Study of Jet Fragmentation in J/ψ and D mesons with CMS

Xiao Wang for the CMS collaboration

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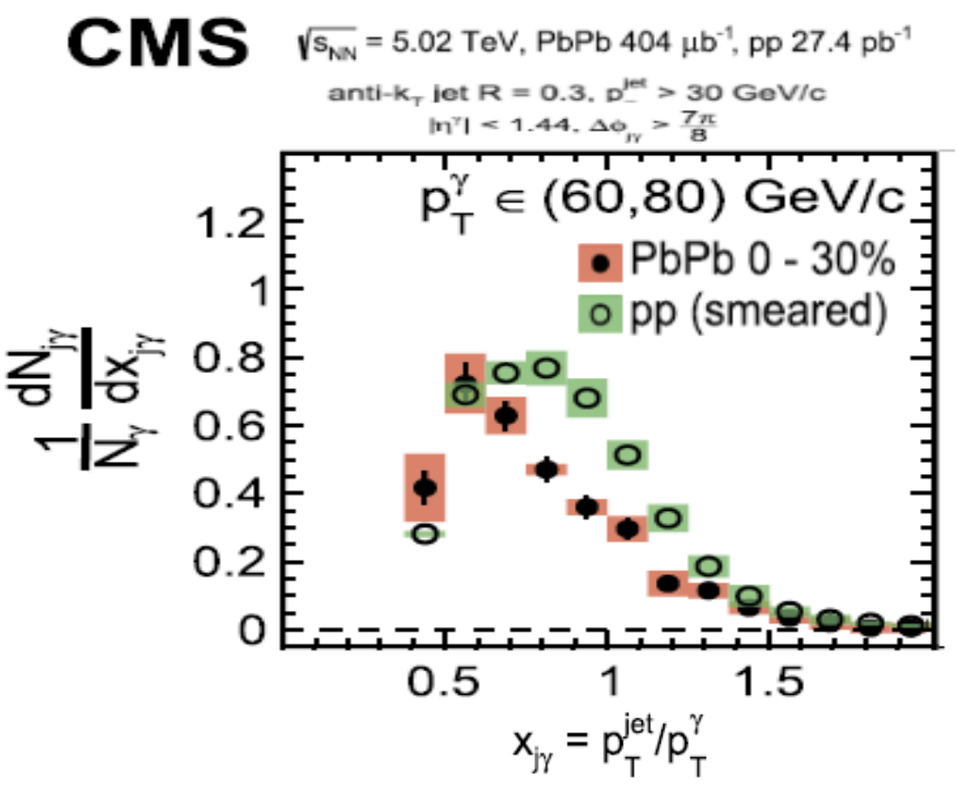
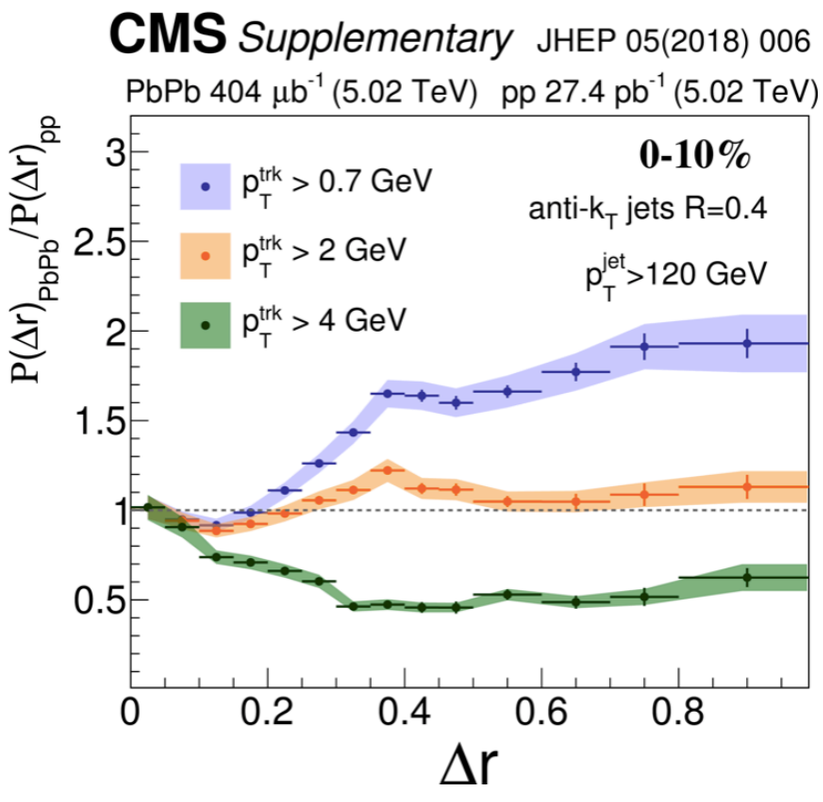
Introduction

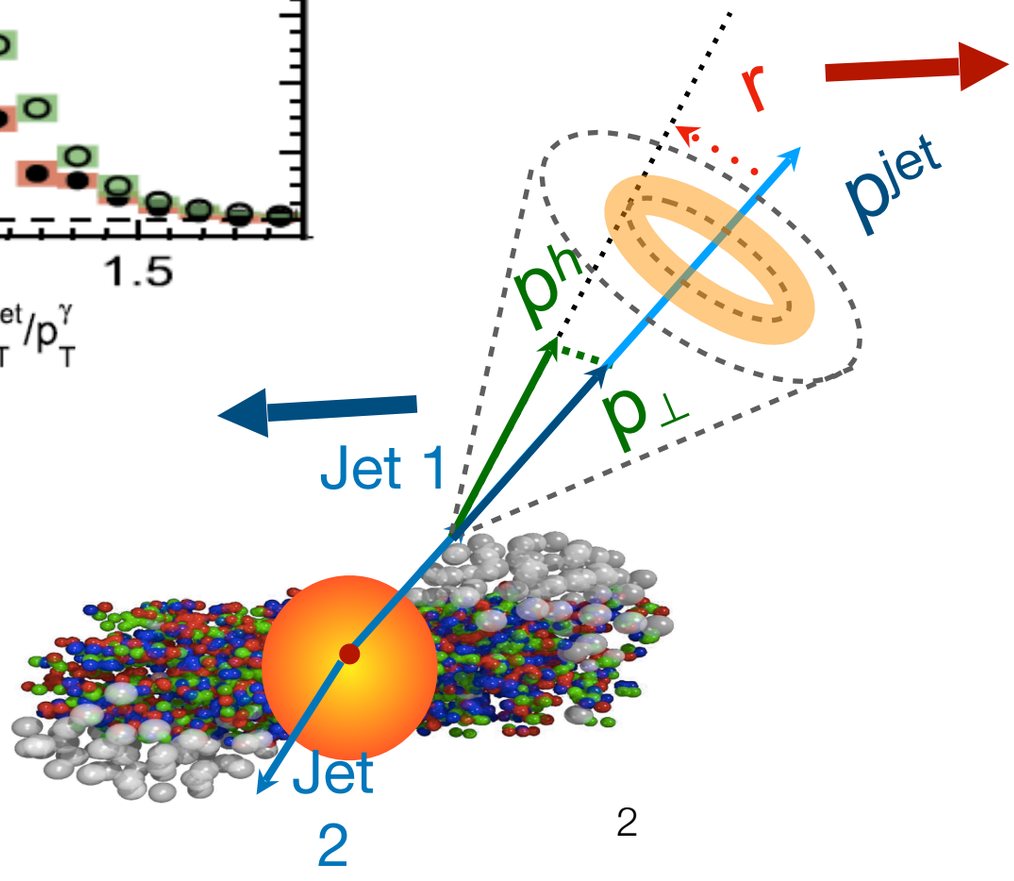
Jets are established tomographic probes for QGP. We know that:

- Jets are quenched and jet fragmentation functions and shapes are modified in heavy ion collisions



PLB 785 (2018) 14





$$\Delta r = \sqrt{\Delta\phi_{JD}^2 + \Delta\eta_{JD}^2}$$

Introduction

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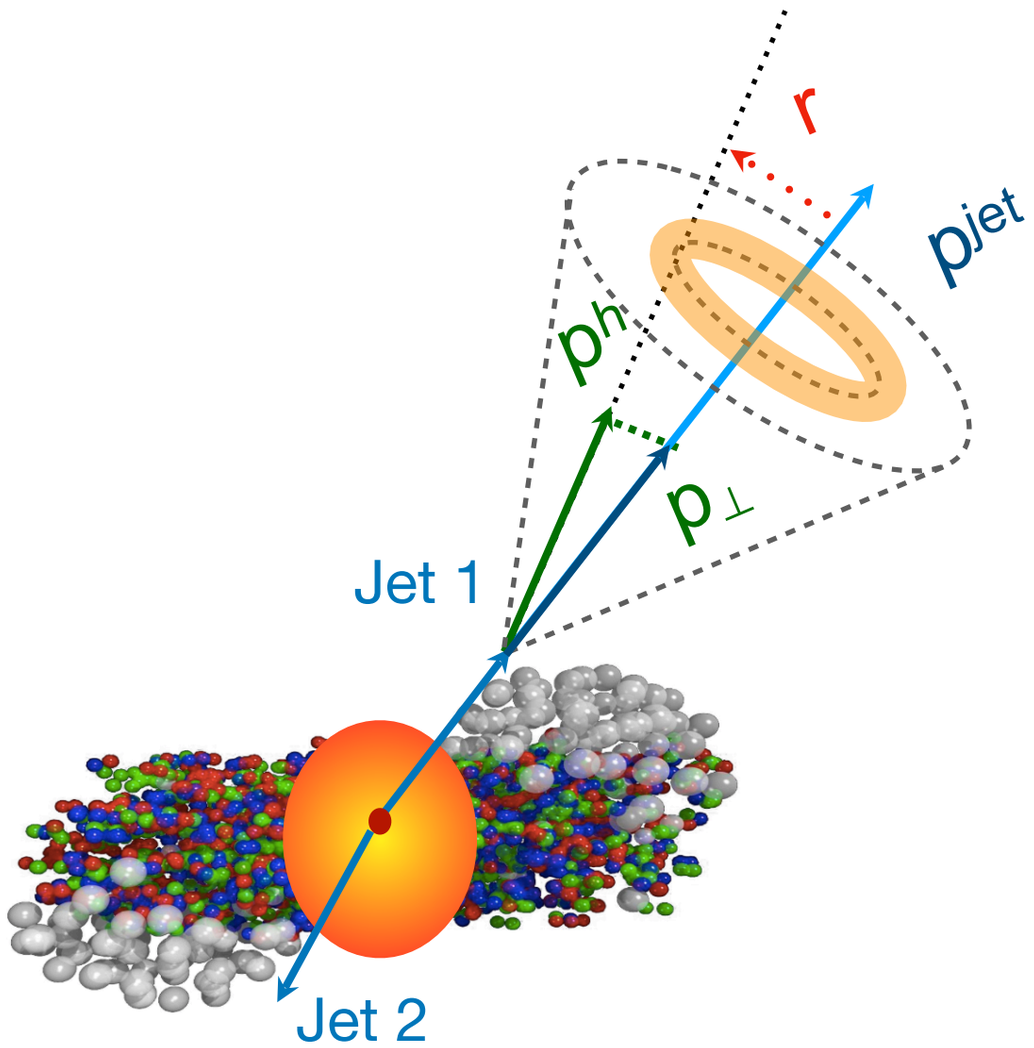
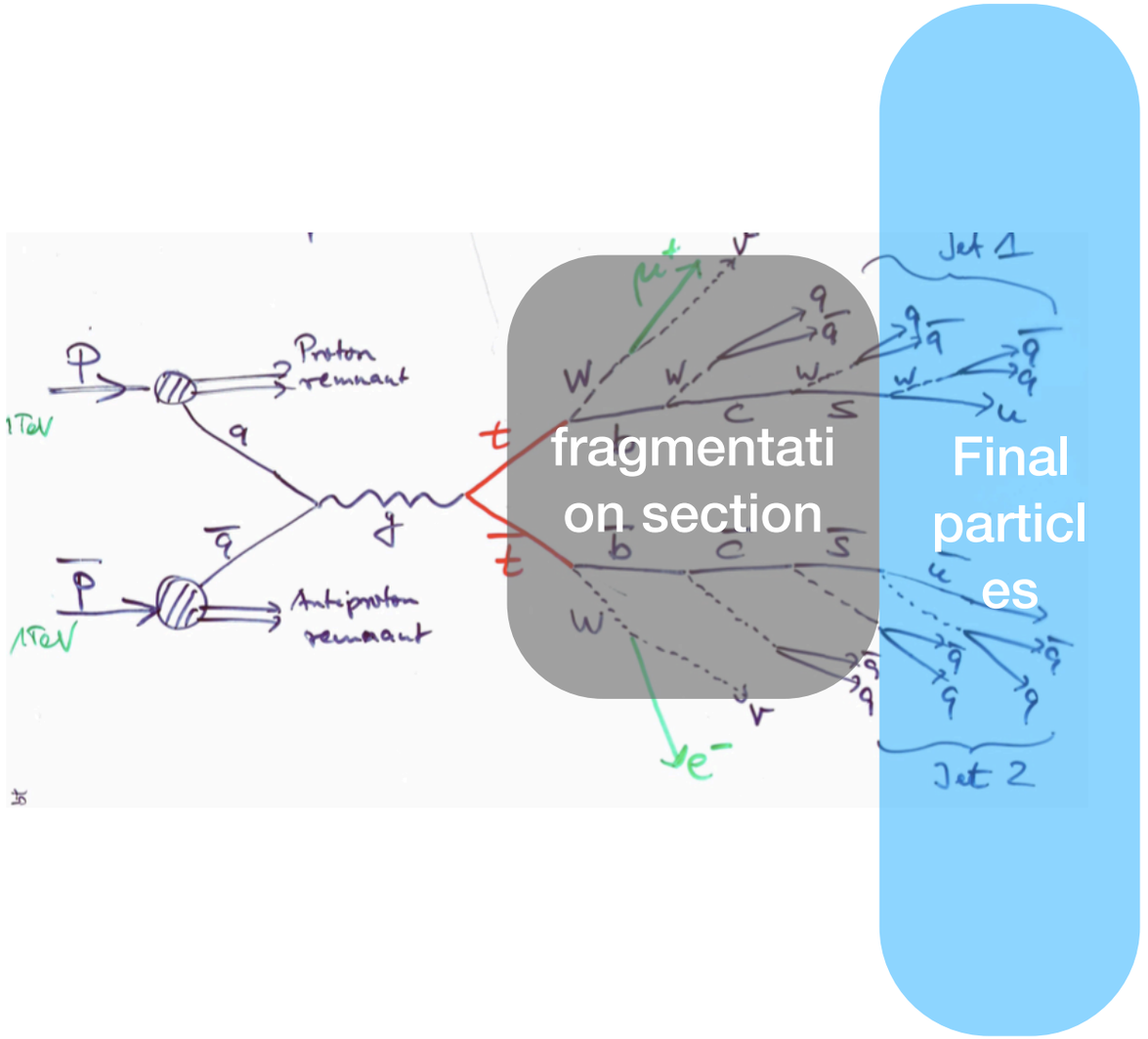
We are now advancing these studies into heavy flavor sector

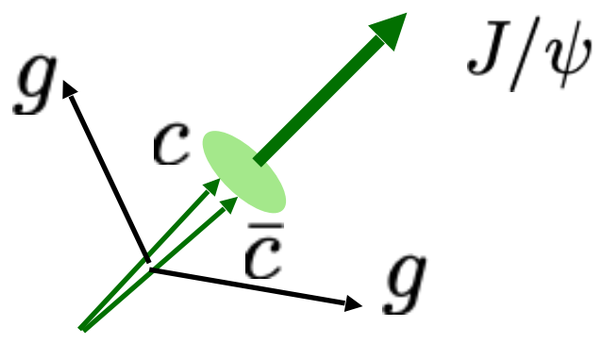


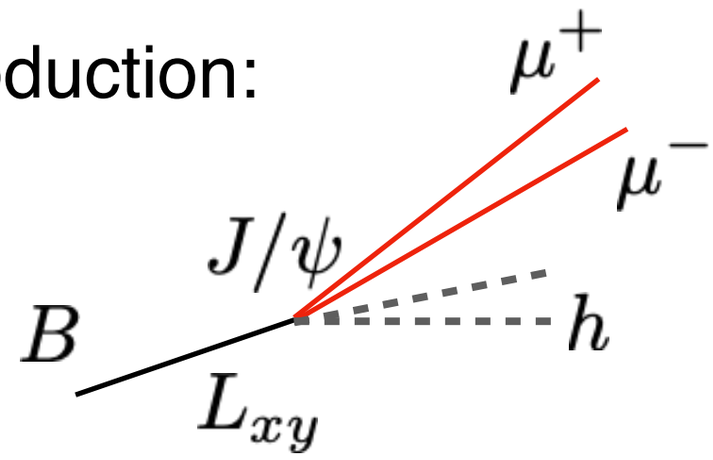


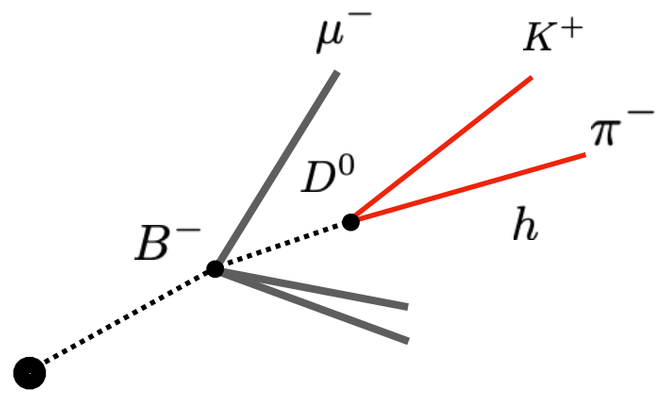
Studies of J/ψ, D^0 in jets

In pp collisions:

- Charm and bottom production:

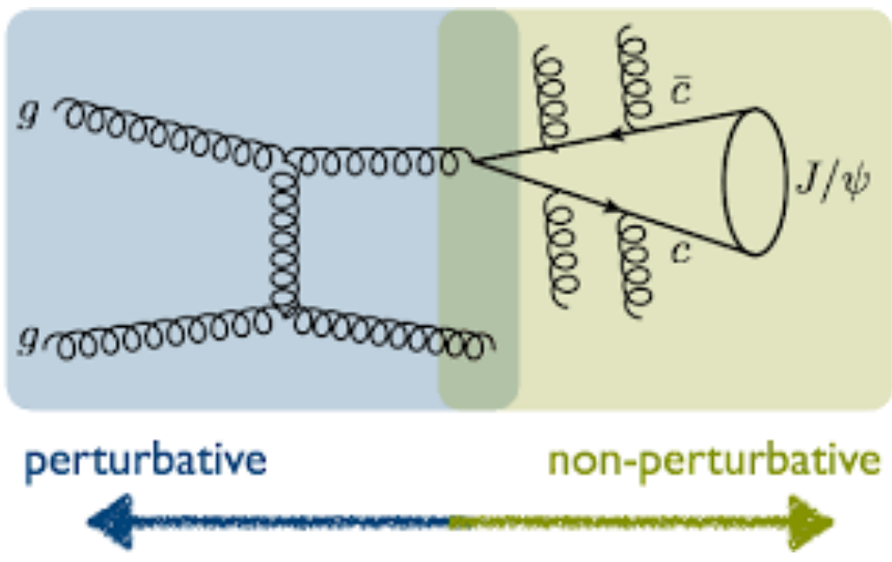






- Allow to constrain charmonium production mechanisms (NLO, parton shower)

pQCD



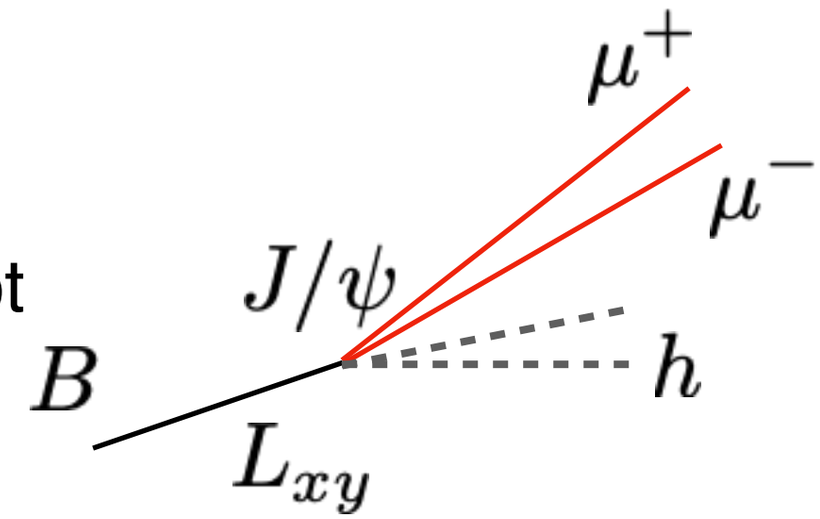
CEM, CSM, COM and NRQCD

In PbPb collisions:

- Explore heavy flavor parton coupling to QGP
- Probe medium response to heavy flavor probes

J/ψ in jets: analysis strategy

- Find J/ψ candidates in jet cones
- Perform 2D fitting to extract prompt/non prompt J/ψ fractions



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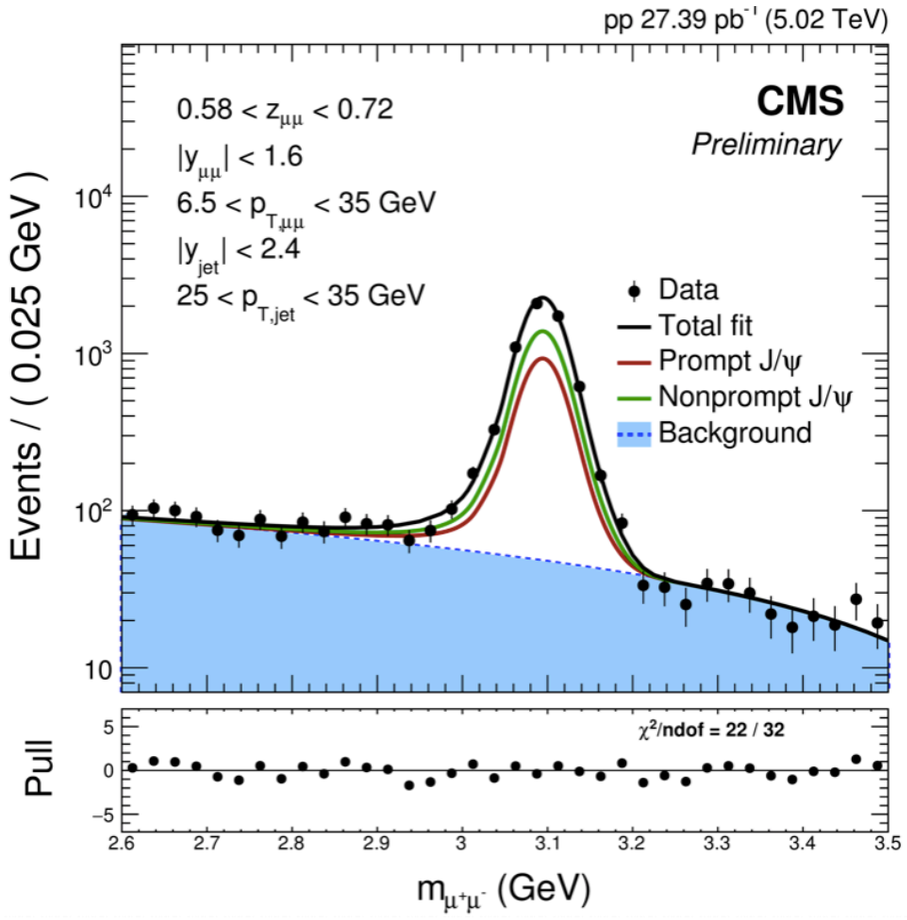
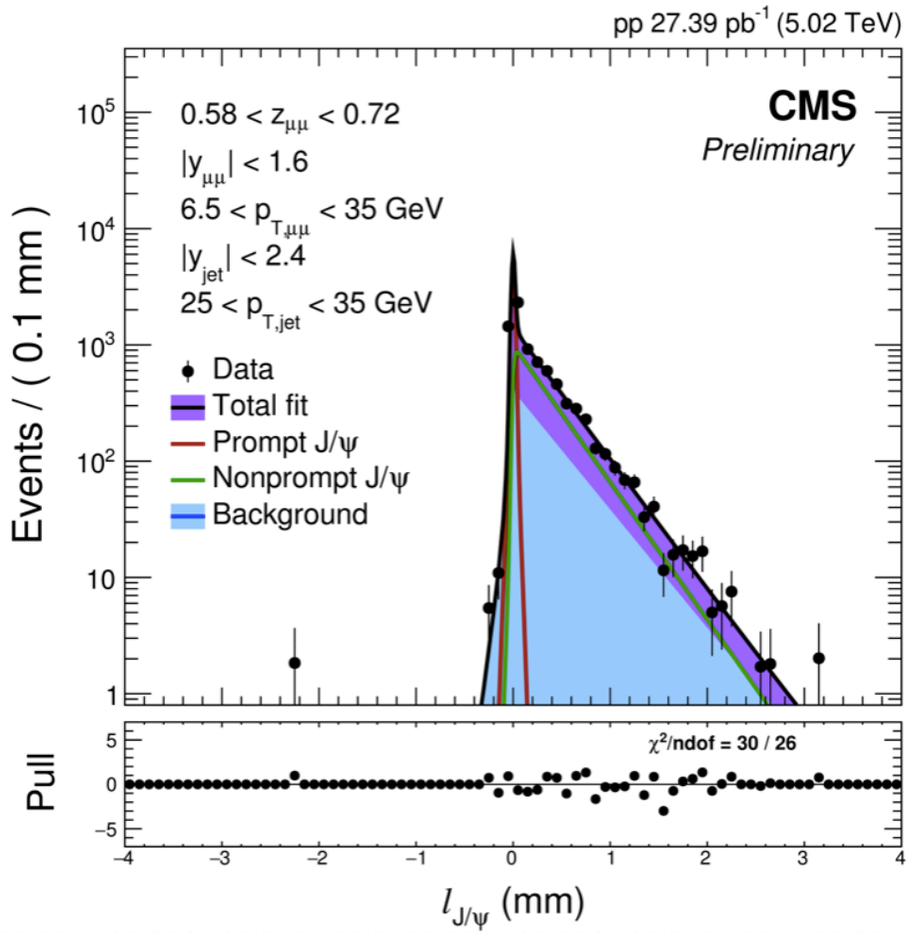
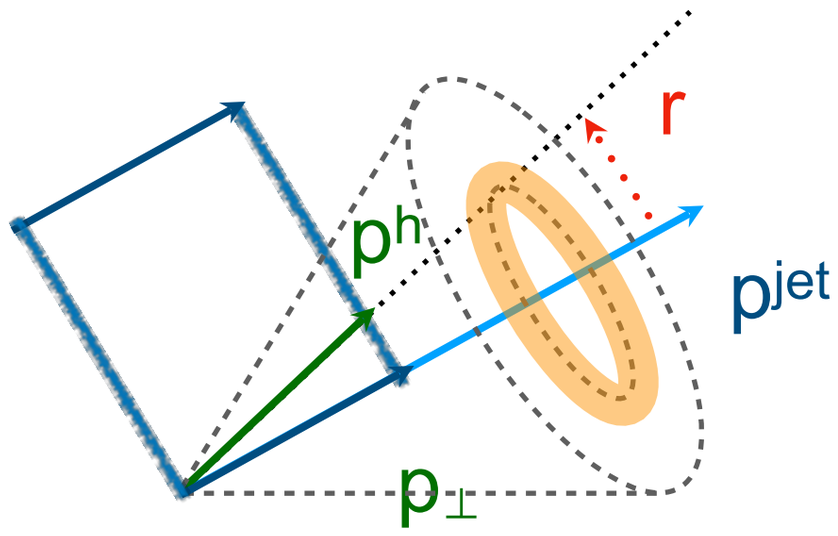




Jet fragmentation function for J/ψ

$$\frac{1}{N}\frac{\mathrm{d}N}{\mathrm{d}z} \qquad z = \frac{p_{T,J/\psi}}{P_{T,\mathrm{jet}}}$$



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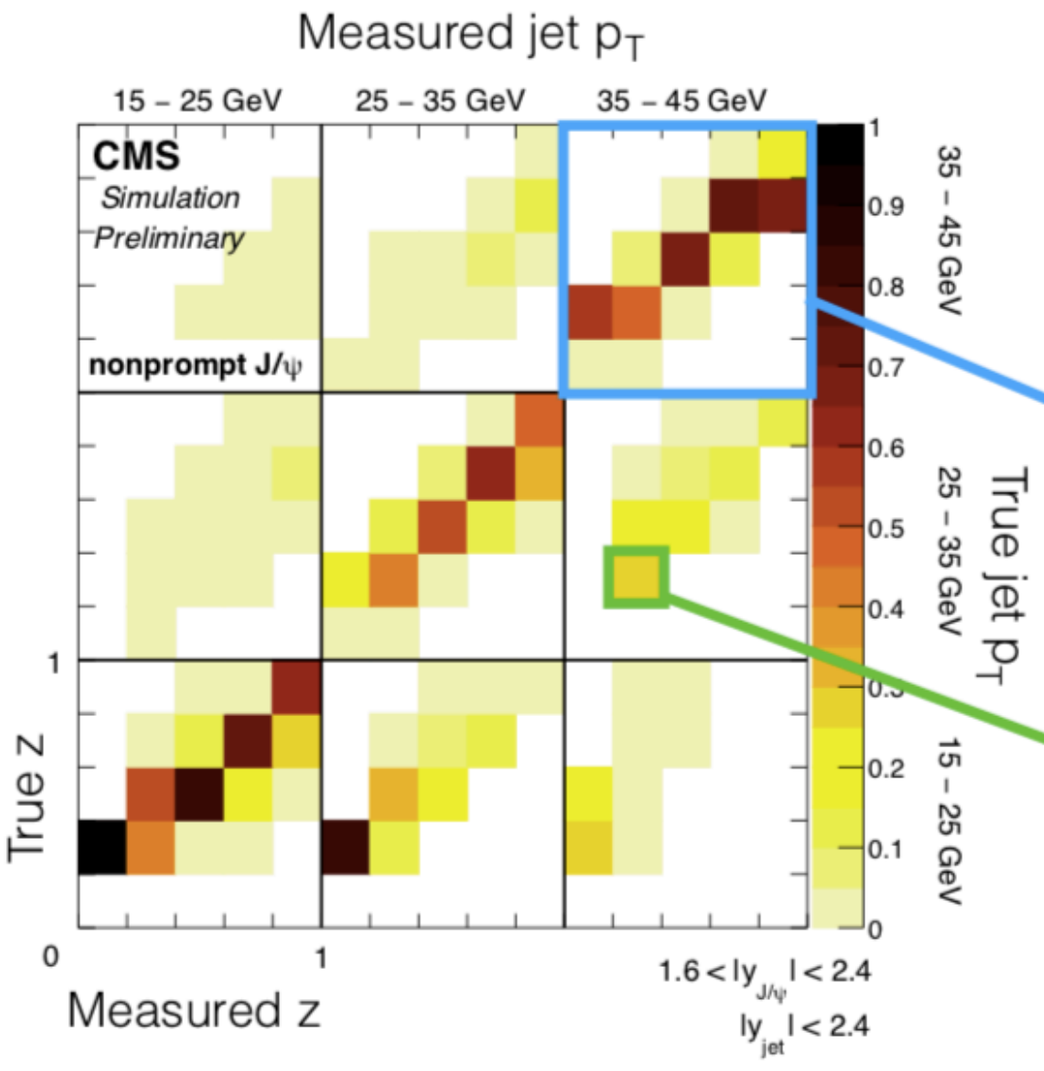

- Unfold to correct for detector effects

Migration between jet p_T bins

Migration between z bins

Non-prompt J/ψ in Jets as function of z

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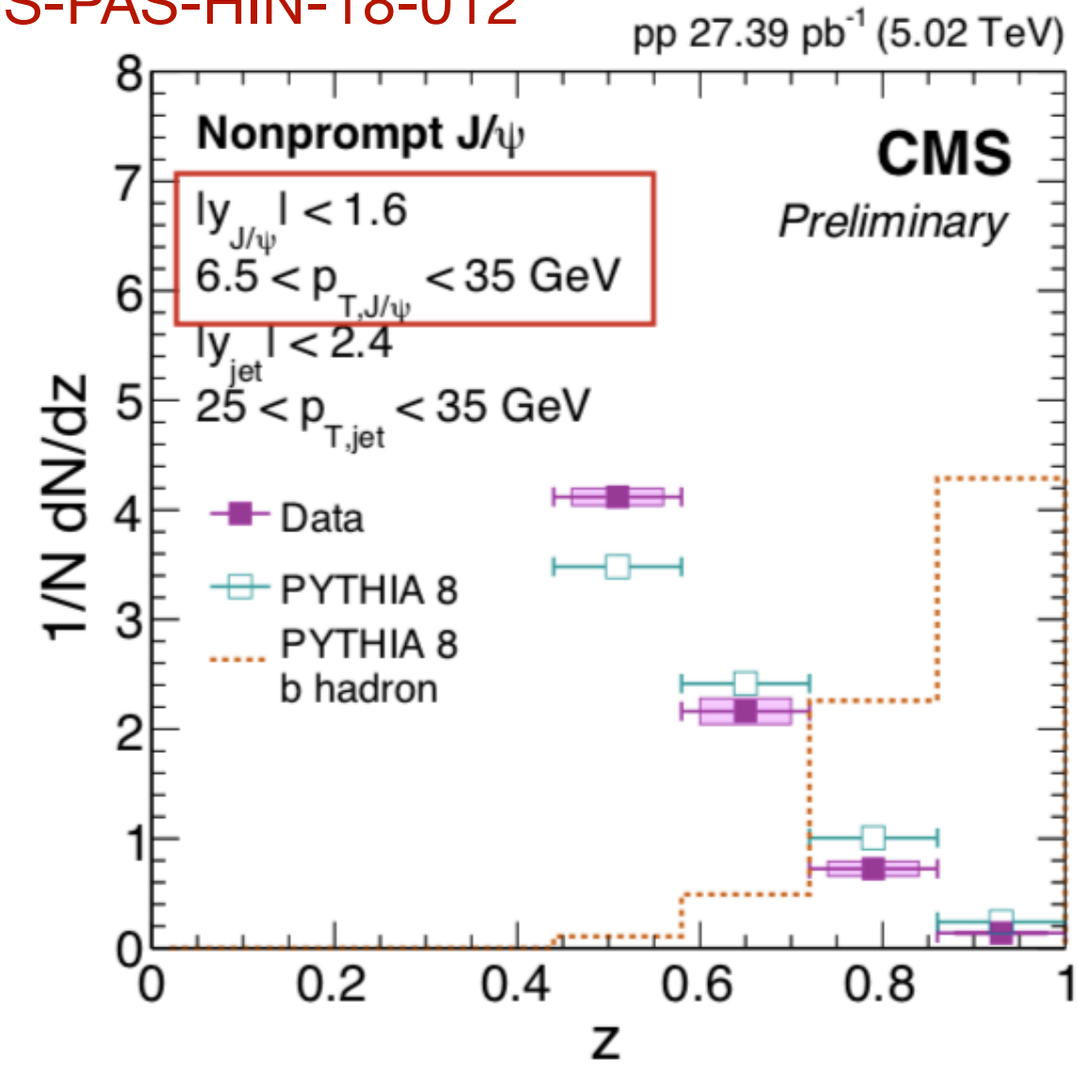
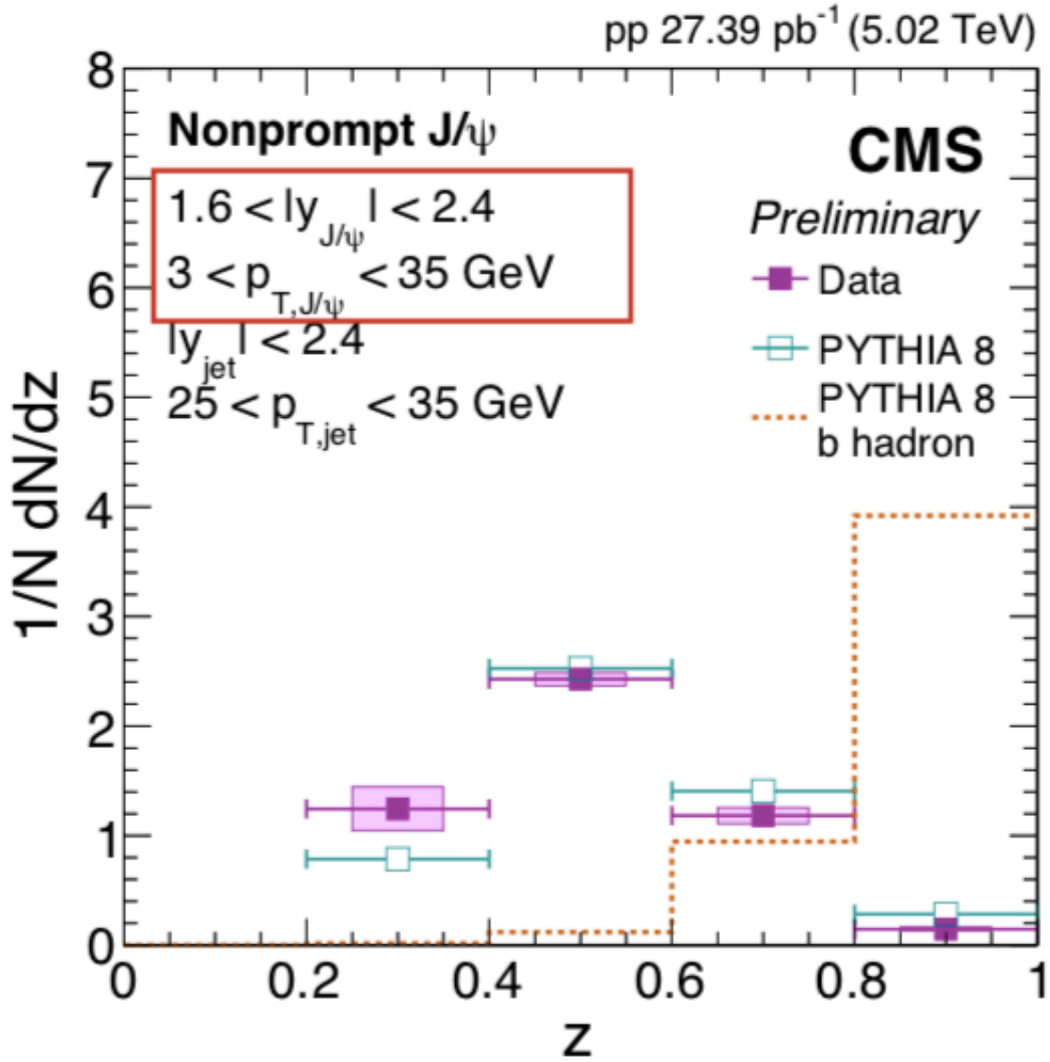
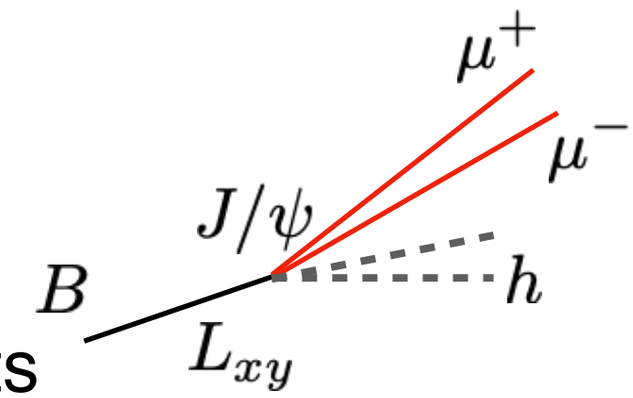




- Non-prompt J/ψ yield in jets: PYTHIA captures the general z trend
- PYTHIA possibly reproduces b hadron production in jets



Prompt J/ψ in Jets as function of z

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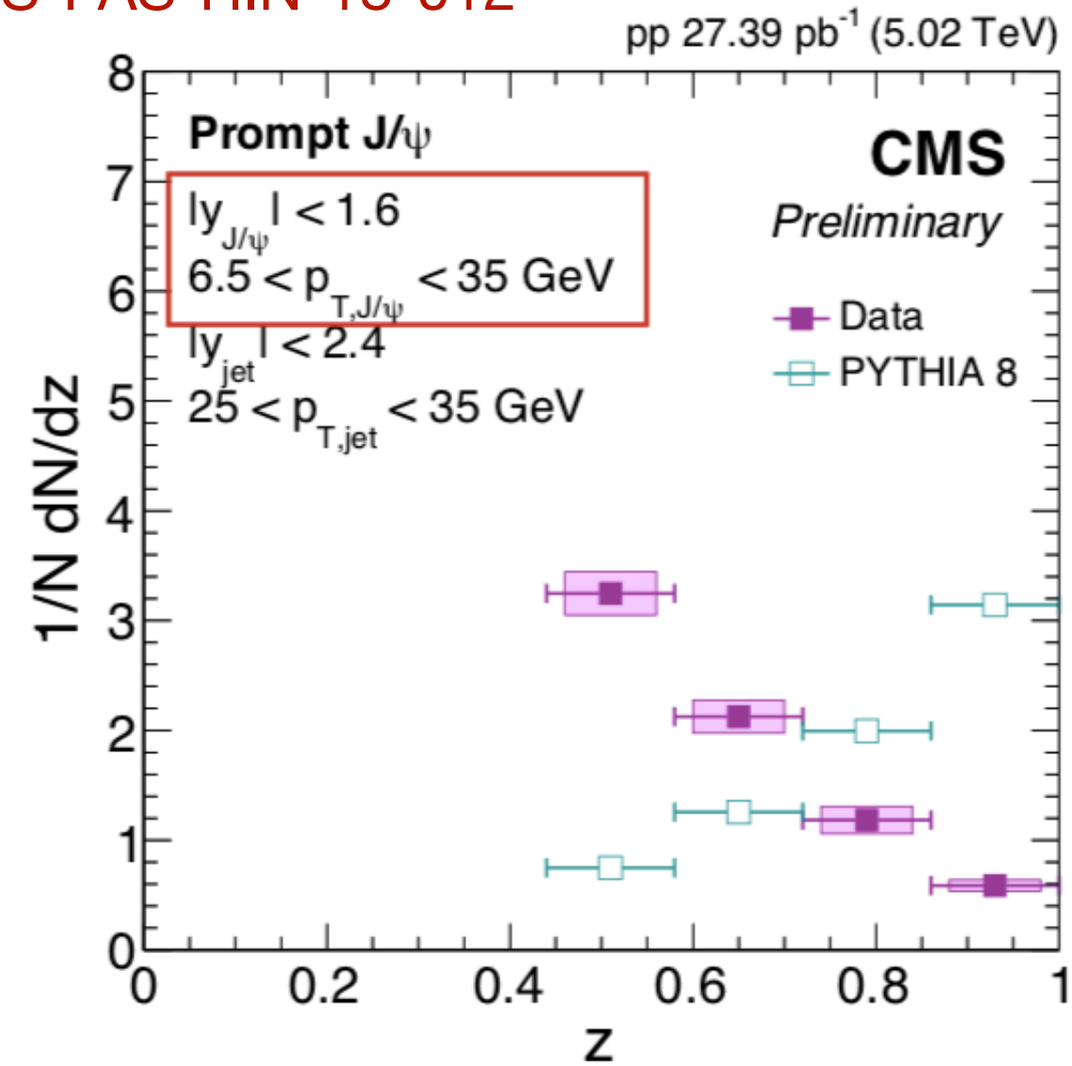

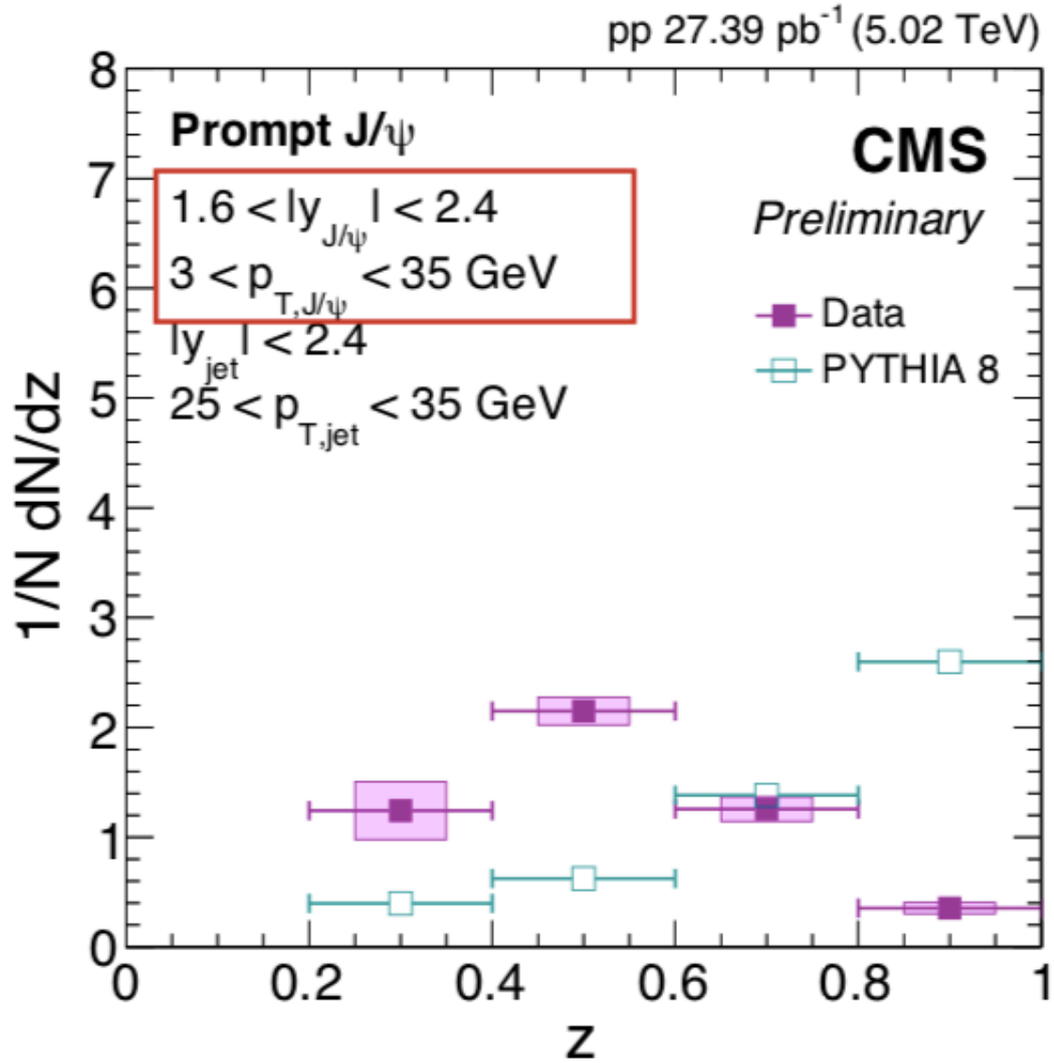

- Prompt J/ψ yield in jets: at odds with PYTHIA predictions

Fraction of J/ψ produced within a jet

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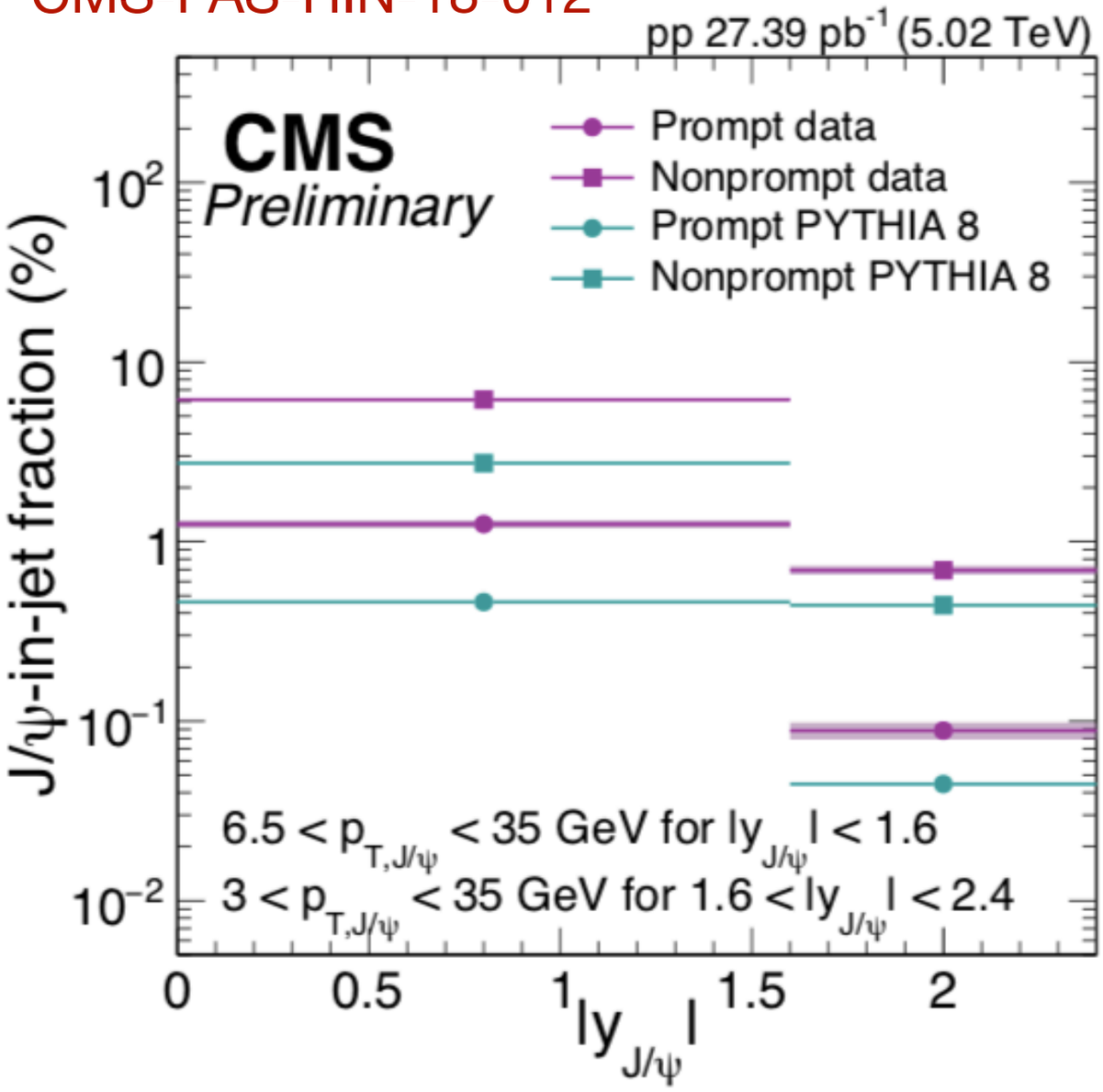

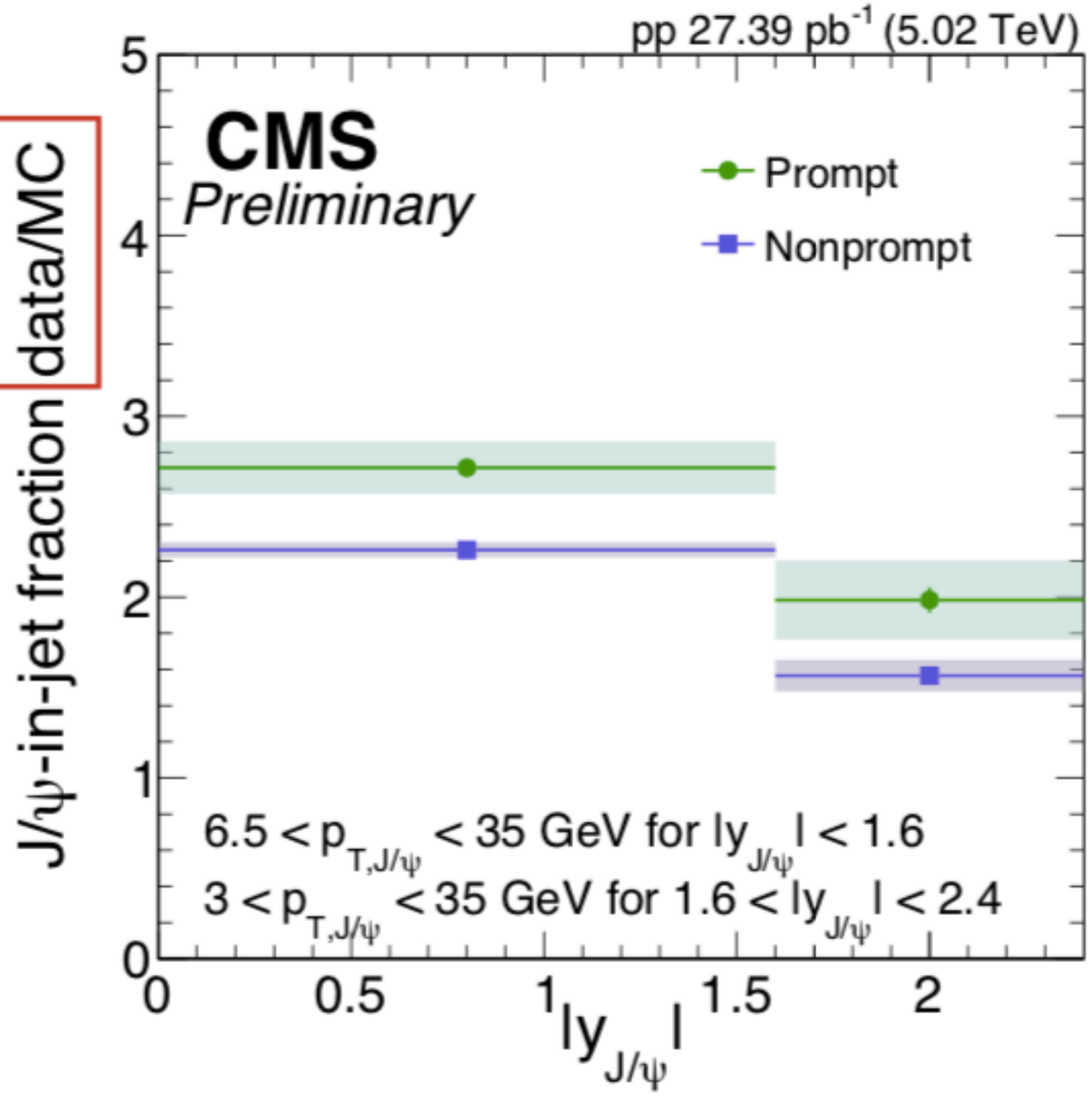

- Prompt and non-prompt J/ψ production in jets is underpredicted by PYTHIA

D^0 meson analysis strategy

1. Find D meson candidates within the jet cones
2. Subtract D-jet background via event mixing (critical to HI!)
3. Apply corrections for detector effects

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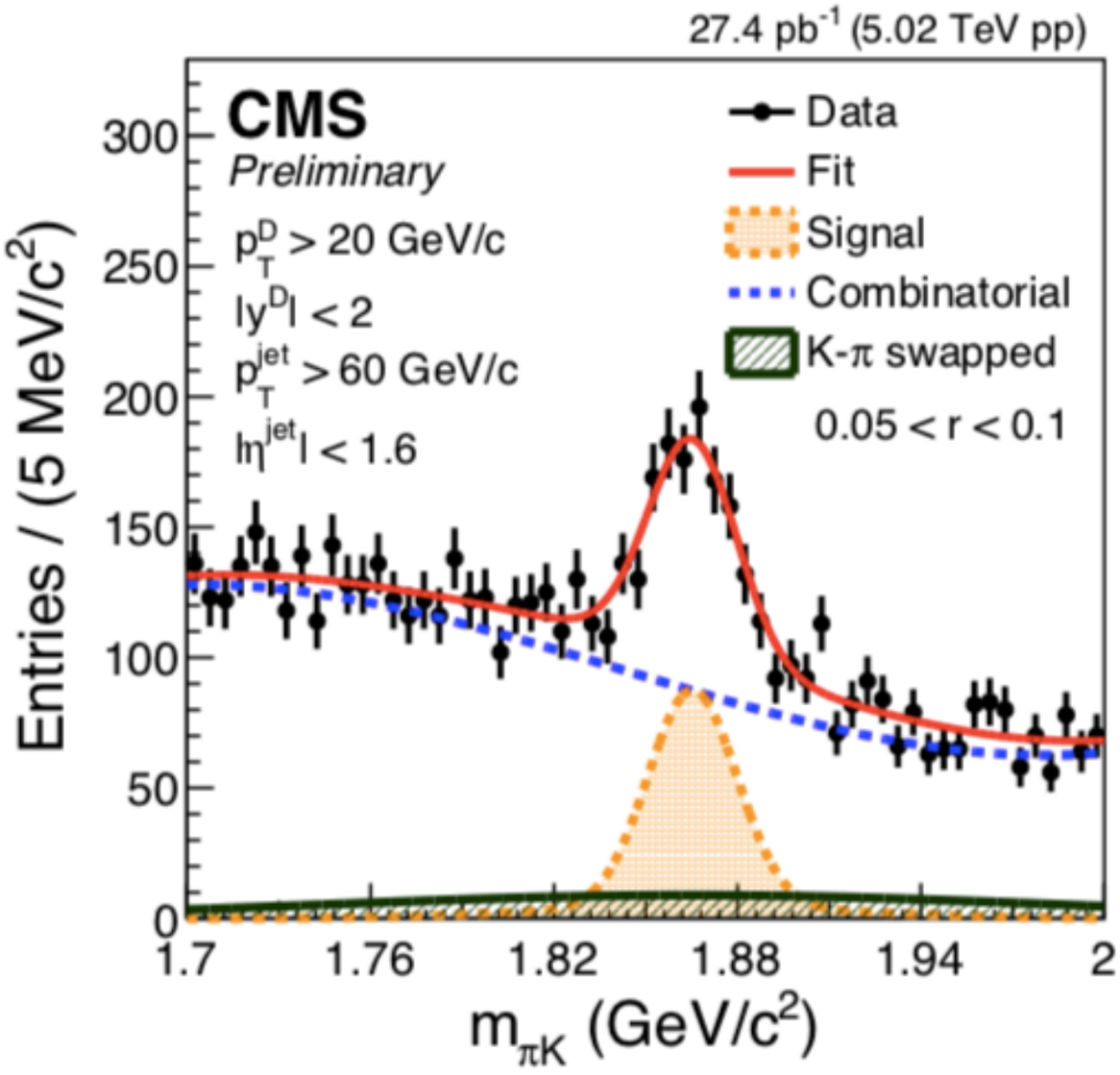
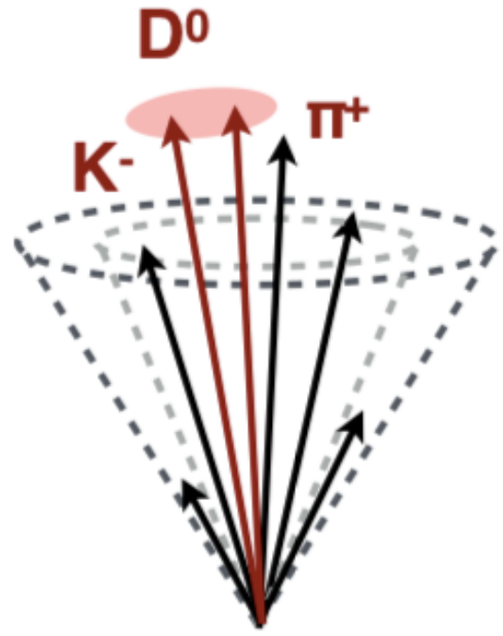


Observable: $\frac{1}{N_{JD}} \frac{dN_{JD}}{dr}$



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Results: the D^0 in jets

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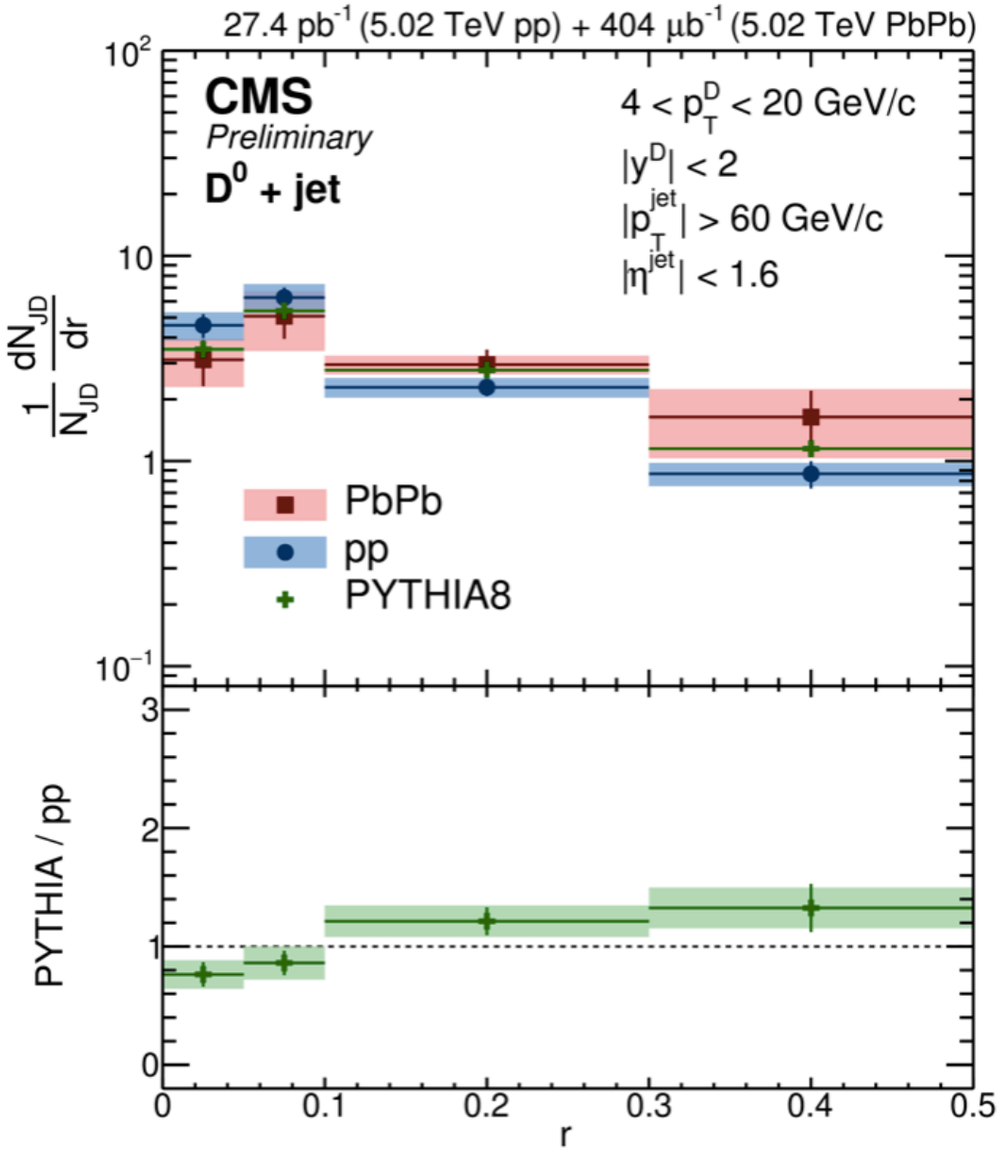
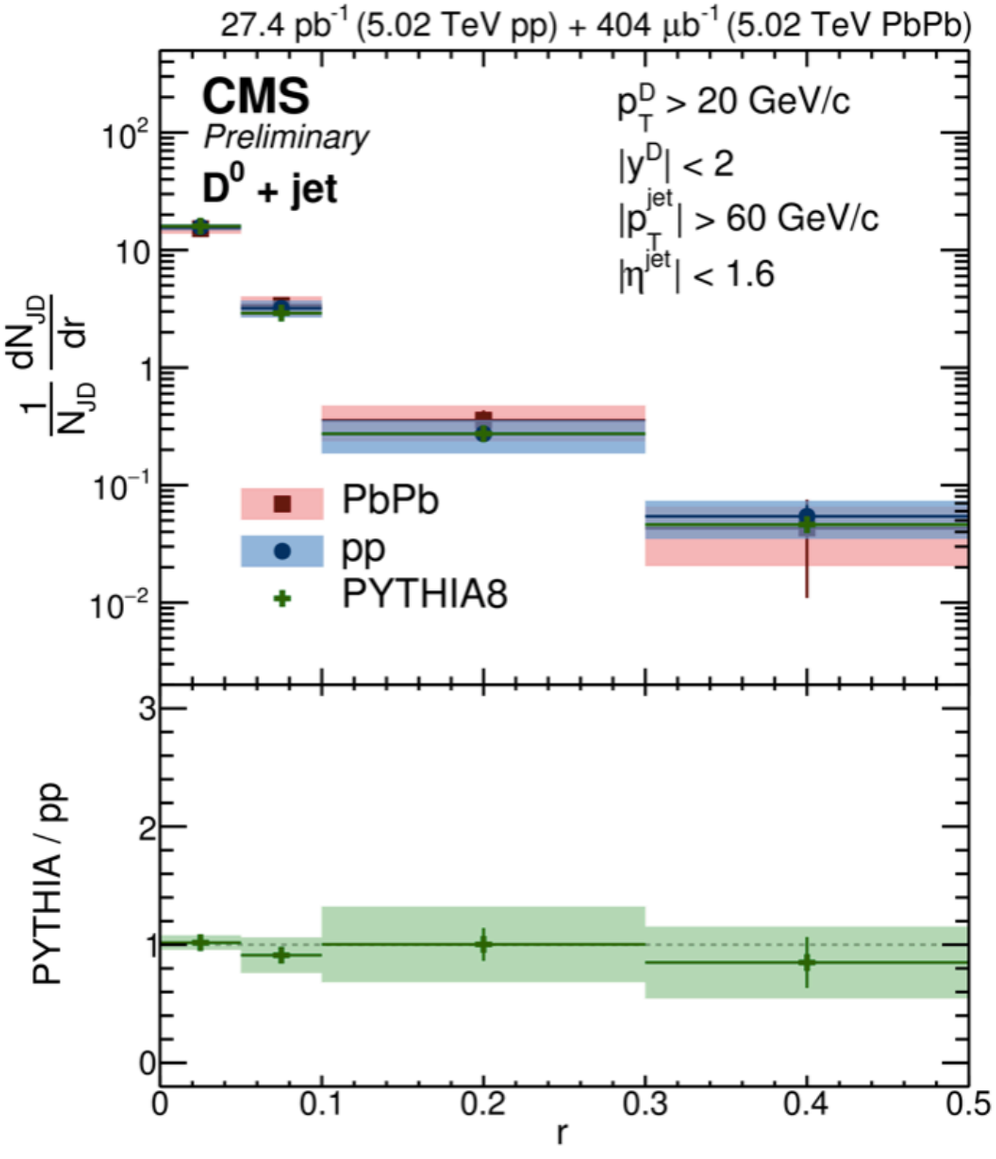


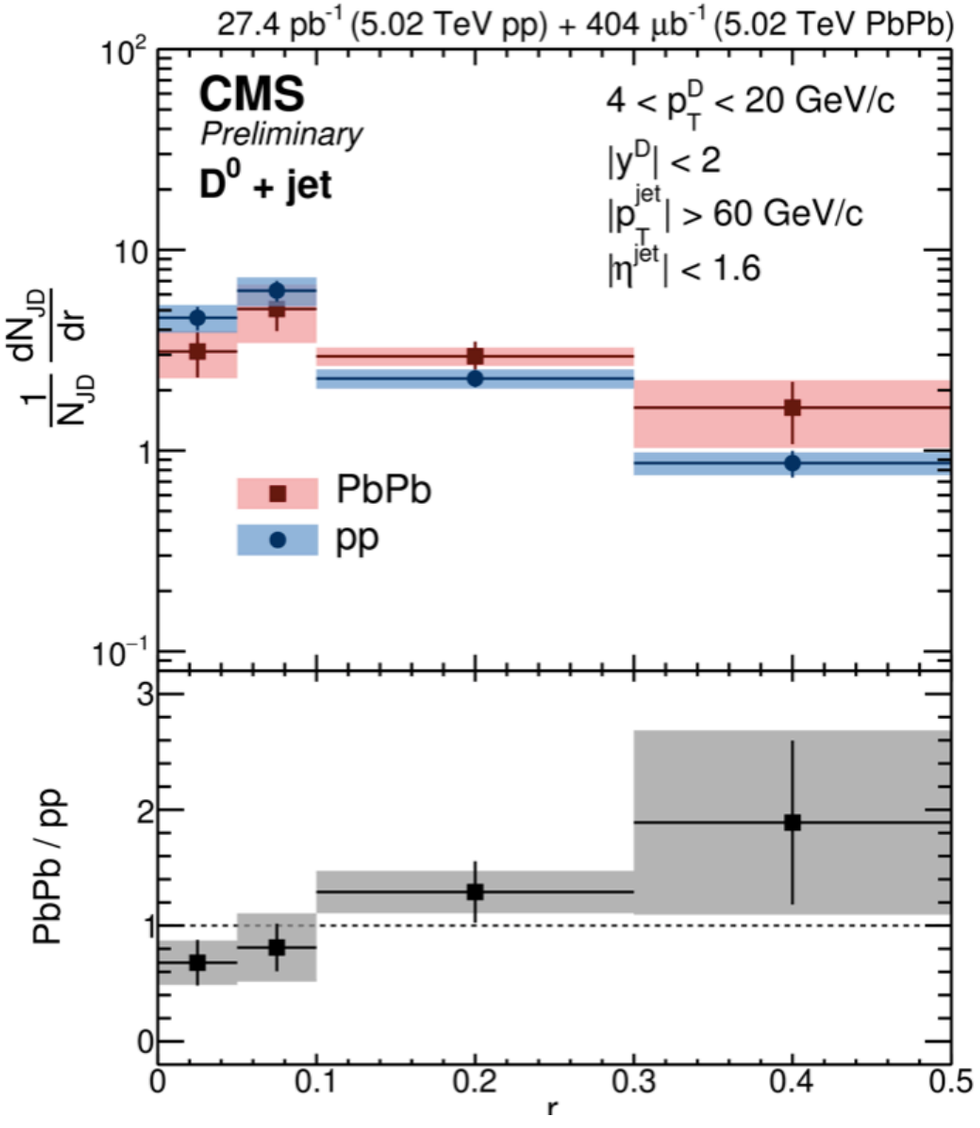


- Radial distribution of D^0 in jets from pp collisions is captured by PYTHIA simulation. Possible tensions at lower p_T.

Results: the D^0 in jets

CMS-HIN-18-007

Low p_T D^0



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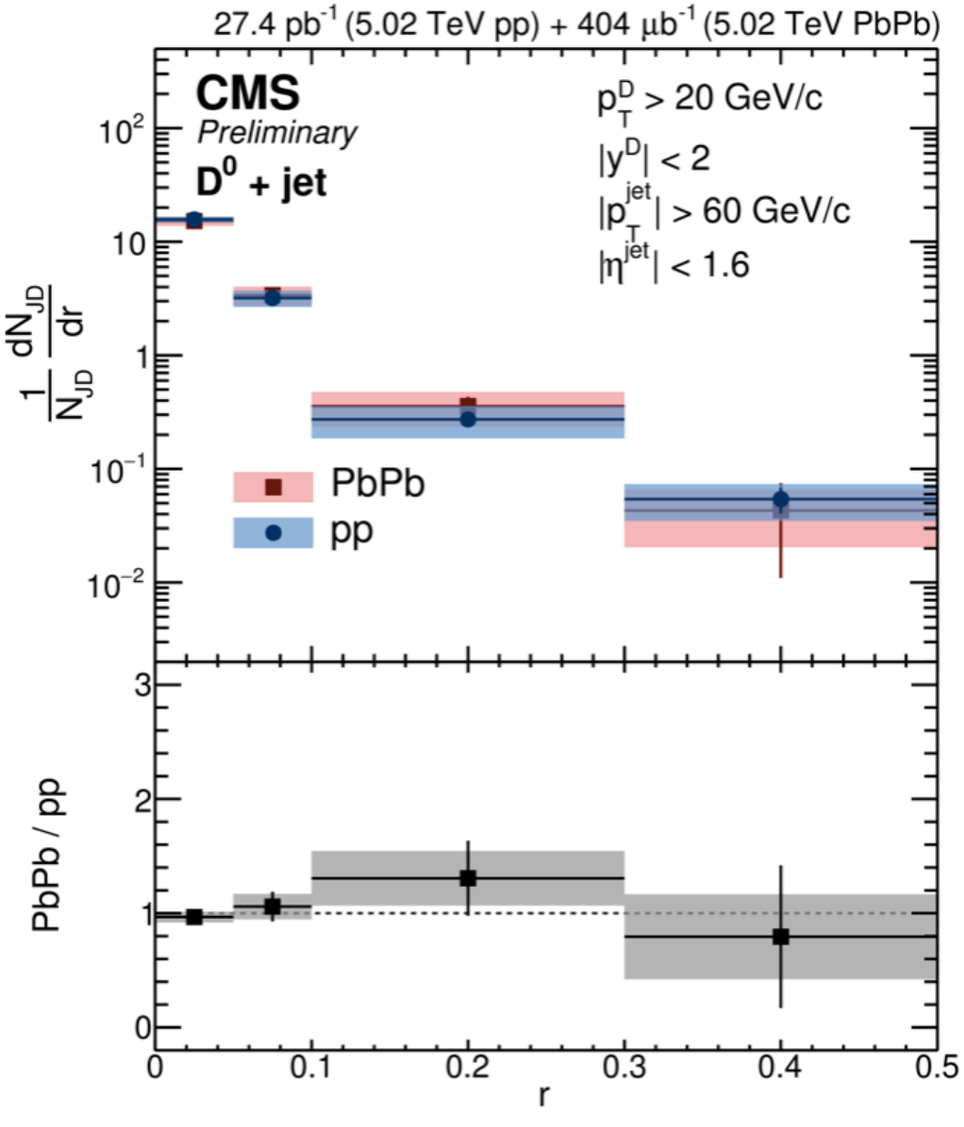


First measurement of D^0 production in jets at the LHC:

- High p_T: consistent with vacuum reference
- Low p_T: a hint of a shift away from the jet axis?

Summary

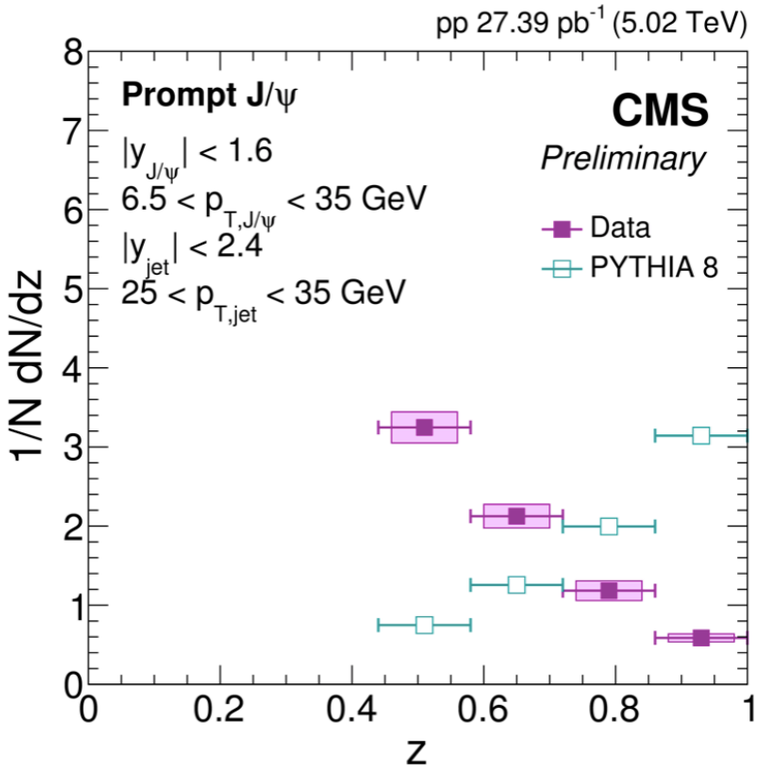
J/ψ + jets in pp:

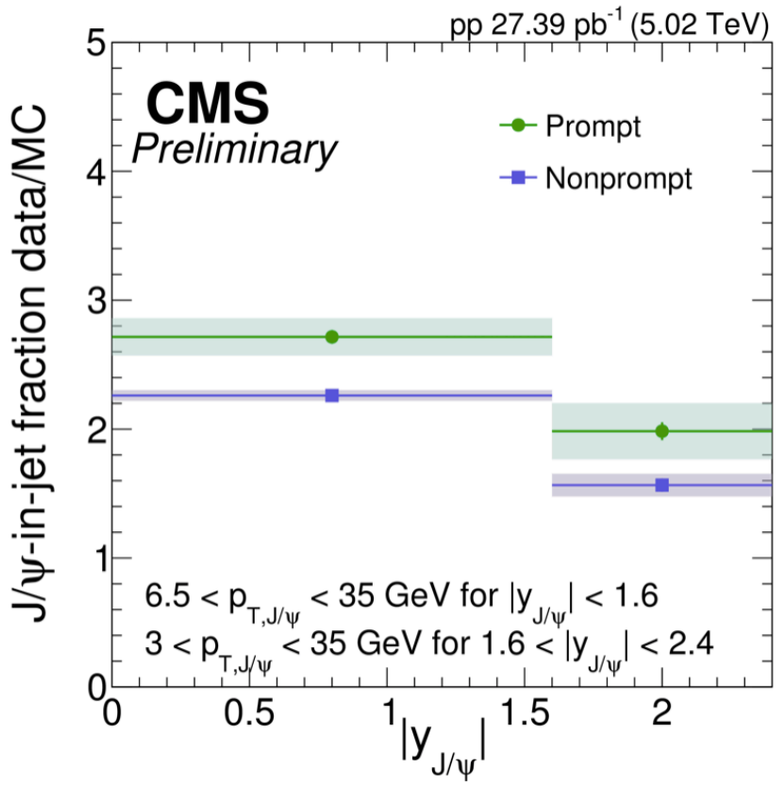
- charm production in jet needs further investigation
- both charm and bottom in jets are underpredicted by PYTHIA

First measurement of D + jets in pp and PbPb collisions:

- new prospects for studies of heavy flavor in QGP

Tons of data on tape (2017/2018 run) we'll work on going deeper!





The UIC group's work was supported by US DOE-NP

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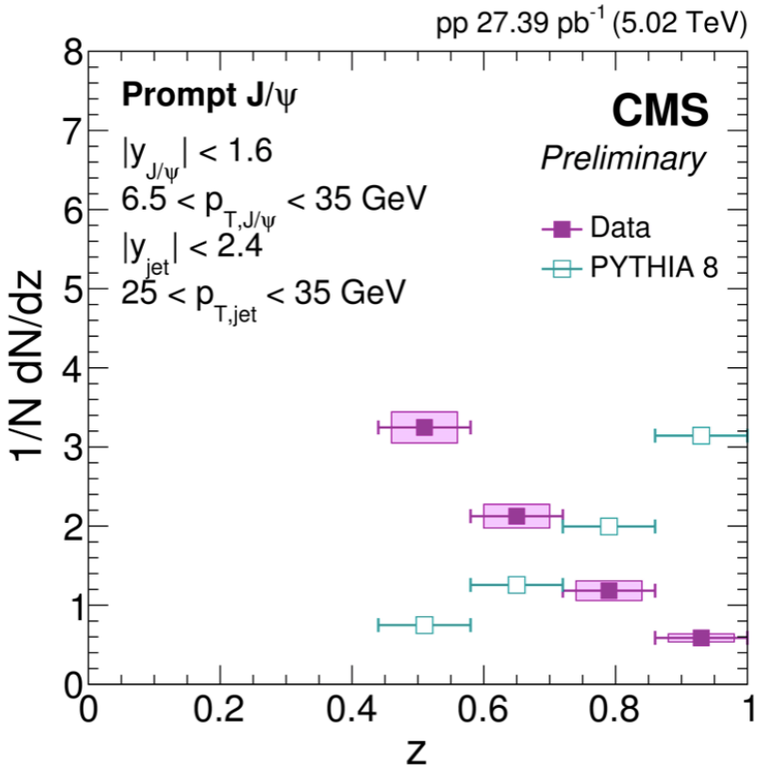

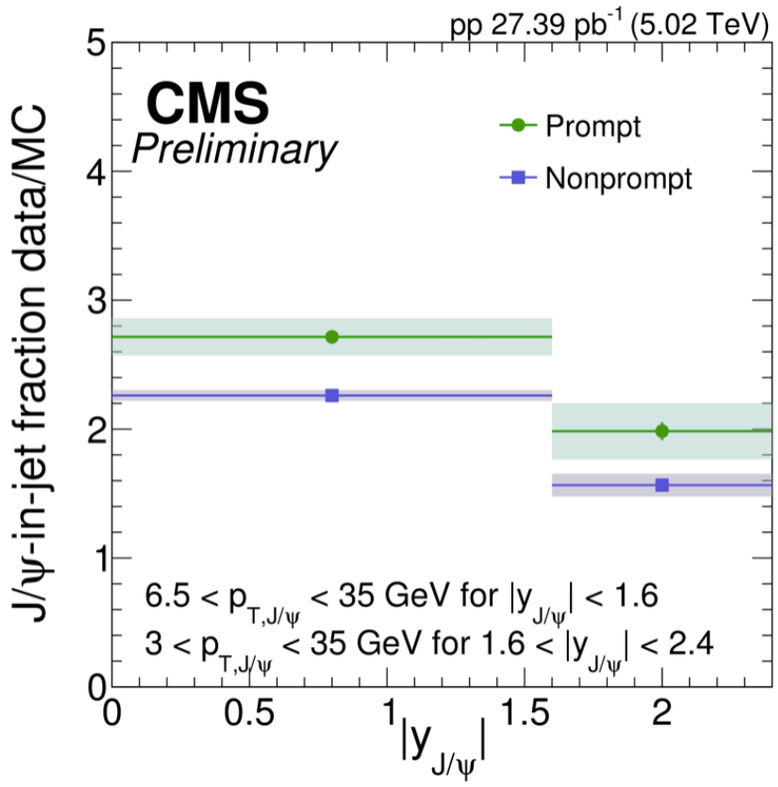

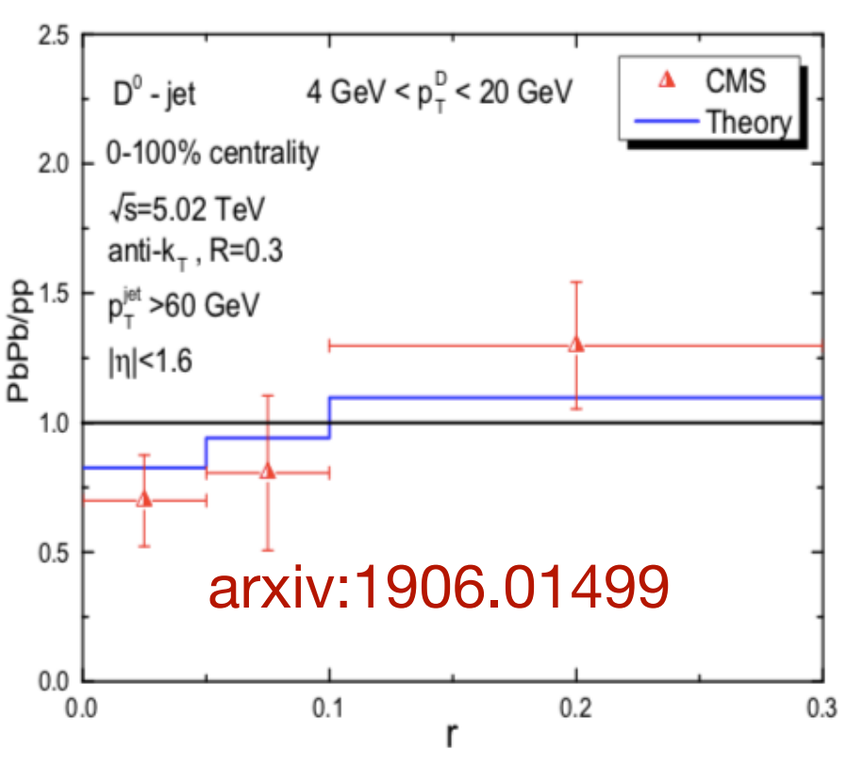

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Thanks

Event mixing technique

Raw D = **MB D** + **Signal D**

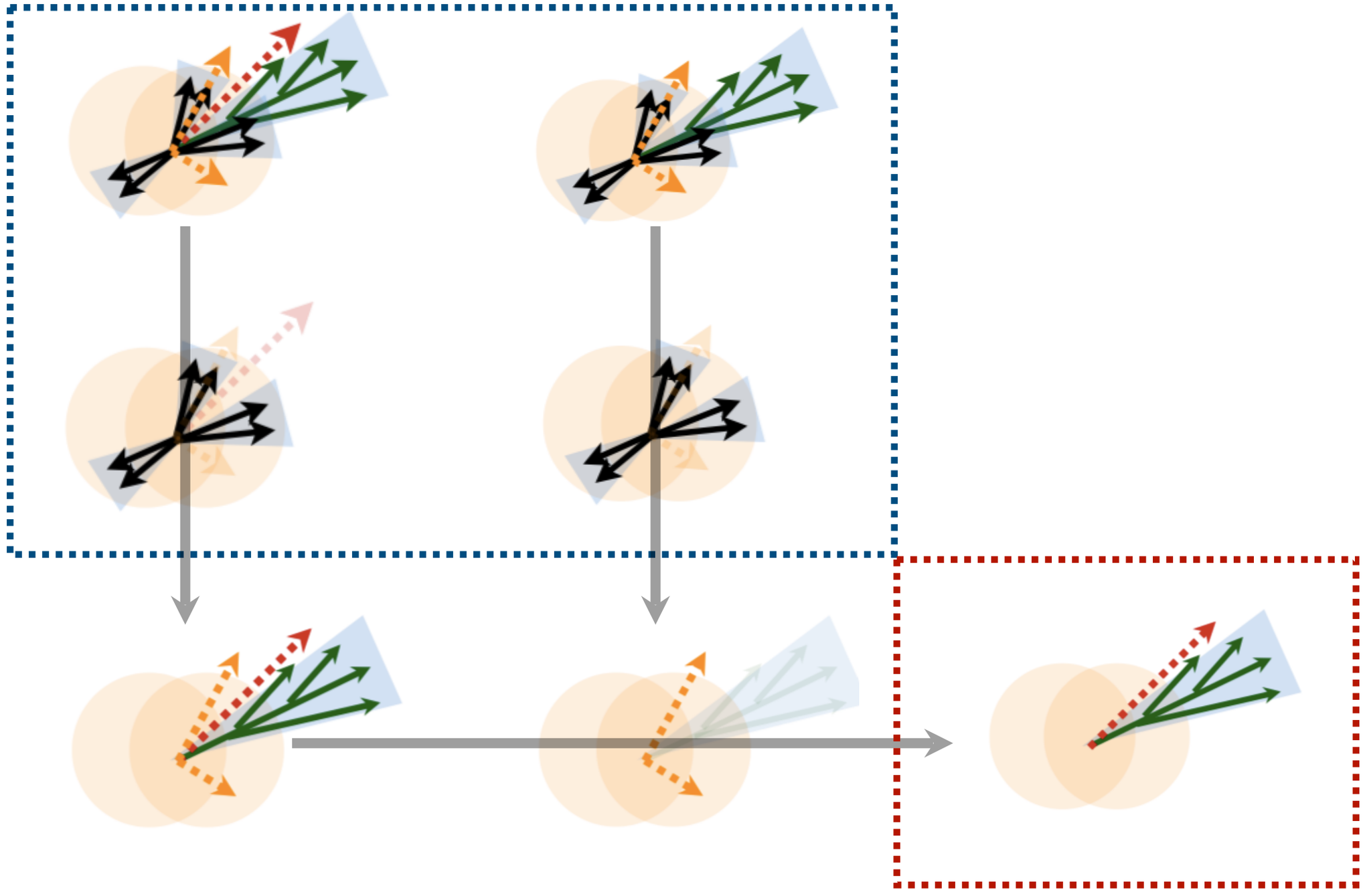
Raw Jets

=

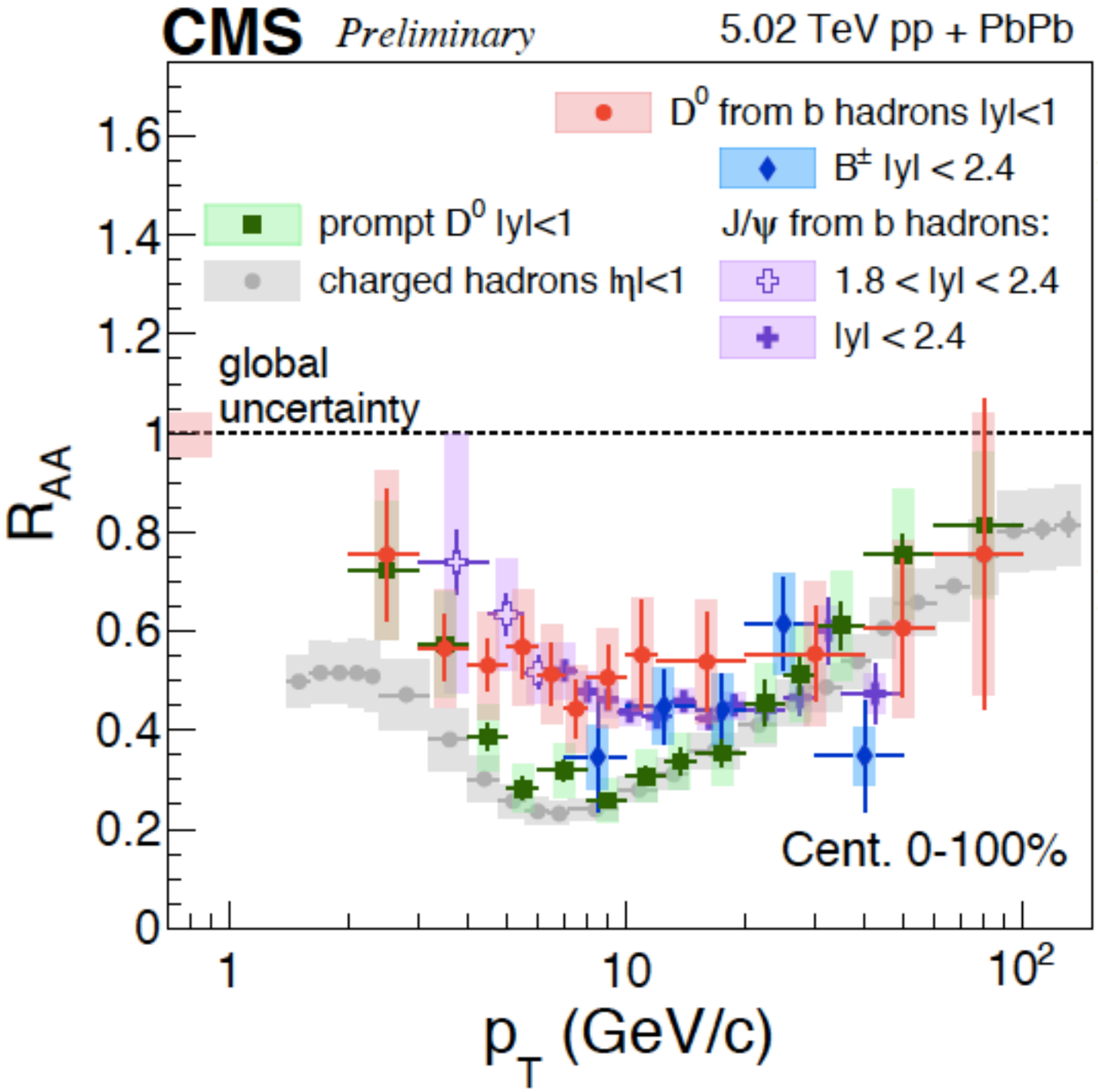
MB Jets

+

Signal Jets



D^0 and jets reconstruction and selections



- **Gluons and Light Quarks**:
  – dominant contributions to charged hadrons
  – strongest suppression at intermediate p_T
- **Charm**:
  – assessed through prompt D0
  – similar suppression level with light hadrons
- **Beauty**:
  – non-prompt J/Ψ, $B^{\pm}$ mesons
  – less suppressed at intermediate p_T
  – at high p_T parton mass seems no longer important

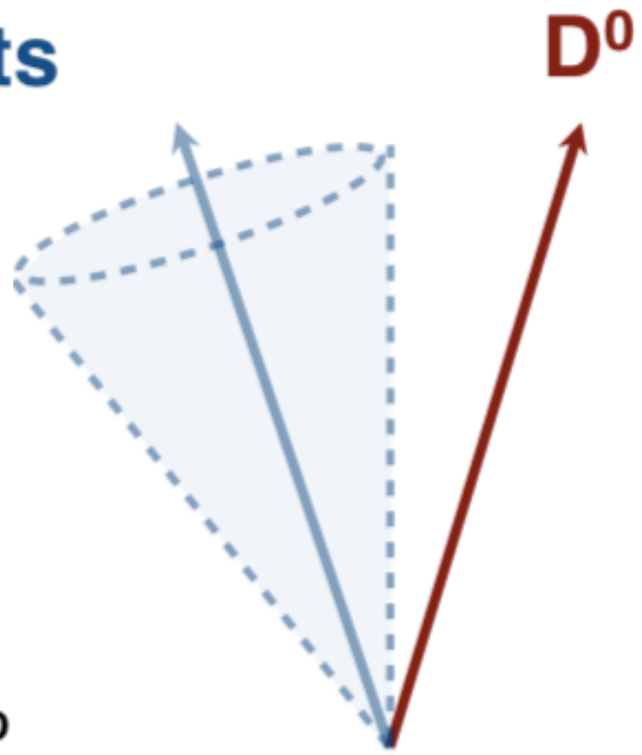
CMS-PAS-HIN-16-016

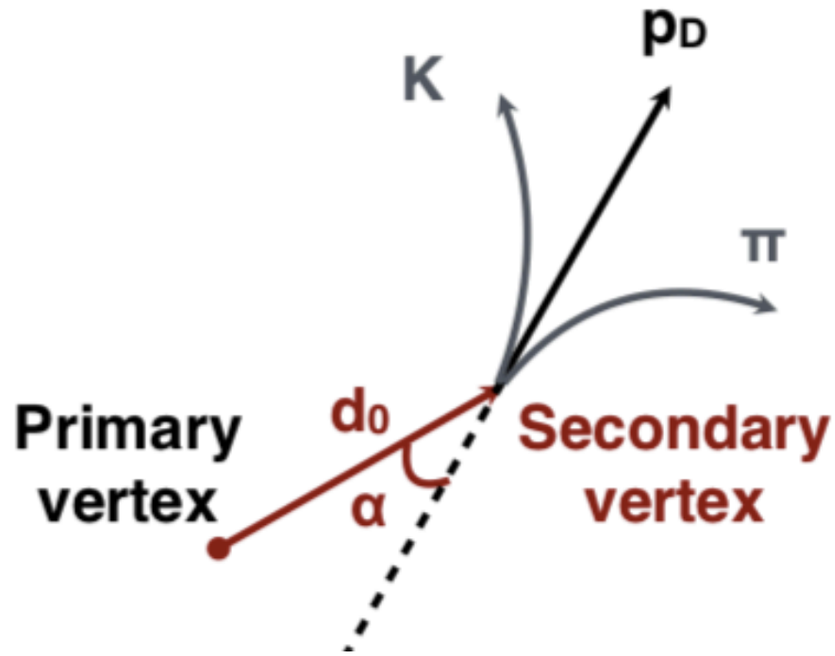
D^0 and jets reconstruction and selections

- **Jet-triggered** events in **pp** (27.4 pb^{-1}) and **PbPb** (404 μb^{-1}) collisions at $\sqrt{s_{NN}}$ **= 5.02 TeV** collected in 2015 with the CMS detector

jets

- Iterative PU-subtracted PF jets
- anti-k_T, R = 0.3
- $p_T^{jet} > 60$ GeV/c
- $|\eta^{jet}| < 1.6$

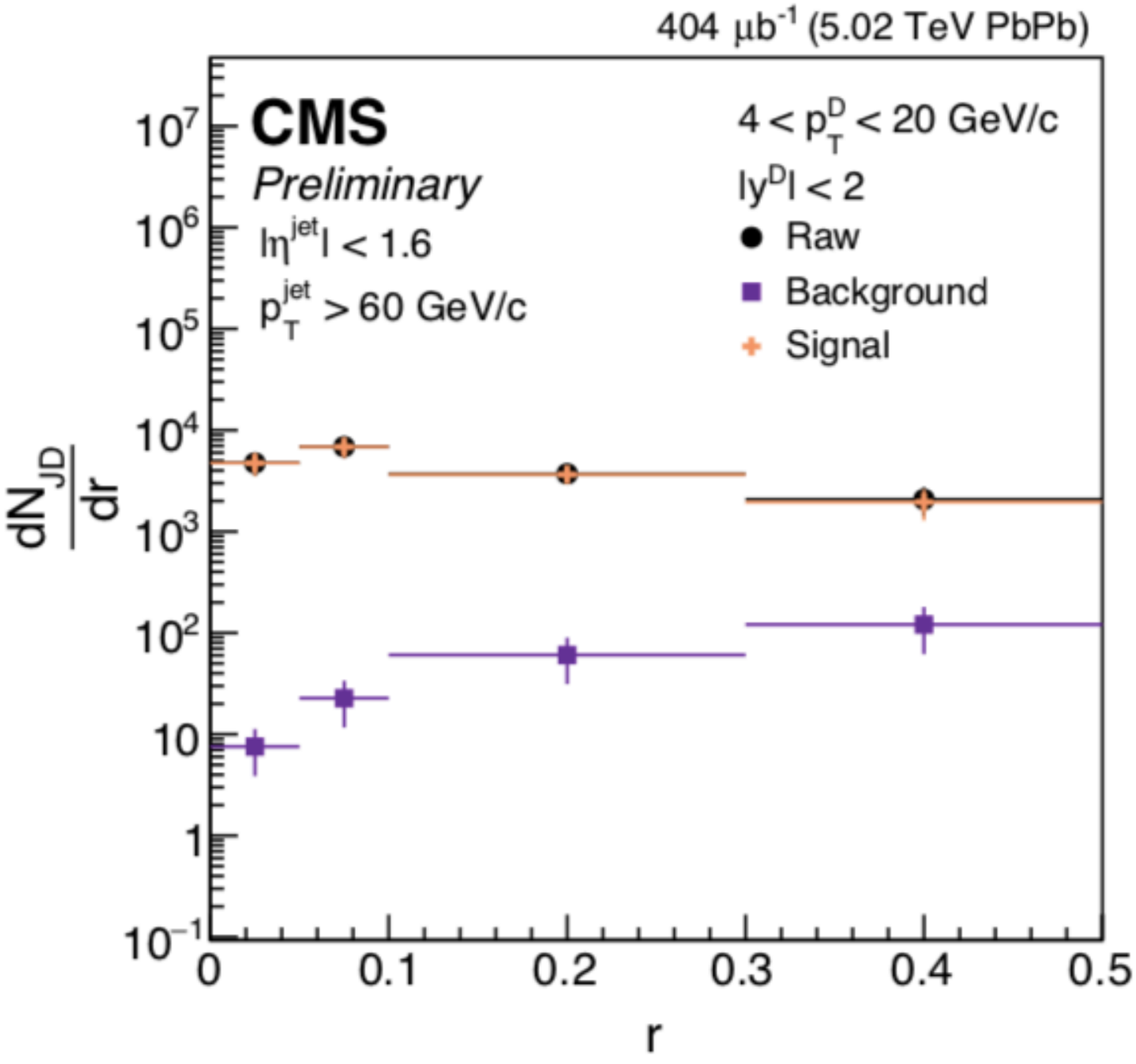




- $D^0 \rightarrow K\pi$
- D^0 vertex reconstruction
  - pairing two tracks
  - kinematic fitter
- Topological selections
  - Pointing angle (α) < ~0.04
  - 3D decay length (d_0) normalized by its error > ~3
  - Secondary vertex prob > ~0.05
- $|y^D| < 2$
- Two p_T bins
  - $4 < p_T^D < 20$ GeV
  - $p_T^D > 20$ GeV

Background subtraction

- Signal = Raw - Background
- Background contributions are much smaller than signal

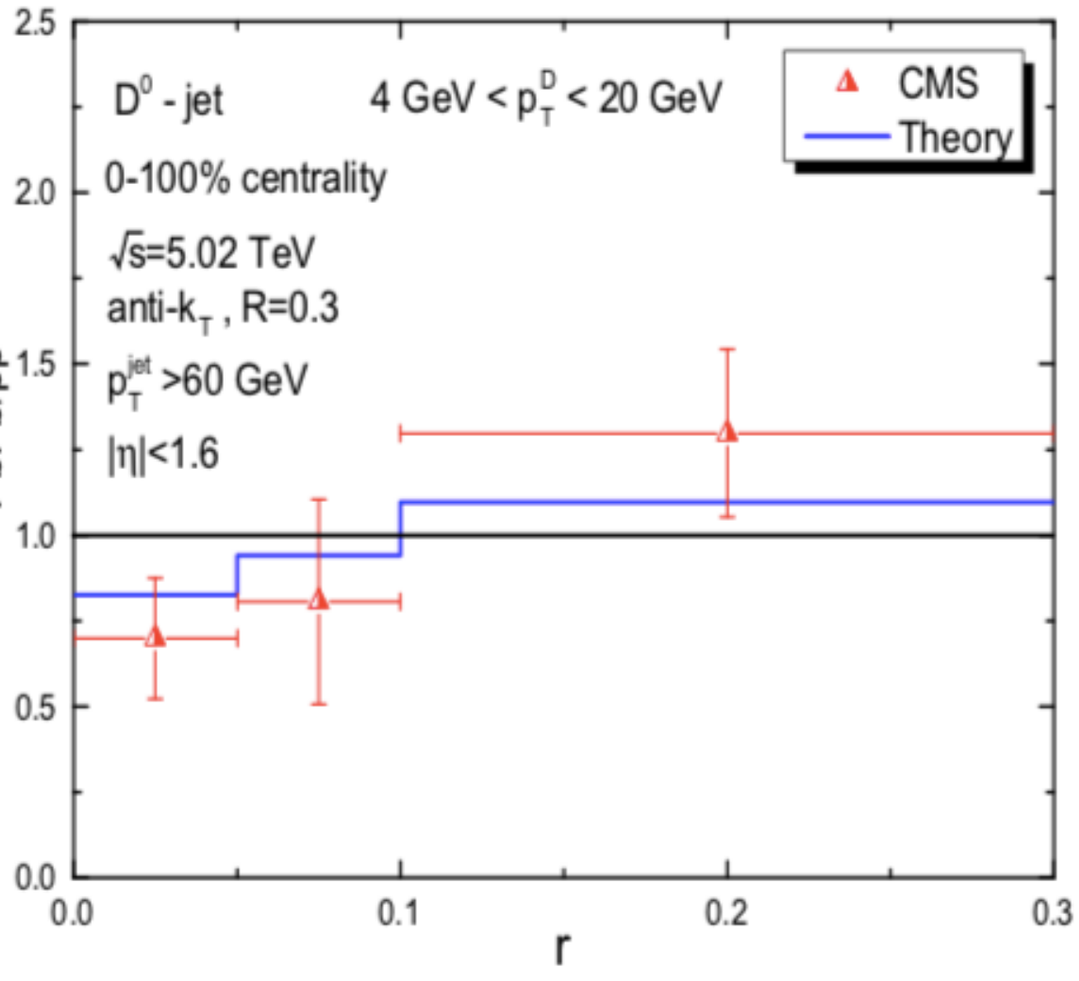


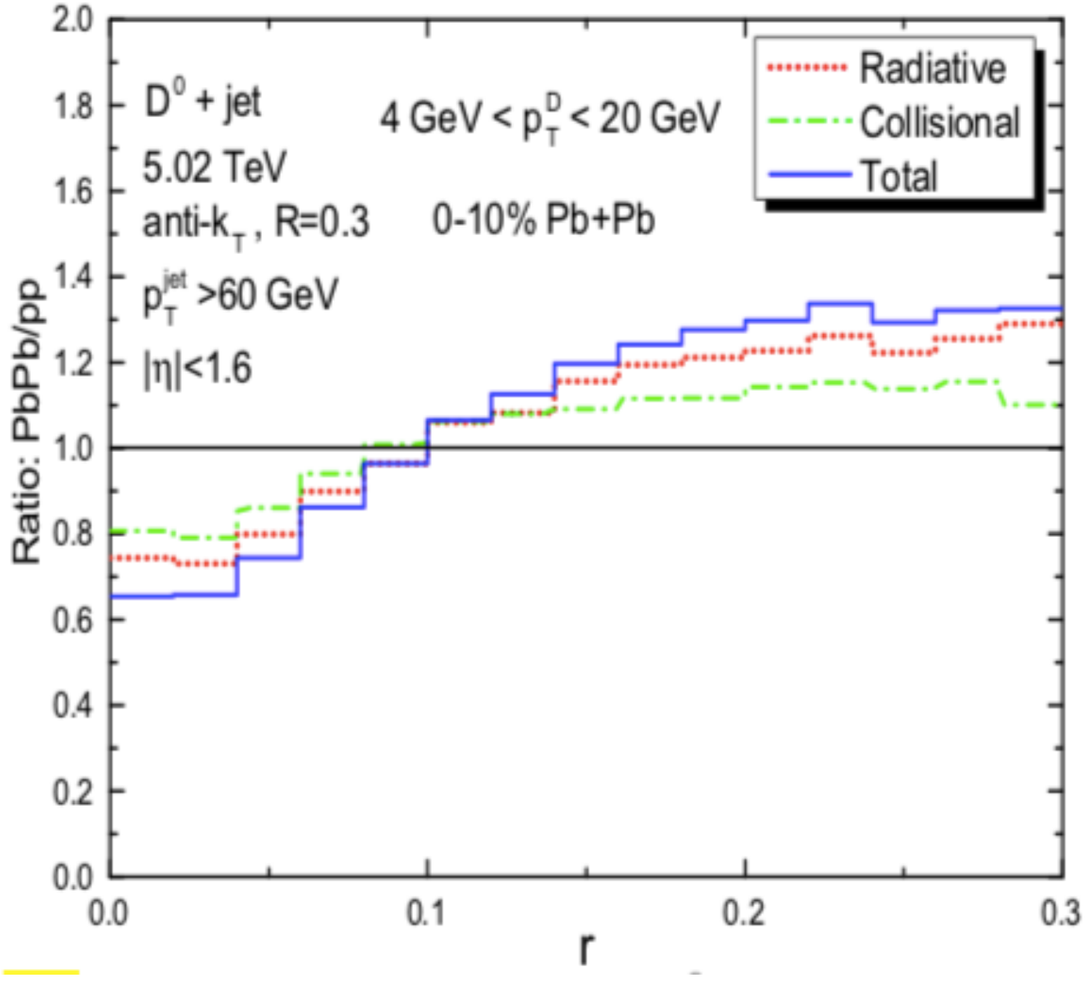
Results: the D meson in jets

High p_T: consistent with the vacuum reference;

Low p_T: a hint that D mesons are pushed away from the jet axis.

Constraint on the diffusion effect and multi-scattering.





arxiv:1906.01499