Pion induced reactions in the Δ resonance energy region

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The PAINUC experiment has collected new data on elastic and inelastic $\pi^{\pm}$ ^{4}He interaction, at the energy where the measured maximum excitation of the Δ resonance on ^{4}He has been observed, at T_π =106 MeV. The events are collected using a triggered Self Shunted Streamer Chamber filled with helium at atmospheric pressure and exposed to the pion beam of the Joint Institute for Nuclear Research (JINR) in Dubna (Russia). All the charged secondaries, down to slow (1 MeV) and highly ionizing helium fragments, are measurable.

The first experimental evidence for a radiative interaction channel, $\pi^{\pm 4}$He$\rightarrow \pi^{\pm 4}$Heγ, is observed. The main physical features of the channel are the high energy of the emitted γs, the high branching ratio and the good agreement of the γs energy distributions with a Planck blackbody at T$\sim$16 MeV.

From the analysis of neutron knock-out reactions, π^- ^{4}He $\rightarrow \pi^-$ ^{3}He n, the first experimental observation of the excitation of the Δ^- resonance, below the pion production energy threshold, has been obtained. The invariant mass of the π^-n system has been measured at $M_{\pi n}$ =(1157 $\pm$ 14) MeV/c^2 with a width Γ =(38$\pm$ 2) MeV/c^2, thus shifted with respect to the free nucleon Δ values. The resonance occurs at high 3-momentum transfer and at low Q^2, suggesting that its excitation involves more than one nucleon. The existence of a giant nuclear resonance, induced by pions and photons on nuclei, has been hypothesized since the 70s. A semi-empiric model has been developed in order to evaluate the main physical features of the collective resonance. The model reveals that the maximum number of involved nucleons is 3-4 and the binding energy is E_B $\sim$50 MeV per additional nucleon.

From the analysis of pion absorption interactions, π^+ ^{4}He $\rightarrow$ 3pn, a fine structure in the three nucleon systems invariant mass spectra is observed, with common values for the different systems: this kind of structure is expected in the hypothesis of the excitation of the giant collective resonance and represents a unique measurement of the allowed mass levels.

The Δ^- mass shift, the narrowing of its width and the structures in the three-bodies invariant mass spectra in the absorption reaction channel could therefore be the first experimental data available for the characterization of the giant collective resonance on nuclei.

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