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SUMMARY OF THE RESEARCH PROGRESS MEETING OF MARCH 20, 1952

S. Shewchuck

April 11, 1952

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I. π^- Mesons from C by 340 Mev Protons at 0° to the Beam. W. Dudziak

The talk was based on work for which an abstract report UCRL-1595 has been published by the author, entitled "Measurement of the Production Cross Section of Negative Mesons in Carbon by 341 Mev Protons". It is quoted as follows:

Meson production cross sections from carbon ($pC^{12} \longrightarrow \pi^-$) in the forward direction to a 341 Mev incident proton-beam, have been measured. The produced charged mesons were magnetically separated and their number detected in Ilford C-2, (200 μ) emulsions. The areas were scanned under 570 diameters magnification. The π^--spectrum is based on more than 450 observed star-forming π^--mesons. A comparison of the π^+ and π^- data shows surprising results which are in complete disagreement with those expected from the relation $\frac{\sigma^+}{\sigma^-} = \frac{A+Z}{A-Z}$ which results from the assumption that production matrices in p-n and p-p collisions are the same. The peaks of the π^-- and π^+-spectra occur at widely separated meson-energies. The σ^- peak occurs at $T_\pi < 25$ Mev while the σ^+ peak occurs at $T_\pi > 70$ Mev. The $\frac{\sigma^+}{\sigma^-}$ ratio of the peaks is approximately $\frac{15}{1}$. Within experimental error the integral of the π^--spectrum over energies is the same as obtained at 90° to the proton-beam. This is not true for the σ^+ integral.

The marked decrease of σ^- with increasing meson-energy might be explained by the effect of the exclusion principle. The large increase of π^+ production may be the result of the resonance-reaction which accompanies deuteron formation.

II. Time of Flight Requirements for the Suppression of Background in Scintillation Counting Experiments with Pulsed Beams from High Energy Particle Accelerators. R. Madey and W. J. Frank

The initial talk was presented by R. Madey and is summarized here.

The finite time interval between the production and the detection of a nuclear event may be used in various ways to discriminate against background. For example, experimental arrangements have been set up to select particles of a definite velocity. Scintillation counter velocity selectors usually consist of two scintillation phosphors P1 and P2, a piece of transmission line, and a short resolving time coincidence circuit, shown in Figure 1.

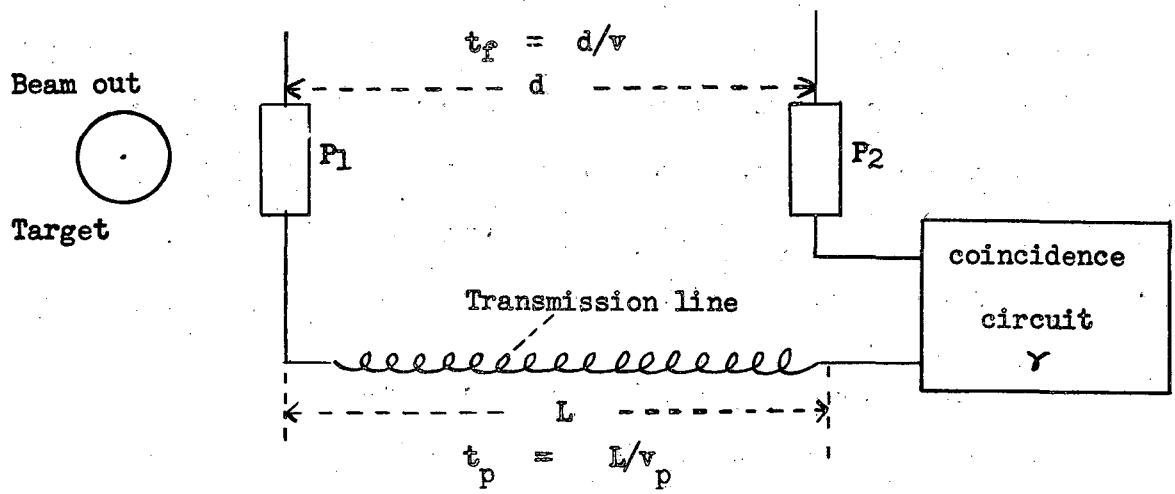

Figure 1. Scintillation Counter Velocity Selector.

Particles produced in the target with velocity v are detected when the particle flight time t_f between phorphors P1 and P2 is equal to the P1 pulse propagation time t_p for the particular length L of delay line used. Different velocities are selected by varying the length L of the delay line. For a given coincidence circuit resolution time τ good resolution in particle velocity v requires large distances d. On the other hand, the solid angle factor causes the counting rate to fall off essentially as the inverse square of the distance d.

Thus, such a velocity selector is most useful when a large flux of particles exists. For a given velocity resolution the spacing d between the phosphors can be decreased as the resolving time of the coincidence circuit is decreased.

A limiting factor on the performance of the velocity selector is the "dead time", which is defined here as the length of time that elapses between responses of the counter to successive pulses. Variations in output pulse amplitudes give rise to variations in the time that is required for the pulse amplitude to decay below a certain value, such as V*. See Figure 2. The time for the pulse amplitude to decay below the particular value V*, which will allow the counter to respond to another pulse, is a measure of the "dead time" of the counter. Thus, large "dead times" (such as t_ℓ) are associated with large amplitude pulses and small "dead times" (t_s) are associated with small amplitude pulses.

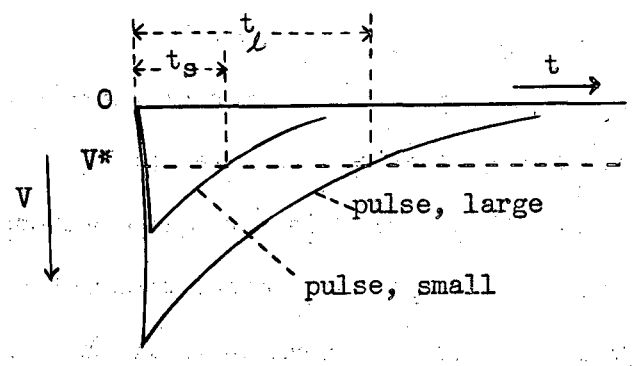

Figure 2

A transmission line type pulse duration limiter is used in order to minimize "dead time". High impedance (200 ohm) cable has been used to limit the pulses to less than 5×10^{-9} sec. Too, a pulse amplitude limiter feature is incorporated as a grid cutoff characteristic in the vacuum tube. An "adder" circuit is another feature where two short (5×10^{-9} sec.) pulses from two photomultipliers can be added without noticeable broadening by connecting together the plates of the double triode. The use of large area counters (4 in. x 6 in.) at speeds of

5×10^{-9} sec. have been successfully tested.

This equipment has been developed to facilitate the study of the reaction $\gamma + n \rightarrow \pi^- + p$, where the total variation in proton angle is about 7.5° for photon energies from 200 Mev to 1000 Mev. In order to discriminate against the large electron background at the synchrotron by counting pion-proton coincidences at a time after an rf beam pulse when the electron background has subsided, then the following conditions must be satisfied:

1. The time of flight of protons from the target to the proton counter must be less than the period of the rf oscillator of the Berkeley synchrotron:

$$t_p < \tau_{r.f.} = 2.2 \times 10^{-8} \text{ sec.}$$

2. The difference in the time of arrival of protons and electrons at the proton counter must be larger than the "dead time" τ_d of the counter. That is,

$$t_p - t_e > \tau_d = 5 \times 10^{-9} \text{ sec.}$$

where t_p = time of flight of protons from target to proton counter.

t_e = time of flight of electrons from target to proton counter.

3. The difference in time of flight between protons and pions should be greater than the resolution time of the coincidence detector, and also should be approximately equal to or greater than one-half the period of an rf cycle because one would expect that the background is smallest somewhere in the middle of an rf period. That is,

$$\tau < 1 \times 10^{-8} \text{ sec.} \approx \tau_{r.f.}/2 \leq t_p - t_\pi < \tau_{r.f.} = 2.1 \times 10^{-8} \text{ sec.}$$

where t_p = time of flight of protons from target to proton counter.

t_π = time of flight of pions from target to proton counter.

τ = resolving time of coincidence detector (5×10^{-9} sec. here).

τ_{rf} = period of rf oscillator of Berkeley synchrotron.

These conditions can be satisfied to varying degrees if the distance of the proton counter from the target is anywhere from about 80 cm to 160 cm. The

larger the distance the better these conditions will be satisfied. However, on the other hand, the smaller the distance the less will these requirements reduce the counting rate since then solid angle would be preserved by using larger area counters and the dispersion in the difference in the time of flight between protons and pions would be minimized.

Information Division
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