SRF R&D status

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May 30, 2014

Outline

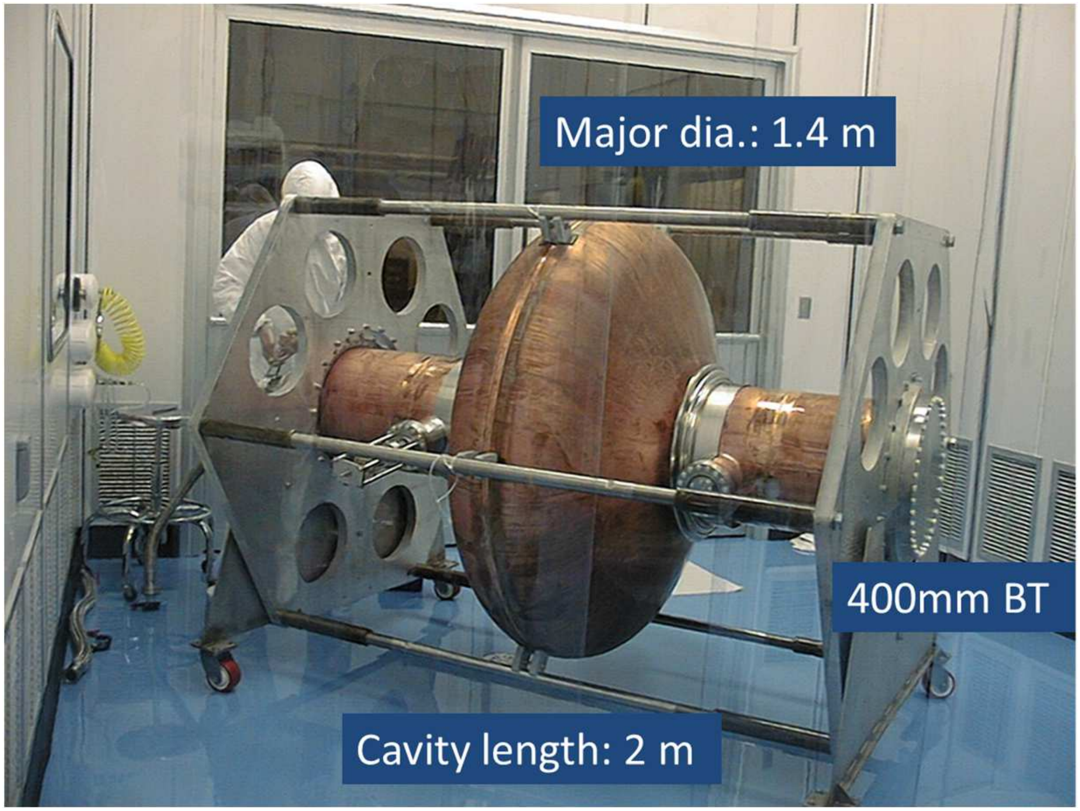
- Muon activities at Cornell
- Nb-Cu clad cavity
- 500MHz Nb/Cu cavity at Cornell
- Next R&D items
- Summary

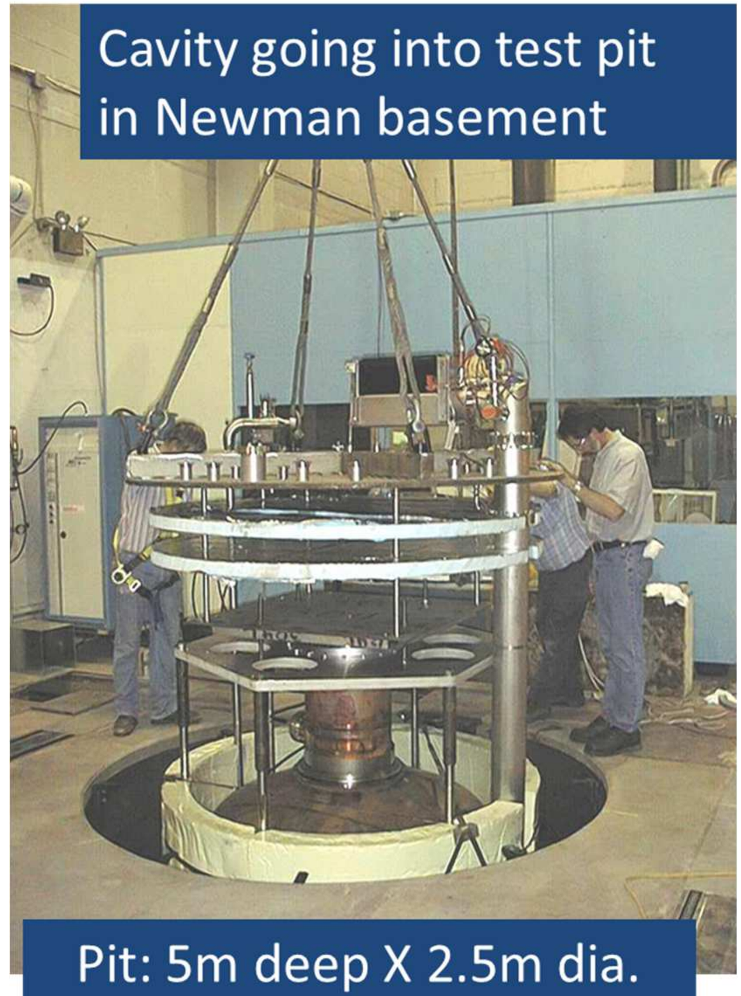
Activities for Low Frequency Muon Cavities at Cornell

200MHz SRF Cavity

- Program started in late 1990's
- Successful collaboration between Cornell and CERN resulting in two 200 MHz sputtered Nb on electropolished Cu cavities.
- Cavity #1 reached 11 MV/m accelerating gradient but with significant Q slope.
- Cavity #2 had bad multipacting, but did demonstrate magnetic field screening up to 1200 Oe.

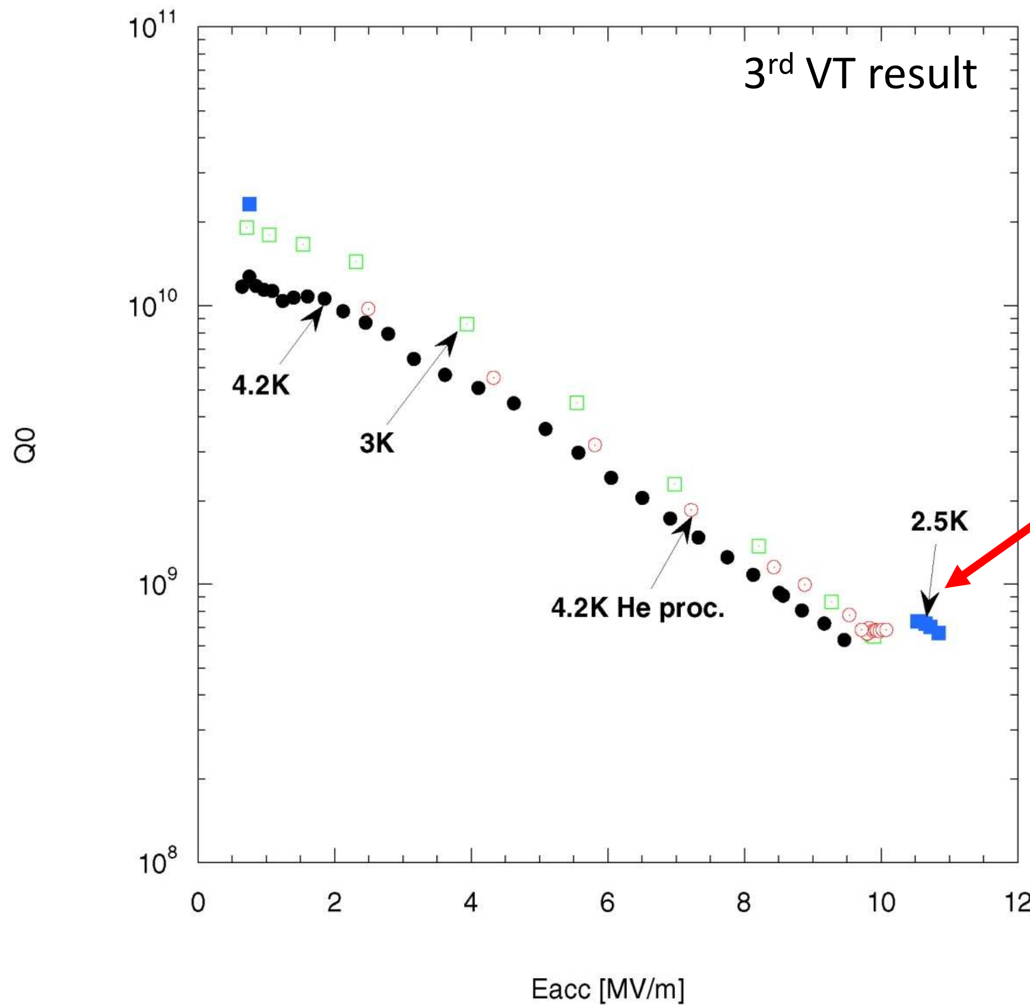
First 200MHz Nb-Cu cavity and First RF test at Cornell





RF test result of 1st cavity

Q_o vs. E_{acc} after combined RF and Helium processing



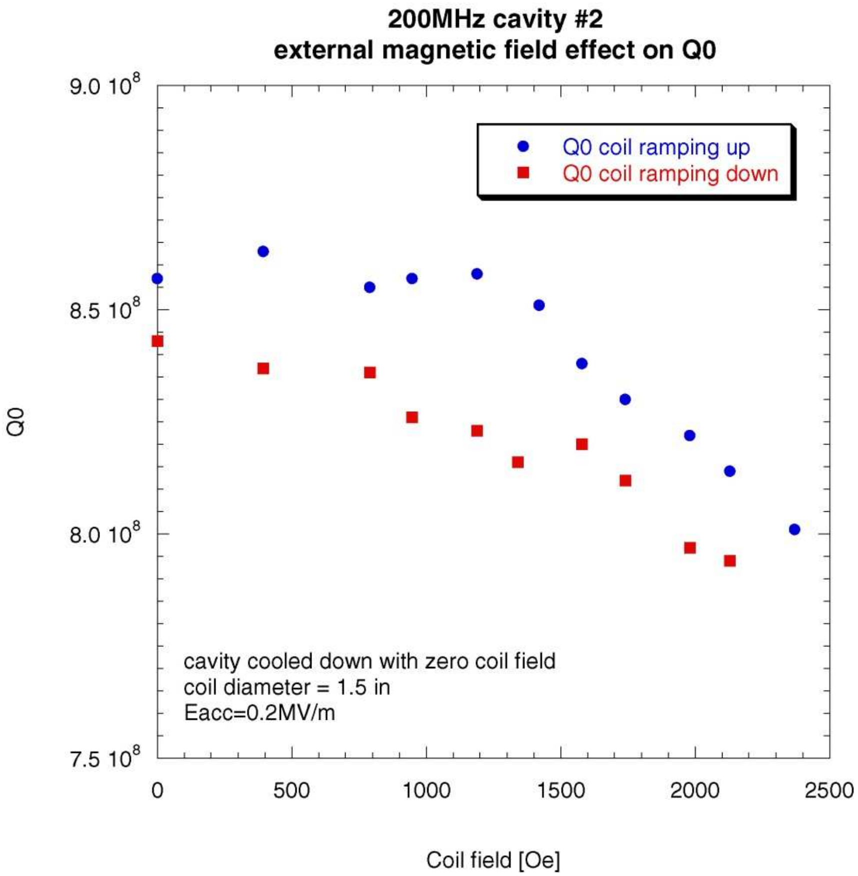
- Eacc = 11MV/m
- Low field Q = 2E10

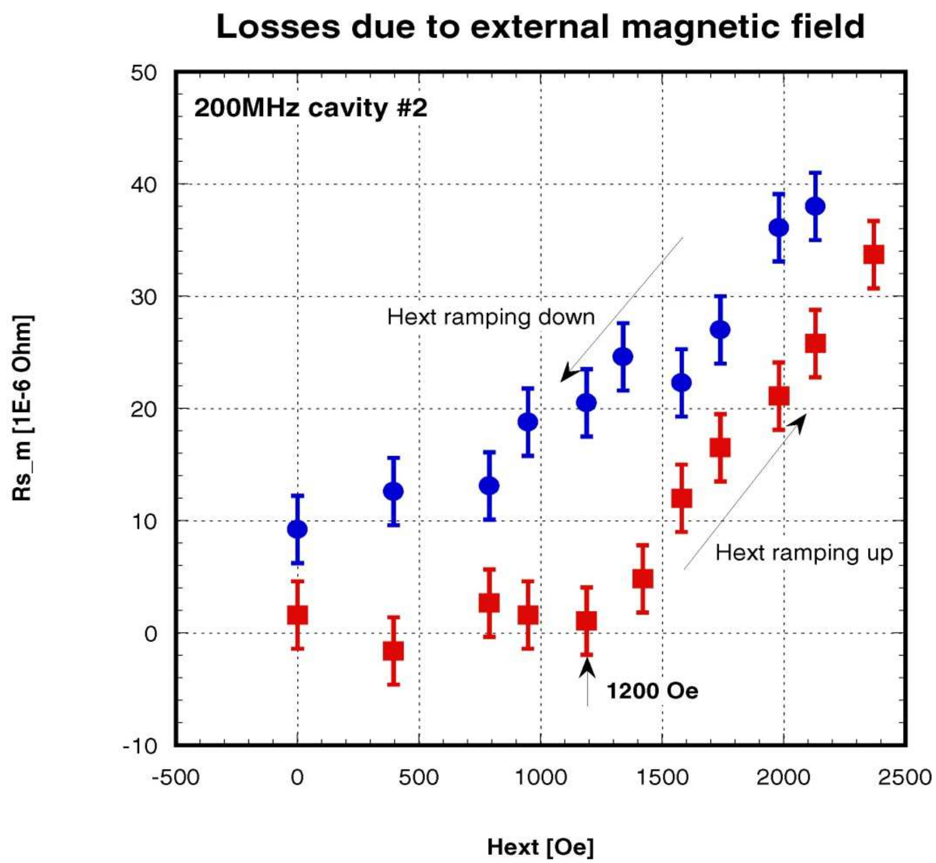
Limited by RF coupler

- 75% goal E_{acc} achieved
- Q-slope larger than expected

Q improves with lower T
→ FE not dominant

H_{ext} effect on 2^{nd} cavity





Cavity Q stays intact up to Hext = 1200 Oe

Activities for Low Frequency Muon Cavities at Cornell

200MHz SRF Cavity

- Currently a low temperature bake ~ 120 ^{o}C seems to significantly reduce the Q slope in solid Nb cavities. This is not suitable for sputter coated cavities because of the diffusion of Cu into the Nb layer. OK for the bonded material since Nb is 1 mm thick and diffusion rates are low.
- Decided to go to 1 mm Nb bonded to 3 mm of Cu structures spun from flat plate and move to 500 MHz to save on testing costs.

500MHz SRF cavity

- Cost of 1 mm Nb bonded to 4 mm of Cu is <1/3 that of 5 mm RRR 300 Nb sheet in small quantities for both hip and explosion bonded material.
- Four cavities (two explosion bonded and two hot isostatic bonded) were produced by our collaborator V. Palmieri.
- Spun cavities from bonded material were sent to ACCEL for flange installation.

Nb/Cu clad cavity

Fabrication of Nb/Cu cavity

Many R&D on Nb/Cu clad cavity has been done with 1.3GHz cavity at INFN, DESY, KEK, Jlab.

(1) - make Nb/Cu sheet by explosive or HIP (hot isostatic pressing) diffusion bonding .
- make cavity by spinning or hydroforming.

(2) - make Nb seamless tube by spinning or deep drawing.
- Nb seamless tube + oxygen free Cu tube -> Nb/Cu clad tube
by explosive / HIP / hot rolling bonding.
- flow forming
- make cavity by spinning or hydroforming.

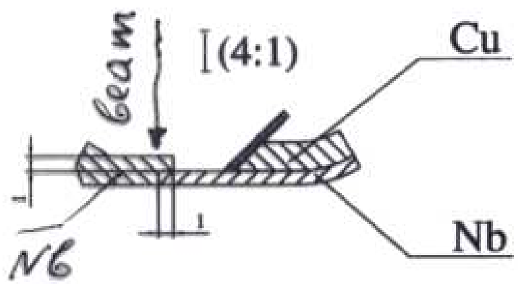
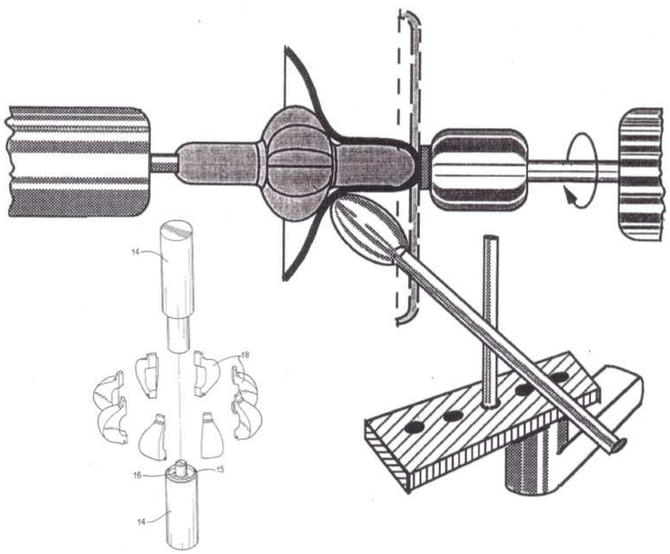


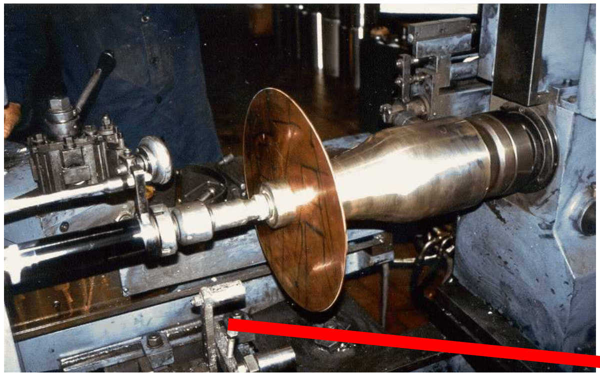
Figure 11: Principle of the welding of NbCu clad cavities

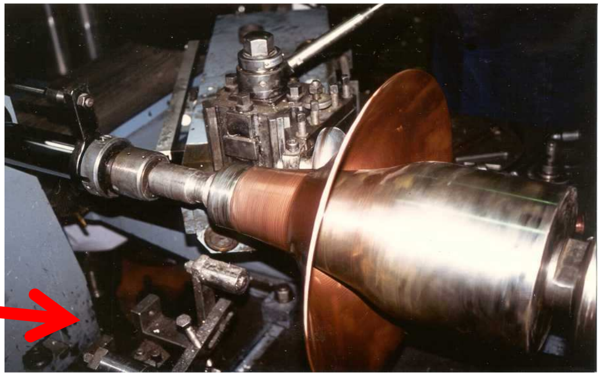
W. Singer, DESY

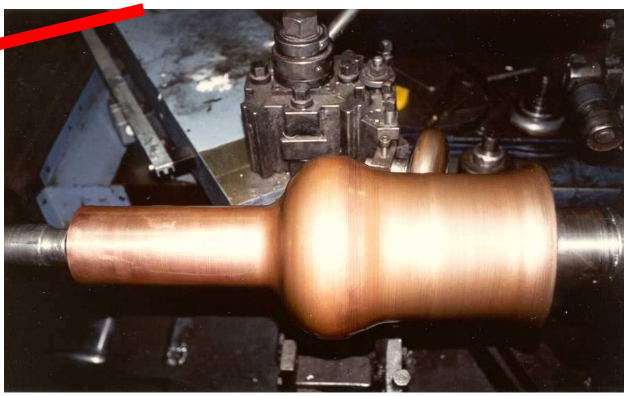
Spun Cavity

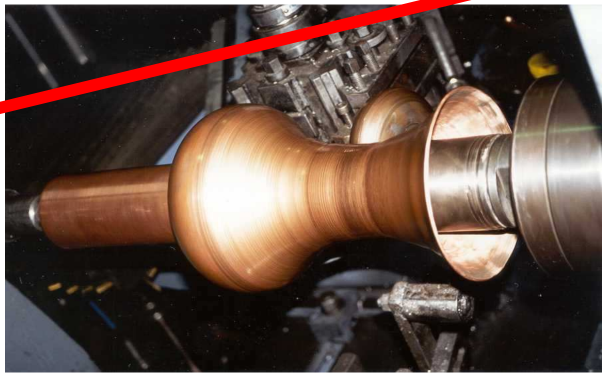
- A few images illustrating the spinning process



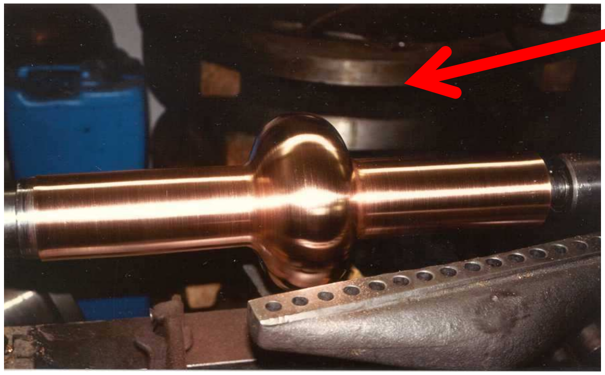








1.3GHz, 1-cell



By V.Palmieri

Cracking Problem of Spun Cavity

Fig. 11 – Section of a Nb clad Cu cavity after vacuum annealing. Pre-existing cracks at the iris due to the material tensile strength at the time of spinning were amplified by the different thermal expansions of Copper and Niobium.

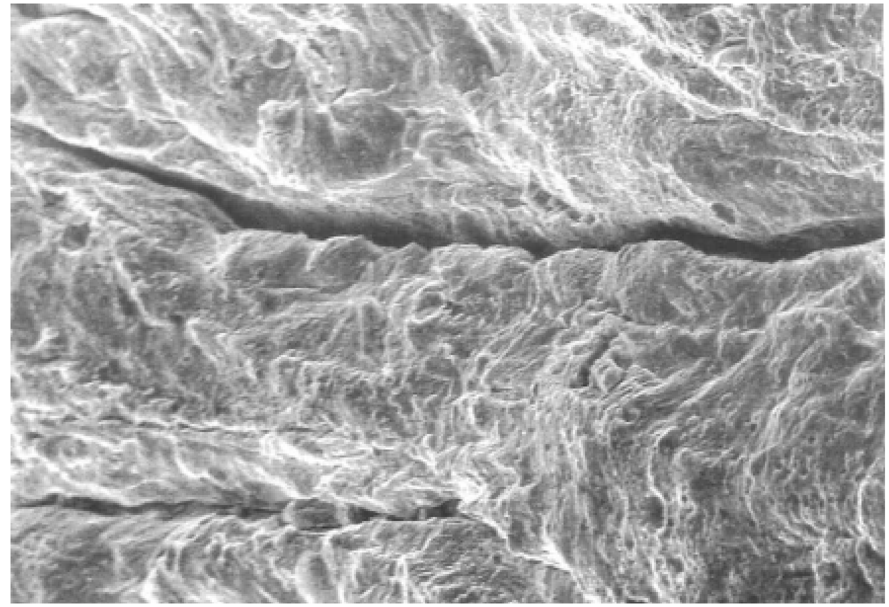
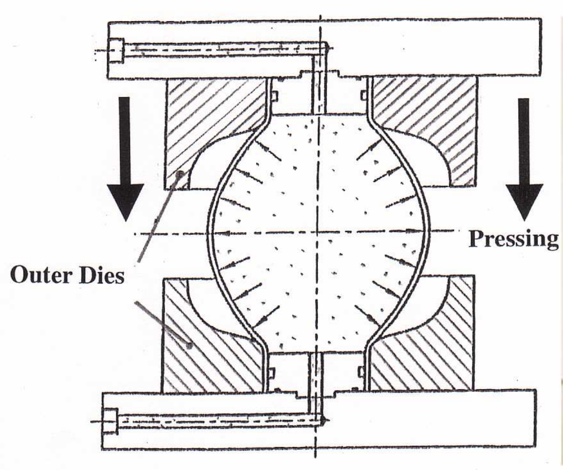
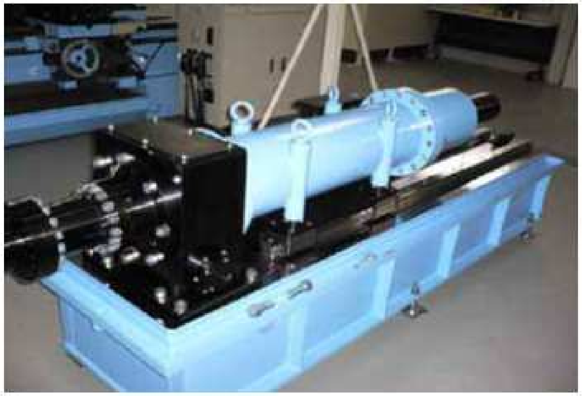


Fig. 12 – Typical longitudinal cracks present at the iris in spun cavities and due to the tensile elongation of Niobium.

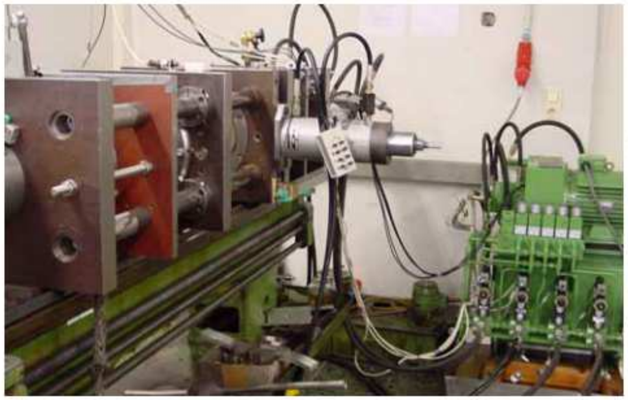
V. PALMIERI
ISTITUTO NAZIONALE di FISICA NUCLEARE
Laboratori Nazionali di Legnaro

Hydroforming of 1.3GHz Cavity





KEK



DESY

Hot Roll Bonding, KEK/ Nippon Steel Co.,/DESY

HOT ROLL BONDING METHOD FOR Nb/Cu CLAD SEAMLESS SC CAVITY

I. Itoh, Nippon Steel Co., 20-1 Shintomi Futtsu-shi, Chiba-ken, Japan
K.Saito, H.Inoue, KEK Accelerator Lab., 1-1 Oho Tsukuba-shi, Ibaraki-ken, Japan
W.Singer, DESY, 22603 Hamburg, Germany

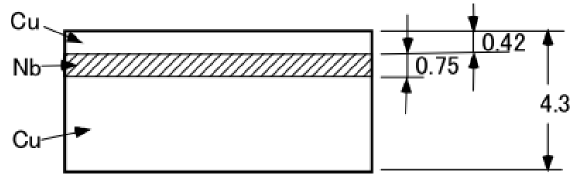


Figure 1: Designed cross sectional view of Cu/Nb/Cu sandwiched clad sheet.

Figure 5: Cu/Nb/Cu clad seamless pipe made by cladding, hot&cold rolling, deep-drawing and spinning.

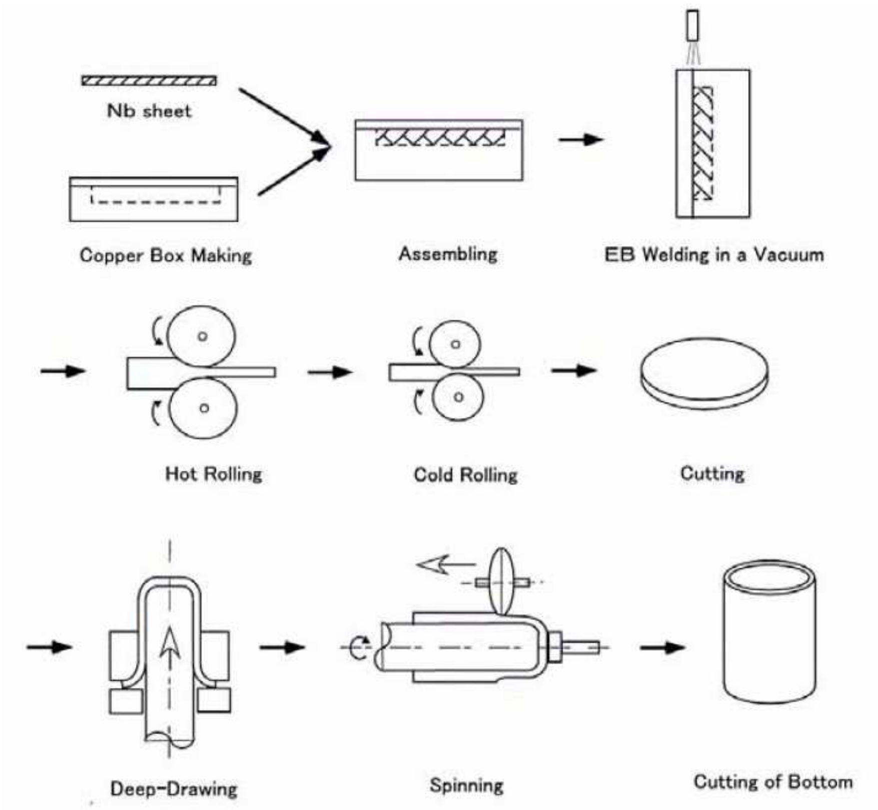


Figure 4: Schematic diagrams of fabricating processes for Cu/Nb/Cu sandwiched clad seamless pipes.

Hydroforming at DESY

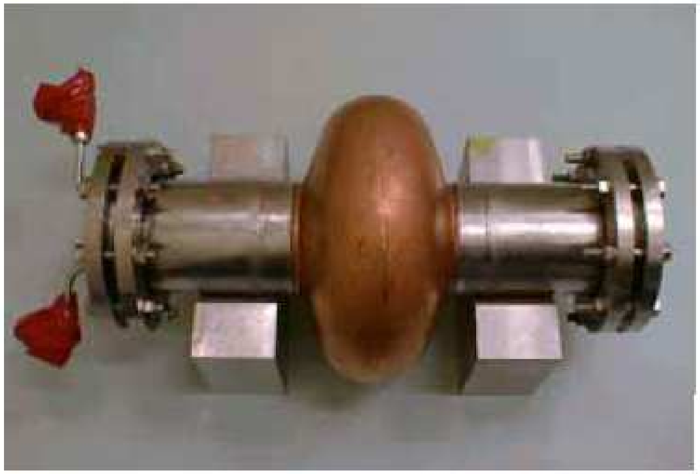
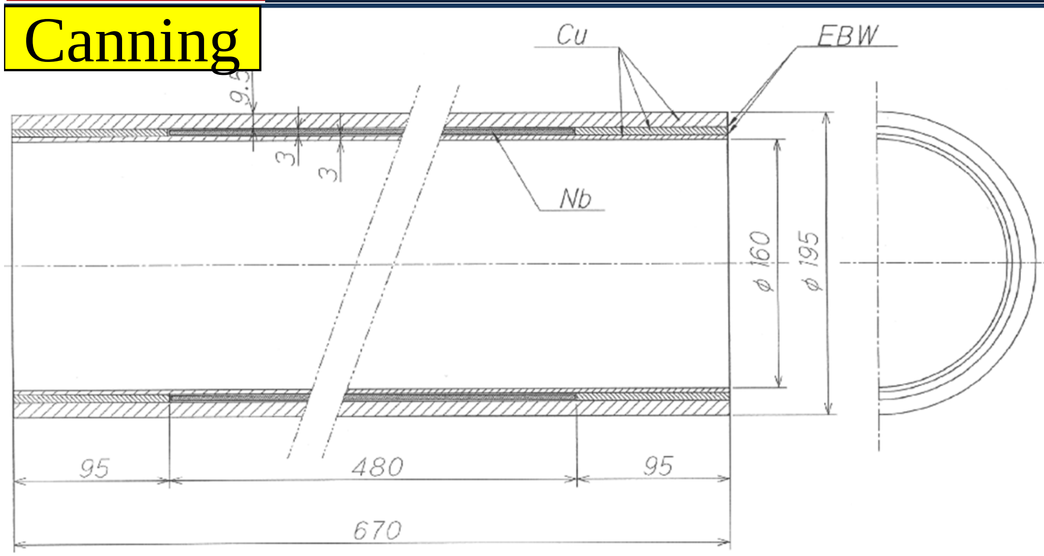


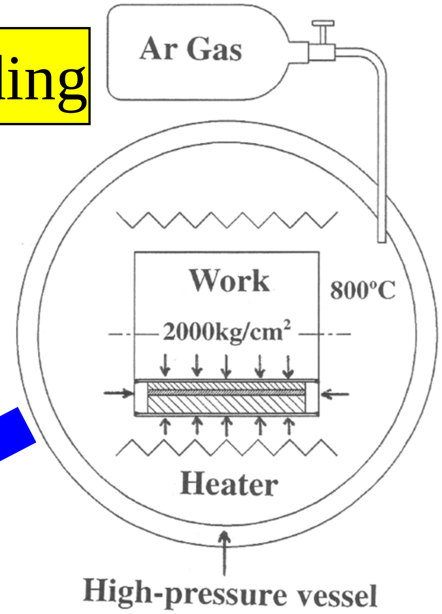
Figure 12: 1300MHz Nb/Cu clad seamless sc cavity.

Hot Isostatic Pressing, KEK

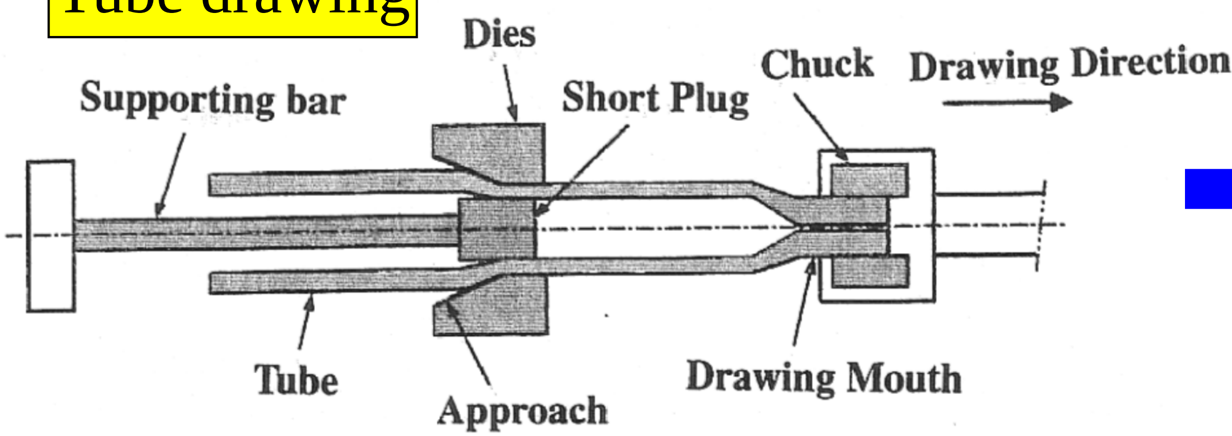
Canning



Bonding



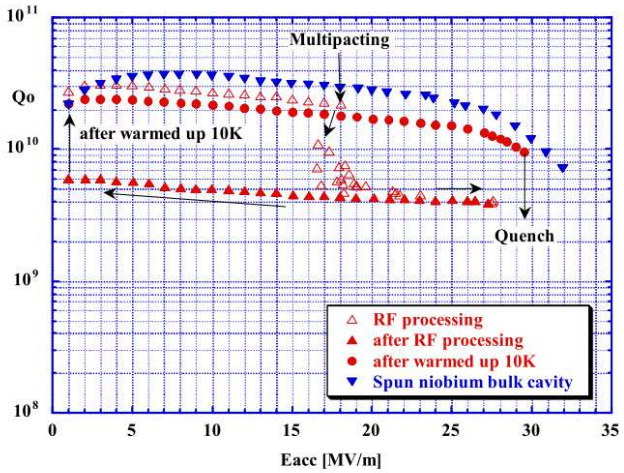
Tube drawing



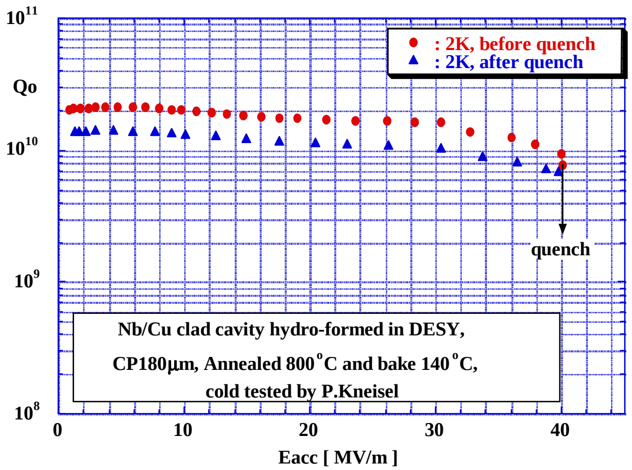
Clad pipe

K.Saito lecture note

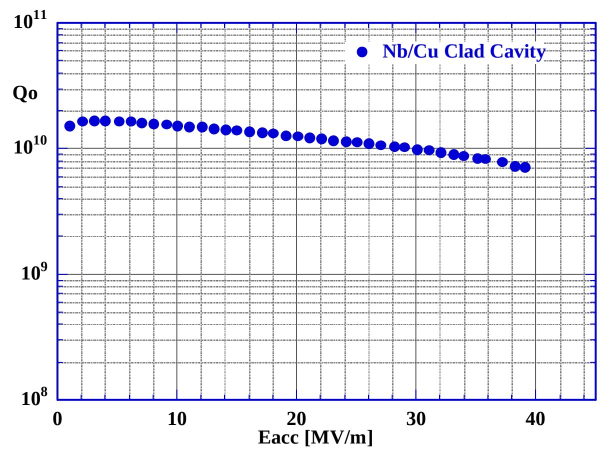
Achievements of 1.3GHz Nb/Cu cavities



1. KEK/INFN-LNL



2. JLAB/DESY/KEK



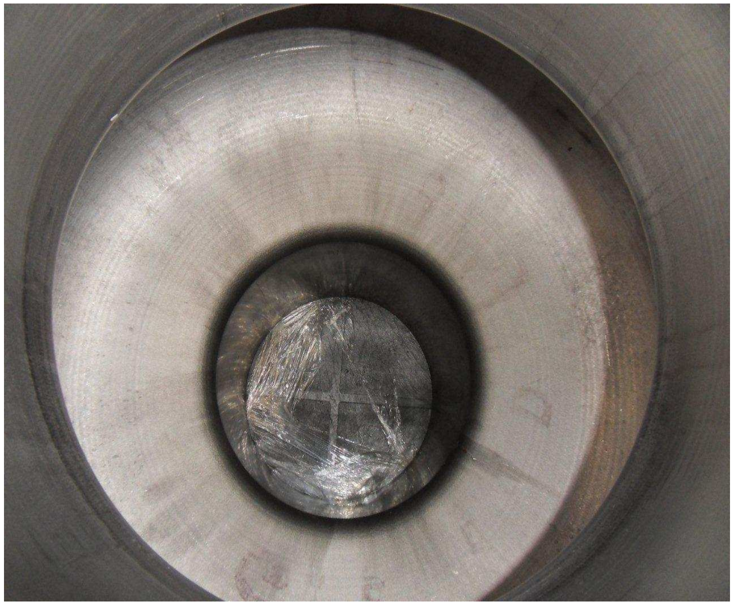
3. KEK/Nippon Steel Co.,/DESY

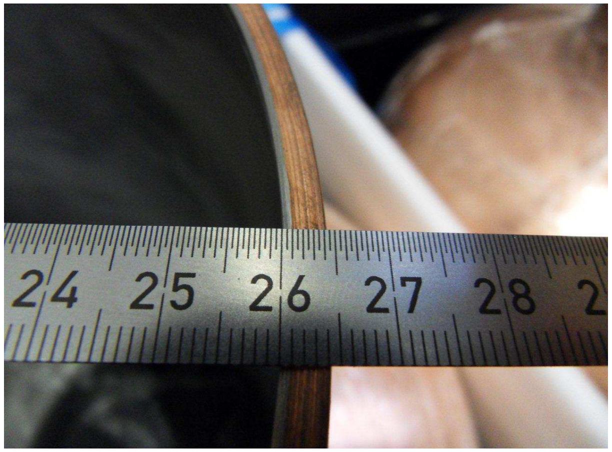
	Material	bonding	Cavity forming	VT results
1	Nb/Cu Disk	Explosive bonding	Spun, 1-cell	30MV/m, 1e10, 1.5K
2	Spun Nb/Cu Seamless tube	Explosive bonding	Hydroforming, 1-cell	40MV/m, 1e10, 2K
3	Deep drawn Nb/Cu Seamless tube	Hot rolling	Hydroforming, 1-cell	39MV/m, 7e9, 1.5K

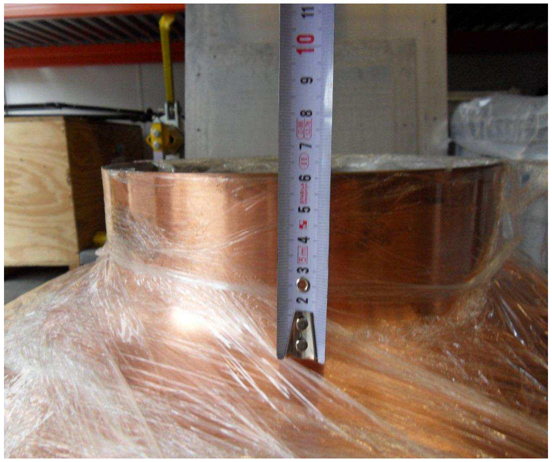
500MHz Nb/Cu cavity fabrication

INFN/Cornell/RI

Spun 500MHz Nb/Cu cavity







500MHz, 1-cell

Cracks on iris

Next R&D items at Cornell

Proposed R&D items

Nb/Cu cavities

- Receive back our Nb/Cu 500MHz cavities and write-up their problems.

- Collaboration with INFN to spin our two remaining sheets of 1mm niobium explosion bonded on 3mm copper into 1.3GHz 1-cell cavities. We will then test these cavities.

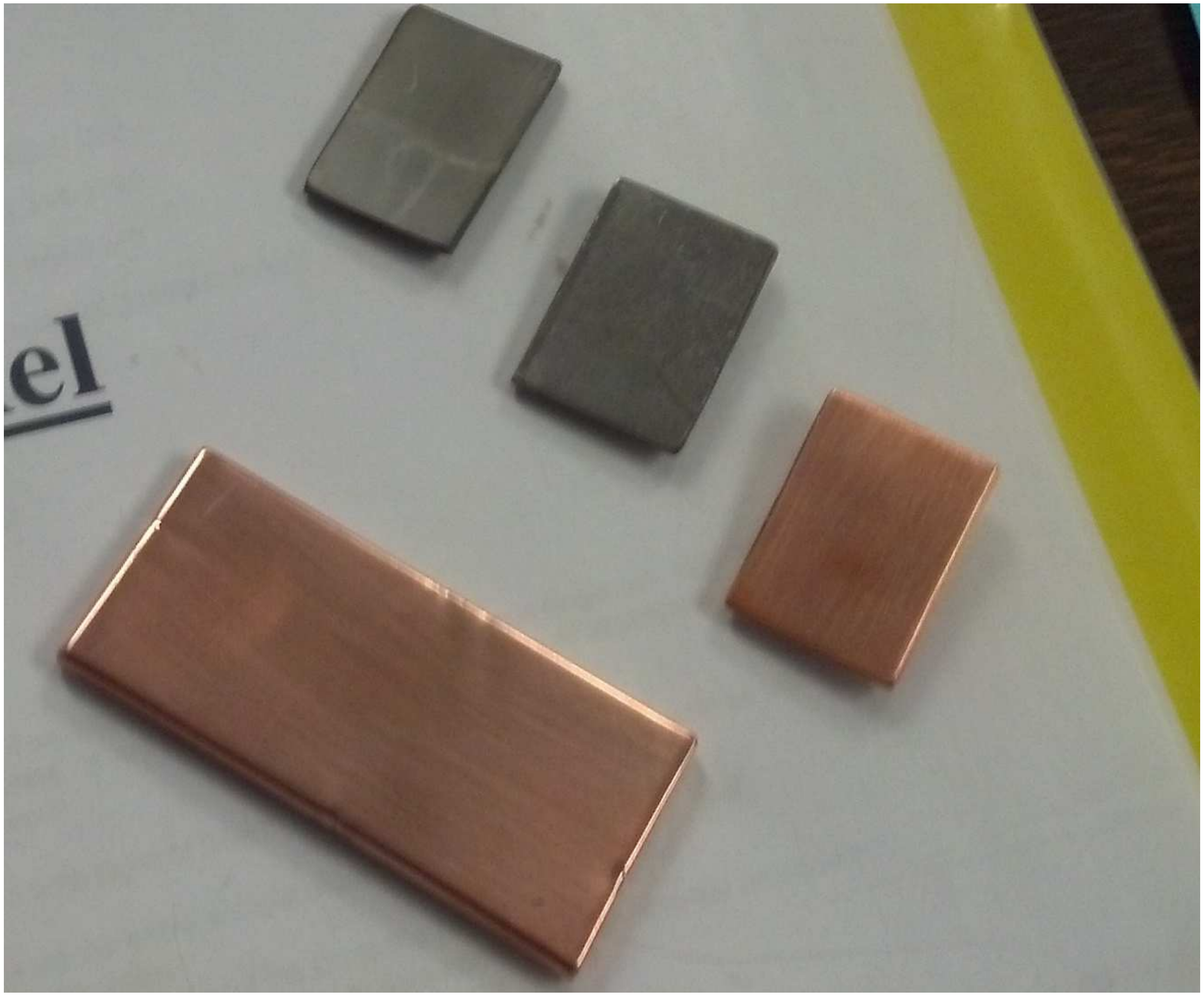
Feasibility study on Nb-Cu Electroplating

- The 1st sample of Nb-Cu electroplating has been made, some analysis are planed

- Produce 5 inch plates of 1mm niobium with 3mm copper electroplated on their back and test this plate in our 6GHz TE cavity.

- Fabricate a 1.3GHz niobium cavity with 1mm wall thickness and electroplate its on the outside with 3mm copper, and test this cavity.

Nb-Cu electroplating sample



Proposed R&D items

A paper study on the feasibility of all-niobium cavities as a function of frequency. As a function of frequency, this study would analyze the following for elliptical cavities:

a) Required thickness of niobium.
b) Thermal issues as a function of gradient and Qo, including loss centers.
c) Material and production cost.
d) Alternative material with niobium on copper, its production cost.

Summary

- Due to the micro cracks on iris and thin wall thickness of iris, it is difficult to weld Nb beam tube and complete spun 500MHz cavities. Receive back four spun cells, analyze them, and make documents.

- We have another explosive bonded Nb/Cu sheets. Collaborate with INFN, fabricate 1.3GHz Nb/Cu spun cavity with them and do surface process and RF test to understand more fundamental issues about Nb/Cu.

- The first sample of Nb-Cu electroplating has been made. Next plans are 1) property test of sample, 2) produce sample for TE cavity, 3) fabricate a 1.3GHz single cell with 1mm wall thickness bulk Nb + electroplates 3mm Cu on outside of it. 4) cost estimation of cavity fabrication.

- Start feasibility study of all-niobium cavities as a function of frequency to see many success of 1.3GHz bulk Nb SRF cavity is applicable for other low frequency SRF bulk Nb or Nb/Cu cavities.