Fragmentation function measurements in Belle†

R. Seidl,[*1] F. Giordano,[*2] M. Leitgab,[*2] A. Vossen,[*3] H. Li,[*3] W. W. Jacobs,[*3] N. Kobayashi,[*4] M. Grosse-Perdekamp,[*2] A. Ogawa,[*5] C. Hulse[*6] and G. Schnell[*6,*7]

Fragmentation functions (FFs) describe the transition of highly-energetic, asymptotically free partons into final state hadrons. They are a quantity which cannot be obtained from first principles QCD but need to be extracted from experiments. In turn FFs can be used as a tool to extract information about the nucleon structure for different parton flavors. In particular, FFs are commonly used in polarized semi-inclusive deep-inelastic scattering and proton-proton collisions to access the spin structure of the nucleon. The cleanest way to access FFs is in electron-positron annihilation due to the lack of hadrons in the initial state. However, only charge square weighted sums over all kinematically availabe quarks and antiquarks are accessible at leading order of the strong coupling α_S in e^+e^- annihilation. To overcome this partially, instead of detecting a single hadron in the final state, two hadrons, preferrably in opposite hemispheres as defined by the thrust axis, have been measured. The combination of charges and hadron types then gives additional information about the FFs if one assumes the hadrons to be fragmenting off different partons. For example, same-sign pions and opposite sign-pions contain different combinations of favored (e.g., $u \to \pi^+$) and disfavored ($d \to \pi^+$) FFs when considering up and down type (anti)quarks only.

The di-hadron cross sections have been extracted from a dataset of 655 fb^{-1} taken by the Belle experiment at the asymmetric-energy e^+e^- collider KEKB. The data was corrected for particle-misidentification, momentum smearing, contributions of QED processes not related to fragmentation (such as τ pair production), acceptence and efficiencies as well as initial state photon radiation[1]. The final cross sections were then extracted for 6 pion and kaon and charge combinations with different physics content. The cross sections, differential in the fractional energies of the two hadrons $z_{1,2} = 2E_{h,1,2}/\sqrt{s}$ relative to the initial, leading order parton energies $\sqrt{s}/2$, can be seen in Fig. 1. For the same hadron types the same sign combinations are generally suppressed in comparison to opposite sign combinations. Additional strangness, especially if likely being created in the fragmentation process such as for same sign kaons seems further suppressed. The assumption whether di-hadrons originated from the same parton or different partons has been tested by selecting hadron pairs in the same or opposite hemispheres when applying an additional thrust criterion. As can be seen in Fig. 2, same-hemisphere dihadrons decrease rapidly as soon as the sum of their fractional energies exceeds unity in agreement that opposite-hemisphere di-hadrons are generally produced off different partons.

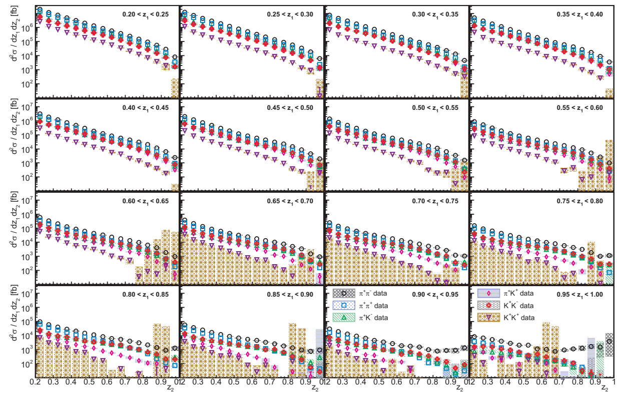

Fig. 1. Di-hadron cross sections as a function of fractional energy z_2 in bins of the fractional energy z_1 without a topology requirement on the two hadrons. Individual hadron combinations are $\pi^+\pi^-$ (black), $\pi^+\pi^+$ (blue), π^+K^- (green), π^+K^+ (pink), K^+K^- (red) and K^+K^+ (purple) including systematic uncertainties as shaded areas.

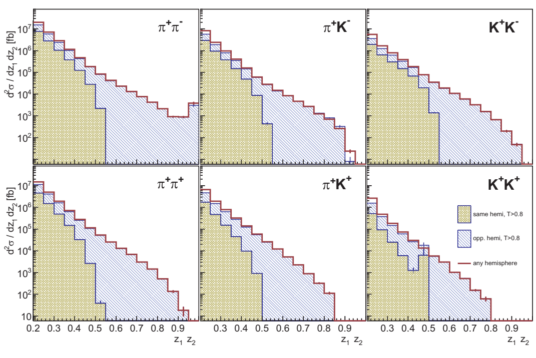

Fig. 2. Stacked di-hadron cross sections as a function of the diagonal fractional energy ($z_1 = z_2$) bins for same (grey area) and opposite (blue area) hemispheres and in comparison to no hemisphere and thrust selection (red).

References

1) M. Leitgab *et al.* [Belle Collaboration], Phys. Rev. Lett. **111**, 062002 (2013).

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*1 RIKEN Nishina Center
*2 Physics department, University of Illinois
*3 Physics department, Indiana University
*4 Department of Physics, Tokyo Institute of Technology
*5 Brookhaven National Laboratory
*6 Department of Physics, University of the Basque Country
*7 Ikerbasque