J/Ψ and Open Charm Measurements at RHIC/PHENIX

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Abstract. PHENIX has measured inclusive single electron spectra at midrapidity in Au-Au collisions at $\sqrt{s_{NN}}$ = 130 and 200 GeV. PHENIX has also studied J/Ψ production at $x_F = 0$ via electrons and at forward and backward x_F via muons for p-p, d-Au and Au-Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. An overview of some of the obtained results are presented here.

INTRODUCTION

Particles carrying charm or bottom quarks are sensitive probes to study the hot and dense matter created in the early stage of high-energy heavy-ion collisions. The PHENIX experiment at RHIC can study open charm production via single lepton spectra and charmonium (J/Ψ) via the dilepton channels. PHENIX is a high rate experiment, able to study rare signals via several different channels while RHIC is able to provide different colliding beam species at different energies. This combination results in a very powerful tool for understanding the relative importance of various phenomena relevant to high-energy heavy-ion collisions, such as effects of the initial gluon density and shadowing.

The PHENIX detector is composed of four spectrometer arms: two forward muon spectrometers covering the full azimuth and $1.1 < |\eta| < 2.4$ and two central spectrometer arms each covering $\pi/2$ in azimuth and $|\eta| < 0.35$. Electrons are identified in the central arms by matching charged particle tracks reconstructed with the Drift Chamber and Pad Chambers to deposited energy in the ElectroMagnetic Calorimeter and rings in the Ring Imaging Cherenkov detector. Muons are found in the forward arms by matching roads from the Muon Identifier planes with tracks from the Muon Tracker stations. The minimum momentum required for a muon to go deep enough to be reconstructed is about 2 GeV/c, while the required minimum transverse momentum allowing a track to be reconstructed in the central arms is about 0.2 GeV/c.

OPEN CHARM MEASUREMENTS IN AU-AU INTERACTIONS

The direct measurement of heavy-flavour is difficult in the high multiplicity heavy-ion collisions at RHIC (especially before the realization of the proposed silicon vertex tracker upgrade). So far, PHENIX has therefore used an alternative approach in which the contributions from heavy-flavor decays to the non-photonic part of the single electron spectra are determined. It is expected at RHIC that the charm decay contribution

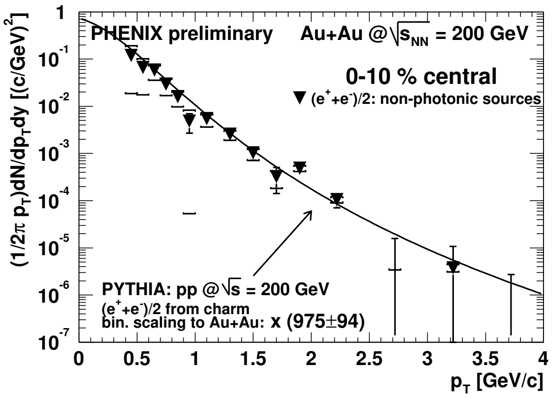

FIGURE 1. Invariant yield of electrons from non-photonic sources in Au-Au collisions, compared with the scaled PYTHIA yield, at $\sqrt{s_{NN}}$ = 200 GeV for the 0-10% and the 40-70% central events, respectively.

would be the dominant component for single electrons with $p_T \sim> 1$ GeV/c, since the charm cross section is large and the production of high p_T pions has been found to be suppressed relative to binary collision scaling. In the analysis of the single electron spectrum from $\sqrt{s_{NN}}$ = 130 GeV data the expected contributions from photonic conversions and light vector meson decays, were subtracted from the inclusive electron yield. An excess, increasing with p_T, was observed and interpreted as a charm signal [1]. The charm cross section at 130 GeV for the 10% most central collisions was found to be $380 \pm 60(stat) \pm 200(sys)\mu b$, and in reasonable agreement with PYTHIA [2], binary collision scaling, and results from experiments at lower energies.

For the 200 GeV run that followed, as an additional handle on the systematics, special runs with and without a 1% brass photon converter were studied. This approach allowed for a better determination of the conversion photon and Dalitz contributions to the spectra. The obtained non-photonic single electron p_T spectra for the most central events and for a semi-peripheral centrality bin compared with the PYTHIA yield, are shown in Fig. 1. The PYTHIA yield has been scaled with the average number of binary collisions for each centrality. There is agreement, within the relatively large uncertainties, between the result and the scaled PYTHIA prediction for all centralities, i.e. no obvious sign of a centrality dependent suppression, as has been observed for the high p_T pions. There are ongoing analyses to look at the single electron (and muon) spectra, also in p-p and d-Au interactions, to have a measured baseline for comparisons with the Au-Au results.

J/Ψ MEASUREMENTS

The original expectation for J/Ψ's in heavy-ion collisions was that due to color screening the production of heavy quarkonia should be suppressed in deconfined matter [3]. However, given the large charm cross section at RHIC, recombination may be important to the production of e.g. J/Ψ, which could instead be enhanced [4].

All the results that follow were obtained at $\sqrt{s_{NN}}$ = 200 GeV.

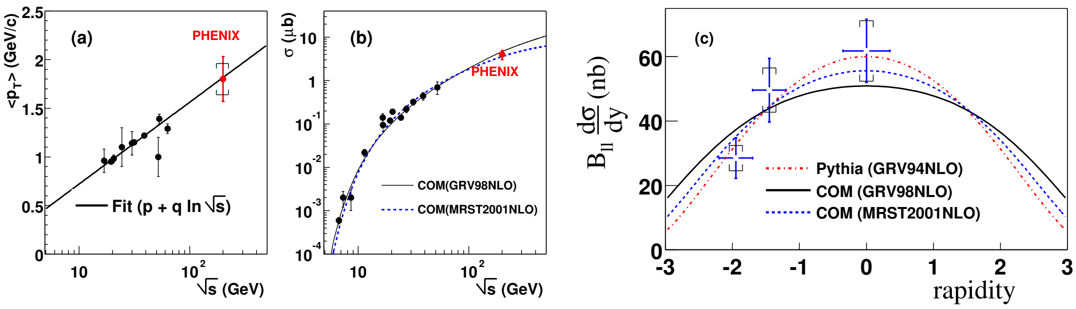

FIGURE 2. (a) J/Ψ mean p_T value and (b) J/Ψ total cross section ; both compared with measurements at lower energy. (c) J/Ψ rapidity distribution.

pp Results

In this analysis, both the dimuon and dielectron channels were studied. The measurements [5] are of intrinsic interest, but also establish a baseline for comparisons with p(d)-A and A-A collissions. The yields were obtained by comparing unlike-sign with like-sign (background) pairs. The muon arm results are divided into two forward rapidity bins, and the electron result gives a point at midrapidity. Together, these results provide information regarding the shape of the rapidity distribution: Fig. 2 (c). The values were fitted to several different shapes and the total J/Ψ cross section was estimated to be $3.99 \pm 0.61(stat) \pm 0.58(sys) \pm 0.40(abs) \mu b$. Also, by combining the dimuon and dielectron results and using several fits to the p_T spectra, a mean transverse momentum of $1.80 \pm 0.23(stat) \pm 0.16(sys)$ GeV/c was obtained. The obtained values are compared to results from experiments at lower energies in Fig. 2.

AuAu Results

In this measurement, which suffered from very limited statistics, the dielectron channel was studied. The results are reported in detail in [8]. The yields were obtained by comparing unlike-sign with like-sign (background) pairs. Three centrality bins were used: 0-20%, 20-40% and 40-90%. For each of these bins, the most probable signal as well as the 90% confidence limits were calculated. The results are summarized in Fig. 3 (a). The most probable values are indicated by square markers, while the arrows shows the 90% confidence limits, and the brackets include the estimated systematic errors. The grey band indicates the binary collision scaling of the p-p result.

Model comparisons are included in Fig. 3 (b). With the present statistical inaccuracy, models that predict enhancement are disfavored, but one can not distinguish between models that predict suppression relative to binary collision scaling.

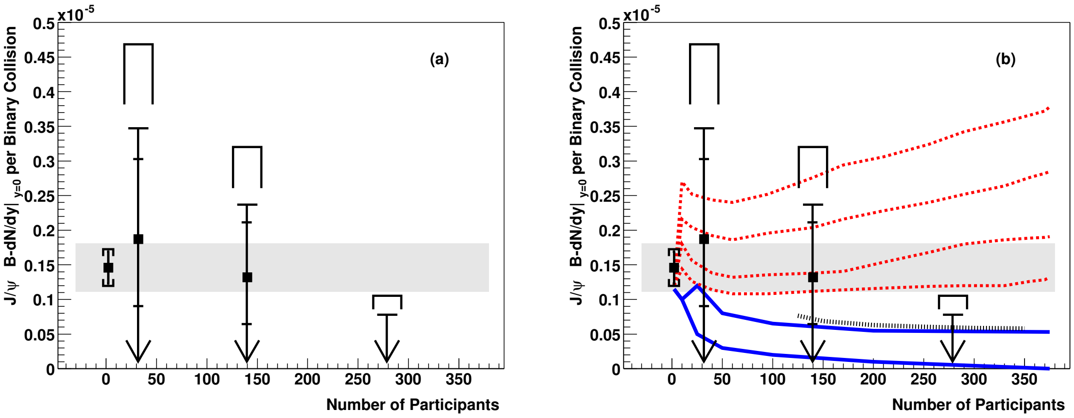

FIGURE 3. (a) The J/Ψ yields for p-p and for the three centrality bins. For additional information; see the text. (b) Model comparisons: The lowest two curves are from a calculation [6] that includes "normal" nuclear absorption, as well as absorption in a Quark-Gluon Plasma. The higher of the two includes recombination also. The next (dotted) curve is from a statistical model [7] and the top four curves is from a coalescence model [4], with different charm rapidity width values.

SUMMARY AND OUTLOOK

The early results from the recently completed (2003) d-Au and p-p runs, unfortunately had to be left out from these proceedings due to the length limits. Suffice it to say, that a larger J/Ψ sample was collected for the p-p part than in the previous p-p run, reported on above, and that the d-Au run resulted in the largest J/Ψ sample obtained so far at RHIC; of the order of 1000 J/Ψ's per muon arm. These data will help to determine the effects of shadowing in cold nuclear matter and will be essential in providing a baseline for the eagerly anticipated high statistics Au-Au run.

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