KEK-PS E570
– Precision spectroscopy of Kaonic Helium $3d \rightarrow 2p$ X-rays –

In E570, we have measured the strong-interaction shift of $3d \rightarrow 2p$ X-rays of kaonic helium 4 atom with a precision better than $\sim$2 eV. The measurement will give the answer to the longstanding "kaonic helium puzzle" and provide a crucial information to understand the basis of the Akaishi-Yamazaki prediction of deeply-bound kaonic nuclei [1] being one of the interpretations of the strange multibaryon candidates recently reported at KEK [2], DAΦNE [3] and BNL [4].

The experiment E570 was performed in October 2005 for the beamtime of 80 shifts and in December 2005 for the extension beamtime of 40 shifts. In E570, a significant improvement over the past experiments [5, 6, 7] was achieved by incorporating the following:

- **SDDs** : Instead of a conventional Si(Li) X-ray detector, we used eight silicon drift detectors (SDDs). In the SDD, the electrons produced by an X-ray hit are radially drifted toward the anode at the center and are collected there, so that the anode size (and hence its capacitance) can be kept small, independent of the detector area. This results in a good energy resolution despite a large effective area of some 100 mm^2. In addition, the small anode area makes it possible to reduce the active layer thickness, while still keeping the small capacitance. The thin active layer (260 μm in the case of E570 SDDs, compared with 4 mm for Si(Li) counters used in the past experiments) helps reduce continuum background caused by the soft-Compton process. The typical energy resolution is $\sim$185 eV (FWHM) at 6.4 keV which corresponds to the energy of $3d \rightarrow 2p$ X-rays of kaonic helium atoms.

- **Fiducial volume cut** : Continuum background events could be drastically reduced by applying a "fiducial volume cut", which requires that the reaction vertex obtained by tracing an incident kaon and a secondary charged particle is within the liquid helium volume. With the fiducial cut, a good S/N ratio of $\sim$4 was achieved as shown in Fig. 2, which is about 5 times better than that of the past experiments.

- **In-beam energy calibration** : The energy calibration was done by characteristic X-rays induced by the incident beam (mainly contaminating pions in the kaon beam) on pure titanium and nickel foils, and simultaneously measuring the kaonic helium atom X-rays. Since the energy of the $3d \rightarrow 2p$ kaonic helium atom X-ray, $\sim$6.4 keV, lies between the characteristic X-ray energies, 4.5 keV(Ti) and 7.5 keV(Ni), this will provide an accurate in-situ calibration. Figure 1 shows a characteristic X-ray spectrum for a typical SDD with calibration self trigger. We have observed 4.0×10^3 titanium K_α X-rays per one shift (8 hours) for each SDD.

Figure 2 shows a preliminary kaonic helium atom X-ray energy spectrum for about 50% of the total E570 statistics. The $3d \rightarrow 2p$ peak at $\sim$6.4 keV has been clearly observed, together with other transitions feeding the $2p$ state, $4d \rightarrow 2p$ and $5d \rightarrow 2p$. In total, E570 accumulated about 1.5×10^3 counts of nearly background-free $3d \rightarrow 2p$ X-rays, which implies, with a 185 eV (FWHM at 6.4 keV) resolution, we will achieve a statistical error of $\sigma \sim 2$ eV (=185/2.35/$\sqrt{1.5 \times 10^3}$ eV). The offline analysis including the systematic error estimation is now in progress.

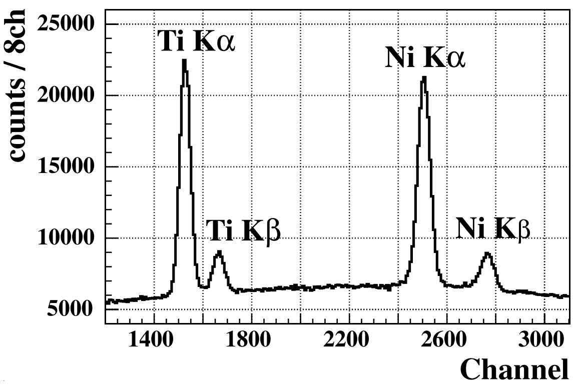

Figure 1: A typical characteristic X-ray spectrum with calibration self trigger.

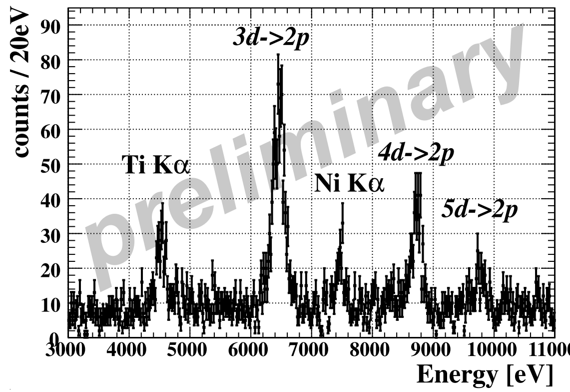

Figure 2: Preliminary kaonic helium atom X-ray energy spectrum for half of all E570 statistics.

References

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