The Single-Mode-Cavity proposed by H. Herminghaus

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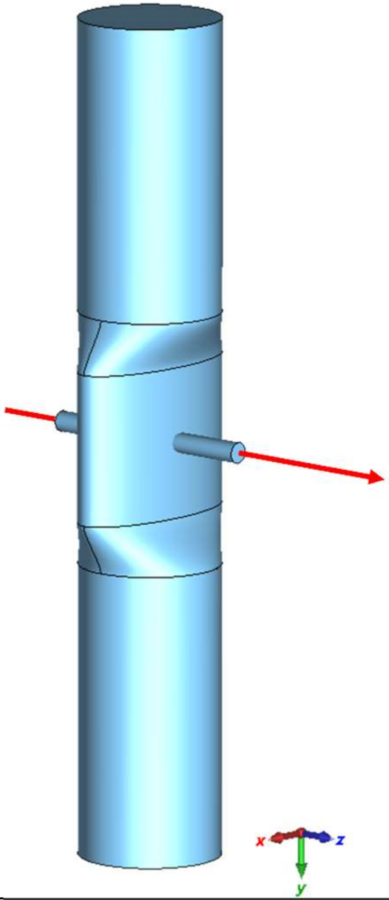

Outline

- 3^{rd} Harmonic Cavity
- Single-Mode-Structures
- Herminghaus‘s Structures
- Simulation Results
- Conclusion and Outlook

3^{rd} Harmonic Cavity

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- Goal for PETRA IV:
  - High Brightness Electron Synchrotron

- Problem - Main degradation Effect:
  - Touschek Effect – Scattering of electrons

- Solution
  - Bunch Lengthening with a Harmonic Cavity
    - Mitigation of this Effect by a Reduction of the Charge Density

3rd Harmonic Cavity
Requirements

- Ground mode at $1500\ \mathrm{MHz}$
- Damped Higher Order Modes
- Detunability

- High Q-Factor
- High Transit Time Factor

$$Q = \frac{\omega W}{P_{loss}}, \qquad T_{\mathrm{Tr}} = \left| \frac{\int_{-L/2}^{L/2} E_0(s)\,\mathrm{co}\,\left(\frac{\omega s}{c}\right) ds}{\int_{-L/2}^{L/2} E_0(s) ds} \right|$$

Single-Mode-Structures

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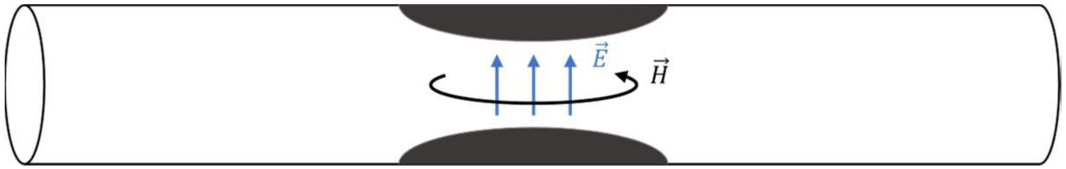
- Excited HOM's can lead to:
  - Disturbing the Acceleration Process
  - Including up to Beam Break Up (BBU)

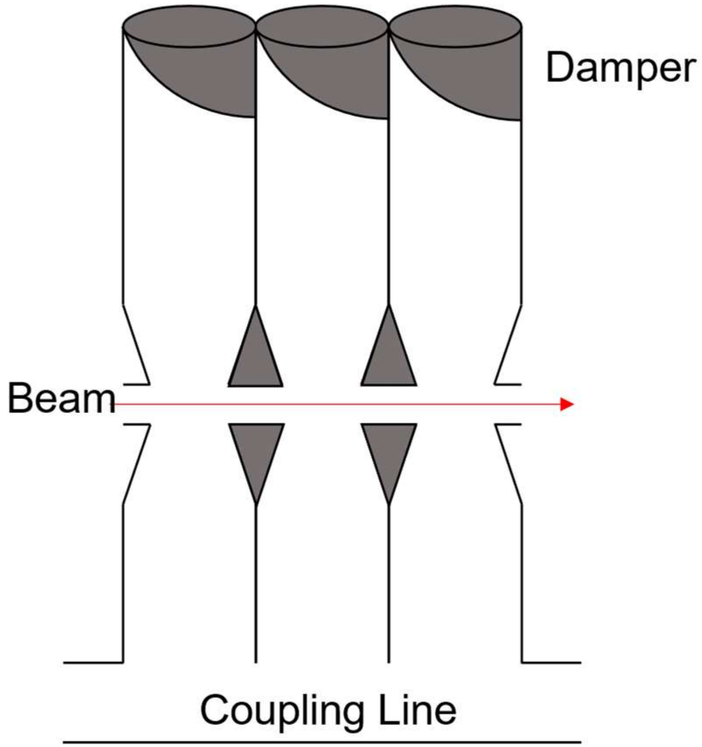
➢ Suppression of Higher Order Modes is desirable
  - Otherwise, excitation is very possible

- Herminghaus and Euteneuer mentioned 3 solutions
  1. Shifting the HOM's resonant frequencies from cavity to cavity
  2. Selective decoupling of modes and damping them isolated from the accelerating mode

3. Single-Mode-Cavity

- Herminghaus Proposition:
  - Circular cylindrical Waveguide as base
  - Reduction of the diameter at the center of the TE_{11}-mode
  - HOM travel out into a damper
  - Accelerating mode is trapped at the indentation





Following: Internal Paper by Herminghaus, Enteneuer 1978 – Vorversuche zur Single-Mode-Struktur

Herminghaus‘s Structures

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- Indentation is formed by the beampipe
- Short circuit posts and plates to trap the accelerating mode
- Measurements of prototype
  - $Q \approx 13700$
  - $T_{\mathrm{Tr}} \approx 0.85$

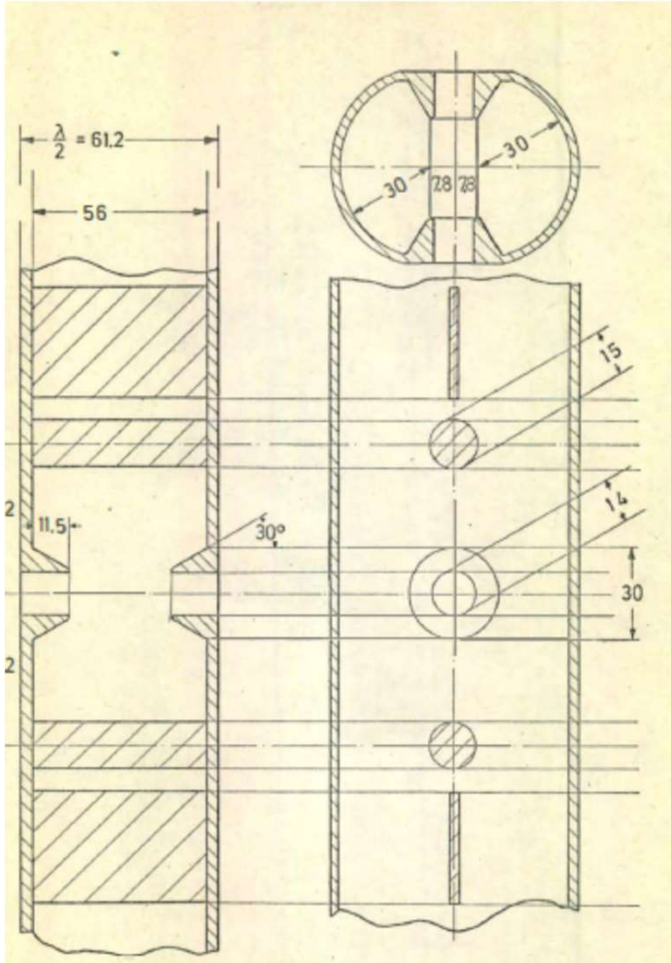
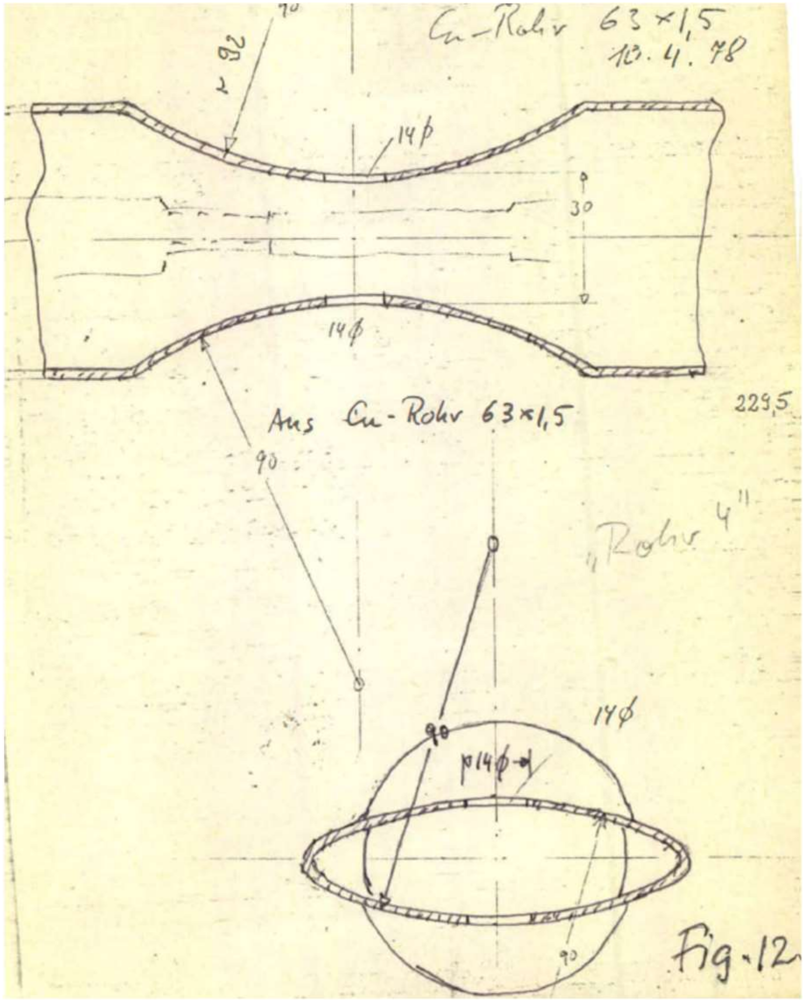


Fig. 10

Source: Internal Paper by Herminghaus, Enteneuer 1978 – Vorversuche zur Single-Mode-Struktur

Herminghaus‘s Structures

- Elliptic narrowing by squashing the circular waveguide



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Simulation Model

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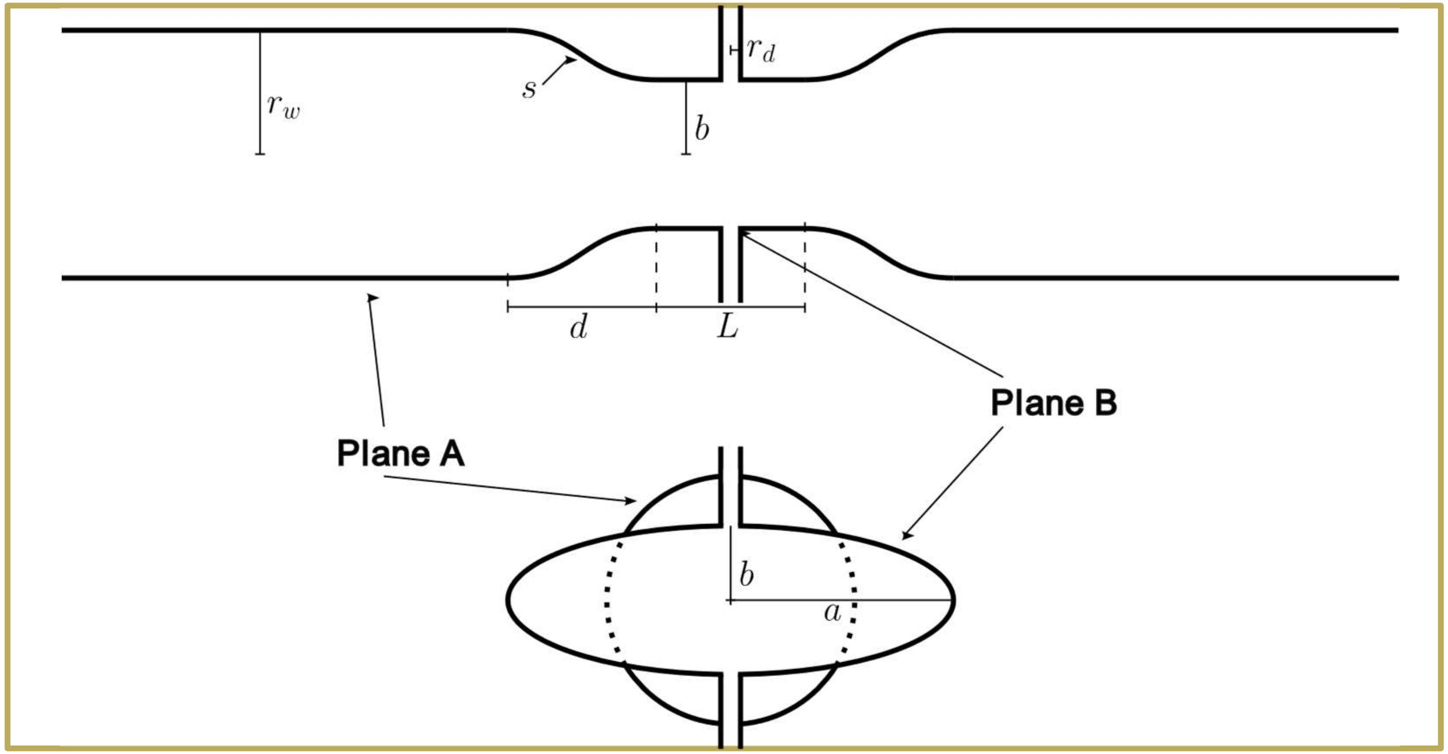


Cutoff Frequency:

- Circular Waveguide: $f_c = \frac{j'_{\mathrm{mn}}}{2\pi r_w} c_0$, j'_{mn}: n[th] zero of the 1[st] derivatve of the bessel function of the m[th] order
- Elliptic Waveguide: $f_c = \frac{\sqrt{q_{mn}}}{\pi a e} c_0$, q'_{mn}: n[th] zero of the 1[st] derivatve of the even mathieu function of the m[th] order

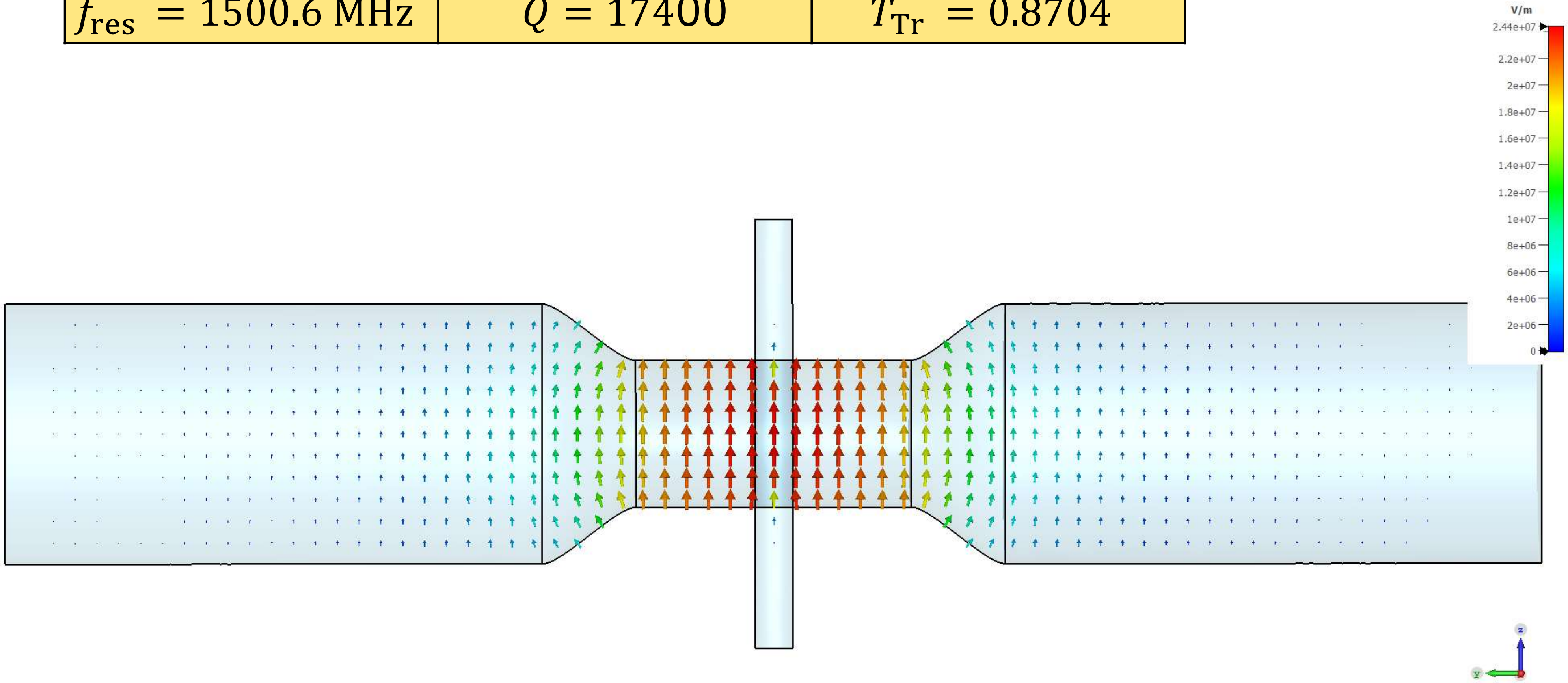
  e: the numerical excentricity

Circumference Ellipse: $C = 4a \int_0^{\pi/2} \sqrt{1 - e^2 \sin^2(\varphi)}\, \mathrm{d}\varphi \approx \pi \left(3 \frac{(a+b)}{2} - \sqrt{ab}\right)$

Simulation Model

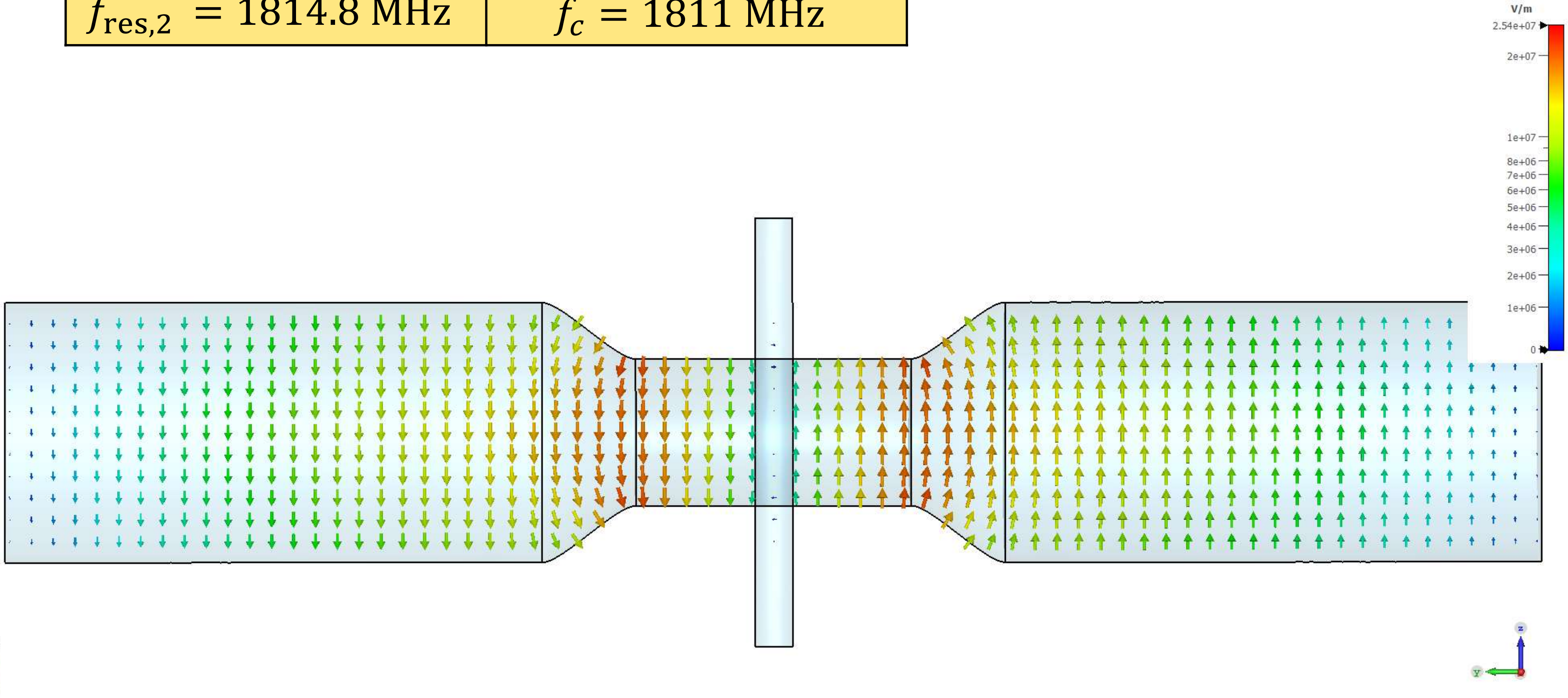
E-Field of 1st Mode

$f_{\mathrm{res}} = 1500.6\ \mathrm{MHz}$	$Q = 17400$	$T_{\mathrm{Tr}} = 0.8704$

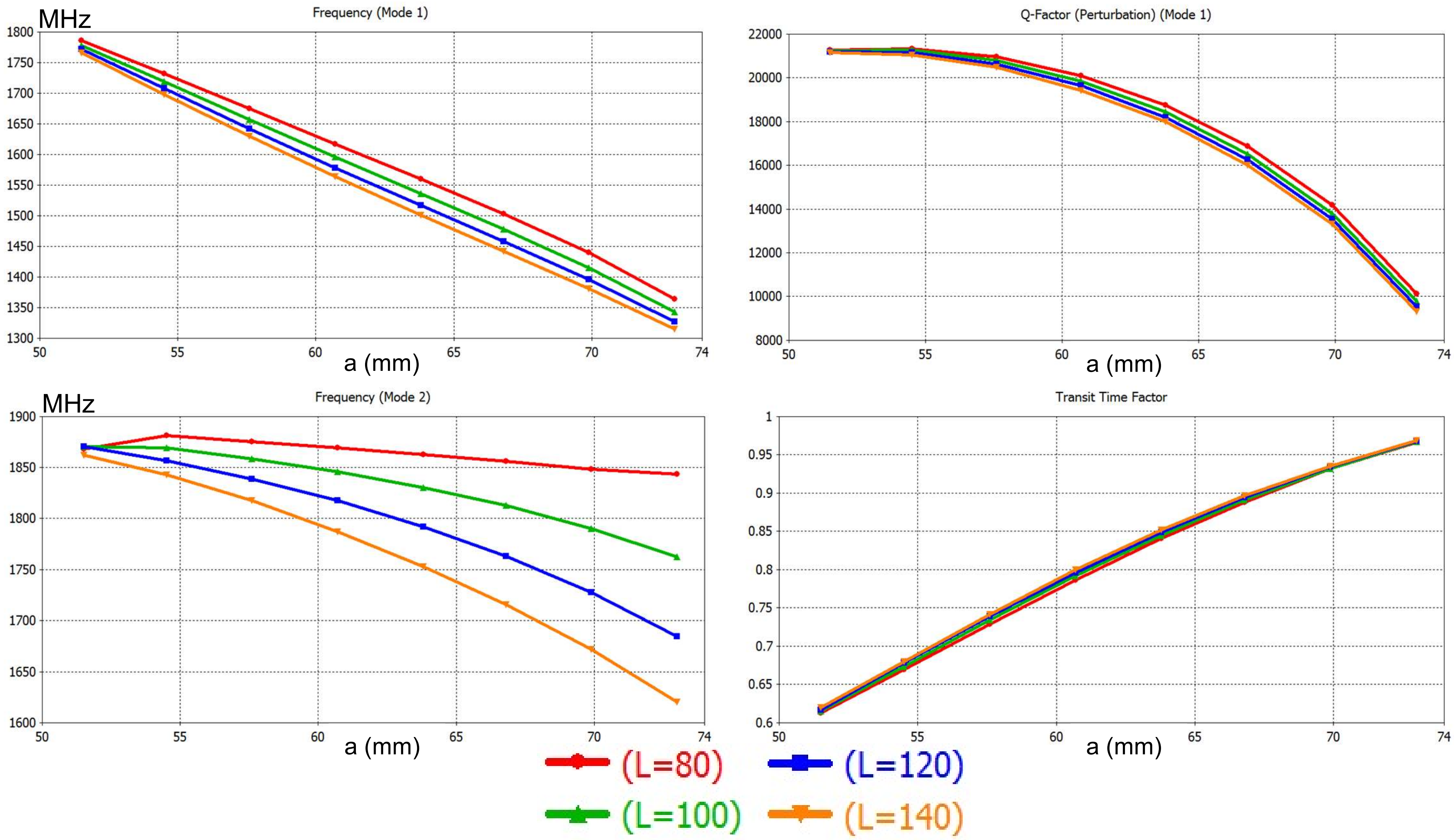


Simulation Model
E-Field of 2nd Mode

$f_{\text{res},2} = 1814.8\ \text{MHz}$	$f_c = 1811\ \text{MHz}$



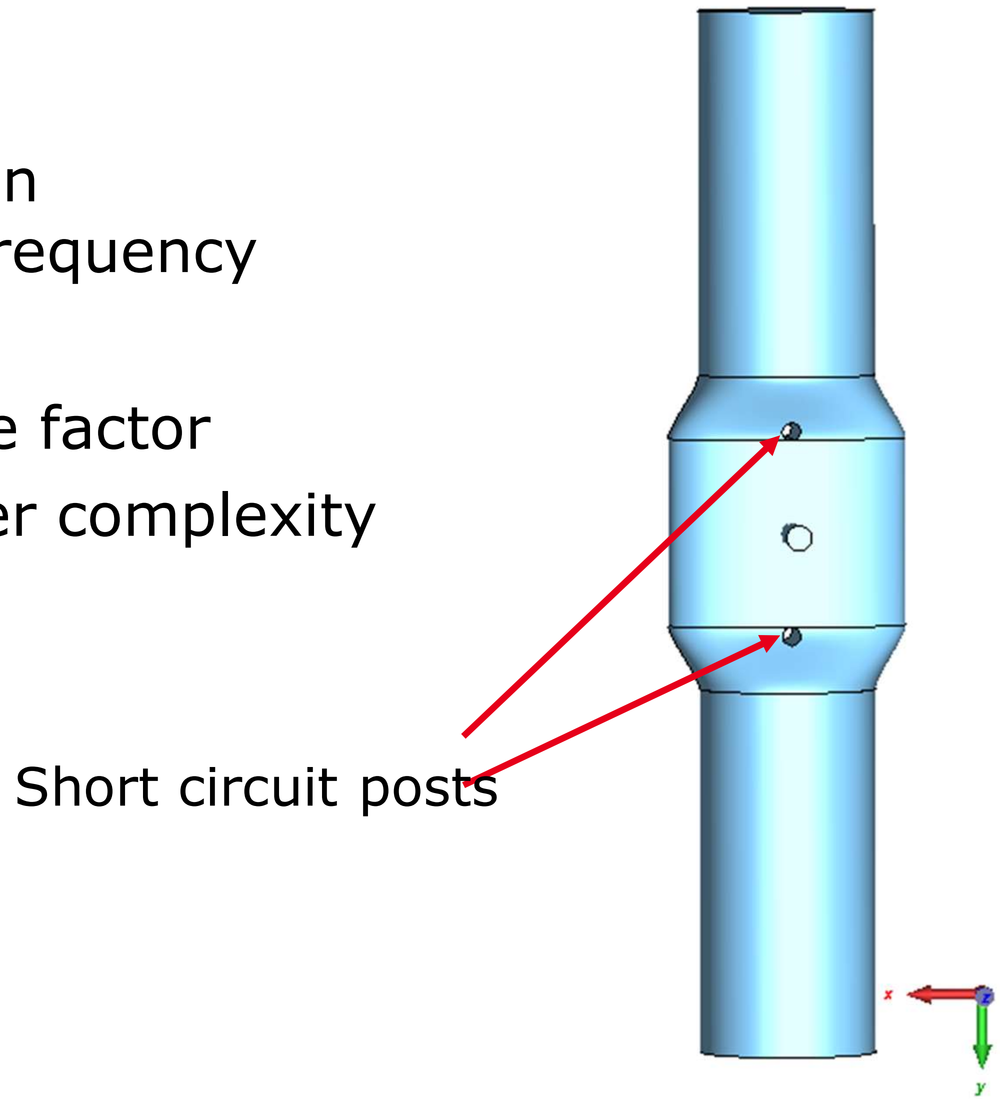
Simulation Model
Parametric Impacts



Simulation Model
Addition of Posts

+ Adds possibility of tuning
+ Increases the gap between the 1st and 2nd resonant frequency

- Decreases the transit time factor
- More parameters → Higher complexity



Conclusion and Outlook

- Q values in excess of 20000 possible

- Difficulties achieving a high Q and a high transit time factor
- High dimension parameter space

- Next steps:
  - Sensitivity analysis for robust optimization
  - Try other geometries
  - Try other inserts (short circuit plates, nose cones)
  - Design a coupler

Thank you for your attention!