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η photoproduction in Hydrogen and Deuterium

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Abstract

We present recent Graal results on beam-polarization asymmetries in the photoproduction of η meson on protons and neutrons in Hydrogen and Deuterium for the incoming photon energy range from threshold to 1.5 GeV. Data have been obtained using the tagged and linearly polarized photon beam and the large solid angle apparata of the Graal facility, located at the ESRF in Grenoble (France). The comparisons between the free and bound (in the deuteron)

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proton and between bound proton and bound neutron are shown. In particular we measured for the first time the beam asymmetry Σ in the η photoproduction on the bound neutron. Data have been obtained from a deuteron target, selecting η events from both bound nucleons in the quasi-free kinematics. In this kinematical condition the results obtained from free and quasi-free proton are almost identical within the experimental errors; hence we deduce that nuclear effects are negligible when measuring the beam-polarization asymmetries for η photoproduction on the quasi-free nucleon.

Key words: π, K and η mesons, Polarization in interactions and scattering, Meson production.
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1. Physics at Graal facility

The meson production on the nucleon allows to observe its excited states, the baryon resonances N*, and to infer the mechanisms related to the dynamics of its constituents. The existence of N* resonances was observed for the first time in πN scattering and most of their properties have been extracted from πN data [1]; however the N* resonances are evident in photonuclear reactions as well. Different theoretical models strive to explain the existence and relative contribution of different N*, often poorly experimentally known: so far a lot of N* resonances are not yet observed. The center of mass energy (E_{cm}) range, going from the photoproduction treshold up to 3 GeV, is a suitable range to discover such a "missing" N*, allowing for a clear selection among different theoretical models. The Graal facility in Grenoble [2] is providing a polarized γ ray beam with energy up to 1.5 GeV, whose interesting features are:

- a polarized high duty cycle photon beam covering an energy range where baryonic resonances may be excited;
- a polarization close to unity (which can be easily rotated), a flat energy spectrum and a very small background;
- an under control charged and neutral particle detection setup associated to an effective photon beam tagging system. The Graal detector covers a solid angle close to 4π, including the very small forward angles. The energy resolution of the γ ray beam is ranging from 10 to 15 MeV.

2. Beam asymmetries

At the Graal facility, by using well tested simulation and data analyzing codes and algorithms, we have already published precise measurements of beam polarisation asymmetries and polarised cross sections for $\pi^+\pi^0$ and η photoproduction on the proton. See, as an example, ref. [3]. A recent report on the overall Graal activities is given in ref. [4]. Here we report an update of the recent Graal results about the beam-polarization asymmetries Σ in the photoproduction of η meson, on protons and neutrons in Hydrogen and Deuterium for the incoming photon energy range from threshold to 1.5 GeV. The beam asymmetry Σ is obtained from the azimuthal distributions:

$$\left[\frac{d\sigma_{\parallel}}{d\Omega}\right] / \left[\frac{d\sigma_{\parallel}}{d\Omega} + \frac{d\sigma_{\perp}}{d\Omega}\right] = \frac{1}{2}(1 + P\Sigma cos(2\phi)) \quad (1)$$

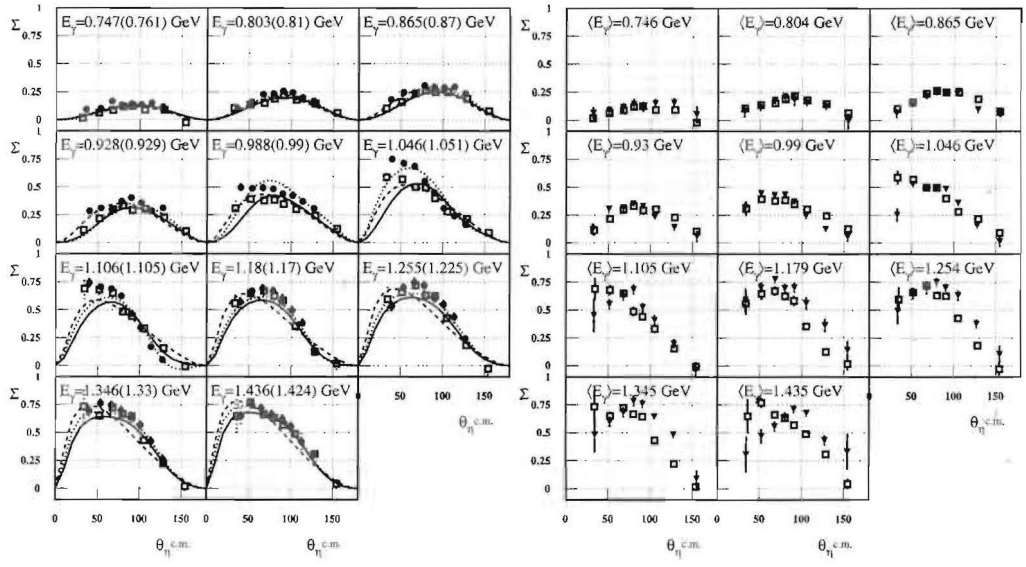

Fig. 1. Left : Beam asymmetries Σ in η photoproduction for the proton (full dots) in ref. [5] and for the quasi free proton in the deuteron (open squares). In dotted lines the predictions of ref. [6] for free proton; in dashed and solid lines those of ref. [7] and [6], respectively, for the quasi free proton. Right: Beam asymmetries Σ in η photoproduction for the quasi free neutron (full triangles) and the quasi free proton in the deuteron (open squares), plotted for eleven energy bins in the θ_η^{cm} angle.

where P is the linear polarization degree of the incident photon and ϕ is the azimuthal angle between the γ polarization direction and the reaction plane. P can be deduced by fitting the experimental azimuthal distributions. The asymmetry measurement is founded on such a method and it is free from absolute errors, that may affect the cross sections.

3. Results

We measured for the first time the beam asymmetry Σ in the η photoproduction on the quasi-free neutron. Data have been obtained from a deuteron target, selecting η events from both quasi-free nucleons in the quasi-free kinematics. Fig. 1 shows that free, quasi-free proton and quasi-free neutron asymmetries are almost identical within the experimental errors and in agreement with previous theoretical calculations [7] ; hence we deduce that nuclear effects are negligible when measuring the beam-polarization asymmetries for η photoproduction on the quasi-free nucleon.

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