

Wakes in Cavities

transverse **short range wake** in TESLA modules and 3rd harmonic cavities

estimated contribution to emittance growth (3rd harm.) !

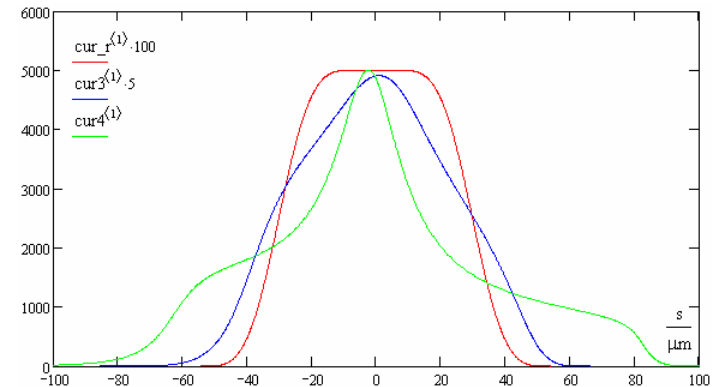
long range: HOM damping - 3rd harmonic cavities (some bands)

- TESLA cavities



possible working point

1.3 GHz system: 130 MV @ 0 deg --> 130 MeV
447.5 MV @ 0.74 deg --> 577.5 MeV
3.9 GHz system: 97.3 MV @ -142.2 deg --> 500 MeV
BC2 r56 = -103.5 mm --> compression factor = 20
1.3 GHz system: 1500 MV @ 0 deg --> 2000 MeV
BC3 r56 = -20.7 mm --> compression factor = 5



sensitivity (10% change of compression)

1.3 GHz system before BC2: $|\Delta V| < 0.19$ MV, $|\Delta\phi| < 0.023$ deg
3.9 GHz system: $|\Delta V| < 0.071$ MV, $|\Delta\phi| < 0.060$ deg

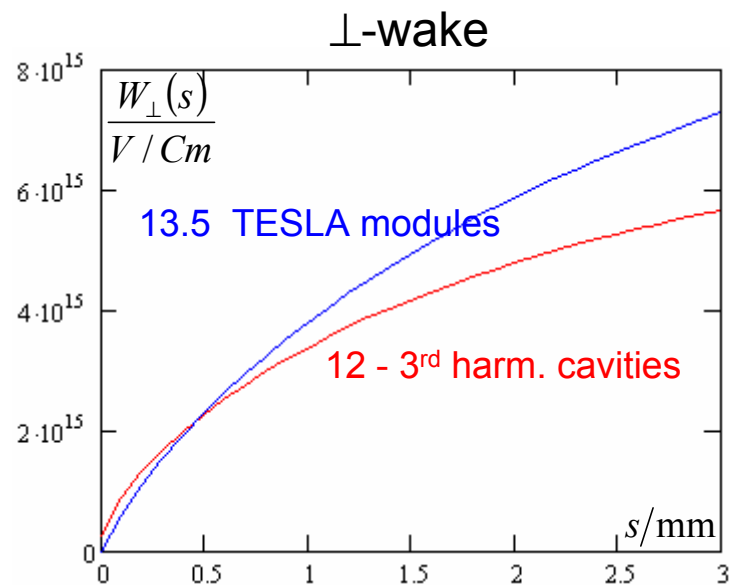


transverse **short range wake** in TESLA modules and 3rd harmonic cavities

⊥-wake / **cavity** scales with fundamental mode frequency ** 2

12 / 24 3rd harm. cavities ~ 13 / 27 TESLA modules !

I. Zagorodnov: TESLA Report 2003-19 (TESLA module)
TESLA Report 2004-01 (LOLA & 3rd harm. cavity)



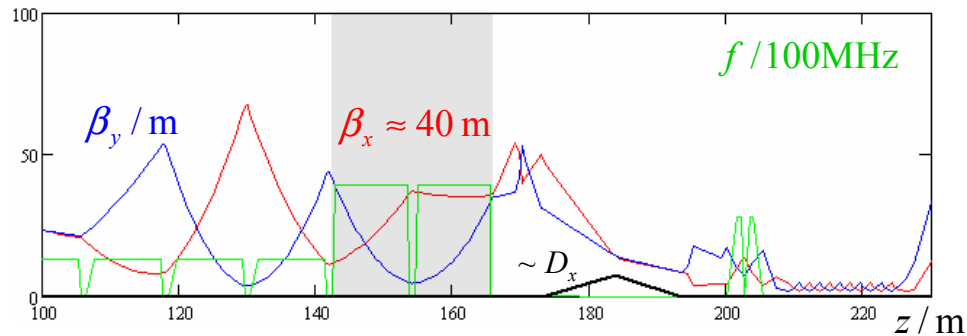
3rd harmonic cavity

emittance growth due to discrete slice centroid kick:

$$\tilde{\varepsilon} \approx \varepsilon \sqrt{1 + \frac{\beta}{\varepsilon} \langle \sigma_{x'} \rangle^2}$$

$$\langle \sigma_{x'} \rangle^2 = \left(\frac{q \cdot \text{rms}\{W_{\perp}^{(\sigma)}\}}{V_{\parallel}} \right)^2 (N^2 \sigma_s^2 + N \sigma_r^2)$$

systematic and random offset
of cavity axis



$$q \approx 1 \text{ nC}$$

$$\sigma \approx 2.4 \text{ mm}$$

$$\gamma_L \varepsilon \approx 1 \mu\text{m}$$

$$eV_{\parallel} = 500 \text{ MeV}$$

N = number of cavities

σ_s = systematic error

σ_r = random error

| $\frac{\tilde{\varepsilon}}{\varepsilon}$ | $\sigma_s = 1 \text{ mm}$ $\sigma_r = 0$ | $\sigma_s = 0 \text{ mm}$ $\sigma_r = 1 \text{ mm}$ | $\sigma_s = 0 \text{ mm}$ $\sigma_r = 0.5 \text{ mm}$ | $\sigma_s = 0.1 \text{ mm}$ $\sigma_r = 0.5 \text{ mm}$ |
|---|---|--|--|--|
| $N=12$ | 1.23 | 1.02 | 1.005 | 1.008 |
| $N=24$ | 1.74 | 1.04 | 1.011 | 1.021 |



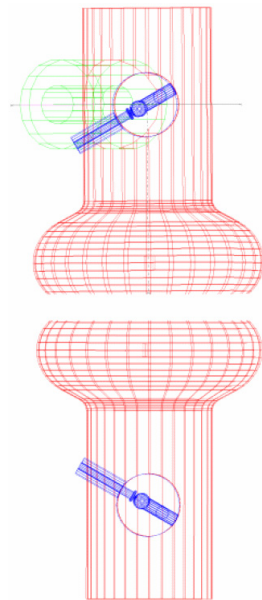
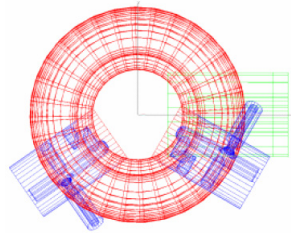
3rd harmonic cavity long range / multi bunch

$$\sum_{f_i < f} \left(\frac{R}{Q} \right)_i$$

FERMILAB-TM-2210
TESLA-FEL 2003-01, May 2003

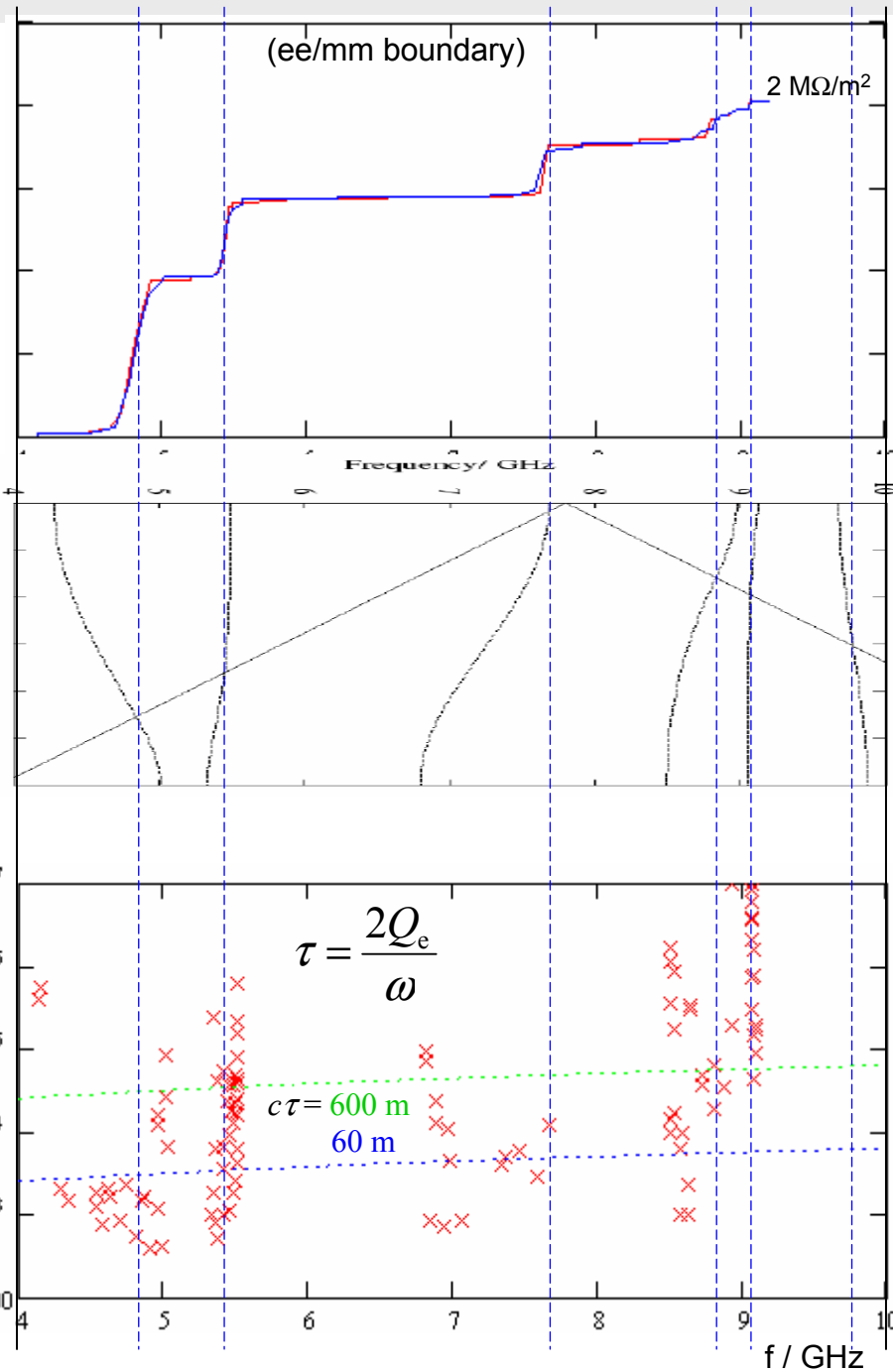
Higher Order Modes of a 3rd Harmonic Cavity with an Increased End-cup Iris

T. Khabibouline N. Solyak R. Wanzenberg



phase advance
in periodic structure
of middle cells
 $\frac{\varphi}{\text{deg}}$

quality
(HFSS calc.
with ee or mm
boundary cond.)
 Q_e

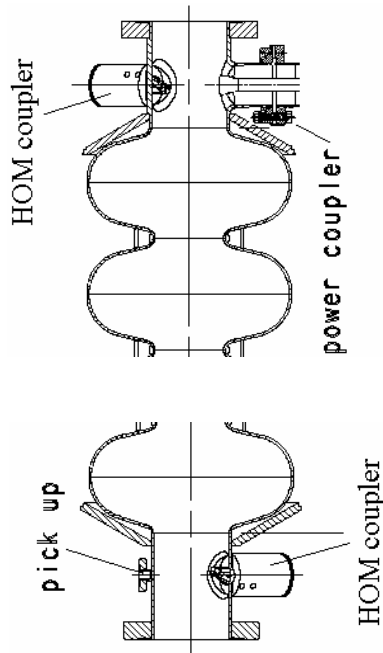


TESLA cavity long range / multi bunch

$$\sum_{f_i < f} \left(\frac{R}{Q} \right)_i$$

Monopole, Dipole and Quadrupole Passbands
of the TESLA 9-cell Cavity

R. Wanzenberg
TESLA 2001-33



phase advance
in periodic structure
of middle cells

$$\frac{\phi}{\text{deg}}$$

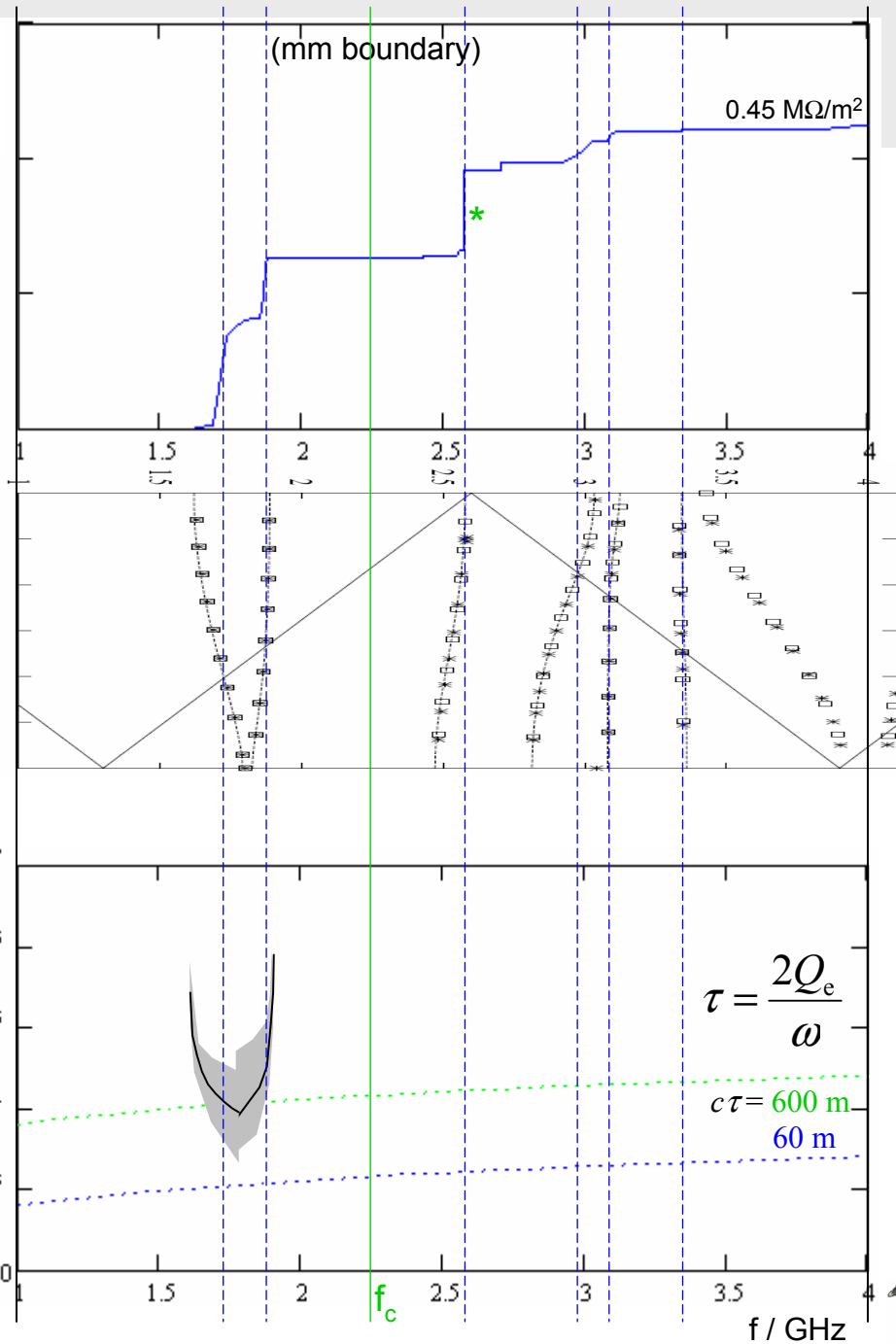
quality

$$Q_e$$

$$\tau = \frac{2Q_e}{\omega}$$

$$c\tau = 600 \text{ m}$$

$$60 \text{ m}$$



* Higher Order Mode Absorption in TTF
Modules in the Frequency Range of the 3rd
Dipole Band

M. Dohlus, V. Kaljuzhny, S.G.Wipf

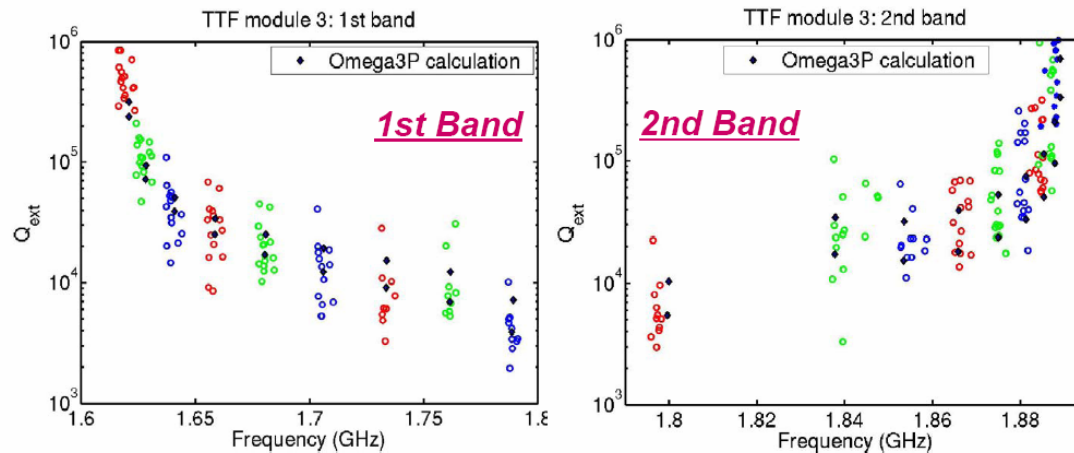
TESLA 2002-05



TESLA cavity 1st & 2nd dipole band

TDR Cavity – HOM Damping (Omega3P)

Comparing measurements (*color*) with **Omega3P** (*black*) complex eigenmode solutions ($Q_{\text{ext}} = f_{\text{real}} / 2f_{\text{imag}}$) shows data scatter around ideal cavity results due to shape deformations



from:

Accelerating Cavity Design for the International Linear Collider

A. Kabel, ...

ICAP 2006, Chamonix Mont-Blanc, October 2-6, 2006

0.53 M quadratic elements, 3.5 M DOFs, 512 CPU with 300 GB on Seaborg, Second Arnoldi with MUMPS, 1 hour per dipole band



scatter of Q values ~ factor ten
??? field distribution
coupler tuning

