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*Previous Physics Quarterly Report (UCRL-1854)
February, March, and April, 1952

I GENERAL PHYSICS RESEARCH

1. Cloud Chamber Program

Wilson M. Powell

90 Mev n-p Scattering at Extreme Angles. ~~Milton Hall~~ C.Y. Chih

An investigation of the scattering of 90 Mev neutrons by protons in the neutron scatter angle regions of 0° to 40° and 140° to 180° in the center of mass system has been performed with an aim of estimating to what extent the exchange forces enter into the interaction between the nucleons. For this purpose a pulsed collimated 90 Mev neutron beam, produced by the 184-in. Berkeley cyclotron by bombarding a half-inch beryllium target with 190 Mev deuterons, was directed into a hydrogen-filled 22-inch pantagraph cloud chamber, operated in a pulsed magnetic field of 22,000 gauss.

The azimuthal distribution of the tracks has been found to be symmetrical. The neutron energy spectra computed from the forward scattered proton tracks and from the sideways scattered proton tracks show an excellent agreement. These facts insure that no significant number of tracks were overlooked or incorrectly measured.

A preliminary analysis of the results of this experiment shows symmetry within statistical error of the differential n-p scattering cross section curve about 90° in the center of mass system in the regions investigated. This supports the current theoretical assumption concerning the role of exchange forces in the interaction between the nucleons.

2. Film Program

Walter H. Barkas

Physical Analysis of Disintegration Products. W. H. Barkas, H. Tyren, R. Deutsch

Thin targets ranging from lithium to uranium have been bombarded with 332 Mev protons, 375 Mev alphas, and 187 Mev deuterons. Secondary particles, which are emitted in the forward direction, enter nuclear emulsions that are located at 90° to the beam direction and below the median plane of the cyclotron. A secondary particle, such as a H^1, H^2, H^3, He^3 and He^4, is indentified by its radius of curvature, range and ionization. Progress has been made in determining the range-energy curve for particles heavier than He^4 so that heavy fragments may also be identified. The investigation of the bombardment of Be and C with 332 Mev protons has been concluded and the results are being prepared for publication.

The angular distribution is also being investigated by observing secondary particles that are emitted at 0°, 45° and 135° to the initial beam

direction. The energies of the bombarding particles are 220 Mev for protons, 242 Mev for alphas and 121 Mev for deuterons.

Mu Meson Interaction with Matter. D. Sherman

An upper limit on the cross section for direct production of negative muons on bombardment of beryllium by 340 Mev protons has been established by comparing the yields of negative pions and muons in the same solid angle and momentum interval, and analysing the muon spectrum into two groups: those arising from decay in flight of pions, and those which might have been directly produced in the target. The maximum value of $\frac{d\sigma}{d\Omega\, dp}$ at pc = 130 Mev, in the forward direction is 0.015 the cross section for production of pions in the same interval.

In two events (0.4 percent of the μ^- endings observed) capture of a negative μ meson appears to produce a fission type disintegration presumably of a light nucleus in which two prongs of ~ 3 micron are produced.

High Energy Beta Spectra. J. Vedder, R. Sagane

A recent experiment to determine the spectrum and upper limit of the β-decay from B^{12} using a spiral-orbit spectrometer demonstrated that this instrument was very satisfactory for continuing the work. It is planned to use this method to obtain the spectra of other high energy β-decays from light elements such as B^8.

Meson Masses and the Energy Balance in Meson Decay. F. M. Smith, W. Birnbaum, W. H. Barkas

An error has been discovered in the assembly of the apparatus used in the measurement of magnetic field. This produced a systematic error in the absolute value of the field. Calculations and experimental determinations showed the previous field values were in error by 0.2 percent. This correction is being applied to the present data as it affects the absolute momentum of the decay μ^+.

The last exposures of film to π^+ mesons and protons, were very satisfactory. The purpose of the exposures was to redetermine the π^+/p mass and to obtain additional μ^+ ranges from π^+ decay. Data is now being collected.

High Energy Electron Processes. P. C. Giles, C. E. Violet, F. C. Gilbert, R. Deutsch, W. H. Barkas

Further investigation of the process leading to the sudden termination of fast electron tracks in the emulsion has (beyond a reasonable doubt) cleared up the mystery. Apparently the tracks which disappear are those of positrons

rather than of electrons as we originally believed. We are then observing the annihilation in flight of positrons. This process has not been observed directly before. Study of nuclear scattering of fast electrons is continuing.

Large Angle Meson Scattering. H. H. Heckman, L. E. Bailey

To date, 105 large angle scattering events have been found in study of large angle scattering of negative pions in Al, Cu and Pb. Extensive scanning of the aluminum plates have yielded twenty-five such events. We feel that this number of events is sufficient for a statistically satisfactory determination of the scattering cross section, and that to increase the statistics any extent does not warrant the laborious scanning task involved.

The aluminum data (uncorrected) gives as the cross section $\sigma_{90 \rightarrow 180} = \int_{90}^{180} \sigma(\theta) d\Omega = 51 \text{ mb} \pm 11.0 \text{ mb}$. The events detected indicate that this large angle scattering is consistent with the assumptions of energy independence and spherical symmetry.

Approximately forty events have been found each in Cu and Pb; and with a little more scanning, we can expect a result accurate to 15 percent.

Meson Spectrometer Magnets. R. Sagane

Nearly all of the parts (including accessories) have been finished for the 22-in. magnet, which is now being assembled. The alignment has been finished and the coils are being installed.

The 40-in. magnet is being engineered, part of the detailed drawings have been finished. Model tests are being made to determine the efficiencies at different field intensities for a range of pole gaps. The constancy of the field distribution as a function of the field intensity was also studied.

3. Total Proton-Proton Scattering Cross Section (345 Mev)

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

Since the counter to be used (an eight inch diameter liquid scintillation counter developed by Mr. Donald Stork) has been previously tested and found satisfactory, it is believed that measurements could proceed as soon as the liquid hydrogen target is ready. It is to be eight inches in diameter and twenty inches long--the beam to go along the axis of the cylindrical vessel.

The target construction is partially complete, however the liquid hydrogen vessel has been accidentally evacuated and collapsed. Another target must be made.

4. Proton-Deuteron Elastic Scattering Using 345 Mev Protons

O. Chamberlain and D. D. Clark

Thus far the counter techniques have proved inadequate to distinguish scattered deuterons from scattered protons as desired. The counters used thus far are not up to the standards that may reasonably be expected of scintillation counters. Further changes and tests are in progress. A 50 millicurie beta-activity source has been requested which it is hoped will enable us to distinguish more readily between fluctuations in pulse height due to the two causes; low light collection efficiency and systematic non-uniformity due to poor optical arrangement.

It is anticipated that a proportional counter may be used to measure the specific ionization in some cases where the scattered particles have short range, and possibly as a check on the results using scintillation counters.

5. Proton-Proton Scattering at Reduced Energies (160 to 250 Mev, 20 to 60 Degrees, C.M. System)

John Garrison

The liquid hydrogen target to be used is complete and satisfactory.

A serious difficulty has arisen in the experimental arrangement. There are some protons scattered from the inside walls of the collimator into the counter telescope. These constitute a background, and they include some low energy protons which can be stopped in the liquid hydrogen target. This means that there is a systematic error made in taking the difference in counting rates with empty and full liquid hydrogen targets. The effect is to diminish the background when the target is filled with liquid hydrogen and one obtains a cross section value too low. One promising scheme to avoid this error is being considered. It involves using magnetic analysis of the proton beam after it has been degraded in energy by the lithium or beryllium absorber. Apparently this can be arranged without great loss of intensity.

6. Internal Momentum Distribution in Light Nuclei

W. N. Hess and J. Wilcox

The method of Cladis, Hess and Moyer for measuring internal momentum distributions in C and D mentioned earlier in these reports has been modified to yield more direct information about the momentum distributions. As before protons resulting from nucleon-nucleon collisions inside the nucleus are observed. The energy distribution of these protons at a given angle is related to momentum distribution of the struck nucleons. A theoretical analysis by P. A. Wolff showed that this energy spectrum is given by an integral involving the momentum distribution.

This method has now been modified by observing the second proton scattered at roughly 90° to the first in coincidence with the first. By observing both protons resulting from the collision and energy analyzing one of them enough parameters are known in the collision process to determine the momentum of the struck particle uniquely. The momentum distribution is therefore determined directly instead of an integral involving the momentum distribution. A preliminary experiment has been performed using the magnetic particle spectrometer previously discussed in these reports to analyze the energy of one proton. The other proton was counted by a scintillation counter telescope. Carbon and CH_2 were bombarded with 340 Mev protons. Using CH_2 a peak was observed in the energy spectrum at the point where protons from collisions with hydrogen should occur. The energy spectra obtained were not satisfactory. The background counting rate of the GM tubes used to determine energy channels in the spectrometer were excessive. It is now proposed to use either proportional or scintillation counters in place of the GM counters.

7. The Triton Reaction ($p + d \longrightarrow \pi^+ + t$)

Kenneth C. Bandtel, Wilson J. Frank, Richard Madey, and Burton J. Moyer

The identification of the triton reaction at the correlated angles of 8° for the triton and 110° for the pion was completed this quarter. A more complete description of the experiment will be issued shortly as a UCRL report, but the results may be summarized as follows:

1. The process observed is a two-body correlated reaction originating from protons on deuterons: A CD_2 - C difference was obtained at the expected angles of correlation, and this difference disappeared (a) when one of the counter telescopes was lowered below the plane formed by the beam axis and the other telescope; (b) when either telescope was moved from the expected angle while the other remained fixed.

2. The particles observed at the pion telescope have the energy expected of the pions to within 10 percent: the CD_2 - C difference disappeared when enough absorber to stop the expected pion was added.

3. The particles observed at the triton telescope have the energy expected of the triton to within 10 percent; again the CD_2 - C difference disappeared when enough absorber to stop the expected triton was added.

4. The particles observed at the triton telescope have the velocity expected of the tritons: the triton telescope is eleven times as far from the target as the pion telescope, so that the time of flight of the particles through the triton telescope can be measured. The CD_2 - C difference is a maximum for particles with the tritons's expected velocity, and disappears for particles of 10 to 15 percent faster or slower velocity.

8. Neutral Meson Yield vs. Z

R. Hales

Proton Production

The results of this experiment are embodied in UCRL Report 1836, revised.

Neutral Photopions

Carbon, aluminum, copper and lead targets were placed in the x-ray beam of the synchrotron and the high energy photons from neutral photopion decays were observed at 135° to the x-ray beam direction. Single photons were observed by means of the pair scattering detector previously reported.

Using this detector to observe single gamma rays at 135° is quite justifiable. The photons came from the target at 135° to the beam direction; they were not scattered from the collimator system at an angle less than 90°. This was shown by target in, target out comparison. They were not photons scattered from the main beam by electrons in the target. All photons scattered through more than 90° have energies ~ 1 Mev. They were not photons from nuclear reactions. The 15 Mev threshold of the detector eliminates this possibility. The counts were not accidental coincidences from independent events. This was shown when the counting rate per unit beam was sharply reduced by inserting delay cable but not by reducing the beam intensity.

There are two good arguments which indicate the photons come from neutral meson decay. Firstly, the counts disappear when the peak of the bremsstrahlung spectrum of the synchrotron was reduced to 160 Mev--close to the meson production threshold. Secondly, a transition curve of the Pb converter was taken. The maximum efficiency was for a converter one-fourth to three-eights inch thick which corresponds to photons of the high energy (70-100 Mev) resulting from π^0 decay.

The targets were placed in a beam of 300 Mev peak energy; the C and Al targets were also exposed to the 280 Mev beam. The results shown in Table I confirm the observations of Panofsky, Steinberger and Steller (UCRL-1495) who detected the γ - γ coincidences of π^0 emitted at 45° to the beam direction. For completeness, the data collected in February from 320 Mev exposure of Li, Be, B, B^{10}, and C; the current data; and that of Panofsky, et al. are given, in terms of relative yield per nucleon. All are referred to carbon as 1.000.

Table I

Element	Rel. σ/A Single γ Detection 320 Mev	300 Mev	280 Mev	Rel. σ/A $\gamma - \gamma$ Coincidence 320 Mev
H				1.43 ± 0.20
Li	1.287 ± 0.078			1.31 ± 0.08
Be	1.162 ± 0.088			1.02 ± 0.05
B	1.092 ± 0.073			
B^{10}	0.945 ± 0.081			
C	1.000 ± 0.087	1.000 ± 0.037	1.000 ± 0.096	1.00 ± 0.06
Al		0.881 ± 0.046	0.888 ± 0.101	0.87 ± 0.08
Cu		0.493 ± 0.051		0.53 ± 0.07
Pb		0.272 ± 0.079		0.35 ± 0.14

9. Nuclear Elastic and Inelastic Scattering of 300 Mev Neutrons

W. P. Ball and Burton J. Moyer

The present phase of the experiment on nuclear elastic and inelastic scattering of 300 Mev neutrons from C, Al, Cu, and Pb has been concluded.

The details and results of the experiment are available in the UCRL Report 1938.

10. Measurement of the Absolute Meson Production Cross Sections

W. F. Dudziak

The experiment on the measurement of meson production cross sections, as a function of meson energy, resulting from the bombardment of carbon by 340 Mev protons has been completed. These measurements were made at a zero angle to the proton beam on both the π^+ and π^- mesons. At present, calculations are being performed to present the data in its final form.

The 22-inch spiral orbit meson spectrometer requested in January is now being assembled and should be delivered for preliminary experiments within a three-week period. This spectrometer shall first be used for the study of absolute production meson cross sections at a 90° angle to the incident proton or neutron beam. Part of the experiment of meson production at 90° to the proton beam from carbon has been completed. This experiment will serve to calibrate the spiral orbit spectrometer. The experiment of π^+ and π^- meson production as a function of Z, will be performed with Dr. Sagane on approximately 15 elements to illustrate the features of this spectrometer.

Work is now in process to study the $p,d \longrightarrow \begin{cases} \pi^+ \\ \pi^- \end{cases}$ spectra by use of the spiral orbit spectrometer. It is felt that this experiment can be done to a 10 percent accuracy without great effort by use of this particular technique.

11. Low Energy Mesons from $p + p \longrightarrow \pi^+ + p + n$

O. Heinz

The study of the low energy mesons produced in the reaction $p + p \longrightarrow \pi^+ + p + n$ was continued, using the photographic emulsion technique. The production cross section in the neighborhood of 22 Mev is being carefully measured, since this quantity might give some information on the very low energy interaction between mesons and nucleons.

12. π^+ Attenuation in H_2

D. Stork, S. Leonard

The instrumentation for the measurement of π^+ attenuation in hydrogen for meson energies down to 30 Mev has been very nearly completed. A 14-inch diameter scintillation counter has been completed and tested. Auxiliary equipment including 2 crystal scintillation counters for pulse height measurements has also been constructed.

13. π^+ and π^- from Carbon in the Backward Direction

S. Leonard

The experiment on the proton production of π^+ and π^- mesons from carbon in the backward direction is nearing completion. Additional data have been collected in the course of several cyclotron runs.

14. π^+ and π^- Mesons from Neutrons on Carbon

J. Peterson

Work on the π^- and π^+ production in the forward direction from neutrons has progressed, and data have been obtained. Photographic emulsions have been used so far, but it is hoped that it will be possible to use scintillation counters and a pulse height method.

A side experiment has produced a sodium iodide scintillation counter which had very high resolution when counting gamma rays. A resolution of 7-8 percent full width at half maximum was obtained.

15. π^+ Production as a Function of Atomic Number

J. Merritt, D. Hamlin

General work is being continued on π^+ meson production by 340 Mev protons as a function of atomic number. Detection is by scintillation crystals and delayed coincidence. New pole faces, incorporating adjustable stainless steel separators, were built and calibrated for the pair spectrometer magnet. A preliminary run was made on deuterium using D_2O, H_2O, CD_2, and C as targets. A second cyclotron run was made on the relative π^+ production from Be^9, B^{10}, B^{11} and C^{12}. Two synchrotron runs were made in conjunction with R. S. White, W. Jarmie and G. Repp to test new light pipes and scintillators.

16. Synchrotron Studies

A. C. Helmholz

There was no running time available for experiments during the month of May because of difficulties in machine operation. However, the donut was removed at the beginning of June, a new conducting coating was put on the quarts sections, and the donut replaced. The beam was quickly found and has essentially been satisfactory since about June 15. There is fading, whose severity depends on the operating conditions, but the cause is as yet unknown.

During the interval, several experiments have been completed. Rosengren and Dudley completed work on high energy photoprotons and a full report is given in Rosengren's thesis. The yield at small angles to the beam has been determined. The yield of high energy protons (170 Mev) does not show the fall off at 0° as indicated in Levinger's theory. The yield of protons as a function of energy shows a break in slope as found in other experiments (for example, these of Keck). If the process were purely a photodisintegration of "quasi-deuterons" in the lower energy region, one might expect this break to occur at different energies for different angles. The results do not seem to show this. The yield of photoprotons is also found to be approximately proportional to Z.

The work of Colgate and Gilbert on the annihilation in flight of positrons has essentially been completed. The rate of annihilation of 150 Mev and 200 Mev positrons in Be agrees with theory to the accuracy of the experimental observations which is about 15 percent. The rate of annihilation or disappearance of electrons is less than one-fifth that of the positrons.

André's experiment on the yield of π^0 mesons from H_2 and D_2 was completed with a run in the first week of August. This will be written up as a UCRL report.

White and Jarmie, and Post and McDonald have made progress in their experiments on mesons, but experimental results are not yet available.

There was a short run for Softky in his search for a short-lived T_2 radioactivity, and some runs for cloud chamber work were also provided. Reports on these and other experiments will be made at a later date.

Jones and Terwilliger have completed an experiment on the yield and excitation function of photoneutrons from 13.5 to 320 Mev. The work from 13.5 to 70 Mev was done at the University of California Hospital in San Francisco. The results show that at low energy the photoneutron yield follows quite closely the "gamma-ray resonance" as found in radioactivity (γ, k) experiments. Above the resonance the cross section for neutron production stays up and does not fall essentially to zero. In fact, in the region of 100-300 Mev it definitely rises, giving the impression that a meson effect is setting in (much as in the deuteron photodisintegration) possibly at energies below 100 Mev. By making estimates of the neutron multiplicity, one can estimate the cross section for photon absorption. This cross section is proportional to A, even at energies as low as 45 Mev. Full reports can be found in the theses of Jones and Terwilliger.

17. Theoretical Studies

David L. Judd

Charged Scalar Meson Field. J. V. Lepore, R. J. Riddell

The problem of a charged scalar meson field with a single nucleon source has been solved by an approximation not involving an expansion in powers of the coupling constant. Comparison with the results of perturbation theory shows that the latter is valid provided the coupling constant is sufficiently small.

Charged Particle Orbits. R. H. Huddlestone

The relative merits of various methods for stepwise plotting the plane orbits of charged particles moving in a static magnetic field are being studied, and criteria for step size are being developed.

Bevatron Pole Shape Calculations. P. Wolff

Calculations of fields and properties of the orbits have been carried out to aid in choosing a suitable pole tip geometry for the bevatron. Model measurements have been used to evaluate the suitability of a proposed pole tip design.

Corrections to Nuclear Force Calculations. M. Ruderman

Higher order corrections to nuclear forces have been calculated from pseudoscalar meson theory with pseudoscalar coupling. They are found to be large enough to invalidate perturbation procedures.

Neutral Photomeson Production. W. Heckrotte

The determination of the relative sign of the proton and neutron meson coupling constants is possible from an experimental study of the photoproduction of neutral mesons from deuterium. Two different reactions leading to the photoproduction have been considered. In the first, that which leads to deuteron formation in the final state (the elastic case), it has been shown that the total cross sections for the cases $g_p = -g_n$ and $g_p = g_n$ differ by a factor of about 25. The angular distributions for the two cases are almost identical.

In the second, so called inelastic case, which corresponds to unbound neutron and proton in the final state, one finds that there is only a slight difference in the total cross sections between the cases $g_n = g_p$ and $g_p = -g_n$. This difference is a factor of 2 or 3. The angular distributions in these two cases do differ appreciably ranging from a difference of a factor of 2 at 90° to 4 in the forward direction.

From these results it appears that the determination of the relative sign of the neutral meson coupling constants is only possible through a study of the cross section of the elastic process. Although there are significant differences between the two cases for the inelastic production, these differences are certainly not large enough to warrant any reliable predictions. We are certainly not entitled to take the results of meson theoretic calculations seriously unless we obtain results which differ between situations by at least an order of magnitude. On the other hand meson theoretic calculations almost always can be trusted to yield results in order of magnitude agreement with experience.

This experiment would have interesting implications regarding the charge independence of nuclear forces since the symmetrical meson theory, the most elegant designed to yield the result, requires $g_n = -g_p$.

Interpretation of High Energy p-p Scattering. D. R. Swanson

A study was made of the high energy protons by protons. Several types of "cut-offs" were introduced into the singular tensor interaction proposed

by Christian and Noyes; the triplet P state radial equations were then solved by essentially exact numerical integration methods. The resulting cross sections show a more pronounced disagreement with experiment that do the Born approximation cross sections of Christian and Noyes. Calculations were carried out in the vicinity of 350 Mev and 120 Mev.

Polarization Effects in Nucleon-Nucleon Scattering. D. R. Swanson

If a beam of unpolarized nucleons is scattered from a target of unpolarized nucleons, the scattered particles are polarized (in a direction normal to the scattering plane) provided that the interaction contains tensor or spin-orbit forces. The polarization can be detected by means of a second similar scattering since the cross section then contains an azimuthal dependence:

$$I(\theta, \phi) = I_o(\theta)(1 + \epsilon \cos \phi),$$

where $\epsilon(\theta)$ is essentially the square of the polarization. Calculations are carried out by the author for a double p-p scattering using the tensor interaction described in the preceding paper, and for a double n-p scattering using the central and tensor potential of Christian and Hart (containing the "half exchange" dependence proposed by Serber). The polarization produced by the first scattering at the optimum angle of $\theta \approx 50^\circ$ was found to vary from 6 percent at 40 Mev to 33 percent at 285 Mev for n-p scattering and from 10 percent at 129 Mev to 15 percent at 350 Mev for p-p scattering. The n-p results (previously published) are consistent with the azimuthal asymmetry detected in a double scattering experiment reported by L. Wouters.

Other Theoretical Studies

Radioactive corrections to nuclear forces are being studied by Ruderman using the Bethe-Salpeter equation. He has also made a short investigation of the effect of chemical finding on the stopping power of materials. Lepore and Huddlestone have been studying the exchange current effects in photo-deuteron processes, while the angular distributions of protons scattered inelastically by nuclei are being investigated by Heckrotte. The diffusion approximation treatment of beam loss in a linear accelerator due to scattering by focussing foils has been extended by Henrich to relativistic particle energies.

II ACCELERATOR OPERATION AND DEVELOPMENT

1. 184-inch Cyclotron Operation

J. Vale

The cyclotron was in operation for research experiments approximately 93 percent of the time that the crew was on duty during this period.

If a target is located properly inside the vacuum tank, mesons that leave this target at the proper angle can emerge from the vacuum tank if a proper window is supplied. A port was installed on the vacuum tank just next to the main probe for this purpose. This port was installed last month during a shutdown for the replacement of bearings in the rotary capacitor.

2. 60-inch Cyclotron Operation and Development

Operations. William B. Jones

The time distribution for the 60-inch cyclotron during this quarterly period was as follows:

Alpha bombardments	437.9 hrs
Deuteron bombardments	382.6 hrs
Proton bombardments	155.6 hrs
Carbon ion bombardments	105.2 hrs
Development	150.8 hrs
	1232.1 hrs
Outage	246.1 hrs
	1478.2 hrs
Shutdown	729.8 hrs
	2208.0 hrs

Operation efficiency: 84.7 percent.

The six-inch copper feelers (reported in UCRL-1729, p. 37) were replaced on June 4 with a similar pair which had been chromium plated to a thickness of 0.01 inch. The purpose of this replacement was to try to eliminate, or at least reduce, the ion bombardment erosion of the feelers. The solution of this problem is very important to operations because oscillator sparking causes unsteadiness as the feelers become more eroded. The results have not been completely analyzed in this two-month period but, thus far, operation has been much steadier and sparking of the oscillator has been greatly reduced.

The lightweight filament holders (UCRL-1854, p. 39) have performed very successfully since a teflon insulator has been placed at the filament end, replacing the fired lavite insulators first used. The lavite was a second choice to zirconium, which was not readily available and was subject to frequent mechanical and electrical breakdown. The teflon replacement has eliminated

mechanical breakage and has minimized electrical difficulties previously encountered. Some carbon coating of the insulating surface occurs but cleaning with toluene readily restores its insulating qualities. The initial installation has been used in steady operation for approximately a month without failure.

Over a period of years the water-cooling lines for the cyclotron have become clogged and the flow has been reduced by a factor of three to four. At these reduced flows, the power dissipation capacities of the system are still adequate but a return to normal flows was deemed advisable. Pumping a one Normal solution of hydrochloric acid through various lines had very little effect; versene solution was pumped through and no gain was observed. A commercial boiler scale solvent was tried and flow was increased by a factor of three. The flow is approximately back to original rates.

Power Drive for Source Adjustments. Charles A. Corum

The installation of remotely controlled adjustments for the filament and ion source systems has been completed. Adjustment time and personnel radiation dosage have both been considerably reduced. It is now possible to adjust to maximum beam intensities with little effort.

The filament holder in-and-out adjustment is driven by one of three aviation flap motors located between the dee stems outside the magnet field. The driving power (from a 2 to 1 gear reduction box at the motor) is transmitted by a 3/16 in. diameter x 7-1/2 foot monel flexible shaft in a phosphor-bronze sheath. A quick spring-snap coupling makes a positive connection to the worm shaft of the filament holder adjustment mechanism (UCRL-1854, p. 39). A ten-turn Helipot potentiometer is geared to the motor shaft which permits monitoring the approximate position of the filament from the control desk.

The filament adjuster in operation is run out to its limit before a filament change is made. It is then returned to a position of peak beam, indicated on the desk monitor, after the filament is installed. This is done to assure an operating position approximately near peak after the change. The two cone adjustment screws (UCRL-1729, p. 39) are also driven by aviation flap motors and flexible cables, coupled by the same style quick coupling clamp as used on the filament holder drive. The operating position of the cone is determined by the maximum beam available and, as there is enough latitude of movement available, no monitoring of the motion is necessary.

Carbon Beam Development. G. Bernard Rossi

The 60-inch cyclotron carbon beam intensities reported in UCRL-1854, p. 42, have proved to be of sufficient intensity to warrant use for bombardments. Time records throughout the past three months indicate that, of 147 hours spent accelerating C^{+6} ions, 105 hours were spent on bombardments. The remainder of the time was spent in adjusting the working parameters to obtain steadiness of operation and intensity levels. A large amount of time

is consumed in replacing the carbon ion source when erosion of the high-hat proceeds to a point where the beam intensity diminishes. After replacement of parts, the beam has consistently returned to peak levels.

The carbon hat, tungsten support arms, and part of the cone structure run at white heat during operation. Filament replacement is necessary after approximately two hours. Walls of the collimating slot above the filament become coated with carbon and restrict its size after some seven to ten hours of use. The high-hat section, which acts as an electron dumper, erodes through in variable time periods. The hat erosion time has proven to be a function of the distance between cone and hat and is now set at 7/8-inch. With this spacing, source changes to specifically change the hat have been eliminated.

A multiple Faraday cup has been designed to better study the external beam characteristics. Trouble has been encountered in this type of bombardment because of residual alpha beams. During carbon operation, a sufficient amount of helium gas is occluded from the surfaces to produce an external alpha beam in excess of the C^{+6} beam at specific magnet resonance. With the multiple cup, the ratio between these beams has been obtained at various magnet settings. Figure 1 shows such a curve.

The multiple cup has two foil barriers preceding the alpha pickup cup. The first foil is of 0.001 in. tantalum and is grounded. It serves to eliminate the C^{+2} and other extraneous particles with energies less than 70 Mev. The second foil is an insulated 0.005 in. aluminum foil which absorbs all C^{+6} particles between 70 and 130 Mev. The insulated cup picks up alpha particles which penetrate the two foil barriers. The layout is shown in Figure 2. The close overlapping of the C^{+6} and He^{+2} beams is due to the similarity in the m/e of the particles, i.e., $(m/e)_{C^{+6}} = 2.0001$ and $(m/e)_{He^{+2}} = 2.0014$. Under select conditions it is possible, with appropriate magnet settings, to bombard with C^{+6} particles with only small amounts of He^{+2} present.

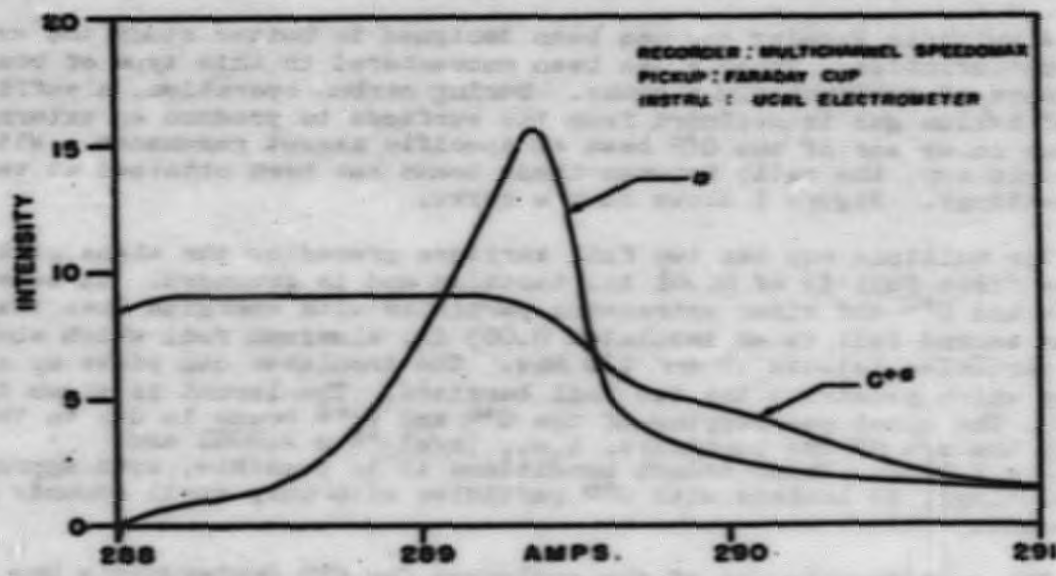
The considerable use of the cyclotron for C^{+6} bombardments has limited the time available for C^{+6} intensity improvement. Further source experiments, however, are being planned.

3. Synchrotron Operation

George C. McFarland

During May the synchrotron did not operate at full energy or at high enough intensities to be useful.

Early in June, after a two-week overhaul, the machine immediately produced a useable full energy beam. During the overhaul, the conducting coating in the quarts vacuum chamber was reapplied. Evidence indicates that non uniform layers of conducting coating had accumulated which disturbed the magnetic field so that a useable beam could not be attained.



α – C^{+6} BEAMS
VS.
MAG. FIELD

FIG. 1

MU-4252

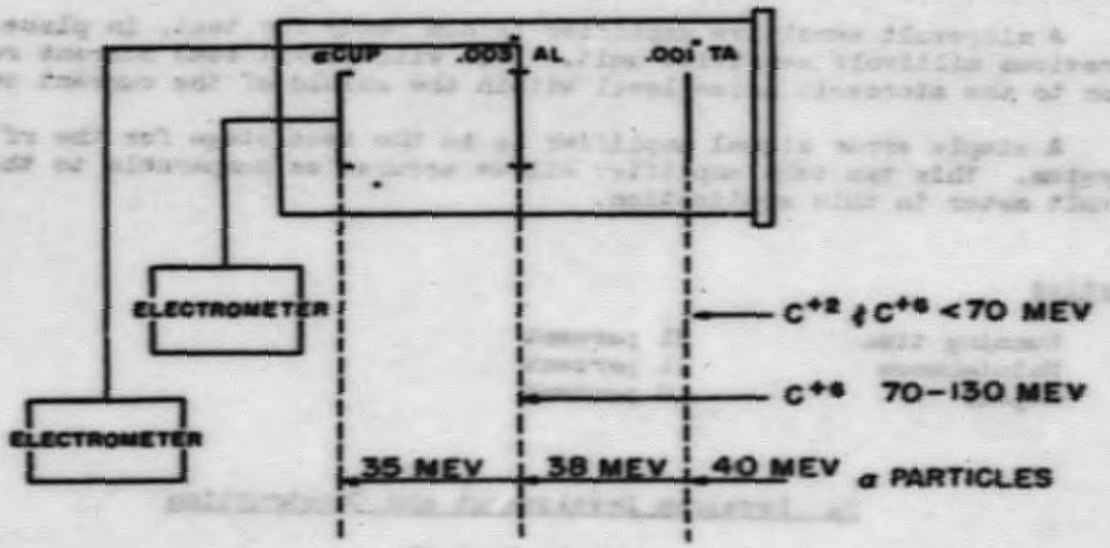

CUP
.005" AL
.001" TA
ELECTROMETER
ELECTROMETER
C+2 & C+6 <70 MEV
C+6 70-130 MEV
35 MEV
38 MEV
40 MEV
α PARTICLES

FIG. 2

MU4251

After regaining the beam in June, the synchrotron was made available for physics research. The operating schedule was expanded nearly 20 percent in order to make up some of the lost time.

4. Linear Accelerator and Van de Graaff Operation

The second electron magnet of the linear accelerator has been constructed and is ready for installation. The power supply for the unit is being constructed. When installed, just behind the present electron magnet, it will allow less exit electron error in the current coil beam monitor.

A microvolt sensitive amplifier is now ready for test, in place of the previous millivolt sensitive unit. This will permit beam current resolution to the microvolt noise level within the shield of the current coil.

A simple error signal amplifier is in the test stage for the rf monitor system. This two tube amplifier allows accuracies comparable to the slide back volt meter in this application.

Statistics

Running time	81 percent
Maintenance	11 percent
Repair	8 percent

5. Bevatron Development and Construction

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Coil Winding

The winding was completed on June 25, 1952, 15 months after it was started. It was originally expected that the winding operation would require about 6 months with a day and night shift, but delays were caused largely by diversion of manpower and cranes to classified work and by poor delivery and quality of vendor furnished coil spacers for the third and fourth quadrants. The coil consists of 176 turns of 1-7/8 inch diameter stranded copper cable, 26 miles long weighing 347 tons and wound on a 108 foot O.D. and 86 foot I.D.

Magnet

The magnet test without pole pieces is proceeding, and pulsing of the magnet with low power had just started on July 31, 1952. The magnet model tests have shown that a shaped pole profile rather than the previously

planned straight edged poles is desirable to obtain maximum useful width of field. An outline drawing of the shaped pole profile, completed at the end of July, was sent to the fabricator so that the die could be made. Model tests are continuing to determine the necessity of minor pole profile modifications, such as could be made by shimming the die. Since the Brookhaven tests have indicated that there is no possible need for a 2 x 6 ft. aperture at UCRL, the pole base length will be shortened to 66 inches, the length of the pole tips with the 1 x 4 ft. aperture, in order to save steel. Pole face windings consisting of 5/16 inch O.D. x 1/16 wall copper tubing at 3-inch centers will provide ample capacity (several hundred amperes) for correcting the field shape if required.

Vacuum System

The first straight tank will probably be completed by October 21. Two transition tanks should be completed by August 1. Sufficient material for the first curved tank should be delivered to UCRL by August 15. The filler frame (for supporting the vacuum tank in the area left unsupported by the smaller pole tips) has been redesigned to reduce eddy current heating.

Injector

The ion gun originally constructed for the Bevatron will be used for a classified project, so a duplicate ion gun is being built and should be completed by November 1. As a result of the Brookhaven visit by UCRL personnel, it has been decided to rotate the centerline of the ion gun 40 degrees relative to the centerline of the linac and to use a magnet for turning the beam. This permits monitoring injector voltage by use of the molecular hydrogen ion portion of the beam and also results in better access to the building cranes. A mercury diffusion pump will be used for the ion gun. The ion gun enclosure is being built.

The measured "Q" of the linac with drift tubes was between 85,000 and 90,000 which is better than expected. The voltage gradient along the tank was constant within 6 percent, which is satisfactory.

Information Division
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