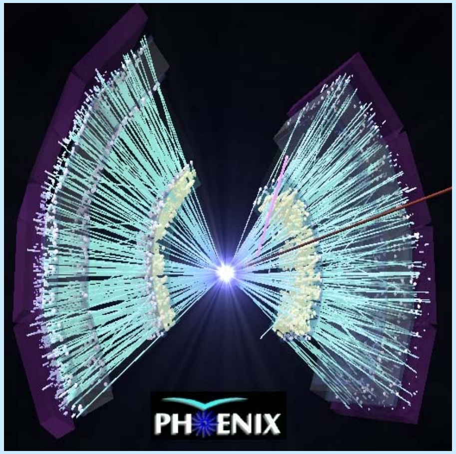
Study of $J/\psi \rightarrow e^+e^-$ in p+p Collisions with Level-1 Electron Trigger in PHENIX

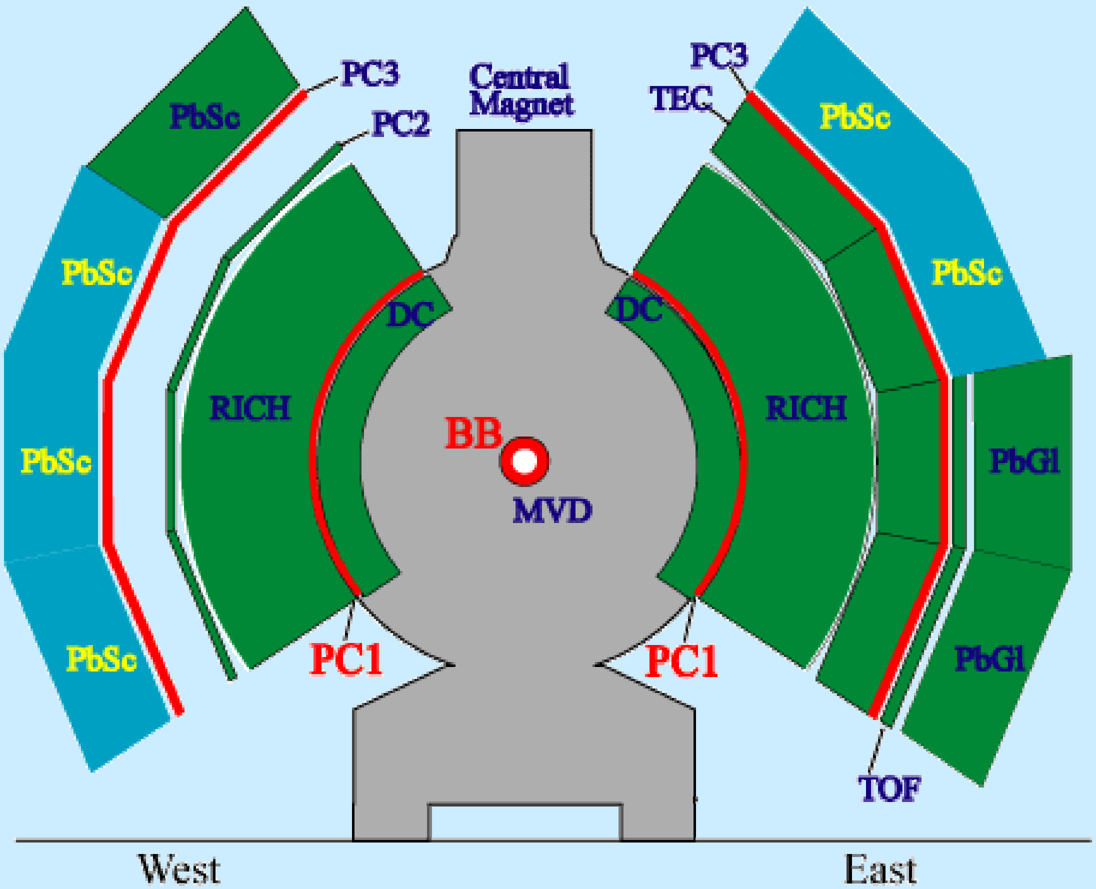
Wei Xie
(UC, Riverside)
for PHENIX Collaboration



Introduction

J/ψ suppression is considered to be an important probe for quark-gluon plasma(QGP), since the charm and anticharm quark pairs which might otherwise form a J/ψ are predicted to separate due to the Debye screening in the plasma. The J/ψ cross section in p+p collisions along with that for p+A collisions, is a baseline for measuring such a suppression effect. Here we describe the LVL-1 electron trigger in PHENIX at RHIC which provides a trigger for J/ψ to electron pairs for p+p collision.

Electron Identification



- Charged tracks are identified by Drift chamber(Dch) and pad chamber (PC1/2/3)
- Ring imaging Cherenkov detector (RICH) and Electromagnetic Calorimeter (EMCal, i.e. PbSc/PbGl) are used to select electron from charged tracks

$J/\psi \rightarrow e^+e^-$ Acceptance and Reconstruction Efficiency

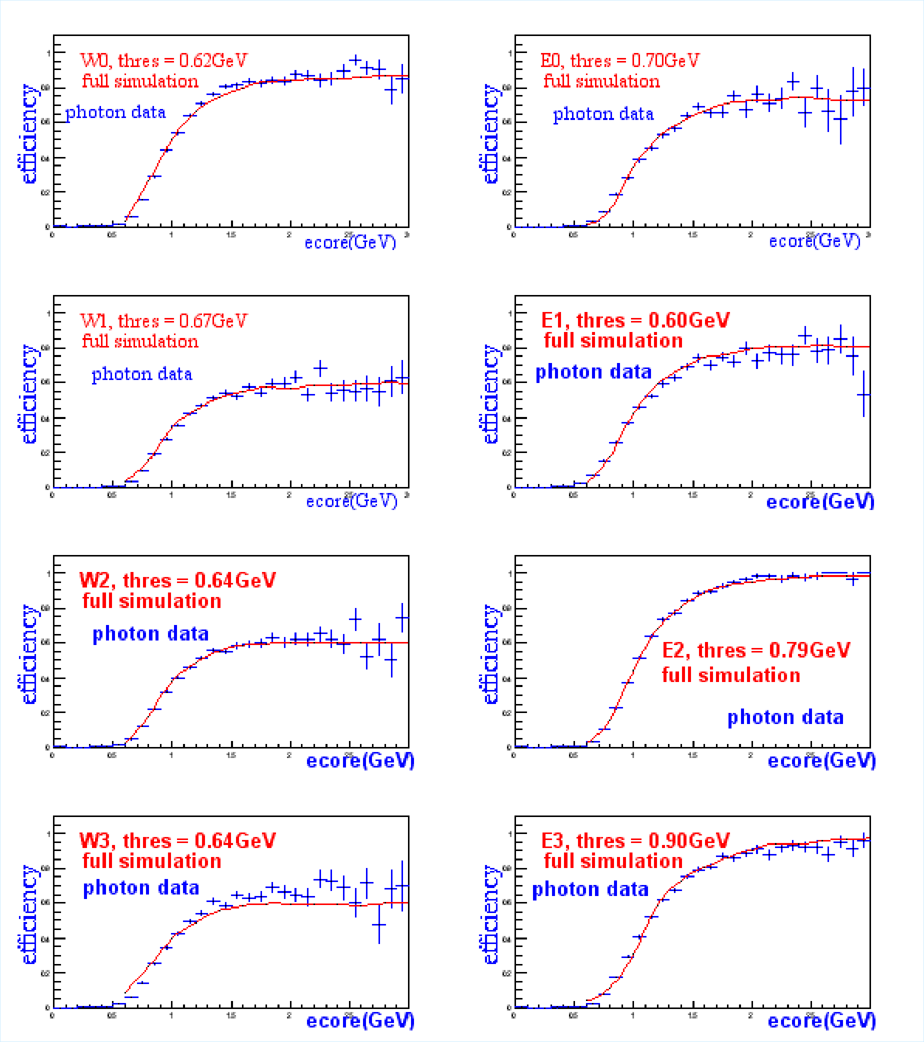
$J/\psi \rightarrow e^+e^-$ with flat J/ψ Pt distribution is simulated in GEANT and PHENIX detector response software. Electron ID cuts are applied to the simulation output to obtain PHENIX acceptance and reconstruction efficiency of $J/\psi \rightarrow e^+e^-$ as a function of Pt. After convoluting this function with a model for the J/ψ pt distribution, the product of efficiency and acceptance within +/- 0.5 unit of rapidity around y=0 is calculated. The value is relatively model independent due to our broad pt coverage and the dependence is included in the systematic error:

$$\varepsilon_{eff}\varepsilon_{acc} = 0.0163 + / - 0.0020$$

LVL-1 Electron Trigger Efficiency

In this run, level-1 electron trigger only based on electromagnetic calorimeter(EMCal). The algorithm require 800MeV threshold cut on 2x2 EMCal tile energy sum. Trigger efficiency and its systematic uncertainty on $J/\psi \rightarrow e^{+}e^{-}$ was estimated using simulation. The plot in the right side shows the electron trigger efficiency as a function of energy from simulation and data in different detector segment. The data is from single photon. Since the trigger based only on EMCal, there's no difference between photon and electron but we gain much more statistics via using photon. Clearly, simulation is well tuned to describe the data. The trigger only sample on minimum-bias event. The efficiency is:

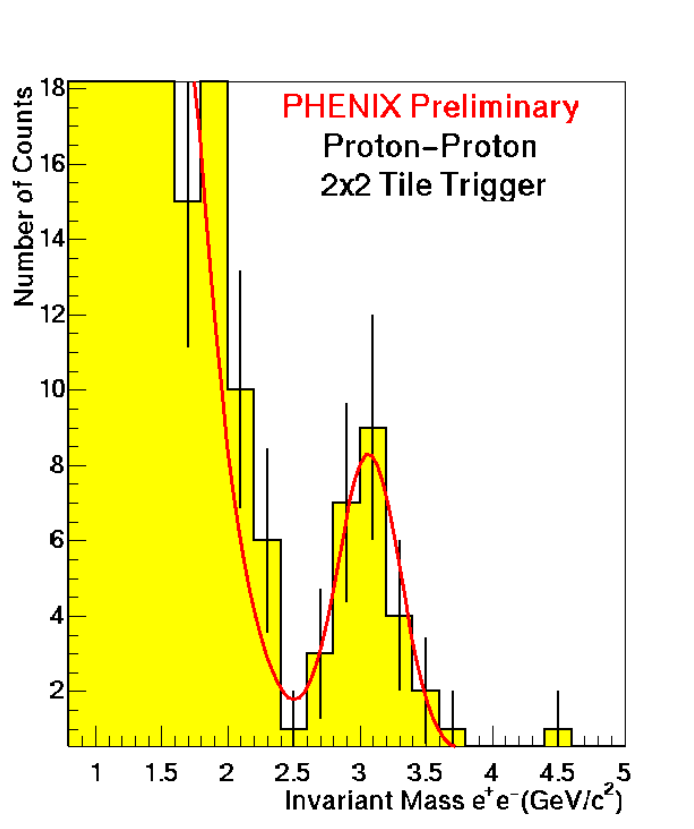
90%+6%-7%



$J/\psi \rightarrow e^+e^-$ Signal from p+p collisions

The following plots shows the invariant mass spectrum of electron and positron pairs. The result corresponding to 1044 million trigger sampled minimum-bias p+p collisions.

There're 24 counts between 2.5GeV and 3GeV. Since the statistical error in this region is large and background is small, it is assumed all counts are from $J/\psi \rightarrow e^+e^-$.



$Bd\sigma/dy|_{y=0}$ for $J/\psi \rightarrow e^+e^-$

The cross section of p+p collision at $\sqrt{s} = 200GeV$ is 42mb. Therefore,

$$Bd\sigma / dy\Big|_{y=0} = 42mb \; \frac{f}{g} \; \frac{N_{J/\Psi}}{N_{event}} \; \frac{1}{dy} \; \frac{1}{\varepsilon_{acc}\varepsilon_{run-run}\varepsilon_{eff}\varepsilon_{trg}}$$

where f is the fraction of p+p inelastic cross section sampled by minimum-bias trigger, g is the fraction of J/ψ in that sample, dy is the rapidity range of analysed tracks, ε_{eff} is the reconstruction efficiency, ε_{acc} is the acceptance, $\varepsilon_{run\text{-}run}$ is the further correction on efficiency and acceptance from run to run, , ε_{trig} is the trigger efficiency.

$N_{J/\psi}$= 24+/-6(stat)+/-4(sys)

N_{event} = 1037.2 million

$\varepsilon_{eff} * \varepsilon_{acc}$ = 0.0163+/-0.0020

$\varepsilon_{run\text{-}run}$ = 0.87+/-0.09

ε_{trig} = 0.90 + 0.06 – 0.07

dy = 1.0

f= 0.51+/-0.10(sys)

g = 0.75+/-0.11(sys)

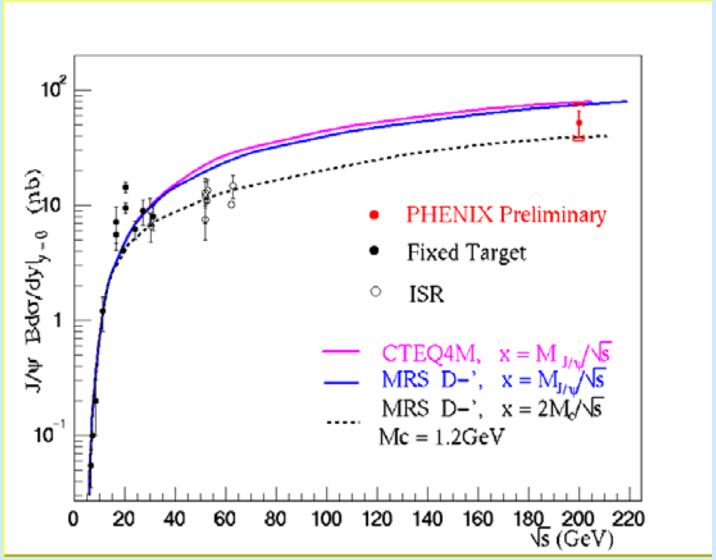
Therefore, $Bd\sigma/dy|_{y=0}$ =52+/-13(stat)+/-18(sys) (nb)

Comparison with Theoretical Predictions

- The plots shows experimental results from FNAL/SPS, ISR and PHENIX experiment. QCD calculation based on different gluon structure functions and free charm/anticharm pair $c\bar{c}$ mass are also shown. In QCD based model, $Bd\sigma/dy|_{y=0}$ mainly depend on gluon density distribution, i.e.

$$Bd\sigma / dy\big|_{y=0} \propto (xG(x))^2 \quad \text{,where} \quad x = 2M_c / \sqrt{s} \quad \text{or} \quad x \approx M_{J/\Psi} / \sqrt{s}$$

•It shows that PHENIX results are consistent with the theoretical predictions but do not have clear preference to any models.



Summary

PHENIX has measured $Bd\sigma/dy|_{y=0}$ ($J/\psi \rightarrow e^+e^-$) in p+p collision at $\sqrt{s} = 200 GeV$. The result shows

$Bd\sigma/dy|_{y=0}$ =52+/-13(stat)+/-18(sys) nb

It is consistent with the QCD calculation but do not have clear preference to any models