Coupling impedance of the FCC-hh cold beamscreen

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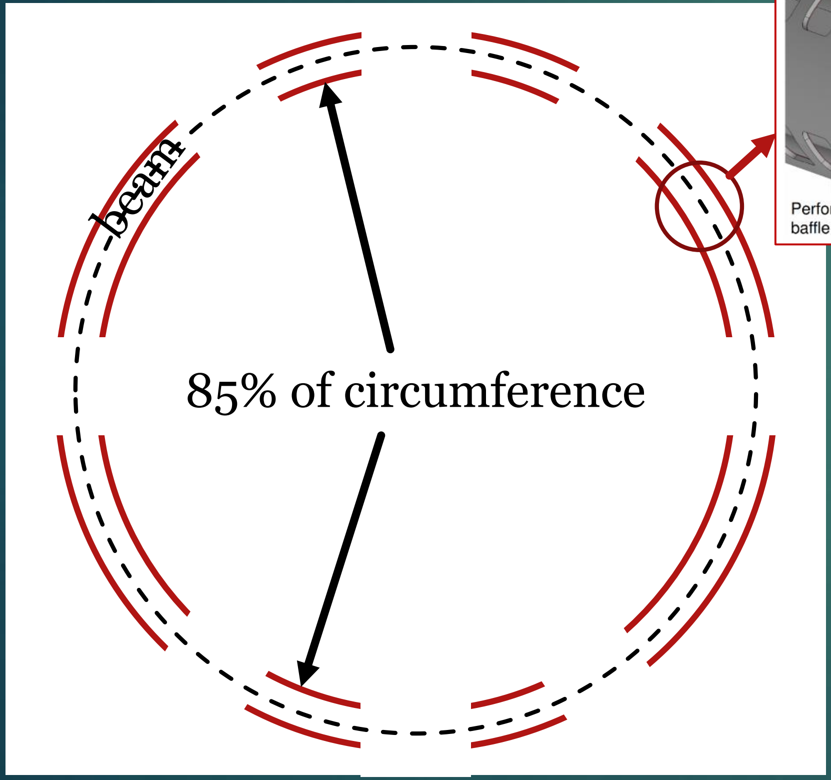
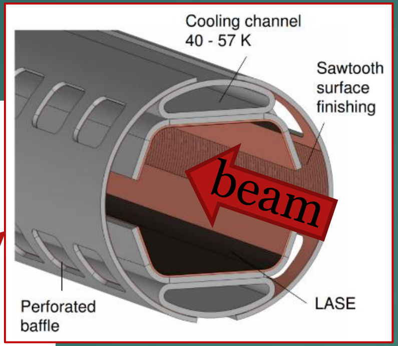
FCC week 2018 in Amsterdam
12 April, 2018

What is cold beamscreen and what is coupling impedance?

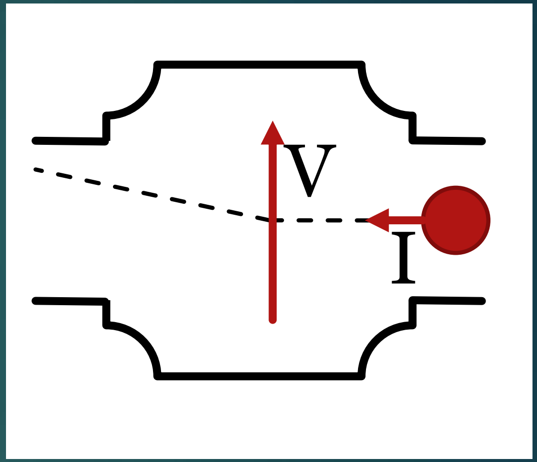




Deflecting voltage

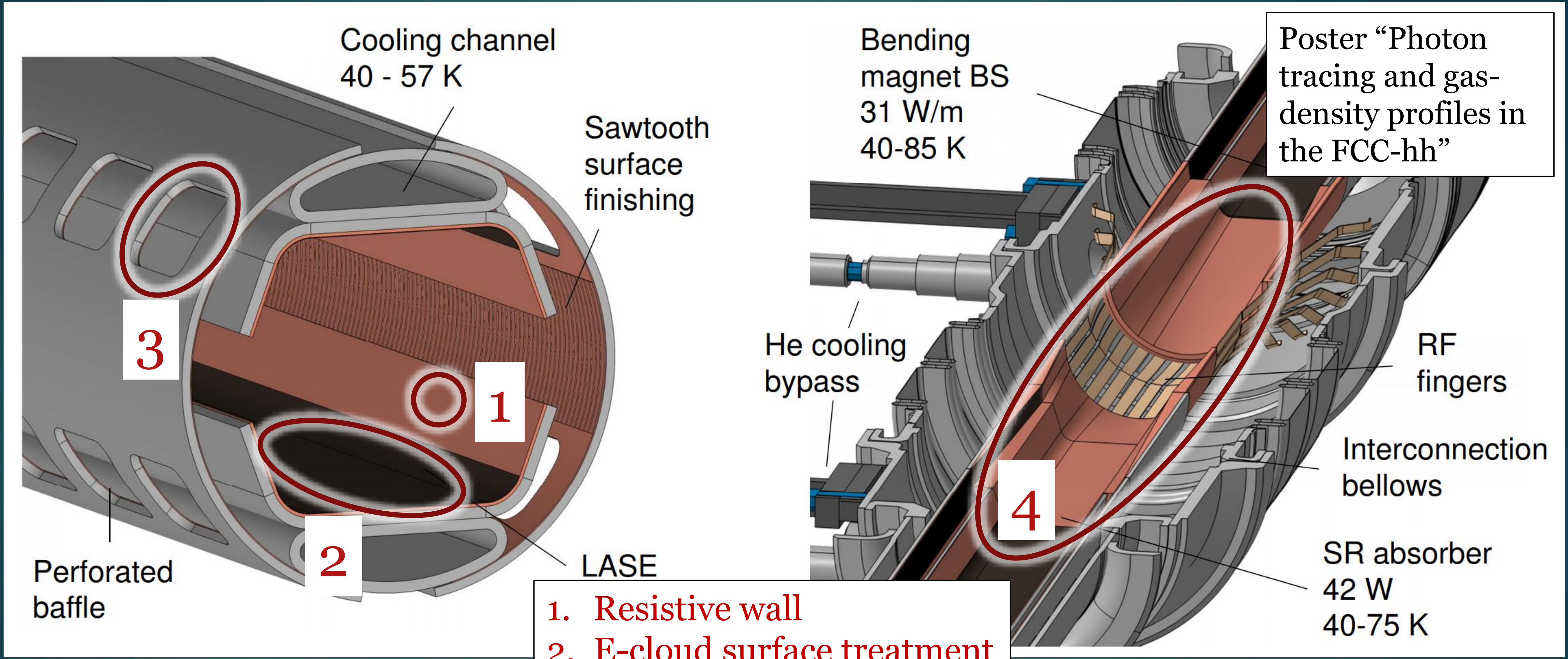
Transverse coupling impedance $Z = \frac{V}{I}$

Beam current



Higher coupling impedance
=
lower maximum beam current before the beam goes unstable

Sources of beamscreen impedance

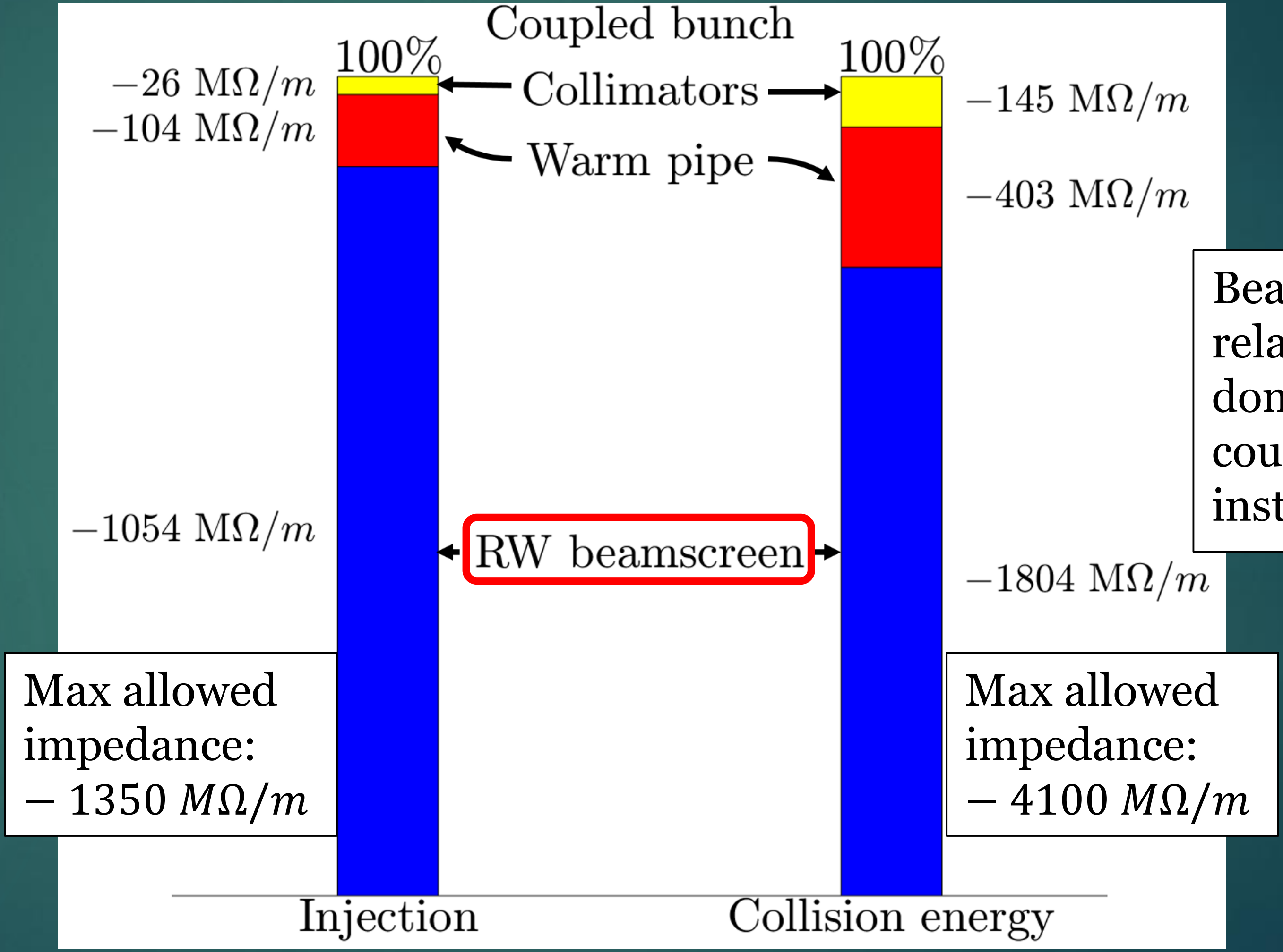


1. Resistive wall
2. E-cloud surface treatment
3. Pumping holes
4. Interconnects

Role of beamscreen in the impedance model (1/2)

Beamscreen-related impedance:

- Resistive wall
- E-cloud surface treatment
- Pumping holes
- Interconnects



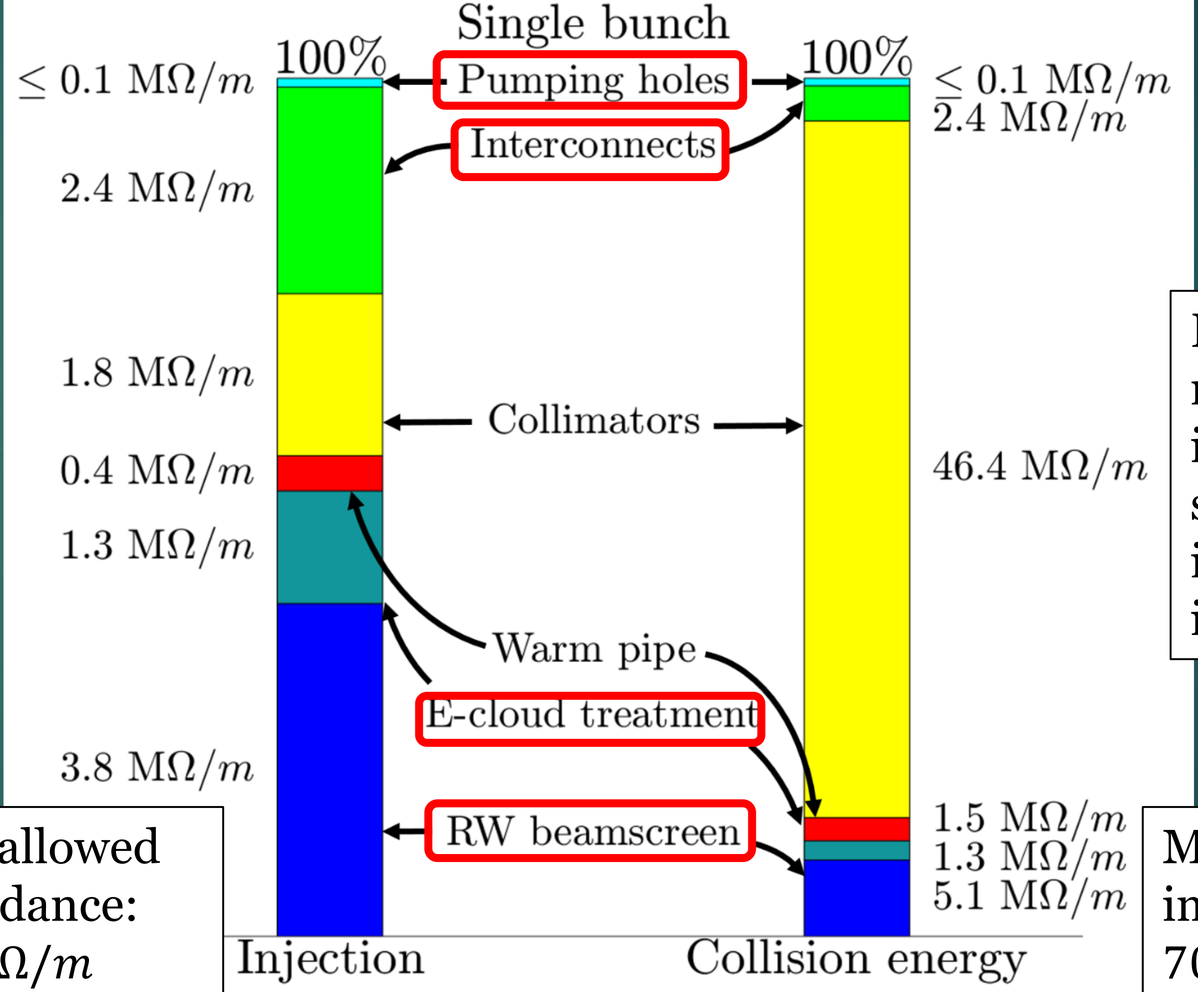
Beamscreen-related impedance dominates coupled-bunch instability

Effective impedance for the coupled bunch instability (y-plane)

Role of beamscreen in the impedance model (2/2)

Beamscreen-related impedance:

- Resistive wall
- E-cloud surface treatment
- Pumping holes
- Interconnects



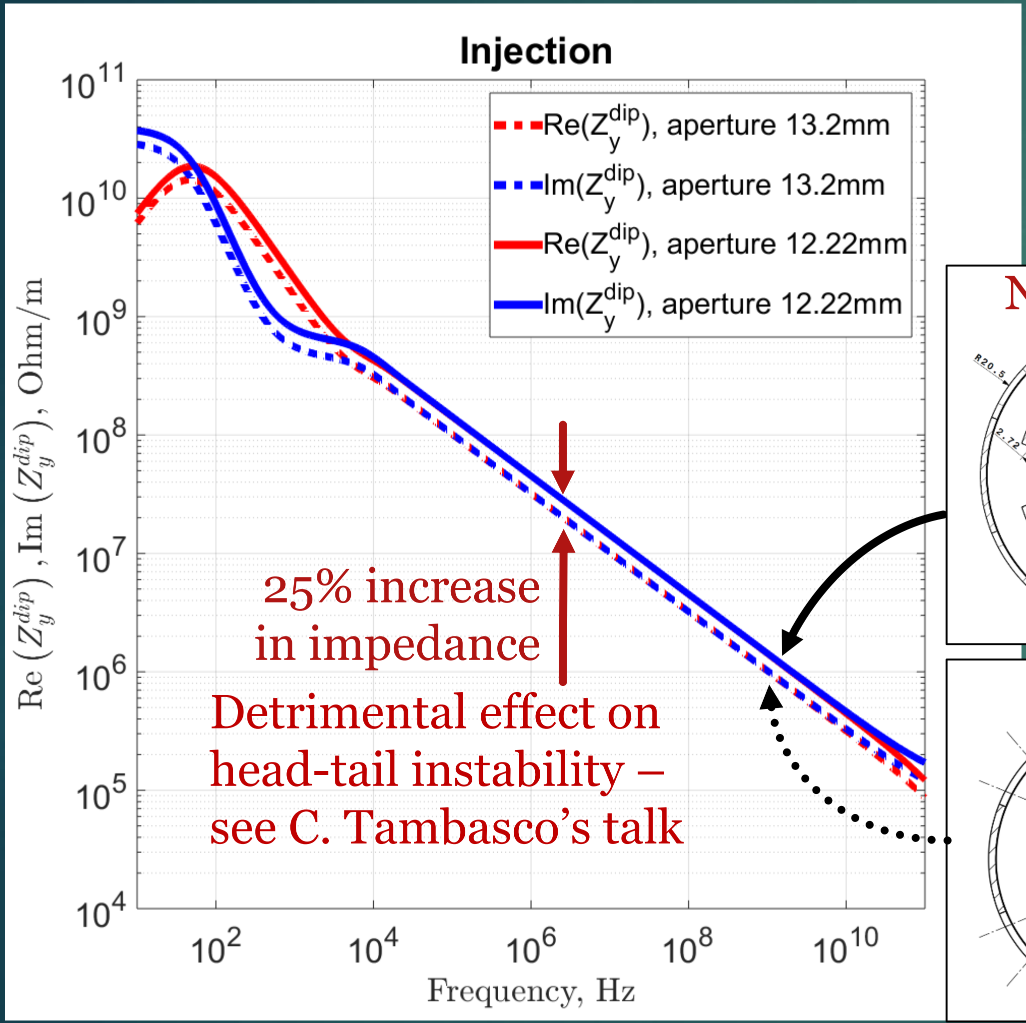
Max allowed impedance: 12 $M\Omega/m$

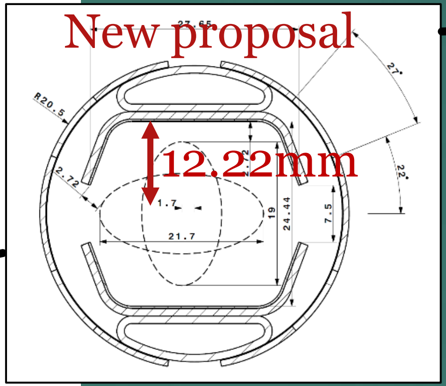
Max allowed impedance: 70 $M\Omega/m$

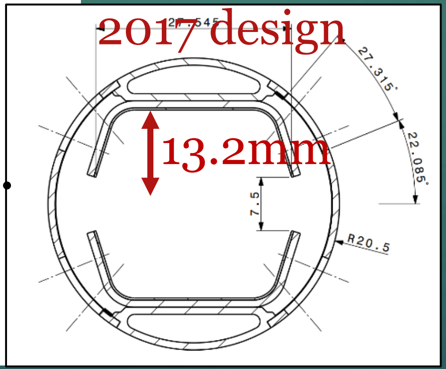
Beamscreen-related impedance is important for single-bunch instability at injection

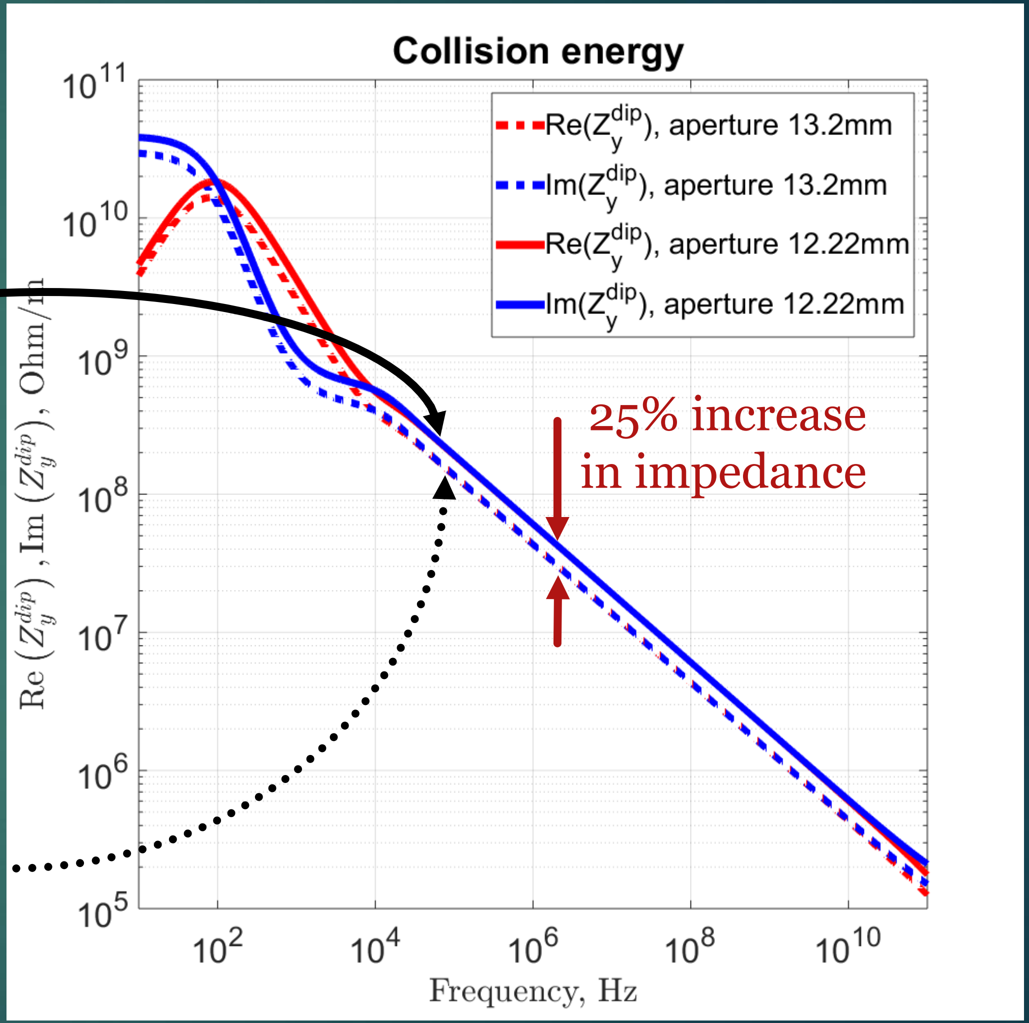
Effective impedances for the single bunch instabilities (y-plane)

Resistive wall impedance of beamscreen



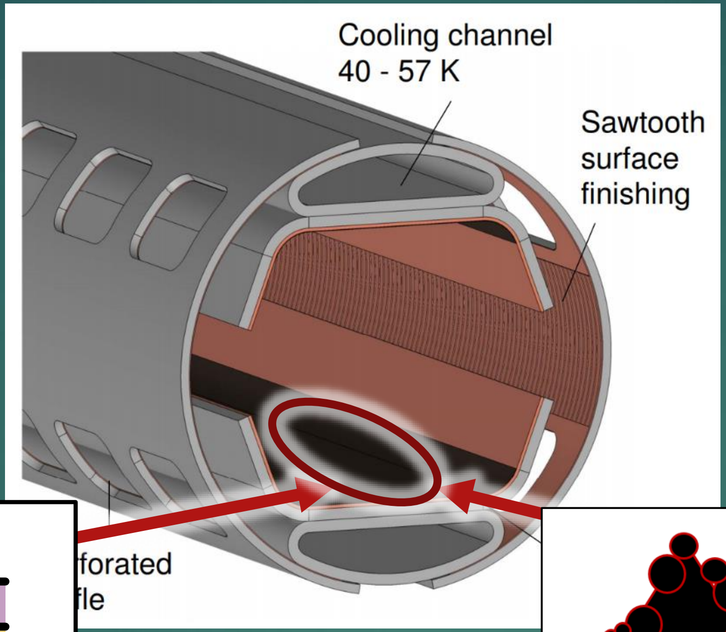


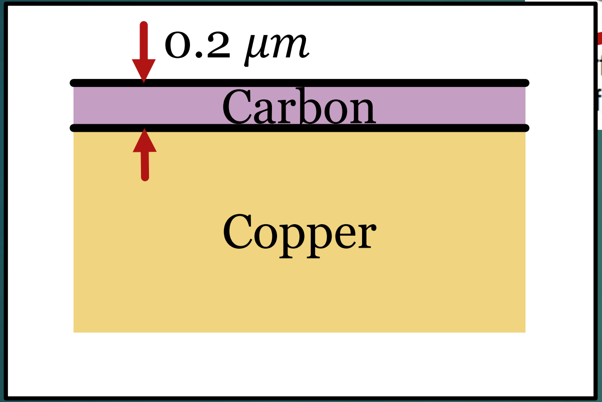




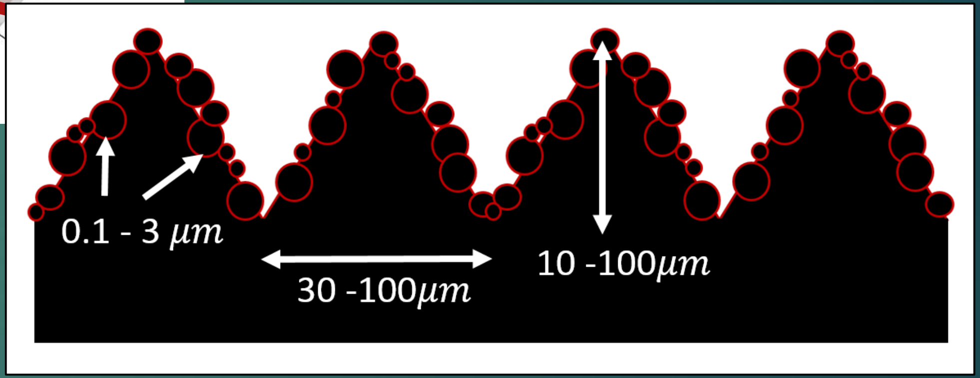
Vertical dipolar impedance weighted by the β-function

E-cloud surface treatment (1/2)





or



Amorphous carbon or TiN coating

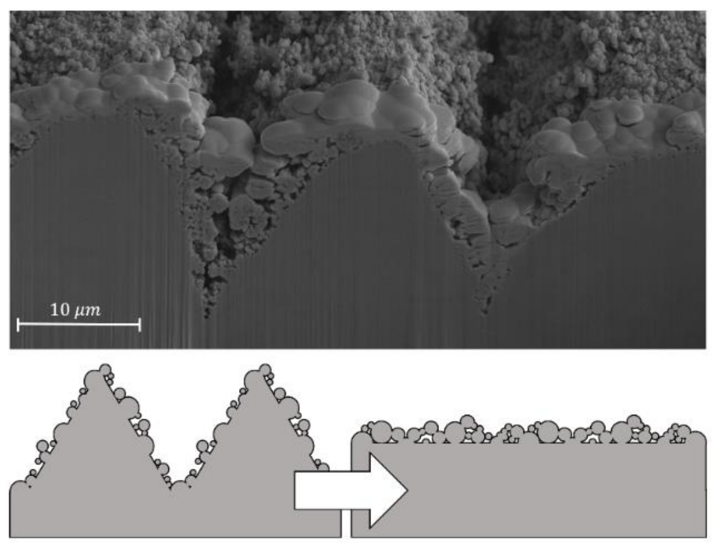
~30% impedance increase at 1 GHz

Laser treatment

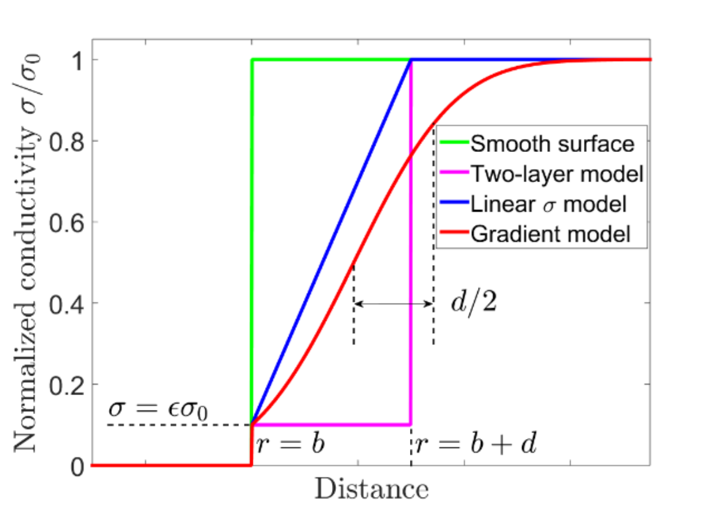
Unknown impedance increase

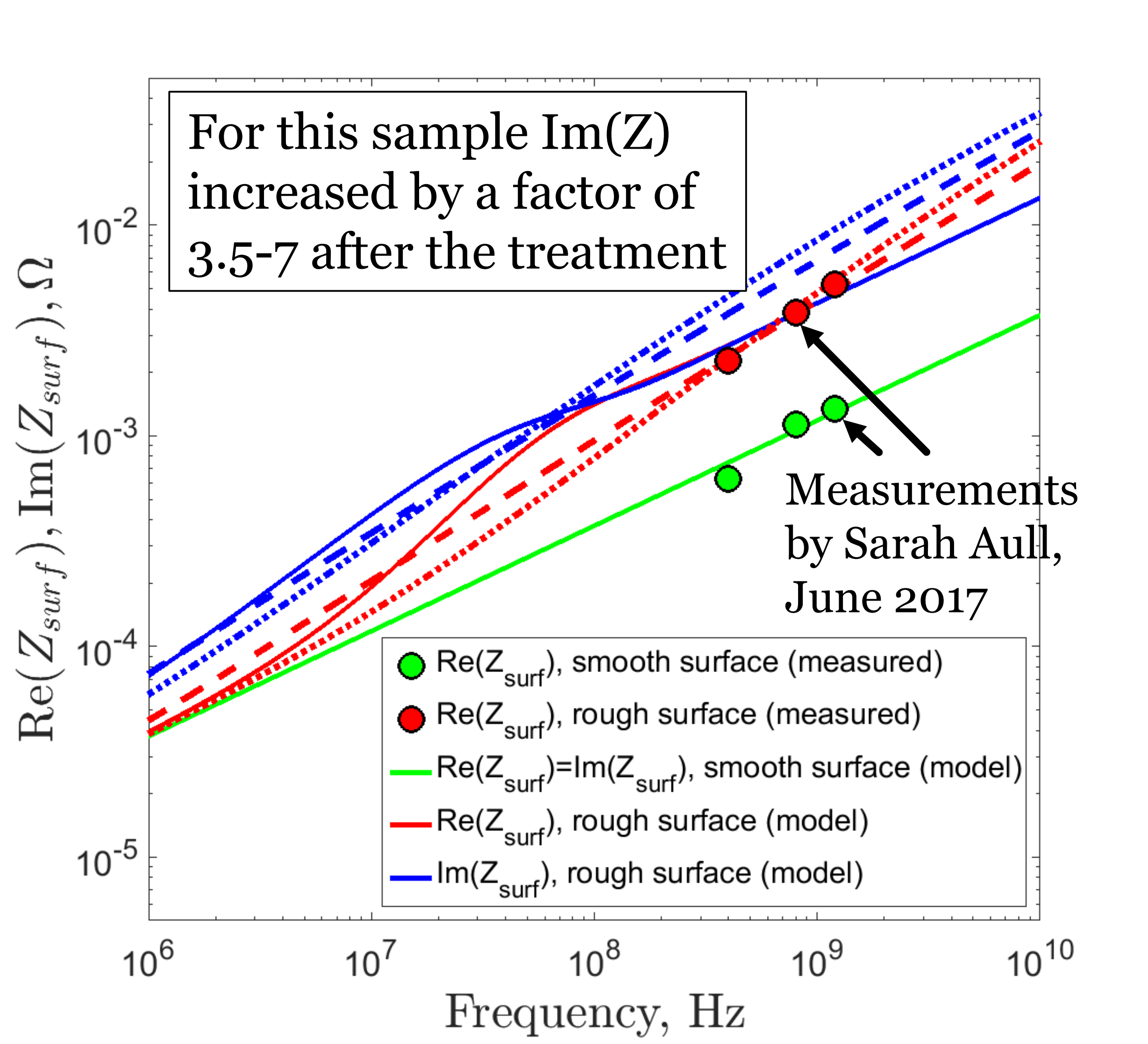
E-cloud surface treatment (2/2)

Interpretation of a rough surface

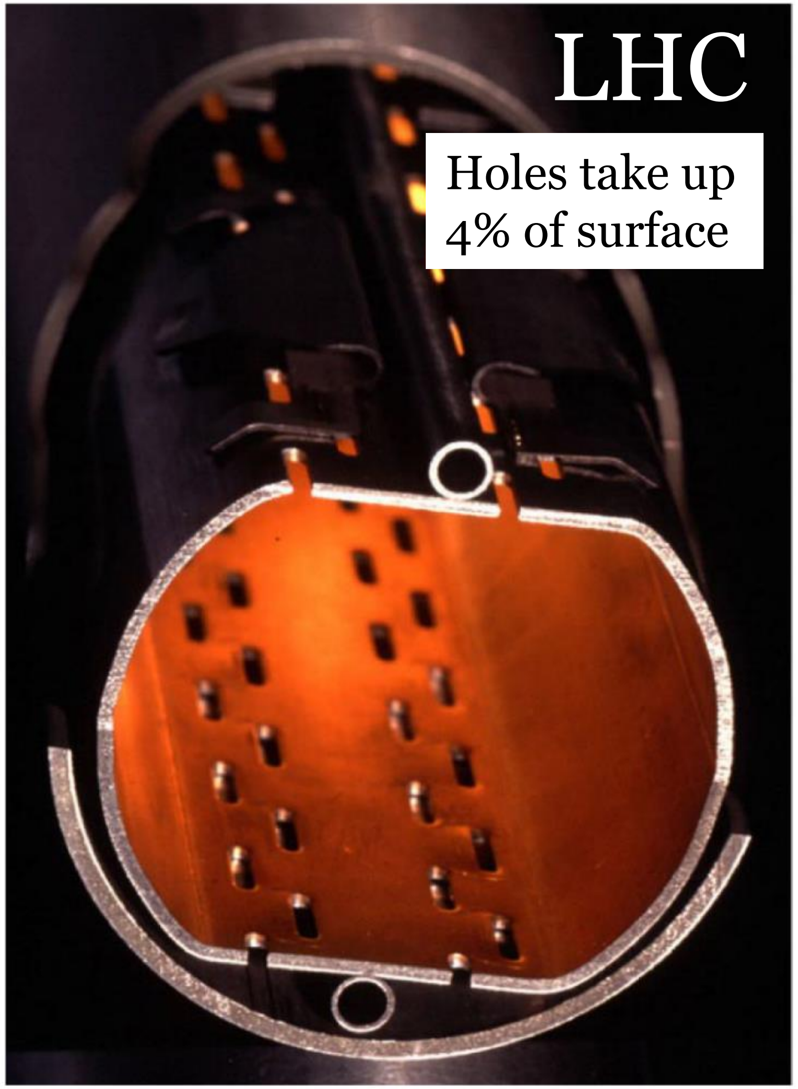


Conductivity vs depth into the wall



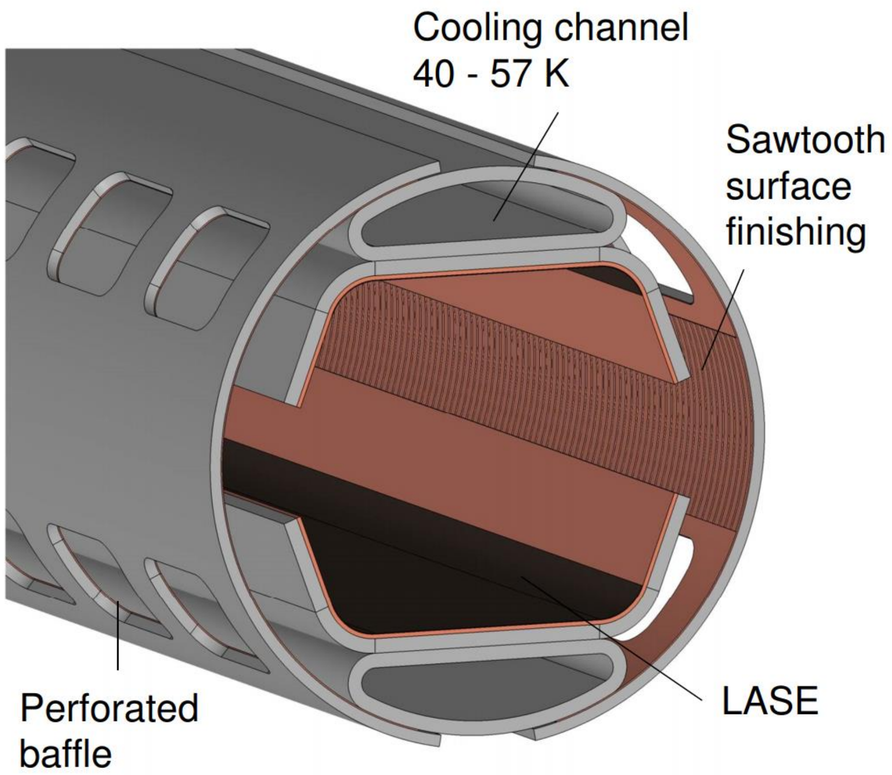


Pumping holes (1/3)

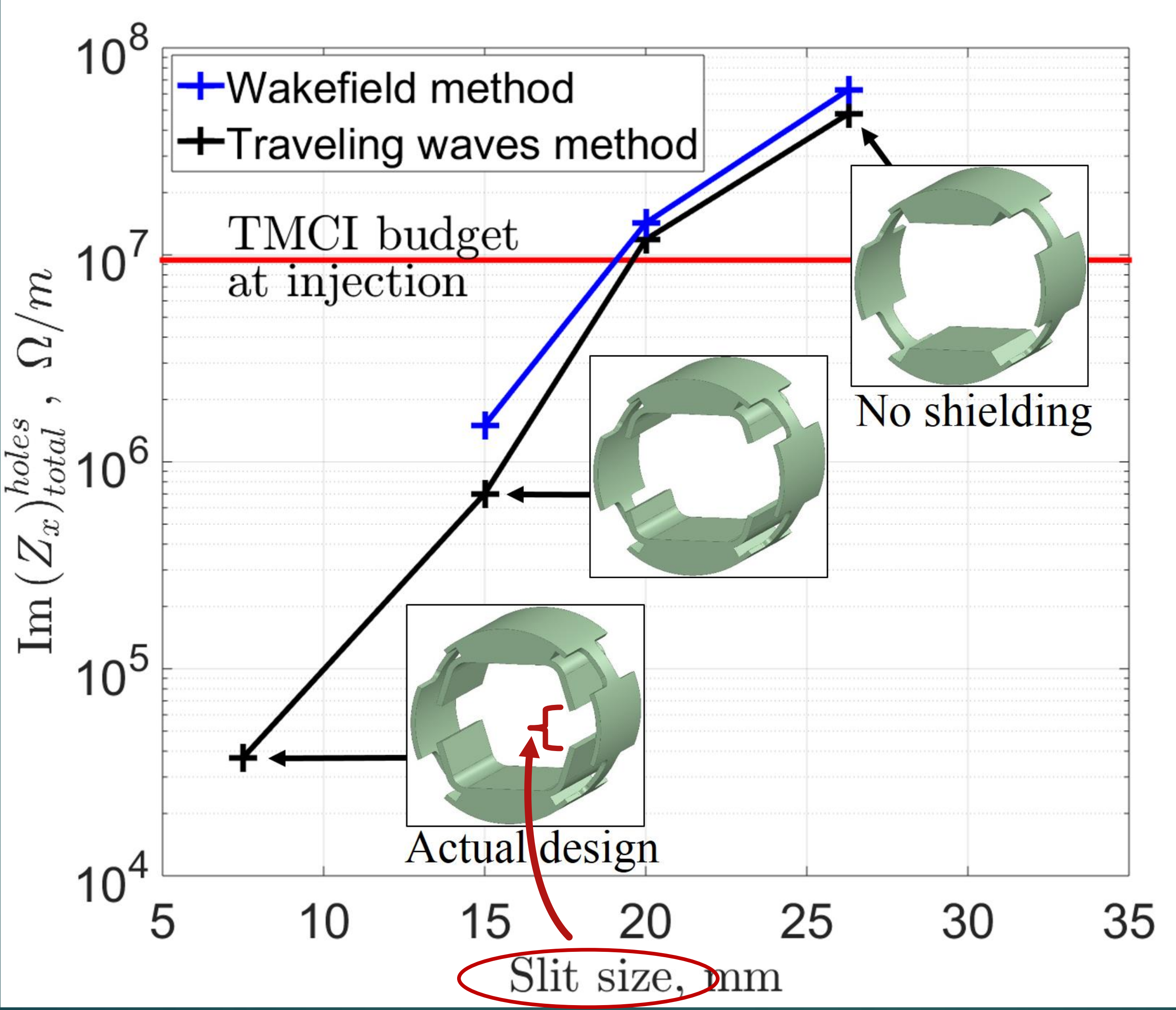


FCC

Holes take up
22% of surface



Pumping holes (2/3)

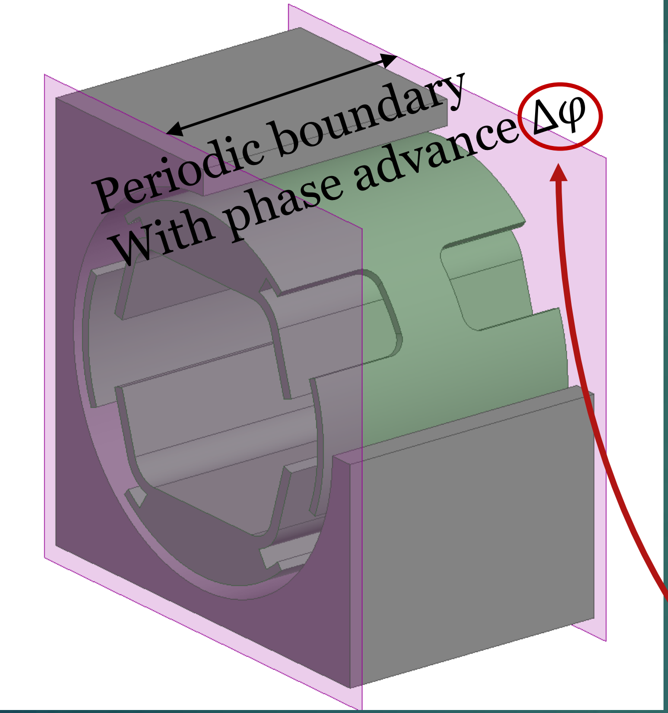


An estimate based on the traveling wave method for the slit size 7.5 mm:

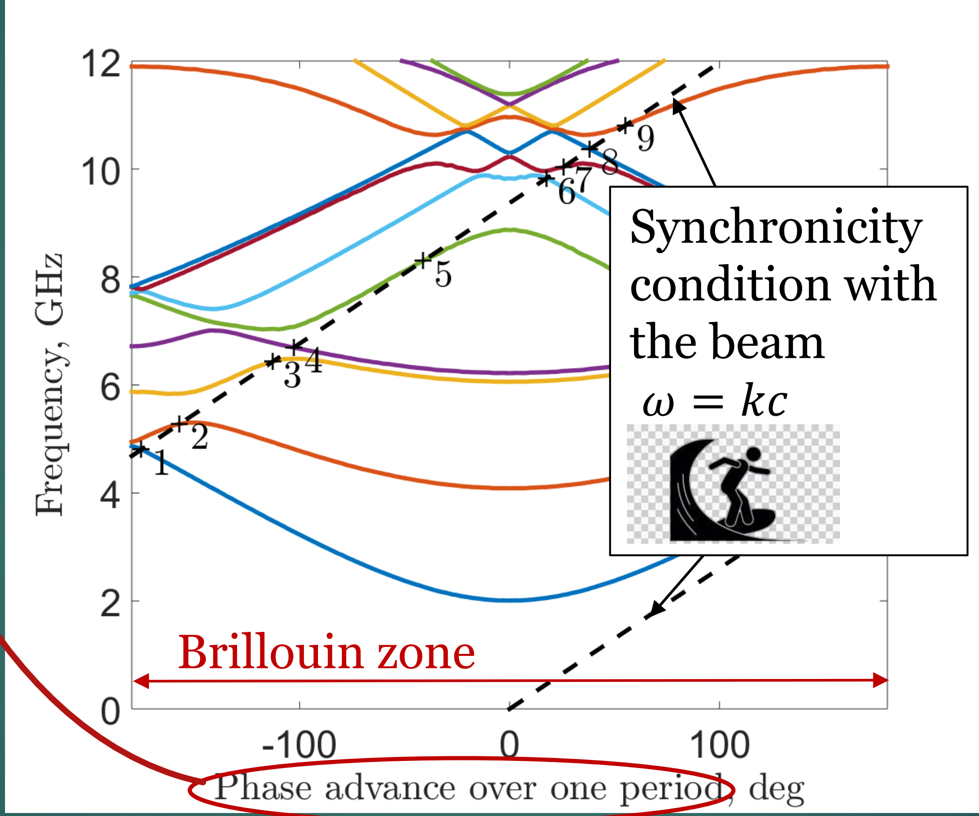
$$Im(Z_x)_{total} \leq 0.1\ M\Omega/m$$

All 10.5 million holes together

Pumping holes (3/3)



Only simulate one period!



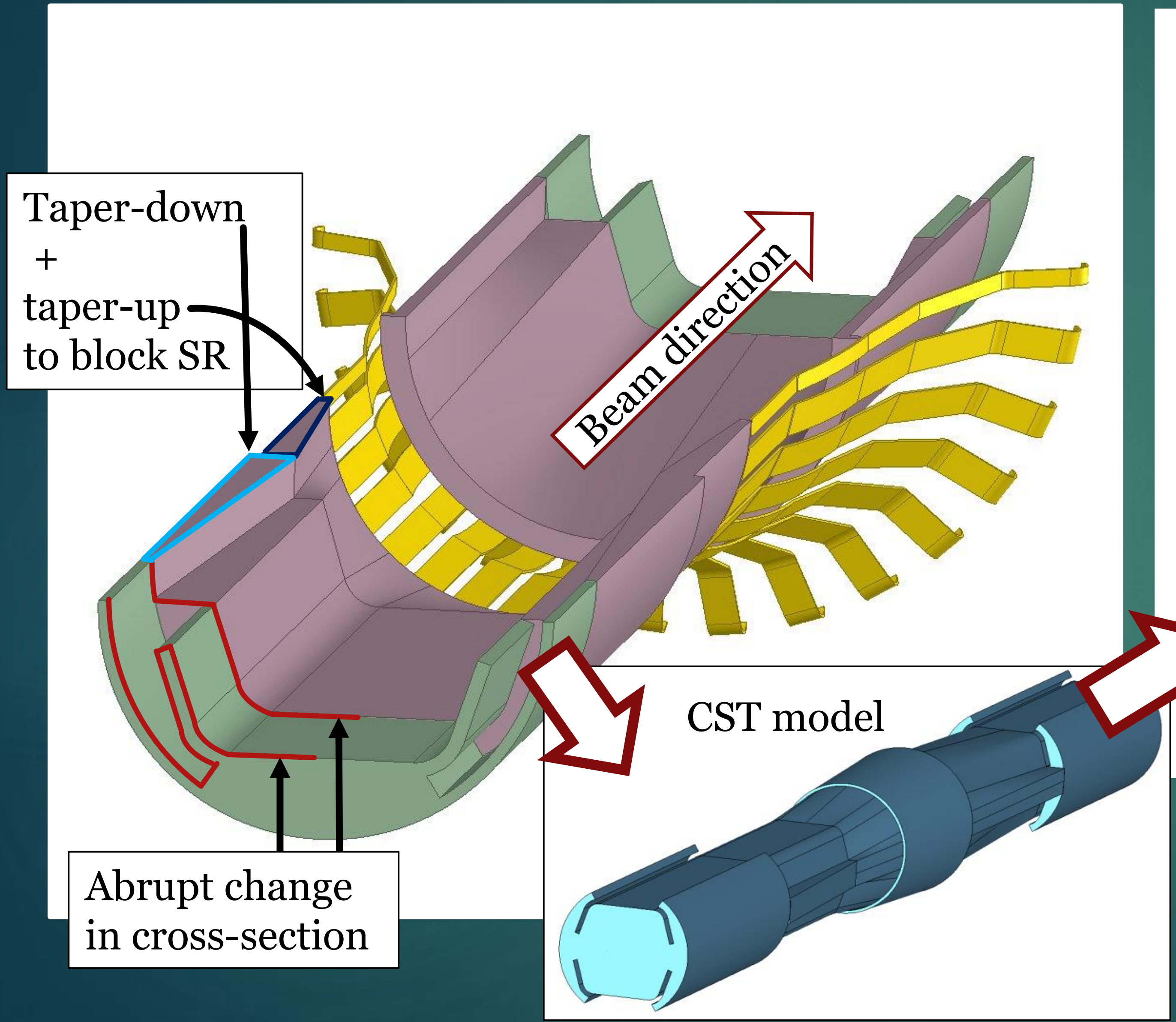
- Find dispersion of N bands in one period
- For each band find intersection with the synchronous line
- For each intersection find $(R/Q)_{||}, (R/Q)_{\perp}$
- Use the resonator model to obtain impedances

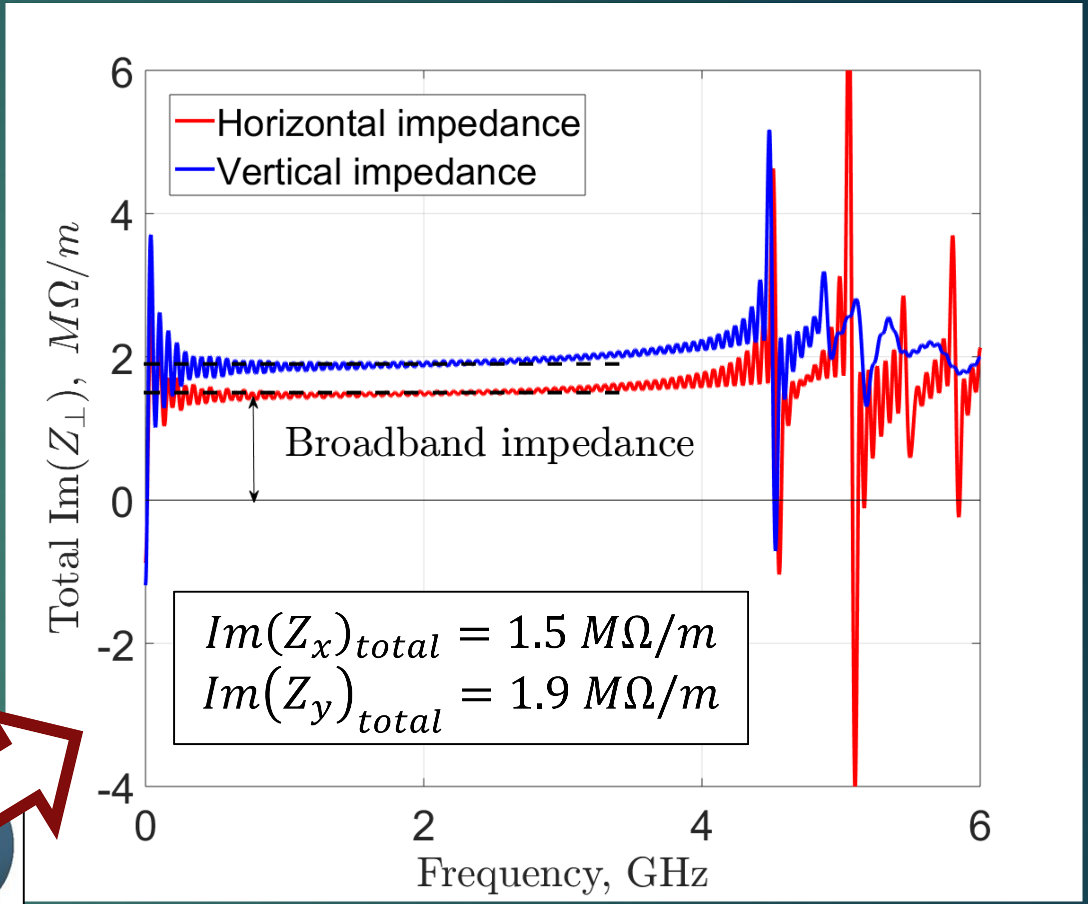
$$Z_{||}(f) \approx i \sum_{n=1}^{N} \alpha_n \frac{f}{f_n} \left(\frac{R}{Q}\right)_{||}^{w}$$

$$Z_{\perp}(f) \approx i \sum_{n=1}^{N} \boxed{\alpha_n} \left(\frac{R}{Q}\right)_{\perp}^{w}$$

Correction due to non-zero group velocity $\alpha_n = \frac{1}{1-v_g/c}$

Interconnects





Imaginary part of dipolar impedance for all 5516 interconnects

Conclusions

Transverse impedance of the

- resistive wall →
  - OK, if aperture=13.2 mm
  - Maybe not OK, if aperture=12.22 mm due to the head-tail instability
- e-cloud surface treatment →
  - OK, if AC or TiN coating is used
  - Unknown, if laser treatment is used (waiting for measurements at FRESCA)
- pumping holes → OK
- interconnects → OK, but can be better

Open questions:

- Power dissipation through the pumping holes (long. impedance)
- Impedance of a laser-treated surface
- Resistive impedance of interconnects (higher temperature)