Measurement of J/ψ Production Cross Section at $\sqrt{s} = 13.6$ TeV at LHCb Experiment

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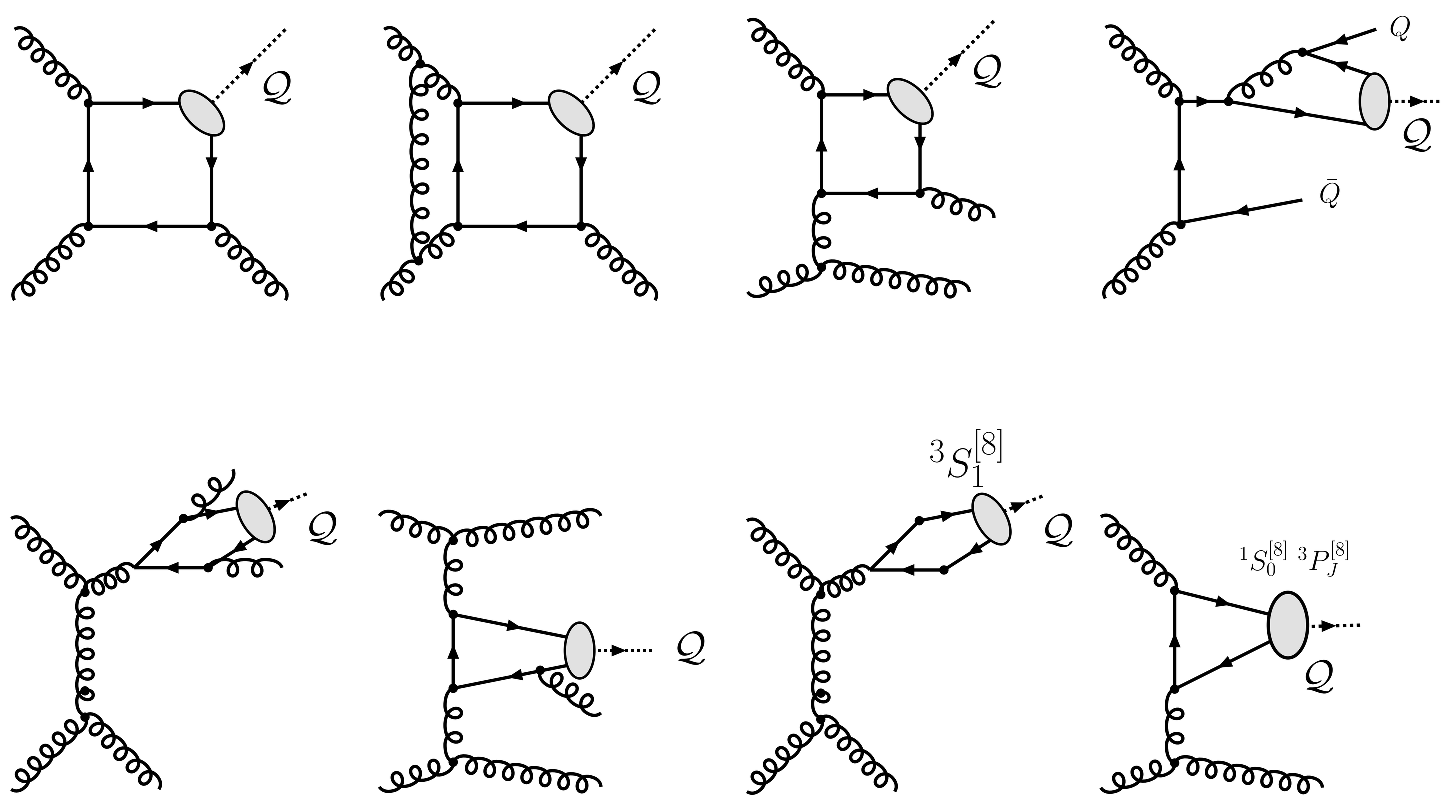
Motivation

Production of heavy quarkonium in pp collisions is an ideal process to understand perturbative and non-perturbative QCD:

- Production of a heavy quark pair $Q\bar{Q}$ → perturbative
- $Q\bar{Q}$ hadronizing into quarkonium → non-perturbative



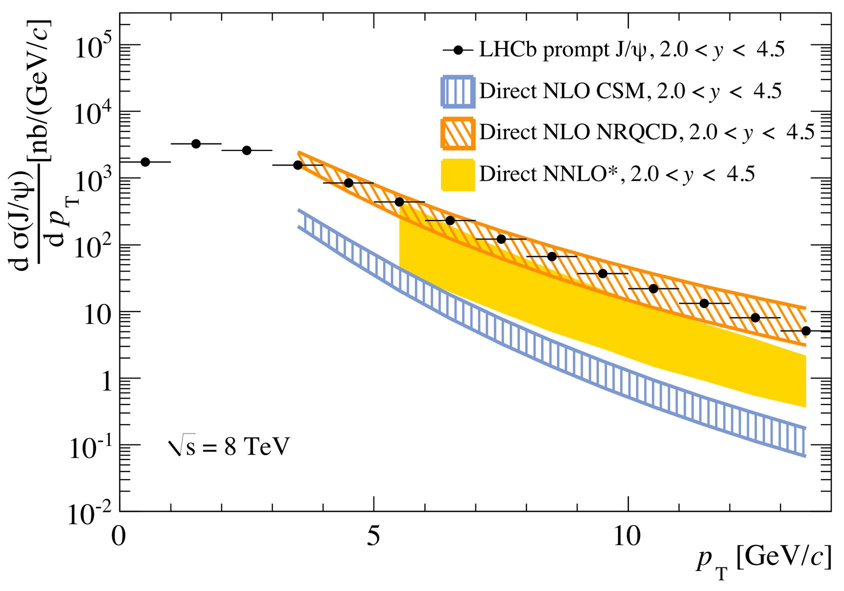
NRQCD (non-relativistic QCD) is the most successful theory modeling the production of heavy quarkonium:

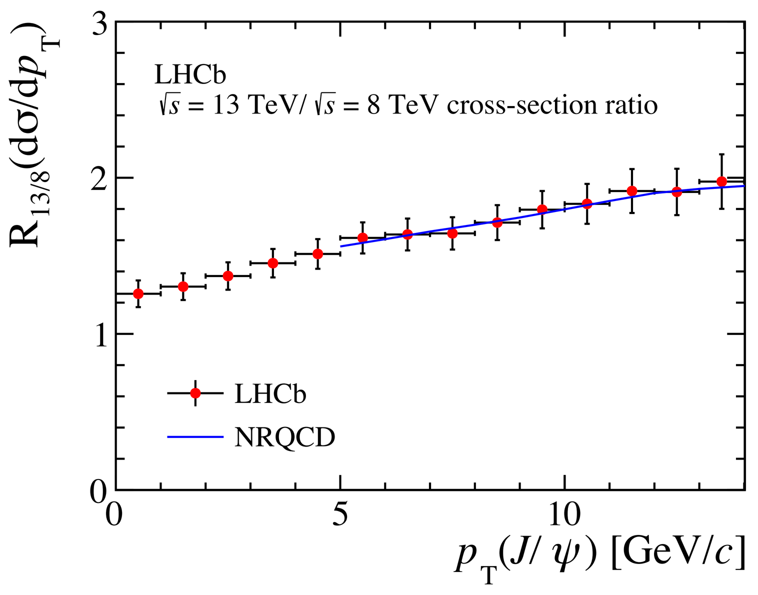
- Non-relativistic approximation: $v/c \ll 1$ (velocity of heavy quarks)
- **Factorization**: $d\sigma_{A+B\to H+X} = \sum_n d\sigma_{A+B\to Q\bar{Q}(n)+X} \times \langle O^H(n) \rangle$

Short distance: perturbative cross-sections + pdf for the production of a $Q\bar{Q}$ pair

Long distance matrix elements (LDMEs), non-perturbative part

Experiment ⇄ **NRQCD** (extract LDMEs / theoretical predictions)



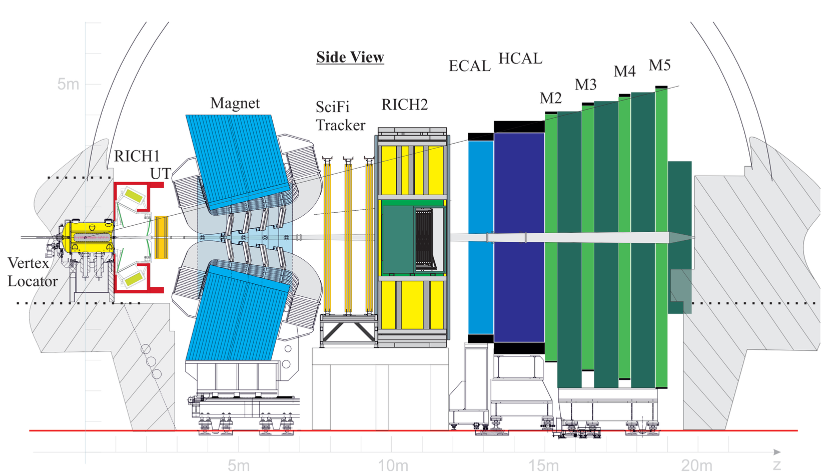


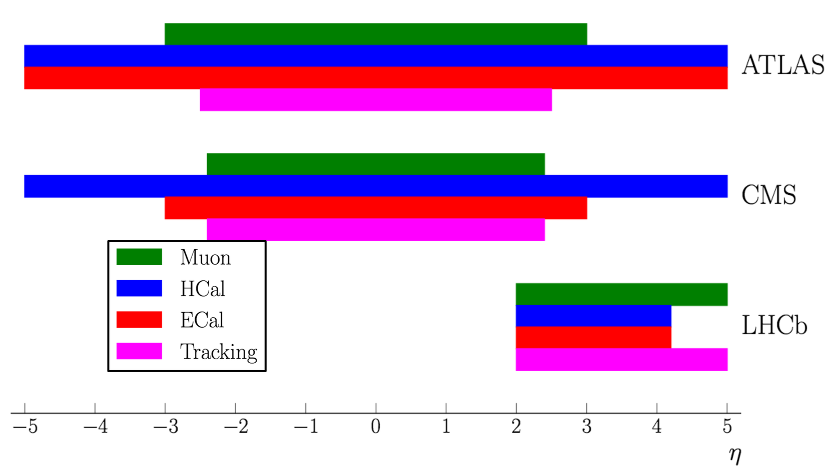
Previous study: measurement of J/ψ production cross-section in run1&2 at $\sqrt{s} = 7, 2.76, 8, 13, 5$ TeV.

New energy 13.6 TeV in run3, it's necessary to do the measurement again! (also as a validation for the new detector's performance.

LHCb Experiment at Run3

LHCb detector is a single-arm spectrometer with a forward angular coverage from 15 to 300 (250) mrad in the bending (non-bending) plane.





Highlights for the study of heavy quarkonium production:

- Great secondary vertex resolution → distinguish prompt & from b
- Unique geometry acceptance → designed for b and c hadrons!

Acknowledgements

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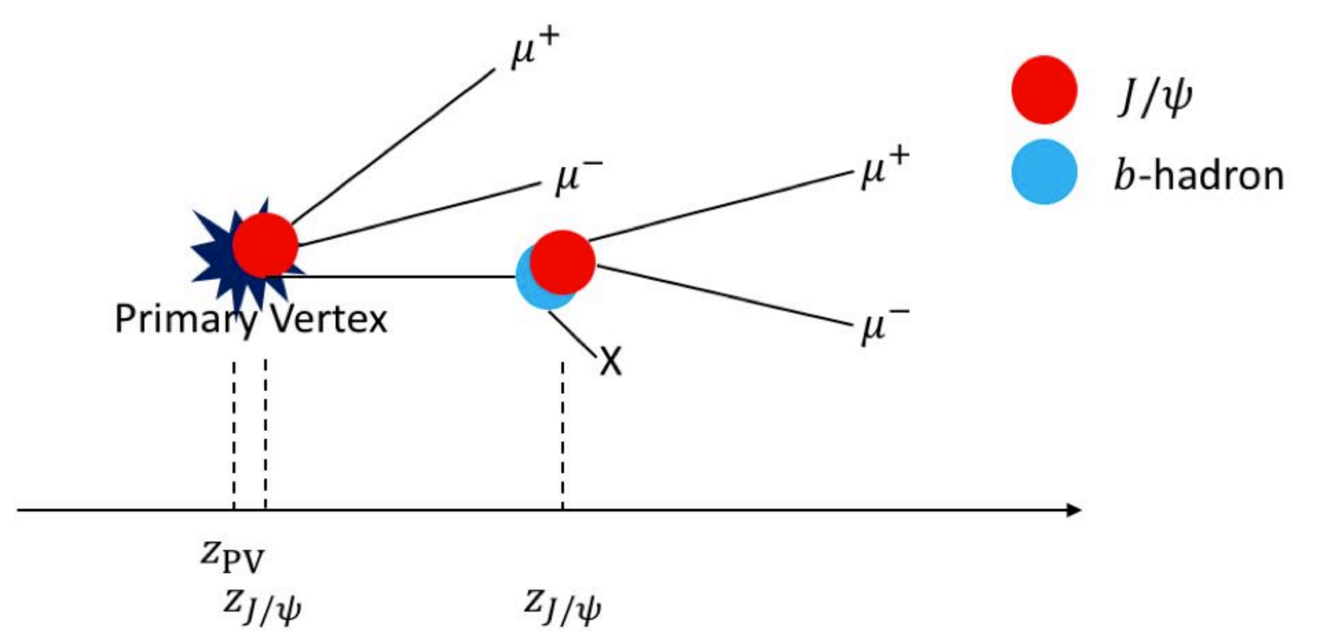
Analysis Strategy

Measurement of the double-differential production cross-section of J/ψ in bins of the kinematic variables $2.0 < y < 4.5$ and $p_T < 14$GeV:

$$\frac{d^2\sigma}{dy dp_T} = \frac{N(J/\psi \to \mu^+\mu^-)}{\mathcal{L} \times \varepsilon_{tot} \times \mathcal{B}(J/\psi \to \mu^+\mu^-) \times \Delta y \times \Delta p_T}$$

Two sources of J/ψ mesons:

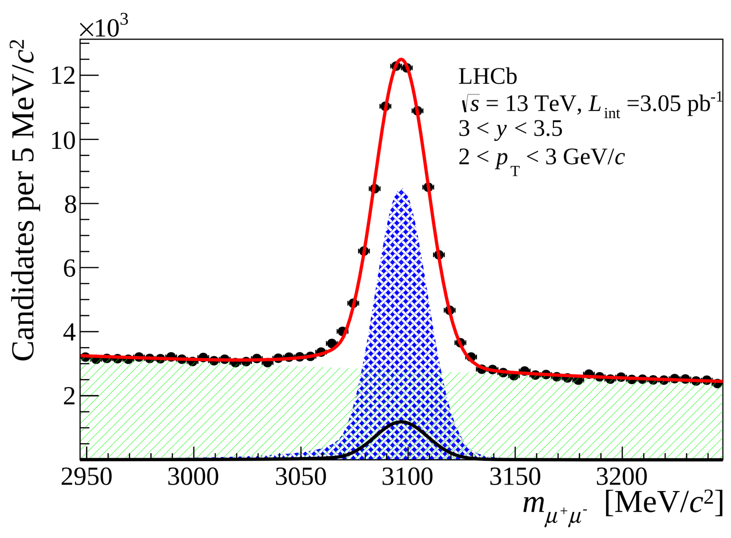
- directly from hard collisions of parton + through the feed-down of excited states ⇒ prompt J/ψ
- via decays of b-hadrons ⇒ from b J/ψ

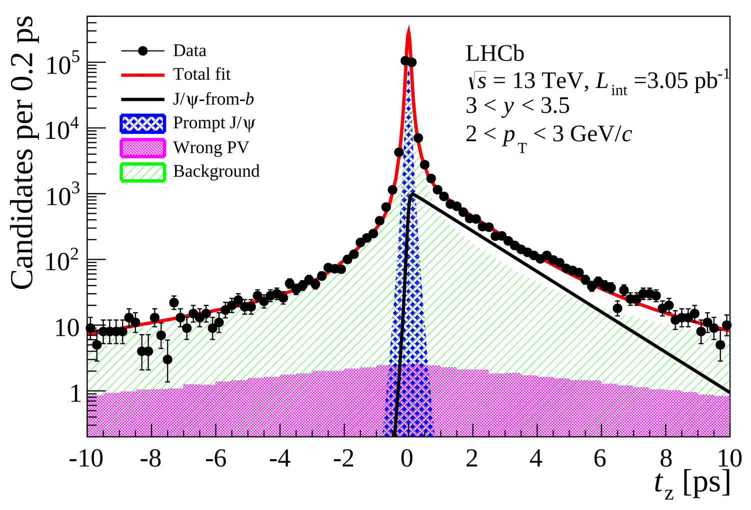


Define pseudo-proper time to distinguish two signal components:

$$t_z = \frac{z_{J/\psi} - z_{PV}}{p_z / M_{J/\psi}}$$

Using mass and t_z fit to extract the yields of the two signal components:

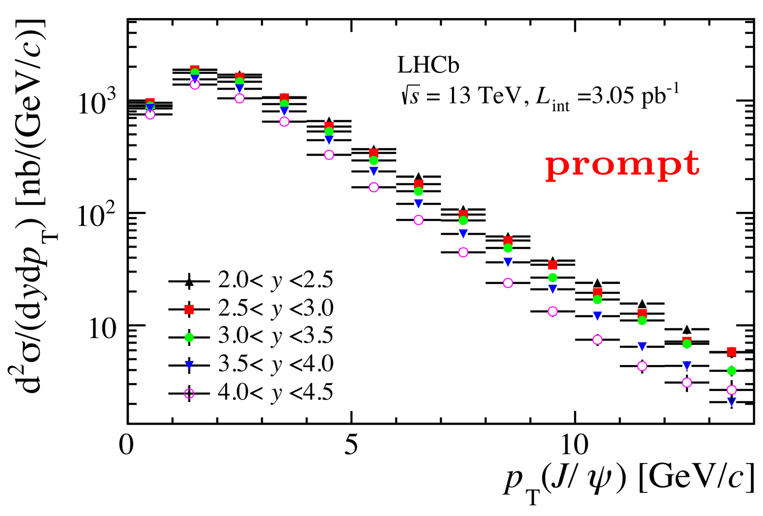


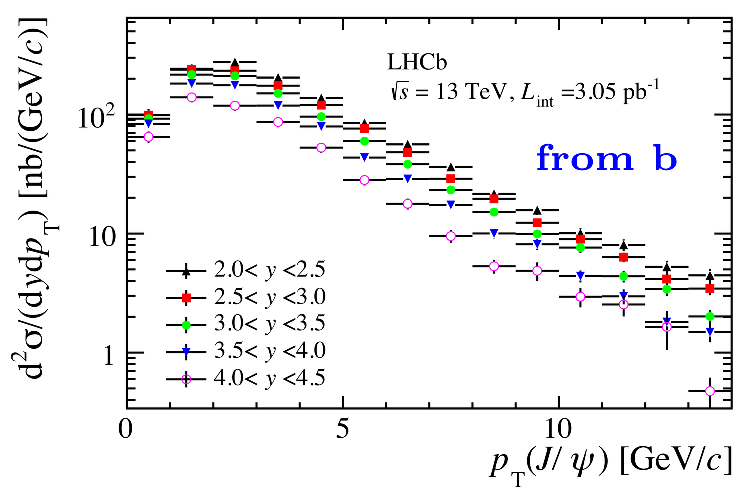


Timetable

- Prepare data samples ✓
- Signal extraction ✓
- Efficiency determination ← we are here now!
- Systematic uncertainties

We expect a final result like this:





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