



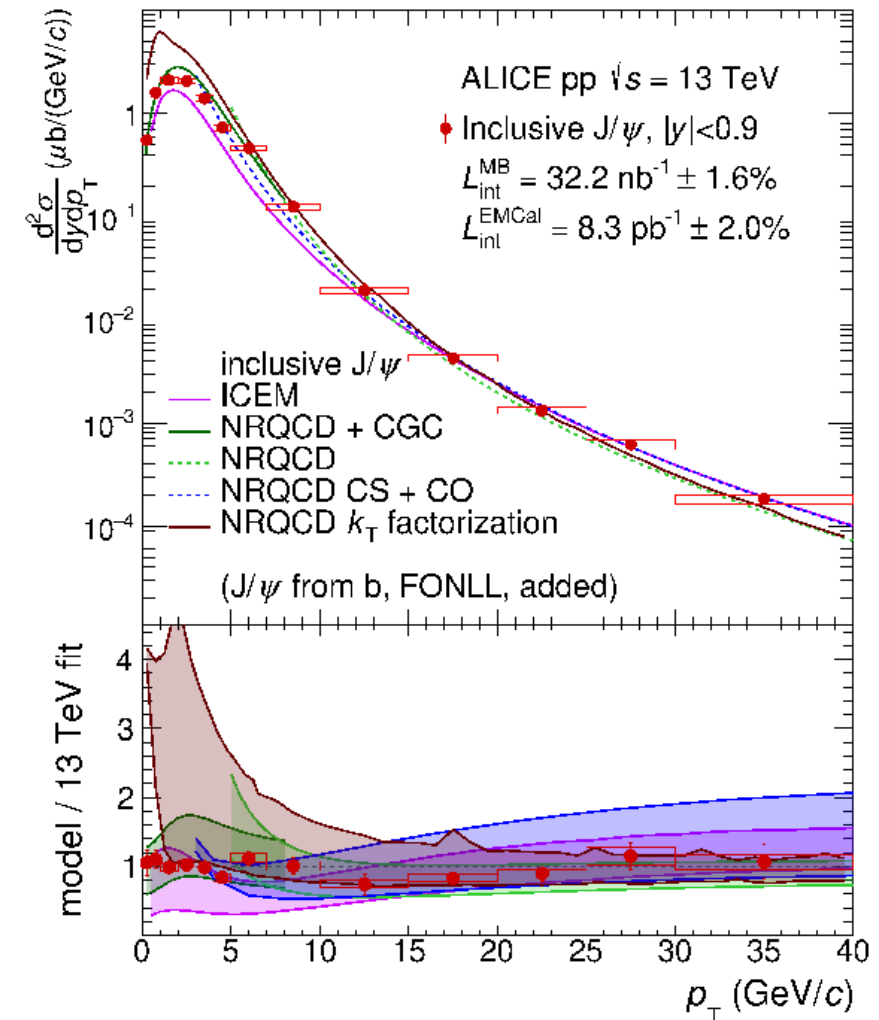
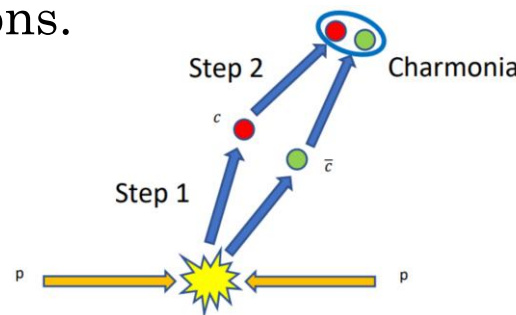
# Charmonium measurement in pp at 13.6 TeV

Zhenjun Xiong

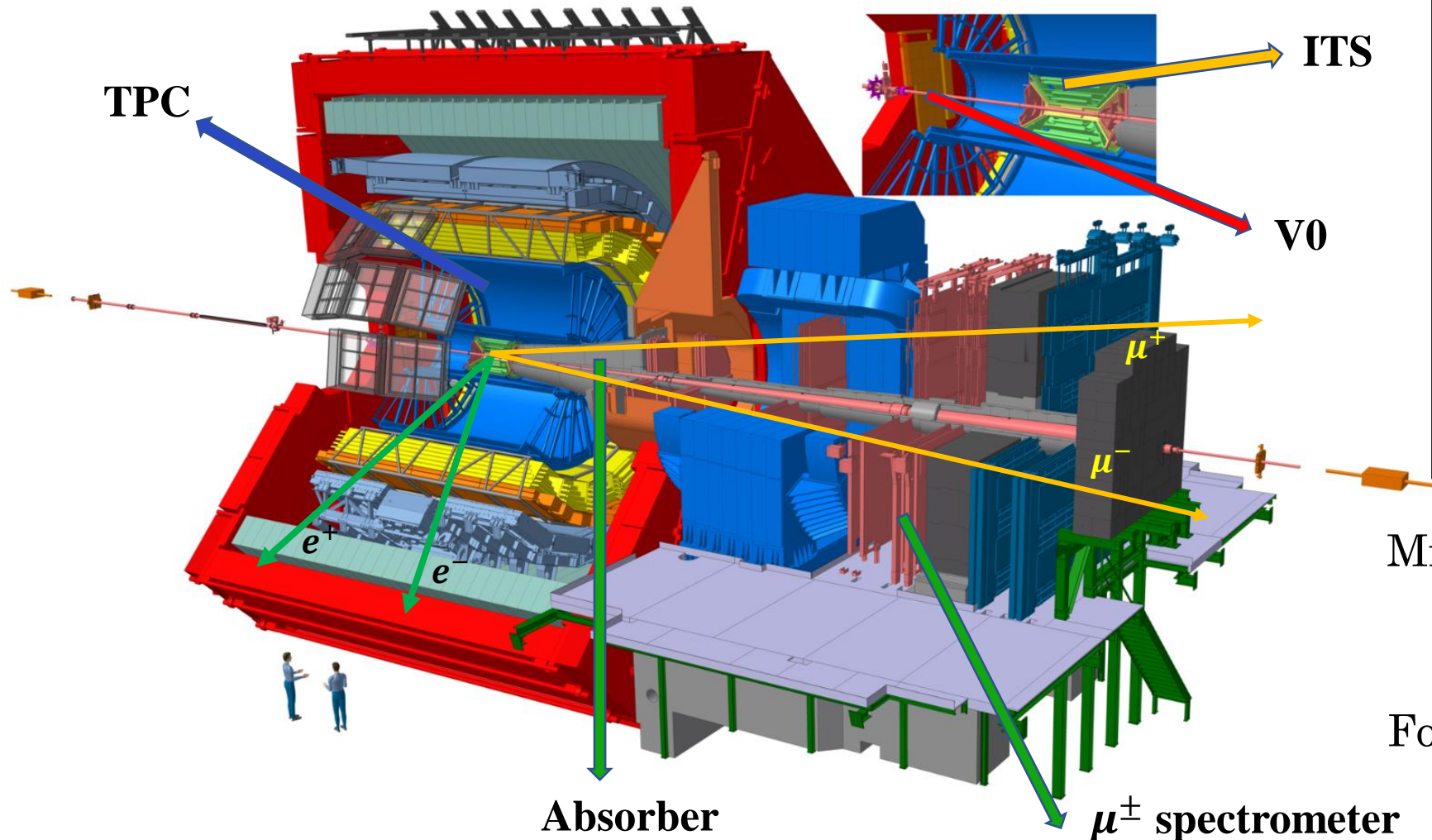
University of Science and Technology of China

USTC-PNP-Nuclear Physics Mini Workshop Series

- Charmonium: a bound states of charm and anti-charm quark pairs.
- Crucial for studying charmonium production mechanisms and testing different QCD-based models.
  - Heavy-quark production (perturbative QCD)
  - Formation of the charmonium states (non-perturbative QCD)
- Used as reference for studying AA collisions.



ALI-PUB-501994



- ◆ **V0 detector**
  - ✓ Centrality determination
  - ✓ Trigger
  - ✓ Background rejection
- ◆  **$\mu^\pm$  spectrometer**
  - ✓ Trigger
  - ✓  $\mu^\pm$  tracking
- ◆ **Time Projection Chamber**
  - ✓ Tracking, Particle identification
- ◆ **Inner Tracking System**
  - ✓ Tracking, Vertex reconstruction

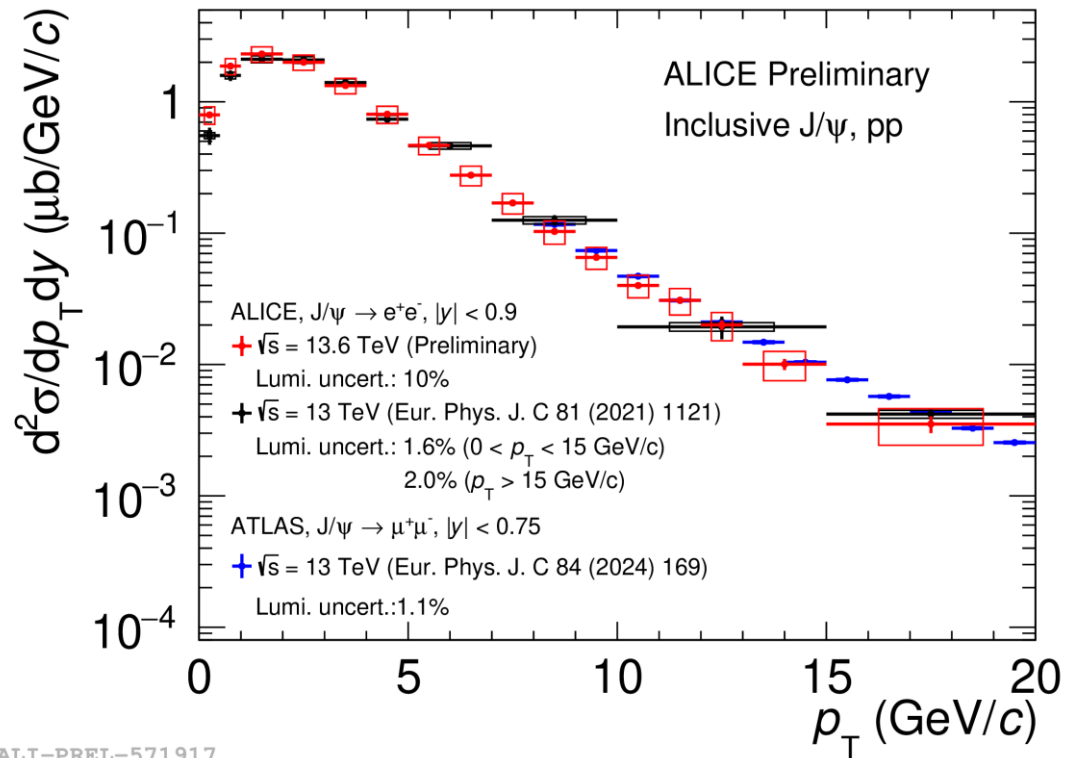
Midrapidity ( $|y| < 0.9$ )

- $J/\psi, \psi(2S) \rightarrow e^+e^-$
- $X(3872), \psi(2S) \rightarrow e^+e^-\pi^+\pi^-$
- ...

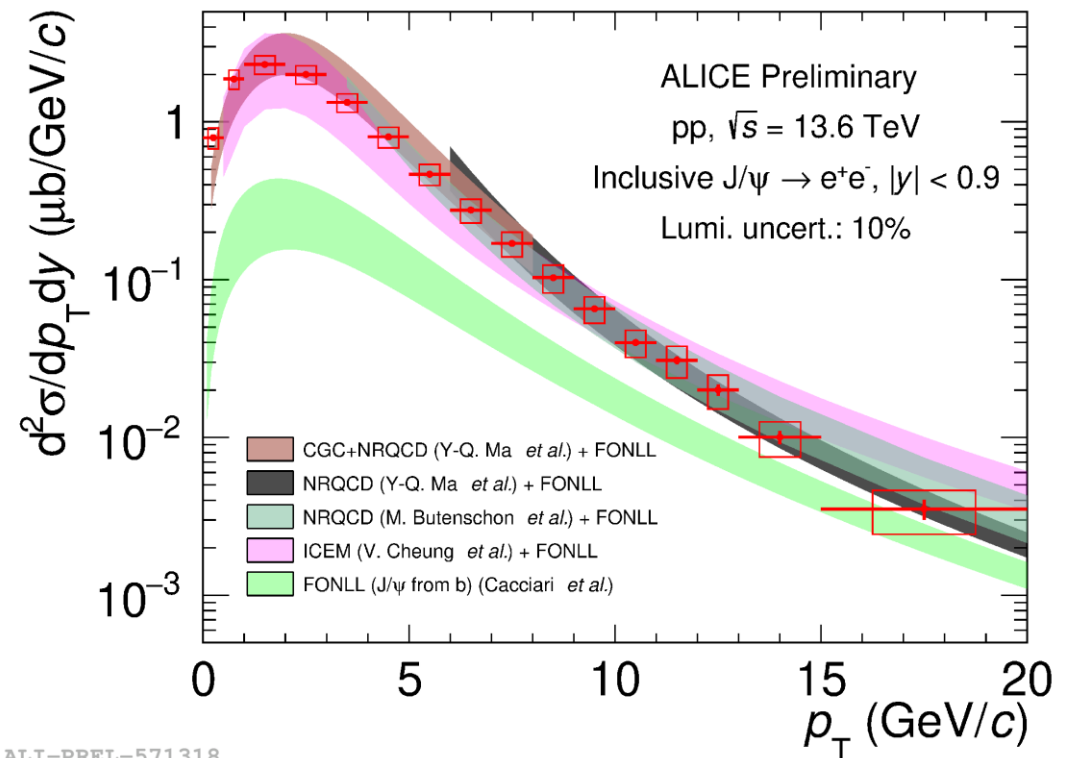
Forward rapidity ( $2.5 < y < 4.0$ )

- $J/\psi, \psi(2S) \rightarrow \mu^+\mu^-$

# J/ψ pT spectrum in pp collisions



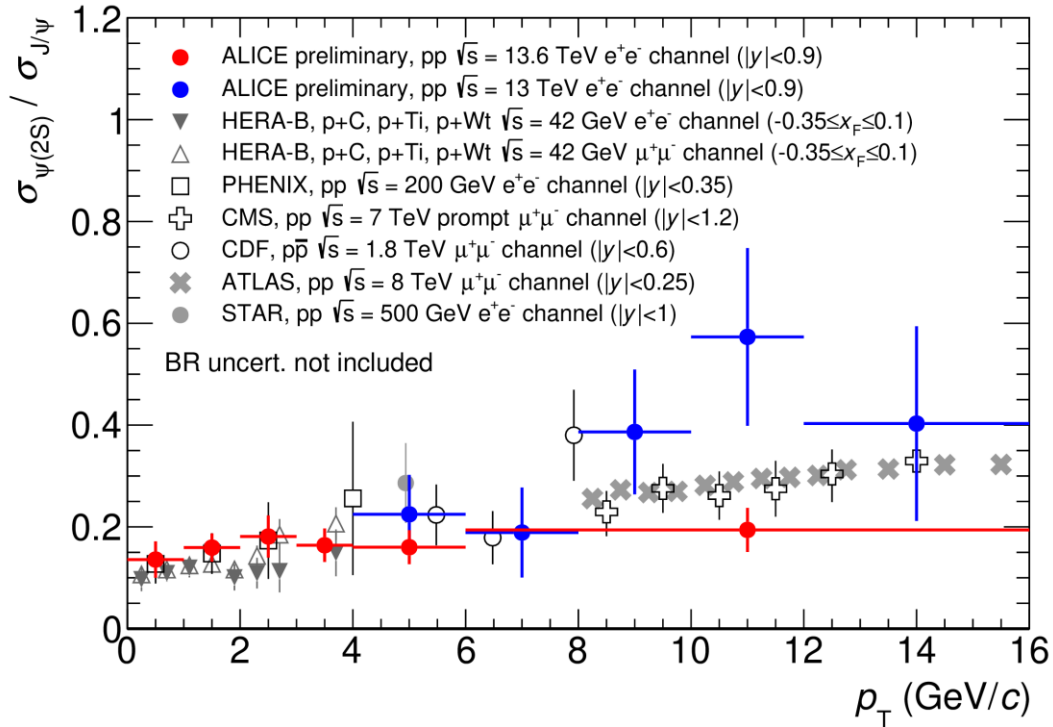
ALI-PREL-571917



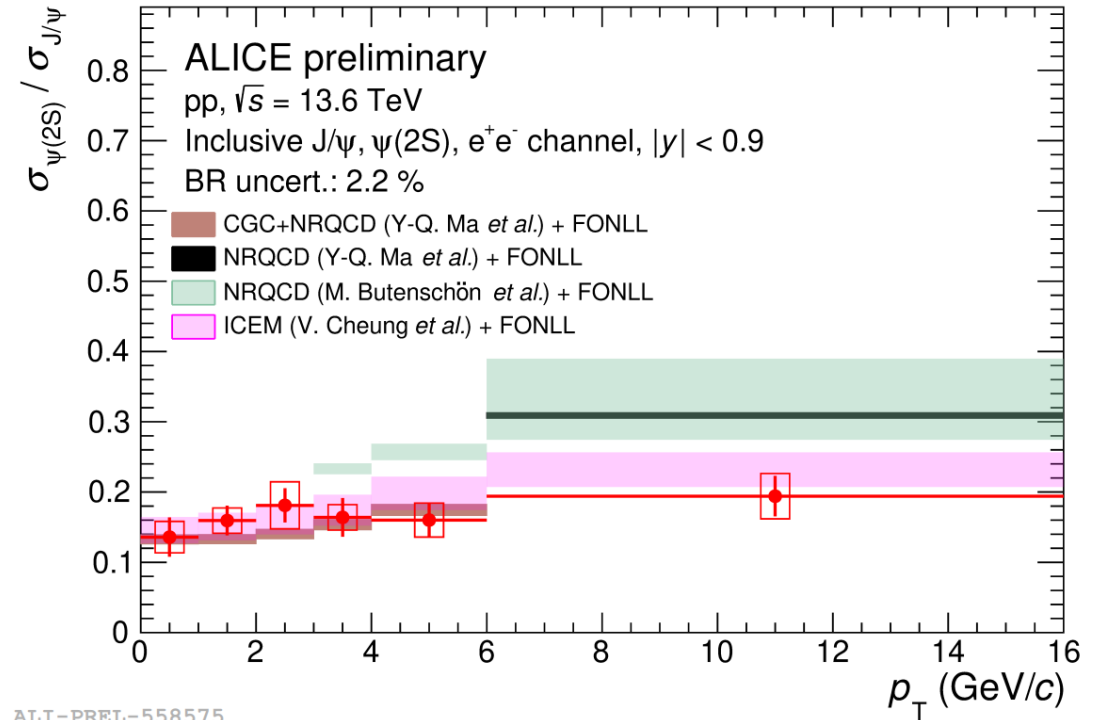
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- Measurement of inclusive J/ψ production in pp 13.6 TeV collisions at midrapidity, p<sub>T</sub> down to 0.
- Significant improvement in statistics for Run 3.
- All models describe data reasonably.

# The ratio of $\psi(2S)$ -to- $J/\psi$



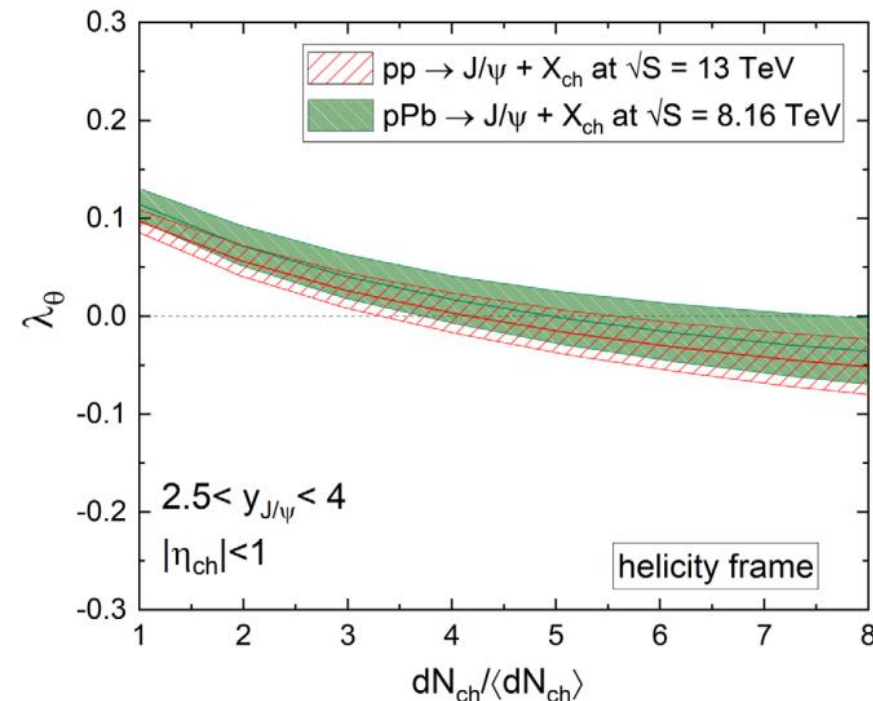
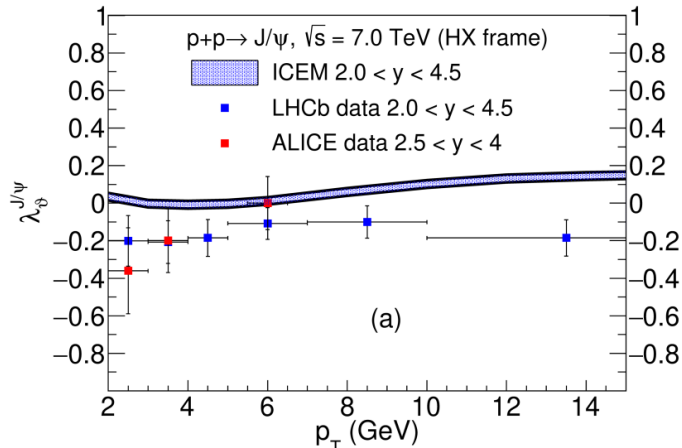
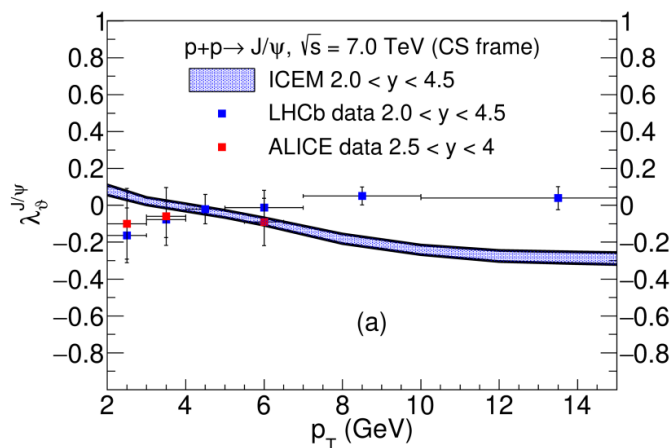
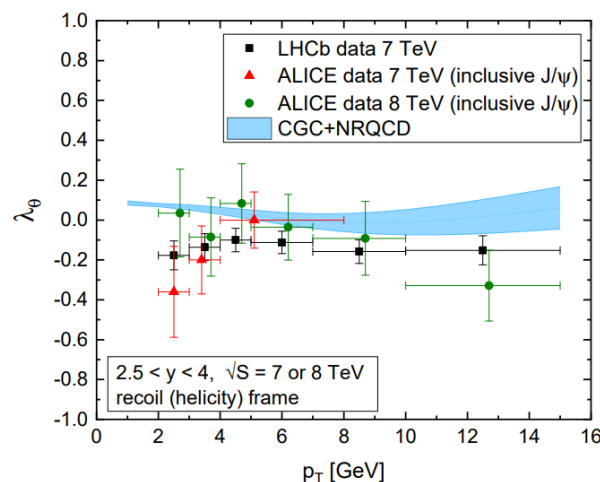
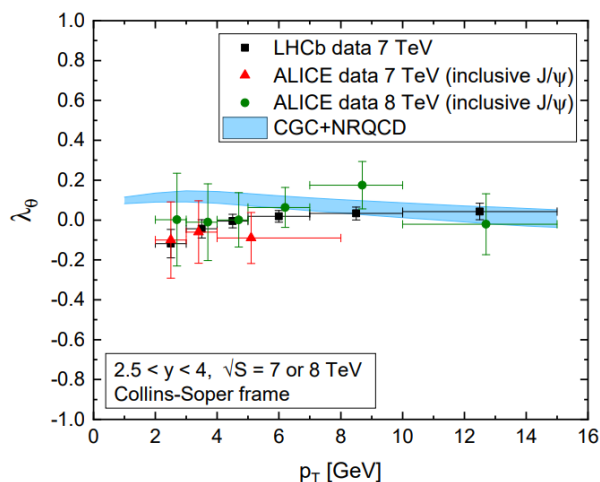
ALI-PREL-548722



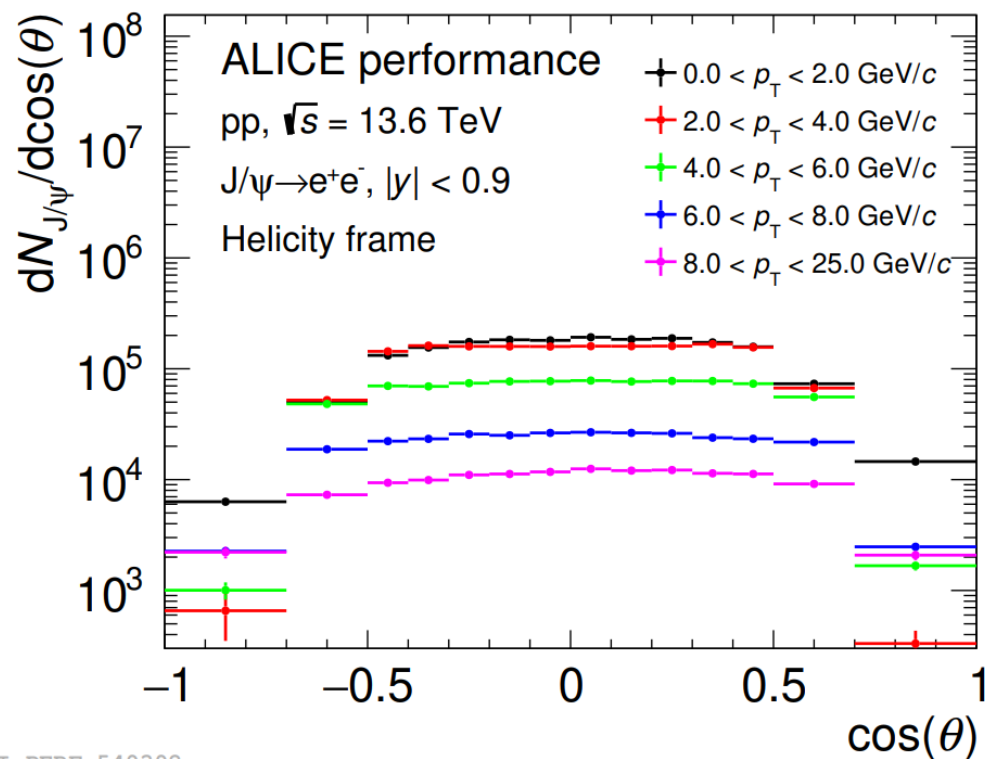
ALI-PREL-558575

- First measurement of  $\psi(2S)$  in central barrel in ALICE.
- $\psi(2S)$ -to- $J/\psi$  ratio measurements at midrapidity and forward rapidity.
- ICEM reproduce measurements reasonably over full  $p_T$  range.

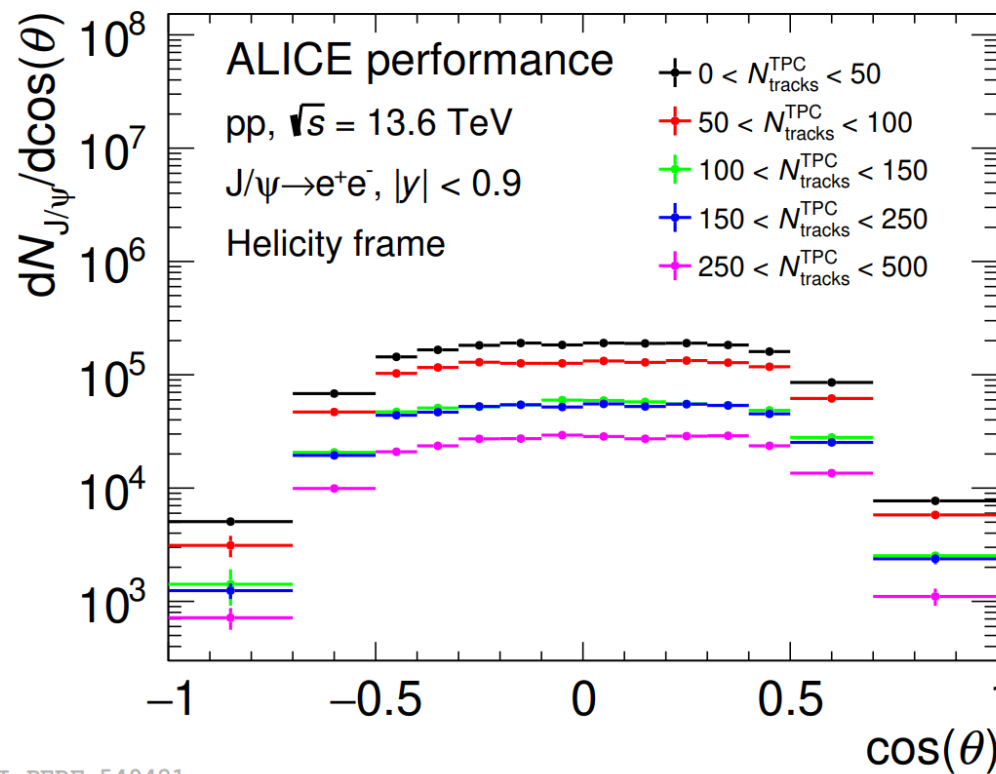




- Golden observable to constrain quarkonium production mechanism.

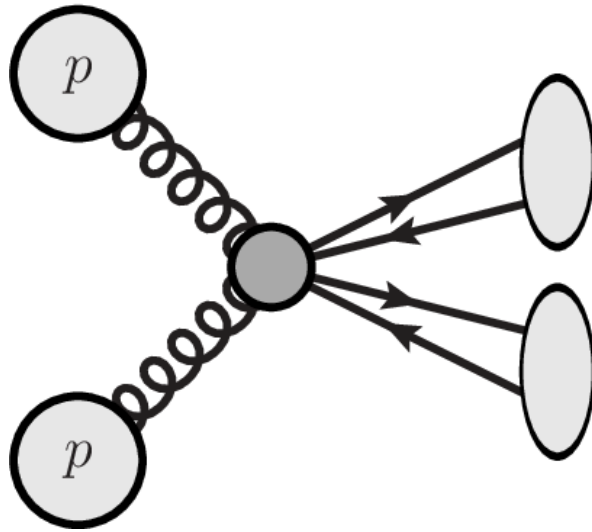


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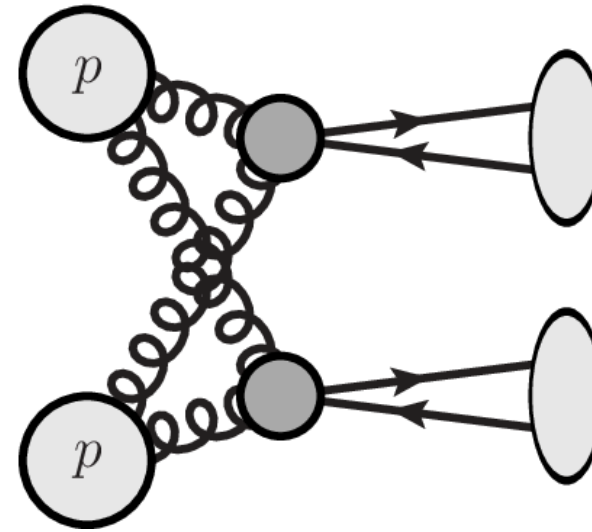


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- First measurement of J/ψ polarization at midrapidity with ALICE Run 3.
- Further analysis are ongoing.



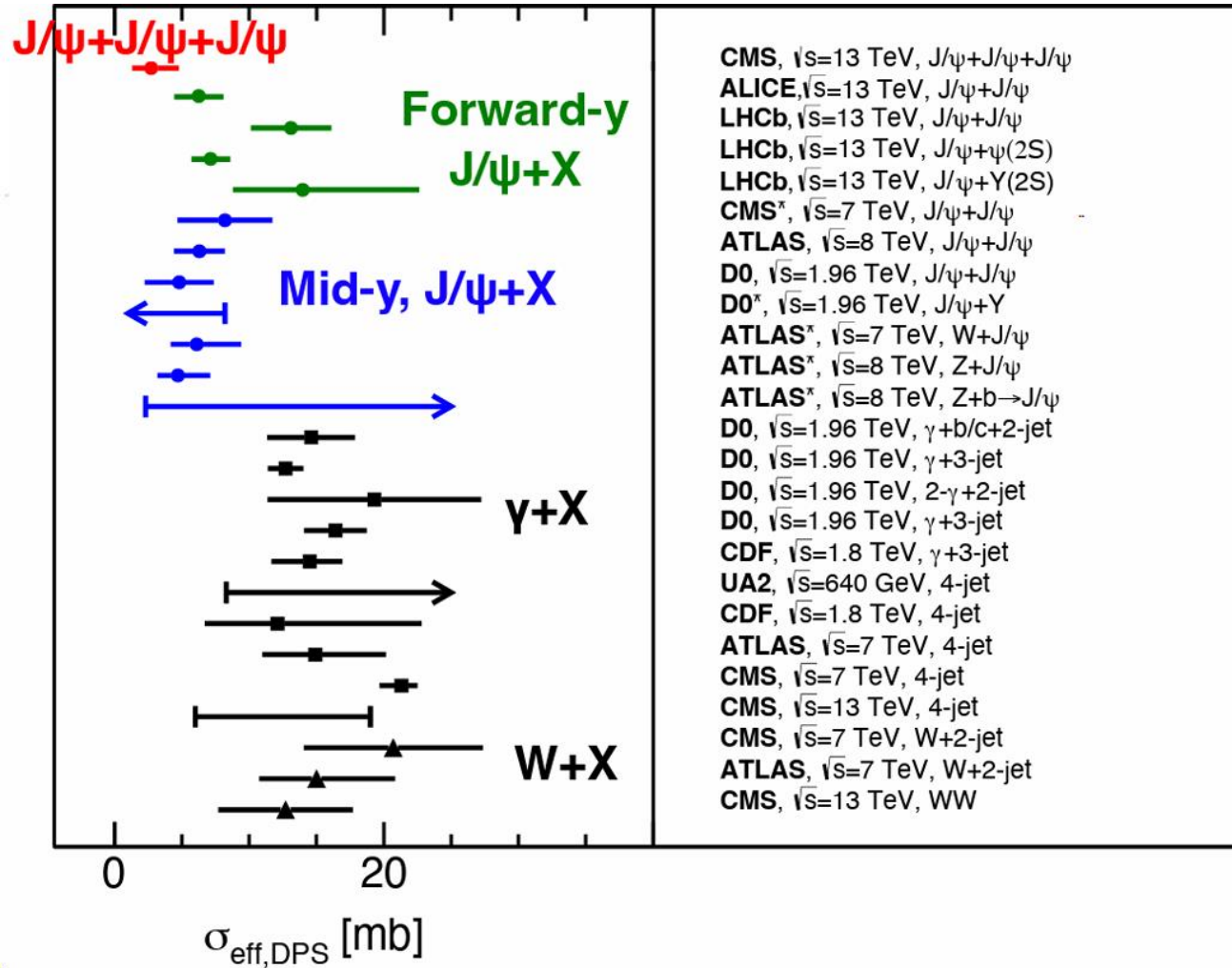
Single-Parton Scattering



Double-Parton Scattering

- The production of c-hadron pairs provides an opportunity to study both **Single Parton Scattering** (SPS) and **Double Parton Scattering** (DPS).
- Study the parton transverse profile and correlations.





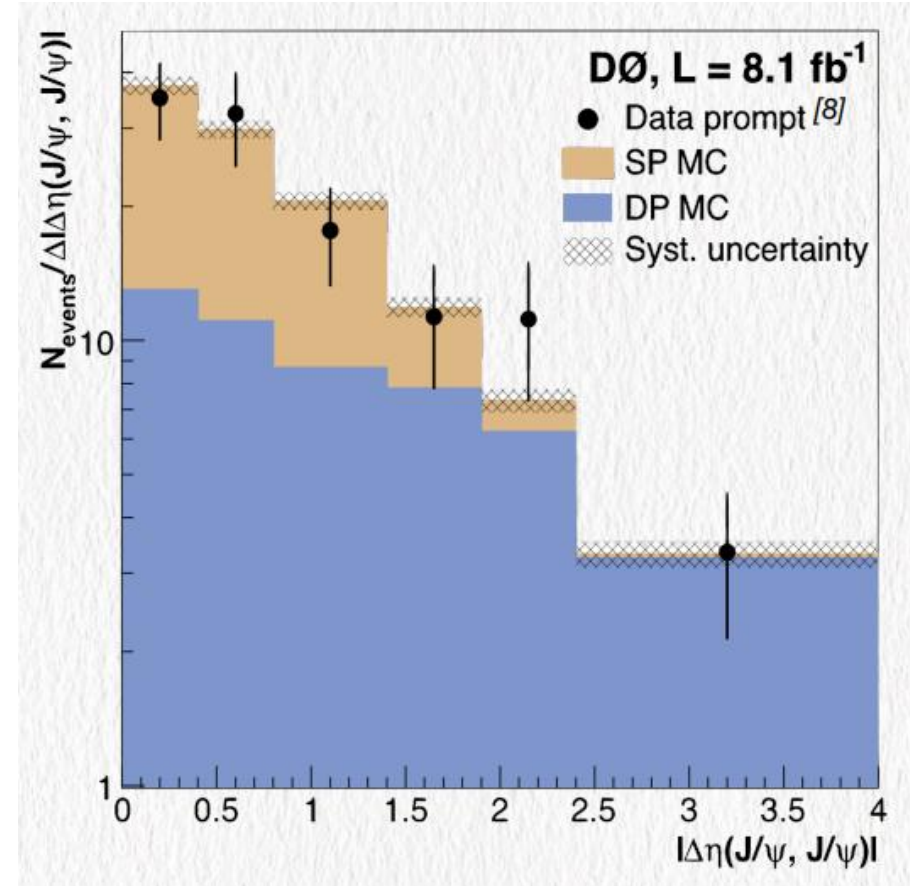
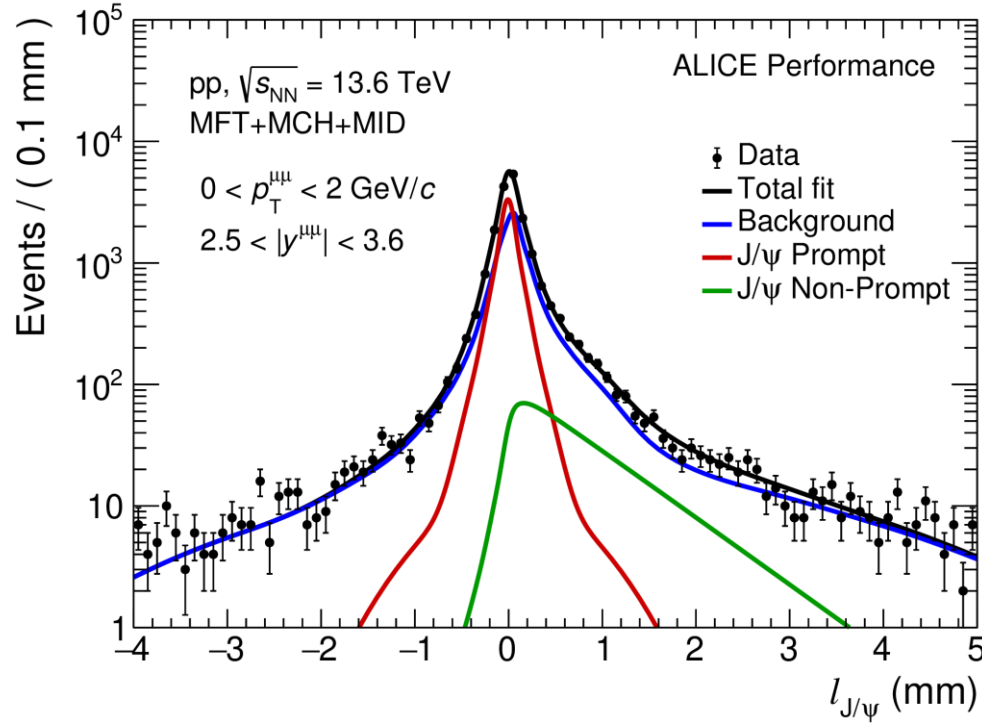
DPS contribution to a final state A + B can be evaluated as:

$$\sigma_{A,B}^{\text{DPS}} = \frac{m}{2} \frac{\hat{\sigma}^A \hat{\sigma}^B}{\sigma_{\text{eff}}}$$

$m = 1$  ( $2$ ) for identical (different) hadron.

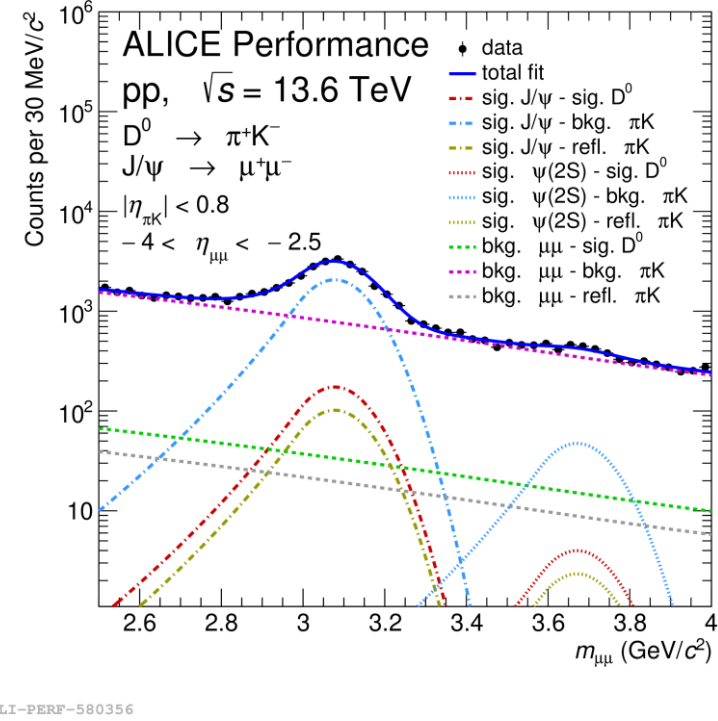
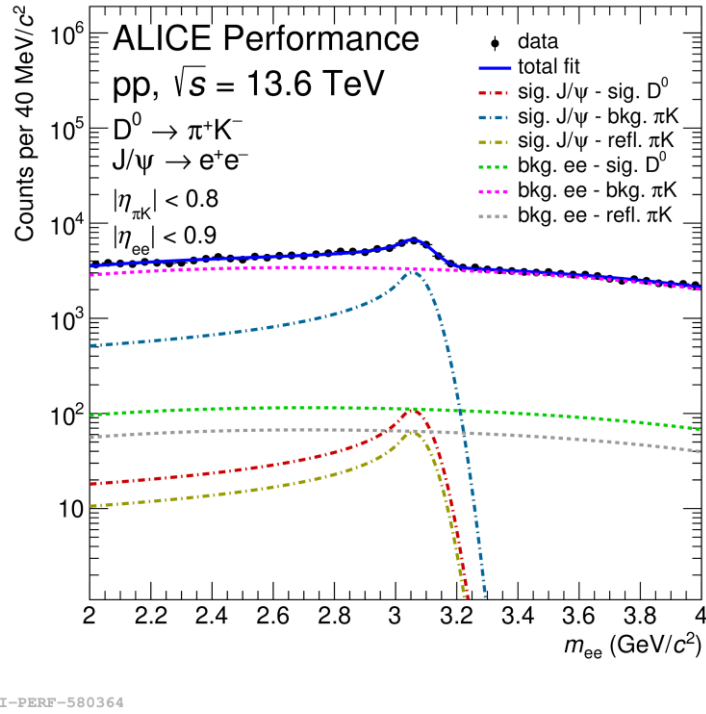
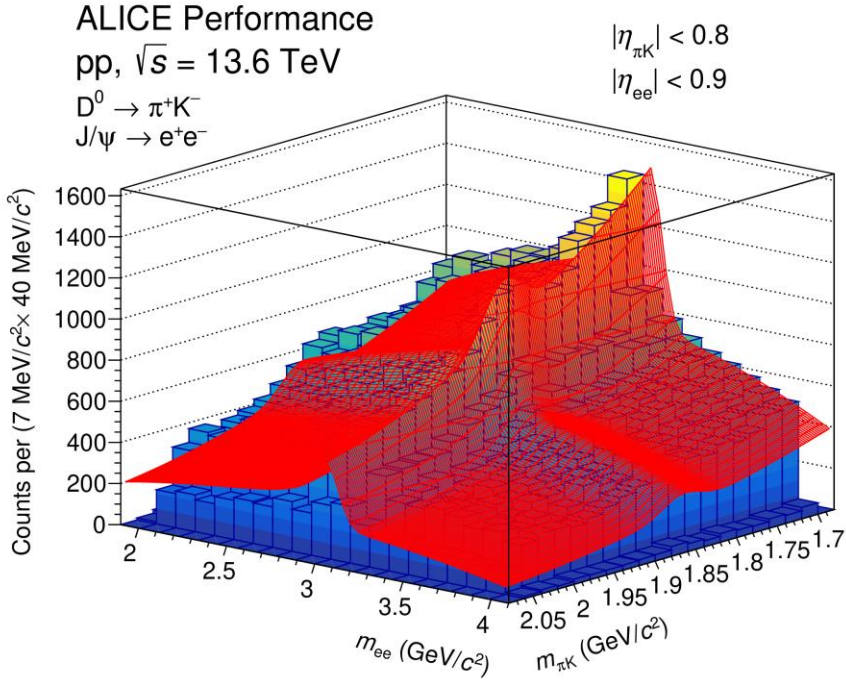
$\sigma_{\text{eff}}$ : effective cross section parameter of DPS.

- Allows the measurements of the effective cross section and the test of its universality.



- In Run 3, ALICE has the possibility to conduct many new analyses, such as:
  - Combined analyses of the central barrel – muon spectrometer. (D0(  $y < 0.8$  )–J/ψ (  $2.5 < y < 4.0$  ))
  - Prompt/non-prompt separation for forward rapidity J/ψ reconstruction .
- SPS –DPS separation sensitive to  $\Delta y$ .

# J/ψ-D pair production

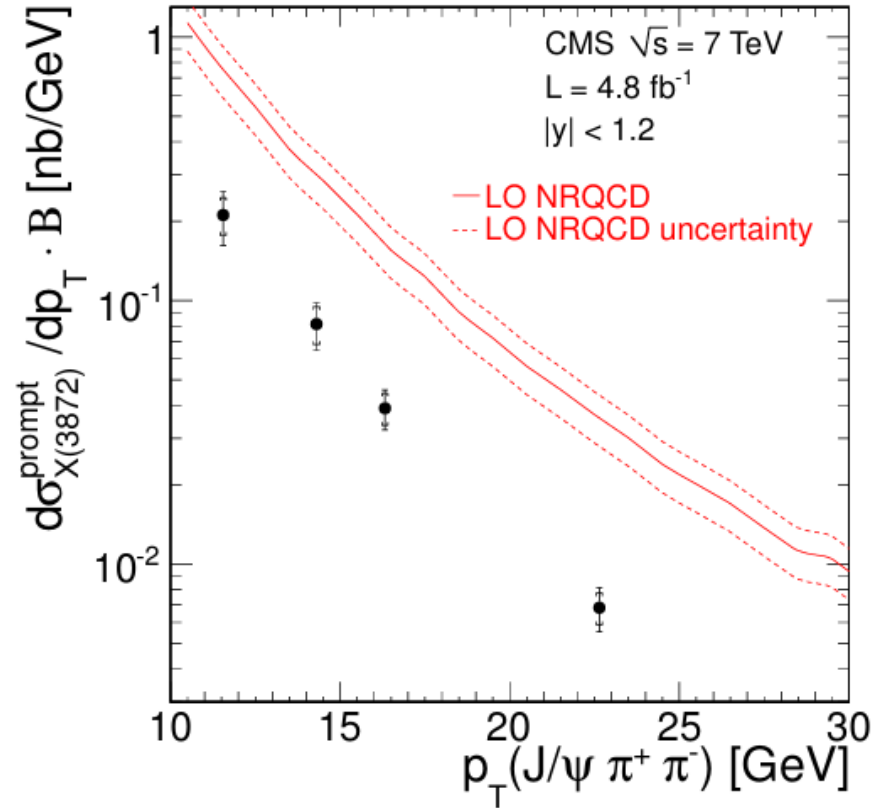
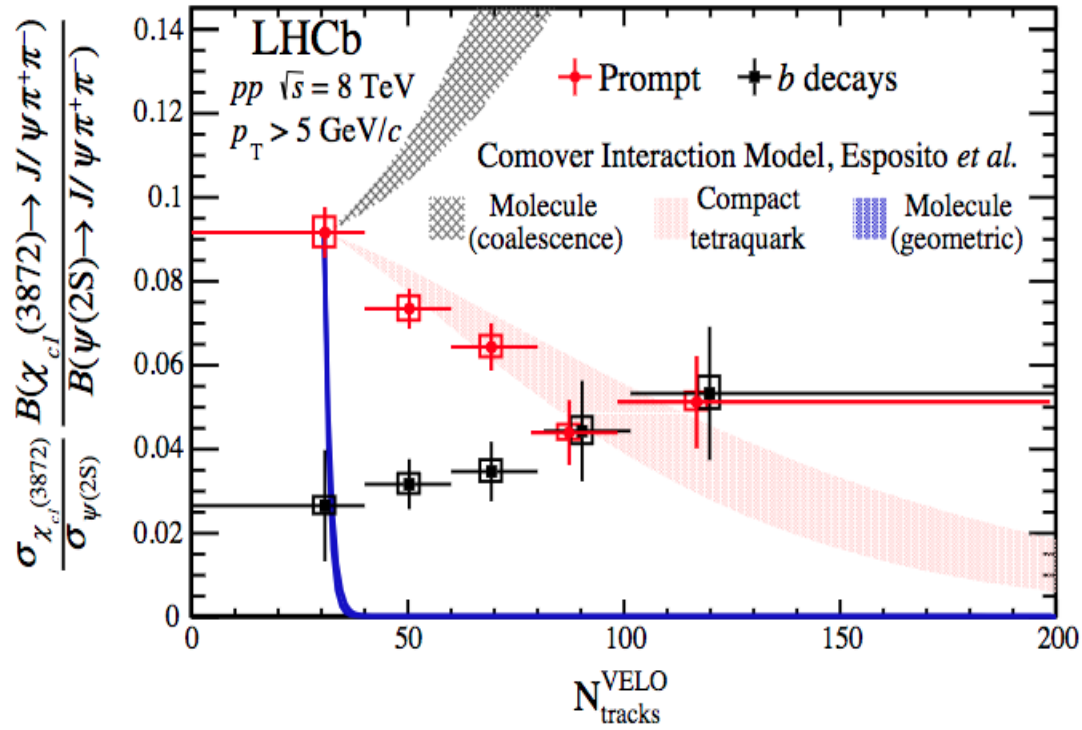


$$F(m_1, m_2) = N \times S_1(m_1) \times S_2(m_2) + R_{B_1, S_2} \times B_1(m_1) \times S_2(m_2) + R_{S_1, B_2} \times S_1(m_1) \times B_2(m_2) + R_{B_1, B_2} \times B_1(m_1) \times B_2(m_2),$$

~ 40% all Run 3 statistics

- First J/ψ-D pair production measurement at mid and forward rapidity in pp collisions with ALICE.
- Further analysis are ongoing.

# X(3872) and $\psi(2S)$ production via $J/\psi\pi\pi$



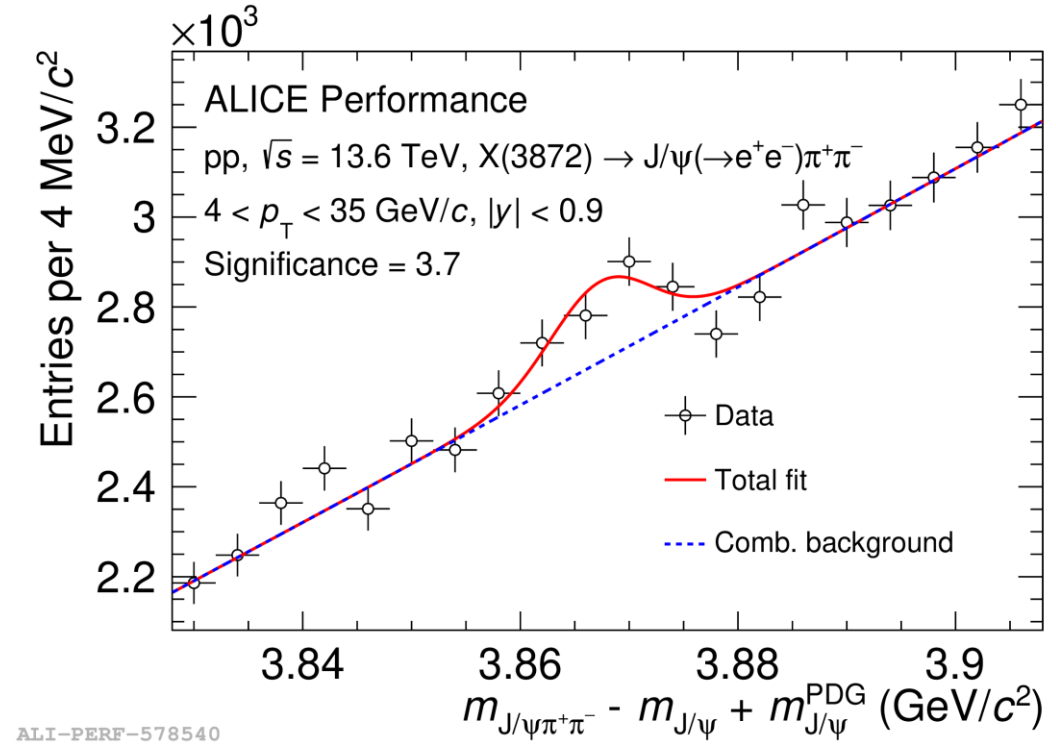
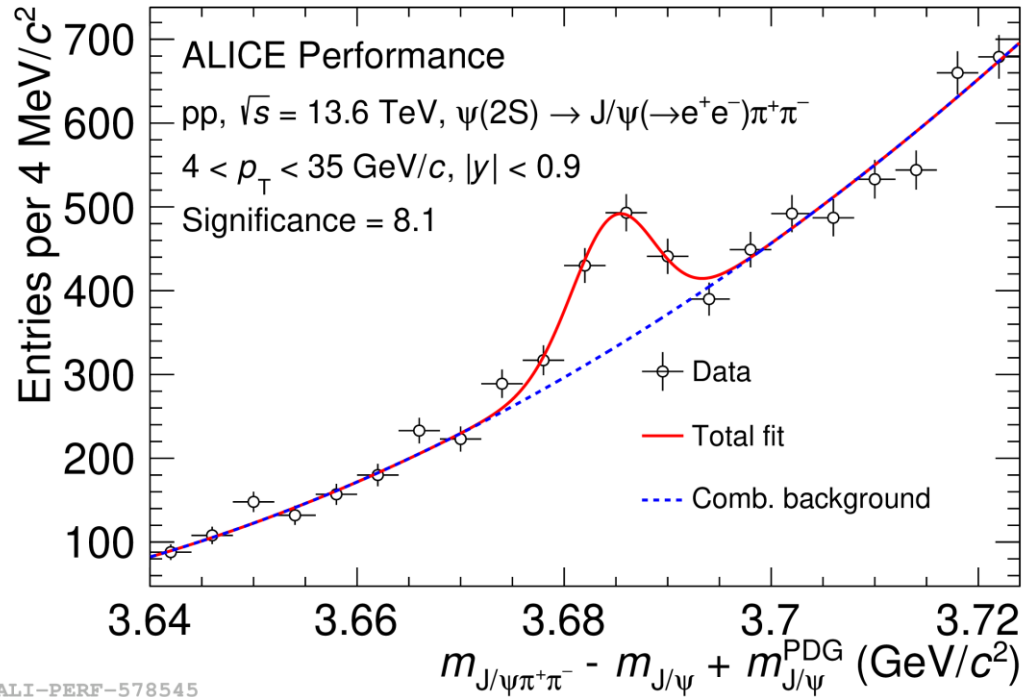
- Molecule or Tetraquark?

- Compact quark structures
- Deuteron-like meson structures

- Measure the production cross-section of X(3872) in the low  $p_T$  region at midrapidity.



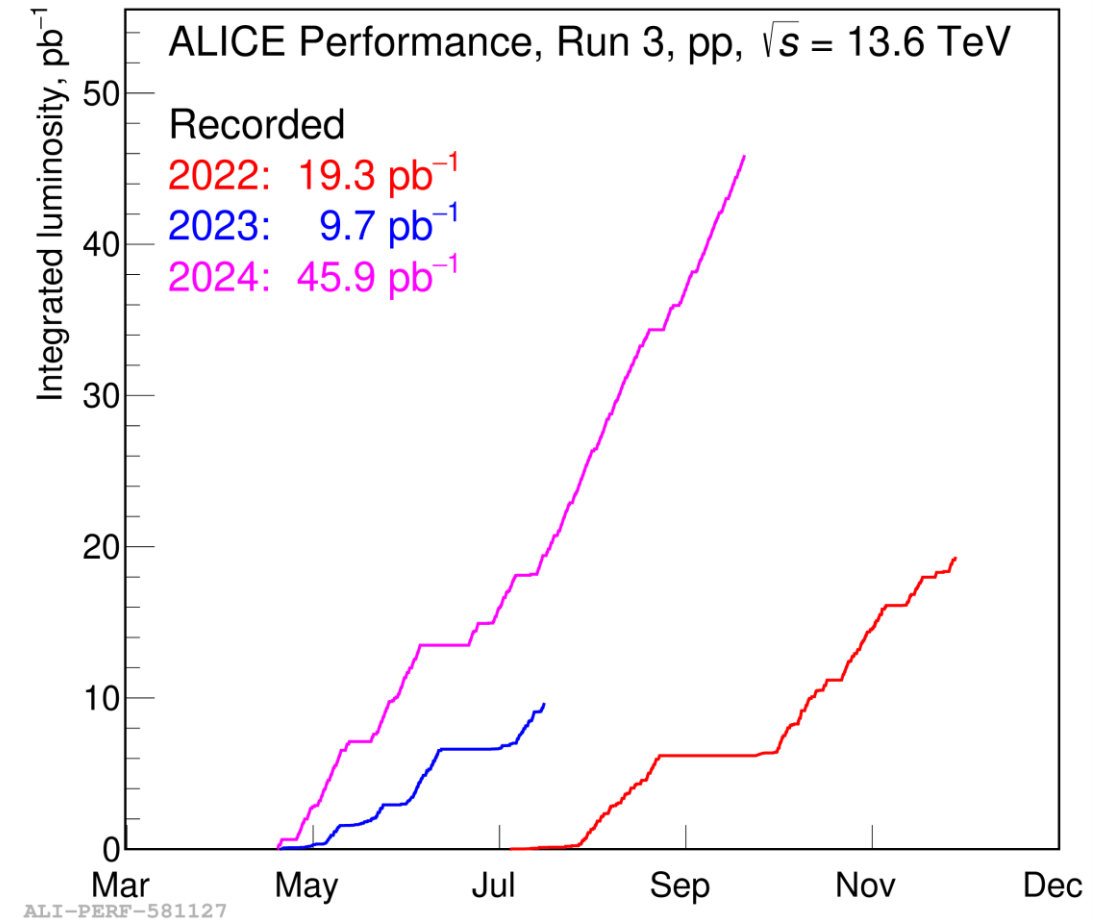
# X(3872) and $\psi(2S)$ production via $J/\psi\pi\pi$



~ 40% all Run 3 statistics

- First reconstruction of  $\psi(2S)$  and X(3872) via  $J/\psi\pi\pi$  decay channel with ALICE Run 3.
- Further analysis are ongoing.

- A lot of charmonium measurements can be done with ALICE Run 3 pp collisions. Thanks to the high statistics bring by continue readout system.
  - $J/\psi, \psi(2S)$  ratio and cross section
  - $J/\psi$  polarization
  - $J/\psi$  associate production
  - Exotic particle...
- Some analysis was stopped due to the progress of the MC.



Thank  
You