



Measurements of inclusive $\psi(2S)$ to J/ψ ratio at midrapidity in pp collisions at $\sqrt{s} = 13.6$ TeV with ALICE

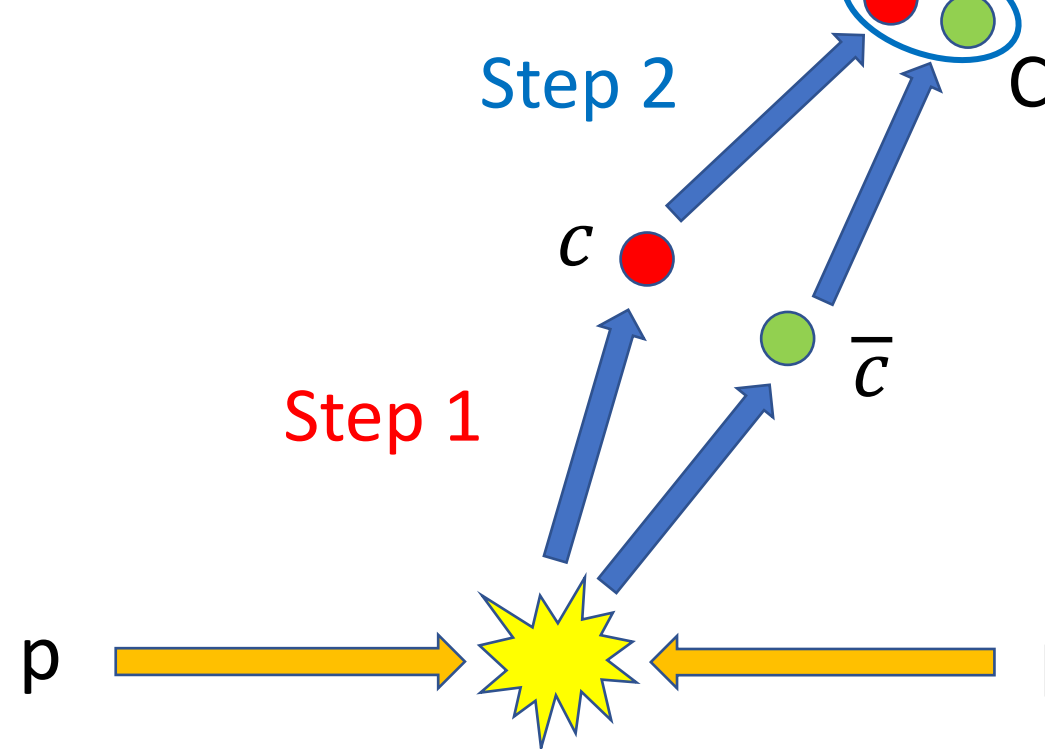


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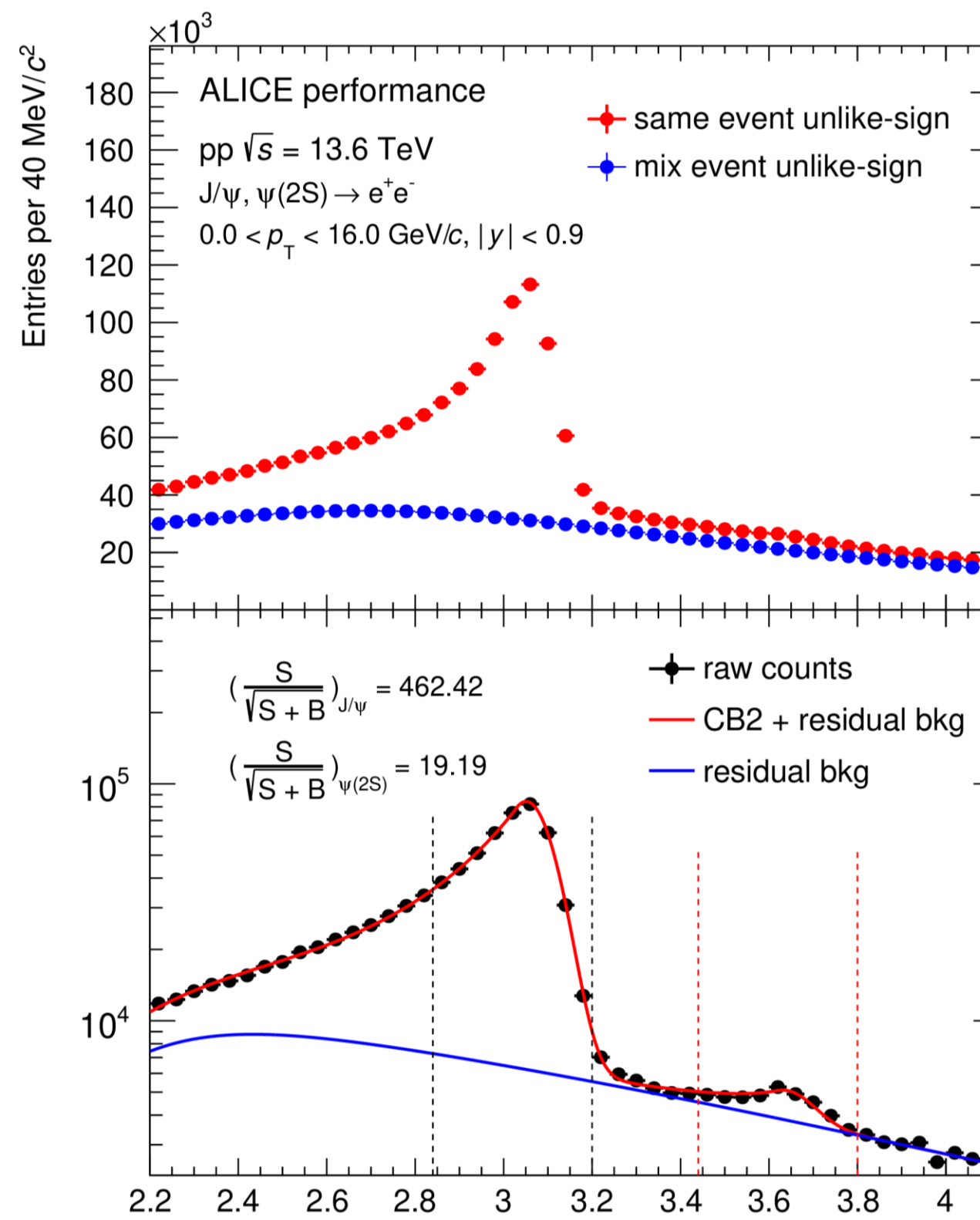
Motivation

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- Crucial for studying charmonium production mechanisms and testing different QCD-based models.
 - Heavy-quark production (perturbative QCD)
 - Formation of the bound charmonium states (non-perturbative QCD)
 - Study the rapidity dependence of charmonium production by comparing to similar measurements at forward rapidity at the same collision energy^[1].
 - Used as reference for studying AA collisions.

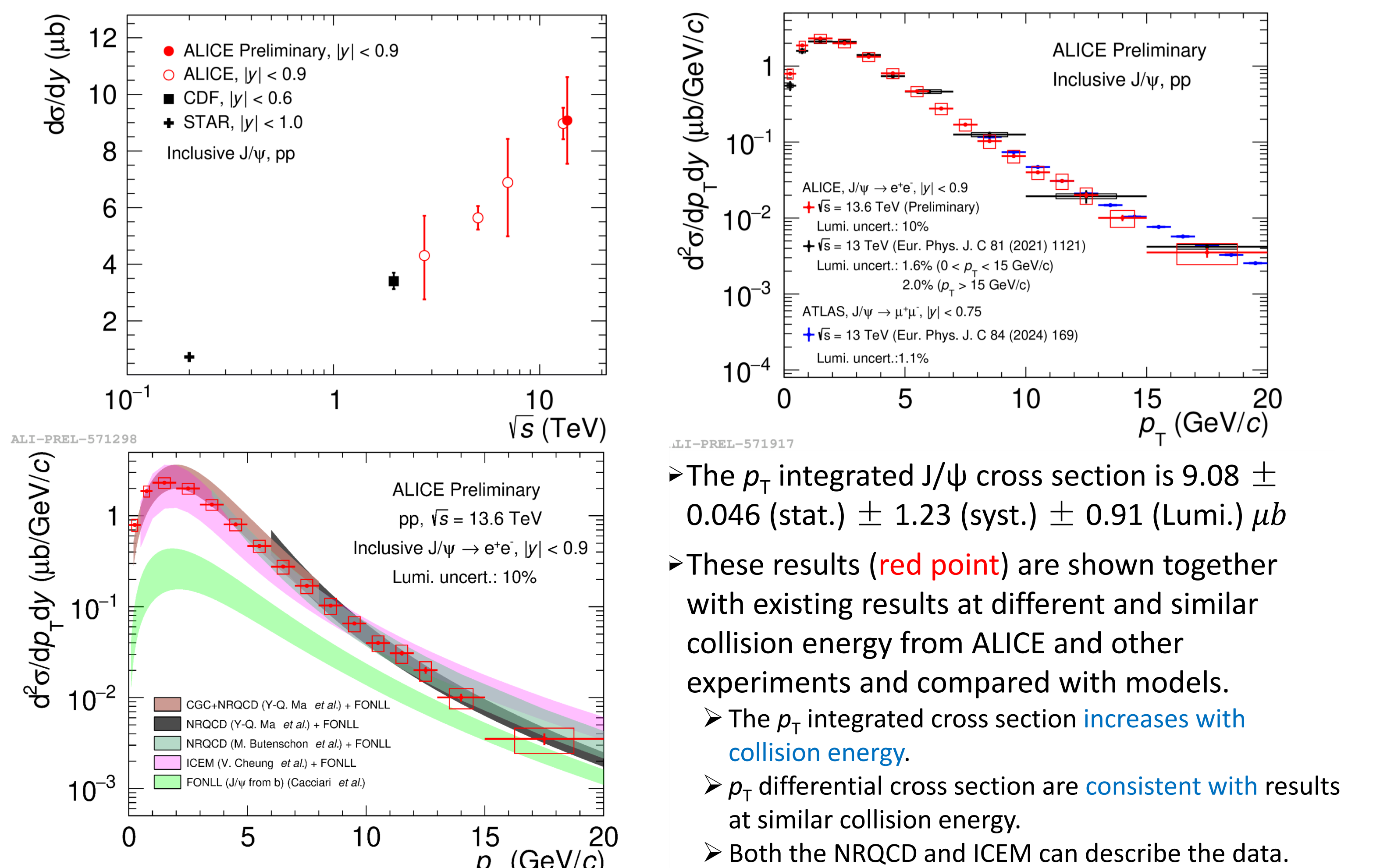
ALICE detector (Run 3 upgrade)

- Inclusive quarkonia are reconstructed in e^+e^- channel at midrapidity ($|y| < 0.9$) down to $p_T = 0$.
- Time Projection Chamber (TPC)
 - Tracking
 - Particle identification via dE/dx measurement
 - Momentum measurement
 - TPC upgrade:
 - Readout chambers replaced with Gas Electron Multiplier (GEM) chambers.
- Inner Tracking System (ITS)
 - Tracking
 - Vertex reconstruction
 - ITS upgrade:
 - 6 layers \Rightarrow 7 layers equipped with Monolithic Active Pixel Sensors.
 - Radius of innermost layer: 39 mm \Rightarrow 23mm.
 - Material budget for each of the 3 innermost layers: 1.15% \Rightarrow 0.35%.

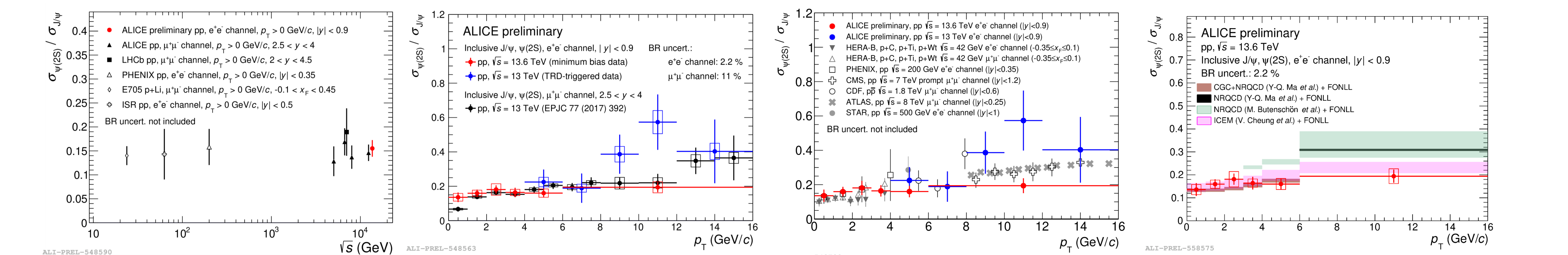
Data analysis procedure

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- Dataset:
 - pp collisions at $\sqrt{s} = 13.6$ TeV collected in 2022 with the ALICE upgraded detector.
 - 524 \times 10⁹ minimum-bias (MB) events collected thanks to the continuous readout.
 - Electron identification via TPC dE/dx .
 - Signal extraction:
 - Combinatorial background is subtracted using mixed-event unlike-sign method.
 - Residual background: second order polynomial function divided by an exponential function.
 - Signal shapes are described by Crystal Ball functions.
 - Efficiency correction:
 - ITS-TPC matching and PID efficiency can be obtained from data-driven method.
 - Large fraction of efficiency and systematic uncertainty are cancelled out by taking ratio.

Results (J/ψ cross section)

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- The p_T integrated J/ψ cross section is 9.08 ± 0.046 (stat.) ± 1.23 (syst.) ± 0.91 (Lumi.) μb
 - These results (red point) are shown together with existing results at different and similar collision energy from ALICE and other experiments and compared with models.
 - The p_T integrated cross section increases with collision energy.
 - p_T differential cross section are consistent with results at similar collision energy.
 - Both the NRQCD and ICEM can describe the data.

Results ($\psi(2S)$ -to- J/ψ ratio)

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- The measured p_T -integrated ratio at midrapidity ($|y| < 0.9$) without BR uncertainty is 0.155 ± 0.010 (stat.) ± 0.014 (syst.)
 - The results (red points) are shown together with existing results from ALICE at forward rapidity and from other experiments [1-10].
 - In agreement with other results.
 - No significant energy and rapidity dependence.
 - Slight p_T dependence (also expected from models).
 - Comparison with models^[11-14]:
 - NRQCD overestimates the ratio at high p_T , but CGC + NRQCD describes the ratio at low and intermediate p_T .
 - ICEM can reproduce the data.

Summary and outlook

- The J/ψ cross section and $\psi(2S)$ -to- J/ψ ratio are measured in pp collision at $\sqrt{s} = 13.6$ TeV at midrapidity.
 - The cross section increases with p_T . Slight p_T dependence (also expected from models) for ratio.
 - The cross section increases with collision energy, but the ratio shows no significant energy and rapidity dependence.
 - Comparisons with theory models (NRQCD, CGC+NRQCD, ICEM) are performed.
- Provides a reference for investigating the quark-gluon plasma in nucleus-nucleus collisions and the cold nuclear matter effects in proton-nucleus collisions.
- The first ALICE spectra on the reconstruction of X(3872) and $\psi(2S)$ using $J/\psi\pi^+\pi^-$ channel have been obtained.

Reference

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