

# Correlation measurements of Heavy flavor in CMS

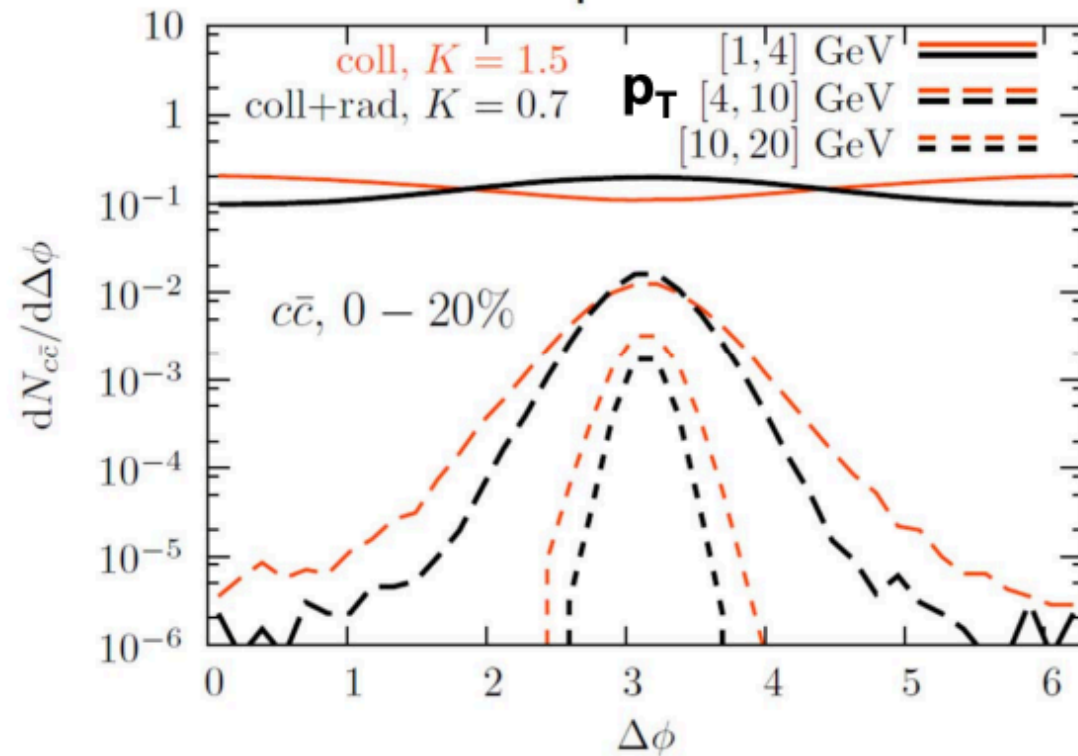
**Soohwan Lee**  
**Korea University**



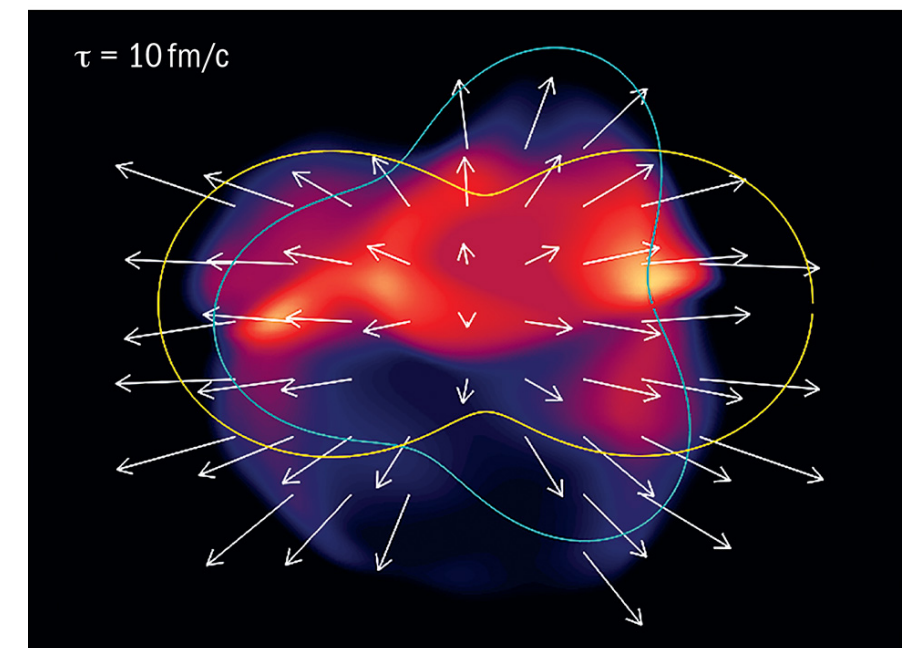
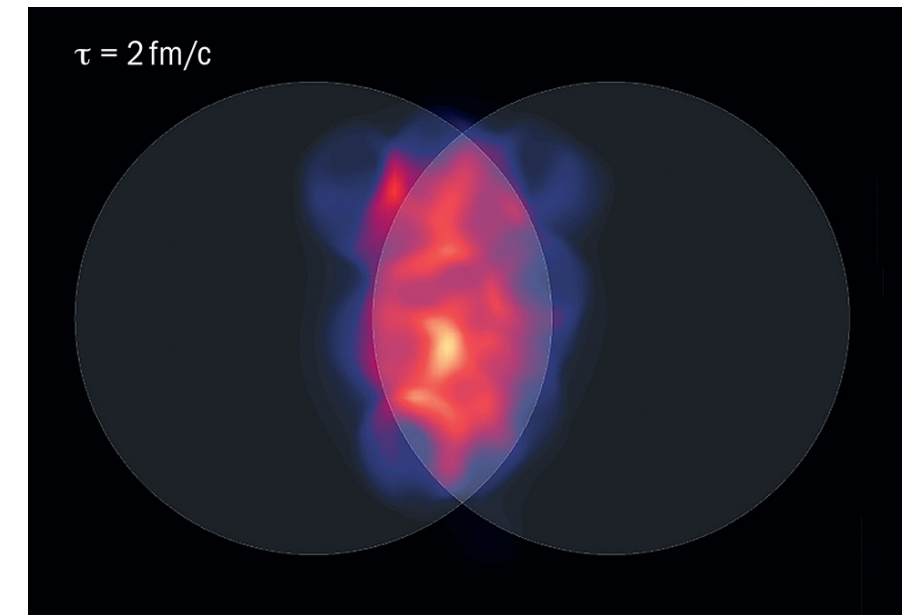
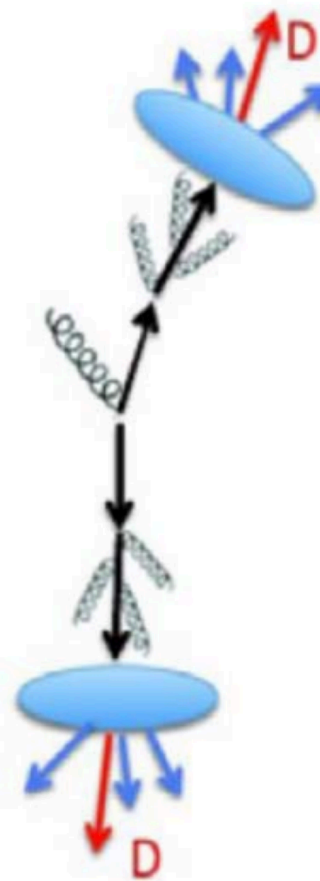
# Introduction

[PRC 90 024907 \(2014\)](#)

charm quarks



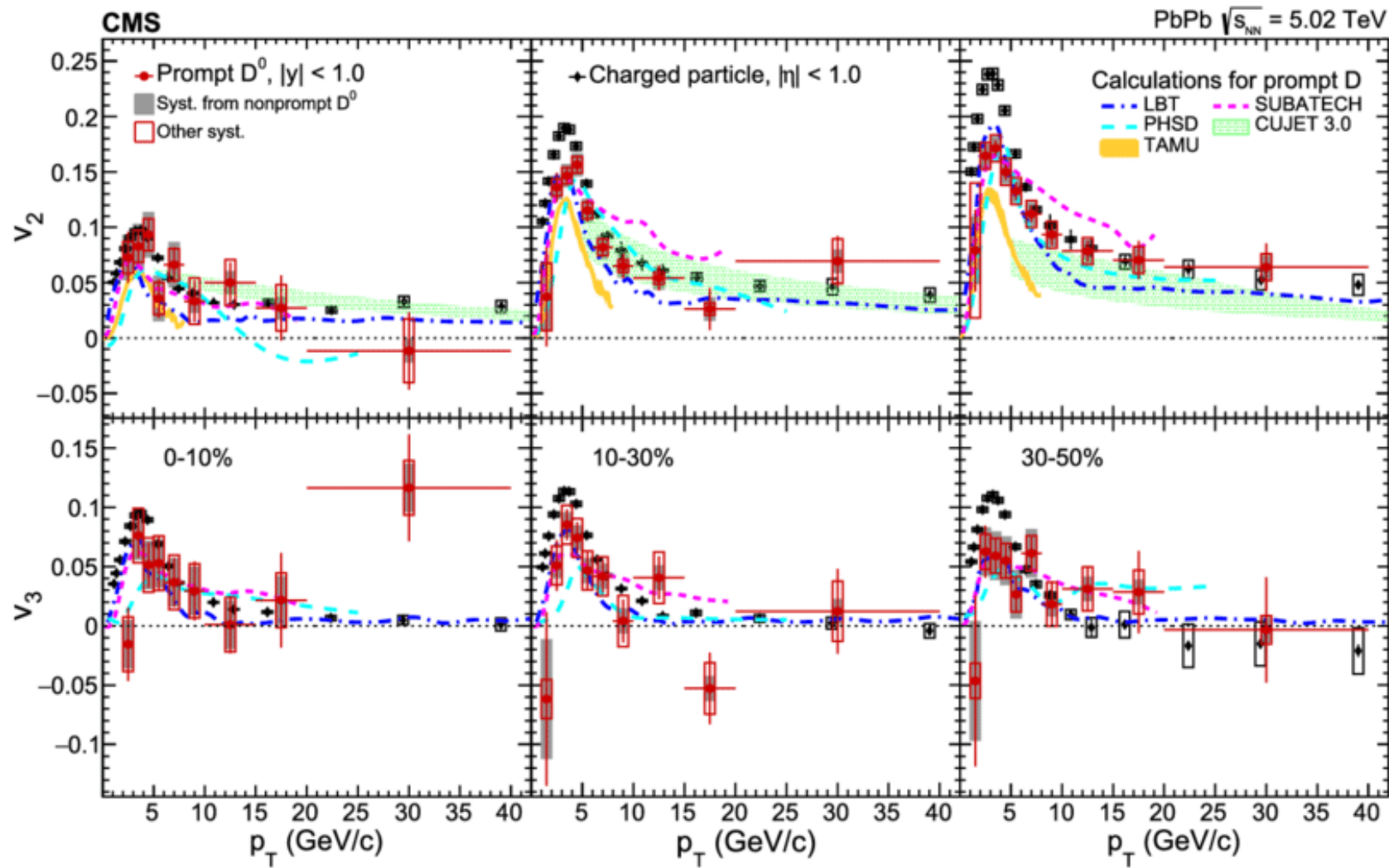
D- $\bar{D}$  or B- $\bar{B}$



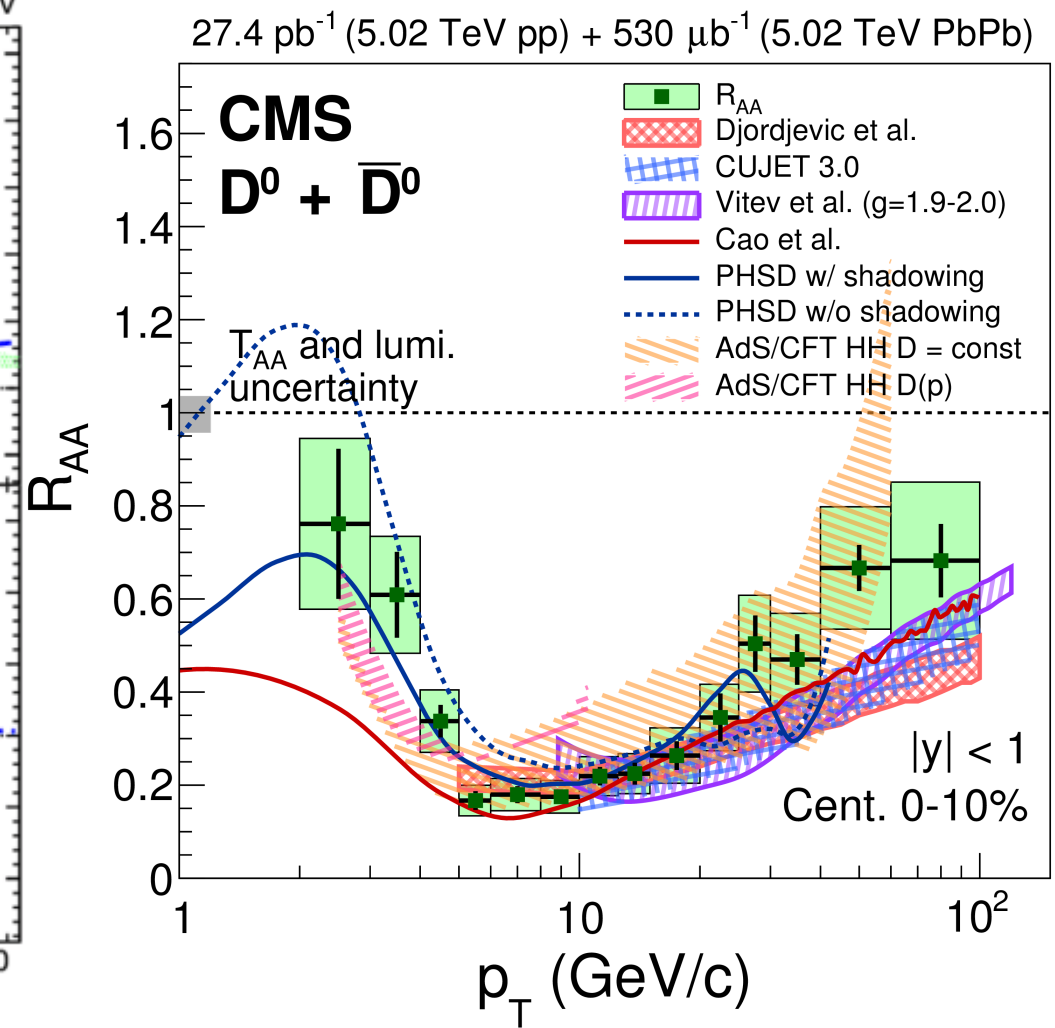
- $m_Q \gg \Lambda_{QCD}$ ,  $T \rightarrow n_Q$  conserved, works in pQCD
- Created early, good penetrating probe to study hot QCD matter
- More information carried out with correlation of other objects



[PhysRevLett 120 202301 \(2018\)](#)



[Phys. Lett. B. 05 \(2018\) 074](#)

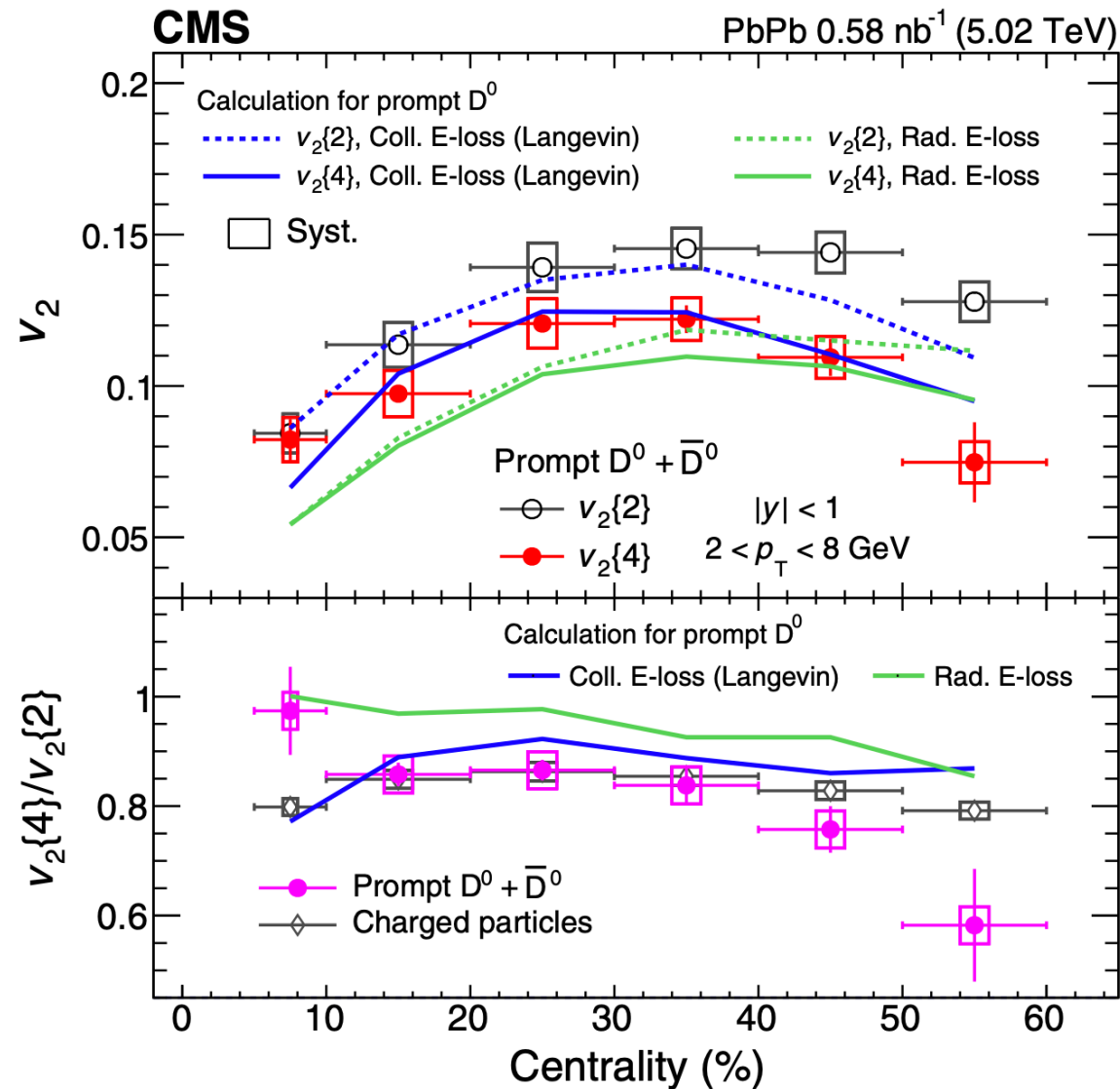


- Already many model on the market that tend to describe the  $R_{AA}$  and the  $v_2$



# Probing initial stage effects with multi particle correlation

[PhysRevLett.129.022001](https://arxiv.org/abs/1202.2001)

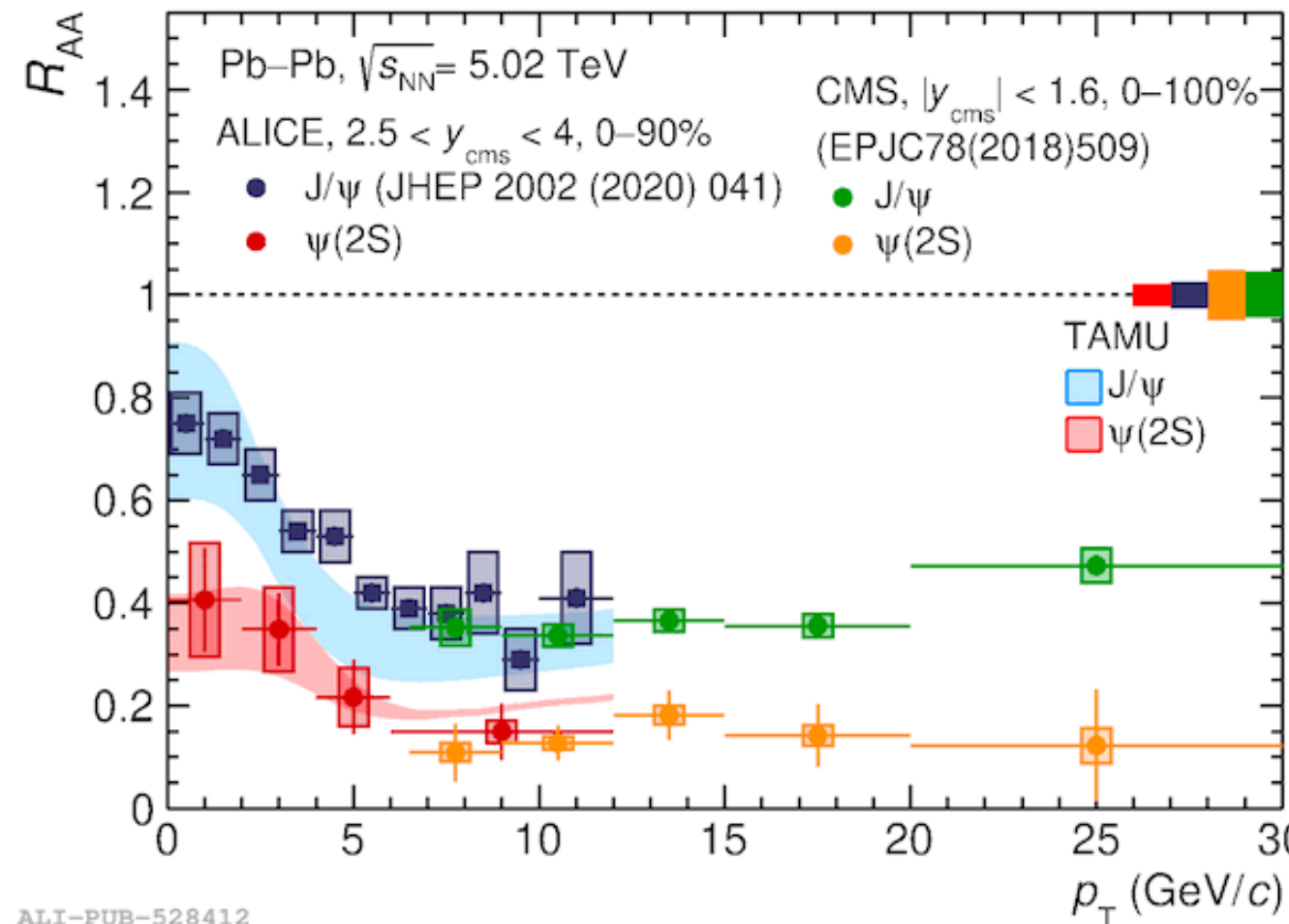
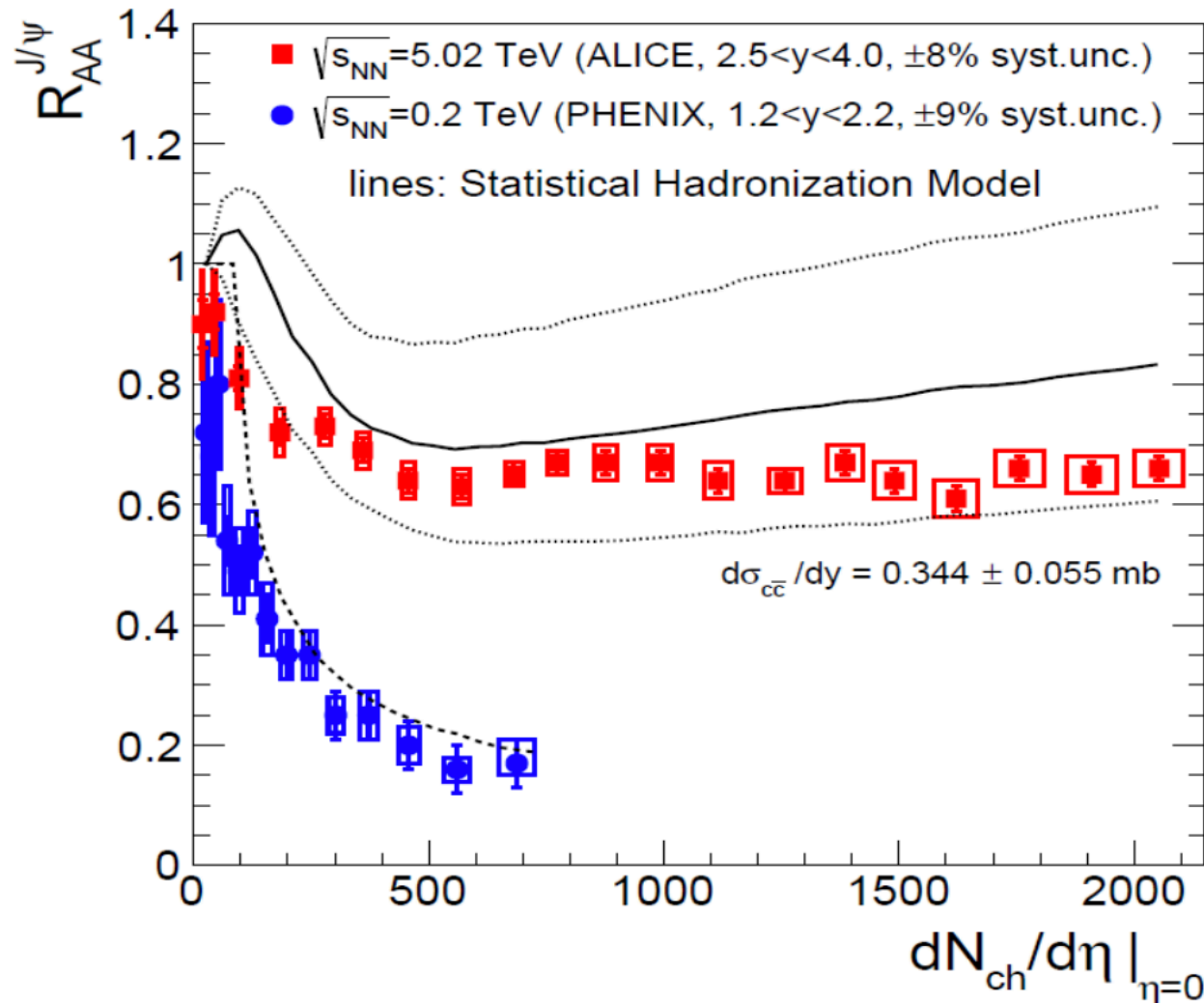


- Multi-particle correlation of D0 data sensitive to parton energy loss mechanism



# Quarkonia measurements

[arXiv:2210.08893](https://arxiv.org/abs/2210.08893)



ALI-PUB-528412

- $R_{AA}$  well described from statistical hadronization method and with transport models

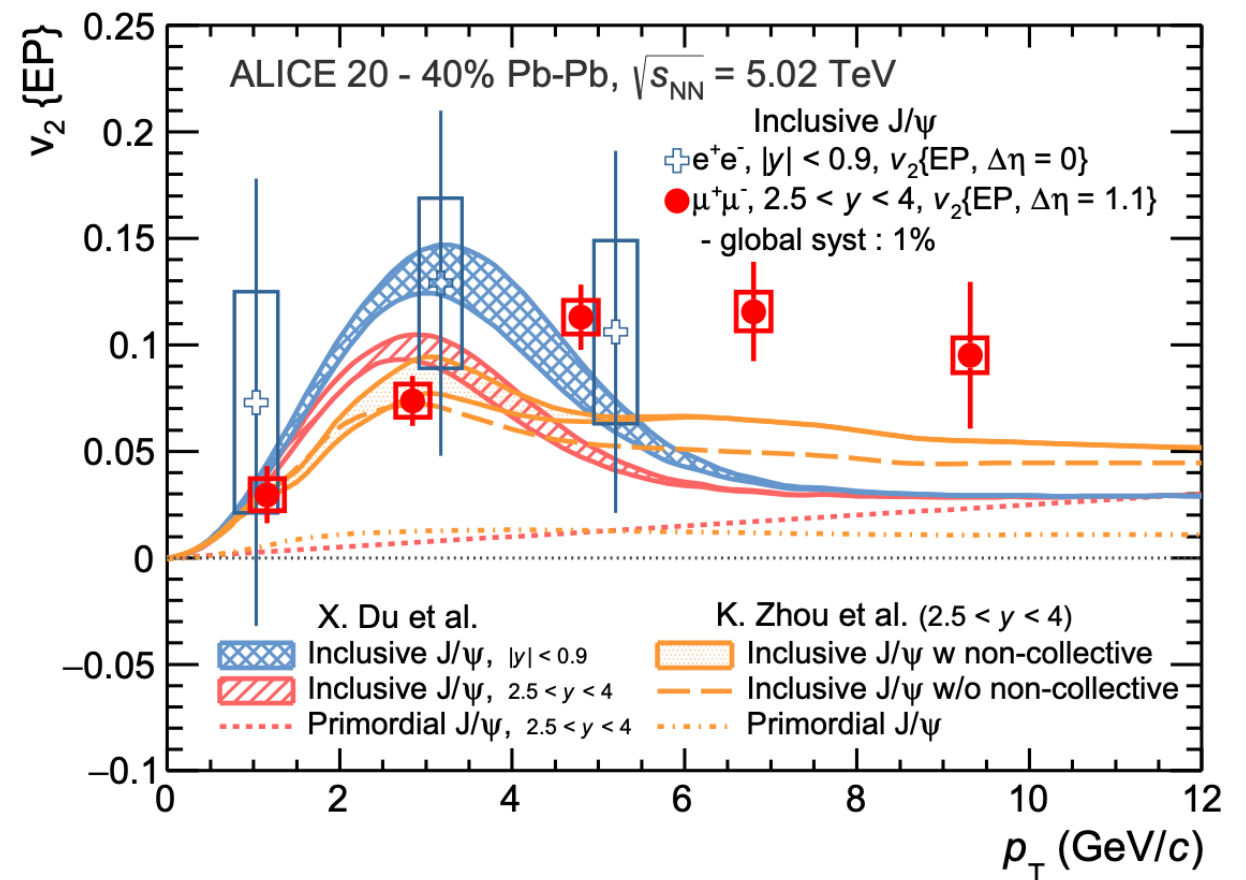
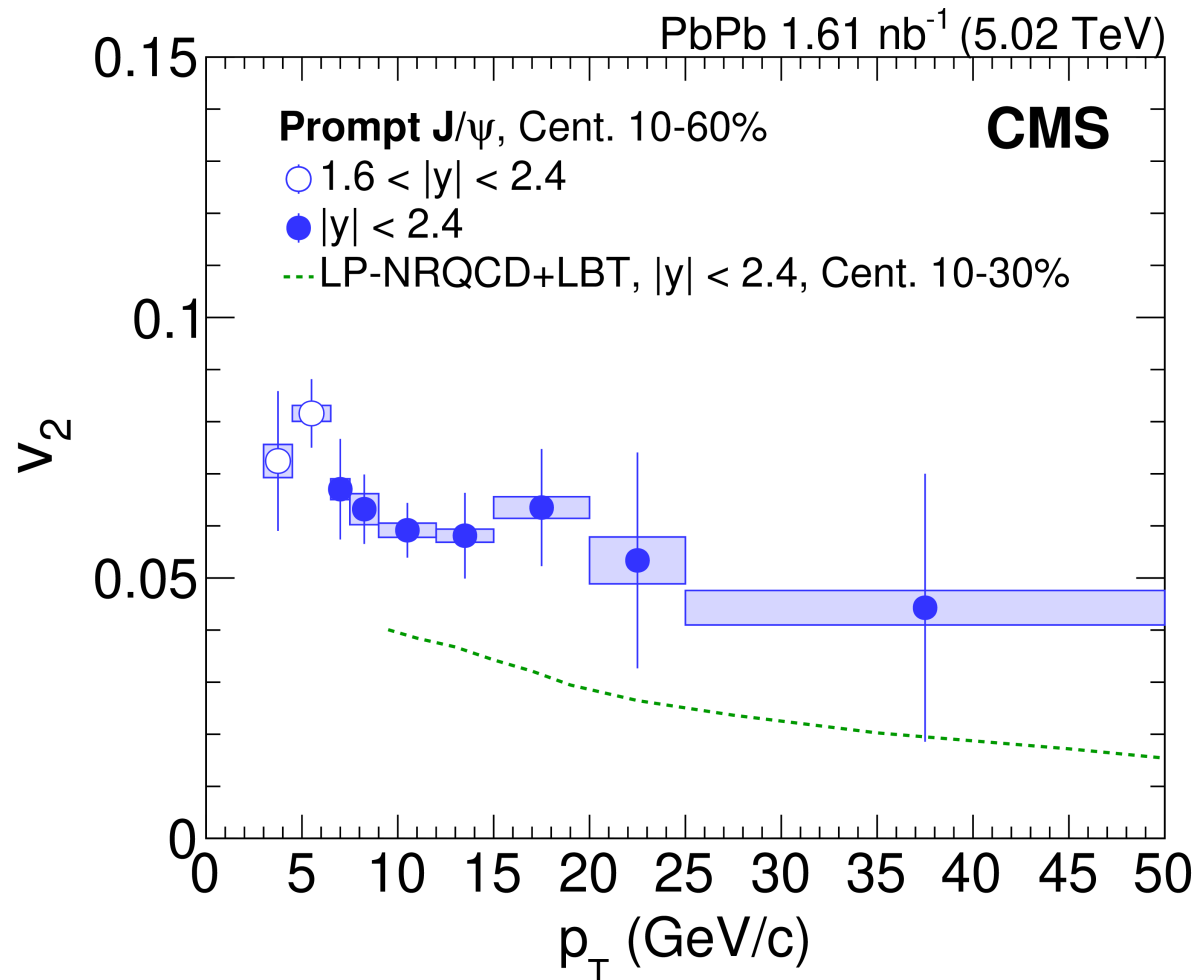




# Azimuthal anisotropy for closed $Q\bar{Q}$

[JHEP 10 \(2023\) 115](#)

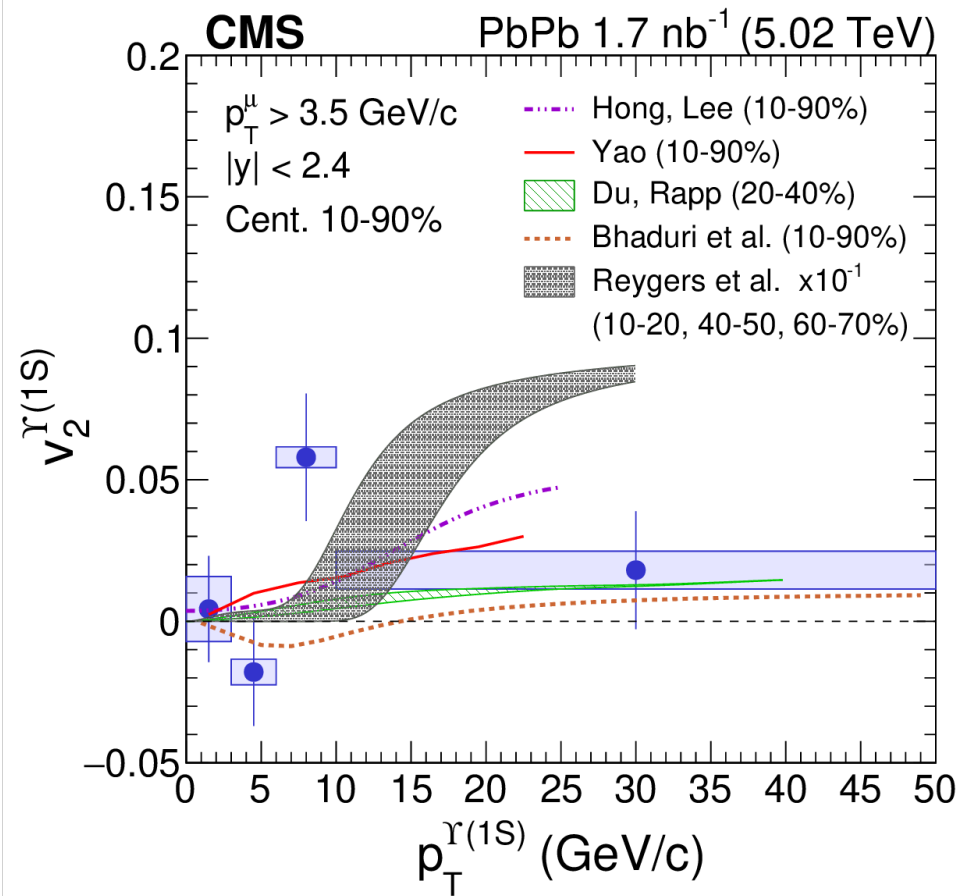
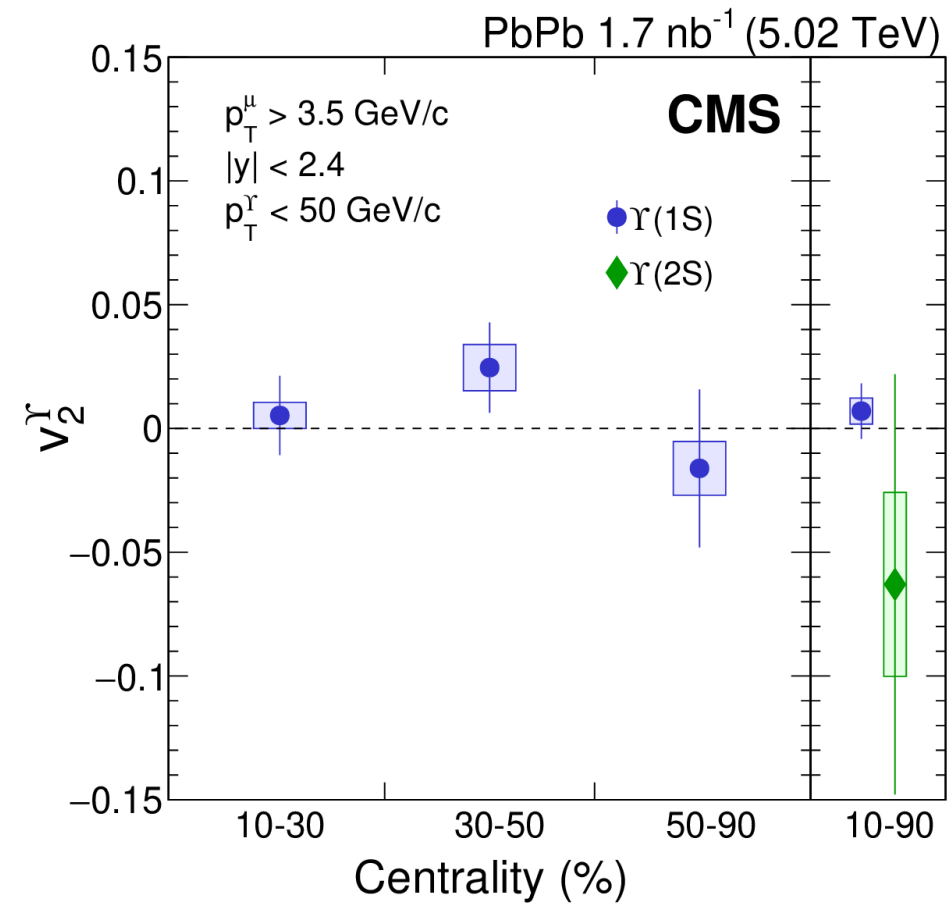
[PhysRevLett.119.242301](#)



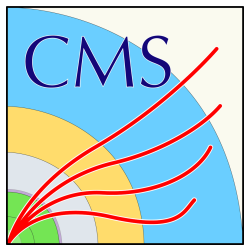
- Bit of short coming in the  $v_2$  side, especially in the mid-high  $p_T$  side
- Path length dependent E-loss



# Azimuthal anisotropy for closed $Q\bar{Q}$

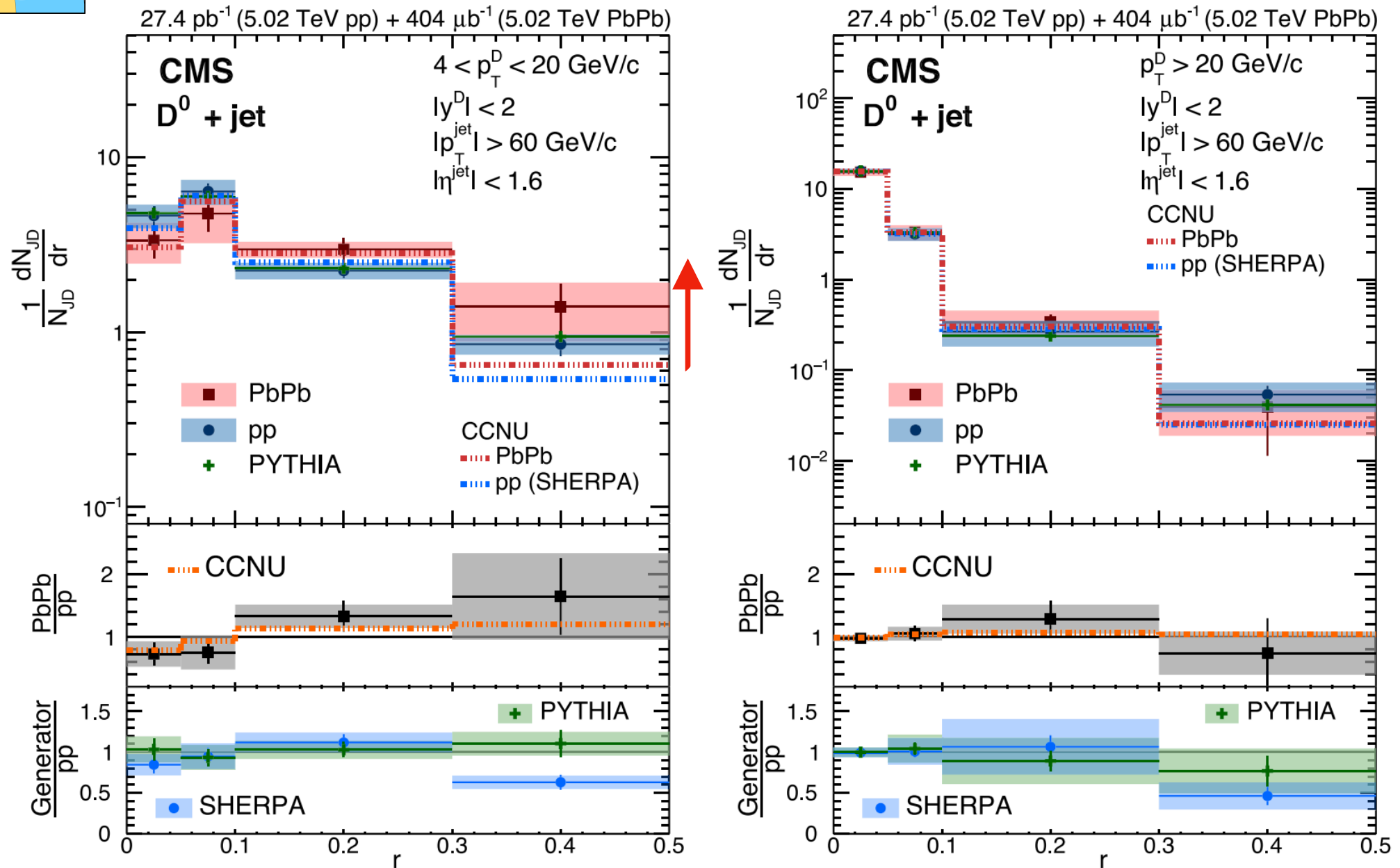


- Absolute  $v_2$  value smaller than  $\psi$ 's  $\rightarrow$  heavier to flow
- Sensitivity not there yet to distinguish between models



# How are the HF created?

[PRL 125, 102001 \(2020\)](#)

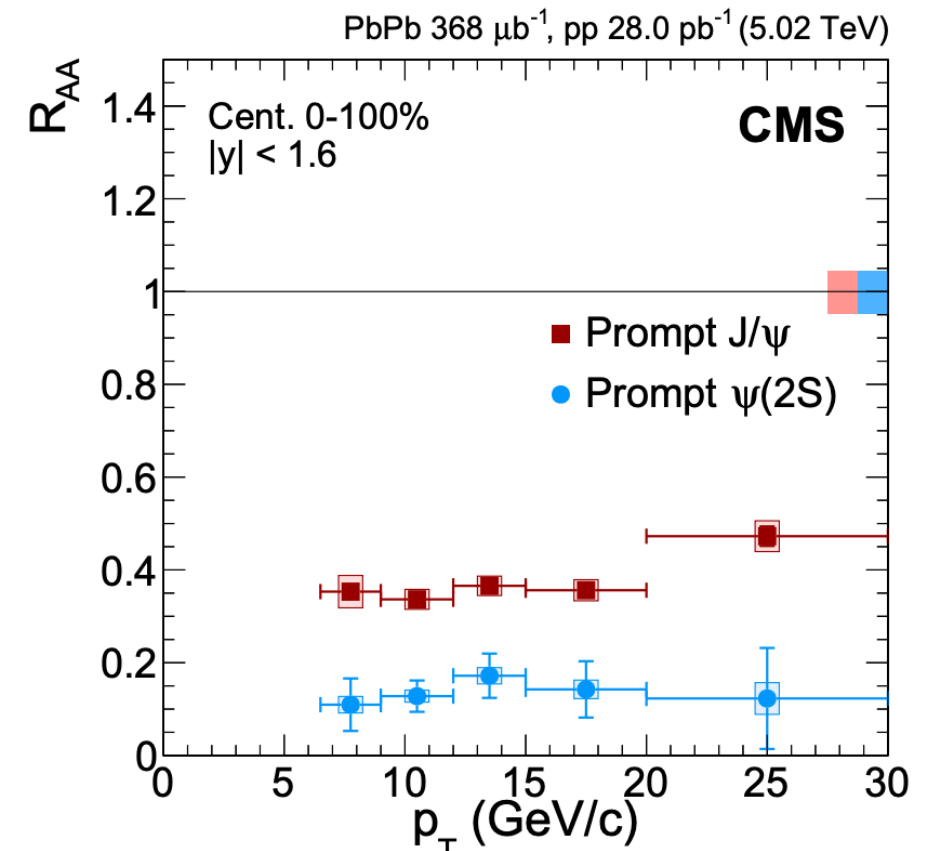
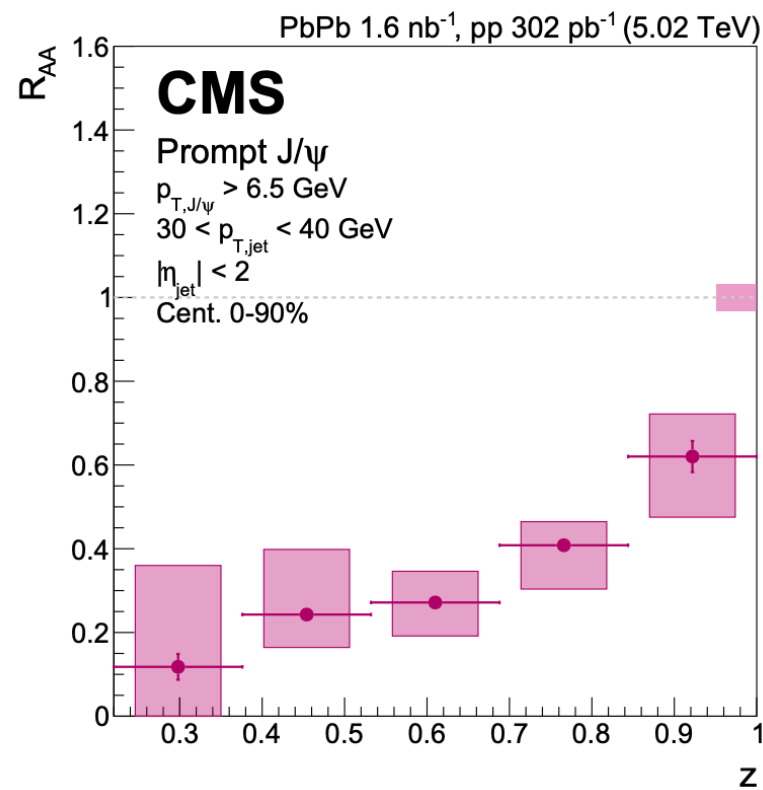
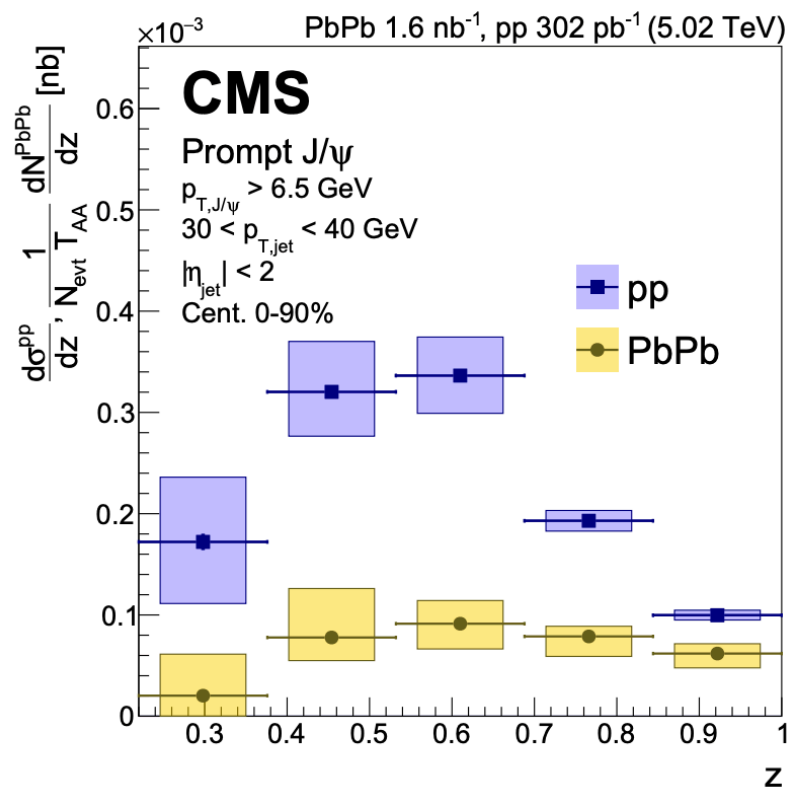


- D0 jet axis further away in PbPb collisions in low-pT





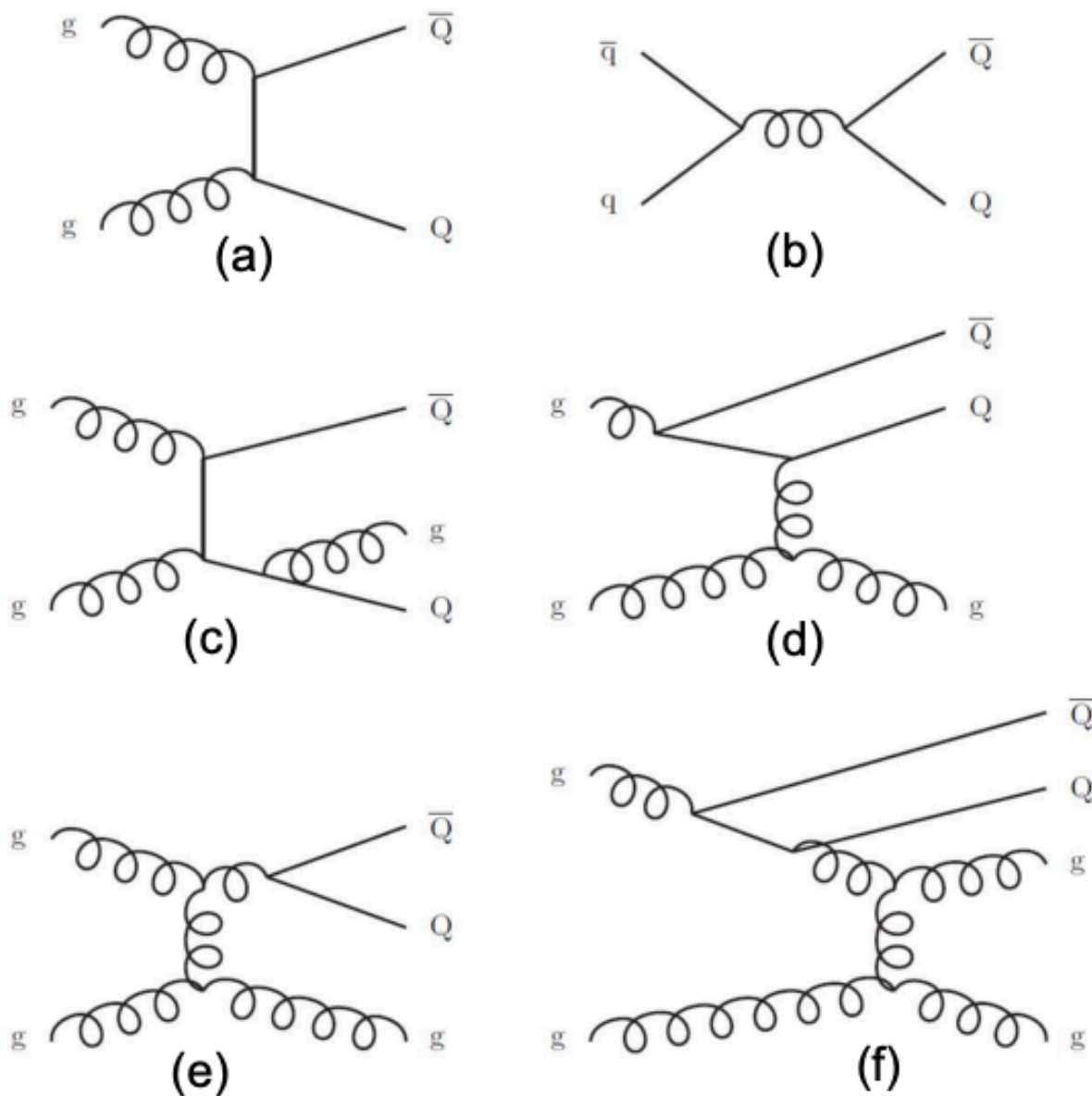
# Charmonia in jet



- $J/\psi$  produced in more jet inclusive way  $\rightarrow$  not produced instantly but with more in parton shower from hard scattered gluon
- bound  $c\bar{c}$  and gluons go through different dynamics, how to better understand the dynamics?

# Talking about $c\bar{c}$

Pol Gossiaux, WWND



➤ LO; (a): back to back peak

➤ NLO;

(c): "blurring" of B2B peak

(d): "flavor excitation": no strong azimuthal correlation expected

(e): gluon splitting: strong peak around  $\Delta\phi=0$

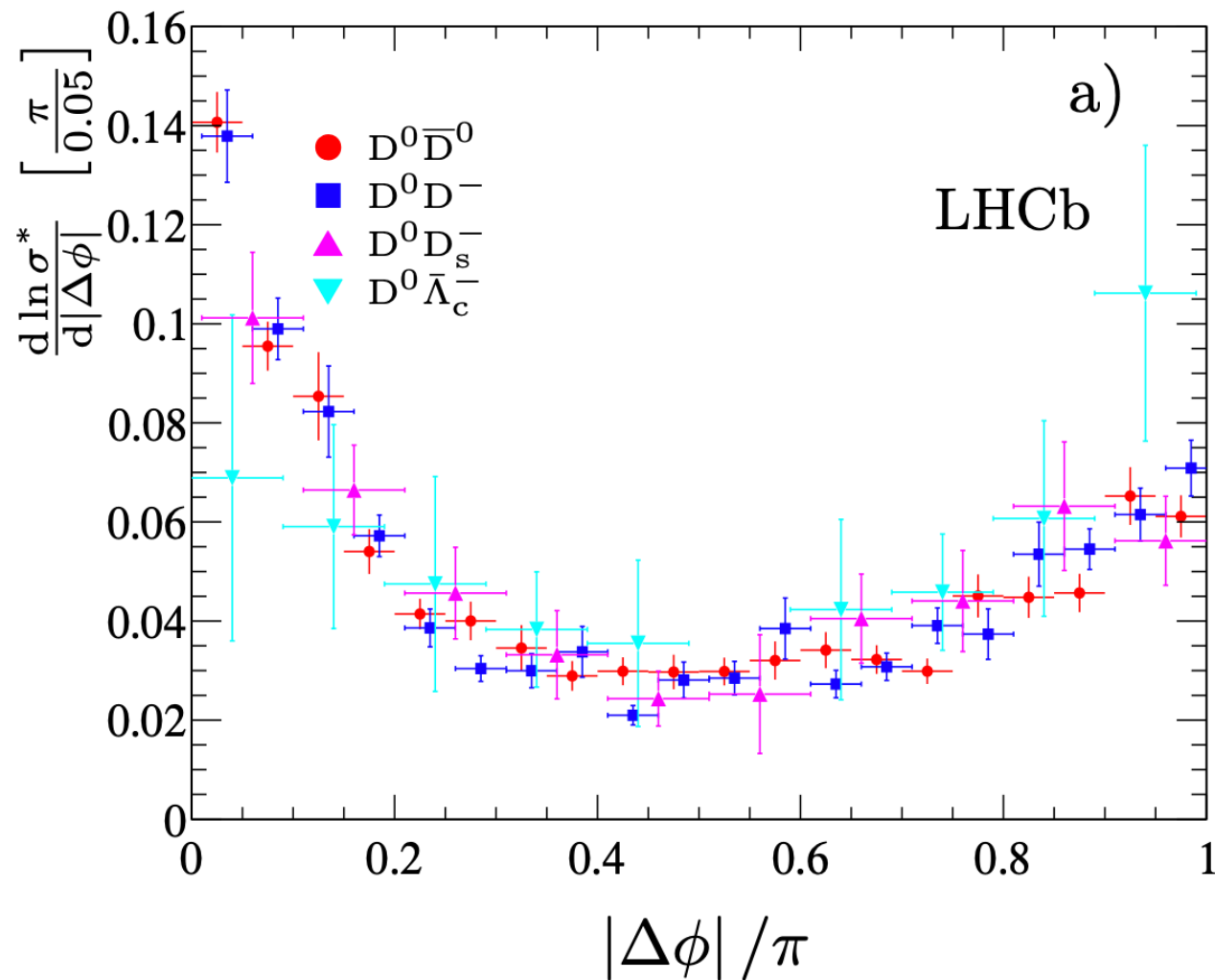
(f): higher order FE; both Q and Qbar in the "remnant" region



# Double D meson as probe for initial collision geometry

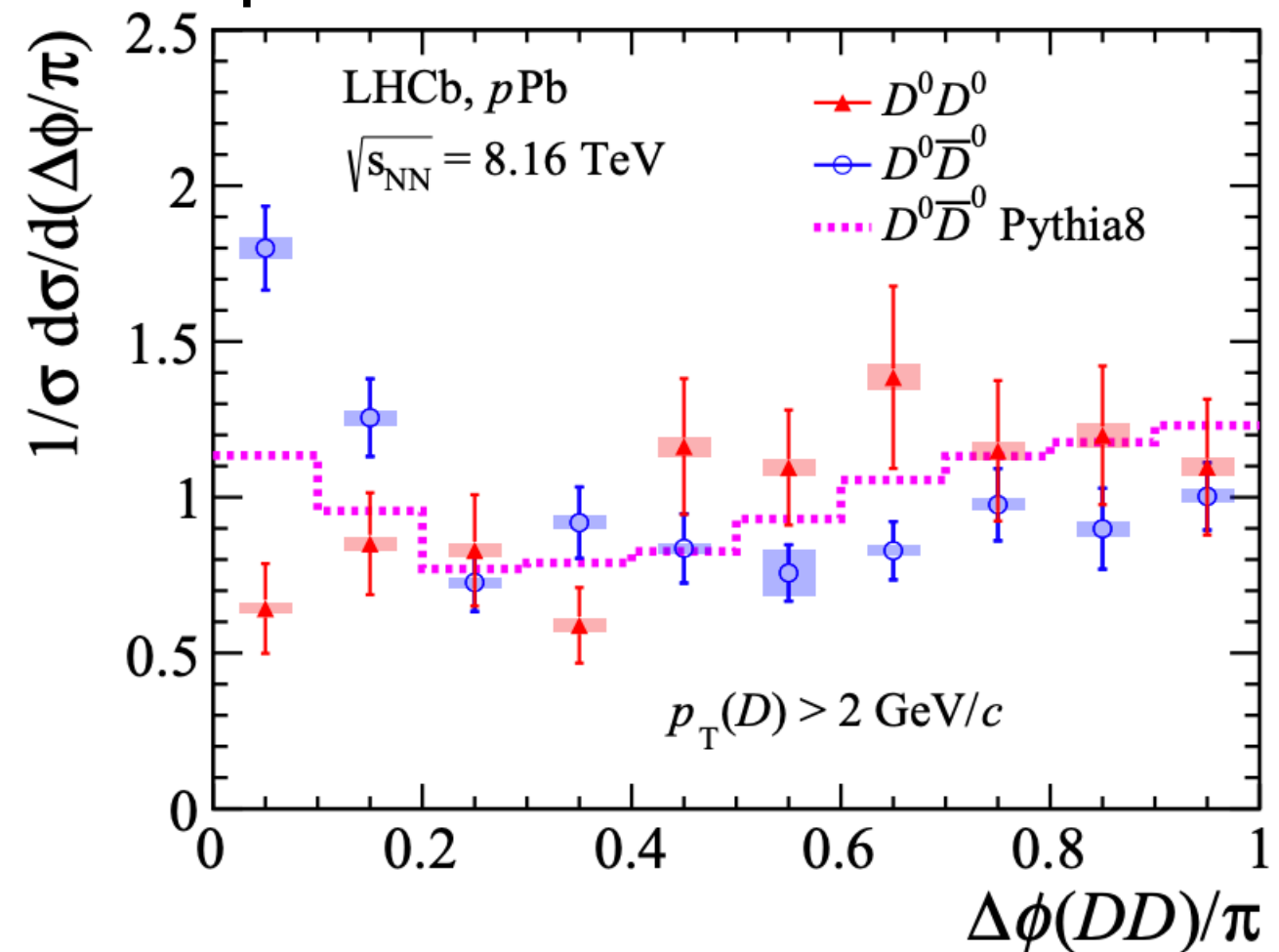
pp

[JHEP 06 \(2012\) 141](#)



pPb

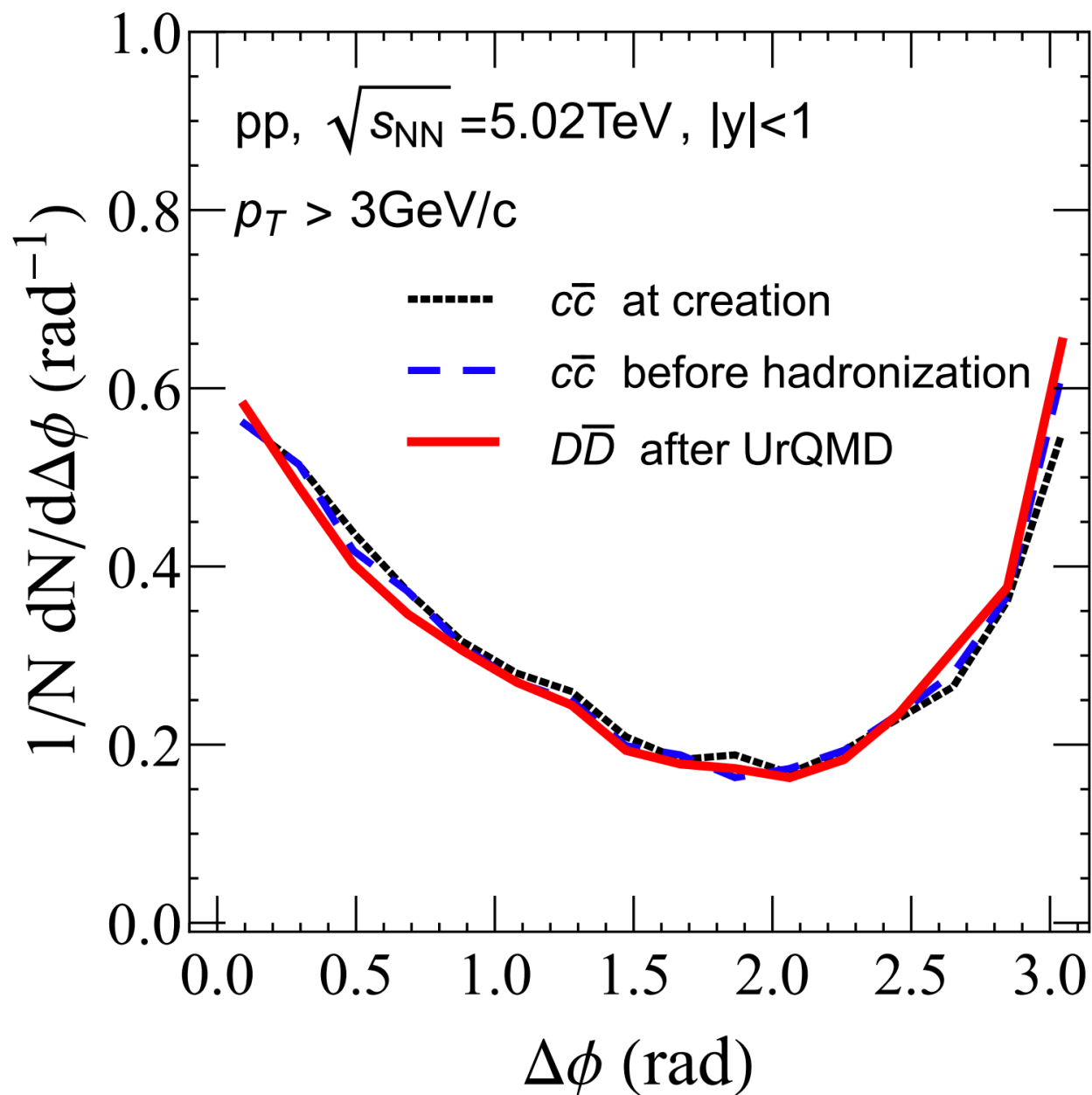
[PhysRevLett 125 212001 \(2020\)](#)



- pp data provide precision differential cross section for model constraints,
- Both result observe significant DPS signal, especially pronounced in pPb

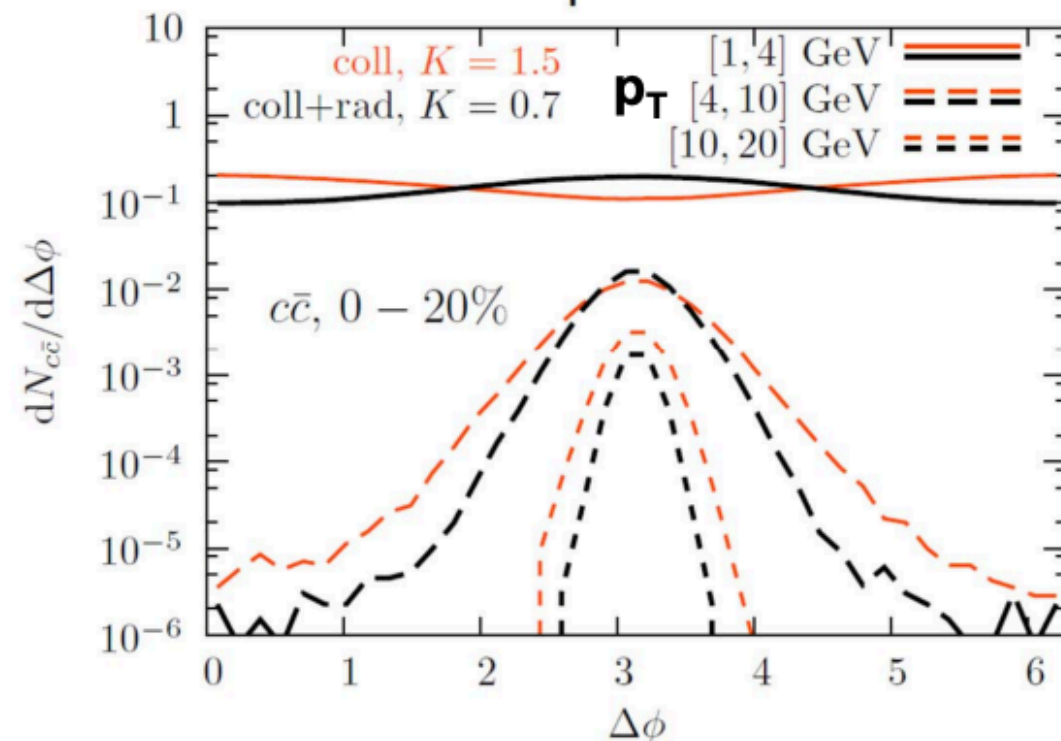
# The initial $c\bar{c}$ correlation

arXiv.2310.08684



PRC 90 024907 (2014)

charm quarks

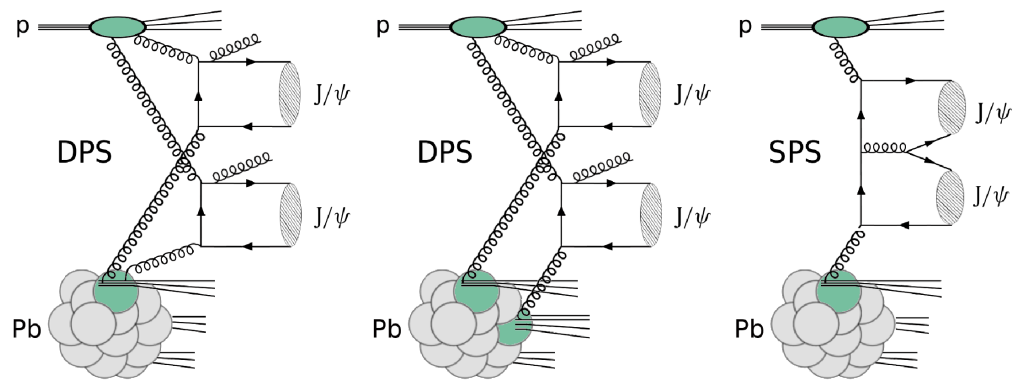


- In PbPb case, the correlation is “washed away” by the medium interactions

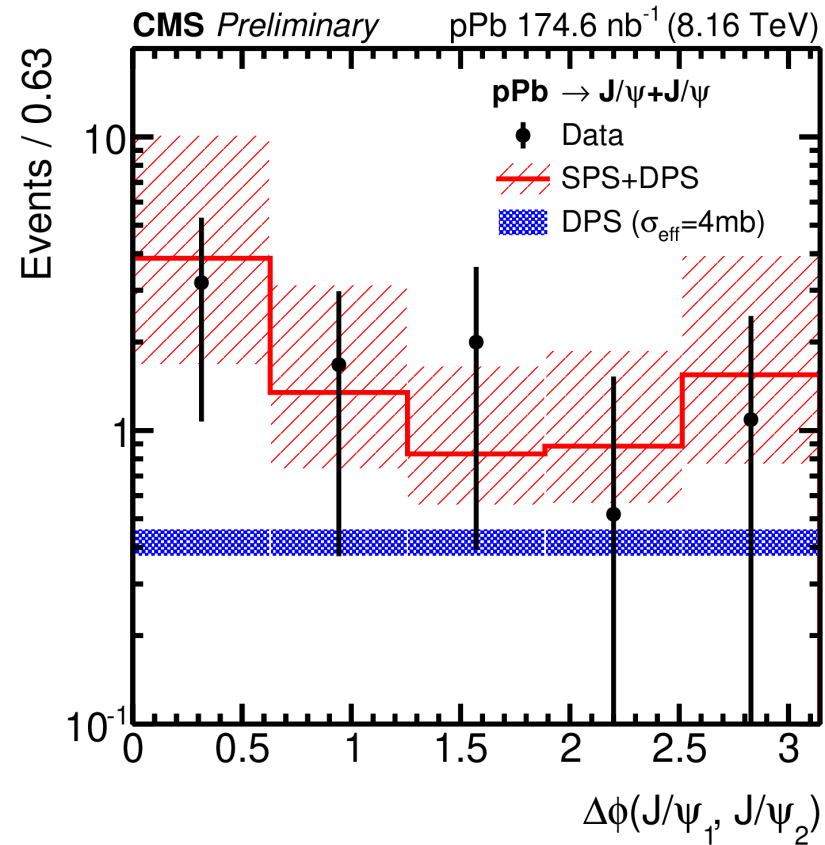
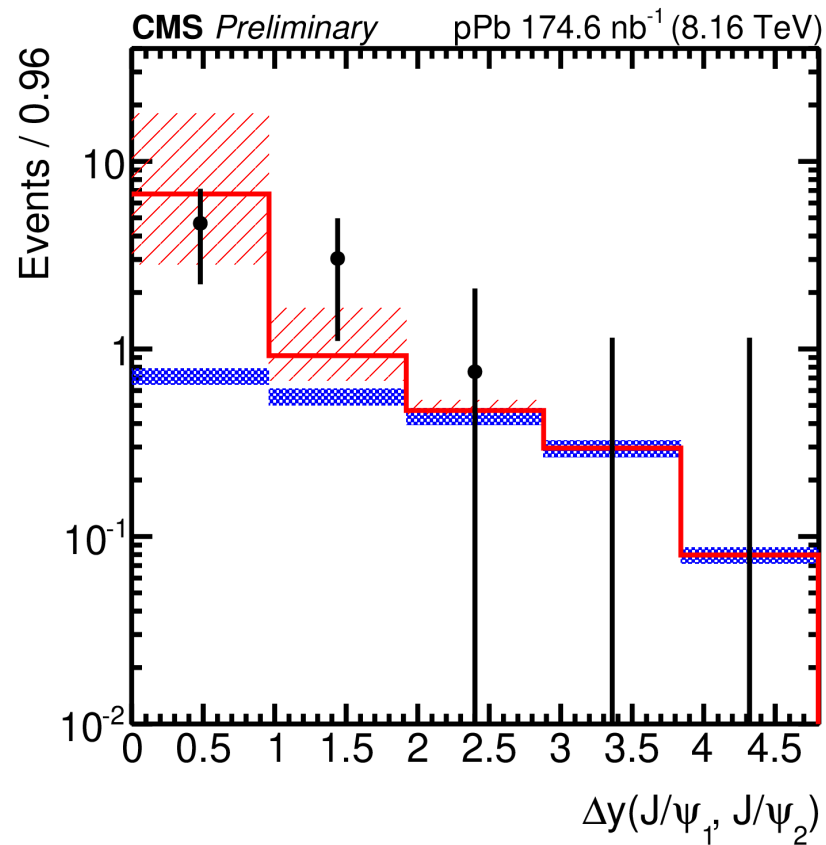
- EPOS4HQ (and the original) describes the initial  $c\bar{c}$  correlation carried by  $D\bar{D}$  in QGP environment in high multiplicity stays unmodified



# Towards understanding $c\bar{c}$ correlation

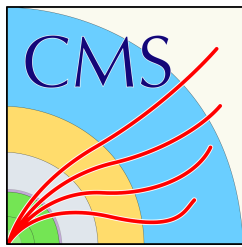


CMS-PAS-HIN-23-013



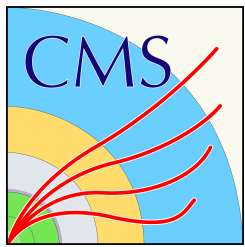
- Understanding background process - multi parton scattering
  - New measurement of di- $J/\psi$  production in pPb collision





# $D\bar{D}$ in CMS midrapidity

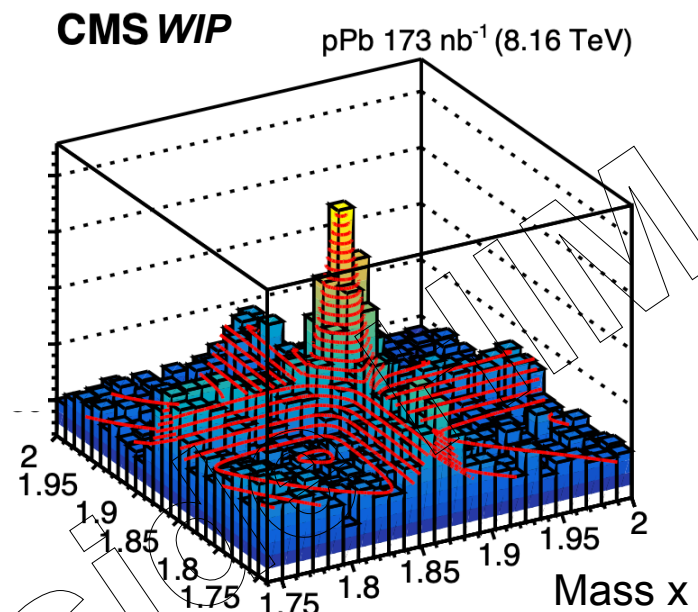
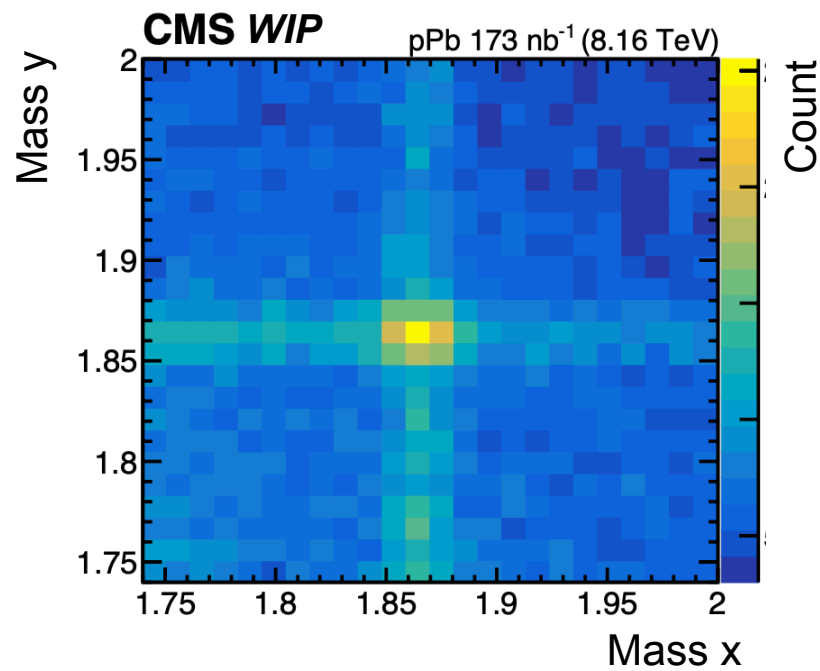
- To further investigate the near/b2b side aspect of the correlated  $c\text{-}\bar{c}$  production
- Technical challenges on purity of the signal  $D\bar{D}$  need to be develop in high multiplicity nuclear collision
- Start with existing 8 TeV pPb collision as done in LHCb
  - Eventually study new pp reference, PbPb 5.36 TeV data with precision



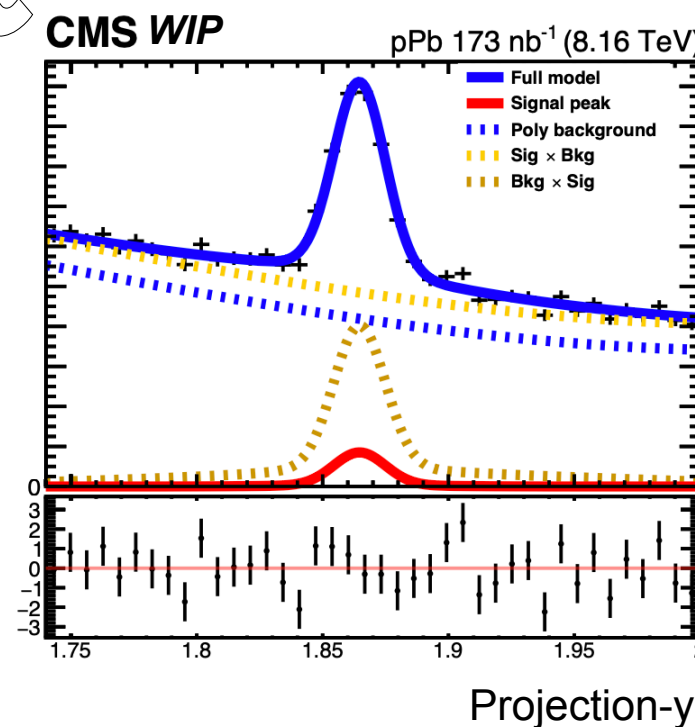
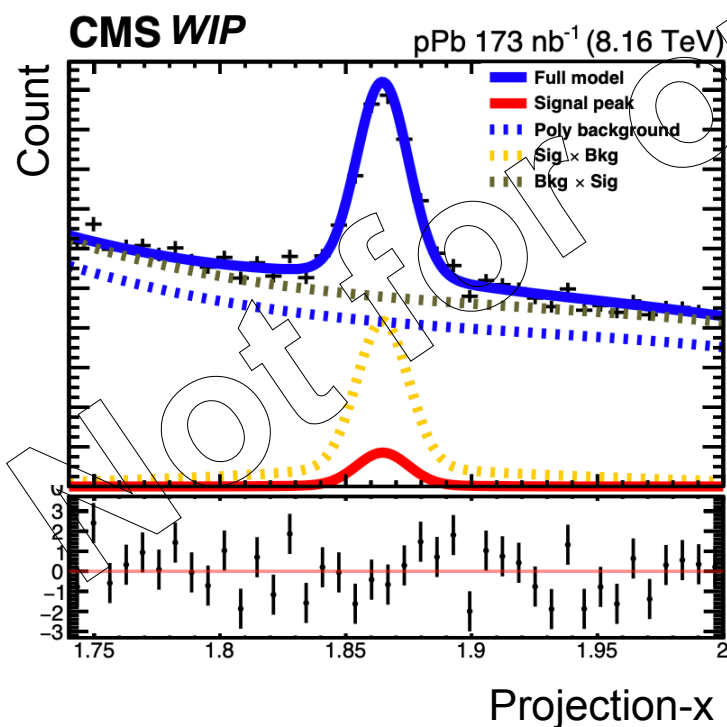
# D $\bar{D}$ in CMS midrapidity

Work In Progress!

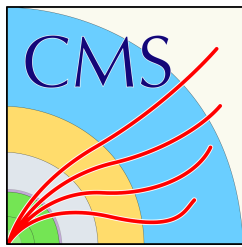
- Start with existing 8 TeV pPb collision as done in LHCb



- Focus on intermediate  $p_T$
- A baseline study to understand nPDF/CNM effects for future PbPb studies



Analysis in early stage!  
 Full result to be presented public 🤔



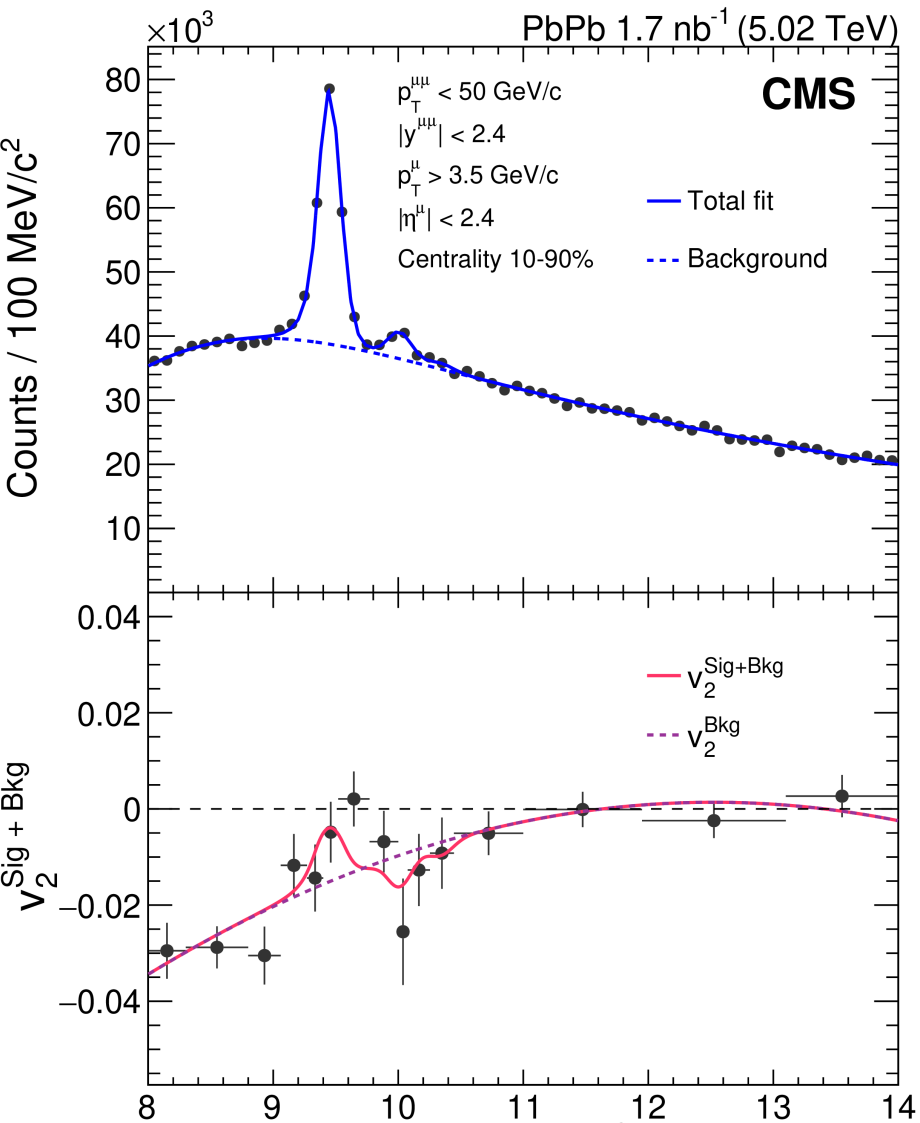
# Near future plans for Run3 data analysis

- Understanding the  $Q\bar{Q}$  production
  - S-wave, P-wave state cross section measurements
  - Polarization studies  $\Upsilon, \psi$
- Updating collectivity measurements with excited states  $\Upsilon, \psi$
- Constraining heavy quark hadronization
  - Precision  $X(3872), B_c$  cross section measurement in PbPb
- $\gamma$ -hadron/jet tagged correlation for  $\hat{q}$  constraint measurement
- $D\bar{D}$  femtoscopy for HQ final state interaction

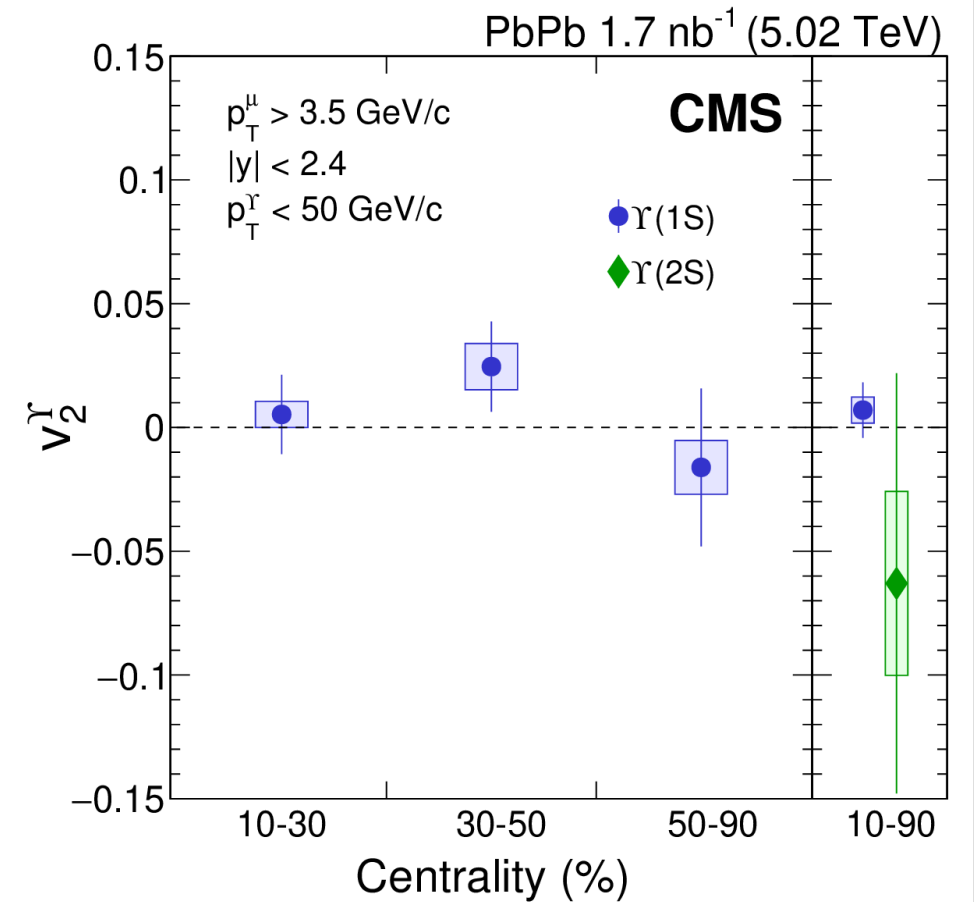
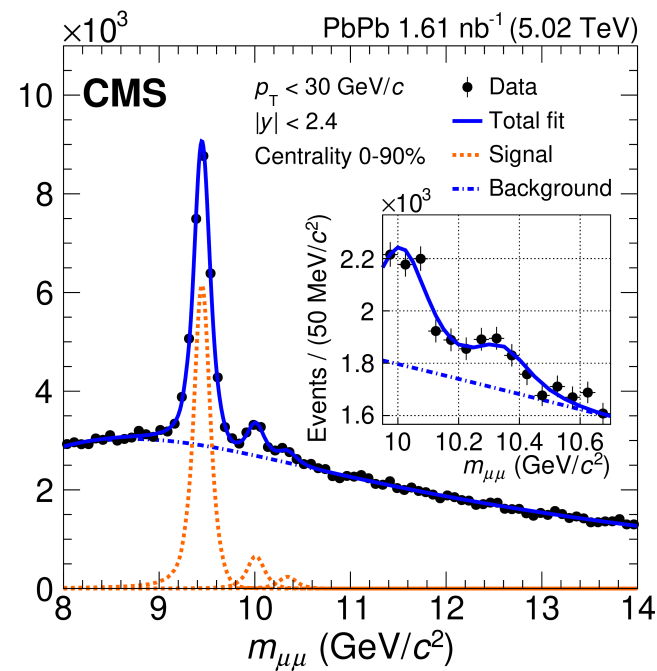


# Precision measurement in Run3

[arXiv:2303.17026](https://arxiv.org/abs/2303.17026)



[PLB 819 \(2021\) 136385](https://arxiv.org/abs/2103.13638)



- Boost to significance crucial for signal  $v_2$  isolation → Pin pointing  $\Upsilon(2S) v_2$ , are they really negative?
-

**Back up**





# $J/\psi$ -D correlation in forward pp in LHCb

