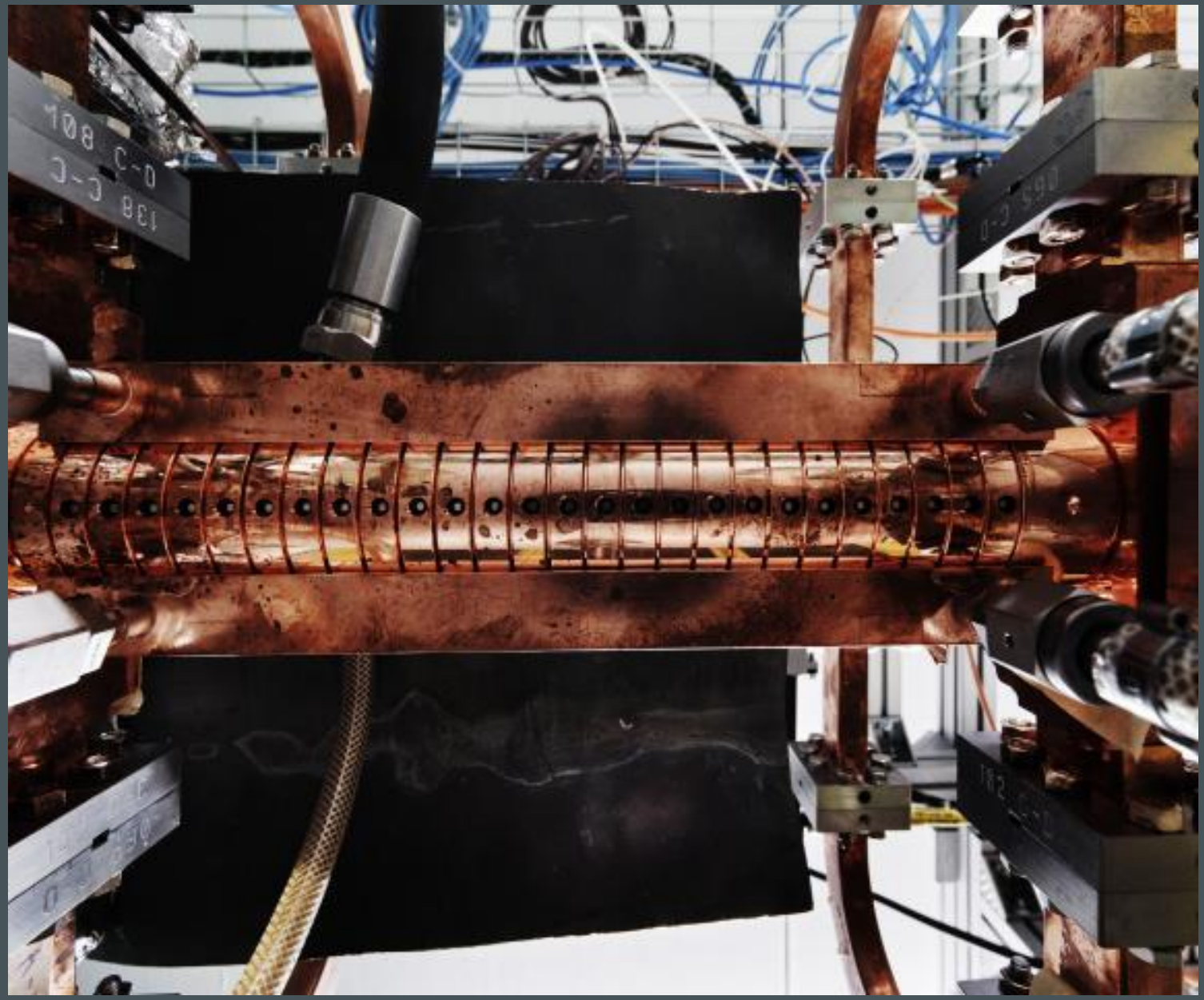
X-BAND STRUCTURE DEVELOPMENT AND FABRICATION ISSUES

D. ALESINI

N. CATALAN LASHERAS



OUTLINE

01

Introduction to the activities in Frascati and planning

02

New prototypes foreseen for CLIC

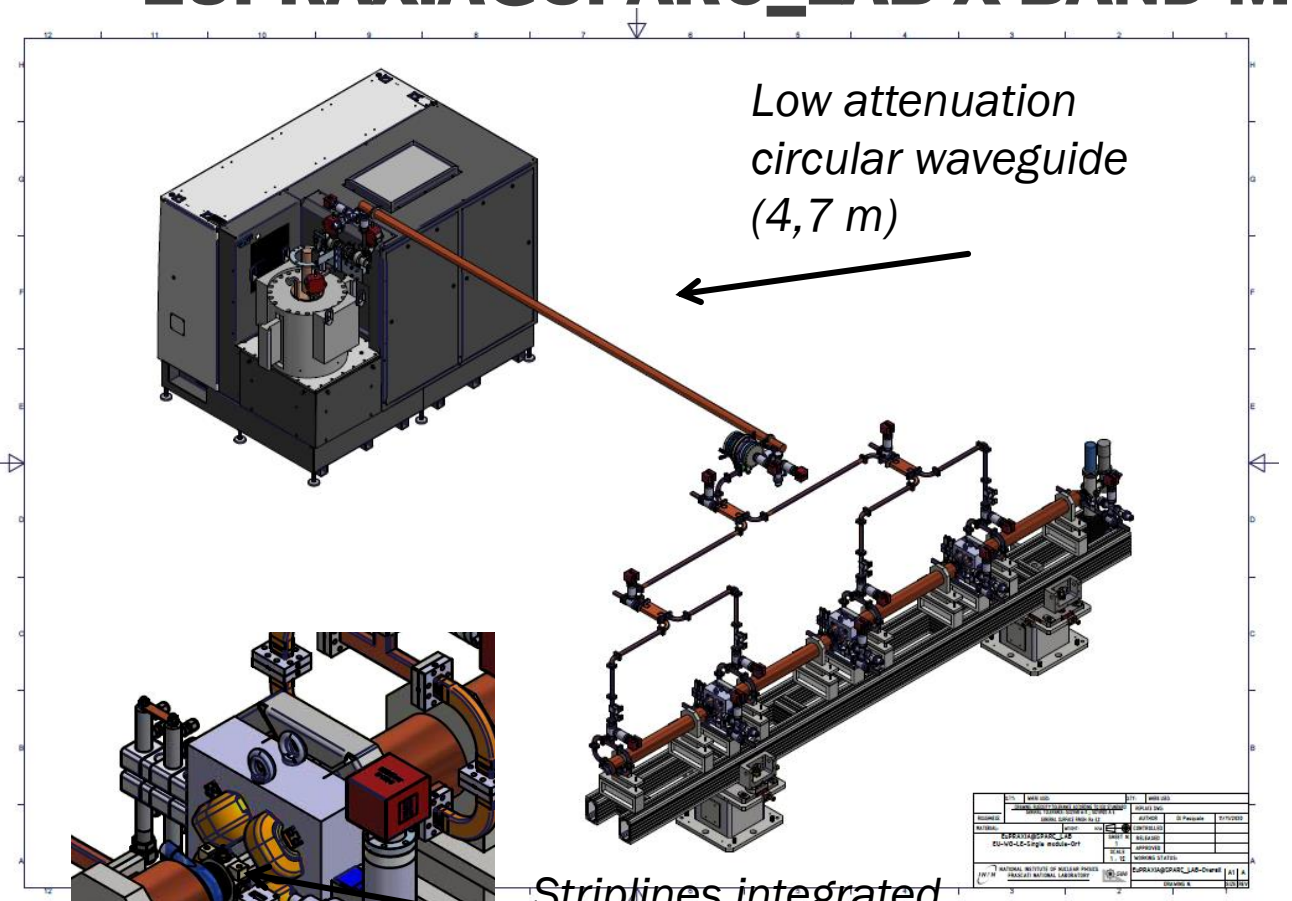
03

Some pertinent examples

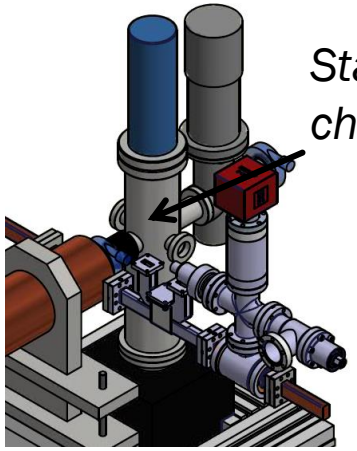
04

Potential synergies and collaboration

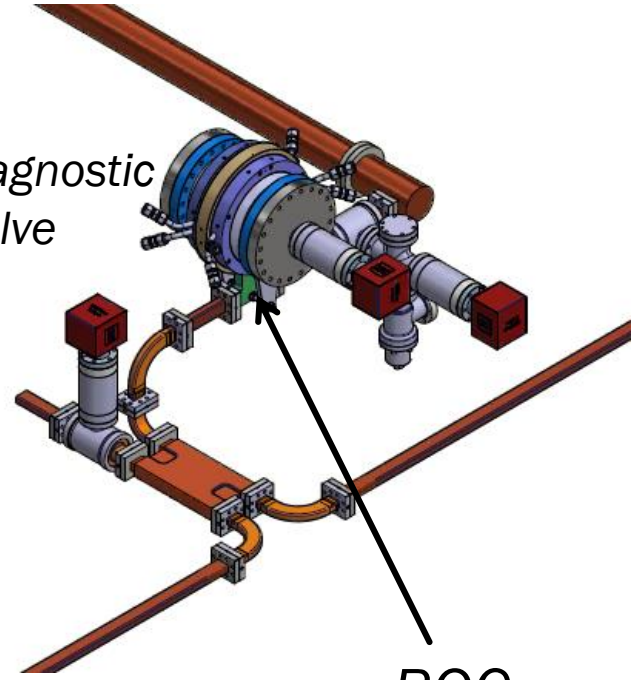
EUPRAXIA@SPARC_LAB X BAND MODULE LAYOUT



Low attenuation circular waveguide (4,7 m)

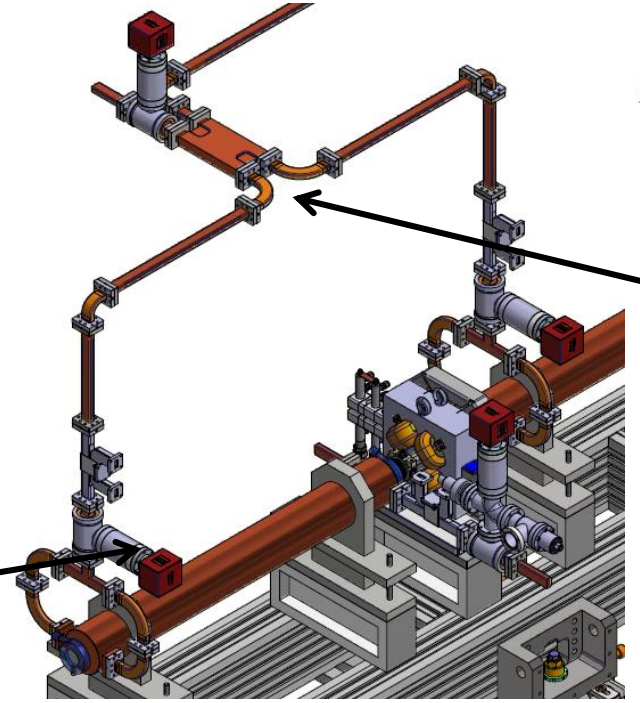


Standard Diagnostic chamber+valve



BOC

Striplines integrated into the QUAD (WP 14)



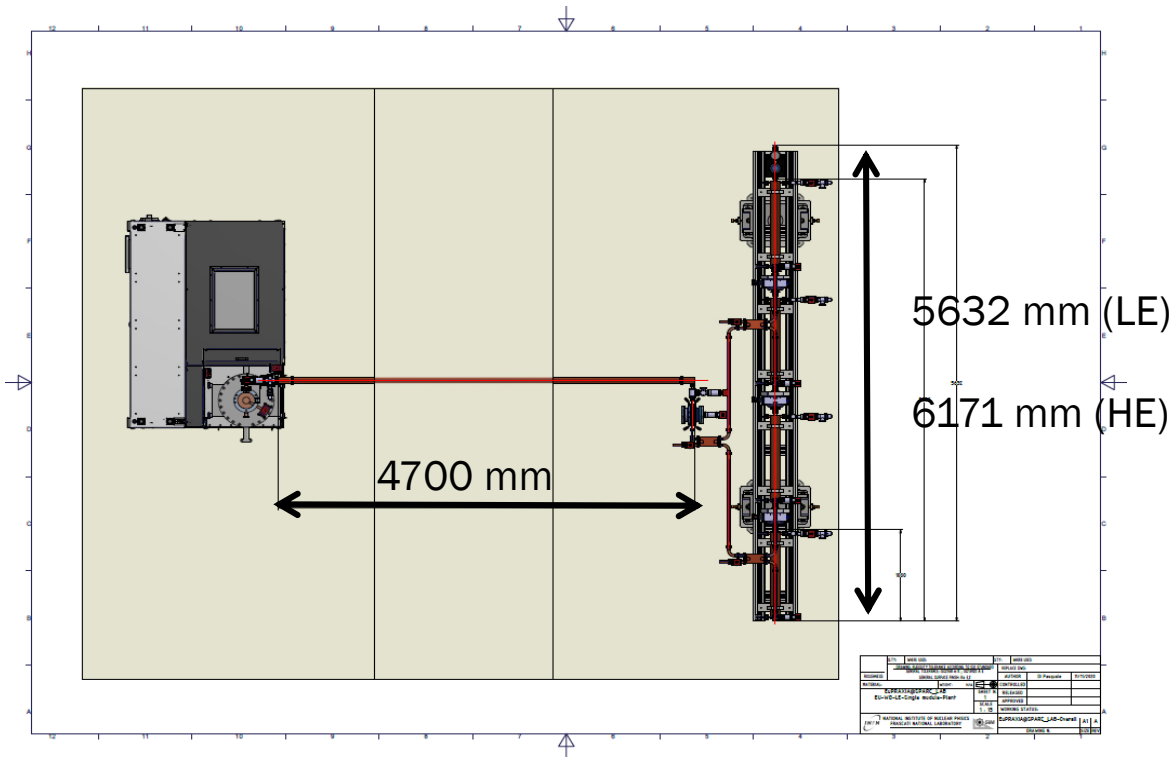
hybrid

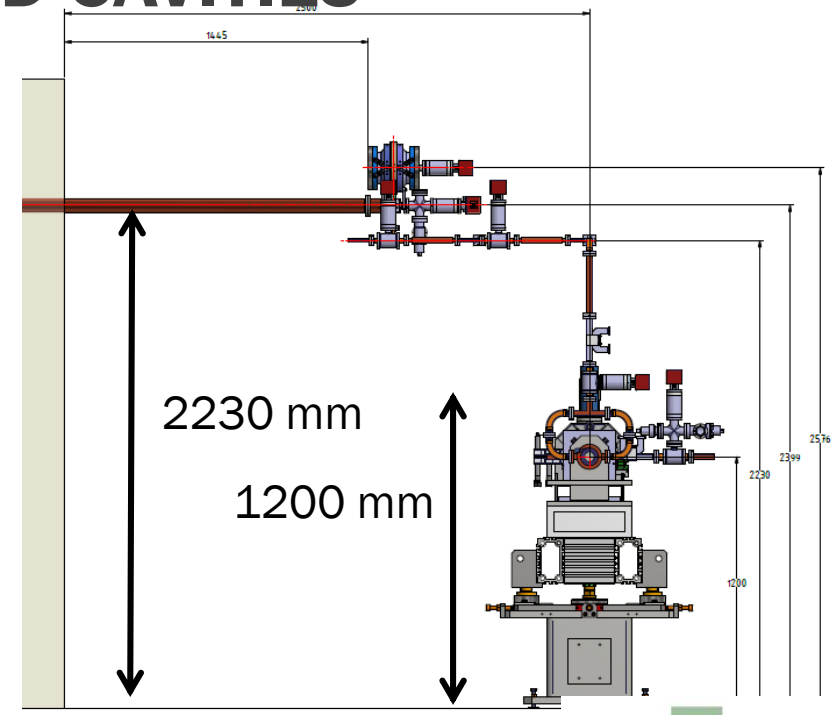
pumps

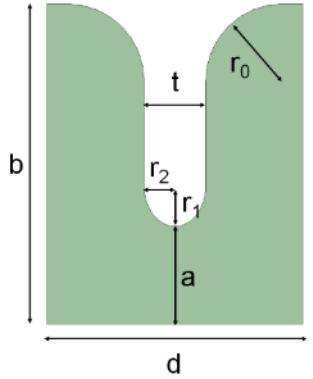
NB:
-waveguide components: CERN design

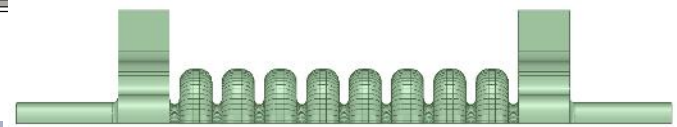
-two version of the module: Low and High Energy

MODULE DIMENSIONS AND X-BAND CAVITIES



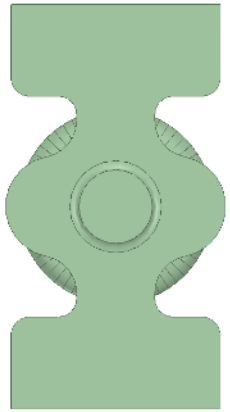


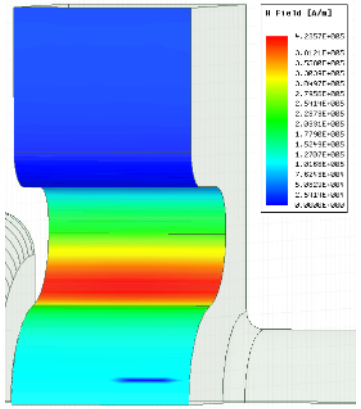


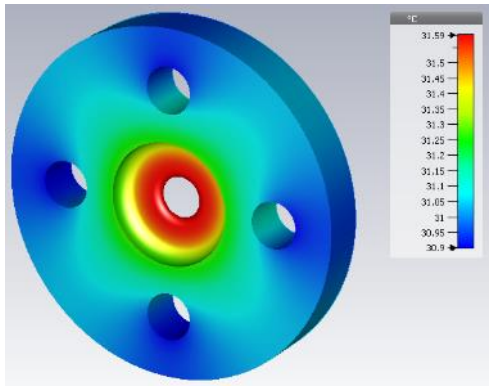


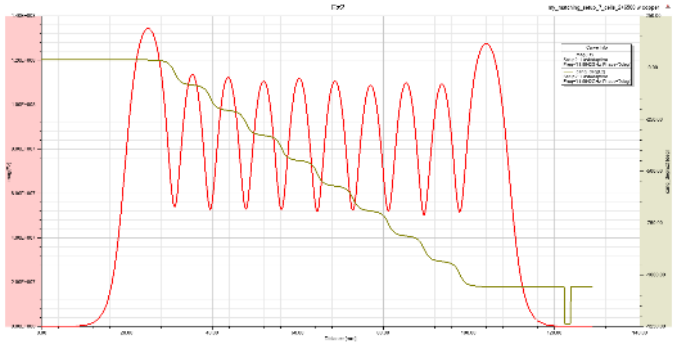
e.m. design of the X band accelerating: Linear tapering of the irises and race track coupler

(*PhD M. Diomede*);



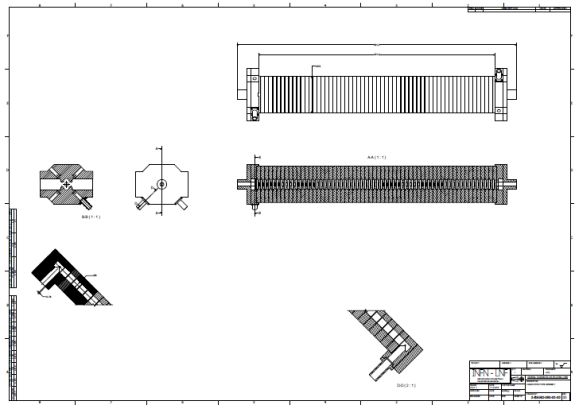


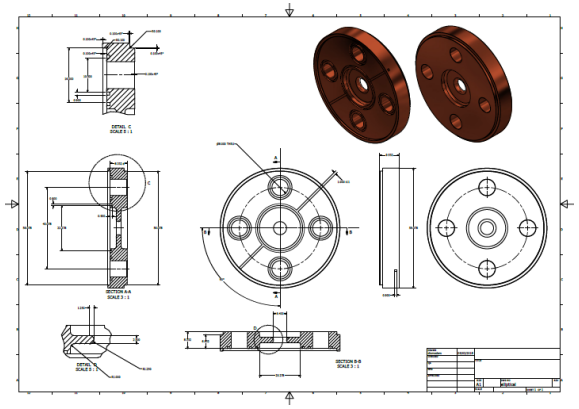




WORK PLAN FOR X BAND STRUCTURE CONSTRUCTION

- X Band structure prototyping phase is splited in:
  - **Mechanical prototype** (full scale low internal precision): test of the vacuum brazing process and structure alignment (snake effects,..)
  - **RF prototype** (10 cells + couplers, high precision): test of RF properties, tuning, low and high power performances
  - NB: Also the **IFAST** proposal has been funded and it foresees the realization of the XLS structure (24 Months): two structures
- Mechanical design of the mechanical prototype (*Mar 21)*
- RF prototype mechanical design (*May 21)*
- Realization (*Fall 21)*





CERN COLLABORATION

Waveguide components

SCIENTIFIC INSTRUMENTS CINEL

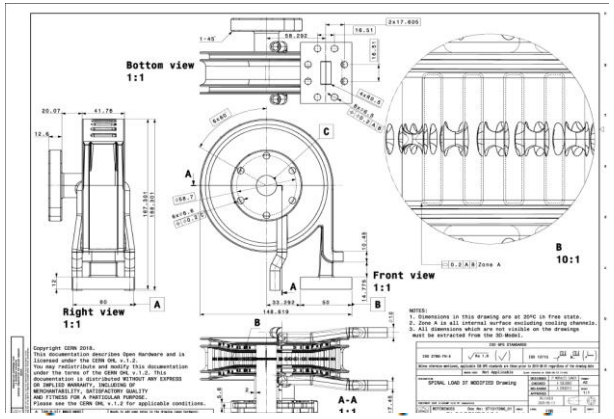
T.S.C. SRL

COMEB

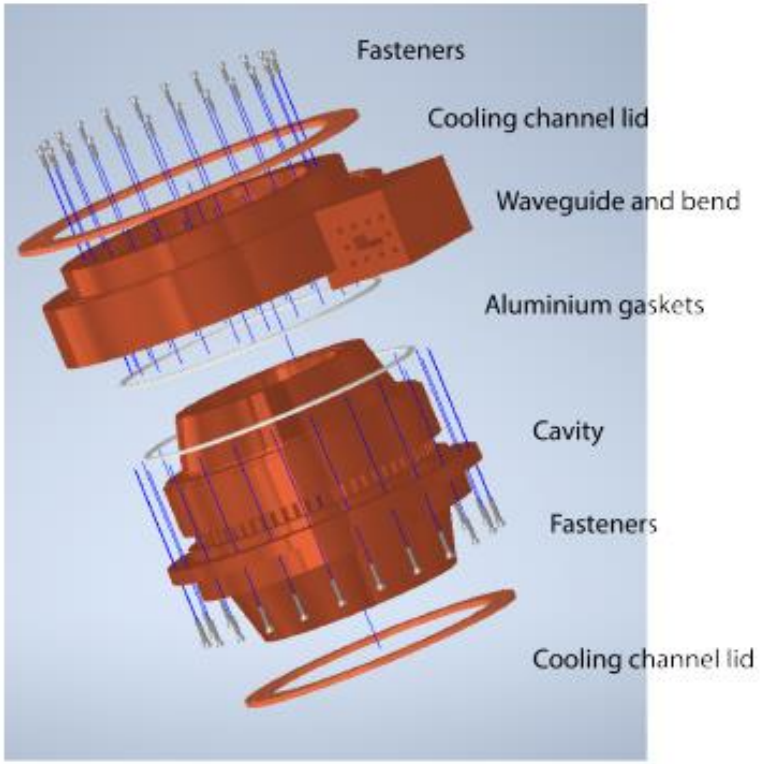
RF structures

POSSIBLE COLLABORATIONS ON X BAND COMPONENT REALIZATIONS

- **Development of an RF load** (spiral one, Titanium) fabricated with standard technologies (milling…): TSC company interested in the development of this technology.



- **Fabrication of a BOC cavity w/o brazing**



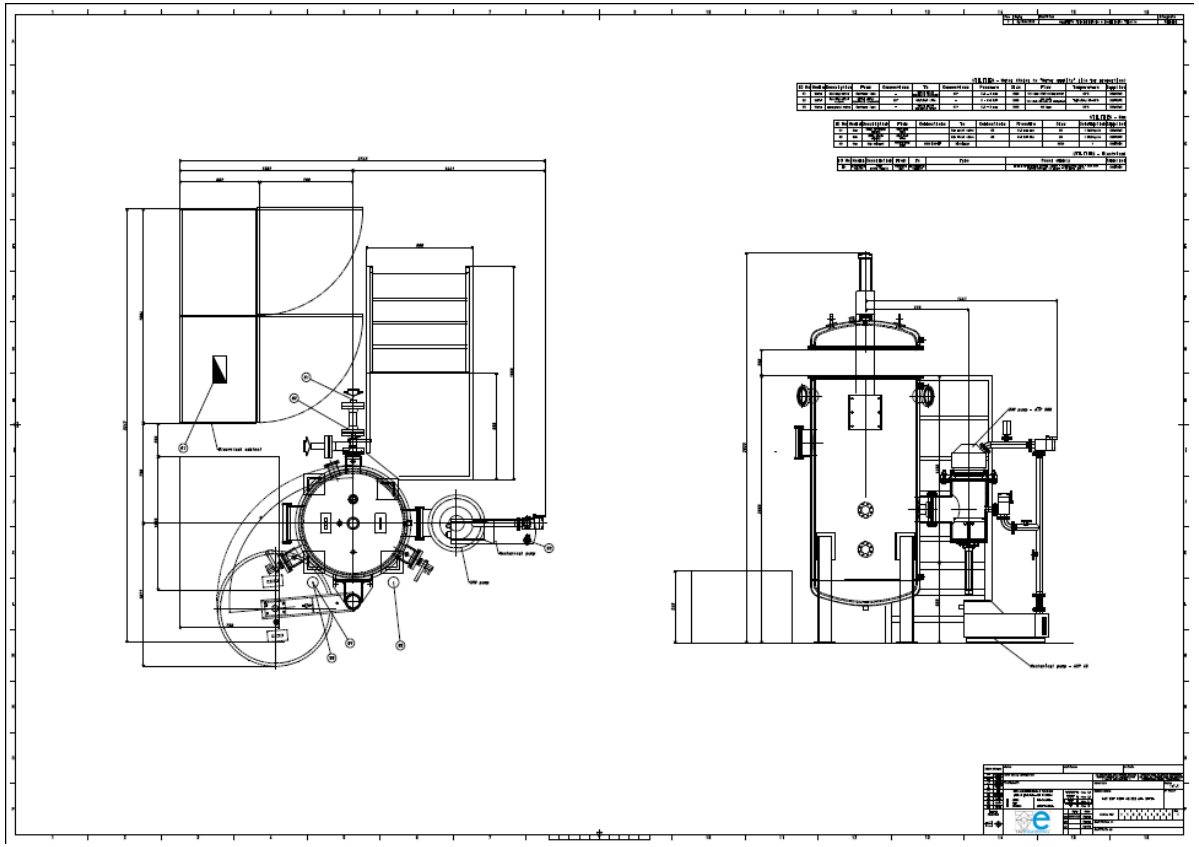
Type	Barrel Open Cavity
Frequency	11.994GH
Resonant Mode	$zTM_{16,1,1}$
Diameter	171.3 mm
Number of coupling slots	62
Coupling factor (β)	7.8
Q_0	150000

- **Circular-rectangular waveguide mode converter realization and test**

- **Dark current** studies: CST license acquired

NEW VACUUM FURNACE AVAILABLE AT LNF-INFN (LATINO PROJECT JUNE 2021)

A new vacuum furnace is under construction (TAV Engineering) and will be available on June 2021. It will substitute the present furnace in operation at LNF (Vacuum lab.)

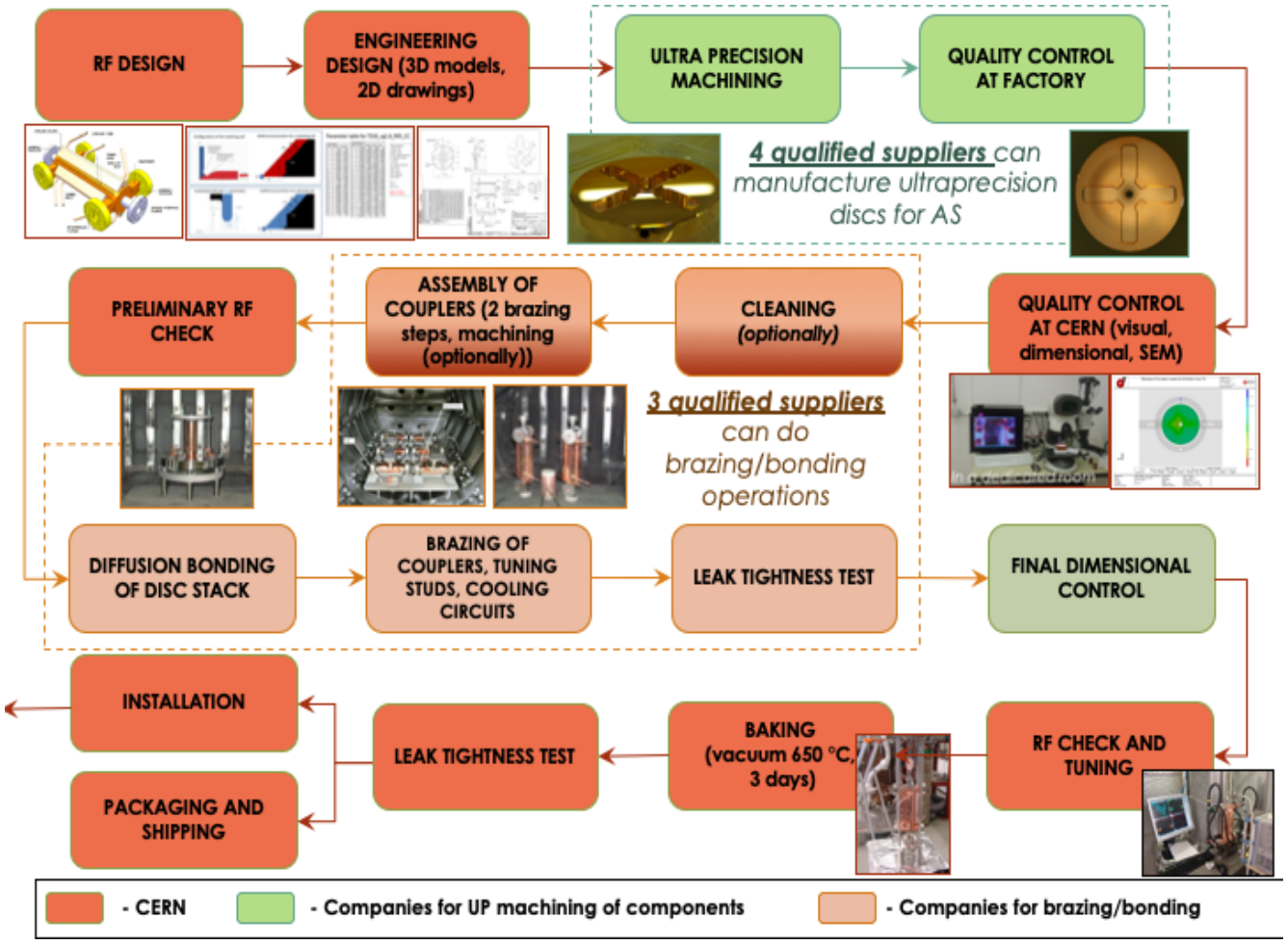


0.2 Dimensioni utili

- Diametro ..... 400 mm
- Altezza ..... 1300 mm
- Volume ..... 163 dm^3

0.3 Temperatura

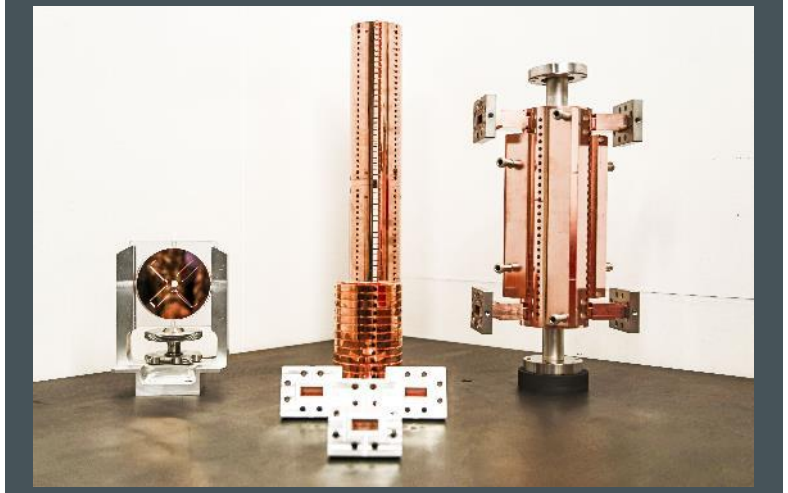
- Temperatura massima ..... 1230 °C
- Temperatura massima operativa ..... 1200 °C
- Uniformità di temperatura in vuoto (T > 700 °C) ..... ± 5 °C



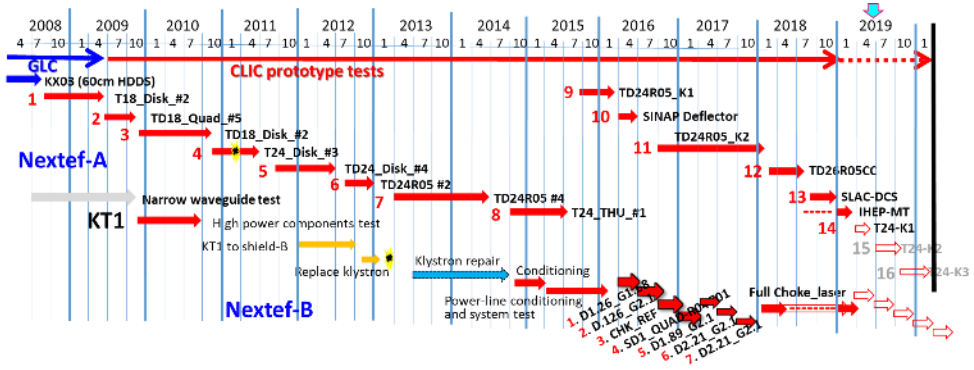
CURRENT PRODUCTION BASELINE AT CLIC

- Based on ultra-precision machining with diamond tools and **diffusion bonding** of the cells
- Gold brazing for parts with access to RF volume
- Silver – alloys for brazing of cooling blocks
- Takes 10 - 11 months to do a full cycle
- 20 - 24 weeks for machining
- 6 - 12 weeks for assembly

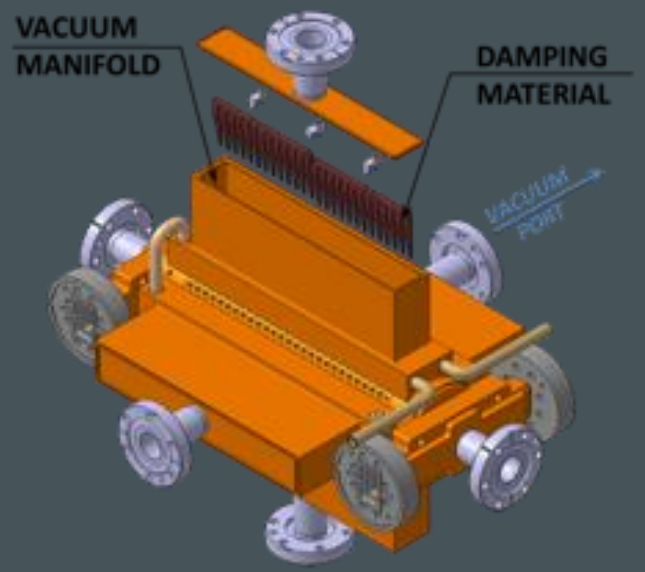
WHAT HAVE WE DONE FOR CLIC?



- More than 30 prototypes at 12 GHz made for high power tests and operation using this baseline.
  - About 20 tested in high gradient and reaching 100-120 MV/m
  - 2 more in operational machines
- About five more done by collaborations using this and other manufacturing processes,
  - Crab cavities done by Lancaster
  - PSI T24 using Swiss FEL method (vacuum brazing)
  - SLAC prototype made of halves. (Silver Brazing)
  - SINAP deflector. Also brazed in vacuum?
  - *SmartLight prototype by Eindhoven*
  - *Probe prototype by Lancaster in S-band*
- KEK parallel development in Asia with ~15 prototypes. Similar baseline



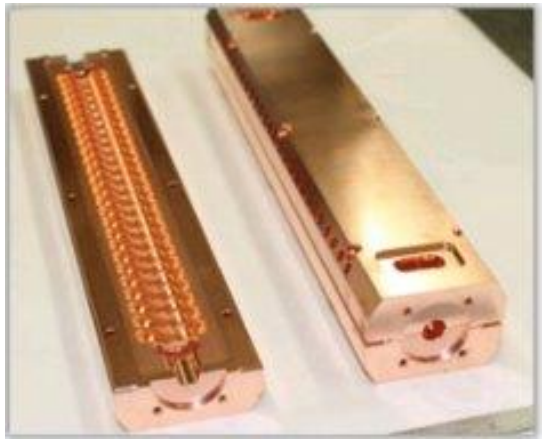
WHAT'S NEXT?



- We know that assembling full prototypes with damping, absorbers and Wakefield monitors is achievable but not optimized
- Up to know, two different approaches with different results
  - Frequent leaks and repair cycles
  - Labor- intensive
  - Alignment between structures outside tolerance
  - Damping features seem to degrade performance
- We also suspect, bonding cycle imposes geometry deformations in the final cells.
  - Not harmful for final performance
  - May require tuning
  - Spoils the machining quality
- And we still have the advantage of hard copper vs. soft copper

Two alternative assemblies

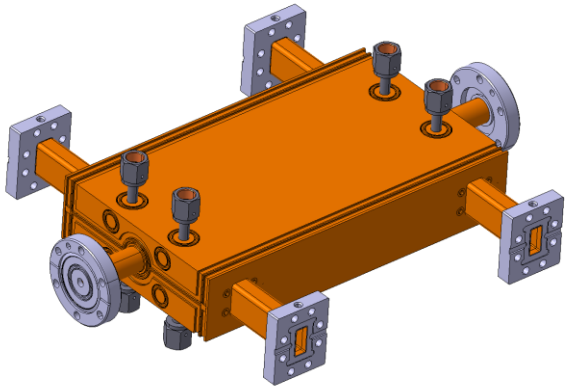
INTEGRATED STRUCTURES MADE OF EB-WELDED HALVES

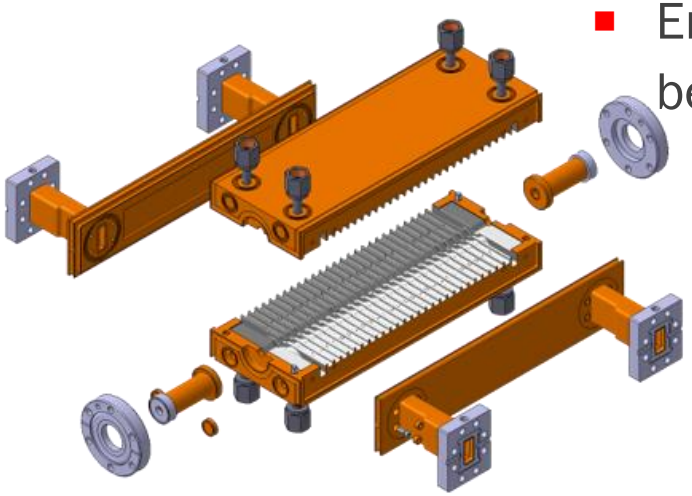


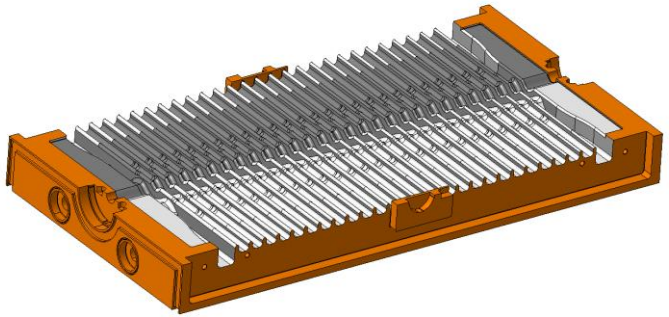
Prototype manufactured by SLAC and tested to 100 MV/m.
New damped prototype arrived from SLAC
Brazed design

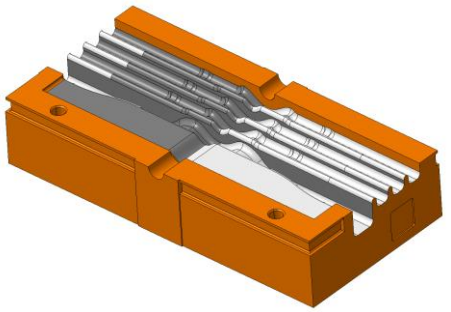
- RF design made by H. Zha and A. Grudiev.
- Mechanical design finished by A. Solodko.
- Asking for quotes

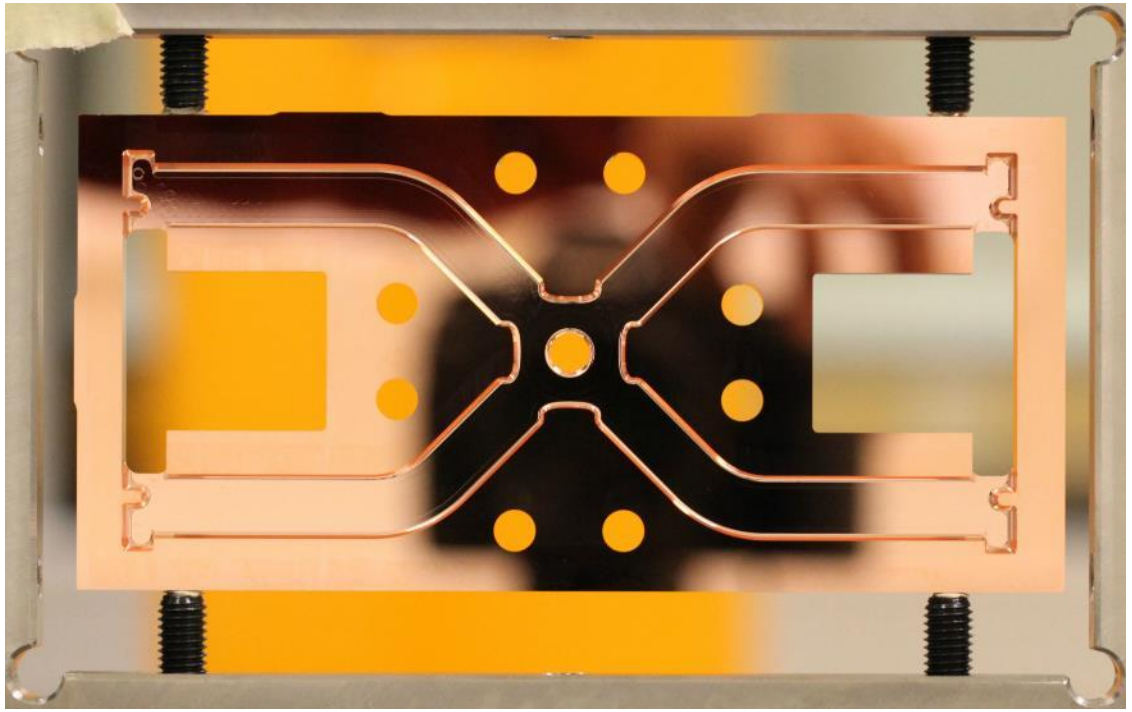
- Eb-welding far from RF area. Hard copper
- Less number of pieces to be assembled
- Integrated design
- Long time of machining makes them more sensible to unforeseen problems. Lower yield. Bigger price
- Qualification piece required
- Errors in alignment have a bigger impact as they become systematic

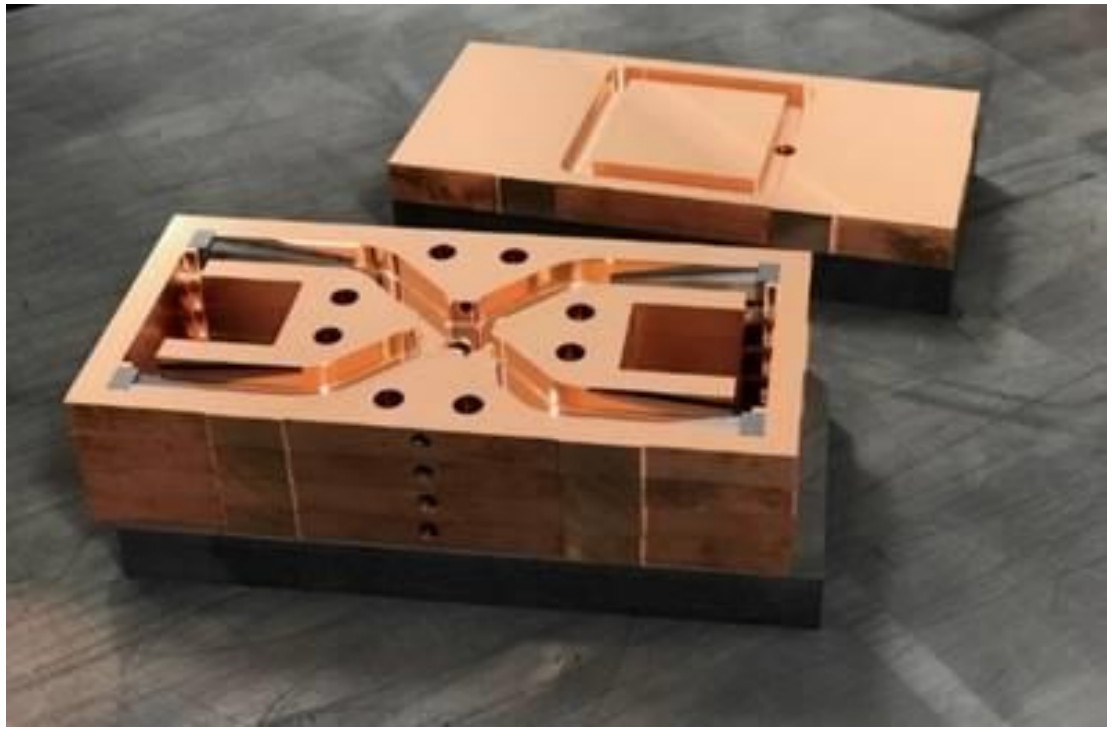












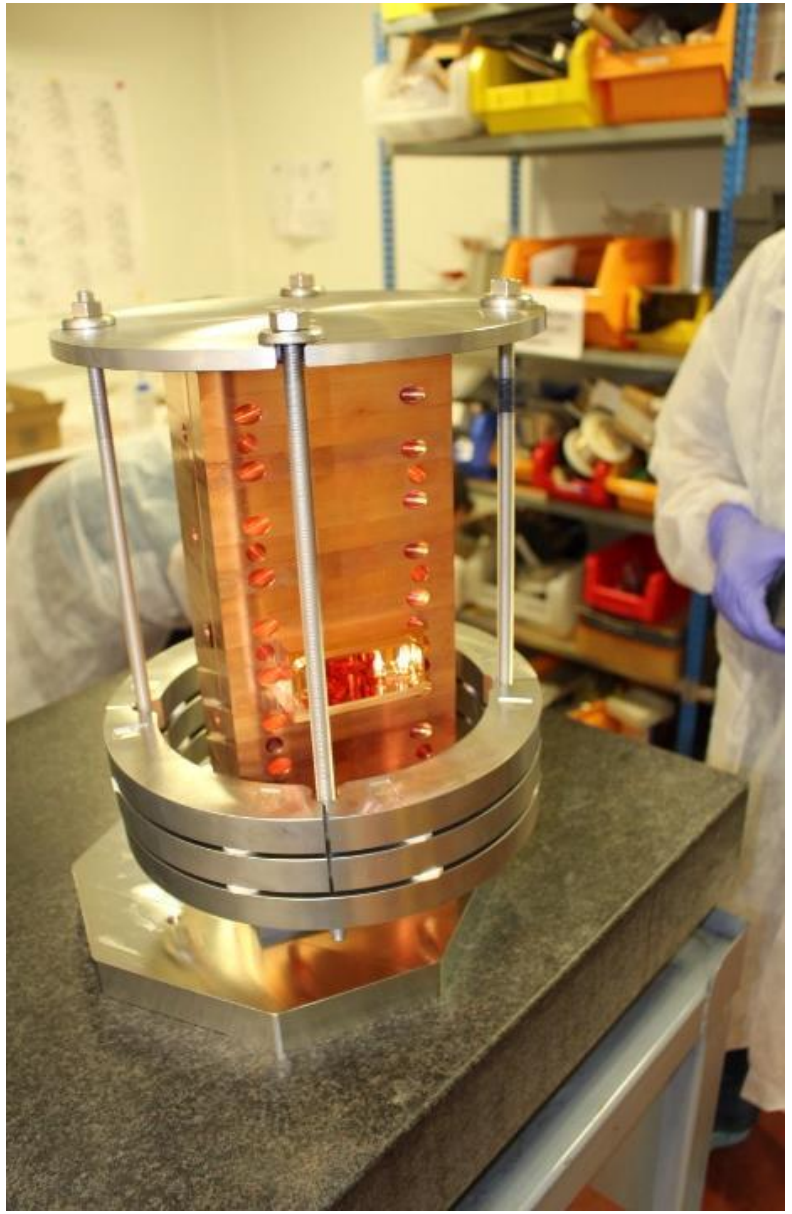
INTEGRATED RECTANGULAR DISKS

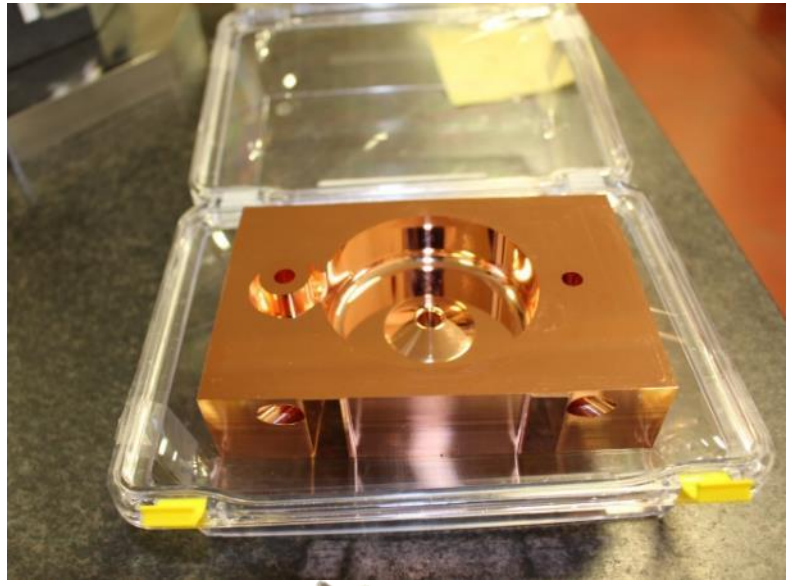
- Bend waveguide design made by H. Zha and A. Grudiev
- Mechanical version by A. Solodko including vacuum, cooling and silicon carbide loads.
- Bonding test. Failed due to silicon carbide height

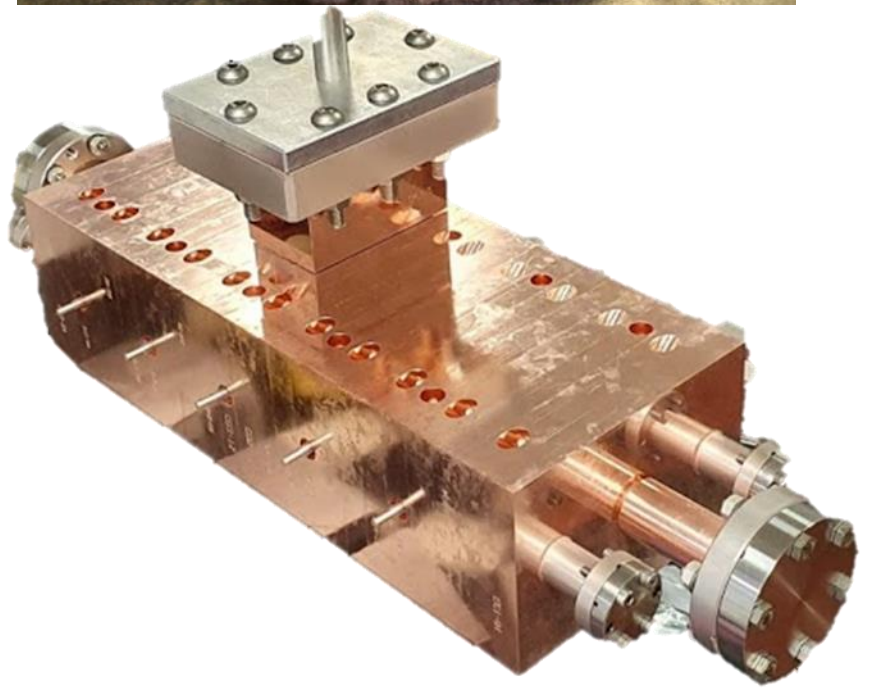
PROBE STRUCTURE

- S-band structure for medical therapy
- Structure designed and built by Lancaster with CERN procedures
- Similar bonding area to CLIC prototype
- No silicon carbide
- Leak tight

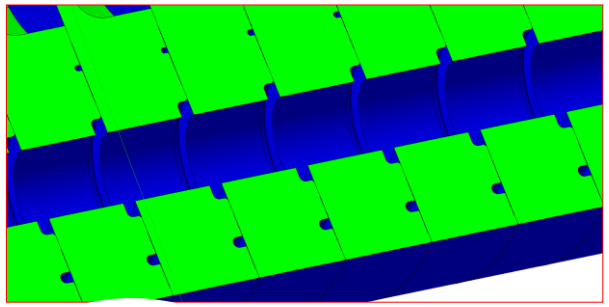
- Using special alignment and weighting tool
- Assembled by CERN technicians and Lancaster staff
- To be tunned at CERN by Lancaster students in the next weeks

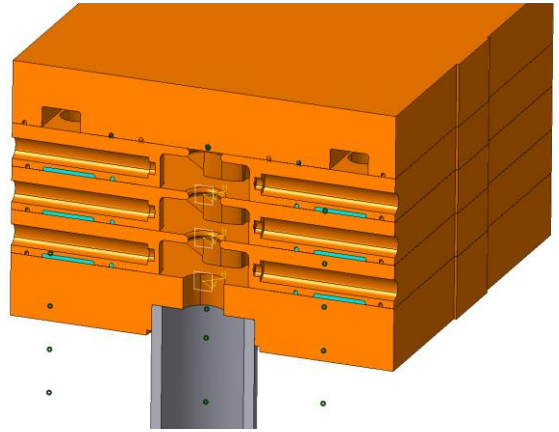




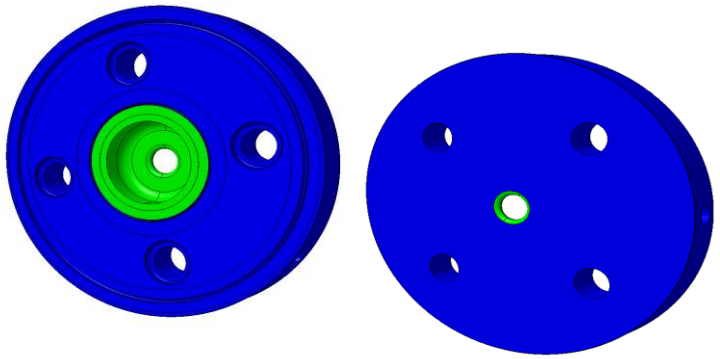


BRAZING DESIGN FOR INTEGRATED DISKS

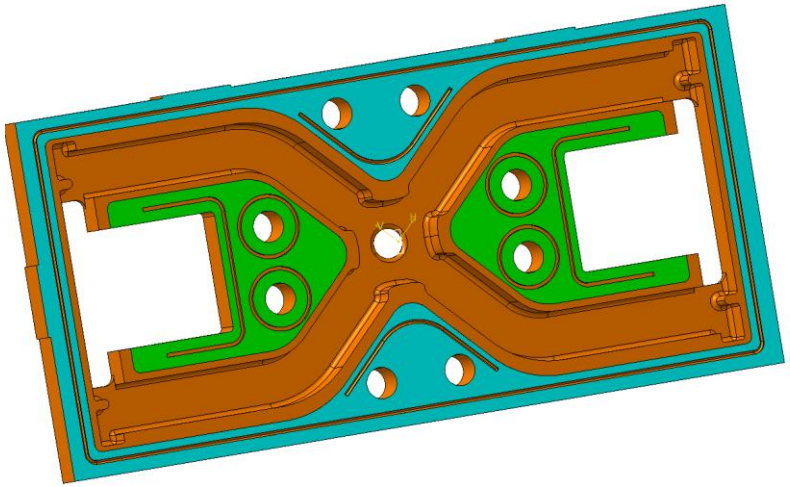




- Re-use spare disks designed for brazing before 2010
- Compare different brazing materials, heat cycles, material/void ratio
- Destructive tests to assess quality and bond



Possible synergy with INFN!



Brazing tests in spare disks → Re-design the disks for brazing → Procurement and fabrication of a mechanical mock-up → RF/Mechanical design of a full structure → Fabrication and test

X-BAND LINEARIZER

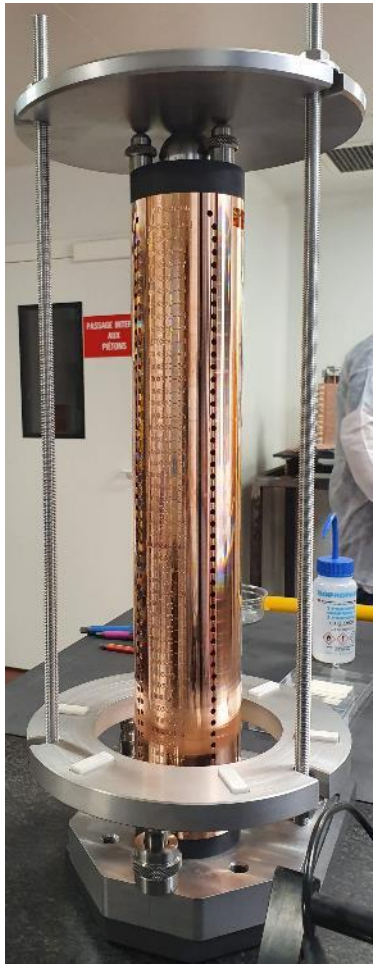
- ~1m-long structure. Linearizer for S and C-band FEL
- Two units in Elettra (Trieste) and two in PSI (Villigen)
- Made from three bonded stacks of ~33cm
- Final brazing with interlock disks
- Currently manufacturing one unit for XCLARA in Daresbury

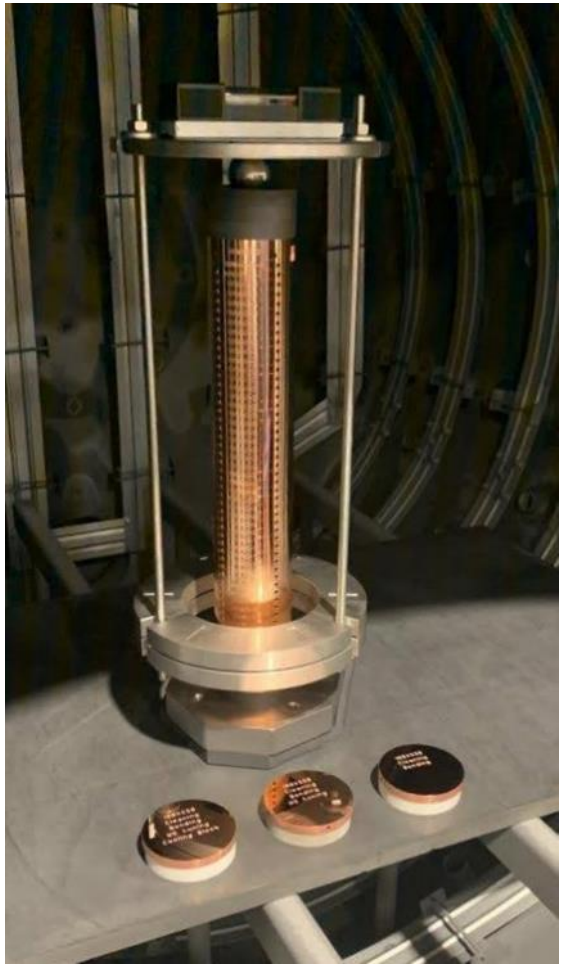
SMART LIGHT STRUCTURE

X-band bunching-accelerating structure for Compton source

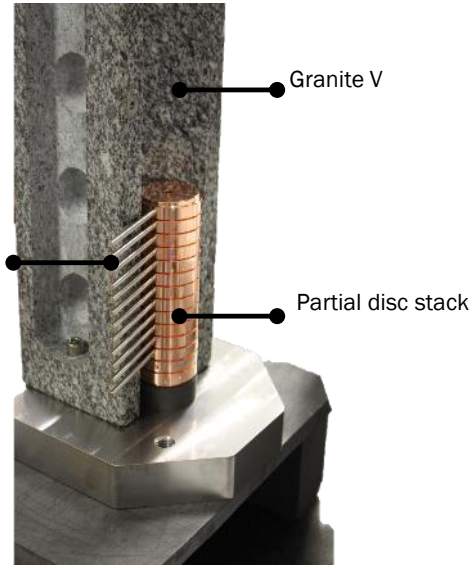
Structure designed and built by Eindhoven with CERN procedures

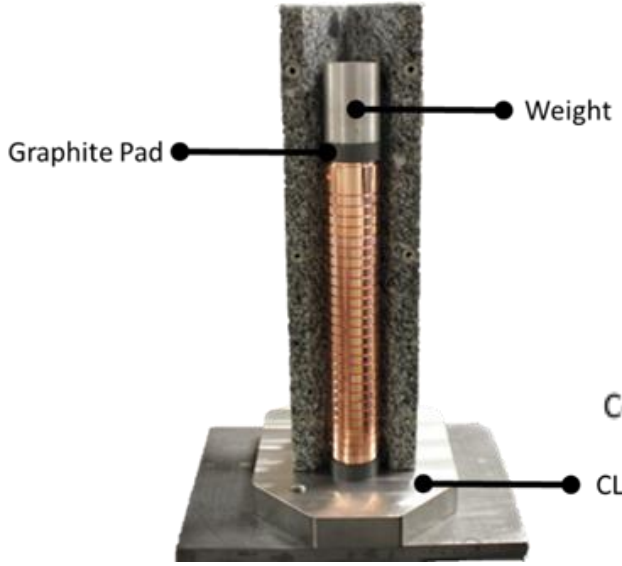
- Using CERN alignment and weighting tool
- Assembled by CERN technicians in the presence of Eindhoven staff
- Tunned at CERN (without Eindhoven presence due to COVID19)

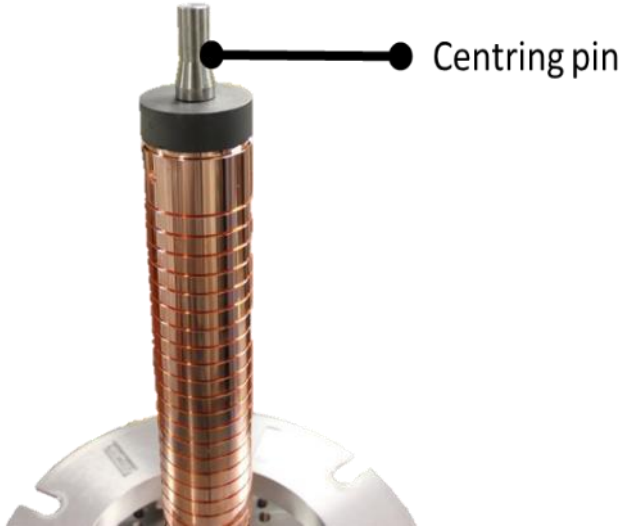


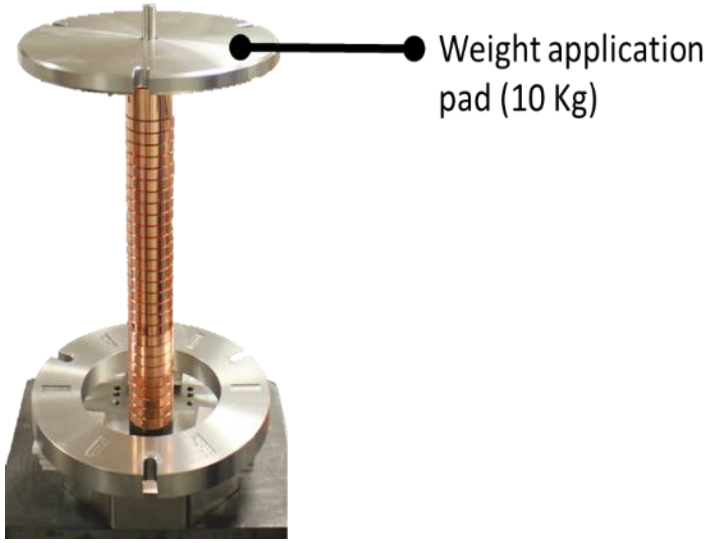


ALIGNMENT AND BONDING TOOLING

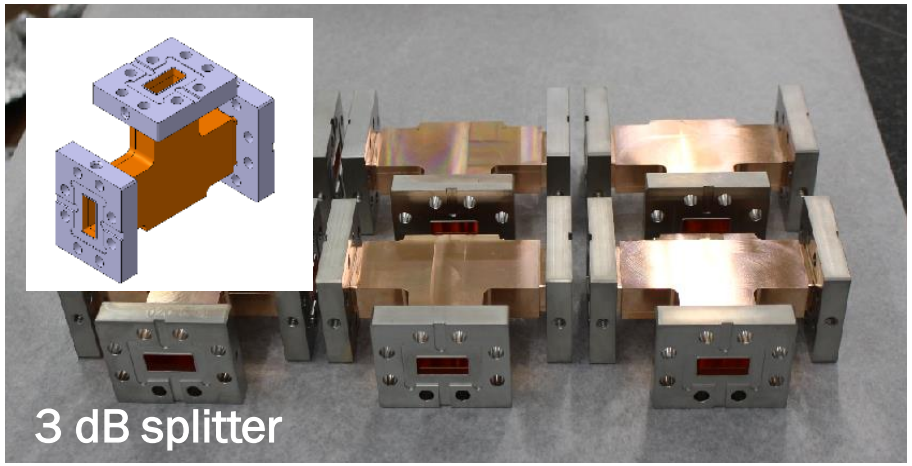


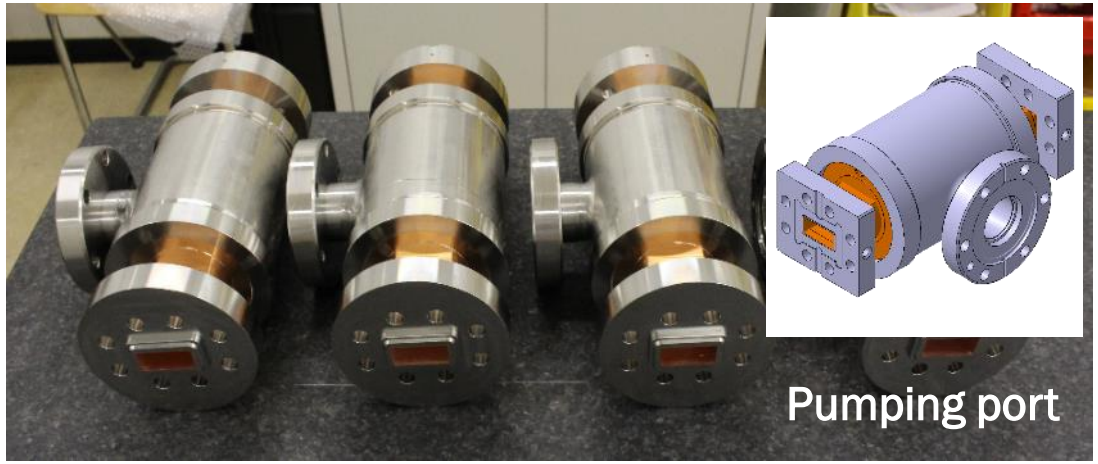


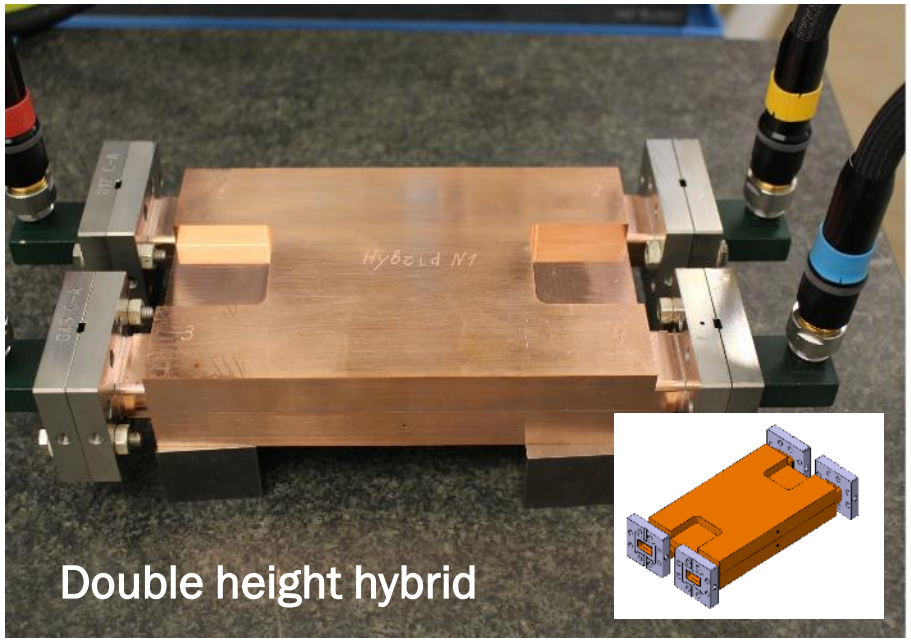


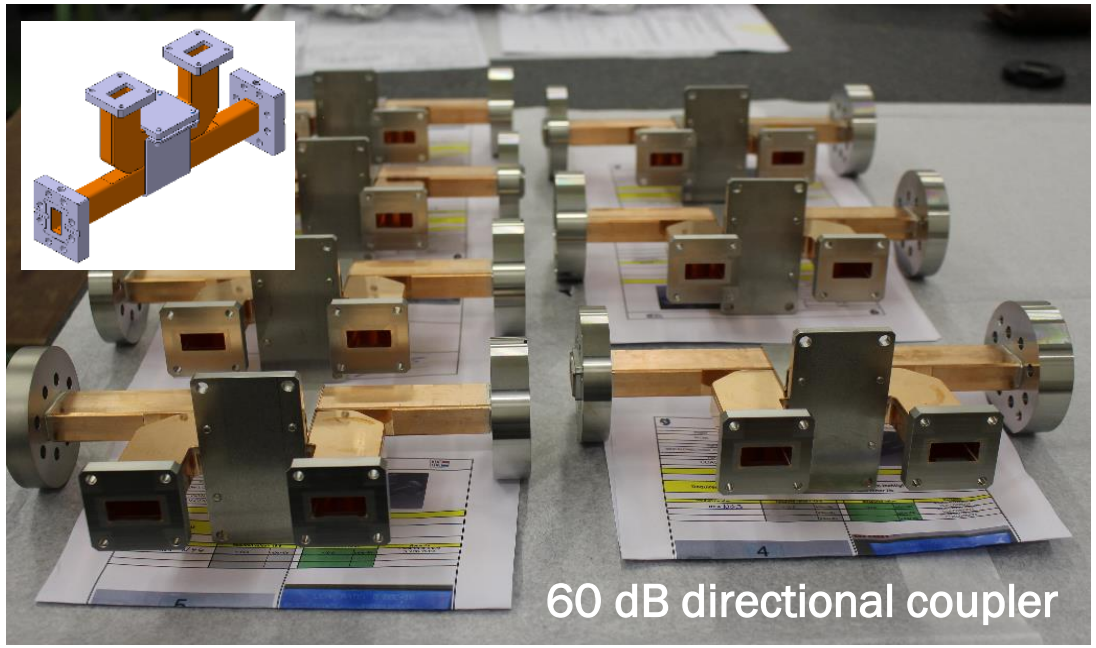


COMPONENTS. HTTPS://ESPACE.CERN.CH/PROJECT-CLIC-XBAND-PRODUCTION/OPEN%20HARDWARE%20XBAND%20COMPONENTS/FORMS/ALLITEMS.ASPX

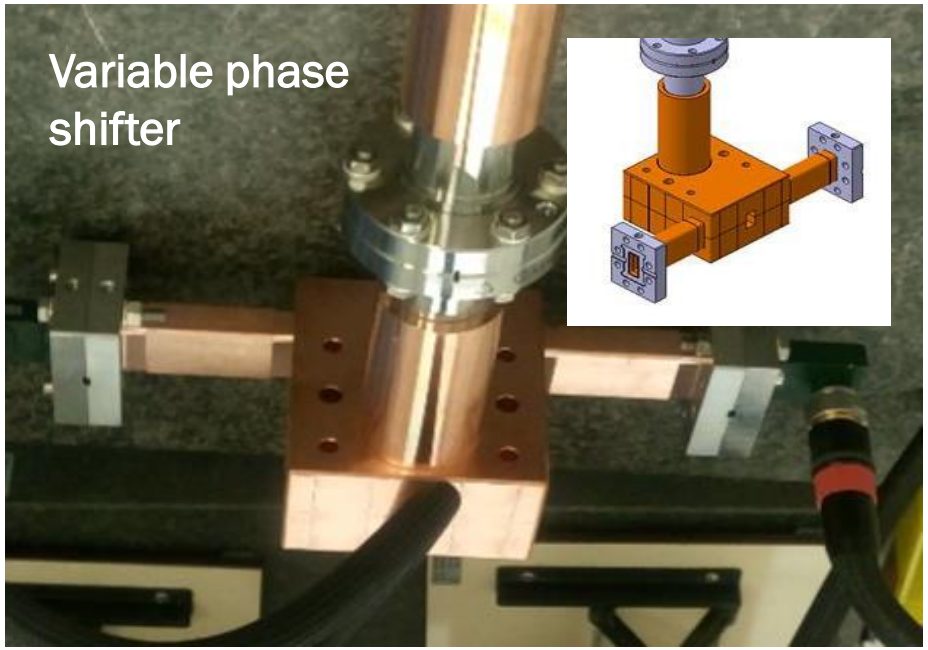


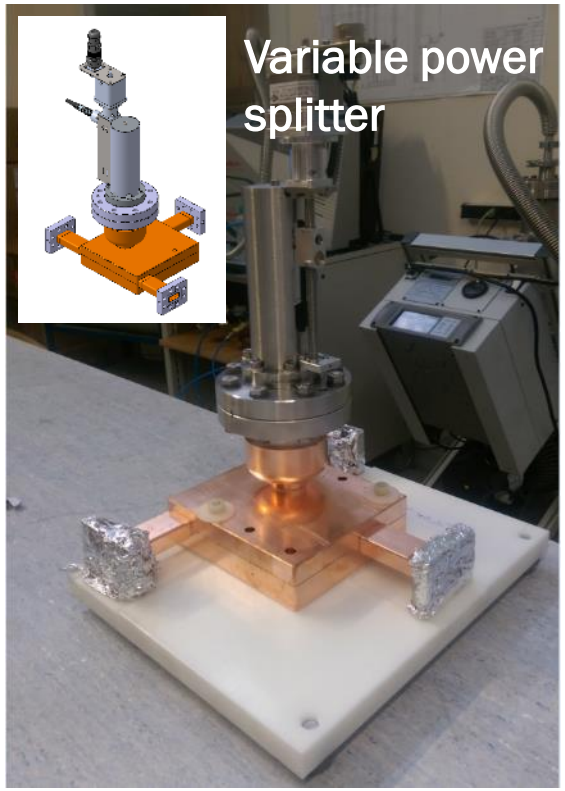


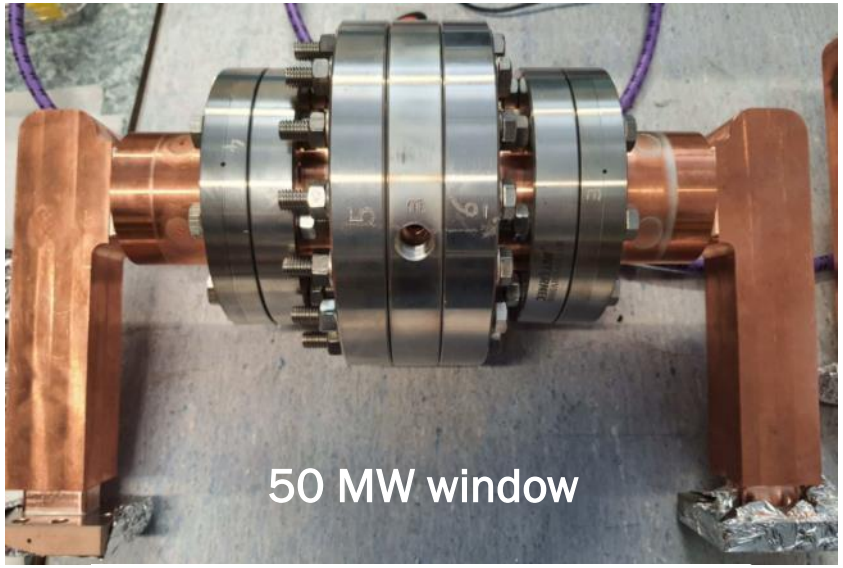


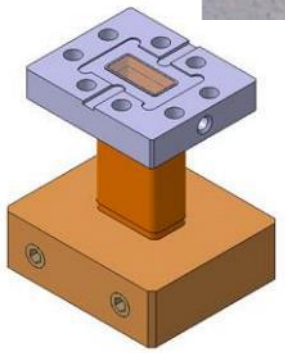


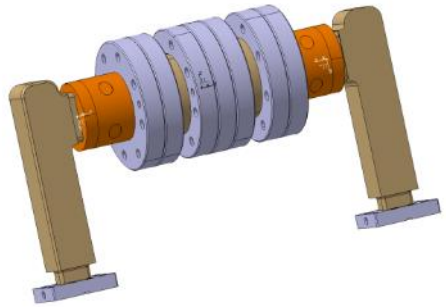
COMPONENTS. NOT YET IN OPEN HARDWARE



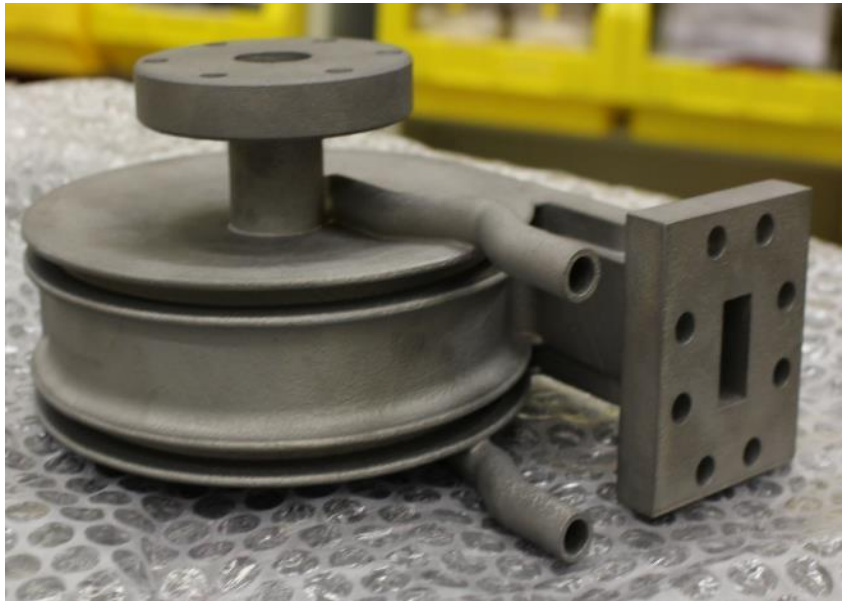


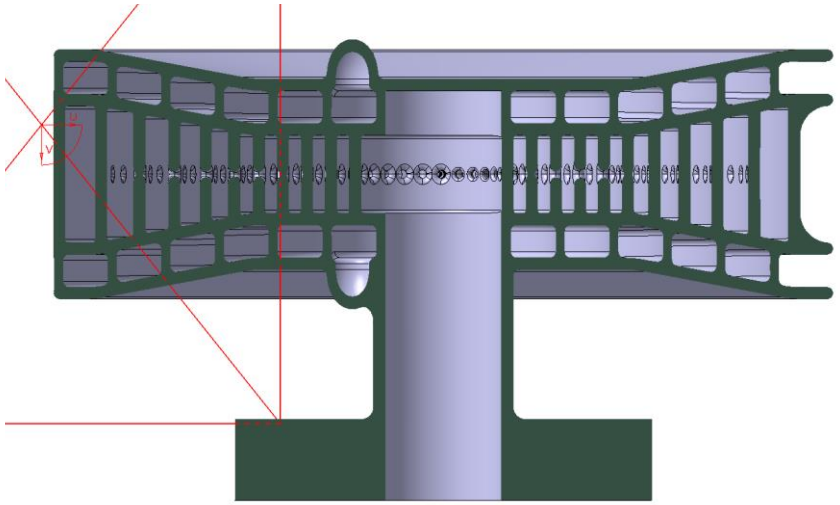




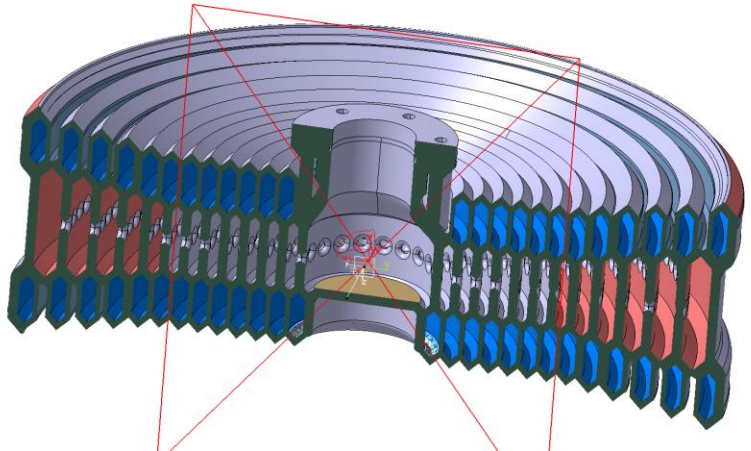


COMPONENTS. SPIRAL LOAD



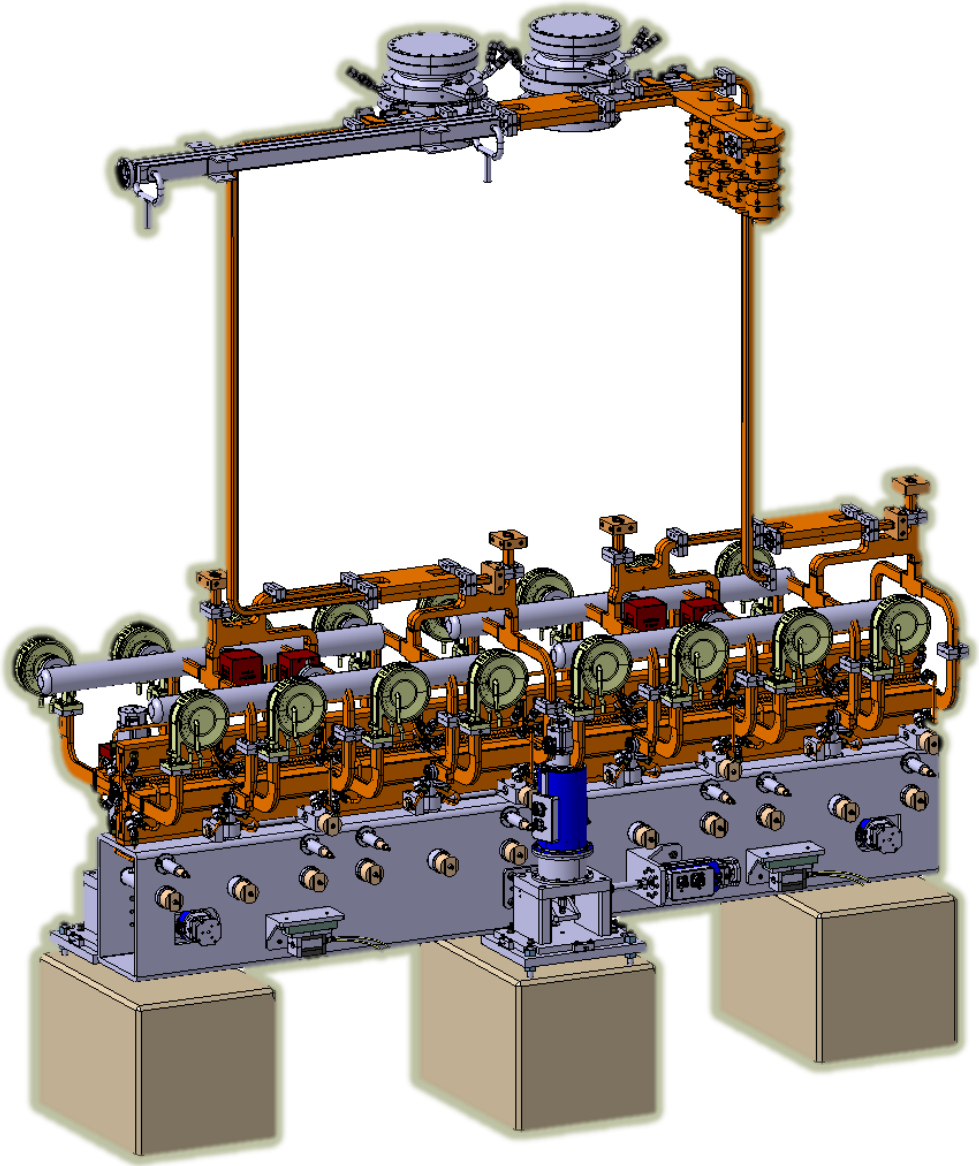


- 3D printed in StSt and Titanium.
- Tested to high gradient > 35MW
- Compact and unexpensive. New design to optimize printing underway
- Maybe difficult to machine



FULL CLIC MODULE FOR KLYSTRON-BASED MACHINE

TBC



Will use final integrated structure to build super-structures
Will need two BOC pulse compressors.
New components to be design and manufactured

SUMMARY AND INPUT FOR DISCUSSION

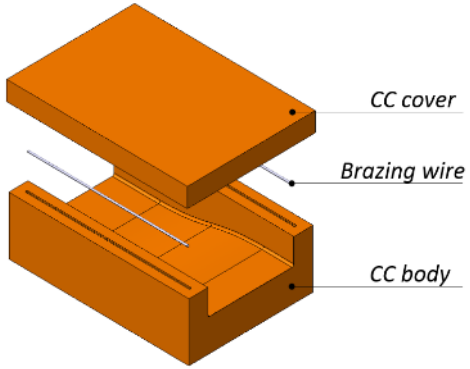
- Efforts in INFN synergetic with CLIC and CERN ambitions

Potential points for collaboration:

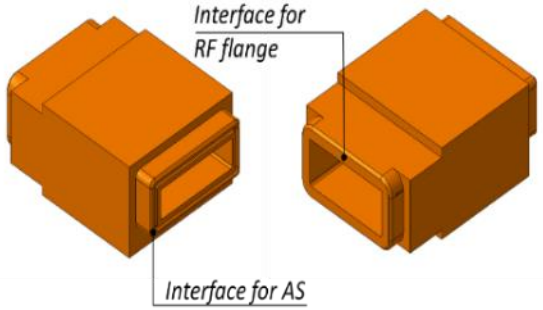
- Common review for assembly steps and tooling after first draft version of mechanical drawings
- CERN participation in the assembly of the INFN prototypes
- CERN assistance for components production in particular spiral load.
- RF design and manufacturing of overmoded waveguide
- Dark current studies in both boxes
- Possible common BOC pulse compressor based on clamping
- *Girder and alignment design*
- *Conditioning*

DISCUSSION TIME

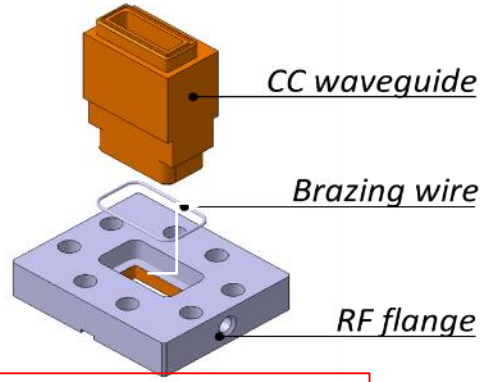
THANKS TO: A. MAGAZINIK, S. SAUZA BEDOLLA, P. MORALES SANCHEZ, S. LEBET, S. GONZALEZ ANTON, S. LACROIX, M. DIOMEDE, A. GALLO



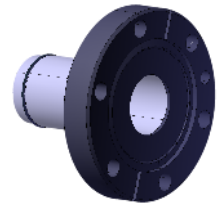
1st Brazing: Au25%-Cu75% 1040 C x 5 min



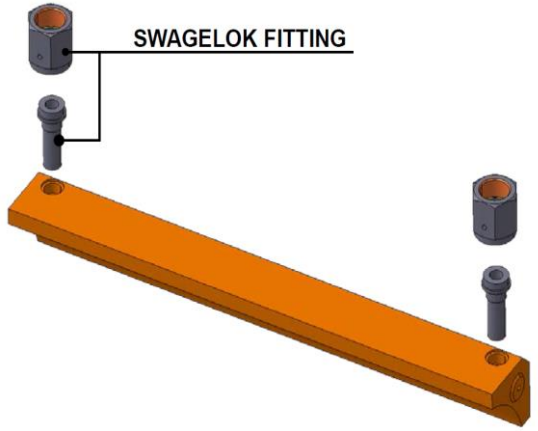
Remachining of interfaces



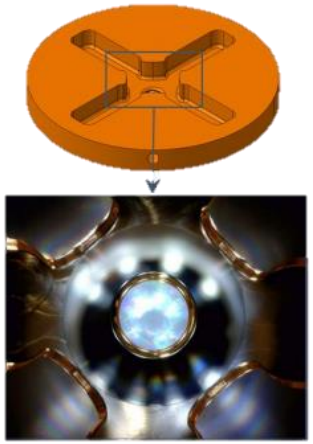
2st Brazing: Au25%-Cu75% 1040 C x 5 min

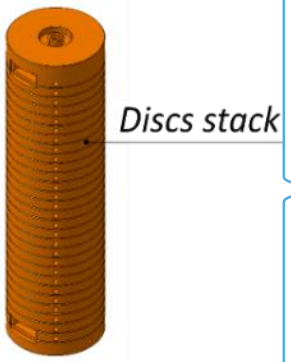


1st Brazing: Au25%-Cu75% 1040 C x 5 min

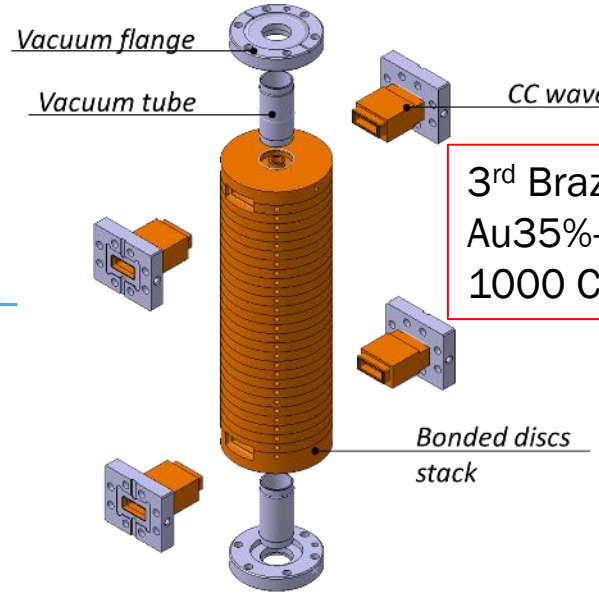


1st Brazing: Au25%-Cu75% 1040 C x 5 min

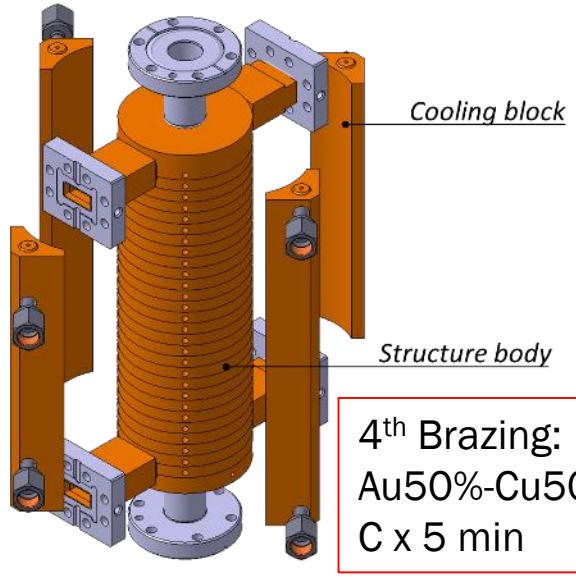




Diffusion bonding 1030 C x 1h30



3rd Brazing: Au35%-Cu65% 1000 C x 5 min



4th Brazing: Au50%-Cu50% 950 C x 5 min