Quality Assurance of the 2012 Endcap π^0 Data at STAR

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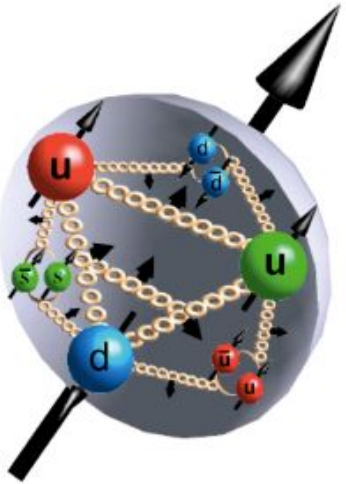
Proton Spin Puzzle



-Protons consist of three quarks (2 ups and a down), gluons, and sea quarks.
-The origin of the proton's "spin", an intrinsic angular momentum, has puzzled physicists for decades.

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

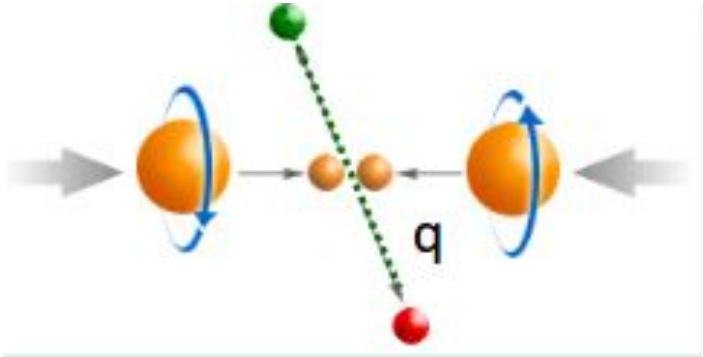
- Proton spin can be broken down as shown above
- We know the quark spin contribution is ~30%
- We are specifically interested in the gluon spin contribution

Asymmetry and Proton Spin

- A_{LL} is proportional to the gluon contribution to the spin of the proton

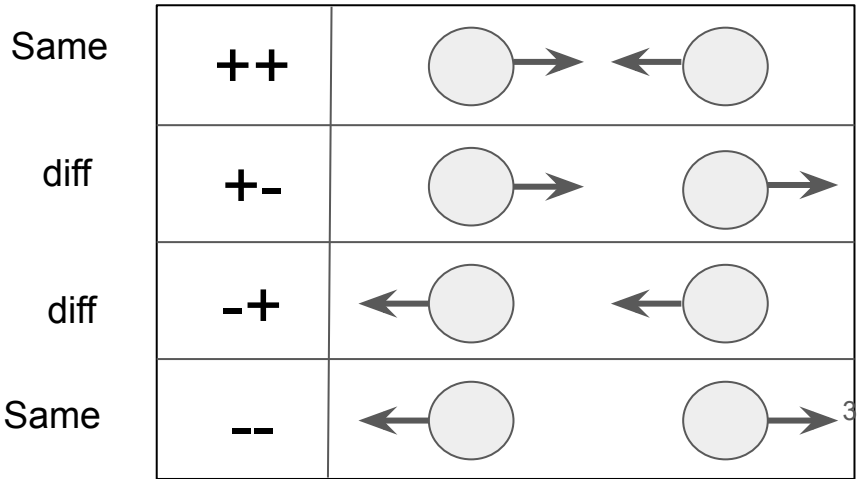
$$A_{LL} = \frac{[N^{same} - N^{diff}]}{P_b P_y [N^{same} + N^{diff}]}$$

- N = # of Particles (Neutral Pions)
- P = Beam Polarization (average polarization ~50%)



Momentum

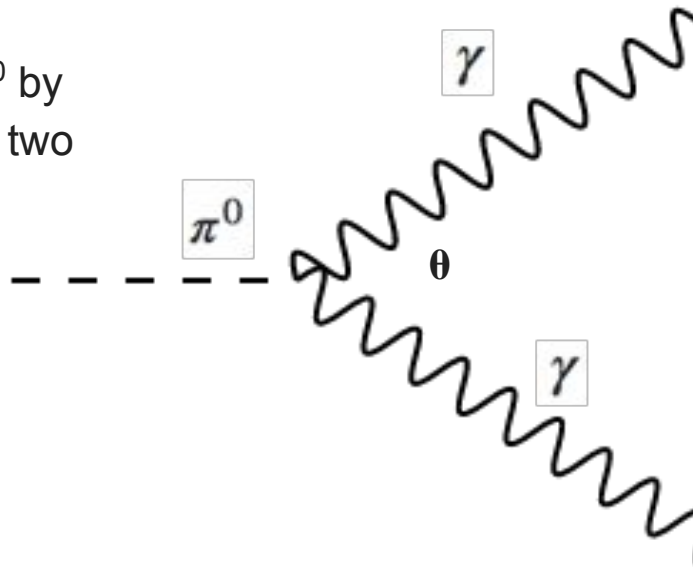
Black Arrows are Spin Vector



Reconstructing π^0's from Photons

- One of the particles produced in the p+p collision is a neutral pion (π^0)
- π^0 decays into two photons in 10^{-16} s.
- An electromagnetic calorimeter reconstructs the $\boldsymbol{\pi}^0$ by measuring the energy and the opening angle of its two decay photons.
- Invariant Mass of Neutral Pion is 135 MeV/c^2

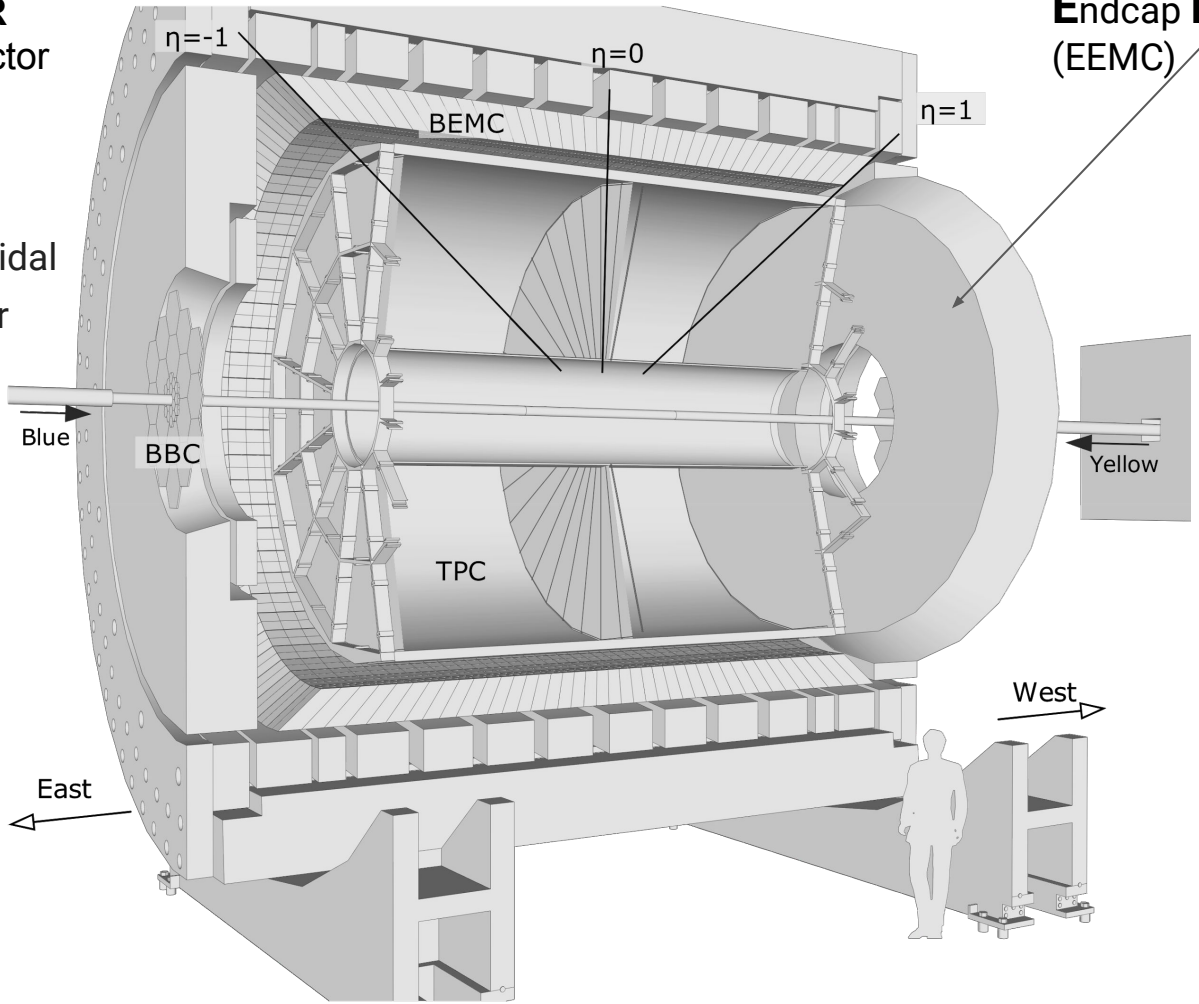
$$\boldsymbol{\pi^0 \rightarrow \gamma + \gamma}$$



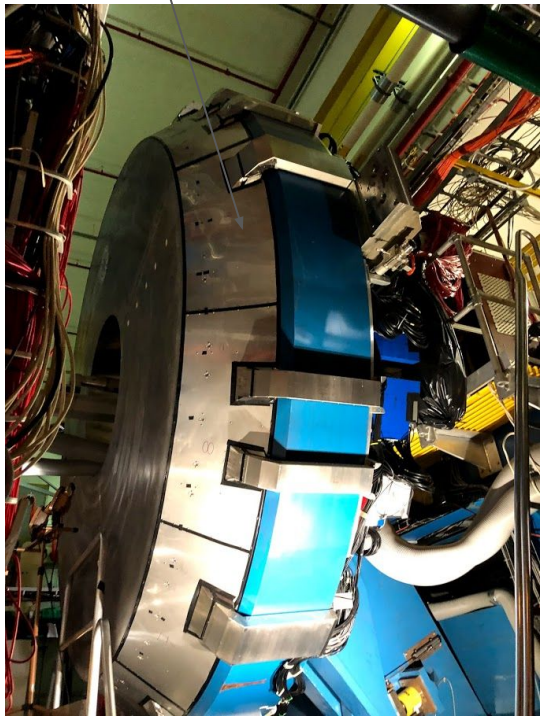
$$M_{\gamma\gamma} = (E_1 + E_2) \cdot \sqrt{(1 - \left(\frac{E_1 - E_2}{E_1 + E_2}\right)^2} \sin\frac{\theta}{2}$$

STAR
Detector

Solenoidal
Tracker
At
RHIC



Endcap **E**lectro-**M**agnetic **C**alorimeter
(EEMC)



2012 Data Quality Assurance

Overview:

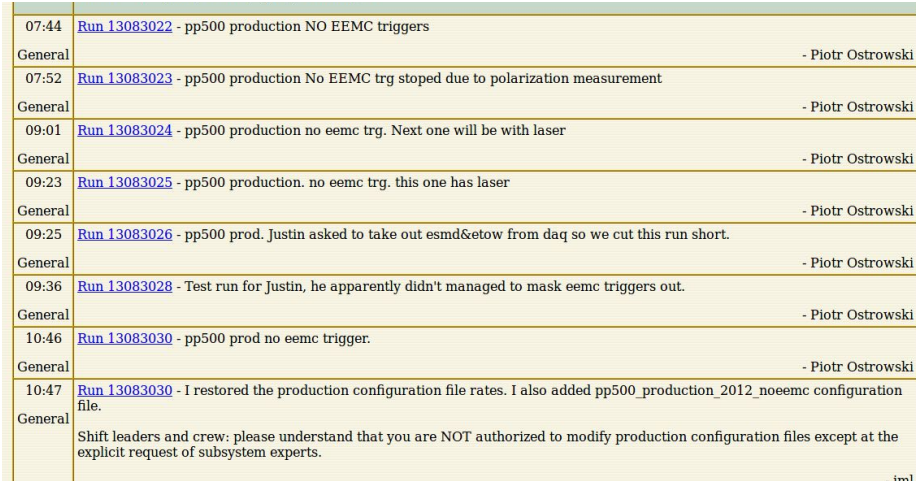
- We are analyzing the 2012 p+p data, so quality assurance is needed to make sure we are selecting good runs.
- Decided to use an already vetted run list from a slightly different analysis containing 497 runs (indexed 1-497).
  - My project is looking at endcap $\pi^{0'}$s, whereas the other project was concerned with jets at mid-rapidity and extending into part of the EEMC.
- A C++ script was written to plot several key characteristics of the neutral pion reconstruction process as a function of run number.
  - The mean mass of the π^0s, the mean number of towers, and the signal fraction.
- Outliers, runs with characteristics >4 sigma, were flagged and will be discussed.

Preliminary Elimination of Runs

An EHT0 event is an event that triggers the high towers of the EEMC above about 5.7 GeV.

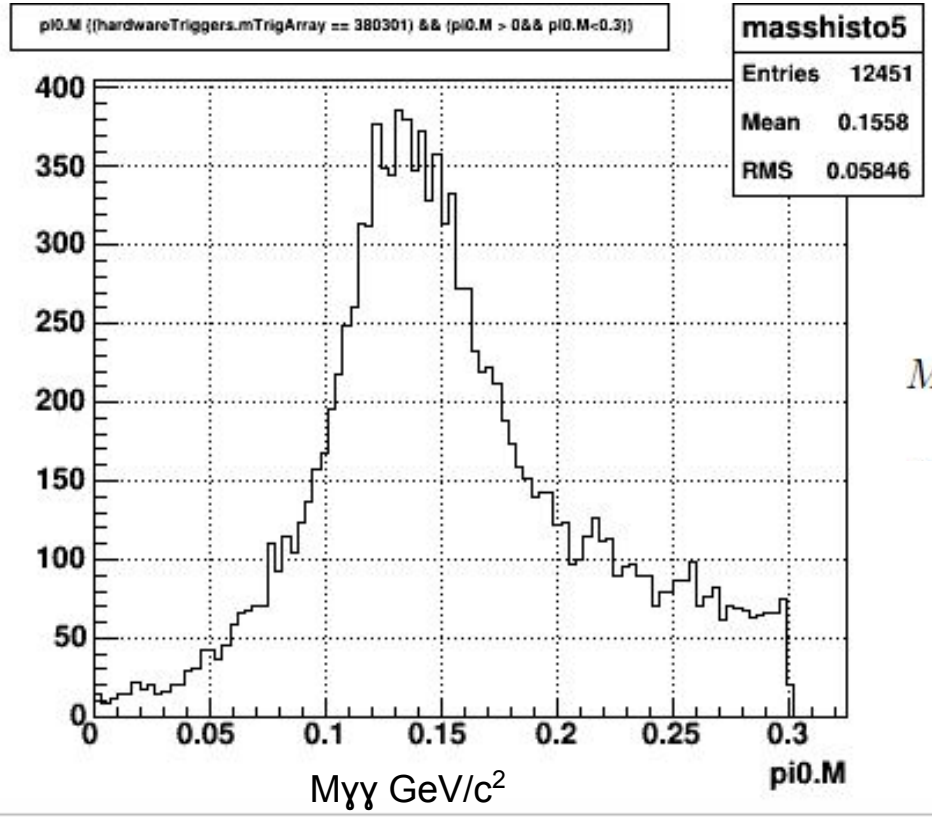
Runs 49 (run lasted a few minutes), 85-90 (did not have the EHT0 trigger) can be eliminated because they have insufficient EHT0 events.

Run 354 did not have files needed to reconstruct π^0's, which was a temporary failure of our analysis code.



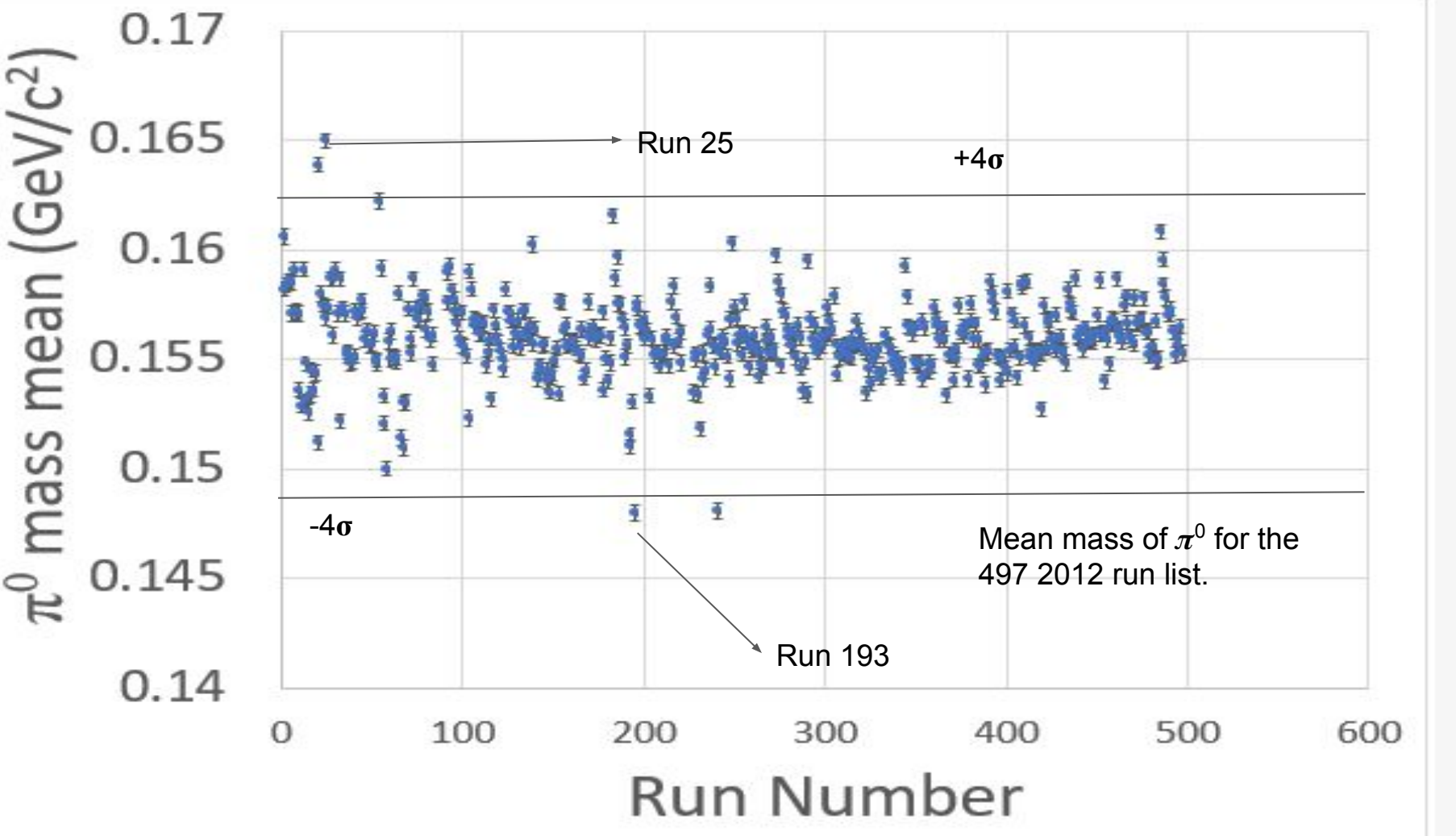
07:44	Run 13083022 - pp500 production NO EEMC triggers
General	- Piotr Ostrowski
07:52	Run 13083023 - pp500 production No EEMC trg stoped due to polarization measurement
General	- Piotr Ostrowski
09:01	Run 13083024 - pp500 production no eemc trg. Next one will be with laser
General	- Piotr Ostrowski
09:23	Run 13083025 - pp500 production. no eemc trg. this one has laser
General	- Piotr Ostrowski
09:25	Run 13083026 - pp500 prod. Justin asked to take out esmd&etow from daq so we cut this run short.
General	- Piotr Ostrowski
09:36	Run 13083028 - Test run for Justin, he apparently didn't managed to mask eemc triggers out.
General	- Piotr Ostrowski
10:46	Run 13083030 - pp500 prod no eemc trigger.
General	- Piotr Ostrowski
10:47	Run 13083030 - I restored the production configuration file rates. I also added pp500_production_2012_noeemc configuration file.
General	Shift leaders and crew: please understand that you are NOT authorized to modify production configuration files except at the explicit request of subsystem experts.
	jml

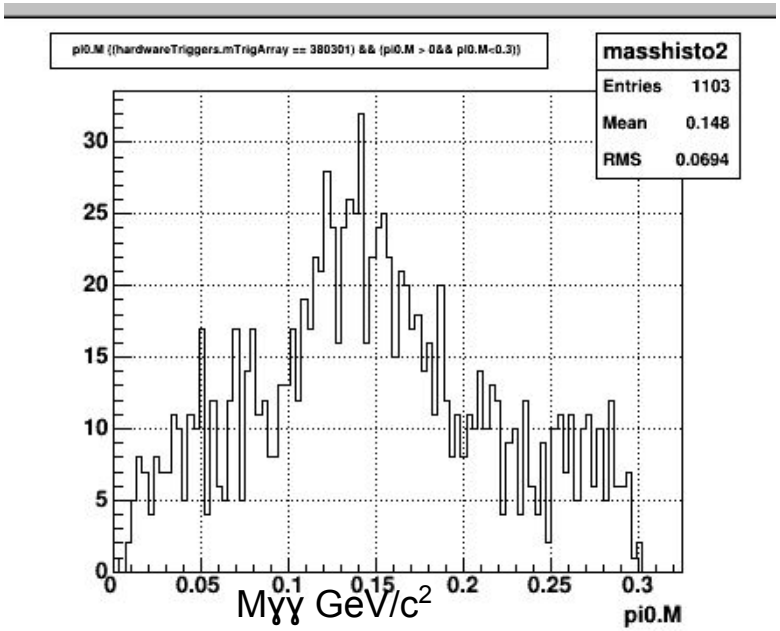
Mean Mass of π^0 (invariant diphoton mass)



Here is an example of the reconstructed mass of the π^0 with the EHT0 trigger cut and no background subtraction for one run.

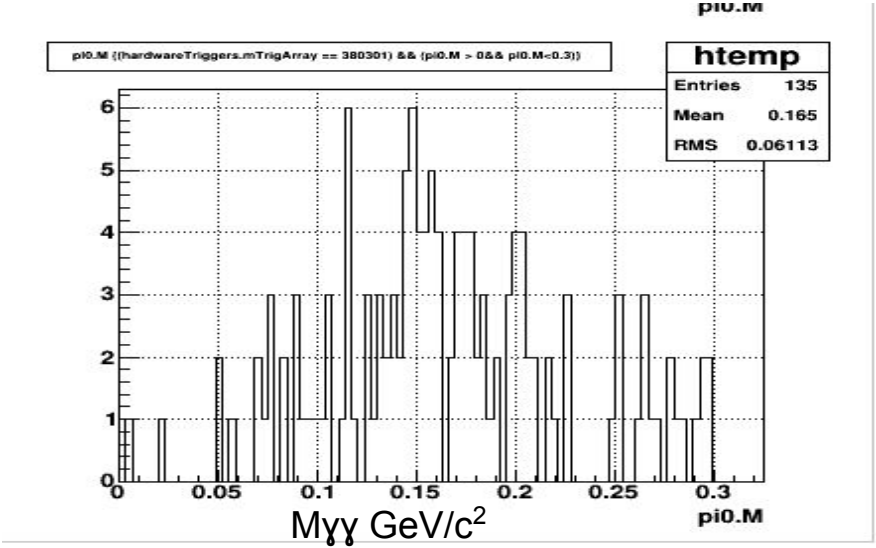
$$M_{\gamma\gamma} = (E_1 + E_2) \cdot \sqrt{(1 - \left(\frac{E_1 - E_2}{E_1 + E_2}\right)^2} \sin\frac{\theta}{2}$$


0.17
0.165
0.16
0.155
0.15
0.145
0.14
π^0 mass mean (GeV/c^2)
Run 25
+4σ
-4σ
Mean mass of π^0 for the 497 2012 run list.
Run 193
0
100
200
300
400
500
600
Run Number



Reconstructed π^0 mass for run 193

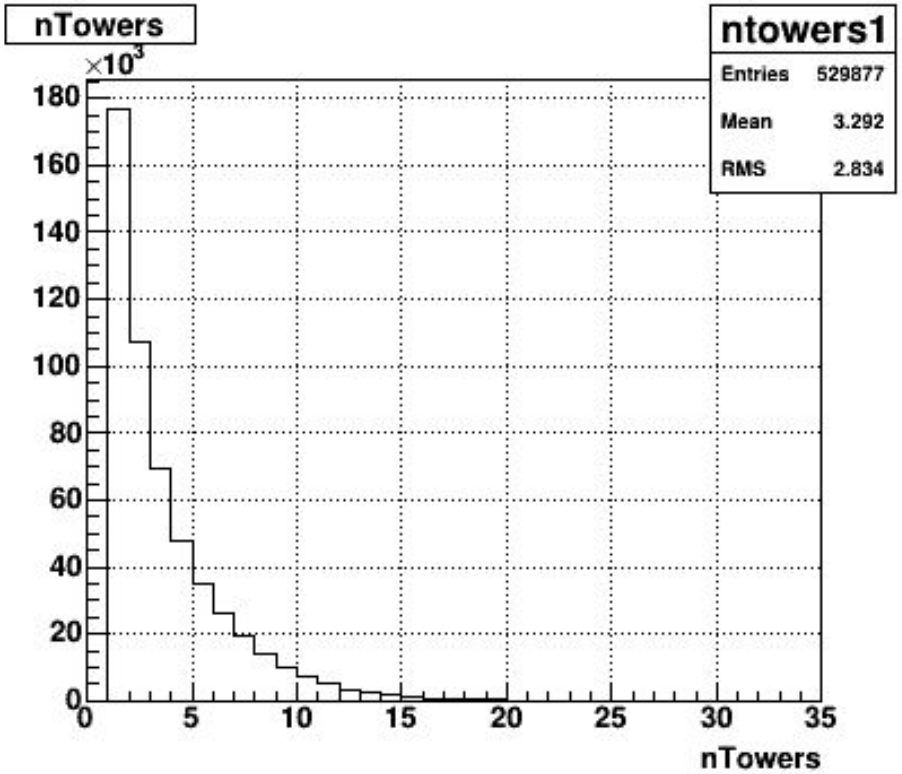
Atypical background yields a low mean.



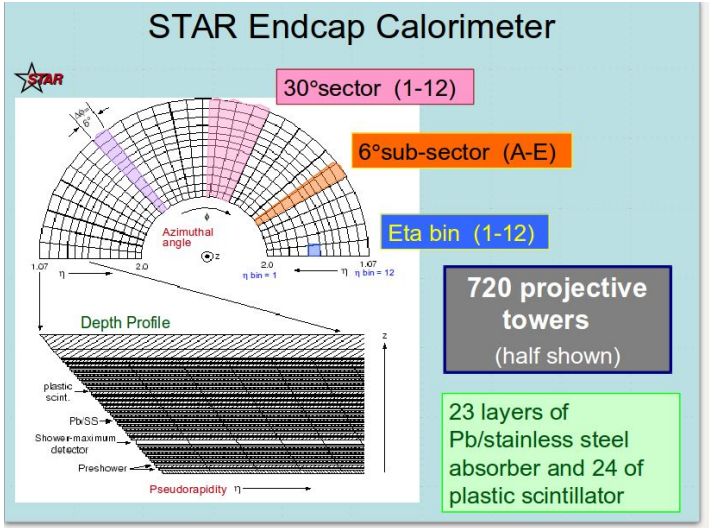
Reconstructed π^0 mass for run 25

No definitive peak because there's very low stats because of short run time.

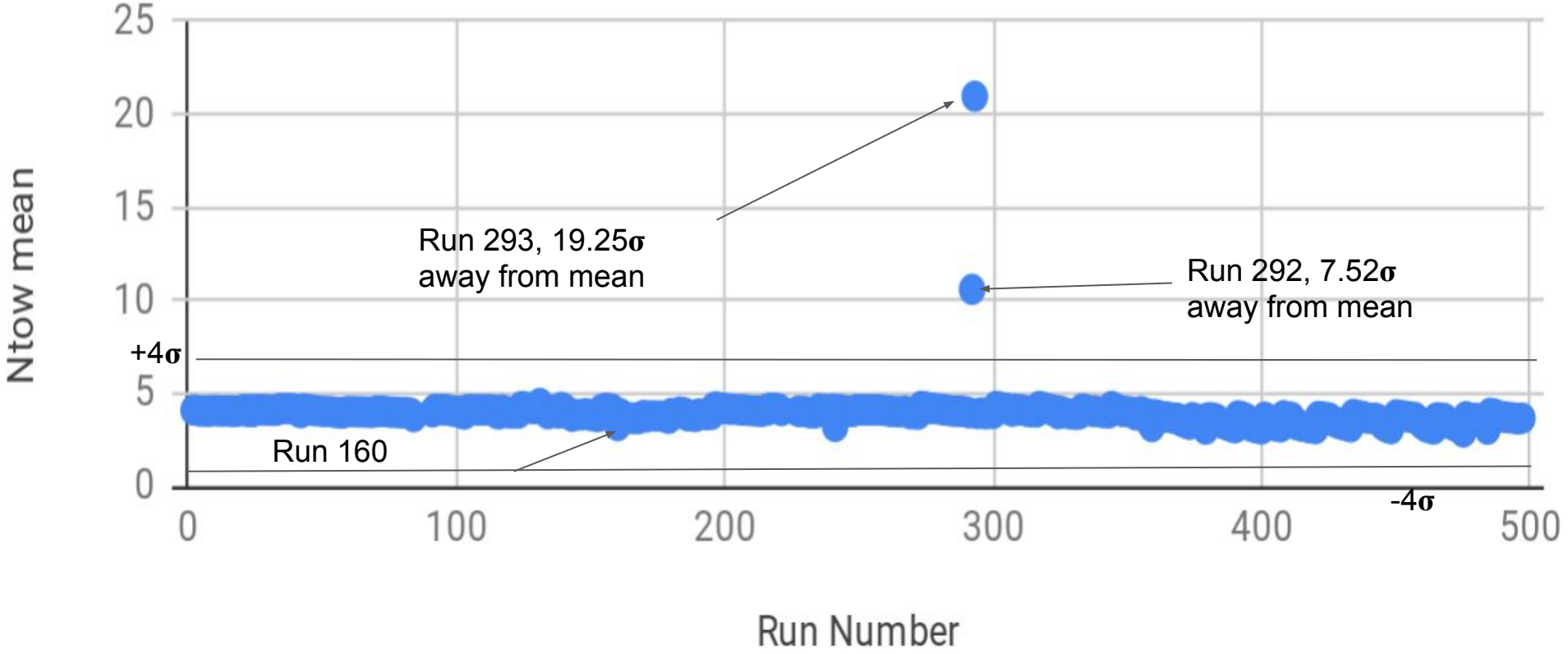
Mean Number of Towers Hit



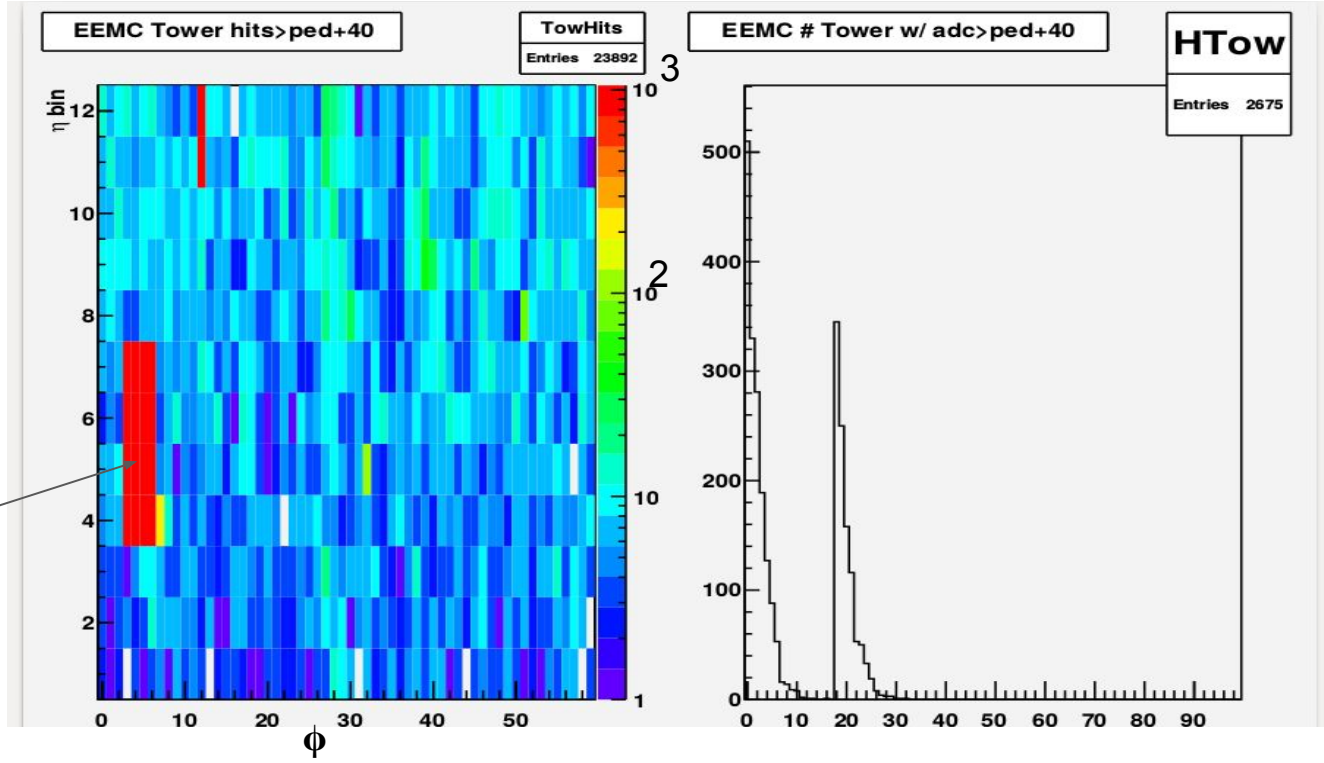
Example of the number of endcap towers hit (threshold is 1 GeV) per event for a single run with no trigger cut.



Ntow Mean vs Run Number



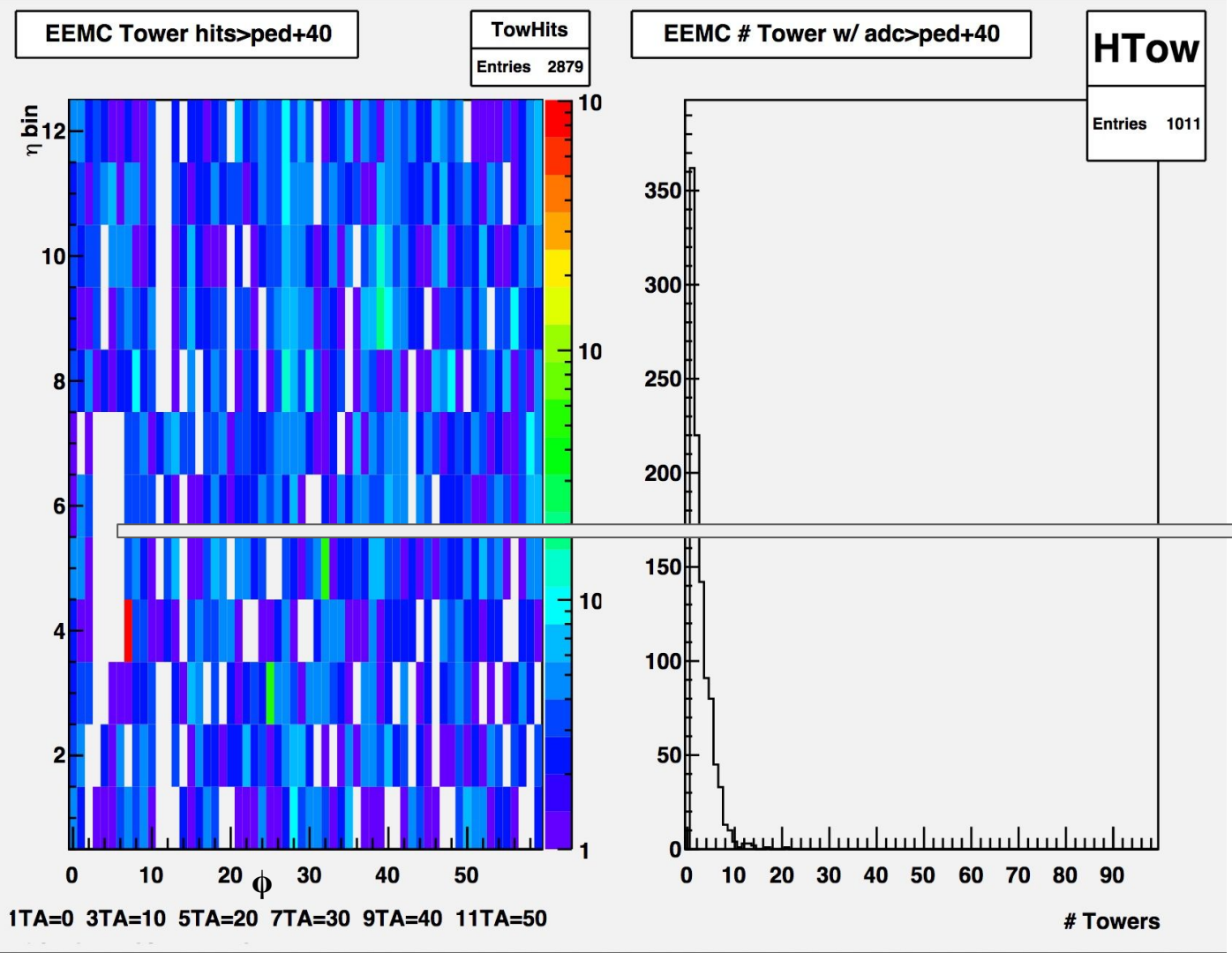
Hot Towers caused problems for runs 292/293.



16 hot towers in crate 2 are showing hits in nearly 50% of events

On the left is the hit distribution in the towers for run 292 and on the right is the # of towers

*Same problem for run 293

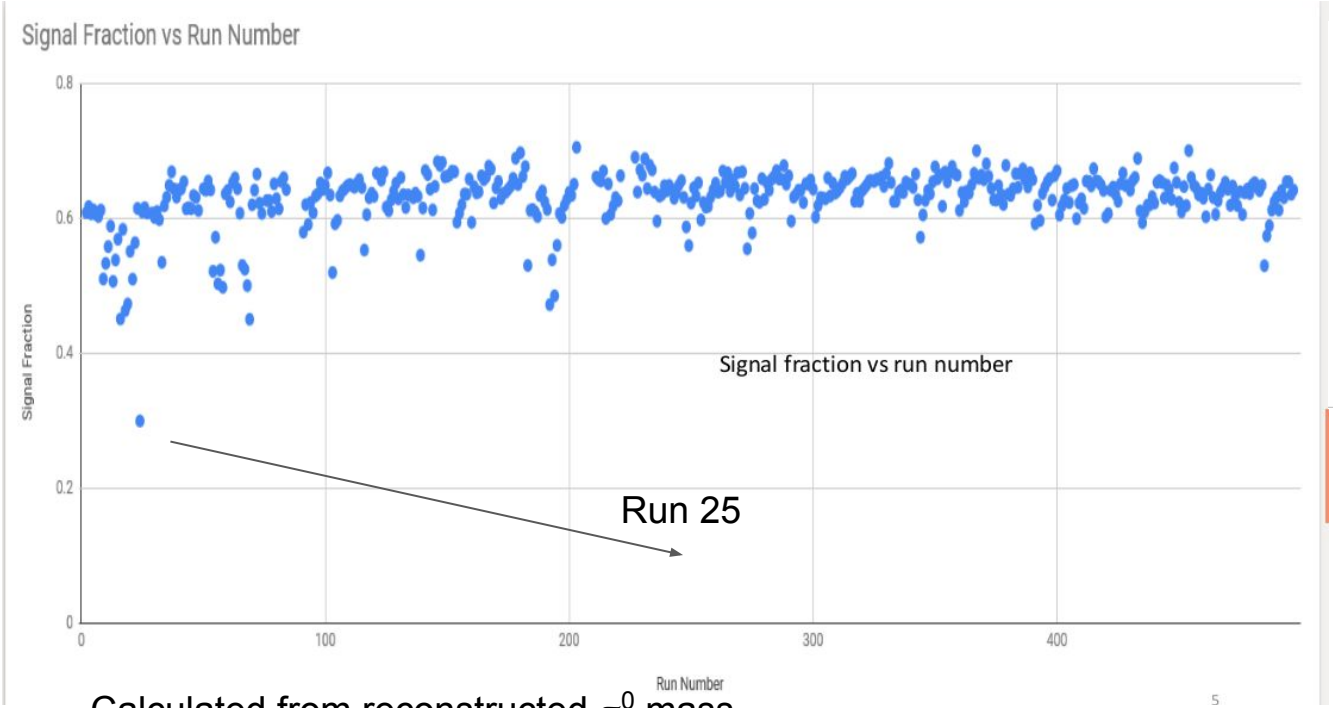


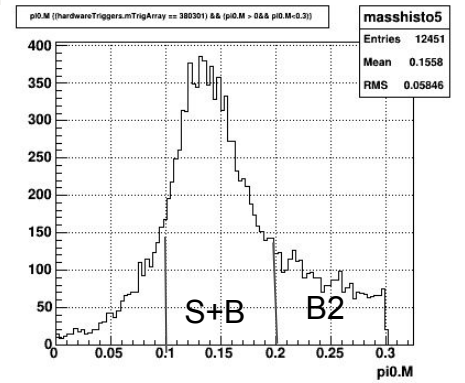
Hit distribution (left) and number of towers (right) for run 159.

The same towers that were hot are now picking up no hits

*Same problem for run 160

Signal Fraction





-Calculated from reconstructed π^0 mass distribution.
-Ranged mainly between 50-60%.
-Prior to run 200, there are more low signal runs.

Signal Fraction=((S+B)-B2)/(S+B)

Summary

We are analyzing the spin asymmetry in the number of neutral pions produced in the 2012 p+p collisions at $\sqrt{s}$=510 GeV.

Needed to perform QA on that data, ended up looking at an already partially vetted run list containing 497 runs.

Wrote a C++ script that would output characteristics of the neutral pion reconstruction process.

Used the STAR run webpage and a 4 sigma cut to omit runs.

Investigation continues into details of Signal Fraction and Ntowers as well as finalizing the list of runs to be eliminated (around 3%).

We'll use this information when making final asymmetry calculations.

Acknowledgements

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The STAR Collaboration