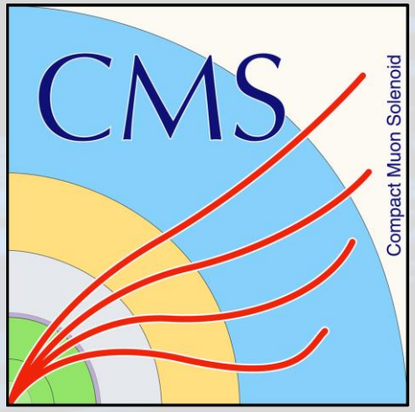
dN/dEta and Z-Hadron



Yen-Jie Lee

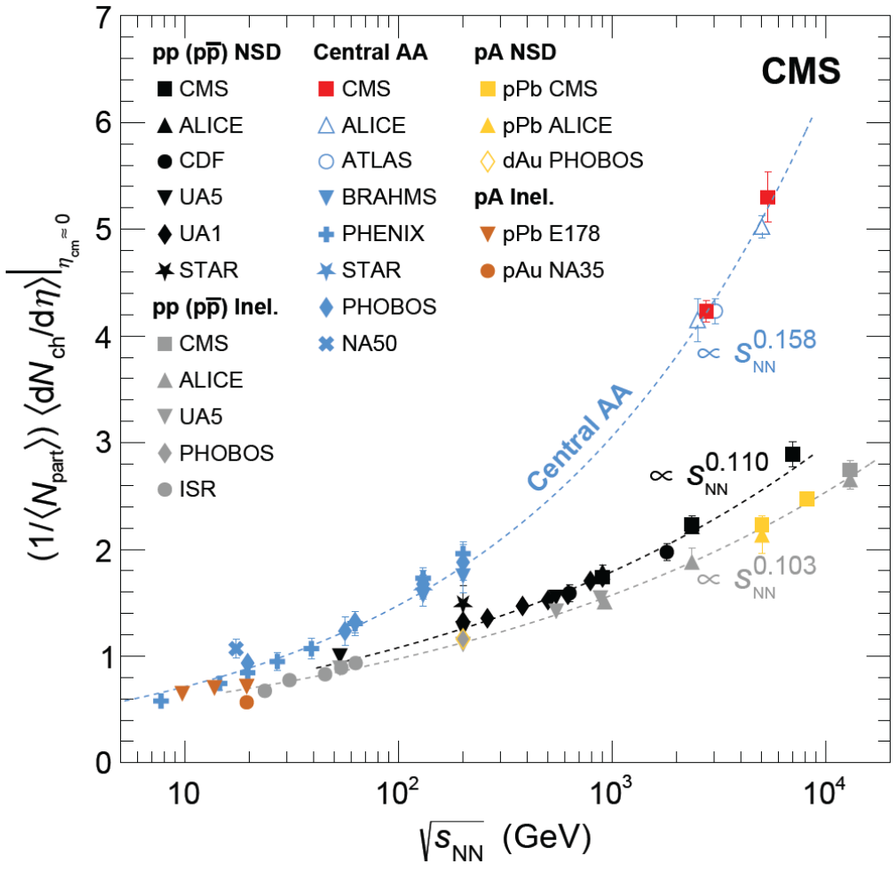
MITHIG Group Meeting

December 20, 2024

MIT HIG group's work was supported by US DOE-NP

Status of dN/dEta (HIN-23-007)

- All the PLB referee comments are addressed
- Received GL from HIN Pubcom chair, iterating with CMS Pubcom
- Hope we get this paper resubmitted soon



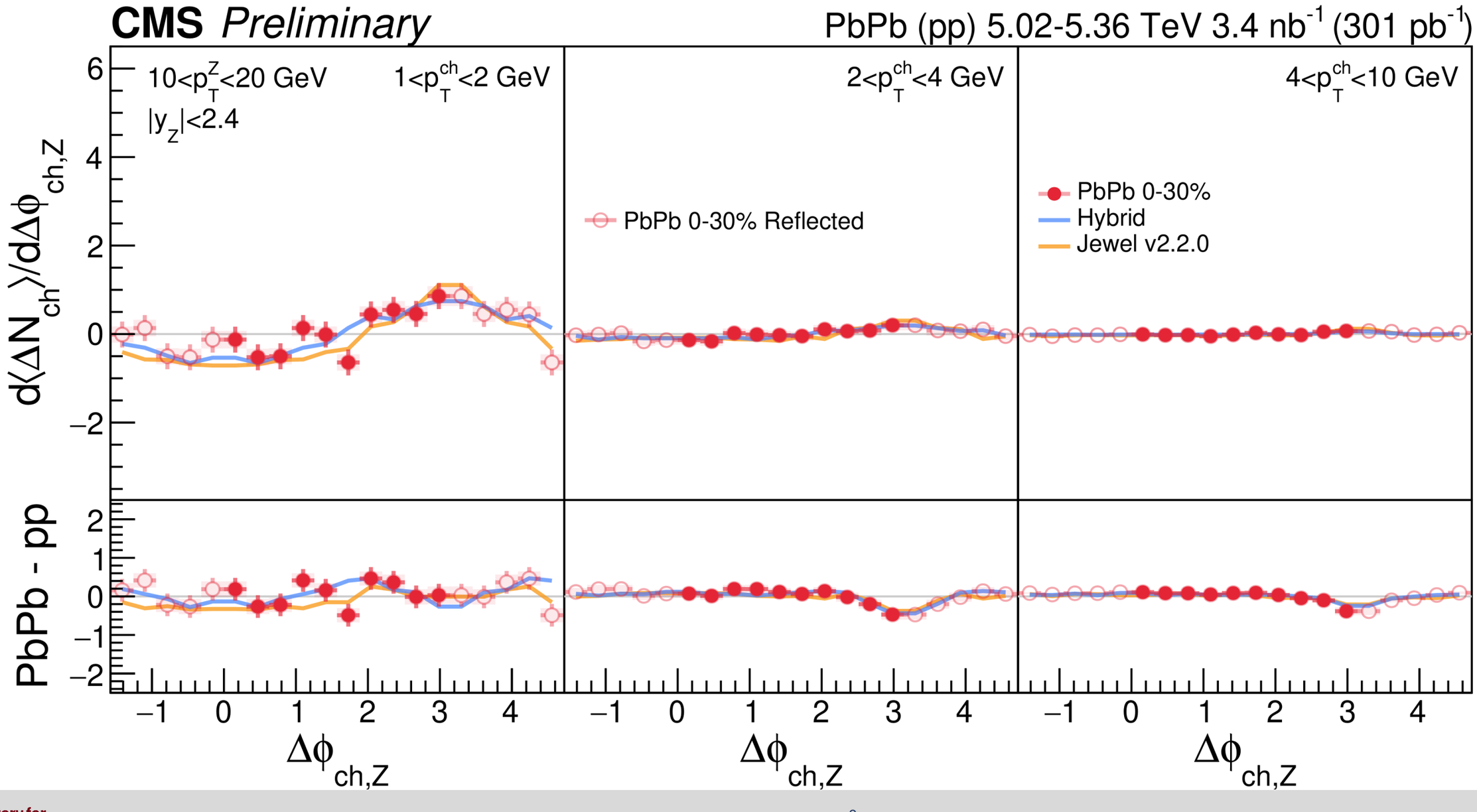
Status of Z-hadron (HIN-23-006)

- Hannah and Yen-Jie prepared the new CWR response, and now blessed by ARC chair. Now in the hand of CCLE (George)

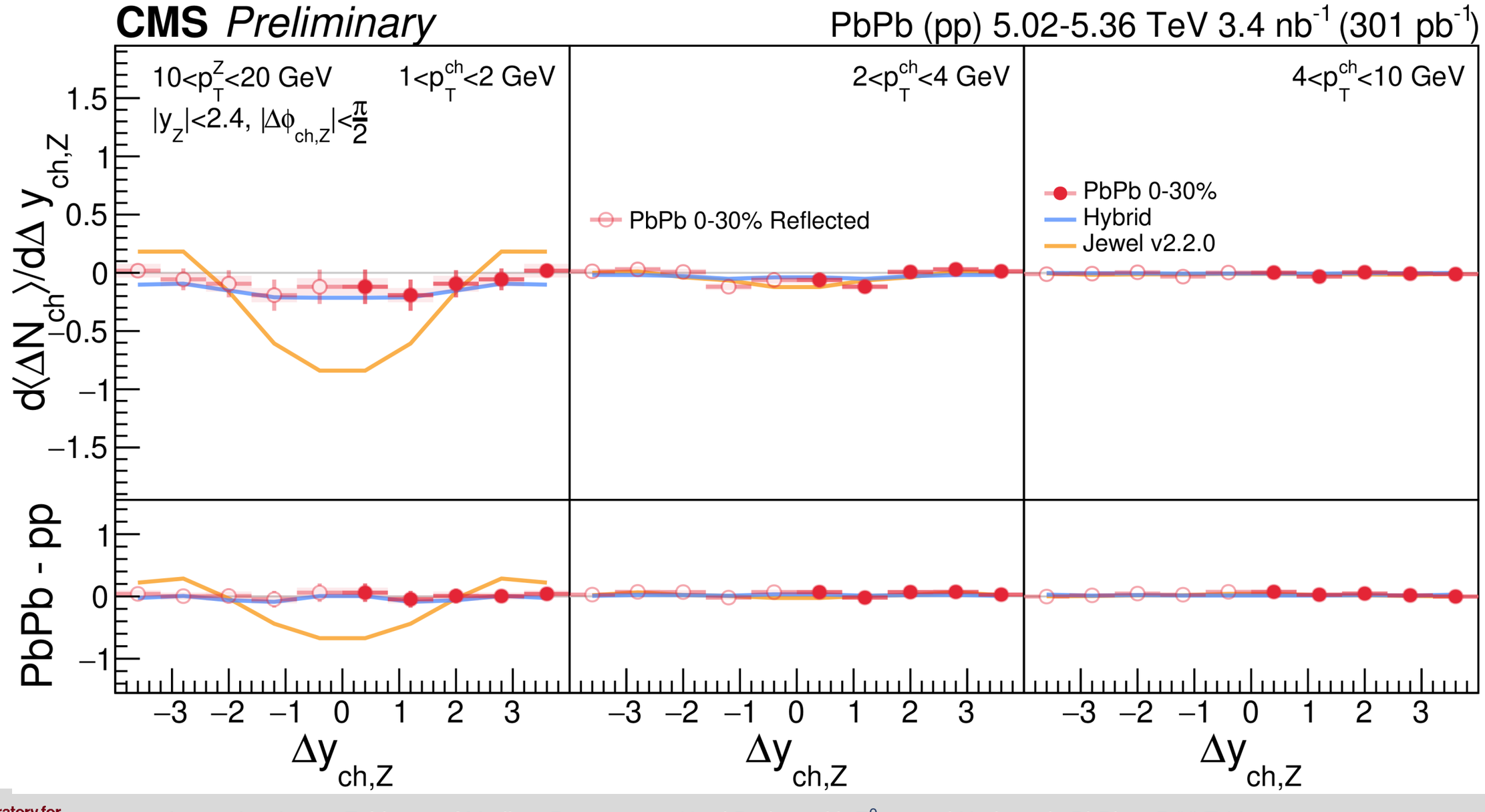
- Cross-check to see if we could turn off the effect by going to very low pT

- Yen-Jie and Luna reprocessed the samples to include neutral hadrons in the reduced tree

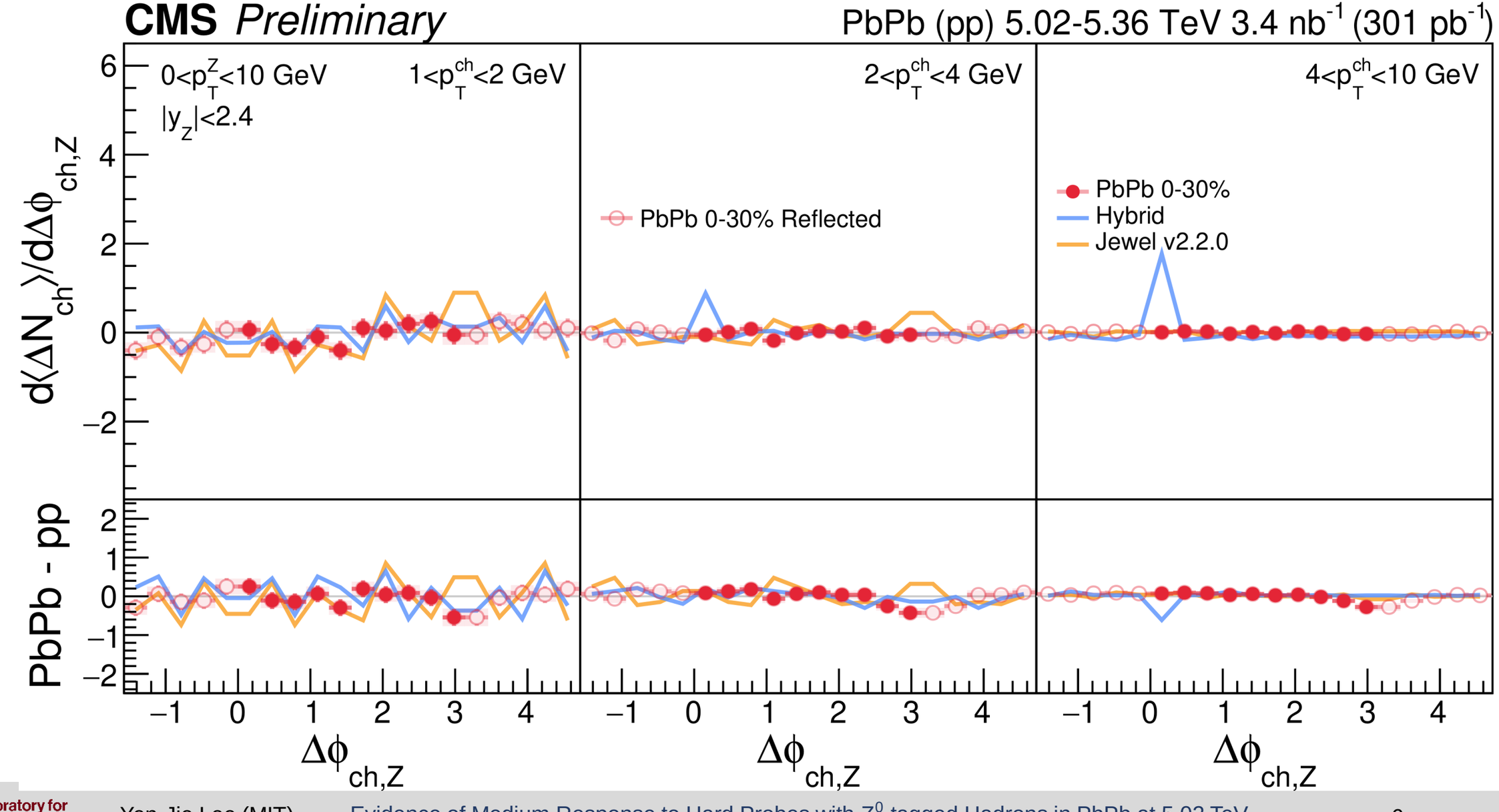
Standard analysis by going to Z pT 10-20 GeV



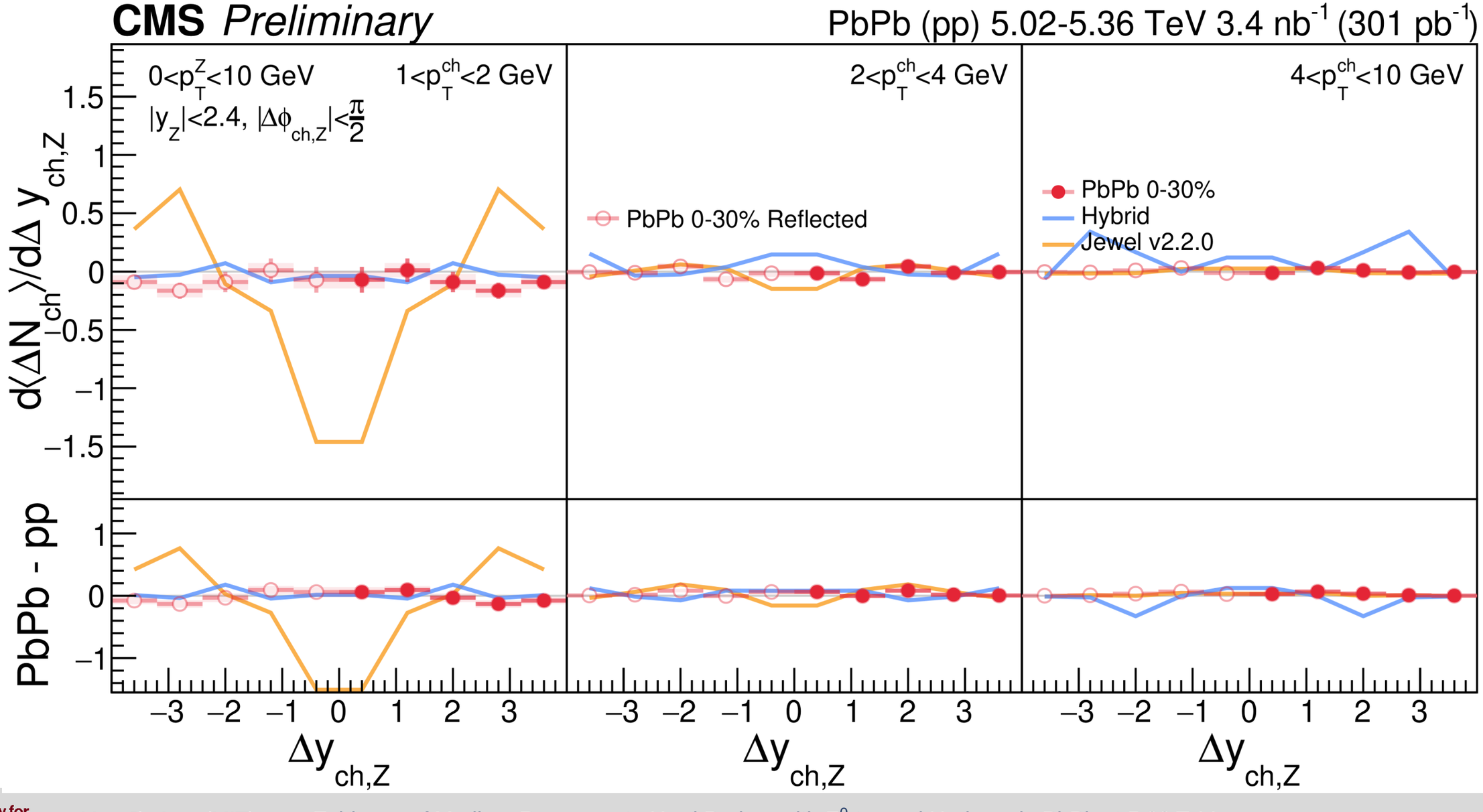
Standard analysis by going to Z pT 10-20 GeV



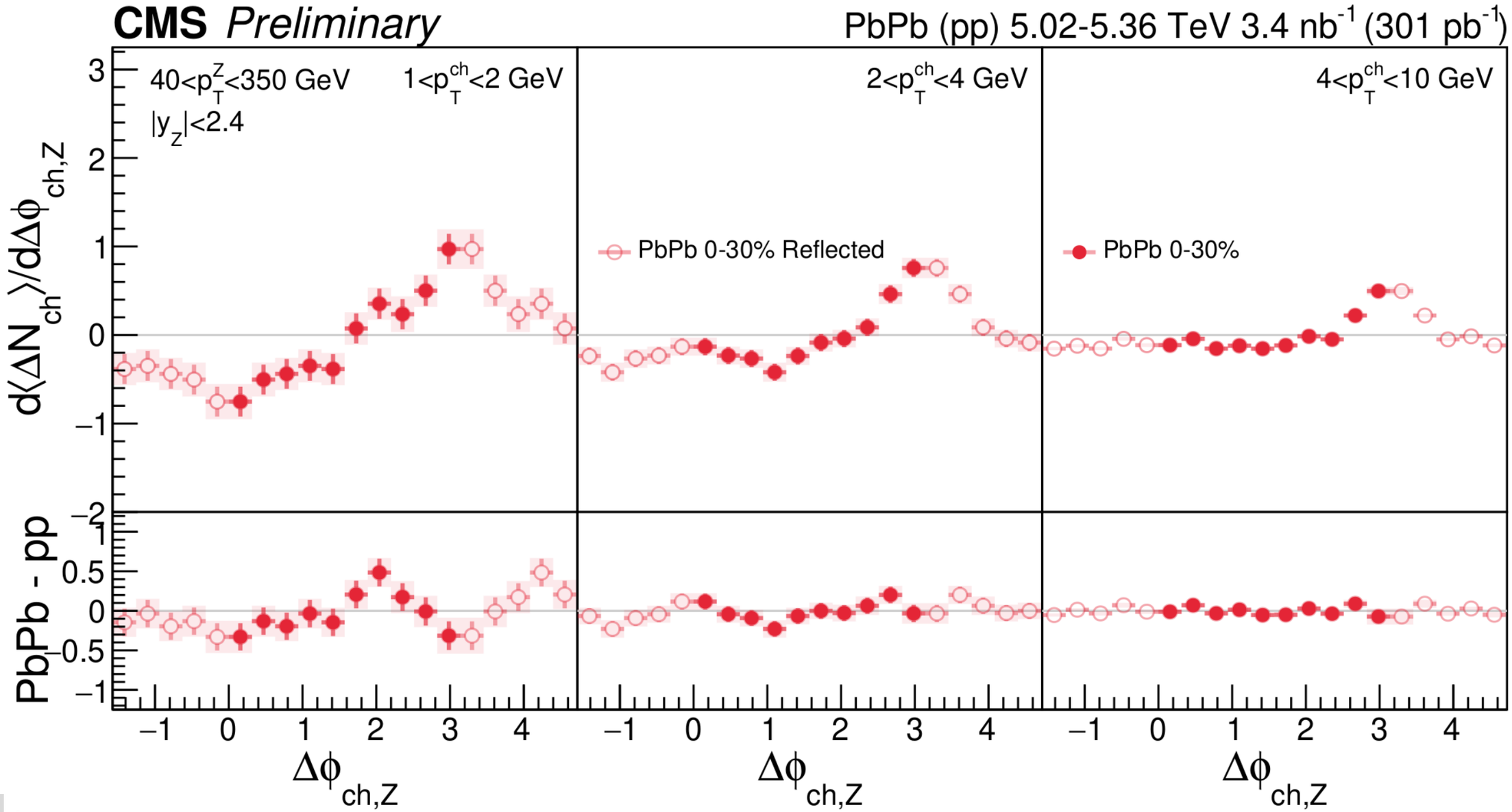
Standard analysis by going to Z pT 0-10 GeV



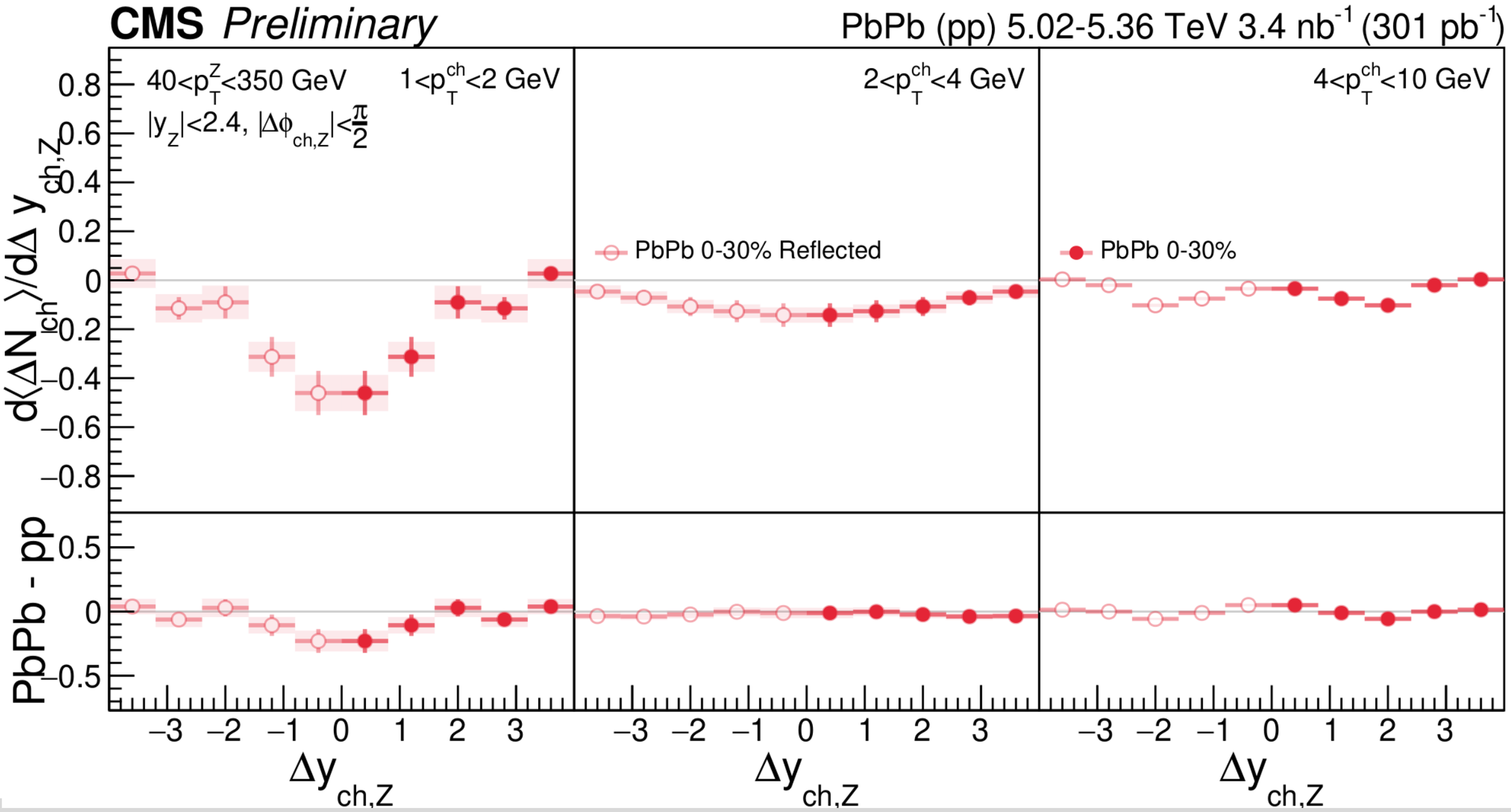
Standard analysis by going to Z pT 0-10 GeV



Neutral Hadron (Delta Phi)

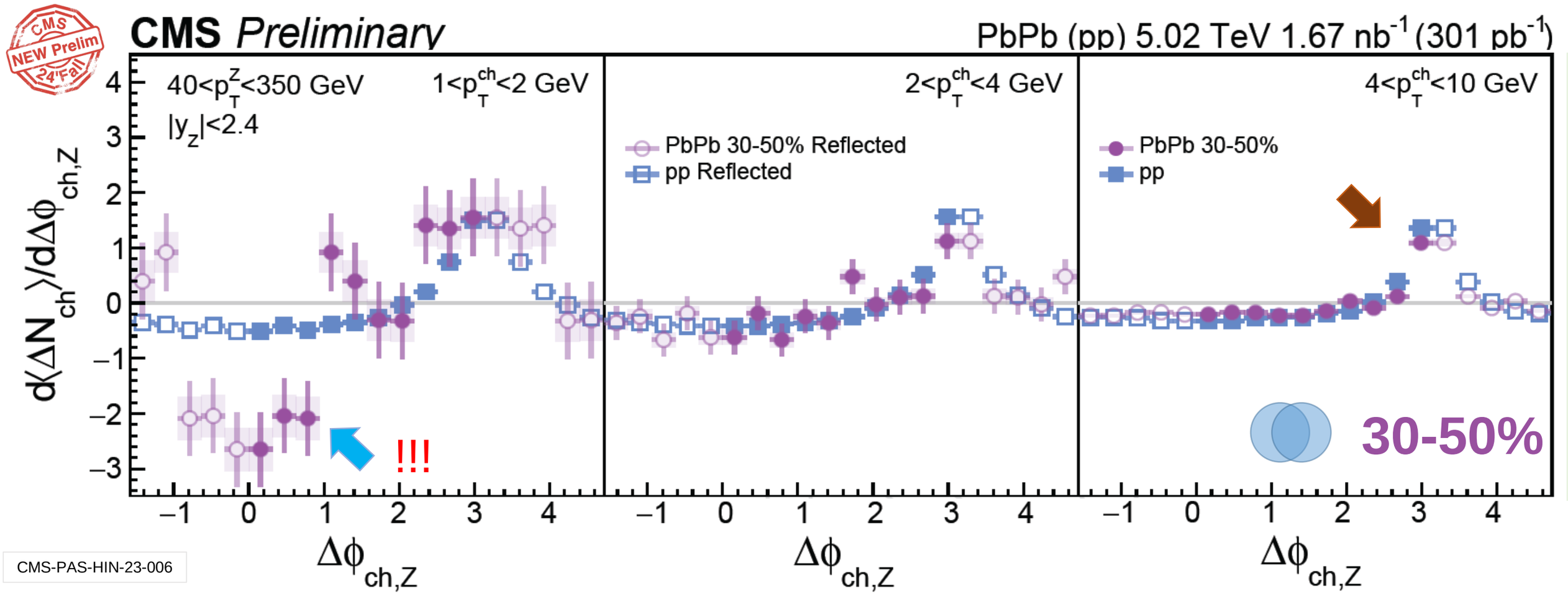


Neutral Hadron (Delta y)



Backup slides

Azimuthal Angle Distributions in pp and 30-50% PbPb



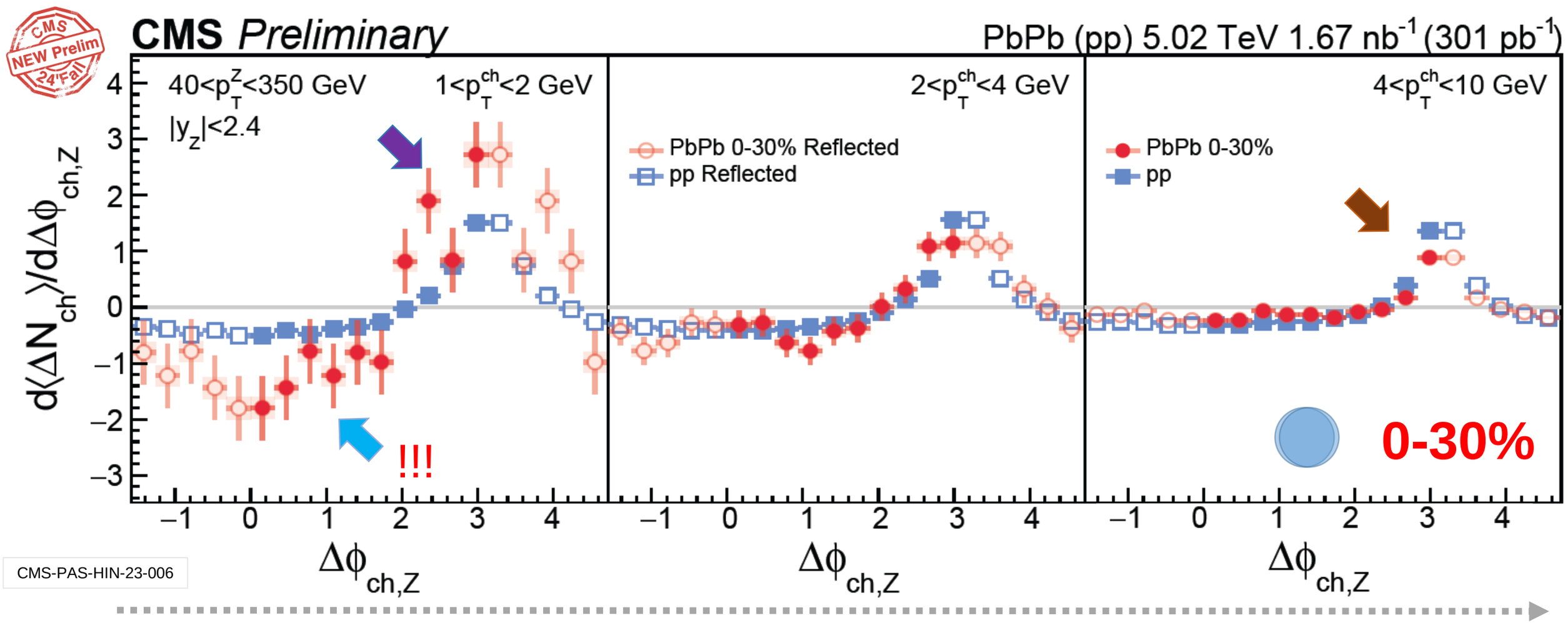
Low Charged Hadron p_T

High Charged Hadron p_T

PbPb: Clear relative depletion in **Z^0 side ($\Delta\phi=0$)**

PbPb: **Jet side peak** ($\Delta\phi=\pi$) reduced due to jet quenching at high hadron p_T

Azimuthal Angle Distributions in pp and 0-30% PbPb



Low Charged Hadron p_T

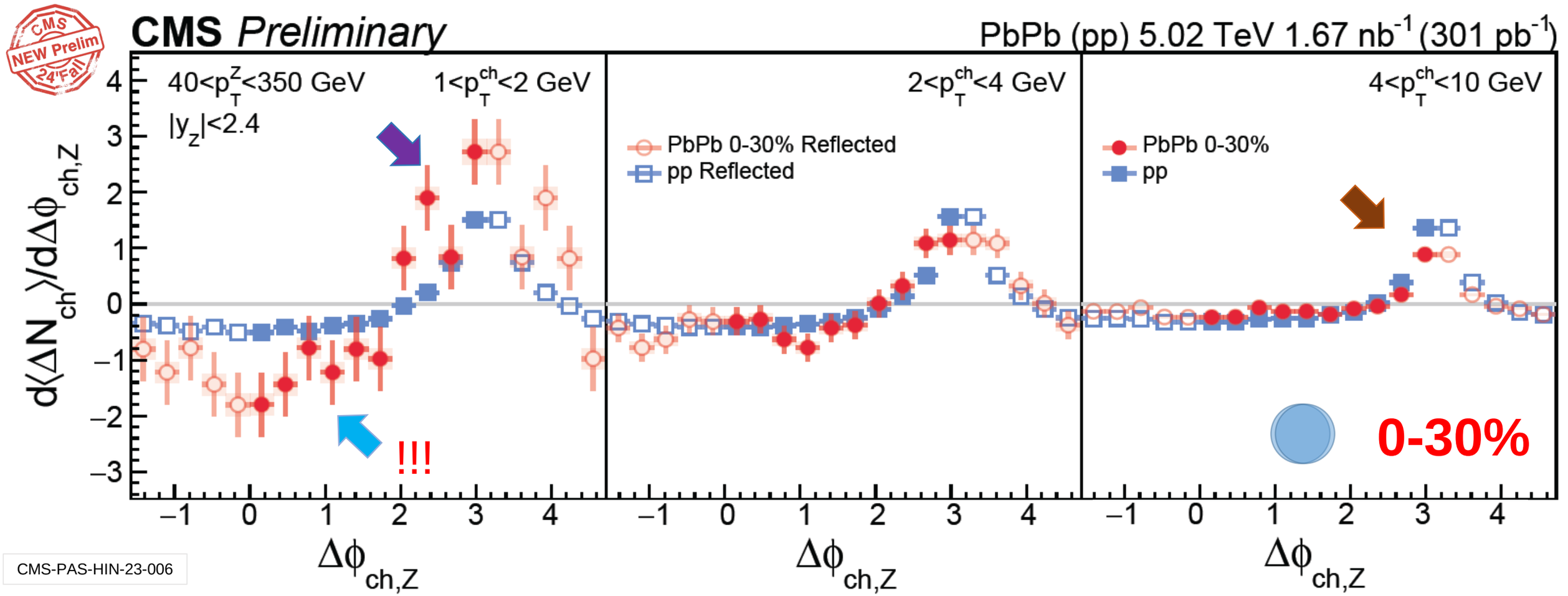
High Charged Hadron p_T

PbPb: Clear depletion in **Z^0 side (Δφ=0)** and enhancement in **jet side (Δφ=π)**

PbPb: Effect reduced in the intermediate p_T region (2-4 GeV)

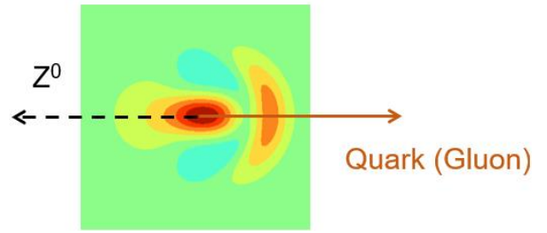
PbPb: **Jet side peak** (Δφ=π) reduced due to jet quenching at high hadron p_T

Azimuthal Angle Distributions in pp and 0-30% PbPb

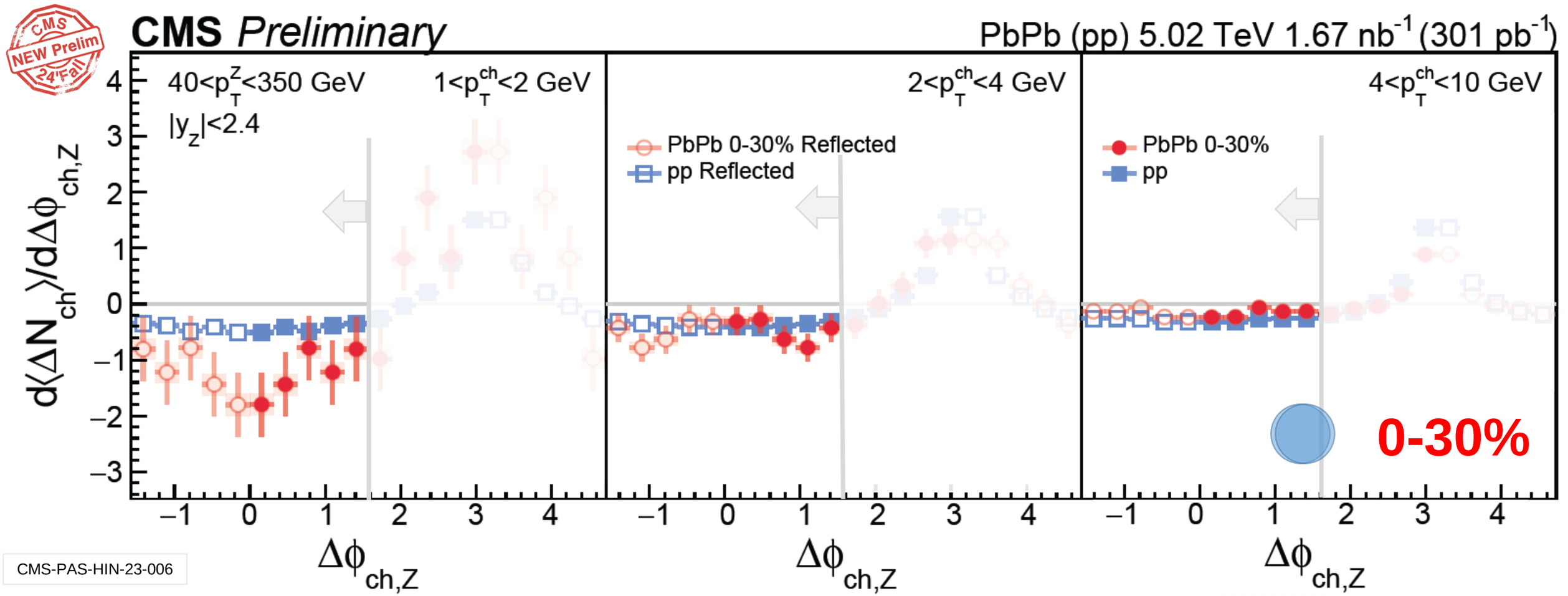


Now we have seen a deeper dip structure at Δϕ~0

How about rapidity distributions?



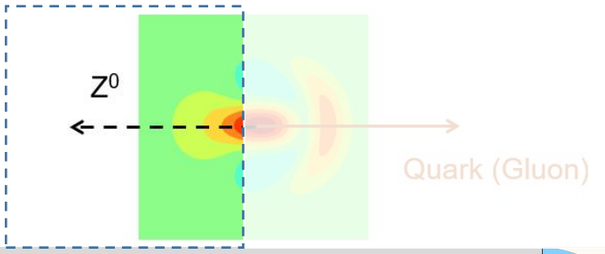
Azimuthal Angle Distributions in pp and 0-30% PbPb



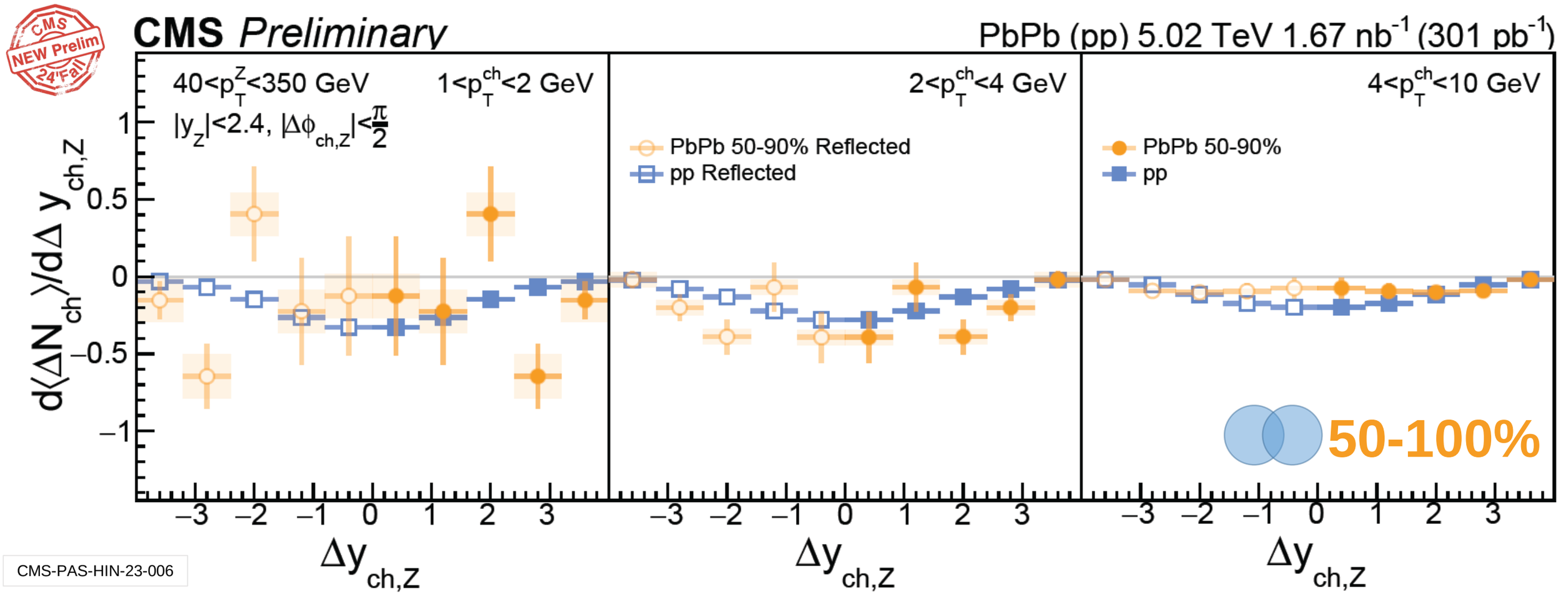
Now we have seen a deeper dip structure at Δϕ~0

How about rapidity distributions?

Let's focus on the **Z^0 side (Δϕ< π/2)** and then look at the Δy spectra



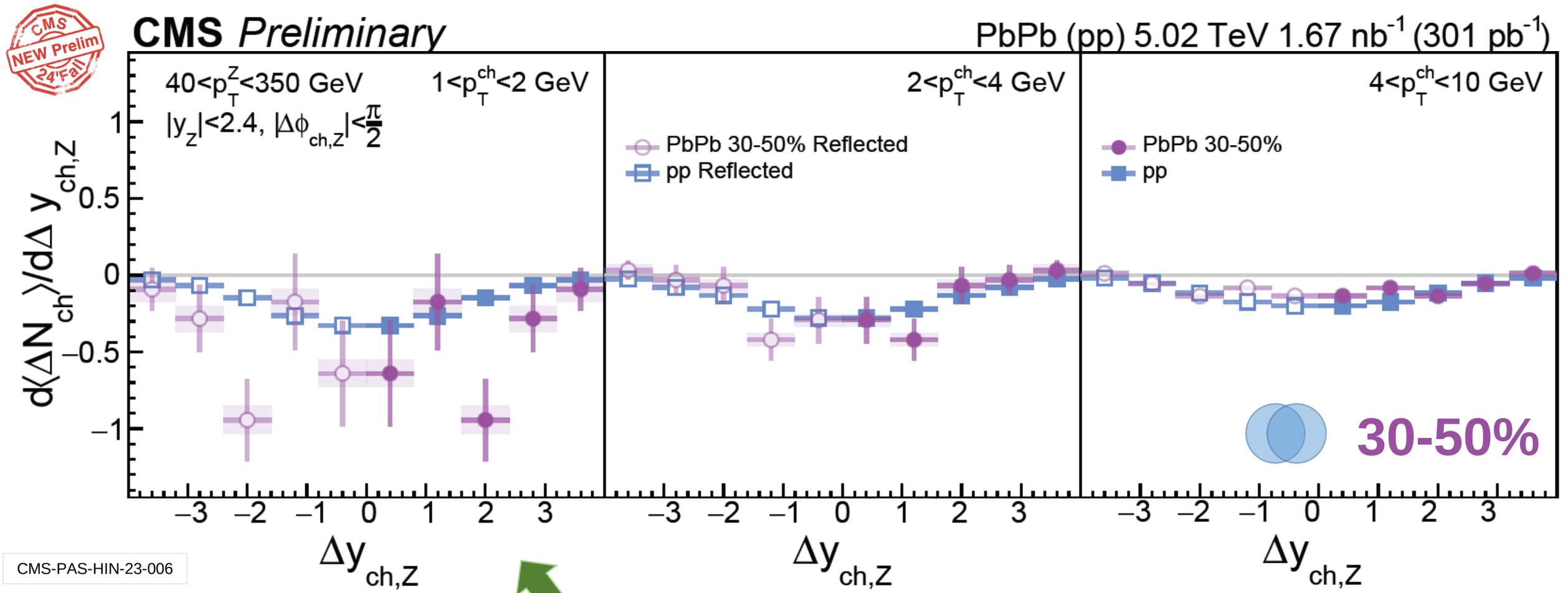
Rapidity Distributions in pp and 50-100% PbPb



Low Charged Hadron p_T

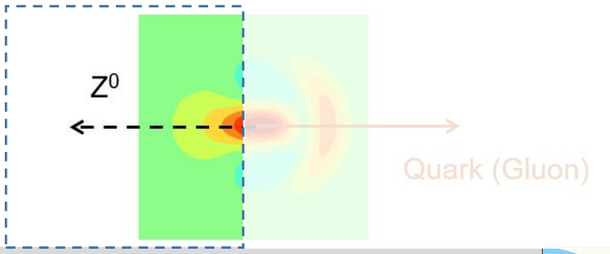
High Charged Hadron p_T

Rapidity Distributions in pp and 30-50% PbPb

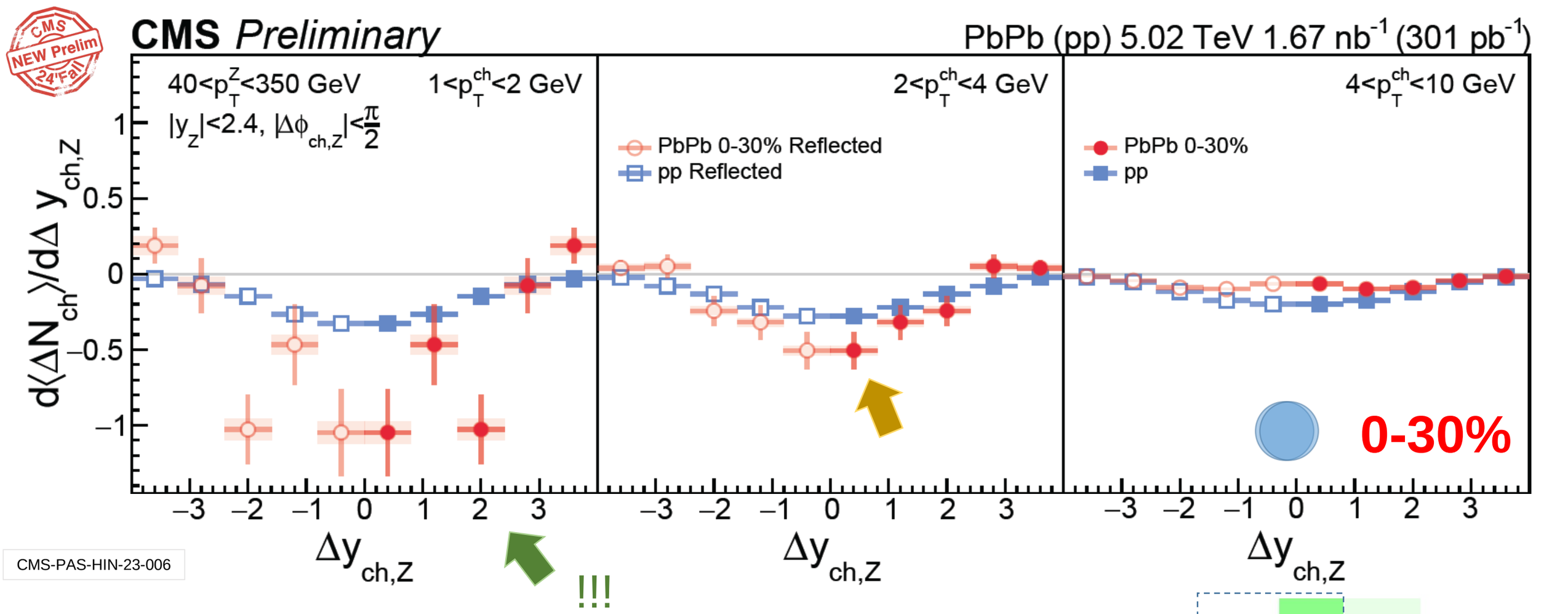


CMS-PAS-HIN-23-006

PbPb: Indication of depletion around the Z ($\Delta y=0$)



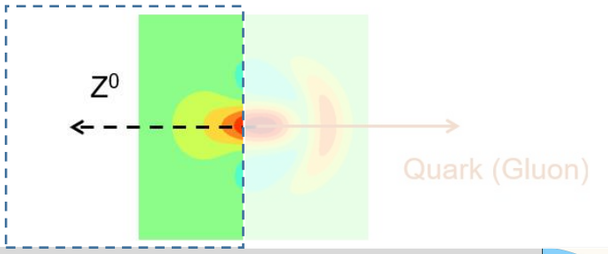
Rapidity Distributions in pp and 0-30% PbPb



CMS-PAS-HIN-23-006

PbPb: Clear depletion around the Z (Δy=0) and the effect reduces at higher Δy

PbPb: Effect reduced in the intermediate p_T region (2-4 GeV)

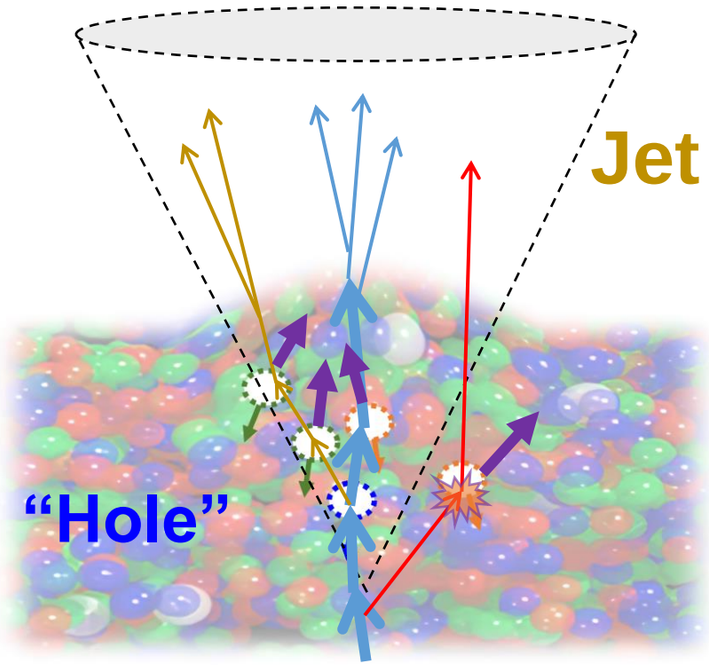


Comparison with Theoretical Models

Jewel Model

(Jet Evolution with Energy Loss)

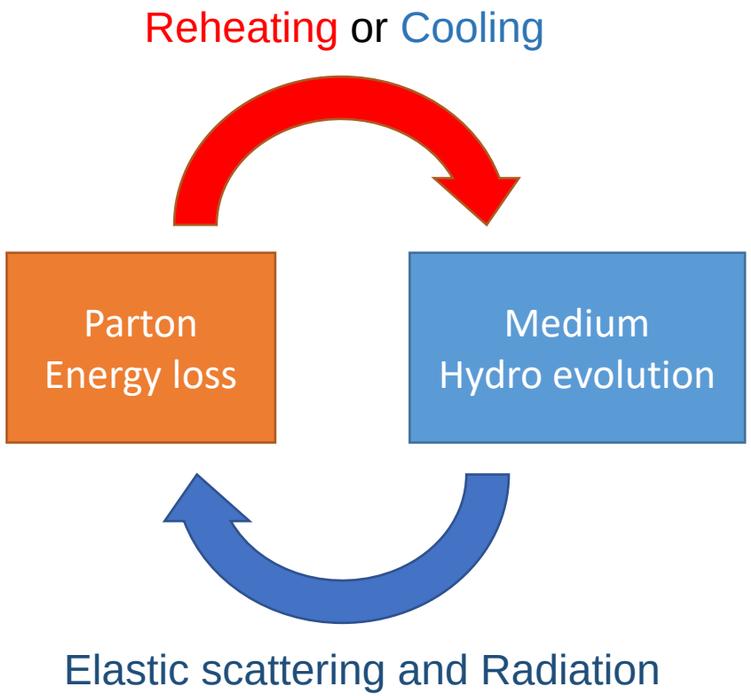
- **pQCD**-based energy loss model
- High-energy partons scatter with medium particles; **Recoiled partons** and **holes** **do not re-scatter** with QGP constituents.



CoLBT hydro Model

(Coupled Linear Boltzmann Transport and Hydrodynamics)

- Based on **pQCD**. Integrates the **Boltzmann transport equation** with QGP hydrodynamic simulations.
- Introduces **reheating**, where parton energy loss could heat and modifies the QGP.

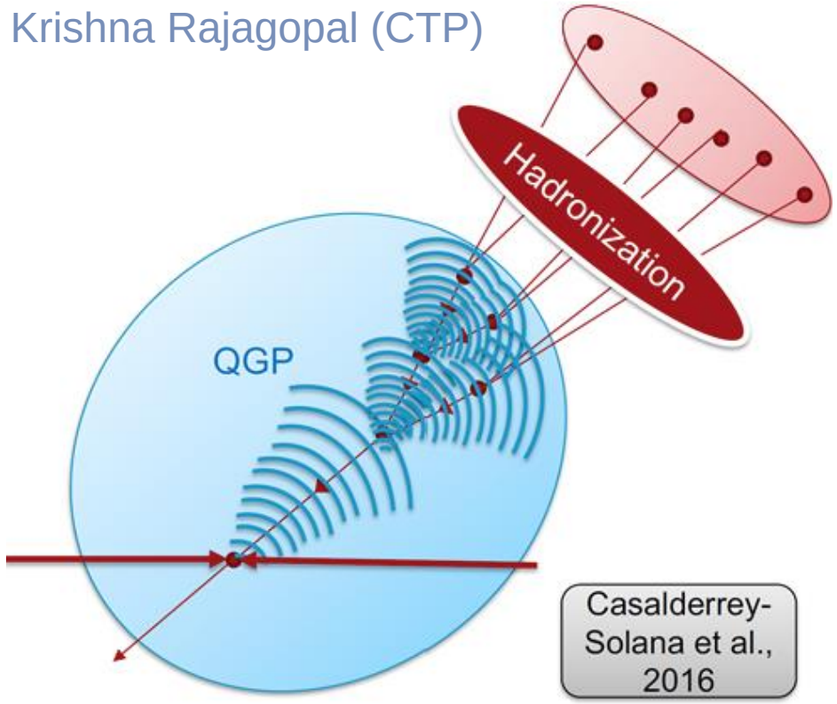


Hybrid Model

(Hybrid Strong/Weak Coupling Approach)

- Based on the **AdS/CFT**, combining pQCD shower and strong-coupling dynamics.
- Lost energy deposits a **hydrodynamic wake** in the QGP via 4-momentum conservation.

Krishna Rajagopal (CTP)



Azimuthal Angle Distribution in 0-30% PbPb vs. Theory **w/o** Medium Response

- **Hybrid without wake** and **Jewel without recoil** (dashed lines) underpredict magnitude at low hadron p_T

- **PYTHIA8 lower p_T Z^0 events:** can approximate jet quenching (similar to **no-wake/recoil** models with only the jet shower). It fails to describe data for hadron p_T < 4 GeV.

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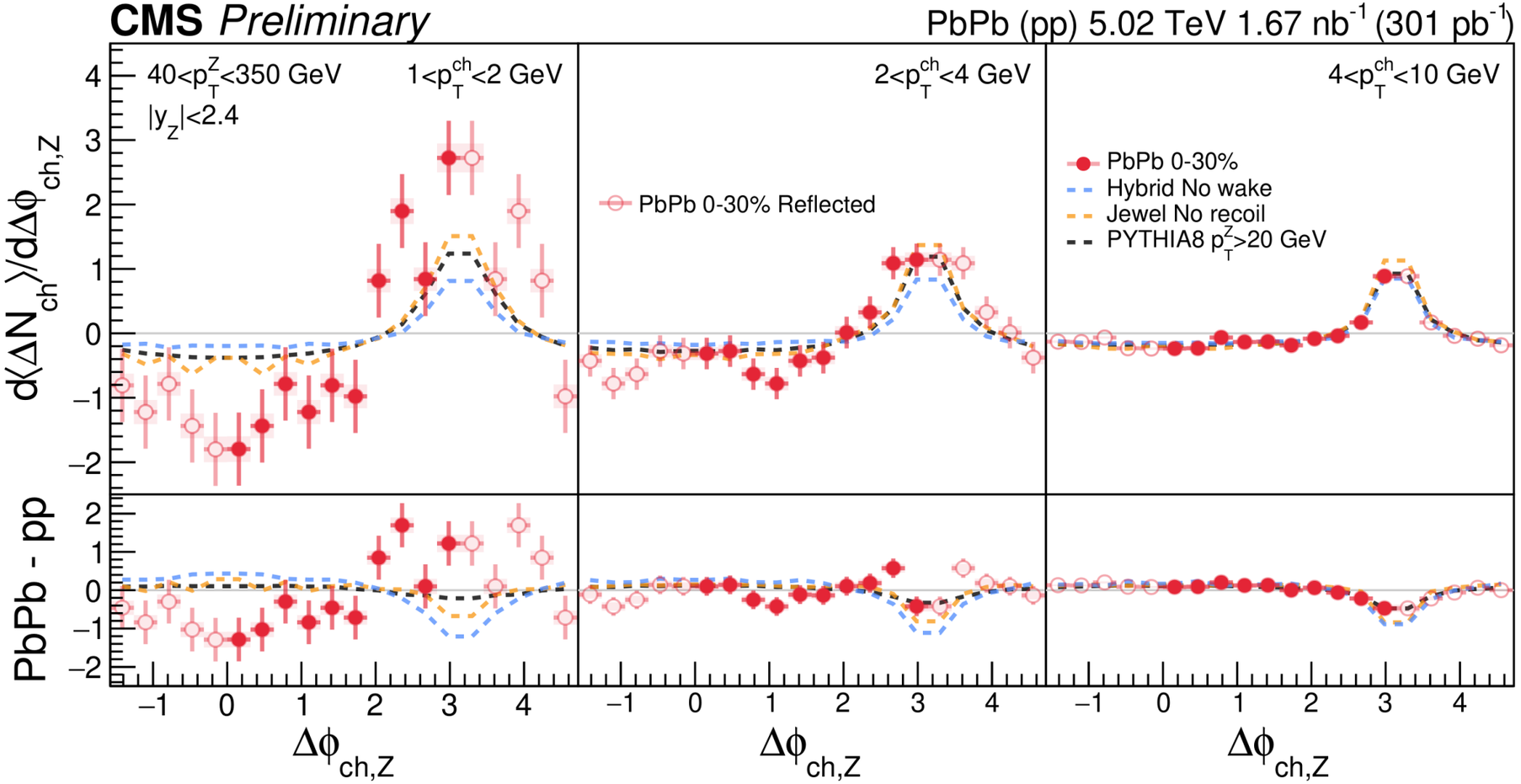
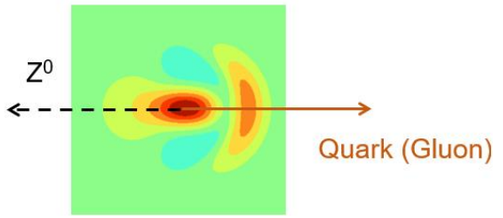


(Another test on magnitude of negative ΔN_{ch} near Z^0 without recoil/wake)

40 GeV Z + 40 GeV jet —Quench→ 40 GeV Z + quenched jet + recoil/wake

Approx. → 20 GeV Z + 20 GeV pythia jet ~~+ recoil/wake~~

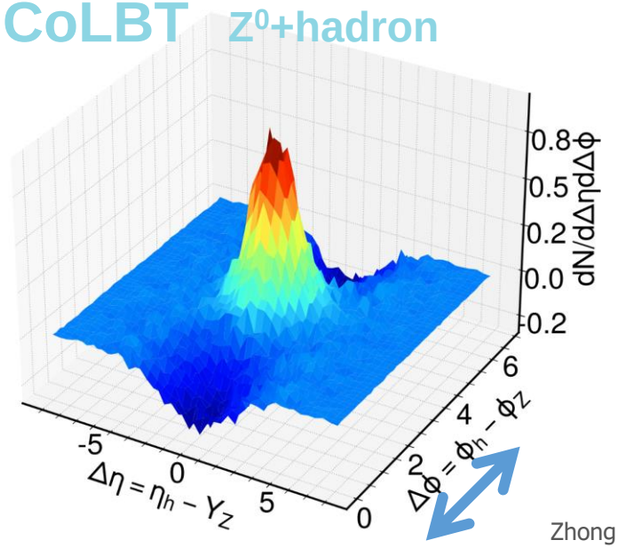


Azimuthal Angle Distribution in 0-30% PbPb vs. Theory

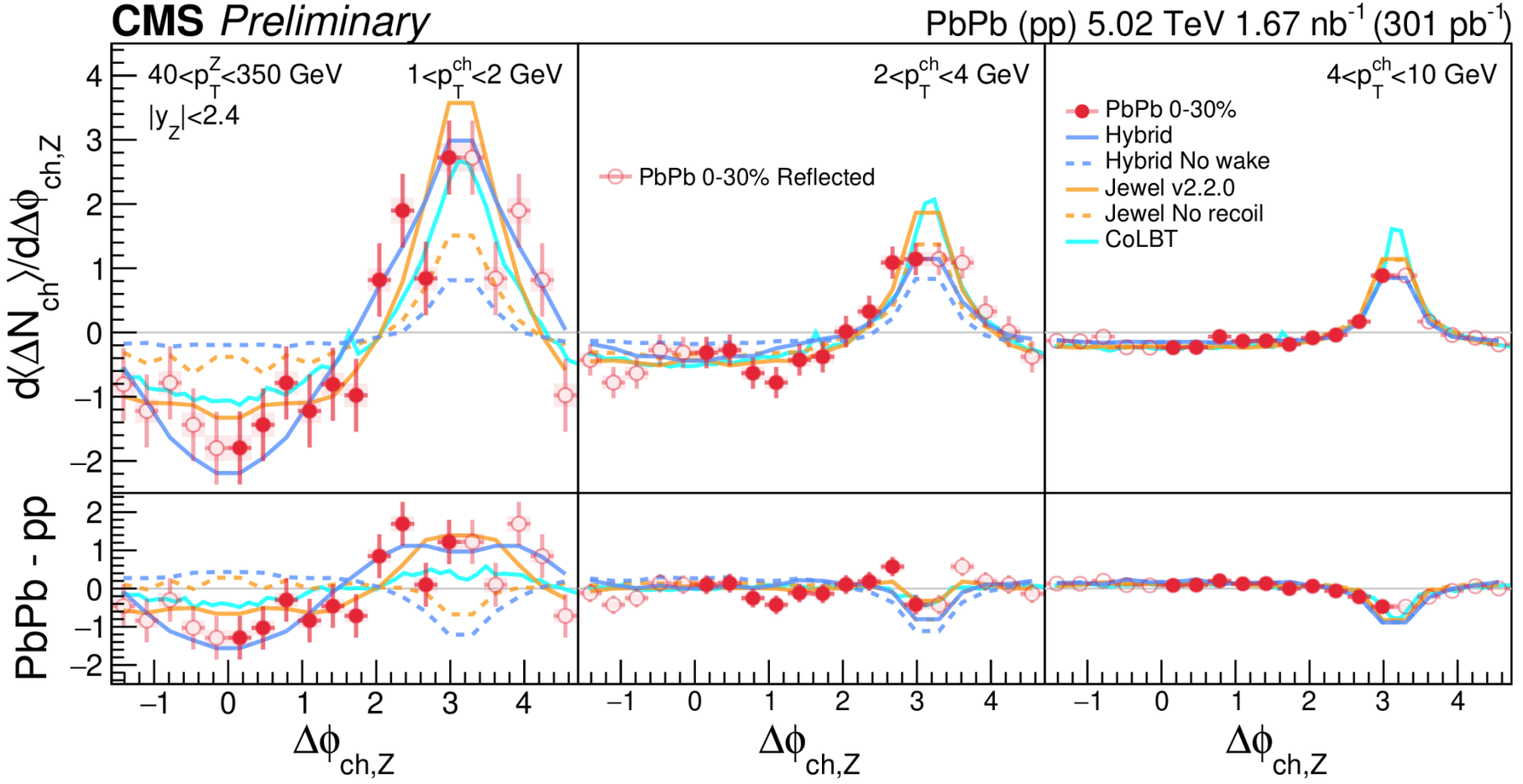
- **Hybrid without wake** and **Jewel without recoil** (dashed lines) underpredict magnitude at low hadron p_T

- **Hybrid with wake**, **Jewel with recoil** and **CoLBT with wake** (solid lines) agree better with the data with hadron $p_T < 4$ GeV

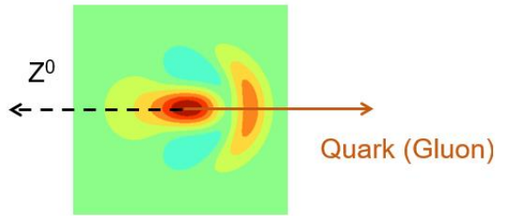
CoLBT Z^0+hadron



Zhong Yang, Xin-Nian Wang



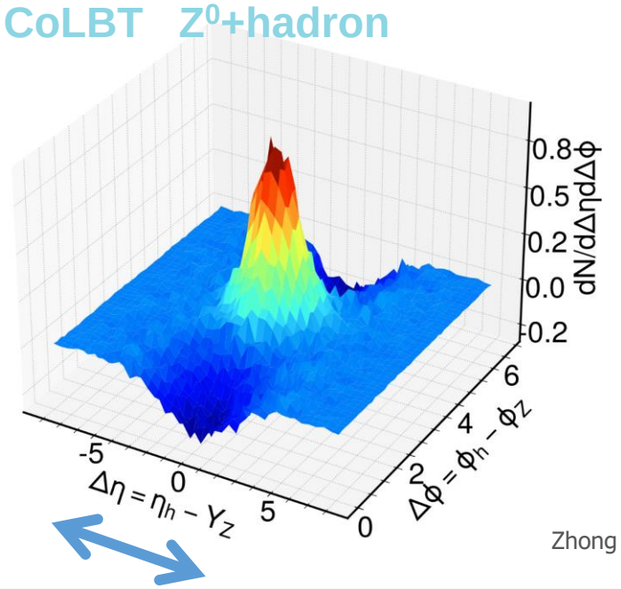
CMS-PAS-HIN-23-006



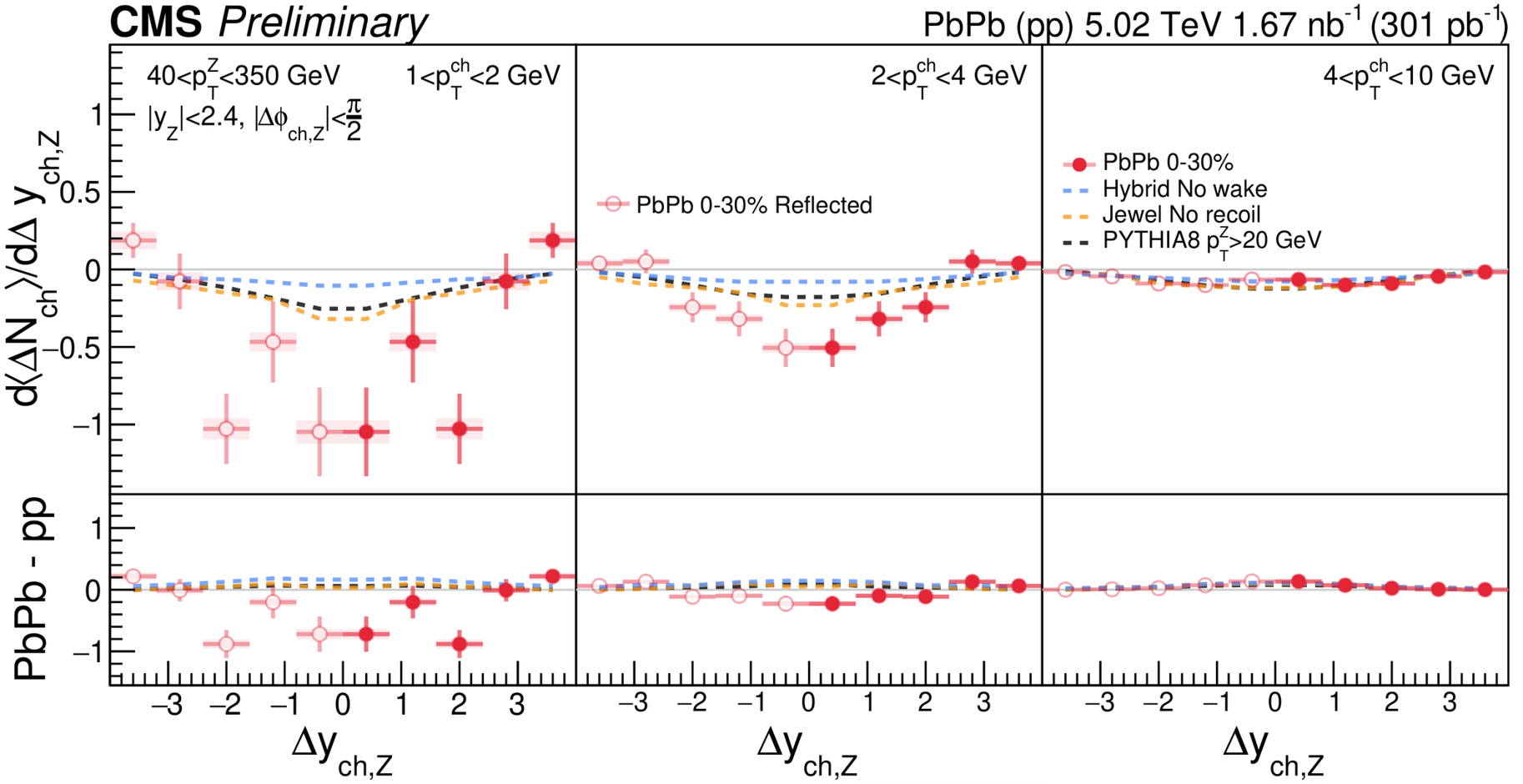
Rapidity Distribution in 0-30% PbPb vs. Theory without Medium Response

- **Hybrid without wake** and **Jewel without recoil** (dashed lines) underpredict magnitude at low hadron p_T

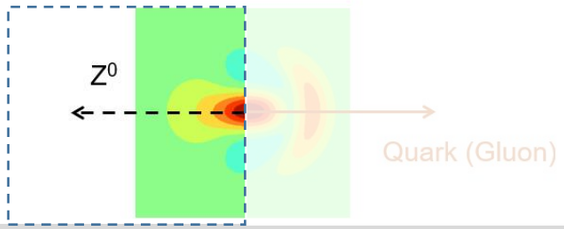
- **Lower p_T Z^0 tagged PYTHIA8 events** also fails to describe data with hadron p_T< 4 GeV.



Zhong Yang, Xin-Nian Wang



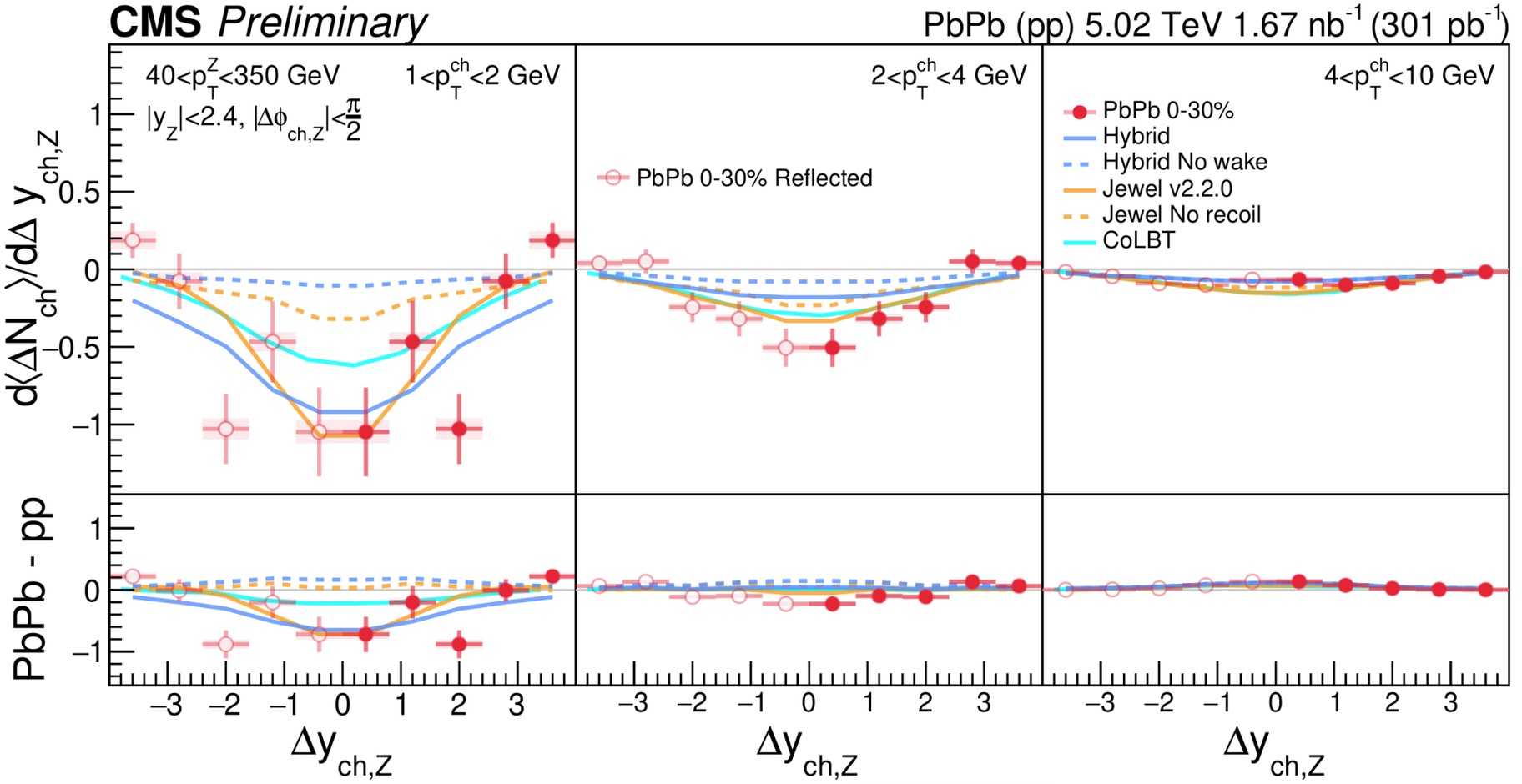
CMS-PAS-HIN-23-006



Rapidity Distribution in 0-30% PbPb vs. Theory

- **Hybrid without wake** and **Jewel without recoil** (dashed lines) underpredict magnitude at low hadron p_T

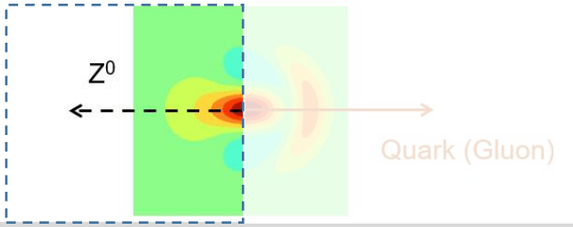
- **Hybrid with wake**, **Jewel with recoil** and **CoLBT** (solid lines) agree better with data



CMS-PAS-HIN-23-006

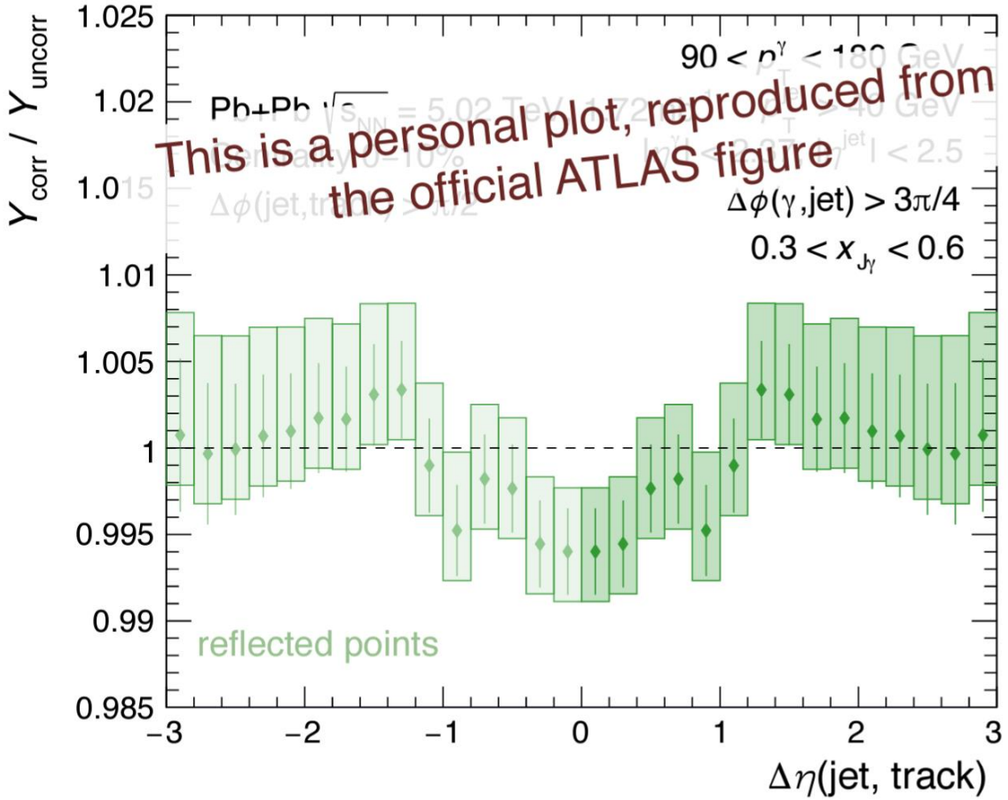
With Δy and Δϕ spectra at low charged hadron p_T:

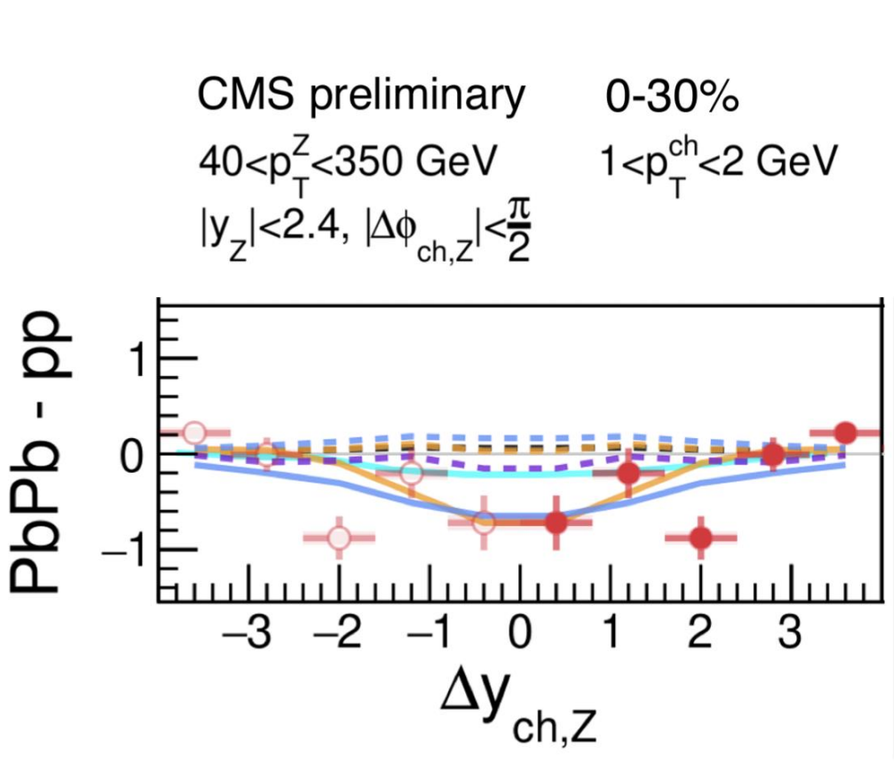
The first evidence of negative **QGP** wake!



News from Soft-Jet 2024 Workshop

Comparison between ATLAS vs CMS





See also Yen-jie and Yi's talks

- Both results shows diffusion wake dip, qualitatively consistent with each other