Measurement of ϕ decay asymmetry in $\vec{\gamma}d \to \phi d$ reaction

K. Horie[1], S. Shimizu[1], T. Nakano[1], and W.C. Chang[2] on behalf of the LEPS collaboration
[1] *Research Center for Nuclear Physics (RCNP), Osaka University, Ibaraki, Osaka 567-0047, Japan*
[2] *Institute of Physics, Academia Sinica, Taipei 11529, Taiwan*

The diffractive photoproduction of ϕ-mesons has been used to study the Pomeron exchange process and to look for a exotic daughter Pomeron trajectory associated with a glueball ($J^{PC} = 0^{++}$) [1]. This is because the baryon and meson exchange amplitudes in the s- and t-channels are suppressed by the Okubo-Zweig-Iizuka (OZI) rule. However, isovector π exchange still contribute to the ϕ photoproduction which makes extraction of the true exotic channel difficult. One of the possible solution to eliminate the π-exchange contribution is to use an isoscalar target such as deuteron. Here, we present a new measurement of decay asymmetry of ϕ meson with respect to the direction of photon polarization in the $\vec{\gamma}d \to \phi d$ reaction. The experiment was performed at the SPring8 facility by using linearly polarized photons in conjunction with the LEPS spectrometer system [2, 3].

Photons with a maximum energy of 2.4 GeV were produced from backward-Compton scattering of 351-nm Ar laser off 8-GeV electrons in the SPring-8 storage ring. The ϕ mesons produced in the liquid-deuterium target were analyzed by detecting K^+ and K^- from the ϕ decay. Chagred patricle momentum was determined by using a silicon-strip vertex detector and three drift chambers. Kaons were identified by the measured time-of-flight between the TOF counters. The missing-mass $MM_{\gamma\phi}$ calculated by assuming the $d(\gamma,\phi)X$ kinematics is shown in Fig. 1(a). Backgrounds from the quasi-free $N(\gamma,\phi)N$ reaction were studied by a Monte Carlo simulation taken into account Fermi motion and off-shell effect in deuteron system. Fig. 1(b) shows the background-subtracted $MM_{\gamma\phi}$ distribution where peak position and peak width are consistent with deuteron rest mass and the expected value, respectively. The ϕ events were extracted by requiring $MM_{\gamma\phi} < 1.9$ GeV/c^2 .

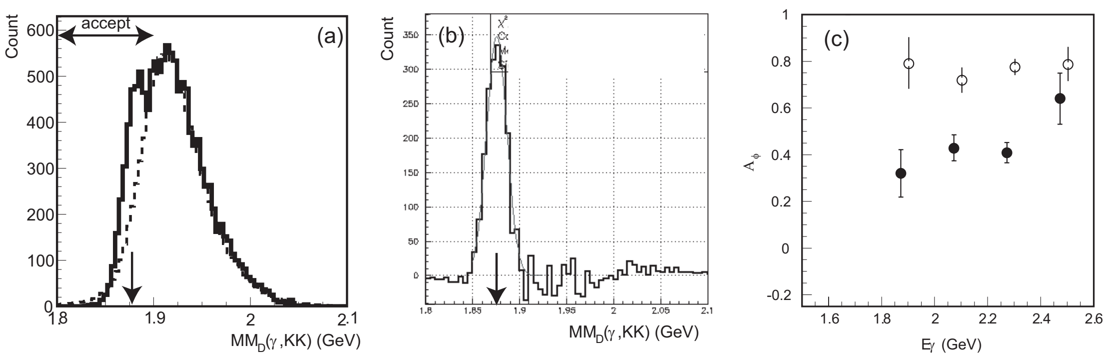

Figure 1: (a) missing mass spectra for the data (solid) and the simulation(dashed) (b) background subtracted missing mass. Arrows in (a) and (b) correspond to deuteron rest mass. (c) is ϕ decay asymmetry as a function of the photon energy for $d(\gamma,\phi)d$ (open) and $p(\gamma,\phi)p$ (closed).

The ϕ decay asymmetry, A_ϕ, is defined as an amplitude of the angular distribution of ϕ decay as [3, 1], $W(\Phi) = 1 + P_\gamma A_\phi \cos 2\Phi$, where P_γ and Φ are magnitude of the photon polarization and K^+ emission angle with respect to the photon polarization direction, respectively. The extracted ϕ events were separated into 8 regions by Φ with every $\pi/4$ step as, $[N(A)]_{pol} = \Omega(A) \cdot Y_{pol} \int_{\pi/4\cdot(A-1)}^{\pi/4\cdot A} W(\Phi) d\Phi$ for $A = 1$–8, where Ω and Y denote the detector acceptance and the number of photons, respectively. *pol* corresponds to the photon polarization direction (HZ or VT). Double ratio quantities between the HZ and VT events were introduced as, $R_1 = [\frac{N(3)N(7)}{N(1)N(5)}]_{\mathrm{VT}}/[\frac{N(3)N(7)}{N(1)N(5)}]_{\mathrm{HZ}}$ and $R_2 = [\frac{N(2)N(6)}{N(4)N(8)}]_{\mathrm{VT}}/[\frac{N(2)N(6)}{N(4)N(8)}]_{\mathrm{HZ}}$. Then, error-weighted average of R_1 and R_2, R, was calculated. Here Ω and Y are automatically canceled out, and A_ϕ was thus derived to be $A_\phi = \frac{1}{P_\gamma} \cdot \frac{\pi}{2} \cdot \frac{1-R^{1/4}}{1+R^{1/4}}$. The ϕ decay asymmetry of the $d(\gamma,\phi)d$ reaction was obtained as a function of the photon energy, as shown in Fig.1(c). It was found that the decay asymmetry is positive, while the A_ϕ value of the deuteron reaction is about twice larger than that of the proton reaction.

References

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