

USE OF PRECISION X-RAY DIFFRACTION, INTERSTITIAL GAS FUSION ANALYSIS AND SQUID MEASUREMENTS TO INVESTIGATE CVD- AND BULK- NIOBIUM SAMPLES



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Sample Characteristics (*red #'s are before Cornell 1000 °C anneal for 6 hours in 10⁻⁶ vacuum, black #'s are after Cornell anneal*):

Bulk Niobium("RRR"): obtained from DESY with nominal RRR=500, annealed at DESY in a vacuum furnace at 1400 °C; grain size is 500-1000 microns.

Results of IFG chemical analysis: H: 1.06 atomic %, O: 186 ppm, C: 108 ppm, N: 44 ppm ("ppm"²=atomic ppm)

CVD Niobium("CVD"): obtained from Ultramet on a Mo mandrel. Highly oriented, with 100 planes parallel to surface; grain size 100-400 microns; estimated impurities from SIMS comparison with RRR were:

H: **7.2 (0.6)** at.% (before annealing), O: **300 (50)** ppm, C: **18 (9)** ppm.

SQUID Tc and Magnetization curves vs. H at 1.9 °K:

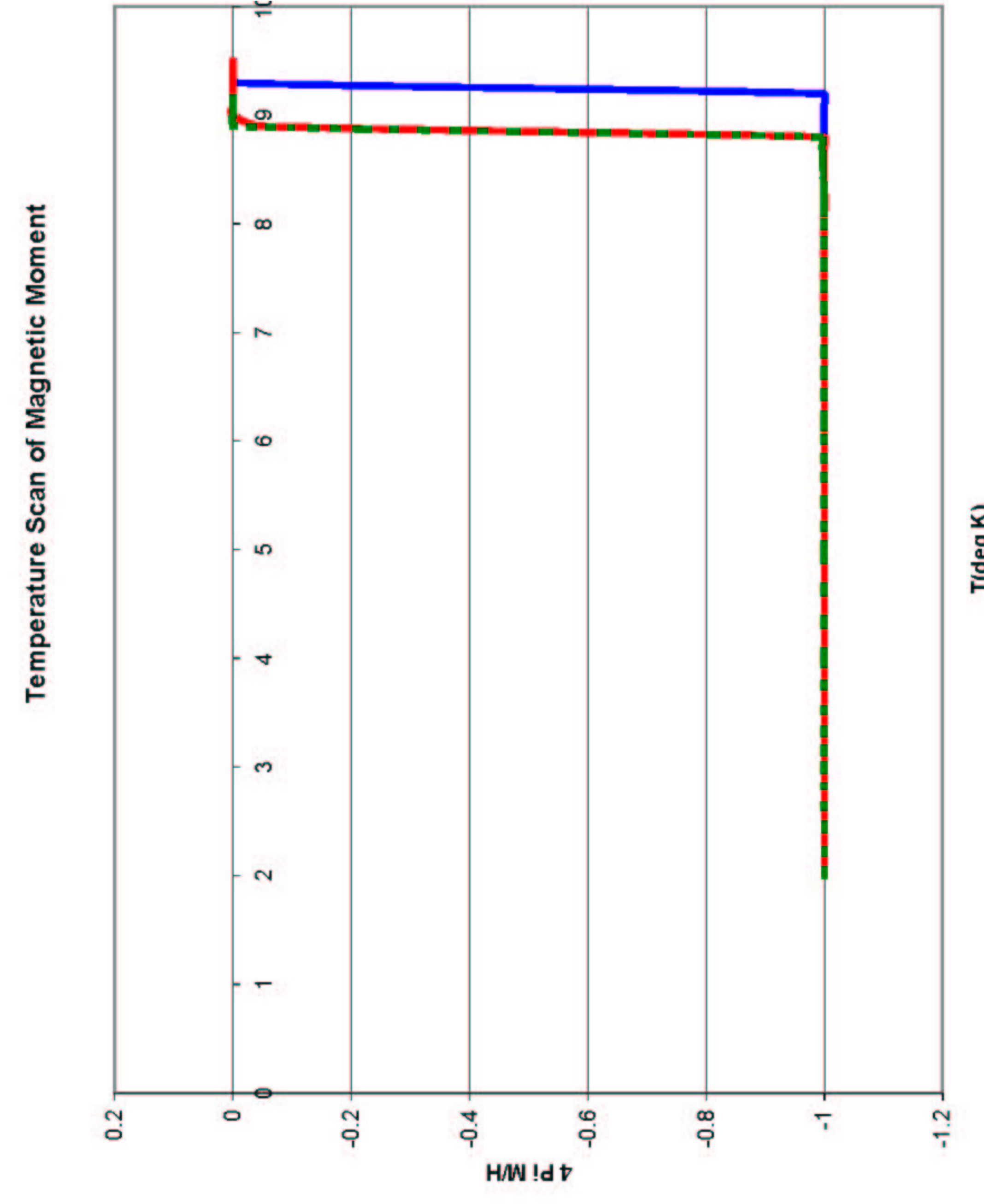


Table 1: Numerical Results for Tc and ΔTc

Sample	Tc[observed]	ΔTc
DESY RRR=282	9.24 +/- .02 K	≤0.1 K
CVD	8.86 +/- .02 K	≤0.1 K
Tc(DESY)- Tc(CVD)	0.38 +/- .03 K	

Tc in Table 1 should be corrected upward by .02 °K for both samples, H=10 Oe. (Note SQUID DESY sample is not RRR=500, but 282.)

-0.38 °K shift in Tc for CVD is not explained by interstitial impurities; removing H by annealing makes no difference. Possible cause: high defect density from pre-anneal H.

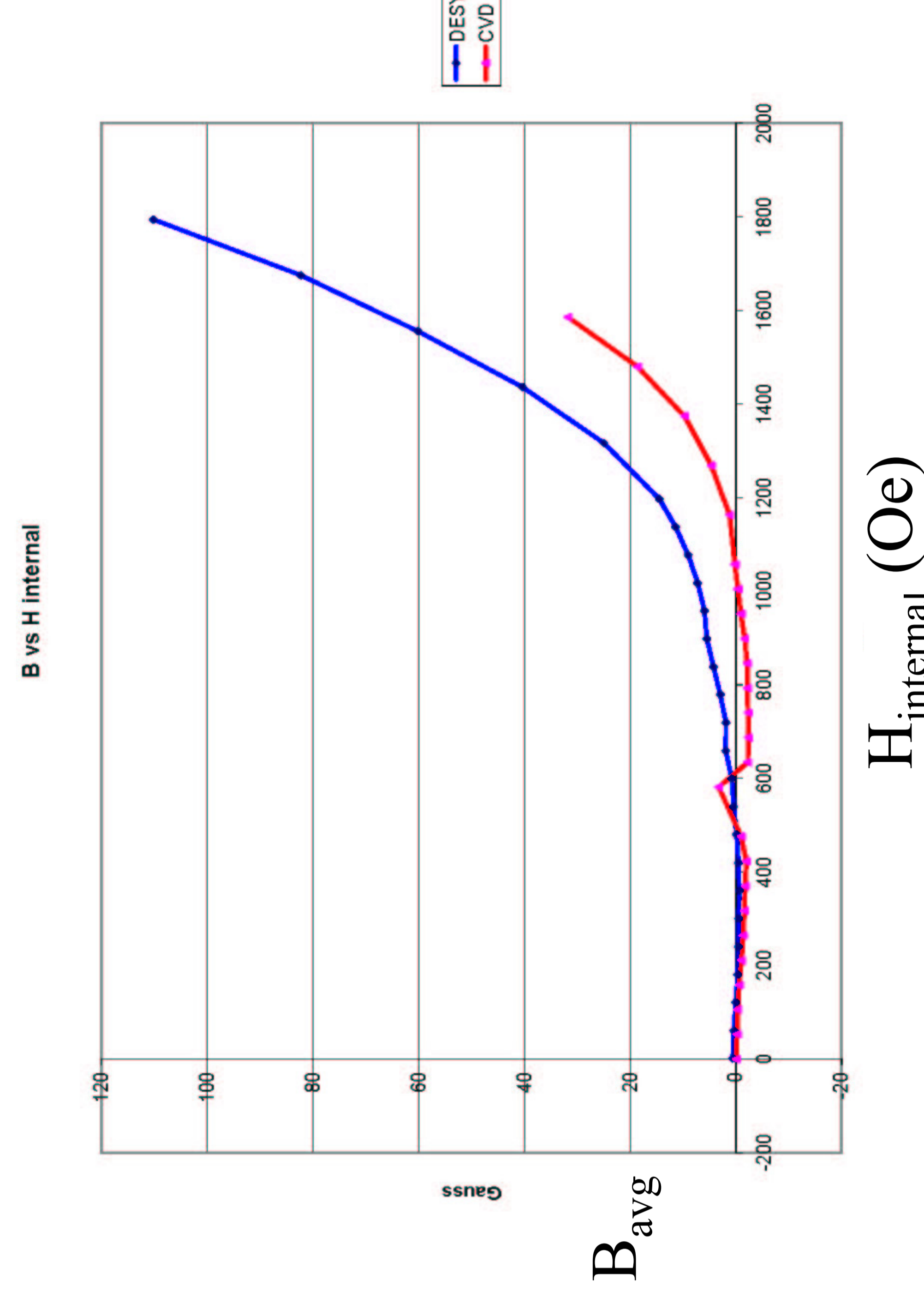
X-ray Results for Lattice Constant "a":

Bragg reflections measured: 110 or 200 and 211. Compared with sapphire 110, silicon 311, and silicon 400 single crystals respectively. Corrected for relative sample heights, transparency and refraction. These data are from 211 reflections only:

Preliminary results(angstroms): a(RRR) = 3.30105(13), a(CVD) = 3.29933(13)

(Lattice expansion for hydrogen, Δa/a = 4.75 +/- 0.25 x 10⁻⁴/atomic % hydrogen)

The RRR-CVD Δa corresponds to 1.10 +/- 0.15 at. % more H in RRR than in CVD



The graph on the left measures the magnetic flux penetration vs. H(internal) in small rectangular samples. (Hc1 is 1765 Oe for pure Nb at 1.9 °K.) These curves show that some flux penetration at sample edges occurs for H < Hc1. The H field has been corrected for depolarization using the initial slope of the magnetization, dM/dH.

Conclusion:

- Chemical Vapor Deposition niobium is a prime candidate for SRF film or bulk cavities. CVD could significantly lower costs for large scale SRF applications. More development work is needed.**