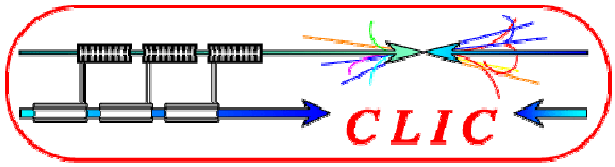
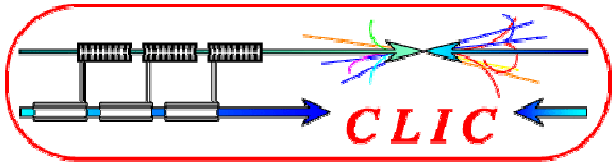


CLIC09 WORKSHOP, WG4-RF structures

CERN production methods

G. Riddone on behalf of the structure production team,
14.10.2009

Content

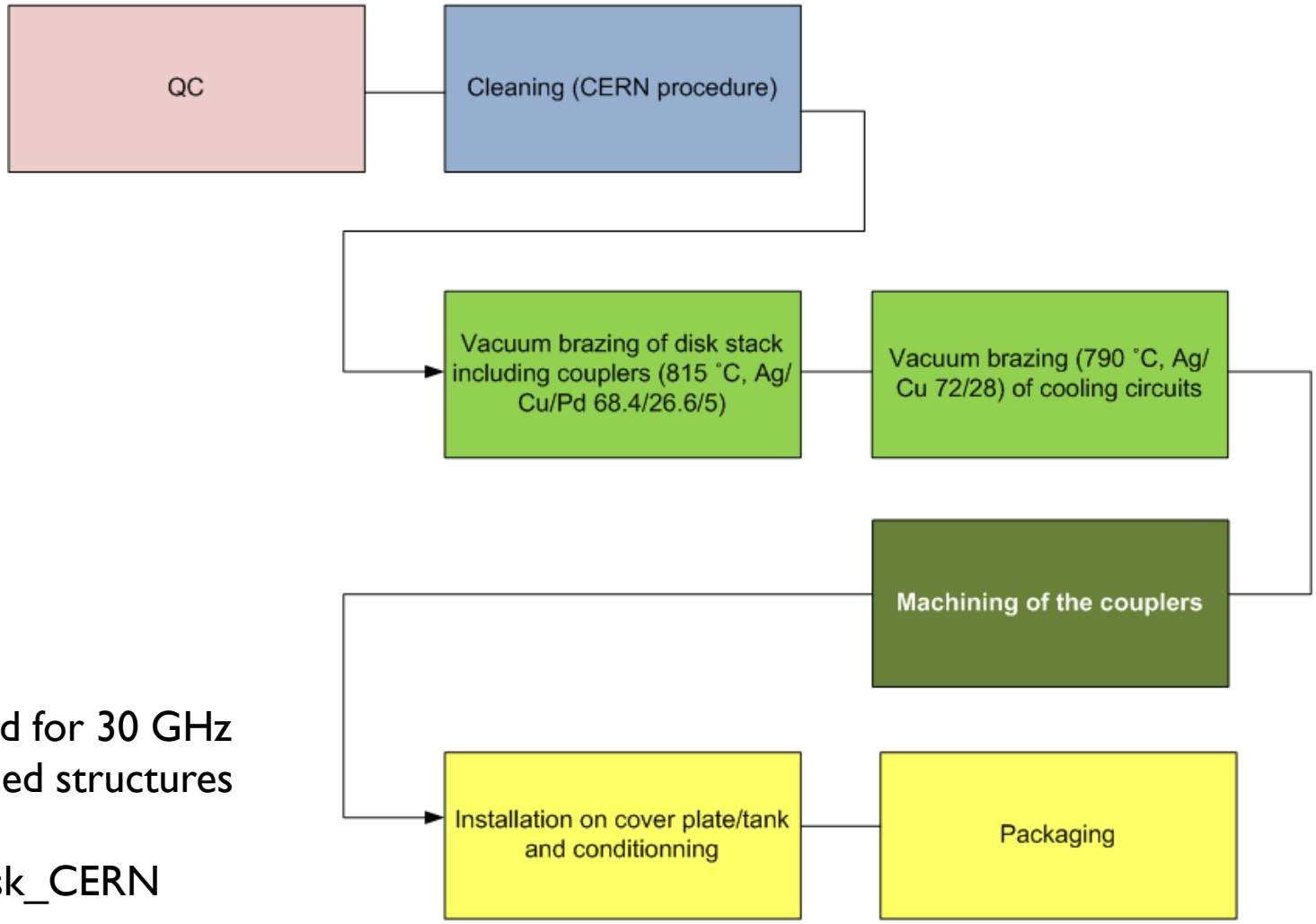


- Recall of CERN old fabrication procedure

FOCUS on

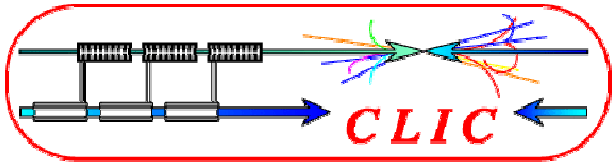
- CERN new fabrication procedure
- Actions implemented at CERN and comparison of production methods
- Structures in the pipeline

CERN old manufacturing flow



Followed for 30 GHz disk-based structures and for T18_disk_CERN

Accelerating structures

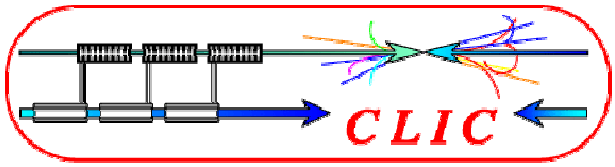


Three T18 structures tested at SLAC/KEK showed excellent test results

consequent validation of design, machining and **assembly procedure**

NLC/JLC fabrication technology: validated to 100 MV/m (baseline for future CERN X-band accelerating structures)

CERN new manufacturing flow



Based on NLC/JLC assembly procedure

High precision diamond machining

QC

Cleaning (light etch)

Diffusion bonding of couplers (H_2, 1045 °C)

Machining of couplers

Diffusion bonding of disk stack incl. couplers (H_2, 1035 °C)

Brazing of cooling circuits , tuning studs,… (AuCu, 1020 °C)

RF check and tuning

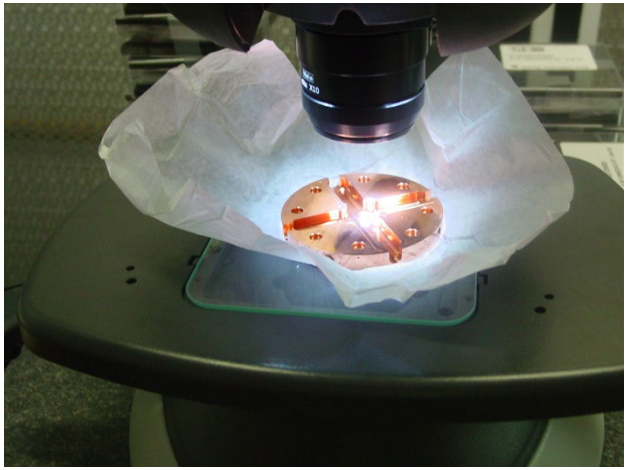
Baking (vacuum, 650 °C, >10 d)

Packaging and shipping

Microscopic inspections

Microscopic inspections before and after each relevant step

Microscopic inspection of disks before and after cleaning (on witness pieces)



Microscopic inspection of couplers after machining

Microscopic inspection of structure after diff. bonding

Video inspections and SEM complement microscopic inspections

Manufacturing at VDL

Enabling Technologies Group — Inspection Report

Drawing no.	CLIAAS120020	Prod. Nr.	1
Description	12WDSDVG1.8T disk 007		

Profile accuracy cross

0.005 A B

Shape tolerance ±2.5 µm

Enabling Technologies Group — Inspection Report

Drawing no.	CLIAAS120020	Prod. Nr.	1
Description	12WDSDVG1.8T disk 007		

Dimensions

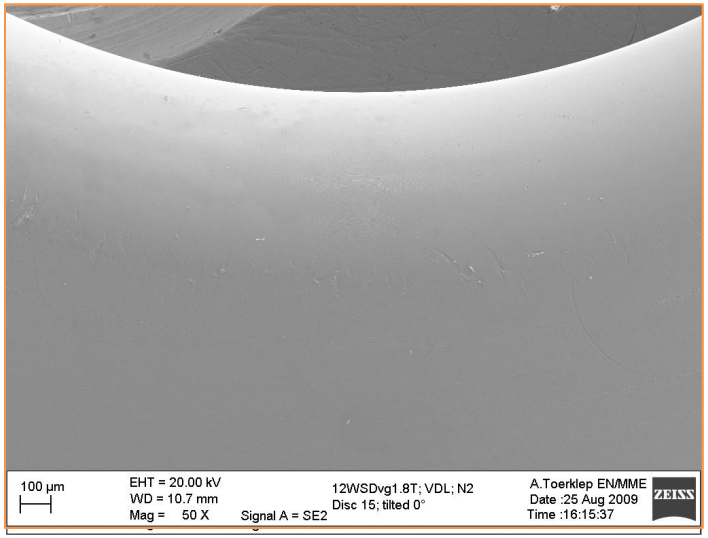
Measurand	Description	Nominal	Upper	Lower	Actual	Deviation	Pass	Fail	Remark
1	Ref A ⌭ 0.002	0.0000	0.0020	0.0000		0.0015	√		
2	Outer diameter Ref B	80.0000	0.0050	0.0000		0.0004	√		
3	⌭ 0.002	0.0000	0.0020	0.0000		0.0005	√		
4	⊥ 0.005 A	0.0000	0.0050	0.0000		0.0001	√		
5	Width of cross Z+	11.2500	0.0025	-0.0025		0.0002	√		
6	Width of cross Z-	11.2500	0.0025	-0.0025	11.2514	0.0014	√		
7	Width of cross Y-	11.2500	0.0025	-0.0025	11.2501	0.0001	√		
8	Width of cross Y+	11.2500	0.0025	-0.0025	11.2501	0.0001	√		
9	⊙ 0.005 A	9.3175	0.0025	-0.0025	9.3171	-0.0004	√		
10	Plane position A ⌭ 0.002	0.0000	0.0020	0.0000	0.0006	0.0006	√		
11	Plane Ref A ⌭ 0.005	0.0000	0.0050	0.0000	0.0036	0.0036	√		
11	Cross ⊙ 0.005 A	6.8368	0.0025	-0.0025	6.8364	-0.0004	√		
12	Bottom plane cross ⌭ 0.002	0.0000	0.0020	0.0000	0.0011	0.0011	√		
13	Depth of recess for solder foil	0.0300	0.0100	0.0000	0.0382	0.0082	√		
14	Diameter undulation	5.8478	0.0025	-0.0025	5.8469	-0.0009	√		
15	⌭ 0.002	0.0000	0.0020	0.0000	0.0004	0.0004	√		
17	⊙ 0.003 B	0.0000	0.0030	0.0000	0.0012	0.0012	√		
9	Measurand t	1.4807	0.0025	-0.0025	1.4801	-0.0006	√		
18	Undulation ⊥ 0.005 A B	0.0000	0.0050	0.0000	0.0038	0.0029	√		
19	Cross ⊥ 0.005 A B	0.0000	0.0050	0.0000	0.0026	0.0015	√		

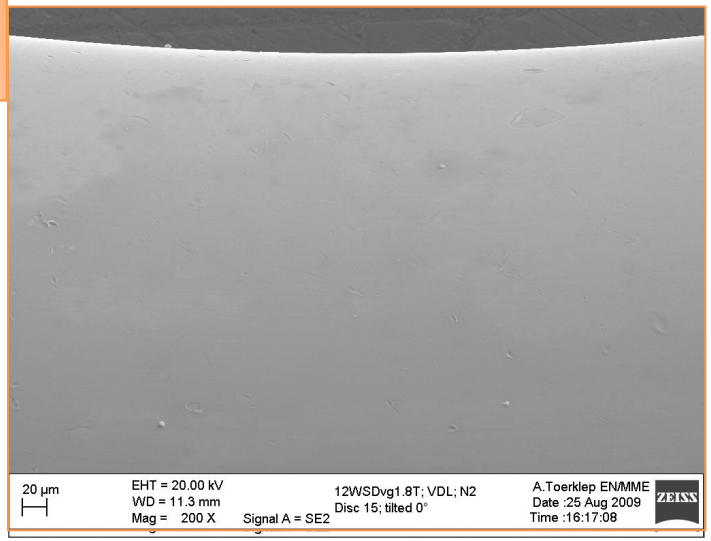
All dimensional checks are conform

Damped disk at 12 GHz

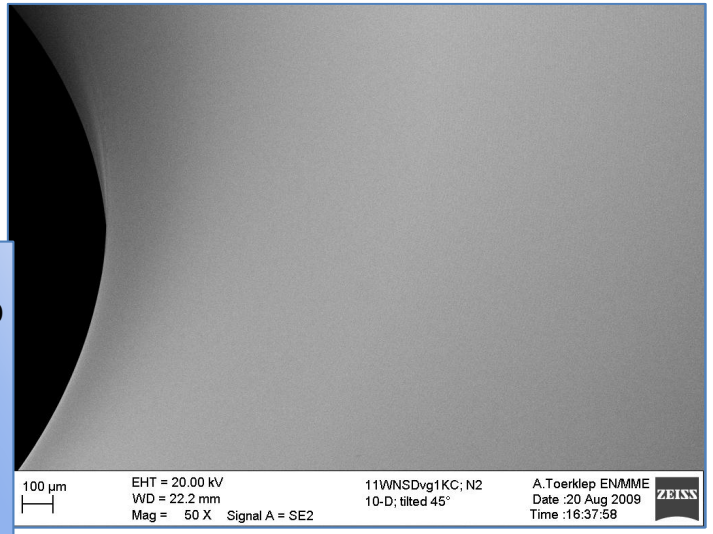
SEM inspections

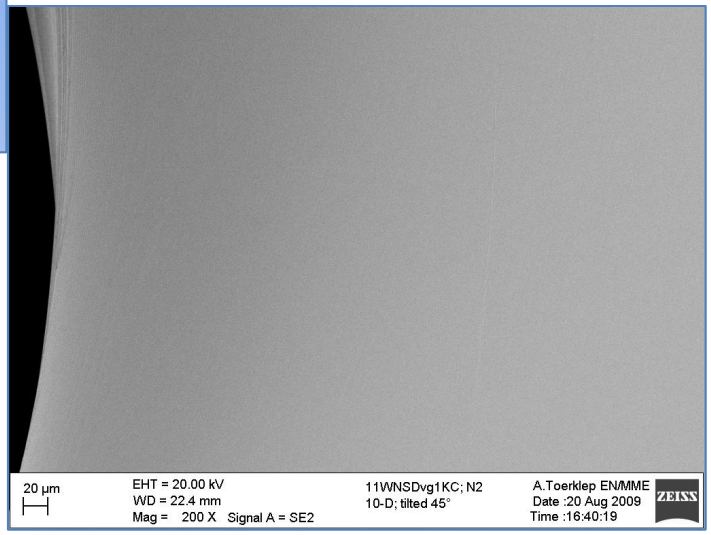
TD24 at 12 GHz



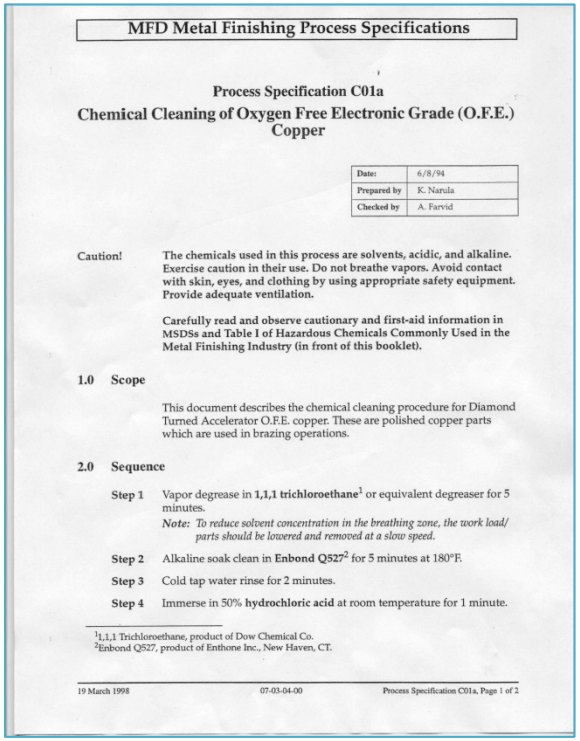


T18 KEK/SLAC design





Cleaning



MFD Metal Finishing Process Specifications

Process Specification C01a

Chemical Cleaning of Oxygen Free Electronic Grade (O.F.E.) Copper

Date:	6/8/94
Prepared by	K. Narula
Checked by	A. Farvid

Caution! **The chemicals used in this process are solvents, acidic, and alkaline. Exercise caution in their use. Do not breathe vapors. Avoid contact with skin, eyes, and clothing by using appropriate safety equipment. Provide adequate ventilation.**

Carefully read and observe cautionary and first-aid information in MSDSs and Table I of Hazardous Chemicals Commonly Used in the Metal Finishing Industry (in front of this booklet).

1.0 Scope

This document describes the chemical cleaning procedure for Diamond Turned Accelerator O.F.E. copper. These are polished copper parts which are used in brazing operations.

2.0 Sequence

Step 1 Vapor degrease in **1,1,1 trichloroethane**[1] or equivalent degreaser for 5 minutes.
Note: To reduce solvent concentration in the breathing zone, the work load/ parts should be lowered and removed at a slow speed.

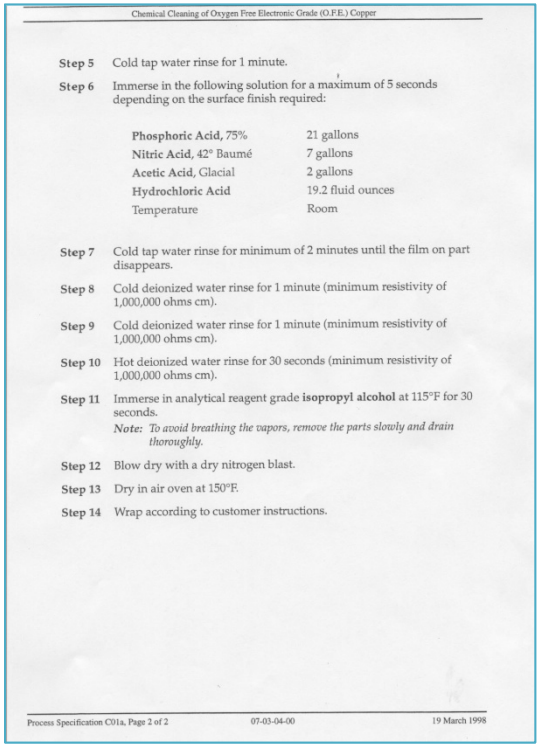
Step 2 Alkaline soak clean in **Enbond Q527**[2] for 5 minutes at 180°F.

Step 3 Cold tap water rinse for 2 minutes.

Step 4 Immerse in 50% **hydrochloric acid** at room temperature for 1 minute.

[1]1,1,1 Trichloroethane, product of Dow Chemical Co.
[2]Enbond Q527, product of Enthone Inc., New Haven, CT.

19 March 1998 07-03-04-00 Process Specification C01a, Page 1 of 2



Chemical Cleaning of Oxygen Free Electronic Grade (O.F.E.) Copper

Step 5 Cold tap water rinse for 1 minute.

Step 6 Immerse in the following solution for a maximum of 5 seconds depending on the surface finish required:

Phosphoric Acid, 75%	21 gallons
Nitric Acid, 42° Baumé	7 gallons
Acetic Acid, Glacial	2 gallons
Hydrochloric Acid	19.2 fluid ounces
Temperature	Room

Step 7 Cold tap water rinse for minimum of 2 minutes until the film on part disappears.

Step 8 Cold deionized water rinse for 1 minute (minimum resistivity of 1,000,000 ohms cm).

Step 9 Cold deionized water rinse for 1 minute (minimum resistivity of 1,000,000 ohms cm).

Step 10 Hot deionized water rinse for 30 seconds (minimum resistivity of 1,000,000 ohms cm).

Step 11 Immerse in analytical reagent grade **isopropyl alcohol** at 115°F for 30 seconds.
Note: To avoid breathing the vapors, remove the parts slowly and drain thoroughly.

Step 12 Blow dry with a dry nitrogen blast.

Step 13 Dry in air oven at 150°F.

Step 14 Wrap according to customer instructions.

Process Specification C01a, Page 2 of 2 07-03-04-00 19 March 1998

SLAC cleaning procedure as a baseline

For degreasing Trichloroethane ➔ at SLAC replaced by Perchloroethylene

CERN proposal:
(Firm AVANTEC Performance Chemicals):
- TOPKLEAN MC 20A
- PROMOSOLV 71IPA

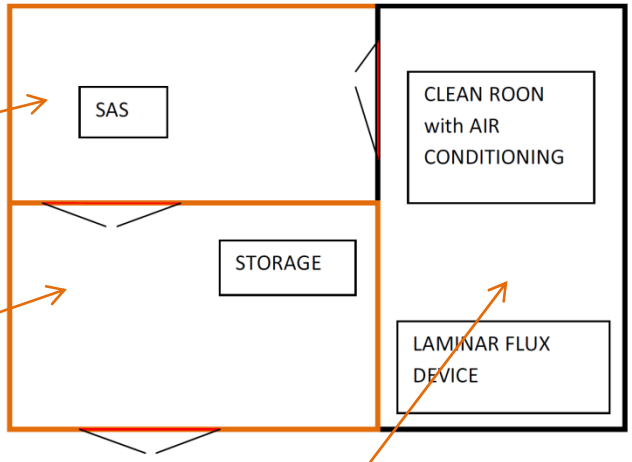
Tool for holding the disks

To avoid the solution entering the tuning holes
CERN proposal: screws with O-rings

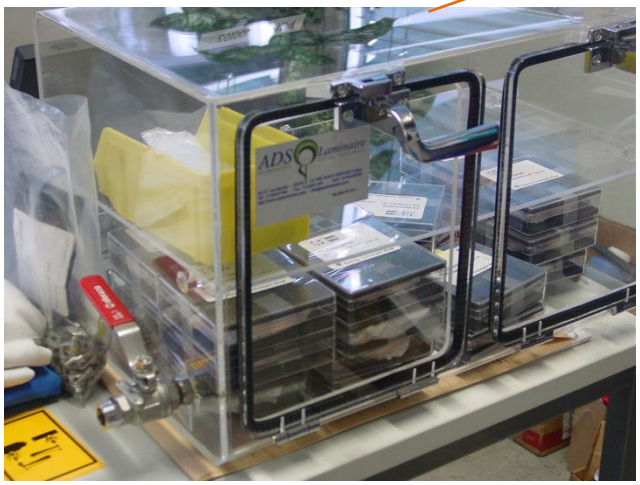
Clean room and storage

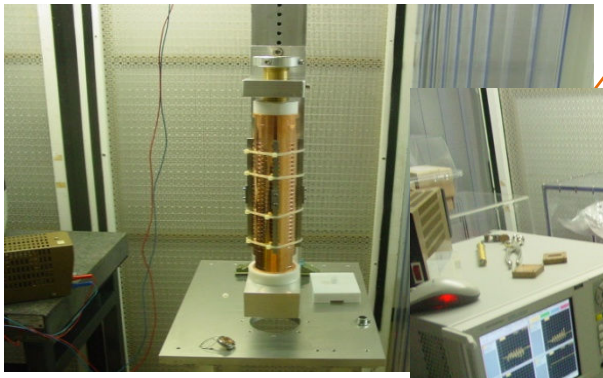
Clean pieces

New clean room

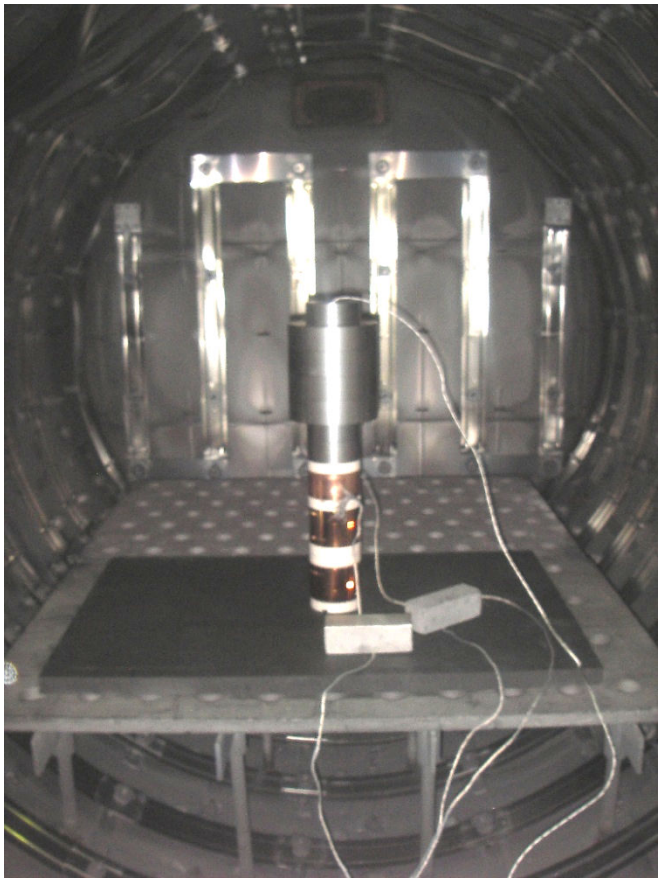


Boxes under N2

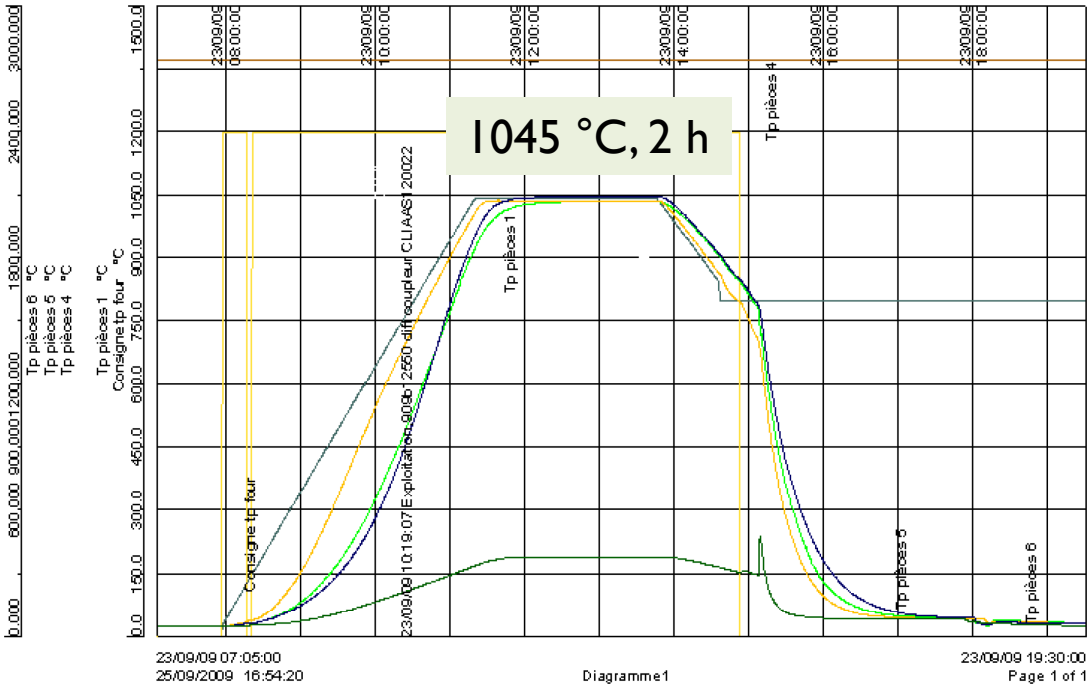




Diffusion bonding

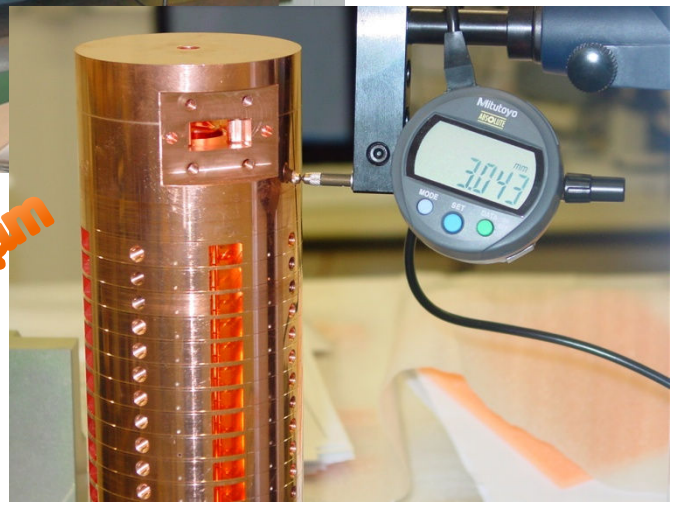


H_2 pure bonding
~ 4 bar



Diffusion bonding cycle

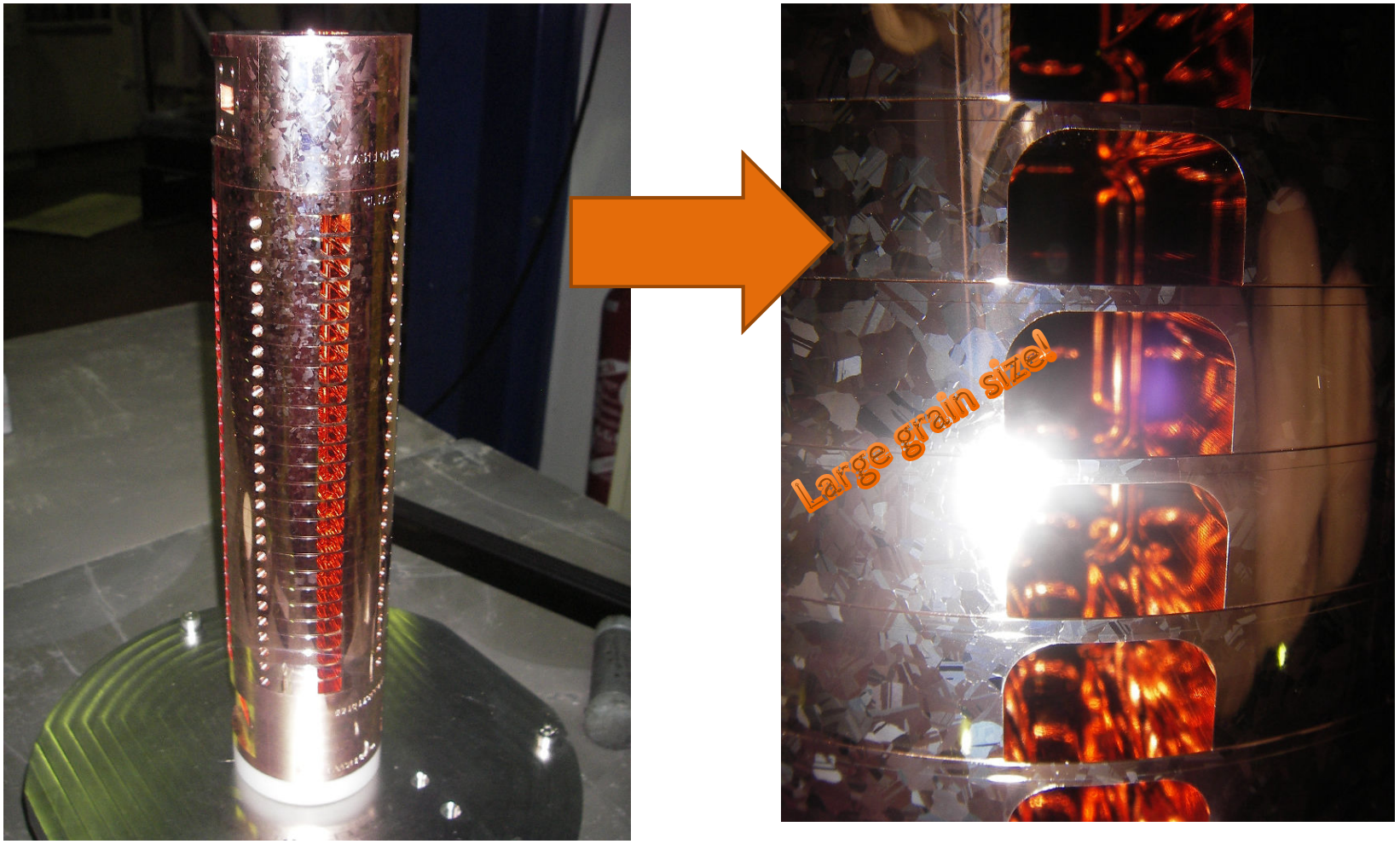
Assembly



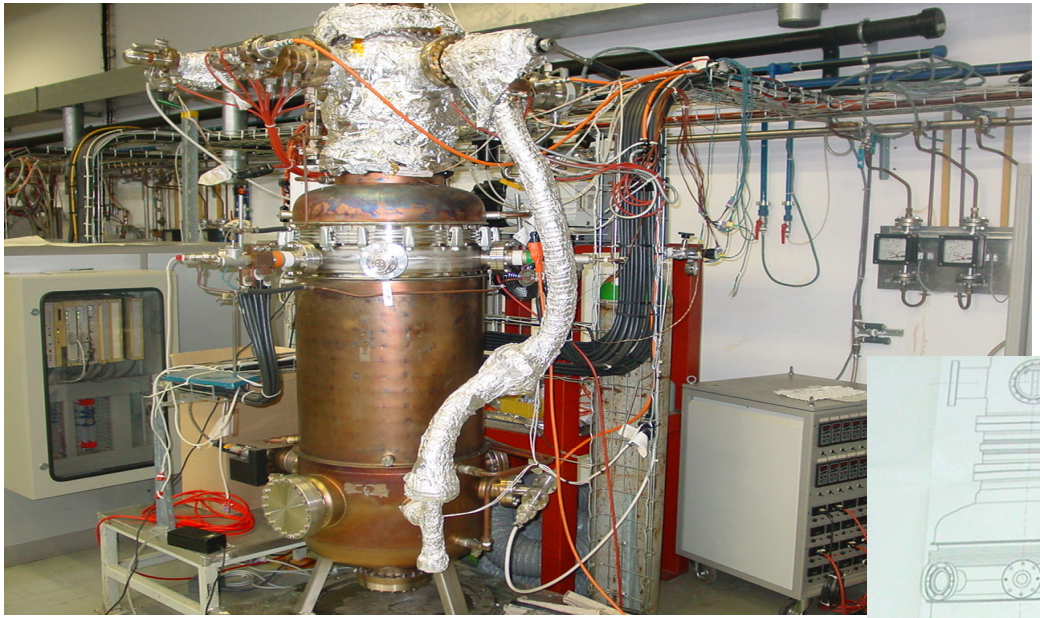
Straightness measurement ±2 µm

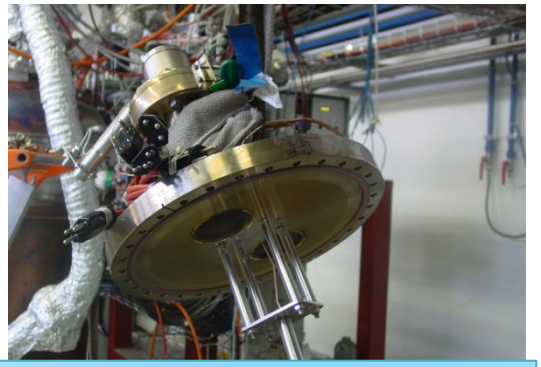
Assembly made on V-blocks
Verification of the assembly (before and after bonding) with a new measurement column: straightness and tilt

Accelerating structure TD24 after diffusion bonding at 1035 °C under H_2

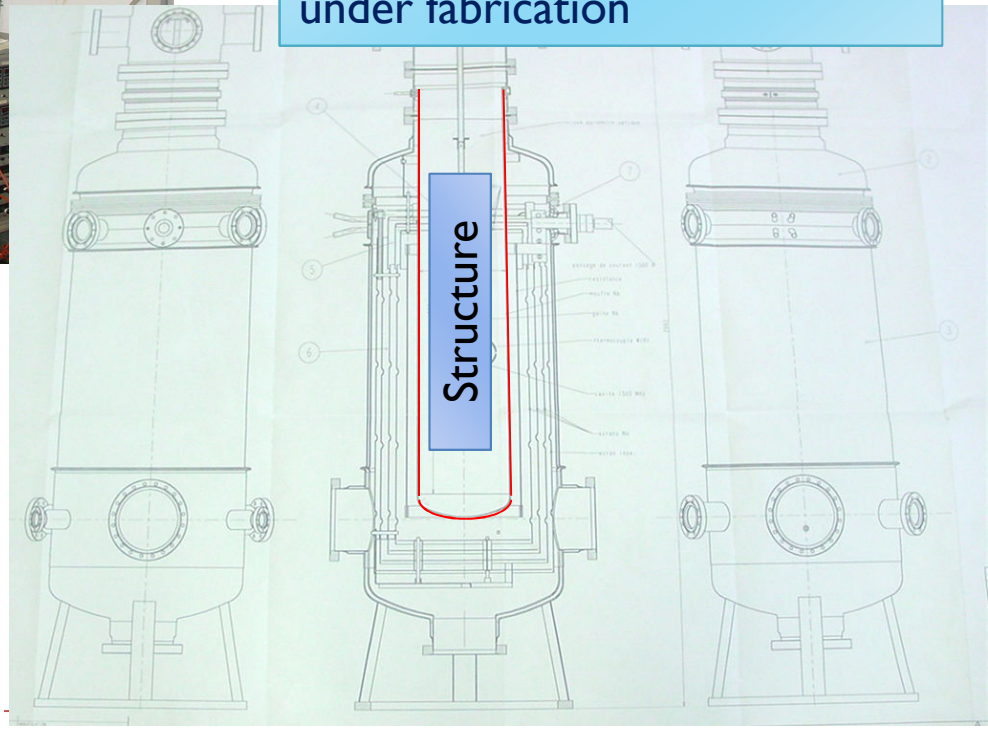


Vacuum baking



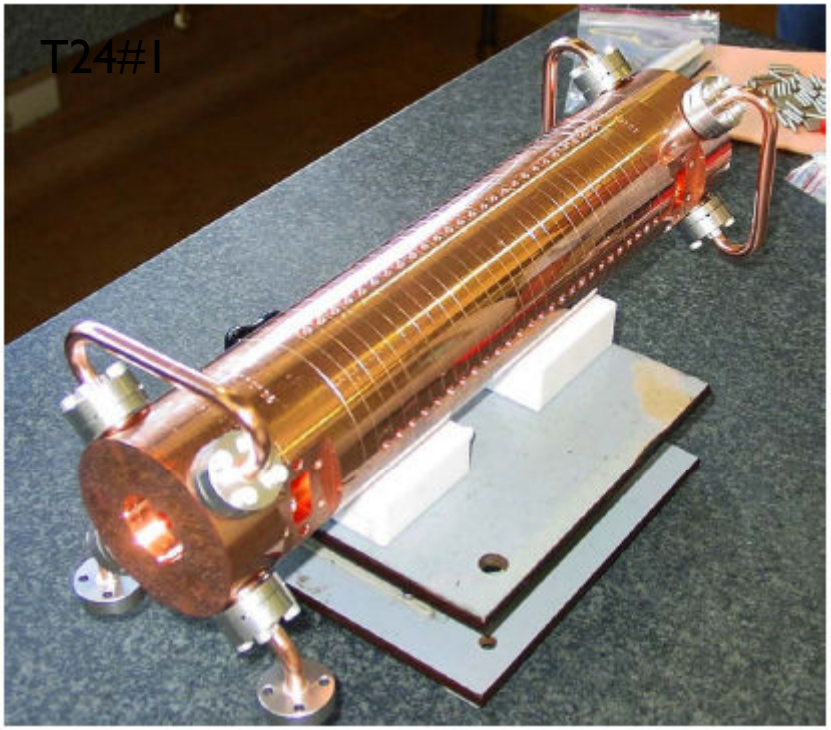


New top flange and supports under fabrication

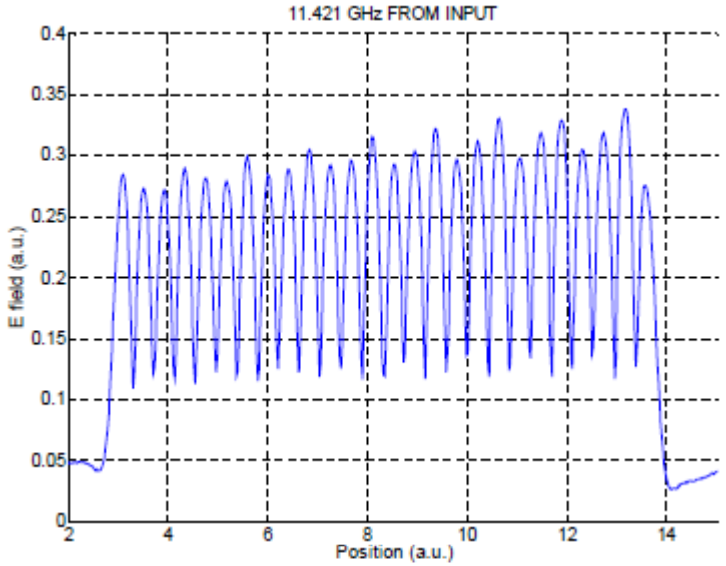


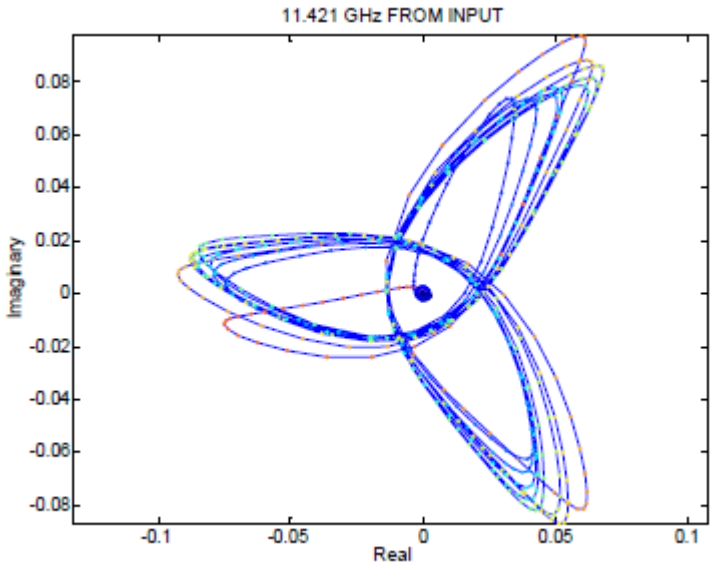
Found at CERN a furnace which an internal cylinder in Nb
Tests on the furnace performed last week satisfactory
Same SLAC cycle will be followed

RF check and tuning



Bead pulling at 11.421GHz after baking



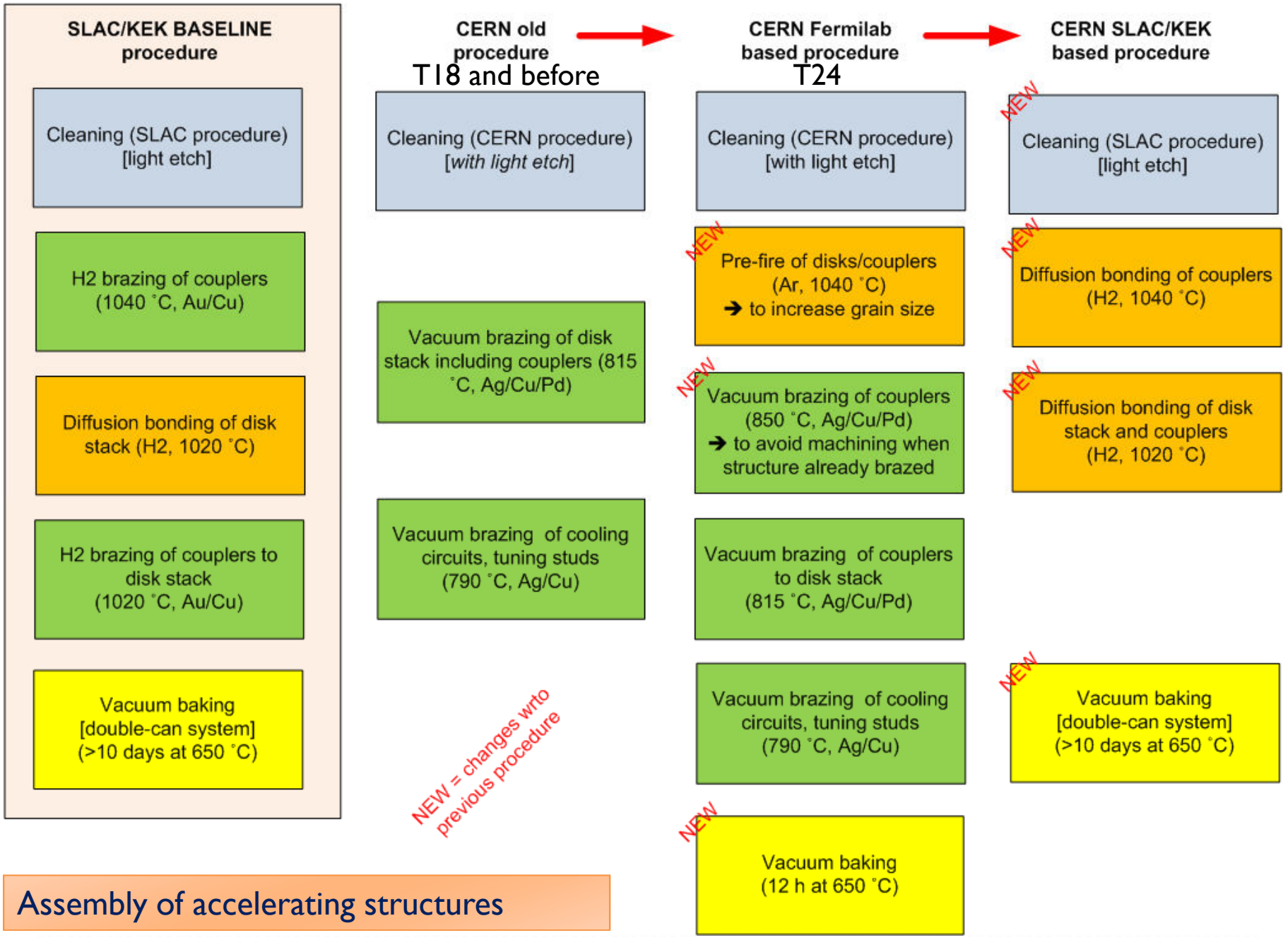


Before shipping RF check and tuning is done and results are good

Packaging for transport

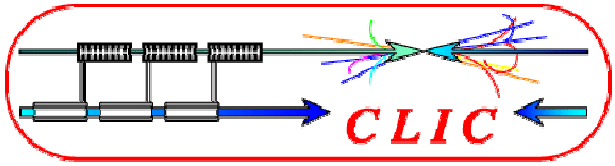
"Sealing" machine

Example of packaging for T24



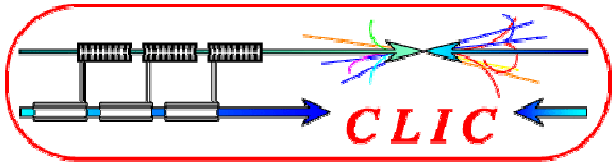
Assembly of accelerating structures

Comparison SLAC/CERN



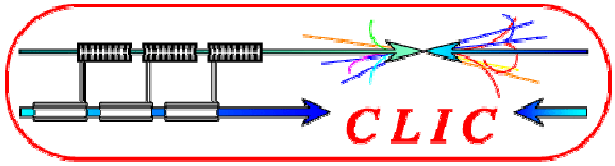
SLAC/KEK BASELINE procedure	CERN SLAC/KEK based procedure	Comparison
Cleaning (SLAC procedure) [light etch]	Cleaning (SLAC procedure) [light etch]	Same procedure
H2 brazing of couplers (1040 ˚C, Au/Cu)	Diffusion bonding of couplers (H2, 1040 ˚C)	Different mechanical design → for CERN couplers bonding can be applied (in addition CERN has little experience with Au/Cu brazing)
Diffusion bonding of disk stack (H2, 1020 ˚C)	Diffusion bonding of disk stack and couplers (H2, 1020 ˚C)	Same cycle
H2 brazing of couplers to disk stack (1020 ˚C, Au/Cu)		This step is not needed for CERN as the couplers are bonded to the disks during the bonding of the disk stack
Vacuum baking [double-can system] (>10 days at 650 ˚C)	Vacuum baking [double-can system] (>10 days at 650 ˚C)	Same cycle

Summary of comparison



	SLAC/KEK	Fermilab	CERN old	CERN new (SLAC/KEK based)
Diamond machining	√	√	√	√
Etch	√	√	√	√
1000 °C pre-fire		√ (Ar)		
~ 1000 °C diffusion bonding	√			√
~ 1000 °C brazing	√			
~ 800 °C brazing		√ (Ar, Au/Cu)	√ (Vacuum, Ag/Cu)	√
Vacuum baking	√	√		√
Tank/sealed	SEALED	SEALED	SEALED	**TANK**/SEALED

Status - assembly



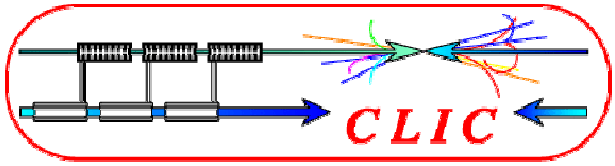
11.4 GHz

- Two damped accelerating structures assembled TD18 (TANK) and TD24 (TANK)
  - TD18- old CERN procedure
  - TD24 diffusion bonding, no etching – to be baked
- Disks for two undamped T18 with SLAC/KEK mechanical design at CERN (*SEALED*) – **to be bonded**
- Disks for undamped T24 (*SEALED*) at CERN – to be bonded

12 GHz

- Disks for two damped TD24 (TANK) at CERN for the two-beam test stand – to be bonded

Status - machining



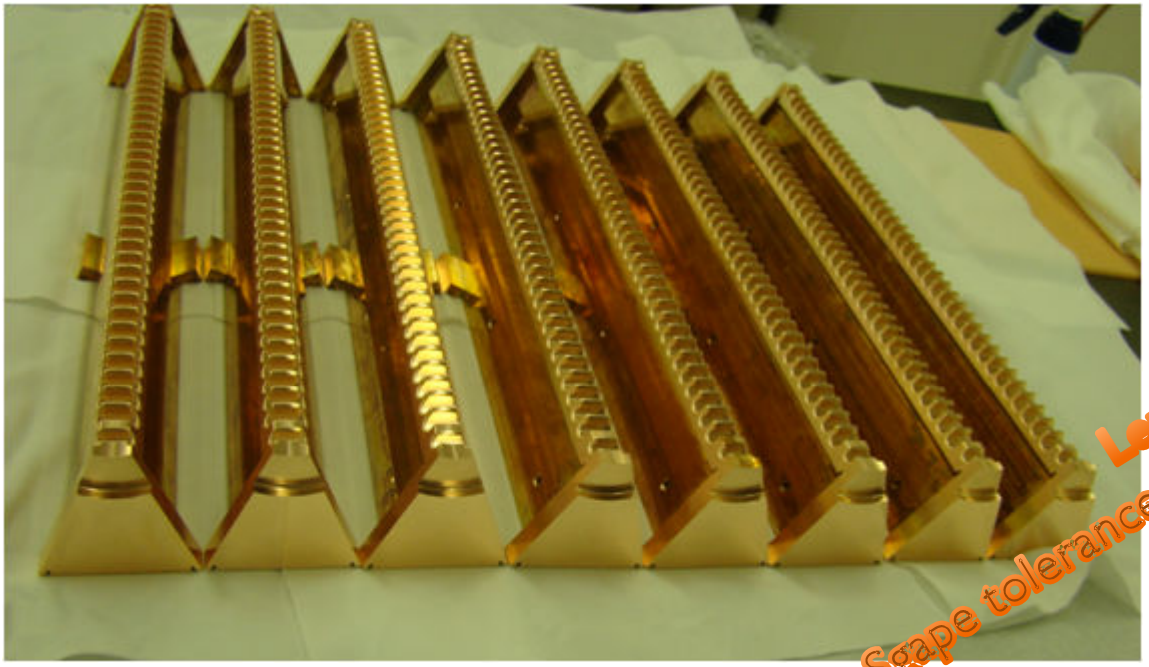
11.4 GHz

- Disks for two undamped T24 smaller diameter (45 mm, SEALED) end of Nov 2009
- Disks for two damped CD10 (vg 1.35) (80 mm, SEALED) end of Dec 2009
- *TD24 sealed to be launched in fabrication*

12 GHz

- Disks for one undamped T24 (80 mm, TANK) beginning of Nov 2009
- Disks for two damped TD24 smaller diameter (45 mm, TANK) beginning of Nov 2009

PETS bars at 11.424 GHz with damping material to be tested at SLAC

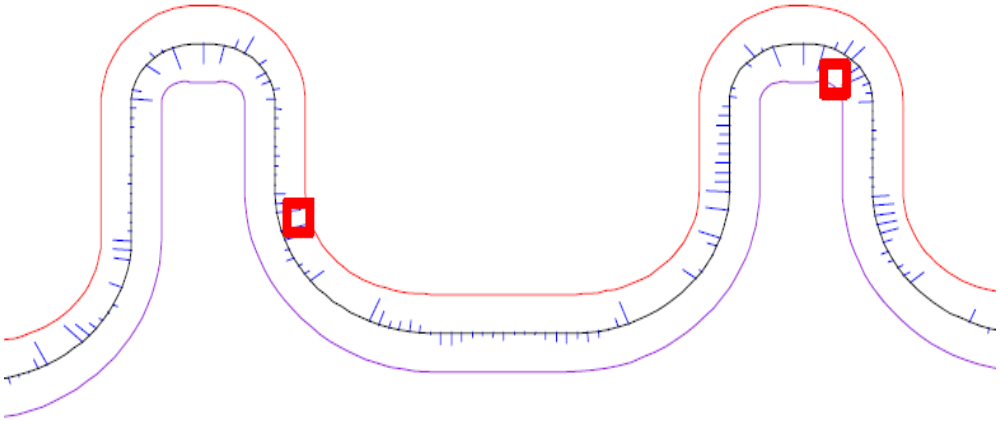


Length ~ 300 mm

Shape tolerance within specification - ± 7.5 µm

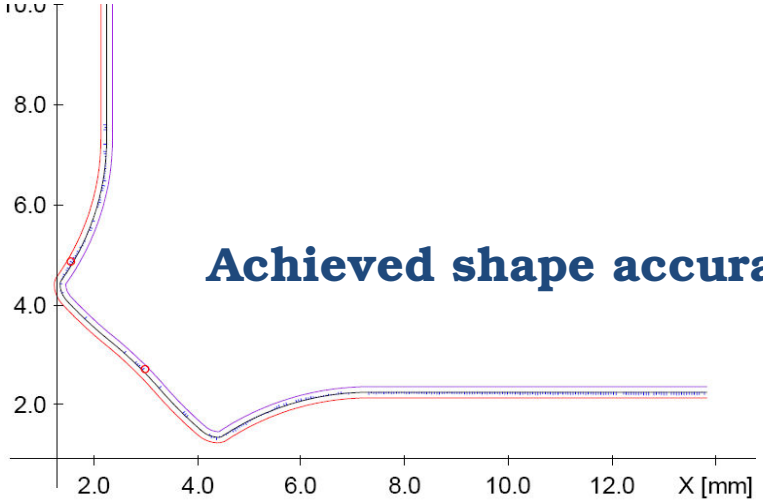
QUADRANTS - HDS thick qualification part according to CLIAAS300062 - KERN (DE)

S. Atieh



Achieved shape accuracy ± 2.1 µm

Roughness Ra = 86 nm – 30 nm according to ISO 97

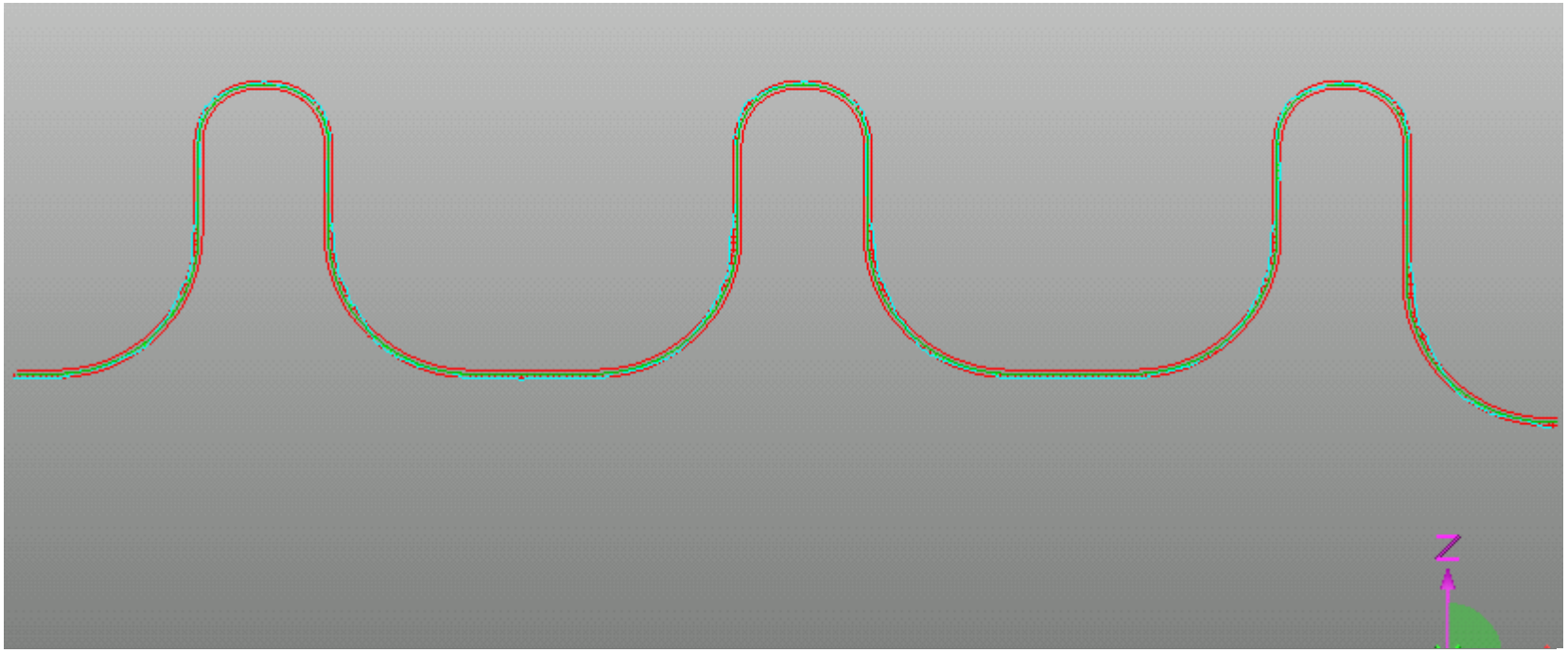


Achieved shape accuracy ± 1.3 µm

Einpassergebnis		Translation	Rotation	Überhöhung	550.0
	X	0.0000	0.0000		
	Y	0.0005	0.0000	Kommentar	
	Z	0.0000	0.0016		

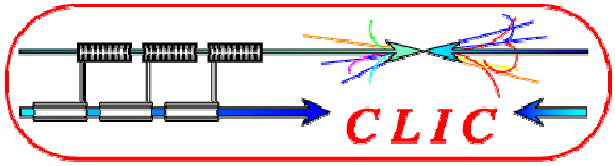
QUADRANTS - HDS thick qualification part according to CLIAAS300062 – DMP (SP)

S. Atieh



Origins translation: X 16 µm and Z -8 µm
Shape accuracy is respected ± 2.5 µm

Conclusions



- NLC/JLC fabrication technology validated for CLIC accelerating structure to 100 MV/m
- CERN is implementing SLAK/KEK procedure
  - Cleaning (etching)
  - Diffusion bonding at ~1040 °C (H_2)
  - Vacuum baking
- All shipped structures passed successfully all fabrication steps and RF checks
- T18 KEK/SLAC is being prepared (proposal for next CERN structure)
- TD24 sealed to be launched