Description of doctoral project
Angelika Widl
Supervisor: Univ.-Prof. Dr. André H. Hoang

Improving Precision for Top Quark Pair Production at Lepton Colliders

My doctoral project focuses on developing tools to improve the precision of the inclusive and differential top quark pair production cross section at electron-positron colliders. It is supervised by Univ.-Prof. Dr. André H. Hoang.

Currently, data on the heaviest of all known elementary particles, the top quark, is coming from proton-proton collisions at the Large Hadron Collider (LHC) at CERN. For the time after the LHC, several new collider proposals are under consideration. Three of the main proposals (ILC, CLIC, FCC-ee) would collide electrons with positrons and would be able to produce pairs of a top quark and an anti-top-quark in electron-positron collisions for the first time. This would give an exciting opportunity to study top quarks with unprecedented precision. For example, it would be possible to measure the top quark mass with higher precision than is currently possible.

In the first part of my doctoral project, I worked with a research group of the University of Valencia and my supervisor Prof. André Hoang to propose a new method for measuring the top quark mass with high precision at an electron-positron collider. Using the process $e^+e^- \to t\bar{t}\gamma$ and a cross section combining threshold and continuum corrections we could show that an electron-positron collider provides the opportunity to measure the top quark mass with high precision ($110 - 150$ MeV) in the region above the top quark pair production threshold at center-of-mass energies of 380 GeV and 500 GeV.

In the second part of my doctoral project I aim to improve the differential cross section for top quark pair production at electron-positron colliders in collaboration with my supervisor Prof. André Hoang, Dr. Simon Plätzer, and Prof. Michael Seymour from the University of Manchester. Top quarks have a short lifetime and immediately decay into a bottom quark and a W boson, making $e^+e^- \to W^+W^-b\bar{b}$ the relevant process. I am developing a C++ code for the differential cross section of $e^+e^- \to W^+W^-b\bar{b}$ at next-to-leading-order precision, taking into account resonant top quarks in the subtraction of infrared divergences.
This project gives me the exciting opportunity to learn about the interface between theoretical particle physics and experiment, about software development, and about how to develop new analytical tools.