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

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Strangeness in Quark Matter
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Outline

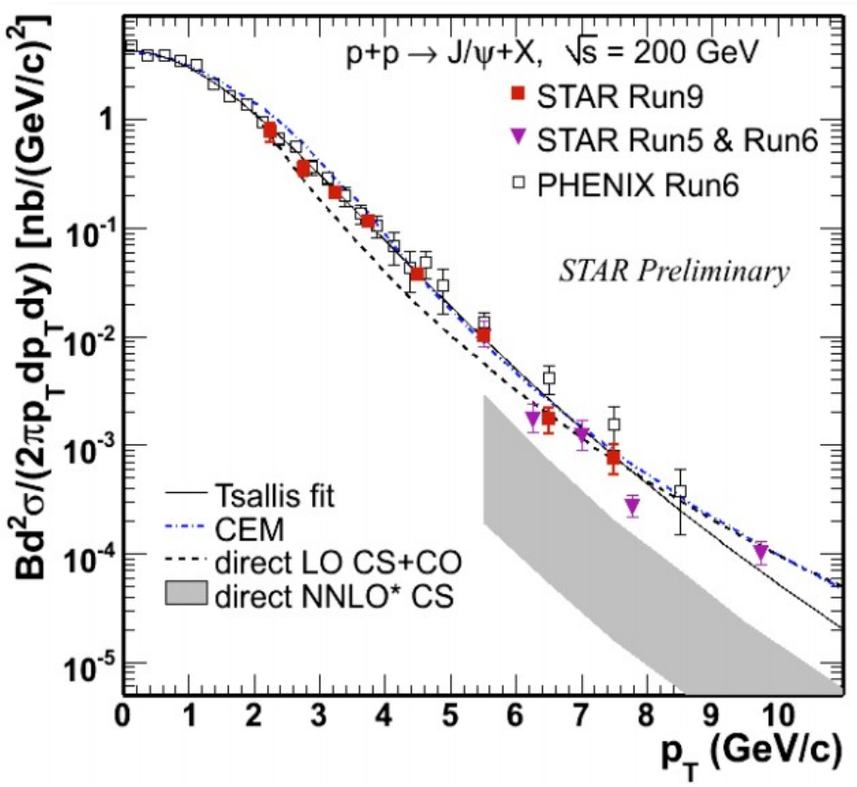
- *Motivation and model predictions*
- *Decay angular distribution*
- *Electron identification*
- *J/ψ signal*
- *Extraction of J/ψ polarization parameter*
- *Polarization parameter vs J/ψ p_T*
- *Summary*

Motivation

- many models with different assumptions regarding J/ψ production mechanism seem to describe the production cross section from experimental data reasonably well

- measurement of J/ψ polarization may help to understand the J/ψ production mechanism

- and could discriminate between different models of the J/ψ production



PHENIX: Phys. Rev. D 82, 012001 (2010)
STAR: Phys. Rev. C80, 041902(R) (2009)
Phys. Rev. D68, 034003 (2003)
Phys. Rev. Lett. 101, 152001 (2008)
JPG 37, 085104 (2010)
arXiv: hep-ph/0311048

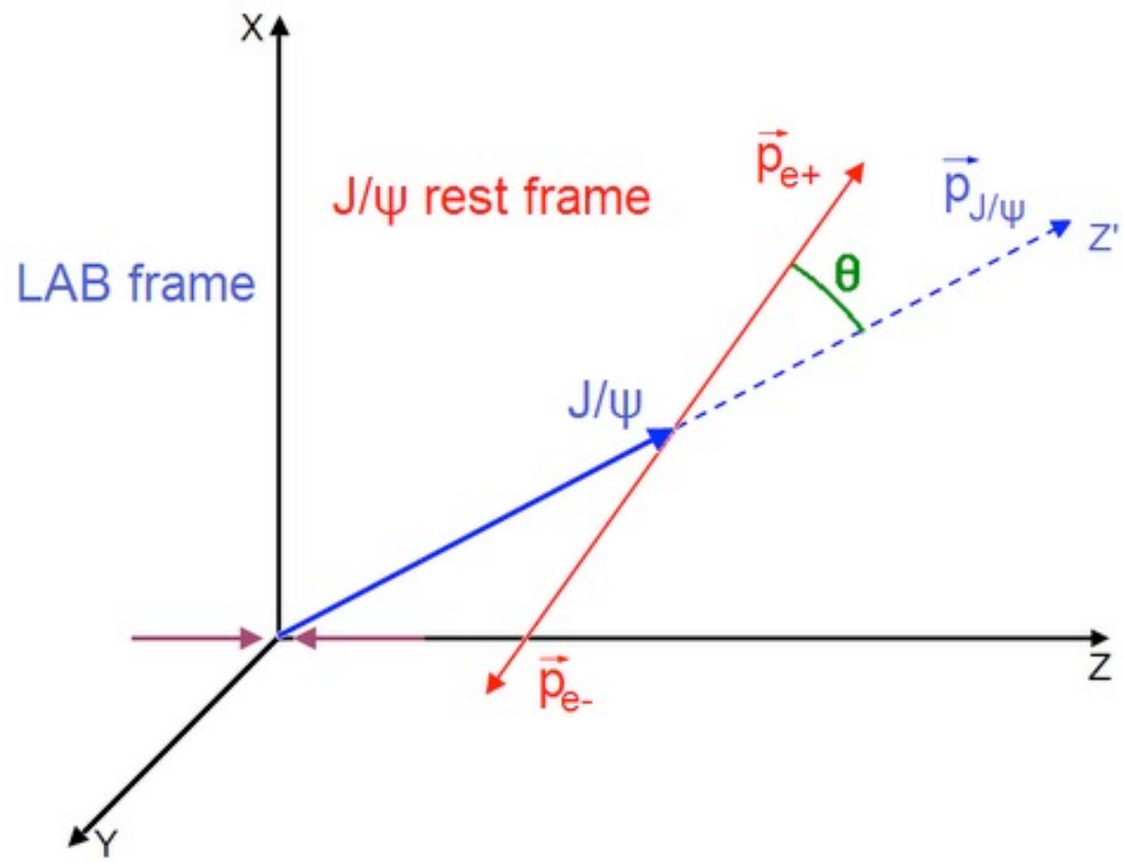
Model predictions

Various models have different assumptions regarding J/ψ polarization:

- Color Octet Model (NRQCD) - transverse polarization at higher p_T
- NLO Color Singlet Model - longitudinal polarization at low and mid p_T
- Color Evaporation Model - has no prediction power regarding polarization

Decay angular distribution

- J/ψ polarization is analyzed via the angular distribution of the decay electron pair
- J/ψ polarization is measured in the **helicity frame**
- θ angle is the polar angle between the positron momentum in the J/ψ rest frame and J/ψ momentum in the lab frame



Polarization parameter λ

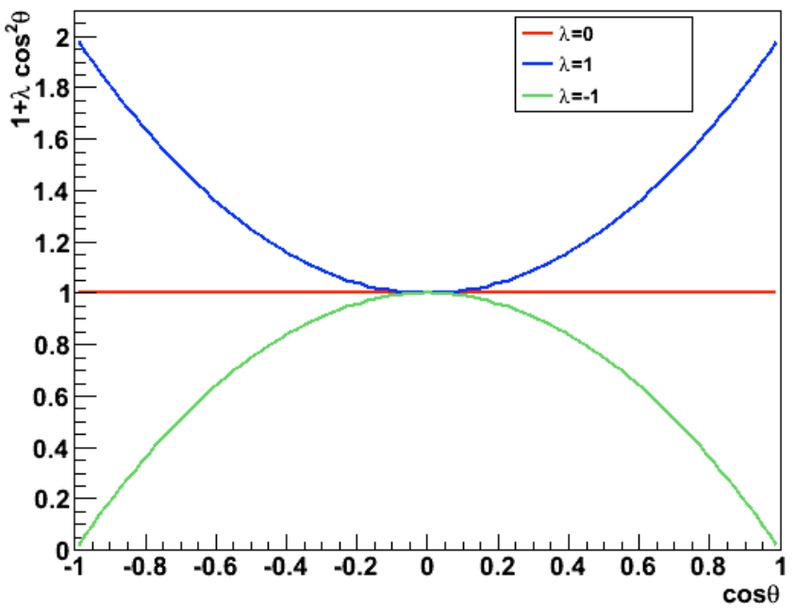
- the angular distribution, integrated over the azimuthal angle, can be parametrized:

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

- polarization parameter λ contains both the longitudinal and transverse component of the J/ψ cross section:

$$\lambda = \frac{\sigma_T - 2\sigma_L}{\sigma_T + 2\sigma_L}$$

- ✓ λ = -1 - full longitudinal polarization
- ✓ λ = 0 - no polarization
- ✓ λ = 1 - full transverse polarization

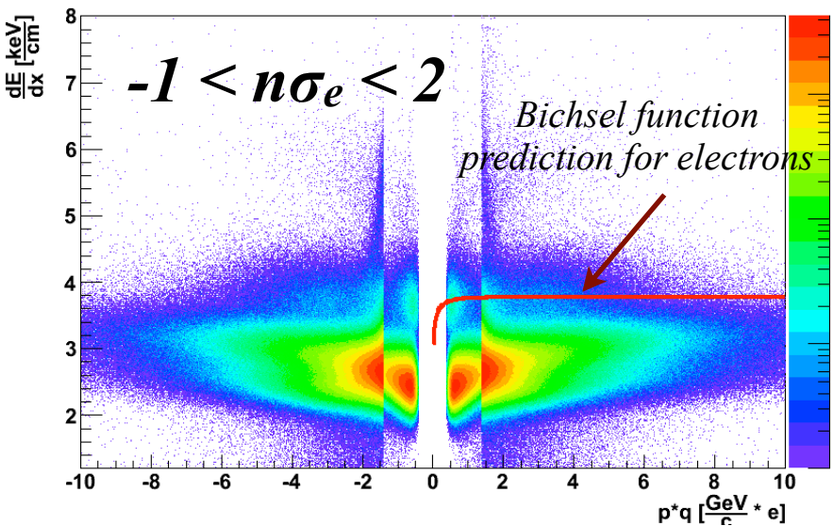


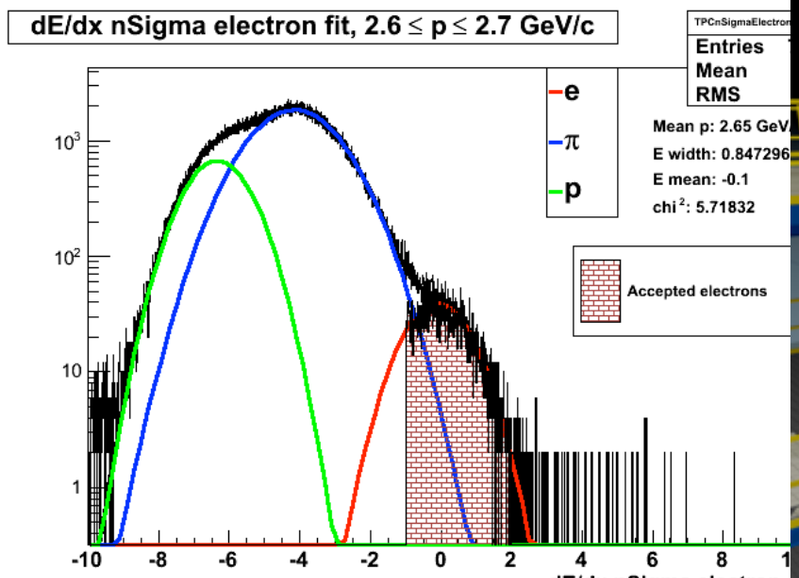
Electron identification in STAR

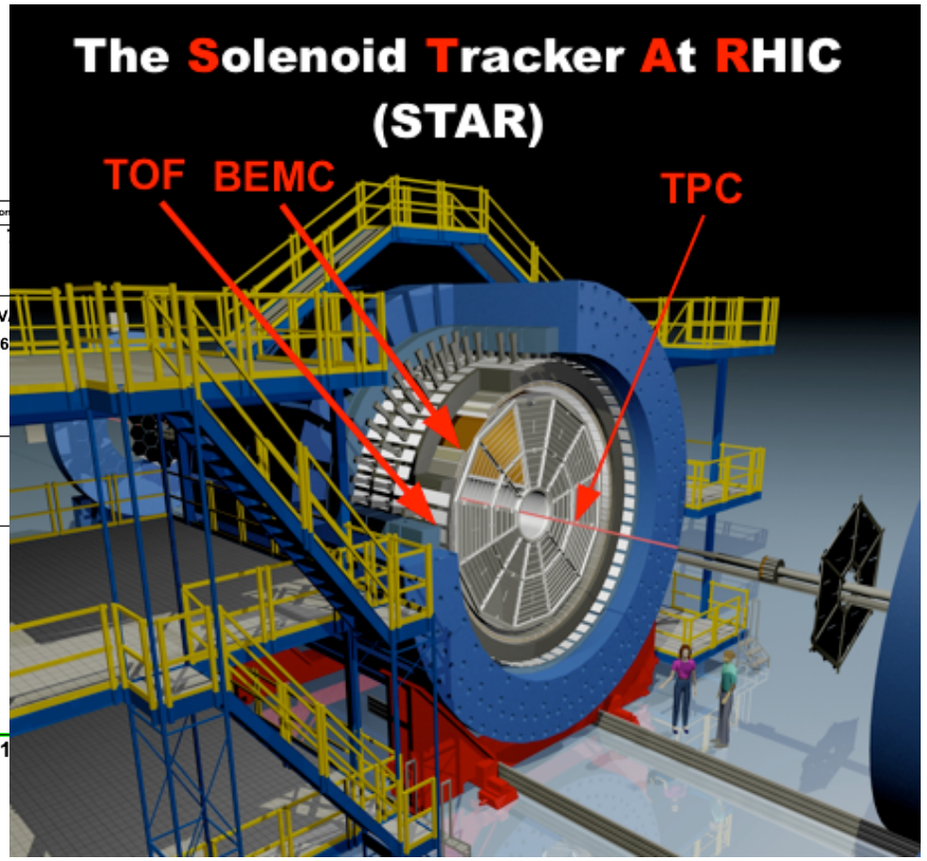
J/ψ is reconstructed via its dielectron decay channel: $J/\psi \rightarrow e^+ e^-$ (BR 5.9%)

Electrons are identified using information from:

- ✓ TPC - dE/dx information, for whole momentum range





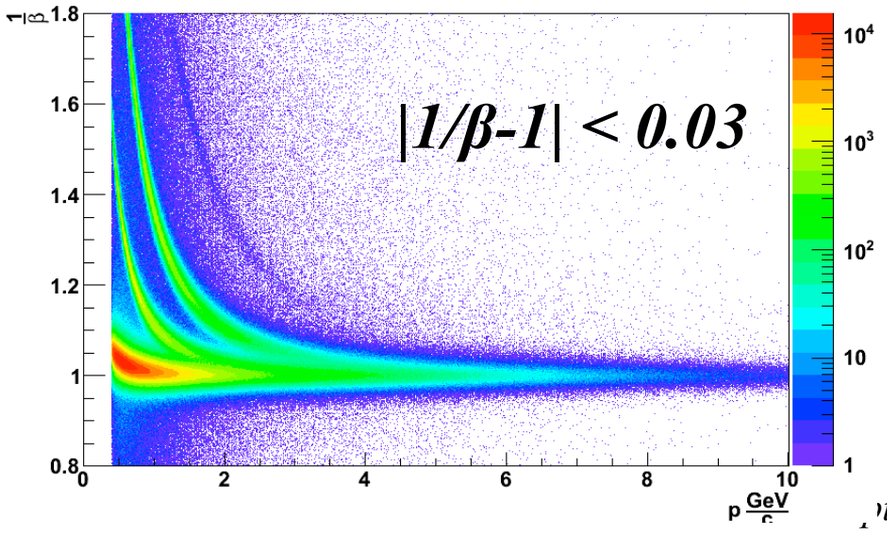


- ✓ BEMC - energy deposited in a tower - for electrons E/p ~ 1

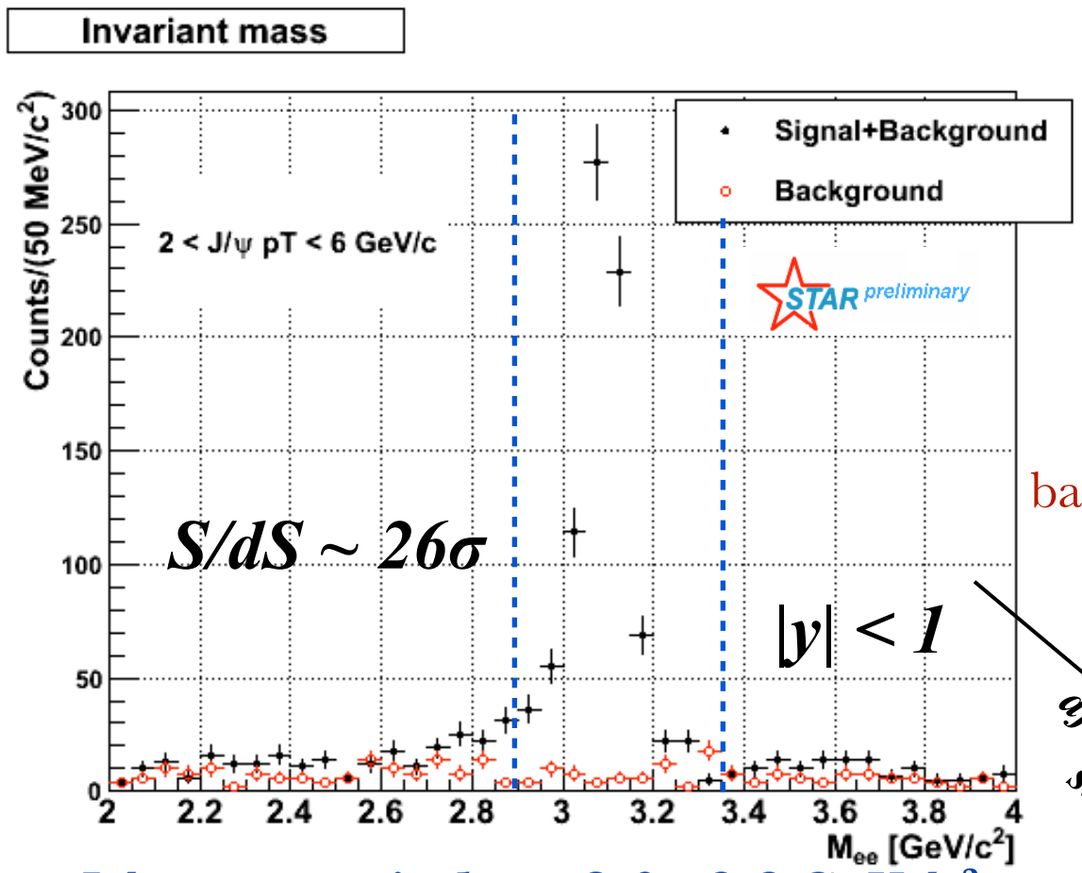
  applied cut: E/p > 0.5, for p ≥ 1.4 GeV/c

- ✓ TOF (72% of full TOF in 2009) - 1/β information, for p < 1.4 GeV/c

β = pathLength/TimeOfFlight



J/ψ signal



J/ψ mass window: 2.9 - 3.3 GeV/c^2

significance: S/dS = S/√(S+2B)

- clear J/ψ signal with high significance of ***26σ*** in J/ψ p_T range: 2 - 6 GeV/c and rapidity: |y|<1
- obtained number of J/ψs ~ 770 allow to split the signal into 3 J/ψ p_T bins for polarization analysis

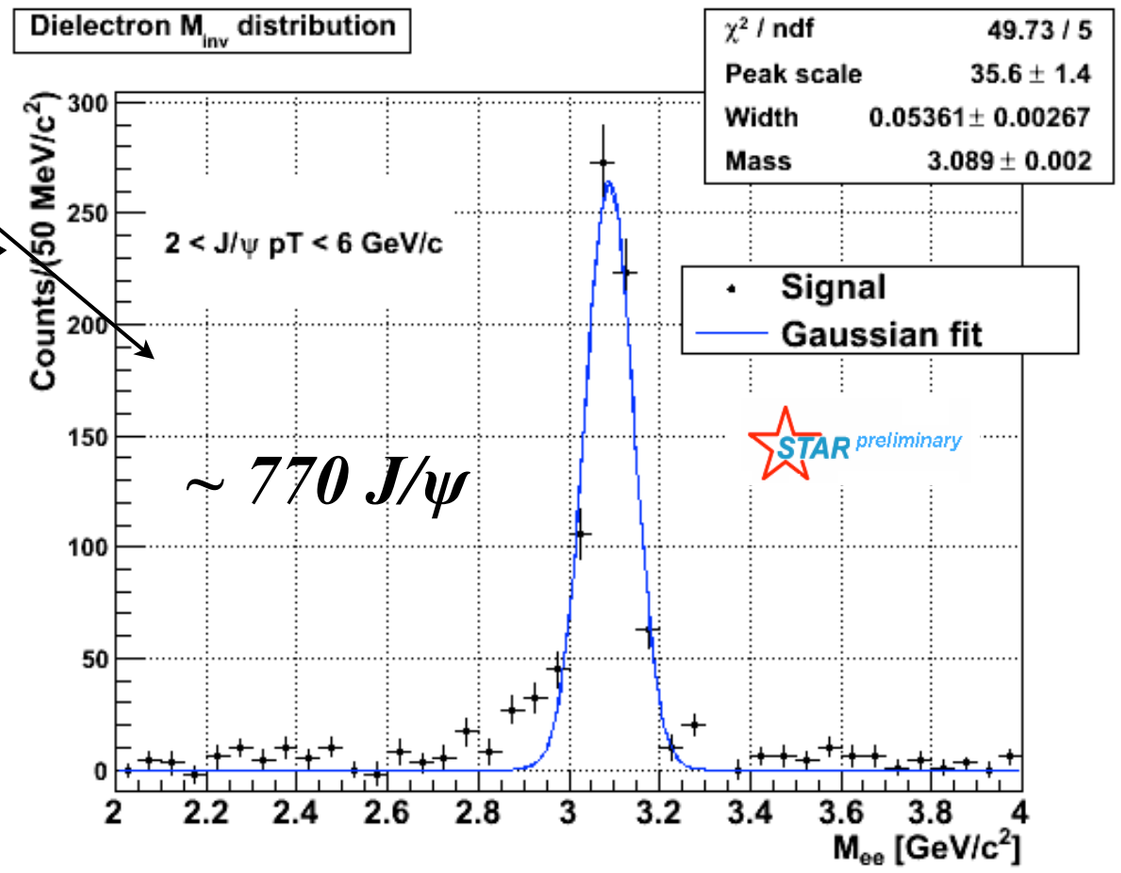
dataset:

- p+p collisions at √s = 200 GeV from year 2009
- ~ 30M events with HT trigger:
  2.6 GeV < E_T ≤ 4.3 GeV
- integrated luminosity ~ 1.5 pb^{-1}

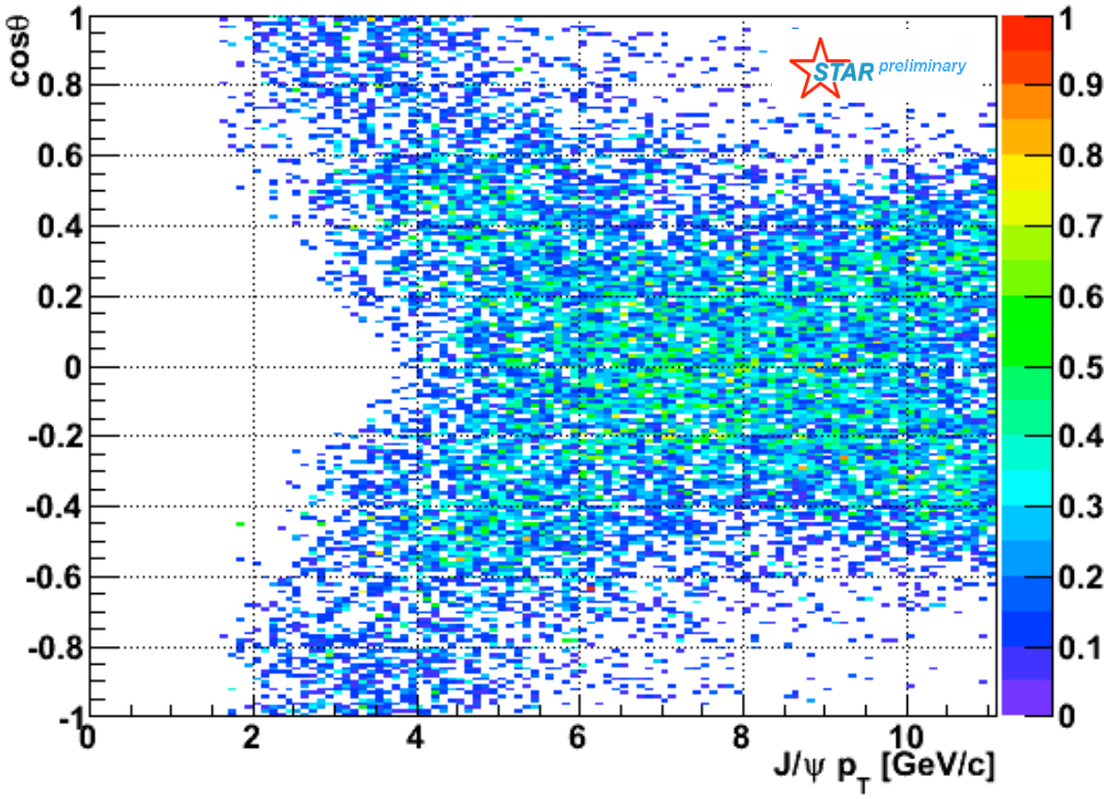
background obtained using like-sign technique:

$$N_{e^-e^-} + N_{e^+e^+}$$

after background subtraction



Corrections

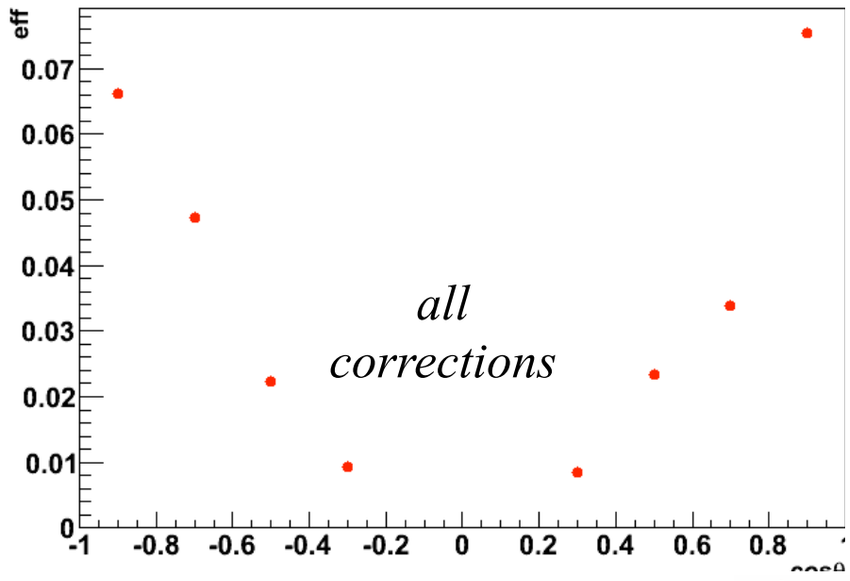


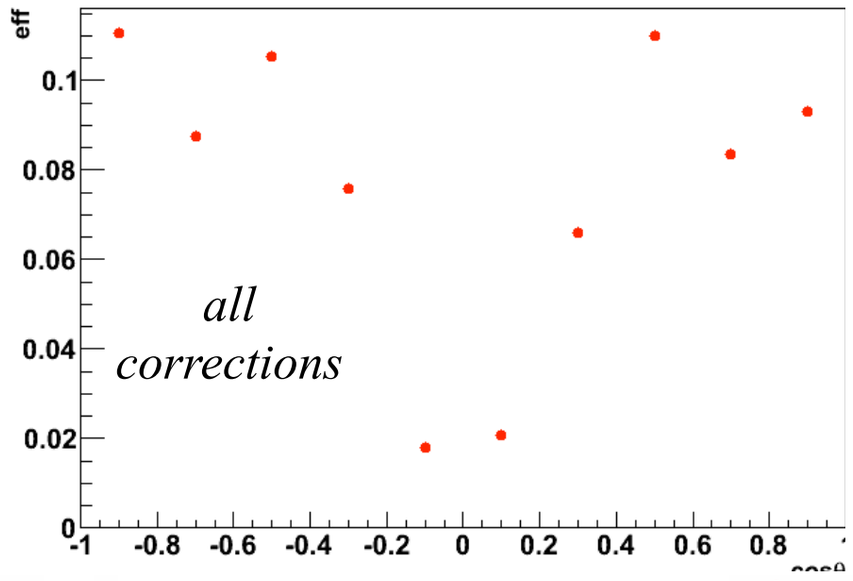
corrections include:

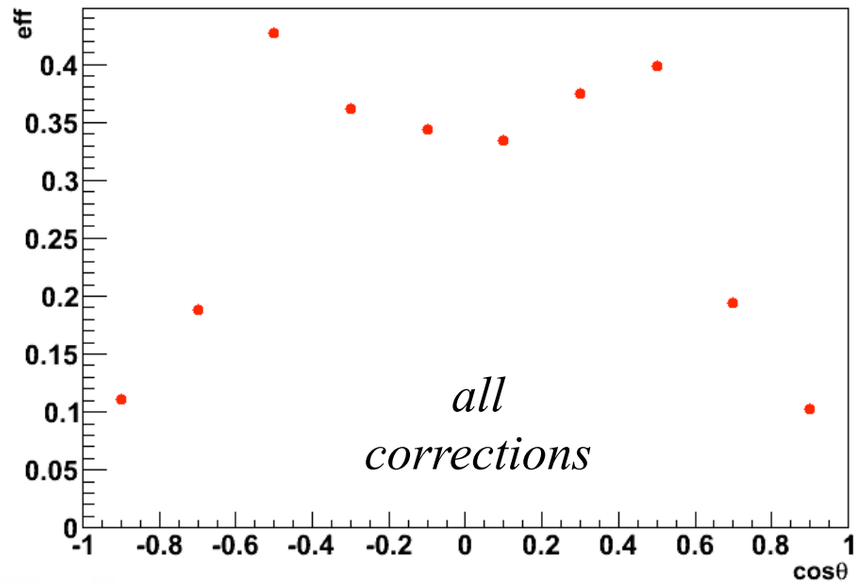
- ✓ *acceptance correction*
- ✓ *tracking efficiency*
- ✓ *electron identification efficiency*
- ✓ *HT trigger efficiency*

- ✳ in order to get cosθ corrections MC J/ψs with uniform pT and y distributions were embedded into real events and the detector response was simulated
- ✳ then all data cuts were applied and obtained cosθ distribution was divided by the input cosθ distribution (in a function of J/ψ p_T) and re-weighted according to the real J/ψ p_T and y distributions
- ✳ obtained corrections are applied to raw cosθ distributions from data in 1GeV/c J/ψ p_T wide bins

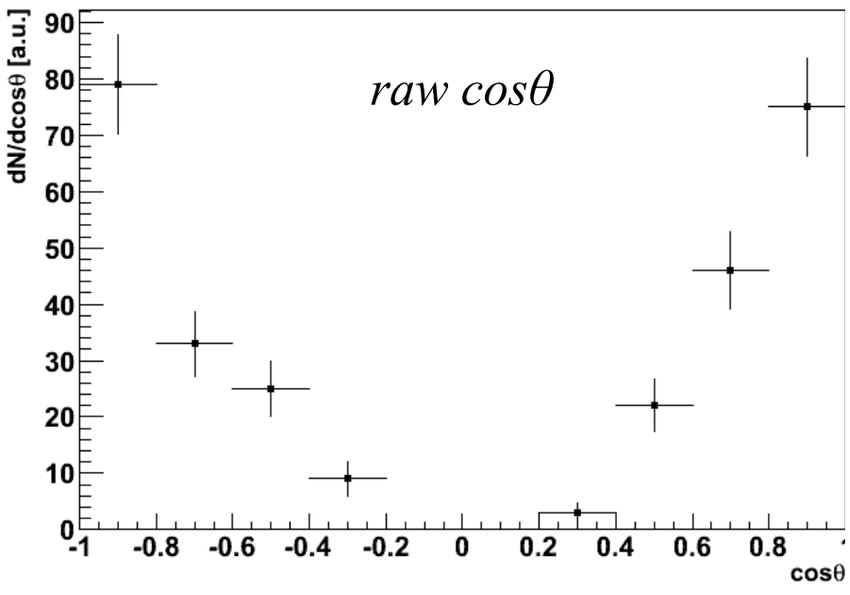
Corrections and raw cosθ

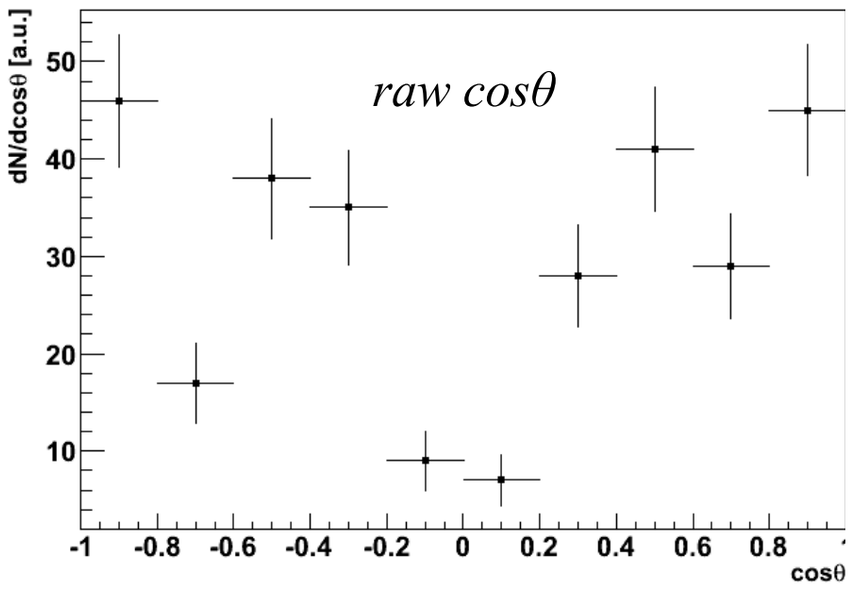


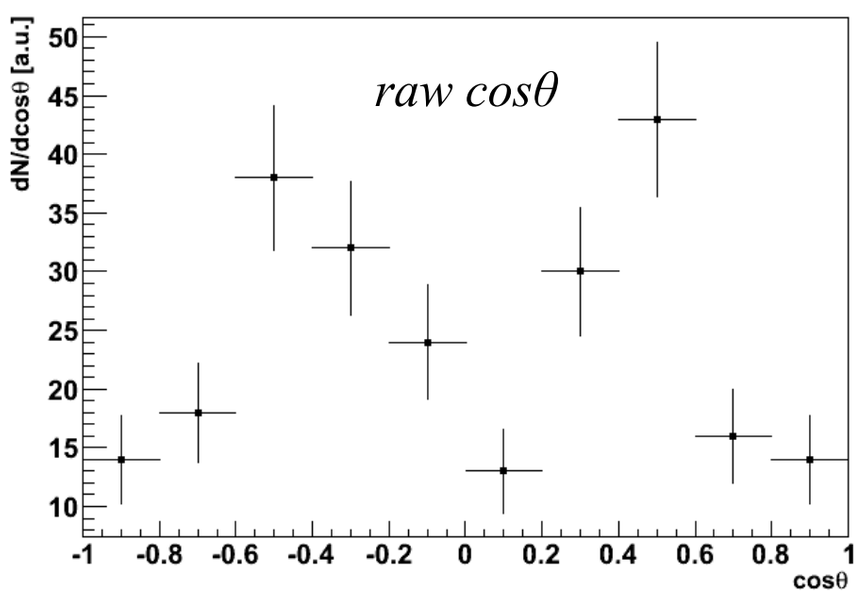




2 < J/ψ p_T < 3 GeV/c STAR preliminary *3 < J/ψ p_T < 4 GeV/c* STAR preliminary *4 < J/ψ p_T < 6 GeV/c*

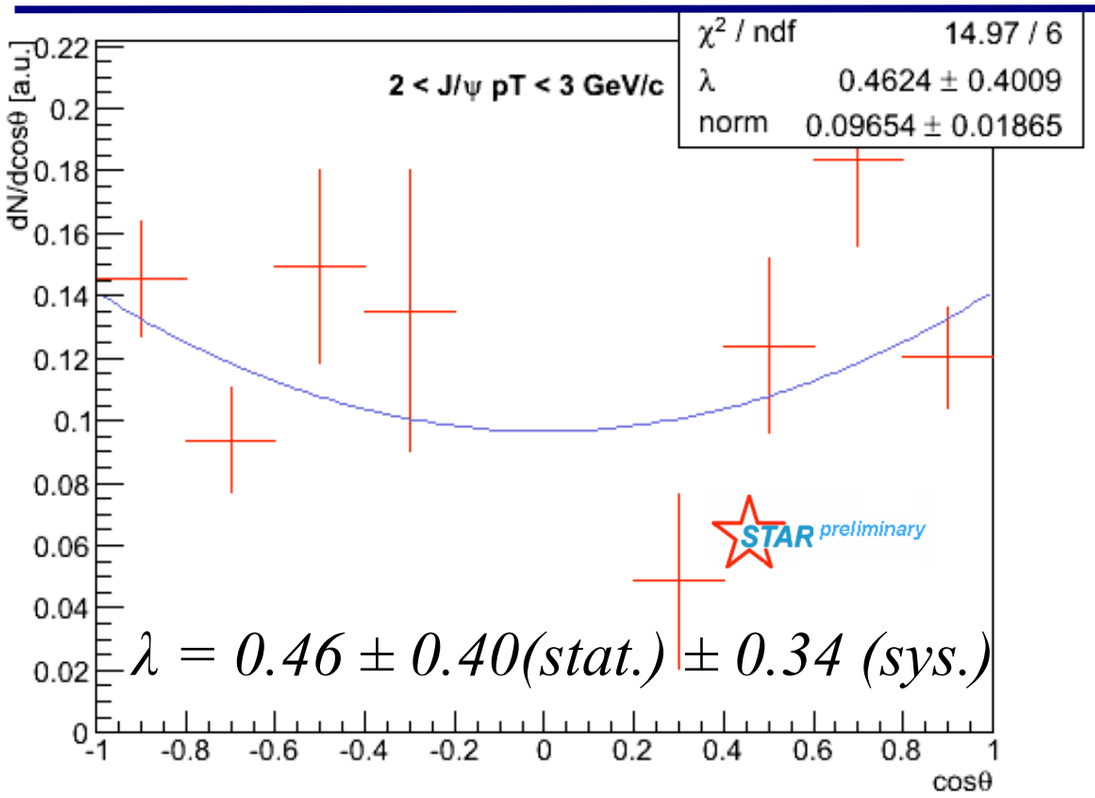






- raw cosθ distributions from data are divided by corrections distributions in each J/ψ p_T bin in order to get corrected cosθ distributions

corrected cosθ distributions



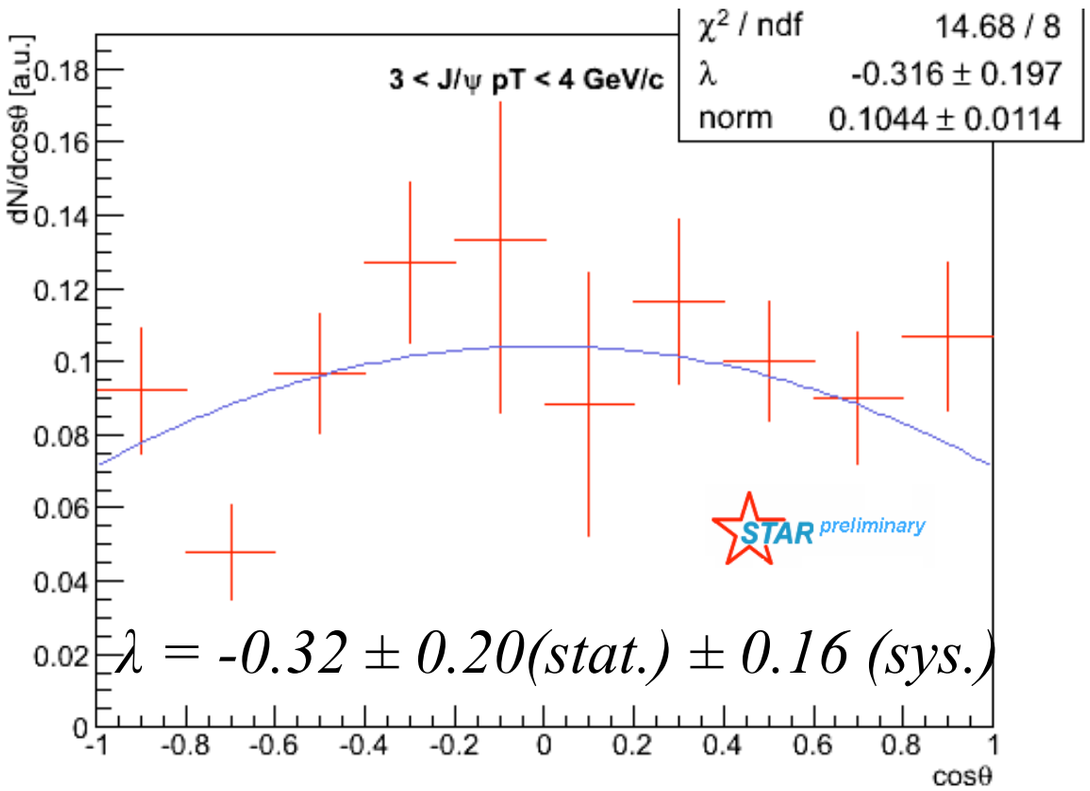
- J/ψ polarization parameter is obtained by fitting

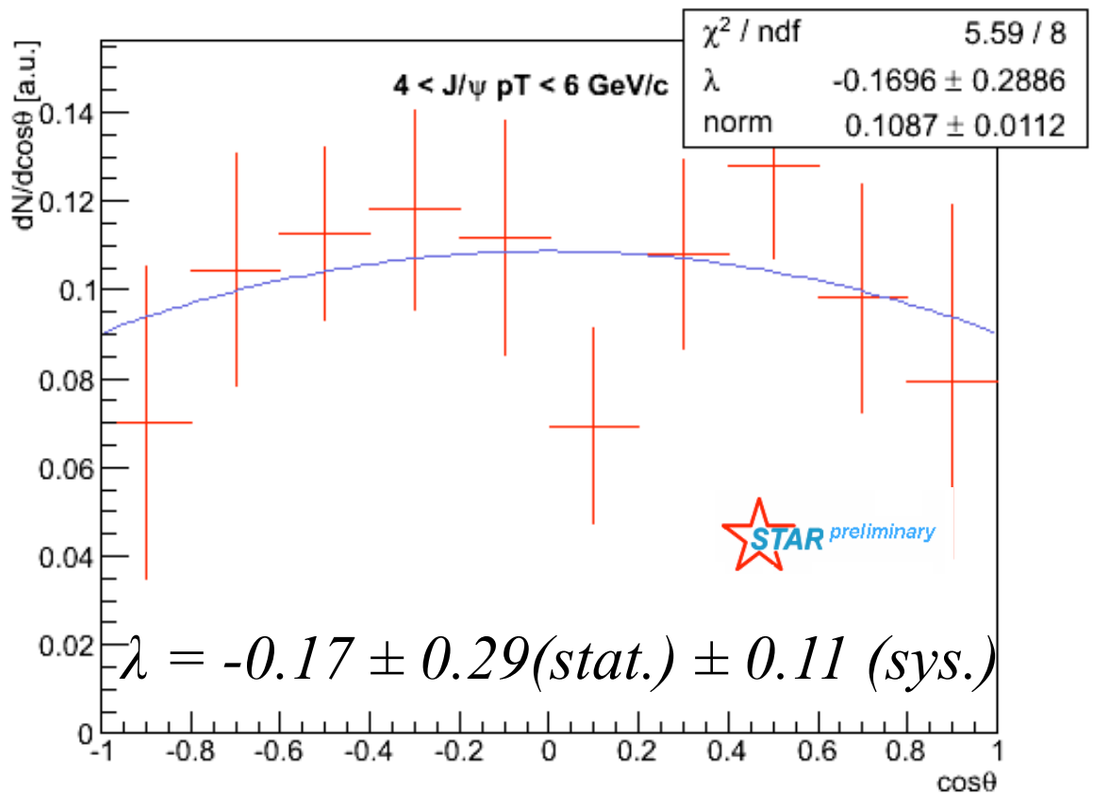
  norm(1+λcos²θ)

  function to corrected cosθ distributions from data

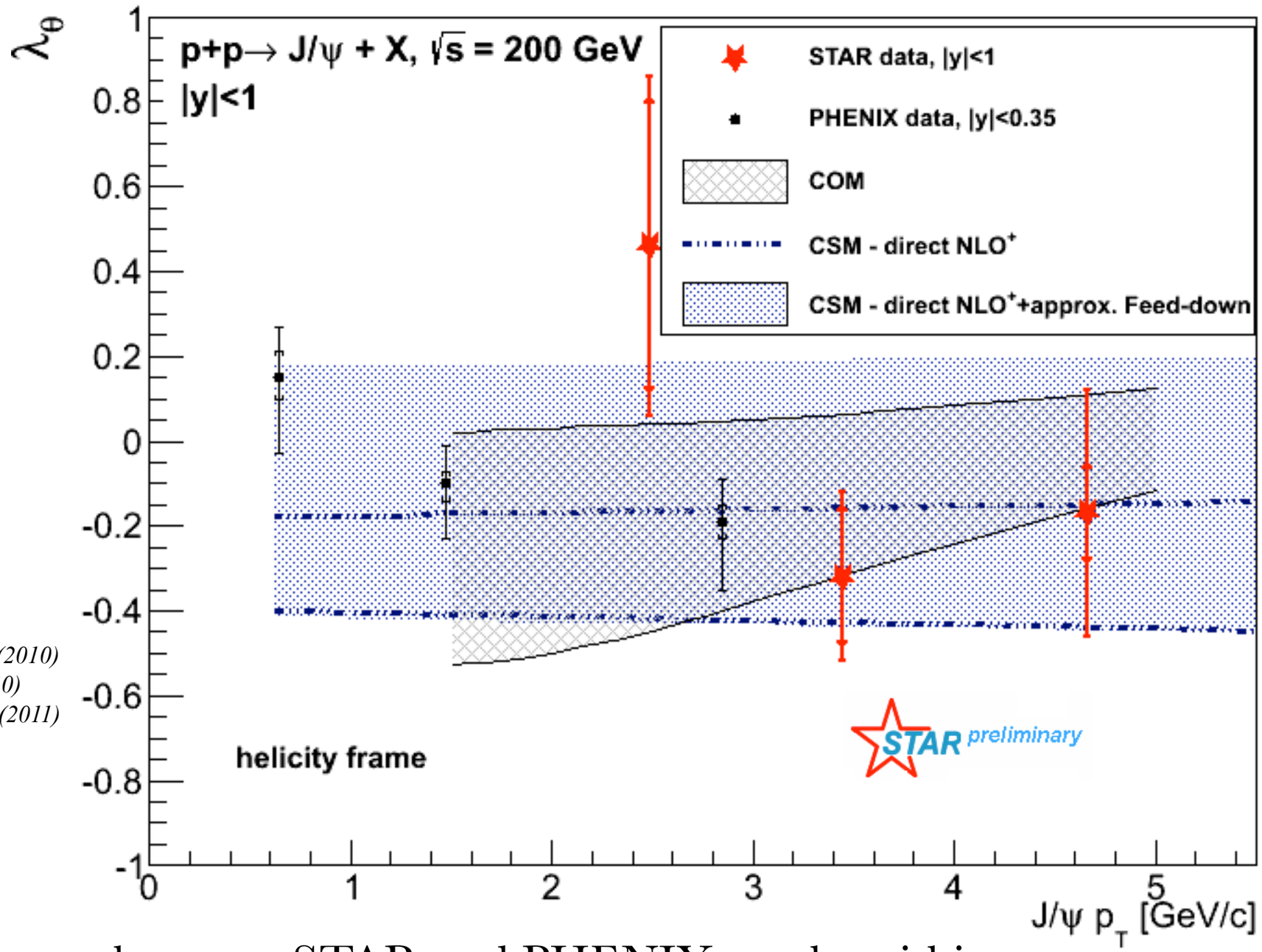
- polarization parameter λ is extracted in 3 J/ψ p_T bins: 2-3 GeV/c, 3-4 GeV/c and 4-6 GeV/c

- combinatorial background is subtracted





J/ψ polarization result



PHENIX: Phys. Rev. D 82, 012001 (2010)
COM: Phys. Rev. D 81, 014020 (2010)
CSM NLO+: Phys. Lett. B, 695, 149 (2011)

- consistency between STAR and PHENIX results within errors
- results are consistent with presented COM and CSM predictions

Summary

- J/ψ polarization measurement from STAR at mid-rapidity was shown.
- Polarization parameter λ was extracted in helicity frame in 3 J/ψ p_T bins.
- Obtained p_T dependent polarization parameter λ is consistent with NLO^+ CSM, COM models predictions and with no polarization within current uncertainties.
- Results are consistent with PHENIX polarization measurement at mid-rapidity.
- Systematic errors to be finalized.

Thank you !