Proc. 19th Winter Workshop on
Nuclear Dynamics (2003) 000–000

19th Winter Workshop
on Nuclear Dynamics
Breckenridge, Colorado, USA
February 8–15, 2003

PHENIX J/Ψ Measurement at $\sqrt{s_{NN}} = 200\ GeV$

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Abstract. In 2002, PHENIX had the first measurement on $J/\Psi \to e^+e^-$ and $J/\Psi \to \mu^+\mu^-$ in $AuAu$ and pp collisions at $\sqrt{s_{NN}} = 200\,GeV$. The preliminary results are presented and discussed. The ongoing analysis status on year 2003 dAu collision data are presented

Keywords: $J/\Psi \to e^+e^-$, $J/\Psi \to \mu^+\mu^-$
PACS: 25.75.-q

1. Introduction

J/Ψ is an important probe of the quark-gluon plasma(QGP) expected to be created in $AuAu$ collisions at RHIC. The $c\bar{c}$ quark pair that might otherwise form a J/Ψ, are predicted to dissociate due to color screening in the plasma[2] Other theoretical models[3] predict J/Ψ enhancement due to the re-combination of $c\bar{c}$ quarks in QGP. The J/Ψ cross section in proton-proton and proton-nucleus collisions provides a critical baseline for the nucleus-nucleus results. In year 2002, PHENIX[1] had the first measurement of J/Ψ in pp and $AuAu$ collisions at $\sqrt{s} = 200AGeV$. The preliminary results are presented and discussed. The J/Ψ signal PHENIX observed in the middle of year 2003 dAu run is presented.

2. PHENIX J/Ψ Measurement in 2002

PHENIX consists of central(electron) and forward(muon) detectors. Electron in pseudo-rapidity range $|\eta| \leq 0.35$ is identified using Ring Image Cherenkov detector(RICH), Electromagnetic Calorimeter(EMCal) and drift chamber(Dch) in central arm. The measured J/Ψ width is expected to be 60MeV. Muon in the range $1.2 < \eta < 2.2$ is identified via finding roads in Muon Identifier(MuID) that are matched to tracks found in the Muon Tracker(MuTr). The measured J/Ψ width is expected to be 110MeV. In both central and muon arm, PHENIX has implemented high performance level-1 and level-2[7] triggers that enable us to select interesting

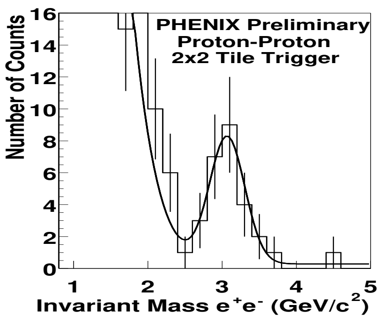

Fig. 1. Minimum-bias e^+e^- invariant mass spectrum with gaussian fit to J/Ψ signal

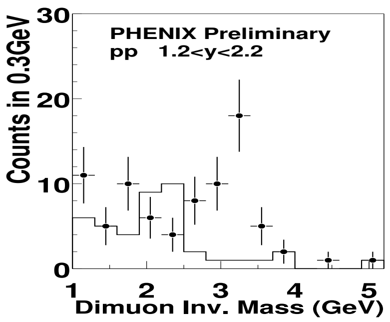

Fig. 2. $\mu^+\mu^-$ invariant mass spectrum with like-sign pair as the background estimation

events in high luminorsity environment. The preliminary results have been shown in QM02[8].

2.1. J/Ψ Measurement in pp Collisions

In 2002, both south muon arm and central arm recorded data in *pp* collision. Level-1 triggers in both arms were activated to trigger on J/Ψ.

Central arm level-1 J/Ψ trigger use EMCal and requires a 700MeV threshold cut on the energy deposit in trigger units and also requires coincidence with PHENIX minimum-bias trigger. The trigger efficiency is about 90% in whole p_t range. The results presented here use only J/Ψ trigger. The data from a higher threshold emcal trigger are being analyzed, and this will significantly increase the signal in high p_t region. Muon arm level-1 J/Ψ trigger requires coincidence of fired quadrants in five layer of MuID and also requires coincidence with minimum-bias trigger. The efficiency to trigger on J/Ψ is about 62%.

The preliminary J/Ψ results come from $81nb^{-1}$ for muon channel and $48nb^{-1}$ for electron channel. Fig.1 and fig.2 shows the observed signal in both central and muon arms. The cross section in mid-rapidity obtained from electron channel is

$$B\frac{d\sigma}{dy}|_{y=0} = 52 \pm 13(stat) \pm 18(sys)nb$$

The cross section in $1.2 < \eta < 1.7$ and $1.7 < \eta < 2.2$ obtained from muon channel are

$$B\frac{d\sigma}{dy}|_{1.2<y<1.7} = 49 \pm 11(stat) \pm 14(sys)nb$$

$$B\frac{d\sigma}{dy}|_{1.7<y<2.2} = 23 \pm 9(stat) \pm 7(sys)nb$$

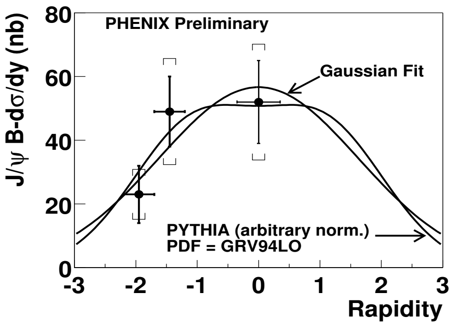

Fig. 3. J/Ψ branching ratio times dN/dy vs rapidity for pp Brackets are maximum plausible systematic spreads.

, where B is the branching ratio of J/Ψ decay to dielectrons.

The rapidity distribution shown in fig.3 is obtained via combining results in electron and muon channel. It is compared with Pythia prediction using GRV94LO parton distribution function(PDF) which very well reproduced the J/Ψ Feynman-x distribution in low-energy experiment[4]. Other PDFs are also tried in the calculation and the difference is less than 3%. Since gluon fusion dominates J/Ψ production at high energy, rapidity distribution is sensitive to gluon distribution. The good agreement between PHENIX data and Phythia calculation indicate that gluon distribution from these PDF are reasonable in the dynamic region covered by PHENIX. The total cross section is obtained from the fitted Pythia calculation and the result is

$$\sigma(p+p \rightarrow J/\Psi + X) = 3.8 \pm 0.6(stat) \pm 1.3(sys)\mu b$$

Fig.4 shows the total cross section as a function of $\sqrt{s}$ and it is in good agreement with the prediction from Color Evaporation model[6]. Fig.5 shows the mean p_t as a function of $\sqrt{s}$. PHENIX measurement is in good agreement with Pythia prediction with $< k_t >$=0.8 which is tuned to reproduce $< p_t >$ and p_t spectrum of E672/E706 experiment at $\sqrt{s} = 38.8GeV$. At low $\sqrt{s}$, the prediction is a bit higher than the measurement and this might indicate $\sqrt{s}$ dependence of $< k_t >$.

We are doing final analysis with much better statistics and the results will come soon.

2.2. J/Ψ Measurement in AuAu Collisions

It was predicted long time ago[2] that the number of J/Ψ in heavy-ion collision should be suppressed due to color screening effect in QGP. At the freeze-out stage, charm quarks have more chance to combine with the much more abundant light

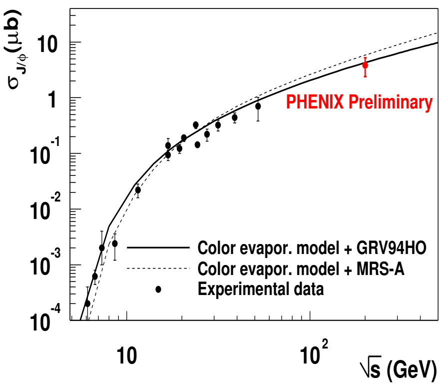

Fig. 4. J/Ψ cross section as a function of $\sqrt{s}$. The lines are color evaporation model prediction with different PDFs.

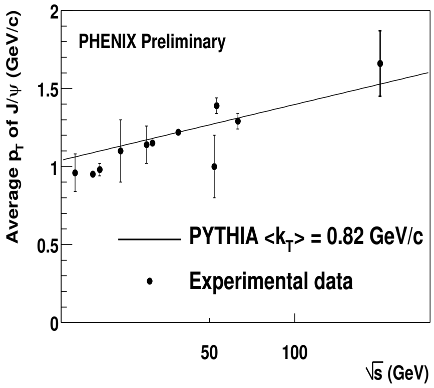

Fig. 5. J/Ψ mean p_t as a function of $\sqrt{s}$ from muon channel. The line is Pythia prediction assuming $< k_t >= 0.82 GeV/c$

quarks to form hadrons. Fig.6 shows the centrality dependence of J/Ψ yield per binary collision. The result is fitted with a straight line to see if it's consistent with the binary scaling. The fit decribe the data with a 16% confident level based on statistical uncertainty alone. The result is also compared with the prediction from a simple normal nuclear model assuming 7.1mb absorption cross section [5] and shows 80% confident level. However, the large error make it hard to draw any conclusion in terms of J/Ψ suppression.

Recently Thews, et al[3] proposed enhancement of J/Ψ yield when QGP is formed at RHIC or higher energy since dissociation and formation of J/Ψ coexist and the charm yield is large. The comparison between Thews's prediction and our data is shown in fig.7 where one can clearly see the disagreement although the error is large. There're still some corrections need to be done in their calculations, for example, they assumed a very narrow rapidity distribution which is not consistent with PHENIX measurement in pp collisions.

The results are from $4.1\mu b^{-1}$ minimum-bias events. PHENIX is analyzing data from level-2 trigger which is about 75% efficient to trigger on J/Ψ. The final result with approximately twice of the present statistics is forthcoming.

3. PHENIX Activities on J/Ψ Measurement in dAu Collisions

Normal nuclear effect, such as nuclear absorption and gluon shadowing can be studied in pA collision. This is essential for the undertanding of results from heavy-ion collisions at RHIC or higher energy since they also cause significent suppression

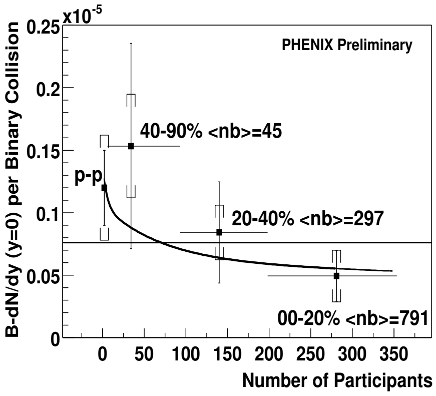

Fig. 6. $J/\Psi \rightarrow ee$ branching ratio times dN/dy scaled by N_{binary}. The flat line is the best fit binary scaling value. The curve is a normal nuclear absorption model calculation

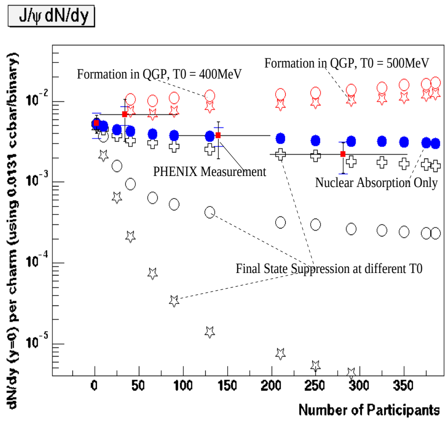

Fig. 7. Midrapidity J/Ψ yield per $c\bar{c}$ pairs as function of number of participants. Different model prediction [3] are compared with the data

of J/Ψ. Now RHIC is in the middle of dAu run. Through its high performance level-1 electron trigger, PHENIX has already observed J/Ψ signal as shown in fig 8. The background from non-correlated pairs is estimated using like-sign pair spectrum. One can clear see the signal above background. Based on expected integrated luminosities, we expect to see a few thousands J/Ψ.

4. Conclusions

PHENIX has measured inclusive J/Ψ cross section at $\sqrt{s} = 200GeV$ in pp collisions using both electron and muon channel.

$$B\frac{d\sigma}{dy}|_{y=0} = 52 \pm 13(stat) \pm 18(sys)nb$$

$$B\frac{d\sigma}{dy}|_{1.2<y<1.7} = 49 \pm 11(stat) \pm 14(sys)nb$$

$$B\frac{d\sigma}{dy}|_{1.7<y<2.2} = 23 \pm 9(stat) \pm 7(sys)nb$$

$$\sigma(p + p \rightarrow J/\Psi + X) = 3.8 \pm 0.6(stat) \pm 1.3(sys)\mu b$$

PHENIX measured centrality dependence of J/Ψ yield in AuAu collision. The data gives constraint on some of the models, and we expect to have much more data in future Au+Au run.

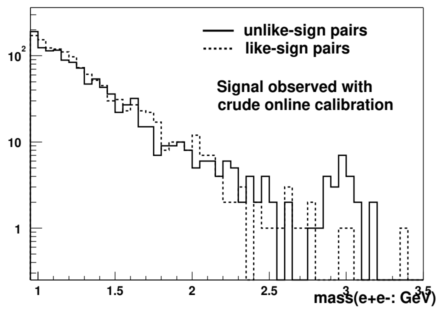

Fig. 8. J/Psi signal observed in the middle of $d - Au$ run

The final analysis on these subjects are ongoing and we expect to significantly increase the statistics.

PHENIX observed J/Ψ in the middle of dAu run which will give us a handle on cold nuclear matter modification to $J\Psi$ production.

Acknowledgement(s)

We thank the staff of the Collider-Accelerator and Physics Departments at BNL for their vital contributions. We acknowledge support from the Department of Energy and NSF (U.S.A.), MEXT and JSPS (Japan), RAS, RMAE, and RMS (Russia), BMBF, DAAD, and AvH (Germany), VR and KAW (Sweden), MIST and NSERC (Canada), CNPq and FAPESP (Brazil), IN2P3/CNRS (France), DAE and DST (India), KRF and CHEP (Korea), the U.S. CRDF for the FSU, and the US-Israel BSF.

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