Summary Jet results in QM2017

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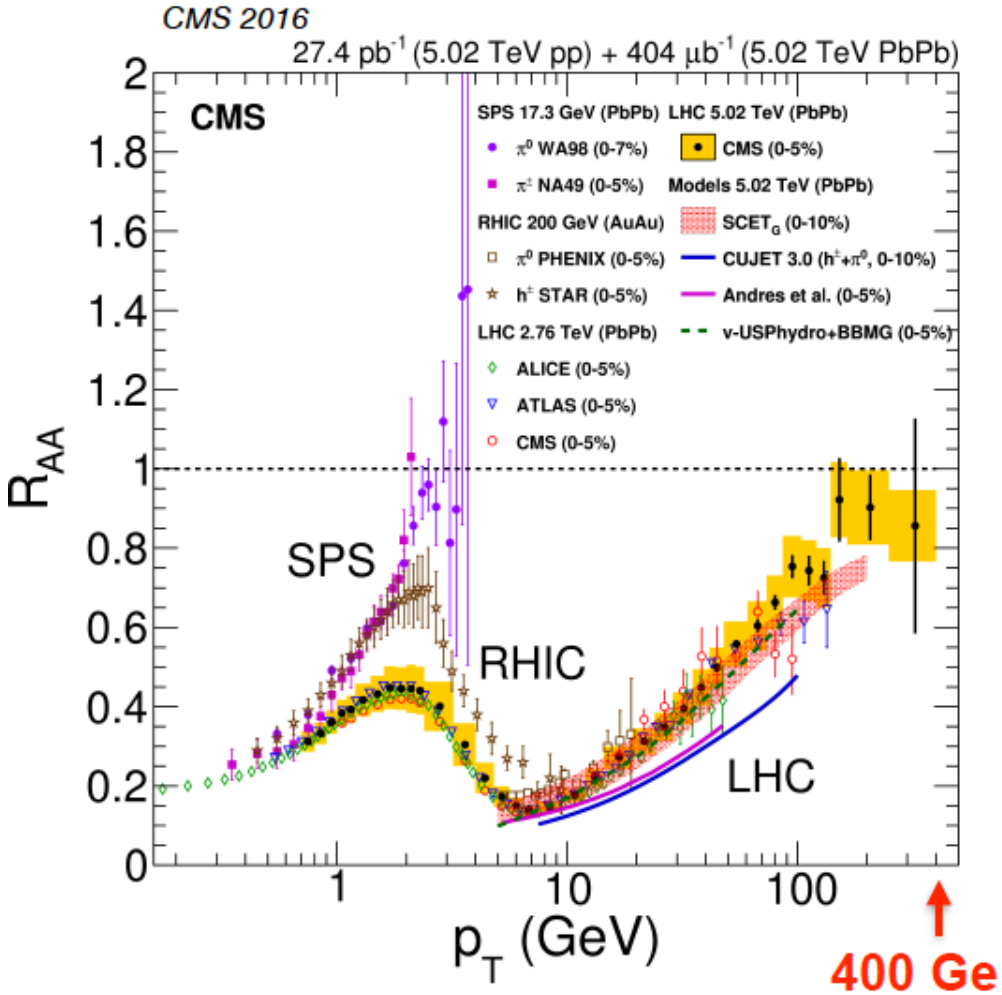
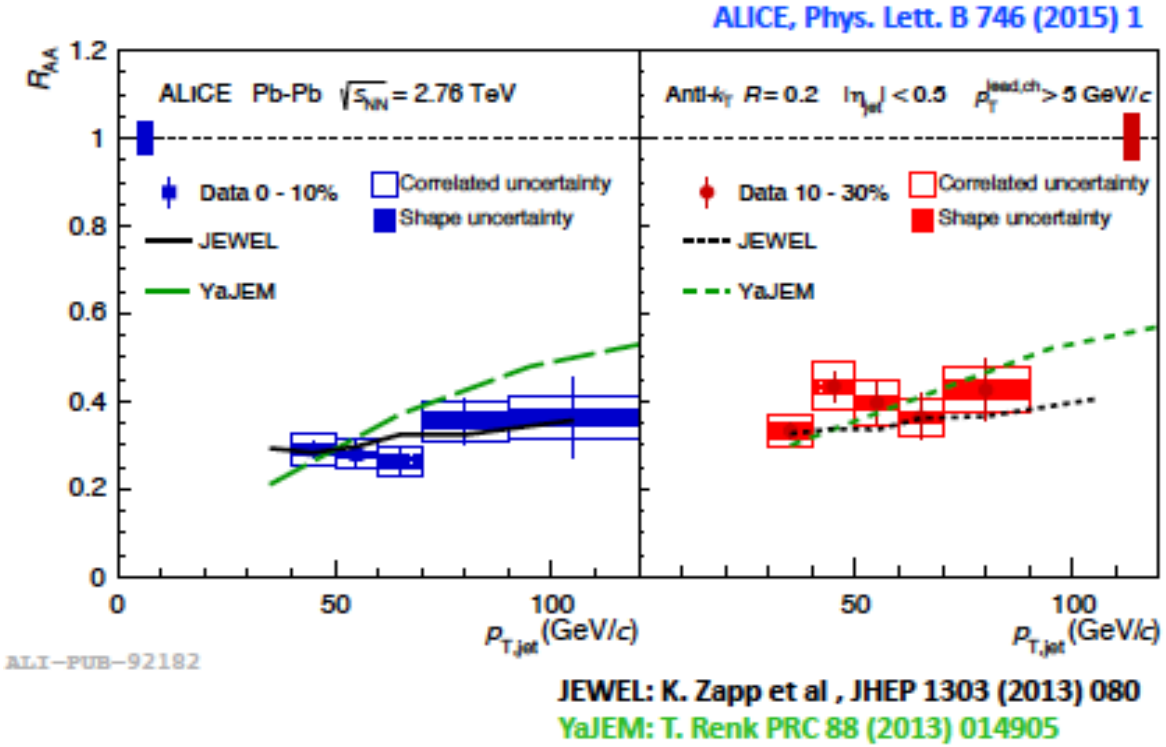
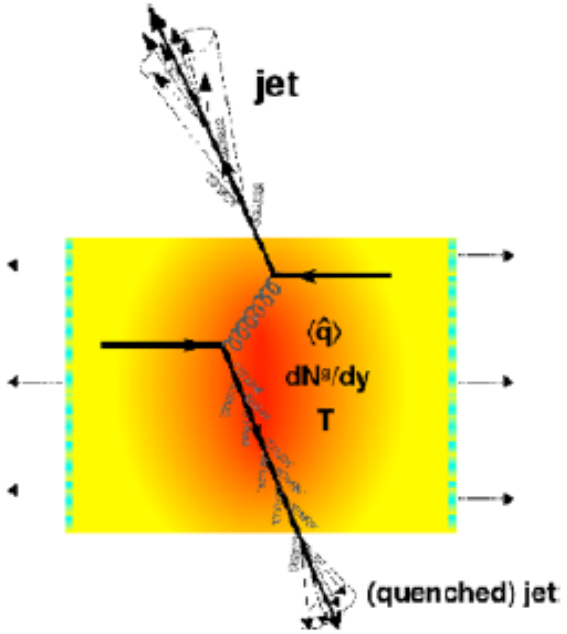
Introduction (1)



- Strong suppression of high p_T particle production in heavy-ion collisions
- Due to energy loss of partons in hot & dense QCD matter
- Energy loss mechanizm
  - Collisional energy loss
    - Collisions with medium
  - Radiative energy loss
    - Induced gluon emission
- Jet measurement
  - Address parton & medium interaction which allows to study energy loss

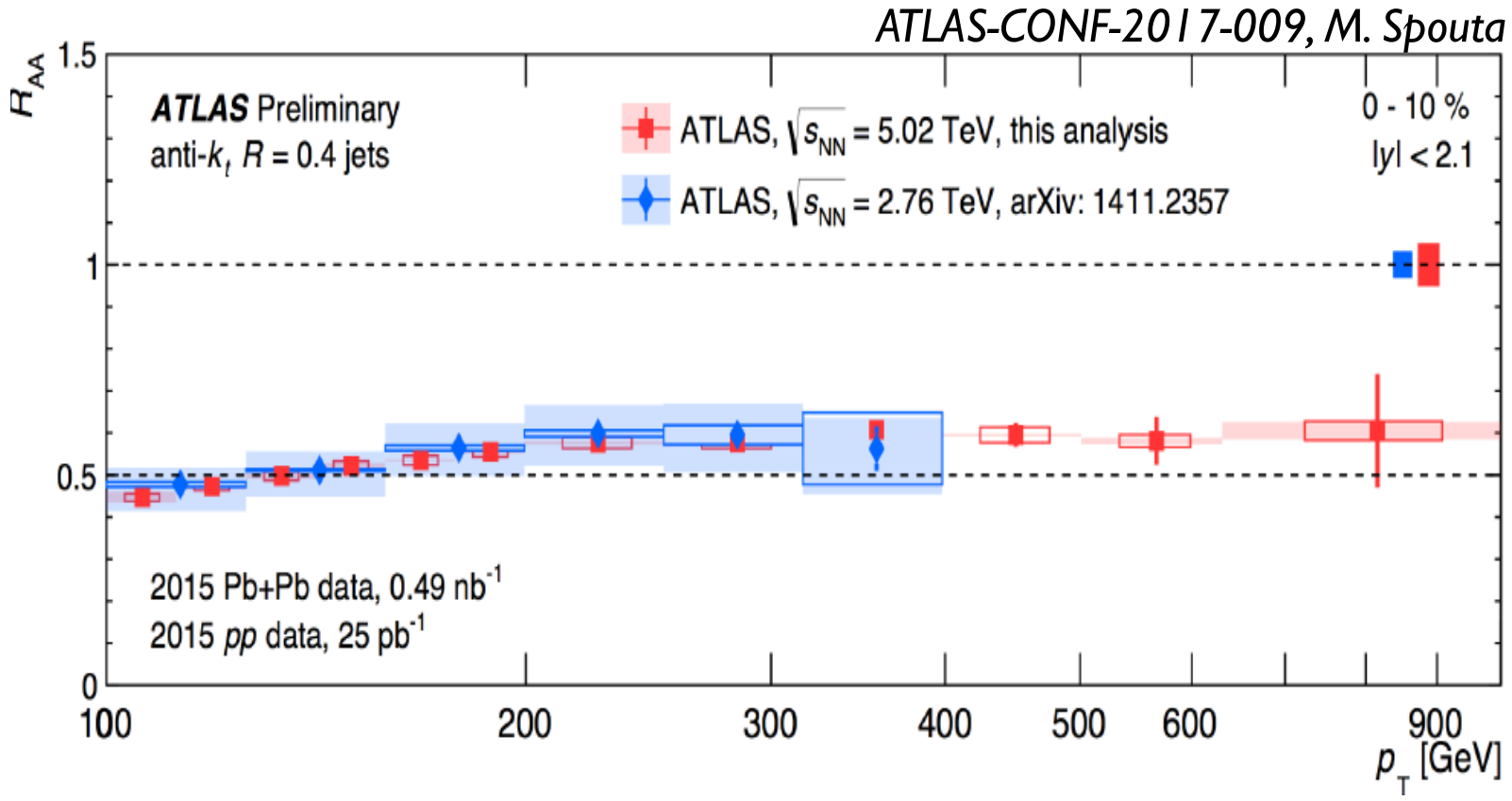
Introduction (2)





- A strong suppression of jets has observed at LHC
- Detailed mechanism of the energy loss can be studied
  - Energy dependence, di-jets & Flavour dependence (jet level)
  - Fragmentation function & Jet structure (inside of jet, constituent level)

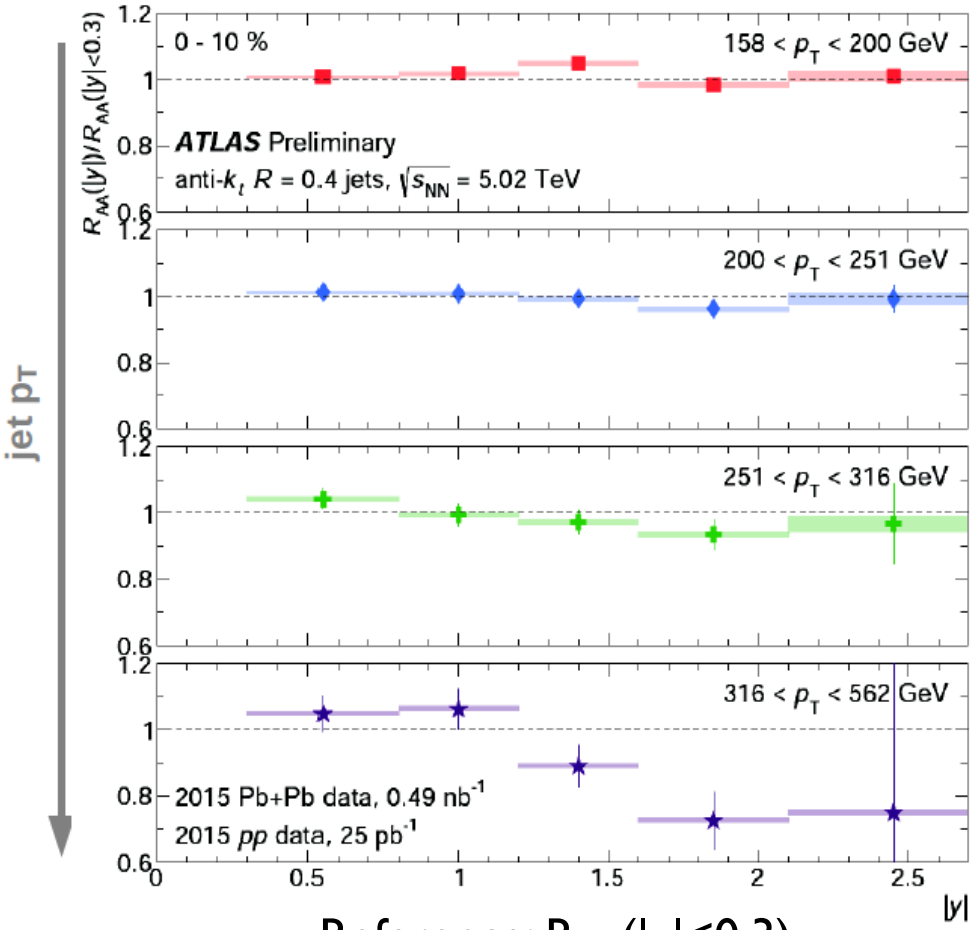
Jet R_{AA} in PbPb at 5.02 TeV (0-10%)



- Jet R_{AA} in 0-10% in 5 TeV PbPb collisions
  - Observed suppression up to 1 TeV
    - 2.76 TeV up to 400 GeV/c
  - Similar suppression between 2.76 TeV and 5.02 TeV (no collision energy dependence)

y-dependence of R_{AA} in PbPb at 5.02 TeV

ATLAS-CONF-2017-009, M. Spouta

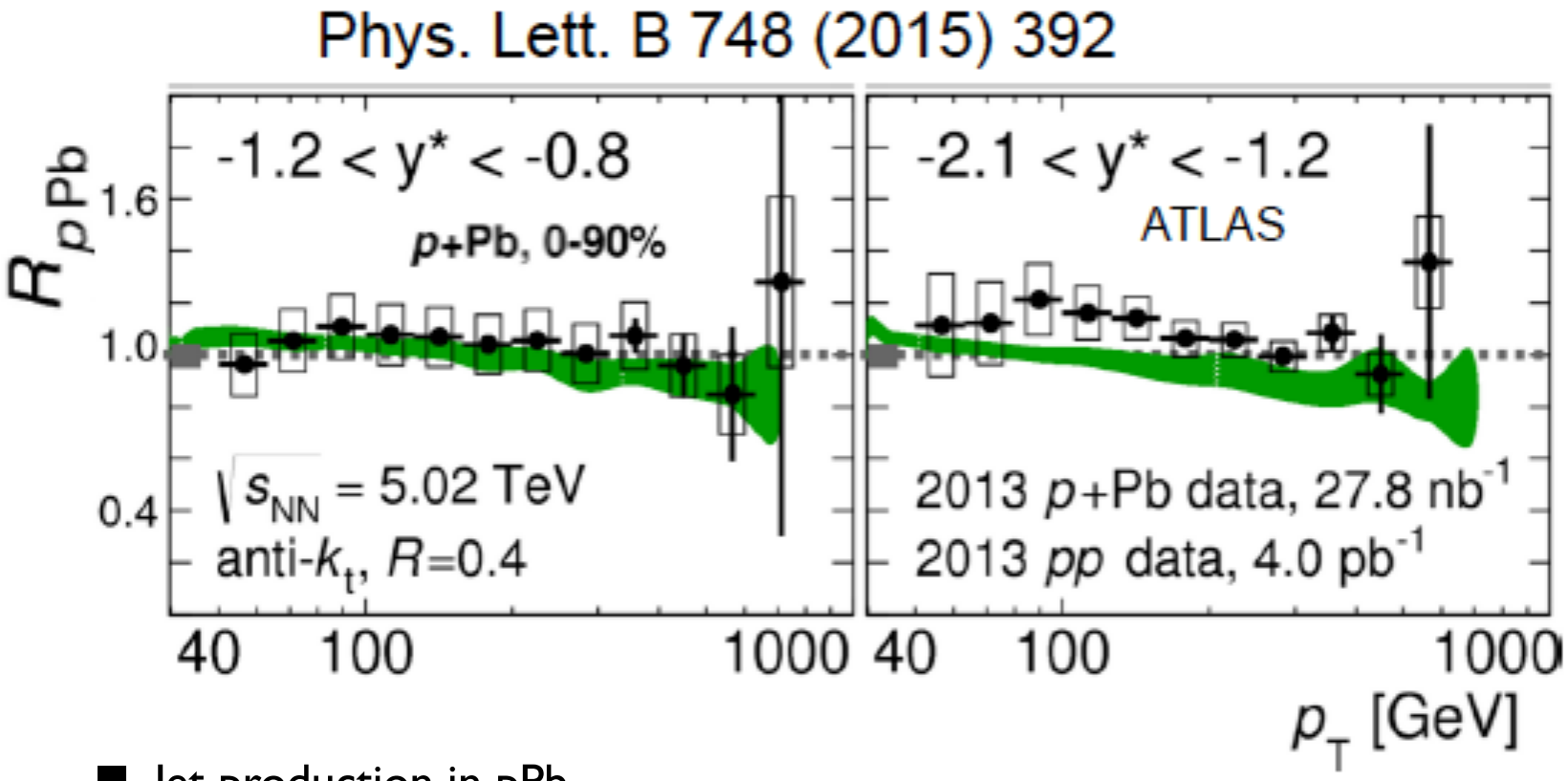


Reference: $R_{AA}(|y|<0.3)$

- Rapidity dependence of jet production
  - Low p_T:
    - No y dependence
  - High p_T:
    - More suppression at forward rapidity
    - increasing steepness of the spectra
    - increasing quark-jet fraction with y

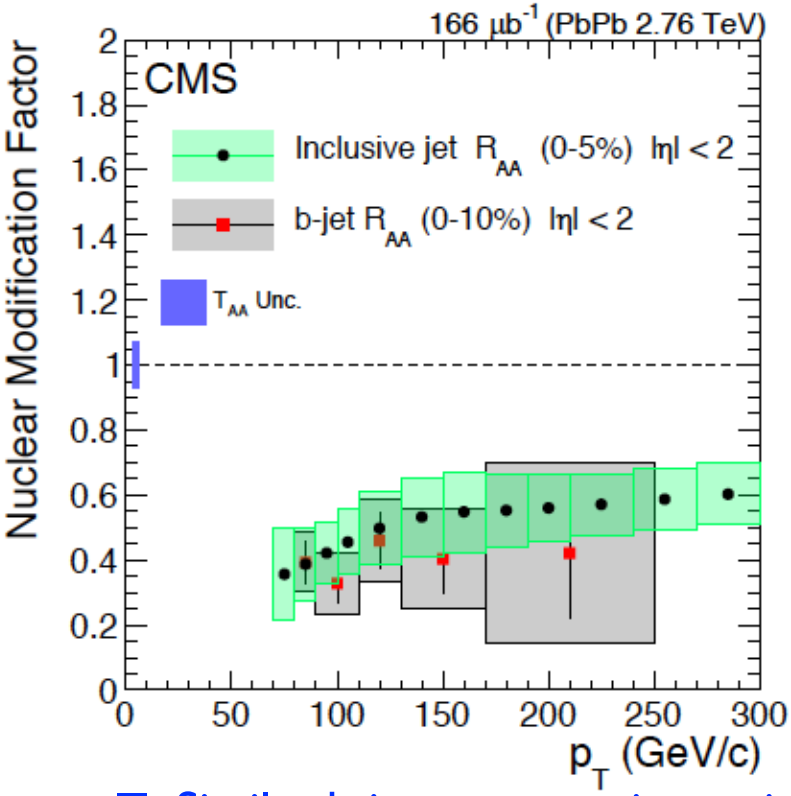
(EPJ C76, 2016, no. 2, 50)

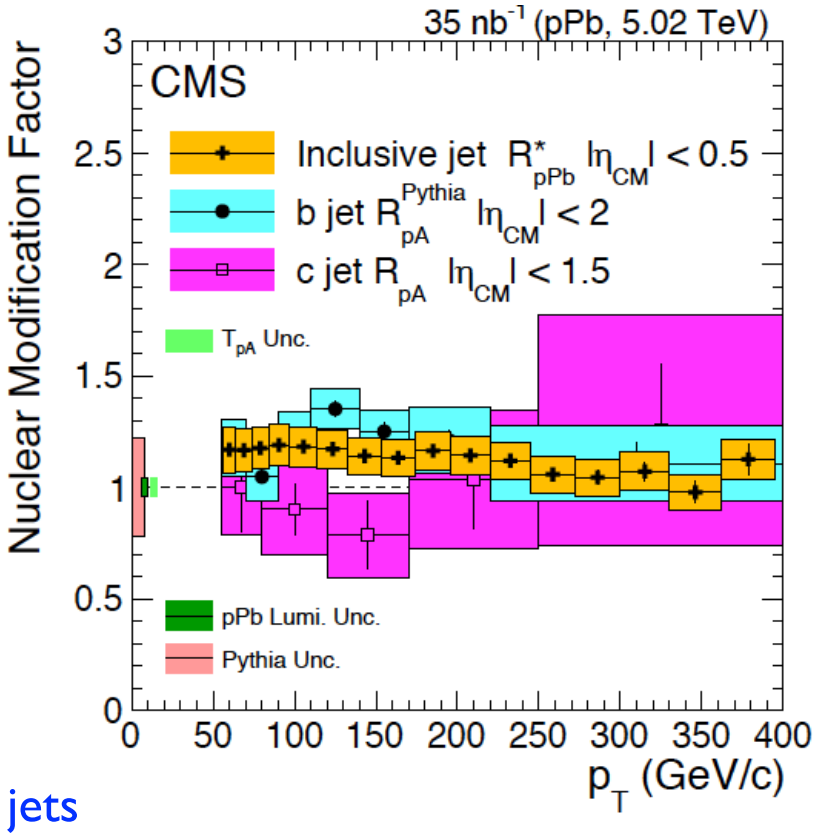
Jet R_{pPb}



- Jet production in pPb
  - control experiment : expect to be absence of hot & dense QCD matter
  - No modification of jet production (RpPb = 1)
  - No significant rapidity dependence

B-jet production in pPb and PbPb



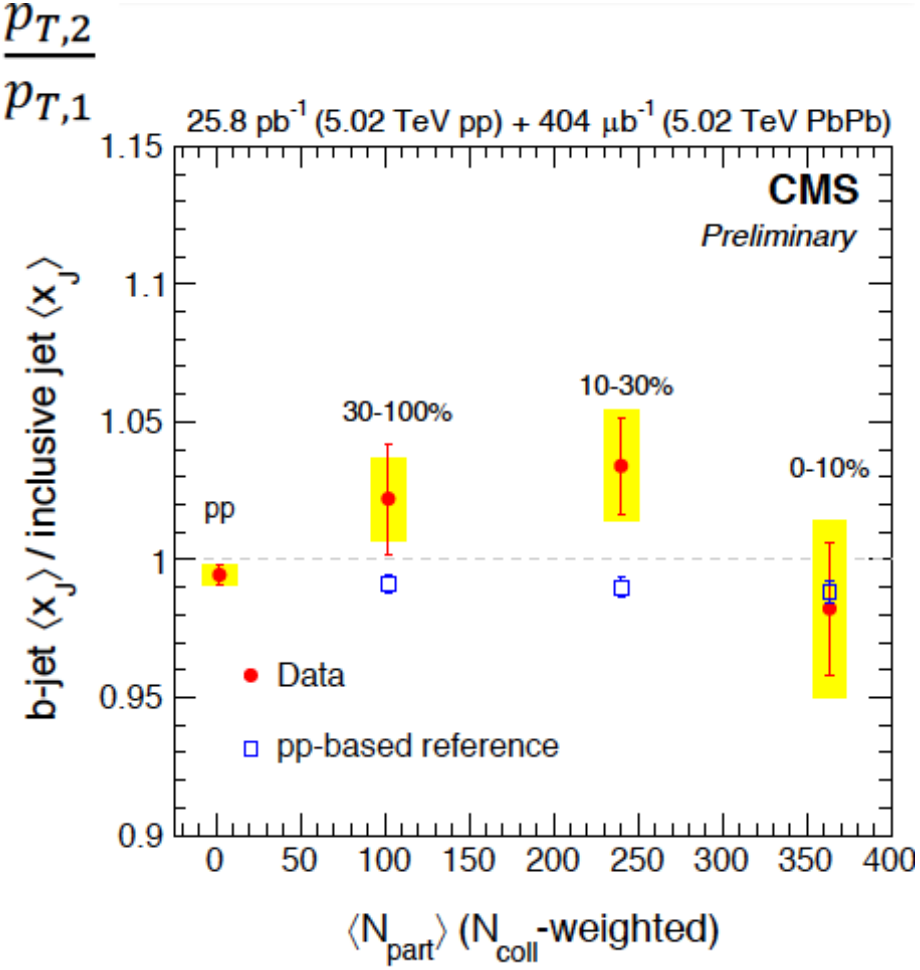


- Similar b-jets suppression as inclusive jets
  - Model prediction: heavy quarks loss less energy than light quarks
- Heavy-flavour jets (b-jets & c-jets) are consistent with unity in pPb collisions
- Heavy quarks also lose significant energy in the matter

K. Jung

Momentum balance of b-jet

$$\langle x_J \rangle = \frac{p_{T,2}}{p_{T,1}}$$

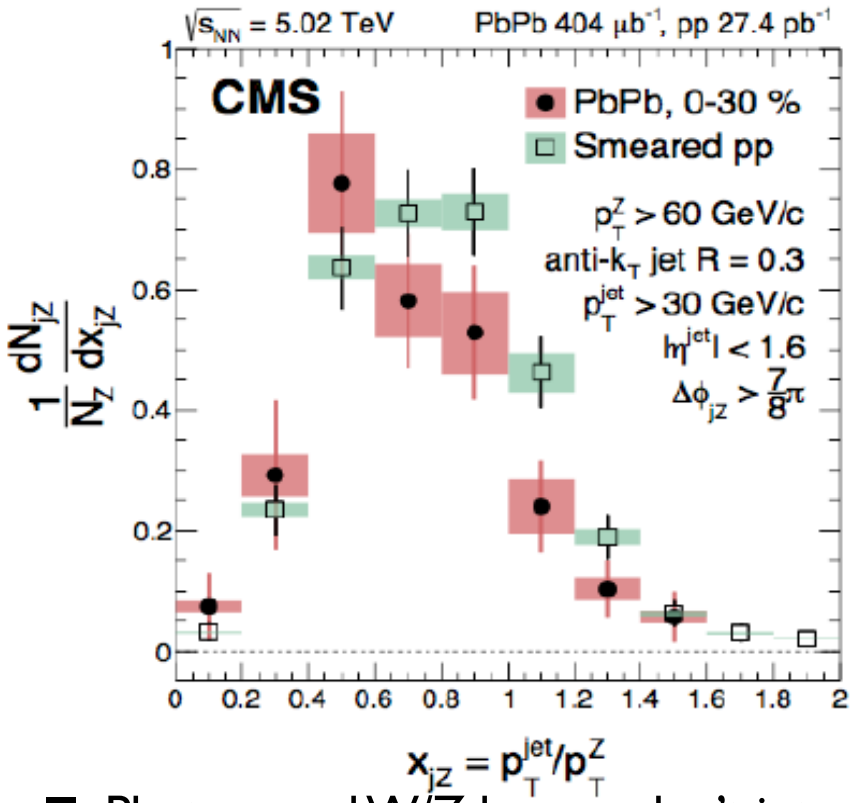


- Similar suppression (R_{AA}) between Inclusive and beauty jets
- Double ratio of dijet and b-dijet
  - Large double ratio if b-jets are less quench
  - Similar momentum imbalance between dijet and b-dijet
- Similar b-jet quenching and Inclusive jet

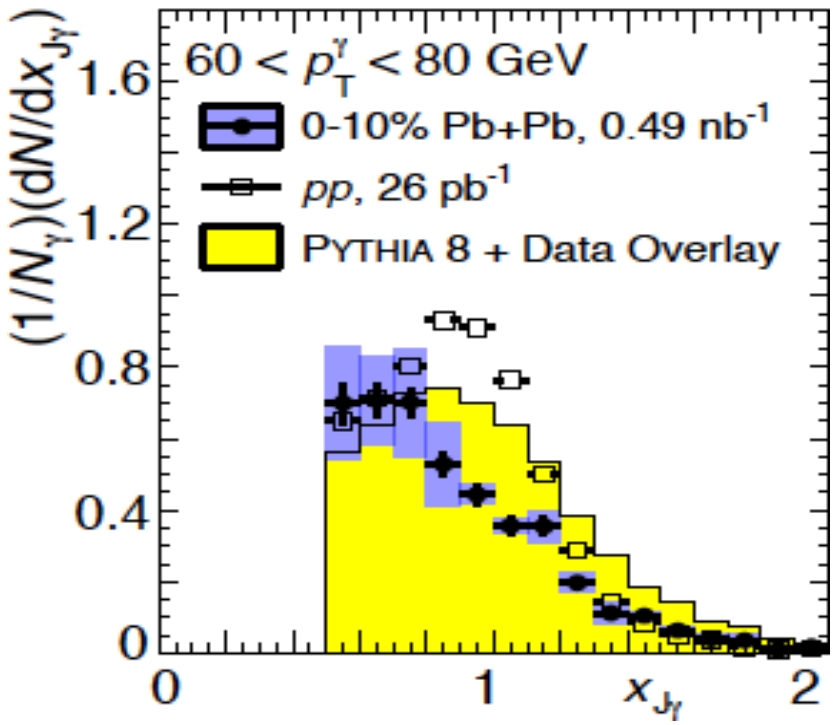
K. Jung

Momentum balance of Z-Jet & γ-Jet

arXiv: 1702.01060, R. Bi



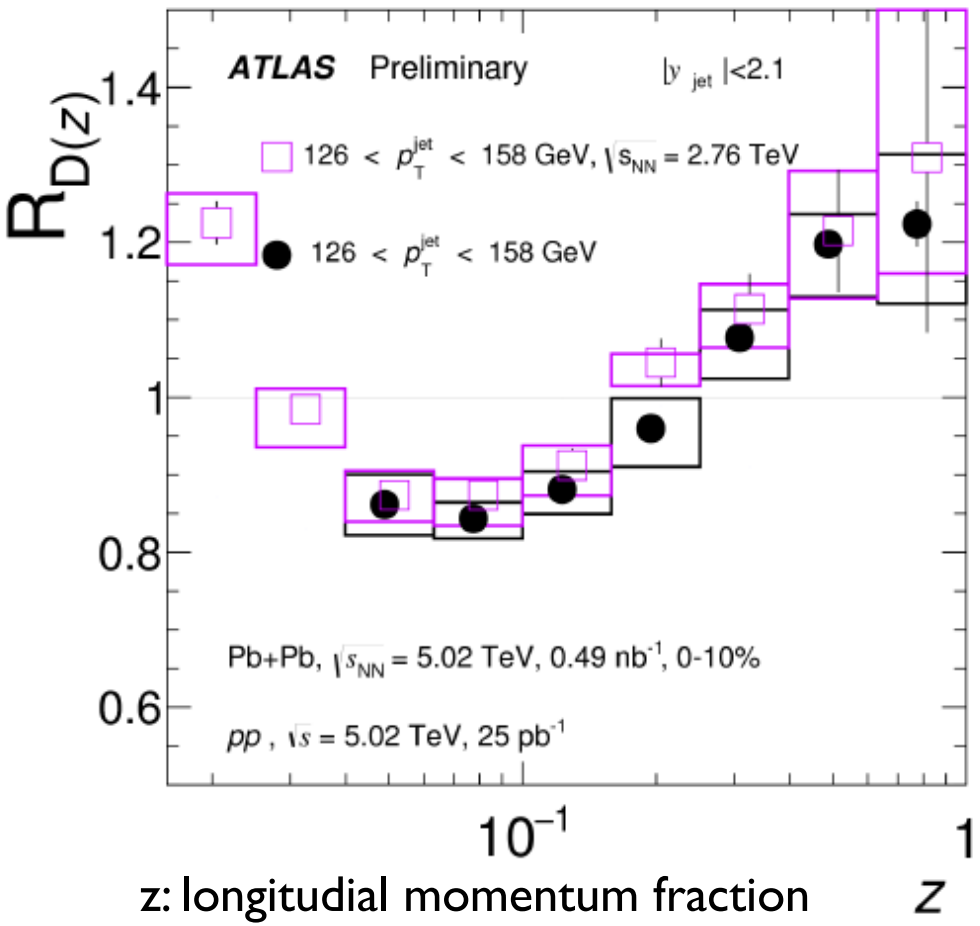
ATLAS-CONF-2016-110, P. Steinberg



- Photons and W/Z bosons don't interact with the medium
  - No energy loss of trigger particle (photons and W/Z)
  - No bias from suppression in trigger particle on recoil jets => absolute energy loss
- p_T balance of the jets is modified, shift to lower x due to energy loss in jets

Jet Fragmentation in PbPb (1)

ATLAS-CONF-2017-005, R. Slovak

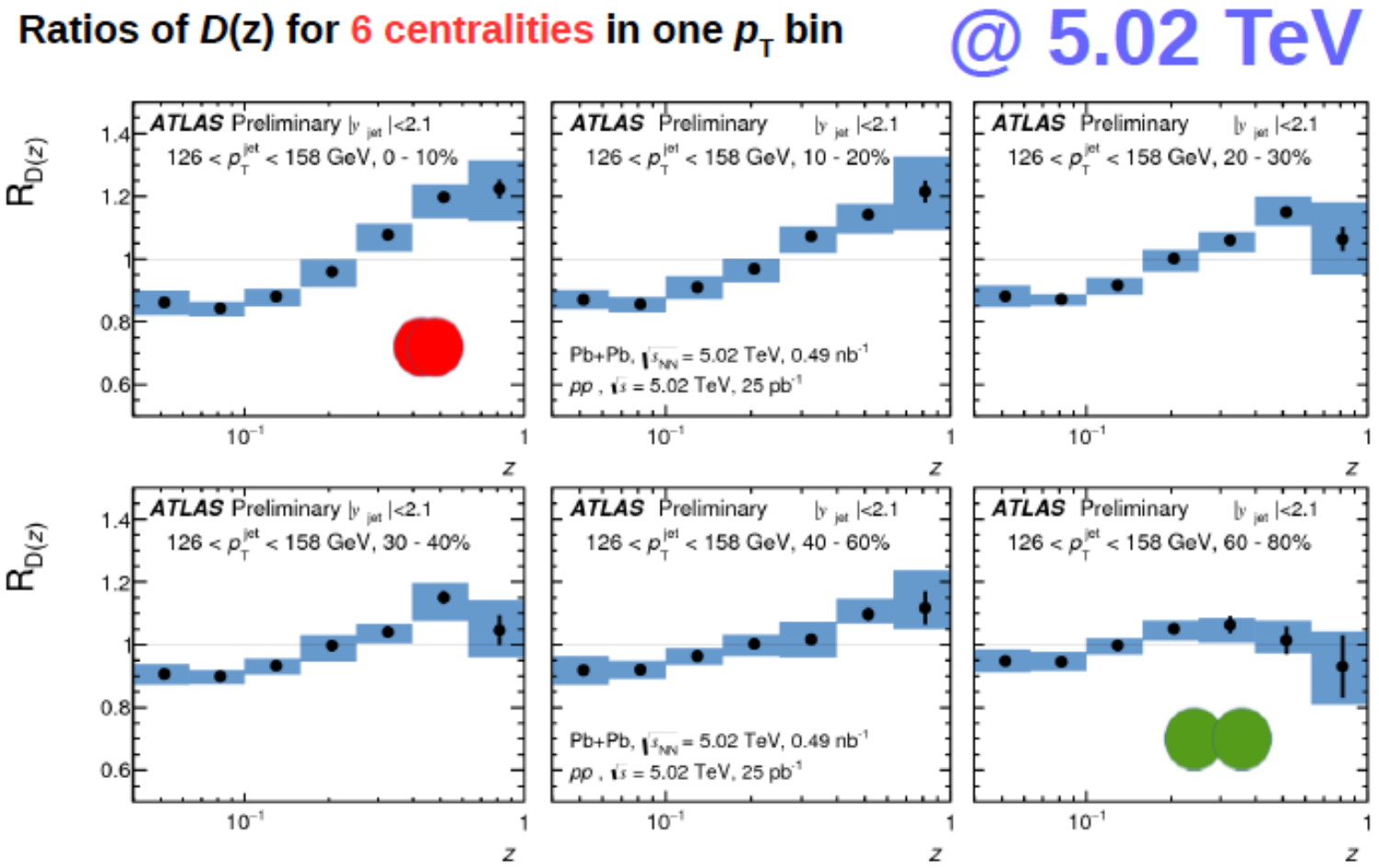


z: longitudial momentum fraction

- Fragmentation function in PbPb
  - Enhancement at low z
  - Suppression at intermediate z
  - Enhancement at high z
  - No √s effect
- Enhancement at low z
  - Due to energy loss by partons is transferred predominantly to soft particles
- Enhancement at high z
  - Consistent with different quenching of quark and gluon jets (EPJ C76, 2016, no. 2, 50)

$$z = \frac{p_{\mathrm{T}}}{p_{\mathrm{T}}^{\mathrm{jet}}} \cos \Delta R$$

Jet Fragmentation in PbPb (2)

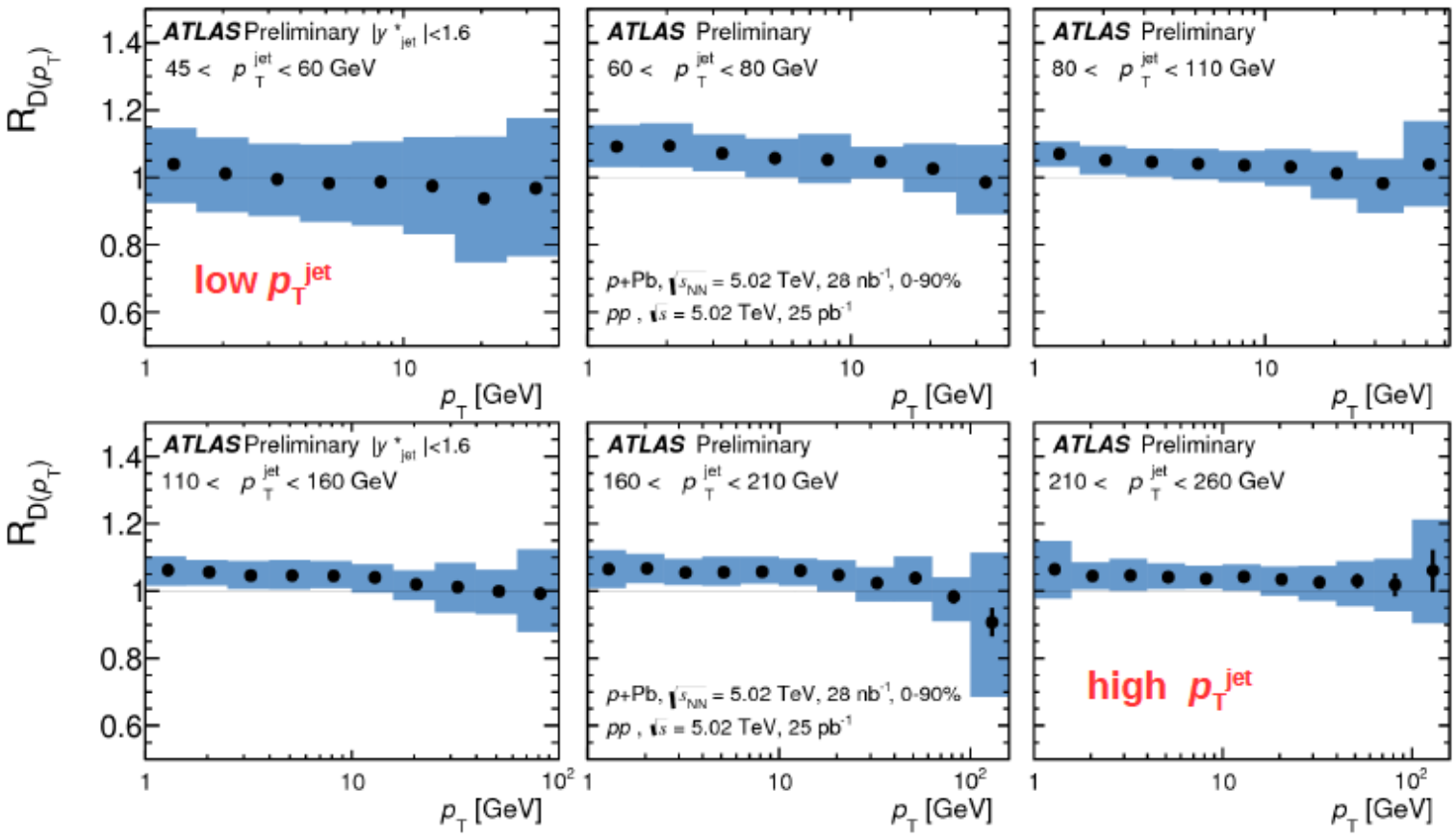


R. Slovak

- Centrality dependence of fragmentation function
  - Strong modification in most central collisions
  - Similar fragmentation function as pp in peripheral collisions

Jet Fragmentation in pPb

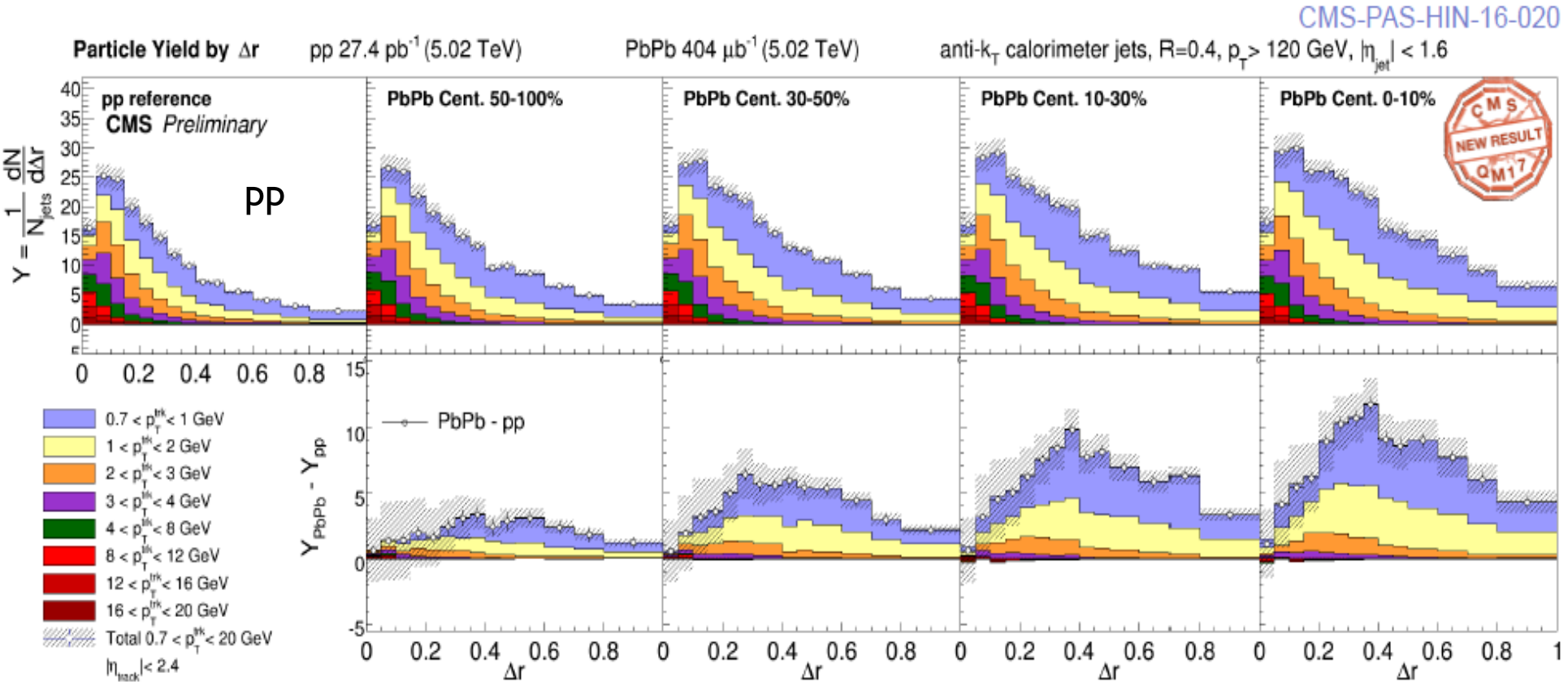
ATLAS-CONF-2017-004



R. Slovak

- No modification of the fragmentation functions is observed from low p_T to high p_T jets in pPb collisions at 5.02 TeV

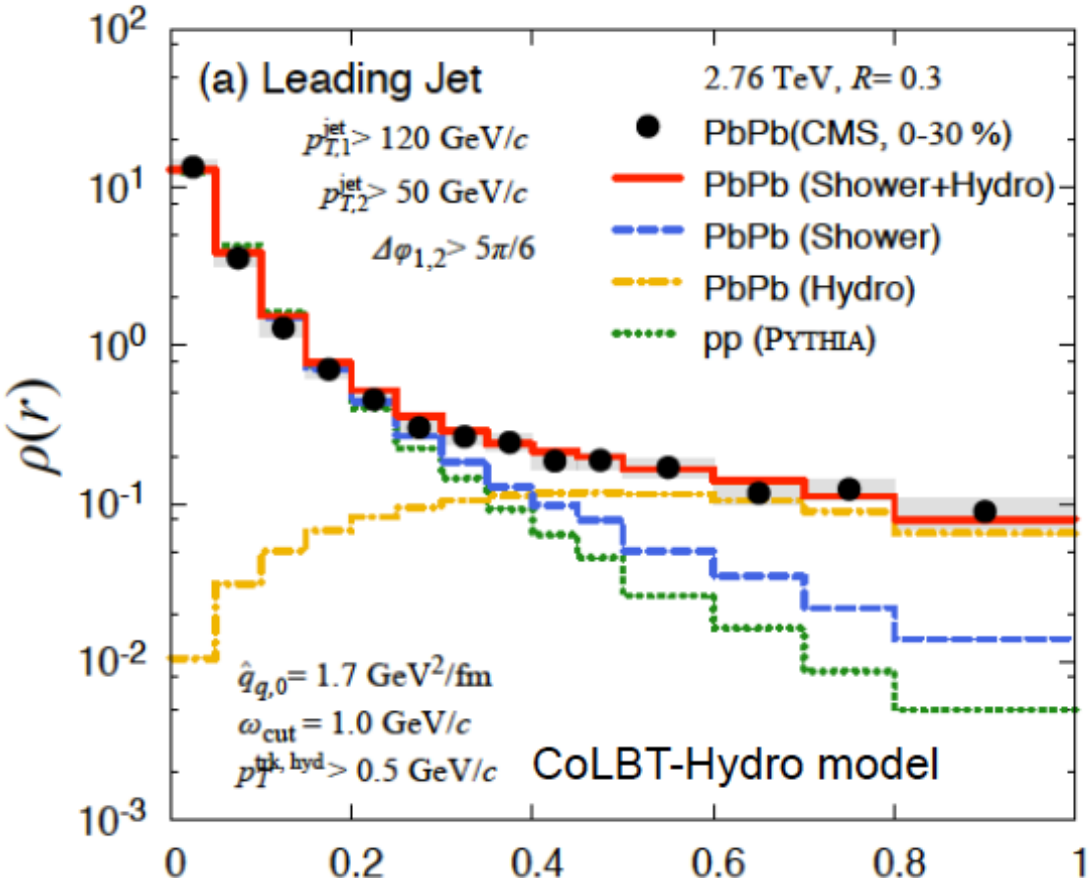
Jet-track correlation



H. Trauger

- Particle distribution w.r.t. axis of leading jets (>120 GeV/c)
- A excess of low p_T particles (p_T < 3 GeV/c) extending to large Δr from jet axis is found

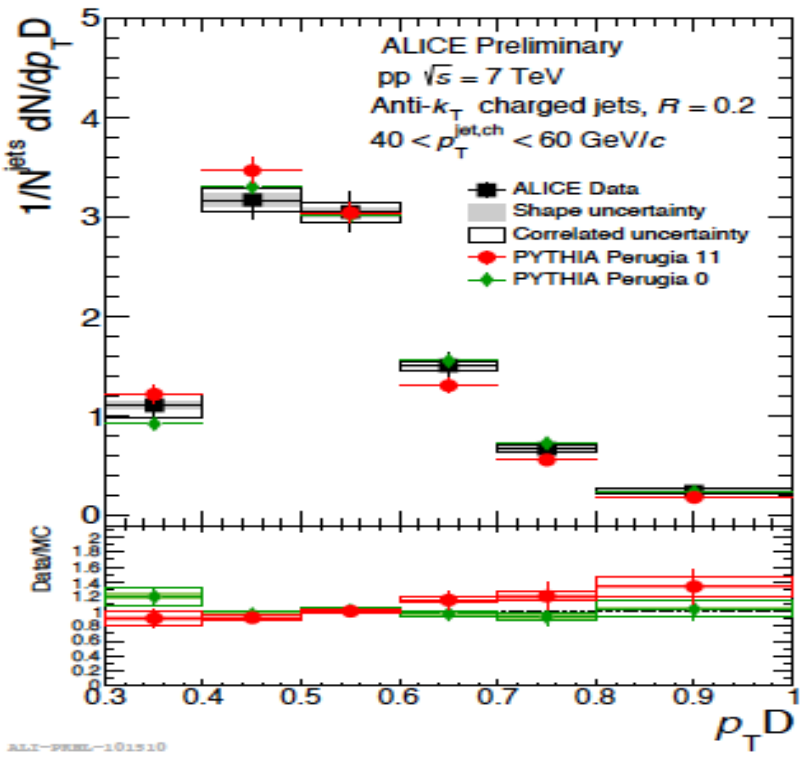
Jet – medium interaction

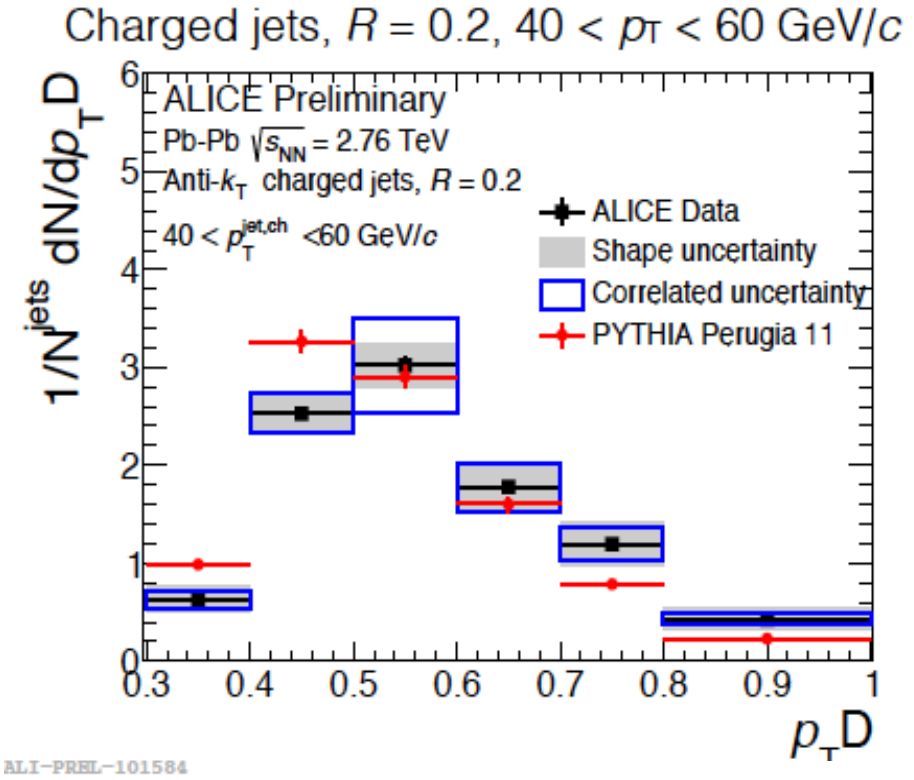


arXiv:1701.07951

- Enhancement at large R due to jet – medium interaction ?
- A model with energy loss + hydrodenamical model well represents the enhance
  - Full jets shower interact with medium by radiative & collisional process
  - Deposit the energy to the medium and then evolve with the medium hydrodynamically.

Jet shape in PbPb : p_T dispersion



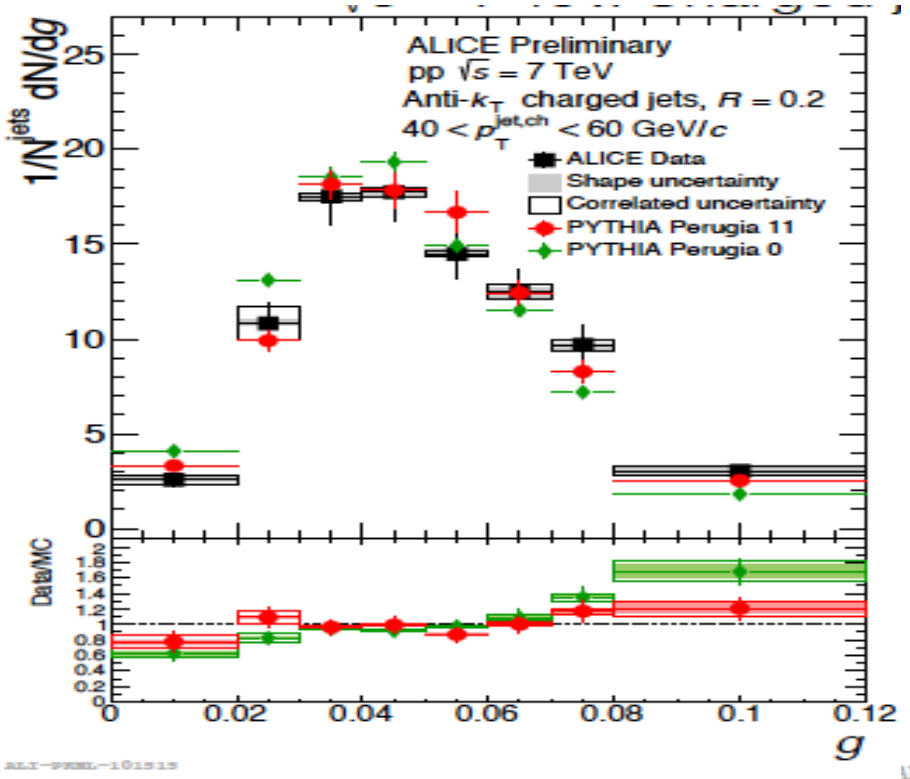


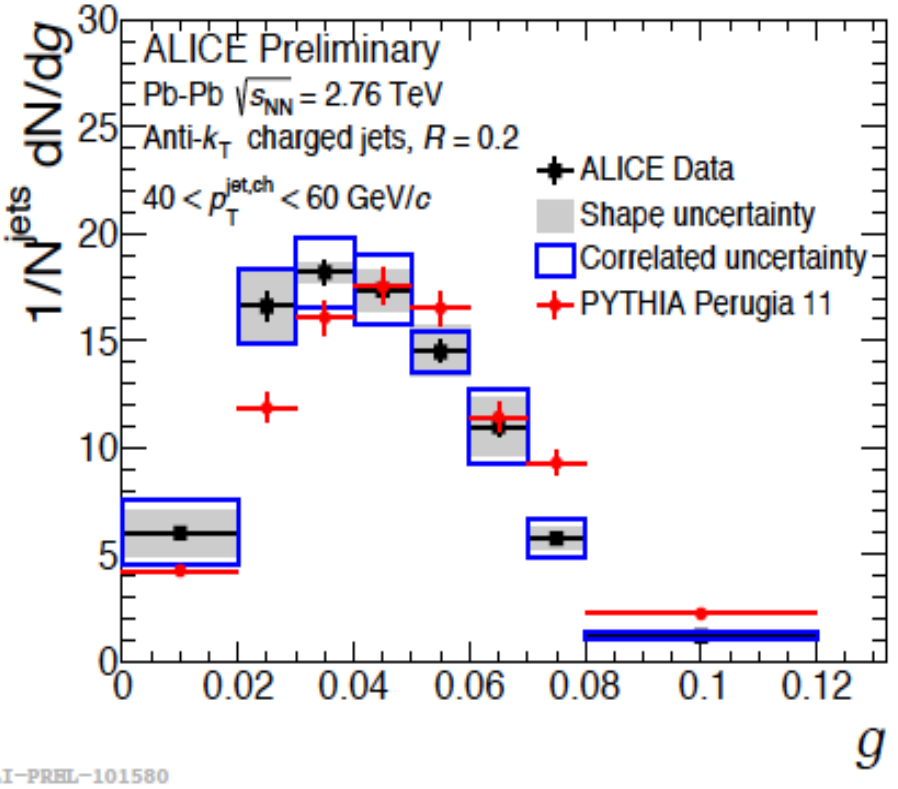
- $p_T D$: p_T dispersion
  - Jets with fewer constituents have higher $p_T D$
  - pp: consistent with PYTHIA predictions (QCD)
  - PbPb: shift to higher $p_T D$ => less constituents than pp

$$p_T D = \frac{\sqrt{\sum_i p_{T,i}^2}}{\sum_i p_{T,i}}$$

D. Caffarri

Jet shape in PbPb : radial moment



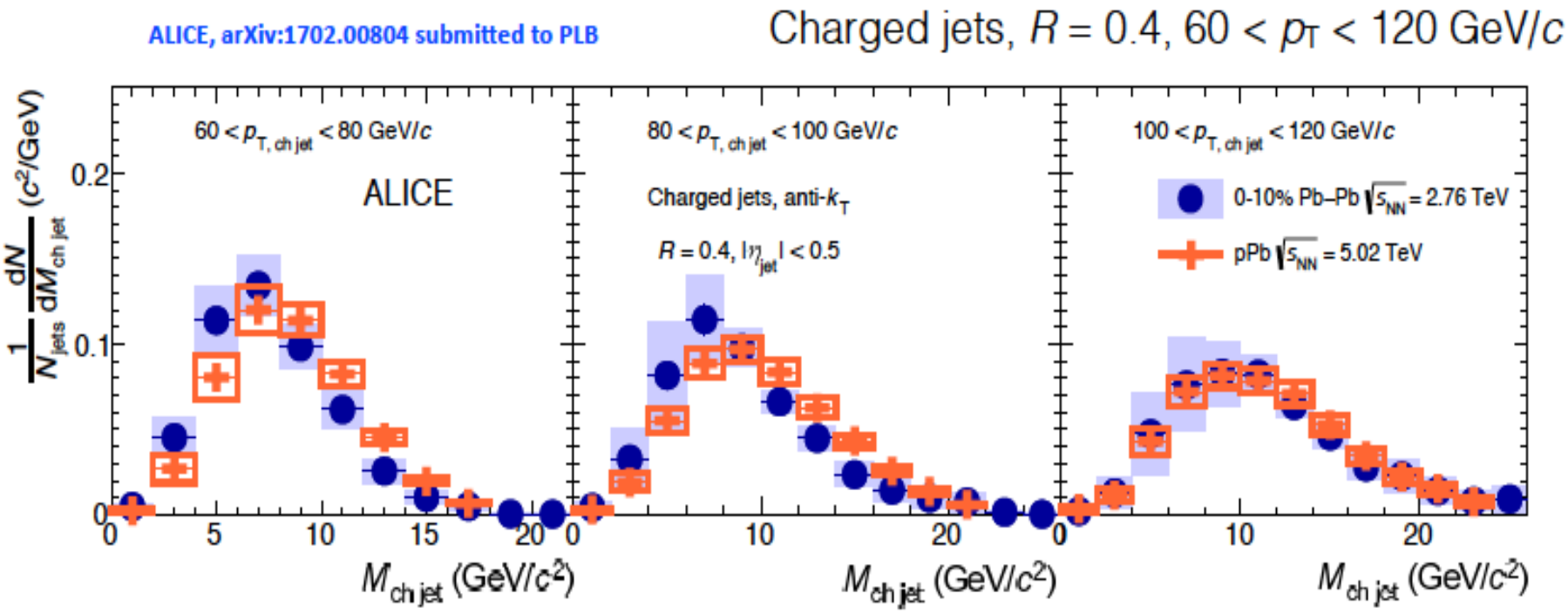


- g : radial moment (jet width)
  - Large g: broadened jets , small g: collimated jets
  - pp: consistent with PYTHIA predictions (QCD)
  - PbPb: shift to lower g => jets are more collimated

$$g = \sum_{i \in \text{jet}} \frac{p_{\text{T}}^{i}}{p_{\text{T}}^{\text{jet}}} |r_i|$$

D. Caffarri

Jet shape in PbPb : Jet Mass

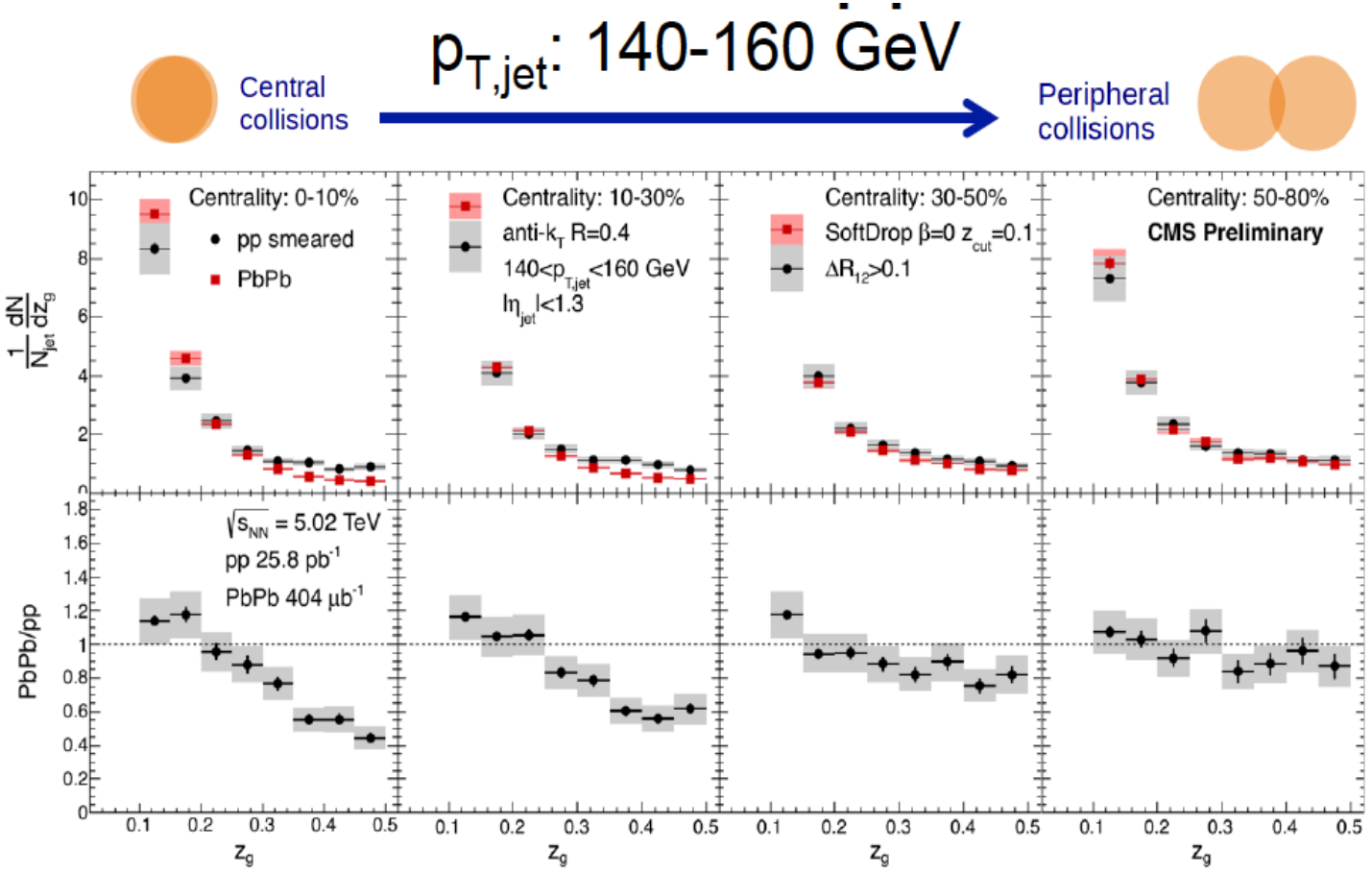


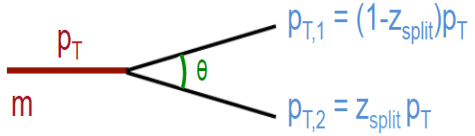
- Jet Mass; $M = \sqrt{E^2 - p_T^2 - p_Z^2}$
- Increase if a significant amount of the radiated gluons are captured with in jet cone
  - On the other hand, depletion due to energy loss
- Jet mass in PbPb, especially p_T<100 GeV/c, shifted to lower mass w.r.t. the mass in pPb

D. Caffarri

Momentum balance of hard splitting partons

CMS-PAS-HIN-16-006





$$z_g = \frac{\min(p_{T,1}, p_{T,2})}{p_{T,1} + p_{T,2}}$$

Y. Chen

- Momentum balance of two partons that from high p_T parton
- Modification of subjet balance observed in central PbPb collisions
  - Medium modified splitting

Summary

- Reached TeV order in jet measurement
  - Still observed strong suppression of jet production
    - Medium still 'opaque' such high pT jets
  - Heavy flavour (beauty) jet is suppressed same as inclusive (light flavour) jets
- In side of jet
  - Enhancement at low Z
    - Enhancement soft particles (pT<3 GeV/c) at large R
      - Well represented jet – medium interaction model
  - Modified jet shape
    - Narrowing of the core of jets
  - Modified splitting of high p_T partons