A Microtron Cyclotron - the Slipatron*

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The motivation for this "microtron cyclotron" or "slipatron" design arises from the idea that a more compact cyclotron type magnet might be built, using the usual sector cyclotron fields for focusing but having a strongly increasing radial gradient in the field, as in FFAG design, to compact the orbits. This deviation from the isochronous field causes the ion frequency to increase with energy. To obtain high intensity we must use constant rf frequency and an integral number of rf cycles per turn, which is the microtron mode of acceleration. The harmonic number (rf freq/ion freq) then must decrease with energy gain. To allow a sufficient number of turns a high starting harmonic number of 50-100 is used, so that it can be decreased each turn during acceleration. A high energy gain per turn is required and can be accomplished with multiple dees. Unlike a microtron cavity, the dees have to extend over the radial aperture. The change of period during acceleration can be matched by changing the angular width of the dees with radius. Phase stability exists because the ion frequency depends upon radius.

A layout of an optimized design is shown in Figure 1. A four sector structure is chosen to give two valleys for rf and space for injection and extraction. The magnet and rf systems are drawn to scale. This design is for a proton accelerator with injection at 2 MeV and extraction at 30 MeV. The harmonic is 100 at injection and 54 at extraction. Average radius at extraction is .84 meter. The field gradient is obtained by tapering the hill gap, with constant hill angular width. The peak field on the hills at the edge is 19 kG. The axial focusing was calculated using the simple hard edge approximation with valley field assumed zero. The high flutter is adequate to compensate the rising average field and give Nuz of .3 or more, using some spiral at the edge. The rf system has 10 gaps in each of 2 valleys. The rf frequency is 770 MHz. The energy gain per turn is programmed from the center to the edge by dee shaping to give .2 MeV/turn at the center and 3.2 MeV/turn, or 160 keV/gap, at the edge. The injection and extraction are shown schematically. The turn separation is 1.1 cm at injection and 1.7 cm at extraction. A figure of merit, F, for this type of accelerator is its radial aperture compared to that of a standard cyclotron of the same energy. F = .7 for this optimized design.

An advantage of this design over that of a cyclotron with the same magnetic fields at extraction is that the magnet can be more compact. But the disadvantages are the greater complication of the dee system and the need for an injector. Perhaps other variations of this design can be developed.

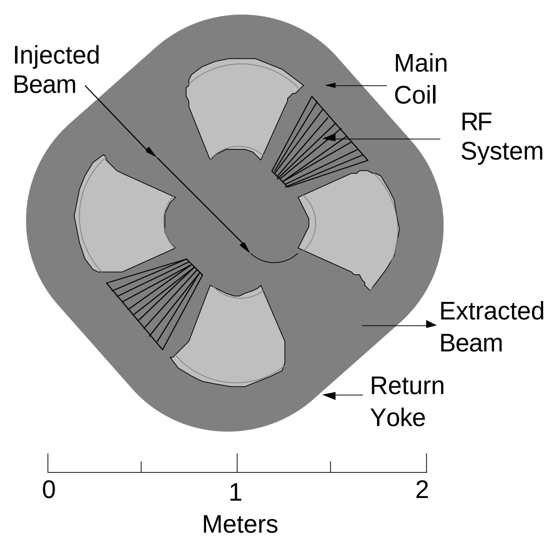

Figure 1: Optimized design layout

Footnotes and References

*Condensed from Proc. 14th International Conference on Cyclotrons and their Applications, Capetown, South Africa, Oct. 8-13, 1995, p. 618.

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