Transverse momentum dependent fragmentation measurements in Belle†

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The Belle experiment at the asymmetric e^+e^- collider KEKB provides a very large data set for not only the study of flavor physics but also the study of the strong interaction, QCD. The clean initial state allows very effective measurements of fragmentation functions. Fragmentation functions describe the formation of confined, final state hadrons out of asymptotically-free high-energetic partons. These fragmentation functions (FF) therefore tell us about the confinement process in itself. They also can be seen as tools used in order to extract flavor and/or spin information in parton distribution functions via their different sensitivities. The transverse momentum dependence of distribution and fragmentation functions is of particular imiportance as it is closely related to the three-dimensional structure of the nucleon planned to be measured in great detail at the Electron-Ion-Collider, EIC, and the Collins and Sivers effects. In Belle, one has the unique chance to study the transverse momentum dependence in single hadron fragmentation using the event-shape variable thrust as the reference axis and as proxy for the initial quark-anti-quark axis. For this analysisa, data sample of 655 fb^{-1} collected at the center-or-mass energy of $\sqrt{s} = 10.58$ GeV was used. Single charged pions, kaons and protons were selected as a function of fractional energy $z = 2E_h/\sqrt{s}$, the thrust value T and the transverse momentum. The raw distributions were corrected for particle mis-identification, momentum smearing, backgrounds from other processes, recontruction and acceptance as well as initial-tate radiation, similar to the description of previous results.[1,2] The resulting transverse momentum dependent cross sections are shown in Fig. 1 for $0.85 < T < 0.9$. The behavior is overall very similar between particle species with protons having generally narrower distributions. As expected by theory, the low transverse momentum region $P_{hT} < 1$ GeV can be successfully described by Gaussians. However, unlike theory predictions of a rather simple fractional energy dependence, the widths of these Gaussian fits are increasing at small fractional energies while they decrease again at higher fractional energies. In these fits, pions and kaons show similar widths while those of proton are significantly smaller, as can be seen in Fig. 2. When compared for different thrust values, the widths are largest at low thrust, where the events are more spherical while they become smaller as the events become more collimated.

These results will be used in global fragmentation analyses in order to increase the precision of the already existing transverse spin data from RHIC and semi-inclusive scattering and inform on the data to be taken at the EIC.

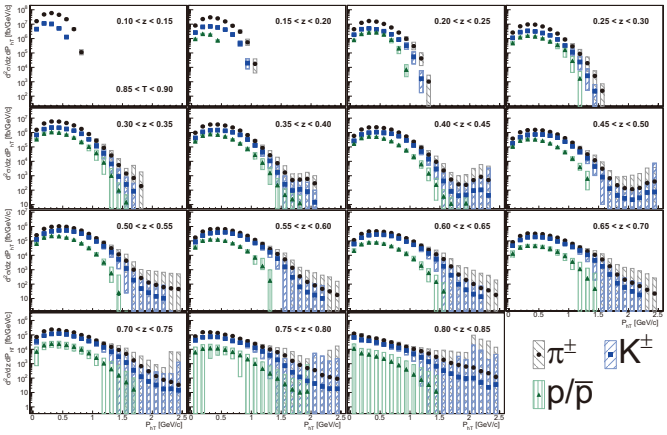

Fig. 1. Differential cross sections for pions (black circles), kaons (blue squares) and protons (green triangles) as a function of P_{hT} for the indicated z bins and thrust $0.85 < T < 0.9$. The error boxes represent the systematic uncertainties. Due to the large uncertainties in them, z bins above 0.85 are not displayed.

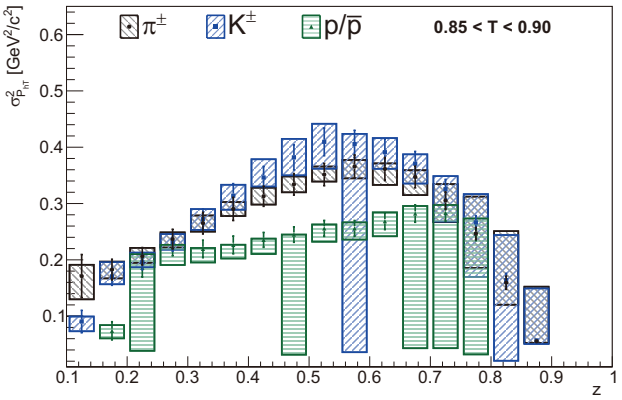

Fig. 2. Gaussian widths as a function of z for pions (black circles and boxes), kaons (blue squares and boxes) and protons (green triangles and boxes) and thrust $0.85 < T < 0.9$. The error boxes represent the corresponding systematic uncertainties as described in the text.

References

1) R. Seidl *et al.* [Belle Collaboration], Phys. Rev. D **96**, 032005 (2017).
2) R. Seidl *et al.* [Belle Collaboration], Phys. Rev. D **92**, 092007 (2015).

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