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Resistive Effects in XFEL Kicker

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XFEL Beam Dynamic Meeting

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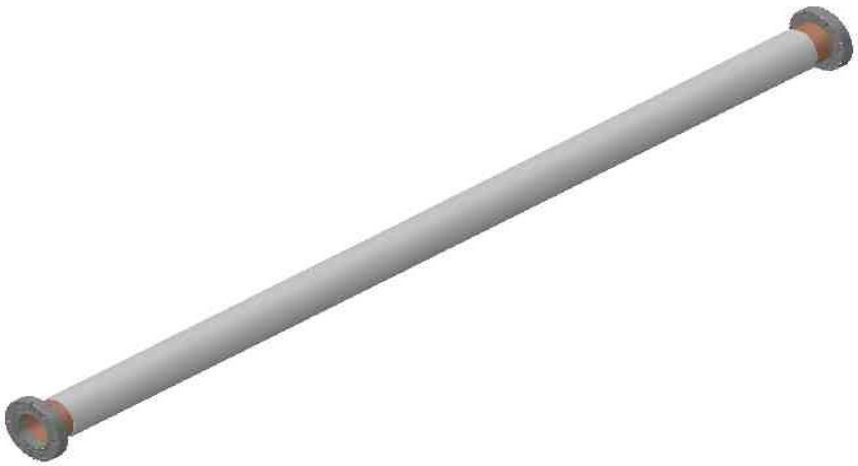
Topics

- Impedances and Wake Fields in XFEL Kicker Vacuum Chamber
- Loss and Kick Factors
- Summary

Impedances and Wake Fields in XFEL Kicker Vacuum Chamber

Ceramic Kicker Vacuum chamber:
Ceramic with Titanium-Stabilized High Gradient Steel (TSHGS) coats



Vacuum Chamber Parameters

Radius - 0.01 m

Lenght - 0.9 m

Beam Parameters

$\sigma_b = 25 \mu m$

TSHGS Parameters

Thickness - 0.7 μ m

Resistance - R/L = 10 - 12 Ωm^{-1}

$\sigma \approx (2.0841 \pm 0.18946) \times 10^6 \, \Omega^{-1} m^{-1}$

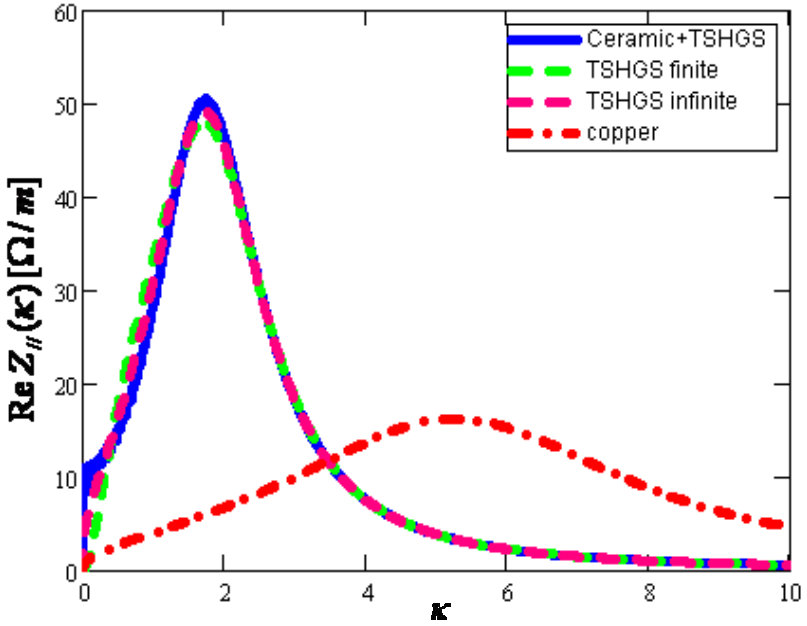
Ceramic Parameters

$\varepsilon_r = 9.1$

$\tan \delta \sim 10^{-4}$

Parameters from T. Wohlenberg

Monopole Term
Longitudinal Impedance Per Unit Length



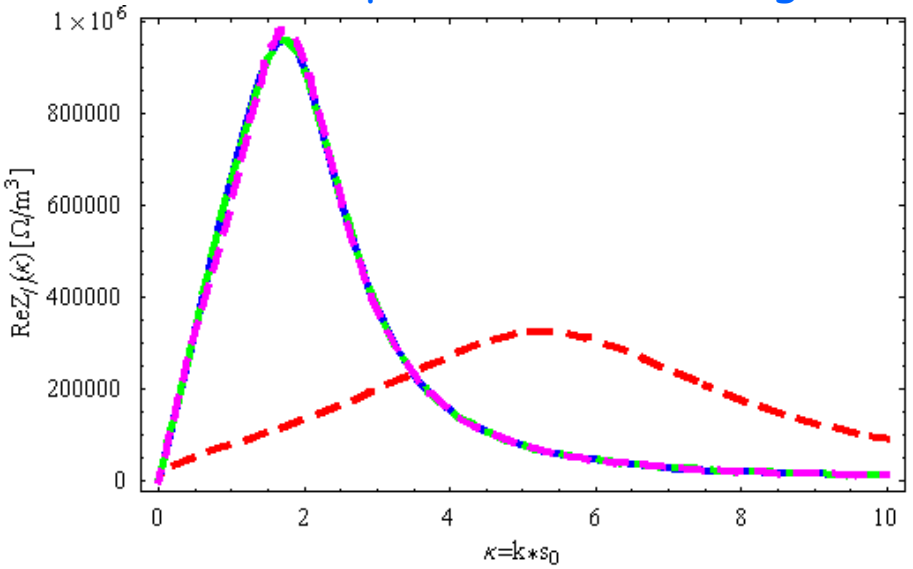
Longitudinal monopole impedance as function of dimensionless wave number $\kappa = k \cdot s_0$ for several cases of vacuum chamber material:

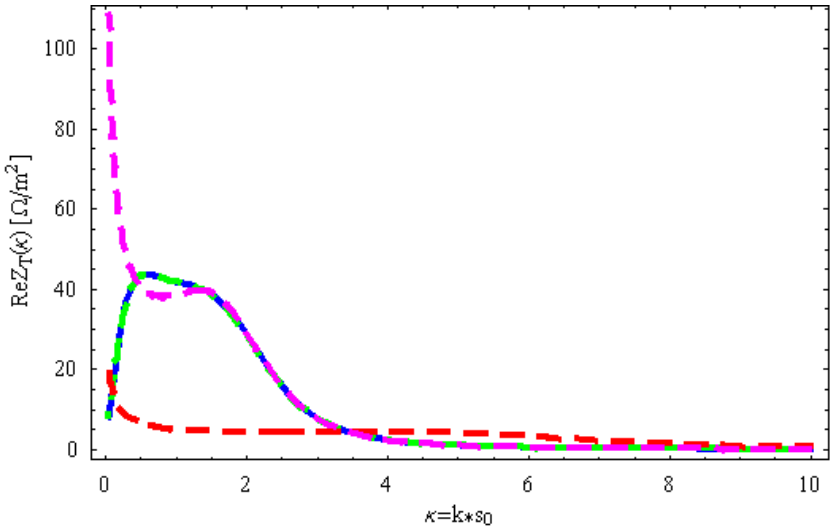
1. Ceramic with TSHGS coats.
2. TSHGS single layer tube with finite and infinite thickness.
3. Copper single layer tube.

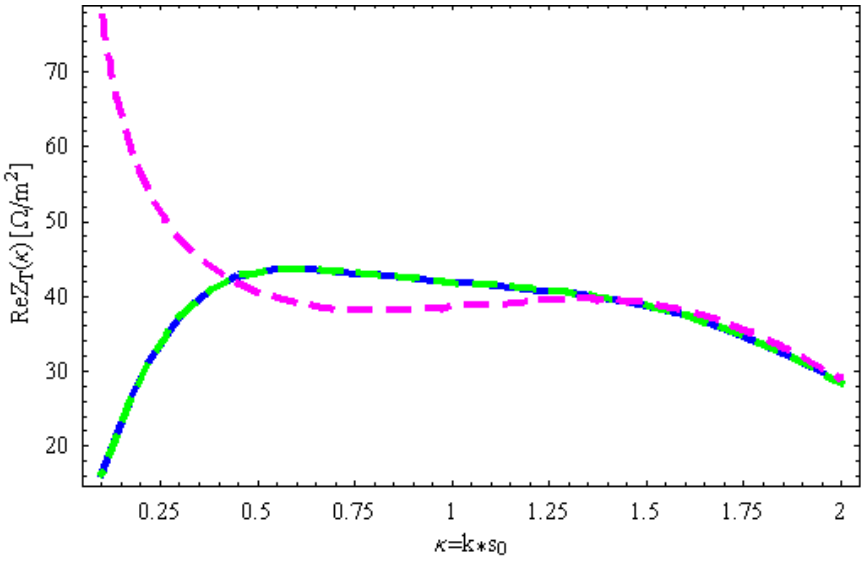
s_0 characteristic distance: $s_0 = \left(2ca^2\varepsilon_0 / \sigma\right)^{1/3} \approx 63.4\,\mu m$

Dipole term

Longitudinal and transverse Impedances Per Unit displacement and Length

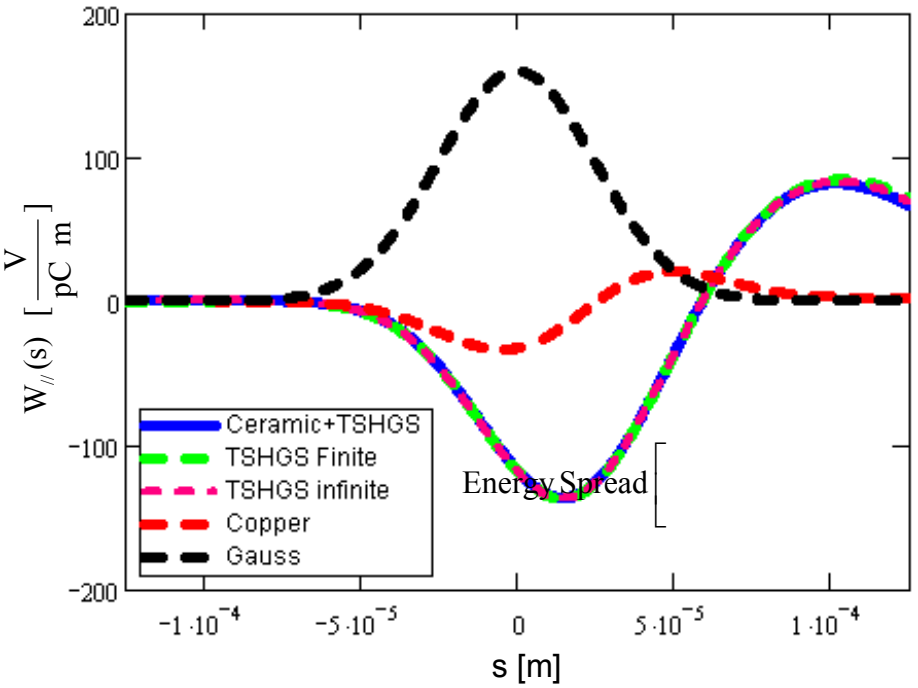






Resistive Wall Wake Potential

Monopole Term

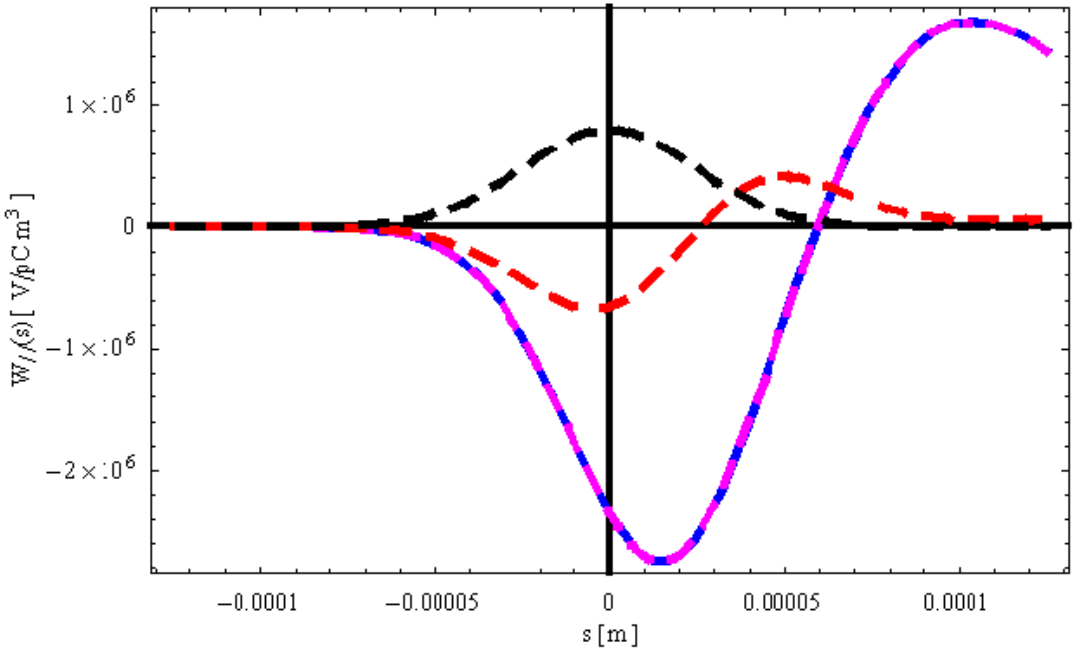


	Ceramic+TSHGS	TSHGS finite	TSHGS infinite	copper
Loss Factor [kV / nC m]	-90.6029	-90.5704	-90.5811	-17.5743

$E = 17.5\,GeV$

Energy Spread ⇒ 5.7067×10^{-4} % (TSHGS)
1.3460×10^{-4} % (Copper)

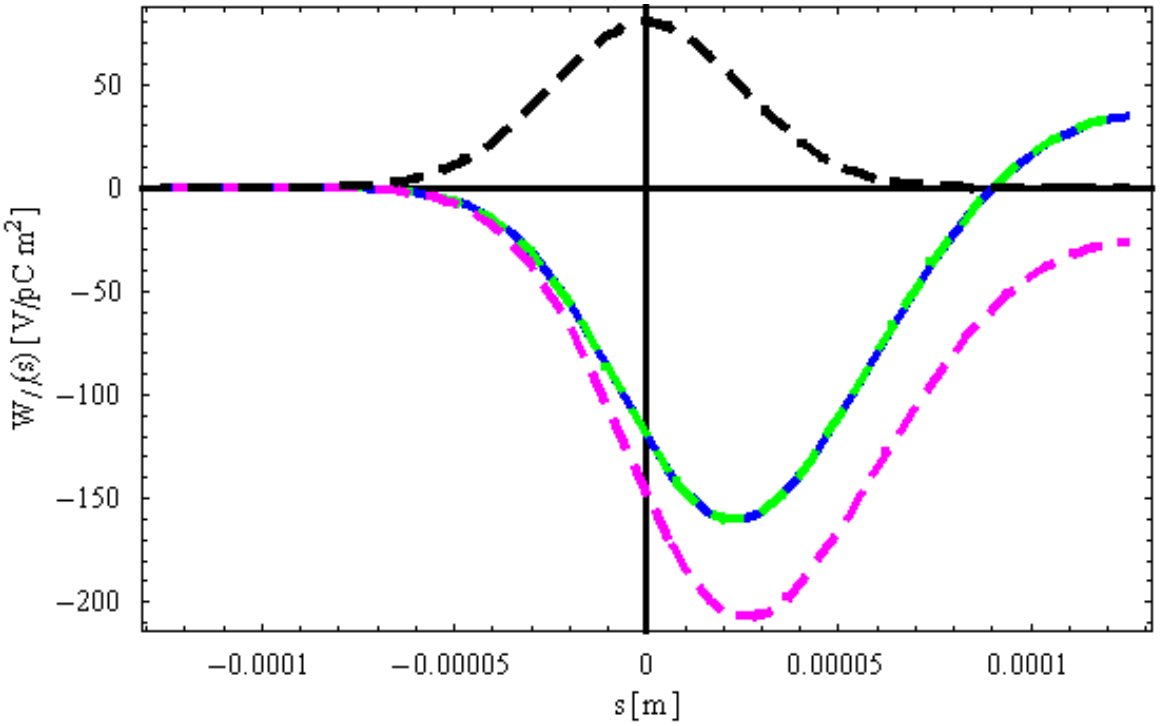
Dipole Term
Longitudinal Wake Potential



	Ceramic+TSHGS	TSHGS finite	TSHGS infinite	copper
Loss Factor $\left[\frac{\text{kV}}{\text{nC m}^3}\right]\times 10^6$	-1.8113	-1.8113	-1.8116	-0.35

Dipole Term

Transverse Wake Potential



	Ceramic+TSHGS	TSHGS finite	TSHGS infinite	copper
Kick Factor $\left[\frac{\text{kV}}{\text{nC m}^2}\right]$	-103.059	-103.062	-131.082	-22.176

Summary

- Wakes, Kick and Loss factors has been calculated
- Kickers induced rms correl. energy spread -

$$\Rightarrow \quad \begin{array}{l} 5.7067\times10^{-4}\ \%\ \ (\text{TSHGS}) \\ 1.3460\times10^{-4}\ \%\ \ (\text{Copper}) \end{array} \qquad \frac{\sigma_{\text{Copper}}}{\sigma_{\text{TSHGS}}} \approx 28$$

- Next step $\Rightarrow$ impact of wakes on beam dynamics