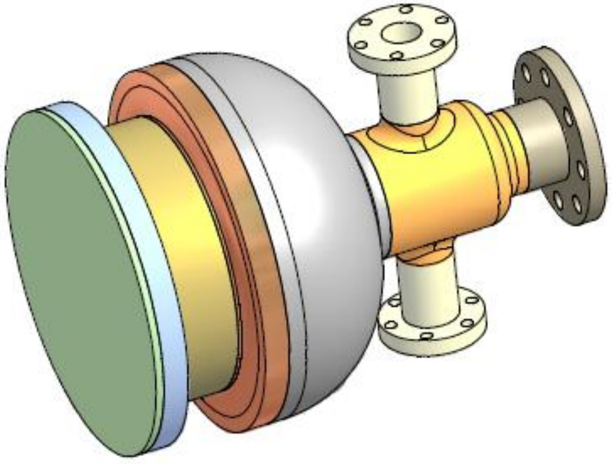
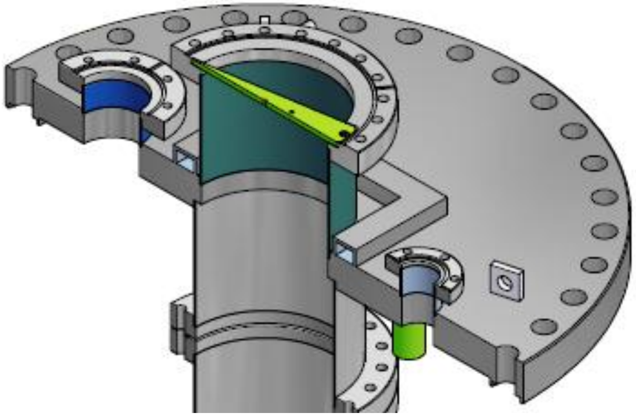
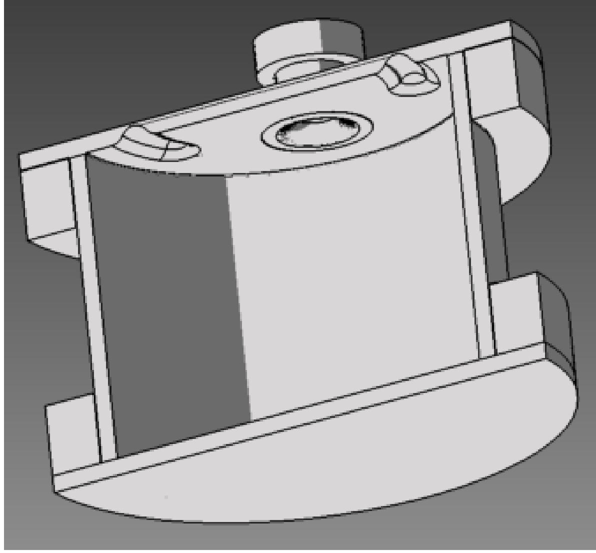




Nb_3Sn Fabrication and Sample Characterization at Cornell

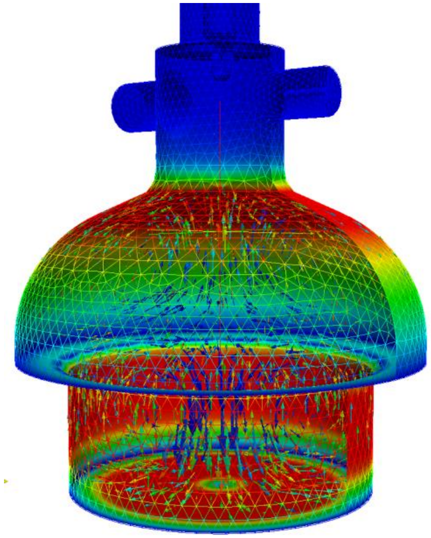
Sam Posen, Matthias Liepe, Yi Xie, N. Valles
Cornell University

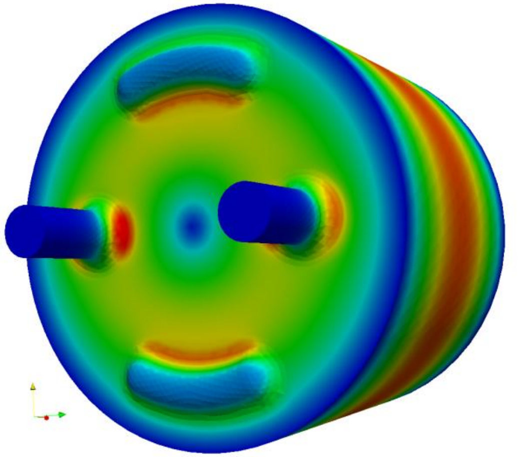
Thin Films Workshop

Presented October 5^{th} 2010

By Sam Posen

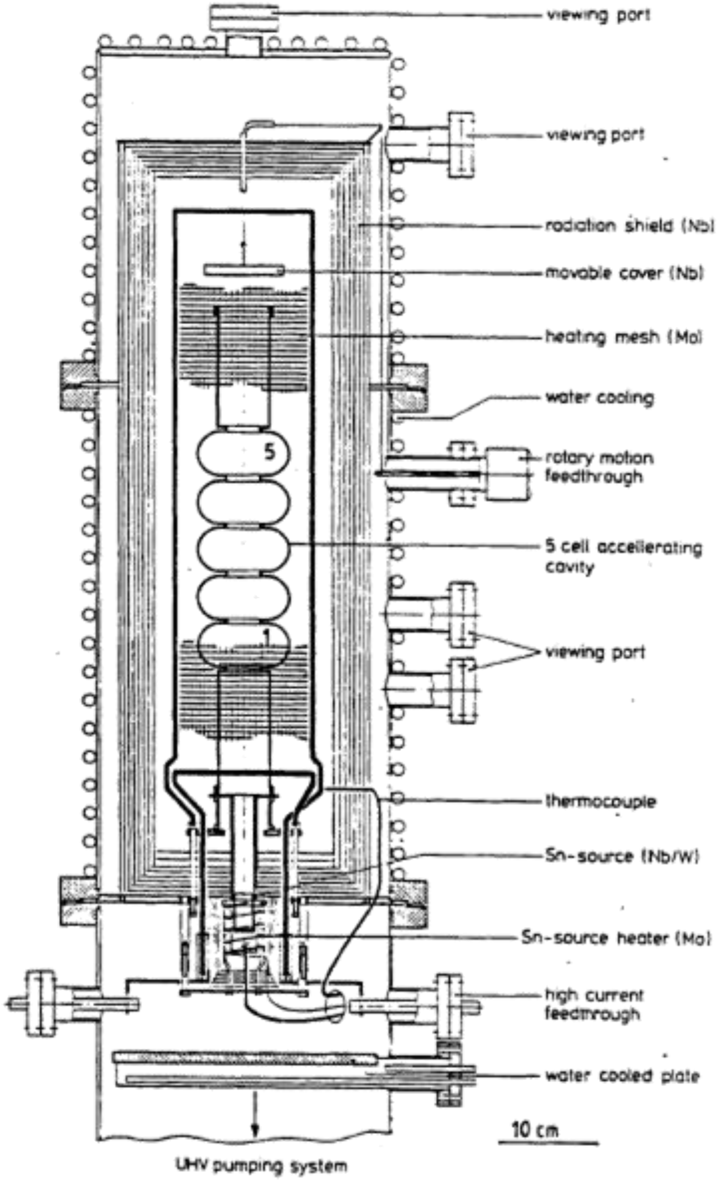
In Padua, Italy





Outline

- Motivation
- A little theory
- Wuppertal Method
- Wuppertal Results
- Activities at Cornell



From Arnolds-Mayer (1984) [1]

Motivation

- SRF cavity preparation techniques have improved from years of R&D
- Cavity gradient is approaching fundamental limit set by superheating field (H_{sh}) of niobium
- As beam energy demands continue to rise, accelerators will have to become longer
- ILC calls for tens of km, thousands of cavities
- Higher gradients = $$$$$$ savings
- Higher Q_0s for CW and at high gradients pulsed = $$$$$$ savings

Motivation

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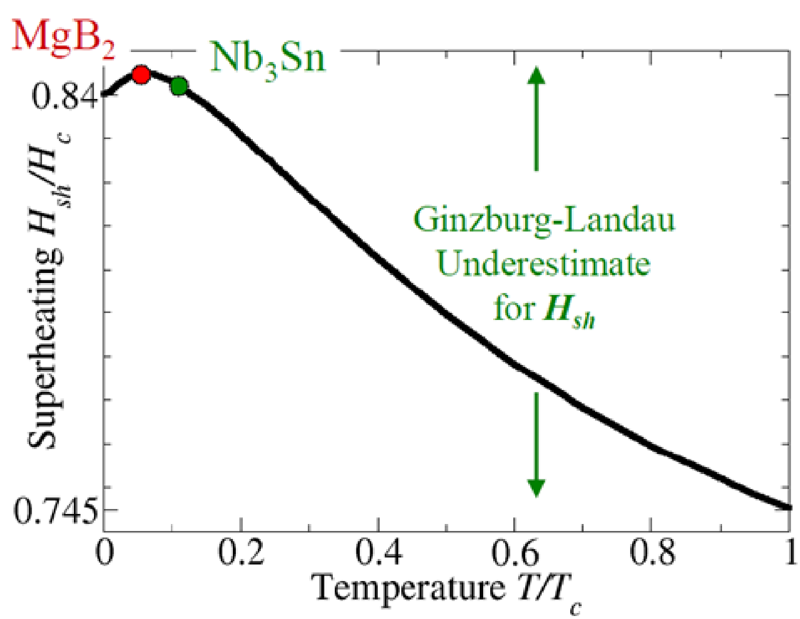
Nb_3Sn promises to give both!

Theory

- T_c higher so Q_0 is higher than for Nb at same T
- GL Theory predicts $H_{sh} = 0.75H_c$, κ large
- But GL Theory is valid only near T_c
- Eilenberger equations give behaviour at lower temperature [Catelani and Sethna, PRB (2008) [2]]

(Assuming large κ, temp = 2K) →

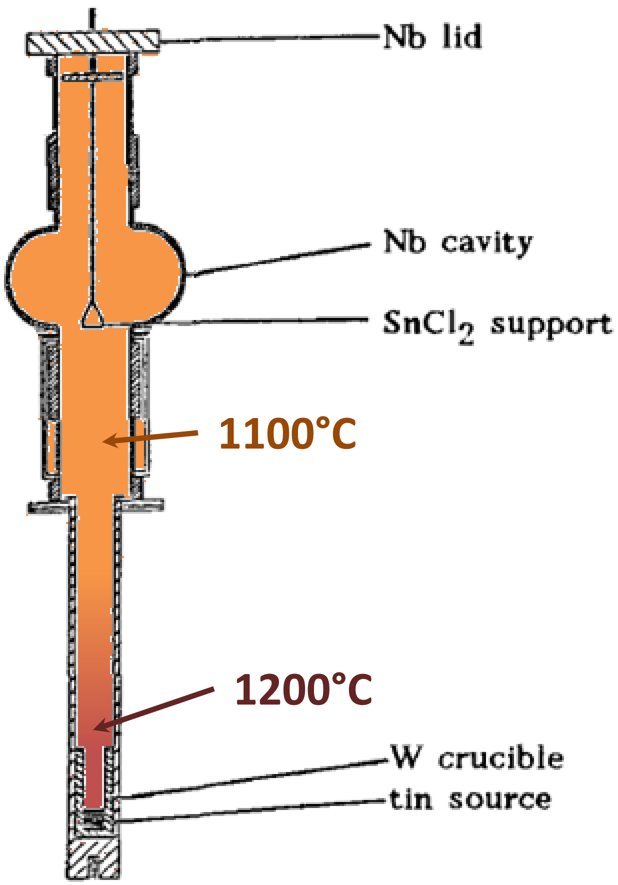


Progress

- Theory indicates gradients of 120 MV/m for perfect Nb_3Sn, 200 MV/m for perfect MgB_2
- Perfect Nb should give ~55 MV/m
- Years of research has led to reproducible >30 MV/m in accelerator structures
- After much R&D, new materials may outperform Nb
- Some research has already gone into Nb_3Sn
- Best performance from vapor diffusion technique at Wuppertal U. in 1990s (G. Mueller, M. Peiniger, et al. – see references)

Wuppertal Method

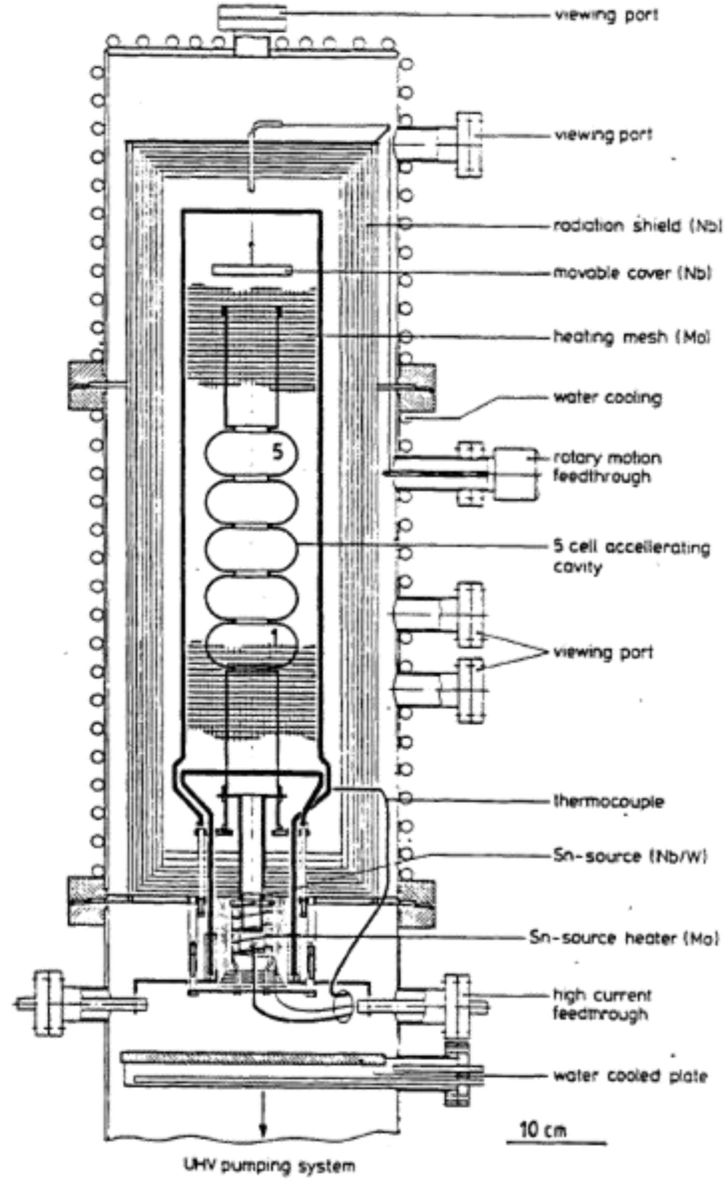
- A crucible of tin is heated in an evacuated chamber
- Evaporated tin coats the connected cavity
- The temperatures of the tin and the cavity are controlled independent of each other
- $SnCl_2$ is used to nucleate growth sites early on



Adapted from Dasbach et al. (1989) [3]

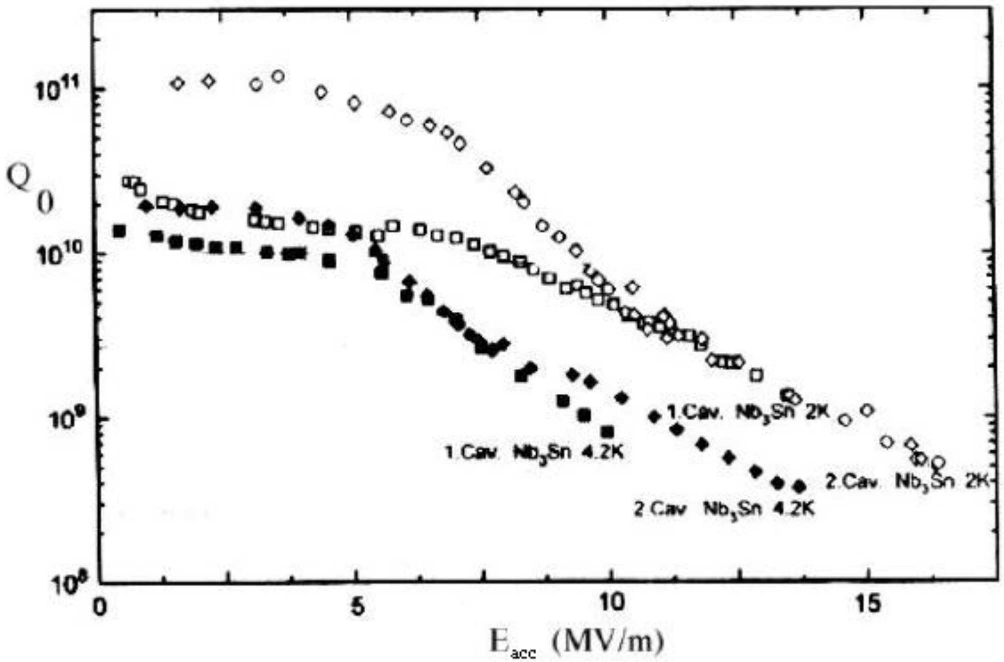
Wuppertal Method - Details

- (1) Initial heating at 200°C and degassing
- (2) Nucleation at 500°C and heating for 5 hrs
- (3) Growth at 1100°C (cavity) and 1200°C (tin source) for 3 hrs
- (4) Tin heating off but cavity still hot for 30 mins (avoid surplus Sn)



From Arnolds-Mayer (1984) [1]

Wuppertal Results – 1996

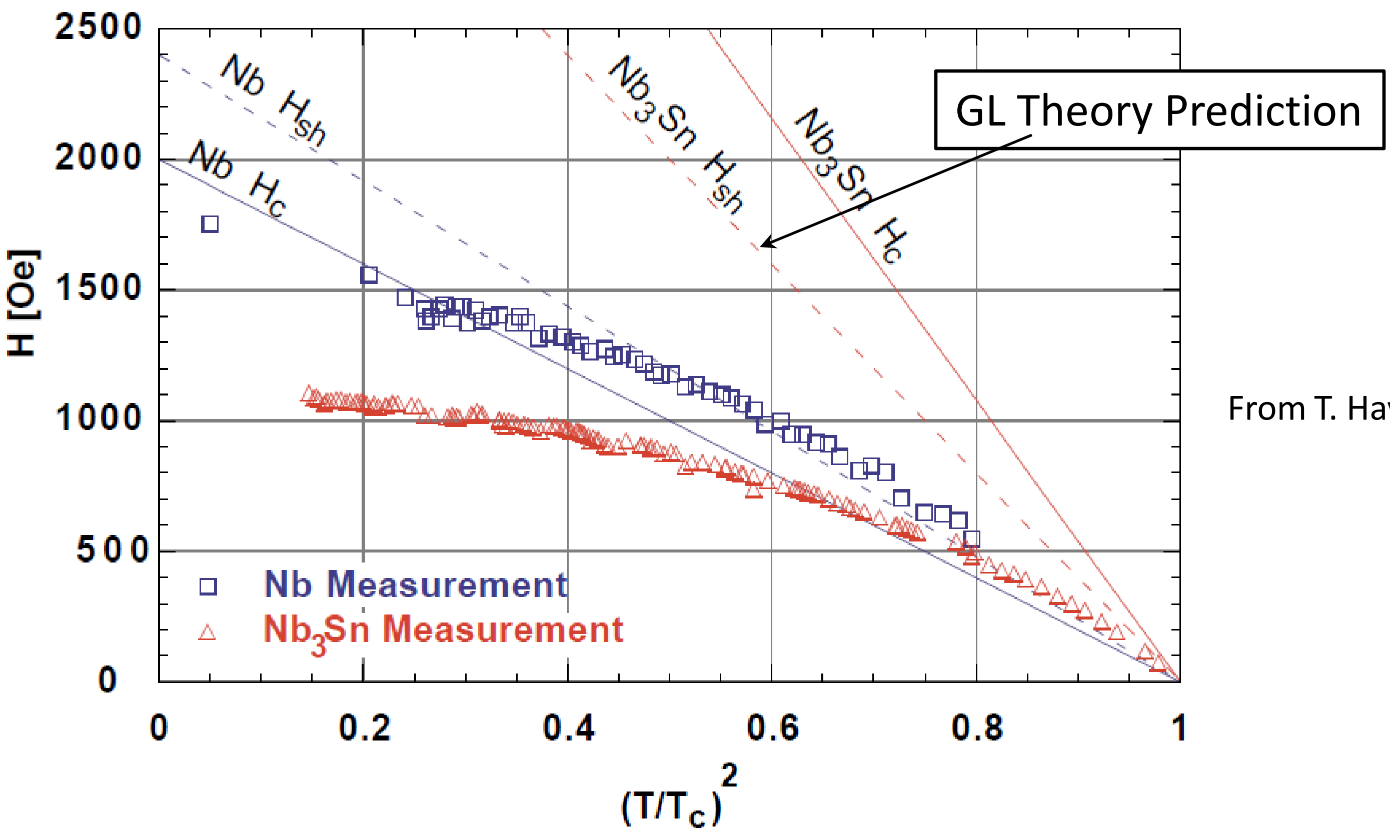


From Padamsee [4]

- Best CW result shown – High Q_0!! Great potential
- However, Q-slope at ~5 MV/m typical for Wuppertal tests
- Max field then: Eacc ~15 MV/m (600 Oe) – need higher Q_0's at medium field level CW, and higher fields pulsed
- EP, baking may help to mitigate problems
- Thermometry and surface studies can also help find any weak spots in coating

Wuppertal Results – 1997

- Pulsed measurements done at Cornell with Wuppertal cavity
- Maybe cavity coating not perfect everywhere

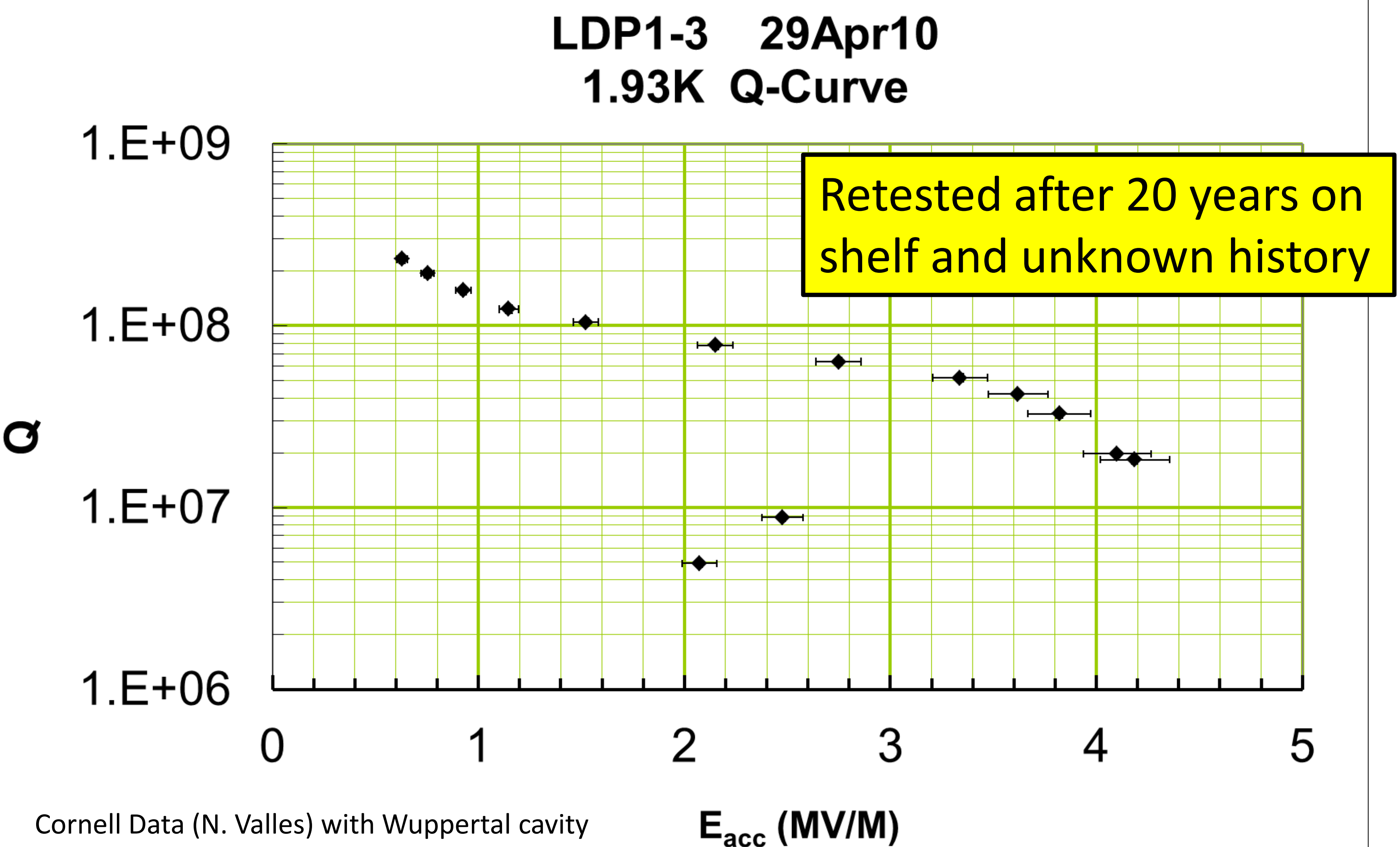


From T. Hays [5]

New Materials at Cornell

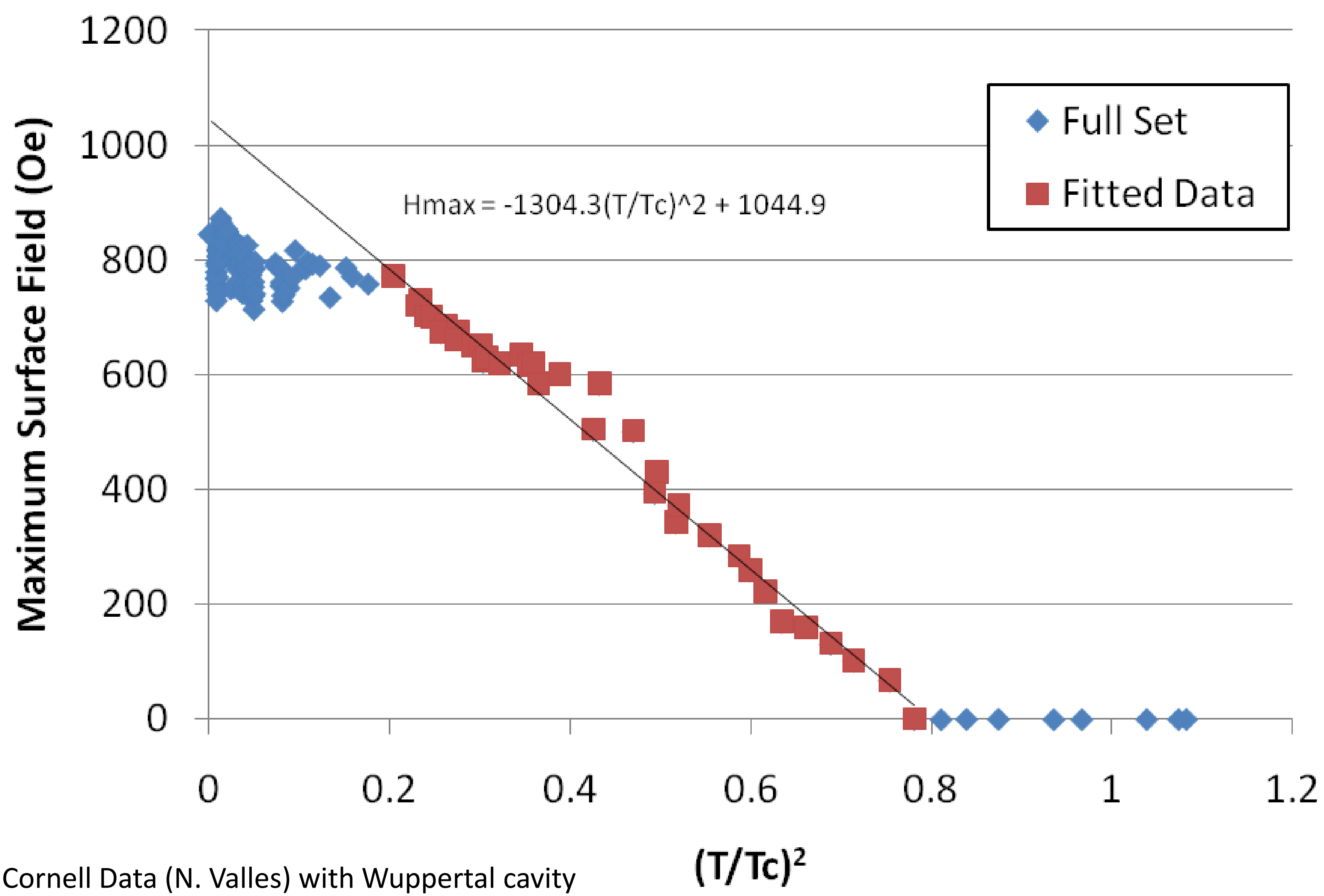
- Restarting Nb_3Sn work at Cornell – older work gives hope for promising results
- 2010 pulsed high power test of Wuppertal Nb_3Sn cavity
- Fabrication of Nb_3Sn coatings on samples
- Planned fabrication of Nb_3Sn coatings on cavities
- Pillbox TE cavity
- Mushroom TE cavity

2010 Test of Wuppertal Nb_3Sn Cavity



Cornell Data (N. Valles) with Wuppertal cavity

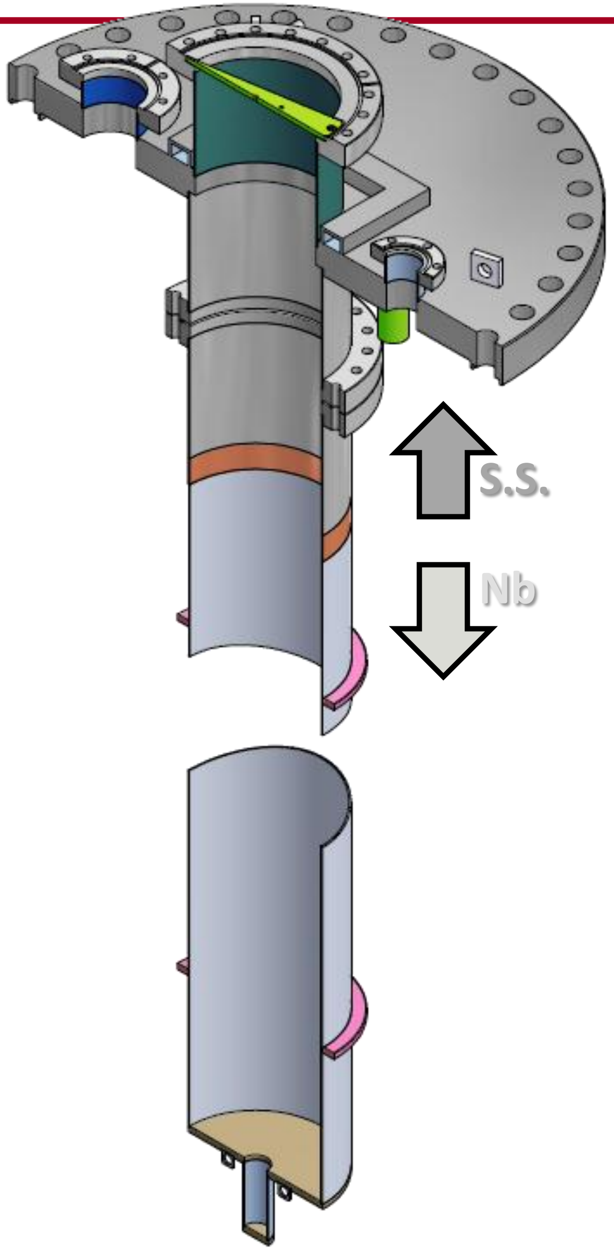
2010 Test of Wuppertal Nb_3Sn Cavity



Cornell Data (N. Valles) with Wuppertal cavity

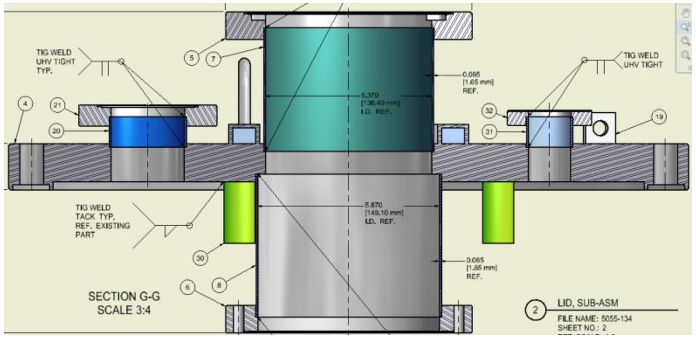
Cornell Nb_3Sn Furnace Insert

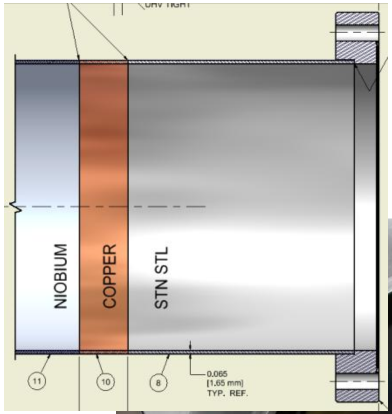
- Compatible with existing single cell UHV furnace
- Start with samples
- Tin in crucible at bottom of insert
- Heater brings tin to higher temp than sample
- Thermocouples for temp measurement

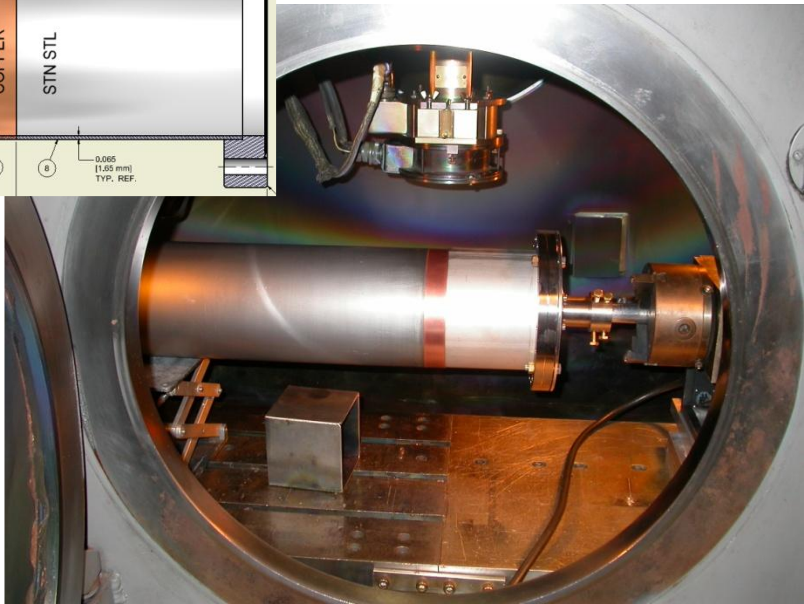


Sample Furnace

- Manufacturing almost complete
- Almost all parts in hand
- Hoping for first coating by end of month





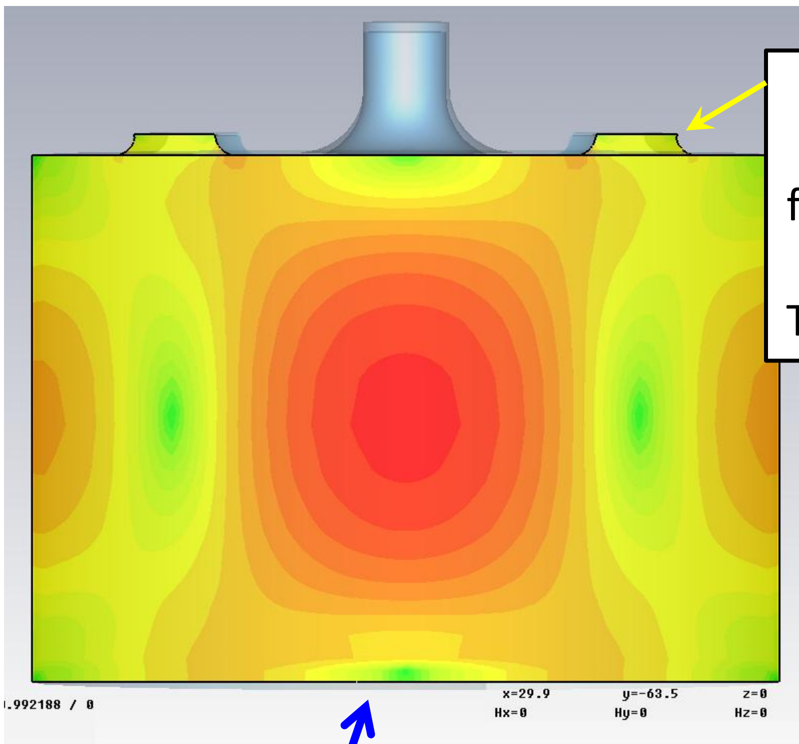


Cavity Furnace

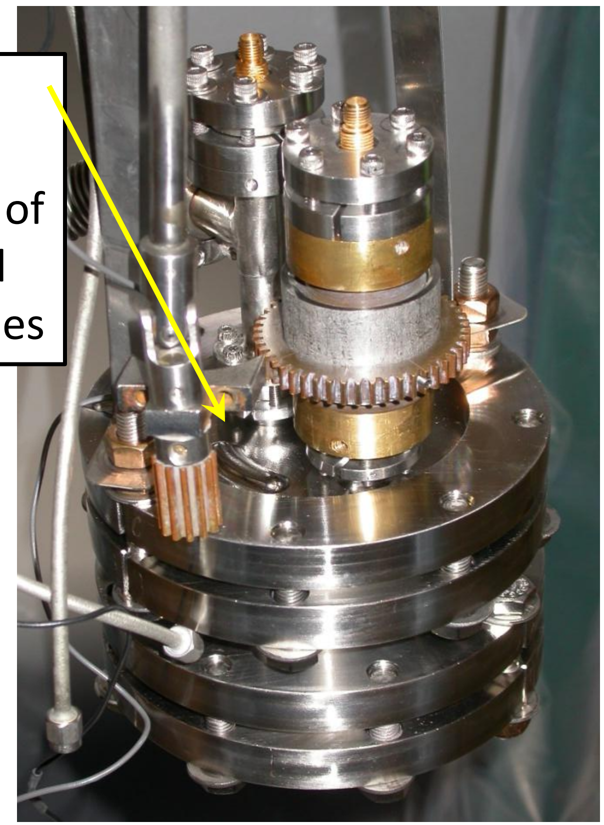
- Plan to weld full cavities into furnace insert
- EP cavities after weld
- Cut cavities out after coating, HPR, and test
- Use thermometry and Cornell OST quench detection to locate any weak areas
- Dissect cavities so that surface studies can be performed on weak areas
- Use this feedback to improve coating technique

Pillbox TE Cavity

- Takes sample plates OR small samples
- In commissioning phase
- Plans exist to test MgB_2 from X. Xi (Temple)



Groove to separate frequencies of TE011 and TM110 modes

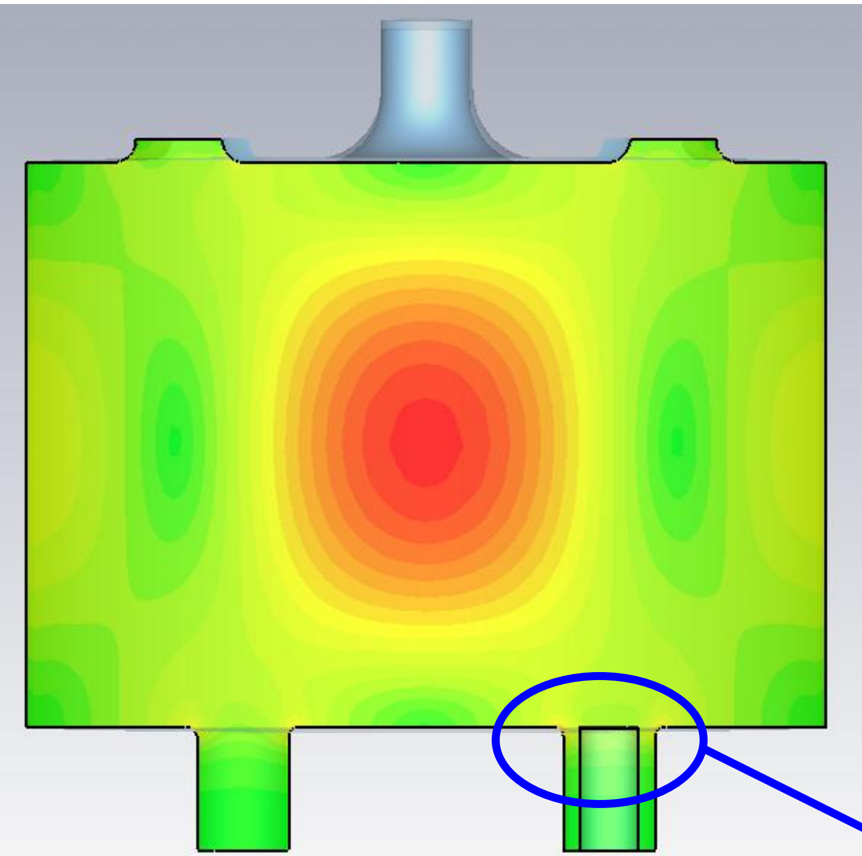


Demountable sample bottom plate

TE011, f = 6 GHz $H_{max, sample}/H_{max, cavity} \sim 0.8$

sample radius = 3.5 cm

Pillbox TE Cavity – Small Samples

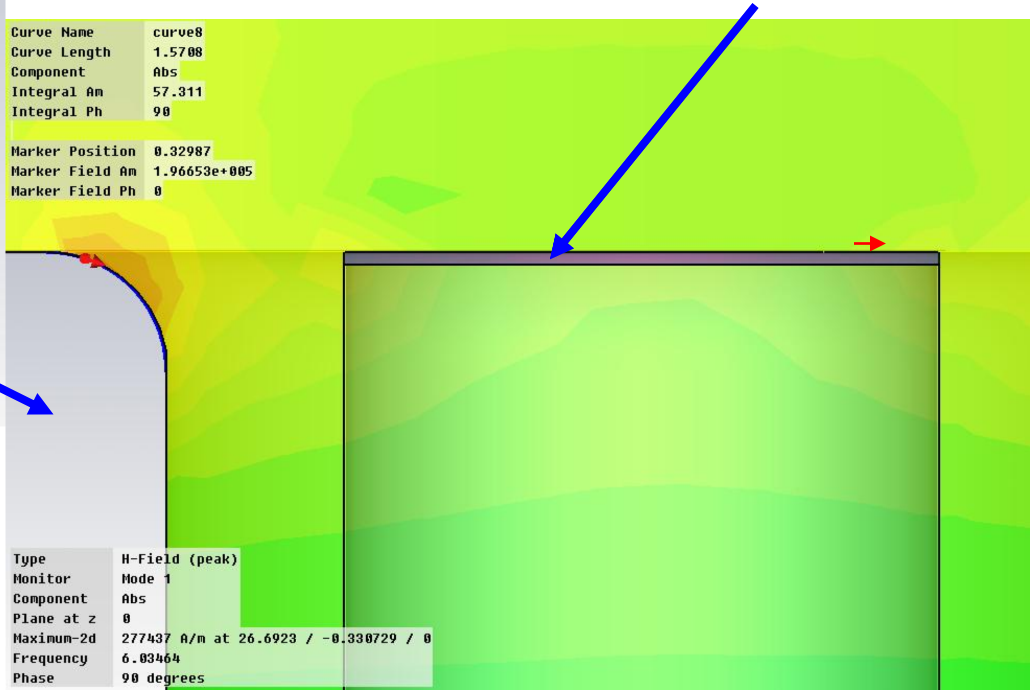


TE011, f = 6 GHz

$H_{max,\ sample} / H_{max,\ cavity}$ ~ 0.64

sample radius = 0.25 cm

small round sample plate



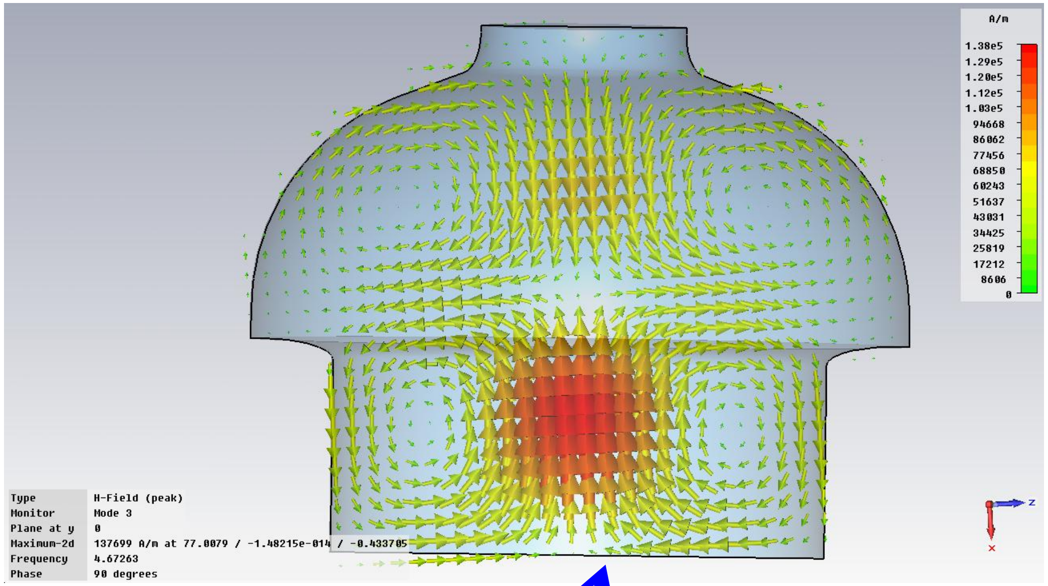
Additional port to keep symmetry

Mushroom TE Cavity

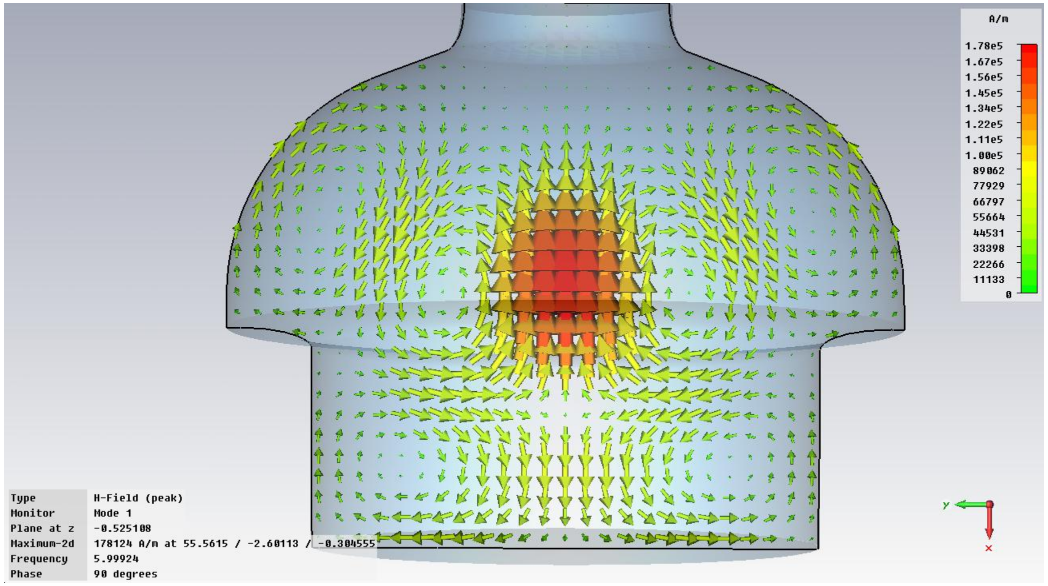
TE012, f = 4.78 GHz

$H_{max,\ sample} / H_{max,\ cavity}$ ~ 1.24

sample radius = 5 cm



Demountable sample bottom plate



TE013, f = 6.16 GHz

$H_{max,\ sample} / H_{max,\ cavity}$ ~ 1.57

sample radius = 5 cm

Current status and future plans

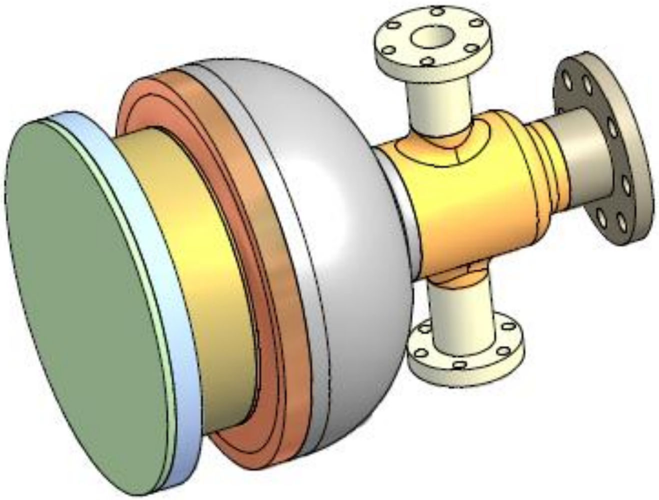
- Current status:
  - Fabrication of small sample pillbox TE cavity done
  - EP, 800C & 120C bake, HRP of pillbox TE cavity done
  - No multipacting from TRACK3P simulation for mushroom TE cavity coupler design
- Test plans and schedule:
  - Pillbox TE cavity commissioning
  - New mushroom-type high gradient TE cavities ready for first tests in early next year
  - Collaboration: Send us your samples!

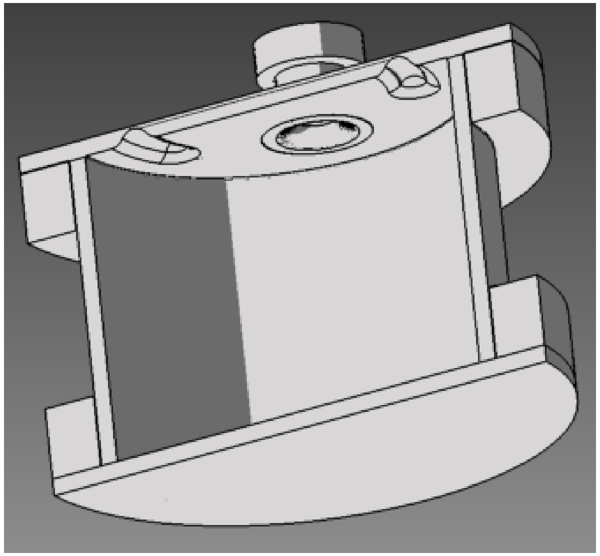
Summary

- Nb_3Sn is good candidate for reaching gradients >50 MV/m
- Wuppertal method for coating cavities using vapor diffusion is being attempted at Cornell
- Furnace insert for coating samples is almost ready
- Pillbox TE cavity commissioning
- Mushroom TE cavity being built
- Call for samples!

Call for Samples!

- If you have any samples you would like to try in an RF test
- 3.5 cm or 0.25 cm radius for the pillbox TE cavity;
- 5 cm radius for the mushroom TE cavity;
- Email Matthias Liepe, mul2 at cornell.edu





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