Update of single and dihadron cross sections for light hadrons in e^+e^- annihilation at $\sqrt{s} = 10.58$ GeV in Belle[†]

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The fragmentation process describes the formation of final-state hadrons from initial high-energetic partons such as quarks and gluons. Due to the strength of the coupling of the strong interaction, described by quantum chromodynamics, QCD, this process is obtained only experimentally and parameterized in fragmentation functions, FFs. FFs are universal and factorize for most relevant processes and FF types. They therefore serve as an important tool in the study of the spin, momentum and flavor structure of the nucleon or other bound states of QCD. Its universality can be used to extract them in one process, such as electron-positron annihilation where no hadrons exist in the initial state, and apply it to semi-inclusive deep-inelastic lepton nucleon scattering SIDIS or hadron-hadron scattering.

In the Belle experiment at the KEKB accelerator, a large amount of data exists that can be analyzed to extract various hadronic cross sections as a function of the fractional energy the hadrons carry relative to the initial parton energies, as well as their spin and transverse momentum dependence.

The extraction of the flavor dependence of fragmentation functions from electron-positron annihilation is not as easy since the cross sections are a sum over all accessible flavors, at Belle energies up, down, strange and charm quarks. To gain some sensitivity the extraction of cross sections for two hadrons in the final state have been published a few years ago,[1,2] where the flavor dependence of each of two single hadron fragmentation functions can be used together. However, the interpretation via single hadron fragmentation functions is only possible when both hadrons appear in opposite hemispheres which in turn can only be ensured via additional quantities. Such variables are difficult to treat theoretically, so in an update two different fractional-energy definitions were used and compared to the conventional one.

Both definitions contain scalar products between the two hadron's four-momenta and therefore only have sizable fractional energies when both hadrons are far separated without the need of an explicit hemisphere assignment. The cross section ratios for pion pairs can be seen in Fig. 1 relative to the default definition. The first definition is actually the oldest one suggested for dihadrons[3] which is meant to also be able to interpret the dihadron cross sections at higher orders of the strong coupling. The second definition is similar, but stresses the transverse momentum in the two-hadron system.[4] As can be seen, at very high fractional energies all three definitions are similar as both hadrons need to be nearly back-to-back and no phase space for transverse momentum remains. At low fractional momenta the cross sections using the alternative definitions are far smaller since the same-hemisphere hadron pairs would appear at much smaller fractional energies due to the scalar product.

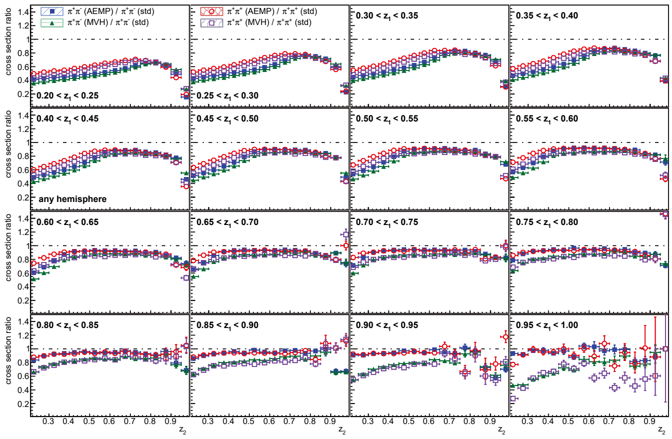

Fig. 1. Dipion cross section ratios as a function of fractional energy z_2 in bins of z_1 relative to the conventional fractional energy definitions. The opposite sign pairs are displayed in blue squares and green triangles for the AEMP and MVH definitions while the same sign pairs are displayed by red circles and purple squares, respectively.

In addition to these updated dihadron cross sections, also single hadron cross sections were updated. The difference to previously published single hadron cross sections for pions, kaons and protons[2,5] (as well as for dihadrons using the default fractional energy definitions) is an improved initial state radiation correction as well as the separation of correlated and uncorrelated systematic uncertainties.

References
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† Condensed from Phys. Rev. D **101**, 092004 (2020)
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