

Jets are streams of particles consisting in quarks and gluons, that is hadrons, produced in high energy collisions between electrons, protons, or even heavy nuclei. The mechanism behind creation of jets is – at least pictorially – quite simple. Suppose we have two protons speeding up head-on, with velocities very close to the speed of light. They necessarily must have great energies, because for any particle which is not weightless, it requires an infinite energy to accelerate them to the speed of light. Those high energy protons interact most of the time just electromagnetically (they have electric charge), but from time to time their constituents, so-called partons, that is quarks and gluons, collide themselves. These collisions are described by the Quantum Chromodynamics (QCD) – a fundamental theory of strong interactions. During such collisions newly produced partons are often kicked out of the interaction point transversely to the collision axis with large velocity. Then, because of the so-called color confinement property of QCD, those partons must transform to collimated streams of hadrons. This parton-hadron duality means that by observing jets, we observe a good deal of internal quark and gluon dynamics.

The following project concerns jets that are produced at quite small angles to the collision axis, all in the same direction – so called forward jets. It turns out that such configurations of jets happen when one of the protons is found in a state which contains much more gluons than the other. Due to the momentum conservation those gluons must carry very small fractions x of the hadron momentum. Thus, this domain of QCD is often called the small- x physics. Theory predicts that the growth of the density of gluons has a particular power dependence on x , when x decreases. When x is small enough, the theory also predicts saturation of the gluon density.

Theory calculations for processes in the small- x limit are more challenging than for processes at moderate x . One of the reasons is that the scattering amplitudes, that is complex functions describing interactions of partons, actually must trade a single incoming small- x gluon to a 'collective gluon' (the so-called Wilson line). The general methods of calculating such amplitudes at lowest order of perturbation theory have been already developed and are being developed for the next to leading order.

The general goal of the project is to build a computer software which will allow to simulate forward jet production processes with a better precision than today. The most versatile programs are the so-called Monte Carlo generators. They perform calculations by randomly generating momenta of partons and assigning a weight calculated from microscopic properties of partons and hadrons. After generating many millions of configurations this allows to calculate the probability for jet events to occur.

Our Monte Carlo program will help to address several important questions in high energy physics. One of those is whether in the experimental data for forward jets gathered so far (and in the future) by the Large Hadron Collider contains clear signals of small x physics, as predicted by the QCD theory.