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Preparation status of missing-mass spectroscopy for Ξ hypernuclei with S-2S magnetic spectrometer

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Abstract. J-PARC E70 experiment measures the missing-mass of Ξ hypernuclei ($^{12}_{\Xi}Be$) in Hadron Experimental Facility at J-PARC. We aim to reach the best missing-mass resolution of 2 MeV/c^2 in FWHM with a new magnetic spectrometer S-2S. The high-resolution spectroscopy of Ξ hypernuclei will play an important role to understand the unknown ΞN interaction. The experiment will start at the beginning of 2023. This article presents the preparation status.

1 Introduction

For the strangeness $S=-1$system, the ΛN interaction has been studied through spectroscopic investigations of Λ hypernuclei at experimental facilities such as KEK, J-PARC, BNL, and JLab. On the other hand, for the strangeness $S=-2$system, the experimental data are scarce. A few events of ΛΛ and ΞN hypernuclei were reported in emulsion experiments [1, 2]. However, the statistics were limited to determine the binding energy and decay width clearly. The data of Ξ hypernuclei which have higher statics and higher precision are awaited to understand the ΞN interaction. The missing-mass spectroscopy for Ξ hypernuclei was done at KEK [3] and BNL [4] in the past. However, they could not observe clear peak structures in the bound region. To further investigate the

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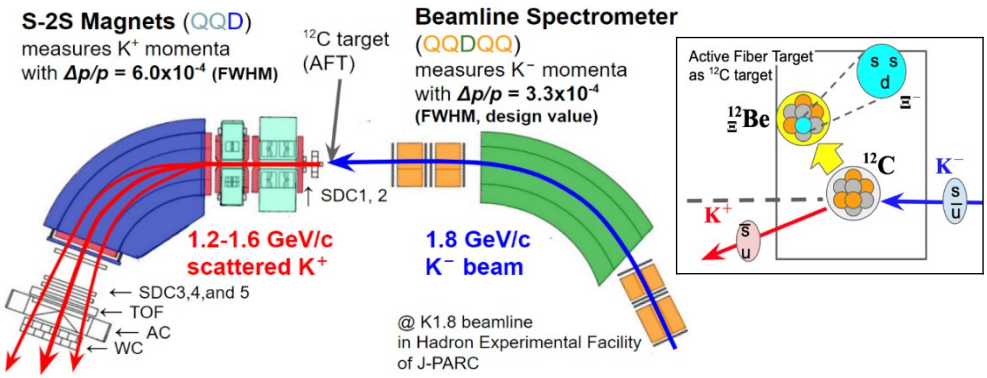
ΞN interaction including spin-dependent forces, peak structures in the missing-mass spectra need to be resolved by better precision experiments. Our goal is to investigate Ξ hypernuclei with the world's highest mass-resolution of 2 MeV/c^2 (FWHM) to study the unknown ΞN interaction [5]. The first target to study is ${}^{12}_{\Xi}Be$ via ^{12}C (K^-, K^+) reaction A new magnetic spectrometer S-2S was designed to realize such a high-resolution spectroscopy of Ξ hypernuclei. Now, S-2S is being installed in the K1.8 beamline at Hadron Experimental Facility of the J-PARC. We aim to make the experimental apparatus ready by the end of 2022, and to start commissioning with the beam at the beginning of 2023. The present article shows the preparation status of the J-PARC E70 experiment [6].

2 Methods and detectors

In J-PARC E70, the high-intensity and purity K^- beam is transported to a ^{12}C target. The K^-



beam which has momenta of 1.8 GeV/c is used for production of Ξ hypernuclei (${}^{12}_{\Xi}Be$) via

Figure 1. Schematics of the experimental setup for J-PARC E70 and the ^{12}C(K^-, K^+)${}^{12}_{\Xi}Be$ reaction.

(K^-, K^+) reaction. The missing-mass is reconstructed by using momenta of K^- beam and scattered K^+. These momenta are obtained by beam-optics analyses of the K1.8 beamline spectrometer and S-2S (Fig. 1). The designed momentum resolutions are $\Delta p/p = 3.3 \times 10^{-4}$ and 6.0×10^{-4} in FWHM, respectively. An information about positions and angles for the momentum analysis is measured by a tracking analysis with 5 drift chambers (SDC1–5). Particles passing through S-2S are not only K^+s, but also 100–1000 times more π^+s and
protons as background. For K^+s identification, an aerogel-Cherenkov detector (AC) and a water-Cherenkov detector (WC) are installed. AC and WC suppress π^+s and protons, respectively. Time-of-flight information to identify K^+ is obtained by plastic-scintillation detectors (BH2 and TOF). In addition, one of important detectors for E70 is active fiber target (AFT). AFT is not only used as the ^{12}C target, but also measures energy loss of particle in AFT to prevent a deterioration of resolution due to the energy straggling. Table1 shows the specifications of detectors for E70.

3 Preparation status

The preparation is in progress for a commissioning beam time in January 2023.

3.1 S-2S magnets

S-2S magnets were newly designed and constructed. The magnetic fields for typical positions were measured in 2016 [7]. In January 2022, S-2S magnets were installed at the K1.8 beam line. S-2S magnets were excited several times to check the field stability.

3.2 Active fiber target (AFT)

An operation test for a single fiber was performed in RCNP in 2017 [8]. A test for multi-channelized fibers was performed in ELPH, in 2019 [9]. The design of the frame is currently in progress, and AFT will be installed in October 2022.

3.3 Drift chambers

SDC1, 3–5 were used in the former experiment at K1.8 beamline. On the other hand, SDC2 is a new drift chamber. A commissioning of SDC1–5 with a radiation source was performed. SDC3–5 were installed in May 2022, and a cabling of their signals was completed in September. SDC1 and 2 will be installed in September 2022.

3.4 PID counters

TOF and WC [10, 11] were newly designed. On the other hand, AC was used for the experiment a long time ago. The condition of silica aerogel tiles as radiator was checked, and they were reloaded in April 2022. TOF and AC were installed in July 2022. WC will be installed in September 2022.

4 Summary

The missing-mass spectroscopy of Ξ hypernucleus ($^{12}_{\Xi}Be$) is planned to be carried out in 2023 at the K1.8 beam line in J-PARC. We designed a new magnetic spectrometer S-2S to realize the highest resolution of 2 MeV/c^2 (FWHM) in a resulting mass spectrum. The installation for S-2S is in progress, and S-2S is going to be ready for the experiment by the end of 2022. The commissioning with the beam is going to start at the beginning of 2023.

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