CLIC Fabrication

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On behalf of the X-Band Production Team

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Summary

- CLIC fabrication in a nutshell
- Discs
  - TD26 Prototype
  - TD31 Prototype
  - Diffusion bonding issues
- Other technical solutions
  - Halves
  - Rectangular discs
- Conclusions

CLIC Fabrication in a nutshell

RF design

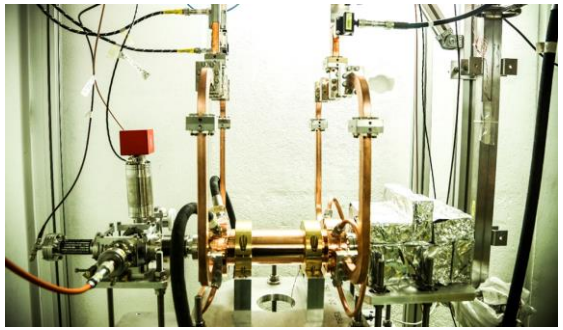
Mechanical design

Manufacturing

Quality

Assembly

High Power Test



TD26

N1

Post-Mortem

More details on bonding issues section

N2

Waiting High Power test

Tuned
Baked

N3

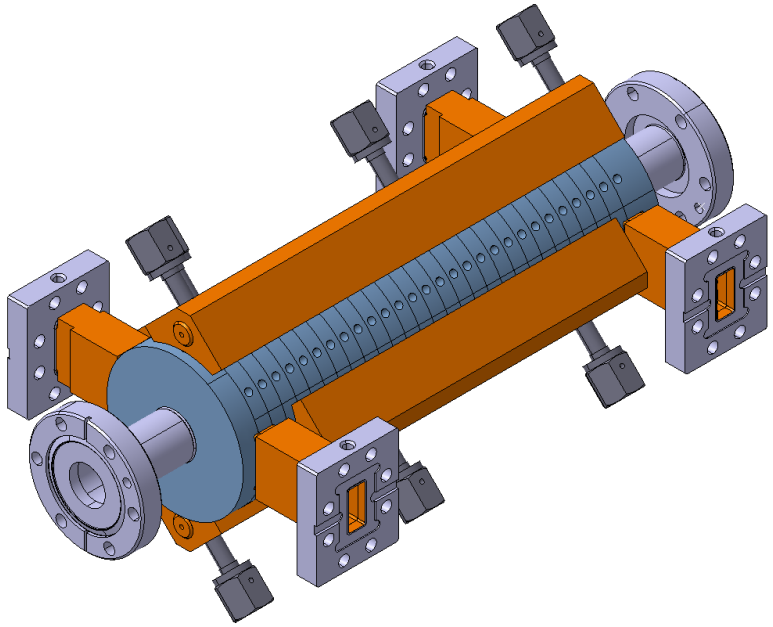
Waiting High power test

Tuned
Unbaked

N4

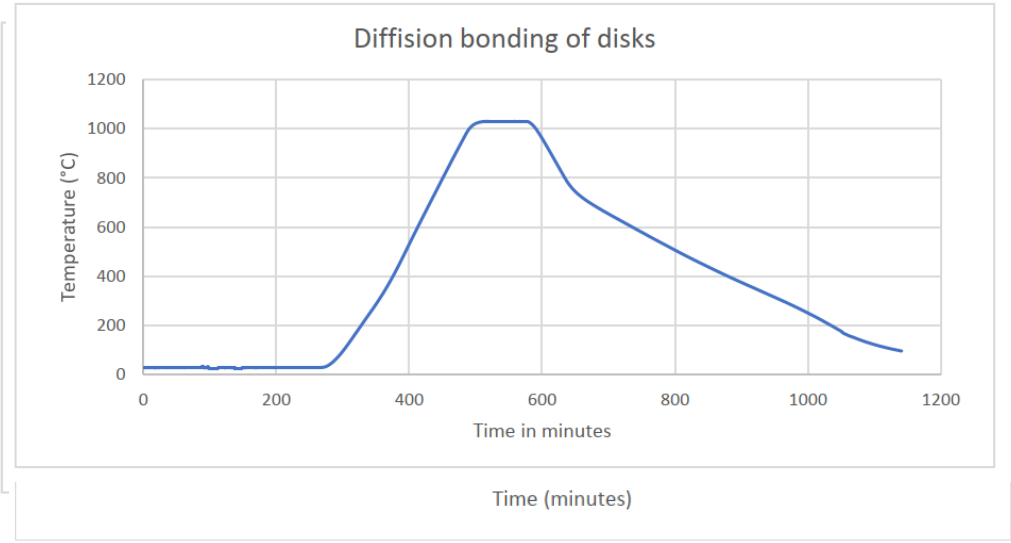
Assembly on-going

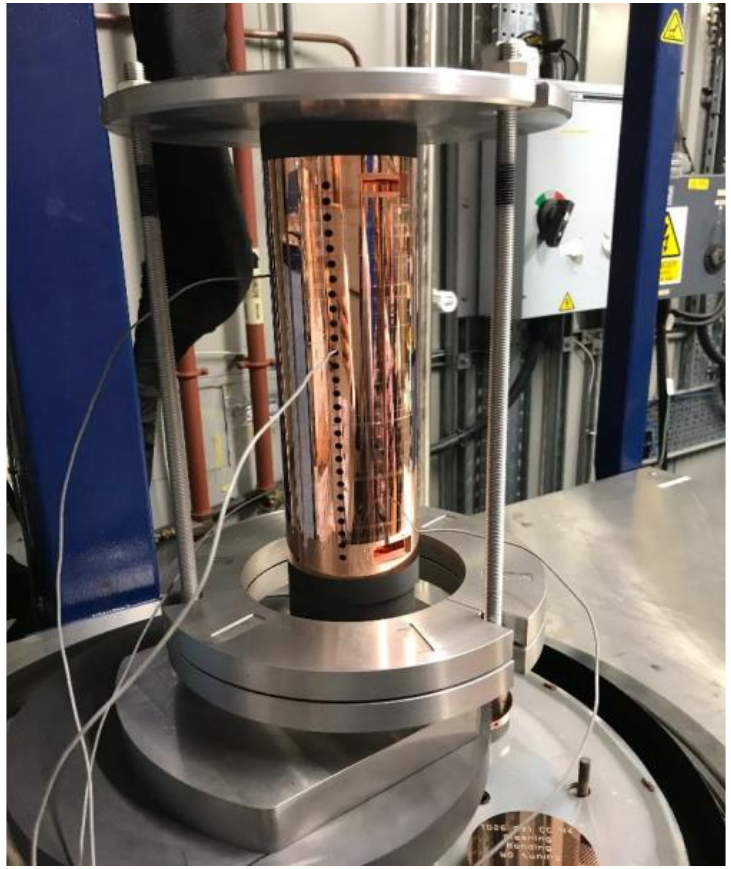
More details next slide



TD26-N4

- Diffusion bonding executed at TMD technologies (UK)
  - 1040 °C x 1h 30 min x 0.06MPa x H_2





TD31

N1

Assembly on-going

Bonding completed
Brazing on-going

New tooling tested

N2

Assembly on-going

Bonding completed
Brazing on-going

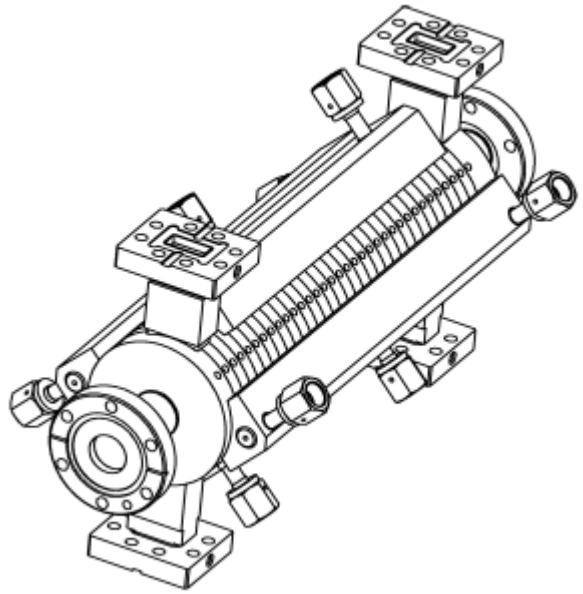
New tooling tested

N3

Manufacturing completed

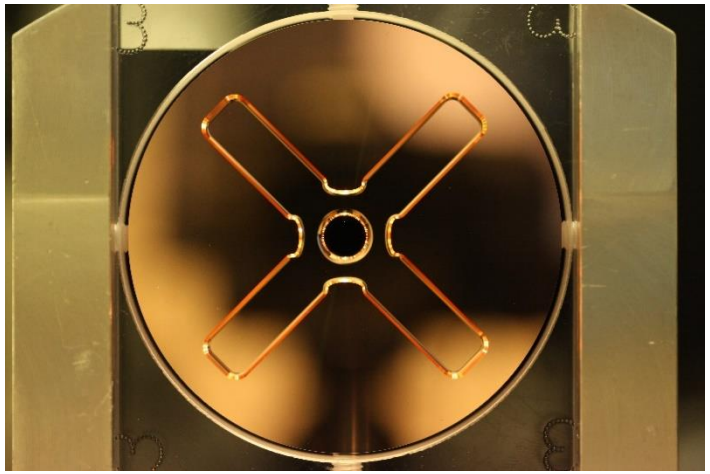
N4

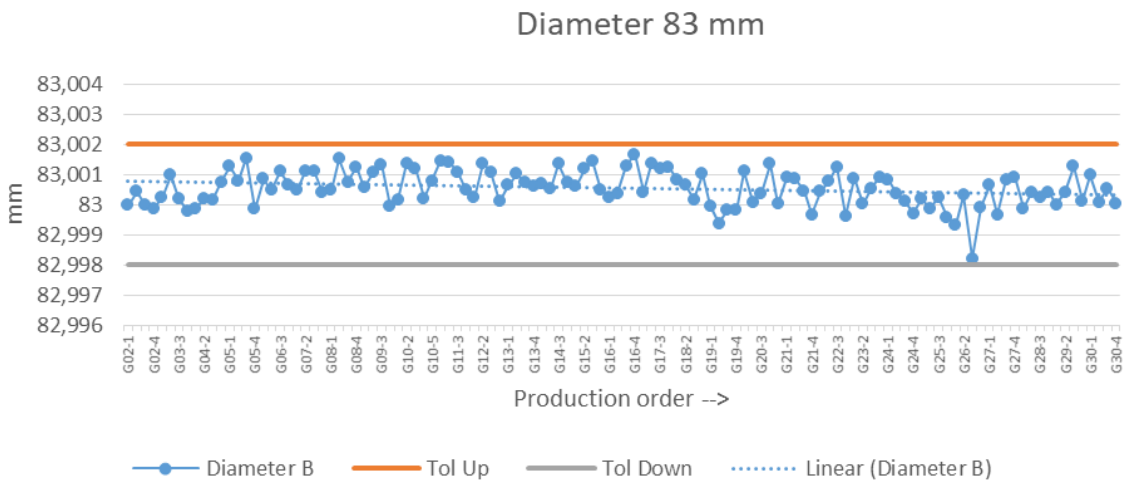
Manufacturing completed



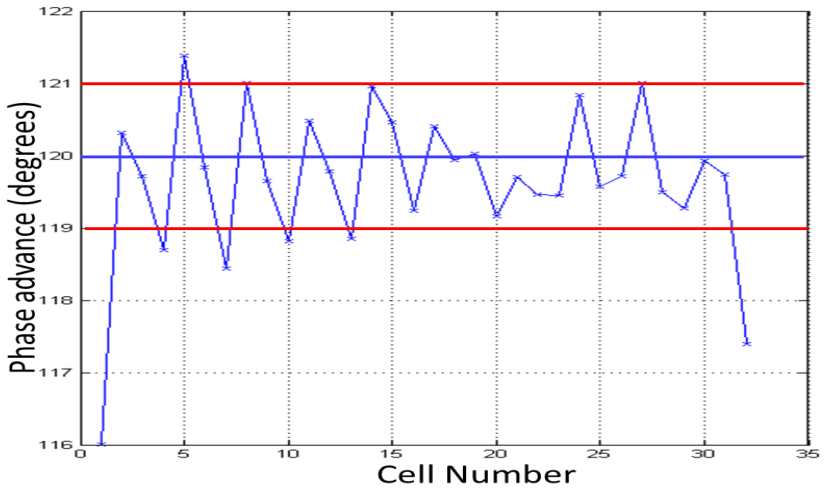
Baseline for CLIC-380GeV

TD31





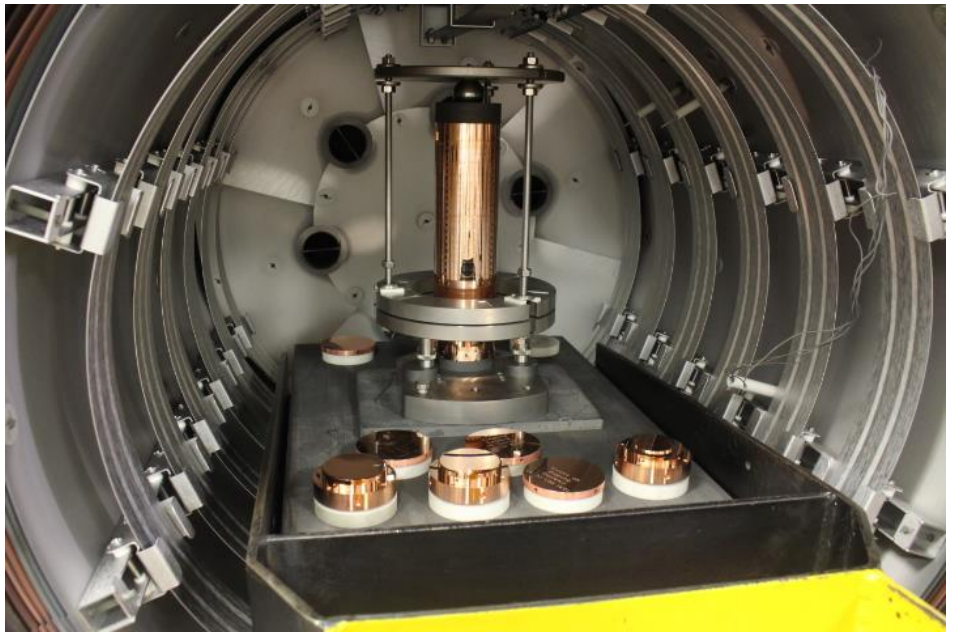
140 discs produced.
0 defects

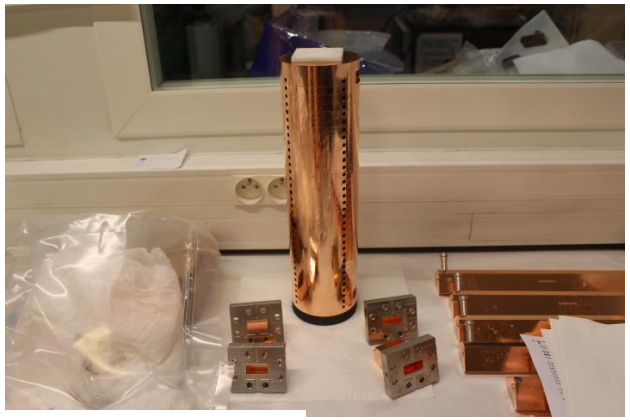


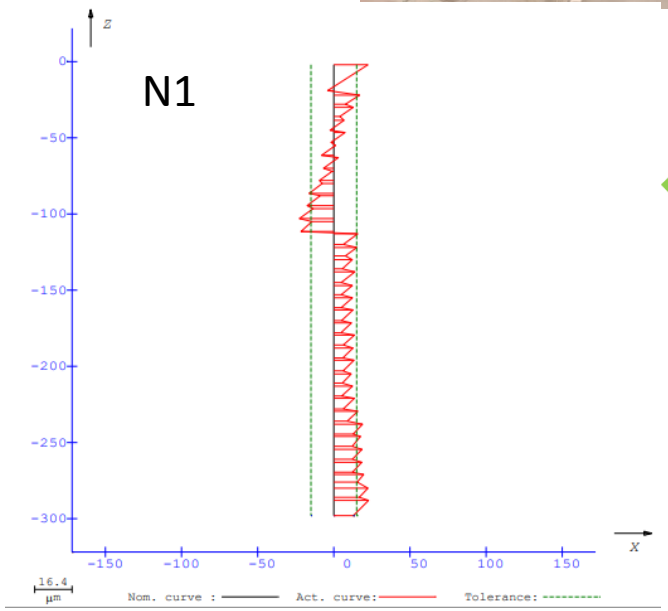
Bead Pull measurements before bonding are better than we usually see.
Phase advance (N1) nearly fulfils the requirements after tuning.
Due to extremely good quality
Also due to the good alignment and RF contact of the tooling.

TD31 – N1 and N2

- Diffusion bonding executed at Bodycote (FR)
  - 1040 °C x 1h 30 min x 0.06MPa x H2







No banana effect

Reduced disc to disc alignment

Straightness: 46 µm

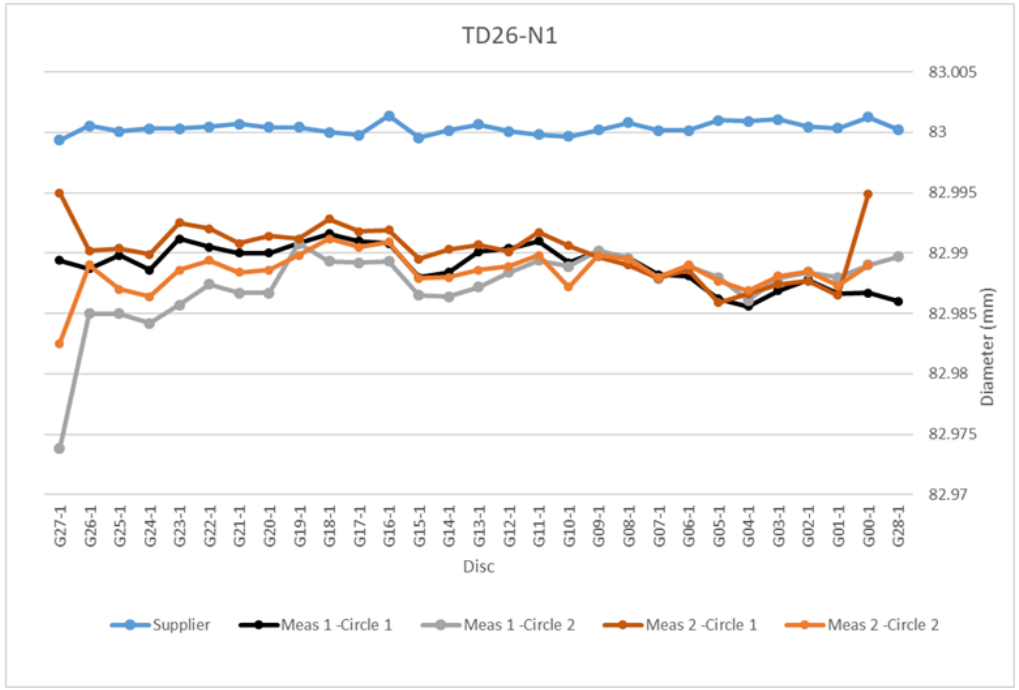
A bump during transport

Diffusion bonding issues

- The process is stable and it works
  - The structures are leak-tight!
  - We have some issues with straightness but the main cause is the transport from the assembly table to the furnace.
- Two years ago, it was decided to assess the contribution of diffusion bonding
  - Careful attention to metrology
  - Cross-check with Bead-Pull Measurements
  - Post-mortem analysis

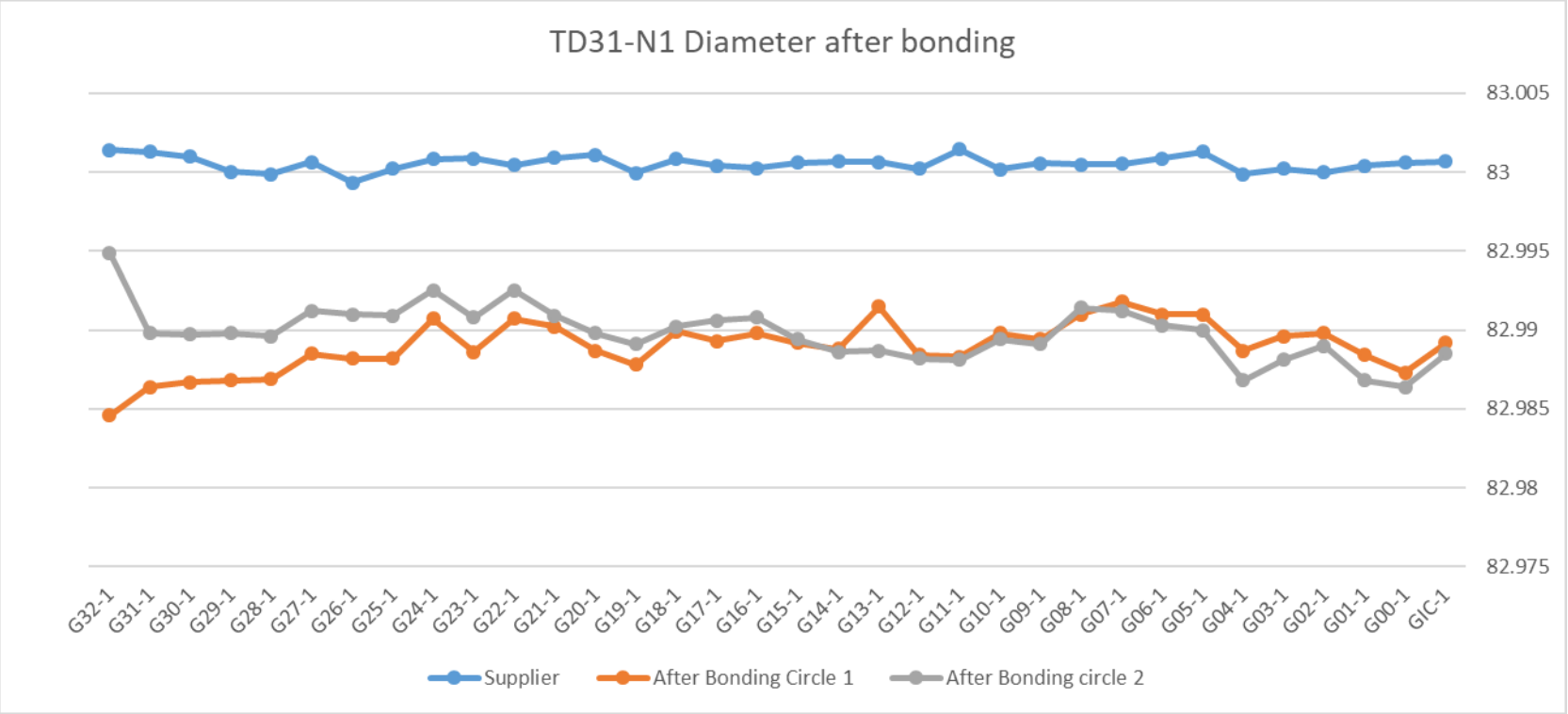
Diffusion bonding issues

- Identical bonding cycles on different days (same supplier) for TD26 N1, N2 and N3.
- N4 different supplier (diameter after bonding was not measured)
- External diameter reduction in average 12 µm
- Observed in structures N1, N2 and N3. Double checked on structure N1.
- The total length of the structure is smaller 25 µm



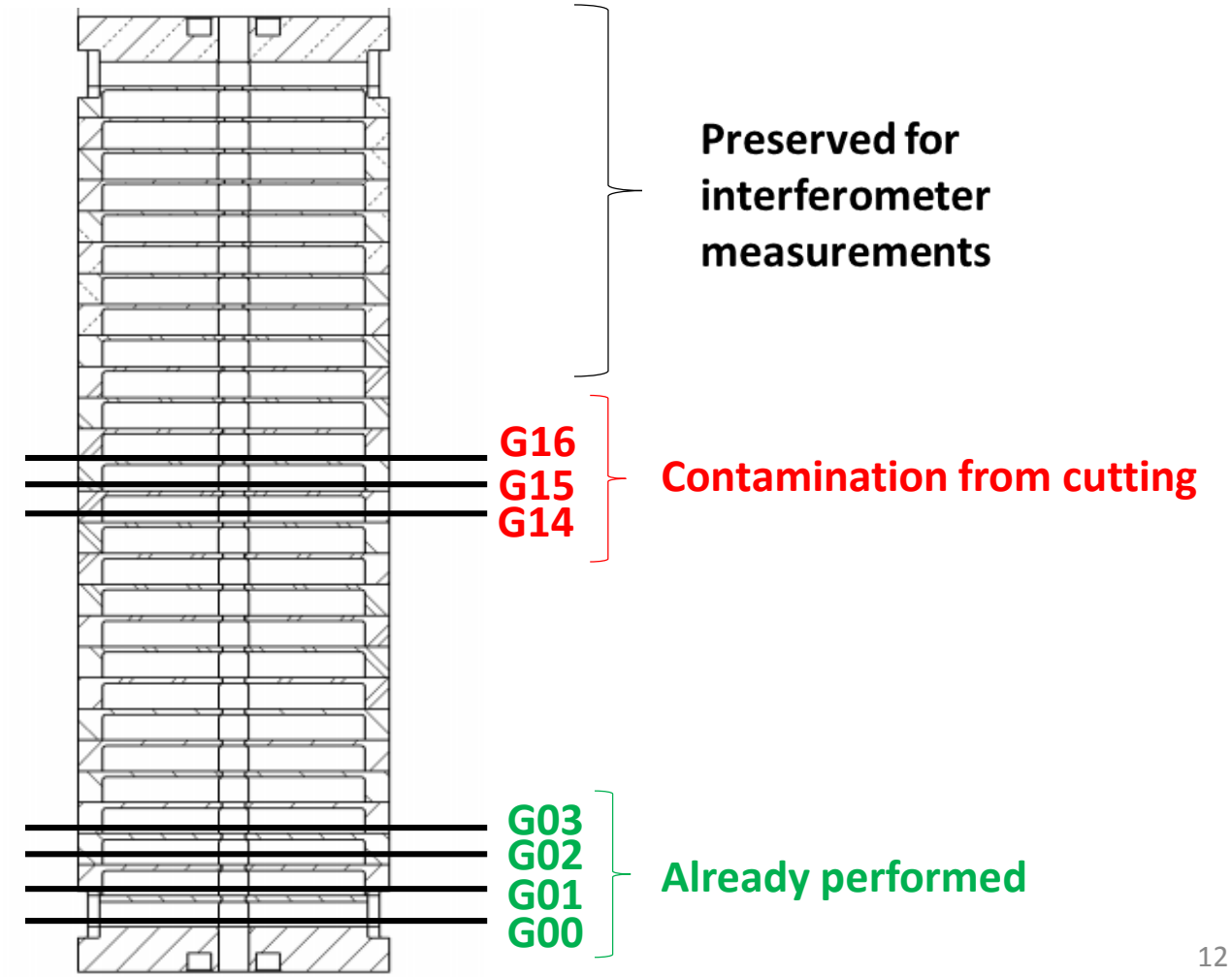
Diffusion bonding issues

- Bonding of TD31 N1 and N2 performed by the same supplier (TD26-N1-N2-N3).
- However, the oven has been completely refurbished in-between.
- Same trend than TD26: diameter reduction in average 11 µm

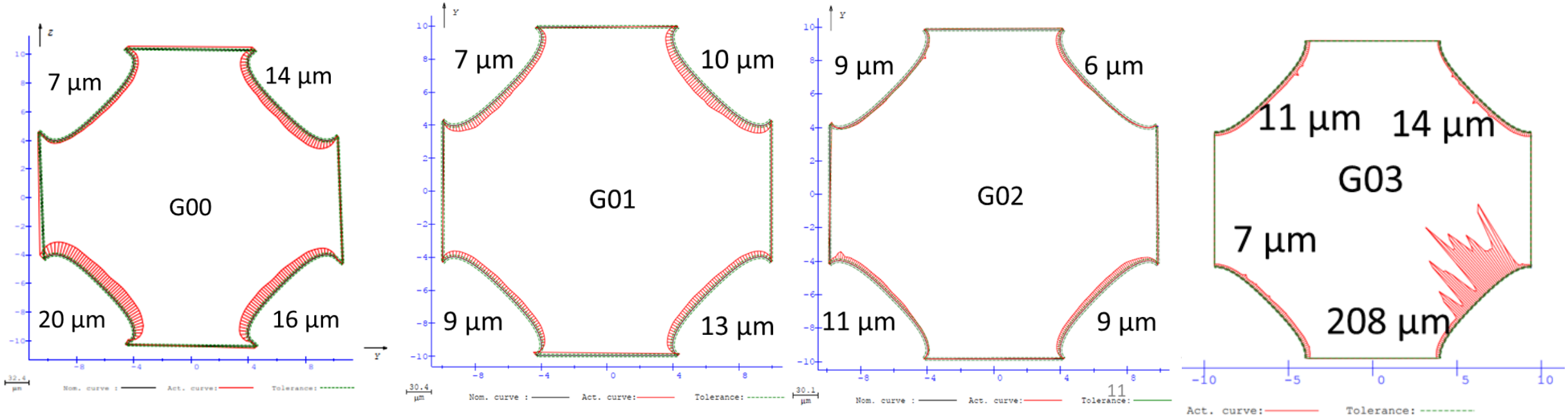


TD26-1

- Post-Mortem analysis
- Cutting plan (EDM):
  - Same reference for all the discs
  - Shape of the nose (horizontal)
  - Shape of the nose (vertical)
  - Irises
  - Flatness of the waveguide

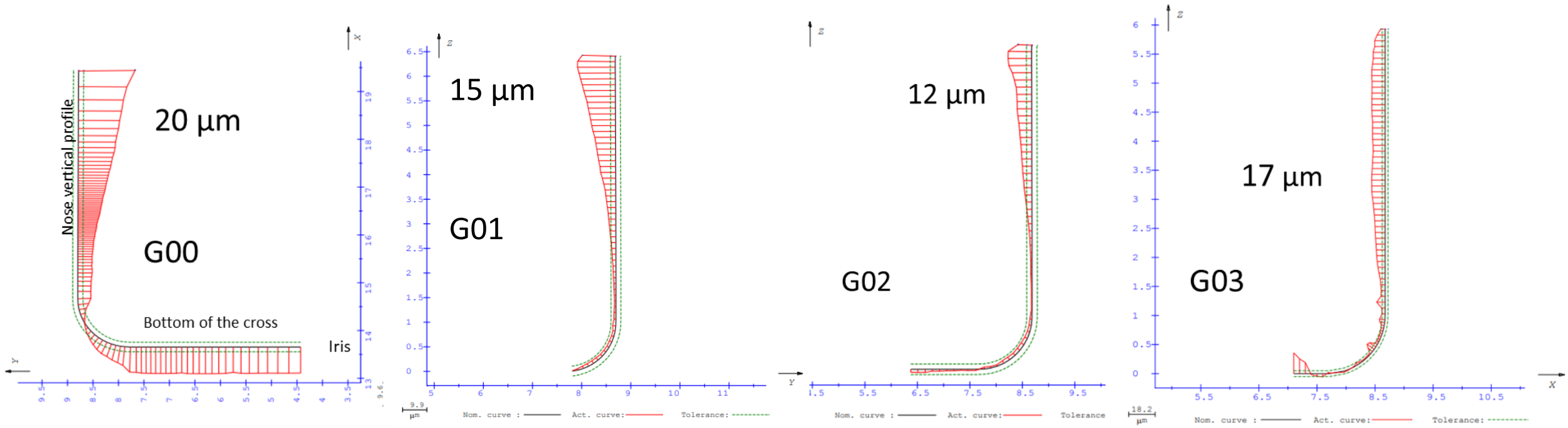


TD26-1: Shape of the nose (horizontal)



- Datum references have changed with respect to original measurements.
- Shape seemed to improve according to disc position. G00 is worst than G02
- First traces of EDM cutting residuals observed on G03

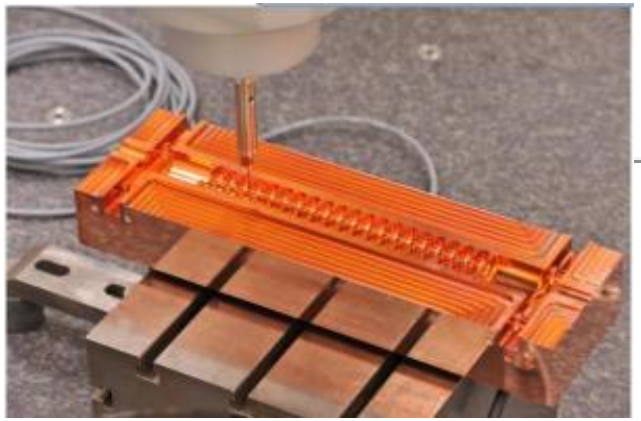
TD26-1: Shape of the nose (vertical)

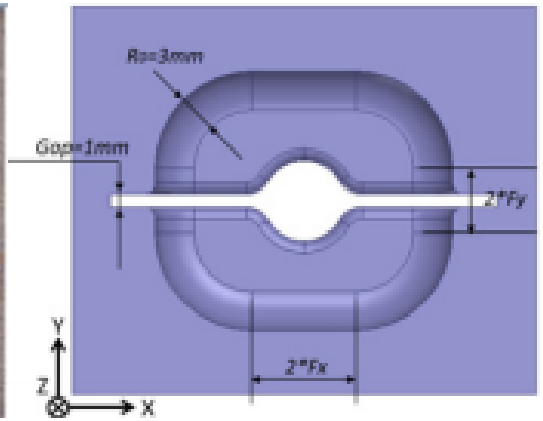


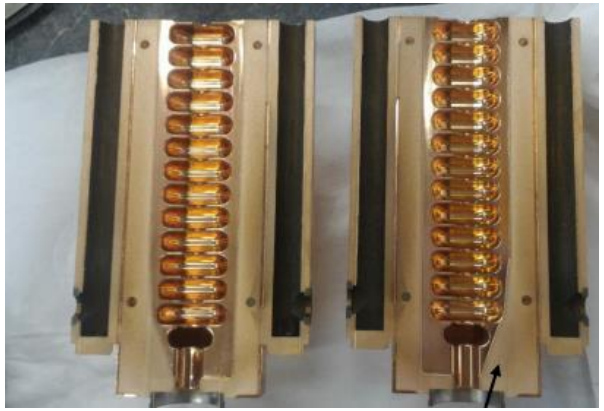
- A cone shape is observed
- The error was diminishing up to G03
- Contamination of EDM cutting on G14

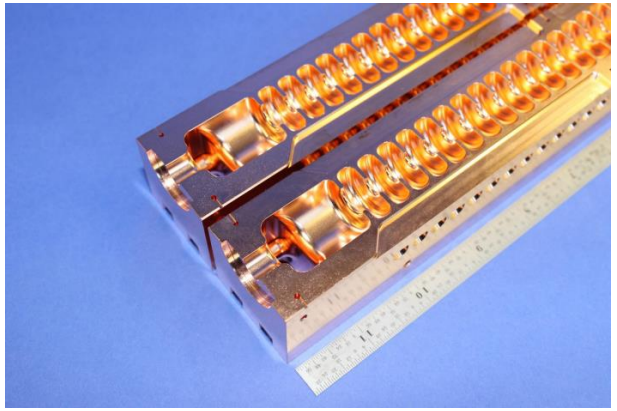
Halves

- Long development process:
  - First trial (bonding - CERN): Good RF before bonding. After boding, a gap between the halves (10-200 µm) and a shift between the irises of 70 µm (systematic error)
  - Second trial (brazed – SLAC): A gap between irises was introduced to minimize field of filling material leaking to the structure. Alignment with pins. RF conditioning ok. Breakdown activity near the brazing region.
  - A third trial (brazed through irises – SLAC): not yet tested but there is a visual misalignment between the irises.



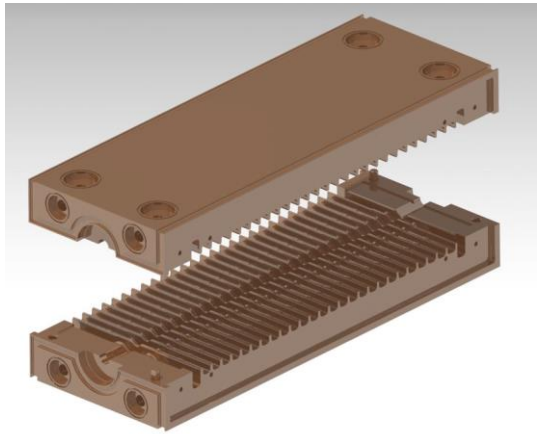


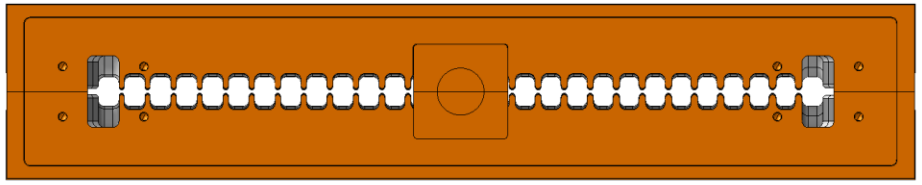


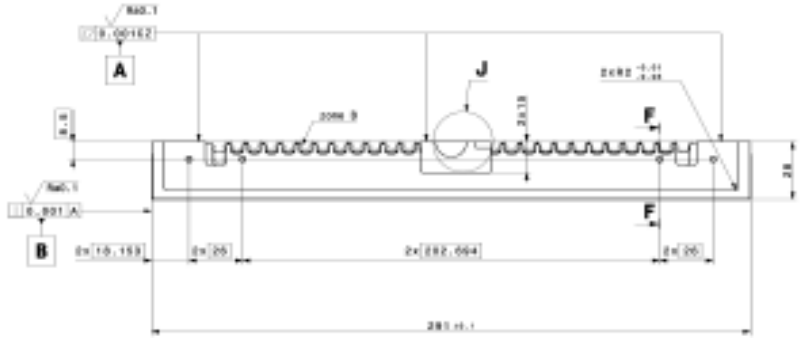


Halves

- Last development TD26:
  - Two identical halves: 285 mm x 146 mm x 14 mm, damped (no SiC), gap.
- Form tolerance: 4 µm on Zone A (zone near the iris of the whole length)
- Electron beam welding design:
  - Hard copper (no heat treatments above 245 °C) showed shorter RF conditioning
  - Welding lips
- Less components to assembly but bigger risks for manufacturing companies
  - Challenging but feasible

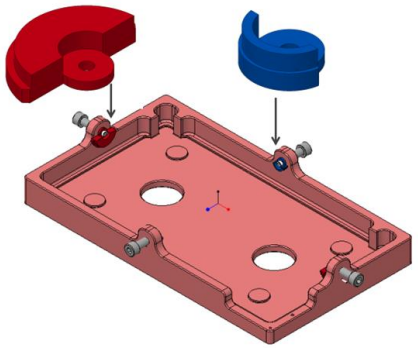


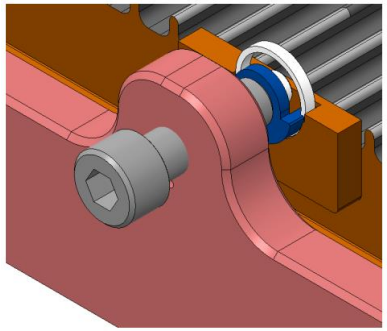


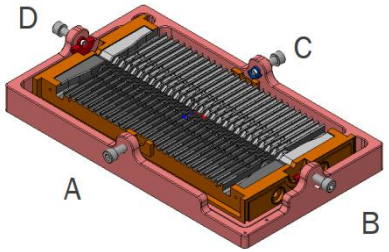


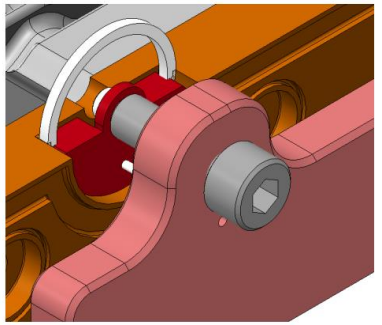
Halves

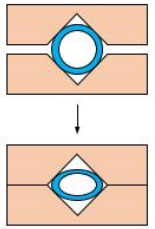
- We do care about the alignment. Special tooling: Herzian deformation of high precision rings.
- Ready to be produced!

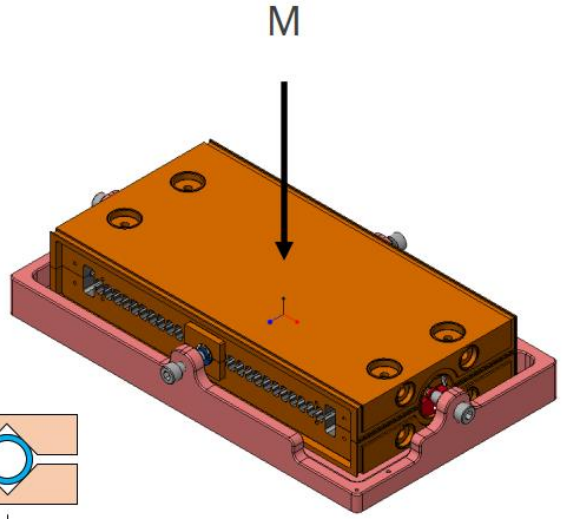


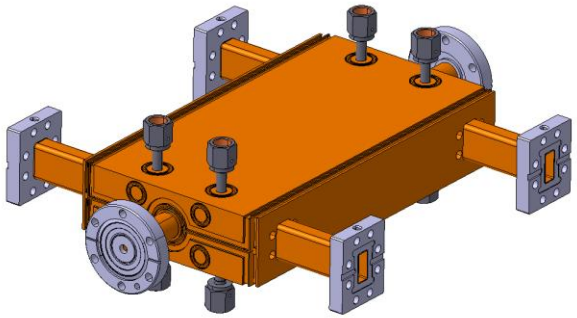






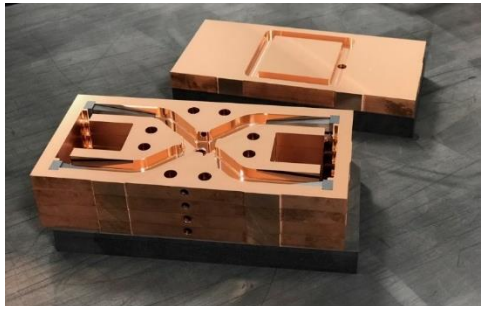


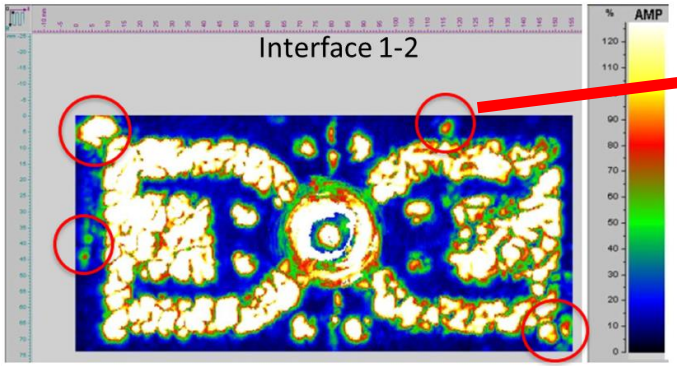


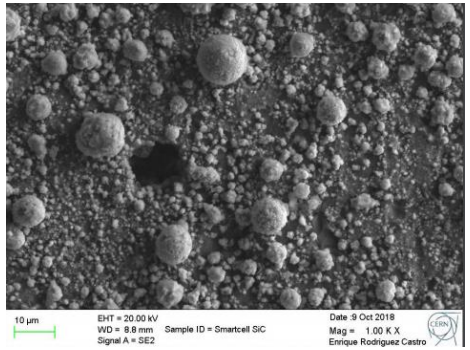


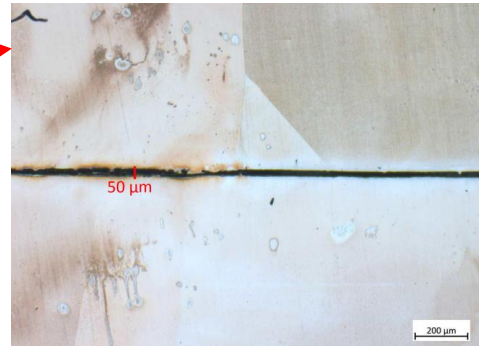
Rectangular discs

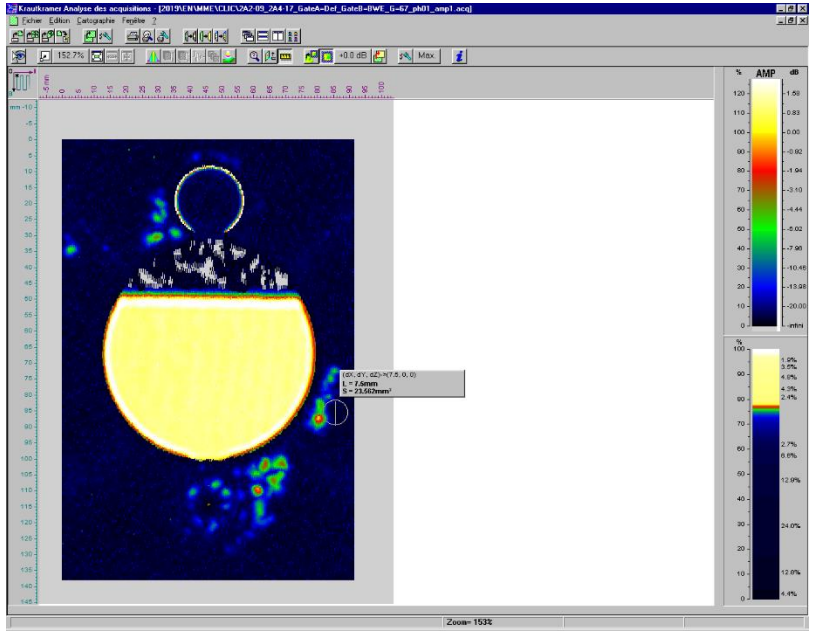
- First trial successful at 95% (it was leaking)
  - Caused by the SiC geometry
  - Not related to the bonding problem: the SiC was copper coated.
- Second trial successful at 99% (it was not leaking)





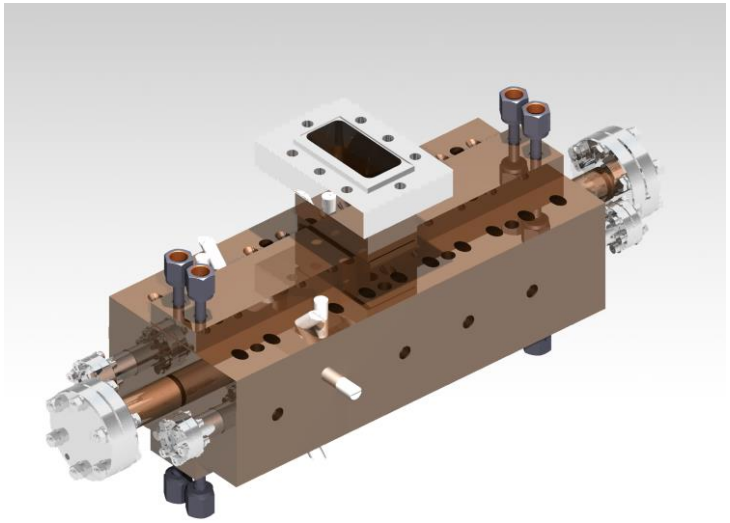


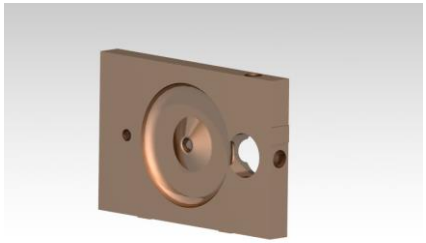


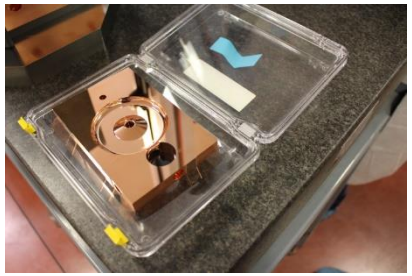


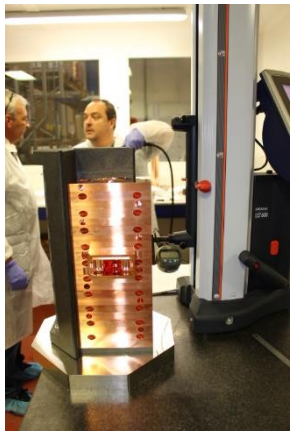
Rectangular discs

- Lancaster University PROton Boosting Extension (PROBE) structure
- High gradient (54 MV/m), side coupled, standing wave, S-Band for Proton Computed Tomography (pCT) scan
- Bonding done. Leak test after brazing of components.
- Straightness of 25 µm





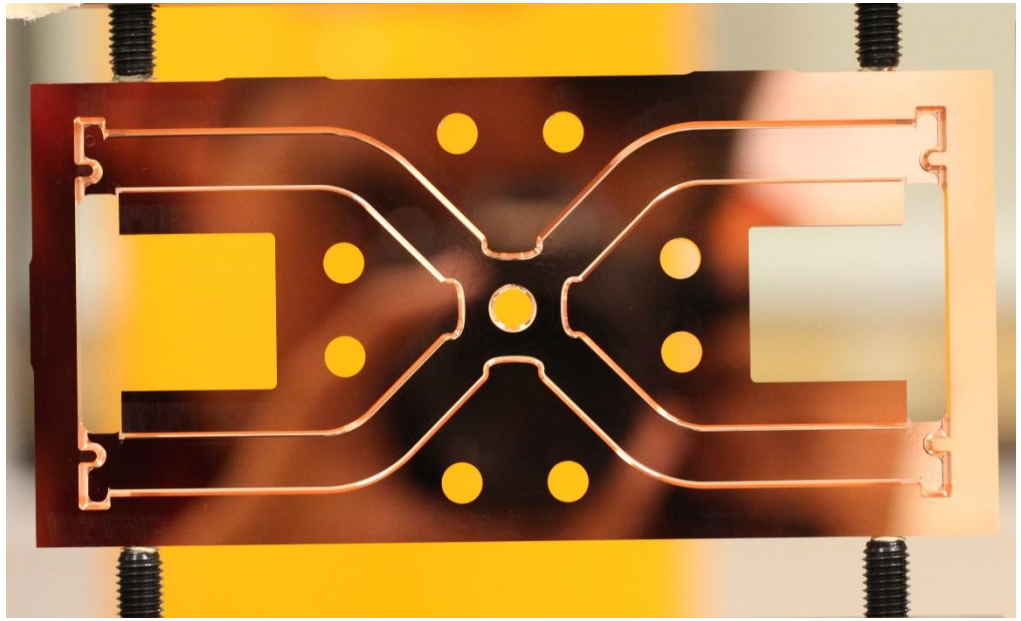




Conclusions

- TD26:
  - N1: Post-mortem finished
  - N4: Brazing operations on-going
- TD31
  - N1 and N2: Brazing operation on-going
- Bonding issues:
  - The diameter reduction (copper sublimation) of 10 µm is confirmed: 6 structures
  - The shape of the nose is changing on both horizontal (collapsing) and vertical shapes (cone shape)
  - The cells are deforming due to bonding
    - Weight is excessive? Already reduced from 0.1 MPa to 0.06 MPa
    - Temperature is too high?
    - Time is too long?
- Halves: Ready for production
- Rectangular discs: Bonding performed on the PROBE structure. Leak test in following weeks.

Thank you



Questions?