Memo: Calculation of MKE kicker heating

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Abstract

MKE heating power is calculated for various bunch lengths.

1 Bunch length

The bunch length can be measured both in time domain and in frequency domain. In the measurement, the calibration of the response function such as cable attenuation calibration is important.

From the SPS bunch spectrum data in May 2002, and cable attenuation data, an rms bunch length of 0.56 nsec is obtained by assuming a Gaussian distribution (see Fig. 1).

In 2003, the bunch length became longer (0.7-0.75 nsec) because the RF voltage was 2 MV (5 MV in May 2002) [1].

Anyway it may be preferable to measure the RMS bunch length in time domain and in frequency domain simultaneously, and check each other.

2 Longitudinal impedance

Measured data on the longitudinal coupling impedance by the single coaxial wire method were taken from [3], as shown in Fig. 2. There is also an analytical formula for the broad-band impedance [4]. These impedances are used for the heating power estimation. The real part of the longitudinal impedance up to 400 MHz is explicitly shown in Table 1.

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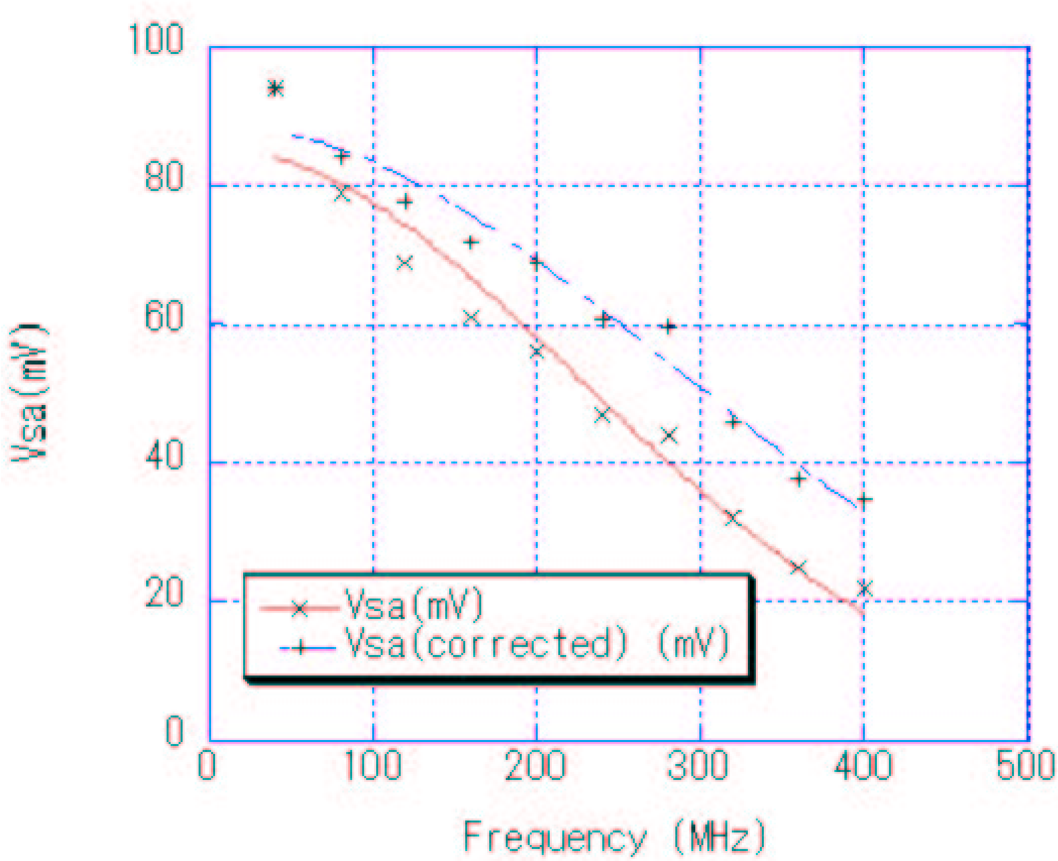

Figure 1: Bunch spectrum measured in the SPS in May 2002, (with 5 MV RF voltage). Cable attenuation corrected. By a Gaussian fit, the rms bunch lengths are 0.70 nsec without cable attenuation correction, and 0.56 nsec after correction.

3 Calculation of MKE heating power

The heating power is calculated by the following formula:

$$P = 2\eta I_0^2 \sum_{n=1}^{\infty} \mathrm{Re}(Z(n\omega_b)) \exp(-n^2\omega_b^2\sigma_t^2), \tag{1}$$

where $\eta = 0.21 \times 0.6 = 0.126$, $I_0 = 0.64$ A, $\omega_b/2\pi = 40$ MHz, σ_t are filling factor (with 3 batches, the azimuthal filling factor is $3 \times 0.07 = 0.21$) times duty cycle, DC circulating current when all bunches exist every 25 nsec, the frequency corresponding to the bunch spacing, and the bunch length, respectively. Results are shown in Figs. 3 and 4.

n	Frequency (MHz)	Measurement (Ω)	Theory (Ω)
1	40	50	24
2	80	200	95
3	120	300	220
4	160	600	408
5	200	900	680
6	240	1300	1053
7	280	1600	1543
8	320	2300	2151
9	360	3000	2857
10	400	3500	3611

Table 1: Real part of the SPS MKE kicker longitudinal coupled bunch impedance.

4 Conclusion

The heating power depends on the impedance, bunch shape, bunch length, number of batches, and duty cycle. The result may differ by about 20 % depending on the choice of the impedance. Also, the result may differ by about 20 % depending on the choice of bunch shape. The dependency of the power on the bunch length is strong.

5 Acknowledgments

Authors would like to thank T. Bohl for valuable discussions.

References

[1] T. Bohl, private communication.

[2] see http://www.ansoft.com

[3] F. Caspers, A. Mostacci, and H. Tsutsui, *Impedance Evaluation of the SPS MKE Kicker with Transition Pieces between Tank and Kicker Module*, CERN-SL-2000-071-AP (2000).

[4] H. Tsutsui, *Some Simplified Models of Ferrite Kicker Magnet for Calculation of Longitudinal Coupling Impedance*, CERN-SL-2000-004 AP (2000).

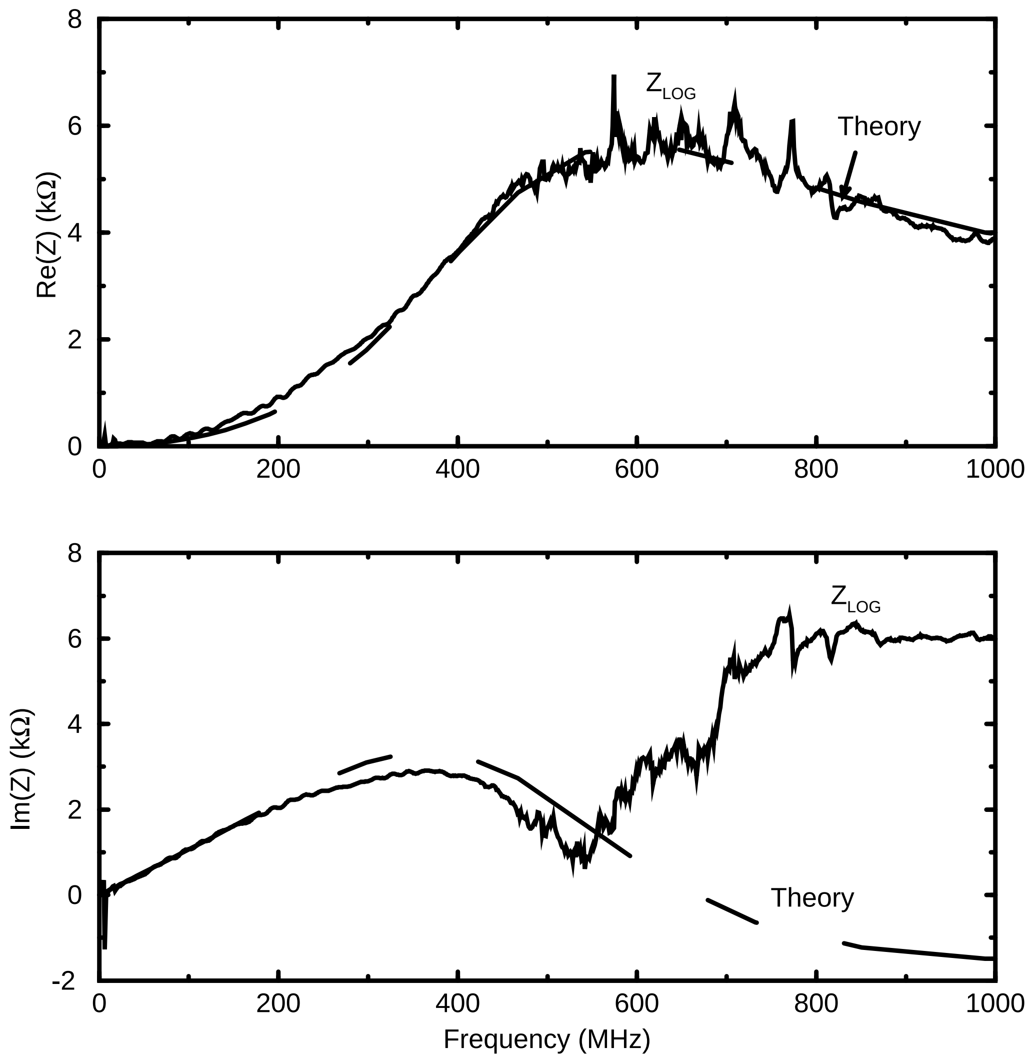

Figure 2: MKE kicker longitudinal coupling impedance. The solid line is by measurement [3]. The dashed line is by analytical calculation [4]. Large difference of the imaginary part at high frequency between the measurement and the theory is due to the resonances from the kicker tank.

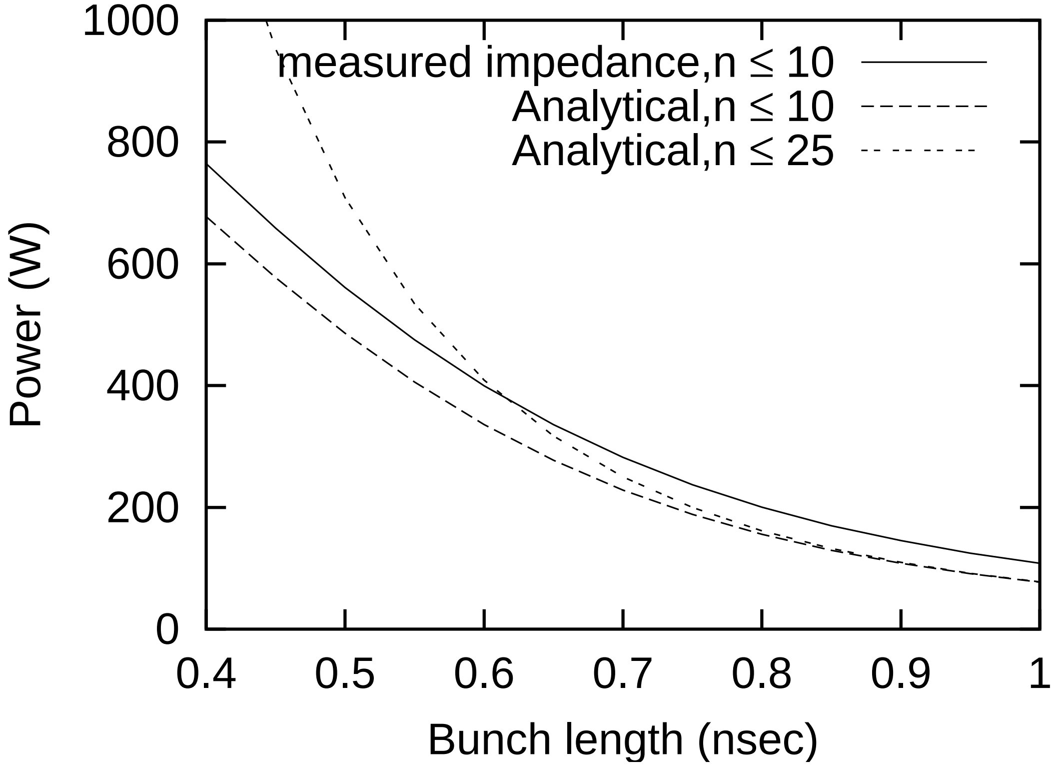

Figure 3: MKE kicker heating power as a function of rms bunch length. A gaussian bunch is assumed. Solid line: with measured impedance up to 10th harmonics. Broken line: with analytic impedance up to 10th harmonics. Dotted line: with analytic impedance up to 25th harmonics.

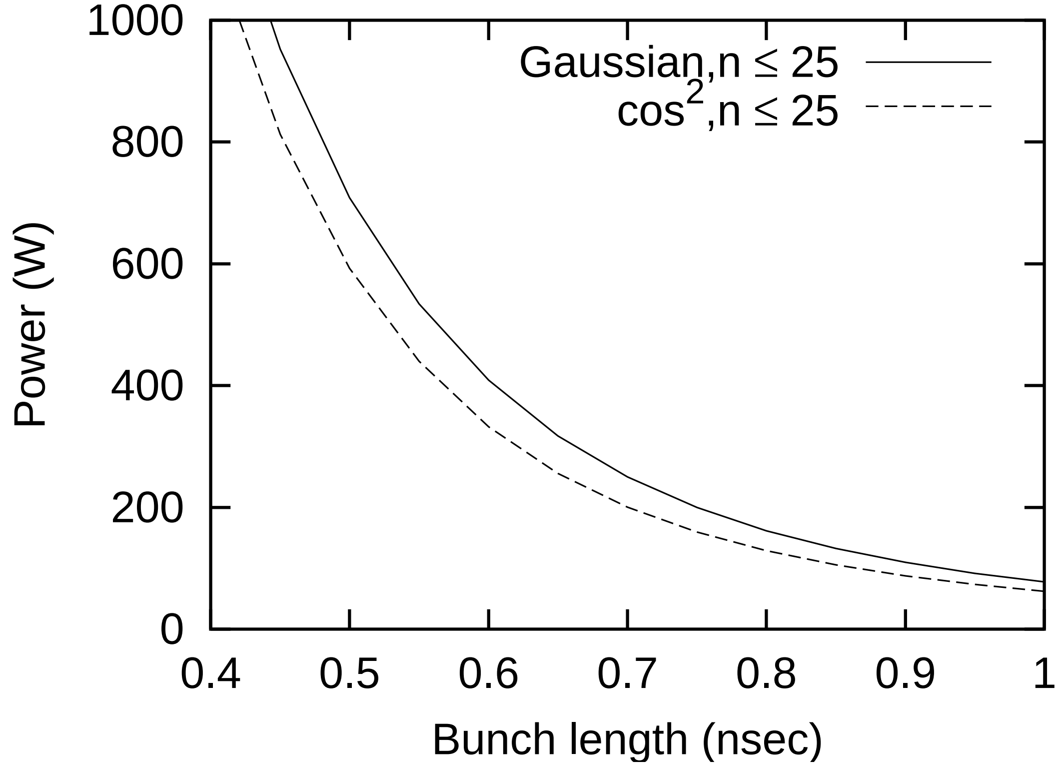

Figure 4: MKE kicker heating power as a function of rms bunch length. Cosine squared / Gaussian bunches are assumed. Solid line: Gaussian with analytic impedance up to 25th harmonics. Broken line: Cosine squared with analytic impedance up to 25th harmonics.