Event topology dependence of the event-by-event mean p_T fluctuations in high multiplicity pp collisions at 13 TeV

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Introduction

In this work we present the results from the study of the contribution of the jetty-like and isotropic event topology to the multiplicity dependence of event-by-event mean transverse momentum fluctuations in pp collisions at $\sqrt{s} = 13$ TeV. The data have been reconstructed with the ALICE detector in 2015. The analysis was performed using tracks within $|\eta| < 0.8$ and $0.15 < p_T < 2$ GeV/c. To classify the event according to the topology we use the event shape transverse spherocity. While the inclusive results (i.e. without spherocity selection) for charged particles are consistent with the published ALICE results at lower energies, the results from jetty-like and isotropic events exhibit a different behavior.

Motivation

Event-by-event fluctuations contain information on the dynamics and correlations in pp collisions. The contribution from soft and hard processes to dynamical fluctuations can help address whether collective effects exist in high multiplicity pp collisions. Such effects have been shown by several experiments at the LHC

$\sqrt{C_m}/M(p_T)_m$

The results of the dynamical fluctuations in units of the average transverse momentum $(M(p_T)_m)$ in a multiplicity class m are presented in terms of the dimensionless ratio $\sqrt{C_m}/M(p_T)_m$. Where

$$M(p_T)_m = \frac{1}{n_{ev,m}} \sum_{k=1}^{n_{ev,m}} M_{\mathrm{EbE}}(p_T)_k, \tag{1}$$

with $M_{\mathrm{EbE}}(p_T)_k$ being an estimation of the mean transverse momentum $\langle p_T \rangle$ of the charged particles accepted after the track selection for a given event k. The correlator (C_m) is the mean of covariances of all pairs of particles in the same event with respect to $M(p_T)_m$:

$$C_m = \frac{1}{\sum_{k=1}^{n_{ev,m}} N_k^{pairs}} \sum_{k=1}^{n_{ev,m}} \sum_{i=1}^{Nacc,k} \sum_{j=i+1}^{N_acc,k} (p_{\mathrm{T,i}} - M(p_T)_m)(p_{\mathrm{T,j}} - M(p_T)_m), \tag{2}$$

where $n_{ev,m}$ is the number of events in multiplicity class m, $N_{acc,k}$ is the number of accepted particles in event k and N_k^{pairs} is the number of particle pairs in the event k.
As mentioned above the event by event $\langle p_T \rangle$ is approximated by the mean value of the $M_{\mathrm{EbE}}(p_T)_k$ since we can not apply efficiency corrections because we are doing event-by-event studies. Moreover the results are corrected for multiplicity using a weighting average procedure using:

$$\sqrt{C_m}/M(p_T)(\mathrm{N_{ch}}) = \sum_m \sqrt{C_m}/M(p_T)(N_m)R(\mathrm{N_{ch}}, N_m), \tag{3}$$

where R is the multiplicity response matrix. A MC closure test has been performed, and the difference has been assigned as a systematic uncertainty along with the ones associated to track and event selection.

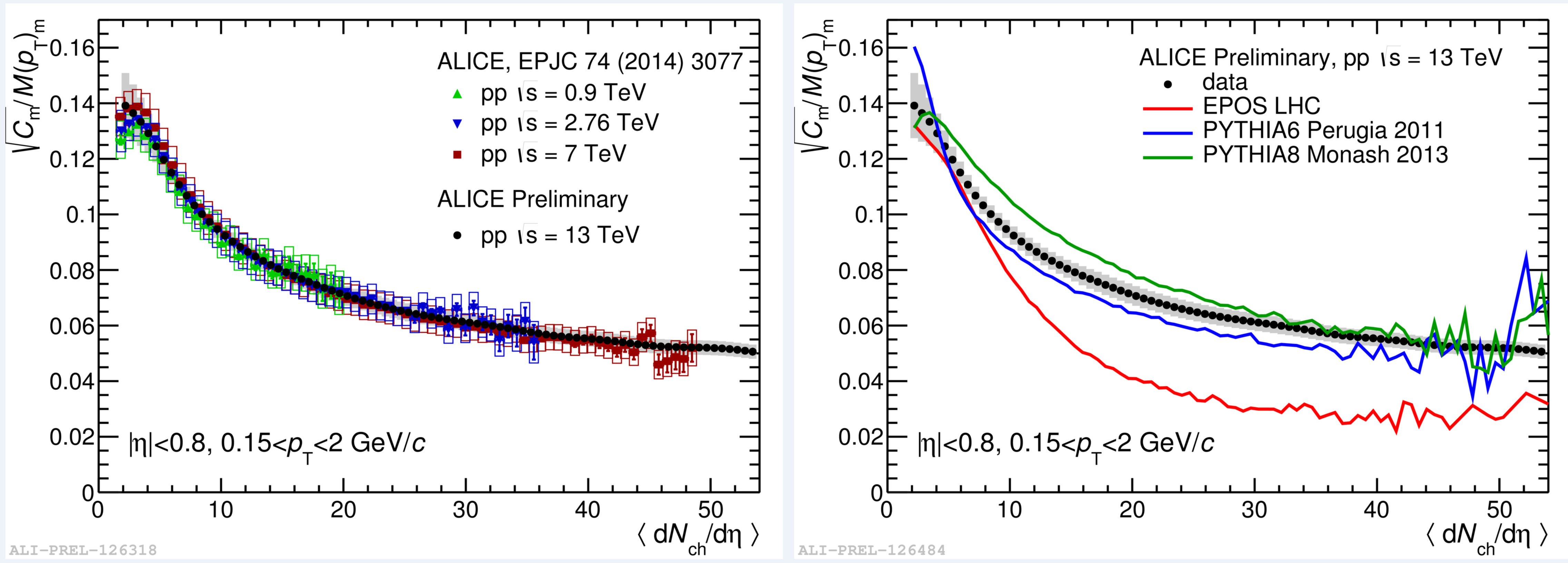

Figure 1: The results for pp collisions at 13 TeV are compared with results at lower energies [1] (left). A comparison of the data with results from MC models is also shown (rigth).

Topology dependence

Contributions from soft and hard events are classified using the event shape transverse spherocity (S_0) through the geometrical distribution of the p_T's of the charged hadrons as in reference [2]. S_0 is defined as follows:

$$S_0 = \frac{\pi^2}{4} \left(\frac{|\sum_i \vec{p_T}_i \times \hat{\mathbf{n}}|}{\sum_i p_{Ti}} \right)^2. \tag{4}$$

with $\hat{\mathbf{n}}$ being a unit transverse vector which minimizes S_0. (Note: that S_0 is collinear and infrared safe and also the bias from the boost along the beam axis is avoid by the restriction to the transverse plane)
The limits of the variable are related to specific configurations in the transverse plane ($S_0 = 0$ for pencil like limit, and $S_0 = 1$ for isotropic limit). Transverse spherocity has been calculated for events having more than two tracks which pass the same quality cuts as the $\sqrt{C_m}/M(p_T)_m$ and same η interval, but with $p_T > .15$ GeV/c.

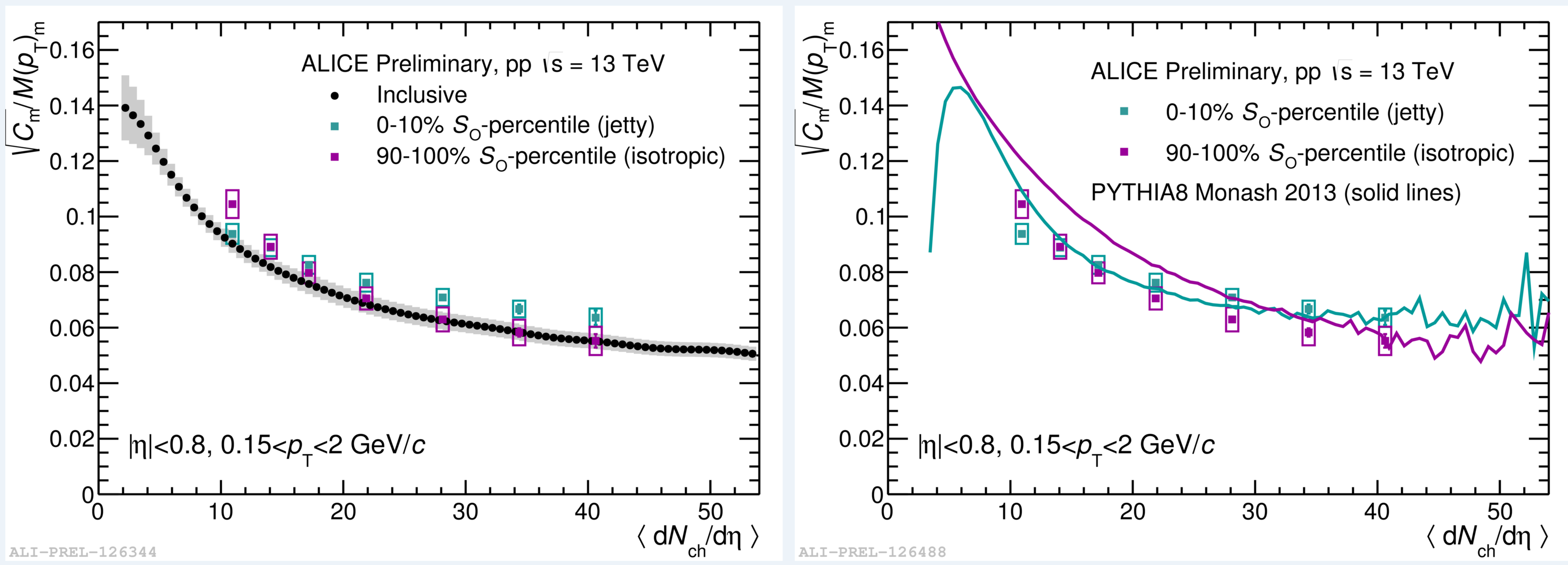

Figure 2: Results w/o spherocity selection are compared with jetty events on the spherocity percentile $S_0 = 0 - 10\%$ and with isotropic events on the spherocity percentile $S_0 = 90 - 100\%$ are shown (left). A comparison of the data and PHYTHIA 8.212 for spherocity percentile selection is also shown (rigth).

Conclusions

- The inclusive results on pp collisions at 13 TeV exhibit the same multiplicity dependence, than previous ALICE measurements at lower energies.
- Results from PYTHIA6 and PYTHIA8 are in qualitative agreement with data. While results from EPOS LHC shown considerable smaller fluctuations for multiplicities $\mathrm{dN_{ch}}/d\eta > 8$.
- Results using the event topology selection show a different evolution of isotropic and jetty events as function of multiplicity. Jetty-like events (coming from hard process) exhibit higher momentum fluctuations than isotropic events for $\mathrm{dN_{ch}}/d\eta > 20$.

References

[1] B. B. Abelev *et al.* [ALICE Collaboration], Eur. Phys. J. C **74** (2014) no.10, 3077

[2] A. Ortiz et al., Nucl. Phys. A941, 78-86 (2015).

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