Fragmentation function measurements in Belle

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Fragmentation functions allow us to study the process of nearly free partons fragmenting into final state hadrons as they also exist in visible matter. While the theory of the strong interaction, QCD, is generally accepted as the force governing all hadronic matter around us, only high energy processes are directly calculable. Parton distribution functions as well as fragmentation functions need to be obtained by experiment. Of particular interest is, how a parton of a certain flavor fragments into certain types of hadrons, how initial parton spin gets translated into the distribution of final state hadrons and how transvserse momentum is generated relative to the initial parton. In the Belle experiment one can study these aspects well since the underlying process of electron-positron annihilation provides a clean initial state without any hadrons to study the emerging final state hadrons. However, normally the quark flavor is not directly accessible as both a quark and an antiquark are created and at least for light flavors (u, d and s quarks) tagging techniques are not reliable. A first way around this limitation was already performed in the Collins type analysis[1)] where two charged pions in opposite hemispheres were studied. Having two hadrons in opposite hemispheres mostly ensures, that one hadron was fragmentating from the quark and another from the antiquark. The ratio of same over opposite charges then revealed the differences of favored and disfavored polarized and un-polarized fragmenation functions. This method was extended for pion-kaon and kaon-kaon combinations to obtain sensitivity of the strange quark Collins functions as well as disfavored u,d quark to kaon Collins fragmentation functions. Preliminary results have been obtained in 2014[2)] as shown in Fig. 1 and are expected to be published soon.

Furthermore the unpolarized fragmentation functions $D^h_{1,q}(z, s)$ can be studied in a similar way and first results have been prepared for all combinations of charged pions and kaons either in opposite hemispheres or also the same for comparison. Here, $z = 2E_h/\sqrt{s}$ is the fractional energy the hadron h carries relative to the initial parton q and $\sqrt{s}$ is the center of mass energy. In the thus obtained cross sections as a function of fractional energy z the ratios between same and opposite sign pion pairs in opposite hemispheres essentially provide the ratio of dis-favored over favored fragmentation from u,d quarks to pions. Favored fragmentation relates to fragmentation into a hadron with valence content the same as the initial parton (ie u to $\pi^+ = |u\bar{d}\rangle$) and dis-favored fragmentation with valence content not the same (ie d to π^+). First results have been obtained and are expected to be shown as preliminary results and be published soon. The expected precision is such, that even the ratios at fractional hadron energies z above 0.8 have still reasonably small uncertainties.

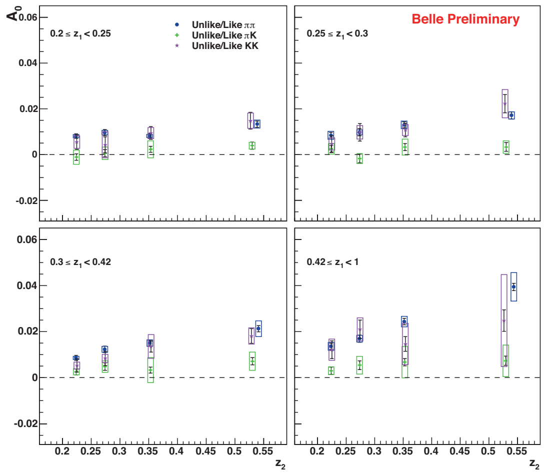

Fig. 1. Collins type azimuthal moments as a fucntion of fractional energy z_2 in bins of fractional energy z_1 for opposite sign over same sign pion pairs (blue), πK (green) and kaon pairs (purple).

In addition an analysis of transverse momenta of one hadron relative to a second hadron is ongoing which should help improve the rather large uncertainties and assumptions of any transvserse momentum dependent distribution and fragmentation functions. These are needed for the analysis of quark transversity and Sivers function data of semi-inclusive deep inelastic scattering and hadron collision experiments. These explicit transvserse momentum dependent measurements are also expected to obtain preliminary status this year.

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