

ETA PHOTOPRODUCTION OFF THE NEUTRON AT GRAAL

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The $\gamma n \rightarrow \eta n$ quasi-free cross section reveals a resonant structure at $W \sim 1.675$ GeV. This structure may be a manifestation of a baryon resonance. *A priori* its properties, the possibly narrow width and the strong photocoupling to the neutron, look surprising. This structure may also signal the existence of a narrow state.

Meson photoproduction off the neutron offers an attractive tool to study certain baryon resonances. A single-quark transition model¹ predicts only weak photoexcitation of the $D_{15}(1675)$ resonance from the proton target. Photocouplings to the neutron calculated in the framework of this approach, are not small. An isobar model for η photo- and electroproduction η -MAID² also suggests significant contribution of the $D_{15}(1675)$ to η photoproduction on the neutron.

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Possible photoexcitation of the non-strange pentaquark is of high interest as well. A benchmark signature of this particle (if it exists) is its photoproduction off the nucleon. The chiral soliton model predicts that photoexcitation of the non-strange pentaquark has to be suppressed on the proton and should mainly occur on the neutron⁴. Estimates of the chiral soliton approach ranges its mass to 1.65 – 1.7 GeV⁵. Modified partial wave analysis of πN scattering suggests two possible candidates, at 1.68 and/or 1.73 GeV, with the total width about 10 MeV. Among various reactions, η photoproduction has been considered as particularly sensitive to the signal of this particle^{4,5,6,7}.

Up to now, η photoproduction off the neutron was explored mostly in the region of the $S_{11}(1535)$ resonance from threshold up to $W \sim 1.6$ GeV⁸. The ratio of the $\gamma n \rightarrow \eta n / \gamma p \rightarrow \eta p$ cross sections was extracted and found almost constant near ~ 0.67 . At higher energies, the GRAAL Collaboration reported the sharp rise of this ratio⁹ and the evidence for a resonant structure in the cross section on the neutron at $W \sim 1.675$ GeV¹⁰. Recently the CB/TAPS Collaboration reported similar observation¹¹.

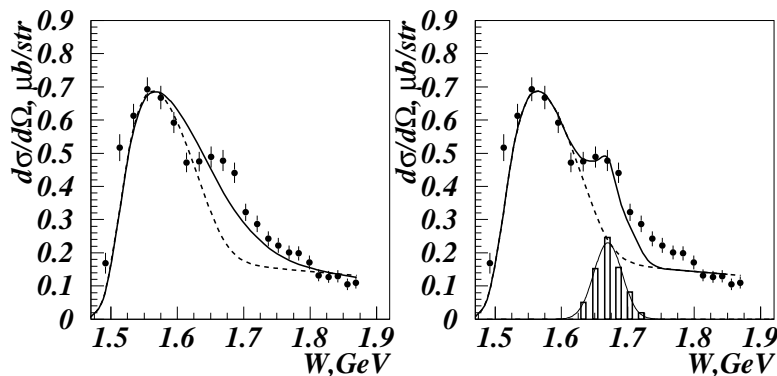


Figure 1. $\gamma n \rightarrow \eta n$ quasi-free differential cross-section at 137° . Left panel: Solid line is the η -MAID prediction folded with Fermi motion. Dashed line is the same prediction without the $D_{15}(1675)$ resonance. Right panel: Dashed area shows the contribution of a narrow state. Solid line is the sum of the η -MAID cross section without $D_{15}(1675)$, folded with Fermi motion, and the narrow state. Dashed line is the same as in the left panel.

Quasi-free ηn differential photoproduction cross section is shown in Fig. 1. The cross section clearly reveals a resonant structure near $W \sim 1.675$ GeV. We compared this cross section with an isobar model for η photo- and electroproduction $\eta - MAID^2$. The model includes 8 main resonances and suggests the dominance of the $S_{11}(1535)$ and $D_{15}(1675)$

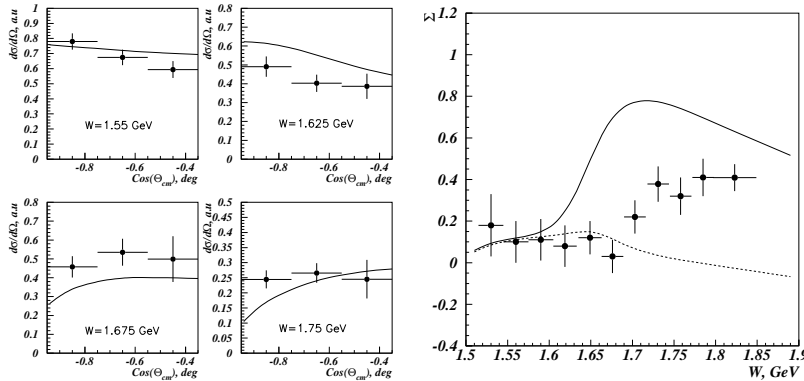


Figure 2. Left panel: angular dependence of the $\gamma n \rightarrow \eta n$ quasi-free cross section. Right panel: $\gamma n \rightarrow \eta n$ beam asymmetry Σ at 137° . Solid lines are η -MAID predictions. Solid and dashes lines are η -MAID predictions with all resonances and without $D_{15}(1675)$ respectively.

resonances in η photoproduction off the neutron below $W \sim 1.7$ GeV^b. The model predicts a bump-like structure near $W \sim 1.675$ GeV in the total η photoproduction cross section on the neutron¹². This structure is caused by the $D_{15}(1675)$ resonance. The η -MAID differential cross section at 137° is smooth (Fig. 1, left panel). η -MAID reasonably reproduces the angular dependence of the cross section while predicts larger beam asymmetries above $W \sim 1.6$ GeV (Fig. 2).

The PDG estimate for the Breit-Wigner width of the $D_{15}(1675)$ resonance is $\Gamma \sim 150$ MeV³. The structure observed in the quasi-free cross section looks more narrow. η -MAID without the $D_{15}(1675)$ resonance fits the cross section in the region of the $S_{11}(1535)$ resonance below $W \sim 1.62$ GeV (Fig. 1). One may assume that above this region there is a contribution of an additional relatively narrow resonance.

In the right panel of Fig. 1, a simulated narrow ($M = 1675$ GeV, $\Gamma = 10$ MeV) state is shown. This state appears as a bump in the quasi-free cross section due to Fermi motion of the target neutron bound in a deuteron target. The sum of the η -MAID without $D_{15}(1675)$ and the narrow state well reproduces the cross section up to $W \sim 1.7$ GeV. At higher energies, the increasing contribution of higher-lying resonances is expected¹³. Thus, the structure in the $\gamma n \rightarrow \eta n$ cross section may signal the existence of a relatively narrow state. If confirmed, such state coincide with the expectation of the Chiral Soliton Model^{4,5} and modified PWA⁶ for the non-strange

^bWe refer to the recent update of η -MAID which includes the corrected helicity amplitude ${}^nA_{\frac{1}{2}}$ of the $D_{15}(1675)$ resonance.

pentaquark. On the other hand, the manifestation of one of usual resonances is not ruled out. *A priori* its properties, the possibly narrow width and the strong photocoupling to the neutron, look surprising. More data and detailed partial wave analysis are needed to identify the nature of the observed structure. New programs to study η photoproduction off the neutron with polarized targets, which are now launched at modern photon factories such as the upgraded MAMI-C Facility (Mainz, Germany), aim to provide experimental data at new level of quality.

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