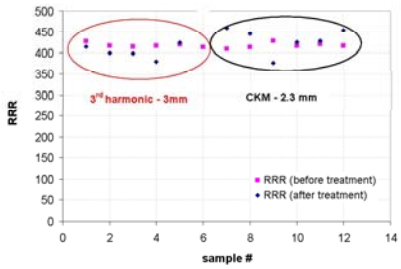
RECENT RRR MEASUREMENTS ON NIOBIUM FOR SRF CAVITIES

P. Bauer, C. Boffo, E. Hahn, D. Hicks, M. Foley, F. McConologue, T. Wokas FNAL, IL, USA

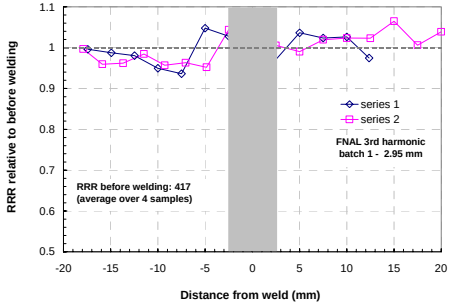
Fermilab is developing superconducting RF cavities of the bulk Niobium (Nb) type for a future linear collider. Several prototypes of a third-harmonic cavity and a transverse deflecting mode (CKM-type) cavity were built. The first 3-cell third harmonic model recently achieved the expected performance limit. Here we report on RRR measurements on samples cut from Nb sheets for the third harmonic and CKM prototype cavities. The RRR parameter is a measure of the purity and thermal conductivity of the bulk material. The RRR was measured upon receipt and after the chemical polishing and heat treatment steps used in the cavity fabrication. These measurements not only serve the purpose of quality control of the pre-cursor material but also as a check of the cavity processing. We also measured the RRR of the electron-beam welds using samples cut from plates produced by joining sheets by e-beam welding in the same device used for welding cavity parts. We also present our next generation RRR measurement system, currently in the design stage.



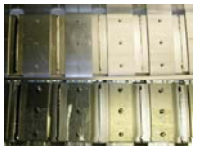
RRR test results on niobium for the FNAL third harmonic and transverse deflecting (CKM) cavities, as received and after a complete standard surface treatment for cavities, including several cleaning, rinsing and etching steps as well as a high temperature anneal.

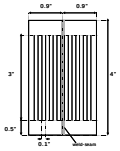
To verify if the various treatment steps applied to the Niobium blanks affect the RRR, the samples underwent a full sequence of treatment steps, including a ~100 min BCP (1:1:2) etch, a high temperature heat treatment (800°C, 5 hrs) in vacuum (<10-6 Torr) followed by another 20 min BCP polish. The results of the RRR measurements on these samples is shown in the figure on the left, indicating that within the measurement reproducibility of ±5% there is no discernible effect of the surface treatment on the RRR.

Weld-Test Series



3rd harmonic batch-1 weld series results (normalized to average RRR before welding, ~417). The gray strip in the center represents approximately the weld region.

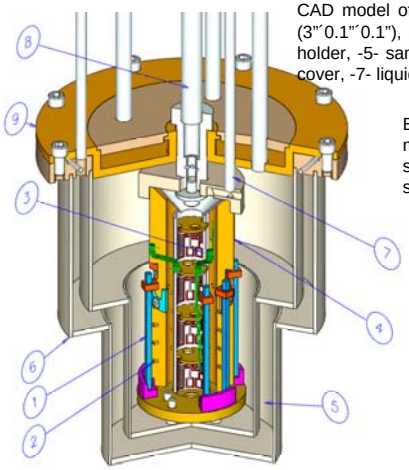




Welding test fixture top and bottom after welding. The samples plates are clamped between aluminum plates

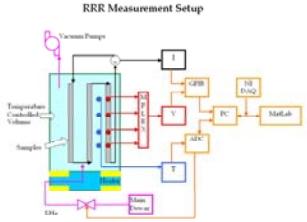
The weld-series results show that the effect of welding on the RRR is minimal. Note that the RRR varies only within ±5%, which is more or less the measurement reproducibility of our 3R measurement system. The lack of an effect of the weld on the RRR was also previously found in four weld-samples made at Sciaky with thinner material used for the first transverse deflecting cavities [SRF05 conference].

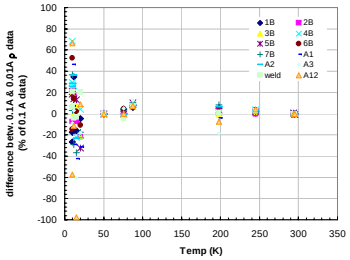
New Fermilab RRR test station



CAD model of new Fermilab RRR measurement insert. –1- Nb sample (3"˝0.1"˝0.1"), -2- Pogo-pin, -3- helium heating channel, -4- G10 sample-holder, -5- sample insert insulating vacuum, -6- removable sample insert cover, -7- liquid helium supply, -8- support, -9- top flange;

Below: pumping manifold, pumping station, measurement system schematic;





A special test was performed on some samples of the 3rd harmonic Nb, not only measuring with the usual measurement current of 0.1 A, but also with 0.01 A. Differences in the results obtained with different currents are indicative of non uniform current distributions or heating effects, especially important at temperatures close to critical.

The figure above shows large differences in the 9-10 K data, very much in contrast to the small difference at higher temperatures. Also the absolute difference is largest at low temperature and decreases exponentially toward larger temperatures. This together with the scattering of the differences to positive and negative signs, indicate that the issue is noise.The analysis of the spread of 9-10 K data for the two different current settings shows that in the 0.01 A case the difference between one measurement and the average of all measurements in this temperature range, averaged over all samples is 25%, much larger than the similar value for the 0.1 A measurements. That indicates that the variations seen in the figure originate to a large extent in the variation of the 0.01 A data themselves. With typical sample resistances of the order of 1 μΩ, the voltage at 0.01 A becomes ~10 nV.