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OLYMPUS: Transient Heating of Vacuum Components due to Wakefields

The computer code CST Microwave/Particle Studio and the code MAFIA have been used to calculate the Wakefields in the tapered vacuum Moeller chamber of the OLYMPUS experiment. From the longitudinal wakefield a total loss parameter k_{tot} is obtained as an integral of the longitudinal wake potential and the charge distribution $\lambda(s)$ of the bunch:

$$k_{tot} = \int ds\ \lambda(s)\, W_{\parallel}(s)$$

The energy loss of one bunch with bunch charge q is $q^2 k_{tot}$. The total energy loss depends on the details of the filling pattern in the ring.

Transient heating due to wakefields

The total dissipated power is:

$P_{tot} = N\ f_0\ q^2\ k_{tot} = I\, q\, k_{tot}$

with

N = number of bunches

f_0 = revolution frequency

q = single bunch charge

k_{tot} = loss parameter (units V/C)

I = total beam current

P_{tot} is the total power loss of the beam. The power may be dissipated over a larger area of the vacuum chamber. Therefore the total dissipated power is only a rough estimate for local losses and the subsequent heating of vacuum components.

The factor $N\ f_0\ q^2$ is given in Table 1 for different assumptions on the beam parameters of DORIS and also for a parameter set of HERA.

	DORIS	DORIS, 10 bunch	HERAe
N_b (# bunches)	5	10	189
f_0 / kHz	1037.0	1037.0	47.3
q / nC	27.2	13.6	5.6
N / 10^{10}	17	8.5	3.5
I_{tot} / mA	140	140	50
$N_b f_0 q^2$ / W nC/V	**3.85**	**1.92**	**0.28**

Table 1: Different parameter sets for DORIS, HERA and the factor $N\ f_0\ q^2$.

A simple model of the Moeller chamber:

The sketch below shows the main geometric dimensions of the tapered vacuum chamber:

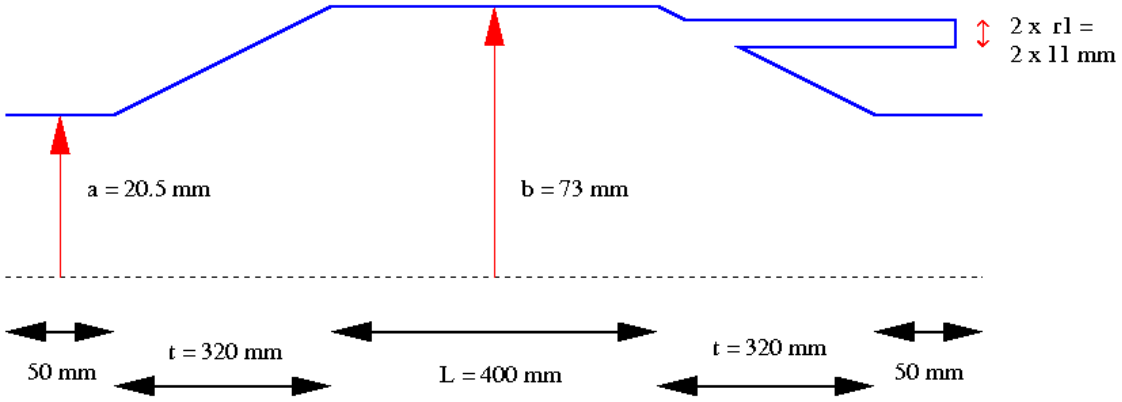

Fig. 1 Sketch of the tapered chamber

The length L has been set to only 400 mm to save computer resources (CPU time and memory). The total length of the real chamber is about 1.8 m.
A 3D model of the chamber modeled with the CST studio simulation code is show in Fig. 2.

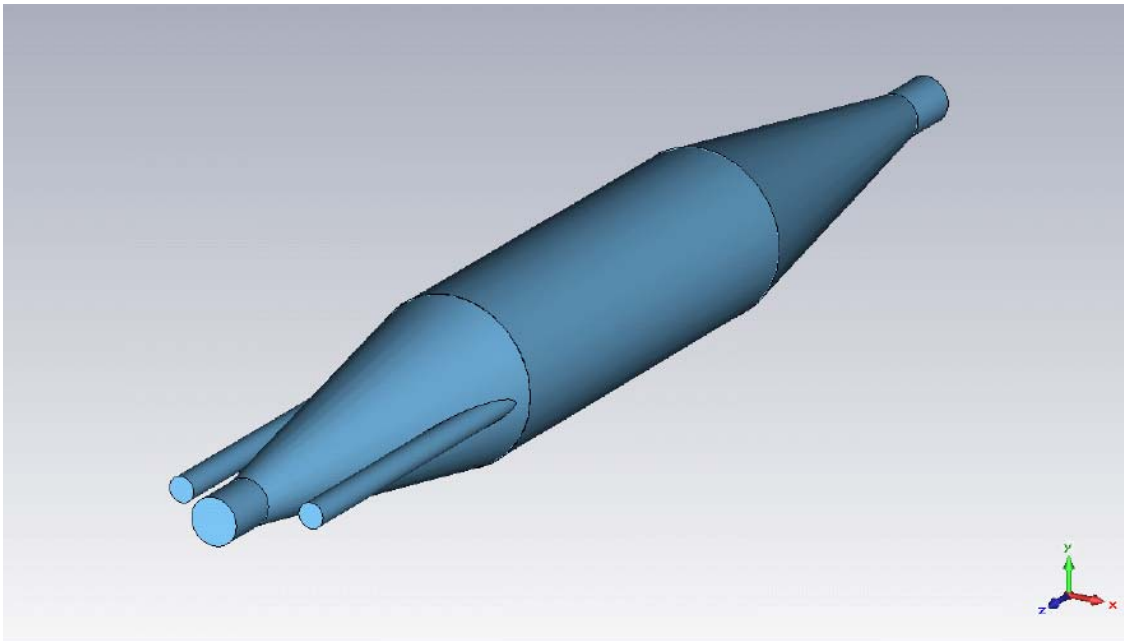

Fig. 2 3D Model of the tapered vacuum chamber modeled with CST particle studio.

The wake potential from the computer simulation is shown in Fig. 3. A bunch length of 10 mm (rms) has been used for the simulation.

CST MICROWAVE STUDIO

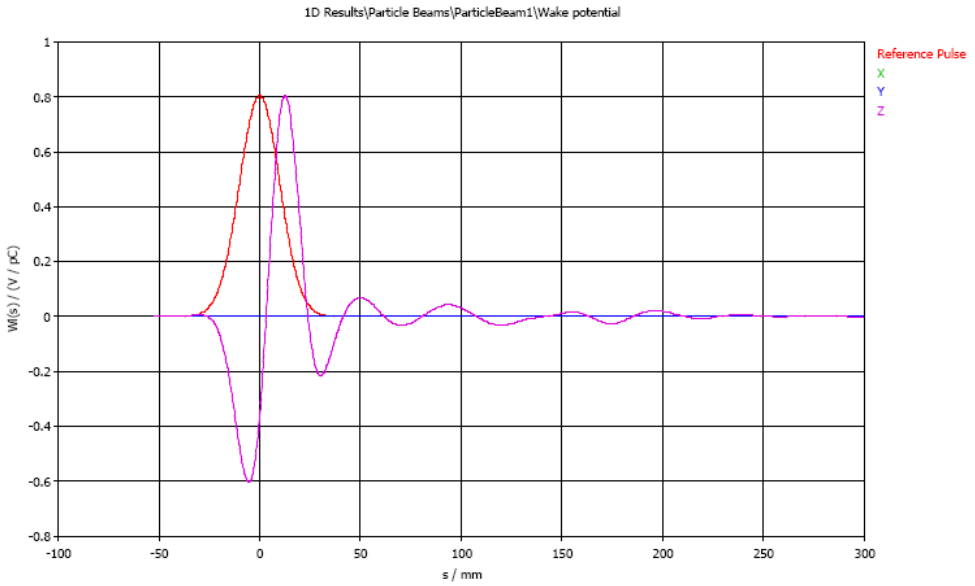

Fig. 3 Longitudinal wake potential for a bunch length of 10 mm (CST particle studio).

The total loss parameter is 68.1 V/nC:

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CST PARTICLE STUDIO - Result: Wake integration infos

     Wake Integration type : Indirect Testbeams
     Simulated wake length : 3.000000e+002 mm
     Wake-Loss-Factor      : 6.808654e-002 V/pC
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From the loss parameter one obtains a total power loss of:

$$P = 3.85\ \mathrm{W}\frac{\mathrm{nC}}{\mathrm{V}} \cdot 68.1\frac{\mathrm{V}}{\mathrm{nC}} = 262\ \mathrm{W}$$

The same structure has also been simulated with the computer code MAFIA for a distance of L = 400 mm and L = 800 mm between the tapers. One quarter of the structure is shown in Fig. 4. The wake potentials are shown in Fig. 5.

Fig. 4 3D Model of the tapered vacuum chamber in MAFIA (L = 800 mm).

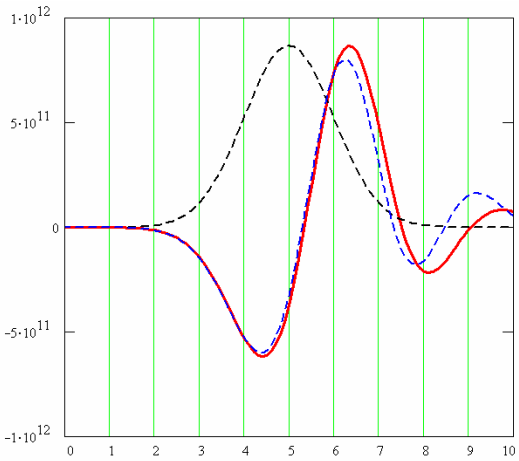

Fig. 5 Longitudinal Wakepotential in units of V/C calculated with MAFIA.
The bunch shape (black, dashed curved) , the wake potential for a distance of L = 400 mm (red solid curve) and L = 800 mm (blue, dashed curved) are shown. The distance along the bunch is measured in units of the rms bunch length (σ_z = 10 mm).

From the wakepotentials the following loss parameters are obtained:

	CST Studio	MAFIA	MAFIA
L / mm	400	400	800
k_{tot} / V/nC	68.1	79.6	69.5

Table 2: Loss parameter from the simulation codes CST Particle Studio and MAFIA.

The results from the simulation code MAFIA confirm the result obtained with CST Particle Studio. The differences are probably due to different step sizes of the grid on with the numerical solution of the Maxwell equations are obtained.