

1.2 Beam Delivery System

The Beam Delivery system (BDS) has to provide the same functions at all energies, as described in ???. The minimal approach is to assume that the BDS layout remains unmodified for all energies. The strength of all magnetic elements in the BDS scales with the beam energy, maybe with the only exception of the final quadrupole QD0. This provides unchanged optics and beam trajectory. To ensure a proper functioning of the collimation system the collimator gaps are left unchanged for all energies. This causes a reduction of the collimation depths in terms of beam sigma. At 3 TeV collimation depths are $10\sigma_x$ and $55\sigma_y$, while at 1 TeV these are $5.8\sigma_x$ and $31.7\sigma_y$. Wakefields at lower energies will not be more severe than at 3 TeV since the bunch charge scales proportionally to energy. The survival of the first collimator after the impact of a full bunch train is guaranteed at lower energies since the total energy of a bunch train is always lower than at 3 TeV, see Table ???.

E/E_0	P/P_0
1.0	1.0
0.75	0.84
0.67	0.79
0.5	0.63
0.75	0.5

An improvement of the luminosity at the lower energies can be achieved in two ways:

1. Adding non-linear correctors in the FFS to better cancel the geometrical aberrations arising for the larger transverse emittances.
2. Increasing the bending angle of the BDS dipoles to require weaker sextupoles for the chromaticity correction.

The first option is the least invasive but potentially has a lower luminosity gain. However, the second option requires a full re-positioning of all the BDS elements. The study and comparison of these two options is left for the technical design phase.