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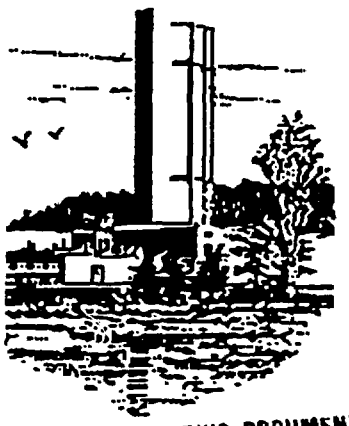

Transverse Momentum Distributions of Neutral Pions from $^{16}O+Au$ Collisions at 200 GeV/Nucleon

WA80 Collaboration

F. Plasil,[1] R. Albrecht,[2] T. C. Awes,[1] C. Baktash,[1] P. Beckmann,[3] F. Berger,[3] R. Bock,[2] G. Claesson,[2] L. Dragon,[3] R. L. Ferguson,[1] A. Franz,[4] S. Garpman,[5] R. Glasow,[3] H. A. Gustafsson,[5] H. H. Gutbrod,[2] K. H. Kampert,[3] B. W. Kolb,[2] P. Kristiansson,[4] I. Y. Lee,[1] H. Löhner,[3] I. Lund,[2] F. E. Obenshain,[1,6] A. Oskarsson,[5] I. Otterlund,[5] T. Peitzmann,[3] S. Persson,[5] A. M. Poskanzer,[4] M. Purschke,[3] H. G. Ritter,[4] R. Santo,[3] H. R. Schmidt,[2] T. Siemiarczuk,[2] S. P. Sorensen,[1,6] E. Stenlund,[5] and G. R. Young[1]

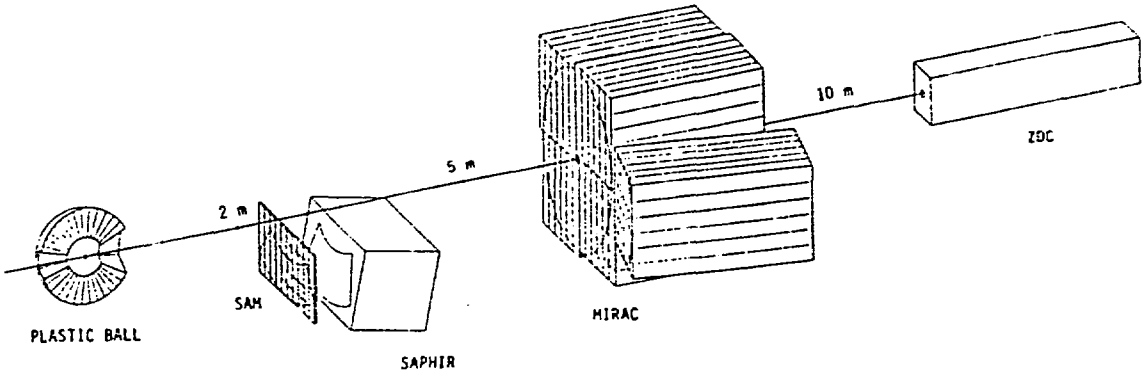

Fig. 1. Simplified version of the WA80 experimental setup. The target is located at the center of the Plastic Ball. SAPHIR is the single-arm photon detector. SAM is an associated charged-particle detector. MIRAC is the Midrapidity Calorimeter, and ZDC is the Zero-Degree Calorimeter. Most of the arrays used to measure the multiplicities of charged particles are not shown.

1. Oak Ridge National Laboratory,* Oak Ridge, Tennessee 37831.
2. Gesellschaft für Schwerionenforschung (GSI), D-6100 Darmstadt, West Germany.
3. University of Münster, D-4400 Münster, West Germany.
4. Lawrence Berkeley Laboratory, Berkeley, California 94720.
5. University of Lund, S-22362 Lund, Sweden.
6. University of Tennessee, Knoxville, Tennessee 37996.

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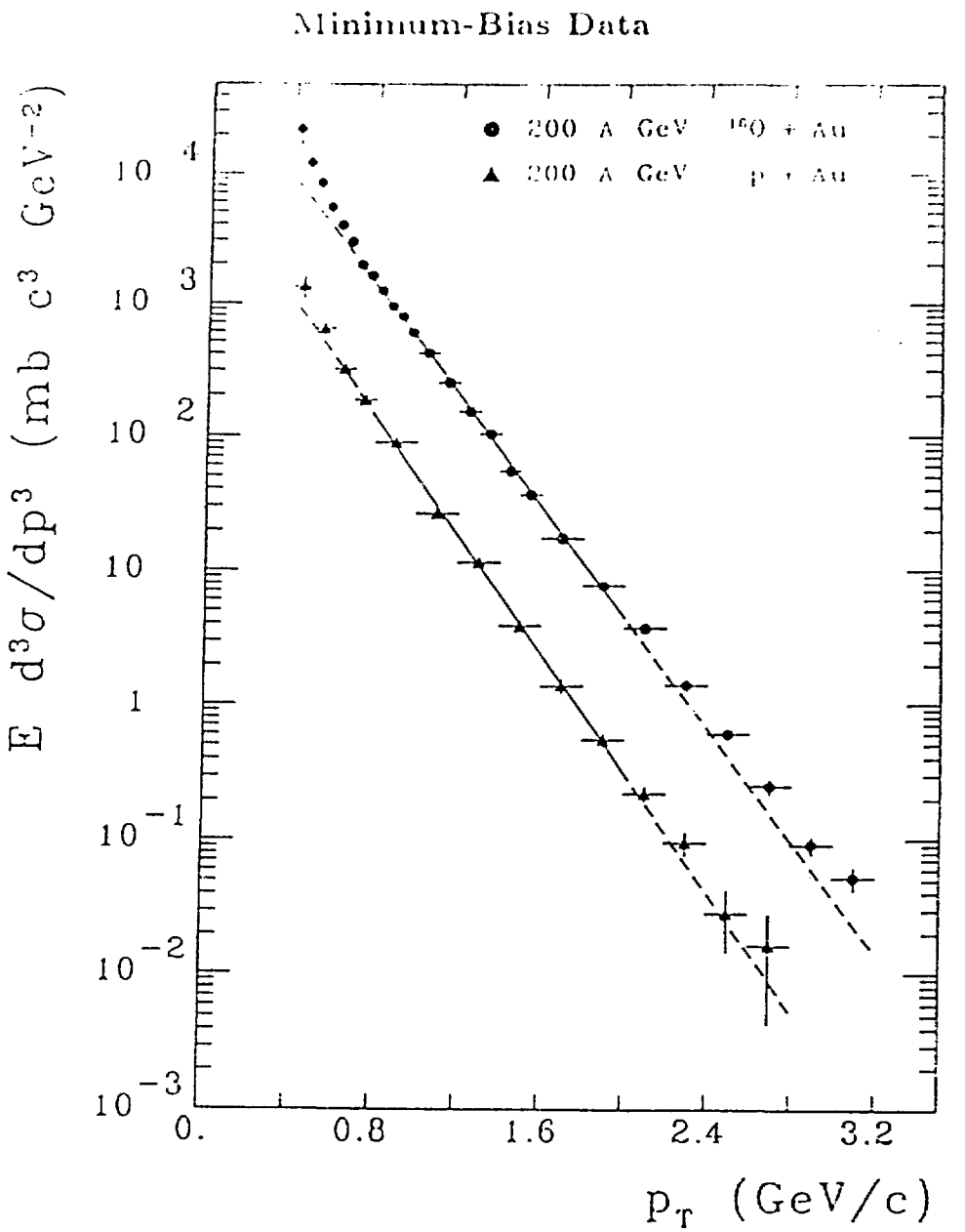

Fig. 2. Invariant π^0 cross sections from minimum-bias collisions of protons and ^{16}O projectiles with an Au target at 200 A GeV measured in the pseudorapidity range $1.5 \leq \eta \leq 2.1$. An exponential function is fitted to the data in the p_T region from 0.8 GeV/c to 2 GeV/c (solid line) and is extrapolated to the full p_T range (dashed line). The slope parameters are $T = 210 \pm 3$ MeV/c for ^{16}O+Au and $T = 196 \pm 4$ MeVc for p+Au, respectively.

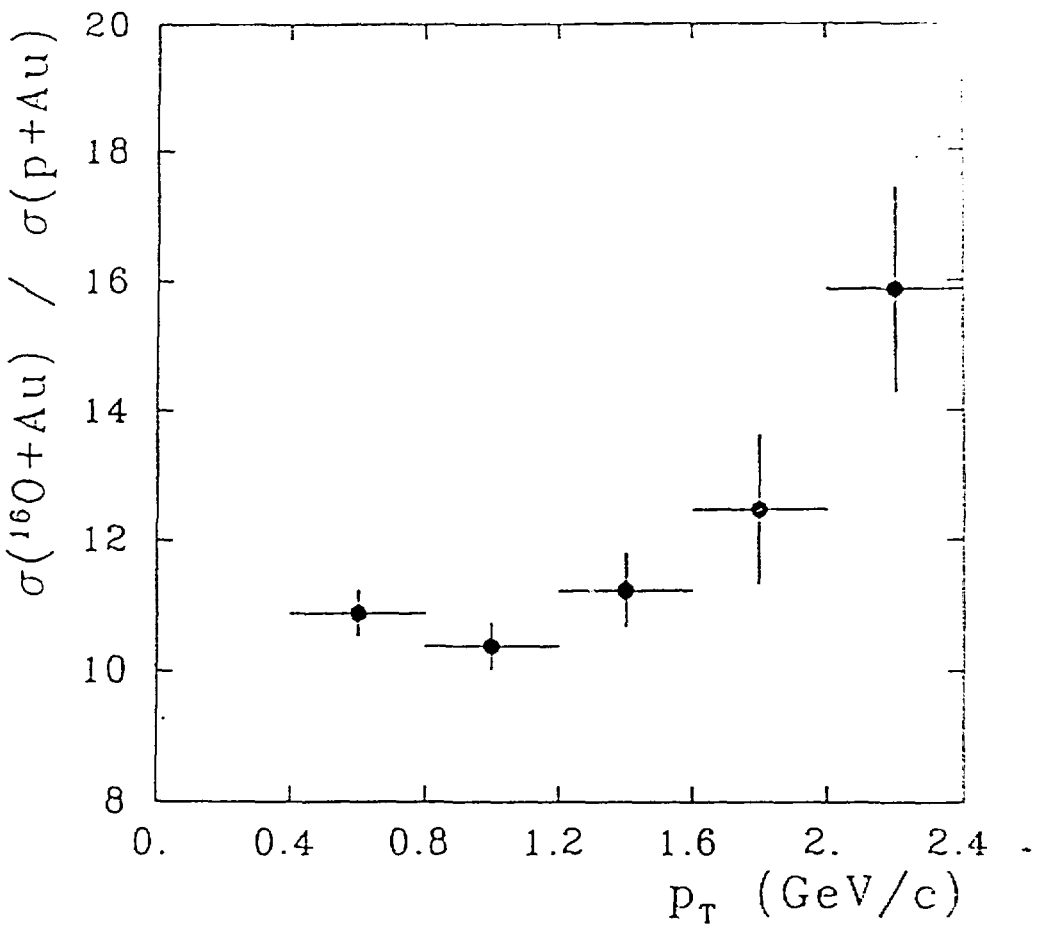

Fig. 3. Ratio $\sigma(^{16}\mathrm{O}+\mathrm{Au})/\sigma(\mathrm{p}+\mathrm{Au})$ of minimum bias π^0 p_T spectra. Similar representation has been used by Cronin et al., Phys. Rev. D 11, 3105 (1975). In that work scaling of minimum-bias cross section ratios with A^{α}_{target} and a rise of α with p_T was observed for charged pions in the range $0.8 \leq p_T \leq 5$ GeV/c. Similar enhancement is seen here.

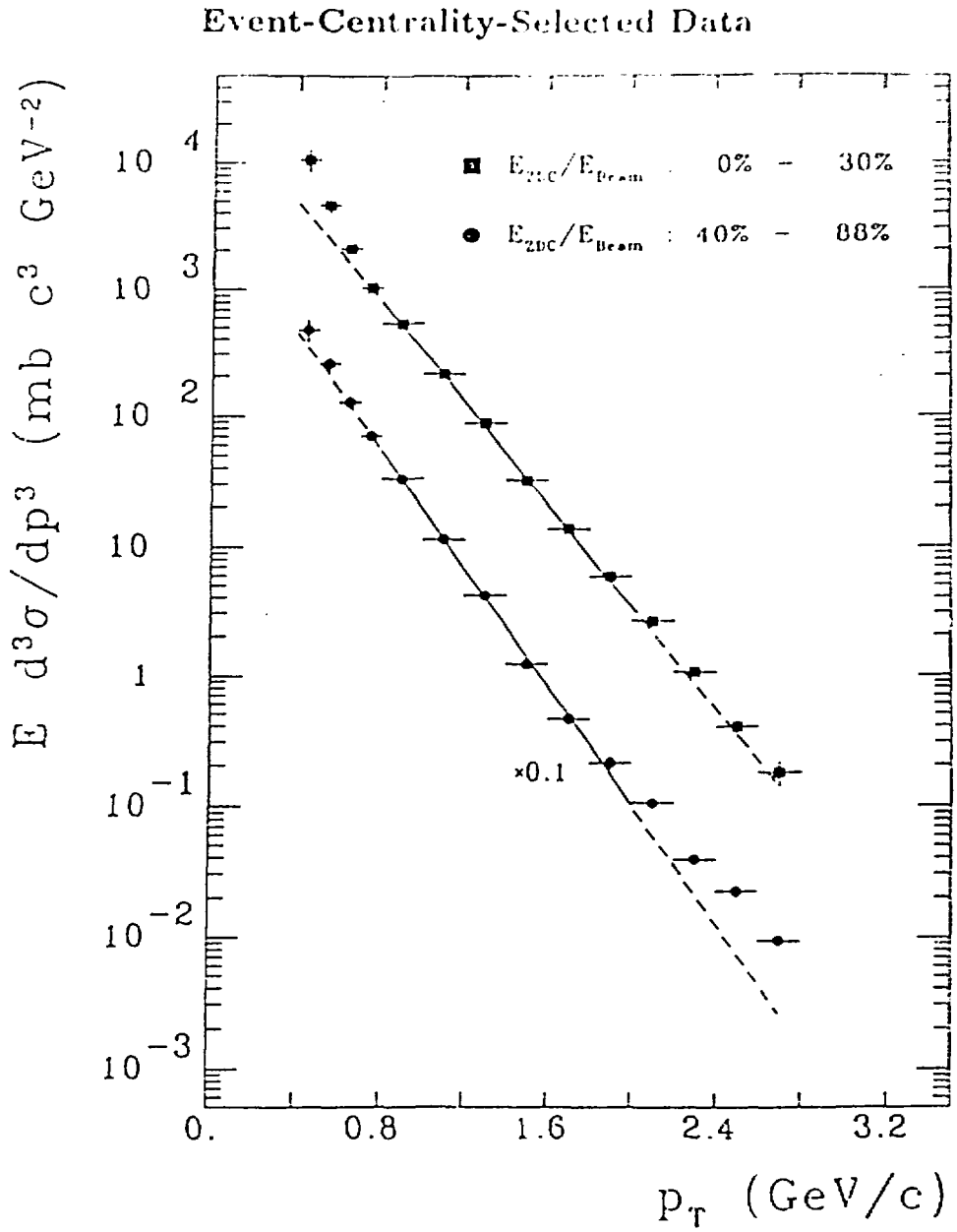

Fig. 4. Invariant π^0 cross sections from collisions of 200-GeV/nucleon ^{16}O projectiles with Au target nuclei measured in the pseudorapidity range $1.5 \leq \eta \leq 2.1$ for different ranges of the energy, E_{ZDC}, measured in the Zero-Degree Calorimeter. The squares correspond to central collisions and the circles to peripheral collisions. Exponential functions are fitted to the spectra in the range $0.8 \leq p_T \leq 2$ GeV/c and are extrapolated to the full p_T range as indicated by the dashed lines.

Event-Centrality-Selected Data

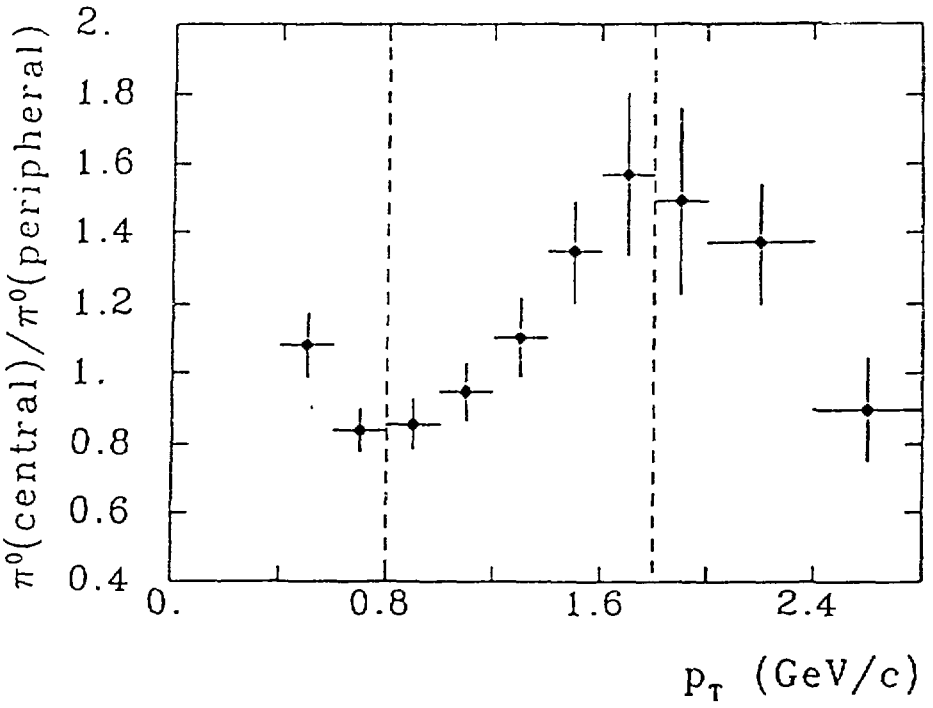

Fig. 5. Ratio of the experimental π^0 p_T yields from Fig. 4. Both yields are normalized to unity.

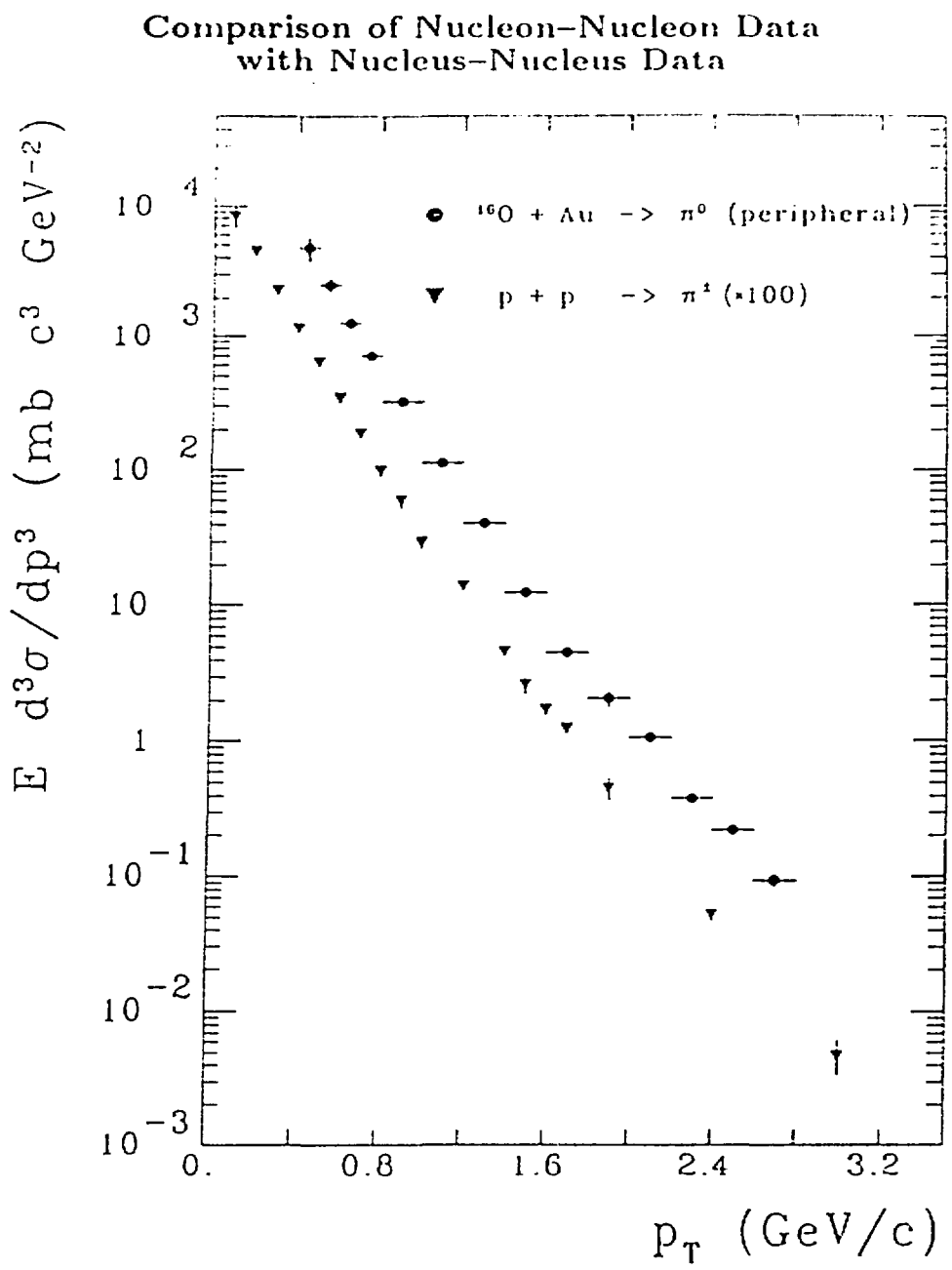

Fig. 6. Comparison of peripheral-collision π^0 spectra from the present ^{16}O+Au experiment at $\sqrt{S_{NN}} \cong 19.4$ GeV with charged-pion spectra from minimum-bias p+p data at $\sqrt{S_{NN}} = 23$ GeV. The charged-pion data are from B. Alper et al., Nucl. Phys. B100, 237 (1975). (π^- and π^+ data are averaged and plotted as a single set of data points.)

Introduction

One means of studying the properties of the compressed and highly excited reaction zone is the investigation of p_T spectra of produced pions and their dependence on the centrality of the reaction. To distinguish different contributing processes and to provide a reliable basis for comparisons with p+p scattering, a large p_T coverage is required. In particular, data at high p_T values, where hard processes become important and may be calculated by perturbative QCD, are of interest. The present study of π^0 spectra concentrates on measurements of p_T spectra up to 2.8 GeV/c and on selections of the data according to the centrality of the reaction.

The experimental setup is shown in Fig. 1. The ZDC measures the forward energy distribution ($\eta \geq 6.0$) which is mainly determined by projectile spectators. It has been found that the ZDC energy for ^{16}O+Au can be related to the number of participants and, hence, is a measure of the centrality of the reaction. The minimum-bias trigger is defined by the requirements that less than 88% of the total projectile energy is measured by the ZDC (for ^{16}O beams but not for proton beams) and that at least one charged particle is recorded by the multiplicity array.

The lead-glass detector, SAPHIR, consists of 1278 modules and measures photons in the energy range from 0.2 to 20 GeV in about 1/6 of the solid angle in the pseudorapidity range from 1.5 to 2.1.

Minimum-Bias Results

Neutral pions are identified by their decay photons ($\pi^0 \rightarrow 2\gamma$), and p_T distributions are obtained for those neutral pions for which both decay photons are measured. Results for minimum bias data are shown in Fig. 2, and ratios of the spectra are shown in Fig. 3. Exponential fits $[1/p_T\ dN/dp_T \sim exp(-p_T/T)]$ to the minimum-bias data were made in the range $0.8 \leq p_T \leq 2$ GeV/c. The slope parameter of the ^{16}O+Au spectrum (T = 210 $\pm$ 3 MeV/c) is larger than the slope parameter of the p+Au data (T = 196 $\pm$ 4 MeV/c).

Event Centrality Selection

Insight into the particular mechanism of heavy-ion reactions at high energies can be gained by selecting central and peripheral collisions. Collective effects or the formation of new states of nuclear matter is expected primarily in central collisions. Data from peripheral collisions, on the other hand, may provide a link to p+A and p+p reactions. Centrality selection has been achieved by cuts in the

ZDC energy. Central events are defined by $0\% \leq E_{ZDC}/E_{beam} \leq 30\%$, while peripheral events are defined by $40\% \leq E_{ZDC}/E_{beam} \leq 88\%$. In Fig. 4 spectra for central and peripheral events are displayed. Exponential fits are shown for $0.8 \leq p_T \leq 2$ GeV/c. The following three main features of the data are to be noted:

(1) Over most of the p_T range, the value of the slope parameter is significantly higher for central collisions than for peripheral collisions;

(2) in the low-p_T region, lower values of the slope parameter are observed than in the central-p_T region, but only in the case of central collisions; and

(3) at high-p_T values, no change is observed in the slope parameter for central collisions, while peripheral collision data exhibit a clear deviation from central-p_T slope parameters to much higher values.

The behavior indicated in item 3 is similar to that observed in the data of p+p collisions at similar energies (see Fig. 6). It is attributed to the onset of hard QCD scattering, which is, presumably, obscured by nuclear effects in central collisions. At lower values of p_T the changing of the slope parameter with centrality can be understood on the basis of a hydrodynamical model with isotropic expansion of a fireball.[1] The increased cross section at low-p_T values in central collisions (item 1 above) is described in a thermodynamical picture as being a consequence of the rescattering of secondary pions.[2] The three regions distinguished above are clearly seen in Fig. 5, where the ratio of the two spectra from Fig. 4 are displayed.

Comparison of Nucleon–Nucleon Data with Nucleus–Nucleus Data

Figure 6 shows a comparison of the peripheral-collision π^0 spectrum from ^{16}O+Au at 200 A GeV ($\sqrt{S_{NN}} \cong 19.4$ GeV) with charged-pion spectra from p+p at $\sqrt{S_{NN}} = 23$ GeV. There is remarkable agreement in the spectral slope of the data up to the highest p_T of the present experiment.

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