Livermore Cyclotron Beam Features

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The Livermore machine was the second one deliberately designed to be a variable-energy machine, Rochester being before us, and it is in the strange position, after listening to this conference, of probably being the last one that will have almost azimuthally uniform magnetic fields.

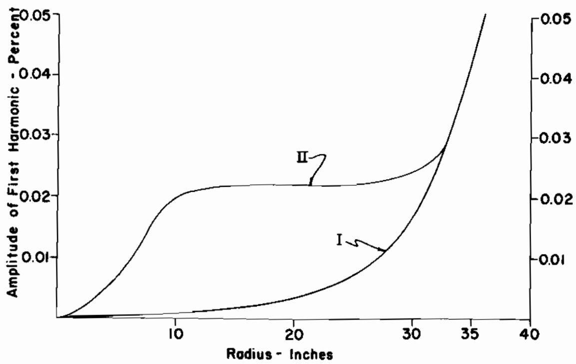

Fig. 200. Amplitude of first harmonic in magnet field vs radius. I and II are extremes which indicate the maximum estimated errors in determining the first harmonic at small radii.

Figure 200 shows a plot of the first harmonic found in the magnet field at one excitation. It is less than 0.05% at the extraction radius of 35 inches. At smaller radii it was hard to determine the first harmonic, but it was quite low. We might say this is a strong-focusing machine with one hill and small flutter. So maybe we are with you after all.

Figure 201 has nothing to do with beam quality, but there are beams in it. I just wanted to show briefly that it

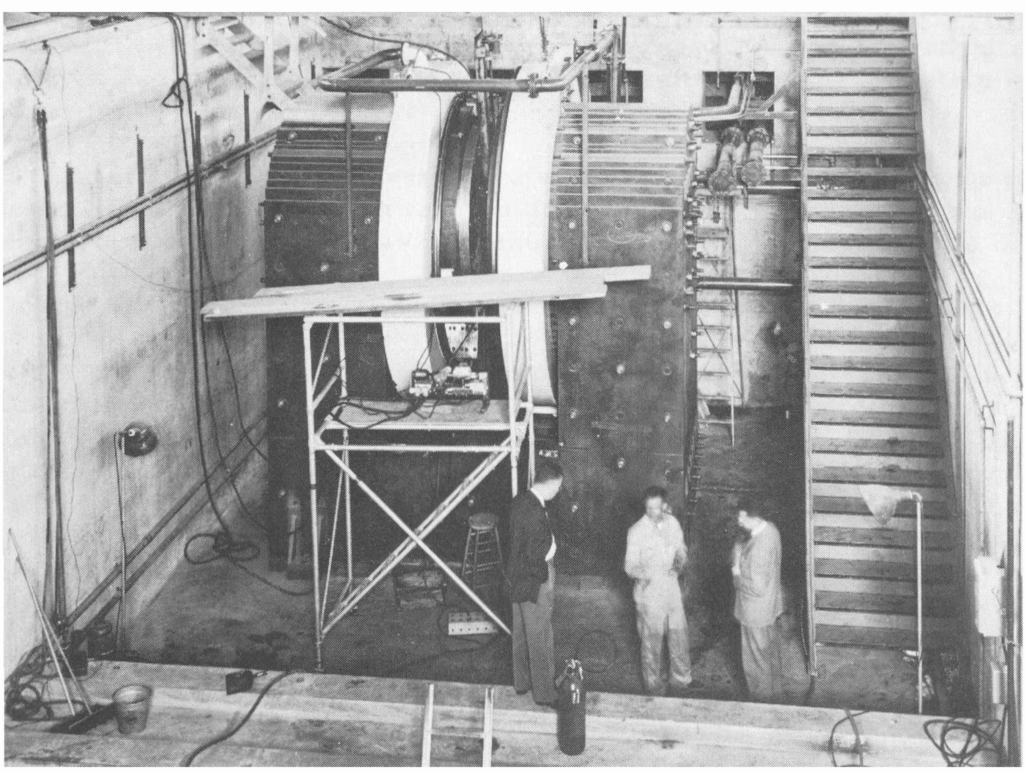

Fig. 201. Livermore cyclotron magnet, shown during construction pole tips and magnet coils in place.

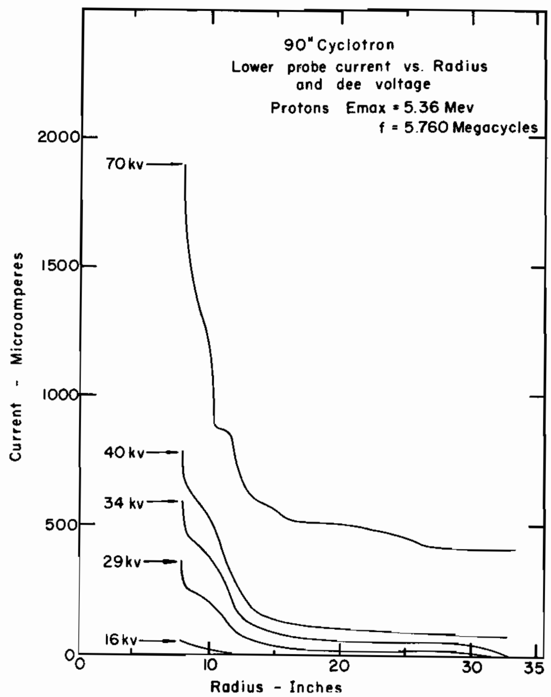

Fig. 202. Beam current vs radius as a function of dee voltage.

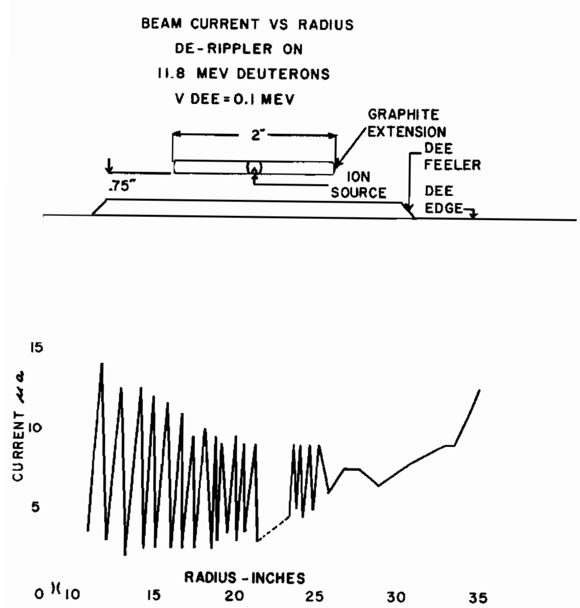

Fig. 203. Turn-to-turn spacing of beam.

is a vertical machine with a C-shaped magnet yoke and has an almost horizontal external beam. The diameter across the pole is something like 90 inches.

Some early data taken when we were checking threshold voltage calculations is shown in Figure 202. The beam is shown as a function of radius for different dee voltages, where the theoretical threshold voltage was 21 kilovolts. These measurements were repeated for protons and deuterons over the whole energy range, and, as best we knew the dee voltage, we were verifying well-known threshold voltage formulas. We also did some work with multifinger probes looking at the axial oscillations, and again saw that the theory fitted very well.

We found that over the energy range we are using, which is protons from 2-1/2 to about 14 Mev and deuterons from 5 to 12 Mev, the extracted beam is a constant within a factor of 2. This was also true of some third-harmonic deuteron acceleration used to get lower deuteron energies. The external beam has an energy spread of about 2%, full width at half maximum.

Something of interest in connection with what W. I. B. Smith has just been talking about is a very crude experiment that we did a few years ago. We wished to improve the acceleration conditions at the ion source and compared an ordinary hooded ion source of the Oak Ridge type with one incorporating graphite extensions (Fig. 203). There were two ideas in mind: first, maybe the electric focusing would be improved and, secondly, ondly, maybe we would stop ions that were coming out quite wrong in phase. By doing both of these things we were able to see turn-to-turn spacing of approximately 0.5 in. quite clearly out to 25 inches. If we did not use these extensions and did not carefully deripple the r-f this whole effect disappeared

Another thing which is important when one talks about beam quantity is the time bunching of the beam as it comes out of the machine. We found that over the whole energy range the time length of the beam is generally about 1/40 of an r-f cycle, which is approximately 6 millimicroseconds at 4 Mc, or 3 millimicroseconds at 9 megacycles. This, of course, is important in time-of-flight experiments.