Goubau-Line Set Up for Bench Testing Impedance of IVUE32 Components

TUPP42

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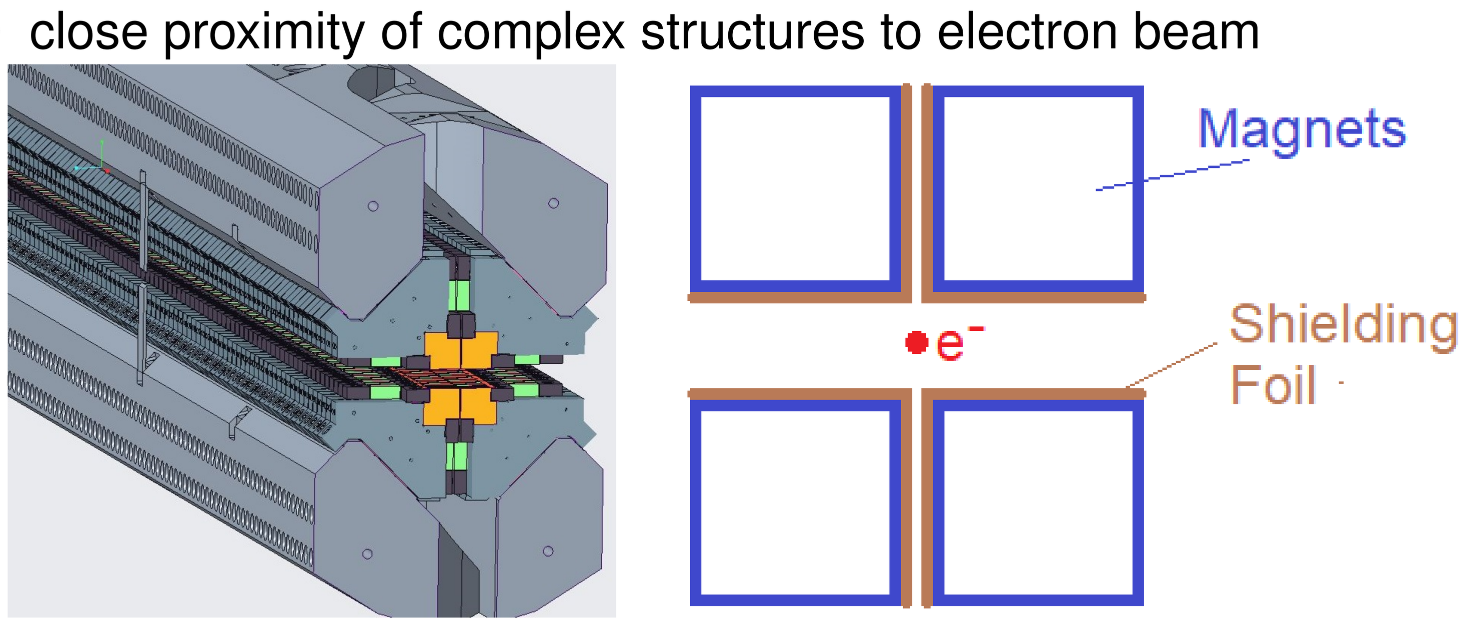
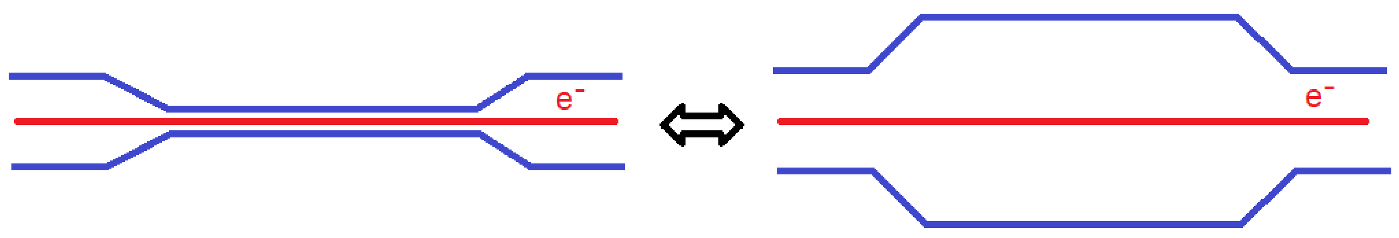
Motivation

- first ever attempt at an elliptical in-vacuum undulator
- shielding foil of separately movable magnet rows poses design challenge
- close proximity of complex structures to electron beam

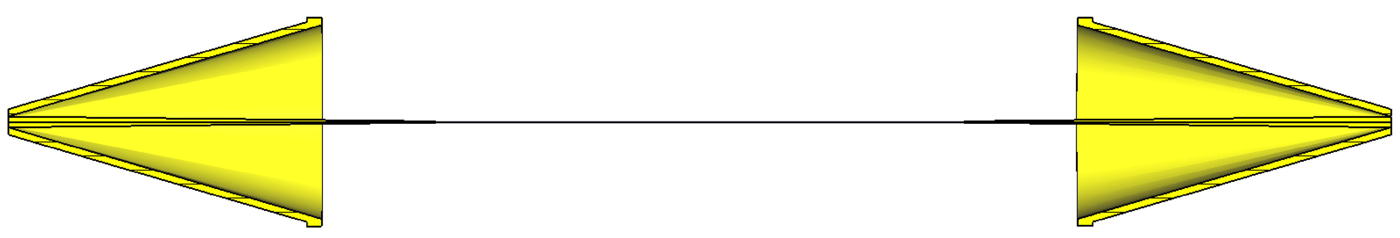


- wake fields of charged particle beams interact with vacuum chamber components
- can influence beam dynamics and heat components
- movable gap of in-vacuum undulators can change between collimator and cavity
- understanding impedance is vital for accelerator operation



What is a Goubau-Line?

- single wire transmission line designed by Georg Goubau in 1950 [**1**]
- Goubau-Lines can be used for bench testing vacuum chamber components
- transverse electric field mimics that of a charged particle beam
- transmission and reflection measurements can determine impedance
- consist of horn antennas and an insulated wire



Theory

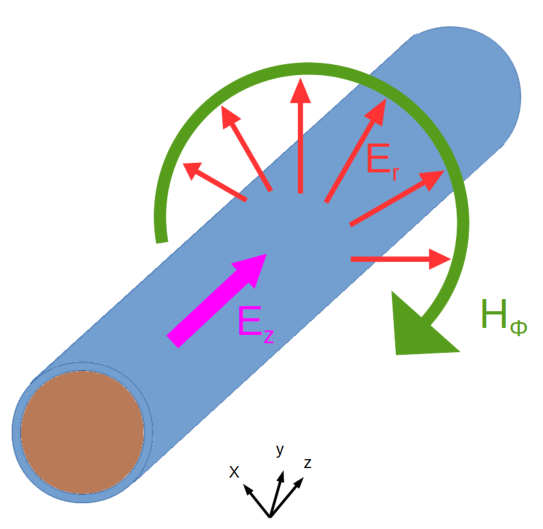
- fields are described by cylindrical Helmholtz Equations [**2**]

$$E_r = iA_i \frac{h}{\gamma_i} Z_1(\gamma_i r) e^{i(\omega t - hz)}$$

$$E_z = A_i Z_0(\gamma_i r) e^{i(\omega t - hz)}$$

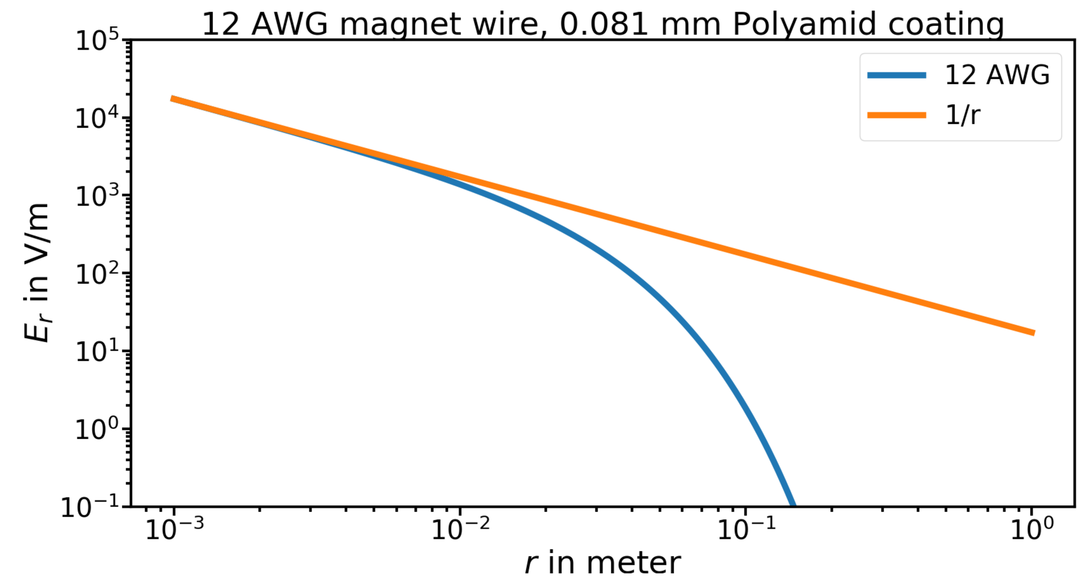
$$H_\phi = iA_i \frac{k_i^2}{\omega \mu \gamma_i} Z_1(\gamma_i r) e^{i(\omega t - hz)}$$

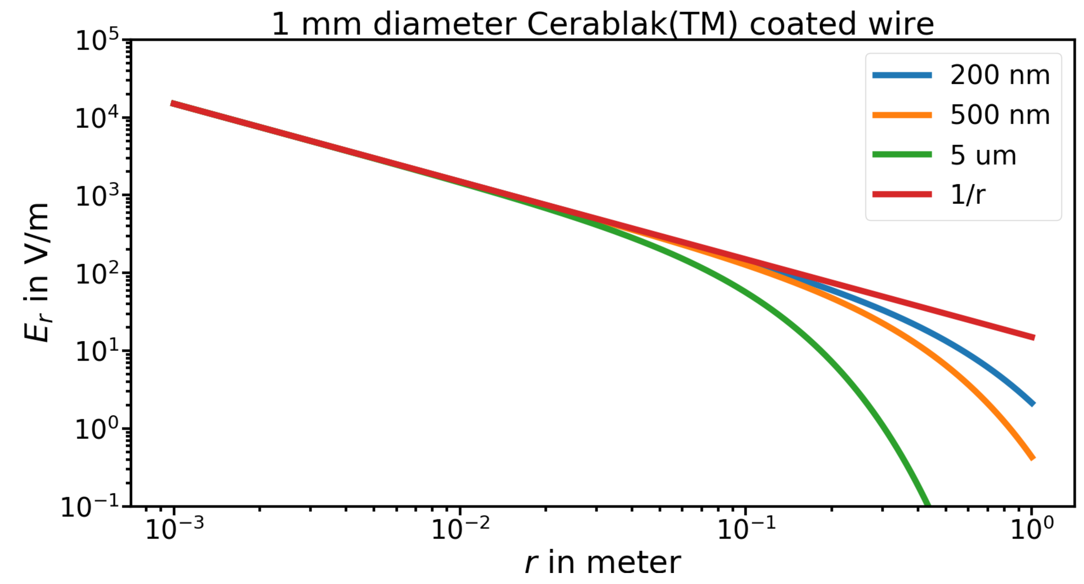
h – guided wave propagation constant
k_i – free wave propagation constant
Z_n – Cylinder functions
$\gamma_i^2 = k_i^2 - h^2$



Wire Parameters

- radial electric field is proportional to $1/r$ close to the wire
- that region needs to extend further than the device aperture
- IVUE32 has a maximum aperture 22 mm

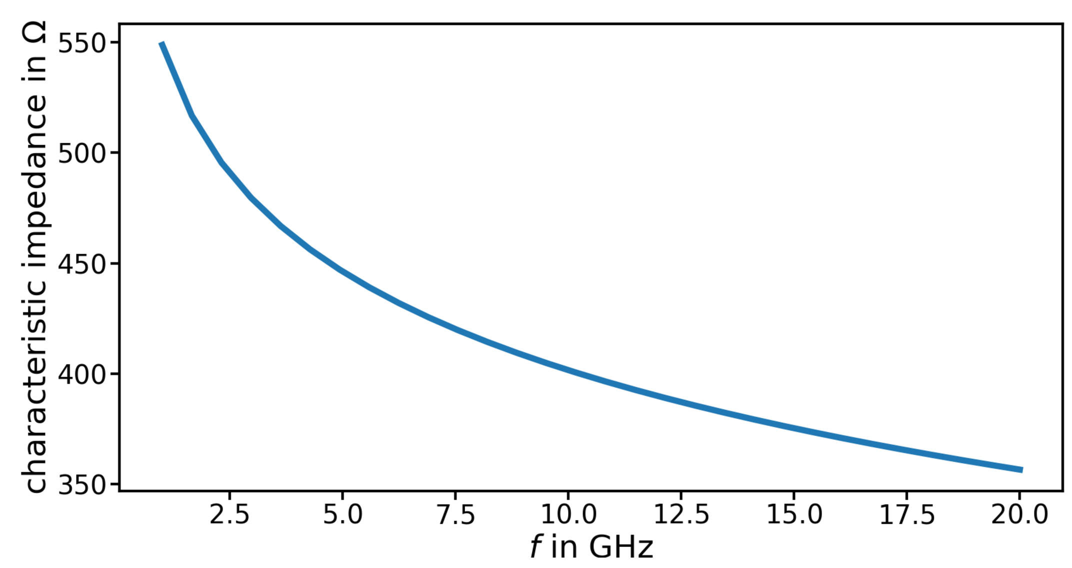




- standard magnet wire is not suitable
- specially coated wire is needed, Cerablak™[**2**] as an example

Characteristic Impedance

- characteristic impedance of Goubau-line can be numerically calculated and is dependent on frequency of guided wave



- horn antennas and transmission line tapers are needed to convert signal from 50 Ω coaxial cable
- impedance trasnmission needs to be smooth in order to avoid reflections
- impedance cannot be matched perfectly for whole frequency band
- optimal compromise needs to be found with taper design

Summary and Outlook

- Goubau-line test stand for frequencies up to 20 GHz needs to be designed
- specialized wire coating is required
- characteristic impedance of the Goubau-line has been calculated for the desired frequency range
- design of the horn antennas and tapers still needs to be finalized
- coated wire for the Goubau-line will be ordered
- first reflection coefficient measurements will be set up

KEY REFERENCES

[1] G. Goubau, "Surface Waves and Their Application to Transmission Lines", Journal of Applied Physics 21, 1119-1128, 1950, https://doi.org/10.1063/1.1699553

[2] B. Vaughn and D. Peroulis, "An updated applied formulation for the Goubau transmission line", Journal of Applied Physics 126, 194902 (2019) https://doi.org/10.1063/1.5125141

[3] Applied Thin Films, Inc. https://www.atfinet.com

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MORE INFORMATION

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