MG Nb technology for achieving high Q_0 and E_{acc} sustainably

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And
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In collaboration with ATI, JLab and KEK

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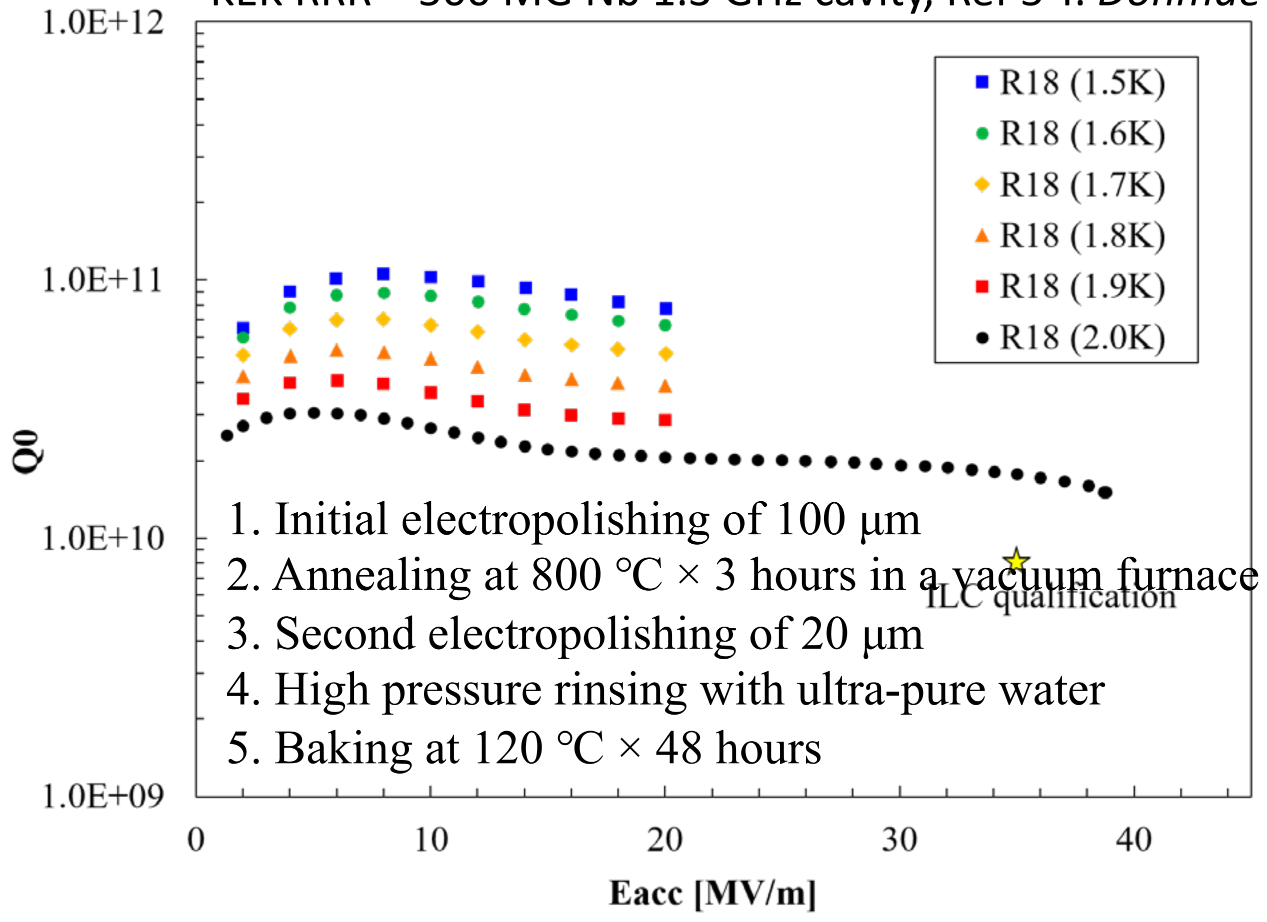
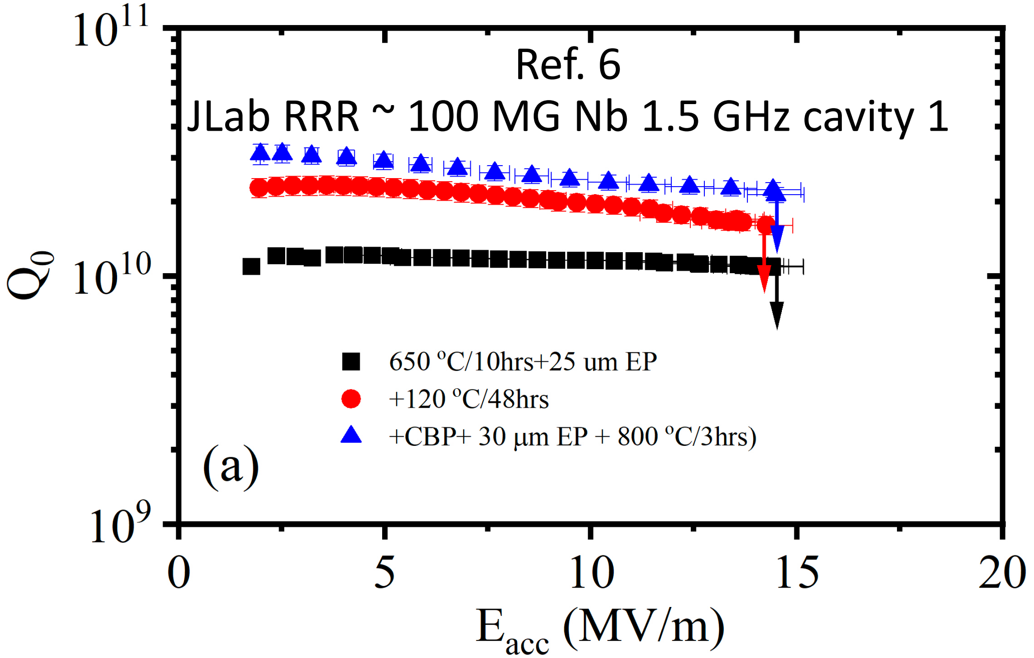
Intro to Nb Technologies for SRF

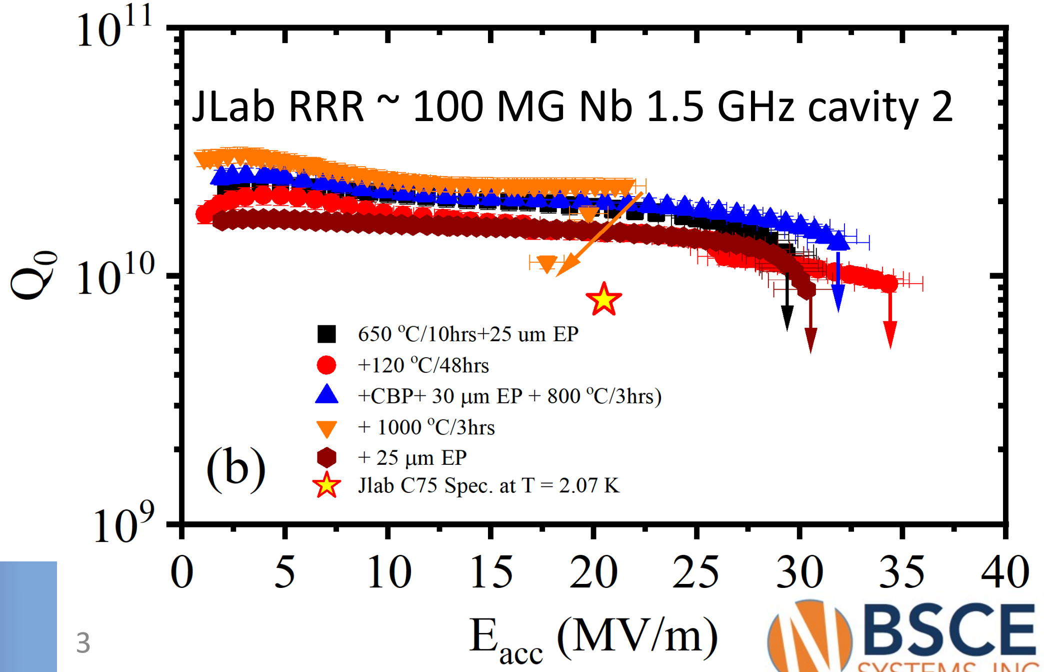
Fine Grain (FG) **Rolled Nb sheets**	**Medium Grain (MG)** **Forged Ingot Nb discs**	**Large Grain (LG)** **Ingot Nb discs**
Up to fourteen manufacturing steps Labor intensive	E-beam melted ingot of larger dia. forged to required dia and then sliced	E-beam melted ingot of required dia. is sliced
Grain Size ASTM 5 ~ 50 µm	ASTM 0 – 3, < 1 mm	Large non uniform grains >>1 cm
Widely used complex technology prone to contamination	New kid on the block and very clean surfaces	Proven clean surface technology
Uniform & adequate mechanical properties	Better uniform mechanical properties	Non uniform mechanical properties
Requires stringent QA & expensive	Better Cost advantage	Cost advantage

MG Nb cavities performance

KEK RRR ~ 500 MG Nb 1.3 GHz cavity, Ref 5 T. *Dohmae et al*

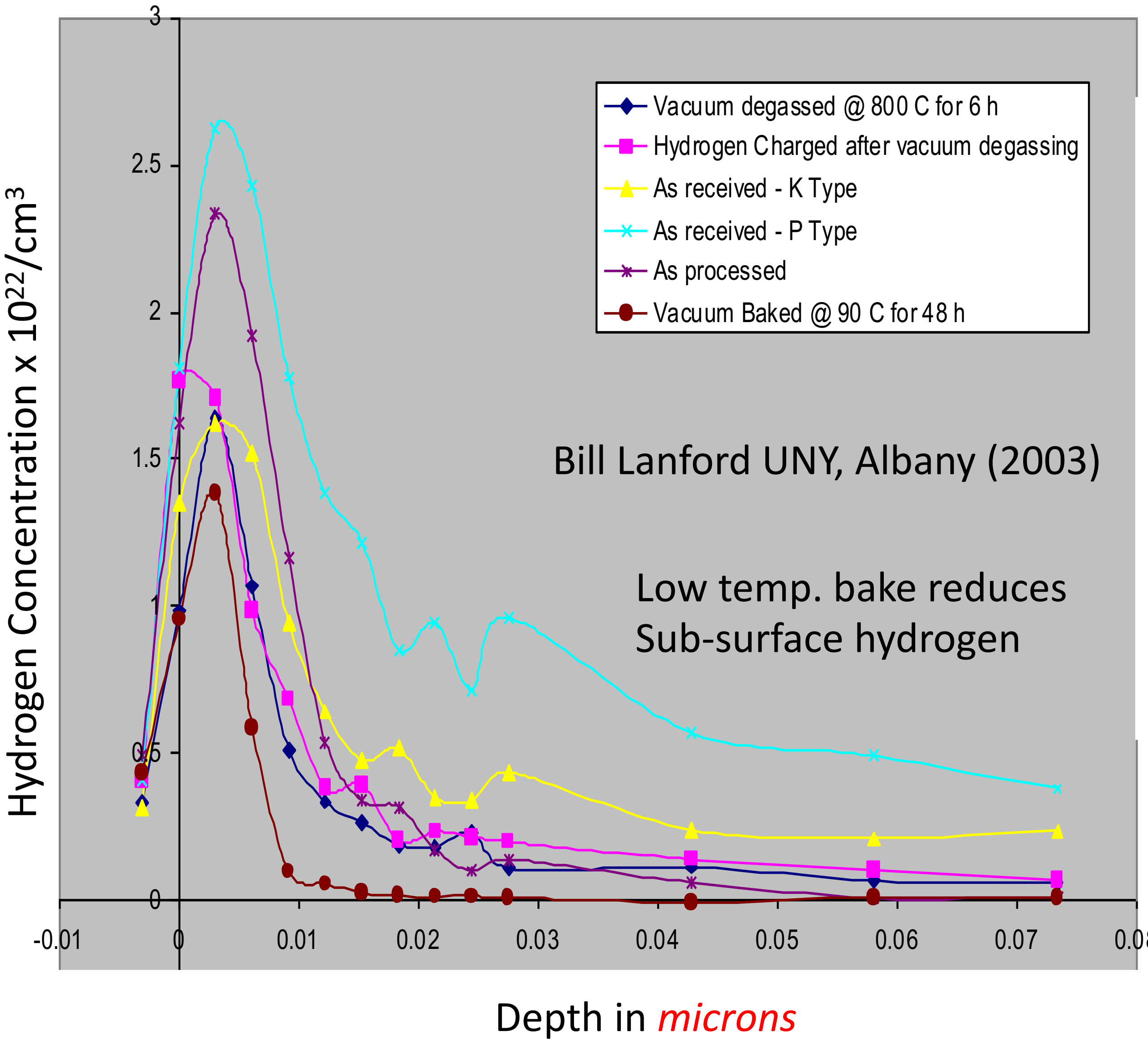




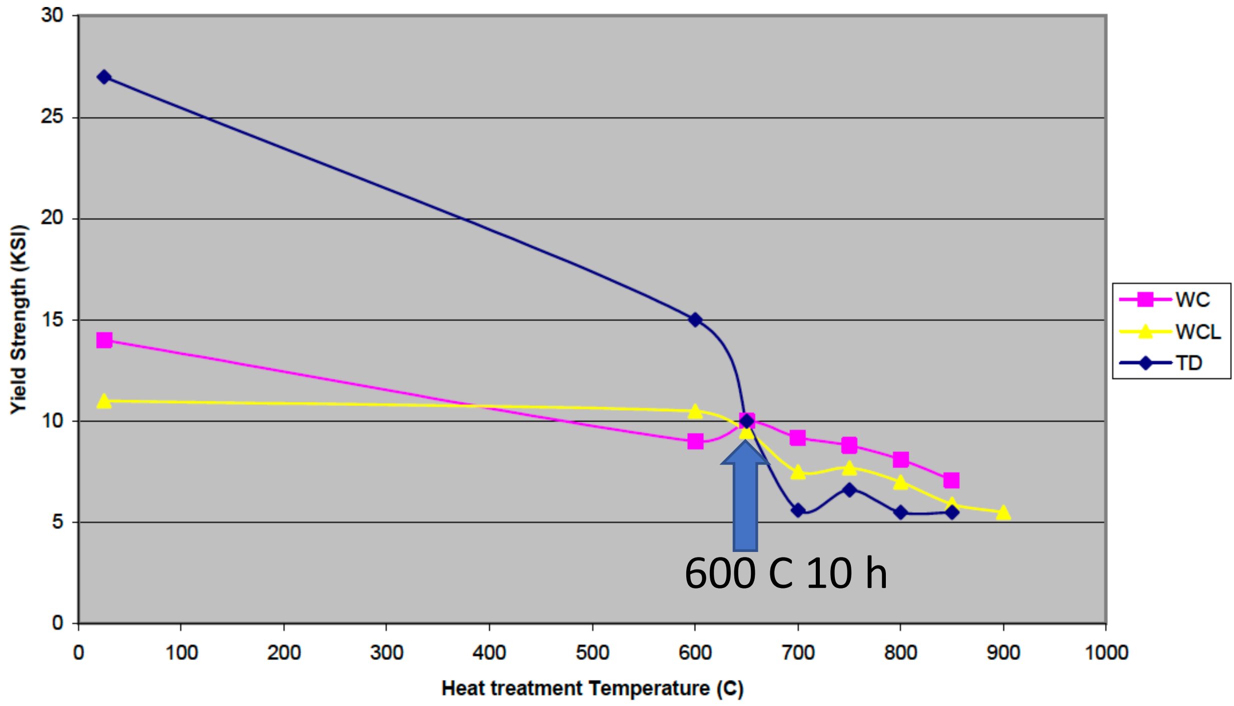


KEK EB welder is modern – no weld defects
JLab EB welder is ancient & refurbished – weld defects limit gradient

Hydrogen depth profile in SRF niobium - NRA

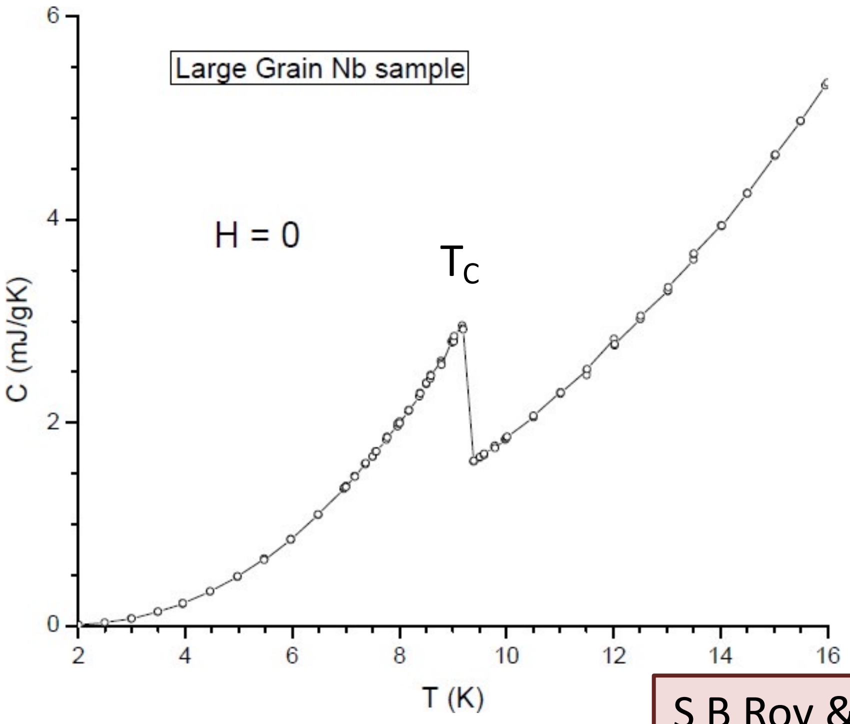


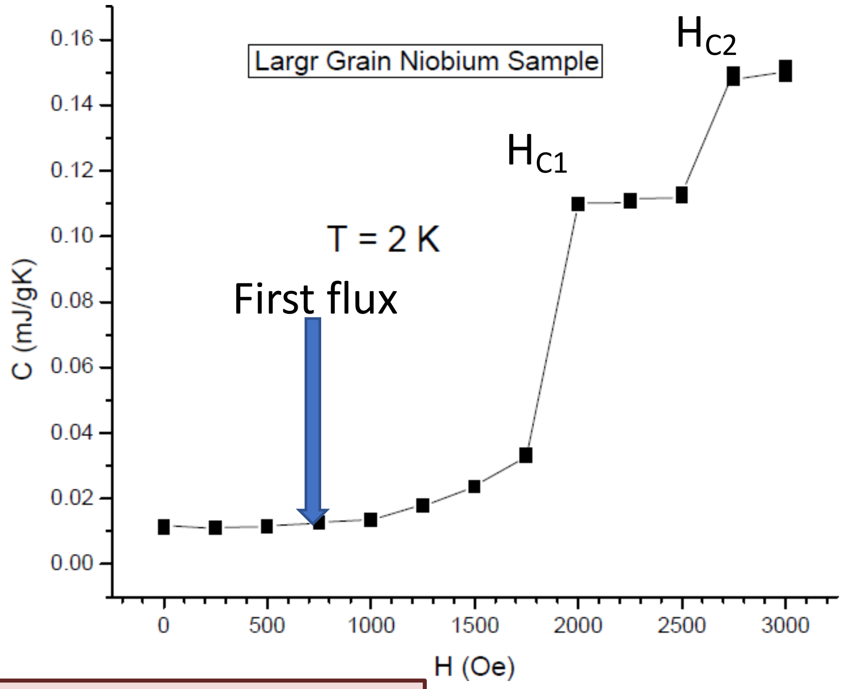
Nb yield strength as a function of annealing temperature



H_2 degasses at ~ 600 °C with out changing the grain structure

Temperature and magnetic field dependence of heat capacity of superconducting large grain Niobium





S B Roy & G. Myneni (unpublished)

During cavity operation heat is deposited in the sc layer of ~60 nm τ (1.5 GHz) ~ 6.6×10^{-10} s

Thermal diffusivity$_{2K}$ α_{2K} ~ $k/\rho C$ = 2333 $cm^2\ s^{-1}$

Discussions

- We need to develop clean UHV furnaces for annealing the cavities to eliminate after chemistry
- Annealing time and temperature needs to be optimized for better H_2 degassing without grain structure change
- Specific heat measurements on samples @ 2 K as a function of magnetic field will help optimize cavity process procedures

References

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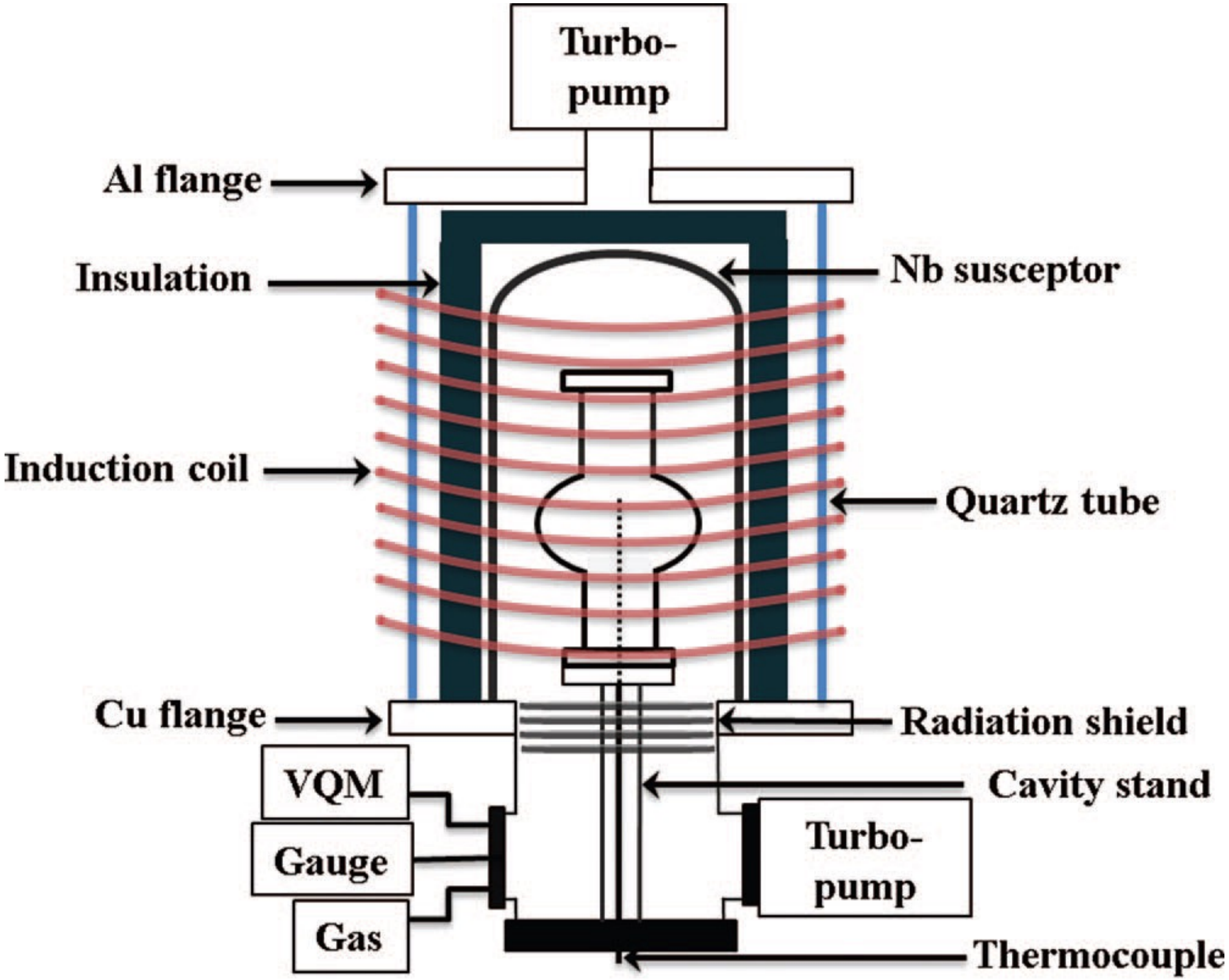
6. G. Myneni et al., "Medium-grain niobium SRF cavity production technology for science frontiers and accelerator applications" arXiv preprint, arXiv:2203.07371. doi:10.48550/arXiv.2203.07371

Schematic of ultra clean induction furnace



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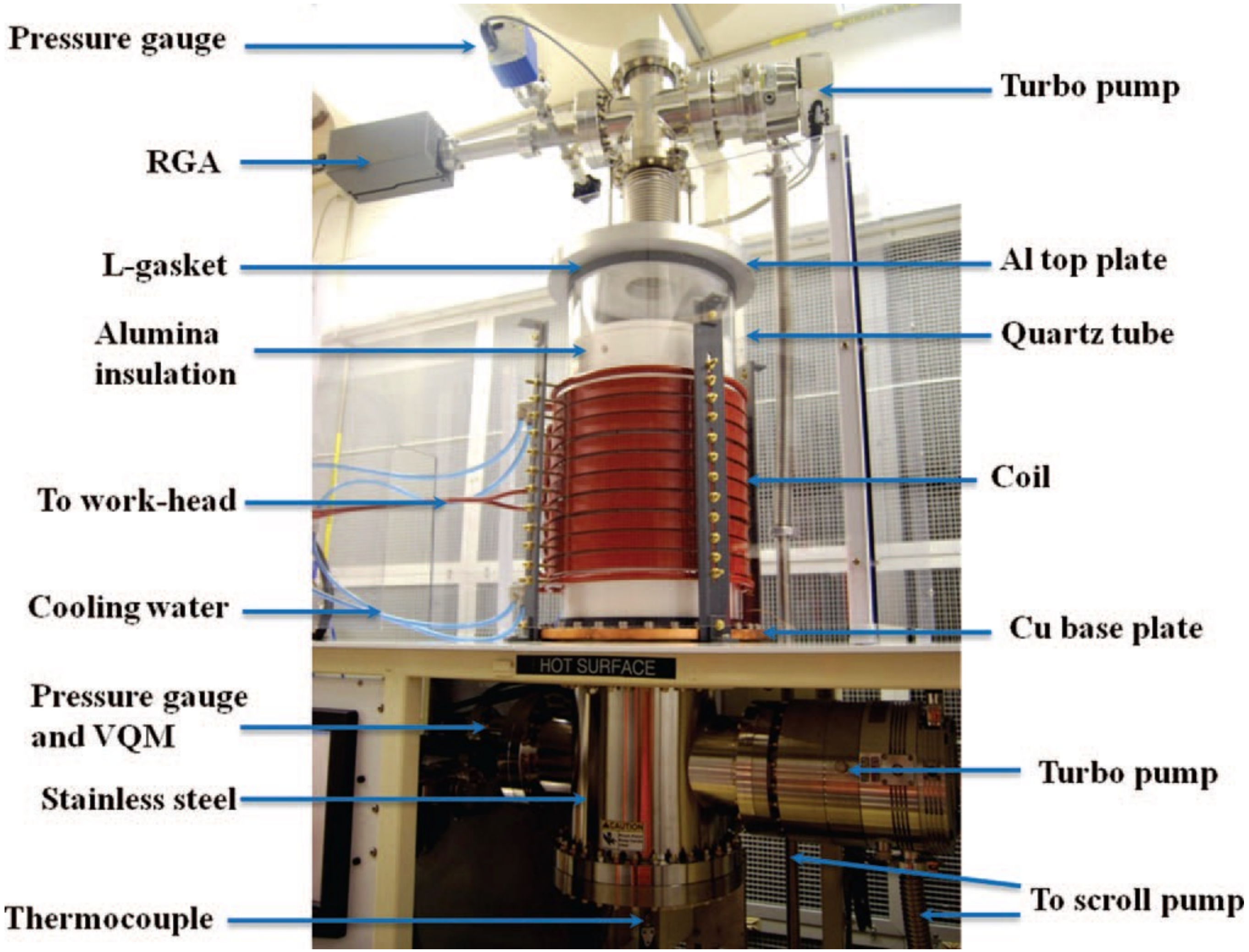
Induction Furnace



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