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Status report on SALAF technical activity on vacuum brazing on X-band linear accelerating structures and RF deflector of the SPARC project at Frascati Laboratories.

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Abstract

A work on brazing RF multicell structures was continued and developed on the base of the same procedure and design already described in the LNF – 05/22 (IR) [1] report.
This activity received a strong improvement as soon as the new, high performance, vacuum oven was installed at Frascati and put into operation at the end of 2006 year.

ALLOYS.

The eutectic Ag.Cu was extensively used on the Copper-Copper joints. In some cases higher melting point alloys were used on structures made in more than two parts when it was necessary to make weldings in sequence, in other words when it was not possible to braze the whole structure in one shot. The Palladium.Copper.Silver alloys were used with different composition and therefore with different melting points. This kind of alloys were used also for brazing Copper-Molybdenum and Copper-StainlessSteel joints.

MATERIALS.

Oxigen Free, High Conductance Copper is the metal generally used for RF Structures, as well known. The use of the standard electrolytic Copper must be generally avoided due to the emission under vacuum and high temperature of the Oxigen absorbed inside the metal. In case of necessity, brazing of good quality has been obtained following a proper procedure (out gassing).

Stainless Steel for flanges and other connections was used. Very good joints were obtained with the above-mentioned Palladium alloy.

Molybdenum. This metal seems to be very promising when used for the irises of the multicell structures because it guarantees the possibility to work at higher RF fields. For this reason an activity on Mo-Cu brazing started recently in order to study this kind of joint.

TUNING.

In order to have a 9 cells structure to be put under vacuum for RF power tests a simple tuning system was tested, consisting in a deformation, using a proper tool, of the inner surface of the single cells. Mechanical and Radiofrequency tests gave very good results (citare tesi di laurea). Three points of deformation on the circumference of the cell, roughly at 120° were obtained using a proper manual device (a motorized device will be prepared) in combination with a 4 mm Stainless steel cylinder. It has a special shaped head in order to guarantee the requested deformation without cracks. A simple relation between deformation depth and frequency reduction has been obtained.

MACHINING.

The tuning itself can be avoided if a machining able to guarantee a precision of +/- 1.5 micron can be obtained: in this case the structure can be tuned simply varying the working temperature.

Recently the company specialised in precision machining, with which we collaborate, obtained the above precision, on single cells. Thermal stability of the room and of the precision lathe itself as well as the use of special diamond tools are the base points in order to obtain good results.

MOLYBDENUM.

It has been demonstrated that a way to increase the RF fields inside the accelerating structure is the use of Molybdenum to make the irises.

An activity on this field started in order to define the best brazing geometry among Mo irises and Cu structure.

The idea was to prepare every cell with a Mo iris inside and then to braze all the cells together.

Two ways were taken into consideration:

1) – Braze a Mo disc inside the cell and then machine it in order to obtain the iris with its proper precision and roughness.
2) – Prepare the Mo disc with its iris already machined and then braze it into the cell.

Comments.

Point 1) – There is the necessity to machine the Molybdenum after the brazing process. This guarantees the precision of the structure but increases the difficulty to obtain a good quality Mo surface due to the Mo structural modification (annealing) as a consequence of the high temperature cycle.
Point 2) – It is generally difficult to maintain the requested high level precision for joints to be brazed between metals with different expansion coefficients because the clearance between the parts is not maintained at high temperature.
Work is in progress both on point 1) and point 2).

RF DEFLECTOR.
For the Frascati linear accelerator SPARC an RF Deflector operating at 2.856 GHz has been designed, built by a company specialized in mechanical precision works and finally brazed using the Frascati vacuum oven.
Many brazed joints both Copper – Copper and Copper – Stainless Steel have been made using the eutectic alloy Ag/Cu in the first case and the Palladium-Silver-Copper alloy in the second case.
The quality of the single joints as well as of the entire structure has been checked, as usual, considering the maintenance of the precision levels and essentially with an accurate leak test using a high sensitivity Helium leak detector.

SPUTTERING SYSTEM.
An RF Sputtering System has been just received. As soon as possible it will be mounted and mainly dedicated to

- prepare Copper layers on metals difficult to be brazed
- deposit special metal layers on the cores to be used in the Electroforming process
- study the possibility to make Molybdenum layers on Copper irises.

FUTURE WORK.
In addition to the brazing of RF Accelerating Copper structures, that can be considered as a standard production, the group will be involved in the following activities.

- to machine routinely Copper components with a precision of a few microns and a roughness Ra less than 0.1 micron
- to machine Molybdenum components with a precision and a roughness comparable to those ones of the Copper, also in the case of thermal treated Mo.
- Sputtering activity as already said.
- To prepare a 9 cells Copper structure complete with vacuum and cooling system ready for the RF power tests.
- To start studying brazing procedures for multi-cell structures (20 – 30 cells). Some tests must be made to find the simplest way to maintain fixed a very long structure during the thermal cycle.

Acknowledgements.
We wish to thank the COMEB company, specialized in precision machining, for the collaboration to solve all the problems related to the machining and the finishing. For the same reasons we wish to thank the CECOM Company.

References

[1] P. Chimenti, V.Chimenti, A. Clozza, R. Di Raddo, V. Lollo, M. Migliorati, B. Spataro - “First results on vacuum brazing of RF 11 GHz, linear accelerating structures at Frascati Laboratories” LNF – 05/22 (IR) 14 November 2005

Figure caption:

Fig 1 A just brazed Mo-Cu cell before final machining .

Fig 2 A copper cell with iris in Mo after machining .

Fig 3 RF cell after a deformation tuning in four points .

Fig 4 Measuring the deformation tuning geometry.

Fig 5 A particular of the maximum deformation obtained in one point inside the cell.

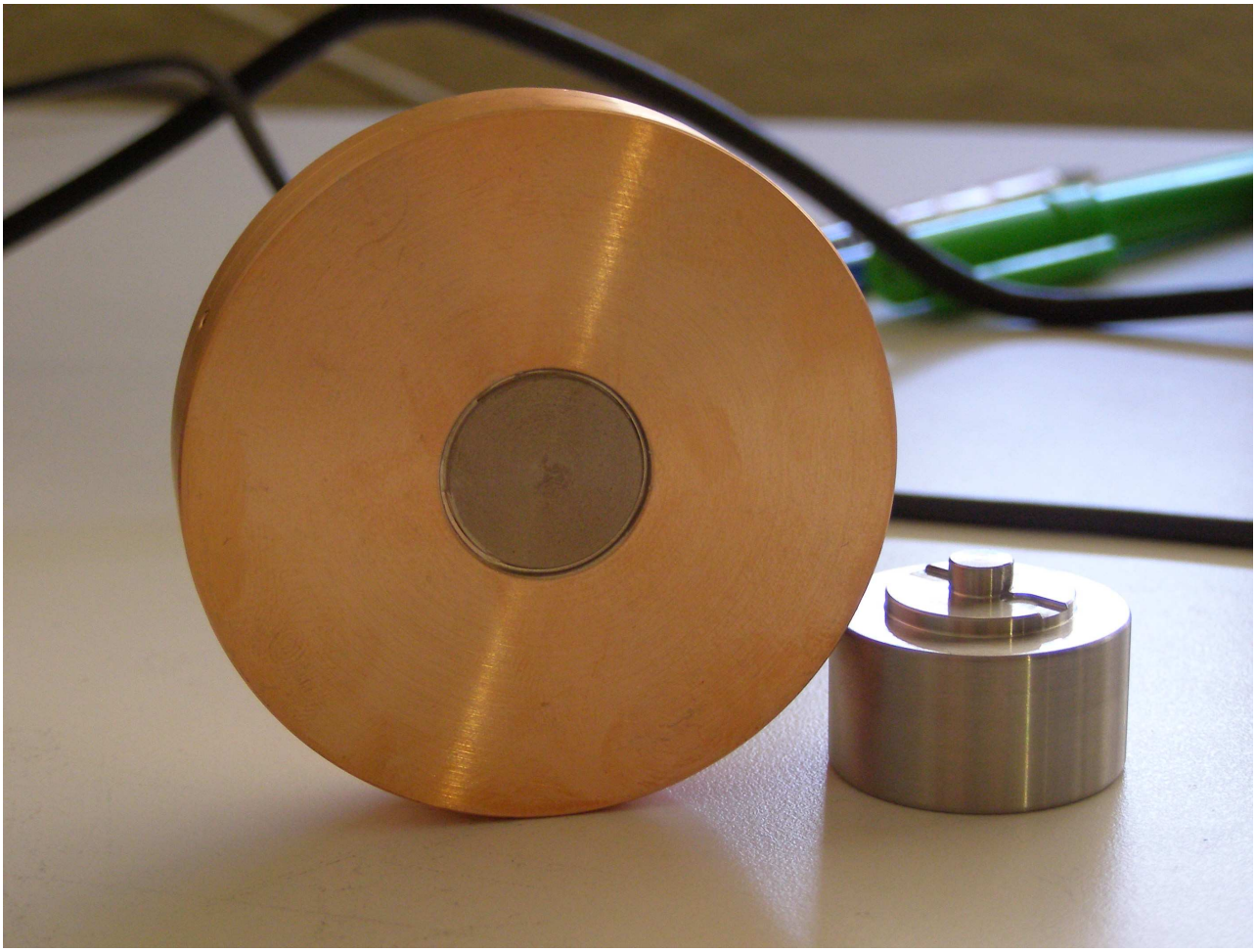
Fig 6 The SPARC RF deflector design.

Fig 7 Some parts of the RF deflector during brazing procedure.

Fig 8 The RF deflector ready to be inserted in the vacuum oven for the final brazing cycle.

Fig 9 The RF deflector inside the vacuum oven.

Fig 10 The RF deflector during RF measurements.



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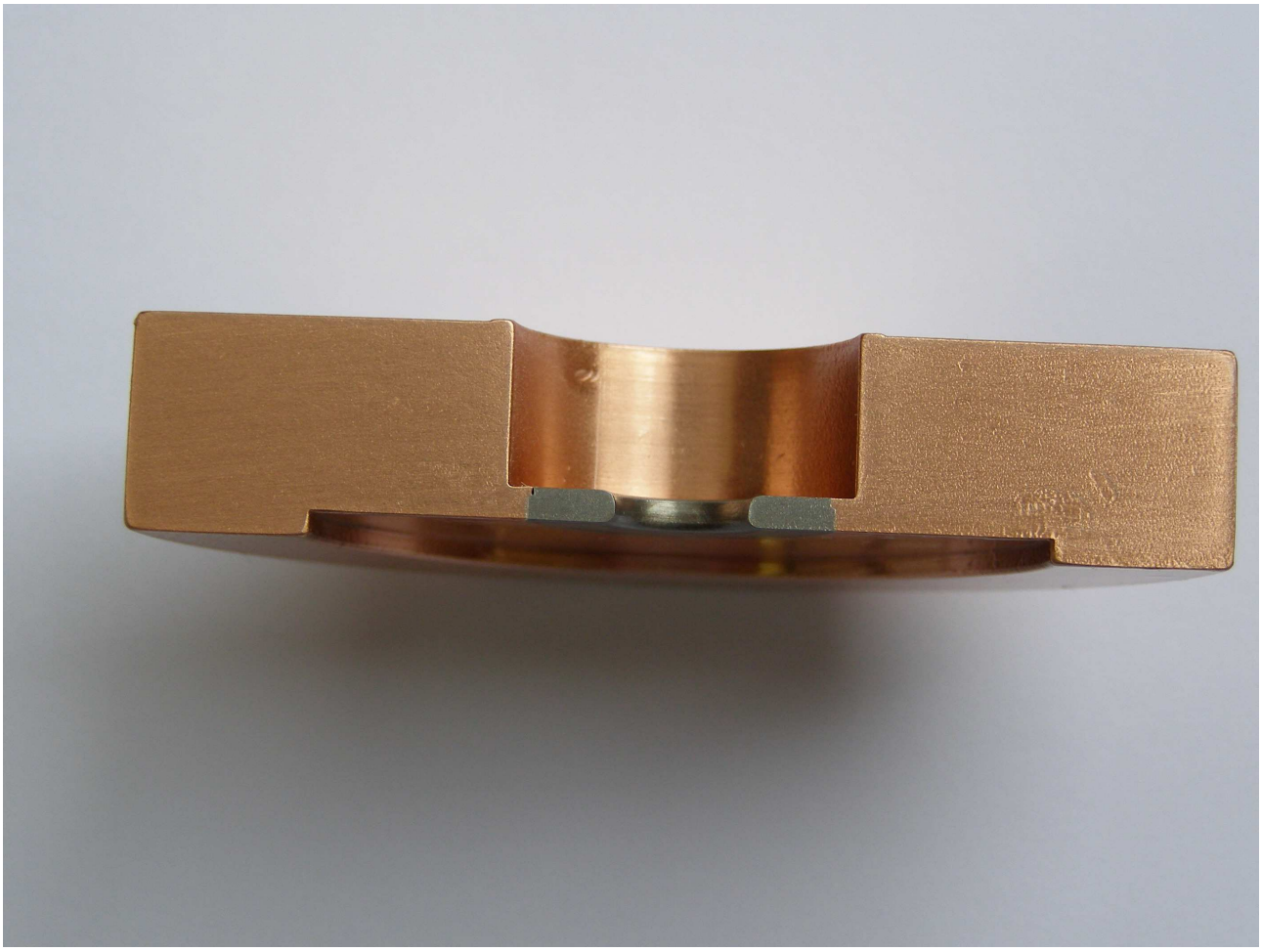

Fig 2 A copper cell with iris in Mo after machining .

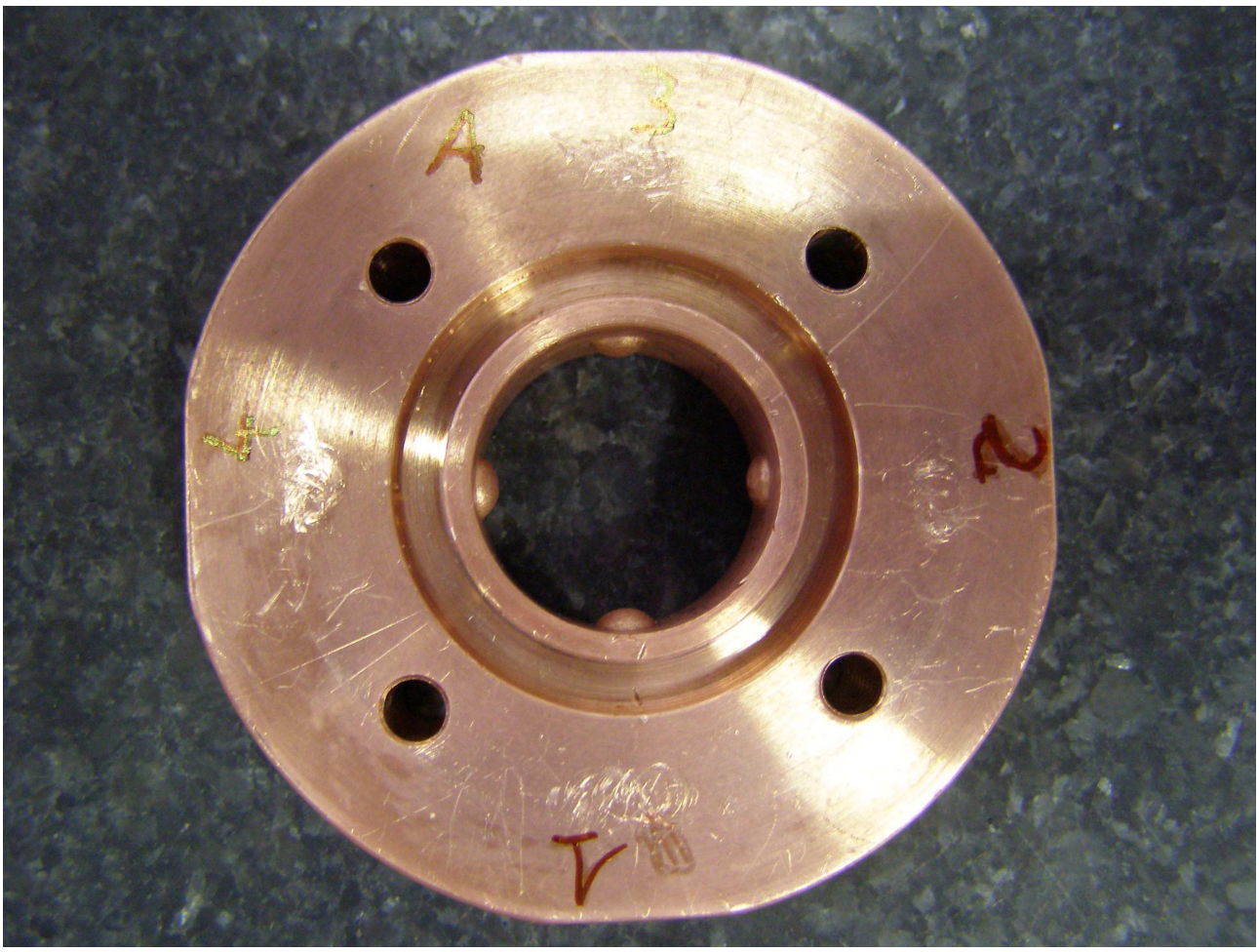

Fig 3 RF cell after a deformation tuning in four points .

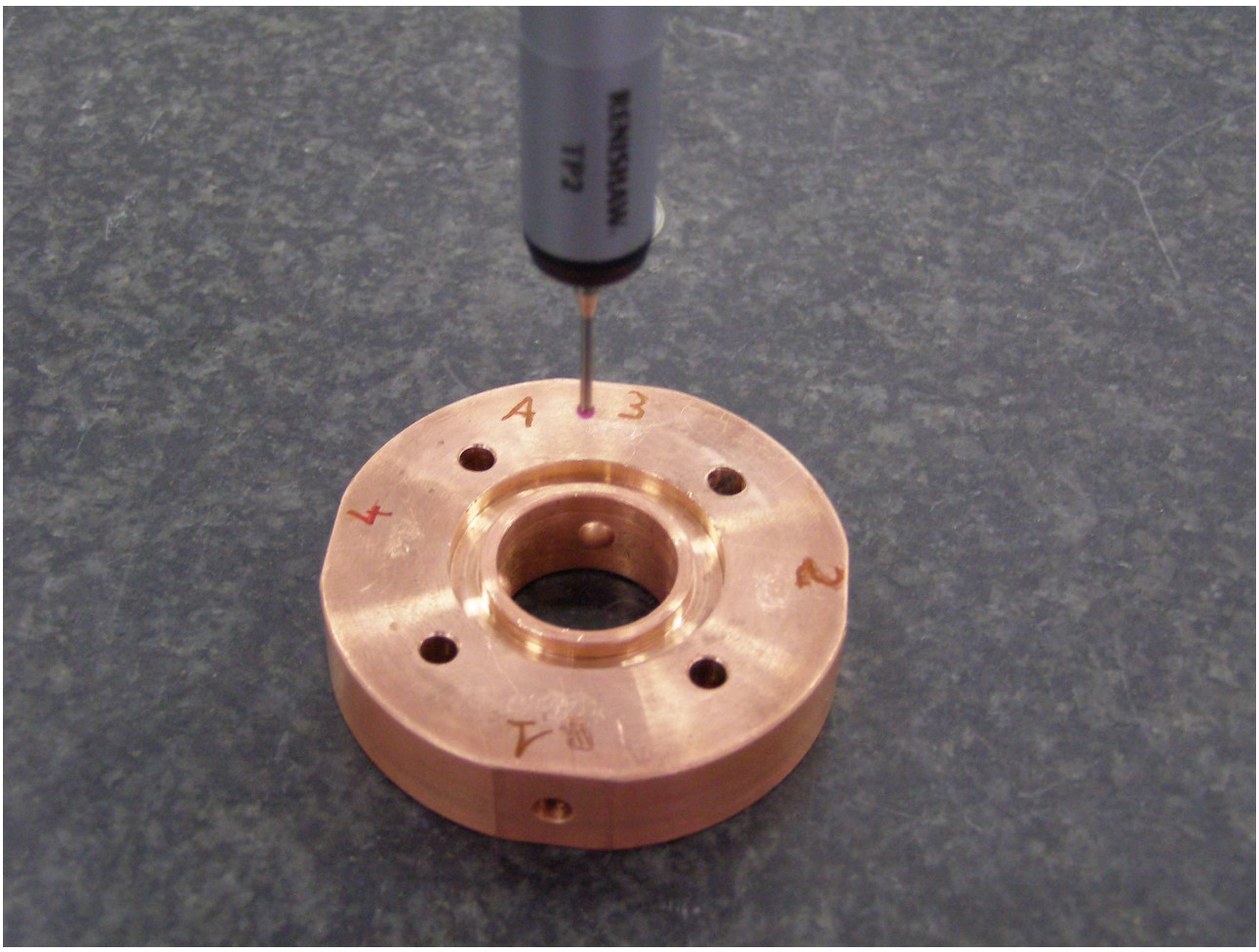

Fig 4 Measuring the deformation tuning geometry.

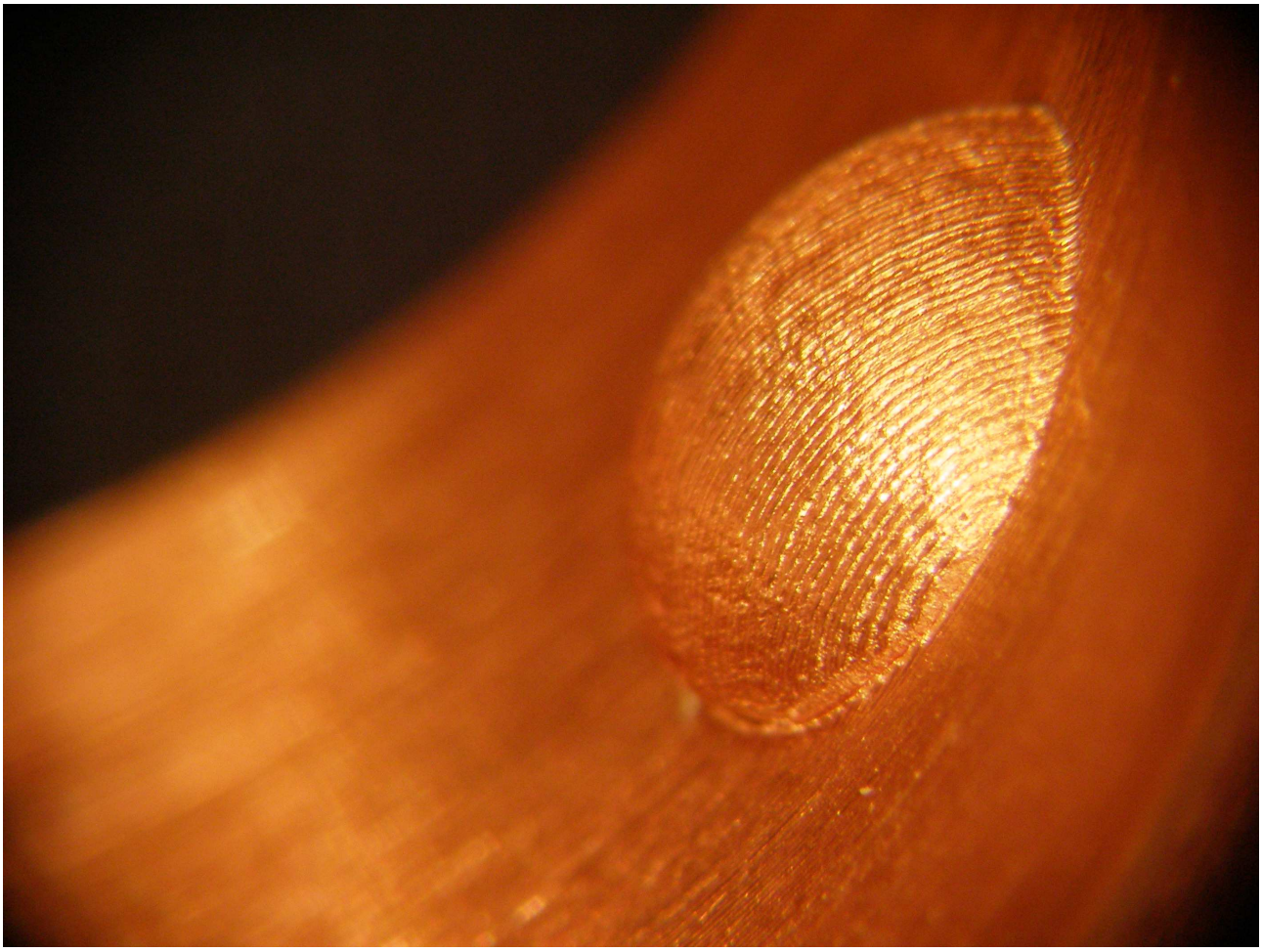

Fig 5 A particular of the maximum deformation obtained in one point inside the cell.

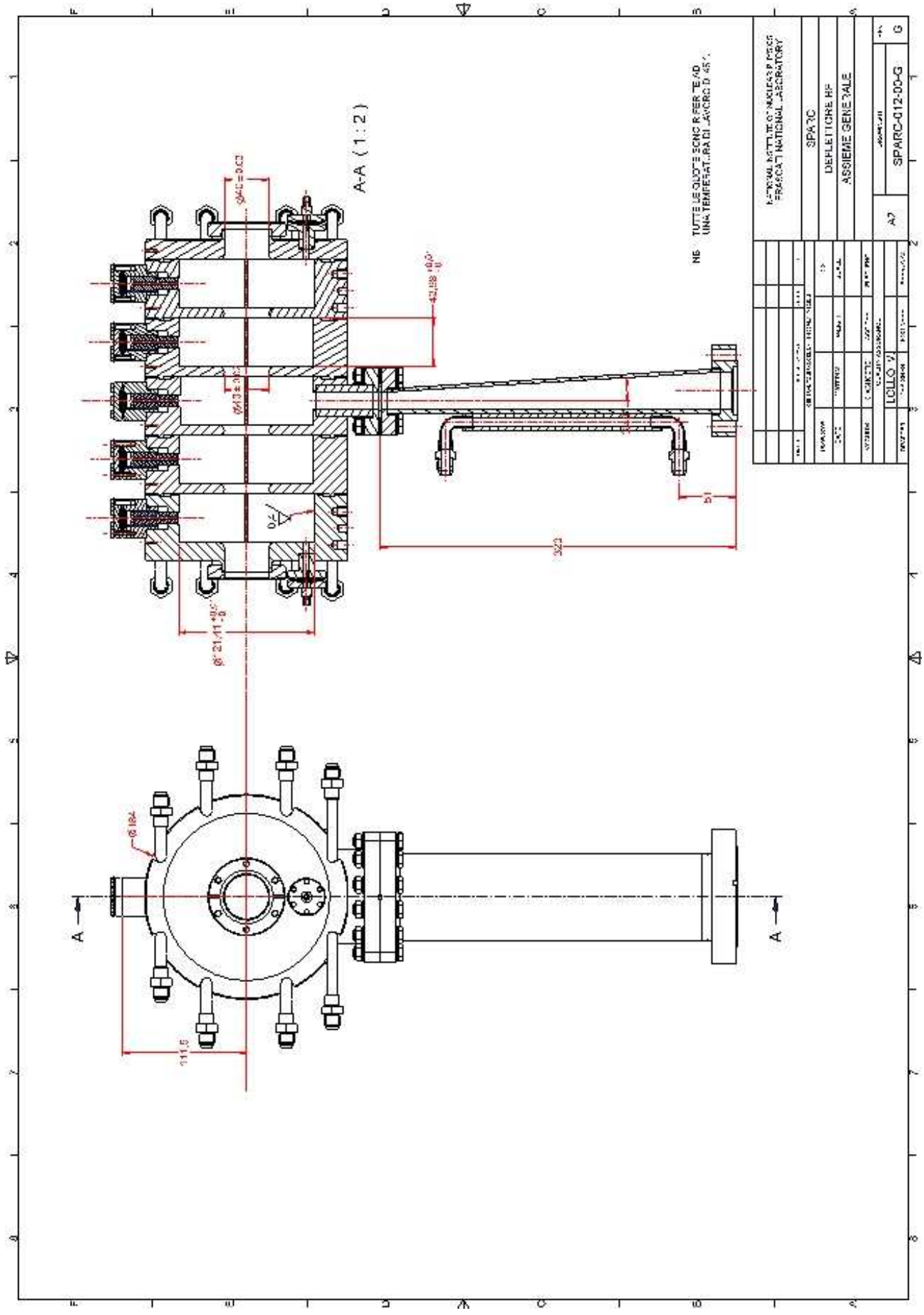

Fig 6 The SPARC RF deflector design.

Fig 7 Some parts of the RF deflector during brazing procedure.

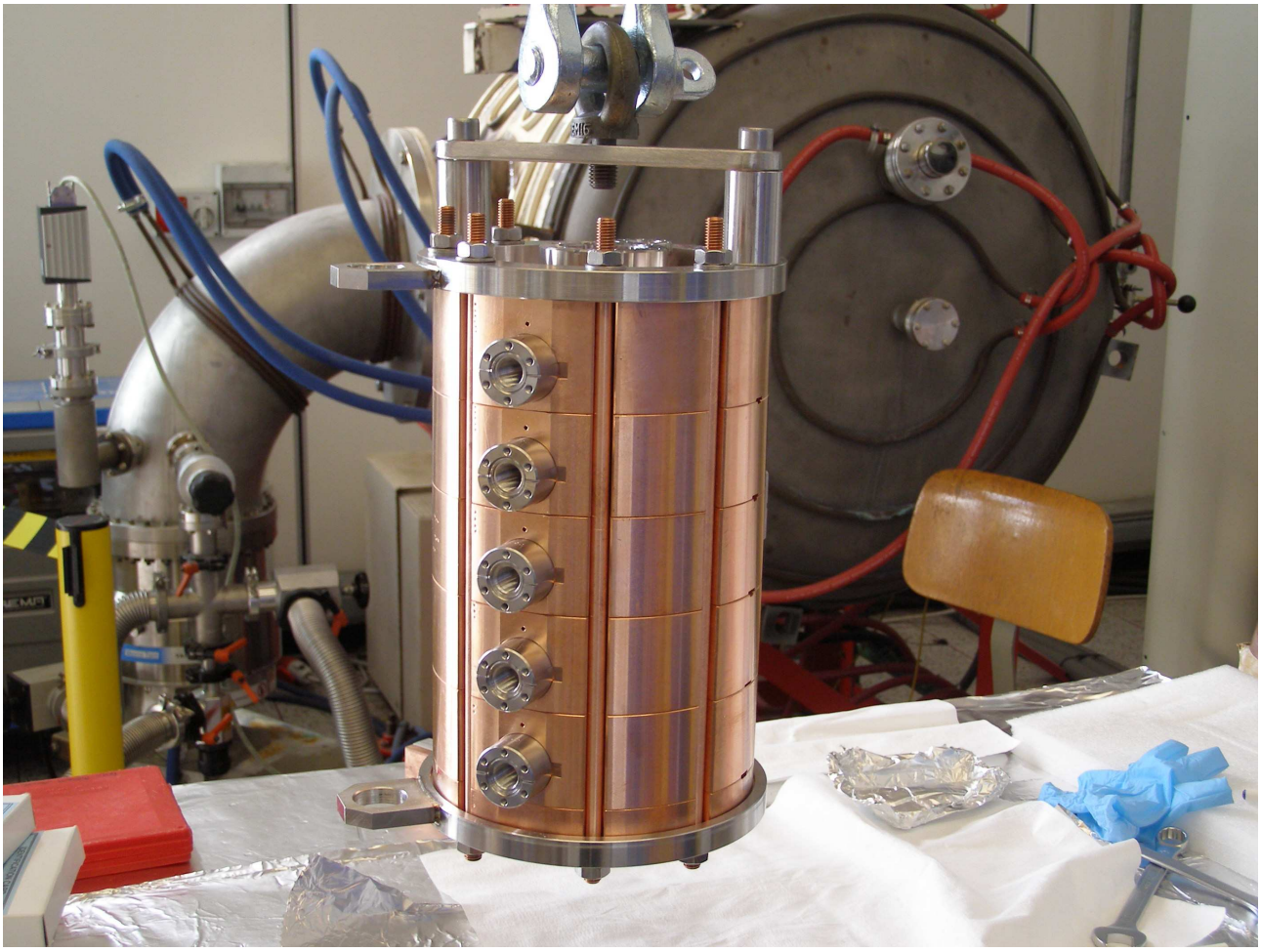

Fig 8 The RF deflector ready to be inserted in the vacuum oven for the final brazing cycle.

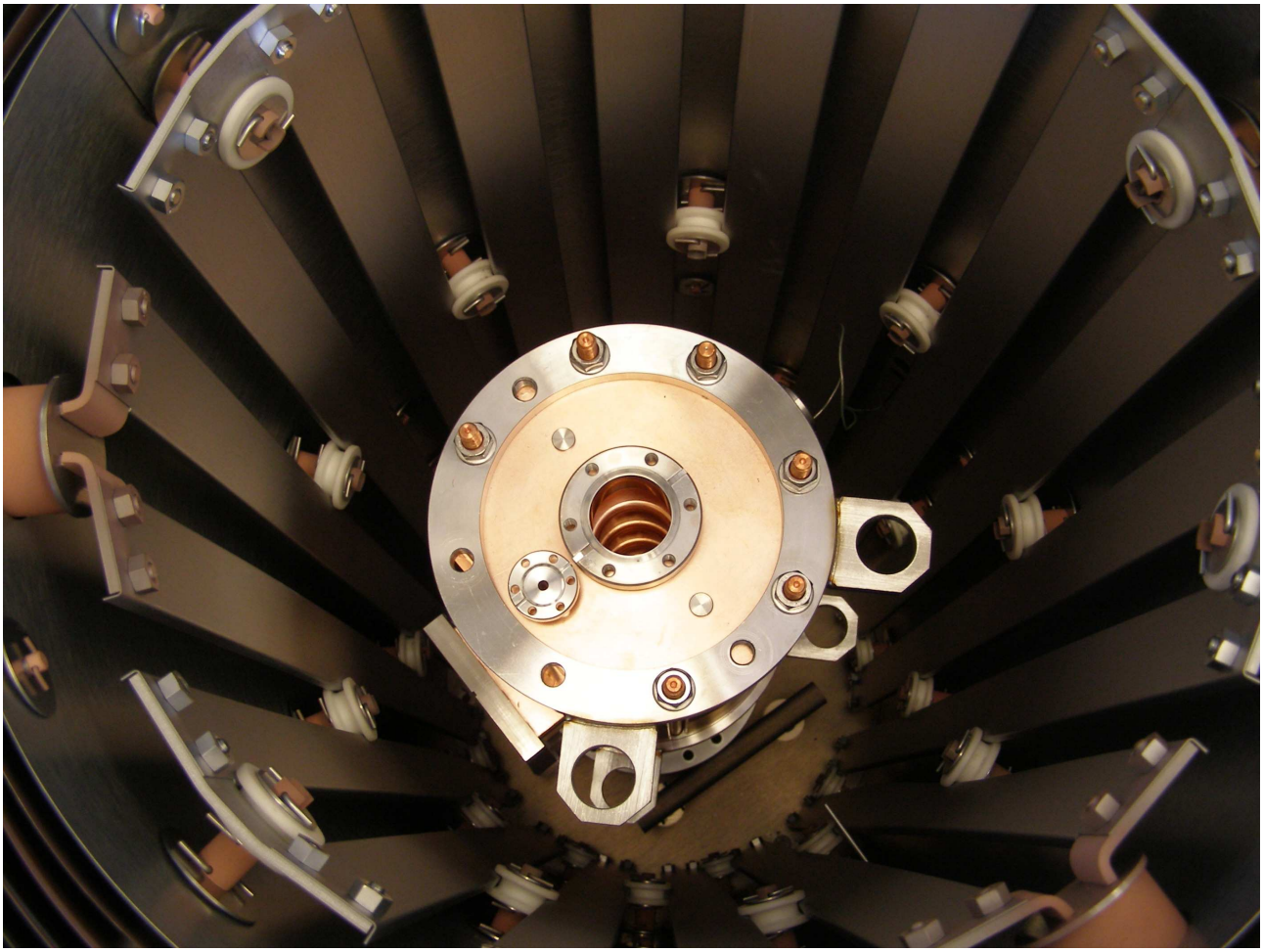

Fig 9 The RF deflector inside the vacuum oven.

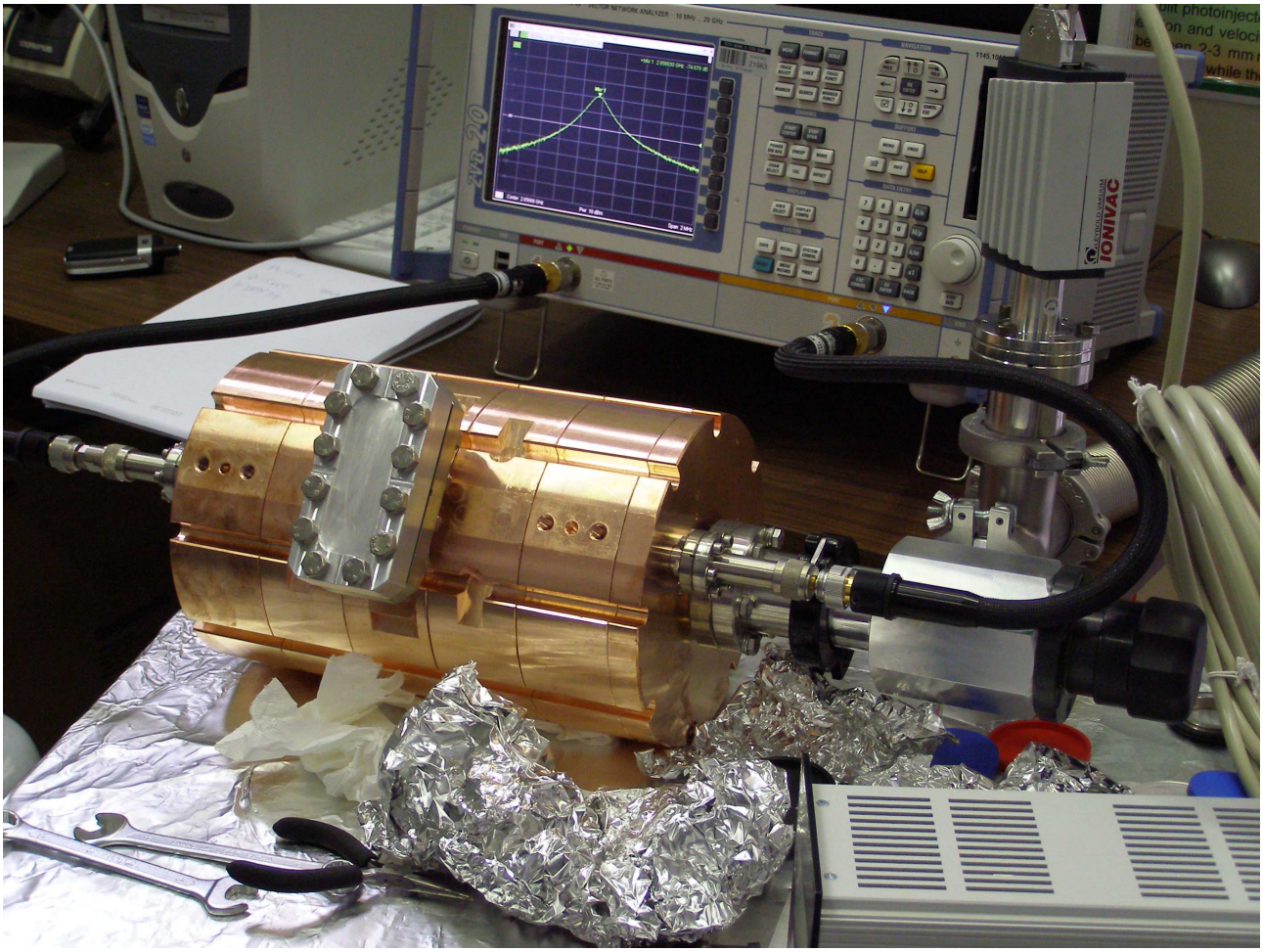

Fig 10 The RF deflector during RF measurements.