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Abstract: Inclusive coherent proton dissociation on helium has been measured for a missing mass near the threshold of one-pion production, in the $|t|$ range 0.05-1.6 (GeV/c)^2 and at an alpha incident momentum of 7.0 GeV/c. A strong t-slope dependence of the cross section at $|t| \leq 0.2$ (GeV/c)^2 is followed at larger $|t|$ by a less structured distribution. Data were analyzed using the Glauber-Margolis formula and by assuming a peripheral elementary diffraction amplitude for the production process.

In the framework of an extensive experimental research in the field of light-nuclei interactions, performed at the "Saturne" synchrotron of Saclay, particular interest has been devoted to coherent one-pion production in the dp and αp reactions, in the energy region near 1 GeV/nucleon.

By using nuclear targets more detailed information can be obtained about the fundamental interaction mechanisms, especially about the propagation of diffractively-produced states in nuclear matter, through multiple scattering and the resulting interference effects [1]. In addition, isoscalar nuclear targets provide quantum-number selection rules for the produced states.

Earlier measurements of the dp → dX [refs. [2,3]] and αp → αX [ref. [4]] reactions, that select a pure isospin $I = \frac{1}{2}$ state for the X-system, were performed some years ago at $p_D = 2.95$ GeV/c, and $p_\alpha = 4.0$ GeV/c and 5.08 GeV/c, respectively. In both processes a bump was observed, centered at $M_X \simeq 1150$ MeV ($\sim$120 MeV wide) for dp, and at $M_X \simeq 1130$ MeV, ($\sim$80 MeV wide) for αp. Diffractive phenomena, and in particular Deck-like mechanisms, have been proposed to explain the enhancement [5].

We present here new data for the inclusive coherent reaction

$$\alpha p \to \alpha X$$

obtained on the Saclay synchrotron "Saturne II", at an incident momentum of 7.0 GeV/c ($T_\alpha = 1.05$ GeV/nucleon) and for momentum transfer and missing mass covering the ranges $0.05 \leqslant |t| \leqslant 1.6$ (GeV/c)^2 and $(m_p + m_\pi)^2 \leqslant M_X^2 \leqslant 1.38$ GeV^2, respectively.

The precision of the present measurement has been substantially improved with respect to the previous one because of fundamental developments performed on the beam intensity and emittance, and the construction of a new particle detection facility.

The extracted α-beam (10^{11}p.p.p.) was focused on a liquid-hdyrogen target, 3.8 cm long. The scattered alphas entered a lead collimator defining a solid angle of $\sim 2 \times 10^{-4}$ sr, and then were analyzed by the double-focusing SPES-IV magnetic spectrometer. Two hodoscopes, 7 scintillation counters at the intermediate image and 44 at the final image, provided combined measurements of energy loss and time of flight (on a base of 16 m), ensuring an excellent identification of the secondary particles. The final hodoscope defined a 7% momentum acceptance, each counter providing a 0.2% momentum resolution. The beam flux was continuously monitored by three telescopes, two of them viewing a thin mylar film placed in the beam line far from the target, and the third the interaction region at fixed angle. These monitors were stable to better than 1%. The absolute calibration was provided by activity measurements of ^{12}C(α, X)^{11}C reaction. The systematic errors on the cross section due to beam monitoring was about ± 5%. Empty-target effects were taken into account in the data analysis.

The differential cross sections, $d^2\sigma/dt\, dM^2$, as a function of $-t$ at different values of the missing mass M_X, are displayed in fig. 1, together with our earlier results at lower energy. The cross sections, at a bombarding momentum of 7.0 GeV/c, drop 5-6 orders of magnitude in the explored momentum transfer range and exhibit a typical diffraction minimum or point of inflection at $|t| \simeq 0.2$ (GeV/c)^2, followed at larger $|t|$ by a less structured distribution. The first slope ranges from 29 to 25 (GeV/c)$^{-2}$, when the squared mass varies from 1.21 to 1.38 GeV^2. A common feature of the data is a kink in the $|t|$ region between 0.15 and 0.25 (GeV/c)^2 for all masses. In the same region proton–helium elastic scattering shows a sharp dip. At higher $|t|$, around 0.7 GeV^2/c^2, another change in slope appears as predicted by multiple scattering calculations. A slow energy dependence of the cross section seems to exist in the comparison of data at different energies. However the earlier data in αp at $p_\alpha = 4.0$ GeV/c and 5.08 GeV/c exhibit a variation of the $|t|$ value of the first minimum, as well as a strong variation of the first slope: these features tend to disappear at $p_\alpha = 7.0$ GeV/c.

The curves in fig. 1 correspond to a prediction of a generalization of the model [5]) employed in the interpretation of our earlier data [3]), taking into account multiple scattering effects by means of the Glauber–Margolis formula [6]).
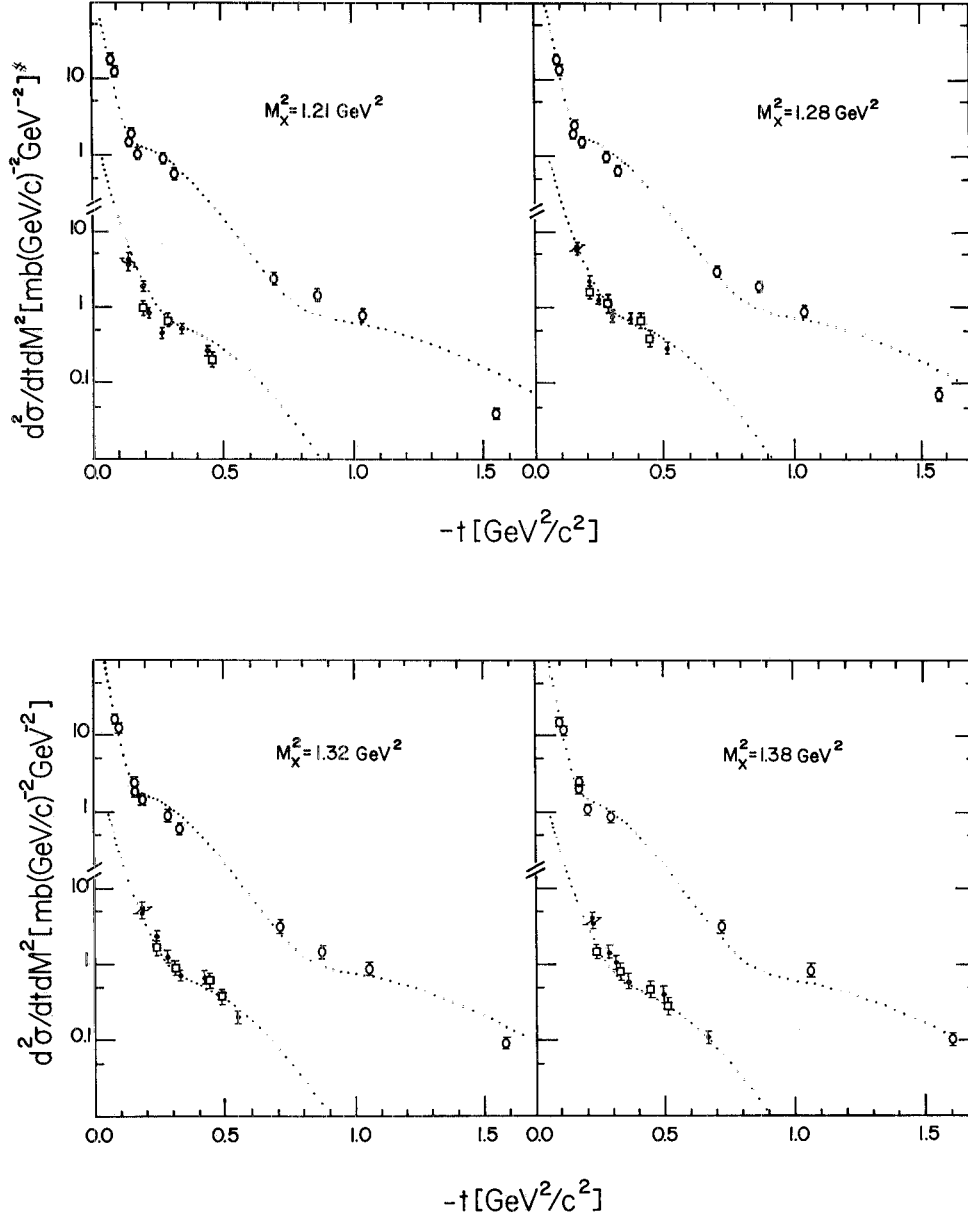
Fig. 1. Differential cross sections as functions of $-t$ for different M_X^2 values for the process $\alpha p \to \alpha X$: $\bigcirc$ - present experiment at $p_\alpha = 7.0$ GeV/c; $\oplus$ - our earlier data at $p_\alpha = 4.0$ GeV/c [ref. [4]]; $\square$ - our earlier data at $p_\alpha = 5.08$ GeV/c [ref. [4]]. The dotted curves have been obtained by using the Glauber-Margolis formula with a peripheral elementary diffraction amplitude for the production process. The parameters of ref. [9]) and ref. [10]) have been used for the NN interaction in the fit of the data at 7.0 GeV/c and 5.08 GeV/c, respectively. Total cross sections of 15.67 mb (17.7 mb) and of 48 mb (40.5 mb) have been obtained by the fit of the data, at 7.0 GeV/c (5.08 GeV/c), respectively, for the one-pion production process and for the elastic xN interaction.

In agreement with the analysis of higher-energy measurements [7], a peripheral elementary diffraction amplitude has been assumed for the production process. We used the form proposed by Białas *et al.*[8]:

$$T_{fi} = -iM_{fi}(T_{ff} - T_{ii}),$$

where M_{fi} represents the proton dissociation amplitude, and T_{ii} and T_{ff} represent the scattering amplitude of the nucleon with the proton and the X-system, respectively.

In the calculation a gaussian mass dependence was assumed for M_{fi}, and the usual gaussian parametrization for T_{ii} and T_{ff}. We use the same parameters for the elementary NN amplitude, T_{ii}, as we used in our previous αp scattering analysis [9]. The parameters for the interaction, M_{fi}, and for the amplitude, T_{ff}, have been determined by an overall fit of our new data (reported here) at 7.0 GeV/c. The trend of the cross sections are reproduced up to highest $|t|$ values.

We remark that the use of a central impact parameter profile, that normally reproduces the main features of elastic αp scattering process, failed to describe the production process, especially in the critical regions where interference effects are relevant.

To summarize, we measured the inclusive one-pion coherent production in the interaction of 7.0 GeV/c α-particles with hydrogen, over a momentum transfer range extending up to $|t| \simeq 1.6$ (GeV/c)^2. The differential cross sections are sharply peaked forward and decrease rapidly with $|t|$. We have provided a preliminary theoretical analysis of the data by inserting a diffractive production amplitude in the standard Glauber-Margolis formula.

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