MICRON Experiment

Attività svolta nel 2022

Role of LNF (RL L. Faillace):
RF design of metallic Ka-Band and W-Band accelerating cavities. RF design of a mode launcher power coupler. Fabrication, manufacturability studies, morphological characterization, and low-power RF characterization of the prototypes (Ka and W-Band) at the INFN-LNF's LATINO infrastructure.

LNF	
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Fabio Cardelli	10
Alessandro Gallo	10
Marco Bellaveglia	10
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Antonio Falone	10
TOT	1,7

1st YEAR (2022) MILESTONES for LNF Unit

1. Evaluation of Figure of Merits on the numerical model (R_{Sh} > 150 MΩ/m, Q> 5000)

Percentuale di completamento: 100%

RF design of two-halves and four-quadrants Ka-Band Accelerating Structures (Figure 1 and 2 below) was carried out with the code HFSS. The optimization of the main RF parameters was performed (R_{Sh} > 150 MΩ/m, Q> 5000) as reported in Table 1. In Figure 3 and 4, the on-axis and surface electric field distributions are given. The quotations for the first Ka-band cavity sample machining and TIG welding tests were acquired and order placed.

Table 1:Main RF parameters for the Ka-band cavity at 150 MV/m accelerating gradient.

Parameter	Value
Resonant frequency, f [GHz]	35.982
Quality factor Q	6000
Shunt impedance [MΩ/m]	160
H_{max} [MA/m]	0.6
E_{max} [MV/m]	400
Power loss [MW]	0.75
a [mm]	2
a/λ	0.24
t [mm]	0.635
Iris ellipticity	1.38
Accelerating Gradient (MV/m)	150 MV/m
Phase advance per cell (deg)	180

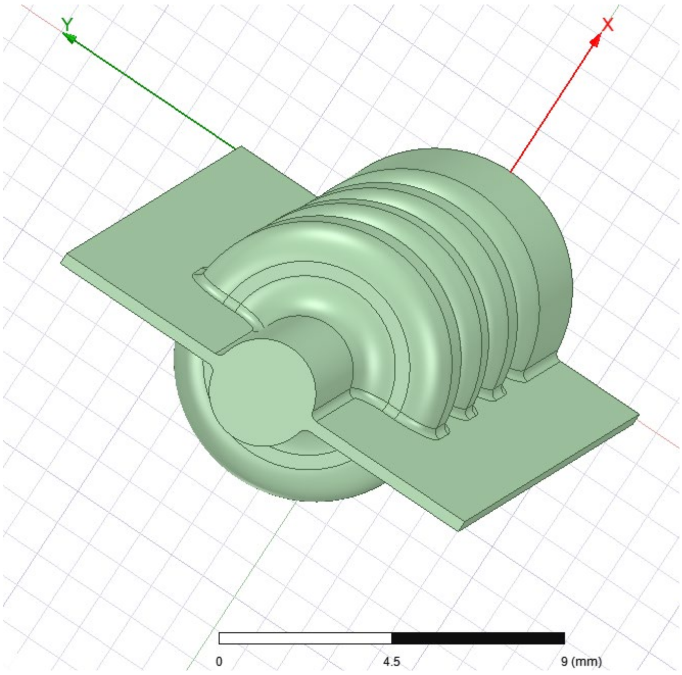

Figure 1: Two-halves Ka-Band Accelerating Structure.

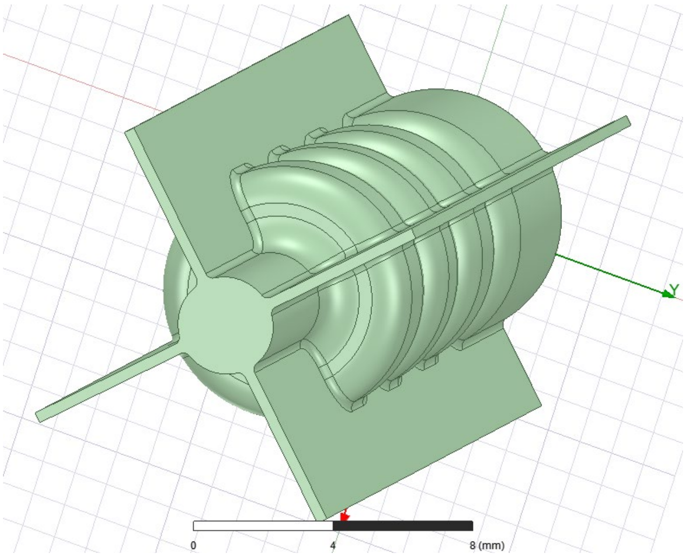

Figure 2: Four-quadrants Ka-Band Accelerating Structure.

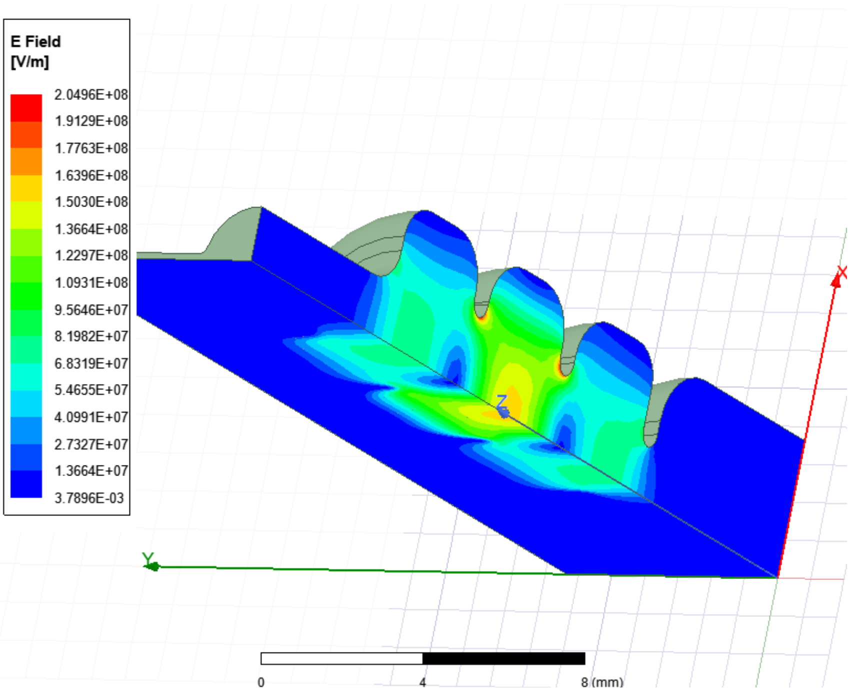

Figure 3: Two-halves Ka-Band Accelerating Structure. Electric Field Distribution from HFSS.

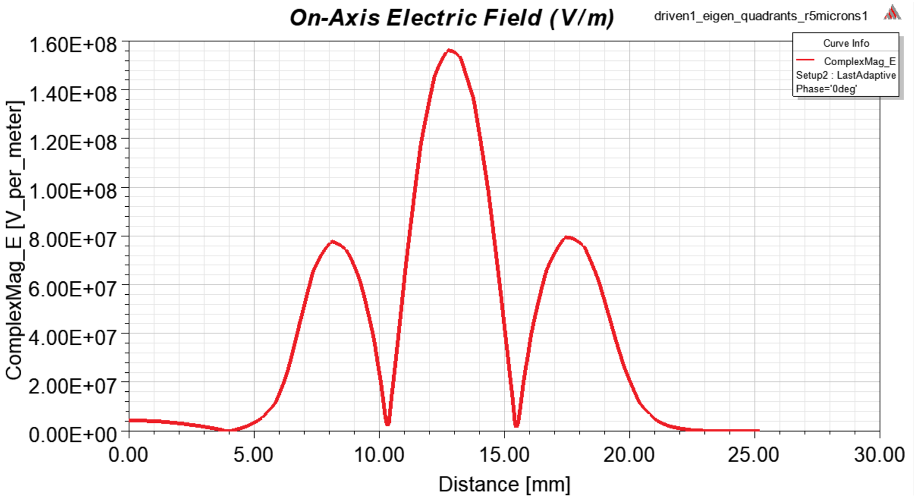

Figure 4: Two-halves Ka-Band Accelerating Structure. Electric Field Distribution along the cavity axis.

2. Manufacturability Tests (tol < +- 3µm, Ra< +- 50 nm)

Percentuale di completamento: 100%

2.1 Fabrication of Ka-band cavity samples (done)
2.2 Metrological measurements/samples testing (done)
2.3 Temperature Measurements vs welding (to use as feedback to RF modeling) (done)

All cavity sectors, for both two-halves and four-quadrants structures, and all parts were manufactured by using a CNC 5-axis milling machine.
The machining tool was crucial and below the achieved mechanical characterization is reported:

- Tungsten-carbide tool → Tolerance = +- 10 µm and Roughness with Ra = 1.6 µm.
- Diamond tool with spherical radius < 1 µm → Tolerance < +- 5 µm and Roughness with Ra < 80nm. These are the best achievable values by the manufacturing company COMEB srl. This type of machining diamond tool will be utilized for the full structure fabrication in the second year of the project.

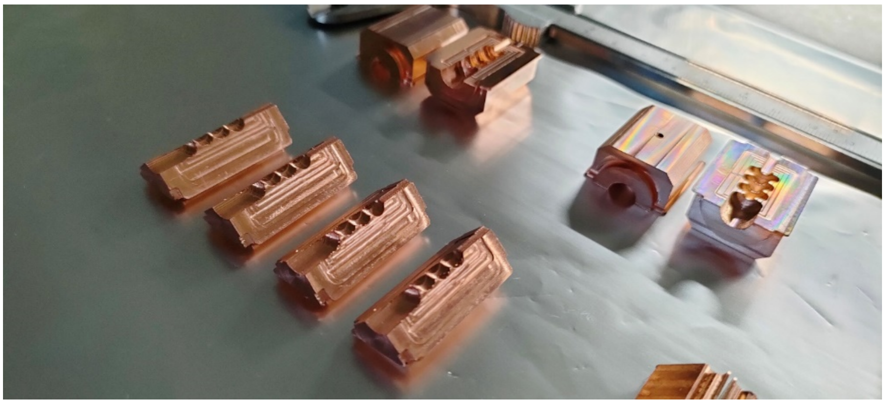

Figure 5: Cavities made of four sectors.

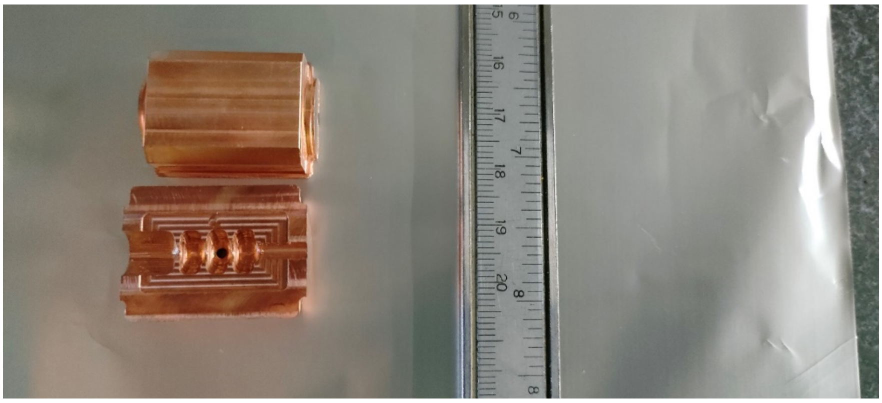

Figure 5: Cavity made of two sectors.

We performed the TIG welding tests (see an example in Figure 6), visual inspection, and temperature monitoring of the Ka-band “split-open” metallic RF structures (two-halves and four-quadrants).

Figure 6: Four-quadrant cavity after TIG welding.

In Figure 7, we show the temperature behavior on the RF surfaces during TIG welding. The temperature was monitor by using thermo-couples. It has to be noted that the temperature stays always below the copper annealing value of about 500 C, which confirms that the structure keeps its hardness, a crucial aspect for high-gradient performance.

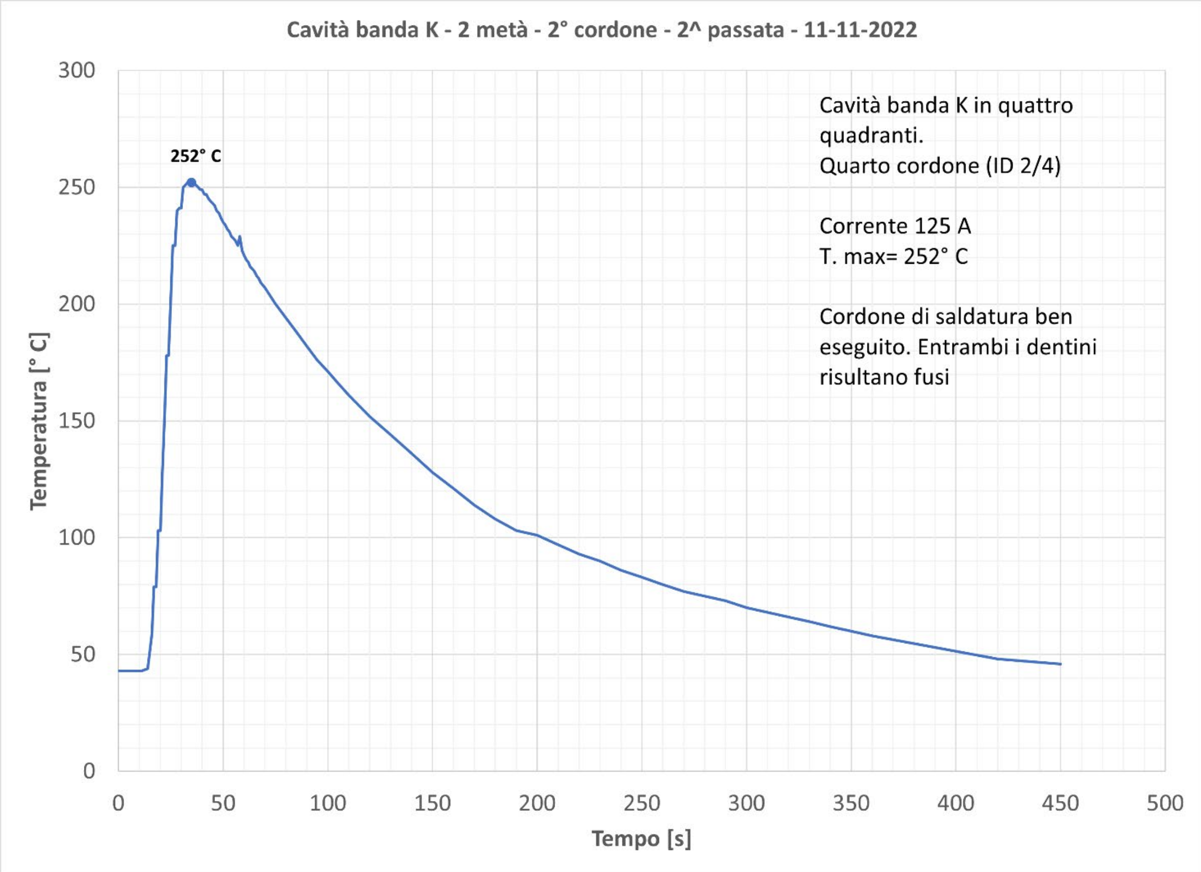

Figure 7: Temperature monitoring during TIG welding.