On the Production of π^+ Mesons in Carbon*

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THE cross section for production of π^+ mesons by 345-Mev protons on carbon has been measured by Richman and Wilcox.[1] The experimental points of the meson energy spectrum are shown in Fig. 1. We have treated this process on the basis of the phenomenological analysis of meson production in free nucleon-nucleon collisions carried out by Watson and Brueckner.[2]

In terms of the free nucleon cross section, $d\sigma_f/dTd\Omega$, using a closure approximation over the unstruck nucleons, it is possible to reduce the meson production spectrum from a complex nucleus, $d\sigma/dTd\Omega$, to the form

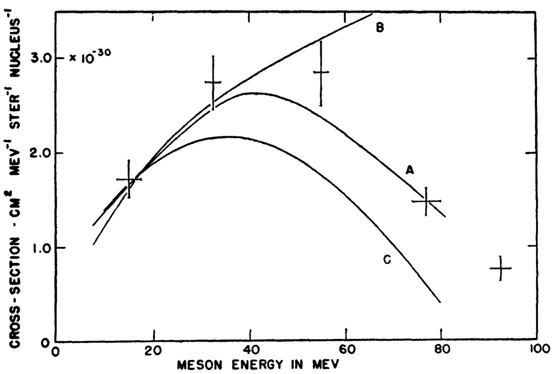

FIG. 1. The π^+ meson production spectra from C^{12} at 90°.

$$\frac{d\sigma}{dTd\Omega}=\int\frac{d\sigma_f}{dTd\Omega}(\mathbf{k})\rho(\mathbf{k})d\mathbf{k},$$

where T and Ω are the kinetic energy and solid angle of the meson, respectively; $\rho(\mathbf{k})$ is the momentum distribution of a nucleon in the nucleus.

From the experiments on meson production from free nucleons by Cartwright, Richman, Whitehead, and Wilcox,[3] the treatment of Watson and Brueckner[2] indicates that the mesons are produced predominantly into p-states. It has been assumed that this type of coupling is still the most important for a bound nucleon. Therefore, the same free nucleon cross section has been used, omitting contributions arising from deuteron formation.

The meson spectra at 90°, corresponding to various momentum distributions assumed for C^{12}, are shown in Fig. 1. The normalization of these curves has been determined from the normalization of the free nucleon cross section to the experimental data. Curve A was obtained using a gaussian momentum distribution corresponding to an average kinetic energy of 19.3 Mev for a nucleon in C^{12}. This distribution is shown as curve A in Fig. 2 and has been chosen to fit the low momentum points obtained by Chew and Goldberger[4] from the deuteron pick-up data of York.[5] Curve B, Fig. 1, is the spectrum corresponding to the Chew-Goldberger momentum distribution, curve B, Fig. 2. The difference in these two spectra is chiefly due to the large number of high momentum components present in the latter distribution. However, as pointed out by Chew and Goldberger,[4] their momentum distribution is in doubt at the high end. Curve C, Fig. 1, is the cross section obtained with a Fermi degenerate gas (maximum momentum = 200 Mev/c).

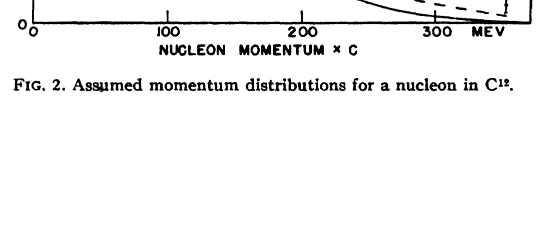

FIG. 2. Assumed momentum distributions for a nucleon in C^{12}.

For the Fermi model, the Pauli exclusion principle was found to modify the meson spectrum only below 25 Mev. In addition, a nuclear model, with a ground state corresponding to momentum distribution A, was examined. The exclusion effect was of the order of 10 percent. Due to the uncertainties in the free nucleon cross section, these corrections have not been included in these preliminary results.

The differences between the spectra at high meson energies indicate a fairly sensitive dependence on the assumed momentum distribution.

The effects of meson absorption and other aspects of meson production in complex nuclei are being studied. These results will appear in a forthcoming paper.

It is with pleasure that we acknowledge the continual guidance of Dr. K. Watson and the stimulating discussions with Professor R. Serber.

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On Measuring Very Short Half-Lives*

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IN a paper given at the April, 1951, meeting of the American Physical Society[1] the principle of a differential coincidence counting method was presented. One possible use of the counting rate *versus* delay curve of the differential-output (we call it the differential delay curve here) was given there, namely narrowing delay curves.

It is interesting to note that the differential delay curve can also be used directly to obtain information about short time relationships. The theorems which have been previously given[2] regarding the moments of the delay curve also hold for the differential delay curve. In addition it is easy to show that, within limits, the change in the counting rate in the linear part of a delay curve (when going from the source producing simultaneous events to the source producing delayed events) is the product of the slope of the curve and the first moment of the decay curve.

To show the limitations, we may write the genuine coincidence counting rate, $N_g(T)$, (where T is the experimentally introduced time delay) as follows:

$$N_g(T)=\int_{-\infty}^{\infty}\nu_g(T-t)p(t)dt, \tag{1}$$

where $\nu_g(T)$ is the delay curve in the case of the source producing simultaneous events, and $p(t)dt$ is the probability of the time delay between events of the decaying source. Expanding $\nu(T-t)$ in a series about T and integrating, we obtain

$$N_g(T)=\nu(T)M^{(0)}[p(t)]-\frac{d\nu}{dT},M^{(1)}[p(t)]+\frac{1}{2}\frac{d^2\nu}{dT^2}M^{(2)}[p(t)], \tag{2}$$

where $M^{(n)}[p(t)]$ is the nth moment of the $p(t)$ curve. If the