CSC-RUB PhD Project Proposal

**Title:** Simulation Study for the future PANDA experiment at FAIR: Determination of the integrated luminosity

**Sector of research:** Physics, Hadron physics

**Degree awarded:** Dr. rer. nat.

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

**Supervisor of PhD project:**

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**Second Supervisor of PhD project:**

Prof. Dr. Hendrik Hildebrandt, Institute of Astronomy, Faculty of Physics and Astronomy

**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:** 948 papers, 771 published, H index: 109 (inspire.net)

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

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


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

**Background:** At the PANDA experiment at FAIR the cross sections of reaction channels will be measured which indicates how probable the measured reactions are. In addition, energy scans will be performed where the line shape of reaction channels is scanned in small energy steps. Depending on the beam and target quality and the time of the data taking, the number of events of the investigated reaction channels changes. To get a general number for comparison, the cross section is determined which needs the integrated luminosity for normalization.

**Study objective:** Goal of this project is to perform a comparison between the luminosity measured with the PANDA Luminosity Detector (last component of PANDA) and the luminosity determined by using the “rest” of PANDA. An extensive simulation study has to be performed where the properties of the beam and the target and additional complications have to be taken into account.

**Expected Results:** The comparison study is crucial for the PANDA experiment to learn more about the systematic uncertainties of the luminosity measured with the dedicated luminosity detector. The results will be presented at the PANDA collaboration meeting and workshops.

**Methods:** The simulation study will be performed by using the PANDAroot software-package which is provided by the PANDA collaboration. For the generation of the data, the physics channel of interest is generated by obeying the physics constraints. After getting the four-momenta of the reaction products, the four-momenta are transferred to the detector simulation. Here all particles are tracked through the detector material. If a particle hits a detector component a signal will be “produced” and archived (as it is done in a real experiment). Afterwards the generated data is analyzed the same way as it will be done in future with real data of the PANDA experiment. The necessary computing resources are available.

**Candidate Requirements:** MSc degree in Physics, Programming skills in C++ and Python, good English language skills.

**Motivation for CSC application:** The group of Prof. Dr. Miriam Fritsch is member of the PANDA experiment at the FAIR facility in Darmstadt, Germany. 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. The PhD candidate will also be part of the Ruhr University Research School for interdisciplinary skills development.