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Energy spread induced in the Tesla Linac

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Introduction

The purpose of this note is to estimate the intrabunch energy spread of the beam emerging from the TESLA linac. The main sources of energy spread are the rf curvature of the accelerating field and the longitudinal wake. Usually the wake induced energy spread is partially compensated by accelerating the bunch off the crest of the rf wave. The latest current shape for the 1.3 GHz TESLA cavity [1] and the parameters of the two machines "Top-Factory" and "1/2 Tesla" [2] are considered.

Longitudinal wake calculations

The short range longitudinal wakes were calculated with the code ABCI [3] , assuming a gaussian bunch distribution. The results are plotted on figures 1 and 2 for two bunchlengths.

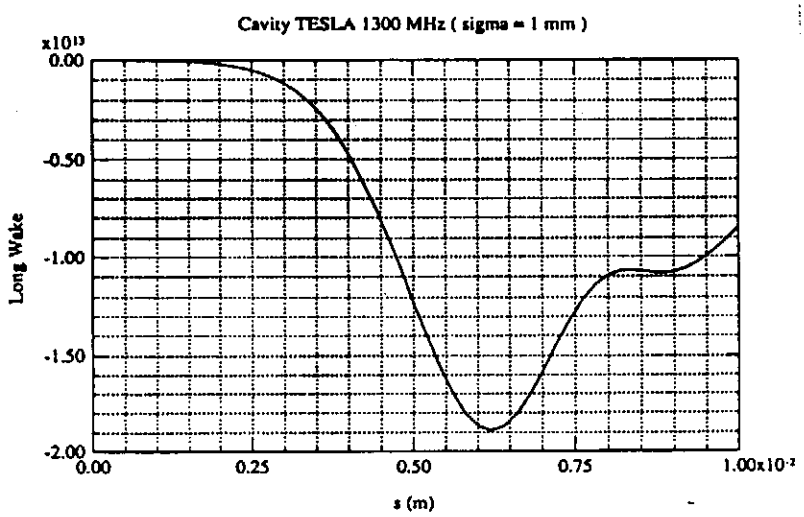

Figure 1 : Plot of the longitudinal wake for σ = 1 mm (V/C/cavity) vs the longitudinal coordinate relative to the head of the bunch.

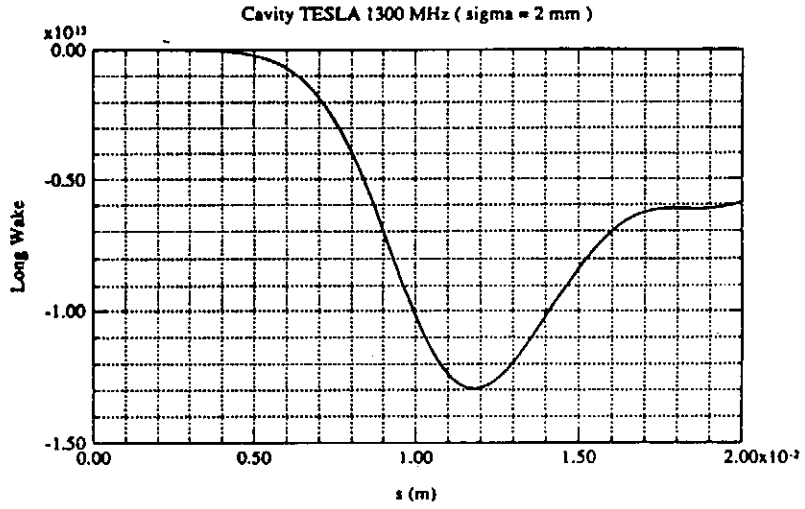

Figure 2 : Plot of the longitudinal wake for $\sigma = 2$ mm (V/C/cavity) vs the longitudinal coordinate relative to the head of the bunch.

The resulting total loss factors for one cavity are

sigma (mm)	1	2
Kz tot (V/pC)	8.8	11.5

Machine parameters

The useful parameters for intrabunch energy spread calculations for the two machines defined in [2] are recalled below

Parameters	Top-Factory	1/2 Tesla
Energy (GeV)	125	250
Bunchlength (mm)	1	2
Bunch population	$2\ 10^{10}$	$5.14\ 10^{10}$
Eacc (MV/m)	12.5	25

Energy spread calculations

The total rms energy spread induced by the rf wavelength and by the longitudinal wake is minimized by proper choice of the linac phase. Figures 3 and 4 show the total rms energy spread for different longitudinal cuts of the bunch distribution, when the rf phase is varied.

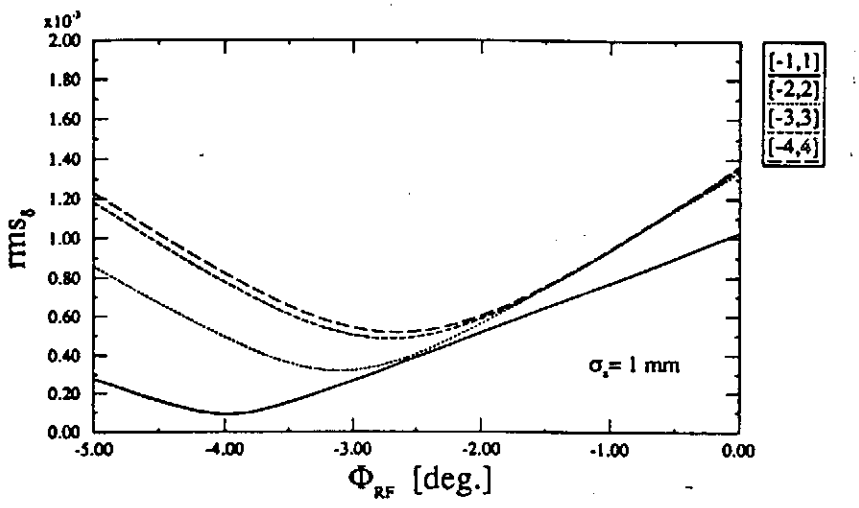

Figure 3 : total rms energy spread vs rf phase for "Top-Factory"

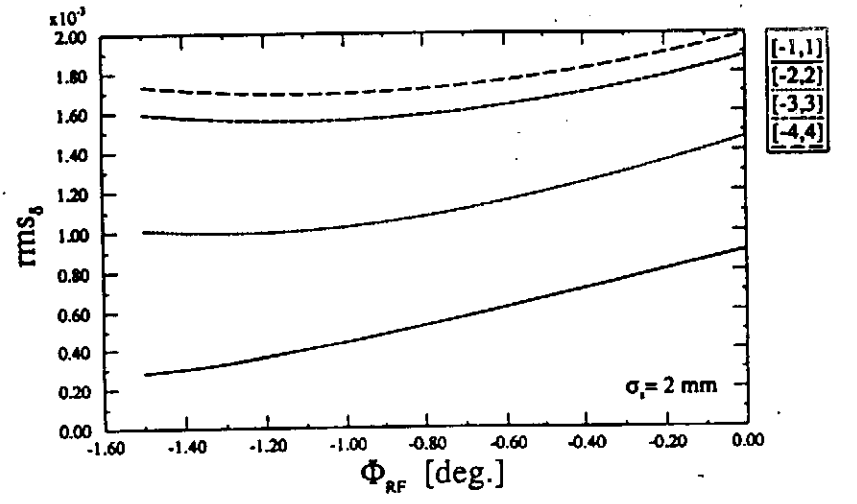

Figure 4 : total rms energy spread vs rf phase for "1/2 Tesla"

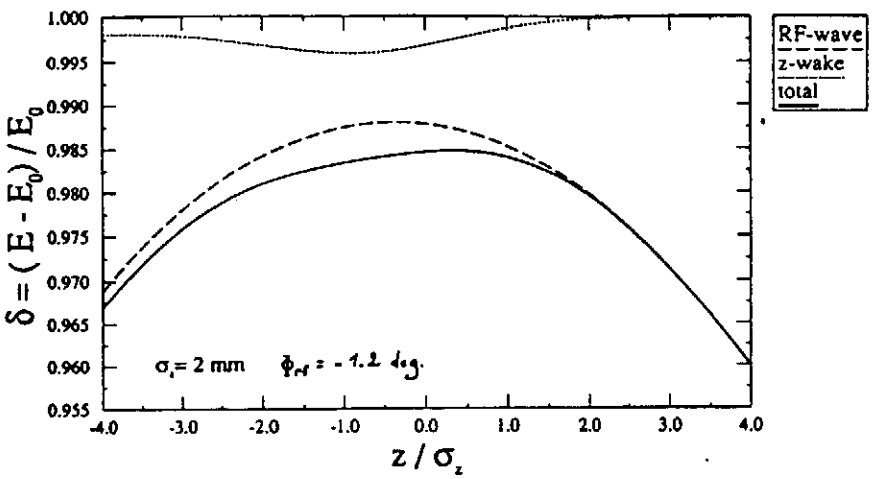

Figure 6 : Energy profiles for "1/2 Tesla"

We note that the longitudinal wake effect was successfully compensated in the "Top Factory" machine, but not in the "1/2 Tesla" machine. In fact, the rf curvature effect is the dominant term and the wake is not strong enough for an effective compensation as we can see on figure 6. Bunch too long or Number of particles too low ? We checked that if the bunchlength is reduced to $\sigma = 1$ mm, the wake effect is higher and is able to compensate effectively the rf curvature effect (final rms energy spread = 6.1 10^{-4} for rf phase = -3.5 °).

References

[1] Saclay Tesla meeting, November 5 & 6, 1991

[2] 5th SRF Workshop, TESLA session, DESY, August 1991

[3] Y.H. Chin, CERN/LEP-TH/88-3