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ЛАБОРАТОРИЯ ЯДЕРНЫХ ПРОБЛЕМ

ОБЪЕДИНЕННЫЙ ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ

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PRODUCTION OF NEUTRAL PIONS IN PROTON COLLISIONS WITH COMPLEX NUCLEI

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1. Introduction

A considerable change of the shape of pion angular distribution with the increase of nuclear weight is a characteristic feature of the reaction of pion production by high energy nucleons on complex nuclei/1,2/. For the case of light nuclei this phenomenon may be explained satisfactorily in the framework of a simple nuclear model (the independent particle model) which takes into account pion absorption and scattering of bombarding protons in nuclear matter/3–5/. In 1956 in order to find out a possibility of employing such a model also for the case of heavy nuclei we undertook detailed investigations of angular distributions of γ-quanta from the decay of neutral pions produced by protons on nuclei of various elements and simultaneously the corresponding calculations were begun to make a quantitative comparison of experimental data with predictions resulting from the chosen nuclear model. Besides in the present investigation the values of total cross sections and cross section energy dependence for carbon in a wide energy range have been found. This provided a possibility of obtaining (see ref./6/) informations on impulse distribution of nucleons in a carbon nucleus. In connection with the fact that two years have passed since the moment of completing the measurements but the calculations are not accomplished up till now, we consider it reasonable to publish main experimental results, the detailed discussions of them being postponed till accomplishing the calculation.

2. Gamma Quantum Angular Distributions

In order to measure the yields of gamma quanta the same experimental technique has been used in the present investigation as in studying the reaction $pp \to pp\pi^o$/5/. The angular distributions of gamma quanta from the decay of neutral pions produced by protons on nuclei of various elements are presented in Figs. 1–9. The procedure of reconstruction of the corresponding neutral pion angular distributions is shown in/5/.

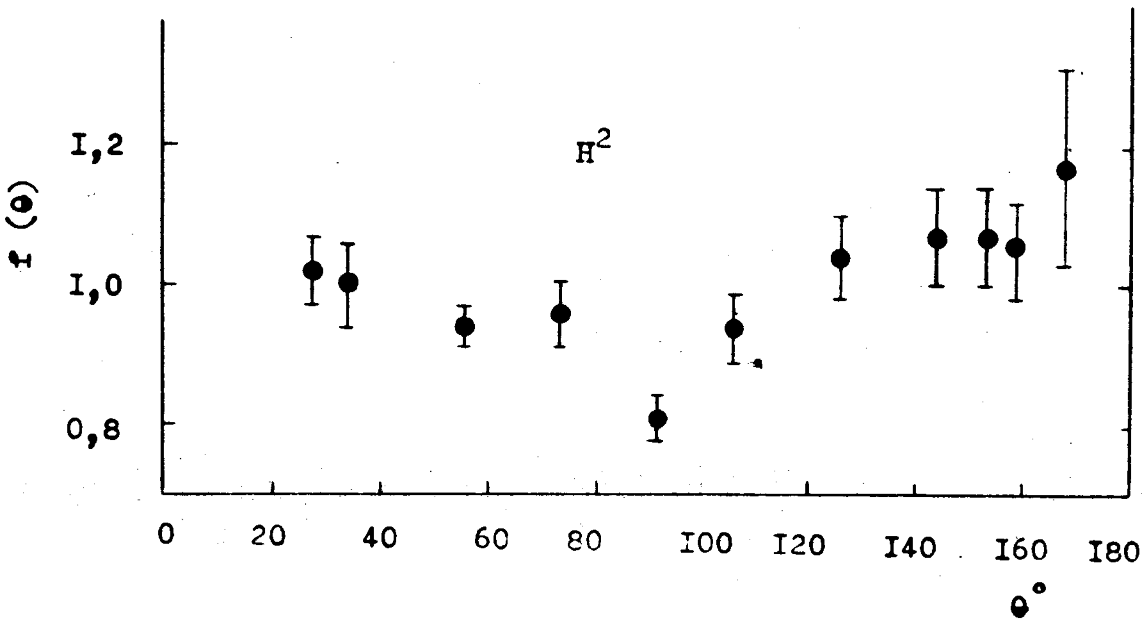

Fig. 1.

Angular distribution in the effective c.m.s. of gamma quanta produced by 660 MeV protons on deuterium nuclei (in relative units).

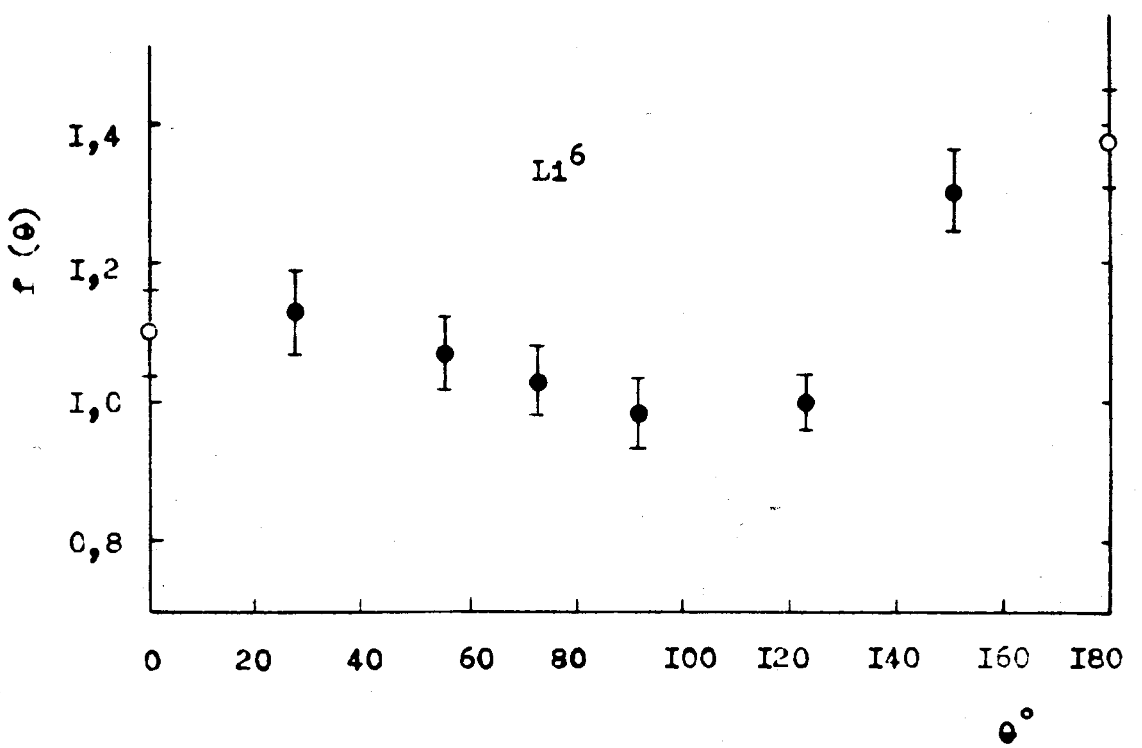

Fig. 2.

The same as in Fig.1 but for a Li^6 nucleus. ● -the results of the present investigations. o - is taken from ref./2/.

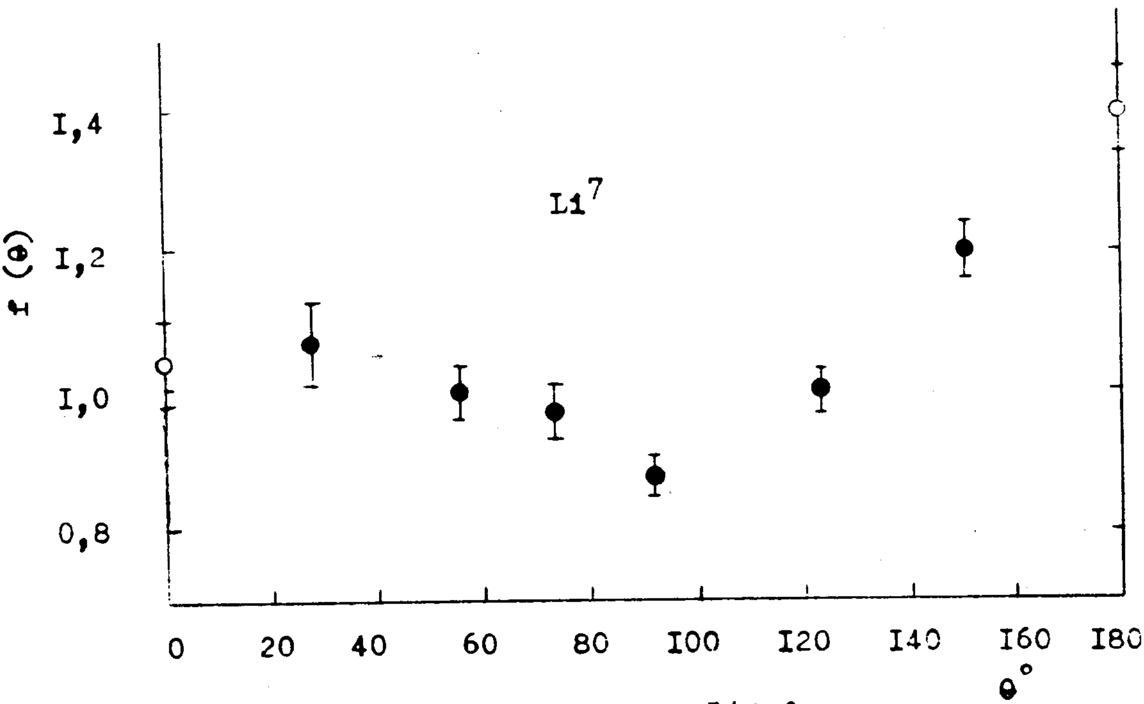

Fig. 3.

The same as in Fig. 2 but for a Li^7 nucleus.

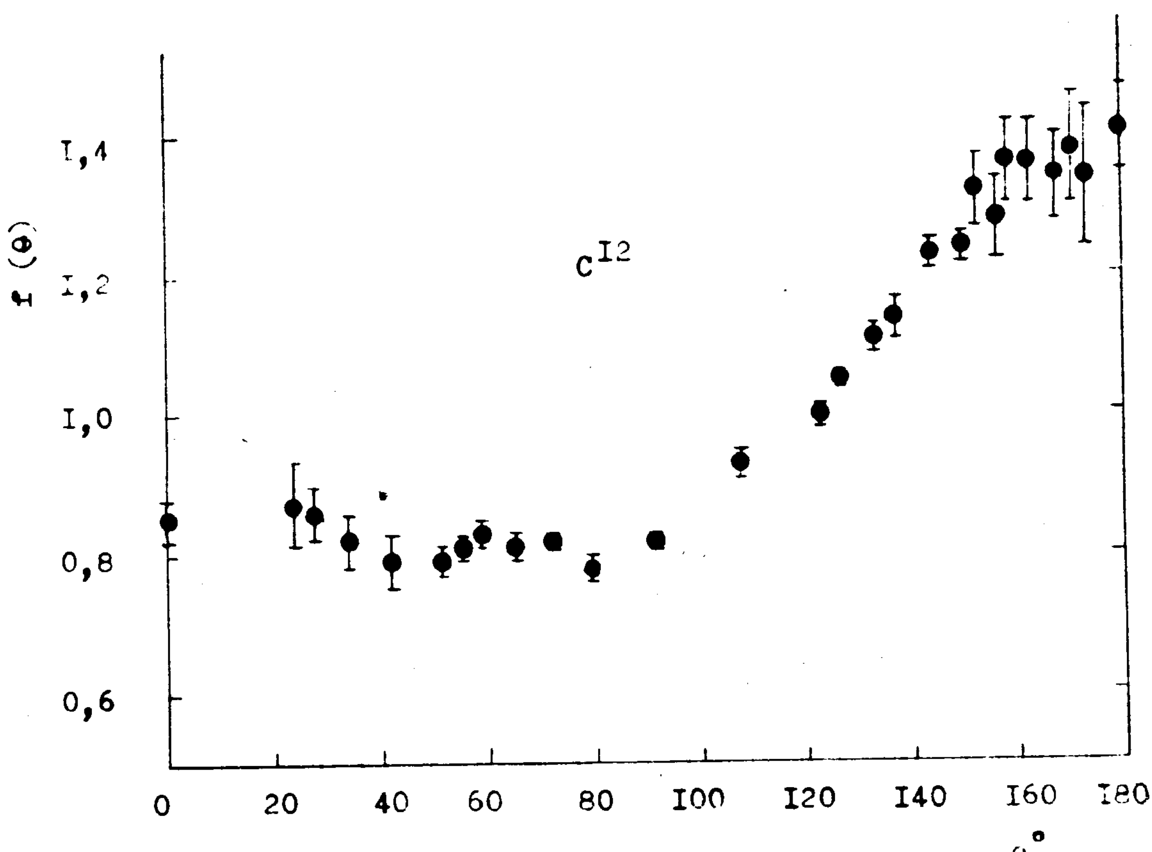

Fig. 4.

The same as in Fig. 2 but for a C^{12} nucleus.

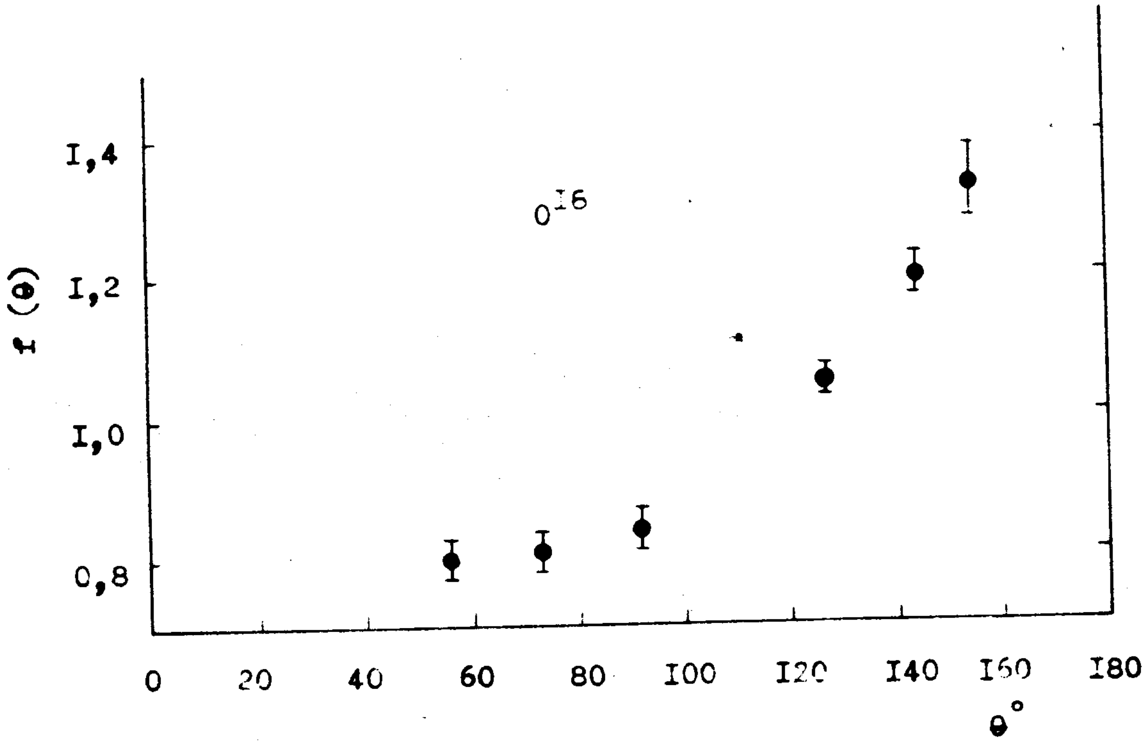

Fig. 5.

The same as in Fig. 2 but for an O^{16} nucleus.

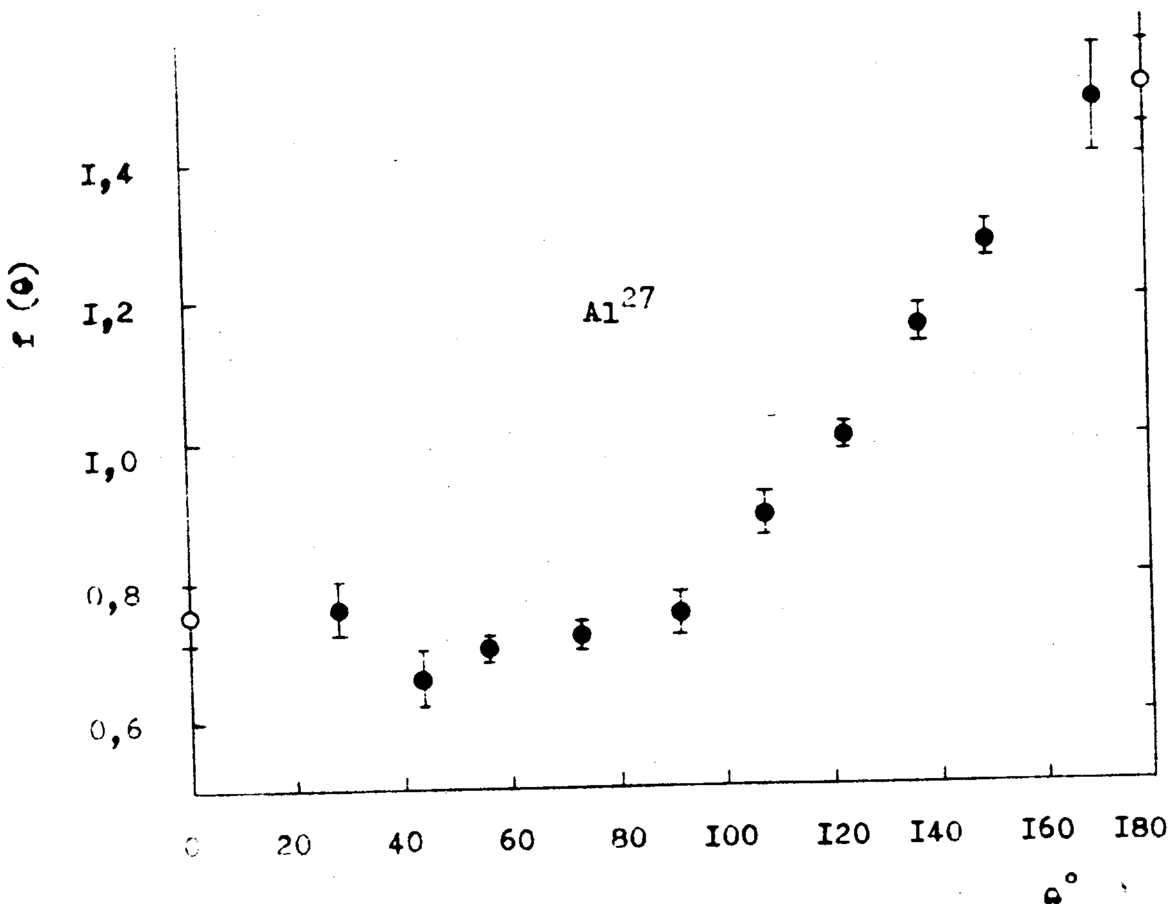

Fig. 6.

The same as in Fig. 2 but for an Al^{27} nucleus.

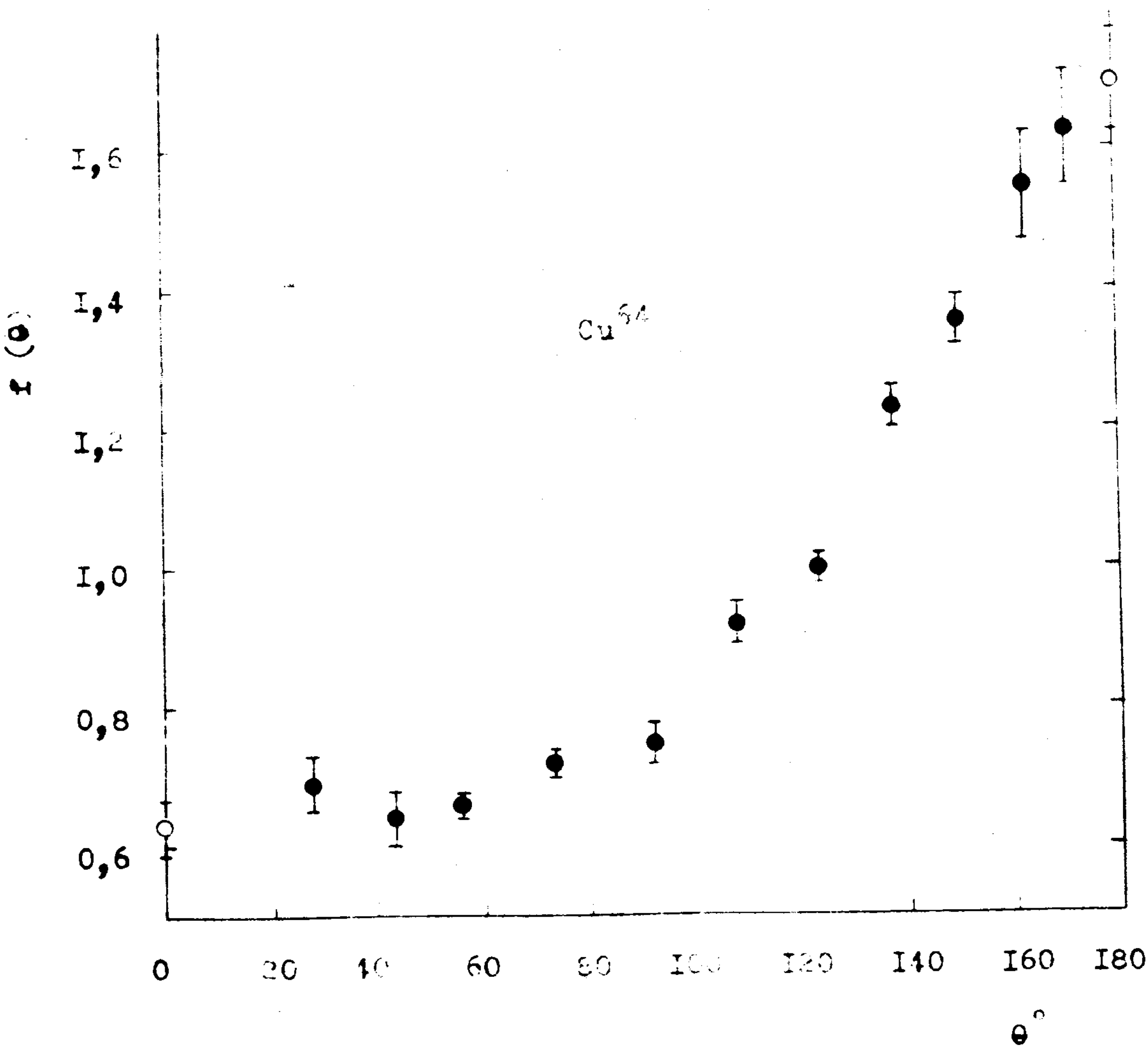

Fig. 7.
The same as in Fig. 2 but for a Cu^{64} nucleus.

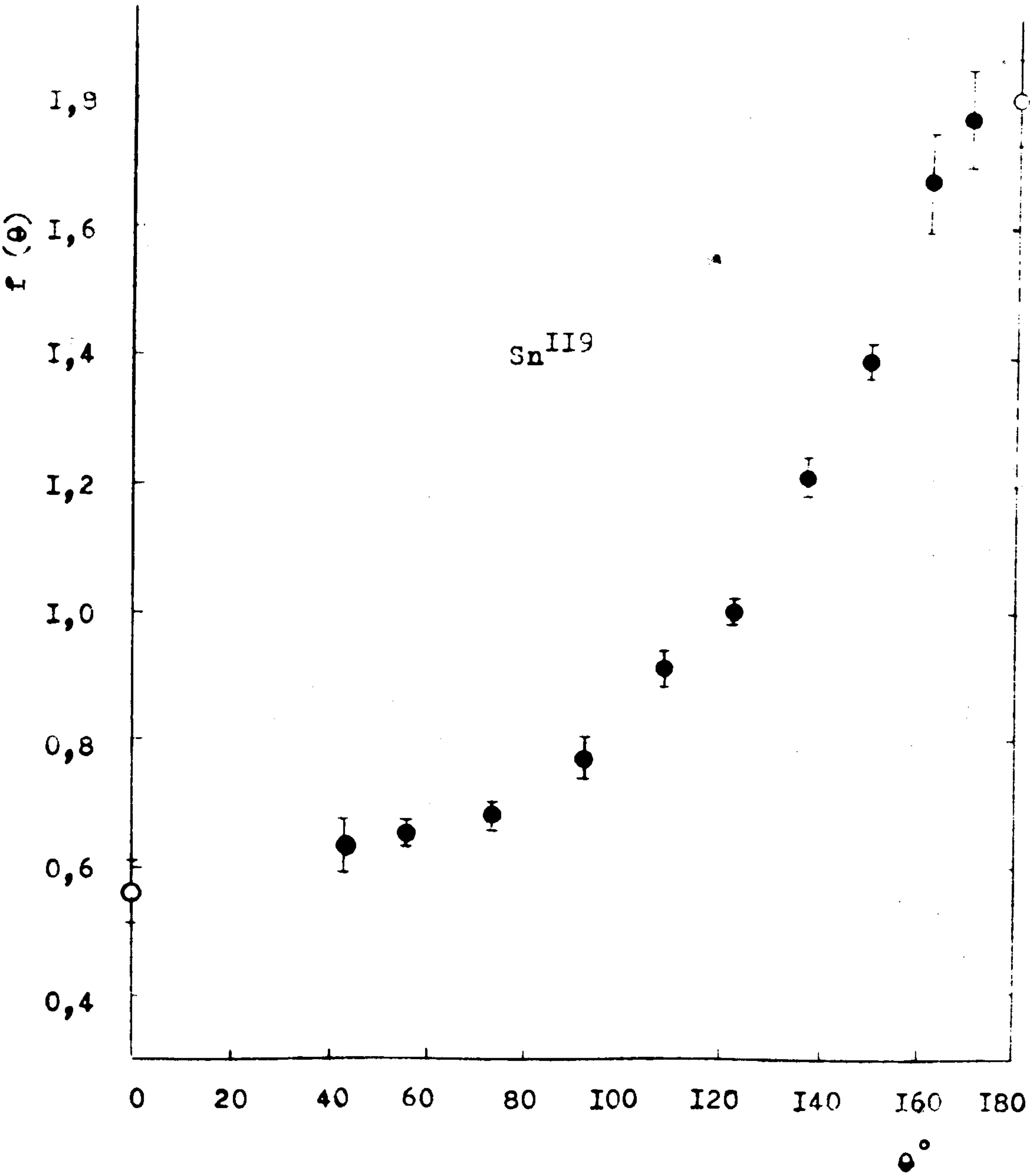

Fig. 8.

The same as in Fig. 2 but for a Sn^{119} nucleus.

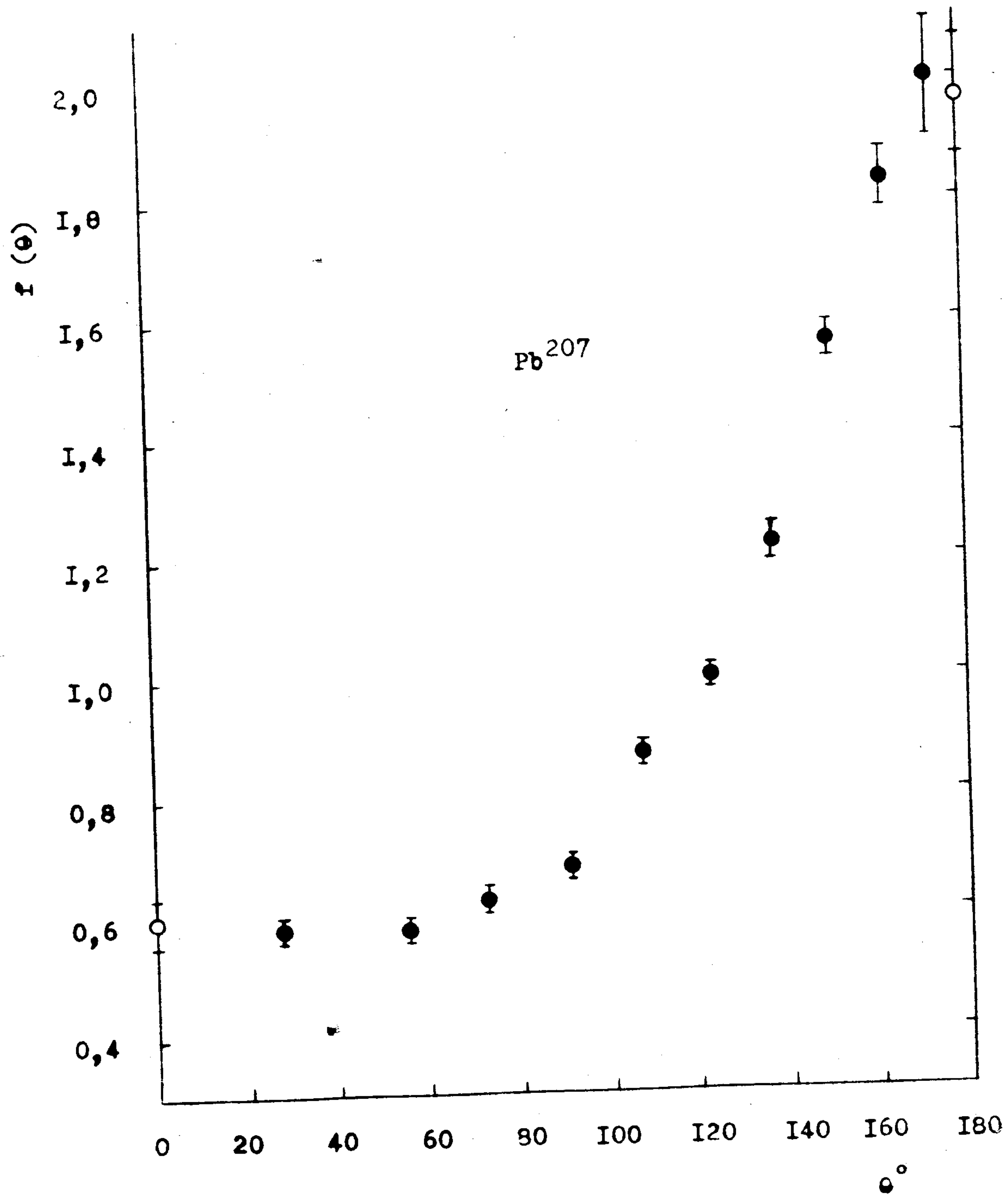

Fig. 9.

The same as in Fig. 2 but for a Pb^{207} nucleus.

3. Total Cross Sections of Neutral Pion Production

The above-shown angular distributions have been used in order to determine the value of the total cross sections of neutral production σ^{π^0} at 660 MeV proton energy (see Table 1).

Table 1.

Element	σ^{π^0}, 10^{-27} cm^2	σ^{π^0}, relative units
H^{1}*	3.22 ± 0.17	0.118 ± 0.005
H^{2}**	7.9 ± 0.4	0.29 ± 0.01
Li^{6}	19.5 ± 1.2	0.71 ± 0.02
Li^{7}	23.6 ± 1.4	0,87 ± 0.02
C^{12}	27.3 ± 1.5	1.00
O^{16}	33.3 ± 1.9	1.22 ± 0.03
Al^{27}	45.9 ± 2.6	1.68 ± 0.04
Cu^{64}	73.4 ± 4.2	2.69 ± 0.07
Sn^{119}	105 ± 6	3.84 ± 0.09
Pb^{207}	143 ± 8	5.24 ± 0.12

4. Energy Dependence of the Total Cross Section $\sigma_{pc}^{\pi^0}$

The dependence of the total cross section of neutral pion production on carbon upon the energy of bombarding protons E is given in Table 2.

* Taken from ref. /5/.

** Taken from ref. /7/.

Table 2.

E, MeV	$\sigma_{pc}^{\pi^0}$, rel. units	$\sigma_{pc}^{\pi^0}$, 10^{-27} cm^2	E, MeV	$\sigma_{pc}^{\pi^0}$, rel. units	$\sigma_{pc}^{\pi^0}$, 10^{-27} cm^2
660	1.00 ± 0.01	27.3 ± 1.5	458	0.38 ± 0.02	10.4 ± 0.8
655	1.00 ± 0.02	27.3 ± 1.5	450	0.34 ± 0.02	9.2 ± 0.7
645	1.01 ± 0.01	27.6 ± 1.5	440	0.31 ± 0.02	8.5 ± 0.7
630	1.01 ± 0.01	27.6 ± 1.5	420	0.24 ± 0.01	6.6 ± 0.7
620	0.98 ± 0.02	26.8 ± 1.5	400	0.21 ± 0.01	5.7 ± 0.5
610	0.96 ± 0.01	26.6 ± 1.5	380	0.18 ± 0.01	4.9 ± 0.4
595	0.87 ± 0.02	23.8 ± 1.4	370	0.16 ± 0.01	4.4 ± 0.3
590	0.82 ± 0.02	22.4 ± 1.4	365	0.16 ± 0.01	4.4 ± 0.3
580	0.70 ± 0.02	19.1 ± 1.2	360	0.14 ± 0.01	3.8 ± 0.3
563	0.67 ± 0.02	18.3 ± 1.1	330	0.11 ± 0.01	3.0 ± 0.3
560	0.66 ± 0.02	18.0 ± 1.1	295	0.08 ± 0.01	2.2 ± 0.2
543	0.62 ± 0.02	16.9 ± 1.2	287	0.065 ± 0.010	1.8 ± 0.3
532	0.59 ± 0.02	16.1 ± 1.0	250	0.030 ± 0.004	0.8 ± 0.1
505	0.48 ± 0.02	13.1 ± 0.9	215	0.020 ± 0.003	0.55 ± 0.08
485	0.42 ± 0.02	11.5 ± 0.8	175	0.011 ± 0.003	0.30 ± 0.08
471	0.40 ± 0.02	10.9 ± 0.8			

The analysis of this dependence shows that the effective impulse distribution of nucleons in a carbon nucleus cannot be described by the Gaussian function.

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