Improving Geometric Description of the sPHENIX Hadronic Calorimeter in GEANT4 for Accurate Jet Energy Measurements

Kristyn Spears, *for the sPHENIX Collaboration*

Abstract

The sPHENIX detector at the Relativistic Heavy Ion Collider (RHIC) includes tracking detectors, an electromagnetic calorimeter (EMCal), an inner hadronic calorimeter (HCal), and a solenoid magnet surrounded by an outer HCal. The description of the HCal geometry in simulation uses a geometry description markup language (GDML) implementation of the as-built CAD drawings of the detector which provides a highly realistic description of the detector geometry at the expense of increased computational time. This poster will present a comparison of a detailed description of the geometry from a GDML implementation of the CAD drawings to using simple GEANT4 shapes to approximate the geometry.

sPHENIX at RHIC

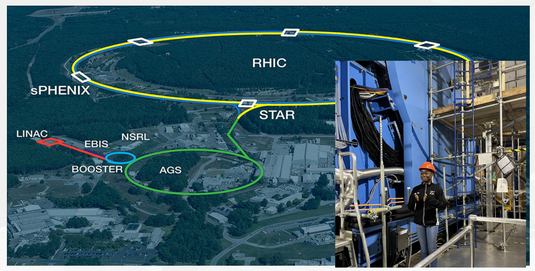


Diagram is from sPHENIX Collaboration https://www.bnl.gov/newsroom/news.php?a=23758

- Scientific Goals of sPHENIX: designed to study properties of quark-gluon plasma (QGP)
- sPHENIX uses jets formed during collisions to study the QGP interactions of quarks and gluons

sPHENIX Hadronic Calorimeter (HCal)

Outer Hcal:
- 32 sectors
- 7680 scint tiles
- 12 tile shapes

Inner Hcal:
- 32 sectors
- 6144 scint tiles
- 12 tile shapes

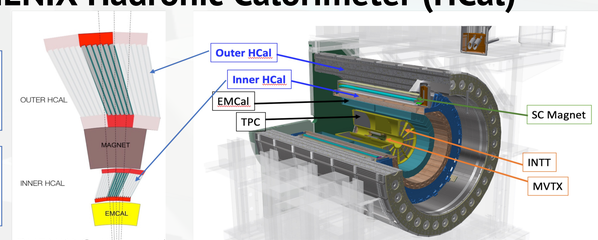
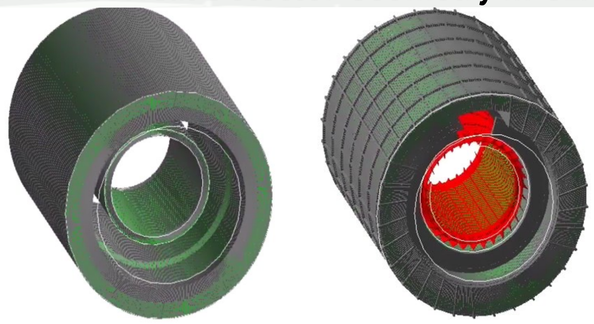


Diagram is from sPHENIX Collaboration https://www.flickr.com/photos/brookhavenlab/49923003571/in/album-72157613690851651/

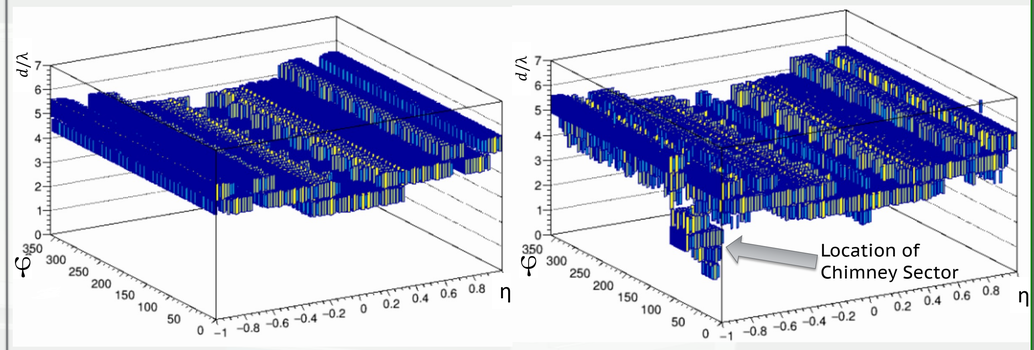
- The Hadronic Calorimeter measures the energy of hadrons in the sPHENIX detector using scintillating tiles
- Tiles were tested by students by GSU's Nuclear Physics before assembly
- The services used to cool the super-conducting magnet requires a chimney sector, which cuts through a section of the outer HCal

sPHENIX HCal Detector Geometry in GEANT4



- Left shows HCal geometry using approximated shapes in GEANT4
- Right shows HCal geometry using as-built CAD drawings
- Chimney sector and intricate tracings are clearly visible in the right

Hadronic Interaction for Outer HCal



(Old Geometry) (New Geometry)

- The plots show the hadronic interaction length as a function of pseudo-rapidity and azimuthal angle in phi
- There is a drop in particle interaction at the chimney sector

Jets in High Energy Collisions

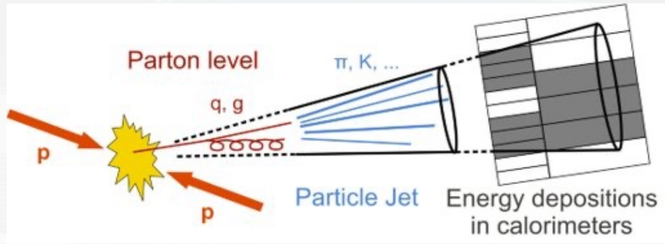
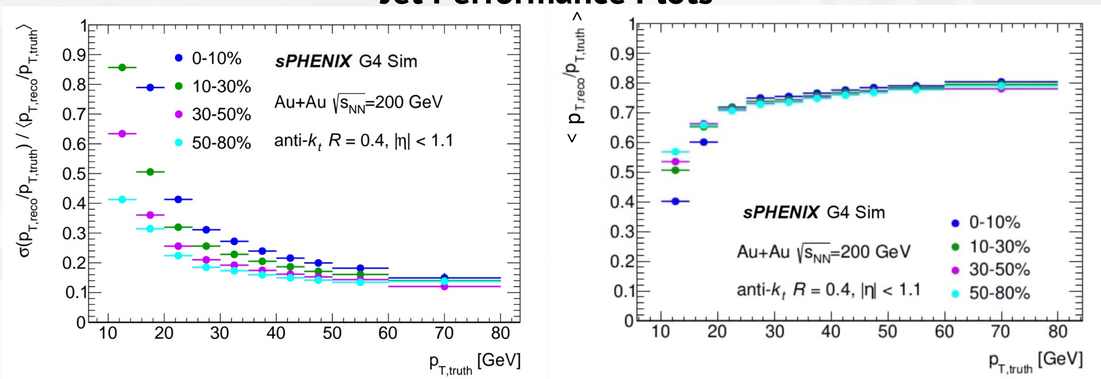


Diagram is from CERN https://cms.cern/news/jets-cms-and-determination-their-energy-scale

- Jets are sprays of particles, quarks and gluons, formed during high energy collisions
- The fragmented particles deposit energy into the sPHENIX detector, causing the scintillating tiles emit light

Jet Performance Plots



- The Jet Performance plots show how well our simulated jets match truth jets with the current as-built CAD drawing geometry
- Left shows Jet Energy Resolution (Standard Deviation); Right shows Jet Energy Scale (mean of distribution)
- For both Jet Energy Resolution and Jet Energy Scale there is a centrality dependence at low p_T that levels off at higher p_T

Summary

- The chimney sector does modify particle interaction, meaning our measurements are affected by the geometry of the HCal
- We need to determine how the geometry difference shows up in data, specifically focusing on difference in tower energy, which will be conducted by the Georgia State University Nuclear Physics Group

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