First physics data of the J-PARC E15 Experiment

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1 Introduction

The $\bar{\mathrm{K}}$N interaction has been determined to be strongly attractive through extensive measurements of the kaonic hydrogen atom and low-energy $\bar{\mathrm{K}}$N scattering. As a consequence of strong $\bar{\mathrm{K}}$N interaction, there are many theoretical predictions of the deeply bound K-nuclear states. In particular, an extensive study on the simplest K-nuclear bound system, $\bar{\mathrm{K}}$NN, has been in progressed on both the theoretical and experimental[1)] sides. Since available experimental information is limited, interpretations of the results are controversial. To completely understand the $\bar{\mathrm{K}}$N interaction, we require more experimental results on various interactions for formation of the $\bar{\mathrm{K}}$NN bound state. The E15 experiment at the K1.8BR beam-line aims to search for the $\bar{\mathrm{K}}$NN bound state[2)] with the in-flight $^3\mathrm{He}(\mathrm{K}^-, \mathrm{N})$ reaction at 1.0 GeV/c. Such measurement allows us to investigate the $\bar{\mathrm{K}}$NN bound state in terms of both its formation via missing-mass spectroscopy and its decay via invariant-mass spectroscopy.

2 Experimental setup

The experimental setup consists of three parts: a high-precision beam-line spectrometer, a cylindrical detector system (CDS) that surrounds a liquid ^{3}He target system, and forward particle TOF detectors. The kaon beam at a momentum of 1.0 GeV/c is identified using an aerogel Cherenkov counter. The kaon beam momentum is analyzed by the beam-line spectrometer, which has a momentum resolution of 2.2 MeV/c at 1.0 GeV/c. The CDS is placed around the target in order to detect decay particles from the $\bar{\mathrm{K}}$NN bound state. The CDS consists of a solenoid magnet, a cylindrical drift chamber (CDC), and a cylindrical detector hodoscope (CDH). The decay particles from the target are detected by the CDS, which has a solid angle coverage of 59% of 4π. With the CDS, we can perform particle identification and track reconstruction (momentum resolution is 5% at 600 MeV/c). A neutron TOF counter (NC), placed 15 m downstream from the center of the target at 0 degrees with respect to the beam direction, measures forward-going neutral particles. The TOF resolution is determined to be 150 ps (σ) using a gamma-ray data sample. The missing-mass resolution of the $^3\mathrm{He}(\mathrm{K}^-, \mathrm{n})$ reaction is estimated to be 9 MeV/c^2 at the region of interest ($P_n \sim 1.2$ GeV/c). The details of the spectrometer system can be found in another paper[3)].

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3 First physics data

The first physics run of the E15 experiment was carried out in May 2013. By irradiating 5×10^9 kaons on the helium-3 target, 3×10^5 forward neutrons were successfully recorded.The accumulated data corresponds to 1% of the statistics requested in the original proposal. Fig 1 shows the missing mass of the $^3\mathrm{He}(\mathrm{K}^-, \mathrm{n})$ reactions measured by the NC. One or more charged tracks are required in the CDS to reconstruct the reaction vertex.

In the spectrum, a peak from the quasi-free reaction $K^- N \to \bar{K} N$ on ^{3}He is clearly seen. The spectrum with K^0_s tagged in the CDS is superimposed on the figure, in which the excess below the $\bar{\mathrm{K}}$NN threshold (2.37 GeV/c^2) is not observed. Therefore the excess below the $\bar{\mathrm{K}}$NN threshold in the semi-inclusive $^3\mathrm{He}(\mathrm{K}^-, \mathrm{n})$ spectrum is barely explained by the detector responses and the quasi-free reaction. Further analysis is in progress to understand the observed spectrum.

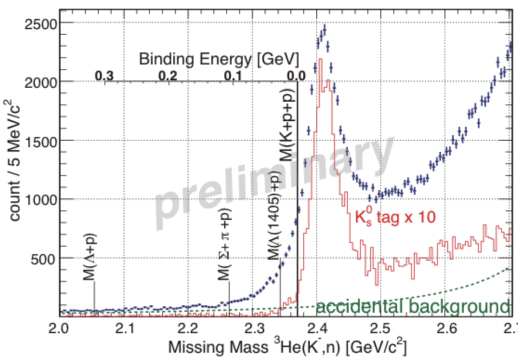

Fig. 1. Missing masses of the $^3\mathrm{He}(\mathrm{K}^-, \mathrm{n})$ reactions.

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