EXPECTED TRIGGER RATES OF HIGH P_T JETS AND DIRECT PHOTONS IN THE STAR EMC

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1. Abstract

The STAR experiment at RHIC is a large acceptance detector. The ElectroMagnetic Calorimeter (EMC) will provide a sensitive trigger to study high p_t jets and hard photons in AuAu, pp, and pAu collisions. The capability for the EMC to trigger on jets and direct photons was studied for trigger level 0. Trigger efficiencies and expected process rates were obtained for pp and pAu reactions, which will be essential to the interpretation of AuAu results as well as for the spin physics program. These studies were performed with the standard STAR software chain which includes GEANT and EMC simulations. The HIJING event generator was used to provide input for the simulations.

2. Introduction

The Solenoidal Tracker at RHIC (STAR) contains many different types of sub-detectors. Among these are the time projection chamber (TPC), silicon vertex tracker (SVT), a central trigger barrel (CTB), forward time projection chamber (FTPC), and an electromagnetic calorimeter (EMC). [1]

The EMC is a lead-scintillator sampling calorimeter consisting of 21 layers of lead and optically isolated plastic scintillator tiles. The EMC will have the capability to measure global E_t, high p_t particles, direct photons, and jets. Shown in Fig's. 1 and 2 are schematics of how the Barrel EMC fits into the STAR detector array.

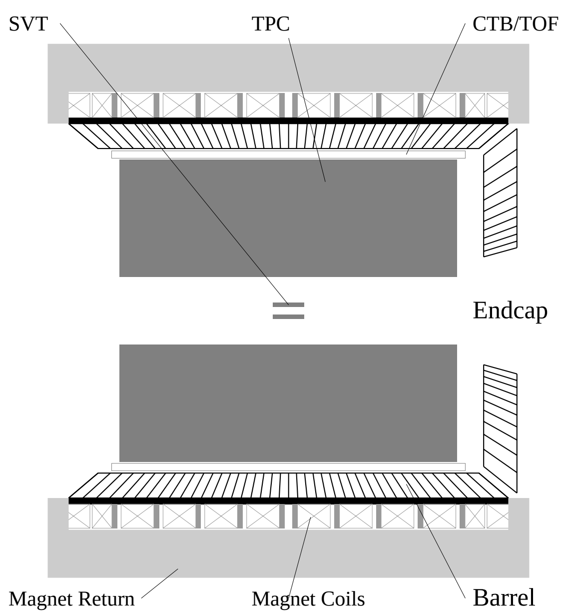

Figure 1: Schematic views of the STAR detector from the side showing the Barrel EMC, and its divisions in η and ϕ.

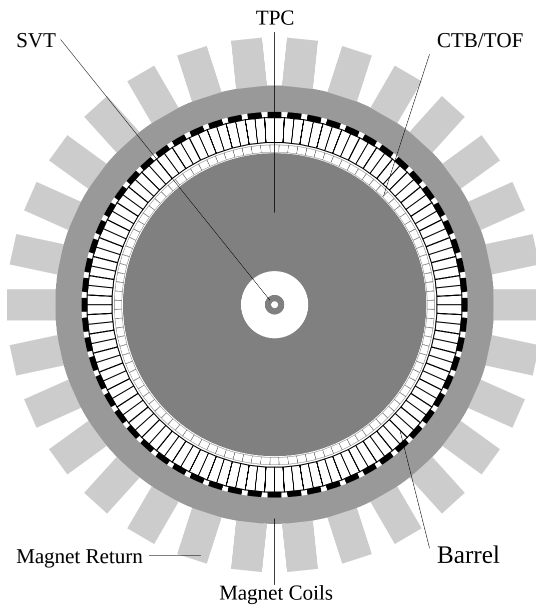

Figure 2: Schematic views of the STAR detector from the end, showing the Barrel EMC, and its divisions in η and ϕ.

The full EMC has 120 modules, with 60 modules in the ϕ direction on each side of the detector. Each of these modules has 40 towers, with 2 divisions in ϕ, and 20 divisions in η. The towers are projective in η, pointing back towards the point of interaction. The full barrel EMC covers -1.0 $\leq \eta \leq$ 1.0 . Each of the 4800 towers subtends $(0.05, 0.05)$ in $(\Delta\eta, \Delta\phi)$. A Shower Maximum Detector (SMD) is located at 5 radiation lengths from the front. The SMD is useful for γ/π^0 separation and distinction between electromagnetic and hadronic showers.

RHIC will collide beams of Au+Au at $\sqrt{s_{nn}} = 200$ GeV, and lighter species, including p+p and p+Au at 200 GeV and p+p at 500 GeV. STAR will study the hot, dense matter formed in the Au+Au collisions.[2] By comparing jets and photons in a pair, evidence may be seen of a jet interacting with a QGP, or other interesting dynamics. Also, the jet measurements in p+p, p+Au, and Au+Au can be compared to see if the jets have the same quark and gluon distributions. RHIC will also have the capability to produced polarized protons. The measurements of $p + p \rightarrow \gamma + jet + X$ and $p + p \rightarrow jet + jet + X$ will be useful for the study of the gluon spin distribution of the proton.

3. Event Simulation

The HIJING [3] event generator was used to simulate p+p and p+Au at 200 GeV, as well as p+p at 500 GeV with triggered hard processes. The high p_t jets and direct photons were produced in a "sweetspot" region $(-0.7 < \eta < 0.7)$. This restriction ensures that the complete jet signal will be detected in the EMC. For a range of triggered p_t (5, 7.5, 10, 12.5, 15, 17.5, 20, 25, 30 GeV/c), 1,000 jet and direct photon events were created. A concern was the proper simulation of high p_t π^0's in the jets, as the cross section for that process is low, but comparable to the direct photon cross section. This is important because a π^0 can decay into 2 high p_t γ's, producing a signal similar to a direct photon. To address this problem, we used a simplified model of the EMC, and ran a fast simulation of 100,000 of each of the jet event types. Shown in Fig. 3 is a comparison of the simplified model to the full simulation.

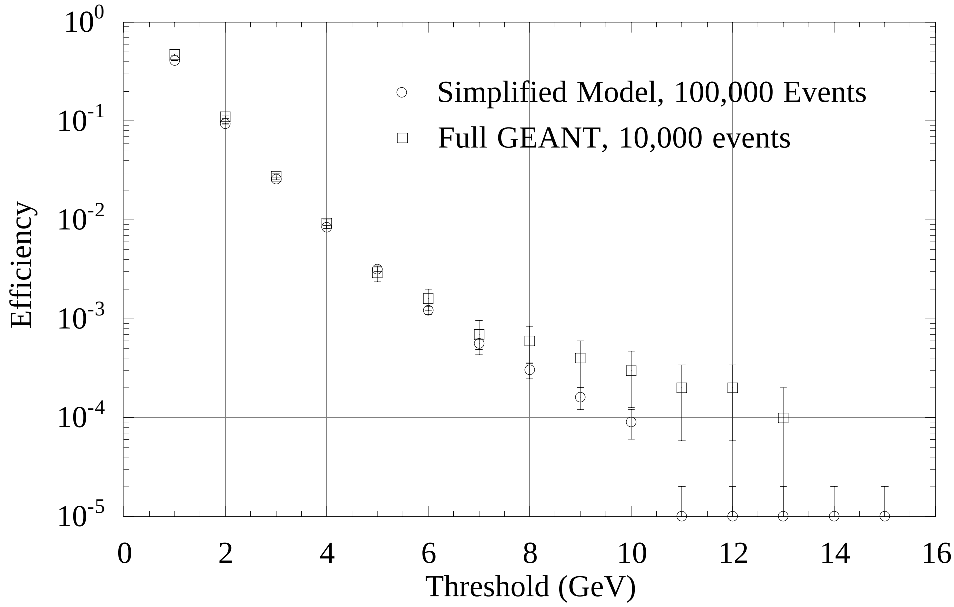

Figure 3: Efficiencies of the simple model and full GEANT simulation for 10 GeV jet events $((\Delta\eta, \Delta\phi) = (0.05, 0.05)$, high tower.)

GEANT was used to simulate the interactions of particles with the full STAR detector. A trigger package was written in STAF (Standard Table Analysis Framework) to simulate the level 0 trigger response from the GEANT EMC output. To calculate the final event rates, a published cross section was used for each jet or direct photon p_t. [4]

The sampling factor of the EMC was also calculated. This factor is necessary for calibration as well as proper simulation of the trigger. To study this, the GEANT phase command was used to send one photon into the center of each EMC tower. This was done 1,000 times per tower, and the average energy out of the calorimeter was found with a Gaussian fit. Here, the sampling factor is defined as the ratio of E_{in}/E_{out}, and changes with respect to η. The results are shown in Fig. 4.

4. The EMC trigger design, efficiency, and event rates

The EMC level 0 trigger is designed to provide fast signals for interesting events. 300 trigger tower patches ($(\Delta\eta, \Delta\phi) =$(0.2,0.2)) are created, then digitized to 6 bits. The direct photon trigger is the high tower in each of those 300 (0.2,0.2) patches, digitized to 6 bits. The jet trigger is 16 jet patches of (1.0,0.8) made from (0.2,0.2) patch sums (non-overlapping). Simulations for (1.0,1.0) will be shown. These results are similar to those for (1.0,0.8). The total transverse energy, E_t is also found from the sum of the trigger towers, which is useful for jet-jet, γ-jet triggers, and centrality measurements. The energies for the triggers will be set to 3 programmable thresholds. For the digitizations, the maximum energy used was 32 GeV. There will also be a ratio of EMC energy to CTB multiplicity of the size of jet patches. This ratio will measure isospin fluctuations as an indication of disoriented chiral condensates. [5]

The trigger efficiency is defined as N_t/N, where N_t is the number of events of a type above a given threshold, and N is the total number of events. Shown in Fig's. 5 and 6 are the efficiencies for the different types of events in a direct photon trigger (0.05,0.05), and a jet trigger (1.0,1.0). It is evident that the (0.05,0.05) suppresses the jet events, while the (1.0,1.0) gives full jet efficiency.

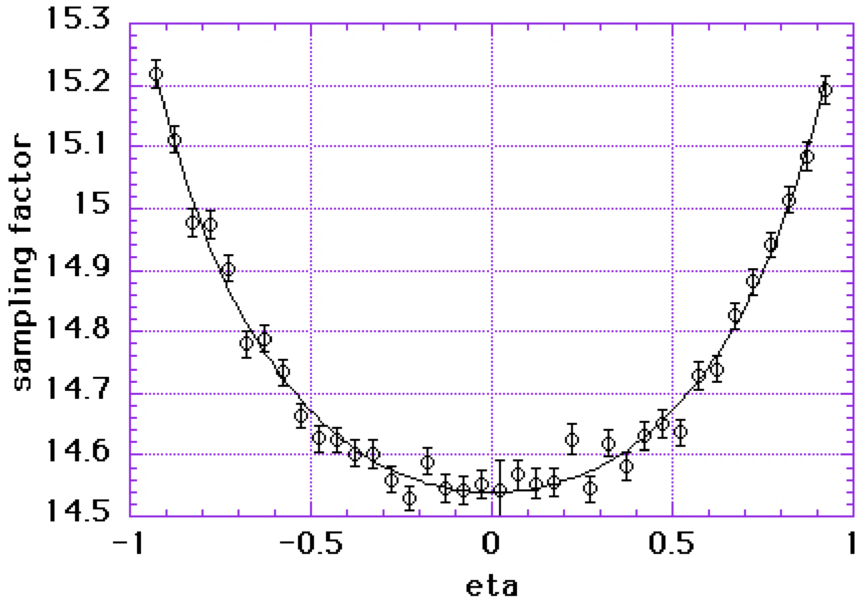

Figure 4: Sampling factor (E_{in}/E_{out}) for different η, best fit: $samplingfactor = 13.73 + 0.805/\cos(1.075 \times \eta)$

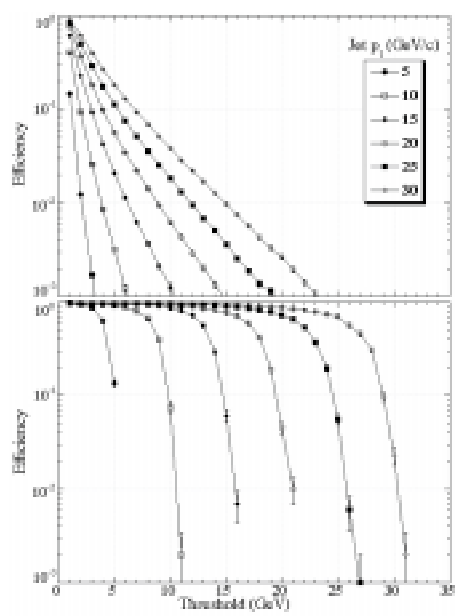

Figure 5: For the photon trigger: Efficiencies for jet (top) events and direct photon (bottom) events. Jet/Direct Photon p_t is 5,10,15,20,25, and 30 GeV from left to right.

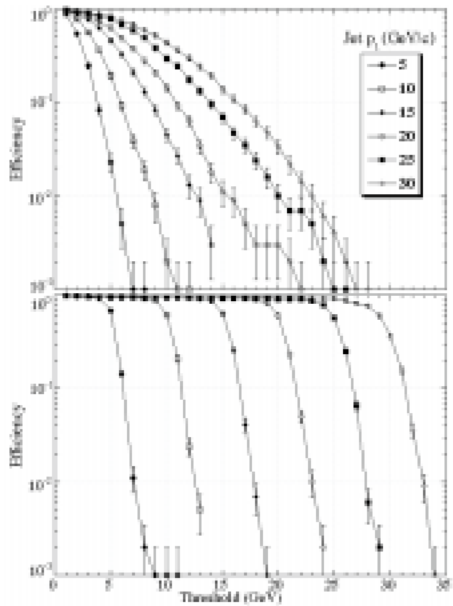

Figure 6: For the jet trigger: Efficiencies for jet (top) events and direct photon (bottom) events. Jet/Direct Photon p_t is 5,10,15,20,25, and 30 GeV from left to right.

The event rate is calculated by $Rate = Luminosity * N_t/N * \sigma$. To obtain the total event rates for each threshold, integration over the differential jet and direct photon p_t events was necessary. Shown in Fig. 7 are the results for expected total event rate for both the direct photon (0.05,0.05) and the jet (1.0,1.0) triggers. The luminosity for these 200 GeV p+p events is $2 \times 10^{32} cm^{-2} s^{-1}$.

5. Conclusions

We have shown that the trigger will work as designed. The high tower $[(\Delta\eta, \Delta\phi) = (0.05, 0.05)]$ suppresses jet events, while selecting direct photons. The jet trigger$[(\Delta\eta, \Delta\phi) = (1.0, 1.0)]$ gives a full counting rate for jets. This provides an effective high p_t jet and direct photon trigger.

References

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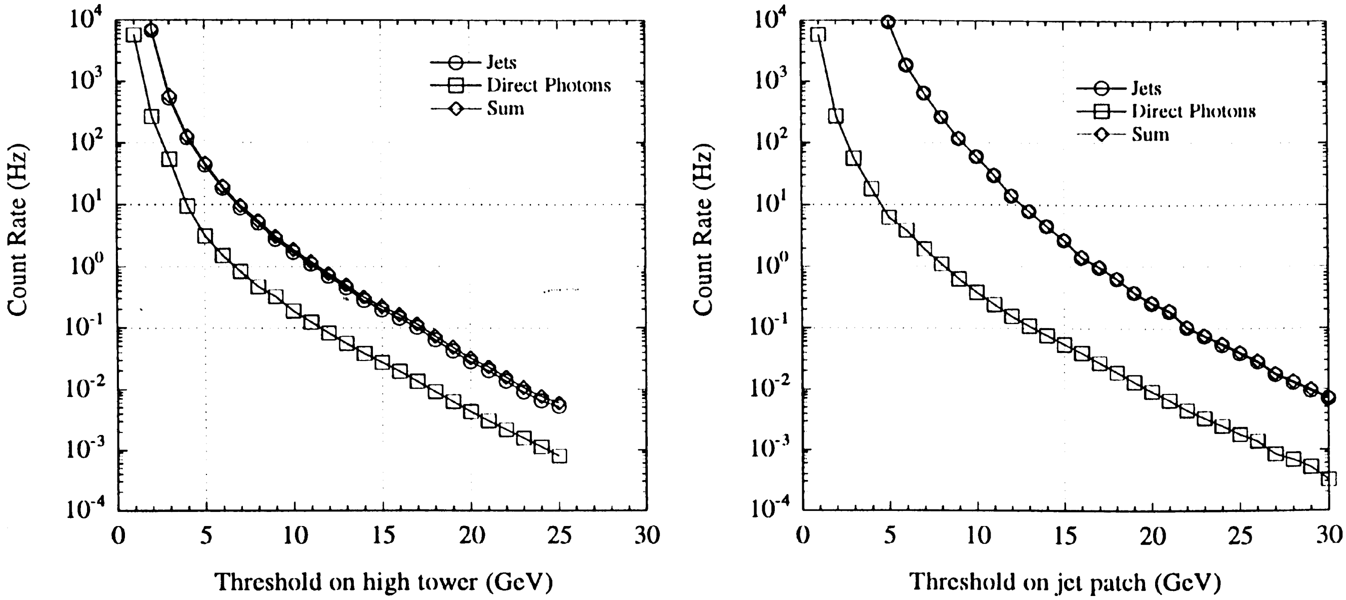

Figure 7: Expected total event rates for direct photon (0.05,0.05) and jet (1.0,1.0) triggers for all jets and direct photons in p+p reactions at $\sqrt{s_{nn}} = 200 GeV$.