J/ψ production in jets at LHCb

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on behalf of LHCb collaboration

12.12.2k+17

9th International Workshop on Multiple Parton Interactions at the LHC
11-15 December 2017, Shimla, India

J/ψ production

- A lot of experimental results
  - $\frac{d^2s}{dpTdy}$ at $\sqrt{s}$=2.76, 7, 8 and 13 TeV
    - both *prompt* and b→J/ψ
    - good agreement with N$^{(*)}$LO NR QCD
  - double J/ψ production at $\sqrt{s}$=7 and 13TeV
    - Large role of **DPS**
  - polarization of prompt J/ψ
    - Agreement with theory can't be declared as a good one …
    - Comparison is not so easy due to feed down from cc and ψ'

But there is no good understanding yet ☹

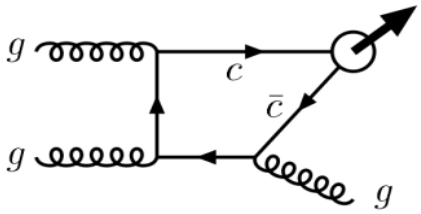
More data and measurements are needed

NR QCD

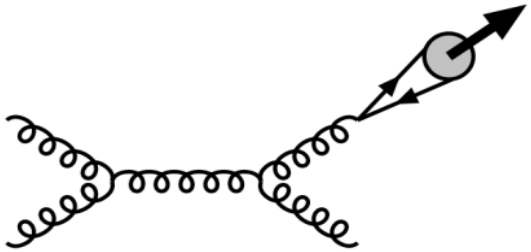
- NR QCD factorization

$$\mathrm{d}\sigma(pp \to H + X) = \sum_{s,L,J} \mathrm{d}\hat{\sigma}(pp \to Q\bar{Q}[^{2s+1}L_J] + X)\langle \mathcal{O}^H[^{2s+1}L_J]\rangle$$

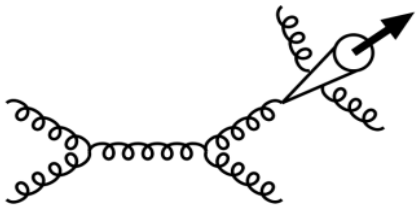
- Physical state expanded into Fock's states



$gg \to c\bar{c}[^3S_1^{(1)}]g$



$gg \to c\bar{c}[^3S_1^{(8)}]g$



$gg \to c\bar{c}[^1S_0^{(8)}, ^3P_J^{(8)}]g$

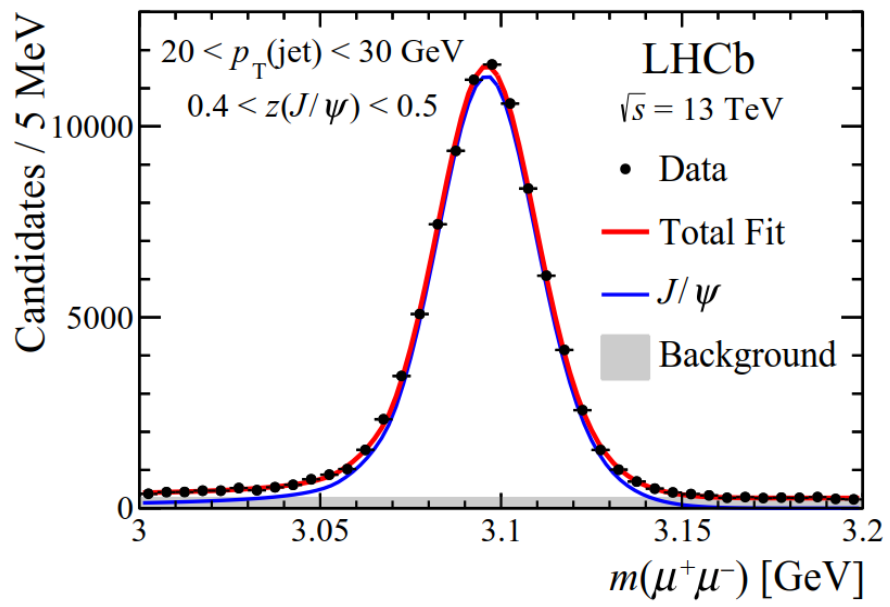
- What about J/ψ in (gluon) jets?
  - Select jets with J/ψ and measure z

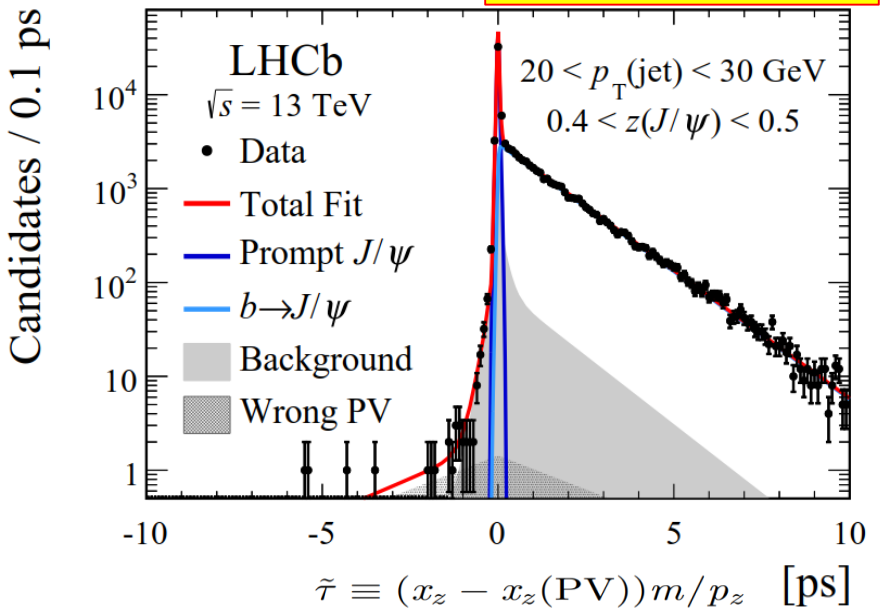
$$z \equiv p_{\mathrm{T}}(J/\psi)/p_{\mathrm{T}}(\mathrm{jet})$$

J/ψ with jets at LHCb

- Very efficient 2μ trigger
  - Reconstruct jets for J/ψ-triggered events
- Separate *prompt* and b→J/ψ components

PRL 118(2017) 192001



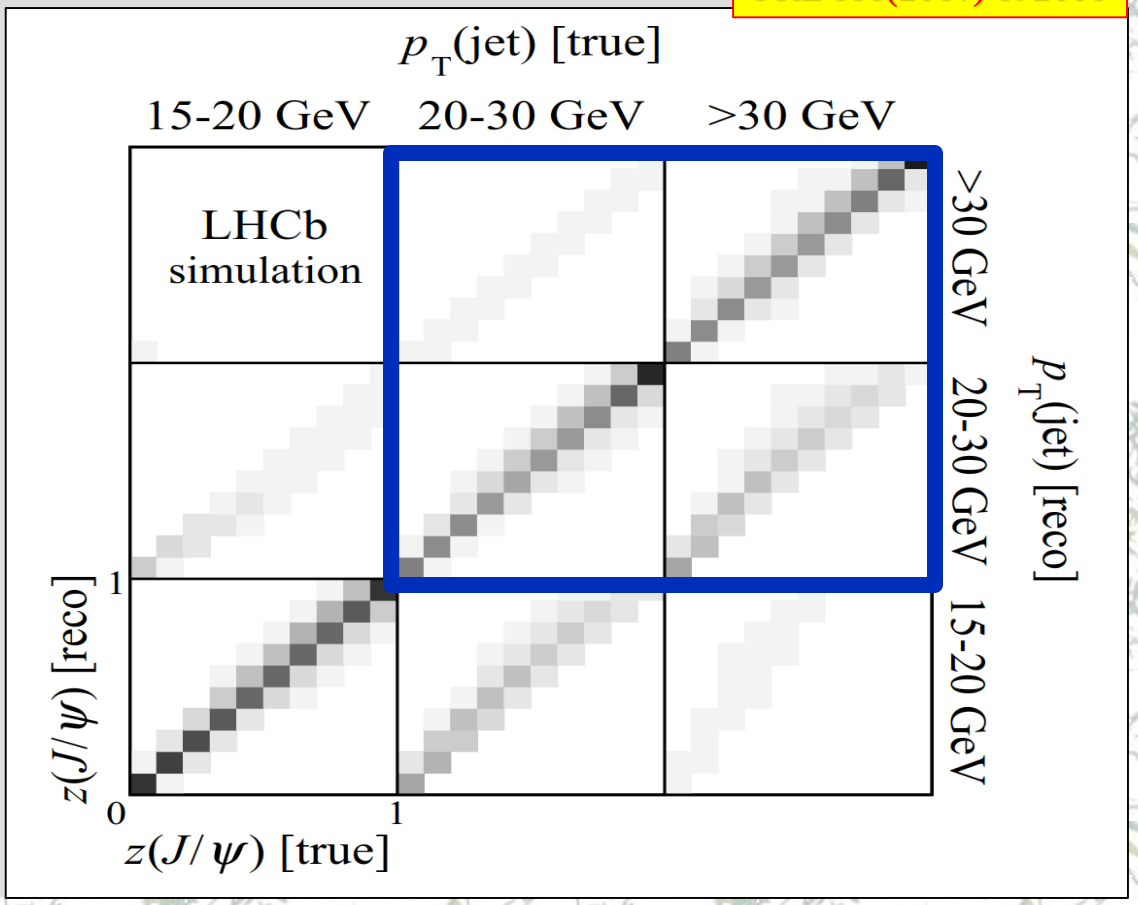


Jets (offline)

- Cluster J/ψ with charged and neutral particles, reconstructed *on-line*
  - *Particle-flow* approach
  - *anti*-k_T algorithm
  - $p_T^{jet} > 15(20)$ GeV/*c*
  - $2.5 < \eta^{jet} < 4.0$
  - 20-25% resolution
  - for p_T^{jet} (nearly uniform)

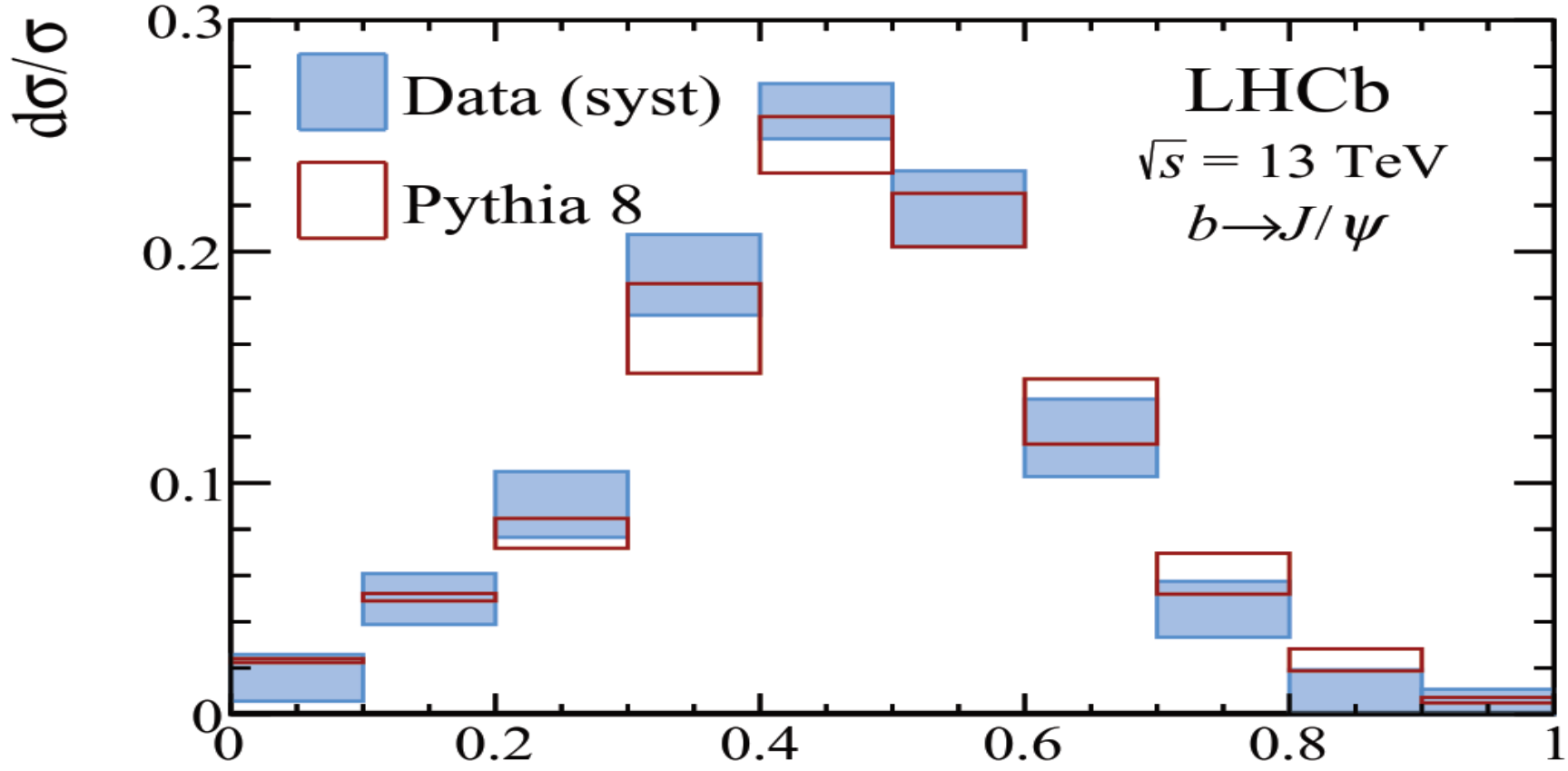
- 2D -iterative unfolding
  - $z(J/\psi)$, p_T^{jet}

PRL 118(2017) 192001



b→J/ψ

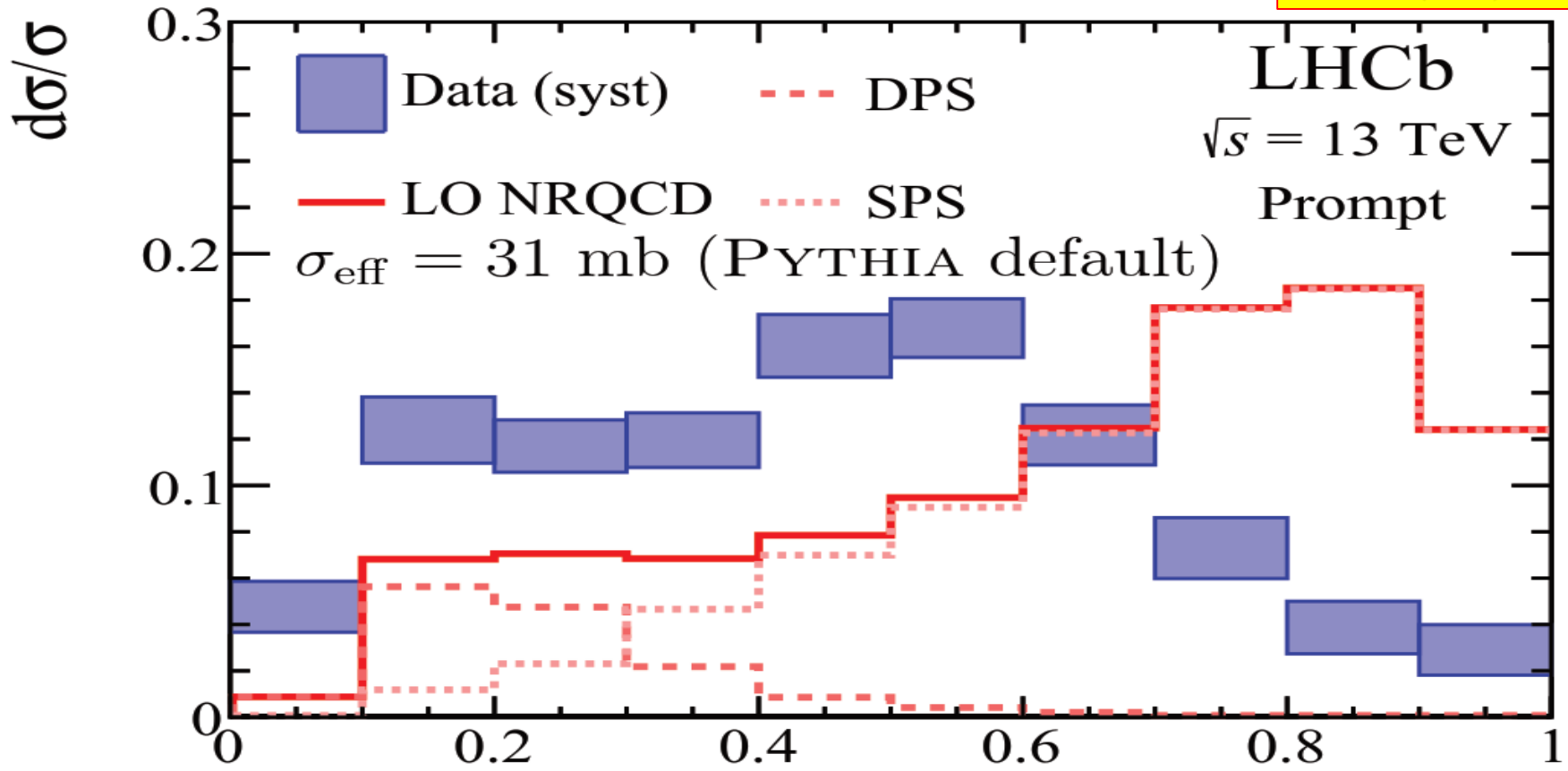
PRL 118(2017) 192001



Good understanding of b-production!

Prompt J/ψ puzzle

PRL 118(2017) 192001



Prompt quarkonium (as usual) is much more difficult to understand

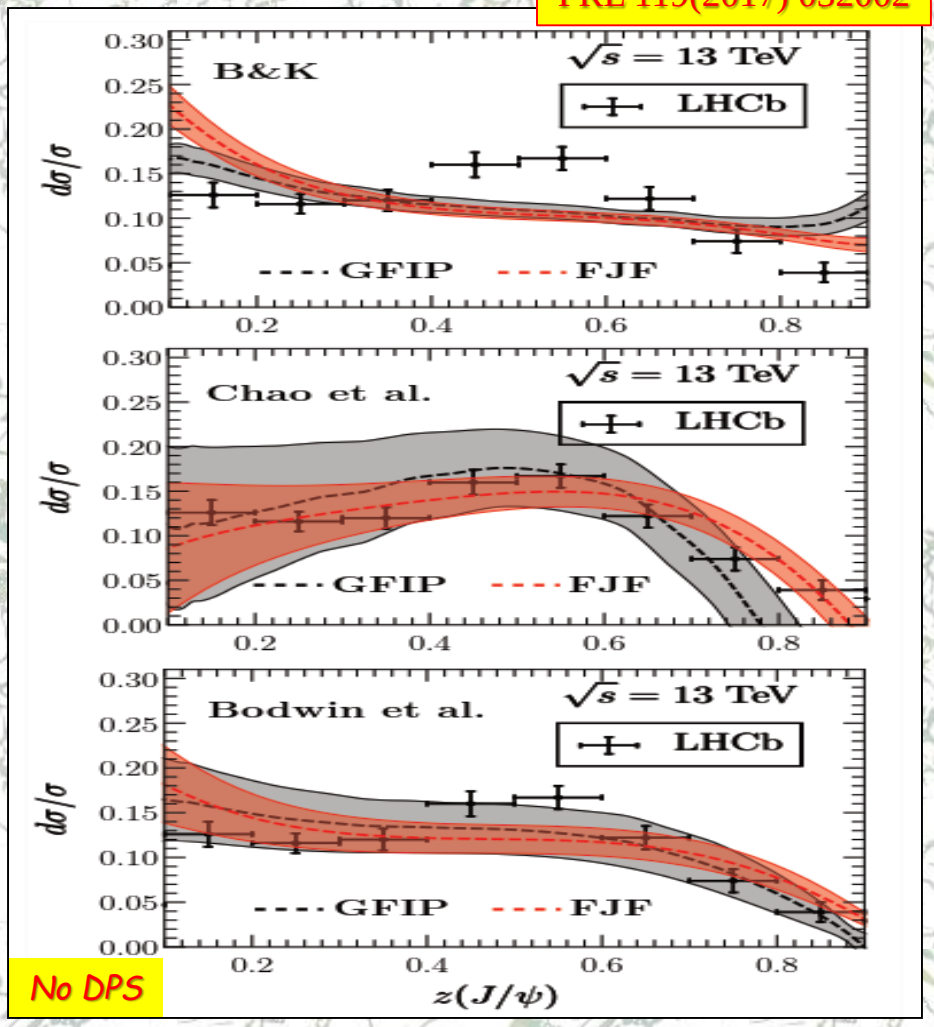
Prompt J/ψ puzzle

PRL 119(2017) 032002

Bain, Makris, Dei & Leibovich

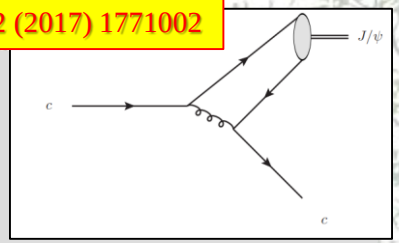
- MadGraph, Pythia + LO NRQCD fragmentation functions
- FJF
  - Fragmenting Jet Functions
- GFIP
  - Gluon Fragmentation Improved in Pythia

Better description than the default Pythia could be achieved



Prompt J/ψ puzzle: c →J/ψ ?

Mod.Phys.Lett A32 (2017) 1771002



- What about c fragmentation into J/ψ ?

$$\frac{d\sigma_{J/\psi}}{dp_T} = \int_{2p_T/\sqrt{s}}^{1} \frac{d\sigma_{c\bar{c}}}{dk_T}\left(\frac{p_T}{z}\right)\frac{D_{c\to J/\psi}(z)}{z}dz,$$

$$\frac{1}{\sigma}\frac{d\sigma}{dz} \sim D_{c\to J/\psi}(z),$$

Braaten, Cheung, Yuan, PRD48 (1993) R5049, Kiselev, Likhoded, Shevlyagin ZPhysC63 (1994) 77

$$D_{c\to J/\psi}(z) \sim \frac{4z(1-z)^2}{(2-z)^6}\left(16 - 32z + 72z^2 - 32z^3 + 5z^4\right).$$

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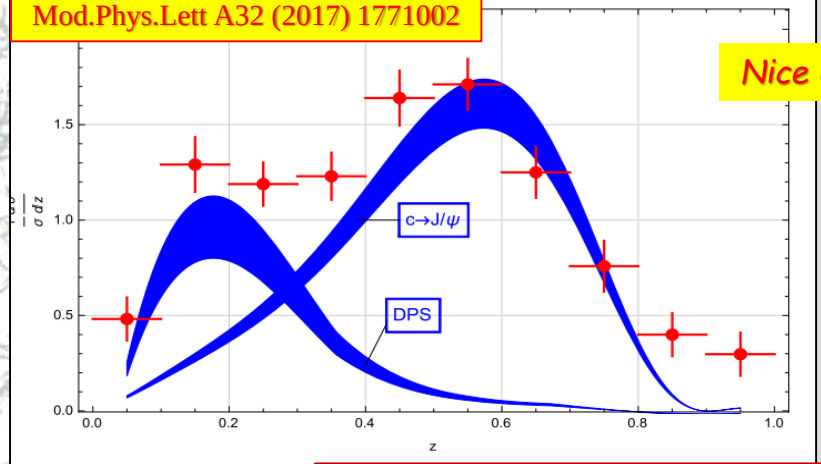

Nice description! DPS is needed!

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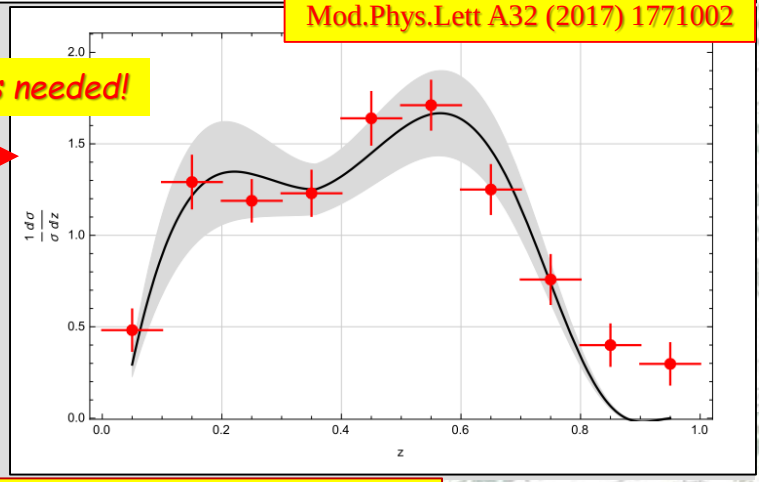

Very easy to check experimentally: there should be open charm hadron in vicinity of the jet

Summary

- Novel measurement of J/ψ production in jets
  - Good agreement for b→J/ψ, confirming good understanding of b-production
- Surprize for *prompt* J/ψ
  - More work of theory is needed
  - **DPS** contribution is probably not small
  - Large contribution from c→J/ψ fragmentation?
- More data is needed!
  - ψ', ϒ, particle and energy correlations, charm hadrons nearby,…

These measurements are universal and should be easy for ATLAS & CMS. It will be very interesting to compare the results, GPDs can probe much higher p_T^{jet} *. Good point for cooperation!*