

sPHENIX Annual MIE Review

WBS 1.05: Calorimeter Electronics

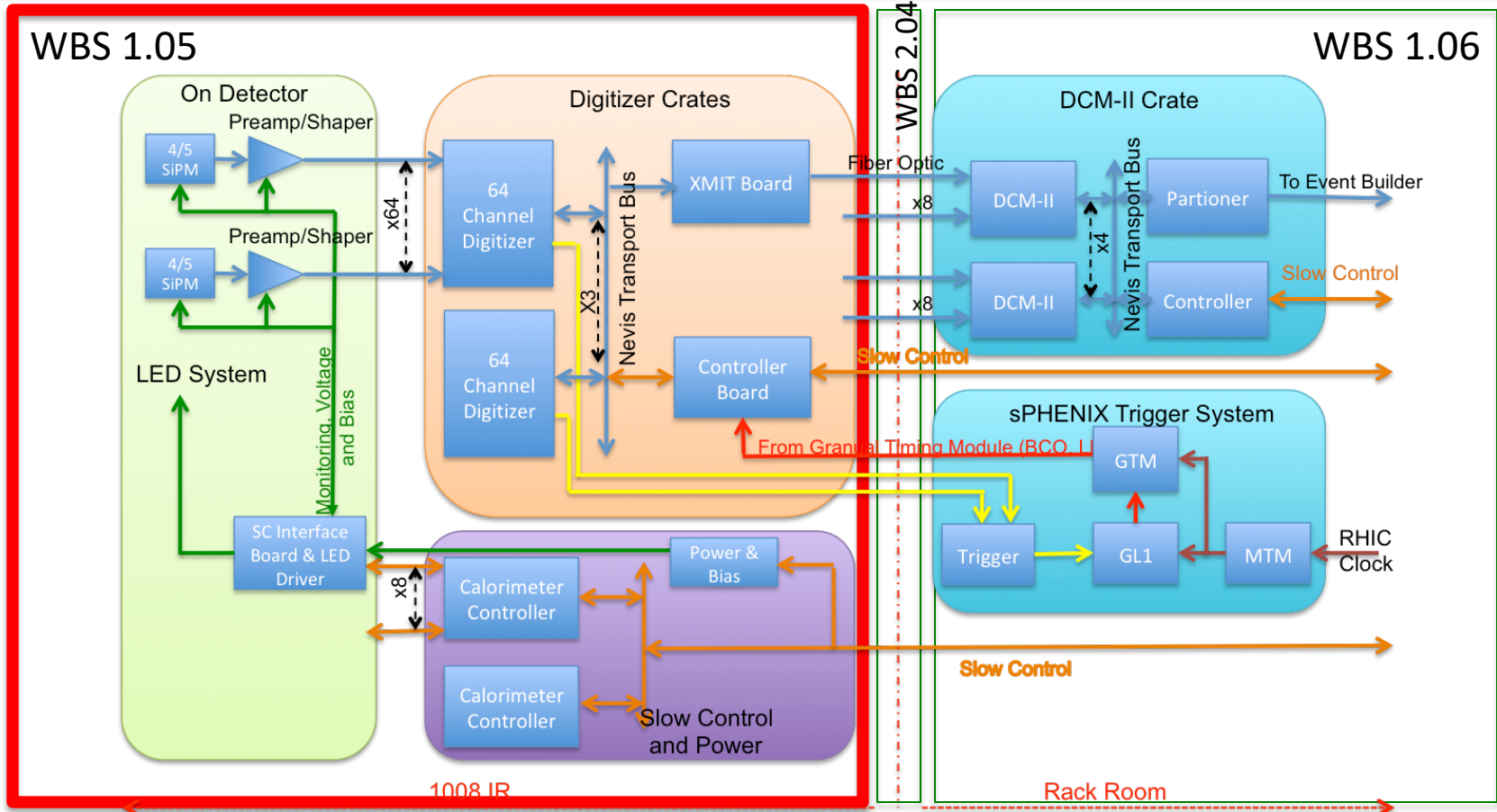
Eric J Mannel

July 14-15, 2021

BNL

- “Common” design for both EMCal and HCal
 - Optical Sensor: Silicon Photomultiplier (SiPM)
 - Front End Analog Section:
 - Amplification/Shaping
 - Gain adjustment
 - Different packaging for EMCal and HCal
 - Digital Backend Section:
 - Continuous waveform digitization
 - Trigger primitives
 - Common Low Voltage and Bias Voltage Systems
- Advance Design:
 - 4 Stages of prototypes and beam testing.
 - Use commercial “Off the Shelf” components - No custom ASICS

WBS 1.05: Block Diagram



WBS 1.05: Scope and Deliverables

- MIE Request (excluding yields)
- Optical Sensors
 - CD-3A Request: 77K devices ordered
 - EMCal: 70000
 - HCal: 7000
- EMCal Front End Electronics
 - 2x2 EMCal SiPM Daughter board: 3744
 - 2x8 EMCal Preamp Boards: 936
 - 64 Channel EMCal Interface Modules: 234
 - EMCal Controllers: 52
 - Crates, Power Systems and Cables
- HCal Front End Electronics
 - HCal SiPM Daughter board: 6240
 - HCal Preamp Boards: 1248
 - HCal Interface, Backplane & LED Driver Modules: 64
 - HCal Controllers: 8
 - Crates, Power Systems and Cables
- Digitizer System
 - Digitizers Modules: 367
 - XMIT Modules: 92
 - Controllers/Crates: 23
 - Clock Master: 6
 - Power systems & Patch Fibers

WBS 1.05: Subsystem Collaborators



- **Brookhaven National Lab:**
 - Eric Mannel, L2 for WBS 1.5
 - Steve Boose, L3 for analog front-end electronics
 - Front end electronics design, production & testing
- **Columbia Univ/Nevis Labs:**
 - Cheng-Yi Chi, L3 for digital back-end system
 - Back-end electronics design, production & testing
- **Lehigh University**
 - Electronics testing
 - Pre-assembly
- **University of Colorado**
 - Digitizer Testing
 - Software control
- **University of Michigan**
 - Christine Aidala, L3 for optical sensor testing
 - Optical sensor testing
- **University of Debrecen**
 - Testing Equipment design and production
 - Optical sensor testing
- **Augustana University**
 - Database management
 - Electronics testing

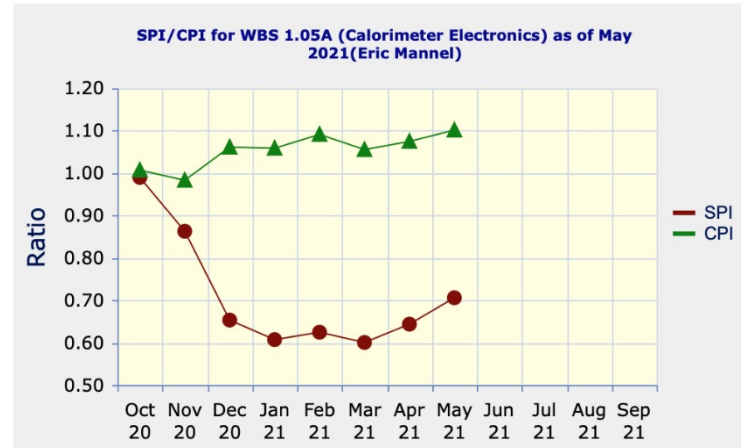
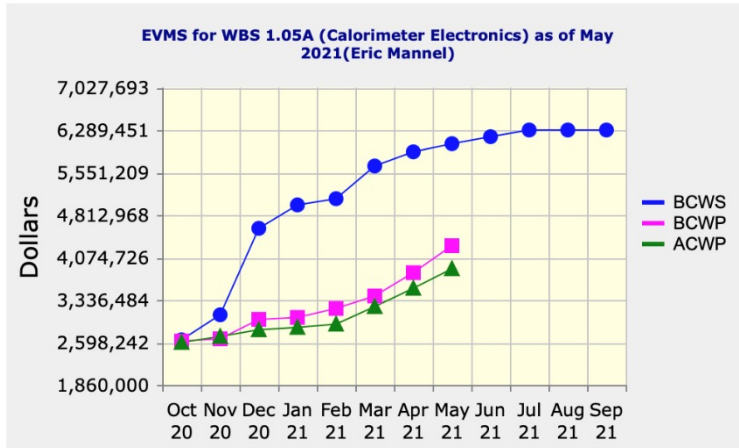
Schedule Performance:

- SiPM Delivery (LLP): completed January 2020
- Front end electronics:
 - Board delivery completed May 2021
 - All interior HCal electronics have been delivered
 - Board testing on going for EMCal, meets/exceeds EMCal sector production schedule
- Digitizer System:
 - Contract with Columbia Univ/Nevis Labs finalized in July 2020
 - 7 of 34 crates have been produced
 - Full delivery scheduled for January 2022
- Power Systems:
 - All components delivered June 2021
 - Distribution board assembly and testing in progress, expected to be complete 4Q 2021

• Schedule To Go:

- External Signal Cable Order is out for Bid:
 - Bid due date July 2
 - Bid award date ~July 15th
 - First article ~2 months from award date.
 - Full delivery ~7 months from award date.
- External Power Cables
 - Quotes have been received
 - Submission of orders to BNL PPM, last week of June
 - Projected delivery 4-6 weeks from contract award.
- Slow Control & Fiber Cables
 - Off the shelf items
 - Have tested sample cables from several vendors and identified acceptable vendors
 - Working with integration group to confirm acceptable lengths
 - Submit requisitions in August of 2021.

WBS 1.05 Cost Performance and Cost To Go



BAC: \$6,290,621 EAC: \$5,910,216 VAC: \$380,405

- Global electronics parts market delayed production of EMCAL preamps and LV Bulk supplies
- One major order to be placed, signal cables \$1.1M

- Exterior cable FDR/PRR- Jan 13, 2021:
 1. A mockup of the cable routing inside the digitizer rack should be used to estimate the length of cable needed from the entry point of the track to the ADC front panel.
 2. A tester for acceptance testing of production cables should be designed and built.
 3. Cables should be delivered with durable unique labels at each end.
 4. The sPHENIX Safety and Quality Assurance officers should be consulted about the exact cables that will be procured as part of the award of the contract.

Completed

Completed for power cables
Part of contract

Completed

- EMCal interior electronics PRR- April 8, 2020

Recommendation

1. Production of the electronics for sectors 13-64 should proceed without changes from electronics for sectors 1-12.
2. Quantities should be carefully evaluated by the calorimeter electronics group in concert with the EMCAL group to account for yield.

Same design files used

Completed

- HCal/EMCal Bias Supply PRR- Mar 6, 2020

Recommendation

1. Purchase of the Wiener bias supplies should proceed.

Purchase completed

- HCal FDR/PRR – Feb 5, 2020

Recommendations

1. In the next two weeks, add to the PRR slides some missing information:
 - a. An introductory slide showing clearly the scope of the production.
 - b. Include the interface boards on slide 3.
 - c. Include a link to quality assurance documents developed for the preproduction sectors.
 - d. Include a link to the electronic design documents.
2. In the next month, document and record the gain and dynamic range of the calorimeter and electronics.
3. Before beginning production, consult the [sPHENIX](#) Quality Assurance Coordinator and the [sPHENIX](#) Safety Coordinator.

All recommendations addressed

- HCal Sector 1-6 FDR/PRR- Oct 8, 2019

- EMCal Sector 1-12 FDR/PRR- Sept 11, 2019

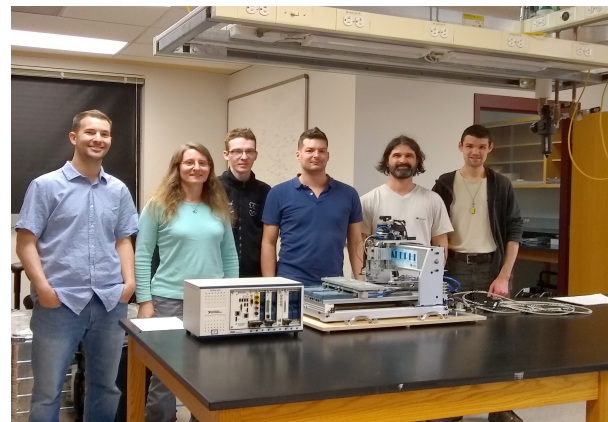
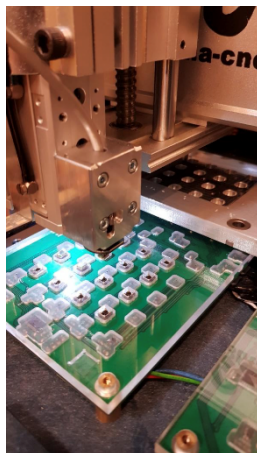
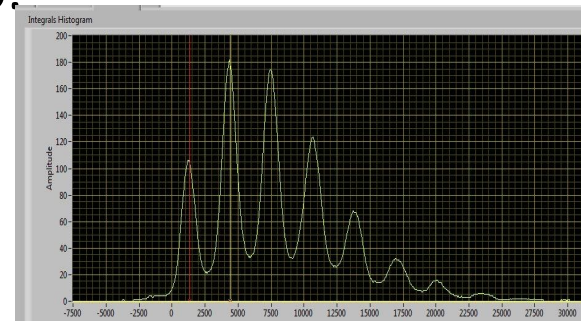
Recommendations

1. It would be prudent to do some further testing of Sector 0 electronics before submitting the final orders. In particular, a test of the cooling system with the complete sector under power, a measurement of crosstalk in the cramped high z end of the detector, and measurements of an optimized test pulse amplitude and LED's are very desirable.
2. The [SiPM V₀](#) testing and sorting method should be understood, and discrepancies should be reconciled.
3. The documentation in [docDB](#) should be completed.
4. The [sPHENIX](#) Q/A officer (Chuck Gortakowski) should sign off on the Q/A plan.
5. The safety issues and ground plan for the EMCAL sectors should be documented.
6. The requirements and how the EMCAL electronics satisfy them should be summarized.

All recommendations addressed

WBS 1.05: Status and Highlights - 1

- SiPM delivery completed in February 2020.
- Device testing completed
 - Test stand developed at Debrecen University
 - Testing completed at University of Michigan
 - Software support from Augustana University



WBS 1.05: Status and Highlights - 2

- HCal on-detector Electronics completed
 - All on-detector electronics tested and delivered to HCal group
 - SiPM boards
 - LED Driver Boards
 - Preamps
 - Interior signal cables
 - Interface boards
 - Transition boards
- Testing of electronics has been completed, thanks to help from Veronica from ISU (preamp testing)

WBS 1.05: Status and Highlights - 3

- EMCal on detector electronics production completed
 - All on detector received, testing on going
 - SiPM boards- testing in progress BNL/CU
 - Preamps- testing in progress
 - Interface boards – testing in progress Lehigh
 - Interior signal cables- complete
- Testing of electronics is on going thanks to help from Lehigh University and Univ of Colorado:



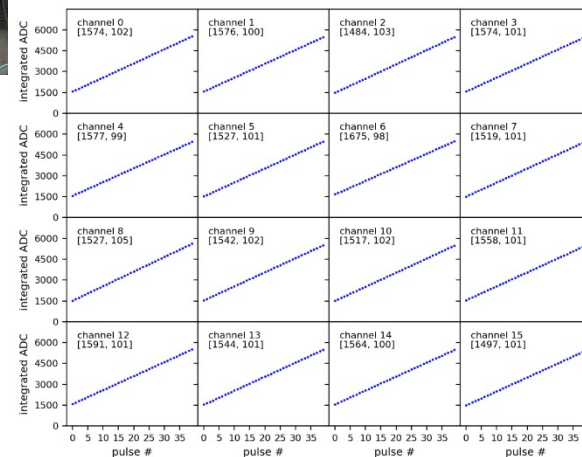
WBS 1.05: Status and Highlights - 4

- Columbia University/Nevis Labs is the lead on digitizer electronics
 - Design of electronics completed
 - Production in progress
- University of Colorado has set up a QA testing stand
- First 7 crates of digitizer boards delivered
 - 84 Digitizers tested
 - Back-plane communications
 - ADC response to calibrated input
 - Pedestal
 - 2 Crates of digitizer boards delivered to BNL
 - Balance are having front panels installed



2 Crates in 1008 for through put testing

Linear response of digitizer system from CU testing



- Safety questions are an integral part of the design review process:
 - Fusing
 - Materials
 - Current requirements
- All board fabrication is done using commercial vendors
- University testing is governed by university safety regulations
- Commercial components are either NRTL Listed (a majority) or inspected by an approved BNL inspector

WBS 1.05: Issues and Concerns



Risk Identification			Risk Handling Plan (Mitigations)	Residual Risk (Post- Mitigation Assessment)										
Risk ID Number	Risk Title	IF/THEN	Risk Handling Plan (Mitigations)	Residual Risk	Low Cost Impa	Likely Cos	High Cost Impa	Low Sched	Likely Sched	High Sched	Overall Impact Sc	Expected Valu	Average Expect	Basis of Impact Estimates
sPH_CalEI_012	Digitizer component prices go up	If digitizer components cost more, then there will be additional costs	Accept	70%	117	117	117	0.0	0.0	0.0	High	81.90	81.90	Based on the BOE and remaining work
sPH_CalEI_013	Digitizer components procurement is late	If student labor unavailable for SiPM testing and/or Calorimeter FEE board testing, then schedule delays	Work with participating University to monitor student availability	10%	0	0	0	1.0	3.0	6.0	Low	0.00	0.00	Based on most recent experience
sPH_CalEI_015	External cables delivery is delayed	If cables are late, then there will be schedule delays up to 6 mo	Work with BNL procurement, maintain Critical Procurement list for POB	25%	0	0	0	1.0	3.0	6.0	High	0.00	0.00	Based on most recent experience

Schedule -

- Availability of students and techs to do acceptance testing
- Availability of parts for the production round of Digitizer system
- Timely processing of Purchase Requests
- Delivery time of external signal cables has increased significantly

- Calorimeter Electronics:
 - All SiPMs were delivered on schedule.
 - All HCal interior electronics have been tested and installed
 - All EMCal interior electronics have been received. Testing is ongoing; being delivered to the the EMCal group for installation ahead of need-by date.
- Digitizer System:
 - 7 of 34 Crates of digitizers have been delivered for testing
 - Parts orders for the remaining 27 crates of digitizers have been placed
 - PCB and assembly orders are being prepared
- Outstanding order:
 - Signal and power cable orders placed
 - Fiber and slow control orders remain to be placed (off the shelf items)

Back Up