Surprising similarities between the high transverse momentum spectra in pp and Pb-Pb collisions

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PHYSICAL REVIEW C 99, 034911 (2019)

Introduction

- The Nuclear Modification Factor (R_{AA}) is an important observable in heavy-ion collisions.
- The rise of the R_{AA} is interpreted as a proof of the decreasing energy loss in heavy ion collisions **(see Figure 1)**.
- Within a limited multiplicity reach, the ALICE Collaboration has shown that such a ratio in pp collisions at 13 TeV exhibits a nonlinear increase with p_T.

JHEP 1509 (2015) 050

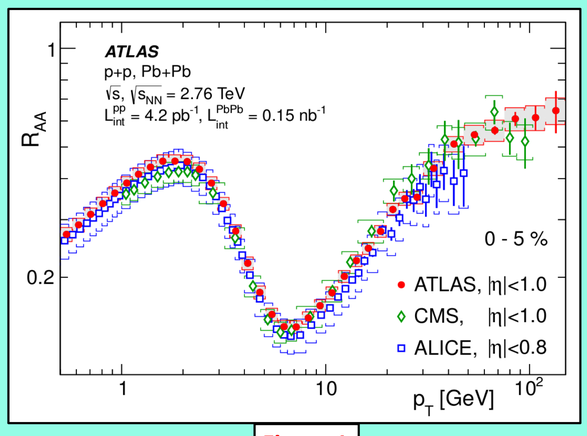

Figure 1

Phys. Lett. B 753 (2016) 319-329

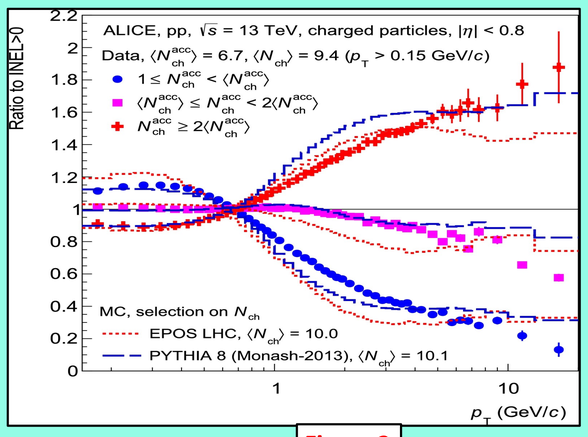

Figure 2

Event multiplicity classes based on the number of charged particles (N_{ch}) within $|\eta| < 0.8$ for pp 13 TeV simulated with PYTHIA 8.212

Class name	I	II	III	IV	V
N_{ch}	0 - 5	6 - 10	11 - 15	16 - 20	21 - 25
percentile	100%	89.54%	73.86%	59.07%	45.30%
Class name	VI	VII	VIII	IX	X
N_{ch}	26 - 30	31 - 35	36 - 40	41 - 50	≥ 51
percentile	32.96%	22.57%	14.48%	8.70%	2.61%

p_T-spectra in pp 13 TeV simulated with PYTHIA 8.212

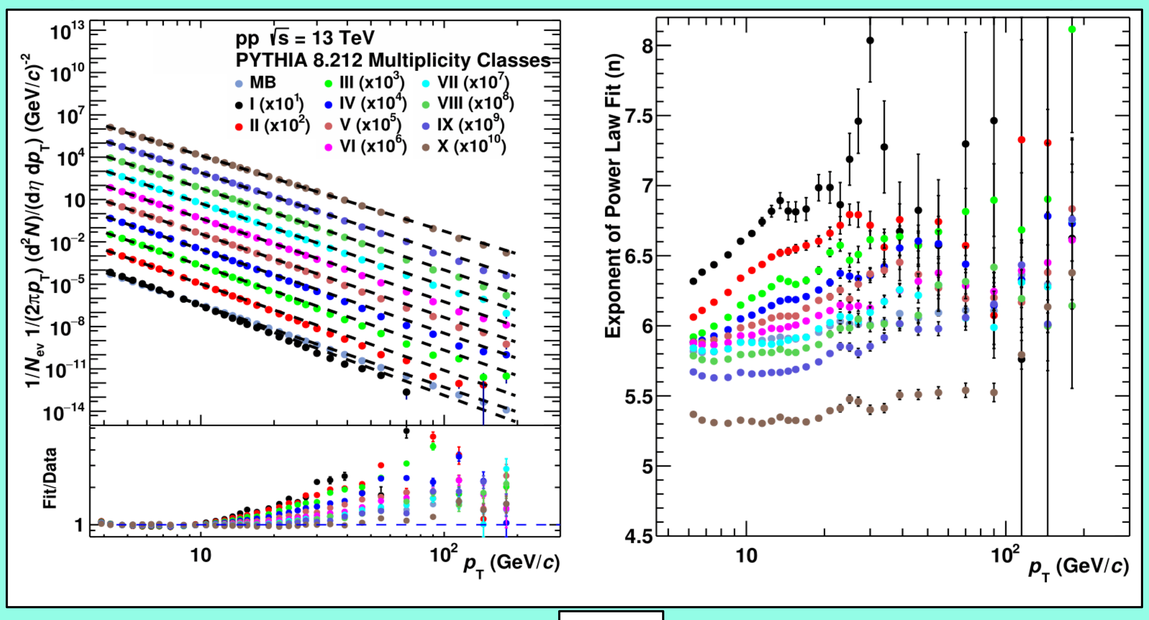

Figure 3

The characterization of the spectra with a power law exponent

- The pp p_T spectra exhibit a power law dependence above ~ 6 GeV/c at all multiplicities and in the minimum bias ones. However **it is not possible to fit the whole momentum range (until 200 GeV/c) with a single exponent.**
- Therefore we adopted a running slope determination in p_T intervals.
- The result of the fitting for minimum bias events at different collision energies is shown on **Figure 4(a)**.
- We observe an ascending trend in the exponents and an impressive scaling if the Bjorken x_T is used as the variable instead of p_T (**Figure 4(b)**) .
- We conclude that the exponents scale perfectly with the x_T representation and do not exhibit any other energy related dependence. However, when analyzing the pp data in multiplicity bins and the PbPb data in centrality a markedly different behavior (**Figure 5**) is observed .
- In both cases the exponents **get markedly** smaller than in the case of peripheral/minimum bias events.

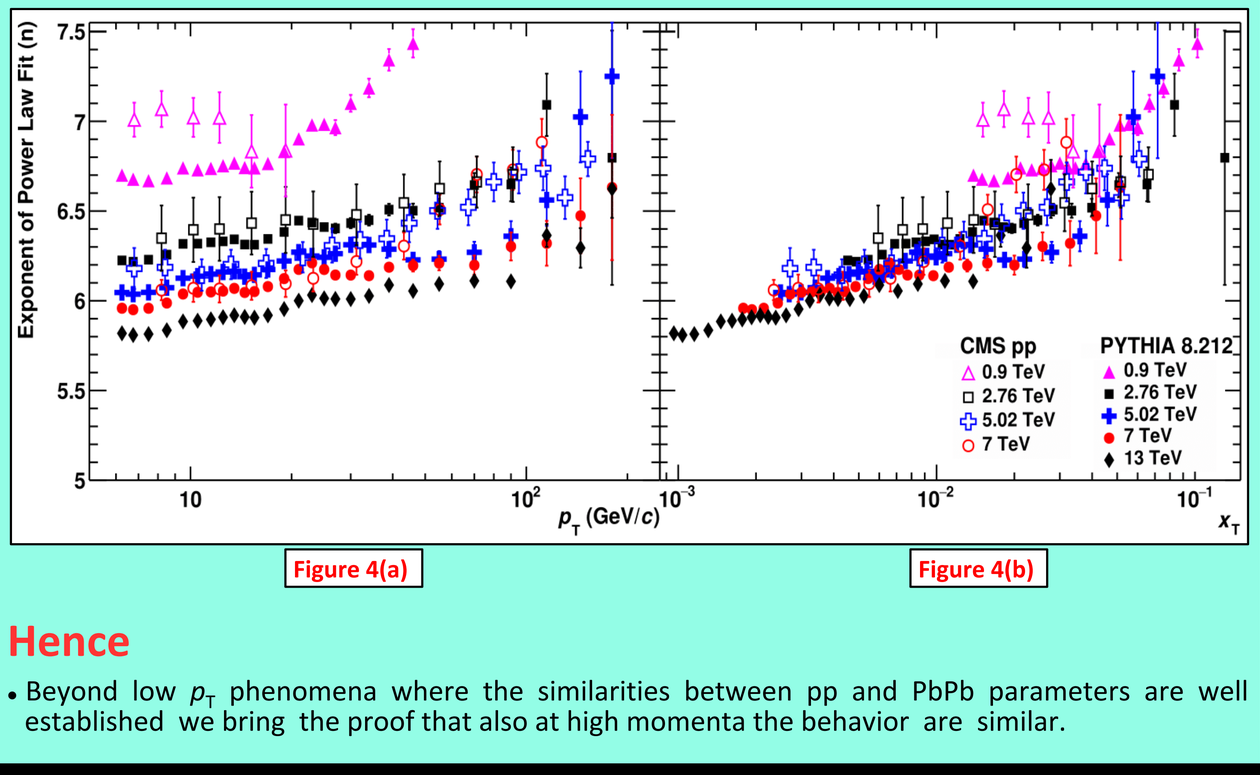

Figure 4(a) Figure 4(b)

Hence

- Beyond low p_T phenomena where the similarities between pp and PbPb parameters are well established we bring the proof that also at high momenta the behavior are similar.

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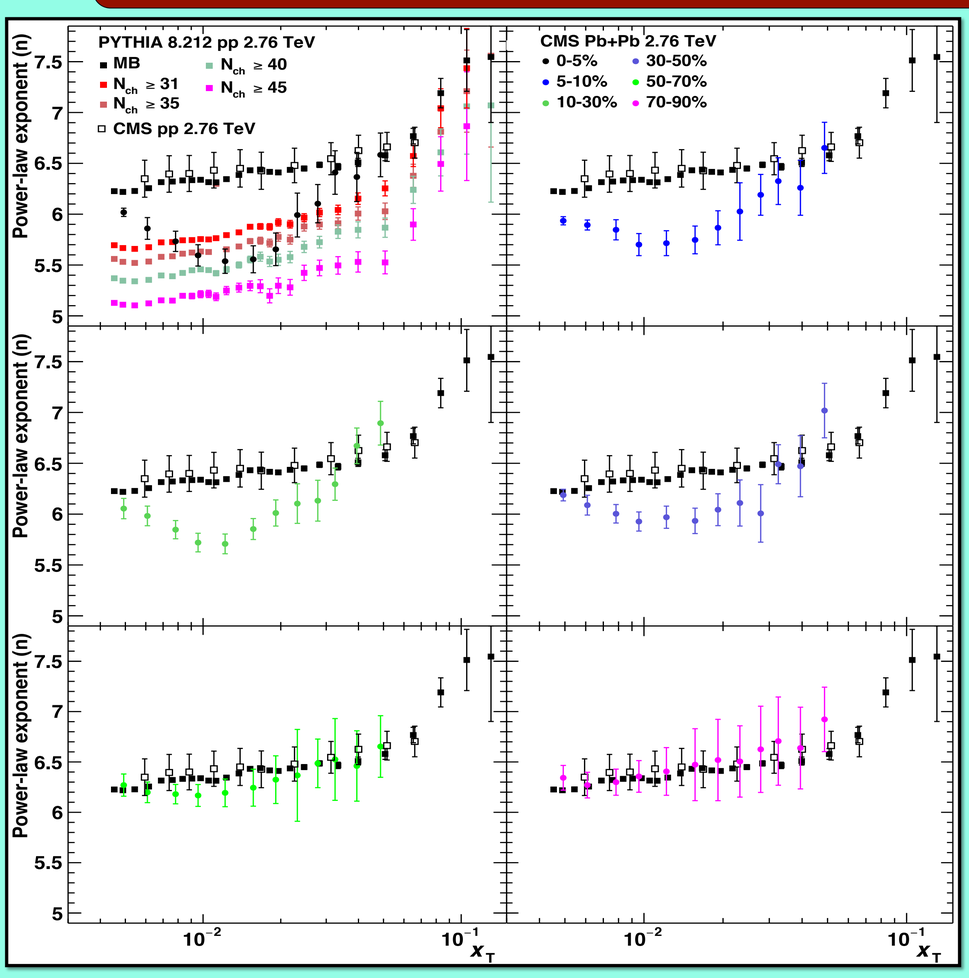
Behavior of the Pb-Pb spectra with centrality and of the pp spectra with multiplicity



Similar behavior is also observed for Pb-Pb collisions at 5.02 TeV

Figure 5

Comperision of exponents obtained from ALICE data and PYTHIA 8.212 in pp 13 TeV

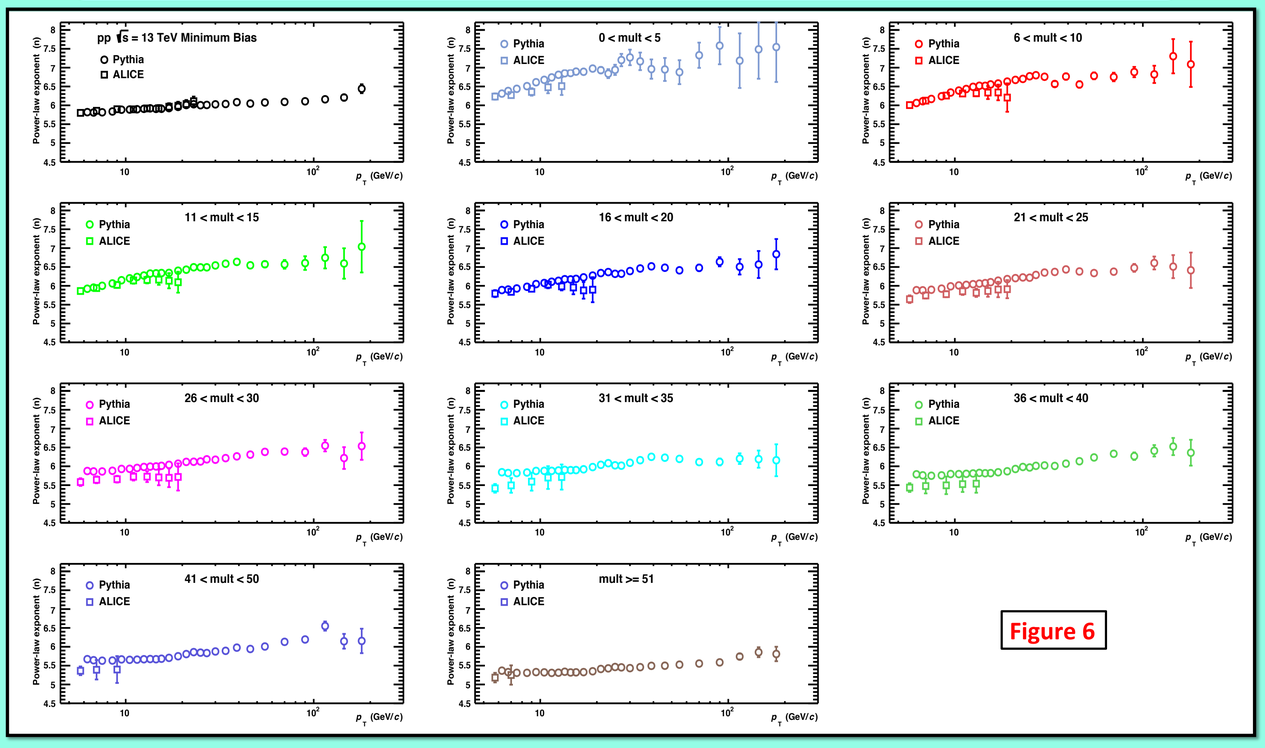


Figure 6

Conclusion

- ☑ The high-p_T part of the p_T-spectra cannot be described by a single power-law function (same exponent value) within a wide p_T interval (8-100 GeV/c).
- ☑ The minimum-bias p_T spectra, when represented in terms of the local exponent as a function of the Bjorken variable x_T, obey an approximate scaling behavior over a wide range of center-of-mass energy √s = 0.2 to 13TeV.
- ☑ The p_T spectral shape (characterized by local exponents) as a function of multiplicity exhibits a specific behavior. For $8<p_T<30$ GeV/c, the local exponents are smaller than those for minimum-bias events, i.e. the p_T spectra are harder for high-multiplicity events than that for minimum-bias pp collisions. At higher p_T (30-100 GeV/c) the exponents gradually increase to reach the values which describe the minimum-bias p_T-spectra.
- ☑ For heavy-ion collisions. the evolution of the local exponent as a function of x_T and collision centrality is qualitatively similar to that for pp collisions. The only specific difference is that the heavy-ion data show a particular shape of the exponent evolution with a downward trend for lower values of $x_T(p_T)$. This is not observed in pp collision, but one has to consider that PYTHIA~8 does not necessarily describe the multiplicity-dependent pp data.
- ☑ Unfortunately at the present, pp data for different multiplicity classes and wide p_T intervals are not available.