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March, April, May, 1953

August 28, 1953

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TABLE OF CONTENTS

TARGET RESEARCH

	Page No.
Target Experimental Program	4
He^3 Purification System	5
Inelastic Deuteron Cross Sections	5
External Neutron Yields from 300 Mev Deuterons	6
Time-of-Flight Neutron Spectrometer	7
Proton Recoil Neutron Spectrometer	7
Liquid Scintillation Neutron Detector	8
On Neutron Evaporation from Excited Nuclei	9
Neutron Yield Extrapolation for Beryllium Primary and Uranium Secondary Targets	10

ACCELERATOR RESEARCH

Studies on Beam Dynamics	16
Dynamical Properties of Mark I	17
Estimates on rf Requirements on a Quarter-Wave Type of Preaccelerator	18
Initiation of Vacuum Sparks	18
Mechanical Design and Studies	19

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TARGET RESEARCH

Target Experimental Program

Frank L. Adelman

A. Physics

The main effort in the high-energy physics group will be associated with the improvement of the 320 Mev deuteron beam from stripped 510 Mev He^3 particles in order to get a larger beam with a smaller energy spread. At the same time an attempt will be made to measure the energy spread of the beam by time of flight.

When this is accomplished, water tank runs to measure total and differential neutron yields will be repeated with much better knowledge of the deuteron energy distribution than could be claimed at the time of the previously reported yields at 320 Mev. The attenuation cross section will also be measured for 320 Mev deuterons on uranium and beryllium for determination of the total inelastic and stripping cross sections.

In order to measure the neutron yield per high-energy neutron incident upon a target, the approximately 170 Mev stripped neutron spectrum from the 510 Mev He^3 beam will be measured by a time-of-flight technique. For monitoring, the $C^{12}(n, 2n)$ cross section will be evaluated. The energy distributions of the "90 Mev" stripped neutron beam from 190 Mev deuterons and the "270 Mev" knock-on neutron beam from 340 Mev protons will be similarly determined.

Work on the time-of-flight equipment for observation of neutron evaporation spectra is continuing, as is the development of the large liquid scintillator for the measurement of neutrons per nuclear event.

B. Nuclear Chemistry

The chemistry group will continue its spallation and fission studies of high-Z nuclei. The total cross section for fission is being estimated by means of fission-product yield curves. The total spallation cross section and the cross sections for individual spallation processes will also be measured to aid in understanding the mechanism involved. For the same reason, studies of Bi spallation are contemplated.

Isotopic composition studies and fission-product range measurements are being continued, at least partly for the purpose of understanding the types of events that occur. Light element spallation studies will probably be stopped after the summer.

Gross measurements on U blocks will be continued. The next set of runs will involve Q-metal foils in Be primary-U secondary targets in order to determine the effect of U^{235} on the neutron internal yield.

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He^3 Purification System

John Ise, Jr. and George P. Millburn

During the past three months the emphasis of the MTA target physics program has continued to be placed on the production of an experiment with the 320 Mev deuteron beam from He^3 stripping. The new parallel recovery system, for use with both the 4 percent and the 95 percent He^3, was tested thoroughly and filled with the 4 percent He^3 before the 95 percent He^3 was admitted to the system. After completion of such a run, with negligible loss of He^3, the 95 percent He^3 was finally admitted to the parallel recovery system. Since the volumes of the two parallel systems are the same, a comparison of the pressures in the two tanks affords a good measurement of the loss of 4 percent He^3 during the total preceding running time, if the total amounts of the two gases were intitially equal. Such a calculation indicated a loss of 4 percent He^3 of about 0.07 percent per hour of actual running time.

The bypass line in the recovery system, which contains the gas actually being recirculated through the cyclotron, contains about 4.5 percent of the total quantity of He^3, so that only about $4000 worth of gas is actually subject to partial loss or contamination.

The first cyclotron run using the 95 percent He^3 gave a maximum beam of stripped deuterons in the cave of about 5×10^{-13} amperes, which is above the usual 4 percent He^3 beam (about 2×10^{-14} amperes) by the ratio of the relative He^3 enrichment. However, with the 4 percent He^3, a beam of 3×10^{-13} amperes had been obtained on two separate occasions, and it was considered desirable to try to gain this factor of ten in beam intensity. Consequently various means were tried to peak the beam, such as optimizing target position, magnetic deflector position, etc., and finally the beam distribution inside the cyclotron was mapped out by means of two ion chambers mounted on the proton probe. The results of these experiments indicated that the optimum target position was inside the cyclotron dee. A target to be mounted in this position is being built.

Inelastic Deutron Cross Sections

W. Birnbaum and W. E. Crandall (CRD), and George P. Millburn

Measurements of the attenuation of 190 Mev deuterons in various elements have been repeated to determine the inelastic cross sections more accurately.

Corrections for multiple scattering in the absorber have been calculated and show excellent agreement with the scattering effects observed. The thicknesses of absorbers have also been corrected for the effect of multiple scattering. These calculations have resulted in sharpening the end of the attenuation curve and in giving increased confidence in the cross sections.

To check the validity of the method, attenuation curves of 340 Mev protons were measured and the inelastic proton cross section computed. The corrections were calculated as above and the agreement with the values measured by Dr. A. J. Kirschbaum (UCRL-1967) was excellent.

The calculations are continuing and a report explaining the method and procedure in detail will be published shortly.

TABLE I

	Kirschbaum				MTA
Element	335-270 $\bar{E}$ = 305 Mev	270-205 $\bar{E}$ = 240 Mev	205-160 $\bar{E}$ = 185 Mev		
Beryllium	0.151 ± 0.004	0.169 ± 0.006	0.172 ± 0.008	△	----------
Carbon	0.187 ± 0.006	0.202 ± 0.007	0.204 ± 0.012	*	0.173 ± 0.020
Aluminum	0.334 ± 0.009	0.383 ± 0.012	0.408 ± 0.025	*	0.343 ± 0.030
Copper	0.608 ± 0.022	0.667 ± 0.031	0.746 ± 0.045	*	0.665 ± 0.060
Lead	1.48 ± 0.06	1.57 ± 0.07	1.55 ± 0.11		
Uranium	1.60 ± 0.06	1.77 ± 0.07	1.90 ± 0.13	□	1.95 ± 0.20

All cross sections in units of barns

△ The beryllium cross section will be determined independent of any uranium cross sections for proton energies 340-0 Mev.

* These cross sections correlated with a cross section for uranium of 1.65 barns for an average energy $\bar{E}$ = 295 Mev.

□ This cross section is calculated for an average proton energy of about 220 Mev corresponding to proton energies 340-0 Mev.

External Neutron Yields from 300 Mev Deuterons

W. E. Crandall (CRD) and George P. Millburn

The yield of neutrons from a uranium target bombarded by the deuterons from He^3 stripping was measured with the $MnSO_4$ tank. The results tended to confirm the earlier measurements with the BF_3 counters but were quite uncertain. The yield was 8.4 ± 1 neutrons per incident deuteron for a 12 x 12 x 10 in. target.

The main uncertainty in the yield is related to the energy of the incident deuterons. Successive measurements of the yield differ by as much as 10 percent, probably because of the fluctuations in the deuteron energy spectrum. The uncertainties and fluctuations in the energy spectrum must be resolved before a definite yield can be measured. Experiments are now under way to measure the energy spectrum and to sharpen the energy distribution.

Time-of-Flight Neutron Spectrometer

Larry Schecter and Donald Hicks (CRD)

Work has been continued on the development of the fast-neutron spectrometer, with emphasis on the limiter circuitry. In order to achieve the required resolution, several systems of self-biasing the photomultiplier have been tried. The limiting action can be achieved only at the expense of output pulse height; since the coincidence circuit operation improves with input pulse height, a compromise solution is being attempted. It has been found necessary to run the 1P21 photomultipliers at 1900 volts, and this has been done for extended periods of time with no adverse effects. The first tests of the spectrometer are to be made shortly, using the monoenergetic 190 Mev deuteron beam from the 184 inch cyclotron to calibrate the resolving power and to check the limiter operation. If satisfactory, the instrument will then be used to examine the energy spectrum of deuterons produced by stripping He^3 particles.

Proton Recoil Neutron Spectrometer

R. Main (CRD)

In order to obtain a better understanding of the neutron production by deuterons on the various targets it is desirable, so far as is possible, to separate the various contributions and study them individually. It has been suggested that the high-energy neutron beam from the 184 inch cyclotron be used in a tank run to simulate the stripped neutrons from deuterons in the target.

To facilitate these measurements it is necessary to have information more accurate than is now available concerning the intensity and energy spectrum of the neutron beam. The proposed method of obtaining this information is to use a three-counter telescope and variable absorber to measure the intensity and energy spectrum of the recoil proton from a polyethylene target placed in the neutron beam.

The equipment and procedure is identical to that used by Schecter (UCRL-1996), modified to fast coincidence in order to eliminate the high background in the vicinity of the neutron snout.

Current work has been limited to the design and construction of a scintillating counter telescope and fast coincidence circuits and to the construction of an automatic absorber changer to speed up the taking of data.

Liquid Scintillation Neutron Detector

John Ise, Jr. and R. V. Pyle

During the past three months a new long-range experiment has been set up, for the purpose of detecting both slow and fast neutrons with high efficiency. The apparatus, as envisioned at present, consists of a large (30 in. x 30 in.) cylindrical steel tank, with end-window photomultiplier tubes spaced appropriately around the tank, viewing a solution of liquid scintillator inside the tank.

In order to make such a tank an efficient detector of neutrons, the liquid scintillator must be loaded with some compound of an element with a high capture cross section for neutrons, which subsequently gets rid of its excess energy by charged-particle or γ-ray emission. There are two further requirements which this solute must fulfill:

(a) the fluorescent properties of the liquid scintillator must not be destroyed, i.e., the solute must not poison the scintillator; and

(b) the solution must remain transparent to the emitted light, with absorption distances preferably of over a meter.

The first element to be considered was naturally boron, in analogy to its use in BF_3 gas counters. Solutions of the borate esters (methyl borate, ethyl borate, propyl borate, etc.) were found to fulfill the above two conditions. However, the neutron capture by boron is followed by emission of a 2.3 Mev α-particle, and it is an unfortunate property of liquid scintillators that heavy particles are much less efficient than electrons in converting their energy to visible light. Thus a 2.3 Mev α-particle gives only as much light as an electron of a few hundred kilovolts or less. Thus it would be desirable to load the liquid scintillator with some neutron-capturing elements which subsequently emit a cascade of γ-rays which are then converted, by Compton scattering or by photoelectric effect, to electrons.

Such a material is cadmium, which emits on the average 4.1 γ-rays of perhaps 2 Mev for each neutron captured, with a capture cross section of 2500 barns for thermal neutrons. Other experimenters have found recently that cadmium propionate is very satisfactory as a solute in toluene terphenyl mixtures. Consequently a tank is being built and photomultiplier tubes have been ordered, with several types of experiments in mind. This tank should be

ideal for measuring the actual distribution-in-number of neturons emitted in fission, both at thermal energies and, using particlebeams from the cyclotron, at higher energies. It should be useful in many inelastic events, such as (n, 2n) events. In connection with high-energy neutron scattering, the large pulses from the successive proton recoils preceded by 0.5 μsecond the subsequent thermalization of the neutron and its capture in the cadmium.

On Neutron Evaporation from Excited Nuclei

Frank L. Adelman

Heckrotte has calculated the energy distribution of neutrons evaporated from highly excited nuclei by a Monte Carlo method (UCRL-2184). This calculation was limited mainly by three factors. At high excitation energies, competition of proton and α-particle emission with neutron emission becomes important; in addition, binding energies far from the region of stability are not known. For low excitation, the competition between γ-emission, neutron emission, and fission should be taken into account.

As the excitation energy increases, the height of the potential barrier is reduced, although there is no agreement on the magnitude of the change. Furthermore, an increasing percentage of the "evaporable" particles will have sufficient energy to overcome the barrier. To aid in the evaluation of this competition, an experiment has been performed by Deutsch to measure the number and energy spectrum of the protons and α-particles.* One run (with α-particles) has already been made, and the data will be analyzed in the coming weeks. If enough energy is released in charged-particle emission, lack of knowledge of binding energies will be less serious.

At low excitation energies the most important competition is between neutron emission and fission, for only near and below the threshold for neutron emission will γ-ray emission occur with reasonable probability. An experimental investigation of the reactions of low-energy protons with thorium** gives some important information on this topic (Table II). At an excitation energy of 12.0 Mev, the compound nucleus can either fission or emit a single neutron (ignoring γ-rays). Since Tewes observed a (p, f) to (p, n) ratio of 2/3, the probability of fission in a Pa^{233} nucleus with 12 Mev is established as 0.4 (within the experimental uncertainties). If we now assume that all the ratios σ_f/σ_{tot} above 8 Mev are equal (within experimental uncertainty), and if we take the value estimated by Batzel for 190 Mev deuterons, then we may conclude that the probability of fissionfor highly excited (>25 Mev) nuclei must be small. More information about the relative probabilities will be gotten after an analysis of a similar but firmer experiment by Tewes on the 32 Mev linear accelerator, in which the (p, 2n) cross section will actually be measured. However, the evaluation of the data will take several months.

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* The technique is like that described in Barkas and Tyren, Phys. Rev. 89, 1, 1953, plus a quantitative measurement of the particle flux by Batzel's group (CRD).

** Tewes and James, Phys. Rev. 88, 860 (1952).

TABLE II

Proton Energy (Mev)	Excitation Energy (Mev)	$\frac{\sigma_f}{\sigma_{tot}}$	Fission is energetically possible after the emission of: 0 neutrons	1 neutron	2 neutrons	3 neutrons
6.7	12.0	0.4	yes	no	no	no
8.0	13.3	0.46	yes	0.2 of the time	no	no
9.3	14.6	0.74	yes	0.7 of the time	no	no
13.3	18.6	0.70	yes	essentially always	rarely	no
17.8	23.1	0.73	yes	essentially always	most of the time	no
19.5	24.8	0.56	yes	essentially always	most of the time	no
21.1	26.4	0.61	yes	essentially always	most of the time	rarely
Deuterons						
190	120	~2/3	yes	yes	yes	yes

Neutron Yield Extrapolation for Beryllium Primary and Uranium Secondary Targets

F. L. Adelman and F. N. Holmquist

While it is possible to estimate the neutron yield from a Be primary-U secondary target combination at higher energies by constant-efficiency approach (LWS-24486), it would be desirable to obtain these estimates from more fundamental considerations. This report discusses the basis of calculations now under way. No results, preliminary or otherwise, will be given here.

The analysis, suggested by UCRL-1958, is complicated by several factors. In the first place, the major production of neutrons takes place in the secondary, making it necessary to find the energy spectrum of the high-energy neutrons entering the uranium. Secondly, the character of the interactions in beryllium is entirely different from that in uranium. Since most of the neutrons in uranium are created at low energies by evaporation processes, water tank measurements can shed some light on the number of neutrons produced as a function of incident energy. But in beryllium, most of the neutrons are of high energy and not subject to easy measurement. Besides, the energy of the neutrons ejected varies more or less strongly with incident energy, so that measurements at one energy do not necessarily parallel those at another. Thirdly, the role played in these interactions by the loosely bound neutron in beryllium is not clear, especially with respect to a function of energy.

In the model for the interactions it will be assumed that the behavior of the loosely bound neutron in beryllium is quite different from that of the rest of the beryllium nucleus (core), that any nucleon-nucleon collision in beryllium will permit both particles to escape from the beryllium, and that stripping plays a very significant role in the beryllium interaction. When a deuteron strikes beryllium, then, a number of different processes may take place (cf. Fig. 1).

(1) The deuteron (energy E_D) may strip, giving protons (S_P) and neutrons (S_N) of half the energy of the deuteron, traveling in the forward direction. We include in this group all processes which give rise to nucleons of energy $E_D/2$; the cross section for the production of a stripped neutron is σ_s^m.

(2) The neutron (proton) of the deuteron may strike the loosely bound neutron of beryllium, yielding a neutron K_1 (K_2) of energy $0.41E_D$ traveling in the forward direction. The assumed monoenergetic character of the ejected neutrons is consistent with the work of Strauch;* the remaining neutron B_N(proton B_P) is assumed to have an energy of the order of 2 Mev. The figure 0.41 is arrived at by assuming that all the energy unaccounted for in Strauch's data goes into nuclear recoils and is therefore proportional to the incident energy.** The cross section for this process is the nucleon-nucleon cross section, shifted in energy by the assumed well-depth.

(3) One of the nucleons of the deuteron may strike the beryllium core, giving rise to 2 nucleons each of energy $0.41(E_D/2 - 20)$ in the forward direction; protons are designated K_3^P and neutrons K_3^N. The cross section for this process is discussed below. The energy chosen is consistent with Strauch's data, but it has been assumed that the ejected particles are monoenergetic with an average energy of half the peak energy for carbon in Strauch's paper. The 20 Mev is deducted to provide energy to knock a nucleon out of the core, in addition to breaking up the deuteron and beryllium nucleus. In each such event there is a probability (as yet undetermined) that the loosely bound neutron will drop into the state vacated by the ejected nucleon. The alternative is for the neutron to be released with about 2 Mev as in (2).

Each of the protons and neutrons created in the deuteron interactions has a chance of making further collisions in beryllium, or of entering the uranium secondary. The energetic neutrons and protons in (1), (2), and (3) can create additional neutrons through processes analogous to (2) and (3),*** while the low-energy neutrons can diffuse out of the beam side of the beryllium primary or into the secondary. Some of these processes may be negligibly small, but others may be so important that the neutrons should be followed through several "generations".

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* Strauch and Hofman, Phys. Rev. 86, 563 (1952).

** The energy required to break up beryllium and the deuteron is negligible here.

*** In the process (3) the nucleon energy becomes $E' = 0.41(E - 18)$, if E is the energy of the incident neutron, as the deuteron binding energy no longer enters.

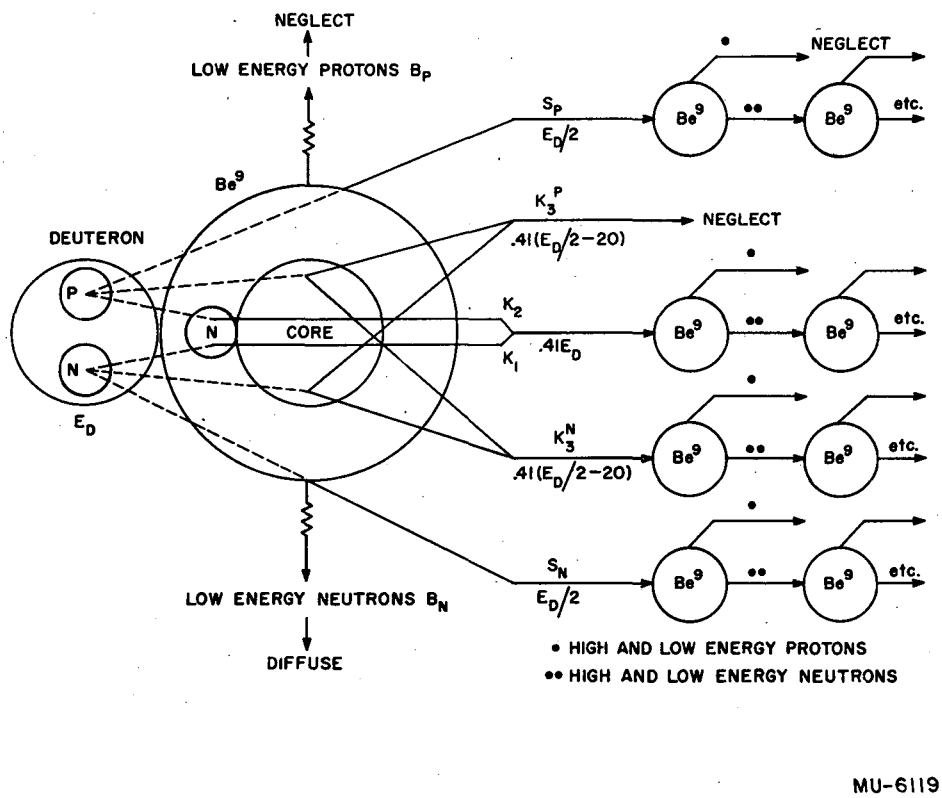

Fig. 1. Possible processes resulting from collision of a deuteron with a beryllium nucleus.

For the calculation we assume:

(a) The only important process involving protons is the creation of neutrons by stripped protons;

(b) The low-energy neutrons created in processes such as (2) and (3) above will diffuse with the constant appropriate to 2 Mev neutrons;

(c) Neutrons below 20 Mev (or some other convenient energy) will be considered to be isotropic and equal to 4 "diffusion" neutrons;

(d) High-energy neutrons striking U will produce a number of low-energy neutrons just as in UCRL-1958;

(e) Neutrons which diffuse into U will be multiplied by a fast effect appropriate to 2 Mev neutrons.

The cross sections used here deserve some amplification. For the purposes of having a specific model, we assume that the beryllium nucleus has a spherical core of 8 nucleons, each of which is 0.8 as effective in interacting with neutrons and protons as a free nucleon, and a loosely-bound neutron which is effectively free. All the nucleons are presumed to exist in a potential well of 30 Mev. Thus taking the geometrical area of the core to be given by

$$G = \pi(1.37 \times 10^{-13} \times 8^{1/3})^2$$

we find that the cross section for incident neutrons is

$$\sigma_N = G(1 - T) + \sigma_{nn}$$

where T is the transparency for the core, calculated from Fernbach, Serber and Taylor, and σ_{nn} is the free neutron-neutron cross section (assumed to be the same as the proton-proton cross section) at an energy equal to the neutron energy plus 30 Mev. This model yields correctly the proton-attenuation cross section in beryllium measured by Kirschbaum and by Crandall and the 90 Mev neutron cross section of DeJuren and Knable, although it misses the 270 Mev neutron measurement of DeJuren by 20 percent (see Fig. 2).

For deuterons the situation is more complicated. It is assumed that the deuteron will cease to be a deuteron if either particle strikes the core. It is further assumed that there is a zone around the beryllium nucleus within which the deuteron bond will be broken, giving rise to a stripping process similar to electromagnetic field stripping of Dancoff, the magnitude of which will be independent of energy (provided that the energy is high enough). The cross section σ_D can then be represented as the sum of

(a) G, the geometrical area of the core;

(b) $(\sigma_{nn} + \sigma_{np})/2$, the cross section for the loosely bound neutron;

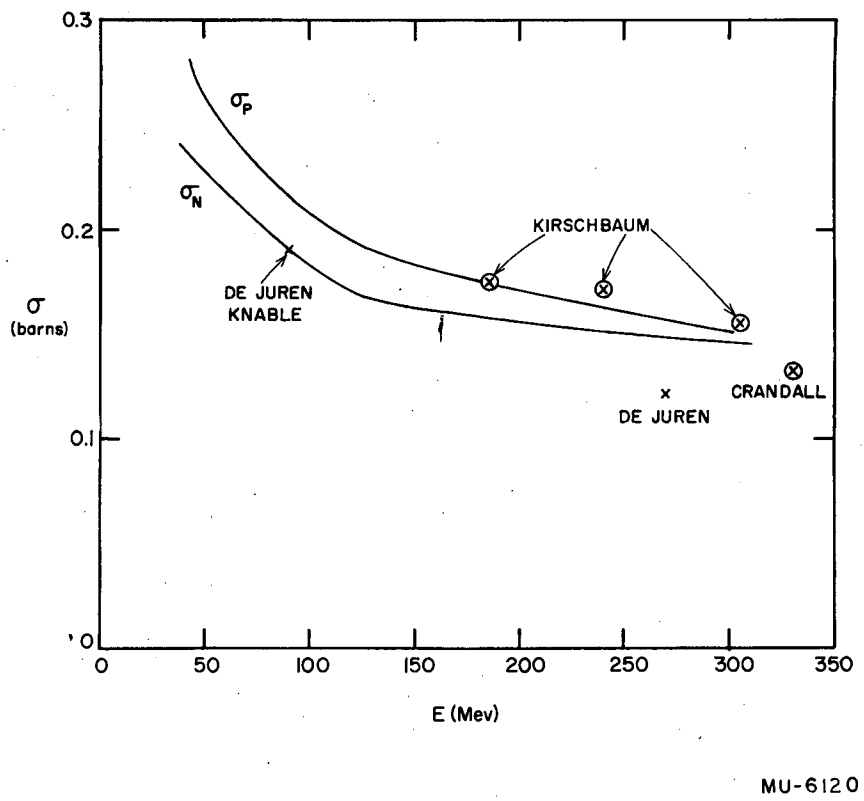

Fig. 2. Cross sections for interactions of neutrons and protons with beryllium.

(c) $\sigma_s^{\,s}$, the cross section for Serber-type stripping;

(d) $\sigma_s^{\,n}$, the cross section for nuclear field stripping.

From an experimental determination of the deuteron attenuation cross section by Crandall et al., $\sigma_s^{\,n}$ can be determined at 190 Mev. The value actually used was 0.45 barns, a little lower than the present "best value" of 0.50 barns. The stripping cross section $\sigma_s^{\,m}$ can also be estimated from these considerations, as

$$\sigma_s^{\,m} = \sigma_s^{\,n} + GT.$$

Now, the cross sections for all processes are known:

(1) Stripping: $\sigma_s^{\,m}$ for protons, $\sigma_s^{\,m}$ for neutrons;

(2) Loose neutron interactions: σ_{nn} for the incident neutron, σ_{np} for the proton;

(3) Core interactions: $G(1 - T)/2$ for neutrons; $G(1 - T)/2$ for protons;

(4) Fast neutron on loose neutron; σ_{nn};

(5) Fast nucleon on core nucleon: $G(1 - T)$;

(6) Stripped proton on loose neutron: σ_{np}.

It is then possible to calculate the energy spectrum of the neutrons incident upon the uranium and to compute the yield of low-energy neutrons as a function of energy for a Be-U combination target.

The results which will be obtained from this computation will not present an accurate picture of the yields of Be-U target combinations. In the first place, the model of the beryllium nucleus used here is entirely too detailed in relation to the state of knowledge of nuclear forces. Thus, it is quite certain that the cross sections of beryllium are different from those assumed here. Secondly, these cross sections are almost certainly wrong at low nuclear energies (< 100 Mev). Thirdly, most of the assumptions here have been chosen to be on the conservative side, in order to get a lower limit to the Be-U yields.

It is hoped merely to get an indication of how the yield will vary with increasing energy and of how reasonable our count estimates of neutron production at higher energies are. A second purpose is to set up a model which may be further pursued if a reliable estimate of yield is needed before the appropriate experiment can be performed.

There is one result which appears immediately. At 700 Mev, for example, one will not want to use the full range of 84.5 cm of Be, but rather would cut the figure to 50 cm or so. This pays off because the heat load in the secondary is increased only slightly, while more of the neutrons created in the nuclear interactions can reach the secondary without energy degradation.

ACCELERATOR RESEARCH

Studies on Beam Dynamics

M. L. Good, F. Holmquist, H. Kramer and L. Smith

The differential-analyzer studies of the 50 Mc preaccelerator described in the last quarterly report have been carried through far enough to show that they agree fairly well with the analytic formulation of both linear accelerator and strong-focussing theory. On the strength of this agreement, an engineering note was written giving the theoretical radial and angular acceptance, and highest permissible electric gradient, for various types of linear accelerators.

Electrolytic tank measurements by Hubbard and Nunan indicate that in the first several drift tubes the magnetic field may vary with axial distance sinusoidally rather than as a square wave with gaps, and accordingly a new strong-focusing stability diagram has been constructed for the case of sinusoidal magnetic field plus rf defocusing in the drift-tube gaps. The necessary magnetic fields are somewhat higher than for the square wave, but not prohibitively so.

The study of the effect of slow changes with strong-focusing parameters has been completed. The amplitudes are smallest when the parameters correspond to the center of the stability zone, and apparently the only way to damp the beam would be to alter the flip frequency and magnet strength simultaneously. Since this cannot be done very effectively in a linear machine, one must conclude that the beam will be essentially undamped all the way through the machine. The lack of damping gives rise to a new source of trouble: if the drift tubes are misaligned, an oscillation will be induced; in particular, if the misalignment is random of root mean square amplitude of 10 mils, the amplitude after 250 drift tubes would be about 1 inch. Work is in progress to see to what extent such effects can be overcome, and if the bore should be flared to accomodate a growing beam.

We are studying nonlinear effects in the strong-focusing system in preparation for tracing orbits in the measured magnetic-field distributions in the early drift tubes. A variety of nonlinear terms has been examined by approximation methods, but we have not found any serious effects from terms which may reasonably be expected to occur.

In order to improve the phase acceptance of the linear accelerator, the use of an initially large synchronous phase angle has been investigated. The differential analyzer studies of the 50 Mc preaccelerator indicated that an acceptance of 180° is obtained by starting at a synchronous phase of 60°. A separate differential-analyzer study of the damping of large phase oscillation is being made in order to find out how rapidly the synchronous phase angle can be tapered back to a conventional value.

Various means of bunching the beam at injection have been considered, in addition to the conventional buncher as used by W. Lamb. One promising device is a linear accelerator section one quarter of a phase oscillation in length, with a synchronous phase angle of 90°. The particles should emerge sufficiently well bunched so that approximately 300° could be caught by a following linear accelerator of 60° synchronous phase.

Dynamical Properties of Mark I

J. F. Waddell

Work on the Mark I rf regulating system has been successfully completed. Final tests and adjustments were made on April 20, 1953.

Prior to the tests, the amplifier units were modified in accordance with the decision indicated in the previous quarterly progress report. These changes insured control of the system during build-up of the rf without need for pulse-shaping networks, by providing a closed loop at all times for frequencies greater than zero. When the rf level has built up into the range of regulation for the system, the d-c loop is closed by means of a switchover network.

The Mark I system, when under rf regulation, has two outstanding shortcomings, both of which have been discussed in previous reports. These are (1) ignitron firing network emission of spurious pulses (2) changes in system gain when changes in level are not accompanied by corresponding induction regulator setting.

The first of these troubles is due to failure of the firing networks to properly transmit signals asking for rapid change in d-c bus voltage. The system is at present compensated for this defect by making the system transient response sufficiently slow. More suitable remedies were outlined in the December progress report.

The second difficulty mentioned above arises only when the operator fails to keep the induction regulator so adjusted that the rf regulator is operating, under quiescent conditions, at a specified point in its range. Since an additional burden is thus placed upon the operator, it would seem desirable to have automatic induction regulator control. Such a servo system was furnished by the General Electric Company as part of the original equipment, but its operation, according to CRD engineers, has never been satisfactory. It should, perhaps, be once more pointed out that the rf regulator is a dynamic regulator (i.e., "fast-acting"), and cannot of itself be expected to set the mean level of operation without seriously affecting its performance. Even so, it can control only over a narrow range of levels. The role of the induction regulator still remains unchanged: namely, to establish the mean rf level in the cavity through control of the input voltage. It is only through automatic control of the induction regulator that one achieves a system with a "one-knob" level control.

Estimates on rf Requirements on a Quarter-Wave Type of Preaccelerator

Fred Voelker

This investigation was for the purpose of approximating the rf skin losses and rf power requirements for a preaccelerator of the linear accelerator type in which a pi mode is excited. The drift tube and its supporting stem are designed to be resonant at the operating frequency, and the energy storage is arranged to be in the gap between drift tube and drift tube stems so that the over all shape of the outside tank is a second-order effect. It was also desired to find the trends in geometry which would minimize the rf losses.

At the low beta end of such an accelerator the drift tube assembly may be calculated as a group of parallel-plane transmission-line sections, without introducing excessive error.

On the basis of these calculations, the rf skin loss was found to vary considerably with stem dimensions. With a six-inch stem width, the smallest which is mechanically practical, and with a ratio of drift-tube gap to stem gap of 1 to 2, the rf skin loss was found to be approximately 12.5 kw/drift tube at 48 Mc with a gap gradient of 75 kv per inch. For the 22 drift tubes proposed, and allowing a 50 percent margin for additional losses in the cavity walls, joints, and transmission lines, a total rf capacity of 425 kw seems necessary.

Initiation of Vacuum Sparks

Harry G. Heard

Further tests of the particle initiation mechanism for high-vacuum sparks were conducted during this quarter.

Measurements of formative time delay of impulse-initiated vacuum sparks have now been completed and will be reported in the immediate future in UCRL-2251.

Experimental work on electron loading and vacuum sparking has now been terminated. A final report, UCRL-2252, will discuss these results in detail.

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Mechanical Design and Studies

W. M. Brobeck

During this period an average of 2.6 members of the Mechanical Engineering Department were engaged in MTA work. This represents a slight increase over the average of two for the preceding quarter. Their work consisted of a liaison with C. R. and D. on Mark I operation and experimental program and design work and studies on the long range MTA program. The approximate division of time was as follows:

1.	Mark I liaison	10 percent
2.	Tube testing and oscillator development	15 percent
3.	Resnatron development	15 percent
4.	Radiofrequency model work	15 percent
5.	Studies on preaccelerators and injection problems including preliminary designs of electrodes and strong focusing systems	45 percent

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