Study of Charged Hadrons in Au-Au Collisions at $\sqrt{130}$AGeV with the PHENIX Time Expansion Chamber

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Introduction

In the summer of 2000 the PHENIX detector recorded data from relativistic Au+Au collisions at the center of mass energy of 130 GeV. Study of transverse momentum (p_t) spectra of created charged hadrons provides insight on state conditions after the collisions. The PHENIX Collaboration reported results of p_t spectra of charged hadrons suggesting suppression of hadrons with large transverse momentum in central Au+Au collisions [1]. In the performed analysis the PHENIX Drift Chamber (DC) was used as a primary device for track reconstruction and momentum measurements. The Time Expansion Chamber (TEC) is another PHENIX subsystem capable of providing tracking and transverse momentum information. During the RHIC physics run in 2000 the TEC recorded data sufficient enough to perform independent analysis of p_t spectra of charged hadrons. It is reasonable to obtain results of p_t distributions employing tracks reconstructed only in the TEC and ignoring tracking information from the DC. By doing this, one can check correctness of track reconstruction in the DC and p_t spectra of the PHENIX published results from the physics run of 2000. On the other hand, one can verify how successfully the TEC functioned as a tracking device in respect to DC performance.

The PHENIX Time Expansion Chamber

The Time Expansion Chamber is a sub-detector located in the East Central Arm of the PHENIX at the distance from the collision vertex approximately R = 410-457 cm. It covers 90^0 of the PHENIX azimuthal angle ϕ and 0.35 units of pseudorapidity.

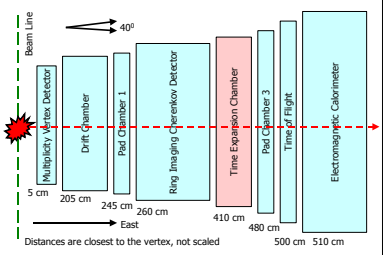

Figure 1. Passage of a charged track from the collision vertex through the PHENIX East Central Arm (view from top).

The TEC is arranged in 6-plane 4 sectors and has 64,080 wires and 20,480 readout channels making it an excellent tracking device. In 2000 the TEC had only two middle sectors with 4 planes instrumented electronically. One of the sectors is used in analysis of charged hadrons. The TEC is capable of measuring only transverse momenta of charged hadrons. For track reconstruction and p_t measurement the following algorithm is applied. On all 4 planes hits of charged particles are found. Two angles are measured: azimuthal angle ϕ and inclination angle α. Hit points of the same track have the same ϕ and α. A peak in ϕ-α. space indicates the track. The transverse momentum is computed as a function of α as

$$p_t = 1/(21.5\alpha).$$

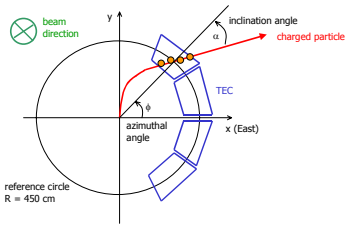

Figure 2. Track reconstruction in the TEC.

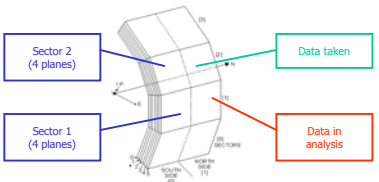

Figure 3. TEC configuration in 2000.

Analysis

The Time Expansion Chamber provides tracking information and the value of transverse momentum of a charged particle. The TEC tracks need to be associated with particles' hits in some other subsystems located in the East Arm of the PHENIX detector: the Pad Chamber 1 (PC1), the Pad Chamber 3 (PC3), the Time of Flight Hodoscope (TOF), and the Lead Glass Electromagnetic Calorimeter (EMC).

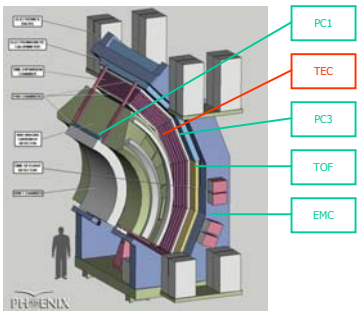

Figure 4. The PHENIX East Arm. The TEC and subsystems that provide complimentary tracking information.

Positive and negative hadrons are analyzed with the following centrality selections: 1) 0-5%; 2) 5-15%; 3) 15-30%; 4) 30-60%; 5) 60-80%; 6) 80-92%; and 7) 0-10%. The available statistics is as follows:

Centrality	Events	Tracks
Min bias	1.3M	10.6M
0-5%	81K	2.6M
5-15%	147K	3.2M
15-30%	202K	2.6M
30-60%	400K	2.0M
60-80%	301K	275K
80-92%	148K	40K
0-10%	155K	4.3M

The analysis procedure includes:

A) Track association cuts. Closest distances between TEC tracks and associated hits in PC1, PC3, TOF, and EMC are computed. Also, the distances between the projections of tracks on the plane perpendicular to the beam line and the collision vertex are found. 3-σ cuts are applied to resulting distributions to select tracks. (2-σ cut is used to estimate systematic errors due to track association).
B) Acceptance. Subsystems' dead areas that result in losing tracking information are found, as well as the range of the azimuthal angle ϕ and pseudorapidity. (Changing this range allow to estimate systematic errors due to acceptance correction).
C) "Unphysical" background subtraction. The background due to accidental TEC track matching with other subsystems' hits ("ghost tracks") is determined by changing the sign of the Z coordinates (which are the coordinates along the beam line) of the subsystem's hits and performing search for closest distances between the TEC tracks and the "flipped" hits. The resulting distributions are subtracted from track association distributions.
D) Study of track splitting and merging. These effects are estimated by comparing the angular differences between two TEC tracks from mixed events and two TEC tracks from the same events. It is found that effects of track splitting and merging are negligible in the TEC.

The following corrections are applied to the resulting p_t spectra:

1) Tracking efficiency. This efficiency is found through the procedure of merging one simulated track into data. Then, the efficiency is the ratio of the number of reconstructed later merged tracks to the total number of merged tracks. The efficiency is a function of the number of tracks in the TEC and changes from approximately 90% for 3-5 tracks to 35-40% for 60-80 tracks.
2) Association cut efficiency. Association cuts are applied on all subsystems used in the analysis except for the cut on the vertex. Then, the distribution of the vertex association is found ("cut distribution"). The same distribution is made when there are no association cuts applied to other subsystems ("uncut distribution"). The ratio of "cut distribution" to "uncut distribution" gives the association cut efficiency.
3) Correction due to finite momentum resolution. In 2000 TEC momentum resolution was 4.8% + 5.5%p_t . To make the correction, one has to fit the measured p_t distribution with exponential function, then smear it with 4.8% + 5.5%p_t , and fit it again to find the correction function.
4) Surviving probability. The correction to decay processes is approximately 97% at p_t = 0.5 GeV and becomes negligible with increase of transverse momentum.
5) Physical background. The PHENIX Simulation Group produced 100K Hijing minimum bias events. The correction due to physical background is computed by finding ratio of the number of primary simulated particles found in the TEC to the total number of simulated particles found in the TEC. The systematic error due to physical background is estimated through the ratio of simulated particles to data particles for each momentum bin.

Final results

After applying all necessary corrections, final results of transverse momentum distributions of charged hadrons are obtained. Figure 5 shows p_t spectra for all centralities studied in the analysis. Only centrality-dependent systematic errors are included in error bars. Figures 6 and 7 show p_t spectra obtained in the TEC in comparison with the PHENIX published results from the Drift Chamber charged tracks. Statistical errors only are included in error bars of p_t spectra from the Drift Chamber and the Time Expansion Chamber tracks. Systematic error bands are shown for the TEC data. The results of transverse momentum spectra from two PHENIX subsystems are in good agreement.

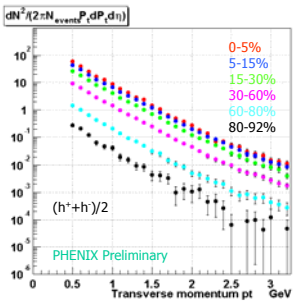

Figure 5. Spectra of charged hadrons reconstructed from TEC tracks for different centralities. Statistical and centrality-dependent systematic errors are shown.

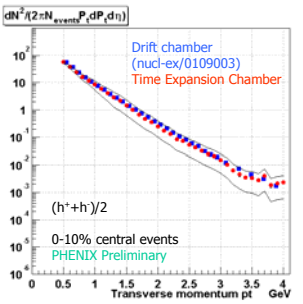

Figure 6. Spectra of charged hadrons for 0-10% central events reconstructed from TEC tracks in comparison with the Drift Chamber data. Systematic error bands are shown for the TEC data.

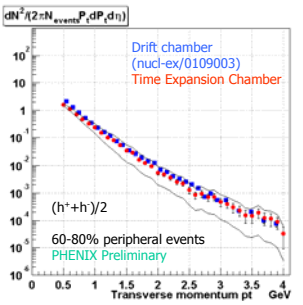

Figure 7. Spectra of charged hadrons for 60-80% peripheral events reconstructed from TEC tracks in comparison with the Drift Chamber data. Systematic error bands are shown for the TEC data.

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Reference

1. K. Adcox et al., "Suppression of Hadrons with Large Transverse Momentum in Central Au + Au Collisions at the C.M. Energy of 130 AGeV", Phys. Rev. Lett., 88, 022301 (2002), nucl-ex/ 0109003.