Preliminary estimates of impedance for the ILC damping ring

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outline

Possible tools (codes)

Coaxial wire method technique

Calculation of the impedances and wake functions for the DR vacuum chamber components.

- round vacuum chamber with slot
- transition between round and rectangular vacuum chamber cross section
- BPM inserted in the round vacuum chamber

Possible tools (codes)

The most famous **ABCI**
that computes the longitudinal and transverse coupling impedances for 2D structures - structures with cylindrical symmetry

To compute the electromagnetic field in specific geometries, 3D numerical code solving Maxwell equations is required. Nowadays, these numerical simulations greatly exploit commercial purpose 3D codes.

3D time domain codes **MAFIA, GDFIDL**
directly provide wake - functions which can be Fourier transformed to get impedances.

Other 3D general purpose codes can be, as well, used to compute impedance
HFSS (frequency domain), **MW studio** (time domain)
but both codes do not compute wake-functions directly

Possible tools (codes)

GDFIDL

have been selected to study impedance model for the DR because they are already used in CI

HFSS

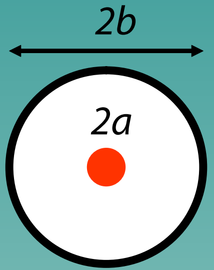
Possible tools (codes)

impedance calculations which will be presented in my talk are performed by

HFSS

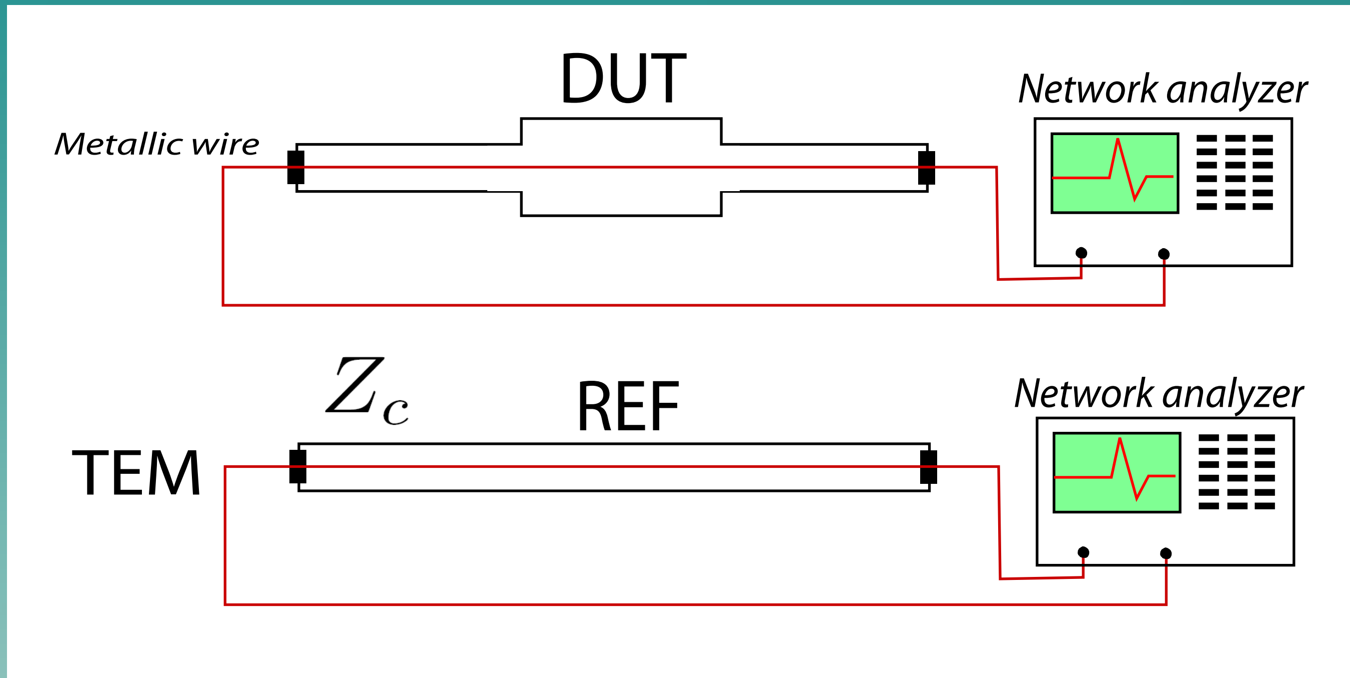
Coaxial wire method technique

A wire in a perfectly conducting cylindrical beam pipe with circular cross section has a characteristic impedance equal to



$$Z_c = \frac{Z_0}{2\pi} \ln\left(\frac{b}{a}\right)$$

a smaller wire results in an higher characteristic impedance



$$Z_{log} = -2 Z_c \ln\left(\frac{S_{21}^{DUT}}{S_{21}^{REF}}\right)$$

Log formula (Walling et al, 1989)

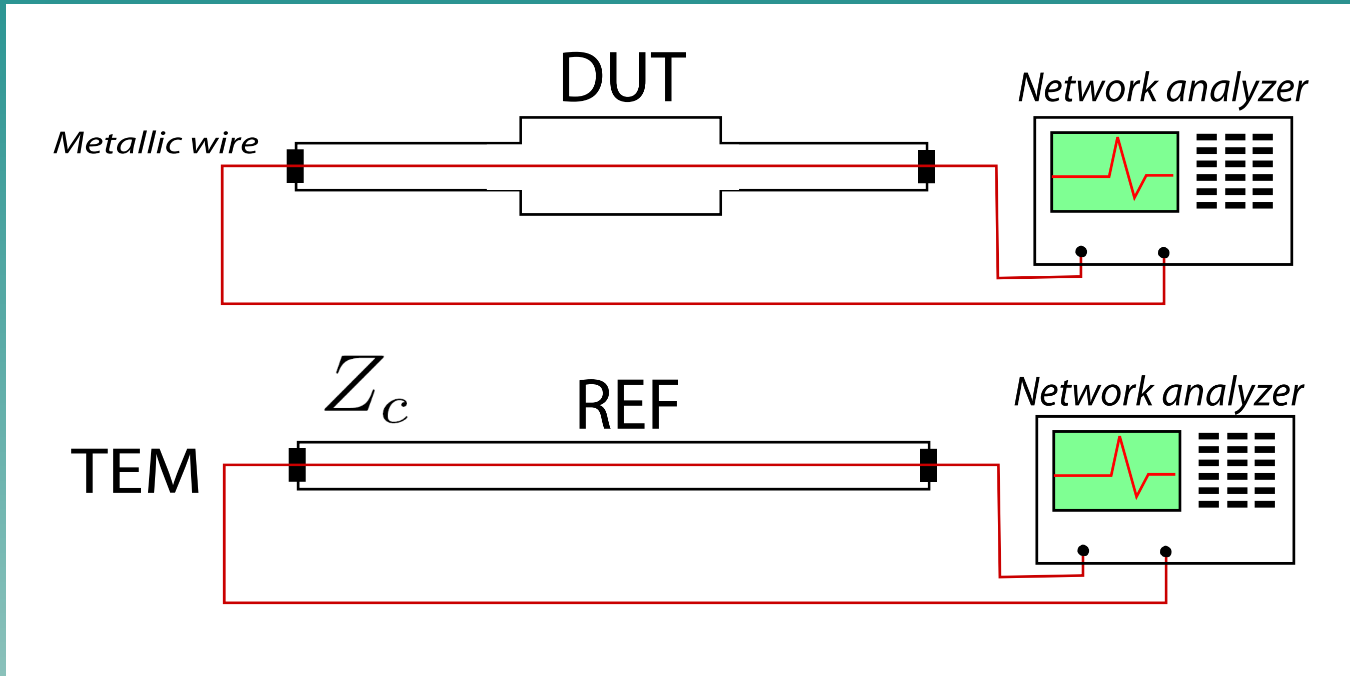
$$Z_{LOG} = -Z_c \ln\left(\frac{S_{21}^{DUT}}{S_{21}^{REF}}\right)\left[1 + \frac{\ln\left(S_{21}^{DUT}\right)}{\ln\left(S_{21}^{REF}\right)}\right]$$

Improved log formula (Vaccaro, 1994)

Coaxial wire method technique

S-parameters

$$Z_{log} = -2Z_c \ln\left(\frac{S_{21}^{DUT}}{S_{21}^{REF}}\right)$$

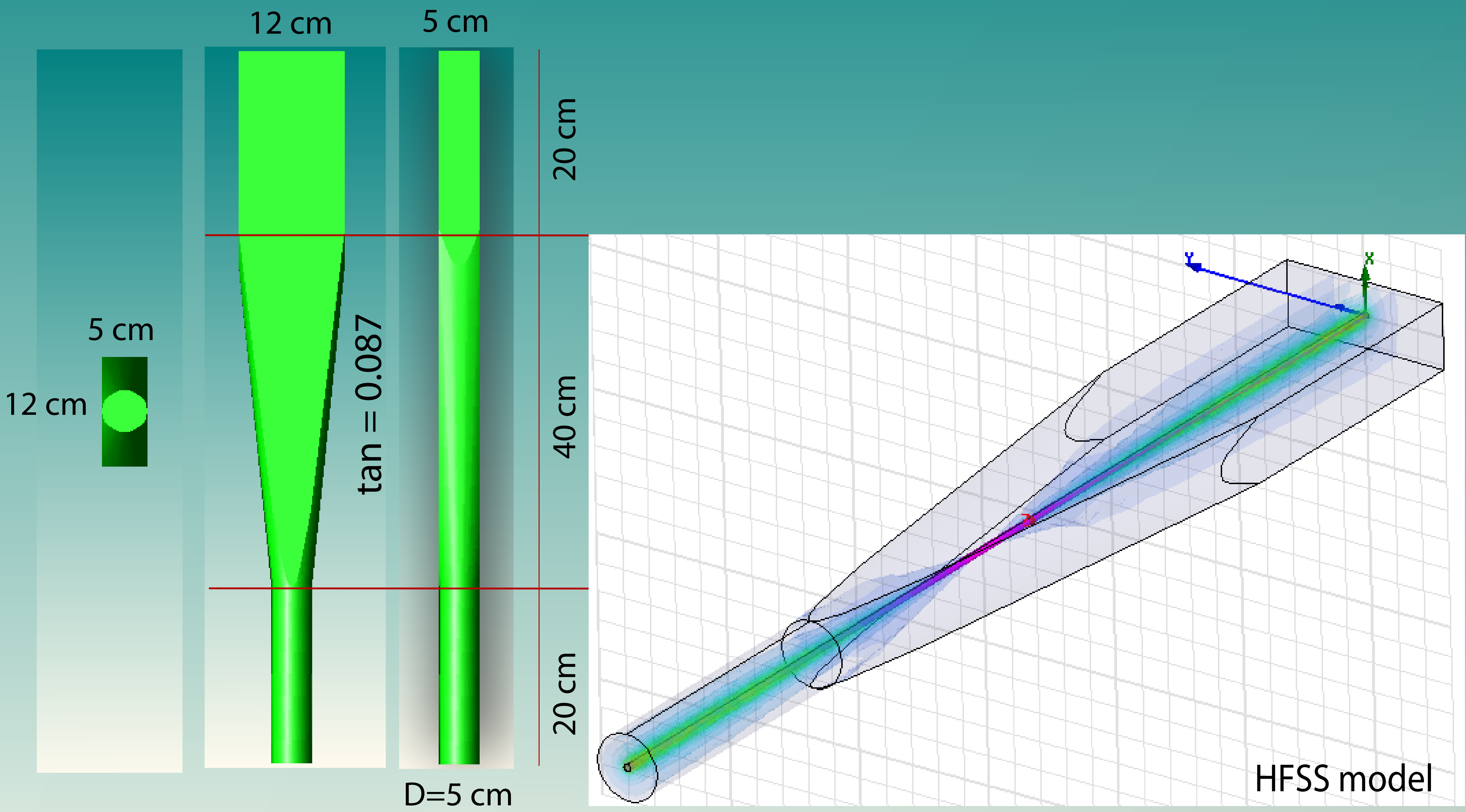


$$\begin{pmatrix} b_1 \\ b_2 \end{pmatrix} = \begin{pmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{pmatrix} \times \begin{pmatrix} a_1 \\ a_2 \end{pmatrix}$$

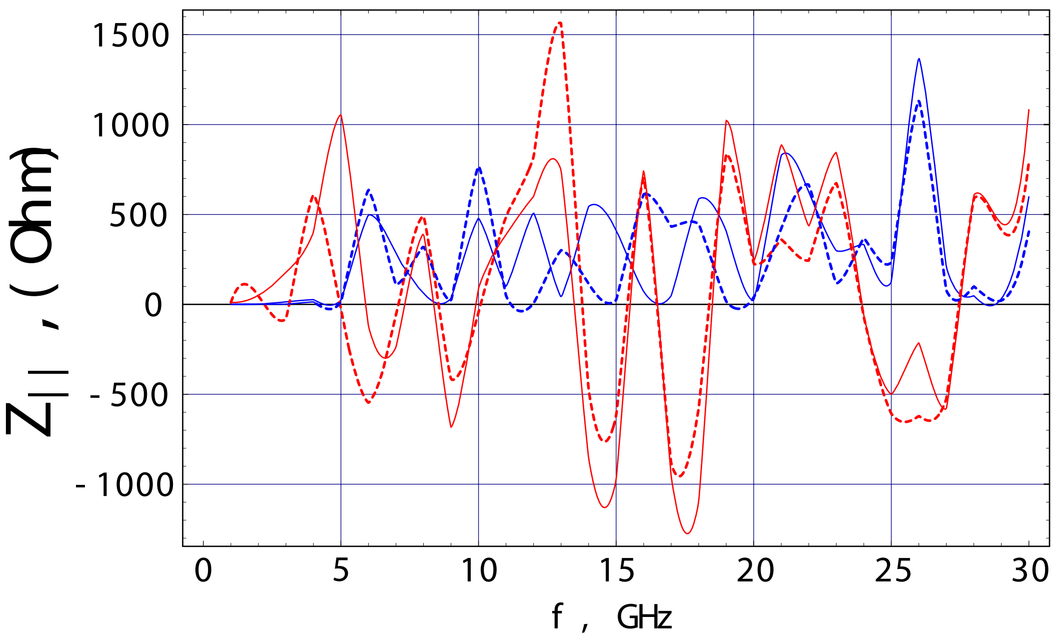
This is the matrix algebraic representation of 2 port Sparameters:

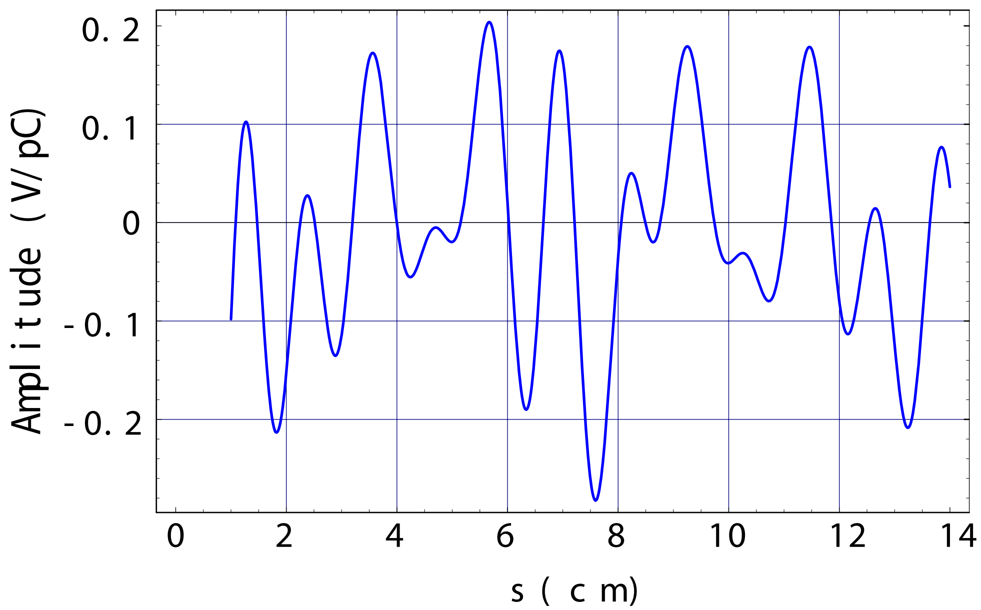
S-parameters can be calculated by HFSS

Transition from cylindrical to rectangular cross-section beam pipe



Longitudinal coupling impedance and wake function of the taper



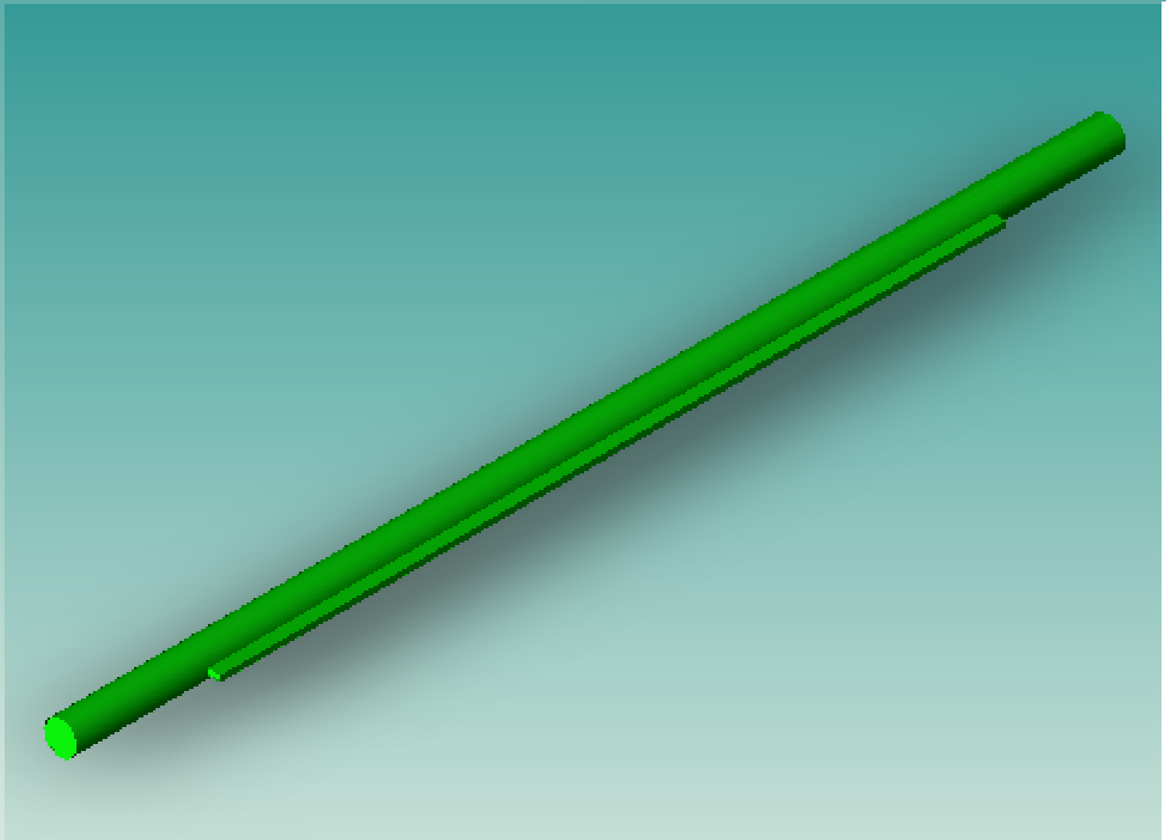


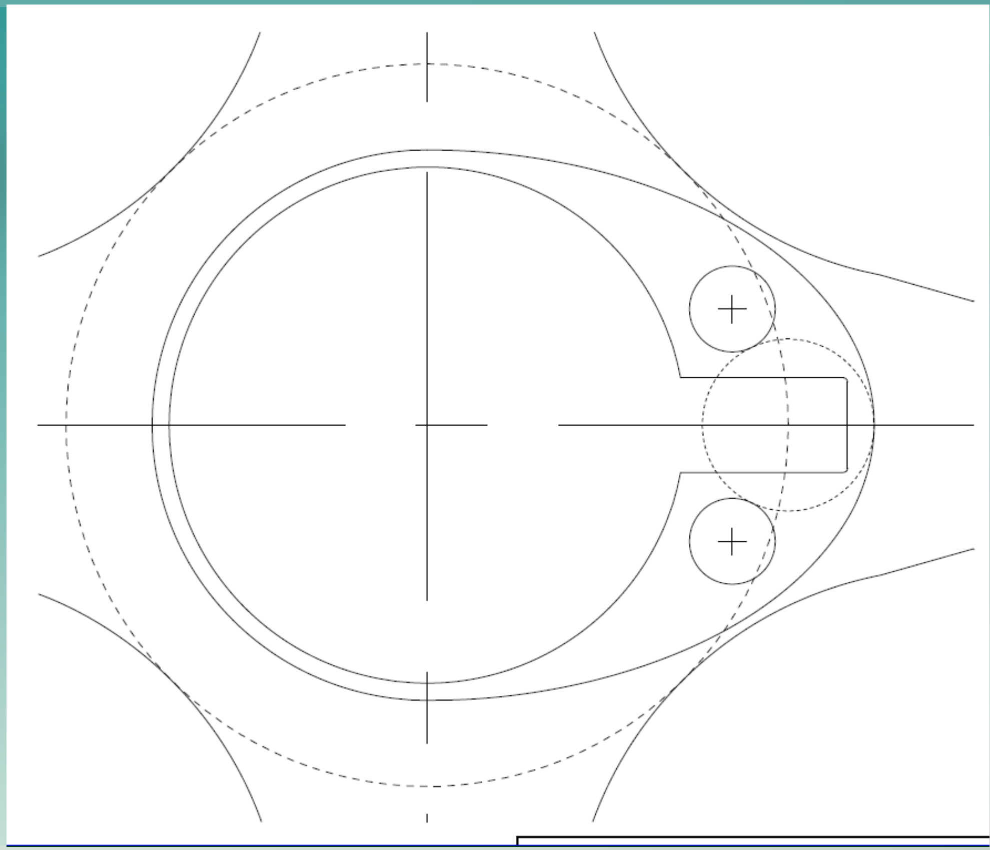
.... Improved log formula

———— Log formula

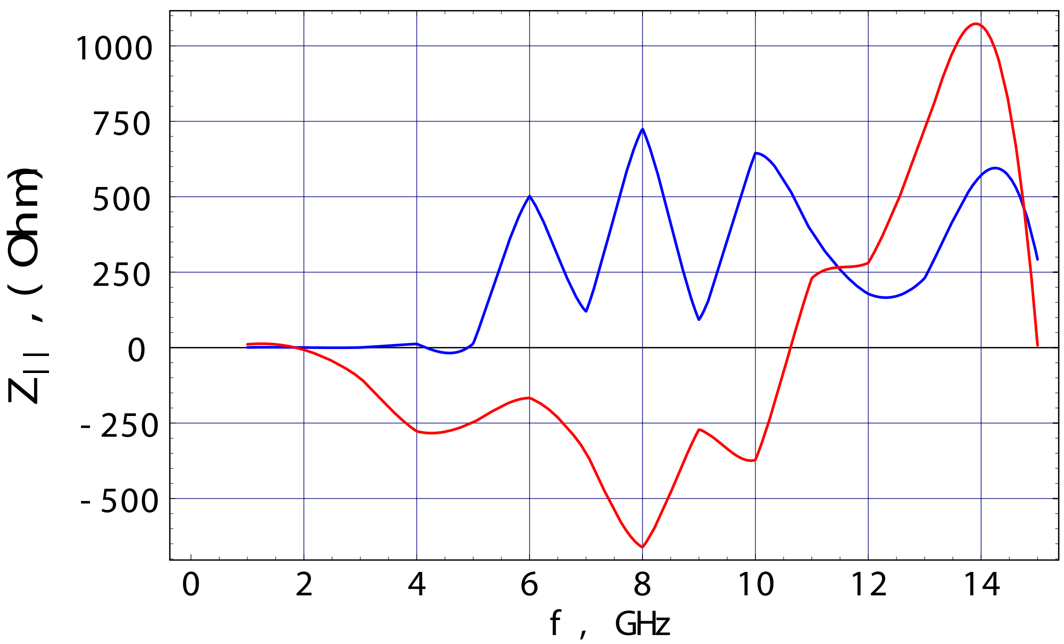
$$W_{\|}(z) = \frac{4\pi}{Z_0 c}\frac{2}{\pi}\int_0^{\infty} d\omega \mathrm{Re} Z_{\|}(\omega)\cos\frac{\omega z}{c}$$

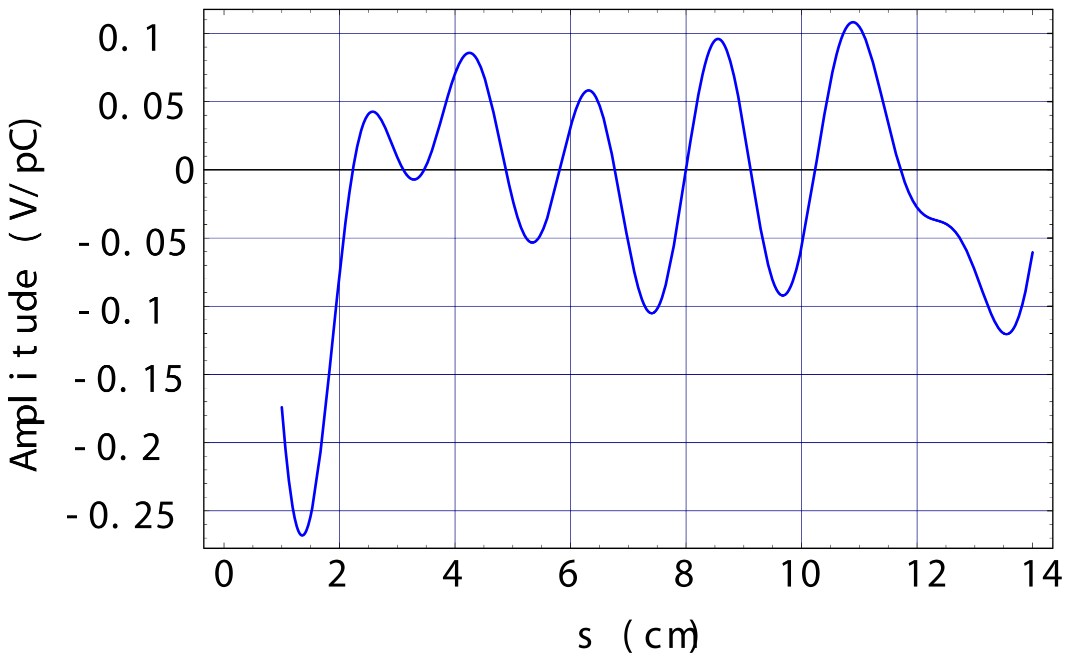
Possible design of the round vacuum chamber with slot





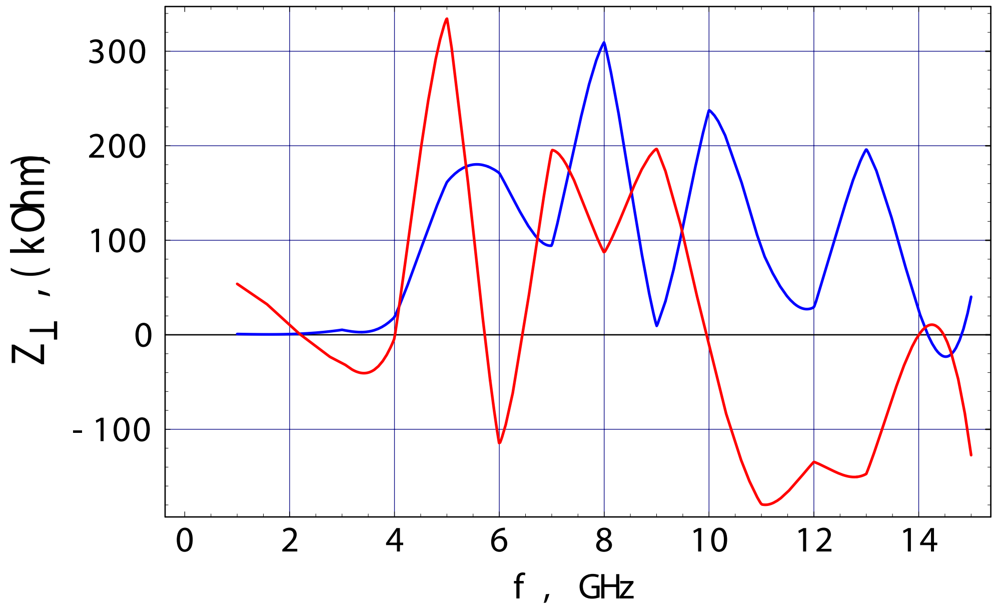
Longitudinal coupling impedance and wake function of the round beam pipe with slot

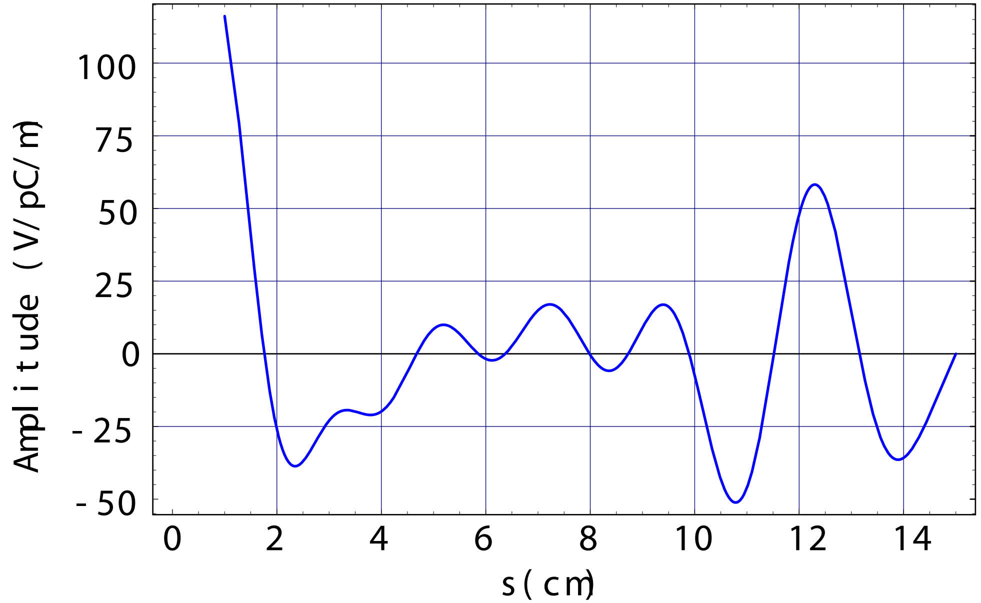




$$W_{\|}(z) = \frac{4\pi}{Z_0 c}\frac{2}{\pi}\int_0^{\infty} d\omega \mathrm{Re} Z_{\|}(\omega)\cos\frac{\omega z}{c}$$

Transverse coupling impedance and wake function of the round beam pipe with slot



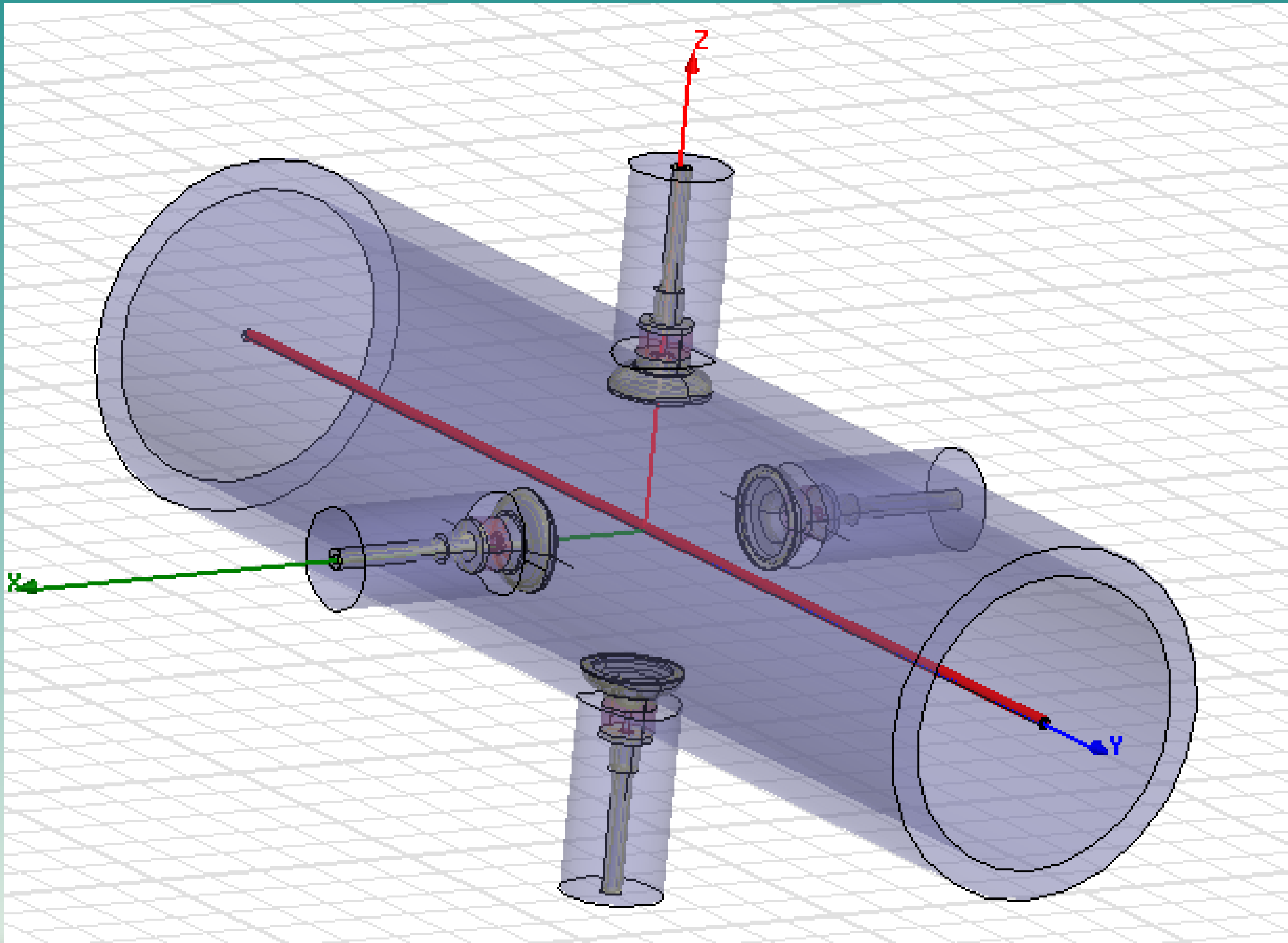


$$Z'_\perp = \frac{c}{\omega}\nabla_\perp Z_\parallel$$

$$Z_\perp \simeq \frac{c}{\omega}\frac{Z_\parallel(x_0) - Z_\parallel(x_0=0)}{x_0^2}$$

$$W_\perp(z) = \frac{4\pi}{Z_0 c}\frac{2}{\pi}\int_0^\infty d\omega \mathrm{Re} Z_\perp(\omega)\sin\frac{\omega z}{c}$$

PEP-II BPM adopted to the ILC DR with some modification: Design details



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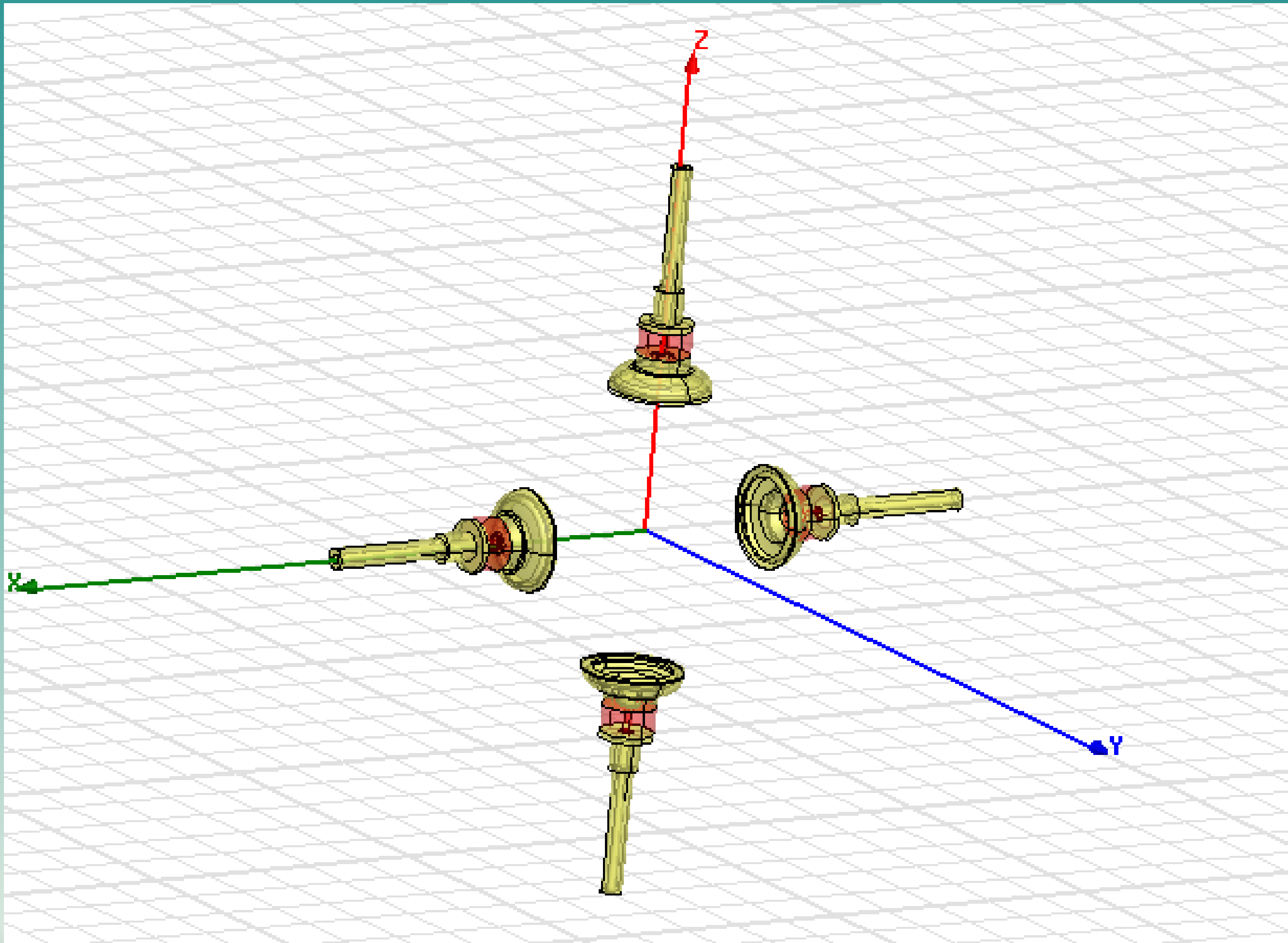

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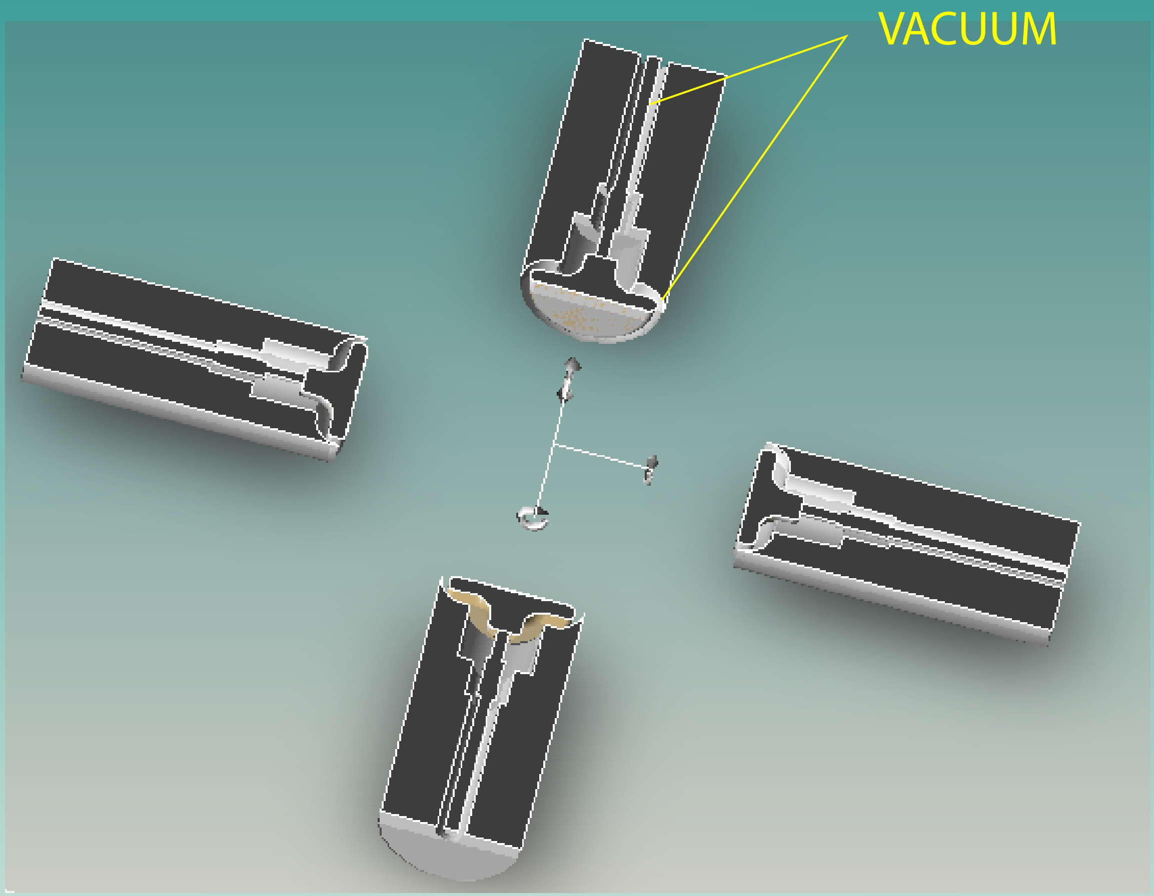
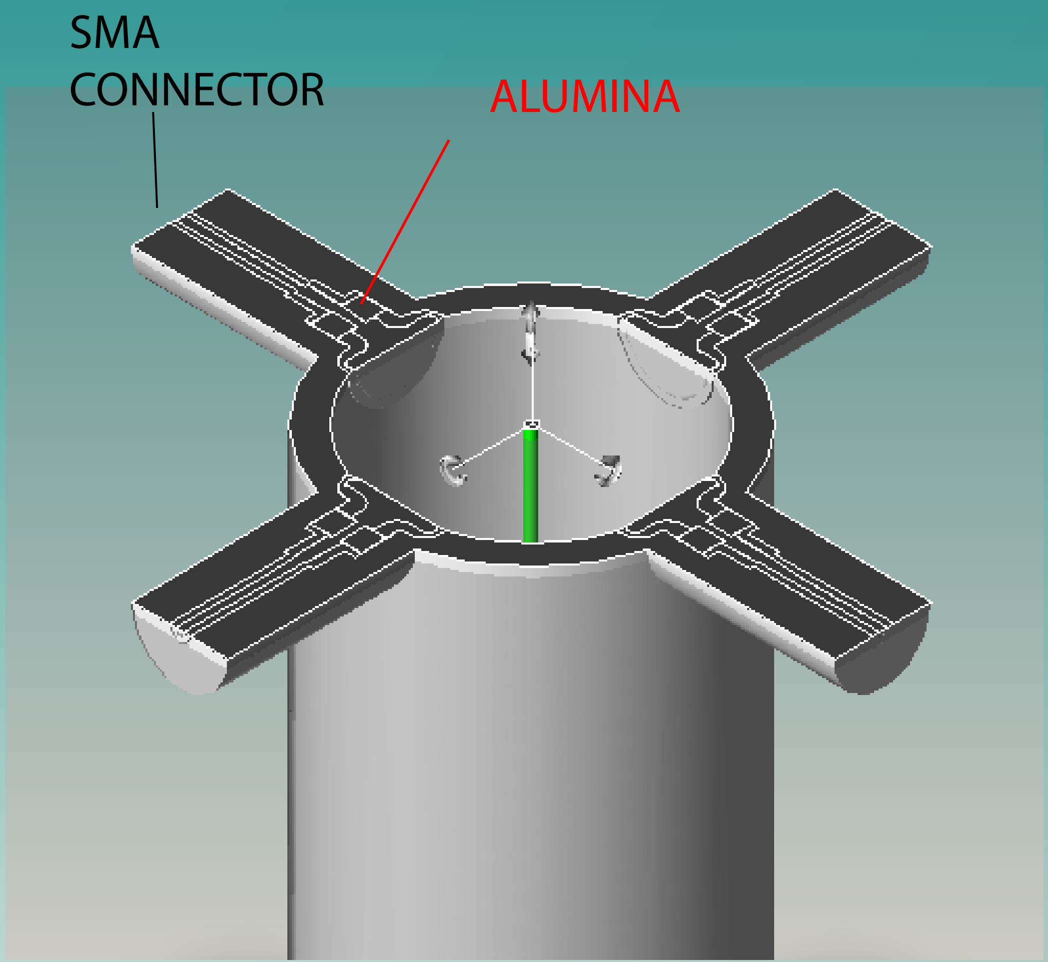
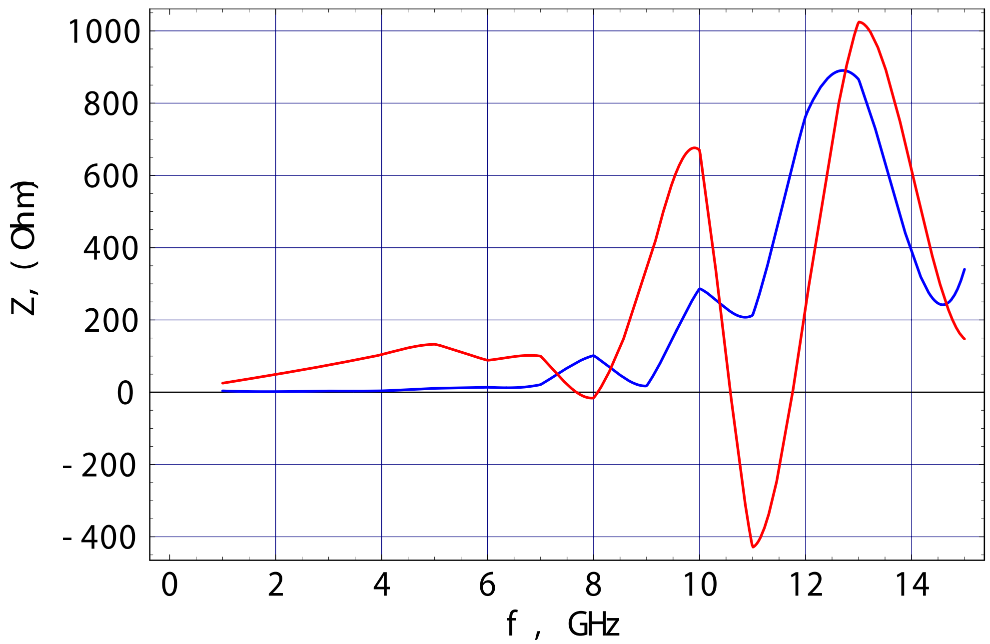
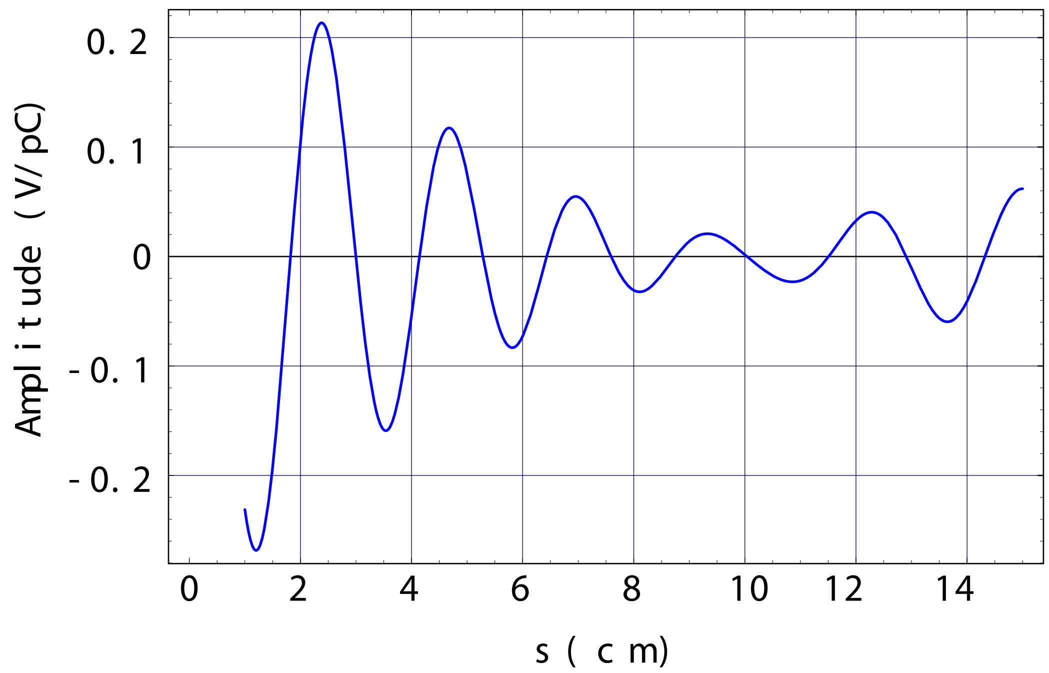




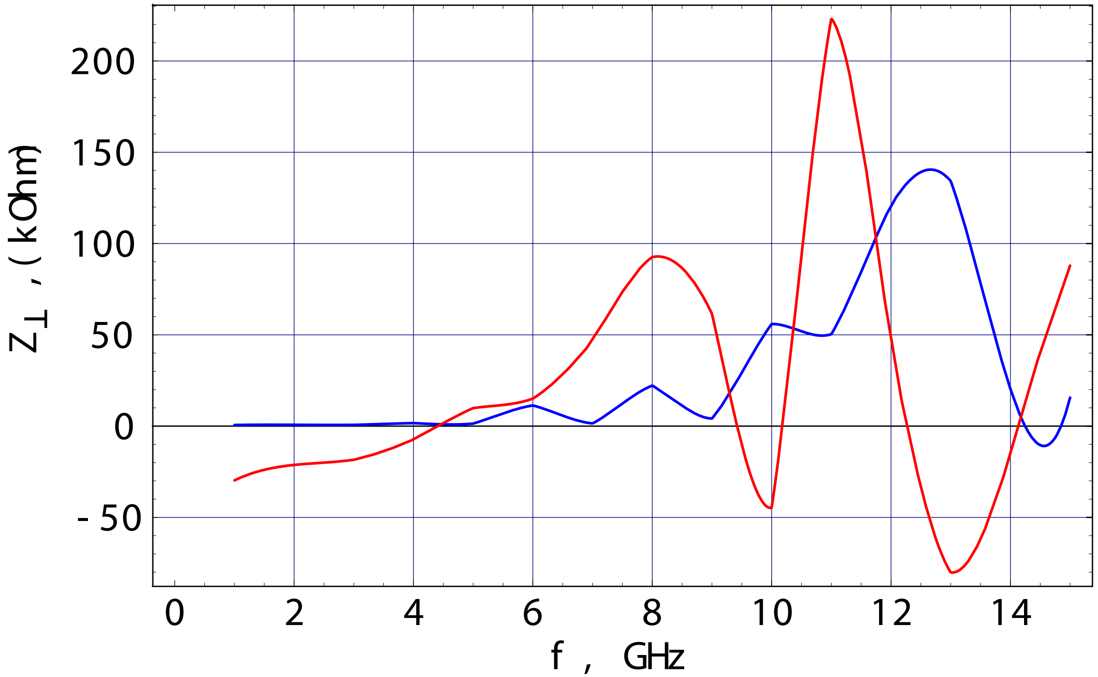
Longitudinal coupling impedance and wake function of the BPM

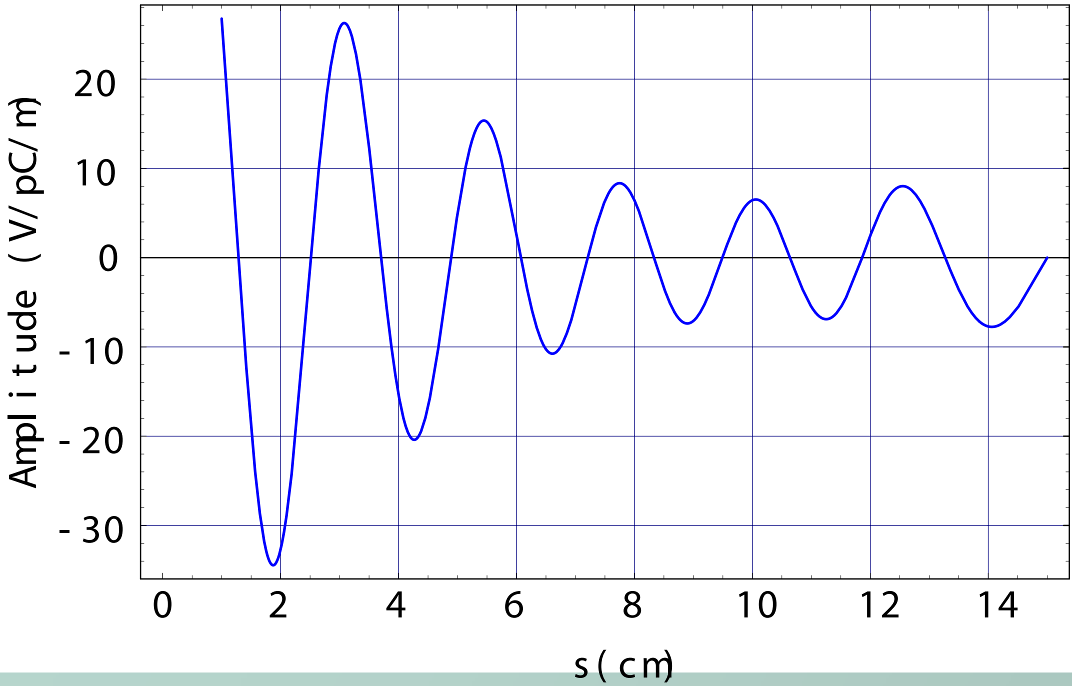




$$W_{\parallel}(z) = \frac{4\pi}{Z_0 c}\frac{2}{\pi}\int_0^{\infty} d\omega \mathrm{Re} Z_{\parallel}(\omega)\cos\frac{\omega z}{c}$$

Transverse coupling impedance and wake function of the BPM





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$$W_\perp(z) = \frac{4\pi}{Z_0 c}\frac{2}{\pi}\int_0^\infty d\omega \mathrm{Re} Z_\perp(\omega) \sin\frac{\omega z}{c}$$

Conclusion

wake field simulations in the BPM with more hight precision is required

cross-check results between Gdfidl and HFSS

generate results for different designs of BPM, for example DIAMOND BPM

investigate propagation of the HOM in the antechamber

to find optimum geometry of the antechamber to minimize impedance