Multiplicity Dependence of Di-Hadron Correlations Measured with ALICE at the LHC

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Motivation

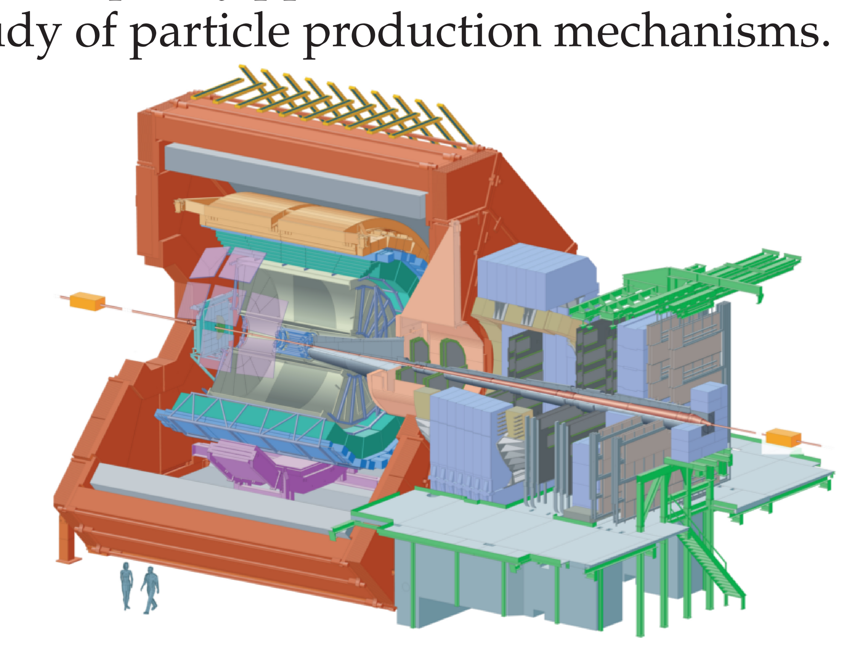
Discussions on multiplicity generation in pp collisions often describe the colliding system as hot fireball associated with uncorrelated, and therefore isotropically distributed particles. Mini-jets are also extensively discussed as a source for particle production [1].

Jets are collimated sprays of particle originating from hard scattered partons, which fragment and hadronize [2]. Mini-jets are defined as particles also emerging from hard scattering, albeit with an energy of the order of particles from the underlying event. Hence, they can not be reconstructed event-by-event.

One option to access mini-jet properties are two particle correlations in $\Delta\phi$. Observing the strength of the correlation as a function of multiplicity can reveal the contribution of mini-jets to the overall event multiplicity. In addition, further information on multiple parton interactions may be disclosed.

ALICE

A Large Ion Collider Experiment (ALICE) is the experiment at the Large Hadron Collider (LHC) optimized for heavy-ion collisions. However, ALICE is also studying pp collisions which not only provides important reference measurements but is also part of a stand-alone pp physics program. In particular, high multiplicity pp collisions are an interesting field of study of particle production mechanisms.



Tracks with combined information of the Time Projection Chamber (TPC) and the Inner Tracking System (ITS) were used in the analysis at hand.

Analysis Strategy

We compute $\Delta\phi$ correlations between all tracks with a transverse momentum of at least $p_T > p_{T,\mathrm{Trigger}}$ and all other tracks with at least $p_T > p_{T,\mathrm{Associate}}$. The resulting $\Delta\phi$ correlations are processed separately for each multiplicity bin and normalized by the number of corresponding trigger particles. The mini-jet activity is characterized by the following observables:

- The number of associated tracks per trigger track at its near and away side $\langle N_{\mathrm{assoc}} \rangle$
- The number of uncorrelated seeds $\langle N_{\mathrm{uncorr}} \rangle$
- The width of the near and away side peak $\langle \sigma \rangle$

References

[1] X. Wang. Role of multiple minijets in high-energy hadronic reactions In *Phys. Rev. D 1991*

[2] G. Salam. Towards Jetography. In *Eur.Phys.J 2010*

[3] T. Sjostrand, S. Mrenna, P. Skands. PYTHIA 6.4 Physics and Manual. In *JHEP 2006*

[4] P. Skands. Tuning Monte Carlo Generators: The Perugia Tunes In *Phys. Ref. 2010*

[5] T. Sjostrand, S. Mrenna, P. Skands. A Brief Introduction to PYTHIA 8.1. In *arXiv:0710.3820v1 [hep-ph] 2007*

[6] R. Engel, J. Ranft, S. Roesler. Hard diffraction in hadron-hadron interactions and in photoproduction. In *Phys. Rev. D 2005*

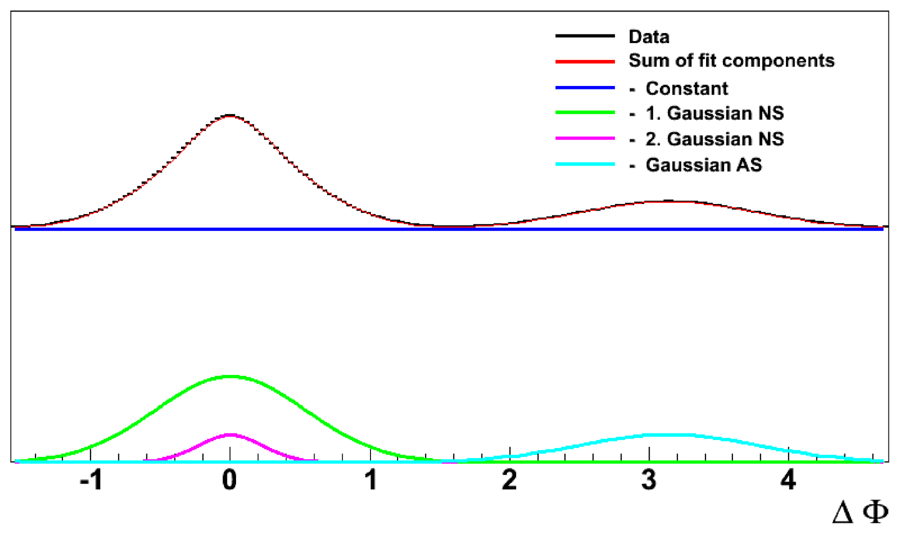
Fit Function

We introduce a fit function in order to estimate the number of tracks in the near and the away side peak above the isotropically distributed background. As the $\Delta\phi$ distribution is a periodically continuing distribution with $\Delta\phi = 0 = 2\pi$, a periodically continuing fit function has to be chosen.

We use a combination of a constant and Gaussian functions:

$$f_{(\Delta\phi)} = C + A_1 \exp\left(-\frac{\Delta\phi^2}{2\cdot\sigma_1^2}\right) + A_1 \exp\left(-\frac{(\Delta\phi-2\pi)^2}{2\cdot\sigma_1^2}\right) + A_2 \exp\left(-\frac{\Delta\phi^2}{2\cdot\sigma_2^2}\right) + A_2 \exp\left(-\frac{(\Delta\phi-2\pi)^2}{2\cdot\sigma_2^2}\right) + A_3 \exp\left(-\frac{(\Delta\phi-\pi)^2}{2\cdot\sigma_3^2}\right) + A_3 \exp\left(-\frac{(\Delta\phi+\pi)^2}{2\cdot\sigma_3^2}\right)$$

Signal Extraction

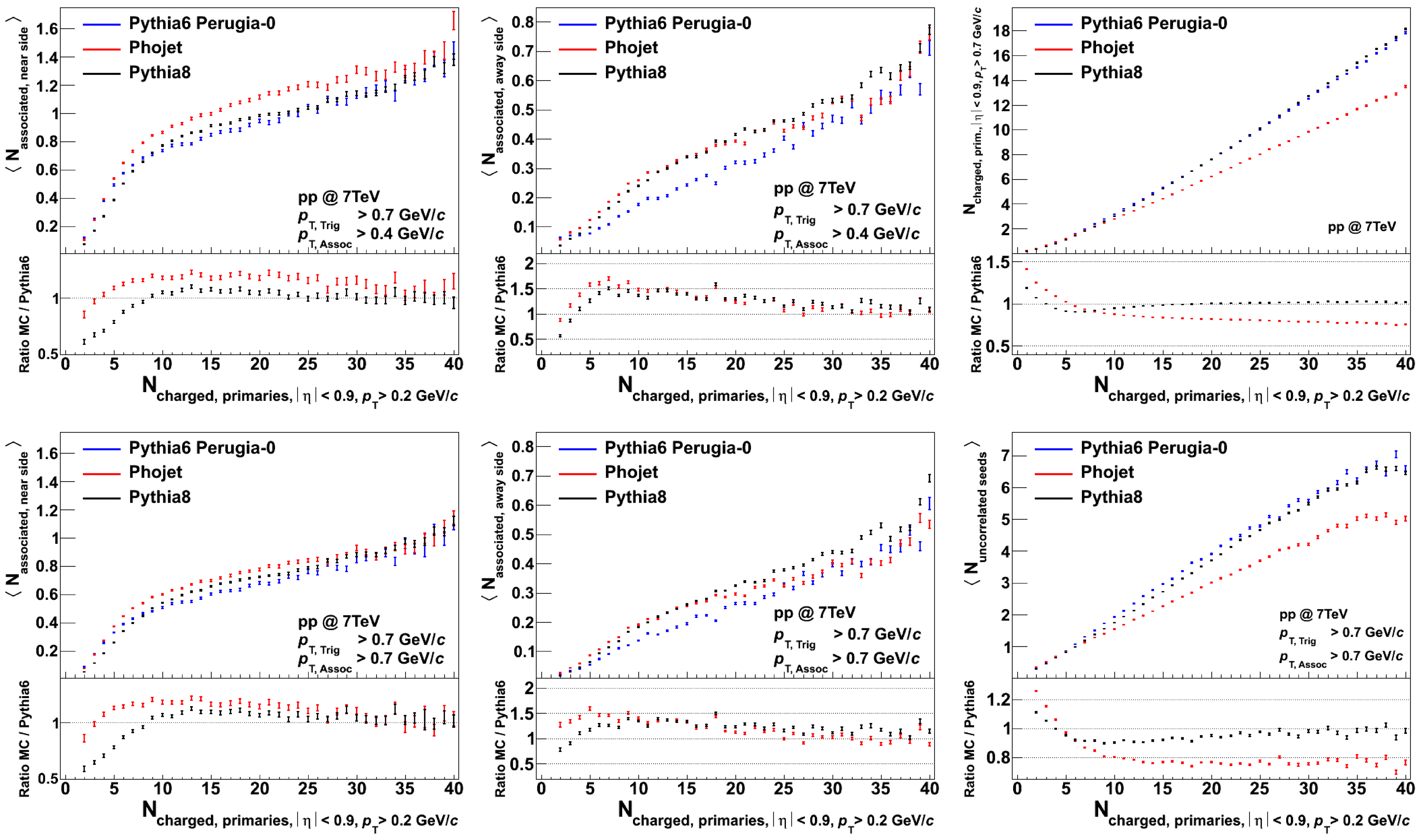


The fit function reproduces the shape of the $\Delta\phi$ distribution with good agreement. The near and away side yields per trigger particle $\langle N_{\mathrm{assoc}} \rangle$ can be derived from integrals of the Gaussians. We estimated the number of uncorrelated seeds by

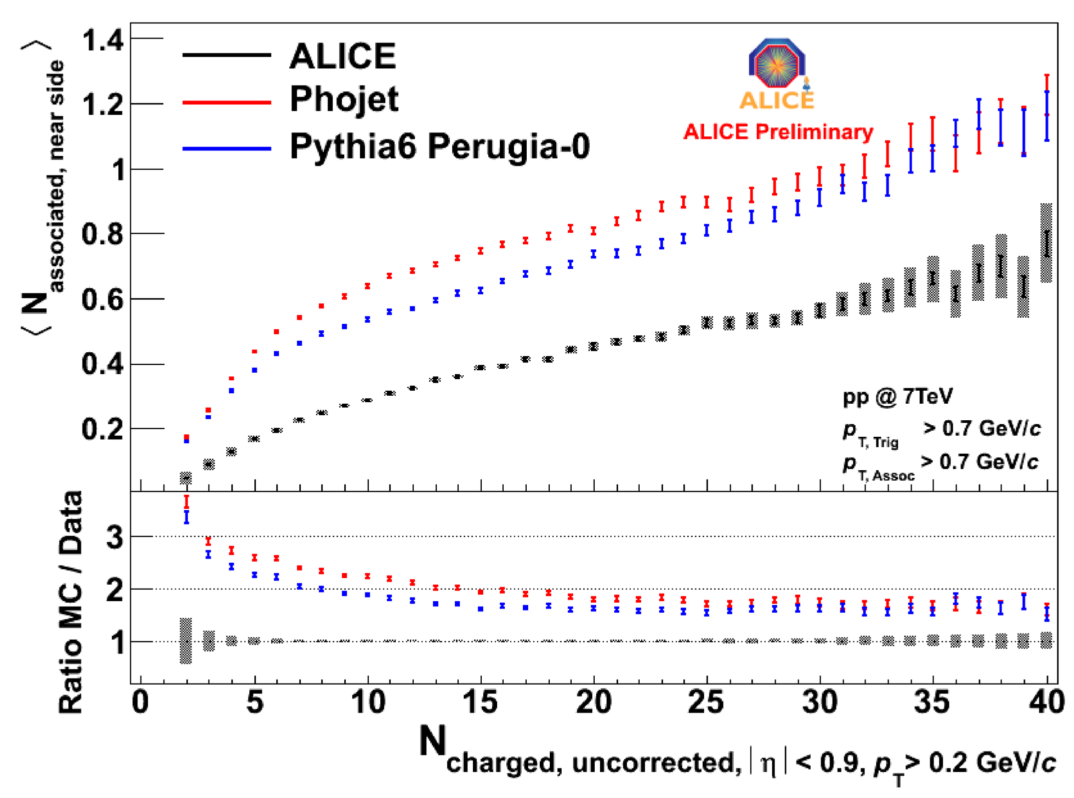
$$\langle N_{\mathrm{uncorr.\ seeds}} \rangle = \frac{\langle N_{\mathrm{possible\ seeds}} \rangle}{\langle 1 + N_{\mathrm{assoc,\ NS}} + N_{\mathrm{assoc,\ AS}} \rangle}$$

Analysis Results

First, the analysis was performed with simulated data of three different Monte Carlo (MC) event generators on the level of Monte Carlo charged primary particles. We use Pythia6 [3] using the tune Perugia-0 [4], Pythia8 [5] and Phojet [6]. The figures below show the main observables of the analysis: The left column shows the average number of associated tracks for the near side plotted for two different cuts in transverse momentum. In the center, we show the same quantity for the away side. In the right column, the number of all possible seeds and the number of uncorrelated seeds are plotted. The number of uncorrelated seeds serves as indicator for the number of multiple parton interactions.



The Perugia-0 tune is used as reference for the ratios in the lower parts of the figures. The two Pythia tunes differ at low multiplicities but are close at higher N_{ch}. At the nearside, Phojet shows higher number of associated tracks at same N_{ch} bins compared to the Pythia tunes. In comparison, the number of uncorrelated seeds is systematically lower in Phojet for all multiplicities above $N_{\mathrm{ch}} > 5$.



For comparison to measured data from ALICE we show here the average number of associated tracks at the near side of the trigger particles as function of the uncorrected charged multiplicity along with Pythia6 and Phojet simulations. The value of the associated tracks for the real data were corrected using correction maps obtained by MC data. The systematic error was computed using cross corrections of the two MCs. The uncorrected charged multiplicity of the MC data was estimated after a full detector simulation.

In the data, we find the number of associated tracks per trigger particle to be significantly lower as compared to the event generators.

Funding

This work is supported by the Wolfgang Gentner Scholarship, CERN, Switzerland, and Universität Münster, Germany.