RF Performance of High-Temperature Superconducting Coated Conductor (HTS-CC) as Beam Screen for FCC-hh

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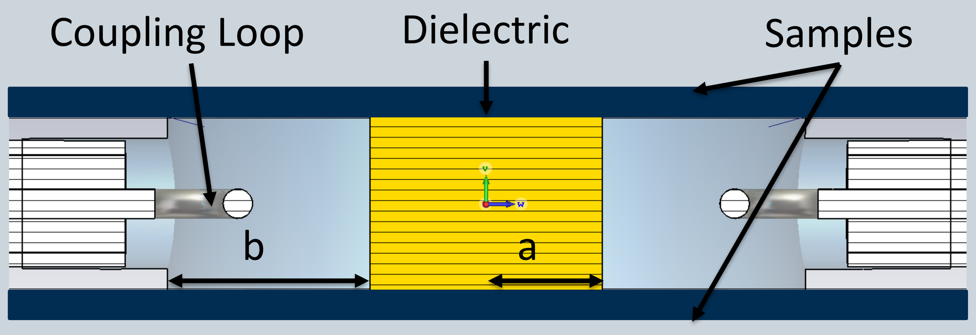
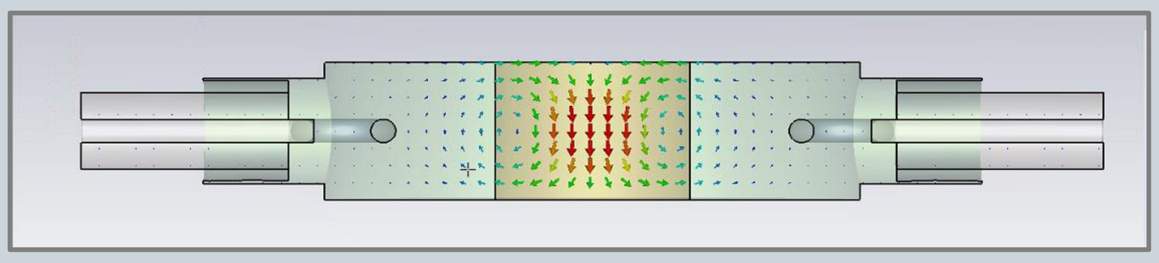
Abstract

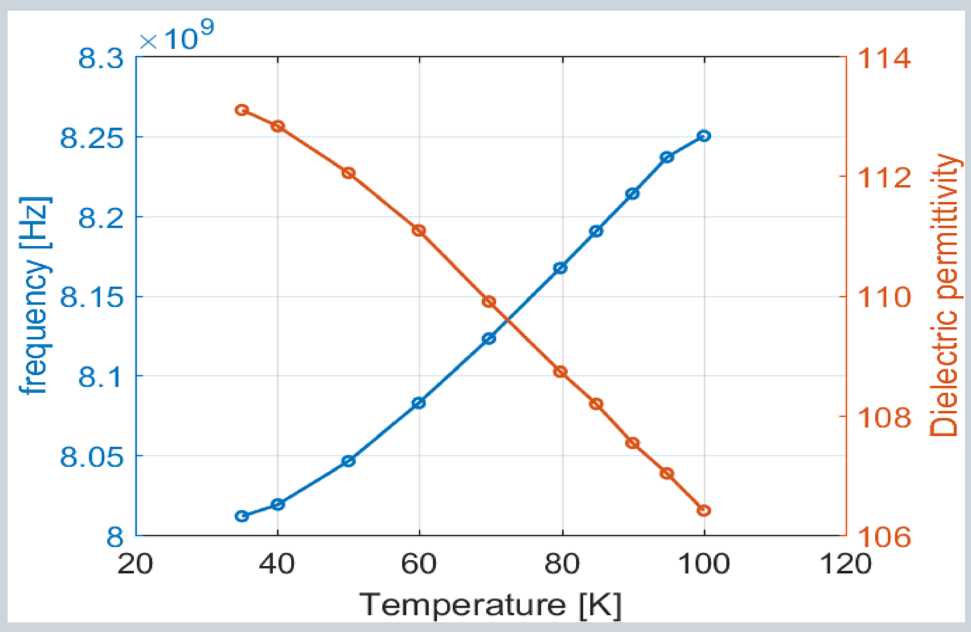
The baseline design of the FCC-hh beam screen is based on an octagonal shaped stainless steel tube coated in its interior with copper. The surface impedance of the beam screen has a strong impact on the beam stability. In the foreseen operating temperature range of FCC-hh (40-60 K) the intended coating might not guarantee an impedance sufficiently low for a stable beam. This motivates the exploration of high-temperature superconducting coated conductor (HTS-CC) tapes based on ReBa2Cu3O7 (RE=Y, Gd) as an alternative coating approach since it envisages a lower surface resistance than copper under the required operating conditions (<1 GHz, 16 T, 40-60 K). Therefore, we study its suitability by validating the RF-performance of HTS-CCs from different manufacturers as a function of temperature and magnetic fields (up to 9 T), using a microwave non-contact dielectric loaded resonator technique and further, by developing a surface resistance measurement facility close to FCC operating conditions. CST simulations have enabled to customise the resonator design as well as to model the experimental results. First results will be discussed and compared to existing data for conventional metallic coating.

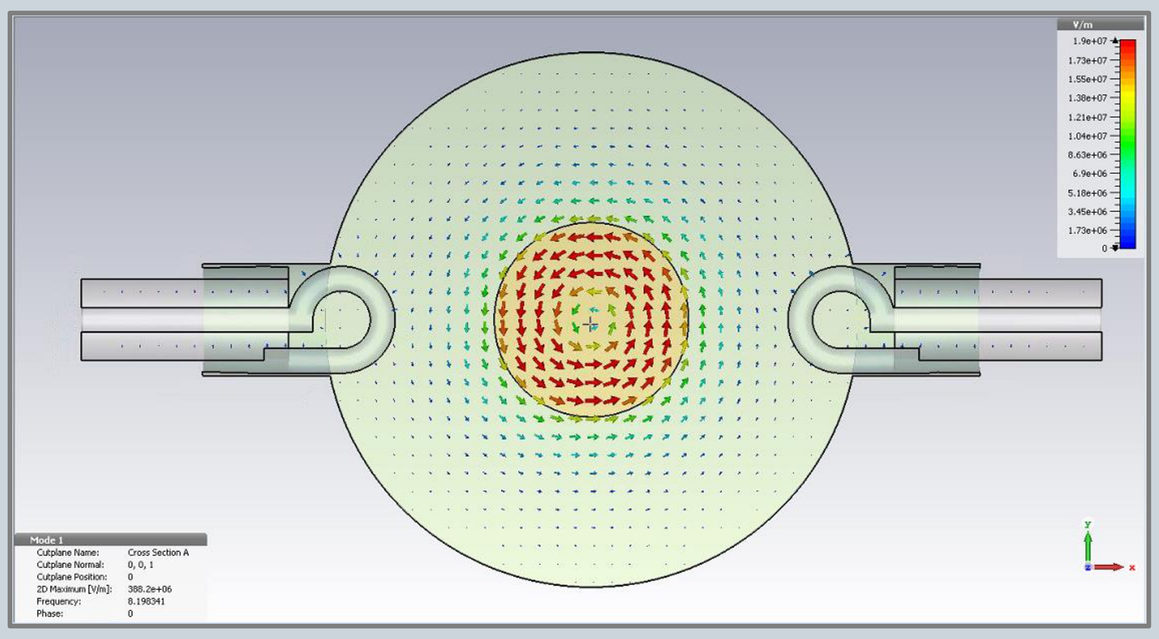
Rutile Dielectric Resonator

A dielectric resonator (DR) is composed of a closed metallic body housing a small dielectric cylinder shielded axially by two samples to be measured. The resonant frequency of the DR is basically determined by the physical dimensions of the cavity and the dielectric constant of the material, for the present resonator is around 8 GHz. A polished c-axis oriented high-purity rutile dielectric cylinder is used. The structure is held together with copper-beryllium springs to avoid a shifting of the rutile. The magnetic coupling is achieved through the lateral walls by a pair of semi-rigid coaxial cables with a loop at the end. The resonator operates in the TE_{011} mode, with circular, planar currents induced in the conducting bases. The sample size is 12 x 12 mm.

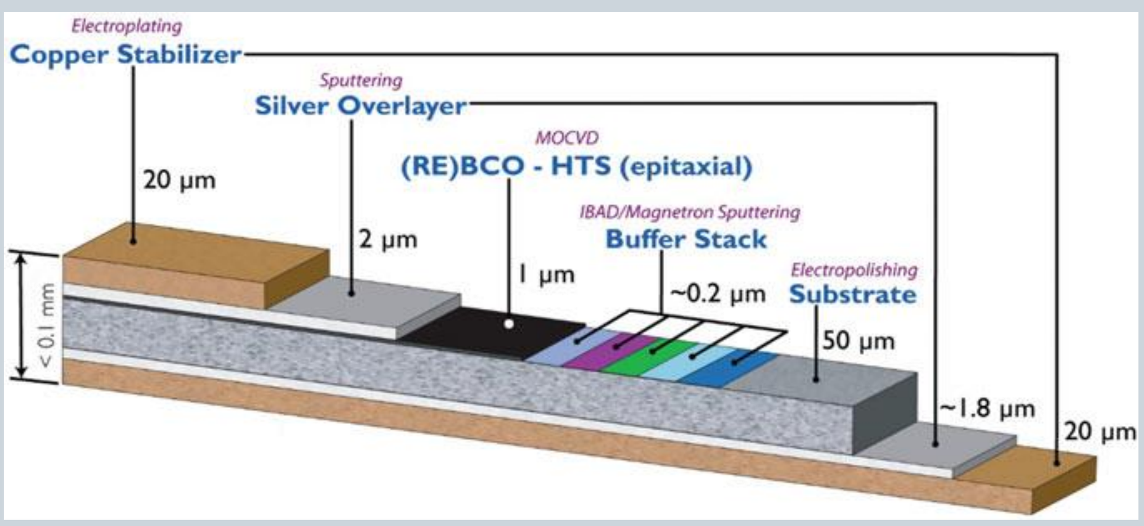


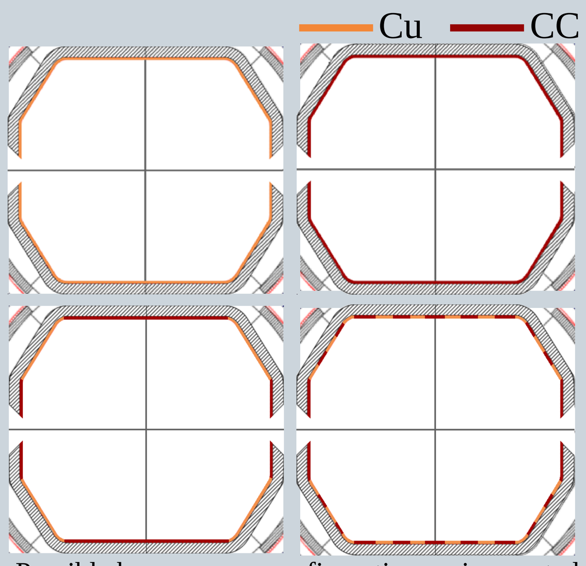






REBCO Coated Conductors





Possible beam screen configurations using coated conductors
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A coated conductor is an epitaxially REBCO film grown on a flexible metallic substrate capable of carrying very large currents and available in km long pieces. The main characteristics are:

- Industrial availability in km length pieces
- Critical temperature $T_C = 90 \pm 5$ K
- Irreversibility field $B_{irr} = 47 \pm 10$ T
- Critical current density $J_C = 50 \pm 40$ MA/cm^2 @ 50 K

(see poster A. Romanov)

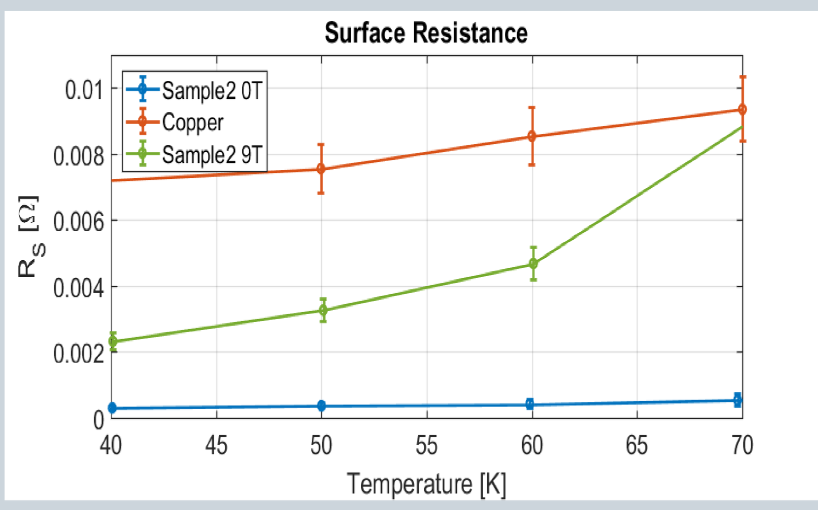
In this work data from 5 different commercial suppliers are compared.

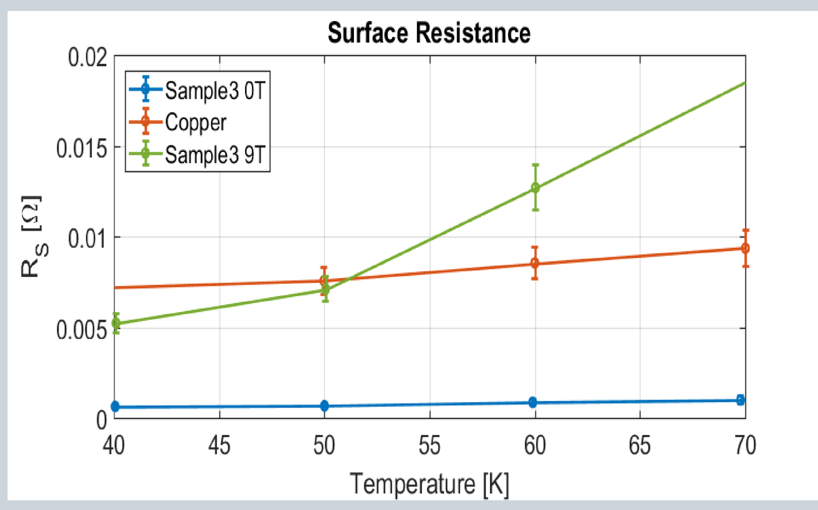
RF Measurements

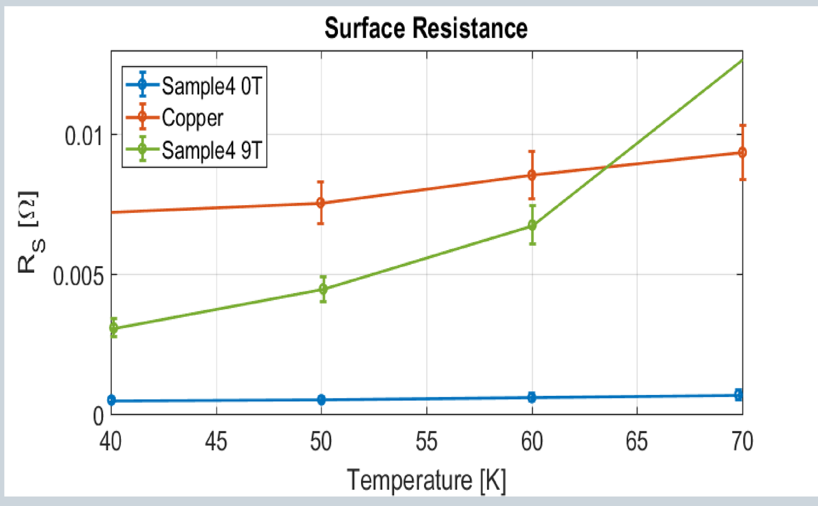
- The physical quantity experimentally accessible is the surface resistance R_S
- By measuring the quality factor Q and resonant frequency f_0 of the DR one can derive R_S

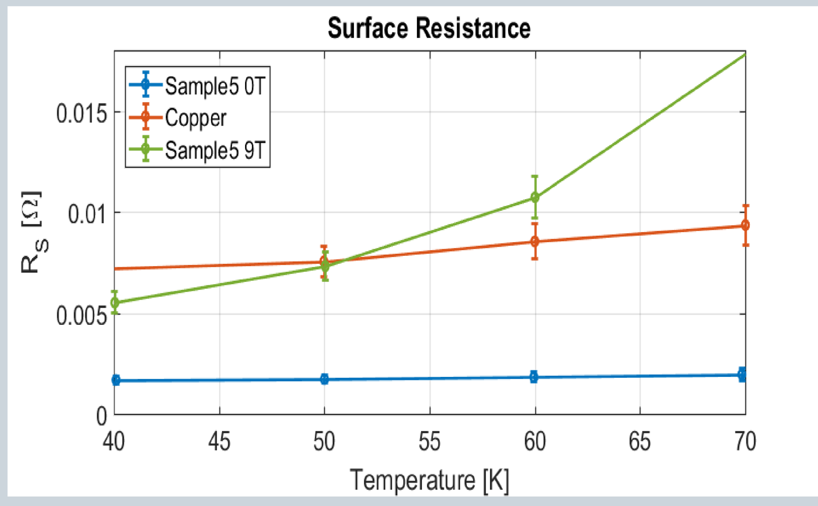
$$\frac{1}{Q} = \frac{R_S}{G_S} + \frac{R_m}{G_m} + p\tan(\delta)$$

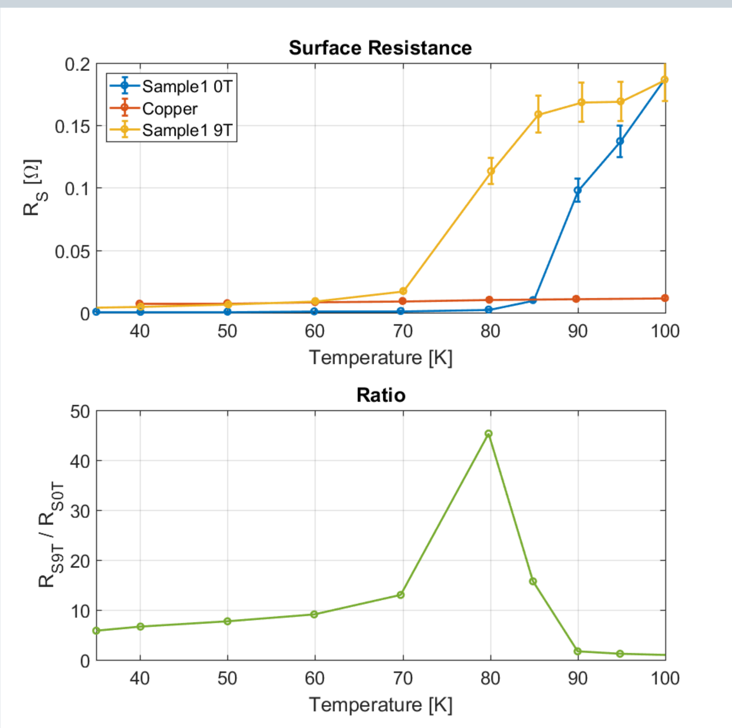
$G = geometrical\ factor$
$p = filling\ factor$
$\tan(\delta) = loss\ tangent$

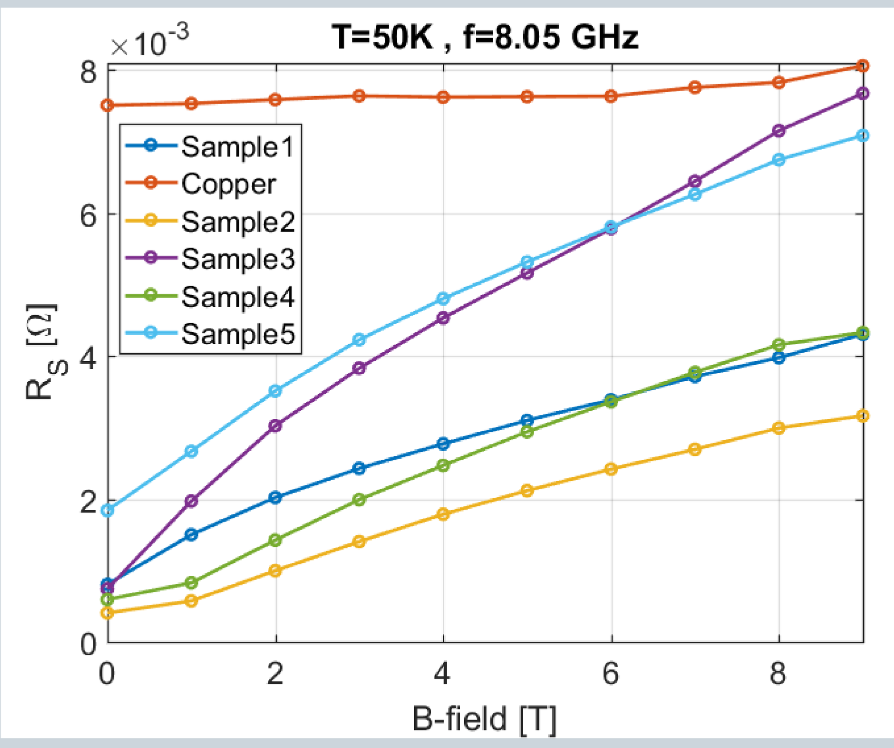


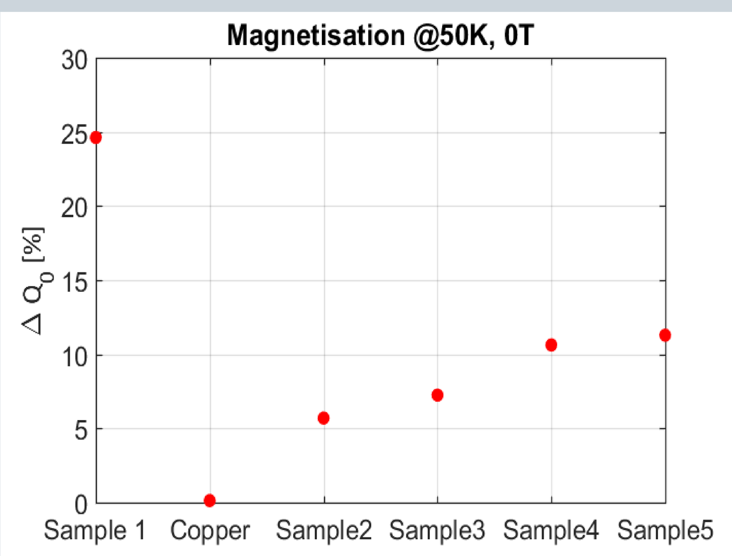


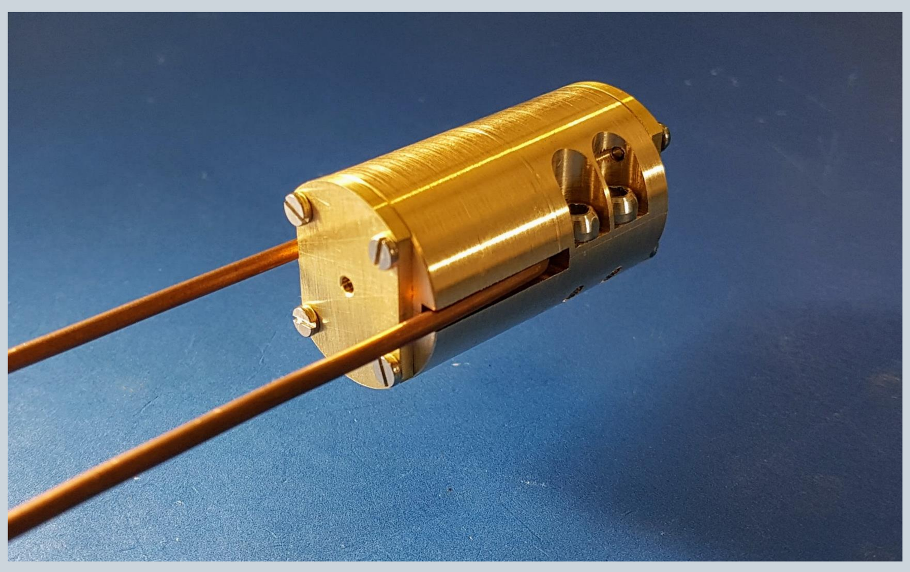












- Coated conductors from different manufacturers show different results
- The dependence of copper on the external field is negligible for this study
- At 50 K all coated conductors have a smaller surface resistance than copper with and without an externally applied magnetic field
- The coated conductor stays magnetised after being exposed to a magnetic field

Outlook and Conclusion

- The main behaviour of SCs in a RF-field show promising results to lower the beam coupling impedance
- A new resonator configuration is under development to lower the resonant frequency and with that to get closer to FCC operating conditions

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