Theoretical Particle Physics at Colliders

(group Massimiliano Grazzini)

Bachelor thesis projects

- Event shapes at hadron colliders

  Event shapes are observables related to geometric properties of hard collisions at particle colliders. This geometry is intrinsically related to underlying features of Quantum Chromodynamics (QCD), the theory of quarks and gluons (partons). A classical example is that of thrust in e^+e^- collisions into hadrons: the event is most likely pencil-like because the detected particles mainly stem from a quark and an antiquark produced back to back. In this project we aim to study event shapes in proton-proton collisions at the Large Hadron Collider (LHC). The hadronic environment introduces additional challenges rendering such observables less clean. We shall study how different classes of observables are affected by the additional partons produced alongside the hard collision event. The work will be performed using well established numerical tools and will provide the chance to develop an intuition of the physics of colliders.

Master thesis projects

- Improved predictions for top-quark pair production at hadron colliders.

  Top-quarks are abundantly produced at the LHC and they constitute an important background for searches of physics beyond the Standard Model. Our group has carried out the computation of the top-quark cross section at the second order in QCD. The project aims at improving the numerical accuracy of the calculation by using novel computational techniques. The work will be performed in an already existing numerical framework, and will combine numerical and analytical aspects.

- Multi-jet production in electron-positron collisions

  Our group has carried out several higher-order computations for important processes at the LHC. This project aims at applying the computational methods successfully used so far to the study of multiple jet production in e^+e^- collisions. Jets are collimated bunches of hadrons copiously produced at high-energy colliders and represent the fingerprints of the high-energy quarks and gluons produced in the hard-scattering interaction. The project will require analytical work to extend our computational framework and numerical applications to obtain quantitative predictions.

- Resummation for jet processes

  Due to the overwhelming number of strong-interacting particles present in each collision at the LHC, experimental collaborations need reliable predictions for processes with one or more jets in the final state. To achieve a precise description of such processes, it is necessary to model QCD accurately in disparate kinematical regimes. This requires to have a theoretical description of the all-order structure of these processes, which can be achieved by suitable resummation techniques. In this project we will study different observables related to processes with one or more jets produced at hadron colliders and we will perform phenomenological studies relevant for LHC physics. The project will involve both numerical and analytical work, and will explore different formalisms in which the resummation can be formulated.