



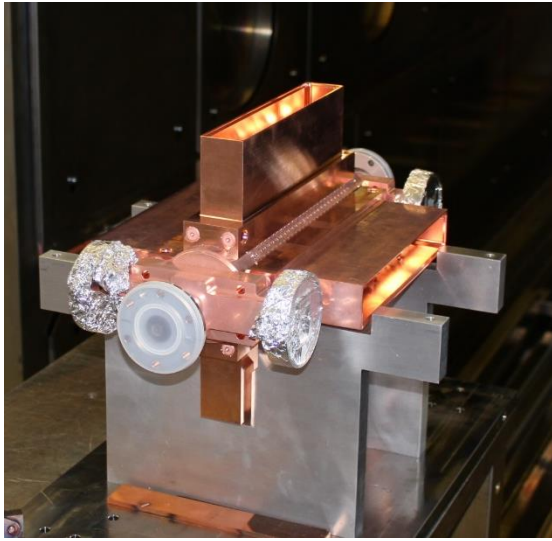
High gradient structure fabrication pipeline and trends

M. Aicheler, S. Atieh, N. Catalán Lasheras, M. Garlasche, A. Grudiev, M. Filippova, S. Lebet, A. Olyunin, A. Perez Fontenla, L. Pradera, E. Rodriguez Castro, A. Solodko, A. Xydou, H. Zha.

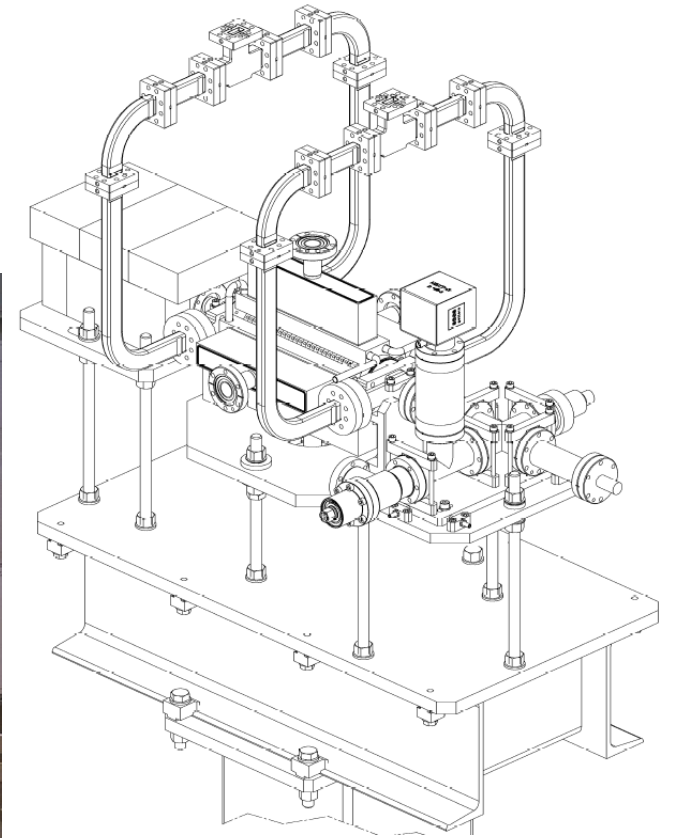
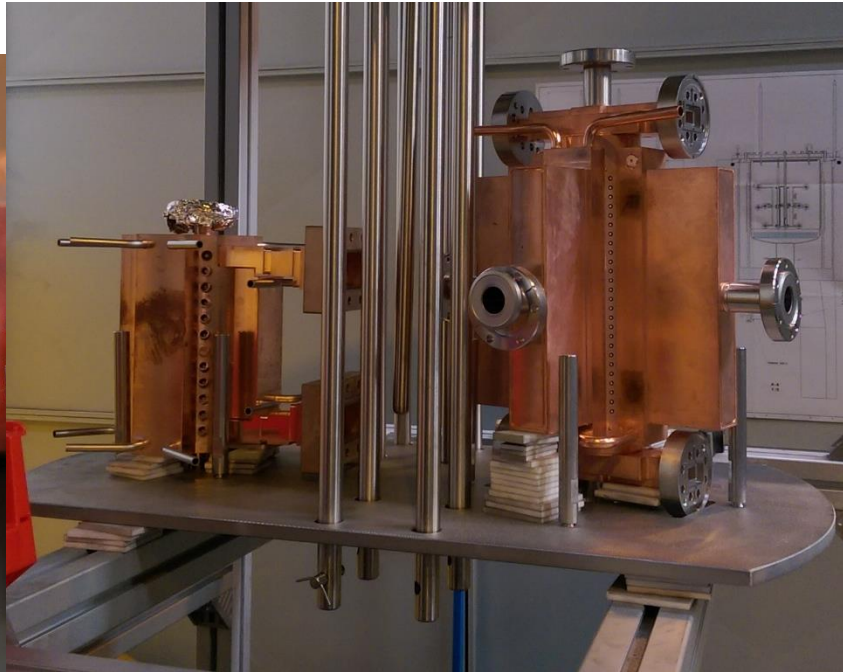
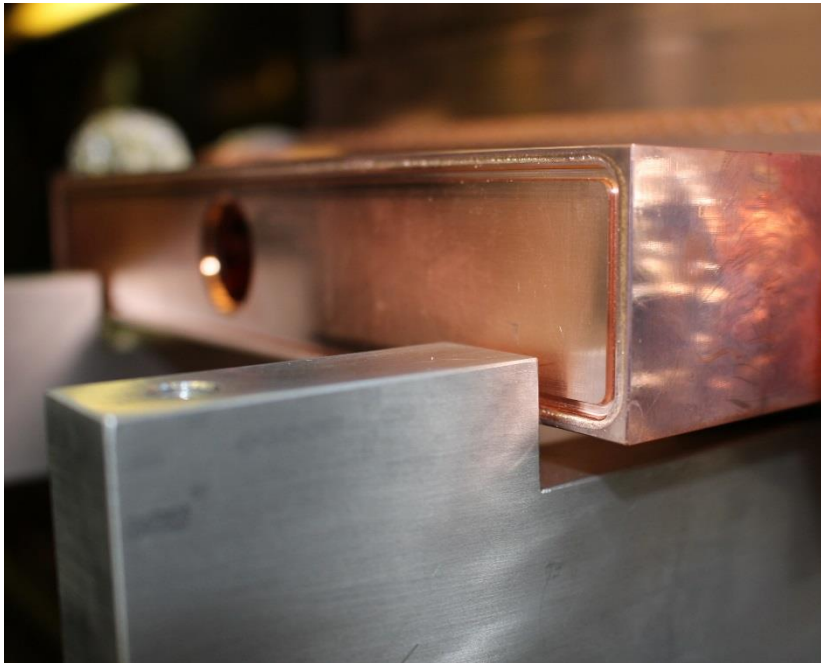


Outline

- Structures produced in 2015
 - PSI N5.
 - TD24_SiC.
 - TD26CC_2.
 - HGTW_1.
- Structures under fabrication
 - TD26CC_N3.
 - TD24R05_SiC_2.
 - HGTW_2
 - T24_4/5.
- Trends
 - CLIC G*
 - Studies on alignment features
 - Bonding quality



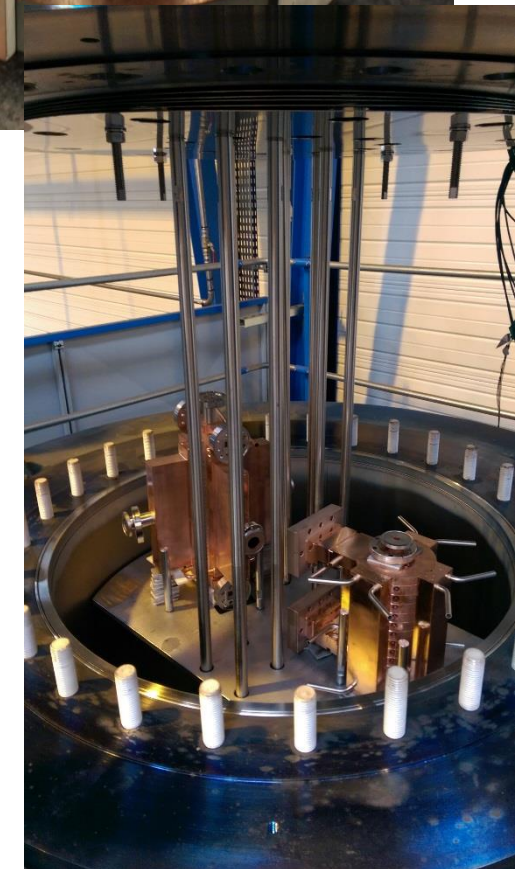
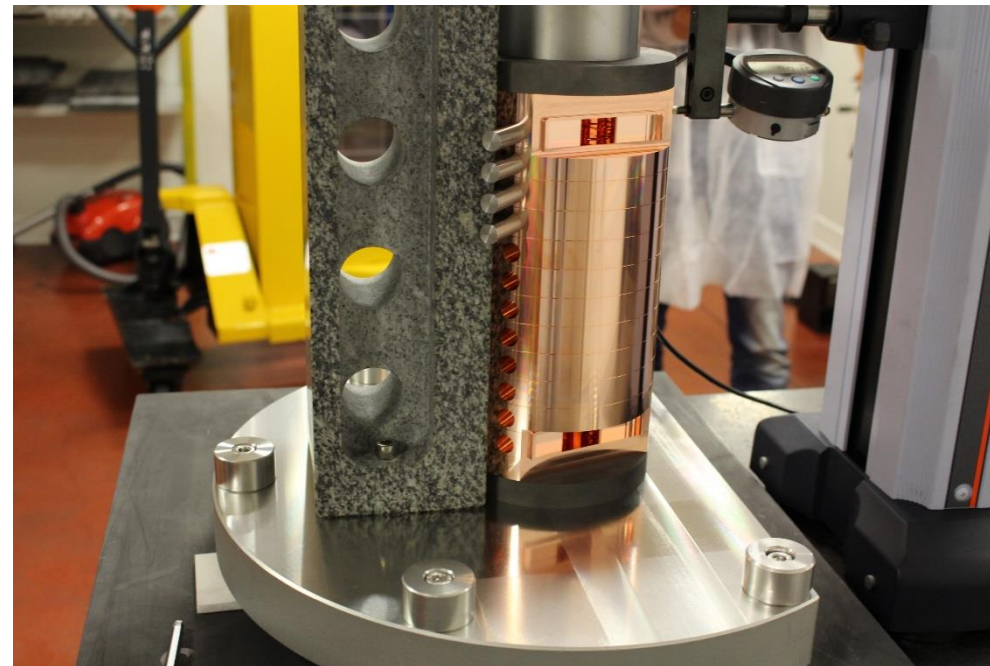
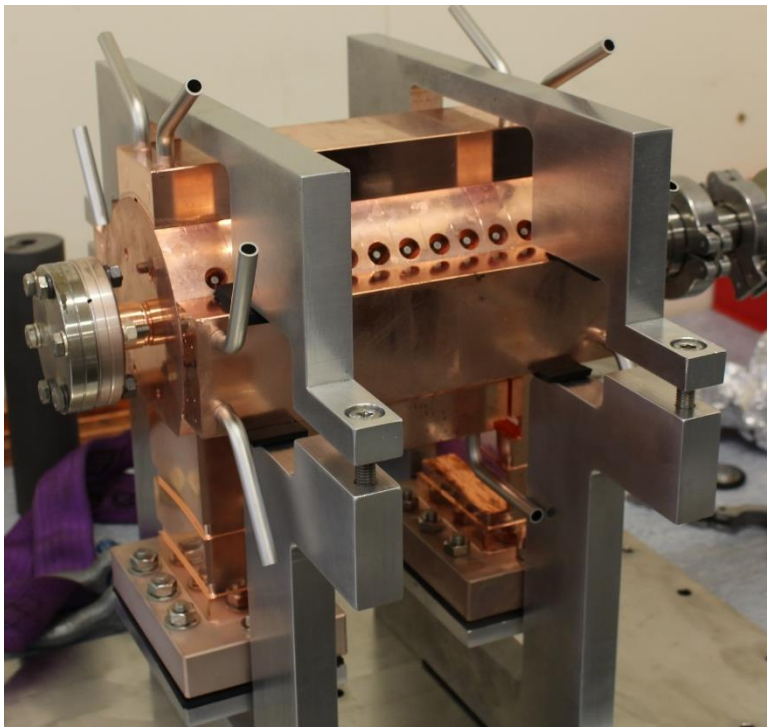
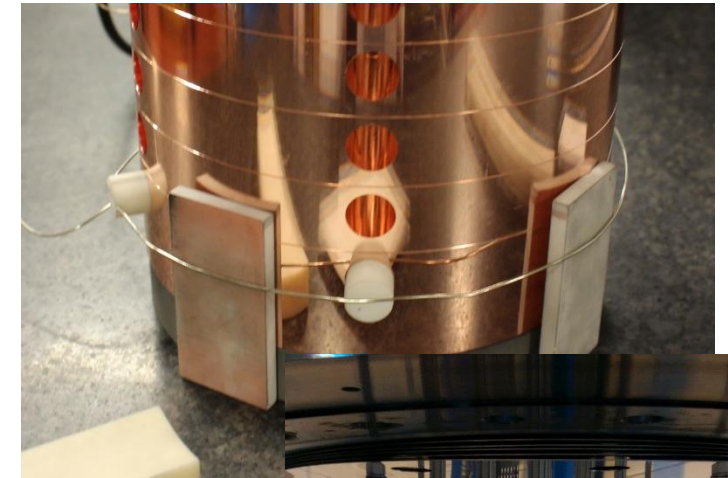
- Damped structure with SiC absorbers.
- Manifold covers Eb-welded successfully. No leaks observed
- Baked at the end of the year together with HGTW structure
- Fiducialization is next
- Ready for firsts tests in Xbox3



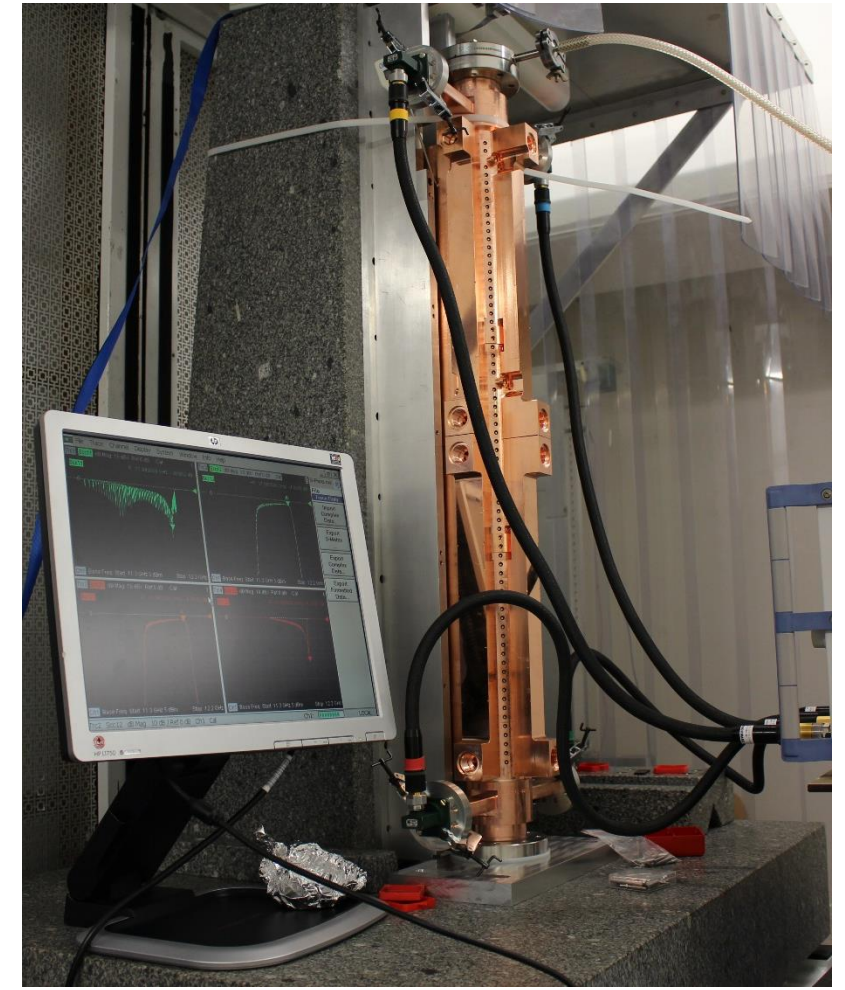
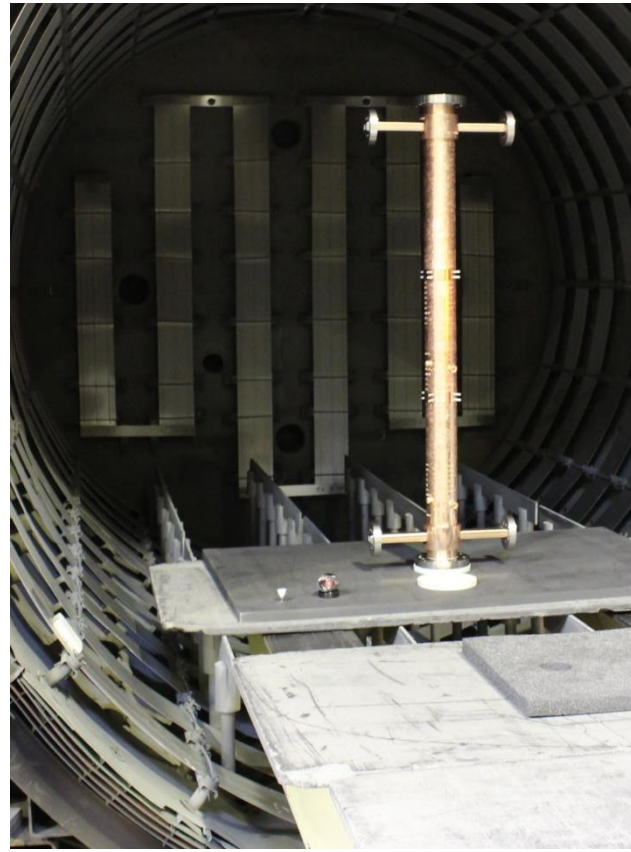
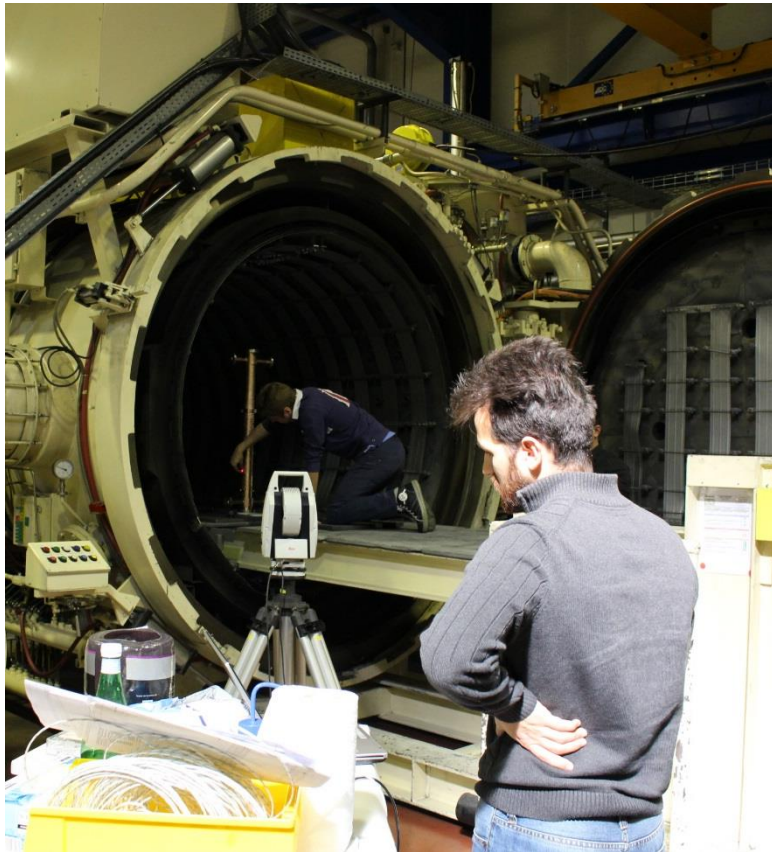


HGTW_N1 aka. KT_1

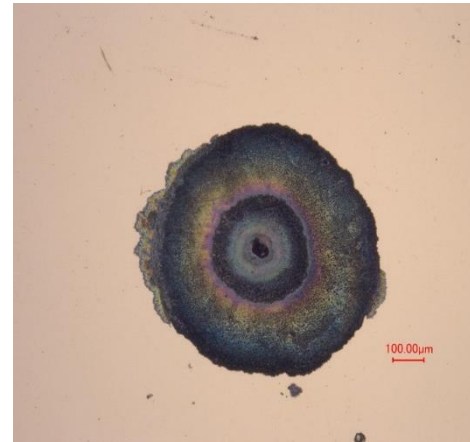
- 3 GHz travelling wave medical structure
- made with the same procedures and suppliers as CLIC prototypes
- Re-using most of the tooling
- Successfully completed at the end of 2015 and waiting now for tests
- Second structure being launched



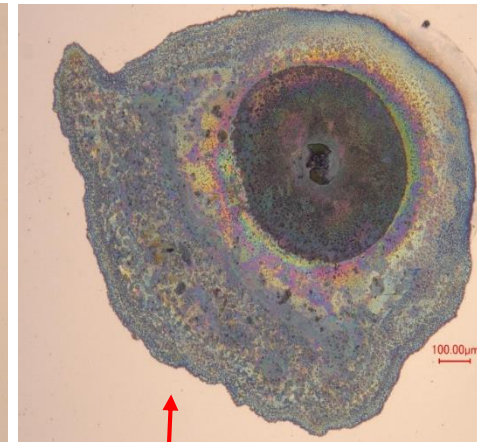
- Last linearizer structure for Elettra (spare) in the Elettra-PSI-CERN collaboration
- Alignment of both structures before brazing made in the oven
- Tuned and shipped to Trieste in October



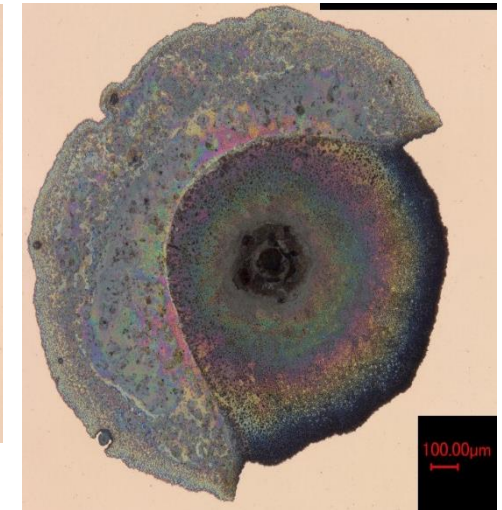
- Lots of visible spots after some months of storage
- Presence of Cl and oxidation
- Soft pickling removed the pollution with minimum impact on Ra
- Proceed with bonding
- Seen in all disks stored



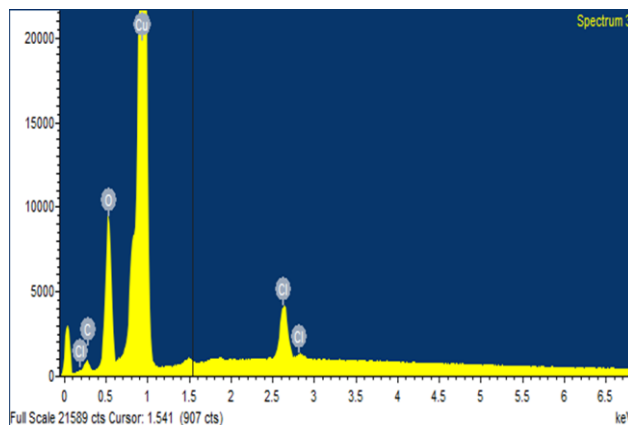
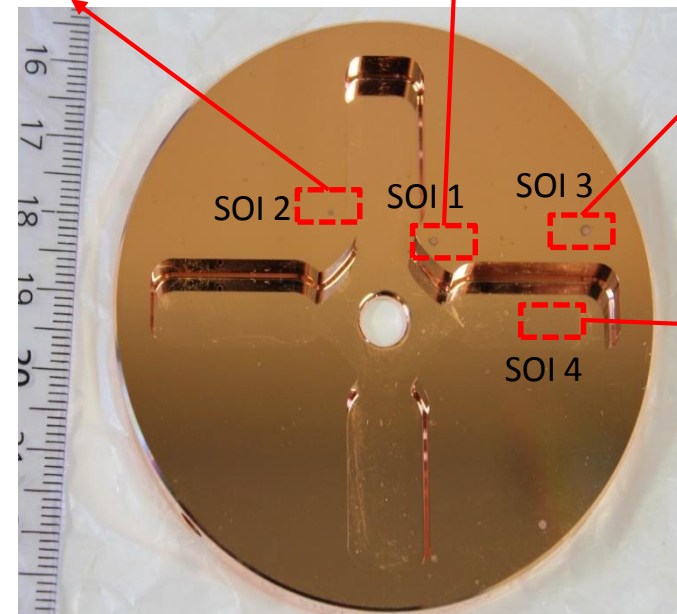
Digital microscope image 200x



Digital microscope image 200x



Digital microscope image 300x





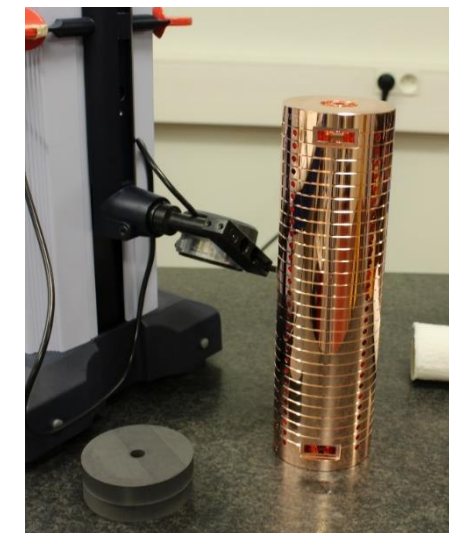
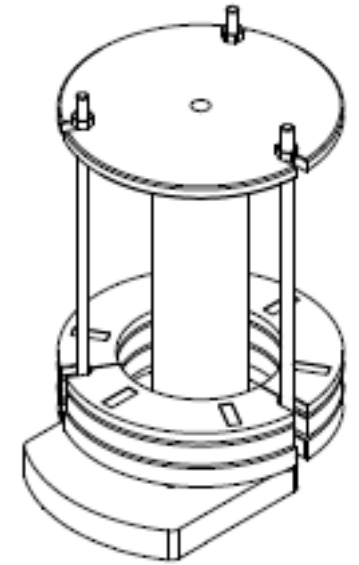
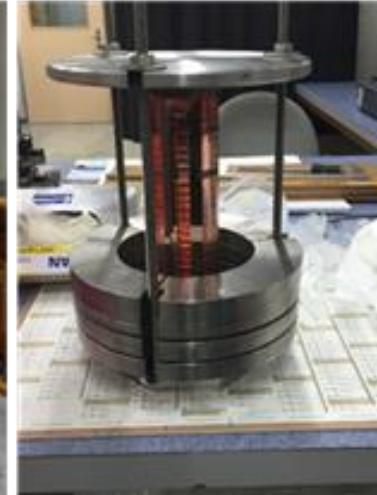
TD26CC_N3. New bonding tooling

- Made of DENSIMET®185. A high density tungsten alloy
- Machined to 10 micron flatness
- Allows for bonding the disk stack without leaving the preparation room
- Will be used for all future small prototypes

OLD

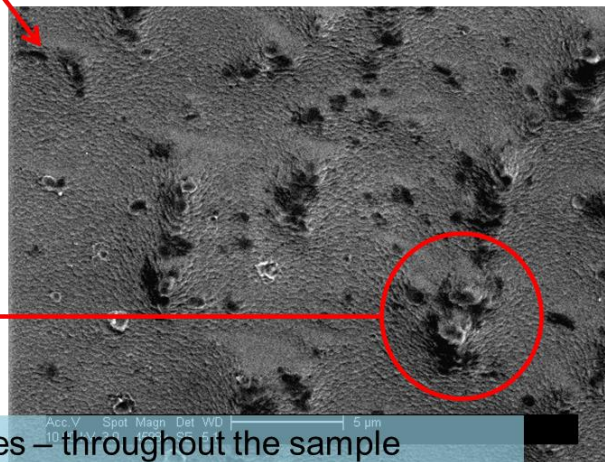
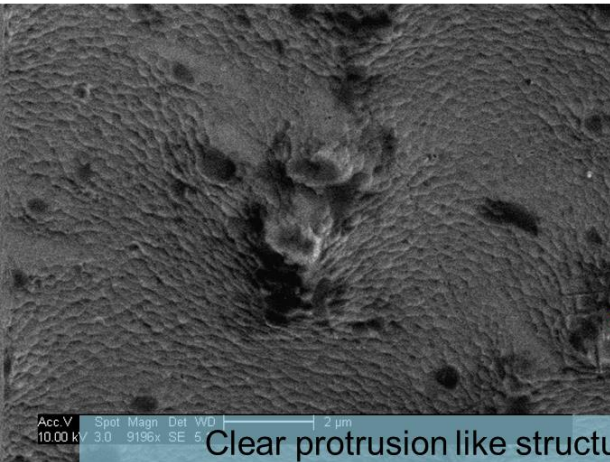
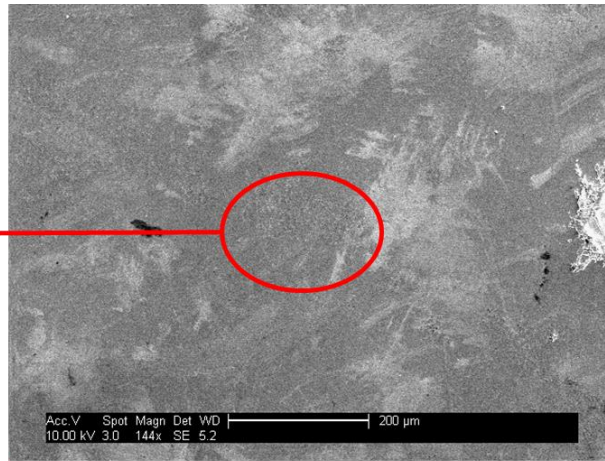
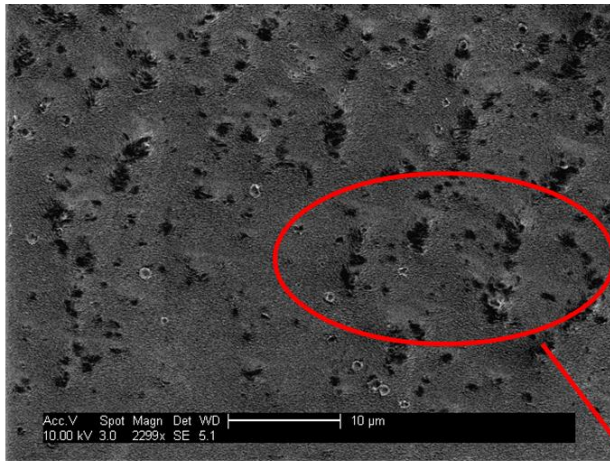


NEW



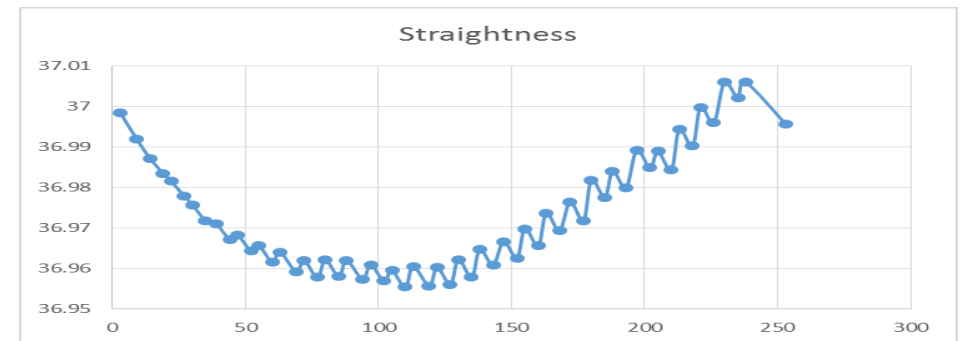
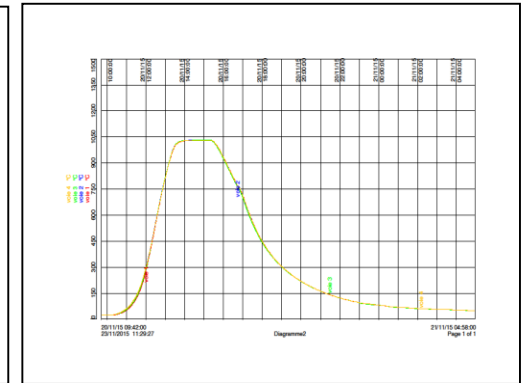
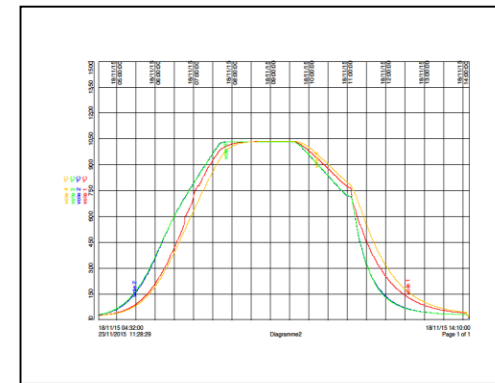


TD26CC_N3. Slow cooling



Clear protrusion like structures – throughout the sample

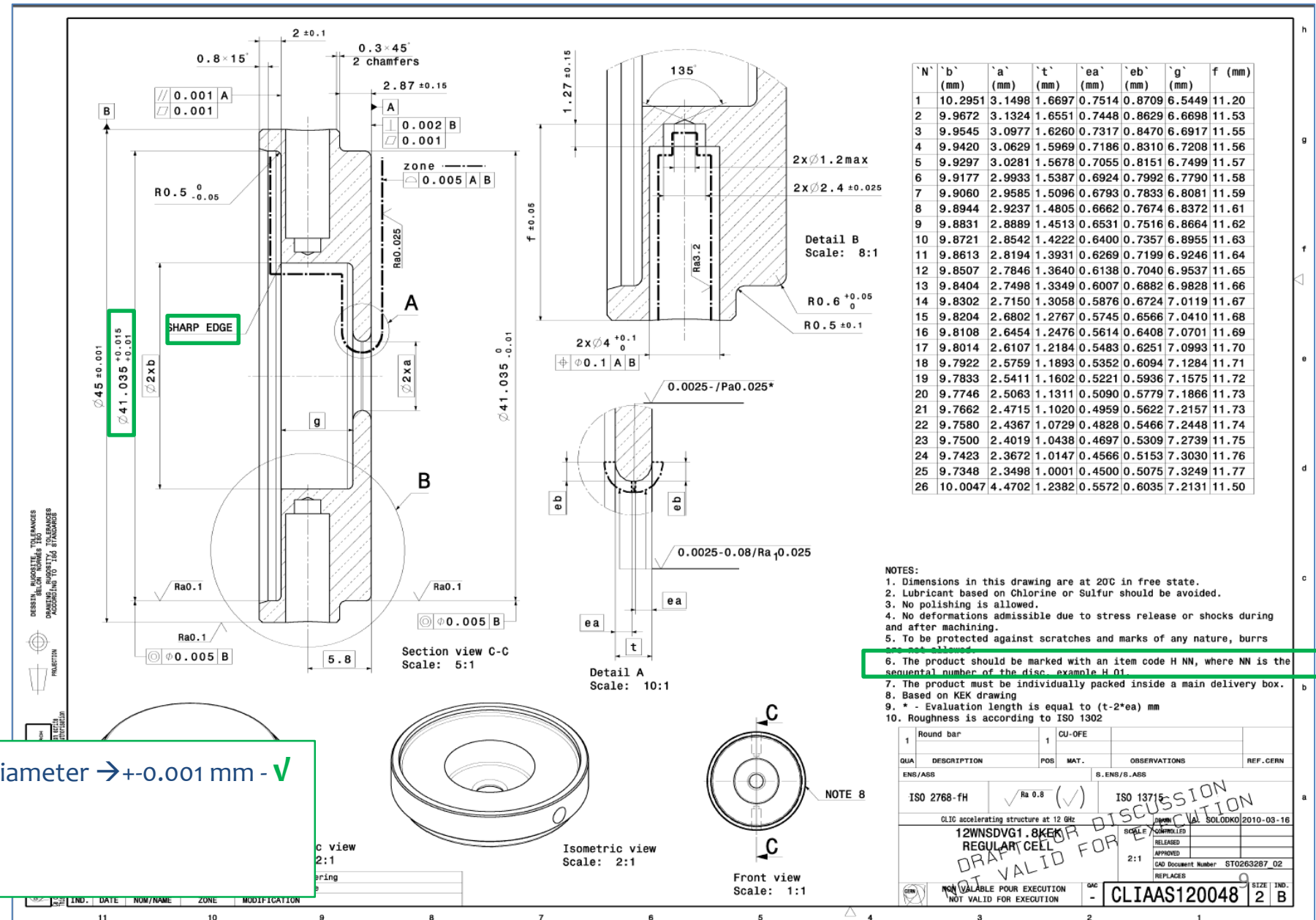
Bubbles observed in small cathode samples
May be due to the fast cooling after bonding
Slow cooling implemented for



First structure to undergo dimensional control after bonding in metrology

Heavy sagging observed!

- Based on the X-band AS review
- Two sets of disks under procurement



'N'	'b'	'a'	't'	'ea'	'eb'	'g'	f (mm)
1	10.2951	3.1498	1.6697	0.7514	0.8709	6.5449	11.20
2	9.9672	3.1324	1.6551	0.7448	0.8629	6.6698	11.53
3	9.9545	3.0977	1.6260	0.7317	0.8470	6.6917	11.55
4	9.9420	3.0629	1.5969	0.7186	0.8310	6.7208	11.56
5	9.9297	3.0281	1.5678	0.7055	0.8151	6.7499	11.57
6	9.9177	2.9933	1.5387	0.6924	0.7992	6.7790	11.58
7	9.9060	2.9585	1.5096	0.6793	0.7833	6.8081	11.59
8	9.8944	2.9237	1.4805	0.6662	0.7674	6.8372	11.61
9	9.8831	2.8889	1.4513	0.6531	0.7516	6.8664	11.62
10	9.8721	2.8542	1.4222	0.6400	0.7357	6.8955	11.63
11	9.8613	2.8194	1.3931	0.6269	0.7199	6.9246	11.64
12	9.8507	2.7846	1.3640	0.6138	0.7040	6.9537	11.65
13	9.8404	2.7498	1.3349	0.6007	0.6882	6.9828	11.66
14	9.8302	2.7150	1.3058	0.5876	0.6724	7.0119	11.67
15	9.8204	2.6802	1.2767	0.5745	0.6566	7.0410	11.68
16	9.8108	2.6454	1.2476	0.5614	0.6408	7.0701	11.69
17	9.8014	2.6107	1.2184	0.5483	0.6251	7.0993	11.70
18	9.7922	2.5759	1.1893	0.5352	0.6094	7.1284	11.71
19	9.7833	2.5411	1.1602	0.5221	0.5936	7.1575	11.72
20	9.7746	2.5063	1.1311	0.5090	0.5779	7.1866	11.73
21	9.7662	2.4715	1.1020	0.4959	0.5622	7.2157	11.73
22	9.7580	2.4367	1.0729	0.4828	0.5466	7.2448	11.74
23	9.7500	2.4019	1.0438	0.4697	0.5309	7.2739	11.75
24	9.7423	2.3672	1.0147	0.4566	0.5153	7.3030	11.76
25	9.7348	2.3498	1.0001	0.4500	0.5075	7.3249	11.77
26	10.0047	4.4702	1.2382	0.5572	0.6035	7.2131	11.50

- NOTES:
1. Dimensions in this drawing are at 20C in free state.
 2. Lubricant based on Chlorine or Sulfur should be avoided.
 3. No polishing is allowed.
 4. No deformations admissible due to stress release or shocks during and after machining.
 5. To be protected against scratches and marks of any nature, burrs ~~are not allowed~~
 6. The product should be marked with an item code H NN, where NN is the sequential number of the disc example H 01
 7. The product must be individually packed inside a main delivery box.
 8. Based on KEK drawing
 9. * - Evaluation length is equal to (t-2*ea) mm
 10. Roughness is according to ISO 1302

1. Tolerance on the external diameter → $+0.001$ mm - ✓
2. Sharp edge - ✓
3. Numbering: short name - ✓
4. Interlocking - ✗

1	Round bar	1	CU-OFE		
QUA	DESCRIPTION	POS	MAT.	OBSERVATIONS	REF. CERN
ENS/ASS				S. ENS/S. ASS	
	ISO 2768-FH		✓ Ra 0.8 (✓)	ISO 13715	
CLIC accelerating structure at 12 GHz					
12WSDVG1.8KEK					
REGULAR CELL					
SCALE: 1:1					
APPROVED					
RELEASED					
2:1					
CAD Document Number: ST0263287_02					
REPLACES					
NON VALIDABLE POUR EXECUTION					
NOT VALID FOR EXECUTION					
CLIAAS120048				SIZE	IND.
				2	B

- Three firms qualified for full assembly of disks into one structure based on:
 - Hydrogen partial or total pressure capability
 - Clean environment
 - Technical visit
 - Oven pollution tests
- Call for tender launched in November
- All parts ready for assembly
- Expect some technology transfer work.

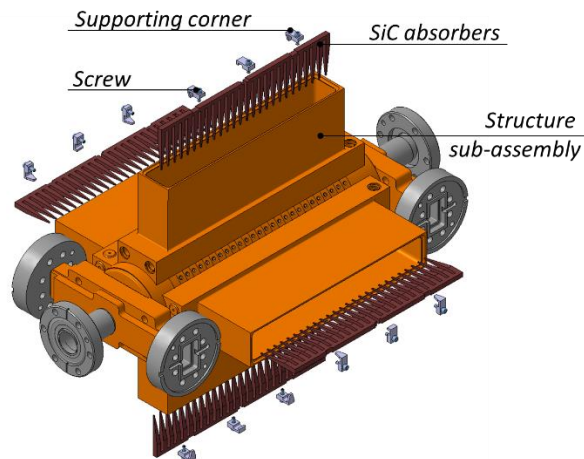
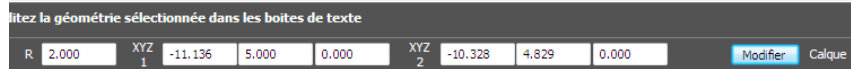
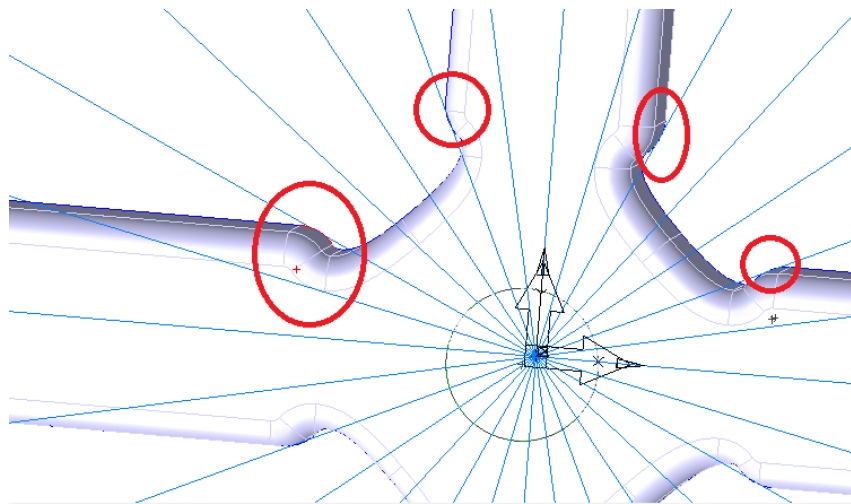


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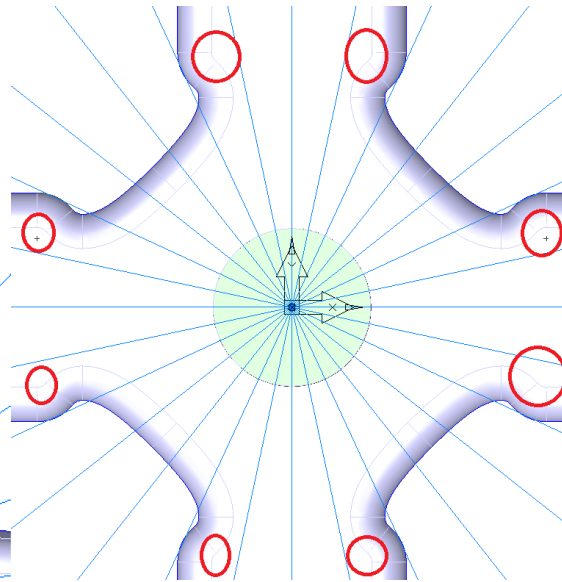
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Bottom limiting radius (1,5;1;0,5;0;0)

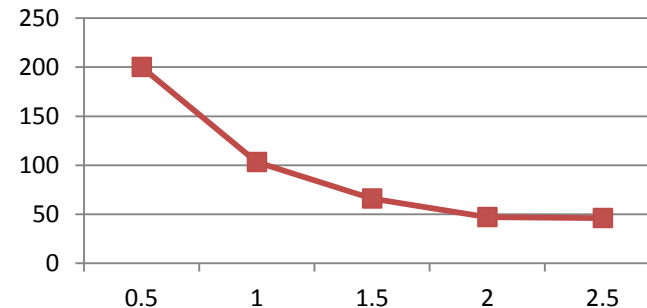
Studied wall radius (0,5;1;1,5;2;2,5)



Corner radius 2mm



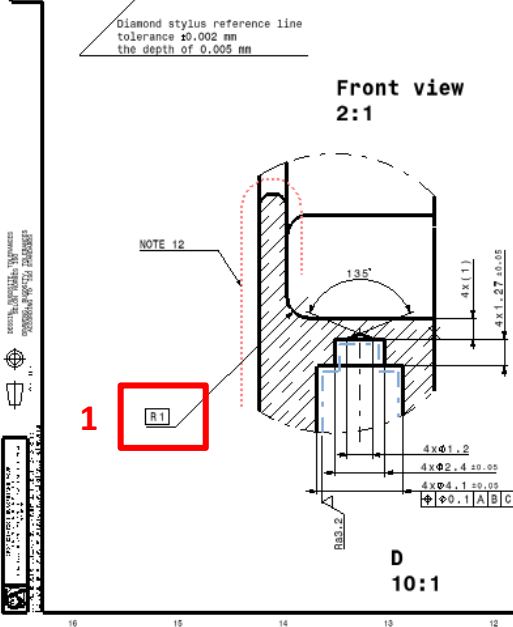
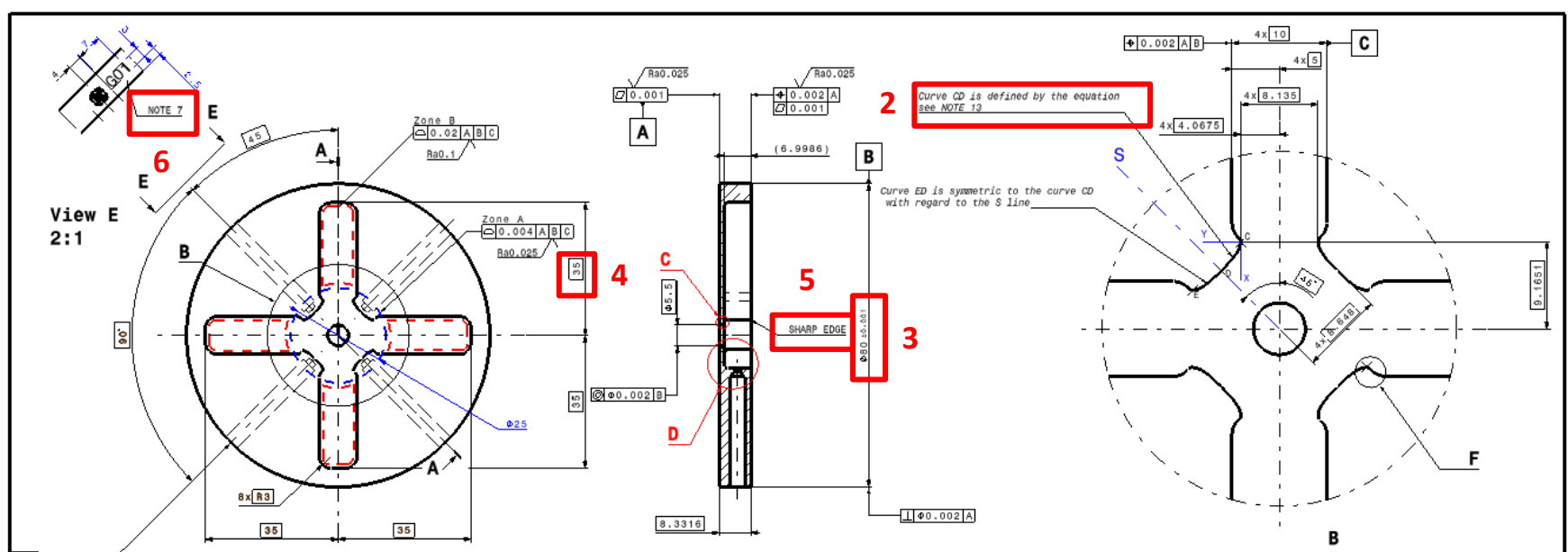
Machining time



- Optimization of the radius in the disk RF design to minimize
 - Machining time
 - Machining costs
 - Disk yield
- Decided on a bottom radius of 0.1 mm



New CLIC-G* TD26 R1 CC mechanical design



N	Modification	TD26 CC R0.5
1	R1 mm	R0.5 mm
2	Cell geometry given by the equation	Ellipse
3	Ø80 mm → Ø83 mm (see next slide)	Ø74 mm
4	70 mm waveguides	64 mm waveguides
5	Sharp edge	R0.02 mm
6	Short name	Drawing name

NOTES:

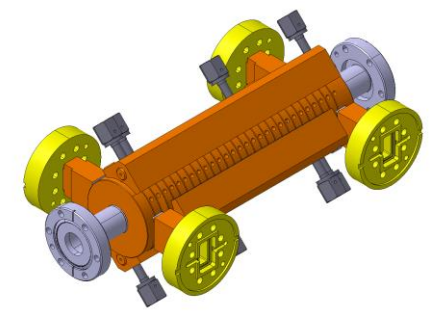
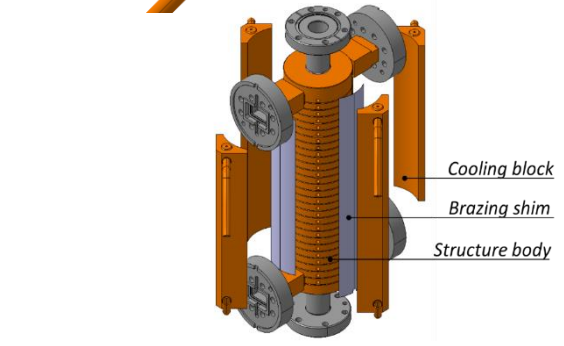
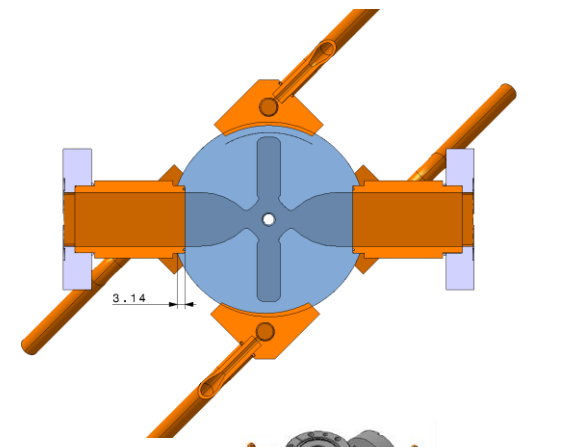
- Dimensions which are not visible on the drawing should be extracted from the 3d-model.
- Dimensions in this drawing are at 20°C.
- Measurement of the disc has to be done as machined in a vacuum chuck. The dimensions and tolerances which have to be measured and documented are specified in the drawing CLIAAS120216.
- Lubricant based on Chlorine or Sulfur should be avoided. No polishing is allowed.
- No deformations admissible due to stress release or shocks during and after machining.
- Any heat treatment for stress relief purpose shall be done in a vacuum furnace.
- The product should be marked with the item code G 01.
- To be protected against scratches and marks of any nature, burrs are not allowed.
- The product must be individually packed inside a main delivery box.
- - Evaluation length is equal to 0.133 mm.
- Roughness is according to ISO 1302.
- The turning of the iris is extended until the beginning of the damping waveguide (specified by shown in Detail D). The step up to 0.002 mm between milled and turned zones is allowed.
- The curve is defined by the equation. The control points are presented in the table.

$$Y = 2.0476 + (X - 3.05) + \left(\frac{X}{3.05} - 1\right) \left(1.0024 - 1.0452 \frac{X}{3.05} + 0.184 \frac{X^2}{3.05} \right)$$

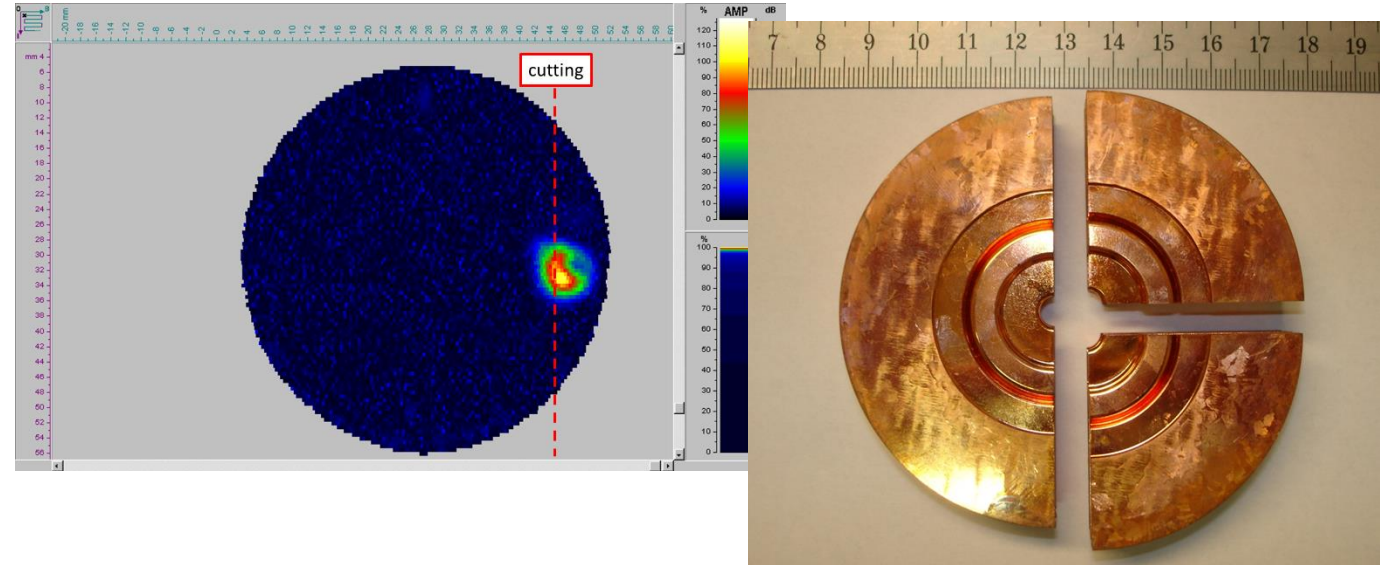
Coordinate table

REF.	Y	X
C	0	0
D	2.0476	3.05

ROUND BAR Ø85	20.220.00	44.00.47
ROUND BAR	Ø276 Ø100	Ø22.4
ISO 2768-M	√	ISO 2715
CLIC G DISC NEW GEOMETRY		
NON VALABLE POUR EXECUTION NOT VALID FOR EXECUTION		
CLIAAS120215		



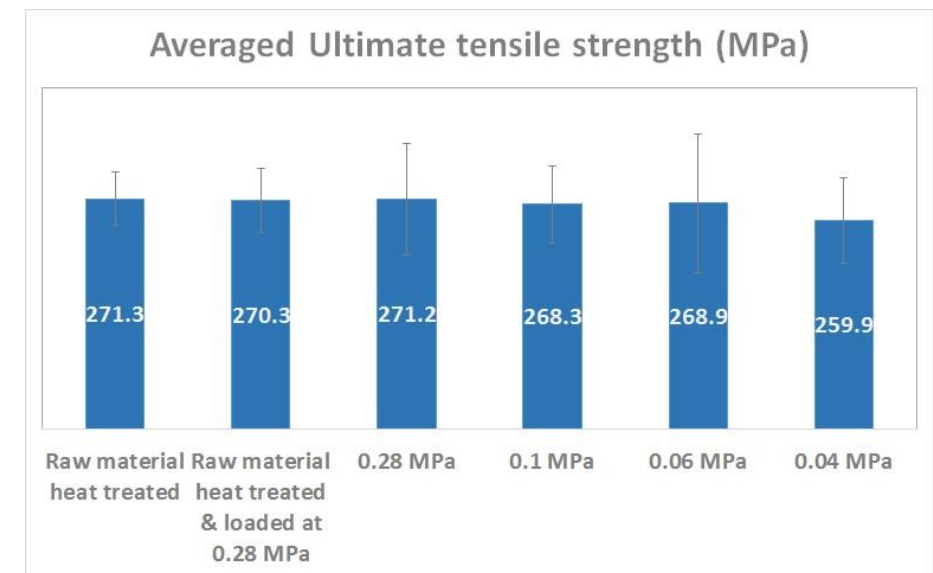
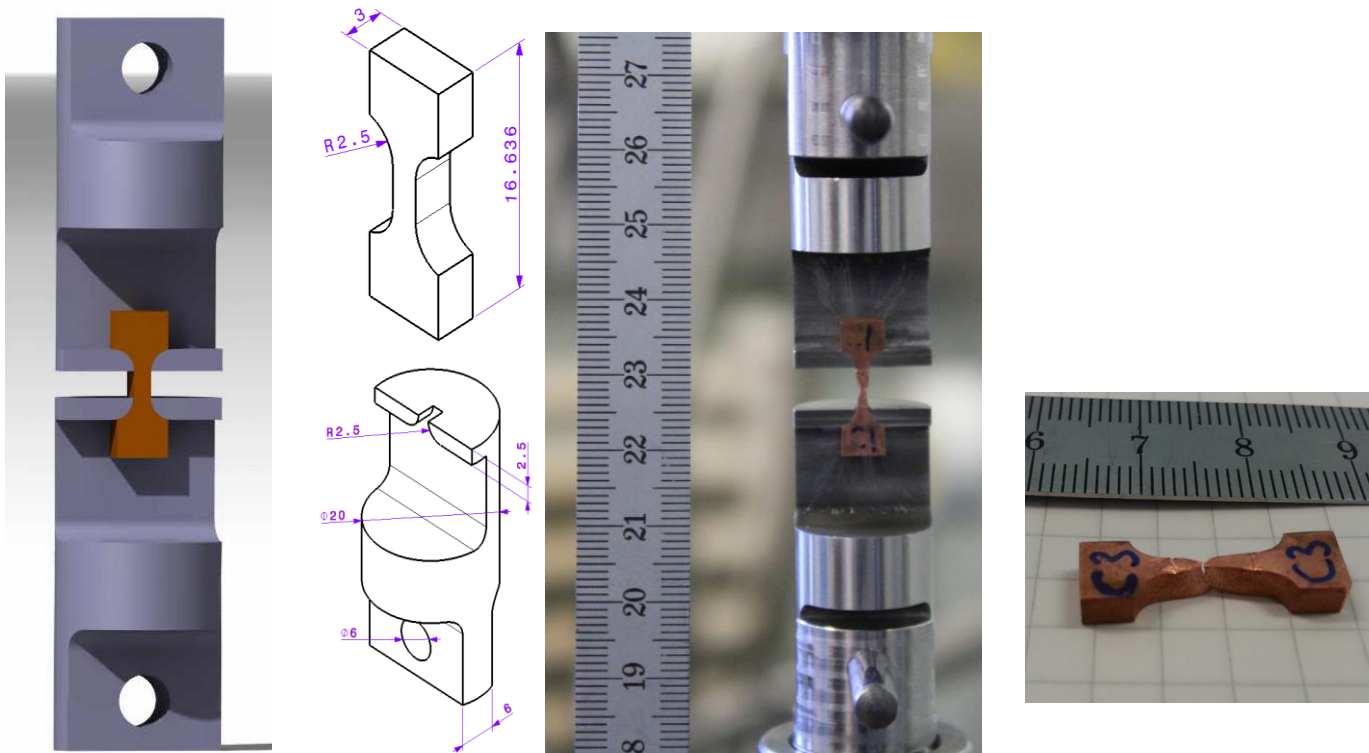
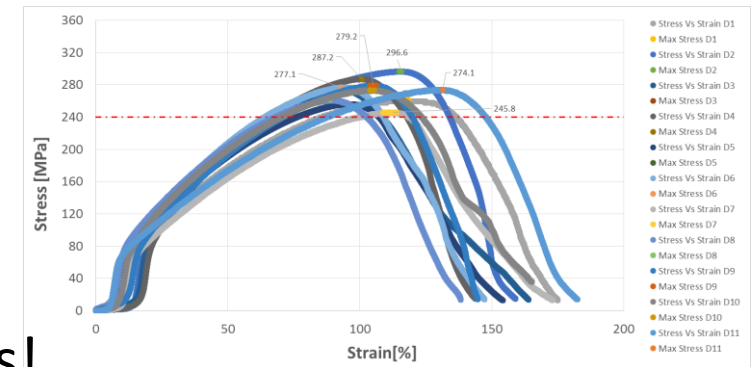
- Bonding quality in the past judged from ultra sound
 - Quantitatively no decisive
 - Very dependent on initial settings
 - Info used for destructive tests



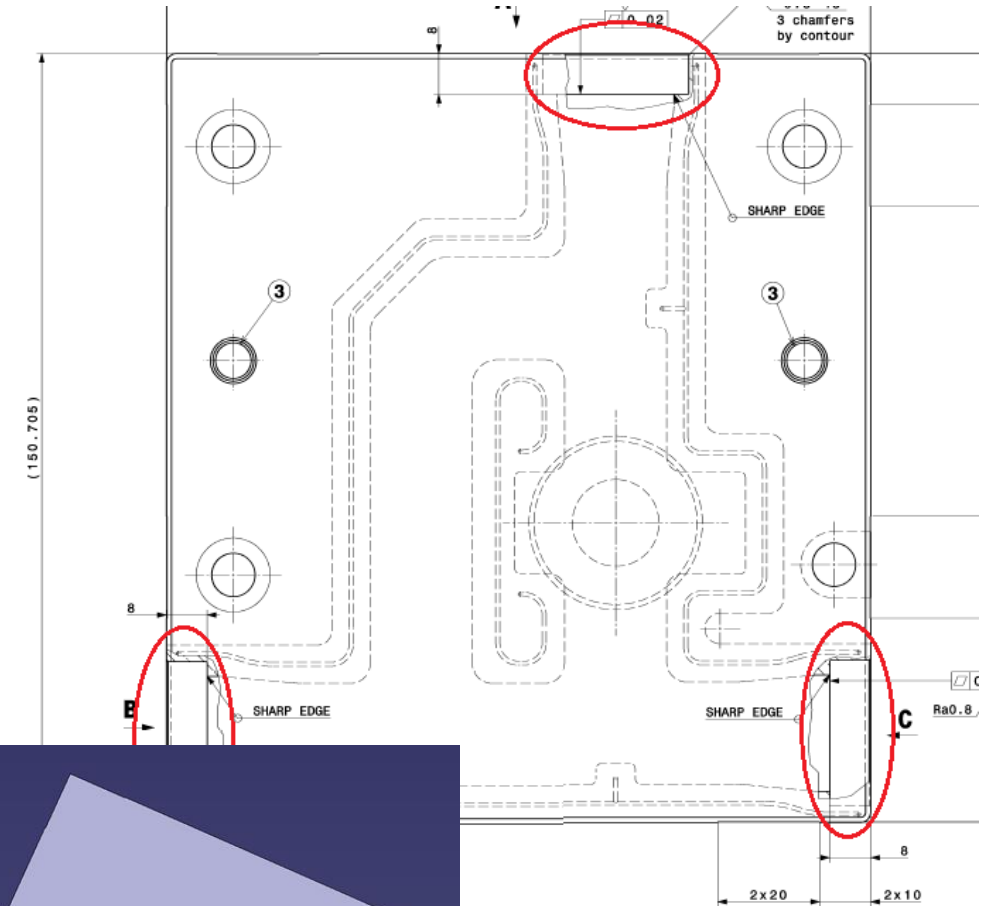
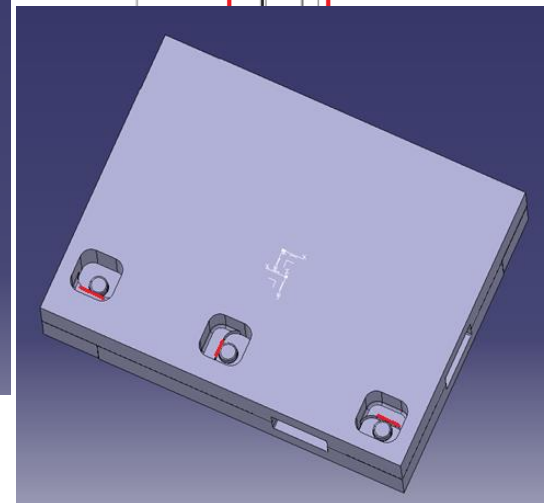
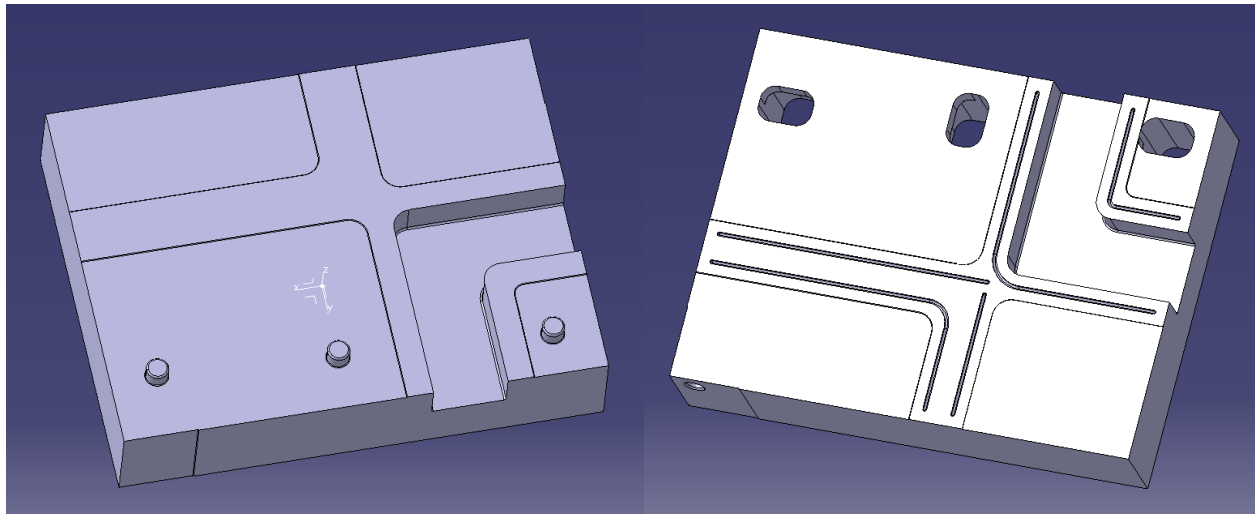
- Cutting the sample and observing it in the microscope
- Time and resource consuming
- Crossing/non crossing grains used as ultimate measure

- Tensile tests used to quantitatively assess bonding quality
- Comparison with raw and heat treated copper
- Average tensile strength is similar for all bonded samples
- Spread increases for bonded samples

Bonding quality is good in all cases!



- Ensure perfect alignment of components and structures made from halves
 - Improve performance by minimizing steps
 - Avoid re-machining of the waveguides
 - Relaxing tolerances in external surfaces





Conclusions and future

- Steady production of CLIC prototypes
 - Introducing functional changes in the already existing structures
 - Quality assurance improved.
 - Feedback on design
- Procurement of disk re-started
 - 2 new T24 prototypes under procurement
- Assembly fully outsourced to industry
 - Full technical specifications
 - Call for tender launched to qualified companies
- New CLIC G* prototype mechanical design and procurement for 2016
- On-going studies for structures and components
 - Cu-SiC joining, Additive methods
- Increasing industrial involvement in fabrication
 - Machining, forming, brazing, coatings, joining, assembly, etc.