Performance Characterization Studies of sPHENIX Outer Hadronic Calorimeter Scintillating Tiles

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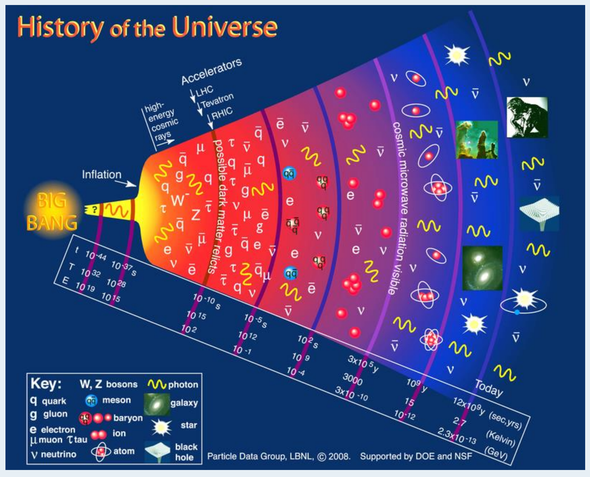
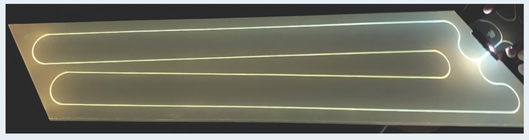
Quark Gluon Plasma

- Seconds after the Big Bang, universe was a hot, dense state of deconfined quarks and gluons.
- These particles interact via the nuclear strong force and are typically confined within protons and neutrons.
- The Quark Gluon Plasma (QGP) can be recreated at near light speed collisions between heavy ions at the Relativistic Heavy Ion Collider (RHIC)



Outer Hadronic Calorimeter

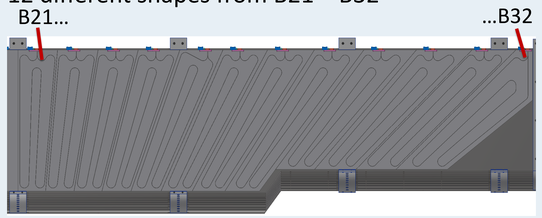
- Measures the energy of hadrons produced in the collisions
- Helps with precise jet measurements
- Comprised of scintillating tiles sandwiched between steel plates
- Similarly performing HCal tiles' SiPM signals aggregated into calorimeter towers



Unwrapped Outer HCal Tile

Scintillating Tiles

- Composed of scintillating plastic, wavelength shifting fiber, and reflective coating.
- Light produced in the tile goes from fiber to silicon photomultiplier (SiPM) where amount of light is recorded.
- 12 different shapes from B21 – B32

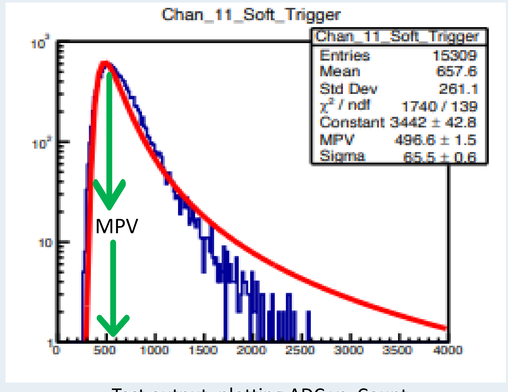


Tile test stand. 10 tiles (2 reference) are tested for 20 minutes.

Dimension tester. Tiles are tested to make sure they are the proper size and will fit in the HCal towers.

Tile Testing at GSU

- Check dimensions of the tile to ensure proper fit into the detector.
- Test for differing light response
  - Cosmic rays strike tile, which we use as a calibration tool to measure how much scintillation light is produced
  - Test for 20 minutes at a time
  - Each test has 8 tiles with 2 reference tiles
  - Determine the Most Probable Value (MPV) of light count, which tells us about the tiles' light output
  - Calculate the Performance Ratio, which determines how tiles are sorted in HCal, using equation:
    - PR = MPVtile/<MPVref>



Test output, plotting ADC vs. Count

sPHENIX

- The sPHENIX Experiment is located at RHIC at Brookhaven National Lab (BNL) and is an upgrade to the previous PHENIX detector
- Aims to take more accurate measurements of jets and upsilons in Au+Au collisions to study the properties of the QGP.
- Studying the QGP and its properties help us better understand the nuclear strong force and the early universe.
- At GSU, we are studying the scintillating tiles that will go in the Hadronic Calorimeter (HCal), which detect the jets that occur during the collisions

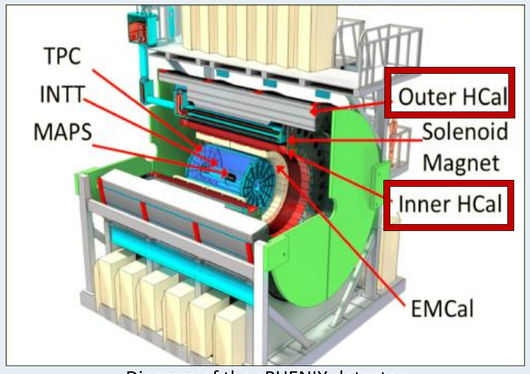
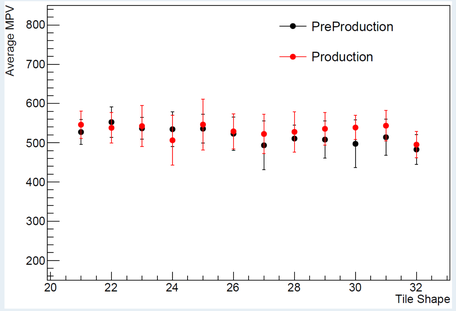


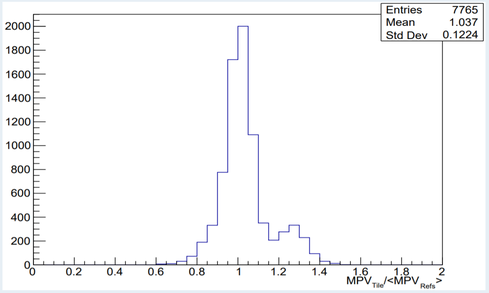
Diagram of the sPHENIX detector

Conclusion

- Studying the QGP teaches us a deeper understanding of the nuclear strong force and gives us glimpse into the early universe.
- GSU has tested all 7,756 of the Outer HCal tiles.
- Only ~1.5% of tiles had low performance.
- sPHENIX construction is on schedule with data collection set to start in 2023



Avg MPV vs Tile Shape of the Outer HCal Tiles



Final global distribution of the Outer HCal tiles