Performance of the PHENIX EMCalorimeter

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In the early summer of 2000, the PHENIX experiment for heavy-ion physics at RHIC began, and that for spin physics was started in 2001. In this experiment, the electromagnetic calorimeter (EMCal) plays an important role in detecting photons and electrons/positrons. In order to cover topics in both areas of physics, e.g., thermal photon measurements in heavy-ion physics, and prompt photon, π^0 and weak boson measurements in spin physics, the EMCal must cover a wide energy range from a few hundred MeV to 80GeV. Spin physics also requires the energy measurement to be within 2% accuracy for measuring cross sections of prompt photons and π^0 production with 10% errors, because the cross sections have steep transverse momentum (p_T) slopes. The PHENIX EMCal consists of a lead scintillator (PbSc) and lead glass (PbGl). In this paper, we will report only the performance of the PbSc and the achievement of 2% accuracy.

The PbSc is a Shashlik-type sampling calorimeter made of alternating tiles of lead and scintillator. The basic block is a module consisting of four towers which are optically isolated and are read out individually[1)]. The module has a $5.52 \times 5.52cm^2$ cross section and $37.5cm$ length. From several beam tests at BNL[2)] and CERN[3)4)], the PbSc was found to have a nominal energy resolution of $\sigma_E/E = 2.1\% \oplus 8.1\%/\sqrt{E}$ from 0.5GeV/c to 80GeV/c , where $\oplus$ represents the quadratic sum.

Figure 1 depicts the comparison of energy deposits by 1.0GeV/c π^+ at the BNL beam test and 0.9-1.1GeV/c π^+ at PHENIX Au+Au collision $\sqrt{s_{NN}} = 130GeV$ with a 0.27GeV minimum ionization peak. The π^+ is identified by the momentum measured by the tracking system and the time of flight measured by the EMCal itself. The relative energy scale[5)] for all towers during Au+Au collision is already calibrated using the minimum ionization energy of a cosmic muon traversing laterally and that of a charged π traversing lengthwise. The minimum ionization peak of 1.1GeV/c(0.9GeV/c) π^+ is predicted to be higher(lower) than that of 1.0GeV/c π^+ by 2%. The above comparisons are consistent within 2% accuracy.

Figure 2 shows the E/p spectrum for the electron sample, which has a peak at 1.02, and the two-photon invariant-mass spectrum with a π^0 peak. The electron sample required a hit in Ring Image Čerenkov counter(RICH). The background in the E/p spectrum is already subtracted. Because of the 2% error in the momentum measurement of the tracking system, the E/p spectrum indicates that the energy measurement has a 1.02 ± 0.02 accuracy. The π^0 mass is evaluated after background subtraction by the event mixing method and is consistent with a nominal π^0 mass within a 2% statistical error.

From these three indipendent measurements, 1.0GeV/c π^+ minimum ionization peak, E/p spectrum, and π^0 mass, we can conclude that the absolute energy scale has 2% accuracy and our physics requirement is satisfied.

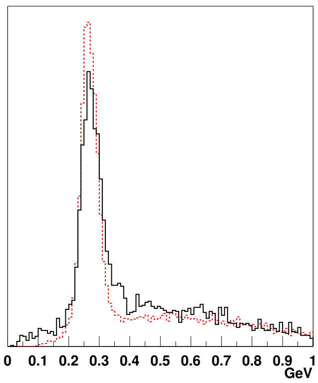

Fig. 1. Comparison of 1.0GeV/c π^+ energy spectrum (dotted line) at AGS beam test and 0.9-1.1GeV/c π^+ energy spectrum (line) at PHENIX Au+Au collision $\sqrt{s} = 130AGeV$.

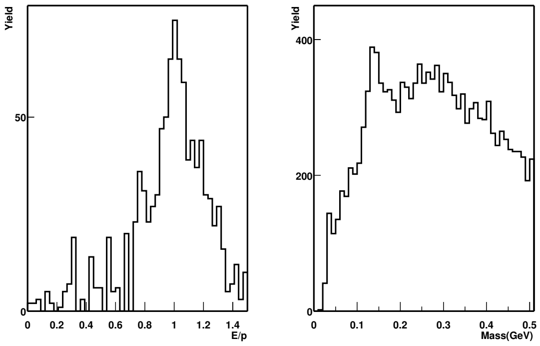

Fig. 2. (Left) Ratio of measured energy and momentum for electron sample at PHENIX Au+Au Collision $\sqrt{s} = 130AGeV$. (Right) Two-photon invariant mass spectrum at PHENIX Au+Au Collision $\sqrt{s} = 130AGeV$.

References
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