

Fragmentation functions for K_S^0 and Λ with complete quark flavour separation

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Abstract

We present new sets of next-to-leading order fragmentation functions for the production of K_S^0 and Λ particles from the gluon and from each of the quarks, obtained by fitting to all relevant data sets from e^+e^- annihilation. The individual light quark flavour fragmentation functions are constrained phenomenologically for the first time by including in the data the light quark tagging probabilities measured by the OPAL Collaboration.

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1. Introduction

At present, experimental results on inclusive hadron production from e^+e^- collisions are the most reliable source for the extraction of universal fragmentation functions (FFs) $D_a^h(x, Q^2)$ (where a labels the fragmenting parton, h labels the produced hadron, x is the fraction of the parton's momentum taken by the produced hadron and Q is the factorization scale), which are crucial for making predictions for such processes in future experiments, as well as for understanding the non-perturbative mechanism of hadron formation in parton jets. However, the extraction of quark flavour separated FFs from experimental data has not been completely possible due to the lack of data for processes in which the individual light quark flavours are tagged. Therefore,

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theoretical assumptions between light quark flavour FFs had to be made. Recently, we published sets of FFs [1] for each of the three light charged hadrons, whose quark flavours were completely phenomenologically separated by including the light quark flavour separated measurements from the OPAL Collaboration [2] in the data used for the fitting. This more reliable separation in the light quark flavour sector of the FFs via real experimental data is important for the description of hadron production in proton–(anti)proton collisions, for example, at the BNL RHIC, FNAL Tevatron, CERN LHC and other experiments, because the proton is composed predominantly of light partons.

In this paper, we extend our analysis of Ref. [1] to determine FFs for K_S^0 and Λ production, in which the quark flavours are phenomenologically separated by including, among the available data, the tagging probability measurements for each of the quark flavours for these two particles provided by OPAL in Ref. [2]. FFs for K_S^0 production have been previously obtained in Ref. [3], however since no data was available to separate the light quark flavours, it was assumed that the d and s quark FFs were equal. Much data for K_S^0 production can also be well described by using FFs for $K^\pm$ [1,4], so it is interesting to verify if these two sets of FFs are really consistent. In Ref. [5], FFs for Λ production were obtained by constraining all light quark flavours to be equal and imposing certain relations between them and the heavy quark FFs, since no data was available at the time to fully constrain the individual quark flavour FFs. A further determination of FFs for Λ production was obtained more recently in Ref. [6], along with FFs for the other octet baryons, again with relations imposed between flavours, but also with some assumptions suggested by fermionic and bosonic statistics. A more reliable determination of these FFs is important due to the recent data on K_S^0 and Λ production, taken by the STAR Collaboration [7] at RHIC. In particular, next-to-leading order (NLO) calculations deviate considerably from the data for Λ production. For the first time, we present FFs for these particles without imposing constraints on the non-perturbative components (except for the choice of parameterization for the FFs).

2. Method

In all cross section calculations in this paper, used to fit FF parameters to data and to produce comparisons to this data and other data, we use precisely the same method and choice of parameterization, scales, etc. as in Ref. [1], and therefore we refer the reader to this paper for details. This includes taking the fitted NLO value $\Lambda_{\overline{\text{MS}}}^{(5)} = 221 \text{ MeV}$ of Ref. [1]. For each parton, our FFs for K_S^0 production are defined to be those for the production of a single K_S^0 particle, which is equal to the average of those for K^0 and $\bar{K}^0$, and our FFs for Λ production are defined to be the sum of those for Λ^0 and $\bar{\Lambda}^0$. Our FFs incorporate both the intrinsic (non-perturbative) and extrinsic (perturbative, dynamically generated) components of hadron production. It is important to note that our FFs contain intrinsic transitions involving intermediate hadrons occurring over durations much greater than that of the interaction, for example, the process $q + \bar{q} \rightarrow \Sigma^0 + X \rightarrow \Lambda + \gamma + X$ in Λ production noted in Ref. [5], since such processes are not subtracted from the data. Treatment of such effects are beyond the scope of this work.

To obtain FFs for K_S^0 production, we fit to all available $e^+ + e^- \rightarrow K_S^0 + X$ data, covering a range of centre-of-mass energies $\sqrt{s}$, being the untagged data from TASSO at $\sqrt{s} = 14, 22$ and 34 GeV [8] and at $14.8, 21.5, 34.5, 35$ and 42.6 GeV [9], from HRS [10], MARK II [11] and TPC [12] at 29 GeV , from TASSO at 33.3 GeV [13], from CELLO at 35 GeV [14], from TOPAZ at 58 GeV [15] and from ALEPH [16], DELPHI [17], OPAL [18] and SLD [19] at

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