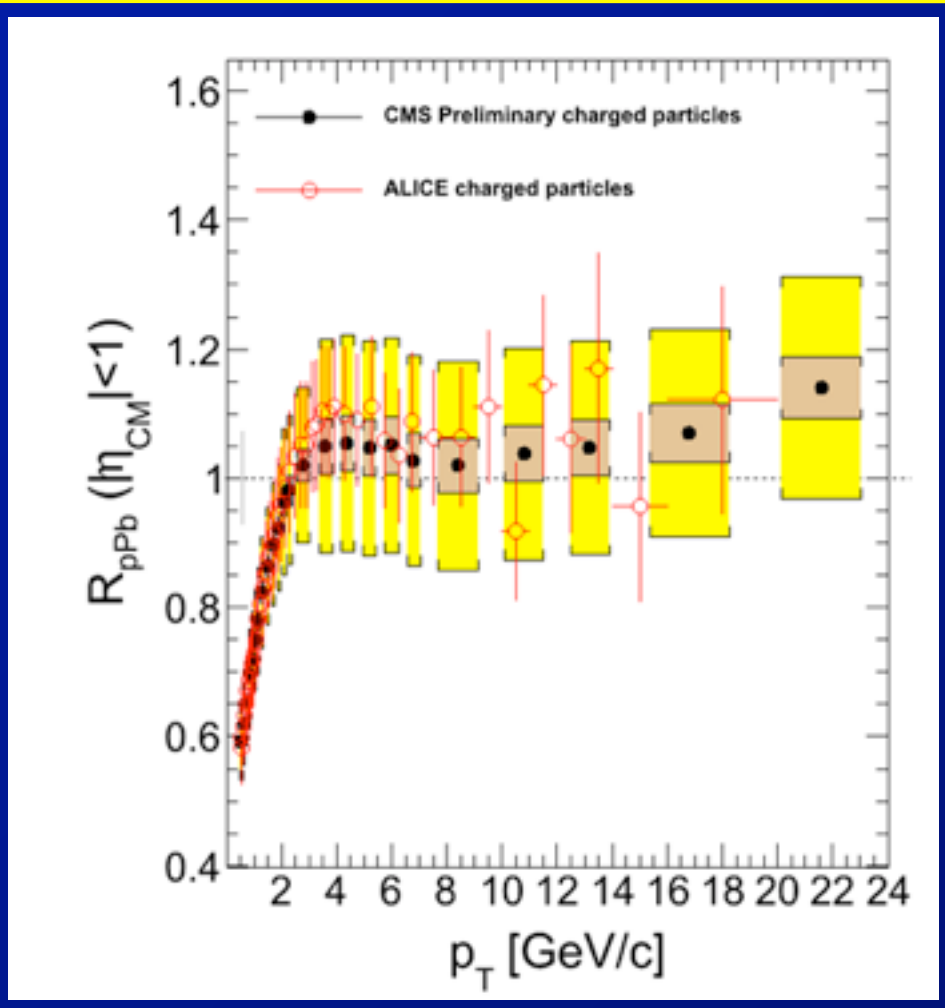
Hard Probes 2013: p+Pb Jets, correlations summary

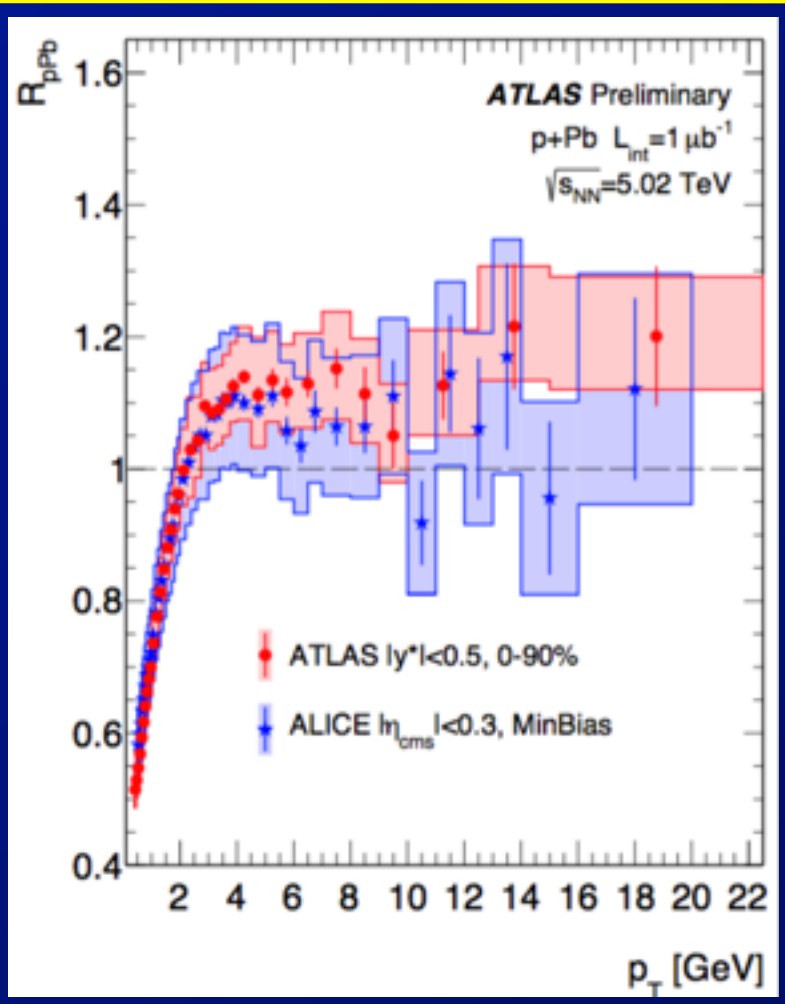
Brian. A Cole

A big thank you to organizers for a great Hard Probes conference

Jets

Charged particle R_{pPb}

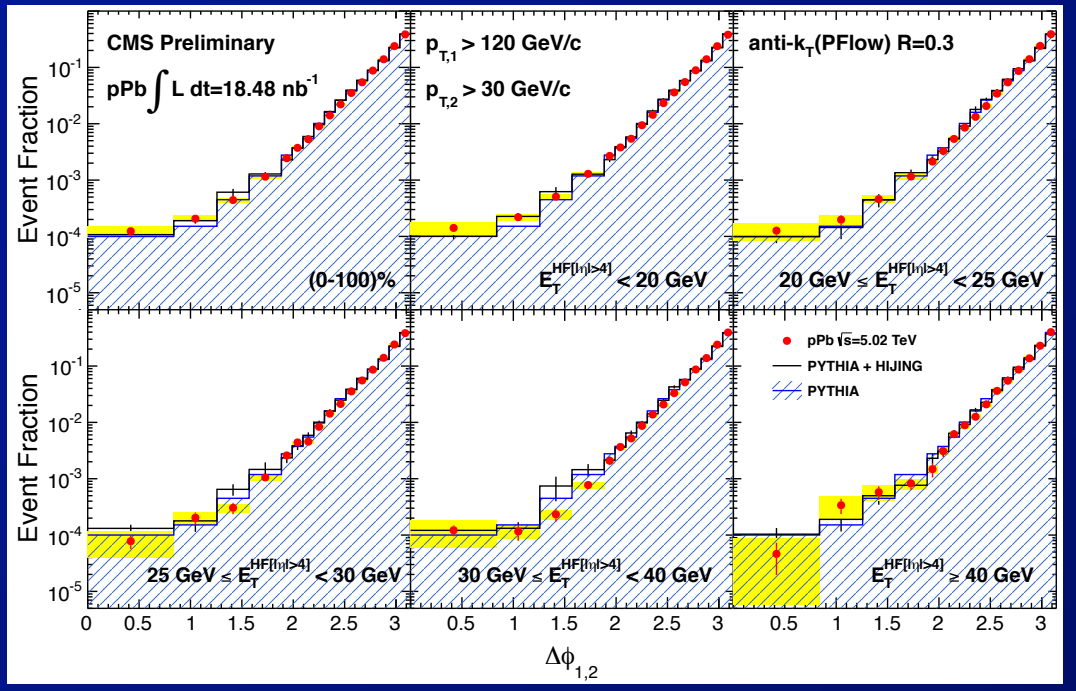


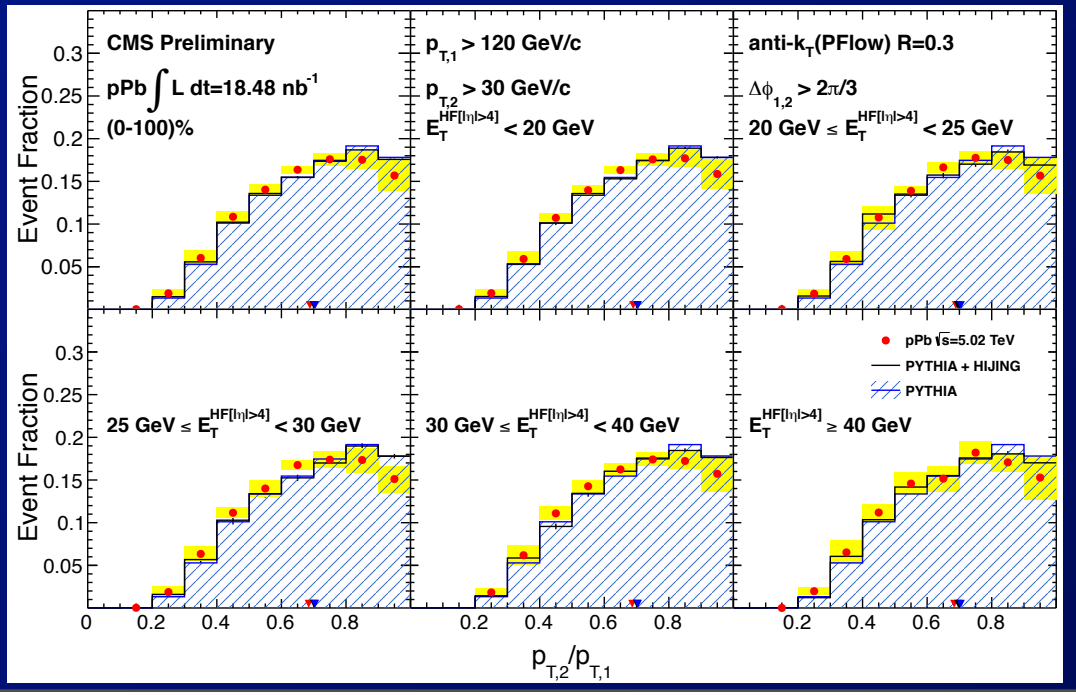


- Good agreement on (almost) minimum-bias charged particle RpPb
  - ⇒Beware differences in event selection

CMS: dijet balance, acoplanarity

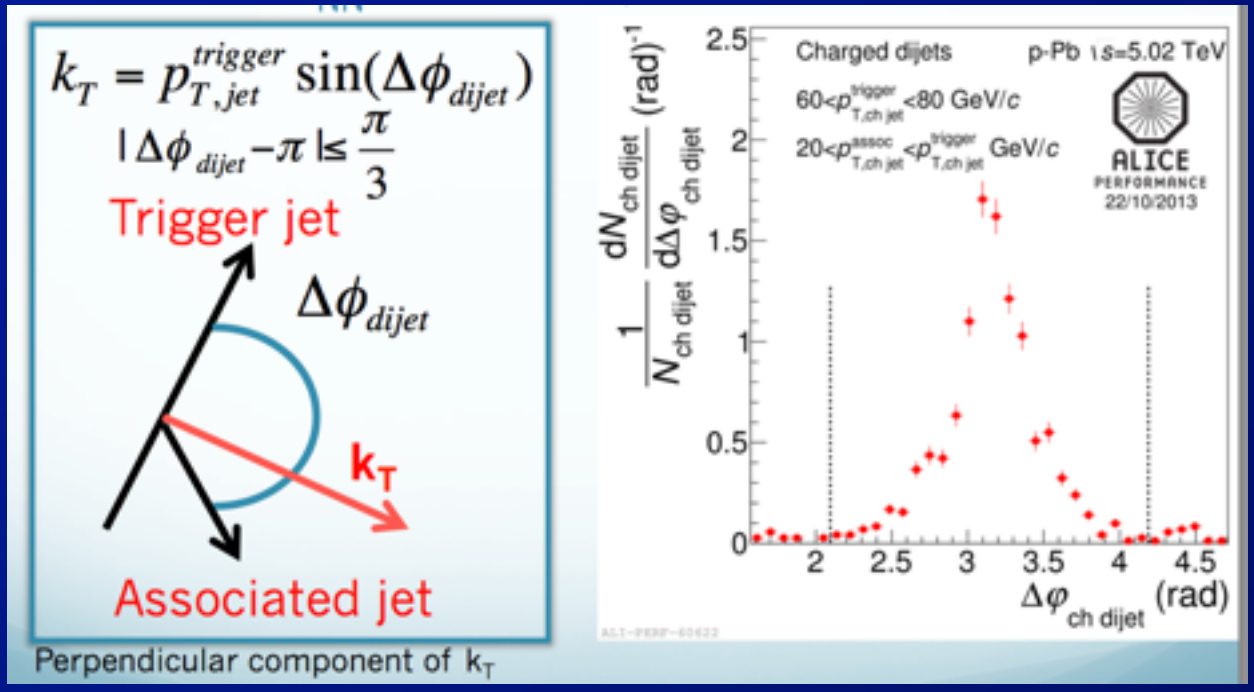
- Dijet $\Delta\varphi$, p_{T2}/p_{T1} in different forward E_T bins
  - ⇒No indication of jet quenching or broadening

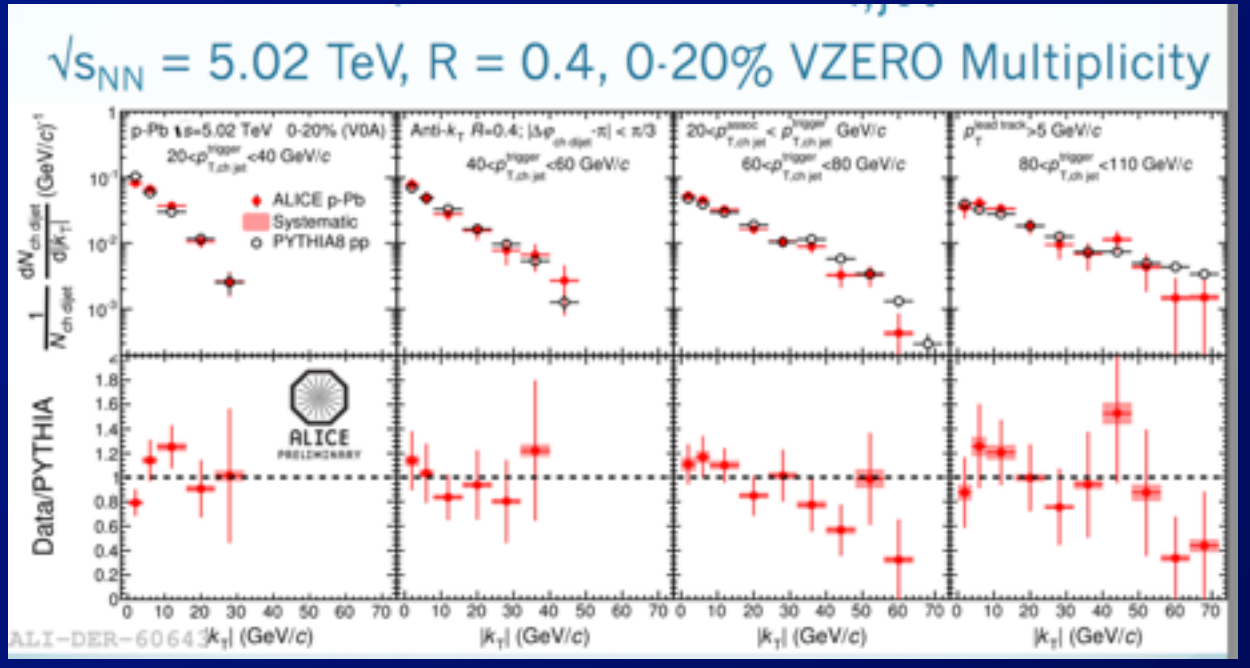




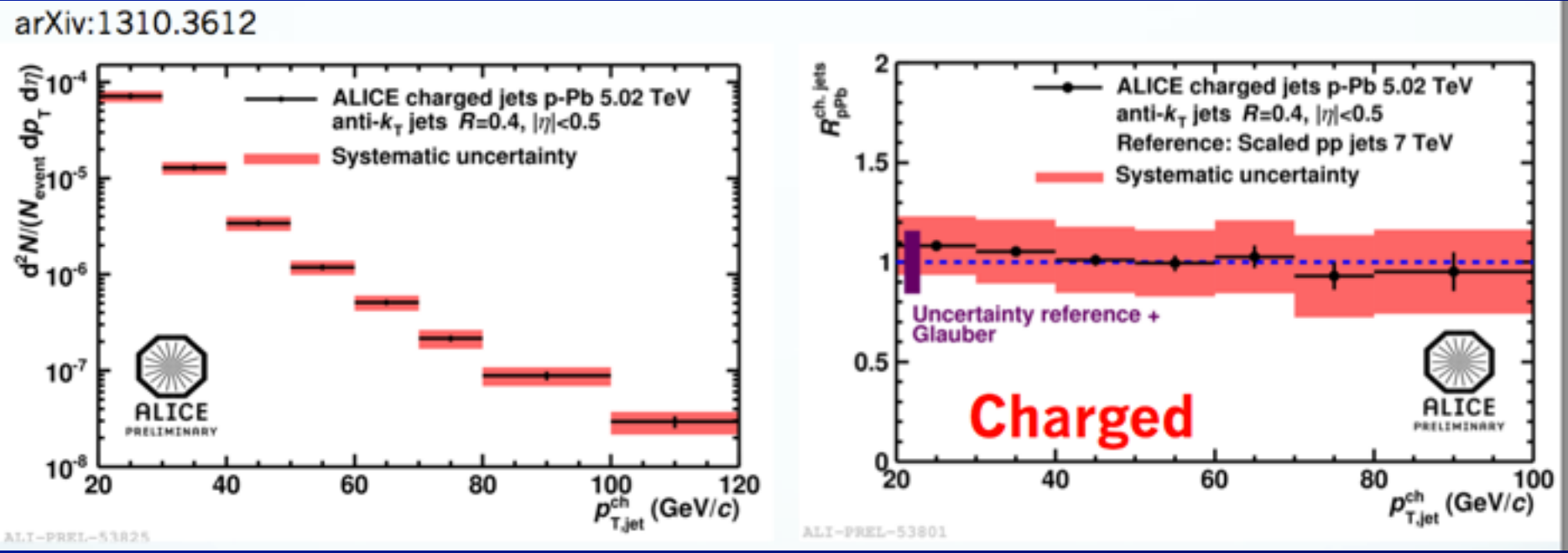
ALICE: Dijet acoplanarity

- Study dijet acoplanarity Using k_T
- Compare p+p to high multiplicity p+Pb
  - ⇒Observe no broadening in p+Pb
  - ⇒Where are the effects of multiple scattering?



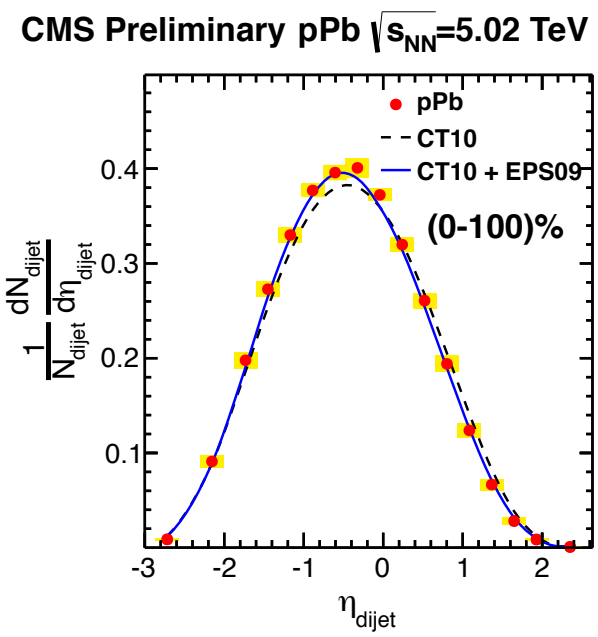


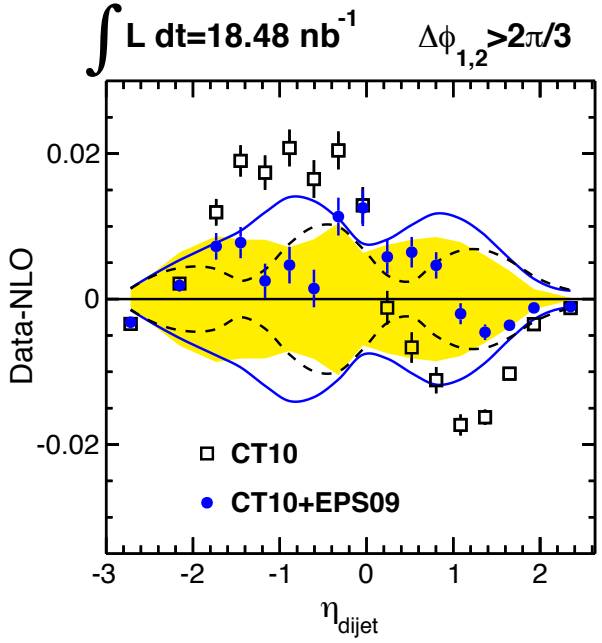
ALICE: (charged) jet R_{pPb}

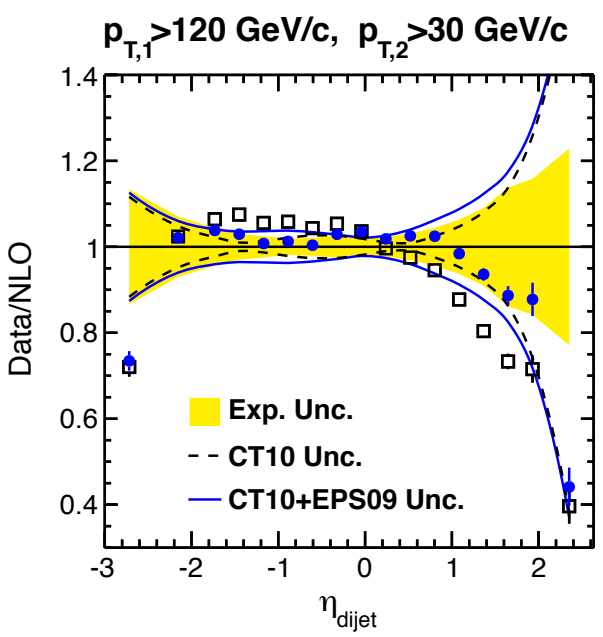


- p+Pb inclusive R = 0.4 charged particle jets compared to scaled 7 TeV p-p ($|\eta| < 0.5$)
  - RpPb ≈ 1
    - ⇒ Since $p_T \geq p_T^{ch}$, implies $R_{pPb} \approx 1$ to larger p_T
    - ⇒ No modification of jet yield out to/beyond 100 GeV in inclusive p+Pb

CMS: dijet pair η



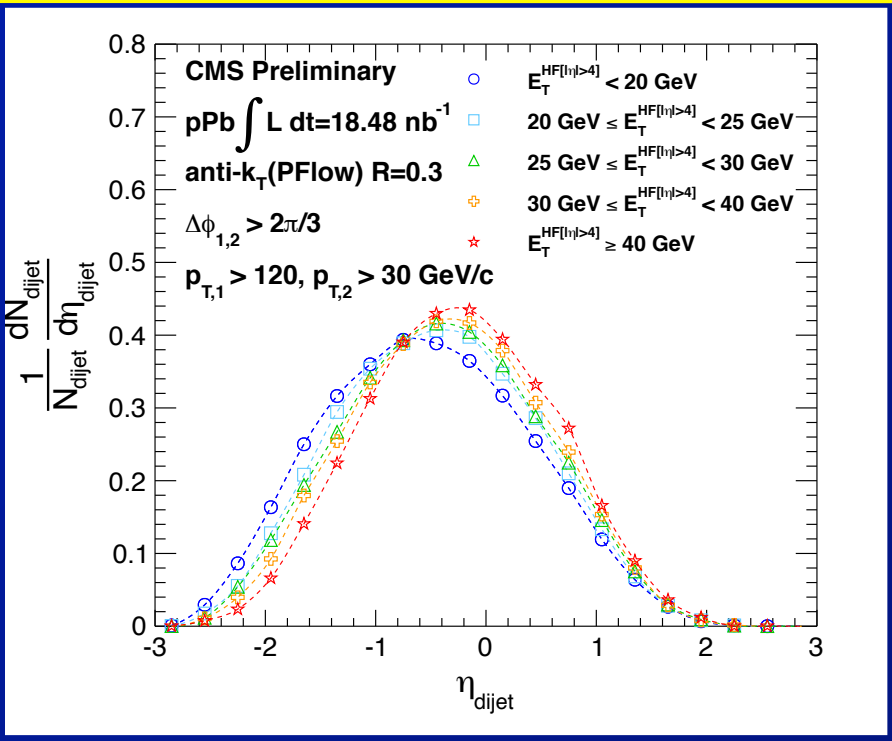




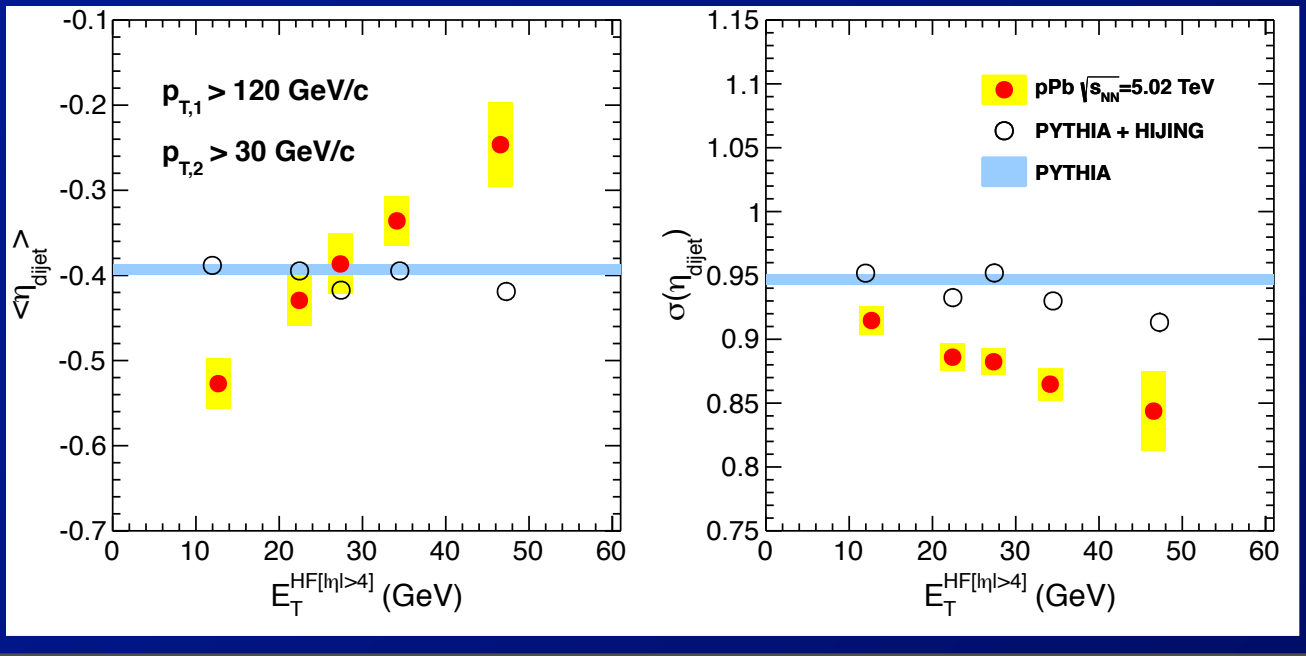
- **Use dijet pair kinematics to probe nPDF**
  - Sensitive to shape of the distribution, not absolute yields

  ⇒See backward (Pb direction) shift of dijet η distribution, consistent with EPS09
- **(Minor) comment: why not y^*_{dijet} ?**

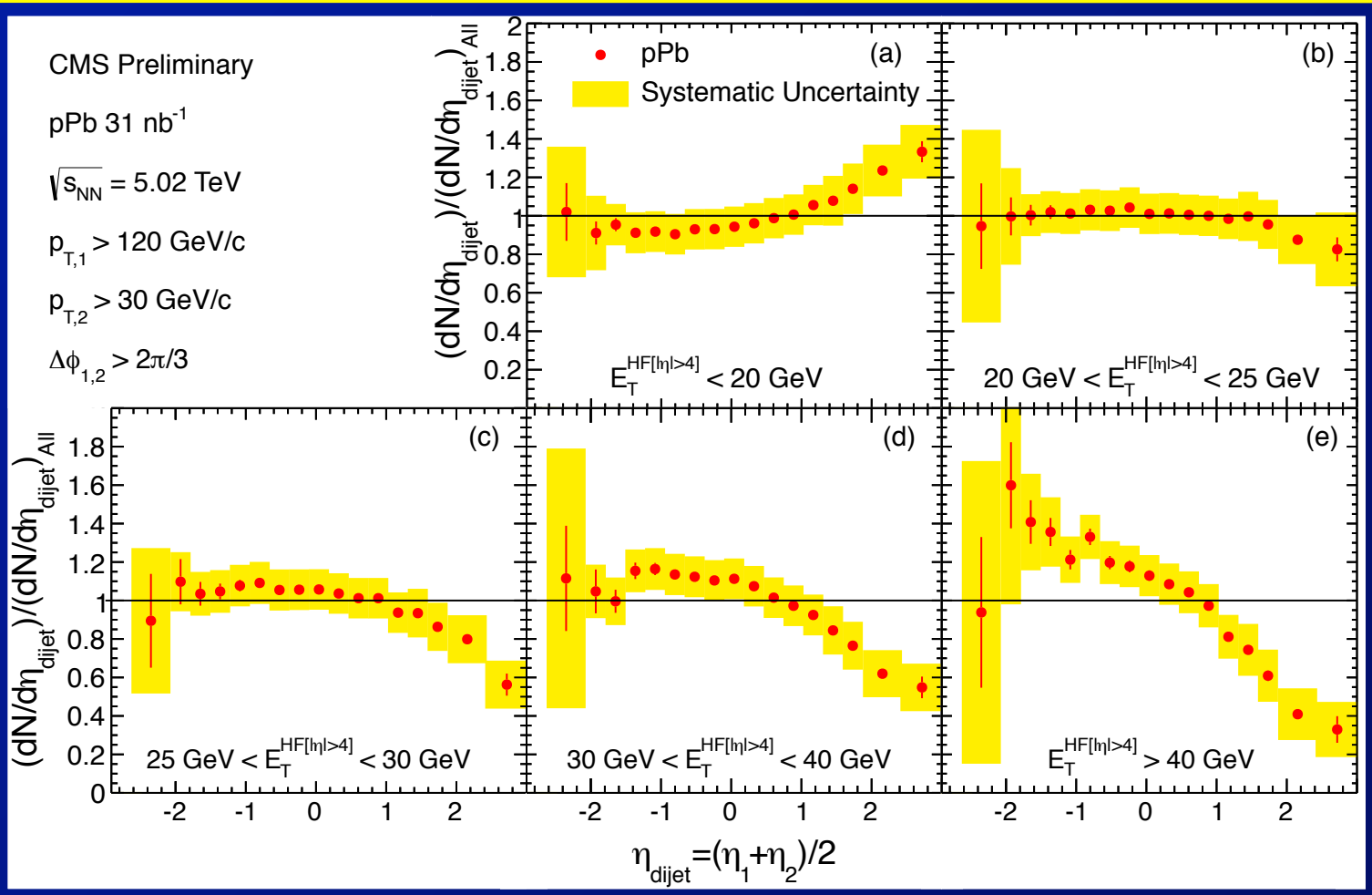
CMS dijet, HF E_T dependence



- For higher HF E_T ($|\eta|>4$), dijet pair η distribution shifts backwards, narrows
  - ⇒Too rapidly to be consistent with nPDF



CMS dijet, HF E_T dependence



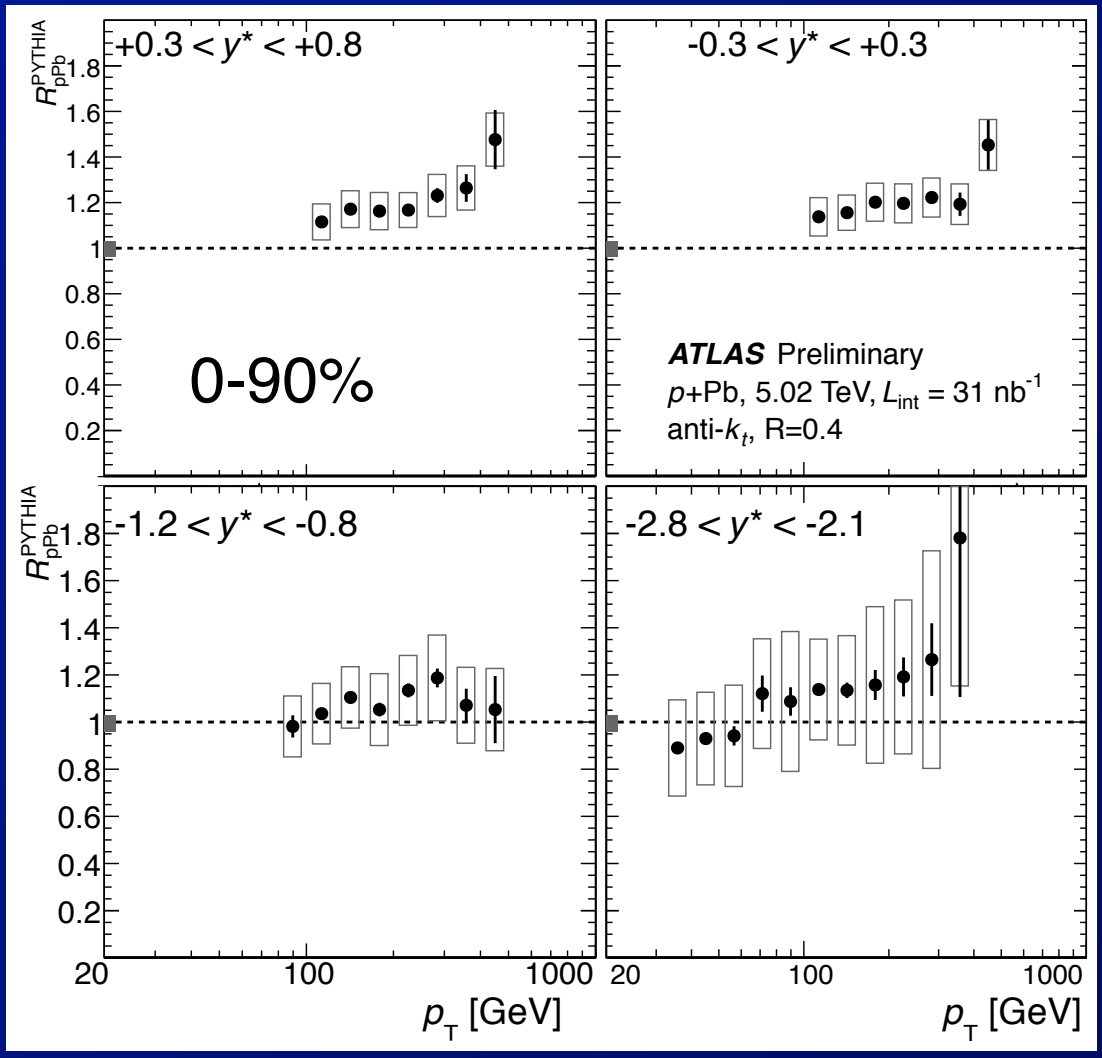
- Strong variation of dijet pair η distribution with increasing HF E_T

ATLAS single jets

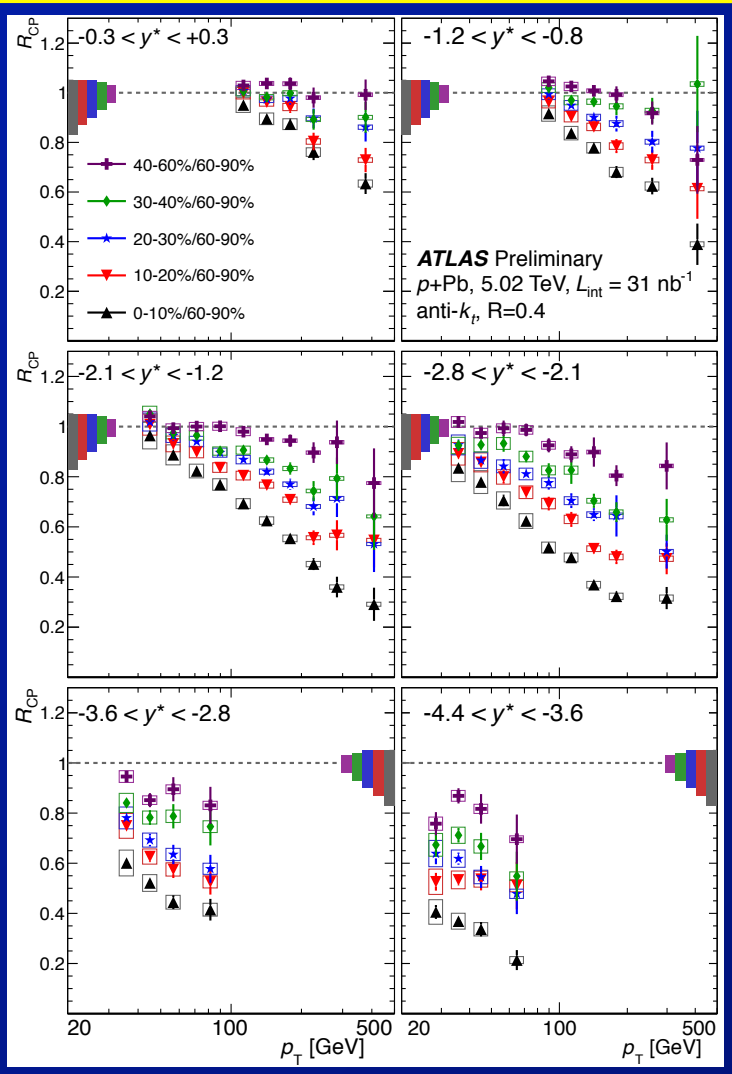
- "Inclusive" RpPb
  - PYTHIA used as baseline
  - Mid-rapidity and forward (proton direction)
  - High p_T where UE has no impact

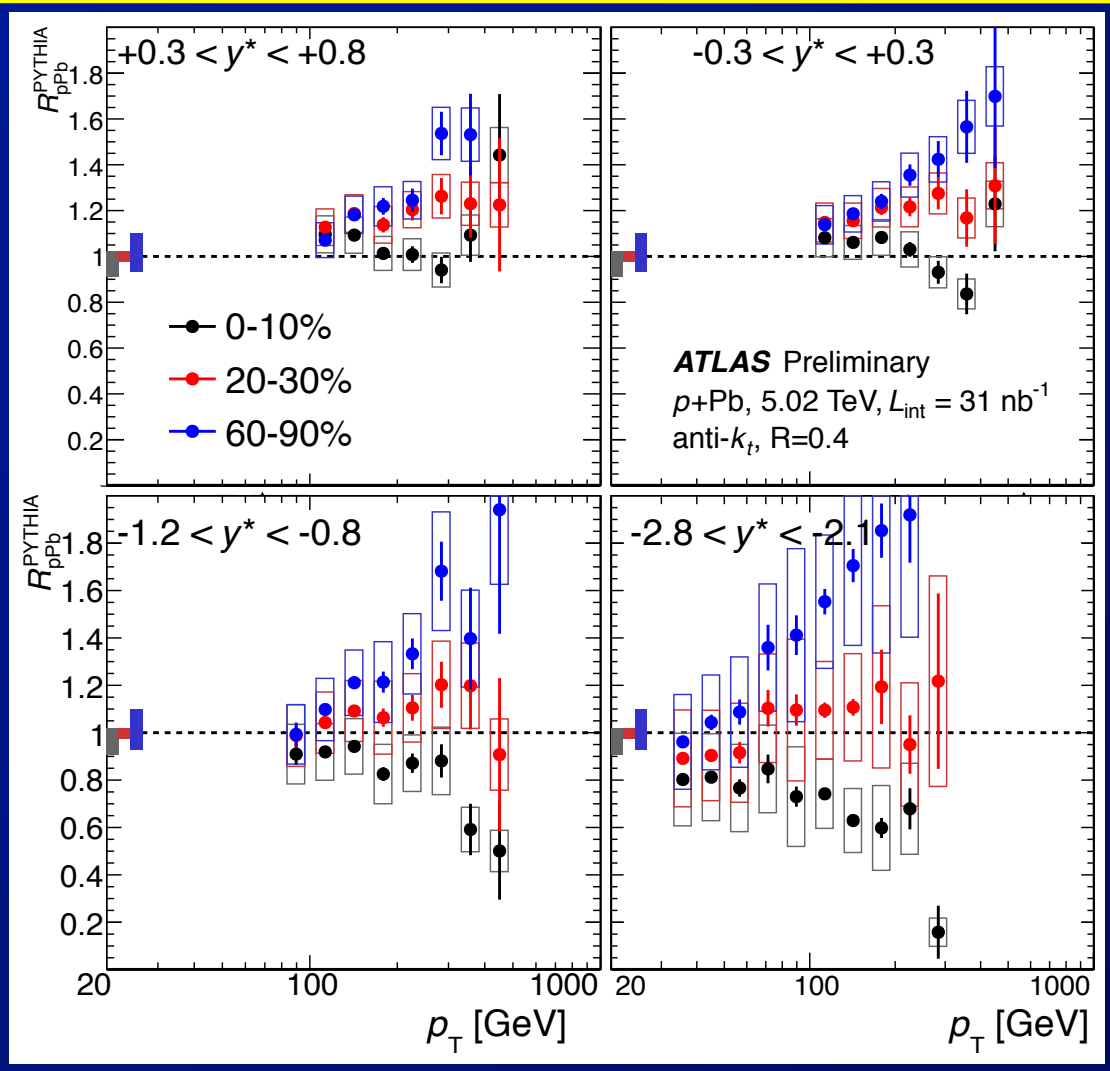
⇒ $R_{pPb} > 1$ at mid-rapidity

⇒ Consistent with 1 more forward (larger errors)



ATLAS p+Pb jet R_{cp}, R_{pPb}





- Enhancement (suppression) of forward/ high p_T jets in peripheral (central)!?

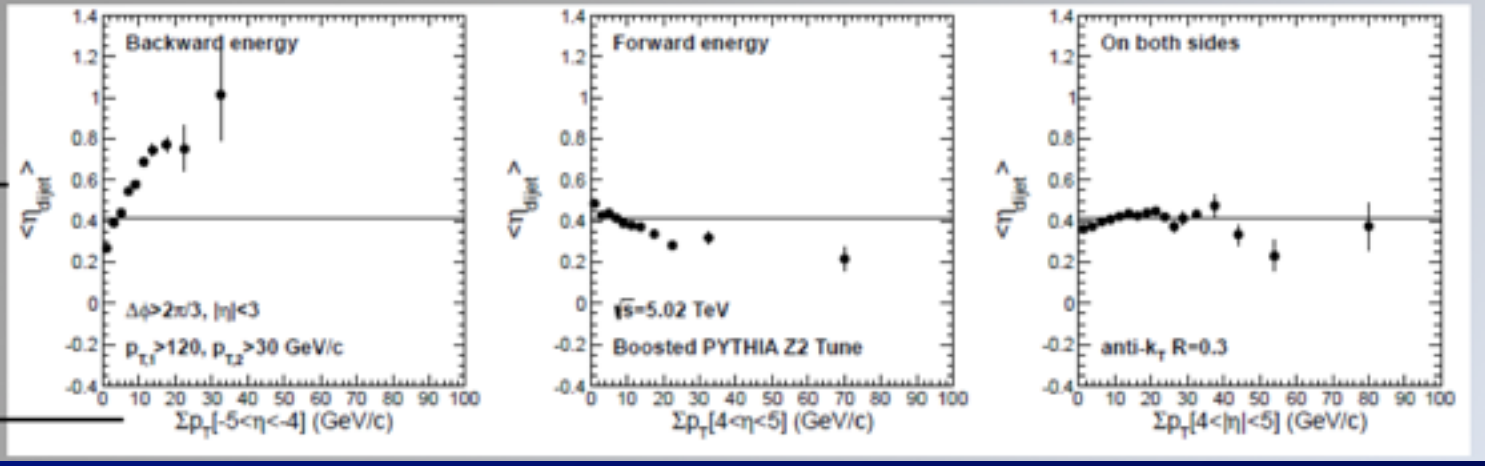
hard-soft correlations, E conservation

- **Beware: we know that there are hard-soft correlations in p-p collisions**
  - e.g. between jets and forward E_T
  - ⇒Anti-correlation for jets close in η to the E_T measurement (see below).
- **Physical origin?**
  - Energy conservation likely important
  - ⇒Where "centrality" is measured important.

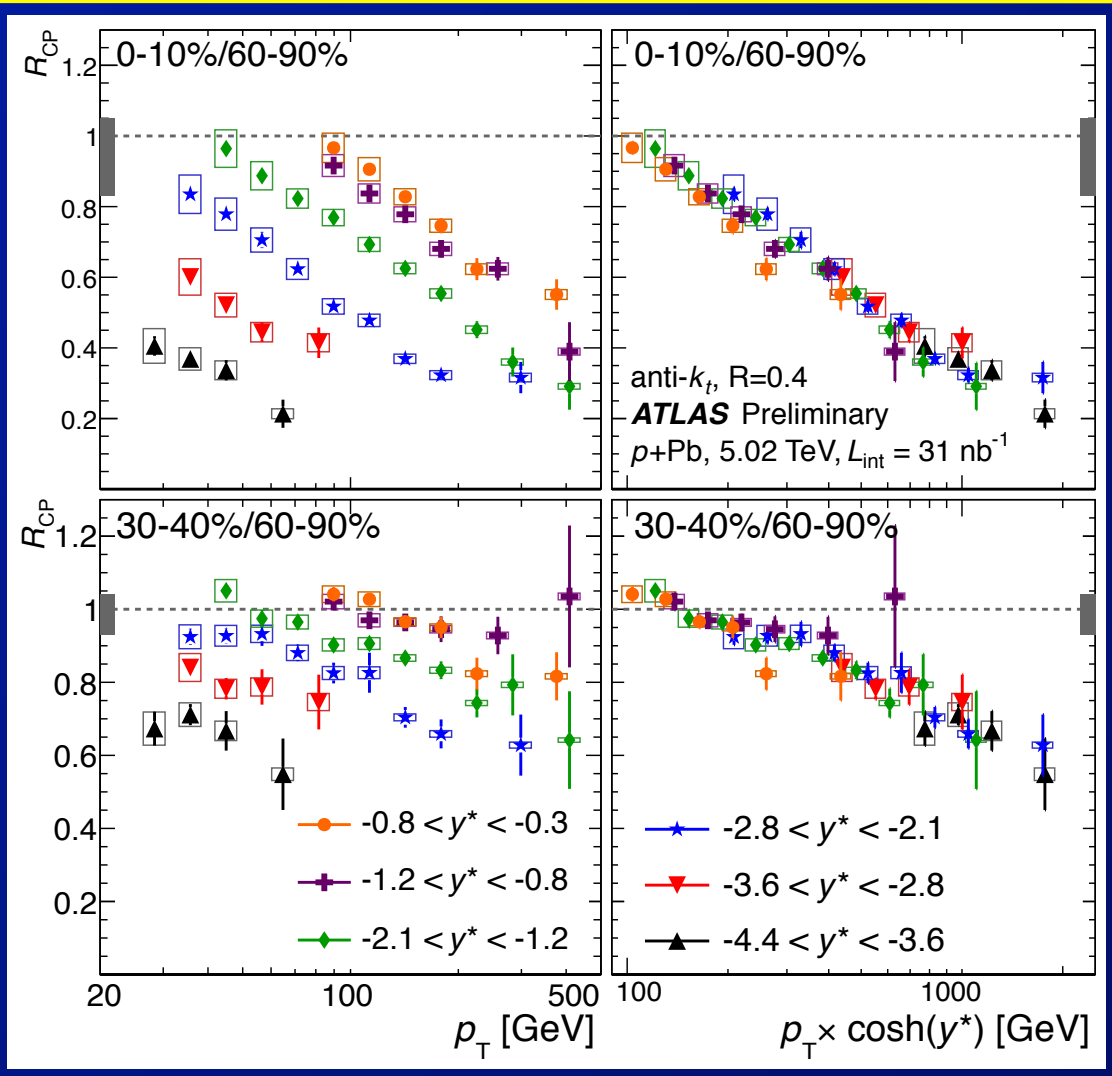
$$\eta_{dijet} = \frac{\eta_1 + \eta_2}{2}$$

η of the frame of hard interaction

Energy in the forward region



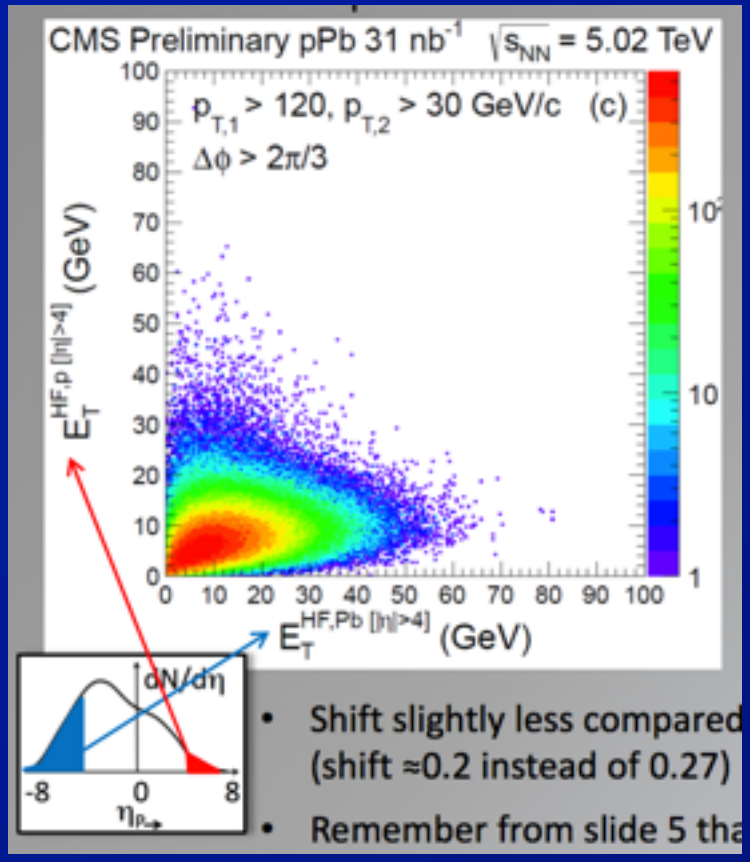
ATLAS jet R_{cp}, E-scaling

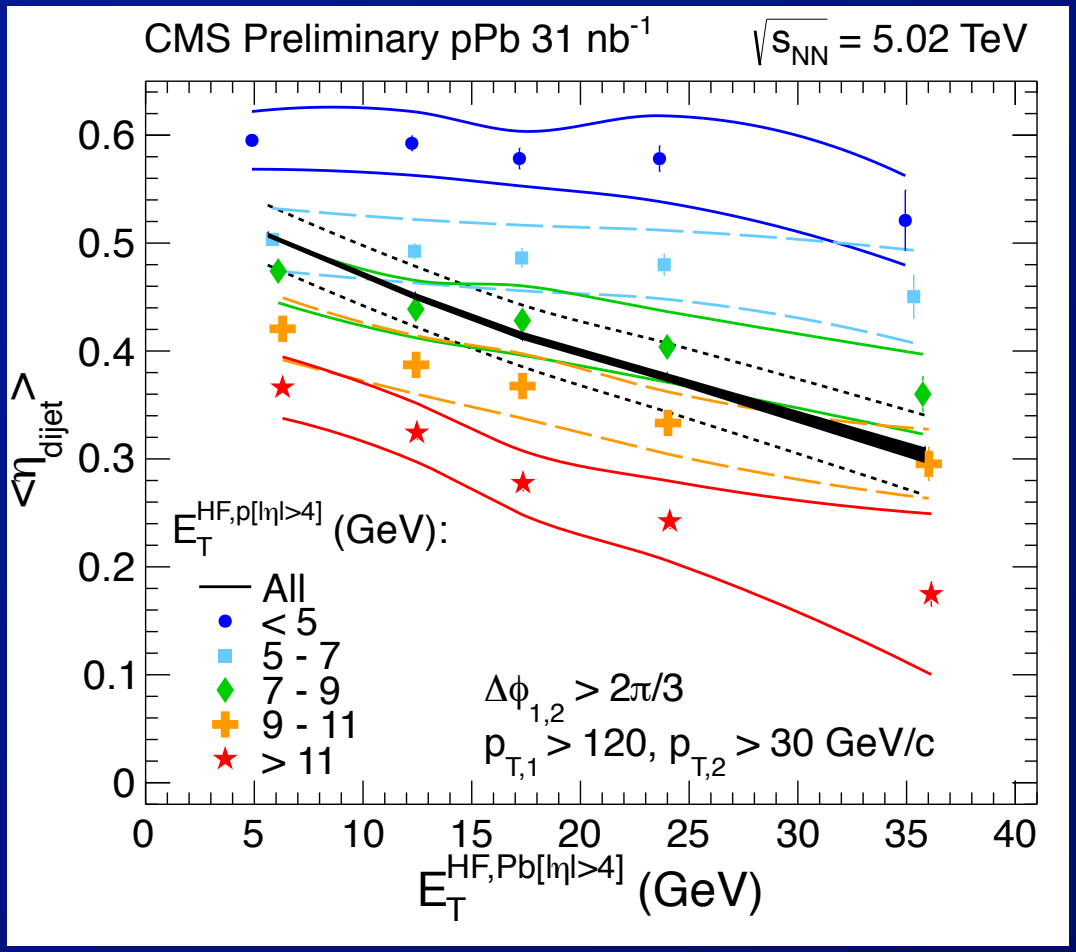


- **The mechanism that is responsible for the centrality dependence of (forward) jet production depends on the jet energy**

CMS dijet, forward/backward HF E_T

From Doga's talk

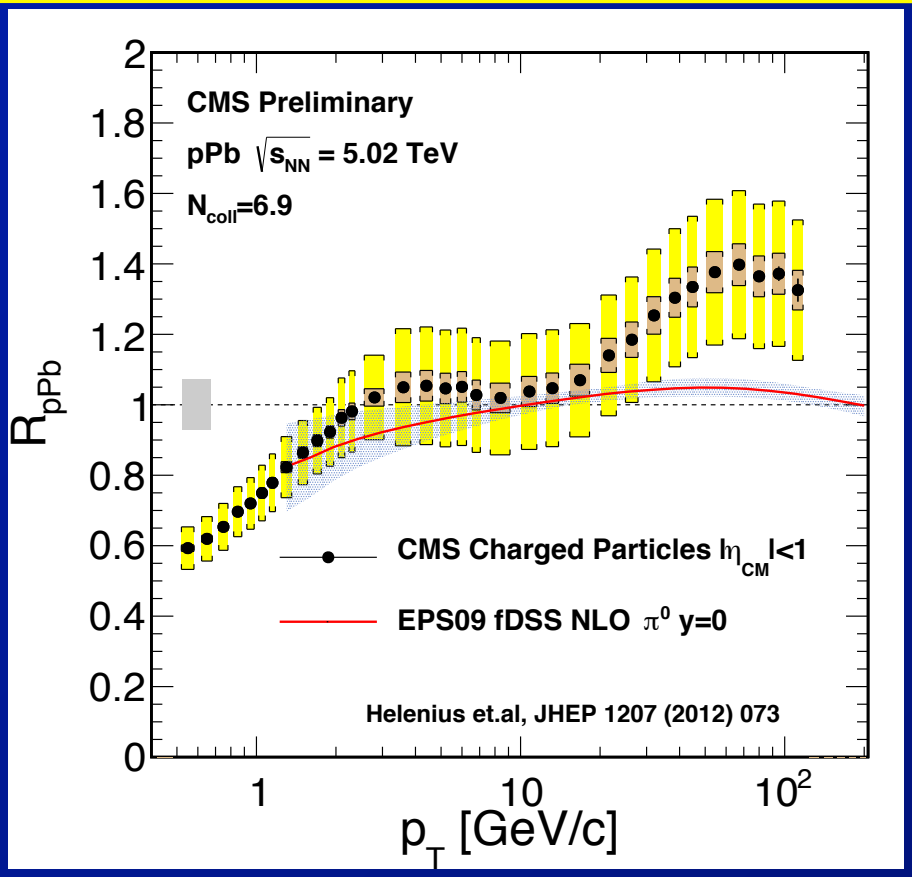


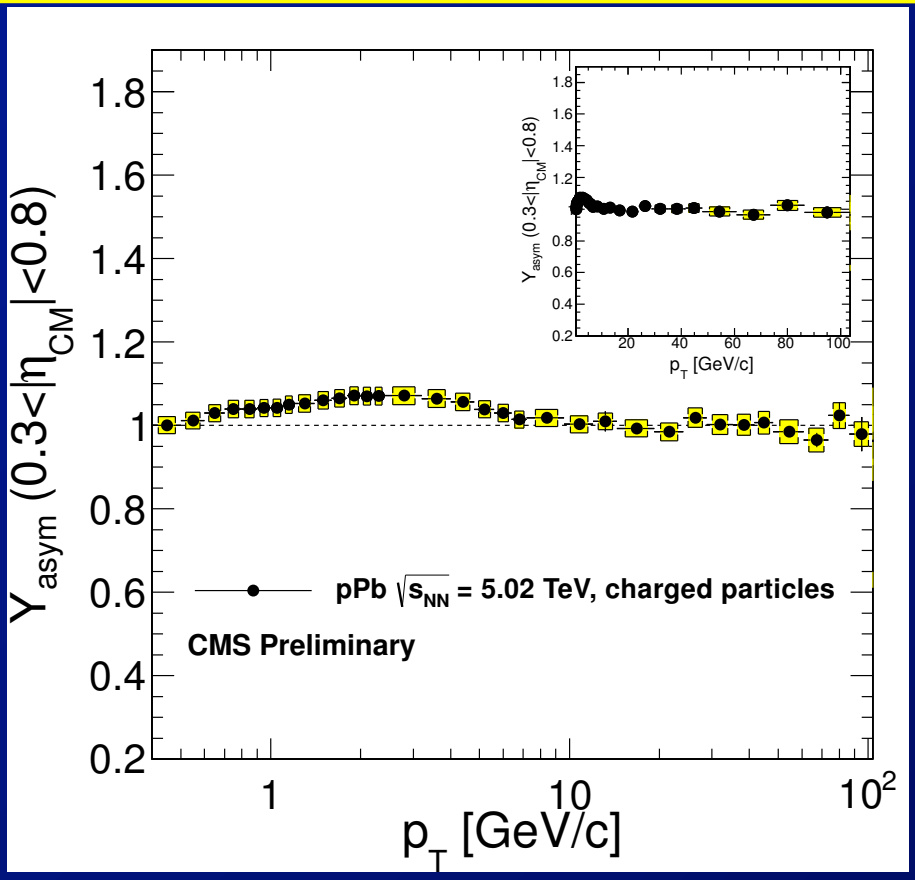


- **Vary both forward and backward HF E_T**
  - **Stronger backward shift with Pb side HF E_T for larger p side HF E_T**

⇒ Dynamics or kinematics?

CMS charged particle R_{pPb}

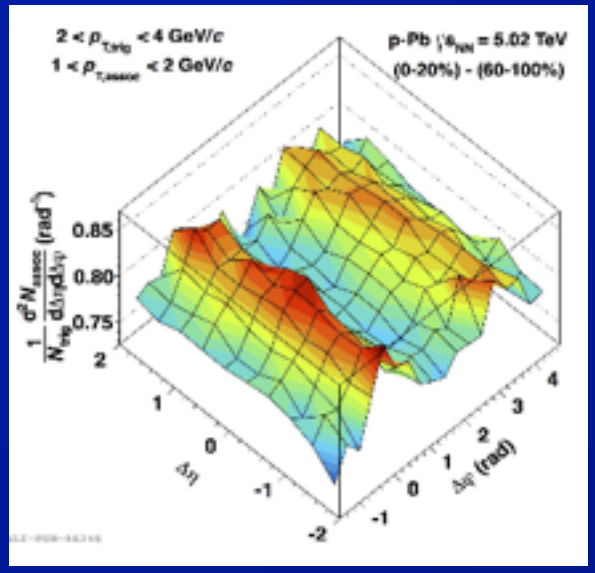


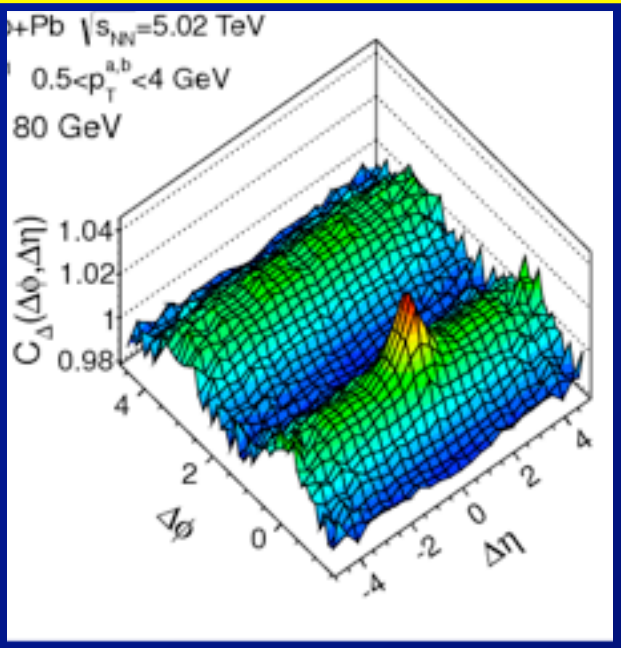


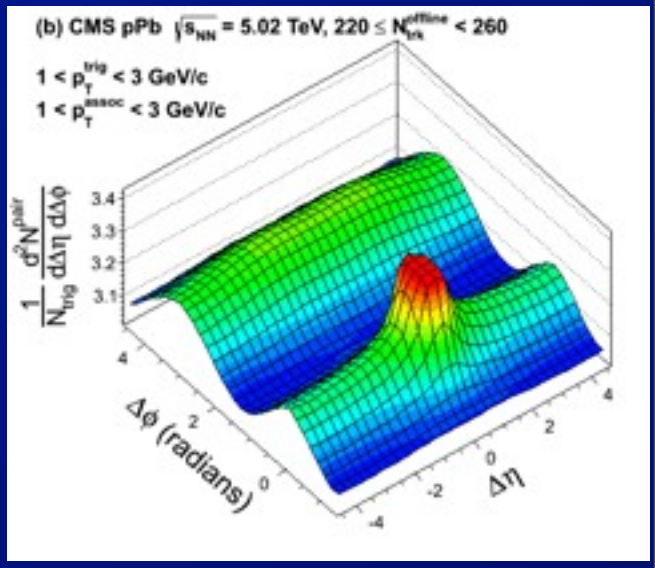
- **Unexpected behavior also observed in inclusive charged particle R_{pPb} ($|\eta_{cm}| < 1$)**
  - **⇒Not consistent with nPDF @ y = 0**
  - **⇒η_{cm} symmetric out to η_{cm} ~ 1.8**

Two-particle (ridge) correlations

Paradigm shift

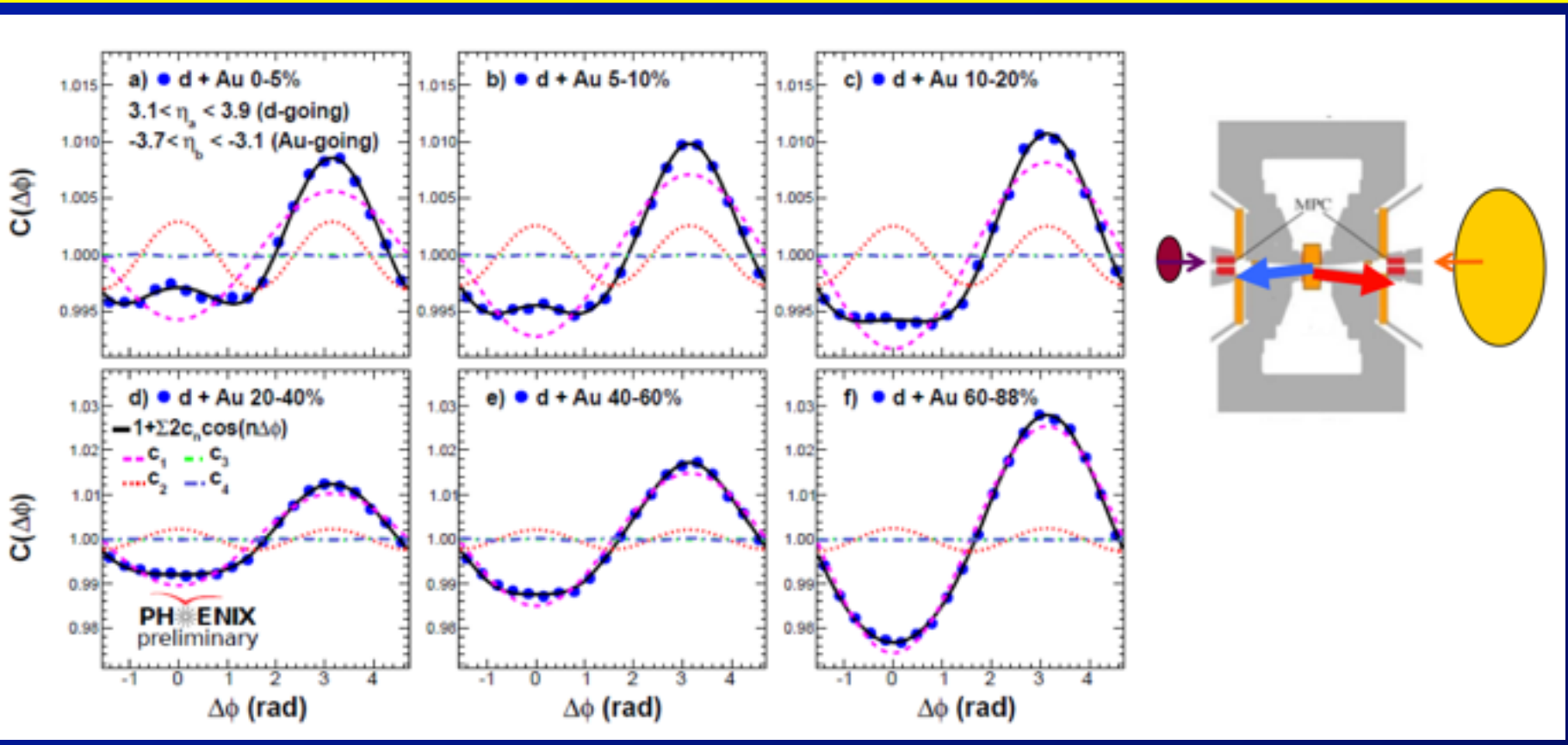






- **Much can happen in one year …**
- **Still too soon to make definitive statement regarding CGC vs final-state collectivity.**
  - **But, recent results suggestive of final-state collective effects.**
- **Focus on new results:**

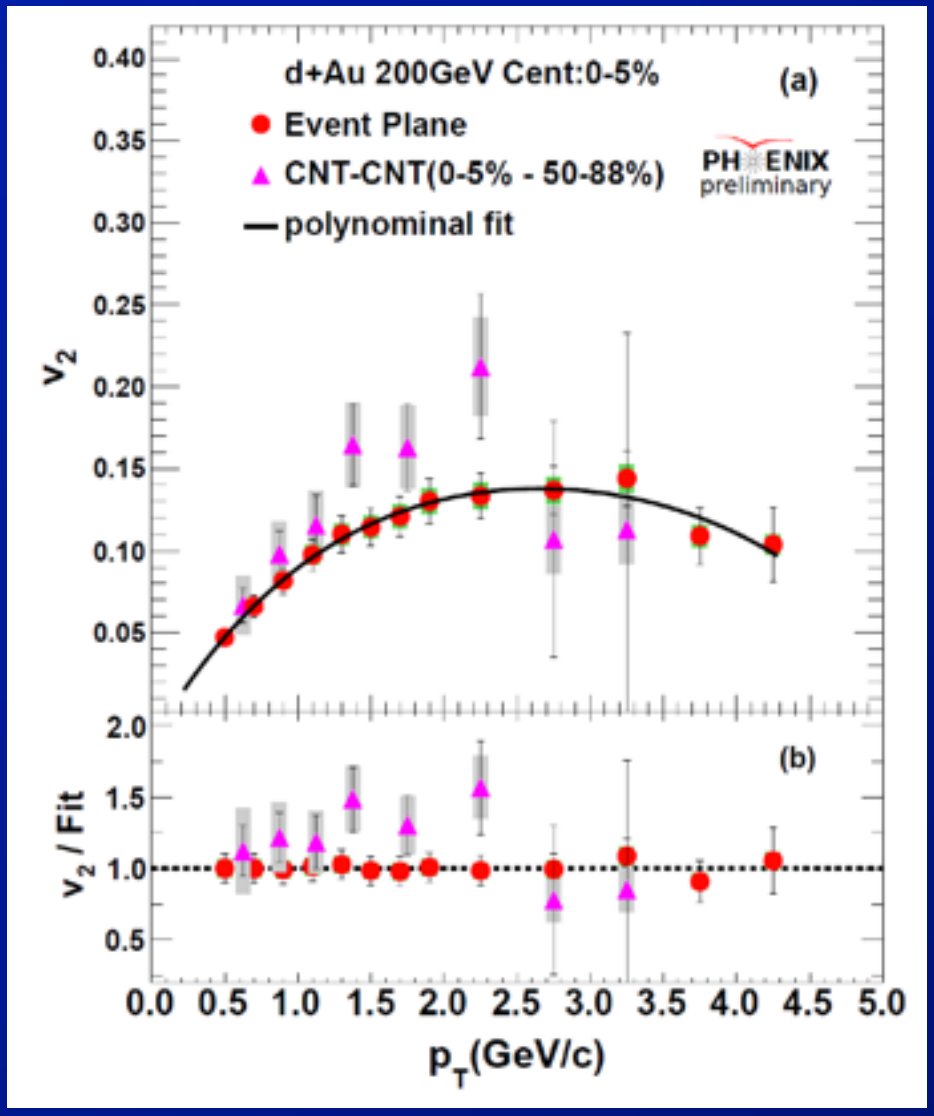
PHENIX: long-range 2-particle correlations

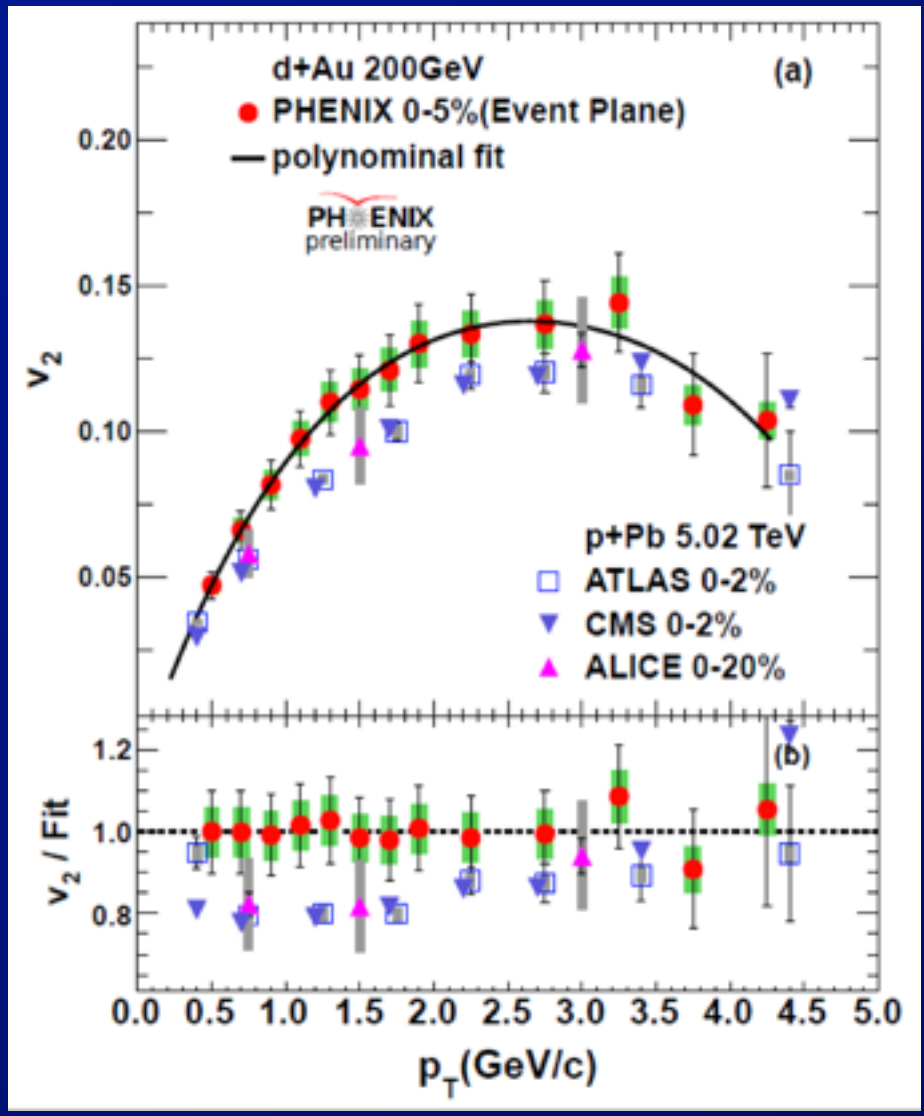


- PHENIX sees near-side ridge for $\Delta\eta > 6.2$
  - but wide dijet peak (or p conservation?) makes peripheral subtraction difficult

  ⇒use scalar product, event plane methods

PHENIX: long-range 2-particle correlations

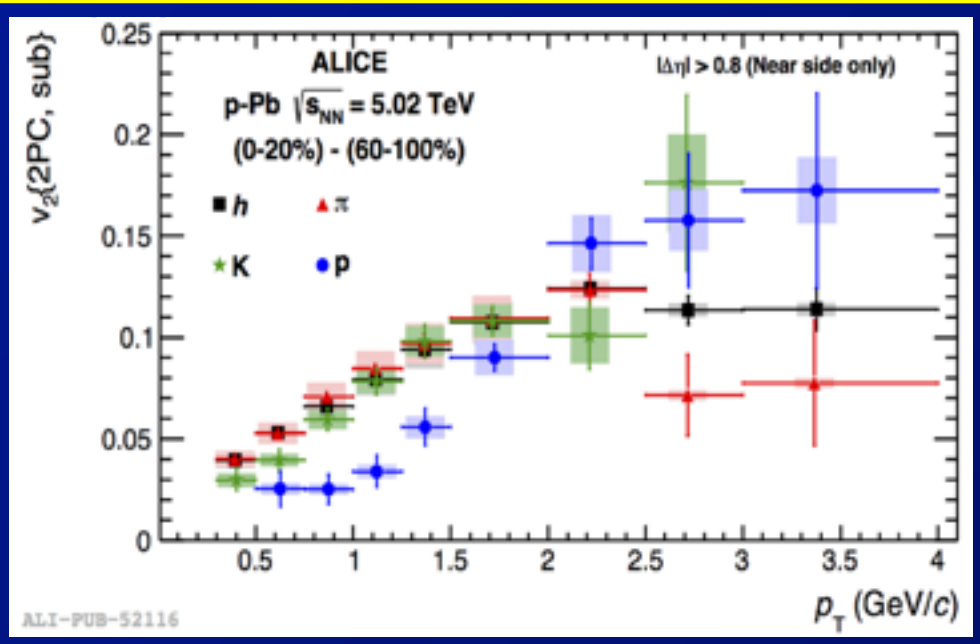


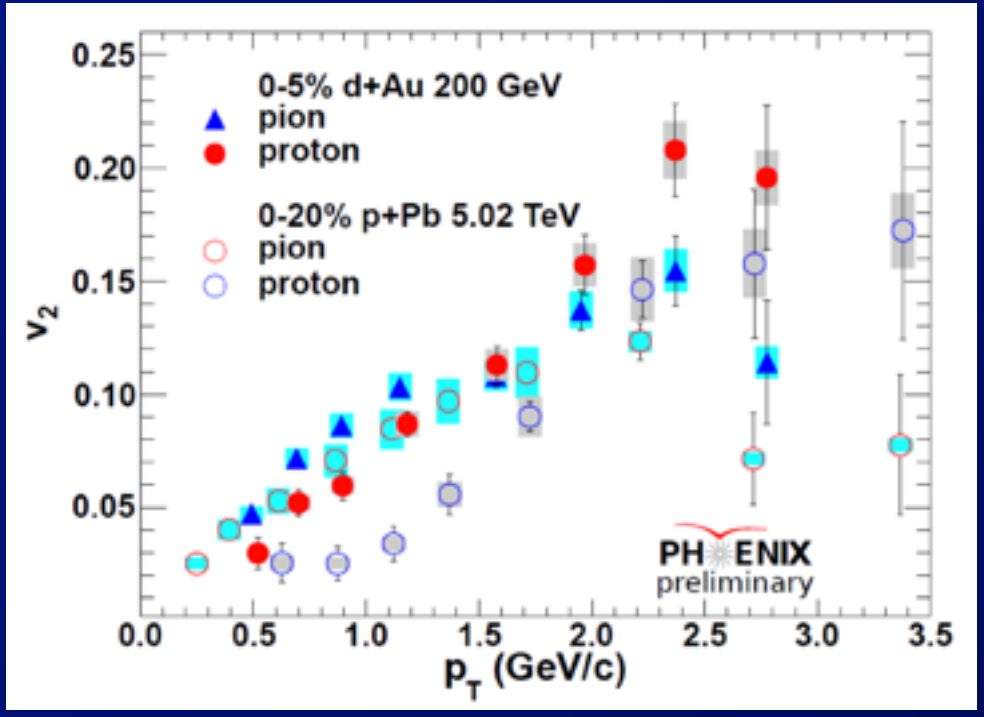


- Event plane method yields smaller v_2 than the published mid-rapidity results.

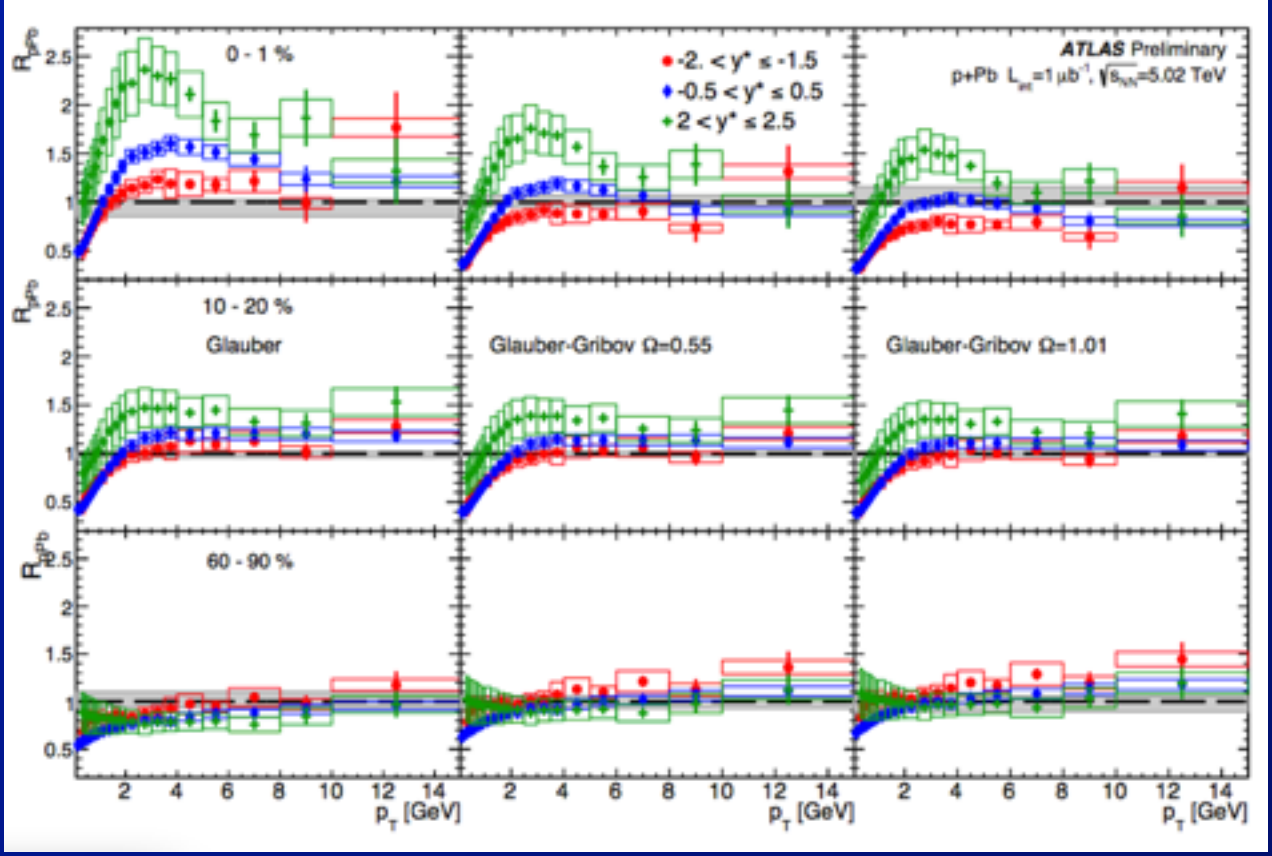
PID dependence

- ALICE previously reported mass dependence to v_2
  - ⇒Strongly suggestive of collective final state origin
- PHENIX now sees mass ordering, but much weaker
  - ⇒Consistent with weaker radial flow, larger initial eccentricity?





ATLAS R_{pPb} vs centrality



- From Peter S.'s talk on Monday
  - Suppose "Cronin effect" is due to collectivity

    ⇒Strongly rapidity dependent

    ⇒ Then, likely v_2 and v_3 will be as well (PHENIX)

Conclusions: jets

- Jet story is not as simple as we might have thought:

From Aaron's talk

- Strong correlation between hard ($q^2 > (100\ \text{GeV})^2$) and soft (UE) particle production
  - In collinear factorized QCD these processes should factorize
  - Correlation not obviously describable by known mechanism
- Case 1: Suppression is the result of a correlation between hard and soft processes affects centrality variable
  - Is correlation due to kinematic constraints?
    - Suppression scales with jet energy
    - Effect significant well away from kinematic limit
  - Is correlation a feature of proton wave function?
    - Likely selecting valence quarks in the proton
  - Know that in *pp* collisions, hard scattering processes are accompanied by larger underlying event
    - Goes in opposite direction as *p*+Pb effect
    - To what extend are these related?
- Case 2: CNM effects cause suppression in central collisions and enhancement in peripheral collisions
  - Correlation enters through centrality dependence of CNM effects

Conclusions: correlations

- Steady progress on p+Pb correlations
- New at this meeting:
  - results from PHENIX and STAR
    - ⇒Reduction in PHENIX v_2 using rapidity separation, event plane method
    - ⇒As argued by STAR?
- But, we still do not have consistent story between PHENIX and STAR
  - ⇒Needs resolution
- Need analysis of η dependence.
- Role of "fluctuations" (Glauber-Gribov, Muller-Qiu, …) needs to be understood.