SLAC-CN--301

DE85 015136

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TITLE : BEAM EMITTANCE AND BEAM DISRUPTION .

Beam disruption during the collision of intense relativistic bunches has been studied by R.Hollebeek (ref.1). In the case of oppositely charged bunches, focussing effects occur causing a decrease in the effective bunch cross section, and thereby an increase of luminosity by an enhancement factor H . The term disruption derives from the fact that the beam emittance changes markedly during the collision.

The behaviour of the bunches during this process is parametrized by a dimensionless beam disruption parameter

$$D = \frac{Nr_e\sigma_z}{\gamma\sigma_x^2}$$

with	N	number of electrons in the bunch
	r_e	classical electron radius $2.818 \cdot 10^{-15}$ m
	σ_x	transverse bunch dimension
	σ_z	longitudinal bunch dimension

where the bunches are assumed to have equal gaussian shapes. The simulation procedure used in ref.1 assumed that the bunches impinge on each other with particles on parallel incident trajectories, which are then deflected to finite angles by the disruption process. In terms of phase space this configuration corresponds to zero emittance for the incident bunches. In order to study the effect of finite incident emittance we have modified the simulation and replaced the original lattice of three dimensions in configuration space, (x, y, z) each with a single (x', y') , by one of five dimensions (x', y', x, y, z) , in order to allow for a spread in angles for each lattice point. The resulting lattice has a total of $(5 \times 5 \times 10 \times 10 \times 10)$

sw

=25000 cells, to be compared to the original one of $(20 \times 20 \times 20)=8000$ cells. The new lattices covers gaussian distributions to $\pm 2.5 \sigma$ for the spatial and $\pm 1.5 \sigma$ for the angular dimensions. Bunch cells were defined at the focus and then tracked backwards to their individual space coordinates before the collision in order to simulate the proper waist behaviour.

The results of the simulation are presented in table 1 and displayed in Fig.1 for four emittance angles and for several values of the disruption parameter D . The results were corrected for

1. the loss due to the limited extend of the lattice;
2. the reduced spatial precision of the 5-dimensional lattice with respect to the 3-dimensional one, for reasons of limited computer space and time.

Fig.1 shows the variation of the luminosity enhancement factor L/L_0 where L_0 is the luminosity without any pinch . Obviously we find $H = 1.0$ for zero disruption $D = 0.0$ and zero emittance. Also we find $H < 1.0$ for $D = 0.0$ when a finite emittance angle is introduced. This is explained by the fact that the smallest bunch width is reached only at the central phase of penetration, and that the effective dimensions are wider before and after. Equivalently, as the length of the beam waist becomes small compared to the bunch length, the luminosity is reduced. At $D = 1.0$, close to nominal conditions, the enhancement is reduced by 20% by introducing the nominal emittance angle $\sigma_x' = 0.25$ mrad.

Table 1 also shows the mean exit angle for $D = 1.0$ and for dimensions of $\sigma_x = 1.2 \mu\text{m}$ and $\sigma_x = 1.0$ mm. The "mean exit angle" represents in fact the initial emittance modified through the disruption process. The angle appears to be dominated by disruption, passing through a flat minimum with increasing mean incidence (=emittance) angle. This is interpreted as the consequence of the focussing effect: there is overfocussing for small entrance angles, then a phase match between entrance angle and focalisation, and eventually the trend towards dominance of the entering distribution.

Table 1. Enhancement Factor H and Mean Exit Angle

emittance angle σ_x (mrad)		0.00	0.25	0.375	0.500
disruption parameter $D =$	0.000	1.000	.972	.968	.966
	0.125	1.045	1.024	1.017	1.013
	0.250	1.121	1.102	1.094	1.085
	0.500	1.411	1.362	1.334	1.305
	1.000	3.600	2.994	2.750	2.514
	1.500	5.193	4.339	3.968	3.665
	2.000	5.624	4.835	4.403	4.159
	3.000	5.115	5.004	4.863	4.602
mean exit angle (mrad)		0.876	0.818	0.804	0.826
$D=1.0, \sigma_z = 1.2\mu\text{m}, \sigma_x = 1.0\text{ mm}$					

Reference : 1. R.Hollebeek, NIM 184 (1981), pages 333-347.

ENHANCEMENT FACTOR H

FIG. 1