BEAM OPTICS DESIGN FOR A 600 MEV MICROTRON

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At the University of Illinois we have studied the feasibility of a racetrack microtron having two 180° bending magnets separated by 6.5 m, a 30 MeV standing wave linac in the common straight section and 19 parallel return paths separated by 14 cm. The problem is similar to that discussed by Wiik and Wilson,[1] except that we call for bending magnets which are about 50% further apart and we have aimed at containing a beam with six times larger emittance: horizontal and vertical extents of ± 2 mm, divergence angles of ± 0.3 mrad, and momentum spread of ± 1% at 30 MeV.

We have required that the deviation in position and angle of an electron's path with respect to the linac axis be uncorrelated with its momentum error. Two things are necessary in order to make the position and angle independent of the momentum to first order. First, all of the horizontal focusing of the beam must be done with optical elements which are coaxial with the linac axis. Second, the optical system in each return path should be symmetrical about the plane which is midway between the two bending magnets.

The beam is defocused vertically in the fringe fields of the bending magnets. To provide vertical focusing we have started with two quadrupole pairs on each separate return path, one pair close to each magnet. If one requires an advance in the vertical oscillation phase for each orbit of 90°, which may be greater than necessary, one computes gradients in the quadrupoles which increase monotonically with the orbit number from 0.1 to 0.5 kG/cm for quadrupoles 20 cm long and separated by 10 cm.

Only very weak horizontal focusing powers are required to contain the beam within ± 2 mm of the linac axis up to 600 MeV. The linac provides some focusing but in the absence of additional horizontal focusing the beam enlarges to about ± 3.5 mm in the common straight section. We have chosen to use two quadrupole singlets on the linac axis, one near each bending magnet, to provide the horizontal focusing. We have tried focusing powers of 0.68 and 0.13 diopter per singlet at 30 MeV. Both are satisfactory, giving horizontal oscillation phase advances of 180° and 90°, respectively, on the first orbit. The beam profile for the latter case is shown up to 240 MeV in Fig. 1. The focusing power of the singlets decreases as the momentum increases, but so does the emittance of the beam, with the net result that the horizontal extent of the beam remains about the same but the beam becomes more parallel from orbit to orbit. There are some 1 mm waists in the horizontal beam envelope as shown in Fig. 1. The locations and size of these narrow waists imply that the divergence angle of the initial 30 MeV beam could be doubled without changing the maximum horizontal beam size very much.

1. B.H. Wiik and P.B. Wilson, Nucl. Instr. and Methods 56, 197 (1967).

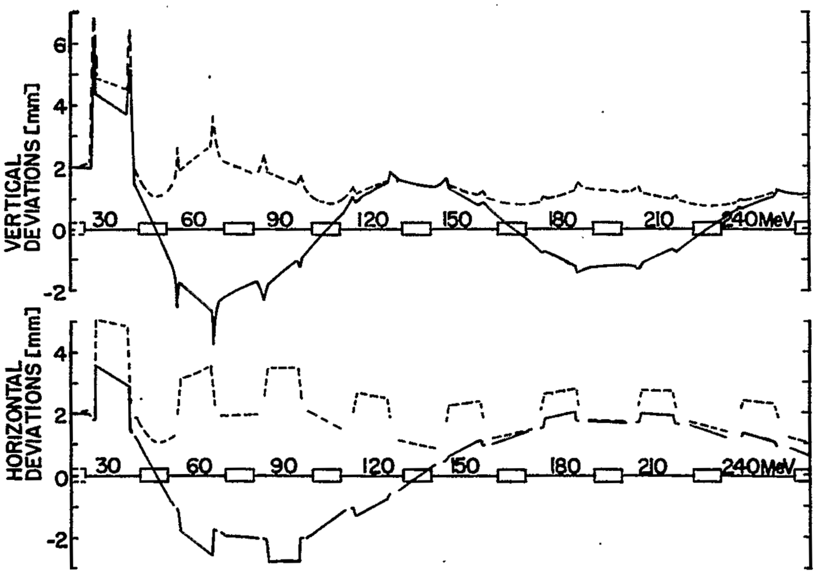

Fig. 1. Vertical and horizontal beam profiles for microtron orbits from 30 to 240 MeV. The boxes indicate the locations of the linac along the path. The dashed lines are beam envelopes. The solid lines are cosine-like principal rays. We have not shown the details of the horizontal beam profile within the 180° bending magnets.