Photodisintegration of ^{4}He into a Triton and a Proton

To understand the nature of the strong many-body interaction among the nucleons in the nucleus, an experiment was performed at Jefferson Laboratory using the CLAS detector in Hall B. In this experiment real photons produced with the Hall-B bremsstrahlung-tagging system in the energy range from 0.35 to 1.55 GeV were incident on a liquid ^{4}He target. The two-body photodisintegration of ^{4}He into a proton and a triton was studied. This reaction has been studied over the years in the low and intermediate energy regions up to 0.4 GeV, where the one- and two-body mechanisms dominate the reactions. The higher photon-energy region used in this experiment allows us to access larger momentum transfers, where the three-body mechanisms, mostly through higher-mass-meson double scattering, are expected to make a larger contribution. Understanding the contribution of three-body forces is an important ingredient of the theoretical calculations that attempt to describe the reaction mechanisms. In a calculation by J.-M. Laget Ref.[1], three types of reaction mechanisms, one-, two-, and three-body diagrams, for this channel have been included. The one-body mechanisms include the proton and triton exchange, the two-body mechanisms include the two-nucleon meson exchange and nucleon-nucleon final-state interaction, and finally, the three-body mechanisms include meson double scattering amplitudes. In this paper, the differential cross-sections for the $\gamma\ ^4\mathrm{He} \rightarrow p+t$ reaction were measured as a function of photon-energy and the proton-scattering angle between 40 and 140 degrees in the center-of-mass frame. These measurements are complementary to the three-body breakup of ^{3}He for the study of three-body reaction mechanisms Ref [2]. The results are compared with the latest model predictions of J.-M. Laget, and previous measurements at lower photon energies as shown in Fig. 1.

The comparison between our data and the Laget calculations indicates a significant contribution of the three-body mechanisms especially in the energy region of 0.6-0.8 GeV, at large momentum transfer. At this kinematics, the model calculation is less uncertain since it depends on the low-momentum components of the ^{4}He wave function and elementary processes where the nucleons are mostly on-shell. There is very limited overlap in the photon energy range between our data and the older data from Saclay Ref.[3] and MIT Ref.[4]. The comparison shows a continuous trend with increasing the photon energy for the previous data to lie below our data in the overlap region. Our data are important for understanding the reaction mechanisms of strong many-body forces in nuclei and developing models of this process for photon energies above 0.4 GeV.

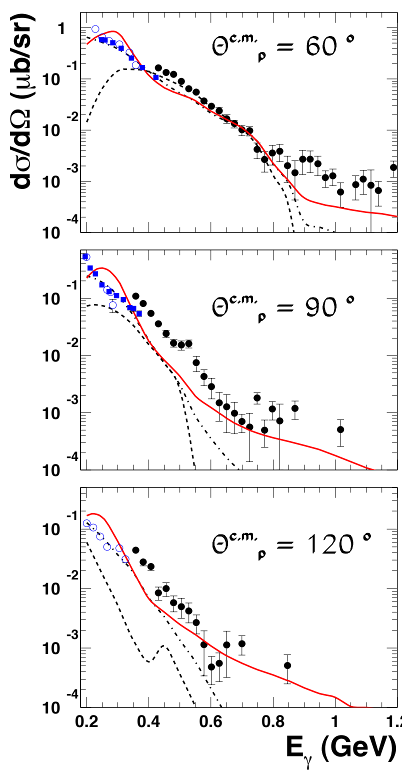

Fig. 1. Measured differential cross sections (closed circles) compared with the data from Ref [3] (closed squares), Ref[4] (open blue circles) as a function of photon-energy for three proton center-of-mass angles. The curves are calculations based on the Laget model Ref.[1] including one-body (dashed line), two-body (dash dotted line), and three-body (solid red line) mechanisms. Error bars indicate statistical uncertainties.

Ref .[1] J.-M. Laget, Phys. Lett. B 609, 49 (2005), and private communications (2009).
Ref .[2] S. Niccolai *et al.,* (CLAS Collaboration), Phys. Rev. C 70, 064003 (2004).
Ref .[3] P.E. Argan *et al.,* Nucl.Phys. A 237, 447 (1975).
Ref .[4] R. A. Schumacher *et al.*, Phys. Rev. C 33, 50 (1986).