INFLUENCE OF NEG–COATING ON THE CHARACTERISTICS OF *SLS* VACUUM CHAMBER

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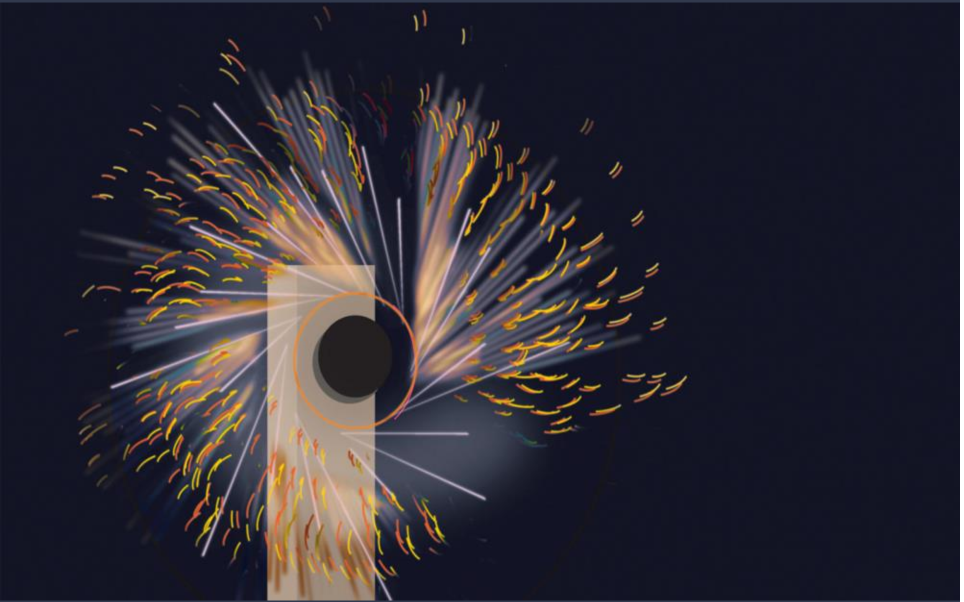

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INTRODUCTION

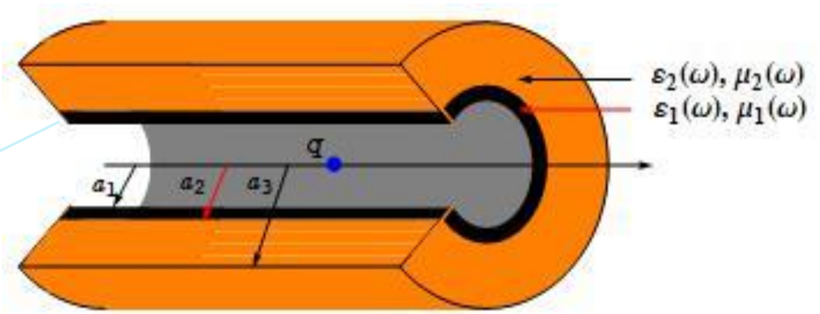
- The current report gives an overview of the results of the impedance study for SLS 2.0 vacuum chamber using the algorithm developed here for an arbitrary number of layers and Influence of Neg-Coating on The Characteristics of SLS 2.0 Vacuum Chamber has been studied.

- The upgrade of the Swiss Light Source is undergoing and is planned to be finished in 2024. Within the upgrade program it is intended to change the storage ring which will give the opportunity to achieve a 40-50 times lower emittance in operation mode. A through study and measurement of impedance are required to avoid instabilities of the beam…

STATEMENT OF THE PROBLEM

Non Evaporable Getter (NEG) material on the surface of the chamber. The NEG material is an alloy of titanium, zirconium and vanadium deposited by magnetron sputtering. The vacuum in a NEG coated chamber benefits with effect: -the NEG coating absorbs residual gas molecules, which contribute to high vacuum maintenance in the beam pipe.

Geometry



Geometrical parameters of the structure (according to data provided by PSI colleagues):

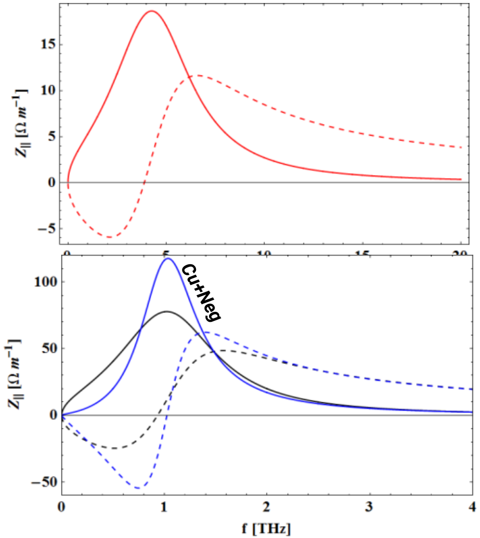
- $a_1 = 9mm$,- Inner radius of the waveguide -
- $a_2 = a_1 + d$, where $d = 500nm$ is the thickness of the inner layer.
- The outer radius of the waveguide is taken sufficiently large - $a_3 = a_2 + \Delta$, with $\Delta = 1\text{cm}$,

Used electromagnetic parameters:

- $\varepsilon_1 = \varepsilon_0 + j\,\sigma_1/\omega\,,\ \varepsilon_2 = \varepsilon_0 + j\,\sigma_2/\omega\,,\ \mu_1 = \mu_2 = \mu_0.$
- Here, $\varepsilon_1, \varepsilon_2$ are permittivities of NEG material and copper,
- μ_1, μ_2 are magnetic permeabilities of NEG material and copper,
- ε_0 is the permittivity of vacuum, μ_0 is the magnetic permeability of vacuum,
- $\sigma_1 = 8 \cdot 10^5\ \Omega^{-1}m^{-1}$ and $\sigma_2 = 58 \cdot 10^6\ \Omega^{-1}m^{-1}$ are conductivities of NEG-material and copper.

LONGITUDINAL IMPEDANCES

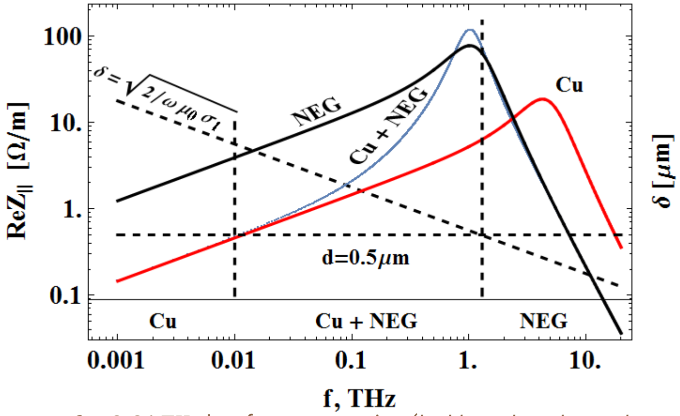
Single layer cases



Impedance Resonant freq.	
f_{rez}^{Cu}	4.263 THz
f_{rez}^{NEG}	1Thz
f_{rez}^{Cu+NEG}	1.034 THz

Monopole longitudinal impedance of the beam pipe; real (solid) and imaginary (dashed) components in the without (red) and with (blue) internal NEG coating. On the graph below, the impedance of a single-layer pipe made entirely of NEG material is shown separately (black).

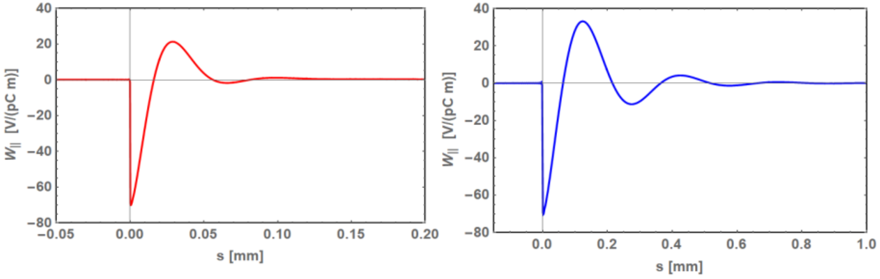
Three frequency regions are distinguished in the spectral distribution of the impedance



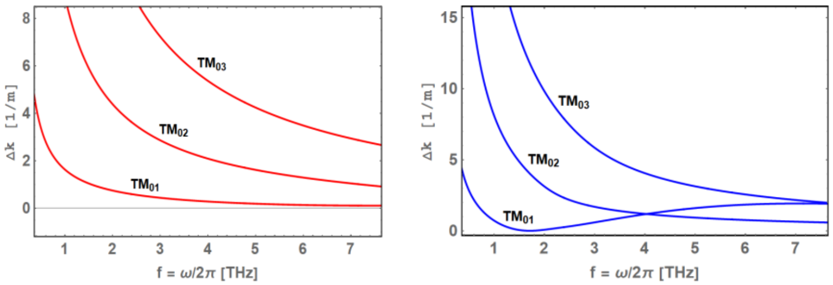
- $\mathbf{f \le 0.01\ THz}$ low frequency region (*in this region, due to the large thickness of the skin layer, the particle does not feel the presence of a NEG coating)*
- $\mathbf{0.01\ THz < f < 1.3\ THz}$*-in the intermediate region the radiation is the result of the complex contribution of the copper wall and the NEG coating material.*
- $\mathbf{f \ge 1.3\ THz}$ *-In the high-frequency region*

due to the small thickness of the skin layer, only the effect of the NEG coating is felt

WAKE FUNCTIONS AND DISPERSION CURVES



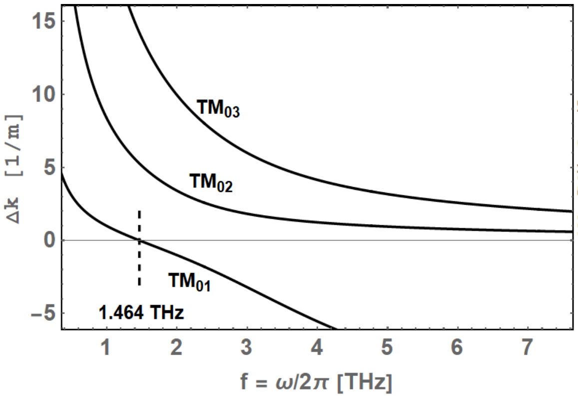
Monopole longitudinal wake function for a single-layer copper pipe (left) and a two-layer copper pipe with an internal NEG coating (right); s - the distance between the leading and test particle going behind ($s > 0$) or in front ($s < 0$) of it.

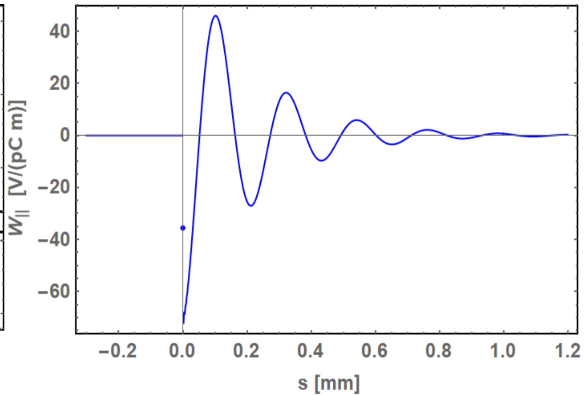


Dispersion curves of the first three TM0i modes for copper (left) and copper-NEG pipes at selected parameters.

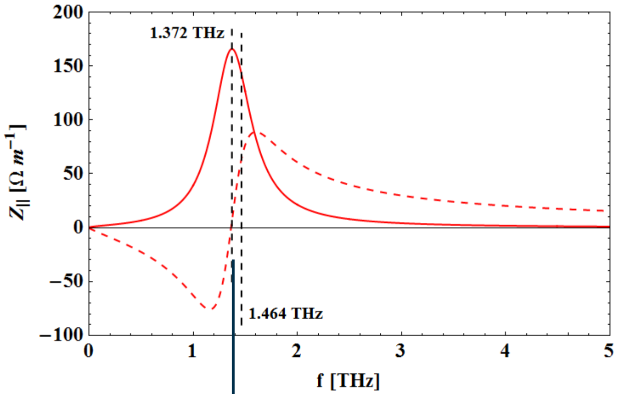
- *condition of synchronization of velocities of particle and slowly propagating waveguide mode velocities*
- $\Delta k = k - Re\, p = 0$*, where* $k = \omega/c$ *(*ω *– frequency) and* $p = \sqrt{k^2 - \nu_{0i}^2}$ *with* ν_{0i} *transverse wavenumber of axisymmetric waveguide mode*

SYNCRONOUS MODE CASE





Dispersion curves (left) and wake function (right) of a two-layer structure with a double reduced NEG layer $(d = 250\ nm)$.



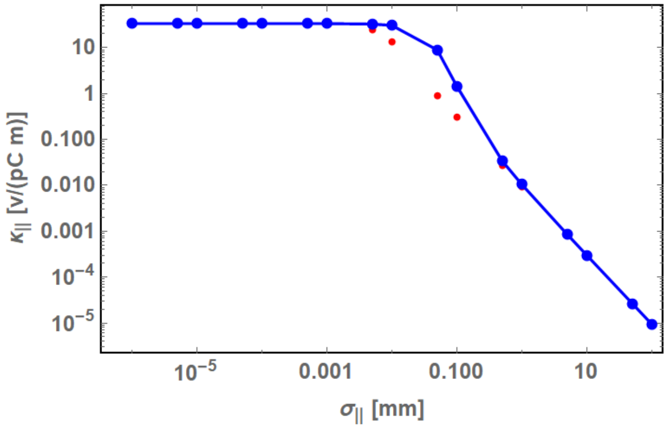
Real (solid line) and imaginary (dotted line) components of the longitudinal monopole impedance of a two-layer structure with a NEG layer thickness $d = 250\ nm$.

Synchronous frequency $f = 1.464\ THz$

Resonant frequency of the impedance $f = 1.372\ THz$

$\Delta f = 92\ GHz$

LOSS-FACTOR



Dependence of the $\kappa_{||}$ loss factor on the rms $\sigma_{||}$ length of the Gaussian bunch; copper pipe (red dots), copper-NEG pipe (blue line with dots).

$\sigma_{||} < \sigma_0$
$\sigma_0 = 5\mu m$ ***for copper pipe***
$\sigma_0 = 10\mu m$ ***for copper-NEG pipe***
For both cases

$\kappa_{||} \approx 37\ V/pC \cdot m$

$\mathbf{50\mu m < \sigma_{||} < 500\mu m}$
The maximum increase in the value of the loss factor

$\mathbf{500\mu m > \sigma_{||}}$

For bunches which rms lengths in this region the effect of the NEG coating on the value of the loss factor is not felt

Conclusion

- The addition of a NEG coating at its optimal choice of the composition and thickness does not lead to the appearance of narrow-band resonances and synchronization of radiation with the particle velocity, so it does not create significant distorting effects for the beam in the vacuum chamber.
- An increase in the impedance level with the addition of NEG coating leads to an increase in radiation losses in the bunch length range $5\mu m < \sigma_{||} < 500\mu m$ (Fig. 8). The maximum increase in the value of the loss factor (10 times) is achieved with $\sigma_{||} = 50\mu m$. For the bunches whose lengths are outside of the mentioned interval ($\sigma_{||} \leq 5\ \mu m$ and $\sigma_{||} \geq 500\ \mu m$), the effect of the NEG coating on the value of the loss factor is not felt.
- Decrease in the thickness of the NEG coating (with the same inner radius and filling of the inner layer) leads to radiation monochromatization and to the appearance of a slowly propagating mode synchronized at a certain frequency with the motion of the particle. This could be considered for possibility of creating a monochromatic radiation source and implement two-beam acceleration.

Thank you for your attention!!