



Measurement of inclusive J/ψ polarization at midrapidity in pp collisions at 13.6 TeV with ALICE

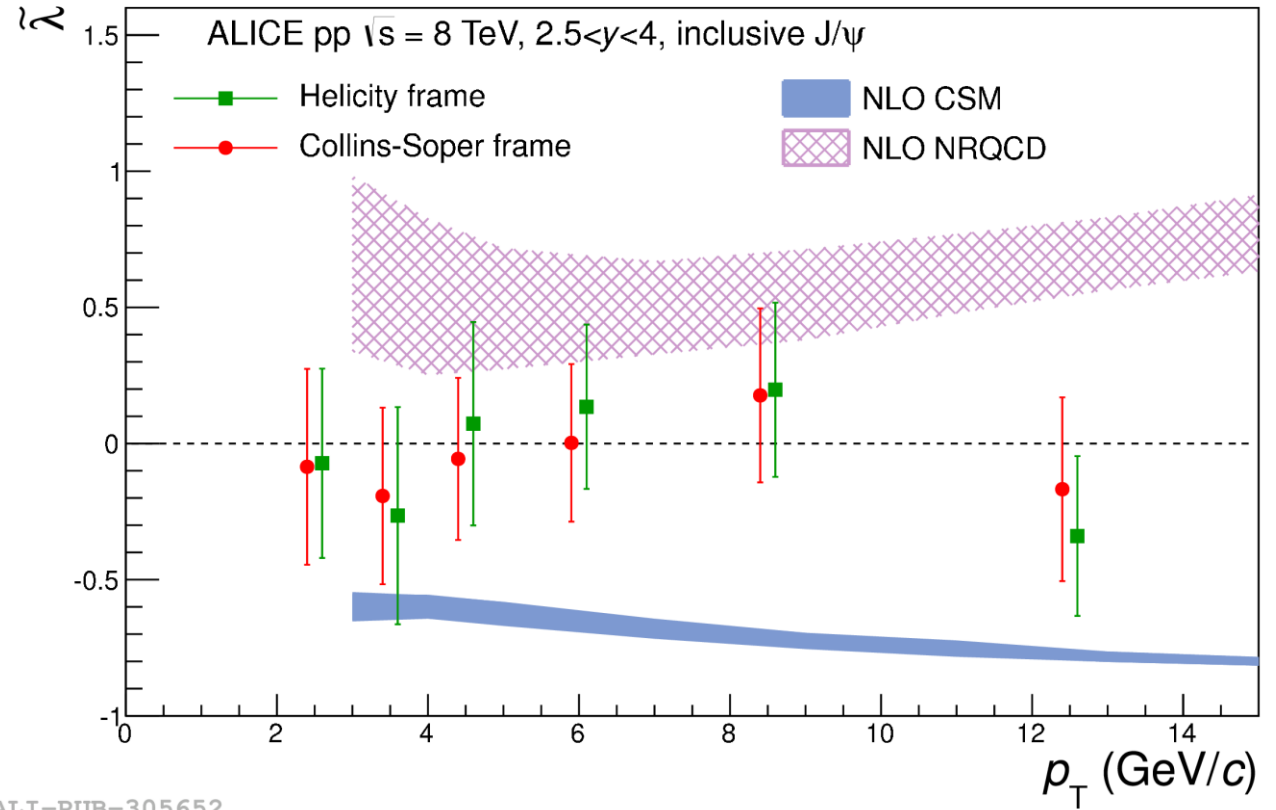
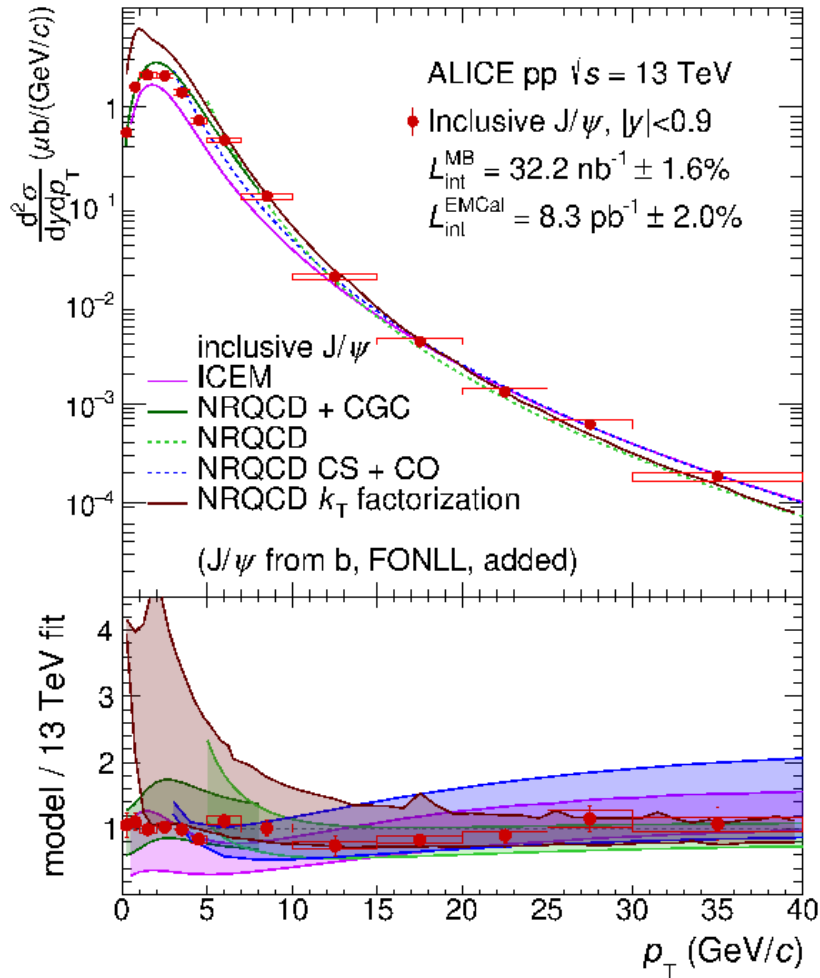
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J/ψ polarization in pp collisions



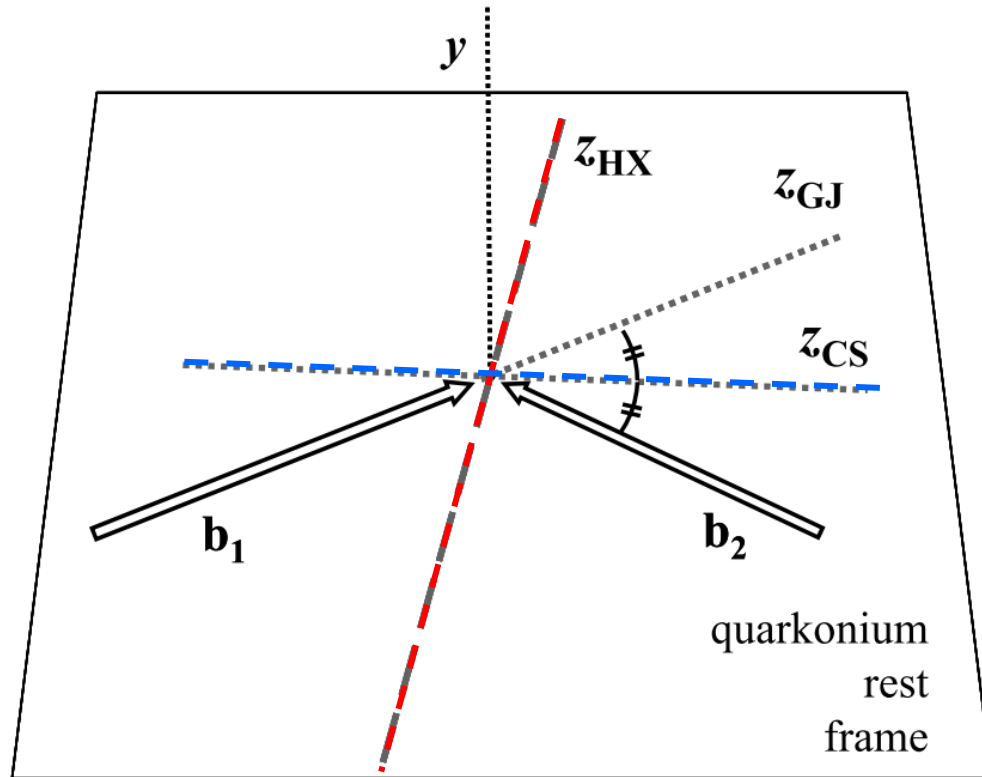
➤ Important observable to constrain J/ψ production mechanism.

① PRL 108, 082001 (2012)

② PRL 108, 172002 (2012)

③ PRL 108, 172002 (2012)

Introduction: Vector meson polarization

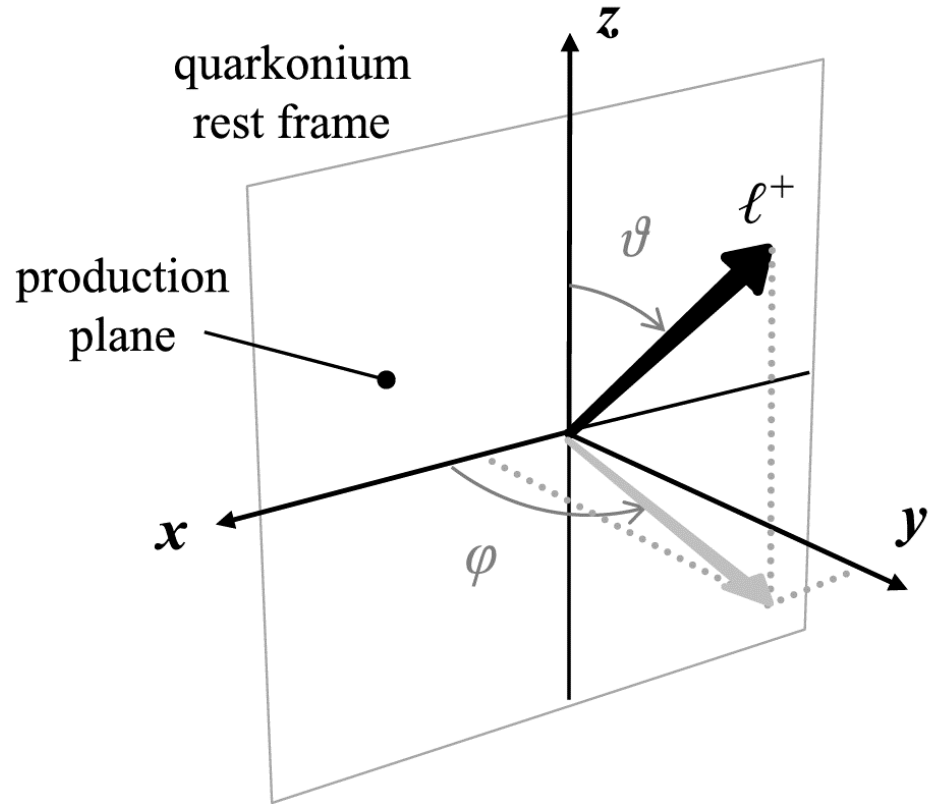


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- **Helicity (HX)**: direction of vector meson in the collision center of mass frame.
- **Collins-Soper (CS)**: the bisector of the angle between the beam and the opposite of the other beam, in the vector meson rest frame

- Polarization is defined as the alignment of spin along a chosen direction.

Introduction: Vector meson polarization



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We assume that the ensemble of vector particles has the following density matrix.

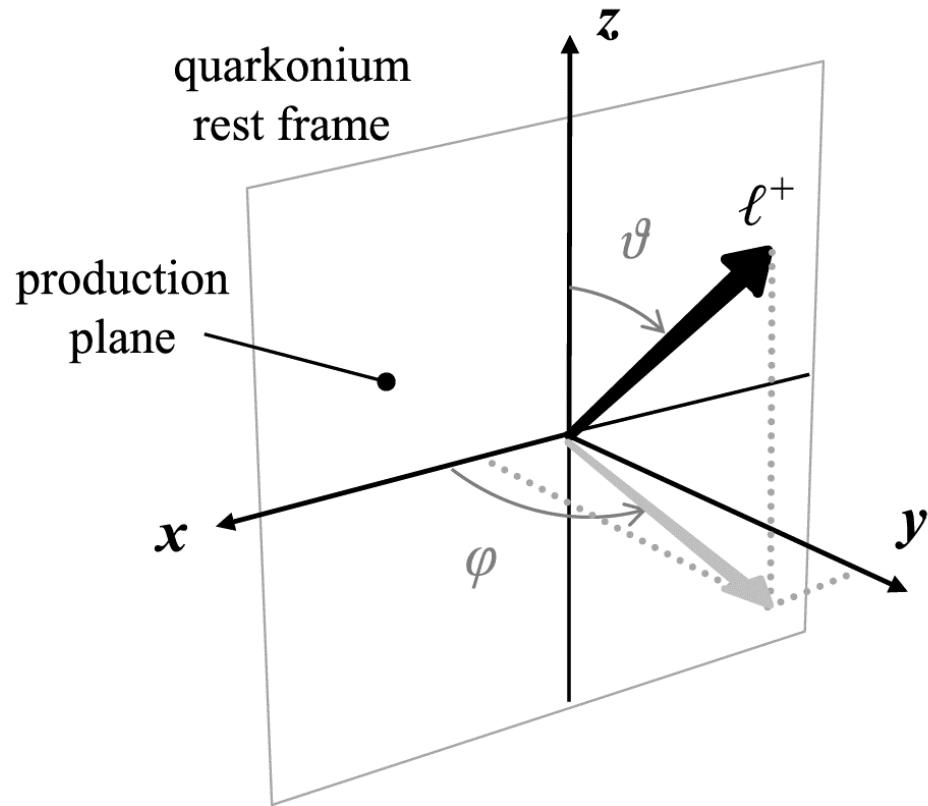
$$|V\rangle = b_{+1}|+1\rangle + b_{-1}|-1\rangle + b_0|0\rangle.$$

We can obtain the angular distribution of the final state particles in a two-body decay by employing rotation transformations.

$$W(\cos\vartheta, \varphi)$$

$$\begin{aligned} \propto \sum_{l'=\pm 1} |B_{l'}|^2 \propto & \frac{\mathcal{N}}{(3 + \lambda_\vartheta)} (1 + \lambda_\vartheta \cos^2 \vartheta \\ & + \lambda_\varphi \sin^2 \vartheta \cos 2\varphi + \lambda_{\vartheta\varphi} \sin 2\vartheta \cos \varphi \\ & + \lambda_\varphi^\perp \sin^2 \vartheta \sin 2\varphi + \lambda_{\vartheta\varphi}^\perp \sin 2\vartheta \sin \varphi), \end{aligned}$$

Introduction: Vector meson polarization



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The integration over either ϕ or $\cos(\theta)$ leads to one-dimensional angular distributions,

$$W(\cos \vartheta) \propto \frac{1}{3 + \lambda_{\vartheta}} (1 + \lambda_{\vartheta} \cos^2 \vartheta),$$

$$W(\varphi) \propto 1 + \frac{2\lambda_{\varphi}}{3 + \lambda_{\vartheta}} \cos 2\varphi,$$

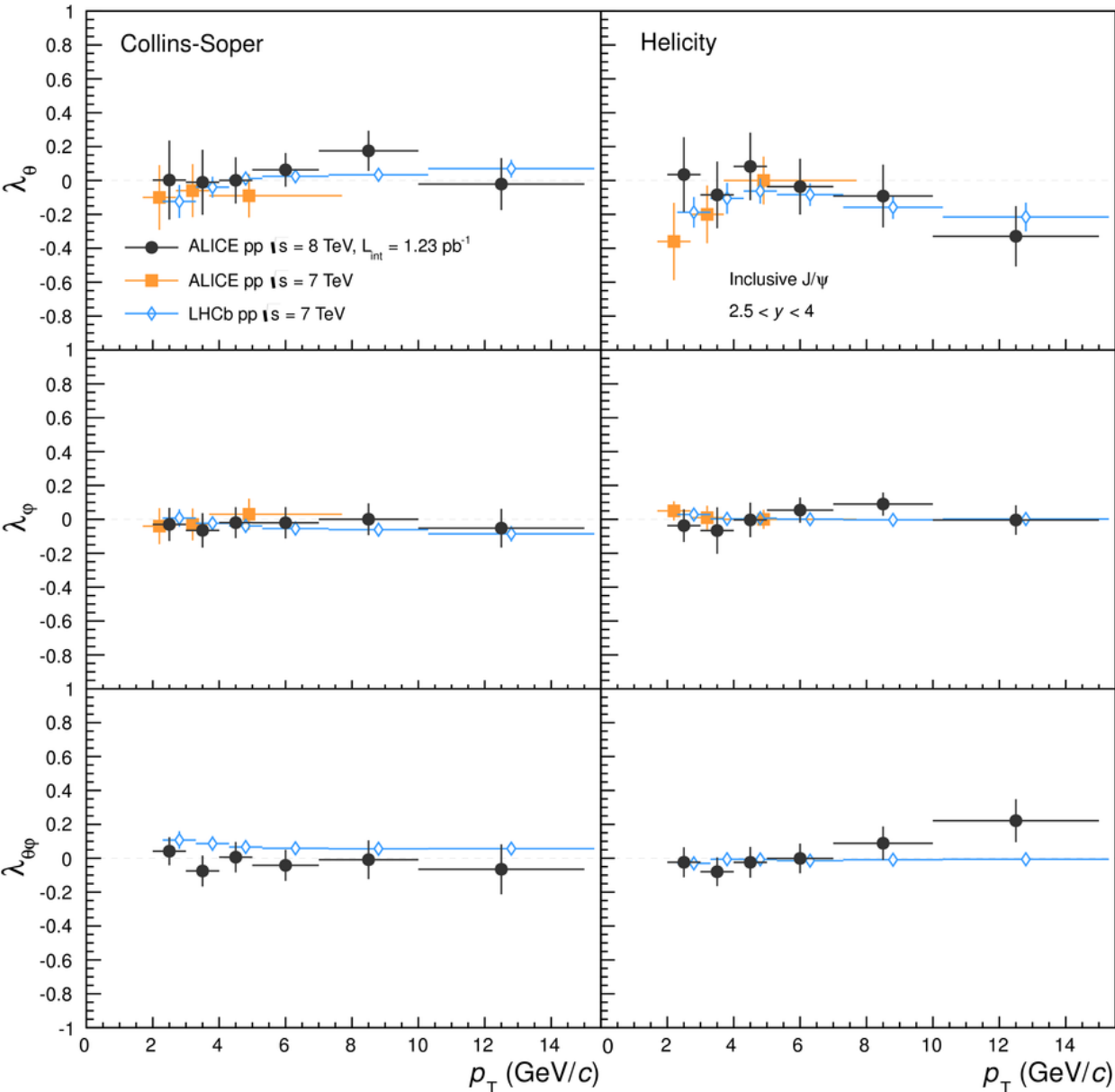
$\lambda_{\theta} = -1$ (pure longitudinal polarization)

$\lambda_{\theta} = 0$ (no polarization)

$\lambda_{\theta} = 1$ (pure transverse polarization)

- Measured through the anisotropy of the angular distribution of the decay products.

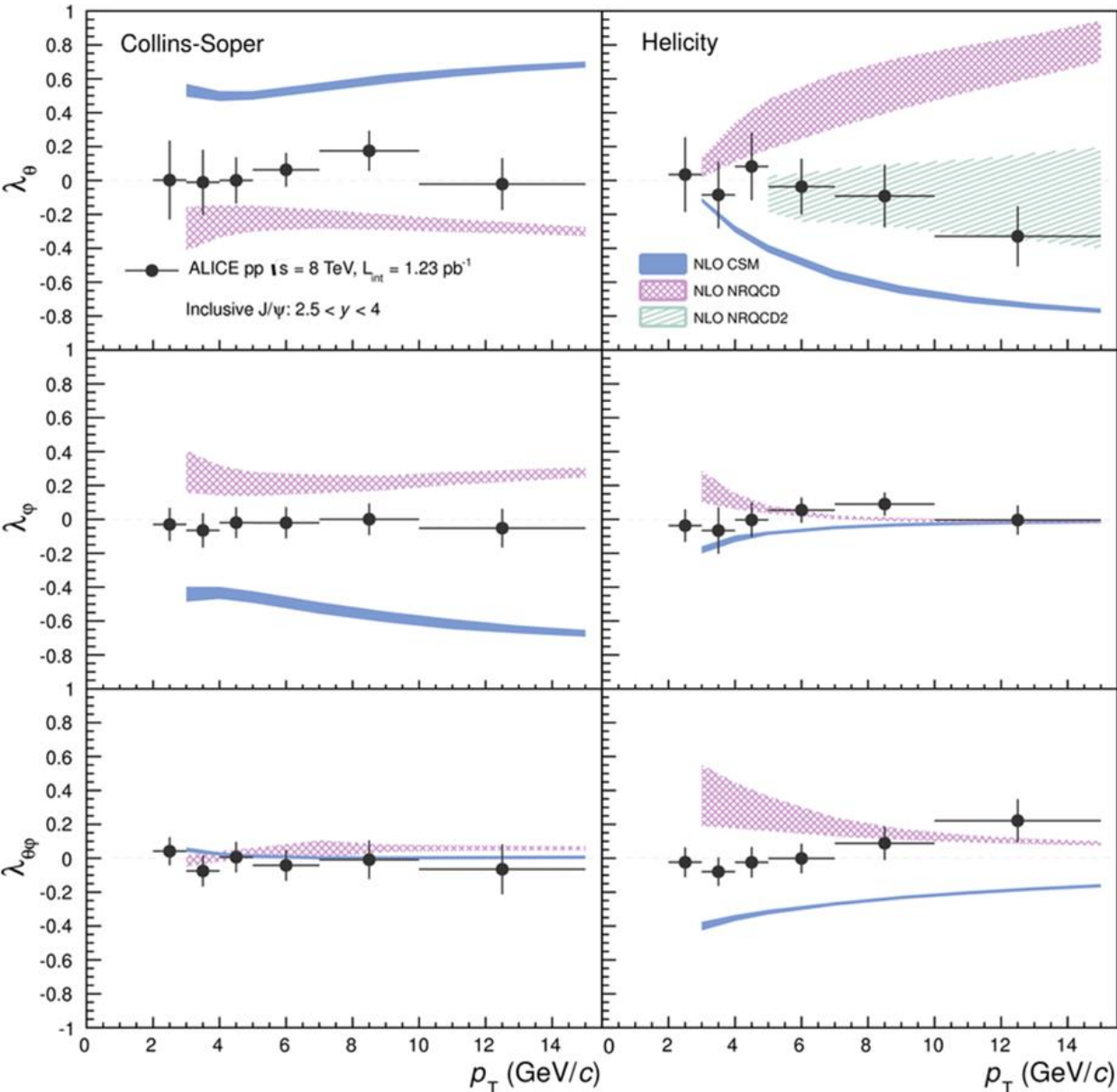
J/ψ polarization in pp collisions with Run 2



- All quarkonium measurements at the ALICE are compatible or close to zero.
- All measurements at ALICE are in forward rapidity.

- ① PRL 108, 082001 (2012)
- ② EPJC 78, 562 (2018)
- ③ EPJC 73, 2631 (2013)

J/ψ polarization in pp collisions with Run 2



➤ All quarkonium measurements at the ALICE are compatible or close to zero.

➤ All measurements at ALICE are in forward rapidity.

✓ NLO CSM: longitudinal polarization

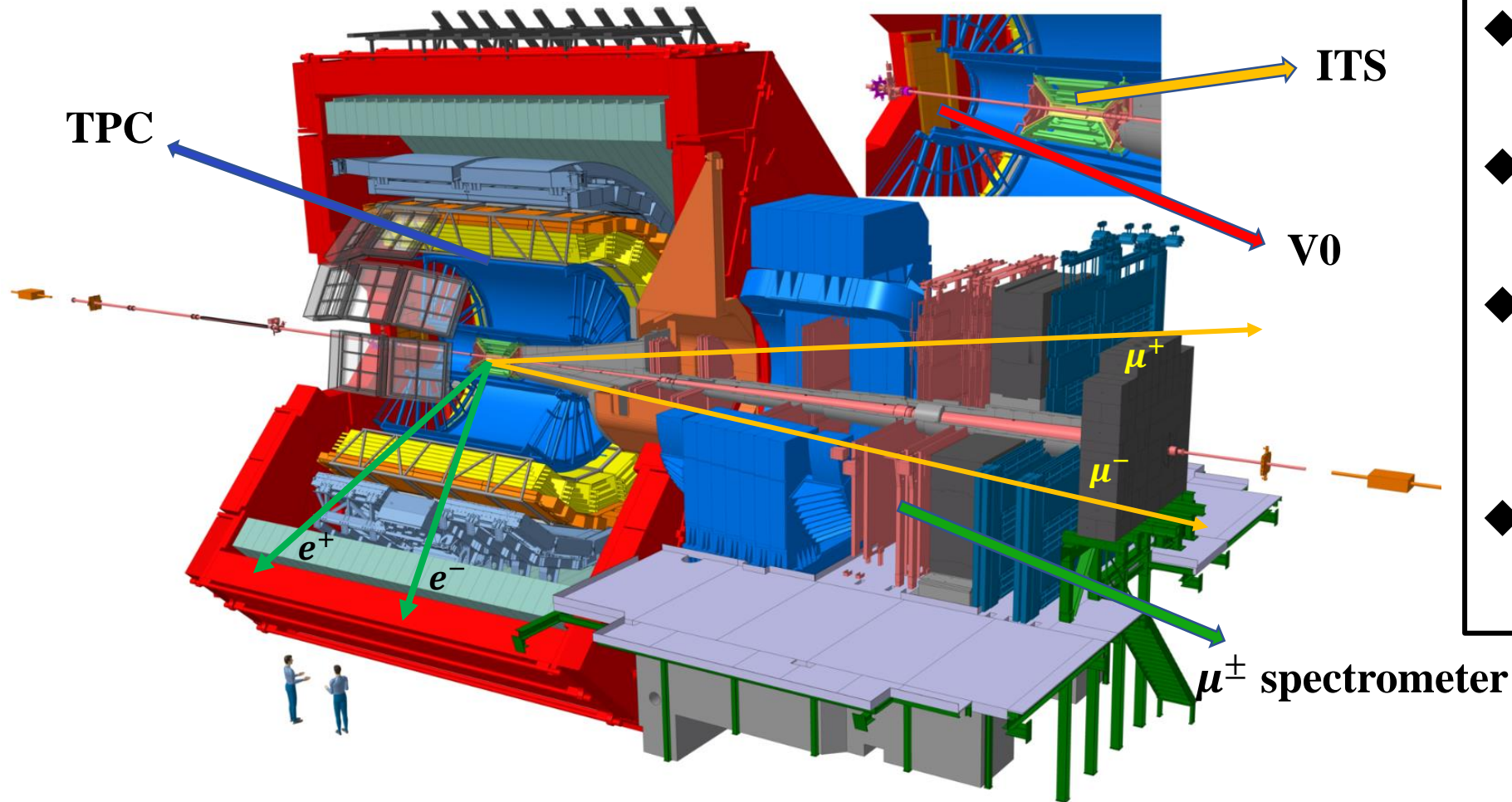
✓ NLO NRQCD: transverse polarization.

① PRL 108, 082001 (2012)

② PRL 108, 172002 (2012)

③ PRL 108, 172002 (2012)

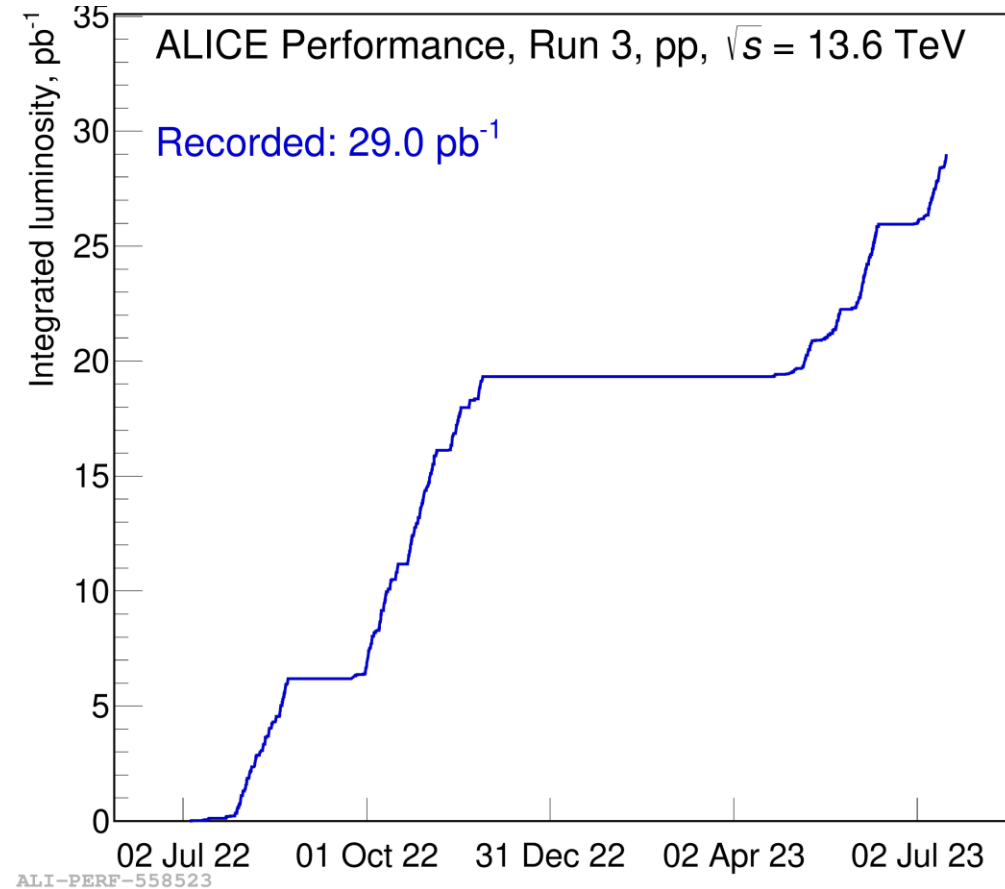
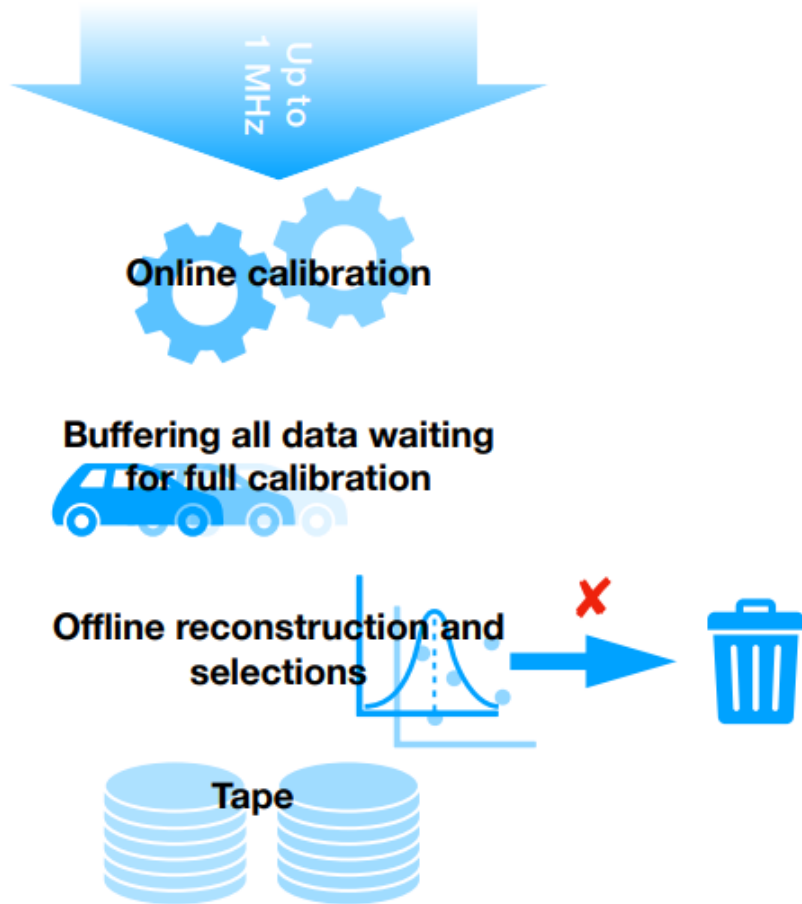
④ PRL 108, 242004 (2012)



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

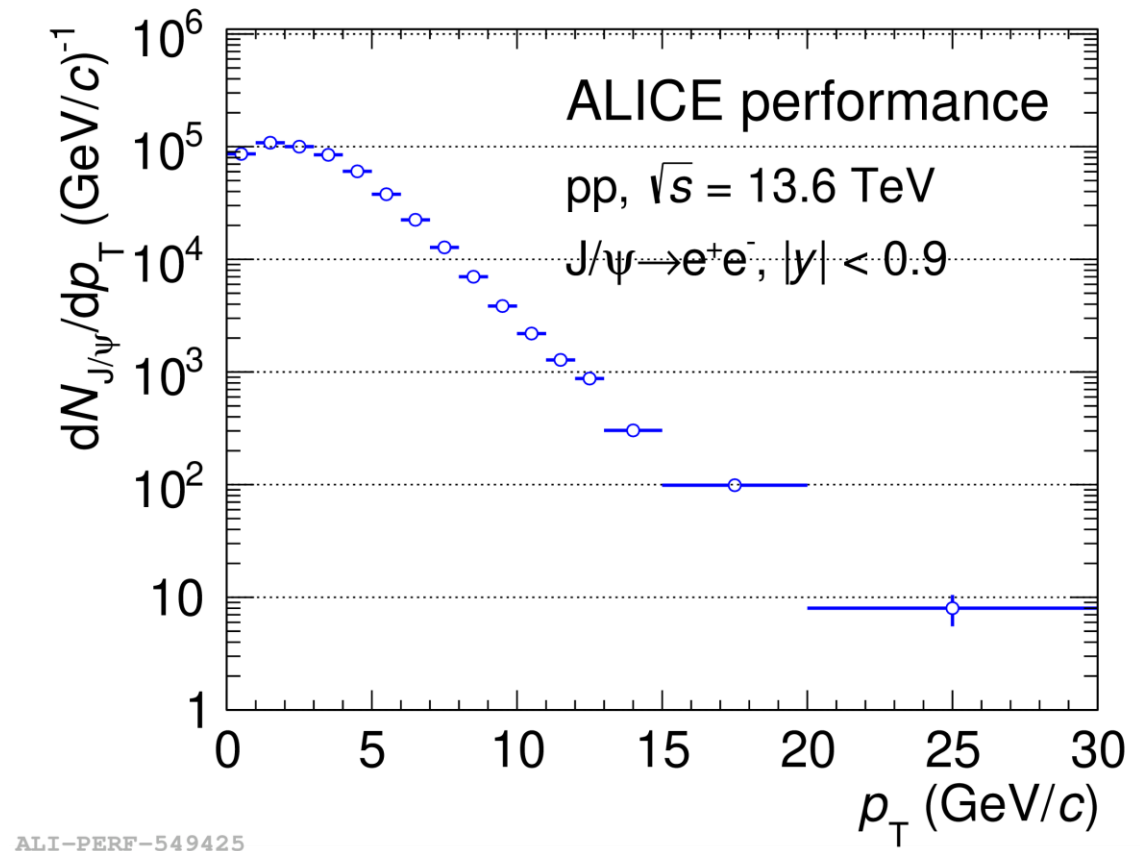
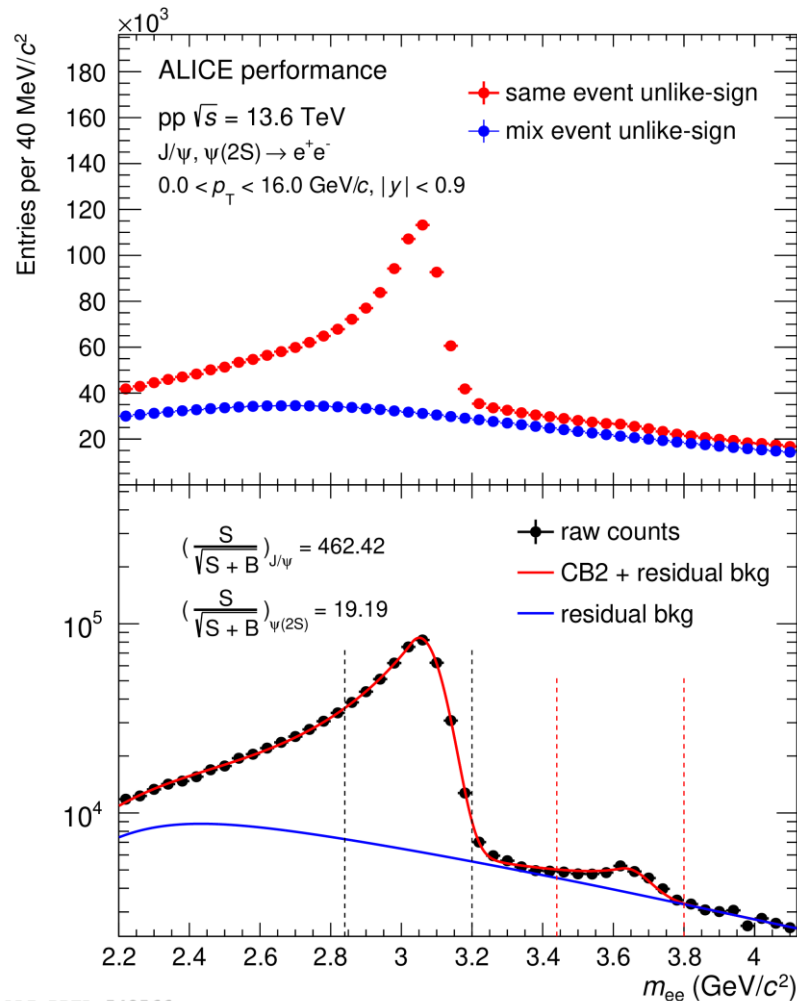
➤ Inclusive J/ψ can be measured down to zero p_T both at mid- and forward rapidity.

Data taken in ALICE Run 3



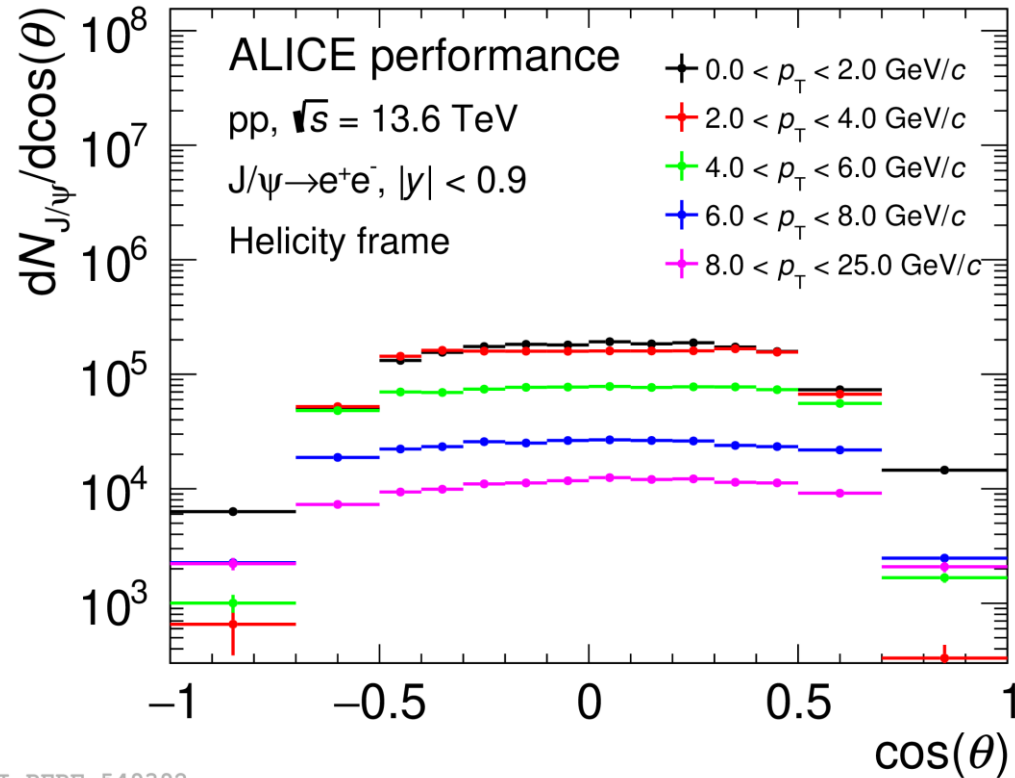
➤ ALICE collected 29.0 pb⁻¹ pp data. (900 times higher than Run 2 pp 13 TeV data)

J/ψ raw counts as function of transverse momentum

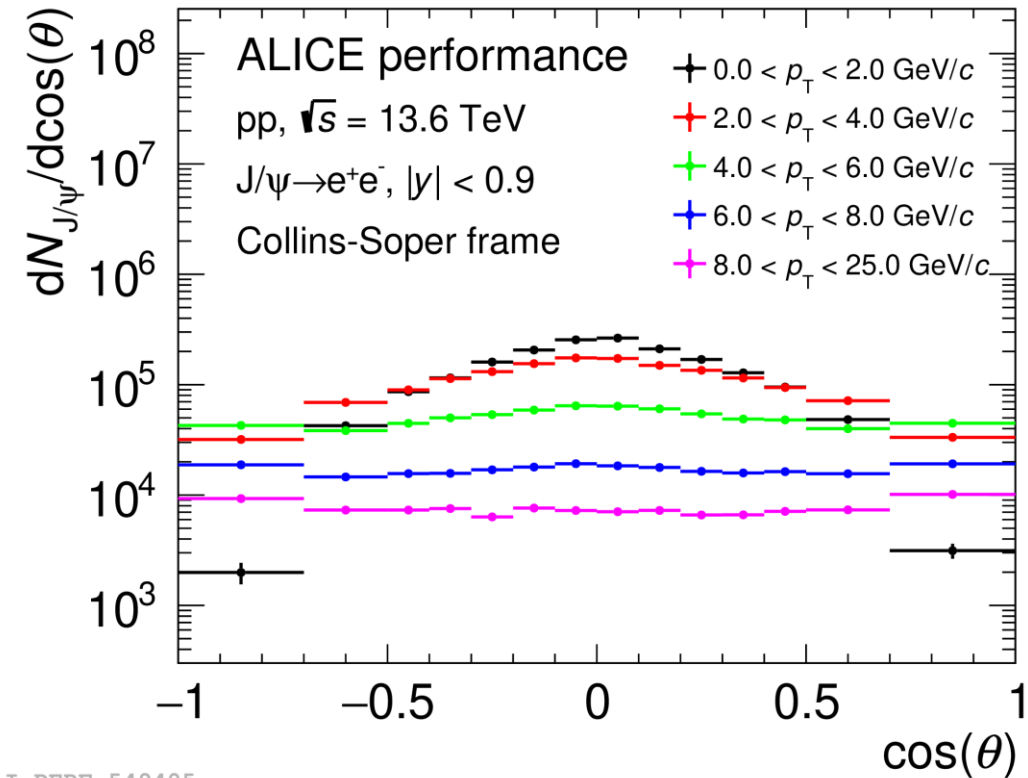


➤ ALICE Run 3 with high statistics, sufficient to measure yields with extremely low statistics error.

J/ ψ raw counts distribution in different pT



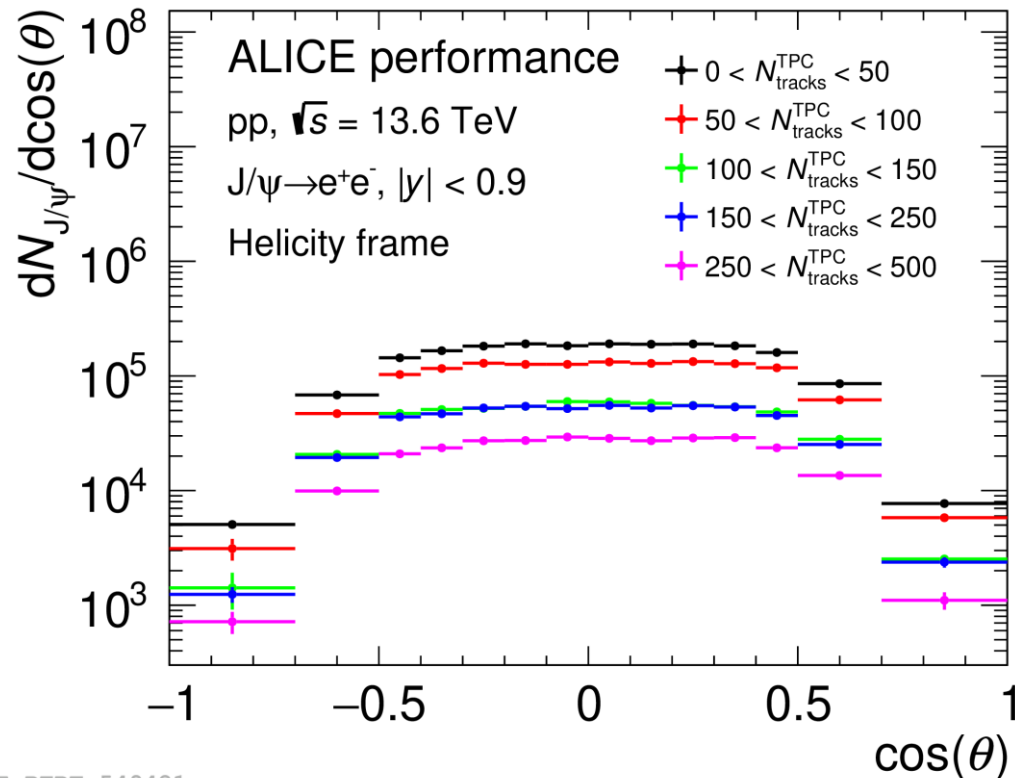
ALI-PERF-549392



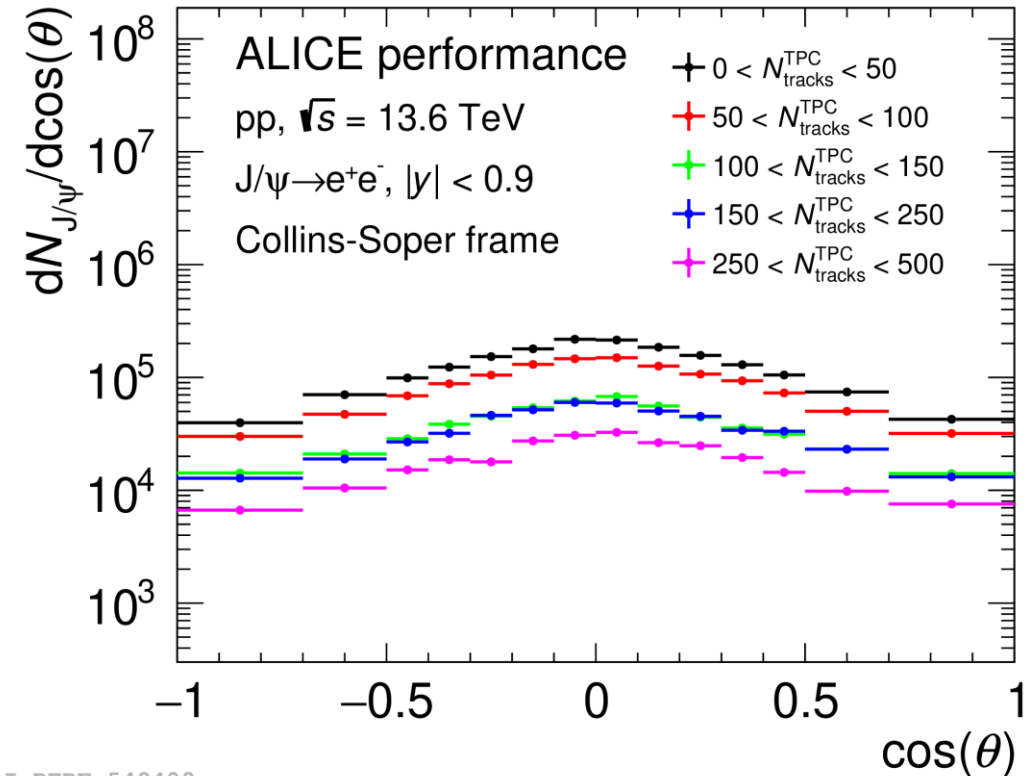
ALI-PERF-549405

➤ First measurement of J/ ψ raw counts as function of $\cos(\theta)$ in different frame with Run 3. (2022 data)

J/ ψ raw counts distribution in different multiplicity



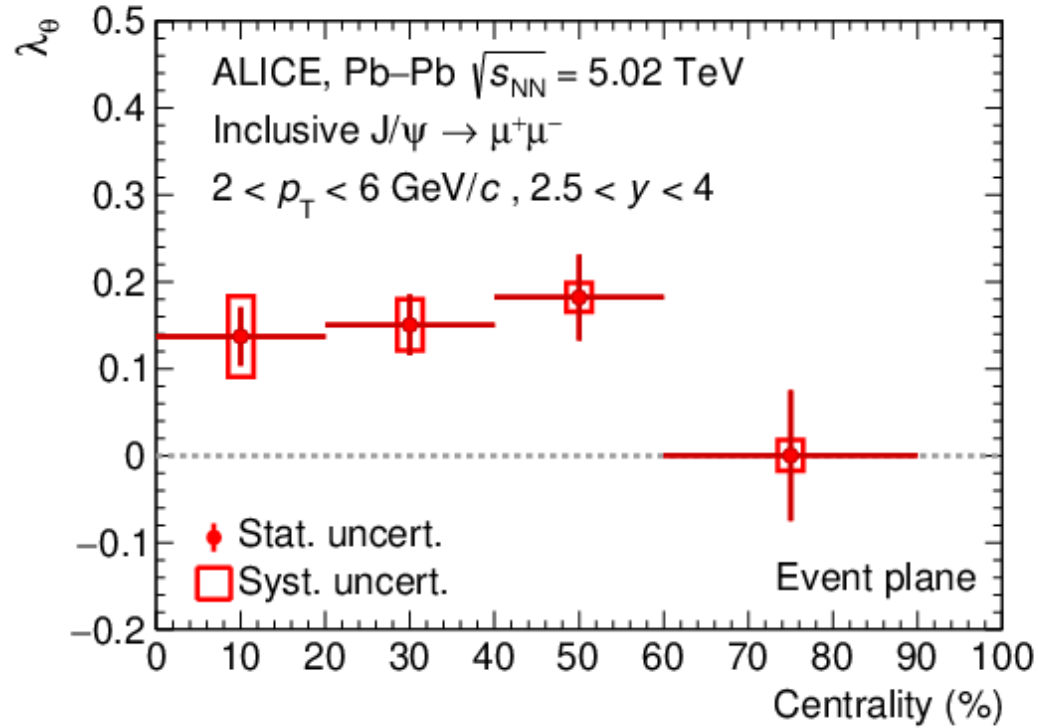
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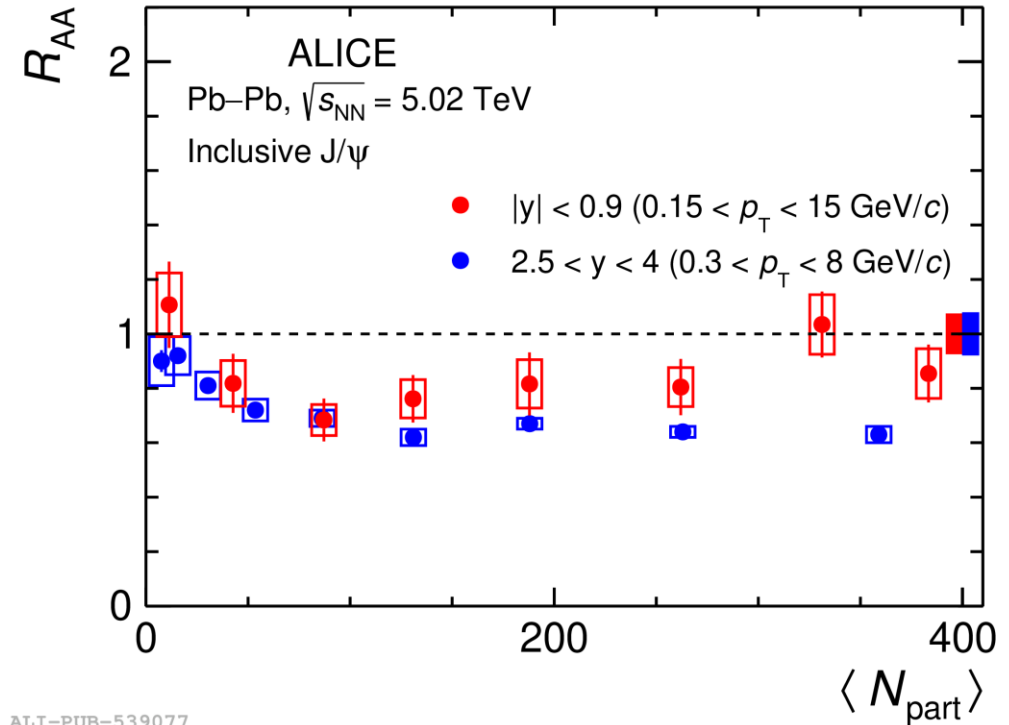
ALI-PERF-549409

➤ First measurement of J/ ψ polarization in different multiplicity ([uncorrected](#)).

Global polarization in Pb-Pb collisions



ALI-PUB-521052



ALI-PUB-539077

- Small but significant (3.5σ) polarization observed in forward rapidity.
- J/ψ regeneration with a larger contribution at midrapidity.

① PRL. 131 042303 (2023)

- The measurement of J/ψ polarization in pp shows not exhibit strong polarization.
- More precise measurements can be expected from the upgraded detector and higher statistics in ALICE Run 3.
- First measurement of J/ψ polarization in pp collisions at midrapidity with ALICE Run 3, but efficiency are still ongoing.

Outlook:

- The J/ψ global polarization in Pb-Pb will be measured at midrapidity.

*Thank
You*