J/ψ measurement in Au+Au collisions at $\sqrt{s_{NN}}$= 39 and 62 GeV

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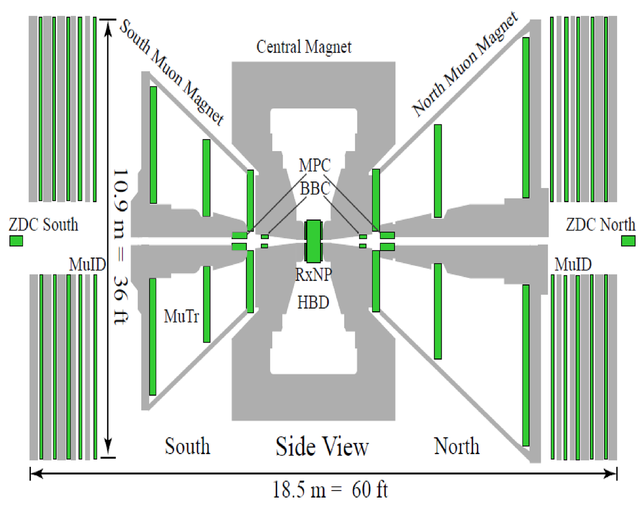
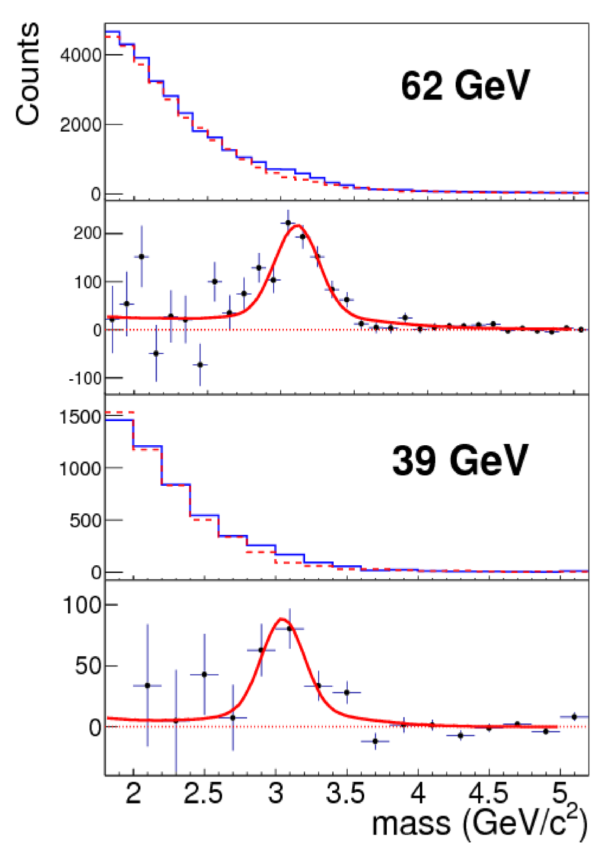
Motivation

J/ψ production is considered as one of the very important probes for studying the properties of quark-gluon plasma (QGP). PHENIX observed a large suppression of J/ψ production in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV in comparison with binary collision scaled p+p collisions [1]. The level of this suppression is similar to that observed in other energies in CERN-SPS and LHC. PHENIX also took J/ψ data from Au+Au collisions at $\sqrt{s_{NN}}$ = 39 and 62.4 GeV in 2010. This data allow us to explore the energy dependent suppression level in order to disentangle the important contributing factors of J/ψ production.

Detector and J/ψ Measurement

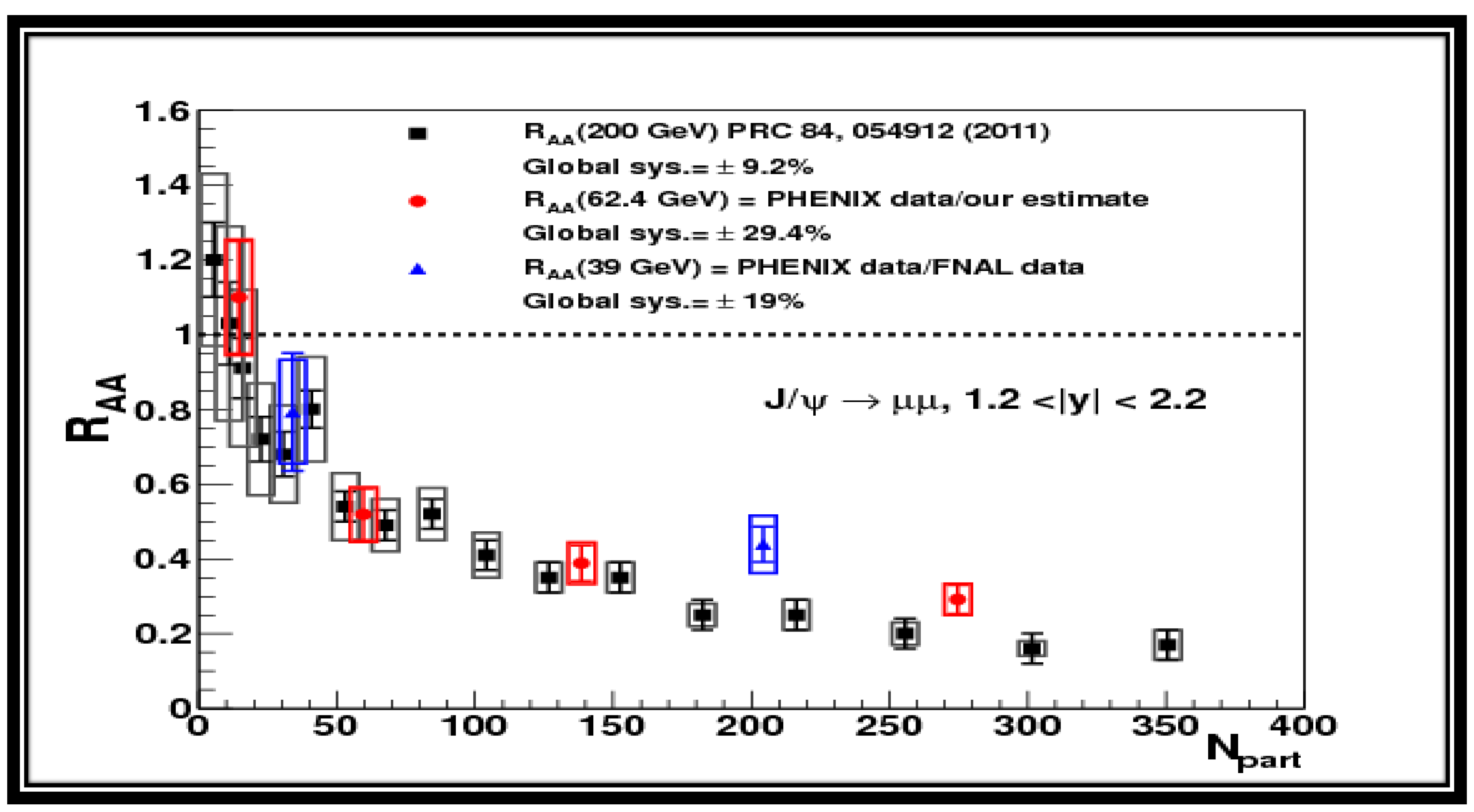




The J/ψ measurement at forward rapidity is made via the dimuon decay channel with two forward angle muon spectrometers. On the left, is a side view of the muon spectrometers, that have acceptance over the range 1.2 < |η| < 2.2 and over the full azimuth. The two spectrometers comprise an initial hadronic absorber followed by three sets of cathode strip chambers which are inside a magnetic field, referred to as the Muon Tracker (MuTr), and then five planes of Iarocci tubes interleaved with steel absorber plates, referred to as the Muon Identifier (MuID). Muon candidates are found by reconstructing tracks through the magnetic field in the MuTr and matching them to MuID tracks that penetrate through to the last MuID plane.

In 2010, PHENIX collected data for Au+Au collisions at $\sqrt{s_{NN}}$ = 39 and 62.4 GeV as part of the RHIC Beam Energy Scan program. The total J/ψ sample corresponding to all centralities in both the arms is approximately 170 counts at $\sqrt{s_{NN}}$ = 39 GeV and approximately 1060 counts at $\sqrt{s_{NN}}$ = 62.4 GeV.

Nuclear Modification

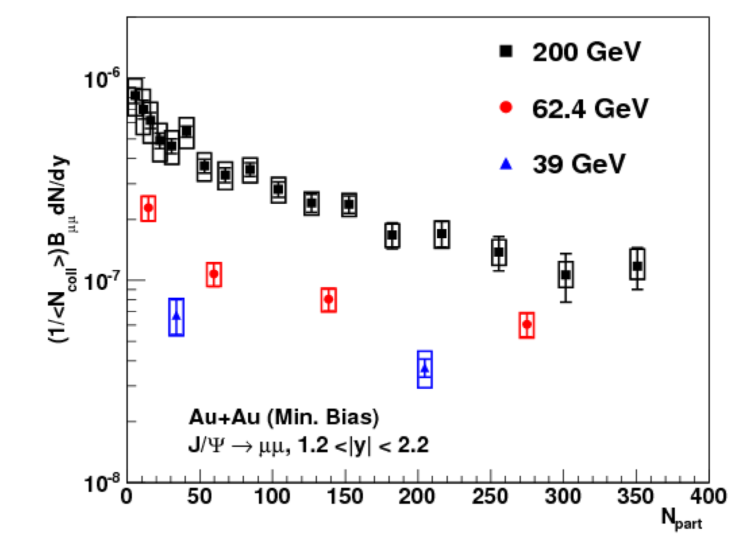


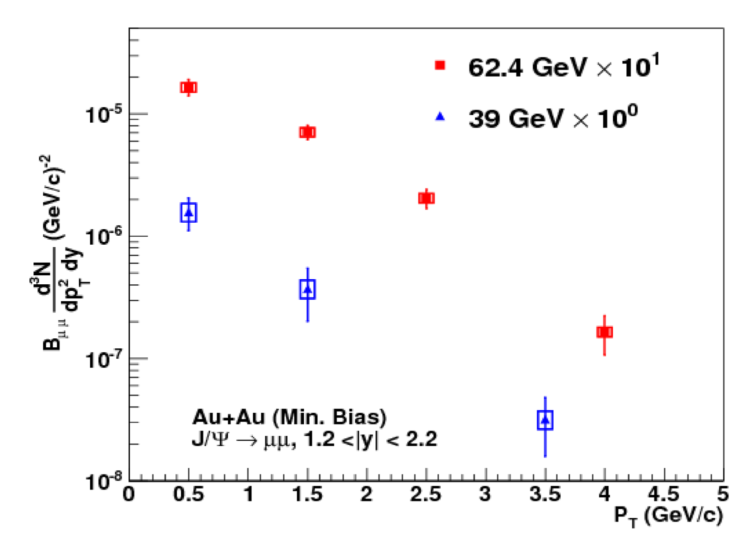
We quantify the nuclear modification factor with respect to p+p as follows

$$R_{AA} = \frac{1}{\langle T_{AA}\rangle}\frac{dN^{AA}/dy}{d\sigma^{pp}/dy}$$

where $\langle T_{AA}\rangle$ is the nuclear overlap function ($\langle T_{AA}\rangle = \langle N_{coll}\rangle/\sigma_{inelastic}$). Unlike 200 GeV, the 39 and 62 GeV p+p references are determined from other measurements rather than being from our own, and detector systematic uncertainties will not cancel in the ratio.

Invariant Yields





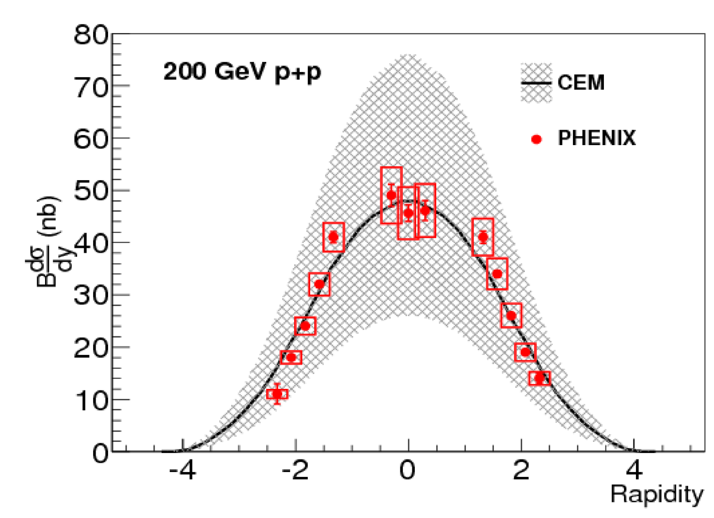
J/ψ invariant yields were calculated as,

$$B_{\mu\mu}\frac{d^3N}{dp_T^2dy} = \frac{1}{2\pi p_T \Delta p_T \Delta y}\frac{N_{J/\psi}}{A\epsilon\, N_{EVT}}$$

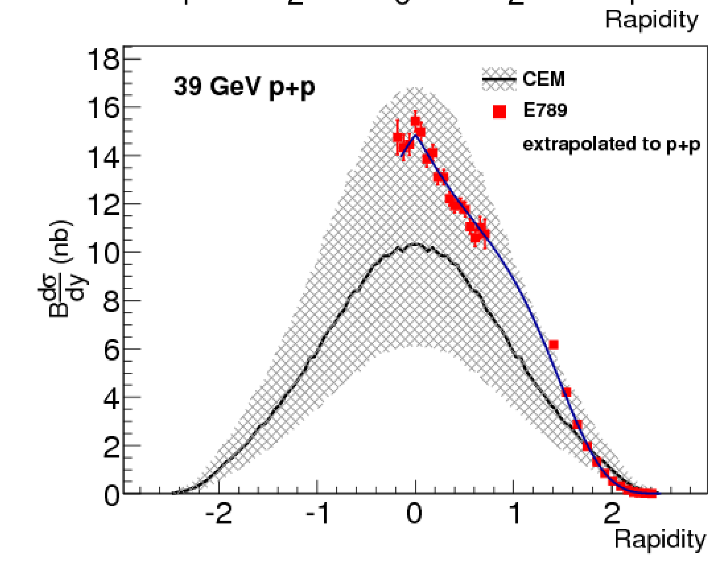
$N_{J/\psi}$ is the number of measured J/ψ, after subtracting the uncorrelated background via an event mixing method. We evaluate the acceptance and reconstruction efficiency by a monte-carlo simulation of pythia-generated J/ψs running through the geant framework of the PHENIX detector and then embedding them into real Au+Au data events.

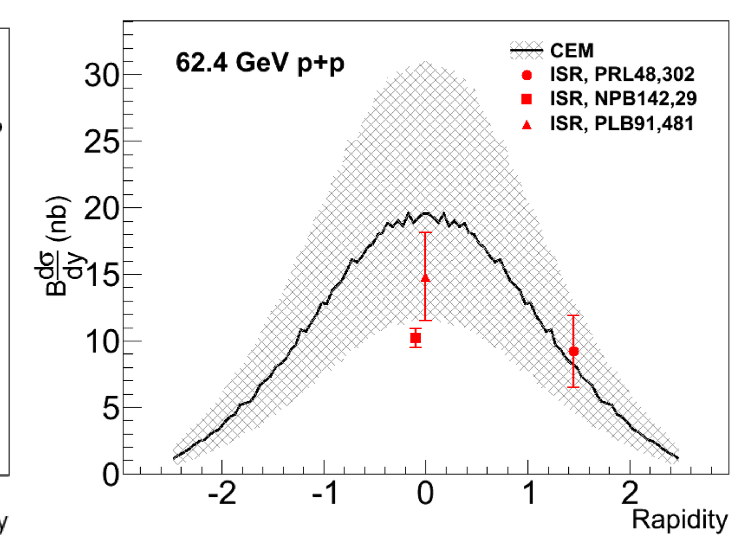
On left (top) the J/ψ invariant yield is shown after rescaled by $1/\langle N_{coll}\rangle$. As expected, the J/ψ yield is larger in Au+Au collisions at larger center-of-mass energy. In addition, the yield per binary collision is decreasing with $\langle N_{part}\rangle$ at all three energies, indicating increasing nuclear suppression for more central collisions. On bottom (left) is the the J/ψ invariant yield as a function of P_T.

p+p extrapolation

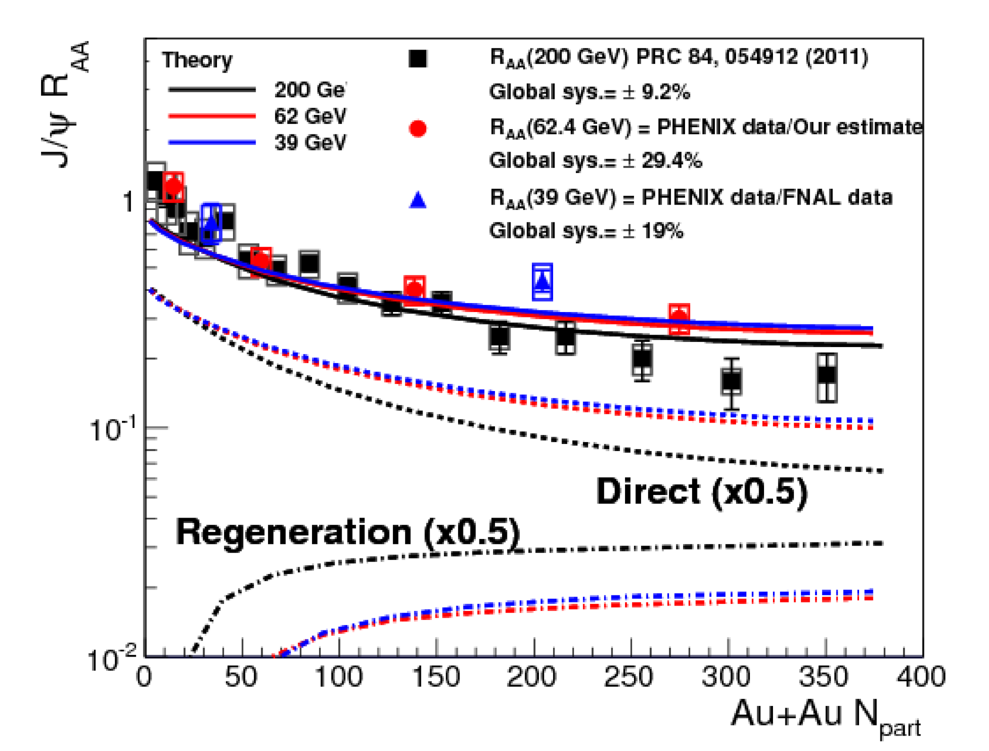


There has been no running of the RHIC accelerator for p+p at $\sqrt{s_{NN}}$ = 39 GeV. Only a limited data was recorded during 2006 for p+p collisions at 62.4 GeV. Therefore, the PHENIX experiment does not have a p+p reference at this energy . We extrapolated J/ψ cross-section from fixed target experiments and R. Vogt's CEM calculations [3] to draw a baseline at this energies. Fermilab's p+A experiments at 39 GeV was extrapolated to p+p and CERN's ISR has 62 GeV p+p measurement. We extrapolated a cross section of 2.91 +/- 19% nb at 39 GeV and 7.66 +/- 29.4% nb at 62 GeV in rapidity 1.2<|y|<2.2.





Discussion



Collision energy dependence of various competing effects contributing the final J/ψ yield is quite different. Thus, the similarity of the J/ψ nuclear modifications RAA from 39 to 200 GeV is a challenge for models incorporating the many effects. These results are consistent with theoretical calculations [2] dominated by the balancing effects of more QGP suppression as well as more J/ψ regeneration for high-energy collisions. However, any firm conclusion regarding the overall level of suppression from the QGP requires additional p+p and p(d)+A data at these energies.

References:

1. A. Adare et al. (PHENIX Collaboration), Phys. Rev. C 84, 054912 (2011).
2. X. Zhao and R. Rapp, Phys. Rev. C 82, 064905 (2010).
3. R. Vogt, private communication (2012).