the various PCIe-related tests and proceed to the procurement of the EBDC and SEB machines.

Issues:

We continue to work on hiring a new member of the sPHENIX BNL DAQ group to replace a group member that retired last year.

WBS 1.7 Minimum Bias Trigger Detector (L2 Manager: Mickey Chiu, BNL)

Current Status:

Nevis has received the 2nd prototype of the Disc/Shaper board. The assembly kit is being prepared and will be sent out in July. We should be able to get started on testing this board in August. Work continues with the infrastructure and integration engineers to design the mechanical support and cable routing for the MBD. We have recruited two new university groups, Howard Univ. and Florida A&M Univ., to help with electronics testing, particularly with the production testing of the final D/S boards.

Work for Next 2-3 Months:

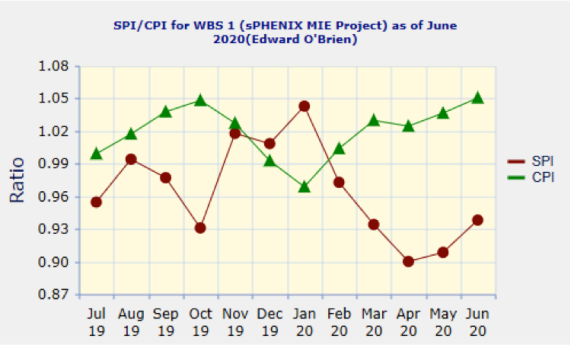
We expect the fully assembled board in August for testing. The FPGA coding for the disc/shaper board will be written ahead of time so that we can get started as soon as the board arrives. We will continue developing the trigger algorithm and how to best implement it. We will continue discussions on the details of what is needed for integration into sPHENIX (cabling, power, electronics racks, etc).

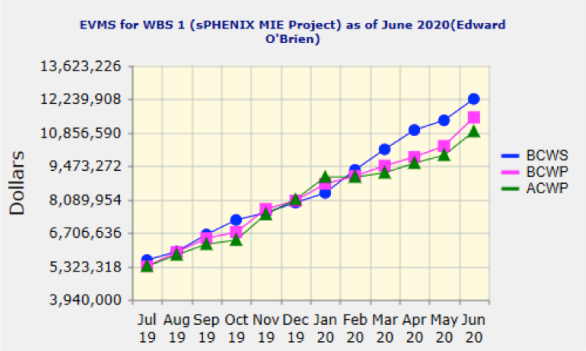
Issues:

Fortunately, Nevis Labs is back open for Nevis employees. However, outside visitors are prohibited. This will require that Nevis engineers and scientists take the lab data, without help from BNL or our

university collaborators on the MBD. BNL will still be able to do anything that can be done remotely, such as analyze the test data and provide feedback.

Performance Indices and Earned Value Data





BAC: $22,198,743 EAC: $23,082,400 VAC: ($883,657)

Cumulative SPI	Cumulative CPI
0.94	1.05

Cumulative BCWS (Scheduled)	$12,239,924
Cumulative BCWP (Performed)	$11,473,560
Cumulative ACWP (Actual)	$10,894,800

DOE SPI or CPI Value Thresholds
- 0.90 to 1.15
- 0.85 to 0.89 or 1.16 to 1.25
- <0.85 or >1.25

June 2020 Cost Performance Report

8. PERFORMANCE DATA

CA (3) ITEM (1)	CUMULATIVE TO DATE: BUDGETED COST WORK SCHEDULED (7)	BUDGETED COST WORK PERFORMED (8)	ACTUAL COST WORK PERFORMED (9)	VARIANCE SCHEDULE (10)	VARIANCE COST (11)	AT COMPLETION: BUDGETED (14)	ESTIMATED (15)	VARIANCE (16)	SPI	CPI
1.01A Project Management	1,693,245	1,693,245	1,544,799	0	148,446	1,951,679	1,803,232	148,446	1.00	1.10
1.02A TPC	2,240,067	1,697,153	1,673,727	-542,914	23,426	4,180,135	4,158,734	21,401	0.76	1.01
1.03A EMCal	3,662,345	3,481,395	3,514,453	-180,950	-33,058	5,255,094	5,593,674	-338,580	0.95	0.99
1.04A HCal	1,992,450	1,928,367	1,648,603	-64,082	279,764	4,033,110	4,107,747	-74,638	0.97	1.17
1.05A Calorimeter Electronics	2,310,655	2,251,425	2,159,554	-59,230	91,871	5,363,466	6,071,680	-708,213	0.97	1.04
1.06A DAQ & Trigger	242,014	322,827	275,360	80,813	47,467	1,245,090	1,198,007	47,084	1.33	1.17
1.07A MinBias Trigger Detector	99,148	99,148	78,304	0	20,844	170,170	149,326	20,844	1.00	1.27
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	12,239,923	11,473,560	10,894,800	-766,363	578,760	22,198,743	23,082,400	-883,657	0.94	1.05
f. Contingency						4,801,257				
g. TOTAL	12,239,923	11,473,560	10,894,800	-766,363	578,760	27,000,000				

$12,187,599	ETC
$10,725,183	BCWR
44.77%	% Contingency on Remaining Work
39.39%	% Contingency on ETC
55.14%	% Planned
51.69%	% Complete
49.08%	% Spent

DOE SPI or CPI Value Thresholds
- 0.90 to 1.15
- 0.85 to 0.89 or 1.16 to 1.25
- <0.85 or >1.25

*Highlights in table above takes variance $ into consideration, not just Indices

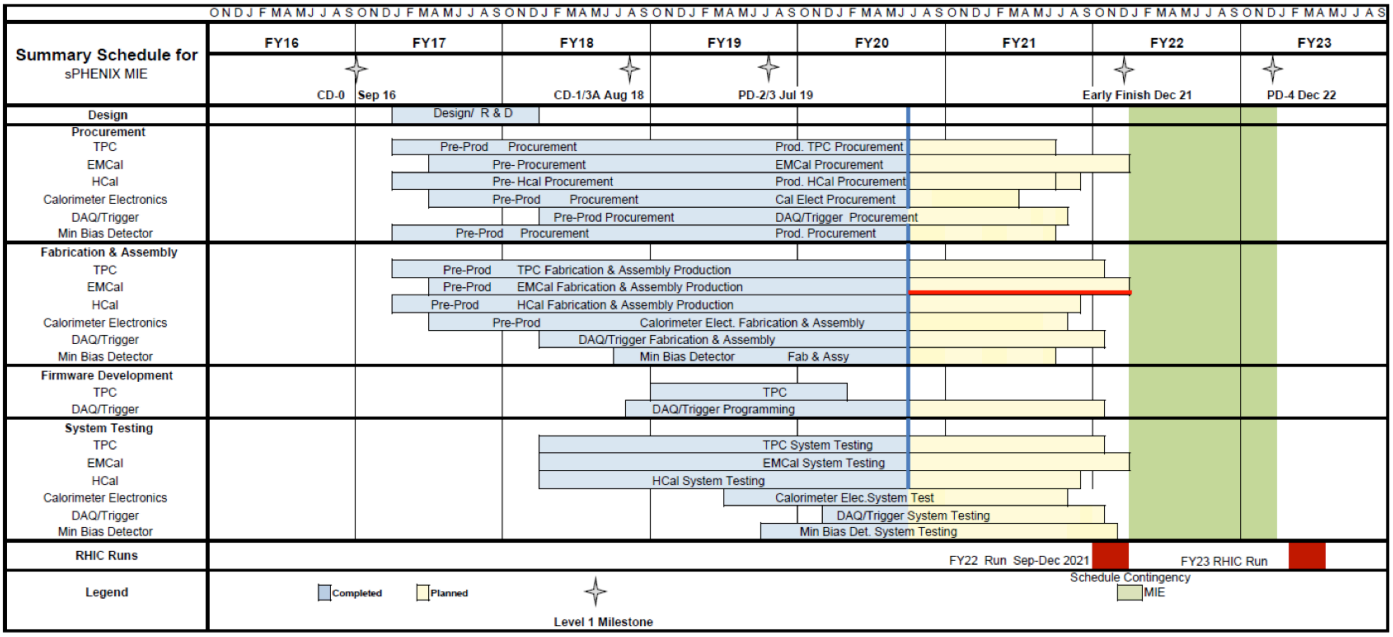
L1 & L2 Milestones

#	WBS	Milestone Name	Target Milestone Date	Forecast	Actual Finish	Variance (in work days)
1	1.01.01	Approve Project Baseline and Construction PD2/3	30-Sep-19	20-Sep-19 A	20-Sep-19	6
2	1.02.02.02	Production Readiness Review - TPC Module Factories	31-Dec-19	17-Dec-19 A	17-Dec-19	8
3	1.03.02.03.02	EMCal Preproduction Sector 0 Assembled	31-Dec-19	25-Nov-19 A	25-Nov-19	23
4	1.02.06.02	Production Readiness Review - TPC DAM	28-Feb-20	04-Feb-20 A	4-Feb-20	16
5	1.05.02.03	HCal Preproduction FEE Complete	30-Apr-20	22-Jan-20 A	22-Jan-20	70
6	1.05.02.01	EMCal Electronics Preproduction Complete	29-May-20	28-May-20 A	28-May-20	0
7	1.03.01.03.01	EMCal W Powder Acquisition Complete	30-Jun-20	15-Jun-20 A	15-Jun-20	11
8	1.03.02.03.03	EMCal Production Readiness Review Blocks/Modules/Sectors Complete	31-Jul-20	21-Aug-20		-16
9	1.02.05.03	SAMPA ASIC Performance Accepted	30-Sep-20	29-May-20 A	29-May-20	86
10	1.05.01	EMCal/HCal SiPM Sensor Procurement Complete	30-Oct-20	28-Feb-20 A	28-Feb-20	171
11	1.05.02.04	HCal SiPM Boards Assembly Complete	30-Nov-20	15-Jan-21		-33
12	1.02.06.03	TPC DAM Felix 2.0 Production Complete	29-Jan-21	28-May-21		-85
13	1.06.02.03	Trigger LL1 Preproduction complete	26-Feb-21	16-Mar-21		-13
14	1.05.02.02	EMCal SiPM Boards Production Complete	31-Mar-21	30-Sep-20		121
15	1.04.04.02	First Outer HCAL Sector and Splice Plates Ready to Install	30-Apr-21	16-Nov-20		112
16	1.04.01	Inner HCAL Support Structure Ready for Installation	30-Apr-21	6-Apr-21		17
17	1.02.01.06	GEM Production Complete	31-May-21	26-Feb-21		65
18	1.03.01.03.01	EMCal Scintillating Fiber Acquisition Complete	31-May-21	3-Mar-21		62
19	1.06.01.03	DAQ Production: DAQ Ready for Operation	31-May-21	27-Oct-21		-104
20	1.05.02.04	HCal Electronics Complete: Production	30-Jun-21	5-Aug-21		-26
21	1.02.05.04	TPC FEE Production Complete	30-Jul-21	15-Jul-21		10
22	1.05.03.02	Calorimeter Electronics Complete	30-Jul-21	5-Aug-21		-5
23	1.05.02.02	EMCal Electronics Complete	30-Jul-21	16-Mar-21		95
24	1.07	MinBias Detector Ready to Install	30-Sep-21	16-Nov-21		-32
25	1.06.03.03	GL1 Ready to Operate	30-Sep-21	13-Oct-21		-9
26	1.01.01	Early Project Completion	29-Oct-21	22-Dec-21		-35
27	1.02.01.08	TPC Ready to Install (Assembly Complete)	29-Oct-21	27-Oct-21		1
28	1.02.06.03	TPC DAM Production Complete	29-Oct-21	6-Oct-21		15
29	1.03.02.03.03	EMCal Ready to Install	29-Oct-21	21-Dec-21		-35
30	1.04.04.02	Last Outer HCAL Sector Ready to Install	29-Oct-21	17-Sep-21		28
31	1.06.02.04	LL1 Trigger Production Complete	29-Oct-21	5-Oct-21		16
32	1.06.02.04	LL1 Ready to Operate	29-Oct-21	5-Oct-21		16
33	1.01.01	Approve Project Closeout PD-4	30-Dec-22	29-Dec-22*		0

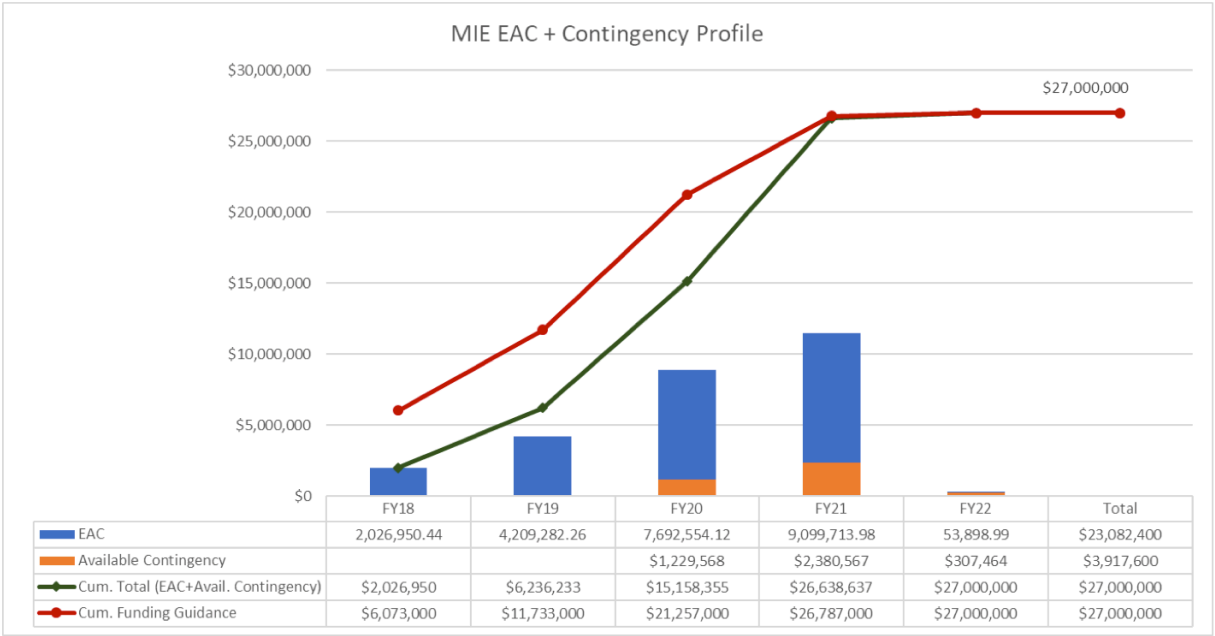
sPHENIX Budget Baseline Profile:

Funding Profile At Year k$								
	Prior Yrs	**FY17**	**FY18**	**FY19**	**FY20**	**FY21**	**FY22**	**Total**
R&D		1,513	4,260	350				**6,123**
CDR		100	200					**300**
PED								
Pre-ops								
OPC (R&D+CDR)		**1,613**	**4,460**	**350**				**6,423**
TEC				**5,310**	**9,524**	**5,530**	**213**	**20,577**
Total Project Cost		**1,613**	**4,460**	**5,660**	**9,524**	**5,530**	**213**	**27,000**

Summary Schedule



Estimate at Completion Profile



	FY18	FY19	FY20	FY21	FY22	Total
EAC	2,026,950.44	4,209,282.26	7,692,554.12	9,099,713.98	53,898.99	$23,082,400
Available Contingency			$1,229,568	$2,380,567	$307,464	$3,917,600
Cum. Total (EAC+Avail. Contingency)	$2,026,950	$6,236,233	$15,158,355	$26,638,637	$27,000,000	$27,000,000
Cum. Funding Guidance	$6,073,000	$11,733,000	$21,257,000	$26,787,000	$27,000,000	$27,000,000

BAC	$22,198,743
Contingency	$4,801,257
TPC	$27,000,000

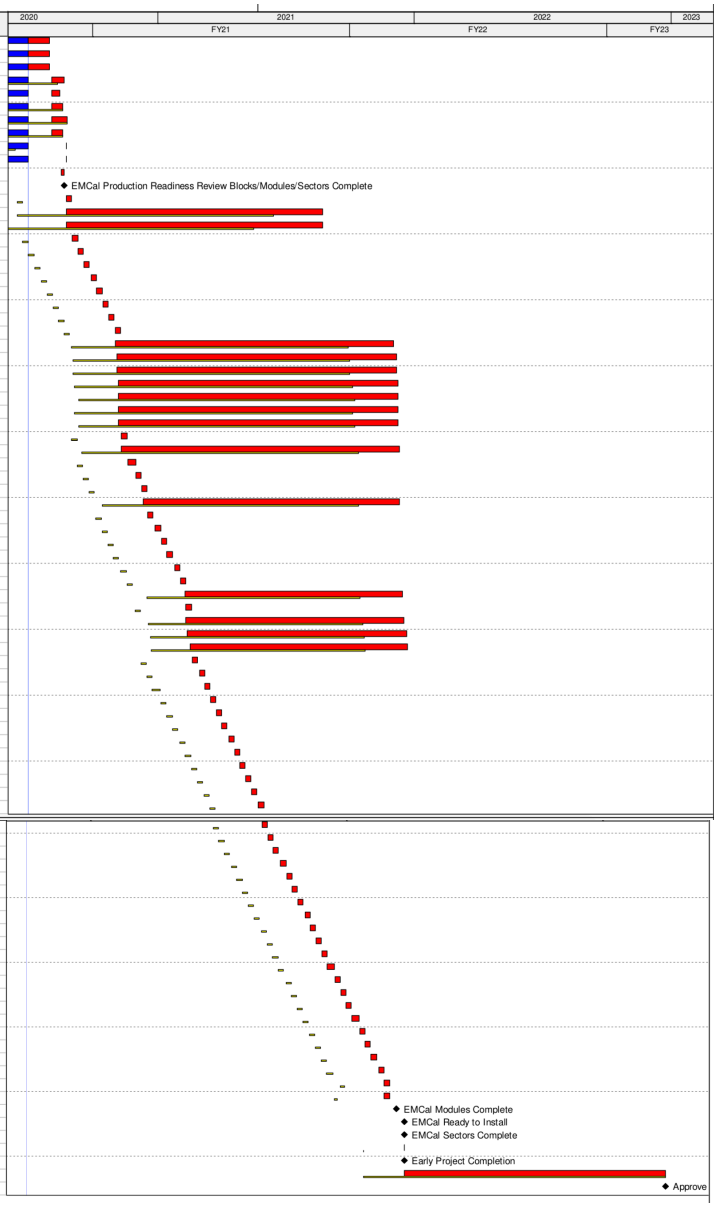
EAC	$23,082,400
Available Contingency	$3,917,600
Total (EAC+Avail Contingency)	$27,000,000

Baseline/Contingency Log

Baseline/Contingency Log - sPHENIX MIE Project							
Date	PCR ID	PCR Title	WBS affected	sPHENIX MIE Baseline Cost	PCR Change	Contingency	Total Project Cost
9/20/2019	Approved MIE	Setting up Baseline	all	$22,169,490		$4,830,510	$27,000,000
9/24/2019	007A	Hcal Scin Tiles placed Contract delivery schedule	1.04 HCal	$22,132,844	($36,646)	$4,867,156	$27,000,000
1/31/2020	008A	OHCal Sci.Tiles delivery schedule update	1.04 HCal	$22,132,943	$100	$4,867,056	$27,000,000
2/27/2020	009A	Extending the lead time for IHCal Support Rings	1.04 HCal	$22,132,943	$0	$4,867,056	$27,000,000
3/31/2020	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
4/28/2020	013A	EMCal Block assembly contract details schedule update	1.03 EMCal	$22,195,549	$ 1,736	$4,804,451	$27,000,000
5/27/2020	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
6/19/2020	015A	COVID-19 Schedule Adjustment	all	$22,198,743	$ 21,780.00	$4,801,257	$27,000,000

Critical Path

WBS Path	Activity ID	Activity Name	At Completion Duration	Start	Finish
01.03.02.03.02	S193600	Build mechanical enclosure for Prepro Sectors 1-12	180	13-Nov-19	31-Jul-20
01.03.02.03.02	S193710	Build mechanical stand/support for Prepro Sectors 1-12 - M&S	180	13-Nov-19	31-Jul-20
01.03.02.03.02	S193700	Build mechanical stand/support for Prepro Sectors 1-12 - Labor	179	14-Nov-19	31-Jul-20
01.03.02.03.02	S193900	Install modules in Prepro Sectors 1-12	115	11-Mar-20	20-Aug-20
01.03.02.03.03	S194500	Revise sector assembly procedure based on preproduction Sector 1-12 fabricatio	107	17-Mar-20	14-Aug-20
01.03.02.03.02	S194000	Install readout electronics on Prepro Sectors 1-12	104	24-Mar-20	18-Aug-20
01.03.02.03.02	S194200	Test and Review Preproduction Sectors 1-12 with LEDs & cosmic rays	109	24-Mar-20	25-Aug-20
01.03.02.03.02	S194100	Install cables and cooling system on Prepro Sectors 1-12	103	25-Mar-20	18-Aug-20
01.03.01.03.01	S171700	Procure EMCAL Epoxy for Final Blocks- Contract/PO - Leadtime	79	01-May-20	24-Aug-20
01.03.01.03.01	S172400	Order parts and fabricate molds for EMCal Sectors 13-64 Blocks - Contract/PO -	79	01-May-20	24-Aug-20
01.03.02.03.03	S194600	Production Readiness Review - EMCal Sectors 13-63	5	17-Aug-20	21-Aug-20
01.03.02.03.03	S194700	EMCal Production Readiness Review Blocks/Modules/Sectors Complete	0		21-Aug-20
01.03.01.03.02	S173000	Fabricate final blocks sector 13	6	24-Aug-20	31-Aug-20
01.03.01.03.01	S171800	Procure EMCAL Epoxy for Final Blocks - Delivery Acceptance	250	24-Aug-20	23-Aug-21
01.03.01.03.01	S172500	Order parts and fabricate molds for EMCal Sectors 13-64 Blocks - Delivery Accep	250	24-Aug-20	23-Aug-21
01.03.01.03.02	S173100	Fabricate final blocks sector 14	6	01-Sep-20	09-Sep-20
01.03.01.03.02	S173200	Fabricate final blocks sector 15	6	10-Sep-20	17-Sep-20
01.03.01.03.02	S173300	Fabricate final blocks sector 16	6	18-Sep-20	25-Sep-20
01.03.01.03.02	S173400	Fabricate final blocks sector 17	6	28-Sep-20	05-Oct-20
01.03.01.03.02	S173500	Fabricate final blocks sector 18	6	06-Oct-20	14-Oct-20
01.03.01.03.02	S173600	Fabricate final blocks sector 19	6	15-Oct-20	22-Oct-20
01.03.01.03.02	S173700	Fabricate final blocks sector 20	6	23-Oct-20	30-Oct-20
01.03.01.03.02	S173800	Fabricate final blocks sector 21	6	02-Nov-20	09-Nov-20
01.03.02.02.03	S187500	Receive, unpack, log & inspect final blocks	270	02-Nov-20	02-Dec-21
01.03.02.02.03	S187600	Install light guides on final blocks Labor	270	04-Nov-20	06-Dec-21
01.03.02.02.03	S187700	Install light guides on final blocks M&S	270	04-Nov-20	06-Dec-21
01.03.02.02.03	S187800	Install reflectors on final blocks Labor	270	06-Nov-20	08-Dec-21
01.03.02.02.03	S188000	Install SiPMs daughterboards on final blocks Labor	270	06-Nov-20	08-Dec-21
01.03.02.02.03	S187900	Install reflectors on final blocks M&S	270	06-Nov-20	08-Dec-21
01.03.02.02.03	S188100	Install SiPMs daughterboards on final blocks M&S	270	06-Nov-20	08-Dec-21
01.03.01.03.02	S173900	Fabricate final blocks sector 22	6	10-Nov-20	18-Nov-20
01.03.02.02.03	S188200	Glue final blocks together into modules	270	10-Nov-20	10-Dec-21
01.03.01.03.02	S174000	Fabricate final blocks sector 23	6	19-Nov-20	30-Nov-20
01.03.01.03.02	S174100	Fabricate final blocks sector 24	6	01-Dec-20	08-Dec-20
01.03.01.03.02	S174200	Fabricate final blocks sector 25	6	09-Dec-20	16-Dec-20
01.03.02.03.03	S196500	Install modules in final sectors	250	11-Dec-20	10-Dec-21
01.03.01.03.02	S174300	Fabricate final blocks sector 26	6	17-Dec-20	24-Dec-20
01.03.01.03.02	S174400	Fabricate final blocks sector 27	6	28-Dec-20	05-Jan-21
01.03.01.03.02	S174500	Fabricate final blocks sector 28	6	06-Jan-21	13-Jan-21
01.03.01.03.02	S174600	Fabricate final blocks sector 29	6	14-Jan-21	22-Jan-21
01.03.01.03.02	S174700	Fabricate final blocks sector 30	6	25-Jan-21	01-Feb-21
01.03.01.03.02	S174800	Fabricate final blocks sector 31	6	02-Feb-21	09-Feb-21
01.03.02.03.03	S196700	Install readout electronics on final sectors	214	08-Feb-21	14-Dec-21
01.03.01.03.02	S174900	Fabricate final blocks sector 32	6	10-Feb-21	18-Feb-21
01.03.02.03.03	S196800	Install cables & cooling system on final sectors	214	10-Feb-21	16-Dec-21
01.03.02.03.03	S196900	Test final sectors with LEDs & cosmic rays	214	12-Feb-21	20-Dec-21
01.03.02.03.03	S197000	Repair or rework any sectors as required	214	16-Feb-21	21-Dec-21
01.03.01.03.02	S175000	Fabricate final blocks sector 33	6	19-Feb-21	26-Feb-21
01.03.01.03.02	S175100	Fabricate final blocks sector 34	6	01-Mar-21	08-Mar-21
01.03.01.03.02	S175200	Fabricate final blocks sector 35	6	09-Mar-21	16-Mar-21
01.03.01.03.02	S175300	Fabricate final blocks sector 36	6	17-Mar-21	24-Mar-21
01.03.01.03.02	S175400	Fabricate final blocks sector 37	6	25-Mar-21	01-Apr-21
01.03.01.03.02	S175500	Fabricate final blocks sector 38	6	02-Apr-21	09-Apr-21
01.03.01.03.02	S175600	Fabricate final blocks sector 39	6	12-Apr-21	19-Apr-21
01.03.01.03.02	S175700	Fabricate final blocks sector 40	6	20-Apr-21	27-Apr-21
01.03.01.03.02	S175800	Fabricate final blocks sector 41	6	28-Apr-21	05-May-21
01.03.01.03.02	S175900	Fabricate final blocks sector 42	6	06-May-21	13-May-21
01.03.01.03.02	S176000	Fabricate final blocks sector 43	6	14-May-21	21-May-21
01.03.01.03.02	S176100	Fabricate final blocks sector 44	6	24-May-21	01-Jun-21
01.03.01.03.02	S176200	Fabricate final blocks sector 45	6	02-Jun-21	09-Jun-21
01.03.01.03.02	S176300	Fabricate final blocks sector 46	6	10-Jun-21	17-Jun-21
01.03.01.03.02	S176400	Fabricate final blocks sector 47	6	18-Jun-21	25-Jun-21
01.03.01.03.02	S176500	Fabricate final blocks sector 48	6	28-Jun-21	06-Jul-21
01.03.01.03.02	S176600	Fabricate final blocks sector 49	6	07-Jul-21	14-Jul-21
01.03.01.03.02	S176700	Fabricate final blocks sector 50	6	15-Jul-21	22-Jul-21
01.03.01.03.02	S176800	Fabricate final blocks sector 51	6	23-Jul-21	30-Jul-21
01.03.01.03.02	S176900	Fabricate final blocks sector 52	6	02-Aug-21	09-Aug-21
01.03.01.03.02	S177000	Fabricate final blocks sector 53	6	10-Aug-21	17-Aug-21
01.03.01.03.02	S177100	Fabricate final blocks sector 54	6	18-Aug-21	25-Aug-21
01.03.01.03.02	S177200	Fabricate final blocks sector 55	6	26-Aug-21	02-Sep-21
01.03.01.03.02	S177300	Fabricate final blocks sector 56	6	03-Sep-21	13-Sep-21
01.03.01.03.02	S177400	Fabricate final blocks sector 57	6	14-Sep-21	21-Sep-21
01.03.01.03.02	S177500	Fabricate final blocks sector 58	6	22-Sep-21	29-Sep-21
01.03.01.03.02	S177600	Fabricate final blocks sector 59	6	30-Sep-21	07-Oct-21
01.03.01.03.02	S177700	Fabricate final blocks sector 60	6	08-Oct-21	18-Oct-21
01.03.01.03.02	S177800	Fabricate final blocks sector 61	6	19-Oct-21	26-Oct-21
01.03.01.03.02	S177900	Fabricate final blocks sector 62	6	27-Oct-21	03-Nov-21
01.03.01.03.02	S178000	Fabricate final blocks sector 63	6	04-Nov-21	12-Nov-21
01.03.01.03.02	S178100	Fabricate final blocks sector 64	6	15-Nov-21	22-Nov-21
01.03.01.03.03	S178900	Pack and ship final blocks for sectors 57-64 to BNL - Purchased Services	5	23-Nov-21	01-Dec-21
01.03.01.03.03	S176010	Pack and ship final blocks for sectors 57-64 to BNL - M&S	5	23-Nov-21	01-Dec-21
01.03.02.03.03	S196600	EMCal Modules Complete	0		10-Dec-21
01.03.02.03.03	S197300	EMCal Ready to Install	0		21-Dec-21
01.03.02.03.03	S197100	EMCal Sectors Complete	0		21-Dec-21
01.01.01	S101020	Internal Project Float	0	22-Dec-21	22-Dec-21
01.01.01	S101022	Early Project Completion	0		22-Dec-21
01.01.01	S101030	WBS 1X Schedule Contingency	255	22-Dec-21	29-Dec-22
01.01.01	S101040	Approve Project Closeout PD-4	0		29-Dec-22*



Variance Analysis