Contribution ID: **53** Type: **On-site project**

Double parton scattering and models for double parton distributions

A brief overview about the project. The main subjects of this project are:

- LHC physics, in particular QCD.
- double parton scattering (DPS), i.e. hadron-hadron collisions with two simultaneous hard interactions.
- double parton distributions (DPDs), the DPS counterpart of regular parton distribution functions (PDFs).
- models for DPDs.

DPS reactions are often neglected when theory predictions for the LHC are calculated. While this is justified in many situations, there are also processes where this is not the case. In these cases one needs DPDs in order to calculate DPS cross sections, but right now an experimental determination of these distributions is not yet possible. Therefore one has to rely on models for DPDs. The goal of this project is to construct and refine such models.

What you will learn in the course of this project. The idea of this project is to construct models for DPDs using PDFs as building blocks and refine these models with the help of the DPD number and momentum sum rules. While doing this you will:

- familiarize yourself with physics at the LHC.
- learn the basics about DPS and DPDs.
- get to know more about PDFs.
- gain practical experience in writing C++ code.

Which knowledge is required? Of course the intent of this project is to learn something, but nevertheless some basics are required, or would at least be very beneficial:

- an introductory course to particle physics.
- some experience writing C++ code.

What exactly is double parton scattering? What exactly is double parton scattering? When we talk about DPS what we have in mind are hadron-hadron collisions with two distinct hard interactions, i.e. from each colliding hadron two partons (quarks or gluons) enter a separate hard scattering reaction, respectively. This produces a final state with two subsets of final state particles with two associated hard scales.
While for a given final state the contribution from DPS is generically less important than the one from single parton scattering (SPS), there are cases where it should be included in order to get a good theoretical estimate. The most well-known example for this DPS enhancement is probably the production of two W gauge bosons with identical charge. Since this channel is an important background for the search for physics beyond the standard model of particle physics (SM) in channels with like-sign leptons it is important to include DPS contributions there.
Besides being of importance for precision calculations for the LHC, DPS is also very interesting to study in its own right, as it gives access to information about the internal structure of the colliding hadrons that is not accessible in SPS. In particular DPS allows us to study correlations between two partons inside a hadron. For instance we can obtain information about the spatial distribution of two partons inside a hadron, or how the spins of two partons are correlated.

What are open issues in the theoretical description of DPS? A theory for the description of DPS processes can be formulated as a generalization of the familiar factorization theorems from SPS and in recent years a lot of progress has been made in this direction.
The double parton distributions (DPDs) in the DPS factorization theorems generalize the concepts of SPS parton distribution functions (PDFs) to two partons and can be thought of as probability distributions for finding two partons with given momentum fractions at a given separation inside a hadron. Unfortunately an experimental determination of DPDs has not been possible yet, since at the one hand DPDs contain more information than regular collinear PDFs, such that also more data is needed to obtain them, while on the other hand the amount of data on DPS is still comparatively small at present.
This necessitates the construction of physically motivated models for DPDs. One important constraint that

can guide us in the construction of such models are number and momentum sum rules for DPDs, which are quite similar to those familiar from PDFs.

Introductory reading. f you want to know more about DPS and DPDs, some –hopefully accessible –introductory material can found in the following slides:

- “Double parton scattering in QCD”by Jonathan Gaunt @ DIS 2019
- “Double parton scattering”by Markus Diehl @ QCD@LHC 2019
- “Double parton distributions: An introduction”by Peter Plößl @ QCD-N2021
- “Constraining DPD models using sum rules”by Peter Plößl @ MPI@LHC 2018

Field

B5: Theory of Elementary Particles

DESY Place

Hamburg

DESY Division

FH

DESY Group

Theory

Special Qualifications:

Introductory course in particle physics.
Some experience writing C++ code.

Primary authors: DIEHL, Markus (T (Phenomenology)); PLOESSL, Peter Josef (T (Phenomenology))