Stability of the Gains of the STAR Endcap Calorimeter from 2009 to 2012

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Stability of the Gains of the STAR Endcap Calorimeter from 2009 to 2012
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Mentor: Dr. Shirvel Stanislaus

Abstract
The Solenoidal Tracker at RHIC (STAR) experiment, based at Brookhaven National Laboratory's Relativistic Heavy Ion Collider, uses polarized-proton collisions to investigate sea quark and gluon contributions to the known proton spin. The STAR detector's Endcap Electromagnetic Calorimeter (EEMC) is of particular interest in this experiment because it covers a kinematic region which is sensitive to gluons carrying a low fraction of the proton momentum, where the gluon spin is almost entirely unconstrained. The EEMC is located in the intermediate pseudorapidity range, $1 < \eta < 2$, and measures the electromagnetic energy of particles produced by the collisions using a lead-scintillator sampling calorimeter. The calorimeter consists of several layers that include pre-shower, shower maximum, tower, and post-shower detectors. In these detectors, the energy gains, which convert a measured signal into an energy deposition, have been determined using data taken from the years, 2009, 2011, and 2012. A comparison of the gains from the three years will be presented.

Background
RHC is the only accelerator in the world capable of colliding high-energy beams of polarized protons. STAR uses these collisions to explore the origin of the intrinsic angular momentum of the proton, known as its "spin". Since a proton is made of two up-quarks and a down-quark, it might seem reasonable to assume that the spin of the proton is equivalent to the sum of the spin components of the individual quarks. Interestingly, previous scattering experiments show that the spin contribution of the quarks inside the proton are only 30% of the total proton spin. In order to explore the remaining fraction of the proton's spin, other factors such as the orbital angular momentum and the spins of the gluons must be taken into consideration. This study using the EEMC concentrates on the spin contributions from the gluons.

Pre-Shower and Towers
post through the detector and deposit energy in the scintillator detectors. The total.

Fig. 1 Model of the STAR detector showing the EEMC

EEMC Calibration
- The EEMC is made up of Pre and Post Shower tiles, Towers, and SMD strips. This project reports the calibration of Pre, Post Shower and Tower tiles, 2880 in total.
- The EEMC is calibrated using minimum ionizing particles (MIPs). These particles pass through the detector and deposit energy in the scintillator detectors. The light in a scintillator produces an electric pulse in the photomultiplier tubes that is then digitized in an ADC.

Fig. 2 Example of a fitted histogram. The red line shows the fitted landau curve.

Pre and Post-Shower Detectors
- For Pre-Shower 1; 2 and Post-Shower, the equation used to calculate the detector tile gains is:
  \[ \text{Gain} = \frac{\text{Mean} \times \text{tile}(i)}{\text{layer} \times \text{tile}(i)} \]
- The "Mean" is the mean of the distribution of ADC outputs from the scintillator tile. The mean is determined from a Landau function fitted to the ADC spectrum.
- The dE/dx is the reference value for the mean energy per unit length deposited in this specific scintillator.
- Any channels that the program failed to fit automatically were fitted manually.

Gains of different years are compared with each other, to help understand the changes in the EEMC.

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Pre-Shower 1</td>
<td>1.014 ± 0.003</td>
<td>0.979 ± 0.003</td>
</tr>
<tr>
<td>Pre-Shower 2</td>
<td>1.007 ± 0.003</td>
<td>0.994 ± 0.003</td>
</tr>
<tr>
<td>Post-Shower</td>
<td>1.025 ± 0.004</td>
<td>0.987 ± 0.003</td>
</tr>
<tr>
<td>Towers</td>
<td>1.030 ± 0.002</td>
<td>1.036 ± 0.002</td>
</tr>
</tbody>
</table>

Table 1 Table showing the preliminary results of the gain ratios of Pre-Shower, Post-Shower and Towers over the years 2009, 2011 and 2012.

Summary of Results
- Preliminary results show that the ratios of the gains for Pre, Post showers and Towers were relatively stable over the years 2009, 2011 and 2012 except for the 2012/2011 ratio for the Towers, in which case it changed by 8%.
- The gains of the tower detectors changed by an average of 2% when the fitted Landau + Gaussian function was used to extract the mean.
- Changes in the parameters in the identification of a MIP changed only the number of events, and yielded little or no change to the gain of the tower detectors.

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