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1. Cloud Chamber Program

Wilson M. Powell

The X-ray Spectrum Produced by 322 Mev Electrons Striking a Platinum Target. The differential energy spectrum of the photons produced by 322 Mev electrons striking a 20 mil platinum target was measured by observing the energy of 3467 pairs produced in a one mil thick lead foil in a Wilson cloud chamber in a magnetic field of 10,000 gauss. The spectrum is found to agree with that predicted by the Bethe-Heitler bremsstrahlung theory using a Thomas-Fermi model with suitable corrections for the thickness of the target. The energy of the 322 Mev electrons was determined by the spectrum of the photons observed in this experiment. Apparatus used and the experimental data and results obtained are reported fully in UCRL-660.

2. Film Program

Walter H. Barkas

Nuclear Interaction of π^- Mesons. Tracks in G-5 emulsion of 38 Mev negative π mesons which are selected in the magnetic field of the cyclotron by a channel have been studied. The tracks are followed through the emulsion, and the length of path and types of events noted. The tracks are identified as those of mesons by direction, small angle scattering, and grain density. A total length of about 404 cm of track of mesons in the range 20-40 Mev has been measured and the following events recorded:

(a) Number of stars - 1
(b) Number of scatterings (apparently elastic) greater than 30° - 9
(c) Number of apparently inelastic scatterings - 1
(d) Scattering angles 2° - 30° roughly Coulombic.

High Energy Protons from π^- Stars. Fast protons from the capture of negative π mesons in emulsion have been studied. The energy is established by comparison of the proton grain densities with those of mesons of measured range. Protons of energies from 20 to 60 Mev are studied in C-2 emulsion, and those of over 51 Mev are studied in G-5 emulsion. Thus far 26 protons of over 51 Mev have been found at the termini of about 1000 negative meson tracks in G-5 emulsion and 20 protons in the energy range 20 - 60 Mev have been found at the ends of 216 negative meson tracks in C-2 emulsion. In addition a 54 Mev deuteron and a 30 Mev triton have been identified by range and grain count in C-2. Geometrical corrections have not yet been included.

Stars Produced by High Energy Protons in Nuclear Emulsions. The absolute cross section per atom for the production of stars of two or more prongs by high energy protons in G-5 nuclear emulsion has been studied as a function of proton energy. It was found that in the energy range 95-345 Mev the cross section increases with energy from 0.13 ± 0.02 to 0.29 ± 0.02 barns per atom. These figures correspond to mean free paths for star production in the emulsion of 619 gms/cm^2 for 95 Mev protons and 285 gms/cm^2 for 345 Mev protons.

Meson Focussing. For a contemplated scattering experiment and related investigations, the orbits of mesons leaving the cyclotron target have been investigated theoretically. It was found[1] that in the radially decreasing field of the cyclotron that the bundle of mesons leaving the target generally in the forward direction passes through a horizontal focus at the outer libration limit, which is a function of the meson momentum. At this position the mesons are in a vertically focussing field. For various combinations of meson energy and radial variation of the field the orbits may stay near the outer libration limit for a relatively long time, and simultaneous vertical and horizontal focussing may be obtained for a limited energy interval. This concept has been extended to bundles of mesons leaving the target in other directions, and partial or complete vertical focussing obtained. Such bundles of mesons may be caused to emerge from the cyclotron by appropriate location of the target.

Electron-Electron and Electron-Nuclear Scattering. It has been found possible to eradicate the accumulated tracks and subsequently to bring back the sensitivity in G-5 emulsion so that tracks of 1 Mev and 1.5 Mev electrons from P^{32} are readily followed in the emulsion. Since these particles are at minimum ionization, electrons of all energies are recorded. Preliminary study of the tracks show both electron-electron and electron-nuclear scattering events. A program of study of these processes as a function of electron energy has been initiated.

Grain Density Studies. It has thus far been assumed without experimental verifications that the grain density in a given sample of emulsion is a function only of the rate of energy loss of the charged particle in the emulsion. This postulate has now been checked for protons and alpha particles of similar grain densities in the same emulsion. It has also been found that the range exponent falls slowly with energy for fully developed emulsions, and also falls with under-development, so that better mass discrimination is obtainable with under-development. A routine assessment procedure for new batches of emulsion has been established.

Meson Mass Measurements. Careful measurements of the ranges and momenta of the protons and mesons in three nuclear emulsion plates are nearing completion. The mesons, which consist of π^+, π^-, μ^+ are being compared with protons in the same plates which have substantially the same velocity. The masses thus deduced are relative to that of the proton, and independent of the absolute value of the magnetic field and the stopping power of the emulsion.

Kinetic Energy of μ Meson. In the decay of the π meson the kinetic energy of the μ meson which is produced has previously been deduced to be about 4 Mev from its range and assumed mass. The magnitude of this kinetic energy is important for the balance of energy and momentum in the π-μ decay process. An experiment is being performed to reduce the uncertainty in the kinetic energy by calibrating the emulsion with π mesons of known momentum while at the same time making all the experimental observations as accurately as feasible.

Other Work. Progress has been made on the design of a magnetic field to hold together a beam of mesons from external targets; some work has been done on meson induced fission, on the use of lithium load plates for neutron measurements, on the production ratio of positive to negative mesons, on the possible branching of the π meson decay process, and on the identification in the emulsion of charged particles with unusual combinations of charge and mass.

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[1] W. H. Barkas, Phys. Rev. 78, 90 (1950).

3. The Neutral Meson Program on the 184-in. Cyclotron

Walter Crandall, R. H. Hildebrand, Richard Hales and B. J. Moyer

The neutral meson experiments during the past quarter have been primarily concerned with the following three studies: the yield of neutral mesons from proton bombardment of hydrogen and deuterium, the life-time of the neutral meson, and the observation of photon pairs from neutral meson decay at the cyclotron.

The Yield of Neutral Mesons from Proton Bombardment of Hydrogen and Deuterium. The study of the yield of neutral mesons from hydrogen and deuterium in the methods thus far employed involve the measurement of the differential yield from carbon and polyethylene targets and from ordinary water and heavy water targets bombarded by the 345 Mev proton beam. These targets are employed internally and the gamma rays from the decay of the neutral mesons are observed by a pair spectrometer located outside the shielding in the usual manner. The problem of beam monitoring is highly critical in these experiments since there is an amount of multiple passage of the protons through the target which is difficult to determine. In the most recent experiments on the yield from hydrogen, monitoring has been accomplished by the use of thin aluminum foils in which the high energy protons produce $sodium^{24}$ whose activity is subsequently counted.

In the case of the water targets it has not been possible to monitor in this manner. A target support system which allowed quick interchange of the two targets was employed and a large number of alternate readings of the neutral meson yield was made under the assumption that the beam variations would either be negligible or would average out. It was of course necessary to make the targets as nearly identical as possible so that the scattering of the beam and the consequent amount of multiple passage would be essentially the same for each.

The yield from hydrogen from these experiments is not more than one percent of the yield from protons bombarding carbon nuclei. This is in agreement with the tentative conclusion from earlier experiments in which the beam was monitored differently. The experiments on the yield from deuterium are not sufficiently complete to warrant a quantitative statement other than to say that the yield from heavy water appears to be somewhat greater than the yield from the same number of molecules of ordinary water.

Life-time of the Neutral Meson. Further experiments directed toward a measurement of a life-time for the neutral meson have been performed employing what was hoped to be a refinement of the original technique, described in earlier reports. In brief, the idea of the method is to observe whether or not the gamma radiation originates precisely within the geometrical boundaries of the target. If it can be demonstrated that the gamma radiation originates in some measure from localities in space slightly removed from the surface of the target it would be evidence of a sufficient life-time of the neutral meson to enable it to escape from the target before decaying. In the most recent attempts we have sought to observe a sharply defined target surface tangentially and then to shadow this surface by a thick block of uranium which is advanced gradually so as to progressively obscure the view of the target. The target was viewed with two types of instruments, one was a pair spectrometer adjusted to record gamma rays from neutral meson decay. The other instrument was a stilbene crystal with associated photo-multiplier tube subtending the same solid angle and sensitive area toward the target as the pair spectrometer converter did. It was presumed that the stilbene crystal would be primarily sensitive to Compton electrons produced from nuclear gamma radiation arising within the target material.

As the shadowing lock progressively obscures the target it would be possible to see a difference in the cut-off curves of the two detectors if the neutral meson gamma rays were emitted from a region in space slightly more extensive than the target proper from which the nuclear gamma rays would emanate. Thus far it is only possible to say that the neutral meson life-time cannot be greater than a few x 10^{-13} seconds.

Observation of Photon Pairs from Neutral Meson Decay at the Cyclotron. Successful experiments have been performed observing the coincident gamma rays from neutral meson decay where the neutral mesons were produced by the cyclotron protons. The appearance and technique of the experiments were essentially identical with those employed by Steinberger, Panofsky and Steller in a similar experiment with the synchrotron. The experiment is considerably harder to perform in the proton beam of the cyclotron than in the synchrotron beam because of the larger number of high energy neutrons which originate at the target and produce effects in the crystal telescopes which are similar to those produced by the high energy photons. However, it has been possible to demonstrate unequivocally that the photons observed under proton bombardment do indeed appear in coincident pairs. Also some very rough angular distribution data has been secured.

4. Particle Spectrometer

John Cladis, James Hadley

N-d scattering experiments using the 270 Mev neutron beam from the 184-in. cyclotron have been undertaken. Measurements of the momentum distribution of charged particles scattered at an angle of 22° to the incident neutron direction give an energy spectrum corresponding closely, within statistical errors, to the energy spectrum of protons from n-p scattering at this angle, and indicate that the differential cross sections for n-p scattering and for the D(n,2n)P process at this angle are very nearly equal. Measurements made with absorbers show that the scattered particles observed are essentially all protons. The energy spectra at a scattering angle of 30 of protons from n-p scattering and from the D(n,2n)P process again correspond in shape, but it is found that the ratio of the differential cross section for the D(n,2n)P process to that for n-p scattering at this angle is reduced to about 0.7. Further runs at these as well as at other angles are to be made.

5. The Pair Spectrometer

Norman Knable

During the past quarter the development of the pair spectrometer has been directed toward perfecting a fast coincidence circuit and investigation of the liquid phosphor detector. A bridge type coincidence circuit developed by L.Neher, has been tested and found satisfactory for resolution time $< 10^{-8}$ sec. The detection system will consist of quartz cells containing a solution of p-diphenylbenzene in xylene, a lucite light pipe and a quartz walled 5819 photomultiplier. All development is now completed, the components are being fabricated and will be installed on the 350 Mev pair spectrometer magnet when the magnet is assembled on its base during the first week in September.

The detection equipment for the 200 Mev spectrometer is essentially the same as that described above and will be installed at about the same time.

6. Scintillation Counters

L. F. Wouters

Pulsed Operation of Photomultipliers. Operation of photomultipliers under pulsed conditions has been continued. Sufficient experience has been obtained to establish it as a usable experimental technique. Our work has differed from that at Stanford University, in that our pulse length is necessarily much longer, ranging from 25 to 100 μsec. which is the length of the radiation pulses from the accelerators here.

Most of the experimental work has utilized the proton beam generated either by the 32 Mev linear accelerator or by the 184-in. cyclotron (345 Mev). The proton signal pulses obtained from photomultipliers operating at maximum d.c. conditions are of the order of 10 volts in height, being limited principally by space charge in the photomultiplier. This is checked by the relative insensitivit of the signal pulse height to the type of phosphor used, and by the behavior when altering the tube voltage. By virtue of the geometry, this phenomenon occurs initially in the next-to-last electrode gap, in the RCA photomultipliers.

It is found that if the voltage on this gap alone is increased, there is a reduction of gain beyond a certain point; this is due to serious defocussing of the electron paths. It is necessary to increase all stage voltages nearly proportionally in order to maintain the proper electron paths, at the same time obtaining an increase in the space-charge limited current.

The overall H.V. limit is a consequence of cumulative gas breakdown in which positive ions drifting back from the anode region strike the early dynodes, releasing an avalanche of electrons which further ionize the residual Cs gas, and so forth. This has a characteristic onset period of the order of 5 μsec; one then wonders why there is any advantage to 100 μ sec pulsing. Under d.c. conditions a photomultiplier will "hold" voltages a few hundred volts higher for several seconds before breaking down. This seems to indicate that there is a rise in gas pressure (due to ion bombardment) prior to the breakdown. Oscillographic observation of the breakdown shows a characteristic oscillation with a half-period of about 5 μsec., each oscillation being of greater amplitude than the preceding, presumably due to this rise in pressure.

In any event, under our conditions, H.V. pulsing does offer a method of applying perhaps 600 v more to the photomultiplier; a typical set of 1P21 operating voltages are:

P.K to D No.8 - 1600 volts pulsed, 100 μ sec. long
(equally divided by means of an R-C network)
D No.8 to D No.9, to A - 300 volts each, d.c.

In order to minimize H.V. pulse pick-up problems, several precautions are observed:

1. Obvious reduction of capacity between output electrodes and H.V. wiring.
2. Long H.V. rise and decay times ($\sim$5 μsec.) to reduce the stray-capacity differentiated pulse.
3. Low signal output impedances (125 to 300 ohms).
4. D.c. operation of the signal electrodes.

The equipment employed in generating the H.V. pulses consists of an adjustable rectangular pulse generator (Fig. 1a) (triggered by an advance pulse from the accelerator circuits) which drives an H.V. keying unit (Fig. 1b). The former is a quite straightforward "one-shot" multivibrator controlling a high-current cathode follower (829-B); this latter tube is required in order to adequately drive the pulse lines and keyer grids.

In order to reduce the H.V. pulse current requirements the keyer is always located near the photomultiplier apparatus. The connecting H.V. coaxial lines are of such length as to furnish the necessary capacitance to give the proper rise and decay to the H.V. pulses. The basic keyer circuit is an electronic switch which connects the "blocking" capacitor across the photomultiplier for the pulse duration.

It must be kept in mind that the signal information supplied by the photomultiplier is in the form of a current flowing externally from anode to dynode 9. It is very necessary to supply low impedance paths for this current in both electrode circuits, and to remember that the impedance across which a viable potential is developed is that actually in the complete circuit between A and D9.

We use low impedance transmission lines between photomultiplier and "pulse interpreter"; if the line is properly terminated, the output circuit then has a characteristic time associated with it of the order of $\tau = R_{line} C_{P.M.}$, which is usually at least as short as the phenomena being observed. The line impedance used is either 125 ohm or 300 ohms since the output currents under the above conditions are 150 to 200 ma. There are thus observed about 20 or 50 volt pulses at the end of the line. These are adequate for operating almost any pulse mixer or fast oscilloscope.

Nothing has been said concerning the phosphors used in these experiments. It is not a critical choice, since the proton ionization is sufficient to obtain adequate light pulses from even the weaker phosphors. The shortest possible time resolution is of chief interest. Accordingly the tests are performed for the most part using either clear trans-stilbene crystals, or terphenyl solutions (in xylene, toluene, etc.). The observed pulse lengths are then 1-3 x 10^{-9} sec.

Fast Oscilloscope Coincidence Mixer. Such large signal pulses facilitate observation of pulse characteristics, as well as make possible much shorter coincidence resolution times. A method particularly adopted for getting all of the resolution possible from scintillation pulses is that using an oscilloscope as the mixing element, as suggested by Hofstadter and others. The two signals to be coincided are applied to the two pairs of plates of a suitable oscilloscope, such as a 5RP11. The angle and shape of the trace then corresponds uniquely to a particular pair of pulse length and voltage conditions. The circuit of the unit constructed here, shown as Fig. 2, employs external H.V. supplies commercially available. The control grid is gated from the same pulser used for controlling the P.M. H.V. keyer.

The photomultiplier signals are brought to the deflection plates by means of a terminated shielded 300 ohm line, balanced to ground (Federal Telegraph K-111 Twinax). The signals delivered by the photomultipliers are balanced by

virtue of the balanced cable surge impedance. The terminations at the oscilloscope consist of standard "twinax" chassis and cable connectors, with 150 ohm 1/2 w carbon terminating resistors from each line to ground, all located as close as possible to the 5RP11 contact nubs. The input terminations at the counters are made through similar sets of connectors. Dynode 8 is granded either directly or through a low inductance condenser; dynode 9 and anode are connected to the line through small ceramic blocking condensers, with the d.c. return being made by means of 10 k resistors.

Using a pulsed 1P21 observing a trans-stilbene crystal, 1/2 inch deflections are observed from gamma induced electrons. Proton pulses from the accelerators (in terphenyl/xylene) produce 1-1/4 in. to 1-1/2 in. deflections. The pulses from a monochromatic proton source (such as the 32 Mev linear accelerator) are quite uniform. A monotonous dependence between pulse deflection and ionization energy loss, below the space-charge limit, was observed though the degree of proportionality could not be ascertained.

When both channels observe the same crystal, with equal overall delays and gains, the pulses appear as straight lines inclined at about 45°. Exactly coincident pulses of different height in the two counters result in straight lines lying at angles other than 45°. The distribution of such pulses serves as a good criterion for the uniformity of the crystal. Such an arrangement may also serve as a useful tool for comparing pulse heights and hence rates of energy loss.

Pulses of equal height but slightly different time phase appear as loops; the breadth of the loops indicates the degree of non-coincidence. In order to obtain equal overall delays, it is necessary to introduce some intentional delay in the line to the second set of deflection plates to compensate for the electron transit time between the two sets of plates. With 1200 v anode accelerating voltage, this is closely 10^{-9} sec. requiring an extra 8 inches of line. Variation of this electrode potential serves as a fine control for obtaining exact coincidence. It is interesting to observe the loops collapse into straight lines and expand back into loops as the critical oscilloscope accelerating voltage is traversed. As an example, this occurs over a 400 v range going from 1/4 in. wide loops (1-1/2 in. long) through the straight line condition and back to the 1/4 in. loop. This corresponds to a "visible" resolution of the order of 2×10^{-10} sec. Intentional introduction of a delay of 2×10^{-9} sec. creates loops which almost completely encircle the effective deflection area.

These results are obviously dependent on the decay time of the phosphor. The results quoted were obtained using a saturated solution of terphenyl in xylene. Using trans-stilbene, the loops observed enclose considerably less area (i.e. they are "narrower") than the corresponding terphenyl pictures, indicating a longer decay time. More interesting, it was observed that terphenyl pulses are far more uniform, with presumably much less random "after glow". The loops lay on top of one another, whereas stilbene showed considerable distribution.

Additional measurements of terphenyl-in-xylene pulse length were made using the "dipping-line" technique. At 2×10^{-9} sec., there is no appreciable diminution in pulse height and no undershoot, indicating an inappreciable pulse energy remaining at that time. At 10^{-9} sec. the pulse height is reduced in half and an almost equal undershoot is observed. An interpretation consistent with this behavior, and with the "loop" observations, is that the contribution to pulse length due to terphenyl decay is at most of the same magnitude as that due to the photomultiplier pulse distribution. Thus the pulses traveling down the lines are of the order of 8 in. to 10 in. in length and more or less triangular in distribution (possibly gaussian). Such a picture is incidentally consistent with Sard's calculated distribution from a photomultiplier alone.

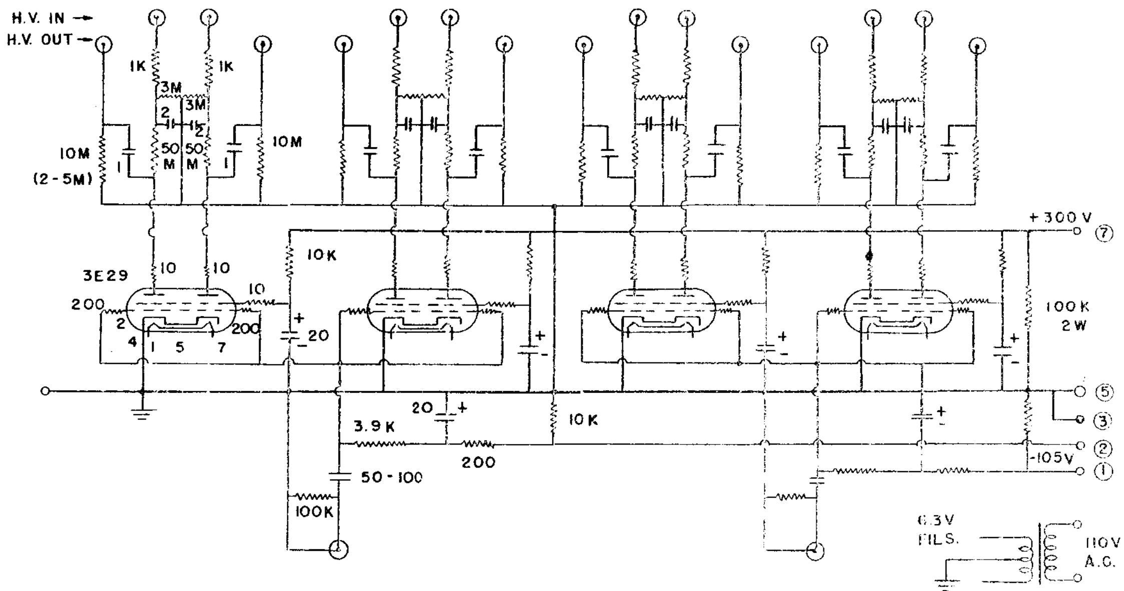
Besides these passing observations on pulse characteristics, this mixer was intended to provide maximum possible resolution for difficult coincidence problems, and to determine the practicability of transit time methods for measuring heavy particle velocities and energies in the near-relativistic region. The development of a new method of energy measurement is necessitated by the large degree of nuclear absorption occuring in absorbers of sufficient thickness to measure proton ranges in this regime.

In order to put the data-taking on a quantitative basis, the 5RP11 screen is observed through a mask, by means of a 1P21 triggering a pulse-generating amplifier which operates a scaler. The mask is cut so as to include virtually the entire narrow distribution of true coincidences (as determined from "single-crystal" tests). In the case of terphenyl solution, this is a rectangular opening somewhat under 1/4 in. wide centered on the time distribution and open at radii of 1/2 in. to 1-1/2 in. from the undeflected spot. This virtually eliminates the bright central halo from observation; such a small area also reduces the background so that a 150 volt plateau for counting the coincidence deflections is observed. Incidentally no d.c. spot position controls are provided; this is because of the difficult termination problem involved as well as the very strong leakage magnetic fields in which this unit is intended to operate. In any case, for proper operation the axis of the scope must be aligned with the leakage flux lines by tilting until the spot lies near the center. Small corrections are made by relocating the mask.

Consider now two pulses non-coincident by 10^{-9} sec. These will trace a loop surrounding the mask; only the vertex of the loop leaves a detectable trace across the opening. By suitably adjusting the sensitivity of the observing photomultiplier, one can readily discriminate between real coincidences which leave at least 1-1/2 in. of visible trace, and 10^{-9} sec. non-coincidences which leave only a 1/4 in. trace. Delay line measurements confirm a resolving time of better than 10^{-9} sec.

What about successive coincidence pulses appearing in less than the screen phosphor decay time? At these low screen intensity levels, which is usually adjusted below visible levels for optimum signal to background ratios, the screen is essentially a proportional recording device, and hence is analogous to a proportional counter. A simple differentiating circuit between observing photomultiplier and trigger-scaler readily separates pulses as close as one μsec. Linearity of counting rates up to an average of one count per 20 μsec. was observed.

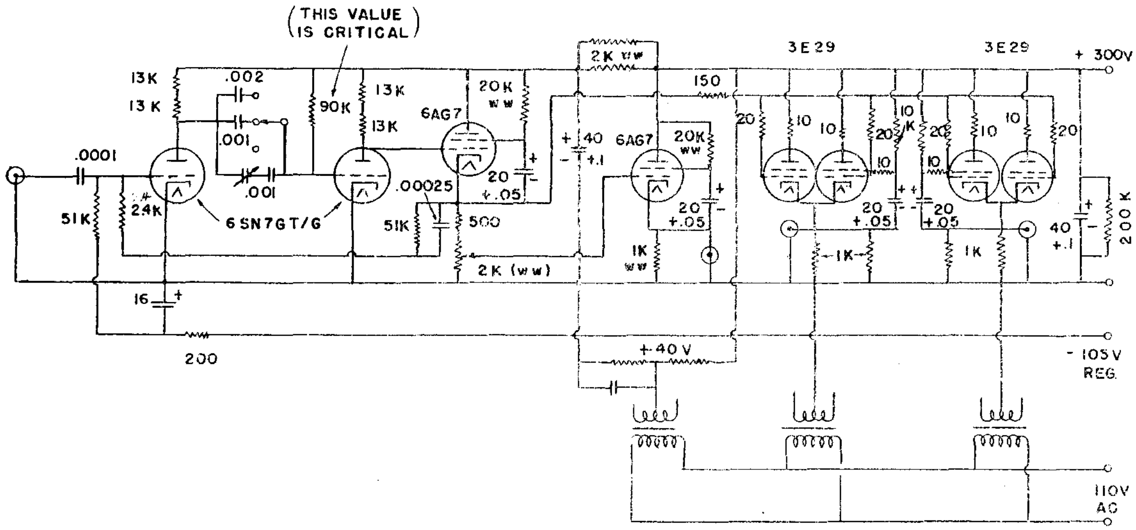
This completes the observations necessary for setting up a transit-time apparatus; preliminary tests have been inconclusive, though useful in orienting the course of improvements in the geometrical lay-out.



P.M. KEYER CHASSIS

MU 770

FIG. 1

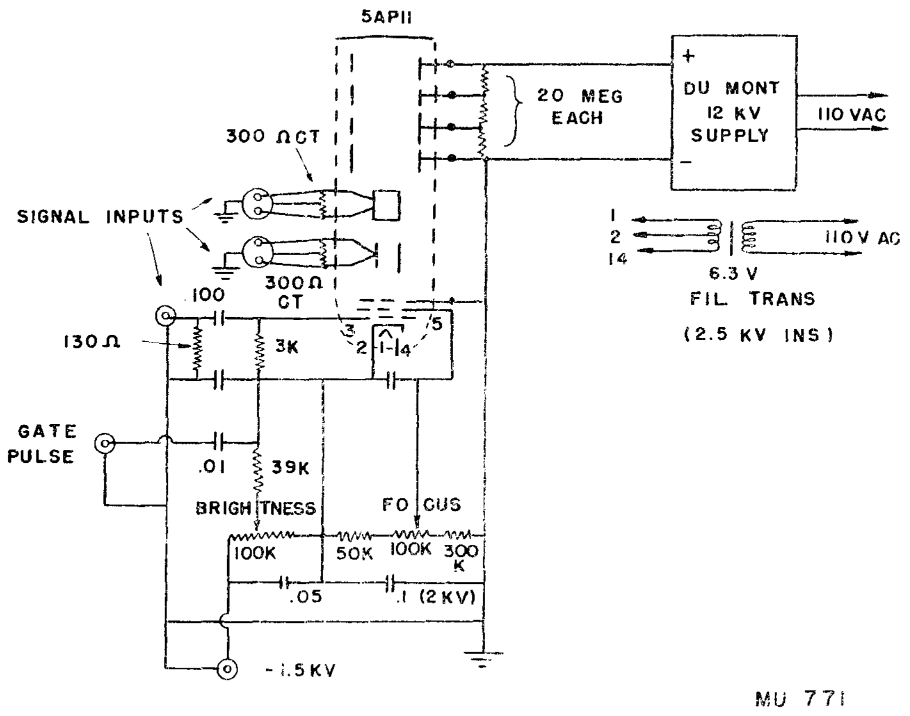


P. M. PULSER

MU 772

FIG. 1a

165631



FAST OSCILLOSCOPE MIXER

FIG. 2

7. Heavy Ion Acceleration in the 60-inch Cyclotron

James F. Miller

An external beam of more than 100,000 $C^{12(6+)}$ ions per second having been obtained from the 60-inch cyclotron, it was decided to try some bombardments. To obtain a larger beam on the target, the targets were mounted on an internal probe.

Aluminum Bombarded with C^{12}. Aluminum was selected for the first target for several reasons: There is a single natural isotope so that the reactions occurring would be well defined. Chemical separation of some of the expected products is relatively simple, and their half-lives long enough to permit finding them after chemical processing. Cl^{34} of 33 minutes half-life (which would be formed by the reaction ${}_{13}Al^{27}({}_6C^{12};\ \alpha n){}_{17}Cl^{34}$) was the first product looked for. On the first run, typical of later runs, a high purity aluminum foil (45 parts in a million impurity) was bombarded for half an hour on a probe face tilted at 9° to the beam. The foil was processed chemically to obtain AgCl precipitate which was then tested for beta-gamma activity. On the first run, the activity of AgCl was 116 counts/second 70 minutes after the end of bombardment. Counter efficiency is about 20 percent. On a later run, the yield was as high as 300 counts/second 73 minutes after the end of bombardment. The AgCl activity showed a single half-life, of which the corrected value from the best run, over a period of seven half-lives, was 33.3 minutes. The sign of the beta-activity was found by magnetic deflection to be positive, as it should be. Absorption measurements of the beta activity by aluminum and of the gamma by lead were not at a high enough counting level to be conclusive.

To insure that the Cl^{34} activity was not caused by alpha bombardment on an impurity or contaminant, the following precautions were used:

1. The high-purity aluminum foil was cleaned and not touched by fingers to avoid sulphur contamination.

2. To avoid the alpha beam from residual helium as nearly as possible, bombardments were made at a magnet current two amperes below the appearance of the external beam of alphas. This permitted still a good C^{12} beam on the probe, since C^{12} resonance is about 5 amperes broad; it completely overlaps alphas, but with a maximum about half an ampere below the alpha maximum. Normally, resonance on a probe target is about 3/4 amperes below external resonance.

As evidence that alphas or other activity present in the tank did not cause the activity found, a number of controls were used:

1. A target was made in the form of a sandwich with high purity 1.2 mil Al foil top and bottom and an absorber between to insure stopping the carbon ions. The alpha particles still had 24.5 Mev energy on striking the bottom foil. The AgCl precipitates from top and bottom foils, in successive readings on the same counter, were in the ratio 52 to 1, with the bottom foil only 3 counts/second above background.

2. Two control runs were made with argon in the ion source after flushing the cyclotron tank with argon over the weekend, before intorducing CO_2 gas. Both

showed an activity of only about 100 percent above background and a hundredth of that obtained with C^{12} ions at the comparable decay time.

3. The effect of alpha bombardment was tested directly by an external bombardment with 1/2 microampere of alphas for half an hour. The AgCl precipitate showed a low activity (7.6 counts/second 73 minutes after the end of bombardment) but its half-life was 110-120 minutes, definitely not that of Cl^{34}. The half-life pointed to $_9F^{18}$ (112 minutes half-life), which could be formed by an (α,pn) reaction on the oxide coating always present on aluminum. After this result, a fluorine holdback carrier was used in later AgCl separations.

4. A bombardment by C^{12} ions was carried out with the aluminum target foil wrapped in a 0.35 mil aluminum foil, to avoid any sputtered activity or any contamination on the target. The AgCl precipitate from the inner foil gave confirmation of the preceding results.

From the highest Cl^{34} count obtained (300 counts/second) a calculation of cross section for the reaction was made, correcting for decay, counter efficiency, and percent saturation. It showed either a high cross section or an unexpectedly large internal beam. With deuterons and alphas, the probe beams ordinarily are from 10 to 25 times the external beam. Assuming for C^{12} ions an internal beam 100 times the external one, or 10^7 ions/second, the cross section is about 4 barns. The liberal estimate for the internal beam may not have been high enough. Some evidence which indicates this is the broad magnet resonance of the carbon ion beam compared to that of alphas or deuterons, and the wide sweep of deflector voltages over which carbon ions appear. These probably result from stripping of carbon ions outside the ion cone by the r.f. field, thus permitting ions of many centers of rotation to hit an internal target. Further evidence is a radioautograph of the C^{12} beam on a probe foil. It showed the beam hitting the foil to be fully a half-inch wide radially. This is larger than expected from a line source of ions.

Search was made for S^{35}(87.1 day half-life) and P^{32}(14.3 days) by chemical separation from an aluminum foil bombarded with carbon ions for 8-1/2 hours. They were not found.

A direct reading was made of some aluminum foils without chemical processing. These gave evidence of several half-lives, particularly one of about 2.8 minutes (probably P^{30} from alpha bombardment) and one of about 8 minutes, which probably is K^{38} (7.5 minute half-life) from a (C^{12},n) reaction.

Aluminum Bombarded with C^{13}. Aluminum foils on the probe were bombarded with C^{13} ions to compare the results with those using C^{12} ions. The results might be expected to differ since, to obtain the same end product with C^{13}, one more neutron must escape from the nucleus. The bombardment should be free of alphas (also deuterons and protons) since the magnet resonance for C^{13} is 342 amperes compared to 289 for alphas and 293 for deuterons and protons. Two bombardments of Al foil, followed by AgCl precipitation, gave no significant evidence of Cl^{34}. On one of these bombardments when CO_2 gas enriched to 52.5 percent C^{13} was used, the external C^{13} beam was 6500 ions/second, about 1/15 that of the C^{12} beam that has been obtained. The large factor between the two beams is mainly due to the unfavorable magnetic field shape at the high field necessary for C^{13}. If Cl^{34} were present, its count was surely less than

1/second, compared to the 300/second maximum obtained with C^{12}.

A direct count was made of an aluminum foil bombarded by C^{13}, with the foil wrapped in a 0.35 mil Al envelope, which was thrown away before counting. The target foil had an activity of 17 counts/second and decayed with several half-lives, the shortest about 4 minutes.

Gold Bombarded by C^{12} and C^{13}. After the aluminum bombardments it was suggested that a definitive test for carbon-ion bombardments, where the presence of the residual alpha beam could not affect the results, might be bombardment of gold, with a search for alpha activity from astatine.

On the first bombardment, typical of the others, a 2.5 mil gold foil was bombarded for 44 minutes with C^{12} ions on a probe inclined 19° to the beam. A direct count of the alpha activity of the foil, made in a ZnS scintillation counter, gave 74.3 counts/second twelve minutes after the end of bombardment (background was 0.019 counts/second). The activity decayed with several half-lives, ranging from about 10 minutes to 9 hours. Various tests indicated that the alpha count was correct despite a high beta-gamma background from the foil (about 20 mr/hr at a few inches). A later short bombardment (8 minutes), yielding 20 counts/second, definitely resolved two half-lives, one of about 25-1/2 minutes, the other of about 7.2 minutes (At^{205} has a half-life of 23 minutes, At^{203} one of 7 minutes).

To compare this result from C^{12} with that from C^{13}, a gold foil was bombarded for 14 minutes with C^{13} ions from the 52.5 percent C^{13} enriched CO_2. Activity was about 1.0 alpha count/second (over 100 times background) and the half-lives appeared to be about 11 minutes and 36 minutes.

Control runs on gold were made as follows:

1. A bombardment at C^{12} resonance was made with an argon arc, before running carbon ions. No alpha activity was found in the foil.

2. An external bombardment was made with an alpha beam of 1 microampere for 5 minutes. The activity (0.074 counts/second) was only a thousandth that induced by carbon ions.

It should be possible to volatilize off the portion of the activity due to astatine. Tests made by cutting the foil and comparing heated and unheated portions showed about three-fourths the activity removed by heating to redness, but that the decay curves of the two portions had very closely the same shape.

Gold foils were then bombarded with C^{12} ions and sent to A. Ghiorso, Laboratory Chemistry Group, for analysis by the pulse height analyzer. The gold foil was melted and the volatilized fractions collected on a disk which was then placed in an ionization-chamber counter. The discrimination between pulse heights was set at about 0.03 Mev and the pulses of different energies recorded by registers; however, simultaneous peaks of activity cannot be resolved this closely.

On the better of the two runs, counting started 14 minutes after the end of bombardment with an activity of about 159 counts/minute in the volatilized fraction. At^{205} definitely was present, a tail of At^{203}, and probably At^{204}, not well resolved in energy from At^{205}, but for which further evidence was the growth of Po^{204} activity. The sum of five registers covering the At^{205} activity gave a half-life of 26 minutes. The At^{205} reaction is ${}_{79}Au^{197}({}_{6}C^{12};4n){}_{85}At^{205}$. Its creation by anything that might have been present other than the carbon ions appears virtually impossible. As in the case of Cl^{34} from aluminum, a calculation of cross section for the At^{205} production indicates either a high cross section (over 0.01 barns) or a higher internal beam than 10^7 ions/second.

8. Charged Particle Emission from Pb After Bombardment with α-Particles

F. N. Spiess

Charged particle emission after α bombardment of Pb has been further investigated. The activity is tentatively identified as α-activity. Bombardments with α-particles from the 60-inch cyclotron in the energy range 25-38 Mev have produced the activities in amounts corresponding to production cross sections of a few times 10^{-27} cm^2. Three life-times have been observed: 0.6 sec., 30 sec., and 3 min. (half-lives).

Bombardment of separated lead isotopes has shown that all three activities result from bombardment of Pb^{208}.

9. Proton-Proton Scattering

O. Chamberlain, E. Segrè, and C. Wiegand

Further measurements have been made with the 345 Mev cyclotron beam reduced in energy by passage through a lithium absorber to as low as 120 Mev. The differential scattering cross section was observed at 90° (center of mass system) to be 4×10^{-27} cm^2 $sterad^{-1}$ (center of mass system). At 167 Mev and 250 Mev measurements were made at 60°, and measurements at 90° were repeated. These cross sections were also 4×10^{-27} cm^2 $sterad^{-1}$.

Discrepancies between recent work with scintillation counters and earlier work with proportional counters have been at least partially resolved by the finding that particles were scattered into the proportional counters in significant numbers by the counter wall material. The extend of the effect has been experimentally demonstrated to be about 8 percent.

10. Deuteron-Proton Scattering

M. O. Stern and A. Bloom

Using the 190 Mev deuteron beam from the 184-inch cyclotron, the elastic scattering has been studied. Results previously reported have been verified in the range of scattering angles 50° to 140° (center of mass system). Methods other than coincidence counting are being investigated in an effort to extend the range in angle.

11. Positive π-Meson Counting Technique

M. Jakobson

Following the measurement of the π^+ meson half-life using scintillation detectors and distributed amplifiers, (as reported in the last quarterly report) an attempt has been made to develop a delayed coincidence counting technique for detecting π^+ mesons. Such a technique is difficult to develop because even distributed amplifiers must be pushed to their shortest pulse times. This method however offers the possibility of counting π^+ mesons with good efficiency with very low background. Some runs using the mesons produced by the synchrotron beam have been successful, but the equipment is not yet in reliable operation.

12. Stopping Power and Energy for Ion Pair Production for 340 Mev Protons

C. J. Bakker* and E. Segrè

The relative stopping powers for 300 Mev protons of H, Li, Be, C, Al, Fe, Cu, Ag, Sn, W, Pb, and U have been measured. The results are shown in Table I. The energy spent per ion-pair production in the gases H_2, He, N_2, O_2, and A at 340 Mev proton energy has also been measured. The results are shown in Table II. This work is reported fully in UCRL 850.

TABLE I

Element		Mass stopping power		q = Stopping power per electron	I_{ev}	I/Z ev
		Cu = 1	Al = 1	Al = 1		
1	H_2(in CH_2)	3.010	2.634	1.280	15.6	15.6
3	Li	1.214	1.062	1.184	34.0	11.3
4	Be	1.171	1.024	1.113	60.4	15.1
6	C	1.285	1.124	1.084	76.4	12.7
13	Al	1.143	1.000*	1.000*	150*	11.5*
26	Fe	1.036	.906	.941	243	9.3
29	Cu	1.000*	.875	.924	279	9.6
47	Ag	.902	.789	.873	422	9.0
50	Sn	.858	.751	.859	453	9.1
74	W	.777	.680	.814	680	9.2
82	Pb	.754	.660	.804	737	9.0
92	U	.720	.630	.786	853	9.3

In each column the reference value is marked by an * .

TABLE II

Gas	$-\frac{dE}{dx}$ (Mev/cm) 340 Mev p	W/W_A 340 Mev p	W(ev) 340 Mev p	W(ev) Po - α-particles
hydrogen	5.84×10^{-4}	1.405	34.9	35.1
helium	5.34×10^{-4}	1.02	25.3	30.2
nitrogen	3.49×10^{-3}	1.315	32.7	36.3
oxygen	3.92×10^{-3}	1.23	30.6	34.5
argon	4.02×10^{-3}	1.00	24.84	27.6
air(calculated)			32.2	35.8

* Zeeman Laboratory, University of Amsterdam, The Netherlands.

13. Capture of Negative π Mesons in Hydrogen

R. L. Aamodt, W. K. H. Panofsky and R. Phillips

An improved gamma ray pair spectrometer has been put into operation to improve the resolving power of the capture experiment. The new spectrometer consists of a magnet producing a field in the shape of an isosceles triangle of 90° apex angle. Improved resolution is produced by the use of 30 Geiger counter channels distributed along the legs of the triangle. The Geiger counters are gated by two pairs of large proportional counters placed outside the Geiger counters. All possible combinations of coincidences were recorded on a moving tape. The results were as follows: 1) The branching between the process $\pi^- + H = n + \pi^0$ and the process $\pi^- + H = n + \gamma$ is 0.96 ± 0.20. 2) The mass of the neutral π meson as deduced from the Doppler shift of the gamma rays from the disintegration of the π^0 is 135 ± 6 electron masses. 3) The value of the π^- mass deduced from the position of the gamma line and also from the central position of the π^0 peak is in excellent agreement with the π^- mass derived from meson range and curvature using photographic plate detectors.

The main point of theoretical interest is the value of the branching ratio given above. On the basis of our knowledge of the inverse processes one would infer that the π^0 produced would predominate over the gamma produced, provided that the matrix elements involved were reasonably energy independent. The fact that this is not so is interpreted to mean that a velocity dependent coupling between the meson field and the nuclei is indicated. The agreement with quantitative calculations is poor.

14. Capture of Negative π Mesons in Deuterium

R. L. Aamodt, J. Hadley, W. K. H. Panofsky

The experiment outlined in the above section has been repeated using deuterium as a capture target. In this case in addition to the two processes given above a third process is possible, namely the emission of two fast neutrons. The principal interest in the experiment lies in the fact that if there is a scalar meson a rigorous selection rule would apply which would forbid this process. The process involving the emission of a π^0 is barely energetically possible, but is not expected to have an appreciable intensity owing to the fact that angular momentum selection rules would make it necessary that the π^0 and the neutrons be emitted in P states, in case the parity of the π^- and π^0 mesons were the same. This has in fact been observed; the observed intensity of π^0 gamma rays correspond to a fraction -0.008 ± 0.01 of the total gamma ray yield observed in the case of hydrogen. The single gamma ray at the upper edge of the spectrum was observed to exist and to have an intensity of 0.30 of the intensity of the total hydrogen spectrum. Accordingly two-thirds of the total absorption spectrum is not accounted for in terms of gamma ray emission and thus represents the third process, namely the emission of two fast neutrons. This has been tentatively confirmed in a qualitative way by an independent experiment by K. Crowe and H. York in which it is attempted to detect these fast neutrons simultaneously. On the basis of the above selection rule it appears thus to be impossible that the π^- is scalar. A possible exception to this conclusion might be the possibility of capture from orbits of high angular momentum but an estimate of this effect shows that the capture life time from P states is too short to compete with radiative transitions to the S states. The question is a similar one here as in the case above in hydrogen, namely why an electromagnetic process can compete with the nuclear process; presumably the explanation is again in terms of a coupling depending on the velocity.

15. Neutron Proton Scattering at Large Proton Scattering Angles

Roger Wallace

The work has been completed on the analysis of the large angle protons produced in neutron-proton scattering in hydrogen of 90 Mev neutrons. The work was done with photographic plates in a gaseous atmosphere of hydrogen at 2 atmospheres of pressure. Approximately 3000 tracks have been analyzed and tabulated. The resultant angular distribution is in excellent agreement with the work of Hadley, Kelly, Leith, Segrè, Wiegand and York in the region where the two experiments overlap. In particular it confirms the rising slope of the curve of Hadley, et al, towards large proton scattering angles and continues to rise.

16. Meson Beam Production

C. Richman and M. Skinner

An intense fairly monochromatic meson beam has been produced using the 340 Mev protons in the deflected beam of the 184-in. synchro-cyclotron. Using a 5 cm polyethylene, $(CH_2)_n$, target and magnetic channels to separate mesons and protons it has been possible to produce a fairly well collimated meson beam of 5000 mesons per sec. issuing from a channel of cross section 2 inches by 2.5 inches. The energy spectrum of the mesons in the beam is peaked at 53 Mev and has a half width of 5 Mev. This work will be fully reported in a forthcoming UCRL special report.

17. Synchrotron Studies

A. C. Helmholz

The synchrotron was shut down on June 12 for repair work, reconstruction, and electrical work which had been sorely needed for some time. The shut-down lasted four weeks. Experiments were resumed on July 10. The details of the shut-down work are dealt with in Section II 3. of this report. Since the resumption of work on the synchrotron a number of experiments have been started, and some of the experiments mentioned in the previous report have been continued.

J. S. Steller and W. K. H. Panofsky are continuing the work on the neutral meson mentioned in the previous quarterly report.

Dr. A. Silverman made several runs in a search for the Compton effect of gamma rays on protons. The experiment involves measuring the recoil protons and the scattered gamma-rays, which are to be correlated in angle, depending on the proton energy. While some coincidences between protons and gamma-rays have been observed, they persist at different angles, and it is concluded that the effect is probably due to the gamma-rays and the recoil protons from the reaction $\gamma + p \rightarrow \pi^0 + p \rightarrow 2\gamma + p$, as observed in the neutral meson experiment. Silverman has also investigated the field of protons from gamma-radiation of Be and found no anomaly in the number.

Karl Strauch's work on transition curves has been completed and is included in UCRL-708. An extension of this work to measure the lateral spread of showers has been started by Strauch and Rose. The beam is collimated to 1/8 in. in diameter, and 1/8 in. Cu detectors utilizing the Cu(γ,n) radioactivity are placed at different lateral distances from the center of the beam. The distributions of intensity as a function of distance from the center of the beam behind different thicknesses of Pb give information as to the build-up of the shower. Comparison with theory is being made. The intensities of the radioactivity are low.

A. S. Bishop is completing some of the measurements started by himself and Dr. J. Steinberger. The next report and special reports should include the results of the several types of experiment now being performed.

18. Theoretical Physics

R. Serber

Scattering Experiments. Two different suggestions for explaining high energy scattering results have been investigated. Jastrow has suggested the possibility of explaining the high energy p-p scattering in terms of repulsive core. His explanation leads to difficulty in that one will expect a minimum in the cross section at around 150 Mev. Experiments show that such a minimum does not exist. Also trouble arises in the n-p scattering. Introduction of repulsive core forces one to reduce the long range tail in order to maintain the proper effective range. This leads to a small angular dependence at the lower energies. While the repulsive core is not a cure-all for scattering difficulties it may turn out to be useful in some states for some kind of interactions. The second suggestion investigated was the spin-orbit force of Case and Pais. The spin orbit force is almost indistinguishable from the tensor force in its effect on the scattering. The chief difficulty with this idea that has turned up is that the sign of the tensor force required to fit the 32 Mev p-p scattering is opposite to that desired by Case and Pais. Calculations are also being carried out on the polarization effects expected in double scattering experiments; and on n-d and p-d scattering.

Meson Theory. Calculations of meson processes involving deuterons have been carried out. The effects of the strong distortion of the nucleon wave-functions by nuclear forces, and particularly the possibility of deuteron formation in meson production has been investigated, and has been shown to radically alter the expected energy distribution of the produced mesons. The modified spectrum, which is much more concentrated to high energies, is in good agreement with the observations. A systematic survey of the predictions of the various meson theories shows that pseudosclar theory with pseudovector coupling most nearly accounts for the observed facts.[1] One outstanding discrepancy is in the large photo production cross section for neutral mesons.

Efforts are being made to understand the π^- capture in hydrogen and deuterium. Suitable selection rules which slow down the rate of π^0 and 2 n emission are provided by pseudoscalar theory with pseudovector coupling; however, since with this theory the principal contribution comes for relativistic terms which are not unambiguously determined, no real quantitative comparison is possible.

Other Studies. Investigations are being carried out on various points concerning shower theory such as the lateral spread of air showers. These are of interest both for cosmic ray and syncrotron problems. A study is also being made of the penetration of high energy particles through matter, in the attempt to answer such questions as the fraction of their energy lost in nuclear events rather than in ionization, the number of neutrons made, and similar problems.

Investigation is also being carried out of polarization effect in bremsstrahling, in the hope that further light on such problems as photo meson production may be obtained by the use of partially polarized x-ray beams.

II ACCELERATOR OPERATION AND DEVELOPMENT

1. 184-inch Cyclotron

James Vale

Operation. Operation of the 184-inch cyclotron during this period was still very steady with a minimum of time taken for shutdowns. The cyclotron was used for research experiments about 94 percent of the time the crew was on duty. The cyclotron has returned to a sixteen hour, seven-day week after a period of five days per week. The shorter week was made necessary by the diversion of part of the the operating crew to other projects in the laboratory. New crew members have now been hired, however, so that the cyclotron can be operated on a full schedule.

Radiation Shielding. The normal operation of the cyclotron is such that the neutron beam from the target goes in a southerly direction. For this reason, a seven foot cube of concrete, called the "igloo", was placed on the platform inside the main concrete shielding. The igloo has holes through it in line with the neutron holes in the main concrete shielding so that the neutron beam is brought outside the shielding for the experimenters. The igloo thus provides additional shielding to keep the fast neutron level quite low during normal operation.

Experiments have developed however in which it is necessary to operate the cyclotron with the magnetic field reversed so that the neutron beam from the target is in the opposite direction, or toward the north. Under these conditions, the radiation level in the north end of the building is too high. Two things have been done to bring the level down. One, a three foot cube of lead has been placed inside the vacuum tank directly in line with the neutron beam, and two, additional concrete blocks have been placed outside the main shielding. These concrete blocks had previously been used as the shielding for the temporary deflected beam cave.

Deflected Beam Cave. The permanent cave shielding was delivered and installed during this period. The new cave is now approximately twelve feet wide by sixteen feet long and can be roofed over. The increased length has enabled more efficient use of the beam, since it is now possible in certain cases to get two pieces of equipment in line with the beam at the same time. This procedure must be limited to experiments that do not interfere with one another.

In addition, under conditions of maximum beam intensity in the cave, the roof reduces the background in the building by a considerable factor.

Main Concrete Shielding. The present radiation shielding around the cyclotron is now ten feet thick, composed of two walls each five feet in thickness. Some time ago it was felt necessary to add another wall to make a total radiation shielding of fifteen feet of concrete. Delivery of this new wall has started and the new completed wall should be in place within the next month or two.

2. 60-inch Cyclotron

Bernard Rossi and M. T. Webb

Operation. During this quarterly period the operation at the 60-in. cyclotron was curtailed to a 5-1/2 day week of 24 hours daily operation. With this curtailment and normal holiday shutdown, there were 1,696 hours available instead of the full time of 2,208 hours. Following is a resume of how this time was consumed:

Alpha bombardments	786.0 hrs.
Deuterium bombardments	226.5 hrs.
Proton bombardments	25.1 hrs.
Development	189.6 hrs.
Total Operations	1227.2 hrs.
Outage	468.8 hrs.
Total Time Available	1696.0 hrs.
Shutdown time	512.0 hrs.
Total Time	2208.0 hrs.

The time allotted to development was almost entirely consumed with work on the heavy ion acceleration program, details of which appear later in the report. A large amount of the outage time was used to install the newly designed pump system.

During the pump installation, an inspection of the dees showed that the west dee had been cut at about the 22-1/2 in. radius on the lower south edge along the median line. The stainless steel driving mechanism for the feelers was completely eaten away inside the east dee. Removal of the entire drive system and repair of the west dee was effected at this time.

While in operation after the pump installation shutdown, the west dee was lowered to prevent further erosion by the beam. Future inspection showed that while this move eliminated the lower dee burning, it introduced new erosion on the north upper edge of the west dee again at about the 22-1/2 in. radius from the center. A probe is now being developed to determine the beam envelope in this region and is to be used during shim adjustment to determine the effect of this adjustment on the median plane of the ions.

Improvement of the 60-inch Cyclotron Pumpting System. The 60-inch cyclotron was originally equipped with one oil diffusion pump unit consisting of six two-stage pumps of four inch diameter connected in parallel to a 24-in. throat. They were backed by a Kinney pump of 23 C.F.M. capacity. This system was connected to the far end of the dee stems. Thus, the vacuum chamber containing the dees had to be exhausted through the narrow throats. With this system it required about 24 hours to reach base pressure. This was about .4 μa (0.04 microns). Gas bursts were slow to pump out.

In 1945 an eight inch Westinghouse diffusion pump was added to the system. This was connected directly to the vacuum chamber containing the dees. It was backed

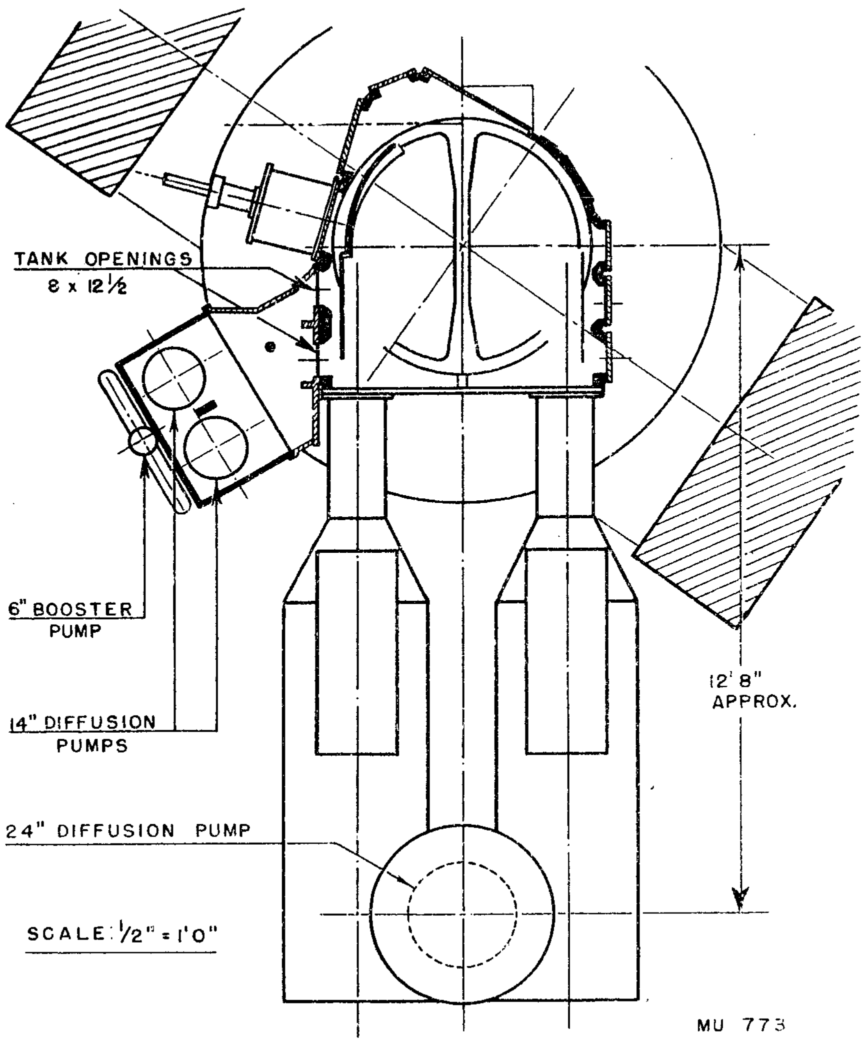
by a Kinney of 46 C.F.M. capacity. At the same time the backing pump of the 24 in. pump was replaced by one of 46 C.F.M. capacity. This reduced the ruffing down time from about 8 hours to about 2 hours, reduced the base pressure to about 0.012 microns and reduced the time for pumping out gas bursts.

From the experiences of other Radiation Laboratory projects using vacuum pumps (especially the model bevatron), it was learned that refrigeration of the diffusion pump baffles aided greatly in reducing sparking in the vacuum chamber. A temperature of -40° F. was being used with Freon 12 as a refrigerant. However, indications were that even better results could be obtained by using a still lower temperature. A temperature of -70° F. could be reached by using Freon 22 as a refrigerant.

Therefore, it was decided to revise the 60-in. cyclotron vacuum system by installing larger pumps with refrigerated baffles. These are in addition to the water cooled baffles. The temperature to be used is -70° F. The 8 in. pump was removed and two 14 in. Radiation Laboratory diffusion pumps with a common manifold were added. They were backed by a 6 in. booster. The forevac line from these and from the 24 in. were brought to a common manifold to which was connected a Kinney pump of 105 C.F.M. besides the two of 46 C.F.M. The refrigeration has not yet been applied to the baffles but the most noticeable effect of this new arrangement has been to shorten the time of pumping out a gas burst, roughly from ten seconds to two seconds. It has also reduced the base pressure to about 0.006 microns. The 24 in. diffusion pump was already equipped with two baffles, one of which will be water cooled and the other refrigerated.

The gates of the 14 in. diffusion pumps are air operated and have been provided with a hand operated locking screw by means of which they can be locked in a closed position while the diffusion pumps are being removed for repairs.

The present location of the 60-inch diffusion pumps is shown in Fig. 1.



60" CYCLOTRON DIFFUSION PUMPS LOCATION

FIG. 1

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3. Synchrotron

George C. McFarland

Machine Performance. During the first of this report period, the synchrotron operated consistently at relatively high beam intensities.

In cooperation with General Electric Company Engineers, considerable time was devoted to investigation of random failures of the high voltage ignitron tubes in the main magnet excitation circuit. It was found that failure of the ignitron tubes could be prevented by slightly delaying the firing of one of each pair of tubes. One possible reason for the success of this firing time differential, is that it allowed the voltage to build up on current dividing reactor, and increased the voltage drop across the tube that fired last.

Fig. 1 shows the two GL506 ignitron tubes in parallel through the current dividing reactor. Before firing of either tube 20,000 volts potential is across plate to cathode of both tubes. As soon as one tube fires the voltage across both tubes, due to arc drop in the tube that has fired is about 35 volts. Current flowing in one leg of the current dividing reactor increases the voltage across the tube that has not fired.

An overhaul of the synchrotron was accomplished during the last two weeks of June. This overhaul included tightening of the magnet proper and all associated parts, cleaning and recoating the quartz vacuum chamber, renewing the gaskets, repairing broken compensating wires. Also the control room circuits were revised and regrouped resulting in an expanded and more efficient monitoring system.

After overhaul a beam was quickly found.

Investigations were made on the Betatron induction acceleration voltage and on an orbit shrinking contracting coil operating with a fast pulse near injection time. This pulse increased the beam intensity by nearly a factor of two and for several days the peak intensity of the machine was greater than ever before.

Further development of the orbit shrinking contractor was postponed in order to make the beam available for the Physics Research Program (neutral mesons, induced activities, neutron cross section etc.). Most of the crystal counting experiments required the synchrotron to be operated with a beam much below peak intensities due to increased background with high intensity beams.

A new collimator was installed and aligned after the overhaul.

The dynamic test of the radio frequency modulator made and used prior to the shutdown proved successful. Equipment is being built for permanent installation at this time.

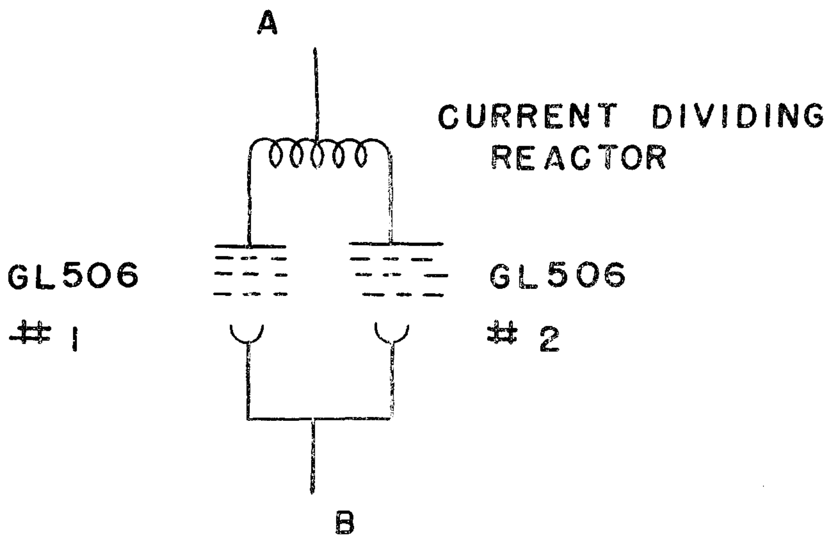

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FIG. 1

4. Linear Accelerator and Van de Graaff Machines

W. K. H. Panofsky

Operating Statistics. During the first period of this quarter the linear accelerator operated smoothly for 83 percent of the time, and runs were made for both the chemistry and physics research groups. In the month of June operations took 61 percent of the time and it was found during this month that the procedure of cleaning the drift tubes with chemically pure acetone cut down the linear accelerator x-radiation by a factor of 10 from the previous level of the former procedure, which consisted of using bulk acetone.

During the latter period of the quarter two of the top textolite supports on the Van de Graaff broke, due to fatigue and cold flow, and this necessitated the entire dismanteling of the machine and replacement of the top three tubes. It was decided at this time to completely rewire and rebuild the high voltage shell equipment.

New oscillator parts have been completed and are now being tested in Building 10. Three of the oscillators have been successfully tested at 400 kw. The oscillator installation program is going ahead on the assumption that the above test is a sufficient sample of oscillator behavior. Total power requirement is 2.2 MW. All of the old oscillators and transmission lines have been removed. A good part of the old electrical wiring has been removed. Installation of the new oscillators and wiring will start immediately.

5. Bevatron Development

W. M. Brobeck

On April 23 a fire in the building containing the mechanical drafting office destroyed bevatron drawings which has taken about two months to replace. Diversion of experienced personnel to classified work during the period may slow progress on parts of the machine not already contracted for, particularly electronic and control equipment installation. However, the schedule for completion of the magnet and installation of the magnet power equipment seems reasonably firm.

During the period the magnet foundation was completed with about two weeks delay due to trouble with insulation of the concrete reinforcing steel. The offices in the building were occupied on July 15. Completion of the building is expected early in September.

All of the plates for the magnet core frame have been machined and about 85 percent had been assembled into slabs at the end of the period. Deliveries of slabs to the building had started in preparation for erection in September.

Tests of the magnet generators by the manufacturers indicated the necessity of changes which has set final delivery back about two months to the first part of October. However, by the end of July a large part of the auxiliary equipment and the first heavy parts for one of the motor generator sets had been shipped.

Magnet model tests on the profile of the pole tips have been completed and indicate the desirability of reducing the residual magnetism. It appears that this can be accomplished by the use of a small auxiliary rectifier to supply a reverse pulse after each forward pulse of the magnet current. Vitreous enamel insulation is to be used on the pole tips inside the vacuum. Drawings of the pole tips and bases amounting to about 1500 tons of 1/4 inch steel plate have been released for procurement.

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