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# SURFACE RESISTANCE CHARACTERIZATION OF $Nb_3Sn$ USING THE HZB QUADRUPOLE RESONATOR

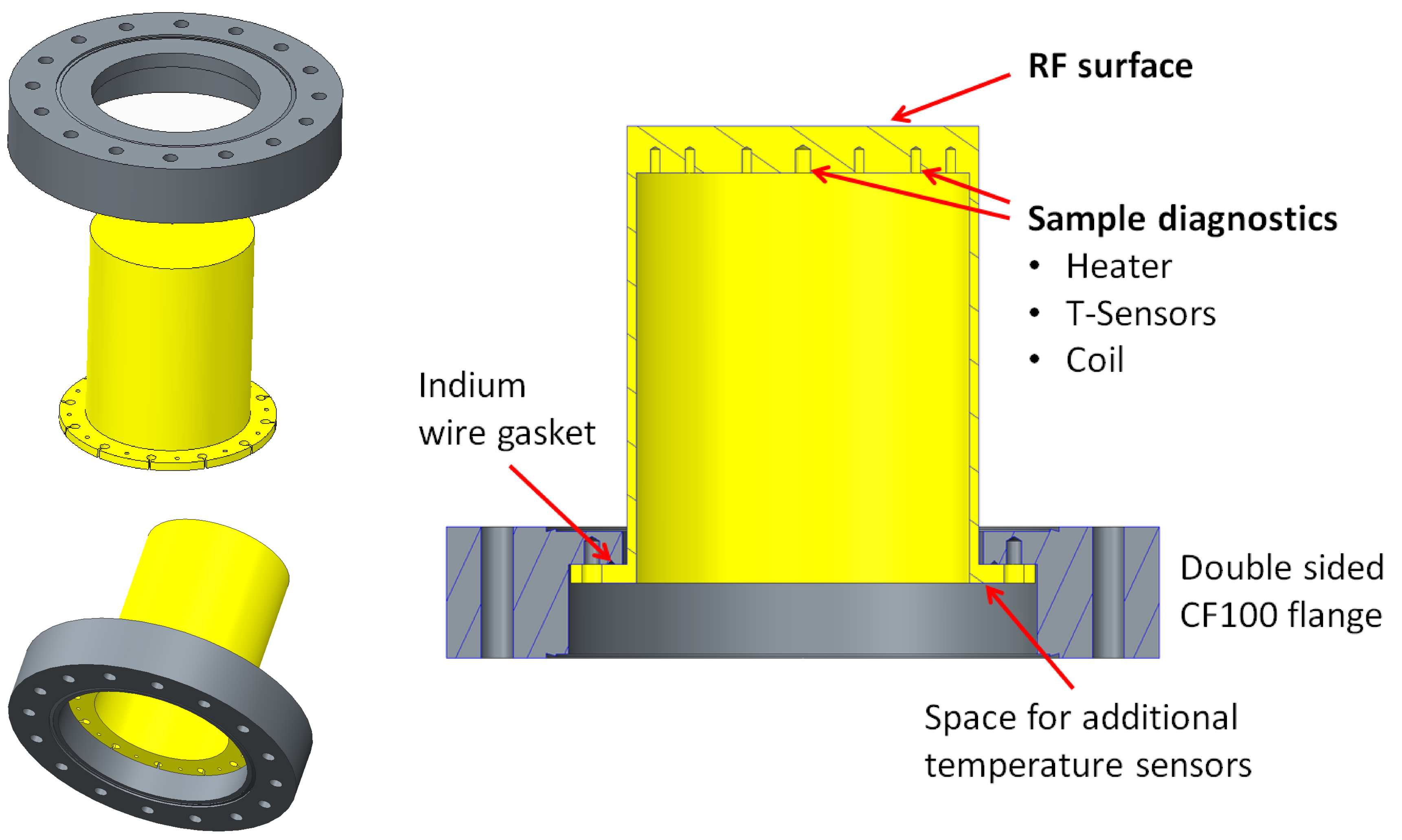
## ABSTRACT AND MOTIVATION

$Nb_3Sn$ is one of the most promising alternative materials to niobium for applications in SRF cavities. With its high critical temperature of about 18.5 K and superheating critical field $B_{sh} \approx 400$ mT, $Nb_3Sn$ provides potential major improvements for both applications currently being investigated in the SRF community, high gradient accelerators as well as high-Q cavities with significantly reduced operating costs. Recent results with cavities have demonstrated $R_s$ values of about 27 nΩ at 4.2 K far beyond the fundamental limit of niobium [1].
The RF properties of a sample prepared by Cornell University were characterized using the HZB Quadrupole Resonator. In this contribution we present surface resistance and RF critical field measurements.

## NEW SAMPLE HOLDER

**Up to now**
Niobium sample brazed into stainless steel flange
⇒ No heat treatments of sample assembly possible (few hundred °C max.)

Workaround: Electron-beam weld on niobium part after treatment
⇒ Possible impact on relevant material properties of the sample




**New sample holder design**
Connection with titanium screws and indium wire gasket
⇒ Pure Nb sample allows high T treatments ($Nb_3Sn$ coating, N doping/infusion, …)
⇒ UHV compatible at RT and in LHe
⇒ Opportunity for additional temperature sensors
⇒ Exchangeability between QPRs at CERN and HZB

## RF CRITICAL FIELD

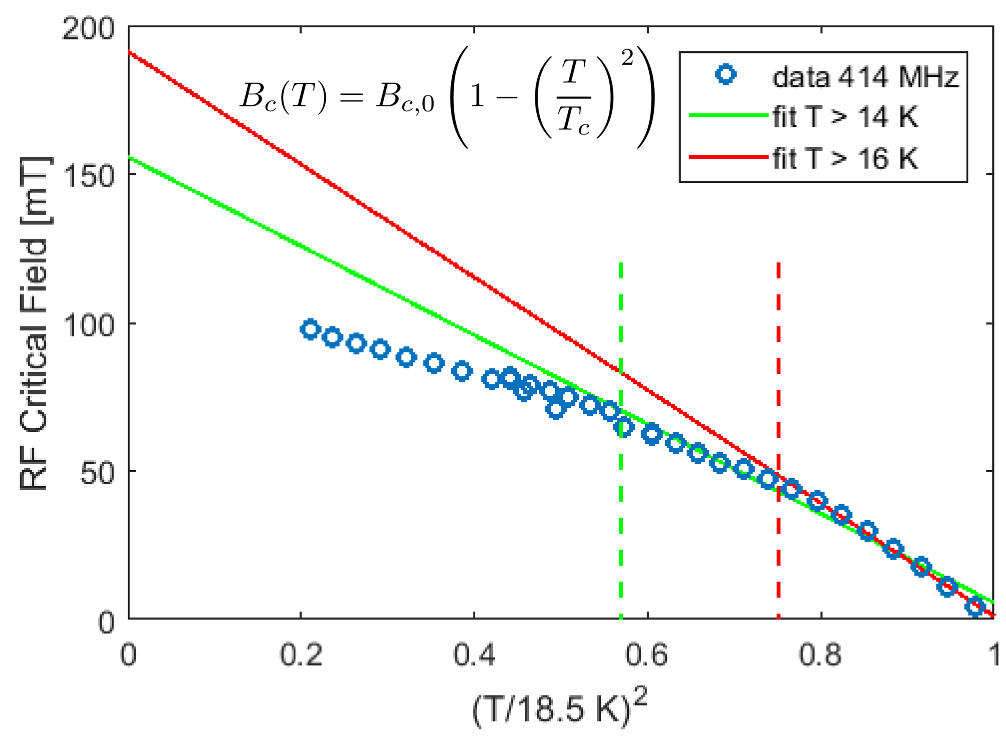
Single pulse measurement, quench field from peak $P_{transmitted}$

$B_{RF,\,crit} \approx 190$ mT

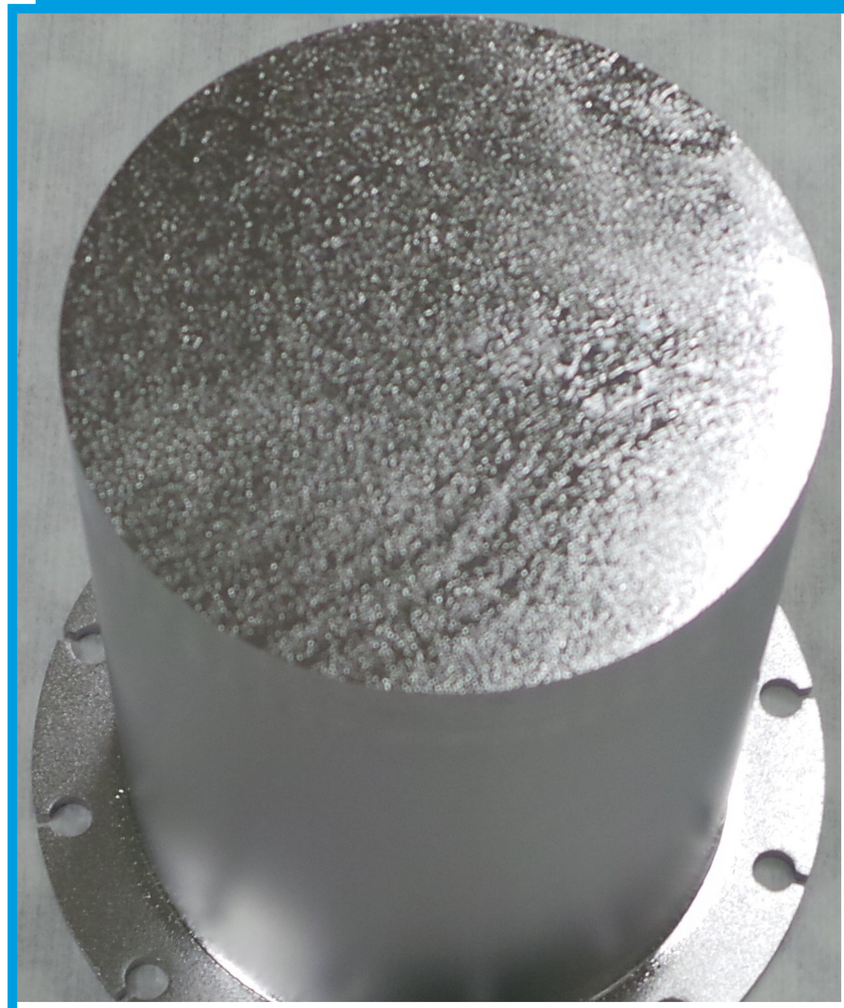
At T < 15 K deviation from linear fit due to RF heating

Literature:
$B_{sh} \approx 400$ mT
$B_{c1} = 25$ mT

⇒ Critical field far above $H_{c1}$




## THE SAMPLE


QPR sample before coating:
fine grain bulk niobium, RRR 300

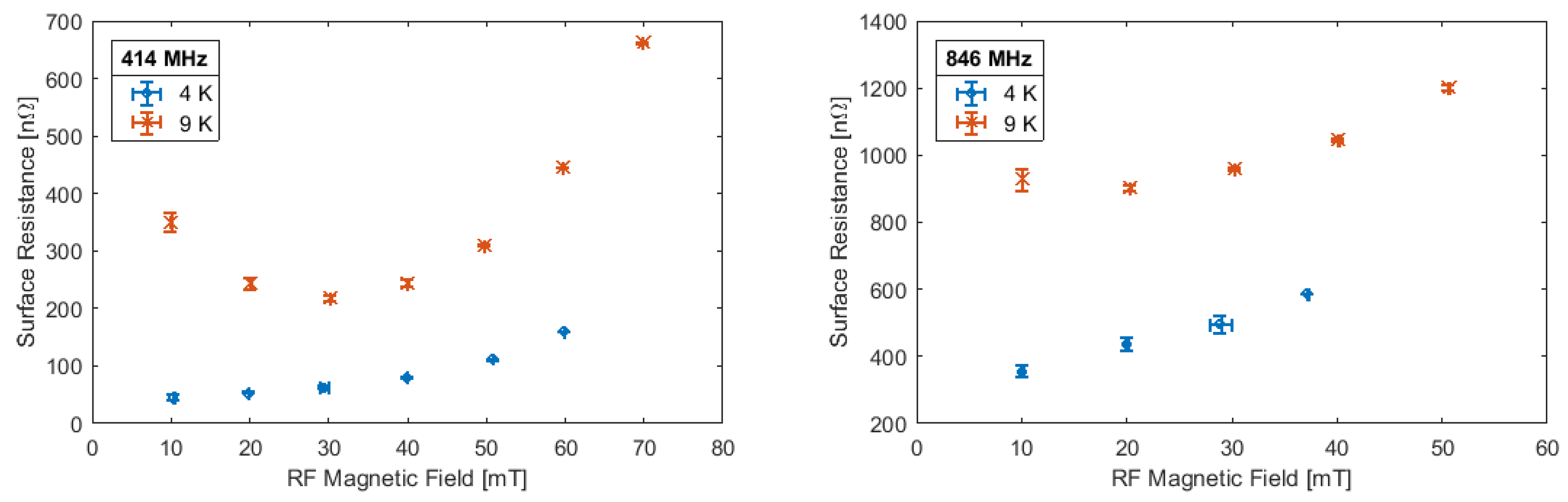

QPR sample after coating with $Nb_3Sn$
Coating procedure as for cavities [1]

**Baseline measurement** with niobium substrate prior to coating [2,3]
⇒ Residual resistance 4 nΩ
⇒ RF critical field 220 mT

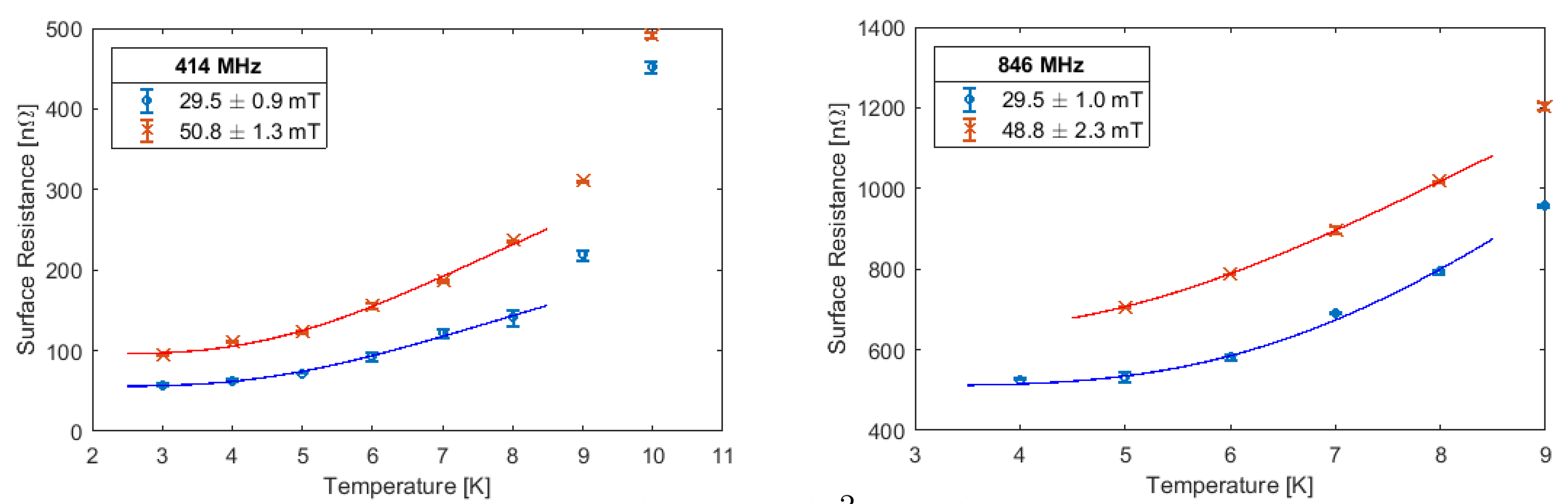
## SURFACE RESISTANCE

⇒ Calorimetric measurement of RF surface resistance
⇒ Extended parameter space (frequency, temperature and RF field)

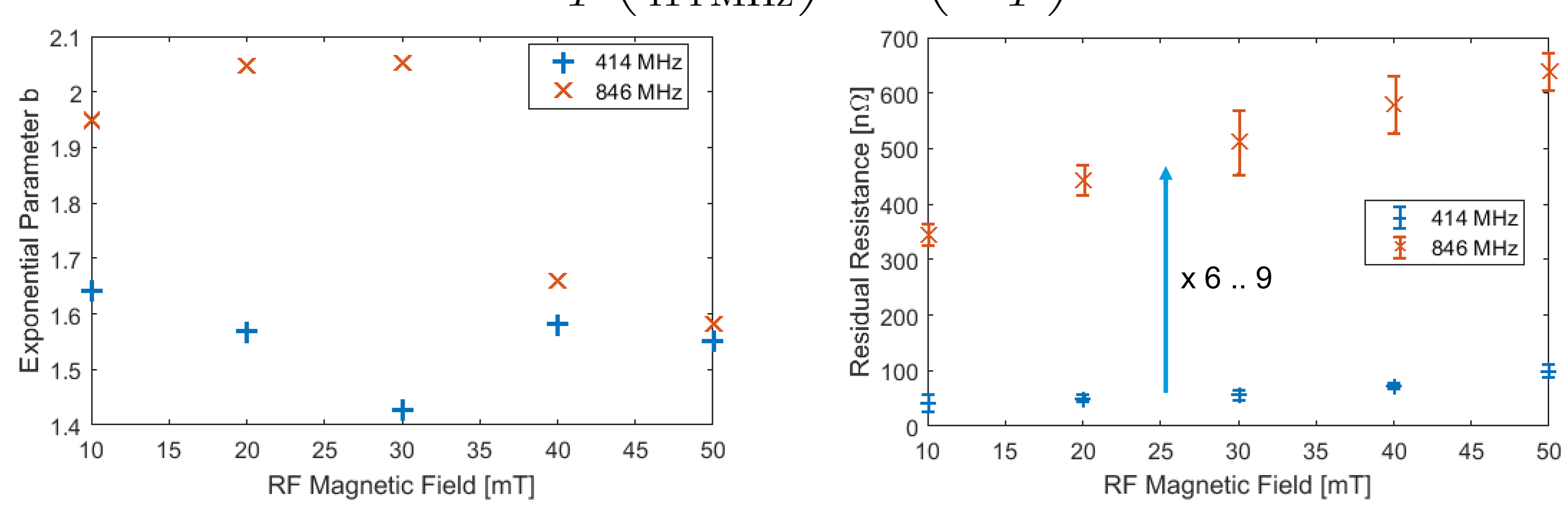
**Surface resistance vs. RF field**




**Surface resistance vs. temperature with BCS fits**




**BCS fit results** $R_s(T) = \frac{a}{T}\left(\frac{f}{414\,\mathrm{MHz}}\right)^2 \exp\left(-b\frac{T_c}{T}\right) + R_{res}$




⇒ High residual resistance with Q-slope and strong frequency dependence

**References**
[1] S. Posen and M. Liepe, Phys. Rev. ST Accel. Beams 17, 112001 (2014).
[2] R. Kleindienst, „Radio Frequency Characterization of Superconductors for Particle Accelerators“, PhD thesis, submitted to University of Siegen, 2017.
[3] R. Kleindienst, A. Burrill, S. Keckert, J. Knobloch and O. Kugeler, „Commissioning Results of the HZB Quadrupole Resonator“, in Proc. SRF'15, Whistler, Canada, 2015.

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