# High gradient structure fabrication pipeline and trends

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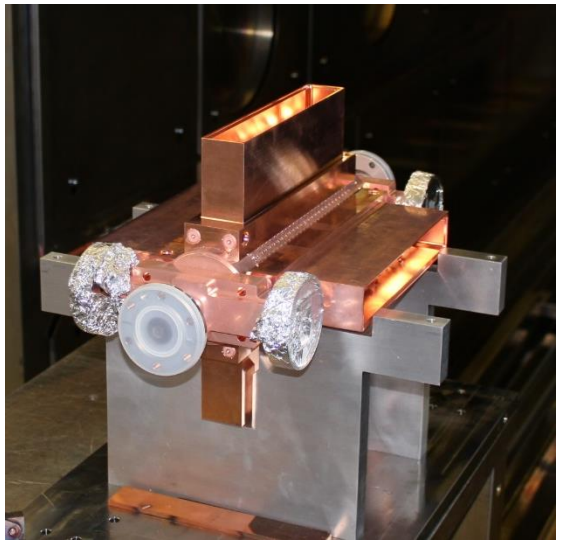
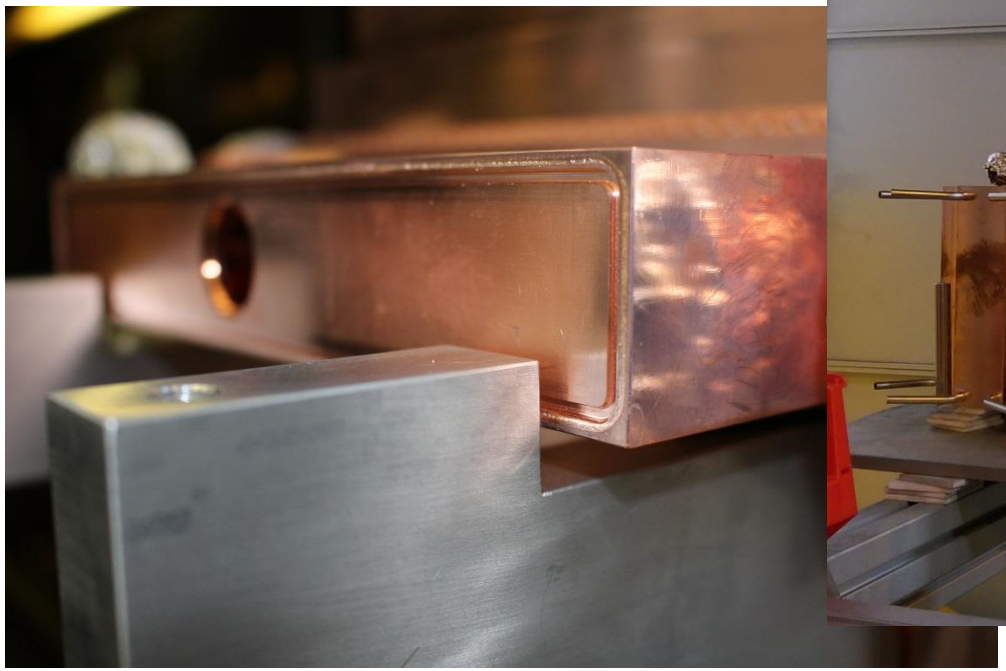
# Outline

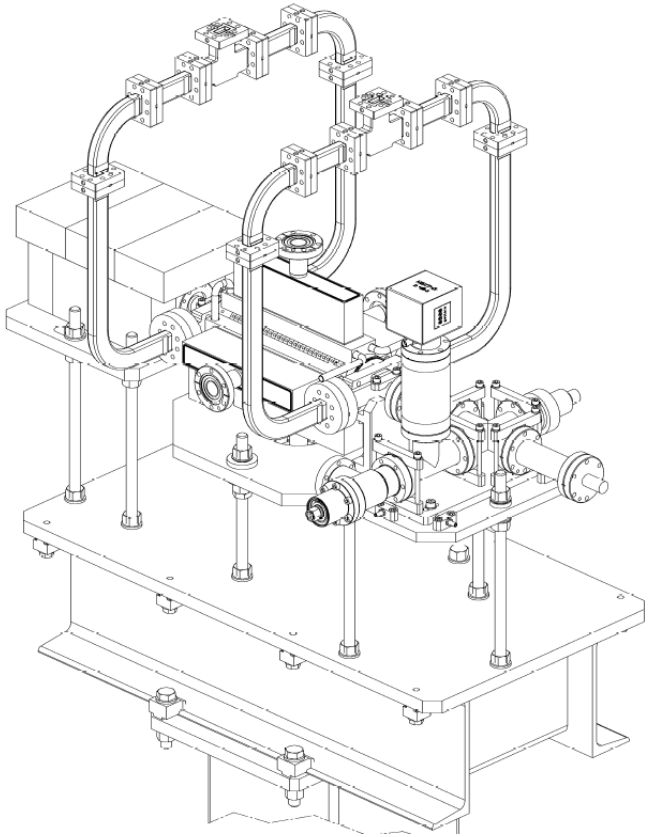
- Structures produced in 2015
  - PSI N5.
  - TD24_SiC.
  - TD26CC_2.
  - HGTW_1.
- Structures under fabrication
  - TD26CC_N3.
  - TD24R05_SiC_2.
  - HGTW_2
  - T24_4/5.
- Trends
  - CLIC G*
  - Studies on alignment features
  - Bonding quality

# TD24R05_SiC_1



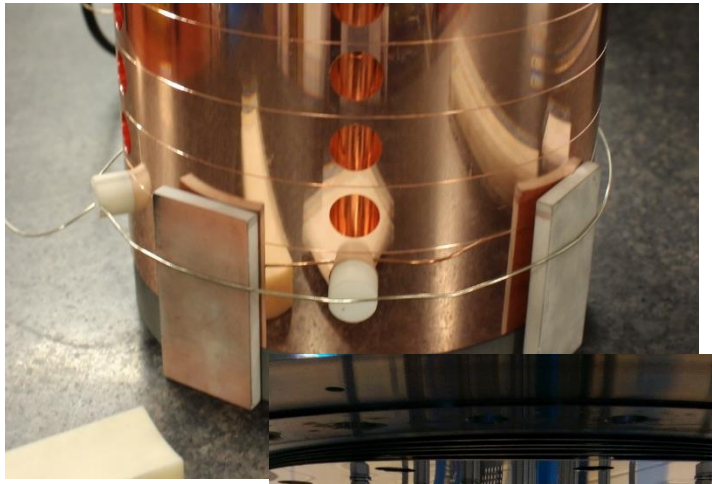
- Damped structure with SiC absorbers.
- Manifold covers Eb-welded successfully. No leaks observed
- Baked at the end of the year together with HGTW structure
- Fiducialization is next
- Ready for firsts tests in Xbox3

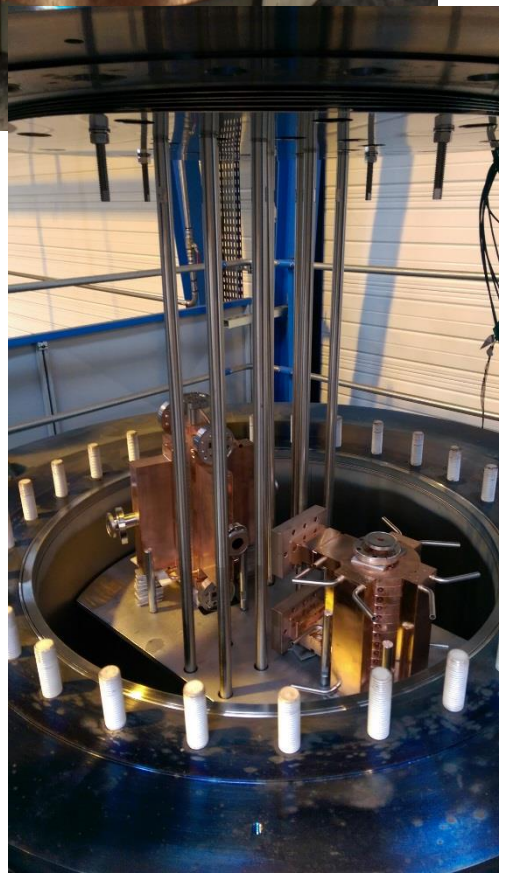


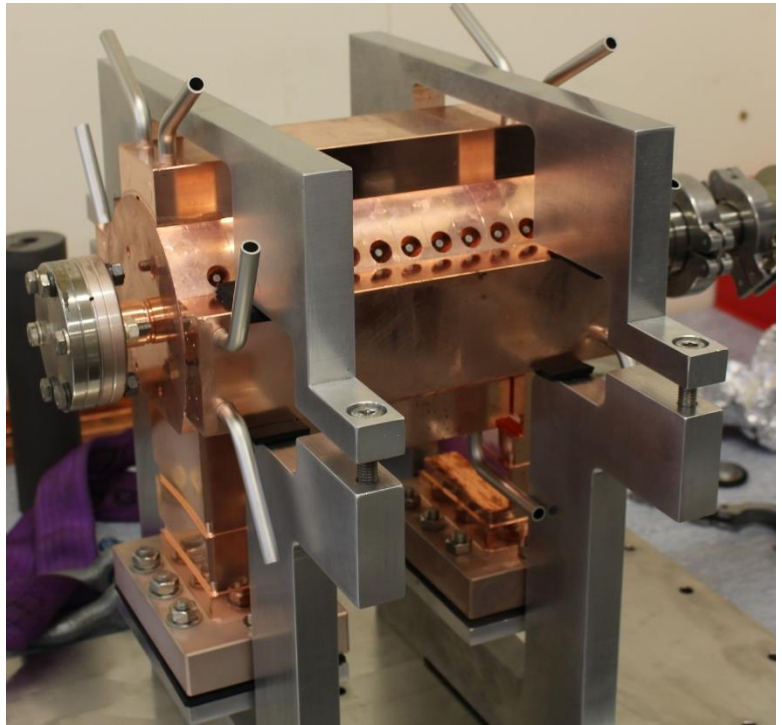


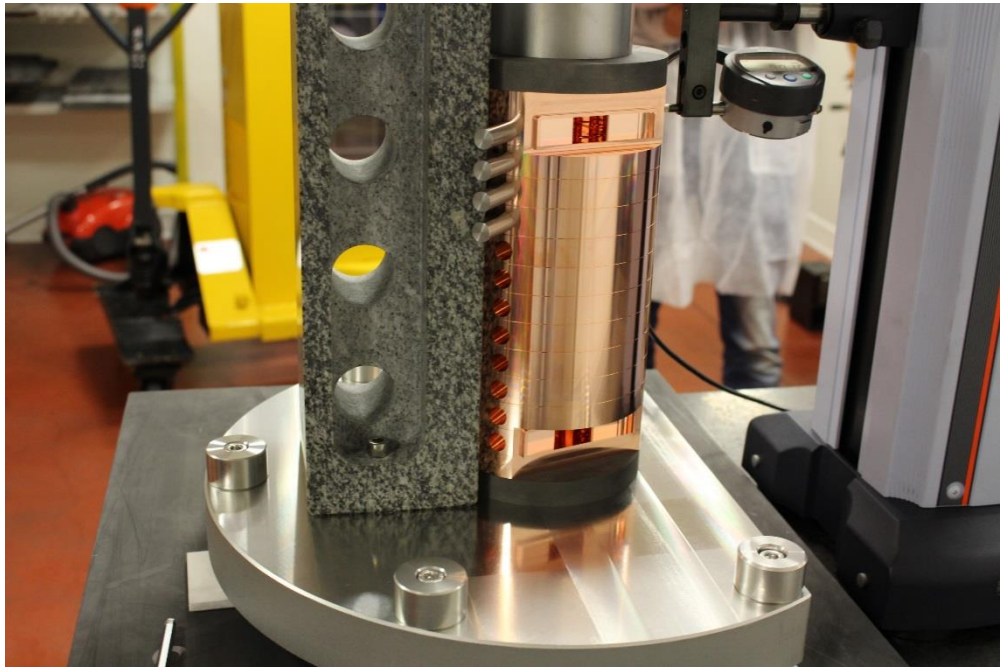
# HGTW_N1 aka. KT_1

- 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



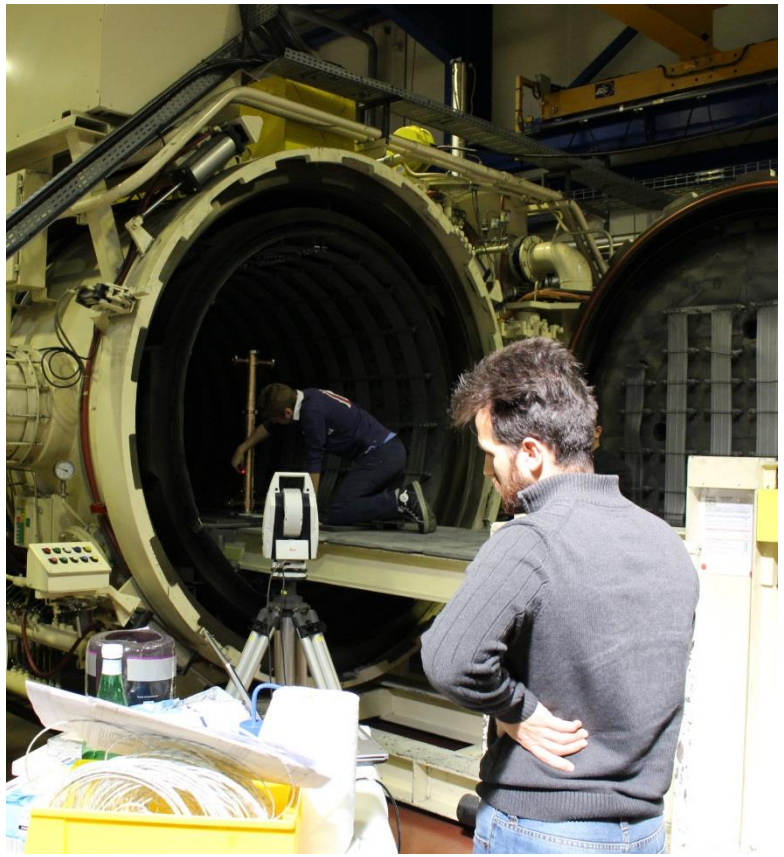


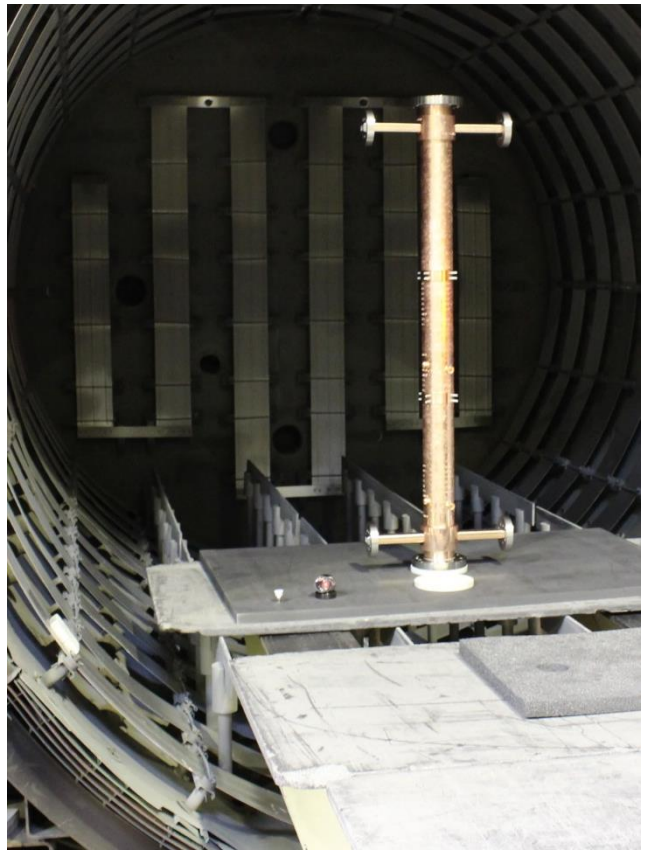


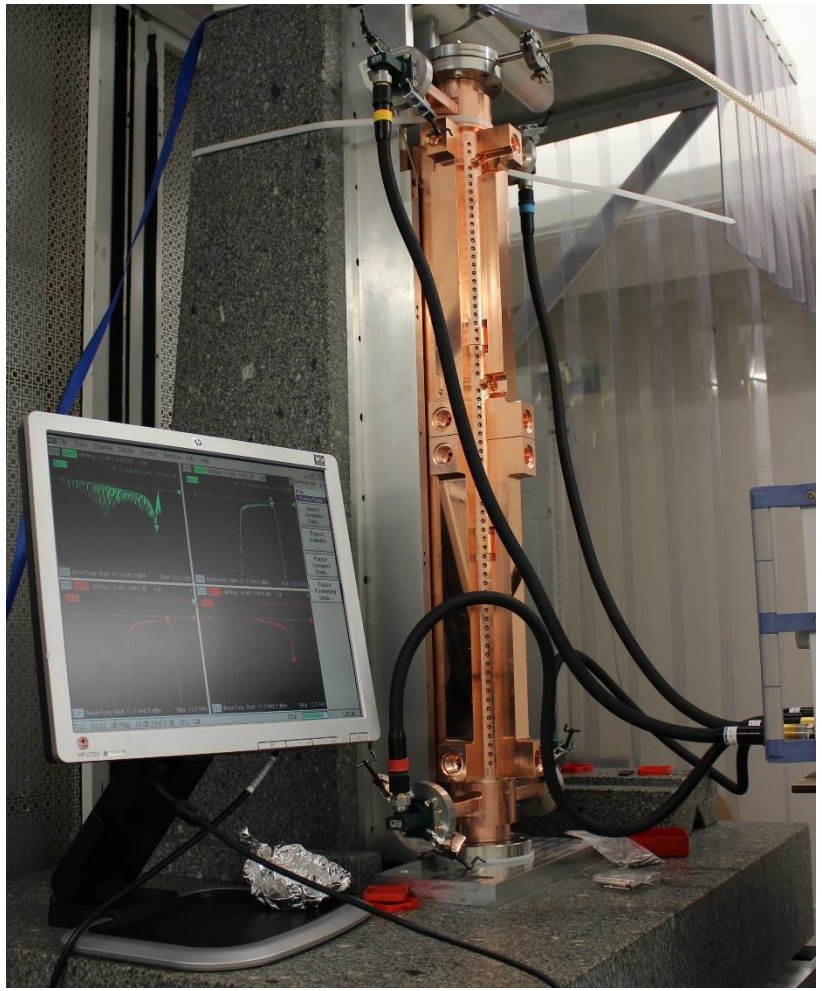


# PSI_N5

- 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

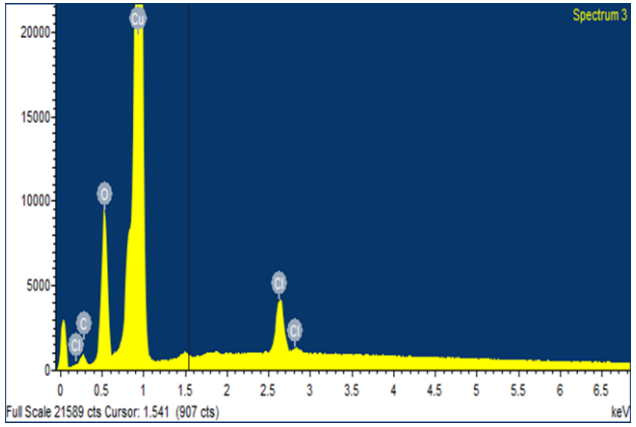


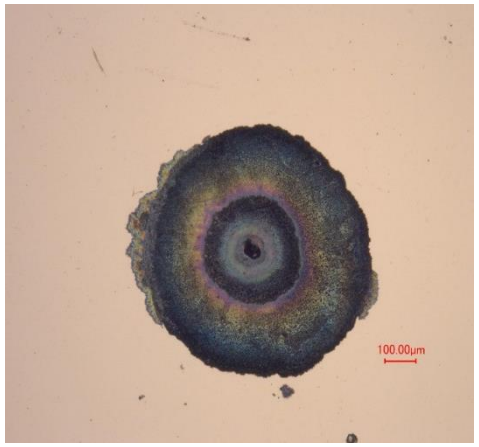




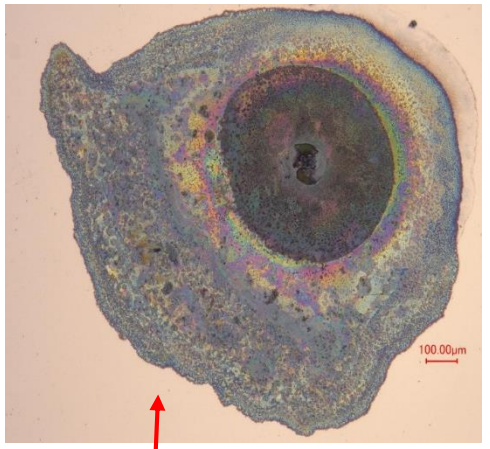
# TD26CC_N3. Disk surface quality

- 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

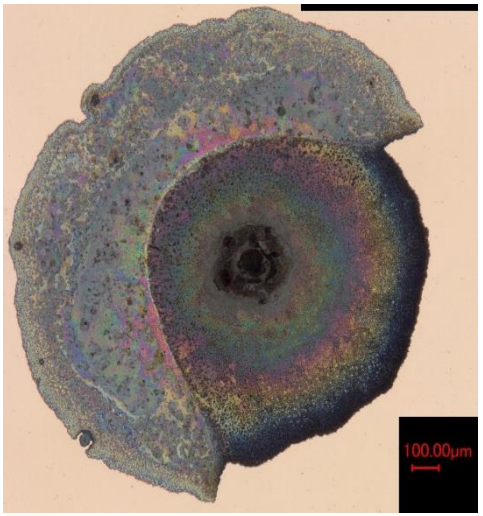


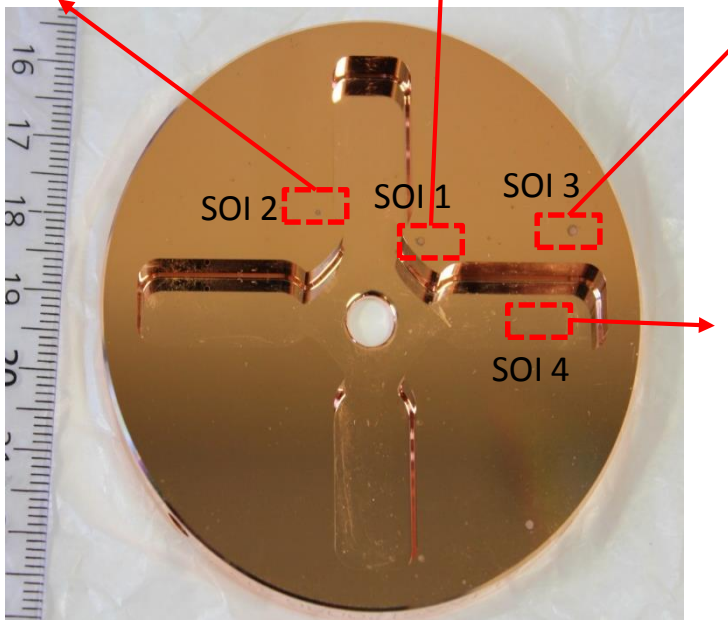

*Digital microscope image 200x*




*Digital microscope image 200x*

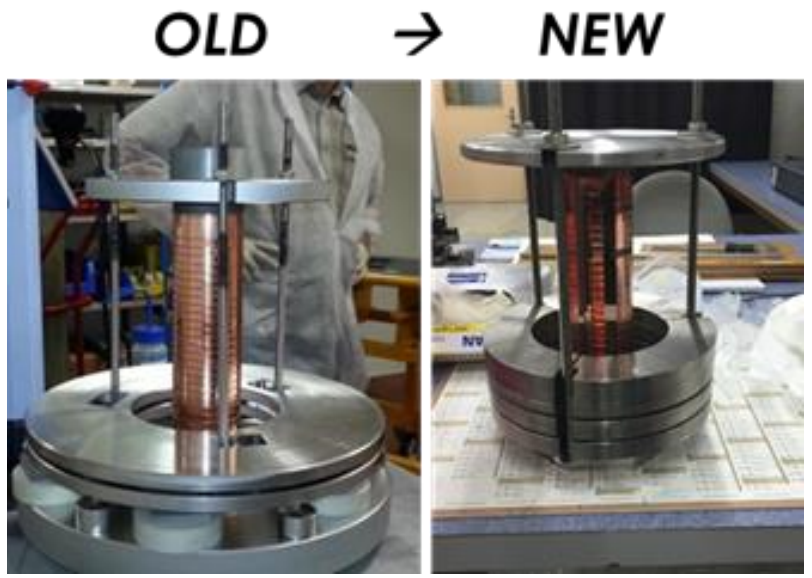


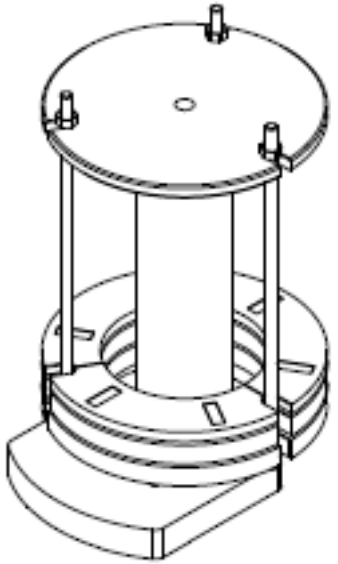

*Digital microscope image 300x*

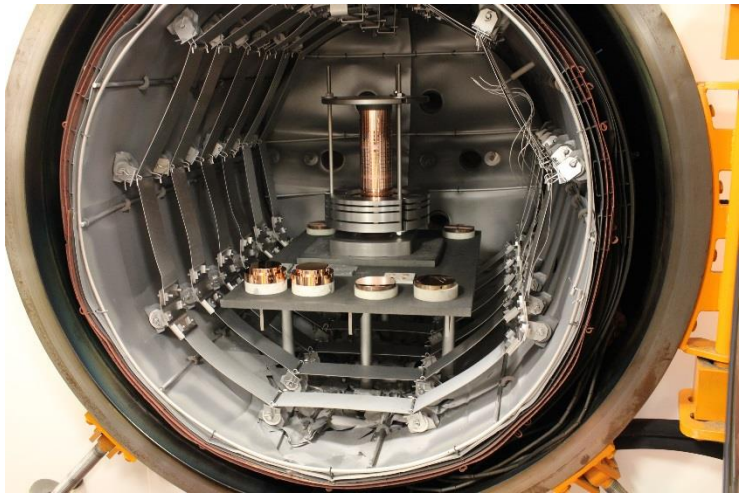


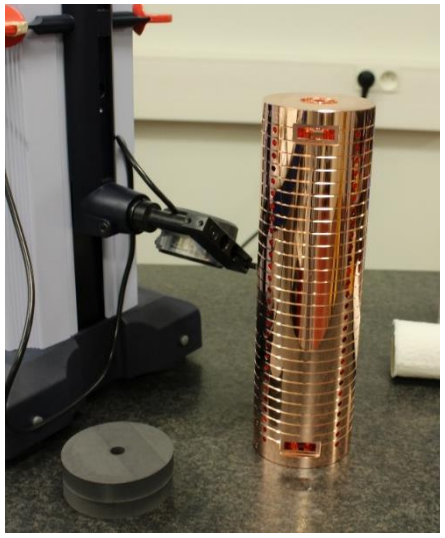

# TD26CC_N3. New bonding tooling

- 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

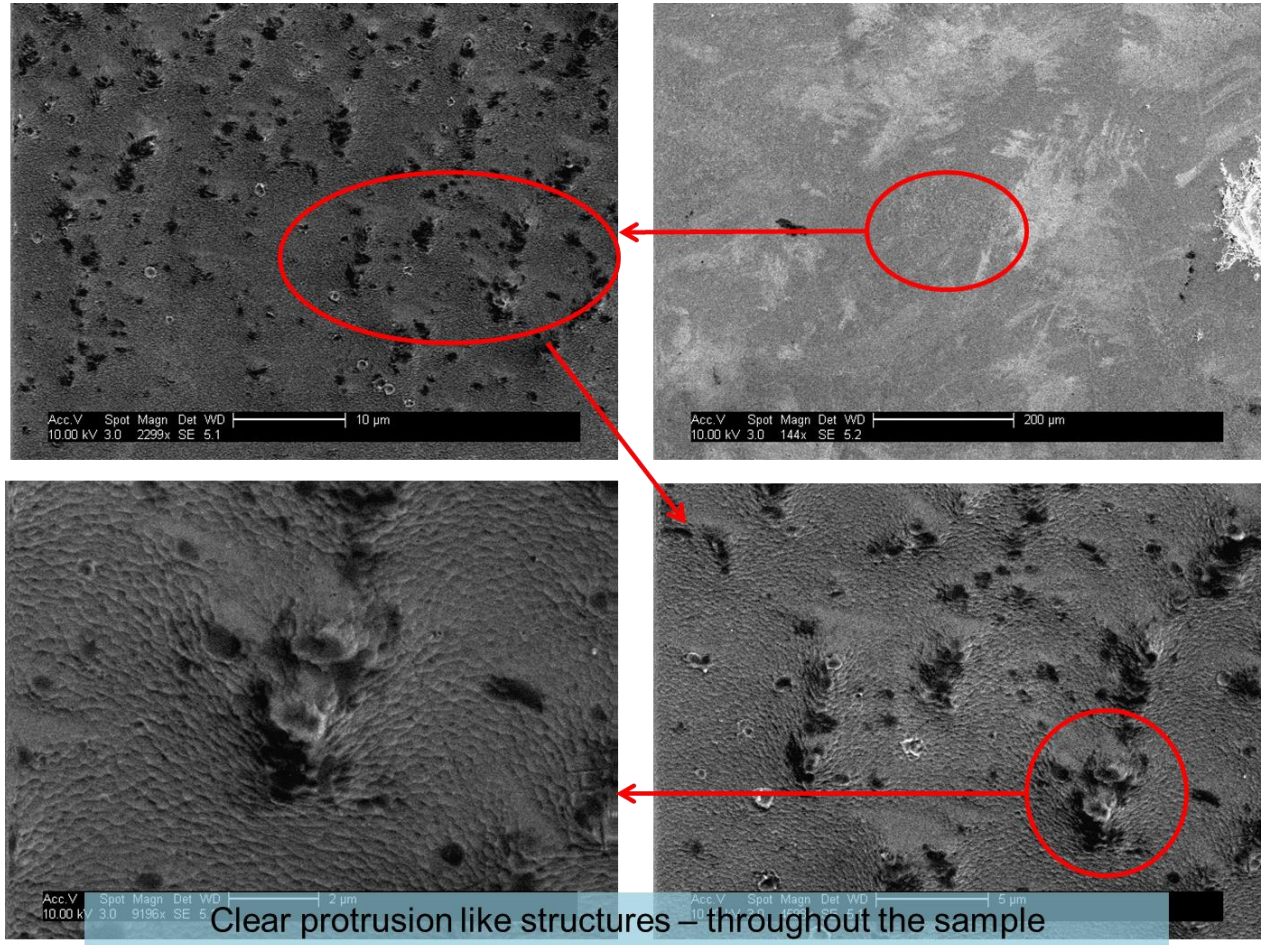






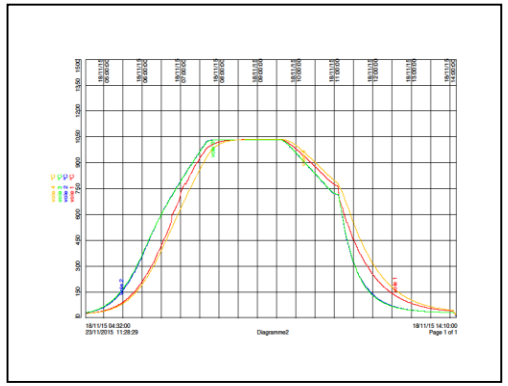
# TD26CC_N3. Slow cooling

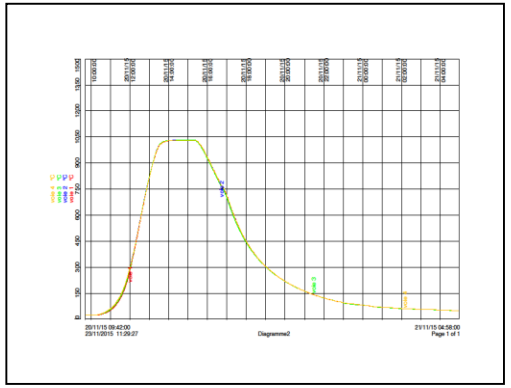


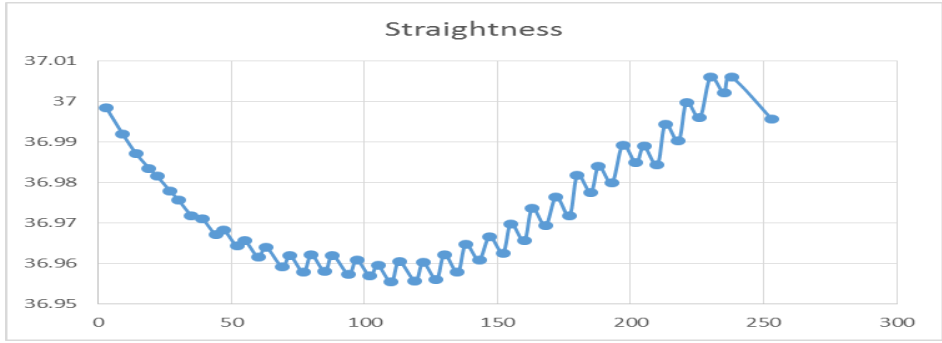

Bubbles observed in small cathode samples

May be due to the fast cooling after bonding

Slow cooling implemented for





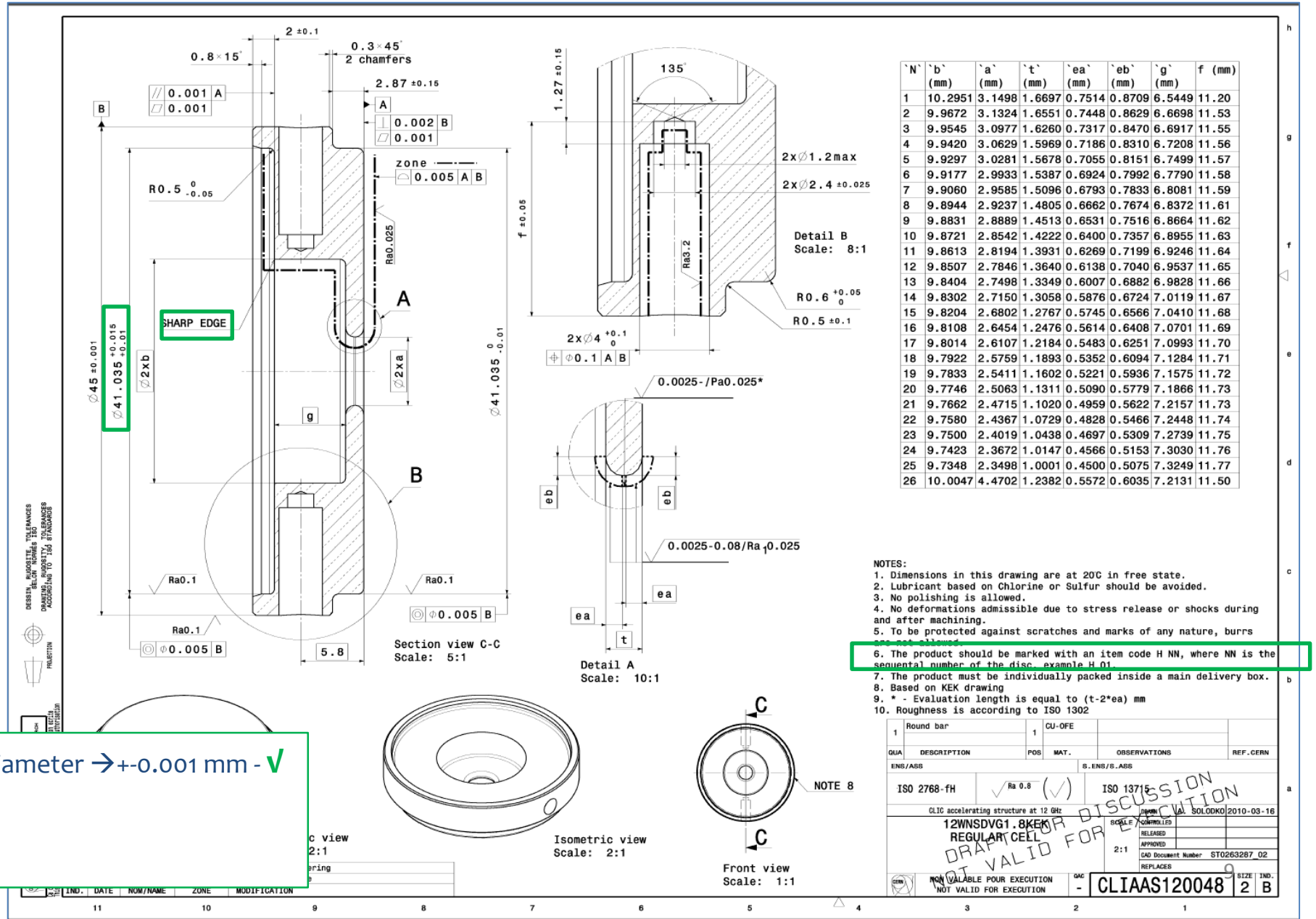



First structure to undergo dimensional control after bonding in metrology

Heavy sagging observed!

# T24 12 GHz updated

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

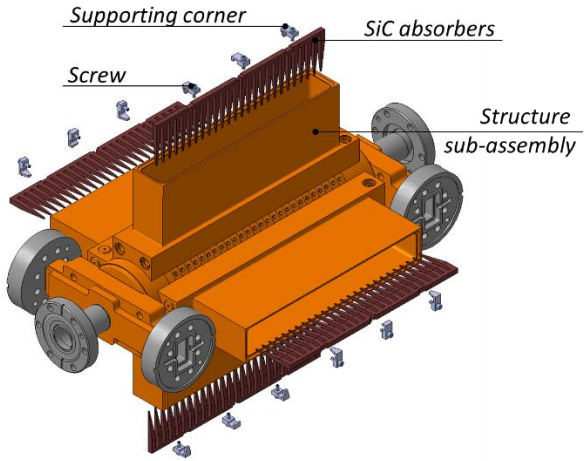



| `N` | `b` (mm) | `a` (mm) | `t` (mm) | `ea` (mm) | `eb` (mm) | `g` (mm) | f (mm) |
|---|---|---|---|---|---|---|---|
| 1 | 10.2951 | 3.1498 | 1.6697 | 0.7514 | 0.8709 | 6.5449 | 11.20 |
| 2 | 9.9672 | 3.1324 | 1.6551 | 0.7448 | 0.8629 | 6.6698 | 11.53 |
| 3 | 9.9545 | 3.0977 | 1.6260 | 0.7317 | 0.8470 | 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 |

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

# TD24R05_SiC2

- 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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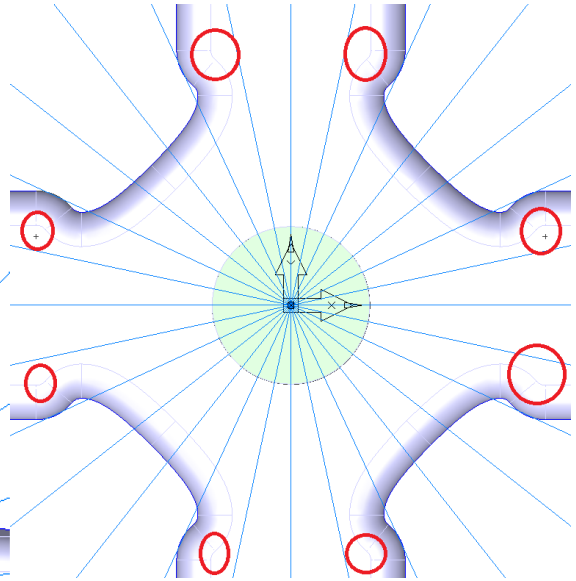
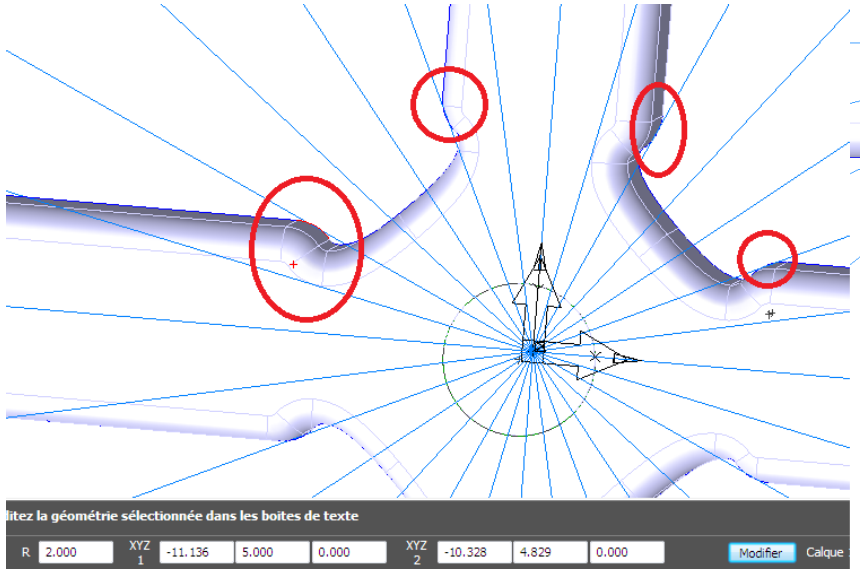
# New CLIC-G* prototype. Machining otimization

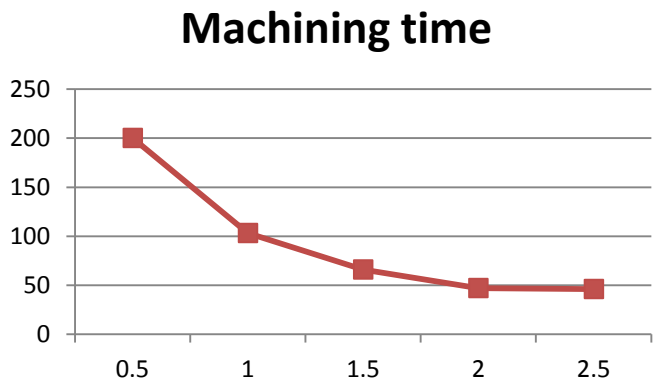
Bottom limiting radius (1,5;1;0,5;0;0)



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

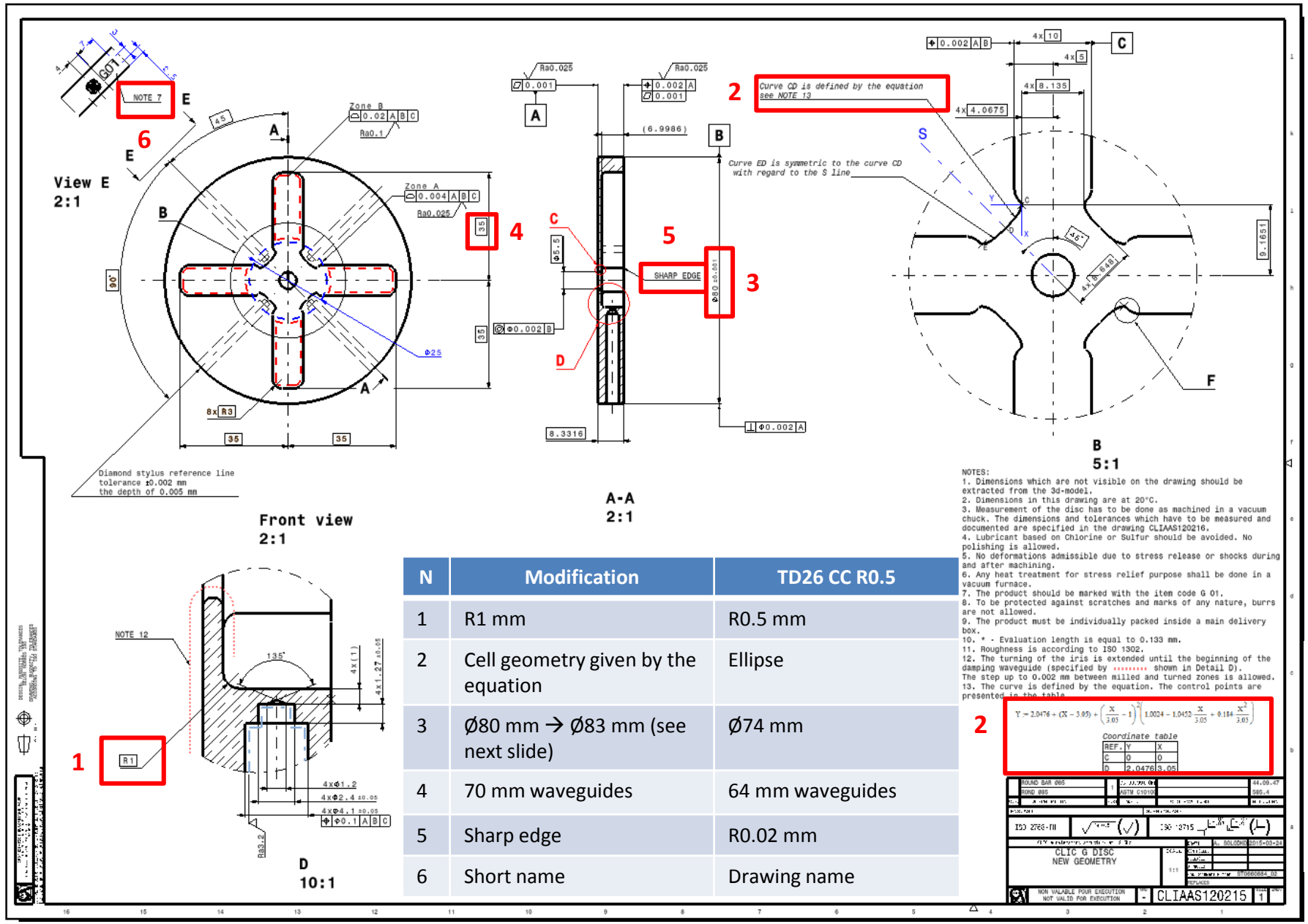



Corner radius 2mm

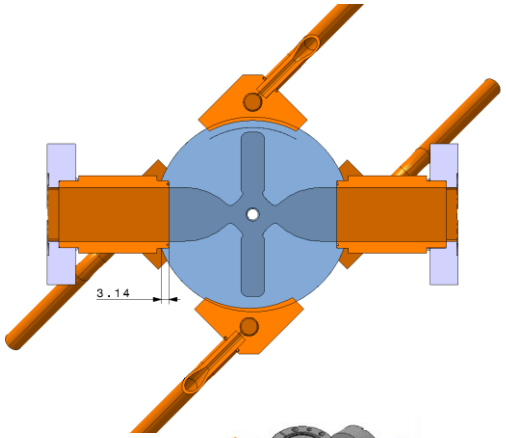


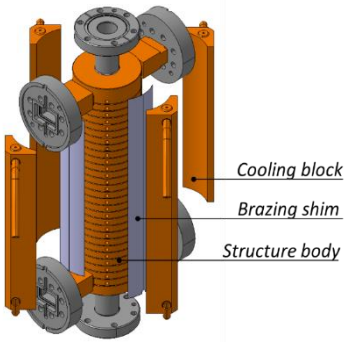

- Optimization of the radius in the disk RF design to minimize
  - Machining time
  - Machining costs
  - Disk yield
- Decided on a bottom radius of 0.1 mm

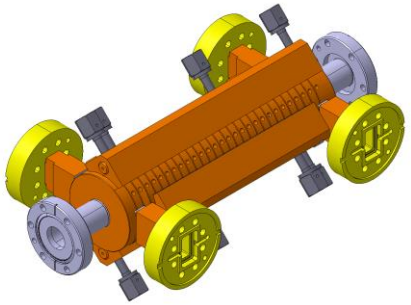
# New CLIC-G* *TD26 R1 CC mechanical design*




| 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 |

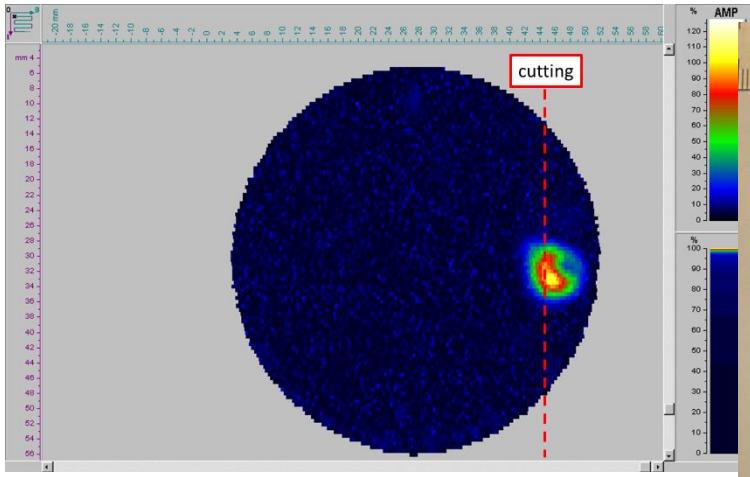


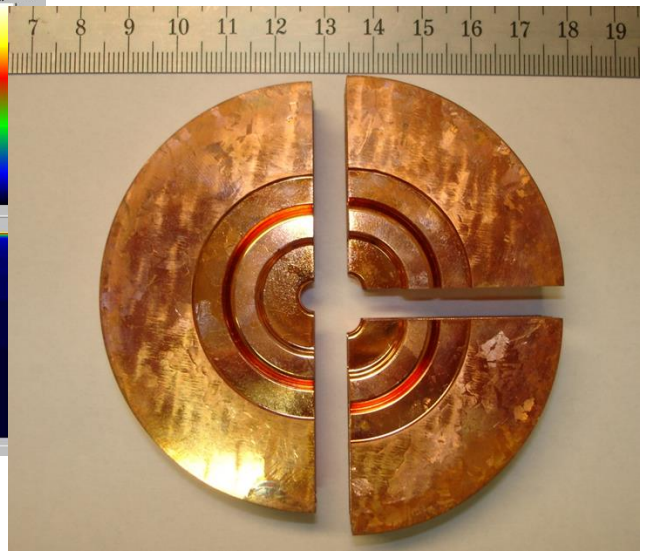



# Assessing the bonding quality

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

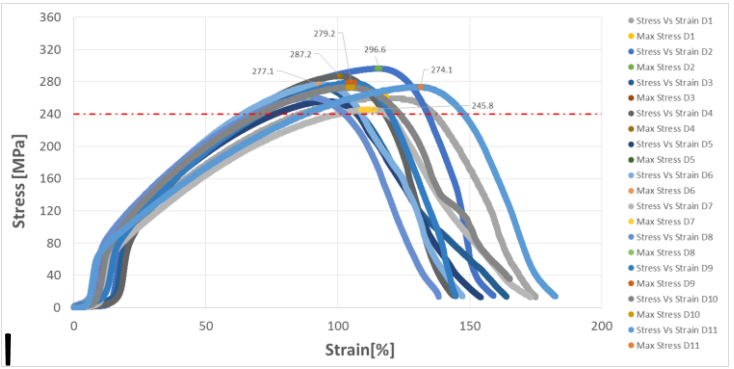


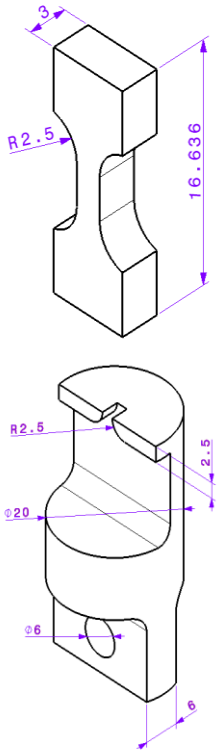
- Cutting the sample and observing it in the microscope
- Time and resource consuming
- Crossing/non crossing grains used as ultimate measure

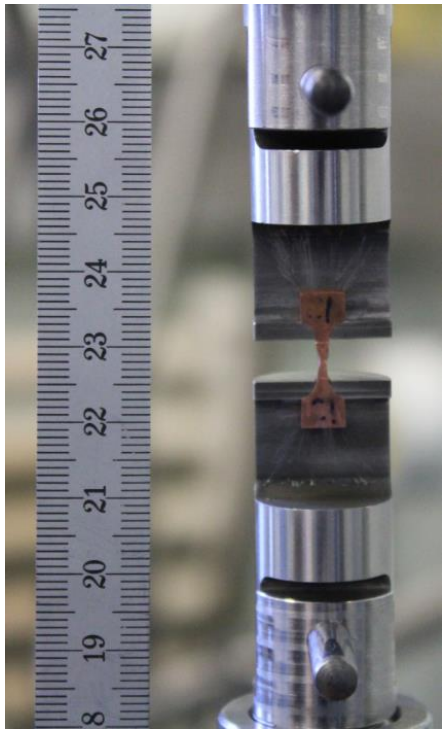
# Assessing the bonding quality

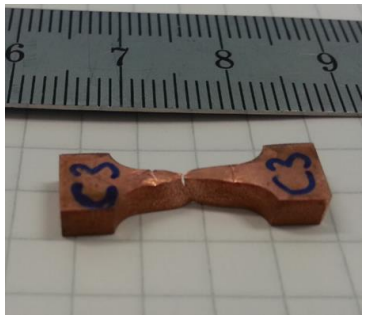
- Tensile tests used to quantitatively asses bonding quality
- Comparison with raw and heat treated copper
- Average tensile strength is similar for all bonded samples
- Spread increases for bonded samples

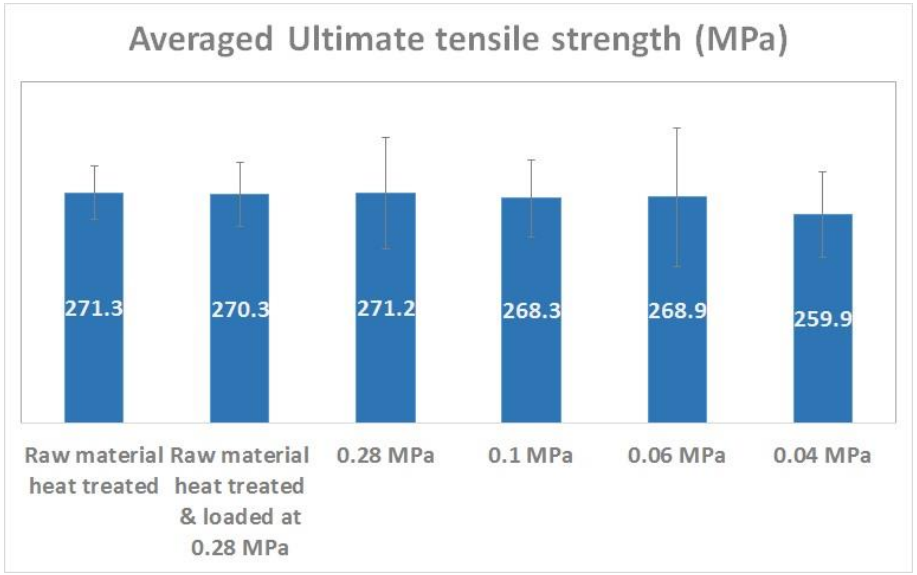



<u>Bonding quality is good in all cases!</u>



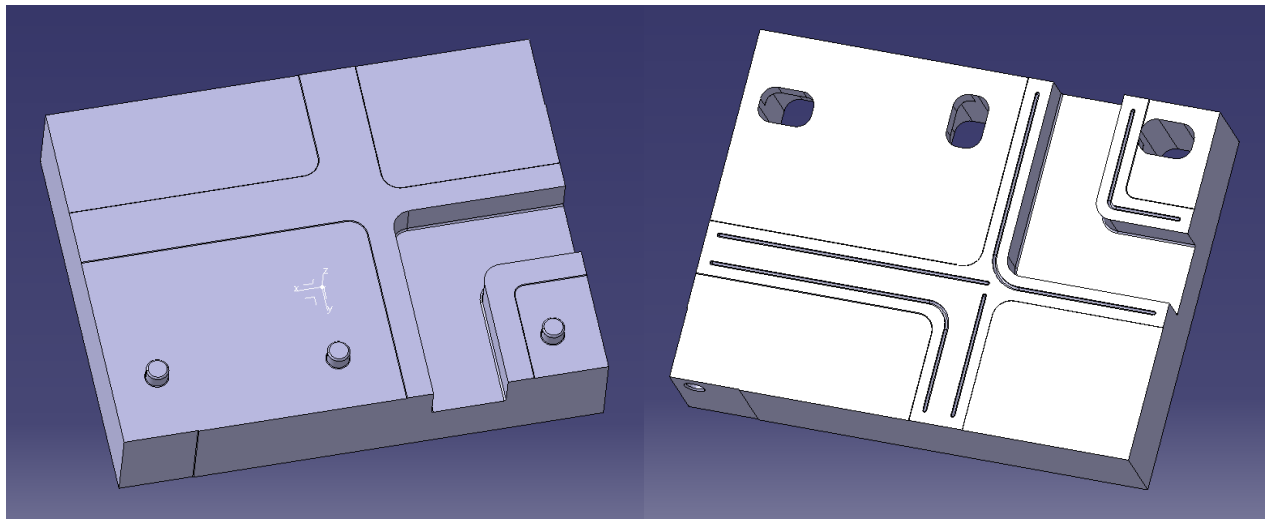



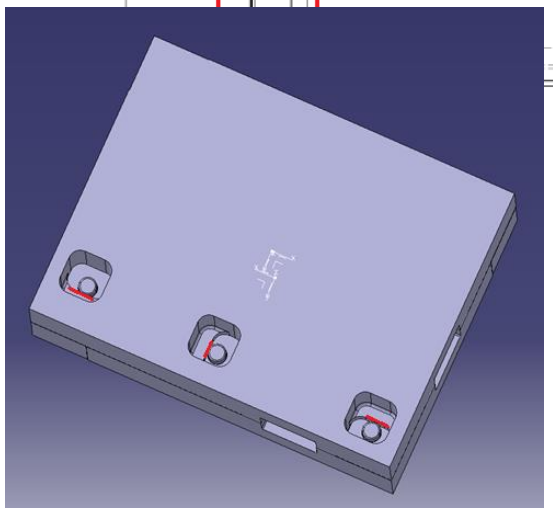


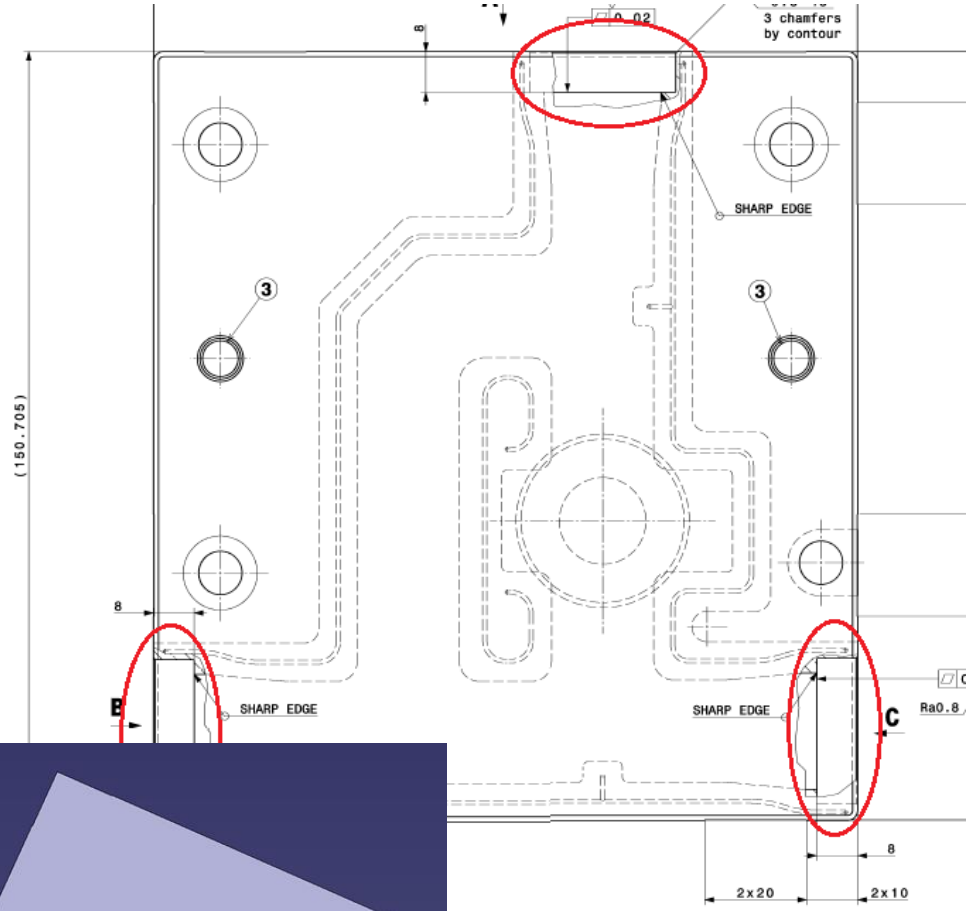


# Alignment features study

- 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.