CURRENT RANGES FOR LEP AT THE BEAM-BEAM LIMIT

J.M. Jowett

CORRECTION

Would you please replace the first page in the above LEP Note with the attached one?
CURRENT RANGES FOR LEP AT THE BEAM-BEAM LIMIT

J.M. Jowett

Abstract

The range of currents which can be stored at the beam-beam limit in the LEP lattice is given with the necessary operating conditions. Data are given for both the 60° and 90° phase advances per cell, a selection of detunings of the low-beta insertions and a range of energies from 40 GeV to the highest energies foreseen. Full details of the performance range at 40 and 51.5 GeV are given. The dynamic aperture and luminosity optimisation calculations for a 60° lattice with detuning factor 1.5 are included.

Introduction

Recent studies of chromaticity effects in several variants of the LEP lattice\(^1,2,3\) have yielded a set of maximum performance estimates for the whole range of operating energies. It was shown that the final limitation on the luminosity is imposed by the dynamic aperture and that, to maximise the luminosity it is necessary to vary the damping partition numbers (and, when necessary, the emittance wiggler excitation) in a prescribed way.

For the purpose of these calculations, it was always assumed that sufficiently large beam currents (up to 17 mA) are there for the asking. Besides the beam-beam effect there are limits on the current which can be stored due to collective effects at injection energy, limitations of the injection system, considerations of operating efficiency etc. It is therefore important to establish what the minimum current is which can be driven to the beam-beam limit (this is assumed to correspond to a value $\xi = 0.03$ for the linear tune-shift parameter), thereby maximising the luminosity at a given energy.

The maximum and minimum currents which can be brought to the beam-beam limit define a useful range of currents for a given energy.
2. Currents at the beam-beam limit

Figures 1 and 2 show the ranges of currents which can be collided at the beam-beam limit in the 90° and 60° lattices with several detunings of the low-beta insertions [e.g. 8 × 2 means that the β functions at the interaction point have twice their nominal values]. These diagrams are arrived at by the following reasoning.

In reference 1) a procedure was given for varying the damping partition numbers with energy in order to maximise the luminosity, with beam-sizes and currents chosen so that the linear beam-beam tune shift parameter is \( \xi = 0.03 \). If the horizontal damping partition number is restricted to the range

\[
0.5 < J_x < 2 ,
\]

then the energy range over which this optimisation can be achieved is limited. Below some energy \( \hat{E} \), the best that can be done is to hold \( J_x \) at the value 0.5 and inflate the beam to the dynamic acceptance limit with wigglers, i.e. keep the horizontal emittance \( \varepsilon_x \) and the r.m.s. energy spread \( \sigma_E \) constant. The use of wigglers in this lower energy range (which includes the maximum energy of LEP Phase 1) allows a larger current to be stored in colliding-beam mode.

If \( \hat{I} \) is the current corresponding to energy \( \hat{E} \) with \( J_x = 0.5 \) then, for \( E < \hat{E} \), the current is given by

\[
I = \hat{I} \left( \frac{E}{\hat{E}} \right)^3 \quad (J_x \text{ constant, } \varepsilon_x \propto E^2 \text{ without wiggler}) \quad (3)
\]

instead of

\[
I = \hat{I} \left( \frac{E}{\hat{E}} \right)^2 \quad (J_x \text{ constant, } \varepsilon_x \propto E \text{ with wigglers})
\]