

Quark/Gluon topics and fractions measurement at LHC

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At hadron-hadron colliders, it is almost impossible to obtain pure samples in either quark- or gluon-initialized hadronic showers as one always deals with a mixture of jets. The analysis presented in this presentation aims to break the aforementioned degeneracy by extracting the underlying fractions and distributions of (light) quarks and gluons through a measurement of the relative production rates of multijet events in a solely data-driven manner.

A measurement of the triple-differential multijet cross section at a centre-of-mass energy of 13 TeV using an integrated luminosity of 139 fb^{-1} of data collected with the ATLAS detector in proton-proton collisions at the Large Hadron Collider (LHC) is presented. The cross section is measured as a function of the transverse momentum, two orthogonal categories defined by the relative orientation between two jets, as well as a Jet Sub-Structure (JSS) observable that is sensitive to the quark- or gluon-like nature of the hadronic shower of the two leading- p_T jets in the event.

The JSS variables used in this analysis can broadly be divided into two categories: one set of JSS observables is constructed by iteratively declustering and counting the jet's charged constituents (track and Soft Drop multiplicity); the second set is based on the output predicted by a Deep Neural Network (DNN), which is trained to discriminate between quark- and gluon-initialized showers in a supervised fashion (NN score).

All JSS observables are measured based on Inner Detector tracks to maintain strong correlations between detector- and particle-level objects. The reconstructed spectra are fully corrected for acceptance and detector effects, and the unfolded cross section is compared to various state-of-the-art parton shower Monte Carlo models. Several sources of systematic and statistical uncertainties are taken into account that are fully propagated through the entire unfolding procedure onto the final cross section.

The unfolded multi-differential cross sections are used to extract the underlying fractions and probability distributions of quark- and gluon-initialized jets in a solely data-driven, model-independent manner using a statistical demixing procedure, which has originally been developed as a tool for extracting emergent themes in an extensive corpus of text-based documents. The obtained fractions are model-independent and based on an operational definition of quark and gluon jets that does not seek to assign a (binary) label on a jet-to-jet basis, but rather identifies quark- and gluon-related features on the level of individual distributions, avoiding common theoretical and conceptual pitfalls regarding the definition of quark and gluon jets.

The gluon/quark fractions as well as their distributions are extracted in several exclusive regions of transverse momentum. Furthermore, an outlook is provided concerning possible applications of the results obtained in this analysis in future studies like, for instance, a measurement of the strong coupling constant based on jet substructure.