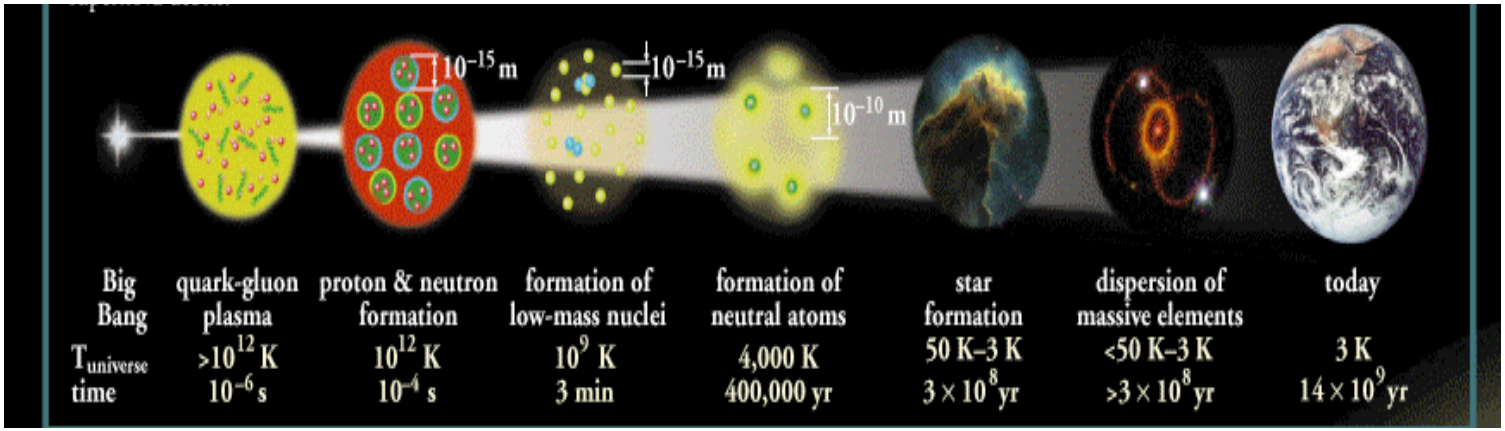
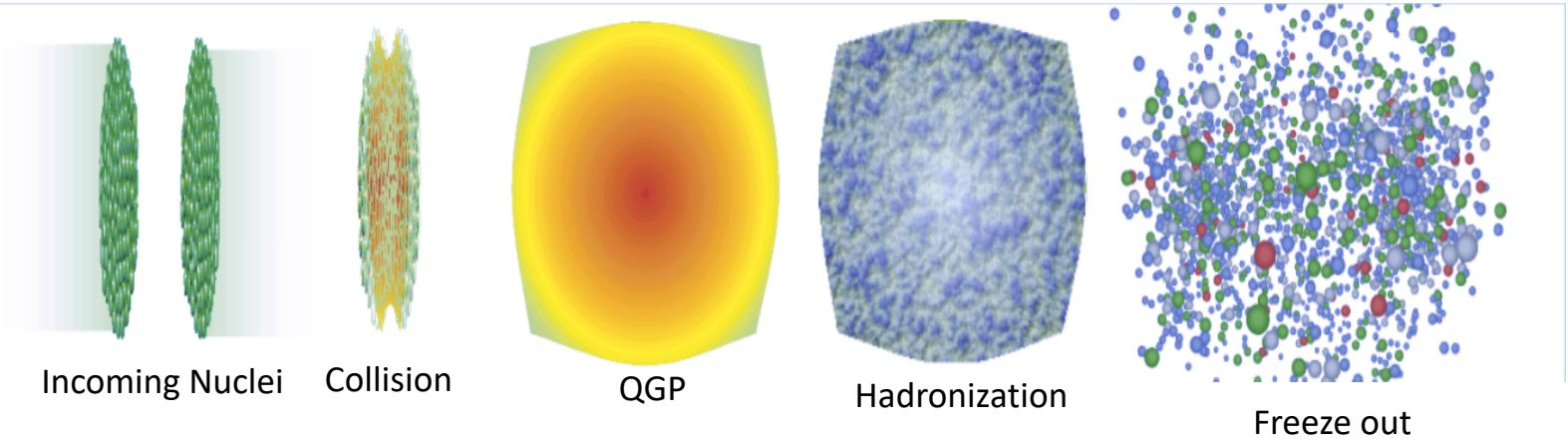
# Testing and Characterization of Scintillator Tiles for the sPHENIX Hadronic Calorimeter.

**Uttam Acharya**
For the sPHENIX Collaboration
DNP19 Meeting of APS
Crystal City, Virginia, USA
October 17, 2019

# Quark Gluon Plasma (QGP)

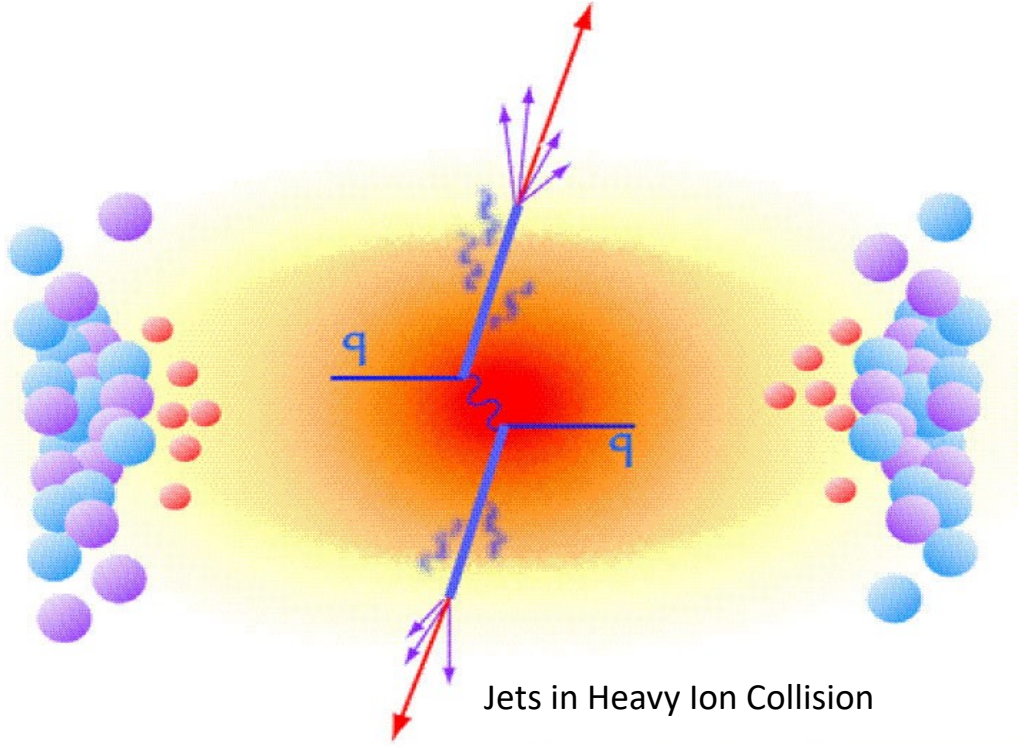
- Extremely hot and dense state of matter.
- Produced at very high temperature($10^{12}$K) and density (1GeV/fm$^3$) where nuclear matter get deconfined.
- Existed few microsecond after Big Bang.



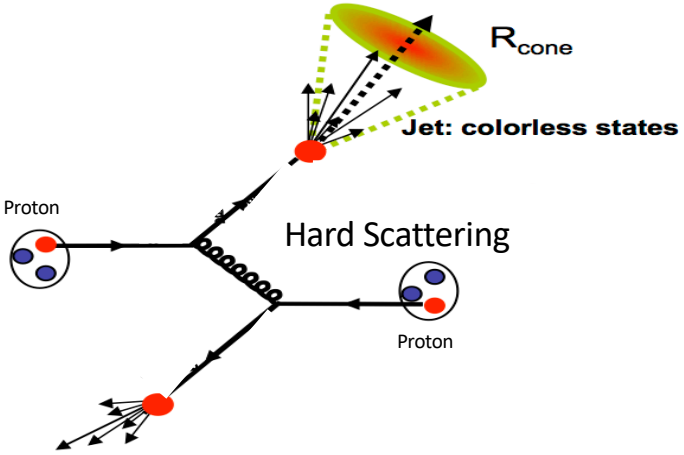



# Jets

- Collimated beams of high momentum particles produced due to partonic fragmentation in collision.




Jets in Heavy Ion Collision

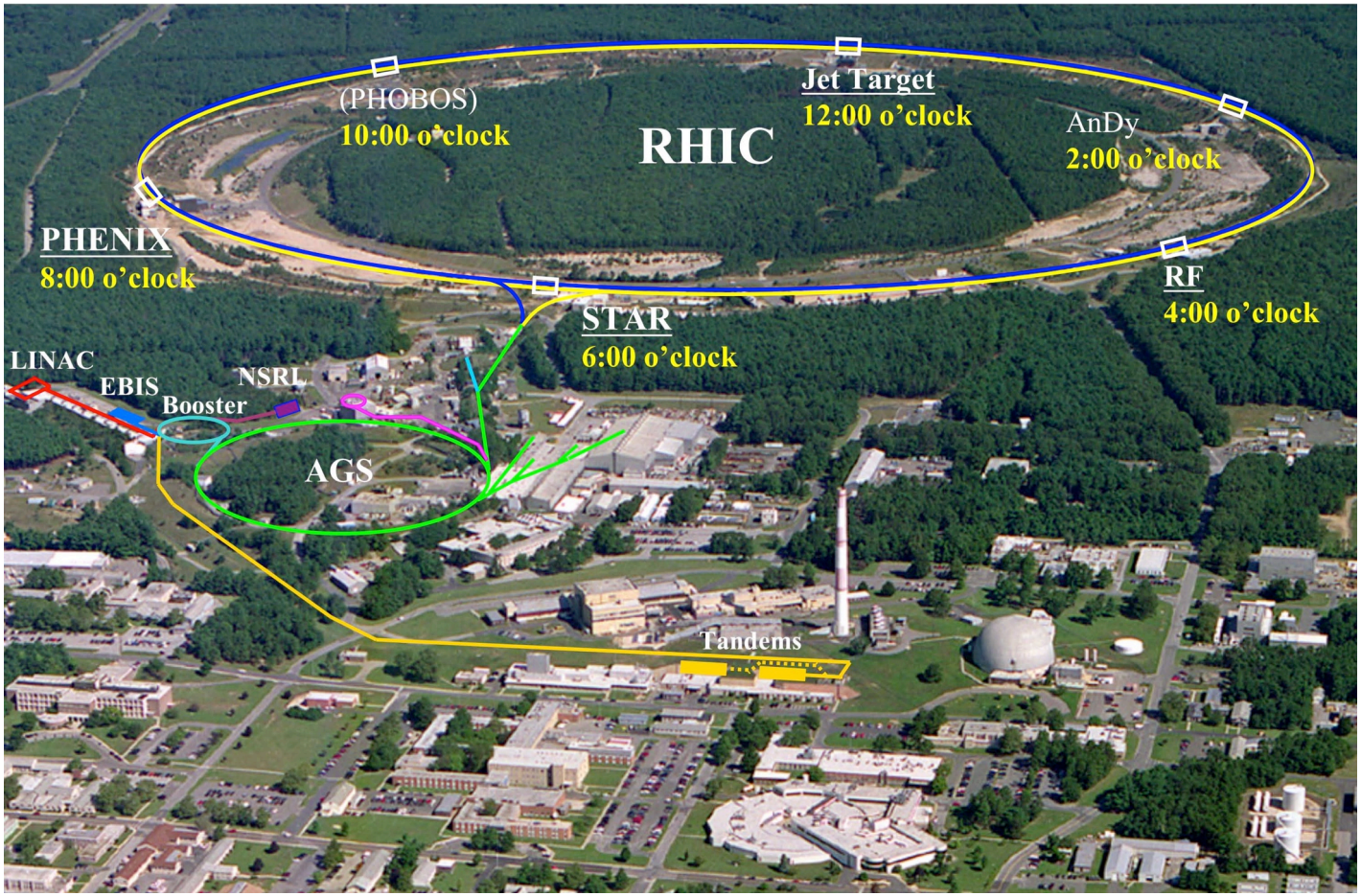



Jets in p+p Collision

- Jet particles loose energy into QGP and modifies the final energy.
- Study modification of jet energy comparing to p-p collision.

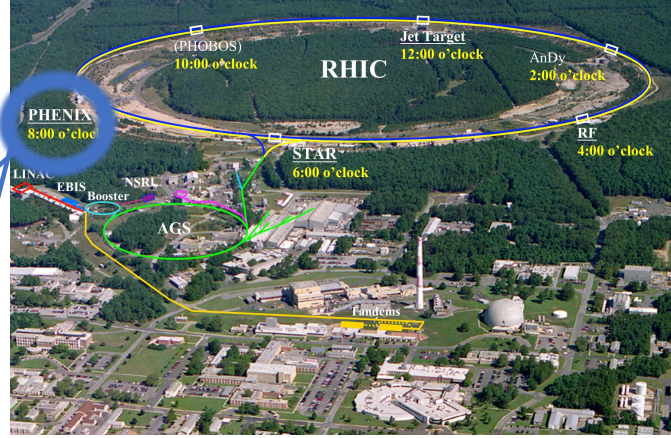
# RHIC: **R**elativistic **H**eavy **I**on **C**ollider

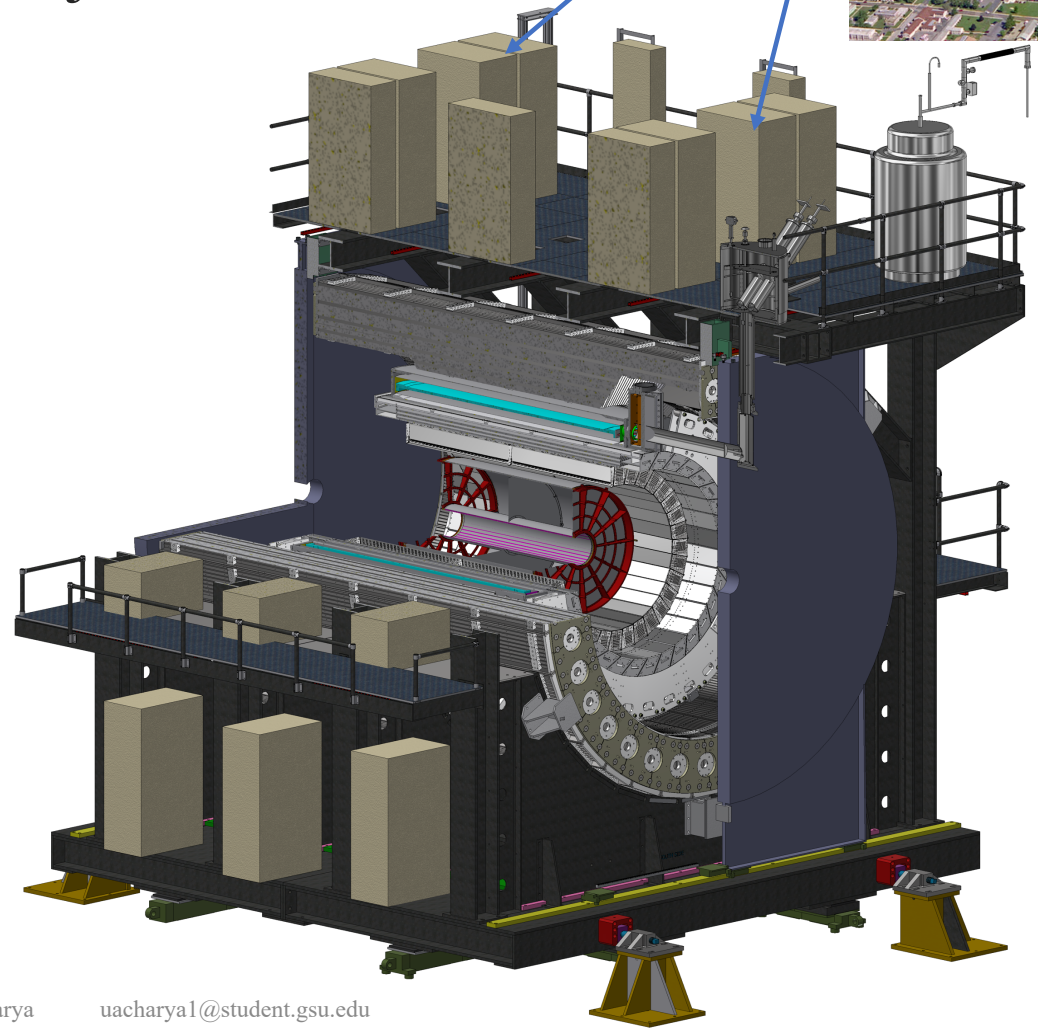
- QGP machine located in Upton, New York.
- Capable of colliding many different atomic nuclei at different center of mass energies.



# sPHENIX – A Jet Detector

- Upgrade to PHENIX.
- Full $2\pi$ acceptance in Azimuth.
- Pseudorapidity coverage $|\eta|<1.1$
- Capable of full jet reconstruction.

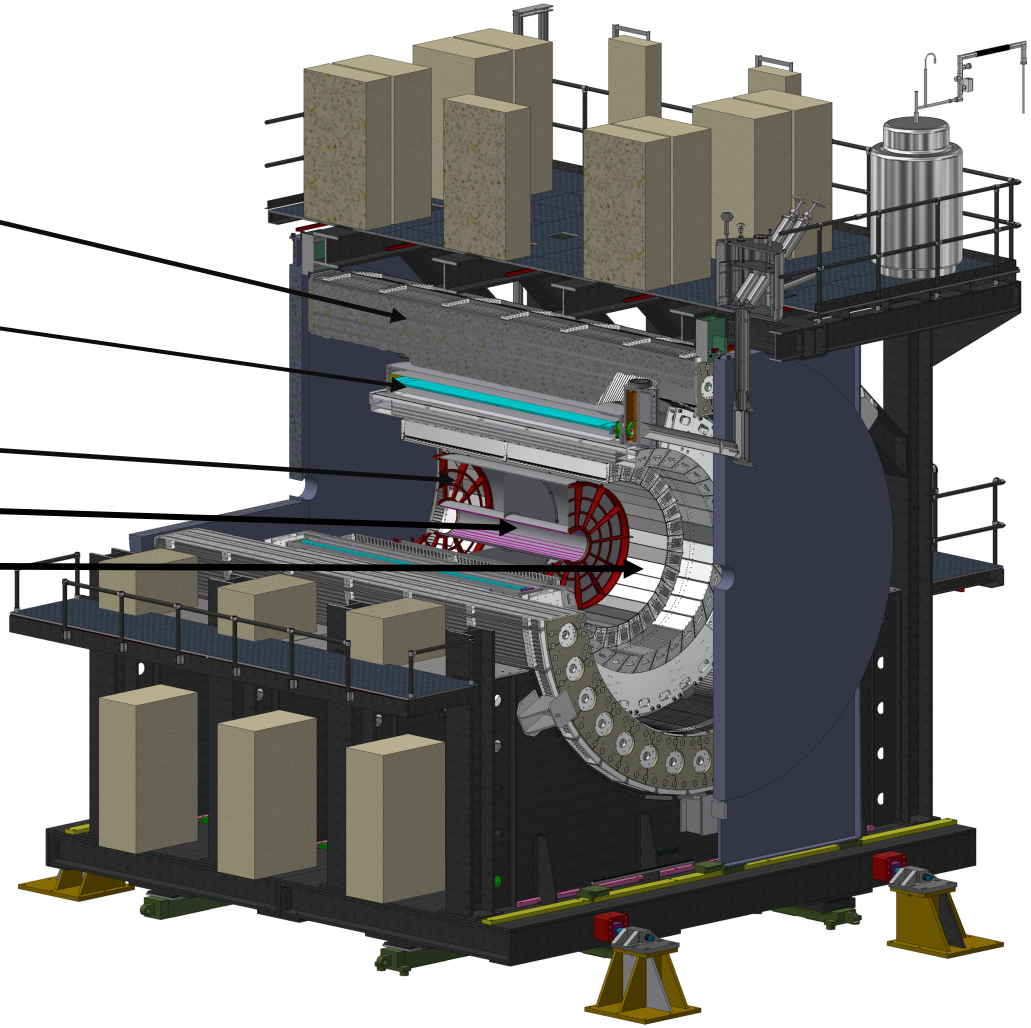


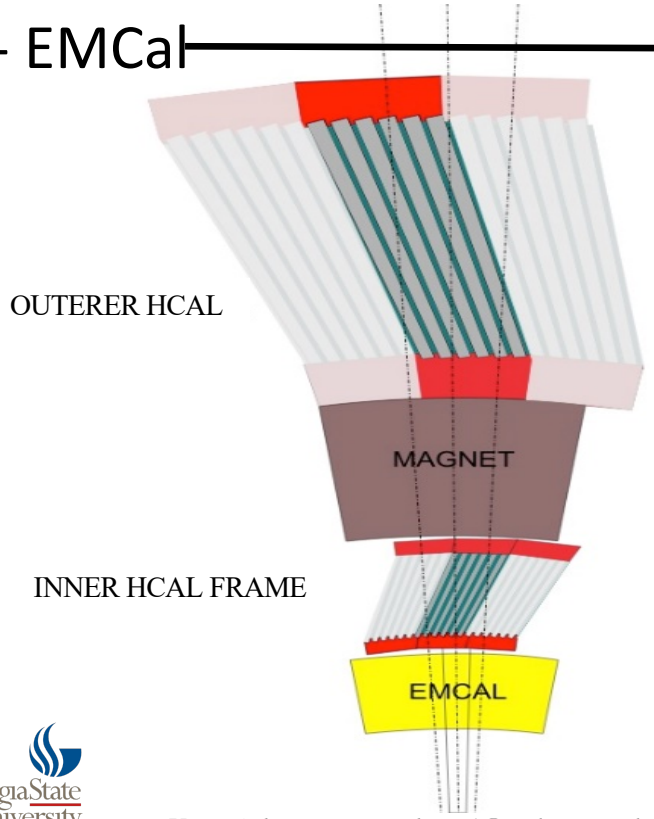



# sPHENIX – A Jet Detector

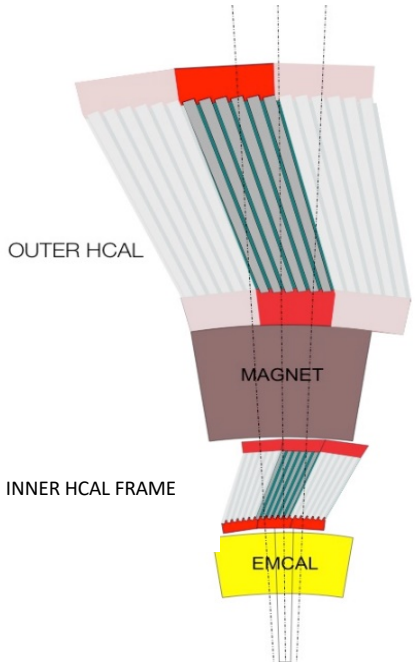
## sPHENIX Components

-Hadronic Calorimeter
- Solenoid
- Magnet
- TPC
- MAPS
- EMCal



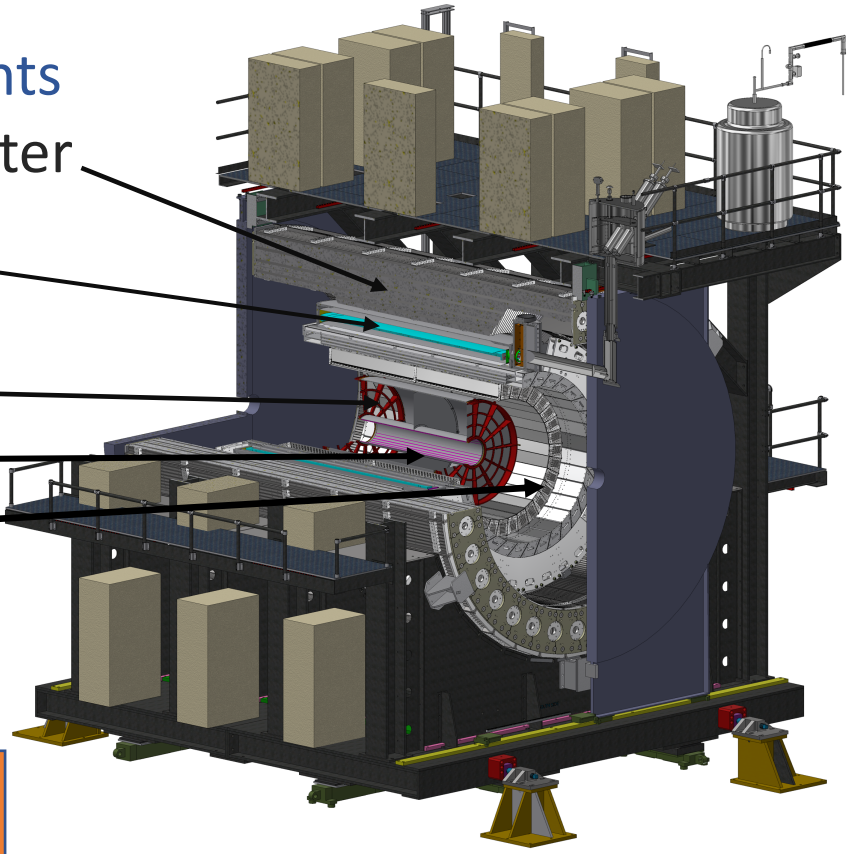


# sPHENIX – A Jet Detector




## sPHENIX Components

-Hadronic Calorimeter
- Solenoid
- Magnet
- TPC
- MAPS
- EMCal



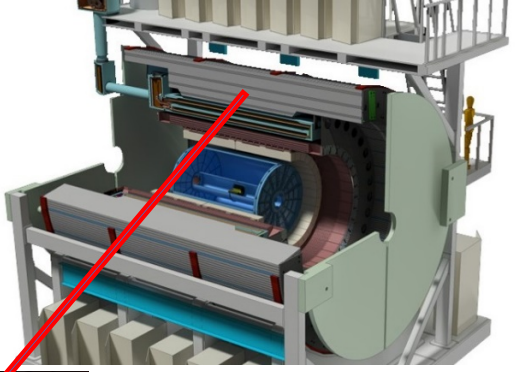
HADRONIC CALORIMETER

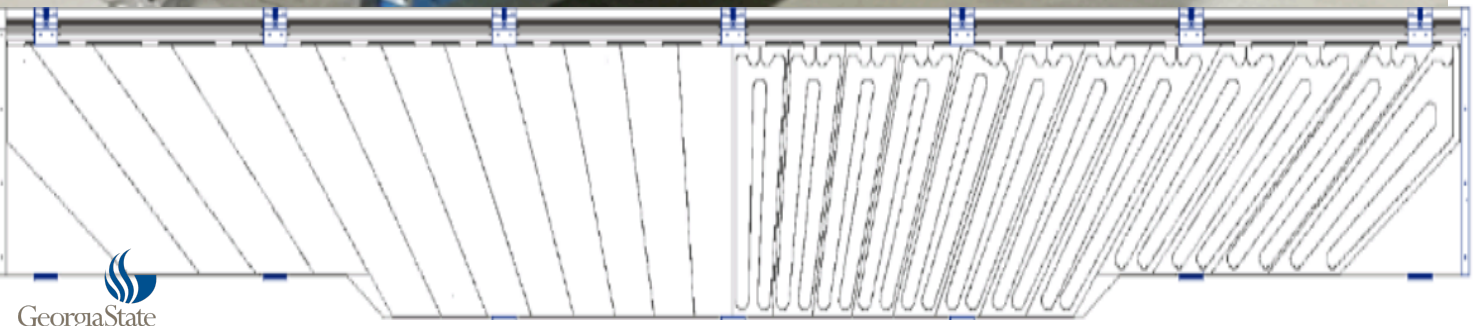
Essential components for measuring energy of jets.

-Outer HCal:- Located outside the magnet.

# The Hadronic Calorimeter: Outer HCal

- Critical for precision jet measurements.
- 32 Sectors.
- 48 tower per sectors.
- 5 scintillator tiles per tower.
- 1536 readout Tower (7680 SiPM's).



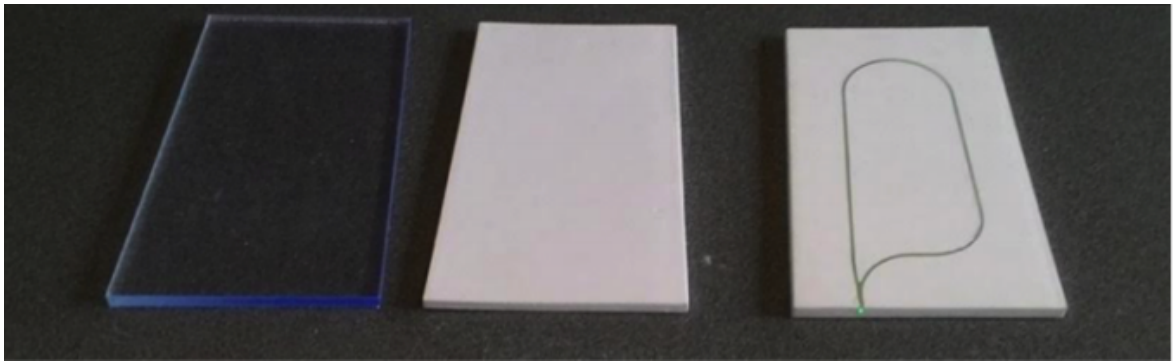


## Sector

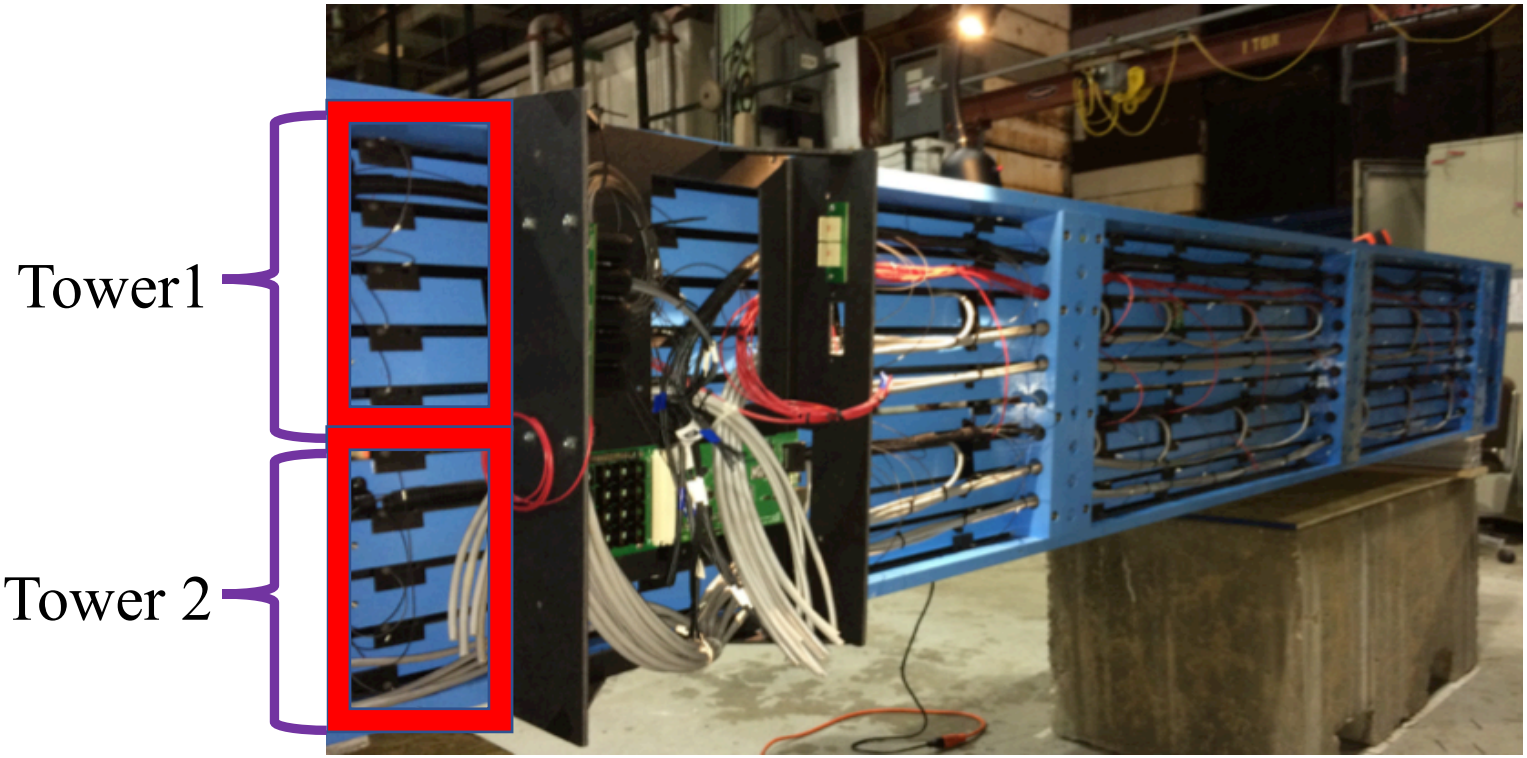
- Each sector has 10 rows with 8mm gap between steel absorber.
- 24 tiles per row.
- 240 tiles in each sector.

# HCal Tiles

- Made by Uniplast.
- Mixture of **Polystyrene**, **Paraterphenyl**, and **POPOP**, wrapped by Tedler.
- Wavelength shifting fiber routes the scintillation light to end of the tile where it is collected by SiPM's.
- 12 different shapes of tiles based on the particle trajectory.
- The signal of every five tiles is aggregated to form a tower.



# Tile Inspection and Testing

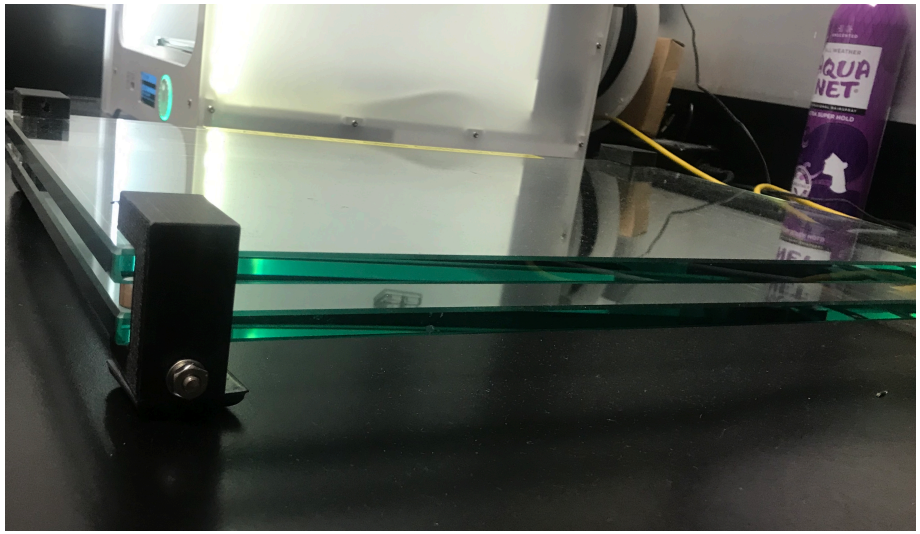


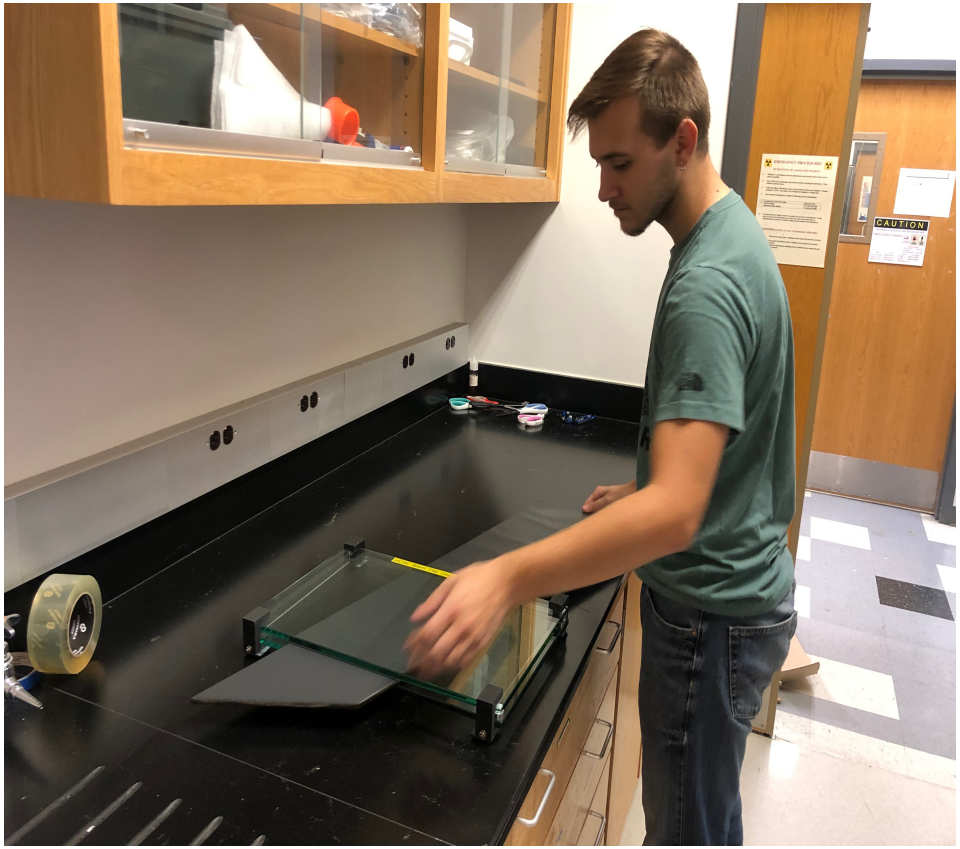

- Tiles within a tower need to have similar behavior.
- Need to be tested before installation into HCal.
- Preliminary Test was done at Uniplast.
- At GSU, we tested: Tile dimensions & Performance.

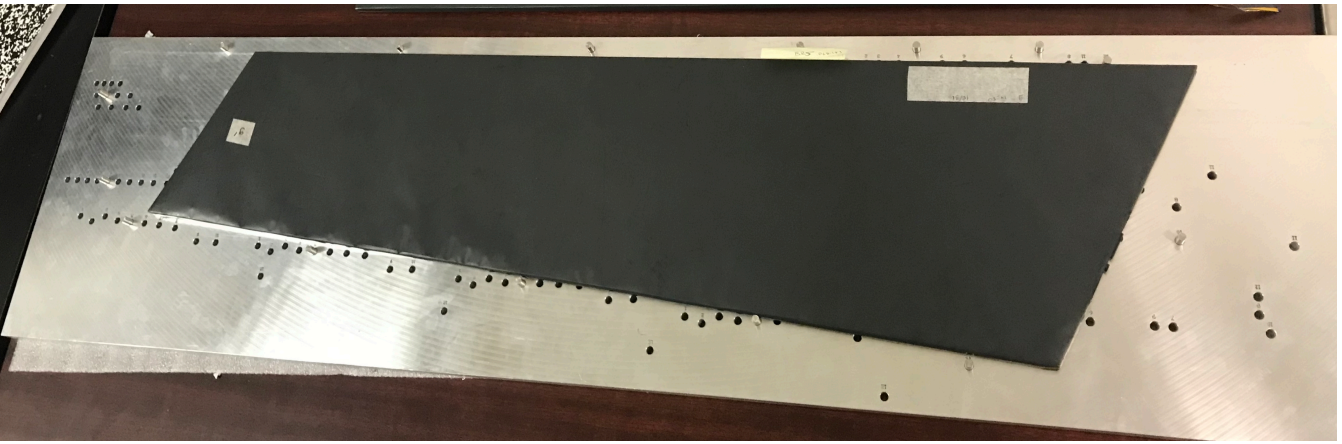
# Tile Inspection

**Thickness Gauge**

- Allow every tiles go through 8mm gap.
- Indicate those which do not go through it.



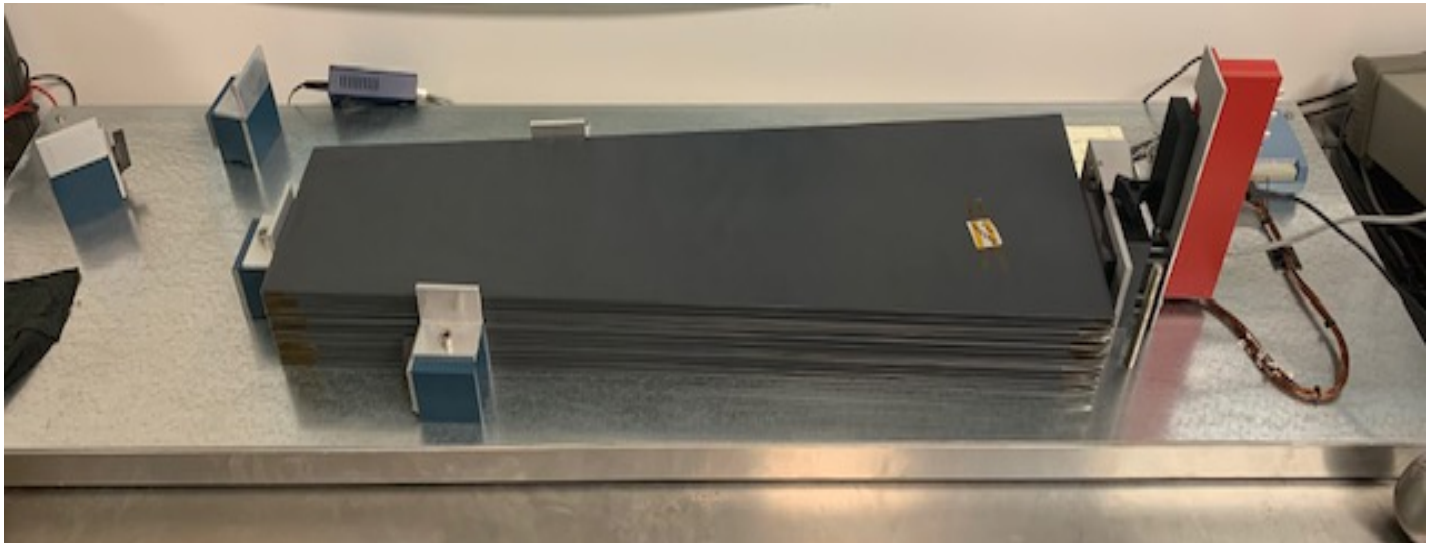


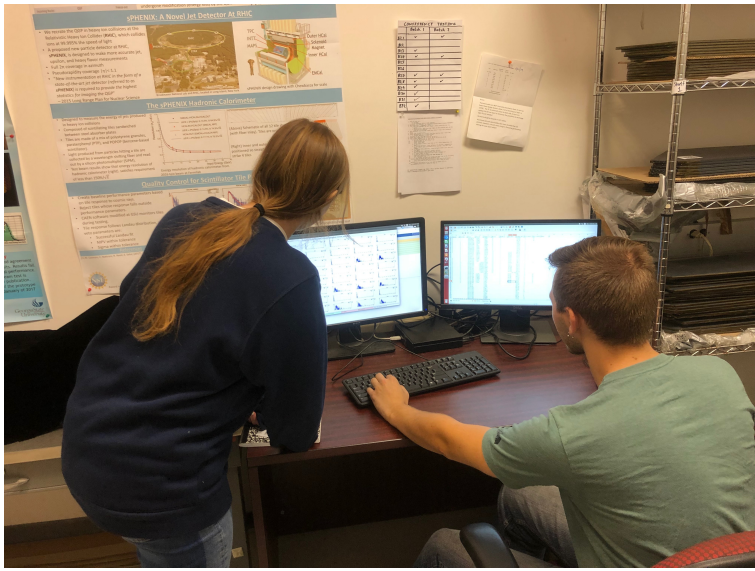
**Dimension Tester**

- Designed such that dimension of all tiles shape be easily measured.

# Tile Testing



- Test stand built at BNL.
- CAEN DT5702 FEB mounted on top to quantify the signal.
- Test tiles by measuring response to the cosmic rays.
- 10 Channels:- test 8 tiles at a time.
- Top and bottom tiles are **reference** tiles.
- Reference tiles allow us track the performance of tile over the course of production.



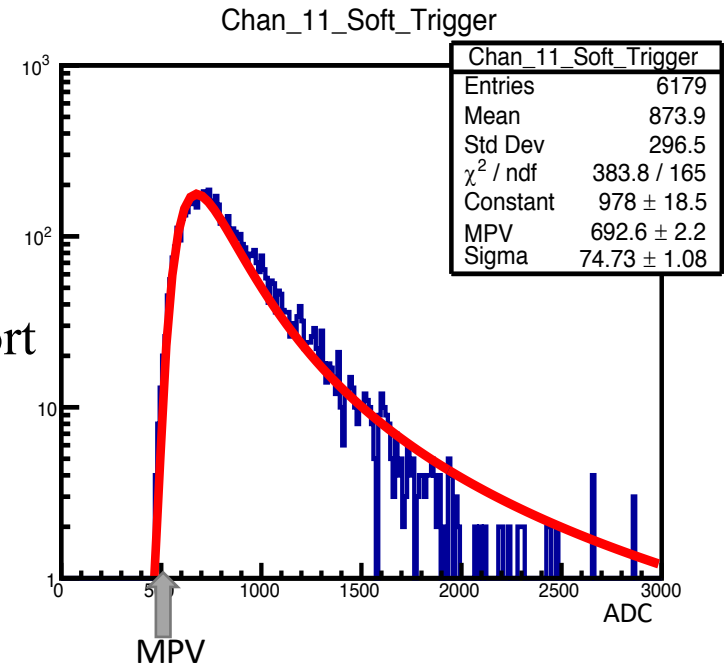
# Performance Characterization

- Cosmic rays strike tiles, produce scintillation light.

- Scintillation light is captured by SiPM and converted into an ADC count: forms the spectrum for all channels.

- ADC spectra is fitted by Landau Distribution with its most probable value(MPV) used to sort tile's performance.

- Take average of the MPV's of the reference tiles and divide each test tile's MPV by this average called "Performance Ratio".

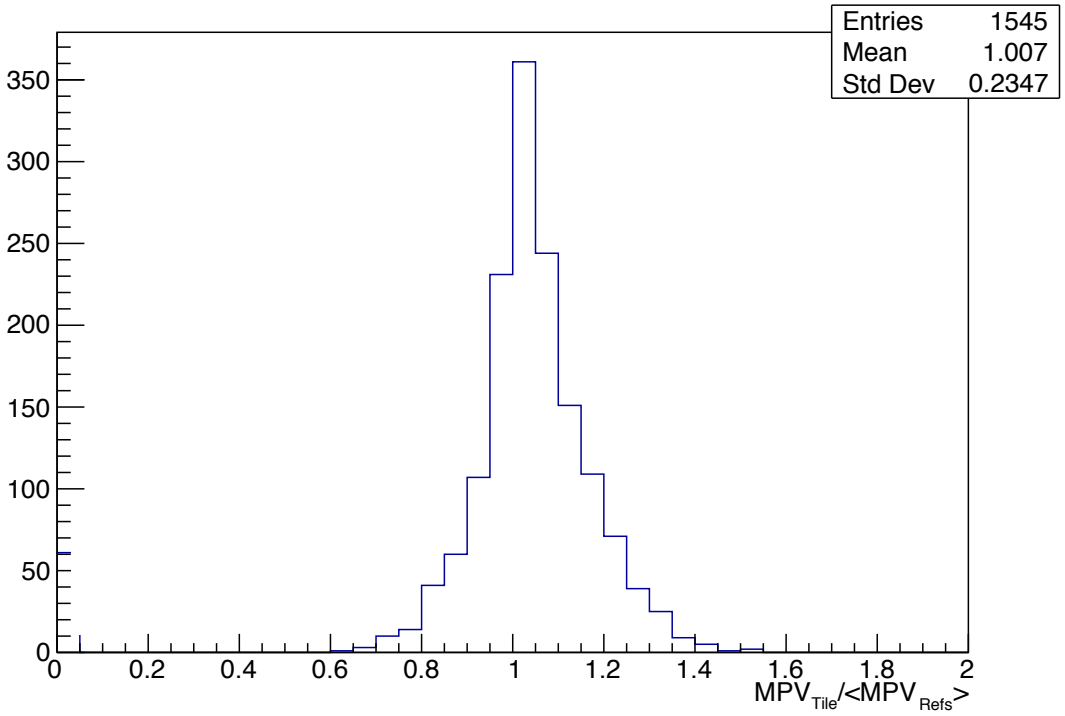



$$\textbf{Performance Ratio(PR)} = \frac{MPV_{tile}}{\langle MPV_{Refs} \rangle}$$

# Performance Characterization

- Received 1560 tiles. (20%of total tiles).
- 12 tiles were used as reference tiles.
- Only 3 tiles were physically damaged.
- Tested 1545 tiles.
- Used performance ratio(PR) to sort tiles in the tower.
- Rejected tiles with PR < 0.8
  - 27 tiles (1.74%).
- Accepted Tiles PR >0.8
  - 1518 tiles (98.26%).

Global Performance Distribution



# Summary and Outlook

- 1,560 of 7,680 tiles received, tested 1545 tiles. Few tiles failed the criteria of tile selection.
- Tested tiles shipped to BNL and installed in HCal Sectors.
- Remaining tiles' production and testing procedure has already started:- first shipment of 94 boxes arrived at GSU for test.
- Estimate to finish tile testing in about 12 months in this pace.
- On track to meet the target of first test starting in 2023.


Fragile

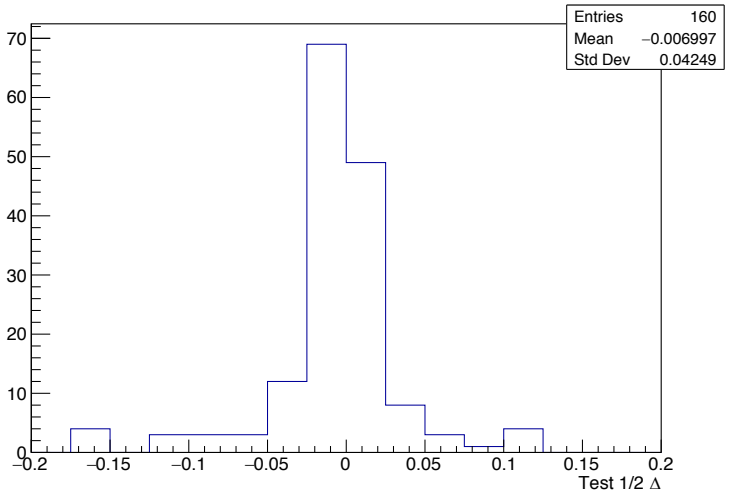

GEORGIA STATE
PANTHERS

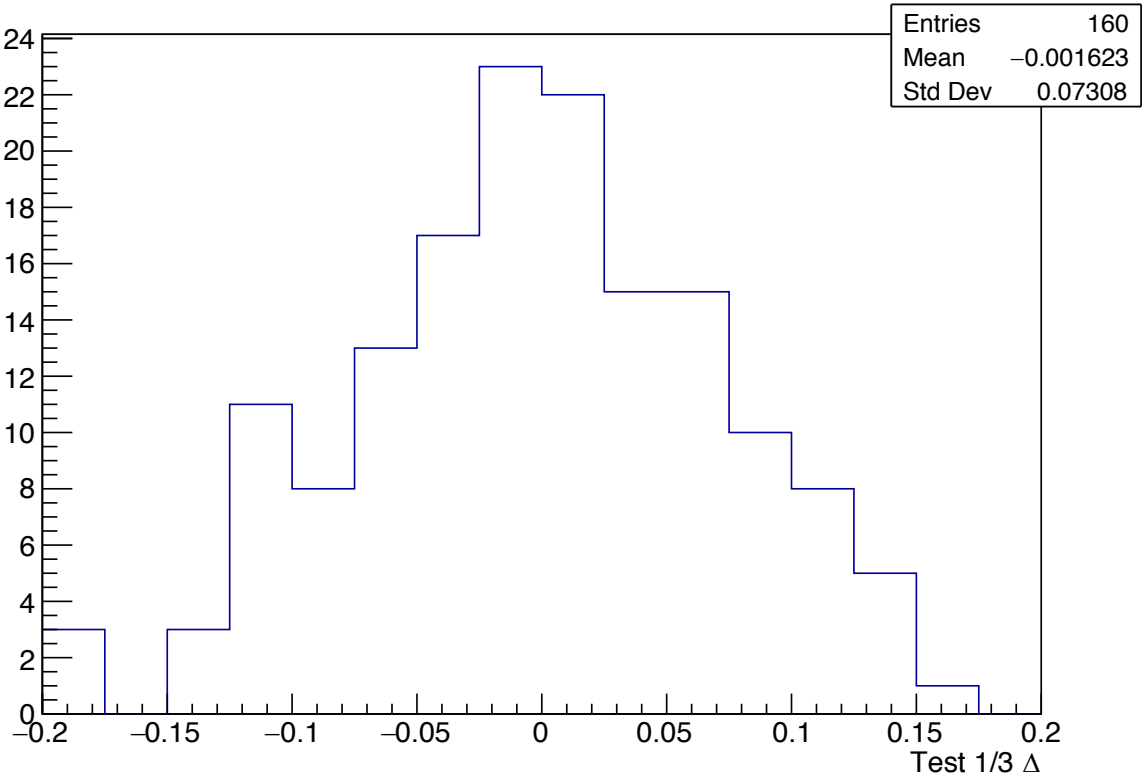

# THANK YOU

# Back Up

# REPRODUCIBILITY TEST

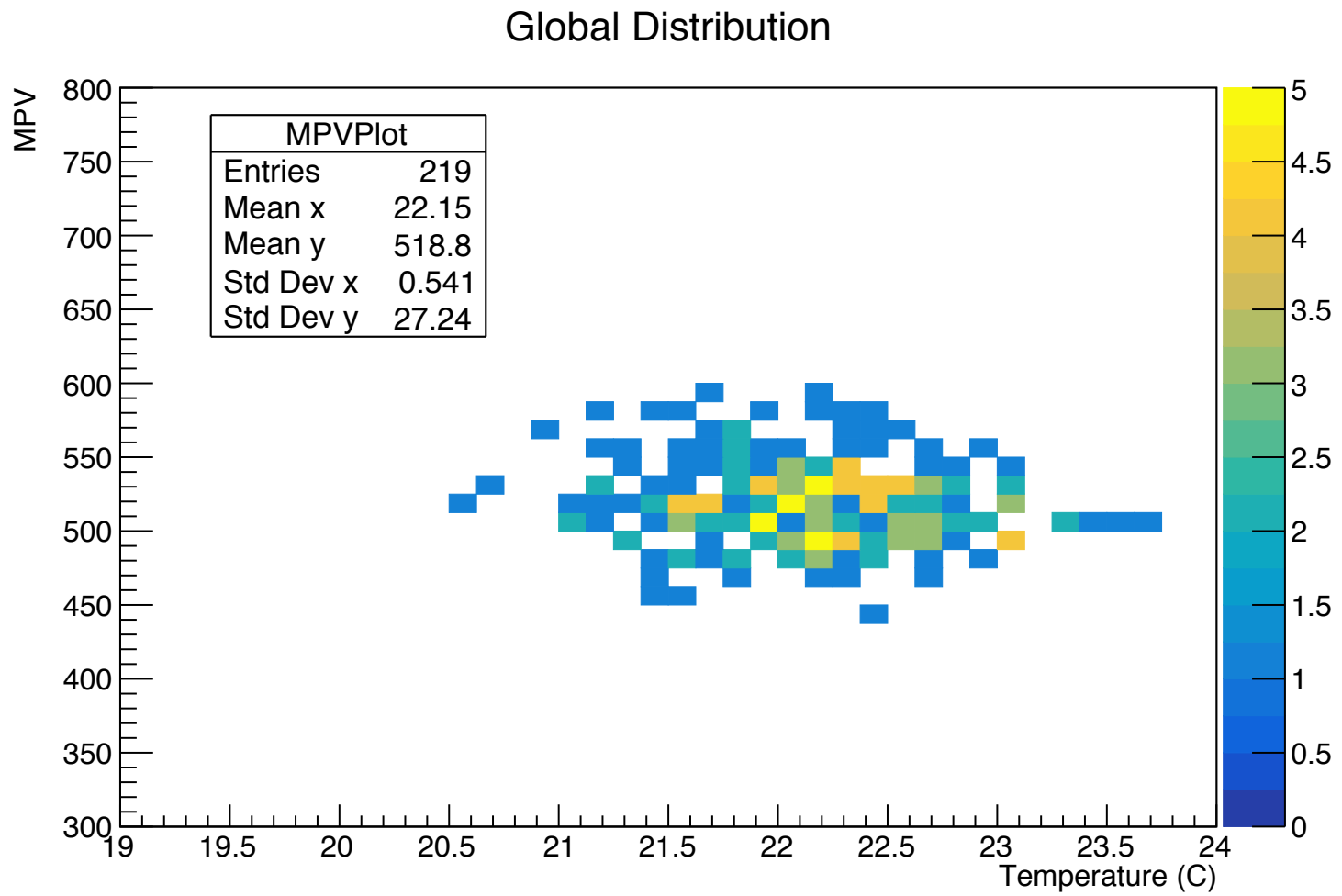
- Does tile have same response when the channel is changed?
- Want to reproduce the same response when they go in the tower.



# TEMPERATURE TEST

- Lab temperature changes by 2 degrees over a day.
- Distribution shows no specific trend in response to temperature change. Data is flat.



# LIGHT LEAK TEST

- Performed Test by turning room lights on and off of the lab.
- Results were consistent.
- Lights makes no difference in performance of the tiles.