Gradient limitations in SC cavities
Gradient limitations due to thermomagnetic quenches (B. Bonin)

The quench threshold of niobium cavities is governed by defects.

Clue : thermal model calculations assuming uniform niobium properties predict global instability limits much higher than the phenomenological limits observed in most cases.

Exception : P. Kneisel's cavity (Tokyo-Denkai material) : Eacc = 43 MV/m, close to the theoretical limit, seems to be defect-free. But this occurred once!

Even high purity material will quench if it has defects.

Clue : cavities made from high RRR russian niobium do not seem to have very high quench thresholds (cf Cornell, Wuppertal results). On the other hand, japanese cavities made from medium RRR material have very high quench thresholds (cf KEK results).

What kinds of defects should we suspect?

Normal conducting particles or inclusions; thermally decoupled superconducting defects. Dangerous size : a > a few x 10 μm. Sheet defects might be produced during rolling or forming.

Where do thermomagnetic quenches occur?

Thermometer mapping ⟶ at equator welds, but also elsewhere on the Nb sheet.

How to cure quenches?

Heat treatment! Benefits of heat treatment are obvious from statistics at Cornell, CEBAF, Saclay, Wuppertal; less obvious at KEK, where results are already very good without heat treatment.

How does heat treatment work? Two hypotheses, maybe both are active, we do not know.

Hyp 1 : Ti gettering ⟶purification ⟶improvement of thermal conductivity ⟶thermal stabilization of cavity.

Clue : There is a (weak) experimental correlation between quench treshold and RRR.

Hyp 2 : material homogeneization, modification of the defects. (many indirect evidences).

Heat treatment parameters are not the same for goals 1 and 2. Purification requires high temperatures (> 1300 C for Ti sublimation) during a long time (several hours); homogeneisation and modification of the defects require lower temperatures and shorter durations. Improved recipes for heat treatment exist (Saclay, Wuppertal).

Much room for improvement in the heat treatment recipes!

Heat treatments have drawbacks : They are risky, complicated and expensive. They spoil the Nb mechanical properties. A deep chemical etching is necessary after a double sided titanification (80-100 μm, reduced to 20 μm for Saclay recipe).

If Nb sheets and welds had less defects, maybe we would not need heat treatments!