The Experimental Landscape for Strange Hadron Physics with HypTPC at J-PARC

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Content

The J-PARC Hadron Experimental Facility offers a unique environment for exploring the structure and interactions of hadrons containing strangeness. It provides high-intensity hadron beams—$\pi^{\pm}$, $K^{\pm}$, p, and $\bar{p}$—around GeV/c, enabling precision studies of hyperon spectroscopy and strangeness nuclear physics. Central to several of these efforts is the HypTPC: a large-acceptance, three-dimensional time projection chamber capable of measuring decay particles, and optimized for reconstructing multi-particle final states with excellent spatial and momentum resolution. In this presentation, we provide an overview of the current and planned experimental programs using HypTPC, with an emphasis on their contributions to strange hadron physics.

We highlight five HypTPC-based experiments that have already been proposed and approved at J-PARC. The J-PARC E42 experiment, conducted in 2021 at the K1.8 beamline, aims to search for the long-predicted H-dibaryon via the ^{12}C(K^-, K^+) reaction at 1.8 GeV/c. Several thousand ΛΛ events have been identified in the preliminary analysis, and the ΛΛ invariant mass spectrum is now starting to unfold. In parallel, analyses of other observables are also in progress, including the Ξ^- conversion spectrum, Ξ^- polarization, and possible signals of kaonic nuclear states. The upcoming E72 experiment targets a narrow Λ* resonance near the Λη threshold (~1665 MeV), as indicated by earlier experimental observations. The observed angular distributions suggest a possible spin-3/2 state not listed in the current PDG, which may indicate a candidate for an exotic hadronic state beyond the quark model. The experiment will determine the spin and parity through measurements of the p(K^-, Λ)η reaction and Λ polarization. In addition, by precisely measuring the shape of the threshold cusp near the Λη threshold using the differential cross sections of K^-p and πΣ channels, the Λη scattering length will also be extracted.

The E45 experiment investigates the spectrum of N* and Δ* resonances via $\pi p \to \pi\pi N$ and $\pi p \to KY$ reactions in the 1.5–2.15 GeV energy range, aiming to clarify the structure of poorly established baryon states. These channels are essential for exploring resonances that strongly couple to $\pi\pi N$ final states, which are difficult to observe in other reactions. In particular, the $\pi N \to K\Lambda$ and $K\Sigma$ channels provide critical access to baryon resonances with significant couplings to strange final states. These reactions are essential for identifying missing resonances that may decay weakly into πN but strongly into KY, thereby offering insight into the role of strangeness in baryon structure. The E90 experiment will measure the ΣN cusp structure in the d(K^-, π^-) reaction at 1.4 GeV/c, aiming to determine the ΣN scattering length through a precise measurement of the near-threshold behavior. This study is of fundamental importance for understanding hyperon–nucleon interactions and the role of coupled-channel dynamics in few-body systems with strangeness. The E104 experiment will study $\varphi\varphi$ production in the $\bar{p}p$ reaction near threshold, aiming to investigate the unusually large OZI rule violation and potential contributions from gluonic or multiquark intermediate states. This measurement may shed light on the role of hidden strangeness in hadronic interactions and offers a promising avenue to explore exotic states such as glueballs or tetraquarks that may contribute to $\varphi\varphi$ production dynamics.

In addition to these approved experiments, new HypTPC-based programs are under development. These include a proposed search for the pentaquark Θ^+ and future hyperon resonance studies. Together, these HypTPC-based experiments cover a wide range of topics in strange hadron physics, from hyperon interactions to the search for new and unusual hadronic states.

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