Measurements of the transverse-momentum-dependent cross sections of J/ψ production at mid-rapidity in proton+proton collisions at $\sqrt{s}$ = 510 and 500 GeV with the STAR detector

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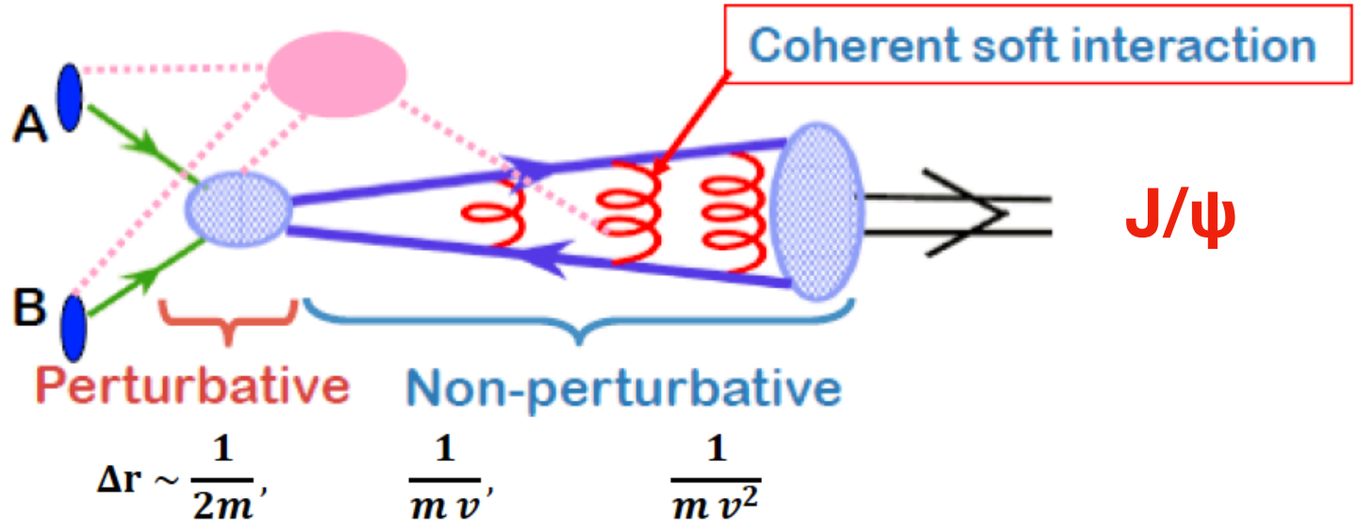
Outline

- **Motivation**
- **STAR experiment**
- **J/ψ measurements in p+p collisions**
- **Summary and outlook**

J/ψ in p+p collisions

- J/ψ is a non-relativistic QCD system(v^2<<1): the simplest system in QCD.

Production of the $c\bar{c}$ (large momentum transfer) → evolution of the $c\bar{c}$ pair intoJ/ψ (small dynamical scale)



- Difficulty:Involving both perturbative and non-perturbative processes

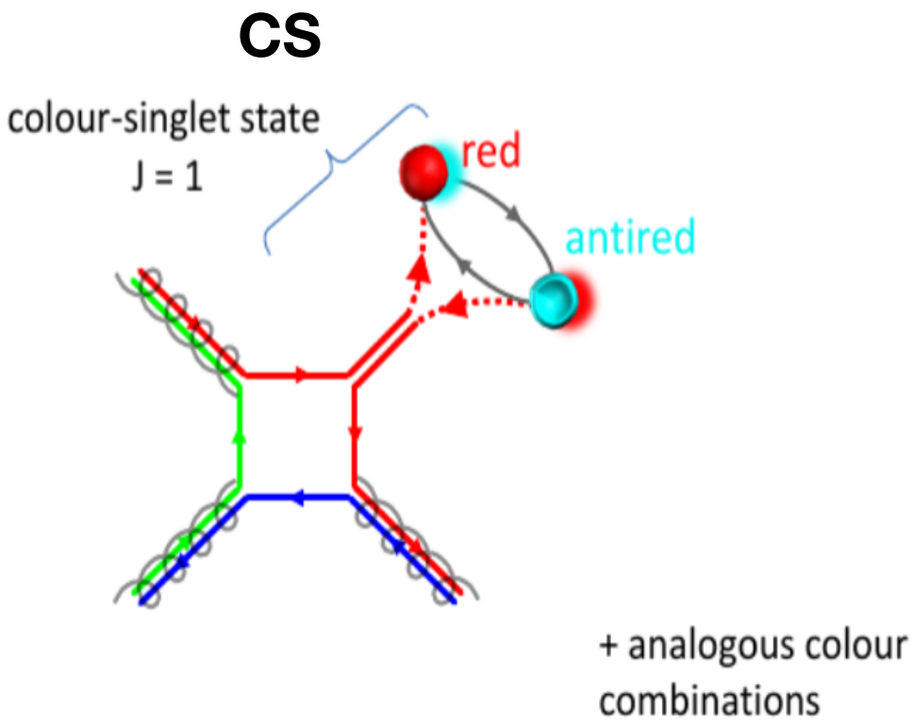
J/ψ: An ideal test ground of QCD!!

Production mechanism

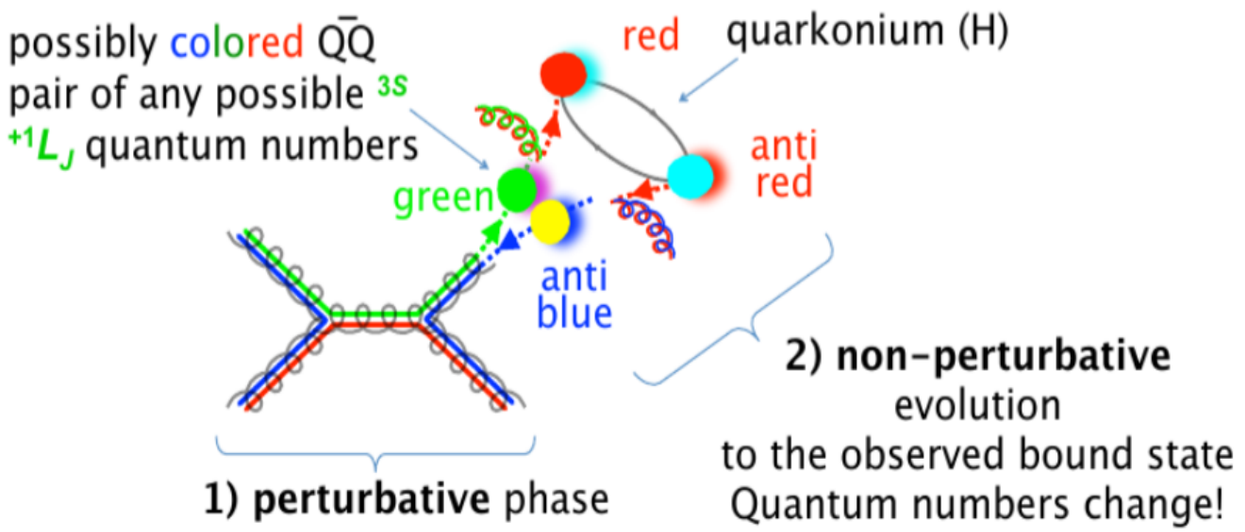
Models differ in the treatment of hadronization:

- Improved color evaporation model
- Color singlet model
- NRQCD approach (CGC+NRQCD at low p_T)

CS



CO

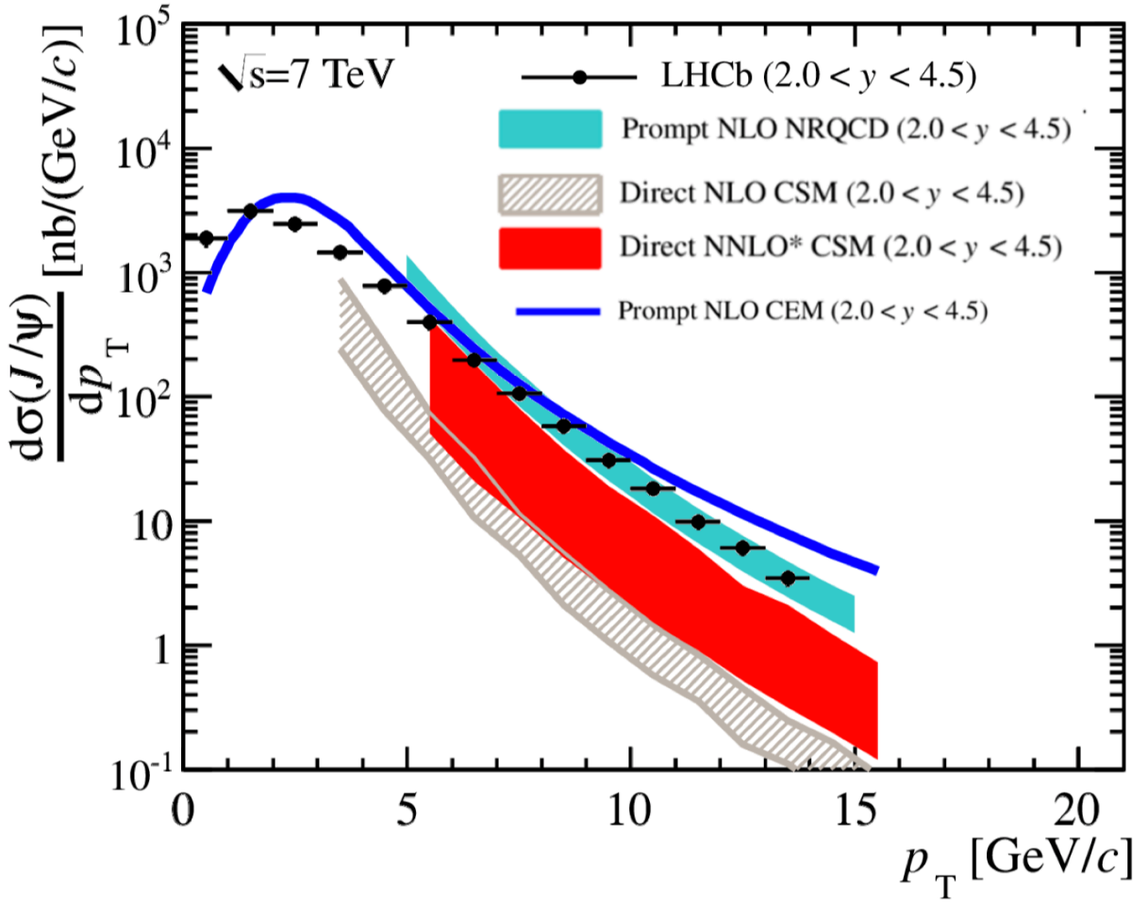


[P. Faccioli, Polarization in LHC physics, Course on Physics at the LHC 2014]

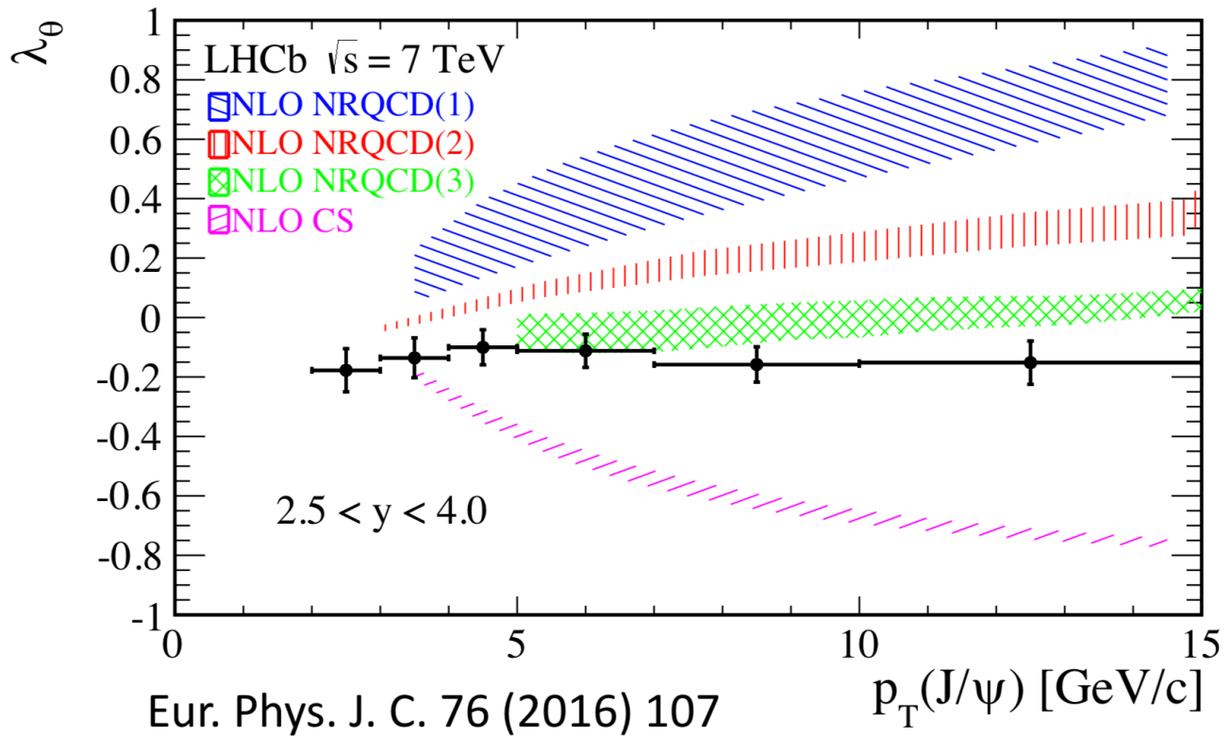
Observables

J/ψ production mechanism in elementary collisions is not fully understood

Cross-section



Polarization



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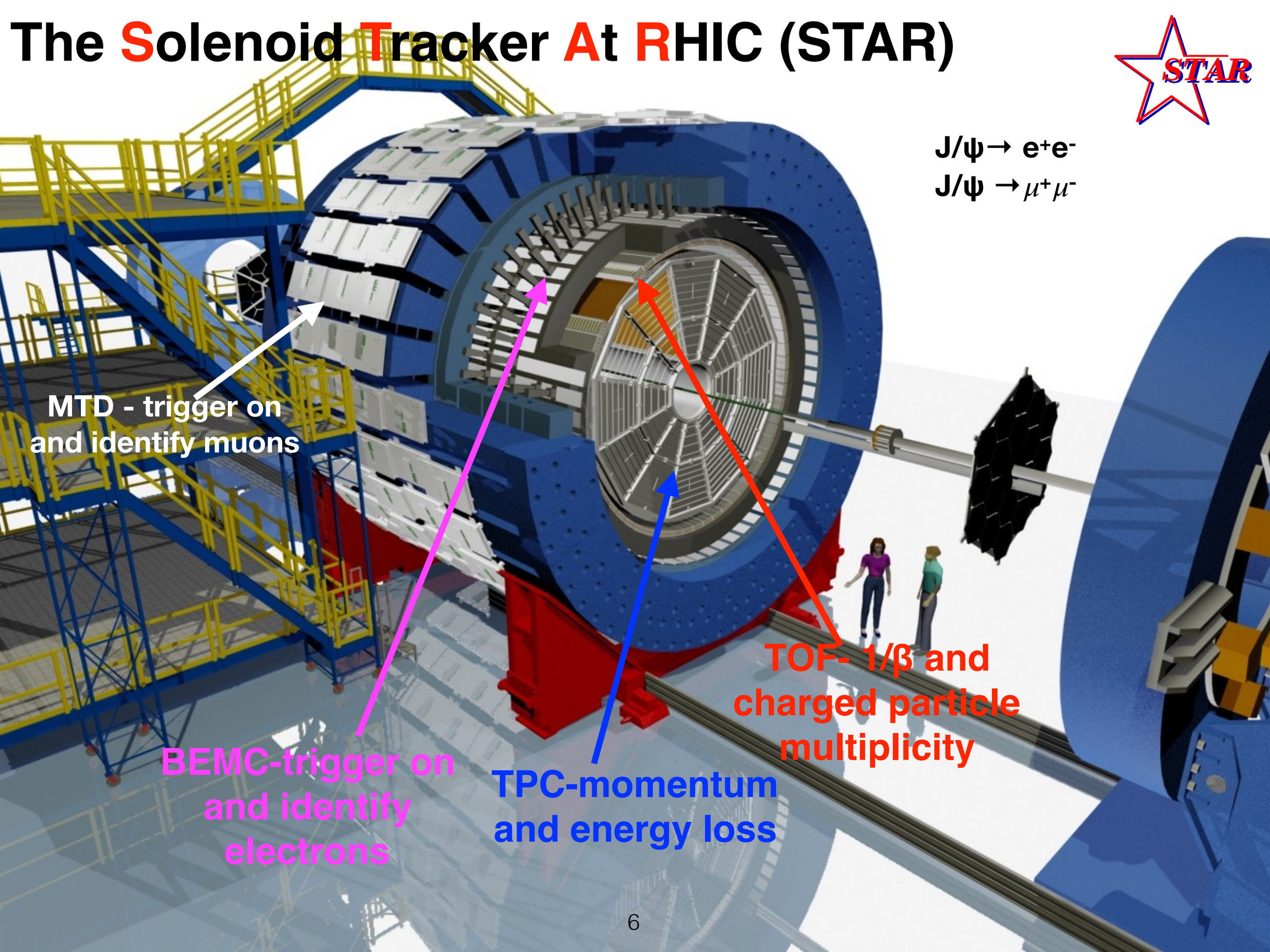
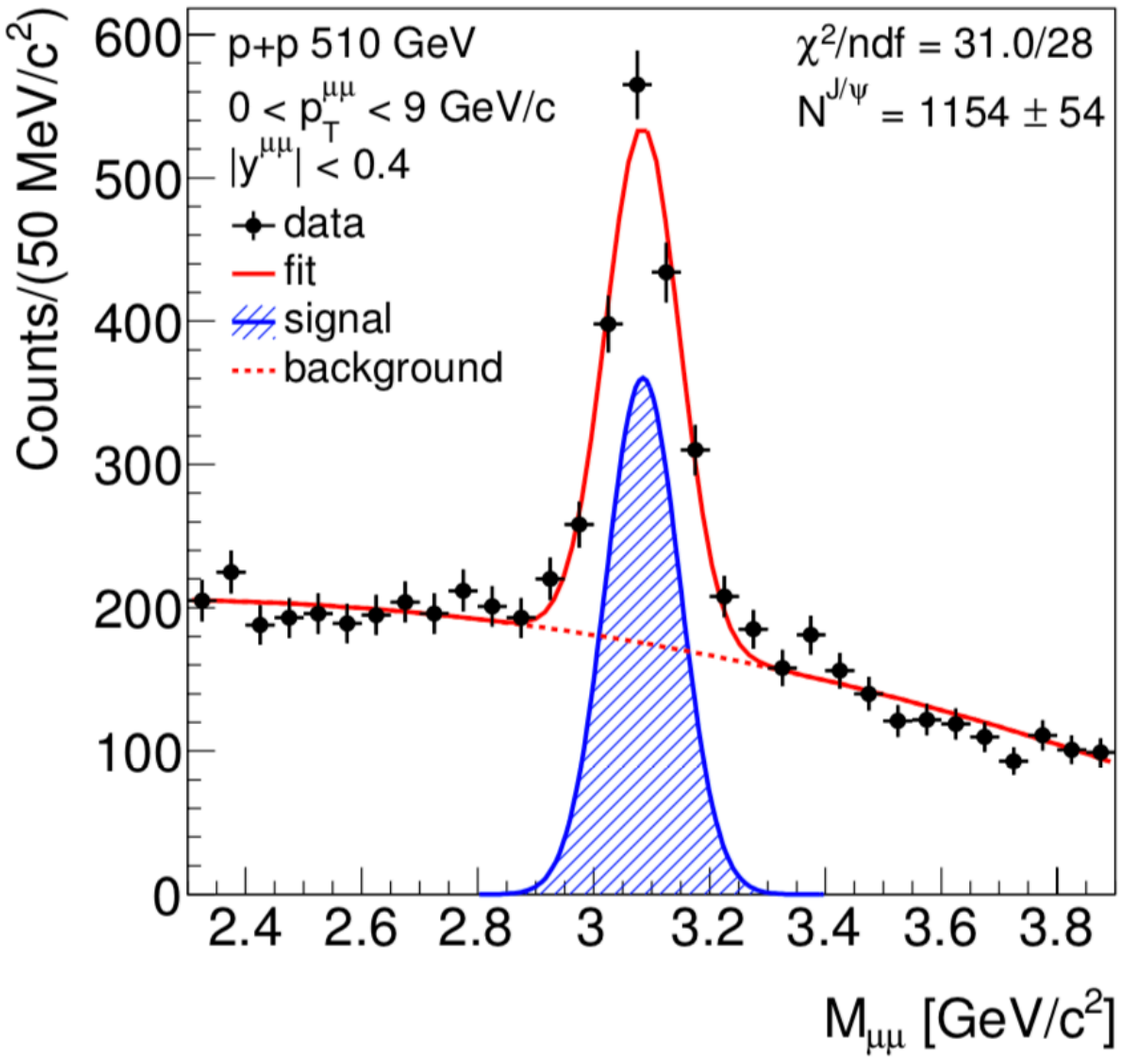
No consistent descriptions of cross section and polarization

The Solenoid Tracker At RHIC (STAR)



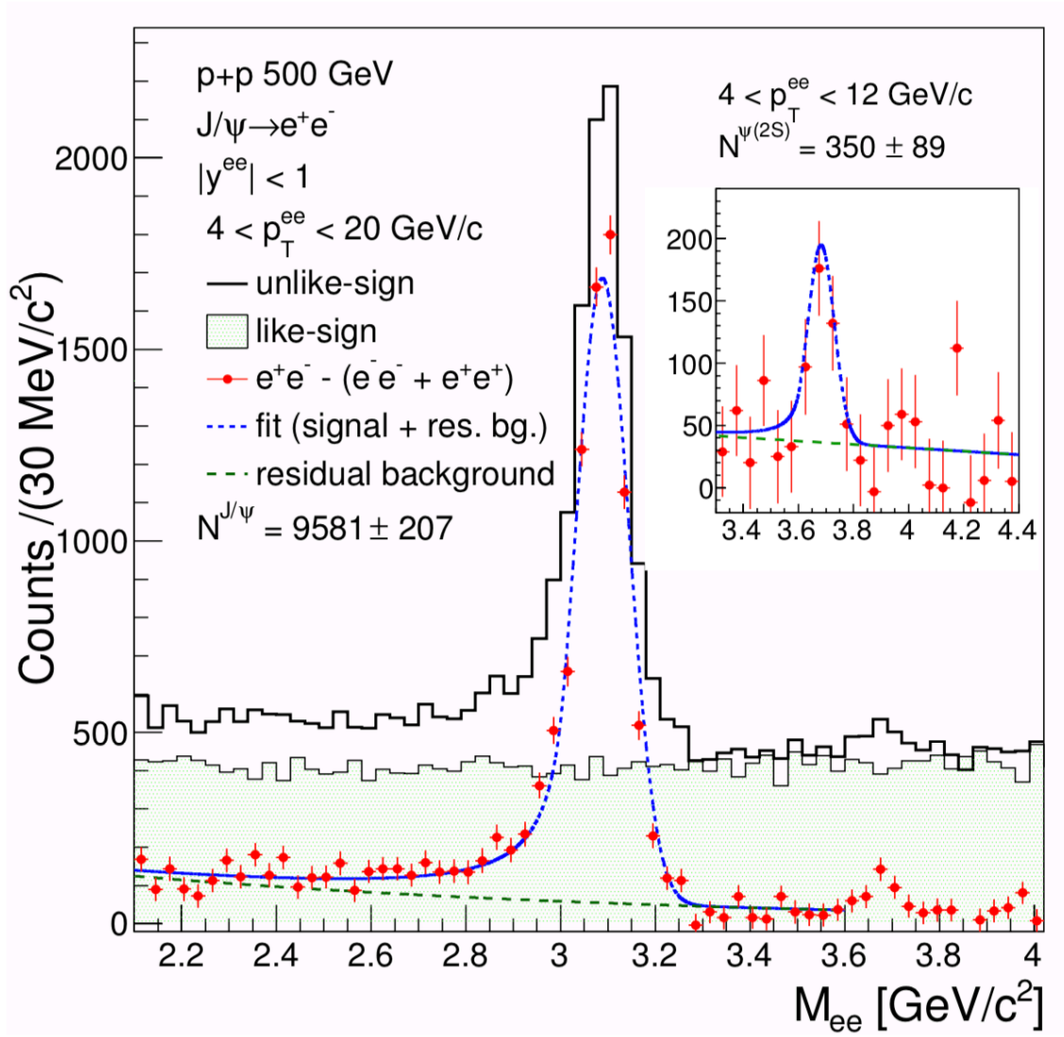
J/ψ signals

J/ψ → $\mu^+\mu^-$



- Gaussian function + second-order polynomial function

J/ψ → e^+e^-



- Crystal-Ball function + exponential function

J/ψ cross section

$$BR \times \frac{d^2\sigma}{2\pi p_T dp_T dy} = \frac{N^{raw}_{J/\psi\to e^+e^-(\mu^+\mu^-)}}{(2\pi p_T)\cdot\int \mathcal{L}dt\cdot\mathcal{A}\varepsilon\cdot\Delta p_T\cdot\Delta y}$$

$N^{raw}_{J/\psi}$:raw number of reconstructed J/ψ

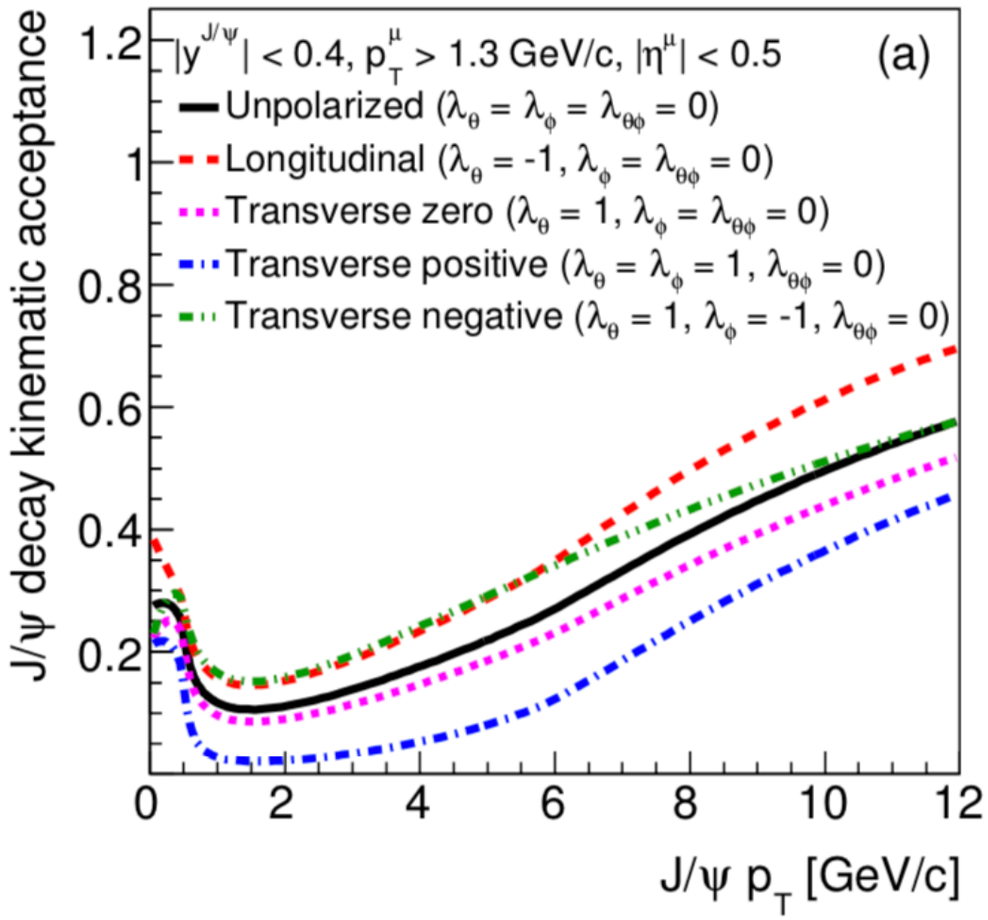
$\int \mathcal{L}dt$:corresponding integrated luminosity

$\Delta p_T, \Delta y$:bin widths in pT and y of the J/ψ

ε :J/ψ efficiency, tracking, trigger

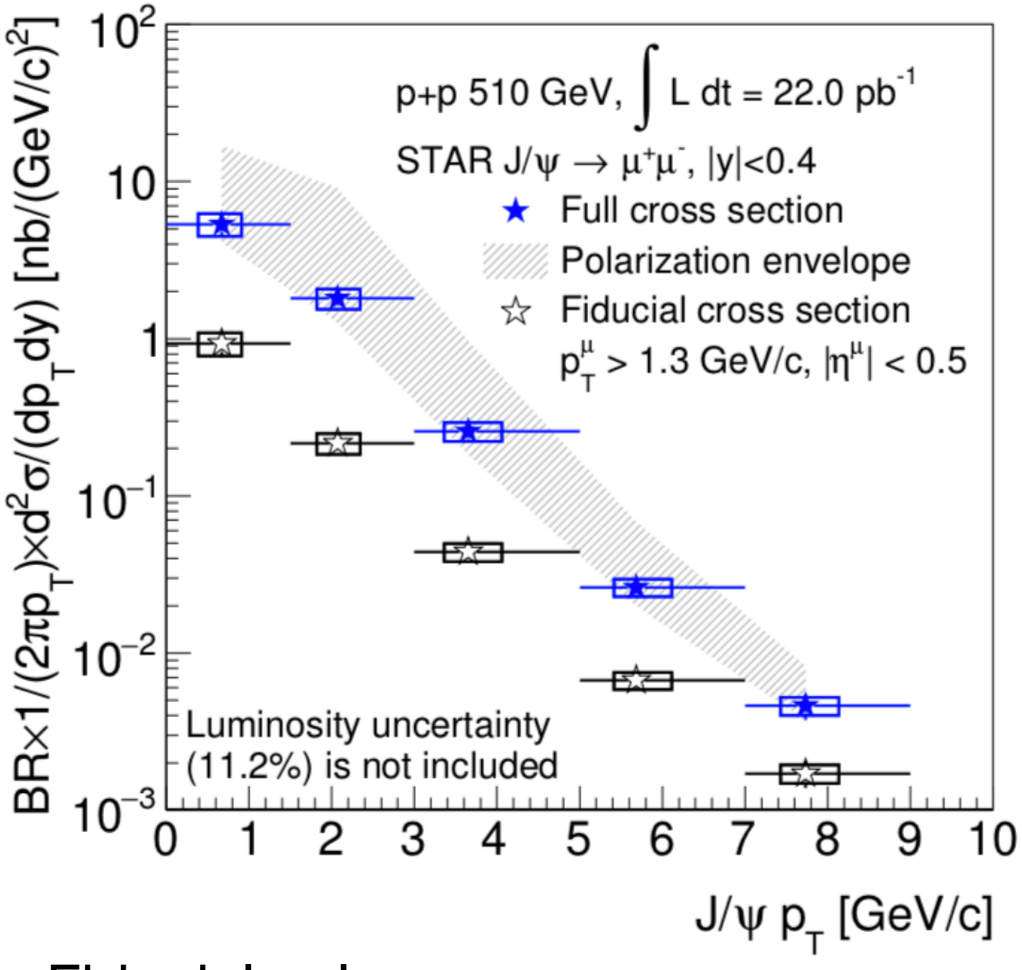
$\mathcal{A}$:acceptance, J/ψ decay kinematic acceptance and detector geometric acceptance

J/ψ decay kinematics acceptance



J/ψ cross section

J/ψ → $\mu^+\mu^-$

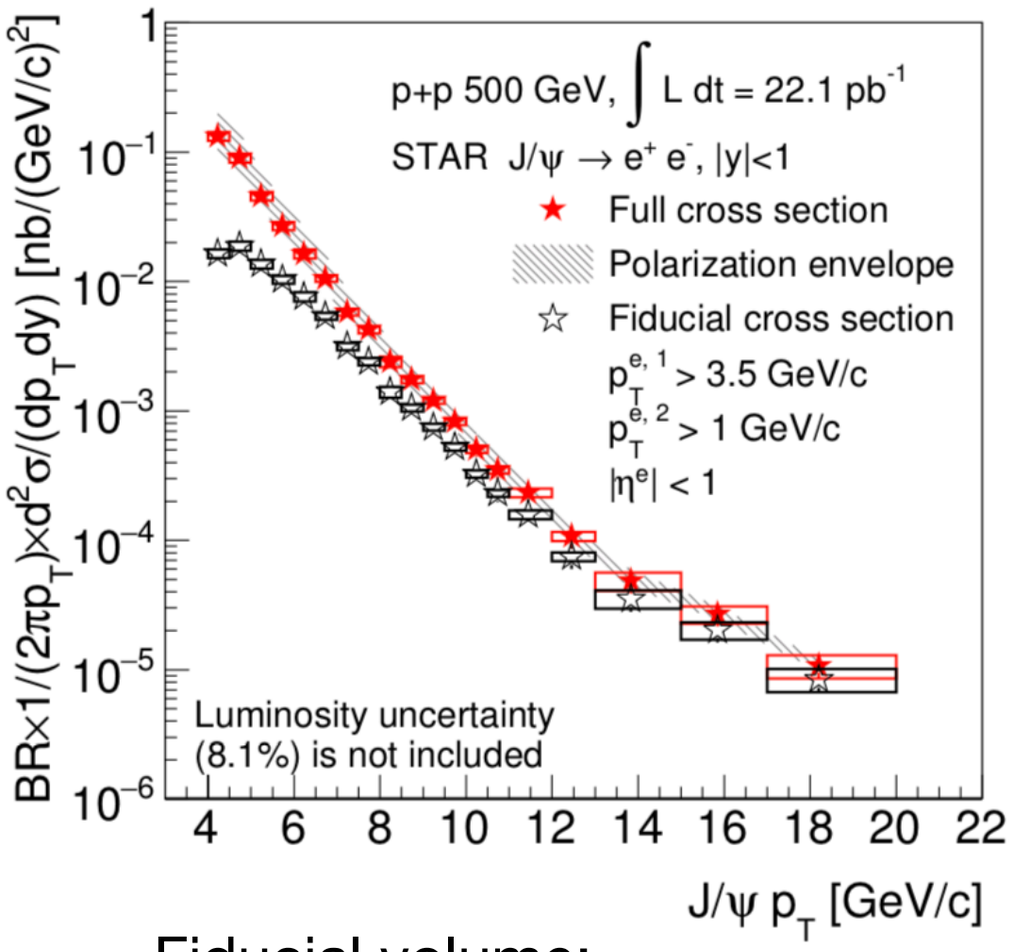


Fiducial volume:

$p_T^\mu > 1.3$ GeV/c

$|\eta^\mu| < 0.5$

J/ψ → e^+e^-



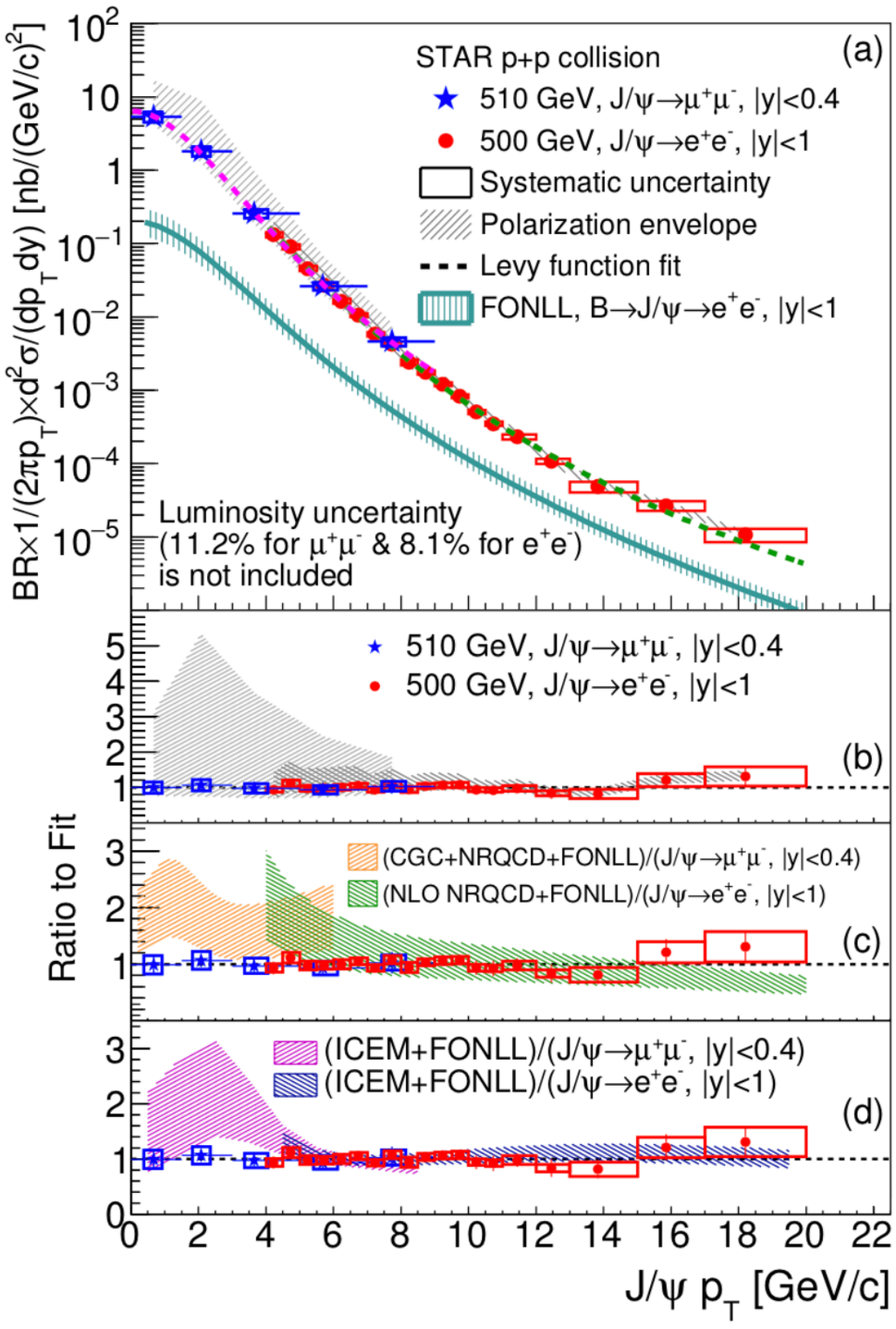
Fiducial volume:

$p_T^{e,1} > 3.5$ GeV/c

$p_T^{e,2} > 1$ GeV/c

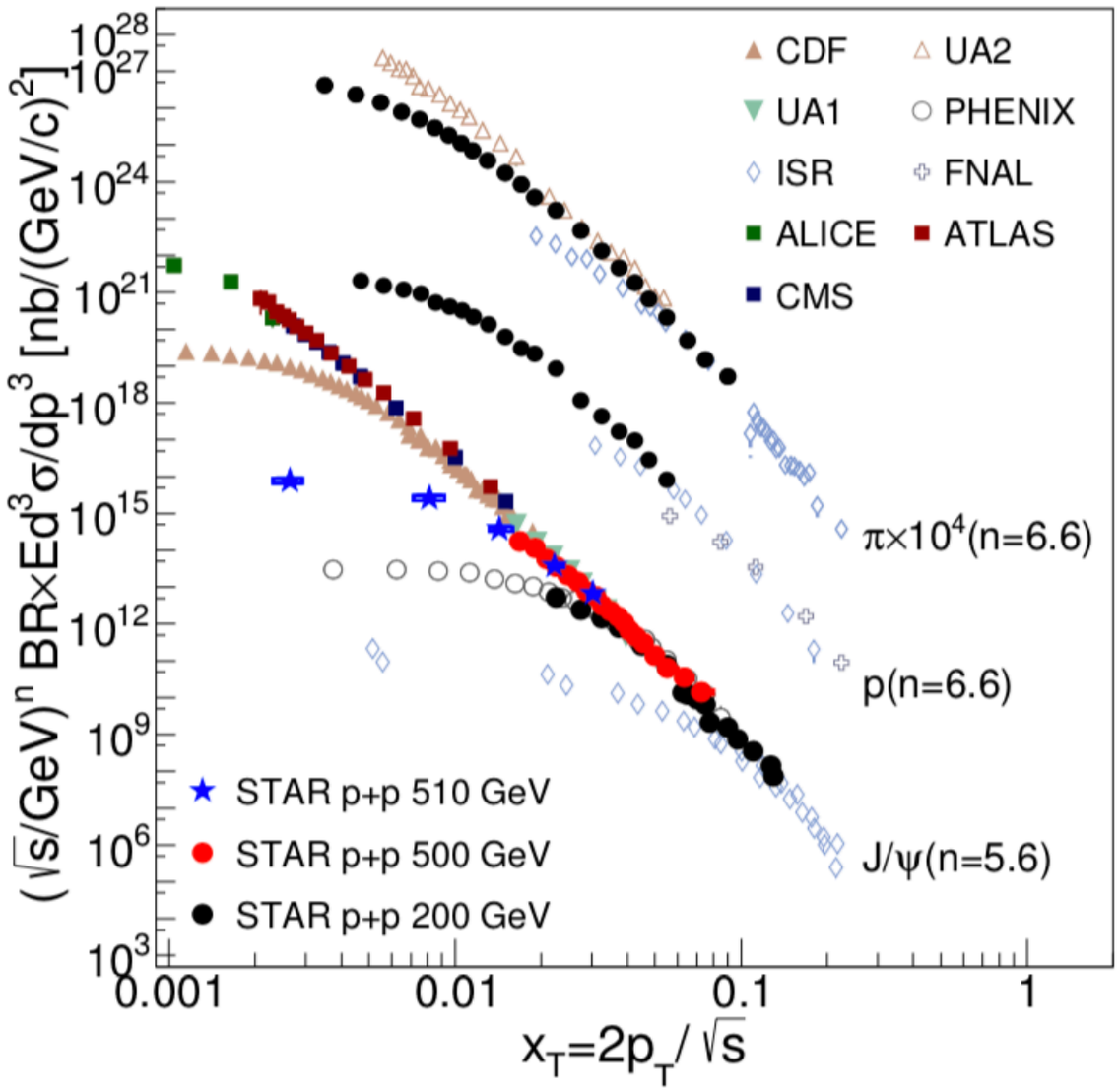
$|\eta^e| < 1$

J/ψ cross section: Compare with models



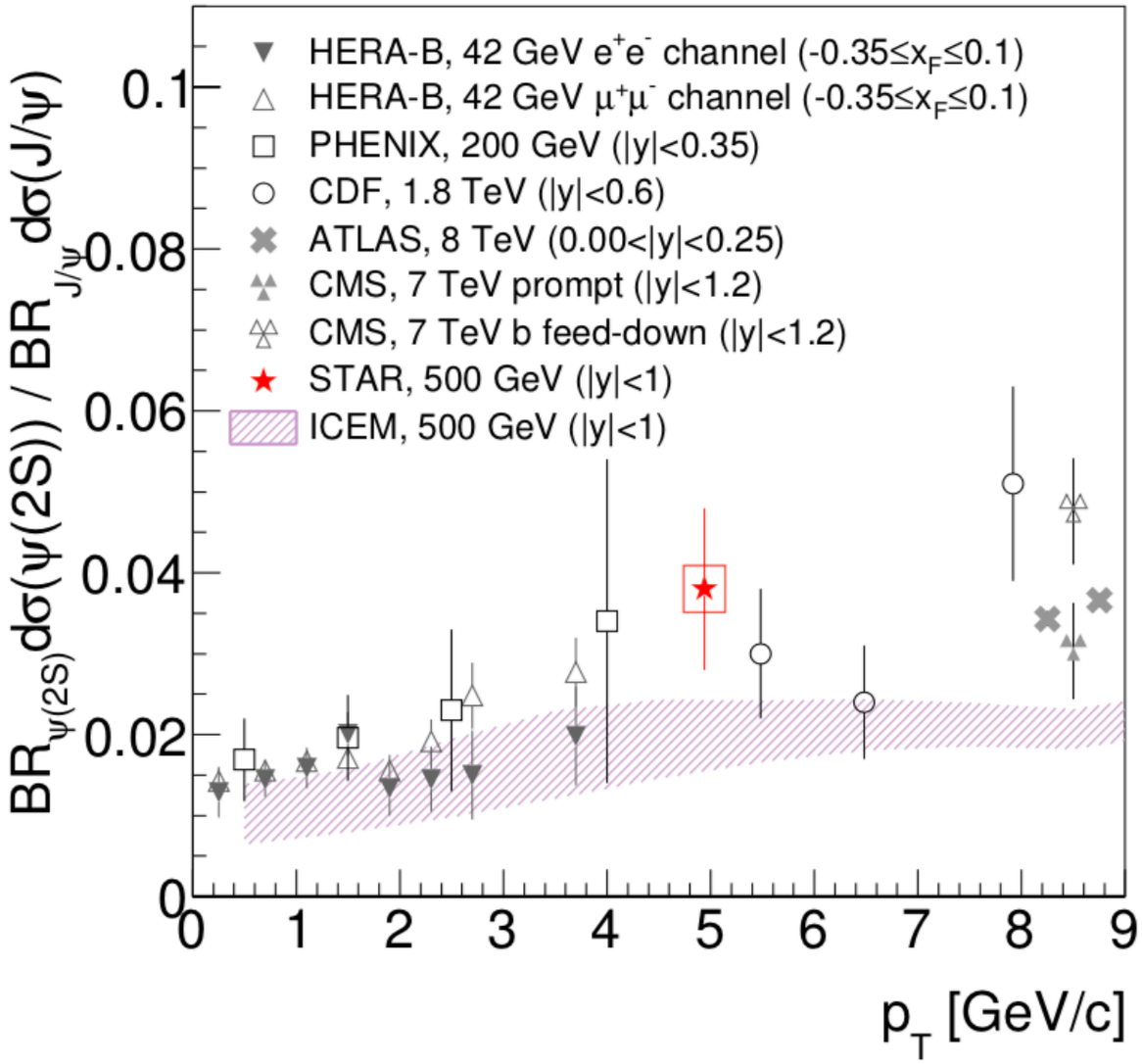
- Precision measurement within large dynamic range
  - J/ψ production cross-section for p_T from 0 to 20 GeV/c
- The prediction from CGC+NRQCD lies systematically above the data at low p_T
- The NLO NRQCD calculation describes the data
- The ICEM calculation can cover the entire p_T range
- Calculations only take prompt J/ψ production into account

J/ψ x_T scaling:



- Scaling behavior behavior for J/ψ at high p_T
  - n=5.6±0.1, CO and CEM (n~6), CSM (n~8)
- x_T scaling breaking - transition from hard to soft process

ψ(2S) to J/ψ ratio



- Measured ψ(2S)/J/ψ ratio is consistent with world-wide data
- The ICEM model can qualitatively describe measurements

Summary

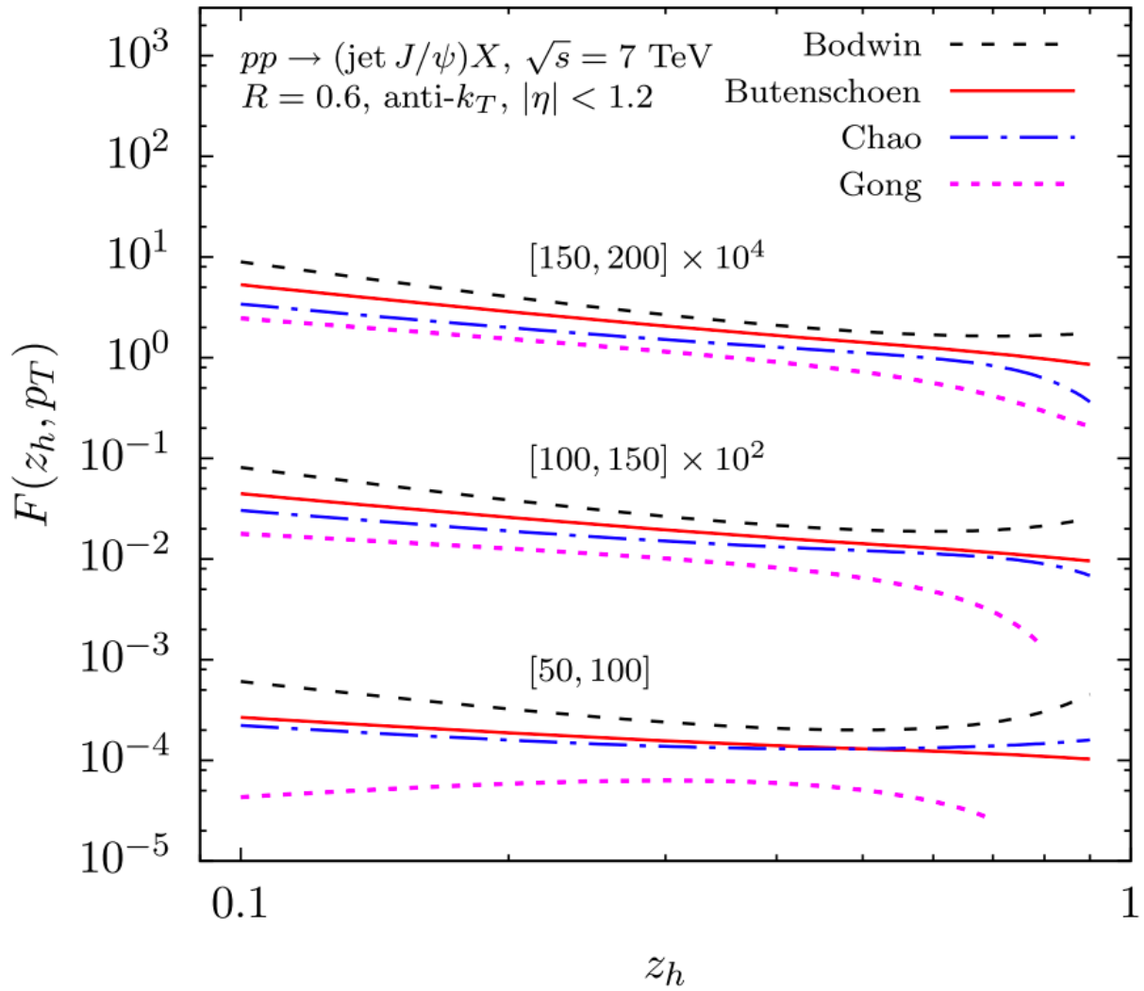
- Differential cross sections for the J/ψ meson in proton+proton collisions at √s = 500 and 510 GeV at RHIC are measured
  - Two different decay channels: e^+e^- and $\mu^+\mu^-$
  - Wide p_T range: 0 to 20 GeV/c

- The calculations from CGC+NRQCD, NL NRQCD and ICEM give a reasonable description for the data within the polarization envelope

- The J/ψ x_T scaling is consistent with measurements at other collision energies

- The ratio of ψ(2S) to J/ψ for pT from 4-12 GeV/c is measured, it is consistent with results from other experiments and there is no obvious collision energy dependence

Outlook: J/ψ production within a Jet



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- More detail information of J/ψ non-perturbative hadronization process
- Stronger discriminative power of different model
- New results from RHIC top energy will coming soon

Thank you for your attention !