sPHENIX Hadronic Calorimeter: Assembly, Testing, and Calibration

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Abstract

The sPHENIX detector is a new experiment at RHIC at BNL, designed to measure jets and upsilons in heavy-ion collisions. The sPHENIX hadronic calorimeters are used to measure jets and are comprised of two metal/scintillator sampling detectors inside and outside of sPHENIX's cylindrical magnet. The outer calorimeter has acceptance of $-1.1 \leq \eta \leq 1.1$ and $0 \leq \varphi < 2\pi$, and a depth of 3.8 nuclear-interaction lengths. Construction of the detector was completed in spring 2021. The 32 sectors comprising the outer calorimeter were built in a factory setting, with multiple sectors simultaneously being assembled (populated with scintillator and electronics), tested (using fixed LEDs to record scintillator response), and calibrated. Each sector was calibrated with cosmic muons. This poster discusses the design, assembly, and testing of the outer hadronic calorimeter. Status of testing and calibration using cosmic rays and simulation are shown.

sPHENIX Detector in General

Calorimeters

- Uniform, hermetic in $|\eta|<1.1$ and $0 \leq \varphi < 2\pi$
- Electromagnetic Cal. (18 X_0, 1 λ_I)
  - Tungsten–Scintillating Fiber
  - $\Delta\eta \times \Delta\varphi \approx 0.025 \times 0.025$
  - $s_E/E < 16\%/\sqrt{E} \oplus 5\%$
- Inner HCAL (0.25 λ_I)
  - Aluminum plates, scintillating tiles w/WLS fibers
  - Used in tandem with EMCal and OHCal
- Outer Hadronic Calorimeter (3.8 λ_I)
  - Low-carbon steel plates, scintillating tiles w/WLS fibers; 6m long, 12t heavy
  - Flux return
  - $\Delta\eta \times \Delta\varphi \approx 0.1 \times 0.1$
  - $s_E/E = 100\%/\sqrt{E}$

Tracking

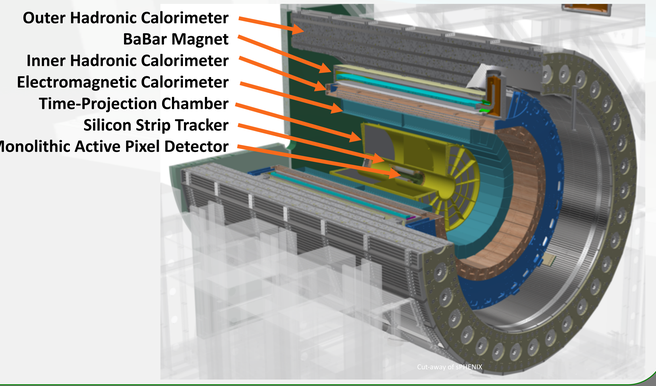
- MVTX (based on ALICE ITS)
  - 3-layer MAPS vertex tracker
  - Excellent 2D DCA resolution, < 25 μm, $p_T > 1$ GeV/c
- INTT:
  - 2-layer Si strip
- TPC:
  - 48 layer, continuous readout, $R = 20 - 78$ cm
  - Good momentum resolution $p_T = 0.2 - 40$ GeV/c

Magnet

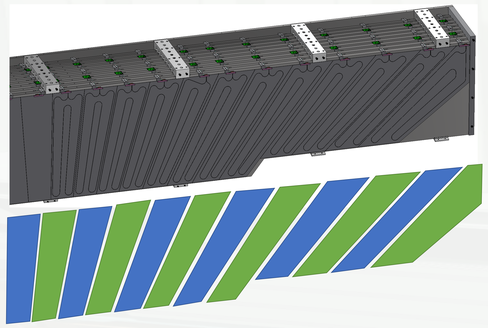
- Babar SC solenoid, 1.4 X_0

Read-out

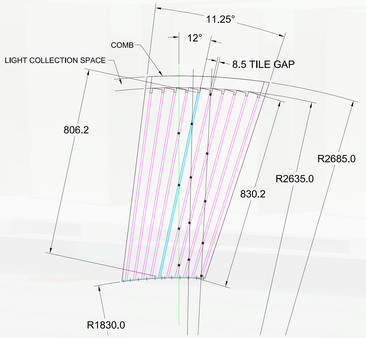
- All detectors at 15 kHz trigger rate



Outer Hadronic Calorimeter Design and Assembly

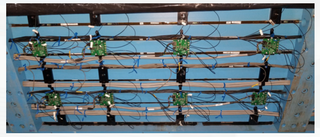


▲ *Scintillating tiles tilted in η from center of barrel*



▲ *Scintillating tiles tilted in φ from radius*

▲ *HCal Assembly at BNL's AGS Fixed-Target Experimental Hall*

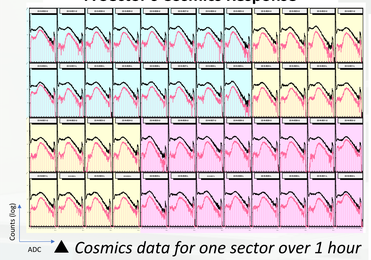


▲ *In-Progress Assembly*

▲ *Electronics; power, signal cables; LED drivers and optical fibers*

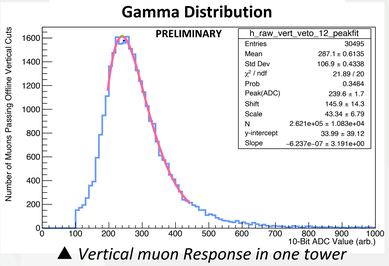
Calibration with Cosmic Muons

A Sector's Cosmics Response



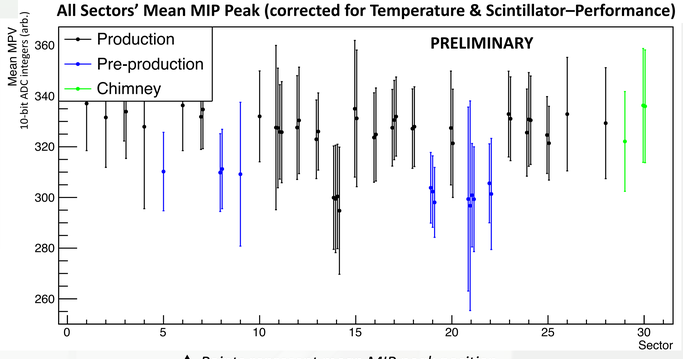
▲ *Cosmics data for one sector over 1 hour (**black** = no cuts; **red** = vertical-muon cuts)*

Fitting Single-Tower MIP Peak with Gamma Distribution



▲ *Vertical muon Response in one tower from one sector over 1 hour*

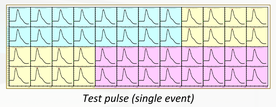
All Sectors' Mean MIP Peak (corrected for Temperature & Scintillator–Performance)



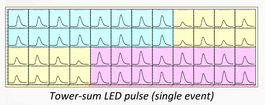
▲ *Points represent mean MIP peak position, error-bars represent RMS of the 48 towers in each sector*

Testing

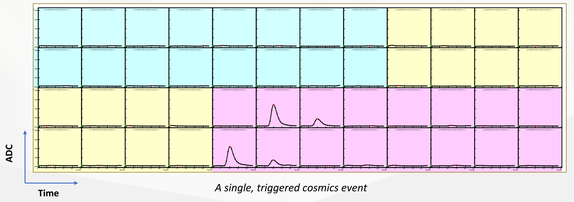
- Tower-ID Test: Check connections
- Test Pulse: Charge-injection to make sure that the electronics are working correctly
- LED Scan
  - tests the SiPMs and associated electronics
  - individual tiles' response to fixed LED light
  - benchmark for changes
- Cosmics
  - Sector is divided into thirds
    1. Group's sum is above a threshold; and
    2. At least two towers in group have their individual signal above another threshold
  - Each triggering event reads out the whole sector



Test pulse (single event)



Tower-sum LED pulse (single event)



A single, triggered cosmics event

Conclusions

- The calorimetry systems of sPHENIX work together to provide unbiased jet measurements for the experiment's jet and fragmentation-function studies.
- The self-trigger developed during testing provides a basis for cosmic muon calibration during the detector's life at RHIC and the EIC
- The data and analysis developed here provide groundwork for additional tools and investigations

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