Experiments to search for deeply-bound kaonic nuclear states E471/E549

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The low energy $\overline{K}N$ interaction studied at KEK-PS E228 by means of energy shift and the level broadening of the kaonic hydrogen atom [1], which shows strong upward shift of the atomic 1s level due to the $\overline{K}N$ interaction. This experiment solves long standing problem, so called "kaonic hydrogen puzzle", and it open the theoretical interpretation that the $\Lambda(1405)$ could be a meson-baryon bound state instead of conventional three-quark sub-threshold resonance below K^-p. By assuming that the $\Lambda(1405)$ to be a K^-p bound state, Akaishi and Yamazaki predicted meta-stable bound state of kaon in several light nuclei [2]. They predicted that the deeply bound kaonic state forms in extremely high nucleon density due to the strong attractive nature of the $\overline{K}N$ interaction in isospin $T = 0$ channel below threshold. The experimental study shows that one can seach such state by observing $(K^- \ {}^4\mathrm{He})_{\mathrm{atomic}} \rightarrow < \mathrm{K^-ppn} >^{\mathrm{T=0}} + \mathrm{n}$ reaction most easily.

Recently, we have been working on experiments to search for such a extremely exotic state extensively by KEK-PS E471 and E549 (dedicated), and E570 (parasitic). In these experiments, we had applied stopped K^- ^{4}He reaction to detect mono-energetic nucleon production by means of time-of-flight (TOF) method. The first result from E471 is published in reference [3], which shows mono-energetic peak formation in the proton spectrum at around 3115 MeV in the missing energy. Observed peak is out of our expectation in many ways. If we assume that the observed peak to be a bound state, then the kaon binding energy is more than twice deeper than predicted and the isospin of the peak should be one instead of zero. It is also true that the E471 experimental apparatus is dedicated for neutron spectroscopy and not for proton. In fact, there is no tracking device for the proton so that the obtained proton spectrum is not inclusive spectrum but requires one additional charged particle to pin down the kaon reaction point as a vertex of the TOF start.

The neutron spectrum, we have obtained in E471, also shows very interesting structure at the similar missing mass as proton's one [4]. However, the statistics of the observed structure is not strong enough to conclude in a definitive way.

Therefore, to study more detail of the proton spectrum and also to have enough statistics for neutron spectrum, we proposed upgraded experiment E549.

Fig. 1 shows our experimental setup for E549/E570. The biggest difference from E471 experimental setup is the newly installed proton tracking devices (two-layers of TOF

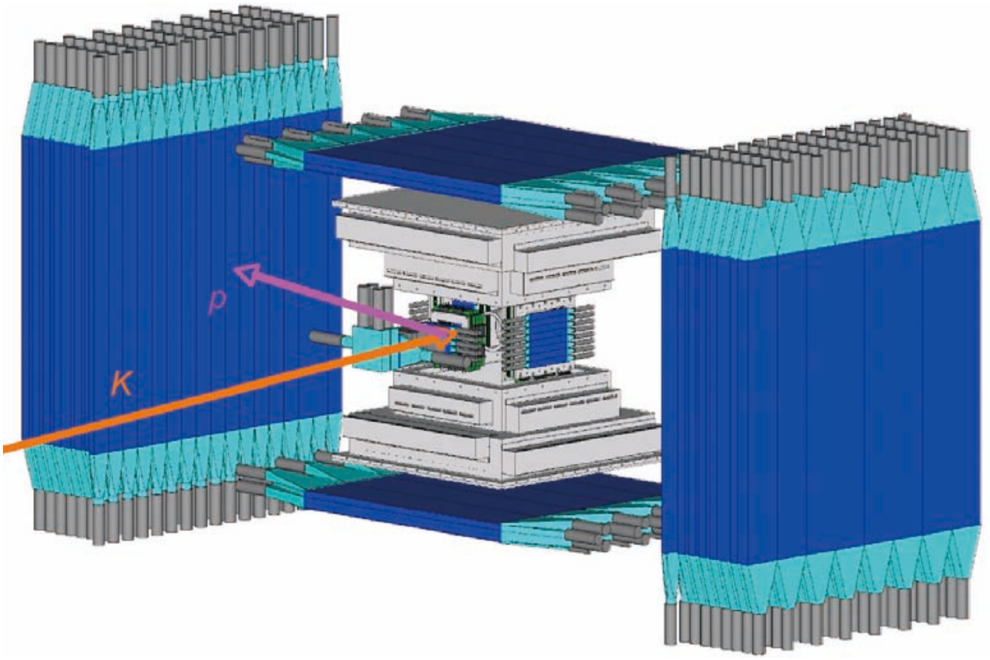

Figure 1: Upgraded experimental setup for E549/E570

counter walls, and a four-layered drift chamber in both left- and right- arms dedicated for proton). To improve statistics of the neutron spectrum, neutron counter walls are also upgraded from four to 7 layers with better neutron shielding around K5 beam-line, which enables us to reduce the threshold level of the neutron counter so as to have better efficiency. In the present setting we are able to detect neutron with 2.5 times better efficiency than before.

As described, the nucleon spectroscopy from the kaon stopped in the liquid helium target was extended to E570 to have enough statistics for the neutron spectrum as a parasitic mode to the experiment until the end of year 2006, which is described in the separate report. Presently, we are extensively analysis on the whole data set. Because of the limitation of the human resource for the analysis, we are proceeding he analysis in two independent analysis teams for the data no to have biased result, we are not yet reached to be able to discuss both neutron and proton data.

References

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