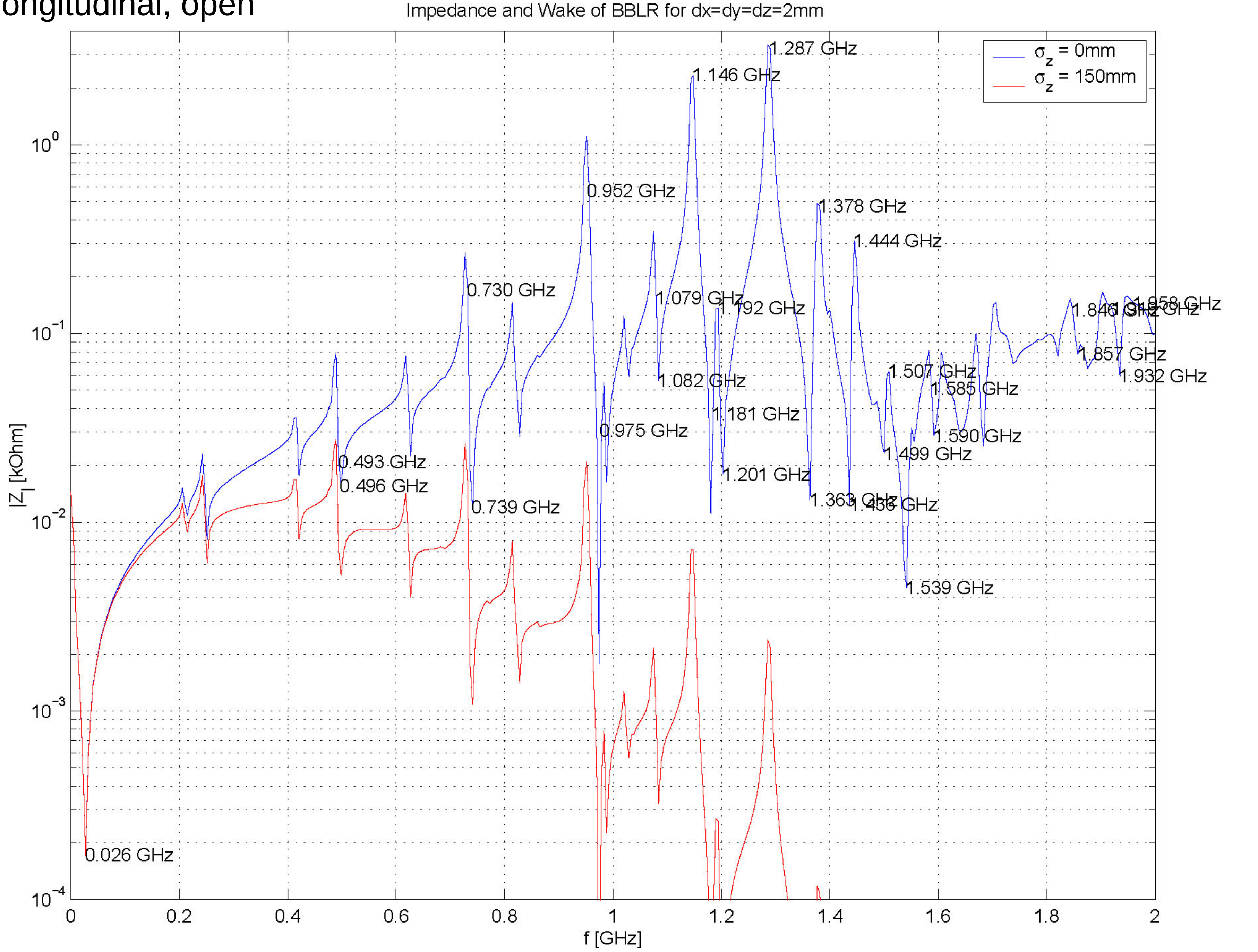
BBLR impedance

Calculations with GdfidL and HFSS for the new device in LSS5 were performed by Alexej Grudiev (team of Erk Jensen) in May 2004.

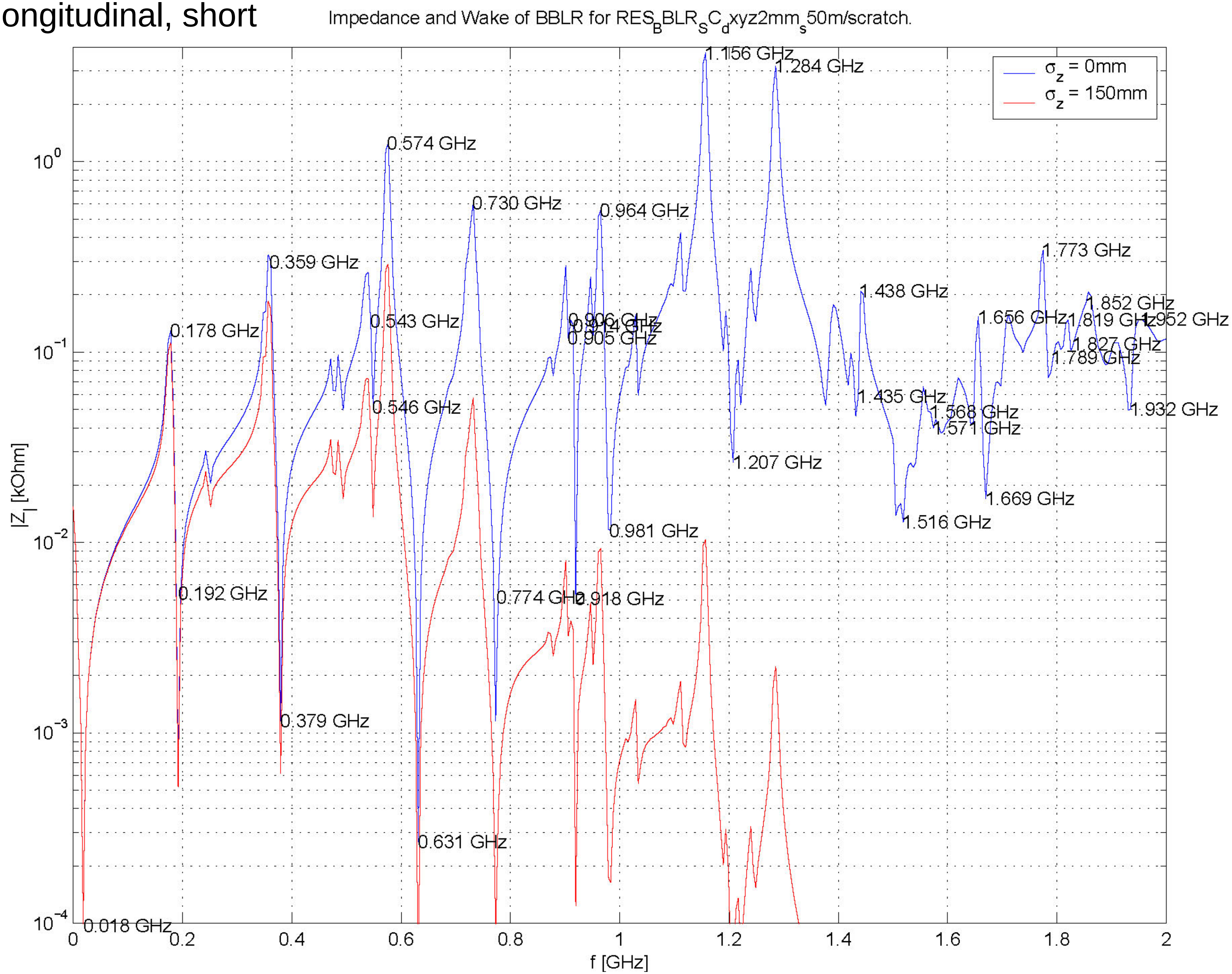
GdfidL: longitudinal impedance, horizontal impedance and vertical impedance both with wire terminations short circuited and open.

HFSS: field patterns of different modes and additional modes not excited by beam, for open geometry.

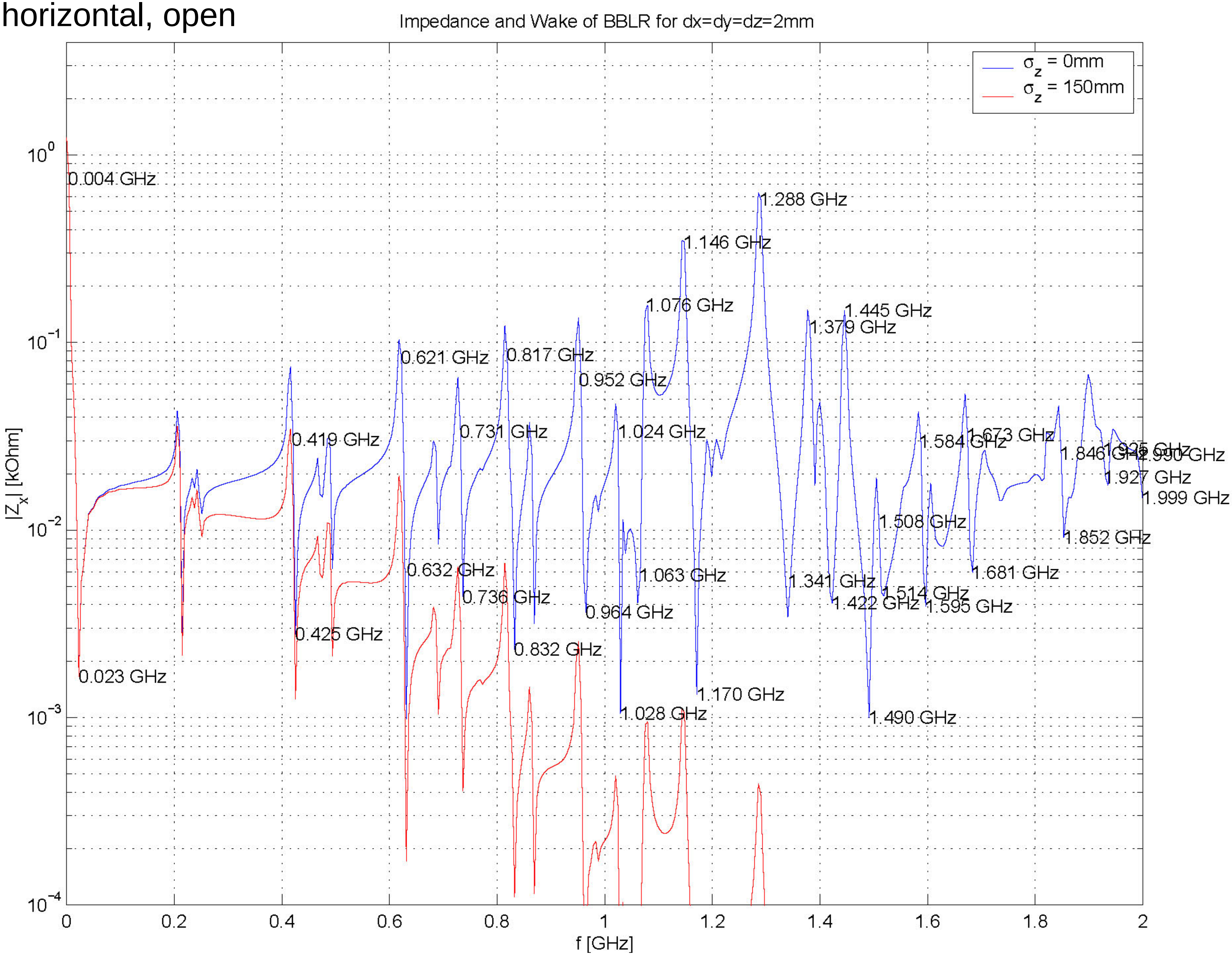
longitudinal, open



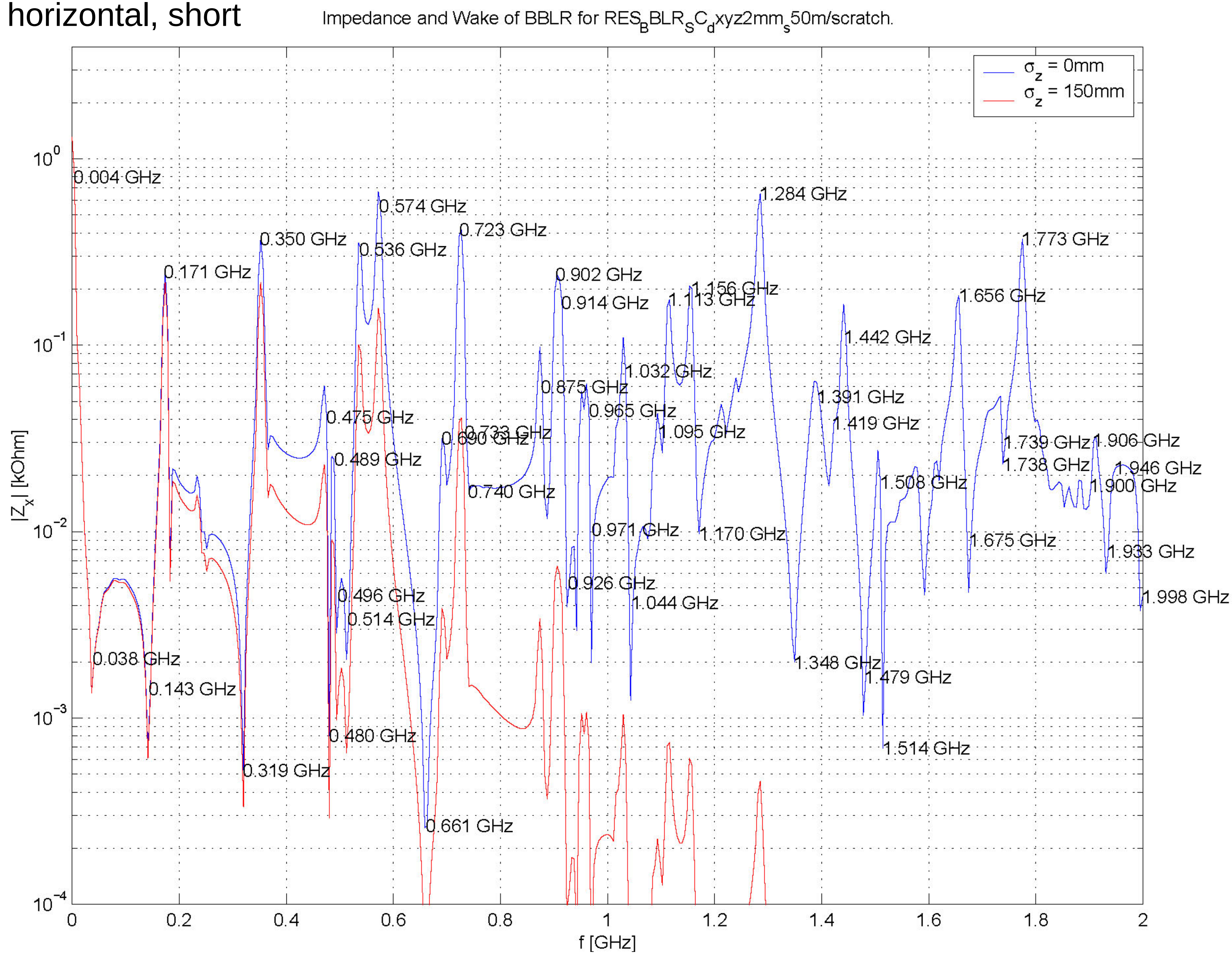
longitudinal, short



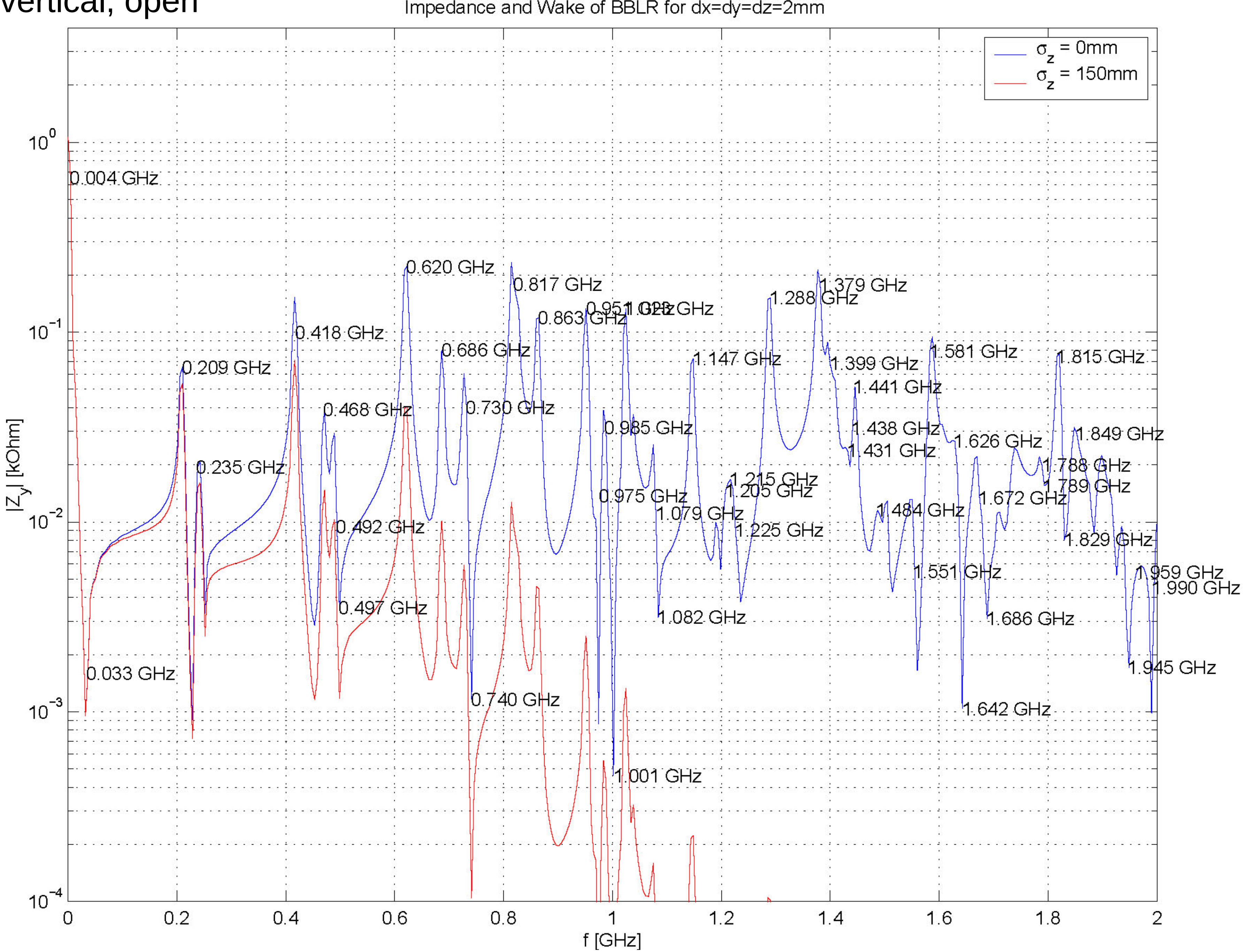
horizontal, open



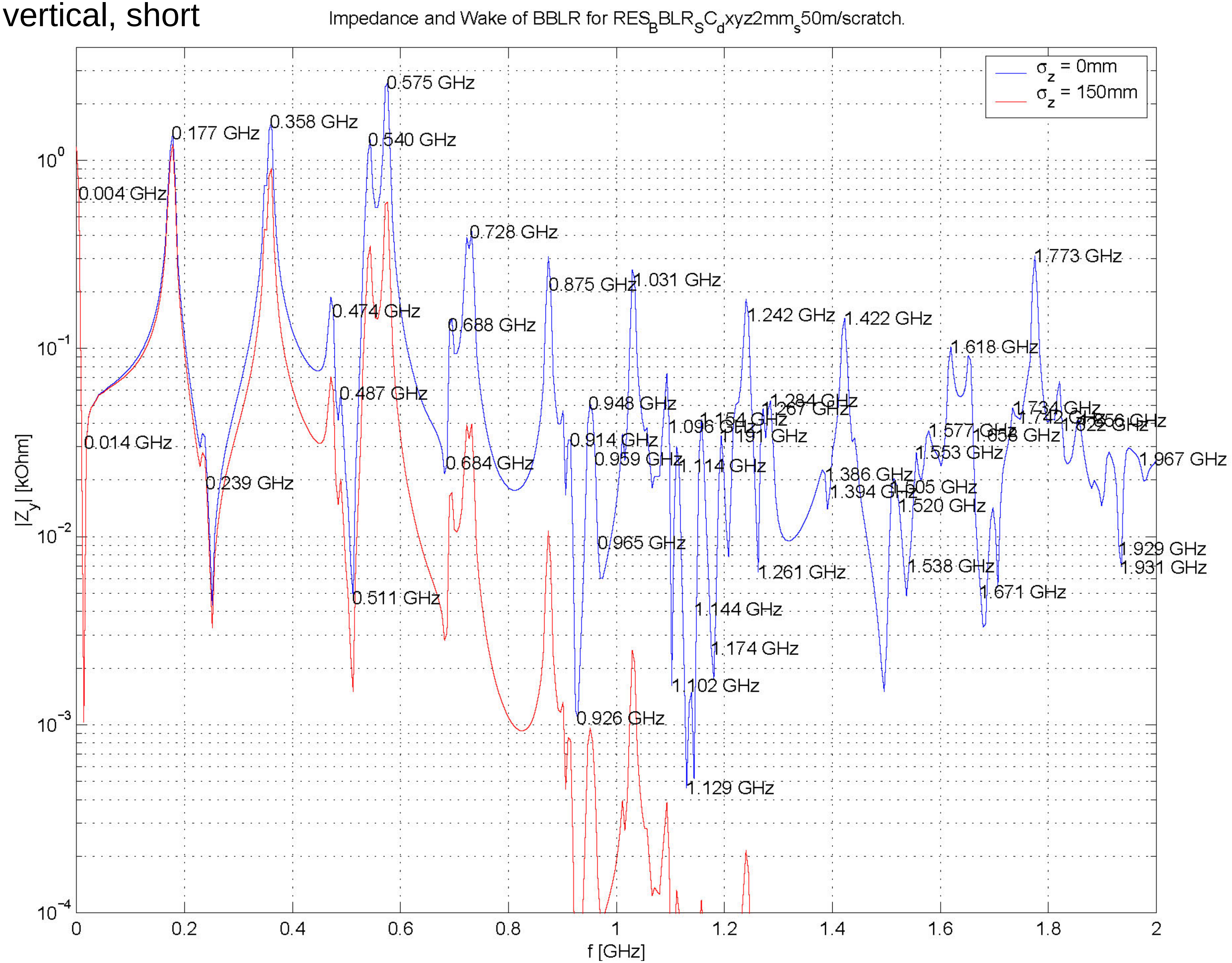
horizontal, short



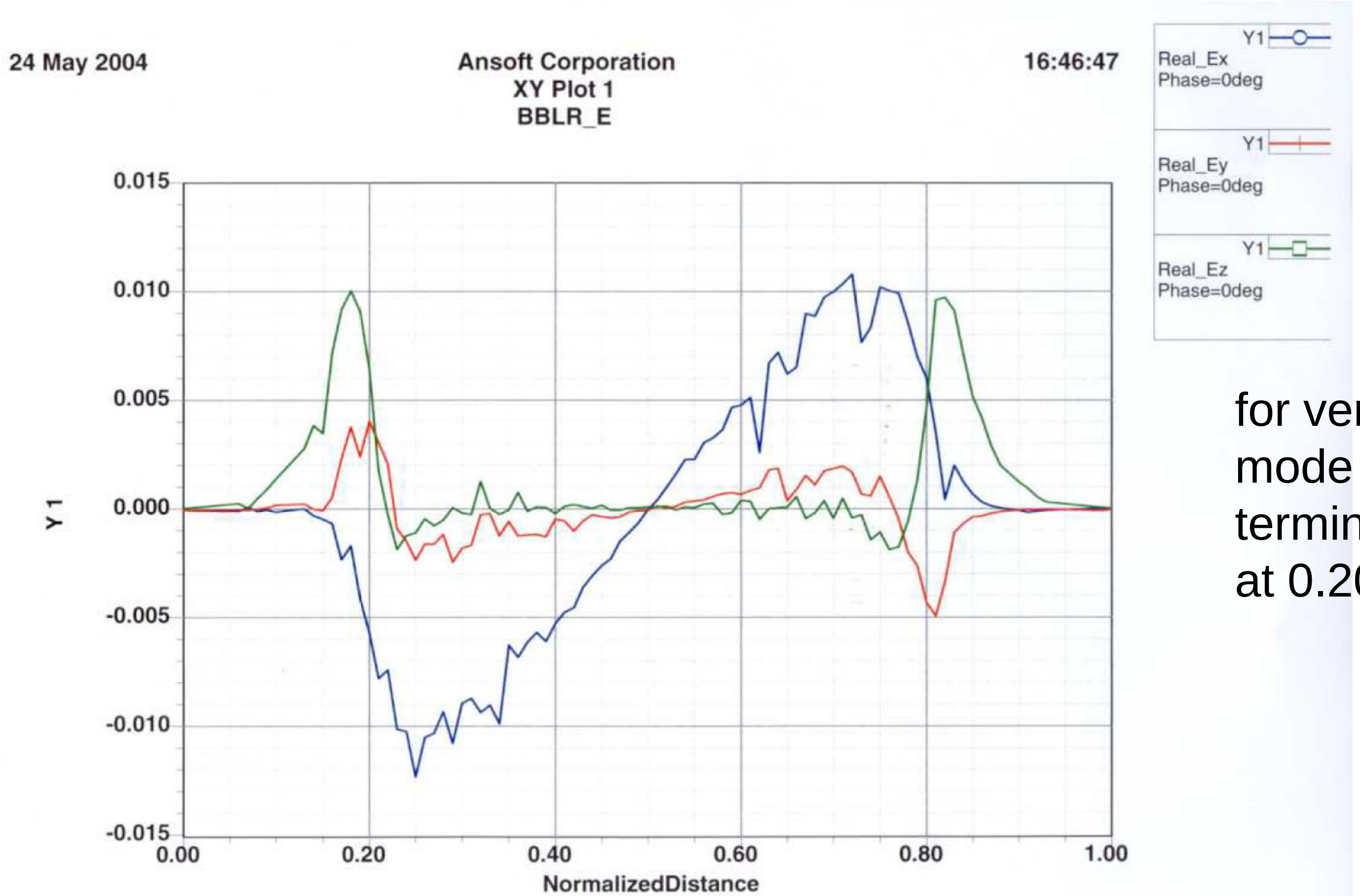
vertical, open



vertical, short



Mode field patterns were computed with HFSS in open geometry. Horizontal field is largest and changes sign at center of chamber.
Typical Q values are ~1000 at 1 GHz indicating that the wake could couple over half a batch.



for vertical mode (open termination) at 0.209 GHz

Asymmetric structure generates current-dependent kick even when beam is on axis.

	Z_y	Z_x
open	-9 Ω	-18 Ω
short	-49 Ω	-9 Ω

Resulting closed-orbit deflection

The kick from an impedance is given by (3.52) in Alex' book

$$\Delta y' = -\frac{N r_p y_0}{2\pi\gamma} \int_{-\infty}^{\infty} d\omega \, \mathrm{Im}(Z_1(\omega)) \left|\tilde{\rho}(\omega)\right|^2$$

$$= -\frac{N r_p c}{2\sqrt{\pi}\gamma\sigma_z} \frac{4\pi}{Z_0 c} y_0 \, \mathrm{Im}\, Z_{eff}$$

where the impedance in the second line is given in Ω/m. The impedance on axis in the asymmetric structure is of the order

$$y_0 \, \mathrm{Im}\, Z_{eff} \approx 10\Omega$$

from which for a single nominal LHC bunch with 30 cm rms length at 26 GeV/c we expect a kick of order **2 nrad**.

Change in impedance per transverse offset, which is impedance driving instabilities, is obtained by *subtracting impedances computed with a transverse offset and on axis*.

Open circuit

on axis: $\mathrm{Im}Z_{x0}$=-18.1 Ω and $\mathrm{Im}Z_{y0}$ = -9.1 Ω

with offset Δy = -2mm: $\mathrm{Im}Z_{x2}$ = -16.7 Ohm & $\mathrm{Im}Z_{y2}$ = -19.0 Ω

[vertical impedance is increased by factor of 2, what one could expect taking into account the field structure of the relevant modes]

so that $\Delta Z_y = -(-19.0+9.1)/0.002 \sim 5\ \mathrm{k}\Omega/\mathrm{m}$ for an open circuit.

Short circuit

results on axis: $\mathrm{Im}Z_x$ = -9.2 Ω & $\mathrm{Im}Z_y$ = -49.1 Ω

with offset Δy=-2mm: $\mathrm{Im}Z_x$ = -3.7 Ω and $\mathrm{Im}Z_y$ = -72.4 Ω

so that $\Delta Z_y = -(-72.4+49.1)/0.002 \sim 12\ \mathrm{k}\Omega/\mathrm{m}$ for short circuit.

$$\Delta Q = \frac{N_b e^2 c}{8\pi^{3/2}\sigma_z E_e}\beta \,\mathrm{Im}\left(\mathrm{Z}_\perp\right)_{\mathrm{eff}}$$

$$\approx 7\times 10^{-6} \quad \mathrm{for}\, 10\ \mathrm{k}\Omega/\mathrm{m}$$

summary

- single-bunch effect insignificant
- there could be a small multibunch effect since Q values are large (~1000 at 1 GHz, exponential damping time ~ half a batch)

comments by Fritz:

- open or short circuits are bad assumptions, should use 50 Ω or 100 Ω to get better estimate; real Q values will be lower
- could use Schottky monitor cables to measure signals induced on BBLR
- could measure terminating impedance in tunnel or in laboratory
- ferrites should be installed and effect measured