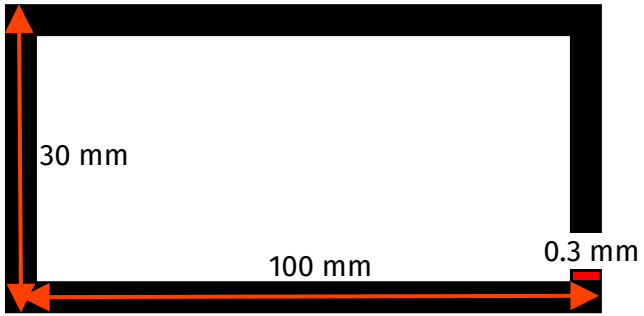
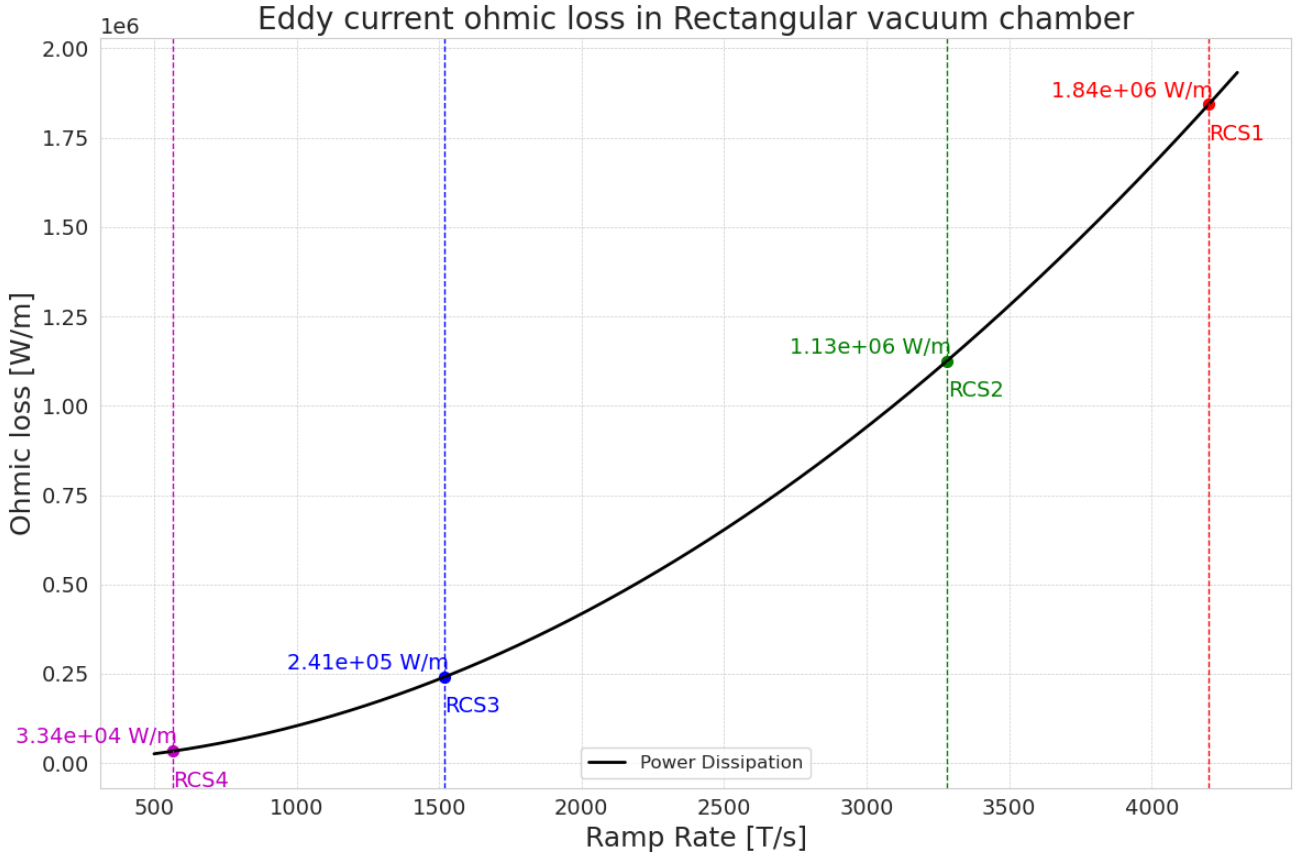
# Eddy Current Power Loss in Stainless Steel Rectangular Vacuum Chamber

**Stainless steel vacuum chamber:**

- Conductivity: $1.1 \times 10^6$ S/m
- Height and width: 30X100mm
- Thickness: 0.3mm




Power loss in the **MW/m** range!

A continuous conducting beam pipe will cause too large Eddy Current losses

# Energy loss

Energy loss per cycle for rectangular beam pipe:

| RCS: | 2 | 3 | 4 |
|---|---|---|---|
| Energy loss [J/cycle/m] | 2462 | 1143 | 425 |

- Segmenting the beam pipe into stripes drastically reduces the loss.

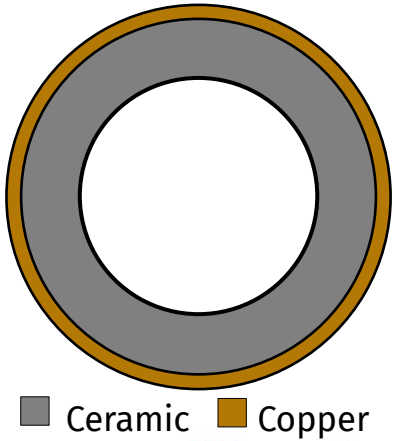
Energy loss per cycle for the longitudinally striped design:

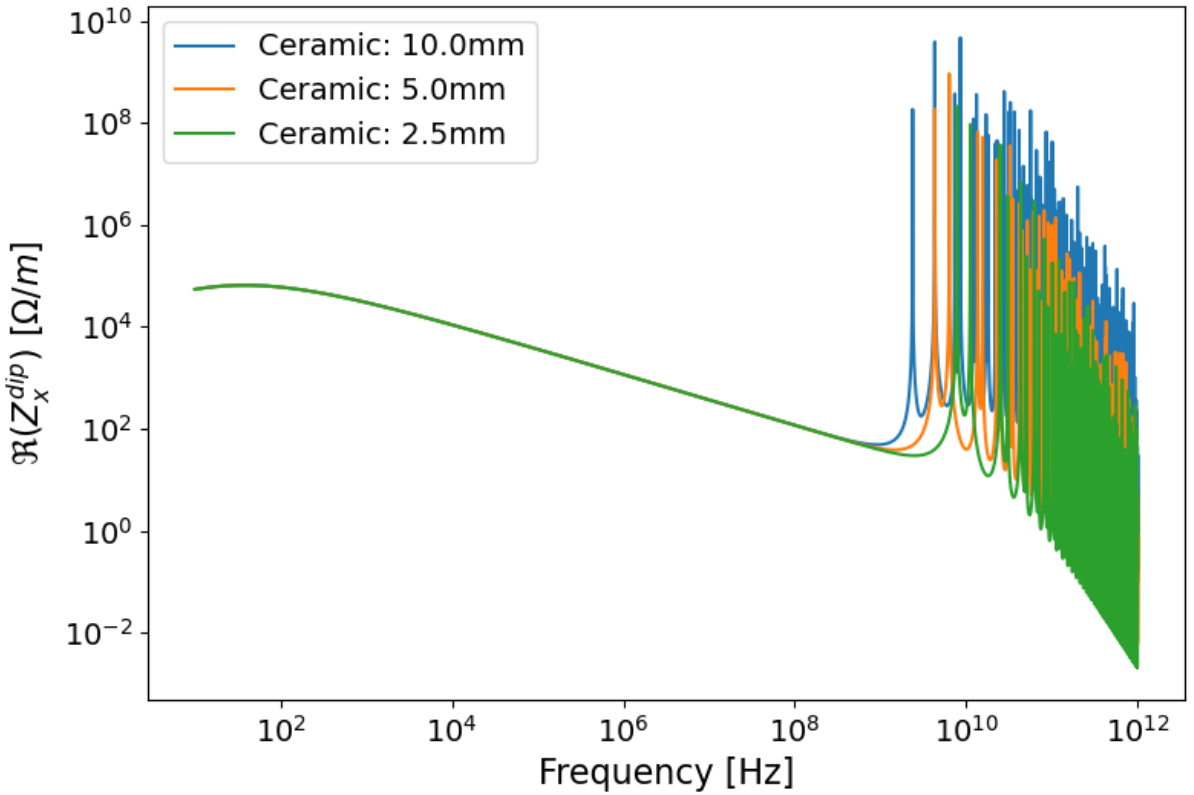
| | RCS: | 2 | 3 | 4 |
|---|---|---|---|---|
| 10 mm stripe width | Energy loss [J/cycle/m] | 16.01 | 7.43 | 2.76 |
| 5 mm stripe width | Energy loss [J/cycle/m] | 4.01 | 1.86 | 0.69 |
| 2 mm stripe width | Energy loss [J/cycle/m] | 0.65 | 0.30 | 0.11 |

# Impedance Dependence on Ceramic Thickness

- The thickness of the ceramic does have an impact on the resonance frequencies.
- The peaks reduce in magnitude when increasing the ceramic thickness. However not by enough, stable beam still not possible with this design.

**Impedance Model Cross Section**



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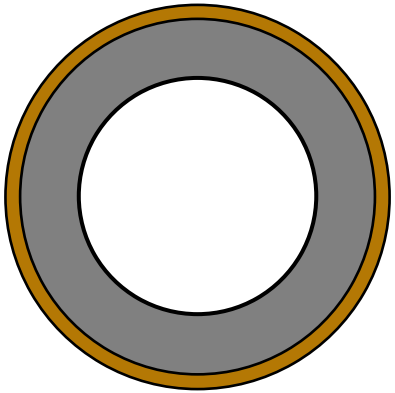
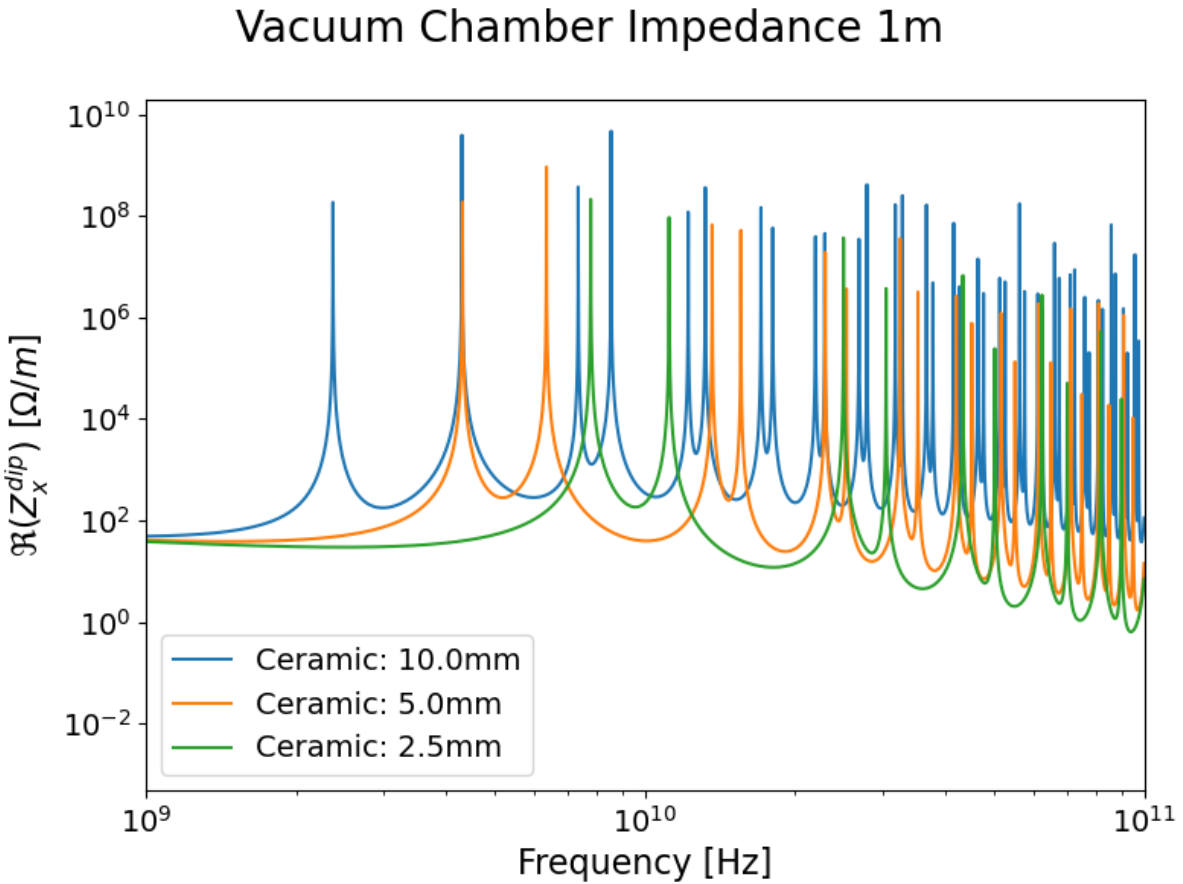
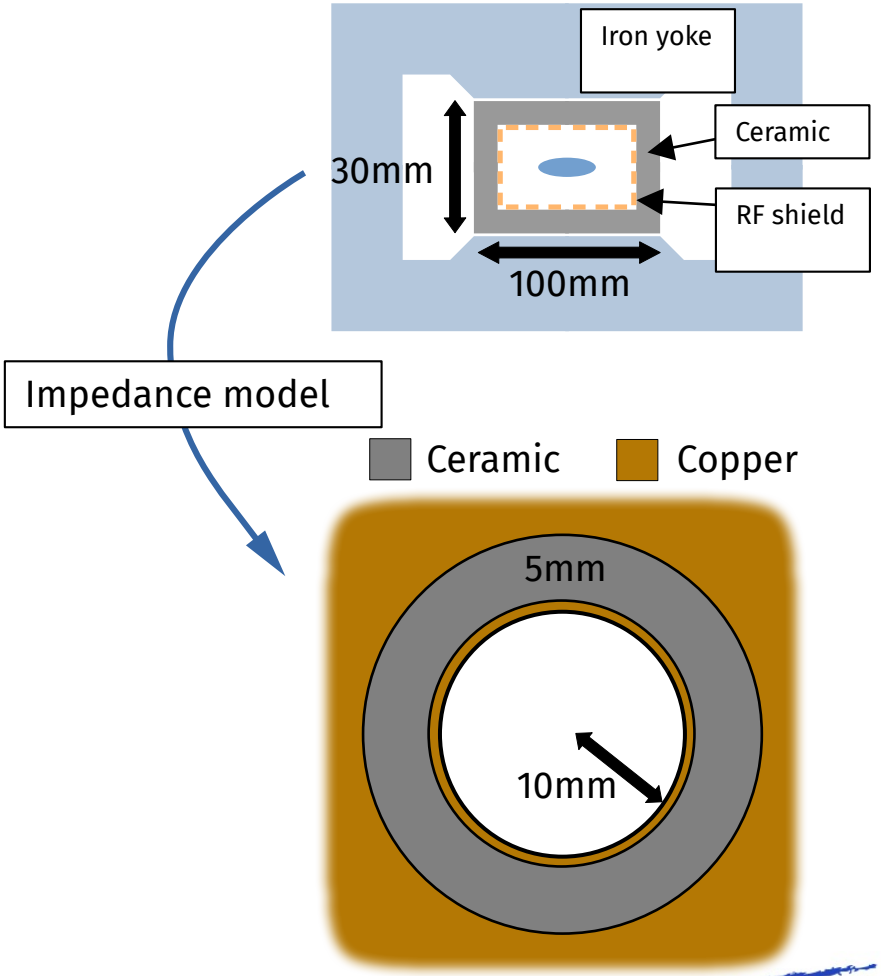


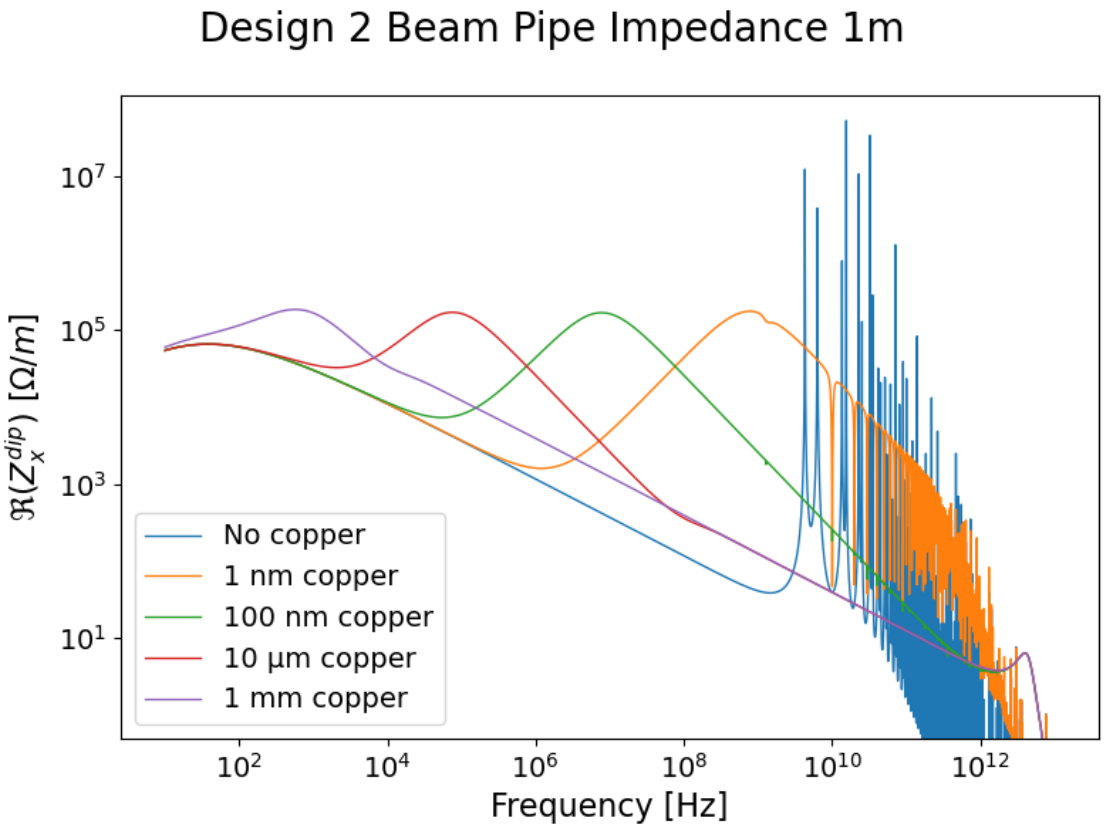
# Design 2: RF-Shield on the Inside of Insulating substrate

- The second design was first conceived by Bruno Zotter, featuring copper stripes attached to the **inside** of an insulating material, which we will assume to be ceramic.
- We will again make the assumption that the copper stripes can be modeled as a **thin cylindrical layer**.
- For simplicity, the magnet is modeled as an infinitely thick layer of copper.
- We use IW2D to compute the impedance and **scan over different copper thicknesses** to find the amount of copper needed to provide the beam with sufficient RF-shielding.
- The inner radius is kept constant at **10mm** while the ceramic thickness is set to **5mm**.



# Design 2: Beam Coupling Impedance

- Even with a very thin (~nm) layer of copper we are able to **suppress the resonances** we saw in Design 1.
  - This effect is explained by Zotter on page 168 in "Impedances and Wakes in High Energy Particle Accelerators"
- Increasing the thickness of the copper layer can significantly **reduce the impedance at higher frequencies**.



# Design 2: Beam Pipe Wake

- The wake has a **strong dependence on the thickness** of the copper layer. By decreasing the copper thickness, we see an increase in the wake.
- By setting the copper thickness to zero, we are essentially left with Design 1 with an infinitely thick copper layer.
- To determine the thickness of copper needed to provide sufficient RF-shielding to the beam, we will conduct full **RCS chain simulations** using XSuite.