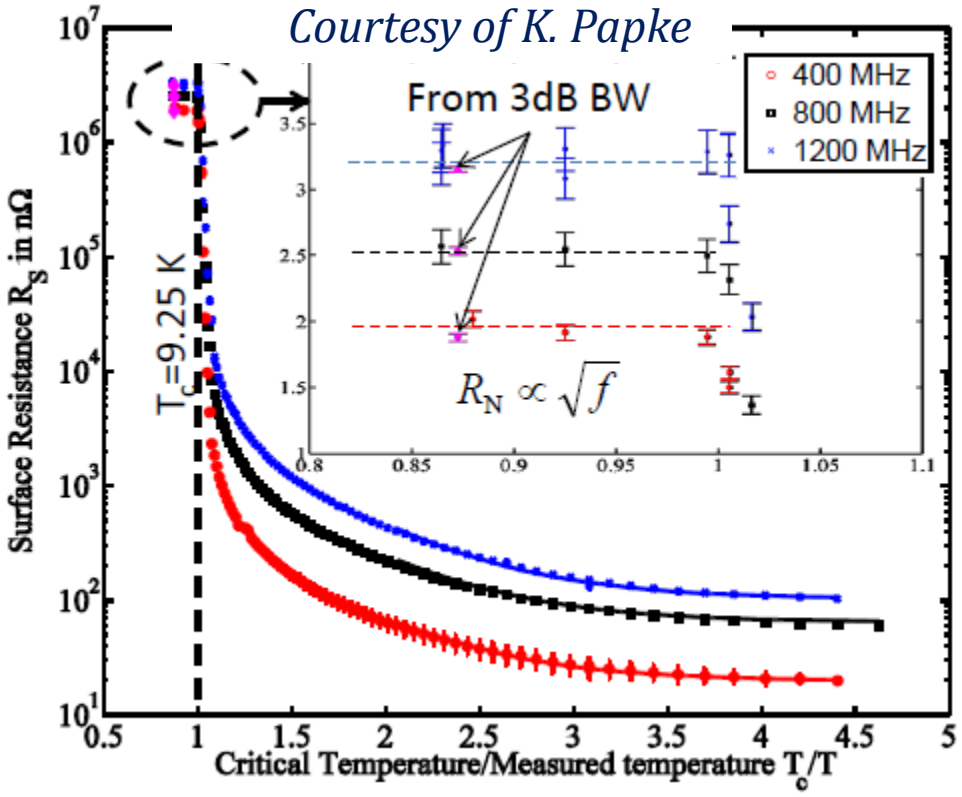
HOM hook BNL cavity, thermal losses with temperature-dependent properties of Nb (electrical and thermal)

1st addendum to the presentation given on 21/2

HOM hook Nb

- Presentation 21/2: Nb ok for HOM hook, Cu not ok
- In that calculation, Rs of Nb was calculated at 2K
- Actually, thermal analysis shows that the hook reaches 3K of temperature for the evaluated RF losses (no active cooling of Nb hook)
- Iterative calculation HFSS/ANSYS is needed to calculate the real temperature distribution if Rs(Nb) is a function of T

Courtesy of K. Papke



- Rs (2K) ~ 10 nΩ
- Rs (3K) ~ 13 nΩ
- Rs (3.3K) ~ 20 nΩ
- Rs (3.5K) ~ 30 nΩ
- Rs (4K) ~ 50 nΩ
- Rs (5K) ~ 85 nΩ

HOM hook Nb

- The thermal conductivity is a function of temperature (this was already considered in 21/2 presentation) and RRR
- See "RF Superconductivity", H. Padamsee, pag. 53 for the plots λ/T as a function of RRR
- Two calculations performed: RRR=380, RRR=40
- No active cooling of Nb hook considered! Massive hook

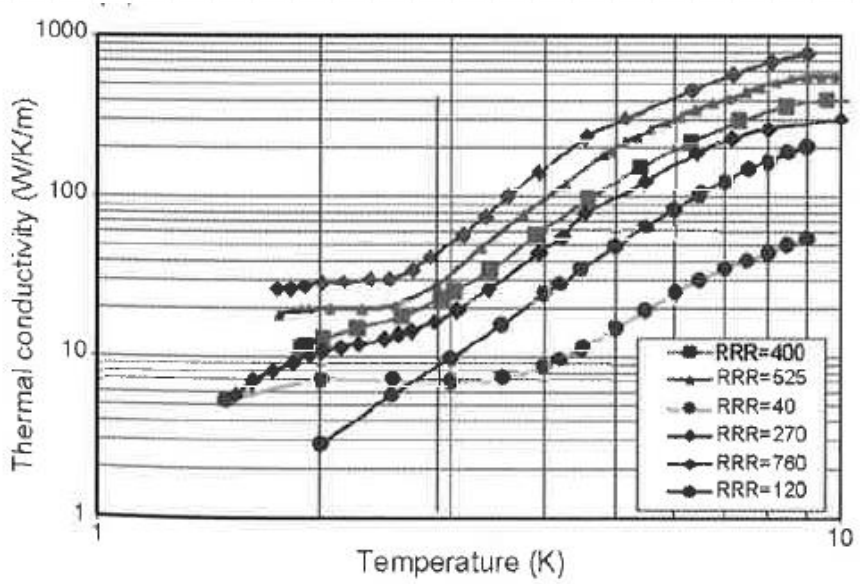
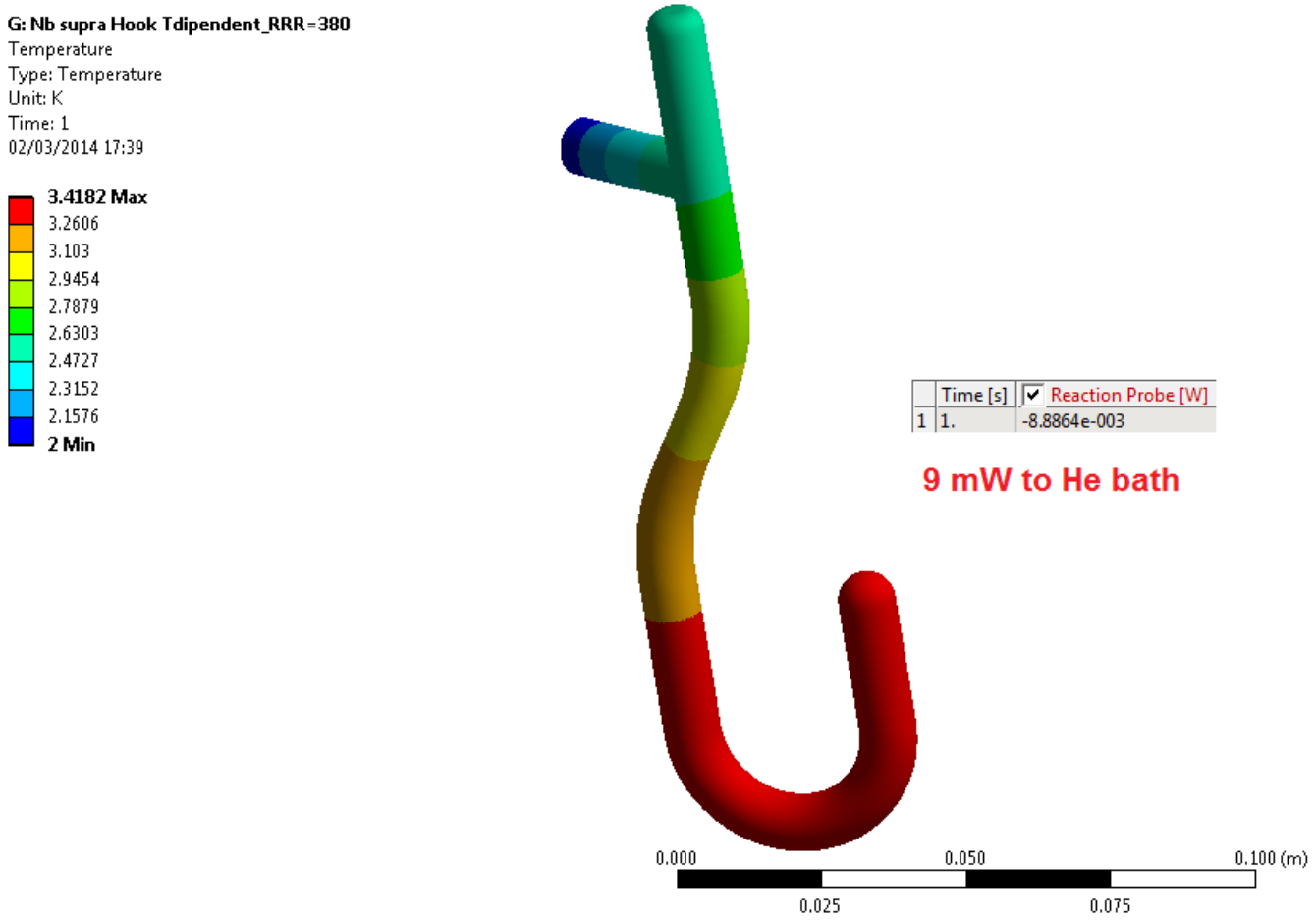


Fig. 3.7 Thermal conductivity versus temperature for l=0.5 mm and RRR=100 (solid), 200 (short dashed line), 300 (medium dashed line), and 500 (long dashed line). (b) Measured thermal conductivity of Nb for various RRR [167] (courtesy of DESY).

HOM hook Nb

- **RRR=380**: T_{max} ~ **3.4K** after iterative calculation, **flux to He bath ~ 9 mW**
- Acceptable results!



HOM hook Nb

- **RRR=40**: **$T>T_c$** not acceptable!
- Solutions if RRR=40 is chosen:
  1. Either active cooling (hollow hook He superfluid-cooled)
  2. Or copper hook with Nb coating
- **The minimum RRR acceptable without active cooling seems to be around 250** (qualitative estimation, pag. 53 Padamsee → to be refined if needed)

Backup slide: HOM hook with T=4K boundary condition

- A boundary condition of 2K is not realistic because there is a certain resistance between the 2K He bath and the hook fixed support
- A new calculation has been performed imposing to a RRR=300 Nb hook (massive) a boundary of 4K
- Results are acceptable: **T_{max} < 5K, Heat losses to He bath ~ 35 mW**