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

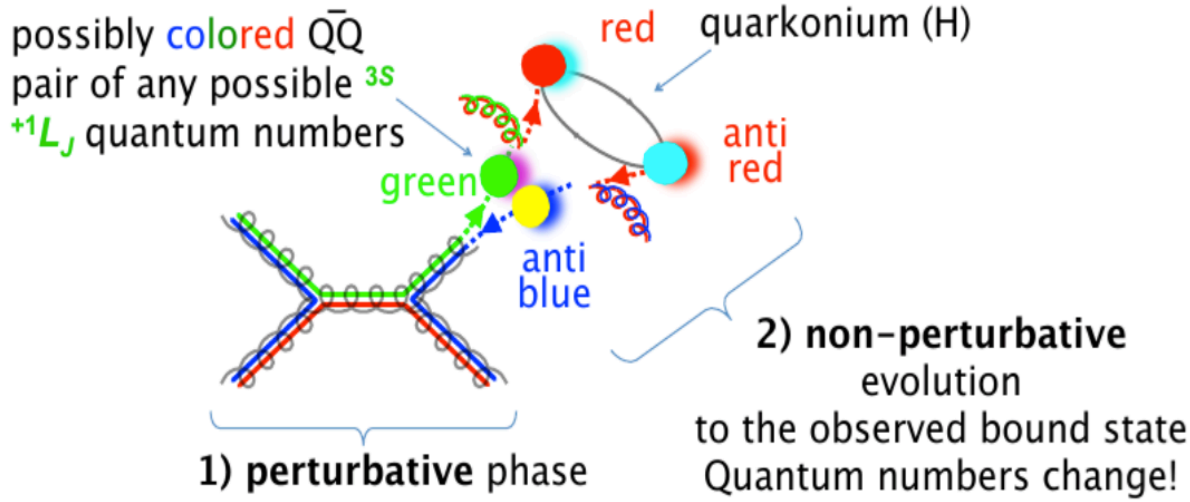
Siwei Luo *(for the STAR Collaboration)*

University of Illinois at Chicago

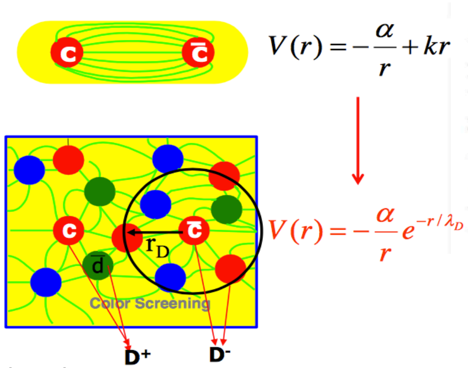
Motivation

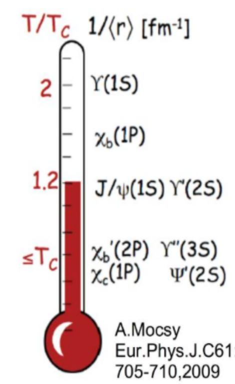
Charmonia Study

1.Help to understand quarkonium production mechanism in QCD



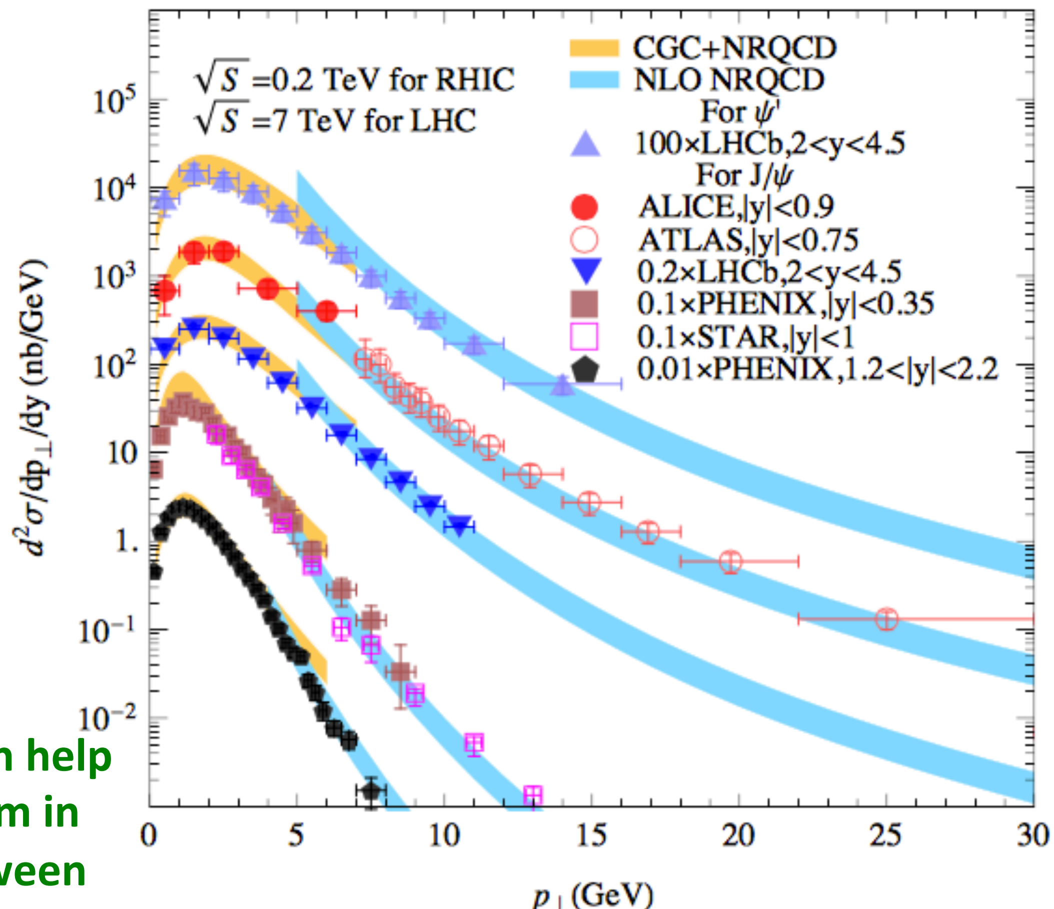
2.Help to understand the interaction with Quark-Gluon Plasma, to probe the properties of QGP.





Motivation

$p+p \rightarrow J/\psi + X$



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Different models can well describe measured cross-sections

- Color Evaporation Model
- NRQCD approach –applicable at high p_T
- Color Glass Condensate+NRQCD – applicable at low p_T

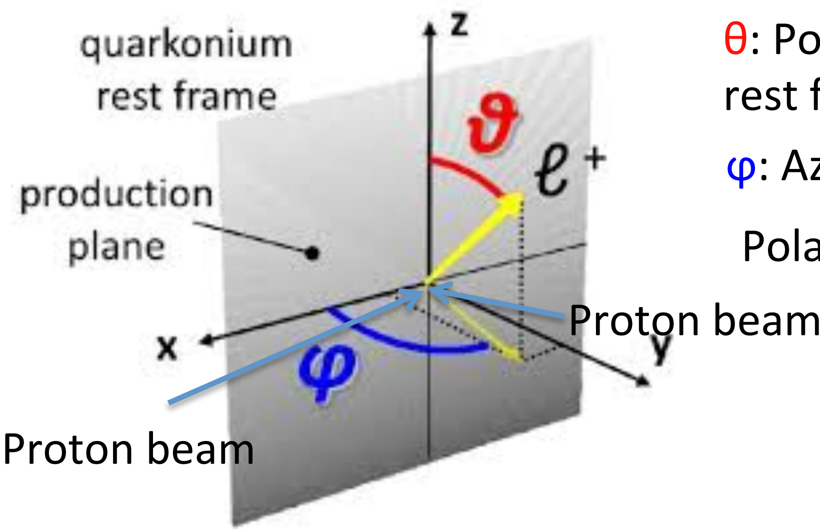
Measurements of *J/ψ* polarization can help understand *J/ψ* production mechanism in hadron collisions and distinguish between different models.

J/ψ polarization

J/ψ polarization can be analyzed via the angular distribution of the decayed leptons

$$\frac{d\sigma}{d\cos\theta d\varphi} \propto 1 + \lambda_\theta \cos^2\theta + \lambda_{\theta\varphi}\sin(2\theta)\cos\varphi + \lambda_\varphi \sin^2\theta\cos(2\varphi)$$

In helicity frame the ***z axis*** is defined along the *J/ψ* momentum in the center of mass frame.



θ: Polar angle between momentum of positron in *J/ψ* rest frame and the polarization axis z

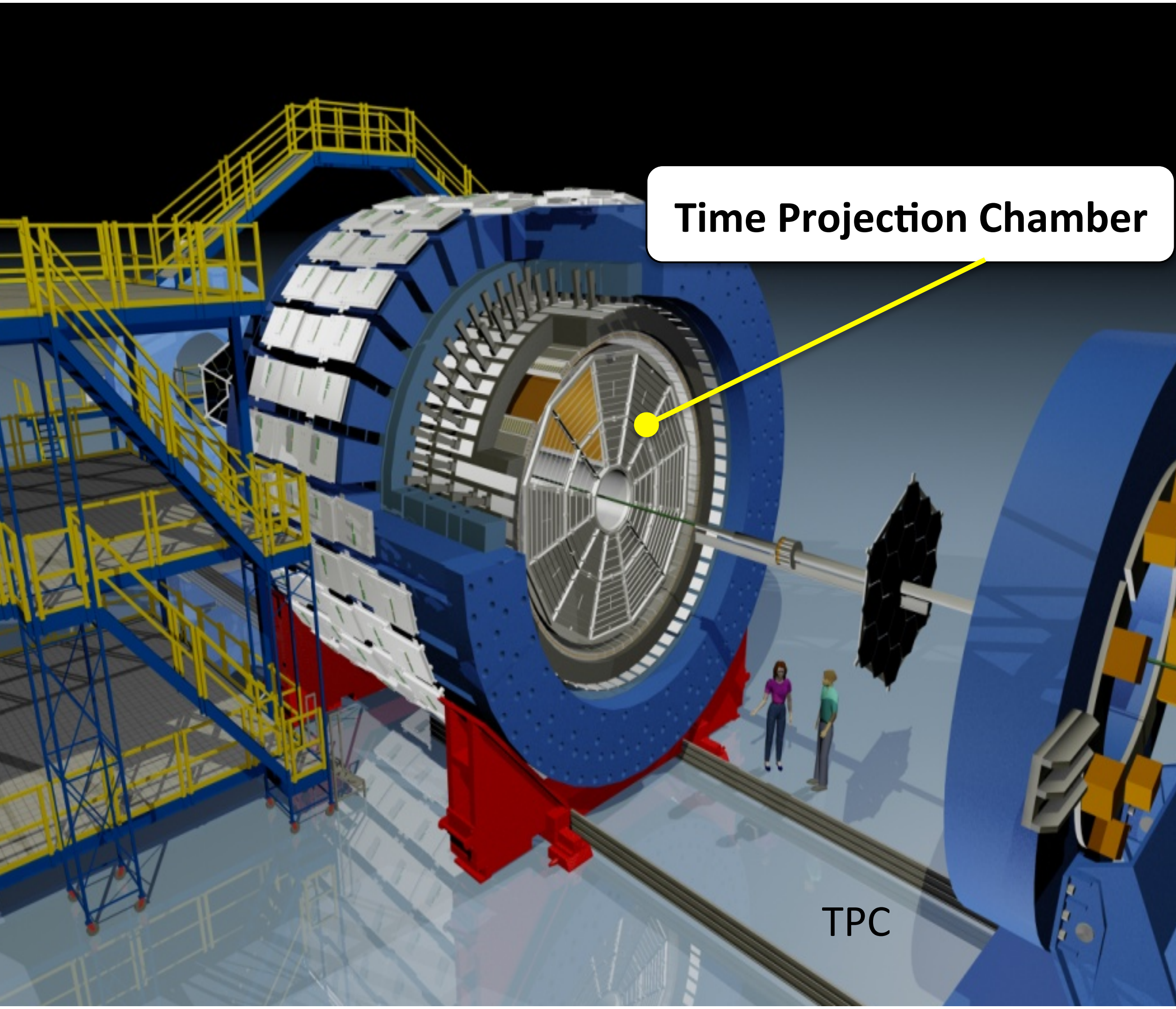
φ: Azimuthal angle

Polarization angular distribution follows:

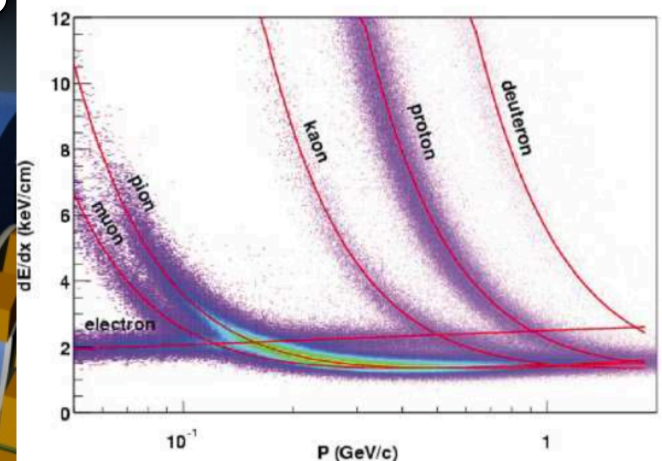
$$w(\cos\theta) \propto 1 + \lambda_\theta \cos^2\theta$$

$$w(\varphi) \propto 1 + \frac{2\lambda_\varphi}{3+\lambda_\theta}\cos 2\varphi$$

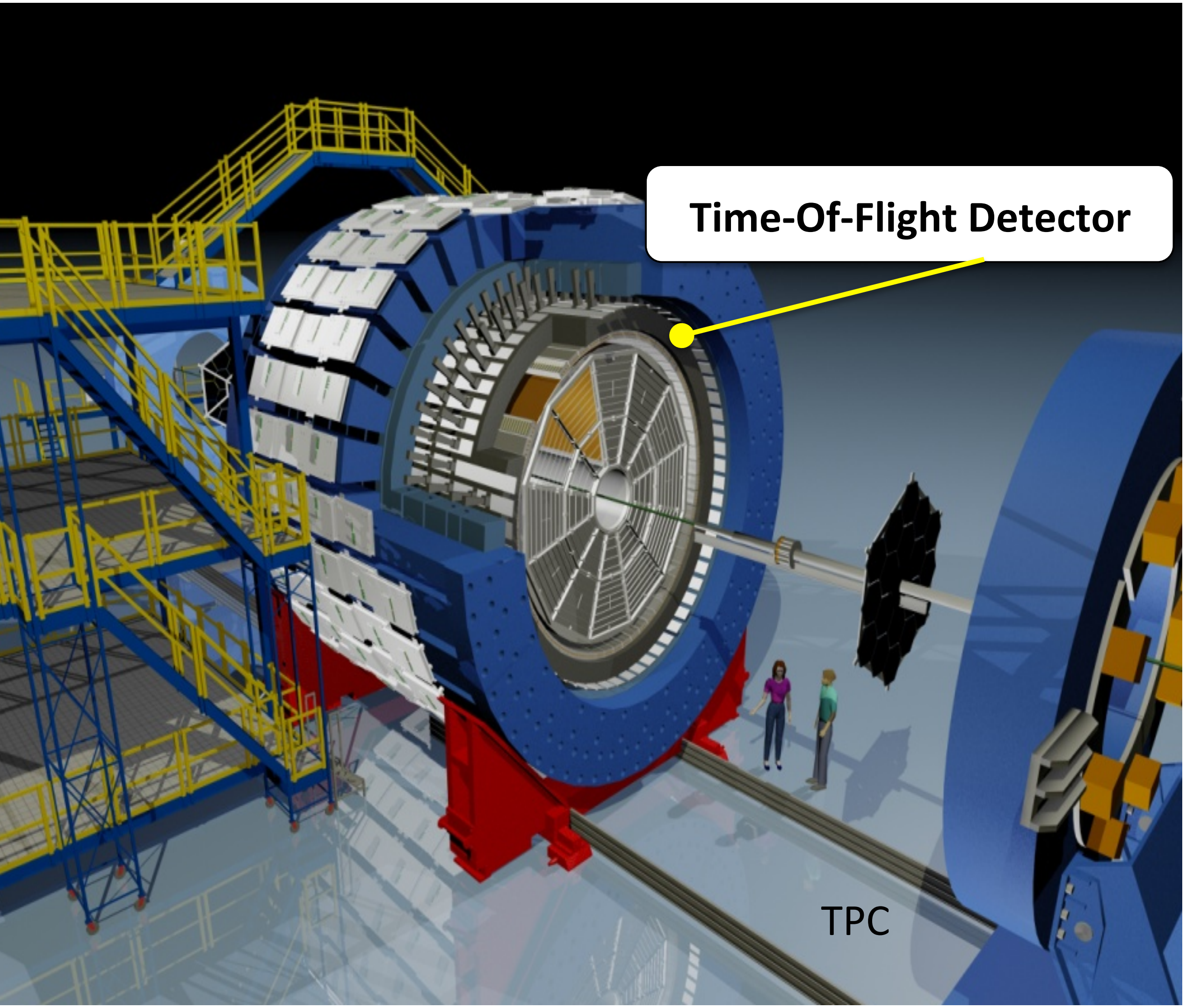
Solenoidal Tracker At RHIC



Time Projection Chamber:
- Tracking
- eID via energy loss.

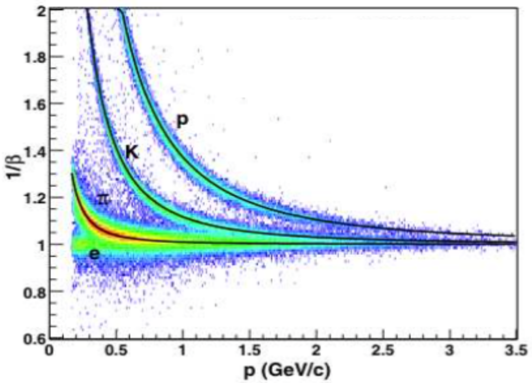


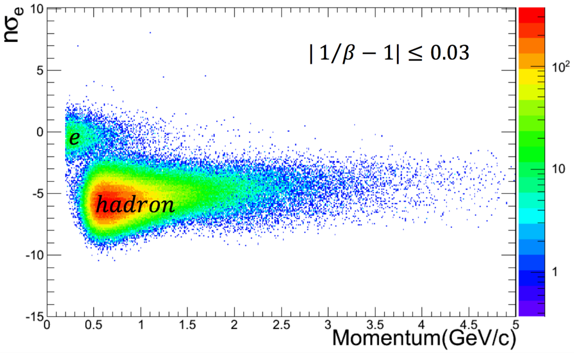
Solenoidal Tracker At RHIC



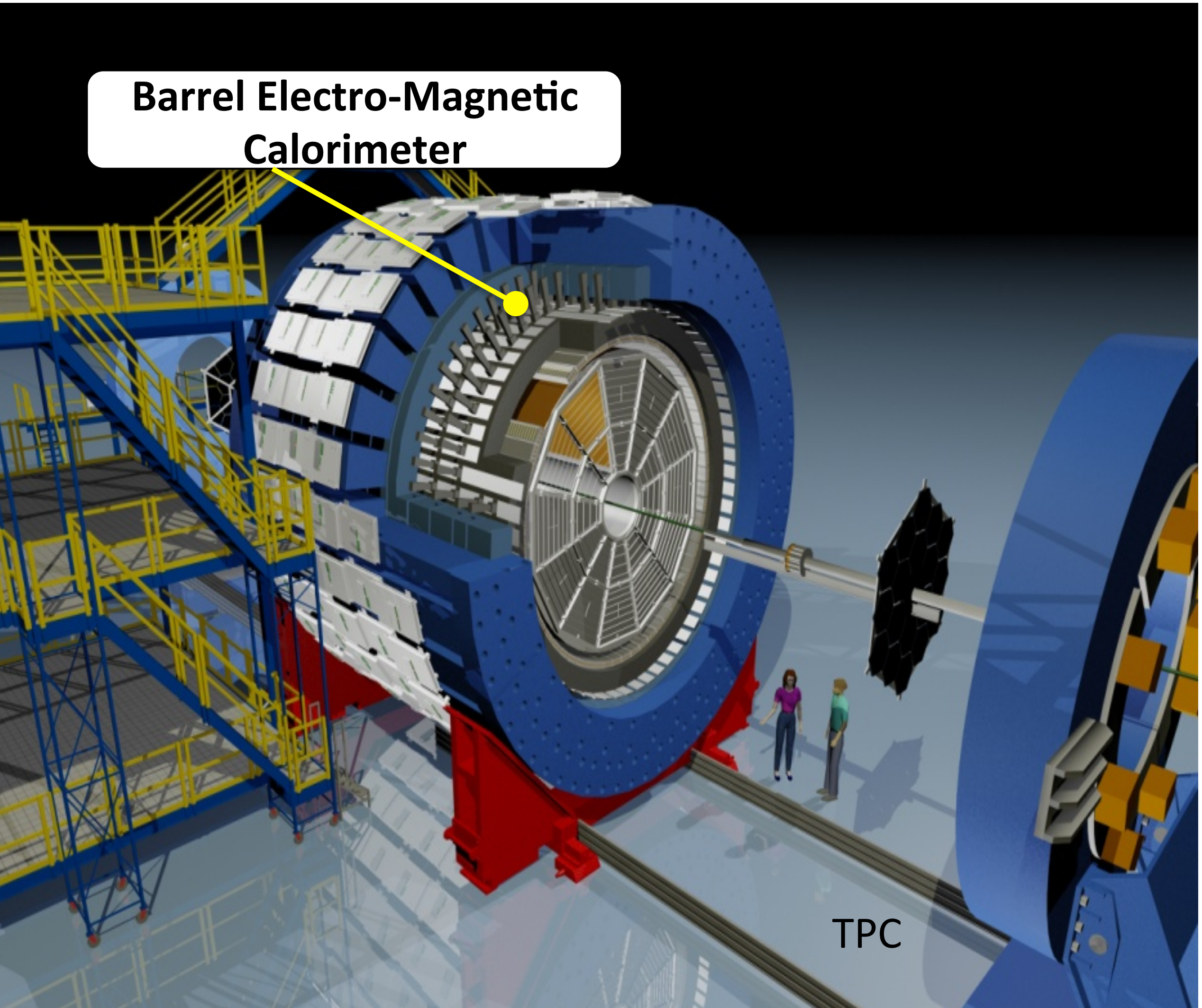
Time-Of-Flight Detector:

- eID at low p_T (<1.5 GeV/c)



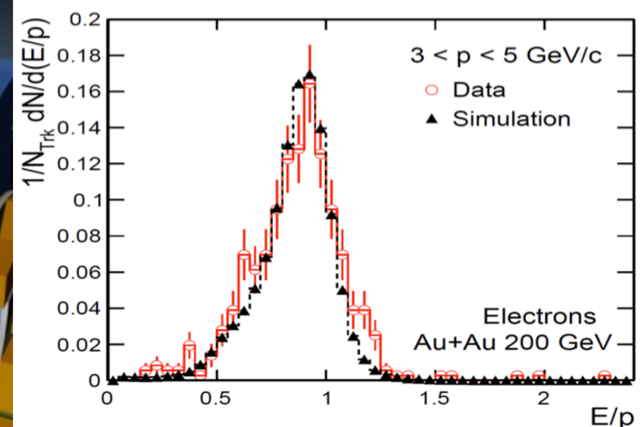


Solenoidal Tracker At RHIC

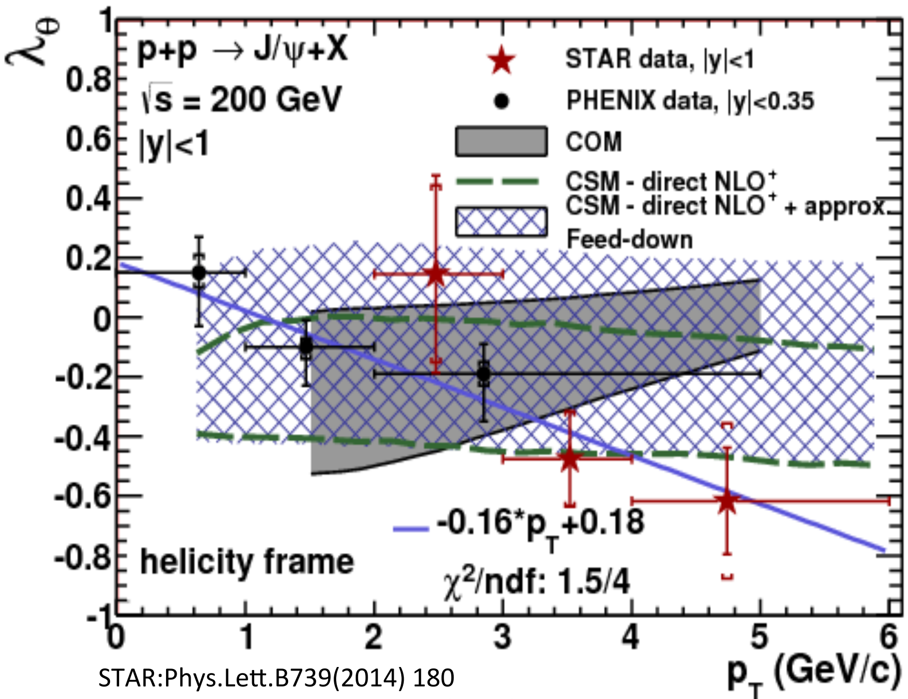


Barrel Electro-Magnetic Calorimeter:

- eID at high p_T (>1.5 GeV/c)
- Trigger



Previous measurement



STAR:Phys.Lett.B739(2014) 180
PHENIX:Phys.Rev.D 82,012001(2010)
COM:Phys.Rev.D 81, 014020(2010)
CSM NLO+: Phys.Lett B 695 149(2011)

Measurement of better precision can be made to higher p_T.

Can not really distinguish different models within precision and kinematic reach of STAR 2009 data.

To make improvement:

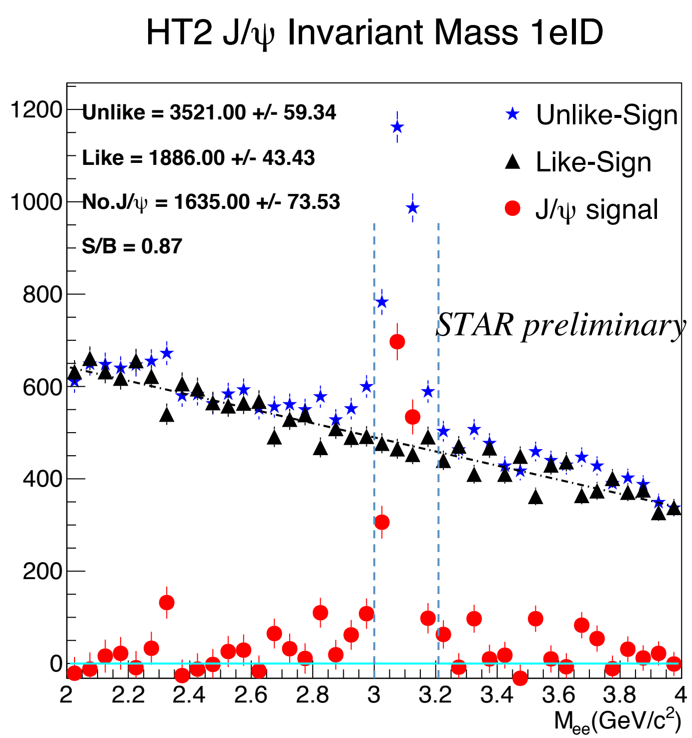
- Need more data sample.
- Need to extend measurements to higher p_T.

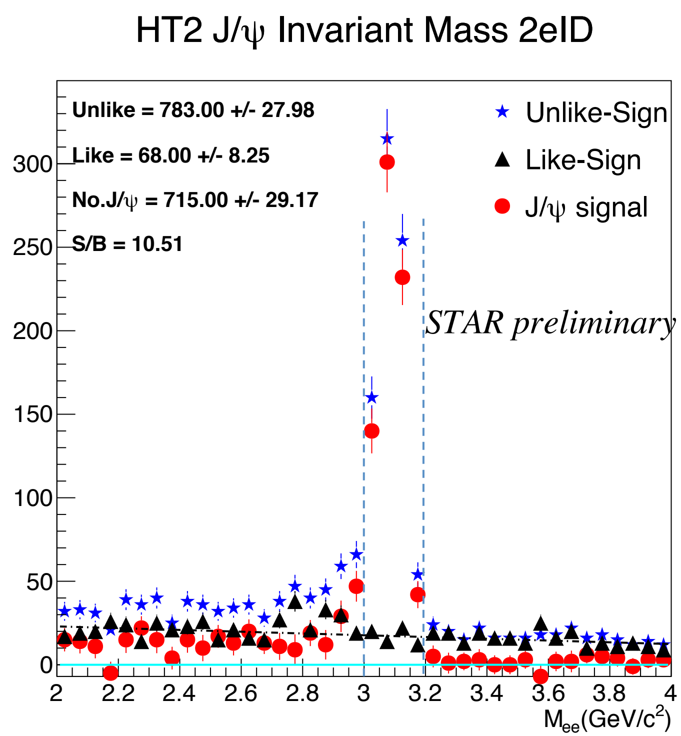
From STAR p+p 200 GeV collisions:

EMC Trigger	Threshold
HT0	E_e>~2.5 GeV
HT1	E_e>~3.6 GeV
HT2	E_e>~4.3 GeV

	2009	2012
	TOF 72%	TOF Fully installed
HT0(&&!HT2)	L=1.8pb^{-1}	
HT0		L=1.4pb^{-1}
HT1		L=9.4pb^{-1}
HT2		L=23.5pb^{-1}

J/ψ signal



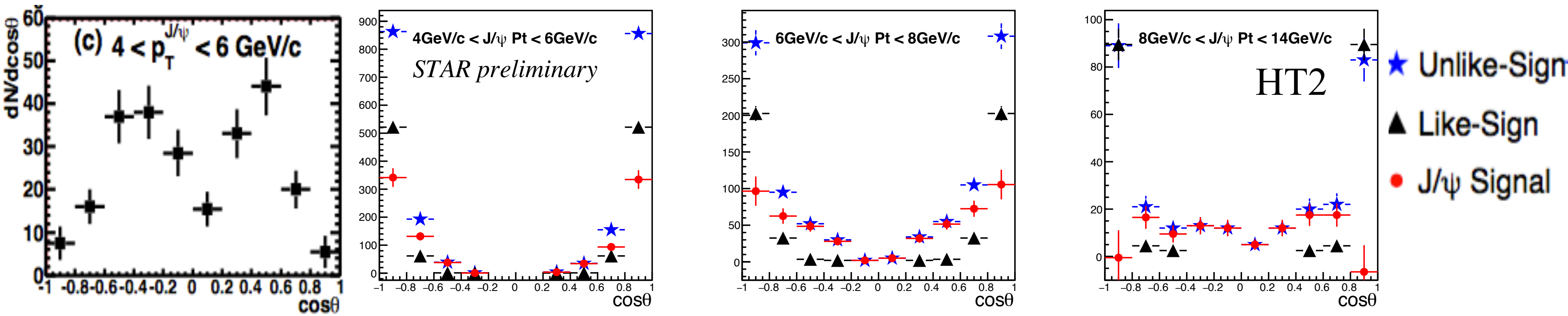


1eID: 1 track requires strict electron identification→has more J/psi signals.

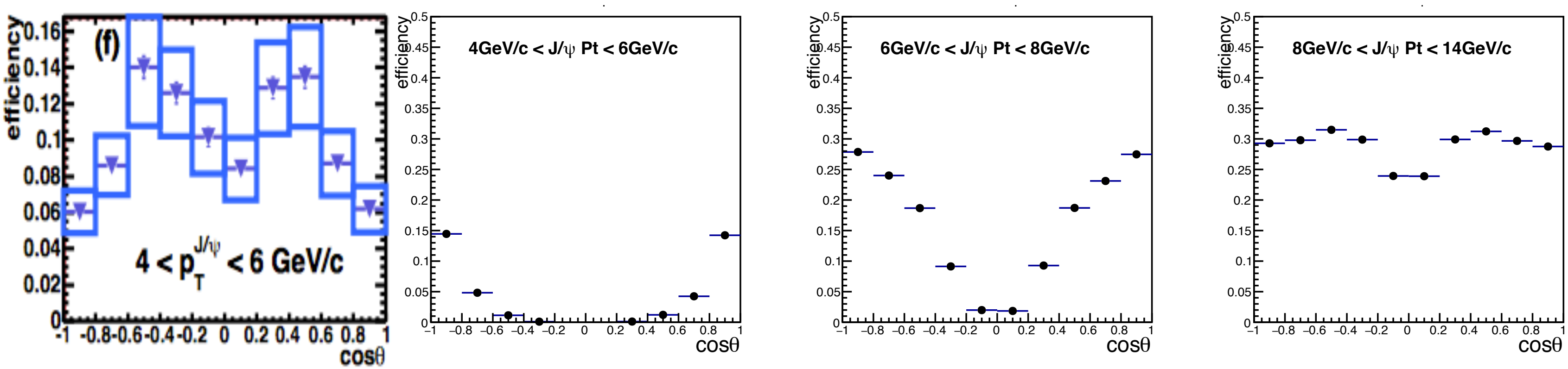
2eID: both tracks require strict electron identification→provide better signal background ratio.

Strict electron identification requires track satisfy the TOF or EMC electron identification cut.

Raw J/ψ cosθ distribution and efficiency



Efficiency extracted from Geant detector simulation



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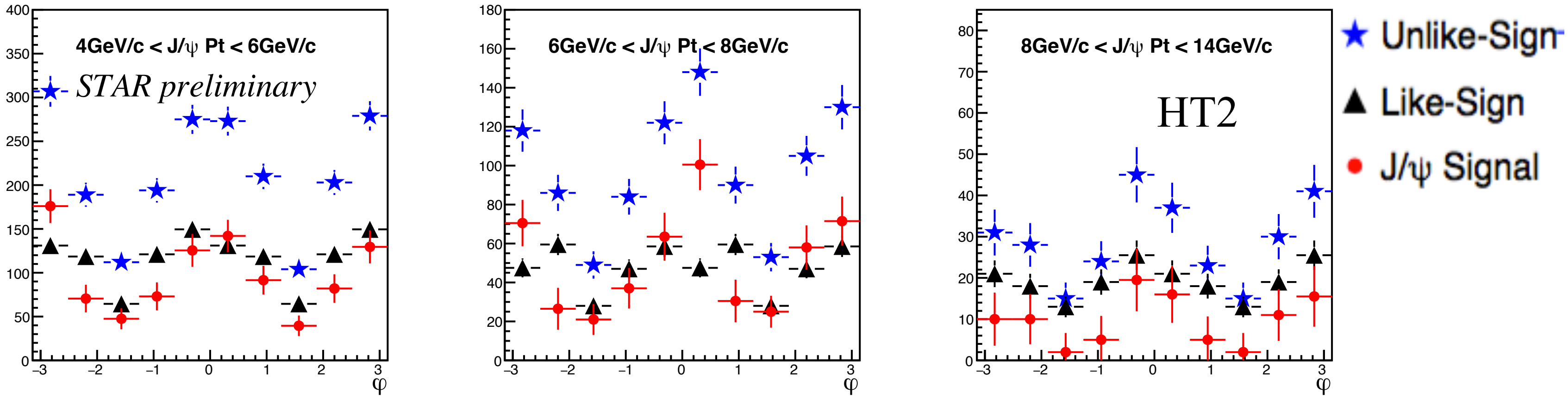
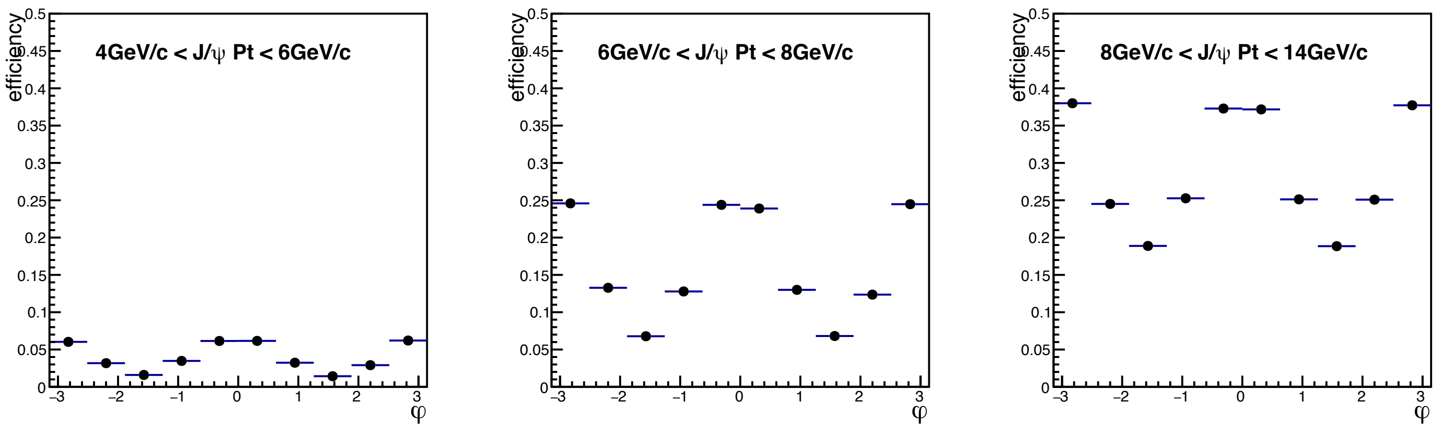
λ_θ measurement is feasible up to 14 GeV/c.

The triggers applied in Run9 and Run12 are different, which lead to different shapes. Compared with Run9 data, Run12 has more statistics.

Raw J/ψ φ distribution and efficiency



Efficiency extracted from Geant detector simulation



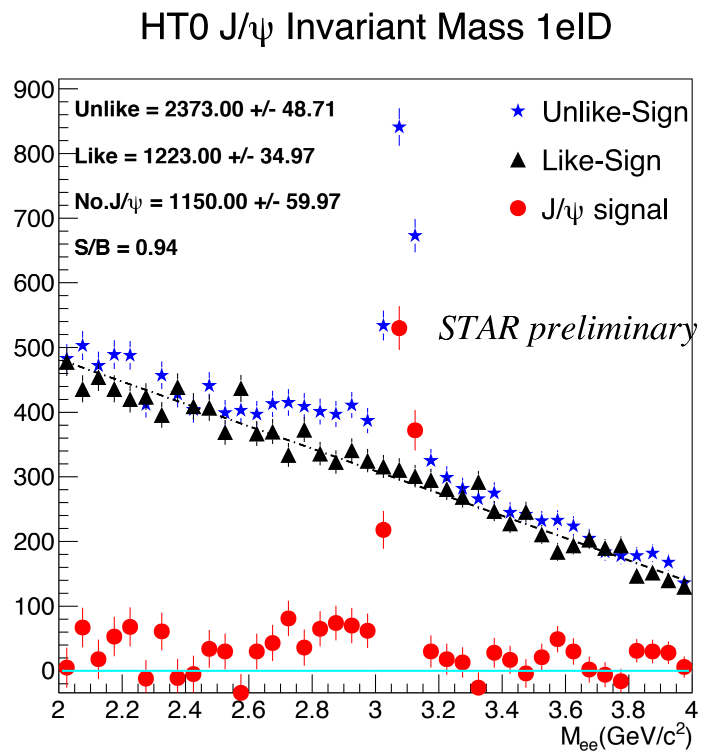
λ_{φ} measurement is feasible up to 14 GeV/c.

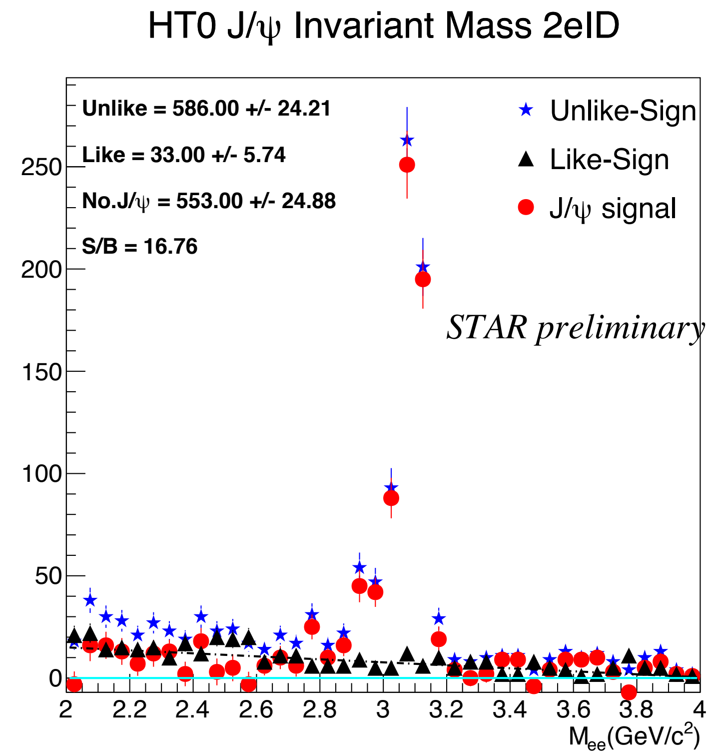
Conclusion

- J/ψ polarization can help understand quarkonium production mechanism and distinguish different models.
- Raw J/ψ $\cos\theta$ and φ distributions have been measured from STAR 2012 p+p 200 GeV data, and efficiency corrections are under way.
- Expect to have more precise measurements on λ_{θ}, λ_{φ} compared with published STAR 2009 data. Measurements can be extended up to 14 GeV/c.

Backup

J/ψ signal





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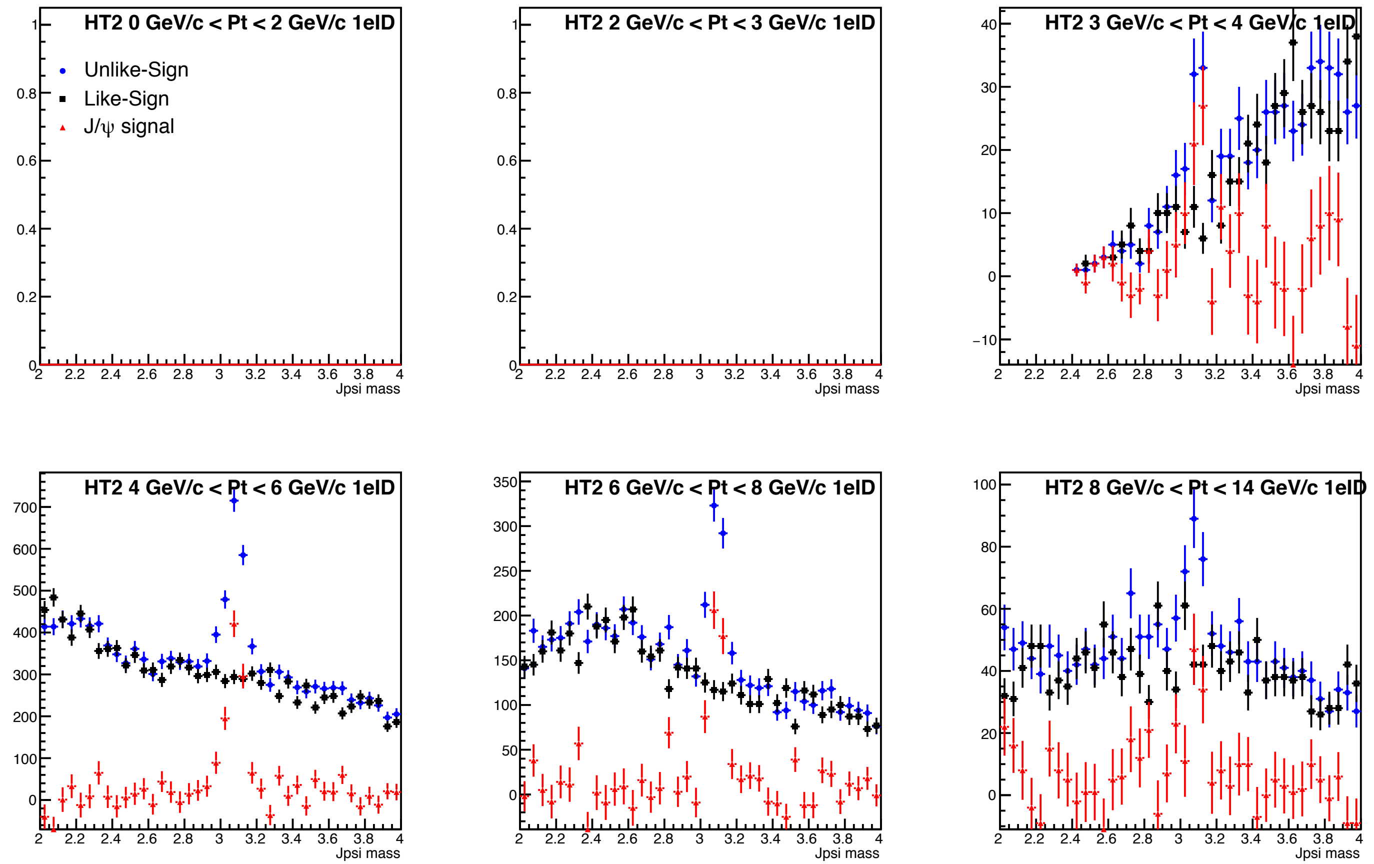
2eID: both tracks require strict electron identification->better signal background ratio.

Invariant mass lineshape with 1eID requirement



Invariant mass lineshape with 2eID requirement