Lattices for 8 and 30 GeV Proton Drivers

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Proton Drivers

1. ISIS Upgrade

ISIS (R = 26 m) → New Ring (R = 78 m)

3 GeV @ 50 Hz → 1 MW Spall. Neutron Source

8 GeV @ 50/3 Hz → Neutrino Factory R & D

RF system same for both operating modes

Modified magnet P/S for 8 GeV

Possibility of developing to 4 MW

2. CERN 30 GeV Driver in ISR Tunnel

0.18 GeV Linac	→	2.2 GeV Booster 50 Hz	→	30 GeV 8.33 Hz 4 MW

Requires combined function magnets in arcs

Costs ~ 10% less than SPL / AC driver

Lattice Requirements

1. R = 78.0 m, F = 50 Hz for 8 GeV

   R = 151.0 m, F = 50/6 Hz for 30 GeV

2. Avoid crossing transition

3. Chromaticity and (high energy) $\square_1$ correction

4. Careful choice of $\square_h$, $\square_v$ for sextupoles and tune split

5. Large acceptance and dynamic aperture

6. Low $\square_h$, $\square_v$ and $\square_p$ parameters

7. Long straights for rf, injection, extraction & collimation

8. Common gradients for main quads; fast trim quads

Basis of Lattice Designs

1. S(arc) = 5 and Q_h(arc) = 4

2. Five groups of three cells in arc, □$_h$ = 3 x 96°

3. High □$_t$ by missing magnets not focusing adjusts

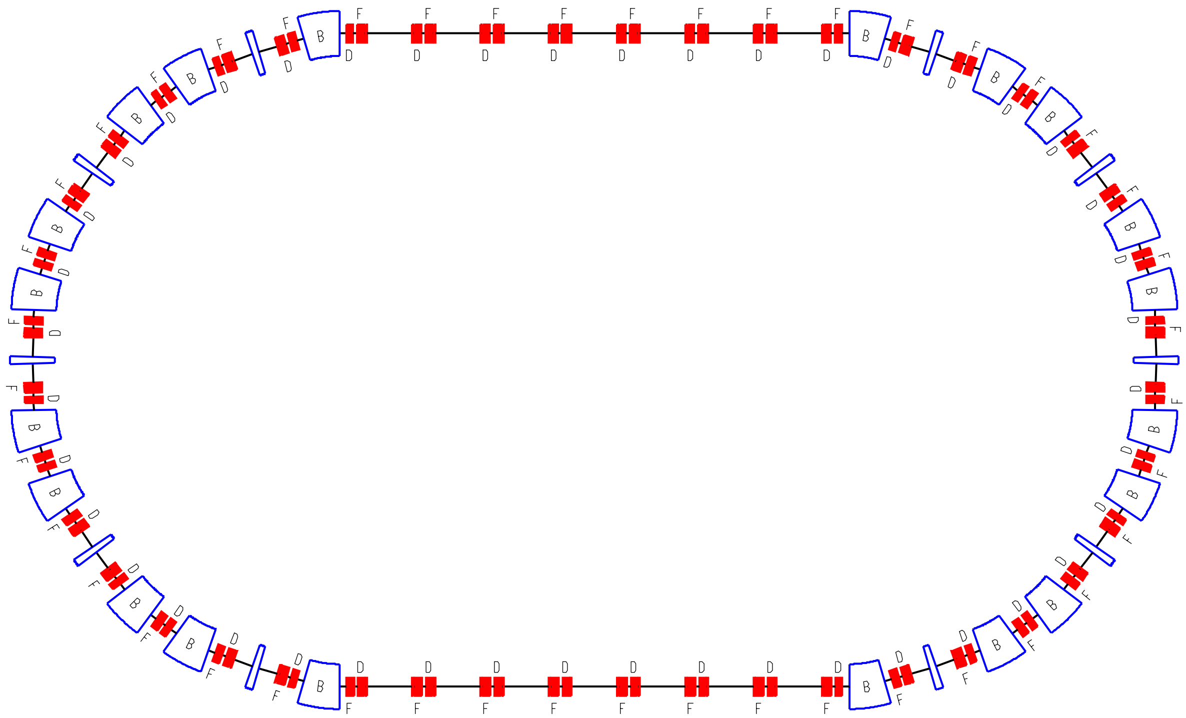
4. □$_v$(arc) = 3 x 60° (8 GeV), 3 x 72° (30 GeV)

5. Superperiods = 2 (8 GeV), 4 (30 GeV)

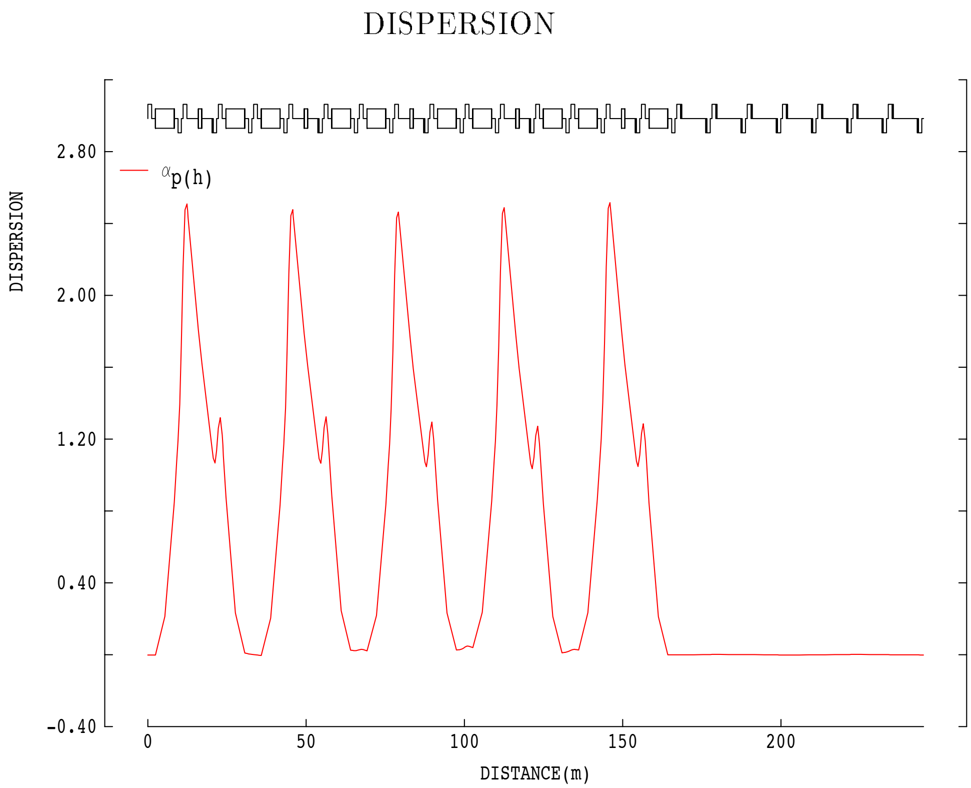
6. Tunes = 11.7, 7.4 (8 GeV), 19.32, 14.84 (30 GeV)
   □ □

7. Resonances, 4 Q_v = 28, 2 Q_v + Q_h = 49 □ 48 (□Q < 1/3)

8. Fewer resonances than for 4 groups of 3, 90° cells



ISIS Upgrade



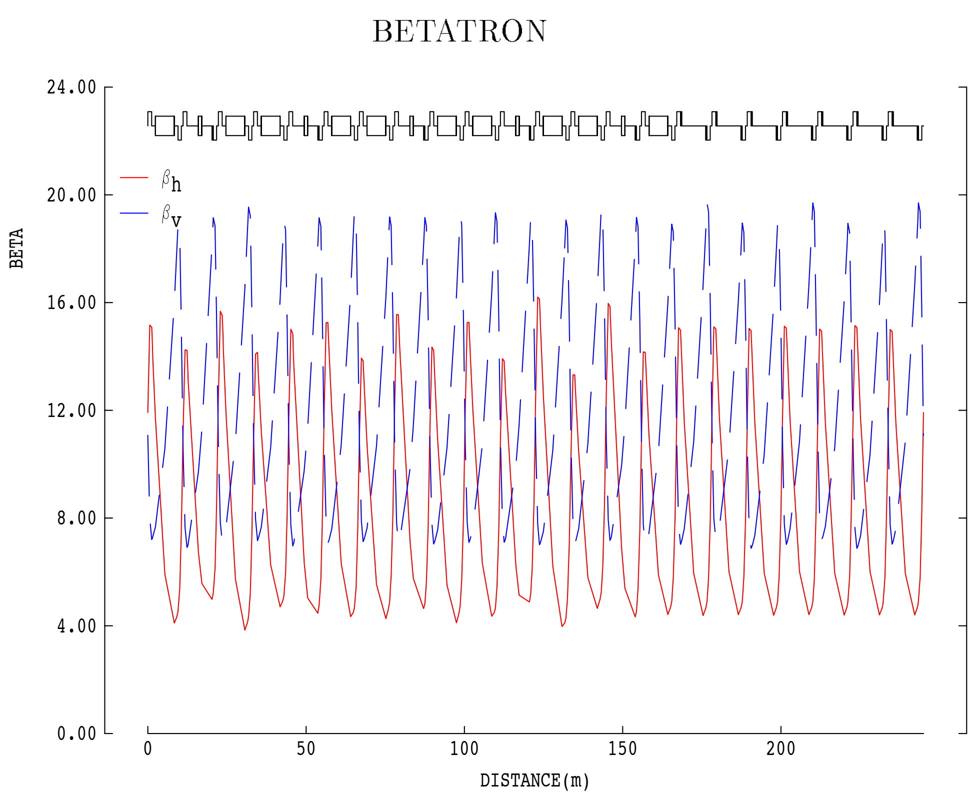


Figure 1: 8 GeV Lattice

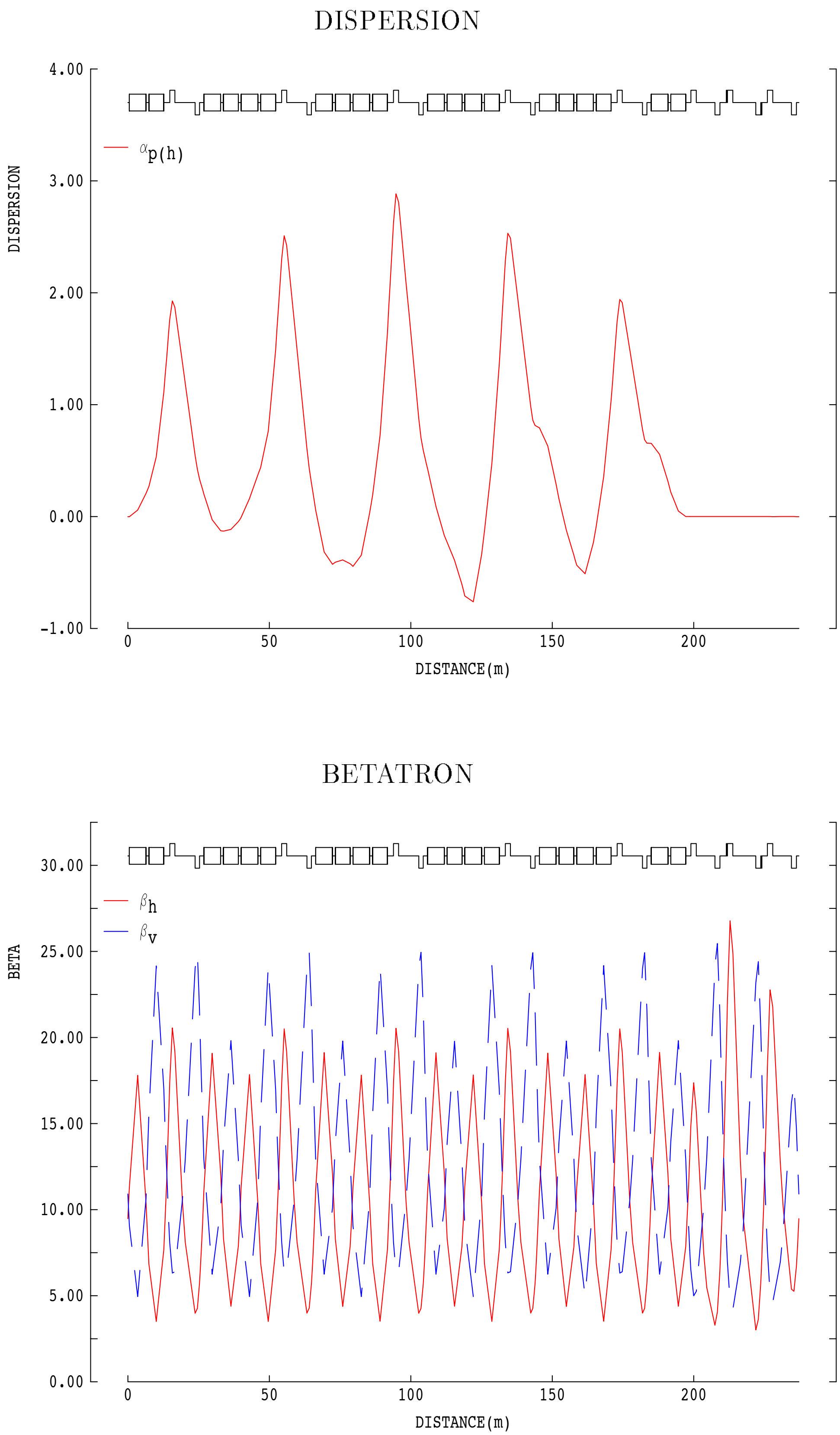


Figure 1: 30 GeV Lattice

8 GeV Lattice Features

1. Structure 2 [5 (C1, C2, C1) , 7 C3] doublets

2. C1, C2 : long, short sector dipoles, resp.

3. C2, C3 : missing dipoles

4. (C1, C2, C1) : almost achromatic

5. $\square_t = 13.78$, $Q_h = 11.7$, $Q_v = 7.4$

6. $\square_h < 16.0$, $\square_v < 20.0$, $\square_p < 2.5$ m

7. Max. quad, dipole fields < 0.98, 1.45 T

8. Straights 14 @ 7.5 m ($\square_p = 0$)

   20 @ 3.23 m

30 GeV Lattice Features

1. Structure 4 [5 (C1, C2, C1), C3, C4, C3]

2. C1 : combined function BF and BD

3. C2, C3, C4 : missing dipole quadrupole doublets

4. 5 (C1, C2, C1) achromatic; (C1, C2, C1) not

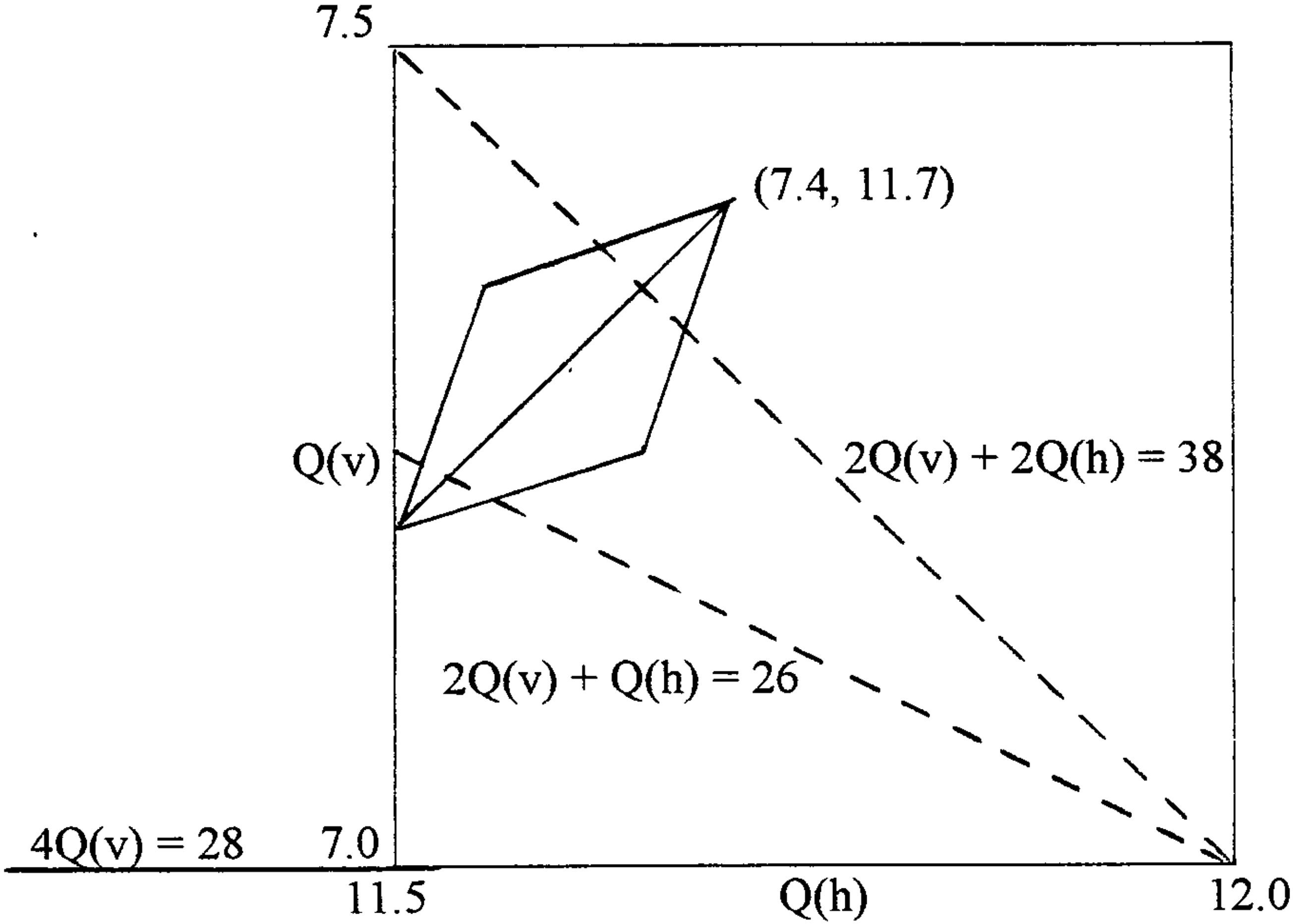
5. $\square_t$ = 40.8, Q_h =19.32, Q_v = 14.84

6. $\square_h$ < 27.0, $\square_v$ < 25.0, $\square_p$ < 2.9 m

7. Max. quad and (BD, BF) fields < 1.0, 1.8 T

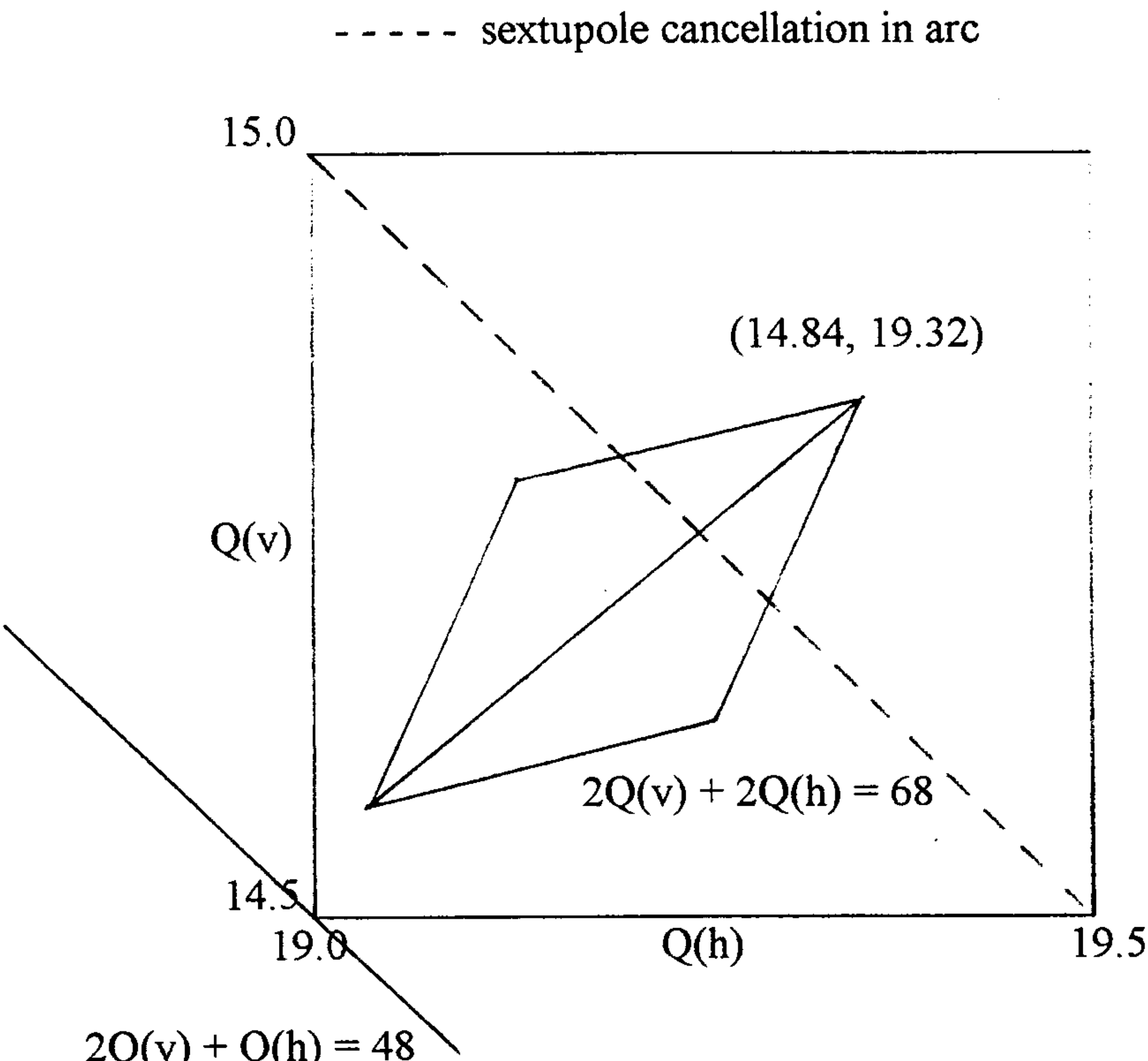
8. Straights : 8 @ 6.6 m, 4 @ 8.1 m ($\square_p$ = 0)

   20 @ 7.15 m



8 GeV Lattice (S = 2)

- - - - - sextupole cancellation in arc



30 GeV Lattice (S = 4)

Lattice Collimation Requirements

1. Momentum collimator (MC) near max. dispersion in arc.

   (max. normalised dispersion for tapered vacuum walls).

2. MC near upstream end of a C2 straight (3.2 m, 8 GeV;
   7.1 m, 30 GeV)

3. Rectangular apertures needed for beam lost longitudinally.

4. Primary and secondary collimators for betatron loss.

5. Secondary collectors at ~20, 90, 164° in 3 adjacent straights

6. Localization efficiency of ~95% for betatron loss.

7. MC downstream of betatron collimation system.

8. Collimator acceptance may be larger for rectang. vac. walls

   (false economy not to use rectangular chambers).

Lattice RF Requirements

1. High rf voltages due to rapid cycling.
2. Approx. 0.9 MV for 8 GeV, 3.8 MV for 30 GeV.
3. Zero dispersion straights: 54 m for 8 GeV, 42 m for 30 GeV.
4. Low dispersion regions: 32 m for 8 GeV, 36 m for 30 GeV.
5. Using 5 arc cells for 4. gives low synchro-betatron coupling.
6. RF: ~3.5 and 7.0 MHz for 8 GeV, 10 MHz for 30 GeV.
7. Cavity voltages are relaxed if low dispersion cells are used.
8. If not: 22, 1.8 m, 175 kV cavities (Pirkl) for 30 GeV.