Analysis of recoil proton detector system for Λp scattering experiment at SPring-8

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Content

We have started a Λ proton scattering experiment at SPring-8 in April 2025. The purpose of this experiment is to investigate the ΛN interaction by measuring the differential cross sections of the Λ proton elastic scattering.

Emulsion and spectroscopic experiments have provided the energy level structures of ground and excited states of Λ hypernuclei so far. In particular, the ΛN interaction description has been improved to reproduce the level structure of few-body hypernuclei. However, neutron stars that have more than twice the solar mass were observed[1]. It becomes clear that theoretical calculations based on such a ΛN interaction picture cannot support such massive neutron stars. This indicates that more detailed information on the ΛN interaction such as the radial dependence is indispensable. Moreover, to determine the three-body ΛNN interaction, which is expected to make a key repulsive force at high densities, it is essential to establish a precise understanding of the pure two-body ΛN interaction. In this experiment, we aim to obtain a model for the two-body ΛN interaction by measuring the differential cross sections of the Λ proton scattering.

We use a recoil proton detector system (CATCH) to identify the Λ proton scattering. This system consists of Cylindrical Fiber Tracker (CFT), BGO Calorimeter, and a scintillator hodoscope (PiID), arranged to surround a liquid hydrogen target. CATCH was put in operation about four years ago and successfully used by the E40 experiment at J-PARC. By taking into account the effect of slight deformation of CFT during this period, the position of CFT fiber was corrected. The positions of the fibers were adjusted to minimize the residuals between the cosmic ray tracks reconstructed by CFT and the actual hit positions of the fibers. As a result, the angular resolution improved to 1.6°, achieving performance comparable to that of the previous experiment (J-PARC E40)[2]. The energy calibration of BGO will be also done using decay protons from Λ particles produced via the $\gamma p \to K^+\Lambda$ reaction, where the energy of proton can be kinematically reconstructed.

In this presentation, we will summarize the objectives of the proton scattering experiment, the position correction of the CFT and the energy calibration of the BGO, and illustrate the performance of particle identification in CATCH.

Reference

[1] P. Demorest, et al., Nature 467 (2010) 1081.
[2] Y. Akazawa, et al., Nucl. Instrum. Meth. A 1029 (2022) 166430.

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