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PRELIMINARY RESULTS ON η' PHOTOPRODUCTION AT GRAAL

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The $\gamma p \to \eta' p$ reaction was studied near the threshold, in the 1.44 GeV$> E_\gamma <$ 1.55GeV energy range with the tagged photons of the former GRAAL experiment. The two neutral decays $\gamma\gamma(\Gamma_i/\Gamma = 2.10 \pm 0.12\%)$ and $\pi^0\pi^0\eta(\Gamma_i/\Gamma = 20.7 \pm 1.2\%)$ were analized and preliminary results of the beam asymmetry were extracted together with the invariant masses.

1. Introduction

Photoproduction of the η' meson from the proton is a very important tool to study the features of the nucleon. $\eta'(958)$ is the heaviest member of the ground state pseudoscalar nonet, with isospin I=0, so for the isospin conservation, the final state $\eta' p$ can only be reached by the formation of N^* nucleon resonances that are I=1/2 intermediate states. For this reason the $\gamma p \to \eta' p$ reaction acts as an "isospin filter" for the nucleon resonance spectrum, and it can be used to investigate and isolate individual excited states and its specific contributions, often difficult to be

studied due to the wideness and overlapping of the resonances. The data for the photoproduction of the η' mesons off the nucleon were very scarce up to 1998: only in the last years differential cross sections were measured with a good statistics at CLAS and SHAPIR collaborations, but there are no yet available data of the beam asymmetry for this reaction.

2. Experimental Apparatus

The GRAAL experiment was performed with the highly polarized photon beam produced by the Compton backscattering of laser light against the 6.03 GeV electrons of the ESRF storage ring. The laser light is almost 100% linearly polarized and the polarization of the scattered photons with the maximum allowed energy, $E_{\gamma max}$, is very close to that of the laser light. Through the use of green or multiple UV laser lines, two overlapping energy regions, from 500 to 1100 MeV and from 650 to 1500 MeV, respectively, can be covered with different polarization degrees. Using the "Far-Uv" line of the laser, it was possible to extend the energy to 1.55 GeV. The coupling of the Graal beam with a large acceptance detector covering $0.95 \cdot 4\pi$ solid angle with cylindrical symmetry (Lagranγe apparatus) was used in order to measure the beam polarization degrees of freedom, in particular the Σ beam asymmetry, with very small systematic errors. For the studied $\gamma p \rightarrow \eta' p$ reaction, we can highlight two fundamental parts of the Lagranγe apparatus, that was fully described in Ref.:[1]

(i) the central part, used to identify the photons coming from the η' decay channels by the BGO calorimeter,covering laboratory angles $25^\circ < \theta_{lab} < 155^\circ$ and having an excellent energy resolution for photons;
(ii) the forward direction part at $\theta_{lab} < 25^\circ$, used to identify protons by the two plane wire chambers, two scintillator walls and a Forward Shower detector.

At GRAAL was possible to use a liquid Hydrogen or Deuterium target, and for the present analysis we considered only the data taken with Hydrogen target.

3. Data Analysis

The treshold for the η' photoproduction is at $E_\gamma = 1.447$ GeV. For this reason we analyzed only the period of data collected with UV and "Far-UV" lines of the laser, in order to have available an energy range from the treshold up to 1.55 GeV. Our study of the above-mentioned reaction in the frame of two-body relativistic kinematics, confirmed us that the reaction dynamic lead to products peaked in the forward direction for both η' and proton in the final state. Fig.1 shows this condition, where the angle of the studied meson, $\theta_{\eta'}$, is plotted versus the proton angle θ_p.

This provided us a good first costraint for the data analysis, because only events producted with $\theta < 18^\circ$ can be selected. After this first selection, we proceed to analyze the two following decay modes of the $\eta'(958)$ meson:

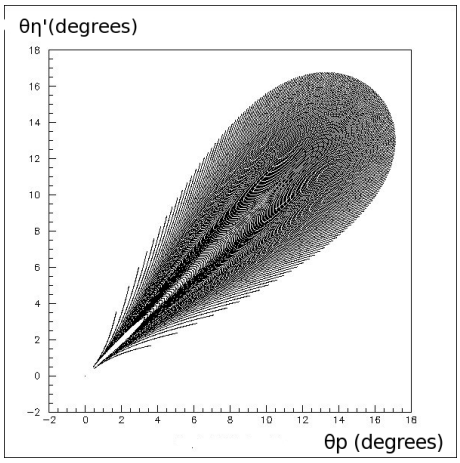

Fig. 1. $\theta_{\eta'}$ vs.θ_p for the interested events.

(i) $\eta' \to \gamma\gamma$
(ii) $\eta' \to \eta\pi^0\pi^0$.

3.1. $\gamma\gamma$ *decay mode*

For this decay mode, the statistics was found to be very poor. The selected events are 20% of the total UV and Far-UV data. Fig.2 shows the invariant mass. It demonstrates that the channel is well indentified, but the statistics of such events it's not enough to obtain a reliable beam asymmetry Σ.

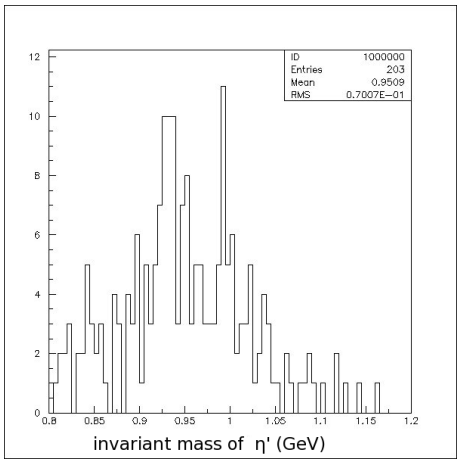

Fig. 2. Invariant mass for the η' photoproduction, by the $\gamma\gamma$ decay mode.

3.2. $\eta\pi^0\pi^0$ decay mode

The analysis of this decay mode is based on the identification of the η and the two π^0 pions in the BGO, by the three couples of photons in which they decay. So it is needed to collect events with six photons in the BGO, in coincidence with a proton in the forward direction. The identification of π^0 and η follows the method described in Refs..[2,3] A bidimensional cut was applied to analyze this decay mode of η', and it is based on the measured mass of the two π^0 mesons by the following condition

$$\sqrt{(M_{\pi_1^0} - M_{\pi^0})^2 + (M_{\pi_2^0} - M_{\pi^0})^2} < 0.05 GeV. \quad (1)$$

where $M_{\pi_1^0}$ and $M_{\pi_2^0}$ are the measured mass of the two pions, and M_{π^0} is the mass of the π^0 as in literature. The effects of this cut is shown in Fig.3, where the black curve represents data before the cut, and the red one after the bidimensional cut.

The shape of the invariant mass is more clear in Fig.4, where the red line represents the invariant mass after the bidimensional cut and the green line is the results when an additional cut on the mass of the η of the decay ($M_\eta < 0.45$ GeV) is considered.

In the case of the present channel we extracted the beam asymmetry Σ and such preliminary results are reported in Fig.5.

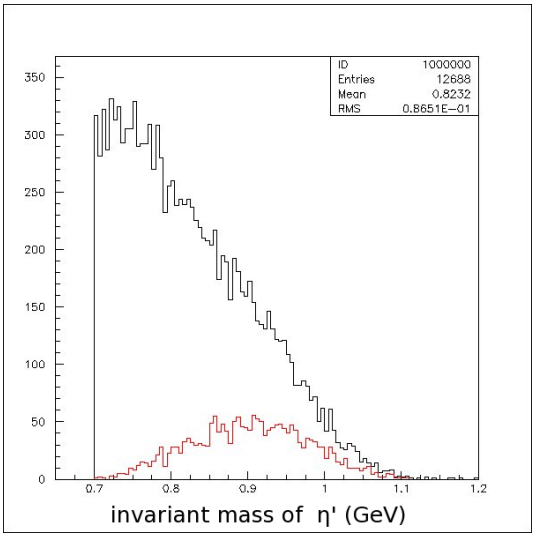

Fig. 3. Invariant mass for the η' photoproduction, by the $\eta\pi^0\pi^0$ decay mode .The black line represents the data before the bidimensional cut, the red one after the cut.

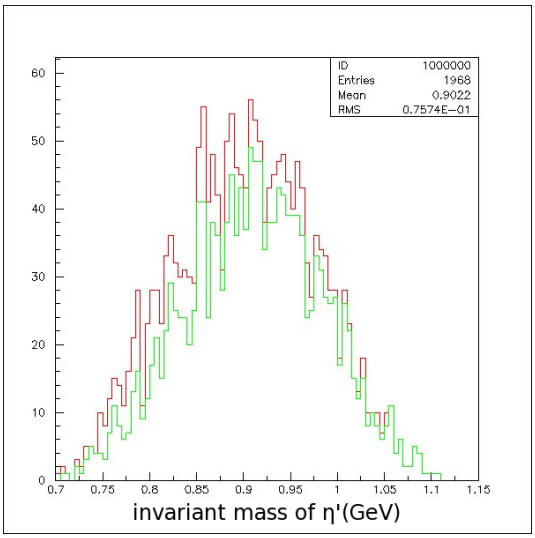

Fig. 4. Invariant mass for η' photoproduction, decay mode $\eta\pi^0\pi^0$ The green line represents the data with the cut on the η of the decay($M_\eta < 0.45$ GeV).

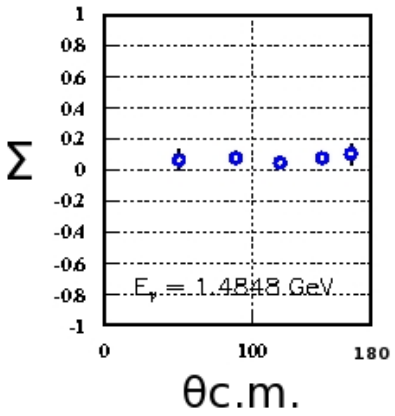

Fig. 5. Preliminary beam asymmetry for the η' photoproduction, by the analysis of the decay mode $\eta\pi^0\pi^0$.

4. Conclusions

The invariant mass for the η' photoproduction near the threshold in the γp interaction for the two $\gamma\gamma$ and the $\eta\pi^0\pi^0$ decay modes were presented. Very preliminary re-

sults of the beam asymmetry Σ were extracted for one energy bin $1.44 < E_\gamma < 1.55$ GeV in the case of $\eta\pi^0\pi^0$ decay mode.

References

1. O. Bartalini et al., *Eur. Phys. J A* **26** (2006) 399.
2. A. Fantini et al., *Phys. Rev. C* **78** (2008) 015203.
3. R. Di Salvo et al., *Eur. Phys. J A* **42** (2009) 151-157.