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
- Length: 0.9 m

Beam Parameters
- \( \sigma_b = 25 \mu m \)

TSHGS Parameters
- Thickness: 0.7 \( \mu m \)
- Resistance: \( R/L = 10 - 12 \, \Omega \text{m}^{-1} \)
- \( \sigma \approx (2.0841 \pm 0.18946) \times 10^6 \, \Omega^{-1}\text{m}^{-1} \)

Ceramic Parameters
- \( \varepsilon_r = 9.1 \)
- \( \tan \delta \approx 10^{-4} \)

Parameters from T. Wohlenberg

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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

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Resistive Wall Wake Potential

Monopole Term

\[ E = 17.5 \text{ GeV} \]

\[ \text{Energy Spread} \quad 5.7067 \times 10^{-4} \% \quad \text{(TSHGS)} \]
\[ 1.3460 \times 10^{-4} \% \quad \text{(Copper)} \]

**Table:**

<table>
<thead>
<tr>
<th>Material</th>
<th>Loss Factor [kV / nC m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceramic+TSHGS</td>
<td>-90.6029</td>
</tr>
<tr>
<td>TSHGS finite</td>
<td>-90.5704</td>
</tr>
<tr>
<td>TSHGS infinite</td>
<td>-90.5811</td>
</tr>
<tr>
<td>Copper</td>
<td>-17.5743</td>
</tr>
</tbody>
</table>

**Graph:**

- Plot of \( W(s) \) vs. \( s \) for different materials and wake potentials.
- Legend includes: Ceramic+TSHGS, TSHGS finite, TSHGS infinite, Copper, Gauss.
Dipole Term
Longitudinal Wake Potential

Loss Factor \( \left[ \frac{kV}{nC \ m^3} \right] \times 10^6 \) for different materials:

- Ceramic+TSHGS: -1.8113
- TSHGS finite: -1.8113
- TSHGS infinite: -1.8116
- Copper: -0.35
Dipole Term

Transverse Wake Potential

<table>
<thead>
<tr>
<th>Kick Factor</th>
<th>Ceramic+TSHGS</th>
<th>TSHGS finite</th>
<th>TSHGS infinite</th>
<th>copper</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\frac{\text{kV}}{\text{nC m}^2}$</td>
<td>-103.059</td>
<td>-103.062</td>
<td>-131.082</td>
<td>-22.176</td>
</tr>
</tbody>
</table>

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Summary

- Wakes, Kick and Loss factors has been calculated
- Kickers induced rms correl. energy spread -
  \[
  \frac{\sigma_{\text{Copper}}}{\sigma_{\text{TSHGS}}} \approx 28
  \]
  \[
  5.7067 \times 10^{-4} \% \quad \text{(TSHGS)}
  \]
  \[
  1.3460 \times 10^{-4} \% \quad \text{(Copper)}
  \]
- Next step: impact of wakes on beam dynamics