J/ψ production in Au+Au collisions at $\sqrt{s_{NN}}$ = 54.4 GeV

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Abstract

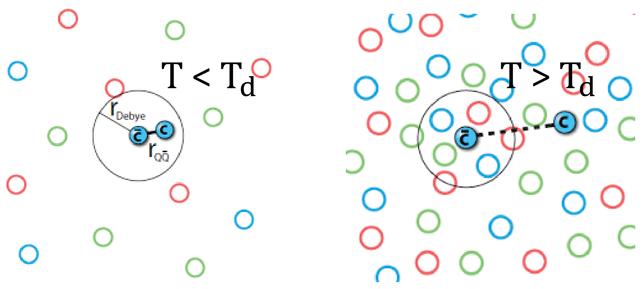
Heavy quarkonia are ideal probes of the Quark-Gluon Plasma (QGP). J/ψ is the most abundantly produced quarkonium state accessible experimentally and its suppression due to the color screening effect in hot and dense medium has been suggested as a signature of the formation of the QGP. Besides of the screening effect, there are other mechanisms, such as the cold nuclear effects and charm quark recombination, which could affect the J/ψ yield in heavy-ion collisions. Measurements of J/ψ production at different collision energies will help to understand the interplay of these mechanisms. STAR has observed significant suppressions of the J/ψ production at mid-rapidity in Au+Au collisions at $\sqrt{s_{NN}}$ = 39, 62.4, and 200 GeV. However, the nuclear modification factors show no significant collision energy dependence from SPS to RHIC top energy within large uncertainties.

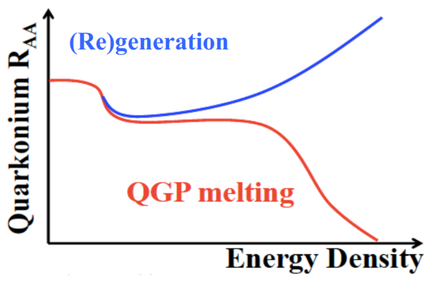
In 2017, STAR took a large sample of 54.4 GeV Au+Au collisions and the statistics is more than ten times of the 39 and 62.4 GeV Au+Au data. In this talk, we will present new measurements of the inclusive J/ψ production in Au+Au collisions at $\sqrt{s_{NN}}$= 54.4 GeV. The collision energy and transverse momentum dependences of the nuclear modification factors will be presented. Physics implications of these results will also be discussed.

Motivation

Heavy quarkonia are ideal probes of the Quark-Gluon Plasma (QGP)

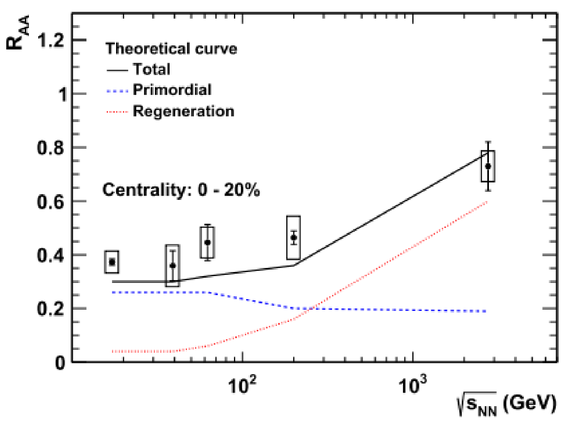
- Dissociation in QGP (static and dynamic color screening)





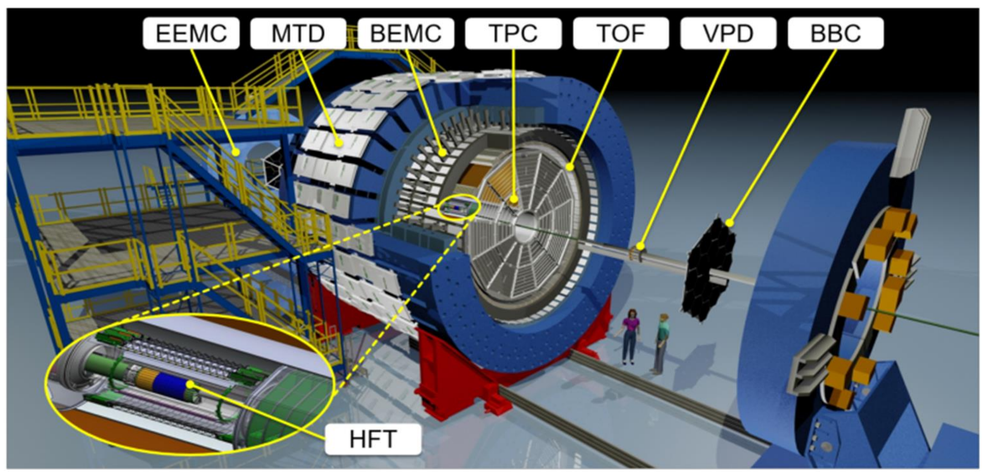
Other effects:

- Regeneration
- Cold nuclear matter effects (e.g. nPDF, coherent energy loss, nuclear absorption)
- Other final state effects (e.g. comovers)



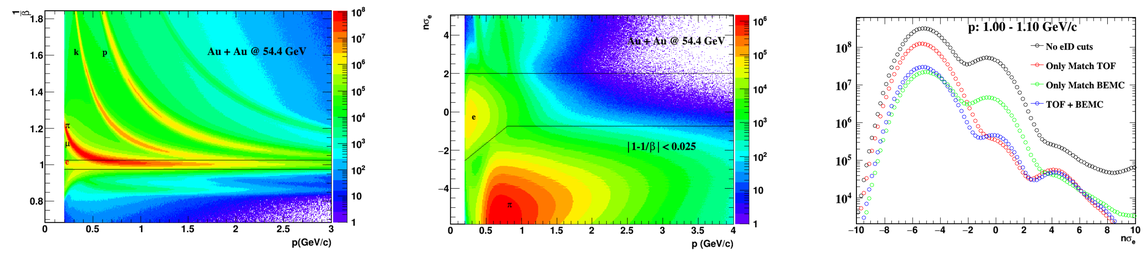
- The J/ψ production has been measured in Au+Au collisions at 39, 62.4 and 200 GeV and in Pb+Pb collisions at 17.2 GeV, 2.76 and 5.02 TeV [1-6]
- No significant energy dependence of nuclear modification factor within uncertainties at $\sqrt{s_{NN}} \leq 200\ GeV$ [2]
  - ➢ Interplay of dissociation in the QGP, cold nuclear matter effects and regeneration
- ~10x more statistics in 54.4 GeV compared to 62.4 GeV, and this will help better understand the energy dependence of J/ψ suppression

STAR detector



- ✓TPC: Tracking, momentum and dE/dx
- ✓BEMC: Identification of high-p_T electrons
- ✓TOF: Time of flight, particle identification
- ✓ Minimum-bias trigger: VPD and ZDC

Electron identification



$p_T \leq 1$ GeV/c

- $|\vec{P}| \leq 0.8$
- $3\times|\vec{P}|$-3.15< $n\sigma_e$ < 2
- $\left|\frac{1}{\beta} - 1.0\right| < 0.025$

$|\vec{P}| > 0.8$

- -0.75< $n\sigma_e$ < 2
- $\left|\frac{1}{\beta} - 1.0\right| < 0.025$

$p_T > 1$ GeV/c

TOF&BEMC

- -1.5 < $n\sigma_e$ < 2
- $\left|\frac{1}{\beta} - 1.0\right| < 0.025$
- 0.5 < E_0/p < 1.5

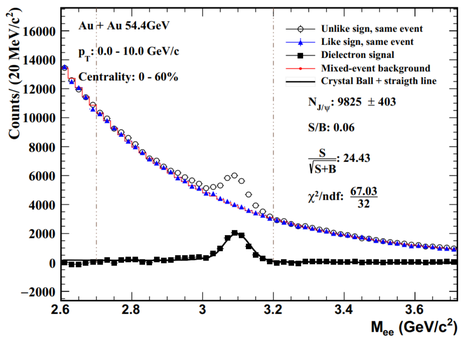
Only match TOF

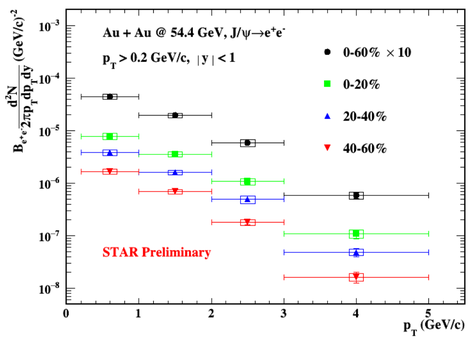
- -0.75< $n\sigma_e$ < 2
- $\left|\frac{1}{\beta} - 1.0\right| < 0.025$

Only match BEMC

- -1 < $n\sigma_e$ < 2
- 0.5 < E_0/p < 1.5

J/ψ raw signal and invariant yield

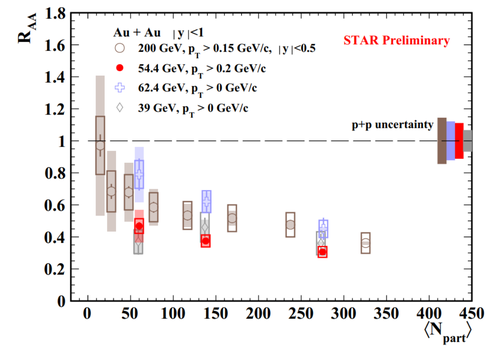


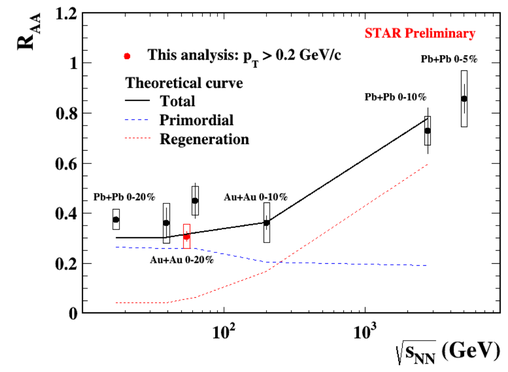


$\sqrt{s_{NN}}$	39 GeV	54.4 GeV	62.4 GeV	200 GeV
S/B	0.34	0.06	0.19	0.03
Significance	10	24	9	22

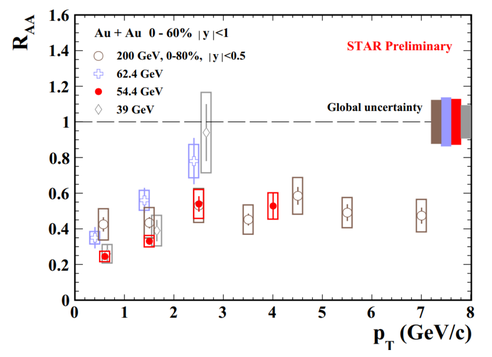
- Acceptance: $p_T^e \geq 0.2$ GeV/c, $|\eta_e| \leq 1$, $|y_{ee}| \leq 1$
- $p_T > 0.2$ GeV/c to exclude coherent photon induced production

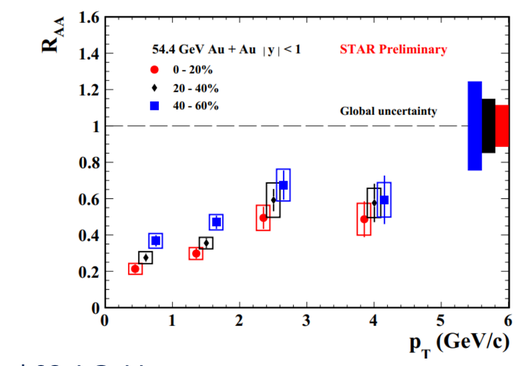
Nuclear modification factor





- Suppression of J/ψ production is observed in Au+Au collisions at 54.4 GeV with better precision compared to 39 and 62.4 GeV
- No significant energy dependence is observed within uncertainties up to 200 GeV



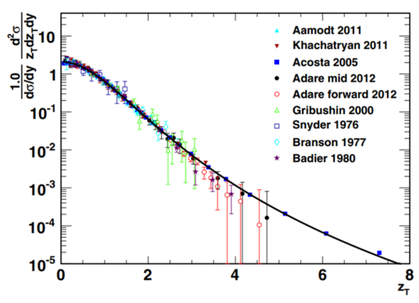


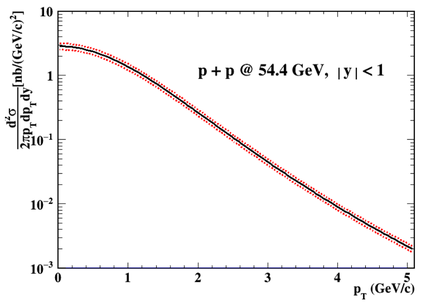
- R_{AA} increases with increasing p_T for 39, 54.4 and 62.4 GeV
- More suppression towards central collisions

p+p baseline at $\sqrt{s}$ = 54.4 GeV

For p+p baselines at 39, 54.4, and 62.4 GeV, they are extracted from phenomenological calculations [7]

- Energy interpolation from the existing total J/ψ cross section measurements
- Energy evolution of the rapidity distribution
- Energy evolution of J/ψ transverse momentum distribution





Summary

- Suppression of J/ψ in Au+Au collisions at $\sqrt{s_{NN}}$ = 54.4 GeV has been observed, with improved precision compared to the previous STAR results
- No significant energy dependence of R_{AA} has been observed in central collisions from 17.2 to 200 GeV
  - ➢ Interplay of dissociation, cold nuclear matter effects and regeneration
- The suppression is more significant at lower p_T and central collisions

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