First measurement of the helicity dependence of ^{3}He photo-reactions in the $\Delta(1232)$ resonance region

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The first measurement of the helicity dependence for several photo-reaction channels on ^{3}He was carried out in the photon energy range between 150 and 500 MeV. The experiment was performed at the tagged photon facility of the MAMI accelerator in Mainz, using the large acceptance Crystal Ball spectrometer, complemented by charged particle and vertex detectors. A circularly polarised tagged photon beam and a longitudinally polarised high-pressure ^{3}He gas target were used [1]. These new experimental results provide information on the Gerasimov-Drell-Hearn (GDH) sum rule on the neutron and allow an investigation of the nucleon properties inside ^{3}He and of the effects of three-nucleon photon absorption mechanisms. Due to the ^{3}He spin structure, these data give complementary and a more direct access to the polarised neutron with respect to the existing data on the deuteron.
As an example, Fig. 1 shows the helicity-dependent total cross section $\Delta\sigma$ for the reaction channels $\gamma\,^3$He $\rightarrow \pi^0 X$, γ^3He $\rightarrow \pi^{\pm} X$ and γ^3He $\rightarrow ppn$. $\Delta\sigma$ is $\sigma_{\rm p} - \sigma_{\rm a}$, where p (a) refers to the relative (anti)parallel $\gamma\,^3$He spin orientation. The data for the first two reaction channels are compared to the predictions of the Fix-Arenhövel model (FA) and of the SFSN model. The first one includes the momentum distribution of the nucleons inside ^{3}He as well as the effects of final state interaction [2]. The other one is a pure incoherent Sum of Free Single Nucleon (SFSN) cross sections determined using the MAID multipole analysis [3] and takes into account only the effects of the neutron spin alignment in ^{3}He.
As clear from Fig. 1, state-of-the-art calculations are unable to describe in a satisfactory manner the helicity-dependent cross section for the πX channels, while no model is currently available for the ppn channel. The same is true for the unpolarised data that were also obtained.

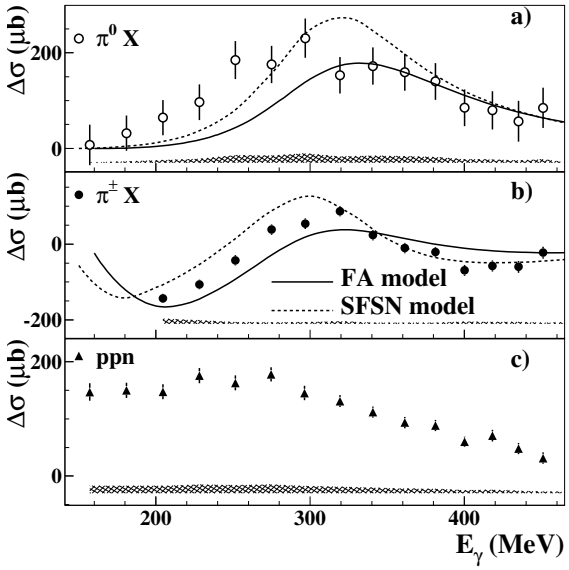

Figure 1: *Helicity dependent cross section $\Delta\sigma$ for a) $\gamma^3He \rightarrow \pi^0 X$, b) $\gamma^3He \rightarrow \pi^{\pm} X$ and c) $\gamma^3He \rightarrow ppn$. The error bars are statistical and the hatched bands show the systematic uncertainties.*

[1] P. Aguar Bartolomé et al., submitted to Phys. Lett. B (2012);
[2] H. Arenhövel and A. Fix, Phy. Rev. C 72, 064004 (2005);
[3] D. Drechsel et al., Eur. Phys. J. A 34, 69 (2007).