

(LNS Experiment : #2552, #2565)

Study of Neutral Kaon Photo-Production at LNS-Tohoku

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§1. Introduction

The investigation of the kaon production on a nucleon by the electromagnetic interaction provides invaluable information on the strangeness production mechanism, strength of meson-baryon coupling constants and structure of hadrons, being labeled by the strangeness degree of freedom. Such studies using beams of real photons and electrons have been conducted experimentally and theoretically since the 1950's, taking advantage of the electromagnetic interaction that is understood better than the hadronic interaction. Until now, the experimental studies have been carried out in $p(\gamma, K^+)\Lambda$, $p(\gamma, K^+)\Sigma^0$ and $p(\gamma, K^0)\Sigma^+$ reactions among six isospin channels ([1], [2]). However, there are no data for the other three channels on a neutron. Theoretically, phenomenological models have been constructed based on measured channels so far. The isobar models, Kaon-MAID [3] and SLA [4], were adopted in the present analysis. The predictions of the photon energy dependence and the kaon angular distribution of the other three channels on a neutron using these models are quite different.

The lack of the key data for strangeness photoproduction of the three channels on a neutron is due to the experimental difficulties to measure neutral kaons and to prepare a neutron target. The measurement of these three strangeness production channels provides much information on the strangeness photoproduction mechanism. In particular, the $n(\gamma, K^0)\Lambda$ reaction has following features. (1) Since no charge is involved, the t-channel Born term does not contribute. (2) It is a mirror reaction to $p(\gamma, K^+)\Lambda$. For the hyperon resonance exchange terms, a coupling constant, $g_{K\Sigma N}$, changes its sign from the

isospin symmetry, $g_{K^0\Sigma^0n} = -g_{K^+\Sigma^0p}$, resulting the different interference effect. Furthermore, the number of resonances to be considered is small in the threshold region. Therefore, the $n(\gamma, K^0)\Lambda$ reaction is expected to play an essential role to investigate the strangeness photoproduction mechanism.

We have already taken exploratory data quite successfully with use of Neutral Kaon Spectrometer (NKS) at LNS-Tohoku in 2003 and 2004. We intend to extend the previous experiment by considerably upgrading the original neutral kaon spectrometer to a completely new neutral kaon spectrometer (NKS2), fully replacing the spectrometer magnet, tracking detectors and all the trigger counters. The new spectrometer NKS2 has significantly larger acceptance for neutral kaons compared with NKS, particularly covering forward angles and much better invariant mass resolution. The estimated acceptance of NKS2 is about 3 to 4 times (depend on momentum and model) larger for K_S^0 than that of NKS. Additionally, it is about 8 to 10 times larger for Lambda. With this advantage, we expect simultaneous measurements of K_S^0 and Λ . Additionally, we plan to measure other strangeness production channels and also Λ hyperon polarization in $\gamma + n$ and $\gamma + p$ reactions.

In this report, we present a status of NKS2 experiment. The NKS results are found in elsewhere [5, 6].

§2. The NKS2 Experiment

The NKS2 spectrometer is located the BM4 beam line of the second experimental hall of Laboratory of Nuclear Science (LNS), Tohoku University (see Fig. 1). The incident beam from LINAC has 0.2 GeV of the beam energy and is accelerated up to 1.2 GeV in Stretcher-Booster (STB) Ring. The photon beam is created as bremsstrahlung of electron by a carbon wire at STB Tagger system of Bending Magnet 4 (BM4). There is a dipole magnet which is called the sweep magnet for e^+e^- from photon conversion. The sweep magnet is the same one which is used in the previous experiment NKS.

The spectrometer is placed following the sweep magnet. The main magnet is a dipole which is renovated from a cyclotron magnet of Cyclotron RI center of Tohoku University (it is so called 680 magnet). Detectors of NKS2 are: Inner Hodoscope (IH), Straw Drift Chamber (SDC), Cylindrical Drift Chamber (CDC), Outer Hodoscope (OH), and Electron Veto counter (EV). Figure 2 shows detector position and 3D views are shown in Figs. 3 and 4. The detail description of the beam line and the spectrometer will be shown in the following sections.

§3. Results of the NKS2 experiment

The data taking for commissioning runs was carried out in Jan. Mar, Jun., and Sep. 2006 using the carbon target. During those runs, we had studied detector performance, data acquisition system, and trigger rate. The data taking using NKS2 was done in Nov. and Dec. 2006, and Jan. and Jun. 2007.

A preliminary invariant mass distribution of $\pi^+\pi^-$ pairs in $0.8 < E_\gamma < 1.1$ GeV is shown in Fig. 5. The number of tagged photons for the distribution was 3.2×10^{11} from 2006's runs.

The events that have two tracks and more was selected. The particle identification was done on 2 dimensional cut on TOF and momentum. After positive and negative pions was identified in the same

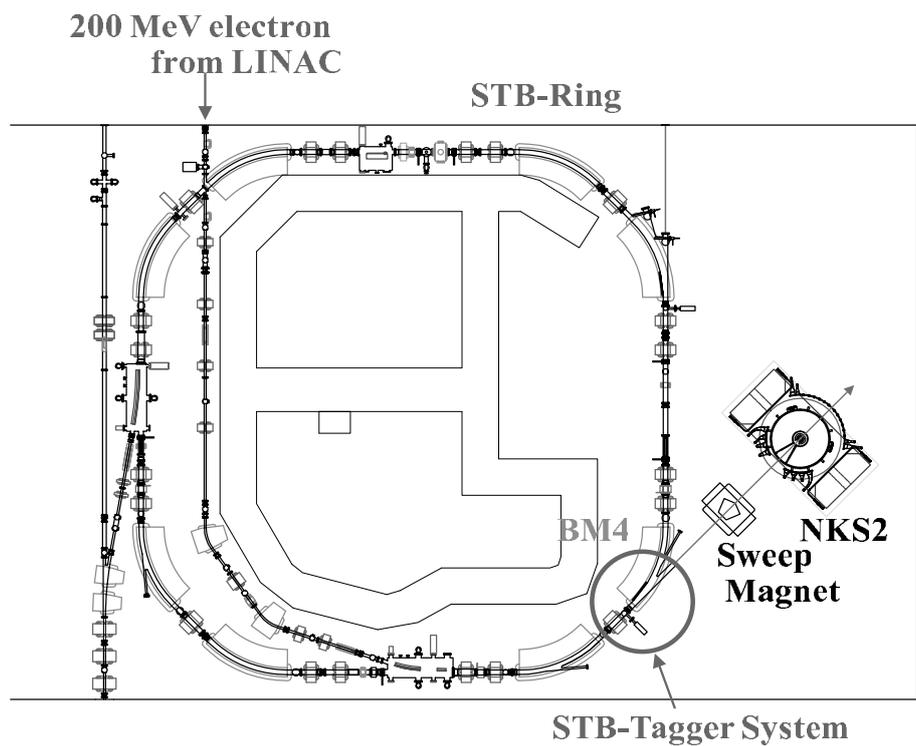


Fig.1. The outline of the second experimental hall of LNS (see text in detail).

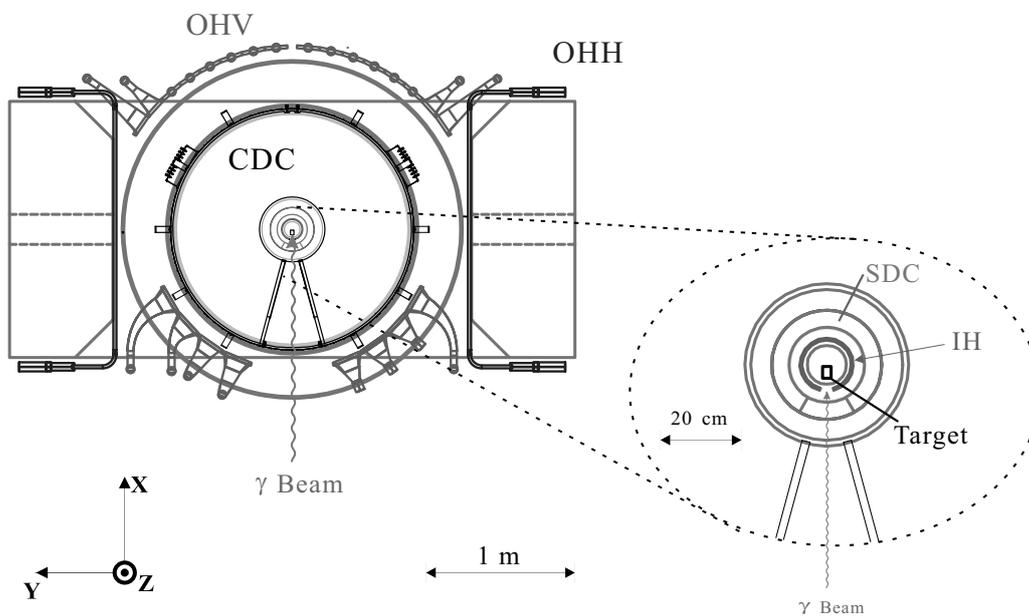


Fig.2. A schematic view of NKS2. The photon beam direction is bottom to top in the figure. The target holder is at center of magnet. The detectors are (the order is center to outer): Inner Hodoscope (IH), Straw Drift Chamber (SDC), Cylindrical Drift Chamber (CDC), Outer Hodoscope (OH, Vertical (OHV) and Horizontal (OHH)), and Electron Veto counter (EV). Note that EV is placed at downstream of OHV but not shown the figure.

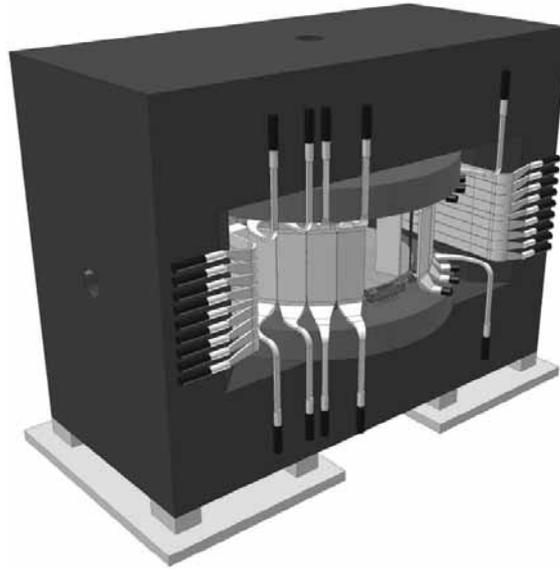


Fig.3. A 3D view of the spectrometer viewed from upstream of beam line. We can see a part of OHH on the magnet yoke and OHV around magnet coil.

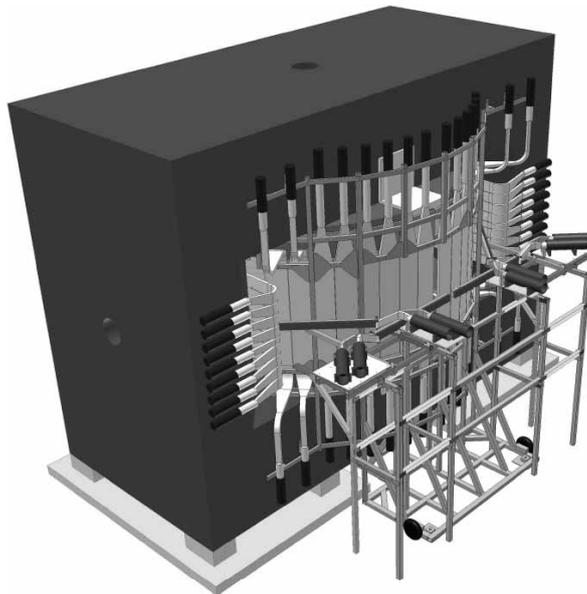


Fig.4. A 3D view of the spectrometer viewed from downstream of beam line. There are OHV around the magnet coil and OHH on the magnet yoke. The EV counters are placed following OHV. The OHV and EV counters are supported by aluminum chassis.

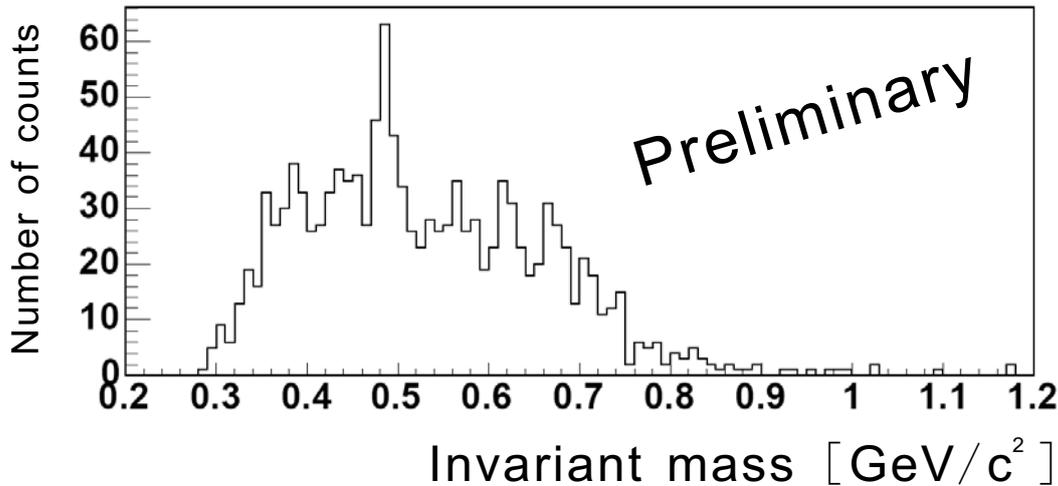


Fig.5. The invariant mass distribution of $\pi^+\pi^-$ pairs in $0.8 < E_\gamma < 1.1$ GeV.

event, the decay vertex was reconstructed from the two tracks. We required $-0.9 < \cos\theta_{OA} < 0.8$ (where θ_{OA} is an opening angle of two tracks) to select K_S^0 candidate. We required an opening angle cut of two tracks to remove e^+e^- background. A decay volume cut was necessary to remove a background of resonances (e.g., ρ , ω). Since photoproduced vector mesons and nucleon resonances decay in the target region and create $\pi^+\pi^-$ background, we did not employ events which have their decay vertex position in the target cell. We employ events which have the decay vertex position at outside of the target cell to remove large contribution of hadronic background.

We have an upgrade plane of the spectrometer, that we will extend the acceptance by changing SDC with a 3D tracking chamber. With this advantage, we expect simultaneous measurements of K_S^0 and Λ . Additionally, we plan to measure other strangeness production channels and also Λ hyperon polarization in $\gamma + n$ and $\gamma + p$ reactions.

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