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Memo on Beam Steering and Focusing for Project M

by

Karl L. Brown

It has occurred to me that the method used in the past for steering and focusing the beam is outmoded, especially if multiple beams are to exist in the accelerator. There is another method which seems more promising to me. It consists of periodically spaced "field" lenses positioned along the accelerator and aligned with the axis of the accelerator pipe (and not the axis of what the accelerator alignment should be). These field lenses in practice would consist of air core magnetic quadrupole lens pairs spaced close enough together to take care of the maximum deviations in accelerator alignment that would normally be expected over a period of, say, six months to a year. These lenses would then constitute a "light pipe" such that the magnitude of the current flowing in their coils determines the index of refraction of the pipe. Any slight shift of the accelerator axis would have the effect of just merely moving the position of the "electron magnetic pipe" to correspond to the actual position of the accelerator axis.

This system has several advantages over using regular steering coils. In the first place, it would tend to keep the beam on the axis of the accelerator and would only steer the beam in the event, for some reason, the beam was off axis. The principal advantage of the proposed system is that if enough quadrupoles are placed along the machine, then the beam steering and focusing could be made more or less independent of beam energy and the problems arising from multiple beams in the machine would become greatly simplified. It has not been proved rigorously as yet, but it is possible that the amount of dispersion occurring in the beam as it is steered down the machine is more or less independent of the types of focusing used and depends to first order on the total angular bend which the beam has gone through in finding its way down the machine. It may even be possible to make the net dispersion zero by appropriate choice of lenses strength and positions. This can be rather important for a very long machine, such as Project M.

Dick Helm and I will look into the beam dynamics implications of this system. Qualitatively reasoning to date seems to indicate that there are no serious problems arising. It is true, however, that the proposed system will consume more power than regular steering coils since regular steering coils would have to be pulsed in order to have multiple beams going down the machine. The idea of having constant currents serving for all beams is indeed very attractive.