Eta meson Fragmentation Functions

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Introduction

The production of identified hadrons in high-energy collisions provides an important probe of Quantum Chromodynamics (QCD). While the production of energetic partons, such as quarks and gluons, can be calculated perturbatively, their subsequent transition into hadrons is governed by non-perturbative dynamics. This process can be described in terms of fragmentation functions (FFs), usually denoted as $D_i^H(z, \mu_F^2)$, which encode the probability for a parton i to produce a given hadron H carrying a fraction z of its momentum at a given factorization energy scale μ_F.

While their dependence on z at a given initial scale is non-perturbative, their dependence on the factorization scale μ_F can be calculated perturbatively through the Dokshitzer-Gribov-Lipatov-Altarelli-Parisi (DGLAP) evolution equations

$$\frac{\partial D_i^H(z,\mu^2)}{\partial \log \mu^2} = \sum_j P_{ij} \otimes D_i^H = \sum_j \int_z^1 \frac{d\zeta}{\zeta} \, P_{ij} \left(\frac{z}{\zeta}\right) \, D_i^H(\zeta, \mu^2). \qquad (1)$$

The dependence on z can therefore be extracted from experimental data through global QCD analyses and subsequently used to make predictions for other processes and energy scales [1]. A global analysis combines measurements from different reactions in order to constrain the fragmentation functions.

Eta Fragmentation Functions

Previous global QCD analyses have extracted η-meson FFs using different sets of experimental data, including the AESSS analysis [2] and the more recent NPC23 analysis [3]. More recently, the ALICE and LHCb experiments at the CERN Large Hadron Collider (LHC) have measured η-meson production as a function of the transverse momentum p_T at different center-of-mass energies $\sqrt{S}$ and rapidities y. The availability of these newer measurements motivates a reanalysis of the η fragmentation functions previously obtained from a global QCD fit. In particular, predictions based on the previous extraction show significant discrepancies with some of the more recent LHC measurements.

Such discrepancies may originate from limitations in the existing determinations of the FFs, from the truncation of the perturbative QCD calculation at NLO, or from a combination of both effects.

In this work [4], we therefore revisit the determination of the η-meson fragmentation functions by performing a new next-to-leading order (NLO) global QCD fit including all available e^+e^- and pp data at the time.

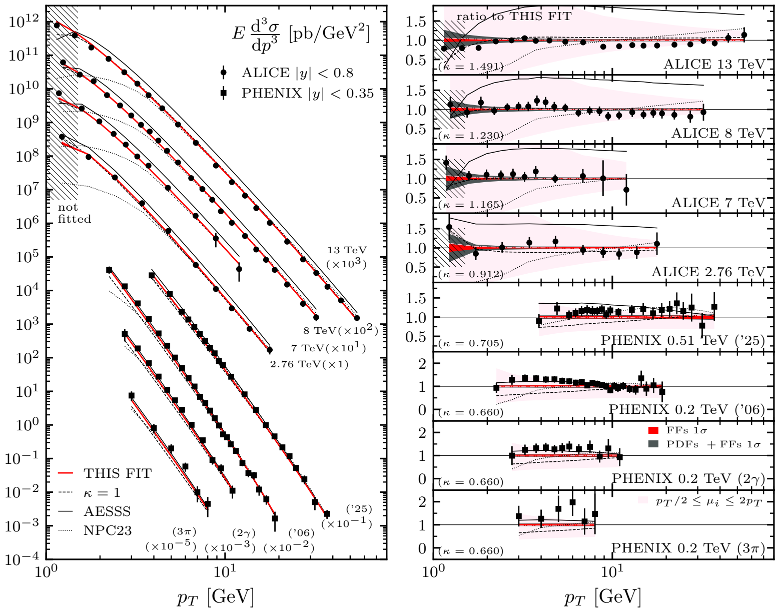

Figure 1: Comparison of our new NLO results (red lines, labeled as "THIS FIT") with the p_T-differential midrapidity hadroproduction data from ALICE and PHENIX at various different $\sqrt{S}$. Also shown are the corresponding predictions obtained using the AESSS [2] and NPC23 [3] fragmentation functions.

Results

The resulting set of η fragmentation functions provides a consistent description of the available experimental data over a broad range of collision energies and kinematic regions. The inclusion of the new proton-proton measurements significantly improves the constraints on the gluon-to-η fragmentation function, while the e^+e^- data provide important information on quark fragmentation. The analysis also shows that accounting for the residual scale dependence of the NLO calculation is important for obtaining a consistent description of the different datasets.

References

[1] D. de Florian, R. Sassot, and M. Stratmann, Phys. Rev. D **75**, 114010 (2007).

[2] C. A. Aidala, F. Ellinghaus, R. Sassot, J. P. Seele, and M. Stratmann, Phys. Rev. D **83**, 034002 (2011).

[3] J. Gao, C. Liu, M. Li, X. Shen, H. Xing, Y. Zhao, and Y. Zhou, Phys. Rev. D **112**, 054045 (2025).

[4] C. A. Aidala, D. A. Loomis, R. T. Martinez, R. Sassot, and M. Stratmann, Phys. Rev. D **113**, 092012 (2026).