

## sPHENIX Project Status Report – April 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 April 30, 2021

Current PD:	<b>2/3</b>	Date of Current CD/PD approval	September 2019	
Next PD:	<b>4</b>	Forecast approval:	<b>1QFY23</b>	Baseline: <b>1QFY23</b>
% Complete:	<b>71.5%</b>	Planned:	<b>88.2%</b>	
ETC:	<b>\$7.12M</b>	TPC or Cost Range:	<b>\$27.0M</b>	
Contingency:	<b>30.2%</b> on ETC	Float to PD-4 in months:	<b>10.75</b>	
Cumulative CPI:	<b>1.01</b>	Cumulative SPI:	<b>0.81</b>	

### 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 and have hired additional technical and engineering labor at both BNL and universities to maintain the project schedule. We expect that the schedule delays that we have experienced during the US COVID peak from November 2020 to 2021 will be reduced going forward from April. There was no change in the MIE early completion date in April. We expect the SPI 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.

The TPC AI stripes will be evaporated onto the central membrane petals. The field cage pieces will begin assembly into the final full unit. Full production of the TPC FEE will be ordered pending a successful performance of the TPC Fee slice test which is a system test of 1/24 of the TPC Fee electronics. Reviews of the laser system (design and safety) will occur in the coming months. SAMPA chip testing which is currently at the final stage will be completed.

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 calendar 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. However, we experienced a schedule disruption in April, and most of May due to a shortage of structural epoxy used in the EMCAL sector fabrication. We received a large delivery of structural epoxy as of May 24, which will mitigate the concerns about additional schedule impacts.

ISU and Rutgers will continue to coordinate with the iHCal sector vendor to ensure good communication and adherence to the production schedule. IHCAL sector assembly at BNL will begin in earnest in the mid- to late-July time frame, driven by the availability of components. Work will continue over the next several weeks in the oHCAL factory to burn-in the oHCAL sectors prior to installation on the sPHENIX carriage.

Work on the Calorimeter electronics 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. The work includes the completion of the testing of the EMCAL SiPM boards and preamps, completion of the first calorimeter digitizer racks, continued production of the calorimeter digitizer boards, placing orders for the calorimeter signal and power cables, fabrication of the LV distribution system and continuing electronics rack assembly.

The DAQ/Trigger will receive the delivery of more computer racks 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, the DAQ/Trigger group will work on the preparations for the slice test, and finalize the engineering for the “hot box” in the 1008 rack room that will help with thermal management.

Columbia University has completed the initial testing of the MBD D/S prototype boards and will deliver the MBD prototype electronics to BNL in June to begin the chain test of the MBD electronics and the MBD detector components. A contract for the fabrication of the MBD production electronics will be placed with Columbia. We are continuing to train the FAMU and Howard students on the MBD simulations and testing software. The current plan is for them to come to BNL in the summer so that they can test the production electronics. However, with the delays in the production electronics procurement, it will more likely be fall 2021 before we can receive the MBD production D/S boards for testing.

### **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 April. 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 April. Cobra and P6 monthly reports uploaded to IPD. The variance reports were approved. The project is 71.5% complete in April with a 30.2% contingency on the ETC. An additional \$3.89M is committed in contracts.

All TPC GEM foils have been shipped from CERN and delivered to Stony Brook University. Stuffing of the TPC R1 pad planes is completed. Initial cooling block parts arrived and were fitted to the actual wagon wheel successfully. Good progress has been made toward the TPC Fee slice test with the DC power system complete and ready. The final updates to the TPC FEE production board layout are underway. The order for assembling 700 TPC Fee boards has been placed with the vendor. SAMPA v5 chip characterization resumed after having been delayed for many weeks at Lund University due to COVID lockdowns. The final stage of SAMPA v5 testing is to complete the 80 nsec testing (all prior tests were done before COVID-related delays). The yield from this final step is above 90% (better than required). The rate of testing removes this step as a concern for being a schedule driver.

The EMCal block production rate has been steadily increasing at the University of Illinois – Urbana Champaign with the additional labor for machining that was added in early April. The machining rate has now reached ~ 20 blocks per day. The overall production rate has exceeded 70 blocks per week for several weeks, which exceeds the goal of 66 blocks per week needed to complete the production of all the remaining blocks for Sector 13-64 by the end of this calendar year. The number of EMCal blocks produced passed the 50% mark at UIUC in mid April and stands at 60% by the 3<sup>rd</sup> week of May. Work on module production and sector assembly continued at BNL. All of the modules for Sectors 1-24 have been completed and the modules for Sectors 22 and 24 are ready to be glued. We currently have enough light guides to complete modules for up to Sector 41 and expect to continue receiving them on a regular basis. Sectors 1-17 have been assembled and tested by the end of April. Sectors 18 and 19 have been assembled and are ready for testing. There was a delay in receiving more structural epoxy due to a nationwide shortage, which temporarily prevented us from gluing blocks into additional sectors. As of April 30 we only had enough structural epoxy to glue blocks for up to Sector 24. However, as noted in the previous section of this report, a large delivery of epoxy was received at BNL 5/24 that will allow the fabrication of 20+ additional sectors.

ISU has contracted with a local machine shop to produce the iHCAL mechanical sectors. The vendor sector delivery schedule has been coordinated with Rutgers to ensure that the parts provided by Rutgers machine shops will arrive well in advance of when they are needed for sector assembly. The Rutgers shops have completed all the absorber end plates and 16 pairs of electronics shelves, which have been shipped to the iHCAL sector vendor. Due to COVID-related furloughs the sector endplates have been subcontracted to UT-Austin, and the first group of eight pairs were received 5/10/2021

Assembly of the last oHCAL sector was completed at the end of March. The current focus of the activity in the HCal factory has shifted to burn-in tests of the oHCAL sectors now that a burn-in test rack is available. Four sectors have been completed burn-in testing, and the availability of a dedicated burn-in test rack should allow completion of the remaining sectors in four to six weeks, consistent with the outer HCal assembly schedule.

Delivery of all the EMCal SiPM boards was completed in April. Deliveries of the EMCal preamp boards continued in April on schedule with 80% of them received. The final delivery is scheduled for May. Testing of both the EMCal SiPM daughterboards and preamps continues with a high yield rate. Delivery of the internal signal cables continues on schedule with 95% of the cables delivered. The delivery of the LV bulk supplies for the calorimeter electronics continues with a final delivery scheduled for early May. The requisition for the EMCal and HCal external signal cables is being processed by Brookhaven procurement. Work on the HCal burn in rack was completed and delivered to the HCal group. Assembly of the two HCal digitizer and control racks has started. The Columbia University purchasing department has started to issue purchase orders for components needed for the production of the full digitizer electronics. Approximately 10% of the digitizer parts have been delivered. The remaining parts are on schedule to be delivered over the next 3 months. The University of Colorado group continues to refine the testing and documentation process for the digitizer boards.

The DAQ/Trigger group has continued to work on the setup for the TPC Fee “slice test”. This will be a test not only of the TPC Fee but also various components of the DAQ/Trigger. We have configured a “Sub-Event Buffer”

(SEB) PC that is equipped with a particular readout card, called "jSEB2". This is the first machine that is part of the real data acquisition installation and will actually be used for the data taking in 2023. The firmware work for the clock fan-out board continues. The clock fan-out board will be exercised in the TPC Fee slice test. Progress has been made with finalizing the final count of the remaining DAQ/Trigger boards. Preparation for the remaining DAQ/Trigger board production continues with orders expected to be placed in June.

The MBD group is preparing for a chain test of the MBD Discriminator/Shaper board (D/S) and the MBD detector. The contract for MBD D/S board production is with BNL Procurement.

### **WBS 1.1 Project Management (L2 Manager: Irina Sourikova)**

#### **Current Status:**

- SPI is 0.81, CPI is 1.01

#### Highlights:

- 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:**

- No issues

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

#### **Current Status:**

All GEMs have been shipped and after a non-typical customs delay were delivered. Stuffing of the R1 pad planes is complete (all were delivered last month).

Initial cooling block parts arrived and were fitted to the actual wagon wheel successfully. They were additionally installed onto the 3D printed model of one section. There the fit was successful but tight, possibly due to imperfections in the 3D printed model. This is not considered a concern as fitting into the real wagon wheel is the actual requirement. Eclipse agreed to alter the design slightly (10 mils extra on each side) to loosen the fit without affecting the performance.

The quartz bar manufacturer has been selected. We have requested from them three quotations as a function of quality of the bars so as to choose the best fit for our application and order.

More progress is made toward the slice test as the DC power system is complete and ready. Optical components exist to allow readout of 10 TPC Fee boards at a time, while all FEEs are powered.

Completion of the “pockets” for the TPC assembly cart is proceeding apace with no hang-ups and delivery is expected soon. Construction of the “delivery sled” has been initiated. One part from the original design fell into obsolescence and a suitable replacement is identified.

The final updates to the TPC FEE are under way and will enable the production cycle to proceed soon.

SAMPA v5 chip testing resumed with a plan to complete the 80 nsec testing (all prior tests were done before COVID-related delays). The yield from this final step is above 90% (better than required) and the rate removes this testing as a concern for being a schedule driver.

**Work Anticipated Next 2-3 Months:**

The Al stripes will be evaporated onto the central membrane petals. The field cage pieces will begin assembly into the final full unit. The full production TPC FEE will be ordered pending a successful preproduction round. Reviews of the laser system (design and safety) will occur in the coming months. SAMPA chip testing is at the final stage and will be completed.

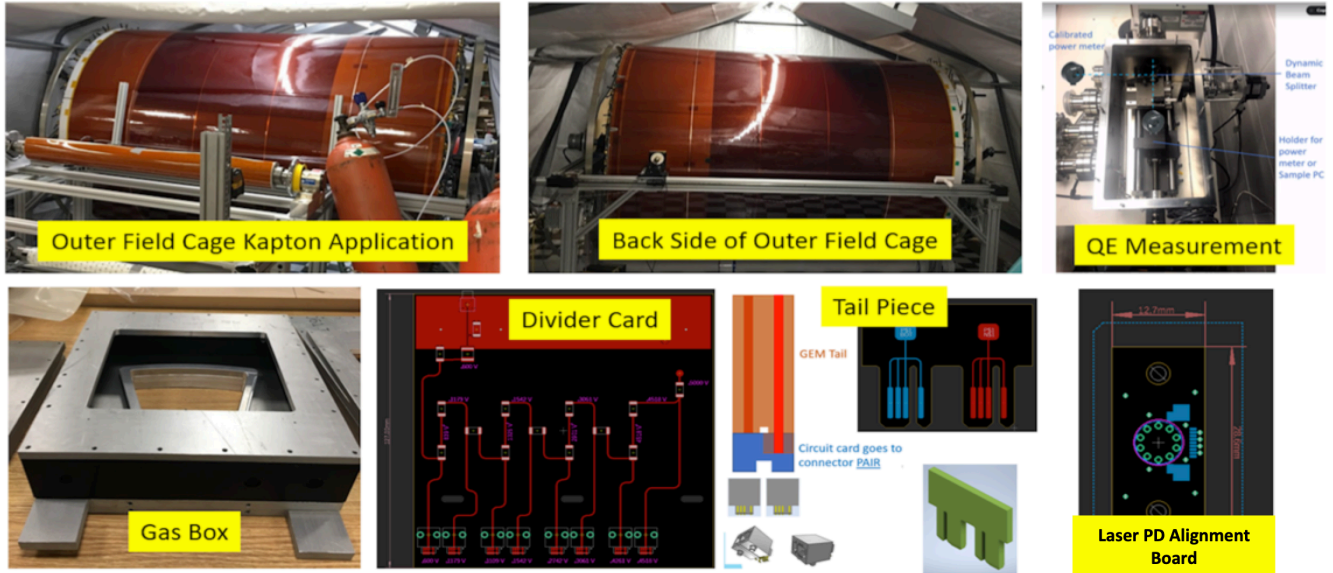
**Issues**

None

**COVID-related**

The Temple factory was idled for two weeks due to COVID positive workers. Because past performance of Temple has shown a capability above the baseline assumptions, we expect that the timeline will be restored in April or May at the latest.

As the sixth and seventh GEM batches are due late April/early May, we are still concerned whether there would be a shutdown of the CERN GEM shop (update: all GEMs have arrived at SBU as of late May). A stand down at Lund University has halted the SAMPA chip testing and a mitigation strategy will be devised in April.

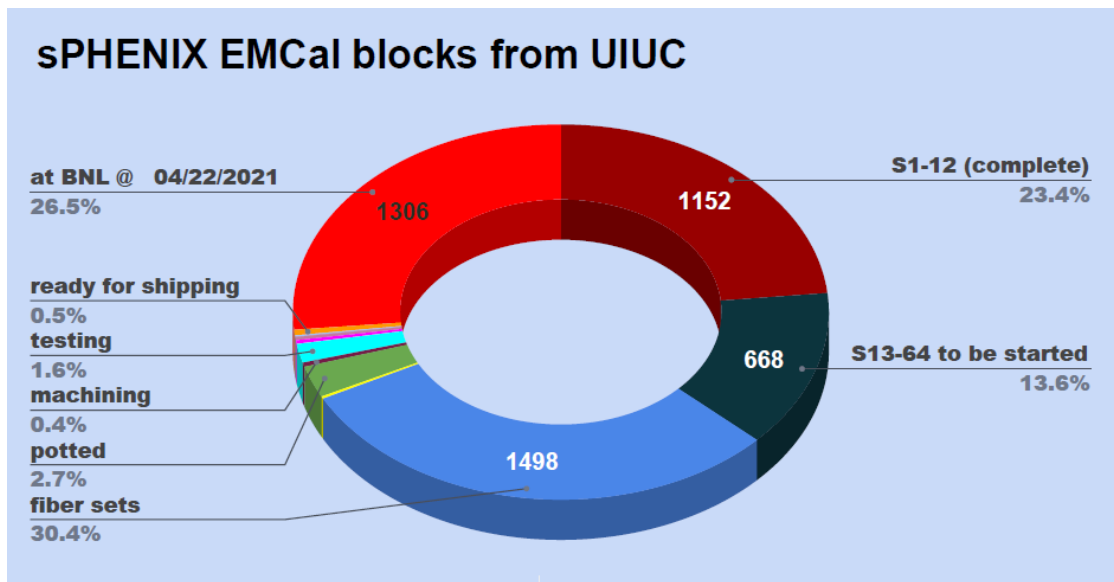


**Figure 1:** Clockwise from upper left: Kapton insulating layer being added to the Outer Field Cage. Reverse side of the Outer Field Cage during Kapton winding. Vacuum chamber to be used for aluminum deposition on TPC central membrane. Design of the Laser photodiode alignment board. Voltage distribution scheme for the GEM layers of the quad-GEM. Divider card for the quad GEM module. Gas box at SBU to be used to test the GEM modules.

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

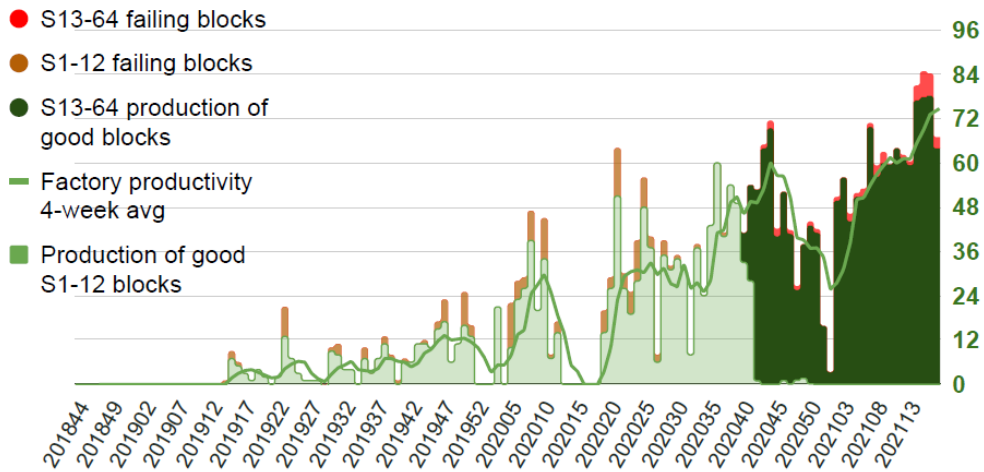
**Current Status:**

Figure 2 shows the overall status of block production at UIUC as of April 24<sup>th</sup>. 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 rejected blocks was ~ 3 %.



**Figure 2.** Status of block production at UIUC as of April 24<sup>th</sup>.

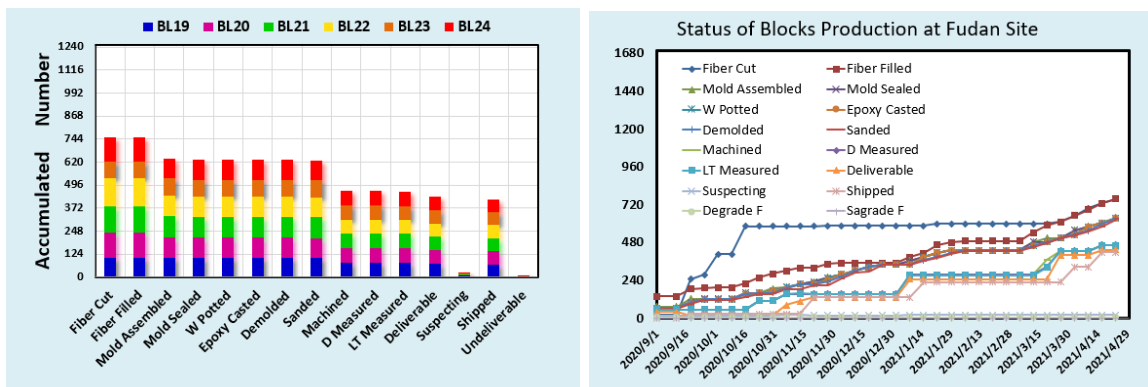
## sPHENIX EMCal blocks: weekly output at UIUC



**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 has been steadily increasing with the additional personnel for machining that was added in early April. The machining rate has now reached ~ 20 blocks per day. The overall production rate has exceeded 70 blocks per week for several weeks, which exceeds the goal of 66 blocks per week needed to complete the production of all the remaining blocks for Sector 13-64 by the end of this calendar year.

Block production also continued at Fudan. Figure 4 shows the status of blocks produced as of April 24<sup>th</sup>. As of this date, five batches of 96 blocks have been shipped to BNL and an additional 116 blocks are being machined and 47 more blocks have been cast and are awaiting machining.



**Figure 4.** Status of block production at Fudan as of April 24<sup>th</sup>.

Work on module production and sector assembly continued at BNL. Figure 5 shows the status of the various stages of module production as of April 30<sup>th</sup>. All of the modules for Sectors 1-24 have been completed and the

modules for Sectors 22 and 24 are ready to be glued. We currently have enough light guides to complete modules for up to Sector 41 and expect to continue receiving them on a regular basis. The shipment of 96 blocks from Fudan arrived at BNL and will provide enough high rapidity blocks to complete up to Sector 29.

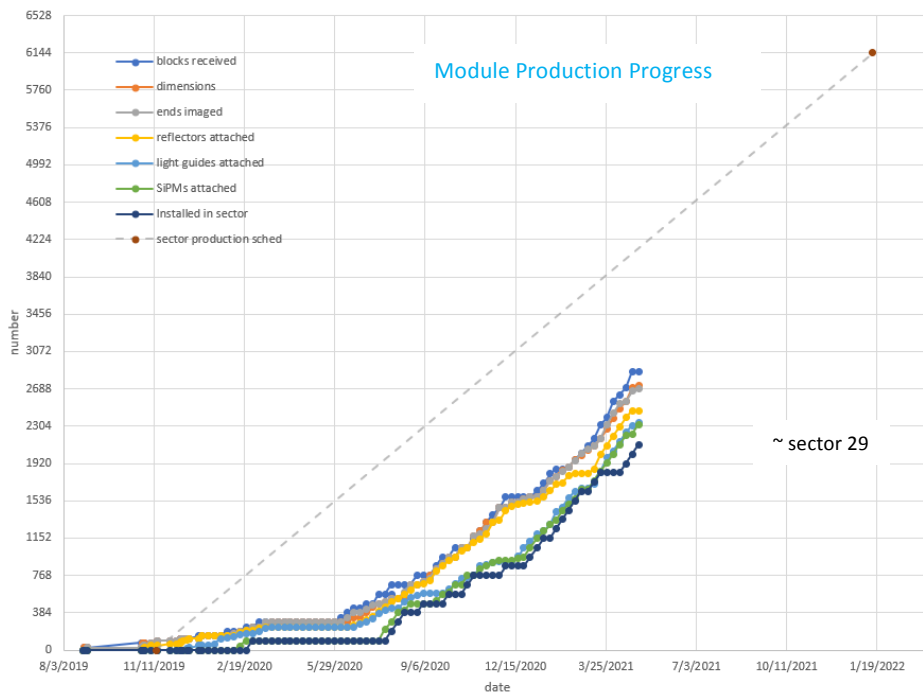


Figure 5. Status of module production at BNL as of April 30th.

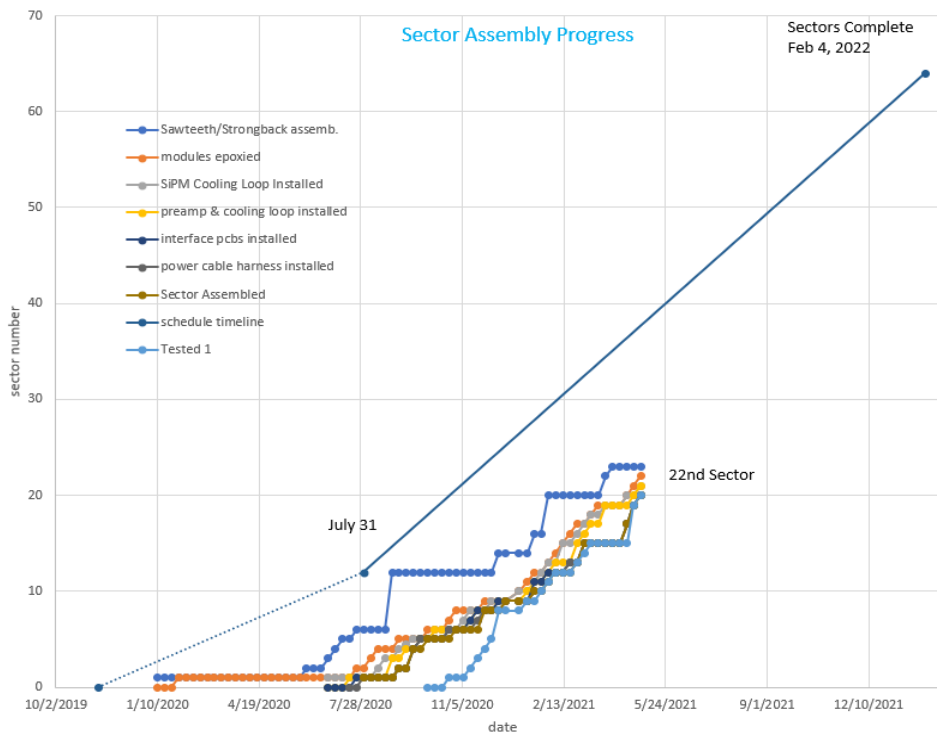


Figure 6. Status of sector assembly at BNL as of April 30<sup>th</sup>.



Figure 6 shows the status of sector assembly. Sectors 1-17 have been assembled and tested and Sectors 18 and 19 have been assembled and are ready for testing. We now have enough cooling loops for up to Sector 28 and enough assembled sawteeth and strongbacks for up to Sector 23. We have also been receiving enough tested electronics on time to keep up with our production schedule. However, there was a delay in receiving more structural epoxy due to a nationwide shortage, which may prevent us from gluing blocks into additional sectors. We currently only have enough structural epoxy to glue blocks for up to Sector 24.

#### **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. However, we foresee having a shortage of structural epoxy in the coming weeks that will prevent us from completing more sectors. (Note: As of May 24 epoxy sufficient for the assembly of an additional 20+ sectors arrived at BNL)

#### **Issues:**

We lost one of our technicians for two weeks due to COVID-19 quarantine and had a temporary pause in the work being done in our module production lab due to safety related issues. We also learned that two of our technicians maybe be called back to CAD for an extended period of time. If this occurs, this will cause a labor resource shortage and we will not be able to stay on our current production schedule. We are working with CAD and the NPP Directorate to keep the EMCal module/sector factory at BNL fully staffed.

### **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 16 pairs of electronics shelves, which have been shipped to the iHCAL sector vendor. Due COVID-related furloughs the sector endplates have been subcontracted to UT-Austin, and the first group of eight pairs were received 5/10/2021. First article inspection of the first assembled sector at the vendor was completed 5/18 and only minor issues were noted during the assembly, all of which have been addressed. Assembly of the remaining seven sectors for a June delivery to BNL is underway.

The iHCAL end rings have been received by BNL and passed inspection.

#### Work for the Next 2-3 Months:

ISU and Rutgers will continue to coordinate with the iHCAL sector vendor to ensure good communication and adherence to the production schedule. Sector assembly at BNL will begin in earnest in the mid- to late-July time frame, driven by the availability of components.

#### 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 26<sup>th</sup>, 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. Four sectors have been completed, and the availability of a dedicated burn-in test rack should allow completion of the remaining sectors in four to six weeks, consistent with the outer HCAL assembly schedule. 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:

Work will continue in the oHCAL factory over the next several weeks to burn-in the oHCAL sectors prior to assembly.

#### Issues:

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



Figure 7: The first completed inner HCAL sector in the assembly fixture at a machine shop in Ames, Iowa. Only minor issues were identified during assembly and first article inspection, and the assembly of the remaining seven sectors for the first delivery to BNL later in June is underway.

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

#### **Current Status:**

Delivery of all the EMCal SiPM boards was completed in April. Deliveries of the EMCal preamp boards continued in April on schedule with 80% of them received. The final delivery is scheduled for May. Testing of both the EMCal SiPM daughterboards and preamps continues with a high yield rate. Delivery of the internal signal cables continues on schedule with 95% of the cables delivered. Testing of the internal cables to meet quality requirements has identified about 5% that have failed and they have been returned to the vendor for repair or replacement. Those cables are expected to be delivered in May of 2021.

The delivery of the LV bulk supplies continues with a final delivery scheduled for early May. The requisition for the EMCal and HCal external signal cables is being processed by Brookhaven procurement. Work the HCal burn in rack was completed and delivered to the HCal group. Assembly of the two HCal digitizer and control racks has started. The first almost completely assembled rack is shown in Figure 8. Procurement documentation for external power and control cables for the EMCal and HCal are in the process of being prepared.



Figure 8: The first of 2 HCal Digitizer and Control racks being assembled in 1008. The racks will be installed on the second level of the detector and provide both slow control and readout of the HCal.

Columbia University purchasing department has started to issue purchase orders for components needed for the production of the full digitizer electronics with 10% of the parts delivered. The remaining parts are on schedule to be delivered over the next 3 months. The University of Colorado group continues to refine the testing and documentation process for the digitizer boards.

**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. Completing the testing of EMCal SiPM boards and preamps
2. Building the first Digitizer racks with a full crate operational
3. Placing orders for external power and communication cables
4. Production 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.

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

**Current Status:**

We have continued to work on the setup for the envisioned TPC “slice test”, where we want to read out a “slice” of the TPC Fee electronics (26 boards) with various DAQ/Trigger components. We have configured a “Sub-Event

Buffer” (SEB) PC that is equipped with a particular readout card, called “jSEB2”. While we already have several such PCs set up for other tests in labs and at test beams, this is the first machine that is part of the real data acquisition installation that will actually be used for the data taking in 2023. Figure 9 shows a picture of the machine with the “jSEB2” card installed.



Figure 9: One of the first configured DAQ machines that will be used for data taking in 2023.

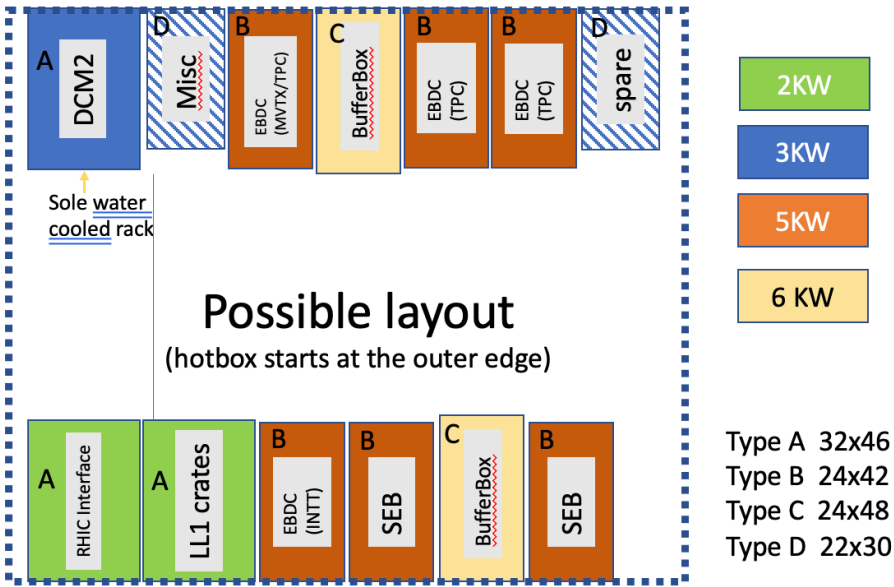


Figure 10: Top view of the envisioned rack arrangement. The row shown here at the top is already in place. Old racks from the former PHENIX experiment are getting removed to make room for more new computer racks that will be delivered soon.

We are in the process of removing old equipment to make room for the computer racks that will be delivered in June. The tentative rack arrangement is shown in Figure 10. At the same time, the electric installation is getting upgraded to include better load balancing and UPS services.

The firmware work for the clock fan-out board, shown in Figure 11, continues. One detector reports success with using the new board. This will be an ingredient in the upcoming slice test.

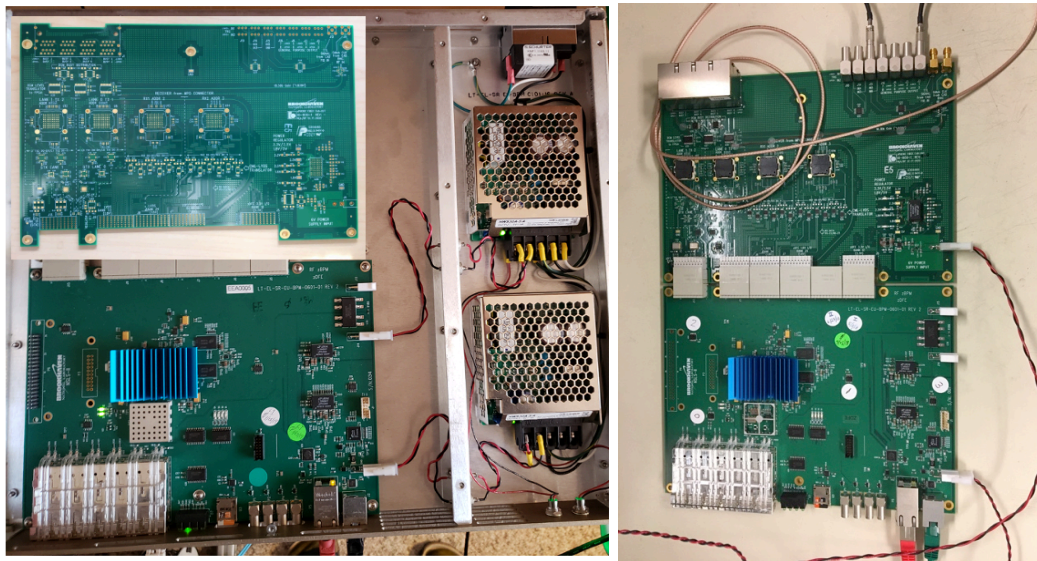


Figure 11: Left: an older “photo-shopped” assembly with the then still unassembled board and how it will go into the FPGA unit in its case. Right: the actual board attached to the FPGA unit being tested (not in a case).

Figure 11 shows on the left an older “photo-shopped” 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).

Progress has been made with finalizing the board count of the remaining DAQ/Trigger cards of various kinds. We are in the process of finalizing the vendor quotes in order to be able to submit this in June.

### **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” in the 1008 rack room that will help with thermal management.

### **Issues:**

None

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

#### **Current Status:**

We are working on the test stand for the chain-test of the prototype MBD electronics with the MBD detector here at BNL. Columbia University and BNL scientists have continued working together to develop the MBD LL1 trigger and the plans for testing it. The contract for purchasing the final production electronics was not placed (as

erroneously reported in last month's report), but the contract is under preparation and will be placed with the trigger electronics order.

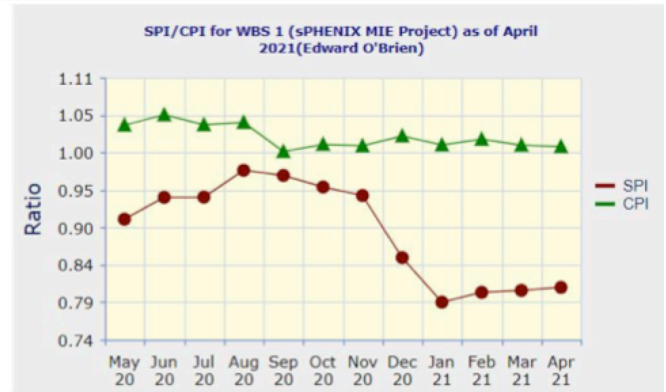
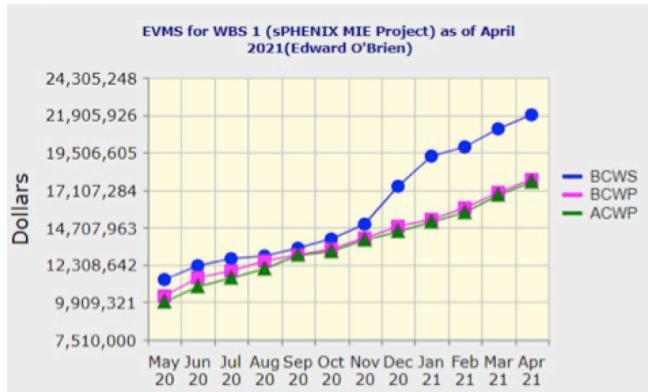
### **Work for Next 2-3 Months**

Columbia University will deliver the MBD prototype electronics on June 14 to BNL. We'll prepare as much ahead of time as possible, so that we can start as soon as the electronics arrives at BNL. We are continuing to train the FAMU and Howard students on the MBD simulations and testing software. The current plan is still for them to come to BNL in the summer so that they can test the production electronics. However, with the delays in the production electronics procurement, it will more than likely be fall 2021 before we can receive these for testing.

### **Issues**

None.

## SPI and CPI Trends



BAC: \$24,853,936 EAC: \$24,722,687 VAC: \$131,249

Cumulative SPI	Cumulative CPI
0.81 <span style="color: red;">●</span>	1.01 <span style="color: green;">●</span>

Cumulative BCWS (Scheduled)	\$21,909,322
Cumulative BCWP (Performed)	\$17,759,620
Cumulative ACWP (Actual)	\$17,606,065

- 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

## April 2021 Cost Performance Report

CA (3)	CUMULATIVE TO DATE						AT COMPLETION			SPI	CPI
	BUDGETED COST		ACTUAL COST WORK PERFORMED (9)	VARIANCE		BUDGETED (14)	ESTIMATED (15)	VARIANCE (16)			
	WORK SCHEDULED (7)	WORK PERFORMED (8)		SCHEDULE (10)	COST (11)						
ITEM (1)	(7)	(8)	(9)	(10)	(11)	(14)	(15)	(16)			
1.01A Project Management	1,865,463	1,865,463	1,729,878	0	135,585	1,951,679	1,816,094	135,585	1.00	1.08	
1.02A TPC	4,698,807	3,458,015	3,072,623	-1,240,792	385,392	5,026,775	4,635,018	391,758	0.74	1.13	
1.03A EMCal	5,466,920	5,101,466	5,422,789	-365,454	-321,322	6,070,008	6,393,882	-323,873	0.93	0.94	
1.04A HCal	2,842,635	2,897,873	3,159,986	55,238	-262,113	4,099,592	4,361,705	-262,113	1.02	0.92	
1.05A Calorimeter Electronics	5,911,712	3,811,876	3,540,228	-2,099,836	271,648	6,290,621	6,040,573	250,048	0.64	1.08	
1.06A DAQ & Trigger	953,615	525,778	593,978	-427,836	-68,200	1,245,090	1,316,390	-71,300	0.55	0.89	
1.07A MinBias Trigger Detector	170,170	99,148	86,584	-71,022	12,564	170,170	159,027	11,143	0.58	1.15	
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	21,909,322	17,759,620	17,606,065	-4,149,702	153,555	24,853,936	24,722,687	131,249	0.81	1.01	
f. Contingency						2,146,064					
g. TOTAL	21,909,322	17,759,620	17,606,065	-4,149,702	153,555	27,000,000					
9. RECONCILIATION TO CONTRACT BUDGET BASELINE											
a. VARIANCE ADJUSTMENT				0	0						
b. TOTAL CONTRACT VARIANCE				-4,149,702	153,555		0	0			
CLASSIFICATION (When Filled In)											
					\$7,116,621	ETC					
					\$7,094,316	BCWR					
					30.16%	% Contingency on ETC					
					30.25%	% Contingency on Remaining Work					
					88.15%	% Planned					
					71.46%	% Complete					
					70.84%	% 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

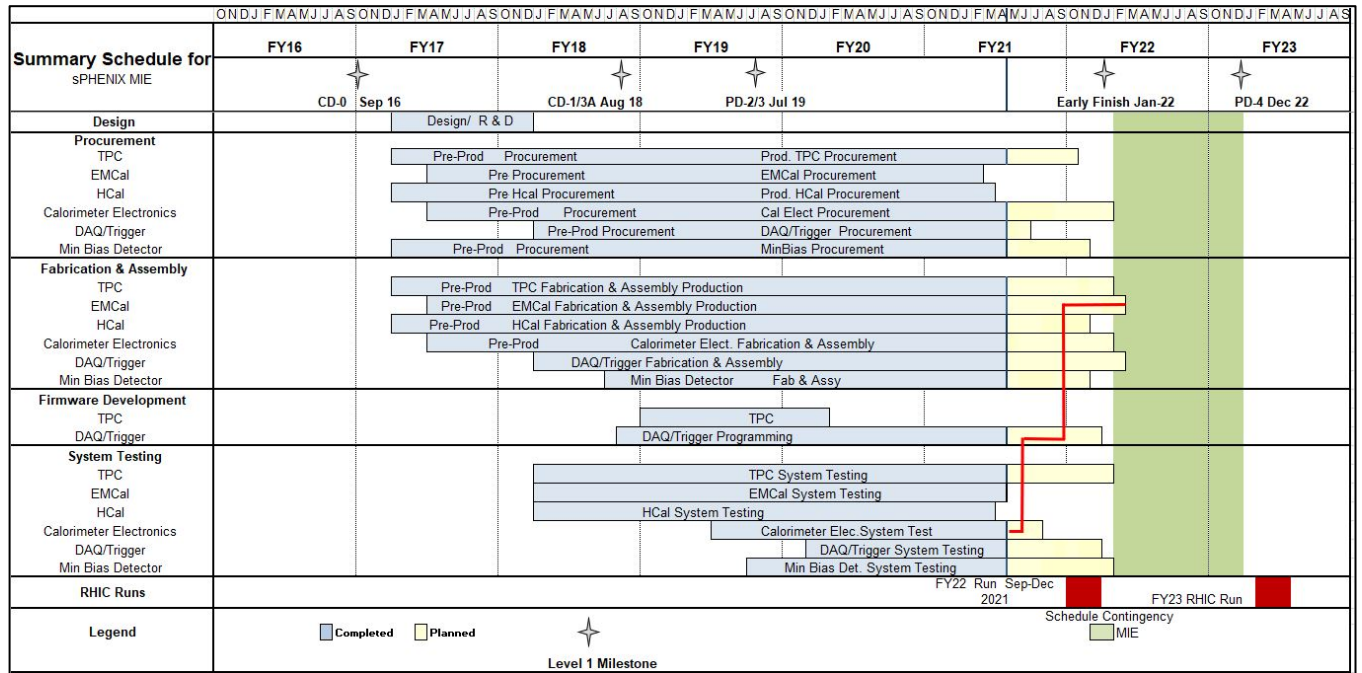


#	WBS	Milestone Name	Target Milestone Date	Forecast	Actual Finish	Variance (in work days)
1	01.01.2001	Approve Project Baseline and Construction PD2/3	30-Sep-19	20-Sep-19 A	20-Sep-19	6
2	01.02.02.02	Production Readiness Review - TPC Module Factories	31-Dec-19	17-Dec-19 A	17-Dec-19	8
3	01.03.02.03.02	EMCal Preproduction Sector O 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	14-Dec-21		-21
26	1.07	MinBias Detector Ready to Install	14-Dec-21	21-Jan-22		-26
27	01.06.01.03	DAQ Production: DAQ Ready for Operation	30-Dec-21	13-Jan-22		-10
28	01.06.03.03	GL1 Ready to Operate	24-Jan-22	4-Feb-22		-10
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

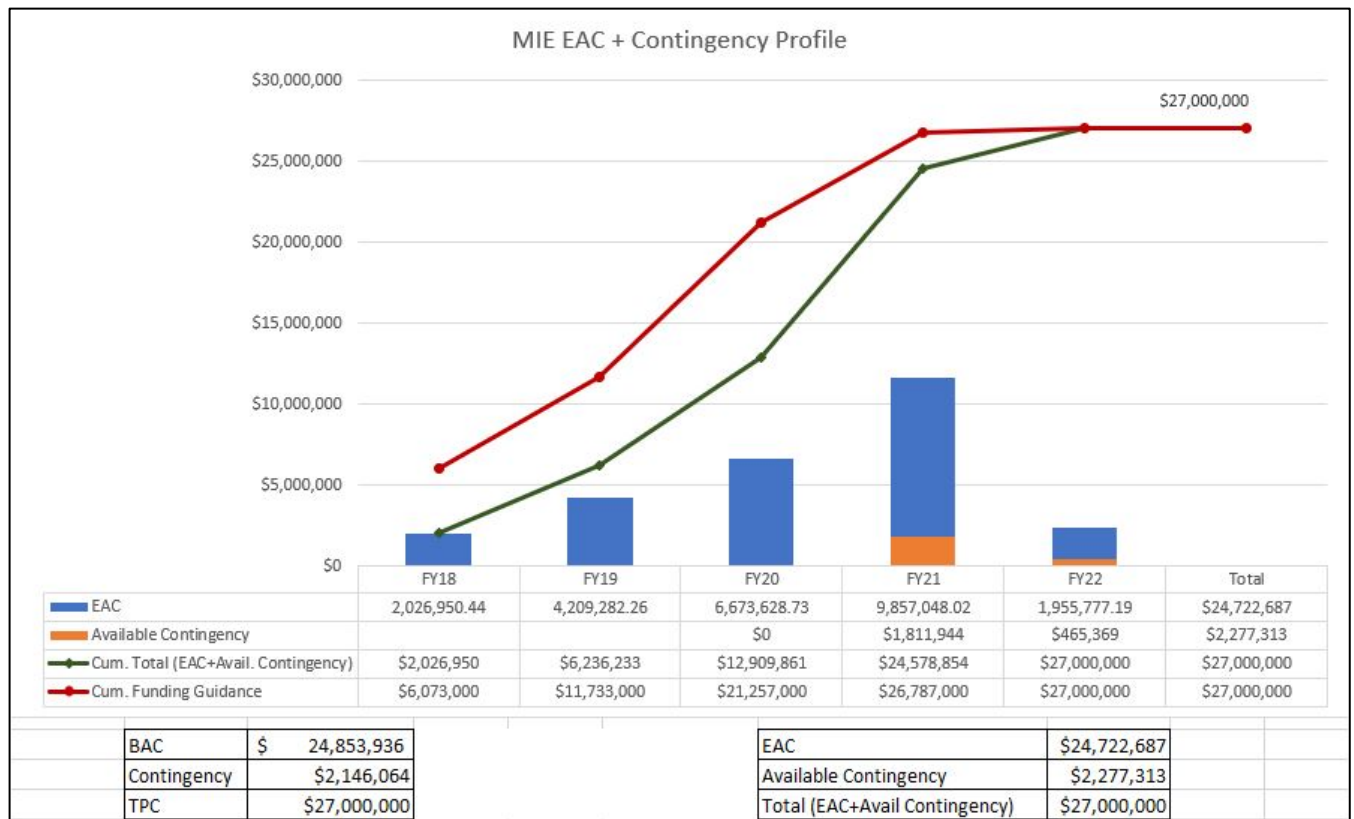
**SPHENIX Budget Profile:**

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								
<b>OPC (R&amp;D+CDR)</b>		<b>1,613</b>	<b>4,460</b>	<b>350</b>				<b>6,423</b>
<b>TEC</b>				<b>5,310</b>	<b>9,524</b>	<b>5,530</b>	<b>213</b>	<b>20,577</b>
<b>Total Project Cost</b>		<b>1,613</b>	<b>4,460</b>	<b>5,660</b>	<b>9,524</b>	<b>5,530</b>	<b>213</b>	<b>27,000</b>

## Summary Schedule with critical path



## Estimate at Completion Profile



## 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	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	2019		2020		2021	
													FY19		FY20		FY21	FY22
S195400	Procure EMCAL Mechanical Parts for Final Sectors - Delivery Accep	165	0	14-Sep-20	12-May-21	04-Jan-21	08-Jan-21	-86	0	251357	291,746	291,746						
S187700	Install light guides on final blocks M&S	257	0	21-Jan-21	31-Jan-22	02-Sep-20	30-Sep-21	-80	0	1650	1,926	1,912						
S188100	Install SIPMs daughterboards on final blocks M&S	259	0	22-Jan-21	03-Feb-22	11-Sep-20	08-Oct-21	-77	0	300	350	348						
S229300	Fabricate EMCAL Production Preamp Boards Sectors 13-64 - Delivery	66	0	26-Feb-21	28-May-21	07-Dec-20	11-Dec-20	-116	0	473550	549,642	549,642						
S229400	Test EMCal Preamp Boards: Production Sectors 13-64	76	0	26-Feb-21	14-Jun-21	14-Dec-20	08-Apr-21	-46	384	0	6,313	6,313						

## Variance Analysis

Reporting Period: 4/1/2021 - 4/30/2021

sPHENIX MIE Project (Edward O'Brien [18368])

Cumulative BCWS \$21,909,322

Cumulative BCWP \$17,734,234

Cumulative ACWP \$17,606,065

SV = -\$4,175,088

CV = +\$128,169

SPI = 0.8094

CPI = 1.0073

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. The activity, S120100 Production of GEM foils, which has had prior SV, is now complete.

Impact – None.

Corrective – None. The order is complete.

#### **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 = -\$18,320 and S125600 TPC R1 Modules test, with SV = -\$18,320. The total SV resulting is -\$36,641. The R1 padplane, the smallest of the three types, were all delivered last month.

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 R1 pad planes have been delivered. The two above activities are now proceeding 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 = -\$123,533,

activity S143200 TPC FEE Production boards and assembly, SV = -\$175,244,

and

activity S143250, TPC FEE components, SV = -\$116,301.

The net SV is -\$541,901.

Impact – None as yet.

Corrective – All the items covered by these activities are being ordered, with one exception, the optical transceivers. The manufacturer announced in February that it is replacing this part with a newer and less expensive version; the new variant will have to be the one purchased by sPHENIX and thus also will need to be tested in magnetic field, although no issues are expected based on technical input from the manufacturer. 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 TPC production board and assembly procurement is progressing, with a vendor identified. The TPC FEE components, mostly the quad transceivers, will be ordered later in the spring because they are added to the assembled boards by hand after the automatic board assembly is complete, thus their delivery schedule does not impede that for the boards.

#### **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.

### **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 =-\$176,986. 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 procured the high value elements including the chiller/re-circulator, SV =-\$73,653.

The total SV for these key items is -\$294,760, some 5% smaller than the prior month due to several components being procured during April.

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. The procurement for the chiller/re-circulator has now been placed with a vendor.

### **WBS 1.3.1 EMCal Blocks**

Description – There are four main items causing the SV. The S171800 Epoxy is only 48% complete, SV =-\$42,088. Molds S172500 are behind schedule, SV =-\$6,272. The S175200-S176600 Blocks for Sectors 35-49 are not complete, SV =-\$74,945, nor is their shipping to BNL, SV =-\$25,952.

The total SV for these items is -\$149,256.

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 61% complete, SV =-\$93,650. The S195400 Mechanical parts for Final Sectors are only 85% complete, SV =-\$43,762. The S196100 Cooling System for Final Sectors was only 33% complete, SV =-\$55,131. The total of these SVs is -\$192,543, some 18% less than the prior month.

Impact – None

Corrective – The light guide production was suspended at the vendor until QA and tooling-fixture issues were examined and resolved. These issues were addressed over October-December and production deliveries have resumed at the planned rate and ahead of when they are needed to produce sectors. The light guide vendor has several more machine shops supplying him now to maintain his delivery rate. 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 – None.

Impact – None.

Corrective – None needed, work is complete.

#### **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 = \$55,238.

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 – Eight separate activities contribute substantially to this SV. They are:

activity S229300 EMCAL preamplifiers only 50% delivered, SV = -\$274,821,

activity S231800 EMCAL internal cables are only 90% complete, SV = -\$28,819,

activity S233200 EMCAL external cables are not complete, SV = -\$205,854

activity S233250 EMCAL trunk signal cables are not complete, SV = -\$486,153,

activity S234000 EMCAL Bias power supplies completed early, SV = \$31,136,

activity S234100 EMCAL LV power system sectors 13-64 only 60% complete, SV = -\$15,708,

activity S244400 HCal External cables are only 50% complete, SV = -\$50,970, and

activity S244450 HCal trunk signal cables not complete, SV = -\$93,319.

The total SV for these activities is -\$1,124,508.

Impact – none except for the EMCAL preamps, which are needed by the EMCAL sector production line.

Correctives – Half of the EMCAL preamplifiers are now delivered and the EMCAL sector fabrication line is back on track.

The vendor for the EMCAL internal cables has been delivering them regularly on a schedule well in advance of the need for them during EMCAL sector construction. 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.

#### **WBS 1.5.3 Calorimeter Digitizers**

Description – There are three activities contributing to this SV. They are

activity S252700 Digitizer Parts, SV = -\$569,972,

activity S252800 Digitizer Boards, SV = - \$149,785,

and

activity S252900 Digitizer Assembly, SV = -\$231,066,

for a total SV = -\$950,823.

Impact – None presently. SV improved by \$109K 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 initial delivery of some 16% of the 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 = -\$62,270, for a total SV = -\$277,238.

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 four items which are not complete.

#### **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.

#### **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 April. 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 April. 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.