BOOSTER EJECTION

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1) Vertical v.v. Radial Ejection

Following the change in the booster design acceptance from 100π by 10π at injection to 50π by 20π, it is necessary to re-examine the relative merits of radial and vertical ejection. The fast kicker requirements have been compared by taking the present emittance ratio $E_h/Ev = 2.5$ and various damping factors during acceleration to take account of beam blow-up.

TABLE 1

Damping Factor (Einj / Eej)	Total Kicker Voltages Vertical	Radial
16.23	47 kV	13
10.8	51.5 kV	161 kV
8.12	64 kV	183 kV

Assuming an 'effective' septum thickness of 4 mm, and fast kickers located in the previous long straight section, the total kicker voltages required for vertical and radial ejection are given in Table 1.

Thus the kicker voltage required for radial ejection (if the emittance ratio of 2.5 is conserved during acceleration) is almost 3 times that for vertical ejection.

On the other hand, for radial ejection the septum can be located at the beginning of the long straight section without requiring extra radial aperture. Also, in this case the D magnet vertical aperture can be decreased by 1 cm.

For vertical ejection the septum must be located about 1.5 m after the D magnet and the average septum field required to avoid the next D magnet is then 14.6 kG as opposed to 9.6 kG for radial extraction.

2) Vertical Ejection Schemes

a) No Closed Orbit Bump at injection

For the present D magnet semi-vertical aperture of 31.75 mm to the inside of the vacuum chamber, the septum would be located 23.1 mm from the median plane reducing the cloud orbit allowance to 1 mm on one side. There would then be slightly less than 50% probability of needing closed orbit correction at injection.

With this arrangement, the location of the slow bump (and consequently its strength) depends on the final beam emittance. Table 2 gives the location and strength of the slow bump required for various damping factors, and the reverse bump in the long straight section.

TABLE 2

Damping Factor (Einj / Eej)	Location	Angle	Bdl	Reverse Bump Bdl Needed
16.23	F-D S.Sn.	3.9 mr	1.41 kGm	1.985 kGm
12.18	1/4 through D	4.5 mr	1.63 kGm	2.78 kGm
8.12	2/3 through D	5.8 mr	2.1 kGm	4.12 kGm

b) Closed Orbit Bump at injection

This scheme proposed by Frank Shoemaker, allows the septum to be placed close to the machine median plane. A closed orbit bump is then applied at injection in the septum straight section, to guide the undamped beam around the septum. If the closed orbit is displaced at injection in this way by means of DC fields, the displacement subsequently decreases $\propto 1/p$. Since the beam radius damps only as $1/\sqrt{p}$, the innermost septum position is that requiring a closed orbit displacement equal to one half of the injected beam radius. In this case the semi-aperture required in the D magnet to permit the ejection of a $20\pi/8.12\,\mu$rm beam is 29.6 mm (i.e. an aperture reduction of 4.3 mm).

If a programmed bump is used, the vertical D magnet aperture could be reduced further.

3) Summary

For vertical ejection of a fully damped beam (no blow up) the present D magnet gap is adequate with no closed oribt bump at injection. With a D.C. bump at injection, the magnet gap can be reduced by 10 mm for the fully damped beam or 4.3 mm for a beam of $20\pi/8.12$ (i.e. factor of 2 blow-up in emittance.)

It should be noted that the advantage of vertical ejection arises almost entirely from the smaller vertical emittance, and in order to take advantage of this feature it is necessary to resort to a more difficult septum magnet and to either increased vertical D magnet aperture or extra closed orbit bumps at injection.

There are then two outstanding questions:

1) Will the ratio of horizontal to vertical emittance persist through acceleration, and the vertical blow up remain below a factor 2 in emittance?

2) What are the effects of introducing a large closed orbit bump at injection?