Study of J/ψ production in jets

Jiajia Qin (UCAS)

On behalf of the LHCb collaboration

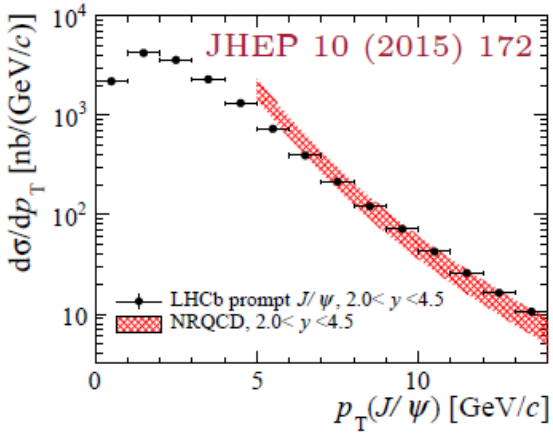
12^{th} International Workshop on Heavy Quarkonium
November 6-10
Peking University
Beijing, China

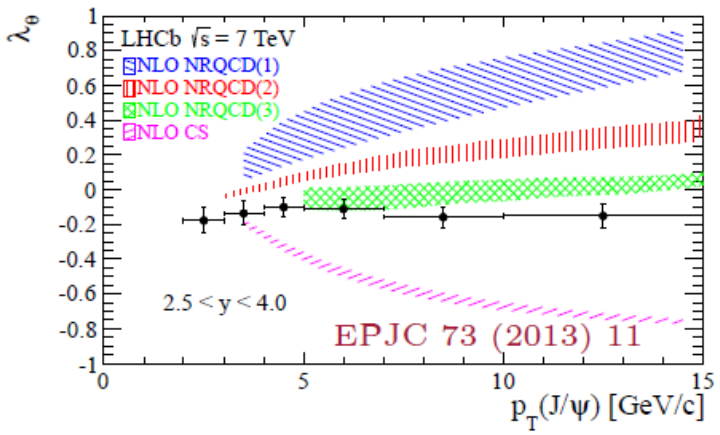
Outline

- Introduction
- LHCb detector
- J/ψ production in jets
- Summary

Introduction

- J/ψ production
  - The underlying production mechanisms are still not fully understood.
  - Powerful QCD test, both for perturbative and non-perturbative aspects.





- J/ψ production in jets
  - J/ψ produced from direct parton scattering (isolated) or through parton showers (in jets)?
  - Possible solution to lack of observed transverse polarization.
  - The variable $z(J/\psi) \equiv \frac{p_{\mathrm{T}}(J/\psi)}{p_{\mathrm{T}}(\mathrm{jet})}$ expected to be large in LO-NRQCD.

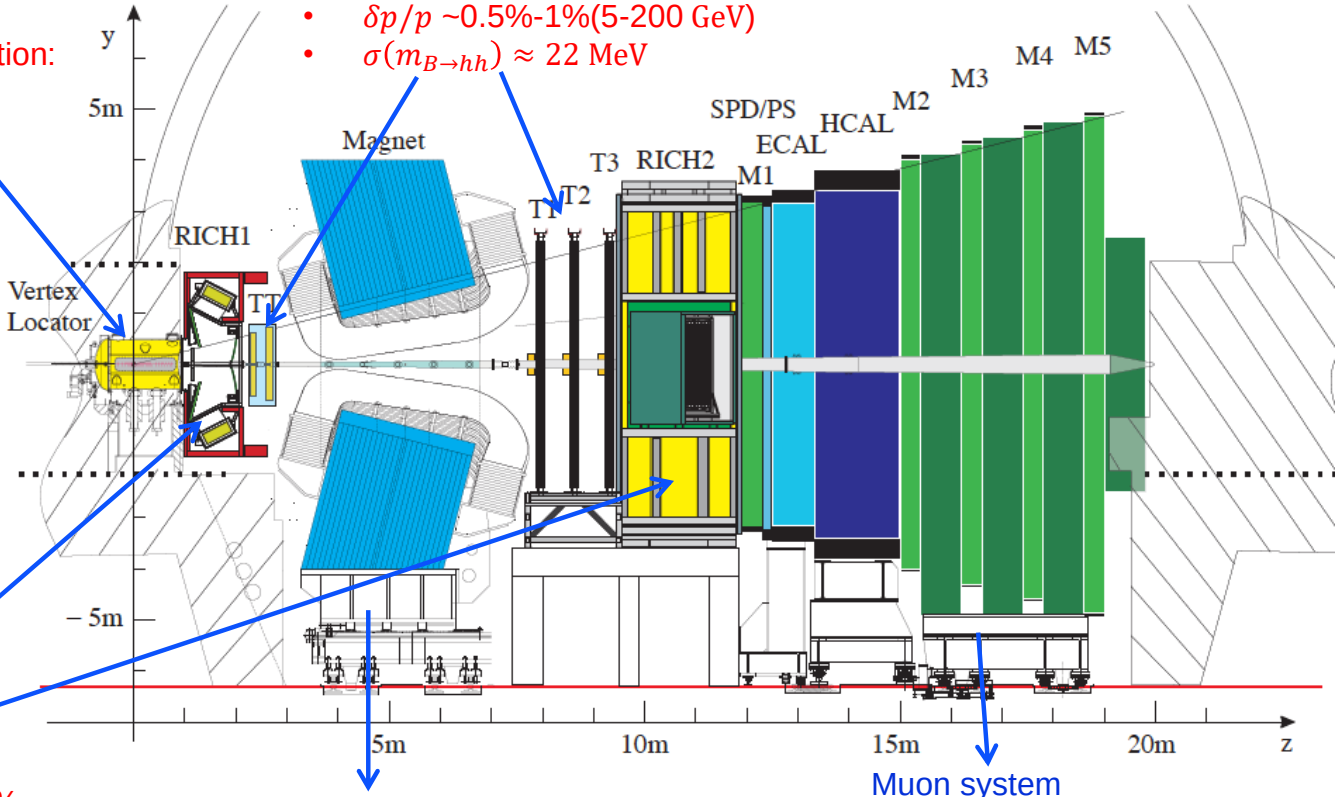
LHCb detector

- Aiming for precision measurements in b, c flavor sectors.
- Fully instrument covering $2 < \eta < 5$.

JINST 3 (2008) S08005
IJMPA 30 (2015) 1530022

Vertex Locator(vertex reconstruction)
- Impact parameter resolution: 20 μm
- Decay time resolution: 45 fs (τ_B~1.5 ps)

Tracking system(particle reconstruction)
- ϵ(Tracking) ~96%
- $\delta p/p$ ~0.5%-1%(5-200 GeV)
- $\sigma(m_{B\to hh}) \approx 22$ MeV



RICH: particle ID
- $\varepsilon(K \to K)$ ~95%
- Mis-ID: $\varepsilon(\pi \to K)$ ~5%

Magnet
Bending power: 4 Tm

Muon system
- μ ID: $\varepsilon(\mu \to \mu)$ ~97%
- Mis-ID: $\varepsilon(\pi \to \mu)$ ~1-3%

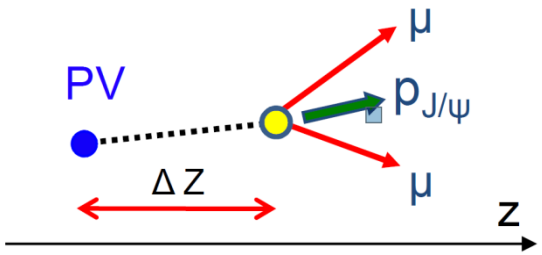
Analysis strategy

PRL 118 (2017) 192001 JHEP 0804 (2008) 063

- Analysis with the 13 TeV 2016 pp collision data:
  - Integrated luminosity is 1.4 fb^{-1}.
  - Data taking with near real-time calibration, alignment and reconstruction.
  - Online selection and storage of events with J/ψ candidates.
  - Jet reconstruction by clustering the J/ψ candidate with charged and neutral particle-flow objects with the anti-k_{T} clustering algorithm.

- Measure the fraction $z(J/\psi)$ of jet transverse momentum carried by J/ψ within:
  - Jets: $p_{\mathrm{T}}(\mathrm{jet}) > 20\ \mathrm{GeV},\ 2.5 < \eta(\mathrm{jet}) < 4$
  - J/ψ: $2.5 < \eta(J/\psi) < 4.5$
  - Muons: $p_{\mathrm{T}}(\mu) > 0.5\ \mathrm{GeV},\ p(\mu) > 5\ \mathrm{GeV},\ 2.5 < \eta(\mu) < 4.5$

- Prompt and displaced J/ψ events are separated via the pseudo-lifetime quantity:

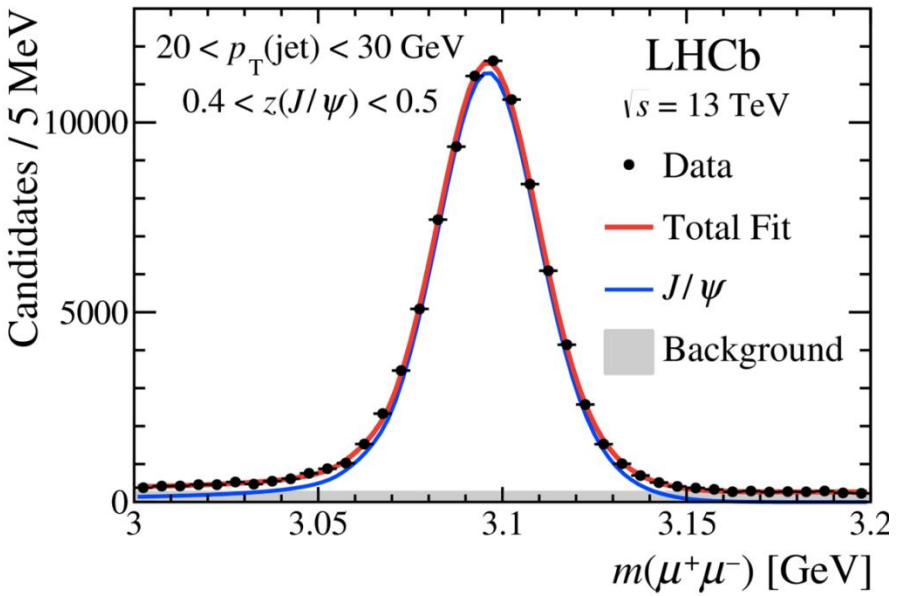


$$t_z \equiv \left(z_{J/\psi} - z_{\mathrm{PV}}\right)\frac{m(J/\psi)}{p_{\mathrm{z}}(J/\psi)}$$

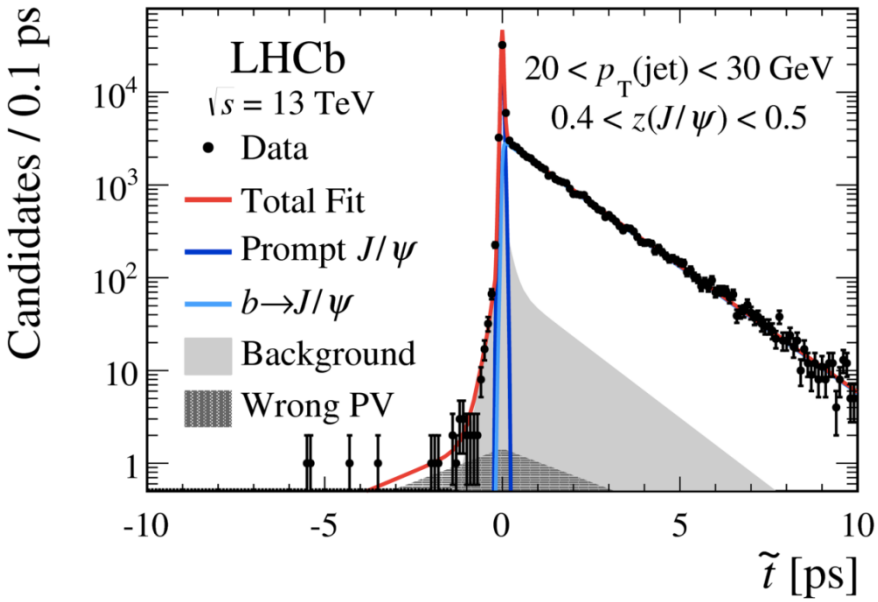
Signal Determination

PRL 118 (2017) 192001

- Perform an unbinned maximum likelihood fit in each bin of $z(J/\psi)$ and p_{T}(jet):



Signal: two CB functions
Bkg: an exponential function



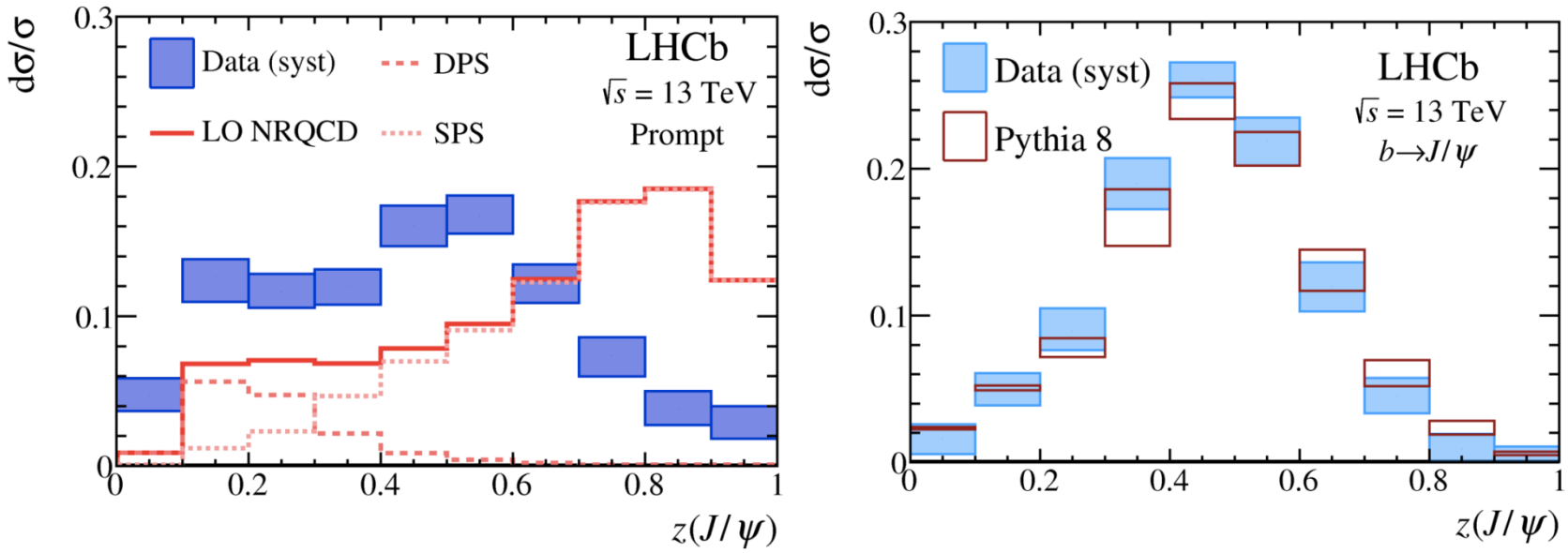
Prompt: a Dirac δ function
b-decay: an exponential function
Bkg: an empirical function

Results

PRL 118 (2017) 192001

- The distribution of $z(J/\psi)$, independent for displaced and prompt J/ψ:

Eur. Phys. J. C74 (2014) 3024

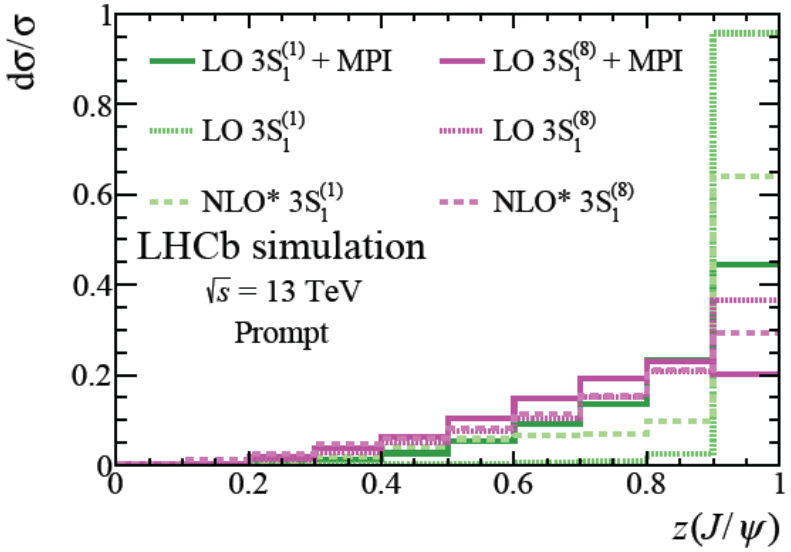


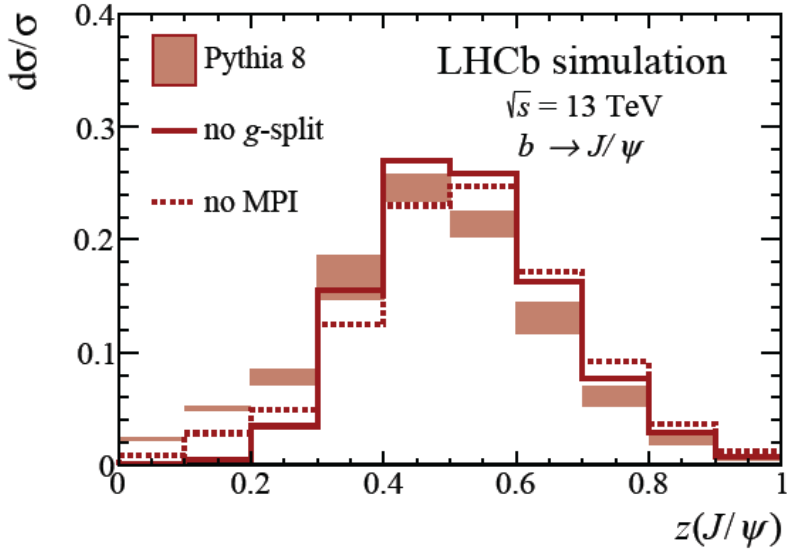
- Prompt $z(J/\psi)$-distribution softer than expected.
- DPS with $\sigma_{\text{eff}} = 31$ mb (PYTHIA default) does not explain the discrepancy.
- Good agreement between data and model for J/ψ from b.

Additional studies

- In LHCb simulation:

PRL 118 (2017) 192001



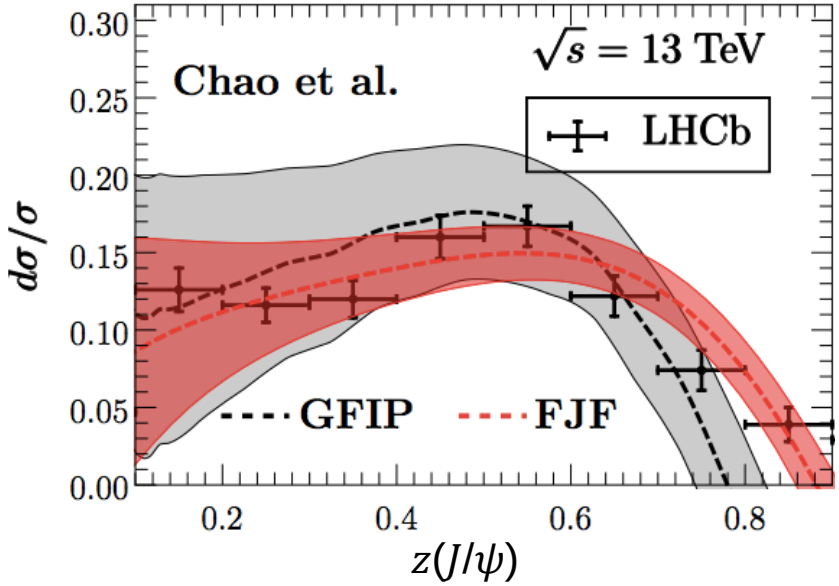


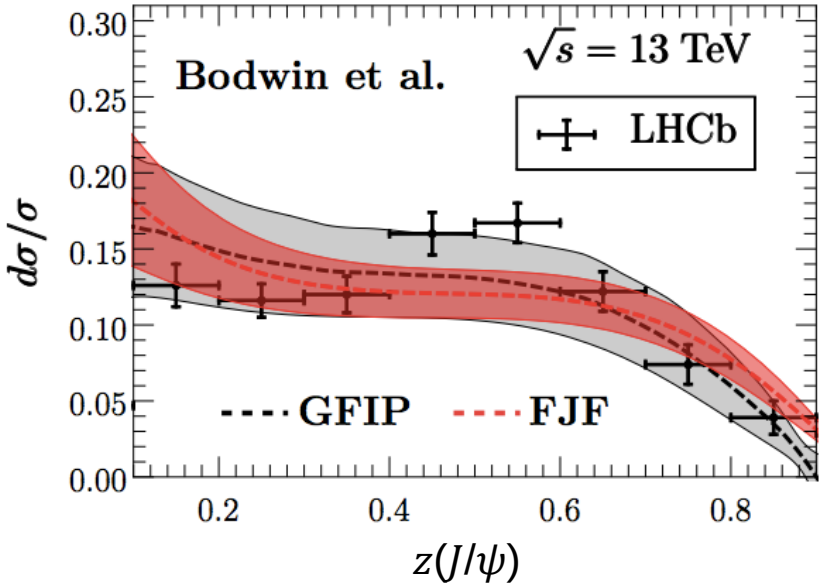
- Hard $z(J/\psi)$-distribution is generic in LO-NRQCD.
- Robust predictions for displaced J/ψ mesons.

Further theory results

- Alternatives to Pythia provided, better qualitative description of prompt $z(J/\psi)$ achieved:

PRL 119 (2017) 032002





Summary

- First study of properties of prompt J/ψ mesons production in jets done at LHCb.

- We measured the fraction of jet p_{T} carried by J/ψ, the observed distribution for J/ψ from b-hadron decays is consistent with the PYTHIA8 prediction. However, for the prompt J/ψ:
  - Softer spectrum than expected results from LO-NRQCD.
  - New calculations based on GFIP or FJF formalism agree with the data well.

- Rich harvest already and more to come.
  - ~5 fb^{-1} in Run II
  - ~50 fb^{-1} in Run III(start from 2021)

Thanks for your attention!

Backup

PRL 118 (2017) 192001

Unfolding detector effect:

- Correct for $z(J/\psi)$ resolution and p_{T}(jet) resolution, ~ 20-25%.
- Perform 2D unfolding in $z(J/\psi)$ and p_{T}(jet) (iterative Bayesian).

For prompt J/ψ: