

## sPHENIX Project Status Report – June 2017

HOST LABORATORY: BROOKHAVEN NATIONAL LAB

FEDERAL PROGRAM MANAGER: ELIZABETH BARTOSZ

FEDERAL PROJECT DIRECTOR: LLOYD NELSON

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### 1. SCORECARD AS OF 03/15/2017

Current CD:	0	Date of Current CD approval	September 2016		
Next CD:	1	Forecast:	1QFY19	Baseline:	
% Complete:	Pre-baseline	Planned:	NA		
ETC:	NA	TPC or Cost Range:	\$29-35M		
Contingency:	NA	Float to CD-4 in Days:	NA		
Cumulative CPI:	NA	Cumulative SPI:	NA		

### 2. NEAR TERM MILESTONES

The most significant milestone this month was the sPHENIX Document Review. The review was organized by the BNL NPP Associate Lab Director's special assistant for projects, Maria Chamizo Llatas, with a committee appointed by the BNL Deputy Director for Science. The review report gave a very positive assessment of the status of document preparation for CD-1 and the Project team's readiness for the upcoming Director's Review scheduled for early August. The review committee evaluated the sPHENIX Resource-loaded Schedule (RLS) and Work Breakdown Structure, Conceptual Design Report, Preliminary Project Execution Plan, the various Basis of Estimate documents for the project, Preliminary Hazard Analysis Plan, Project Organization. A number of other CD-1 related documents were examined and discussed by the committee including drill downs of the RLS.

### 3. STATUS HIGHLIGHTS

The sPHENIX Project plan including the WBS and RLS continues to be refined and improved. It is currently based in MS-Project but will be transitioned to Primavera-6 over the next 2-3 months. Cost estimates, contingency estimates, schedule and resource estimates have been established. Conceptual engineering design is ongoing for each sPHENIX detector system.

Detector R&D for the Time Projection Chamber, EMCal, HCal and Calorimeter electronics continues to progress. Recent R&D highlights include the completion of a Full-size mechanical (structural only) prototype of an Inner HCal module. Scintillating tiles to instrument the Inner HCal prototype have been designed and will be fabricated later this year using sPHENIX OPC funds. Work is steadily progressing on the EMCal prototype v2.1. Most components are in hand at BNL and UIUC for production of this prototype including the scintillating fibers and tungsten powder. Production of this EMCal prototype will be carried out over the next few months. Construction of the prototype field cage for the Time Projection Chamber is progressing at SBU. Design of the TPC GEM prototype modules is progressing well at SBU. A prototype v0 of the TPC FEE card was produced by BNL and has been successfully tested. The concept of using the ATLAS FELIX card as the basis for the sPHENIX TPC Data Aggregator Module was evaluated using a FELIX v1.5 card. The evaluation was positive and the TPC electronics team is awaiting the next version of the FELIX card, v2.0, to continue their work. Work continues on test-bed for the eventual use in testing the 100k Silicon Photomultipliers in sPHENIX. Prototype work on the calorimeter LED driver board and preamplifier board continues. Studies continue with mock-up for the design of the EMCal internal cable routing.

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

#### **Status:**

- sPHENIX had a successful CD-1 document review by BNL Project Oversight Board (POB) subcommittee chaired by Bill Wahl.
- sPHENIX MIE activities are in Primavera P6.
- All sPHENIX CAMs are trained in EVMS.

#### **Highlights:**

- Advanced drafts of all CD-1 documents are in sPHENIX DocDB.
- June 5-6 CD-1 document review and drill down was a very positive experience for the sPHENIX team. The review committee commended the scientific and technical expertise of the team and agreed that sPHENIX is on the right track getting the documentation ready for CD-1 DOE review. Productive discussions after sPHENIX presentations and drill down exercises resulted in many good suggestions that would help to adjust individual presentations to make overall sPHENIX presentation more cohesive and clear.
- Follow-up meetings between sPHENIX management team members and POB members helped to work out the details of various CD-1 document improvements.

#### **Plans for the next 2-3 month:**

- Work with BNL PPM on sPHENIX CD-3a procurements.
- Improve CD-1 documentation based on recommendations from June 5-6 review.
- Continue setting up Primavera P6 codes for PARS-II DOE reporting.

#### **Issues:**

None

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

#### **Status:**

##### **1.2.1 TPC Mechanics**

1.2.1.1 SBU/BNL: TPC v1 Field Cage Prototype. Foam board installation completed. Striped Circuit Card orders placed. Inner mandrel drawings submitted to SBU shop. Resistor order quoted (2 vendors) and going through purchasing. Wagon wheels out on bids. Central membrane 1/3 prototype completed and undergoing study to verify ansys calculations which will be scaled to full sized membrane. Parts for kapton tensioner system ½ delivered.

1.2.1.2-3: No scheduled activity.

1.2.1.4 BNL: TPC v1 Modules. Design for v1 prototype modules has progressed to include GEM segmentation and HV routing. We plan to segment each GEM into 16 arc-shaped stripes and send all stripes outside of the gas for connection to the HV system. HV will be routed through the internal layers at the end of the circuit card (making a gas seal) and the individual current-limiting resistors will be housed OUTSIDE the gas volume. This increases the number of feedthroughs, but significantly improves both the diagnostic capability and simplifies any repairs (eliminating breaking the gas system for many repairs).

Additional tests on the pad plane indicate that the next stages of R&D should pursue laser-etching to compare with the current industry-best chemical etched boards. This comparison among prototypes will allow a technology choice for sPHENIX.

1.2.1.5-8: No Scheduled activity.

**1.2.2 TPC R1 Modules:** No scheduled activity.

**1.2.3 TPC R1 Modules:** No scheduled activity.

**1.2.4 TPC R1 Modules:** No scheduled activity.

#### **1.2.5 TPC FEE**

1.2.5.1 BNL: TPC FEE Prototype v1. First version of the prototype was operated successfully. Operation requires additional current from Artix-7 LVDS drivers. Furthermore, beam clock cleanliness necessitates that addition of fanouts. These changes necessitate changes in the next version prototype design and implementation of these changes has begun. The possibility of increasing the card size has been discussed with sPHENIX authorities for configuration control and we are approved to increase to 14 cm depth, if necessary.

1.2.5.2: No scheduled activity.

1.2.5.3: No scheduled activity.

#### **1.2.6 TPC DAM**

1.2.6.1 BNL: TPC DAM Evaluation – Felix 1.5. Evaluation of the 1.5 card shows success. Further development should be put on hold until the 2.0 version becomes available.

1.2.6.2: No scheduled activity.

1.2.6.3: No scheduled activity.

#### **Plans for the next 2-3 months:**

##### **1.2.1 TPC Mechanics**

1.2.1.1 SBU/BNL: TPC v1 Field Cage Prototype. The mandrel foam will be cut to the precision cylindrical shape needed for the field cage. End rings should be delivered. 2<sup>nd</sup> half of kapton tensioner parts should be delivered and tensioner system assembly will begin.

1.2.1.2-3: No scheduled activity.

1.2.1.4 BNL: TPC v1 Modules. Expect to complete design of v1 prototype modules (informed by R&D) and send out for bids.

1.2.1.5-8: No Scheduled activity.

**1.2.2 TPC R1 Modules:** No scheduled activity.

**1.2.3 TPC R1 Modules:** No scheduled activity.

**1.2.4 TPC R1 Modules:** No scheduled activity.

**1.2.5 TPC FEE**

1.2.5.1 BNL: TPC FEE Prototype v1. Complete the design for the next stage prototype (8 SAMPA) and start the bidding process for production.

1.2.5.2: No scheduled activity.

1.2.5.3: No scheduled activity.

**1.2.6 TPC DAM**

1.2.6.1, BNL: TPC DAM Evaluation – Felix 1.5. Development will wait for the availability of the 2.0 version FELIX card.

1.2.6.2: No scheduled activity.

1.2.6.3: No scheduled activity.

**Issues:**

None

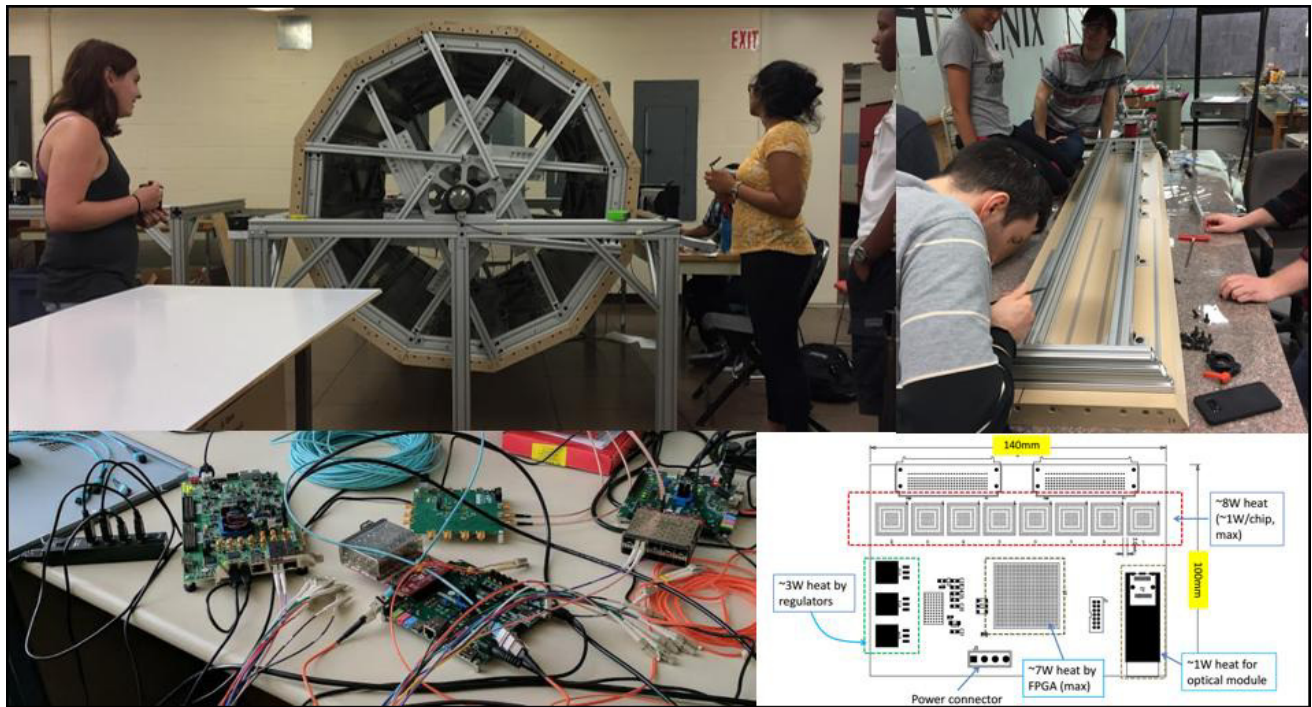


Figure 1: (Upper left & right) Fabrication of the Mandrel for the outer field cage prototype. (Lower left) Tests of Test of TPC Fee prototype 0. (Lower right) Layout for TPC FEE prototype 1.

## WBS 1.3 Electromagnetic Calorimeter (L2 Manager: Craig Woody)

### **Status:**

The sPHENIX CD-1 Document Review took place on June 5-6, 2017 where the current status of the EMCAL cost and schedule, along with all related documentation, was presented. This included the status of the EMCAL Microsoft Project File, Basis of Cost Estimates (BOEs), WBS Dictionary and Risk Registry. The Committee drilled down into several EMCAL WBS items and the overall cost and schedule was reviewed. One concern from the Committee was the ability for UIUC to produce the necessary number of blocks at a rate that could keep up with the delivery schedule to BNL. This concern was addressed by the UIUC group where they explained the main limit to the production schedule was filling the fiber assemblies, which would be done by students. They said they felt they had sufficient resources at UIUC to accomplish this, but that additional student labor could be brought into play if necessary. Some inconsistencies remain between the Project File and the supporting BOEs which will be addressed in the future. In addition, a new schedule will be developed that is consistent with the foreseen budget and funding profile.

Additional progress was made on building a mockup of the preproduction prototype using 3D printed parts and other available components. The purpose of the mockup is to see and better understand how the blocks, readout electronics and cooling system of the EMCAL sectors will be assembled. Figure 1 shows parts of the mockup and cooling system with some of the prototype readout electronics installed.



Figure 2. Mockup of the EMCAL preproduction prototype made from 3D printed parts with mockup parts of the cooling system (red) and prototype readout electronics installed.

### **Work for the next 2-3 Months:**

The main effort over the next several months will be building the v2.1 prototype and building the mockup of the preproduction prototype. The materials for the blocks for the v2.1 prototype are in hand at UIUC and production of the blocks should start in early July. The main missing components for the

v2.1 prototype are the light guides, and it is hope to place the order for these light guides in early July as well. The construction of the mockup of the preproduction prototype is ongoing and will be completed as the various components become available.

**Issues:**

One major concern is the funding profile for the EMCAL. The current schedule requires ordering half of the fibers for the final calorimeter in early 2018 (after a CD-3a approval) in order that UIUC have enough fibers to start filling the fiber assemblies in the summer of 2018. It then requires ordering essentially all of the remaining EMCAL materials (totaling ~ \$4M) in September of 2018 (after a CD-3b approval) such that full scale production of all the EMCAL blocks, modules and sectors can start in early 2019. However, given that CD-1/CD-3a approval of sPHENIX will likely get delayed until FY19, this schedule will need to be revised.

An additional concern is that we still do not have a senior mechanical engineer assigned to the EMCAL project. Progress on the mechanical design is being made with the help of an intern engineer who has been working with us for 12 months, along with a second intern engineer who will be working with us this summer. However, the final mechanical design of the EMCAL detector cannot be completed without the support of experienced, professional mechanical engineer.

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

**WBS 1.4.2 Inner Hadronic Calorimeter**

**Status:**

A prototype for the inner hadronic calorimeter sector has been completed by Technical Services Incorporated in Ames, Iowa (see Figure 1). The BNL engineers are traveling to Ames and will inspect the prototype and meet with the machinists at TSI to discuss issues encountered in manufacturing the prototype. A revised, bottoms-up cost estimate for the inner HCAL has been complete and was part of a BNL Director's CD-1 Documentation Review June 5<sup>th</sup> – 6<sup>th</sup>. A full set of tiles for the inner HCAL sector has been ordered from Uniplast, with delivery expected in September, and planning is underway for the test beam in early 2018. Efforts continue between Georgia State University and Debrecen (in Hungary) to develop an automated tile tester for use in tile production at Uniplast. It is hoped a prototype will be available in time for the production of the test beam tiles.

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

Work for the next 2-3 months will center on preparation for a final beam test of the inner and outer HCAL at FNAL in early 2018, and analysis and publication of the 2017 test beam data. An electronics chain test, including the inner HCAL test beam prototype, has been set up at BNL to test the full electronics chain, including the pre-production digitizers.

**Issues:**

- With the prototype completed, we will revisit the cost estimate for the inner HCAL sector mechanical structure, taking in to account the lessons learned from the prototype construction.

**WBS 1.4.3 Outer Hadronic Calorimeter**

**Status:**

A revised, bottom-up cost estimate for the outer HCAL has been completed and was part of a BNL Director's CD-1 Documentation Review June 5<sup>th</sup> – 6<sup>th</sup>. A prototype for an outer HCAL sector is under

construction by Streck, and completion of the prototype is anticipated in 2-3 months. A full set of tiles for the inner HCAL sector has been ordered from Uniplast, with delivery expected in September. Tiles used in the outer HCAL in the 2017 test beam have been sent to the University of Colorado for unwrapping and mapping in an LED tile tester to verify light collection uniformity. Initial tests are consistent with the results from previous Uniplast tiles.

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

Work for the next 2-3 months will center on preparation for a final beam test of the inner and outer HCAL at FNAL in early 2018, and analysis and publication of the 2017 test beam data.

**Issues:**

None



Figure 3: The completed inner HCAL sector prototype at TSI in Ames, IA. This view shows the absorber plate gaps where the scintillating tiles will be installed.

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

**Status:**

Work continues on a testing device for production SiPM testing. The Debrecen group has identified a number of design changes that will increase the testing rate. These modifications will be implemented when the Debrecen group visits BNL in September and used for preproduction testing. The Univ. of Michigan group has started to train students for SiPM testing and revising test procedures based on initial testing. Discussions are in progress with Hamamatsu technical MPPC group about potential testing that can be provided by Hamamatsu on production devices.

Work has continued to study the performance of the electronics for the EMCAL and HCal, both the frontend analog and back end digital sections. Designs of the HCal LED driver board and EMCAL preamplifier boards have been updated to reflect design improvements based on prototype testing. Design work has started and/or continues on the following:

1. Revise and update the EMCAL electronics design to improve cable routing and reduce noise.
2. Test stations for the preproduction electronics and will serve as a prototype for production testing.
3. Digitizer Crate controller redesign incorporating an interface to the timing system.
4. Design and specify analog signal cables for the EMCAL and HCal detectors.

**Work for the next 2-3 months:**

Work over the next 3 months will be focused on the electronics needed for the next EMCAL prototype for the 2018 FNAL Test Beam run and preproduction EMCAL and HCal detectors. This work will include:

1. Finalizing plans for testing and sorting preproduction SiPMs.
2. Implement design changes in SiPM testing device identified by the Debrecen group
3. Work on redesign of EMCAL signal cable design to reduce cost and improve ease of installation.
4. Develop test fixtures for EMCAL and HCal frontend boards.
5. Prototyping the redesigned Digitizer Crate Controller.

**Issues:**

None

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

**Status:**

The standalone readout system has now been put in routine use to take cosmic-ray data, and is on the verge of becoming a tool that is available to non-experts.

We had previously discussed with the experts at the RHIC-ATLAS Computing Facility the various scenarios with the data logging, and had also identified a set of commercially off-the-shelf file servers that could serve as the buffer boxes if we had to procure them today. A recent updated quote revealed that the price for an incrementally more powerful server has actually gone down since the RACF purchase, which is a welcome development. By the time we actually need those servers, we expect completely new technology to be available, but this shows that suitable hardware is available today.

The work to refine the envisioned trigger strategies and capabilities from simulated has continued, and we are moving towards the discussion how to implement those algorithms.

**Work for the next 2-3 months:**

We are expecting a very early prototype firmware version for the ATLAS FELIX card, which is the leading candidate for the TPC "Data Aggregation Module". It will be possible to obtain (fake) data from the card



in the same way as the later actual data from the front-end, and develop the skeleton readout software, libraries, and drivers.

Work has begun to integrate the existing readout into our standard "RCDAQ" data acquisition system, which could not receive a lot of attention due to a number of other commitments. RCDAQ has been used for most test beam setups and in many smaller lab setups for various R&D efforts. An implementation in RCDAQ is a usual stepping-stone towards the later integration into the full sPHENIX DAQ system later. We expect the first implementation for the FELIX card readout to be developed entirely in the RCDAQ framework, eliminating the integration step for this system altogether.

**Issues**

None

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

**Status:**

We recruited a new group to collaborate on MBD, Lehigh University, led by Rosi Reed. Her group will be very beneficial since she can contribute students to the support of the MBD during the R&D and especially when we are taking data in the sPHENIX era. This brings the group up to three institutions, BNL, RIKEN, and Lehigh. We have summer students evaluating different Digital Signal Processing algorithms (in C++) for extracting the time from the digitized pulse. These studies will be used to determine the best algorithm to use in the sPHENIX Digitizer FPGA when extracting the time for the L1 trigger.

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

Continue construction of non-magnetic test setup for the BBC PMTs, and further studies of the PMTs with the PiLas laser. Finish DSP time extraction algorithm studies.

**Issues:**

None