Recent heavy ion results from CMS

Subash Chandra Behera

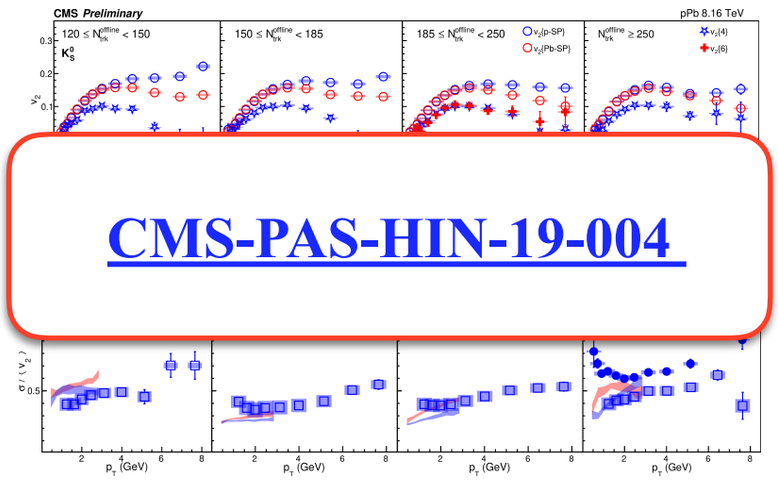
on behalf of the CMS Collaboration

Indian Institute of Technology Madras

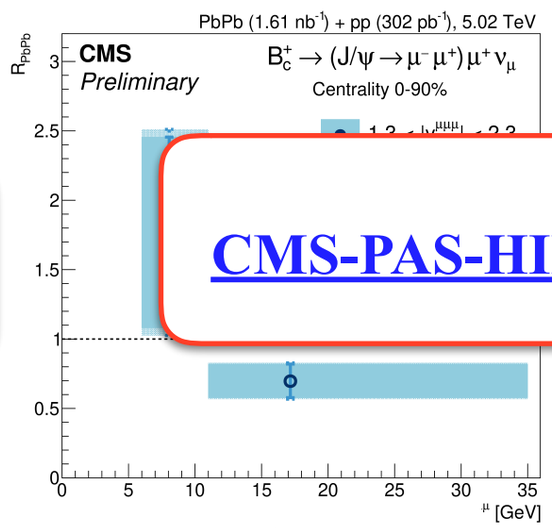
22nd edition International Conference on Particle and Nuclear Interaction

PANIC 2021, 5-10 September

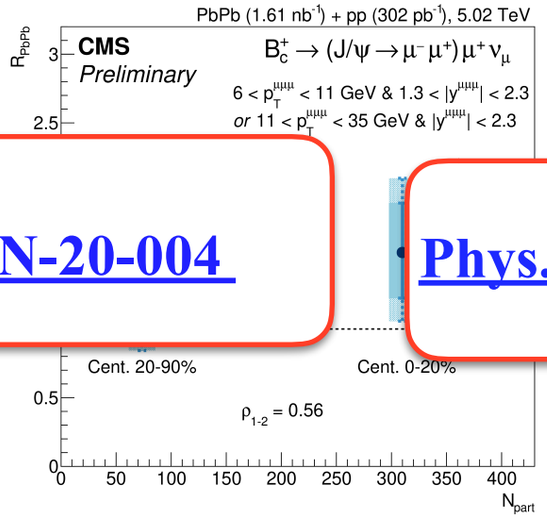
Recent heavy-ion results



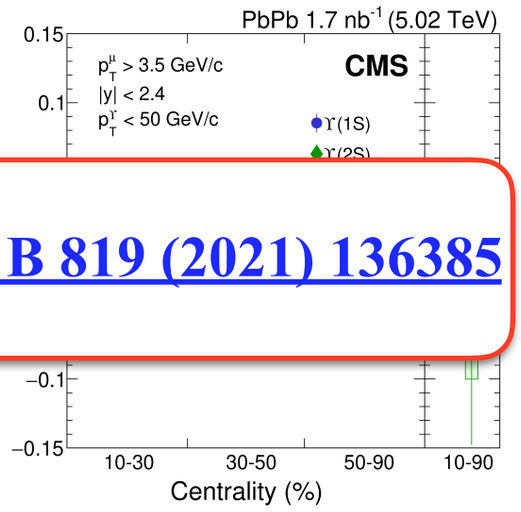
[CMS-PAS-HIN-19-004]



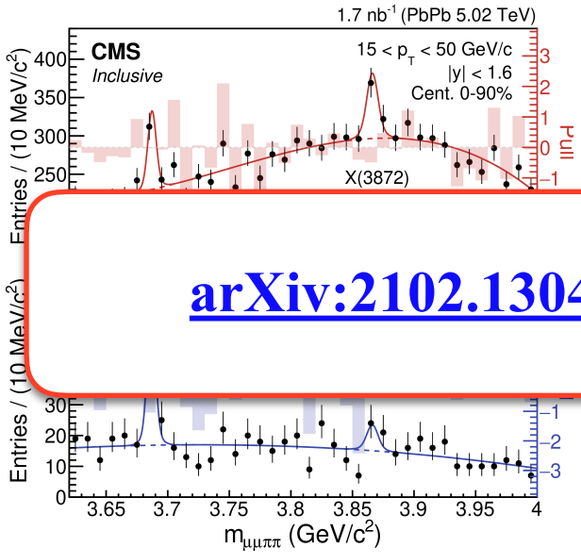
[CMS-PAS-HIN-20-004]



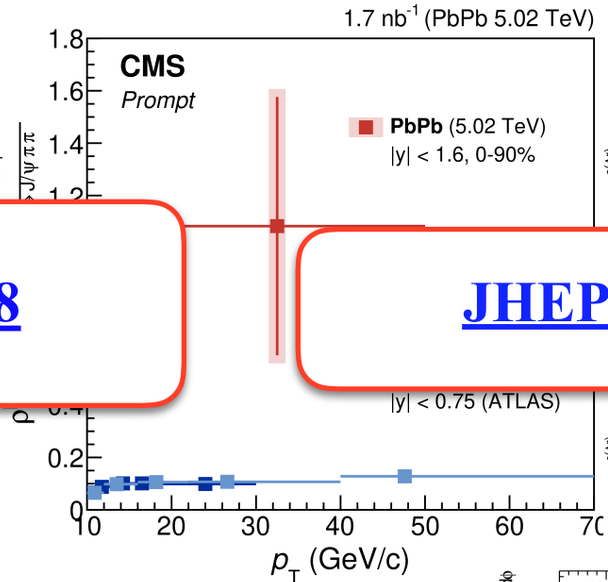
[Phys. Lett. B 819 (2021) 136385]

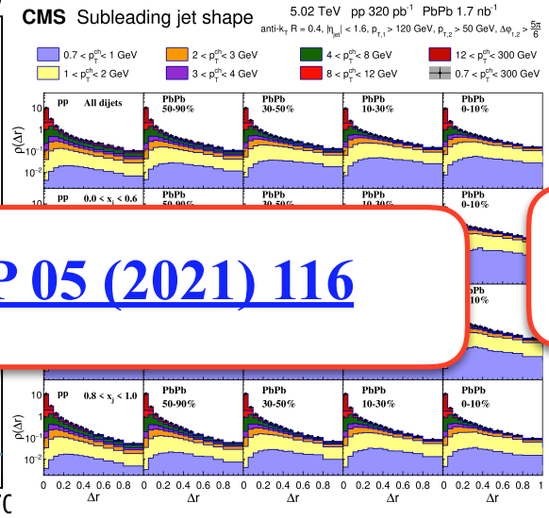


[arXiv:2102.13048]

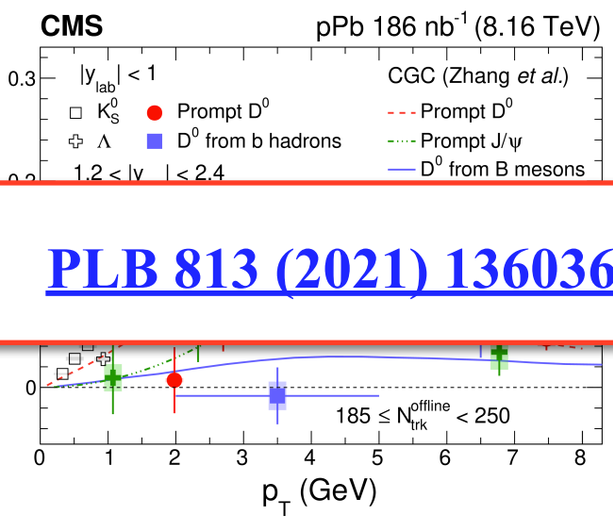


[JHEP 05 (2021) 116]

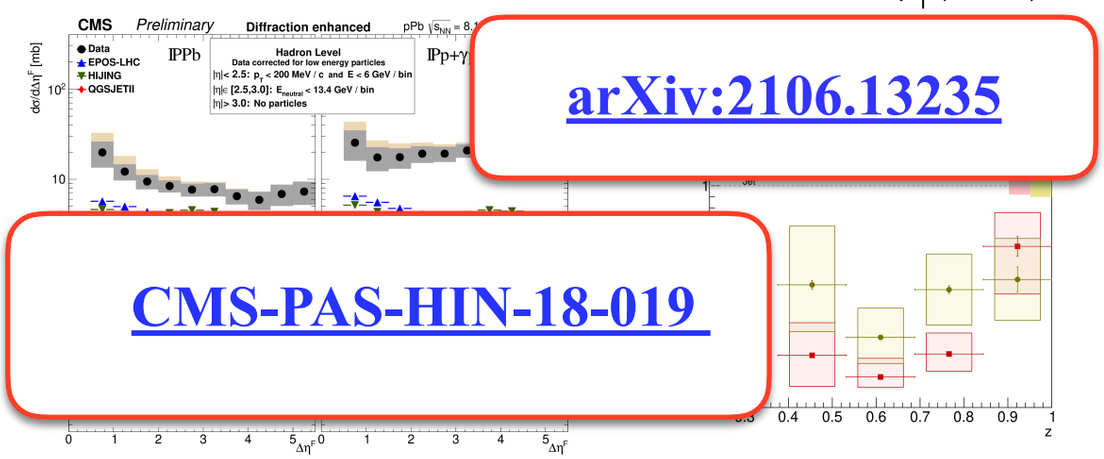




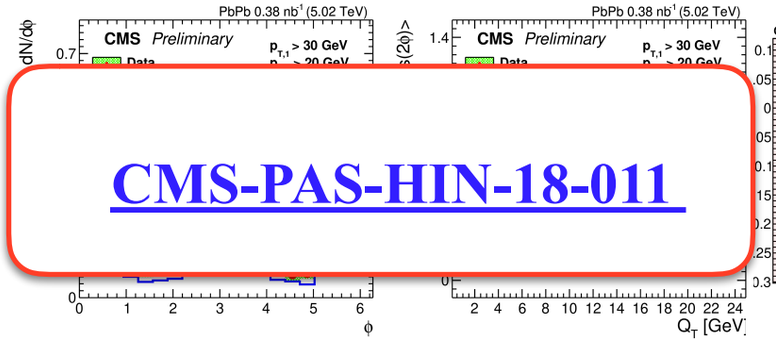
[PLB 813 (2021) 136036]



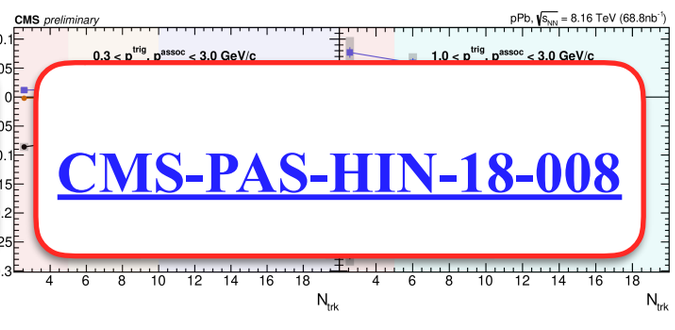
[arXiv:2106.13235]



[CMS-PAS-HIN-18-011]



[CMS-PAS-HIN-18-008]



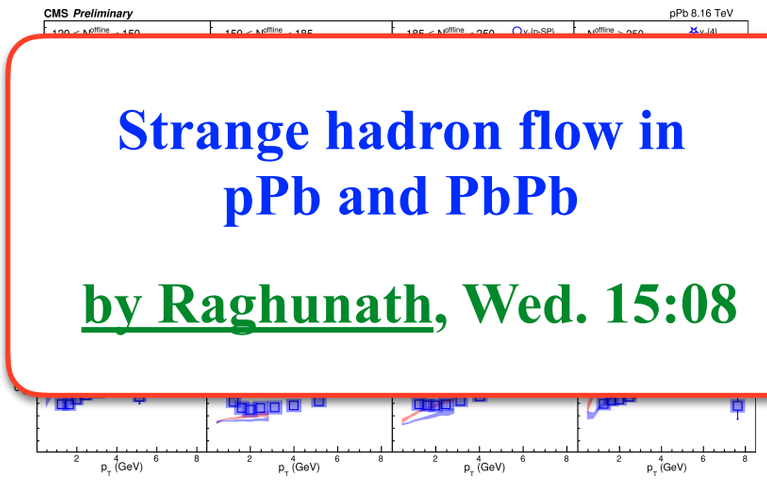
[CMS-PAS-HIN-18-019]

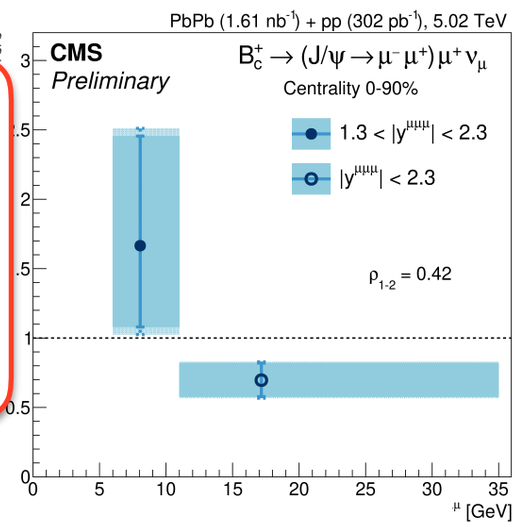
Many interesting results

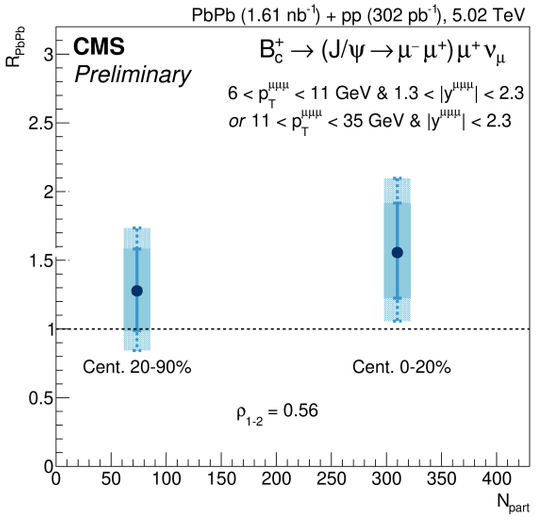
Recent heavy-ion results

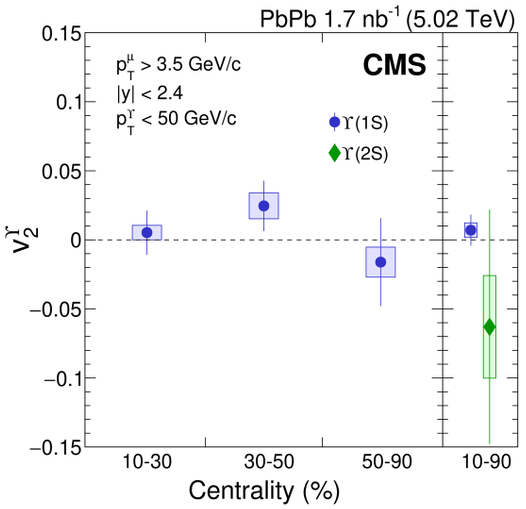
Strange hadron flow in pPb and PbPb

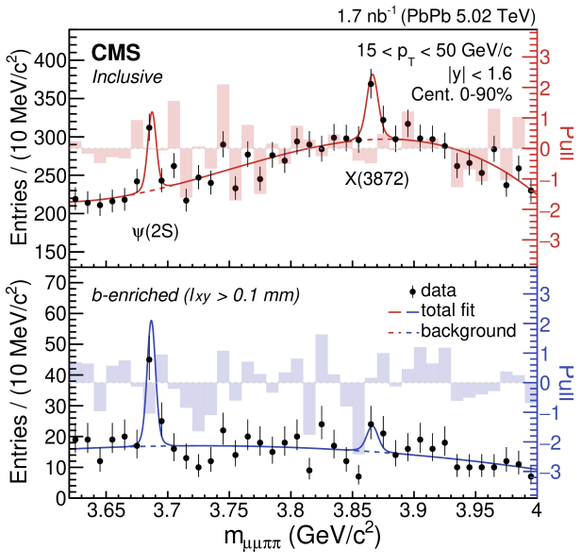
by Raghunath, Wed. 15:08

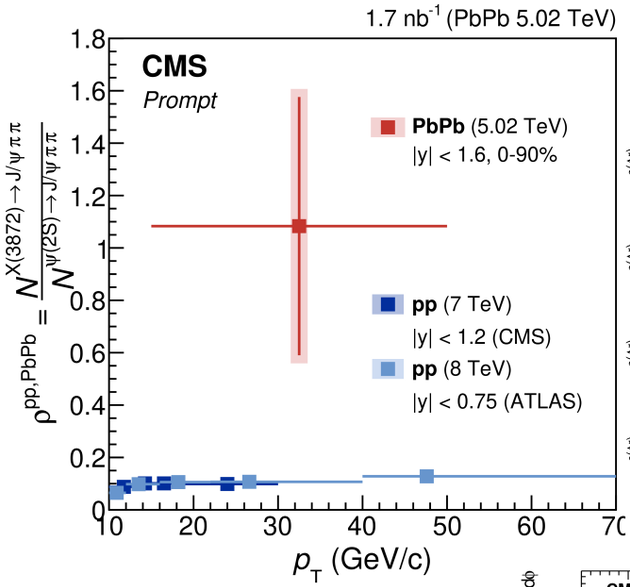


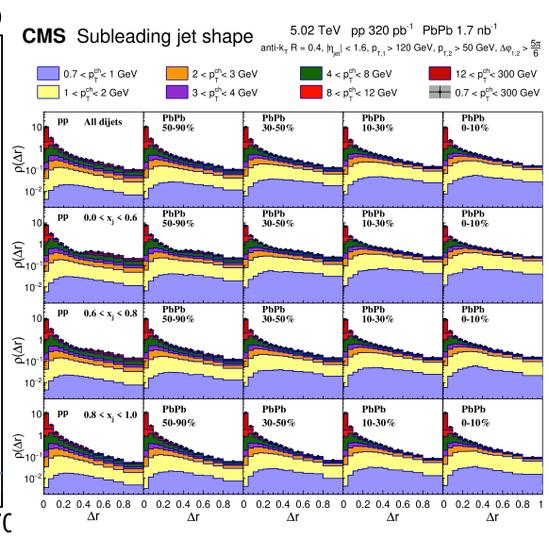


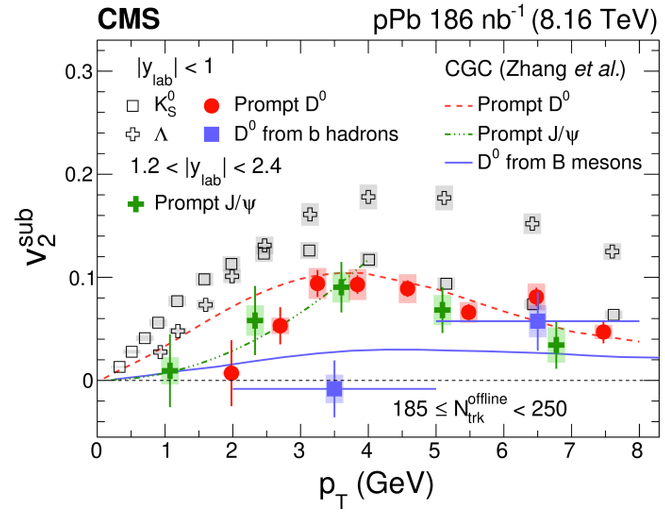


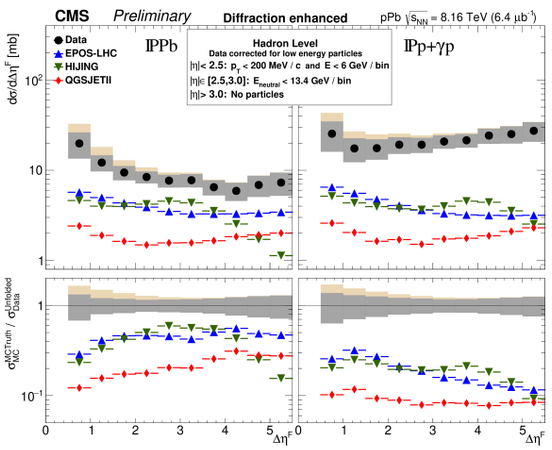


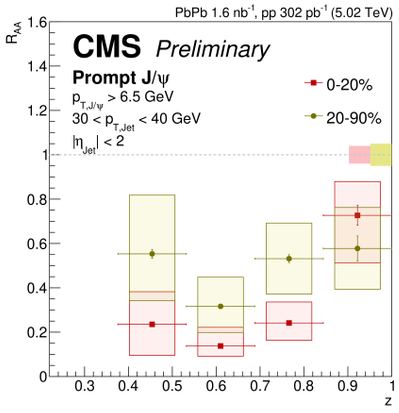


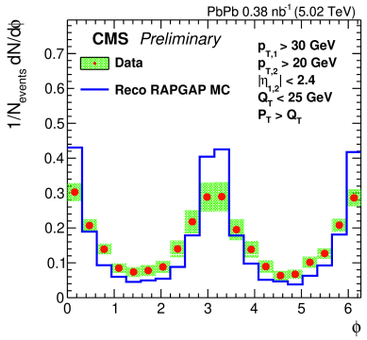


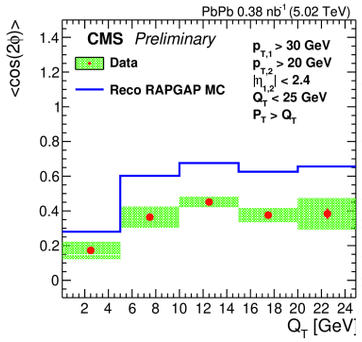


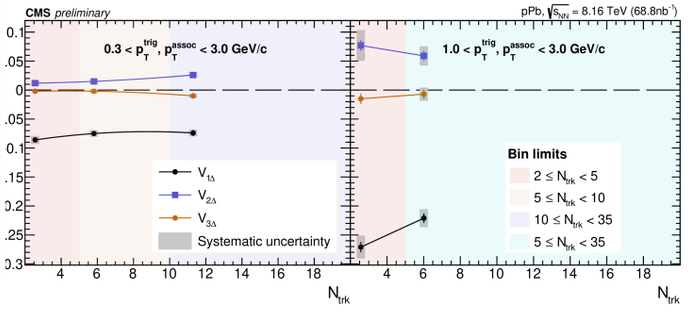




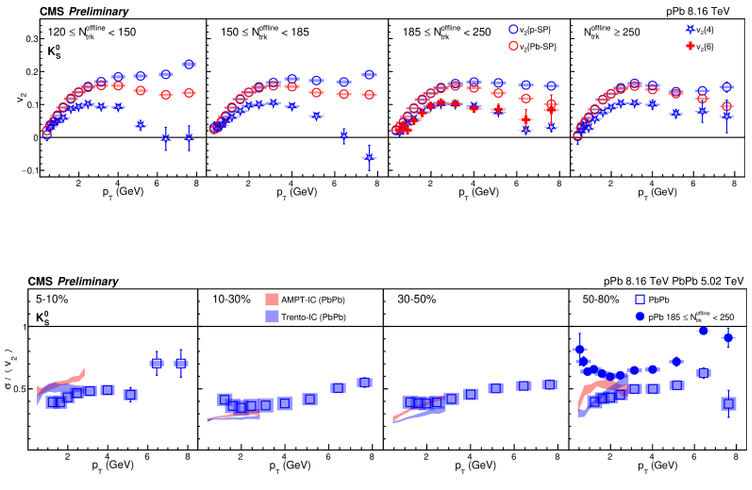


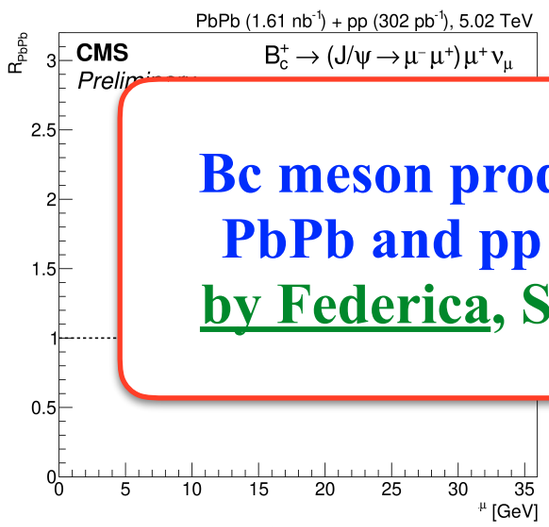


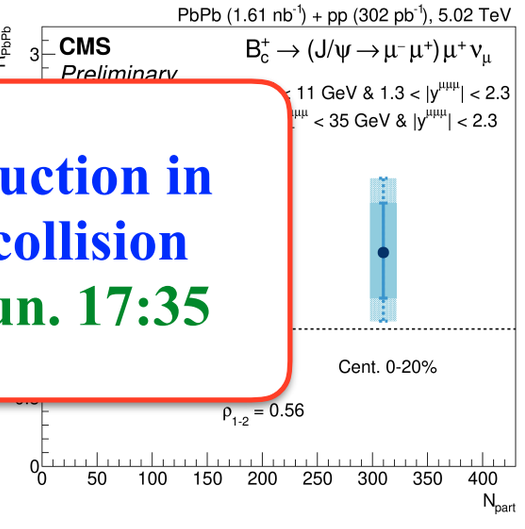




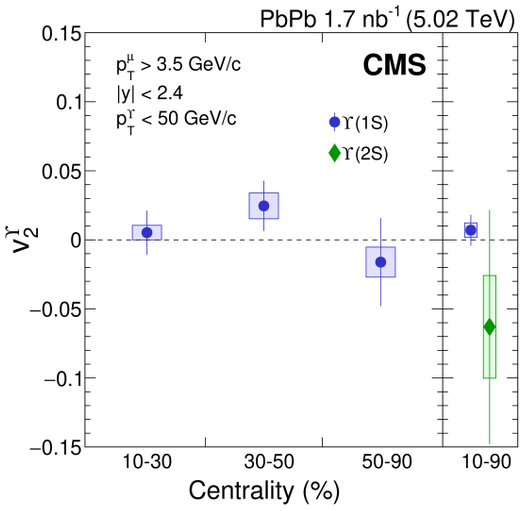
Recent heavy-ion results

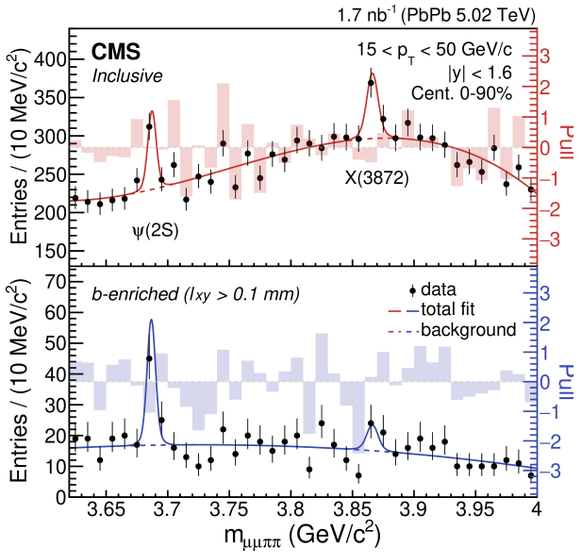


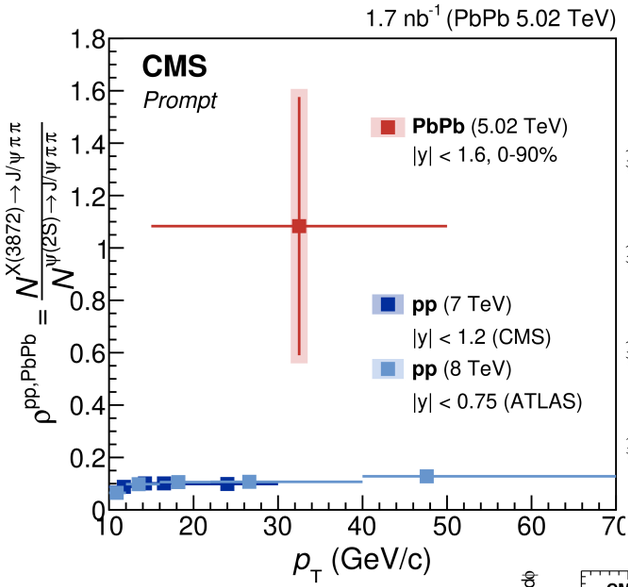


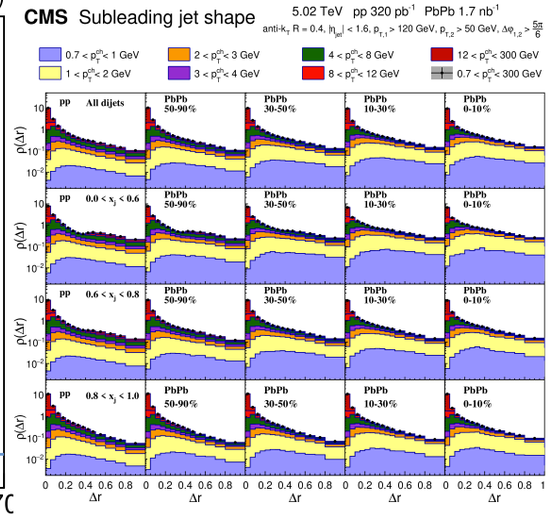


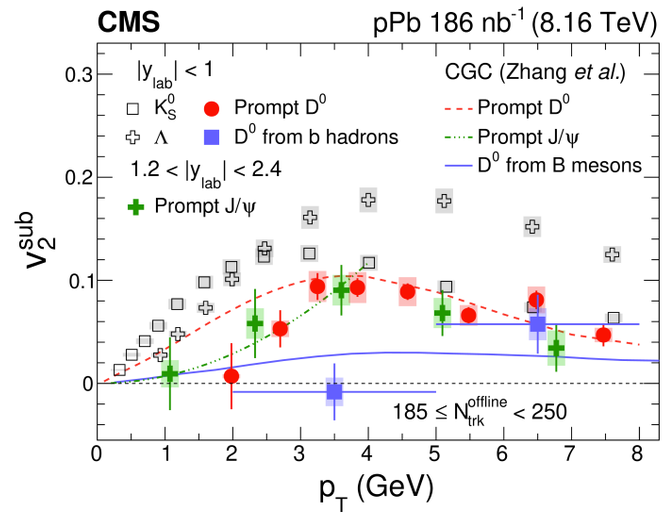
Bc meson production in PbPb and pp collision
by Federica, Sun. 17:35

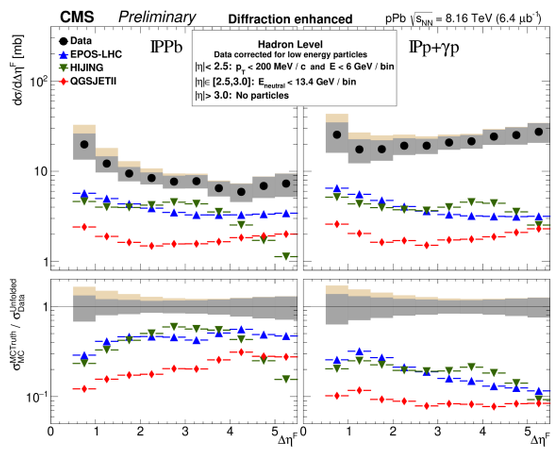


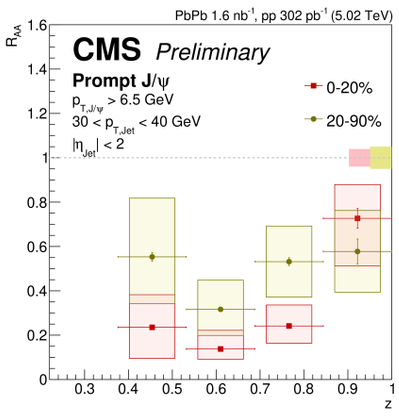


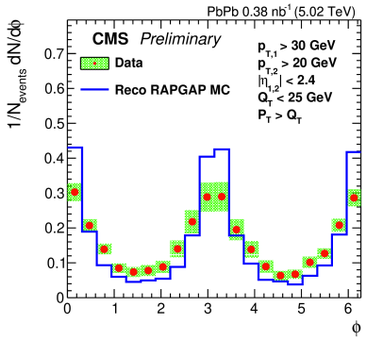


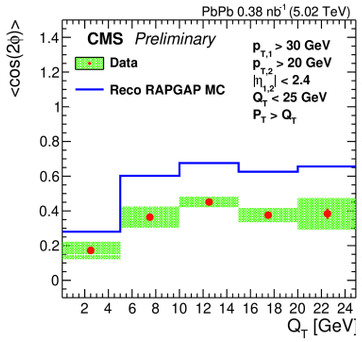


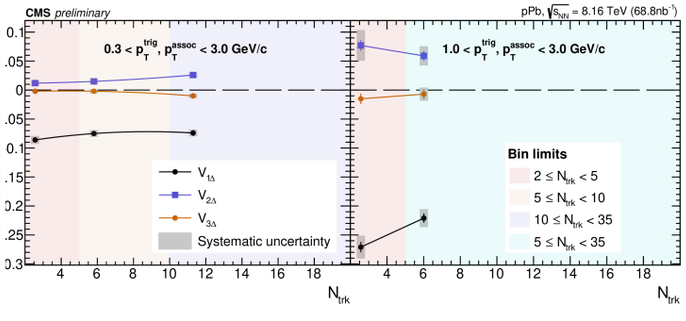




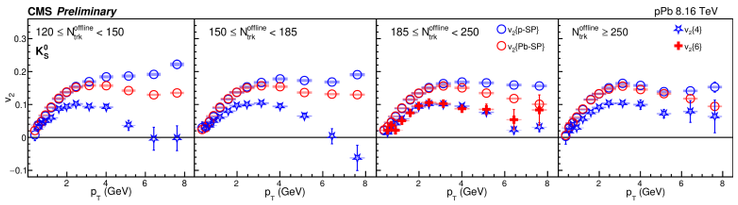


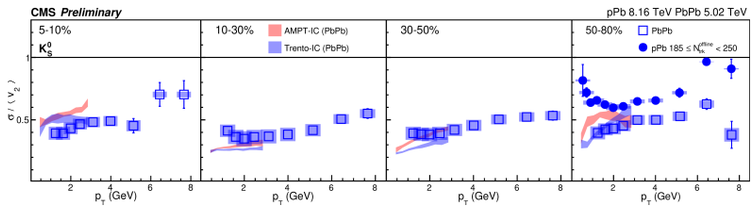


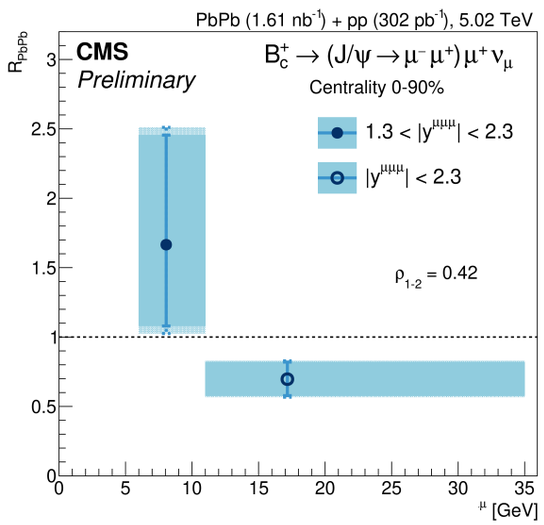


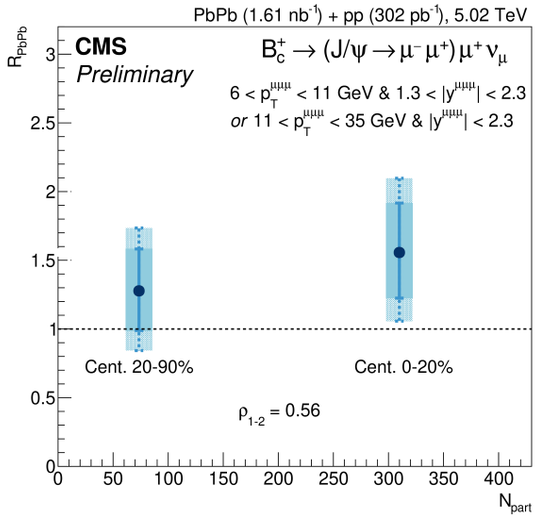


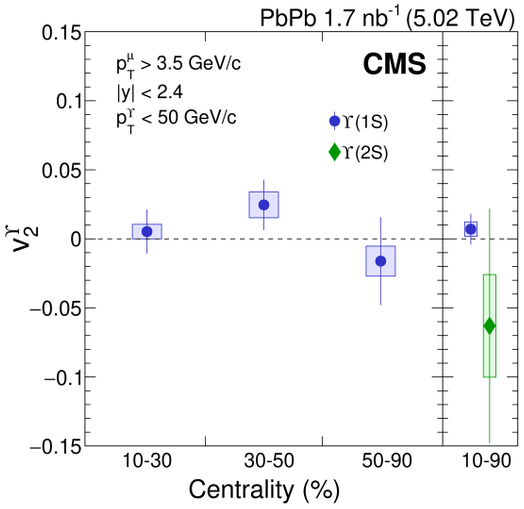
Recent heavy-ion results

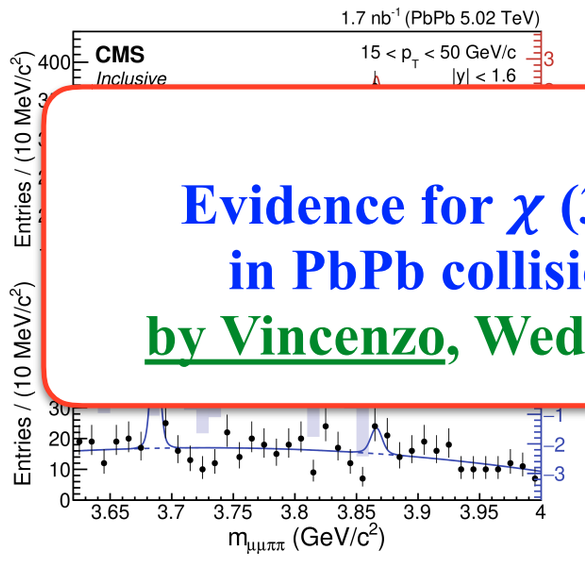




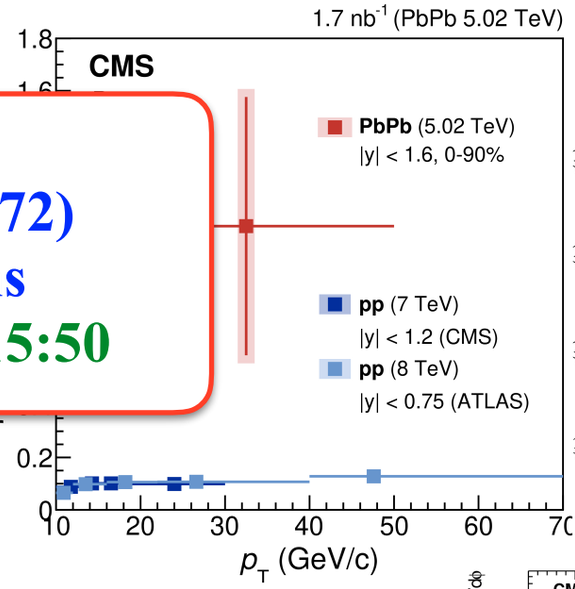


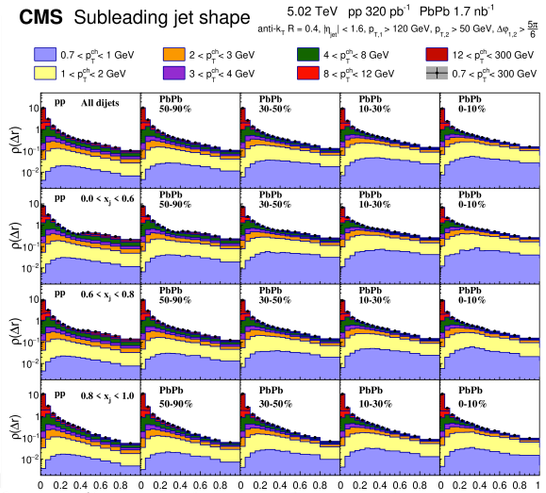


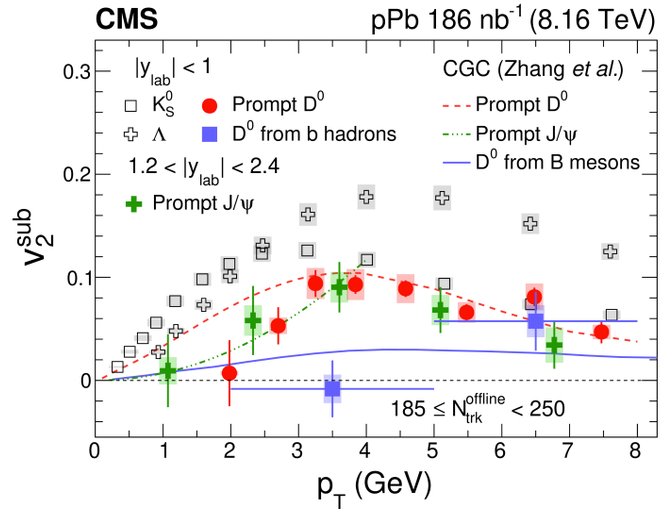


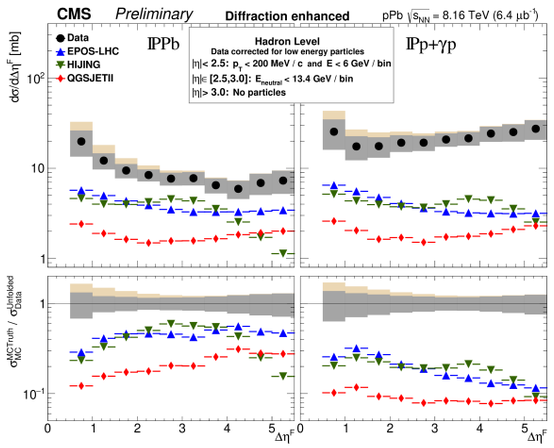


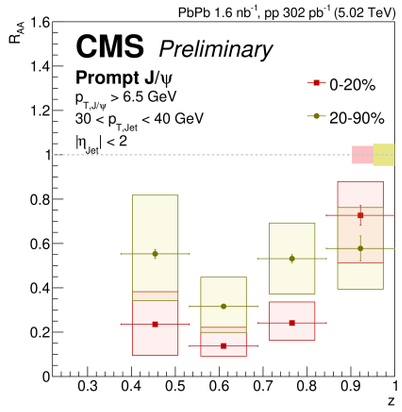
Evidence for χ (3872) in PbPb collisions
by Vincenzo, Wed. 15:50

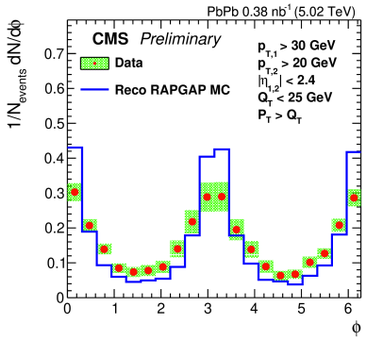


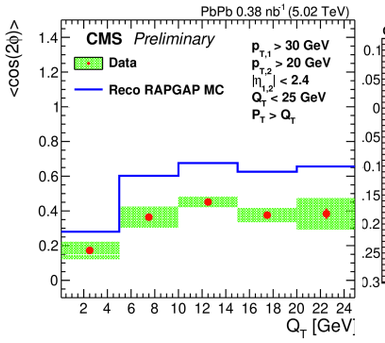


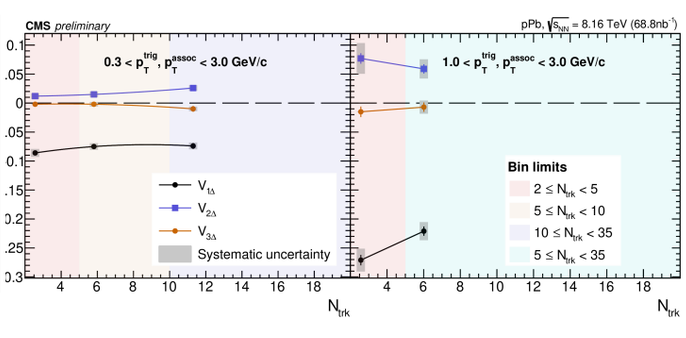




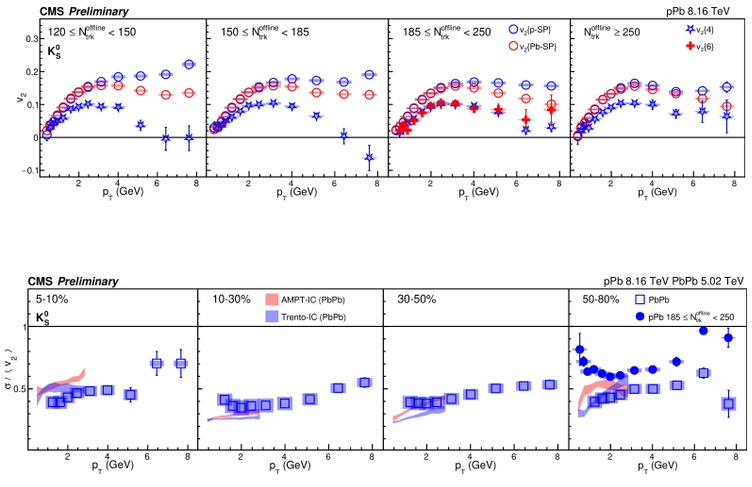


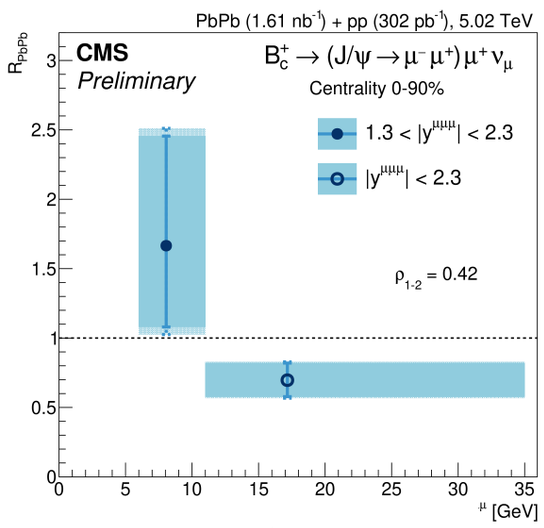


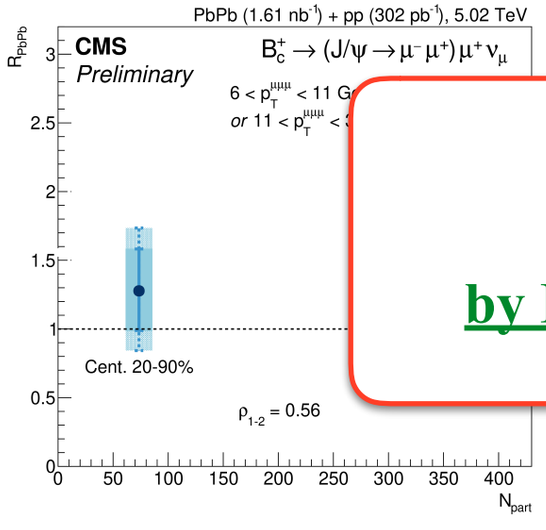


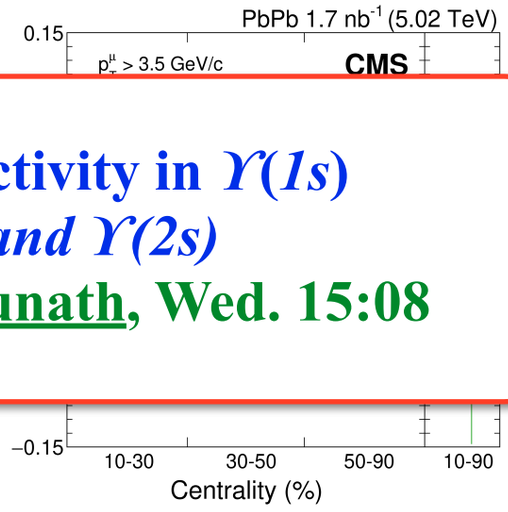


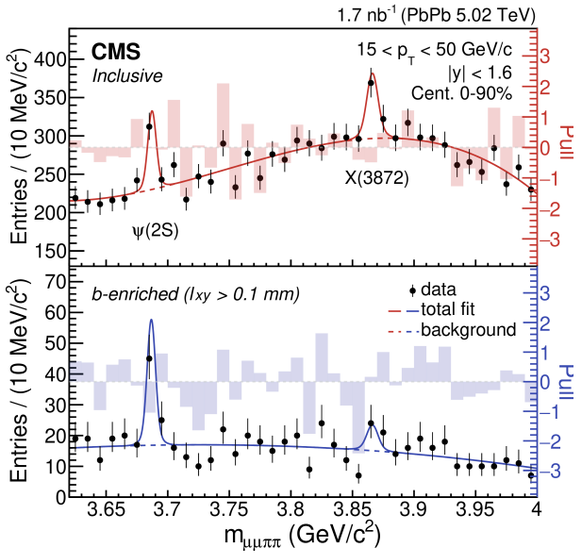
Recent heavy-ion results

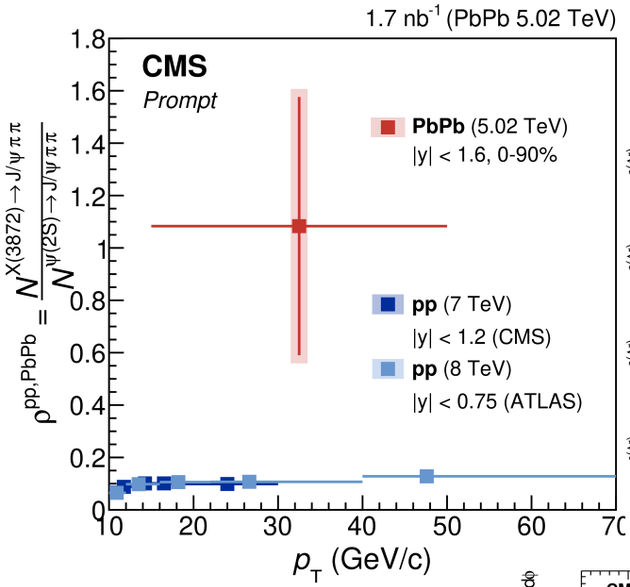


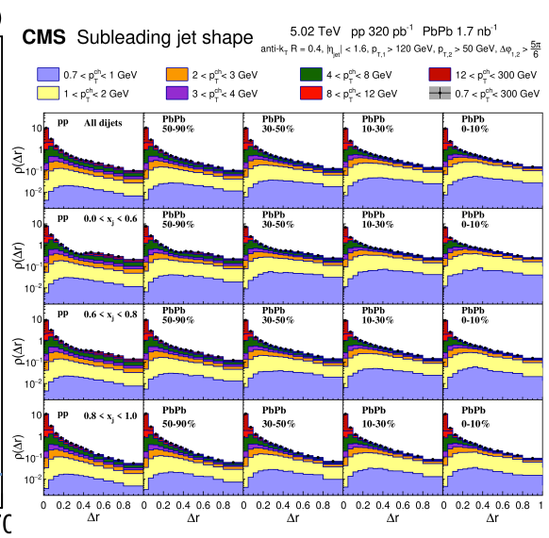


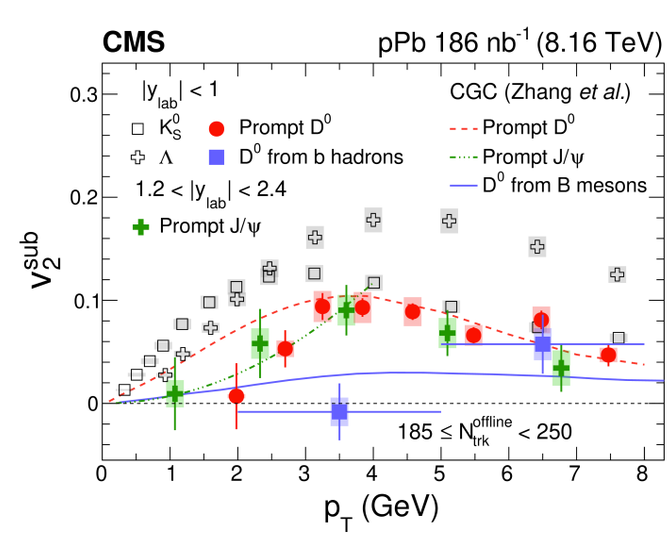


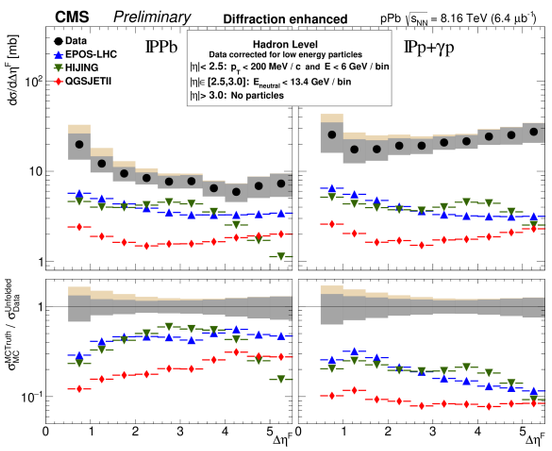


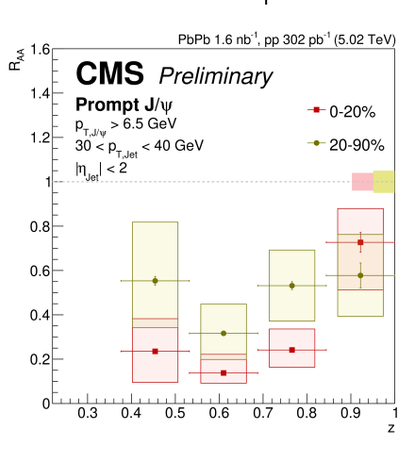


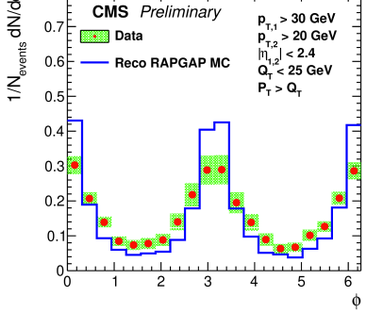


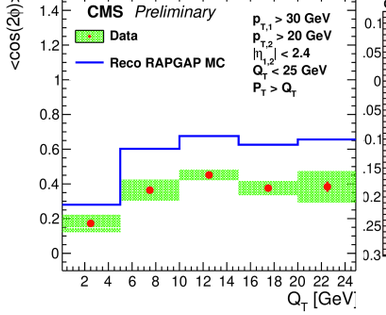


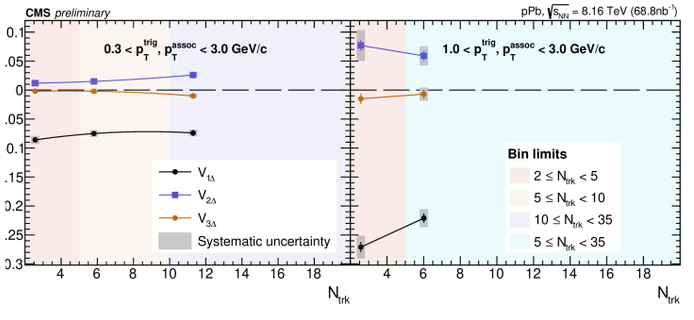












Collectivity in *Υ(1s)* *and Υ(2s)*
by Raghunath, Wed. 15:08

Outline

Intial state interaction :

- New constraints of initial states in PbPb collisions with Z boson yields and azimuthal anisotropy
- Search for strong electromagnetic fields in PbPb collisions via azimuthal anisotropy of D^0 and $\overline{D}^0$ mesons
- Forward neutron multiplicity dependence of dimuon acoplanarity in ultra-peripheral PbPb collisions

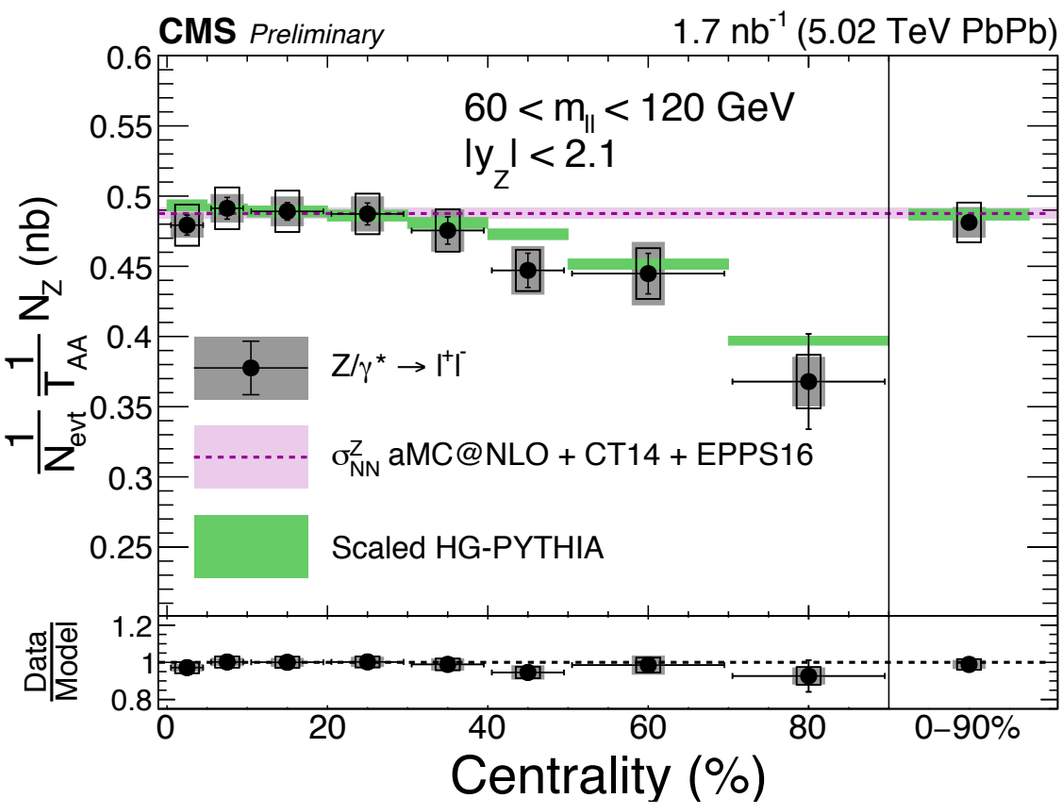
QGP medium effect:

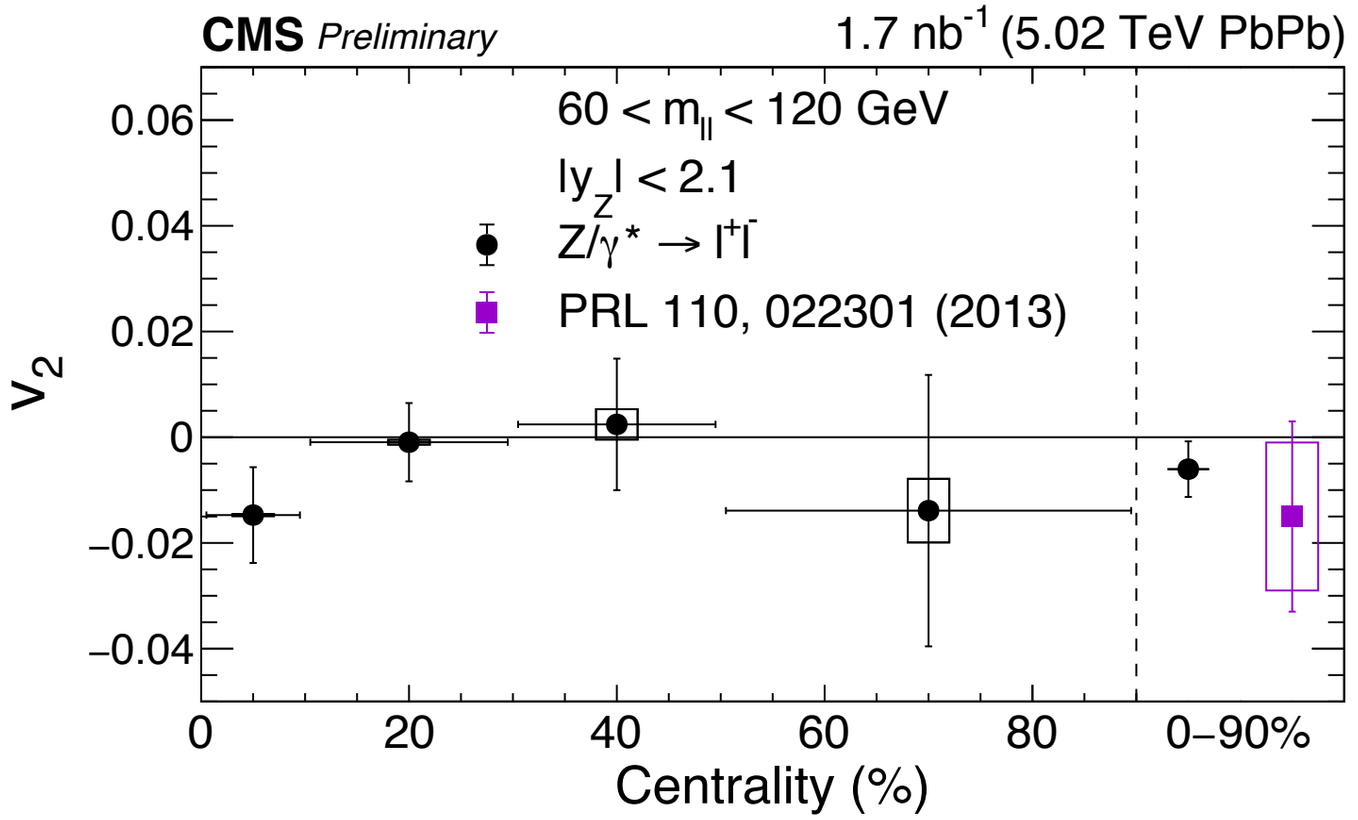
- First observation of B_s^0 in PbPb
- J/ψ meson within a Jet in PbPb and pp collisions
- Probing charm quark dynamics via multiparticle azimuthal correlations

Intial state interaction

Z boson yields and azimuthal anisotropy

Phys. Rev. Lett. 127, 102002





High precision

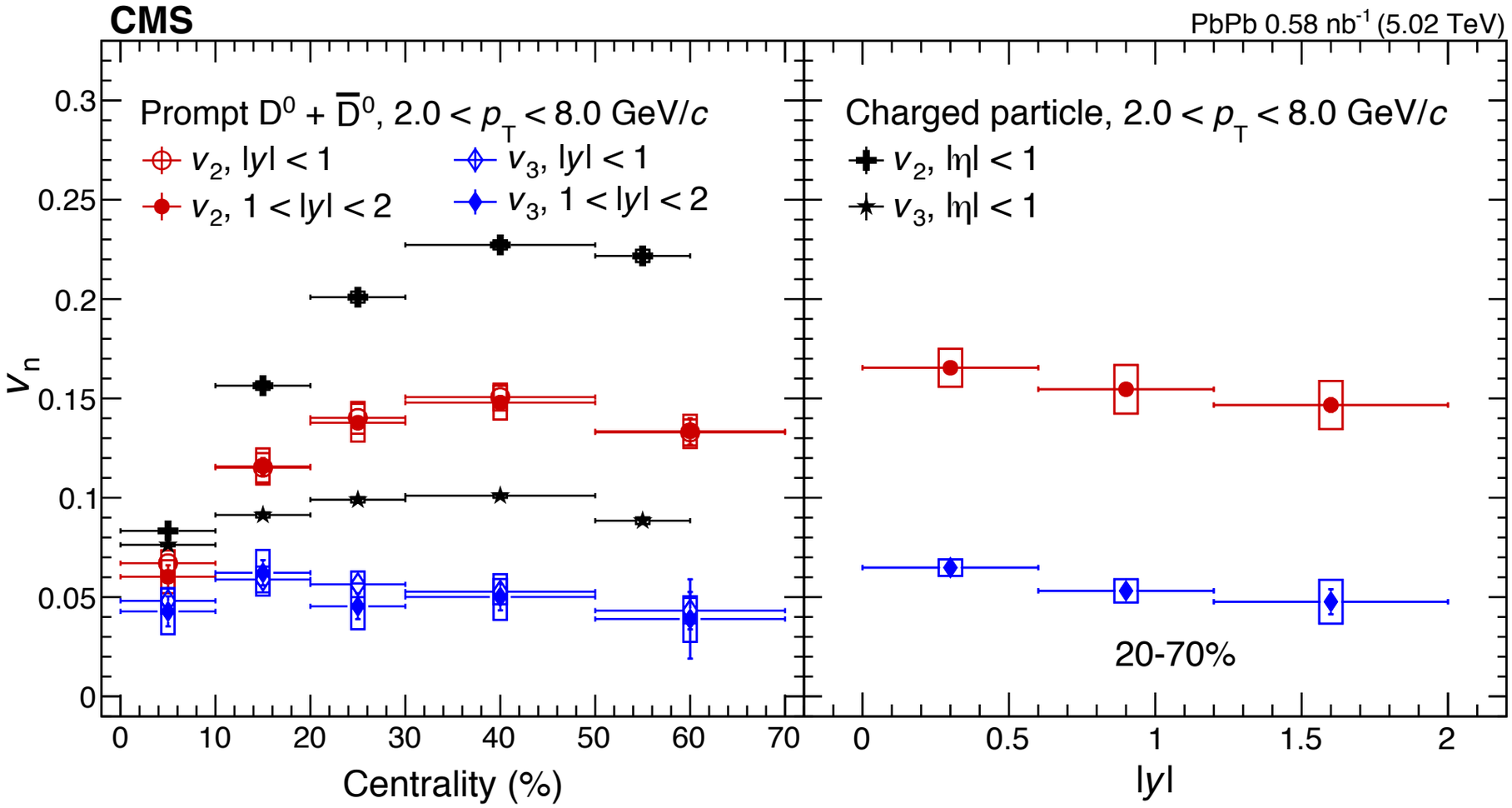
Indicates the presence of initial collision geometry

- The Z boson azimuthal anisotropy (v_2) is compatible with zero within the uncertainties.

Azimuthal anisotropy of D^0 and $\bar{D}^0$ mesons

v_2 & v_3 as function of Centrality and Rapidity

PLB 816 (2021) 136253



Weak dependence observed

- Clear dependence of v_2 as function of centrality
- v_3 is almost constant with centrality
- v_n trends understood in terms of collision geometry
- Slight tendency to lower values at larger rapidities

$\Delta V_2(D^0 - \bar{D}^0)$ as a Function of Rapidity

Electric field generates non-zero Δv_2

- Predictions for charged hadrons at LHC energies:

$\Delta v_2 \sim 0.001$ [Phys. Rev.C 98, 055201 (2018)]

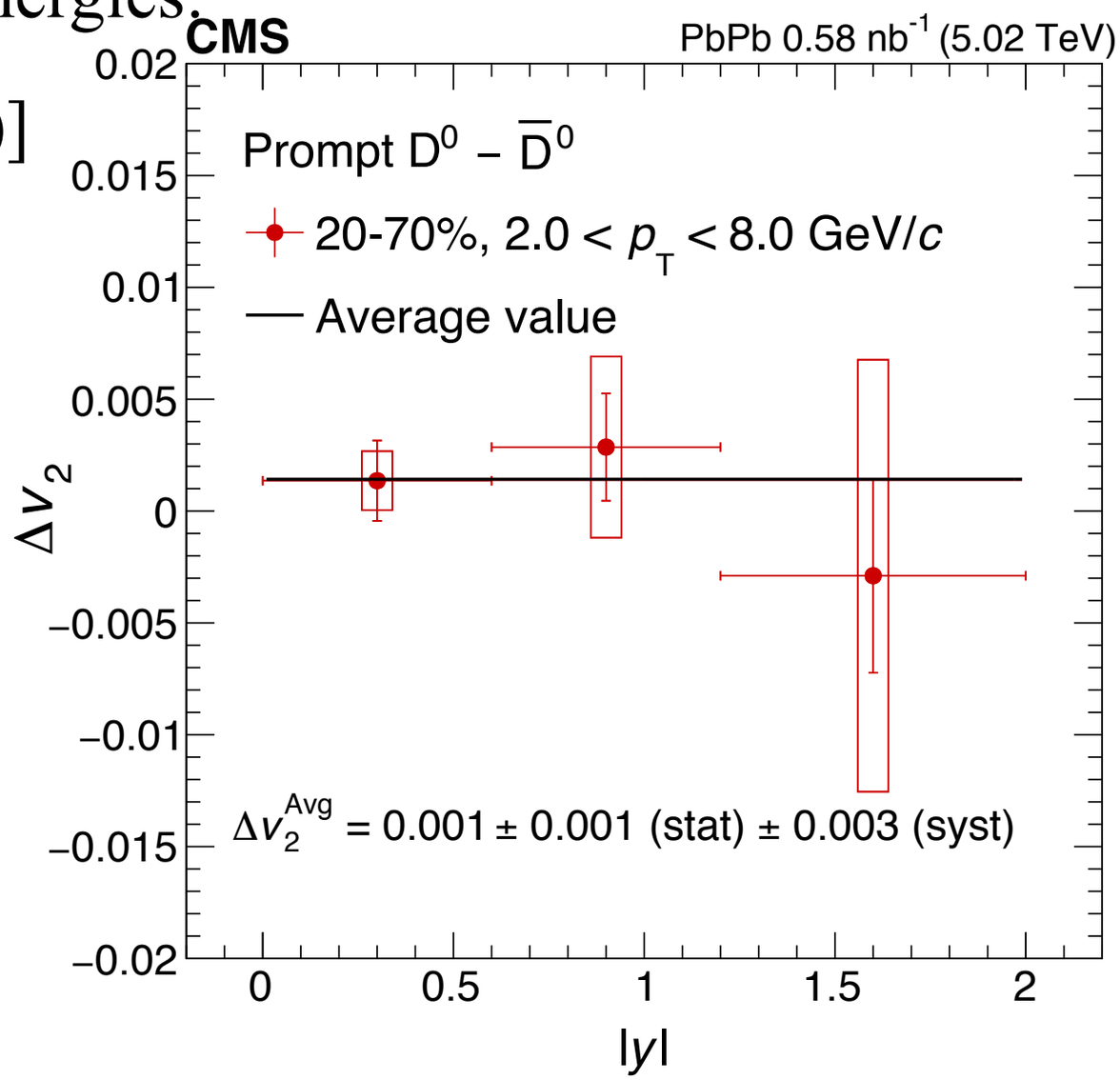
- Bigger values expected for D^0

  [Phys. Rev.C 98, 055201 (2018)]

- Rapidity average value extracted with fit

$\langle \Delta v_2 \rangle = 0.001 \pm 0.001\ (\text{stat}) \pm 0.003\ (\text{syst})$

- Experiment shows consistent results for D^0 and $\bar{D}^0$ with charge hadron



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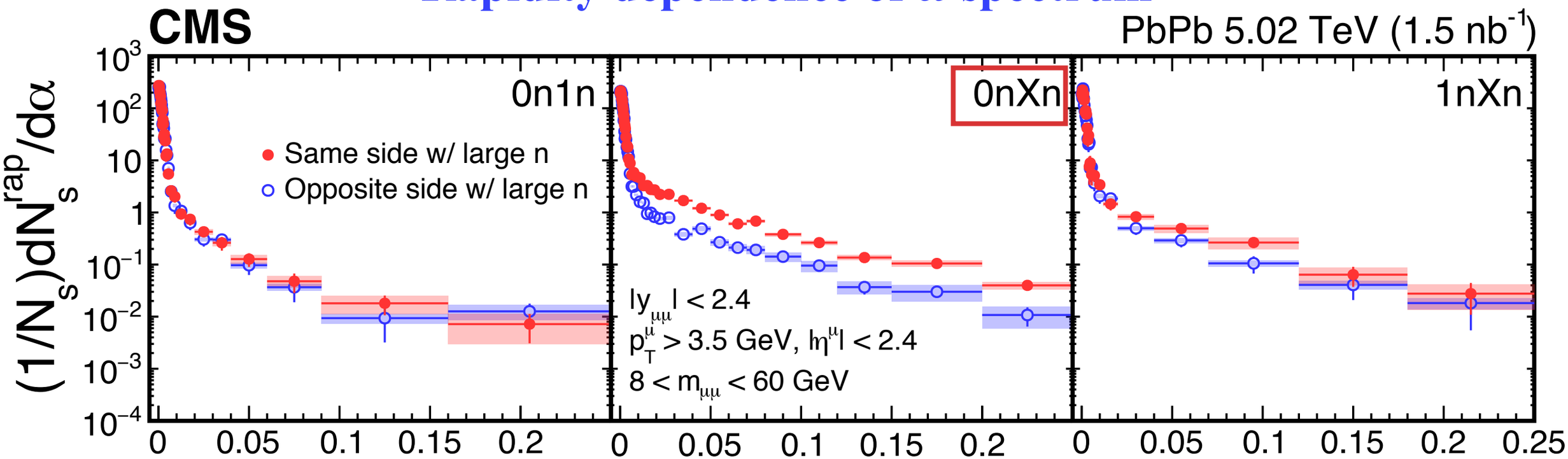
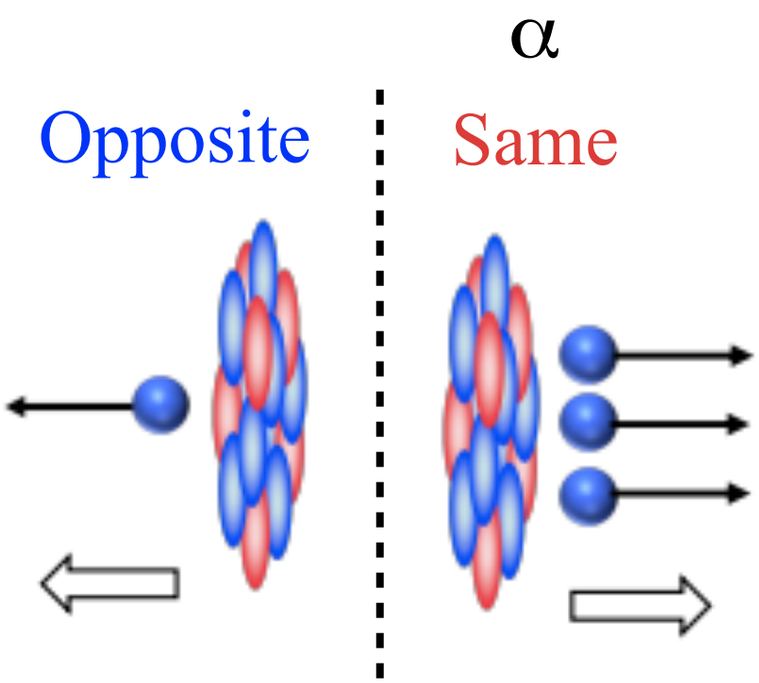
Dimuon acoplanarity in UPC PbPb

Rapidity dependence of α spectrum





0n0n (fewer neutrons) ⇒ XnXn (more neutrons)

- In 0nXn, the tail contribution

☞ Same y hemisphere > Opposite y hemisphere

Accepted by PRL : arXiv:2011.05239

$\langle \alpha^{\text{core}} \rangle$ vs. neutron multiplicity

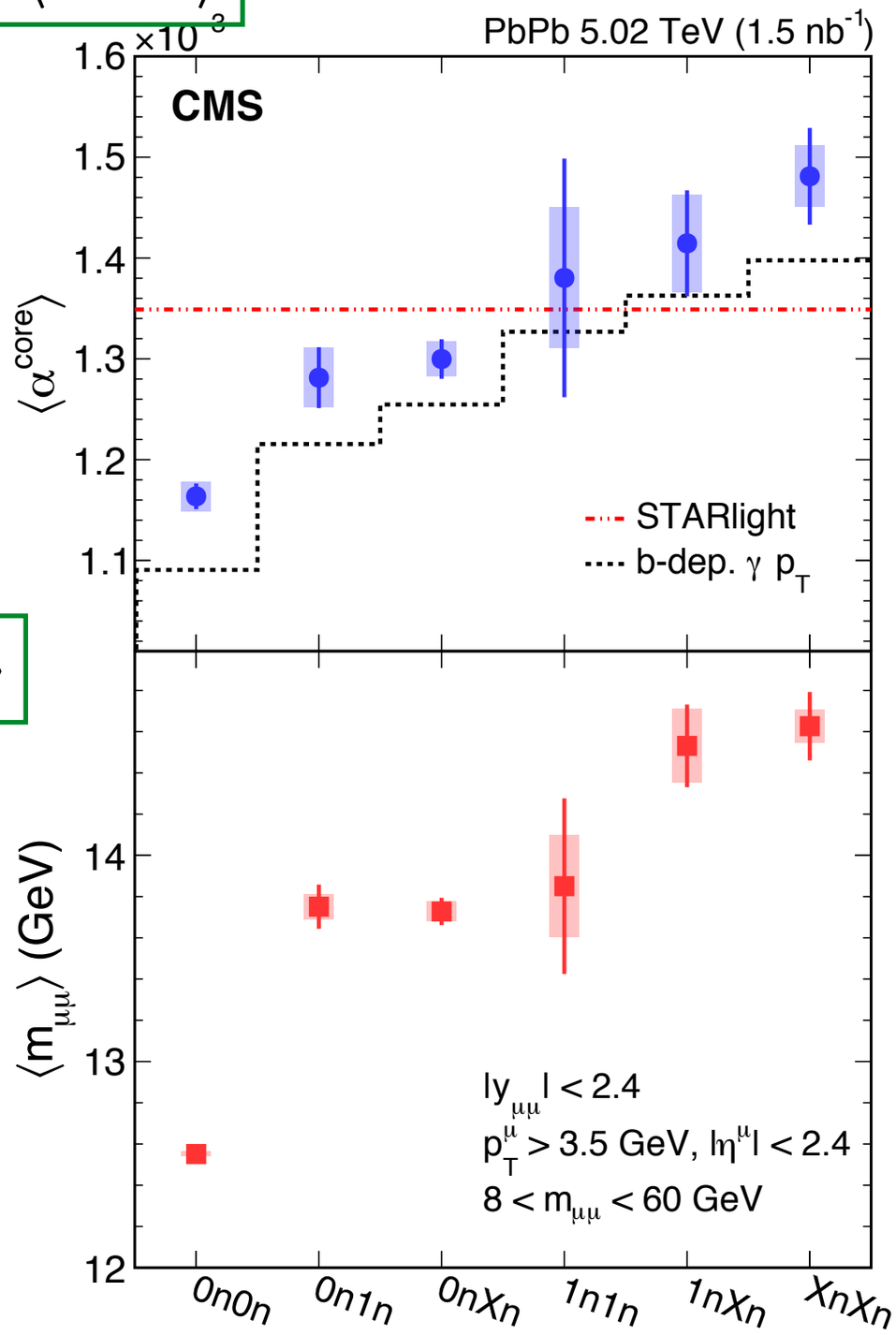
Strong (5.7σ)neutron multiplicity dependence of $\langle \alpha^{\text{core}} \rangle$

- ☞ *b* dependence of initial photon p_T
- ☞ Qualitatively described by a leading order QED model

Strong neutron multiplicity dependence of $\langle m_{\mu\mu} \rangle$

- ☞ Deviation from constant: » 5**σ**
- ☞ *b* dependence of initial photon energy

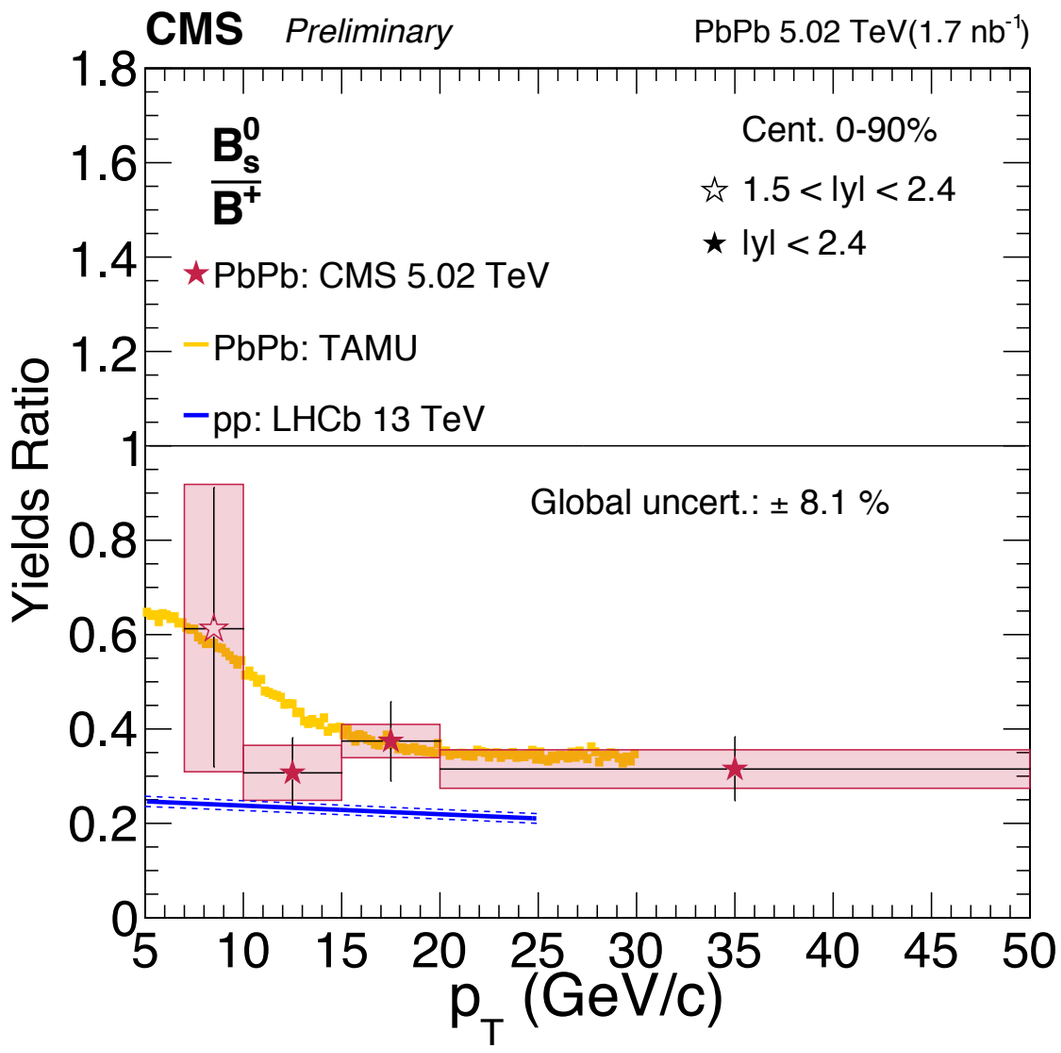
Accepted by PRL : arXiv:2011.05239

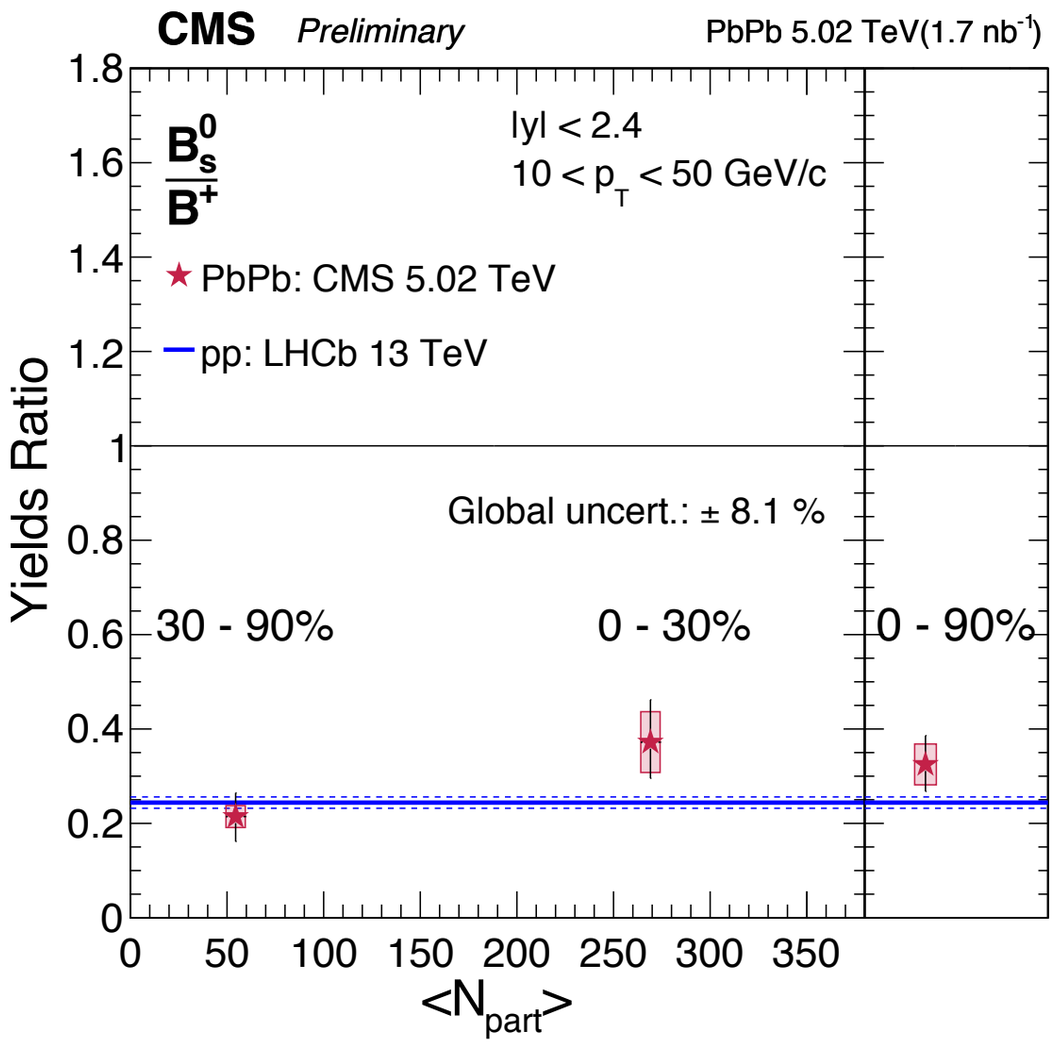


QGP medium effect

Ratio of B_s^0 & B^+ Vs p_T & $<N_{part}>$

CMS-PAS-HIN-19-011

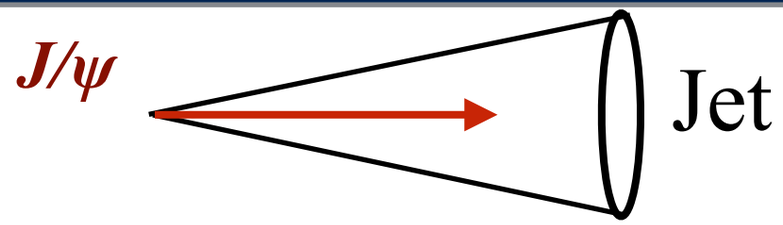




- Strangeness enhancement in PbPb may increase the yield of B_s^0
- Ratio of B_s^0 / B^+ is similar in PbPb & pp collisions.

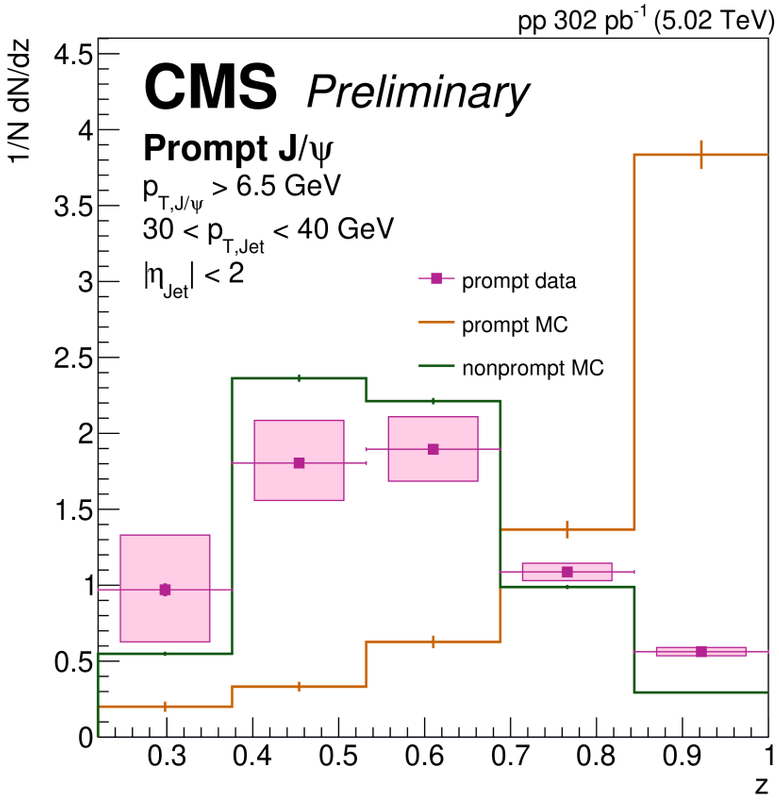
J/Ψ within jets

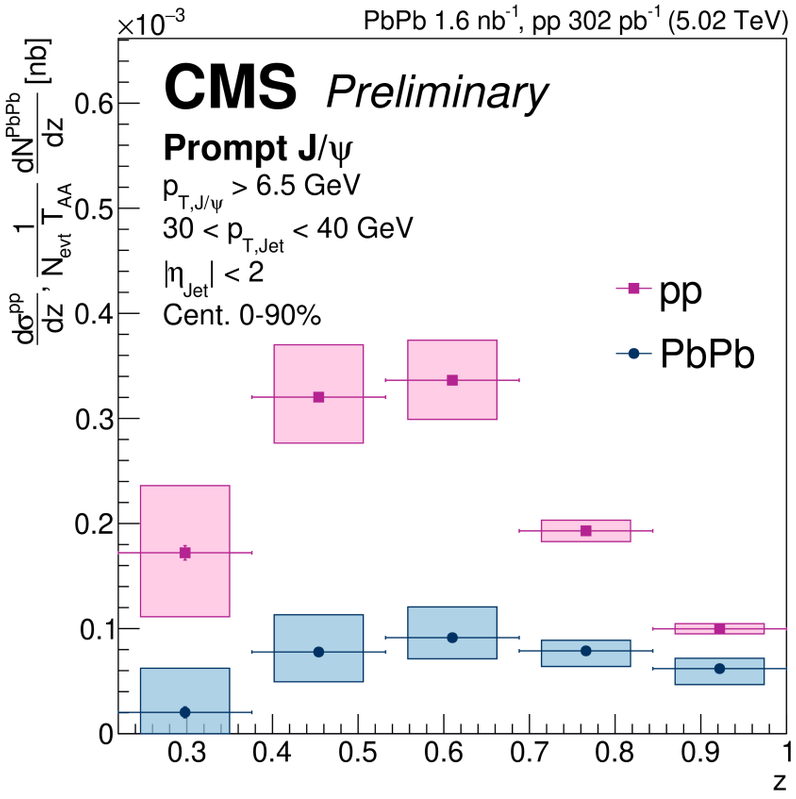
arXiv:2106.13235

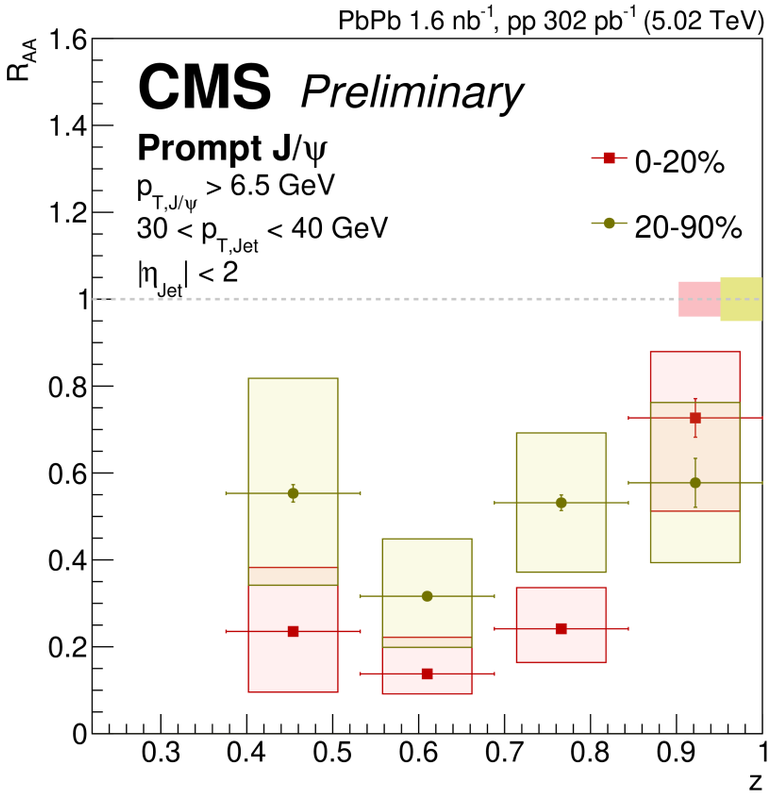


$$Z = \frac{J/\psi}{\text{Jet}}$$

pp

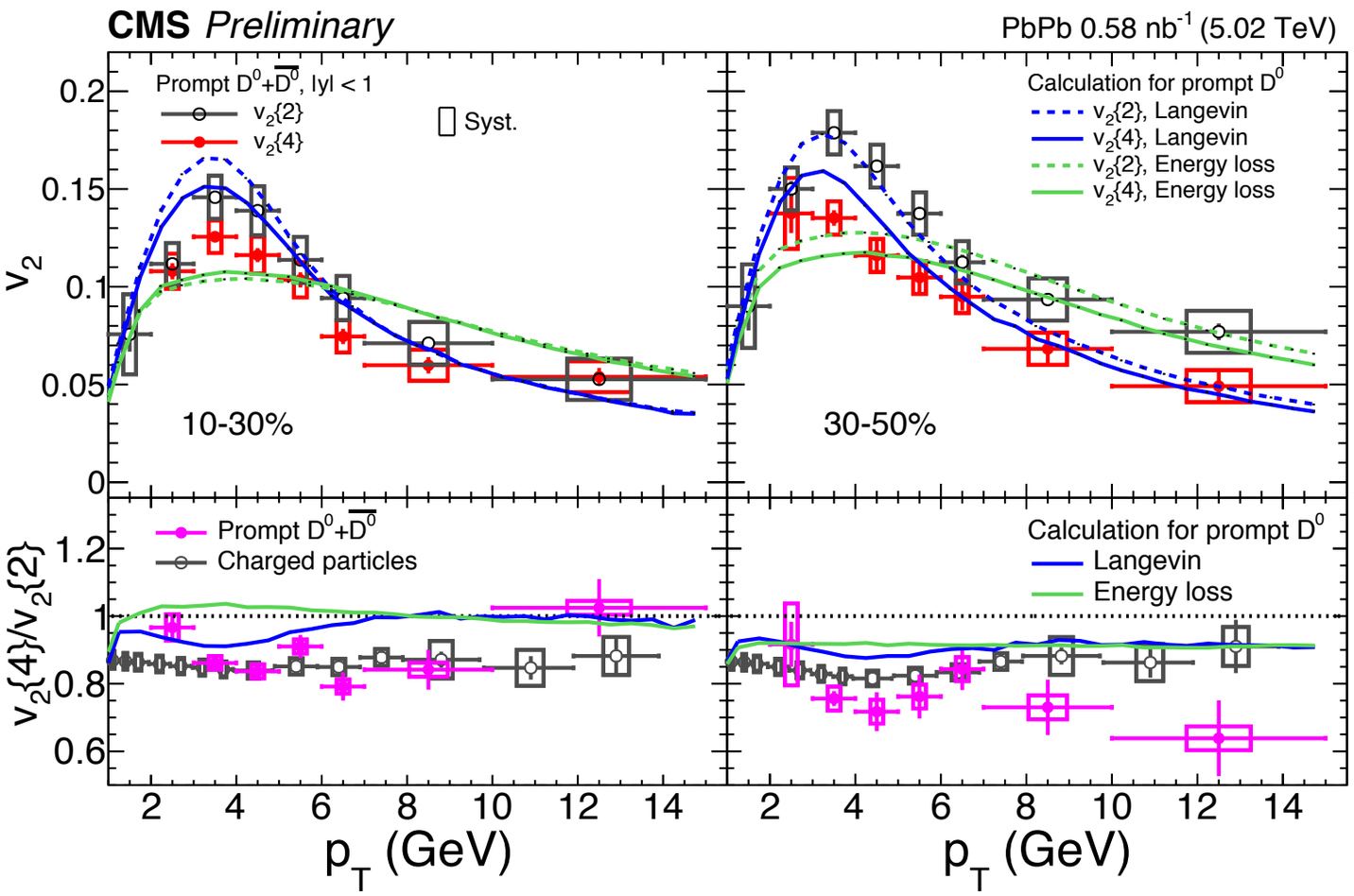






- Connected to quenching and hot nuclear effect in PbPb
- *J/Ψ* within the jets are more suppressed in central collision

Probing charm quark dynamics via azimuthal correlations



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Barrel region: |y| < 1

- $v_2\{4\} < v_2\{2\}$
  - ☞ azimuthal anisotropies are affected by the initial state geometry and it is by EbyE fluctuation
- $v_2\{4\}(D^0) < v_2\{2\}(D^0)$ ratio are consistent with those for the charged particles
  - ☞ suggests soft processes are dominant.

Probing charm quark dynamics via azimuthal correlations

- $v_2\{4\}$ increases from the most central to mid-central events and decreases toward the peripheral events.

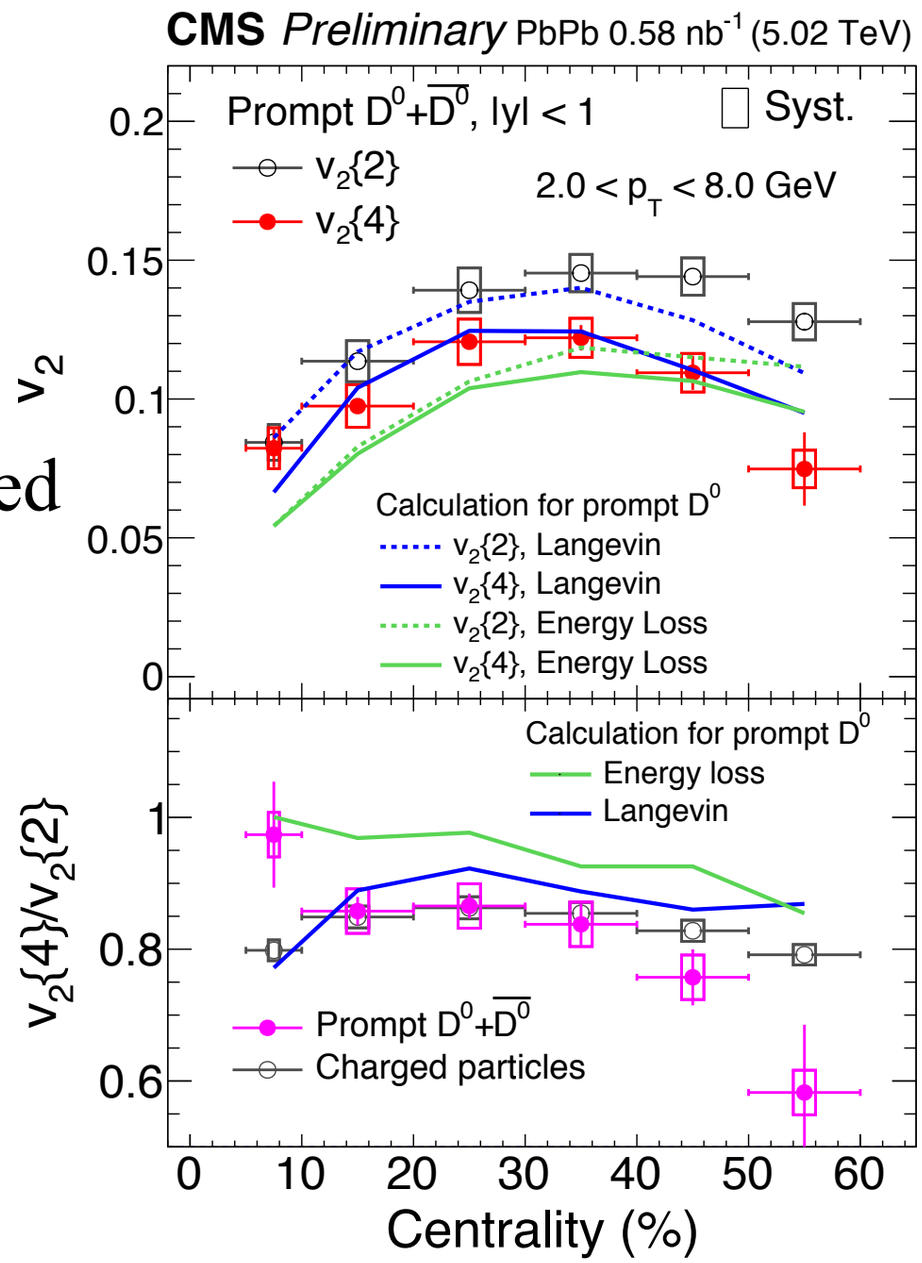
  ☞ This trend can be explained by the initial state geometry .

- D^0 $v_2\{4\}$(cent.) / D^0 $v_2\{2\}$(cent.) are compared to those charged particles.

  ☞ This indicates splitting between the D^0 mesons and charged particles in the most central and peripheral events

  ☞ Hard fluctuation effect visible from charm mesons

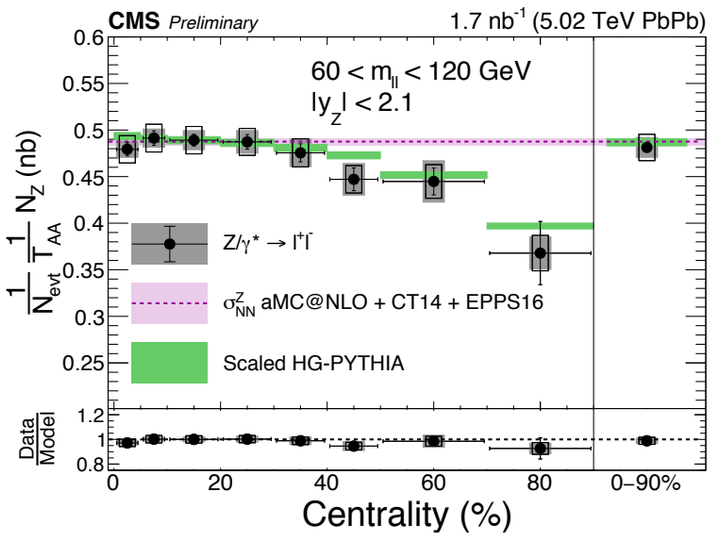
Barrel region: |y| < 1



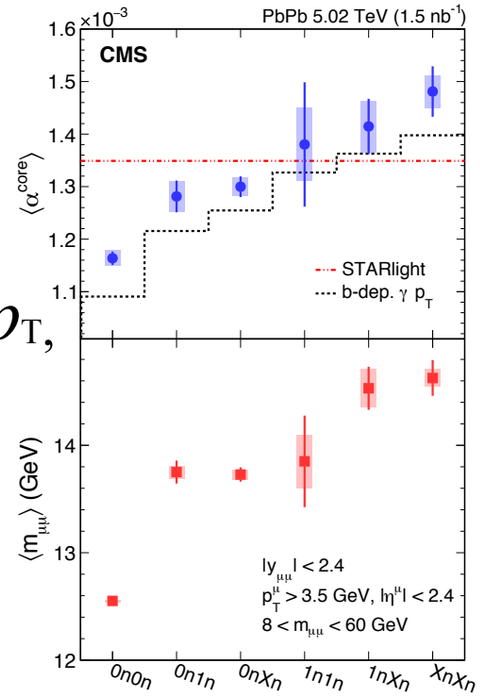
CMS-PAS-HIN-20-001

Summary

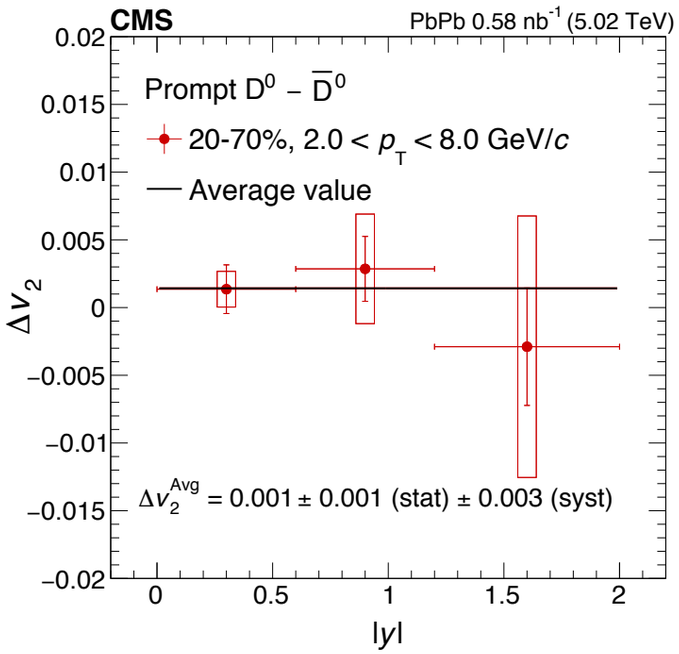
Probing Initial state effect:

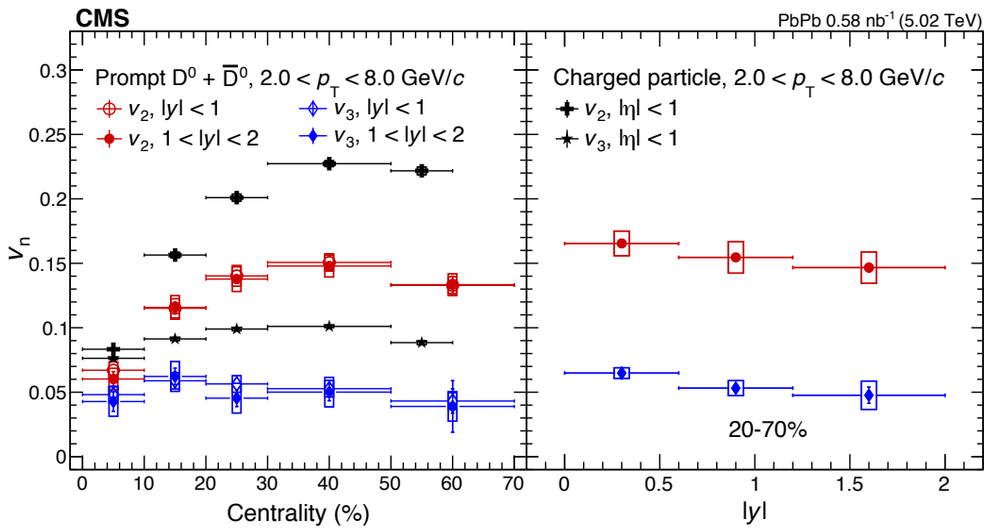


- *b* dependence of initial photon p_T, photon energy



- Indicates the presence of initial collision geometry

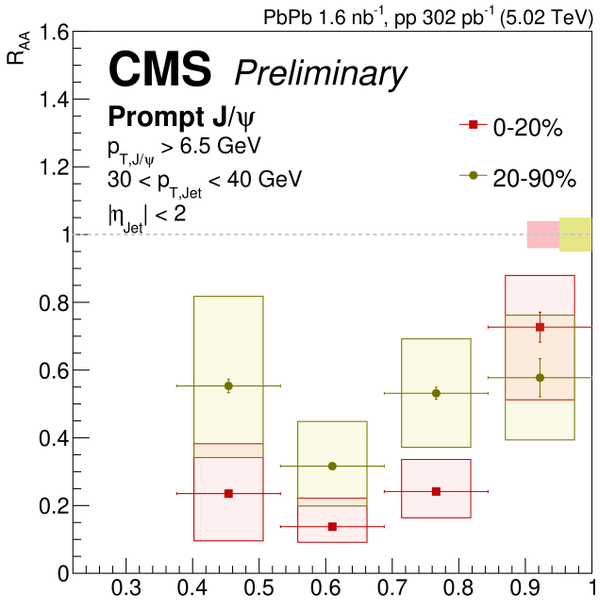


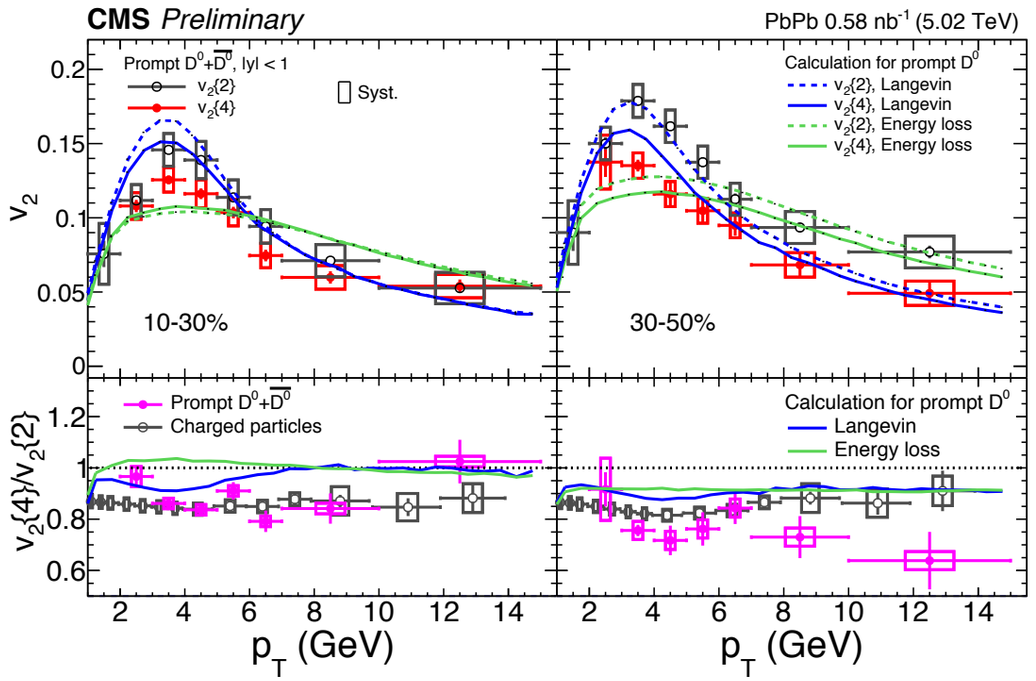


- v_n trends understood in terms of collision geometry
- Constrain medium properties: electric conductivity

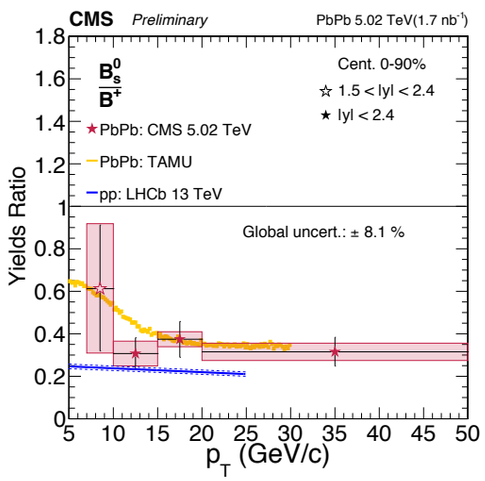
Summary

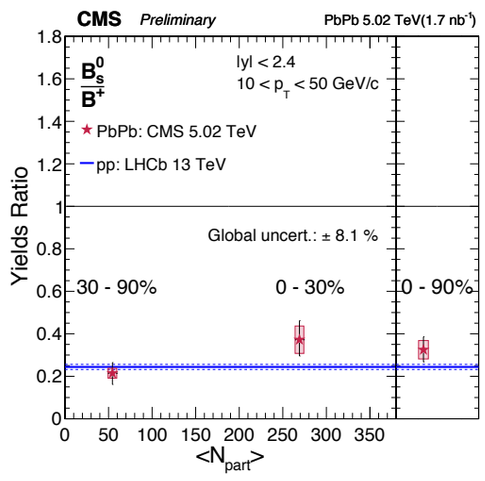
Probing QGP medium effect :





- *J/Ψ* in the jets more suppressed in central





- Suggests soft processes are dominant
- Azimuthal anisotropies are affected by the initial state geometry

- Ratio of B_s^0 / B^+ is similar in PbPb & pp collisions.

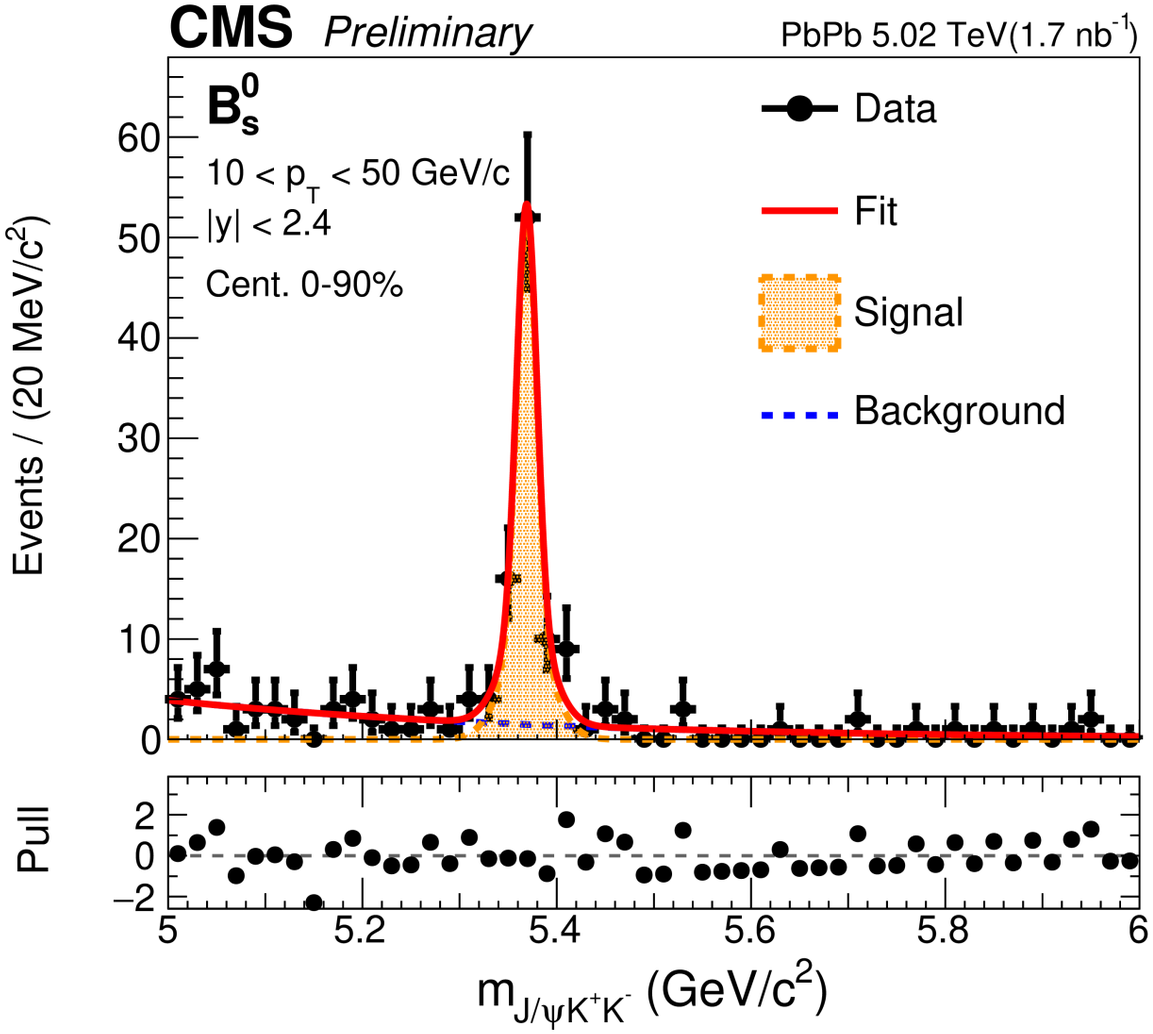
Thank you!

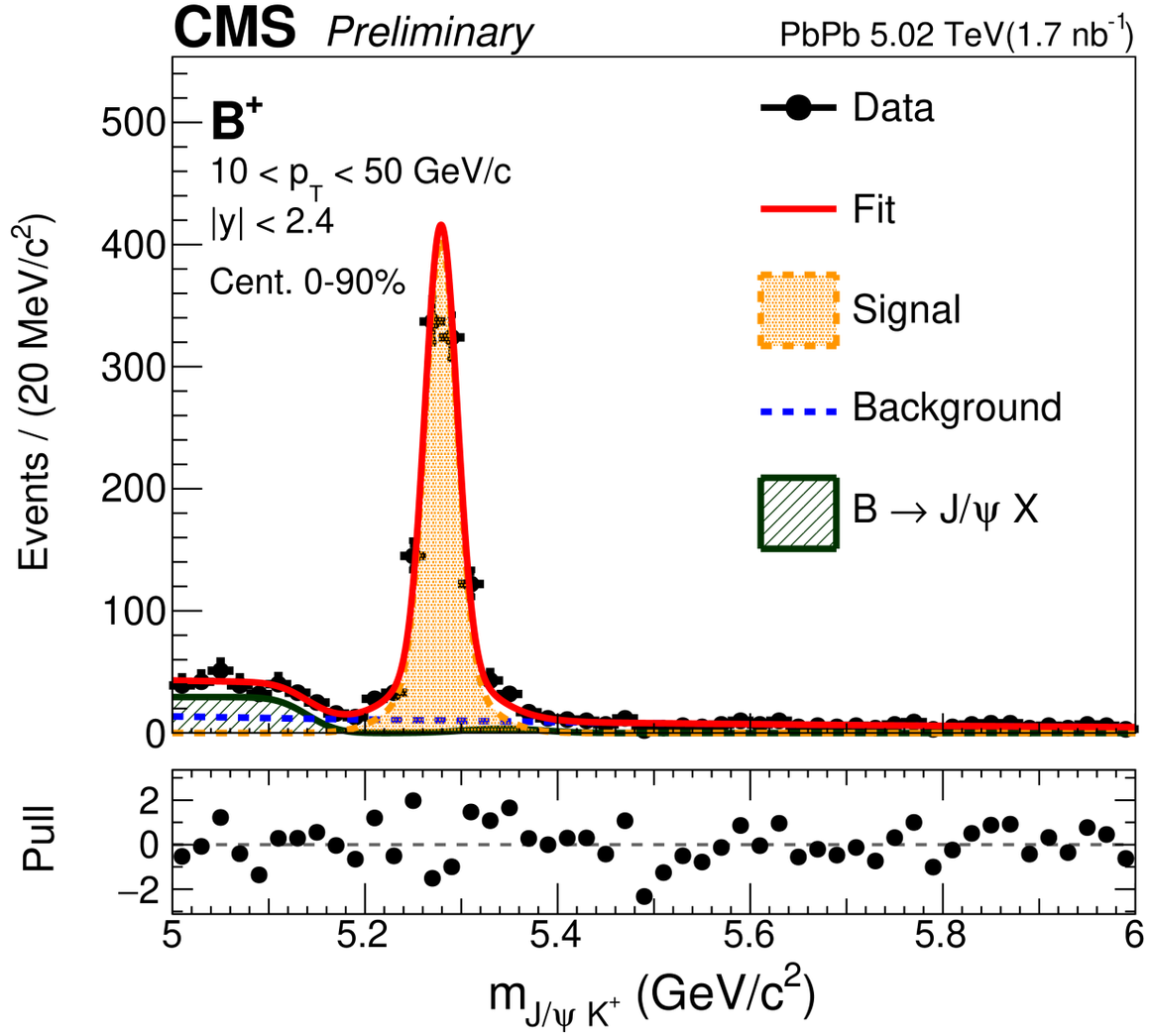
All CMS results: https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsHIN

Backup

First observation of B_s^0 in PbPb

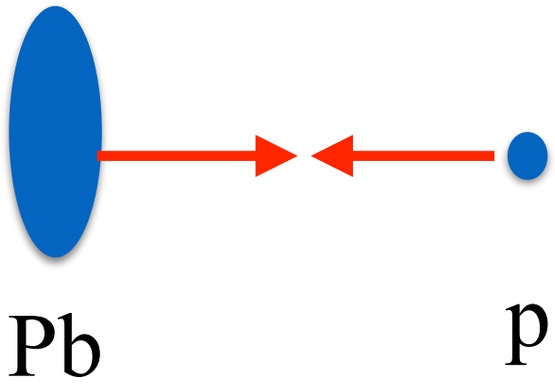
CMS-PAS-HIN-19-011





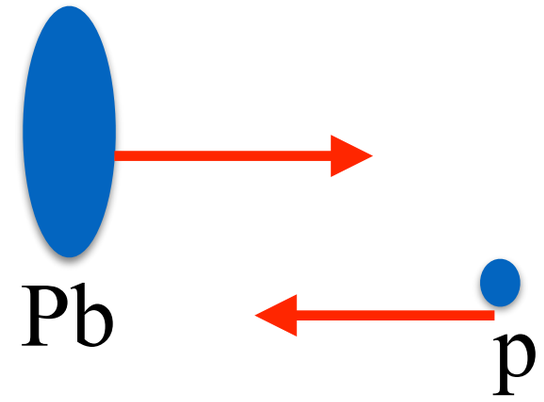
- Strangeness enhancement in PbPb may increase the yield of B_s^0

Two particle correlation in UPC pPb

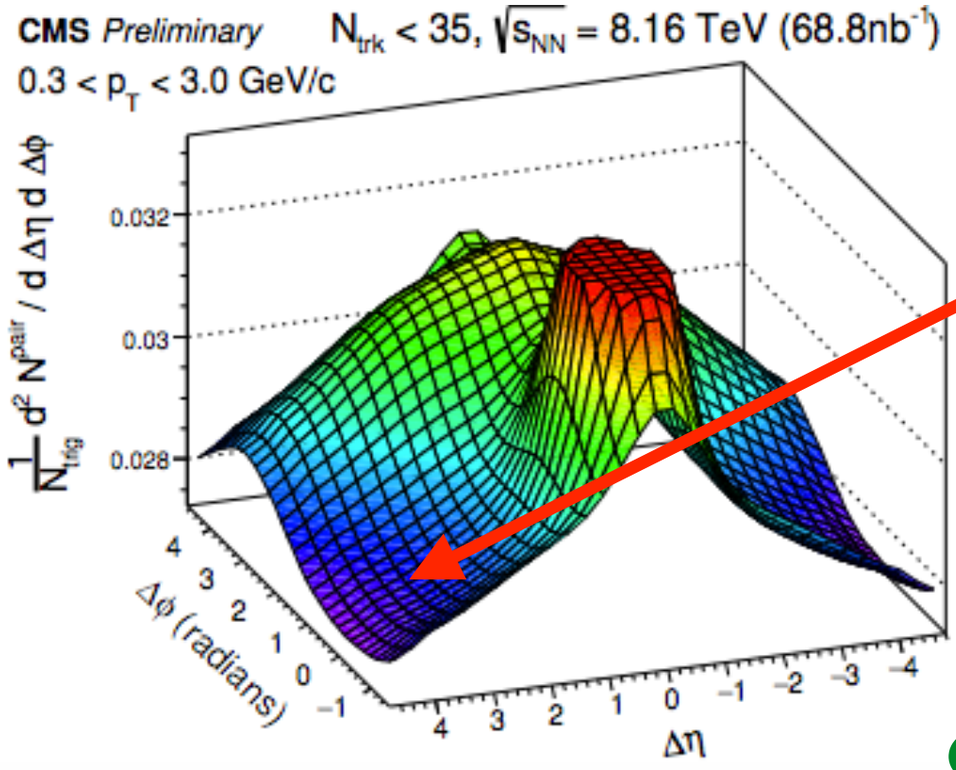


Minmum Bias

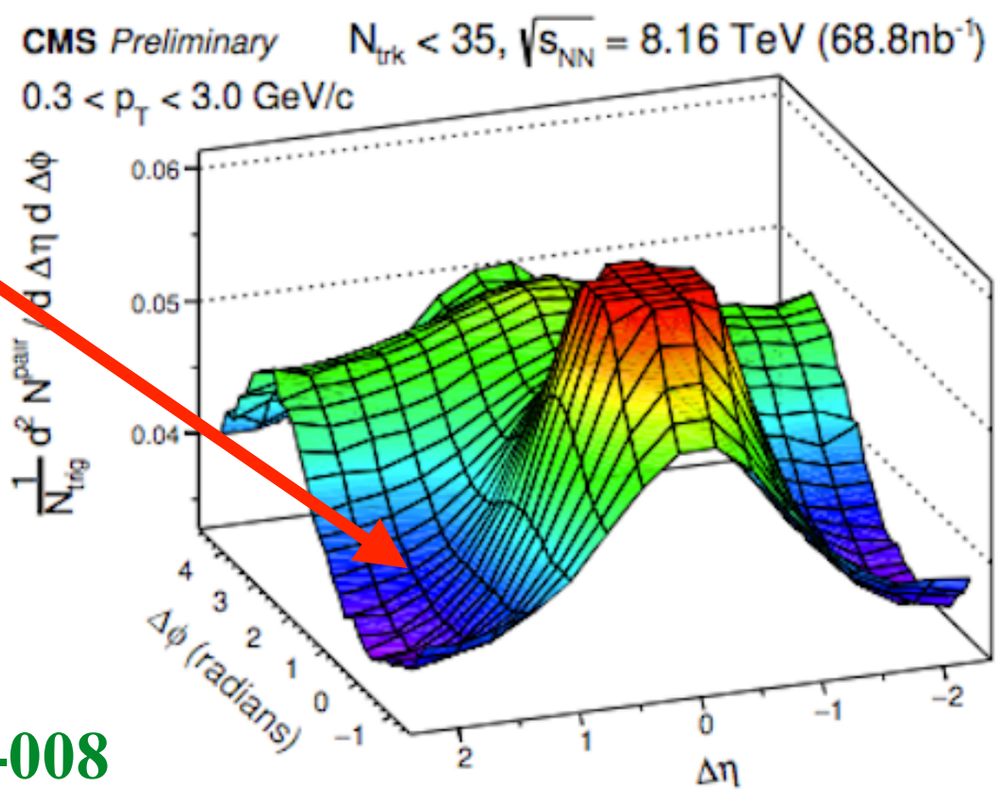
Correlation in smaller system



γp enhanced



No evidence of ridge structure

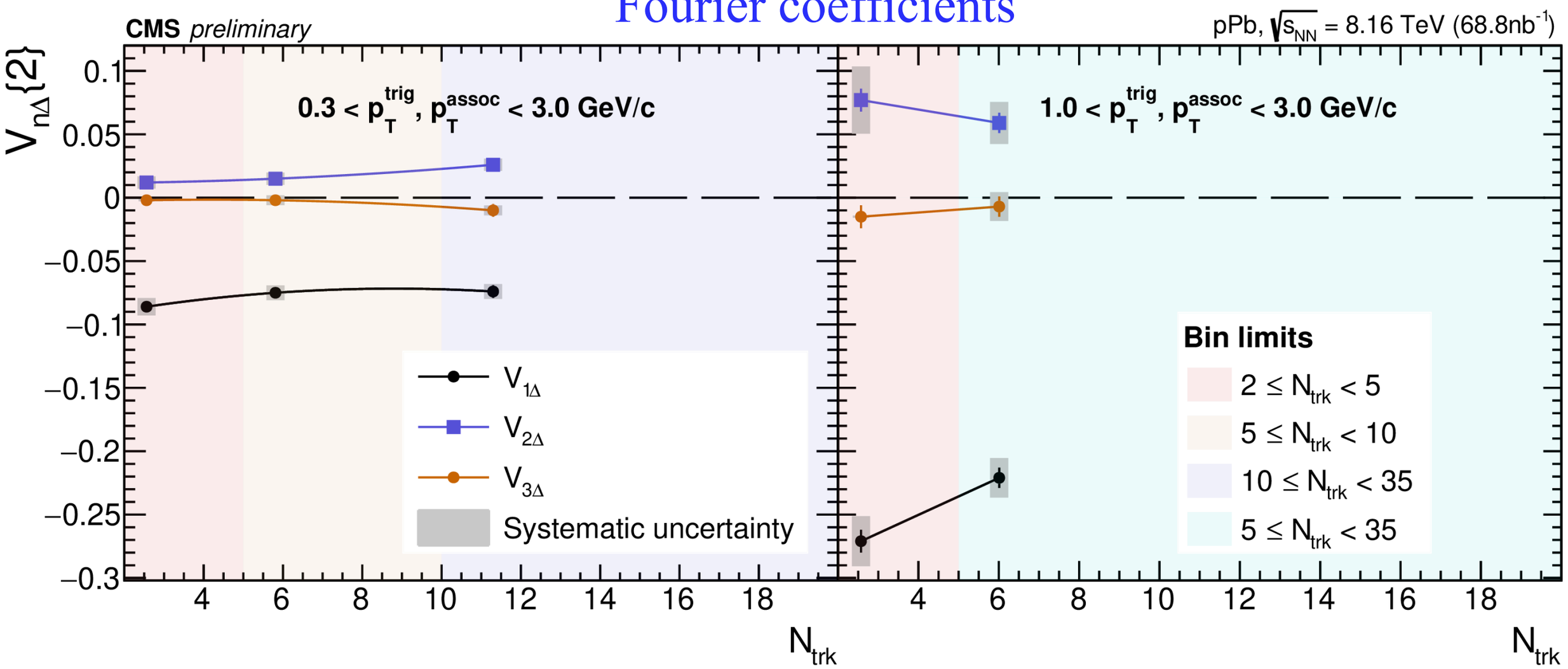


CMS-PAS-HIN-18-008

- No ridge-like structure is observed in minimum-bias pPb and γp enhanced system

Two particle correlation in UPC pPb

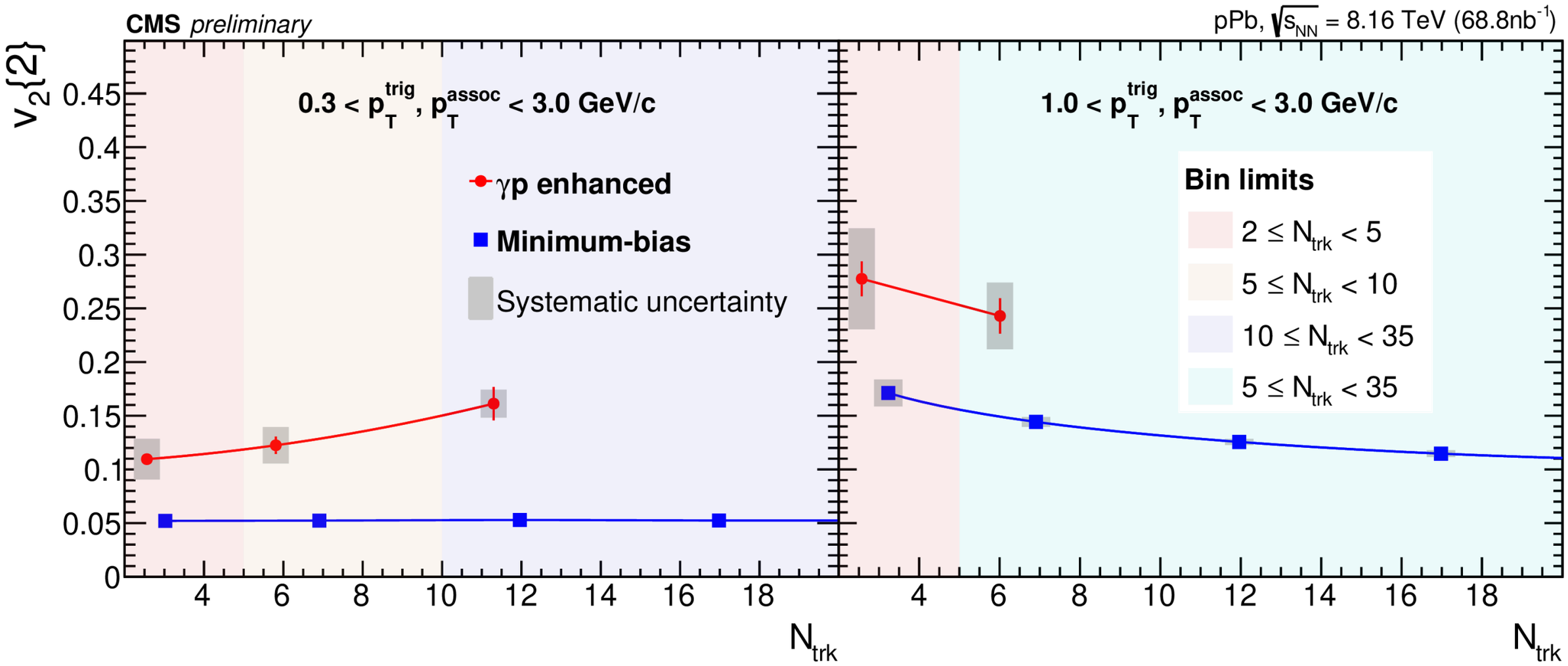
Fourier coefficients



- The $V_{2\Delta}$ coefficient is positive while $V_{1\Delta}$ is negative suggesting a strong effect of jet-like correlations.
- The flow coefficient $v_2(p_T)$ increases with p_T

CMS-PAS-HIN-18-008

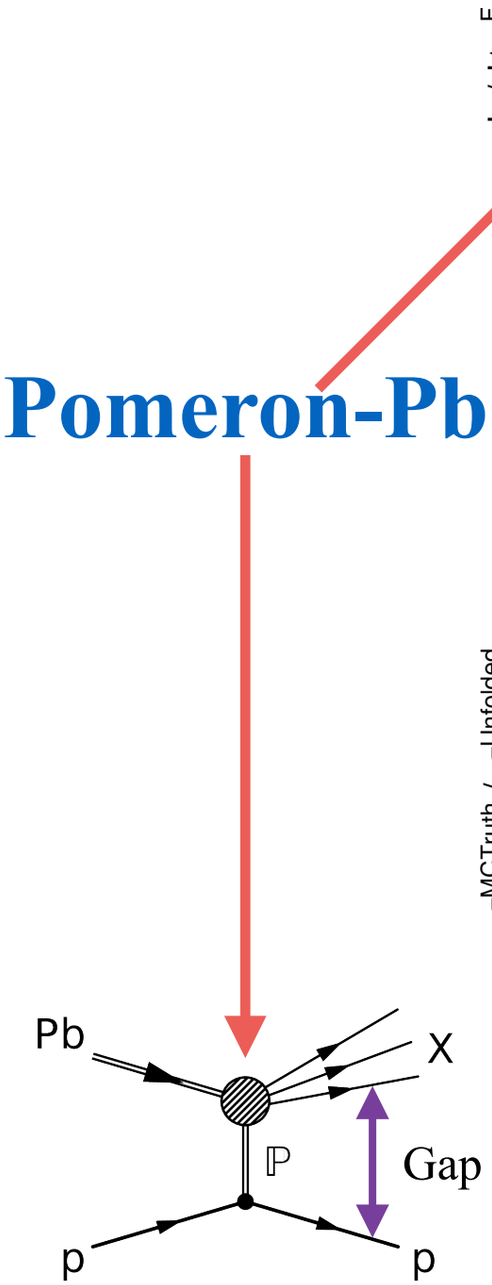
BACKUP

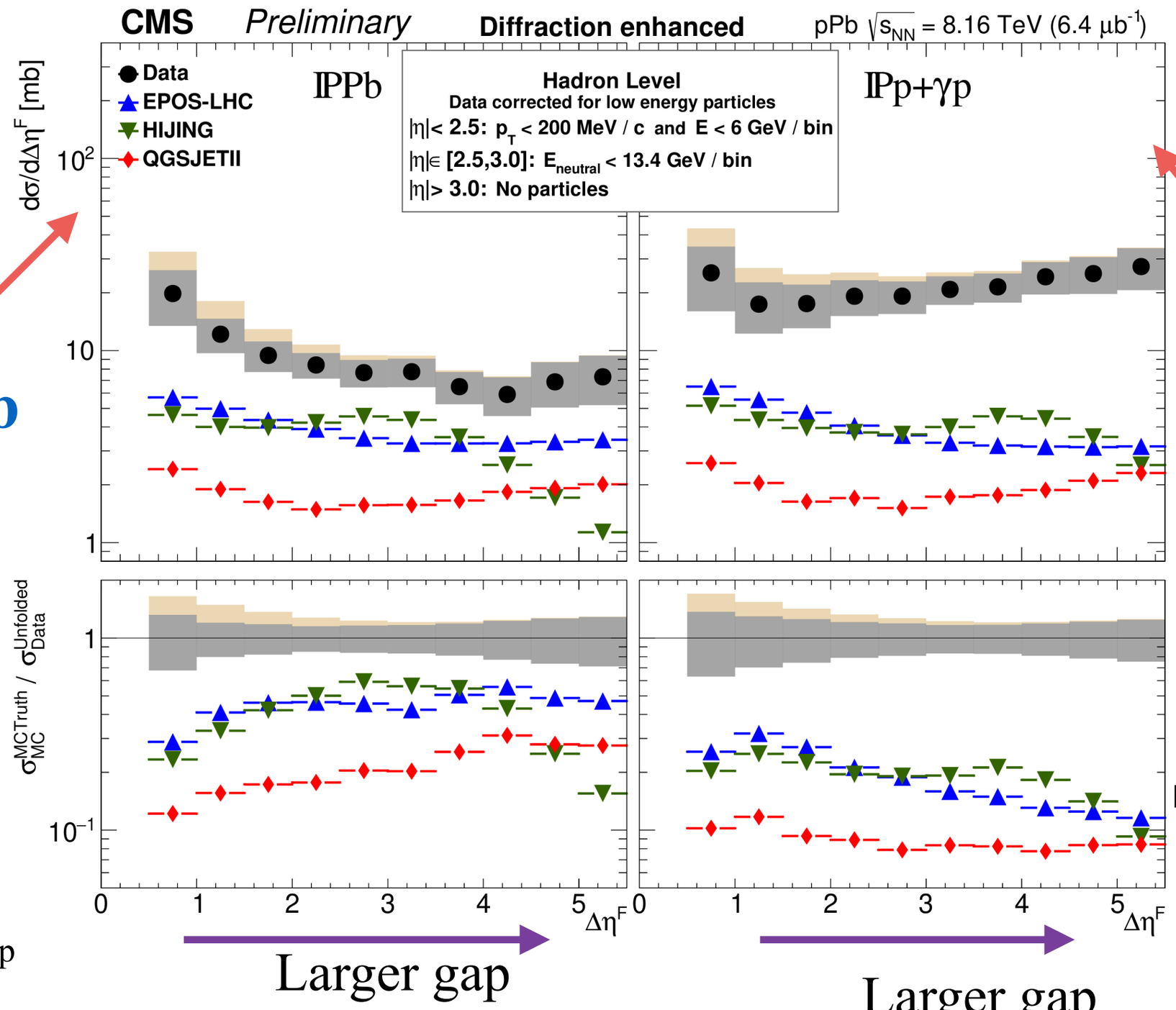


- Single-particle azimuthal anisotropy v_2 versus N_{trk} for γp enhanced and minimum-bias samples in two different pT regions.

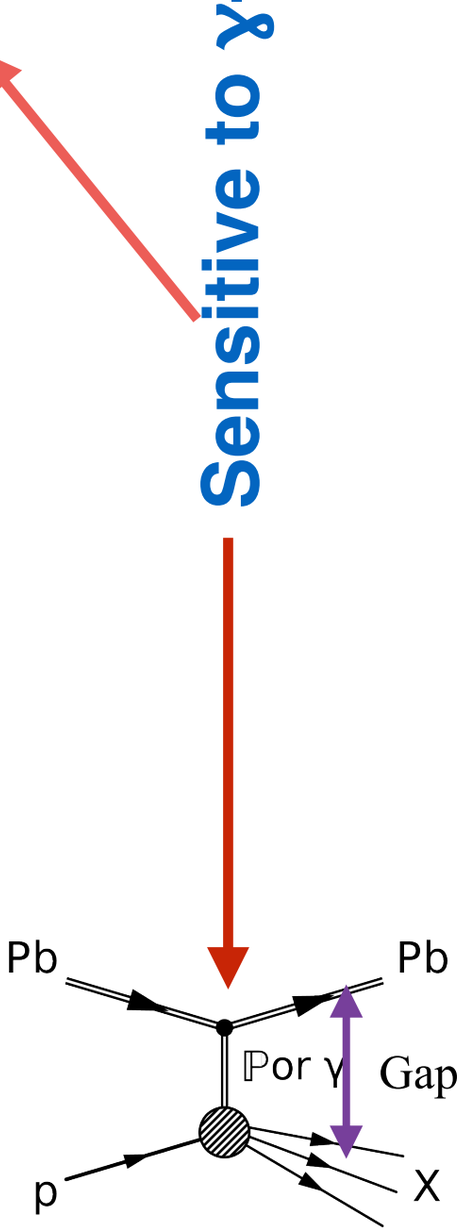
Forward Rapidity Gap

Pomeron-Pb





Sensitive to γ-p

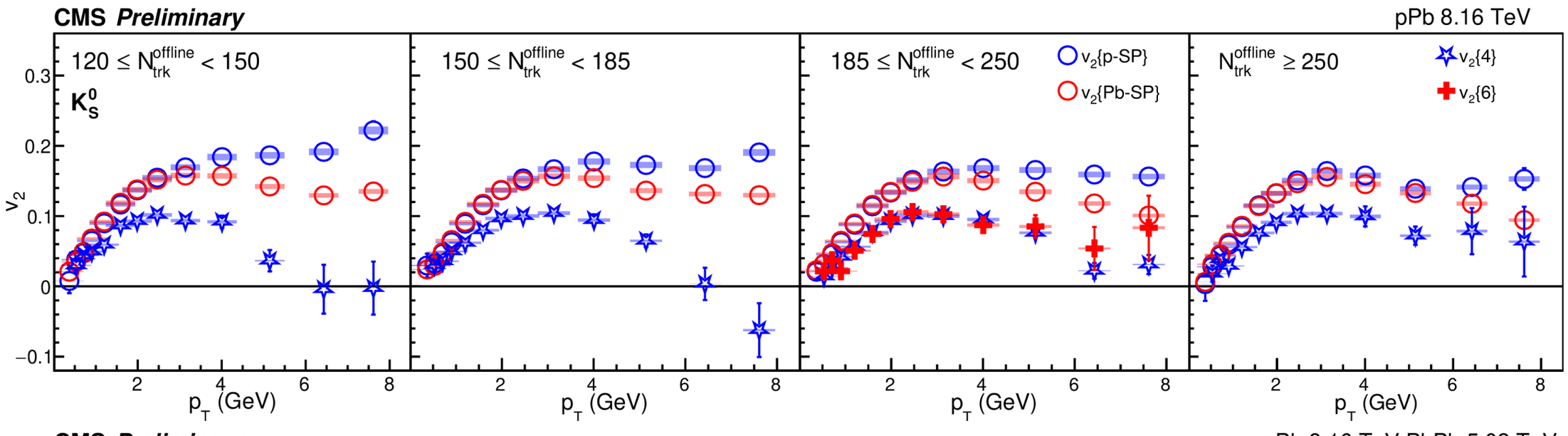


Valuable input to the generator

CMS-PAS-HIN-18-019

Strange particle collectivity

CMS-PAS-HIN-19-004



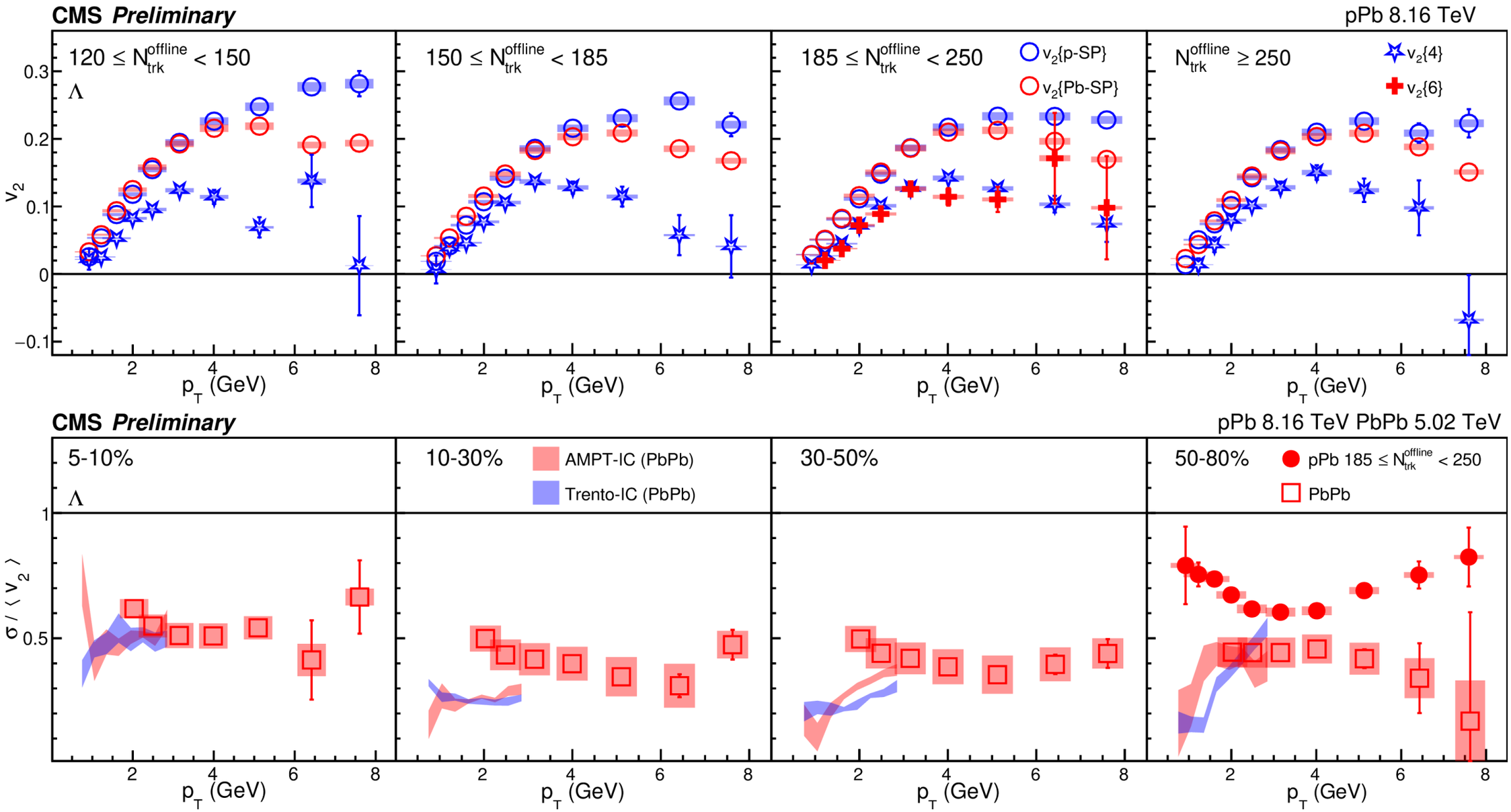
- Fluctuations are stronger in pPb than PbPb.
- Model do not describe the data.

$$\frac{\sigma}{\langle v_2 \rangle} = \sqrt{\frac{v_2\{\mathrm{SP}\}^2 - v_2\{4\}^2}{v_2\{\mathrm{SP}\}^2 + v_2\{4\}^2}}$$

[Raghunath talk, 15:08 PM]

Strange particle collectivity

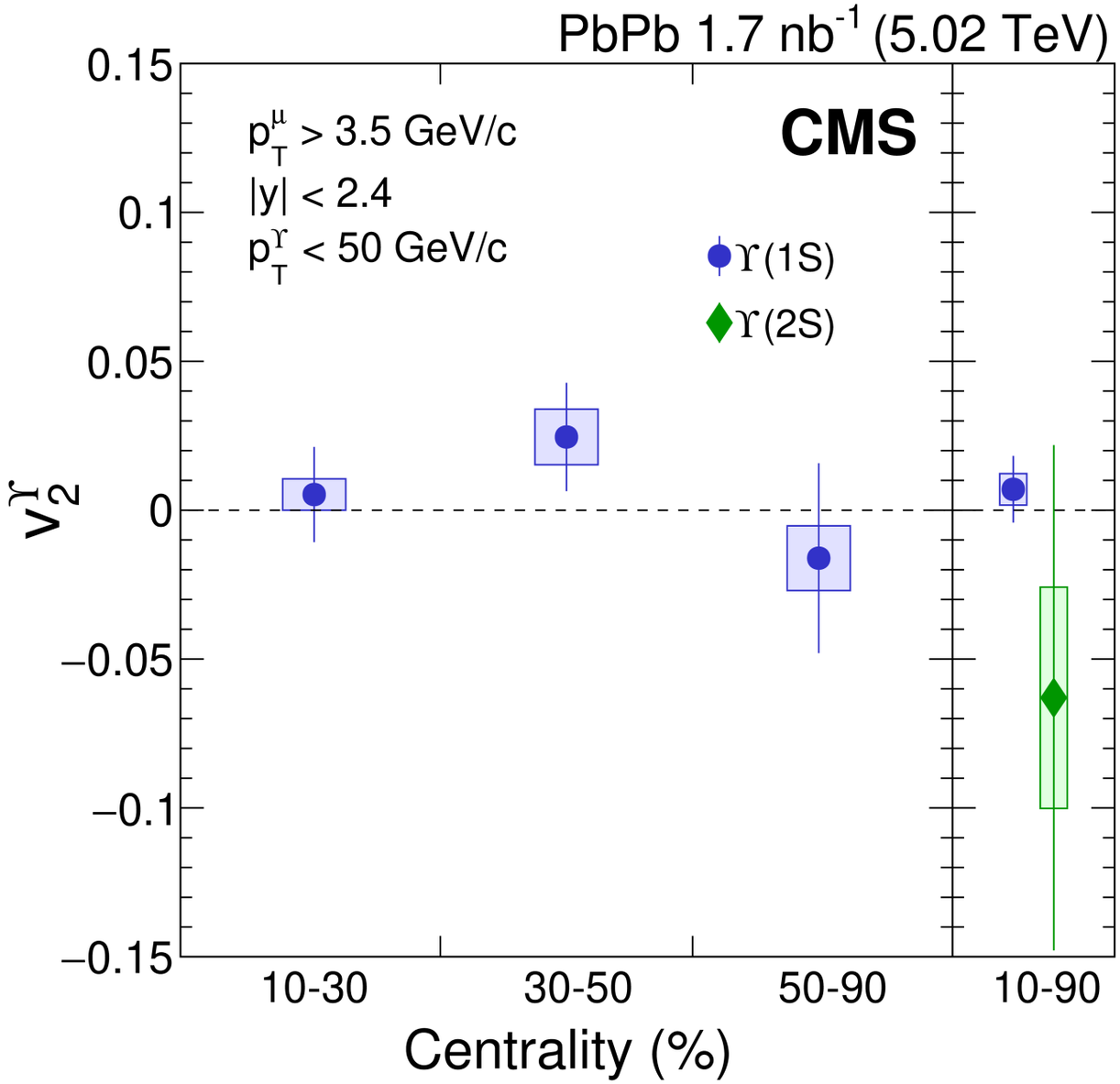
CMS-PAS-HIN-19-004



- Fluctuations are stronger in pPb than PbPb.
- Model do not describe the data.

[Raghunath talk, 15:08 PM]

Collectivity in Υ(1S), Υ(2S)



PLB 819 (2021) 136385.

First time measurement of v_2 Y(2S)

- The Υ(1S) v_2 values are consistent with zero within the uncertainties.

[Raghunath talk, 15:08 PM]