Low p_T J/Ψ production in *d*+Au collisions at $\sqrt{s_{NN}}$=200 GeV in *STAR*

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Outline

- Motivation
- Experiment
- Data
- J/Ψ Reconstruction
- Reconstruction Efficiency
- Results
- Summary

Motivation

Why J/Ψ?

- Charm quarks produced in the initial hard parton scattering of the collision.
- Suppression of J/Ψ expected due to colour screening in the hot, dense medium – can be used to probe the QGP.
- Dilepton decay channel is mostly unaffected by the medium.

Why *d*+Au?

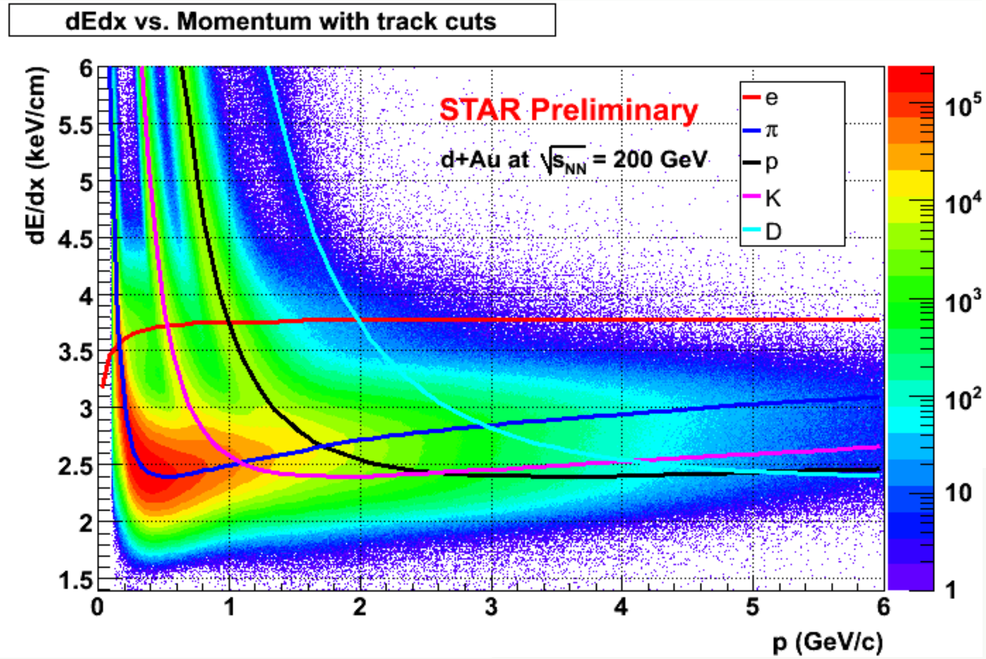
- Used to understand cold nuclear effects and to create a reference for underestanding hot nuclear effects in heavy ion collisions.
- Run 8 is the first run with reduced material around the beam pipe → factor 10 less conversion electrons.

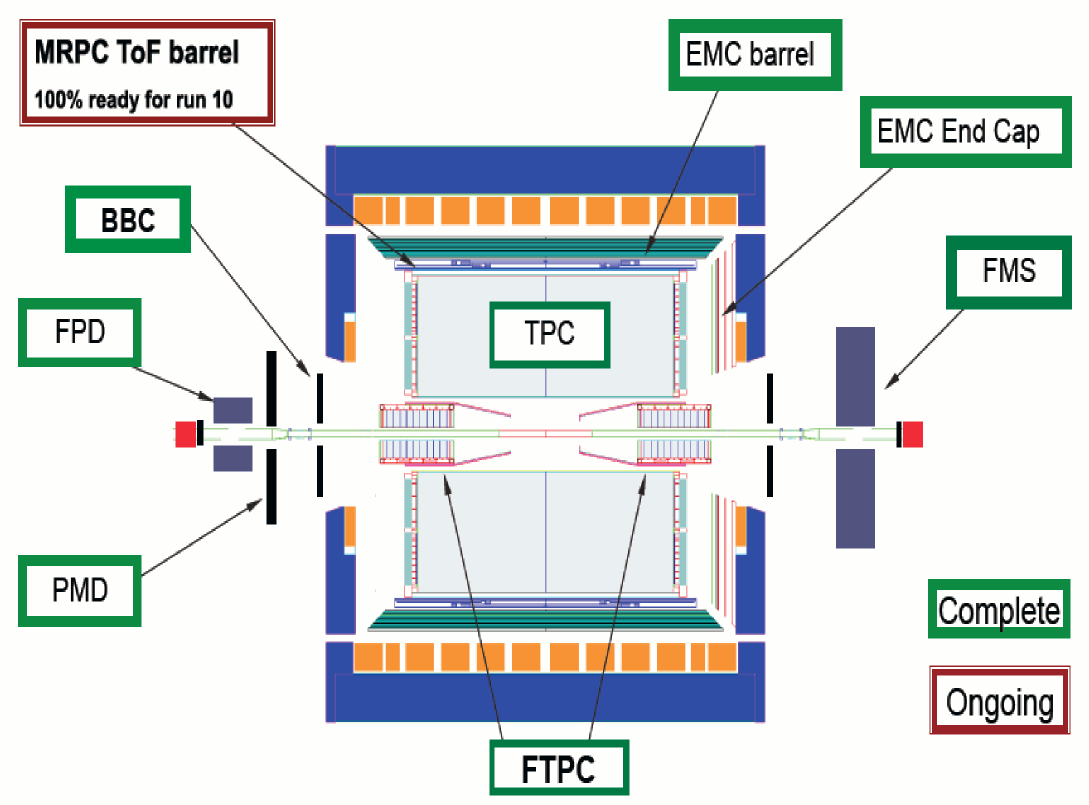
Experiment

The STAR Detector

Time Projection Chamber (TPC):
Track reconstruction and particle identification

Coverage: $0 \leq \Phi < 2\pi$
$-1 \leq \eta \leq 1$





Full azimuthal particle identification!

Track curvature → momentum reconstruction with resolution $\delta p/p \approx 2\%$ at 1 GeV/c
Ionization in TPC gas → dE/dx used for particle identification

Data

Data: d+Au run 8 collisions at $\sqrt{s_{NN}}$ = 200 GeV

Trigger: minimum bias (VPD-ZDCE)

Event Selection: $|V_Z| < 40$ cm → 34 Million events

Track Selection: $p_T > 1$ GeV
$|\eta| < 1$
$|DCA| < 3$ cm
nHits > 20
nHits/nPoss > 0.52

J/Ψ Reconstruction

Decay Channel: $J/\Psi \rightarrow e^+e^-$ (5.98%)

Electron Identification:

We normalize the measured dE/dx to the expected value from the Bicshel function:

$$n\sigma_e = \log\left(\frac{\mathrm{d}E/\mathrm{d}x\ |_{\text{measured}}}{\mathrm{d}E/\mathrm{d}x\ |_{\text{actual}}}\right)/\sigma$$

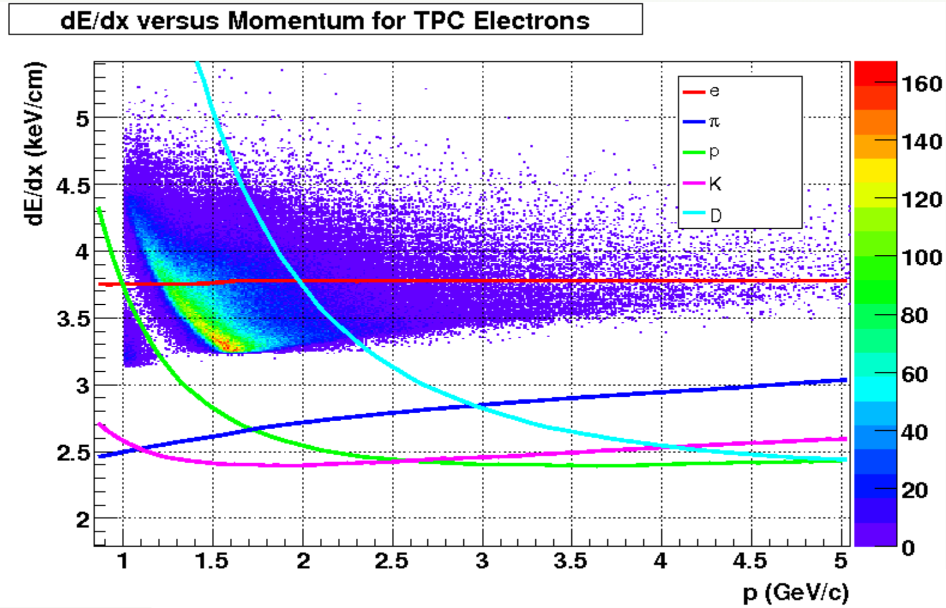
Identify electrons as tracks with:

$|n\sigma_e| < 2.4$

$|n\sigma_p| > 2.2$

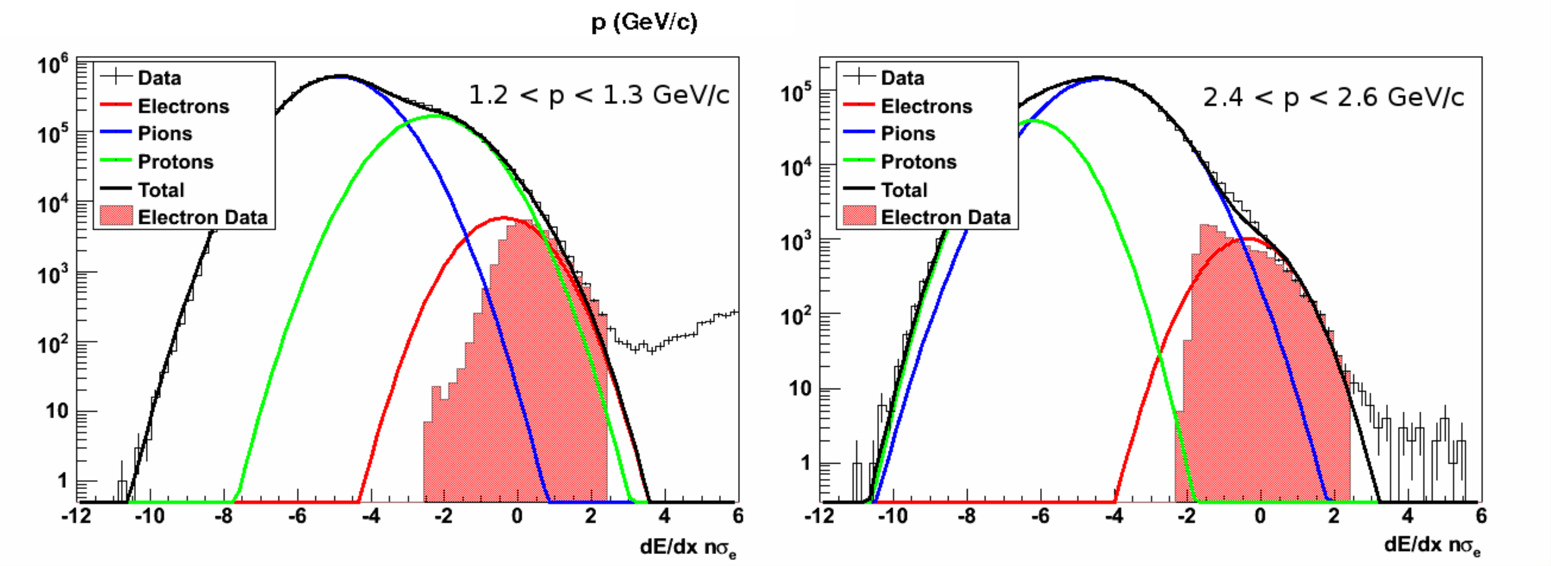
$|n\sigma_\pi| > 2.5$

J/Ψ Reconstruction



Accepted electrons

Identified electrons dE/dx (left) projections in nσ_e units (below, red). Multiple Gaussians are fitted to the data to determine proton, pion and electron contributions.

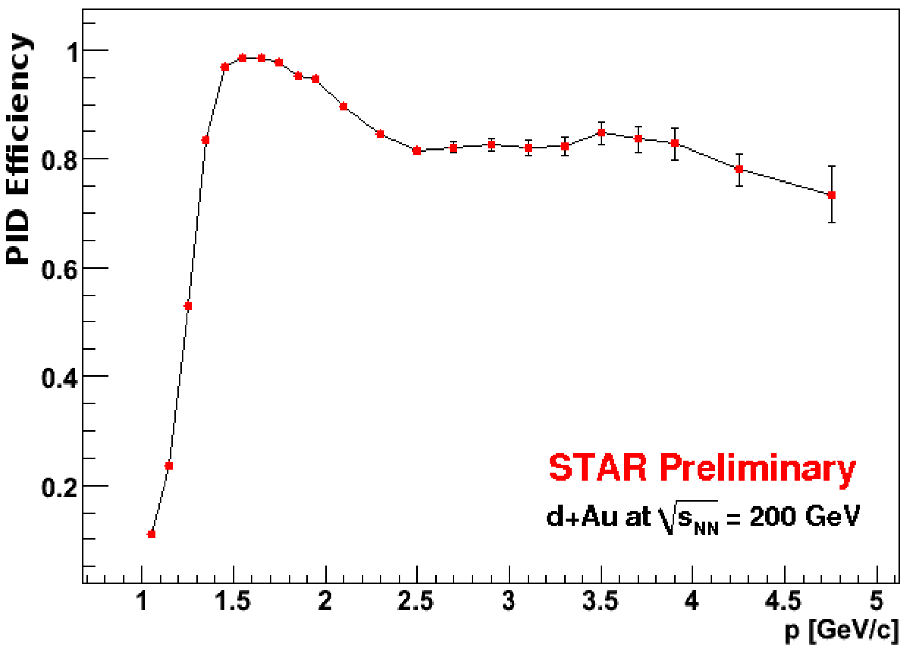


Reconstruction Efficiency

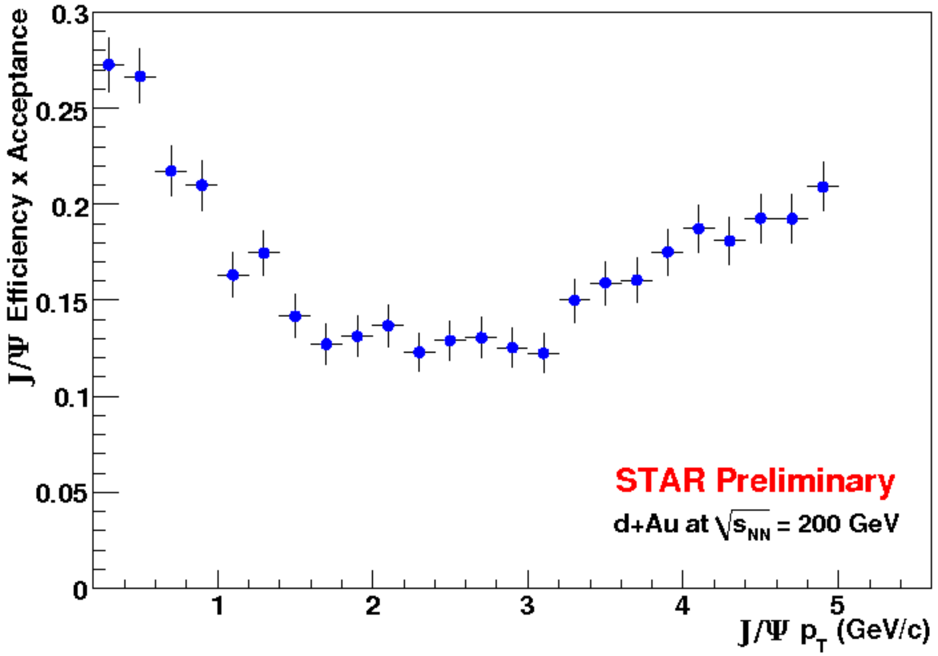
Total J/Ψ efficiency is a product of tracking efficiency and detector acceptance, and both daughter electron ID efficiencies:

$\varepsilon_{Total}(p_T^{J/\Psi}) = \varepsilon_{Tracking}(p_T^{J/\Psi}) \times \varepsilon_{PID}(p^{e1}) \times \varepsilon_{PID}(p^{e2})$

Electron ID Efficiency



Total J/Ψ Efficiency



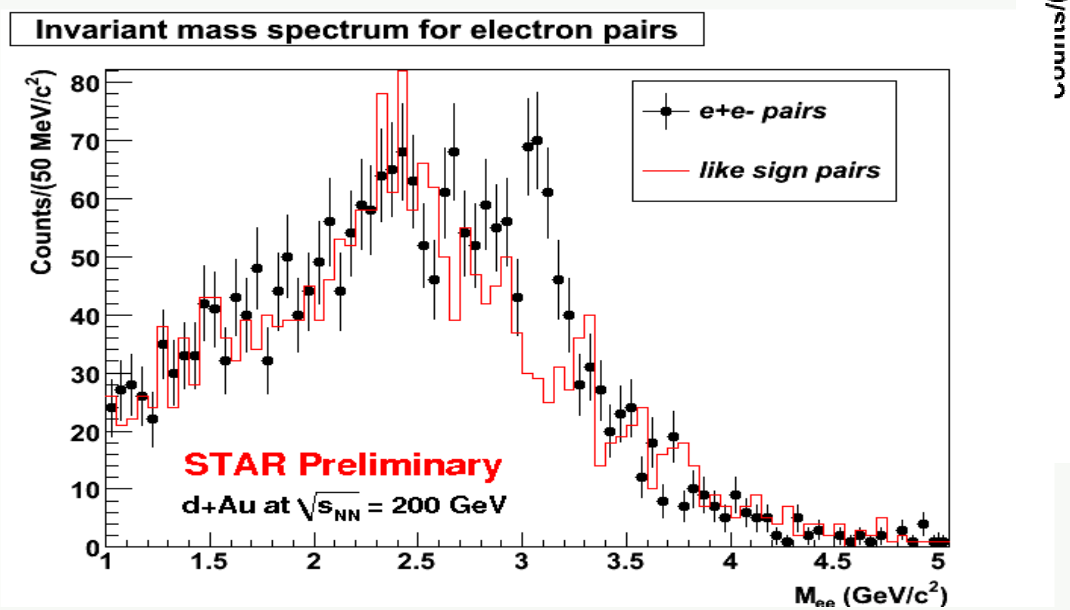
Results

Invariant Mass Spectrum

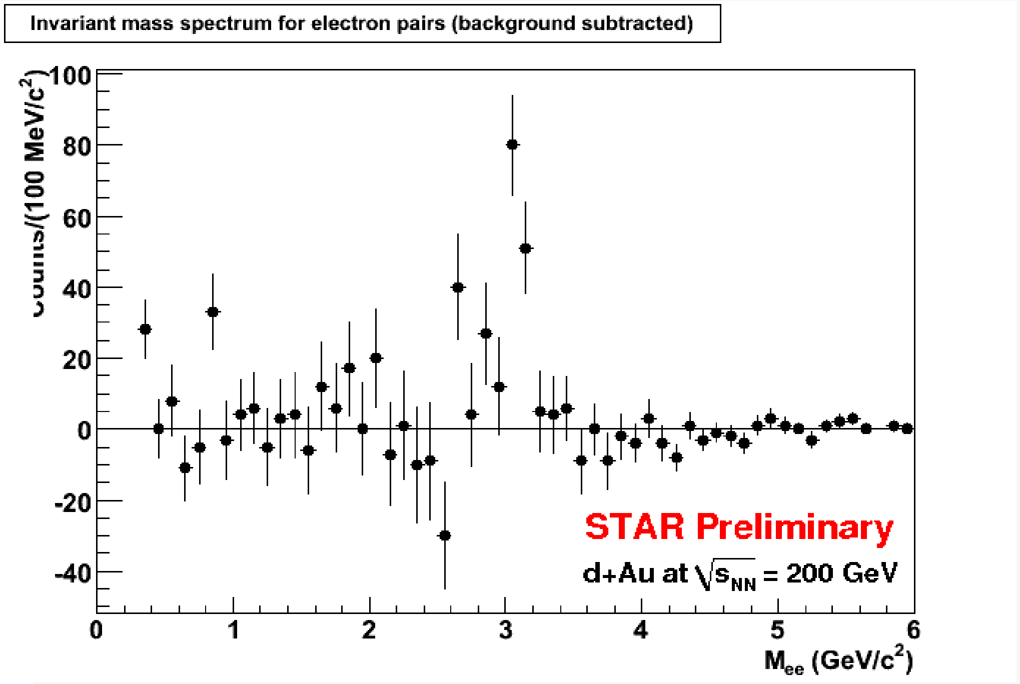
In 2.8 < m_{ee} < 3.2 GeV/c^2:

$N_{J/\Psi}$ = 175 ± 29
S/B = 1.5
Significance = 6.0

Before Background Subtraction



After Background Subtraction



Red: Like-sign combinatorial background: BG = N^{++} + N^{--}

Results

Invariant Mass Spectrum

For all centralities:

Embedding is used to determine yield. Difference in lineshape between embedding and crystal ball function is included in systematic errors

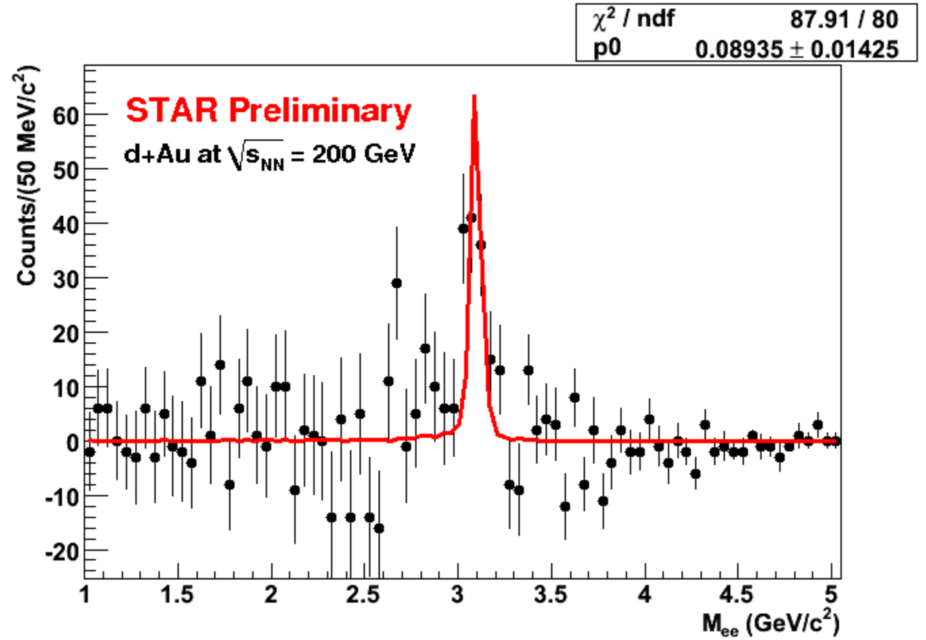
Crystal Ball function fitted to signal:

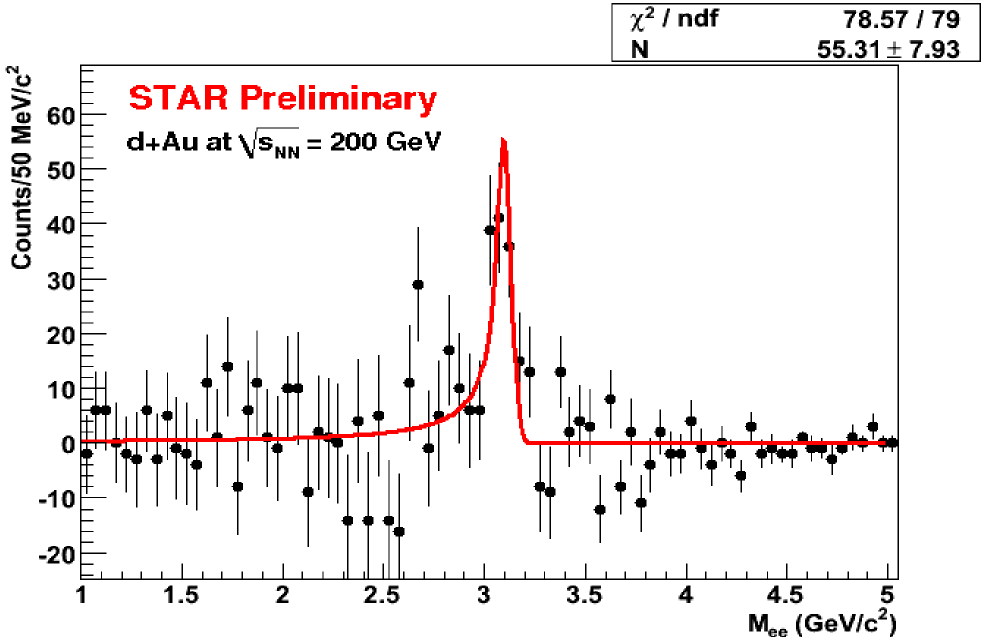
$$f(x;\alpha,n,\bar{x},\sigma) = N \cdot \begin{cases} \exp(-\frac{(x-\bar{x})^2}{2\sigma^2}), & \text{for } \frac{x-\bar{x}}{\sigma} > -\alpha \\ A \cdot (B - \frac{x-\bar{x}}{\sigma})^{-n}, & \text{for } \frac{x-\bar{x}}{\sigma} \leqslant -\alpha \end{cases}$$

$$A = \left(\frac{n}{|\alpha|}\right)^n \cdot \exp\left(-\frac{|\alpha|^2}{2}\right) \quad B = \frac{n}{|\alpha|} - |\alpha|$$

J. E. Gaiser, SLAC-R-255 (1982)

Embedding lineshape fitted to signal:

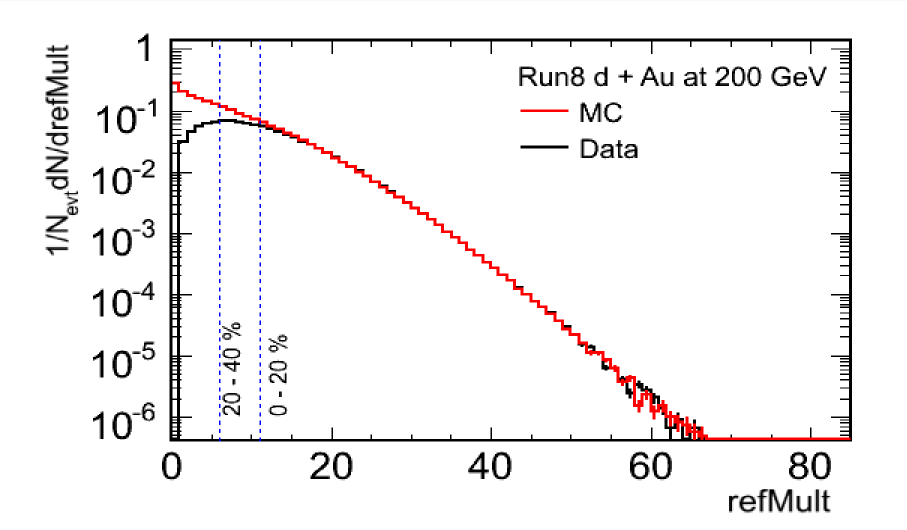




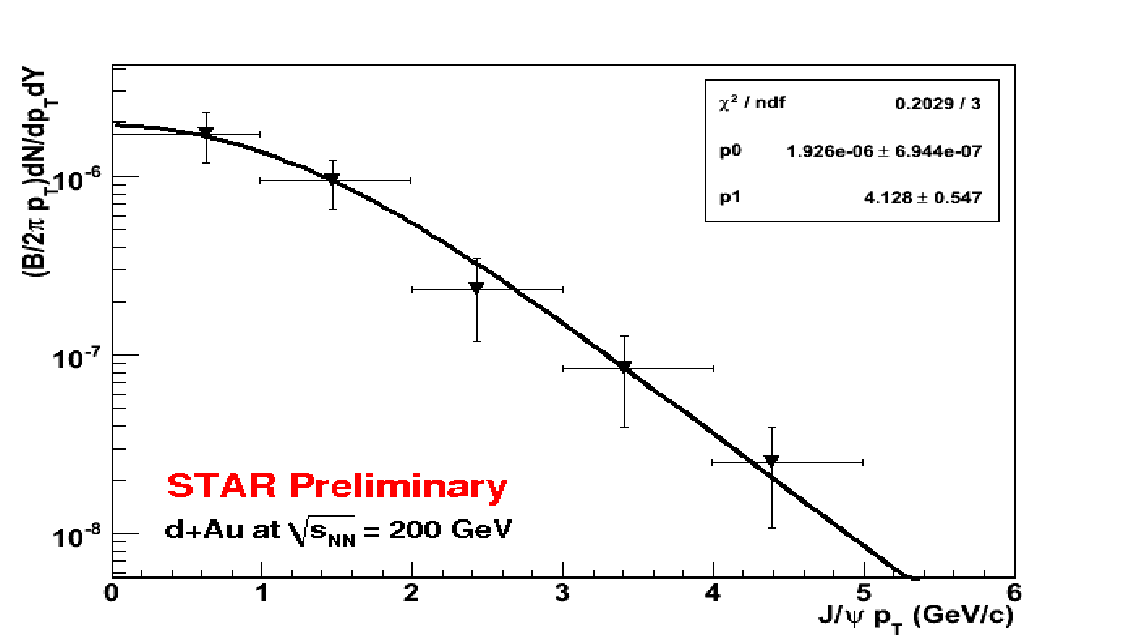
Results

Corrected Spectrum in 0% - 20% Central Collisions

Centrality selection based on East FTPC multiplicity (-3.8 < η < -2.8)



Integrated yield for 0% - 20% central collisions (11.2 M events):
B • dN/dY = 2.0 ± 0.4 x 10^{-5}



Number of binary collisions of 0% - 20% central collisions:

N_{coll} = 14.6 ± 1.7

Power-Law fit to data:

$$f(p_T) = A \cdot \left(1 + \left(\frac{p_T}{B}\right)^2\right)^{-6}$$

Results

Systematic Uncertainties

- Background Subtraction: $\sigma_{BG} = 7\%$
- Electron ID Efficiency: $\sigma_{eID} = 9\%$
- Yield Efficiency: $\sigma_{Yield} = 33\%$

(Due to uncertainty in tail of mass spectrum)

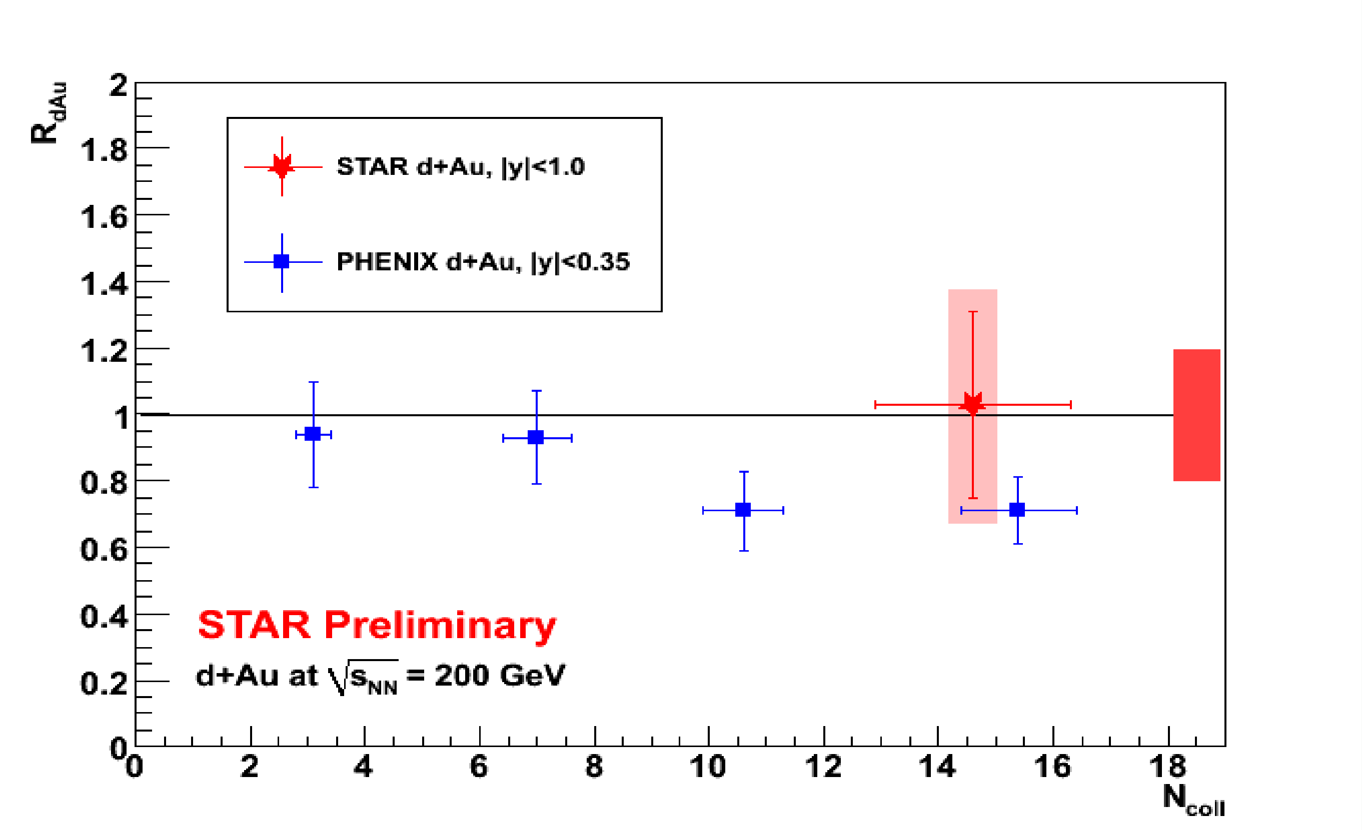
Total systematic uncertainty (uncorrelated errors)

$$\sigma_{J/\psi} = \sqrt{(\sigma_{BG}^2 + \sigma_{eId}^2 + \sigma_{Yield}^2)} = 35\%$$

Results

Nuclear Modification Factor

The J/Ψ yield in *d*+Au collisions has been scaled by p+p data* to obtain the nuclear modification factor R_{d+Au}



New result from Quark Matter 09:
-increased statistics
-yield is obtained from lineshape
-systematic uncertainties included

* M. Cosentino, arXiv:0806.0347v1 [nucl-ex]
**A. Adare, et al., PHENIX Collaboration, Phys. Rev. C 79, 059901 (2009)

Summary

- A clear J/Ψ signal with high significance is observed in the dielectron invariant mass spectrum.
- The preliminary J/ψ nuclear modification factor for 0% - 20% central mid-rapidity d+Au collisions is consistent with binary scaling.
- Analysis on centrality dependence is underway.