A SEPARATED-FUNCTION LATTICE FOR THE NAL BOOSTER

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With separated bending and focusing, and focusing accomplished by FDF triplets, one can achieve a lattice in which the β_x function is comparatively uniform, while β_y is large only in the D element of the triplet and quite small in the bending magnets.[1]

To provide room for RF injection and ejection, fairly substantial straight sections are required. Another feature that is desirable is to have the transition energy substantially above the ejection energy--this avoids the very sharp bunching at transition and, in particular, the longitudinal space-charge effects at transition which have been studied by Hereward and Sórenssen at CERN.[2]

Both these requirements can be met by the same device: Produce straight sections by omitting bending magnets from some of the cells; raise the transition energy by arranging the periodicity of the "missing" bending magnets so as to exhibit a large Fourier component of an order close to, but above, ν_x.[3]

A further requirement is that two straight sections be provided with somewhat below 90^o of phase shift between them, to facilitate fast ejection with a kicker in one and a septum magnet in the next one.

Using these principles, a lattice has been designed having the following properties for 10 BeV protons (the SYNCH computer program was employed):

Mean Radius	100 meters
Normal Cell	FODOFOBOOBO

F   Quadrupole, length 0.56 m, 190 kG/m

D   Quadrupole, length 1.046 m, 190 kG/m

O   Space, 0.3135 m

OO   Space, 1.132 m

B   Bending magnet, 8 kG, length 2.974 m (sector ends - angle $2\pi/96$).

Special Cell	FODOFOOO

OOO   Long straight section, length 7.707 m

Lattice   6 superperiods, each with two special cells in a row followed by eight normal cells

Thus these are a total of 12 long straight sections (7.707 m) and 48 short ones (1.132 m)

Orbit Properties

	Horizontal	Vertical
ν	11.355	9.224
γ_{trans}	16.234	(Transition energy 14.29 BeV kinetic)
β_{max} in Quadrupole	10.3	18.85 m
β_{max} in Bending Magnet	10.1	10.85 m
Maximum X_p	3.28 cm for $\Delta p/p = 0.01$	

Matrix between centers of successive long straight sections:

$$H \begin{pmatrix} 0.382 & 7.924 \\ -0.1078 & 0.382 \end{pmatrix} \qquad V \begin{pmatrix} 0.569 & 7.809 \\ -0.866 & 0.569 \end{pmatrix}$$

(This is useful for computing beam extraction parameters.)

If we postulate bending magnets with an aperture of 1.7 x 5 inches (4.4 x 12.7 cm), net available semi-apertures for betatron oscillations may be 1.5 cm vertical, 4 cm horizontal. This gives acceptance of 2.06 π mrad-cm vertical, 16 π cm-mrad horizontal (generous room for multiturn injection).

The quadrupoles may have an 8 cm diameter circular aperture with 7.6 kG pole tip field. With these dimensions, the quadrupoles do not restrict the aperture provided the inscribed vacuum chamber is elliptical, say 5 cm high and 12 cm wide.

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REFERENCES

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3. E. D. Courant and H. S. Snyder, Annals of Phys. 3, 1 (1958), Eq. (5.29).