Squark and gluino production at hadron colliders

Anna Kulesza
Helmholtz Alliance Fellow, RWTH Aachen University

Motivation: searches for supersymmetry at hadron colliders

- Production of coloured supersymmetric particles (squarks and gluinos) is a very important supersymmetry (SUSY) discovery channel at hadron colliders

Higher-order corrections and the role of soft gluons

- Next-to-leading-order (NLO) SUSY-QCD corrections to total cross sections for production of squarks and gluinos are known to be significant, of the order of tens of percents. For the gluino-gluino production at the LHC, the correction reaches 100% for masses of gluinos $\lesssim 1$ TeV.

- Given large masses of squarks and gluinos, the production process is expected to often take place at threshold, defined by the condition $s\to 4m^2$, where $m$ is the average mass of a particle in the produced pair.

- At threshold, emission of real gluons is suppressed; mostly soft-gluons emitted.

- Mathematically, the soft-gluon emission manifests itself in the theoretical expressions for the total cross sections through appearance of logarithmic terms of the form

  $$\alpha_s \ln \left( \frac{4m^2}{\mu^2} \right)$$

- The logarithmic terms contribute substantially to the full higher-order corrections, as seen at NLO. In the threshold limit, $s\to 4m^2$, they diverge, leading to breakdown of the conventional fixed-order perturbation theory.

- The predictive power of the perturbation theory can be restored in the threshold limit if the most dominant logarithmic contributions are taken into account in all orders.

Threshold resummed soft gluon corrections

Resummed cross sections

Resummation of soft gluon corrections is performed in the scale of Mellin moments $N$ taken w.r.t. variable $e^{-4\mu^2}$, in which the cross section factorizes.

Schematic representation of factorization for the $2\rightarrow 2$ process involving all four particles carrying colour.

The soft function $S_\beta$ is obtained through solving renormalization-group equation:

$$\frac{\partial}{\partial \ln \mu^2} S_\beta(\mu^2) = -\frac{\beta_0}{\beta_0} S_\beta(\mu^2) - \frac{\beta_1}{\beta_0} S_\beta(\mu^2) \Gamma_L$$

Soft anomalous dimensions

At the level of accuracy required here, i.e. so-called next-to-leading logarithmic (NLL) accuracy, new ingredients are required to perform resummation.

Hard function

- At NLL accuracy, the hard function at threshold is given by Mellin moments of the contributions to leading–order cross sections from different colour channels.

Summary

- Total cross sections for all squark and gluino production processes at the LHC and the Tevatron calculated at NLL (NLO) accuracy.

- Calculations of one-loop soft anomalous dimension matrices $\gamma_i$ for $2\rightarrow 2$ processes with non-threshold colour structure and massive final-state particles are calculated by combining appropriate colour structure with one-loop integrals corresponding to the following diagrams calculated in the eikonal approximation.

Threshold-resummed predictions for squark and gluino production total cross sections

Table of references:


Publications