SC Cavities: Fabrication. Material

W. Singer

Overview of last activities and plans for the next future

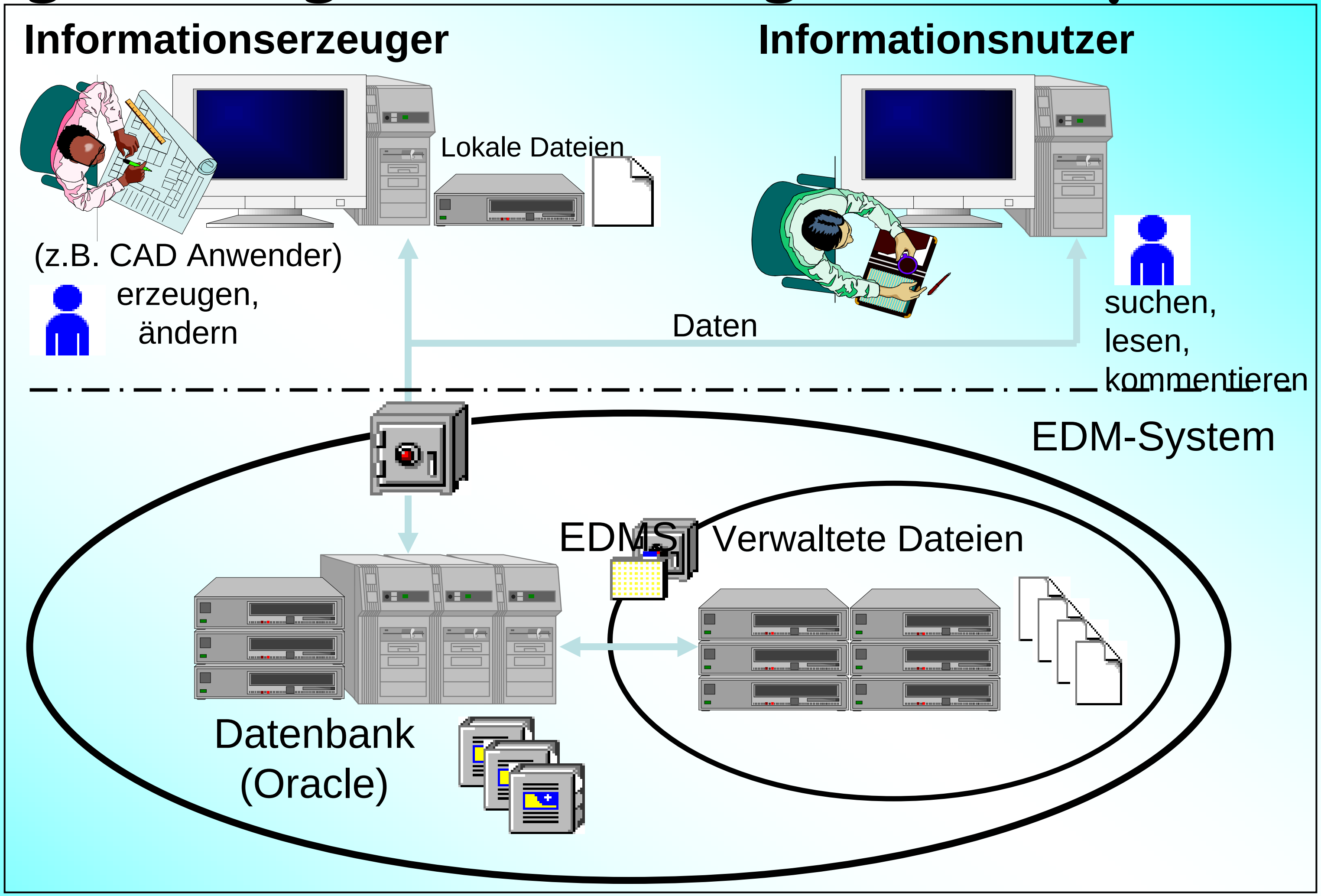
Main last activities are dedicated to preparation for XFEL

Current fabrication of 30 TTF cavities at ZANON - a good opportunity for XFEL

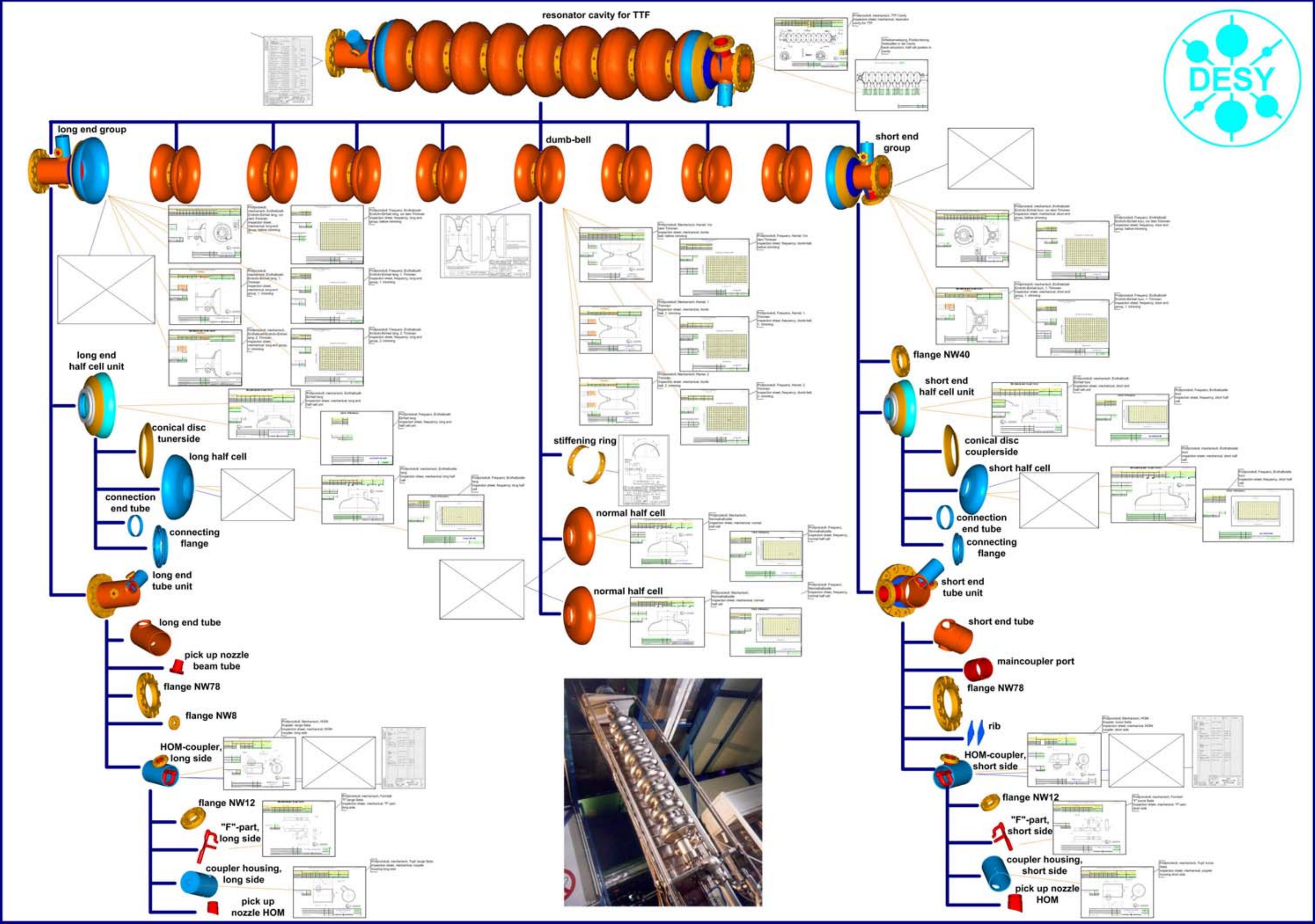
Fabrication procedure

Fabrication procedure of ZANON could be a good basis for cavity mass production. Eacc>35 MV/m can be reached

Engineering Data Management System



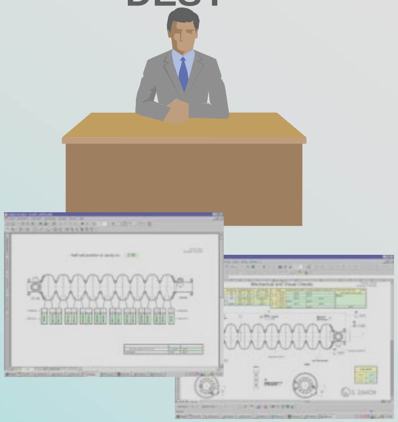
Application of EDMS for cavity fabrication. Aim: - paper less documentation, up to date information, tracking the trends.



Application of EDMS for cavity fabrication

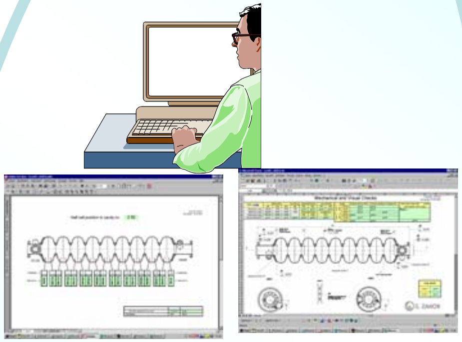
Involvement of ZANON

DESY



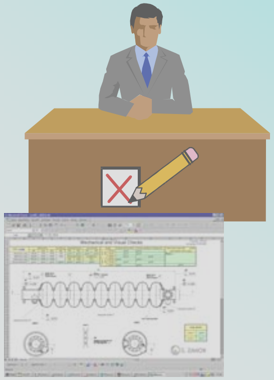
- create the work description (in EDMS).
- create the protocol template (in EDMS).
- message to Zanon.

Zanon



- log in to EDMS.
- open the Inbox.
- read work description
- produce accordingly cavity part
- fill out the template of protocol.
- submit the protocol to release -life-cycle.

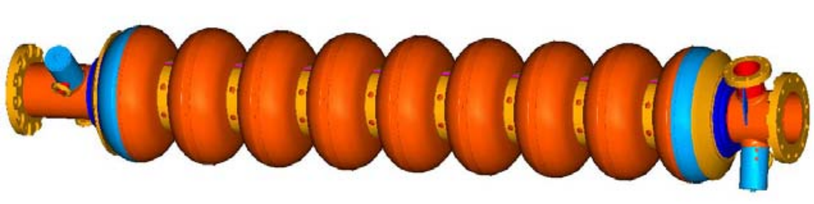
DESY



- check and release the protocol.
- message to Zanon (in EDMS).

Check the procedure on the level “cavity inspection sheet”

New specification for fabrication of 1000 XFEL cavities



Specification for prototype cavity fabrication are available: What should be change for series production?

• Analysis of the sequences of part fabrication and completing and create a new specification from industry point of view (experts of DORNIER involved)

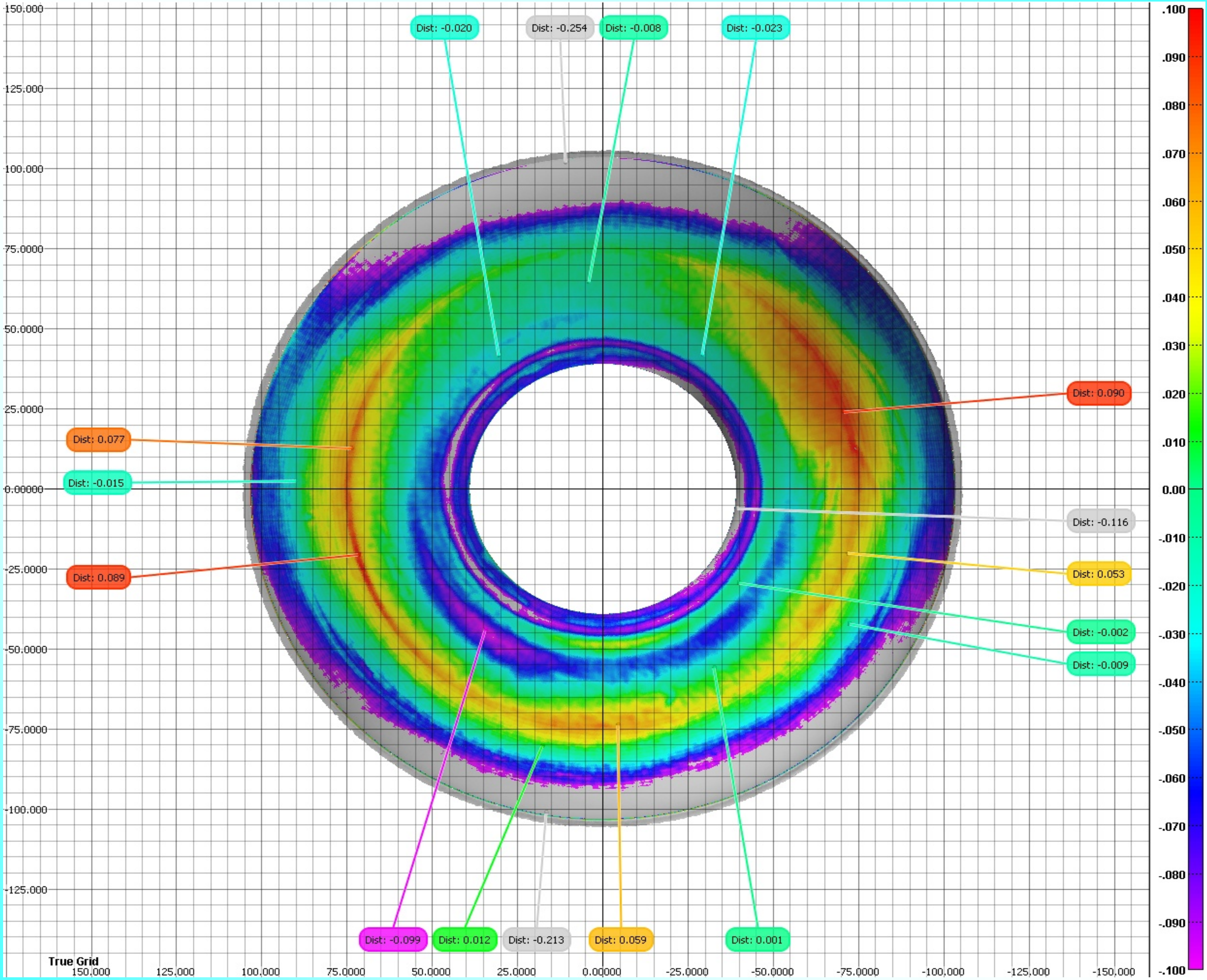
• Create a new strategy for QC and QA and create a new specification for parts inspection (experts of Babcock Noel Nuclear involved)

• New set of cavity drawings

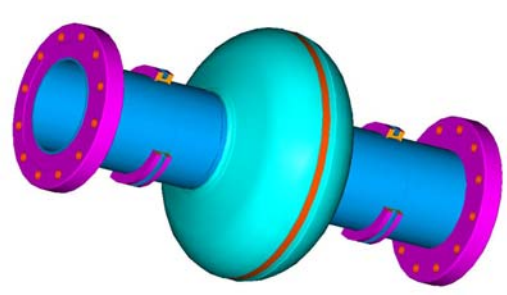
• Check some requirements of the present spec.: e.g. < 8 hours between etching and welding

• Reduce the number of steps “frequency measurements + trimming”

• Improve the half cells shape control (3 dimensional shape measurement, fast procedure for shape control)



Optical 3D measurement of the deep drawn TTF half cell



Single cell cavity R&D at DESY

DESY EB welding device

1. Qualifying of new Nb suppliers

- Two qualified Nb sheet suppliers: Wah Chang (USA), Tokyo Denkai (Japan).
- HERAEUS (Germany) quit the sheet fabrication. Proposed option. HERAEUS-supply high purity Nb ingots. Fa. Plansee (Austria) - sheet fabrication from Nb ingots. Plansee have to be qualified.
- Several companies anticipate to be qualified. Most of companies installed or overhauled the EB melting facilities: CBMM (Brazil), Cabot (USA), NIN and Ningcha (China)

2. Rework the specification for fabrication of 9- cell cavity

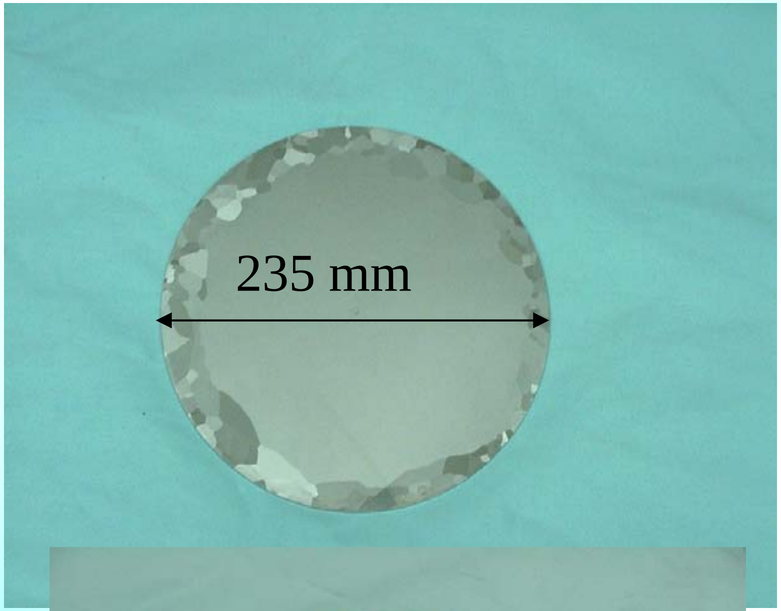
- Check the eight hours rule etc.

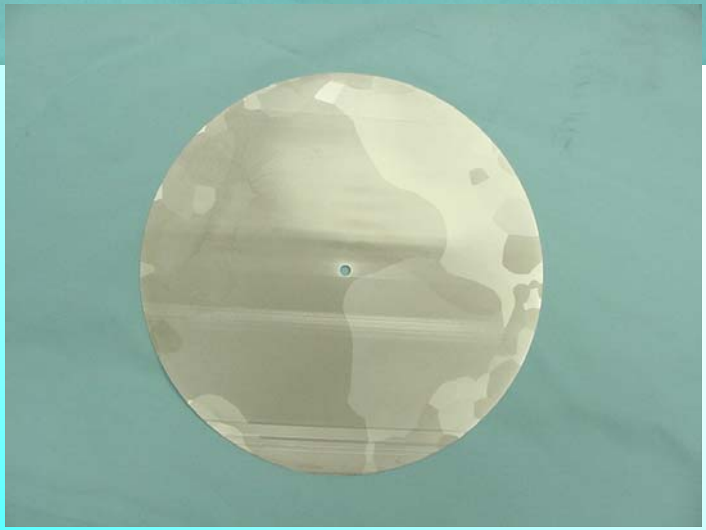
3. Rework the Nb specification:

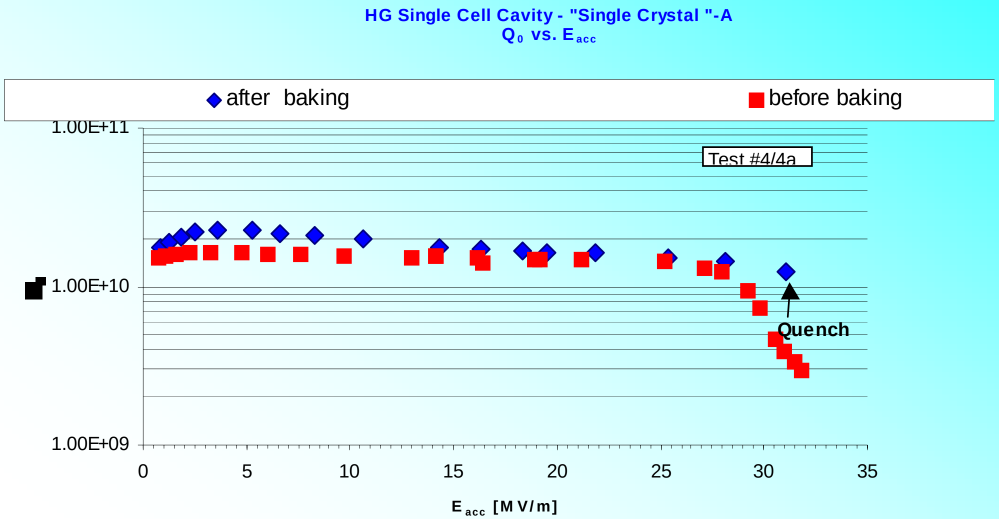
- Nb with high thermal conductivity (RRR 700-900)
- Check the Ta content

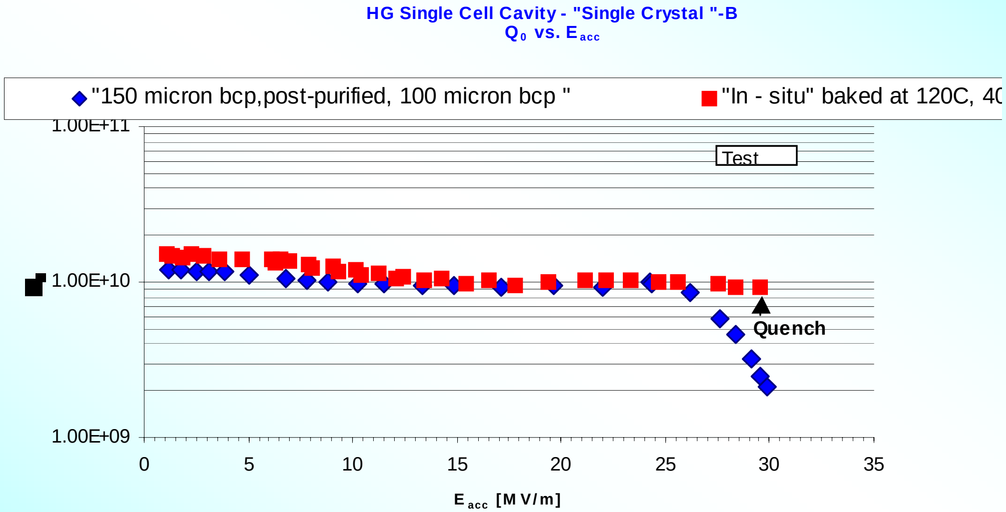
4. Cavity from ingot with very large grain

Cavity from ingot with very large grain

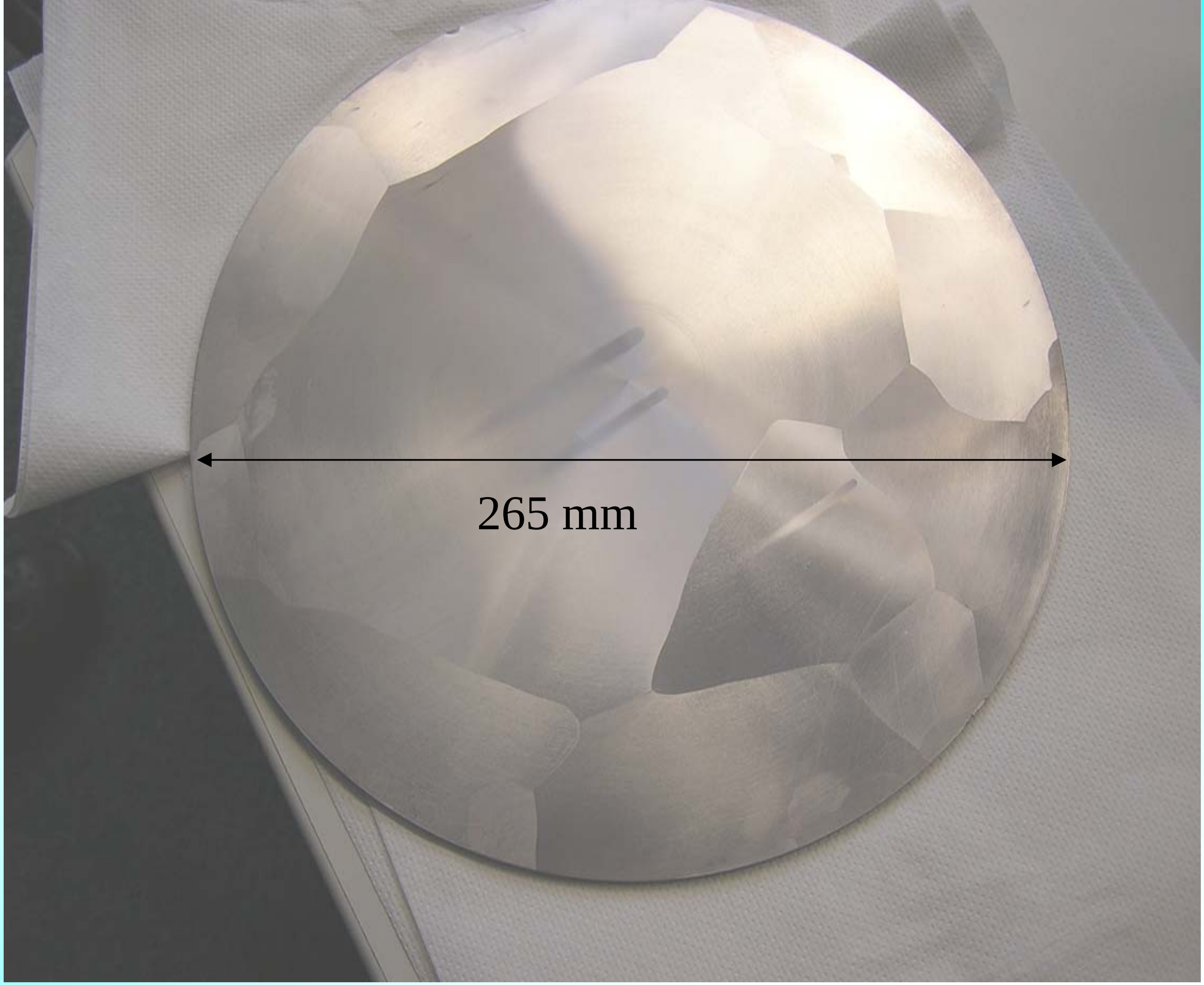








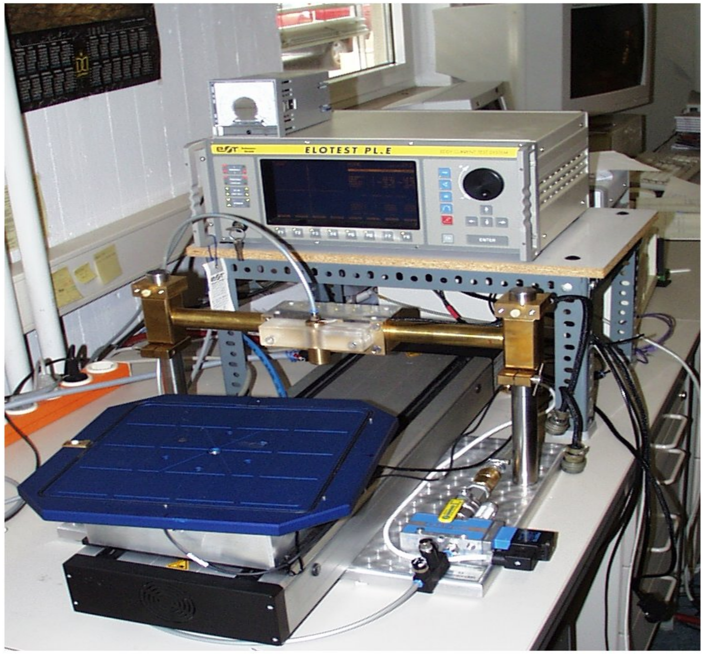
P.Kneisel; JLab (1,5 GHz single cells)



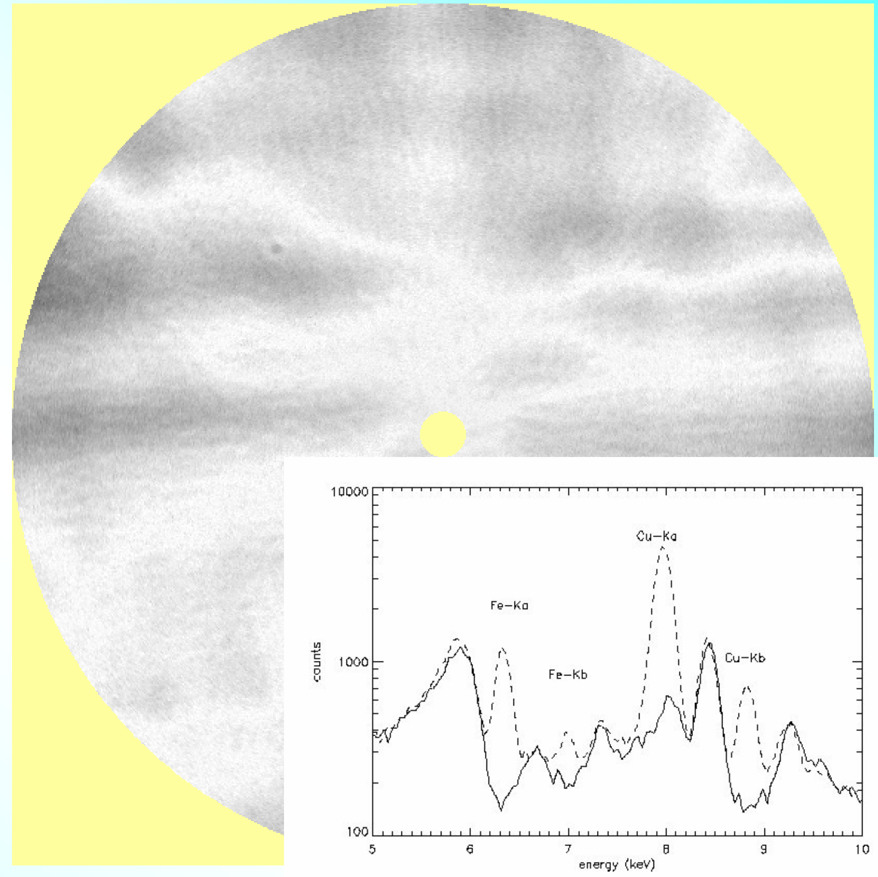
Special task to melt an ingot with very large grain.
Image of the disc from new HERAEUS ingot

Material

Search for cluster in Nb sheets. Eddy current.

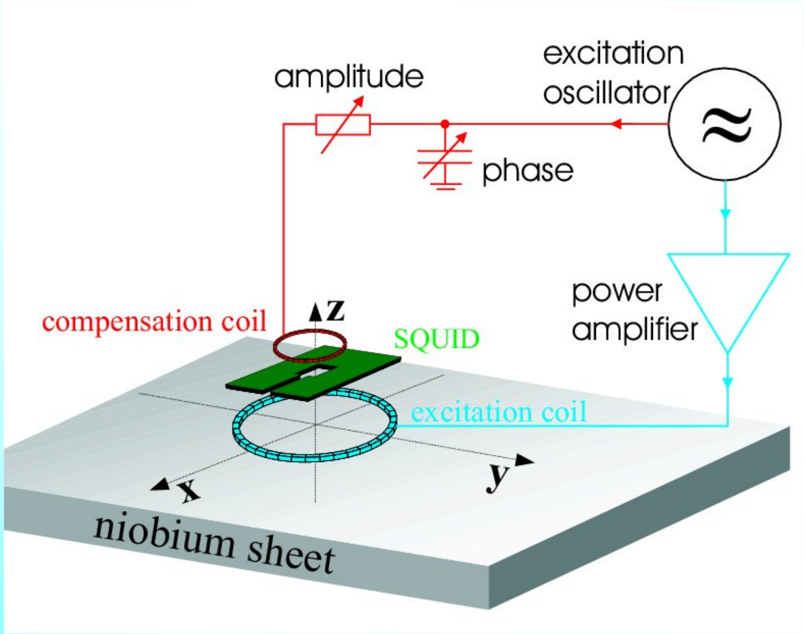


DESY eddy current scanning apparatus for niobium discs. More than 1000 Nb sheets for TTF scanned and sorted out

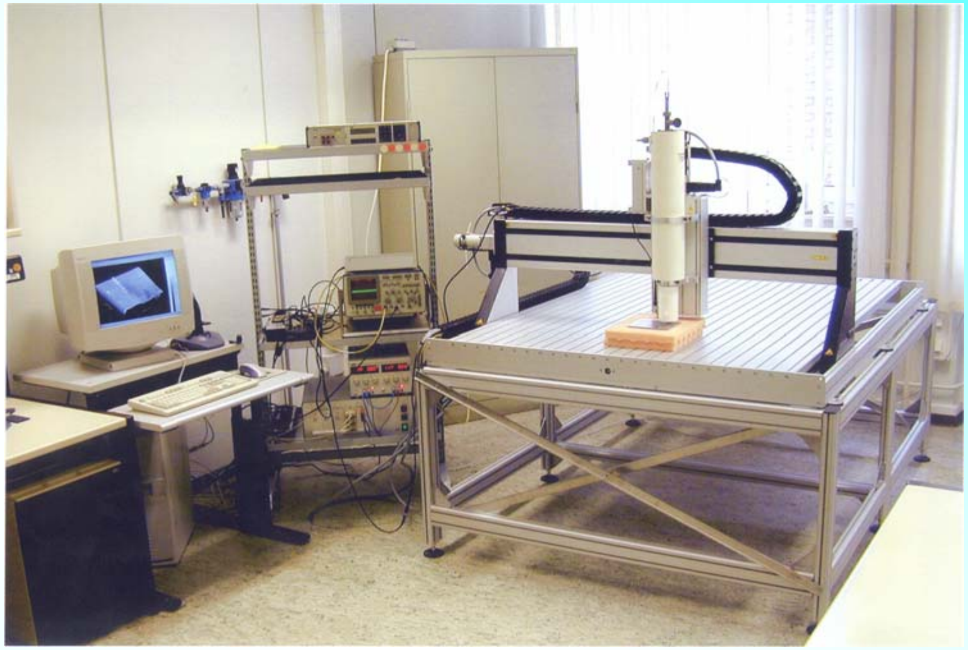


Example of the Nb sheet eddy current scanning test. The spot was identified as an inclusion of foreign material. Cu and Fe signal has been observed in the SURFA spectrum in the spot area.

Search for clusters in Nb sheets. Eddy current or SQUID system? After finishing of SQUID development a decision should be taken what scanning system is more reasonable for XFEL. SQUID system seems to be more sensitive but more complicate



An excitation coil produces eddy currents in the sample, whose magnetic field is detected by the SQUID.



SQUID-based scanning system for niobium sheets of company WSK (Germany)

Low Tc superconducting SQUID based prototype for testing of niobium sheets (Work will be done in frame of CARE program)

Rework of the specifications for high purity niobium

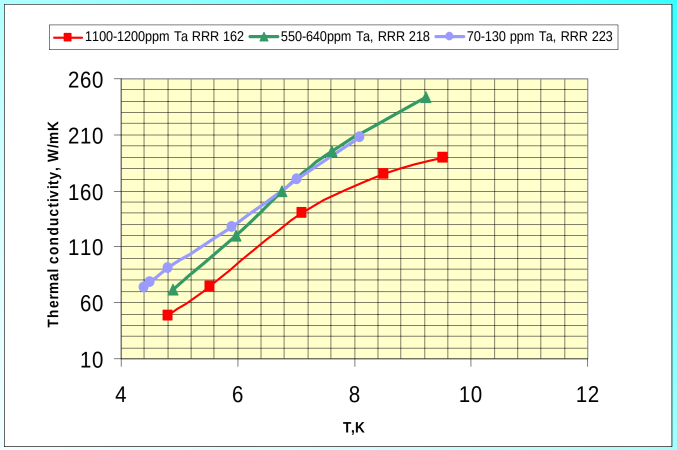
Technical Specification for Niobium Applied for the Fabrication of 1.3 GHz Superconducting Cavities RRR 300. W. Singer, D. Proch

Concentration of impurities in ppm (weight)				Mechanical properties	
Ta	≤ 500	H	≤ 2	RRR	≥ 300
W	≤ 70	N	≤ 10	Grain size	≈ 50 μm
Ti	≤ 50	O	≤ 10	Yield strength, $\sigma_{0,2}$	> 50 N/mm^2 (Mpa)
Fe	≤ 30	C	≤ 10	Tensile strength	> 100 N/mm^2 (Mpa)
Mo	≤ 50			Elongation at break	30 %
Ni	≤ 30			Vickers hardness HV 10	≤ 60

Could be the Ta content increased? Possibly material cost reduction

Influence of tantalum content on cavity performance

In collaboration with JLab



Single cell cavities produced from three CBMM ingots with different Ta content (70-1300 ppm).

Material # Sheet #	Ta content [wtppm]	Test #1 100 micron	Test #3 200 micron	Test #4 Post.Pur. +bak.	Average Eacc[MV/m] Hp [mT]
1164_12_12	1300	**18.12**	**20.58**	**30**	**18.14 / 83**
1164_11_14	1300	**20.23**	**23.56**		**22.23 / 102**
1161_31_34	~150	**22.27**	**21.22**	**35**	**21.86 / 100**
1161_32_33	~150	**23.57**	**23.65**		**23.24/ 106**
1162_33_34	~600	**23.34**	**23.49**		**23.14 / 106**
1162_32_35	~600	**20.37**	**22.76**		**22.17 /102**

Eacc for cavities with different Ta content

Eacc> 20 MV/m can be achieved even by Ta content of 1300 ppm

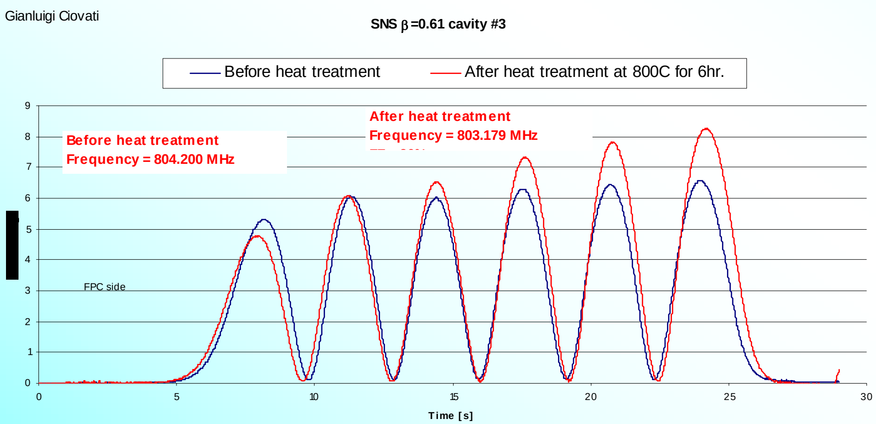
Preliminary results: Ta influence on cavity performance within 100-1300 ppm is not significant in order to reach moderate Eacc.

For high gradient 30-35 MV/m it plays a role

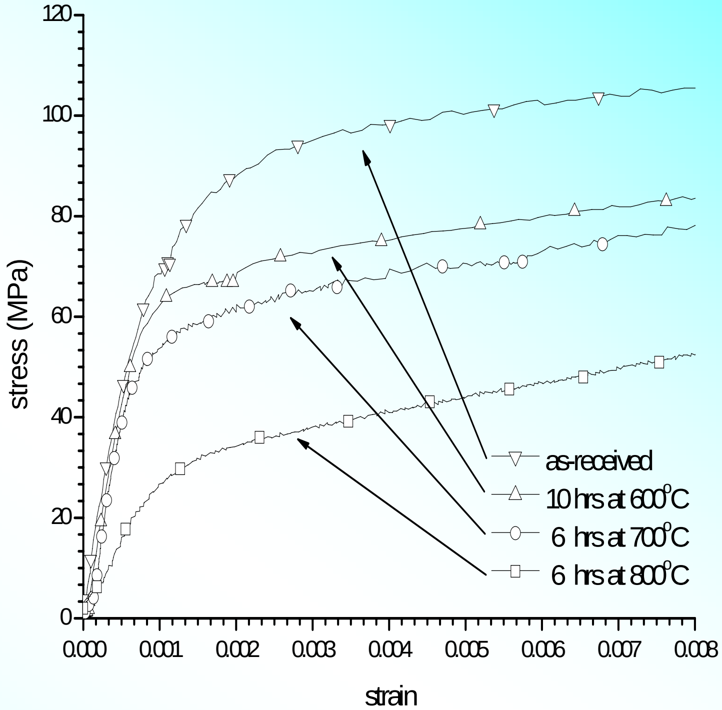
Cavity annealing parameters.

Are the TTF cavity annealing parameters 800°C, 2h correct? (In conflict with SNS parameters 600°C, 10 h)

Main question: Yield Strength after annealing (cavity stiffness), hydrogen degassing.

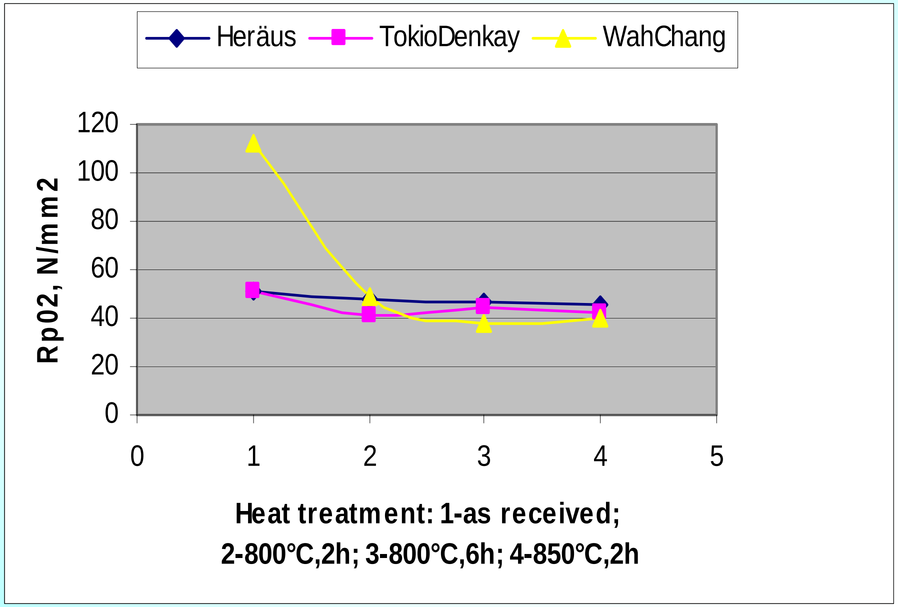


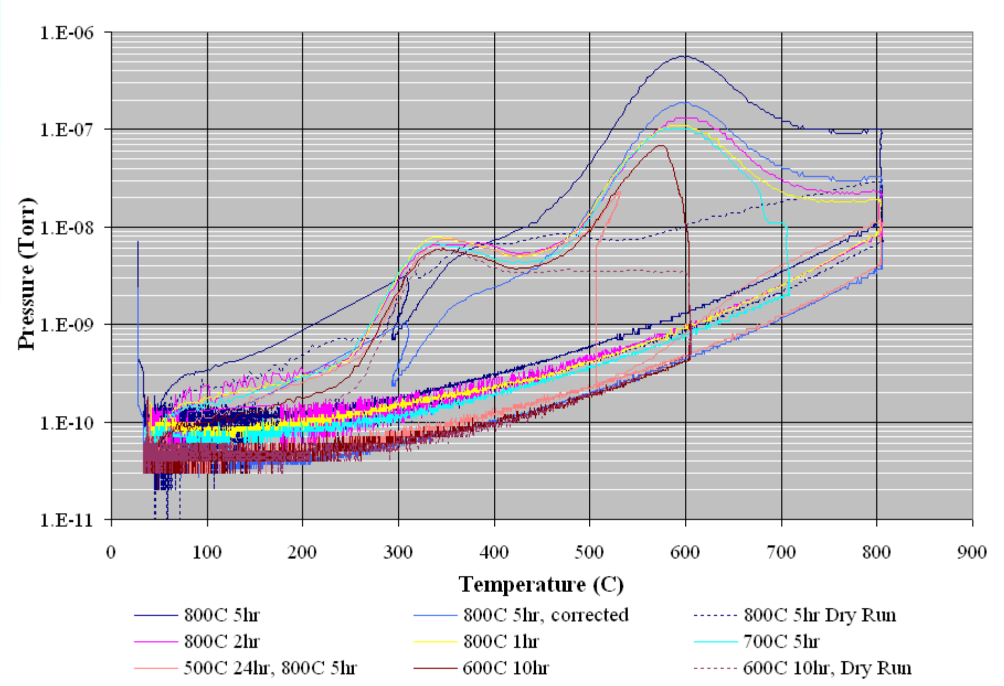
SNS cavity field profile



What is the difference in behavior of Nb from different companies?

Tensile test with small strain rate 10^{-6} s^{-1}. Wah Chang niobium (G. Rao, Jlab)





Small change of Yield Strength even after annealing at 850°C (DESY)

Hydrogen partial pressure versus annealing temperature (FNAL)

Comparing the hydrogen partial pressures indicates more hydrogen depletion at 800C°, five hours than at 600°C, ten hours.

Preliminary conclusion: no heavy reasons to change the TTF cavity annealing parameters (800°C, 2h)

Fabrication of cavity from bimetallic bonded NbCu tube by seamless technique (hydroforming).

DESY* - KEK collaboration

* DESY works in the frame of CARE program

Advantages

- cost effective: allows saving a lot of Nb (ca. 4 mm cavity wall has only ca. 1 mm of Nb and 3 mm Cu). Especially significant for large projects like ILC

- bulk Nb microstructure and properties (the competing sputtering technique does not have such advantages)

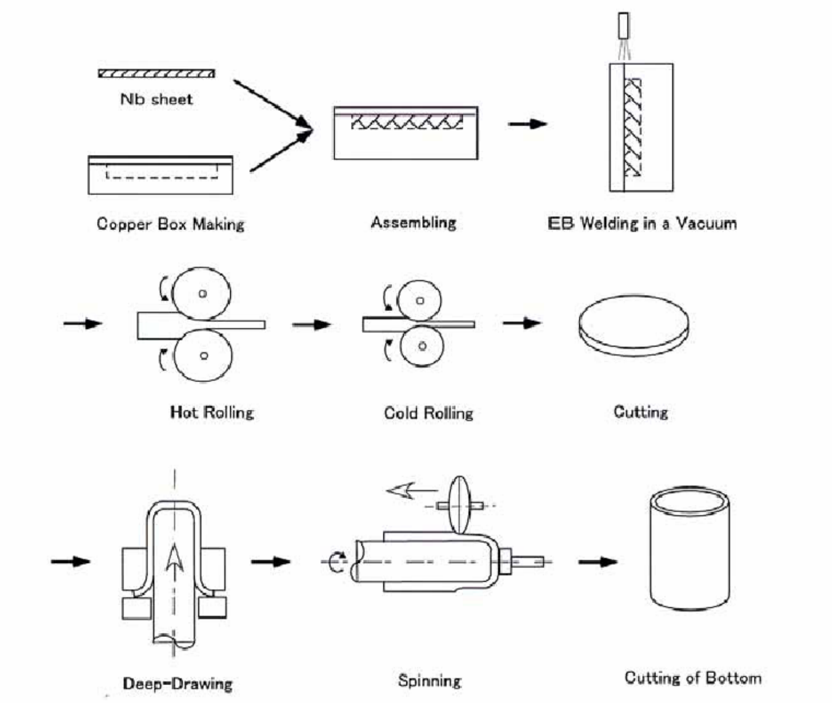
- the treatment of the bulk Nb BCP, EP, annealing at 800°C, bake out at 150°C, HPR, HPP can be applied (excluding only post purification at 1400°C).

- high thermal conductivity of Cu helps for thermal stabilization

- stiffening against Lorentz - force detuning and microphonics can be easily done by increasing of the thickness of Cu layer.

- fabrication by seamless technique allows elimination of the critical for the performance welds especially on equator

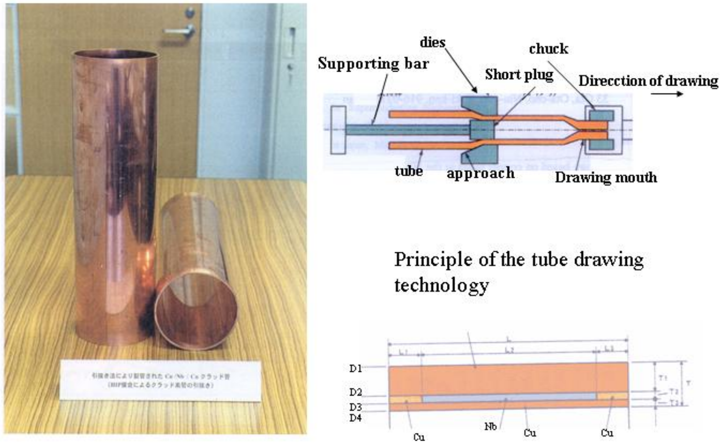
KEK: Fabrication of hot bonded NbCu tubes



Fabrication principle of sandwiched hot rolled Cu-Nb-Cu tube (KEK and Nippon Steel Co.)

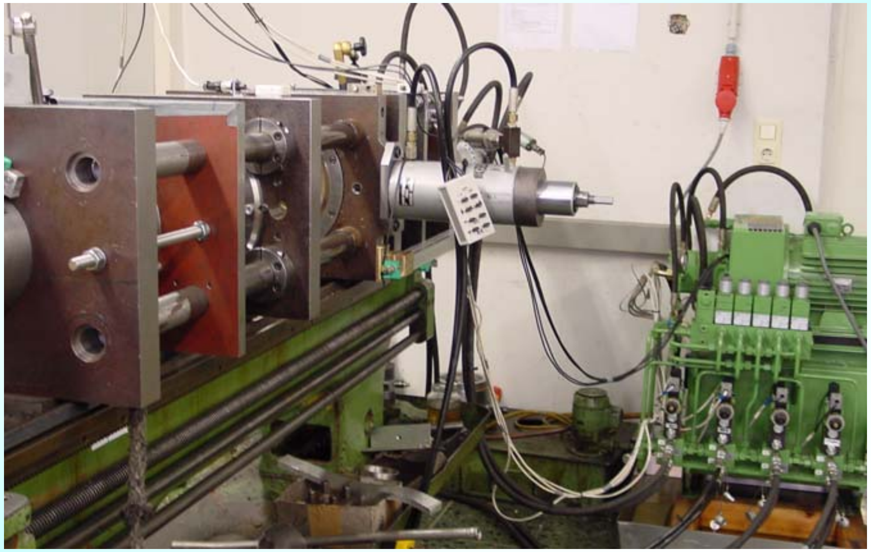
Hot roll bonded Cu-Nb-Cu tube
Nippon Steel Co. and KEK

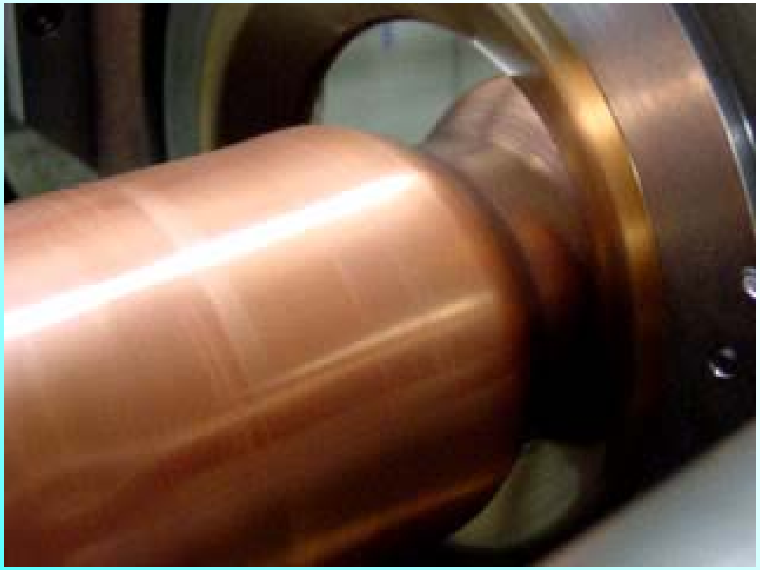
Fabrication principle of sandwiched coextruded Cu-Nb-Cu tube (KEK)



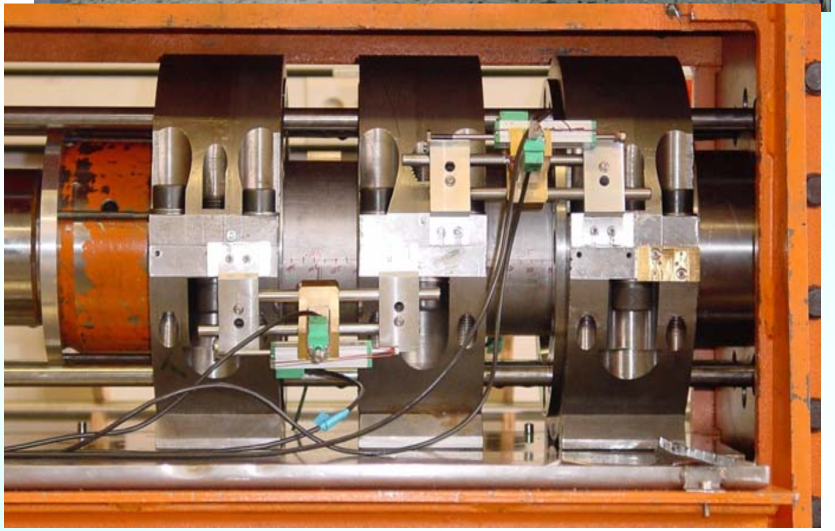
Cu-Nb-Cu Sandwiched Tubes (KEK)

DESY: Fabrication of NbCu clad cavities





DESY Necking machine: new PC controlled necking procedure



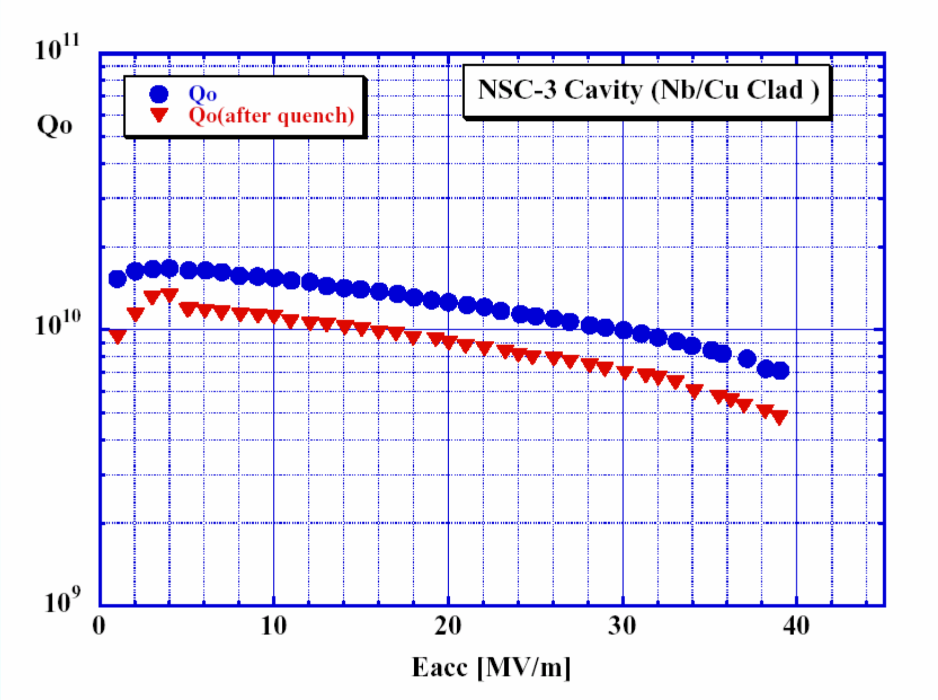
DESY PC controlled hydroforming machine

Single cell NbCu cavities produced at DESY by hydroforming from KEK sandwiched tube.

Next step : Fabrication of multicell NbCu clad cavities

One NbCu sandwiched cavity was tested NSC-3.

Hot roll bonded tube fabrication at Nippon Steel Co., hydroforming at DESY, Preparation and RF tests at KEK



NSC-3: Barrel polishing, CP(10microns), Annealing 750^{o}C x 3h, EP(70microns) by K.Saito

4 NbCu clad tube of KEK

Tubes after reduction
in the iris areas

First 2 cell NbCu clad cavities recently produced at DESY from first two KEK tubes
(two another tubes are currently in work)

The End