The search for exotic states with the BESIII experiment

Motivation and Introduction During the past years a lot of fascinating discoveries within the charmonium and charmonium-like sector have been made. The BESIII experiment plays a crucial role in this research. Colliding electrons and positrons, so a particle and its anti-particle, in a symmetric double ring accelerator, a center-of-mass energy of around 3 GeV to 4.6 GeV is available to produce new particles. In particular, states containing a c-quark anti-c-quark pair can be produced, so-called charmonium states. The investigation of the different states which are created in this energy regime is called charmonium spectroscopy. From theory side, there are predictions how many states in this regime should be observed and how they would behave concerning their decay pattern. However, a serious overpopulation was measured, rendering those states unlikely to be charmonium states. Their nature and quark content can not be described as mesonic, meaning that a particle is only made up of a quark-antiquark pair, in the conventional quark model, which means that they are, most likely, not conventional charmonium states. These charmonium-like states are therefore labeled exotic.
One of the main aims of the BESIII experiment is to get insights into the exotic nature of those states. This can be done by studying their decay mechanisms. To do that, BESIII accumulated high statistics data sets at center-of-mass energies from 3 GeV to 4.6 GeV including the world's largest data set at the J/ψ resonance. With that, high performance analyses can be performed, searching for couplings of exotic states to new investigated decay channels.

Project Description This project will be a part of a running analysis of BESIII data. The student will learn to perform Monte Carlo simulations of signal and background processes and will analyze BESIII data. Here, a pre-sorting of big data sets on high performance cluster machines is performed, allowing the student to get a detailed impression of such applications on research. The student will then work together closely with a PhD student in the analysis of experimental data, investigating the possibility to reconstruct light, short-lived charmonium states like the η_c in high energy electron-positron annihilations. Therefore, the student will take part in an analysis of the data of one of the world's leading experiments in the search for exotic states in the charmonium and charmonium-like region.

Where it will be done The project is offered in the working group of Prof. Dr. Alfons Khoukaz at the institute of nuclear physics of the Westfälische Wilhelms-Universität in Münster. The institute has been hosting RISE students since 2005.
The working group joined the BESIII collaboration in 2015. A young team frequently including multiple bachelor and master students, and currently employing three PhD students and a Postdoc is involved in the running analyses of BESIII data in Münster. Besides students from the Erasmus Programme, the Research Training Group (Graduiertenkolleg) 2149 "Strong and Weak Interactions - from Hadrons to Dark Matter", where about 30% of the PhD students come from abroad, is an inherent part of our institute.

Therefore, our institute is strongly multicultural.
Münster itself is a city of about 300.000 inhabitants located in the state North Rhine-Westfalia in Germany. The Westfälische Wilhelms-Universität Münster with its 45.000 students is one of the largest universities in Germany. It is not a campus university, but is spread out over the city. That makes it a real student city.

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