Programme Matter and Technologies

Reducing power dissipation in sc cavities by thermal cycling

ARD-ST1 Superconducting RF Science and Technology

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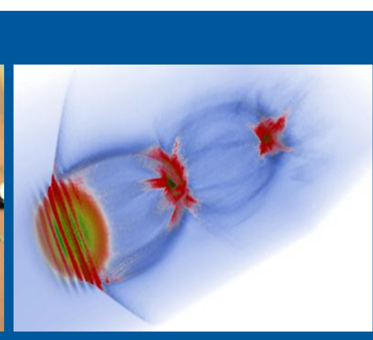
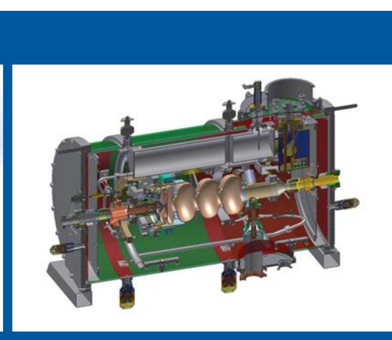
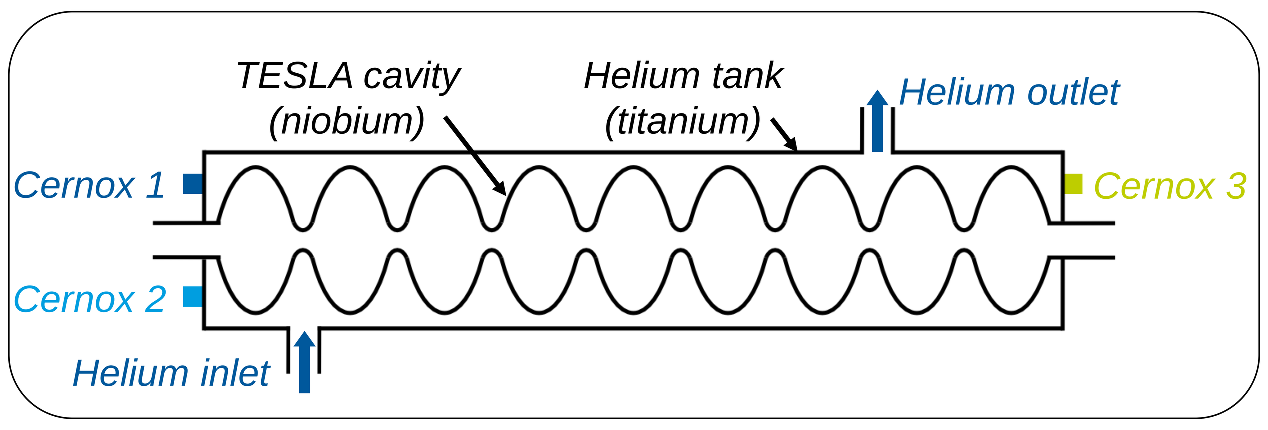



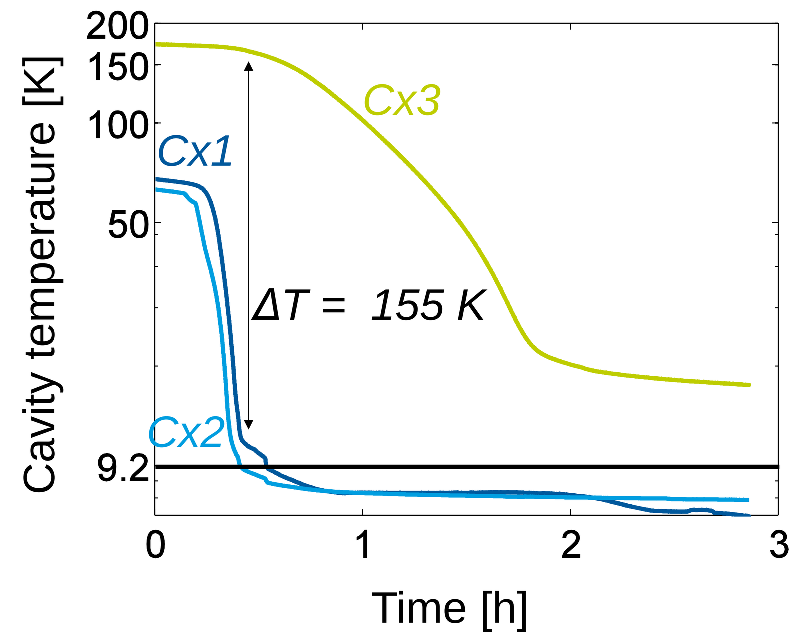
Motivation

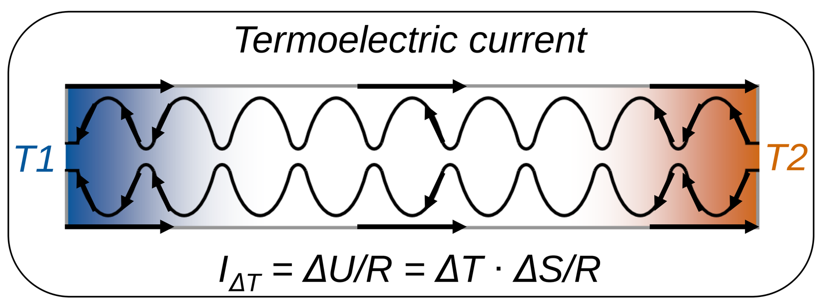
- Superconducting RF technology enables a variety of future projects due to its low power dissipation.
- Even the few watts dissipated in SRF cavities have to be cooled away. Cryoplants for SRF accelerator projects are large, complex and costly.
- **Reduction of cavity surface resistance** is one central point in todays research.
- We observed in horizontal tests that the residual resistance and hence the dissipated power can be reduced by up to a factor of 2.5 simply **by changing the cooling conditions** during the superconducting phase transition. If this effect can be repeated in cw LINACs (e.g. LCLSII or if XFEL operates cw) the impact on investment and operation costs is enormous.

Hypothesis



Ambient magnetic flux present during cooldown causes additional power dissipation. Hence the earth magnetic field is shielded. We believe that the temperature difference along the cavity-tank-system induces additional magnetic flux inside the shielding by thermoelectric effect which gets trapped during the phase transition.





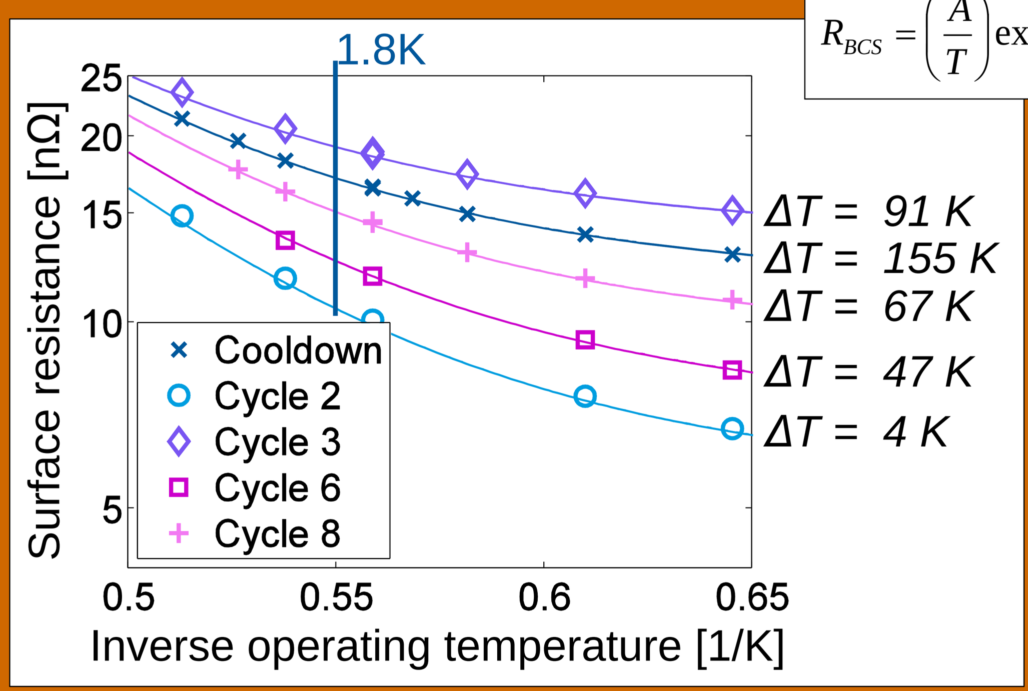
Checking the hypothesis ...

... with a cavity

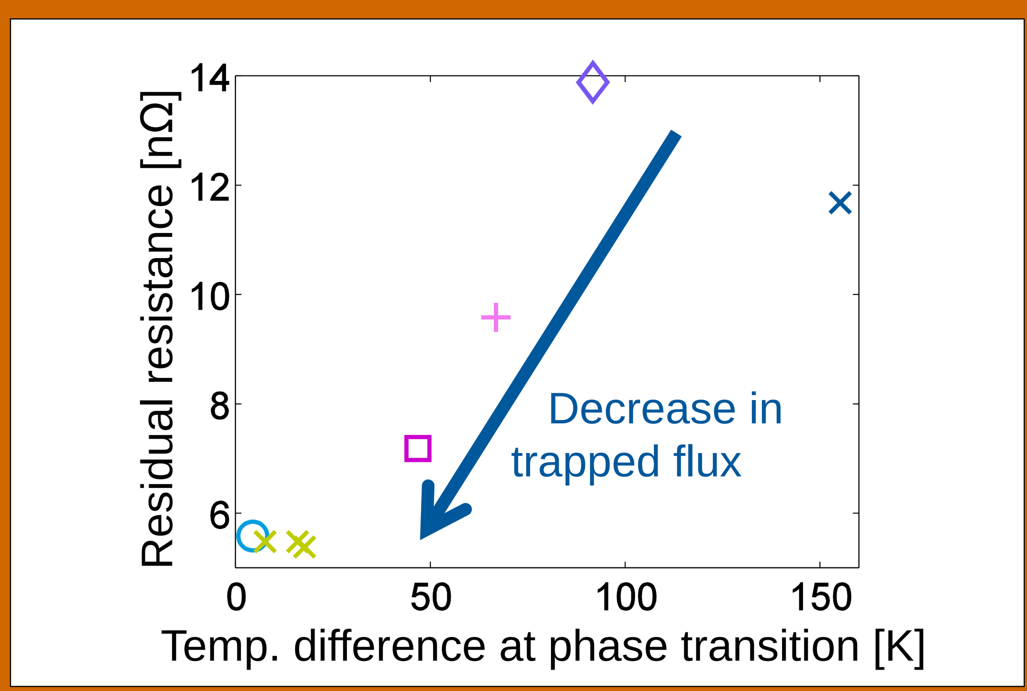
Surface resistance *(= losses)* as a function of the inverse operating temperature for different temperature differences during cooldown:

$$R_s = R_{BCS} + R_{res}$$

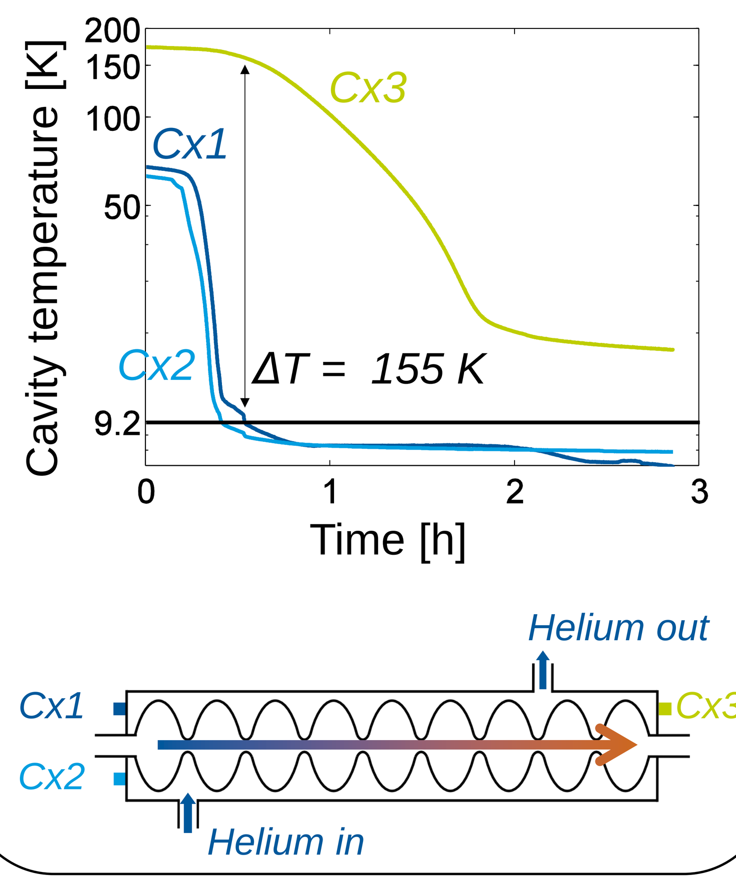
$$R_{BCS} = \left(\frac{A}{T}\right)\exp\left(-\frac{B}{T}\right)$$



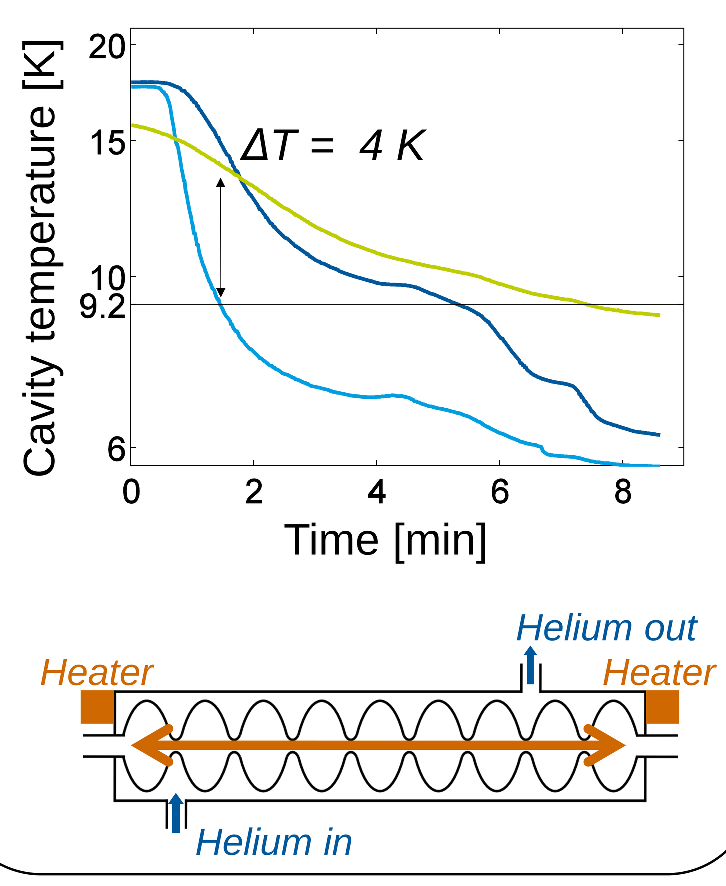
Residual resistance *(= losses we can influence)* due to, presumably, trapped magnetic flux as a function of temperature difference during cooldown:



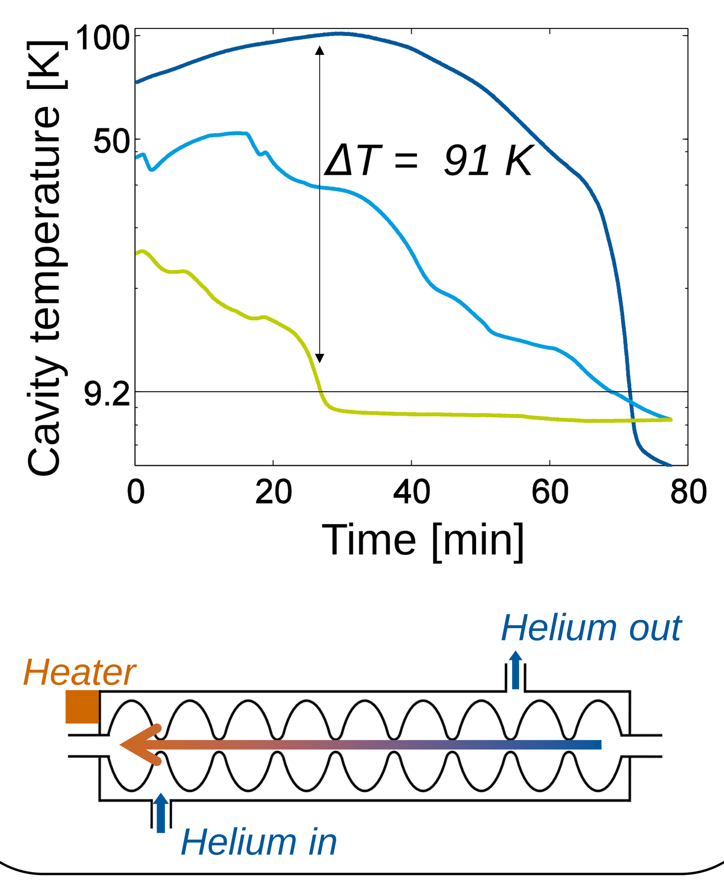
Initial cooldown



Cycle 2:
Suppressing the effect



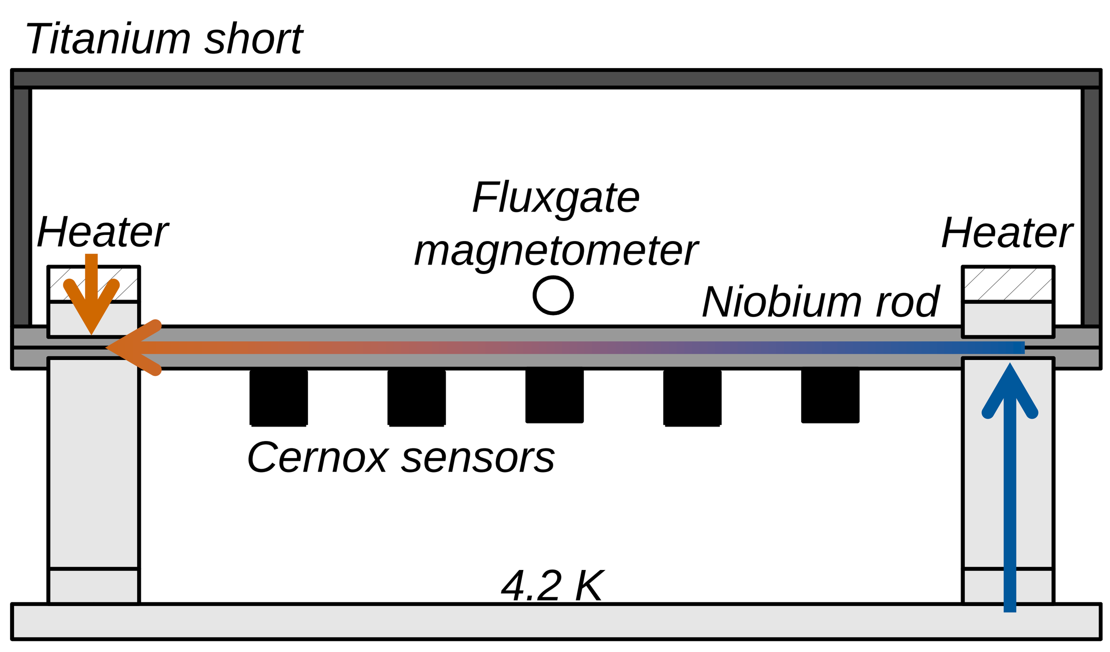
Cycle 3:
Breeding the effect

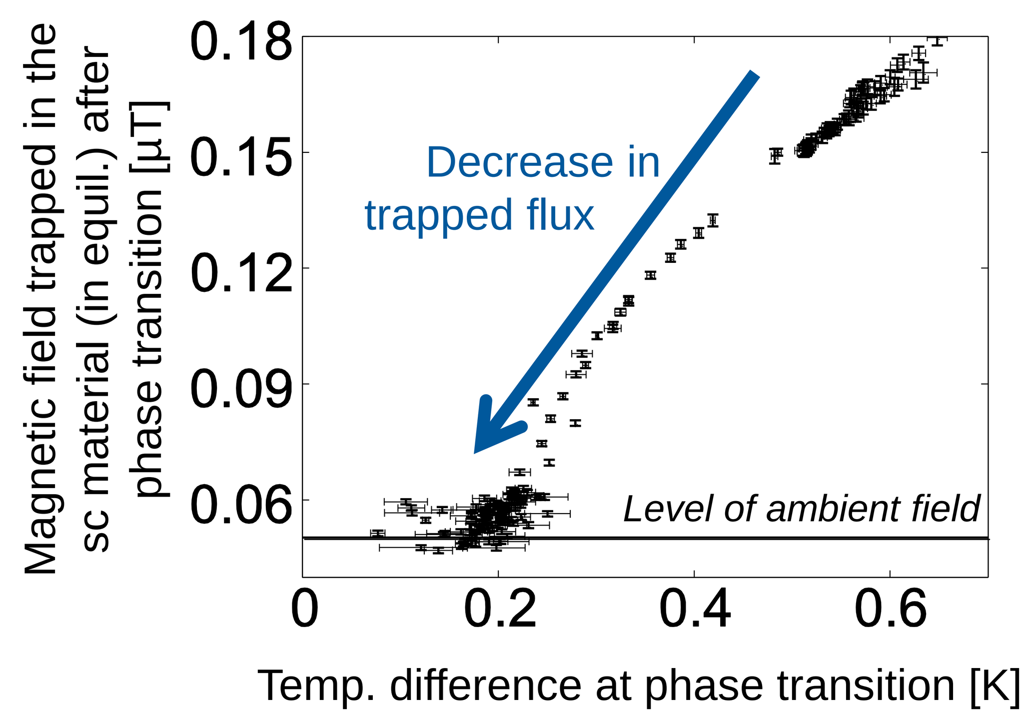


... with a model system

We designed a **model system** to simulate the **thermoelectric properties** of the cavity-tank-/ niobium-titanium-system consisting of a niobium rod with a titanium short.

The impact of a temperature gradient during sc phase transition is evident in the model system as well as in the cavity-tank-system.





Conclusion and Application

We demonstrated an **improvement of R_{res}** of an SRF cavity **by up to a factor of 2.5** by thermal cycling. We believe a temperature gradient along a cavity leads to thermally induced magnetic field that gets trapped in the sc material. Thermal cycling diminishes the effects by reducing the ΔT prior to the phase transition. We were able to gather further evidence for this effect in a model system. A decreased R_{res} **reduces cryo costs significantly** and hence the proposed cycling procedure may enable **new accelerator** concepts and applications. Even **existing SRF accelerators** could implement a similar procedure to minimize the amount of trapped flux and hence the cryo load.

Coworkers and Acknowledgment

These studies have been performed and supported by O. Kugeler and J. Knobloch. We thank our engineers André Frahm, Axel Hellwig, Sascha Klauke, Dirk Pflückhahn, Stefan Rotterdam and Michael Schuster for patient support.

Literature

[1] S. Aull, O. Kugeler and J. Knobloch, Phys. Rev. ST Accel. Beams 15, 2012
[2] J. Vogt, O. Kugeler and J. Knobloch, Phys. Rev. ST Accel. Beams 16, 2013

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