Measurement of J/Ψ Polarization via Dielectron Decay Channel in $\sqrt{s}_{NN}$ = 200 GeV d+Au and Au+Au Collisions by the PHENIX Experiment at RHIC

Alexandre Lebedev, Iowa State University
for the PHENIX Cllollaboration

- Motivation
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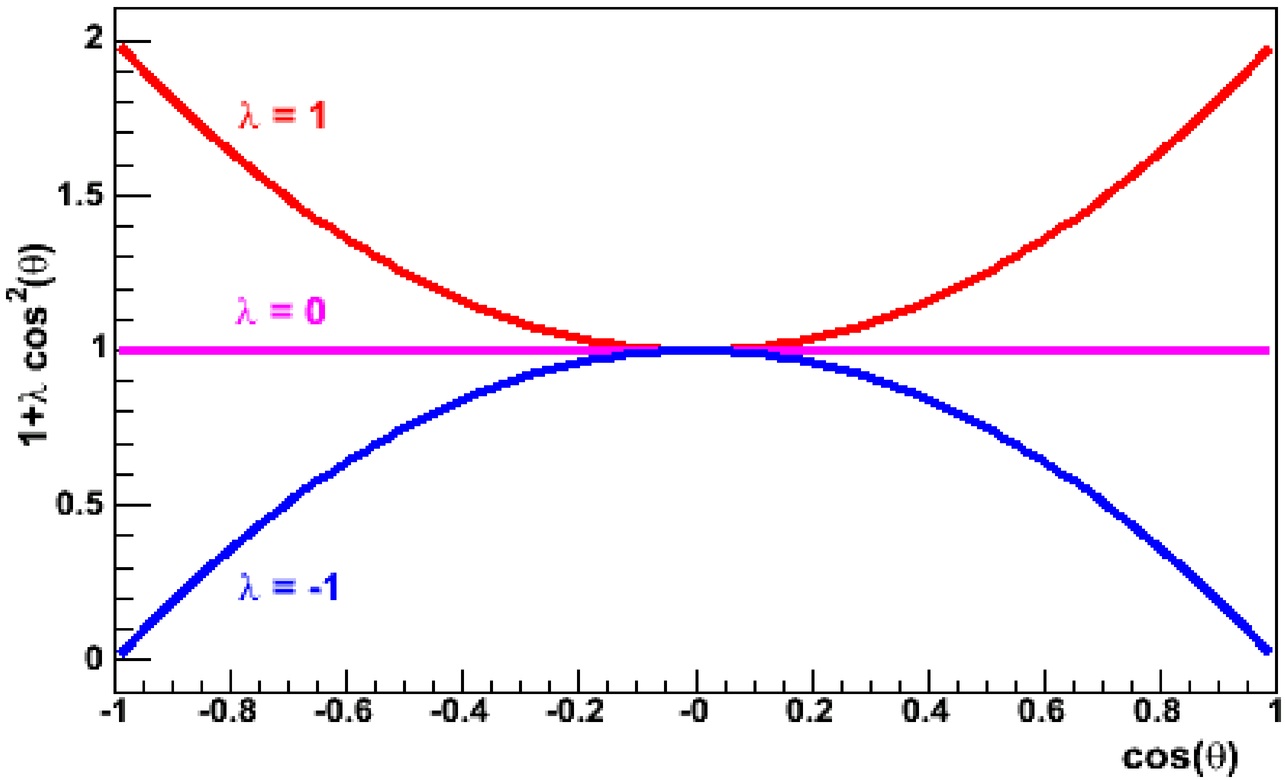
- d+Au measurement
- Au+Au measurement
- Conclusions

How polarization is measured?

J/Ψ polarization can be studied through the angular distributions of the decay lepton pairs. Angular distribution of the decay leptons is usualy parametrized as **$1+\lambda*\cos^2(\theta)$**, where θ is the angle between lepton momentum in the J/Ψ rest frame, and J/Ψ momentum in the lab frame.

In absence of polarization, this distribution should be uniform (λ=0). λ>0 is called transverse polarization, λ<0 is called longitudinal polarization.



Motivation

Polarization measurement is a powerful tool for understanding charmonium production mechanism.

CEM and CSM: no polarization

COM: transverse polarization at high P_T

NRQCD: transverse polarization at very high P_T (> 6 GeV/c)

Ioffe and Kharzeev, Phys.Rev. C68:061902, 2003:

transverse polarization (~0.35-0.40) at low P_T if QGP is formed

Khoze, Martin, Ryskin, and Stirling, Eur.Phys.J. C39:163-171, 2005:

transverse polarization at low P_T and longitudinal polarization at high P_T

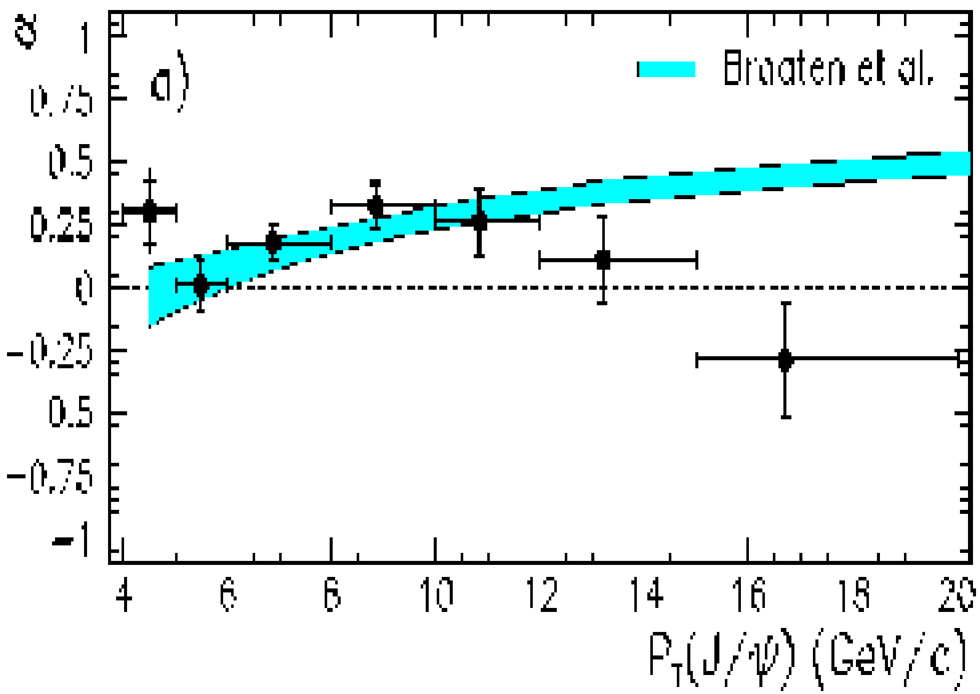
Measurement of polarization vs transverse momentum is important!

Motivation (continued)

Existing pp and pA polarization measutrements

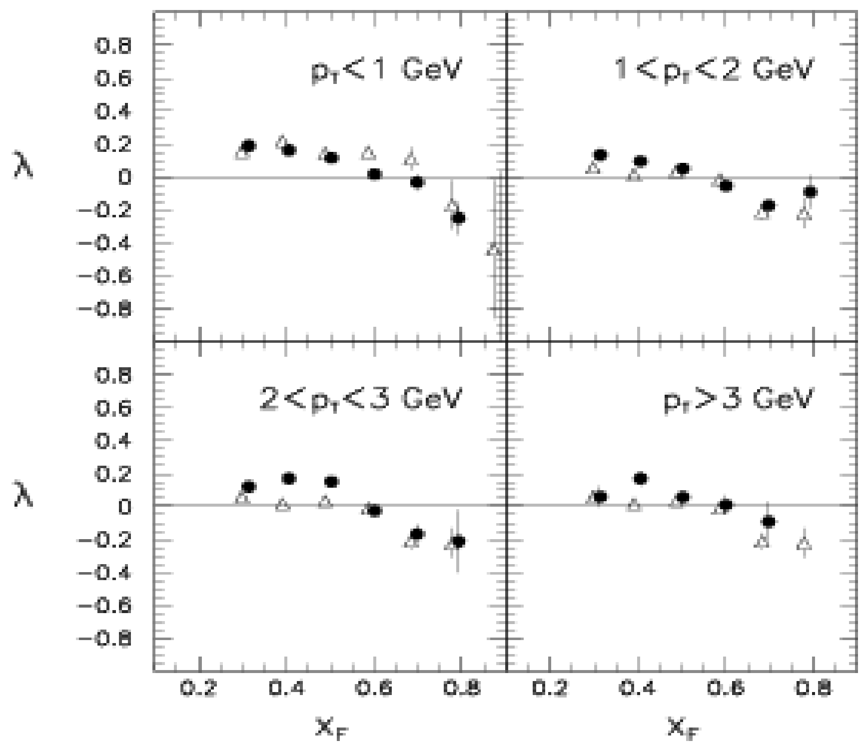
J/Ψ polarization in p+pbar @ 1.8 TeV

T.Affolder et al., (CDF Collaboration), Phys. Rev. Lett. 85(2000) p.2886.



J/Ψ polarization in p+Cu @ 800 GeV

T.H.Chang et al., (E866/NuSea) Phys. Rev. Lett. 91:211801, 2003



Acceptance calculation

Acceptance is calculated using detailed simulation

Single J/Ψ with flat distribution in P_T and rapidity are generated, and full detector simulation is done. Two ways to make acceptance correction:

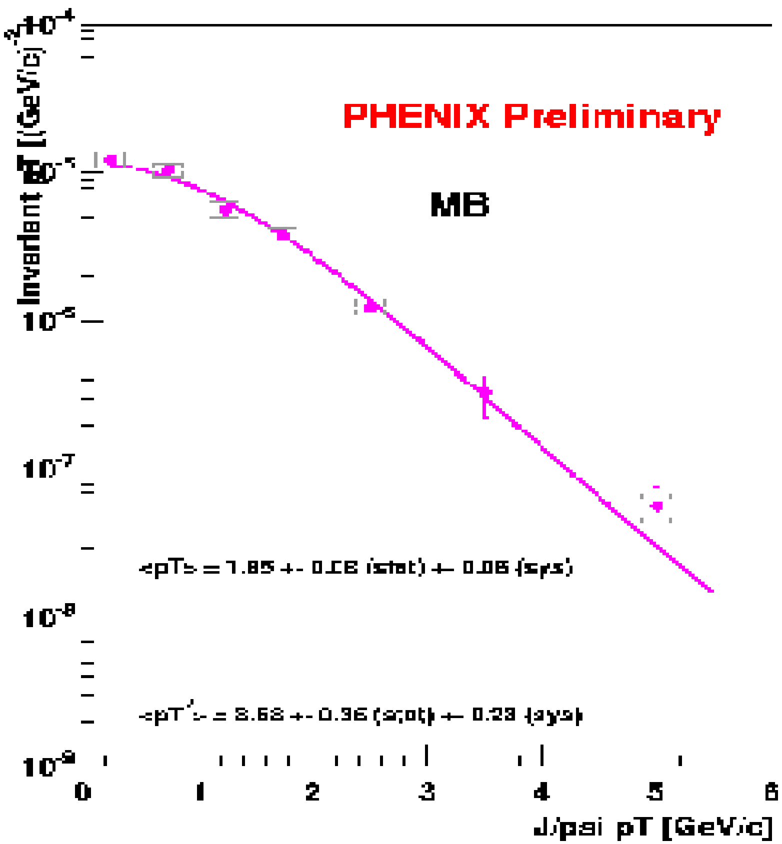
1) **Inclusive correction:** Acceptance is calculated using measured P_T and rapidity distributions as weights. Does not require a lot of simulations. But is sensitive to J/Ψ kinematics. Small statistical error, but non-negligible systematic error.

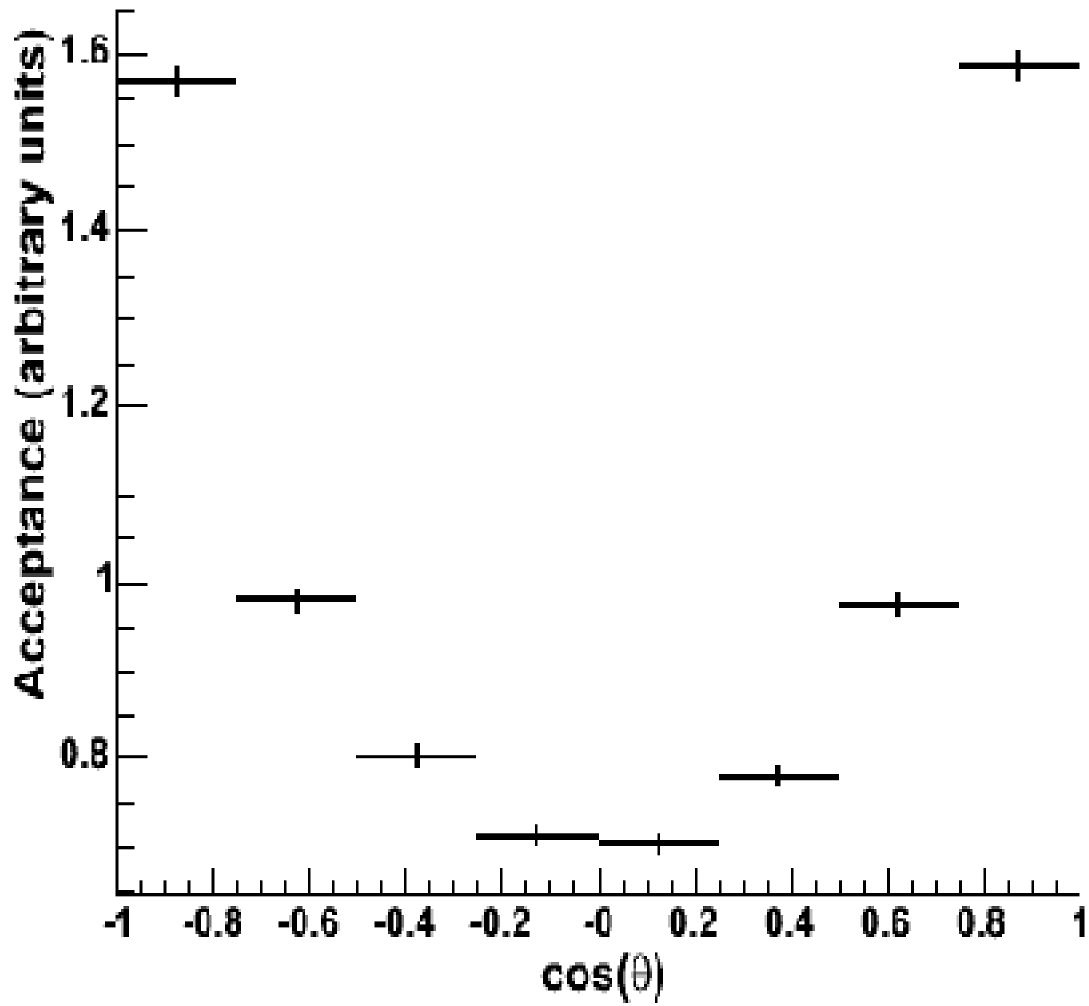
2) **Event-by-event correction.** Two-dimensional acceptance is calculated: P_T vs rapidity, and acceptance correction is made on event-by-event basis. Not sensitive to J/Ψ kinematics, but requires a lot of CPU time. Small systematic error, but each P_T vs rapidity bin has non-negligble statistical error.

Acceptance calculation (continued)

Both methods give the same results but we use the first one, because statistical error of the final result is better.

Acceptance is calculated using weights obtained from the fits to the experimental results.

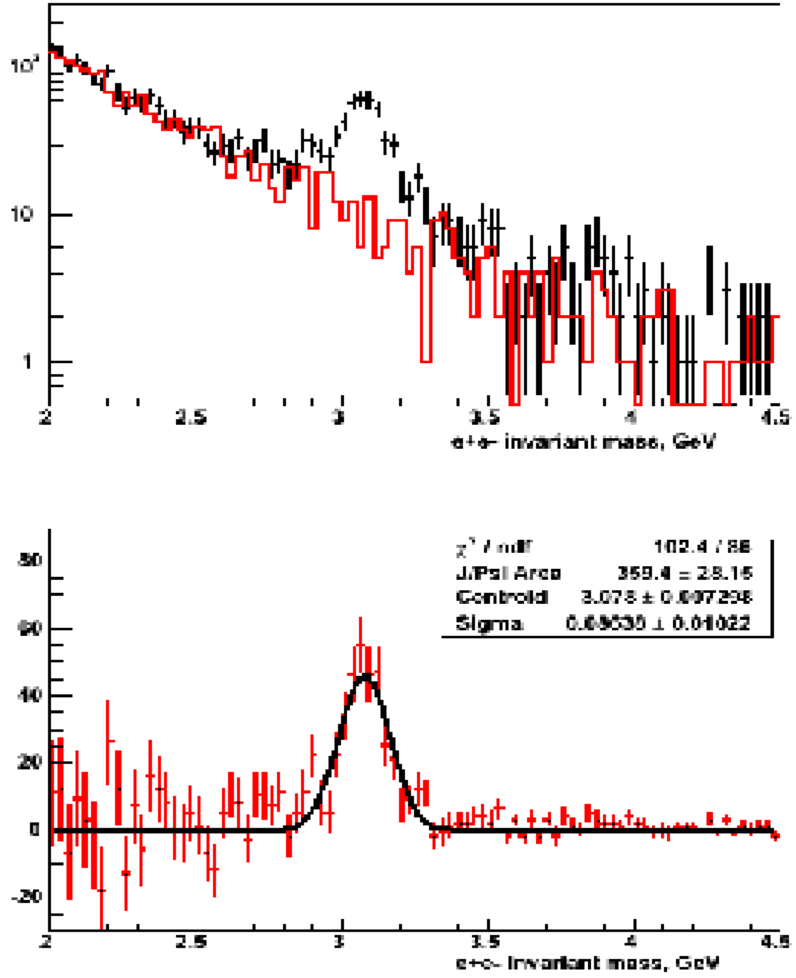




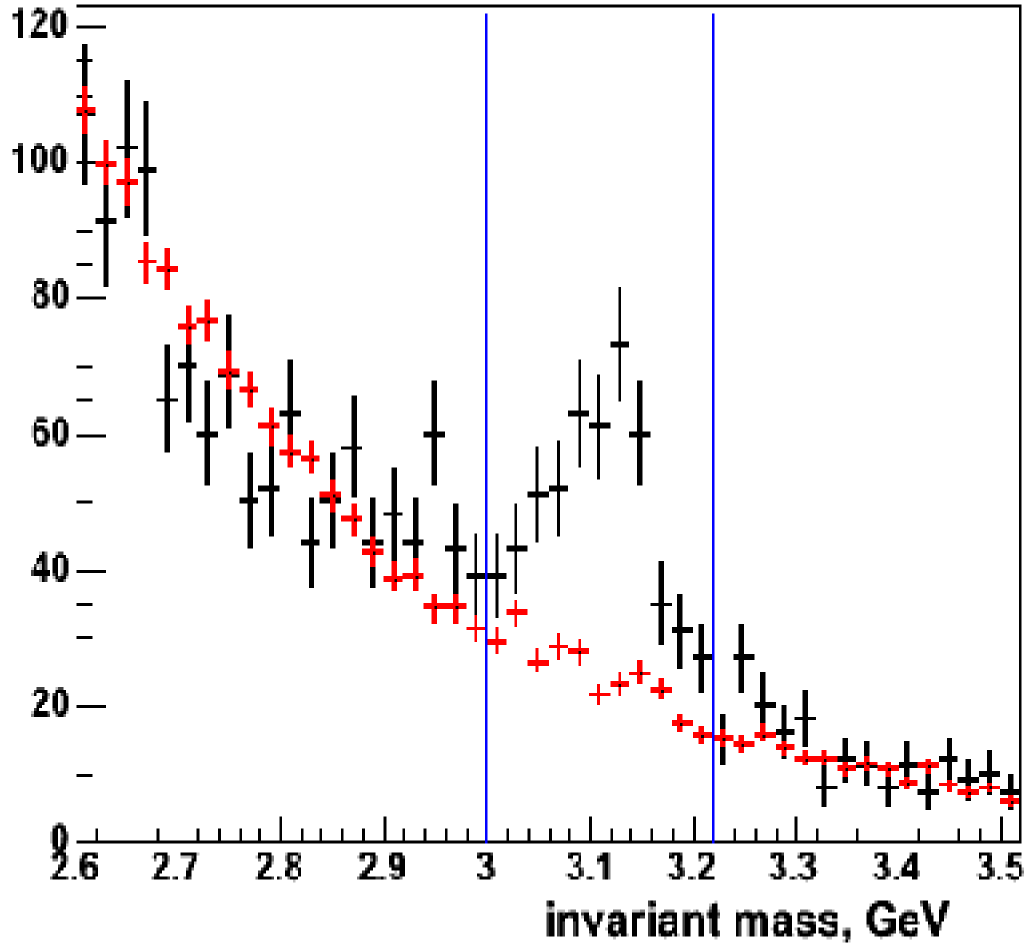
J/Ψ counting vs cos(θ)

Background is subtracted and J/Ψ are counted for every cos(θ) bin.

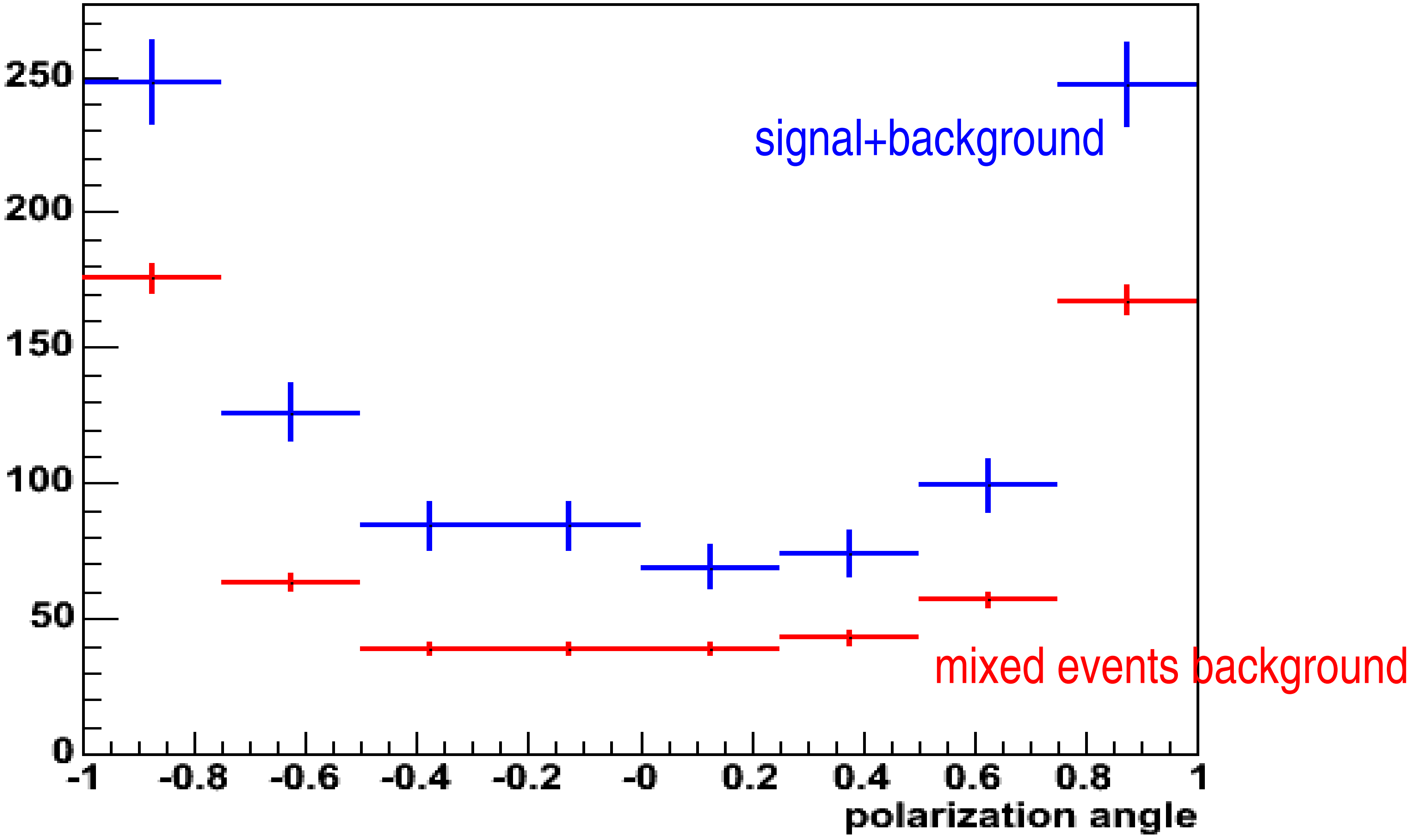
d+Au



Au+Au



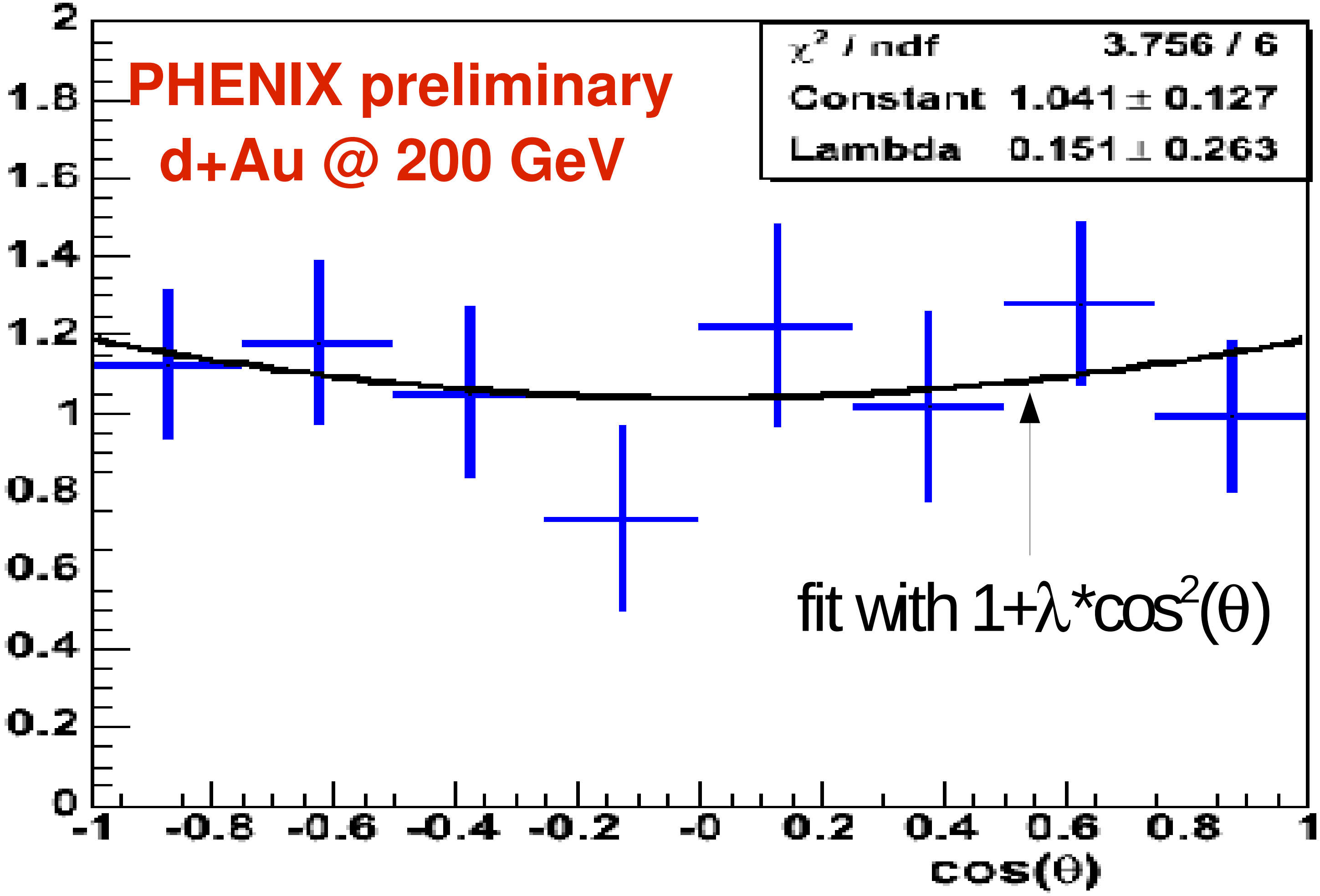
Uncorrected cos(θ) distribution from the data



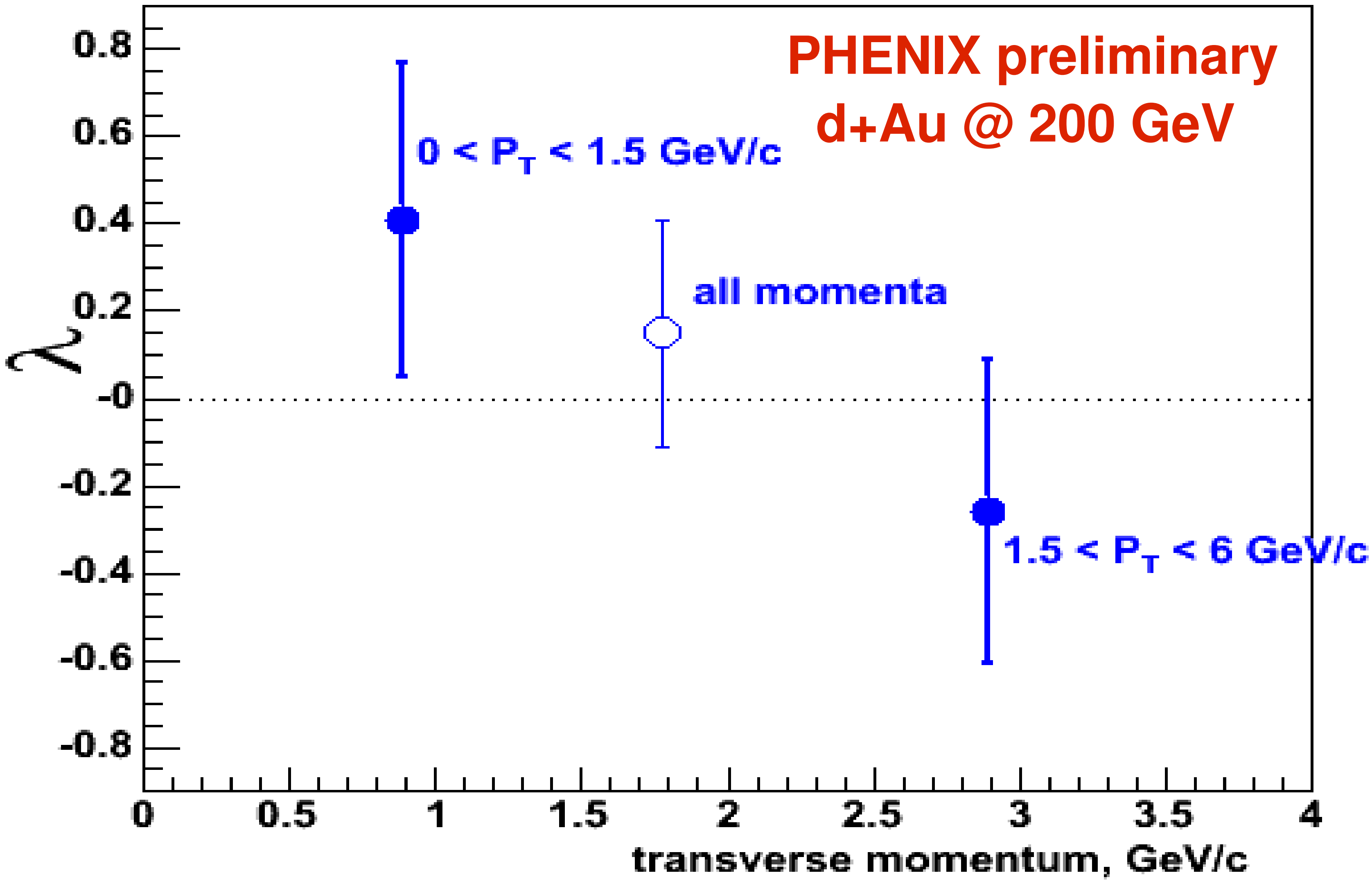
Acceptance corrected cos(θ) distribution d+Au

All transverse momenta

λ = 0.15 +- 0.26 (stat) +- 0.04 (syst)

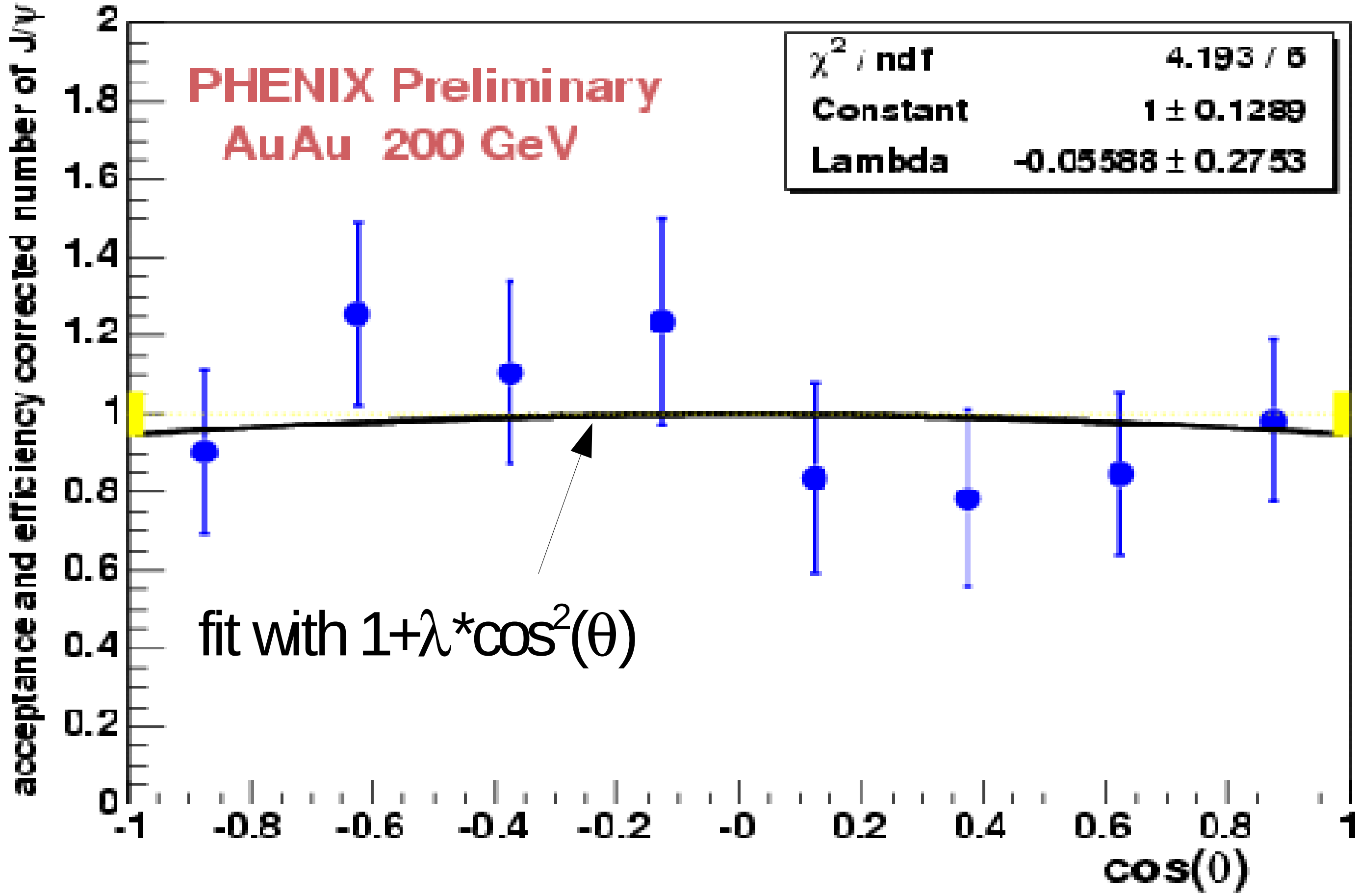


d+Au results vs P_T



Au+Au results, all P_T

λ = 0.06 +- 0.28 (stat) +- 0.05 (syst)



Approximately half of RHIC run4 AuAu ststistics is analysed for this plot.
Study of P_T dependence of polarization is under way.

Conclusions and outlook

Not enough ststistics to make definitive conclusions.
Total error is dominated by the statistical error, **need more data!**
Both d+Au and Au+Au results are compatible with no polarization.

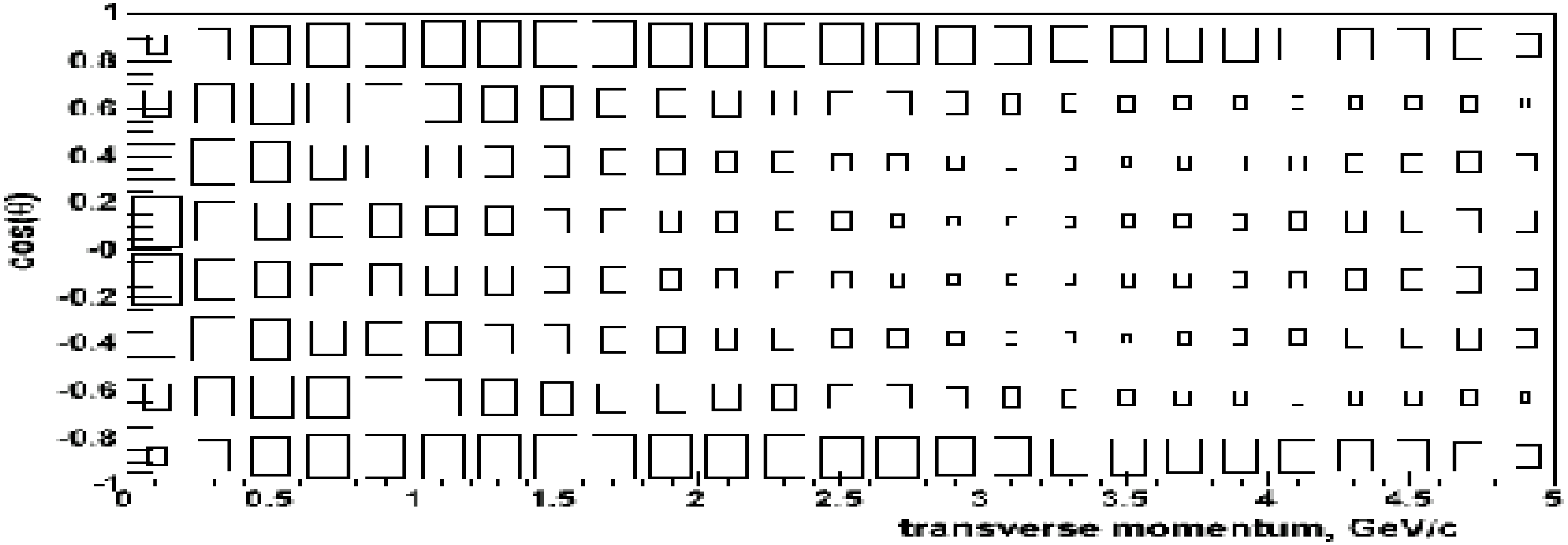
The technique for polarization measurement is well established, acceptance properties understood.

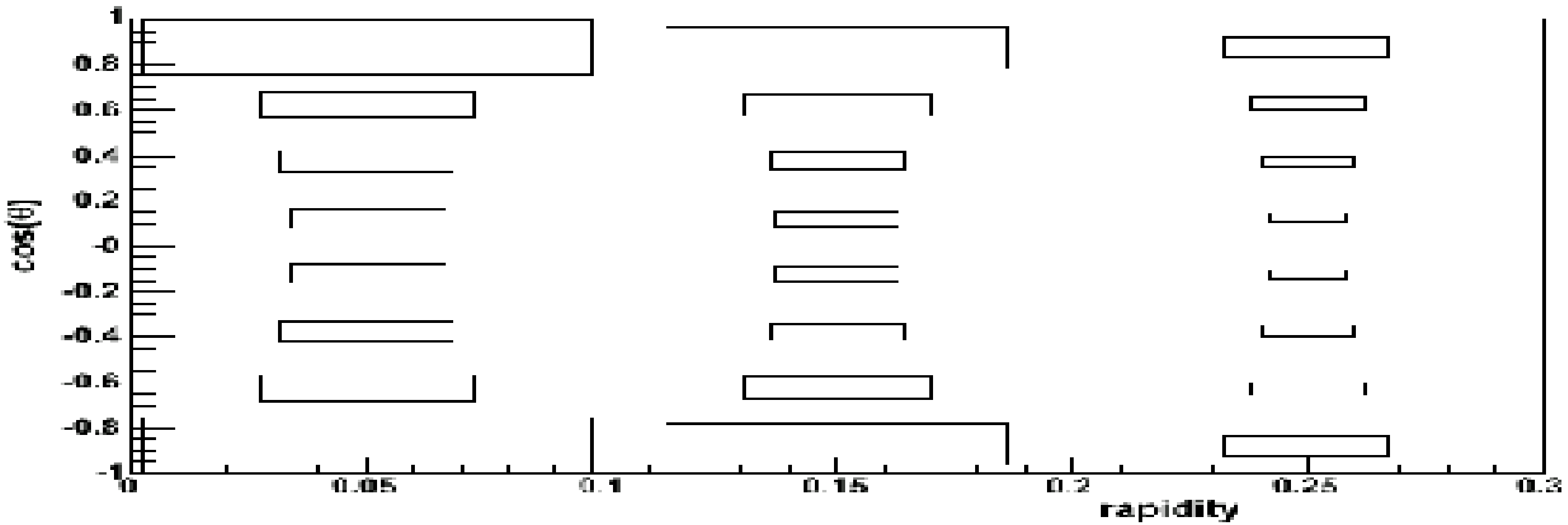
Expect ~3 times more J/Y from RHIC run5 (Cu+Cu).
Maybe even more from run6, if it will be Au+Au run ???

BACKUP SLIDES

Acceptance calculation, method two

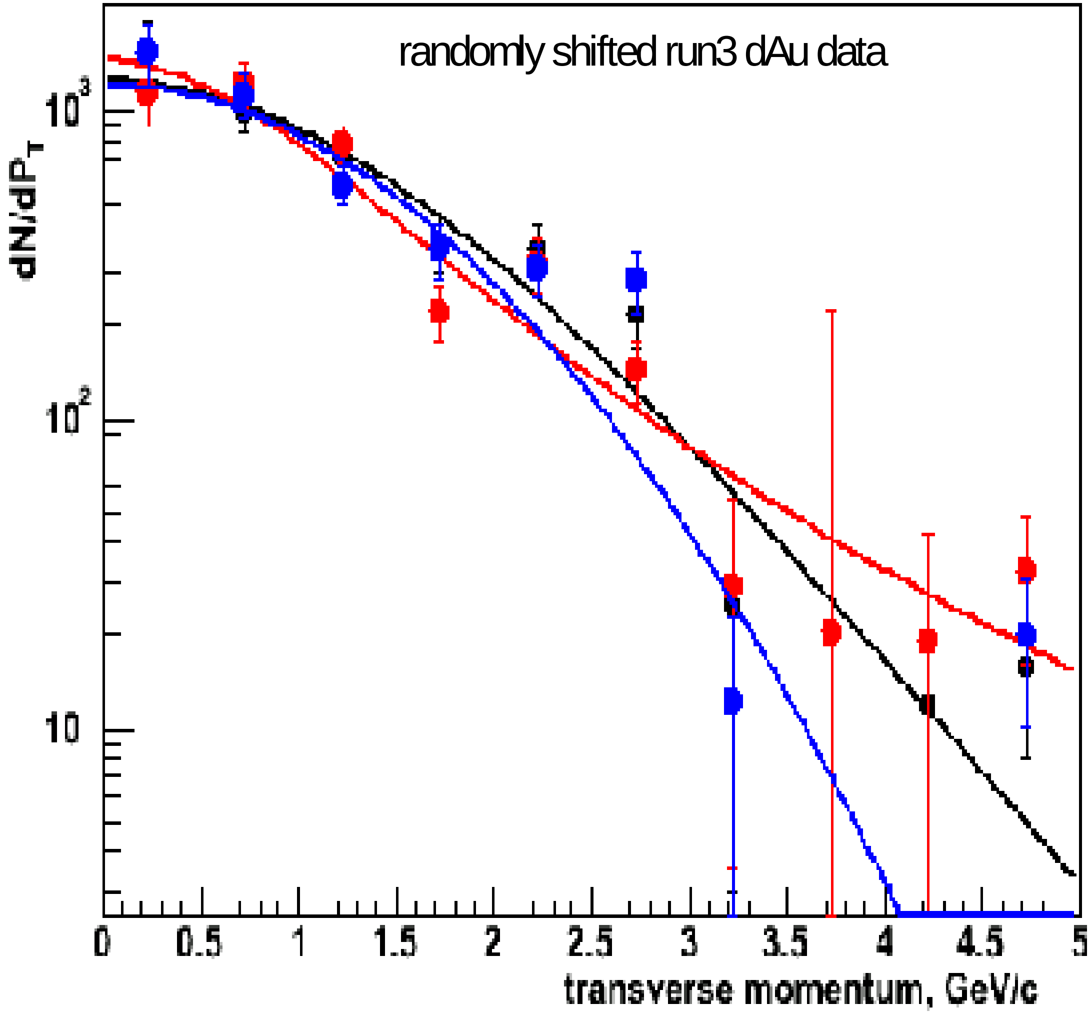
Event-by-event correction





Systematic error estimate

Randomly smear each data point and fit the results again.



Fit: $C*(1+(P_T/P_0)^2)^N$

P_0 = 4.56 N = -7.59

P_0 = 1.63 N = -1.94

P_0 = 127.6 N = -6051.0

Do this many times. Divide obtained acceptance by the original acceptance, and calcualte λ for the ratio.
Variation in λ gives us the systematic error.