Spectra of protons emitted in the back hemisphere upon disintegration of C^{12} by 3.7 GeV/c π^- mesons

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We measured the spectrum of the protons emitted backward in the laboratory frame upon disintegration of the C^{12} nucleus; the spectrum is adequately described by an exponential relation of the type $A\exp(-Bp^2)$. The slope parameter coincides within the limits of errors with the value of B obtained from the spectra of the protons emitted backward in other processes.

Nuclear scaling, wherein the inclusive spectra of the protons emitted backward in the laboratory frame can be described by a universal function

$$f(p^2) = \frac{E}{p}\frac{d^2\sigma}{dp^2 d\Omega} = A e^{-Bp^2}$$

(E is the total energy and p is the momentum of the proton), was observed in[1,2]. In first-order approximation, the function $f(p^2)$ is independent of the energy and of the nature of the incident particle, and is also independent of the atomic number of the target nucleus when normalized to the total cross section for the interaction between the incident particle and the nucleus. The slope parameter in the argument of the exponential was found in[1,2] to be $B \approx 11(\mathrm{GeV}/c)^{-2}$.

In the present study we measured the spectrum of the protons emitted backward upon disintegration of the C^{12} nucleus by π^- mesons with momentum 3.7 GeV/c; this spectrum confirms qualitatively the nuclear scaling phenomenon.

Among ~120 000 photographs obtained with the 1.5-meter track spectrometer of our institute,[3] we selected events with four and five positive particles, of which at least one satisfied the conditions for triggering the apparatus, i.e., it had a momentum >700 MeV/c and an emission angle $<15°$, with no tracks of negative particles.

Since the total charge of the $\pi^- C^{12}$ system is -5, it was natural to connect the events selected in this manner with the disintegration of the C^{12} nucleus. To check on this hypothesis, calculations were performed by the Monte Carlo method with allowance for the geometric efficiency of the installation. The distributions of the number of events with respect to the missing registered-particle mass were in good agreement with the calculated curves under the assumption that all the secondary particles are protons. Another qualitative confirmation of this hypothesis is the fact that the average kinetic energy for each assumed neutron from the disintegration of C^{12} is approximately equal to the kinetic energy of the observable proton.

We processed altogether 142 events with four positive particles and 15 events with five. The angular distribution of the protons emitted backward was isotropic for the selected events, within the limits of errors. Figure 1 shows the function $f(p^2)$, which describes the proton spectra. The solid line is the best fit to the experimental data and corresponds to a slope parameter $B = 9.2 \pm 1.3$. The dashed line shows the slope obtained earlier.[1,2]

Figures 1b and 1c show the same data, but broken up into two proton-emission angle intervals. In this case, too, the experimental points can be described by exponentials with $B = 9.8 \pm 1.8$ for the angle range $-1 \leq \cos\theta_p \leq -0.75$ and $B = 9.3 \pm 2.0$ for $-0.75 \leq \cos\theta_p \leq 0$.

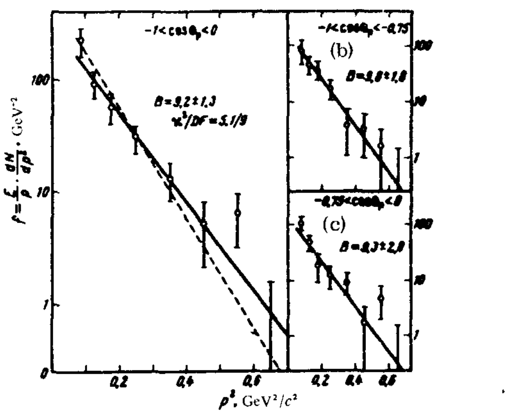

FIG. 1. The function $f(p^2)$ for protons emitted backward in the laboratory frame upon disintegration of the C^{12} nucleus; b and c—the same for emission angles $-1 \leq \cos\theta_p \leq -0.75$ and $-0.75 \leq \cos\theta_p \leq 0$, respectively.

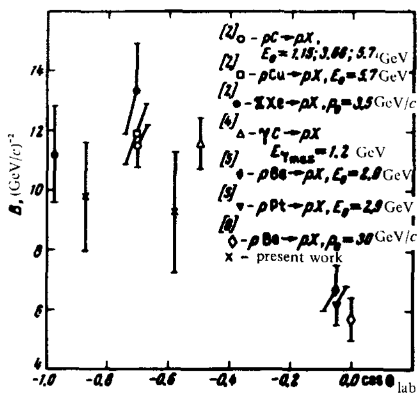

FIG. 2. Value of the slope parameter B for the spectra of backward protons from different processes.

In other words, no dependence of the slope parameter of the spectrum on the proton emission angle is observed within the limits of errors.

The general situation with the dependence of the slope parameter of the proton spectrum on the emission angle in the laboratory frame as obtained from all the known data is shown in Fig. 2.

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