UNIVERSITY OF CALIFORNIA — BERKELEY

UCRL-2121

UNCLASSIFIED

TWO-WEEK LOAN COPY

This is a Library Circulating Copy which may be borrowed for two weeks. For a personal retention copy, call Tech. Info. Division, Ext. 5545

RADIATION LABORATORY

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

UCRL-2121
Unclassified-Instrumentation Distribution

UNIVERSITY OF CALIFORNIA

Radiation Laboratory

Contract No. W-7405-eng-48

SUMMARY OF RESEARCH PROGRESS MEETING OF DECEMBER 11 AND 18, 1952

Sergey Shewchuck

March 11, 1953

Berkeley, California

SUMMARY OF RESEARCH PROGRESS MEETINGS OF DECEMBER 11 AND 18, 1953

Sergey Shewchuck

Radiation Laboratory, Department of Physics,
University of California, Berkeley, California

March 11, 1953

Meeting of December 11

I. Bevatron Progress. W. Brobeck.

Since the last talk of more than a year ago, the work on the bevatron has consisted mostly of electrical mechanical construction. Coil winding was completed in July. It had been slowed down by other work and by trouble with the bakelite spacers. The fabricator of the spacers finally gave up after seven-eighths of the spacers were in, the last one-eighth hence cost four times more to complete than the rest.

The magnet has been connected to the power supply and tests have been run from early August to early November. Two of the major difficulties encountered were an unbalanced loading between the two power generators and a ripple in the magnet current. The ripple was reduced considerably by grounding the circuit through capacities at four points. No point of the magnet is then at more than 4500 v from ground, although the total voltage is 18,000 v. See Fig. 1. There was trouble in balancing the energy return to the generators with the original arrangement. Now one generator is connected to each rectifier, as in Fig. 1. One can get half current at full voltage with one generator. The re-connection was easy to make temporarily. It is up to Westinghouse to make the permanent change from parallel connection to series and the costs will have to be borne by them.

Magnetic measurements without the pole pieces were made at slightly less than full power during the time that the generator tests were being conducted. Azimuthal variations of only 0.1 percent were found in uniformity measurements. Tests made on the shield and peaking transformers in the magnet circuit have shown that both units must be redesigned to eliminate spurious signals. It is going to be necessary to make them coaxial.

In March it was decided to go ahead with the 1-inch × 4-inch aperture and ~6 Bev energy after receipt of a favorable report on the Brookhaven machine. Steel for the pole tips is now being fabricated. The pole faces are being

assembled, and pole tip fabrication is to start about the first of the year. Another larger magnet model (1/7 scale) has been made for final pole tip testing. Model testing is being done on the proposed use of pole face windings to change the field shape slightly. The windings may be needed to correct for the change of the shape caused by the residual field. However, a residual field on the model does not give one an accurate picture for the full scale machine.

There is some concern over the 1400 cycle ripple of about two percent which is going to cause trouble with increase in phase oscillations. At this frequency a ripple of more than one part per million cannot be tolerated. The use of filters may be tried on the power supply.

Delivery of the pole base plates was begun in October, and the delivery of the pole tip plates was expected to start in January. However, the steel strike has held up the work schedule on the poles both here and with the fabricator in Texas. At the present the steel stock, most of which has already been delivered, is being punched in Texas and the plates are being assembled in the plant.

A new ion gun is being assembled to replace the one given to Livermore. It is a Cockroft Walton type with high voltage supply. The high frequency voltage supply has been giving trouble and so it will be replaced by an 800 cycle frequency rather than a kilocycle, operating in air. In the linear accelerator the drift tubes are being installed and aligned. Another drift tube has been added (total: 44) at the low energy end to lower the injection energy to 430 kv. The output energy will be 10 Mev with 0.5 Mev/foot increase in the linac. A mercury diffusion pumping system has been decided upon for the linac and is being assembled.

An electrostatic inflector is being designed which will turn the beam 40 degrees on an 18 foot radius, the magnet will have a gap of about two cm. The use of the inflector will permit better monitoring of the injector voltage and better access to the building cranes.

The accelerating system is continuously being developed. The operating voltage has been raised from 22 kv to > 30 kv which will result in the saturable core being almost quadrupled. An RCA 2330 tube is to be used, which is readily available.

The curved vacuum tanks are under construction and one tangent tank is already in place. One quadrant is completed. The transition tanks are on hand and are being vacuum tested. The gaskets have caused some trouble and have been found to be of poor production and not too well molded.

The latest time schedule calls for the initial run of the bevatron about October, 1953. It is hoped that it may be in running condition by then, but it is expected that a lot of last minute work may need to be done first. However, most of the machine should be together by next summer.

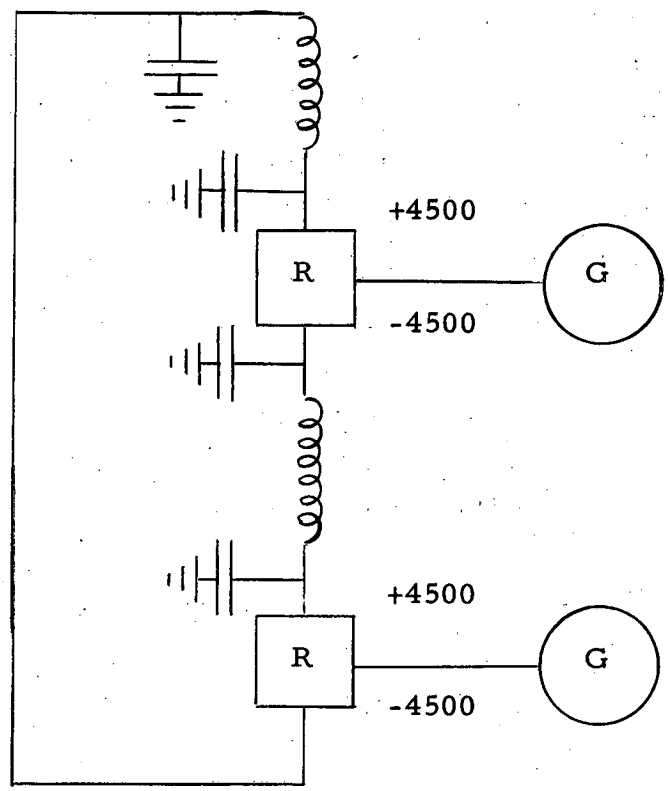

Figure 1

II. Gamma-Gamma Coincidence Detection of Neutral Pions from the Cyclotron. R. Madey.

The details of this talk may be found among the contributions to the Physics Quarterly Report UCRL-2152 for the months of Nov., Dec., 1952, and Jan., 1953; which report at the present time is in the process of being compiled. The contribution is entitled "Gamma-Gamma Coincidence Detection of Neutral Pions Produced by 340 Mev Protons on Beryllium" by co-authors K. Bandtel and R. Madey.

Meeting of December 18

I. 184-inch Cyclotron Modification Plans. M. Martin.

Increasing the energy of the 184-inch cyclotron involves two features: increasing the magnetic field, and devising an oscillator and resonator combination for the required frequency swing. In regard to the magnetic field, the proposed changes consist of decreasing the gap from 18 inches to 12 inches by adding extra pole pieces and adding auxiliary coils. See Fig. 2. The new pole diameter will be about 189 inches. The magnet model tests indicate that the central field will approach 23 kg and that it will not be lower than 22 kg. The new energies (allowing for five percent drop in field at 83 inch radius) for the respective particles will be as follows:

$$E_{proton} = 730 \text{ Mev}$$

$$E_{deuteron} = 456 \text{ Mev}$$

$$E_{He_3} = 1140 \text{ Mev}$$

The problem of the required frequency swing is being extensively studied and model tests are being made. As the rotating condensers are unsatisfactory for this purpose, a vibrating reed type of condenser will be built. There will be no brushes or contacts, the reeds themselves serving as a part of the transmission line. The reed will have 3, 4 or 5 sections, about 30 inches in length. The rectangular dee will be about 15 feet wide. See Fig. 3. The frequency range for protons is 35.2 to 18.7 megacycles/sec which will require one inch amplitude on the blades; for deuterons it is 17.6 to 13.4 Mc with one-half inch amplitudes on the blades. For He_3 particles the frequencies and amplitudes are intermediate. The cavity wall position, changed by remote control, will be adjusted for each particle as shown in Fig. 3. The duty cycle of 1/60 sec will not be controllable since the blades are tuned to a 60 cycle/sec natural frequency. The beam pulse duration, it is hoped, may prove to be somewhat longer than is presently available due to the controllable approach of frequency to the final ion frequency. See Fig. 4.

The schedule for shutting down the cyclotron for modification was originally set around Oct. 1, 1953. However, there is already foreseen a delay of two or three months. All new components are going to be throughly pre-tested to insure the shortest possible period of shutdown.

The present deflector for the beam is not easy to convert to the higher energy. Several proposals have been offered for deflecting the beam. One is an electrostatic type. The beam is scattered by a target and then is guided out of the fringing field by the magnetic field in a transmission line, which is "tailored" to meet the electrostatic field. Baker is confident that this type can be operated. It will be tried first on the present machine. Another type is a Tuck deflector or a "regenerative pealer". With this method a hole in the field tries to deflect the particles out and those that don't get out encounter a "bump" farther on which sends them back into the orbit for a second try. Another proposal, which is talked about, would bring out the meson beam without using deflection of the internal beam, as in the Chicago cyclotron. It would add a shielding wall near the present probe location. If funds are available this plan may be added.

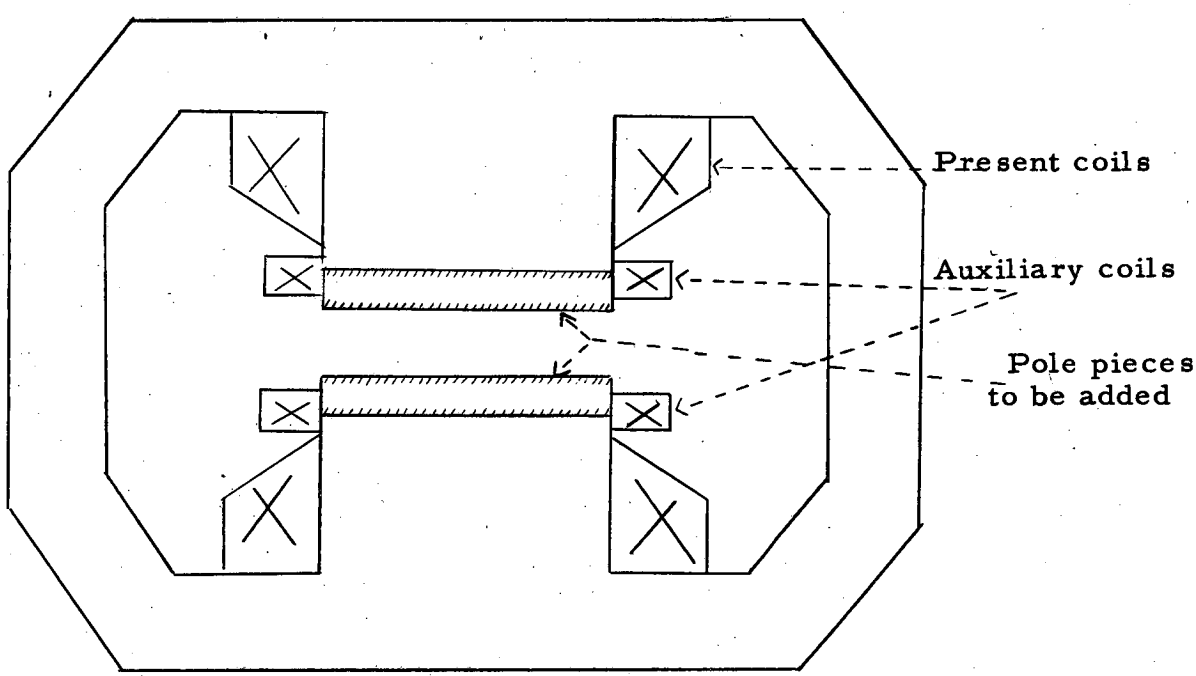

Figure 2.

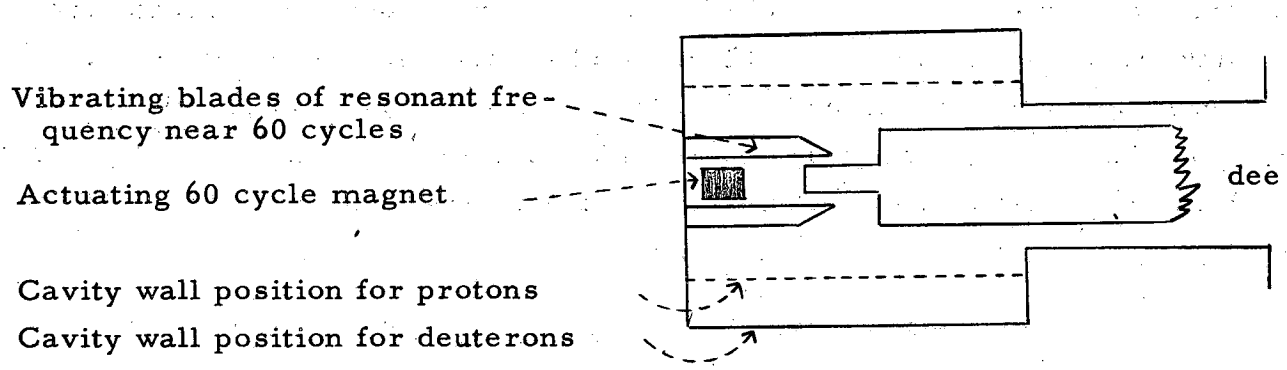

Figure 3.

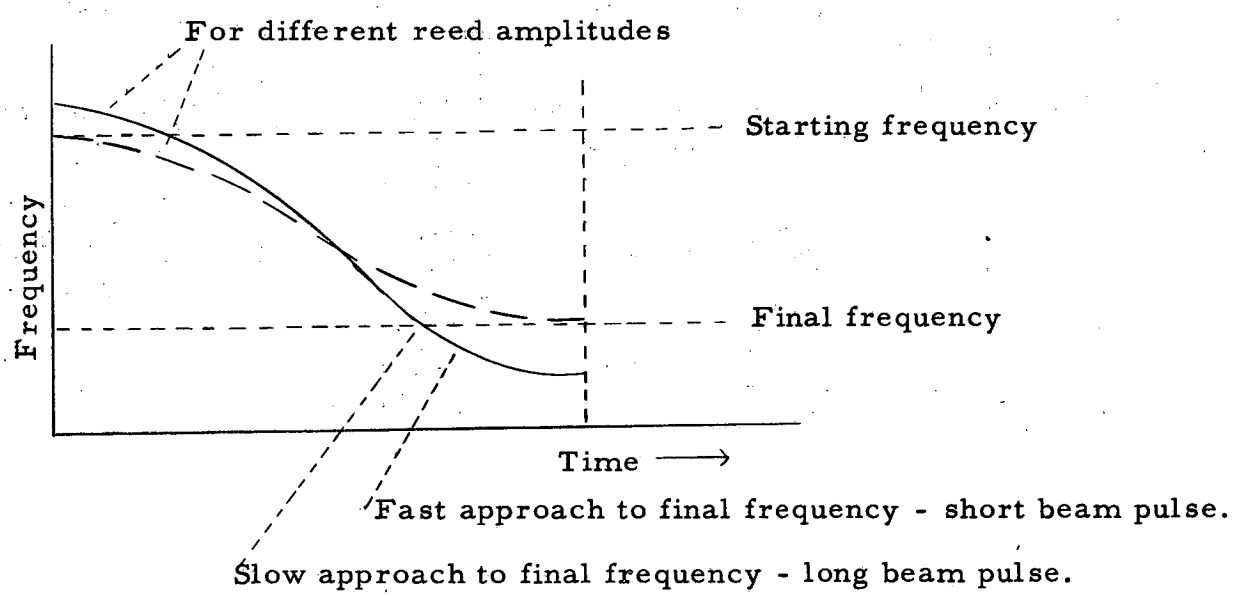

Figure 4.

II. Strong Focussing in the 32 Mev Linear Accelerator. C. S. Nunan.

The main purpose for using the strong focussing principle in the linac is to increase the beam intensity by eliminating grids and/or foils. In the 32 Mev linac the intensity can be increased a factor of four; in a 700 Mev linac the factor could be 1000. In the 40 ft linac the drift tubes have 3/4 inch bore. With no room for a magnetic lens, a small electrostatic lens was built and tried first on the Van de Graaff beam. It was calculated to work at 22 kv to ground at each electrode (total of 44 kv) and the test turned out correct. It focussed a 3/4 inch Van de Graaff beam down to about a 1/2 mm spot. The hyperbolic shape and arrangement of the electrodes is shown schematically in Fig. 5, together with the respective curves for the focussing and defocussing characteristics of the beam. Electrode sets of this type were put in the linac drift tubes; eight were used in a lens instead of four with 6 - 8 kv because of possible sparking. There are now 48 drift tube cells; two more had been added to the existing 46.

In Fig. 6 are shown the various focussing tendencies of the beam at different conditions of incident phase angle. At synchronous phase the emerging particle should go out parallel to the direction at entrance. The rf cycle shifts the diagram in time because of the fields between the drift tubes; hence a divergent beam leaves the exit end. Also, the same divergence is found as with grid focussing, i.e., ±.001 radian.

A force plot is diagrammed in Fig. 7 showing the relative regions of stability between focussing and defocussing. There exists an electric gradient due to defocussing forces in the gaps, g, which can be represented as:

$$\frac{dE}{dx}_{\text{defocussing}} = \frac{1}{g}\left[\frac{E_{(\phi_s=0)}}{\cos\phi_s} \times \sin\left(\frac{\pi g}{\beta\lambda}\right)\right] \sin\phi$$

One makes ϕ as large as possible to increase beam acceptance from the Van de Graaff. This increases defocussing forces; so, there is a need to add more focussing from the lens. Now it is operated at between ± 6 and ± 8 kv; higher voltages give trouble with sparking.

$$\text{Lens length } L = \pi\sqrt{\frac{(mv^2)}{e(dE/dx)}}$$

$$\text{Let } L = 8 \text{ drift tubes, then}$$

$$= 8\beta\lambda = \pi\beta c\sqrt{\frac{m/e}{dE/dx}} \quad \text{, or}$$

$$dE/dx = \frac{m}{e}\left(\frac{\pi c}{8\lambda}\right)^2$$

The same gradient would be used throughout the length of the machine, if there were no defocussing force between drift tubes and if no gap were provided between drift tubes. This condition being used as a starting point, orbit plots were made to find the working voltage, taking into account phase defocussing force and axial gaps between electrodes. A comparison of the results between the two systems of focussing are listed as follows:

		With Grids	With Strong Focussing
ϕ_s	=	-20°	-10°
I_{ave}	=	0.25 μa	0.5 μa
Divergence	=	±.001 rad	±.001 rad

If the sparking trouble can be solved, reconnection to $L = 6\beta\lambda$ and $V = \pm 11$ to 14 kv would be expected to gain another factor of two in beam intensity. However, it is harder now to tune the machine to maximum beam due chiefly to the type of sine angle. Much remains to be learned about the correct handling of the machine.

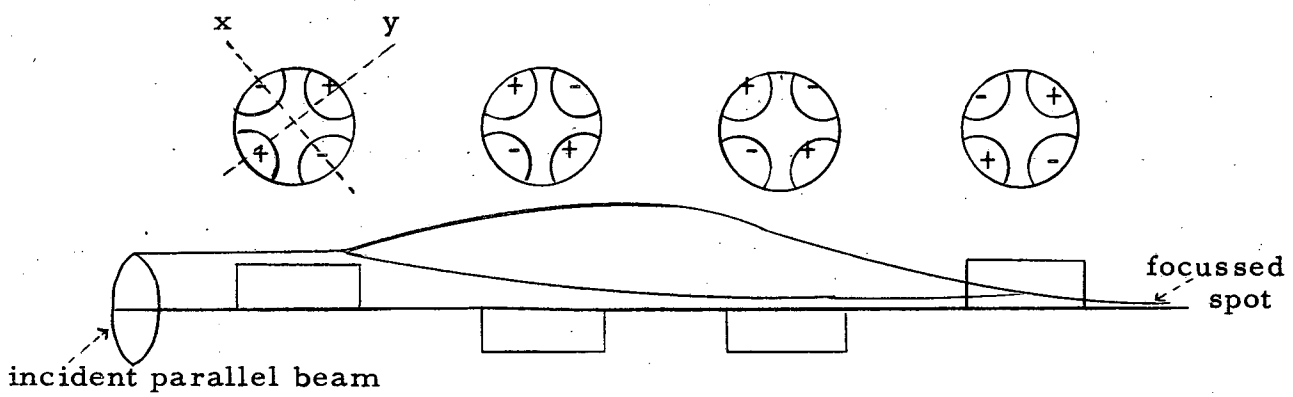

Figure 5.

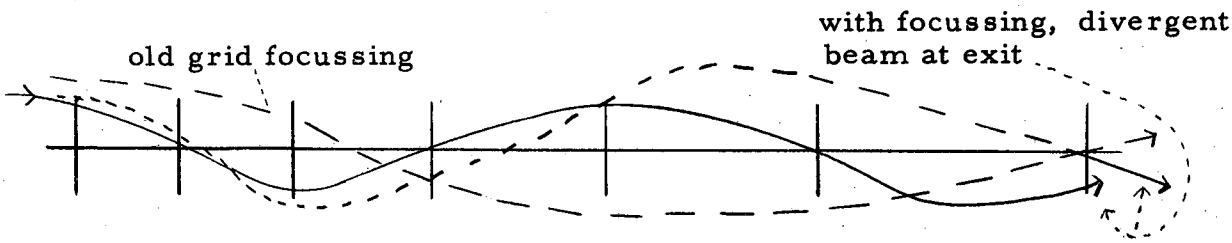

Figure 6.

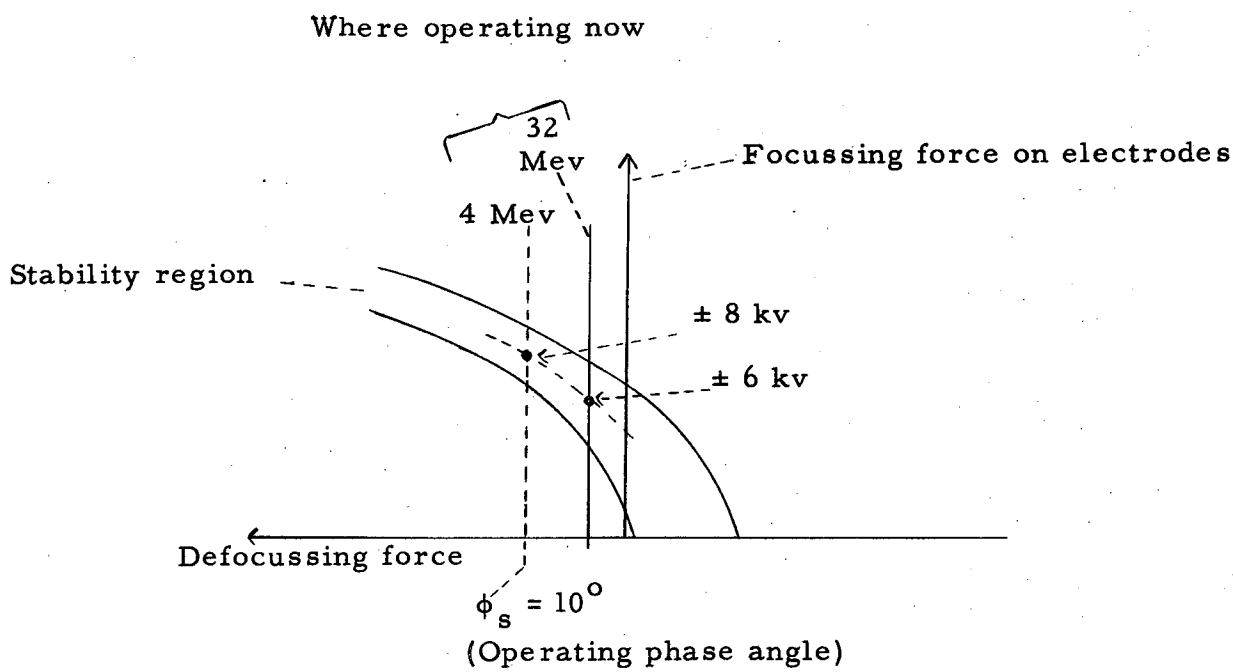

Figure 7.