The Choice of Adiabatic Capture into the Low Energy Booster

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The original CDR called for a bunch-to-bucket transfer scheme for filling the low energy booster (LEB). After further study, we have concluded that the adiabatic capture method offers large improvements in performance and reliability while reducing risk and cost.

In the bunch-to-bucket method, the frequency of the beam from the linac must be equal to the LEB bucket frequency, f, at injection time ($f \cong 50$ MHz). The linac must inject into each bucket N times, where N = (charge in LEB bucket)/(charge in linac bunch), and N is the minimum number of LEB revolution periods needed to fill the LEB. In the adiabatic capture process, the linac beam debunches before being captured into LEB buckets. There is no constraint on the linac bunch frequency. A linac bunch frequency of about 425 MHz is preferred because of a number of considerations having to do with RFQ performance, beam emittance and current, and rf power tube availability. Since this frequency is 8 or 9 times higher than in the bunch to bucket scheme, the LEB can be filled to the same charge per bucket with some combination of lowered linac bunch charge and shortened LEB fill time.

In a linac designed for adiabatic capture, a conservative average current of 25 mA fills the LEB to design spec charge per bucket in four turns. A linac pulse length of less than 50 μsec provides the additional factor of five needed for test beam operation.

For reasons relating to ion source performance and emittance growth in the LEBT and RFQ, the charge per linac bunch in a machine designed for bunch-to-bucket transfer should probably not exceed two times the value used in the adiabatic capture design. Then it could take a minimum of 18 turns to fill the LEB. For test beam operation, a linac pulse length as large as 200 μsec could be required. Due to the long capture time, emittance growth and beam loss due to scattering in the stripper foil is becoming appreciable.

In order to obtain adequate performance, the RFQ for a bunch-to-bucket linac would have a frequency of at least 200 MHz. Some form of chopping scheme is needed to reduce the beam frequency to the LEB frequency. Several chopping methods have been suggested. They all tend

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to be complex and increase the beam emittance. There is no operational experience with any chopping method in high brightness proton accelerators.

The linac required for adiabatic capture is comfortably within the state of the art in all parameters. There is operating experience at several laboratories indicating that a capture efficiency in excess of 90% is achievable. The linac required for bunch-to-bucket transfer would involve some additional risk (high current, chopper system), be more expensive (pulse length, chopper system), be potentially less reliable (ion source current, chopper system), and require very long multi-turn injection.