NIMROD INJECTOR

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(Presented by H. Wroe)

General Status

The Nimrod Injector is at present operating with a 600 keV proton beam current of 38 mA which, with the buncher, gives 18 mA at 15 MeV. The maximum 15 MeV beam current achieved has been 24 mA.

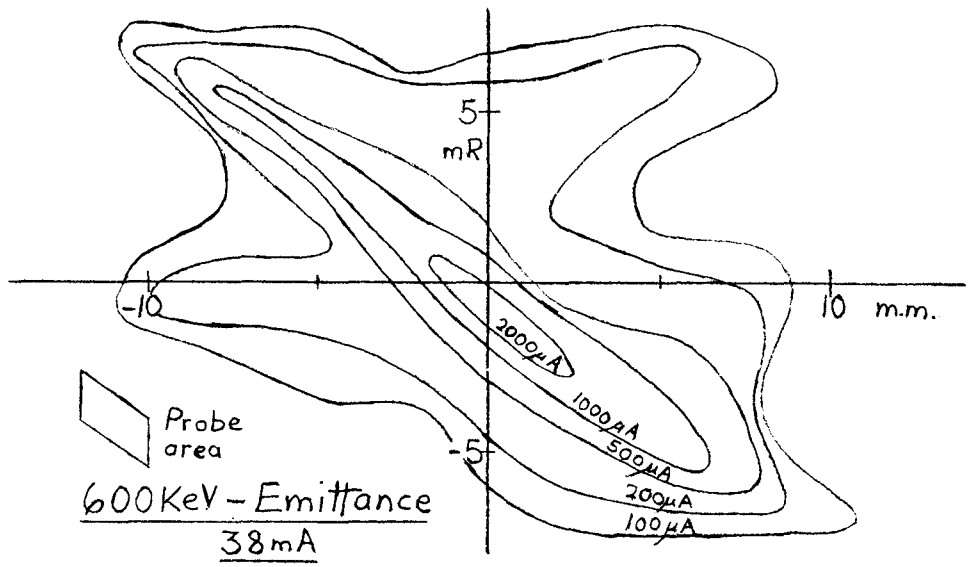
Emittance plots of the 600 keV and 15 MeV beams are shown in Fig. 1. An estimated 90% of the 600 keV beam current can be contained within an ellipse of area 7 π cm-mrad, and 90% of the 15 MeV beam within an ellipse of area 3.3 π cm-mrad.

The 600 keV beam is currently badly misaligned from the axis of the dc accelerating column, and this fact, together with the effect of aberrations, would explain the asymmetries of the 600 keV emittance. The accelerating column assembly, however, can be steered to align the beam on to the linac axis.

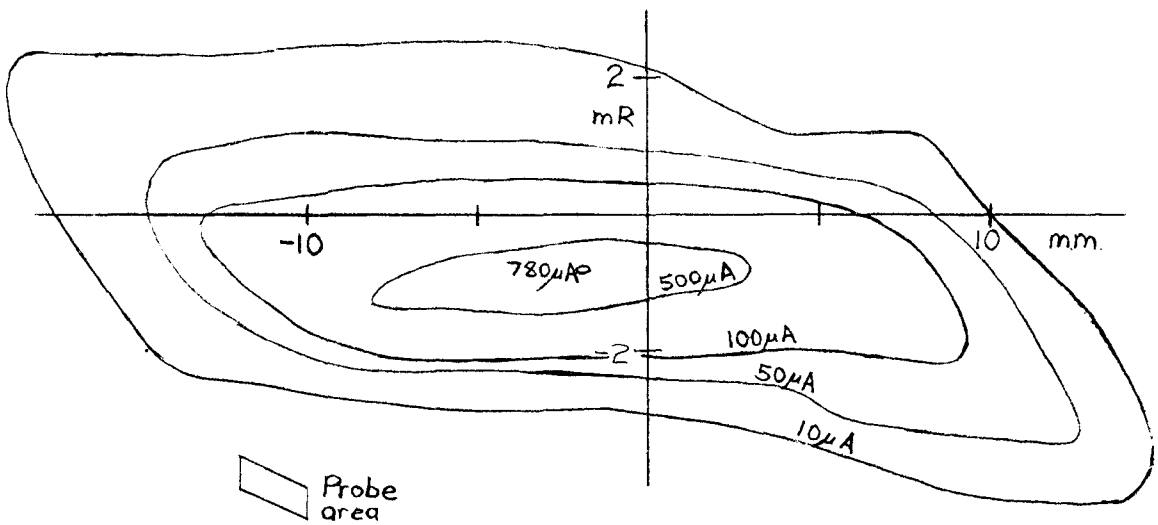
The mode of operation at present is to set up the injector to a standard beam condition. This means that all controls are set to predetermined levels. The 15 MeV beam current produced under these standard conditions is usually within 10% of the nominal, from week to week. The alignment of the beam as it leaves the linac is checked occasionally by means of a pair of four-jaw defining apertures. The results of the measurement are used to calculate the adjustments to a set of four steering magnets required to align the beam to the axis. The misalignments found are usually small, and the beam is only realigned infrequently.

Multipactor Experience

The occurrence of multipactoring in the Nimrod injector linac and the method of inhibiting it by coating the drift-tube faces with carbon black were reported at the Brookhaven Linear Accelerator Conference in 1962. Since then, it has been found possible to leave the faces of the first ten drift tubes uncoated, and to coat the remaining drift-tube faces only over four small areas, corresponding roughly to the positions of the quadrupole pole tips. This has considerably reduced the sparking problem. The effectiveness of the carbon black is demonstrated by the



600 KeV – Emittance
38 mA



15 MeV – Emittance
18 mA

Fig. 1 Nimrod Injector

fact that the linac will still multipactor if the quadrupoles are switched off.

Similar multipactor trouble has been experienced with the buncher and debuncher cavities. It may be significant that the copper used in their construction was not oxygen free. Both of these single gap cavities were designed to allow a whole cavity end wall to be biased by a dc voltage of up to about 6 kV, but in neither case did the bias prevent multipactoring.

With the buncher cavity, a carbon black coating on the whole of each drift tube and end wall was found to be effective for a time, but eventually multipactoring occurred between the drift-tube faces. A gap splitter, capable of being biased, was then fitted. This consisted of a thin plate suspended at the center of the gap, parallel to the end walls, and of diameter equal to that of the drift tubes. For good measure, the gap splitter, as well as the other cavity surfaces, was carbon blacked. The cavity now operates without multipactoring even with no bias applied to the gap splitter.

In the case of the debuncher, carbon blacking the drift tubes and end walls failed to prevent multipactoring to the end walls. A gap splitter was then fitted, of diameter nearly equal to that of the cavity, and biasing it appeared to eliminate the multipactoring. Subsequently, it was discovered that the cavity was in fact operating at a high multipactor level and eventually operation became unstable. Inspection of the cavity showed that the multipactoring had occurred between the cavity end wall and the cylindrical wall, very close in the corner of the cavity, where there are low fields even at high gap voltages. Finally, all surfaces of the cavity were carbon blacked, including the cylindrical wall and the gap splitter, and since then multipactor-free operation has been possible.

The carbon black used is dispersed in alcohol and painted on the surfaces by brush. The presence of large carbon blacked surfaces does not appear to have any significant effect on the cavity Q factor or on the vacuum pressure.

BLEWETT: I have the greatest difficulty in understanding these remarkable experiences with multipactoring.

WHEELER: Some years ago at Yale, we built a single cavity proton linac operating at 50 Mc/sec. The resonator was a quarter wavelength coaxial

cavity, shorted at one end and capacitatively loaded at the other end where the acceleration took place. Therefore this resonator had radial electric fields except in the accelerating gap. The post loaded TM_{010} resonator that Wroe has mentioned also must have radial electric fields near the end walls. Now, in this coaxial resonator, the electric field between the post and the outer wall varies continuously from zero to the maximum gap field so that there will always be some point at which the voltage is correct for multipactoring. We tried every known scheme to suppress the multipactoring except carbon black. The method which finally worked was a high rate rise of the rf drive, which was accomplished by an oversized rf system.

BLEWETT: The only difference between this and other machines seems to be in the frequency. I can't believe that the 50 Mc drop in frequency could be responsible for all of these extraordinary effects.

DICKSON: On the last slide that you showed, there was scalloping on top of the drive pulse. Have you looked at the frequency of this scalloping in the same way as has been done on other linacs?

WROE: No. You will have to ask Nigil West about that.

WHEELER: That looks a little bit like an oscillation in the drive system.