Charged Particle Production in PbPb and pp Collisions at 5 TeV with CMS

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on behalf of the CMS Collaboration

Initial Stages 2016, Lisbon, Portugal
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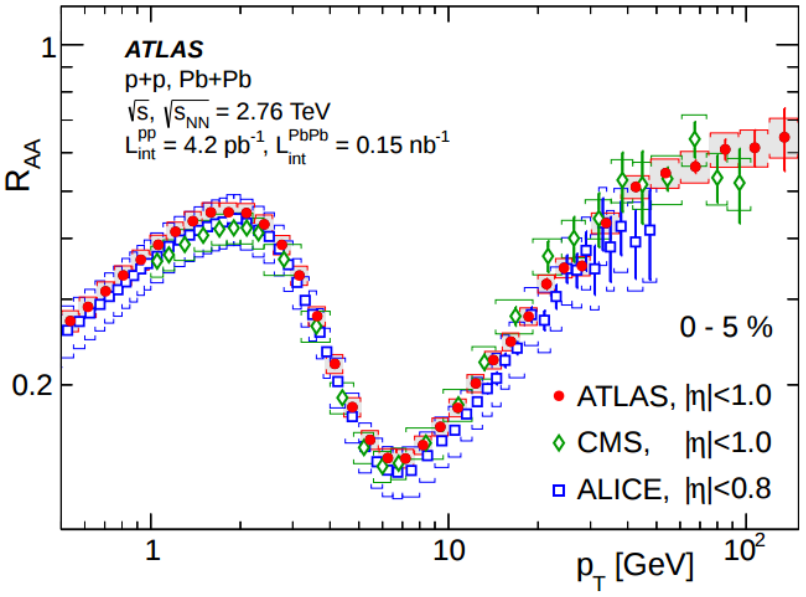
Motivation

- First measurement of 5 TeV charged particle R_{AA} to as high p_T as possible
- Large suppression already seen at 2.76 TeV
- Constraints on energy loss models
  - Strength of medium interaction
  - Average path length
  - Lifetime of medium
- Reference for heavy flavor measurements
  - See Gian Michele Innocenti's talk on Thursday!
    - 'Heavy flavour production in pp and PbPb collisions with the CMS detector'

$$R_{AA}(p_T) = \frac{d^2N_{ch}^{AA}/dp_T\,d\eta}{\langle T_{AA}\rangle\, d^2\sigma_{ch}^{pp}/dp_T\,d\eta}$$

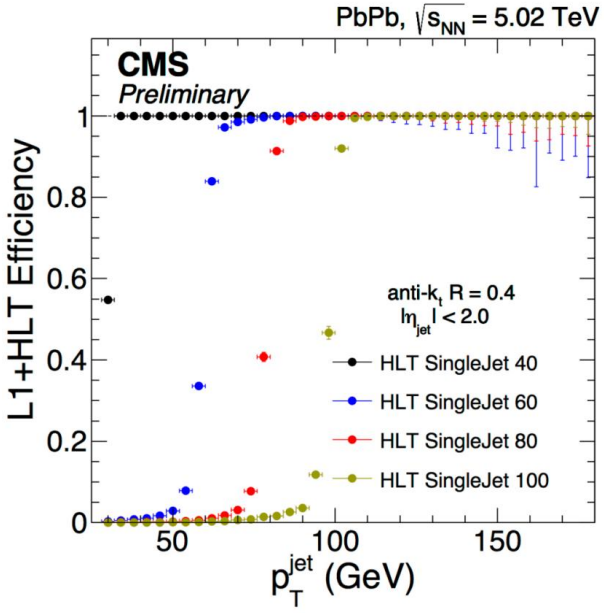
JHEP 1509 (2015) 050



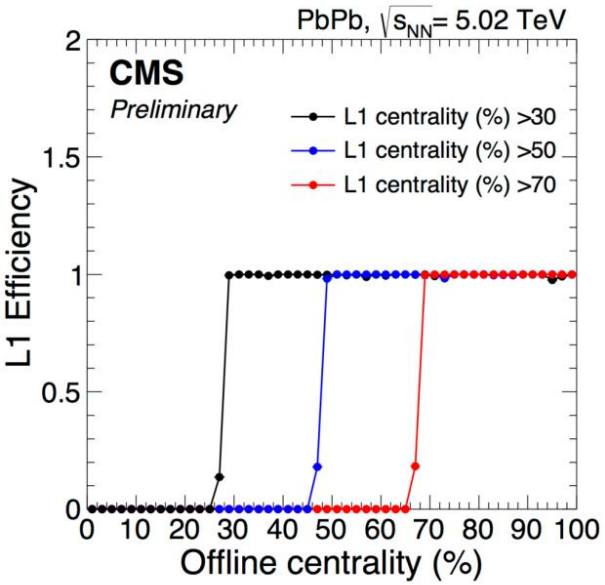
Dataset

- 404 μb^{-1} (PbPb) and 25.8 pb^{-1} (pp) from Fall 2015
  - Previously 150 μb^{-1} (PbPb) and 0.23 pb^{-1} (pp) at 2.76 TeV
- Minimum Bias and Jet Triggers
  - Peripheral triggers boost statistics in 30-100% and 50-100%
- Checked with high-p_T track triggers
- 28 triggers total – High statistics; reach up to 400 GeV

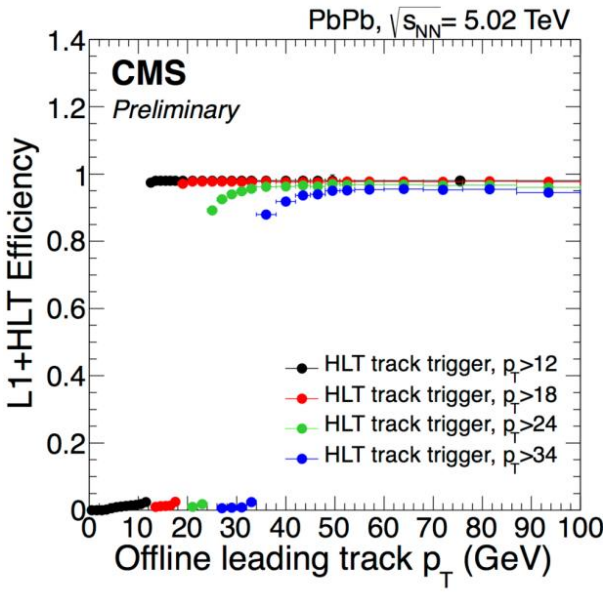
Jet Triggers



Peripheral Triggers



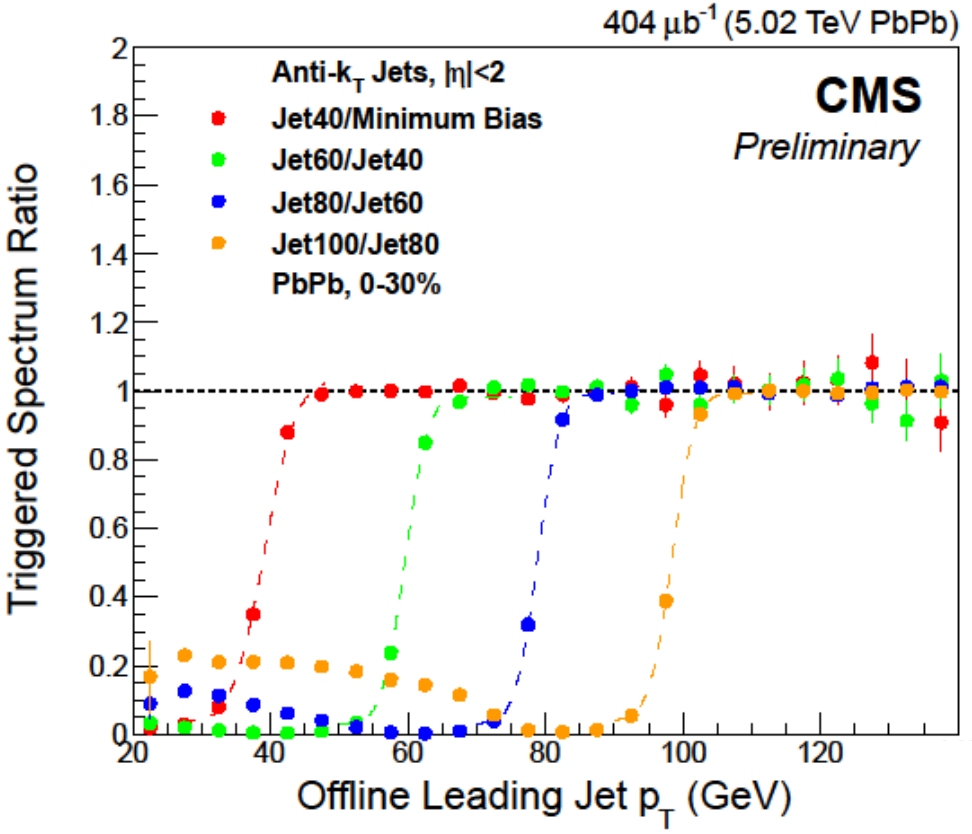
Track Triggers



Trigger Combination

- Take distributions of leading jet p_T with $|\eta|<2$
- Ratio of number of jets from each trigger in p_T region of constant efficiency

$$Scale|_{jet40} = \frac{N^{MB}_{pt>60}}{N^{jet40}_{pt>60}}$$

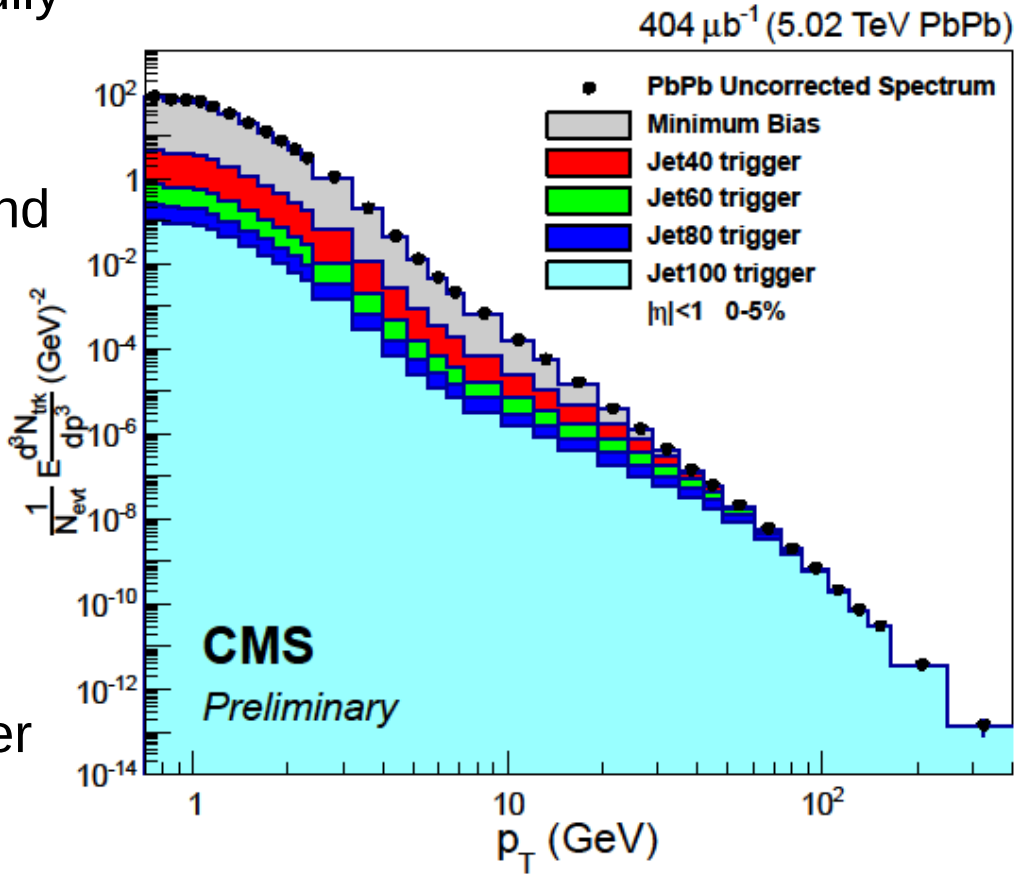


- Compare jet 60 with jet 40, etc.
- Done for 0-30%, 30-50%, 50-100%
  - Scale factors different due to inclusion of peripheral triggers

- Scaled leading jet p_T distribution agrees

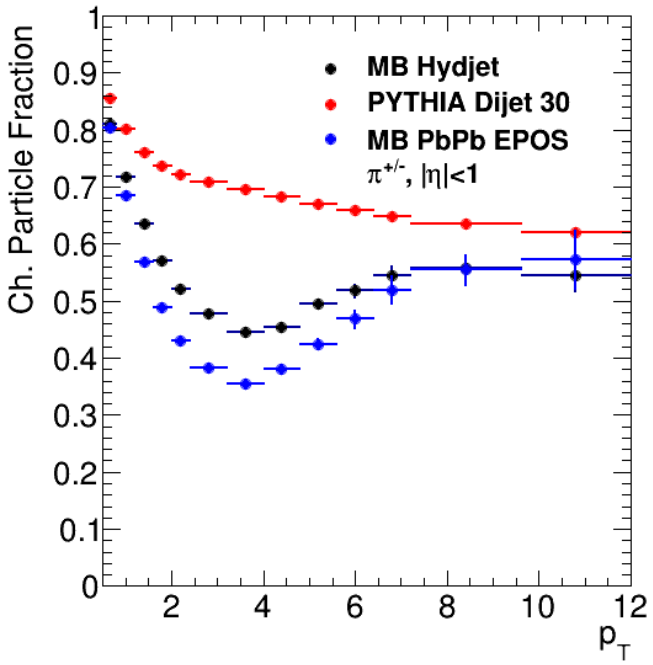
Building PbPb Spectra

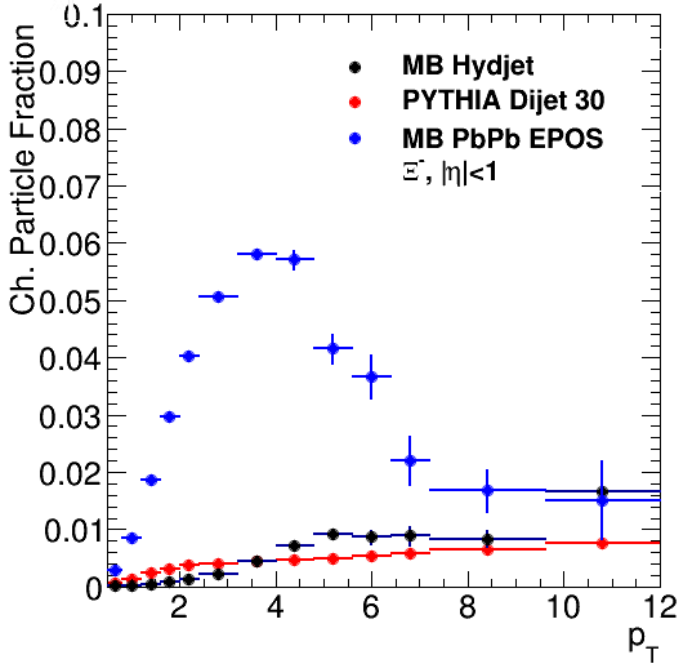
- At given leading jet p_T, count tracks originating only from the highest fully efficient trigger
  - Require track $|\eta|<1$
- Repeated using leading track p_T and track triggers in both PbPb and pp
- Normalization
  - PbPb – Number of MB events
  - pp – luminosity
    - Inelastic event class
    - Scaled by T_{AA} from Glauber



Corrections

- Efficiency, misreconstruction corrections applied on track-by-track basis
  - PYTHIA or PYTHIA+Hydjet
- Correct for changing primary particle composition as a function of centrality
  - Σ, Ξ, Ω have a much lower efficiency than π, K, p
  - Few data-based constraints on strangeness enhancement vs. centrality
    - Correction reweighted halfway between PYTHIA and EPOS
    - Affects the 3-6 GeV region where models differ the most





R_{AA} Systematics

Sources	Uncertainty [%]
Event-selection correction	<1
Momentum resolution	1.5
Particle species composition	1.5–15.5
Fraction of misreconstructed tracks	3
Tracking correction non-closure	5
Tracking efficiency	6.5
Track selection	4
Pileup	3
Trigger combination	0–2.5
Luminosity	12
Glauber-model uncertainty	1.7–16
R_{AA} uncertainty	10–17

- CMS track momentum resolution is very good – no unfolding is applied

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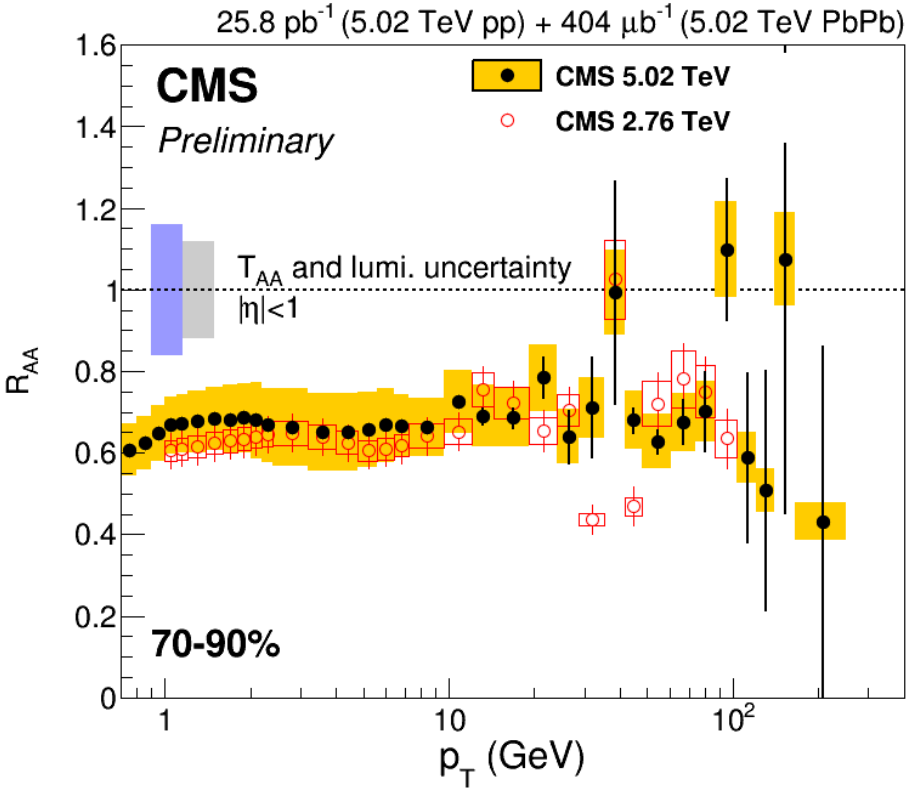
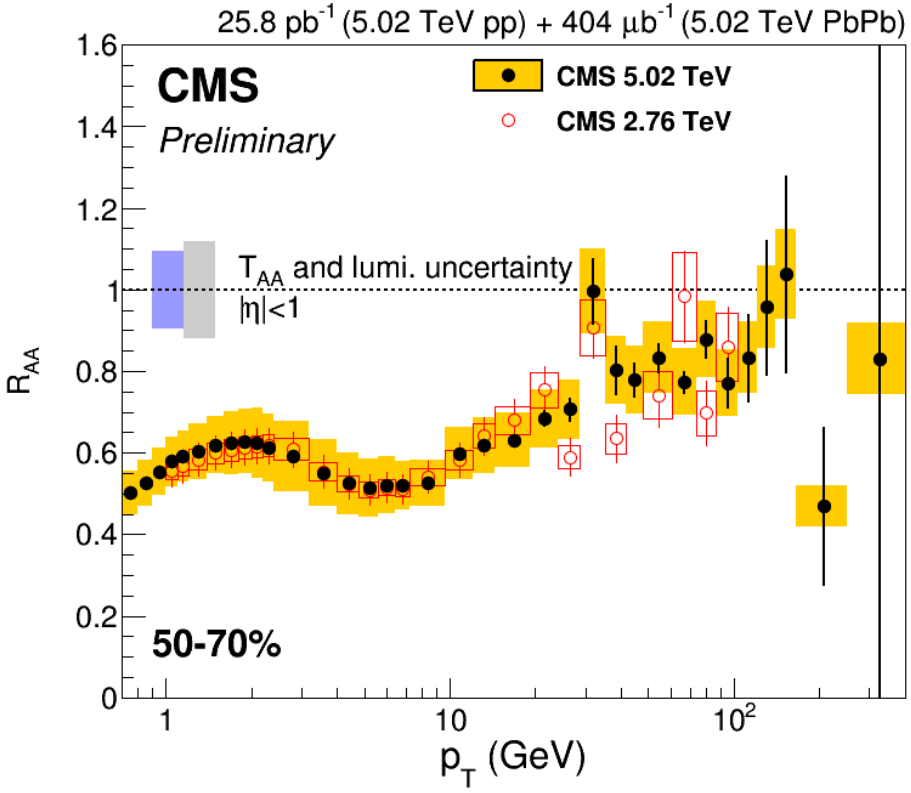
- Particle species correction is the leading systematic in 3-6 GeV range
- 6.5% uncertainty from data-driven studies of tracking efficiency using decays from D* mesons in pp and variation of track selections in PbPb
- R_{AA} uncertainty: 10-17% not including 12% from pp luminosity (expected to improve in the future) and Glauber uncertainty

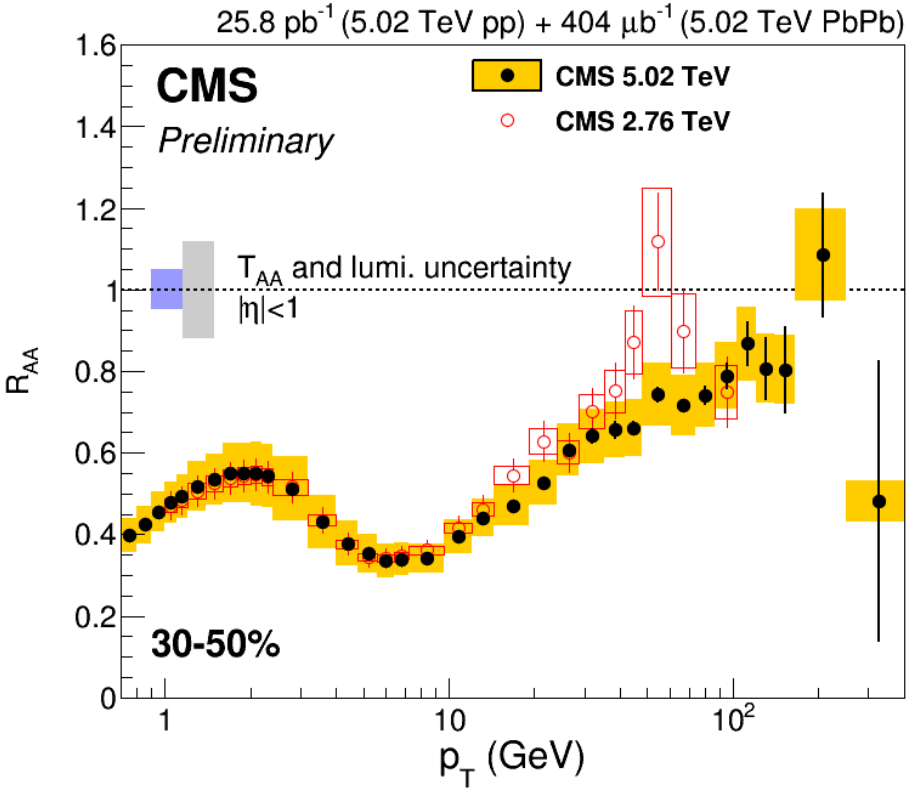
Peripheral R_{AA}

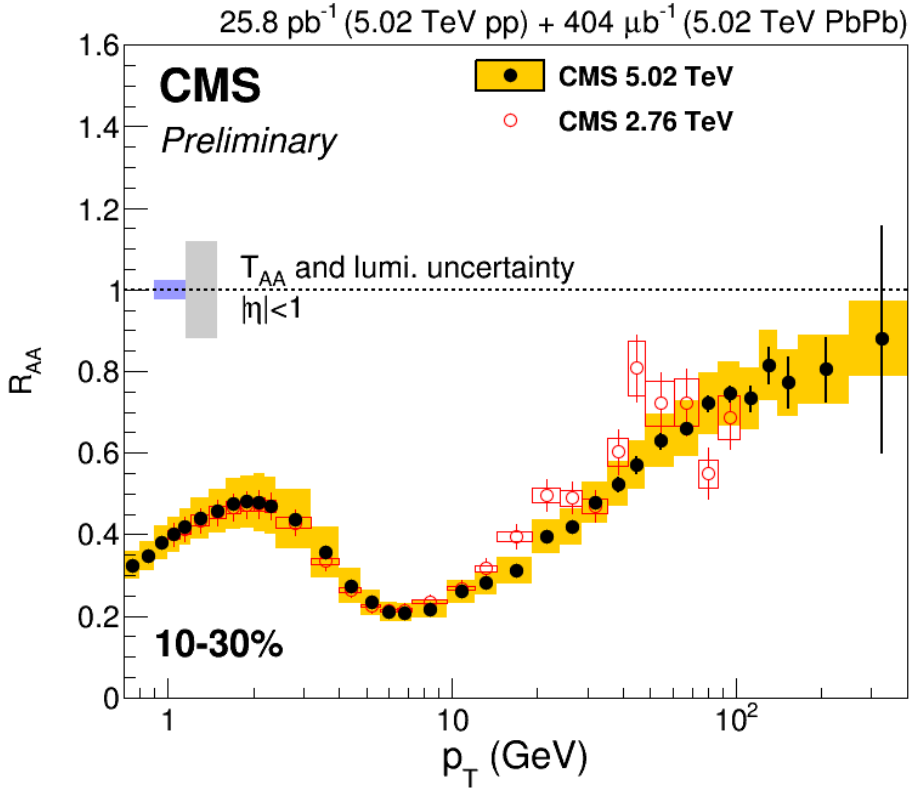




- Peripheral R_{AA} is fairly flat at ~0.65 up to ~100 GeV
  - Same value as previous CMS measurement at 2.76 TeV
  - Large Glauber uncertainty

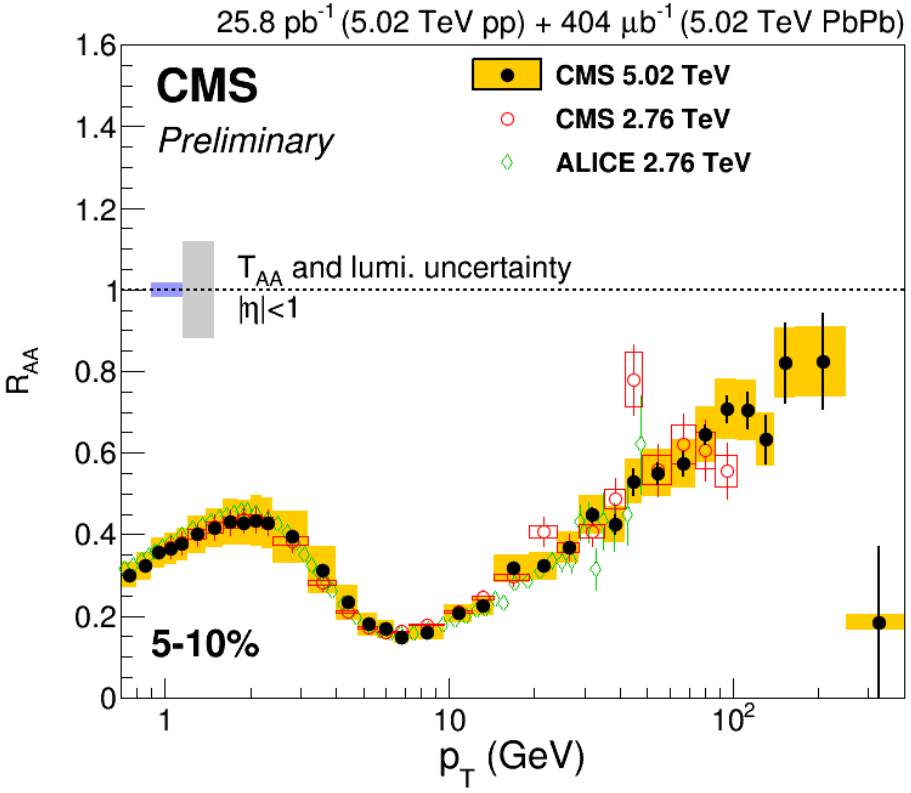
Mid-Central R_{AA}

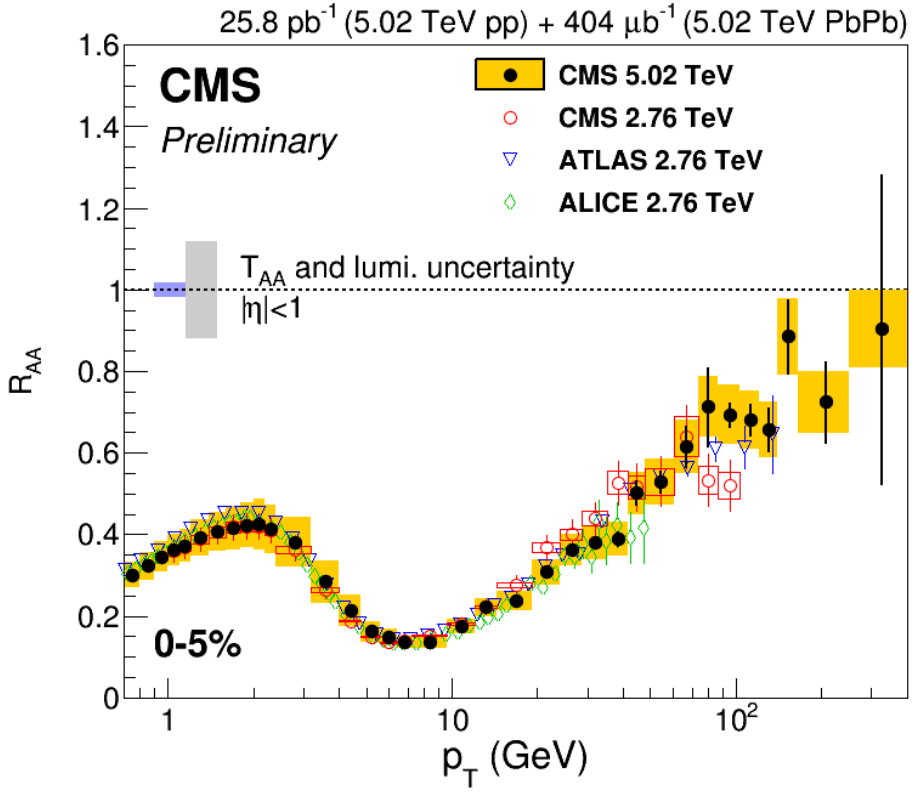




- Slightly more suppression seen than in 2.76 TeV
- 10-30% suppressed by a factor of ~5 at 10 GeV, but only 1.2 at 400 GeV

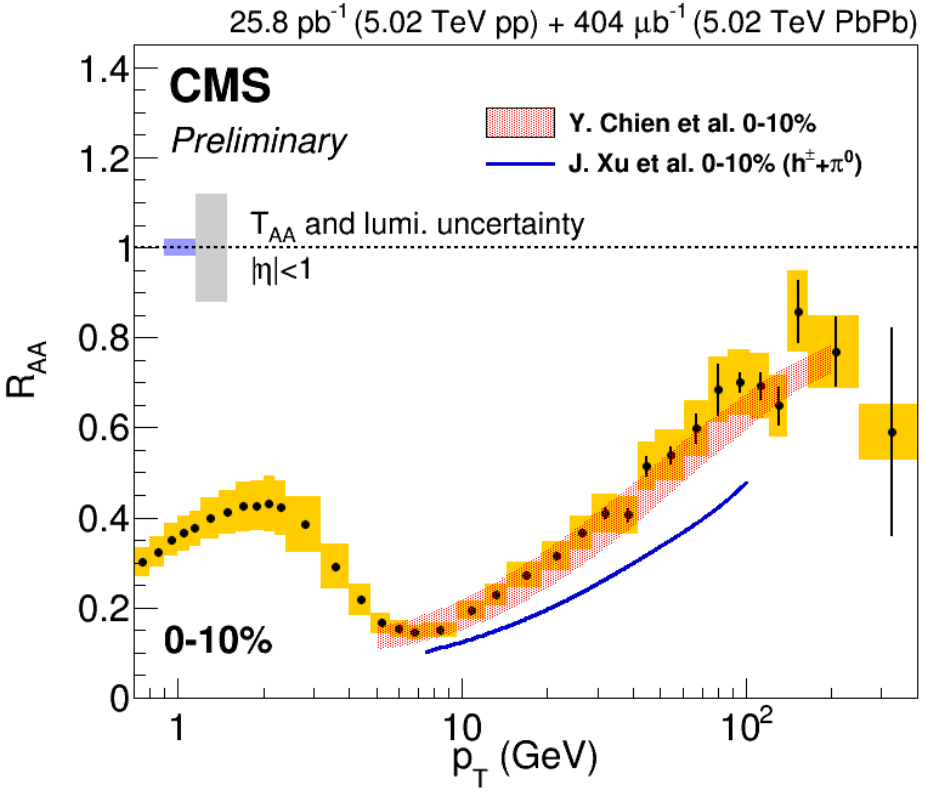
Central R_{AA}

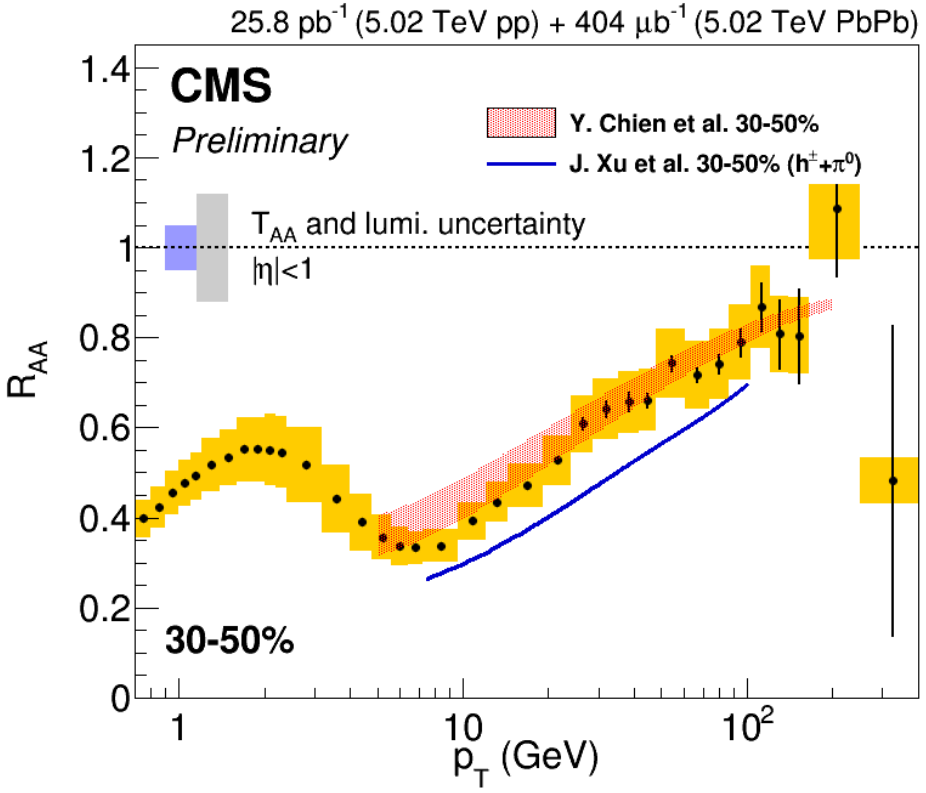




- Rising trend in central events continues well past 80 GeV
- No strong increase in suppression as compared to 2.76 TeV data in central events
  - Doesn't necessarily mean energy loss is the same!

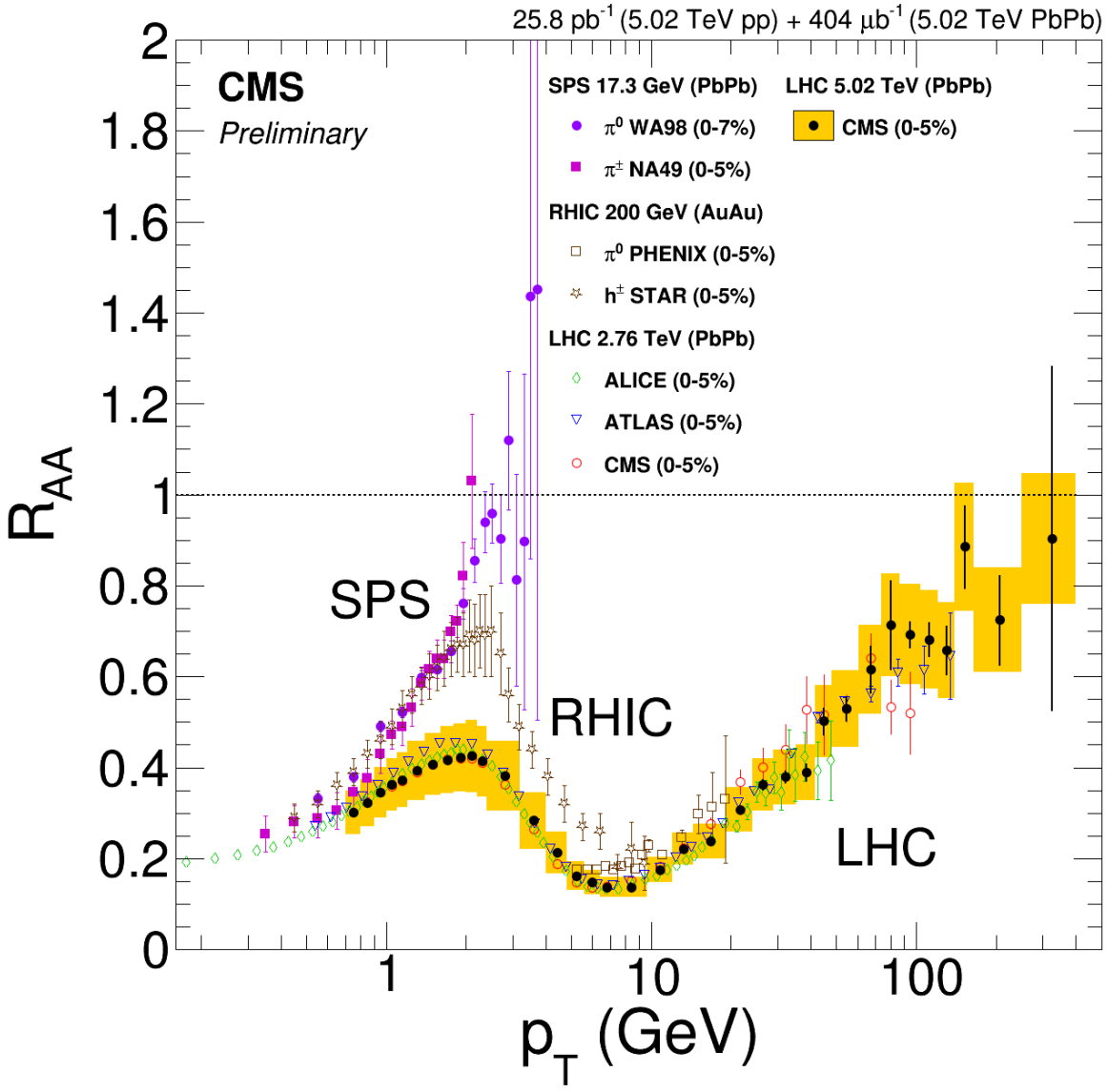
Comparison with Models





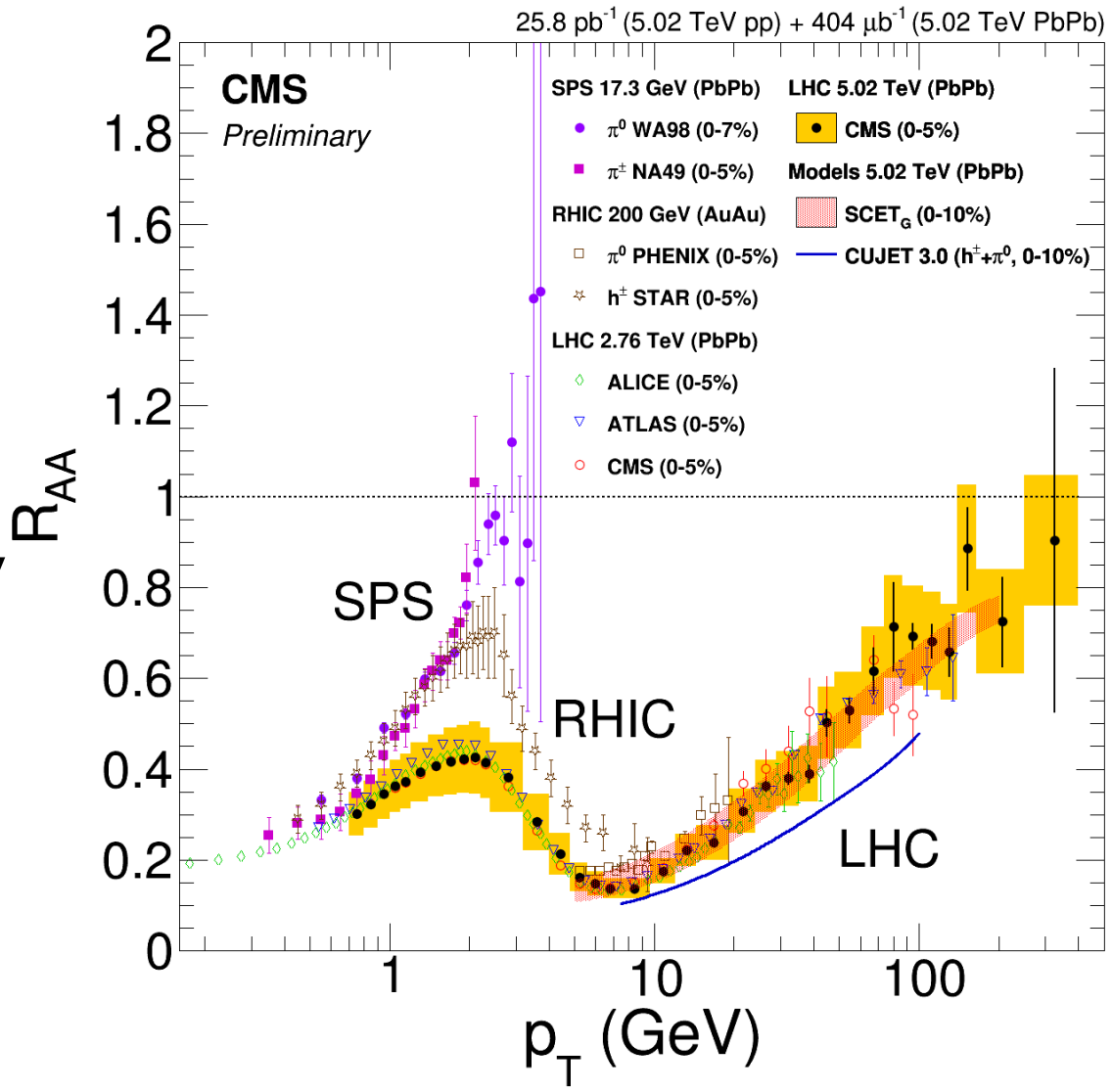
- SCET$_G$ - QCD evolution with in-medium splitting functions
  - Y. Chien et al. arXiv:1509.02936 (with cold nuclear matter effects)
- CUJET 3.0 Model
  - J. Xu et al. JHEP 1602 (2016) 169

R_{AA} Compilation



Conclusions

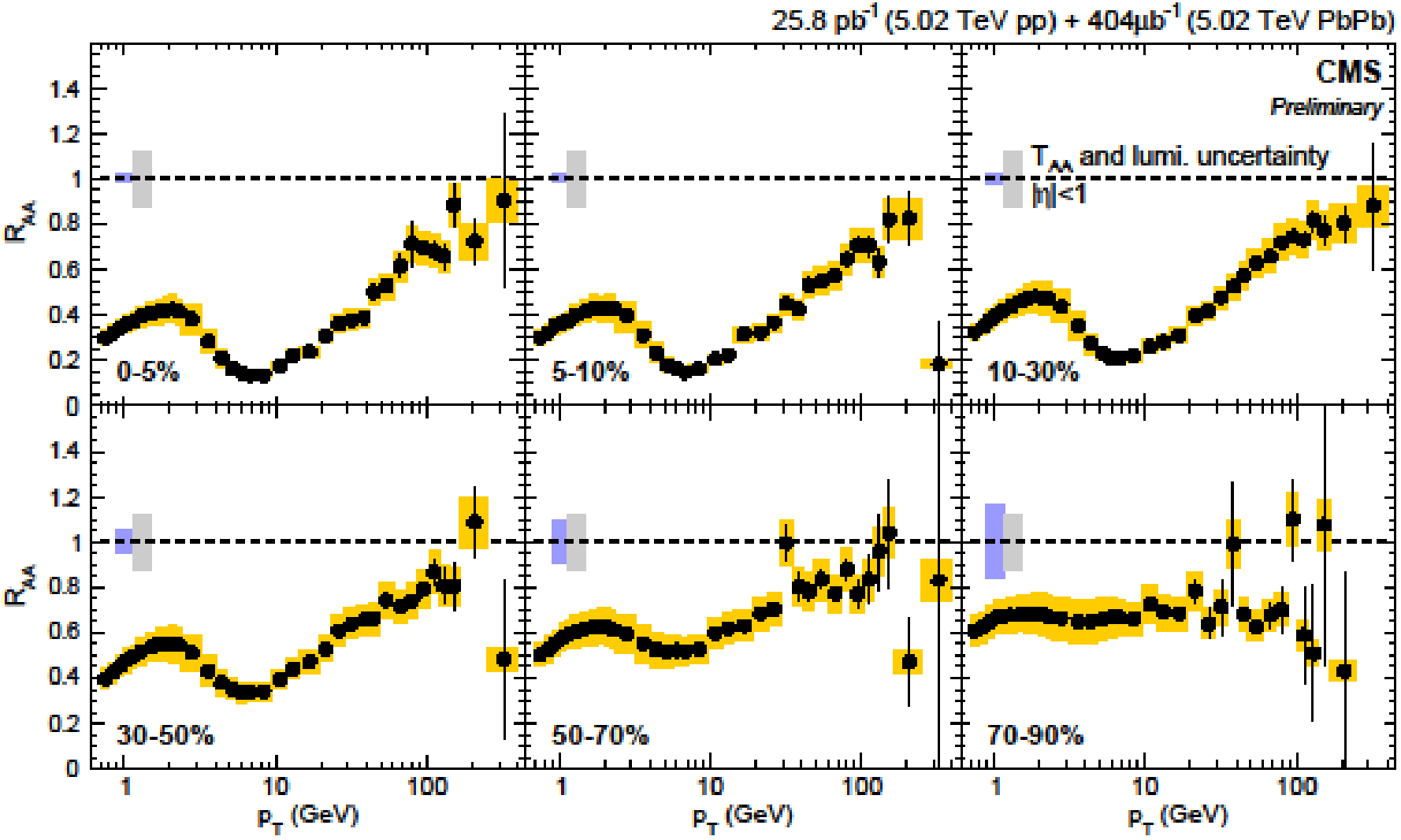
- CMS measured charged particle R_{AA} at 5 TeV from 0.7 to 400 GeV
  - Significant increase in high-p_T reach to constrain energy loss models
- Central suppression at 5 TeV looks similar to 2.76 TeV
  - Doesn't necessarily mean the energy loss is the same!



CMS-PAS-HIN-15-015

Thank You!

All Centrality Bins



With Comparisons