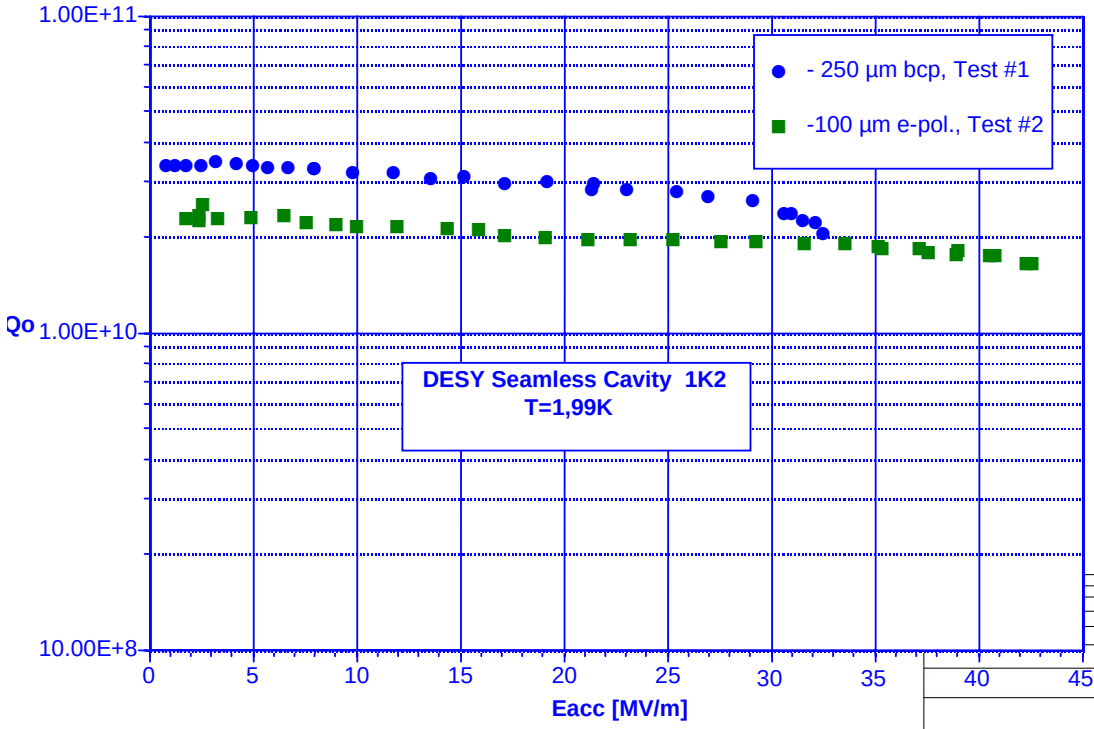
Progress in Seamless RF Cavities

Activities of DESY, INR, INFN, KEK, JLab, MSU, Black Laboratories

Presented by W. Singer
DESY

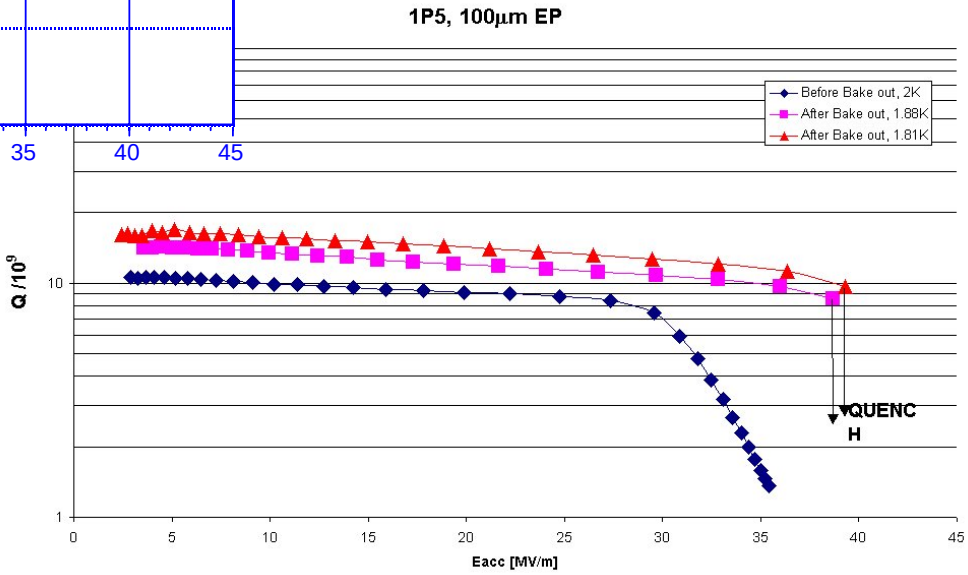
Hydroforming, Spinning

Proof of principle is done



The best Q(Eacc) result of by hydroforming produced single cell cavity

The best Q(Eacc) result of by spinning produced single cell cavity



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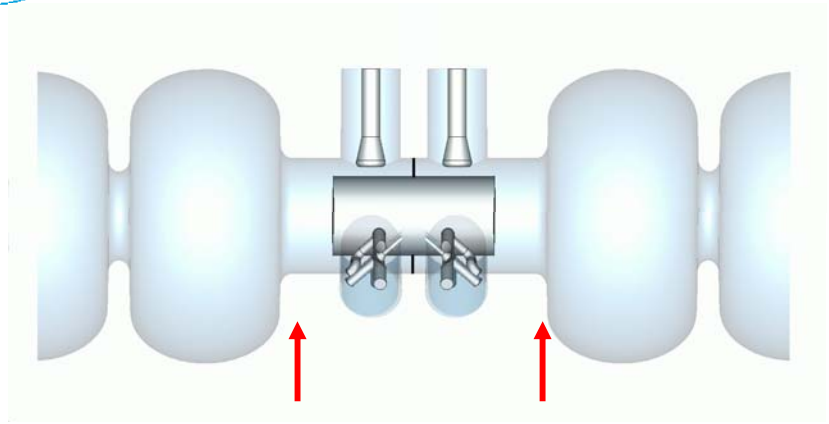
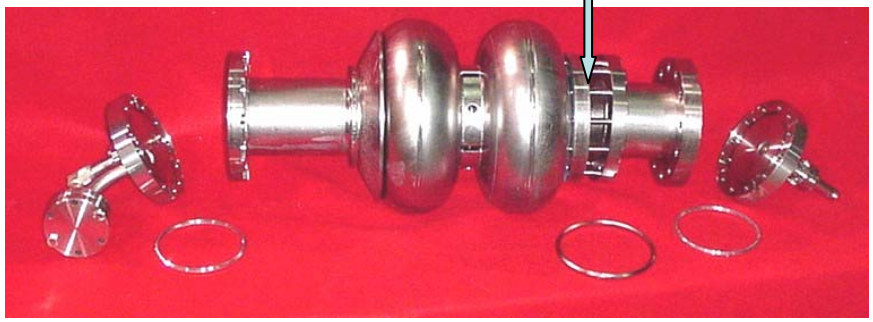
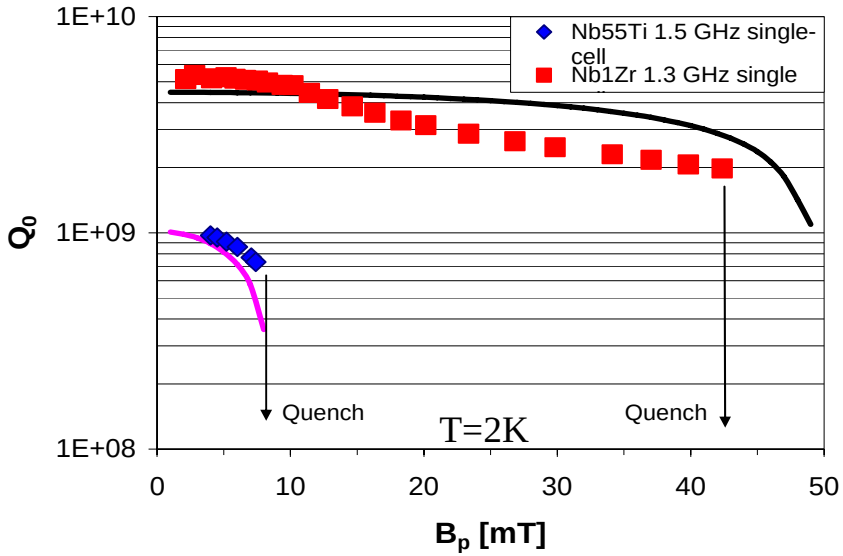
Progress in superconducting joints is beneficial for the seamless option



Superconducting Joints





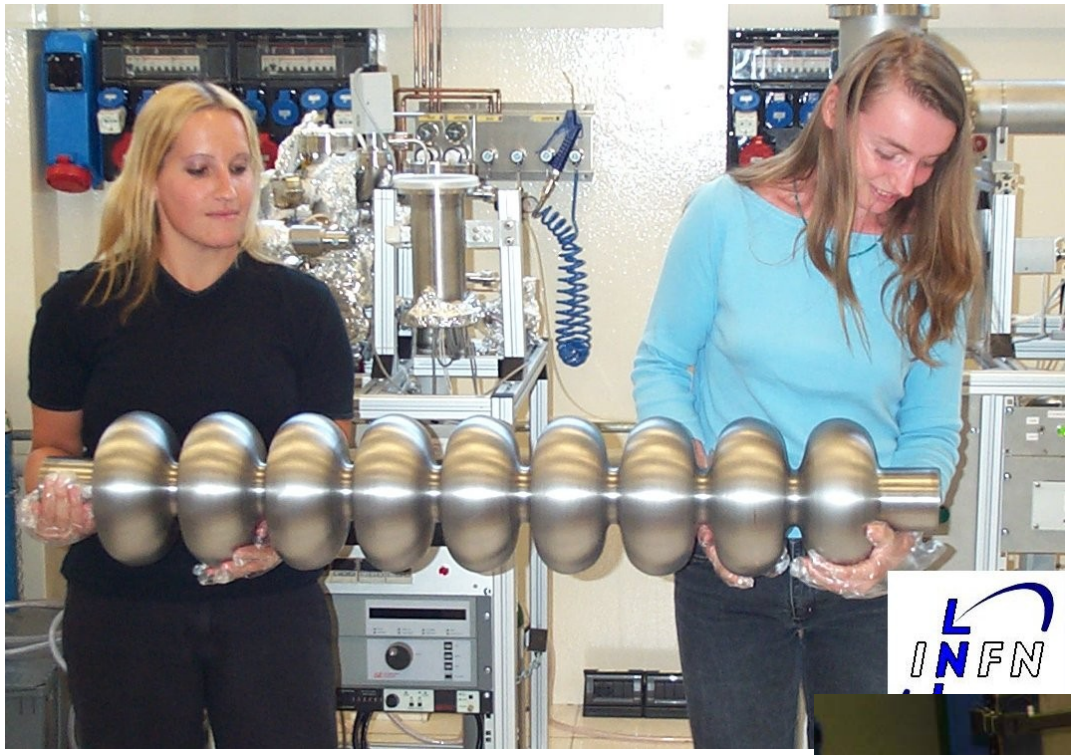
NbZr – cavity quenched at 42 mT, a sufficiently high enough magnetic field for a superconducting joint configuration

Make possible produce the cavities consisting of a rotationally symmetric cells part (by applying “seamless” fabrication technologies) and asymmetric end groups

DEVELOPMENT OF A SUPERCONDUCTING CONNECTION FOR NIOBIUM CAVITIES. P. Kneisel, G. Ciovati, J. Sekutowicz, A. Matheisen, X. Singer and W. Singer. PAC 07 June, 25-29, 2007, USA (WEPMS062)

For more see P. Kneisel etc. Poster TUP56

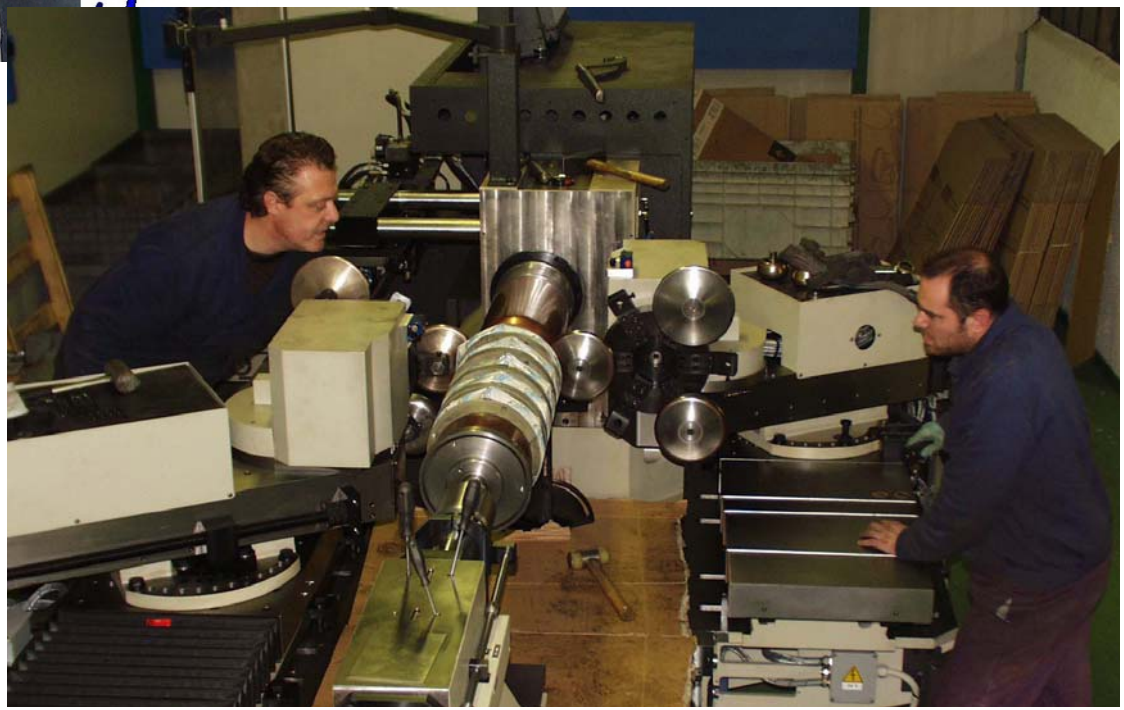
W. Singer. Seamless Cavities. 13th International Workshop on RF Superconductivity, October 15-19, 2007, Beijing, China

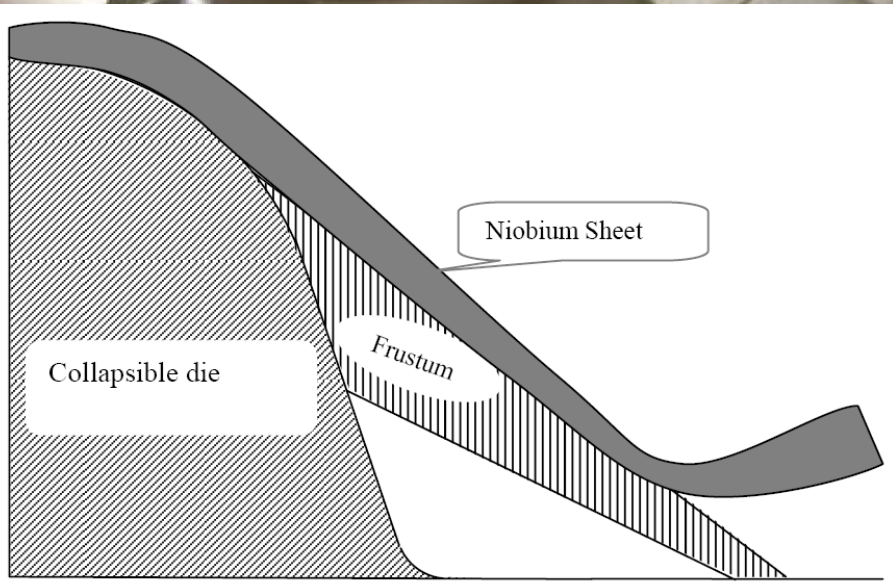


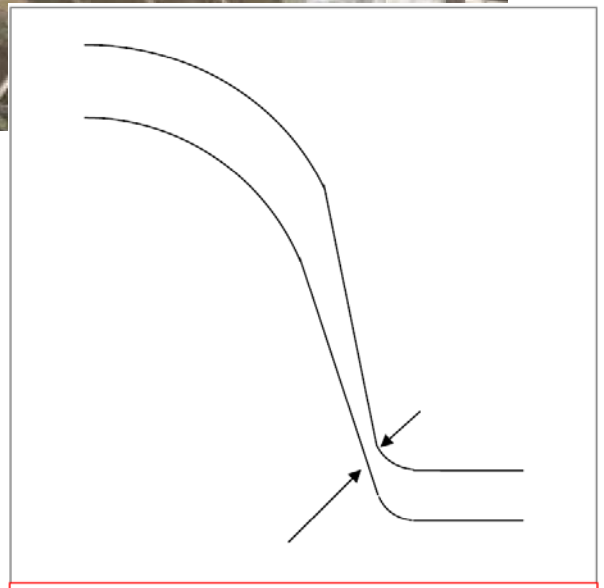
Spinning (V. Palmieri, INFN)

First spun 9-cell cavity

New spinning machine. The two spinning turrets (revolver heads) work one against each other.







The problem of excessive thinning at the terminal iris

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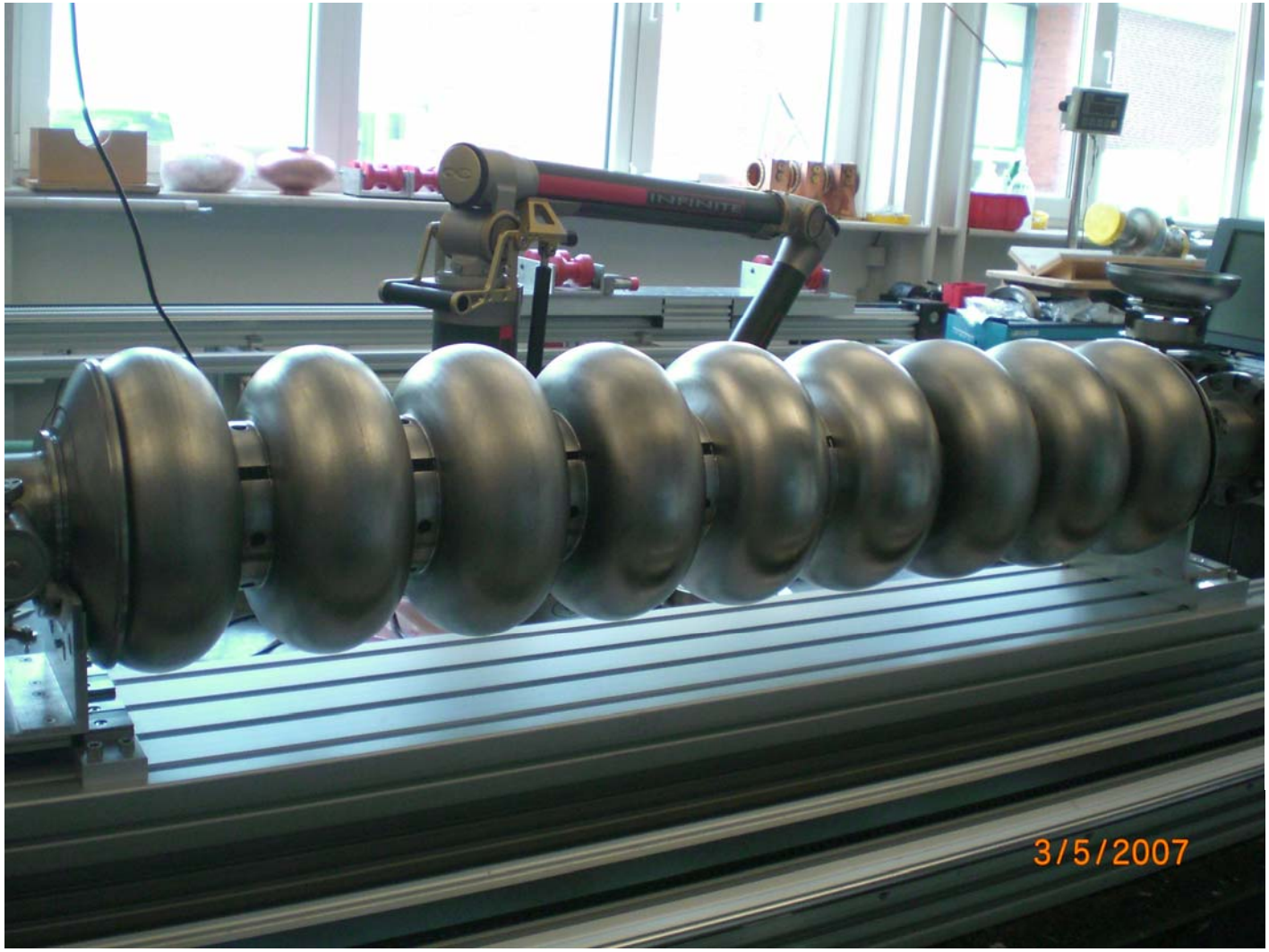
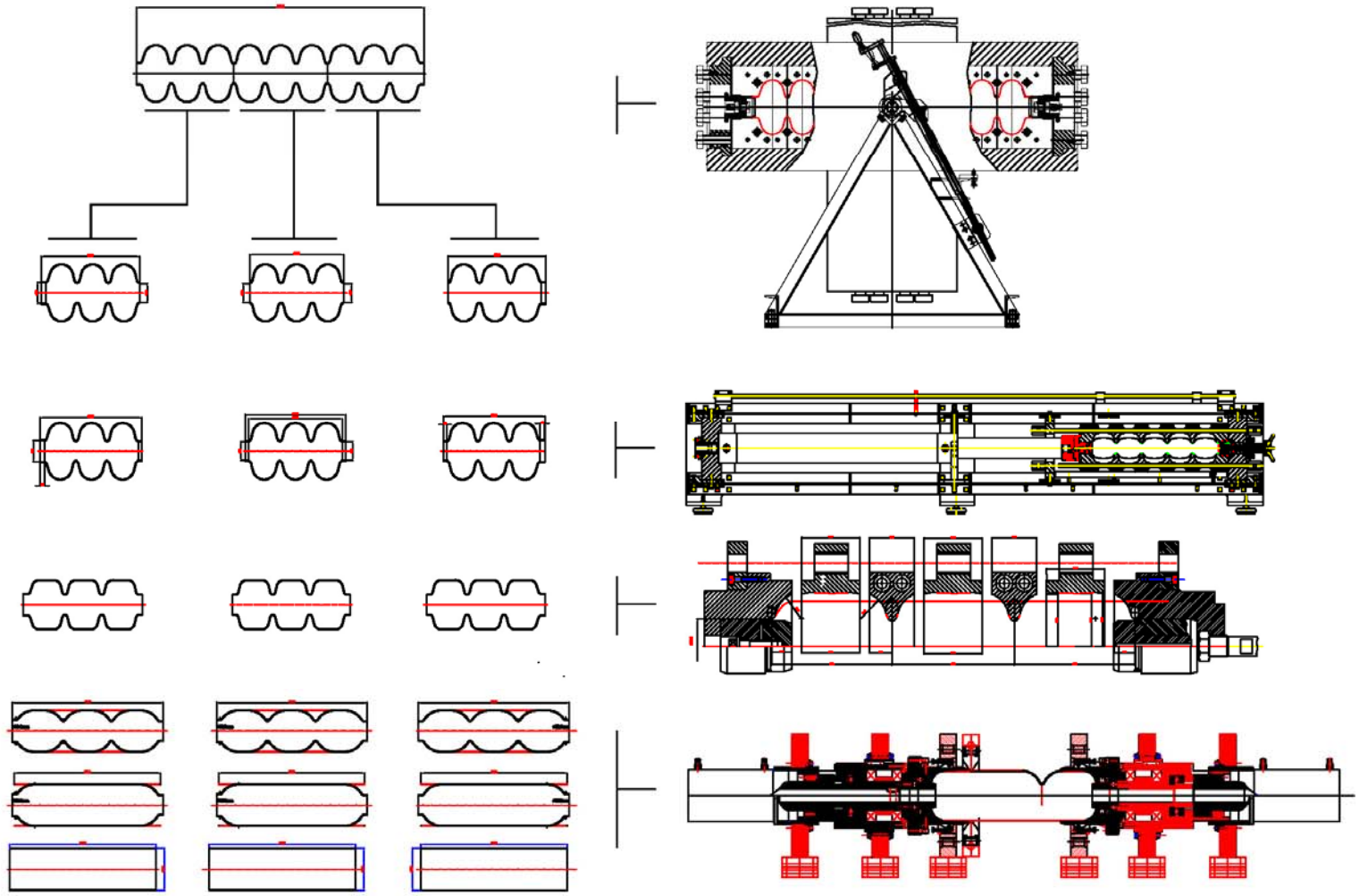
DESY: Z145: 9-cell as 3x3 cell cavity hydroformed. **Poster TUP52**

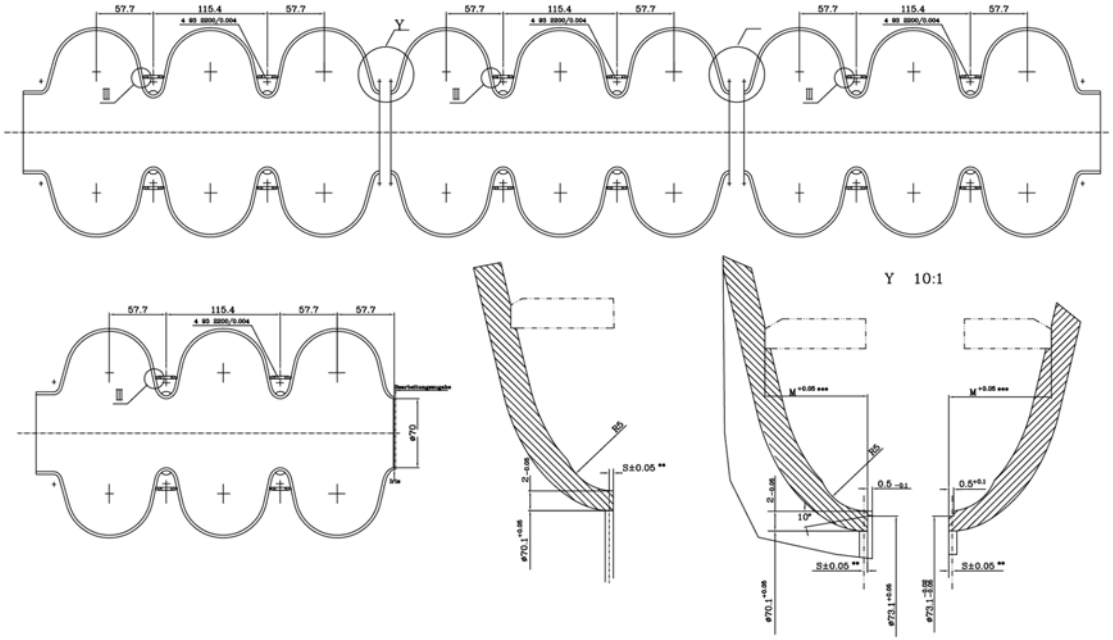


Work was supported by CARE

Fabrication steps of 9 cell cavity by hydroforming as option 3x3



The 9-cell hydroformed cavity was completed at E. ZANON

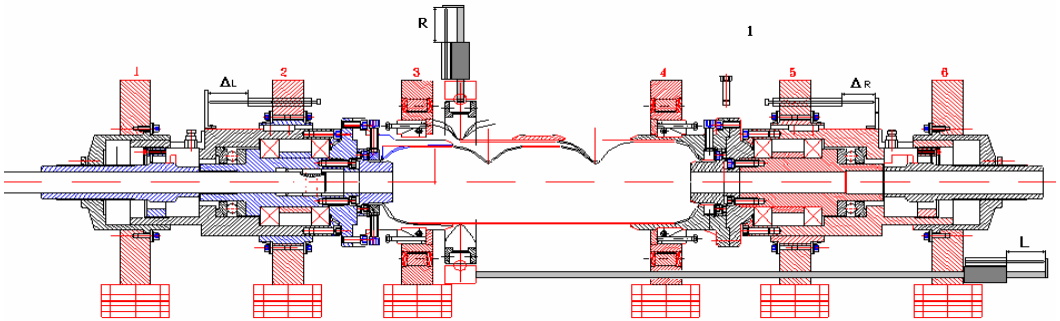


Fabrication included following steps:

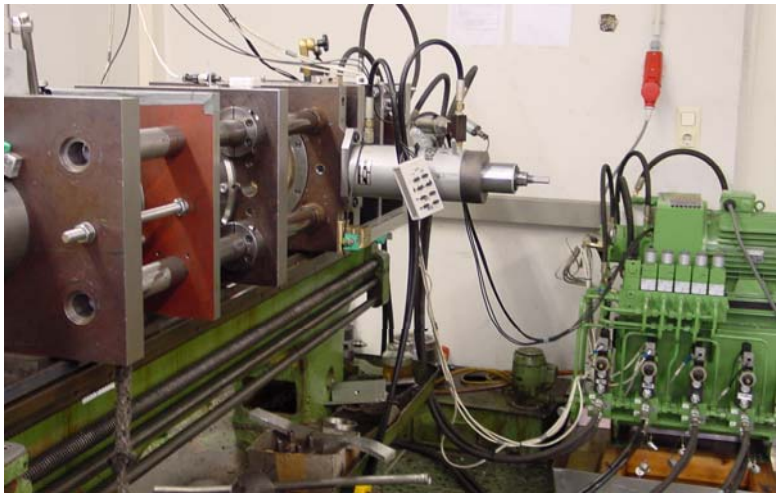
- Fabrication of the long and short end groups connected with three cell units
- Machining, preparation and welding of three units together in a 9 cell cavity (two iris welds done from outside)
- Machining, preparation and weld on of the stiffening rings

The cavity in in preparation for the RF test at DESY

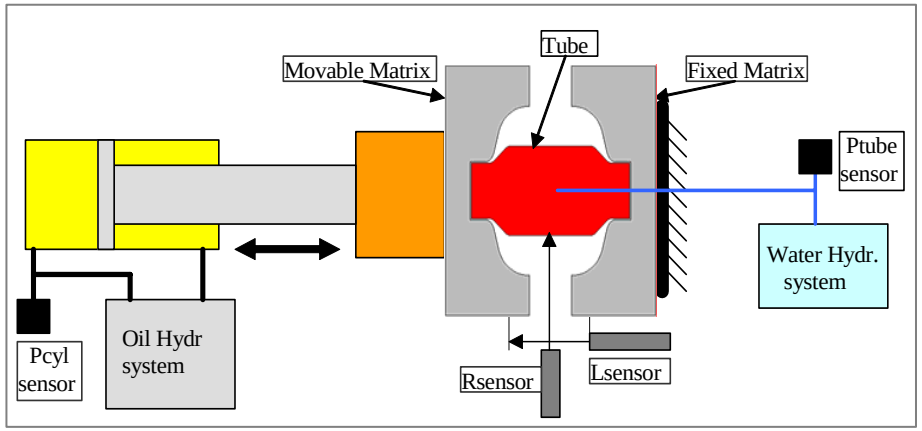
Seamless technique by hydroforming



Principle of tube diameter reduction in the iris area (necking)



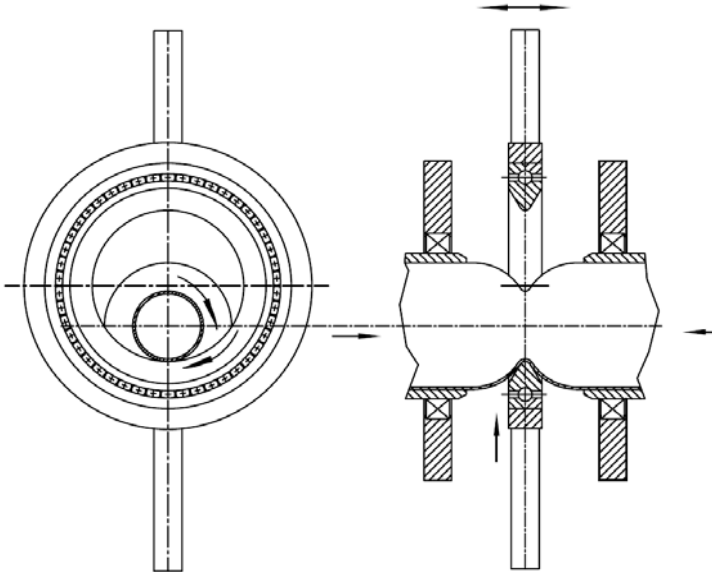
Necking equipment



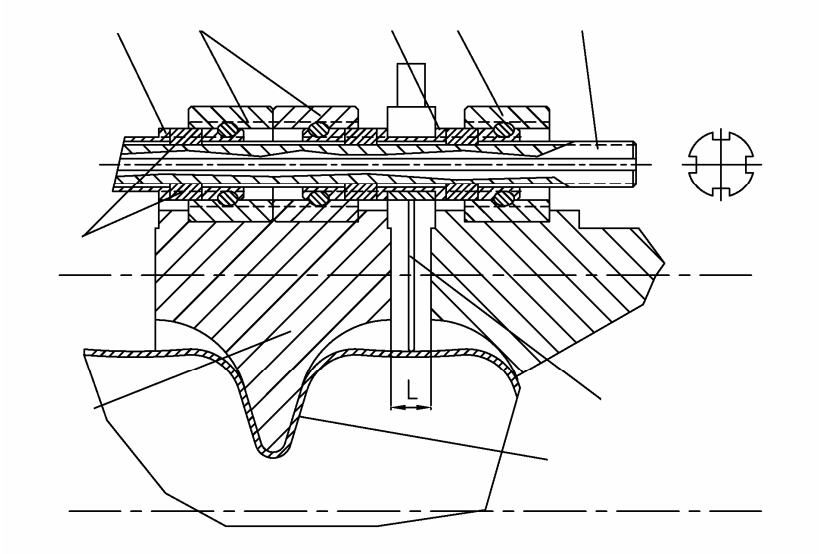
Principle of hydroforming

Hydroforming machine HYDROFORMA

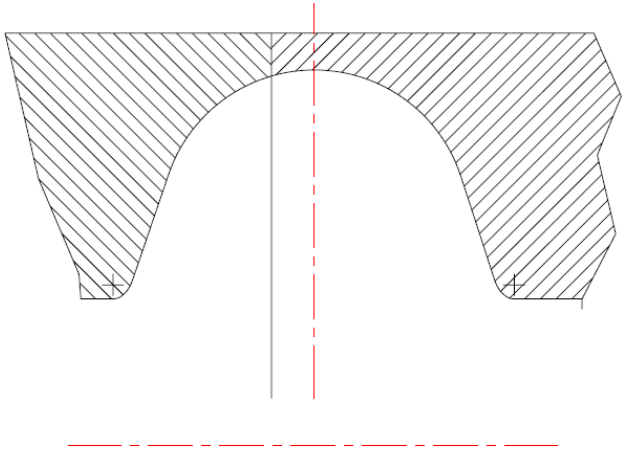
Some key ideas that have been decisive for hydroforming success



Principle of diameter reduction in the tube end and in the tube middle

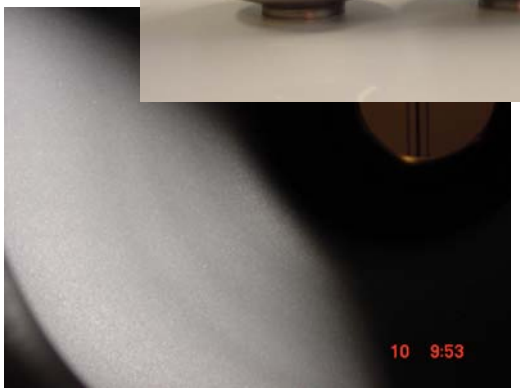


Synchronization mechanism for the final step of hydroforming



Nonsymmetrical mould for hydroforming

Second hydroformed 9-cell cavity



Inside surface after CBP

Three cell units for second cavity are in work on CBP at DESY.
FNAL would like to work with that cavity after it completing

Barrel polishing, 800° C annealing, EP (KEK recipe) seams to be a most appropriate treatment for seamless cavities

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DESY-KEK

Fabrication of NbCu clad cavities

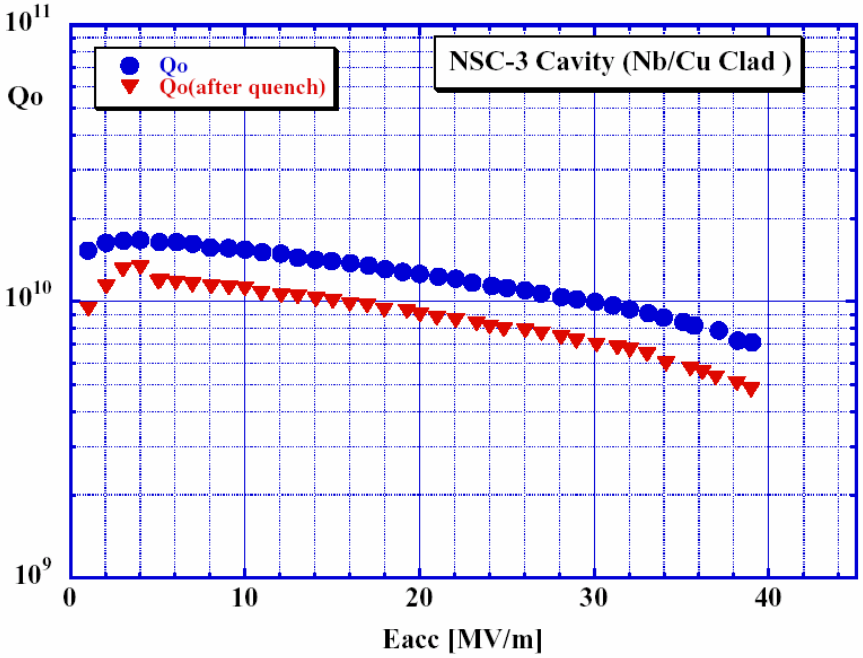
Single cell NbCu cavities produced earlier at DESY by hydroforming from KEK sandwiched tube.

Four double cell NbCu clad cavities produced at DESY from KEK tubes

(no cracks on the inside surface)

One NbCu sandwiched cavity was tested NSC-3.

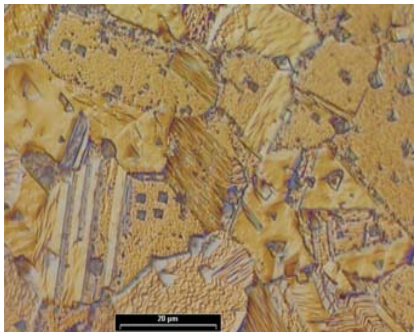
Hot roll bonded tube fabrication at Nippon Steel Co., hydroforming at DESY, Preparation and RF tests at KEK



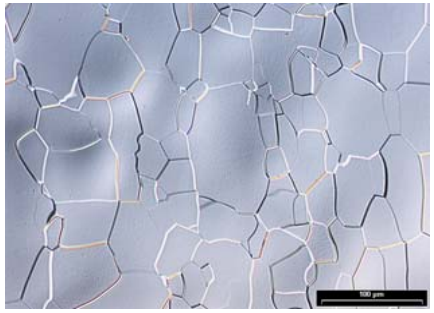
NSC-3: Barrel polishing, CP(10 mμ), Annealing 750°C x 3h, EP(70 μm) K.Saito

Up to now only sandwiched tube. Cu layer on both sides prevent creating of cracks in Nb; removing of inside Cu layer after forming chemically (costly)

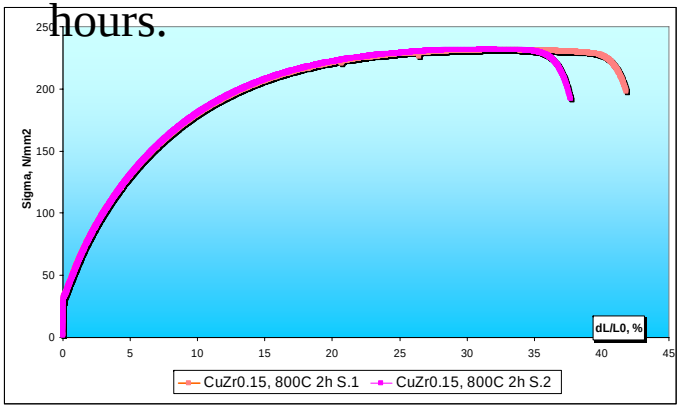
DESY proposal: Using special Cu with high recrystallization temperature



Microstructure of Cu0.15%Zr (left) and Nb (right) after annealing at 800° C for 2 hours.



Stress –strain behavior and thermal conductivity of Cu0,15%Zr after annealing at 800° C for 2 hours compared with Cu and Nb.



Thermal conductivity can be recovered by aging at ca. 400° C/one hour. Zr leaved the solid solution and creates precipitates Cu_5Zr finely distributed in Cu matrix

The Cu0.15%Zr shows a high elongation after annealing at 800° C, small and rather uniform grain and can be a good candidate for replacing of pure Cu in NbCu clad tubes

Cu only outside: Cu0.15%Zr special Cu with high recrystallization temperature

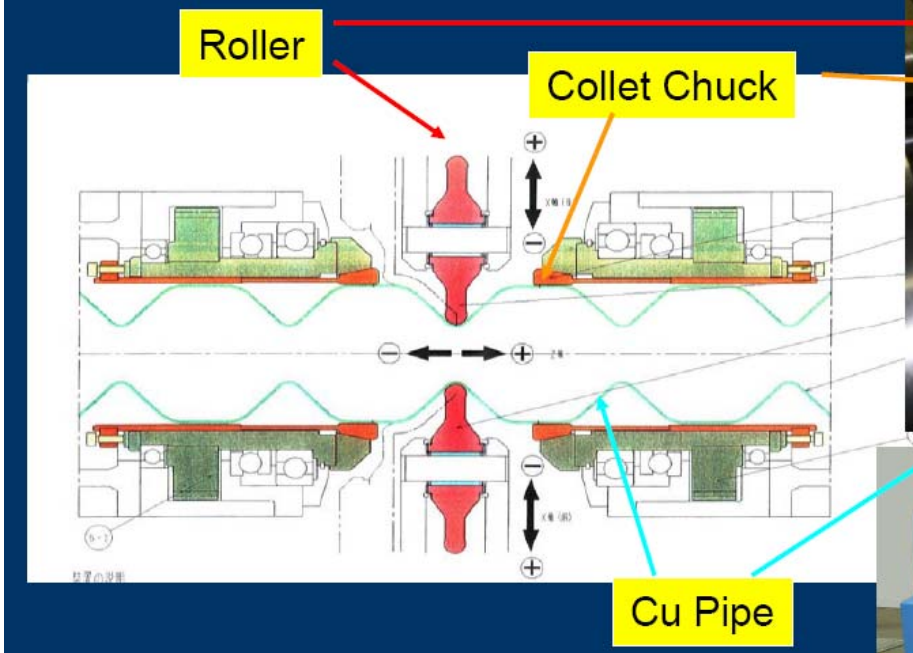
NbCu0.15%Zr tube, produced at Company NU-TECH Precision Metals (Canada)

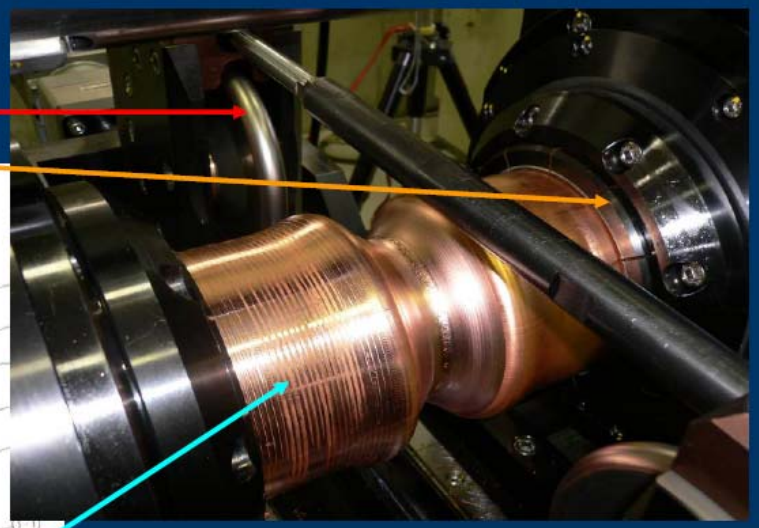
Single cell cavities produced from Nb/ Cu0.15%Zr clad tube

P. Kneisel is willing to do the preparation and RF test after cavity completing

Nb/Cu Clad Seamless Cavity (Necking Machine & Hydro-forming Machine)

Status of 3-cell Necking Machine





3-cell Necking Machine was completed.
Tests with Cu pipes started.

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ILC activities provided a new push for seamless option. KEK (K. Ueno, K. Saito)

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Necking Machine for 9-cells cavity

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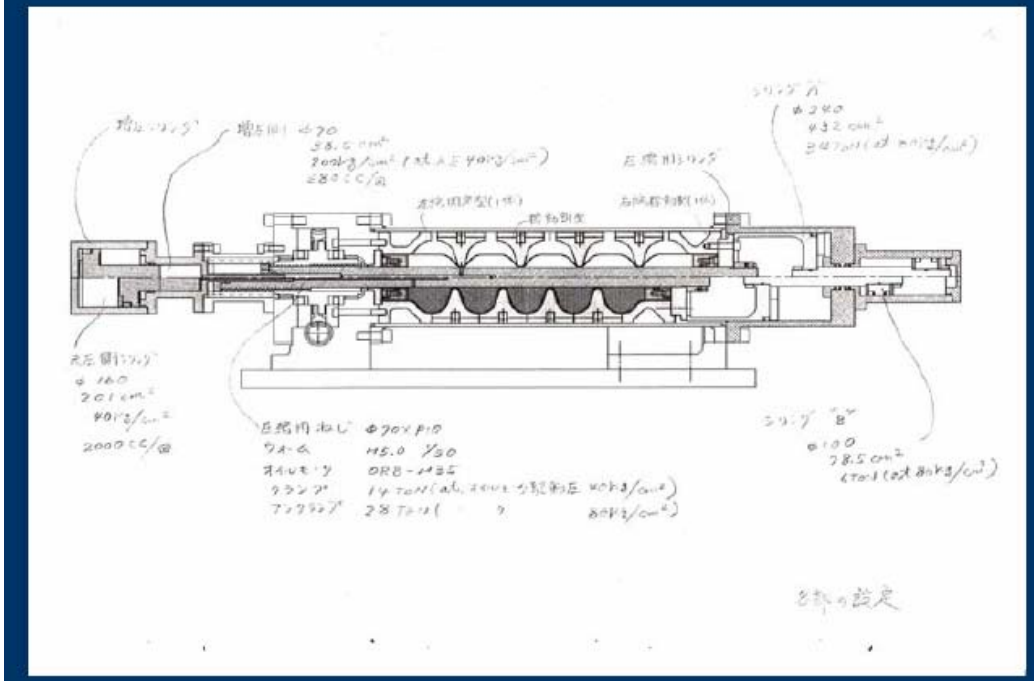
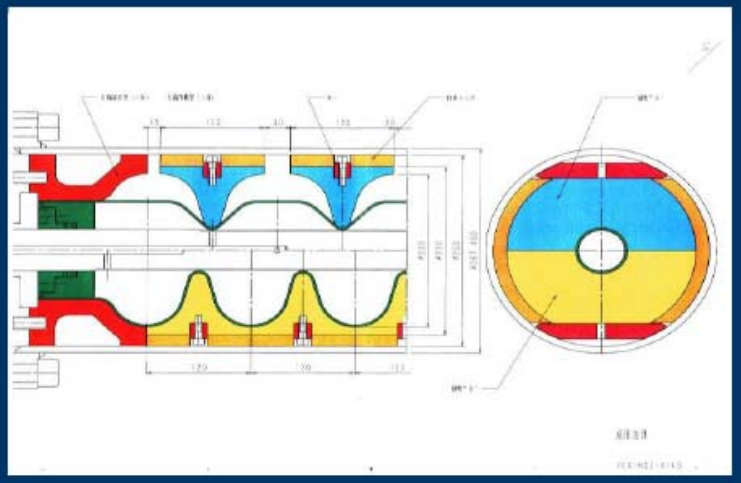
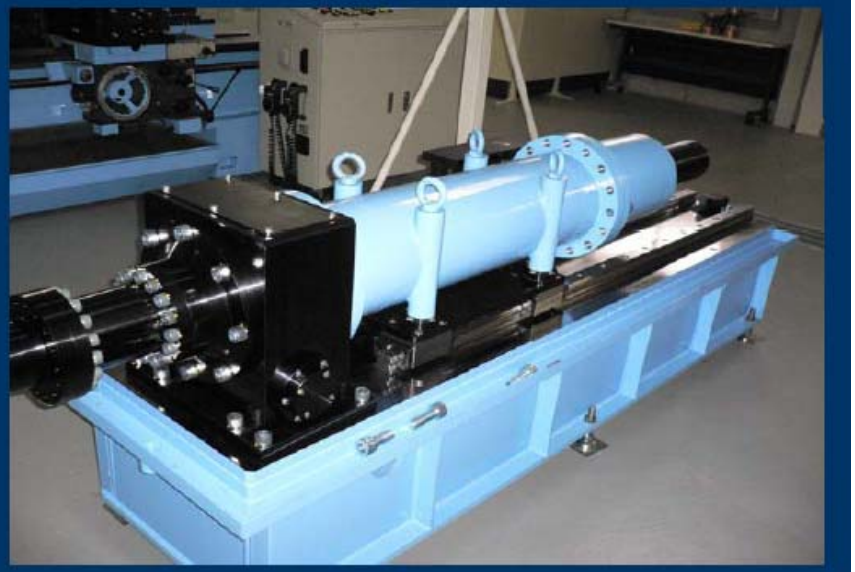
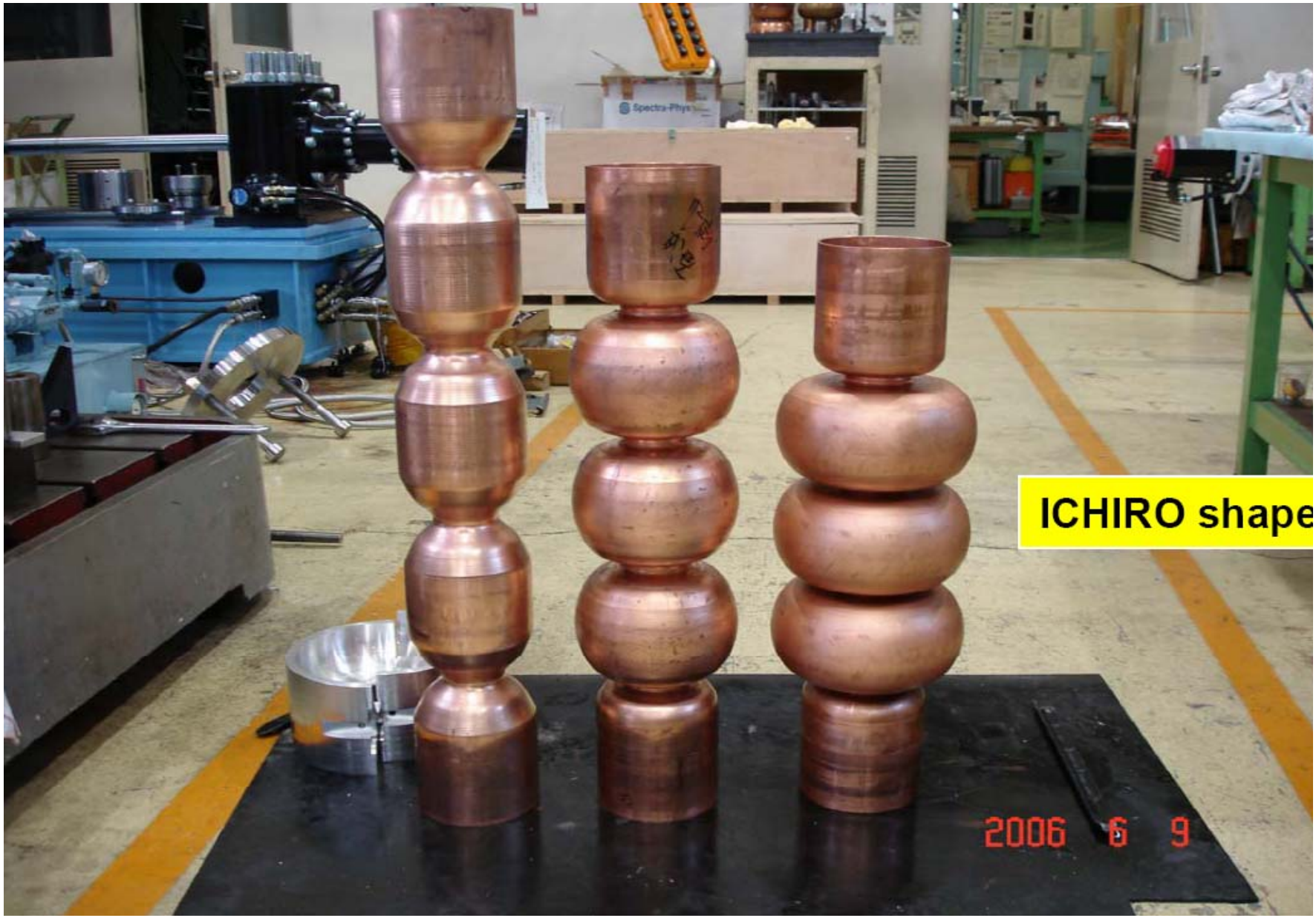






KEK hydroforming machine. Upgrade from 3 cell to 9-cell hydroforming is in work



Hydroformed multi cell Cu cavities of ICHIRO shape

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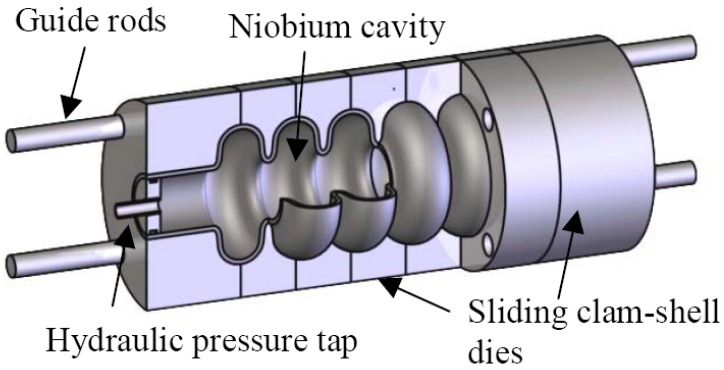
Chris Compton
Looking to Industry for the answers

Don't get technical, "build my widget"

- US industry with 125 year of experience
- Formed similar products, Bellows
- Dies inexpensive, easy to fabricate and modify



Cavity after hydro-forming

Prototype copper 2.45 GHz (reduce initial costs)

- annealed (700°C, 1 hr > 50% elongation (Nb ~ 55%)
- starting wall thickness: 0.125"

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Poster WEP01

Hydro-forming Samples

One step ~3000 psi, with axial force

- Thinning observed at equator (0.125” →0.08”)
- Little thinning at Iris, showing material to swag/groove to smaller diameter
- Some “orange peeling” observed at equator

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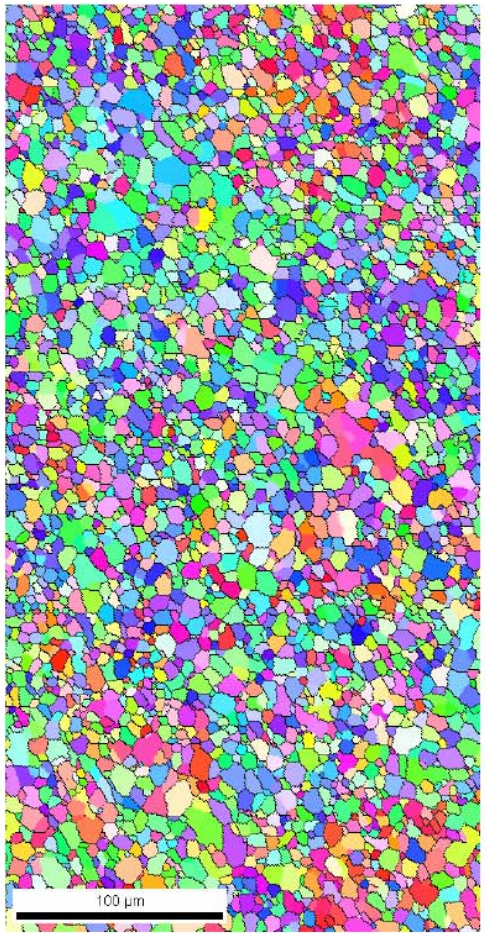
R. Crooks

Black Laboratories – ATI Wah Chang – Florida State University



Inverse Pole Figure,
SPD + Recrystallized

Plan:

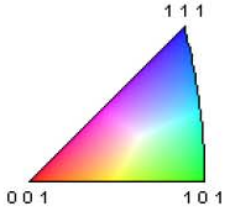
- Homogeneous, fine-grained, tube for hydroforming

Progress to date:

- Bulk processed, RRR Nb billet
- Fine-grained, equiaxed
- 94% Recrystallized

Scheduled (Spring '08):

- 150 mm diameter RRR tube



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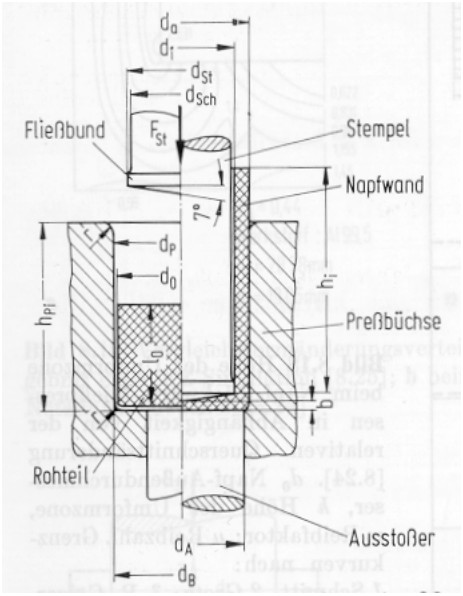
BLACK LABORATORIES L.L.C.

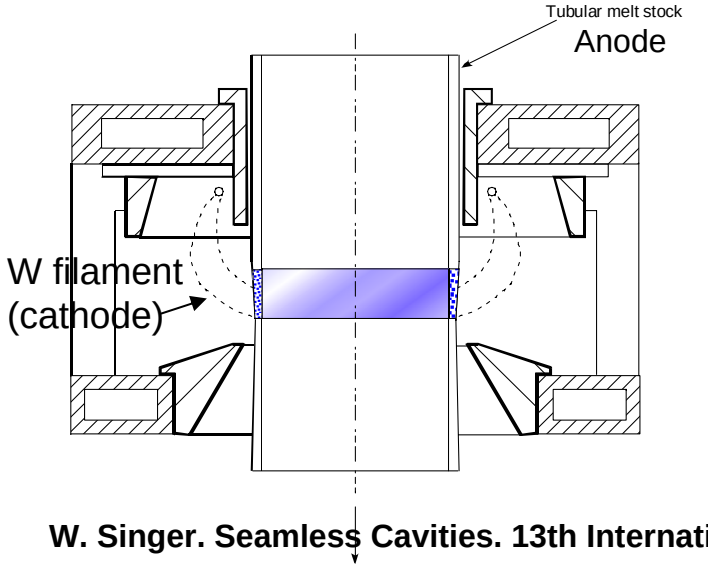
Alternative ideas: Cavity fabrication from single crystal tubes



Proposal of E. Palmieri: Single crystal cavity fabrication from back extruded single crystal tubes by spinning or hydroforming

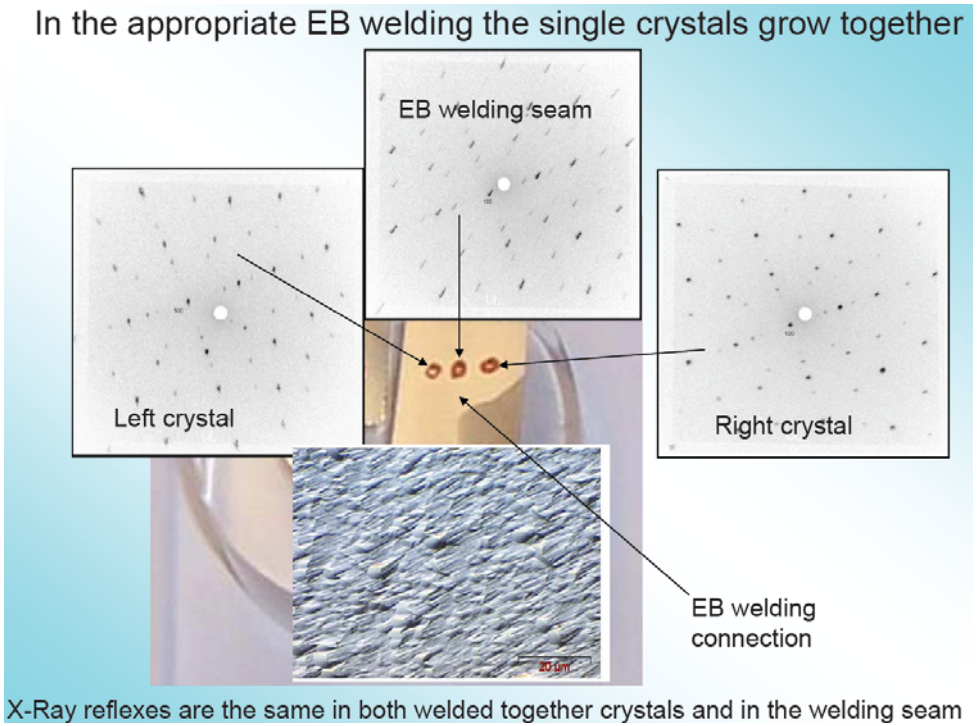
Seamless tube fabrication by back extrusion.

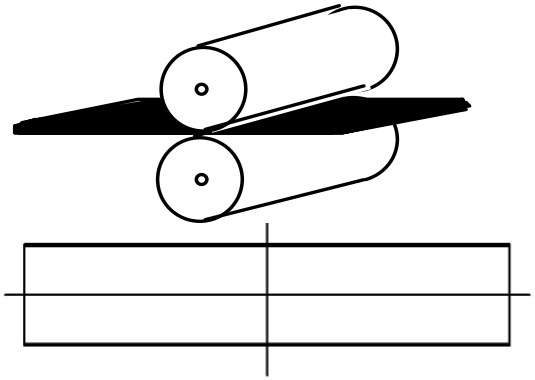
Proposal of R. Graham (Wah Chang): Single crystal cavity fabrication from single crystal tubes produced by EB floated zone method

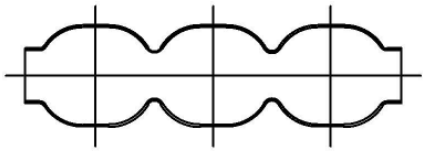


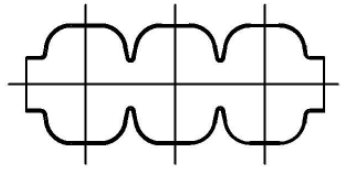
- EBFZ on tubular melt stock
- May be able to produce a single crystal tube
- Thin wall contains molten zone
- Surface tension may be able to support molten metal column
- Benefits of zone refining
- Tube could be hydroformed or spun to cavity shape

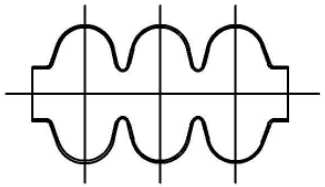
Welded single crystal tube











Single crystal tube fabrication:

- Rolling of the single crystal with intermediate annealing,
- EB welding with matching of the orientation, welding
- Cavity fabrication by e.g. hydroforming

结论

1. 生产细胞洞成为现实到目前为止的加氢重整和转动的技术

2. 应该放更多努力入无缝的技术

3. 的工业化加氢重整或转动单晶洞在有趣的选择能成为

Conclusions

1. Proof of principle is done. Eacc of 40 MV/m is achieved. 9-cell cavities are produced

3. More effort should be put into industrialization of seamless technique.

3. Seamless activities have newcomes with new ideas e.g. hydroforming or spinning of the single crystal cavities

Many thanks for support by preparing of the presentation to

C. Compton

R. Crook

R. Graham

I. Jelezov

P.Kneisel

V. Palmieri

K.Saito

K. Ueno