Description of doctoral project
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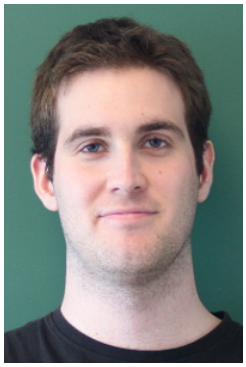
QCD resummation for jets with massive quarks



In my doctoral projects I study the effects of massive quarks in calculations of differential cross sections in different approaches: effective field theories (EFT) and Monte Carlo (MC) event generators. In both cases I focus on the kinematical situation where the quark is highly boosted and acts as the progenitor of a so called jet, a stream of high energetic collimated hadrons. In this case large logarithmic corrections to the cross section have to be resummed to all orders in perturbation theory.

One way of achieving this is by using EFT methods to disentangle the physics of the different energy scales. While this is well-established and has been done to high orders for many processes in the massless case, it becomes much more complicated when keeping the full quark mass dependence because this provides an additional energy scale in the process. My first project was to set up so called "variable flavor number schemes" (VFNS) in Soft-Collinear Effective Theory (SCET) - the appropriate EFT to describe strong interactions in the jet limit - for deep-inelastic scattering and the Drell-Yan process. These VFNS allow for resummation of all those logarithmic corrections connected to the quark mass over the whole spectrum, ranging from the heavy quark limit to the massless limit. I also calculated the various mass dependent beam-, jet- and soft-functions, that are the basic ingredients in the SCET factorization theorems, to next-next-to-leading-order.

The second project in my doctoral studies is to study the interpretation of the top quark mass that is measured at hadron colliders like the LHC. In these top quark mass measurements we have the interesting situation that though the experimental uncertainties are becoming smaller and smaller due to better statistics, an additional theoretical uncertainty remains because it is still not understood exactly how the mass parameter extracted from experiment is related to a renormalized mass scheme in quantum field theory, like e.g. the pole mass or the $\overline{\text{MS}}$ mass. This is because the theory predictions used for these measurements are usually generated with MC event generators. These are powerful tools that simulate the whole event from the collision of the incoming particles down to the formation of the observable hadrons, based on a probabilistic approach. It is the goal of my project to understand the relation of the top mass parameter in a MC event generator and in analytic QCD calculations. In a first step we have already identified the mass scheme that is effectively implemented in the parton shower - an essential part of every MC generator where the perturbative branching of quarks and gluons is modelled - of the HERWIG 7 MC generator, by analytically solving the underlying algorithm for a simple observable and compare it to calculations in SCET. The result was that the mass scheme can not be interpreted as the pole mass, but rather as a cutoff dependent short-distance mass. Currently I am testing and trying to improve the hadronization model of the HERWIG 7 event generator with respect to having better control on possible contributions to the mass scheme coming from the hadronization model.