Inclusive ψ(2S)-to-J/ψ ratio at forward rapidity in pp collisions at $\sqrt{s}$ = 13.6 TeV with ALICE

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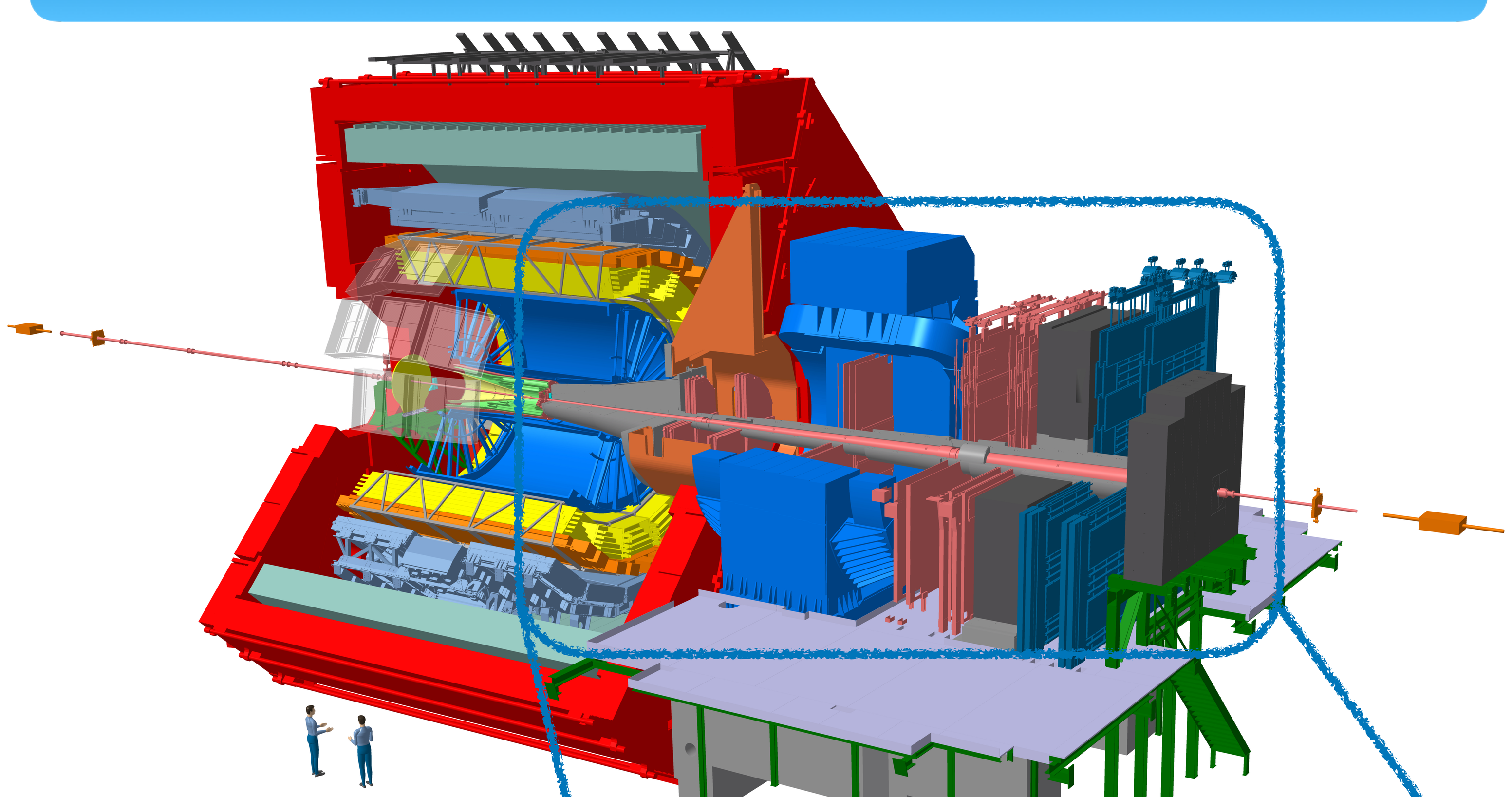
Physics motivation

The investigation of **quarkonium production in proton-proton** (pp) collisions is essential to understand its production mechanisms, involving both **perturbative** and **non-perturbative** aspects of Quantum Chromodynamics (QCD). In addition, quarkonium production in pp can be used as a tool to constrain **Parton Distribution Functions** (PDFs) and as a reference for Pb—Pb collisions studies.

The study of **inclusive ψ(2S)-to-J/ψ ratio** allows a deeper understanding of charmonium production mechanisms, in particular for what concerns the role of radially excited state as the ψ(2S). It can provide more stringent tests to models for production mechanisms than simple cross section measurements, as theoretical uncertainties cancel partially in the ratio. The cancellation of part of the systematics uncertainties also makes this measurement an ideal testing ground for a **first preliminary analysis** of the performance of the upgraded ALICE set-up that started taking data in the **LHC Run 3**.

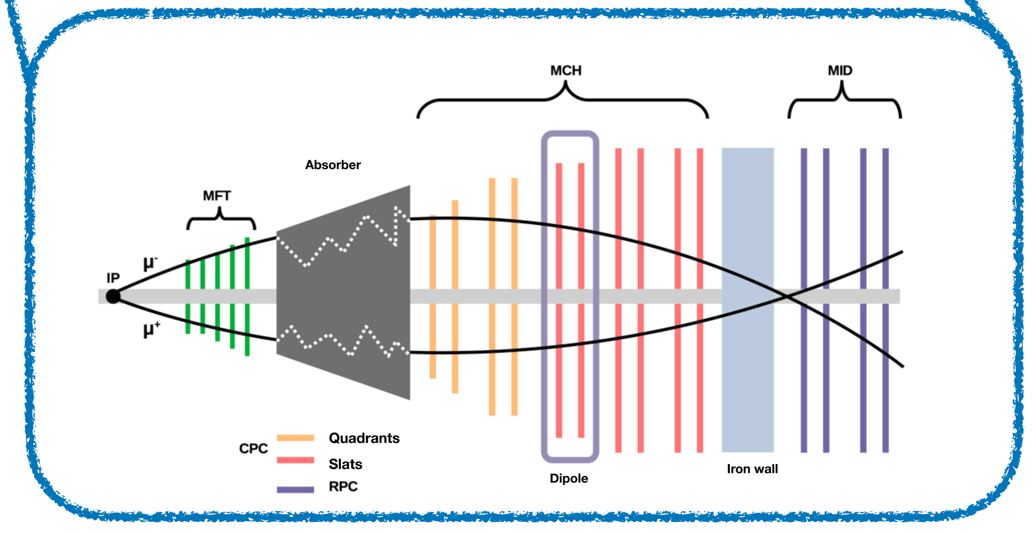
ALICE muon spectrometer in Run 3



The ALICE experiment[1] is designed to study the **quark-gluon plasma**.

For the LHC Run 3, several upgrades have been made such as :

- new **Inner Tracking System** (ITS)
- new detector electronics to support the **continuous read-out mode**
- inclusion of the new **Muon Forward Tracker** (MFT)

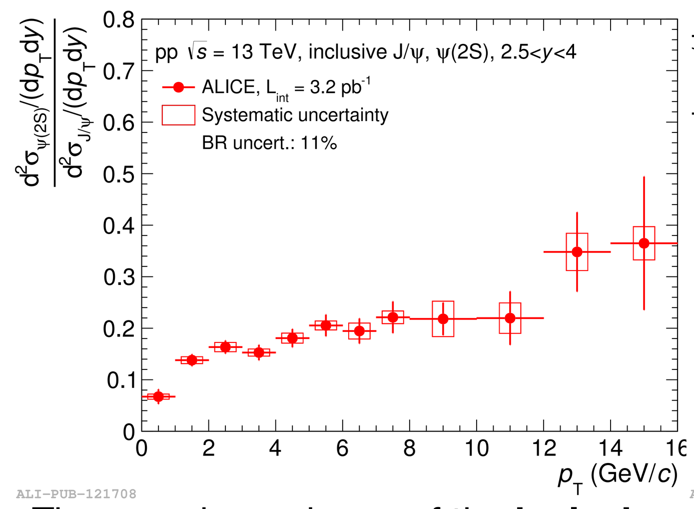


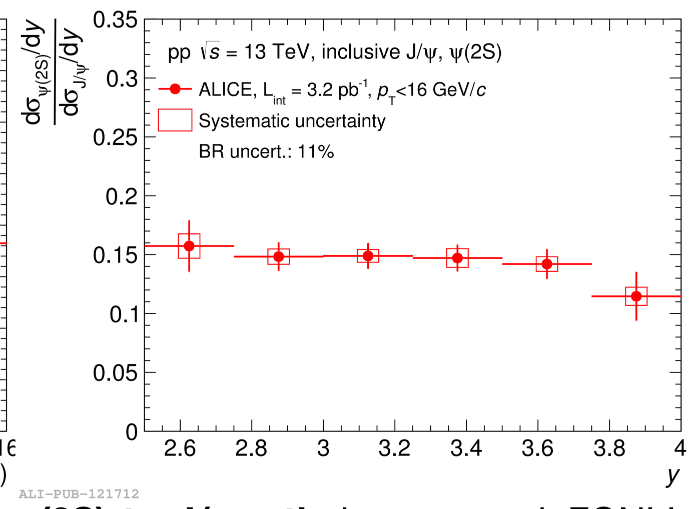
The muon spectrometer is composed of the Muon Chambers (MCH) and the Muon Identifier (MID) with a pseudorapidity acceptance :

$$-4 < \eta < -2.5$$

- **Absorbers**
  - **Front absorber** installed upstream from MCH to **reject background** coming from hadrons, secondary muons
  - **Iron wall** installed upstream of MID to filter out remaining hadrons
- **MCH**
  - Muon tracking system
  - MWPC based
  - 5 stations each composed of 2 chambers
- **MID**
  - Particle identification for muons
  - RPC based
  - 2 stations each composed of 2 chambers

ψ(2S)-to-J/ψ ratio in Run 2

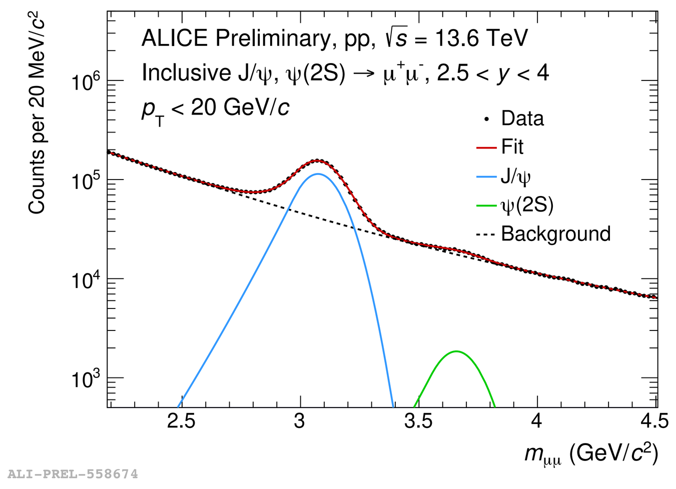




Inclusive ψ(2S)-to-J/ψ ratio measured as a function of y and p_T in pp collisions at $\sqrt{s}$ = 13 TeV and forward rapidity[2].

The p_T—dependence of the **inclusive ψ(2S)-to-J/ψ ratio** is measured. FONLL calculations[3] shows that the J/ψ non-prompt fraction increases with p_T and can reach up to 50% for p_T > 15 GeV/c. This motivates the need to separate the two contributions for a deeper understanding of **charmonium production**.

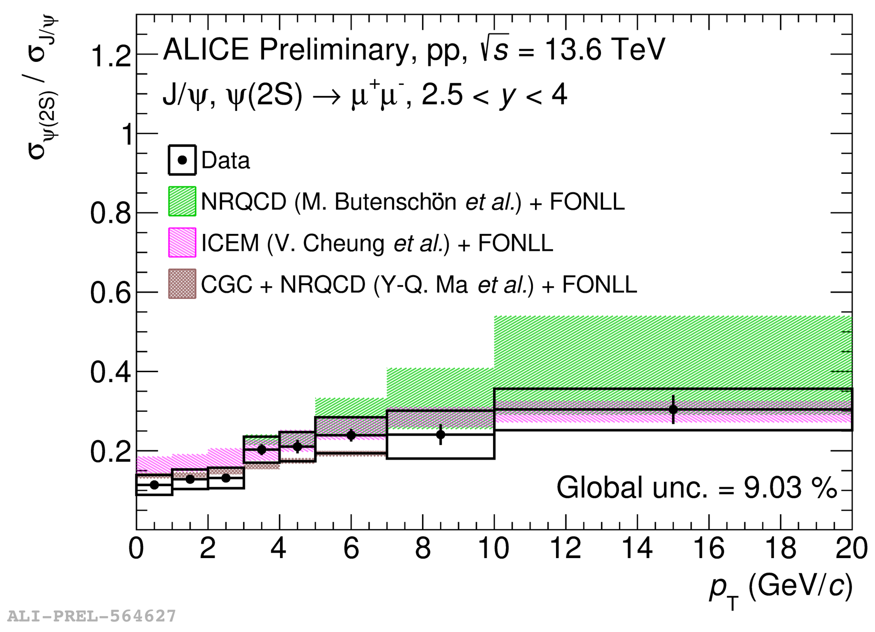
ψ(2S)-to-J/ψ ratio in Run 3

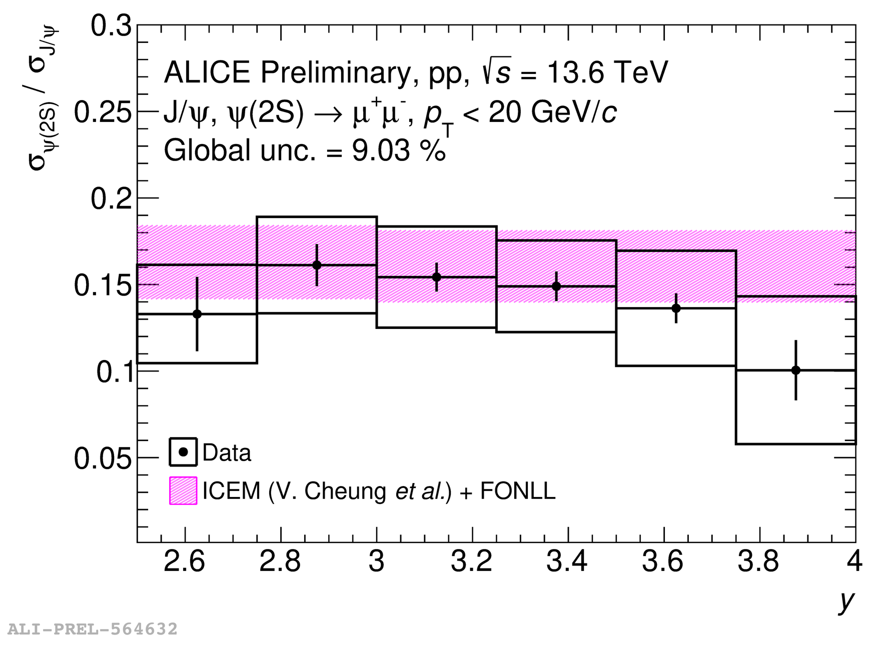


Invariant mass fit of the inclusive J/ψ and ψ(2S) in the dimuon decay channel.

Signal extraction is performed with a Double Crystal Ball function for both **inclusive J/ψ and ψ(2S)**.

The systematic sources considered in this analysis are the signal extraction (variation of signal and background shapes, as well as the ψ(2S) width with respect to J/ψ), the Monte Carlo (MC) signal input kinematic distributions used to evaluate the AxEff corrections, and an additional systematic uncertainty on the AxEff due to missing simulated detector effects in the MC.





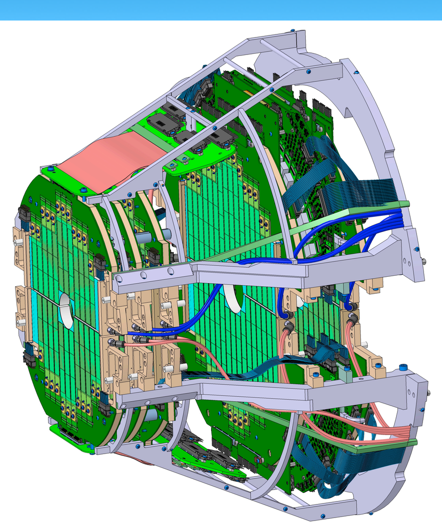
Inclusive ψ(2S)-to-J/ψ ratio as a function of p_T (left) and y (right)

First ALICE Run 3 preliminary measurement of the **inclusive ψ(2S)-to-J/ψ ratio** in pp collisions at $\sqrt{s}$ = 13.6 TeV and **forward** rapidity is performed with the **ALICE muon spectrometer** in the pseudorapidity interval $-4 < \eta < -2.5$ down to p_T = 0. It is in **agreement with Run 2 data**.

Results are compared with different models such as the Non-Relativistic QCD (NRQCD)[4], the Improved version of the Color Evaporation Model (ICEM)[5] and the Color Glass Condensate (CGC) + NRQCD model[6]. Those models describe the prompt J/ψ production and FONLL was added on top to describe the non-prompt component. All models are able to reproduce the ratio as a function of p_T, within the large data and model uncertainties. The ratio as a function of y is well described within the systematic uncertainties by the ICEM model.

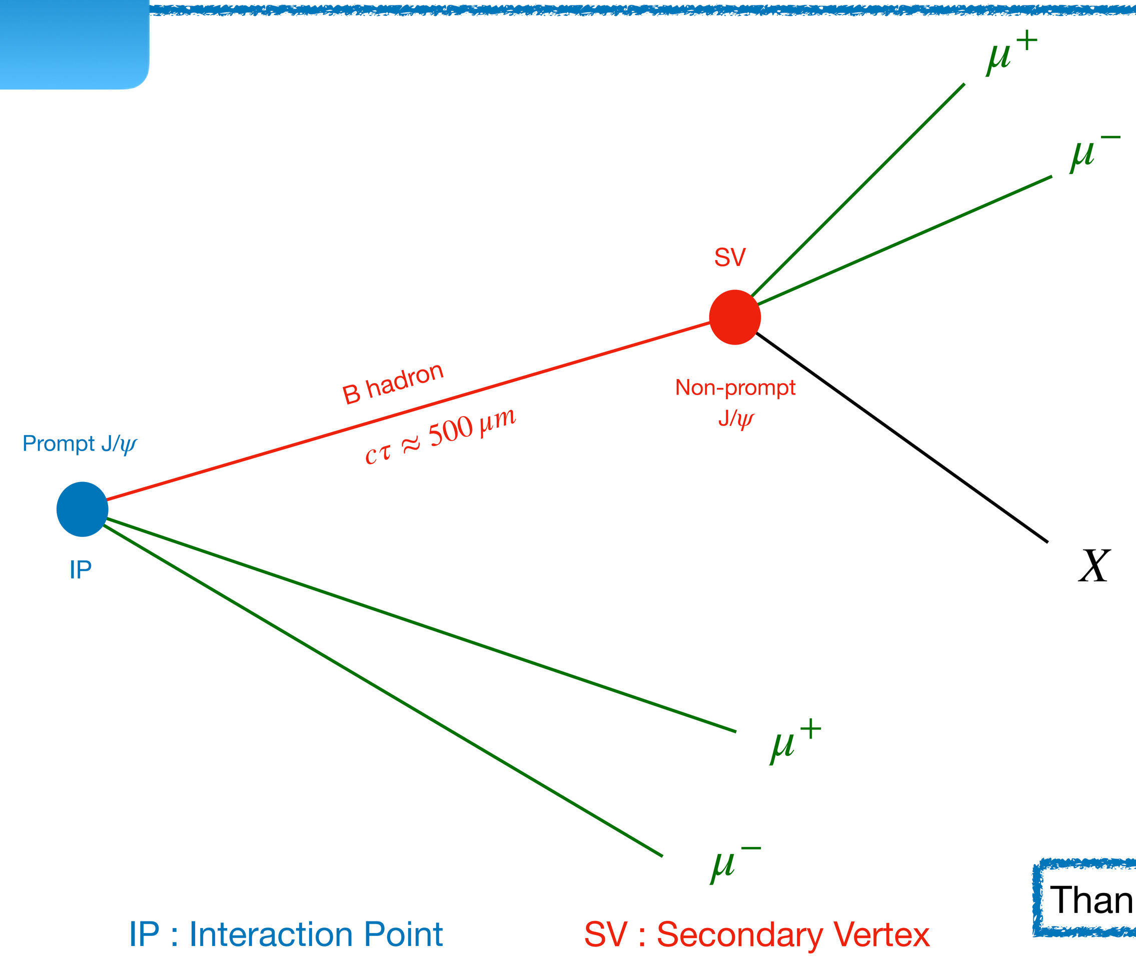
The next step is to separate the J/ψ **prompt** and **non-prompt** contributions.

Outlook

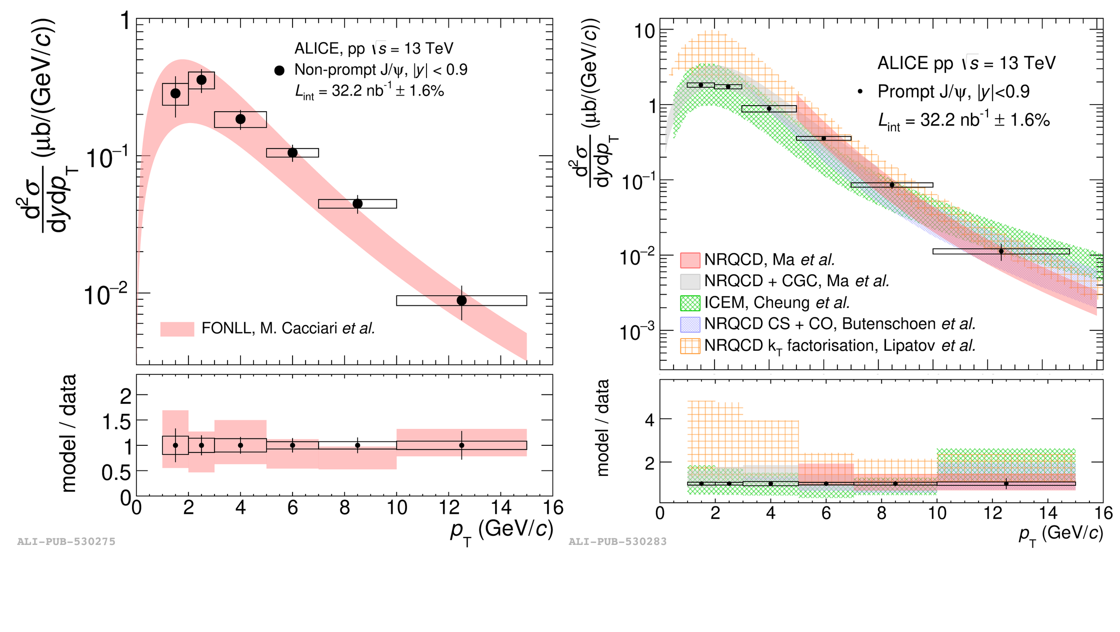


The new **Muon Forward Tracker**[7] (MFT) has been installed in December 2020. First data were taken on July 2022.

It is designed with five double sided disks composed of silicon pixels to reach **high tracking resolution performances** in the pseudorapidity range $-3.6 < \eta < -2.5$.



J/ψ prompt and non-prompt separation have been done in Run 2 at **mid-rapidity**[8].



Thanks to the MFT we will perform the separation at **forward** rapidity in Run 3.

References

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[8]ALICE, JHEP 03, 190 (2022)