Proposed J/ψ Polarization Study for Run-4 AuAu / pp Data

Hai Qu, Gobinda Mishra, Xiaochun He

Georgia State University

6/21/2004

Contents

- Parameterization for J/ψ polarization measurement
- J/ψ rest frames
- Analysis procedure
- Expectation from Run4
- Further Work

Introduction

J/ψ polarization measurement is done through the study of the angular distribution of one of the decay muon in the J/ψ rest frame.

Several efforts (see an161 & an269) have been made to explore the possibility for extracting J/ψ polarization for Run-3 data.

With the large number of events taken in Run 4, we may have a good shot to be able to quantitatively study J/ψ polarization.

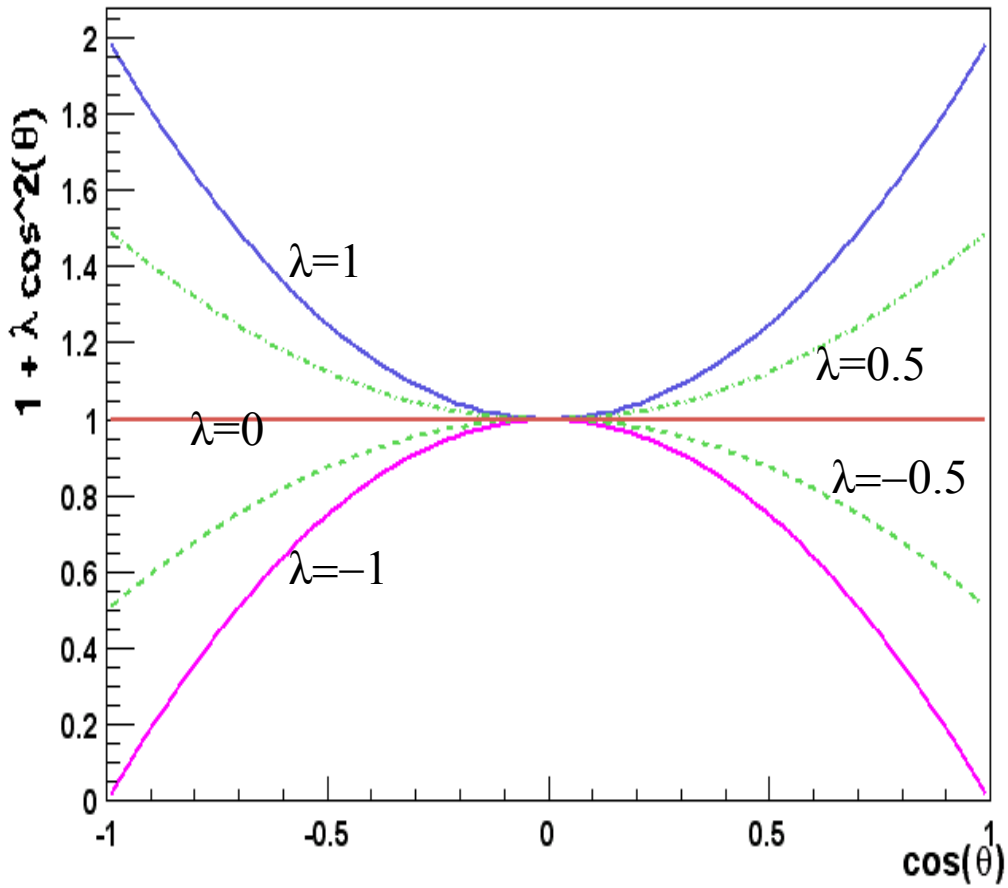
Angular Distributions

Angular distribution of muon pair in J/ψ rest frame is commonly parametrized as follows:

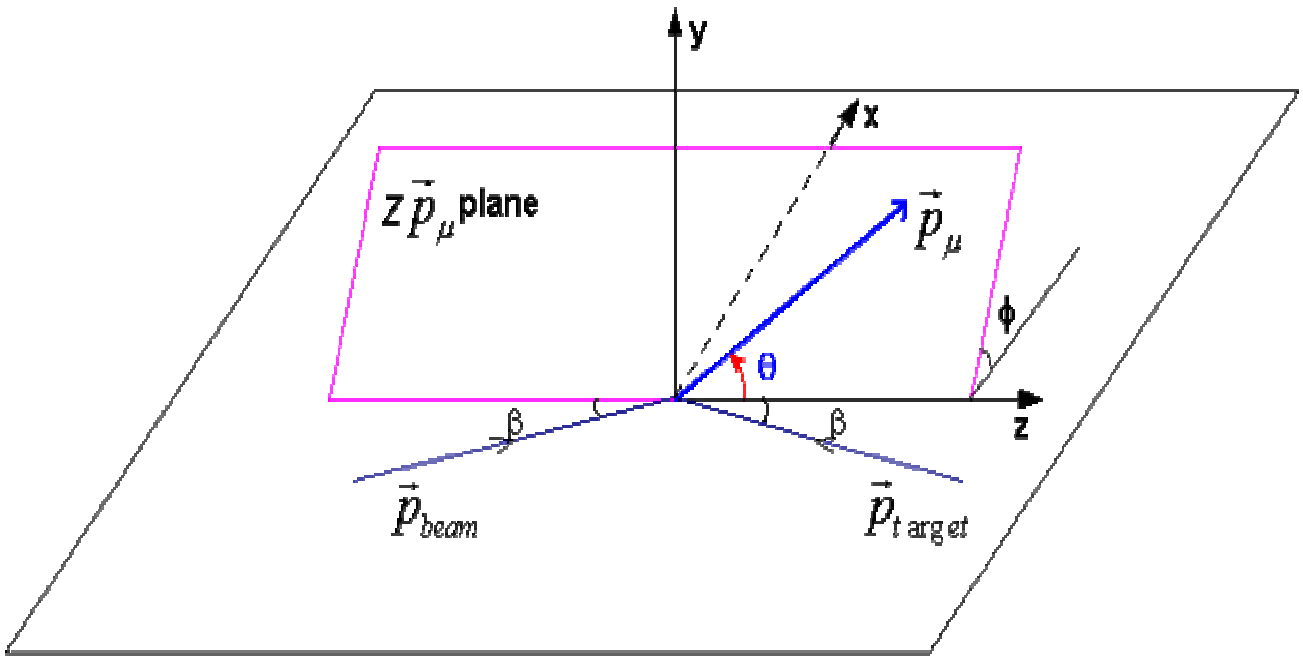
$$\frac{d\sigma}{d\cos\theta} \sim 1 + \lambda \cos^2\theta$$

λ < 0 Longitudinal
λ = 0 Unpolarized
λ > 0 Transverse

Where θ is the angle between one of the muon with the z-axis in the J/Psi rest frame. We can choose different frame with z-axis.

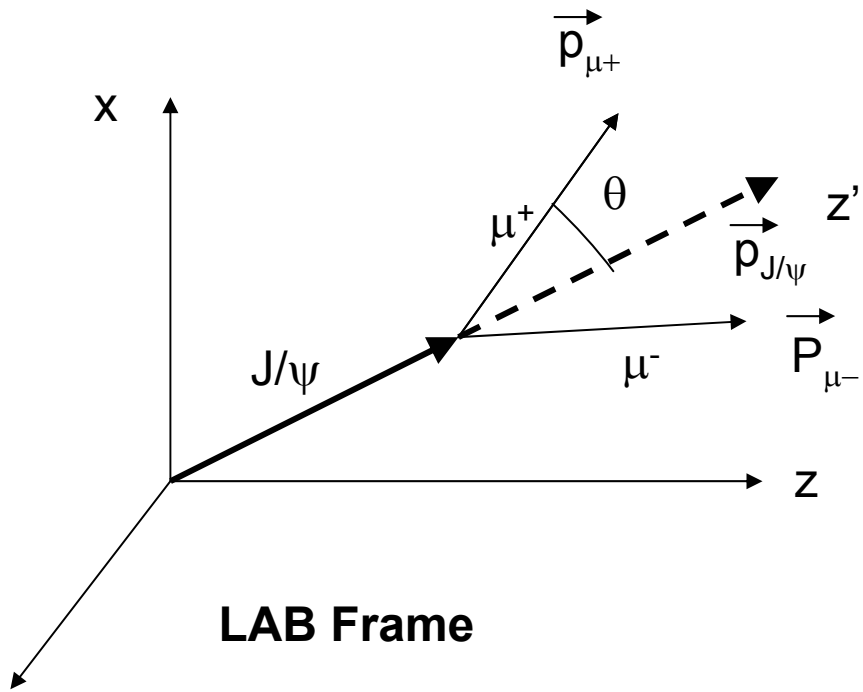


Collins-Sopper Frame – Used in an161 & 269



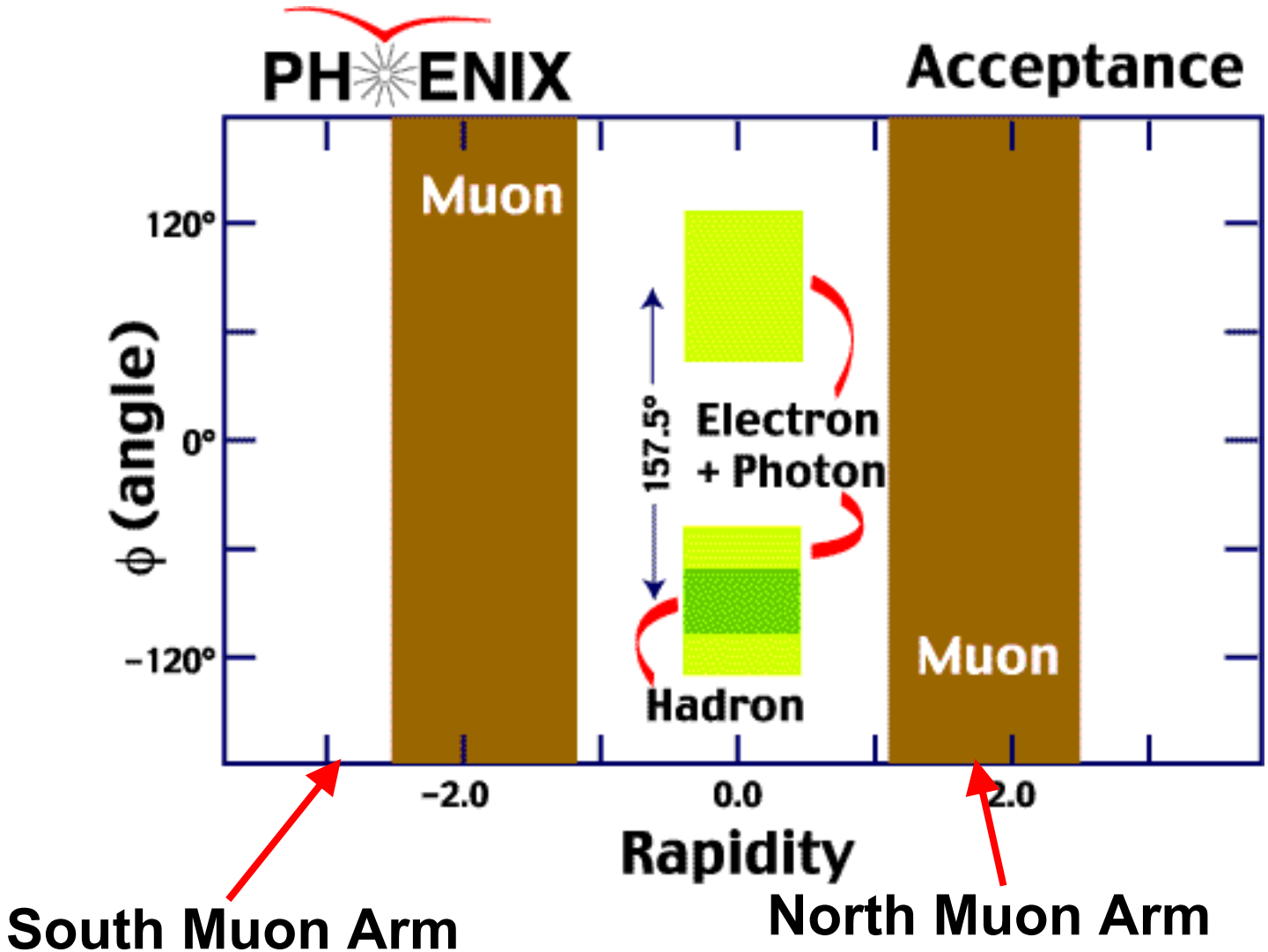
z-axis is chosen along the bisector of P_{beam} and $-P_{target}$ seen in this rest frame

Helicity Frame

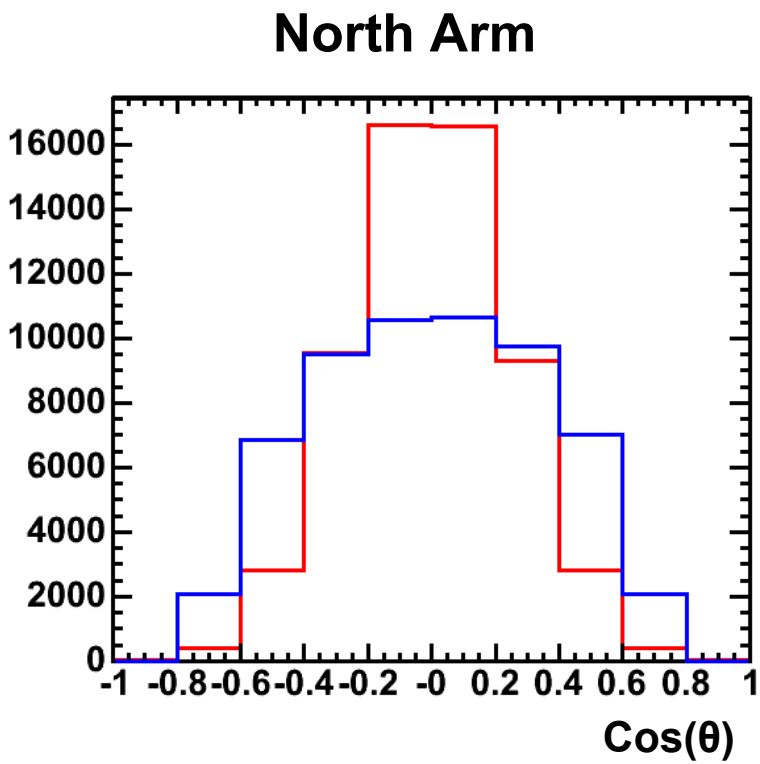


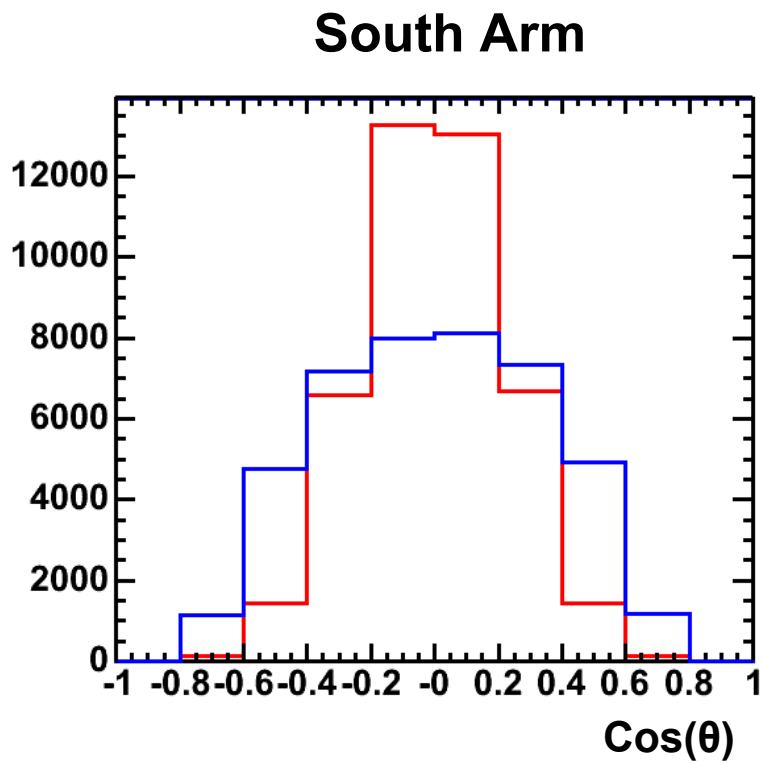
Z-axis is chose along the momentum of J/ψ in lab frame (or hadronic CMS frame)

PHENIX Muon Arm Acceptance



Flat cosθ distribution within detector acceptance



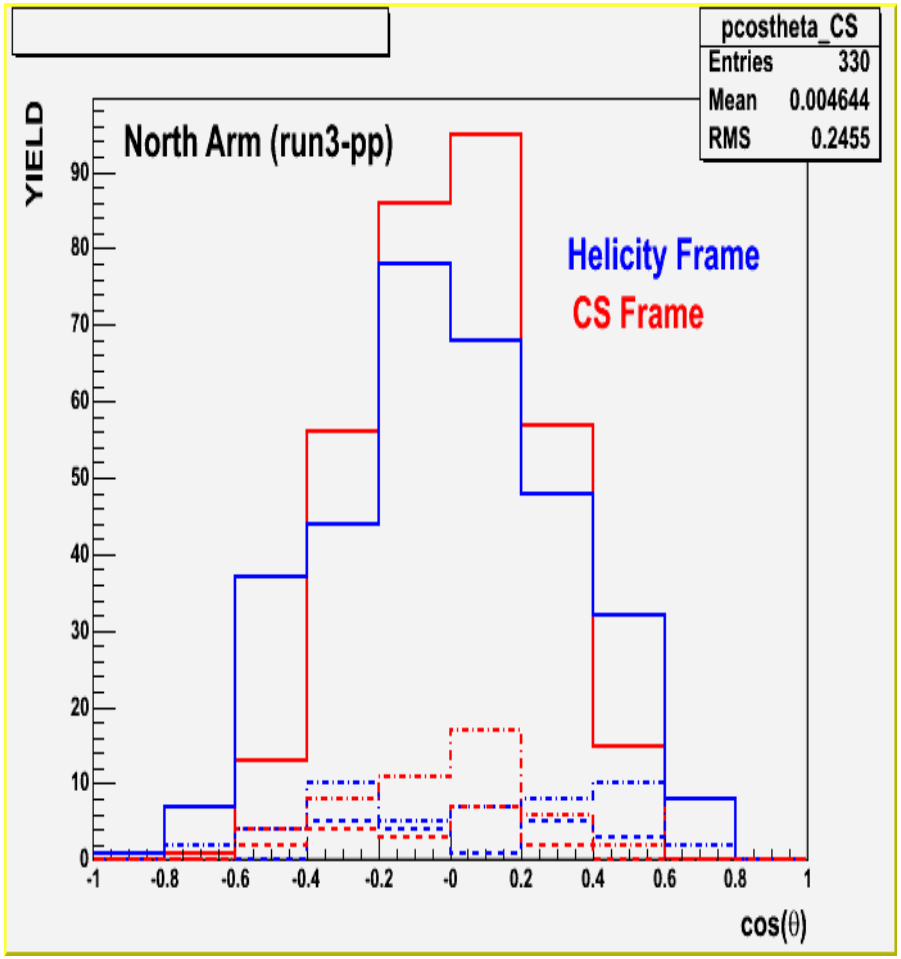


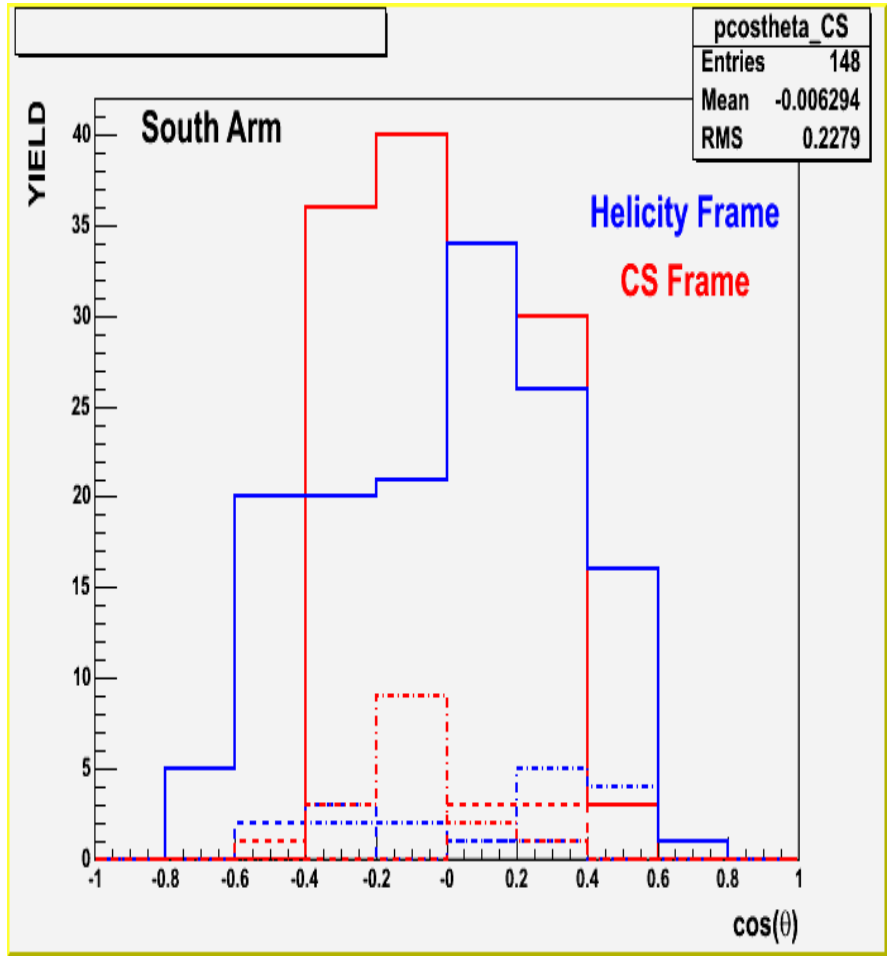
1M pure J/Psi MC events (CS/ helicity frame)

Run3 pp data selection

- Data sample comes from official run3 pp nanodst with following cuts:
  - Rapidity $1.2 < y < 2.4$ (north) , $-2.2 < y < -1.2$(south)
  - Vertex $|z| < 38$ cm
  - Single track selection $\chi^2 < 20$
  - Invariant Mass $2.65\text{GeV} < M < 3.73\text{GeV}$

Uncorrected cosθ distribution from run3 pp data





Analysis Procedure

- Detector acceptance correction (Two-Stage Simulation)

$$F(\cos\theta) = \frac{DATA(\cos\theta, \phi, p_T, x_F)}{MC(\phi, p_T, x_F)}$$

1. Monte Carlo (MC1) events with flat p_T, x_F, ϕ and $\cos\theta$ are used to correct p_T and x_F distribution obtained from real data.
2. Monte Carlo events (MC2) with corrected p_T, x_F which generated with flat ϕ and $\cos\theta$ are used to calculate the final $\cos\theta$ distribution.

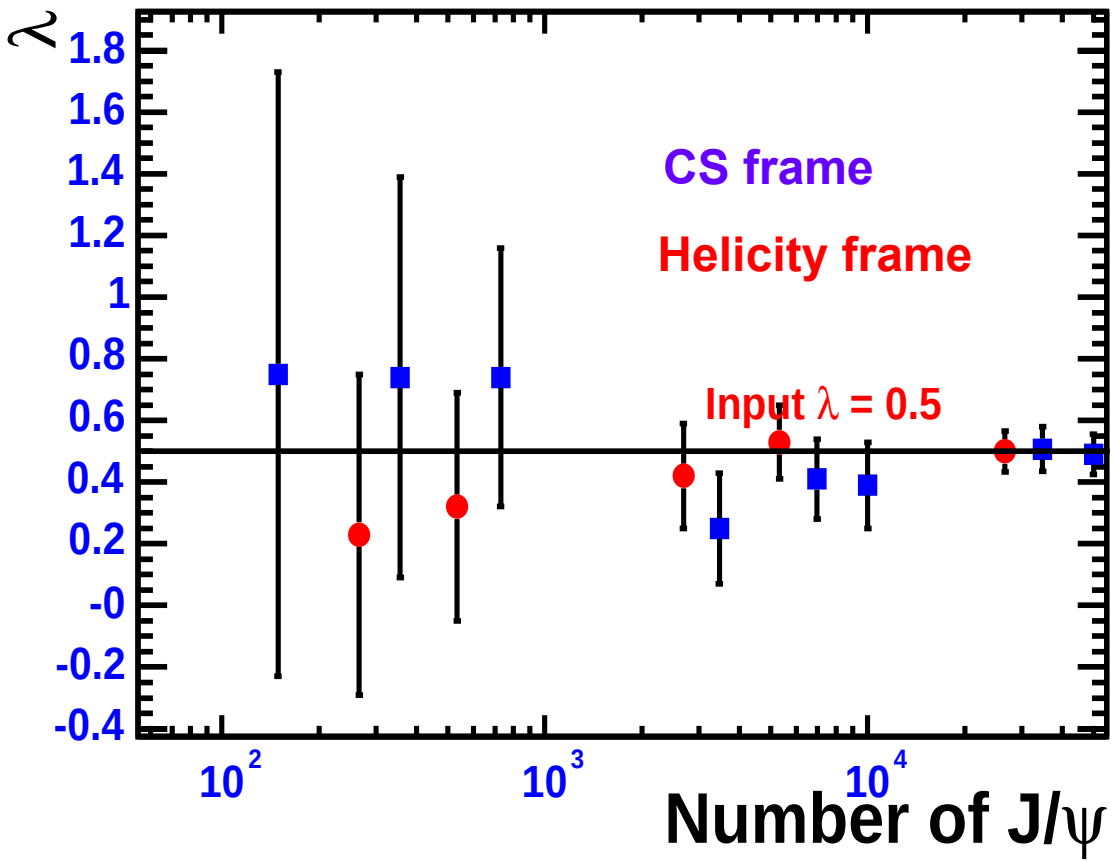
- All procedures go through whole muon offline analysis chain.

Phenix Analysis notes: an161 (XR Wang et al.)

Statistical Error Estimation

Here different number of Fake J/ψ data events were generated in PHENIX muon arm acceptance, and were acceptance corrected using very high statistics Monte Carlo events.

The acceptance corrected cosθ distribution were fitted by $1+\lambda\cos^2\theta$. The resulting λ with error are plotted vs number of fake data events.



Future Work

- Focus on Run4 data.
- Make vertex dependent event-by-event correction with mixed detector noise. This also requires that acceptance correction should be done in multi-dimensional bins (p_t, x_f, vertex slice and $\cos\theta$).
- Make reliable background subtraction.
- Extract polarization parameter.

Thank you

Back up

Physics Motivation

- J/ψ polarization measurement provides a crucial test for various quarkonium production mechanisms as different models predict different polarization.

  NRQCD factorization approach including the color octet mechanism predicts that the directly produced J/ψ will be increasingly transversely polarized at higher p_t. CDF experiment result doesn't agree with this prediction. (**PRL 85 (2000) 2888)**

  Color evaporation model predicts that J/ψ is unpolarized, because it assumes unsuppressed gluon emission from $c\bar{c}$ pair during hadronization, which randomizes spin and color. Fixed target experiments (E537,E672,E771, CIP, E866) showed unpolarized results.

- PHENIX detector has unique ability to study J/ψ production through $\mu^+\mu^-$ and e^+e^- decay channel. In the mean time, it also offers us a good opportunity to study J/ψ polarization