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Contract No. W-7405-eng-48

SUMMARY OF THE RESEARCH PROGRESS MEETING

of October 20, 1949

H. P. Kramer

December 12, 1949

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Meson Production. T. Taylor

K. Brueckner, G. Chew and the speaker have undertaken calculations to determine the differential cross section for the production of charged mesons in the bombardment of nuclei by highly energetic protons.

The speaker based his calculations on the simplifying assumptions that the meson is produced in the impact of a proton on a free nucleon to which he ascribed momentum distributions that characterize its motion within a nucleus. He did not, however, consider forces between the struck and other nucleons. Furthermore, the coulomb barrier was neglected. Its effect is, however, not negligible in heavy elements such as lead, where the barrier is about 14 Mev, so that the calculated results are not applicable to mesons with energy comparable with the coulomb barrier energy.

The point of departure was the formula

$$d\sigma = \frac{1}{v} \cdot \frac{2\pi}{\hbar} \left|H\right|^2 \frac{1}{(2\pi\hbar)^6} \cdot \frac{\rho^2 d\rho\, d\Omega\, p_1^2 dp_1 d\Omega_1}{dE_f}$$

where

v - the velocity of the impinging particle

H - the matrix element

ρ - the momentum of the meson

p_1 - the momentum of one of the nucleons resulting from the collision

E_f - the final energy of the system, and

$d\Omega$ - the element of solid angle into which the meson is emitted.

$|H|$ was determined from scalar and pseudoscalar meson theories and found to be approximately constant. Integration over p_1, the momentum of one of the accelerated nucleons, and the principles of conservation of energy and momentum showed that

$$p_1 = \int (\cos\Theta_1, E_o, \rho)$$

where Θ_1 is the angle between the directions of the momenta of the two accelerated nucleons resulting from the collision.

It was ultimately found that

$$d\sigma \simeq \sqrt{Mc^2(T_o-E) - |p_o-\rho|^2 c^2 \rho \varepsilon}\; d\varepsilon\, d\Omega$$

where

M - the mass of the proton

T_o - the kinetic energy of the incident particle, and

ε - the total meson energy.

It is felt that the resulting formula could be improved by introducing corrections to account for the fact that all particles considered move at relativistic speeds. This has not, however, been done as yet.

Chew has carried out calculations for the same purpose but used a more realistic model for which he assumed the struck nucleon to be bound and a bell-shaped empirical momentum distribution for the struck nucleon.

The calculations compare fairly well with experimental data obtained by C. Richman and H. Wilcox. They do not, however, constitute a test for meson theories since the choice of meson theory has no profound effect on the results of the calculations.

Figs. 1 and 2 show the results of the speaker's calculations.

Charge Increase of III in the Bombardment of Tin with Protons and Alpha-Particles. L. Marquez.

Very pure tin (99.997 percent) was bombarded with protons and α -particles with the result that several new iodine isotopes were produced. The isotope table has been extended to the neutron deficient region of iodine as follows:

Mass Number	Half-Life	Radiation Emitted
124	4.5 d	β^+, K
123	13 hr.	K, γ, e
122	4 min.	β^+, (K?)
121	1.8 hr.	K, β^+, γ, e^-
⋮	⋮	⋮
119	30 min.	β^+, γ (K?)

The possibility that the charge increase might be produced by the adhesion of an α-particle to the tin nucleus and the emission of a π^- meson was considered but was ruled out since iodine was also produced by the bombardment of tin with protons.

A check was made to determine whether or not the possible antimony contamination in the tin might be sufficient to give the observed yield of iodine isotopes. To this end, antimony was bombarded and the excitation curves for the production of the various iodine isotopes determined. By this means, it was concluded that the antimony contamination would have to constitute an excessive fraction of the tin target, which, in view of the purity of the tin, rules out the possibility of the production of iodine in the observed yields from antimony contamination.

A tentative conclusion that has been drawn from the described results is that the charge increase of three may be due to the emission of a lithium isotope from a tin nucleus as a result of α-bombardment and the capture of this lithium by another tin nucleus with the resultant production of an iodine isotope.

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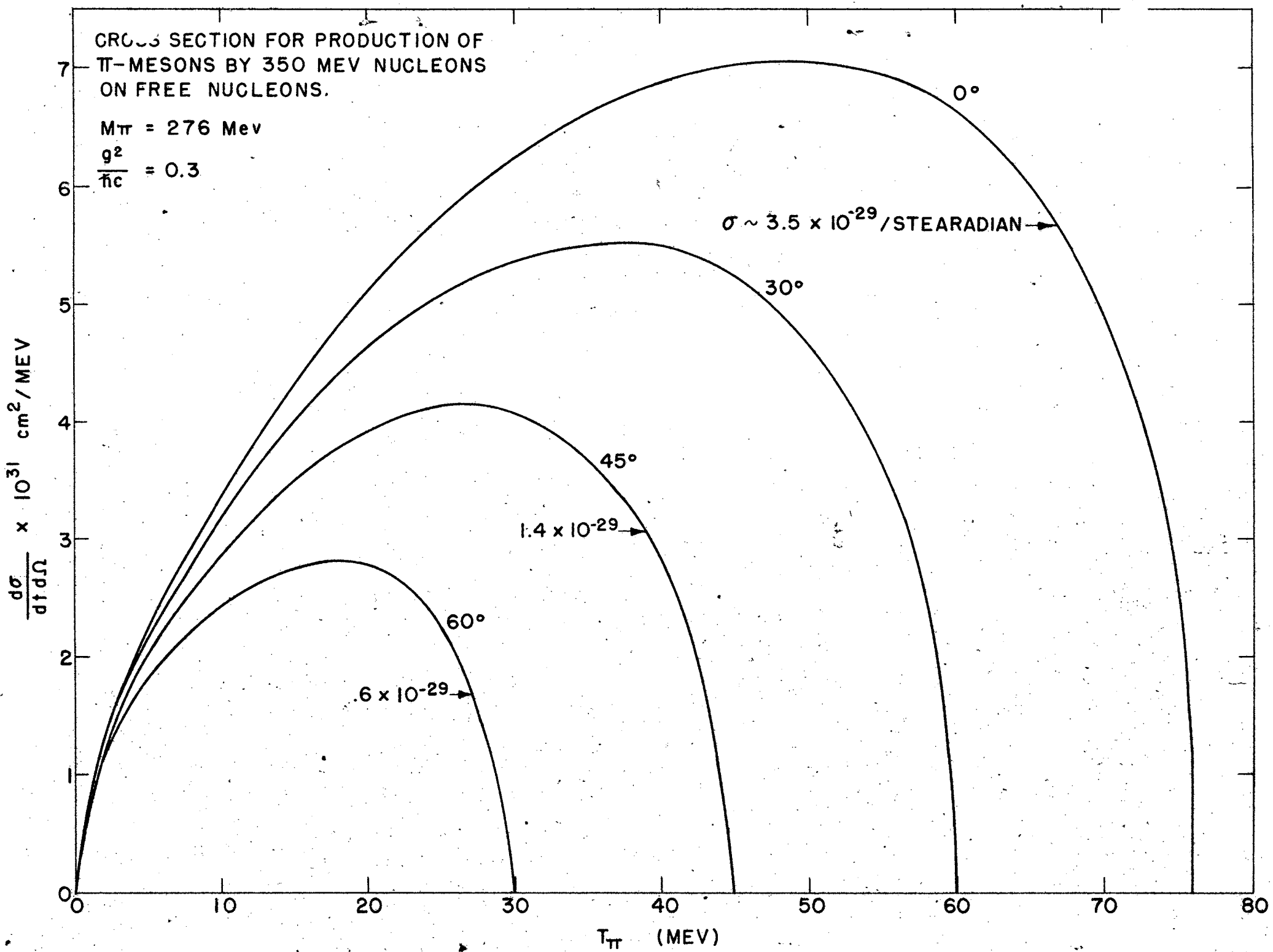
CROSS SECTION FOR PRODUCTION OF
π-MESONS BY 350 MEV NUCLEONS
ON FREE NUCLEONS.
Mπ = 276 Mev
g²/ħc = 0.3
0°
30°
45°
60°
σ ~ 3.5 x 10⁻²⁹/STEARADIAN
1.4 x 10⁻²⁹
.6 x 10⁻²⁹
dσ/dt dΩ x 10³¹ cm²/MEV
T_π (MEV)
0
10
20
30
40
50
60
70
80
1
2
3
4
5
6
7

FIG. 1

14358-1

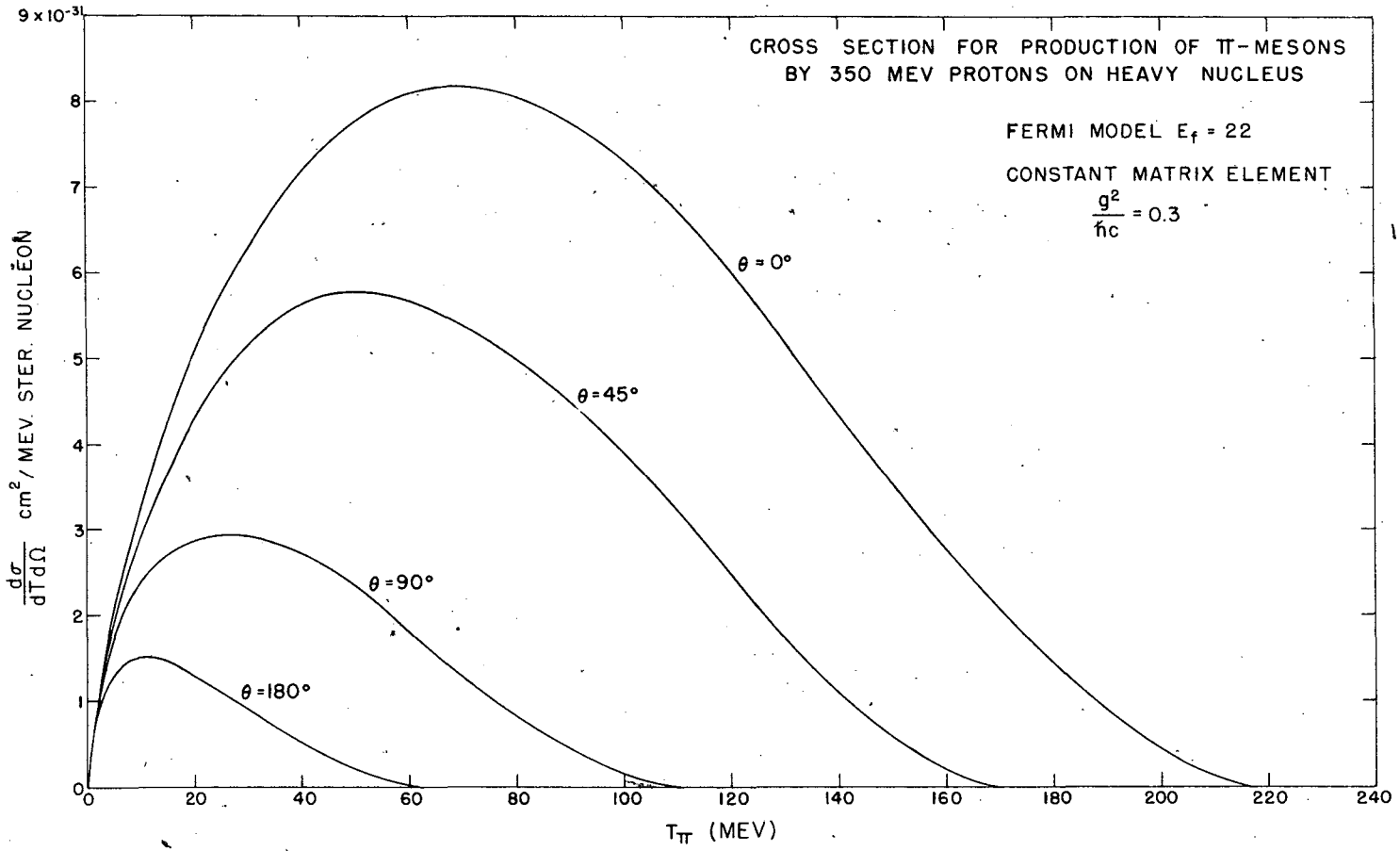
CROSS SECTION FOR PRODUCTION OF π-MESONS
BY 350 MEV PROTONS ON HEAVY NUCLEUS
FERMI MODEL E_f = 22
CONSTANT MATRIX ELEMENT
$\frac{g^2}{\hbar c} = 0.3$
$\theta = 0°$
$\theta = 45°$
$\theta = 90°$
$\theta = 180°$
$\frac{d\sigma}{dT d\Omega}$ cm²/ MEV. STER. NUCLEON
T_π (MEV)
9 x 10⁻³¹
8
7
6
5
4
3
2
1
0
0
20
40
60
80
100
120
140
160
180
200
220
240

FIG. 2

OZ 789