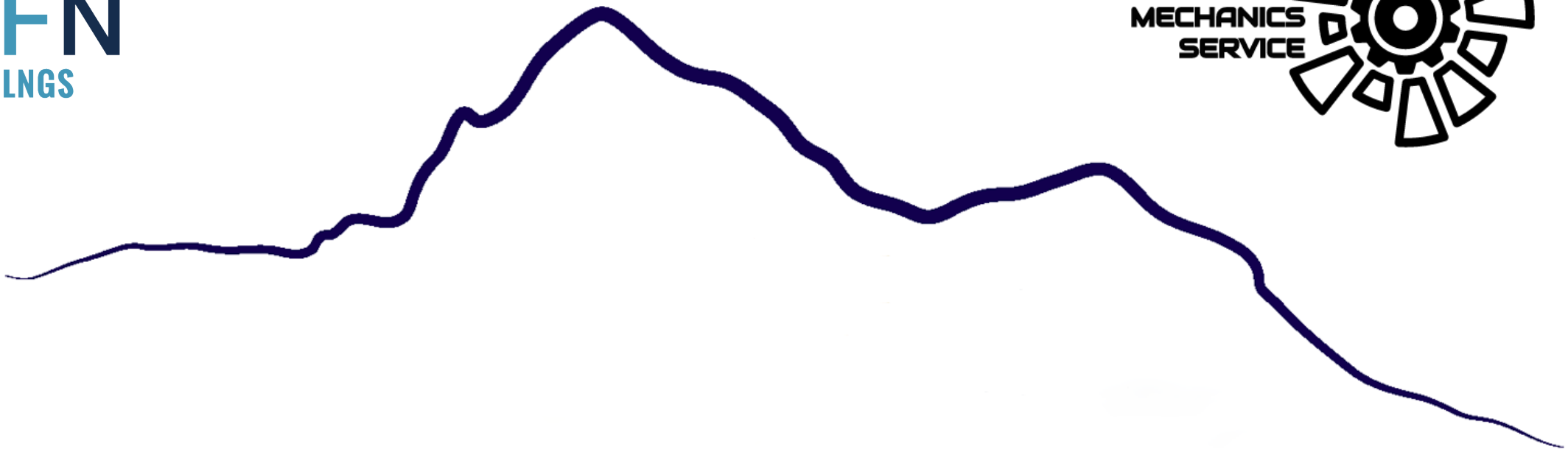
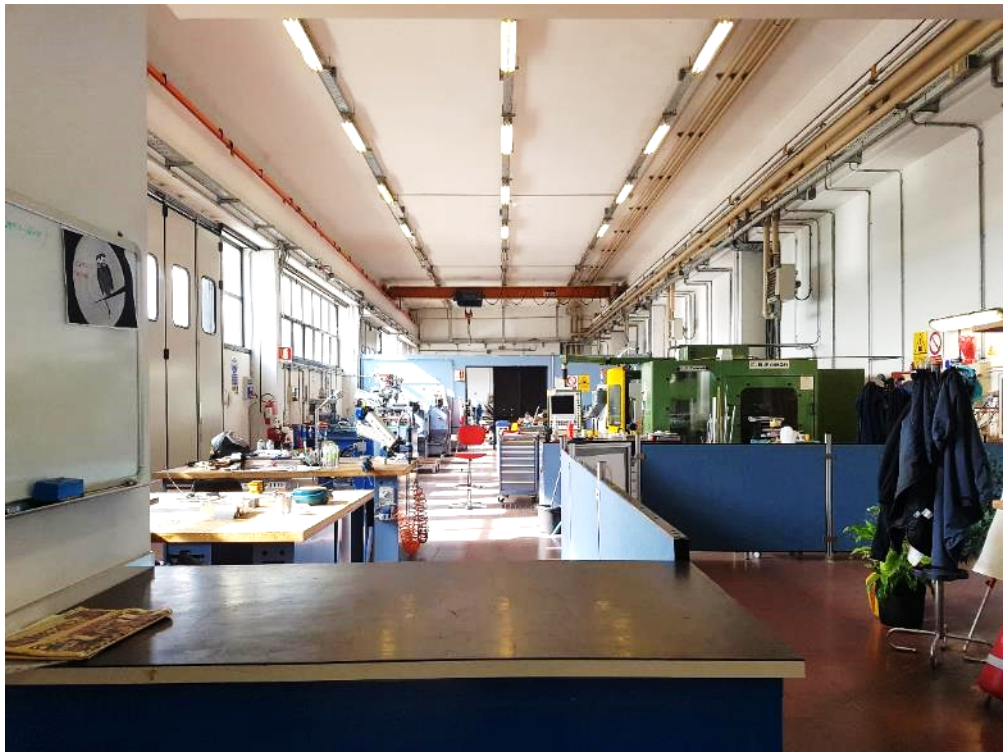


Mechanics Service

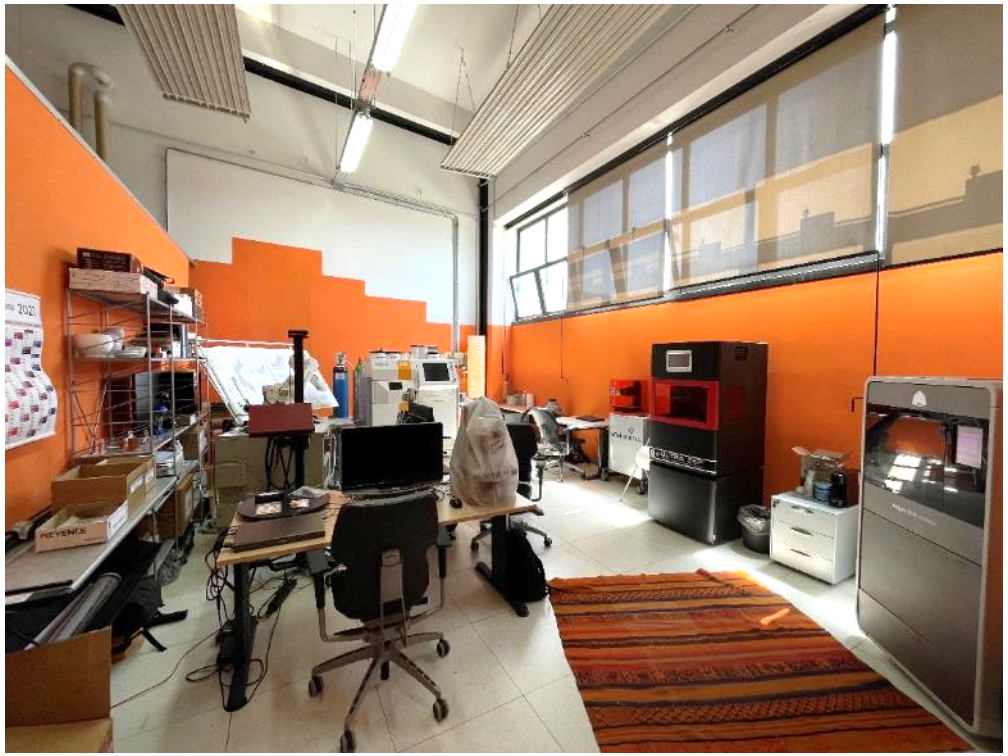
Facilities and Tech Heritage

Mechanics Service

Gran Sasso National Laboratory – LNGS



Mechanical Workshop Department



Design and Additive Manufacturing Department

Organization

Gran Sasso National Laboratory – LNGS

LNGS MECHANICS SERVICE

Responsible: *Donato Orlandi*

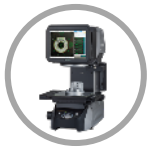
Workshop Department

Responsible: *Angelo Corsi*

Main activities

Traditional machining, CNC, quality control





Design and Additive Manufacturing Department

Responsible: *Donato Orlandi*
Activities Ref: *Daniele Cortis*

Main activities

Design, multi-physics simulations (FEA / CFD), additive manufacturing with plastic and metal materials, reverse engineering, technology transfer, research and analysis on materials.



Working Flow

Gran Sasso National Laboratory – LNGS

Client
(Experiment, Working Group, etc..)

Ticket System
INFN National Management System
Unique request code:
LNGSMECC-XXX

Reporting
Technical and administrative (performance, productivity)

Production
CNC Machining
Additive Manufacturing

Input data
Extrapolation of technical data from requests

3DExperience (PLM System)
LNGS Local PLM System
Unique code: **PRD000XXXX**
+ reference to the Ticket System code

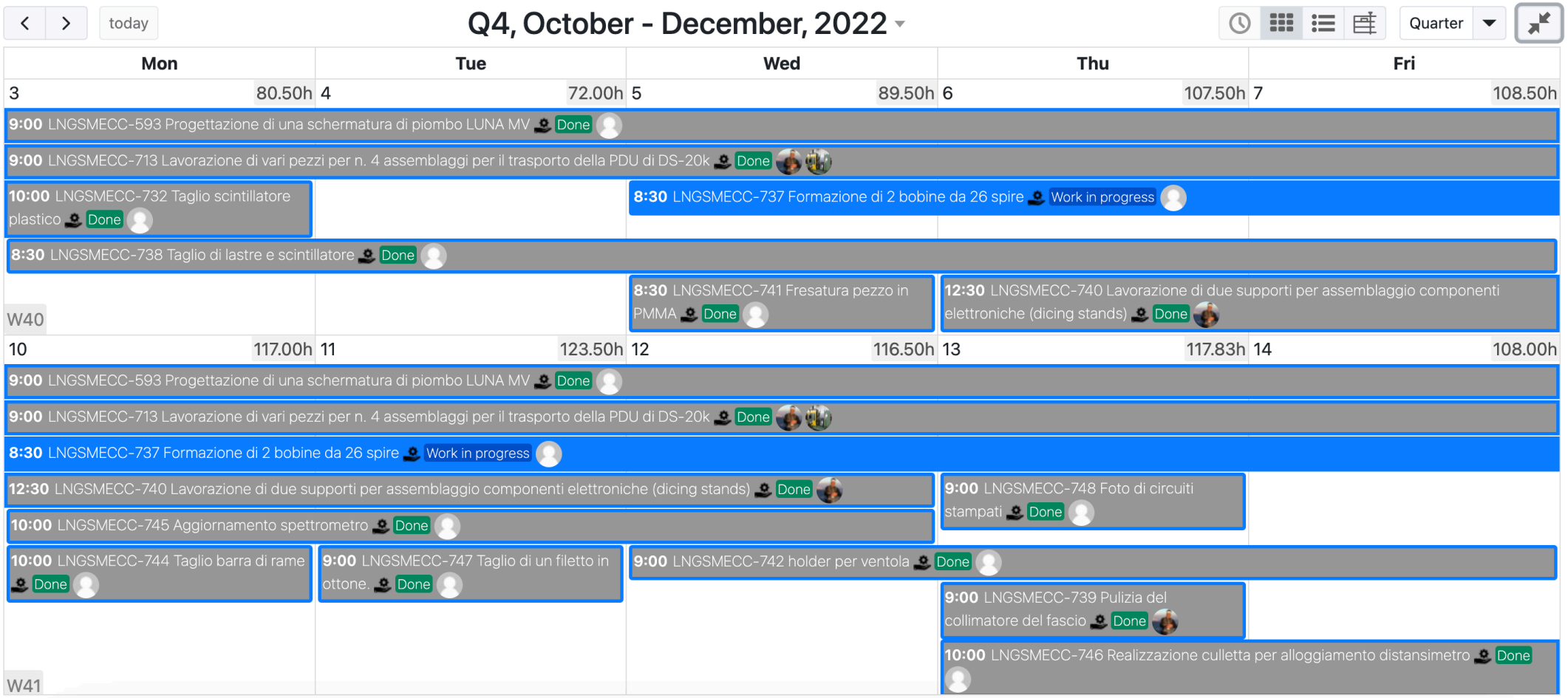
Output data
Files for storage and interchange (e.g. technical drawings, neutral format CAD, etc.)

CAD

Cloud System
Code-based LNGS local backup system
LNGSMECC-XXX

Ticketing Calendar

Gran Sasso National Laboratory – LNGS



Technologies and equipment (AM)

Gran Sasso National Laboratory – LNGS

Realization of the components is realized by classic subtractive technologies (CNC) and by machines for additive manufacturing for plastic and metal materials (Additive Manufacturing).

SISMA
L-PBF (SLM)

3DSYSTEMS
PoliJet

ENVISIONTEC
SLA

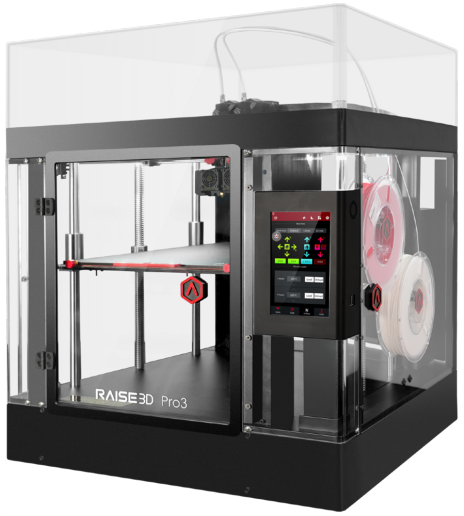
ENVISIONTEC
DPL

Technologies and equipment (AM)

Gran Sasso National Laboratory – LNGS

Realization of mechanical components by additive manufacturing for plastic and metals

PRIMA
L-PBF IR Laser (SLM)



RAISE3D General purpose plastics FDM

PRIMA
L-PBF GREEN LASER (SLM)

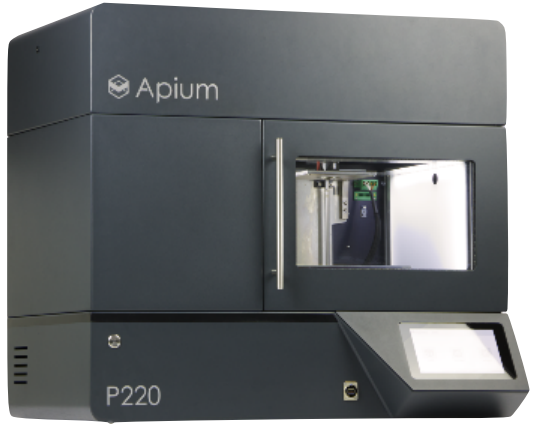
Technologies and equipment (AM)

Gran Sasso National Laboratory – LNGS

The service is constantly evolving to get the highest level in terms of technology frontiers

Atomizer of metal powders for L-PBF

Traction machine with climatic chamber (-150°C / +600 °C)



PEEK/Carbon Filled PEEK, Ultem FDM

Technologies and equipment

Gran Sasso National Laboratory – LNGS

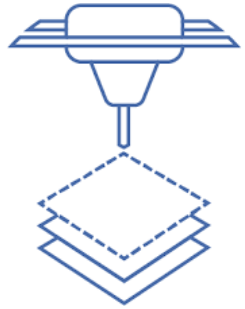
Metal Additive Manufacturing

Similar to all other processes, metal additive manufacturing machines produce objects by adding material one layer at a time.

In this way it is possible to build objects with geometries that are impossible to produce with "traditional" subtractive (CNC) or training (Metal Casting) technologies, without the need for specialized equipment (for example a mold).

Technology available at LNGS:

- **Laser Powder Bed Fusion (L-PBF): Selective Laser Melting (SLM)**



Technologies and equipment

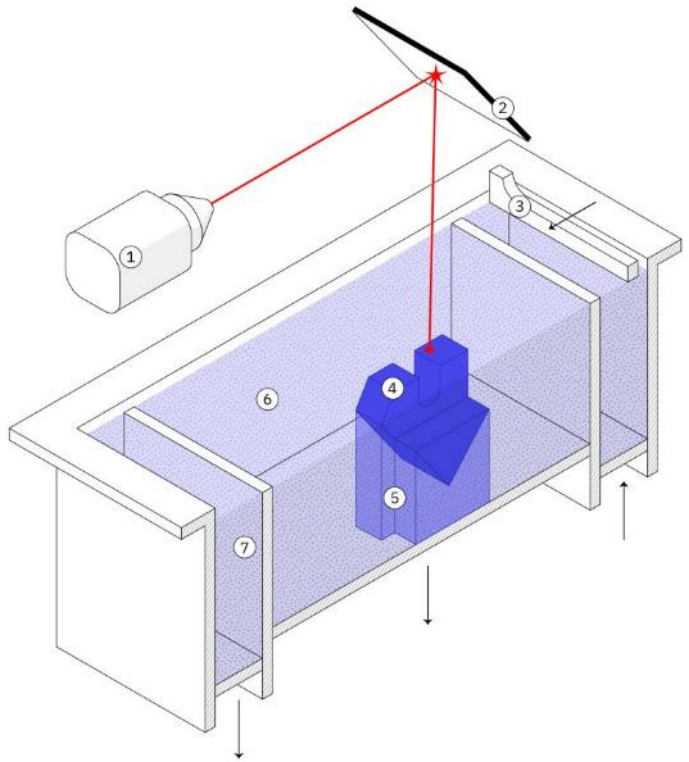
Gran Sasso National Laboratory – LNGS

SLM (Selective Laser Melting)

SLM technology uses a laser beam to selectively melt a powder bed in order to produce a layer-by-layer component as schematically represented in the figure.

A layer of metal powder is deposited on a construction platform through the use of a recoater characterized by a ceramic, steel or rubber blade according to the type of metal powder used.

The melting of the powders is carried out with a high-power laser beam guided in the construction plan through appropriate galvanometric mirrors and the entire process takes place in a controlled atmosphere of inert gases such as Ar or N.



Processed materials

Gran Sasso National Laboratory – LNGS

The materials that can be used by the machine are Steel, Titanium alloys, Nickel alloys, Aluminum alloys, Copper alloys, precious metal alloys and Cobalt Chrome alloys.

Materials currently processed at LNGS:

Steel	Aluminium alloys	Copper Alloys	Copper
AISI 316 L	SCALMALLOY®	CuCrZr	Cu > 99.8 %
	AlSi10Mg		Cu OFE

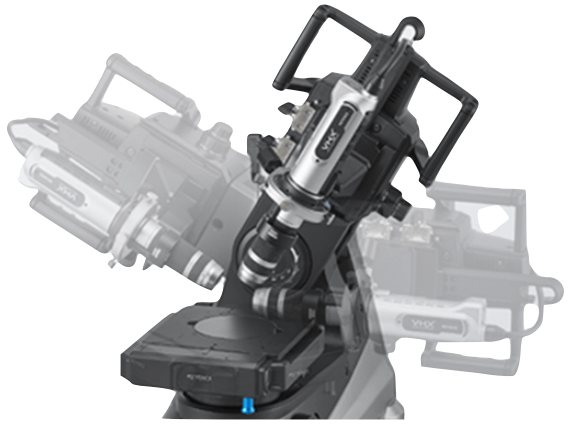



Quality analysis

Gran Sasso National Laboratory – LNGS

In addition, tools are available for the quality analysis of the components produced and reverse engineering (e.g. 4K **high-resolution optical microscope**, GOM **3D scanner**, **high-resolution optical profile meter**).

GOM
Atos Core 185



KEYENCE
VHX-7000

KEYENCE
IM series

HAMMER

Gran Sasso National Laboratory – LNGS

HAMMER - Hub for Additive Manufacturing, Materials Engineering and Research

The Hub focuses on the design and production of complex components for both nuclear/ astroparticular physics research and technology transfer.

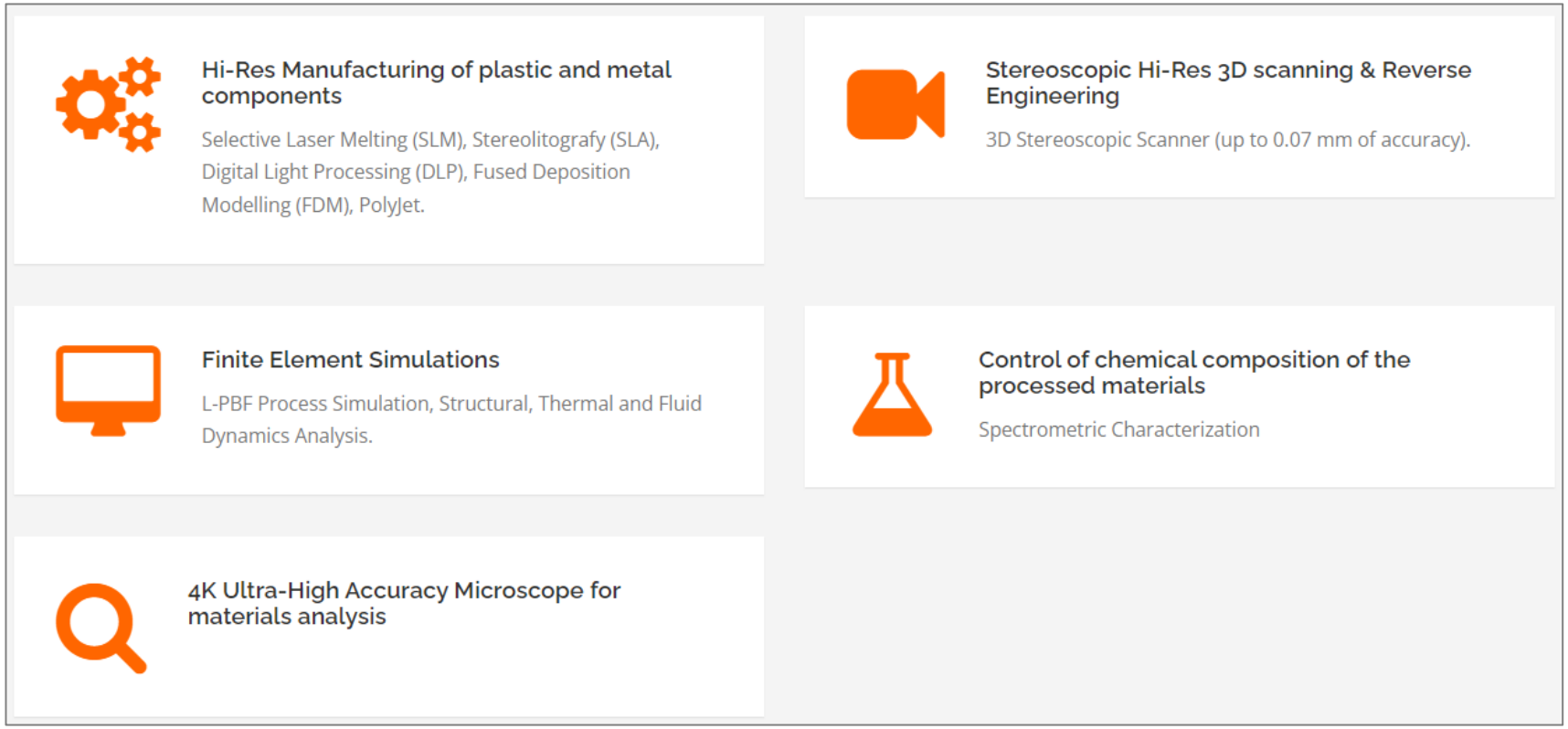
HAMMER

https://hammer.lngs.infn.it/

HAMMER

Gran Sasso National Laboratory – LNGS

HAMMER - Hub for Additive Manufacturing, Materials Engineering and Research



Research Activities & Case Studies

[LNGS: CROSS/DS20K] Production of PDU Transportation Assemblies

Components made:

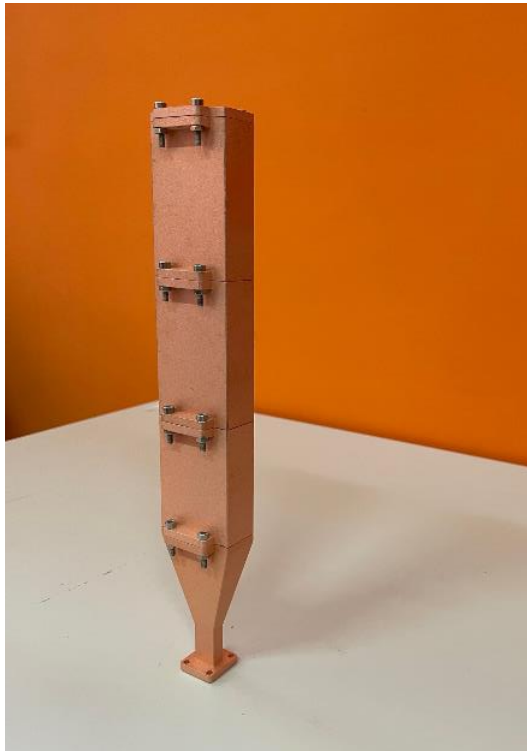
- Black PEN Holders
- Aluminum Frames
- Installation@LSC

Components made:

- Hi-Res Condenser
- ASTM 316L
- Vacuum Tight Weldings

Research Activities & Case Studies

[LNGS: PTOLEMY] Design and production of waveguides



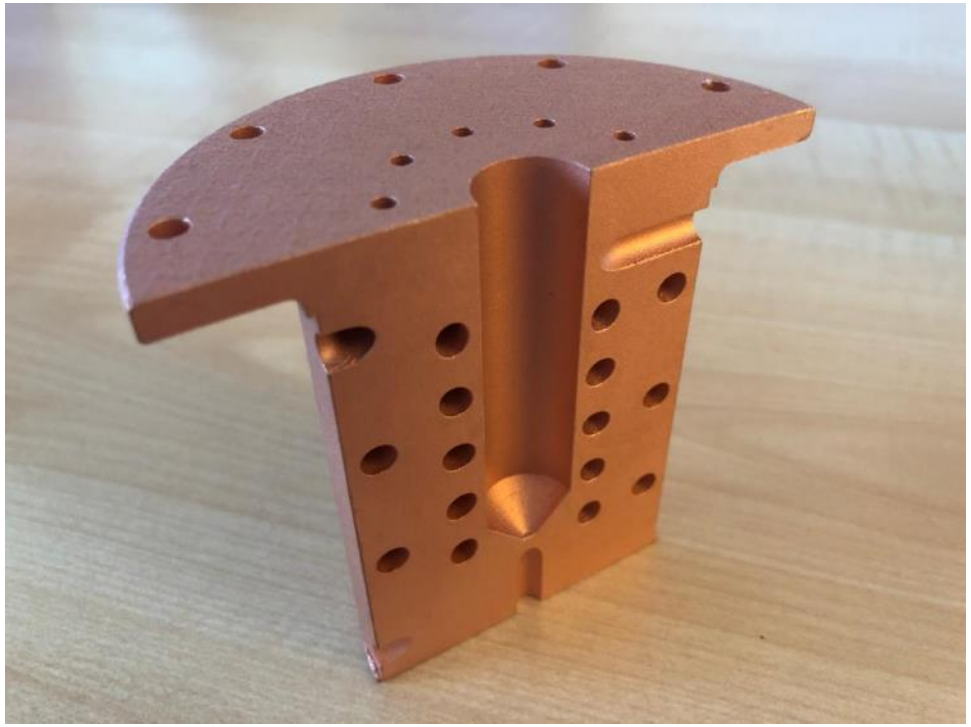
Design requirements:

- Vacuum component
- Cryogenic conditions
- High precision mechanical coupling

- **Material:**
- Cu OFE

Research Activities & Case Studies

[LNGS: ADM2021 Conference] Design of Ar – N Condenser



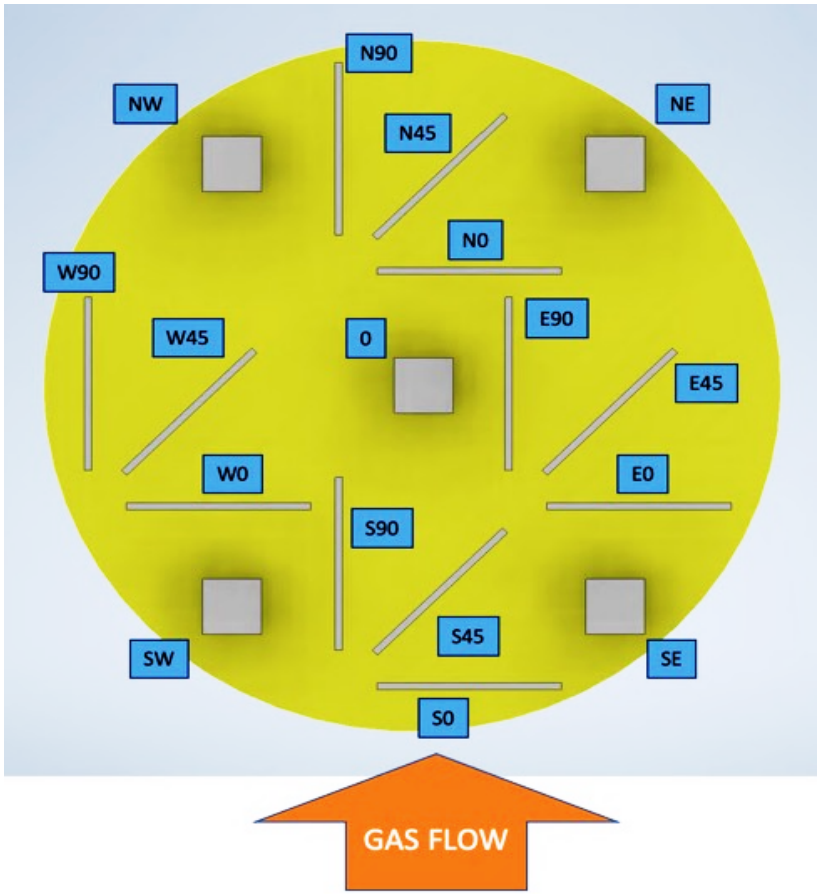
Design requirements:

- Vacuum component
- Cryogenic conditions

- **Material:**
- Cu > 99.8%

Research Activities & Case Studies

[HAMMER: LNGS - RM1] Collaborative research SIAD-SEAMTHESIS



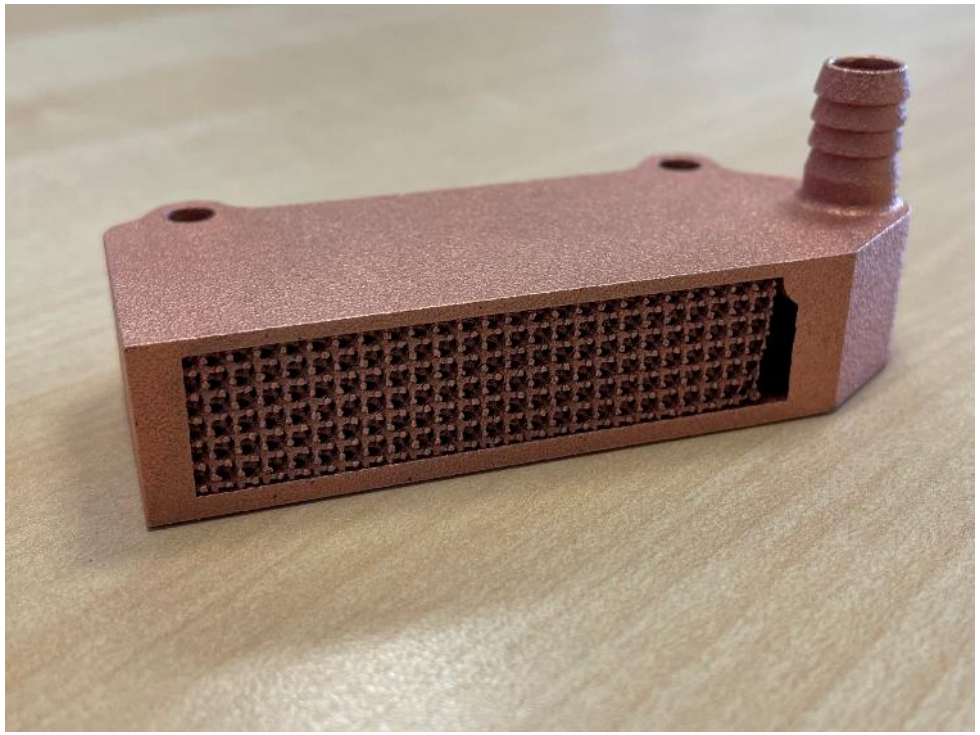
Objectives:

- Evaluate the effects of inert gas flow
- Evaluate the effects of the type of inert gas (N, Ar, He)

- **Material:**
- Cu > 99.8%

Research Activities & Case Studies

[LNGS: Koral Technologies] Collaborative research of lattice structures



Objectives:

- Development of innovative heat exchangers with lattice structures for electronics

Material:

- CuCrZr

Research Activities & Case Studies

[LNGS: UNIVAQ] Characterization of mechanical property CuCrZr

Objectives:

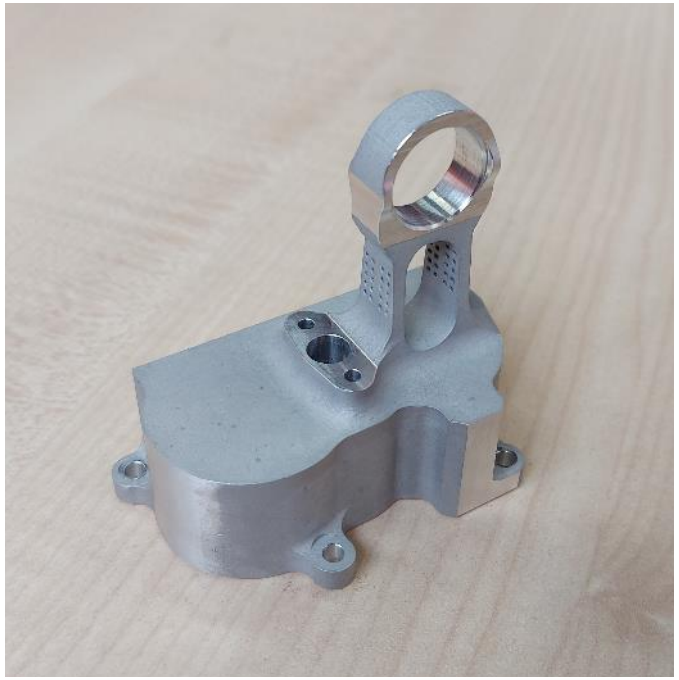
- Study and characterization of the mechanical, static and dynamic properties (strain-rate), of the CuCrZr copper alloy produced by SLM, with and without heat treatment

Materials:

- CuCrZr

Research Activities & Case Studies

[LNGS: OMA-FaVRIA] Commissioned research



Objectives:

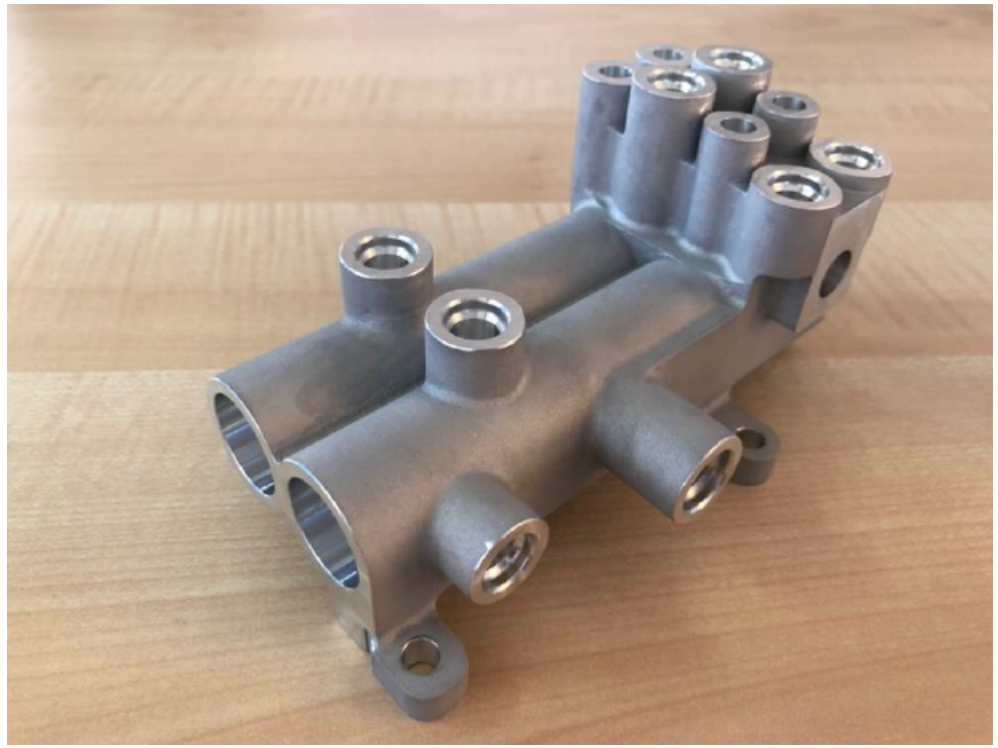
- Design for Additive Manufacturing (optimization) of aeronautical components and their realization

Material:

- Aluminum Alloy (SCALMALLOY®)

Research Activities & Case Studies

[LNGS: OMA-FaVRIA] Commissioned research



Components made:

- N.3 **hydraulic valves** with optimized channels via CFD analysis

N.3 **electromechanical actuators** optimized by topological optimization

- **Complementary activities:**
- Static and fatigue characterization tests

Spectrometric characterization

Dimensional checks

Cryogenic tests

Research Activities & Case Studies

[LNGS: UNIROMA1] Study of the realization of multimaterial components

Objectives:

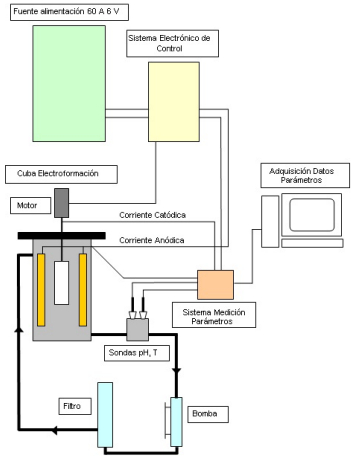
- Study of the realization of multi-material components using SLM technology

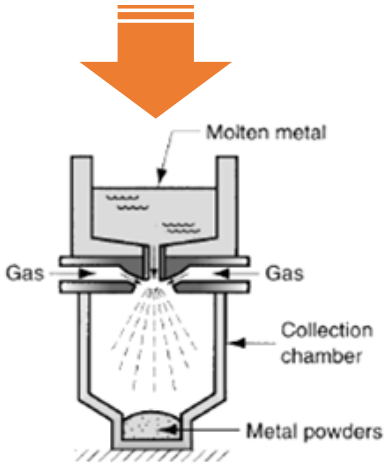
Material:

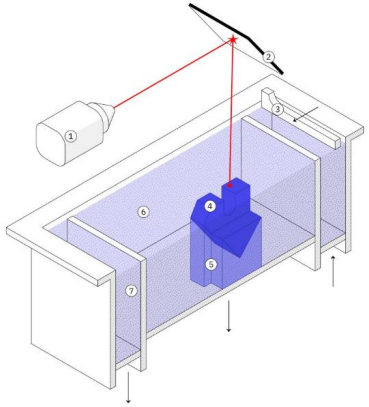
- Steel AISI 316L / CuCrZr

Research Activities & Case Studies

[LNGS & LSC] Innovative hybrid process based on EF/Atomization/SLM







Objectives:

- Realization of complex components using SLM technology
- By atomizing Electro-formed Copper

Material:

- EF Copper from LSC

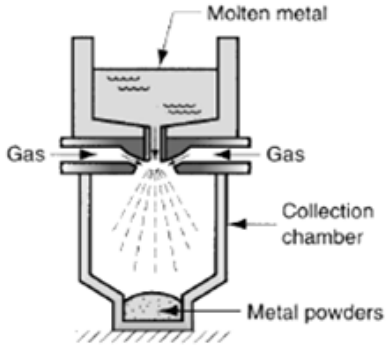
Laboratorio Subterráneo Canfranc

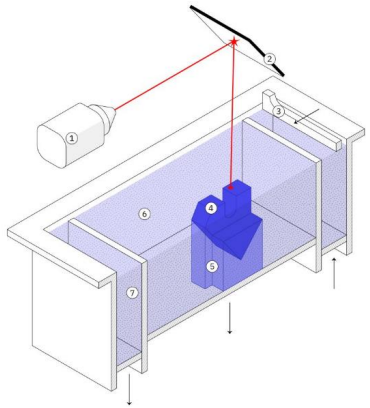
Research Activities & Case Studies

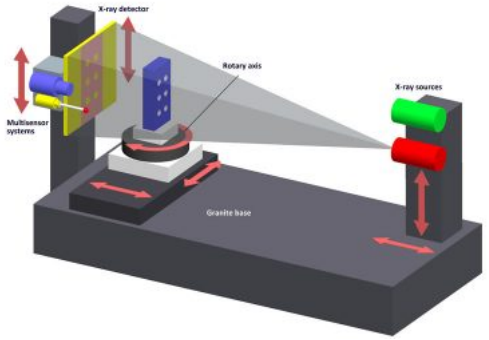
[LNGS] Innovative hybrid process based on Atomization/SLM

National Project SISMA

[MISTER] Innovative Cu and Al Alloys by Atomization/SLM







Objectives:

- Characterization of new alloys by SLM technology
- Quality Analysis by Industrial Tomography
- Scientific and Technological Demonstrators

Materials:

- Copper and Aluminum Alloys

P on-
T ecorvo
O bservatory for
L ight,
E arly-universe,
M assive-neutrino
Y ield

Collaborations&Projects

Gran Sasso National Laboratory – LNGS

LNGS MECHANICS SERVICE

MAD

UNIONE EUROPEA

Agenzia per la Coesione Territoriale

Ministro per il Sud e la Coesione territoriale

SAPIENZA UNIVERSITÀ DI ROMA

4CH

Bundesministerium für Bildung und Forschung

HOKKAIDO UNIVERSITY

UNIVERSITÀ DEGLI STUDI DELL'AQUILA

OMA Foligno - Italy

INFN

Publications (2022)

Gran Sasso National Laboratory – LNGS

- Conferences Articles

1) **D. Cortis**, E. Mancini, **S. Nisi**, **D. Orlandi**, P. Di Stefano., M. Utzeri, M. Sasso. *Compression Tests at High Strain Rate on 3D-Printed CuCrZr Alloy Specimens - Material Model Calibration*. Proceedings of ICIPE 22 Edition, Journal of Physics Conference Series – JPCS.

2) M. Sasso, E. Mancini, M. Utzeri, G. Chiappini, **D. Cortis**, **D. Orlandi**, L. Di Angelo. *High strain rate behavior of 3D printed CuCrZr*. Proceedings of the 2022 SEM Annual Conference and Exposition on Experimental and Applied Mechanics.

3) M. Sasso, E. Mancini, M. Utzeri, G. Chiappini, **D. Cortis**, **D. Orlandi**, L. Di Angelo. *Comportamento dinamico a trazione di una lega di rame ottenuta da stampa 3D*. Atto di convegno, AIAS2022, Società Scientifica Italiana di Progettazione Meccanica e Costruzione di Macchine.

4) **D. Orlandi**, **D. Cortis**. *Metal Additive Manufacturing at INFN-LNGS Laboratory: Facilities, Testing and Future Capabilities*. Proceedings of LRT Conference 2022.

5) **D. Cortis**, **A. Lalli**, **D. Orlandi**. *Additive Manufacturing Design of an Argon Condenser made with Pure Copper Powder for High-Purity Physics Applications: Technological Issues.* Lecture Notes in Mechanical Engineering: Design Tools and Methods in Industrial Engineering II, Proceedings of the Second International Conference on Design Tools and Methods in Industrial Engineering, ADM 2021, September 9–10, 2021, Rome, Italy.

6) I. Rago, M Iannone, F. Marra, M.P. Bracciale, L. Paglia, **D. Orlandi**, **D. Cortis**, V. Pettinacci. *3D Printed Pure Copper – Density and Thermal Treatments Effects.* Lecture Notes in Mechanical Engineering: Design Tools and Methods in Industrial Engineering II, Proceedings of the Second International Conference on Design Tools and Methods in Industrial Engineering, ADM 2021, September 9–10, 2021, Rome, Italy.

- Journal Articles

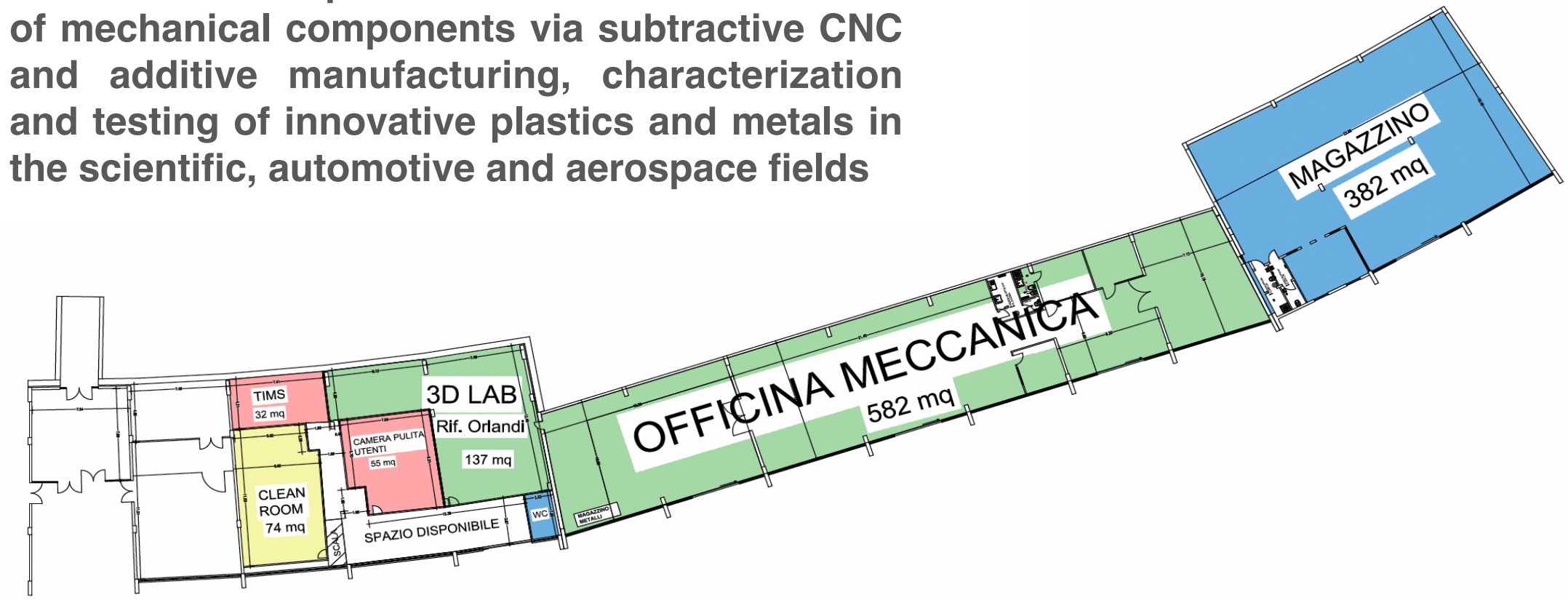
7) **D. Cortis**, F. Campana, **D. Orlandi**, S. Sansone, "*Strength and fatigue behaviour assessment of the SCALMALLOY® material to functionally adapt the performance of L-PBF components within CAE simulations*". Progress in Additive Manufacturing, Springer, 2022.

8) **I. Caravella**, D. Cortis, L. Di Angelo, **D. Orlandi**. "*Experimental analysis of the effect of SLM process parameters 2 on the surface quality of CuCrZr manufactured specimens*". Material Journal, MPDI, 2022.

Mechanics Facility

Gran Sasso National Laboratory – LNGS

More than 700mq dedicated to the construction of mechanical components via subtractive CNC and additive manufacturing, characterization and testing of innovative plastics and metals in the scientific, automotive and aerospace fields



To be continued…

Gran Sasso National Laboratory – LNGS

Ｊ－ＰＡＲＣシンボルマークとロゴ（２点）

HOKKAIDO UNIVERSITY

ESPRIT
HEXAGON

Neutron Techniques (Bragg-edge, CT Imaging) in Japan:

- Hokkaido University (Fall 2023 free of charge beam time)
- J-Parc (First half of 2024 by proposal)

Innovative Multi-Materials by SLM:

- Copper, ASTM 316L, Tungsten

NAMOR (Neutrons for Additive Manufacturing On-site Research) Experiment

- CSN5 LNGS/INFN-FI/INFN-TO

CAD/CAM at Mechanical Workshop Dept.

- 5 Axis CB Ferrari - 3 Axis Makino PS105 - 3 Axis Hurco
- **Total integration with AM**