

Status of Hypertriton lifetime measurement at J-PARC

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Hypertriton (${}^3_{\Lambda}\text{H}$) is a bound system of a proton, a neutron, and a Λ hyperon. As the simplest hypernucleus, ${}^3_{\Lambda}\text{H}$ provides essential benchmarks for hypernuclear physics. It is naively expected that the lifetime of hypertriton should be similar to that of Λ hyperon ($\tau \sim 263$ ps) because the binding energy is small ($B_{\Lambda} = 130 \pm 50$ keV¹), and thus, the effects from the largely-separated deuteron core are little. However, in the period 2013–2018, several heavy-ion-based experiments reported much shorter ${}^3_{\Lambda}\text{H}$ lifetime than that of Λ hyperon, by up to $\sim 30\%$.²⁾ In combination with new precise mass measurements being performed by other groups, we aim to provide an independent measurement of the hypertriton lifetime by a counter-based experiment and pin down the puzzling situation.

We employ the (K^{-}, π^0) reaction at 1 GeV/ c to produce hypertritons almost at rest and obtain a direct time-domain measurement of the decay time. The spin-none-flip nature of this production channel eliminates the possible contamination of spin 3/2 excited states, and the time-domain measurement is complementary to the decay-length measurement in the heavy-ion-based experiments. The challenge is identification of the (K^{-}, π^0) reaction. Our idea is just to tag one high-energy γ ray from the forward-going π^0 decay and identify the hypernucleus production using the monochromatic momentum π^{-} from the two-body decay, ${}^3_{\Lambda}\text{H} \rightarrow {}^3\text{He} + \pi^{-}$. The experiment was approved as J-PARC E73 to be performed at the K1.8BR beamline in the Hadron hall.

Figure 1 shows the experimental setup of J-PARC E73 as of 2024. The K^{-} beam comes from the left, and hypertriton is produced in the liquid helium-3 target at the solenoid spectrometer's center. Forward-going π^0 is tagged by detecting a high-energy γ ray with the electromagnetic calorimeter consisting of PbF₂ and PbG crystals. Then, the hypertriton is identified from its decay π^{-} measured with the solenoid spectrometer. The decay time is also reconstructed with the TOF counters in the solenoid. The solenoid spectrometer is the one we developed for the kaonic nucleus experiments.³⁾

Table 1 summarizes the data-takings of J-PARC E73. We have already performed a proof-of-principle experiment using a helium-4 target in 2020, with which we reported the lifetime of ${}^4_{\Lambda}\text{H}$.⁴⁾ Then, in 2021, we acquired test data with a helium-3 target and successfully observed a signal of hypertriton production. In 2024, after the new installation of a vertex detector made of plastic scintillation fibers and the enhancement of the calorimeter acceptance, we finally started

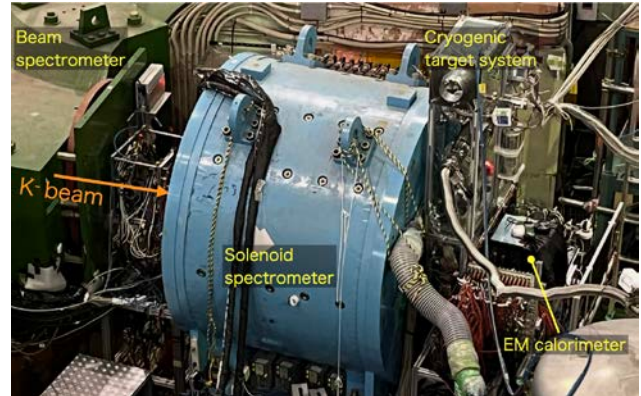


Fig. 1. Experimental setup for J-PARC E73.

Table 1. Data summary of J-PARC E73. The experimental setup was upgraded after (2).

	period	target	# of K^{-} on target
(1)	May–Jun. 2020	liq. ${}^4\text{He}$	6.0×10^9
(2)	May–Jun. 2021	liq. ${}^3\text{He}$	11.3×10^9
(3-1)	Apr. 2024	liq. ${}^4\text{He}$	5.5×10^9
(3-2)	Apr. 2024	liq. H_2	2.9×10^9
(3-3)	Apr.–Jun. 2024	liq. ${}^3\text{He}$	24.6×10^9
(4-1)	Jan. 2025	liq. ${}^4\text{He}$	5.7×10^9
(4-2)	Jan.–Feb. 2025	liq. ${}^3\text{He}$	$\sim 30 \times 10^9$ (scheduled)

the main physics campaign to measure the hypertriton lifetime. We will complete the data-taking in early 2025, and hope to publish the results in the near future. The solenoid spectrometer will end its role at J-PARC with the present experiment and will be transported to RIKEN-RIBF.

Finally, we would like to remark that the dataset of J-PARC E73 is also useful for studying kaonic nuclear states, such as “ $K^{-}pp$ ” and “ $K^{-}ppn$,” and it bridges to the future project with an upgraded solenoid spectrometer under construction.

References

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