Toward understanding relativistic heavy-ion collisions with the STAR detector at RHIC

M. Cervantes, R. Clarke, M. Codrington, L. Dunkelberger, A. Hamed, S. Mioduszewski,
and the STAR Collaboration

I. Charmonium and Bottomonium Measurement

Charmonium ($c\bar{c}$) and bottomonium ($b\bar{b}$) are measured via their decay to an electron-positron pair in the STAR detector [1]. The large background from hadrons in heavy-ion collisions, such as Au+Au, makes the measurement particularly challenging. To improve such measurements, we are working on better electron identification (*ie*, stronger hadron rejection). The Barrel Pre-Shower (BPRS) detector of the Barrel Electromagnetic Calorimeter (BEMC) was designed to identify particles that begin to shower already in the first 2 layers of the calorimeter [2], and thus is ideal for rejecting hadrons. We have made quite some progress commissioning and calibrating the BPRS in the past year. First there were issues with the software mapping of channels not matching the hardware configuration. Most of these problems have been identified. The pedestal values were checked and subtracted, and minimum-ionizing peaks (MIP's) were fit for each channel with associated tracks.

The improvement in electron identification can already be seen in the data from the current Au+Au RHIC run (see Fig.1 below).

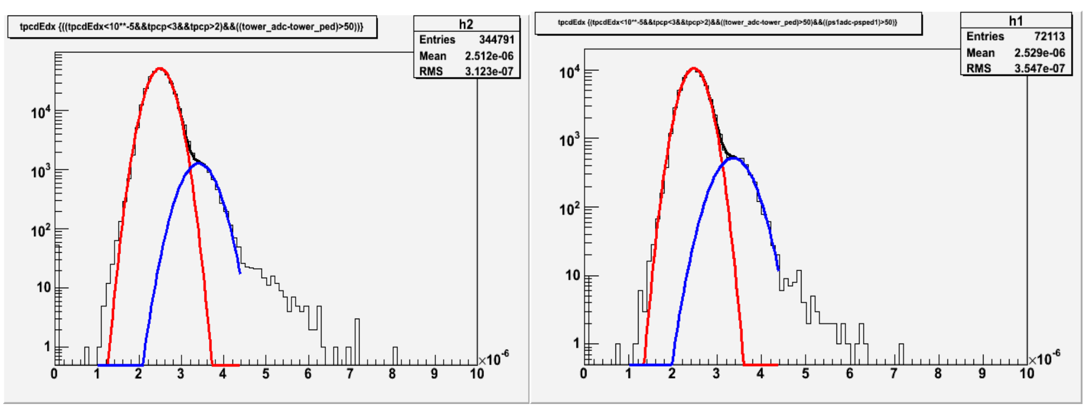

Figure 1. Ionization energy loss (dE/dx) measured in the Time Projection Chamber (TPC) for tracks with momentum between 2 and 3 GeV/c and associated with a hit tower in the BEMC. In the left plot, the ADC measured in the tower is above the minimum ionizing peak for hadrons, and in the right plot the ADC measured by the Barrel Pre-Shower is also above the minimum ionizing peak. The distribution is fit with 2 gaussians, one for the hadrons (the red peak) and one for the electrons (the smaller, blue peak). The ratio of the integral of the blue gaussian to the integral of the red Gaussian (ie, the electron yield to hadron yield) increases from 3% to 7% by adding the cut on the Barrel Pre-Shower.

II. Gamma-Jet Measurement

The "golden probe" of measuring parton energy loss in heavy-ion collisions is the γ-jet measurement [3]. The idea is to trigger on a "direct" photon, which originates directly from a hard scattering and does not interact strongly with the medium, and measure the jet on the away-side which does suffer from parton energy loss. For the current Au+Au RHIC run, we have implemented a Level-2 gamma (L2Gamma) trigger to filter events that have a high energy cluster in the BEMC to an express stream (files that will be reconstructed earlier in order to yield results in time for the Quark Matter conference in 2008). The challenge is to separate the direct photons from those originating from π^0 decays, particularly when the two decay photons from a π^0 hit the same BEMC tower. For this case, the Barrel Shower-Max Detector (BSMD), a wire chamber after 5 layers within the BEMC, can help to distinguish between a single photon shower and 2 photon showers. A first look at the express stream files from the L2Gamma trigger shows a reasonable invariant mass reconstructed from photon pairs (see Fig. 2). The plot on the left is the invariant mass for photon pairs when the two photons hit different BEMC towers, and the right plot shows the case when the two photons hit the same tower (and are separated using the BSMD). The mass calculation is not as good for the right (not exactly at mass=0.135 GeV/c^2), presumably because the energy assignments for the separate photons is not perfect when they hit the same tower.

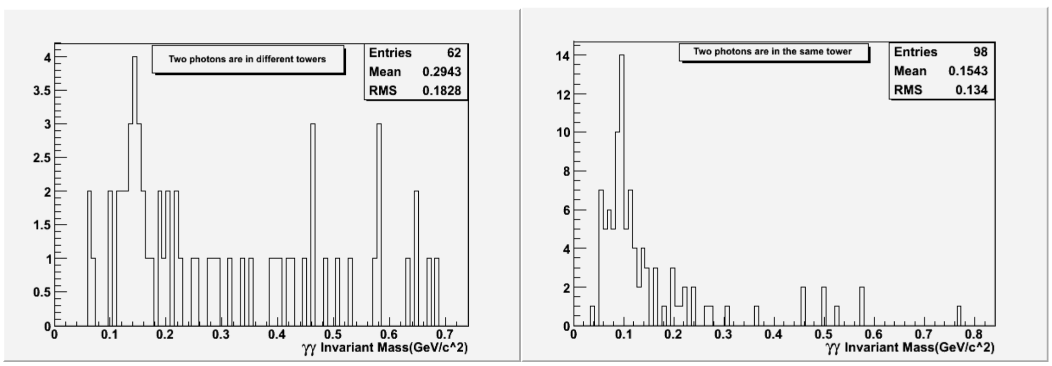

Figure 2. Reconstructed invariant mass from Level-2 triggered (L2Gamma) data.

To improve the identification of truly "direct" photons, we are currently running simulations, and comparing the response of the BEMC and BSMD in data to the simulation response. Establishing good agreement between the simulation and the data (see the π^0 invariant mass peak in Fig. 3), we can use the

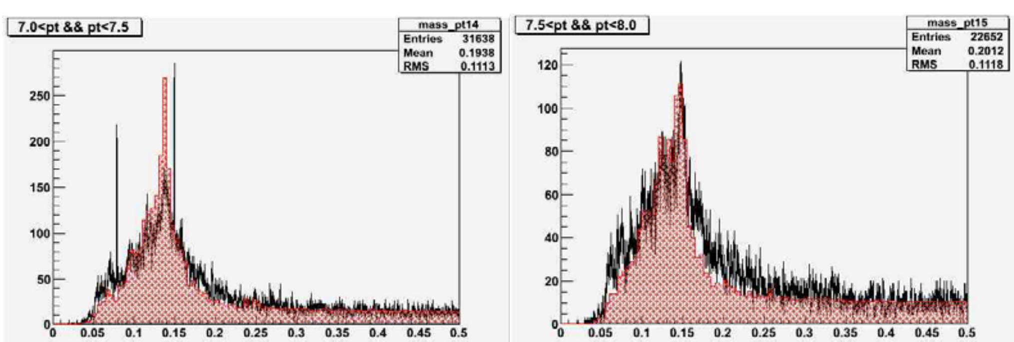

Figure 3. Comparison of the reconstructed invariant mass of photon pairs (in GeV/c^2) between p+p data (2006 RHIC run) and simulation. The solid black line is the distribution calculated from the data, and the filled red histogram is from the simulation. The left plot is for the transverse momenta 7.0-7.5 GeV/c and the right for 7.5-8.0 GeV/c.

simulation to find stronger cuts to separate direct photons from decay photons.

[1] Mauro R. Cosentino for the STAR Collaboration, e-Print: **arXiv:0706.0892** [nucl-ex].
[2] M. Beddo *et al.* (STAR Collaboration), Nucl. Instrum. Methods Phys. Res. **A499**, 725 (2003).
[3] X-N Wang, Z. Huang, and I. Sarcevic, Phys. Rev. Lett. **77**, 231 (1996).