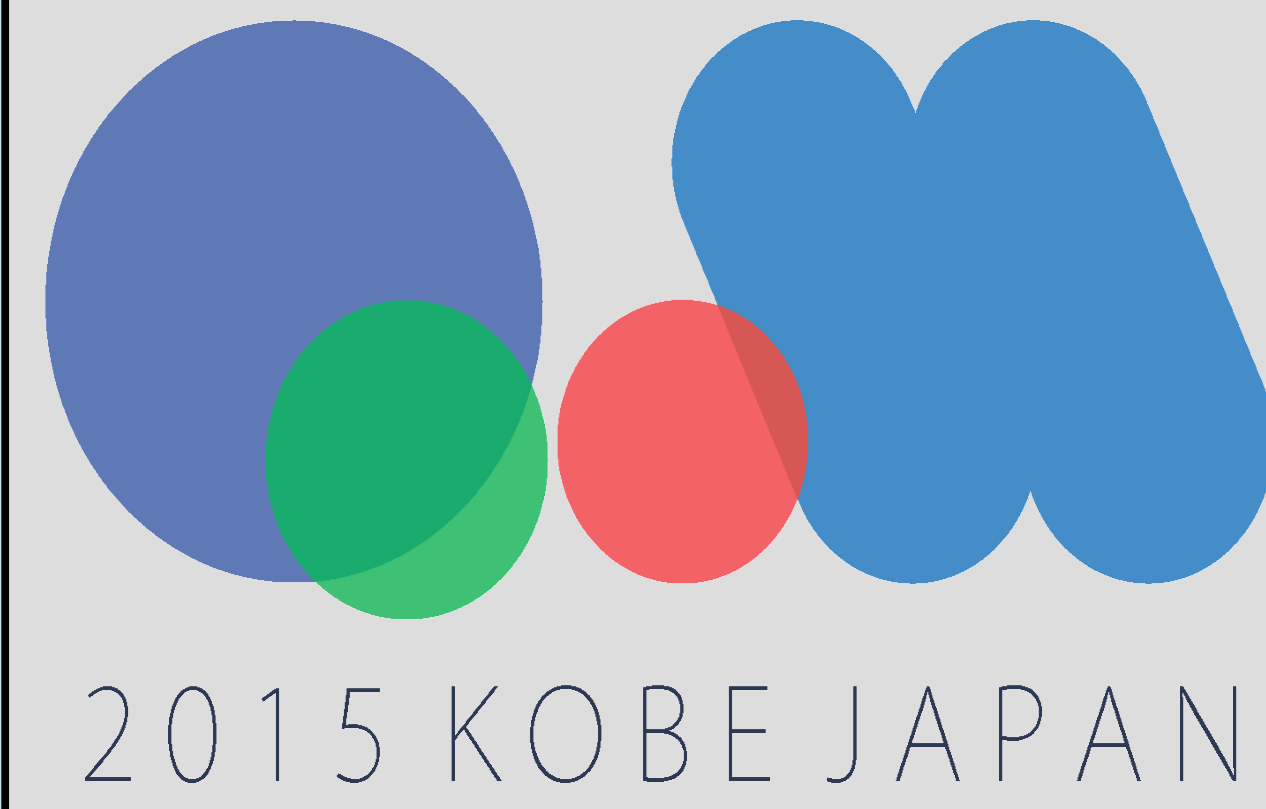


J/ψ polarization measurement in p+p collisions at $\sqrt{s} = 500$ GeV with the STAR experiment

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Abstract

Despite extensive studies, the J/ψ production mechanism in hadron collisions is not yet exactly known. Measurements of the J/ψ polarization provide constraints for the J/ψ production models and new insight into the J/ψ production mechanism. This poster presents a measurement of J/ψ polarization in p+p collisions at $\sqrt{s} = 500$ GeV in the STAR experiment. The measurement has been performed in a wide transverse momentum range of $5 < p_T < 16$ GeV/c. Two polarization parameters λ_θ and λ_ϕ , related to the polar and azimuthal anisotropy respectively, have been extracted in the helicity and Collins-Soper reference frames. The frame invariant parameter, λ_{inv} , has also been determined in these two frames.

Dataset and cuts

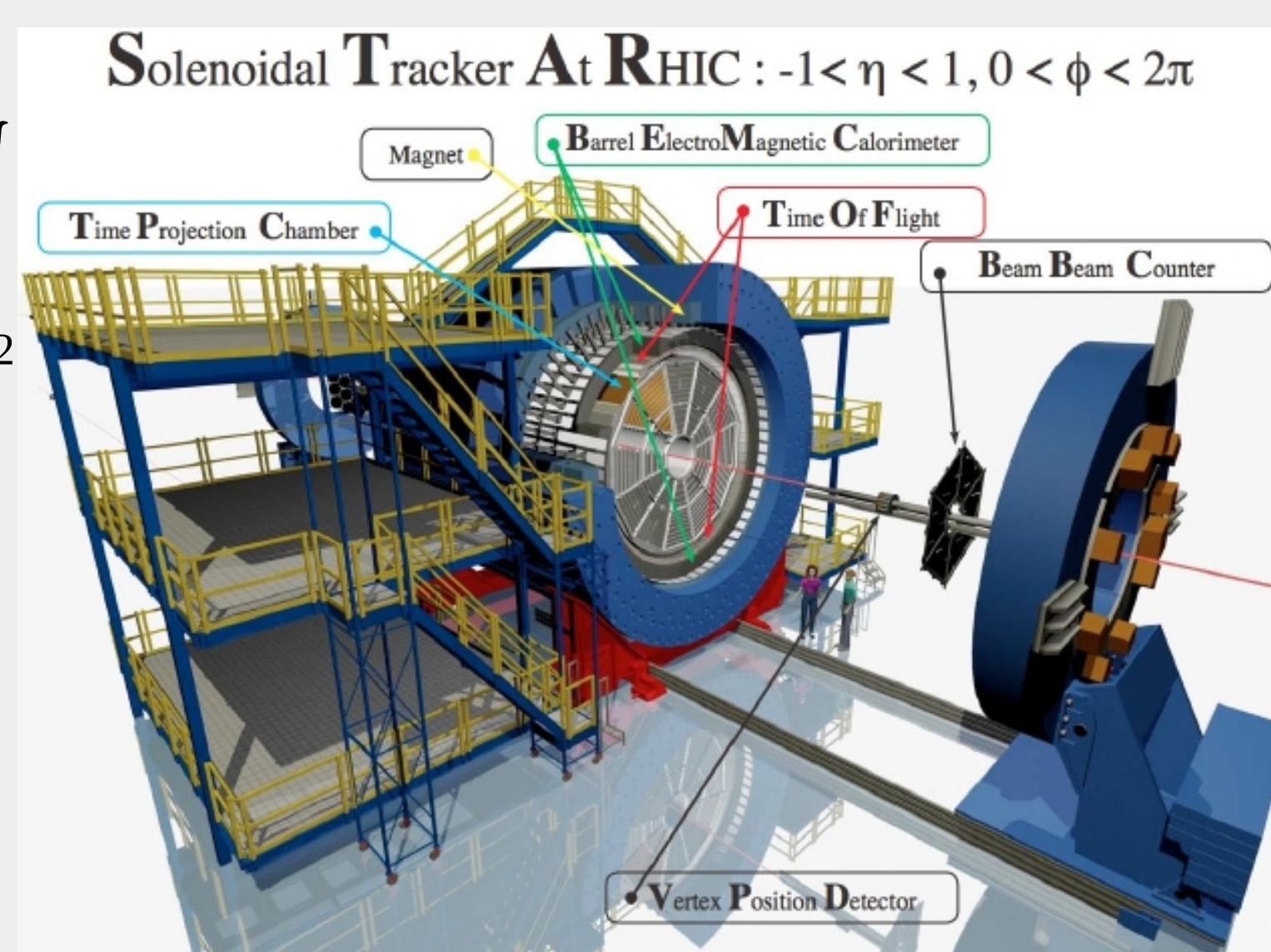
$$J/\psi \rightarrow e^+e^- \text{ (BR 5.9\%)}$$

- p+p collisions at $\sqrt{s} = 500$ GeV from the year of 2011
- High Tower Trigger – transverse energy in a BEMC tower $E_T > 4.3$ GeV
- Integrated luminosity ~ 22 pb⁻¹
- At least one electron from the J/ψ decay is required to fire the trigger

J/ψ mass window: 2.8 – 3.3 GeV/c²

Electron kinematic cuts:

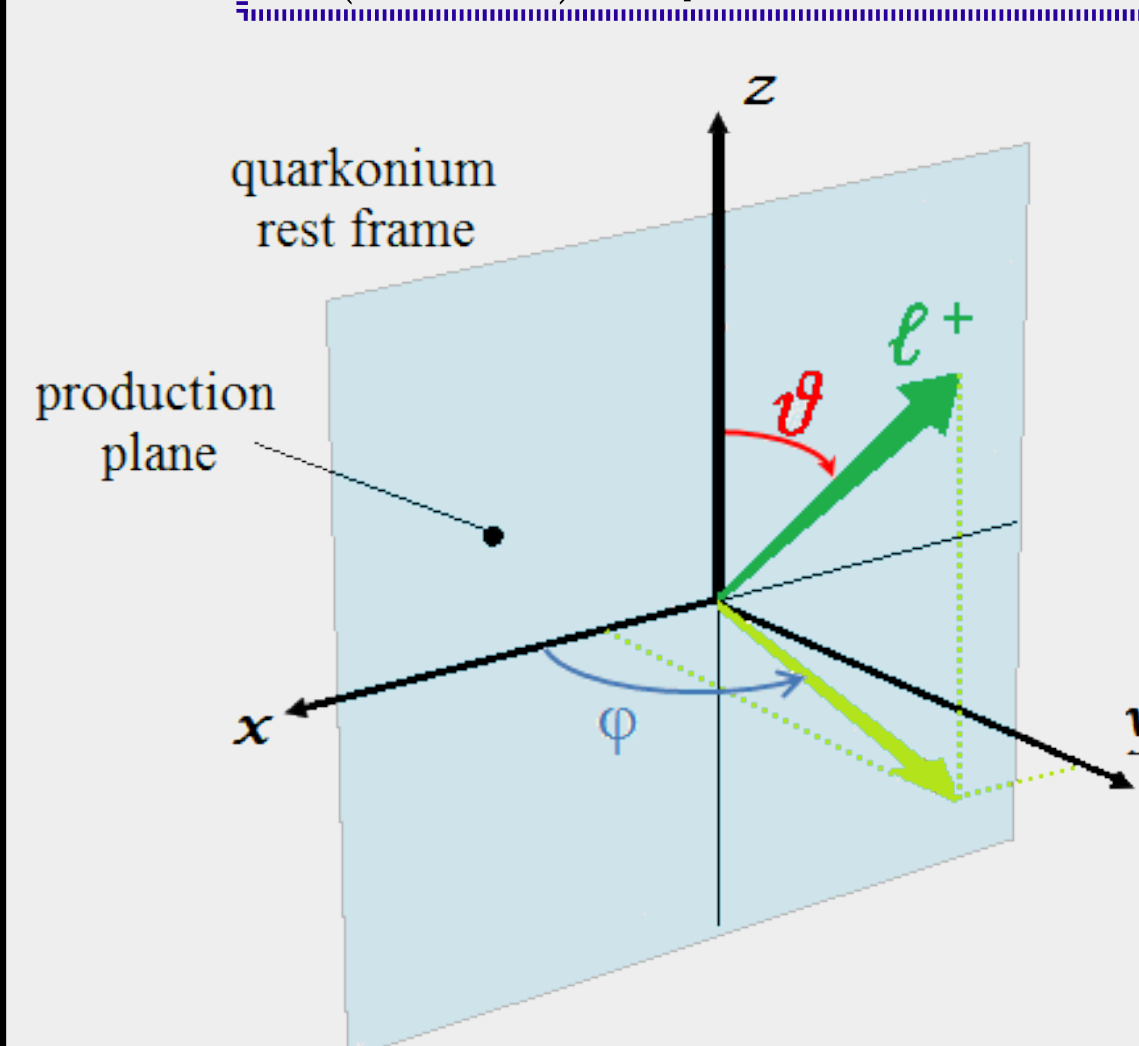
- ✓ $p_T > 0.3$ GeV/c
- ✓ $|\eta| < 1$
- ✓ $p_T > 3.5$ GeV/c - for electron from J/ψ decay that fired the trigger



Method

→ Angular distribution of a lepton pair from the J/ψ decay:

$$\frac{d^2 N}{d(\cos\theta)d\phi} \propto 1 + \lambda_\theta \cos^2\theta + \lambda_\phi \sin(2\theta)\cos\phi + \lambda_\psi \sin^2\theta \cos(2\phi)$$



✓ θ - polar angle between the momentum of a positive lepton in the J/ψ rest frame and the polarization axis z

✓ ϕ - corresponding azimuthal angle

→ **Polarization z axis:**

✓ **Helicity (HX) frame:** along the J/ψ momentum in the center of mass of the colliding beams

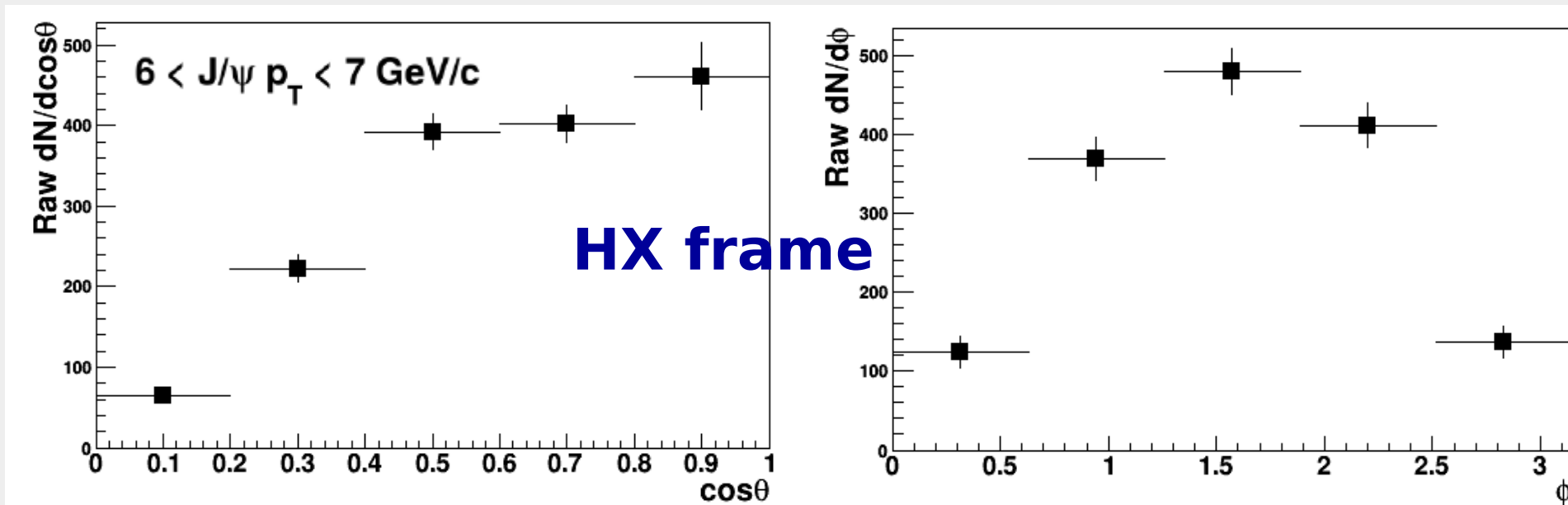
✓ **Collins-Soper (CS) frame:** bisector of the angle formed by one beam direction and the opposite direction of the other beam in the J/ψ rest frame

→ **Frame invariant parameter**

$$\lambda_{inv} = \frac{\lambda_\theta + 3\lambda_\phi}{1 - \lambda_\psi}$$

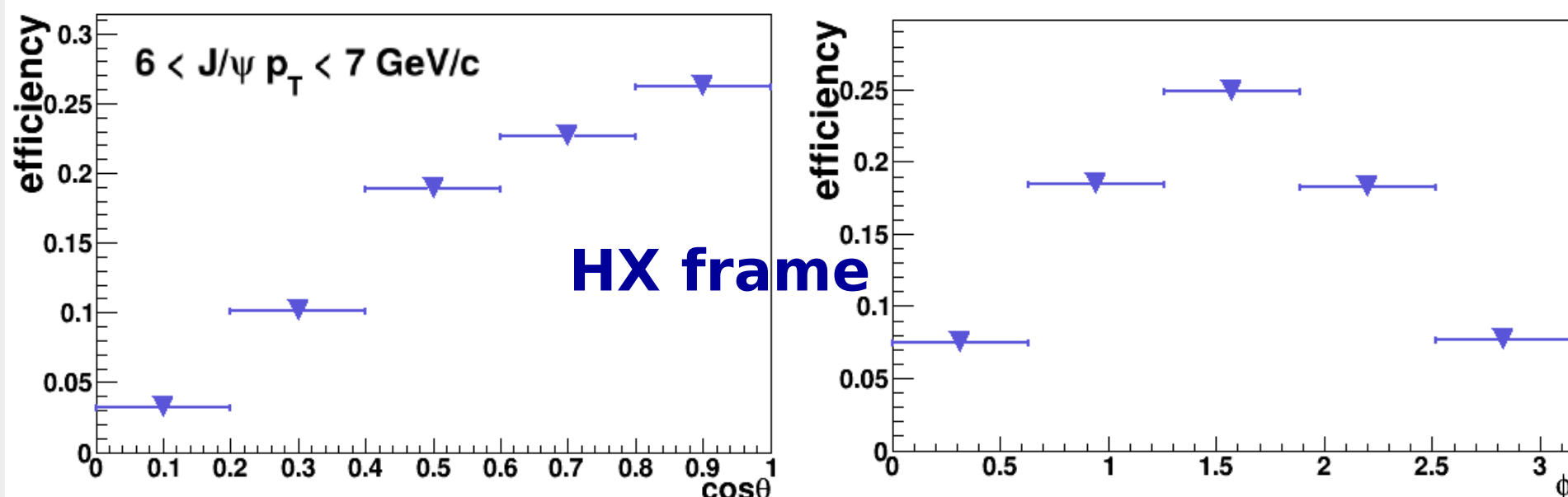
Good cross-check on measurements performed in different frames [1]

Raw $\cos\theta$ and ϕ , and corrections



✓ J/ψ signal obtained using bin counting method in each $\cos\theta$ and ϕ bin, in 5 p_T bins and in HX and CS frames

✓ Combinatorial and correlated backgrounds subtracted

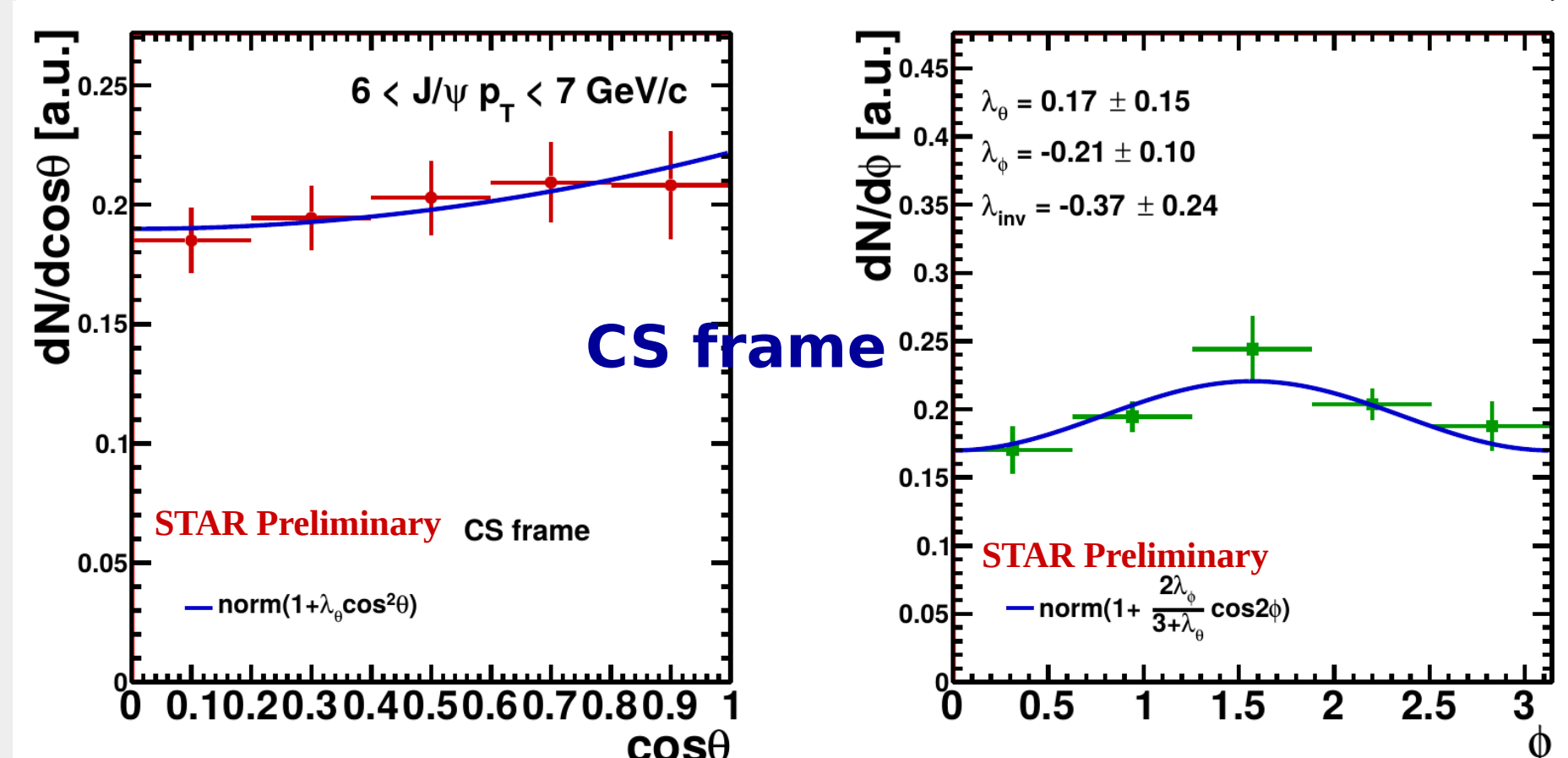
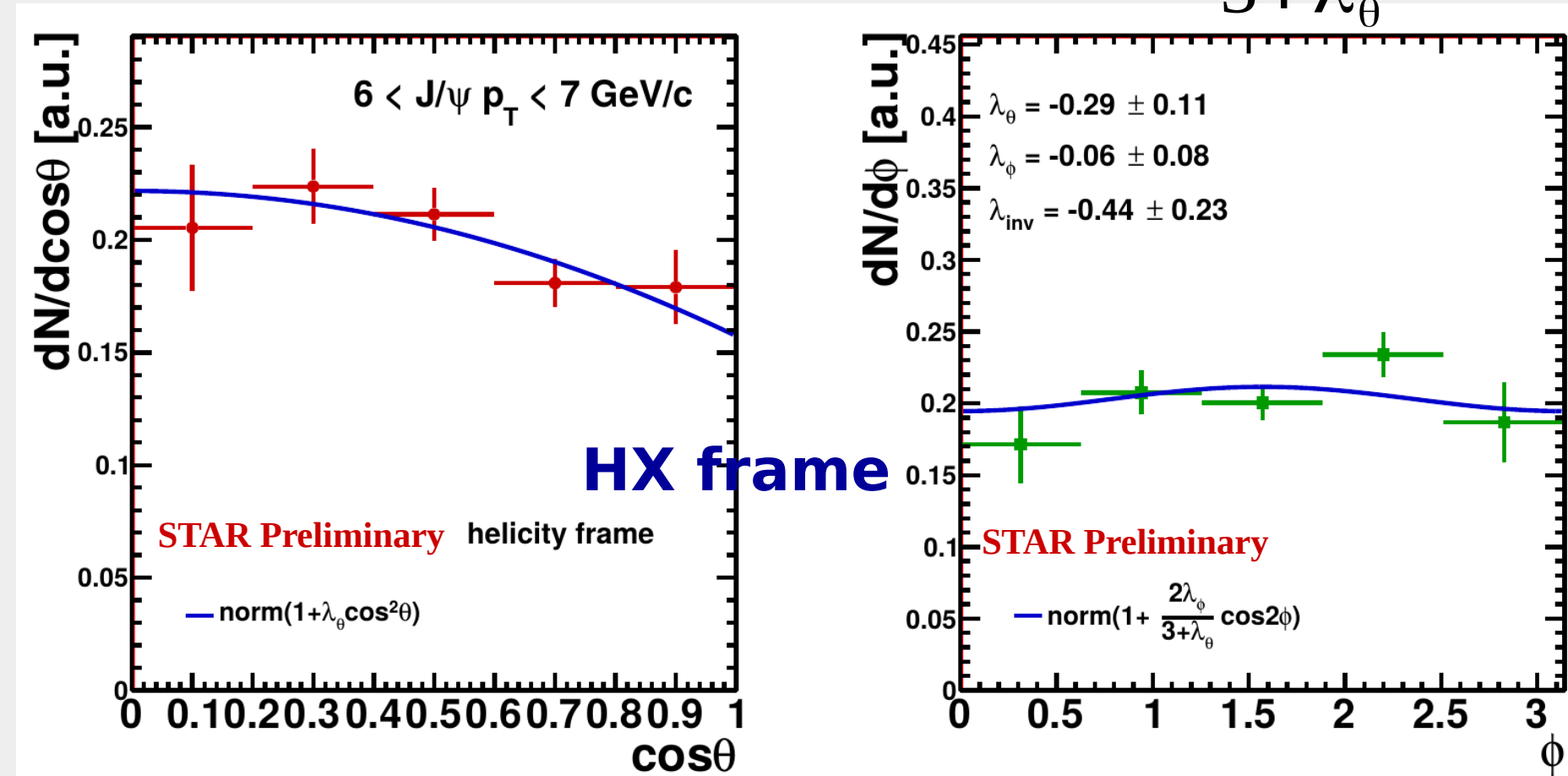


✓ Total corrections include: acceptance, tracking, electron identification and trigger efficiencies, obtained using MC simulations with input $\cos\theta$ and ϕ distributions obtained from the data

Corrected $\cos\theta$ and ϕ distributions in HX and CS frames

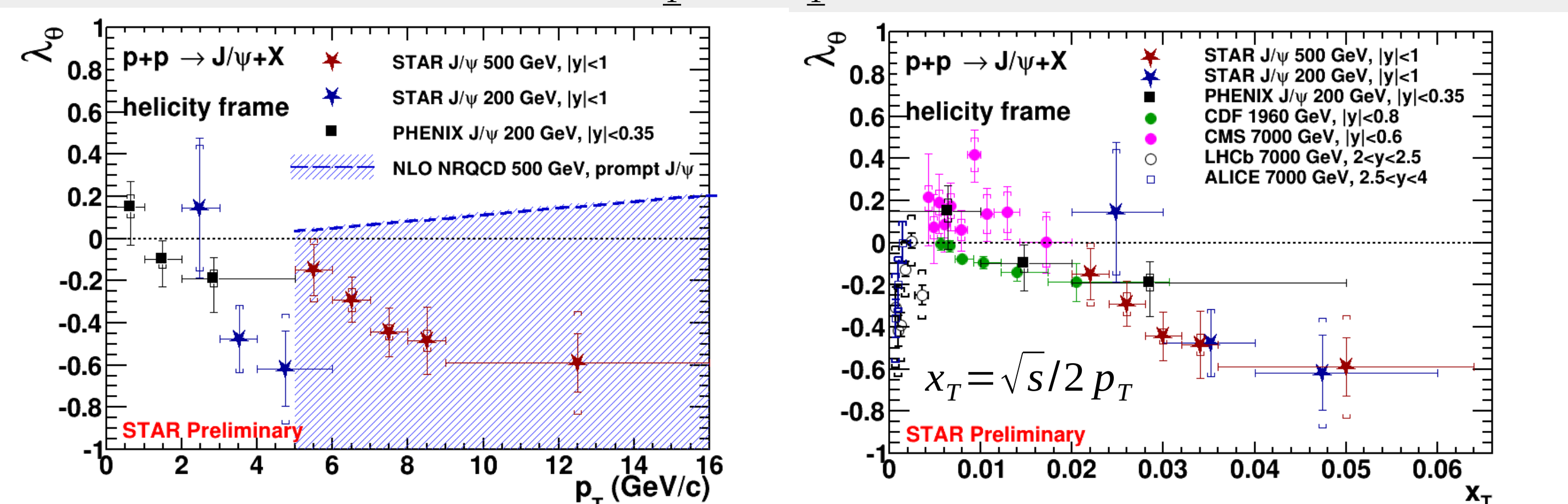
✓ Simultaneous fit to $\cos\theta$ and ϕ distributions

$$W(\cos\theta) \propto 1 + \lambda_\theta \cos^2\theta \quad W(\phi) \propto 1 + \frac{2\lambda_\phi}{3 + \lambda_\theta} \cos 2\phi$$



Results

→ λ_θ parameter in HX frame vs p_T and x_T

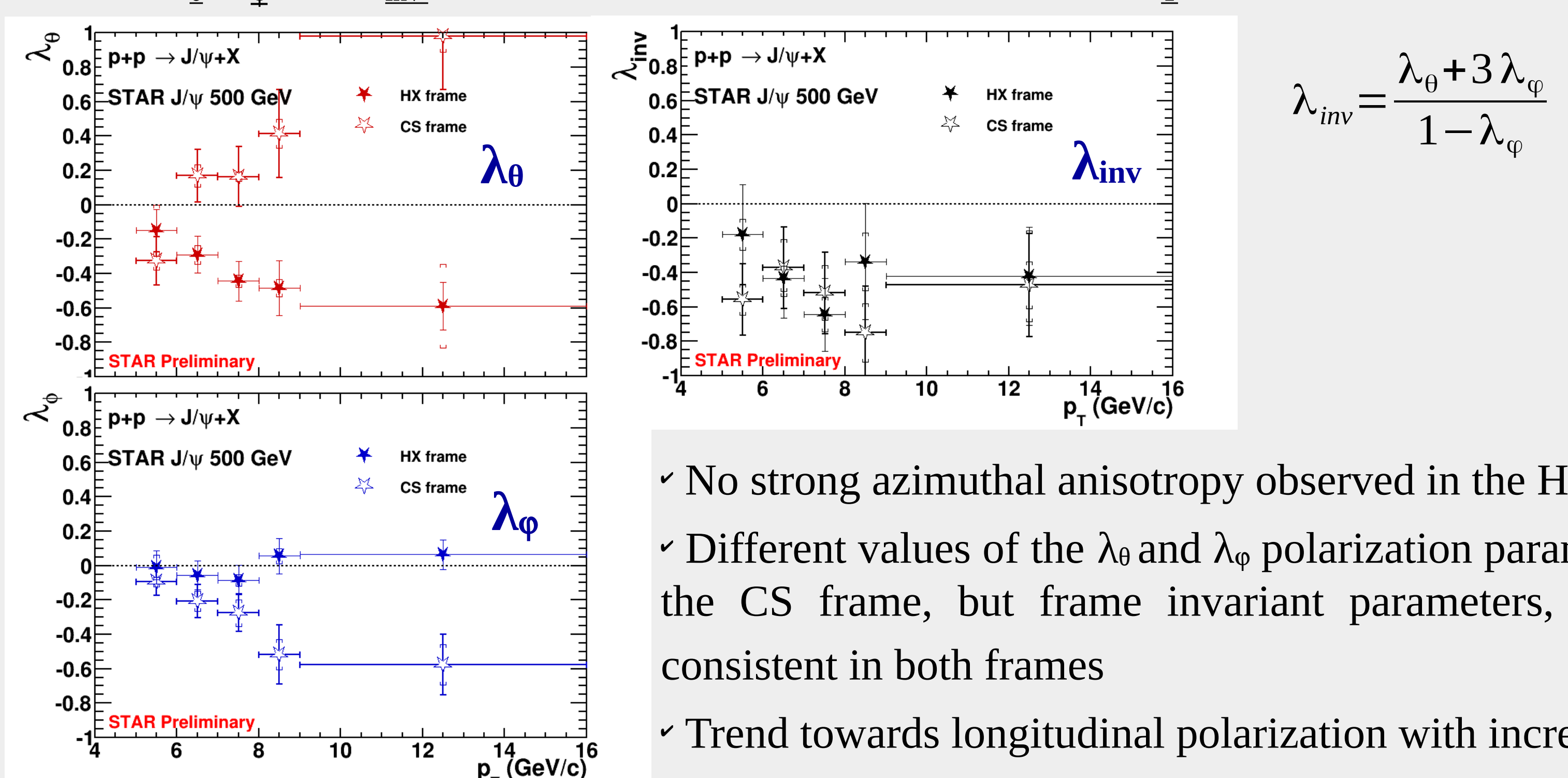


✓ Similar trend observed in 500 and 200 GeV [2] p+p collisions in the HX frame

✓ Common trend of results from different experiments which is towards longitudinal polarization with increasing x_T

✓ Data can help to constrain Color-Octet Long-Distance Matrix Elements for NRQCD [3]

→ λ_θ , λ_ϕ and λ_{inv} parameters in HX and CS frames vs p_T



- ✓ No strong azimuthal anisotropy observed in the HX frame
- ✓ Different values of the λ_θ and λ_ϕ polarization parameters in the CS frame, but frame invariant parameters, λ_{inv} , are consistent in both frames
- ✓ Trend towards longitudinal polarization with increasing p_T

Conclusions

→ Longitudinal J/ψ polarization in the HX frame at $\sqrt{s} = 500$ GeV

- No strong azimuthal anisotropy observed
- x_T dependence of λ_θ observed

→ Frame invariant parameters agree in the HX and CS frames

[1] Eur. Phys. J. C 69, 657 (2010)
 [2] Phys. Lett. B 739, 180 (2014)
 [3] Phys. Rev. Lett. 108 (2012) 242004, Phys. Rev. D 90 (2014) 1, 014002, Phys. Rev. Lett. 112 (2014) 18, JHEP 1505 (2015) 103 and private communication

