LER Lattice with IP Beta

$\beta_x^*/\beta_y^* = 100/1.5$ cm and $25/1.5$ cm*

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Abstract

In this note we briefly describe two versions of the LER lattice with IP beta functions of $\beta_x^*/\beta_y^*=100/1.5$ cm and $25/1.5$ cm, based on the current commissioning lattice (rev. 1.55). These lattices can be used to analyze beam-beam collisions as a function of beam size ratio at IP during the PEP-II commissioning. The complete MAD lattice decks are stored in

`"/nfs/fischer/u3/yuri/Ler/Ler1.55/Beta=100_1.5/ler.beta=100_1.5.mad"` and
`"/nfs/fischer/u3/yuri/Ler/Ler1.55/Beta=25_1.5/ler.beta=25_1.5.mad"`.

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The nominal LER beta functions at IP are $\beta_x^*/\beta_y^*=50/1.5$ cm. In this note we describe two alternative versions of the LER lattice with IP beta functions of $100/1.5$ cm and $25/1.5$ cm. These lattices can be used to analyze beam-beam collisions as a function of beam size ratio at IP during the PEP-II commissioning. The modified lattice is based on the current commissioning LER lattice (rev. 1.55) without solenoid and SK1 magnets, and with wigglers turned on to generate 48 nm horizontal emittance.

The change of IP beta can be achieved by adjustment of quadrupole strengths in the IP region. In order to avoid global perturbation of the betatron motion the lattice modification was done locally. The IR local correctors of chromaticity, coupling and orbit residing in the IR were adjusted as well.

To modify the IP betas, the strengths of the following magnets in the LER region between straights 12 and 4 were adjusted:

- 22 IR quadrupoles to vary the IP beta and make a local beta and dispersion match,
- 14 local and global skew quadrupoles to cancel the IP coupling and localize the IR coupling (SK1 magnets were not yet available),

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- 4 IR vertical orbit correctors to make local cancellation of the vertical orbit introduced at IP,
- 6 families of the IR and global sextupoles to minimize linear and non-linear chromaticity,
- 7 families of tuning quadrupoles in the tuning sections 12 and 4 to adjust for the design tune.

The strengths of the above magnets for the nominal ($\beta_x^*=50$ cm) and two alternative β_x^* values are shown in Tables 1-4, where β_y^* is kept constant at 1.5 cm. Note that the steering corrector strengths shown in the Table 3 are the half values of the total angle.

TABLE 1. Quadrupole K-Values (m^{-2}).

Magnet	$\beta_x^*=25$ cm	$\beta_x^*=50$ cm	$\beta_x^*=100$ cm
QFBM1	.251018	.256908	.264190
QFBM2	.099129	.086642	.081658
QDBM3	-.641562	-.650491	-.637171
QFBM4	.187641	.134656	.083697
QFBM5	.391677	.332587	.205478
QDBM6	-.482878	-.469359	-.380656
QFBM1L	.667371	.662705	.656114
QDBM2L	-.526469	-.514489	-.531499
QDBM3L	-.325425	-.309320	-.292018
QDBM4L	-.440330	-.543113	-.502998
QFBM5L	.797590	.747307	.642991
QDBM6L	-.381677	-.305071	-.317822
QFS1	.609599	.673806	.669229
QDS2	-.534560	-.551842	-.556849
QFS3	.518774	.537352	.541139
QDS4	-.293005	-.275901	-.264104
QFS5	.454109	.464385	.468477
QFS1L	.561771	.627187	.644128
QDS2L	-.544182	-.566743	-.560203
QFS3L	.538142	.537027	.529480
QDS4L	-.353010	-.325353	-.320928
QFS5L	.451707	.446319	.469333
QFP3	.498834	.499296	.517676
QDP4	-.442917	-.441608	-.440656
QFP5	.493188	.492176	.491376
QDP6	-.380291	-.380624	-.377544
QFP7	.469806	.468822	.452798
QDP8	-.393287	-.394759	-.409963
QFP9	.537770	.540005	.560801

The lattice functions around IP are shown in Fig. 1, 2. In the case of $\beta_x^*=25$ cm the β_x -peaks in the final doublet and at the SCX1,2 sextupoles naturally increase by a factor of 2 compared to the nominal lattice. In the case of $\beta_x^*=100$ cm these peaks

TABLE 2. Skew Quadrupole K-Values (m^{-2}).

Magnet	$\beta_x^*=25$ cm	$\beta_x^*=50$ cm	$\beta_x^*=100$ cm
SK2	-.158441e-2	-.288956e-2	-.185139e-2
SK3	.285820e-2	.371789e-2	.350194e-2
SK4	.153601e-2	-.279668e-3	.566772e-3
SK5	.205858e-2	.840104e-3	.197509e-2
SK6	.159883e-2	.577745e-3	.152685e-2
SK2L	.573485e-2	.267185e-2	.185387e-2
SK3L	-.629845e-2	-.351841e-2	-.316571e-2
SK4L	.431333e-2	.300391e-3	.175701e-3
SK5L	.676135e-3	-.103310e-2	-.175820e-3
SK6L	.100698e-3	-.230117e-3	-.455387e-3
SKG1	-.436450e-2	-.270983e-3	.919796e-3
SKG2	-.668578e-2	-.283516e-2	-.136798e-2
SKG3	-.011662	-.341273e-2	-.739391e-2
SKG4	.983009e-3	.336021e-2	-.105105e-5

TABLE 3. Half Bend Angles of the Vertical Steering Correctors (rad).

Magnet	$\beta_x^*=25$ cm	$\beta_x^*=50$ cm	$\beta_x^*=100$ cm
VCOR1	.123735e-2	.123751e-2	.123736e-2
VK2	-.466547e-3	-.466628e-3	-.466556e-3
VCOR1L	-.100598e-2	-.100587e-2	-.100597e-2
VK2L	.470883e-3	.470802e-3	.470878e-3

TABLE 4. Sextupole K-Values (m^{-3}).

Magnet	$\beta_x^*=25$ cm	$\beta_x^*=50$ cm	$\beta_x^*=100$ cm
SF1	6.403971	6.618404	6.715075
SD1	-13.416432	-13.456305	-13.443631
SF2	12.807943	13.236808	13.430150
SD2	-19.166332	-19.223294	-19.205187
SCX1,2	3.45	3.0	3.0
SCX1L,2L	-3.45	-3.0	-3.0

are reduced, but another large β_x -peak appears in the vicinity of QFBM1,2 quads. The amplitude of this extra peak is determined by the fixed optics transformation between the IP and QFBM1 quad, since the quad strengths in this region could not be varied.

In the modified lattices, the coupling generated in the IR is compensated locally in the region between straights 12 and 4, as opposed to the nominal lattice where the coupling exists everywhere except the IP.

The larger β_x^* values cause smaller beta peaks near IP and result in a reduction of the LER natural horizontal chromaticity as shown in Table 5. The residual linear chromaticity left after the change of β_x^* was compensated primarily by adjustment of the global sextupoles. In the case of $\beta_x^*=25$ cm, the SCX1,2 sextupoles were also adjusted to improve the dynamic aperture. The other IR sextupoles were kept at the nominal strength proved to be adequate in terms of dynamic aperture and chromatic correction. The momentum dependence of the betatron tune and IP beta is shown in Fig. 3-6.

One can notice that the sextupole strength in case of $\beta_x^*=100$ cm is slightly increased compared to the nominal lattice, even though the natural chromaticity is reduced. This indicates that the larger β_x^* value caused relative reduction of the beta functions at the IR sextupoles and hence reduced the effect of the IR sextupoles on linear chromaticity.

TABLE 5. Natural Chromaticity.

	$\beta_x^*=25$ cm	$\beta_x^*=50$ cm	$\beta_x^*=100$ cm
ξ_x	-69.3	-59.8	-56.5
ξ_y	-69.9	-69.8	-69.6

The dynamic aperture was verified using MAD tracking for machine without errors and for $\delta = \pm 10\sigma_p$ momentum oscillations, where $\sigma_p = 7.7 \times 10^{-4}$. The results are shown in Table 6 where the aperture $A_{x,y}$ is expressed in terms of rms beam size $\sigma_{x,y}$ for the fully coupled beam emittance ($\epsilon_x=48$ nm, $\epsilon_y=24$ nm). The stronger focusing at the IP generally results in a smaller dynamic aperture.

TABLE 6. Dynamic Aperture for Ideal Lattice
and $\delta = \pm 10\sigma_p$ Momentum Oscillations.

	$\beta_x^*=25$ cm	$\beta_x^*=50$ cm	$\beta_x^*=100$ cm
A_x/σ_x	17	25	28
A_y/σ_y	26	30	30

FIGURE 1. LER Beta Functions around IP for $\beta_x^* = 100$ cm, $\beta_y^* = 1.5$ cm.

FIGURE 3. LER Tune vs Momentum for $\beta_x^* = 100$ cm, $\beta_y^* = 1.5$ cm.

FIGURE 4. LER Tune vs Momentum for $\beta_x^* = 25$ cm, $\beta_y^* = 1.5$ cm.

FIGURE 5. LER IP Beta vs Momentum for $\beta_x^* = 100$ cm, $\beta_y^* = 1.5$ cm.

FIGURE 6. LER IP Beta vs Momentum for $\beta_x^* = 25$ cm, $\beta_y^* = 1.5$ cm.