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SUMMARY OF THE RESEARCH PROGRESS MEETING OF MARCH 27, 1952

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S. Shewchuck

April 14, 1952

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SUMMARY OF THE RESEARCH PROGRESS MEETING OF MARCH 27, 1952

S. Shewchuck

April 14, 1952

I. The Triton Reaction ( $p + d \rightarrow \pi^+ + t$ ). W. J. Frank

This talk was originally scheduled to be included with that of the previous week entitled "Time of Flight Requirements for the Suppression of Background in Scintillation Counting Experiments with Pulses Beams from High Energy Particle Accelerators" wherein the electronics for this experiment was described by R. Madey. The postponement was necessitated by the lack of time.

Since the cross section of the process  $p + d \rightarrow \pi^+ + t$  will probably be lower by several orders of magnitude than that of the similar process  $p + p \rightarrow d + \pi^+$ , the main trouble of the experiment will come from background. However, several features of the production kinematics aid in discriminating against the background.

There is more of the energy of the bombarding proton available for the triton reaction because the extra nucleon in the target deuteron results in a smaller center of mass velocity. About 160 Mev is available for the deuteron reaction, whereas about 220 Mev is available for the triton reaction. Depending on the nature of the excitation function for the "pick up" process, the production cross section may be increased with increasing energy above threshold.

Since the reaction is a two body process with mono-energetic bombarding protons, the angles and energies of the resulting particles are correlated and can be calculated from the conservation laws. Pion energies in the laboratory system range from 40 Mev at  $180^\circ$  to 130 Mev at  $0^\circ$ . Tritons are confined to a  $12^\circ$  cone around  $0^\circ$ , and range in energy from 70 Mev at  $0^\circ$  ( $180^\circ$  in the center of mass) to 160 Mev at  $0^\circ$  ( $0^\circ$  in the center of mass).

A scintillation counter telescope for each particle makes use of the angular correlation to discriminate against the general background from the target. Further, since a certain energy particle is expected at a certain angle, the absorber in each telescope can be adjusted so that the particle passes through the phosphors at the end of its range. The consequent large pulse allows a lower voltage (around 1000 volts) to be used on the type 1P21 photomultiplier.

The use of time of flight is the main defense against the background from the target. The tritons (in the forward direction) are moving slowly relative to the protons that are slightly scattered or diffracted. (A triton of 150 Mev has  $\alpha \beta$  around 1/3, while a 340 Mev proton has a  $\beta$  around 2/3.) The pions in the backward direction are moving relatively fast compared to the low energy products from the target in that direction. Moving the counter telescopes back from the target and putting in the calculated delay line discriminates against the background provided the coincidence circuit has a short resolution time and provided the scintillation counters have a short recovery time. In the actual experimental arrangement, only the triton telescope is moved back because the triton telescope can go almost 12 ft. back and still require only a 2 in. x 4 in. stilbene phosphor. The reason for this small phosphor is the constricted triton distribution in the lab system. A one degree angular interval in the laboratory system is equivalent to about a  $10^\circ$  angular interval in the center of mass system. (This effect, in itself, aids against the background.) No large vertical height is needed for the triton phosphors since the triton phosphors are close to the axis of the beam where they subtend a large azimuthal angle.

For example, the two runs to date have the following correlated angles and energies:

$$\begin{array}{ll} \theta_\pi = 110^\circ & T_\pi = 56 \text{ Mev} \\ X_t = 8.0^\circ & T_t = 148 \text{ Mev} \end{array}$$

A finite counter window size and an energy spread caused by production at different points in the target result in some dispersion in the energies of the particles but not enough to cause any trouble.

Suppose now a proton beam pulse of about  $5 \times 10^{-9}$  sec. duration goes through the target and makes a pion and a triton. The pion arrives at the pion telescope about  $1 \times 10^{-9}$  sec. after the initial act of production; the slow background arrives a little later. The elastically scattered 340 Mev protons arrive at the triton scope at  $1.5 \times 10^{-8}$  sec. with the slower protons and other slow background appearing later. Finally, the triton arrives at  $2.75 \times 10^{-8}$  sec. Delaying the pion telescope signals by the proper amount allows the correlated pion and triton signals to arrive at the coincidence circuit at the same time. See Figure 1. The background in the triton scope arrives too early to meet the background from the pion telescope at the coincidence circuit.

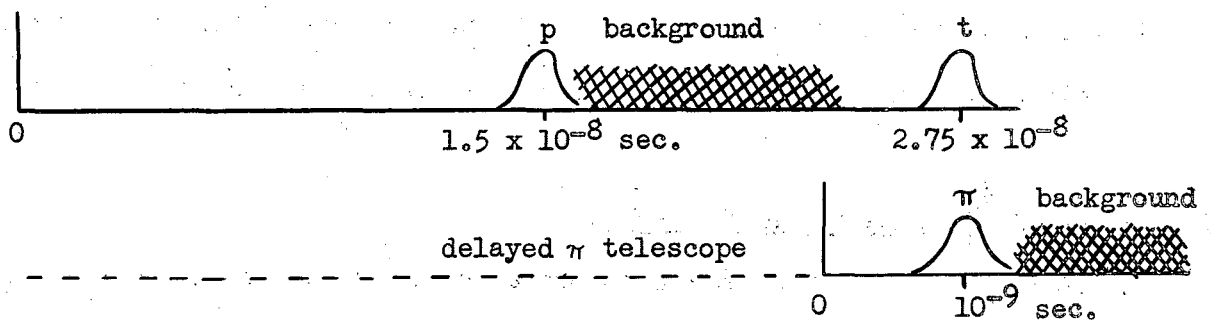


Figure 1

A plot of the quadruple counting rate versus delay line in the pion telescope shows that background is truly discriminated against by using time of flight. It is planned to spread this curve out further by increasing the distance of the triton detector from about 8' to about 12'.

If the pion telescope is moved to either side of the correlated angle then the  $CD_2-C$  difference should vanish. A plot of the difference vs  $\theta_\pi$  shows that

there seems to be an effect present. A similar effect should be observed if the triton telescope is moved away from the correlated angle. The  $CD_2-C$  difference disappeared at a triton angle of  $12^\circ$ ; but, at angles smaller than the correlated angle of  $8^\circ$  background became too high to get a  $CD_2-C$  difference in a reasonable time.

The main trouble is that the real  $CD_2-C$  difference counting rate is on the order of only one count per unit of integrated beam (integrator volts). At a beam channel meter reading of  $0.2 \times 10^{-8}$  one integrator volt required about two minutes of running time. The  $CD_2-C$  difference counting rate per integrated beam unit was found to be independent of beam intensity over a factor of five from beam channel meter readings of  $0.1 \times 10^{-8}$  to  $0.5 \times 10^{-8}$ . However, the running time required to obtain satisfactory statistics on the  $CD_2-C$  difference was not improved because the background counting rate also increased at beam channel meter readings higher than about  $0.2 \times 10^{-8}$ .

In the next run it is planned to move the triton scope back even further and to use modified electronics to reduce the background at the higher beam intensities.

## II. Use of $C^{14}$ in Humans. N. T. Berlin

The long half-life of  $C^{14}$  makes it dangerous to humans and hence it had been classified as poisonous from health physics standpoint. However, in experiments with mice it was established that  $C^{14}$  was rapidly excreted from the body. On this basis permission was finally received to use it in human studies. The patients selected had a low life expectancy and, as a precaution, the dosages used were far below tolerance levels even if no  $C^{14}$  were excreted. There has been a large enough number of cases studied as to reveal almost the entire story now.

Charts on specific activity of expired  $C^{14}O_2$  vs time and on integrated excretion for 24 days' period show that the high point in excretion is reached within one-half hour after intravenous injection of  $C^{14}$  labeled glycine and that the

slowest component to be excreted took about 7 to 10 days. Three rates of half time show up: 223 hours, 31 hours and 3 hours. A graph showed 40 percent of excretion the first day and a possible 92 percent in 40 days. This method of excretion accounted for about 85 percent of the dose.

Charts on urinary  $C^{14}$  excretion indicate that a total of 13.4 percent of the excretion is taken care of by this method, and that an overall total of 97 percent of the  $C^{14}$  administered takes place in about 100 days. The extrapolation of the data from mice to humans was in general justified. However, a slowest component of 50 days was found for humans which was much slower than could be predicted from animal data. The biological significance of this is not known.

An analysis of tissues for  $C^{14}$  was performed as a result of autopsies on four of the patients, who had serious diseases and had died. The findings on tissues of the lung, myocardium, kidney and liver show that the average time of turn over is about 50 days, which is probably allied with the period of turn over of certain protein components in the cells, which are relatively inert metabolically. One of the patients had somewhat higher values. A small amount, about 2 percent, still was left to be eliminated later.

Curves based on the data received are most useful in calculating the amount of the dose needed for various purposes, provided it is uniformly distributed. A dose of 3 mrep's would be reduced in 60 days to 0.2 mrep, which is below the effects from natural radiation and cosmic radiation. In the case of  $C^{14}$ , animals provided sufficient useful data for a basis of its use in humans. However, this is not true in the case of all radioactive elements. In mice the urinary excretion amounted to about 10 percent of the total dose, which was somewhat lower than in humans. It is concluded from these studies that  $C^{14}$  use in humans seems to be safe when used in natural biochemical compounds, most of which will behave similarly to glycine.



III. Meson Exchange Contributions to the High Energy Deuteron Photoeffect.

R. H. Huddleston.

The talk was based on an abstract report UCRL-1713, bearing the same title, by R. H. Huddleston and J. V. Lepore. It is quoted as follows:

Recent measurements at Berkeley and elsewhere on the photodisintegration of the deuteron between 140 and 290 Mev yield a cross section which appears to be an order of magnitude larger than that expected on the basis of the usual photoelectric dipole and quadrupole contributions.

The size of the cross section suggests that meson exchange phenomena may play an important role at these energies. An attempt has been made to estimate these effects on the basis of the pseudoscalar meson theory with gradient coupling.

It is important to note that not all exchange effects in this theory can be interpreted as due to exchange currents. Furthermore, the energy and angular dependences do not correspond to electric dipole disintegration alone so that it is not possible to treat these processes by the use of Siegert's theorem. The meson exchange diagrams are treated non-relativistically in the initial nucleon momenta by using a deuteron wave function in the initial state.

The results for a value of  $f^2/4\pi \sim 0.1$  are in approximate agreement with the mildly rising energy dependence of the observed total cross section and the differential cross section is not inconsistent with experiment.