# Lattice Modifications to Increase Vertical Magnet Separation

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With the shift to dipole magnets with 5 cm coil aperture it appears advisable to design a lattice with increased vertical separation between the two rings, since the cryostat containing the new magnet will undoubtedly have an increased diameter.

The lattice GREV5 devised by A.A. Garren, like previous versions of the lattice, accomplishes the vertical separation of the two rings by a two-step process. Following the interaction point and the strong quadrupole triplet, a set of vertical bending magnets BV1+ separates the two beams. Emerging from these magnets the beams drift apart with a non-zero slope; then they are bent back to horizontal motion by a second set of vertical benders equal and opposite to the first. At this point the beam separation is 40 cm. There follows a compact section of quadrupoles whose cumulative transfer matrix is the negative unit matrix (the "M=-1" section). Its function is to reverse the value and slope of the vertical dispersion function, so that the vertical dispersion function will return to zero at the end of the second set of vertical benders: Next the beam is deflected vertically by another set of bending magnets, three bending the beams apart some more and three bringing it back to horizontal (BV2). Now the beams are 80 cm apart, moving horizontally, and with the vertical dispersion restored to zero.

To accommodate the bigger cryostats for the new magnets the beam separation has to be increased from 80 cm to a larger value. The following describes how this has been achieved, with separations of 90 and 100 cm.

In all cases, the first step (BV1) is different in the low-beta and medium-beta IR's; in the low beta IR three separator magnets are used, followed by three magnets bending back to the horizontal; in the medium-beta IR one needs five and five. The space for the second step is limited; to achieve 90 or 100 cm separation it was found necessary to lengthen this space and shorten the space for the first step.

Two problems are: The separation of the two beams at the end of the first set of separator magnets (which have both beams going through them) is considerable and necessitates a large aperture (but these magnets have a somewhat lower field than the standard lattice dipoles. Furthermore, the peak beta function at some point within the M=-1 transformation section may be unpleasantly large. Both these problems become worse as the vertical separation increases, as we shall see.

The results of the calculations are:

| | Old lattice 80 cm separation | 90 cm sep. | 100 cm sep. |
|---|---|---|---|
| Separator magnet BV1 | | | |
| Low beta IR | | | |
| Length (m) | 5.0 | 6.0 | 7.0 |
| Number | 6 | 6 | 6 |
| Field (T) | 4.41 | 4.30 | 4.27 |
| Central free space (m) | 184.8 | 173.8 | 162.8 |
| Total step length | 229.8 | 224.5 | 219.8 |
| Beam separation at end of common magnets | 17.0mm | 22.8mm | 31.2mm |
| Medium beta IR | | | |
| Length (m) | 5.0 | 6.0 | 7.0 |
| Number | 10 | 10 | 10 |
| Field (T) | 4.41 | 4.51 | 4.72 |
| Central free space | 92.0 | 77.0 | 62.0 |
| Total step length | 150.0 | 145.0 | 140.0 |
| Beam separation at end of common magnets | 51.8mm | 71.0mm | 96.6mm |
| Peak beta in "M=-1" section | | | |
| Collision optics | | | |
| Low beta | 619 m | 752 m | 898 m |
| Medium beta | 342 m | 425 m | 518 m |
| Injection optics | | | |
| Low beta | 578 m | 538 m | 500 m |
| Medium beta | 268 m | 233 m | 203 m |

The input and output files for these cases are in the directory USER2:[COURANT] under the names GREV5, GREV5I, VSEP90, VSEP90I, VSEP100, VSEP100I with extension .SYN for input data and .SYNOUT for output; the files whose names end with I refer to injection optics and the others to collision optics..