Update on fundamental SRF R&D at FNAL

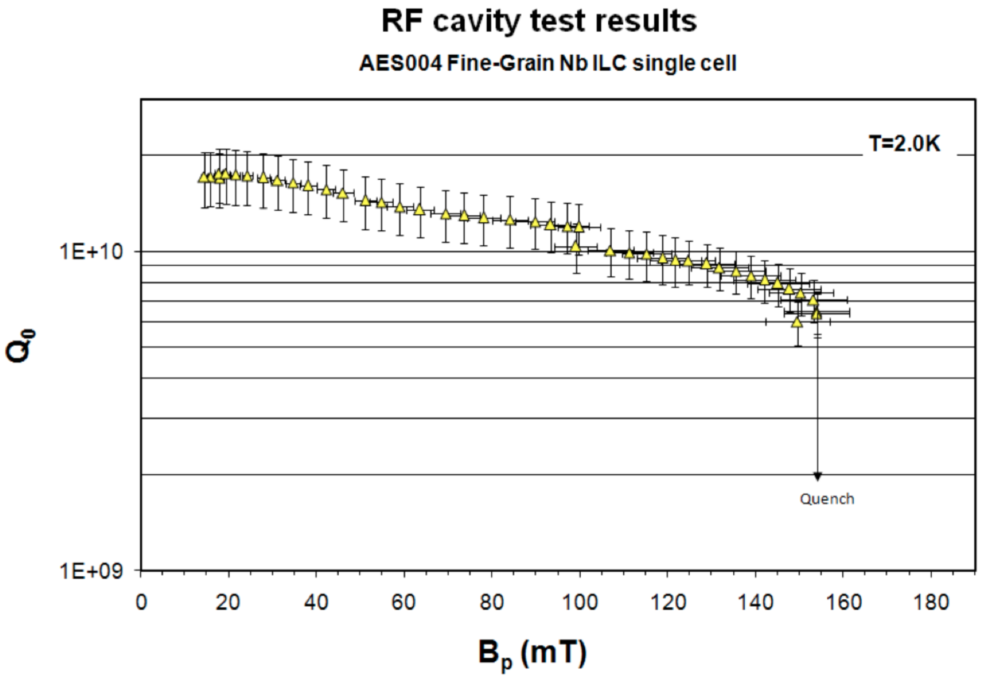
A. Romanenko
Fermilab

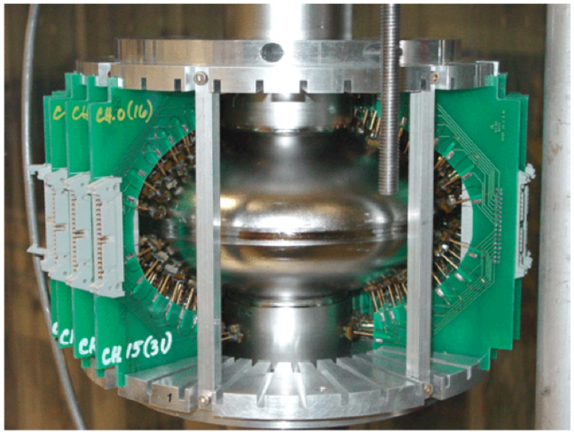
Overview of experiments

- High field quench studies
  - Quench site localization and cutout
- Post-baking losses
  - Dissipative areas in the absence of HFQS
- RF layer profiling via HF rinsing
- Near-surface hydrogen enrichment and evolution
- High field Q-slope studies
  - EP cutout (RF test with thermometry – current visit)
- Medium field Q-slope studies
  - T and treatment dependence
- SRF University collaboration (Northwestern, UIC, NHMFL/FSU)

High field quench and post-baking losses

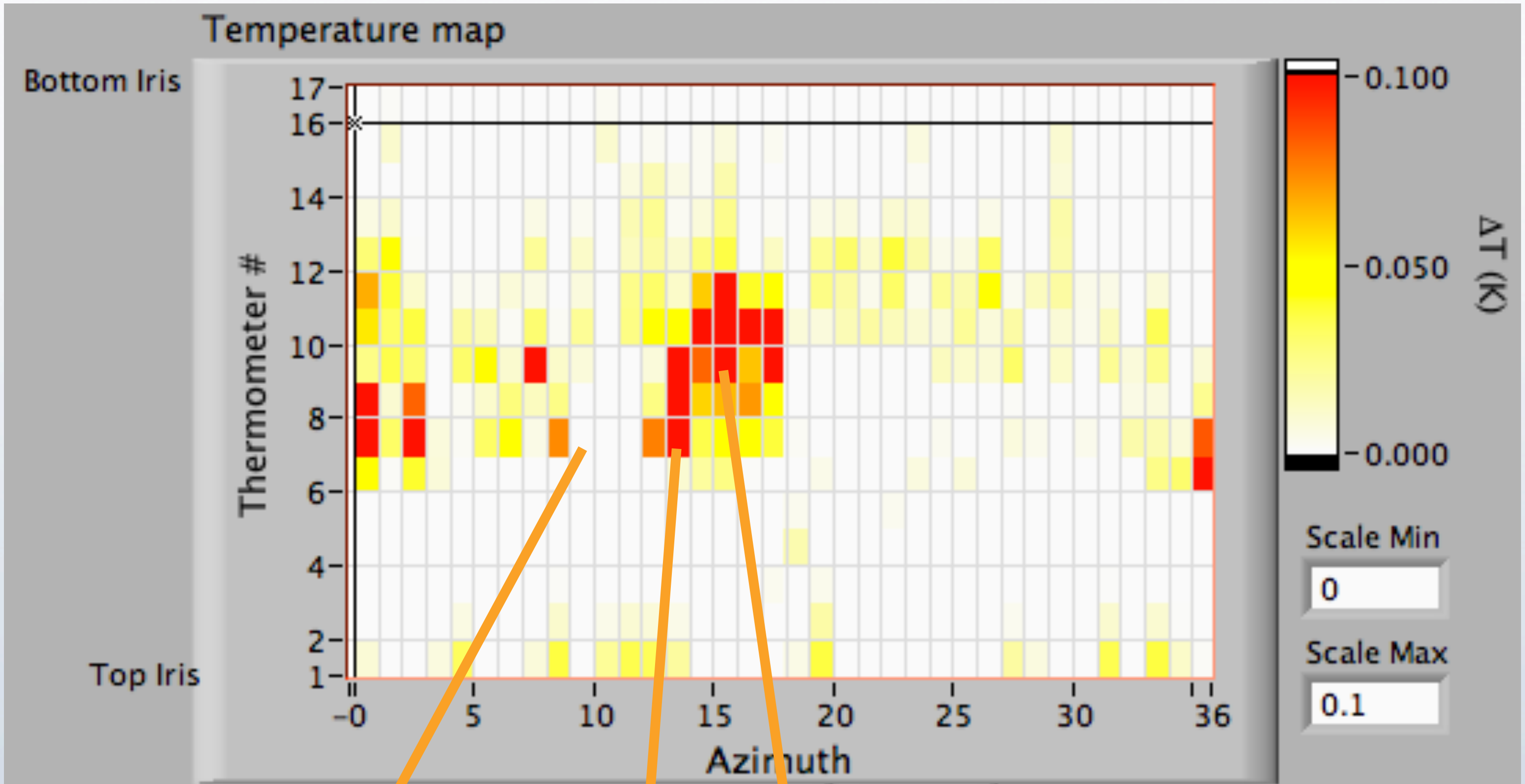
- 1.3 GHz fine grain single cell
  - EP+120C bake at ANL/FNAL
  - RF tested at JLab with thermometry last year (collaboration with G. Ciovati)





Thermometry system attached to outside cavity walls

Lossy areas AFTER mild baking

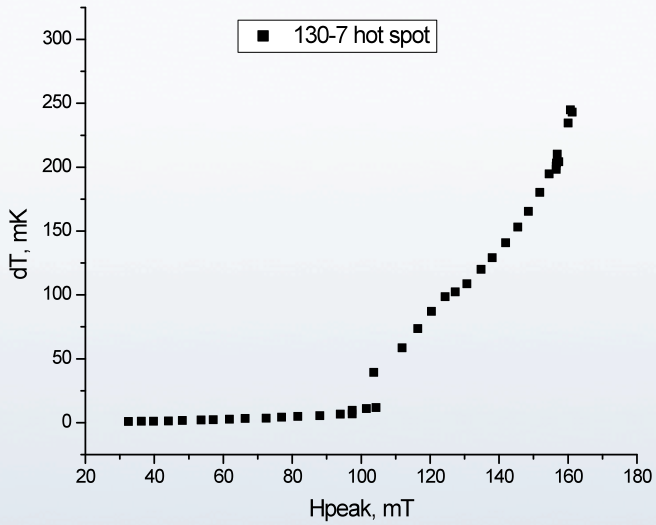


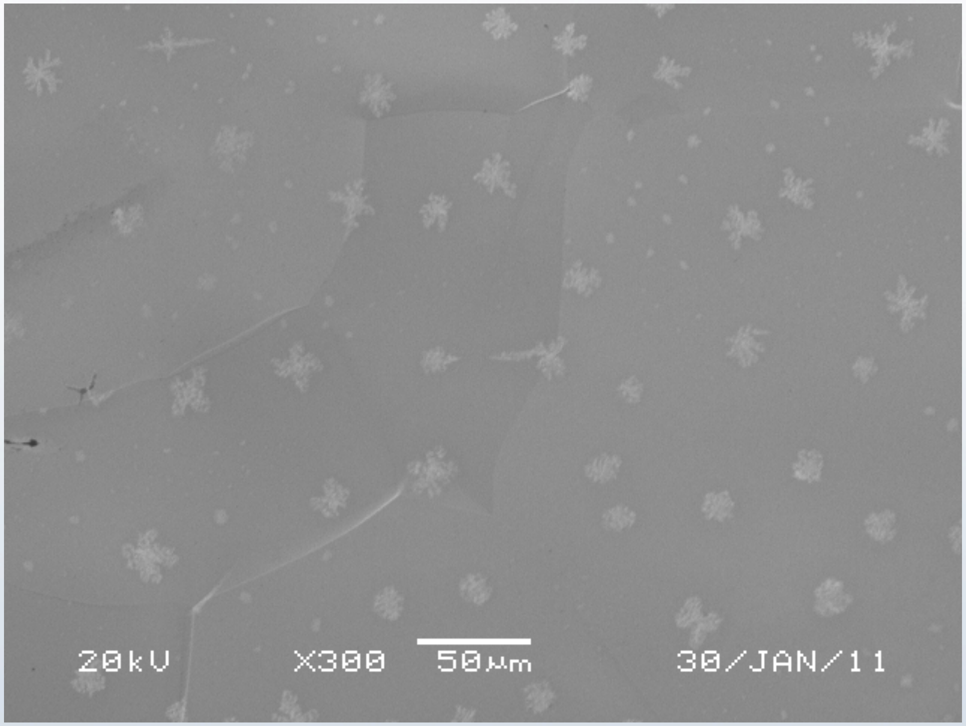
130-7 hot spot

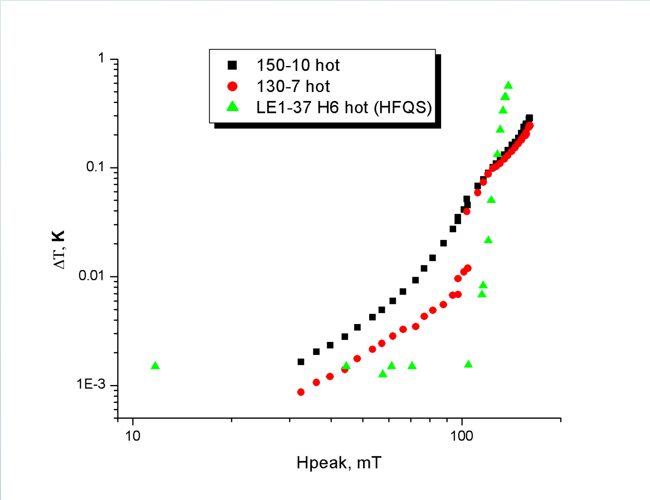
150-10 hot spot

90-7 cold spot

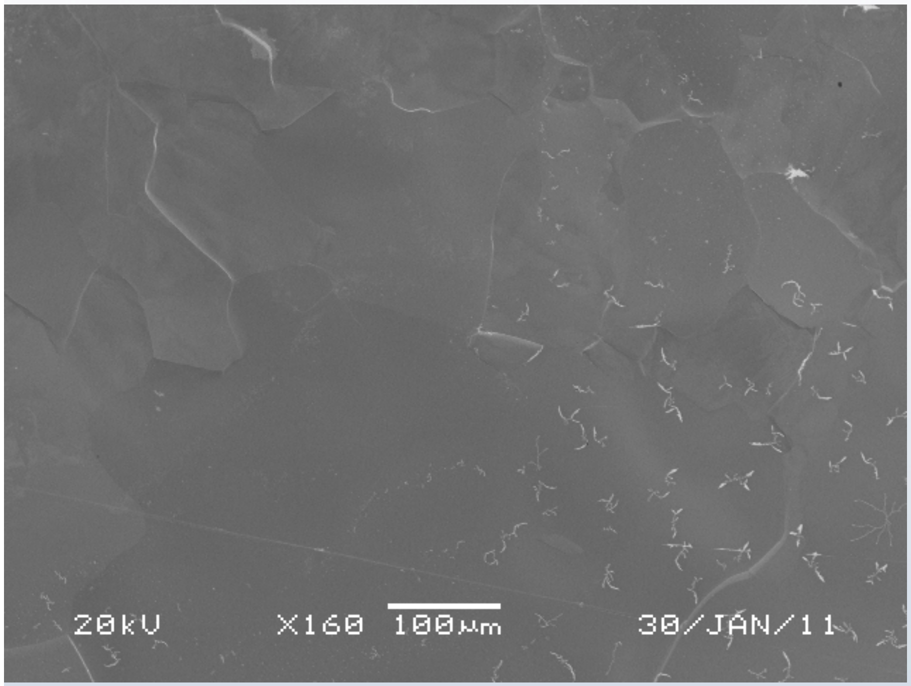
130-7 hot spot

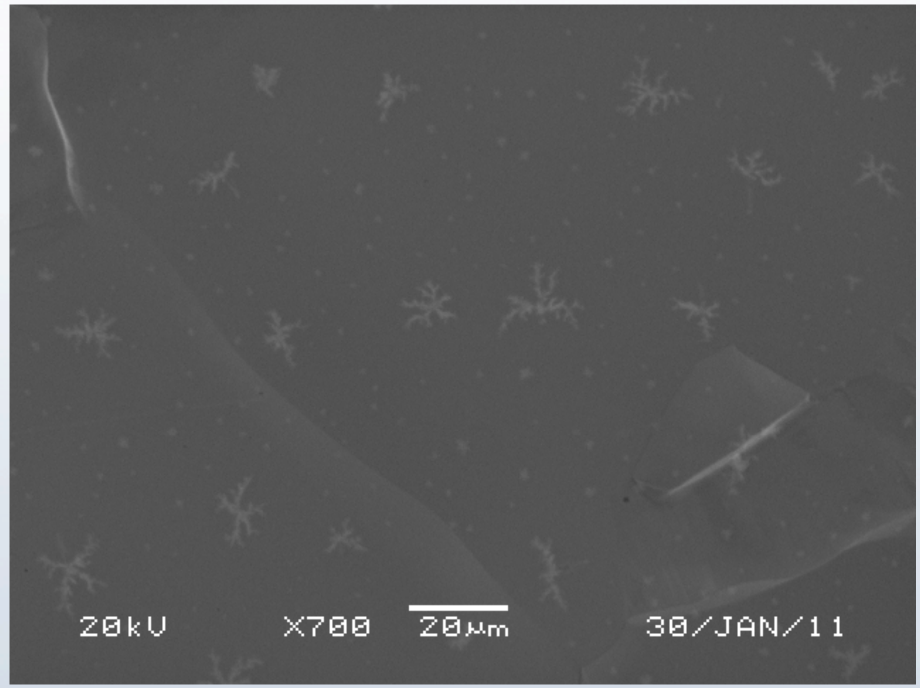




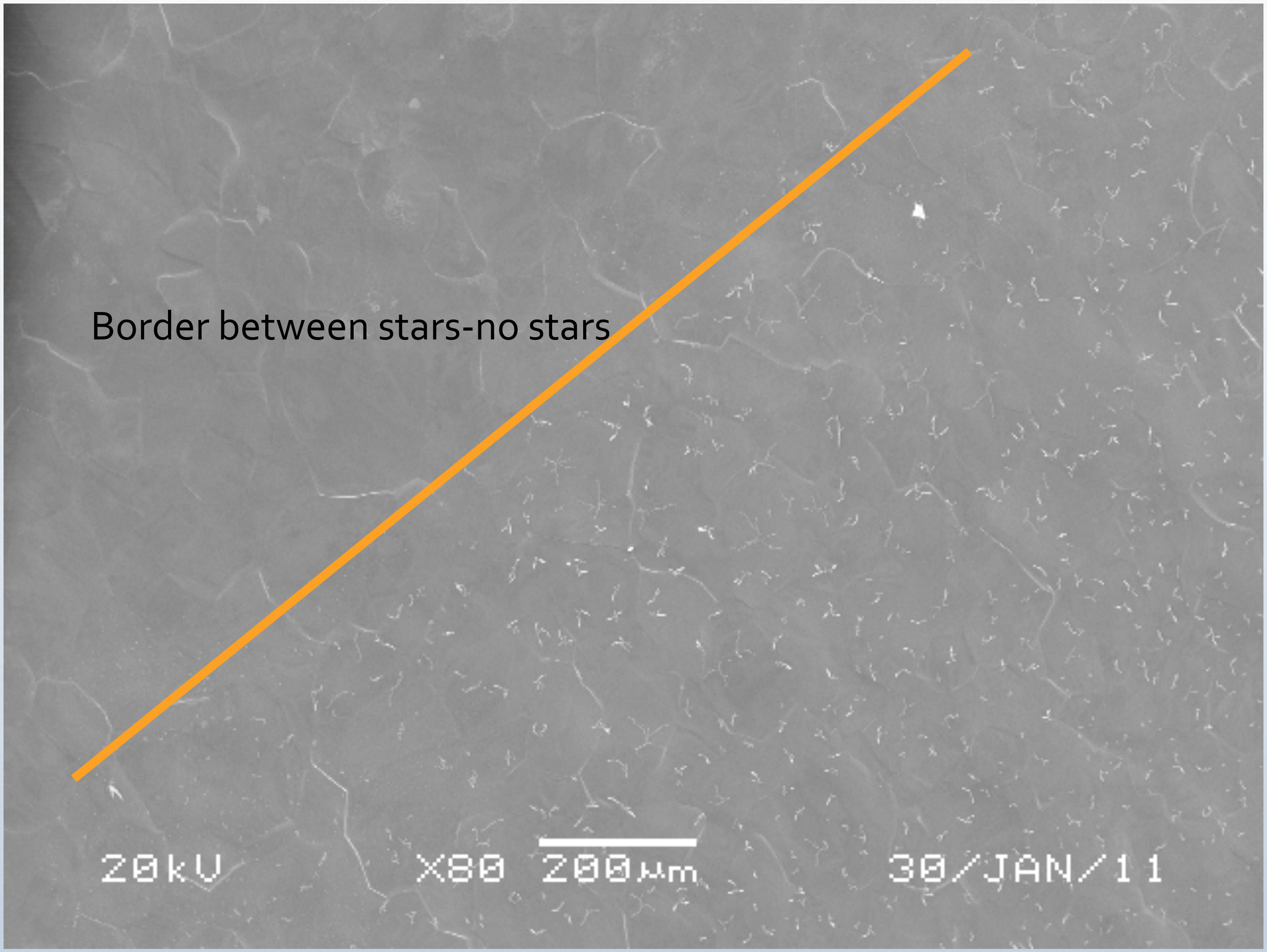


130-7 hot spot

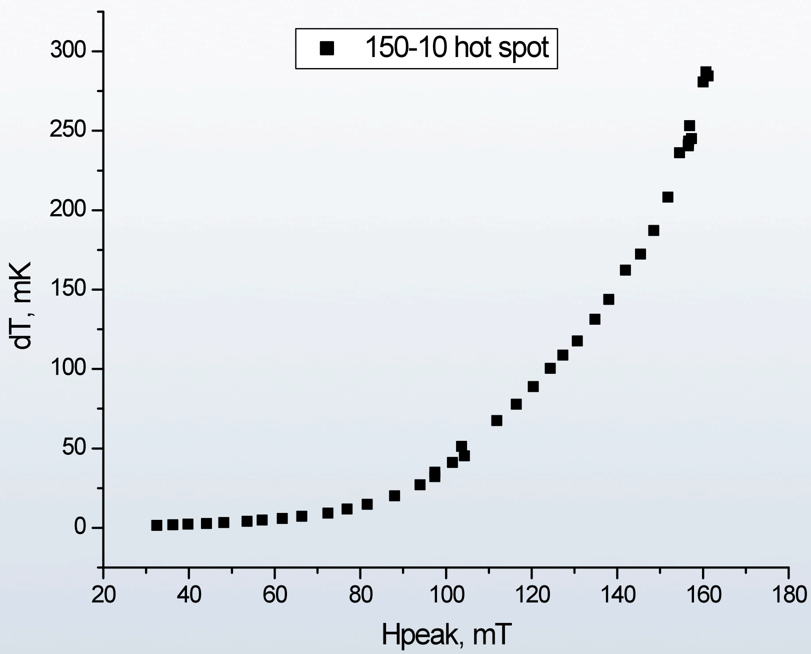


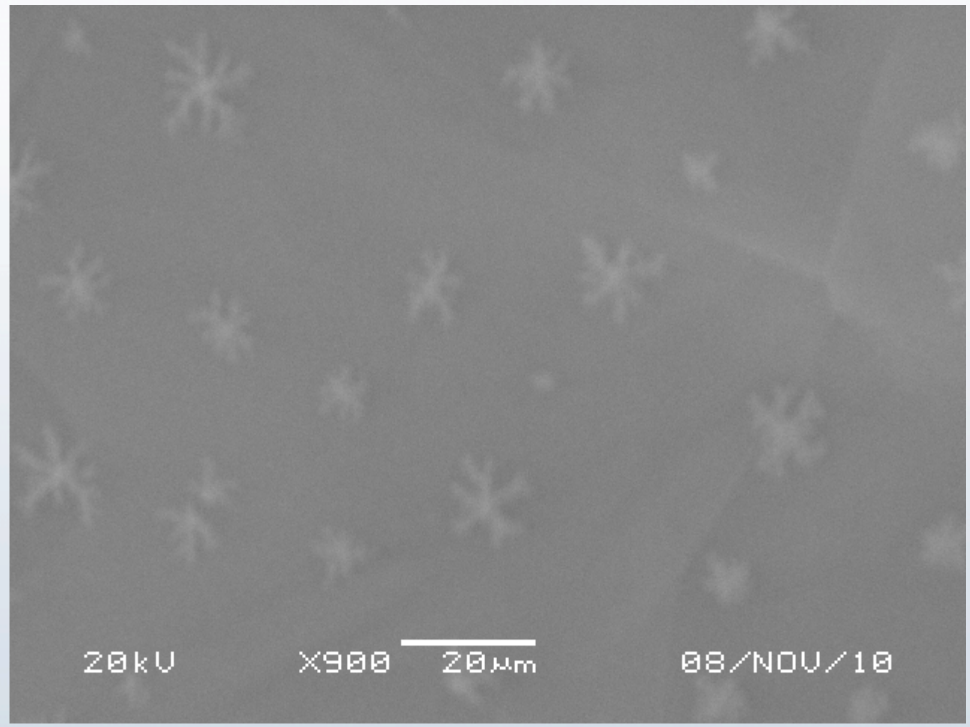


130-7 hot spot

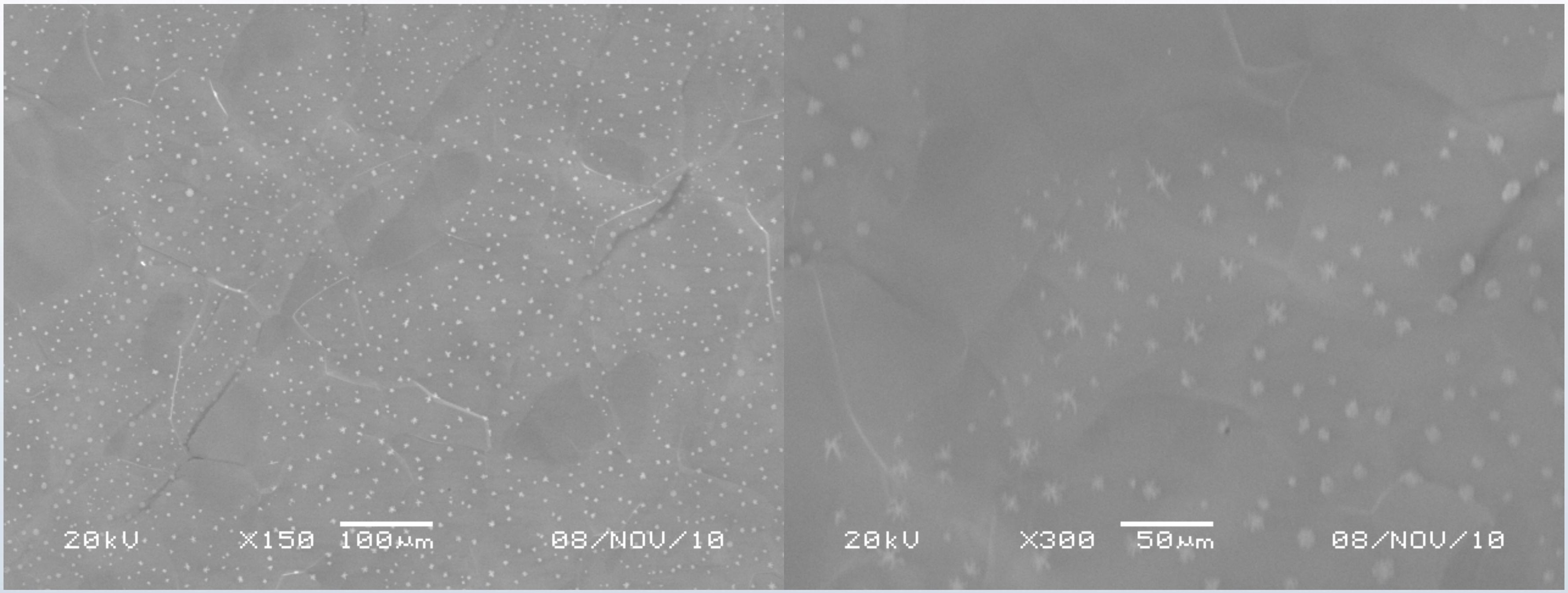


150-10 hot spot

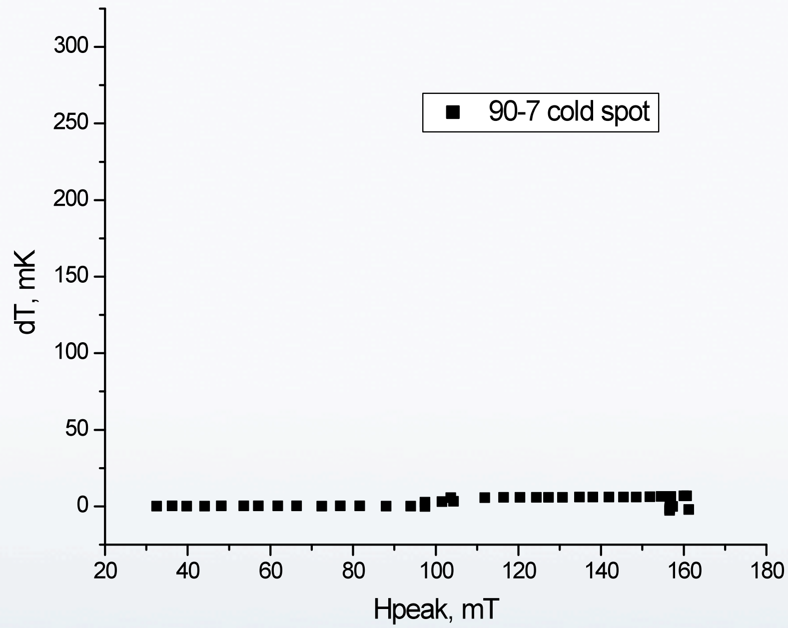


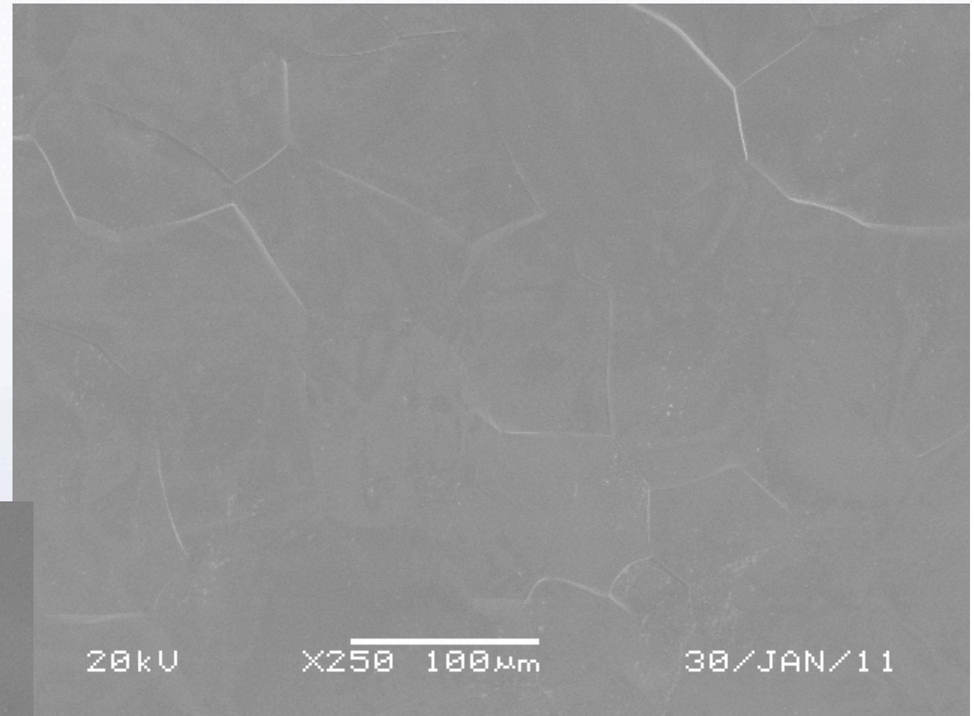


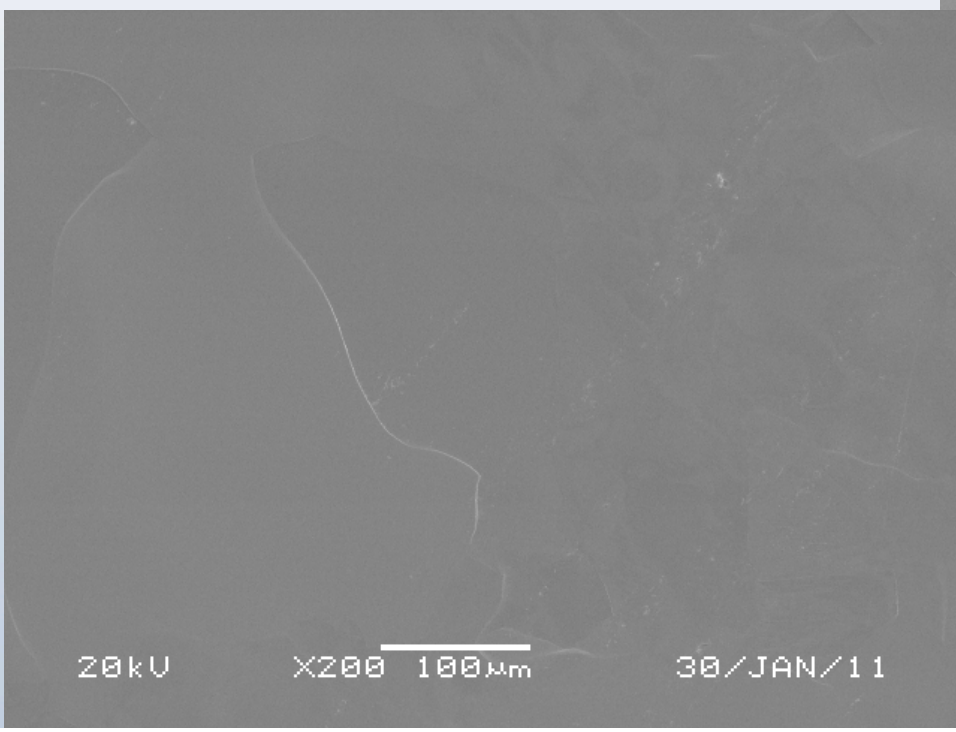
150-10 hot spot



90-7 cold spot



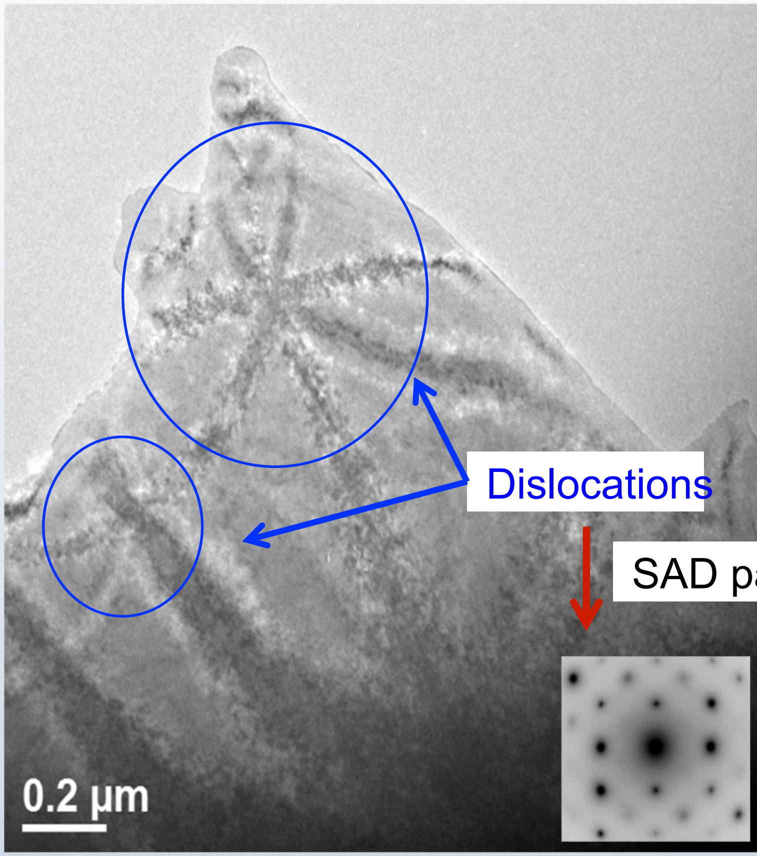




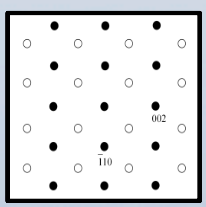
❑ TEM – Pure Nb

Y. Kim, D. Seidman – Northwestern Univ.

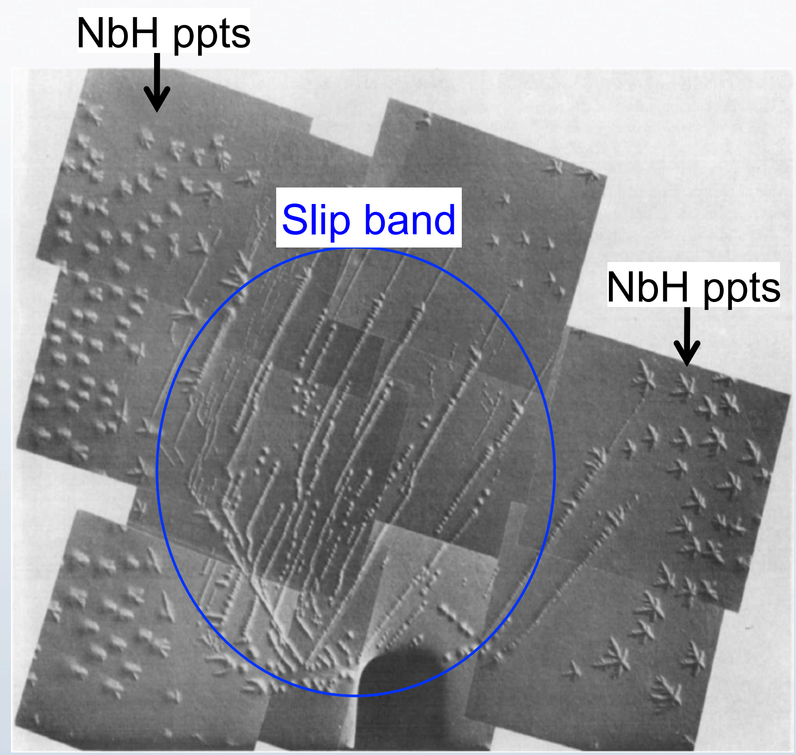
◆ NbH precipitates near dendritically shaped dislocations



Nb 110 zone
Simulated SAD
pattern



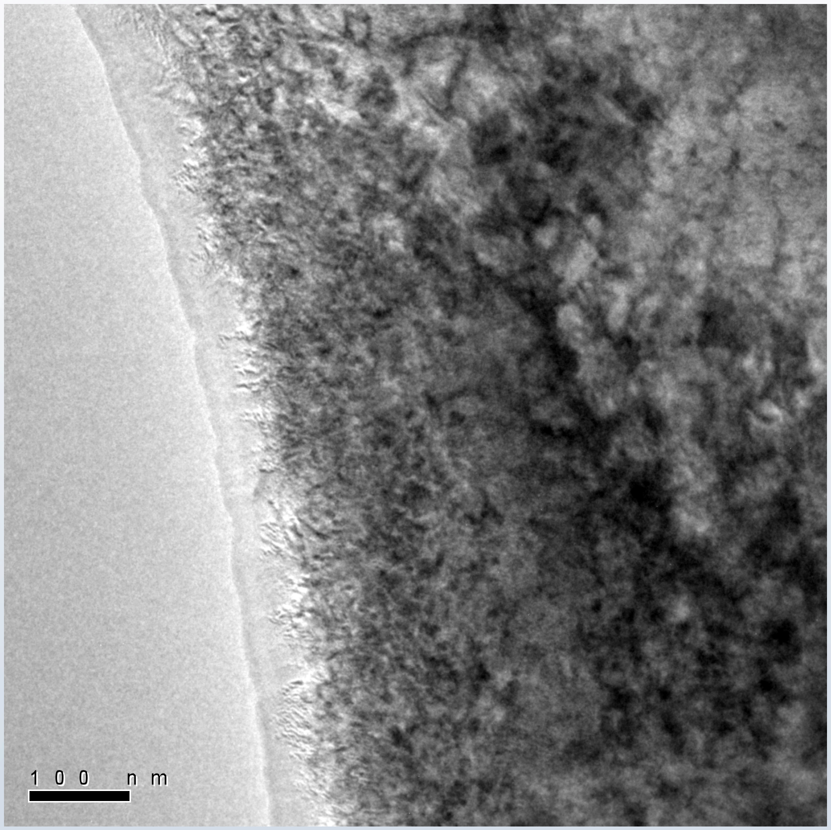
● Nb ○ H sublattice



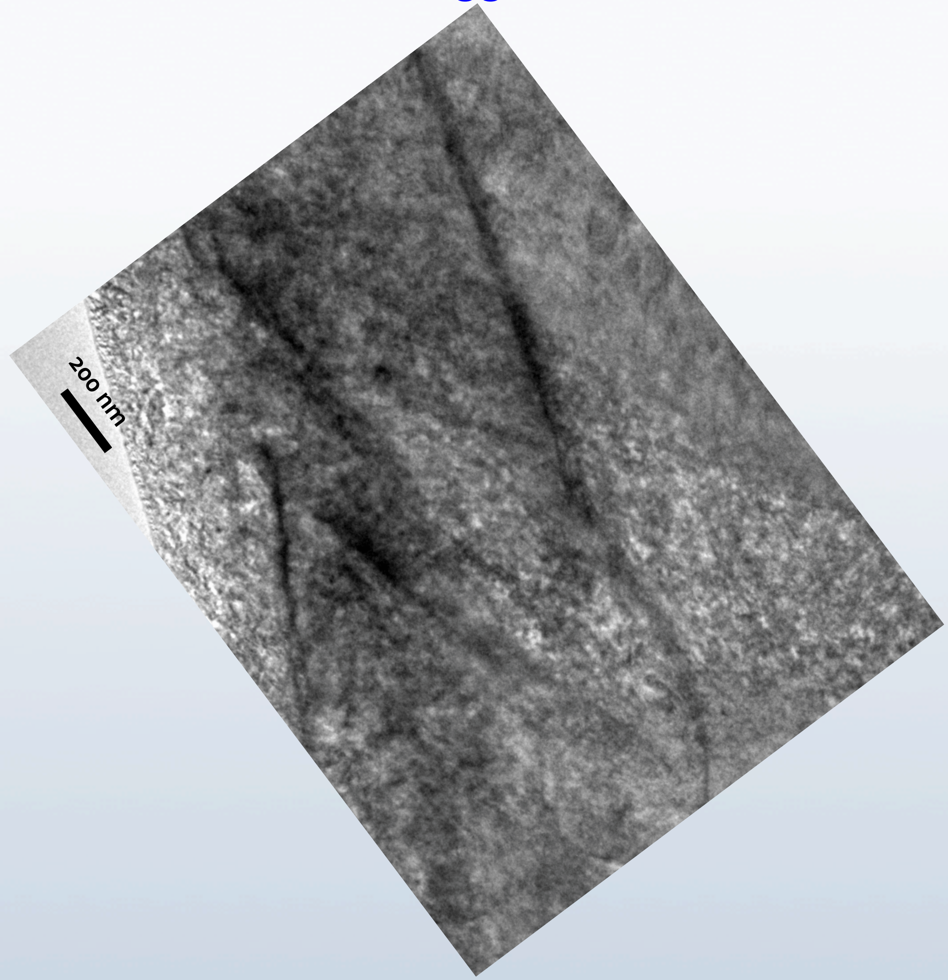
Grossbeck, Birnbaum , Acta Metall. 25 (1977) pp. 135

In-situ cooling of Nb cavity sample:

300 K



95 K



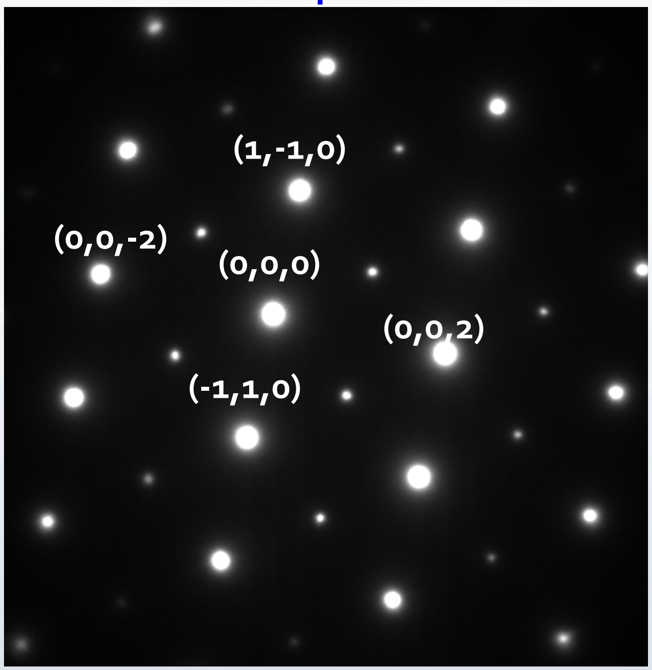
R. Tao and R. Klie

Nanoscale Physics Group

UIC Physics

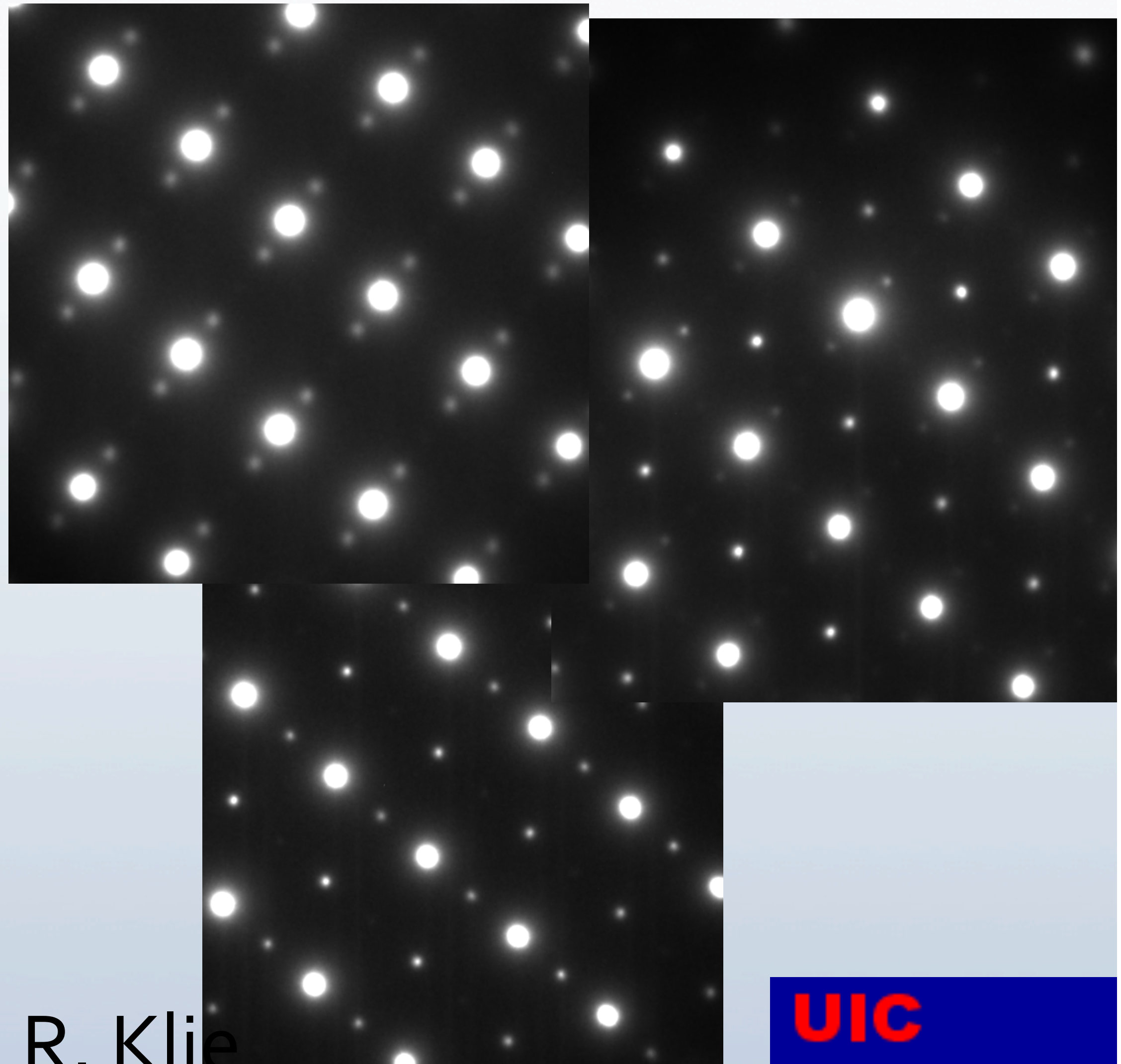
Effects of in-situ cooling:

Room temperature



NbH (110) ?

Superlattice at 95K



Nanoscale Physics Group

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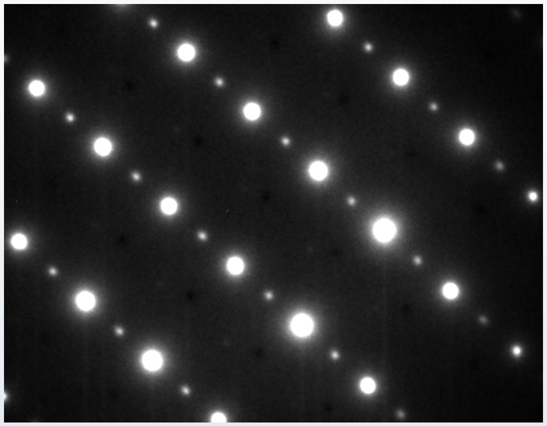
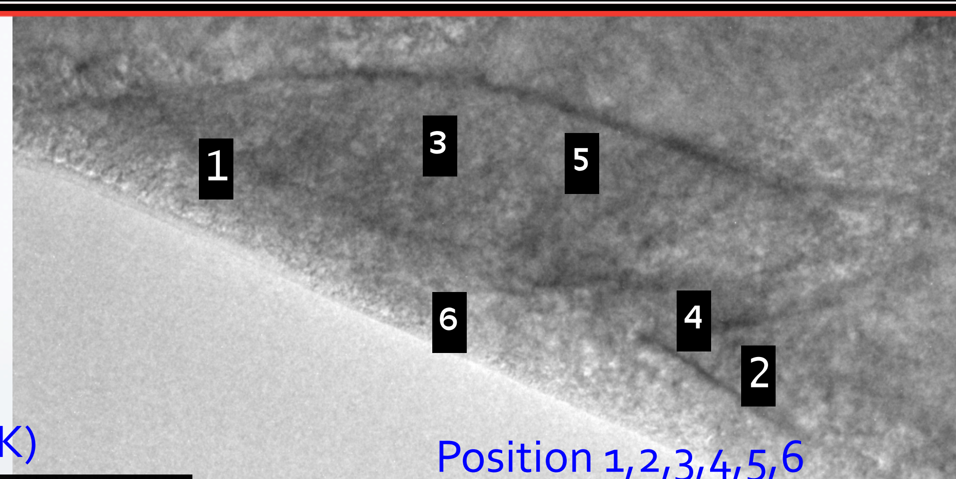
UIC Physics

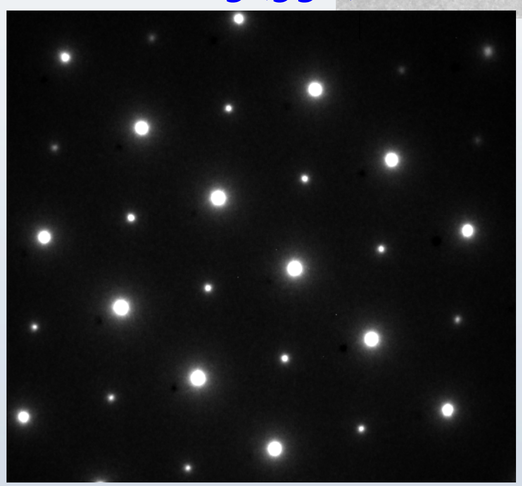
Superlattice at 96 K:

Position 1,3,6 (95K)

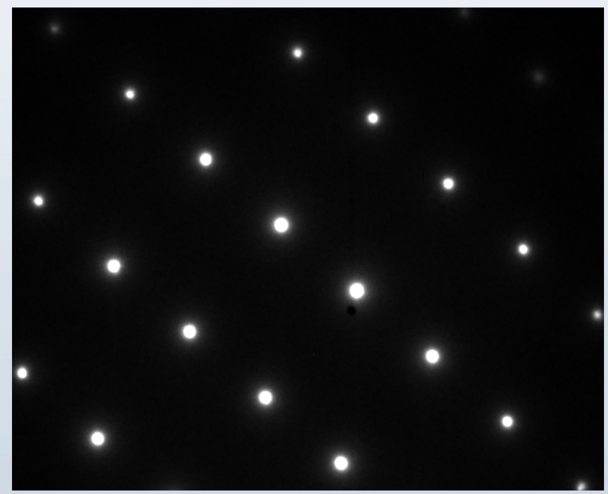




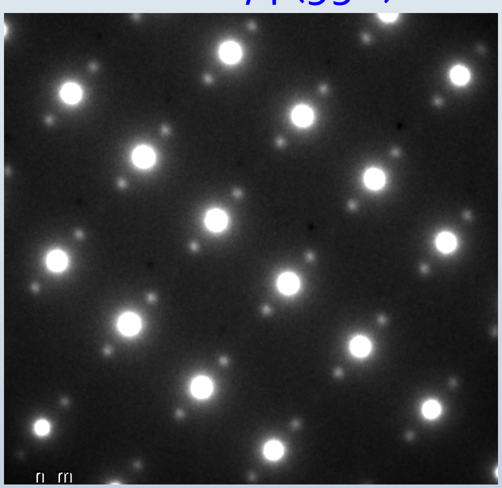
Position 5 (95K)



Position 1,2,3,4,5,6
(room temperature)



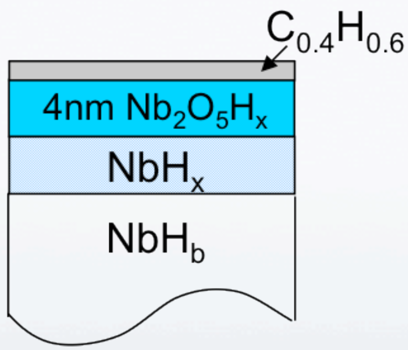
Position 2,4 (95K)



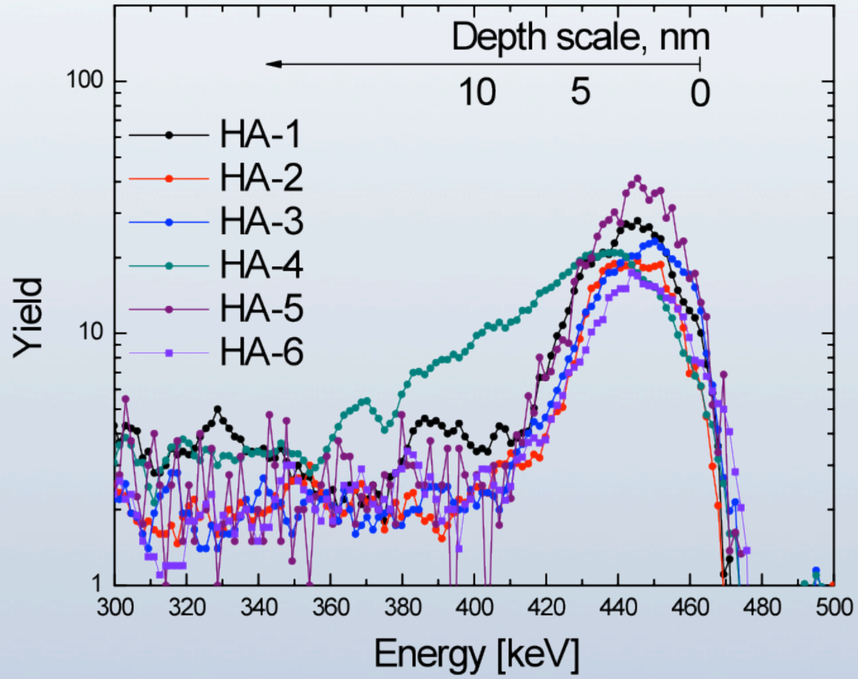
Superlattice totally disappears once back to room temperature.

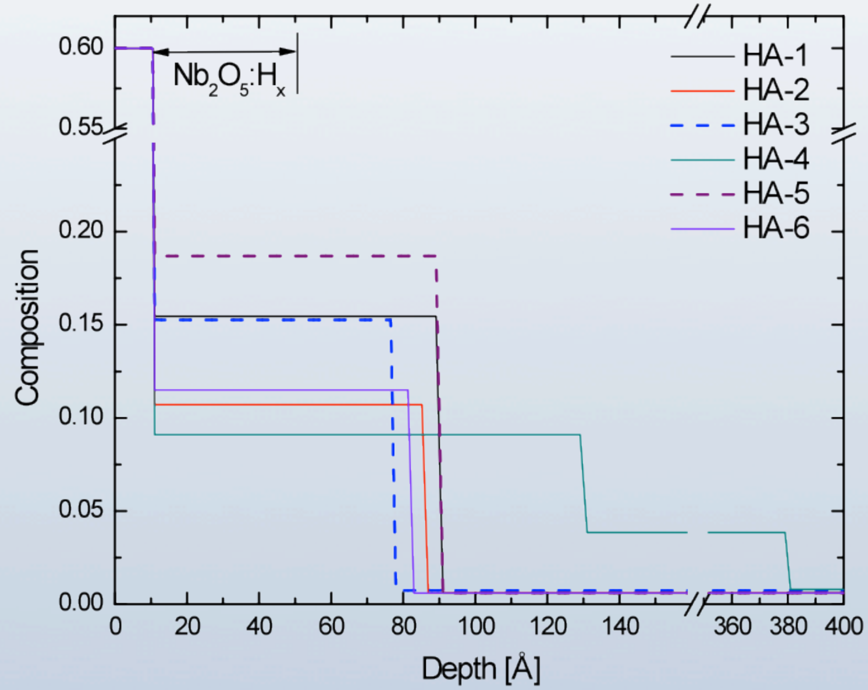
R. Tao and R. Klie

Hydrogen near-surface enrichment

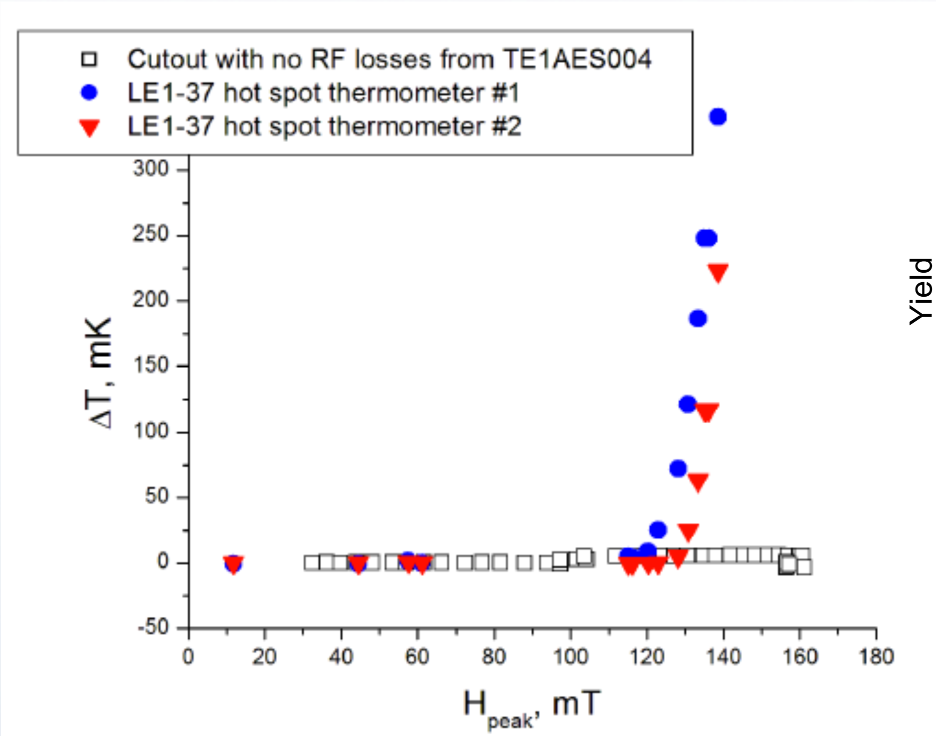


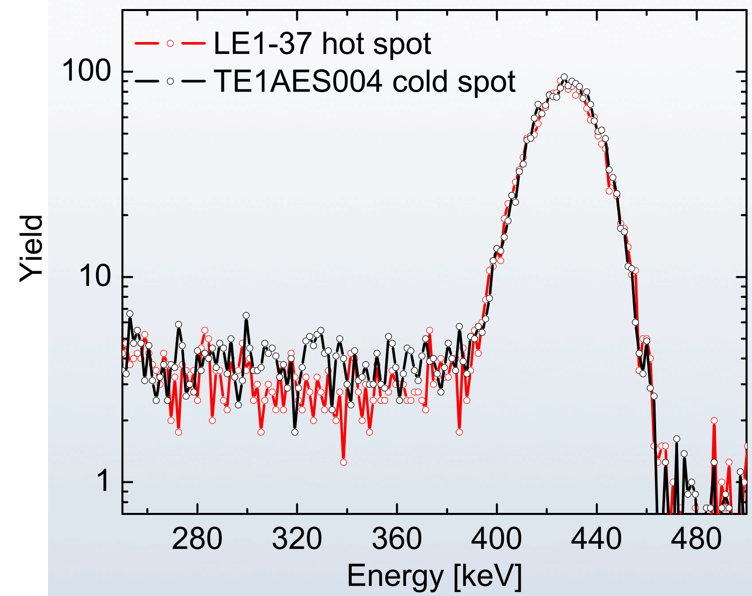
Elastic recoil detection shows hydrogen enrichment
in all samples





Hydrogen studies by Elastic Recoil Detection

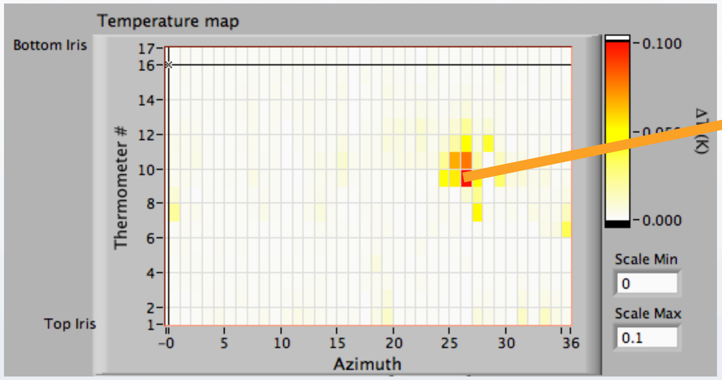




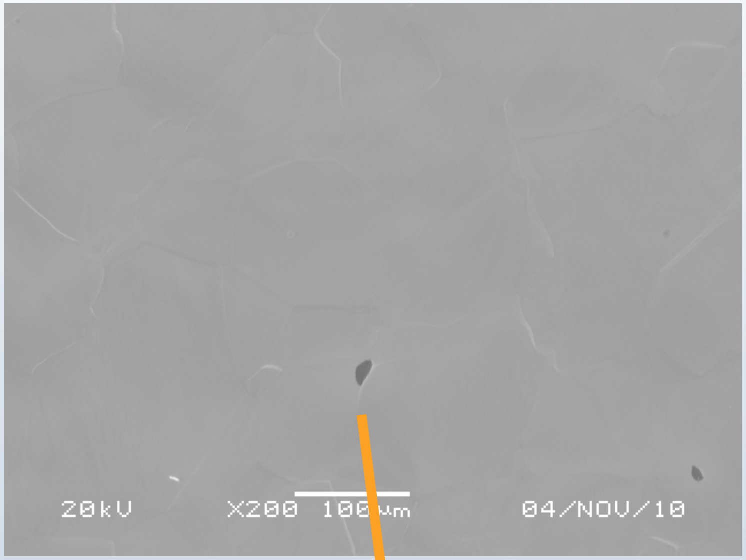
Drastically different RF losses – exactly same H depth profile!

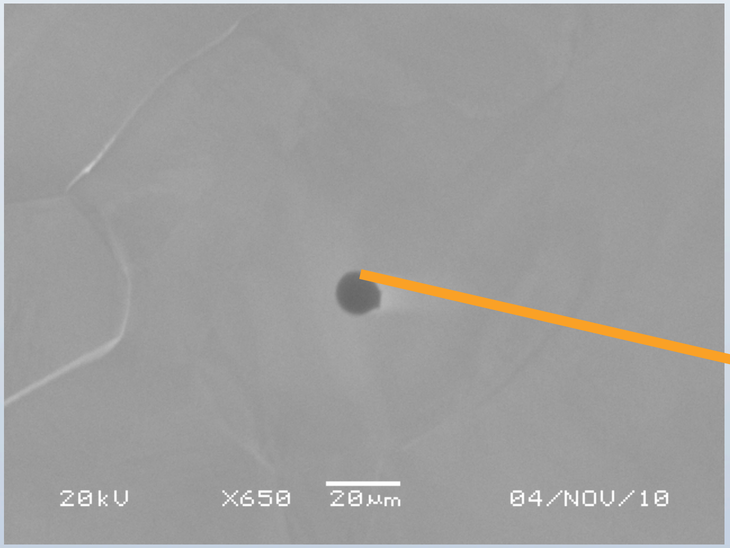
Same amount of hydrogen but precipitated/not precipitated?

Quench



Quench at 160 mT
Site localized and cut out





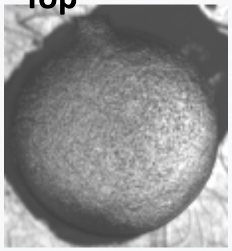
Carbon spots - the only feature found so far

A. Polyanskii, Z. H. Sung

MO imaging - the observation of the flux penetration

00%

Top

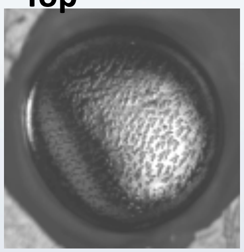


N_z=0.6667,
N_{enh}=1/(1-N_z)=3.001

T=6K H=0, Remn
after H=80 mT

23%

Top



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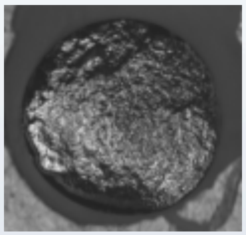
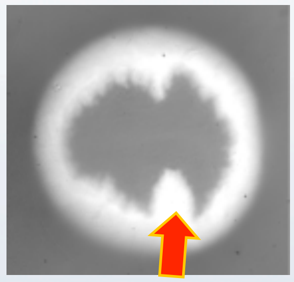
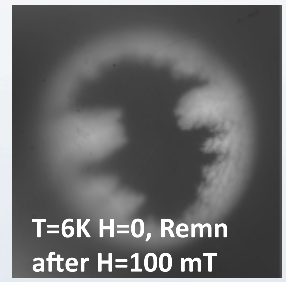




N_z=0.653,
N_{enh}=2.882

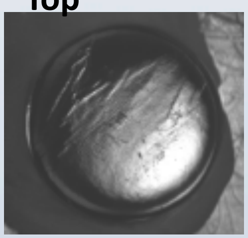
T=7K H=0, Remn
after H=52 mT

bottom



35%

Top



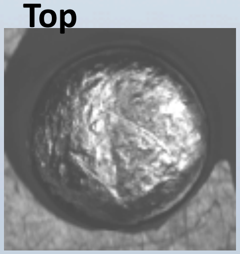
bottom

N_z=0.649,
N_{enh}= 2.858

T=6K H=0, Remn
after H=96 mT

46%

Top

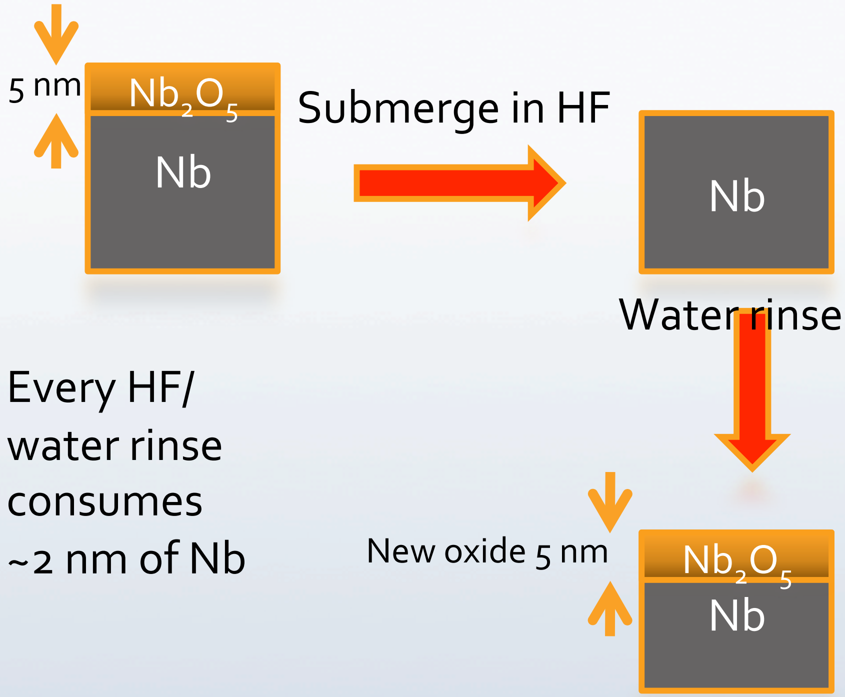


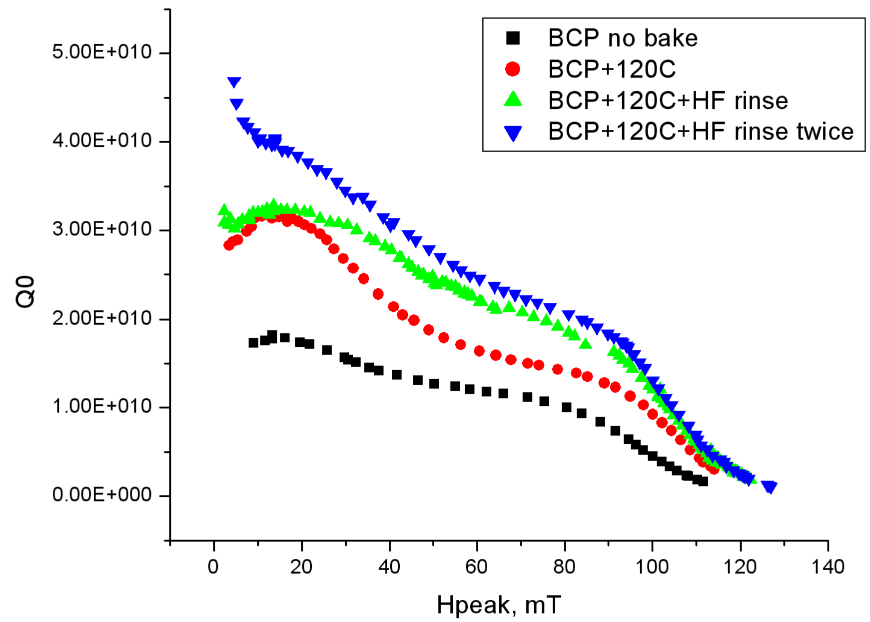
N_z=0.637,
N_{enh}=2.257

T=8K H=0, Remn
after H=32 mT

Flux penetration is aligned to the deformed direction

RF layer profiling by HF rinsing



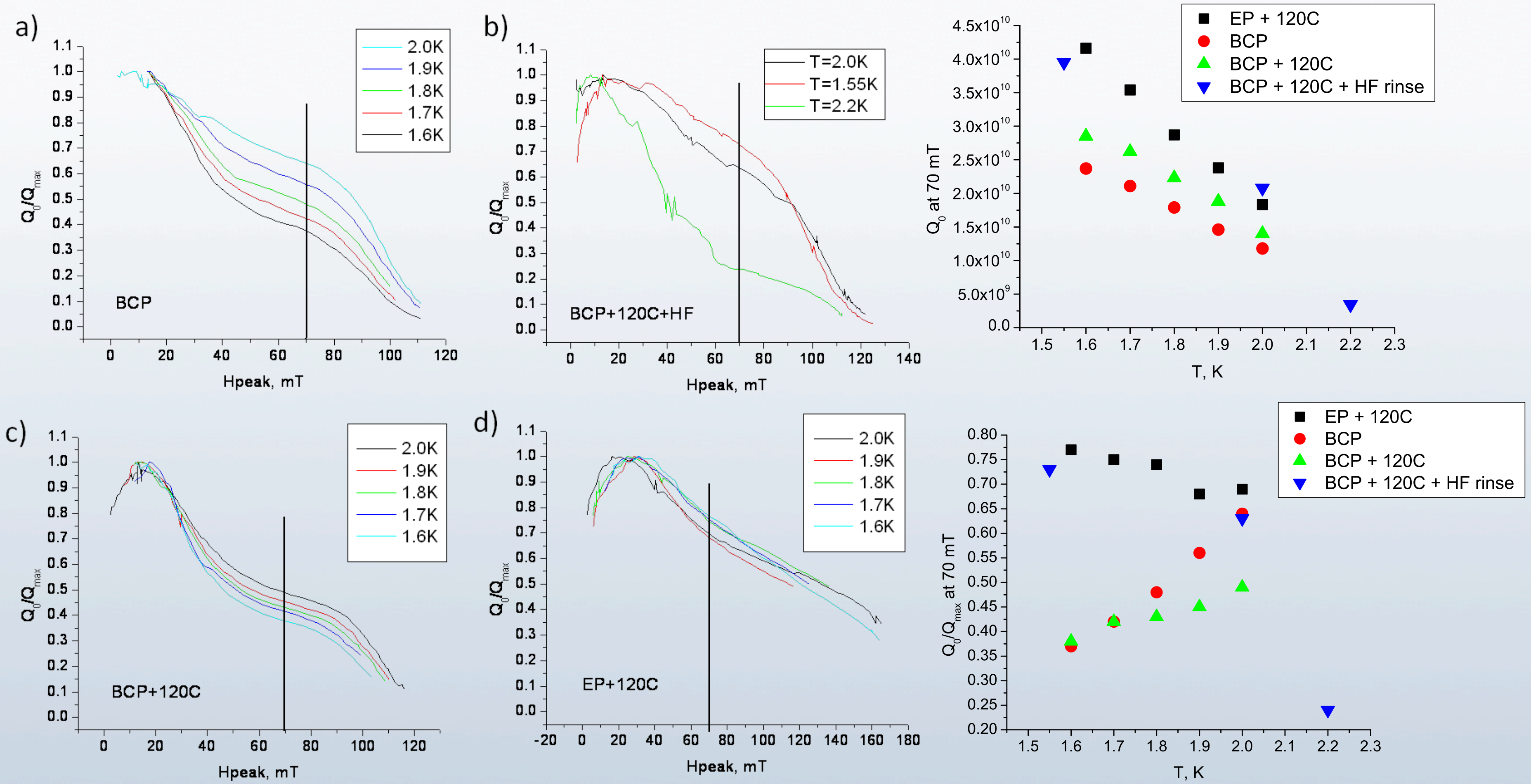


- Anodizing experiments indicated about 20 nm of mild baking modified layer (Eremeev et al, SRF'2005 ,TuAO8; Ciovati et al, PRST AB 10, 062002 (2007)) – ~10 HF rinse steps
- In principle might be possible to distinguish what layer(s) responsible for what regions of Q(E) curve
- High Q_0 at low and medium fields after 2 rinses

Medium field Q-slope studies

- Project X – CW linac – dynamic losses are a very significant cost factor
  - Two 650 MHz TESLA shape cavity sections of β=0.61 and 0.9 currently planned to be operated at E_{acc}=17 MV/m (H_{peak}=72 mT)
  - No clear understanding of how to maximize Q_0 at medium fields if not concerned with "as-high-gradient-as-possible"
    - Residual resistance, MFQS significant factors
- Need to choose from the available chemical/mechanical/heat treatments (and study the mechanism of losses)

Effects of bath T/surface finish



Thanks