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MULTITURN EXTRACTION FROM AN AGS

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The problem posed by a relatively small circumference booster synchrotron injecting into a larger machine is that if one desires the beam uniformly distributed about the larger machine, then one must do one of two things. One can operate the smaller machine at a high repetition rate. This requires a great deal of rf power as well as putting a premium on stored energy because of the high cycling rate. The other alternative is a slow cycling machine, which suffers from none of the objections of the rapid cycling machine, but requires a method of extracting the beam over the course of a few revolutions (~ 10). A simple method of doing this is described below.

The proposed method is simply to run the multiturn injection scheme backwards. That is, one produces a "bump" in the orbit at the "inflector", which is now the extraction channel. The beam must move past the ejector septum in the required number of revolutions. A typical R.B.D. is a fair approximation to a 10 turn extraction system. In order to obtain maximum efficiency 3 things are required. The extraction channel septum must be at a horizontal β_{max}. This assures the minimum angular divergence in the beam, which is relevant for computing the loss on the septum. That is, the angular divergence plays a role in determining the septum's effective thickness. Furthermore, which is obvious, the septum should be as thin as possible, at least to the point where it is thin compared with the increase in effective thickness due to the angular spread. Lastly, the effective thickness is reduced by making the field in the septum magnet as high as possible. This allows one to "tilt" the septum, the entrant beam being bent by the field away from the septum. For a beam .6" in diameter at a β_{max}, the maximum angle is only .35 mR. A 20" septum has an effective width of only about 7 mils. This can be further decreased by making a bend in the septum of 1 mR or more. Since the extraction is occuring in a time of $\sim$ 30μs, the septum need only be pulsed with something like a 1 kc half sine wave. The heat dissipation in such a system is negligible. Remember that the extremely thin septum must only kick the beam past another quite thin septum for final extraction. A 40 mil fast pulsed septum is adequate for complete extraction from the machine at 30 BeV.

One other criterion for efficiency is the phase space dilution in the ejected beam. This is related to injection effieiency for multiturn injection. With injection, given an arbitrarily long linac pulse, the injectable beam is not a function of the ν value. However, the efficiency goes down as one moves away from a ν value of $n + \frac{1}{2}$. Therefore, it is important to operate the multiturn extraction right on the half integral resonance. Recent measurements have shown that these stopbands are $<$ .01 ν units wide. Furthermore, the addition of sin, cos 17θ gradient components in the AGS has been demonstrated to reduce these stopbands to vanishingly small amounts. Therefore, the operation at ν = 8.5 in the AGS should not present a problem. Also the application of sextupoles can reduce the ν spread, although this is not expected to be a problem. Reasonable estimates of the extraction efficiency give about 90%, with a phase space dilution factor of about 1.4.

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