Title
SUMMARY OF THE RESEARCH PROGRESS MEETING OF NOV. 23, 1951.

Author
Shewchuck, S.

Publication Date
1952-01-24

UCRL- 1650

UNCLASSIFIED

UNIVERSITY OF CALIFORNIA – BERKELEY

RADIATION LABORATORY

UCRL-1650
Unclassified-Physics Distribution

UNIVERSITY OF CALIFORNIA

Radiation Laboratory

Contract No. W-7405-eng-48

SUMMARY OF THE RESEARCH PROGRESS MEETING OF NOVEMBER 29, 1951

S. Shewchuck

January 24, 1952

Some of the results reported in this document may be of a preliminary of incomplete nature. It is the request of the Radiation Laboratory that the document not be circulated off the project nor the results quoted without permission.

Berkeley, California

SUMMARY OF THE RESEARCH PROGRESS MEETING OF NOVEMBER 29, 1951*

S. Shewchuck

Radiation Laboratory, Department of Physics
University of California, Berkeley, California

January 24, 1952

I. Meson Scattering Experiments. R. Jastrow

The first interesting result to be reported concerns the π^- scattering cross section on hydrogen found at Chicago. The first measurements showed a linear rise of the cross section, but later results show a levelling off. See Fig. 1. The values reported are:

Cross section		50 ± 6mb at 135 Mev
"	"	65 ± 4mb at 176 Mev
"	"	$\leqslant$ 60mb at 210 Mev

A possible resonance peak is therefore indicated at about 200 Mev. This happens to be just about the point for the location of a nucleon isobar assumed by Brueckner and Case in their explanation of photoproduction of mesons. However, it is a little premature to draw any real conclusions about the location of a peak pending further experiments.

From Nevis cyclotron at Columbia a result is reported from measurements of the angular distribution of π^+ and π^- mesons scattered from carbon. A comparison in the small angle range is shown by the curves in Fig. 2. This is interesting in that there should be a pronounced interference with the Coulomb field, enabling one to determine the sign of the meson interaction force. Results imply that the interaction is attractive. (π^- cross section is larger.) This is contrary to the theory which attempts to explain the

* No summary of the Research Progress Meeting of November 15, 1951 will be issued. At that time a talk was given by Dr. M. E. Haine of England on "Recent Advances in Electron Microscopy."

nuclear forces on the basis of a saturation of forces. This theory says that nucleons repel one another at high nucleon density. The new results indicate that the many body problem works against the saturation rather than helps it.

Columbia also found the ratio of π^+ to π^- total cross sections to be 1.6 ± 1 at 80 Mev. This result shows that the π^+ cross section is larger than the π^- but not as large as the results at Chicago.

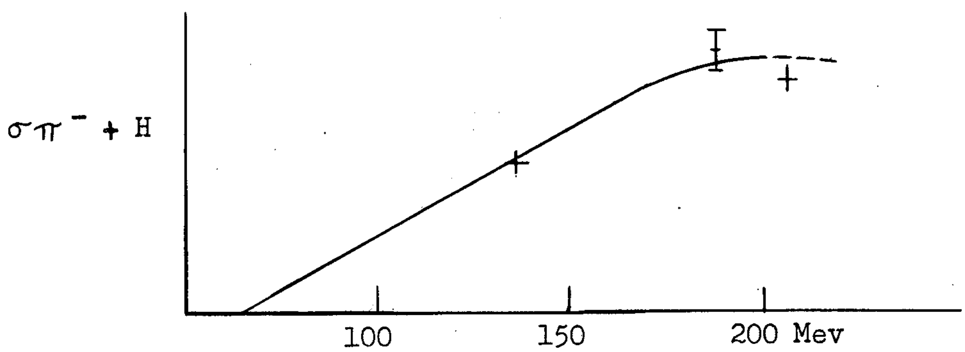


Fig. 1

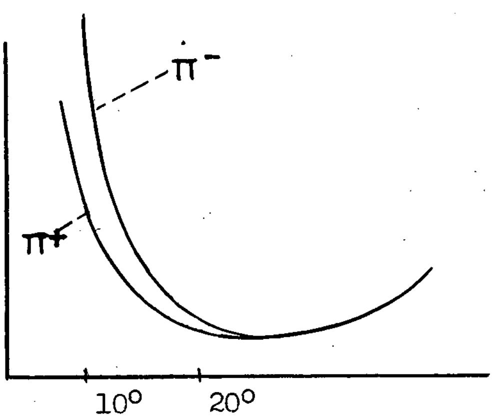


Fig. 2

II. Differential Analyzer Methods for Orbit Problems in the Cyclotron and a Proposed Meson Beam. B.. Rankin

The principle of using two wheels as an analogue to integration was first thought of by Lord Kelvin, but the first real analyzer utilizing it was perfected by Bush of MIT. See Fig. 3.

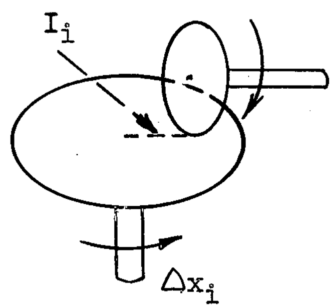


Fig. 3

$$K \sum I_i \Delta x_i \rightarrow K \int I(x)\, dx$$

Consider the differential equation

$$dy^2/dx^2 = -y \qquad (1)$$

$$y' = dy/dx, \qquad y = \int y' dx$$

$$-y = dy'/dx, \qquad y' = -\int y dx$$

In order to solve the equation (1) two integrating units are required. Then one lets each unit do an integration with the output of one as the input of the other.

Nordsieck at Illinois designed an analyzer with selsyn drives instead of mechanical drives and thus using electrical impulse connections between integrators. During the summer he was at UCRL with the analyzer and it was tried on a problem, suggested by W. Barkas, of solving equations of motion of a charged particle in an axially symmetrical magnetic field. Three general questions of interest expected to be answered by this experiment were:

1. Is the machine adapted to the solution of the problem?
2. What are the focussing properties of the cyclotron field for mesons?
3. What is the feasibility of getting a meson beam outside the tank?

Answers:

1. The machine will do the job. The plane case uses six integrators,

but for a general three dimensional case 14 integrators are needed.

2. It was possible with the machine to draw many orbits and determine the focussing properties of the field in the median plane.

3. Investigation is not yet completed, though a number of useful conclusions have been reached tending to indicate a possibility of a good π^- beam.

It is necessary to interpret the problems for the analyzer in order for the machine to understand them. Thus, the equations of motion were handled as follows:

$$d/dt\,(m\bar{v}) = e/c\,(\bar{v} \times H)$$

$$\bar{v} \times \bar{A} = H$$

transform to, using cylindrical coordinates.

$$\begin{cases} mr^2\varphi + e/c\; rA - Q \\ m\ddot{r} = \dfrac{Q\varphi}{r} + e/c\; \dot{\varphi} r\, \dfrac{dA}{dr} \\ m\ddot{Z} = e/c\; \varphi r\, \dfrac{dA}{dZ} \end{cases}$$

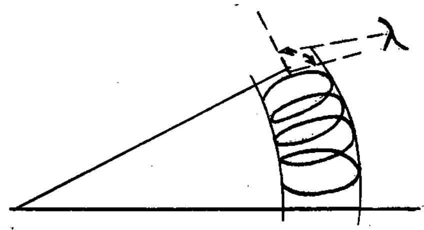
$$A = A_\varphi = \frac{1}{r}\int_o^r rH\,(r,Z)\; dr$$

For median plane

$$\begin{cases} \dot{\varphi} = \dfrac{Q}{mr^2} - \dfrac{e}{mr^2c}\displaystyle\int_o^r rH\,(r,o)\; dr \\ \dot{r}^2 + r^2\varphi^2 = v^2 \end{cases}$$

$$\dot{r} = \pm\sqrt{v^2 - r^2\varphi^2}$$

The machine had trouble with this formulation of problem; it could not find $\dot{r}$. Because of the square root function it could not decide on the correct sign. Hence, a new parameter λ was introduced:



$$\frac{dr}{r\,d\varphi} = \tan\lambda$$

Rewrite equations: $\dot{r} = v \sin\lambda$; $r\dot{\varphi} = v \cos\lambda$

$$\dot{r} = \int r\dot{\varphi}\ d\lambda = \int rd\left[\int \varphi\ d\lambda\right]$$

which can be solved on machine, since:

$$\lambda = \int \dot{\lambda}\ dt; \qquad \dot{\lambda} = \dot{\varphi} + \frac{eH}{mc}$$

Introduce the transformation:

$$T \equiv \begin{cases} t' - t/\gamma \\ m' = m_o = m/\gamma \\ \text{where } \gamma = \frac{1}{\sqrt{1-\beta^2}}\ ; \quad v' - \gamma v \end{cases}$$

This makes the input functions independent of the initial conditions.

Fig. 4 shows the wiring diagram of the analyzer for solving this problem. Fig. 5 shows the orbits for a 70 Mev particle of mass 275.1 e_o for $\lambda_o = 0^o - 120^o$. Fig. 6 shows the orbits for the same particle for $\lambda_o = 240^o - 360^o$. Fig. 7 shows orbits for various energies.

Recent data for the π^- cross section in the forward direction for carbon, as measured by W. Dudziak, is $0.388 \pm 0.04 \times 10^{-13}$ cm^2. After correction for nuclear absorption the cross section is 0.495×10^{-30} cm^2. Using these figures, the number of mesons is computed as follows:

$$E = \sigma \times \Delta\Omega \times \Delta E \times \frac{I}{e} \times \frac{\rho Na}{A}$$

if $\Delta E = 1$ Mev; and $I = 5 \times 10^{-7}$ amp,

$$E = 90 \text{ mesons/sec/cm}^2.$$

This is equivalent to one half the number of π^+ mesons emerging from the channel in Richman's apparatus. Due to better energy resolution, the flux per Mev is actually greater. Also, the mesons can be taken far enough out to get proper shielding and to use counters, etc.

III. Deuteron Photodisintegration. W. Gilbert

The talk was based chiefly on a thesis by the author which has been prepared as report UCRL-1590, an abstract of which follows:

The reaction $\gamma + D \rightarrow p + n$ was investigated using the photon bremsstrahlung spectrum from the Berkeley electron synchrotron which has a quantum limit of approximately 320 Mev. The target consisted of deuterium gas at a pressure of 2000 P.S.I. and at a temperature of 77° K. Protons were detected by a scintillation counter telescope system consisting of three liquid phosphors viewed by several photomultiplier tubes each. The outputs from these counters were pulse height discriminated and then the pulses of the proper height were fed into coincidence circuits in such a manner that the detection system was specific in its acceptance of proton events and in its rejection of meson events. The energy of a proton accepted by the system could be determined by the use of absorbers in front of the counter telescope and the angular and energy resolution of the system was sufficient to define the energy of the initial γ-ray to a few Mev.

$(d\sigma/d\Omega)_\theta$ were determined at laboratory angles of 30°, 45°, 60°, 75° and 90° for $E_{\gamma \text{center of mass}} = 200 \pm 15$ Mev; and at laboratory angles of 30°, 45°, 60°, 75°, 90°, 105°, 115° for $E_{\gamma \text{center of mass}} = 250 \pm 15$ Mev.

$$\sigma \text{ total (200 Mev)} = (10.0 \pm 3.0) \times 10^{-29} \text{ cm}^2$$

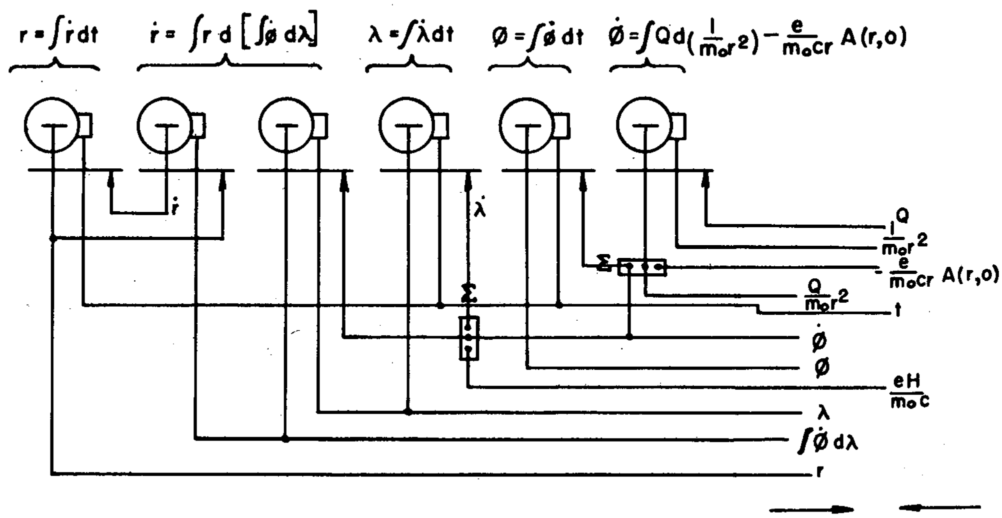
$$\sigma \text{ total (250 Mev)} = (15.9 \pm 6.4) \times 10^{-29} \text{ cm}^2$$

These cross sections are far greater than reasonable extrapolations of theoretically predicted cross sections at lower photon energies could yield. These data indicate that above the threshold for the production of mesons, the cross section for the photo effect rises with increasing photon energy and that around this energy, 140 Mev, the cross section is larger than theories which exclude the effects of meson interaction can predict.

Information Division
1-24-52 bm

DIFFERENTIAL ANALYZER WIRING FOR SOLVING THE EQUATIONS $m_o r^2 \dot{\phi} + \frac{e}{c} r\, A(r,o) = Q$

$r\,\dot{\phi} = \gamma v \cos\lambda$, $\dot{r} = \gamma v \sin\lambda$



MU2798

Fig. 4

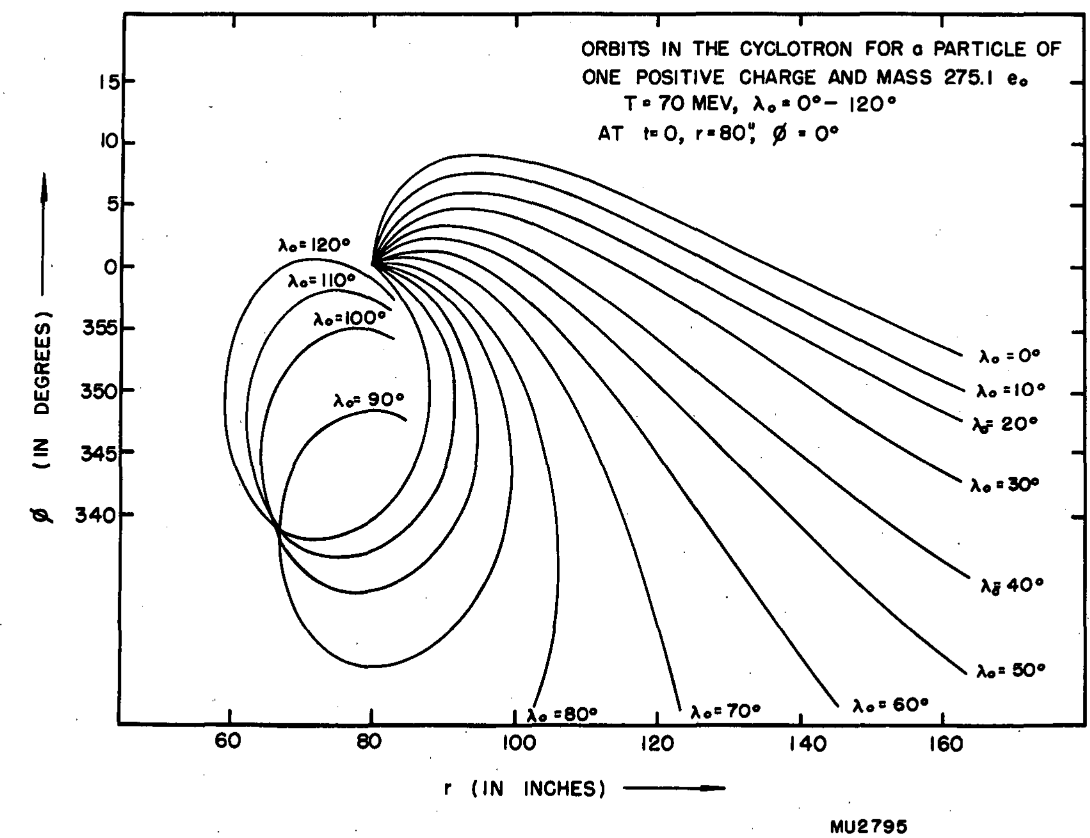
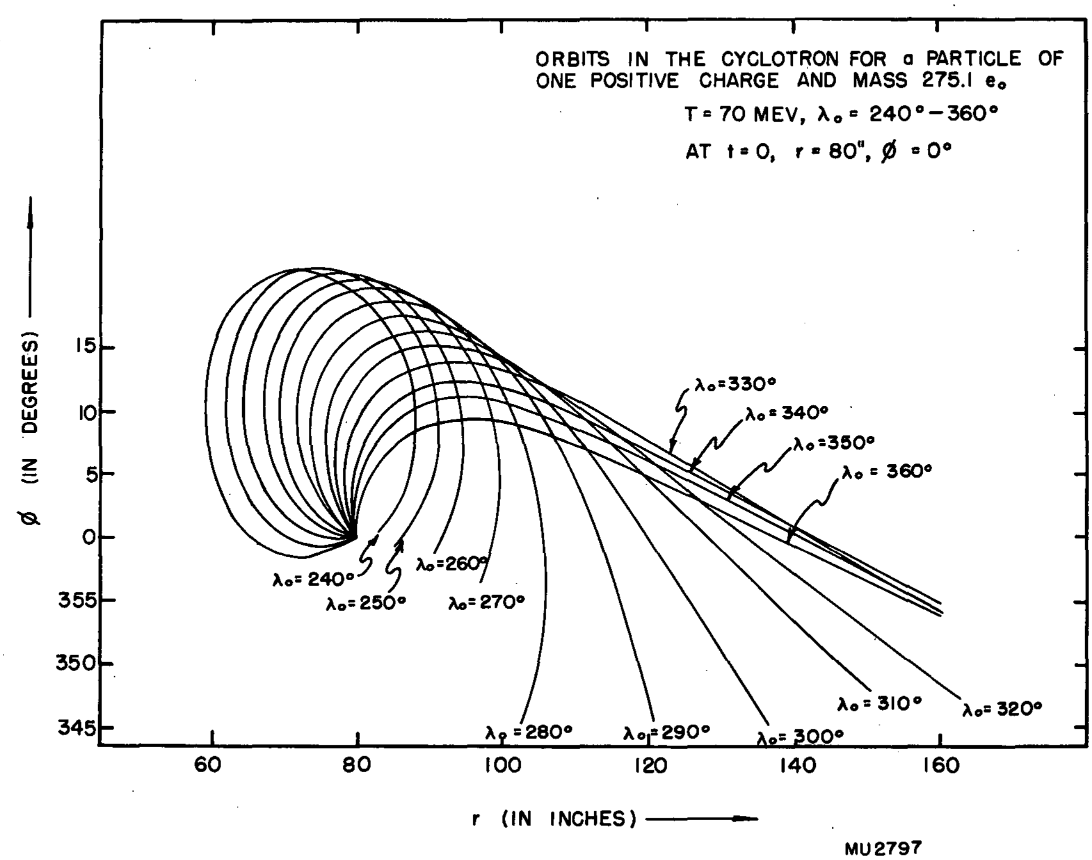

ORBITS IN THE CYCLOTRON FOR a PARTICLE OF
ONE POSITIVE CHARGE AND MASS 275.1 e₀
T = 70 MEV, λ₀ = 0° – 120°
AT t = 0, r = 80", ∅ = 0°
15
10
5
0
355
350
345
340
∅ (IN DEGREES)
λ₀ = 120°
λ₀ = 110°
λ₀ = 100°
λ₀ = 90°
λ₀ = 0°
λ₀ = 10°
λ₀ = 20°
λ₀ = 30°
λ₀ = 40°
λ₀ = 50°
λ₀ = 60°
λ₀ = 70°
λ₀ = 80°
60
80
100
120
140
160
r (IN INCHES)
MU2795

Fig.5



ORBITS IN THE CYCLOTRON FOR a PARTICLE OF ONE POSITIVE CHARGE AND MASS 275.1 e_0
T = 70 MEV, λ_0 = 240° – 360°
AT t = 0, r = 80", ϕ = 0°
λ_0 = 240°
λ_0 = 250°
λ_0 = 260°
λ_0 = 270°
λ_0 = 280°
λ_0 = 290°
λ_0 = 300°
λ_0 = 310°
λ_0 = 320°
λ_0 = 330°
λ_0 = 340°
λ_0 = 350°
λ_0 = 360°
ϕ (IN DEGREES)
15
10
5
0
355
350
345
60
80
100
120
140
160
r (IN INCHES)
MU2797

Fig. 6

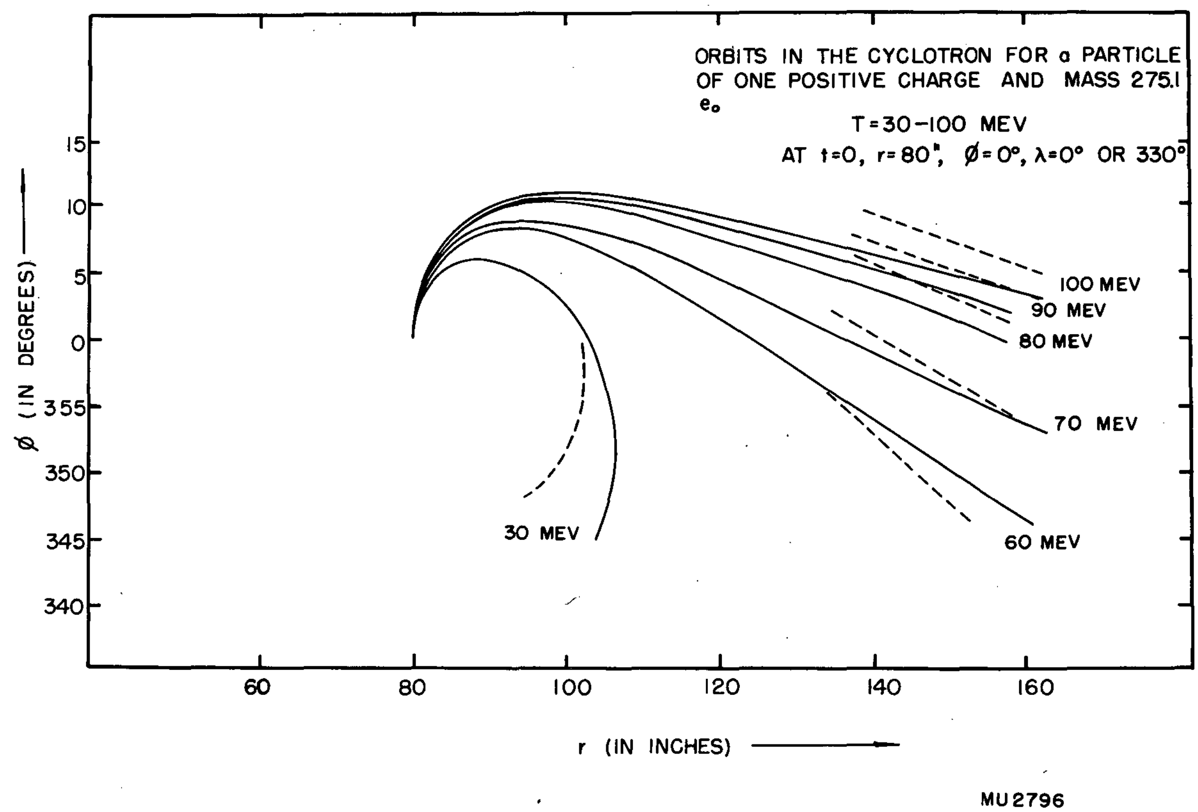

ORBITS IN THE CYCLOTRON FOR a PARTICLE OF ONE POSITIVE CHARGE AND MASS 275.1 e₀
T=30-100 MEV
AT t=0, r=80", ϕ=0°, λ=0° OR 330°
100 MEV
90 MEV
80 MEV
70 MEV
60 MEV
30 MEV
ϕ (IN DEGREES)
15
10
5
0
355
350
345
340
60
80
100
120
140
160
r (IN INCHES)
MU 2796

Fig. 7