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Lambda transverse polarization in proton-proton interactions in NA61/SHINE at the CERN SPS

Abstract

The transverse polarization of Λ hyperons produced in inclusive collisions of unpolarized protons with unpolarized targets was first observed in the 1970s. For over 40 years, such studies have been conducted for proton collisions with various targets at widely varying beam energies (or beams) and for various hyperon production angles. Several theoretical models have been proposed to describe the experimental data in this regard. Nevertheless, the polarization mechanism of Λ particles and other hyperons remains incompletely understood.

The main goal of this thesis is to measure the Λ hyperon transverse polarization in proton-proton interactions at a beam momentum of 158 GeV/c in the fixed-target experiment NA61/SHINE at the CERN SPS. The NA61/SHINE Collaboration recorded these data in 2009- 2011. The project adapted methods for polarization studies used by other experiments to the NA61/SHINE case and developed techniques that are most suitable for this analysis. They were applied to a NA61/SHINE physics analysis for the first time.

The obtained results are compared to the phenomenological function fitted to many experimental data, as well as new results from CERN (LHC, SPS), DESY, and Fermilab experiments, and predictions from the theoretical model. The biases related to the detector acceptance, data preparation technique, and analysis methodology were corrected using Monte Carlo simulations with two models. It was also shown that the precession of Λ hyperons in a magnetic field is negligible. The systematic uncertainties were estimated and discussed. The measured transverse polarization is consistent with results from other experiments and the model predictions. Unfortunately, the current measurement, due to significant statistical and systematic uncertainties, does not resolve the tensions that arise from the results of previous experiments.

The methodology, techniques, and software elaborated in this work will be used for the analysis of the high-precision proton-proton interaction data to be recorded in 2025. Furthermore, the study of Λ transverse polarization can be extended by analyzing of the data on light ion collisions recorded by the NA61/SHINE Collaboration in 2025 and planned for after Long Shutdown 3 of the CERN accelerator complex.

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