Search for baryon resonances in the $\gamma p \to \pi^0 \eta p$ reaction at LEPS/SPring-8

T. Matsumura[1,2], J.K. Ahn[3], S. Daté[4], M. Fujiwara[1,2], K. Hicks[5], T. Hotta[1], T. Ishikawa[6], J. Kasagi[7], H. Kawai[8], T. Kinoshita[7], H. Kohri[1], T. Mibe[1,2], K. Miwa[6], M. Miyabe[6], N. Muramatsu[2], T. Nakabayashi[7], H. Nakamura[9], T. Nakano[1], M. Niiyama[6], Y. Ohashi[4], T. Ooba[8], D. Oshuev[10], C. Rangacharyulu[11], P.M. Shagin[12], Y. Shiino[8], H. Shimizu[7], Y. Sugaya[9], M. Sumihama[13,2], Y. Tajima[14], H. Yamazaki[7], T. Yorita[4], H.Y. Yoshida[14], and R.G.T. Zegers[1]

[1] *Research Center for Nuclear Physics, Osaka University, Ibaraki, Osaka 567-0047, Japan*
[2] *Advanced Science Research Center, Japan Atomic Energy Research Institute, Ibaragi 319-1195, Japan*
[3] *Depertment of Physics, Pusan National University, Pusan 609-735, Korea*
[4] *Japan Syncrotron Radiation Research Institute, Sayou, Hyogo 679-5143, Japan*
[5] *Depertment of Physics, Ohio University, Athens, Ohio 45701, USA*
[6] *Depertment of Physics, Kyoto University, Kyoto 606-8502, Japan*
[7] *Laboratory of Nuclear Science, Tohoku University, Taihaku, Sendai 982-0826, Japan*
[8] *Graduate School of Science and Technology, Chiba University, Inage, Chiba, Japan*
[9] *Laboratory of Nuclear Studies, Osaka University, Toyonaka, Osaka 560-0043, Japan*
[10] *Institute of Physics, Academia Sinica, Nankang, Taipei 11529, Taiwan*
[11] *Depertment of Physics and Engineering Physics, University of Saskatchewan, Saskatoon SK S7N 5E2, Canada*
[12] *Department of Physics and Astronomy, University of Minnesota, Minneapolis ,MN 55455 USA*
[13] *Depertment of Physics, Osaka University, Toyonaka, Osaka 560-0043, Japan*
[14] *Depertment of Physics, Yamagata University, Kojirakawa, Yamagata 990-8560, Japan*

Studying the baryon excitation is one of the key issue for understanding the hadron structure. Recent discovery of the pentaquark state (Θ^+) from LEPS collaboration [1] led to new insight into this field. Under such circumstances, understanding the non-strange cryptoexotic states, which are categorized as the member of exotic pentaquark states but have non-exotic quantum number, became important [2, 3]. The N*(1710) and/or N*(1440), where the spin-parity of both states are $J^P = 1/2^+$, are assigned to the candidates of these states by some theorists [4, 2]. However, it surely need further investigation.

The $\gamma p \to a_0(980)p \to \pi^0 \eta p$ reaction might be a good tool when one try to search for a new cryptoexotic baryon in the s-channel. The reason is that a $J^P = 1/2^+$ baryon can decay into a $a_0(980)$ and a proton with s-wave since the $a_0(980)$ is a scalar state ($J^P = 0^+$); therefore, the decay probability would be expected to be high because there is no angular-momentum barrier comparing to the case of the decay to a pseudo-scalar meson and a proton. Furthermore, the $a_0(980)$ resonance has relatively narrow width ($\Gamma \sim$ 50-100 MeV/c^2) among the all low-mass scalar mesons, and it is a well-established resonance. Experimental search for baryon resonances in the decay mode (scalar meson + nucleon) has never been performed. In this report, we discuss the experimental search for new baryon resonances in the γp→ $a_0(980)$p reaction.

The experiment was held in November, 2001 at the LEPS/SPring-8 facility [5]. The main experimental device was a 2π-calorimeter consisting of 252 modules of lead scintillating fiber blocks [6]. The calorimeter was used in order to detect 4-photons coming from π^0 and η decays. We employed CH_2 (50 mm thickness) and carbon (40 mm thickness) targets. The proton-target data were obtained by subtracting the carbon contribution from CH_2 spectra. Totally 469 events for carbon target and 380 events for the CH_2 target were obtained as $\gamma p \to \pi^0 \eta p$ event samples.

Figure 1 shows the invariant $\pi^0\eta$-mass ($M_{\pi^0\eta}$) spectra for each target. A peak around $M_{\pi^0\eta} = 980$ MeV/c^2 was observed in both the carbon and CH_2 data. The peak corresponds

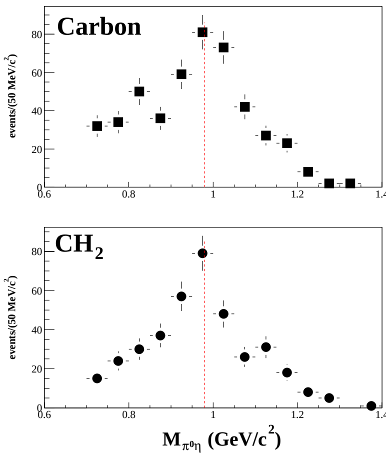

Figure 1: Invariant $\pi^0\eta$ mass ($M_{\pi^0\eta}$) spectra for the carbon and CH_2 samples. The dashed lines indicate the position of $M_{\pi^0\eta} = 980$ MeV/c^2.

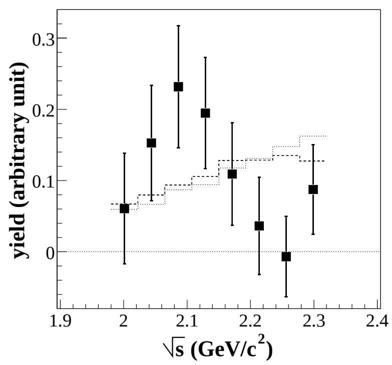

Figure 2: $\sqrt{s}$ distribution for the proton target. The histograms show the distributions obtained by a MC simulation. (dashed line) $\gamma p \to \pi^0\eta p$ phase space. (dotted line) $\gamma p \to a_0(980)p$ phase space.

to the scalar-isovector $a_0(980)$ resonance which couples strongly to the $\pi^0\eta$ system [7].

The distribution of the $\sqrt{s}$ (energy of the γp CM-system) for the proton-target data is shown in Fig. 2. The distribution shows a resonance-like structure at around 2.1 GeV/c^2. The mass and the width of the resonance were estimated by assuming a Breit-Wigner resonance; They were $M = 2080^{+20}_{-20}$ MeV/c^2 and $\Gamma = 100^{+60}_{-20}$ MeV/c^2, respectively. This result might be interpreted that this state is a new baryon resonance that couples strongly to a $a_0(980)$ and a proton.

The statistics are not good enough to confirm whether the baryon resonance really exists or not. Nevertheless, it is worth discussing the spin-parity of the state. The $a_0(980)$ momentum in the CM system is about $k \sim 0.40$ GeV/c; thus, the characteristic parameter kR is 2.0 by assuming $R \sim 1.0$ fm. This means that the dominant contribution to the decay would be s-wave or p-wave. Therefore, the spin-parity of the state would be $J^P = 1/2^+$ for s-wave, and $J^P = 1/2^-$ or $3/2^-$ for p-wave. The iso-spin of the resonance is either $I = 1/2$ or $I = 3/2$ since the $a_0(980)$ is a iso-vector state. In order to improve the data statistics, we are now performing a data analysis with new data which have been taken in the autumn of 2003.

One of the authors (T.M.) would like to thank Dr. A. Hosaka (RCNP), Dr. M. Koma (MPIM), and Dr. A. Titov (JINR) for helpful discussion.

References

[1] T. Nakano *et al. Phys. Rev. Lett.* **91**, 012002 (2003)
[2] R. Jaffe and F. Wilczek *Phys. Rev. Lett.* **91**, 232003 (2003)
[3] R.A. Arndt *et al. Phys. Rev.* D **69**, 035208 (2004)
[4] D. Diakonov, V. Petrov and M.V. Polyakov *Z. Phys.* A **359**, 305 (1997)
[5] T. Nakano *et al. Nucl. Phys.* A **684**, 71c (2001)
[6] T. Matsumura *et al. Nucl. Phys.* A **721**, 723c (2003)
[7] K. Hagiwara *et al. Phys. Rev.* D **66**, 010001 (2002)