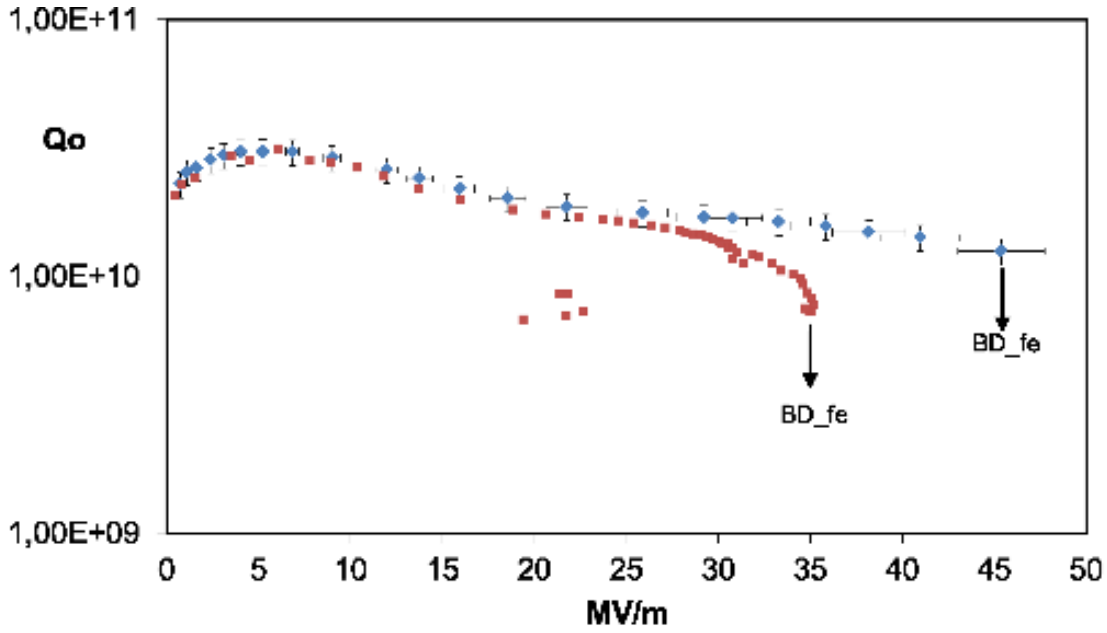
Stoichiometric Nb_3Sn in First Samples Coated at Cornell

Sam Posen

Cornell University

Motivation – High Gradients

- Nb cavities are reaching fundamental limit

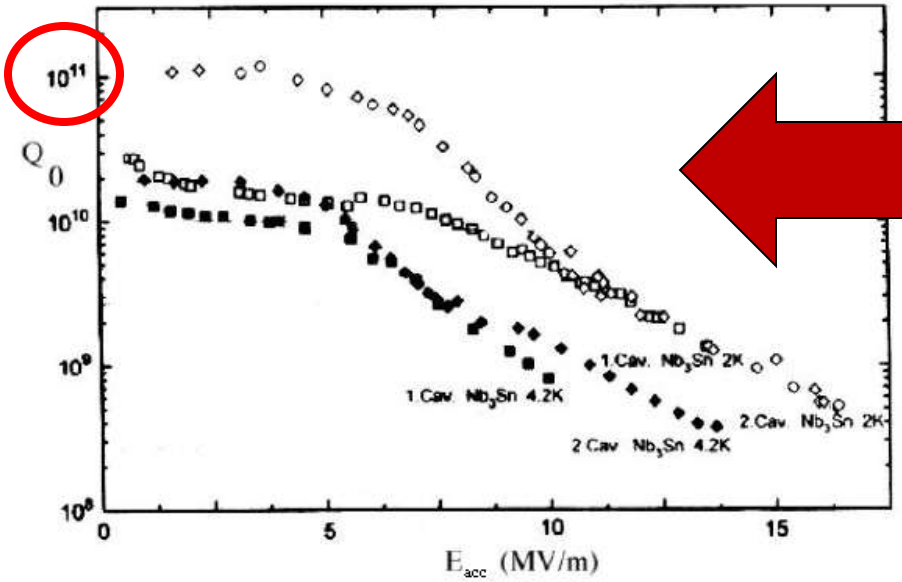


From Akira Yamamoto's talk "Advances in SRF Development for ILC" on Monday

- Alternative materials required to reach higher gradients
- Nb_3Sn 100 MV/m?

Motivation – Low Surface Resistance

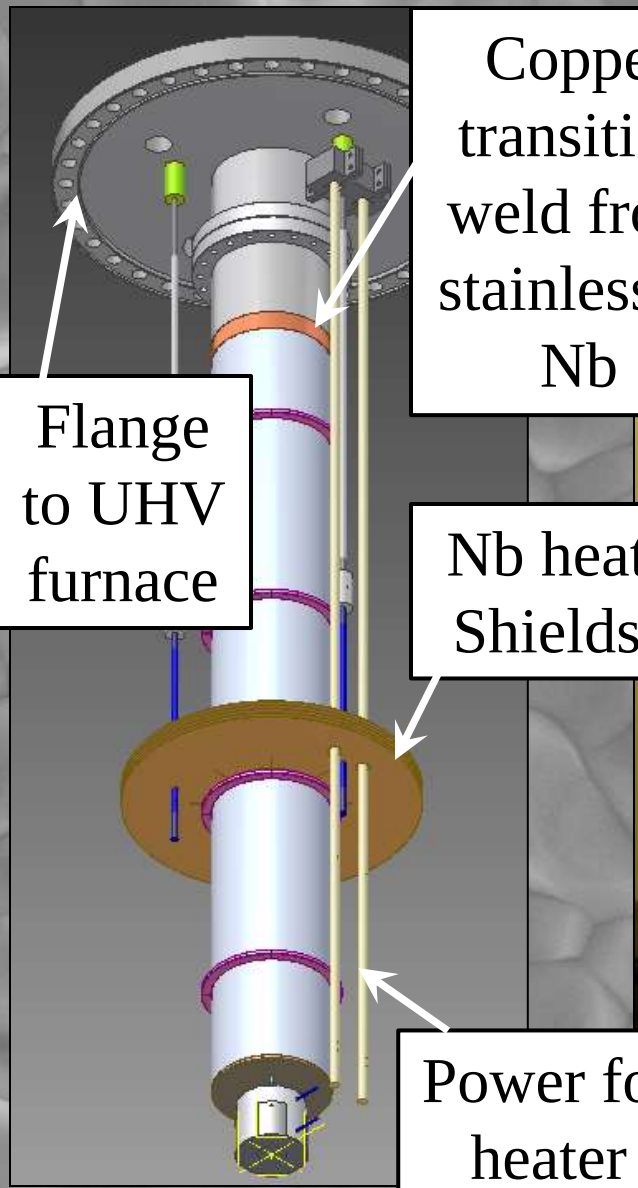
- Nb_3Sn has already shown great promise

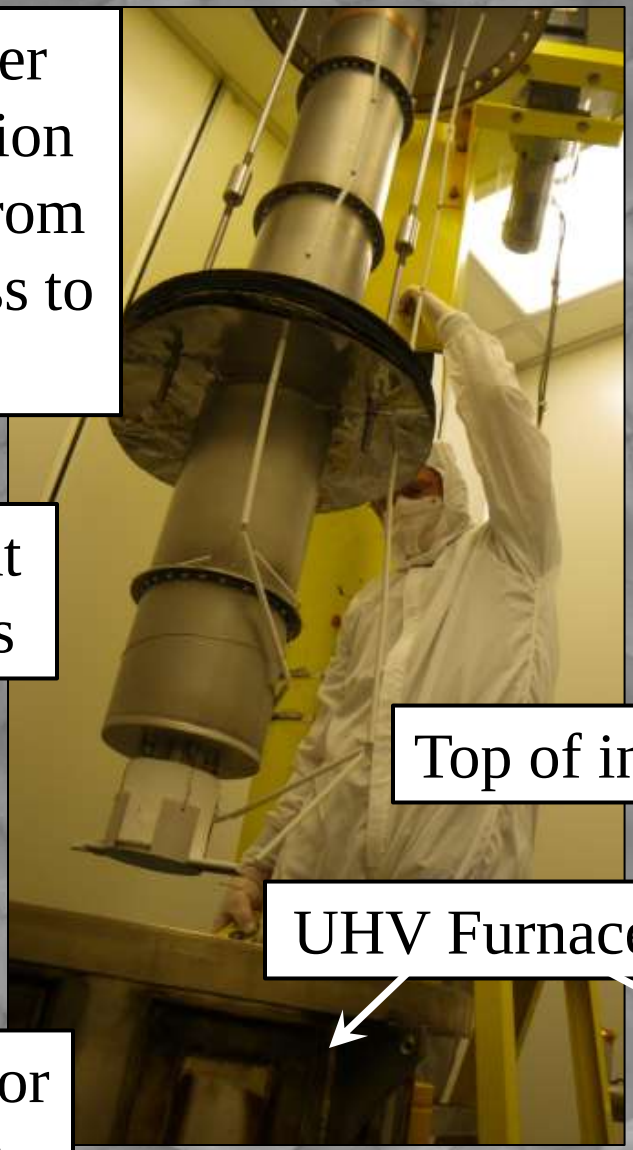


Cavities produced by University of Wuppertal

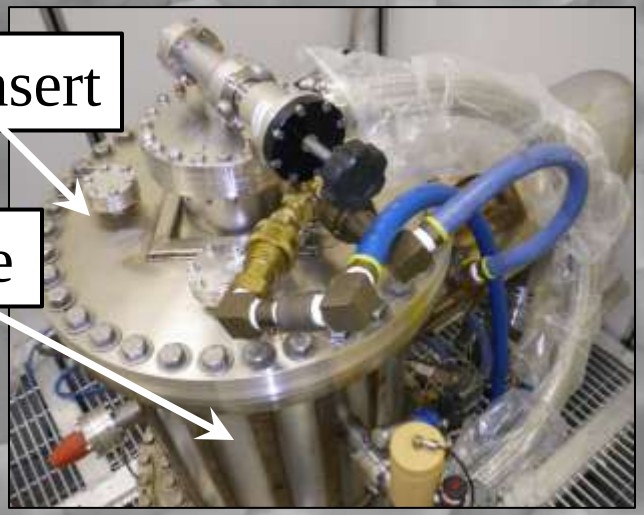
- Great potential of Nb_3Sn for moderate field, high Q machines. Modest cyrogenic costs!
  - ~10^{10} at 4.2K! ~10^{11} at 2K!

Nb_3Sn Furnace Insert





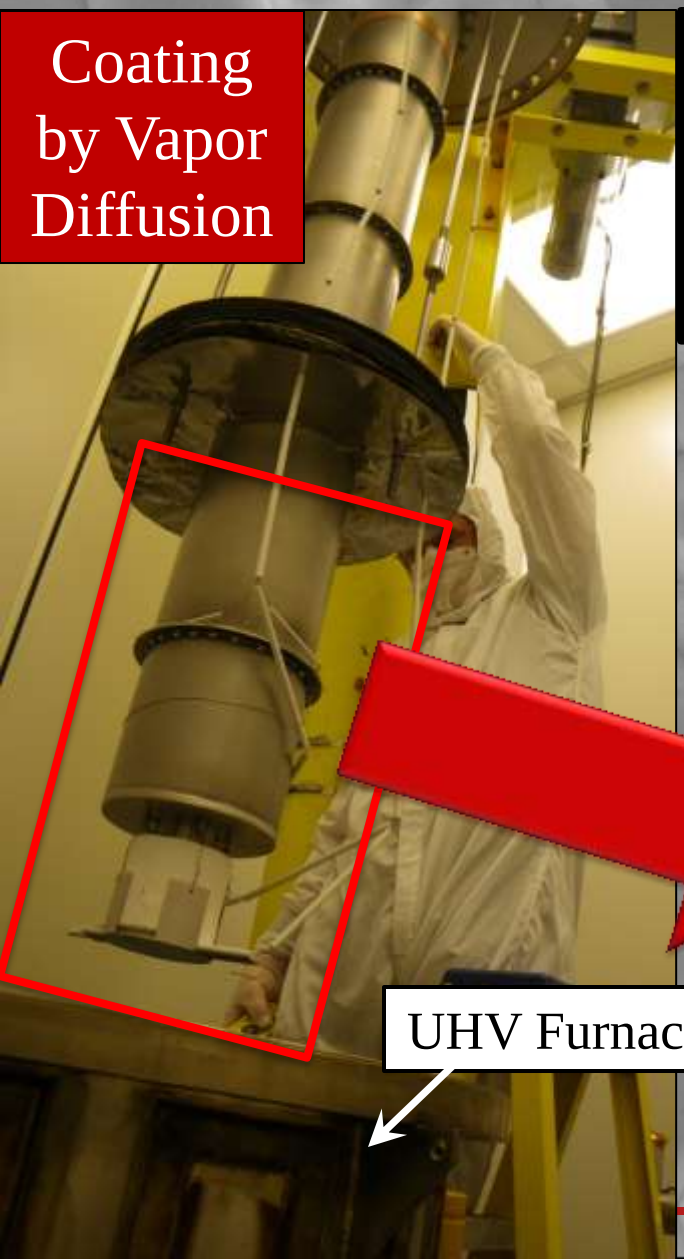
Coating chamber is inserted into UHV furnace. Separate vacuum system keeps cavity furnace free from tin contamination

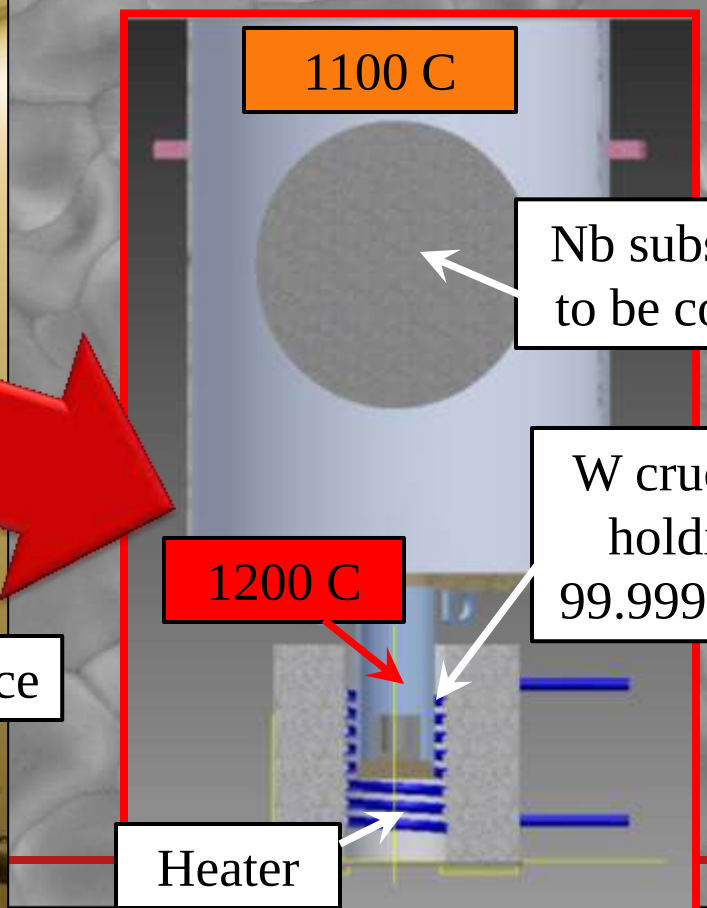


Nb_3Sn Fabrication at Cornell

Coating by Vapor Diffusion

Coating procedure follows work of Müller et al., University of Wuppertal in 80s and 90s





Temperature monitoring by thermocouples inside furnace. Gradient <1 K across sample

New Surface Preparation Techniques

- Add to Wuppertal procedure new techniques that have increased Q and E values in Nb cavities

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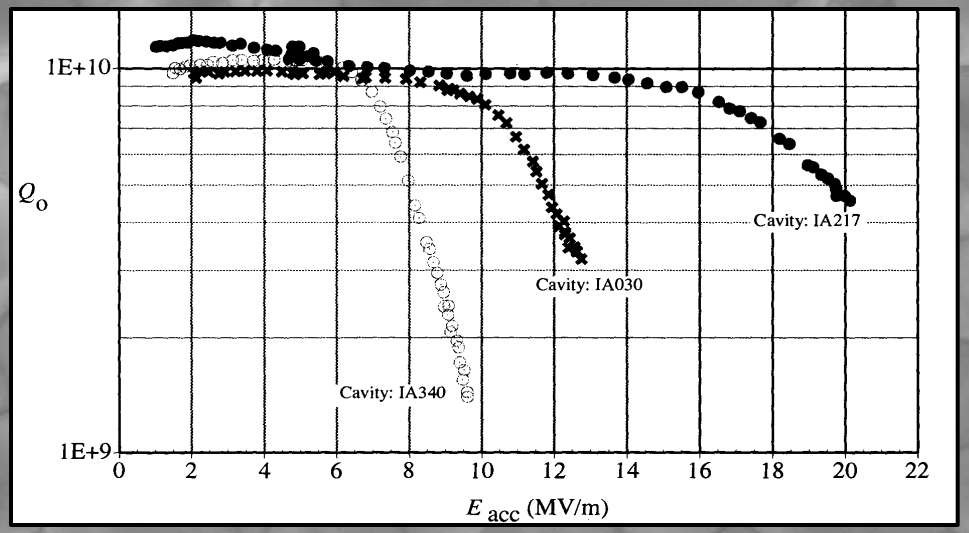
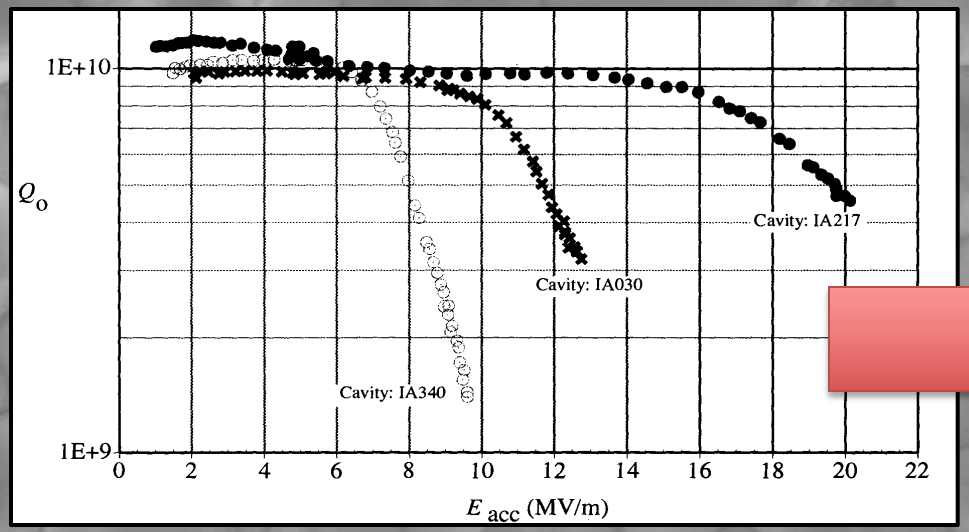
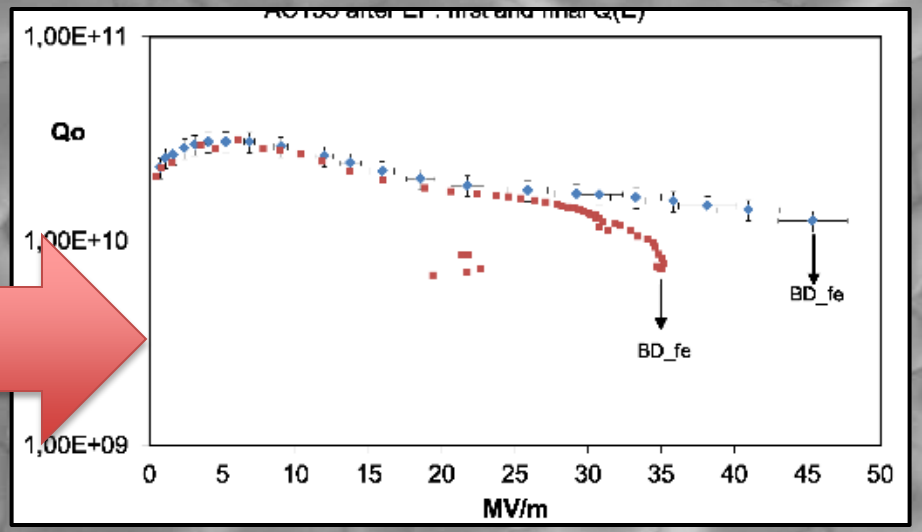


Nb, 1993

New Surface Preparation Techniques

- Add to Wuppertal procedure new techniques that have increased Q and E values in Nb cavities





Nb, 1993

+ HPR, EP, 120 deg C bake, CBP, single crystal Nb

Nb, 2011

New Surface Preparation Techniques

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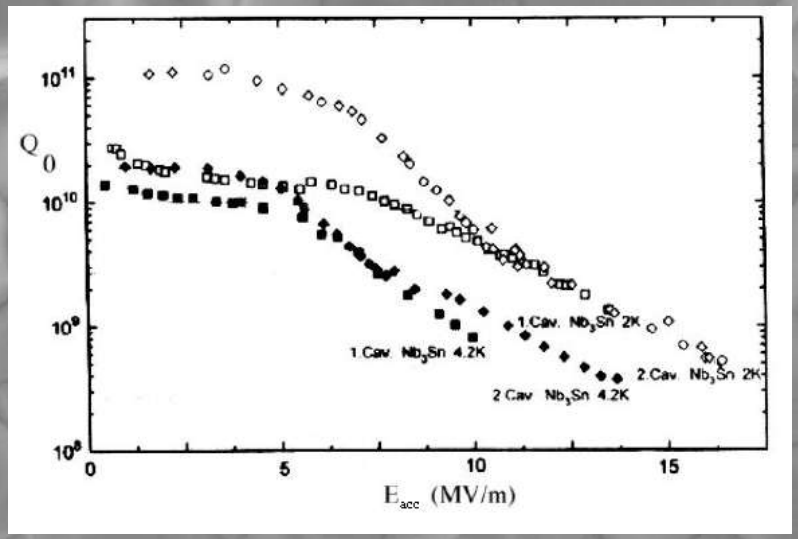
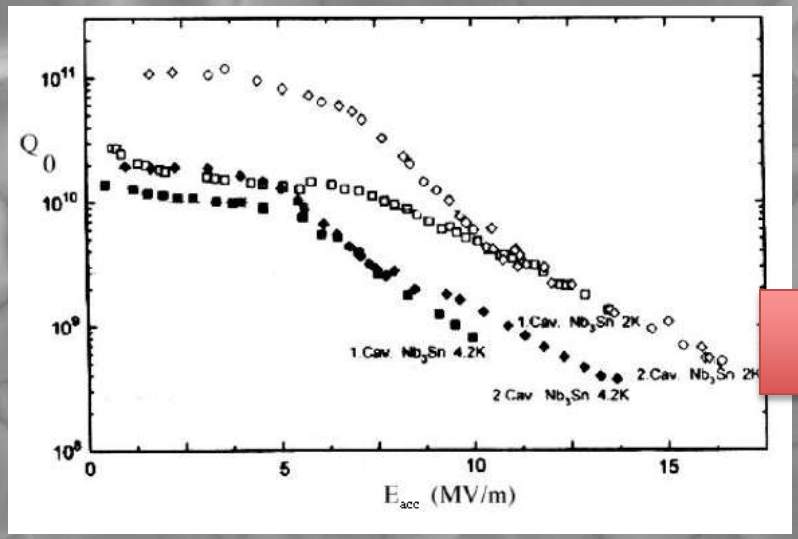


Nb_3Sn, 1995

New Surface Preparation Techniques

- Add to Wuppertal procedure new techniques that have increased Q and E values in Nb cavities



???

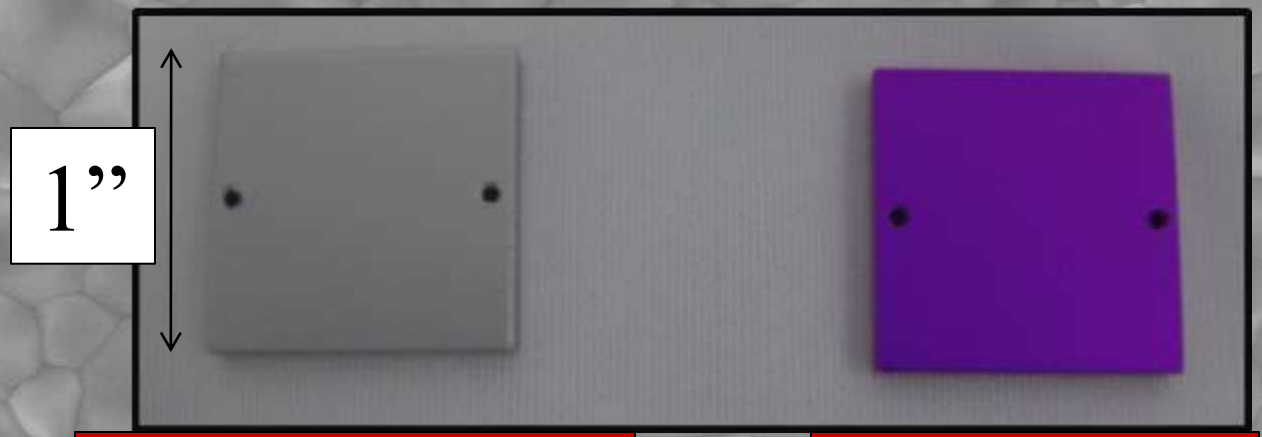
Nb_3Sn, 1995

+ HPR, EP, 120 deg C bake, CBP, single crystal Nb

Nb_3Sn, 2012

First Coated Samples

- 2 square samples were coated
- Coatings were characterized in various ways
- One of the samples was anodized in NH_4OH at 75V
- **Nb->blue Sn-> yellow Nb3Sn -> Pink/purple**
- Uniform coating! No excess tin on surface!



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- **Nb->blue** **Pink/purple**
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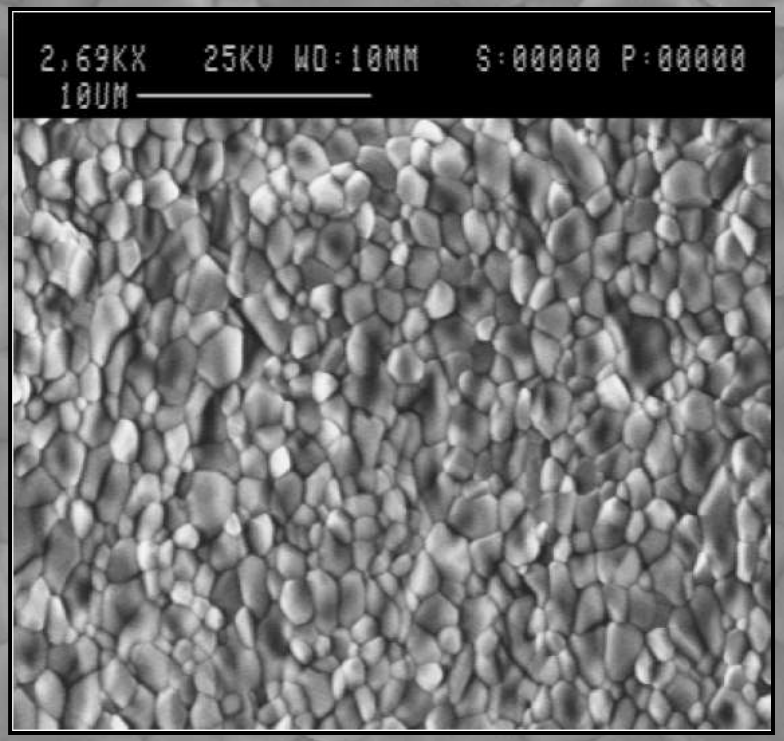
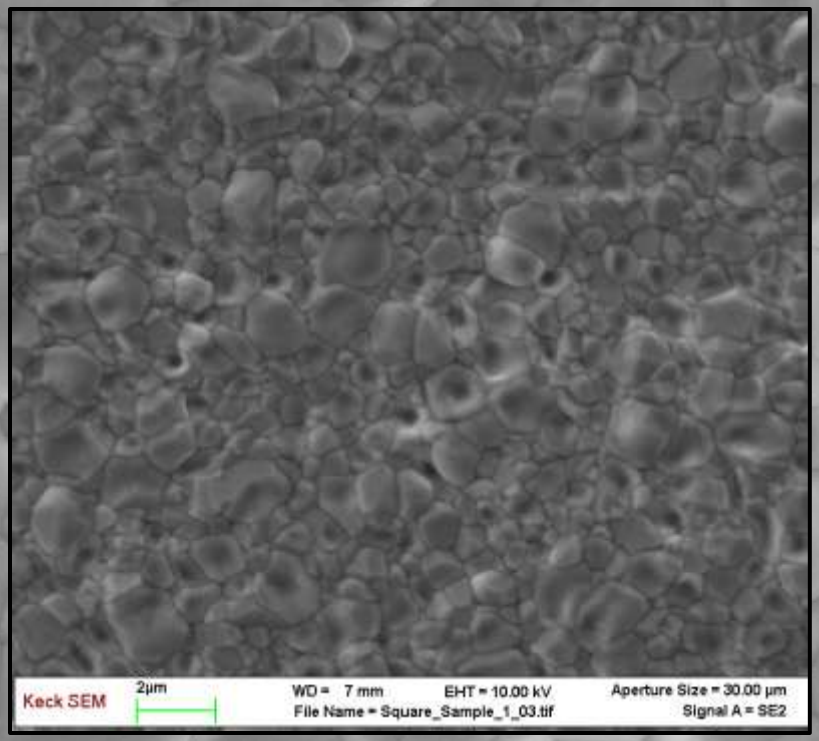
Not anodized **Anodized**

SEM Images



Wuppertal, 1996



Cornell, 2011

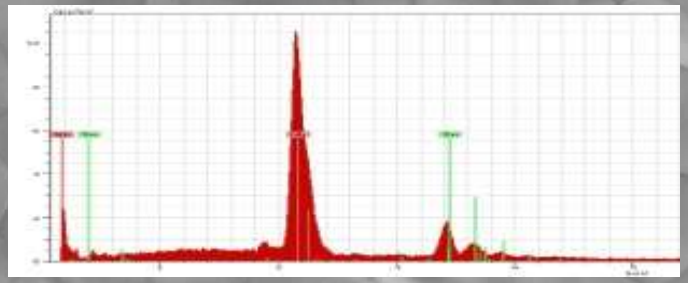
SEM Images

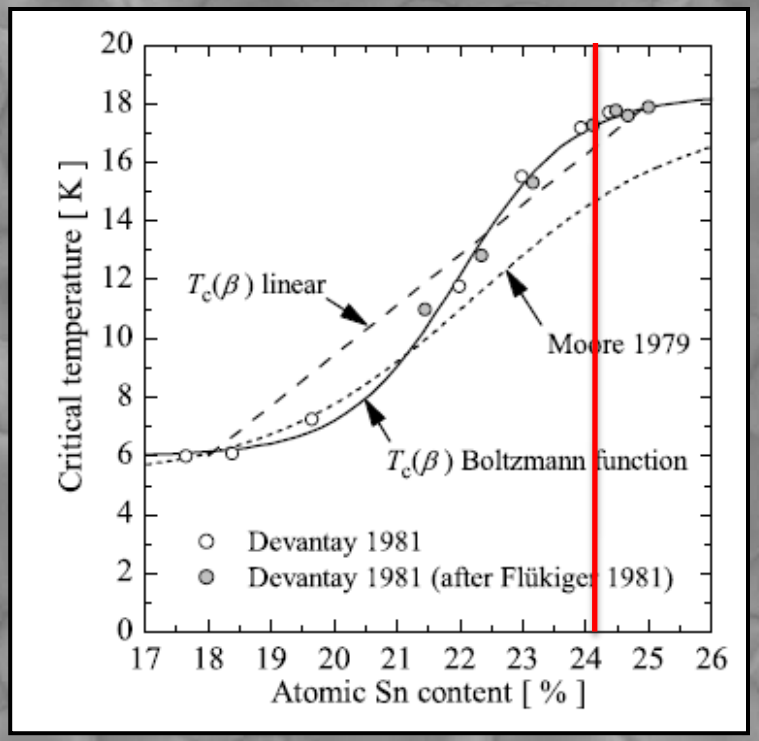
Wuppertal, 1996

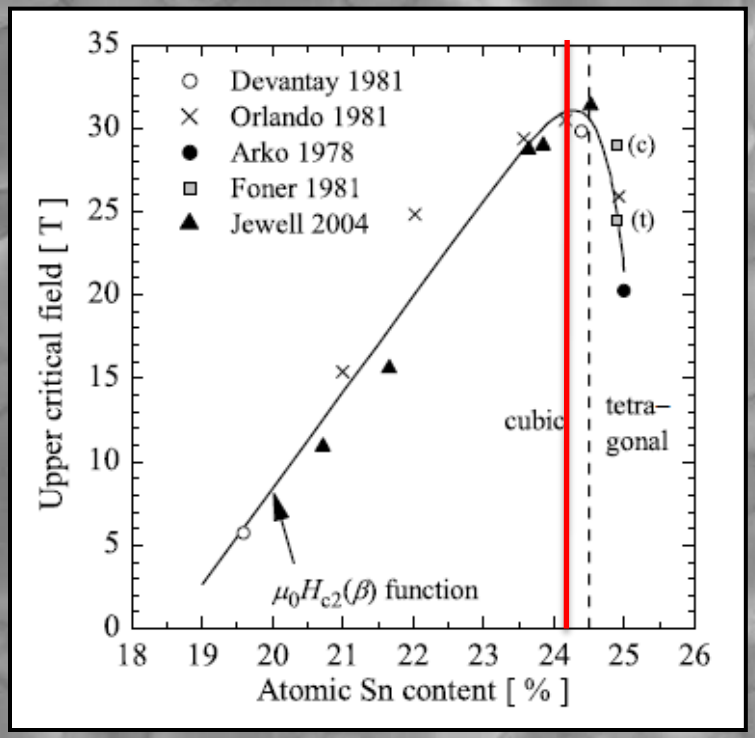
Cornell, 2011

EDX Analysis

- Uniform coating!
- 24.2±0.5 atomic % Sn!





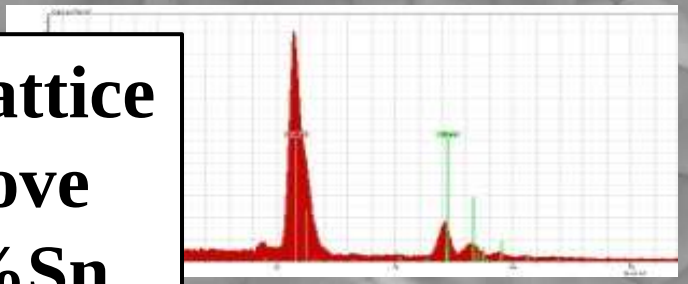


T_c vs %Sn

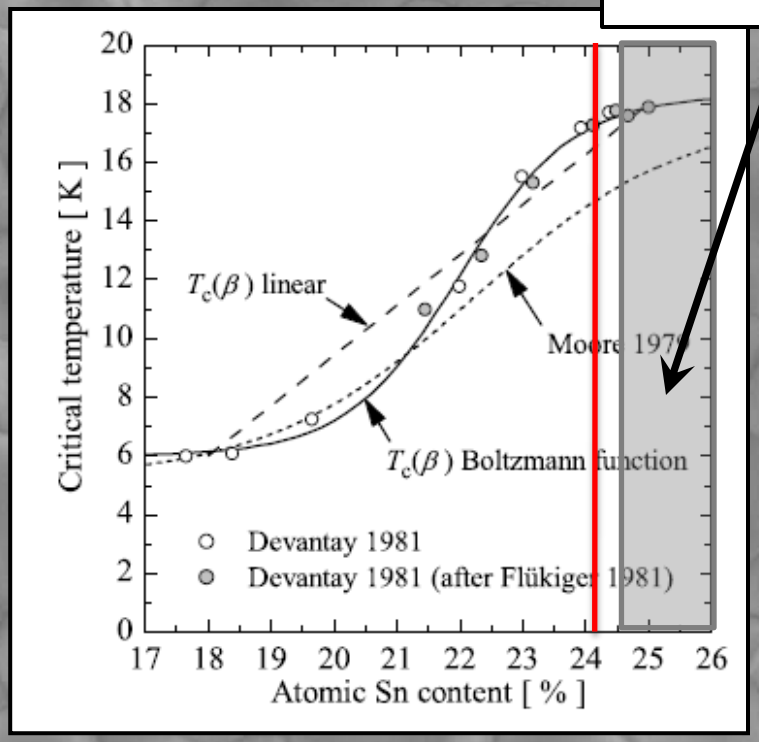
H_{c2} vs %Sn

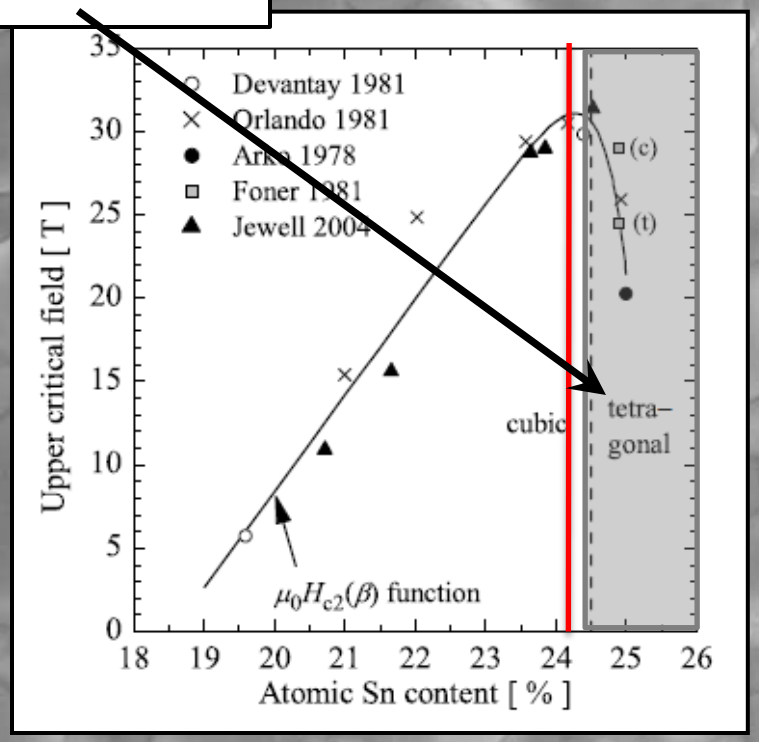
EDX Analysis

- Uniform coating
- 24.2±0.5 atomic



Increased lattice strain above 24.5 atm%Sn





T_c vs %Sn

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EDX Analysis

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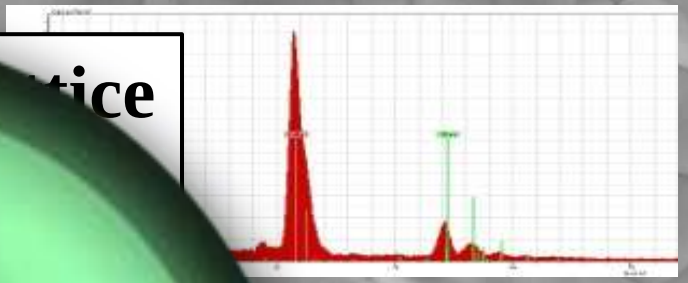
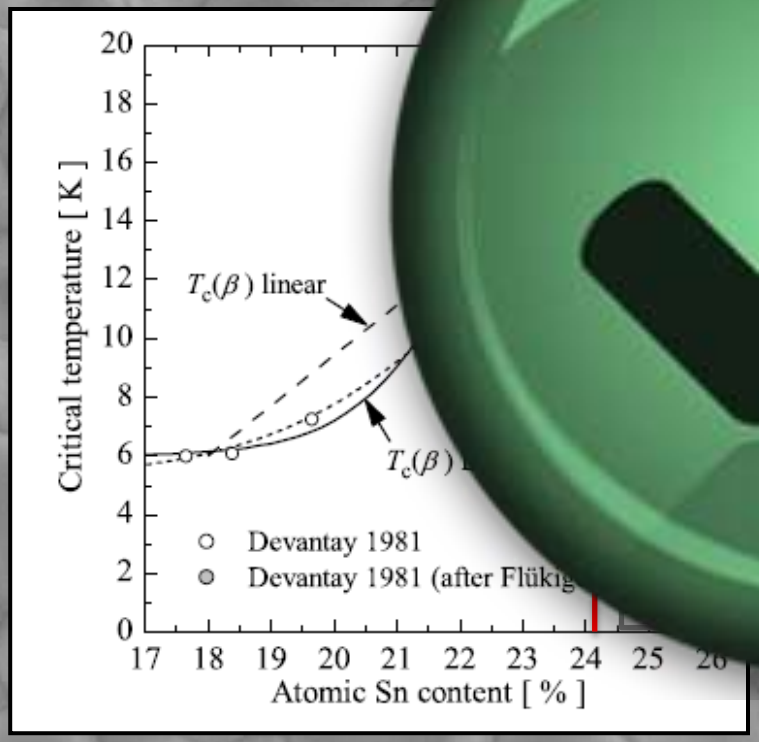
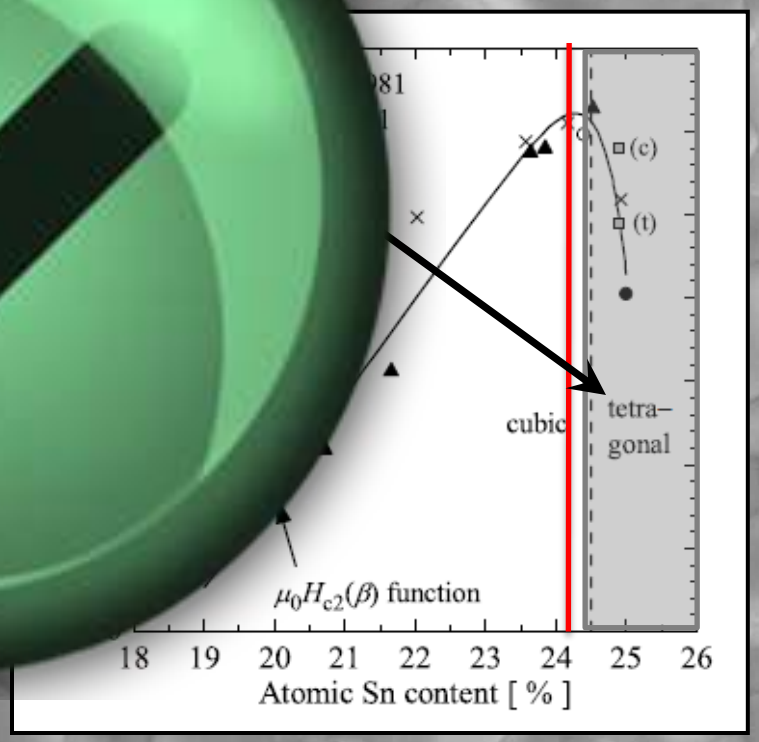


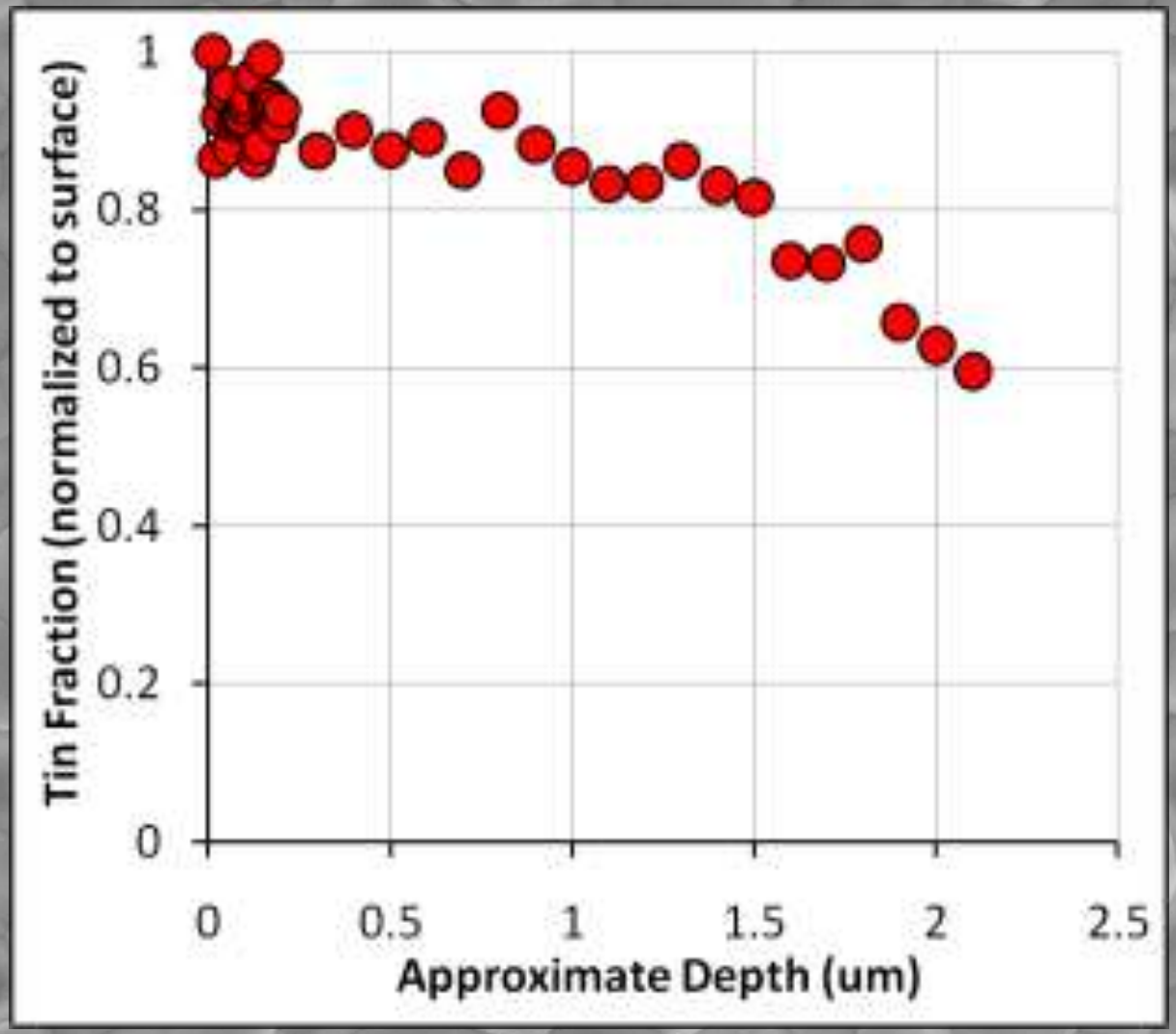




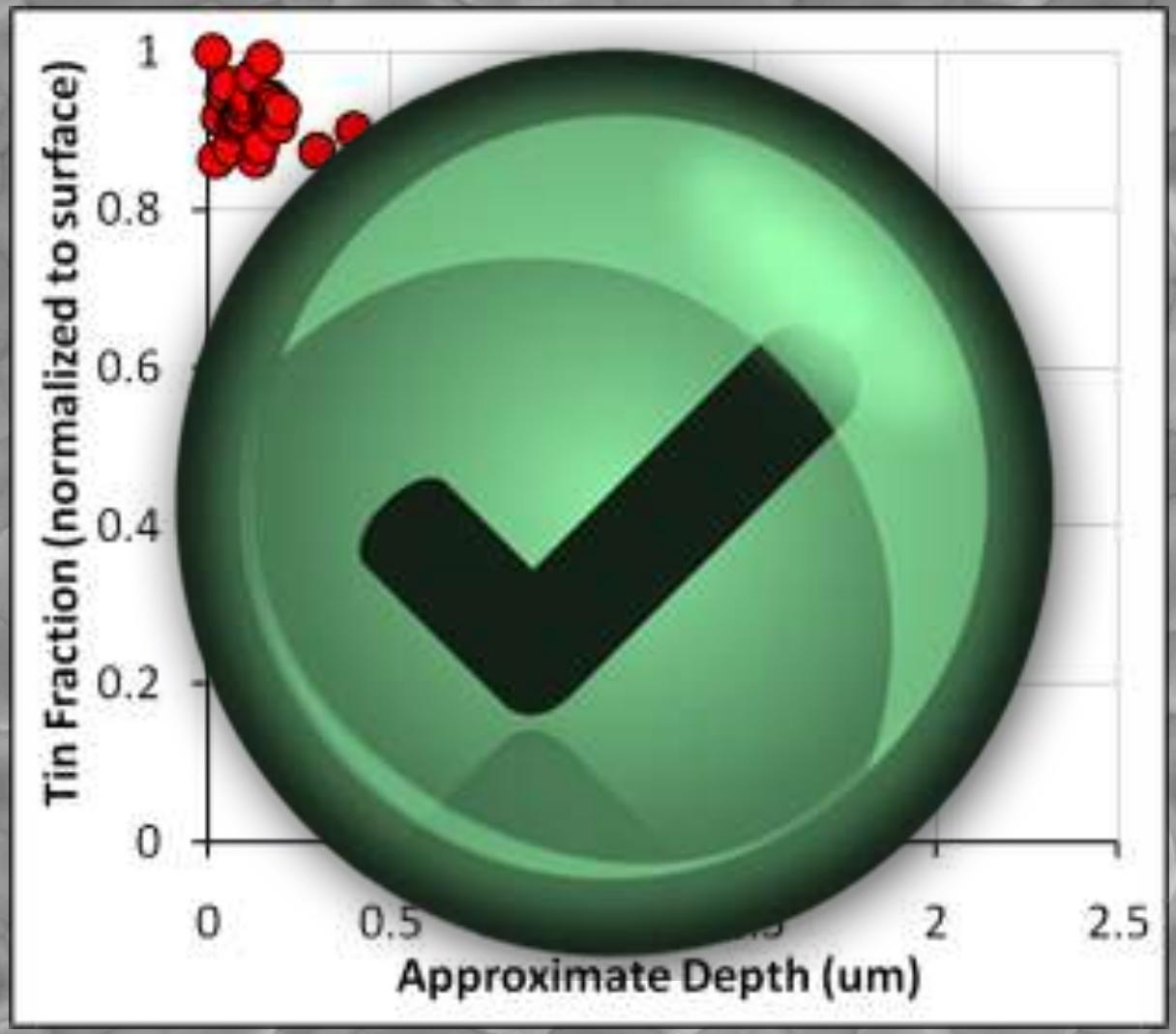
T_c vs %Sn

H_{c2} vs %Sn

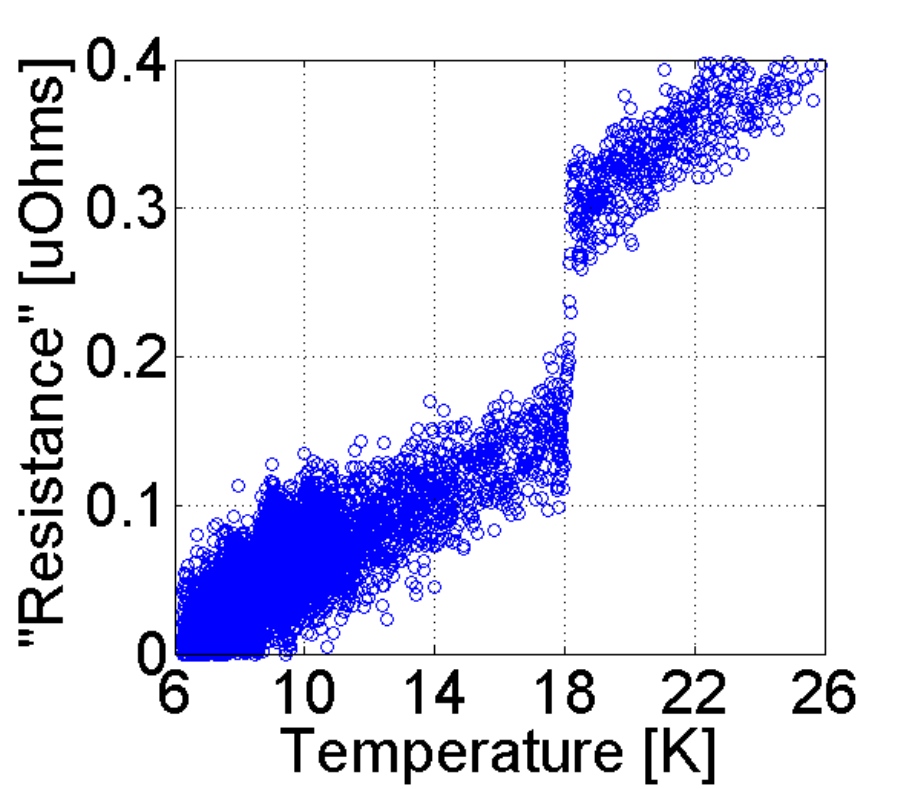
XPS Analysis



XPS Analysis

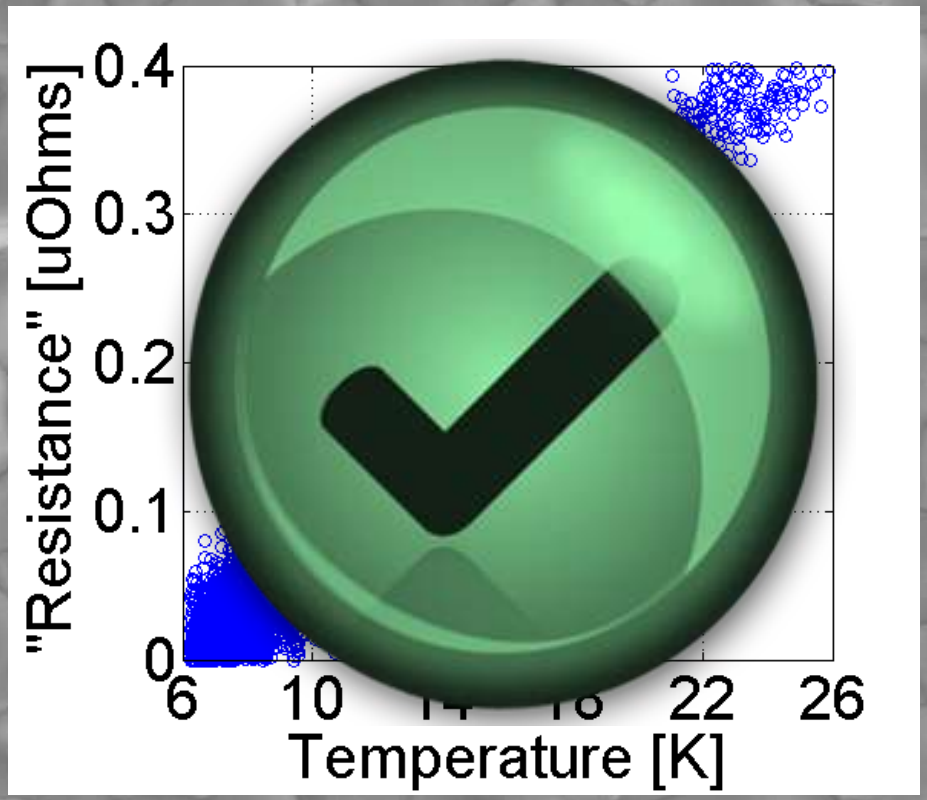


4-Wire Resistance Measurement



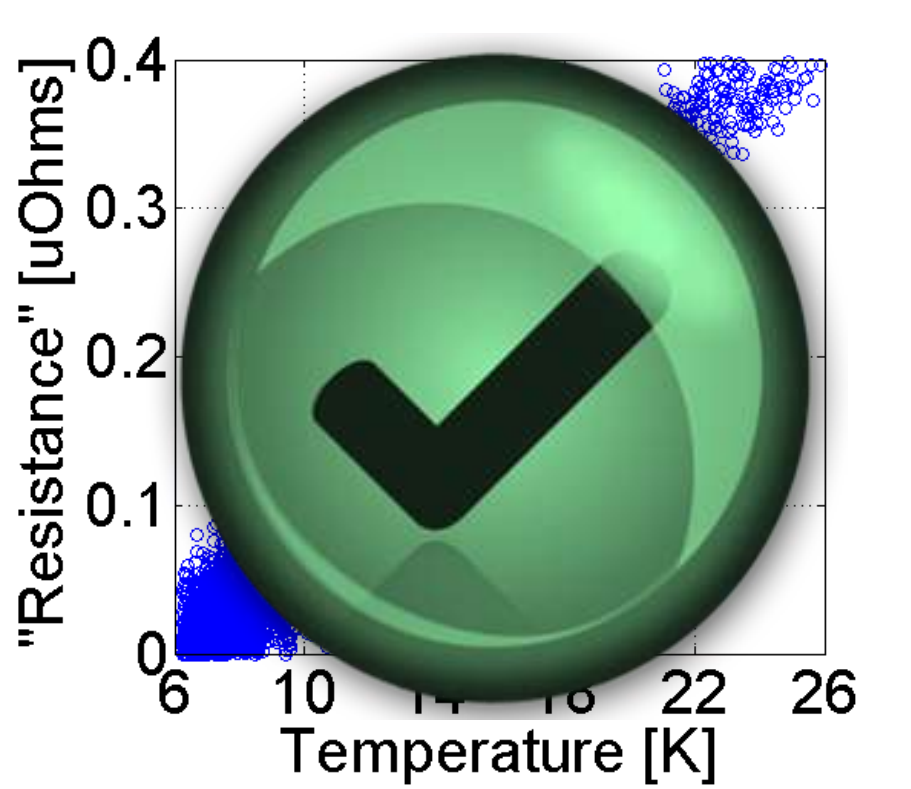
T_c

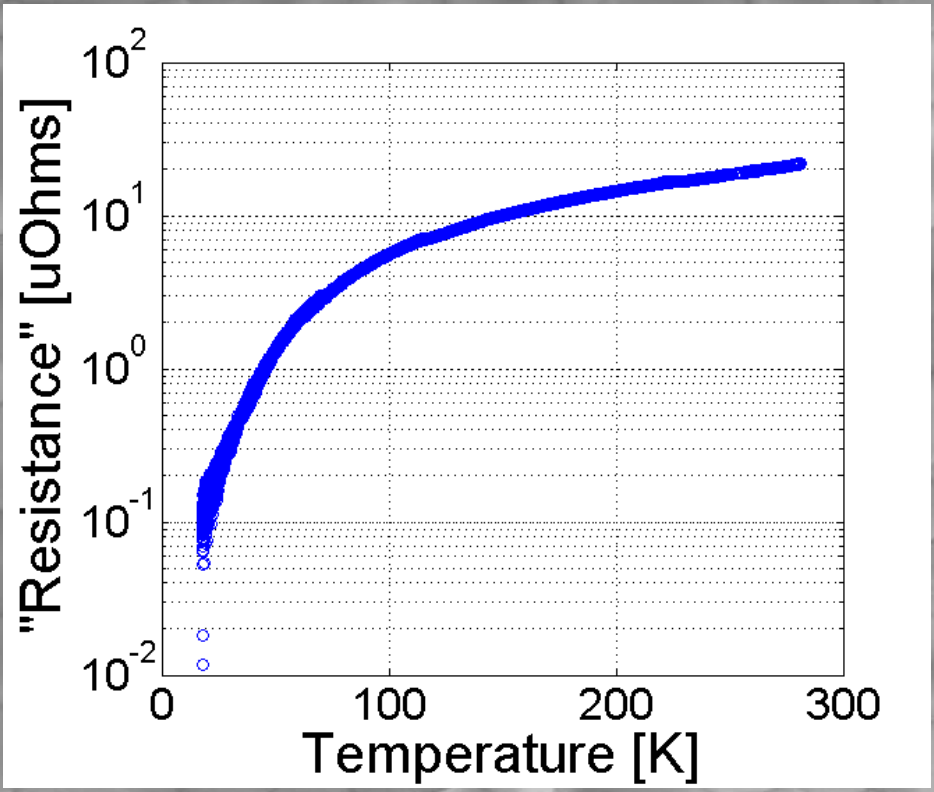
4-Wire Resistance Measurement



T_c

4-Wire Resistance Measurement

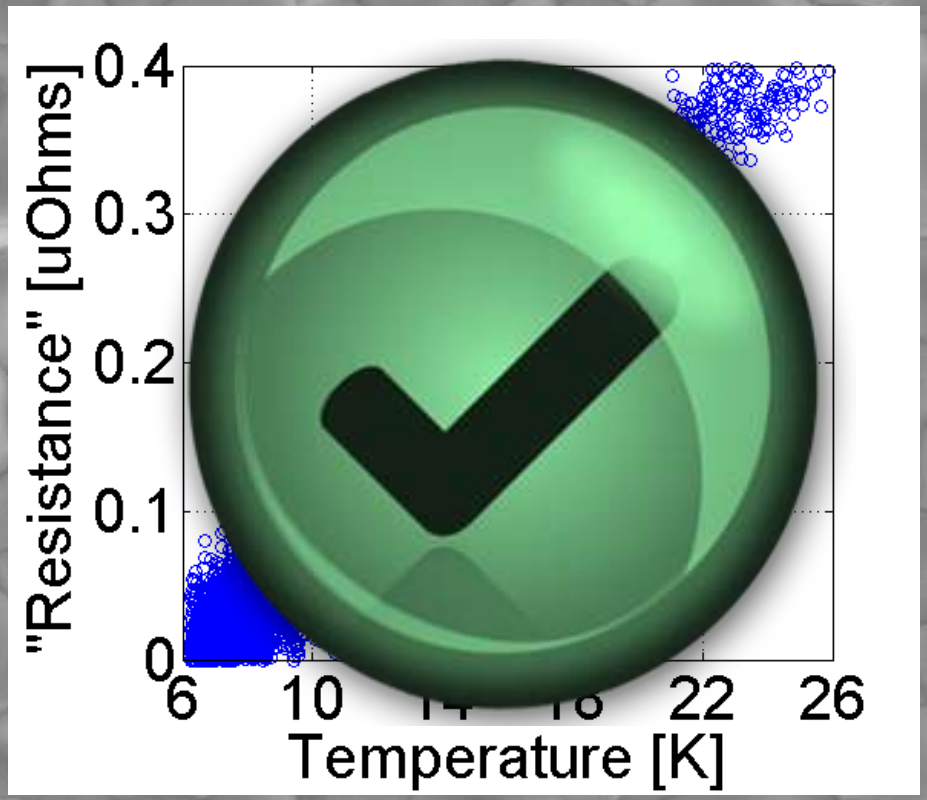


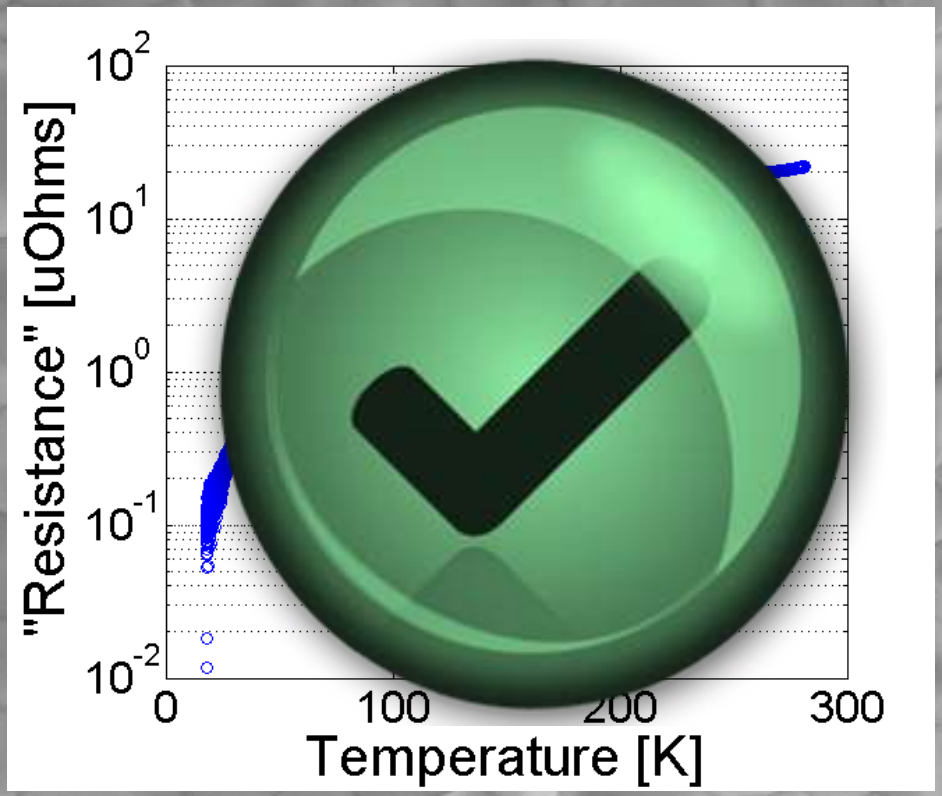


T_c

RRR

4-Wire Resistance Measurement



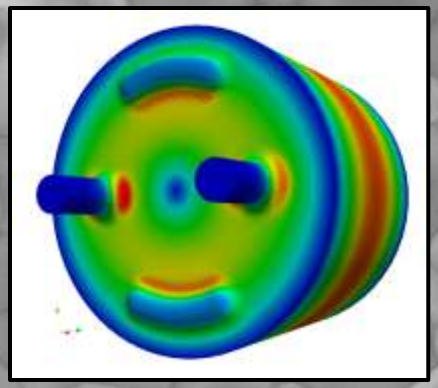


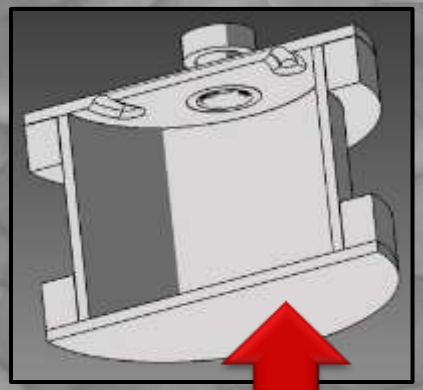
T_c

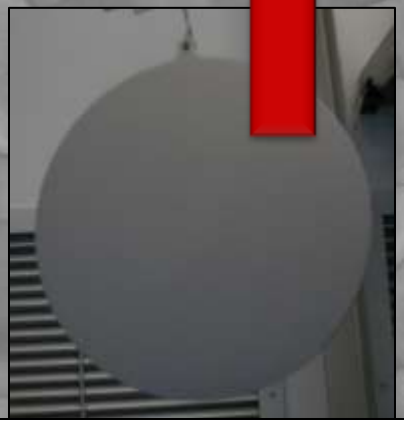
RRR

RF Tests of Samples

Already fabricated Nb_3Sn bottom plate for Pillbox TE cavity. Anodization, EDX, SEM show similar results. RF testing very soon!



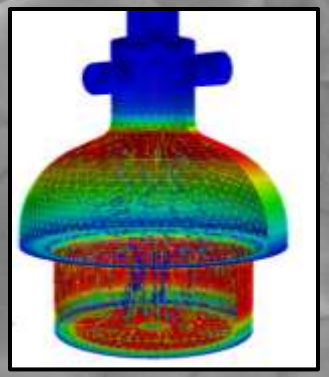


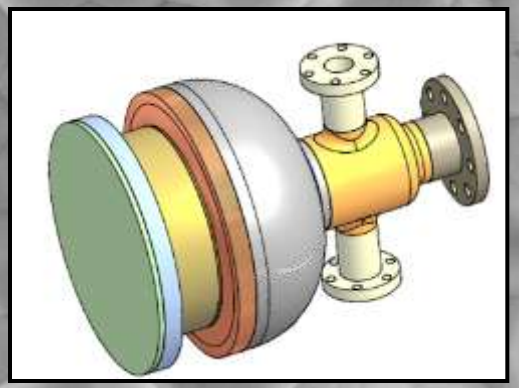


Before coating

With Nb_3Sn coating

Next step: Mushroom TE cavity. Designed to reach >200 mT on sample!





See Yi Xie's poster THPO050

Future Plans

- Next few months
  - RF tests of samples in TE cavities
- 2012
  - Coat single cell 1.3 GHz cavity
  - RF tests with full cavity T-map
- Beyond
  - At any locations with poor performance, cut cavity and perform surface analysis
  - Use RF performance as feedback to guide improvement of coating process

Acknowledgements and References

Special thanks to my advisor Matthias Liepe for his guidance and insight and to Hasan Padamsee for his knowledge and advice

- A. Yamamoto's "Advances in SRF Development for ILC," this conference.
- G. Müller et al. "Nb_3Sn layers on high purity Nb cavities with very high quality factors and accelerating gradients," EPAC 1996, Barcelona, Spain, pp. 208-2087, 1996.
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- A. Godeke, "A review of the properties of Nb_3Sn and their variation with A15 composition, morphology and strain state," Supercond. Sci. Technol., 19, R68–R80, 2006.
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