The sPHENIX Calorimeter System: Current Status of the Design, Construction, and Testing

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***Abstract*—Designed to make detailed studies of the Quark-Gluon Plasma, the sPHENIX detector has been approved and construction started. A primary component of the sPHENIX detector, is the calorimeter system consisting of both an hadronic and electromagnetic detectors. The design of electromagnetic and hadronic calorimeters has been finalized and construction of the first modules has started. In this paper we will present the current status of the construction of the electromagnetic and hadronic calorimeters and show results from the testing of the first full scale modules of the detectors.**

Keywords- Electromagnetic, Hadronic, Calorimeter, SiPM, sPHENIX

I. The Hadronic and Electromagnetic Calorimeter Designs

A key element of the sPHENIX detector is the hadronic calorimeter, HCAL, which is a sampling calorimeter consisting of 2 radial sections; the inner HCal detector which is located inside the solenoid directly behind the electromagnetic calorimeter, and the outer HCal detector that is located immediately outside the solenoid. Both inner and outer HCal detectors are constructed from alternating layers of absorber plates and scintillating tiles with a wave-shifting fiber. The plates are tilted from the radial direction to provide a more uniform sampling of showers and minimize channeling. The inner HCal is constructed of aluminum plates and corresponds to $\sim$ 1 interaction length. The outer HCal uses steel plates which also serve as the flux return for the solenoid and corresponds to $\sim$ 4 interaction lengths. To prevent channeling, the tilt angle of the outer HCal plates is in the opposite direction of the inner HCal. A cross section of the calorimeter system is shown in Fig 1.

The design for the electromagnetic calorimeter, EMCal, is a 2-D projective SPACAL design that consists of tungsten powder and epoxy with embedded scintillating fibers (W/SciFi) [1], [2]. A 2×2 array of SiPMs is attached to a short light guide mounted on the inner radius of of the tungsten block to sample the light produced by a shower in the tower. The analog front end electronics are located next to the light guides on cooling plates which are connected to a water-glycol based cooling system to maintain a stable operating temperature.

The compact nature of the EMCal and HCAL, and their close proximity to the solenoid requires an optical sensor that is both small and capable of operating in a high magnetic field. In order to meet these requirements, the Hamamatsu S10362-33-15C MultiPixel Photon Counter (MPPC) has been selected for the sPHENIX calorimeters. A common electronics design has been developed to readout the calorimeters using a system that allows for continuous digitization of the waveforms and provides trigger primitives for the sPHENIX trigger system.

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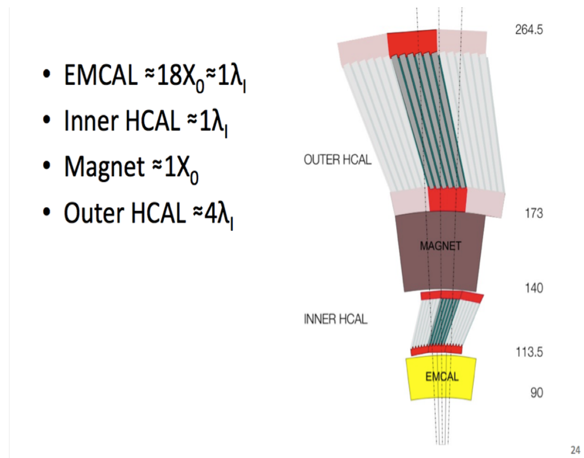

Fig. 1. Cross section of the sPHENIX calorimeter system showing the relative locations of the EMCal, inner HCal and outer HCal. The inner radius of the EMCal is 90 cm. from the beam line.

II. Current Status of the Calorimeter System

The first sector of the EMCal has also been assembled and is currently undergoing testing. Critical to the performance of the EMCal is the ability to monitor and control the temperature of the SiPMs to minimize variations in the gain of the SiPMs due to temperature variations. To maintain a stable temperature environment, the EMCal employs two cooling loops. The first loop directly cools the SiPM boards, while a second cooling loop is used to cool the analog electronics located directly next to the SiPM daughter-boards, with insulation used to help provide a thermal barrier between the SiPM daughter-boards and the electronics. The SiPM daughter boards are designed with a thermistor on the board that is readout as part of the sector monitoring. As part of the QA testing, the temperature of the SiPM daughter-boards are monitored as the sector goes through its initial testing. The standard deviation of the temperatures for the entire first sector assembled are shown in Fig. 2.

The initial calibration of the EMCal sectors requires the observation of the pixel spectrum. The spacing between the pixel peaks is a direct measurement of the overall gain of the system in ADC counts. In order to observe the single pixel peak, the sector was operated at 15° C and data collected using the preproduction digitizer system triggered randomly.

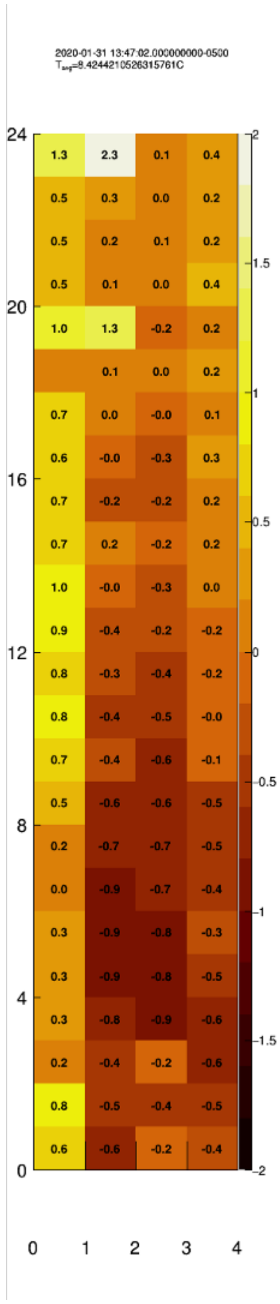

Fig. 2. The standard deviation in the SiPM daughter-board temperatures while going through initial testing. With the exception of one tower, variation over time was less then 1°C.

The pixel spectrum for 64 towers in the first full sized EMCal sector is shown in Fig. 3.

All 32 steel modules for the outer HCal have been delivered to BNL and the first 6 modules have been instrumented with scintillating tiles and electronics. Quality assurance procedures have been developed to insure that the modules are fully functional before installation into the sPHENIX detector. For calibration and stability monitoring each tile is illuminated by a pulsed blue LED. The response of the 48 towers to an LED pulse is shown in Fig. 4. Variations in the pulse amplitude are understudy but believed to be associated with the light distribution system.

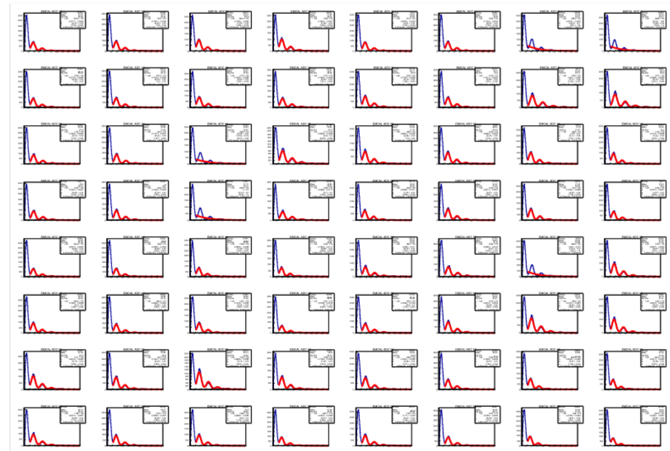

Fig. 3. The pixel spectrum for 64 of the 364 towers in the first full size EMCal sector. The position of the single and double pixel peaks are used to determine the absolute gain of the tower in ADC counts. The preproduction sPHENIX digitizer system was used to collect the data.

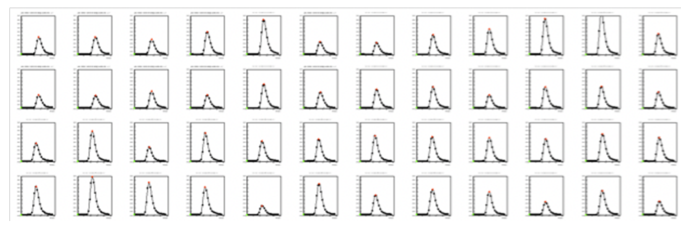

Fig. 4. The response of the 64 towers in the first production outer HCal module to a pulsed LED. The light from the LEDs are distributed to each of the tiles in the module using different length fibers.

III. Conclusions

The design of the sPHENIX calorimeter system has been completed. Construction of the EMCal and outer HCal is ongoing and the inner HCal will begin construction in the fall of 2020. A QA testing program has been developed and will be used to insure that the modules are fully functional and capable of meeting the design requirements of the sPHENIX calorimeter system. All three detectors are scheduled for completion in 2021 and be ready for installation into the sPHENIX detector located in the RHIC 1008 interaction hall starting late in 2021.

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References

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