

# Using charged particles to study jet quenching in heavy ion collisions with CMS

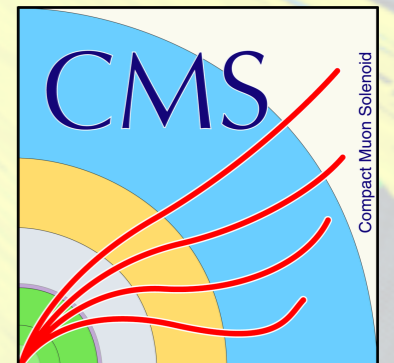
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Rice University

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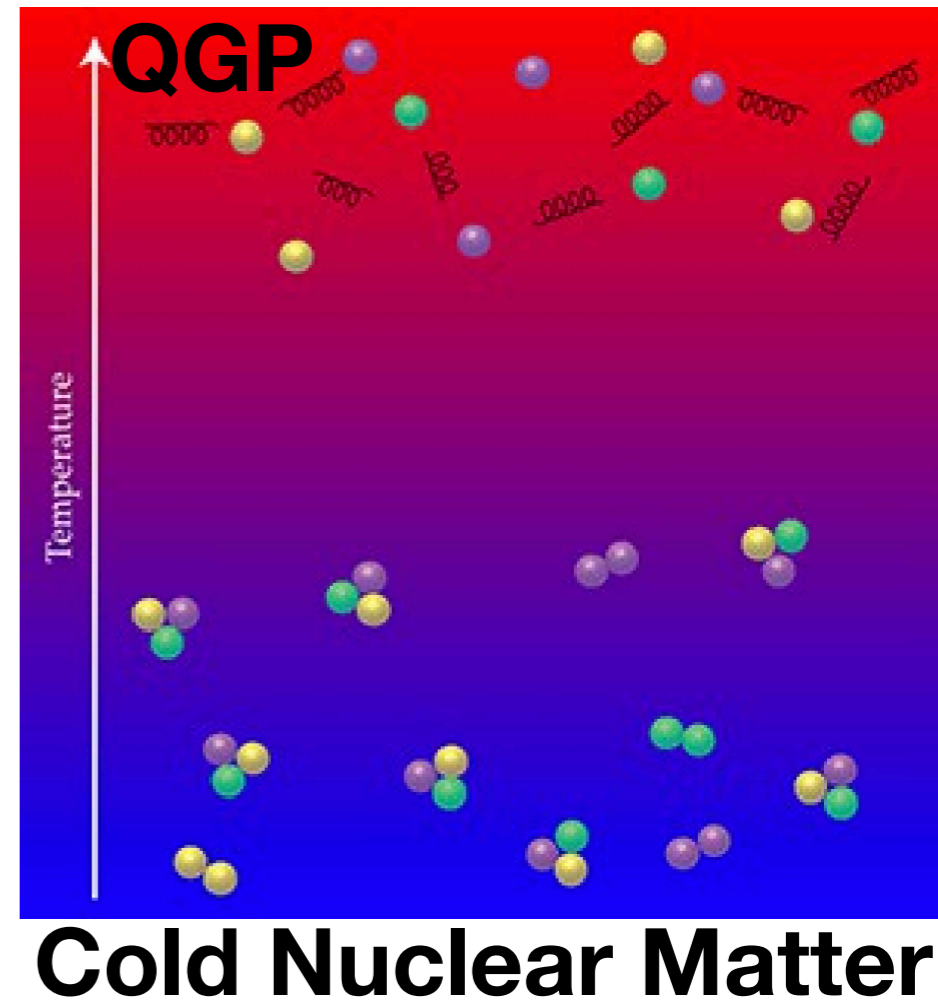


RICE

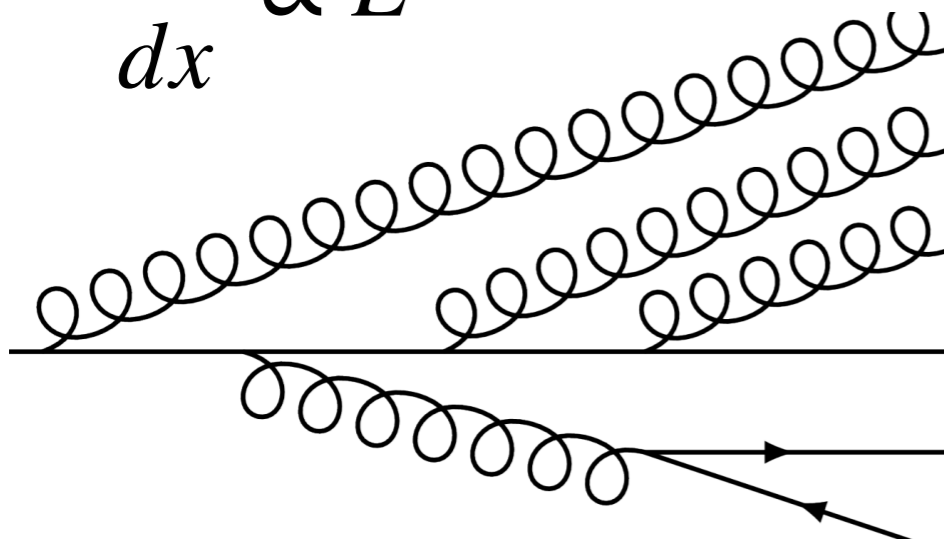


# Introduction - jet quenching

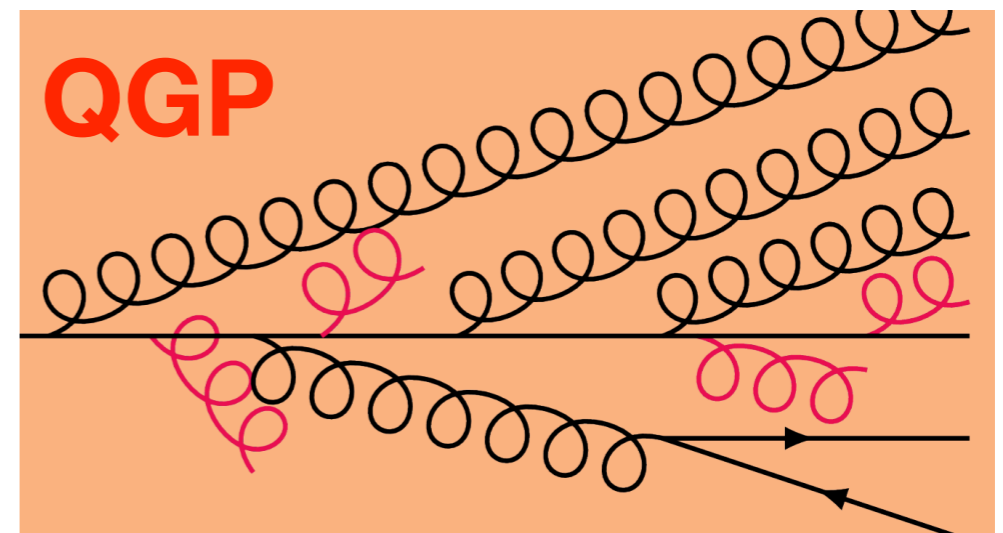
- Heavy ion collisions produce Quark-Gluon Plasma
- Can use jets to probe QGP's short-range structure
- QGP induces additional radiation
  - Jets appear to lose energy
  - 'jet quenching'
- Path-length dependence of energy loss?



$$\frac{dE}{dx} \propto L^\kappa$$



vs.

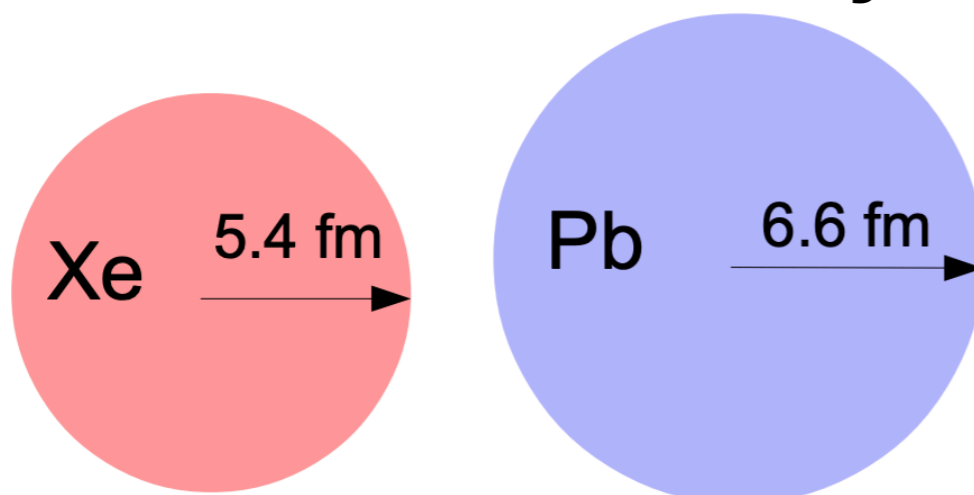
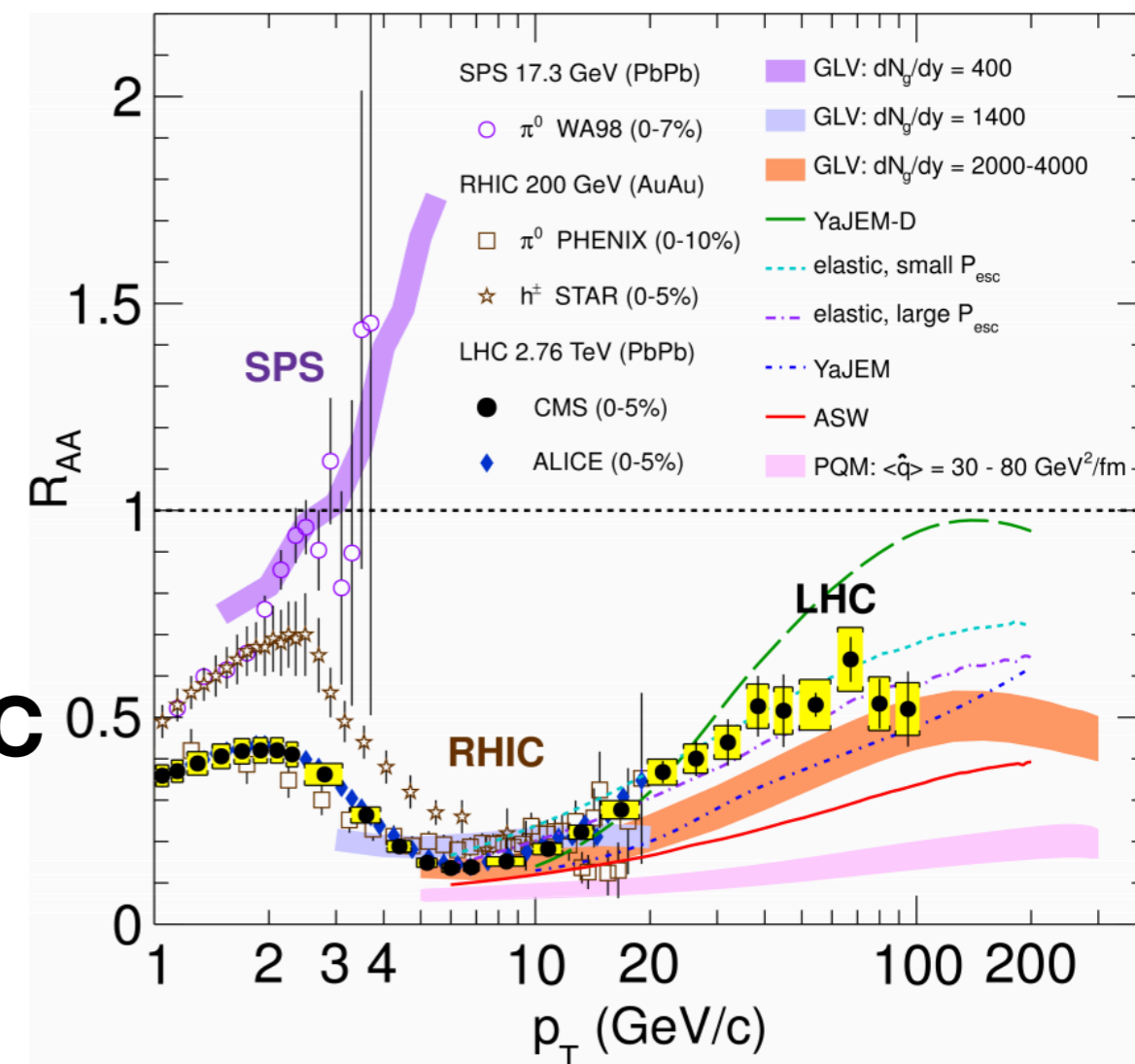


# Nuclear Modification Factor

- High- $p_T$  hadrons come from jets
- Quenching quantified by charged hadron  $R_{AA}$
- $R_{AA} = 1$  means no jet quenching
- Run 2 data lets us compare different ion sizes
- Unprecedented PbPb luminosities
  - Can probe high- $p_T$  region
- First time XeXe data analyzed at LHC

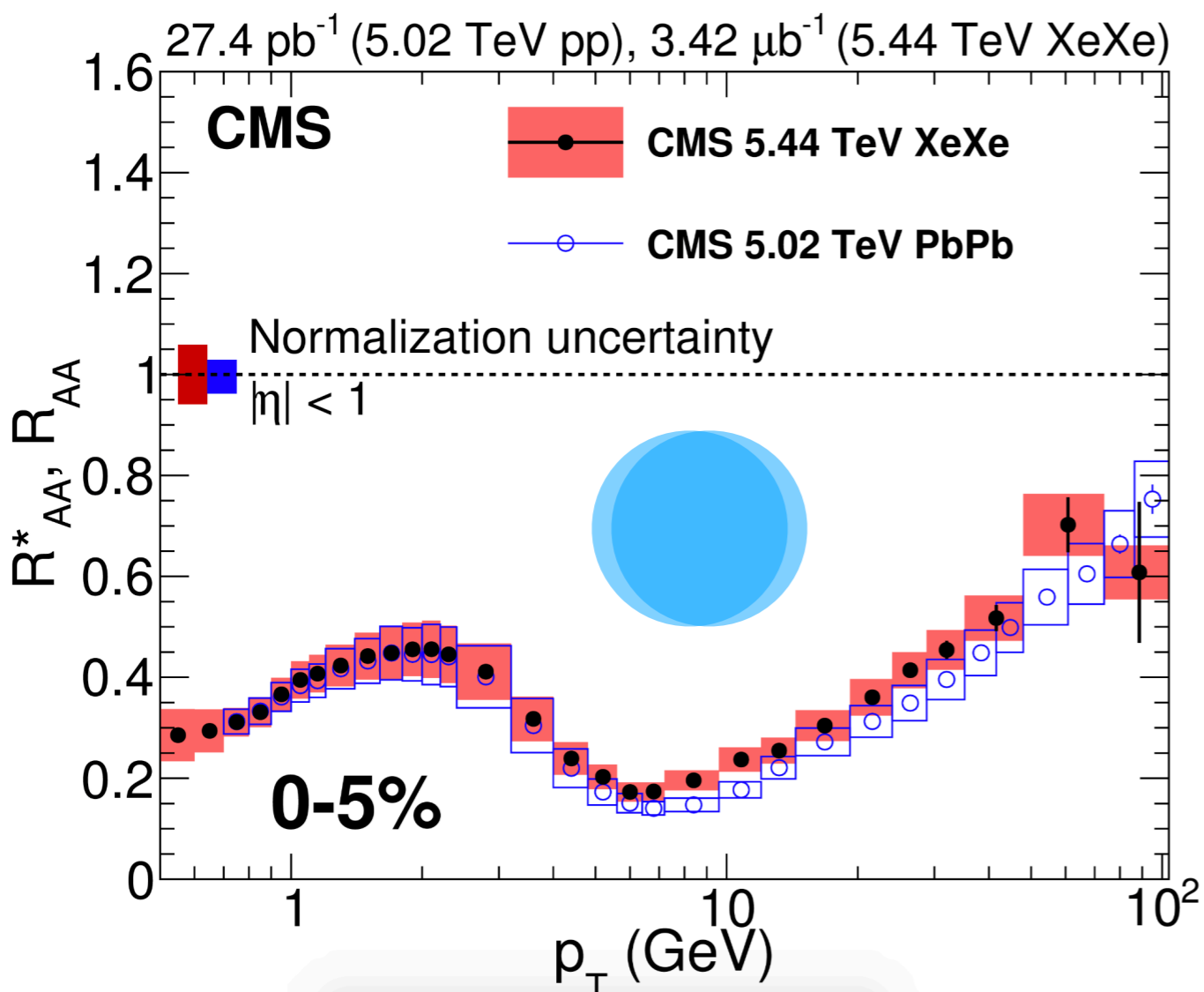
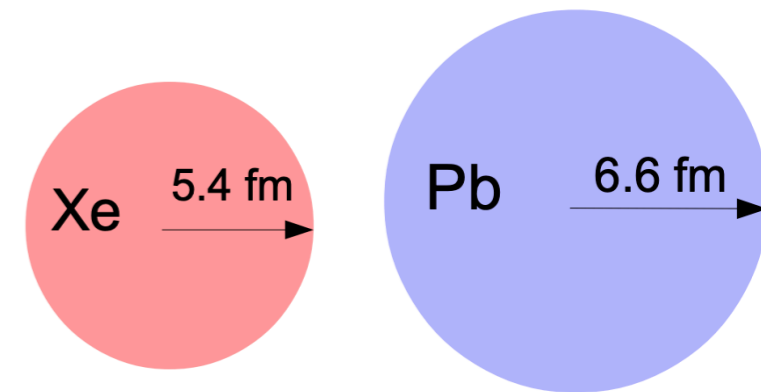
$$R_{AA}(p_T) = \frac{1}{T_{AA}} \frac{dN^{AA}/dp_T}{d\sigma^{pp}/dp_T}$$

EPJC 72 (2012) 1945



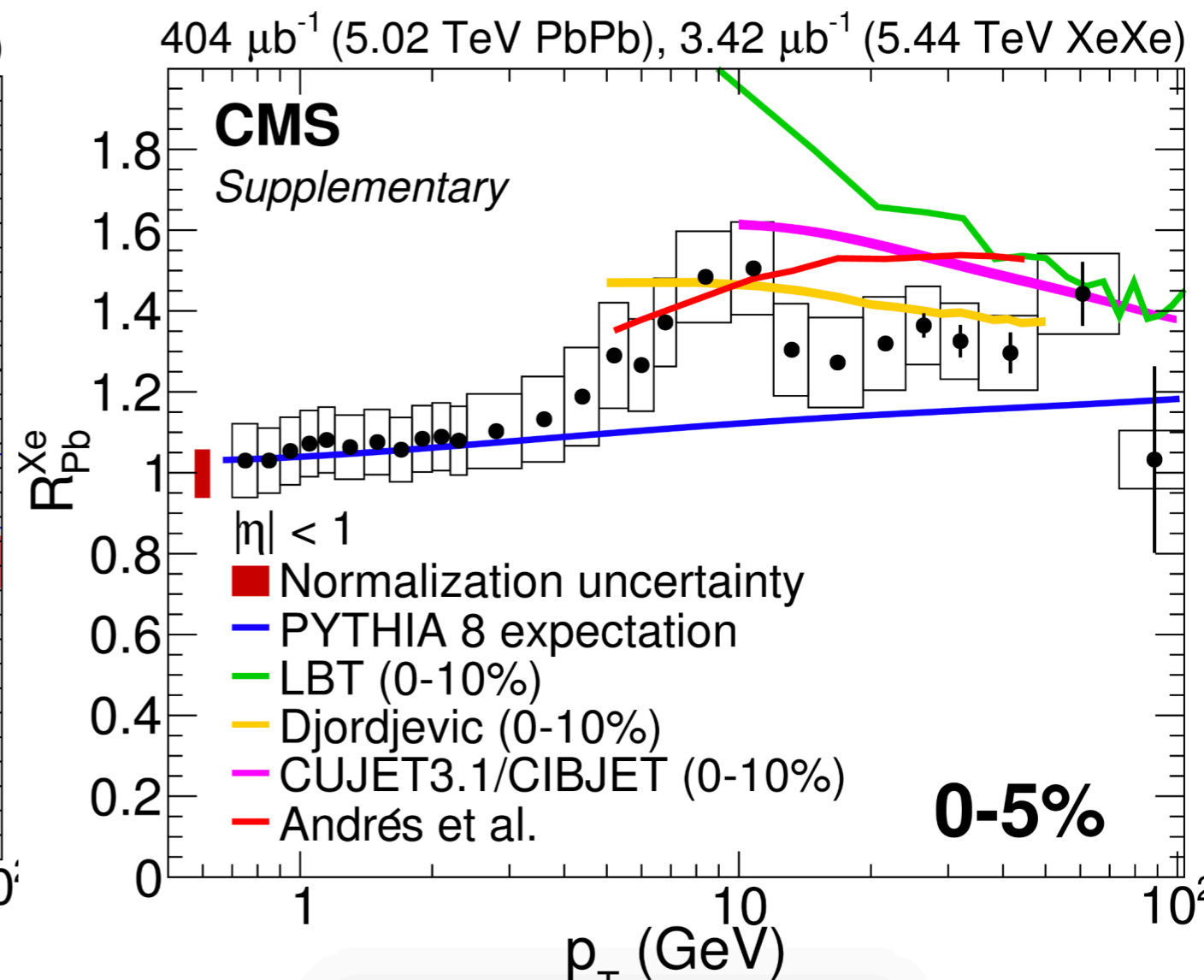
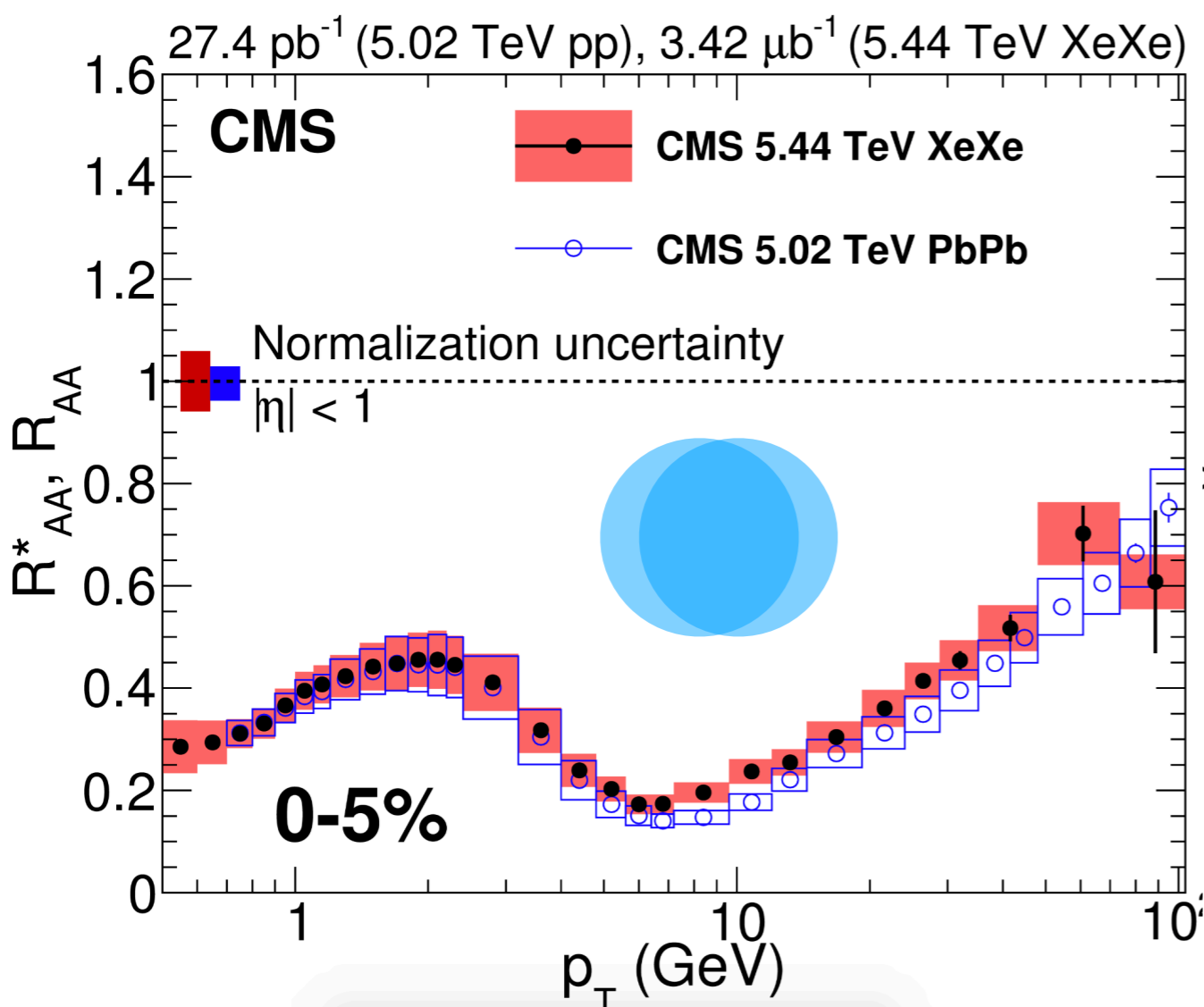
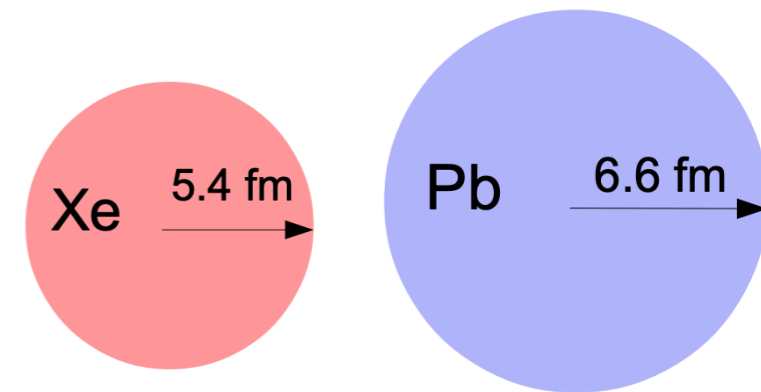
# $R_{AA}$ - similar centrality

- Compare head-on collisions - circular QGP
- **XeXe** less suppressed than **PbPb** at high  $p_T$
- Expected from smaller path length

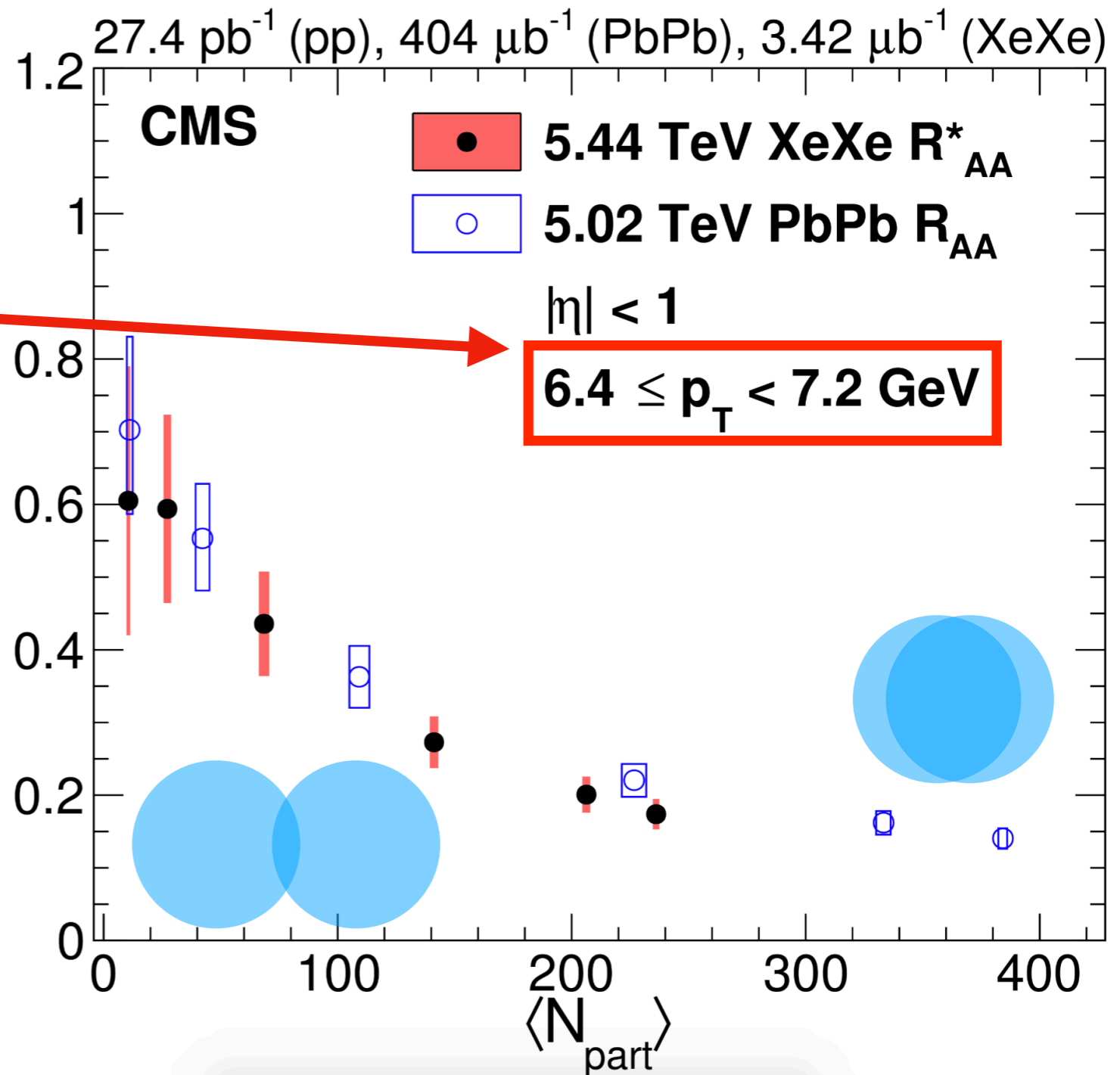
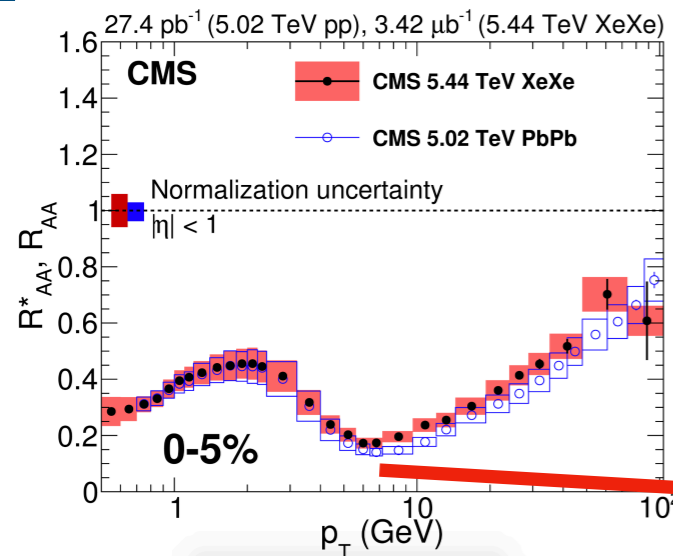


# $R_{AA}$ - similar centrality

- Compare head-on collisions - circular QGP
- **XeXe** less suppressed than **PbPb** at high  $p_T$
- Expected from smaller path length
- Ratio can not be predicted by all models
- What if we compare similar-sized QGPs?



# Comparing similar QGP size



Increasing QGP Size  
 (Path length) →

- Look at 1  $p_T$  bin and vary impact parameter
- $N_{part}$  measures QGP 'size'
- Similar suppression for similar QGP size
- Can constrain path-length dependence of quenching

# Research Impact

- One of first analysis of ions smaller than Pb at LHC
- Quenching signal observed even in small QGPs
- Informed discussion of running lighter nuclei
- Oxygen-Oxygen run planned ~2023
- Complementary to RHIC studies

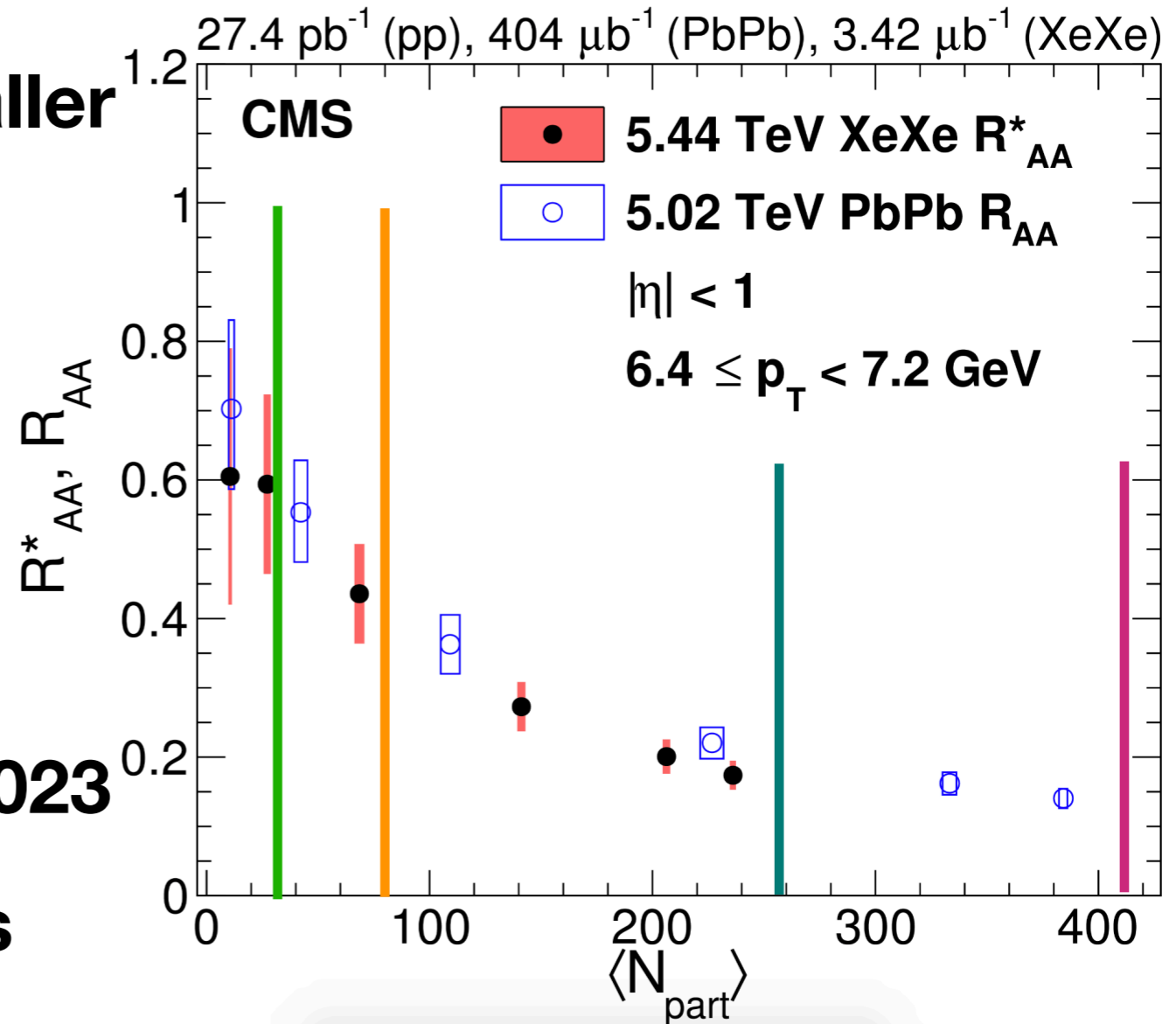


Table 4: Parameters and performance for a range of light nuclei with a moderately optimistic value of the scaling parameter  $p = 1.5$  in (5).

CERN-LPCC-2018-07	$^{16}\text{O}^{8+}$	$^{40}\text{Ar}^{18+}$	$^{40}\text{Ca}^{20+}$	$^{78}\text{Kr}^{36+}$	$^{129}\text{Xe}^{54+}$	$^{208}\text{Pb}^{82+}$
$\gamma$	3760.	3390.	3760.	3470.	3150.	2960.
$\sqrt{s_{NN}}/\text{TeV}$	7.	6.3	7.	6.46	5.86	5.52

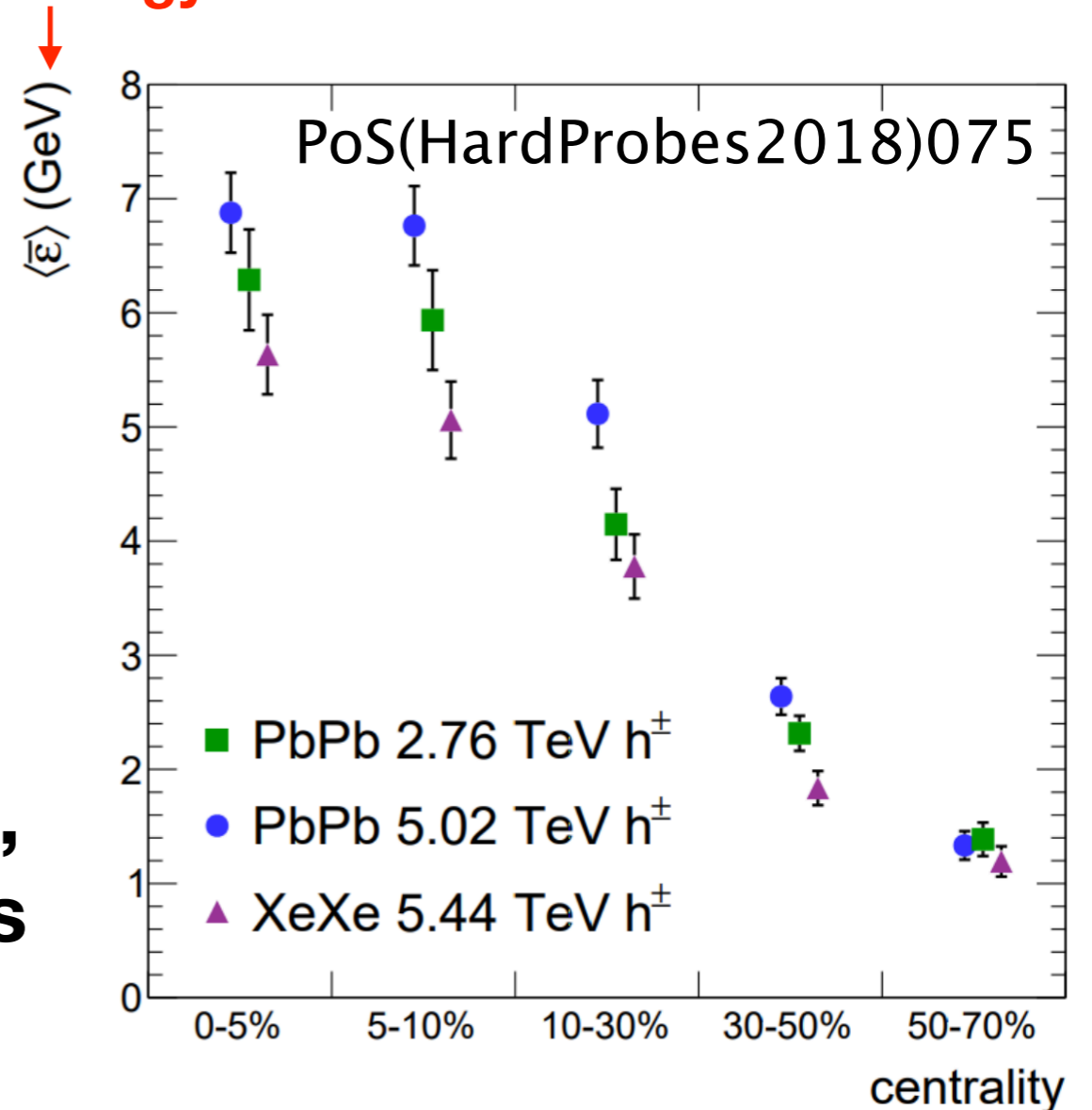
# Research Impact

- Simple models can be tried to extract path-length dependence

$$\frac{dE}{dx} \propto L^{0.3 \pm 0.5}$$

- Other projects, such as JETSCAPE, are also attempting to do global fits of  $R_{AA}$  data
- Useful input to such analyses

Average energy loss

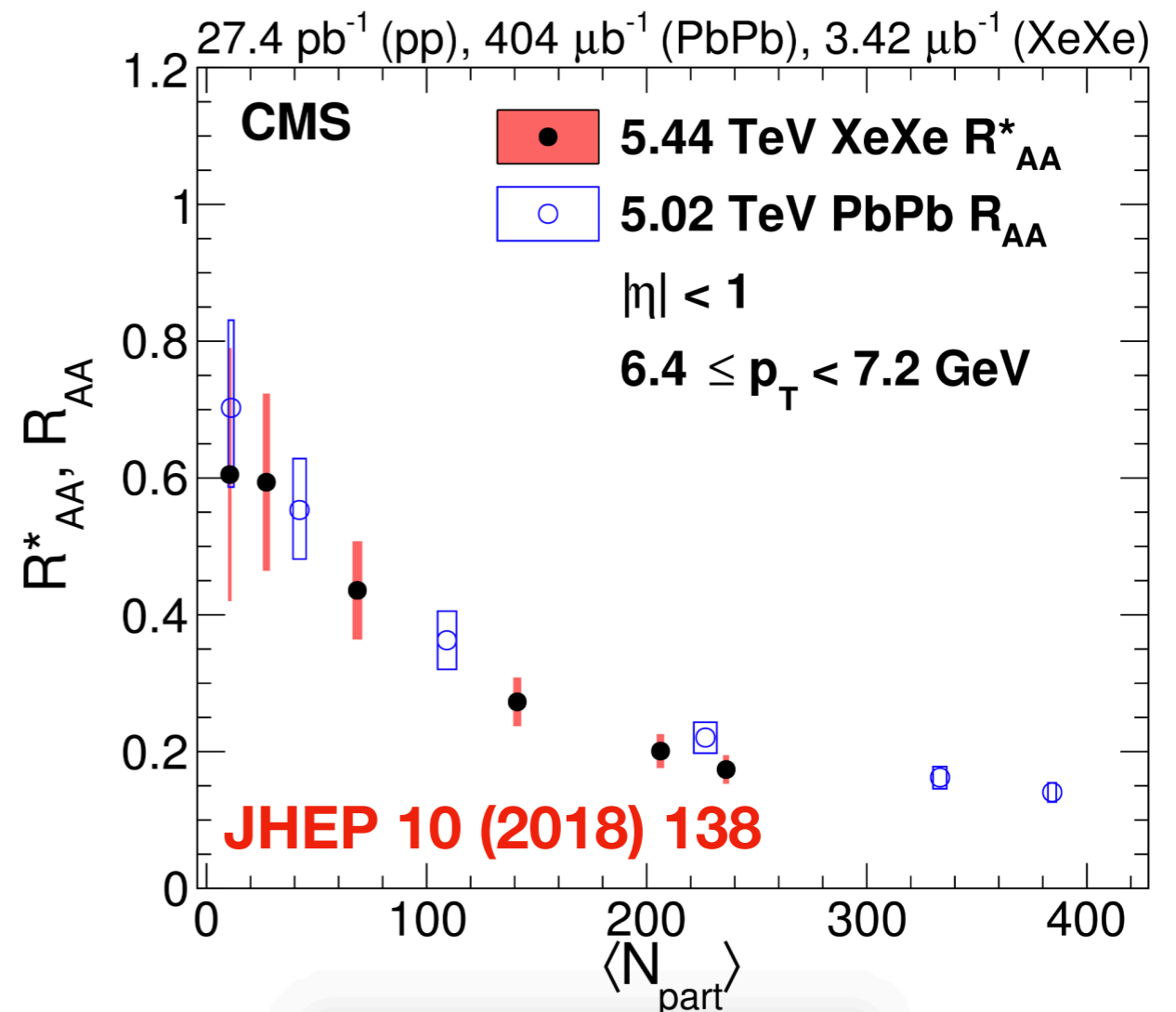
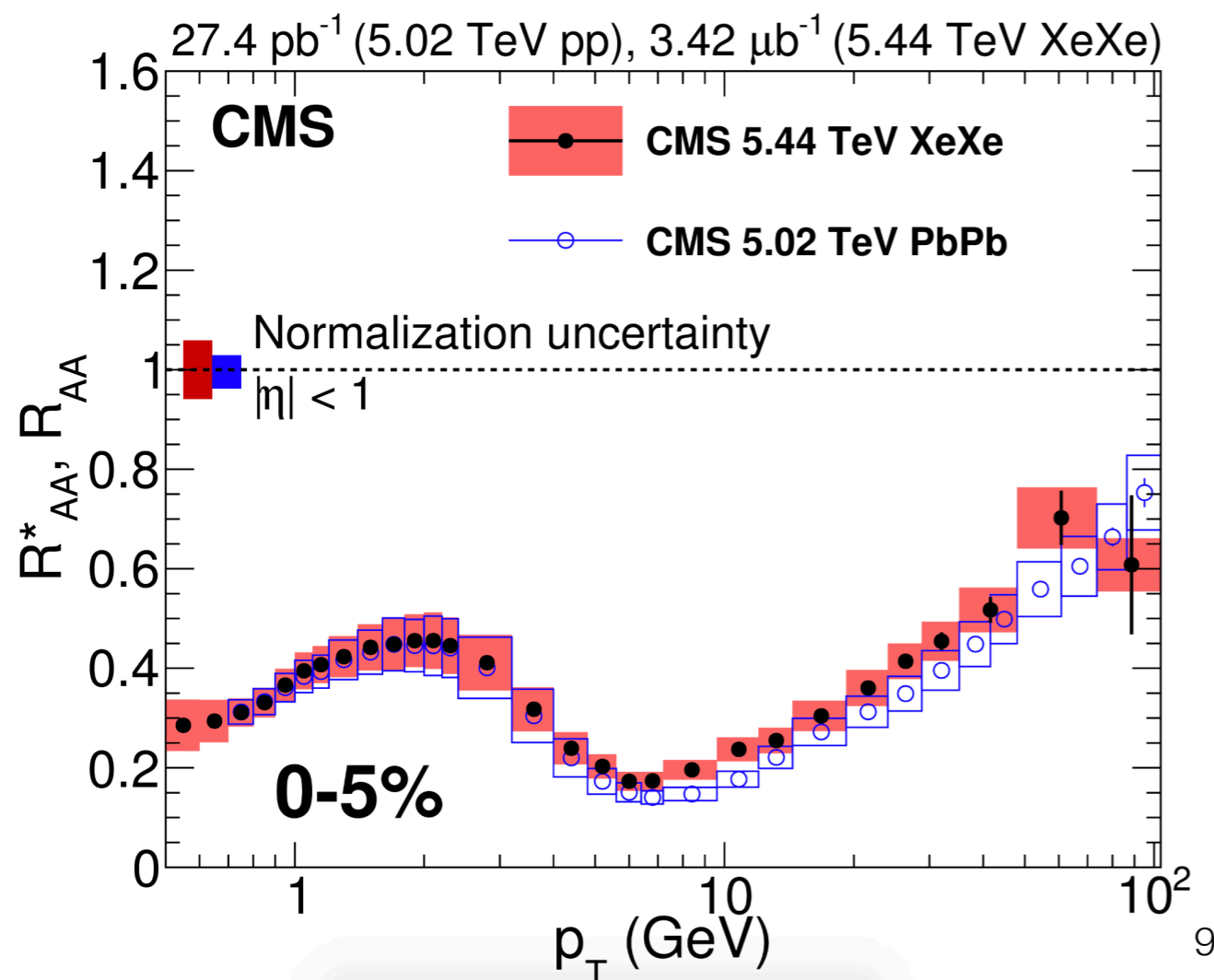


← Increasing QGP Size  
(Path length)



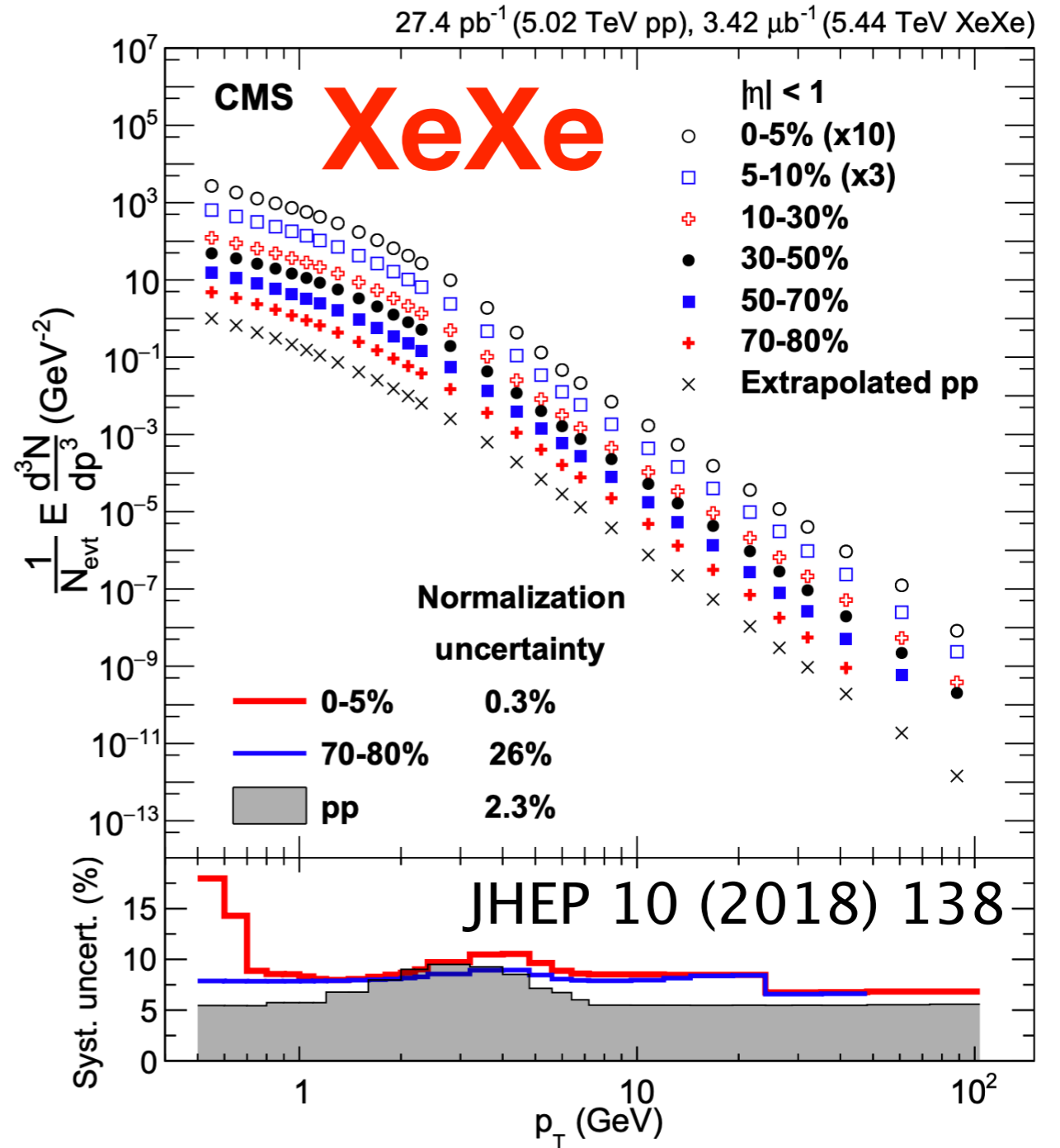
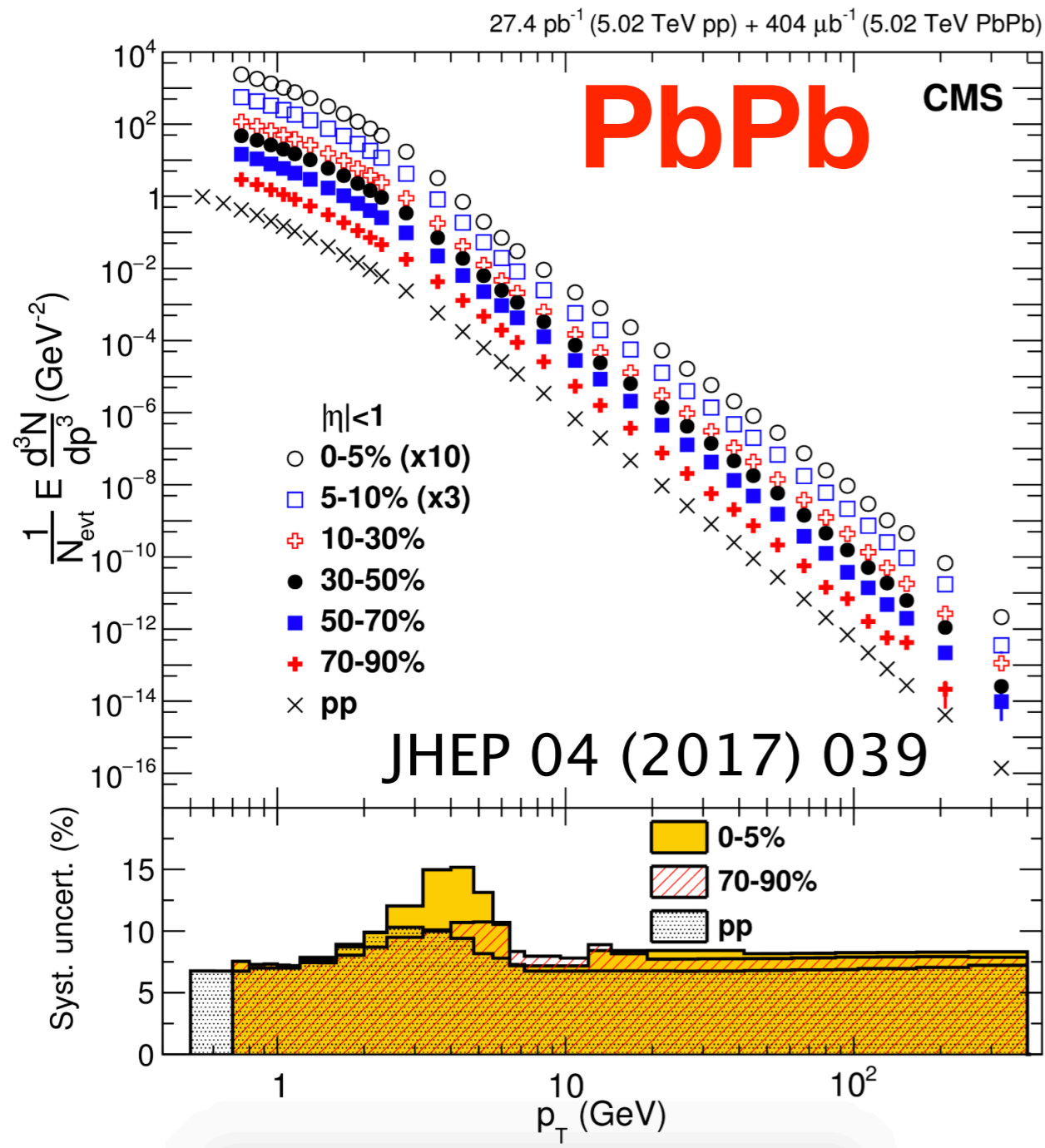
# Summary

- Charged particle  $R_{AA}$  measured in PbPb and XeXe collisions
  - Quenching signal depends on size of system, regardless of ion producing QGP
- Motivates further study of lighter nuclei in Runs 3 & 4
- Path-length dependence of jet quenching can be constrained
  - Teaches us about QGP short-range structure

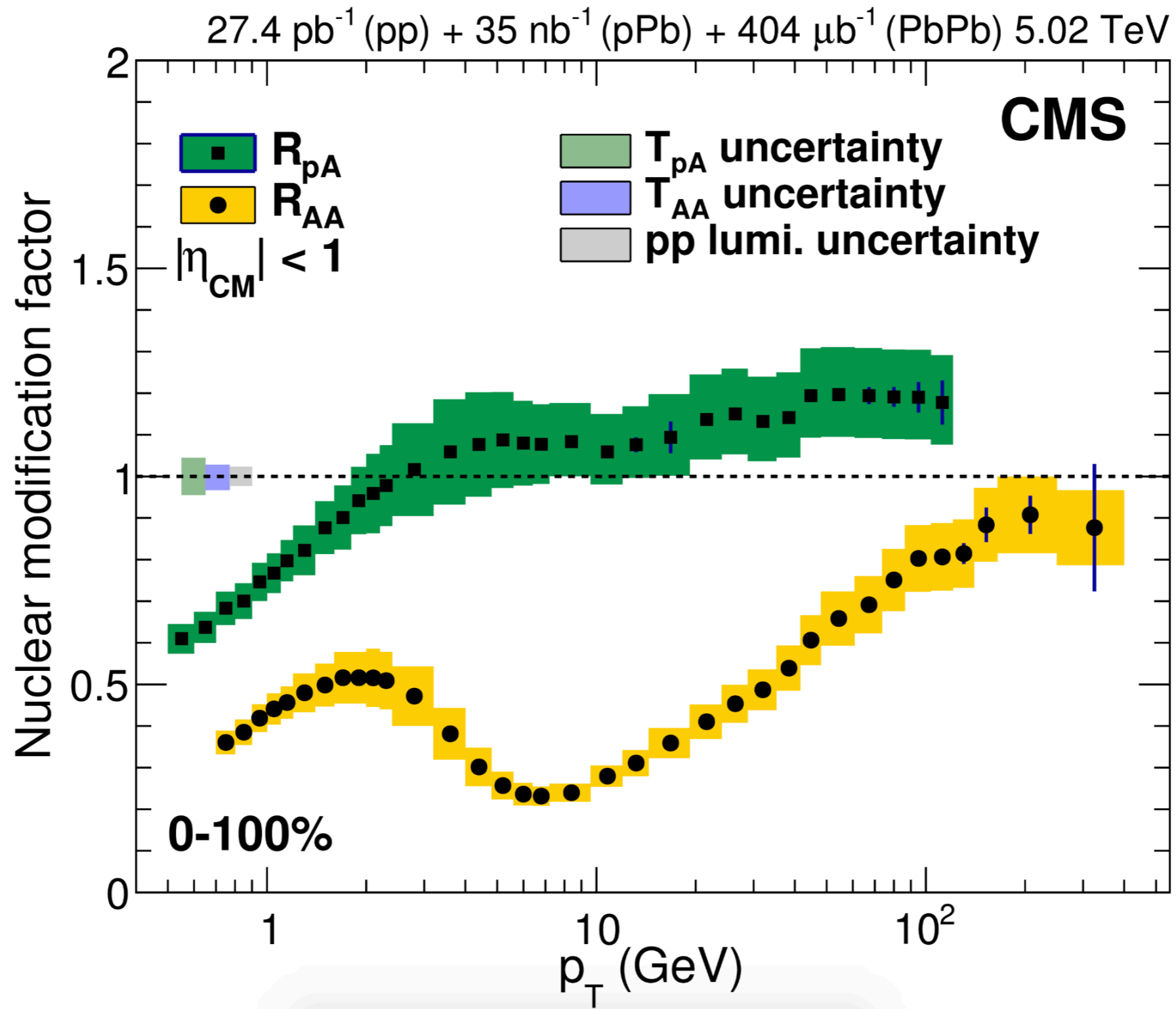


# Backup

# Charged Particle Spectra



# $R_{pPb}$



# Comparing to lower energies

