NUCLEUS-NUCLEUS COLLISIONS AT 60 TO 200 GeV/NUCLEON: PHOTON MEASUREMENT RESULTS FROM THE WA80 EXPERIMENT AT CERN

WA80 Collaboration

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Photon measurement results from $^{16}O+^{197}Au$ reactions at 200 GeV/nucleon obtained by the WA80 collaboration at the CERN SPS are presented. Transverse momentum spectra of neutral pions and of direct photons are shown. At an accuracy within 15% limits, all observed photons are accounted for by known hadronic decays.

INTRODUCTION

Photon measurements of WA80 have been carried out by means of a single-arm lead-glass photon detector[1] (SAPHIR) of modest acceptance ($\Delta\phi = 2\pi/3$ and $13.7° \leq \theta \leq 25.9°$) and of limited resolution ($\sigma/E = 0.4\% + 6\%/\sqrt{E}$). We present here our results on the spectra of direct photons as well as transverse momentum spectra of neutral pions obtained from reactions of ^{16}O with ^{197}Au at 200 GeV/nucleon.

DIRECT PHOTONS

The purpose of this study is to measure the spectra of direct photons which may be emitted from the quark–gluon plasma (QGP). The procedure used to deduce these spectra relies on our ability to account for all photons impinging on the surface of SAPHIR that result from known hadronic decays. The difficulties associated with this task can be appreciated when we consider the uncertainties associated with SAPHIR's efficiency (in a high-multiplicity environment), its limited acceptance (making certain invariant-mass reconstructions impossible), and the unknown transverse momentum distributions of the other hadronic decays that contribute to the background (η, ω, and η') in addition to the dominant neutral pions.[2,3]

In mid-1988, we reported preliminary results on direct photon emission from reactions induced with ^{16}O projectiles at 200 GeV/nucleon.[4] Subsequent work on the evaluation of SAPHIR efficiency and acceptance, however, has led to a revision of our preliminary findings.[5] The revised results are shown in Fig. 1 in which the γ/π^0 ratio is shown for central and peripheral ^{16}O+Au reactions at 200 GeV/nucleon as a function of p_T. The Monte Carlo calculations depicted in the figure give the contribution of all decay photons. The Monte Carlo procedure and its assumptions are described elsewhere.[3] Within the limits of uncertainties, all of the observed photons are accounted for by known hadronic decays. Given all sources of uncertainties, we set an upper limit of about 15% for the contribution of direct photons to the γ/π^0 ratio in our p_T range. With better statistics, it should be possible to set a limit at the 5% level.

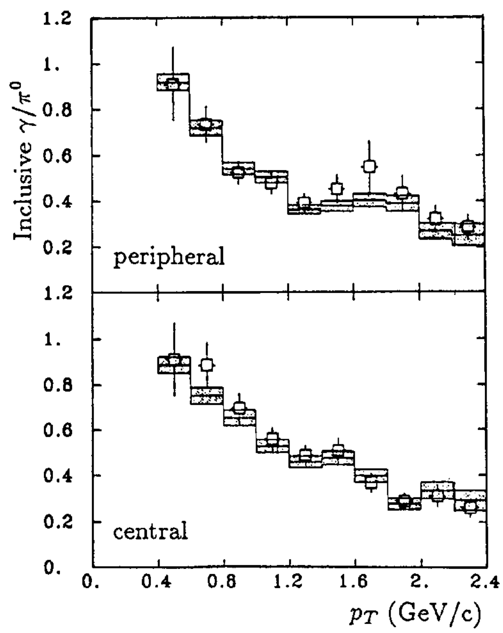

Fig. 1. Ratio of inclusive photon cross section to π^0 cross section as a function of transverse momentum for central and peripheral ^{16}O+Au reactions at 200 GeV/nucleon. The squares indicate data, and the shaded histograms are Monte Carlo results representing hadronic decays. The difference between the data and the histograms can be attributed to the contribution of direct photons.

TRANSVERSE MOMENTUM DISTRIBUTIONS OF NEUTRAL PIONS

The investigation of the π^0 spectra presented here covers a p_T region up to 3.6 GeV/c and involves the selection of data according to collision centrality. The results cover the full data set of the 1986

^{16}O+Au run and extend the subset of data published in Ref. 6. They are described together with data analysis and efficiency and acceptance corrections in a forthcoming publication.[2] Only selected highlights are presented here. In Fig. 2 invariant π^0 cross sections are shown for minimum-bias collisions of protons and ^{16}O projectiles with central and peripheral 200-A-GeV ^{16}O+Au events. Similar data have been obtained for Au nuclei. Attempts to fit the spectra with a combination of two thermal distributions did not give reliable results since the two extracted temperatures turned out to be sensitive to both the relative normalization and to statistical fluctuations. Following Hagedorn[7] the spectra were parametrized by:

$$E\frac{d^3\sigma}{dp^3} = \begin{cases} A\ \exp(-m_T/T) & \text{for } p_T \leq 0.8 \text{ GeV/c} \\ C\ \left(\frac{p_0}{p_T+p_0}\right)^n & \text{for } p_T \geq 0.8 \text{ GeV/c} \end{cases} \qquad (1)$$

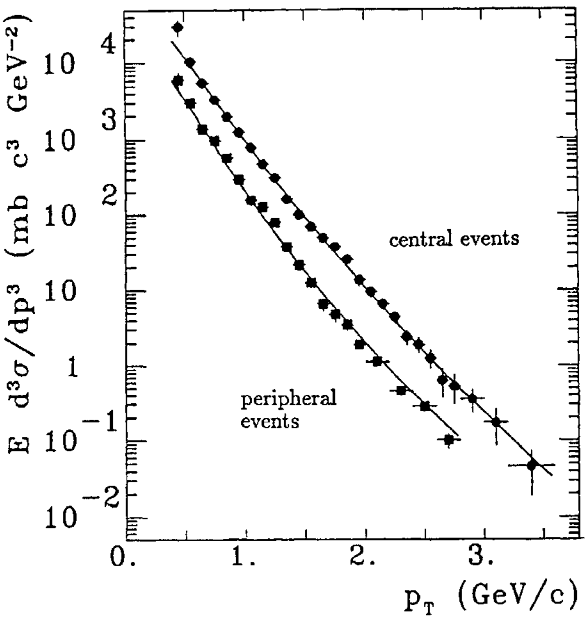

Fig. 2. Invariant π^0 cross sections from central (circles) and peripheral (squares) collisions of ^{16}O projectiles with an Au target at 200 A GeV measured in the pseudorapidity range $1.5 \leq \eta \leq 2.1$. The lines represent fits to the data with Eq. (1) and parameters of Table 1.

where A, T, C, p_0, and n are parameters and m_T is the transverse mass, $m_T = (p_T^2 + m^2)^{1/2}$. The first expression is an approximation to a thermal distribution, while the second expression is empirical and based on QCD considerations. Two parameters are eliminated by the requirement that the values and slopes of the two expressions match at $p_T = 0.8$ GeV/c. The fit values of the remaining three parameters, A, T, and n, are given in Table 1. The fitted curves are shown in Fig. 2. The two points to be noted are that the value of the parameter T remains constant (within experimental errors) for all data sets, and that the parameter n varies from one data set to another, indicating differences in the spectra at p_T values above 0.8 GeV/c. The differences in the high p_T region become more apparent when comparisons are made to data from $p+p$ collisions and when ratios of spectra are plotted as a function of p_T. A marked change of slope at higher values of transverse momentum is seen in the p+Au case and has previously been ascribed to the onset of hard QCD scattering.[8] This effect is also found in our peripheral-collision ^{16}O data, but not in results from central collisions where, presumably, the effect is obscured by nuclear effects.

Table 1. Parameters obtained from fitting Eq. (1) to experimental data of Fig. 2 and to minimum-bias data from p+Au and ^{16}O+Au reactions at 200 GeV/nucleon.

System	A (mb c^3 GeV^{-2})	T (MeV/c)	n
200-GeV p+Au	(1.3±0.5) 10^4	180±16	37.6±3.9
200-A-GeV O+Au			
minimum-bias	(3.6±1.3) 10^5	184±16	25.9±2.4
peripheral	(6.6±2.9) 10^4	174±18	16.8±1.9
central	(1.7±0.8) 10^5	194±22	26.0±3.1

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