Jet substructure analysis as a search tool for new physics in the ATLAS experiment at the Large Hadron Collider

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Reconstructing particle jets in high energy hadron collisions gives access to the character of the underlying forces mediating the interactions, and the nature of the elementary particles produced in their final states. In past experiments, these jets have mostly been interpreted as a proxy for light quarks and gluons emerging from the collision, with a focus on the measurement of their transverse momentum and angular distributions, and their multiplicity. With the higher energies reached at the Large Hadron Collider (LHC) at CERN, Geneva, Switzerland, the decay products of boosted heavy quarks and other boosted heavy particles with considerable momentum can be collected into jets. The highly granular multi-purpose detectors employed by the ATLAS and CMS experiments at the LHC allow analyzing the internal structure of these jets, which is measured in terms of observables sensitive to the momentum flow of the detectable particles inside of them. Such measurements give experimental access to the origin of the jet by reconstructing likelihood estimates based on observables indicative for flow patterns characteristic for a given decay. For example, two-prong hadronic decays of boosted particles like W and Z bosons and three prong hadronic decays of boosted top quarks can be detected this way. In addition, searches for new (heavy) particles expected from physics beyond the Standard Model can be conducted based on similar likelihood measures, possibly adapted according to the search goal.

In this talk I introduce the most commonly used strategies used today to perform the analysis of jet substructure, with a focus on the underlying phenomenological principles and experimental challenges as they present themselves in particular for the ATLAS experiment. The quality of the measurements of the most powerful substructure observables used in the reconstruction of hadronically decaying SM particles and in searches for new physics is discussed. The combined employment of these observables in a so-called tagging tool is demonstrated using the example of the W-boson tagger in ATLAS. Selected results from recent searches employing these techniques are presented to demonstrate their effectiveness.