

Transverse sphericity dependence of di-hadron angular correlations in pp collisions with ALICE at the LHC

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Introduction

Two-particle angular correlations are a useful tool to study the mechanisms of particle production. Different structures in the $(\Delta\eta, \Delta\phi)$ space of the correlation function are caused by various modes of particle production and interactions between particles shortly after production. Examining these structures can give us insight into the nature of these interactions. Transverse sphericity is a momentum space event shape variable giving a measure of how isotropically particles and their momenta are distributed within an event. This variable allows us to differentiate events containing jets produced in hard processes from those events containing multiple soft, non-perturbative QCD processes.

In this contribution, two-particle angular correlations from Pythia simulations of pp collisions at $\sqrt{s} = 7$ TeV are analysed using transverse sphericity and multiplicity to explore how selecting events based on an event shape variable such as transverse sphericity affects the shape of the correlation function and primarily the jet peak.

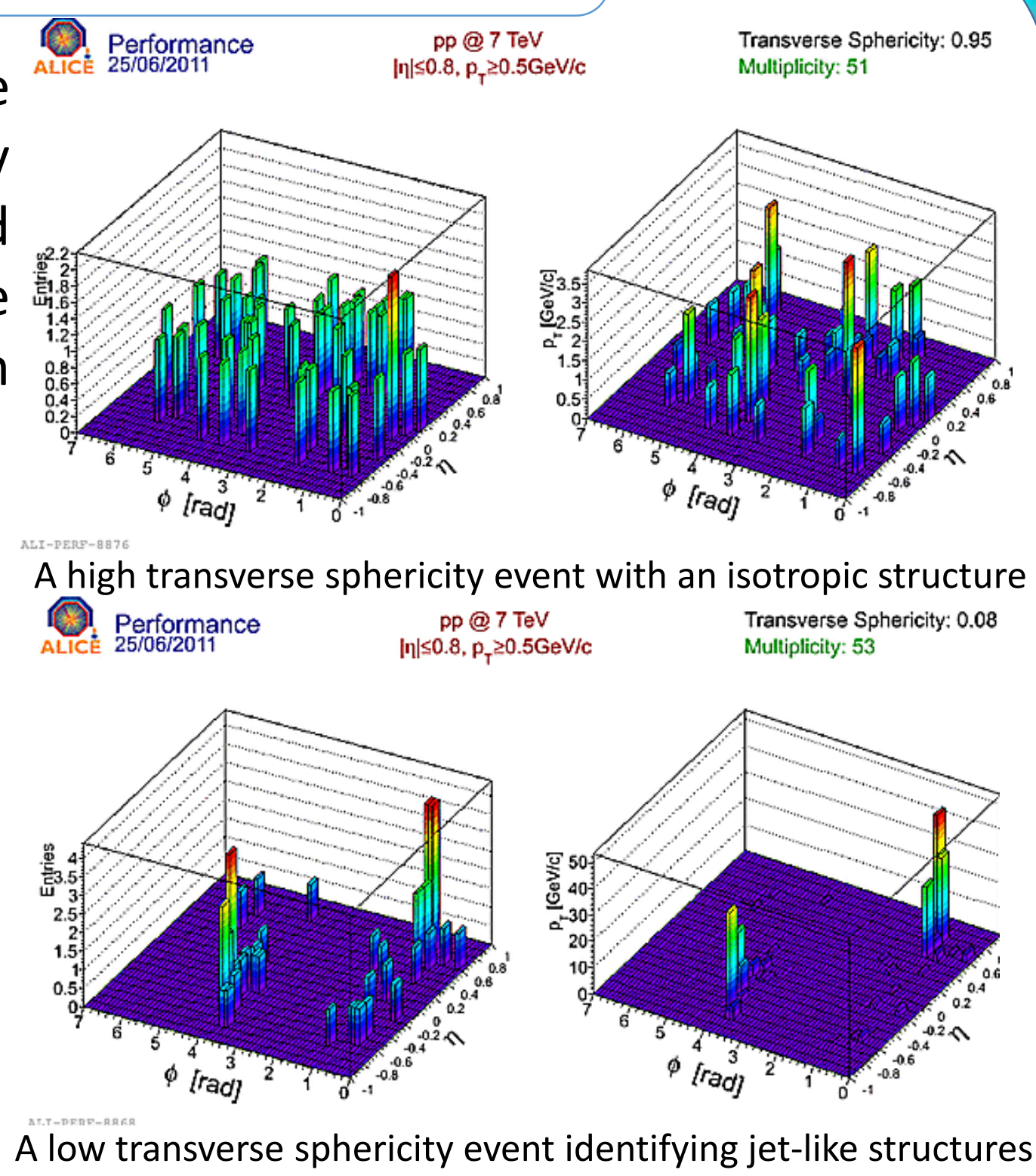
Transverse sphericity

Transverse sphericity (S_T) is an event shape variable giving a measure of how isotropically particles and their momenta are distributed within an event. It is defined using the eigenvalues λ of the transverse momentum matrix:

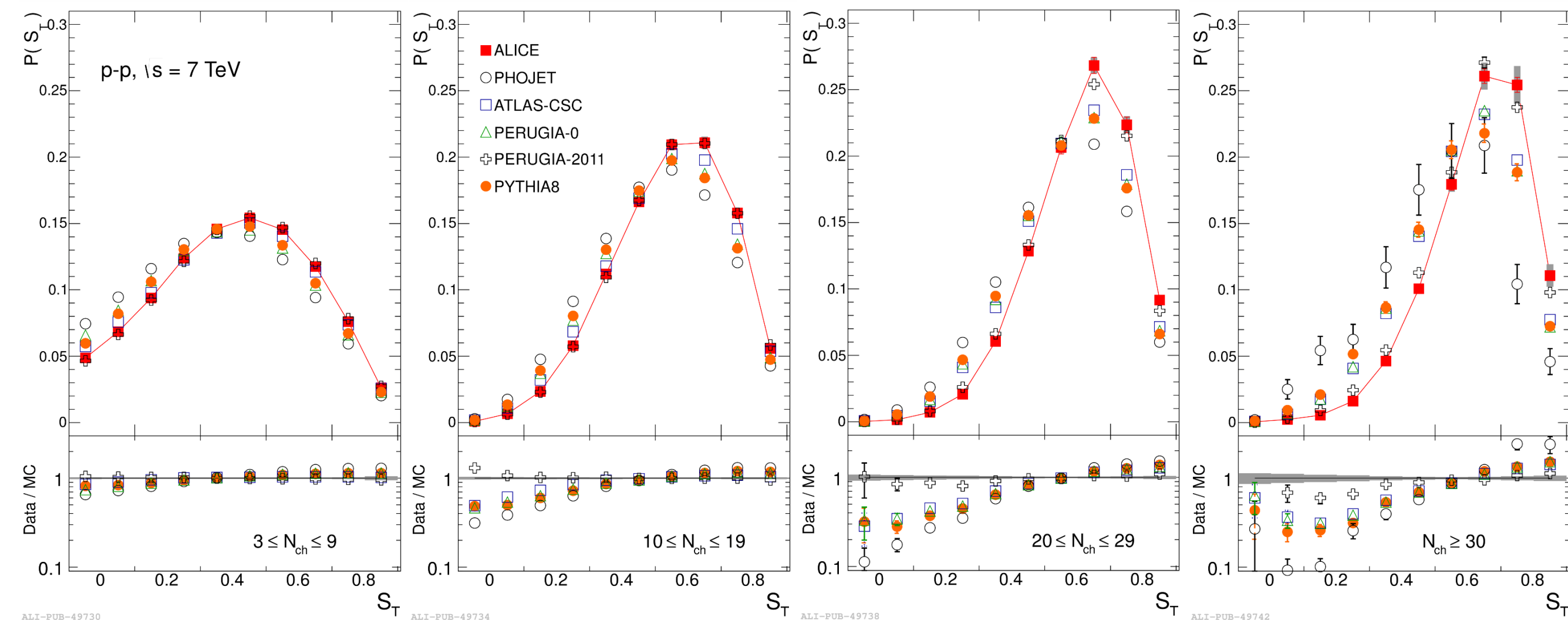
$$S_T^L = \frac{1}{\sum_i p_{Ti}} \sum_i \frac{1}{p_{Ti}} \begin{pmatrix} p_{xi}^2 & p_{xi}p_{yi} \\ p_{yi}p_{xi} & p_{yi}^2 \end{pmatrix}$$

$$S_T = \frac{2\lambda_2}{\lambda_1 + \lambda_2} \Rightarrow S_T = \begin{cases} \approx 0 & \text{Pencil-like} \\ \approx 1 & \text{Isotropic} \end{cases}$$

Two-particle correlations in pp collisions are dominated by structures related to jet fragmentation. By classifying events according to sphericity, it is possible to enhance the fraction of soft, isotropic events in the analysed event sample.



A low transverse sphericity event identifying jet-like structures

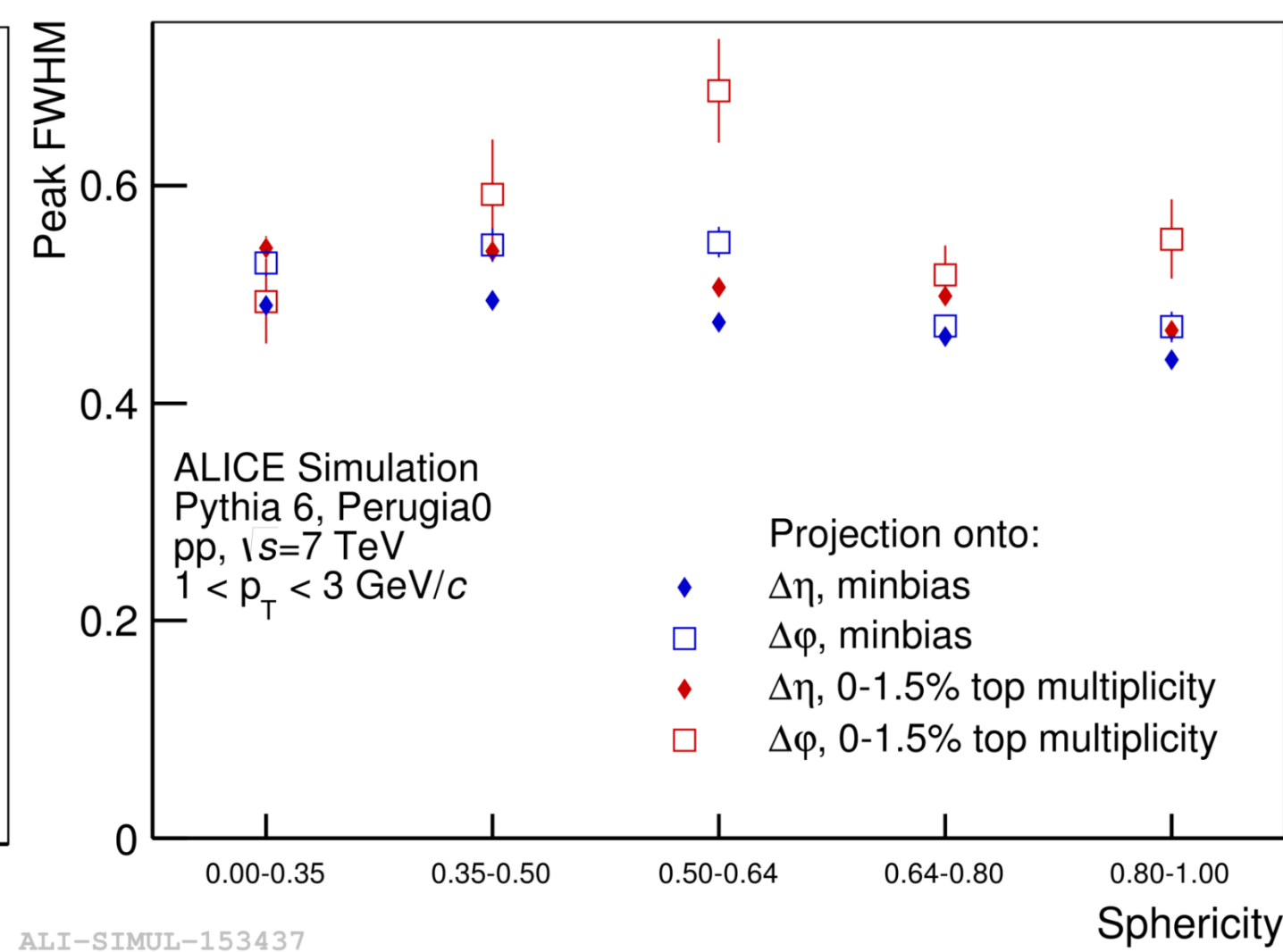
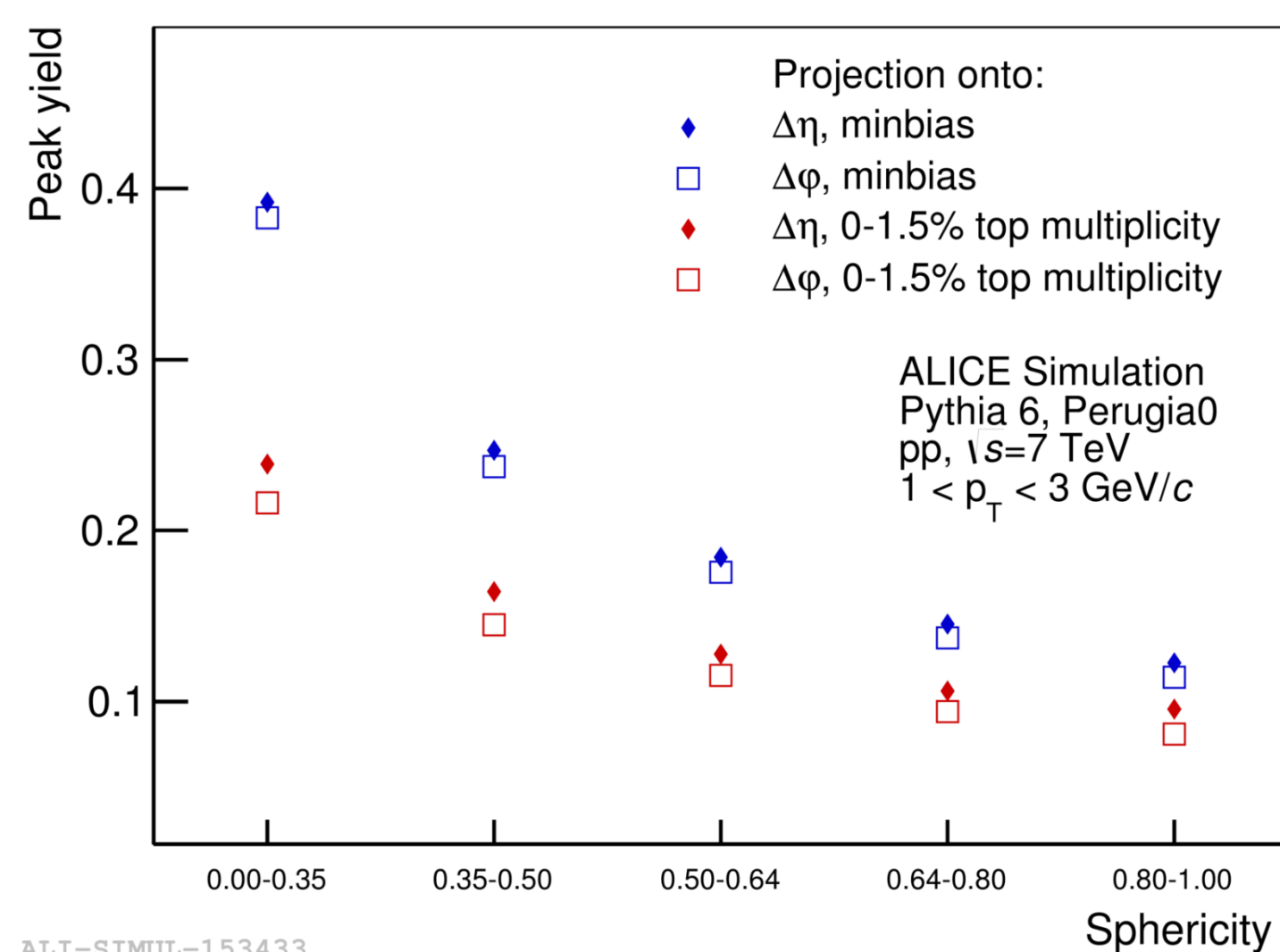
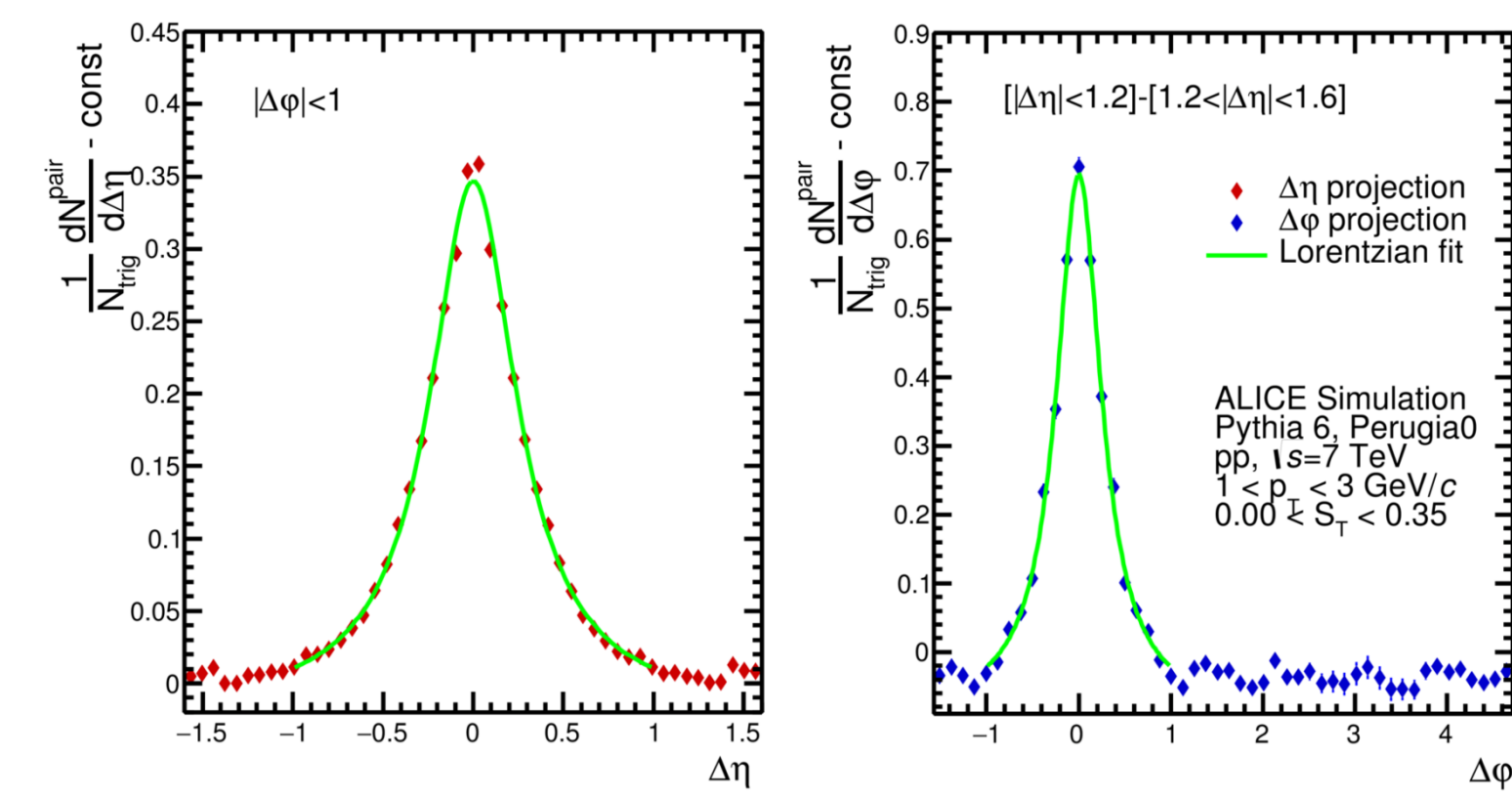


Cutting on events with high multiplicity will select events with higher S_T on average but cutting on higher S_T events selects events of all multiplicities. Cutting on events with high S_T removes fewer events than cutting on events with high multiplicities since the number of events at high multiplicities falls off exponentially.

Peak shape

Fitting the main jet peak with a Lorentzian function $f(x) = I \left[\frac{\gamma^2}{(x-x_0)^2 + \gamma^2} \right] + f_0$ allows the extraction of the peak width (2γ) and integrating over the peak allows for the extraction of the peak yield.

The $\Delta\phi$ projection peak fit is done for $[|\Delta\eta| < 1.2] - [1.2 < |\Delta\eta| < 1.6]$ in order to isolate the jet peak from the underlying long range structures in $\Delta\eta$.



With increasing S_T the main jet peak is reduced in height but remains present. However the full width at half maximum (FWHM) of the peak remains relatively constant. We see a significant reduction in the number of particle pairs contributing to the jet peak with increasing S_T . In high multiplicity events the number of particle pairs is halved going from low to high S_T , and in events containing all multiplicities the number is reduced by a factor of 3.

Di-hadron correlations

The correlation function $C(\Delta\eta, \Delta\phi)$ gives a measure of the angular distribution of particles relative to one another. These angular correlations enable the study of various different particle production mechanisms since they exhibit distinct behaviour in $(\Delta\eta, \Delta\phi)$ space.

$$C(\Delta\eta, \Delta\phi) = \frac{1}{N_{trig}} \frac{S(\Delta\eta, \Delta\phi)}{B(0,0)B(\Delta\eta, \Delta\phi)}$$

$$S(\Delta\eta, \Delta\phi) = \frac{1}{N_{trig}} \frac{d^2 N^{same}}{d\Delta\eta d\Delta\phi}$$

$$B(\Delta\eta, \Delta\phi) = \frac{1}{N_{mix}} \frac{d^2 N^{mix}}{d\Delta\eta d\Delta\phi}$$

Same-event distribution:

Includes two-particle correlation structures due to physics effects, detector acceptance, and single-particle distributions.

Mixed-event distribution:

Includes two-particle correlation structures due to detector acceptance and single-particle distributions.

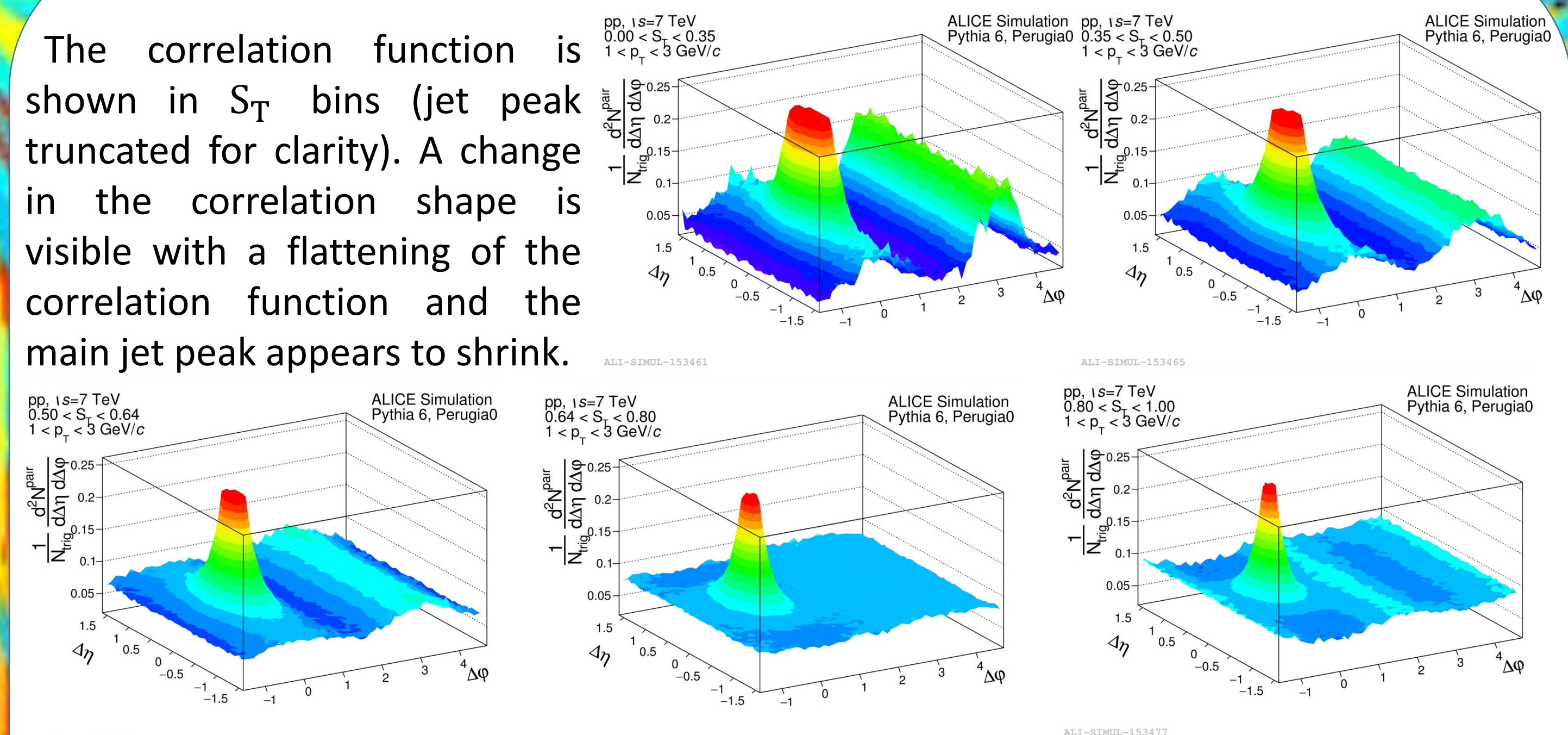
Dividing removes all single particle and detector contributions!

Structures in the correlation function are caused by:

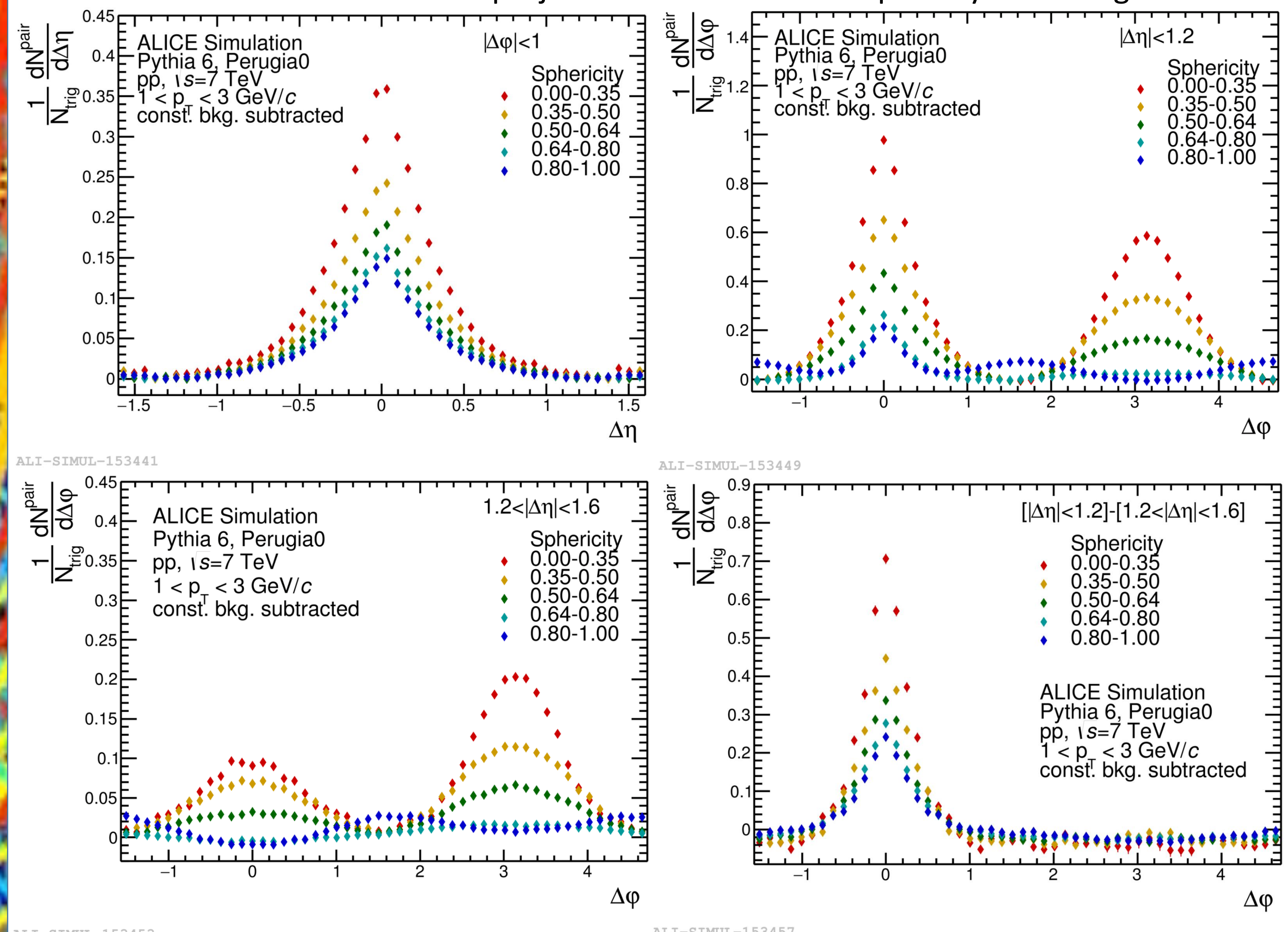
Conservation laws, jets, Bose-Einstein correlations, resonances, photon conversion, gluon strings, coulomb interactions, flow (elliptic..), ridge....

Correlation function vs S_T

The correlation function is shown in S_T bins (jet peak truncated for clarity). A change in the correlation shape is visible with a flattening of the correlation function and the main jet peak appears to shrink.



The correlation functions can be projected onto the axes to quantify the changes:



A reduction in peak height is visible with increasing S_T . In highest S_T bins for the $\Delta\phi$ projection an inversion is seen, with depressions at $0, \pi$ and peaks at $\frac{\pi}{2}, \frac{3\pi}{2}$. This is a consequence of high S_T being obtainable in events with a few perpendicular tracks.

References:

- [1] **Phys.Lett. B** 719 (2013) 29-41
- [3] **Eur.Phys.J. C** 72 (2012) 2124

- [2] **JHEP** 0408 (2004) 062
- [4] **Phys. Lett. B** 718 (2013) 795