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# Centrality and Collision System Dependence of Antiproton Production from p+A to Au+Au Collisions at AGS Energies

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Antiproton production in 11.7 A·GeV/c Au+Au collisions over a wide transverse-mass coverage was studied in the AGS-E866. The inverse slope parameter increases rapidly as a function of centrality. Antiproton yields in Si+A and Au+Au collisions are consistent with

the scaling with the 2/3 power of the number of participant nucleons. Transverse-mass spectra are similar to those of protons from peripheral to central Au+Au collisions.

## 1. Introduction

Antiproton ($\overline{p}$) production in heavy ion collisions reflects subtle interplay between initial production and absorption by nucleons. Because the AGS energies ($10 - 20$ A $\cdot$ GeV/c) are close to the $\overline{p}$ production threshold, $\overline{p}$ may be sensitive to cooperative processes such as QGP [1] and hadronic multi-step processes [2]. On the other hand, $\overline{p}$ has been proposed as a probe of baryon density due to large $N\overline{N}$ annihilation cross sections [3]. Cascade models [4–6] predict the maximum baryon density reaches about 10 times the normal nucleus density in central Au+Au collisions, where the strong $\overline{p}$ absorption is expected. In this paper, we show systematic studies of $\overline{p}$ production from p+A to Au+Au collisions.

## 2. Analysis in AGS-E866 Experiment

The AGS-E866 experiment is aimed at studies of particle production in 10−12 A·GeV/c Au+Au collisions as a function of centrality. The experimental setup is described elsewhere [7,8]. In this analysis, data taken in 1994 in the Forward Spectrometer are used. Centrality is defined with the zero-degree calorimeter (ZCAL). The kinematic coverage for $\overline{p}$ is $1.0 < y < 2.2$ and $0 < m_t - m_p < 1.2$ [GeV/c$^2$], where $y$, $m_t$, and $m_p$ denote rapidity, transverse mass, and $\overline{p}$ mass, respectively. About 800 $\overline{p}$ candidates were extracted out of about 15 million minimum-bias collisions.

## 3. Results

Fig. 1 shows $m_t$ spectra in minimum-bias events. Kinematic reflections of the spectra in each rapidity are consistent within statistical uncertainties. E886 [9] and E878 [10] results at $p_t \simeq 0$ agree with our data. Fig. 2 shows $m_t$ spectra in $1.0 < y < 2.2$ in centrality windows of $0 - 8$ %, $8 - 23$ %, $23 - 38$ %, and $38 - 77$ % (zero corresponds to most central). Inverse slope parameters increase rapidly as a function of centrality from 0.18 to 0.28 GeV/c$^2$. E864 [11] and E878 [10] data at $p_t \simeq 0$ agree with our data except for in the most centrality window, where the E864 point is 4 times larger than the E878 point, and the exponential extrapolation of our data comes between them. It is an open question whether this is due to acceptance difference of the $\overline{p}$ decaying from $\overline{\Lambda}$. The acceptance in our spectrometer is estimated to be 42 % including the branching ratio of 64 %.

Fig. 3 shows comparison of $dN/dy$ among p+A [12], Si+Al and Si+Au data [13] at 14.6 A·GeV/c in $y_{NN} - 0.6 < y < y_{NN}$ and Au+Au data at 11.7 A·GeV/c in $|y - y_{NN}| < 0.6$ as a function of the number of participants ($N_{part}$). The $N_{part}$ was calculated with FRITIOF 1.7 [14]. A beam energy correction factor of 0.47 is applied to p+A and Si+A data. Si+A and Au+Au data are consistent with the $N_{part}^{2/3}$ scaling.

These data are compared with RQMD (solid line) and the first collision model (dashed line). RQMD calculations are from Ref. [15] for p+A and were done with version 2.3 for Si+A and 2.1 for Au+Au. In RQMD, initial $\overline{p}$ production is enhanced by multi-step processes and free $N\overline{N}$ annihilation cross sections are used. The first collision model gives $\overline{p}$ yields as $dN/dy = dN/dy_{p+p} \cdot N_f$, where $dN/dy_{p+p}$ is $dN/dy$ in p+p collisions, and $N_f$

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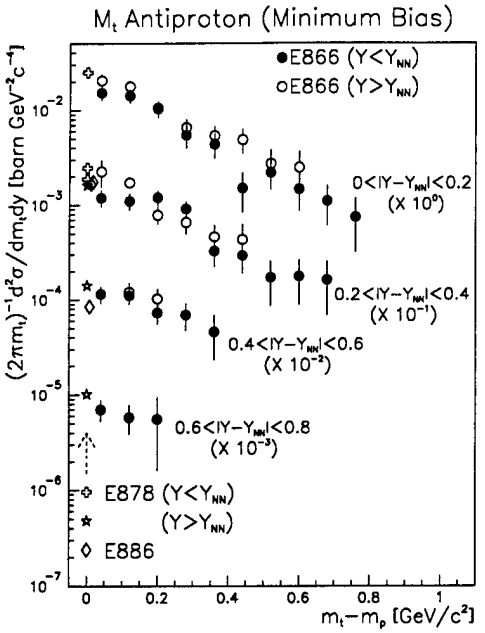


Figure 1. Transverse-mass spectra in minimum bias events. See text for details.

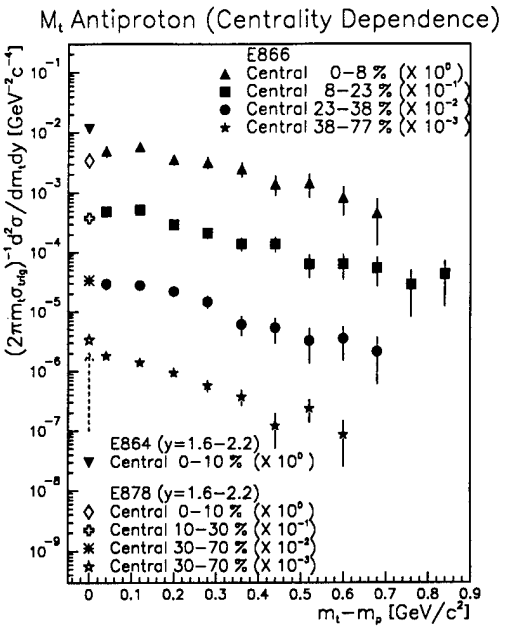


Figure 2. Transverse-mass spectra in 4 centrality windows. See text for details.

is the number of binary collisions between unstruck nucleons. No absorption is assumed. Both models reproduce p+A data, and the scaling of $N_{part}^{2/3}$ from Si+A to Au+Au data.

In Fig. 4, $m_t$ spectra are compared with those of protons. For all centrality windows, their shapes appear similar, but more data are needed for a quantitative evaluation.

## 4. Conclusions and Outlook

E866 measured $\overline{p}$ production in Au+Au collisions at 11.7 A·GeV/c in wide transverse mass coverage. The $dN/dy$ from Si+A to Au+Au collisions scales with $N_{part}^{2/3}$. Both RQMD and the first collision model reproduce the global system dependence of $\overline{p}$ yields. However, by construction, the latter cannot reproduce the rapid development of the inverse slope parameter with centrality in Au+Au collisions. This observation implies that it is important to investigate $m_t$ spectra to explore $\overline{p}$ production mechanisms. The $m_t$ spectra of $\overline{p}$ are similar to those of the proton from peripheral to central Au+Au events, and this will be investigated in more detail with a larger data sample in 1995, as well as the data in E866's large angle spectrometer, Henry Higgins.

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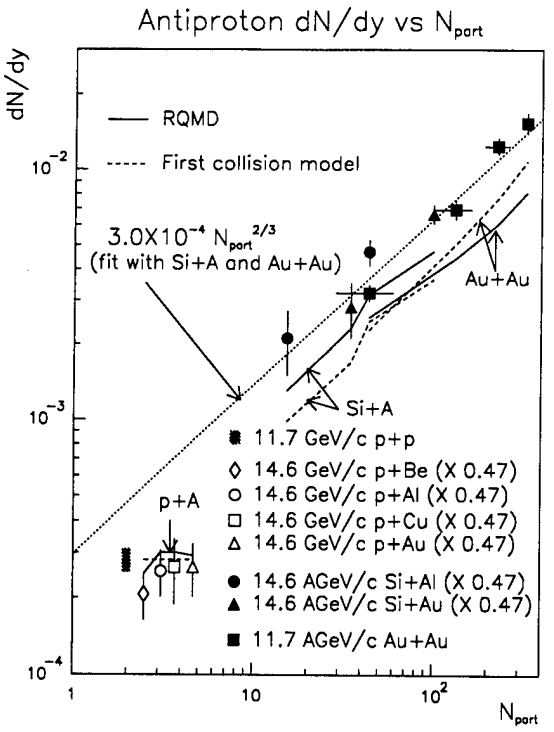


Figure 3. The $dN/dy$ in p+A, Si+A and Au+Au collisions as a function of $N_{part}$. See text for details.

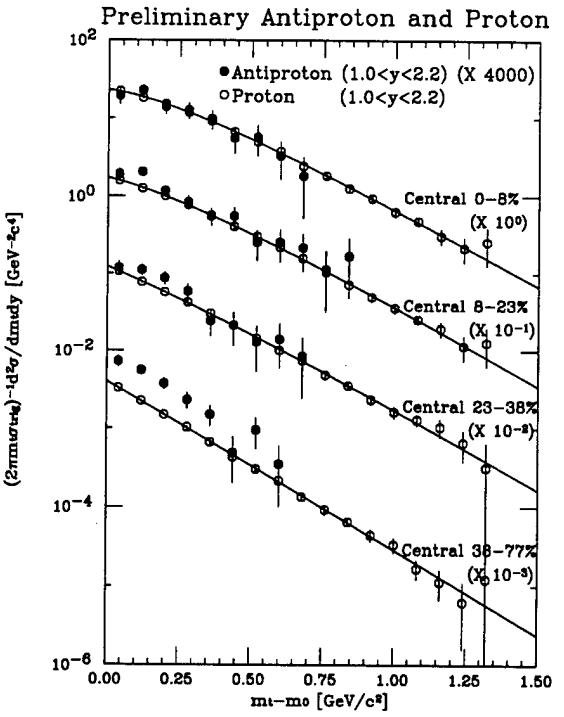


Figure 4. Comparison of $m_t$ spectra between $\overline{p}$ (scaled by 4000) and the proton in Au+Au collisions. See text for details.

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