Fermilab

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TRANSPORT OF A 30π BEAM IN THE 200 MeV LINE

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In a previous note (TM-643) the aperture size at the entrance to each line element was calculated using the two design configurations (single turn momentum match and multiturn achromatic match). Tables were made listing the restrictions in order of decreasing importance (increasing aperture size). Areas of beam loss for large linac beams have been observed to coincide with these restrictions. In this note the apertures required to allow transport of a 30π mm-mrad beam are calculated.

Calculations

Using the same two configurations as in the earlier note, the aperture of each device was calculated to just pass a 30π mm-mrad emittance beam based on the larger of the beam sizes at either the entrance or exit of each element in a transport calculation. The quadrature of the beam position shifts due to a 0.5 mm position and a 0.25 mrad angle shift at the entrance to S1 was calculated and added to the 30π aperture radius. Table I and II show a list of devices that would start restricting a 30π beam for the two modes of operation with and without the beam shift of the incoming beam. The plane of interest and the present aperture size is shown. The first group in each table is more or less the same without regard to the mode of injection to the Booster. The inflector is listed only on the single turn table but the 0% $\Delta p/p$ would apply to a single turn match with the achromatic setup.

Conclusion

The devices that are underlined are those that need increased aperture to transport a 30π mm-mrad beam with no beam shift. If one is more pessimistic and wants to allow for transient beam motion (or just some tolerance in excess of the 30π emittance) than the list of devices and sizes required approaches the complete list with the larger aperture sizes. The inflector size is a problem for a single turn momentum match even without any transient beam motion.

Modifications to the line in the MV1 area are difficult because of the limited space available; larger aperture devices seem to be the easier route. Quad 21 is a problem only for the achromatic case. This is a result of wanting a small horizontal beam size for multiturn injection as well as an achromatic line. If one wants an achromatic line to pass single turn injection beam widths only (eliminate the multiturn injection mode) new line designs with the relaxed constraint may be found that also have less of an aperture problem.

Table I

APERTURE FOR 30π mm-mrad

Single Turn Match
(5/24/76)

Device	Plane	Present Aperture (inches)	30π Beam Shift* (inches)	30π No Shift (inches)
S1	V	(1.5)	1.68	1.64
MH1	V	(2)	1.98	1.69
Q8	H	(3)	3.63	3.48
MV1	H	(2.5)	3.59	3.5
Q14	H	(3)	3.16	2.89
Q18	V	(3)	3.03	2.68
MH2	V	(1.31)	1.71	1.58
S2	V	(1.5)	2.31	2.12
INF	H	(0.9)	——	1.41 ± 0.1% Δp/p
			——	1.16 0% Δp/p

*Beam shift added equal to the quadrature of shifts due to 0.5 mm position and 0.25 mrad angle shift at the entrance to S1.

Table II

APERTURE FOR 30π mm-mrad

Multiturn Match
(5/24/76)

Device	Plane	Present Aperture (inches)	30π Beam Shift* (inches)	30π No Shift (inches)
S1	V	(1.5)	1.68	1.64
MH1	V	(2)	1.98	1.69
Q8	H	(3)	3.63	3.48
MV1	H	(2.5)	3.67	3.5
Q14	H	(3)	2.93	2.67
Q18	V	(3)	3.36	3.03
MH2	V	(1.31)	1.61	1.44
Q21	V	(4)	5.19	4.55
Q22	V	(3)	3.56	3.13
Q25	V	(3)	3.74	3.36
S2	V	(1.5)	2.12	1.95

*Beam shift added equal to the quadrature of shifts due to 0.5 mm position and 0.25 mrad angle shift at the entrance to S1.