Measurement of the spectra of the protons from the C^{12} nucleus and of the target-nucleus mass-number dependence of the inclusive reaction $\gamma + A \to p + \ldots$ at a maximum bremsstrahlung energy $E_\gamma^{max} = 1200$ MeV

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We measured the inclusive spectra of the protons in the (γp) reaction on the C^{12} nucleus and the dependence of the proton yield on the mass number of the target nucleus at various angles, at a maximum bremsstrahlung energy $E_\gamma^{max} = 1200$ MeV.

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An analysis of the experimental data on the interaction of high-energy particles ($\gtrsim 1$ GeV) with atomic nuclei has shown[1,2] that the spectra of the secondary particles at large angles are described by the universal function

$$\frac{E}{p^2}\frac{d^2\sigma}{dp\,d\Omega} = C\exp\{-Bp^2\},$$

where p and E are the momentum and total energy of the secondary particles. It has turned out here that the parameters B and C do not depend (or depend very weakly) on the energy, on the sort of emitted particle and target nucleus (if the parameter C is normalized to the total cross section of the interaction of the incident particle with the nucleus). Bayukov *et al.*[1,2] called this phenomenon "nuclear scaling."

Recent work[3–5] on a π^--meson beam with momentum 1–3.7 GeV/c consisted of studies of the spectra of the protons and the deuterons and of the dependence of their yields on the target-nucleus mass number.

We obtained new data on the proton yield following irradiation of nuclei by a bremsstrahlung γ-quantum spectrum with maximum energy 1200 MeV. The work was performed with the Khar'kov linear electron accelerator. The experimental procedure is described in[6].

The results of the measurement of the spectra of the protons emitted by C^{12} are shown in Fig. 1. The spectrum measurement error was determined by the statistics and amounted to less than $\pm 3\%$, with the exception of the last two points at 144°, where the statistical errors reached $\pm 30\%$. The curves were drawn visually. These data were used to estimate the parameter B for the proton-momentum interval $p^2 = 0.2$—0.7 $(\mathrm{GeV}/c)^2$ and is given in the following table:

$\theta°$	30	60	100	120	144
$B(\mathrm{GeV}/c)^{-2}$	6.3	9.1	12.7	13.0	15.1

It is seen that the parameter B depends on the proton emission angle.

The dependence of the yield of protons of various energy on the target-nucleus mass number is shown in Fig. 2. The ordinates are (in relative units)

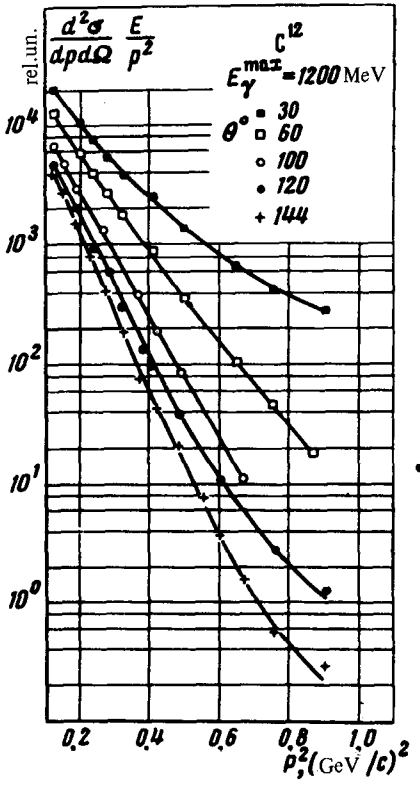

FIG. 1.

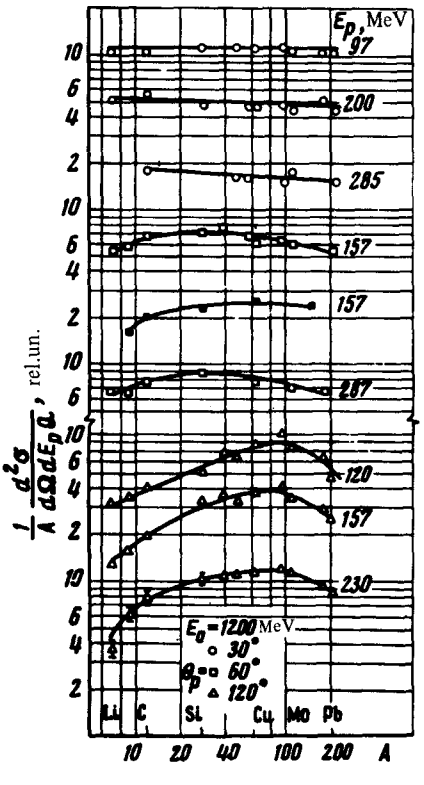

FIG. 2.

the ratios of the cross section to the mass number of the target nucleus (Li^7, Re^9, C^{12}, Si^{28}, Ca^{40}, Ti^{48}, Cu^{63}, Mo^{96}, Cd^{112}, Ta^{181}, W^{184}, Pb^{208}) at angles 30, 60, and 120°. The black squares show the results obtained in[7] at 60° and $E_\gamma^{max} = 4$ GeV. The curves are drawn visually.

At small angles, $< 60°$, the proton yield is approximately proportional to the number of nucleons of the target nucleus. At large angles the yield cannot be described in the form A^n with n constant in the entire range of values of A.

Since the total cross section of the hadronic interaction of the photons with the nuclei is proportional to A in this region, the curves of Fig. 2 represent the dependence of the ratio of the parameter C to the total cross section, C/σ_{tot}, on the mass number of the target nucleus. At large angles, C/σ_{tot} depends on A strongly.

[1]Yu. D. Bayukov *et al.*, Yad. Fiz. **18**, 1246 (1973) [Sov. J. Nucl. Phys. **18**, 639 (1974)].
[2]Yu. D. Bayukov *et al.*, Yad. Fiz. **19**, 1266 (1974) [Sov. J. Nucl. Phys. **19**, 648 (1974)].
[3]Yu. D. Bayukov *et al.*, Pis'ma Zh. Eksp. Teor. Fiz. **21**, 461 (1975) [JETP Lett. **21**, 210 (1975)].
[4]A. V. Aref'ev *et al.*, Preprint ITÉF 56, 1975.
[5]N. A. Bugrov *et al.*, Preprint ITÉF 66, 1975.
[6]Yu. P. Antuf'ev *et al.*, Yad. Fiz. **12**, 1143 (1970) [Sov. J. Nucl. Phys. **12**, 627 (1971)].
[7]K. W. Chen *et al.*, Phys. Rev. **135**, B1030 (1964).
[8]I. Favier *et al.*, Phys. Lett. **25B**, 409 (1967).