sPHENIX Project Status Report – May 2021

HOST LABORATORY: BROOKHAVEN NATIONAL LABORATORY

FEDERAL PROGRAM MANAGER: ELIZABETH BARTOSZ

BHSO POINT OF CONTACT: ROBERT CARADONNA

CONTRACTOR PROJECT DIRECTOR: EDWARD O'BRIEN

1. **SCORECARD 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**	

2. **NEAR TERM MILESTONES**

The sPHENIX Project team will continue the monthly EVMS process, Change Control, and updating of the ETC. We will continue to place orders for detector components approved at PD-3. We will also continue to implement the plan to mitigate COVID-19 related delays. We have hired additional technical and engineering labor at both BNL and universities to maintain the project schedule. The schedule delays that we had experienced during the US COVID peak from November 2020 to March 2021 have not been an issue in April and May 2021.There was no change in the MIE early completion date in May. The April SPI of 0.81 improved to 0.83 in May. We expect that the SPI will continue to slowly improve over the next few months as the US COVID cases continue to diminish and vendors deliver on components that had previously been delayed. We will continue to hold Final Design Reviews and Production Readiness Reviews for any MIE components remaining to be ordered. Project Change Requests will be made as appropriate.

The TPC Al stripes will be evaporated onto the central membrane petals at SBU. GEM layers will continued to be framed and QA'ed at collaborating institutions Wayne State, Weizmann, Vanderbilt and Temple. Quad-GEM Modules will begin to be assembled at SBU. The field cage pieces will begin assembly into the final full unit at SBU. The full of production TPC Front End Electronics will be ordered pending a successful completion of preproduction Fee testing at BNL. Reviews of the laser system (design and safety) will occur in the coming months.

Production of EMCal blocks for Sectors 13-64 will continue at UIUC. The current rate of block production is at a pace that will allow the completion of all of the blocks by the end of 2021. Production of the high rapidity blocks for Sectors 13-64 will also continue at Fudan. They are being produced at a rate that will keep up with module production and sector assembly at BNL. EMCal Module production and Sector assembly will continue at BNL. Sector testing will also continue including testing of all sectors using cosmic rays.

Inner HCal Sector assembly at BNL will begin in earnest in the late-July/early-August time frame, driven by the availability of components and labor. Over the next few weeks we will complete the electronics burn-in of the Outer HCAL sectors prior to installation in 1008.

Calorimeter electronics work over the next three months will be focused on the continued testing of assembled EMCal and HCal sectors and design and construction of racks for on-detector electronics. This work includes the completion of testing of EMCal SiPM boards and preamps, testing of the first digitizer racks, assembly of the LV distribution system, and production of the digitizer system. We will place the order for external power and communication cables.

The delivery of more computer racks for the DAQ/Trigger is expected in a few weeks. It will take some time to install and set up the hardware, and then set up the networks and install the operating system on the PCs. Concurrently, we will work on the preparations for the slice test and finalize the engineering for the HVAC "hot box" that will help with thermal management.

The Min Bias Detector group will perform the chain test and other tests with the prototype MBD electronics. We are continuing to work on simulations for the trigger study, as part of the training for the FAMU and Howard grad students. We plan to bring them to BNL to actively help with the electronics testing this summer. After the testing is complete, we will let Nevis know if there are any final tweaks that need to be made to the electronics design.

3. **STATUS HIGHLIGHTS**

Production components for the sPHENIX detector continue to arrive. Recent project activities are primarily associated with production and assembly of final detector components. The early completion date for sPHENIX did not change in May. The MIE early completion date is the first week of Feb 2022. Ten months and three weeks of schedule contingency to the PD-4 date remains. The project cost performance remains excellent. EVMS processing was completed for May. Cobra and P6 monthly reports uploaded to IPD. The variance reports were approved. The project is 75.1% complete in May with a 34.6% contingency on the ETC. As of May, $3.9M is committed in outstanding contracts.

All TPC GEM foils are in the hands of the TPC GEM factories (Wayne State, Weizmann, Vanderbilt, Temple) that are producing GEMs at greater than required yield (80% required 93% typical). All R1/R2/R3 pad planes delivered, stuffed, QA inspected. Good progress is made toward the slice test as the DC power system is complete and ready. All items are in place and successful communication with the Fee board has been established in preparation for full readout. The TPC central tube for the assembly cart is delivered. The final revisions to the TPC FEE design are underway and will enable the production cycle to proceed in the near future. Present delivery of fully tested/characterized SAMPA chips has now exceeded the baseline need. Because the yield exceeded expectations, extra chips can be considered for use in future upgrades.

UIUC continues to produce EMCal blocks at a consistently high rate. As of the end of May 60.1% of the blocks are complete and tested, with only 8.6% of the blocks not yet begun any of the production steps. The rate of bad blocks remains at around 3%. The block production rate is now consistently above 60 blocks per week. In April there was a nationwide shortage of epoxy that especially affected the EMCal sector production rate, but that problem has seen considerable improvement in May. Work on module production and sector assembly

continued at BNL. We are currently finishing the modules for Sector 27 and attaching light guides and SiPM readout boards on the modules for Sectors 28. We are currently assembling Sector 26 and plan to glue the blocks into Sector 27 in early June. We have been able to find enough structural epoxy (DP-460) to continue gluing blocks. Sector testing is proceeding at a good rate. Every sector is tested for functionality both during and after assembly, and is then placed in a burn-in stand for several weeks to look for longer-term problems.

ISU has contracted with a local machine shop to produce the iHCAL sectors. The delivery schedule has been coordinated with Rutgers to ensure that the parts provided by them will arrive well in advance of when they are needed for assembly. The Rutgers shops have completed all the absorber end plates and electronics shelves. The first inner HCAL sector was assembled and passed inspection May 19th. The first set of 8 iHCAL sectors were shipped to BNL in June. Assembly of the last Outer HCAL sector was completed in March. The focus of the activity in the BNL HCal factory has now shifted to burn-in tests of the sectors. As of the first week in June seven sectors have been completed with eleven additional sectors under test.

All on detector electronics and cables for the EMCal and HCal have been received. Testing of both the EMCal SiPM daughterboards and preamps continues with a high yield rate. The first 32 EMCal sectors of SiPM daughter boards has been completed and testing of the balance is in progress at the rate of 2 sectors per week which meets the EMCal delivery schedule. The University of Lehigh group has restarted testing of the EMCal preamps and expects to deliver enough tested preamps for 1 EMCal sector each week. All major components for the EMCal and HCal Bias and LV distribution systems have been delivered to BNL. Procurement documentation for the EMCal and HCal signal cables has been submitted to BNL procurement office and the procurement plan as provided by BNL PPM indicates a contract award in early July. Delivery of the remaining 80% of the digitizer parts are on schedule to be delivered to Columbia Univ over the next 3 months. The Colorado group continues to refine the testing and documentation process for the digitizer boards with the first delivery of tested modules scheduled for early June. The first HCal digitizer and control rack for installation was assembled and is being prepared for testing.

Work on the setup for the TPC "slice test" has continued. The firmware development continues on the clock fan-out board. The development of the successor of the clock fan-out board, which will give us the full complement of 24 transceivers, is in progress.

The prototype MBD Discriminator/Shaper electronics for the chain-test was shipped from Columbia Univ to BNL and the test stand is being assembled at BNL. The contract to fab the production MBD D/S boards is with BNL Procurement and is waiting to be placed with Columbia University.

WBS 1.1 Project Management (L2 Manager: Irina Sourikova)

Current Status:

- SPI is 0.83, CPI is 1.02.

Highlights:

- Schedule performance improved in May.
- EVMS processing complete.
- Cobra and P6 monthly reports uploaded to IPD.
- Variance reports approved.

Plans for the next 2-3 month:

- Continue monthly EVMS process and Change Control.

Issues:

- None

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

Current Status:

All GEM foilds are in the hands of the factories (Wayne State, Weizmann, Vanderbilt, Temple) that are producing framed GEMs at greater than required yield (80% required 93% typical). All R1/R2/R3 pad planes delivered, stuffed, QA inspected.

Good progress is made toward the TPC Fee slice test as the DC power system is complete and ready. All test stand components are in place and successful communication has been established in preparation of full readout.

TPC "Pockets" are fully delivered and the central tube for the assembly cart is delivered. No further outside pieces are required and assembly is ongoing in the SBU shop.

The final revisions to the TPC FEE layout are under way. The TPC Fee board production cycle will start soon.

Present delivery of fully tested/characterized SAMPA chips has now exceeded the baseline need. Because the yield exceeded expectations, extra chips can be considered for use in future upgrades.

Work Anticipated 2-3 Months

The TPC Al stripes will be evaporated onto the central membrane petals at SBU. GEM layers will continued to be framed and QA'ed at collaborating institutions Wayne State, Weizmann, Vanderbilt and Temple. Quad-GEM Modules will begin to be assembled at SBU. The field cage pieces will begin assembly into the final full unit at SBU. The full of production TPC Front End Electronics will be ordered pending a successful completion of preproduction Fee testing at BNL. Reviews of the laser system (design and safety) will occur in the coming months.

Issues

None

COVID-related Issues

None

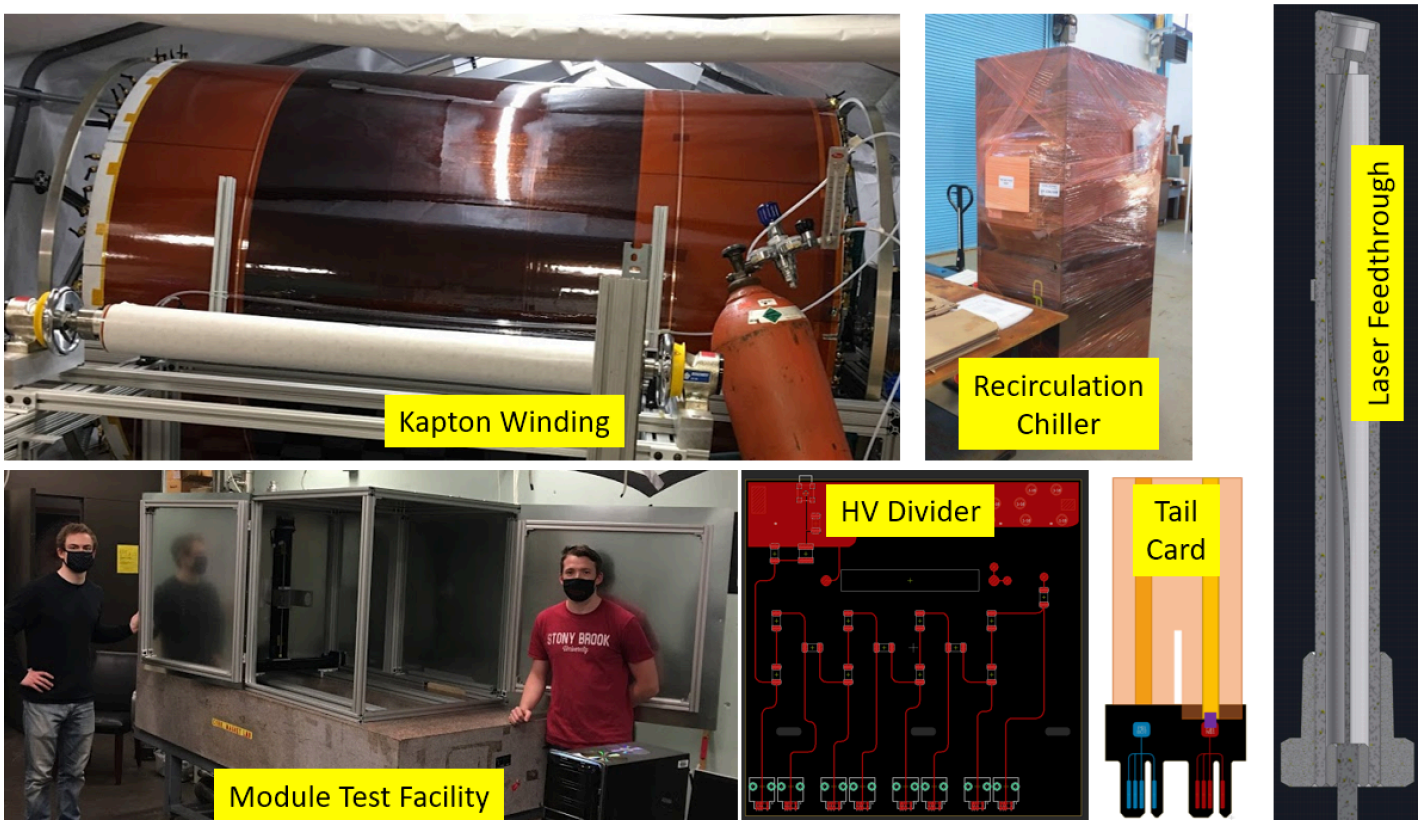


Figure 1: Clockwise from upper left: Kapton insulating layer being added to the Outer Field Cage. Recirculation chiller for the TPC Fee cooling system. Laser feedthrough for optical fiber in TPC gas volume. GEM foil "tail card" used to distribute HV to GEM modules. HV divider for quad GEM modules. GEM module test facility. .

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

Current Status:

Figure 2 shows the overall status of block production at UIUC as of the end of May. It shows the number of completed blocks, the number that have been shipped to BNL, the number of Sector 13-64 blocks to be started, the number of fiber sets completed and available for assembly, and other blocks at various stages of production. The rate of bad blocks remains at around 3%.

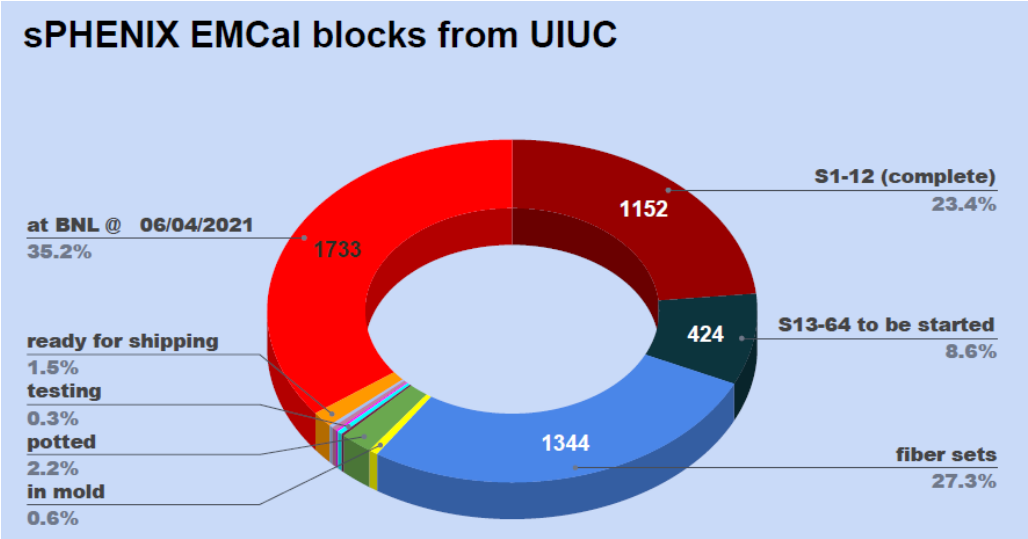


Figure 2. Status of block production at UIUC as of the end of May.

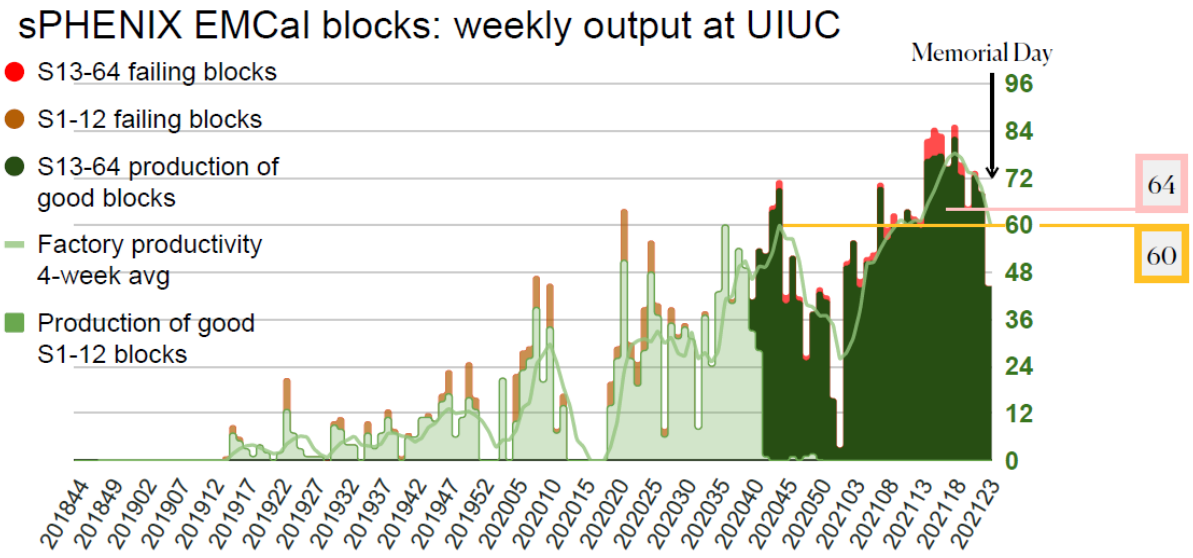


Figure 3. Weekly rate of block production at UIUC (moving average over 4 weeks; note that the last bin does not include 4 full weeks).

Figure 3 shows the weekly rate of block production at UIUC. The production rate is now consistently above 60 blocks per week. The rate required to complete all of the block production by the end of this year is 64 blocks per week and it looks like we will be able to maintain this rate if no unforeseen issues occur. One issue could be the availability of epoxy, which has been difficult to obtain due to a nationwide shortage. This situation seems to be improving.

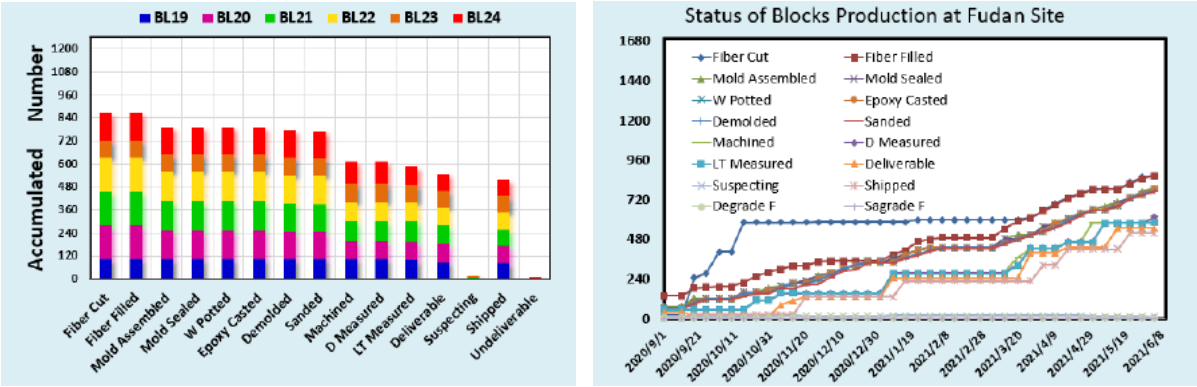


Figure 4. Status of block production at Fudan as of the end of May.

Block production also continued at Fudan. Figure 4 shows the status of blocks produced as of the end of May. Six batches of 96 blocks have been shipped to BNL and another batch is scheduled to be shipped around the middle of June. Thirty-six more blocks are currently being tested, 66 more blocks have been cast and an additional 106 blocks are being machined.

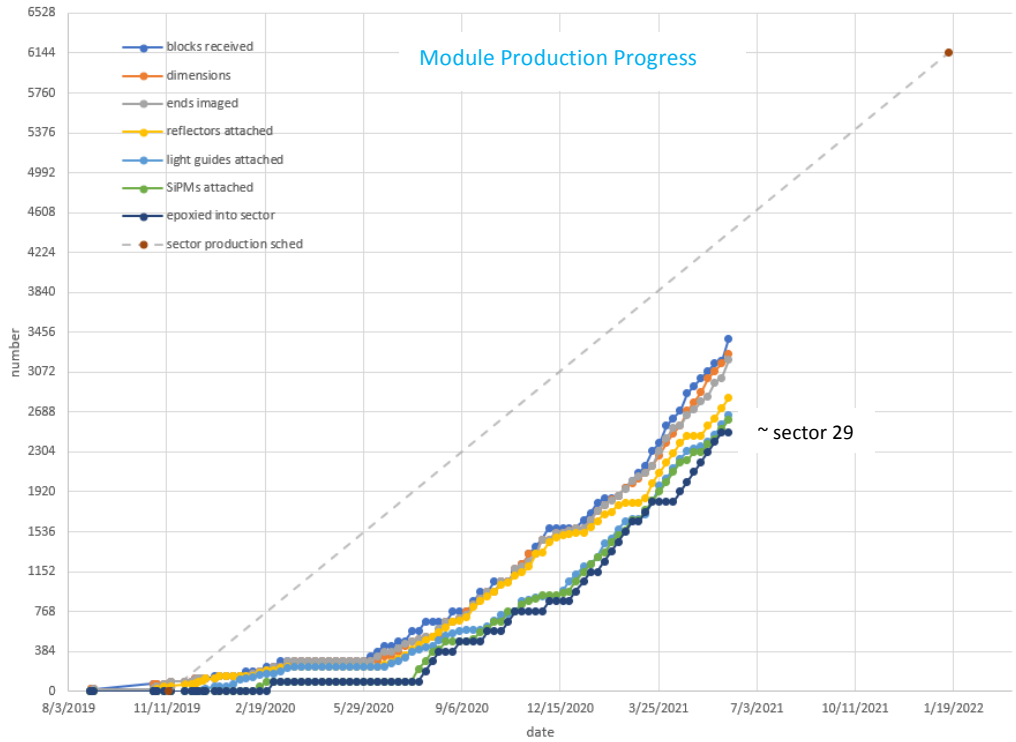


Figure 5: Status of module production at BNL as of the end of May.

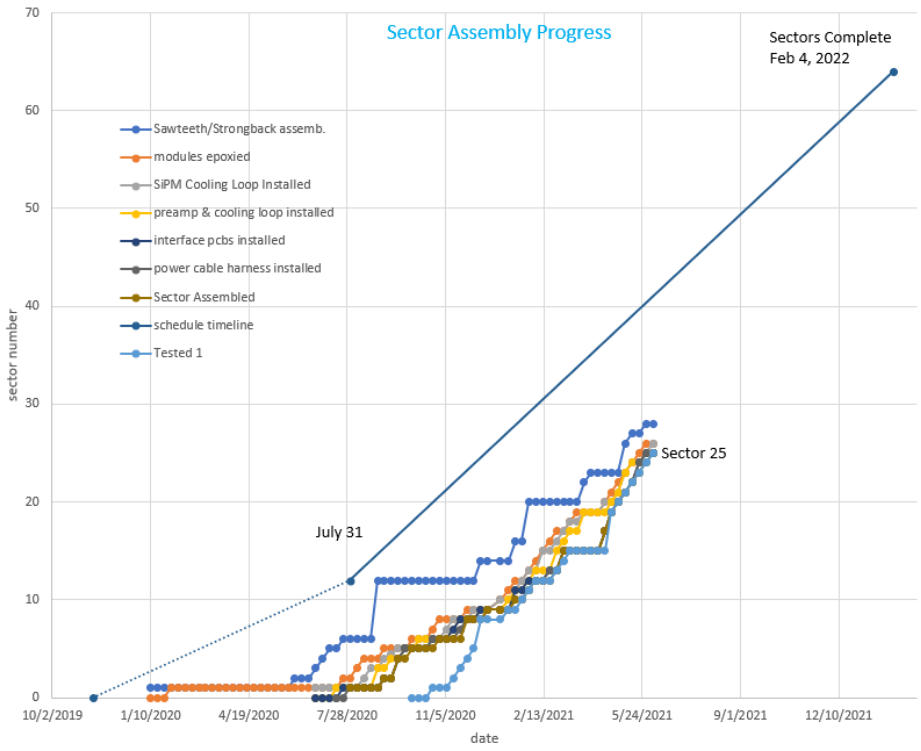


Figure 6: Status of sector assembly at BNL as of the end of May.

Work on module production and sector assembly continued at BNL. We have received a total of 48 shipments of blocks from UIUC and 6 shipments from Fudan, which gives us enough complete sets of blocks for up Sector 33. Figure 5 shows the status of the various stages of module production as of the end of May. We are currently finishing the modules for Sector 27 and attaching light guides and SiPM readout boards on the modules for Sectors 28. We have enough light guides for up to Sector 45 and additional light guides continue to come in at a steady pace.

Figure 6 shows the status of sector assembly. We are currently assembling Sector 26 and plan to glue the blocks into Sector 27 in early June. We have been able to find enough structural epoxy (DP-460) to continue gluing blocks and the nationwide shortage of epoxy seems to be easing. We have enough preamp assemblies on hand for up to Sector 29 and more should become available as needed.

Sector testing is also proceeding. Every sector is tested for functionality both during and after assembly and is then placed in a burn-in stand for several weeks to look for longer-term problems. In addition, several sectors have been tested using cosmic rays, which showed that we are able to obtain a minimum ionizing peak in a single block with about 2 days of cosmic ray data taking. An example of this is shown on the left in Fig. 7 for Sector 4.

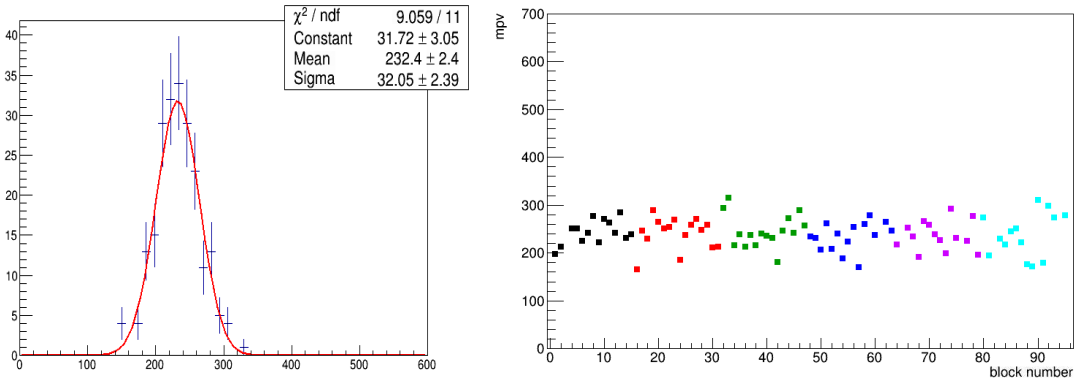


Figure 7: Left: Minimum ionizing spectrum from cosmic rays for a block in Sector 4. Right: MIP peak for each block in Sector 4.

Being able to obtain a MIP peak in a single block allows the possibility to calibrate each block using cosmic rays as shown on the right in Fig. 7. We now plan on measuring all sectors in our cosmic ray test stand. From this data we also discovered that there is a difference in the light output for blocks made using Kuraray fibers (which is the case for some blocks produced at Fudan) versus blocks made using Saint-Gobain fibers (all UIUC blocks and some Fudan blocks are made with SG fibers). This is shown in Figure 8 for Sector 17 where the high rapidity blocks made with Kuraray fibers show ~ 50% higher light output than the blocks made with SG fibers. However, this is not a problem and can be corrected for in our calibration procedure.

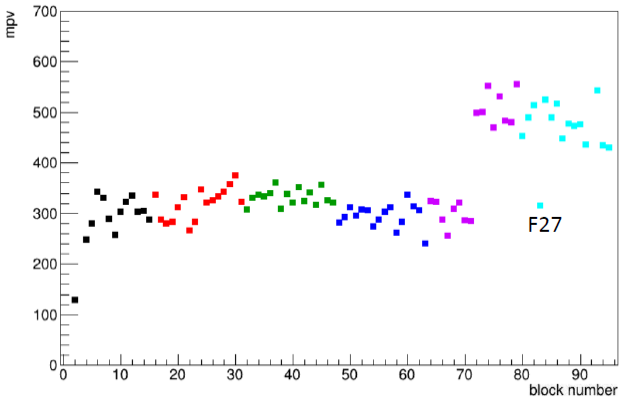


Figure 8. MIP peaks in each block for Sector 17 where the group of blocks on the left of the plot were made with Saint-Gobain fibers and the blocks on the right were made with Kuraray fibers which show higher light output (note that the block labeled F27 was also made with SG fibers).

Work For the Next 2-3 Months:

Production of blocks for Sectors 13-64 will continue at UIUC. The current rate of block production is at a pace that will allow the completion of all of the blocks by the end of 2021. Production of the high rapidity blocks for Sectors 13-64 will also continue at Fudan and is at a rate that should keep up with module production and sector assembly at BNL.

Module production and sector assembly will continue at BNL. We should have enough mechanical and electronic components to keep up with our current production schedule. At the present time we also have enough structural epoxy to continue with production and it appears that the problem with obtaining the structural is easing. Sector testing will also continue including testing of all sectors using cosmic rays.

Issues:

We currently have enough structural epoxy to continue producing sectors and the recent nationwide shortage of epoxy seems to be easing.

We lost one of our technicians who returned to CAD and we are currently down to only 5 production techs as opposed to the 6 that we have had for the past five months. We are looking to add one additional tech to the EMCal factory crew at BNL.

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

WBS 1.4.1 Inner Hadronic Calorimeter

Current Status:

ISU has contracted with a local machine shop to provide the iHCAL sectors. The delivery schedule has been coordinated with Rutgers to ensure that the parts provided will arrive well in advance of when they are needed for assembly. The Rutgers shops have completed all the absorber end plates and electronics shelves, which have been shipped to iHCal sector vendor, and UT Austin has shipped most of the remaining module endplates. The first inner HCAL sector was assembled and inspected May 19th, and on June 15th the first set of 8 iHCAL sectors were shipped to BNL.

Work for the Next 2-3 Months:

Sector assembly at BNL will begin in earnest in the late-July/early-August time frame, driven by the availability of components and labor. Clarity on the ability of undergraduates to work at BNL over the summer would be appreciated as they form the bulk of the labor available during the summer.

Issues:

The COVID-19 pandemic can potentially have a negative schedule impact on the inner HCAL assembly schedule due to the availability of student labor in summer 2021. It will be critical that iHCAL sector assembly proceed quickly to avoid delays in the sPHENIX installation schedule.

WBS 1.4.2/3/4 Outer Hadronic Calorimeter

Current Status:

Assembly of the last oHCAL sector was completed on March 26th, 2021. The focus of the activity in the bldg. 912 factor has now shifted to burn-in tests of the sectors now that a burn-in test rack is available; seven sectors have

been completed as of June 8th with eleven additional sectors under test. The first sectors for iHCAL barrel assembly, scheduled to start June 21st, have already been completed. Work is also underway to complete analysis of the cosmic ray and LED data and prepare the initial calibration constants for the sPHENIX offline database.

Work for the Next 2-3 Months:

Over the next few weeks we will complete the burn-in of the oHCAL sectors prior to assembly.

Issues:

Due to COVID limitations on non-BNL personnel onsite it may be difficult to have sufficient workforce in place to test sectors during oHCAL assembly. We are working with sPHENIX PM and the collaboration members providing trained personnel to attempt to alleviate this concern.

Figure 9: The first seven of eight completed inner HCAL sector in the assembly fixture at TSI in Ames, Iowa, being prepared for shipment.

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

Current Status:

All on detector electronics and cables for the EMCal and HCal have been received. Testing of both the EMCal SiPM daughterboards and preamps continues with a high yield rate. The first 32 EMCal sectors of SiPM daughter boards has been completed and testing of the balance is in progress at the rate of 2 sectors per week which meets the EMCal delivery schedule. The University of Lehigh group has restarted testing of the EMCal preamps

after the COVID shutdown and expects to deliver enough tested preamps for 1 EMCal sector each week. Students testing and preassembling EMCal preamps at the lab in Lehigh University is shown in Figure 10.

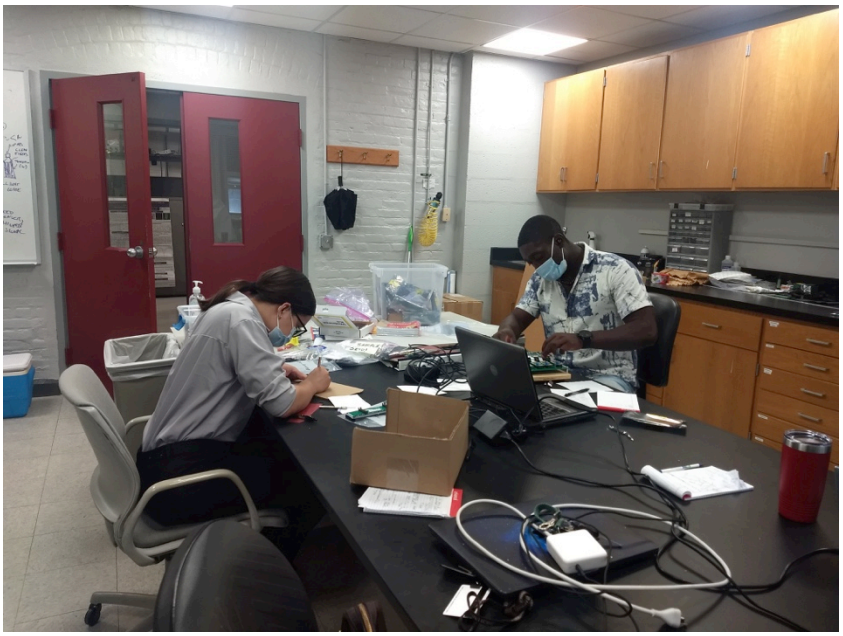


Figure 10: Lehigh students testing and doing preassembly of the EMCal preamps.

All major components for the EMCal and HCal Bias and LV distribution systems have been delivered to BNL. Work is now focused on final assembly and installation into the Power and Control racks for the EMCal and HCal.

Procurement documentation for the EMCal and HCal signal cables has been submitted to BNL procurement office and the procurement plan as provided by BNL PPM indicates a contract award in early July. Documentation and request for quotes for the power and slow control has been prepared and submitted to potential vendors.

Columbia University purchasing department has started to issue purchase orders for components needed for the production of the full digitizer electronics with 20% of the parts delivered. Delivery of the remaining parts are on schedule to be delivered over the next 3 months. The Colorado group continues to refine the testing and documentation process for the digitizer boards with the first delivery of tested modules scheduled for early June. The first HCal digitizer and control rack for installation was assembled and is being prepared for testing. The rack is shown in Figure 11 with one crate of digitizers installed, Boards for the second crate are currently being tested at Colorado University and will be shipped to BNL in early June for installation and testing.

Figure 11: First HCal Digitizer and control rack partially assembled in 1008. Once all modules are installed it will be tested and installed onto the detector.

Work for the next 2-3 months:

Work over the next 3 months will be focused on the continued testing of assembled EMCal and HCal sectors and design and construction of racks for on-detector electronics. This work includes:

1. Testing of EMCal SiPM boards and preamps
2. Test the first Digitizer racks with a full crate operational.
3. Place orders for external power and communication cables.
4. Assembly of low voltage distribution systems.
5. Production of the digitizer system
6. Rack assembly

Issues:

- COVID-19 travel and work restrictions will impact the short-term schedule for testing of delivered electronics.
- Ongoing supply chain issues for the external cables.

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

Current Status:

The work on the setup for the envisioned “slice test” has continued. We want to read out a “slice” of the eventual detector with various systems. One part of this test is the readout of more than one crate of sPHENIX calorimeter digitizers, which has become possible after a delivery of another crate worth of the units. One of the machines that will be part of the PC lineup in 2023 has been configured accordingly (Fig. 12).

Fig. 12: One of the first configured DAQ machines that will be used for data taking in 2023.

The upgrade of the rack room has continued. About 80% of the electric installation to accommodate the new computer and electronics racks has been completed.

The firmware work for the clock fan-out board, shown in Fig. 13 and reported already last month, has continued. One detector group has continued to improve the firmware and support software using the new board. This will be an ingredient in the upcoming slice test. Fig. 13 shows on the left an older assembly with the then-unassembled board and how it will go into the FPGA unit in its case. The right side shows the actual board attached to the FPGA unit being tested (not in a case).

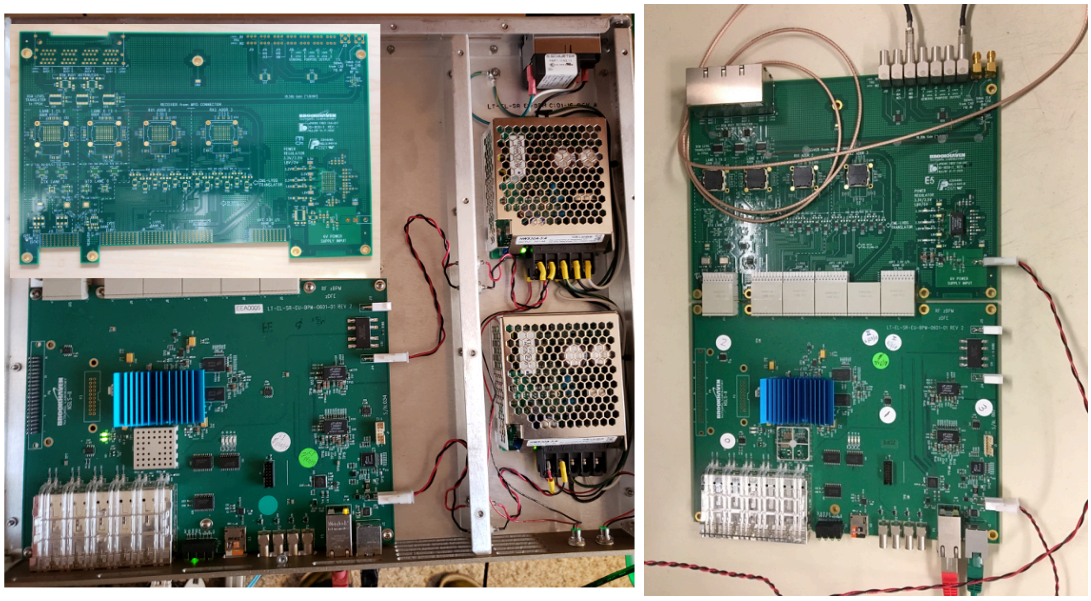


Figure 13: Left: an older “photo-shopped” assembly with the then still unassembled board and how it will go into the FPGA unit in its case. Right: the actual board attached to the FPGA unit being tested.

The development of the successor FPGA board, which will give us the full complement of 24 transceivers, is in progress. Fig. 14 shows a picture of the current layout work for the new board. We expect a prototype of this board to become available later in the September timeframe.

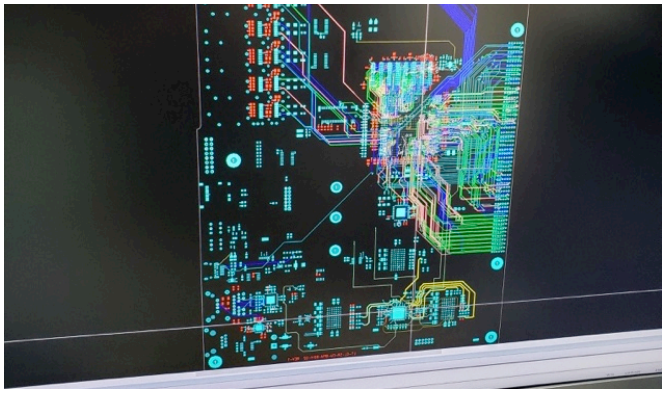


Figure 14: This picture shows the layout work for the larger FPGA board in progress. One can see the similarities with the current board shown in Fig. 13. (One needs to turn this layout by 90 degrees counterclockwise to see it.)

Work for the next 2-3 months:

The delivery of more computer racks is expected in a few weeks. It will take some time to install and set up the hardware, and then set up the networks and install the operating system on the PCs. Concurrently, we will work on the preparations for the slice test and finalize the engineering for the “hot box” that will help with thermal management.

Issues :

Two of our computer vendors experience parts shortages that are common in the tech industry at this point. One order that consists of 30 PCs and 3 racks could only assemble 23 PCs. In this case, we have accepted a partial delivery of what is available. The remaining 7 PCs will be delivered once the back-ordered parts become available.

Another vendor providing our file servers experiences a delay of 15 weeks for the delivery of 520 hard disks that are part of that order. We have negotiated the delivery of the (empty) racks that will hold the servers once those get delivered. This will allow us to complete the mechanical and electrical installation of the racks on schedule.

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

Current Status:

This month we received the prototype MBD electronics for the chain-test of the prototype MBD electronics with the BBC detector here at BNL. We are currently getting all the other components for the test stand together.

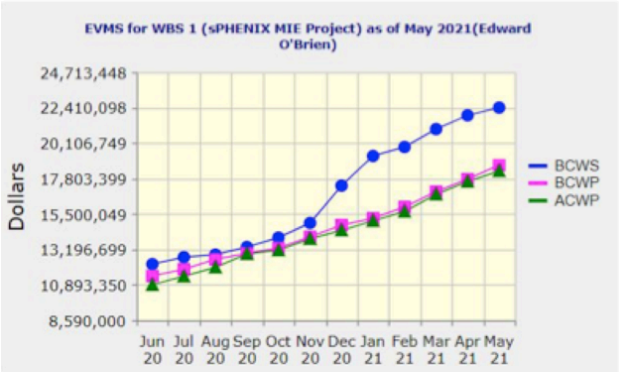
Work for Next 2-3 Months:

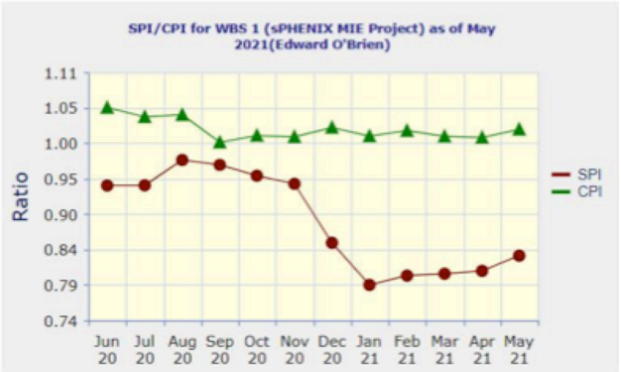
We'll do the chain test and other tests with the prototype MBD electronics. We are continuing work on simulations for the trigger study, as part of the training for the FAMU and Howard grad students. We still hope to bring them to BNL to actively help with the electronics testing this summer. After the testing is complete, we will let Nevis know if there are any final tweaks that need to be made to the electronics design.

Issues:

None

SPI and CPI Trends





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

Cumulative SPI	Cumulative CPI
0.83	1.02

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

Cumulative BCWS (Scheduled)	$22,411,549
Cumulative BCWP (Performed)	$18,673,335
Cumulative ACWP (Actual)	$18,291,928

2021

May Cost Performance Report

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

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

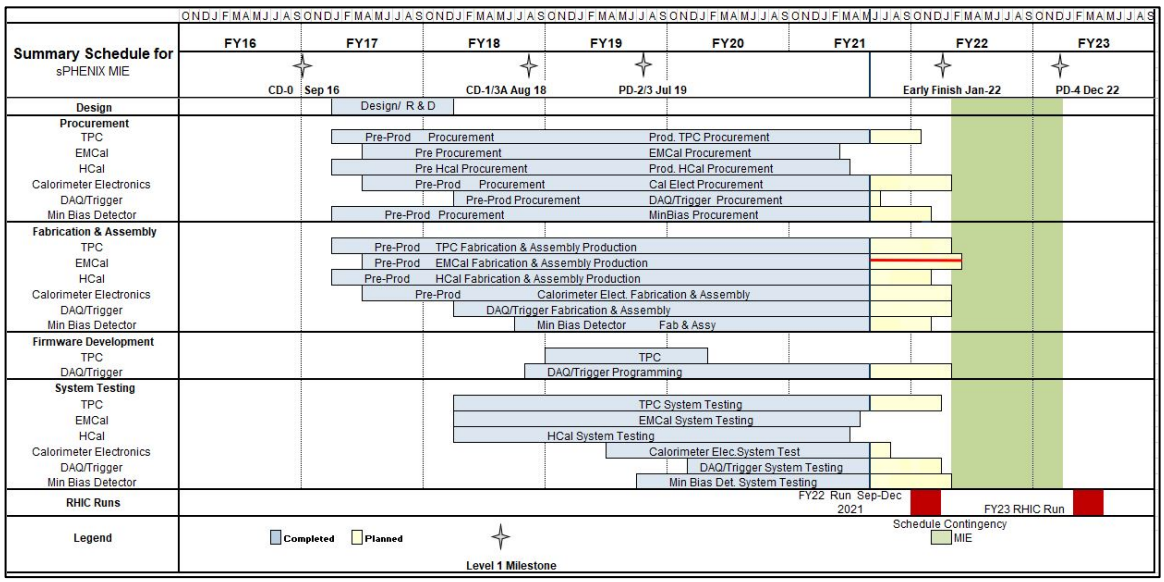
L1 & L2 Milestones

#	WBS	Milestone Name	Target Milestone Date	Forecast	Actual Finish	Variance (in work days)
1	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

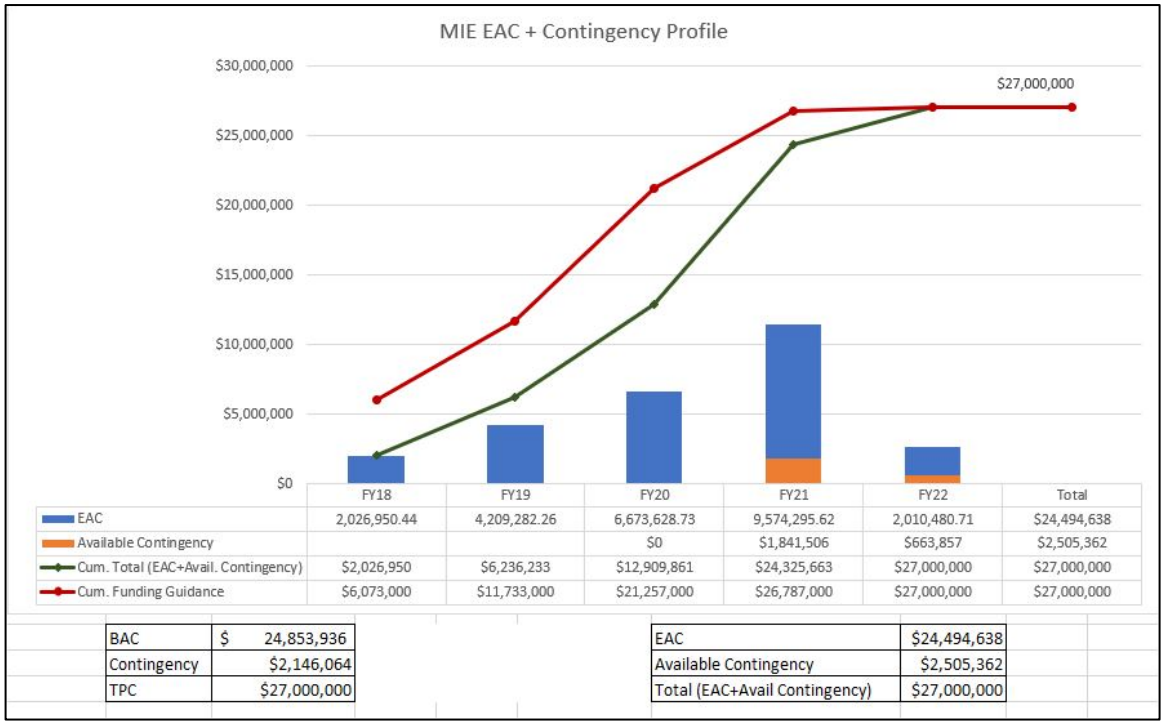
sPHENIX Budget Profile:

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 with critical path



Estimate at Completion Profile



	FY18	FY19	FY20	FY21	FY22	Total
EAC	2,026,950.44	4,209,282.26	6,673,628.73	9,574,295.62	2,010,480.71	$24,494,638
Available Contingency			$0	$1,841,506	$663,857	$2,505,362
Cum. Total (EAC+Avail. Contingency)	$2,026,950	$6,236,233	$12,909,861	$24,325,663	$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	$ 24,853,936
Contingency	$2,146,064
TPC	$27,000,000

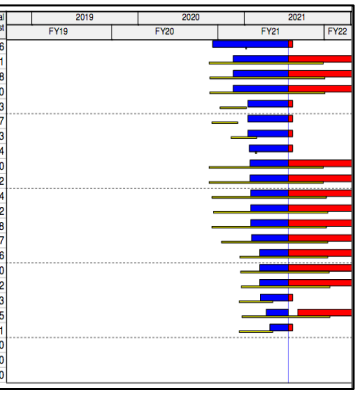
EAC	$24,494,638
Available Contingency	$2,505,362
Total (EAC+Avail Contingency)	$27,000,000

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
20.09.2019	Approved MIE	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	$ 2,111,093.00	$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

Critical Path

Activity ID	Activity Name	At Completion Duration	Total Float	Start	Finish	BL Project Start	BL Project Finish	Variance - BL Project Finish Date	Budgeted Labor Units	Budgeted Nonlabor Units	Budgeted Total Cost	BL Project Total Cost
S195400	Procure EMCAL Mechanical Parts for Final Sectors - Delivery Acceptan	187	0	14-Sep-20 A	14-Jun-21	04-Jan-21	08-Jan-21	-108	0	251357	291,746	291,746
S187500	Receive, unpack, log & inspect final blocks	295	0	23-Nov-20 A	31-Jan-22	31-Aug-20	28-Sep-21	-82	1384	0	179,682	178,031
S187800	Install reflectors on final blocks Labor	295	0	23-Nov-20 A	31-Jan-22	04-Sep-20	04-Oct-21	-78	1384	0	179,723	178,148
S187900	Install reflectors on final blocks M&S	295	0	23-Nov-20 A	31-Jan-22	04-Sep-20	04-Oct-21	-78	0	0	0	0
S196200	Build mechanical enclosures for final sectors	107	0	12-Jan-21 A	14-Jun-21	09-Oct-20	08-Jan-21	-108	720	0	84,633	84,633
S196300	Build mechanical fixtures for final sectors	107	0	12-Jan-21 A	14-Jun-21	10-Sep-20	08-Dec-20	-129	720	0	84,633	84,017
S196400	Build cooling system for final sectors	107	0	12-Jan-21 A	14-Jun-21	16-Nov-20	12-Feb-21	-84	180	0	27,303	27,303
S196100	Procure EMCAL Cooling System for Final Sectors - Delivery Acceptance	103	0	18-Jan-21 A	14-Jun-21	08-Feb-21	12-Feb-21	-84	0	70893	82,284	82,284
S187600	Install light guides on final blocks Labor	257	0	21-Jan-21 A	31-Jan-22	02-Sep-20	30-Sep-21	-80	1384	0	180,018	178,070
S187700	Install light guides on final blocks M&S	257	0	21-Jan-21 A	31-Jan-22	02-Sep-20	30-Sep-21	-80	0	1650	1,926	1,912
S188000	Install SiPMs daughterboards on final blocks Labor	259	0	22-Jan-21 A	03-Feb-22	11-Sep-20	08-Oct-21	-77	1384	0	180,039	178,304
S188200	Glue final blocks together into modules	259	0	22-Jan-21 A	03-Feb-22	15-Sep-20	13-Oct-21	-75	1384	0	180,039	178,382
S188100	Install SiPMs daughterboards on final blocks M&S	259	0	22-Jan-21 A	03-Feb-22	11-Sep-20	08-Oct-21	-77	0	300	350	348
S196500	Install modules in final sectors	257	0	26-Jan-21 A	03-Feb-22	14-Oct-20	13-Oct-21	-75	1845	0	234,726	232,867
S196700	Install readout electronics on final sectors	240	0	22-Feb-21 A	04-Feb-22	16-Dec-20	15-Oct-21	-74	1845	0	235,148	232,976
S196800	Install cables & cooling system on final sectors	240	0	22-Feb-21 A	04-Feb-22	18-Dec-20	19-Oct-21	-72	3573	0	500,103	495,600
S196900	Test final sectors with LEDs & cosmic rays	239	0	23-Feb-21 A	04-Feb-22	22-Dec-20	21-Oct-21	-70	5532	0	125,693	124,632
S229400	Test EMCal Preamp Boards: Production Sectors 13-64	76	0	26-Feb-21 A	14-Jun-21	14-Dec-20	08-Apr-21	-46	384	0	6,313	6,313
S197000	Repair or rework any sectors as required	224	0	16-Mar-21 A	04-Feb-22	23-Dec-20	22-Oct-21	-69	3921	0	252,651	250,055
S229405	Test EMCal Preamp Boards: Production Sectors 13-64 - Contributed La	55	0	29-Mar-21 A	14-Jun-21	14-Dec-20	08-Apr-21	-46	249	0	31,221	31,221
S196600	EMCal Modules Complete	0	0		03-Feb-22		13-Oct-21	-75	0	0	0	0
S197300	EMCal Ready to Install	0	0		04-Feb-22		12-Jan-22	-16	0	0	0	0
S197100	EMCal Sectors Complete	0	0		04-Feb-22		22-Oct-21	-69	0	0	0	0



Variance Analysis

sPHENIX MIE Project (Edward O'Brien [18368])
Reporting Period: 5/1/2021 - 5/31/2021

Cumulative BCWS $22,411,549
Cumulative BCWP $18,673,335
Cumulative ACWP $18,291,928

SV = -$3,738,214
CV = +$381,407

SPI = 0.8332
CPI = 1.0209

The following report discusses the major sources of schedule variance, including all items comprising 1% of the total schedule variance, plus a few select other items, and discusses the impact as well as the corrective actions taken. The analysis is done at level 3 of the Work Breakdown Structure. An accompanying Excel file shows BCWS, BCWP, SV and status for the various item noted in the following text.

WBS 1.2.1 TPC Mechanics
Description – None
Impact – None
Corrective – None

WBS 1.2.2 TPC GEM Modules R1
Description – Two activities were delayed by late arrival of TPC R1 padplanes. These are S125500 TPC R1 modules build, with SV = -$9,476 and S125600 TPC R1 Modules test, with SV = -$9,476. The total SV resulting is -$18,952. The R1 padplane, the smallest of the three types, are all delivered.
Impact – None as yet. The rest of R1 module construction is proceeding. Pad planes are to be attached to the modules as a late step in the module assembly sequence. Positive float remains.
Corrective – The two above activities are proceeding, are over 80% complete, and will not impede overall TPC construction.

WBS 1.2.5 TPC Front End Electronics.
Description – There are six activities with significant SV. They are:
activity S136500 TPC FEE Cooling System, SV = -$57,393,
activity S141500 TPC FEE Production components (optical transceivers), SV =-$22,999,
activity S141800 TPC FEE Production Components, SV = -$46,432
activity S142500 TPC FEE Low Voltage Power system, SV = -$88,238,
activity S143200 TPC FEE Production boards and assembly, SV = -$175,244,
and
activity S143250, TPC FEE components, SV = -$116,301.
The net SV is -$506,607.
Impact – None as yet.
Corrective – All the items covered by these activities are being ordered. The optical transceiver tests noted in prior months' reports have been concluded with successful outcomes. Thus, the full quantity needed of the new transceiver variant has been ordered. The required design and procurement reviews are complete. The cooling system requires a series of machined parts, for which the procurement is placed, and manufacturing is ongoing. The TPC FEE production components are on order and around 80% in hand. The TPC FEE Low Voltage power supplies are under contract and partially delivered, with the vendor scheduling all remaining deliveries over the next month. The contract for the TPC board production and assembly is awarded. Execution of this contract awaits submission of an updated board layout incorporating all changes resulting from the ongoing system test. This layout is underway.

WBS 1.2.6 TPC Data Aggregator Modules
Description – Three activities contribute to the SV:
activity S147300 FELIX 2.0 production board, SV = $30,262,
activity S147370 FELIX 2.0 board optical components, SV =-$93,719, and
activity S148400 EBDC computers and peripherals, SV =-$244,769.
Impact – None
Corrective – The EBDC computer prototype passed all tests. The production order is now awarded to a vendor. The FELIX production board order is submitted; the components are in hand and thus the activity is 80%

complete, and only board preparation and assembly remains; these activities are underway. The FELIX optical components are fiber optics and specialized connectors to group and route signals from the TPC FEE cards (WBS 1.2.5) to the FELIX boards. The topology of these connectors must accommodate a board used to reprogram the FEE cards in case of radiation-induced single event upsets (SEUs); the architecture of this board was determined at the beginning of March. This fiber topology was updated, the bill of materials for the fiber optic components was revised, and submissions started to Procurement in April. This production will require first articles be built and tested prior to releasing the full production.

WBS 1.2.7 TPC Support Systems

Description – There are three areas of effort. The TPC Lasers delivery has started but only the first articles have been delivered, SV =-$208,570. The TPC Gas System has procured and received some 60% of the components but still needs to place requisitions for the balance, SV =-$44,121. The TPC Cooling system has not started installation of equipment or controls, SV =-$25,721.

The total SV for these key items is -$278,412, again some 5% smaller than the prior month due to several components being procured during May.

Impact – These are all items being procured well ahead of their needed installation in order to allow for more time to test them on the bench and adjust settings.

Corrective – The Preliminary Design reviews are complete and all three of these subsystems have moved to acquiring first articles. Operation of the first laser under the necessary field conditions was demonstrated. The Final Design reviews and the Procurement Readiness reviews for the laser system, which has the remaining items with multi-month procurement lead times, were held in March.

WBS 1.3.1 EMCal Blocks

Description – There are four main items causing the SV. The S171800 Epoxy is only 55% complete, SV =-$43,140. Molds S172500 are behind schedule, SV =-$7,611. The S175500-S176900 Blocks for Sectors 38-52 are not complete, SV =-$72,587, nor is their shipping to BNL, SV =-$20,165.

The total SV for these items is -$143,503.

Impact – None

Corrective – The Epoxy must be bought within a few weeks of use, due to shelf-life issues. It is a commodity item and is purchased on an as-needed basis. The delayed Blocks were caused by personnel absences due to the COVID-19 pandemic. Block production resumed over the summer of 2020 and returned to planned production rates in the fall. This particular SV will persist until about 2 weeks before the Project is complete, at which time block production will be complete. The Early Completion date for the MIE project was adjusted in January 2021 to reflect this.

WBS 1.3.2 EMCal Modules and Sectors

Description – The S187400 Production Light Guide contract is only 69% complete, SV = -$74,440. The S195400 Mechanical parts for Final Sectors are only 90% complete, SV = -$29,175. The S196100 Cooling System for Final Sectors was only 35% complete, SV = -$53,485. The total of these SVs is -$157,100, again some 18% less than the prior month.

Impact – None

Corrective – The light guide vendor has continued to have several outside machine shops supplying him to maintain his delivery rate. This contract is now 2/3 complete. The mechanical parts are being delivered somewhat ahead of schedule, with all but the sawteeth/strongbacks in fact being complete; the sawteeth delivery schedule is about a month ahead of need-by date. The cooling system components are being manufactured by a local small company at a pace about 2 months ahead of need-by date.

WBS 1.4.2 Outer HCal Mechanics
Description – The S200000 Inner HCal Support Rings were delivered ahead of schedule, SV =$141,886
Impact – None.
Corrective – None needed, work is complete. The positive SV will go away in July when the schedule catches up with the progress.

WBS 1.4.4 Outer HCal Sector Assembly and Testing
Description – The S209800 – S210200 assembly and testing of the production Outer HCal Sectors was completed ahead of schedule, SV = $42,265.
Impact – None.
Corrective – None needed, work is complete ahead of schedule. Some part of the positive schedule variance will persist until September 2021, which is the planned completion date for this effort.

WBS 1.5.2 Calorimeter Front End Electronics
Description – Five separate activities contribute substantially to this SV. They are:
activity S233200 EMCal external cables are not complete, SV = -$205,854
activity S233250 EMCal trunk signal cables are not complete, SV = -$578,753,
activity S234100 EMCal LV power system sectors 13-64 only 70% complete, SV =-$11,781,
activity S244400 HCal External cables are only 50% complete, SV = -$50,970, and
activity S244450 HCal trunk signal cables not complete, SV =-$111,094.
The total SV for these activities is -$958,452, a 15% improvement over last month.
Impact – None.
Correctives – The Procurement readiness review was held in January for the external/trunk cable orders, EMCal and HCal, and procurement documents have been delivered to the Procurement group. Potential vendors indicate they can meet the requested delivery schedule for these cables. The remaining cables noted above are either stock items or catalog items built to custom length. The procurements for these are all being placed. These remaining items are all for installation external to the calorimeters and thus do not impact the progress in the rest of the MIE project.

WBS 1.5.3 Calorimeter Digitizers
Description – There are three activities contributing to this SV. They are:
activity S252700 Digitizer Parts, SV = -$427,479,
activity S252800 Digitizer Boards, SV = - $149,785,
and
activity S252900 Digitizer Assembly, SV = -$231,066,
for a total SV = -$808,330, a 15% improvement over last month.
Impact – None presently. SV improved by $142K this month. The EMCal and OHCal sector production lines have an adequate number of digitizers to perform all needed QA during remaining detector construction. Therefore, the remaining digitizers are only needed by the completion of the MIE project.
Corrective – The contract for the production digitizers is placed. The vendor indicates they are placing orders for production quantities of all parts but that world-wide supply chains have led to more lead time than foreseen pre-COVID. An second delivery of parts occurred this month. We continue to monitor the progress by this vendor.

WBS 1.6.1 Data Acquisition
Description – Four activities contributed to this SV, including:
activity S255900 Production boards not complete, SV = -$121,503,
activity S256700 crates not complete, SV = -$74,284,
activity S258700 jSEB slow control boards not complete, SV = -$19,181,

and
activity S259500 Buffer Box procurement not complete, SV = -$217,946,
for a total SV = -$432,913.
Impact – None. These items do not affect the production schedule for any other MIE items.
Corrective – Procurement documents are being prepared but are not yet complete for the first three items. The order for the buffer boxes has been placed with a vendor.

WBS 1.6.2 Local Level-1 Trigger
Description – Activity, S263600 Preproduction Local Level-1 trigger, is not complete, resulting in SV = -$69,641.
Impact – None
Corrective – The prototype Local Level-1 trigger board has been under full-speed testing for several months. Results to date indicate it will meet all requirements, completing the above activity. A review held in late February determined that a few small revisions to the board are needed. These revisions are proceeding. The production manufacture is still expected during 2021 based on the existing board assembly house and Bill of Materials. That production will complete this level-3 WBS. The contract with the vendor has not yet been placed, although BNL Procurement and the vendor were in contact during May.

WBS 1.6.3 Global Level-1 Trigger
Description – Activity S267600 Production of final GL1 is not complete, SV =-$32,673.
Impact – None
Corrective – The prototype Global Level-1 Trigger is being used as part of an extended test of electronics for sPHENIX. This test requires multiple front-end cards to operate, respond to triggers and timing signals, and send data to the production DAQ computers correctly over an extended period. This test is continuing as of the end of May. Assuming a positive outcome, the production Global Level-1 Trigger will be assembled using the existing blueprints.

WBS 1.6.4 Timing System
Description – Activity S270300 Production of Timing System is not complete, SV =-$48,284.
Impact – None
Corrective – The prototype Timing System is being used as part of an extended test of electronics for sPHENIX. This test requires multiple front-end cards to operate, respond to triggers and timing signals, and send data to the production DAQ computers correctly over an extended period. This test is continuing as of the end of May. Assuming a positive outcome, the production Timing System will be assembled using the existing blueprints.

WBS 1.7 Min Bias Trigger Detector
Description – Activity S273500 Min/Bias production digitizers is not complete, SV = -$17,143, and activity S273600 MBD Shaper/Disc Board is not complete, SV = -$53,879, for a total of -$71,022.
Impact – None
Corrective – The digitizers needed for the MBD are part of the larger digitizers order noted above for WBS 1.5.3. A final design review and production readiness review were held for the MBD shaper/discriminator board in February, no required changes were identified, and the board approved for production procurement. This procurement is being placed with the vendor who prepared and tested the prototype versions. Completion by December 2021 is anticipated.