Determining Gluon Contribution to Proton Spin with STAR 2015 Endcap Electromagnetic Calorimeter Data

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Background - Proton Spin

- Spin is the intrinsic angular momentum of a particle
- The proton has spin ½ ħ
- Quarks are elementary particles which make up composite particles called hadrons (e.g. protons, neutrons, pions, etas)

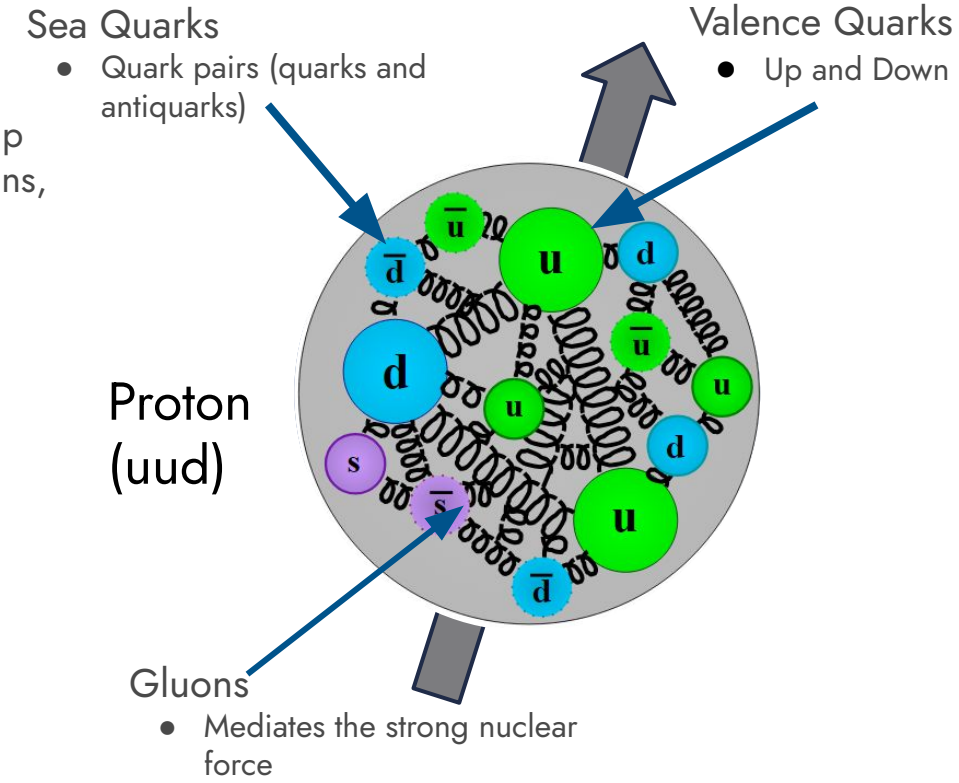
$$\frac{1}{2}\hbar = \frac{1}{2}\Delta\Sigma + \Delta G + L_q + L_g$$

Gluon spin

Gluon orbital angular momentum

Quark spin ~30%

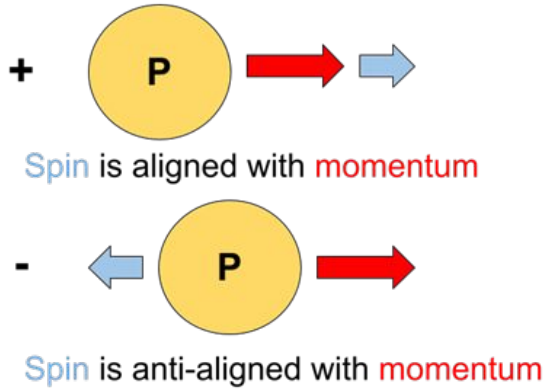
Quark orbital angular momentum



Asymmetry (A_{LL})

- Using the number of the π^0 or η particles and the known polarization of the beams, we can calculate the asymmetry of π^0 and η particle production from different spin states of the protons
- The asymmetry formula:
  - Pb and Py are the polarization of the blue and yellow beams
  - N^{++} and N^{+-} are the number of π^0 or η particles in the respective spin state
  - R is the relative luminosity ratio
- If this calculation is nonzero, then there is a sensitivity to π^0 or η production from spin of the proton

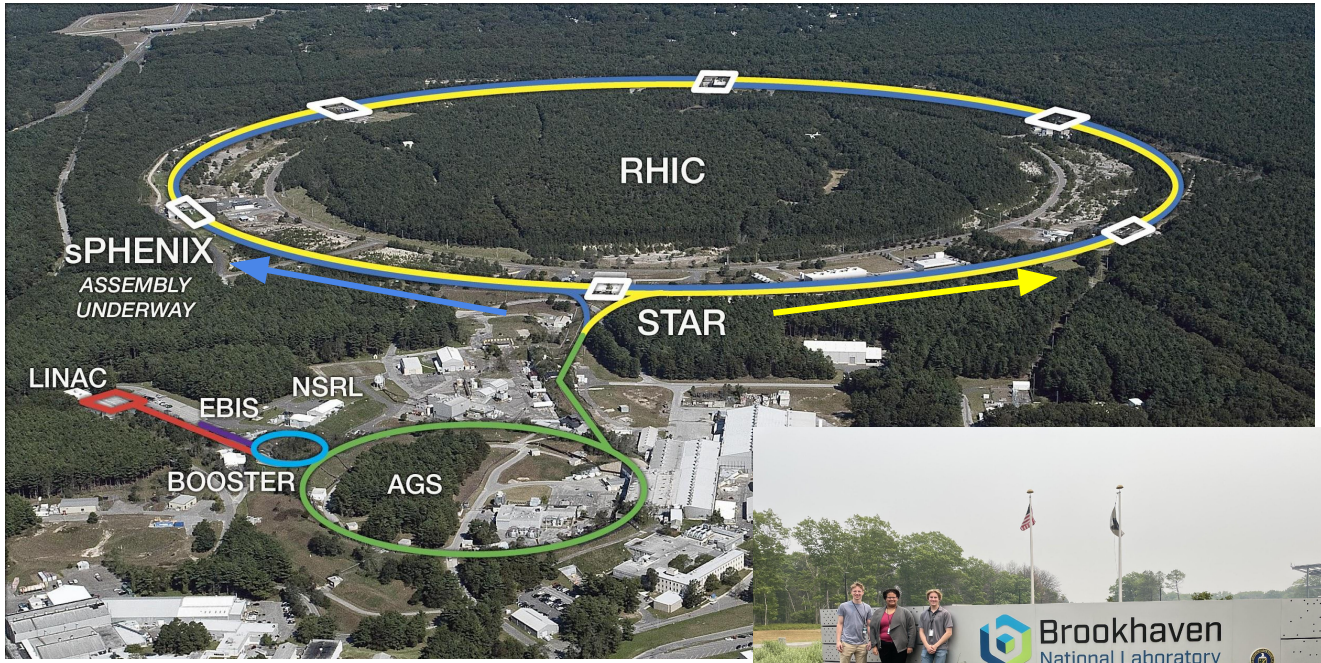
$$A_{LL} = \frac{N^{++} - RN^{+-}}{P_b P_y (N^{++} + RN^{+-})}$$



Asymmetry is related to the gluon contribution to the spin of the proton

RHIC and STAR

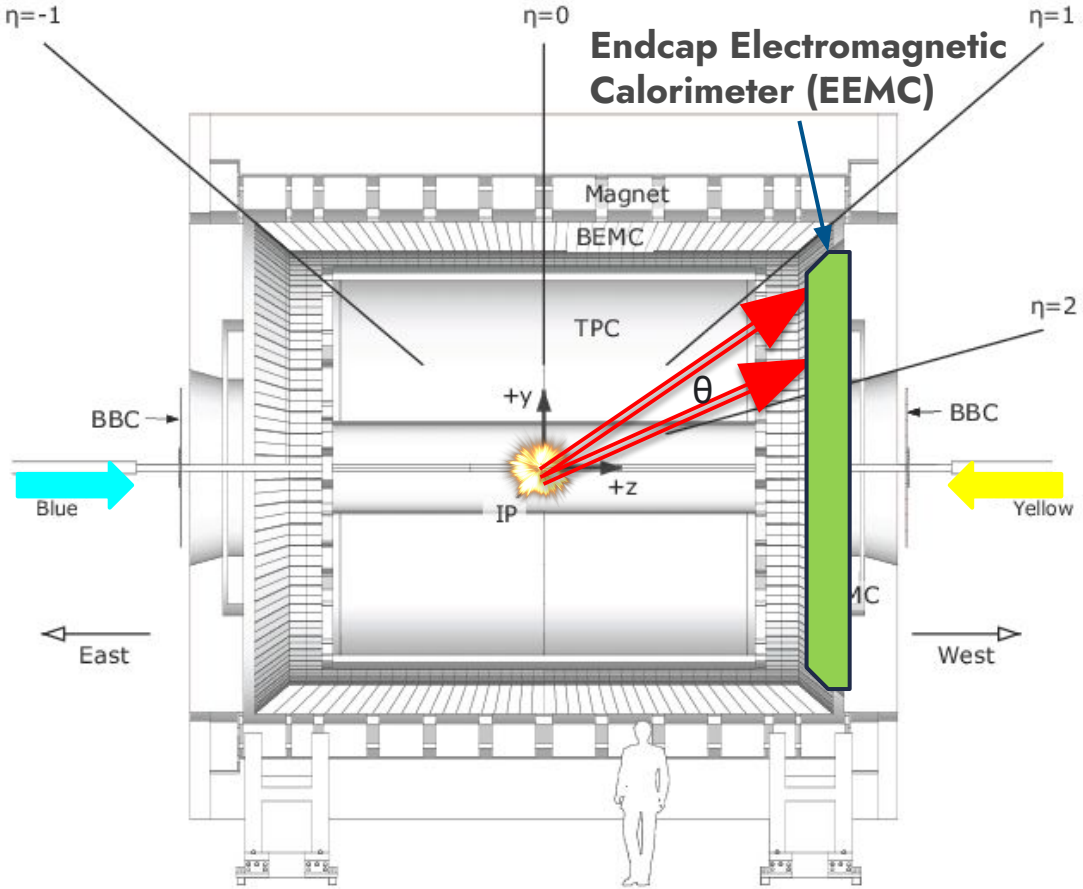
Relativistic
Heavy
Ion
Collider

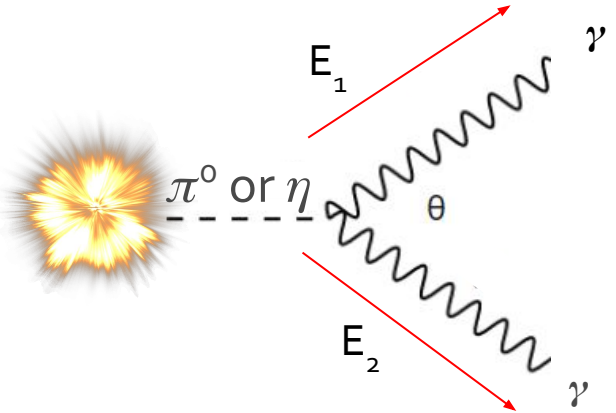


Solenoidal
Tracker
At
RHIC

~2 mile circumference
Particles accelerated to >99.998% speed of light

RHIC and STAR

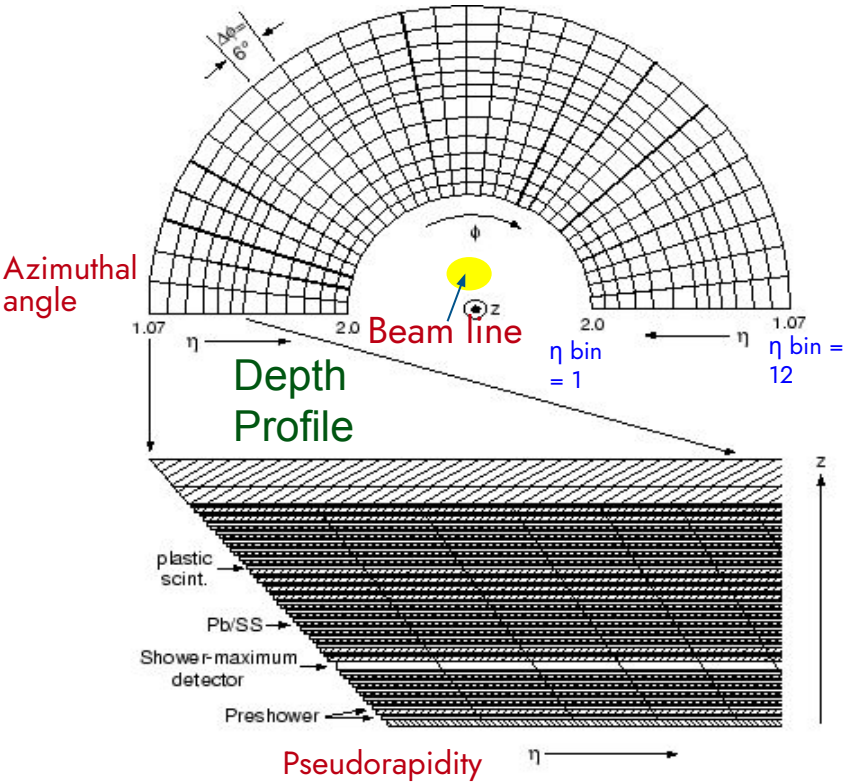




Neutral pion (π^0) and eta (η) particles decay rapidly into two photons
π^0 mass: 0.135 GeV/c^2
η mass: 0.5478 GeV/c^2

There are 720 smaller, individual detectors in the EEMC which are called towers

Endcap Electromagnetic Calorimeter



Face view of EEMC

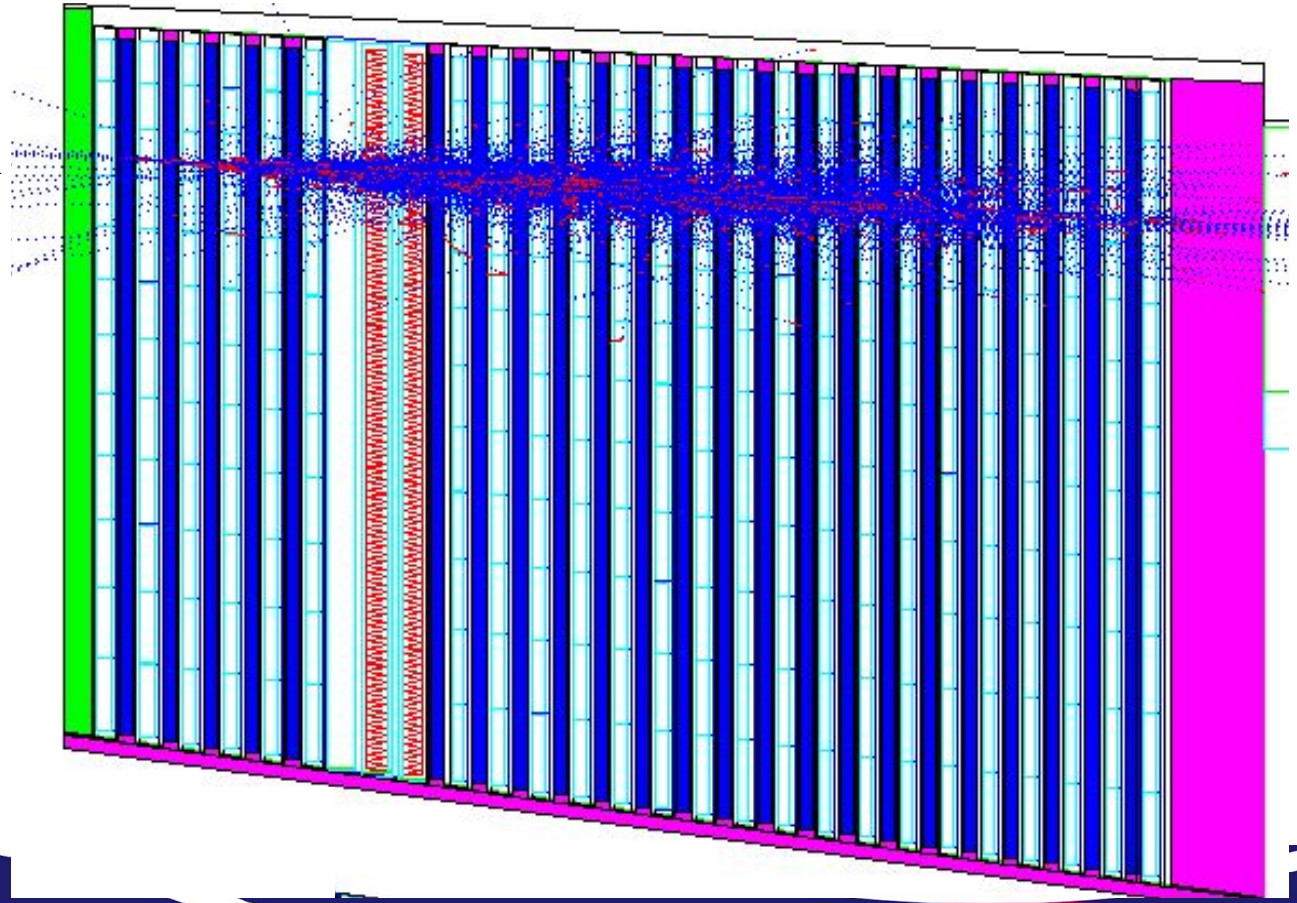
Side view of EEMC

720 projective towers (half shown)

23 layers of Pb/stainless steel absorber and 24 layers of plastic scintillator

Particle Interacting With EEMC

6 GeV photon



Processing the Data

- Begin with minimally processed data
  - Information from detectors
  - Each run can include hundreds of these files
    - Around 760 Tb for 2015 data ($\sqrt{s}$ = 200 GeV)

- Analysis code does many things
  - Calibrate the data
  - Identify photons
  - Calculate invariant mass of photon pairs
  - Determine possible π^0 or η candidates

- 1416 Runs processed for 2015 data ($\sqrt{s}$ = 200 GeV)
  - ~3.3 billion events
  - ~3.0 Tb output

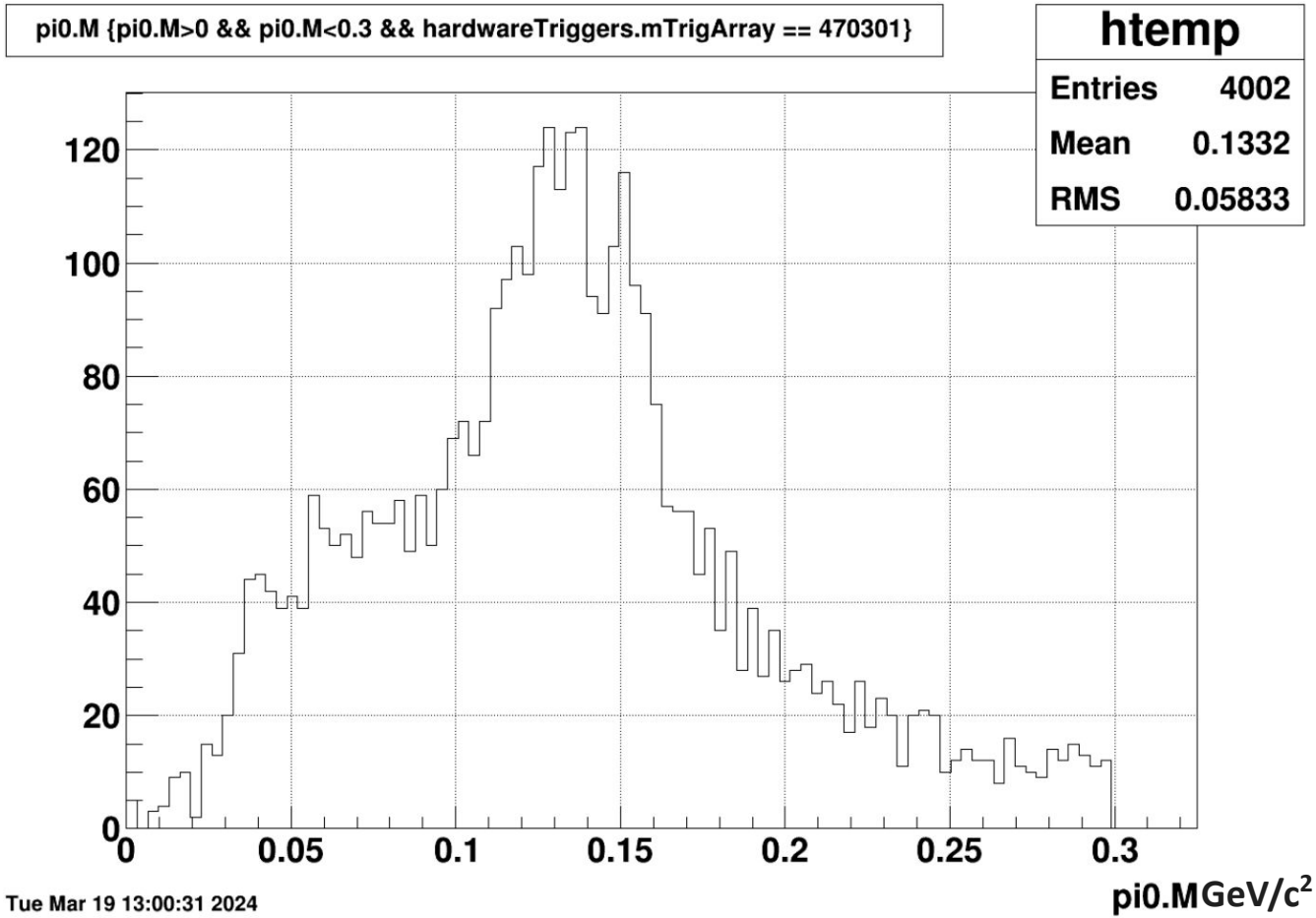
Data Quality Assurance (QA)

- To make sure we are using the best data available, we use quality assurance tests at the run and fill level
- For run level QA, we investigate:
  - Invariant mass
  - Number of towers hit
- For fill level QA, we investigate:
  - Invariant mass
  - Signal to background ratio

Run Level π^0 Invariant Mass Histogram

Run: A period of time STAR is collecting data

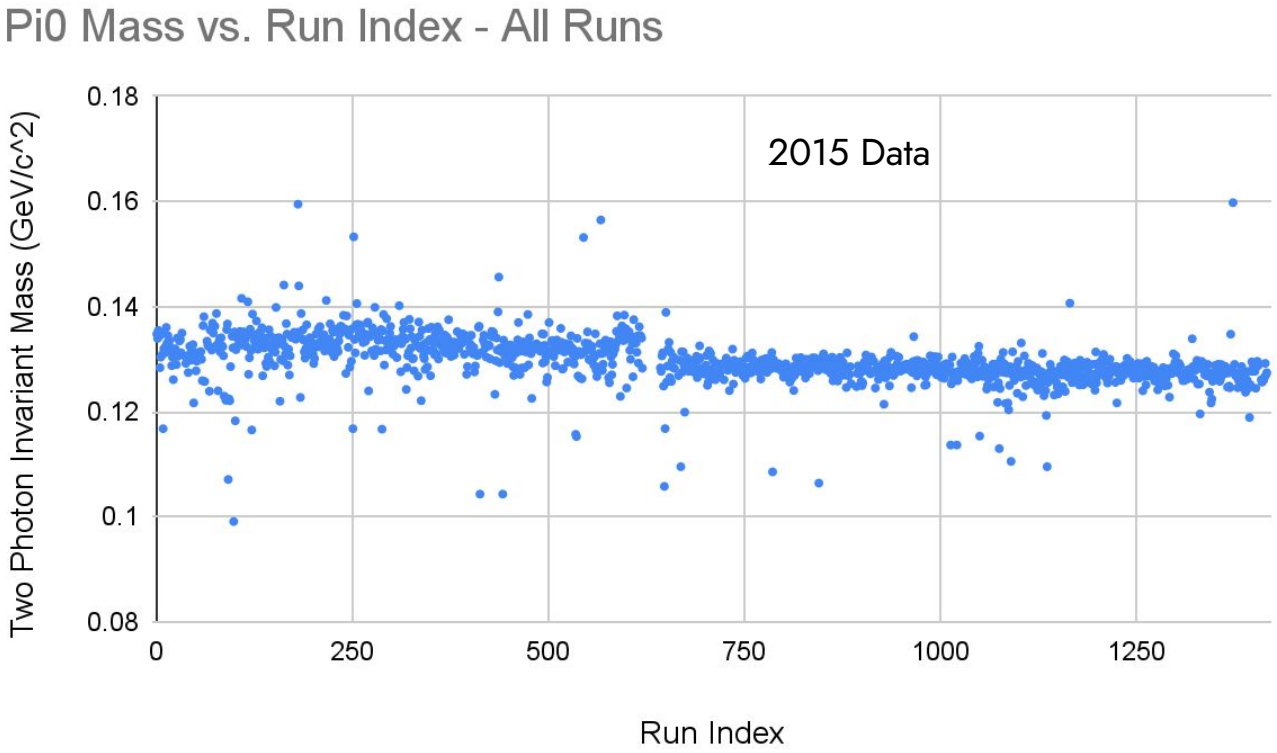
Fill: Data collection window between beam injection and beam dump



π^0 Invariant Mass

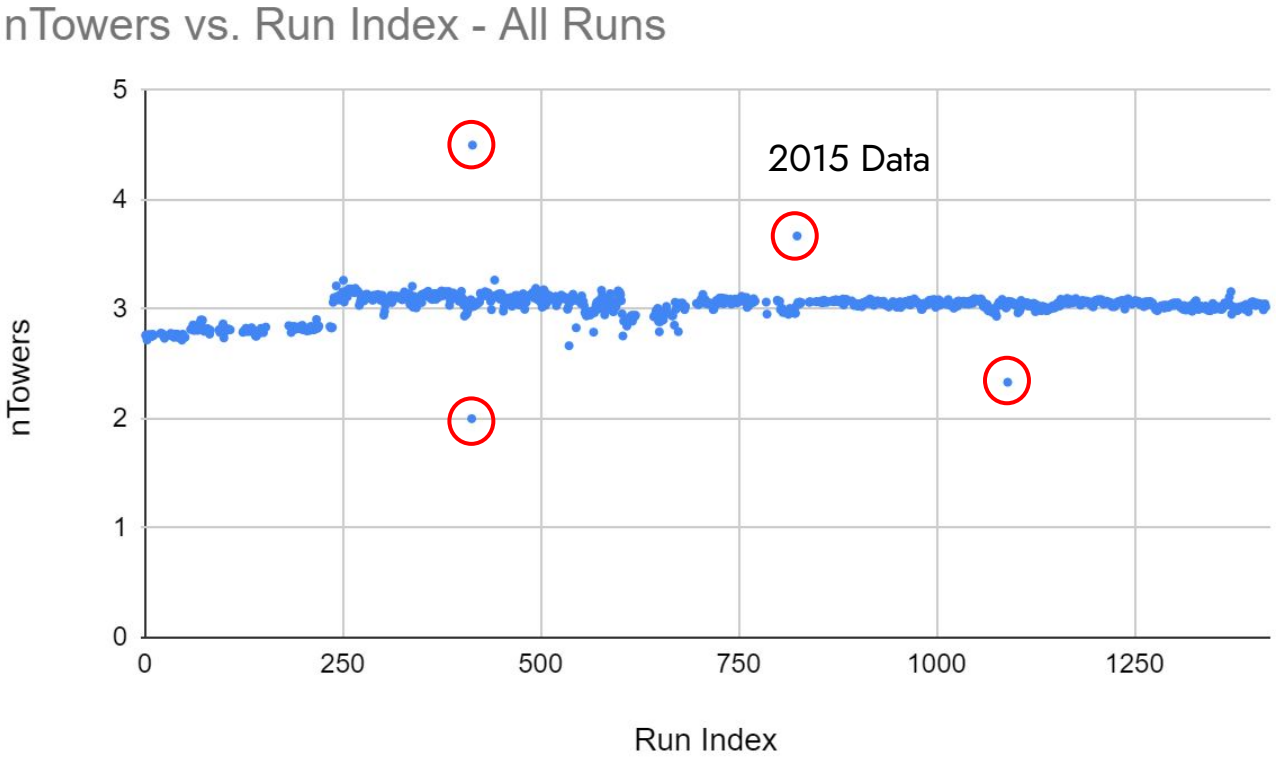
Mean: 0.129 GeV/c^2

15 Runs > 4 Standard Deviations from the Mean



Number of Towers Hit

Mean: 3.03



Summary

- Run level QA was performed on the 2015 200 GeV data set
- Next steps would involve fill level QA testing
  - Invariant Mass
  - Signal Fraction
  - Width of π^0 or η signal
- Calculation of A_{LL} value