PRECISION CALCULATIONS IN PARTICLE PHYSICS
(group Thomas Gehrmann)

Bachelor thesis project

How to define an isolated photon?

Final state photons at hadron colliders can originate from two mechanisms: the direct radiation of a photon from a quark, and the production of the photon in the fragmentation of a hadronic jet. Only the former process can be computed from first principles in particle theory, and its contribution to a measured cross section can be enhanced by applying an isolation criterion to the photon. This isolation is highly non-trivial both in experiment and theory, and each type of criterion has advantages and drawbacks. In this project, we aim to compare different isolation criteria that are currently in use, and to develop alternative photon isolation schemes. The work will be performed in an already existing numerical framework, and will combine numerical and analytical aspects.

Master thesis projects

Single and double spin asymmetries in the polarized Drell-Yan process

Collisions of longitudinally polarized protons allow to probe the distribution of the proton spin among its constituents. Recent precision measurements of weak boson production (Drell-Yan process) at the RHIC collider in Brookhaven allow for a clean determination of the contribution of quarks and anti-quarks to the proton spin. To interpret these precision data within the QCD parton model, we plan to compute the second-order QCD corrections to spin asymmetries in the Drell-Yan process. The work combines analytical work on the extension of the antenna subtraction method to polarized particles with numerical developments for the cross section predictions.

Event shapes in hadronic Higgs decays

A future high-energy electron-positron collider (Higgs factory) will provide a large sample of Higgs bosons produced in a very clean environment, enabling in-depth studies of Higgs decays. By computing geometric event properties (event shapes) of Higgs decays to hadrons, we aim to find ways to distinguish $H \to b\bar{b}$, $H \to c\bar{c}$ and $H \to gg$, thereby enabling the first direct measurement of the Higgs decay branching fraction to gluons, and aiming for precision determinations of its Yukawa couplings to different quark flavours. The main emphasis of the work is in the development of numerical codes for the computation of the Higgs decay event shapes in QCD.

Unitarity in multi-Higgs processes: Higgsplosion or Higgspersion?

In the limit of infinitely large collision energies, cross sections for the production of multiple Higgs bosons display an exponential growth, owing to the self-coupling of scalars (Higgsplosion scenario). This behaviour is in apparent contradiction to unitarity. Various theoretical approaches to this problem have been suggested in the literature, based on perturbative and non-perturbative methods, often with contradicting results. We will perform a careful assessment of these approaches, largely based on the analytical application of quantum field theory methods, and aim to arrive at consistent predictions for multiple Higgs production at asymptotic energies.