J/ψ polarization in p+p collisions at $\sqrt{s} = 200$ GeV at STAR

Barbara Trzeciak (Warsaw University of Technology, LBNL)
for the STAR Collaboration

QUARK MATTER ANNECY 2011

Abstract

Currently there are many models with different assumptions regarding J/ψ production mechanism that seem to describe the production cross section from experimental data reasonably well. Information on J/ψ spin alignment, commonly named as J/ψ polarization, may allow to discriminate J/ψ production models. Moreover the prediction that J/ψ polarization is transverse momentum dependent needs to be tested.

Analysis of J/ψ polarization at mid-rapidity in p+p collisions at $\sqrt{s} = 200$ GeV registered in the STAR experiment will be presented. Data were triggered by the STAR Electromagnetic Calorimeter. J/ψ is analyzed through its dielectron decay channel. The J/ψ polarization is extracted from the angular distribution measured in the helicity frame.

Motivation and model predictions

Measurement of J/ψ polarization may help to understand the J/ψ production mechanism and could discriminate between different models of J/ψ production.

Some model predictions:

- Color Evaporation Model – has no prediction power regarding J/ψ polarization [1]
- s-channel cut contribution to Color Singlet Model – polarization goes towards longitudinal values at higher p_T [2]
- Color Octet Model (NRQCD) – transverse polarization at high p_T [3]

Dataset

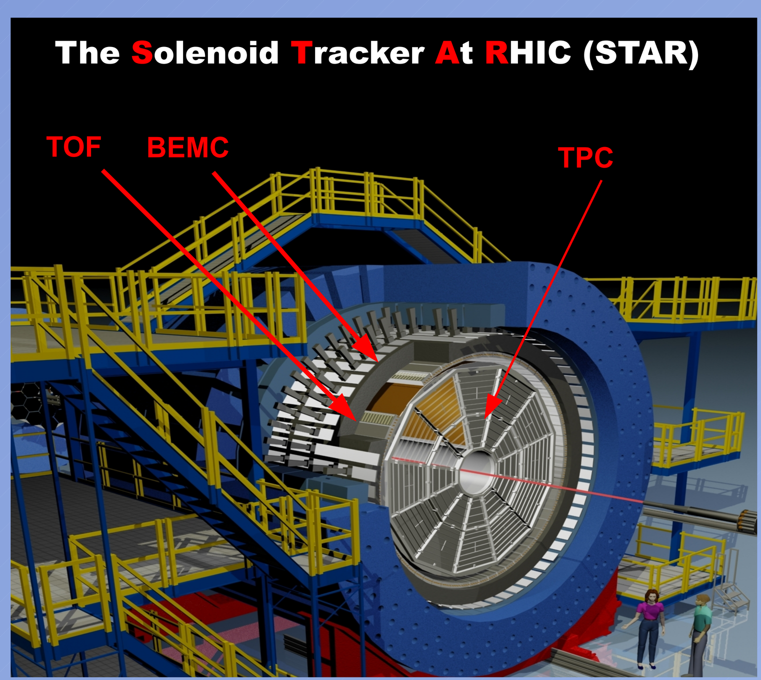
- p+p collisions at $\sqrt{s} = 200$ GeV from 2009 year
- High Tower Trigger (HT) – trigger is fired when transverse energy in BEMC tower is 2.6 GeV < $E_T \leq$ 4.3 GeV
- Integrated luminosity ~ 1.8 pb^{-1}

Electron identification

J/ψ is reconstructed through its dielectron decay channel:

$$J/\psi \rightarrow e^+e^- \text{ (BR 5.9\%)}$$

Electrons are identified using information from **Time Projection Chamber** (TPC), **Time of Flight** (TOF) and **Barrel Electromagnetic Calorimeter** (BEMC):



- TPC – dE/dx information

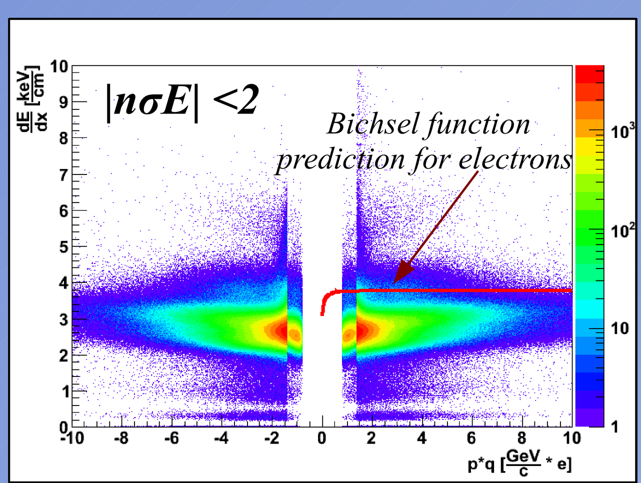


Fig1. dE/dx vs p*q

- BEMC – E/p > 0.5
  (E - single BEMC tower energy)
- TOF – |1/β-1| < 0.03
  (β = pathLength/TimeOfFlight)

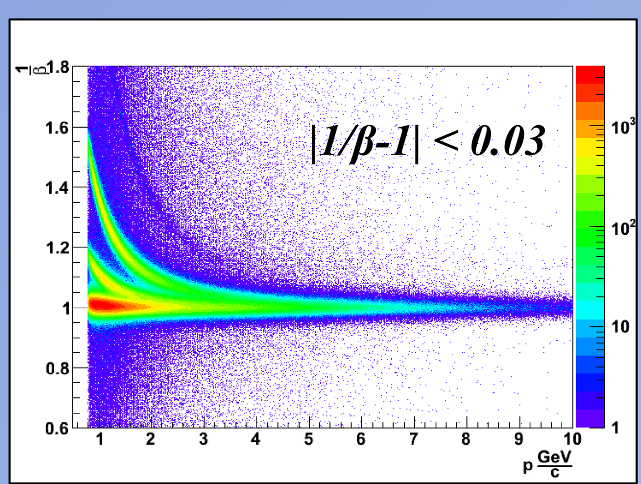
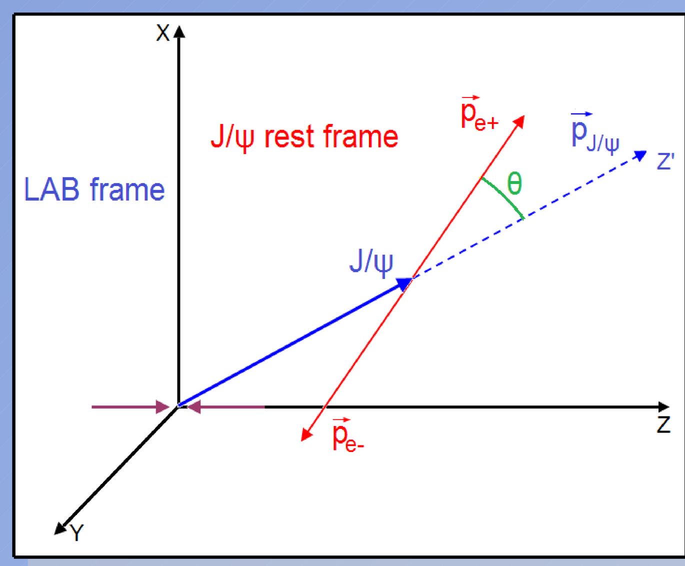


Fig2. 1/β vs momentum

Decay angular distribution

J/ψ polarization is analyzed via the angular distribution of the decay electron pair.

In this analysis we measure J/ψ polarization in the ***helicity frame*** where θ is the angle between the positron momentum in the J/ψ rest frame and the J/ψ momentum in the laboratory frame.



Polarization parameter λ

angular distribution can be parametrized:

$$\frac{dN}{d\cos\theta} \propto 1 + \lambda\cos^2\theta$$

- **λ = -1** – full longitudinal polarization
- **λ = 0** – no polarization
- **λ = 1** – full transverse polarization

J/ψ polarization

J/ψ polarization parameter λ is obtained by fitting $A(1+\lambda\cos^2\theta)$ function to corrected cosθ distribution from the data.

Raw cosθ distribution is corrected by applying: acceptance correction, tracking efficiency, electron identification efficiency and HT trigger efficiency.

Polarization parameter λ is extracted in two J/ψ p_T bins:

2–3 GeV/c and 3-4 GeV/c

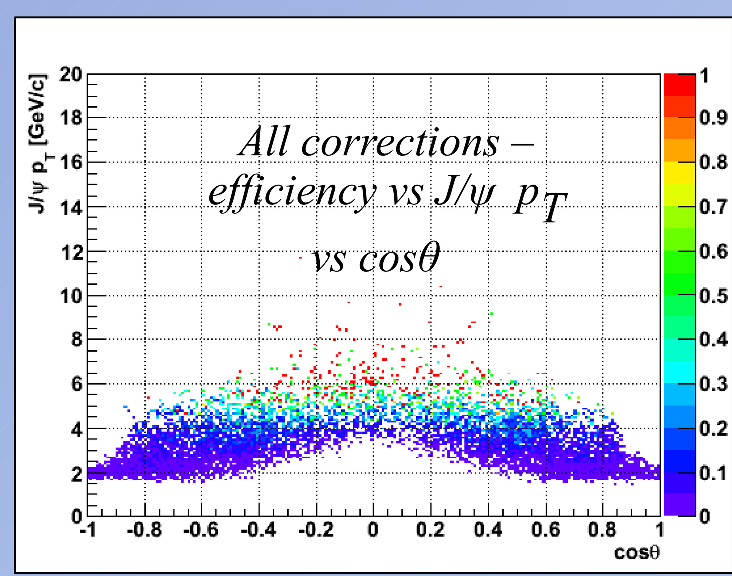


Fig5. efficiency vs J/ψ p_T vs cosθ

Statistical errors only

λ = 0.609 ± 0.573

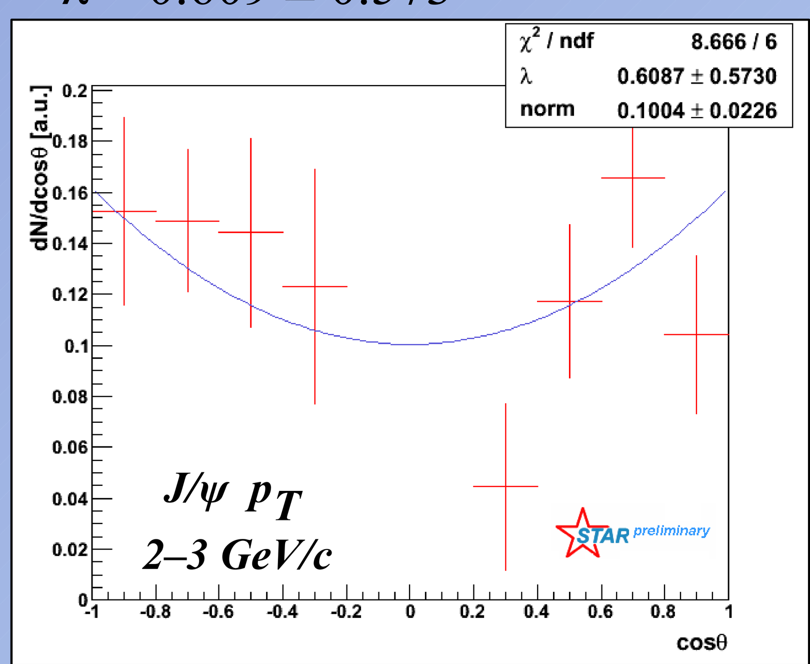


Fig6. corrected cosθ with the fit, 2-3GeV/c

λ = -0.276 ± 0.340

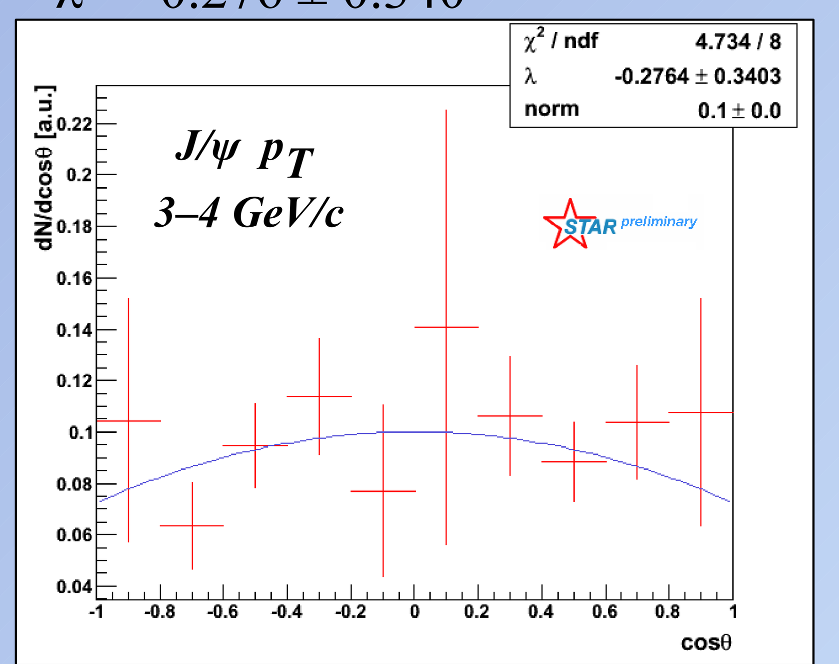


Fig7. corrected cosθ with the fit, 3-4GeV/c

J/ψ signal

J/ψ signal is obtained by subtracting like-sign background - $e^+e^+ + e^-e^-$ *(red distribution)* from all combinations of e^+e^- pairs *(black distribution)*

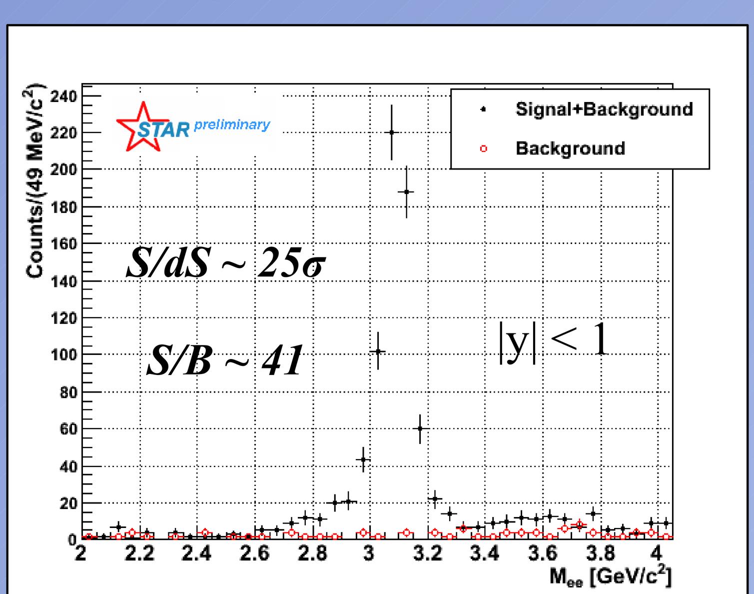


Fig3. Invariant mass distribution

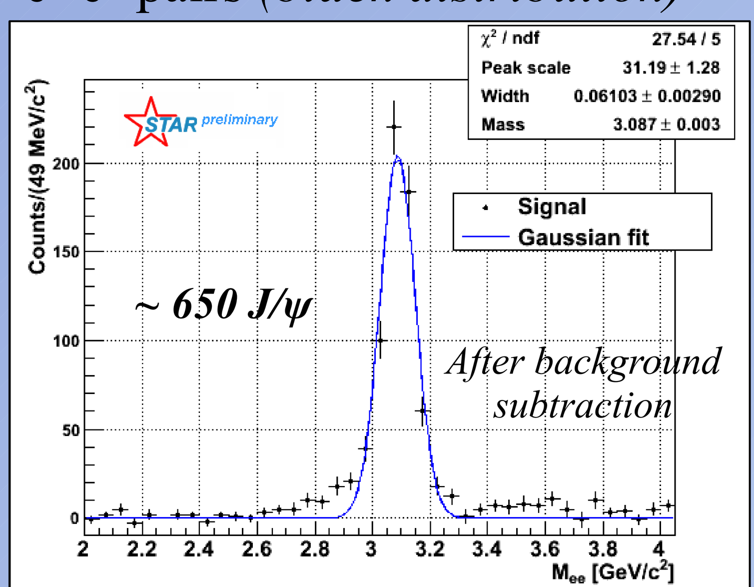


Fig4. J/ψ signal with Gaussian fit

J/ψ mass window:

2.9 – 3.3 GeV/c²

J/ψ ***p_T : 2 - 6 GeV/c***

J/ψ ***|y| < 1***

Summary

- First results of J/ψ polarization in the HX frame at mid-rapidity at STAR are presented
- Polarization parameter λ is measured in two J/ψ p_T bins
- Presented J/ψ polarization analysis will be extended to higher p_T in order to help distinguish among J/ψ production models

References

[1] G.A. Schuler arXiv: 9403387 [hep-ph]
[2] H. Haberzettl and J. P. Lansberg, Phys. Rev. Lett. 100, 032006
[3] H. S. Chung, S. Kim, J. Lee, and C. Yu, arXiv: 0911.2113 [hep-ph]