中国物理学会高能物理分会

第十三届全国粒子物理学术会议

J/ψ production within jet in p+p collisions

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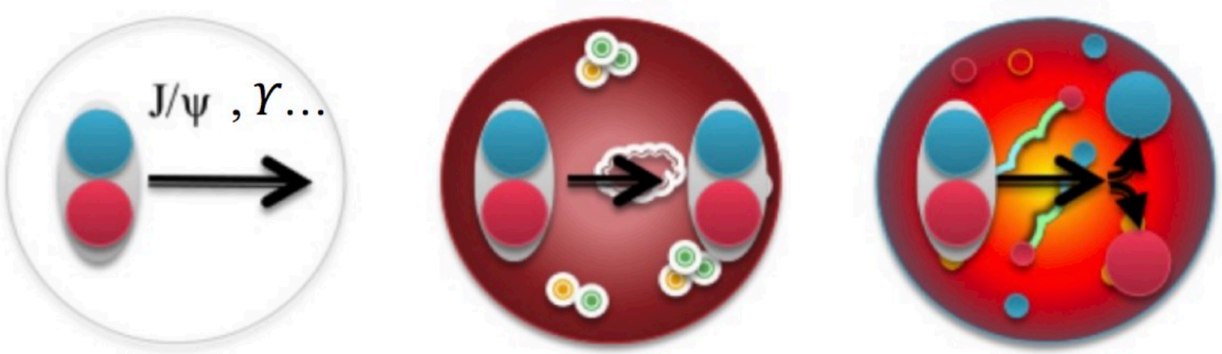
- Motivation of studying J/ψ production
- J/ψ fragmentation function measurements
- Summary

J/ψ in heavy-ion collision

J/ψ is a sensitive probe of the deconfinement in the QGP: color screening dissociation

J/ψ: heavy mass (m_c = ~1.5 GeV/c^2,) ➜ early creation
long lifetime



T = 0 0 < T < T_C T > T_C

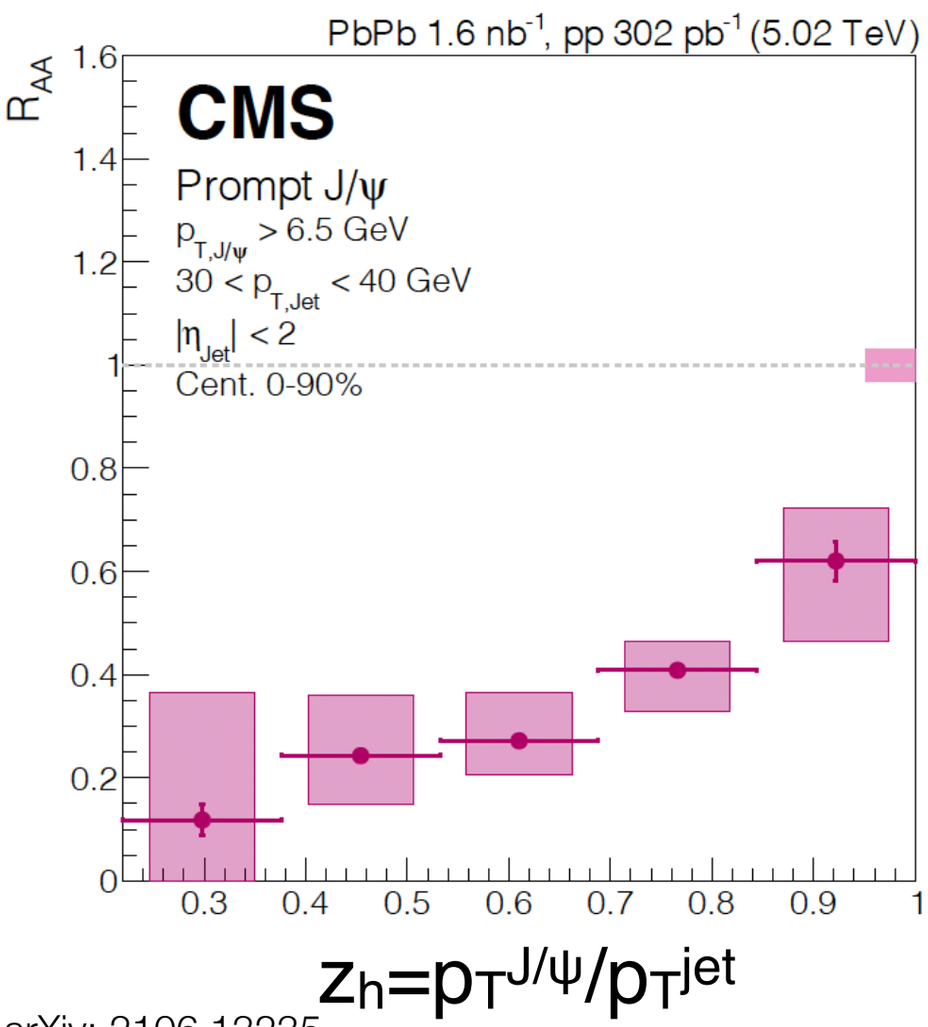
Illustration: A. Rothkopf

$$R_{AA} = \frac{1}{\langle N_{\mathrm{coll}} \rangle} \times \frac{\left(\frac{d^2 N_{J/\psi}}{2\pi\, p_T dp_T dy}\right)_{\mathrm{Au+Au}}}{\left(\frac{d^2 N_{J/\psi}}{2\pi\, p_T dp_T dy}\right)_{p+p}}$$

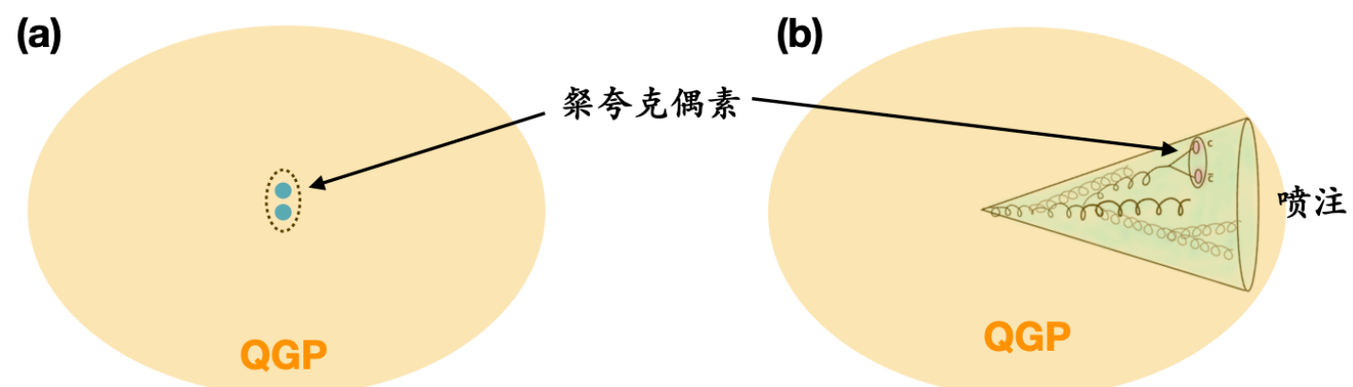
J/ψ production in jet

"Jet fragmentation accounts for almost all prompt J/ψ meson produced at large p_T (>15 GeV/c)"

- p+p @ 8 TeV CMS PLB,804 (2020) 135409



CMS, arXiv: 2106.13235



Jet quenching mechanism is an importance source of J/ψ in A+A collision, which is not token into account in theory yet!

Limited knowledge about J/ψ production in jet!

J/ψ production mechanism

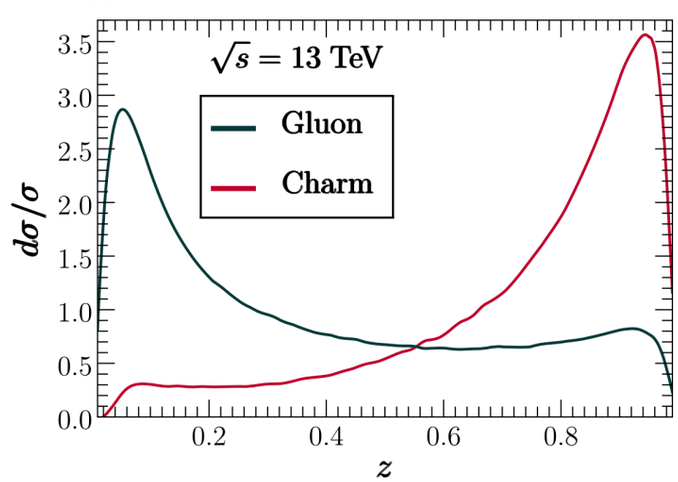
Models differ in $c\bar{c}$ production and the treatment of hadronization:

- NRQCD approach: color singlet/octet $c\bar{c}$ + its evolution to J/ψ (Long distance matrix elements)

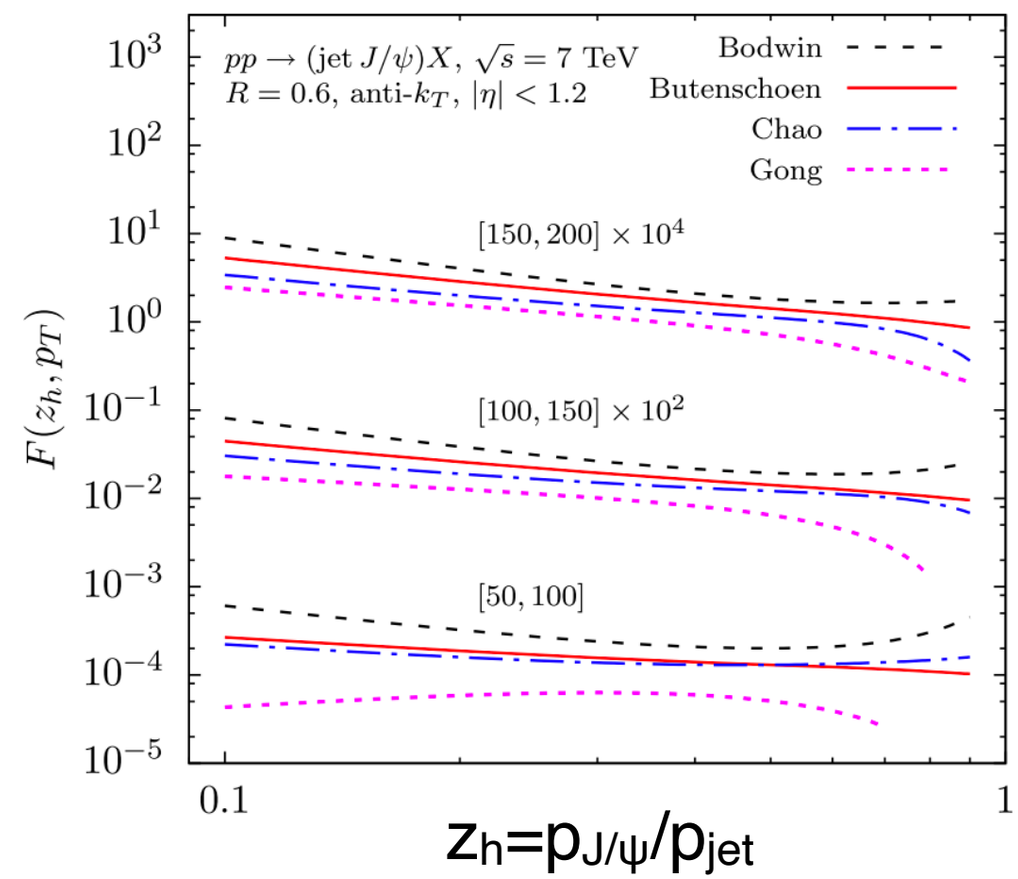
J/ψ NRQCD LDMEs from four different groups

	$\langle\mathcal{O}(^3S_1^{[1]})\rangle$ GeV^3	$\langle\mathcal{O}(^1S_0^{[8]})\rangle$ 10^{-2} GeV^3	$\langle\mathcal{O}(^3S_1^{[8]})\rangle$ 10^{-2} GeV^3	$\langle\mathcal{O}(^3P_0^{[8]})\rangle$ 10^{-2} GeV^5
Bodwin	0[a]	9.9	1.1	1.1
Butenschoen	1.32	3.04	0.16	−0.91
Chao	1.16	8.9	0.30	1.26
Gong	1.16	9.7	−0.46	−2.14

Reggie Bain et .al, PRL, 119 (2017) 032002



Zhong-Bo Kang et .al, PRL, 119 (2017) 032001

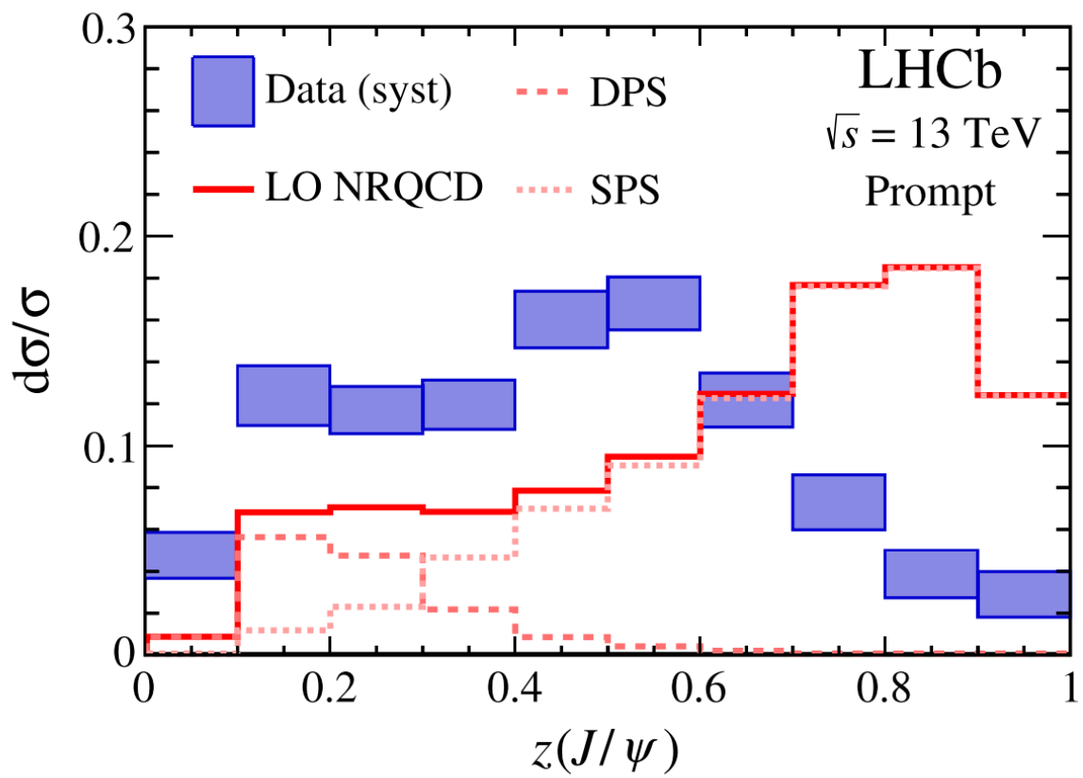


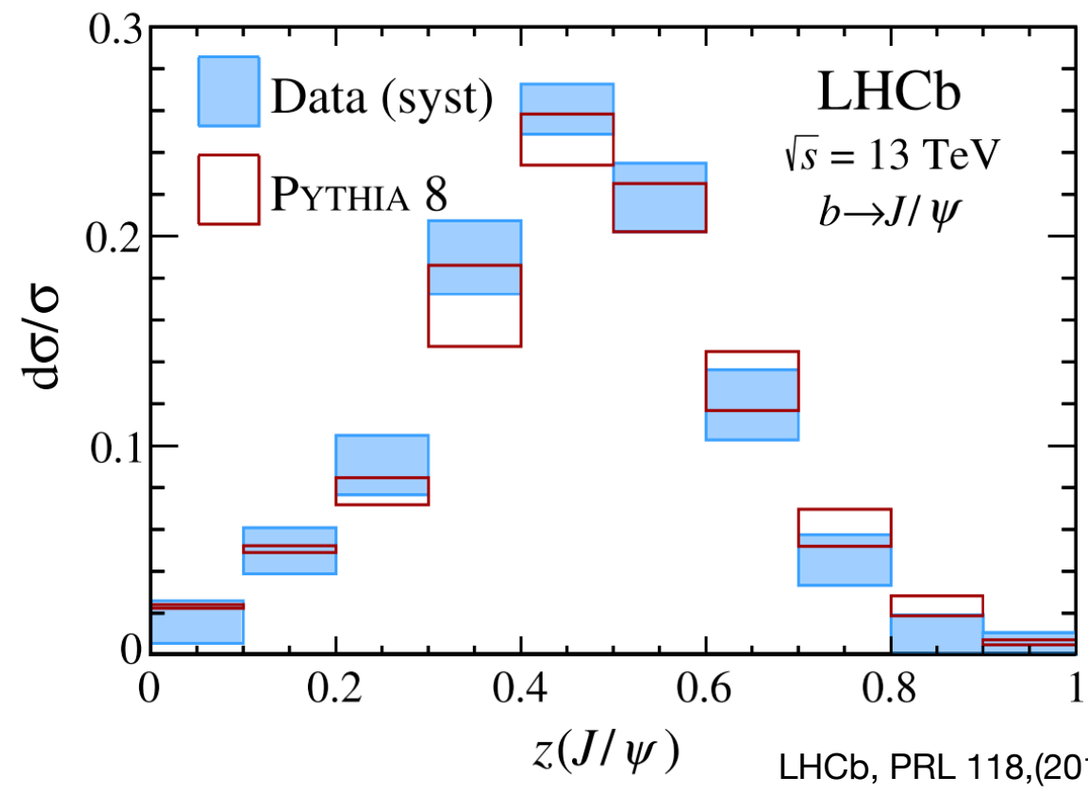
- Sensitive probes for different J/ψ production mechanism

J/ψ measurement at LHCb

Forward rapidity

p_T (jet) > 20 GeV/c
2.5 < η(jet) < 4.0
R= 0.5

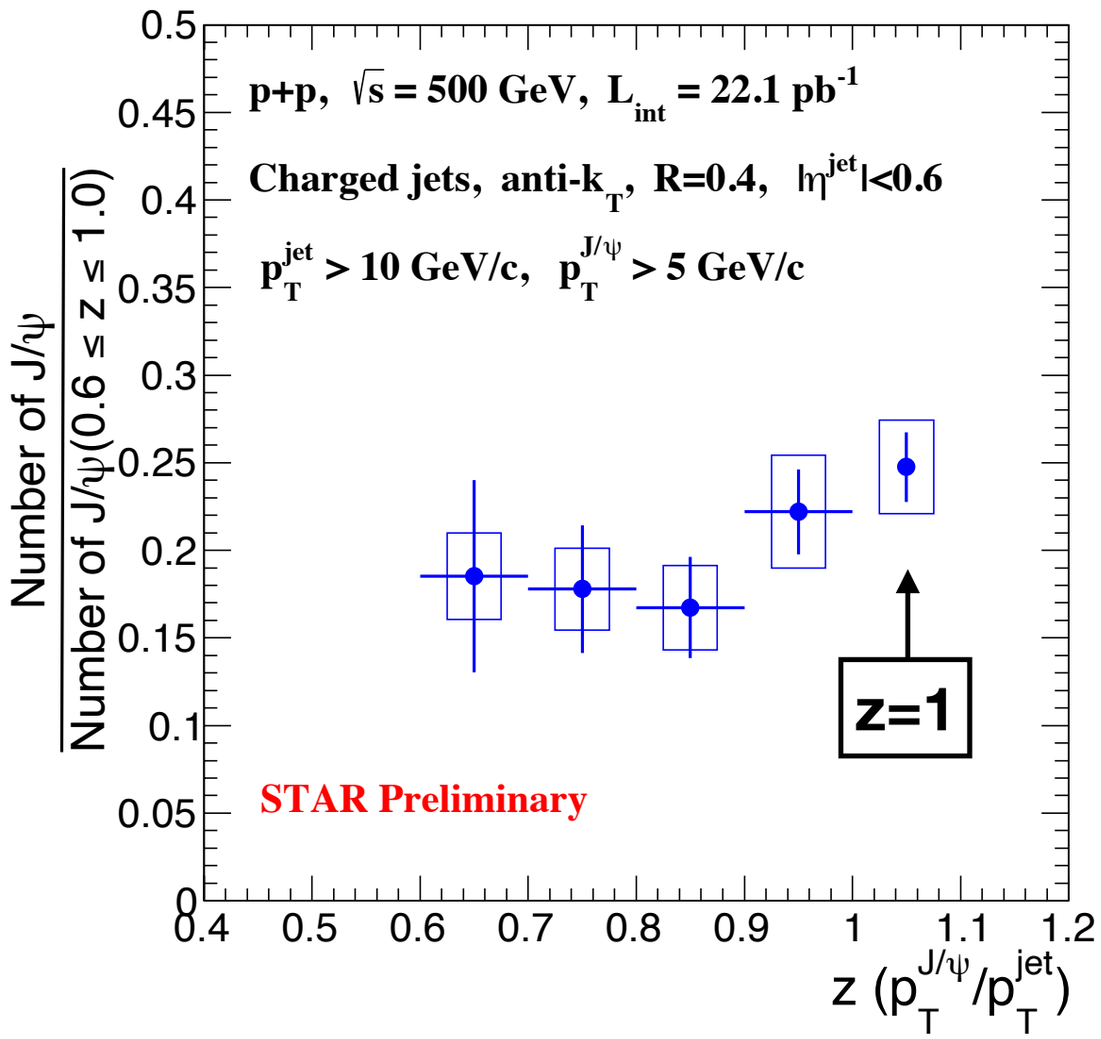




LHCb, PRL 118,(2017)192001

- Prompt J/ψ in data is produced much less isolated than Pythia8 prediction
- Non-prompt J/ψ in jet production consistent with Pythia8 prediction

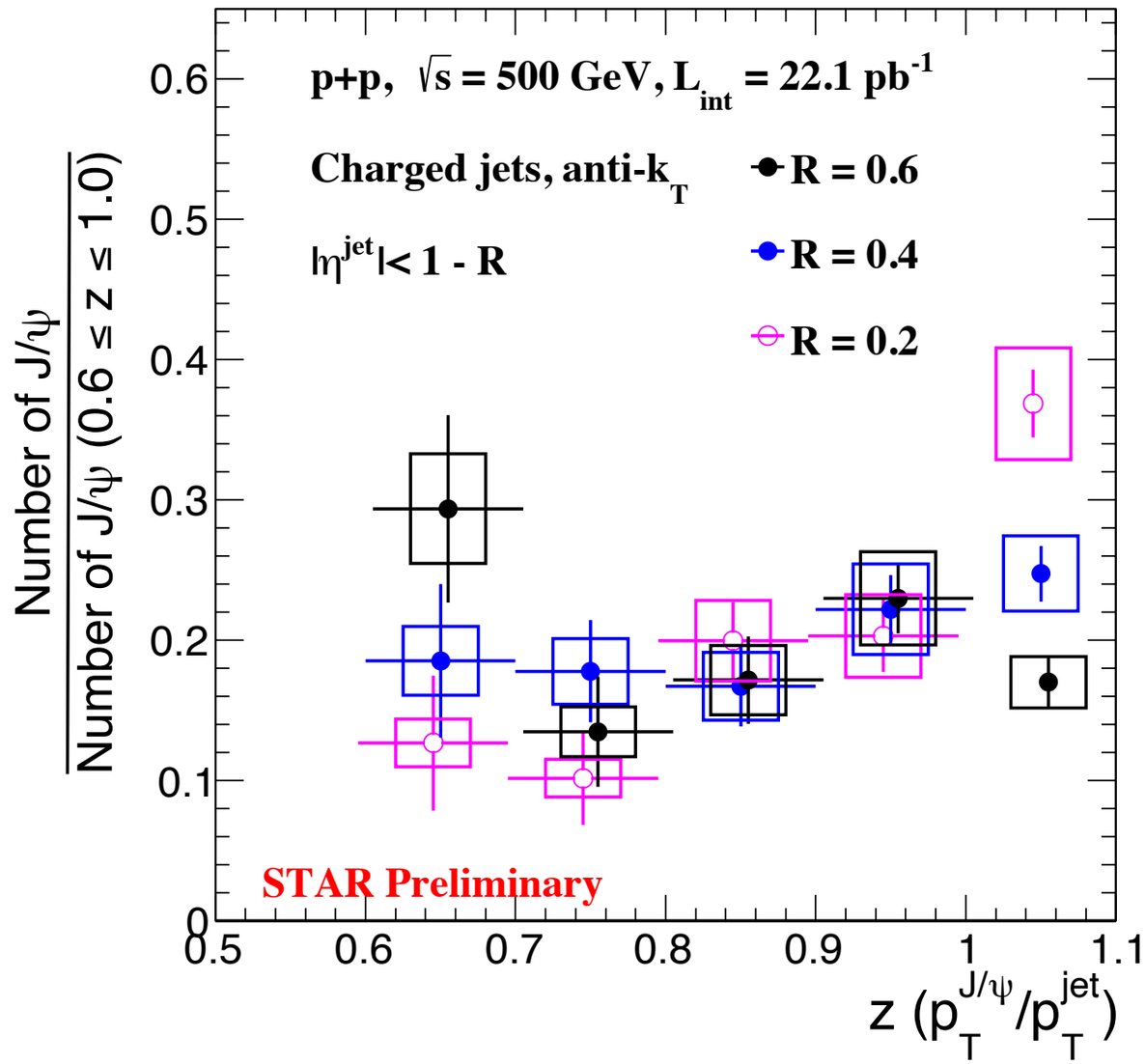
J/ψ in jets at STAR



- z is the fraction of the jet transverse momentum carried by the J/ψ meson
- z=1 data point (bin-width=0) is moved to 1.05 for visualization

- First measurement of J/ψ production in jets at RHIC
- Detector effects are accounted for via unfolding
- Charged jet to J/ψ fragmentation function :
  - No significant z dependence observed within uncertainties

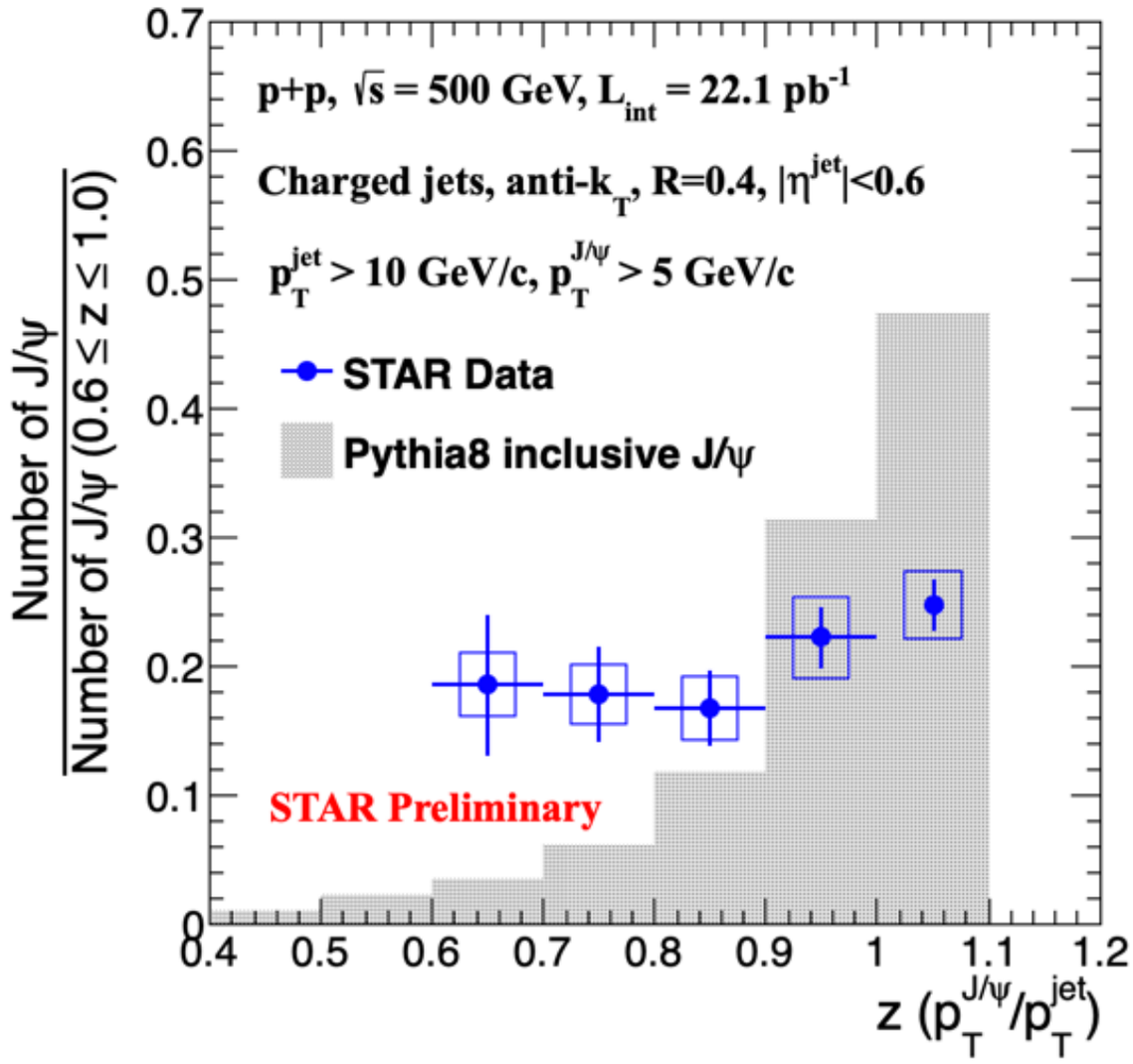
Cone size dependence



- More data is needed to study the R dependence
- Analysis of high statistics data sample from 2017 (L_{int} = 336.4 pb^{-1}) is ongoing

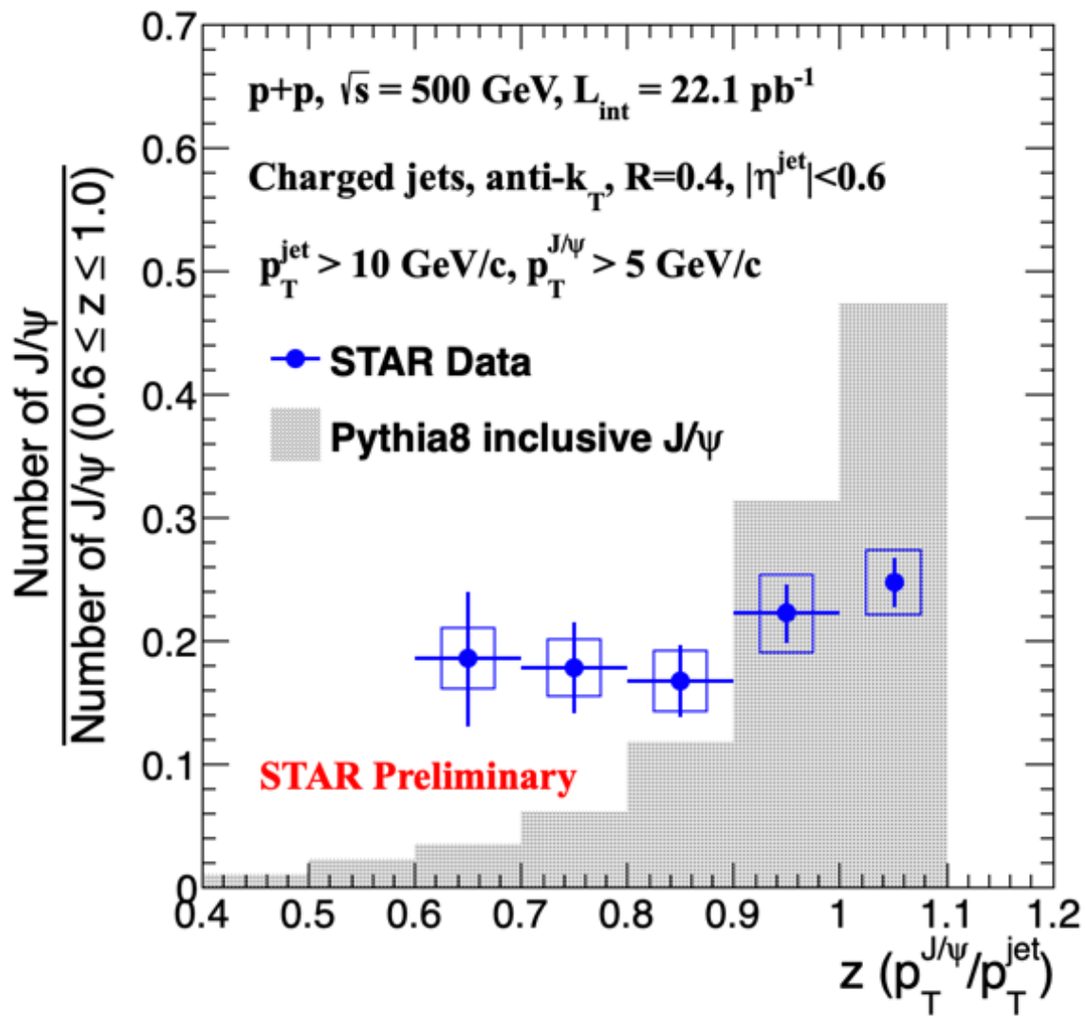
  ➜More precise measurement

Fragmentation: data vs Pythia8

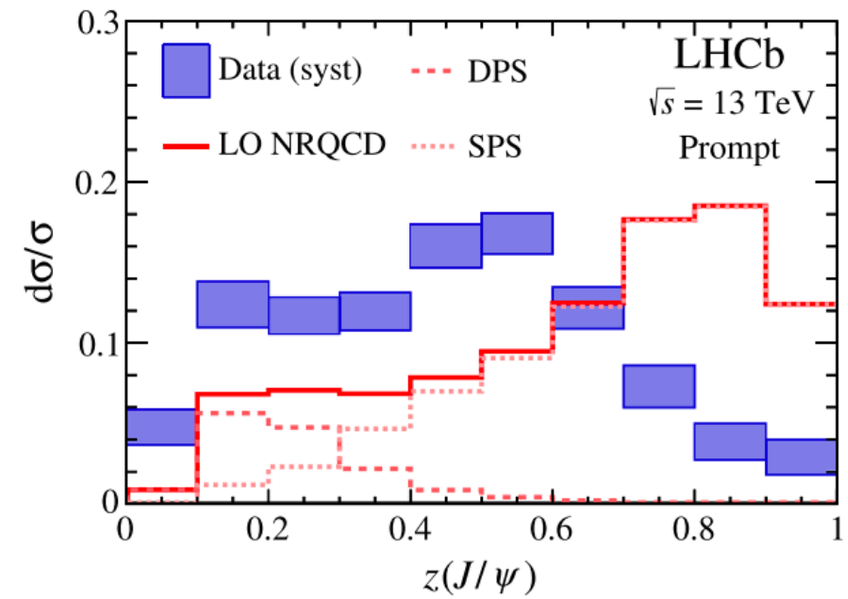


- Different trends, and J/ψ production is less isolated in data than in Pythia8
- May help to understand J/ψ polarization: Lin Dai et .al, PRD, 96 (2017) 036020
  - Production: parton showers vs parton-parton scattering ?

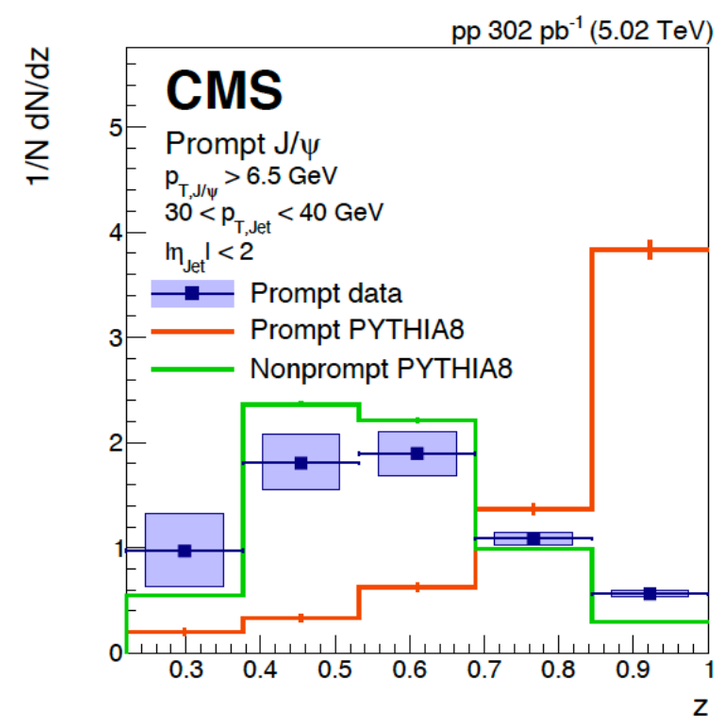
Fragmentation: RHIC vs LHC



LHCb, PRL 118 (2017) 192001

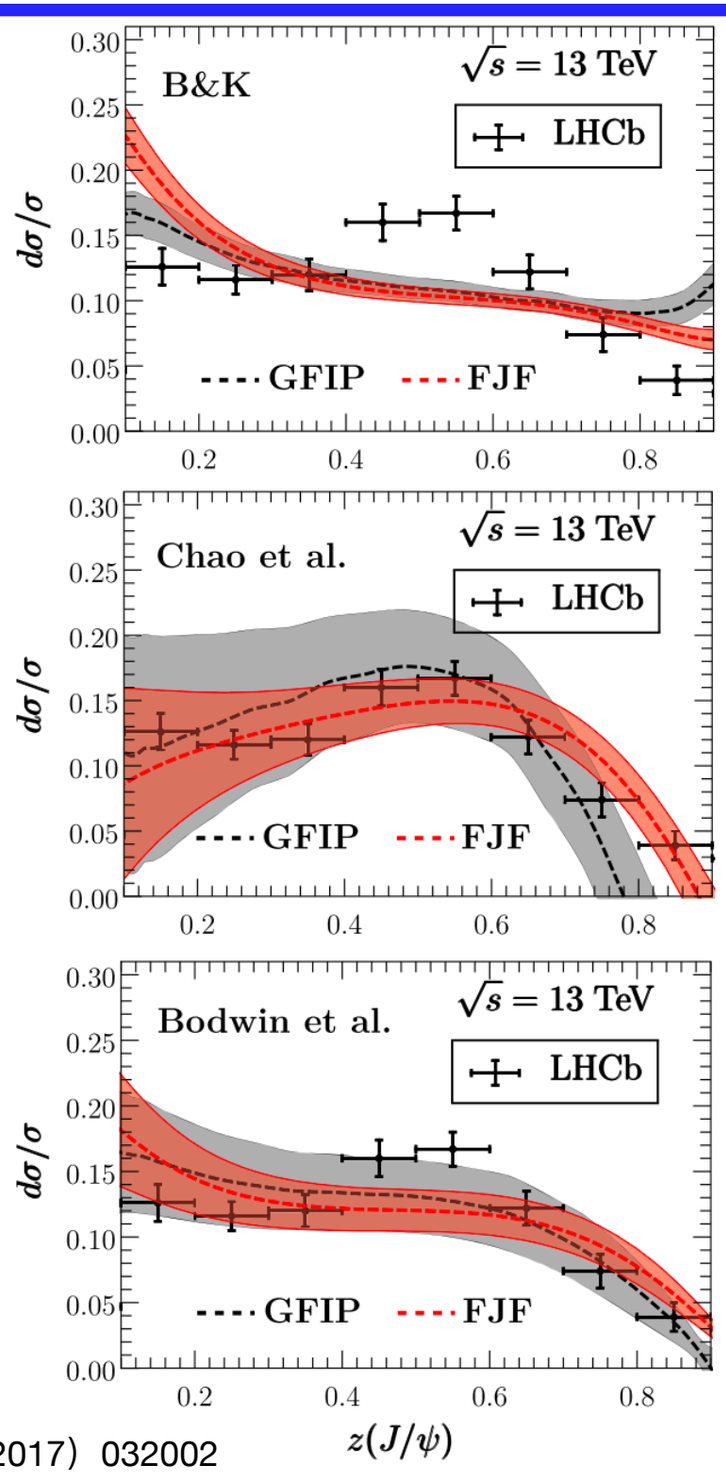


CMS, arXiv: 2106.13235



- Both show less isolated production
- Difference in jet measurements
  - Charged jet at RHIC vs. full jet at LHC
  - Different kinematic range

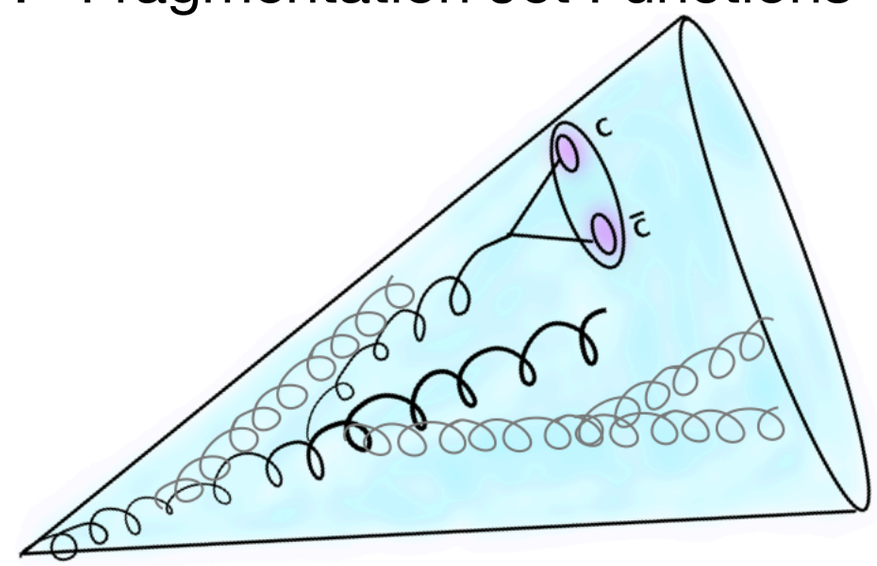
Measurement vs. NRQCD



LHCb, PRL119 (2017) 032002

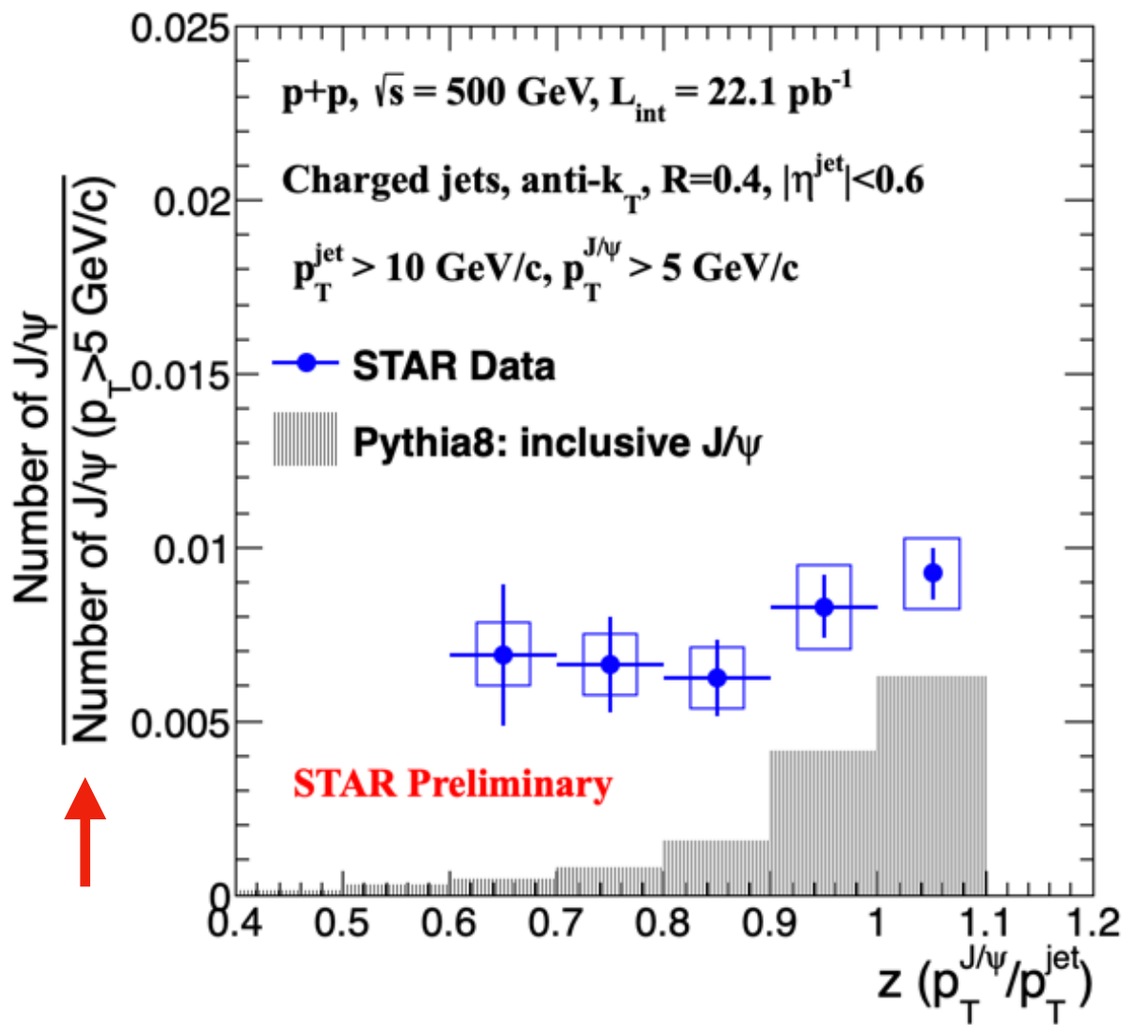
GFIP: Gluon Fragmentation Improved Pythia

FJF: Fragmentation Jet Functions



- Better agreement with LHCb measurement
  ➜J/ψ produced in parton showers
- LDMEs from global fits (B&K) give worse agreement than LDMEs from high-pT fitting (Chao et al. and Bodwin et al.)
- High energy parton or color-octet $c\bar{c}$ will shower first, then form a J/ψ

Fraction of J/ψ produced in jets



STAR, Phys.ReV.D 100(2019) 052009
for p_T > 5 GeV/c J/ψ cross section

- The fraction of a p_T > 5 GeV/c J/ψ produced in a p_T > 10 GeV/c jet is 3.7% ± 0.3% (stat.) ± 0.2%(sys.)
- The probability of producing a J/ψ in charged jet is significantly higher in data than in Pythia8 for the measured kinematics

Summary

- J/ψ production in jet studies are important for QGP study as well as for J/ψ production mechanism study
- Compared to Pythia8
  - Less isolated production in data
  - More J/ψ produced in jets in data
- Similar observations of less isolated J/ψ production in jets compared to Pythia8 at both RHIC and LHC, despite of different jet measurement methods (charged jet vs. full jet) and different kinematic ranges
- Theory inputs are very welcome for STAR measurements

Thanks!