SC Cavities
From Prototype to Series Fabrication

W. Singer

1. Conventional cavity fabrication (deep drawing+EB welding).

- Fabrication procedure
- Documentation

2. Not conventional cavity fabrication

- Cavity from ingot with very large grain
- NbCu clad cavities

Prototype (TTF)

↓

Small series (XFEL)

Main last activities at DESY are dedicated to preparation for XFEL

↓

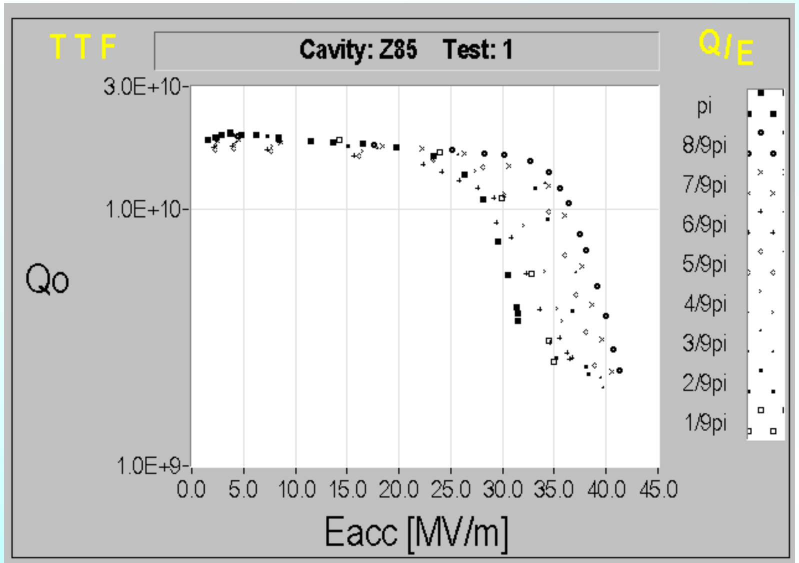
Large series (ILC)

Current fabrication of 30 TTF cavities at ZANON

Fabrication procedure

- fabrication of dumb bells and end groups
- assembling of all parts by special tool
- tacking
- disassembling
- completing

- Fabrication procedure of ZANON could be a good basis for cavity series production.
- Recently verified that Eacc>35 MV/m can be reached



mode / cell	pi	8/9pi	7/9pi	6/9pi	5/9pi	4/9pi	3/9pi	2/9pi	1/9pi
1&9	31.46	41.28	38.10	36.76	29.84	23.32	19.88	13.30	6.07
2&8	31.46	36.30	20.27	0.00	19.48	31.42	39.75	33.67	17.48
3&7	31.46	26.94	7.04	36.76	36.61	12.41	19.88	38.28	26.78
4&6	31.46	14.33	31.06	36.76	6.76	35.73	19.88	24.99	32.85
5	31.46	0.00	40.55	0.00	38.96	0.00	39.75	0.00	34.96
Limit:	PWR	PWR	PWR	PWR	PWR	BD	PWR	PWR	PWR

Critical aspect:

Example: current dumb-bell fabrication

1. Mechanical and Visual Checks,
2. Check of frequency,
3. Calculation of 1.trimming,
4. “1.trimming“
5. Mechanical and Visual Checks,
6. Check of frequency,

7. Decision :

- “accepted to use for a cavity“ or
- “2.trimming necessary“ or

➔ **If decision „Accepted to use for a cavity !**

7. Calculation of position in cavity and prognoses of cavity length and frequency after welding,

➔ **If decison “2.trimming necessary” !**

8. Calculation of 2.trimming,
9. “2.trimming“
10. Mechanical and Visual Checks,
11. Check of frequency,

12. Decision :

- “accepted to use for a cavity“ or
- “3.trimming necessary“ or

➔ **If decision „Accepted to use for a cavity !** (see 7).

➔ **If decision “3.trimming necessary” !**

13. Calculation of 3.trimming,
14. “2.trimming“
15. Mechanical and Visual Checks,
16. Check of frequency

17. Decision :

- “accepted to use for a cavity“ oder
- “Bad quality, don’t use this dumb-bell for a cavity“

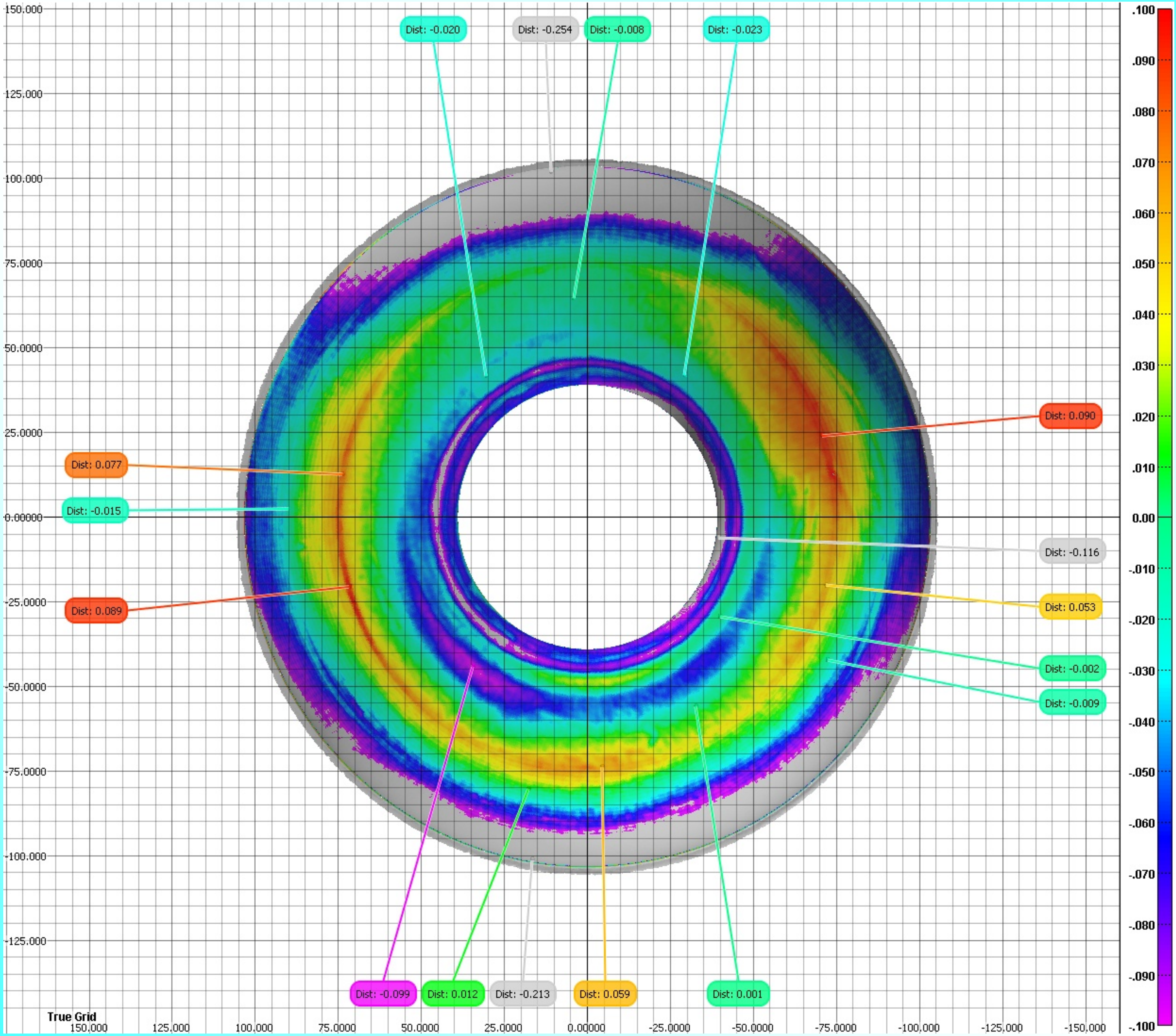
➔ **If Decision „Accepted to use for a cavity !** (see 7.)

For series production the “frequency measurement - trimming” steps have to be avoided. Cost estimation for TESLA cavity fabrication did not consider these steps

At the moment not possible meet both (frequency and cavity length) without “frequency measurement - trimming” .

Important:

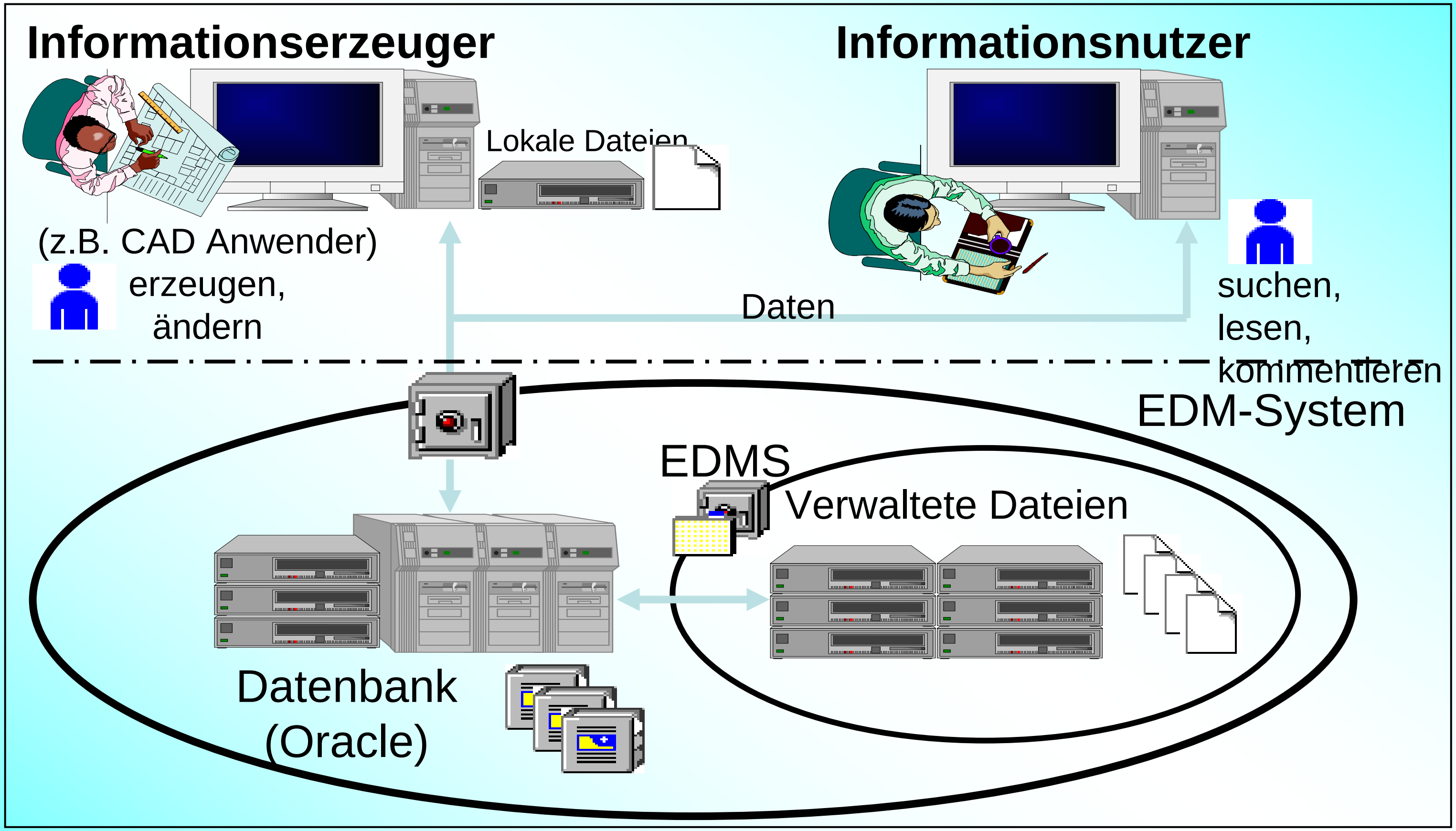
Improve the deep drawing quality of half cells (shape accuracy)



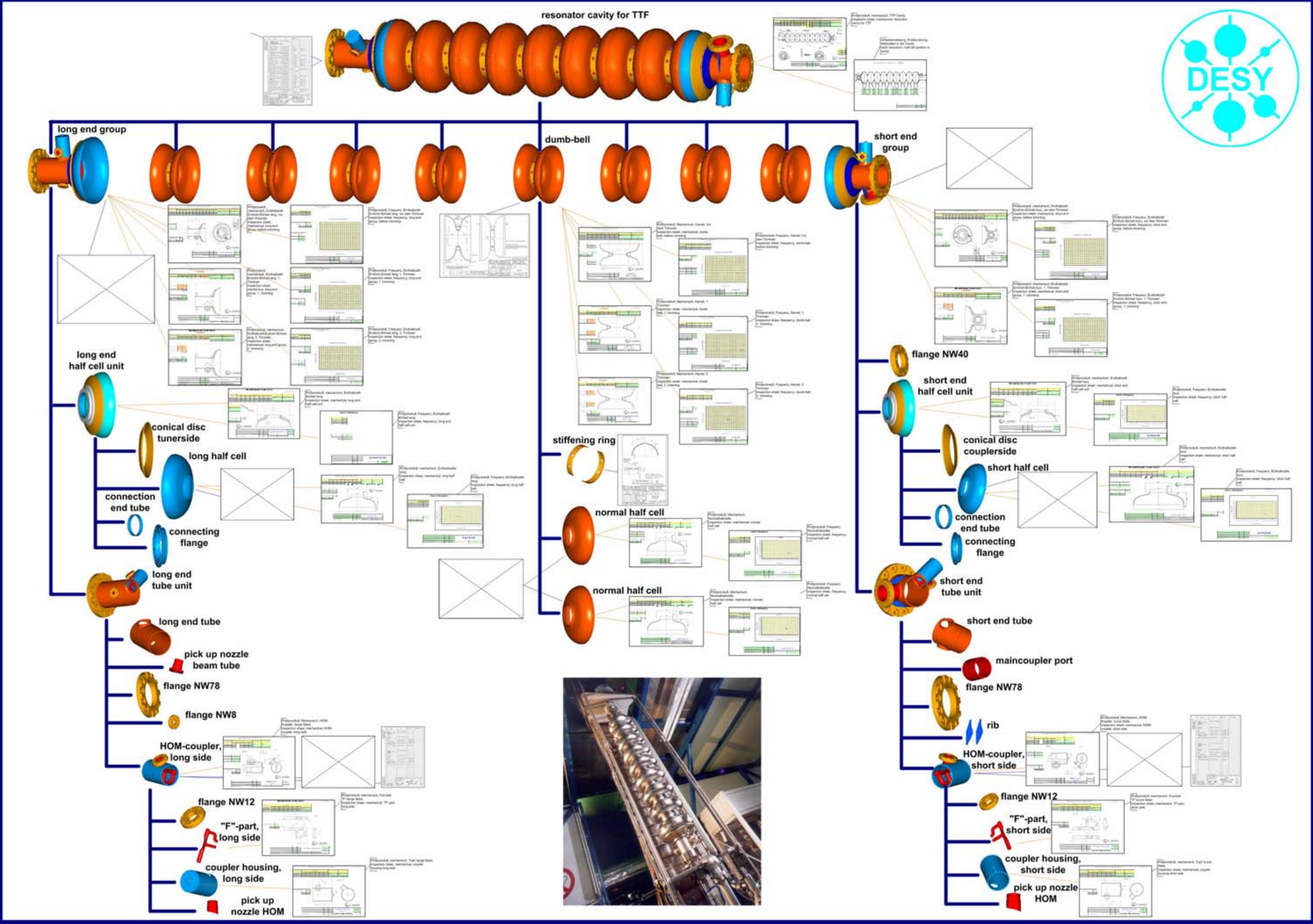
Instead shape correction by trimming improve the shape accuracy

Optical 3D measurement of the deep drawn TTF half cell

Documentation: Engineering Data Management System



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

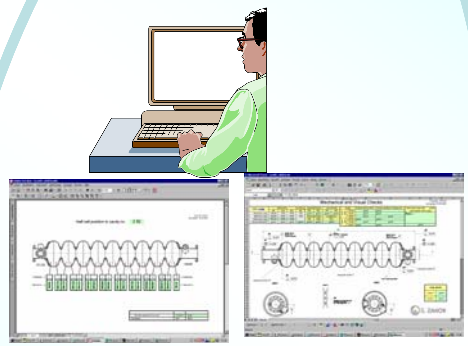


Application of EDMS for cavity fabrication

Involvement of cavity producer

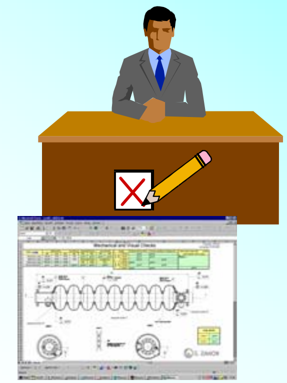
- create the work description (in EDMS).
- create the protocol template (in EDMS).
- message to Zanon.

Zanon



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

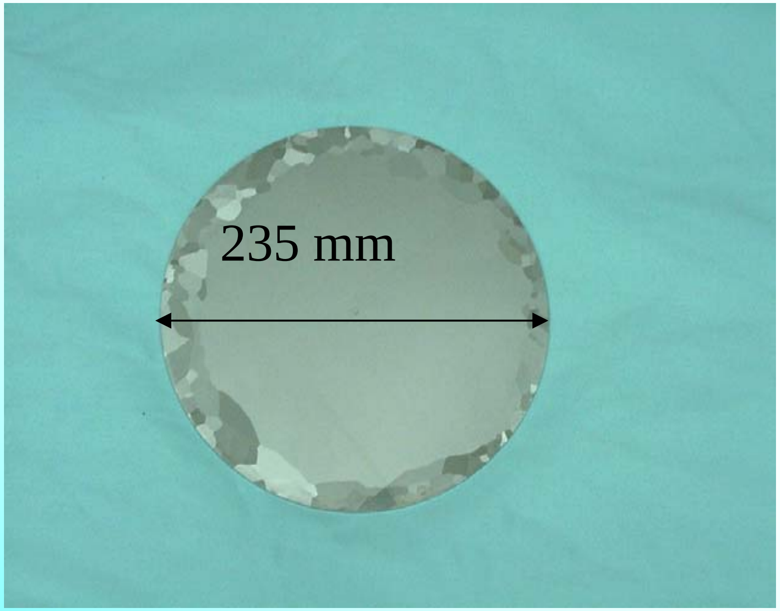
DESY



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

Cavity from ingot with very large grain

Special task to melt an ingot with very large grain and large diameter.



Disc from CBMM ingot,
P. Kneisel

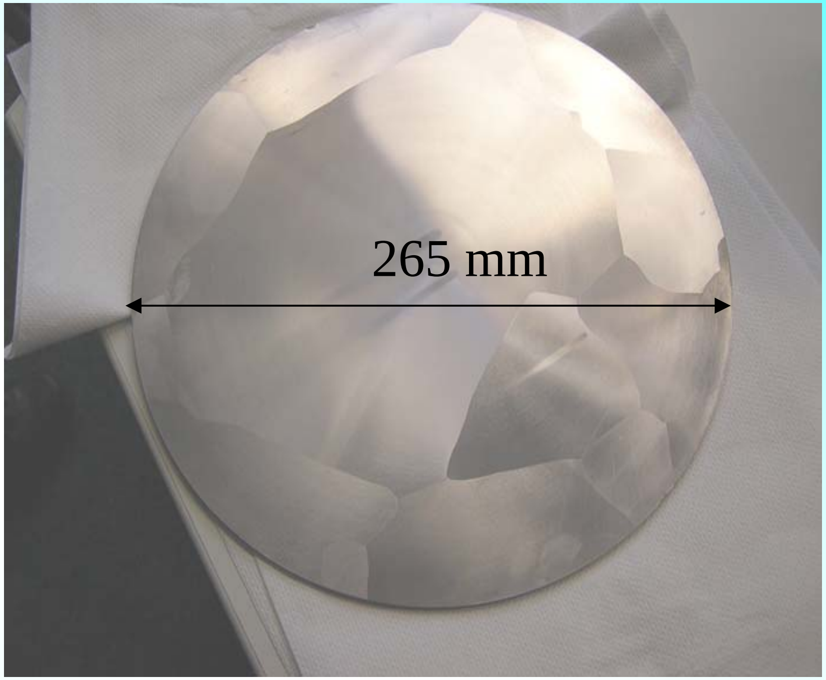
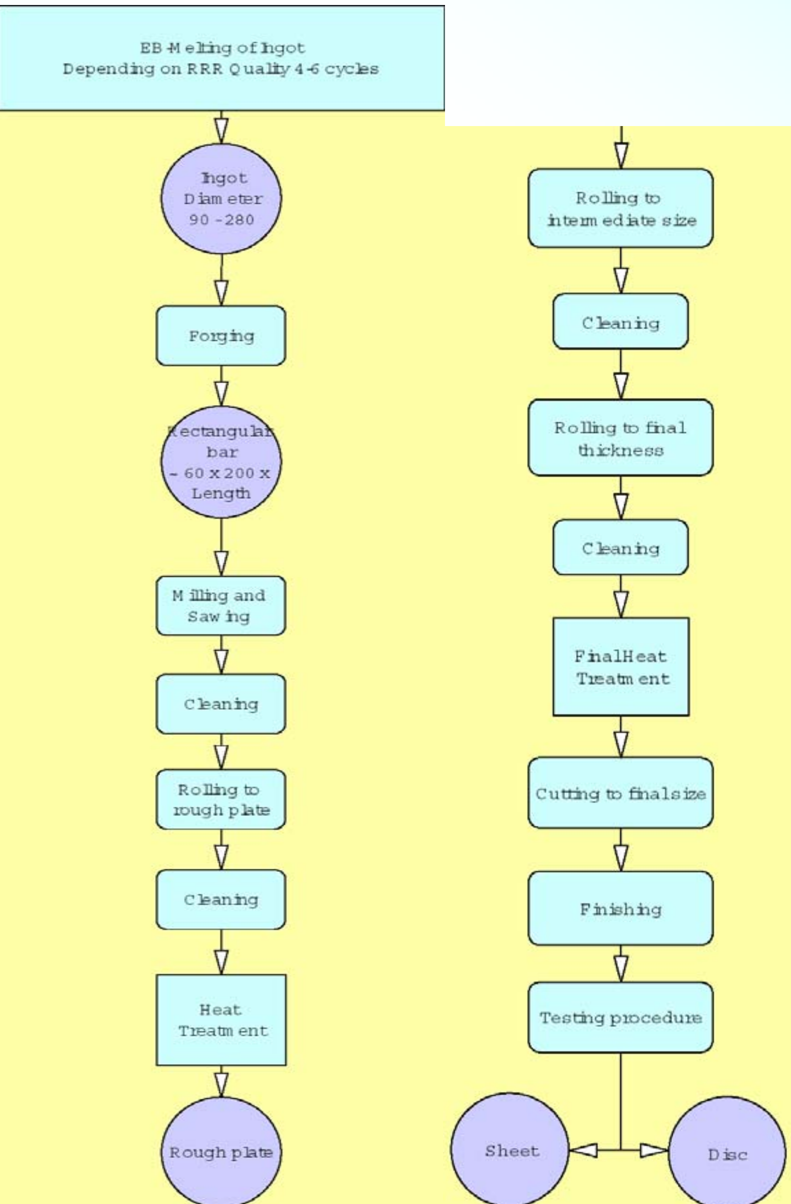


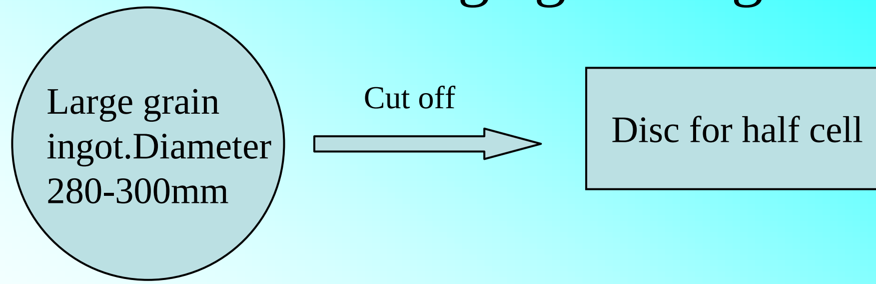
Image of the disc from new HERAEUS ingot

Melting of the large grain ingot with diameter sufficient for TESLA shape cavity seems not to be a problem

Steps of conventional sheet fabrication



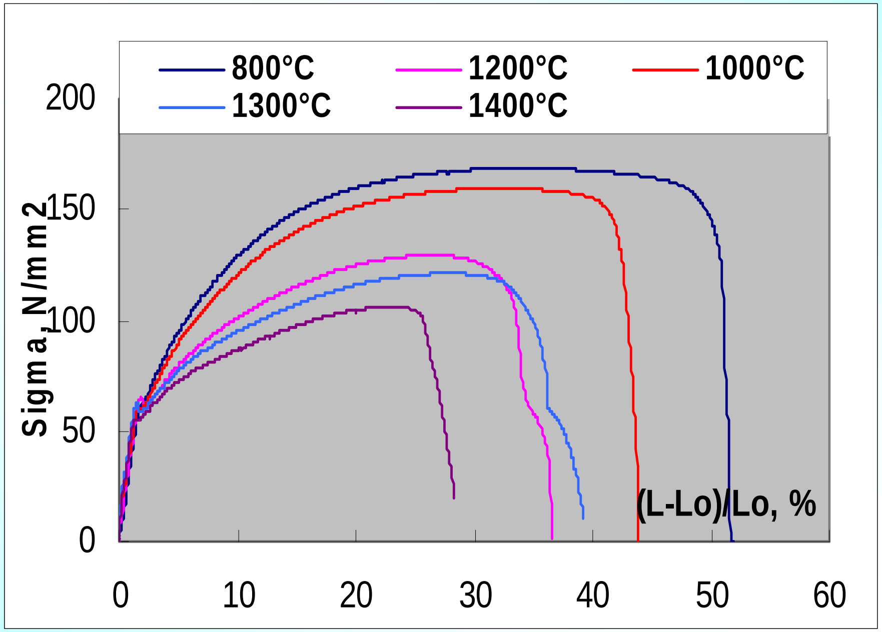
Discs from large grain ingot



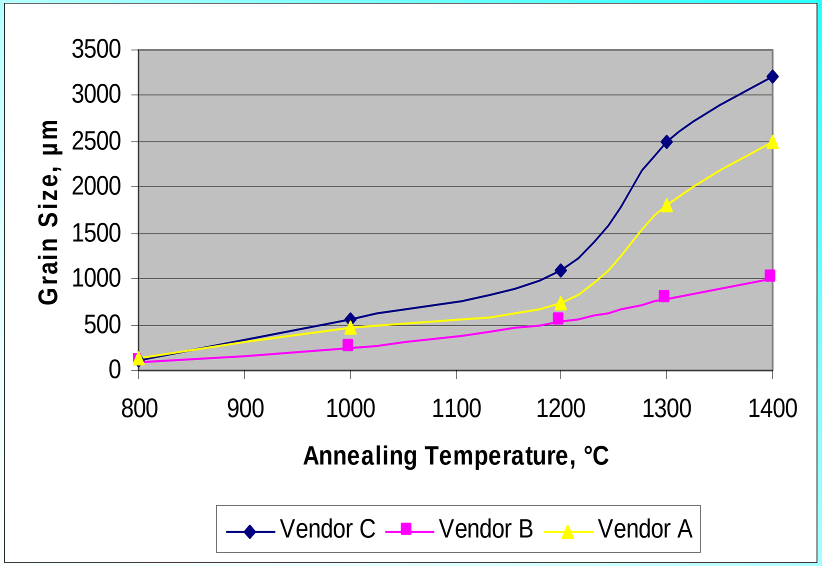
Possible advantages:

- Seems to be cost effective
- More uniform properties for deep drawing
- Better purity. RRR=600 in the ingot is achievable
- Simplified quality control (reduced number of measurements: grain size, mech. prop. etc, possibly no scanning)
- Simplified treatment: possibly BCP instead of EP

Remaining question: How cut slides cost effective (keeping the tolerances +/- 0,1 mm and producing smooth surface) ??



Strain-stress curves of Nb after annealing

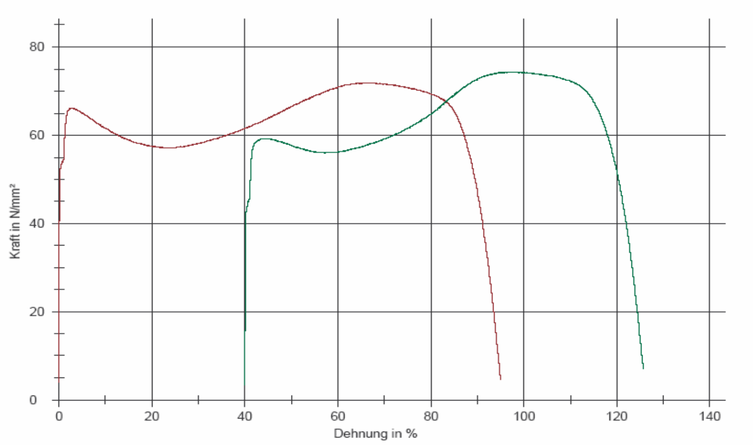


Grain size versus annealing temperature

Ergebnisse:

Nr	Probe	b0 mm	a0 mm	Rp 0.2 N/mm²	Rm N/mm²	A 30mm %
1	Mitte Ingotscheibe	7,95	2,56	52,6	71,9	95,0
2	radial am Rand Ingotscheibe	8,15	2,88	43,0	74,3	85,7

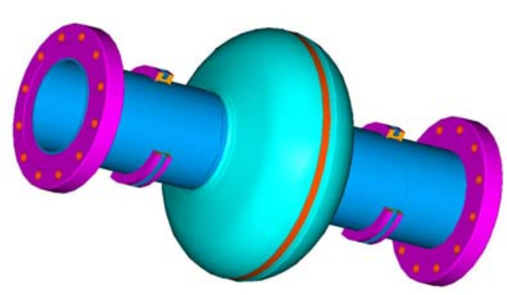
Seriengrafik:



Strain-stress curves of large grain Nb (Heraeus)

Specific behavior of the discs from large grain Nb ingot should be understood:

- High elongation at break
- Grain boundaries
- Texture



Single cell cavity R&D at DESY

DESY EB welding device

1. Cavity from ingot with very large grain

2. 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)

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

- Check the eight hours rule etc.

4. Rework the Nb specification:

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

Fabrication of cavity from bimetallic bonded NbCu tube by hydroforming technique (DESY*, KEK, INR, JLab).

Seamless technique is not foreseen for XFEL, but it could be an interesting option for ILC

* 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)

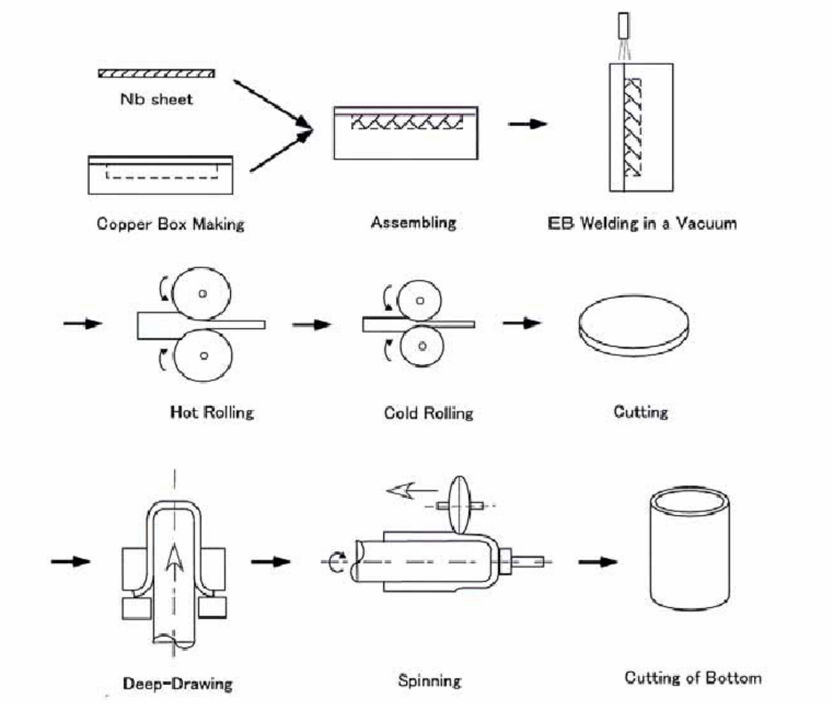
• the treatment of the bulk Nb BCP, EP, annealing at 800°C, bake out at 150°C, HPR, HPP can be applied (excluding only post purification at 1400°C).

• 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

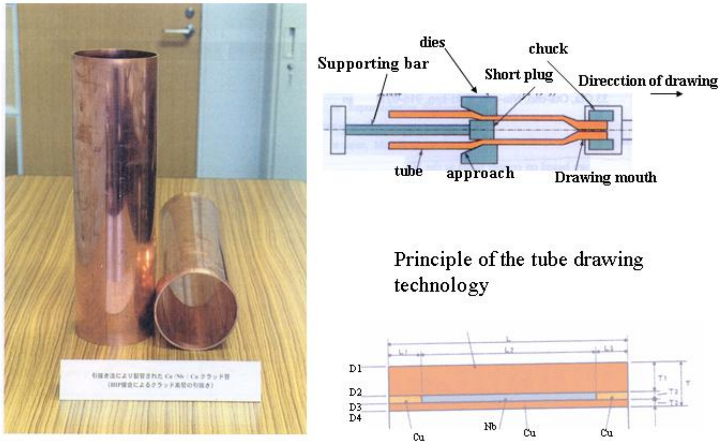
KEK: Fabrication of hot bonded NbCu tubes



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

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

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



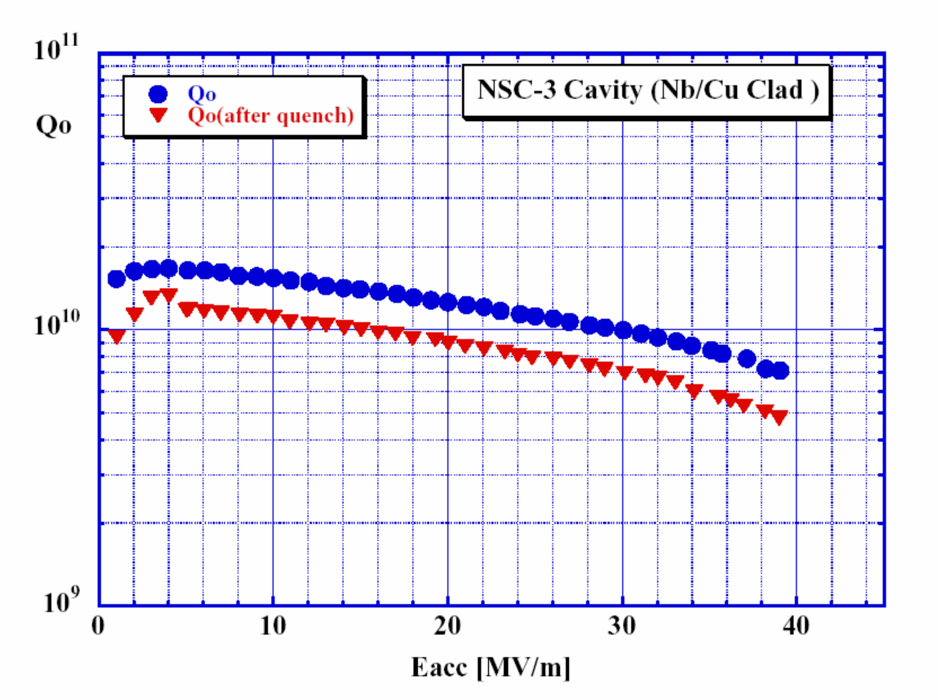
Cu-Nb-Cu Sandwiched Tubes (KEK)

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

Next step : Fabrication of multicell NbCu clad cavities

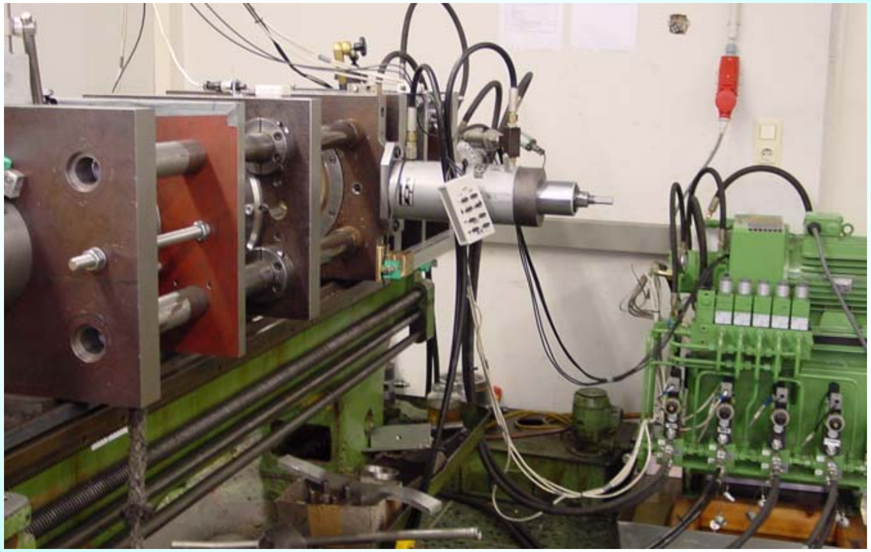
One NbCu sandwiched cavity was tested NSC-3.

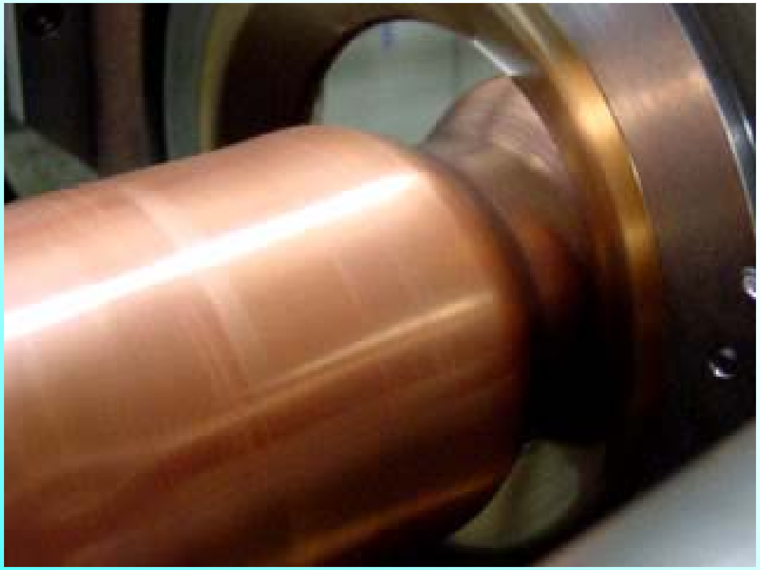
Hot roll bonded tube fabrication at Nippon Steel Co., hydroforming at DESY, Preparation and RF tests at KEK



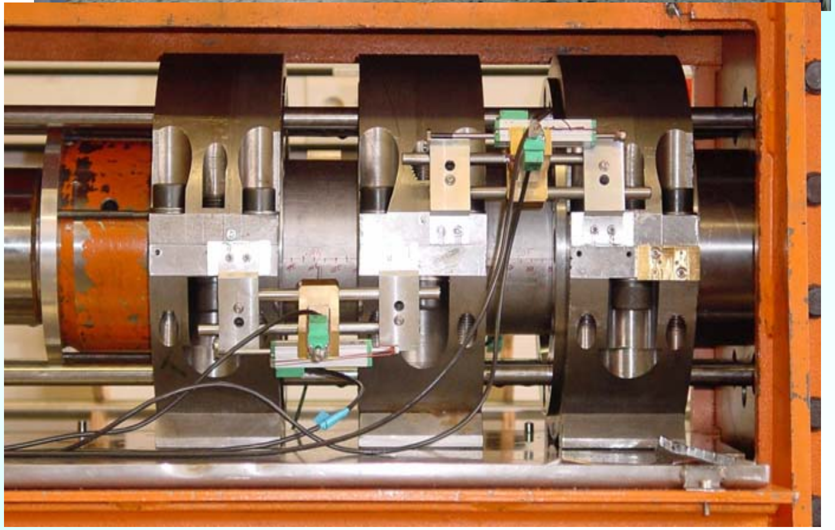
NSC-3: Barrel polishing, CP(10microns), Annealing 750^{o}C x 3h, EP(70microns) by K.Saito

DESY: Fabrication of NbCu clad cavities





DESY Necking machine: new PC controlled necking procedure



DESY PC controlled hydroforming machine

4 NbCu clad tube of KEK

Tubes after reduction in the iris areas

First four 2-cell NbCu clad cavities recently produced at DESY from four KEK tubes

Conclusive remarks

- Further optimization of the conventional cavity fabrication procedure are necessary for mass fabrication
- Using of EDMS like support for cavity muss production will be unavoidable
- Cavity from large grain is a new interesting option and should be precisely investigated
- Seamless technique gives to bimetallic NbCu cavities new chance. The accelerating gradient of bonded NbCu cavities is similar to bulk Nb cavities.
- Proof of principles for seamless fabrication is done on level of laboratory equipment; main task is industrialization