Experimental Wrap-Up: Energy loss

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Hard Probes 2013

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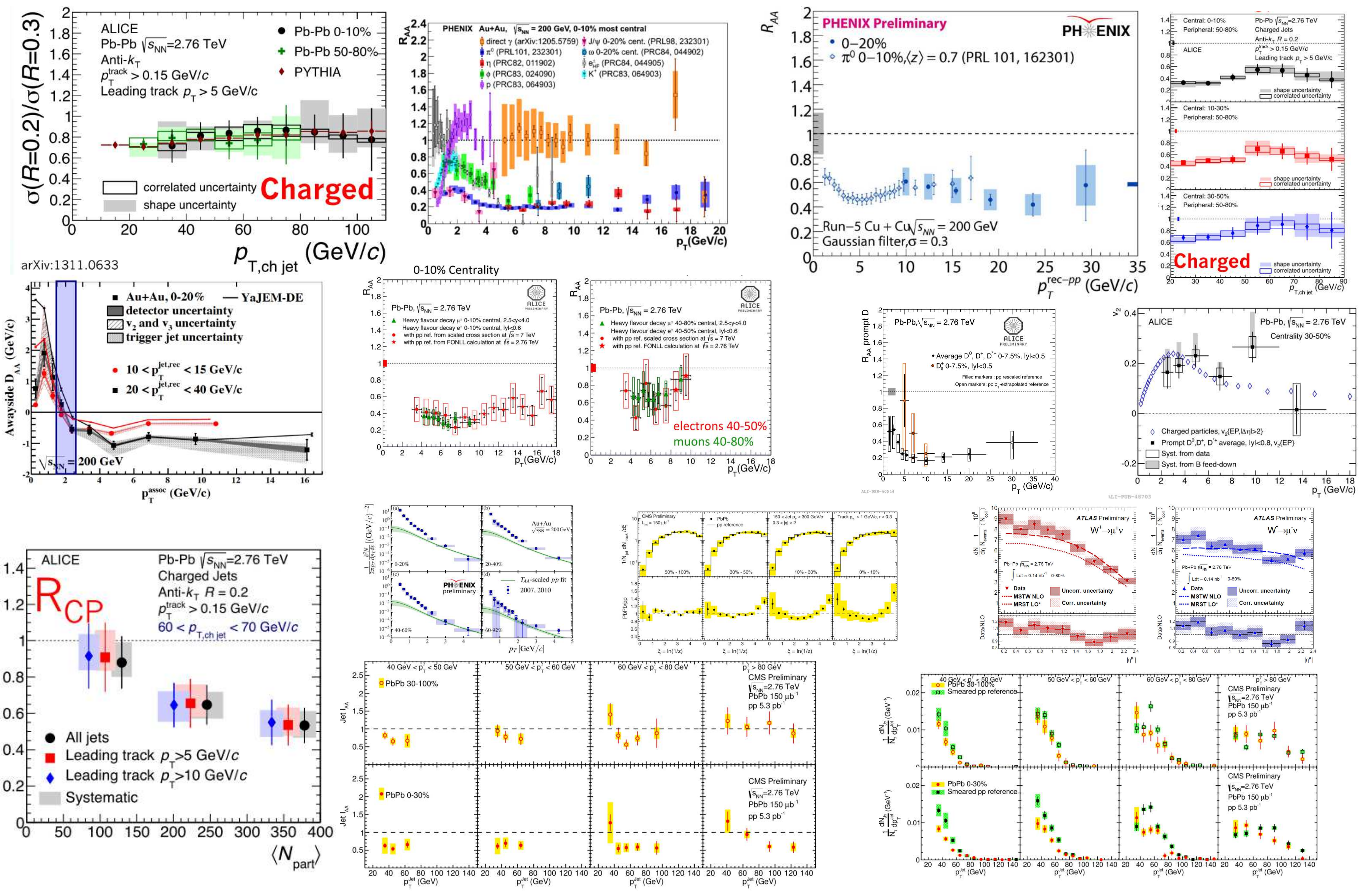
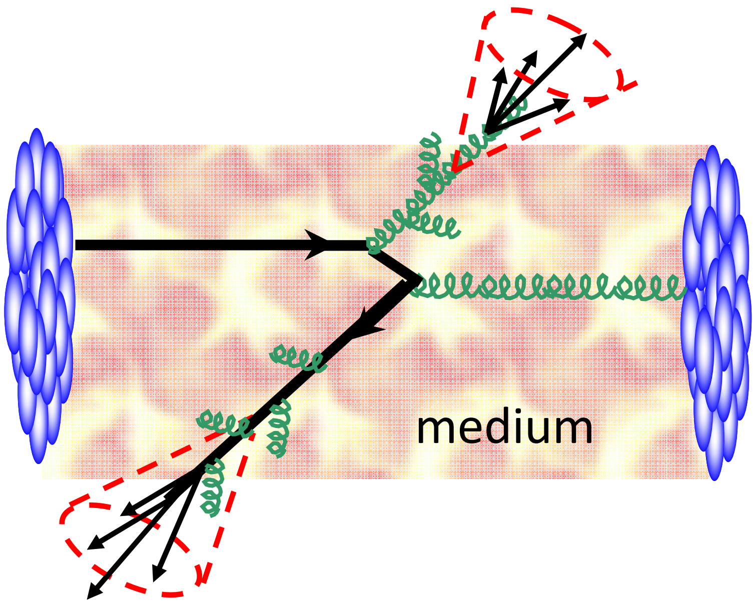
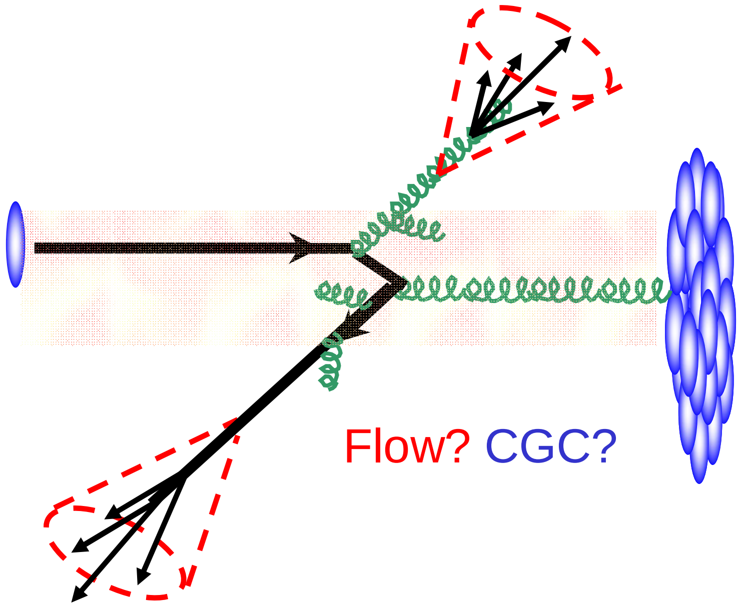
Introduction



AA results: EW probes, jet fragmentation functions, jet shapes and dijet (photon-jet) azimuthal correlations



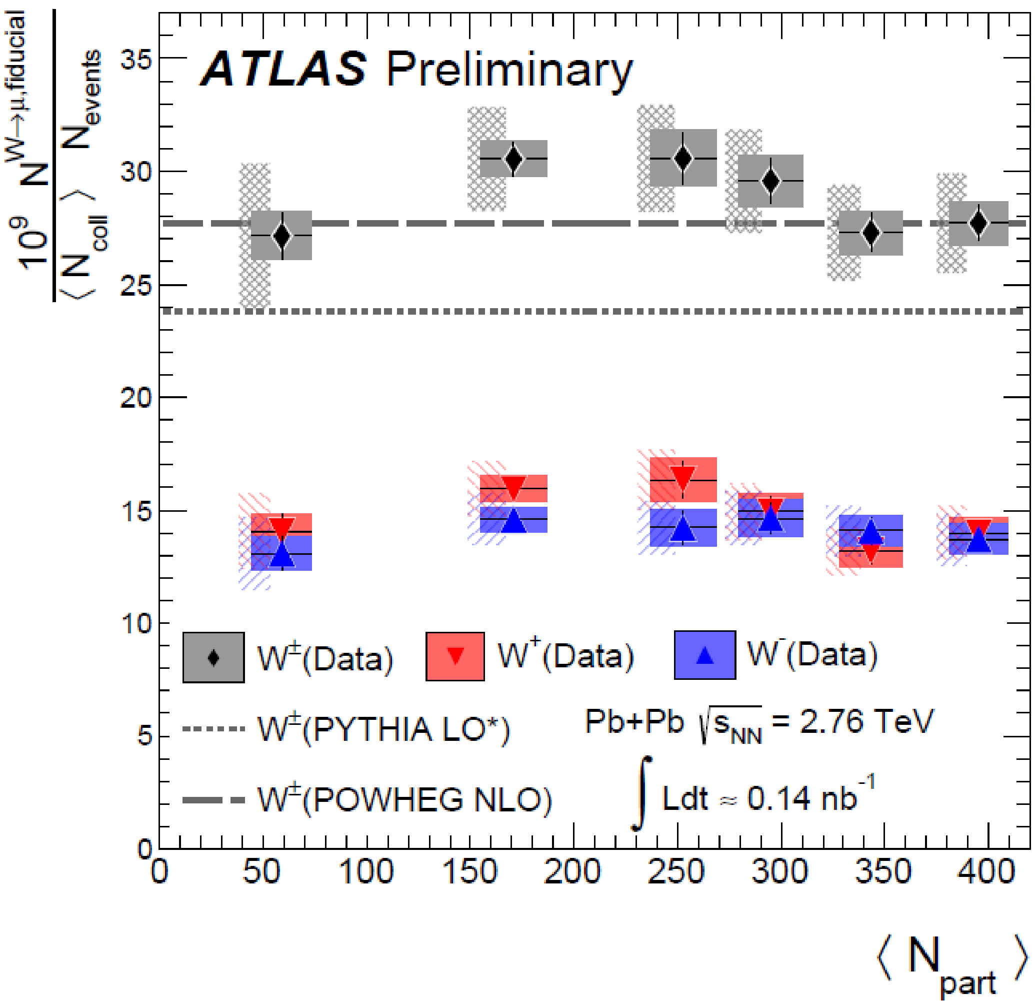
AA collisions



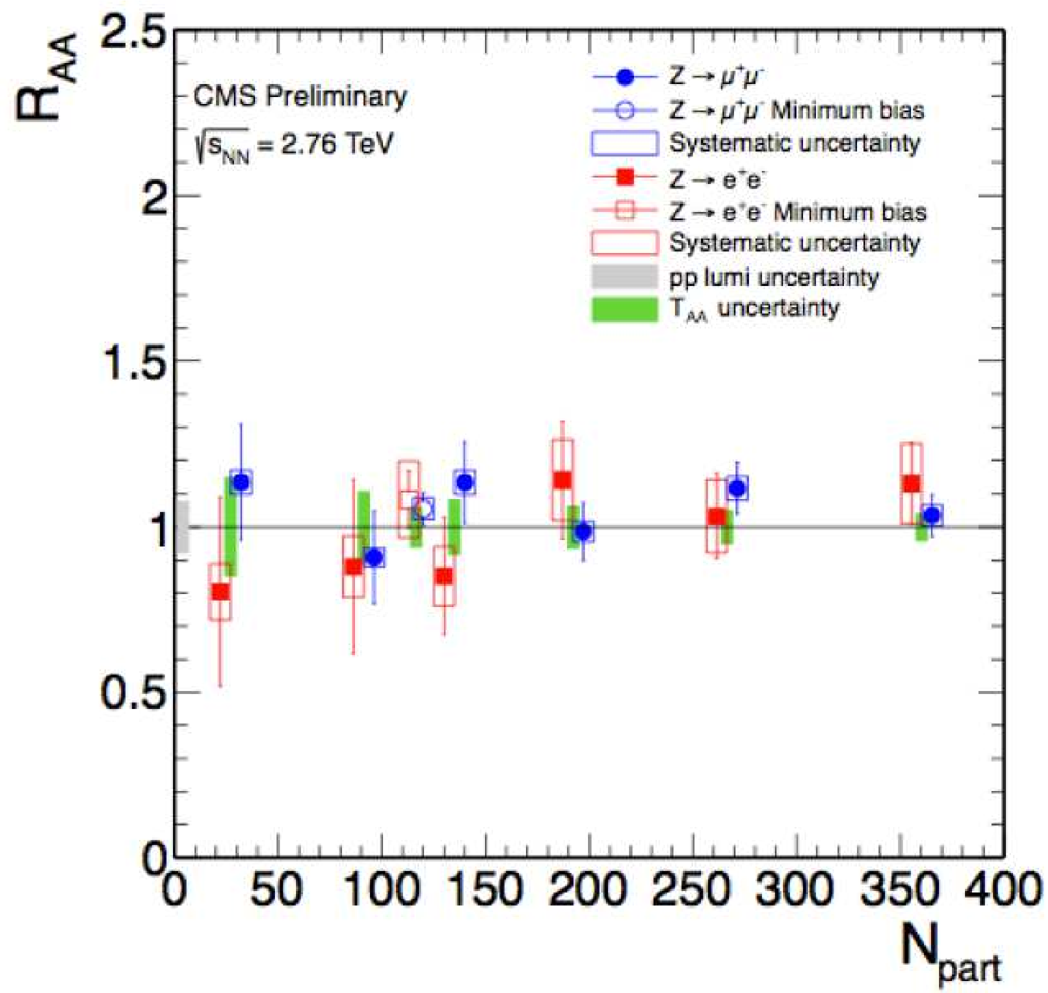
pA collisions

The unmodified bosons in PbPb collisions

ATLAS W boson



CMS Z boson



Results of W, Z boson production from **high statistics PbPb data**

W and Z bosons (as well as isolated photons) are **unmodified**

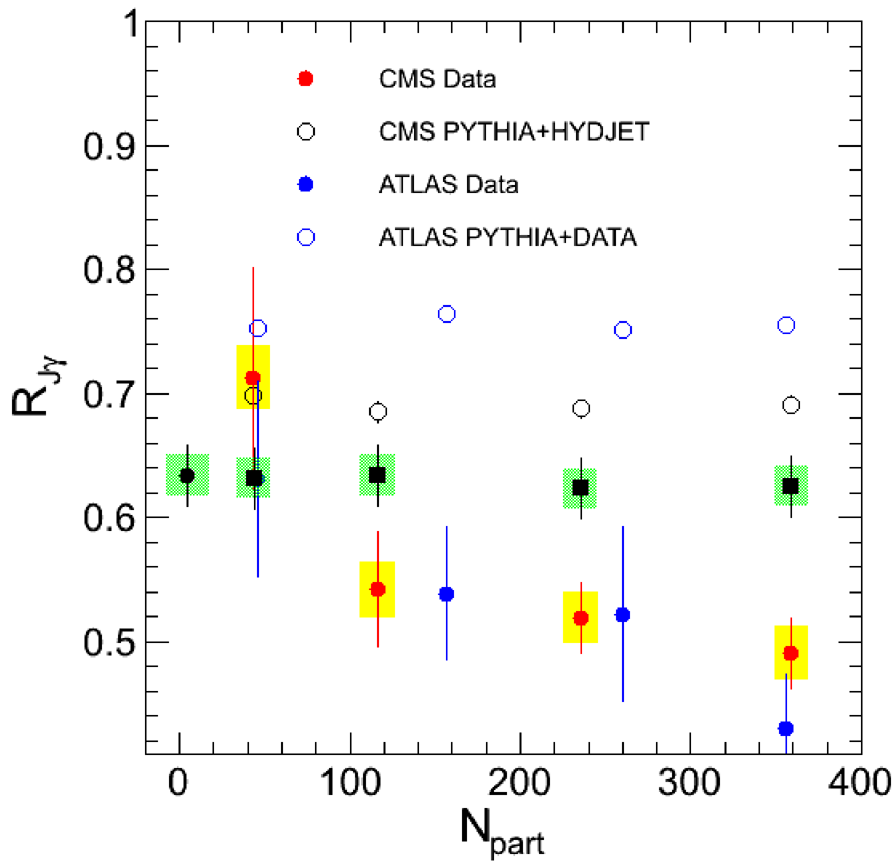
Photon+jet correlation at LHC

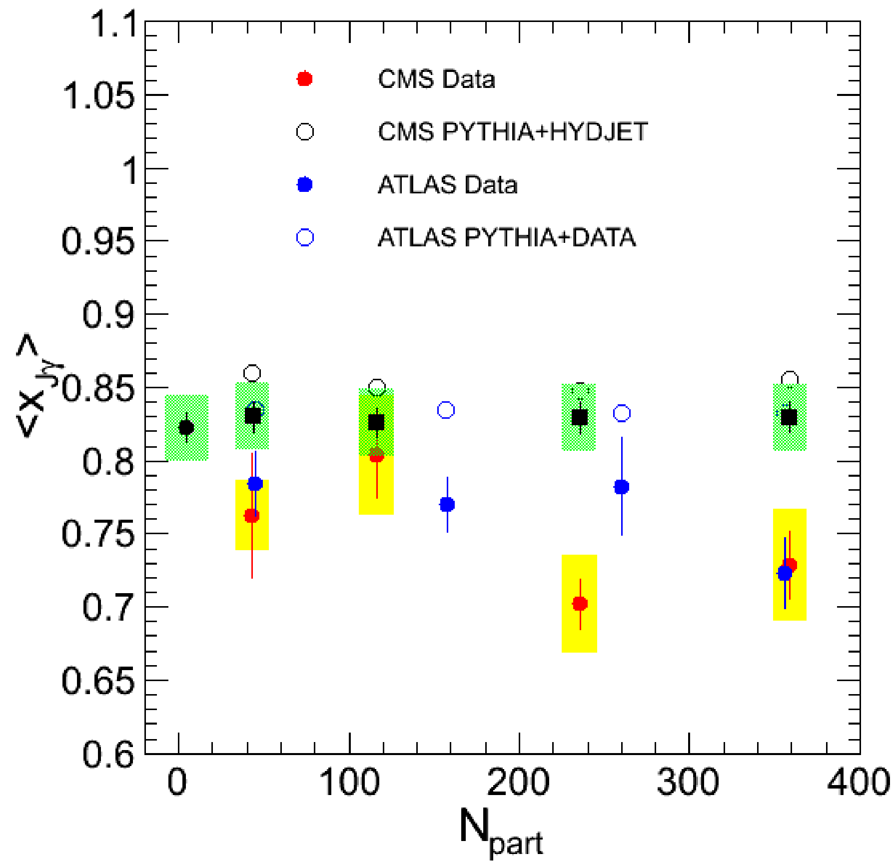
CMS published result photon+inclusive jet

Photon p_T > 60 GeV/c, Jet p_T > 30 GeV/c

ATLAS preliminary photon+leading jet

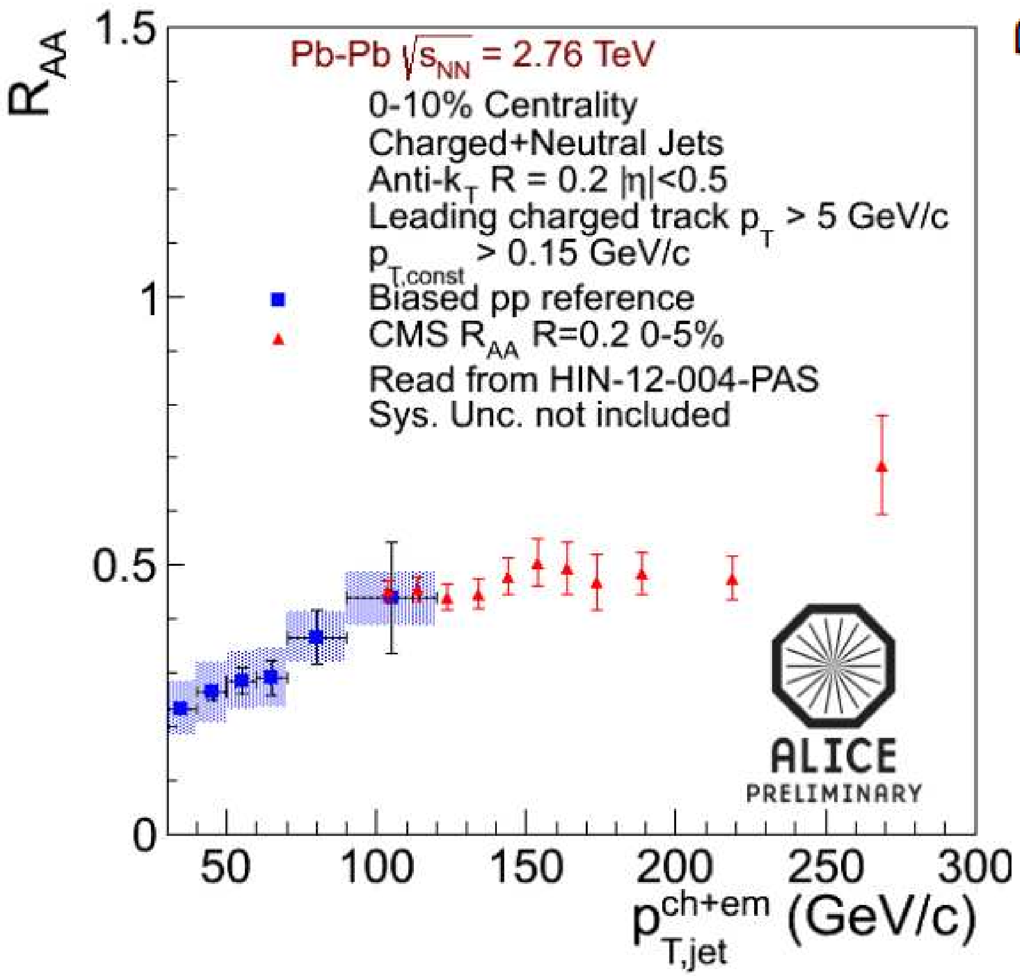
60 < Photon p_T <90 GeV/c, Jet p_T/Photon p_T > 0.4

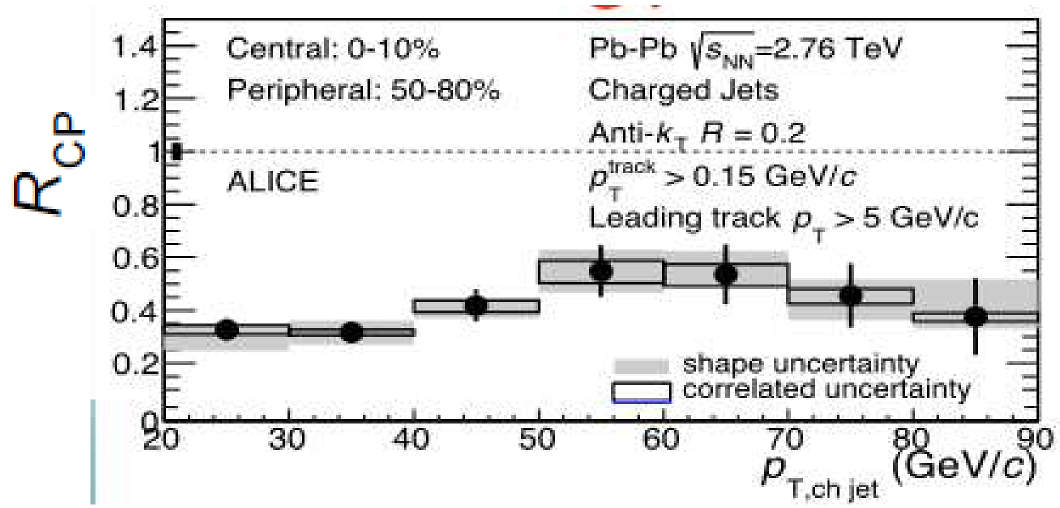


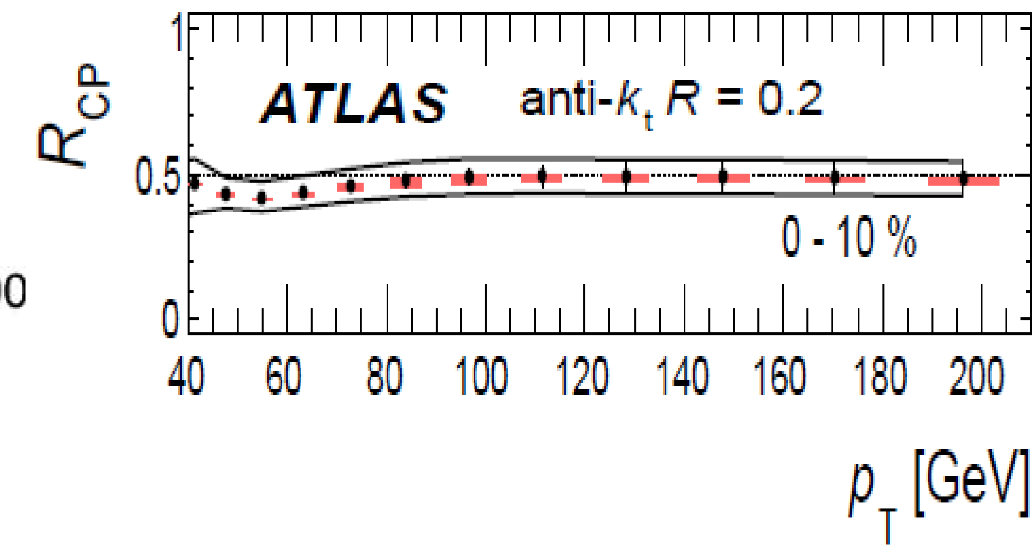


Qualitative consistent result between ATLAS and CMS

Jet R_{AA} (R_{CP}) at LHC

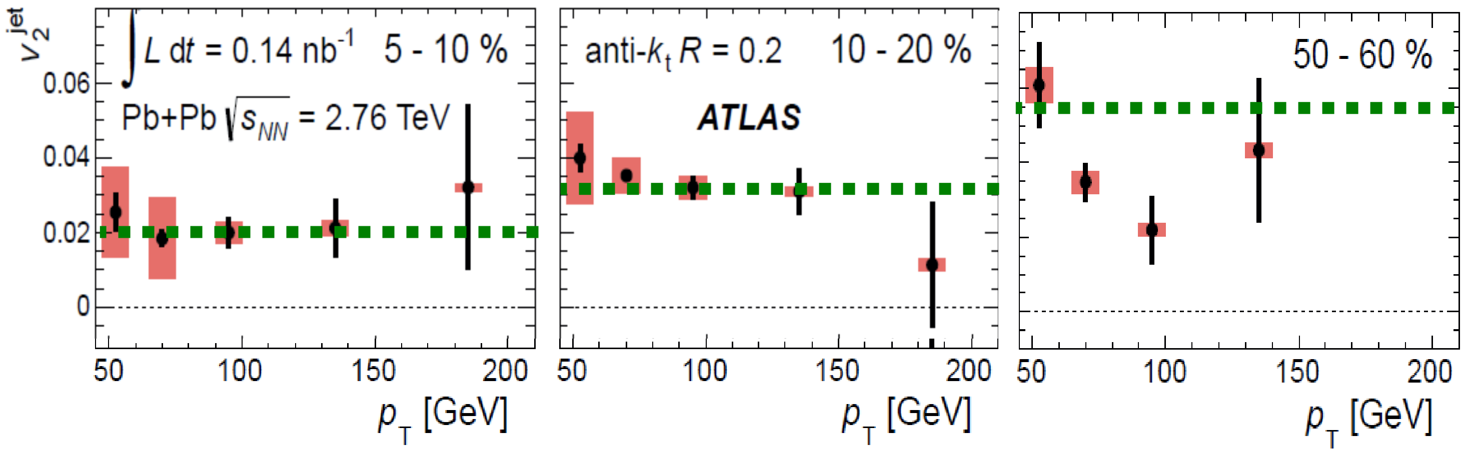




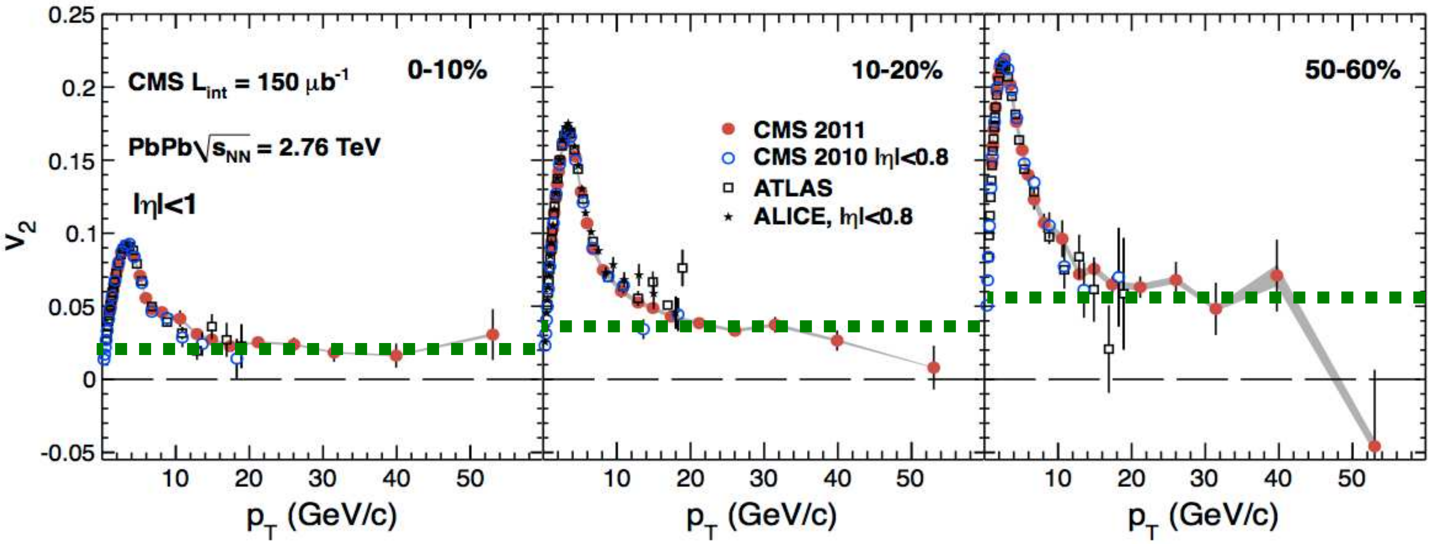


Jet and high p_T track v_2 at the LHC

Jet v_2

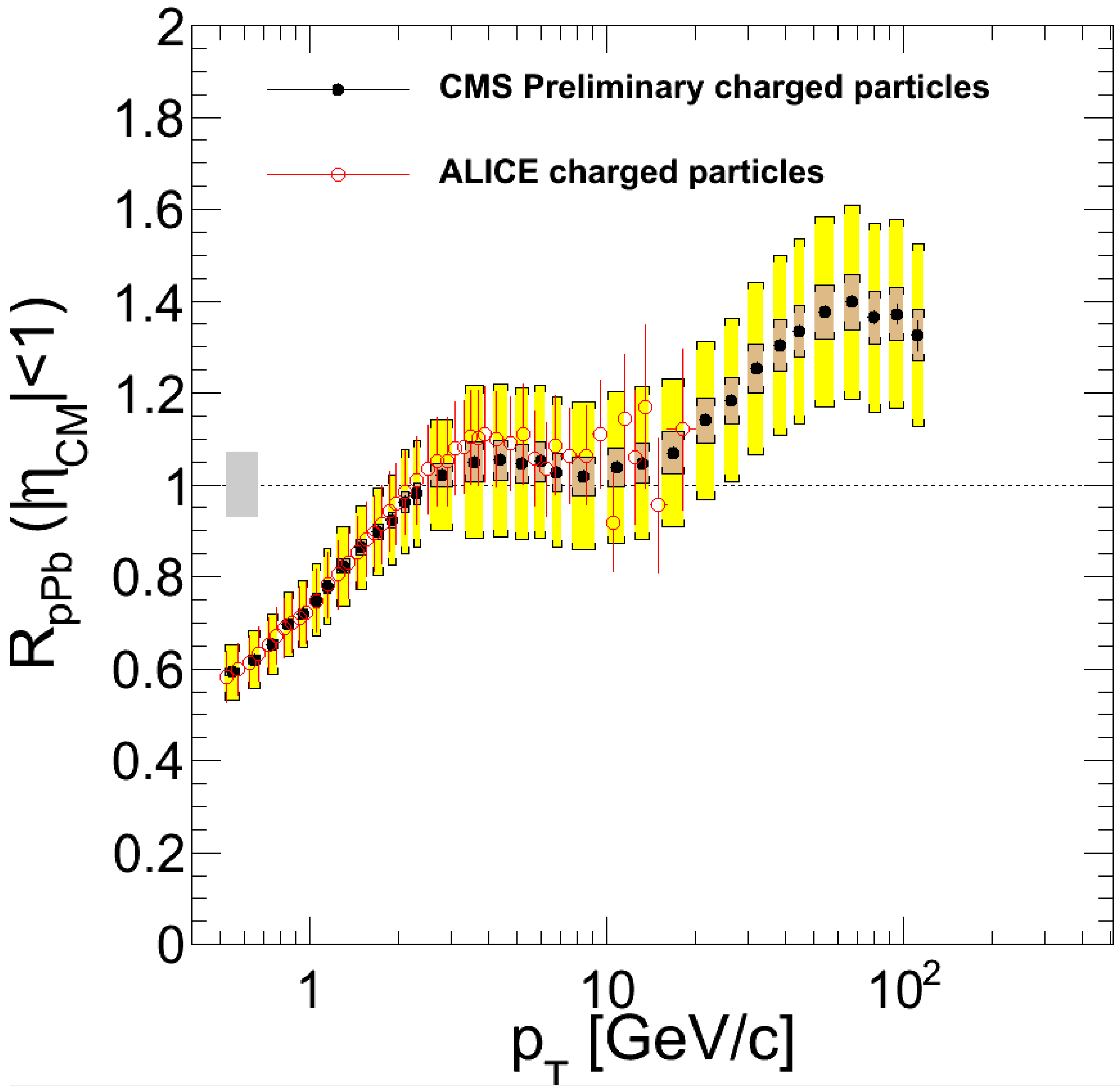


High p_T Track v_2

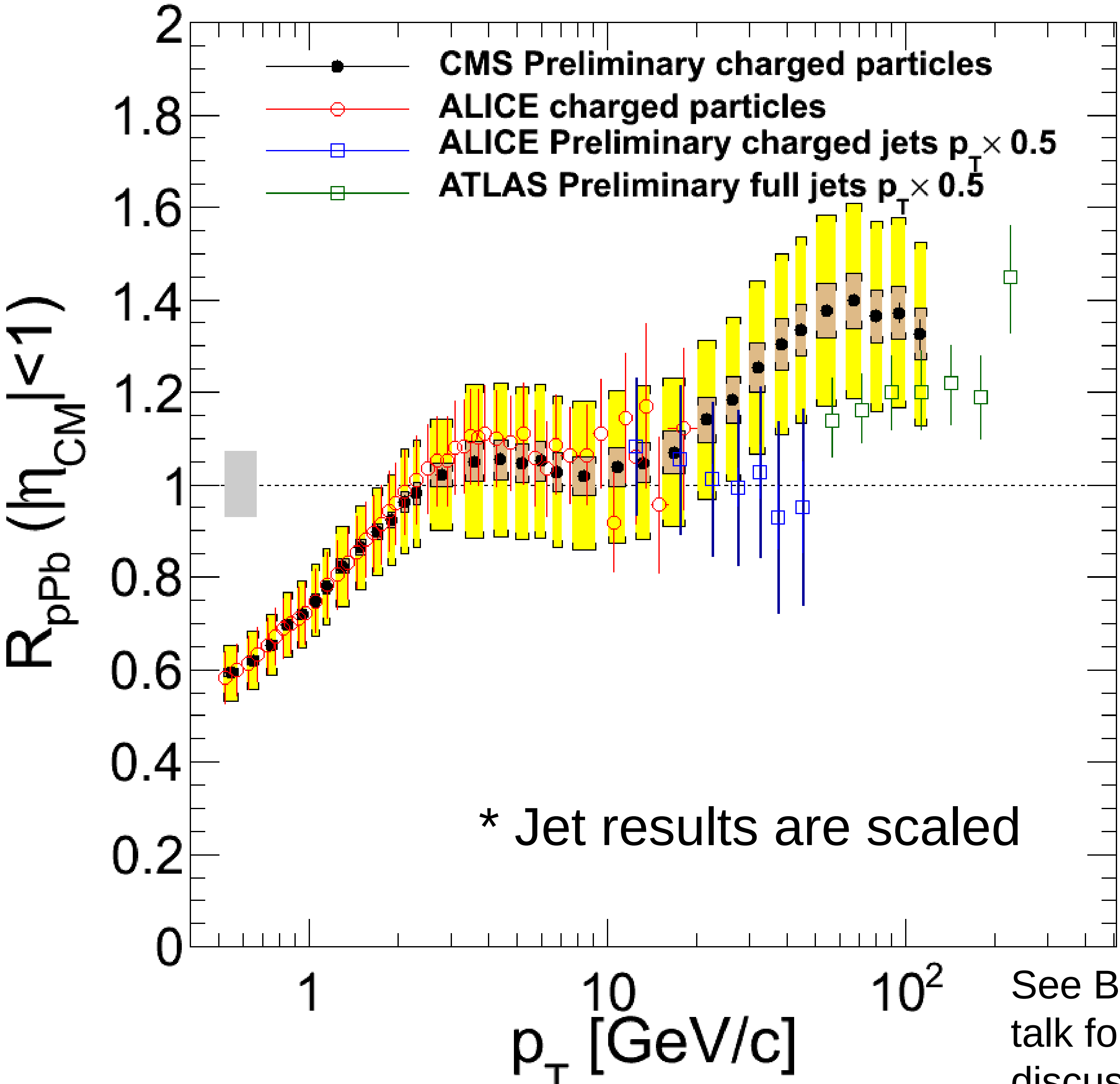


- Jet and high p_T track v_2 : non-zero up to very high p_T
- Sensitive to the path length dependence of energy loss

Charged Particle R_{pPb} v.s Scaled Jet R_{pPb}

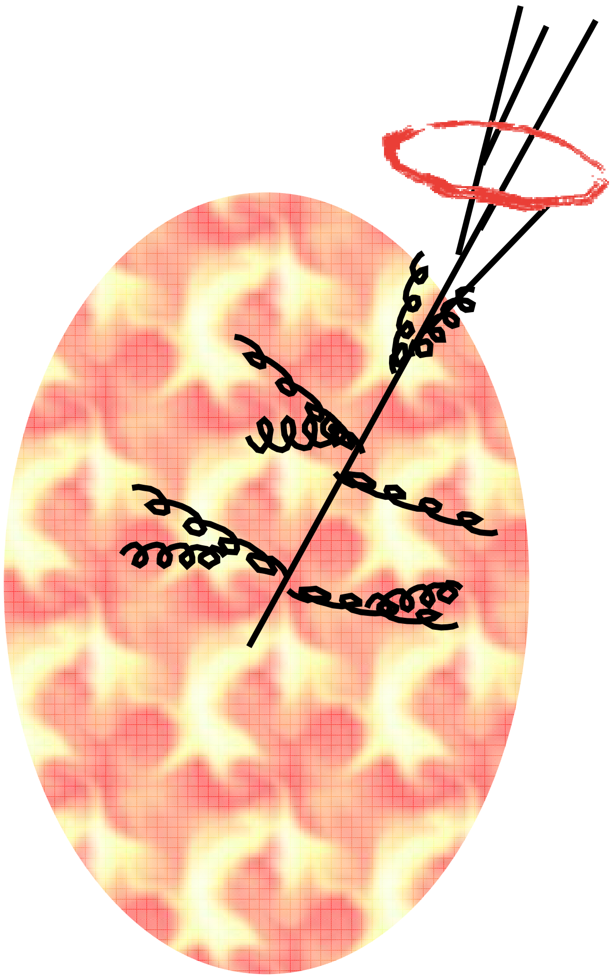


Charged Particle R_{pPb} v.s Scaled Jet R_{pPb}



See Brian and Andrea's talk for detailed discussions

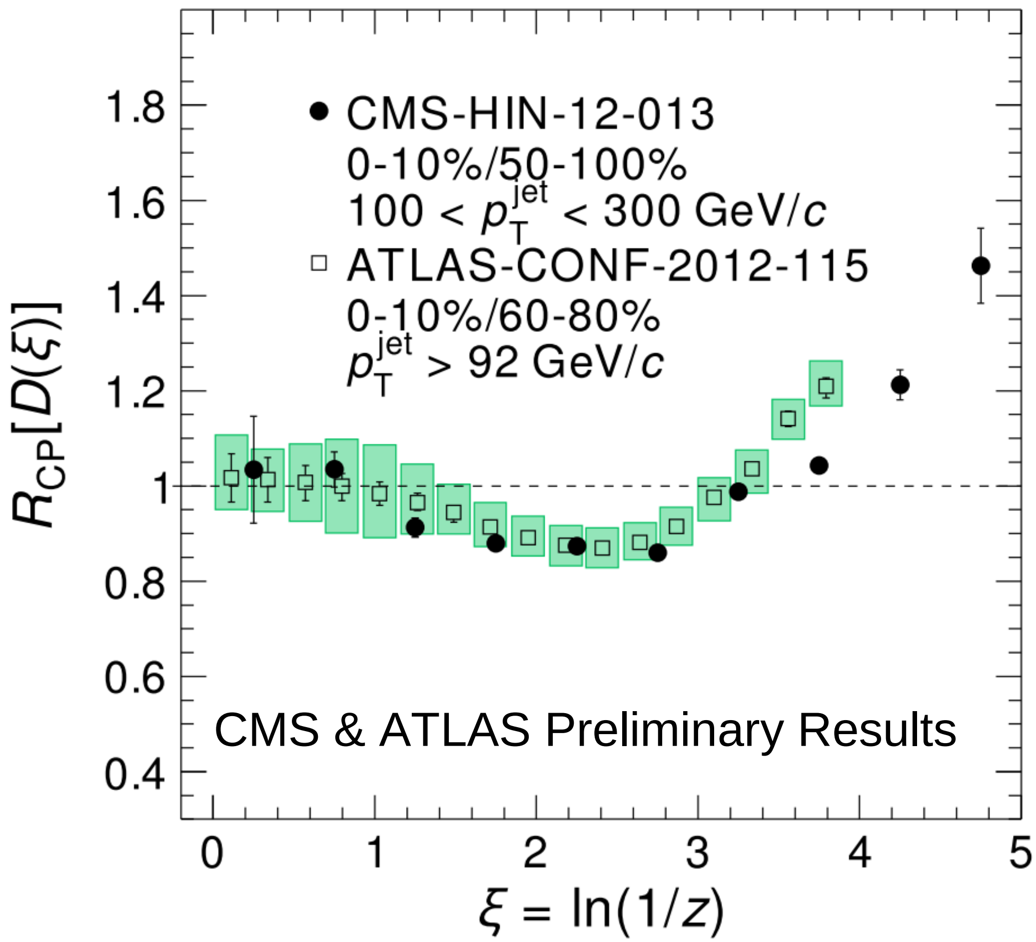
Jet Fragmentation Function



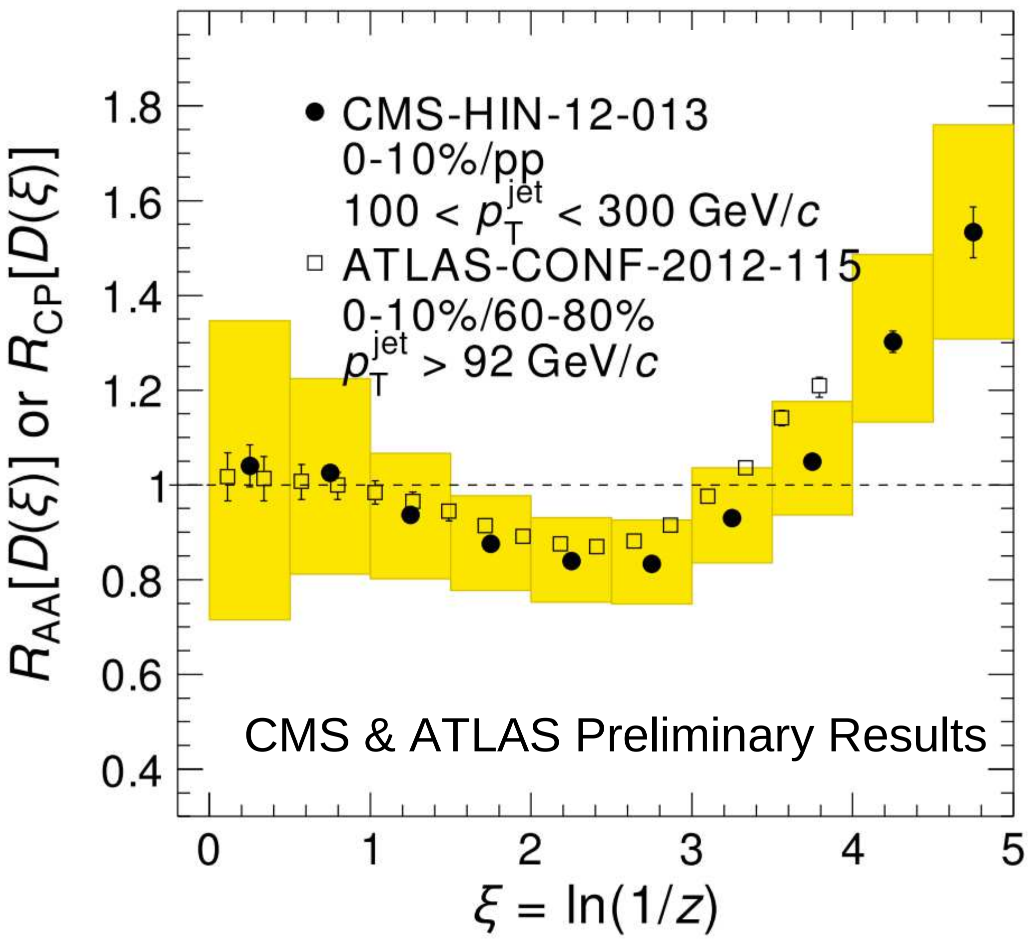
Jet Fragmentation Function

Using Jet Energy as a reference

FF R_{CP} comparison



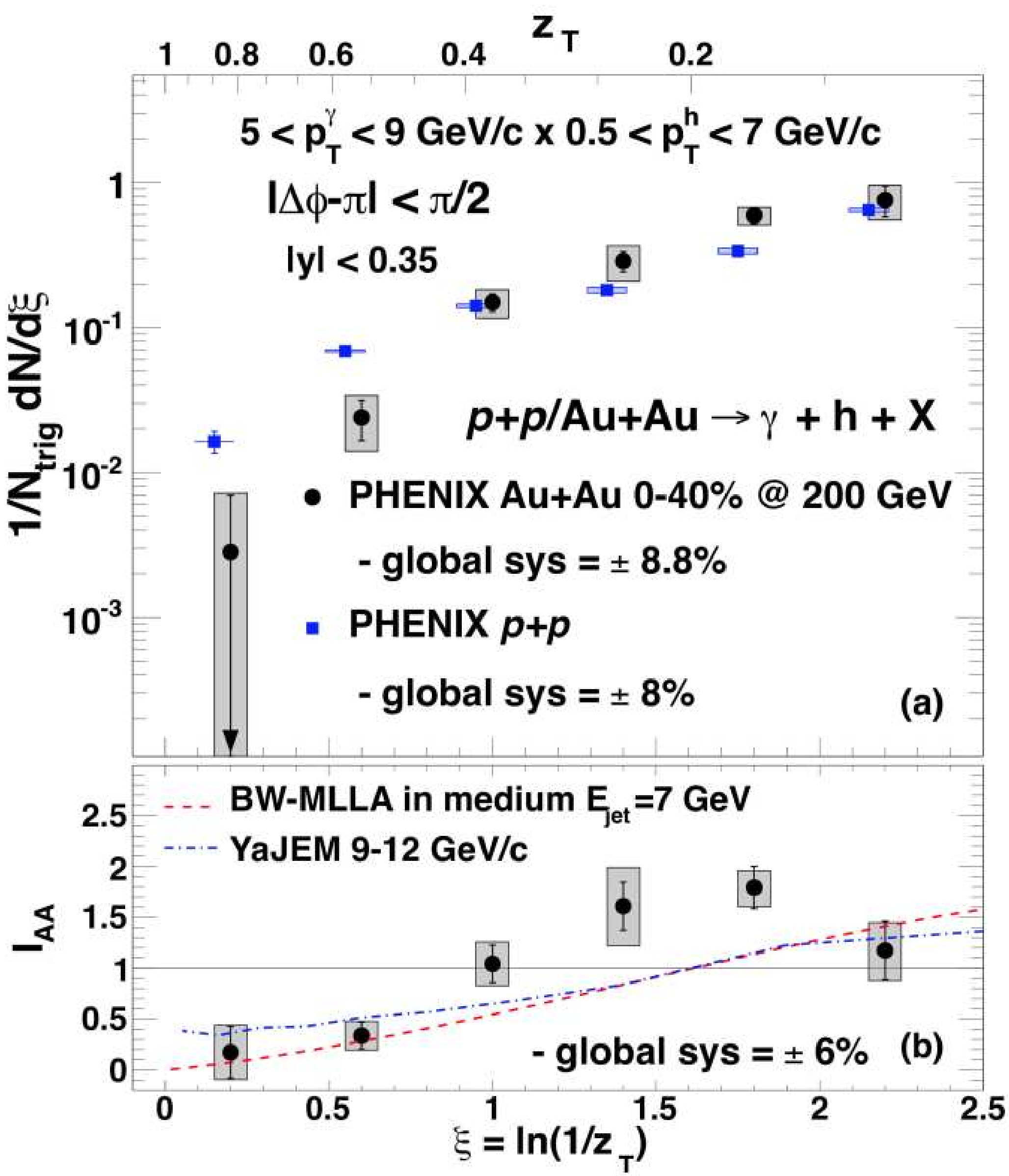
CMS FF R_{AA} compared to ATLAS FF R_{CP}

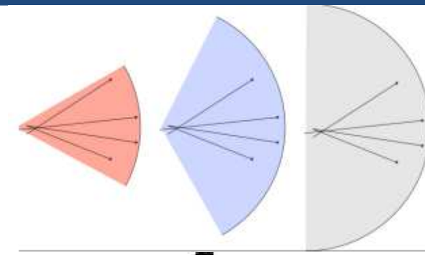


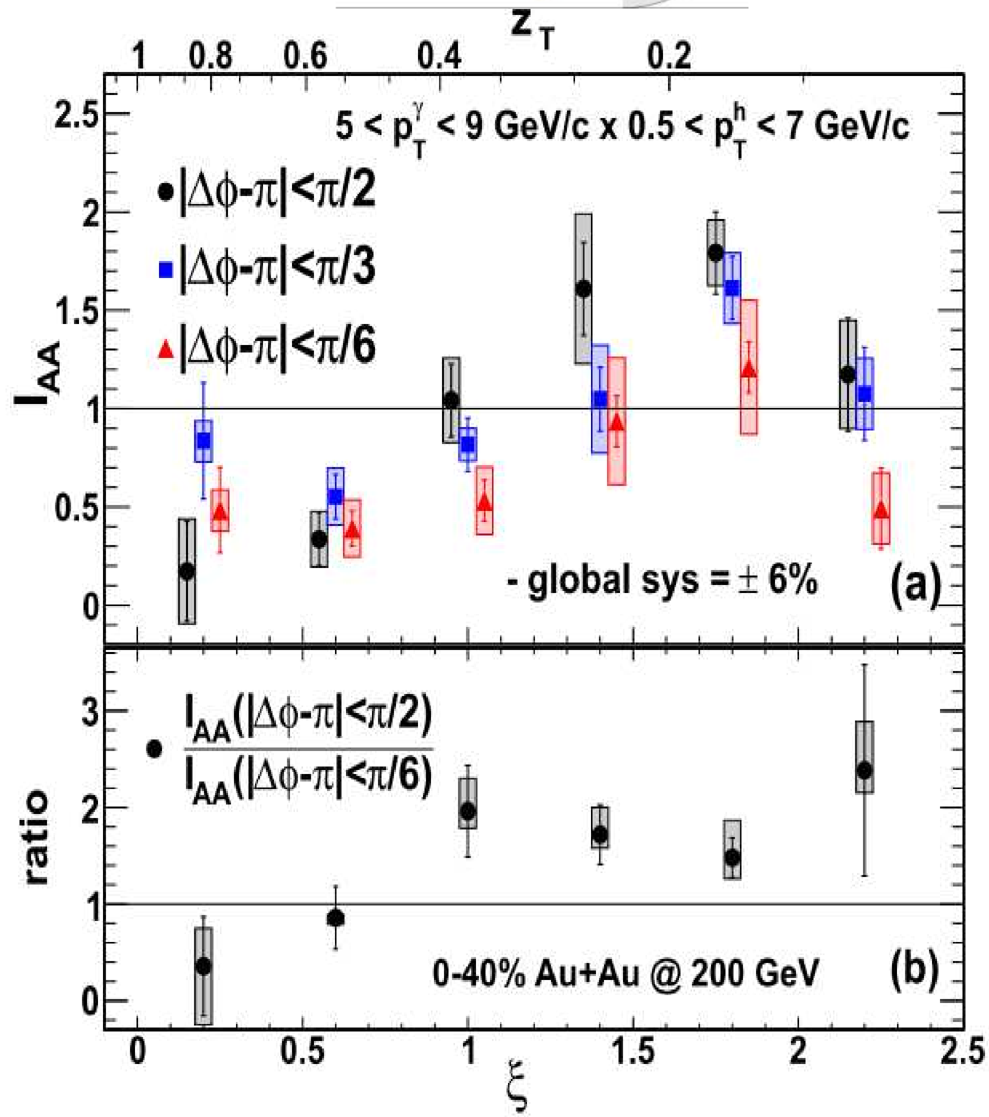
Consistent results from CMS and ATLAS

Photon-hadron correlation

Using Photon Energy as a reference







Photon-hadron correlation

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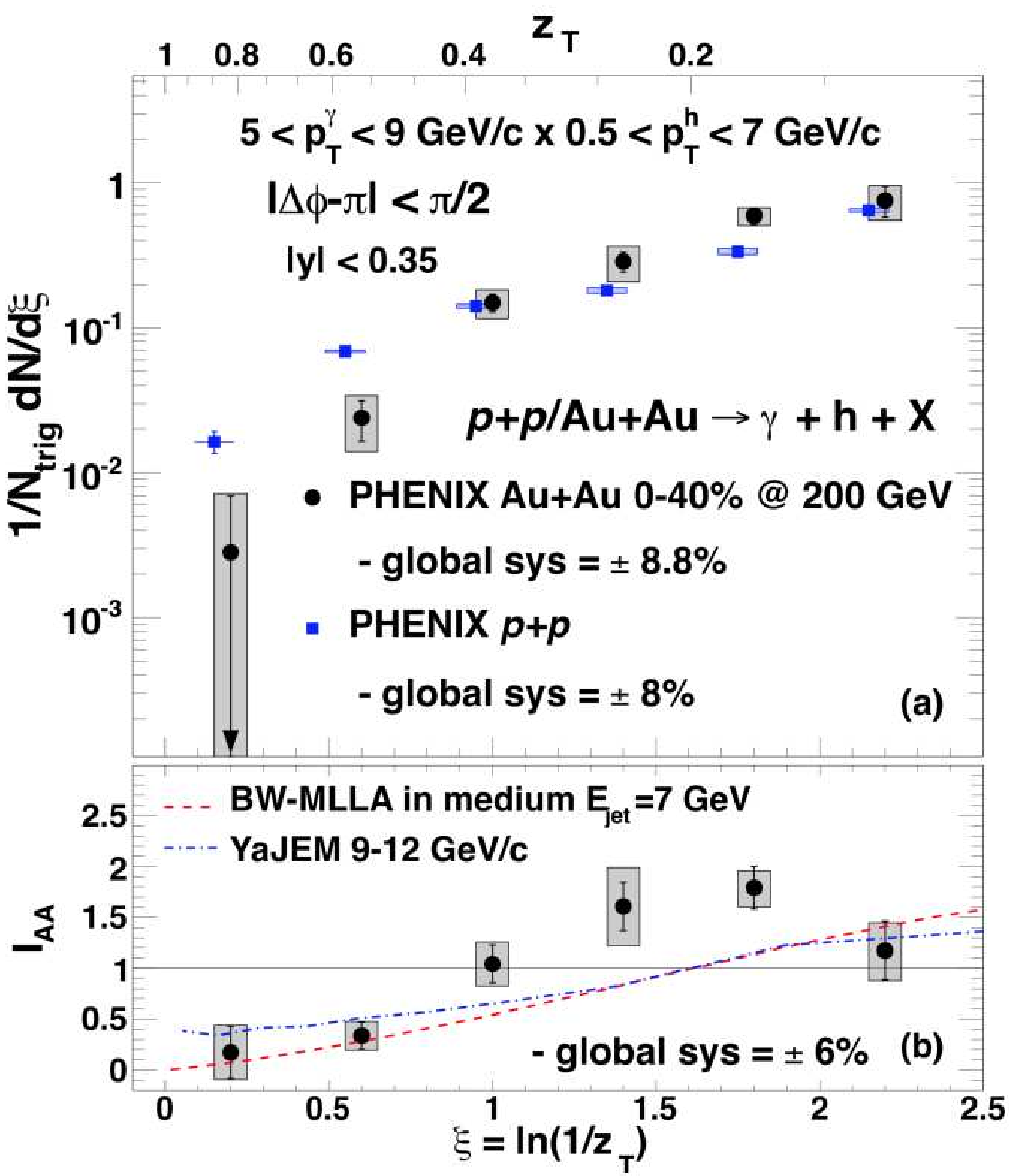
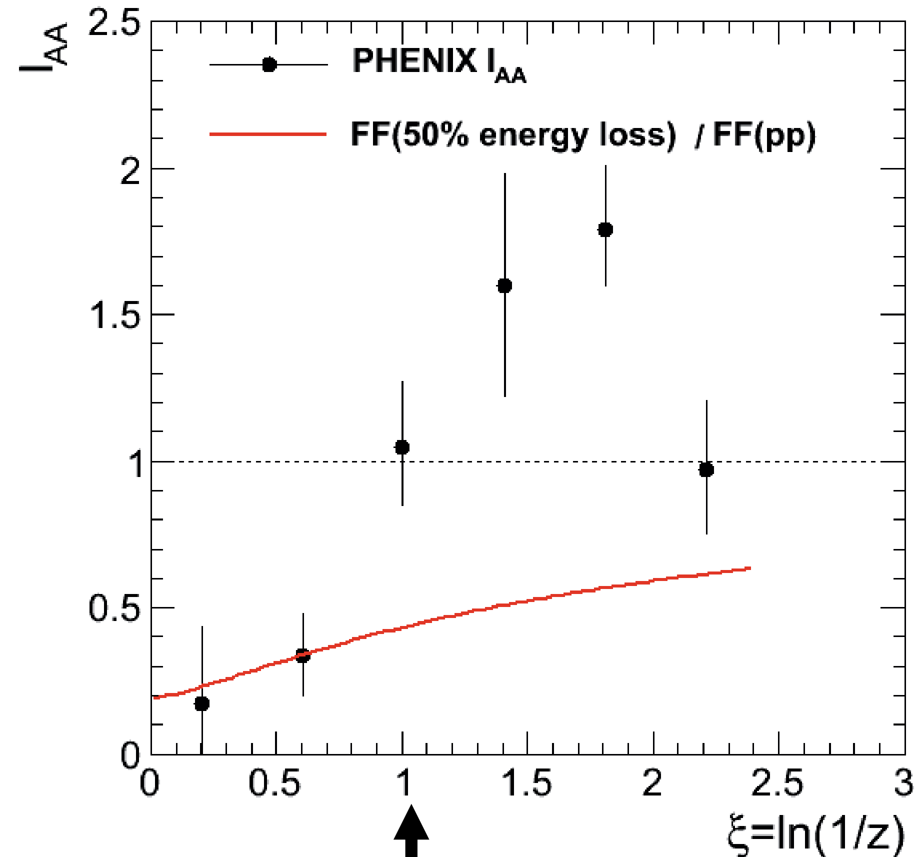


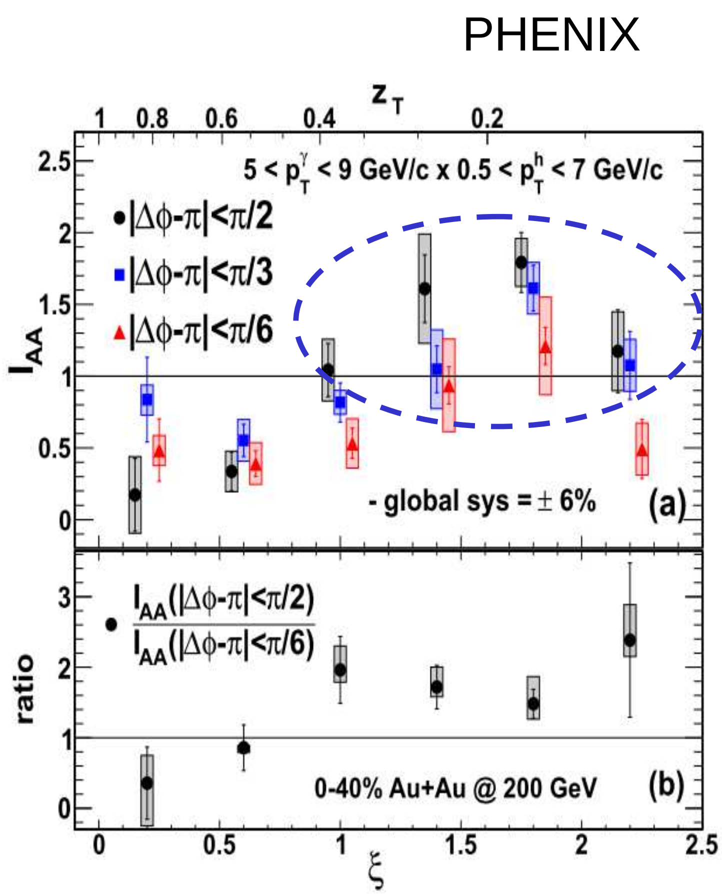
The FF shape can not be explained by simple shift of pp fragmentation function

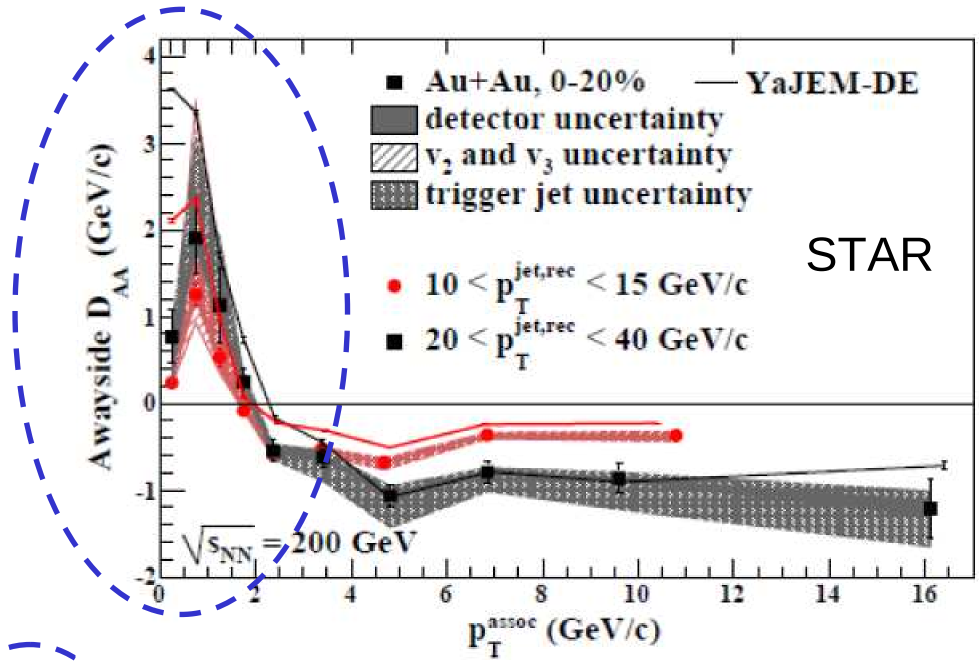


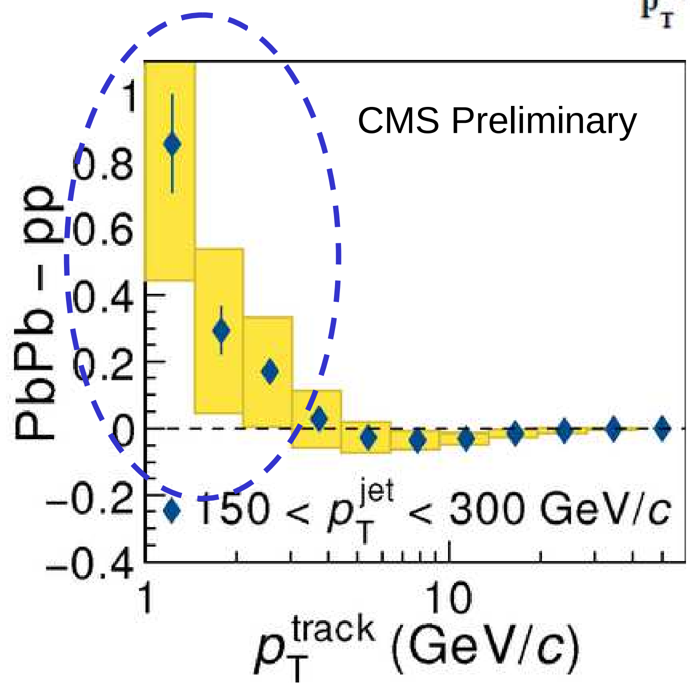
Track p_T ~2 GeV

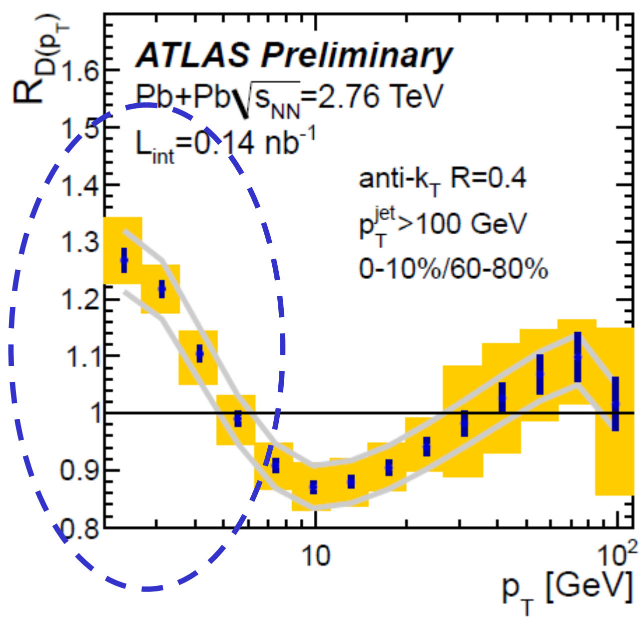
Enhancement of low p_T particles

Consistent picture: excess of low p_T particle in the jet cone

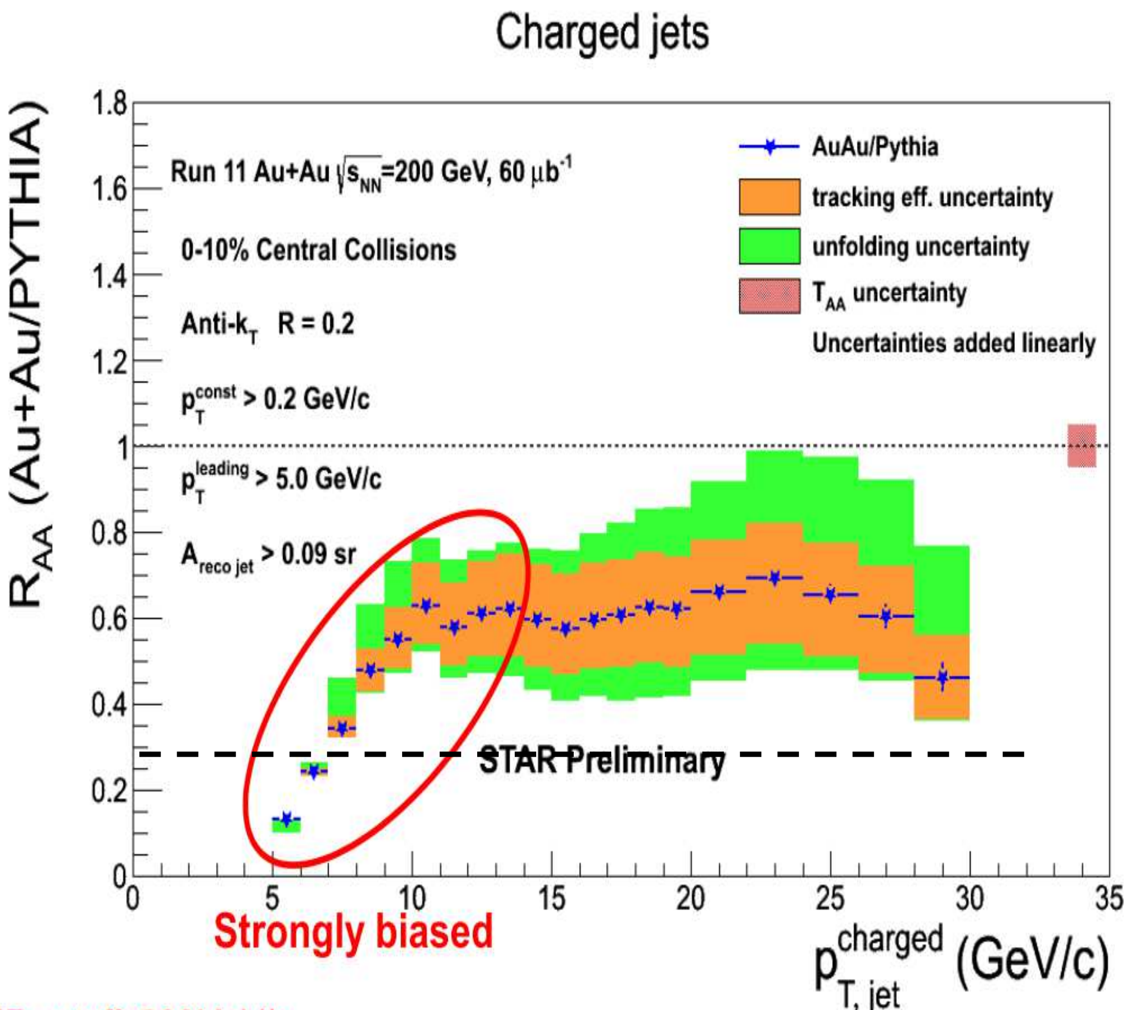


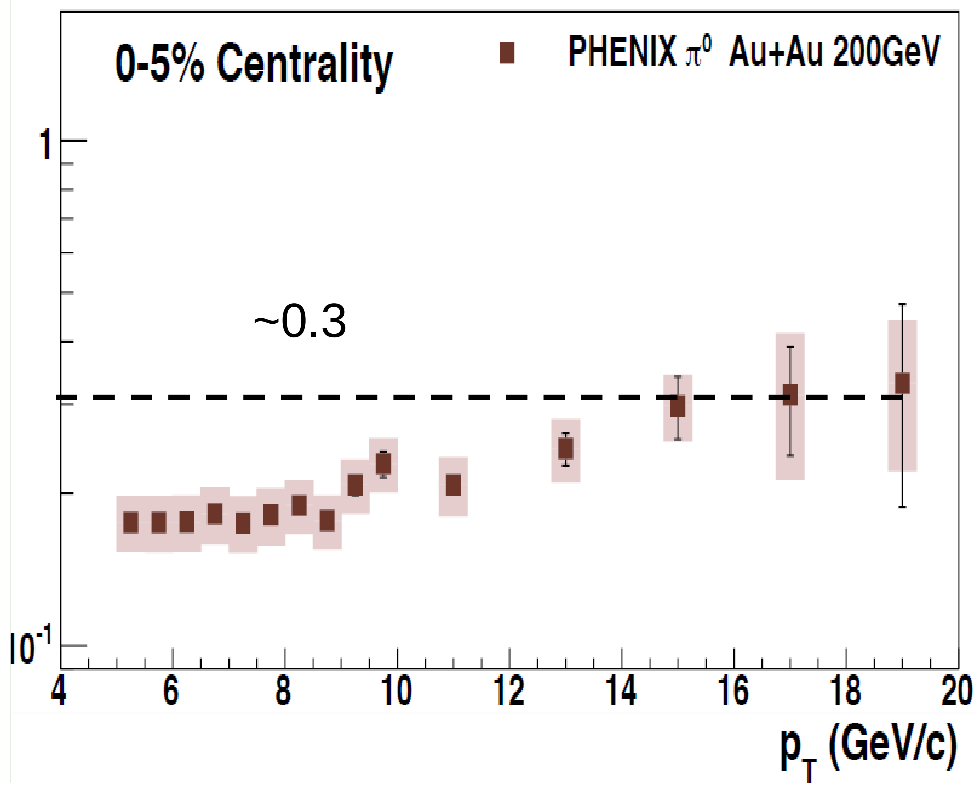






Jet R_{AA} v.s π R_{AA} at RHIC





IR cutoff: 200MeV/c

New charged jet R_{AA} results, is it consistent with single particle R_{AA}?

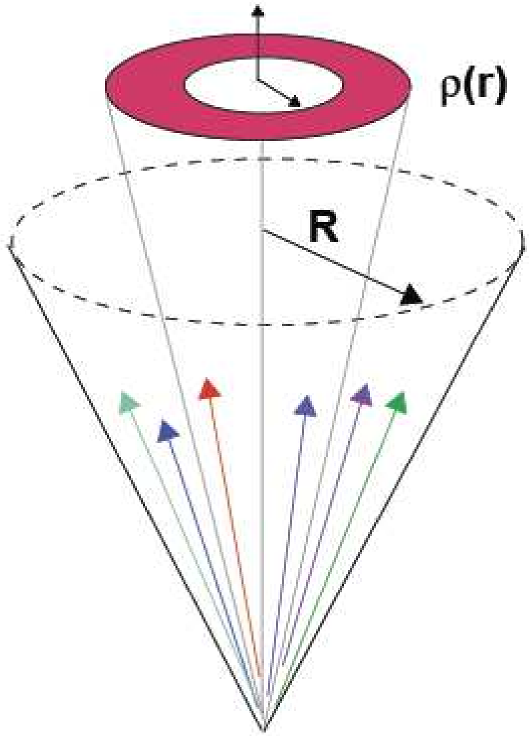
Indication of modification of jet fragmentation function?

Due to the steeply falling p_T spectra?

Jet shapes:

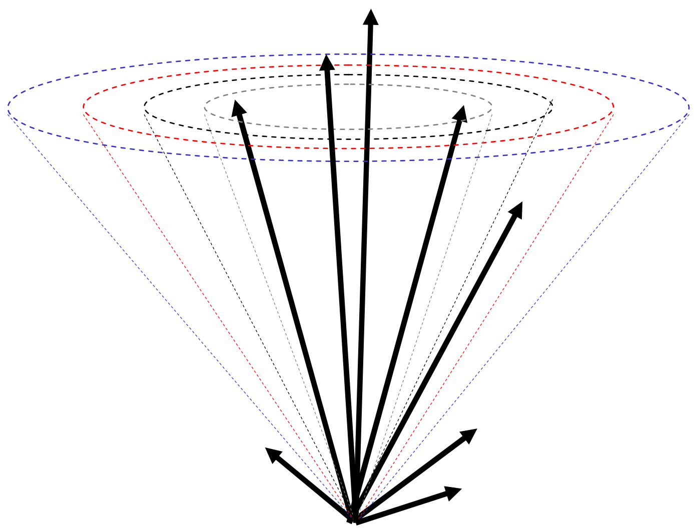
$R_{AA(CP)}$ Ratios, Δ_{Recoil},

direct jet shape measurements

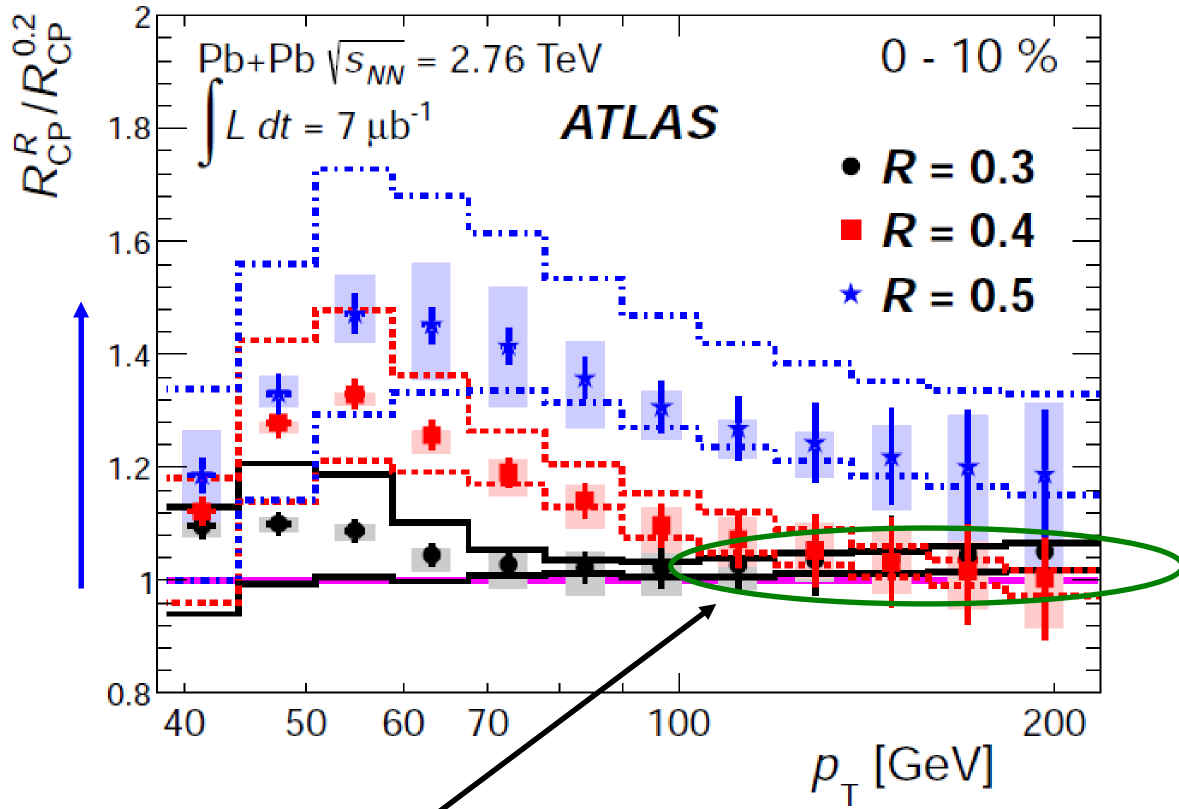


Do we collect the radiated energy with large cone size?

Anti-k_T jets with
R = 0.2, 0.3, 0.4, 0.5

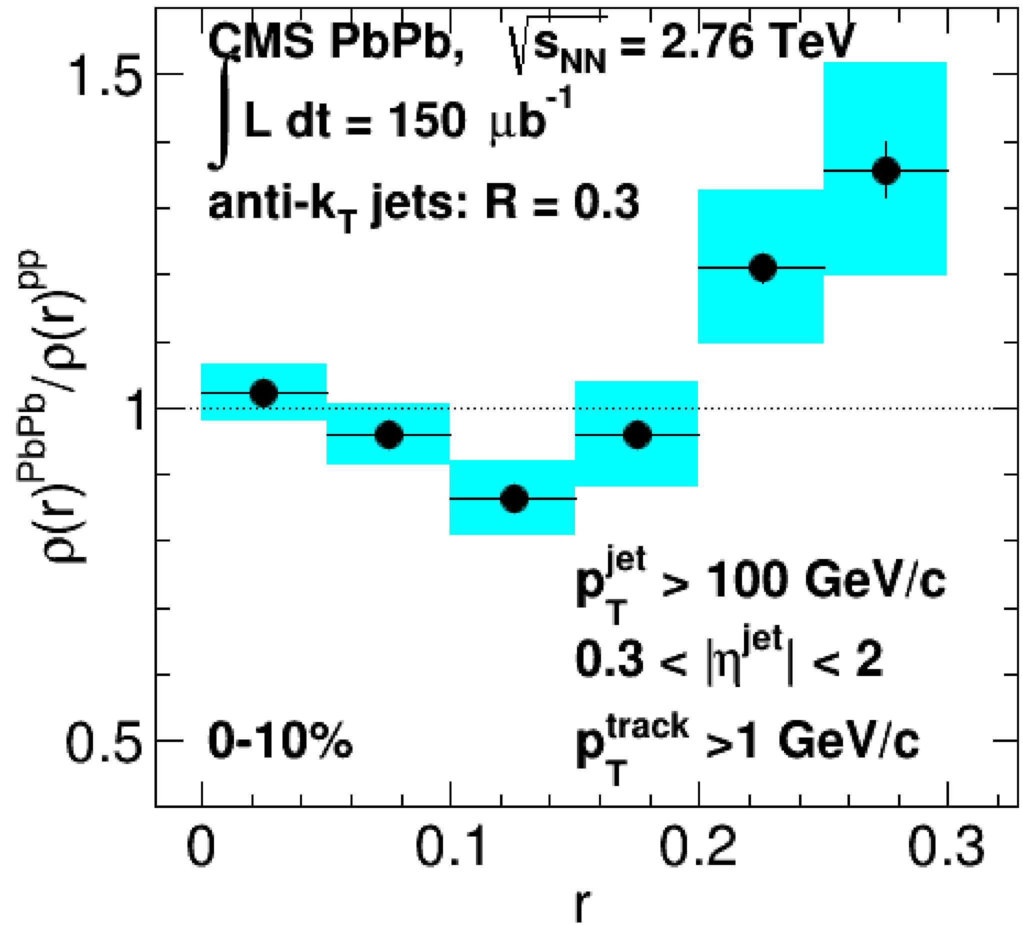


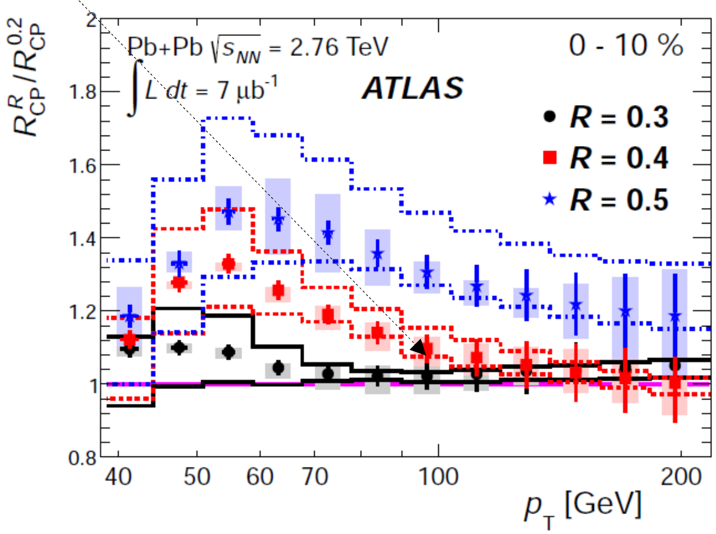
Ratio of R_{CP} with different cone sizes



ATLAS Jet R_{AA} (R=0.3) / R_{AA} (R=0.2) ~ 1.0 ±0.2
Allows to recover up to ~4% more jet energy when moving from R=0.2 → R=0.3 in PbPb collisions than pp reference

Jet shape v.s. R_{AA} ratio





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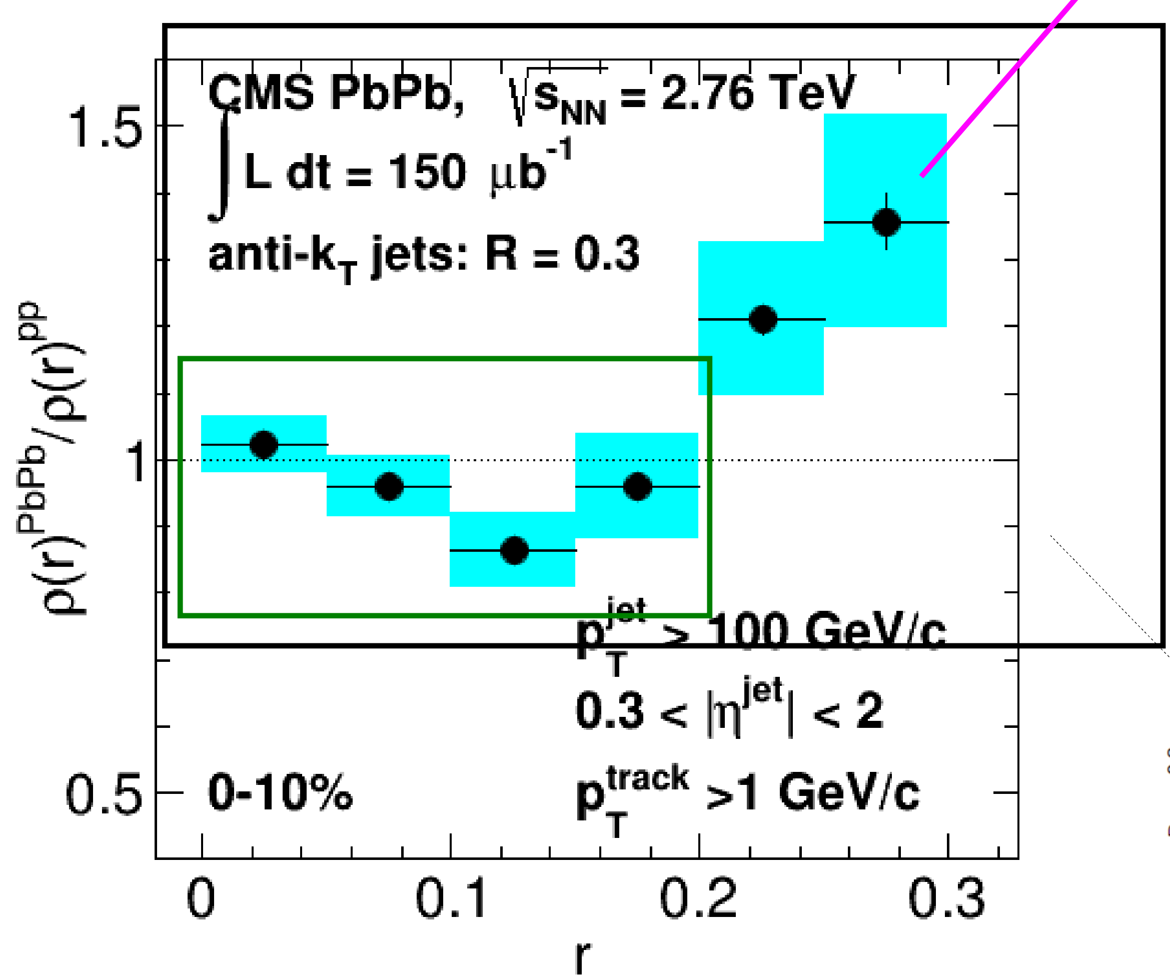
Jet shape v.s. R_{AA} ratio

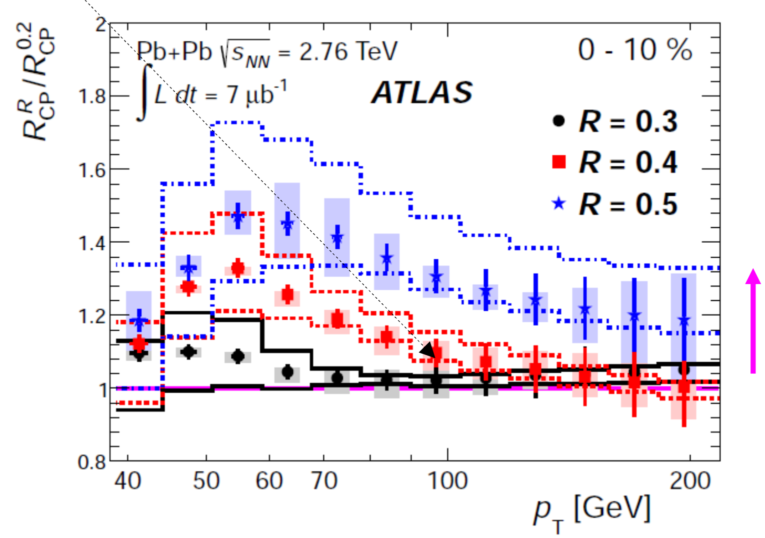
If increase R further..



Changing the R from 0.2 to 0.3→ recover more radiated energy associated with the parton

The observed change recover ~1% more energy

CMS and ATLAS results are compatible



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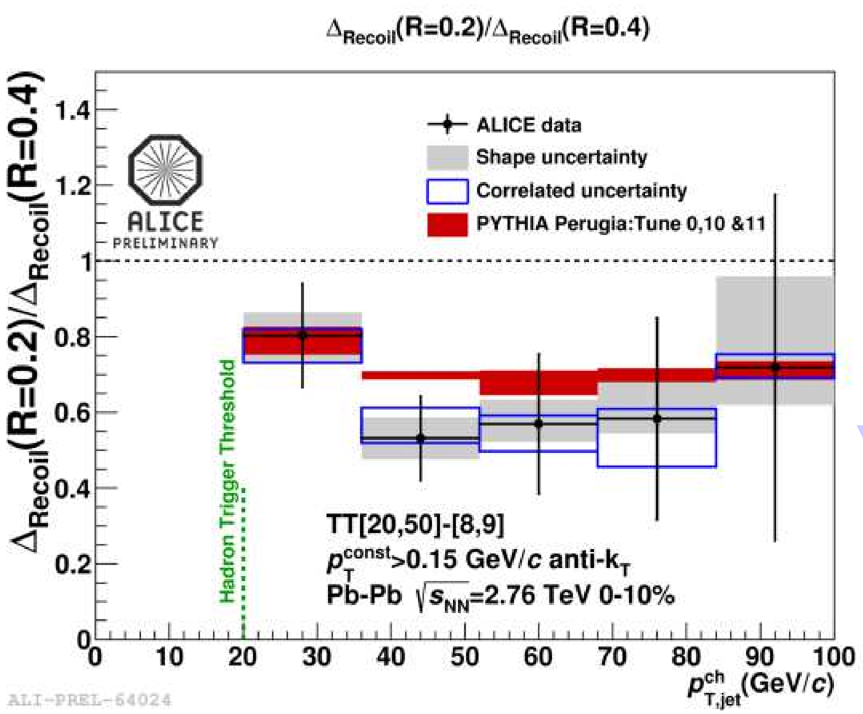
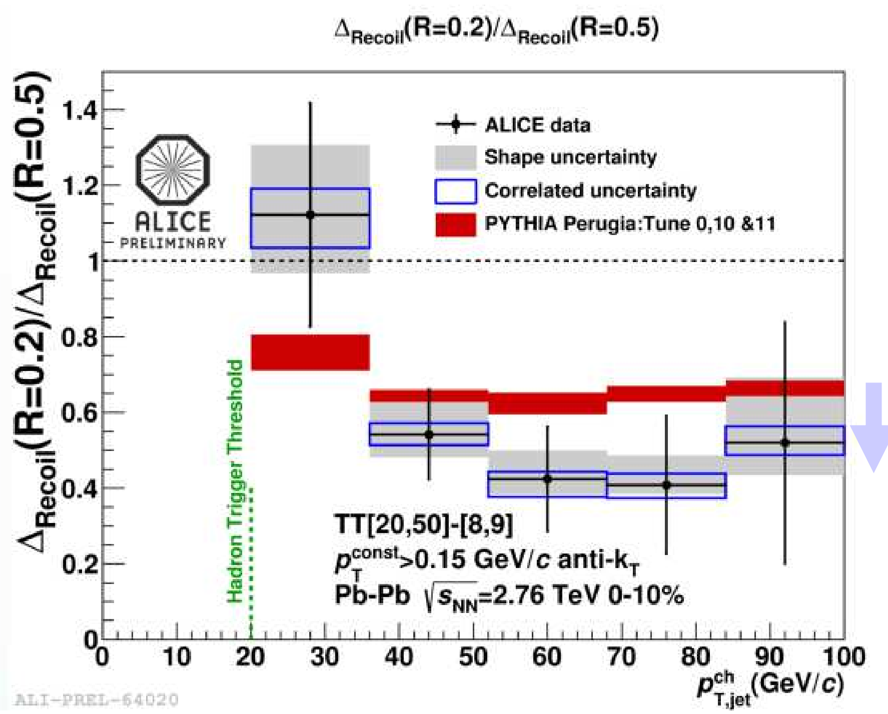
Allows to recover up to 4% more jet energy than pp reference

Δ_{Recoil} Ratio

$$\Delta_{recoil} = \left(\frac{1}{N_{trig}}\frac{dN}{dp_{T,jet}}\right)_{20-50} - \left(\frac{1}{N_{trig}}\frac{dN}{dp_{T,jet}}\right)_{8-9}$$

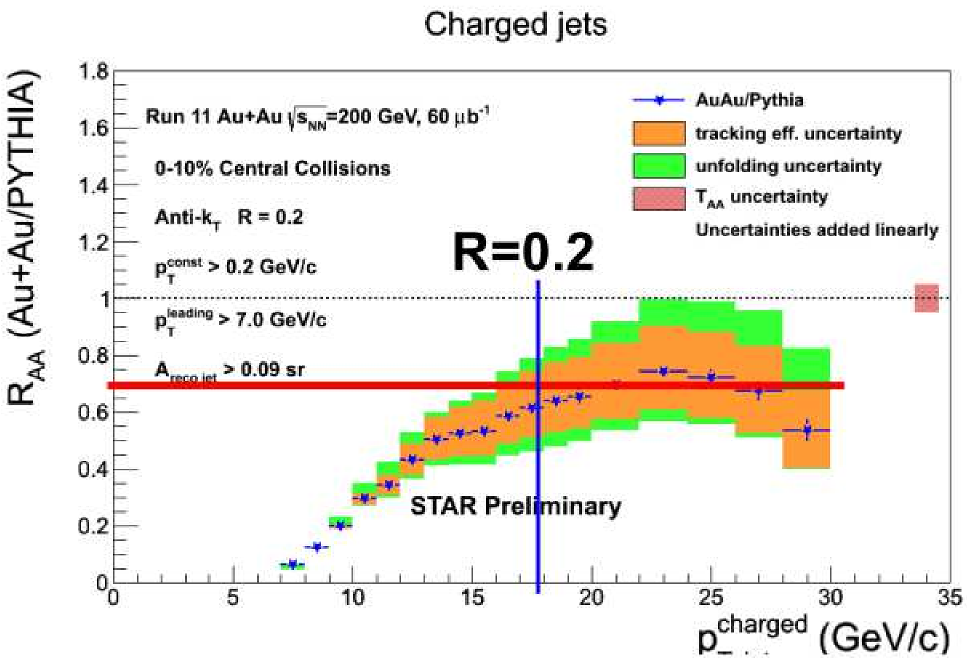


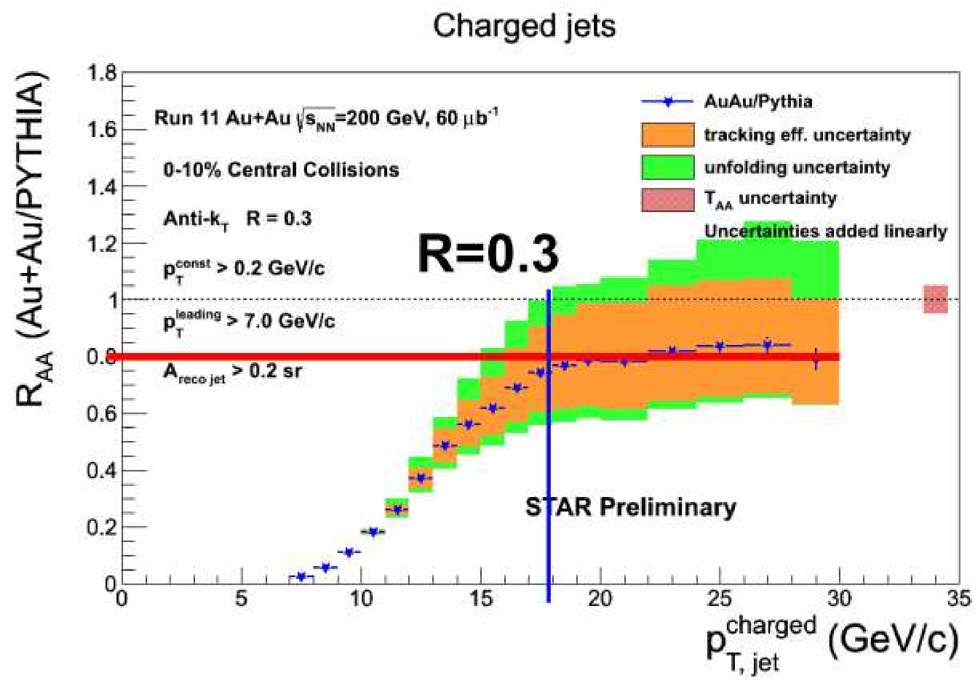


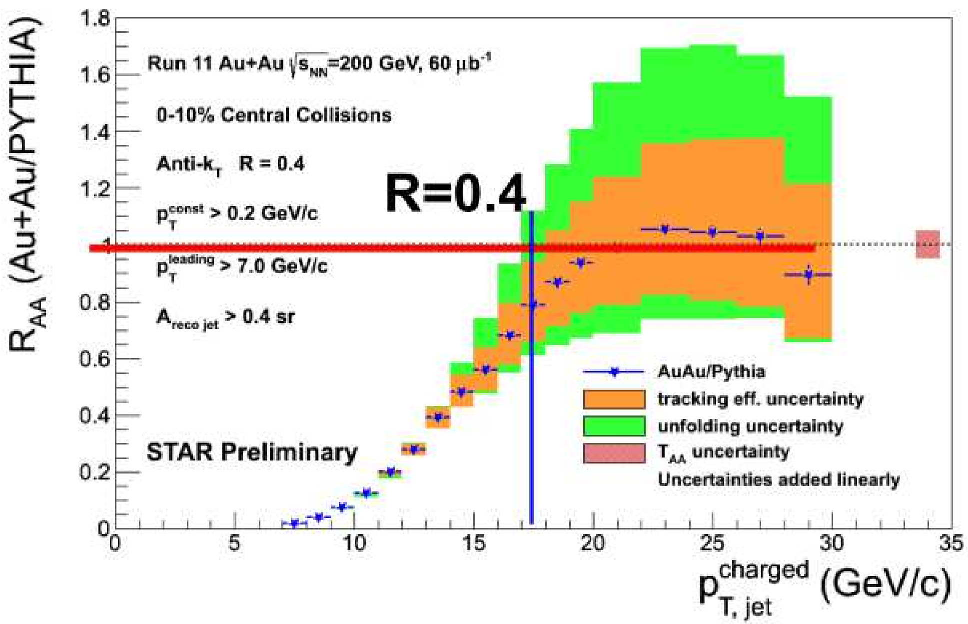
Indication of recovery of the lost parton energy
with larger cone size
(also consistent with no energy redistribution)

Consistent picture between CMS, ATLAS and ALICE

STAR R_{AA} v.s. R







Anti-k_T jets with

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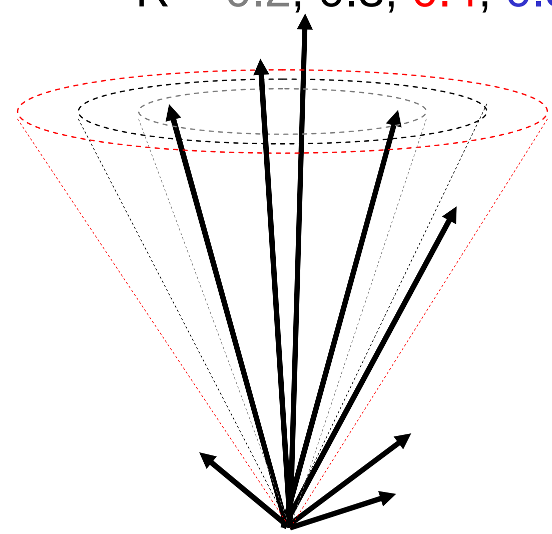
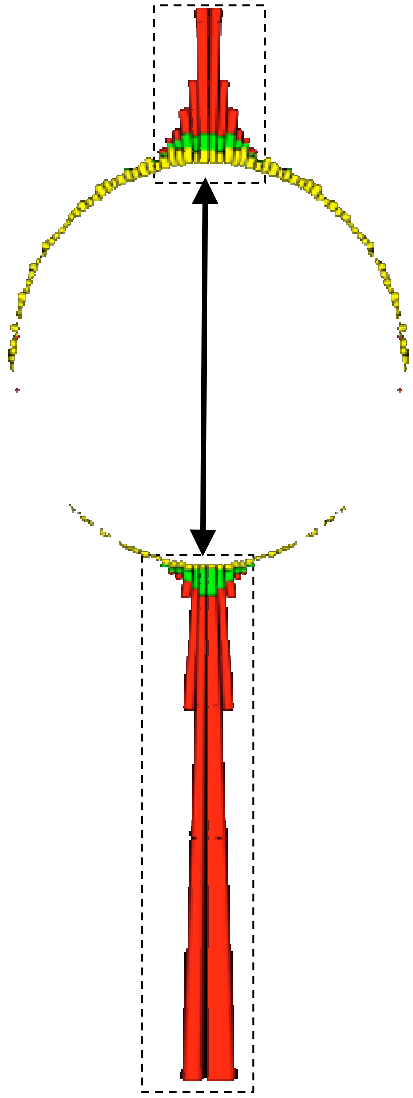


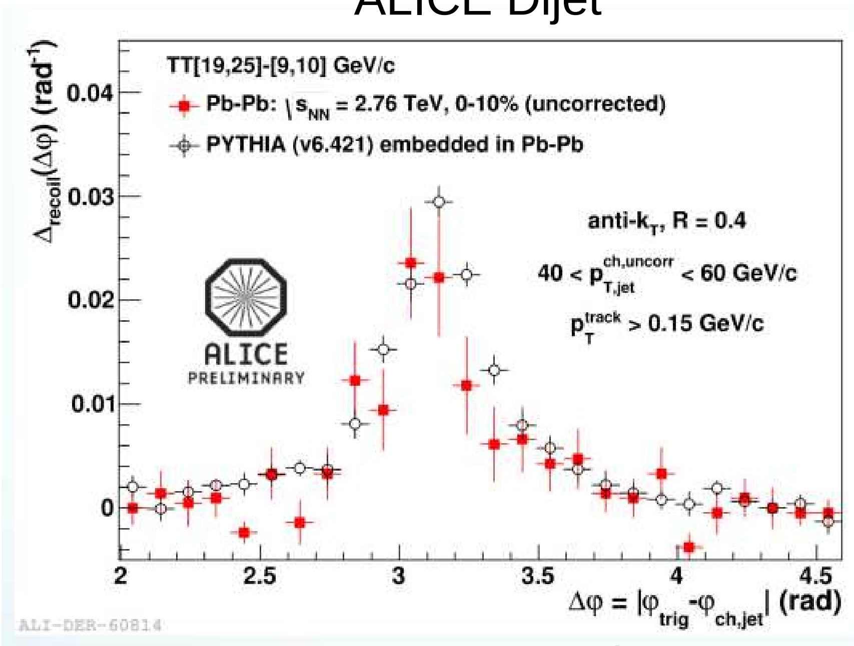
Azimuthal Angle Correlation:

Dijet and photon-jet

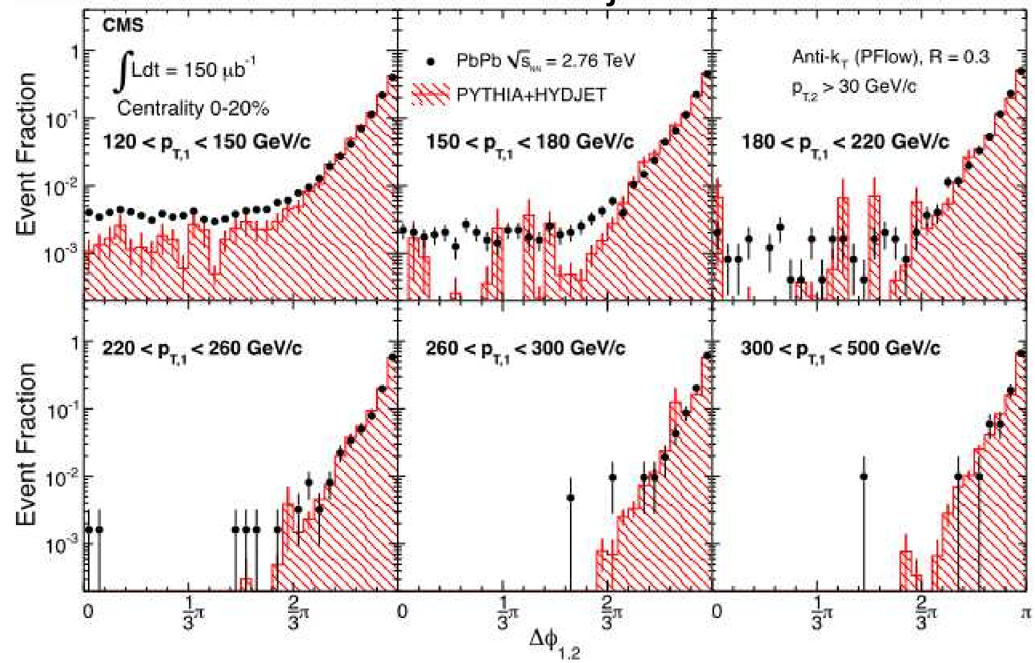


Azimuthal Angle Correlation

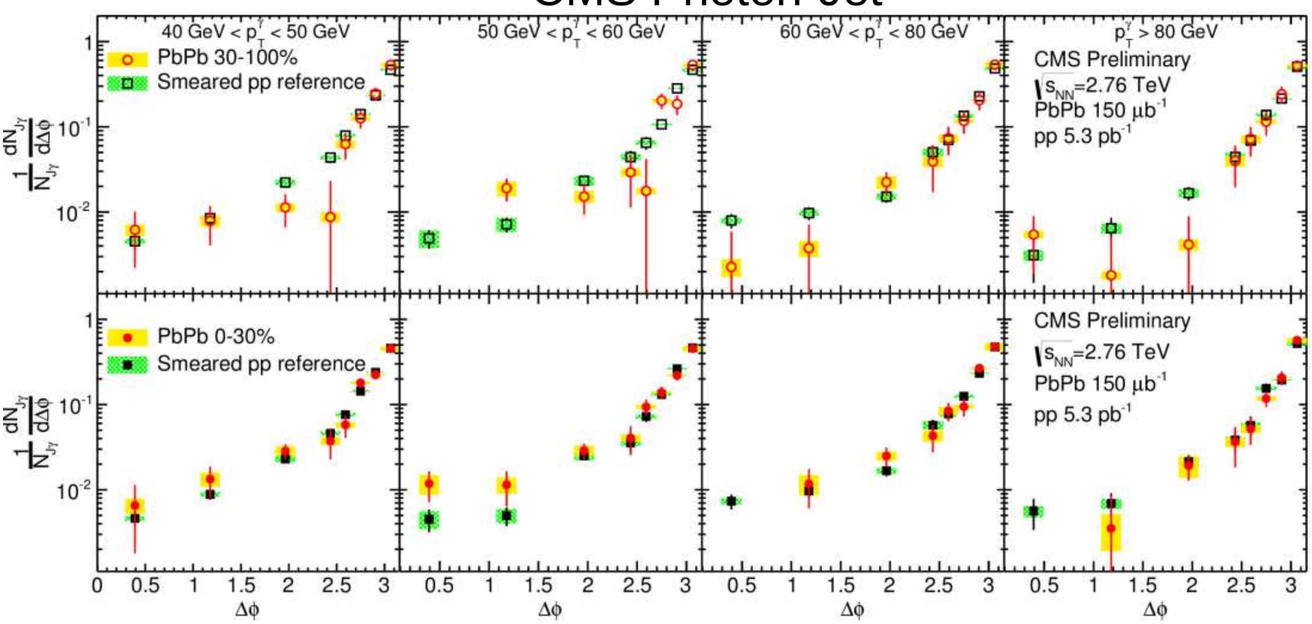
ALICE Dijet



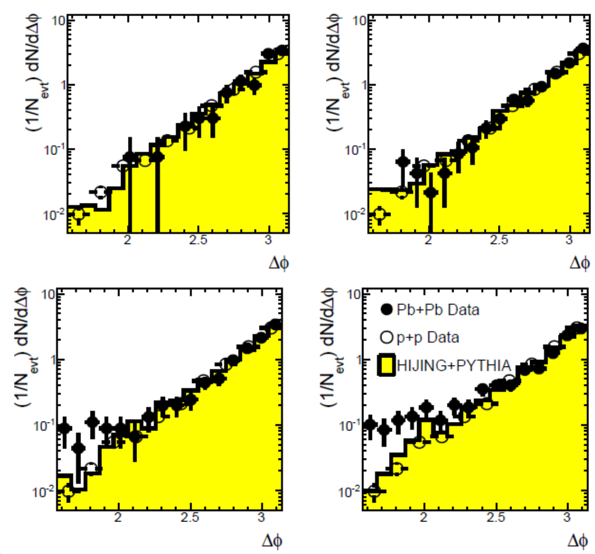
CMS Dijet



CMS Photon-Jet



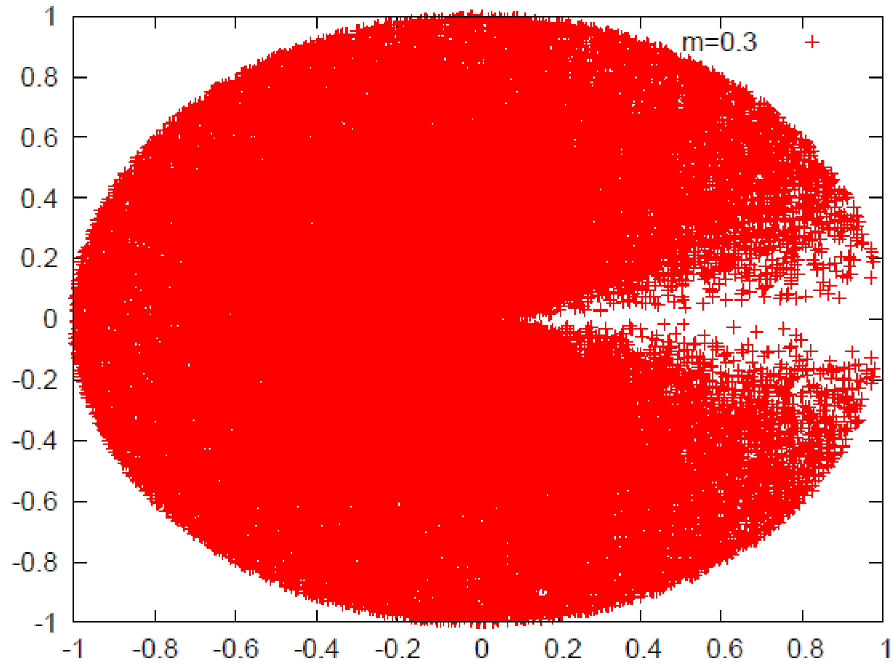
ATLAS Dijet



Flavor dependence of jet energy loss:

Pion, D and B meson R_{AA}

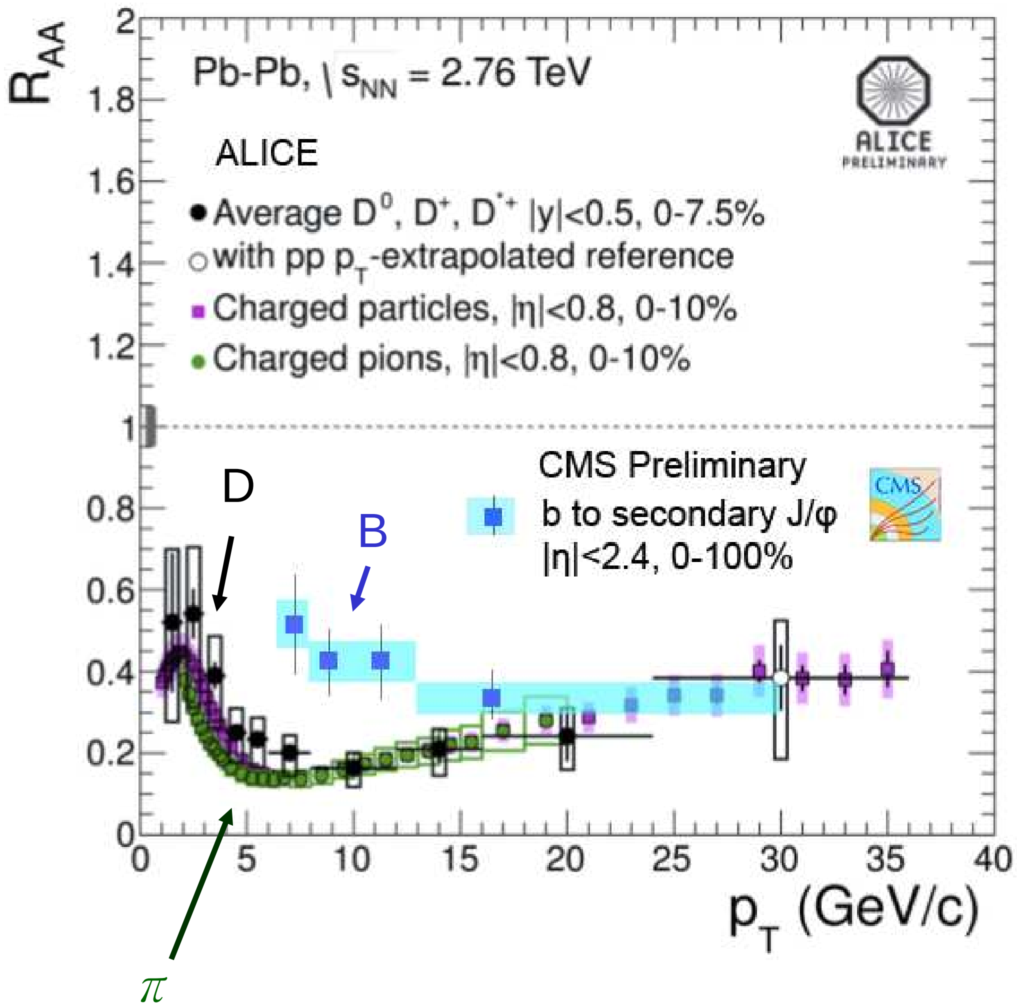
b-jet R_{AA}



Flavor Dependence of Jet Quenching

Indication of $R_{AA}(B) > R_{AA}(D) > R_{AA}(\pi)$ at low p_T

(However, spectra slope are different)



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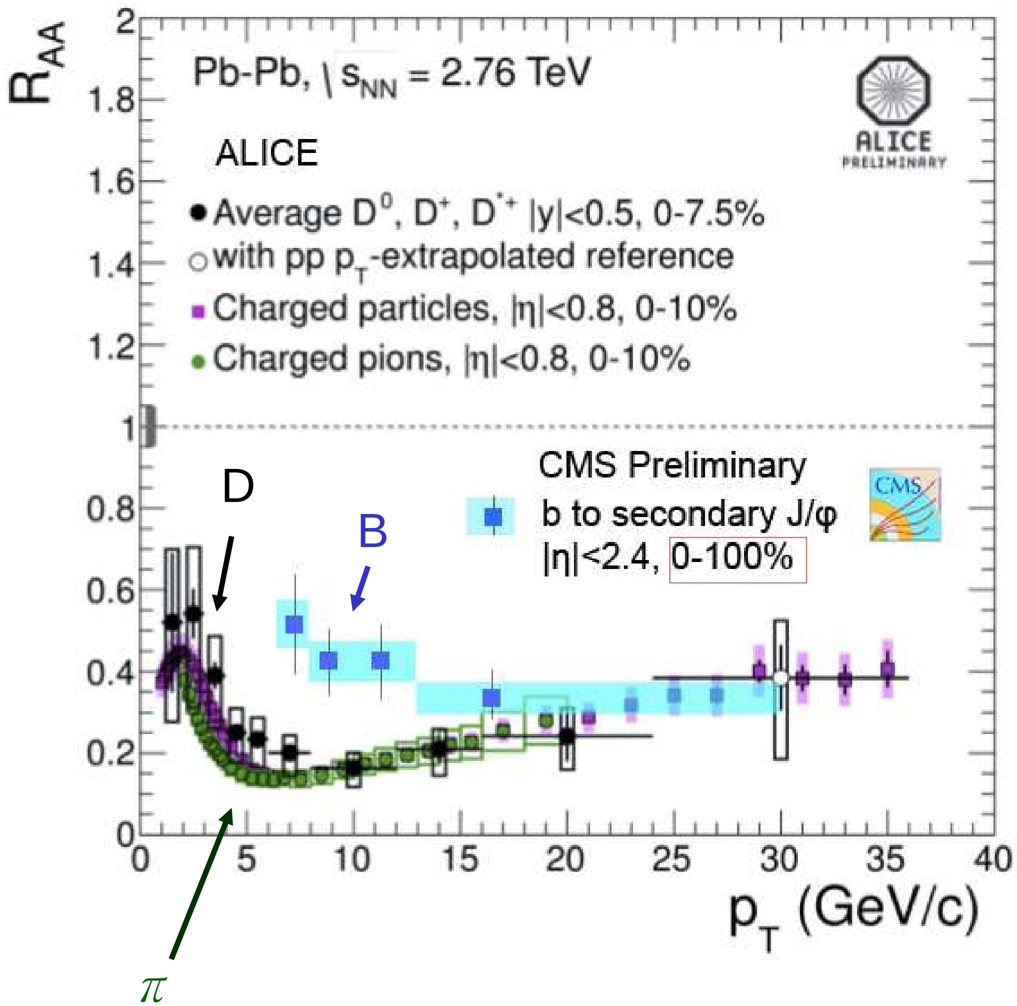
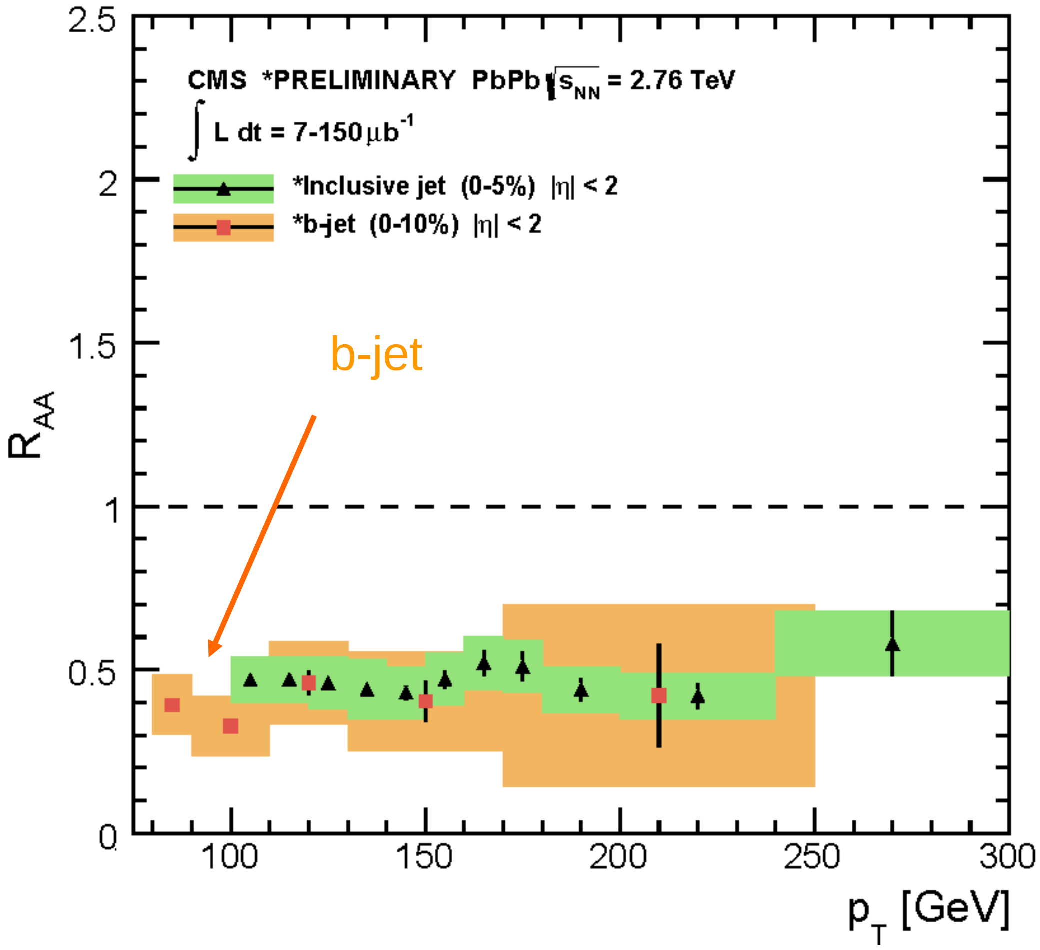


Indication of R_{AA}(b-jet) ~ R_{AA}(all jets) at high p_T



What Have We Learned with RHIC and LHC Data?

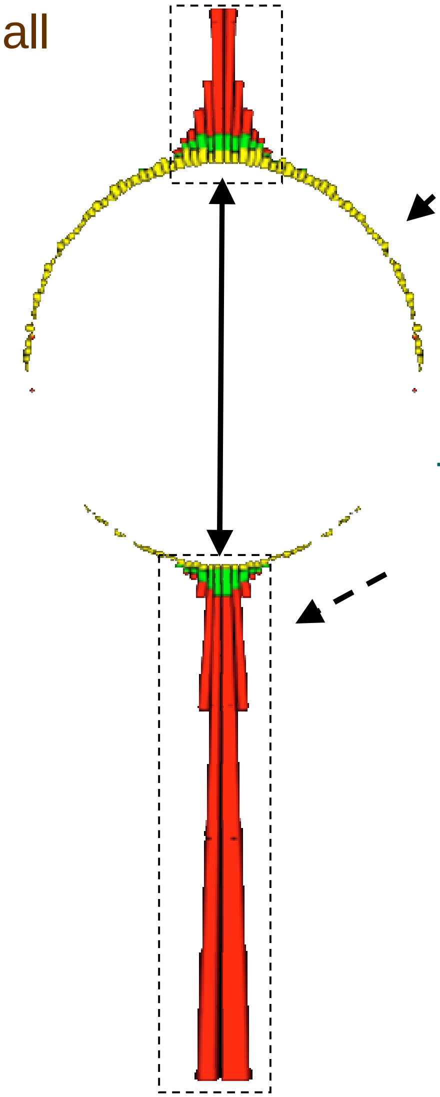
1. High p_T jet suppression
→ΔR = 0.2 - 0.8 doesn't capture all the radiated energy

2. Large average dijet and photon-jet p_T imbalance

3. Non-zero high p_T jet (track) v_2

4. Angular correlation of jets (photon-jet) not largely modified

For jet p_T 40-300 GeV



5. p_T difference found at low p_T particles far away from the jets

6. Observation of modified jet fragmentation function and jet shape

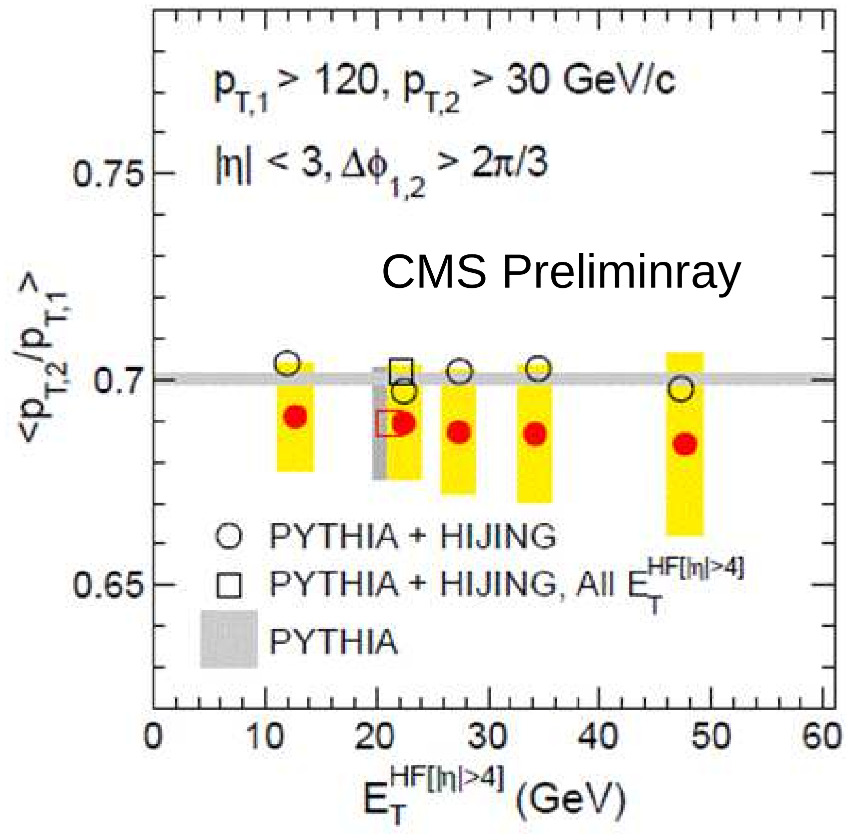
Excess of low p_T particles in the jet cone

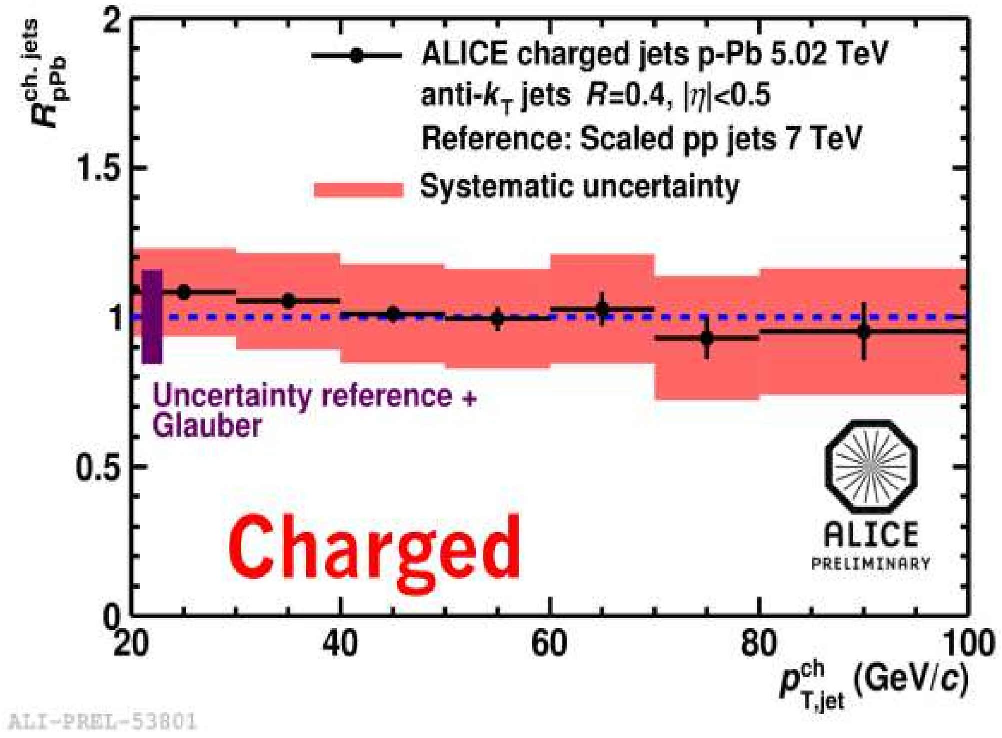
Indication of larger modifications at low jet p_T

7. Indication of flavor dependence of energy loss at low p_T
At high p_T b-jets are also quenched and similar to inclusive jets

Backup slides

Jet energy loss in pPb collisions

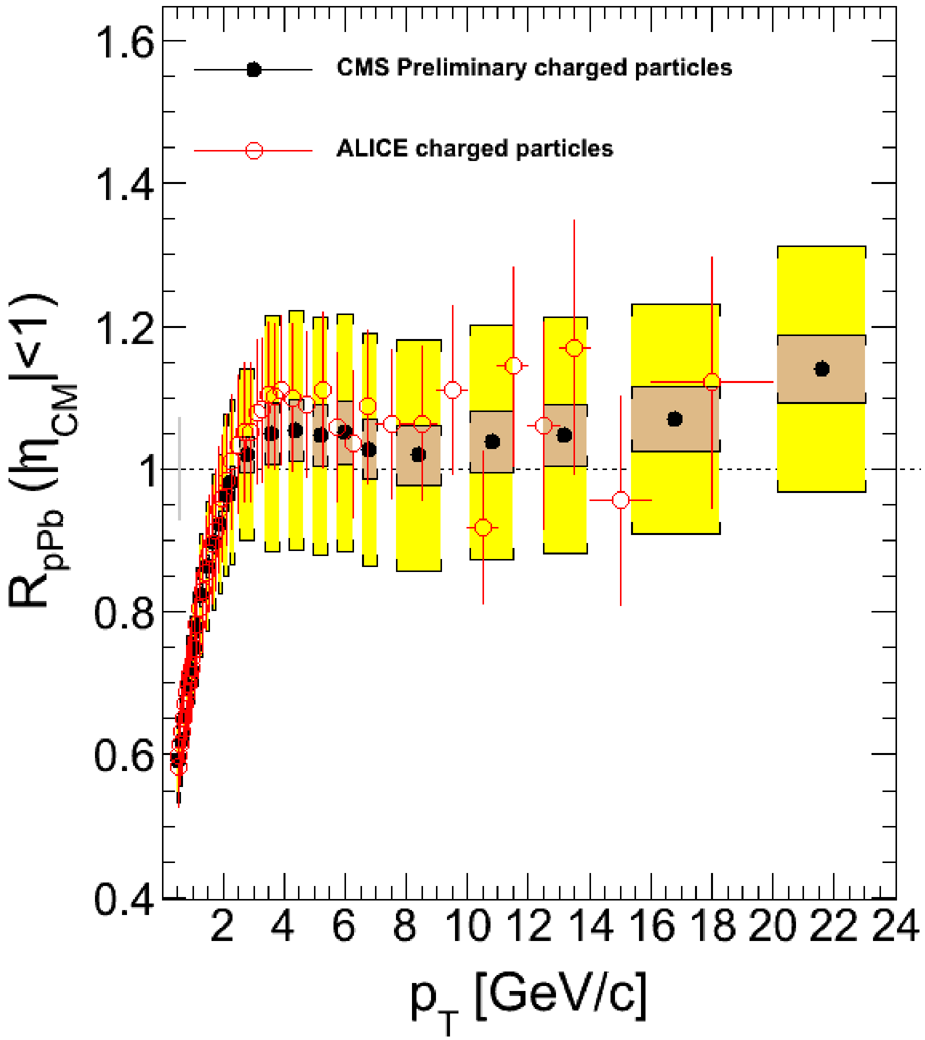




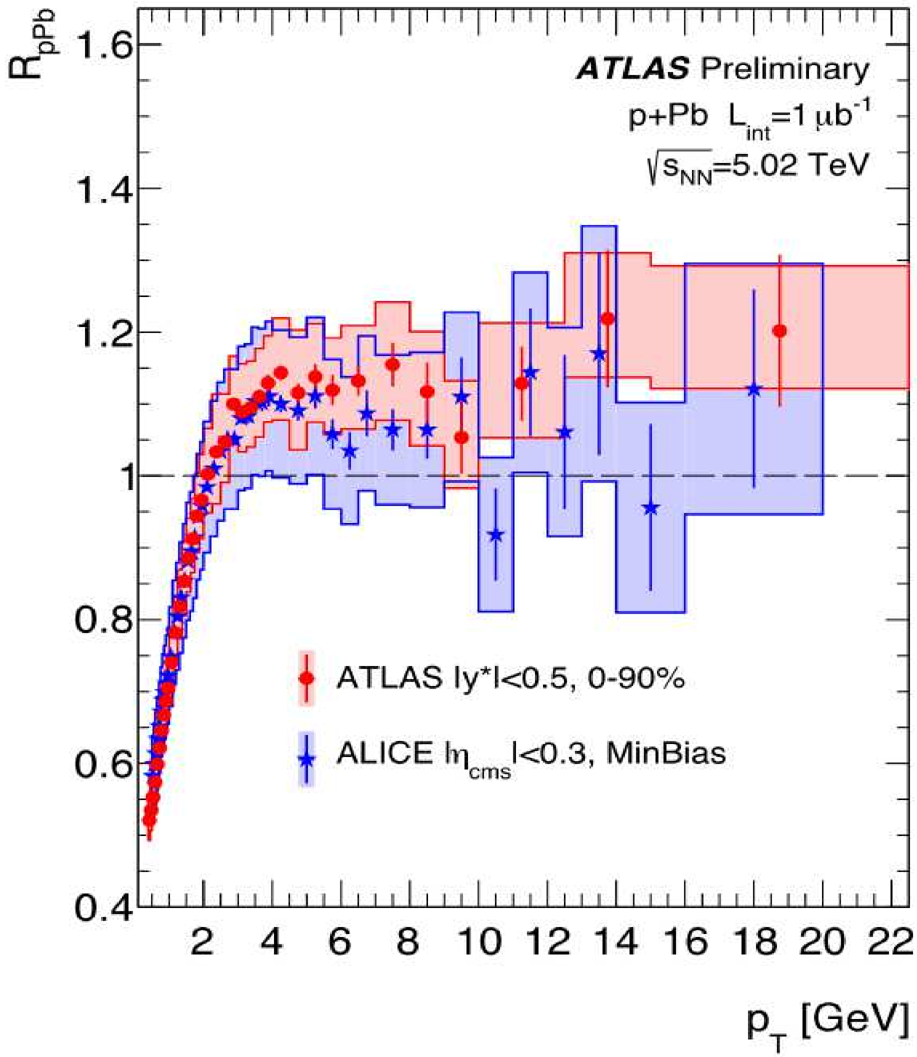
No indication of dijet asymmetry
Change of dijet p_T ratio < 2%

ALICE Charged Jet R_{pPb} ~ 1.0±0.2

Charged Particle R_{pPb}



CMS NSD compared
ALICE NSD



ATLAS 0-90% compared
ALICE NSD