This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under GA No 101004730.

AM manufacturing of Superconducting cavities

I.FAST - WP10.4

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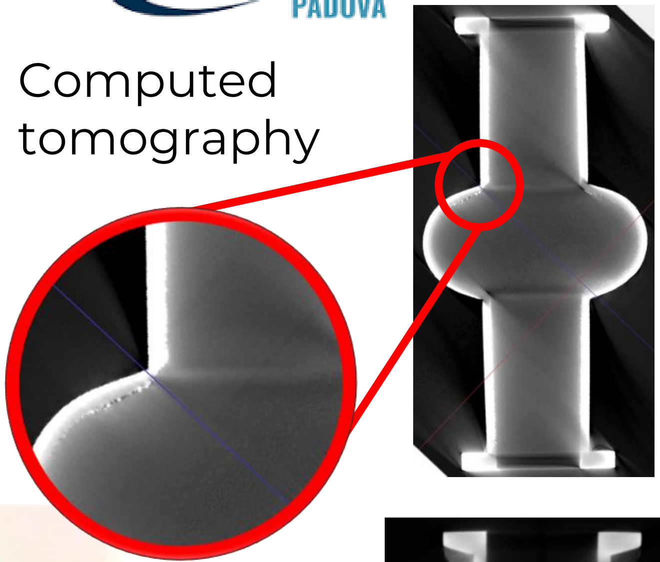
AM of Nb and Cu SRF cavities

Cu

Green laser (515 nm)

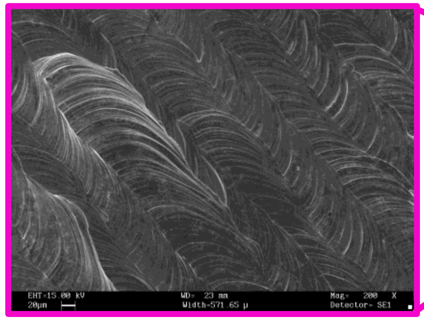
Computed tomography

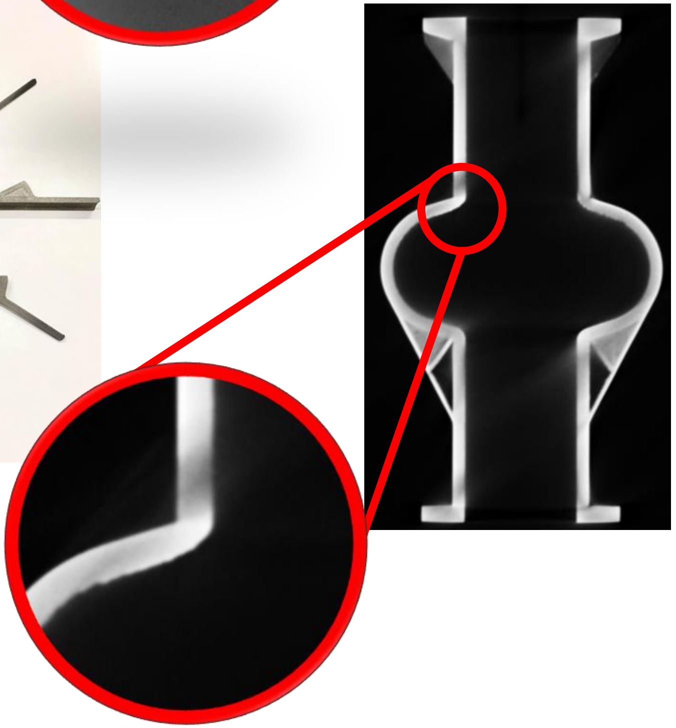


Build direction

Nb

TANiOBIS
inspiring metal evolution





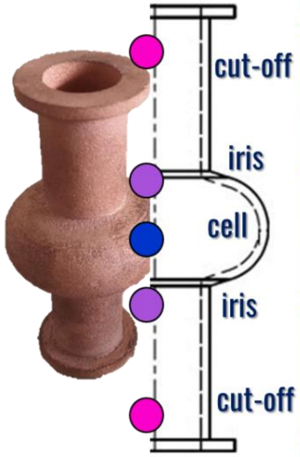
Build direction

Maximum density achieved: 99.9%

Surface Treatments

Treatment details	copper T1	copper T2
Mass-finishing @ Rösler Italiana S.r.l.	✔	✔
Vibro-tumbling @ LNL-INFN	VT1: 60 min; 15 μm	✗
	VT2*: 35 min; 23 μm	
Electropolishing @ LNL-INFN	EP1: 80 min; 116 μm	EP1*: 70 min; 92 μm
	EP2: 67 min; 105 μm	✗
Total average thickness removed	259 μm	92 μm

Treatment details	niobium Nb1	niobium Nb2
Vibro-tumbling @ LNL-INFN	VT1: 180 min; 15 μm	VT1: 120 min; 13 μm
	VT2: 300 min; 12 μm	VT2: 90 min; 6 μm
	VT3: 24h min; 18 μm	✗
Electropolishing @ LNL-INFN	EP1: 60 min; 90 μm	EP1: 45 min; 55 μm
	EP2: 90 min; 150 μm	EP2: 45 min; 70 μm
	EP3: 90 min; 150 μm	✗
Total average thickness removed	445 μm	144 μm
Resonant frequency	**5,995 GHz**	**6,04 GHz**
	~20 K ✗	*Test*



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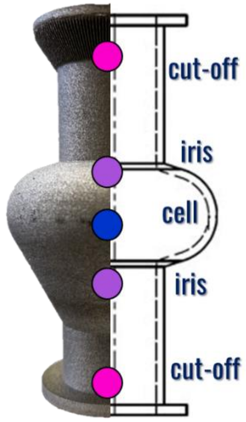

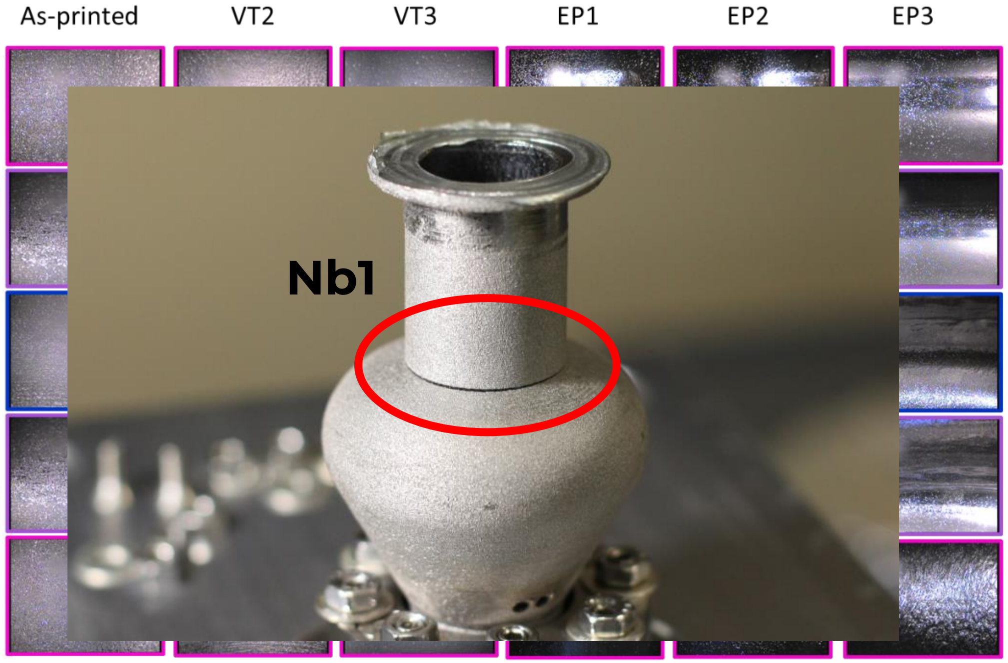

Test Procedure

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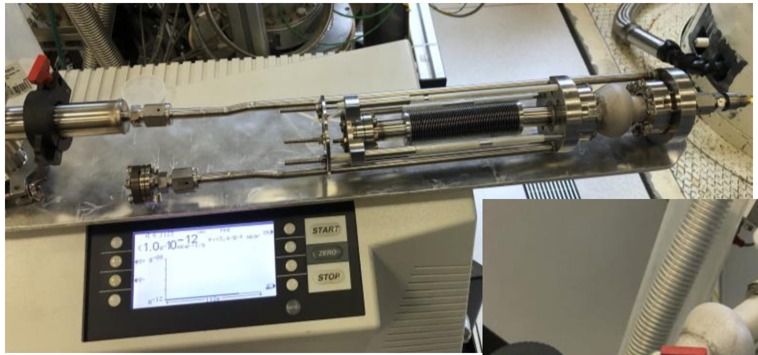
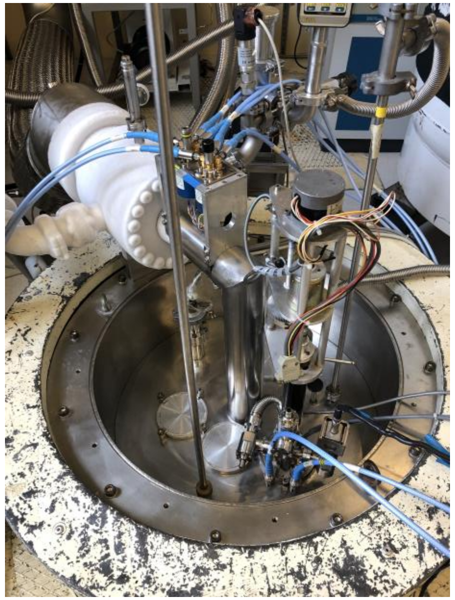
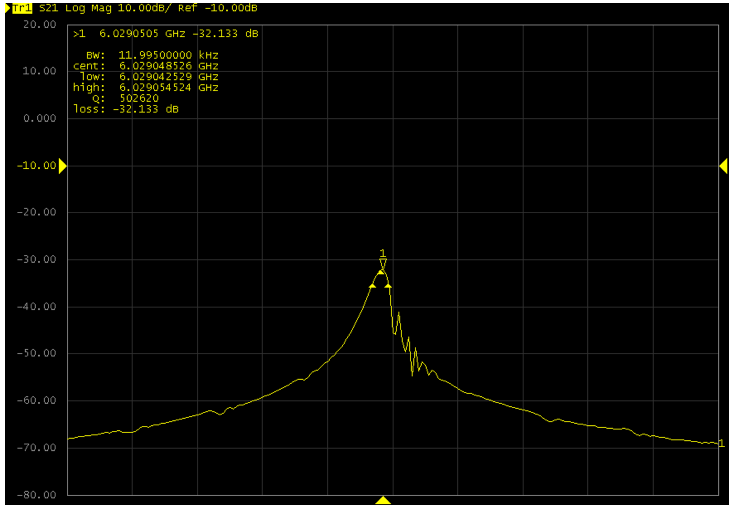
- ✓ AM Production Process
- ✓ Surface treatments

- Multiple leak tests
  - ➢ After each Surface Treatments
  - ➢ before assembly in the cryostat
- Resonant frequency measurement
  - ➢ Measured after S.T. → **6,04 GHz**
- Assembly in the cryostat
- LHe leak test
- Q_{Loaded} @ zero field with Network Analyzer
  - ✓ $\boldsymbol{Q_{Loaded} \simeq 5,03 \cdot 10^5}$

Approximately 5 times better than as-printed ($Q_{Loaded} \simeq 1,36 \cdot 10^5$)
… But still to improve!

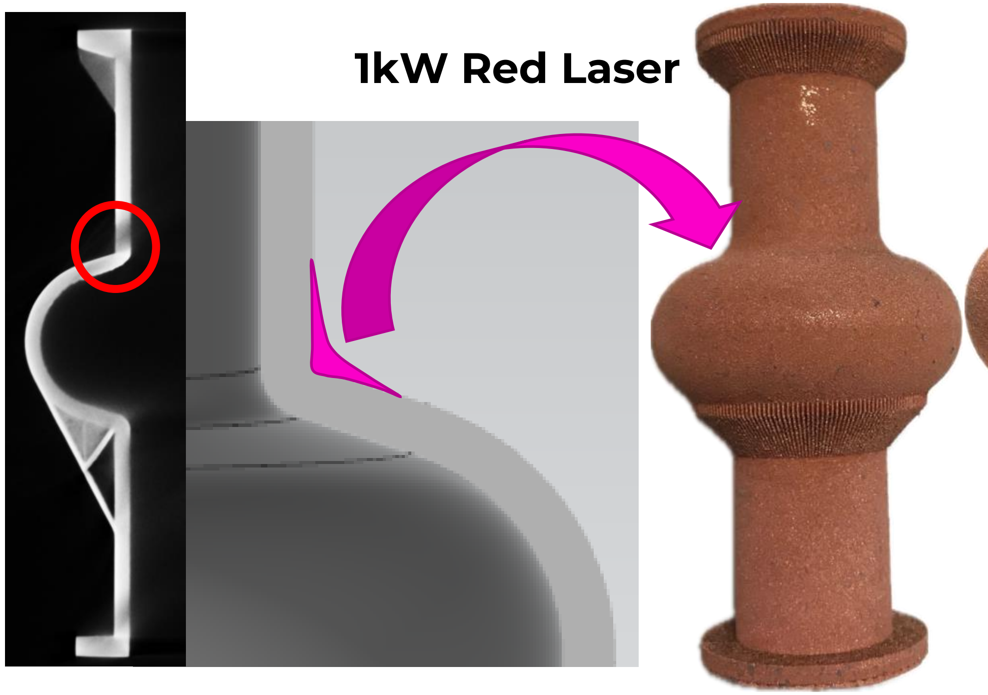




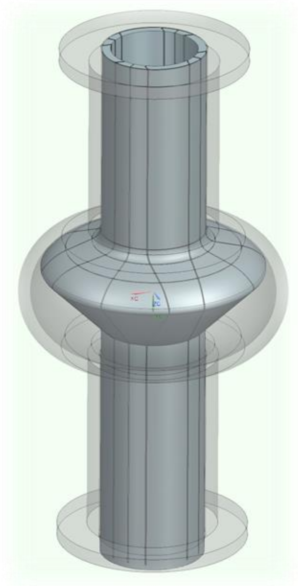


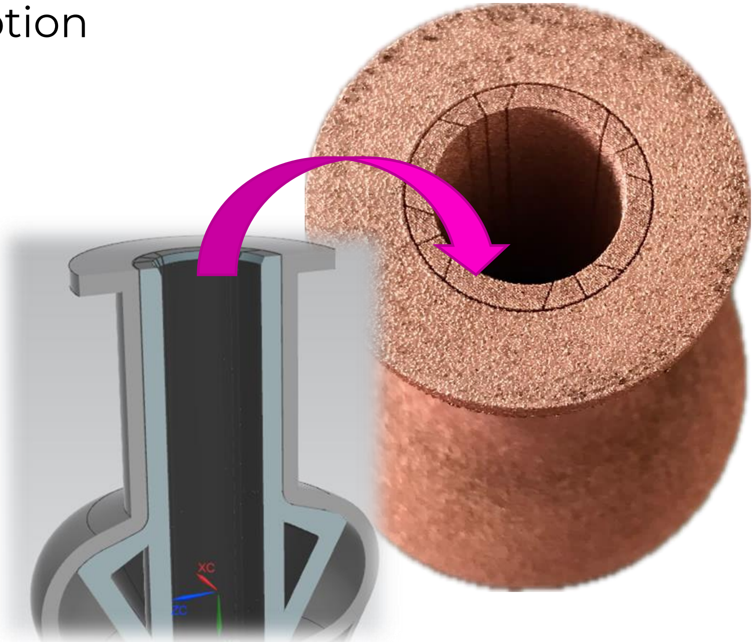
New optimized SRF cavities production and test

✓ **NEW DESIGN**: Thickened area to ensure resistance in the iris area during surface treatments



✓ **IMPROVED QUALITY of the INNER as-built SURFACE** Contactless supporting structures and external support optimized to reduce the building time and material consumption





- **SURFACE TREATMENTS** optimization studies of the quantity of material removal are needed to understand the minimum average surface thickness removal and maximum values to avoid rupture @ IRIS area
  - **HEAT TREATMENTS** (in particular annealing) can as well contribute to the final performance
    - optimization of **PRINTING PARAMETERS** & use of machine with **HIGH POWER and SMALL LASER SPOT** can potentially improve the down-skin region quality, thus enhancing the final RF performance.

Conclusion

✓ **Deliverable completed: Production of SRF Cu and Nb Cavities by AM technology**

✓ **Milestone completed: Performance of Superconductive Cavities made by AM technology**

Publications

1. V. Candela, M. Pozzi, E. Chyhyrynets, *et al*. **Smoothening of the down-skin regions of copper components produced via Laser Powder Bed Fusion technology**, *Int J Adv Manuf Technol* (2022), DOI:10.1007/s00170-022-10408-8
2. S. Candela, P. Rebesan, D. De Bertoli, S. Carmignato, F. Zanini, V. Candela, R. Dima, A. Pepato, M. Weinmann, P. Bettini **Pure niobium manufactured by Laser-Based Powder Bed Fusion: infuence of process parameters and supports on as-built surface quality**, *The International Journal of Advanced Manufacturing Technology* (2024) DOI: 10.1007/s00170-024-13249-9

Additional Work that is/will be done

✓ **NEW DESIGN** and **PRODUCTION –** *INFN Pd and EOS*

✓ **IMPROVED QUALITY of the INNER as-built SURFACE –** *INFN Pd and EOS*

➢ **SURFACE TREATMENTS –** *INFN LNL and Rösler*

➢ **HEAT TREATMENTS –** *INFN LNL*

} → *Resonant frequency* ***< 6 GHz***

➢ **TEST –** *INFN LNL* → *RF test @ 4.2 K (**Q vs** E_{acc}) - RF test @ 1.8 K (**Q vs** E_{acc})*

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Thank you!

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