CSC-RUB PhD Project Proposal

Title: Analysis of the reaction channel $\psi' \rightarrow$anti-p Σ^+ Ks with BESIII data

Sector of research: PhD, Dr. rer. nat.

Degree awarded: Physics

Keywords: Nuclear and Particle Physics, PANDA Experiment, Simulation Study, Data Analysis

Supervisors of PhD project:

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Research focus of supervisor:

One of the most fascinating questions in the field of physics is concerned with the structure of matter, namely the fundamental building blocks and composite systems. Hadrons are bound states of quarks and gluons with the proton and neutron as most prominent representatives. The interaction among quarks is described by Quantum Chromodynamics (QCD), the theory of the strong interaction. However, neither QCD nor other theoretical descriptions are able to fully describe the spectrum of hadrons. The ground state hadrons contain either three valence quarks or an antiquark-quark pair. Since a few years, there are strong indications that hadronic state with further quark and/or gluon content exist. My group is searching for these kinds of states which allow to learn more about QCD. We take data and perform data analysis at the experiment BESIII (China), we are preparing for data analysis at the PANDA experiment (Germany) and construct the PANDA Luminosity Detector with silicon pixel sensors.

Publications: 809 papers, H index: 107

BESIII Collaboration, Search for the reaction $e^+e^- \rightarrow \chi_{cJ}\pi^+\pi^-$ and a charmonium-like structure decaying to $\chi_{cJ}\pi^\pm$ between 4.18 and 4.60 GeV, Phys. Rev. D 103 (2021) 052010.

BESIII Collaboration, Search for the reaction channel $e^+e^- \rightarrow \eta_c\eta\,\pi^+\pi^-$ at center-of-mass energies from 4.23 to 4.60 GeV, Phys. Rev. D 103 (2021) 032004.

PANDA Collaboration, Precision resonance energy scans with the PANDA experiment at FAIR: Sensitivity study for width and line-shape measurements of the X(3872), Eur. Phys. J. A 55 (2019) 42.

R. A. Briceno, et al., Issues and Opportunities in Exotic Hadrons, Chin. Phys. C 40 (2016) 042001.

BaBar Collaboration, Observation of a broad structure in the $\pi^+\pi^-$ J/ψ mass spectrum around 4.26 GeV/c^2, Phys. Rev. Lett. 95 (2005) 142001.

Summary of research plan:

Background: In the last years many new states where already observed at the BESIII experiment which do not fit in the spectrum of hadronic ground states (consisting of three quarks or an antiquark-quark pair). These states most likely contain additional quarks or gluons, so-called exotic states. There is a world-wide effort going on to search for exotic states. Also, the group of Prof. Miriam Fritsch is part of this effort.

Study objective: Goal of this project is to perform a data analysis of BESIII data. As a first step the branching fraction of the reaction channel $\psi' \rightarrow$anti-p Σ^+ Ks will be determined. This number describes the possibility how likely the reaction channel is produced. In a second step, the dynamics of this reaction is investigated by performing a so-called Partial Wave Analysis. This kind of analysis determines possible intermediate states and their quantum numbers. Some of the intermediate states might be exotic states.

Expected Results: As result the branching fraction of the reaction channel $\psi' \rightarrow$anti-p Σ^+ Ks is expected and also the interpretation of the data by using the Partial Wave Analysis method. The results will be presented at the BESIII collaboration meeting and workshops. The results will be published.

Methods: The data analysis will be performed by using the BOSS software-package which is provided by the BESIII collaboration. For the Partial Wave Analysis, the package ComPWA will be used. For the determination of the systematic uncertainties of the analysis, extensive simulation studies have to be performed. For simulated data, the physics channel of interest is generated by obeying the physics constraints. Then the four-momenta of the reaction products are transferred to the detector simulation. There, all particles are tracked through the detector material. If a particle hits a detector component a signal will be “produced” and archived. The generated data is analyzed the same way as real data of the BESIII experiment. The necessary computing resources are available.

Candidate Requirements: MSc degree in Physics, good English language skills.

Motivation for CSC application: The group of Prof. Dr. Miriam Fritsch is member of the BESIII experiment in Beijing, China. The PhD student will regularly participate in the Collaboration Meetings where he/she will present the progress of the PhD studies. The PhD candidate will be part of the HGS-Hire Research School, which is centered around the GSI Helmholtz-Center of Heavy Ion Research and the FAIR facility in Darmstadt. This school offers three weeks of soft skill seminars and lectures weeks in the context of Nuclear, Hadron and Particle Physics.