

# Additive Manufacturing at LNGS: Facilities, Metals Testing and Future Capabilities

**Donato Orlandi**

**Aerospace Engineer**

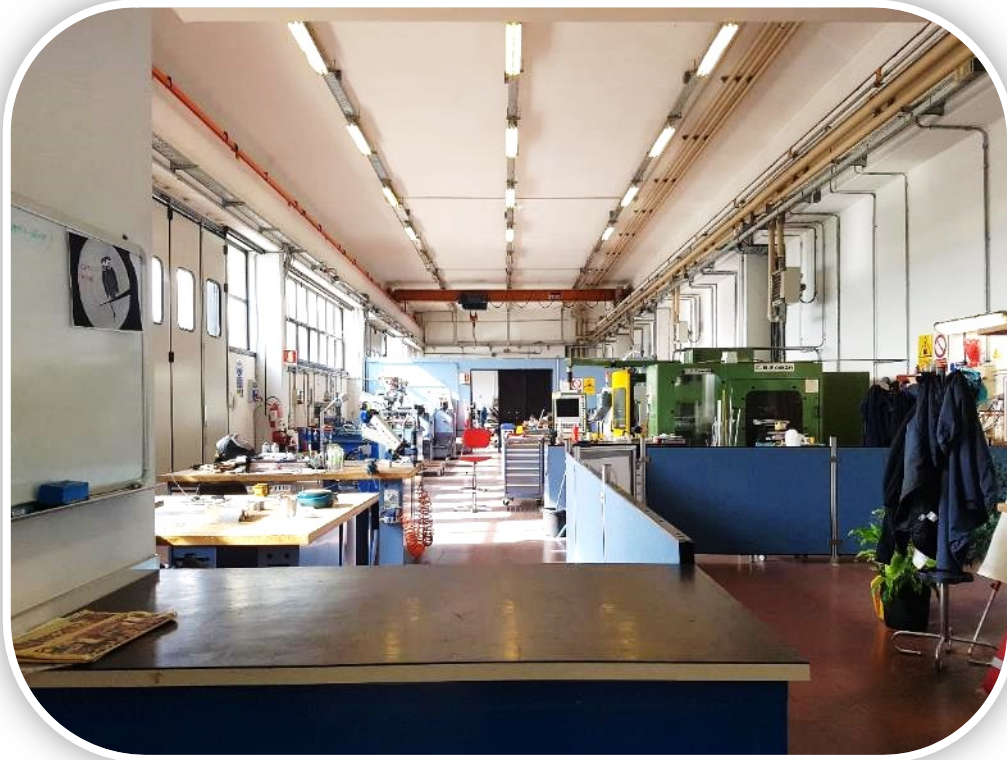
**National Institute for Nuclear Physics**

**Gran Sasso National Laboratory**

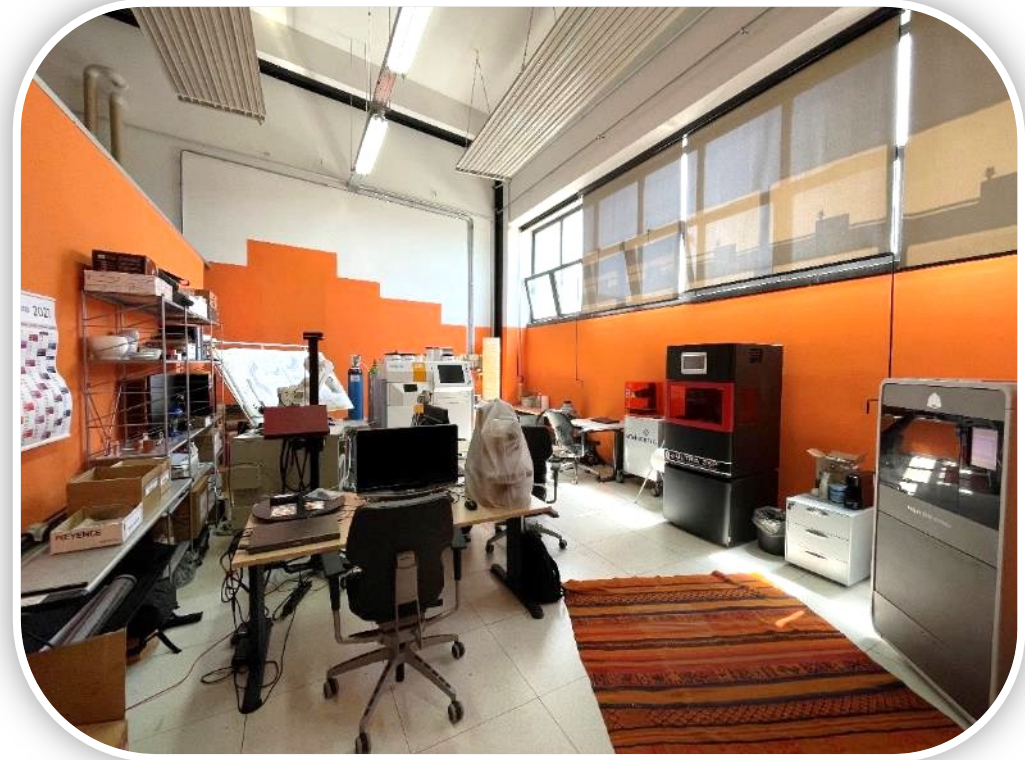
**Head of Mechanics Service**

# Mechanics Service

Gran Sasso National Laboratory – LNGS



Workshop Department



Design and Additive Manufacturing Department

# The Mechanics Service

Gran Sasso National Laboratory – LNGS



Responsible: *Donato Orlandi*



## Workshop Department

Responsible: *Angelo Corsi*

### Main activities

Traditional machining, CNC, quality control



## Design and Additive Manufacturing Department

Responsabile: *Daniele Cortis*

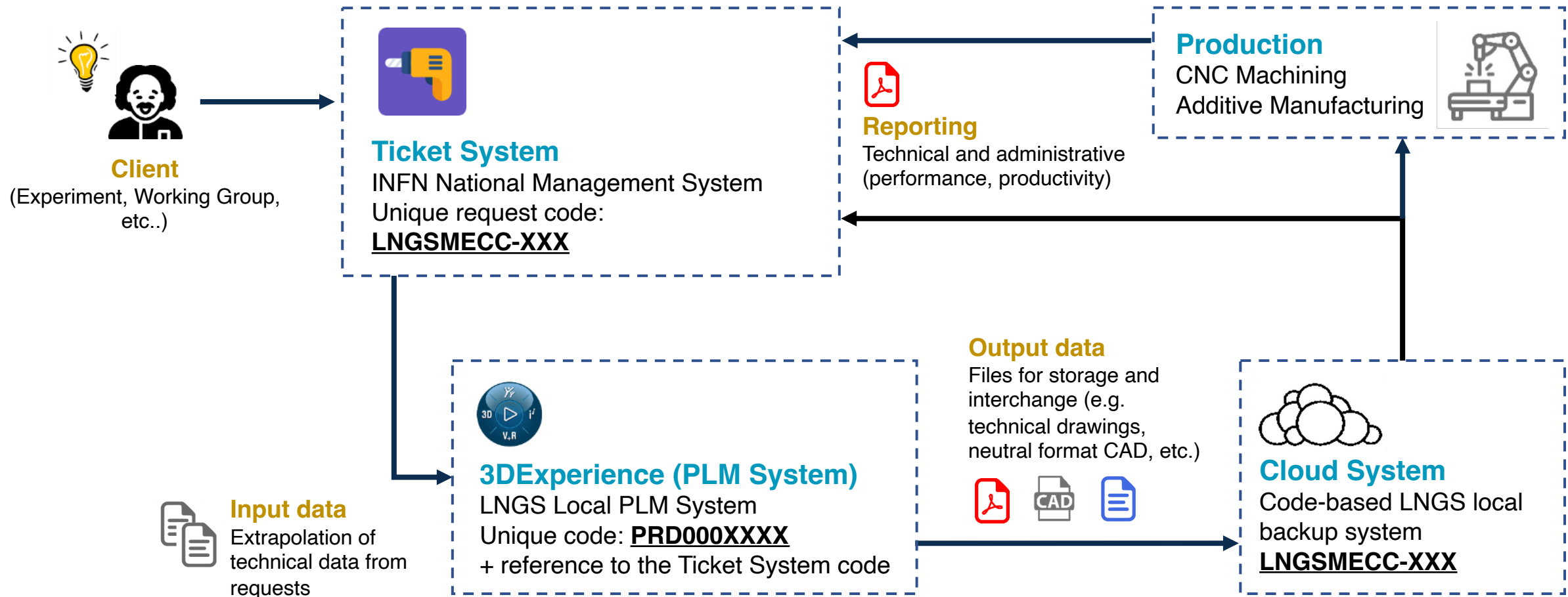
### Main activities

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



# The Mechanics Service

Gran Sasso National Laboratory – LNGS



# Technologies and equipment

## Gran Sasso National Laboratory – LNGS

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



**SISMA**  
L-PBF (SLM)



**3DSystem**  
PoliJet



**ENVISIONTEC**  
SLA



**ENVISIONTEC**  
DPL



# Technologies and equipment

## Gran Sasso National Laboratory – LNGS

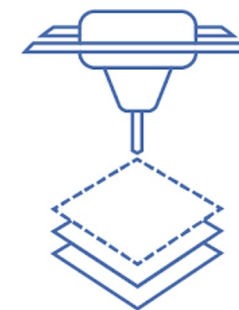
### Metal Additive Manufacturing

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

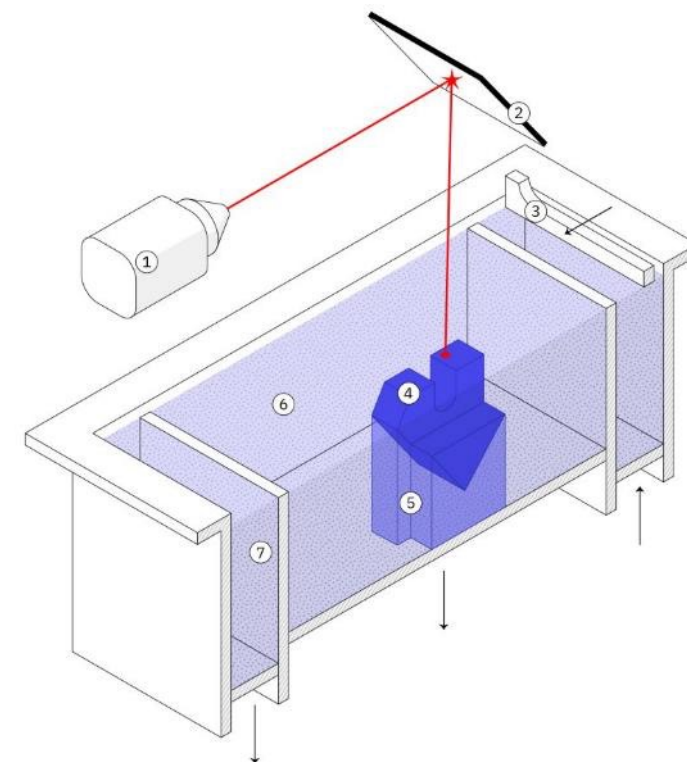
## Gran Sasso National Laboratory – LNGS

### 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.



# Technologies and equipment

## Gran Sasso National Laboratory – LNGS

### SISMA MySint 100 (PM/RM)

Version developed specifically for R&D.

#### Main Features:

Building volume	Ø 100 mm x 90 mm
Laser source	175 W (single laser)
Laser spot	30 $\mu\text{m}$
Layer thickness	20-40 $\mu\text{m}$ (regolabile)
O2 sensor	100 ppm

#### Other:

- Patented Coater tilting offers reduced re-routing times
- Each processing parameter is customizable





# 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**



**KEYENCE**  
**VHX-7000**



**KEYENCE**  
**IM series**

# Future investments

## Gran Sasso National Laboratory – LNGS

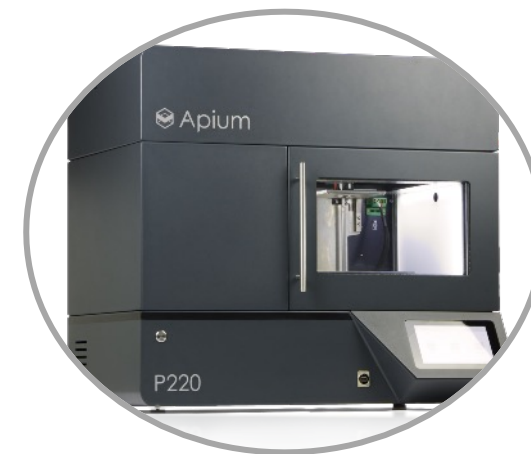
The service is also constantly evolving and technological renewal of its machine park.



Atomizer of metal  
powders for L-PBF



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



PEEK/Carbon Filled  
PEEK Printer FDM

# 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/astroparticle physics research and technology transfer.



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



### HAMMER - Hub for Additive Manufacturing, Materials Engineering and Research



#### Hi-Res Manufacturing of plastic and metal components

Selective Laser Melting (SLM), Stereolithography (SLA), Digital Light Processing (DLP), Fused Deposition Modelling (FDM), PolyJet.



#### Stereoscopic Hi-Res 3D scanning & Reverse Engineering

3D Stereoscopic Scanner (up to 0.07 mm of accuracy).



#### Finite Element Simulations

L-PBF Process Simulation, Structural, Thermal and Fluid Dynamics Analysis.



#### Control of chemical composition of the processed materials

Spectrometric Characterization



#### 4K Ultra-High Accuracy Microscope for materials analysis



# Research Activities & Case Studies

## [LNGS: PTOLEMY] Design and production of heat exchanger



### Design requirements:

- Vacuum component
- Cryogenic conditions
- High thermal conductivity
- Coupling with electric motor
- Highly customized geometry (electronic components)

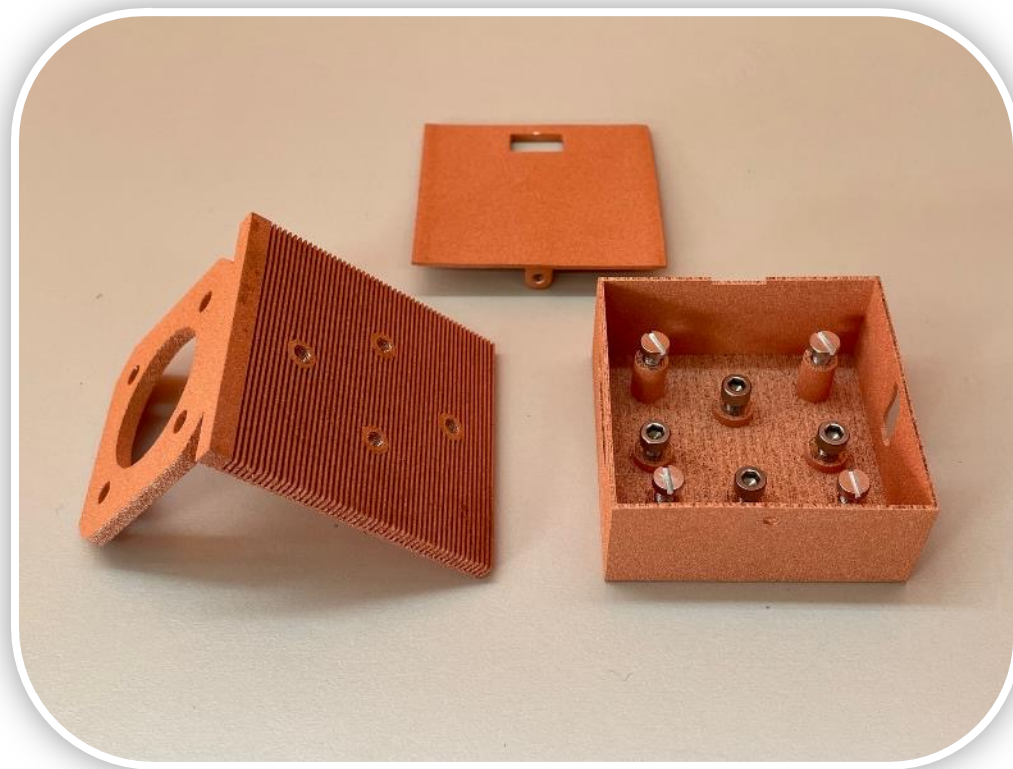
### Material:

- Cu OFE



# Research Activities & Case Studies

[LNGS: PTOLEMY] Design and production of heat exchanger



## Components made:

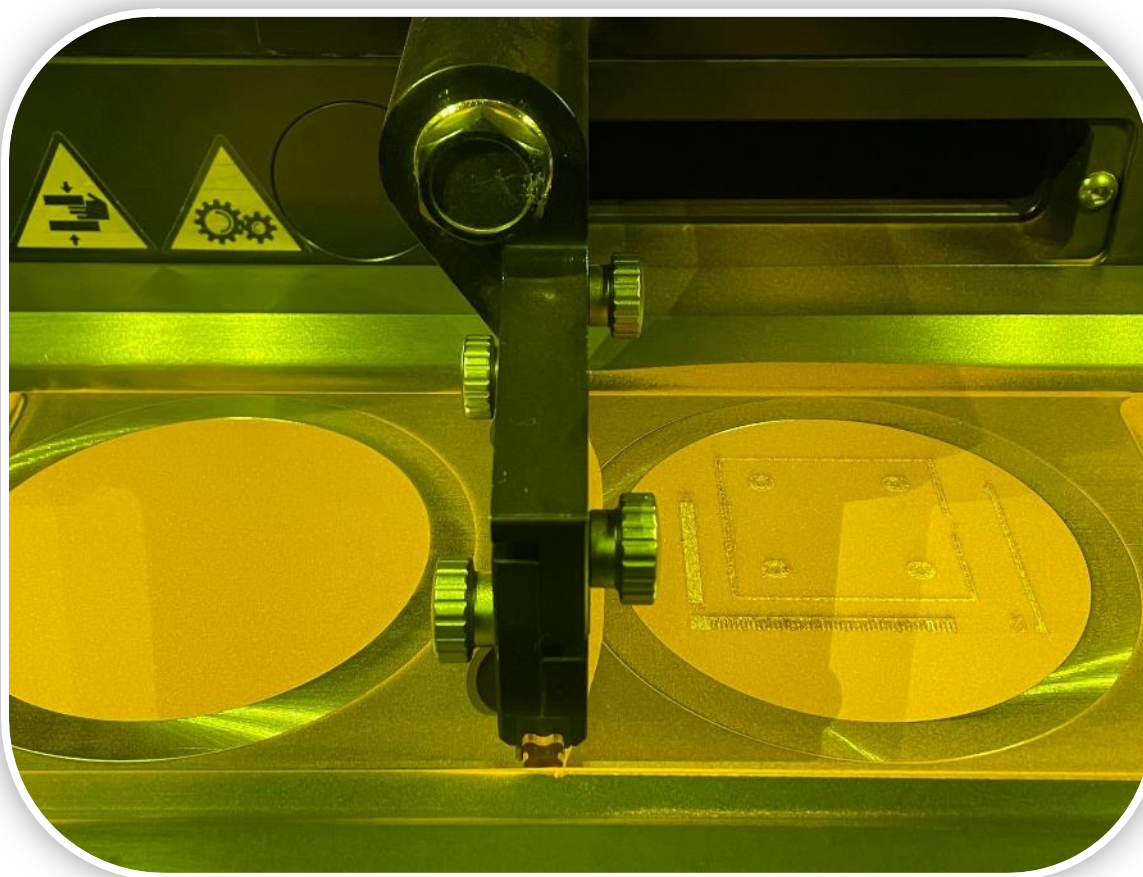
- Heat exchanger
- Electronics case
- Case cover

## Post-operations:

- Sandblasting
- Threaded holes

# Research Activities & Case Studies

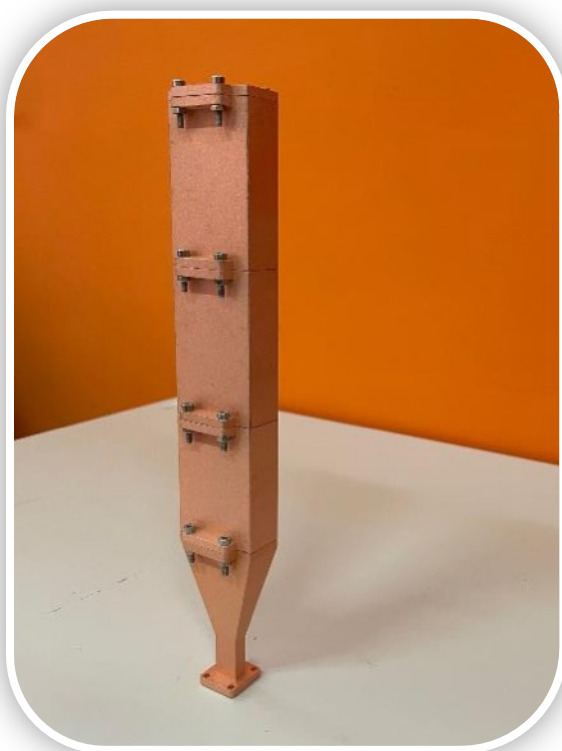
[LNGS: PTOLEMY] Design and production of heat exchanger



Construction phase

# 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: PTOLEMY] Design and production of waveguides



## Components made:

- N.4 waveguide sections
- N.2 caps with different geometry

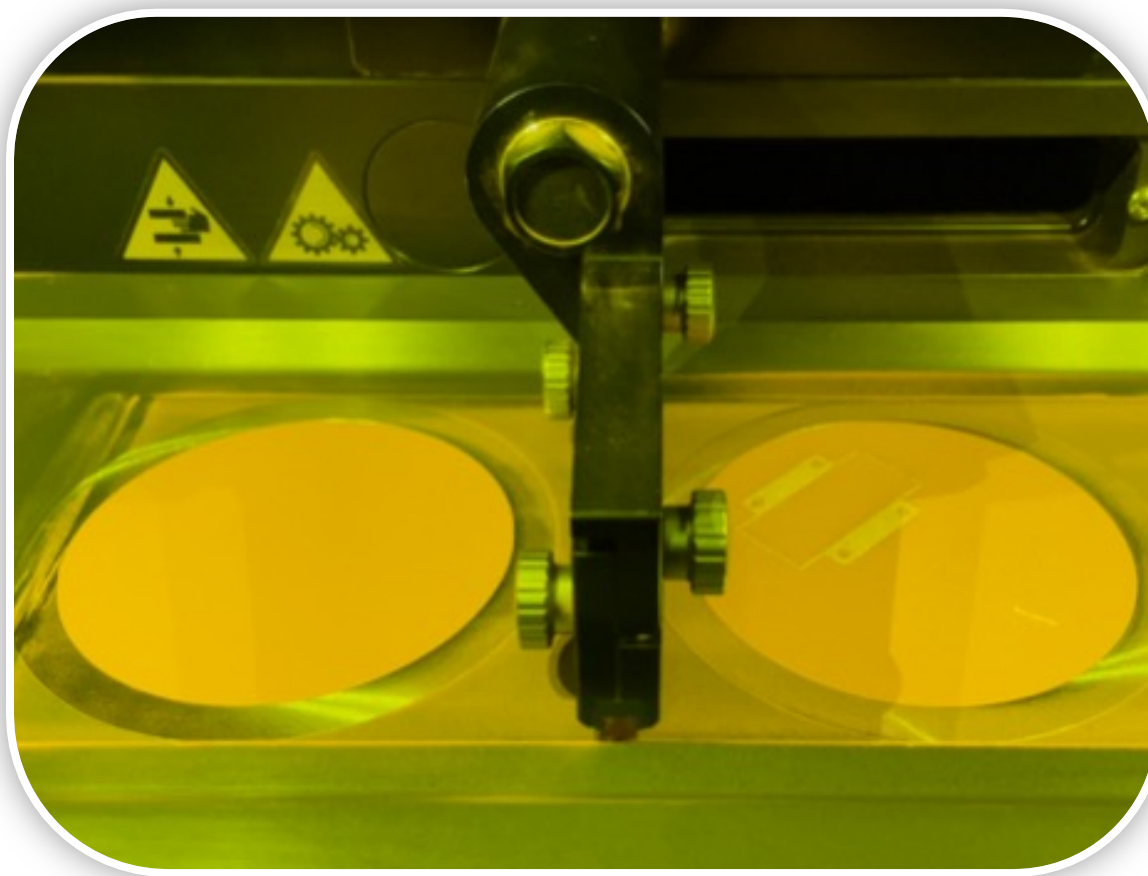
## Post-operations:

- Sandblasting
- Threaded holes



# Research Activities & Case Studies

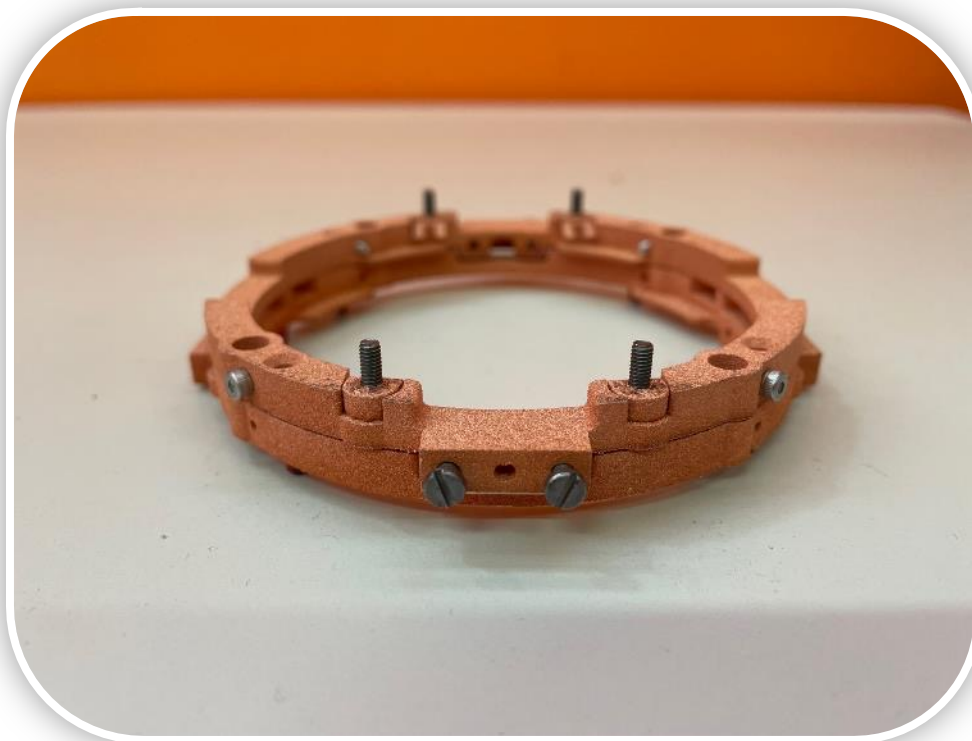
[LNGS: PTOLEMY] Design and production of waveguides



Construction phase

# Research Activities & Case Studies

## [HAMMER: LNGS - ROMA1] Sandwich frame production



### Design requirements:

- Vacuum component
- Cryogenic conditions
- High precision mechanical coupling

### Material:

- Cu OFE



# Research Activities & Case Studies

## [HAMMER: LNGS - ROMA1] Sandwich frame production



### Components made:

- N.2 frames (prototypes)

### Post-operations:

- Sandblasting
- Threaded holes

# Research Activities & Case Studies

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



## Design requirements:

- Vacuum component
- Cryogenic conditions

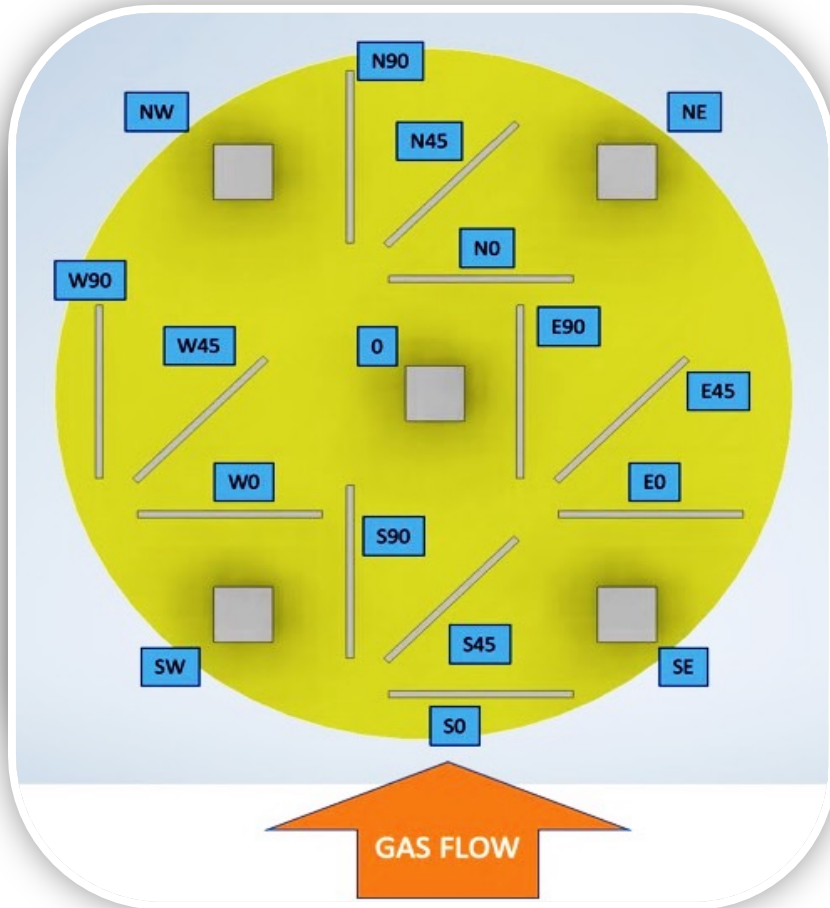
## Material:

- Cu > 99.8%



# Research Activities & Case Studies

[HAMMER: LNGS - ROMA1] 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

[HAMMER: LNGS - ROMA1] Development of new materials



## Objectives:

Development of new copper metal matrix materials

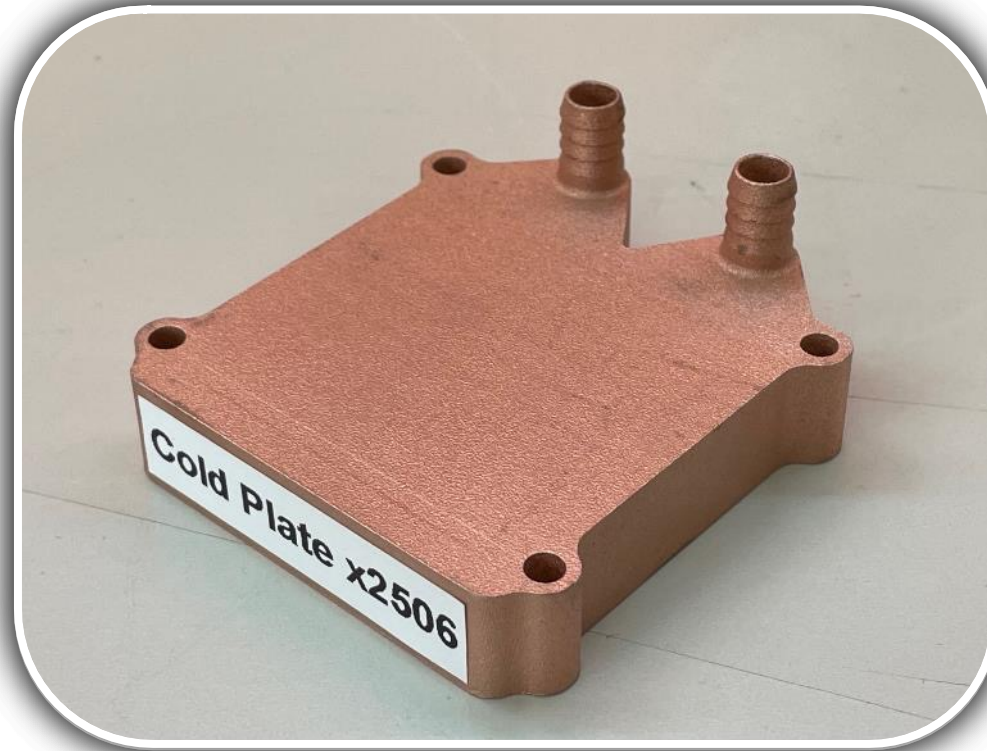
## Material:

- 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

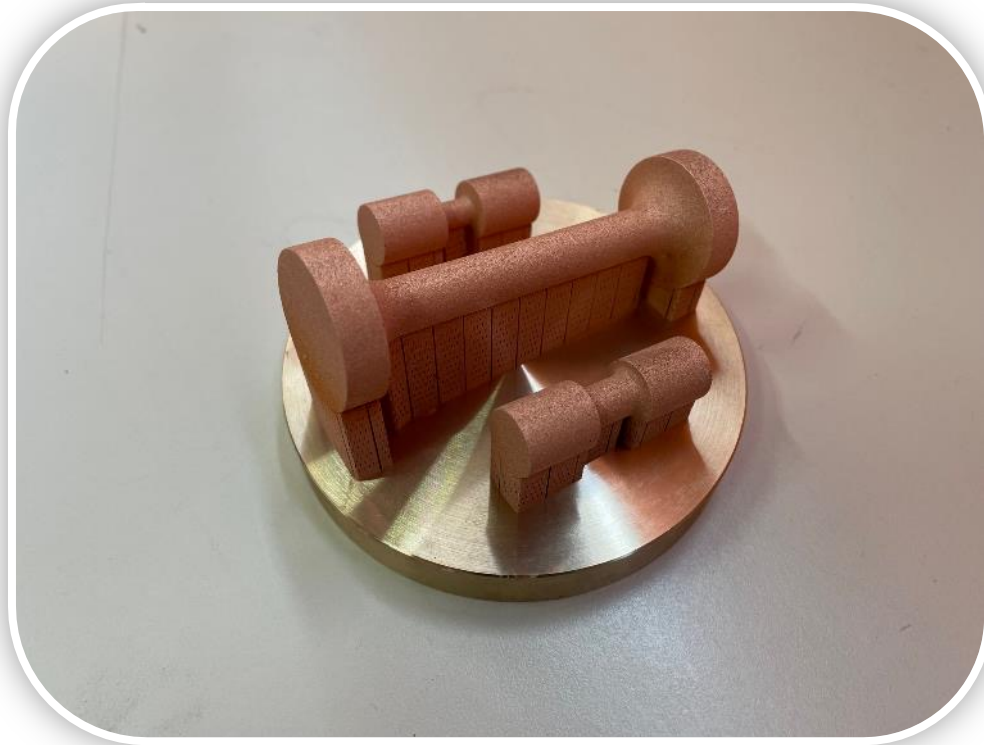
## Material:

- 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

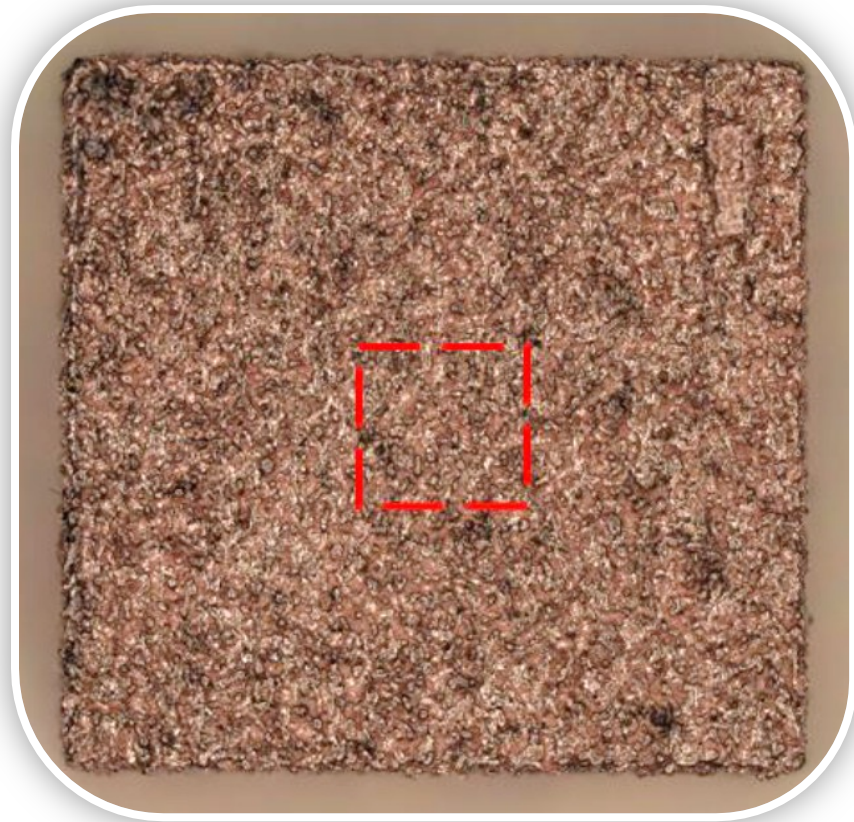
## Materials:

- CuCrZr



# Research Activities & Case Studies

[LNGS: UNIVAQ] Study of surface quality



## Objectives:

- Study and analysis of the surface quality of parts made of CuCrZr copper alloy by SLM

## Material:

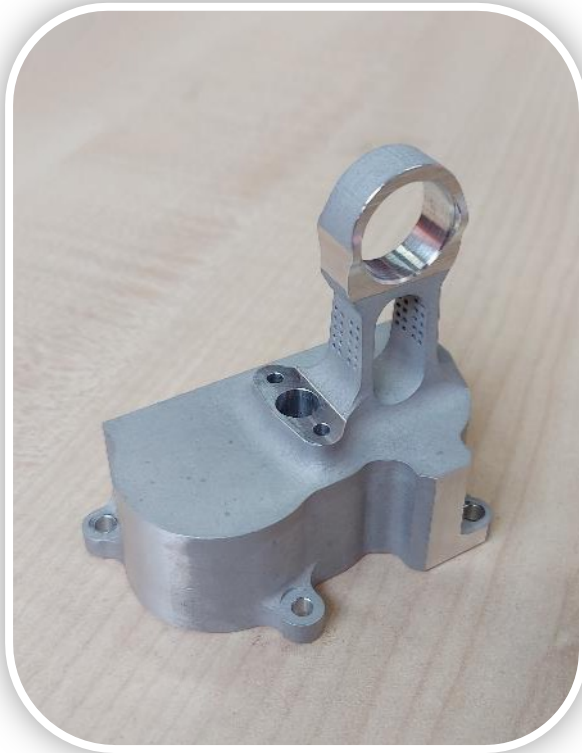
- CuCrZr





# Research Activities & Case Studies

[LNGS: OMA-FaVRIA] Commissioned research



## Objectives:

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

## Material:

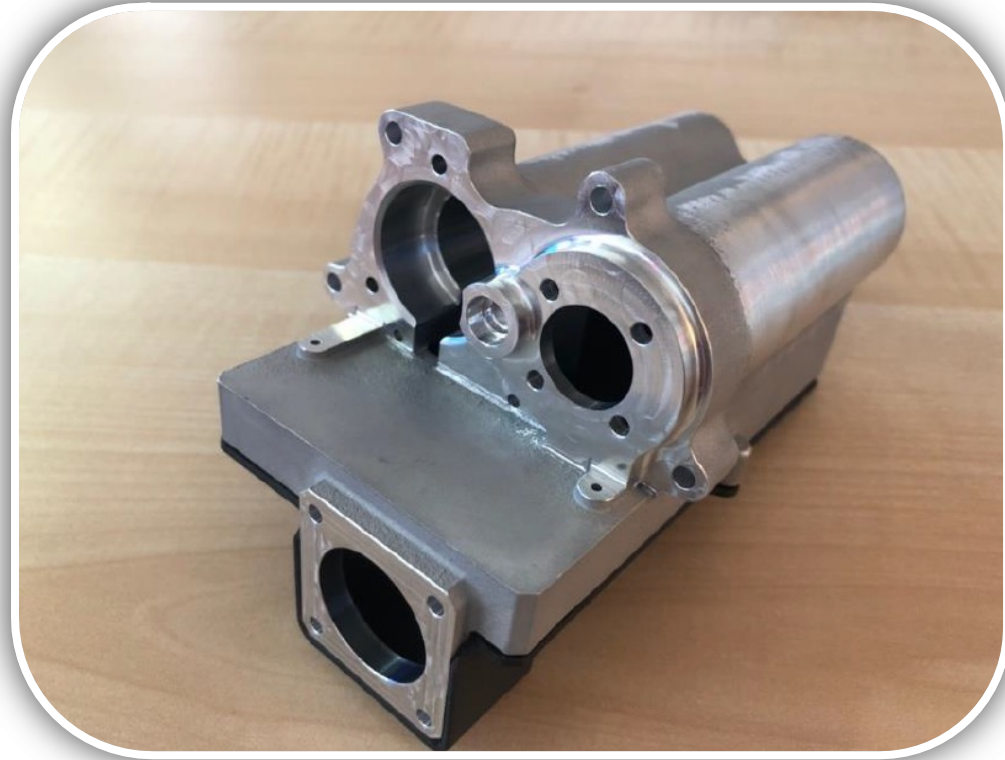
- Aluminum Alloy (SCALMALLOY®)





# Research Activities & Case Studies

[LNGS: OMA-FaVRIA] Commissioned research



## Components made:

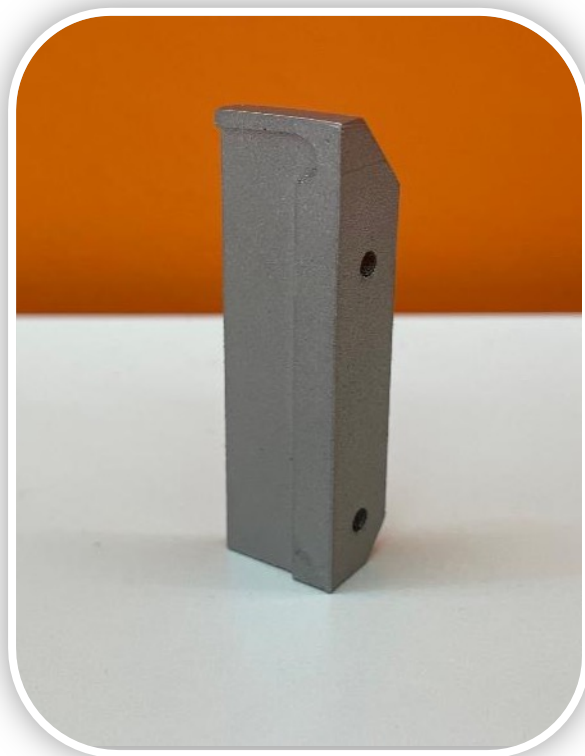
- N.3 **hydraulic valves** with optimized channels via CFD analysis
- N.3 **electromechanical actuators** optimized by topological optimization

## Complementary activities:

- Static and fatigue characterization tests
- Spectrometric characterization
- Dimensional checks
- Cryogenic tests

# Research Activities & Case Studies

## [LNGS: PLANETA] Design and production of crystal holders



### Objectives:

- Vacuum component
- High precision mechanical coupling

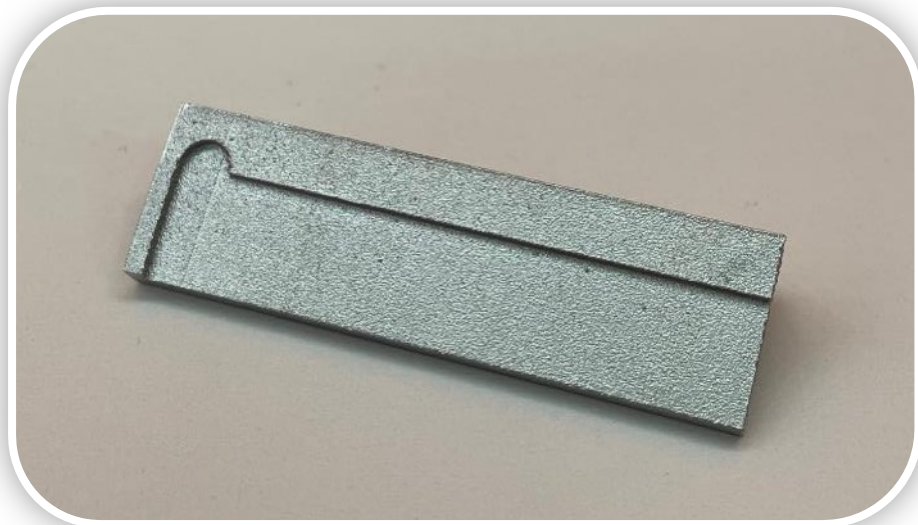
### Material:

- Steel AISI 316L



# Research Activities & Case Studies

## [LNGS: PLANETA] Design and production of crystal holders



### Components made:

- N.4 holders

### Post-operations:

- Sandblasting
- Threaded holes

# 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

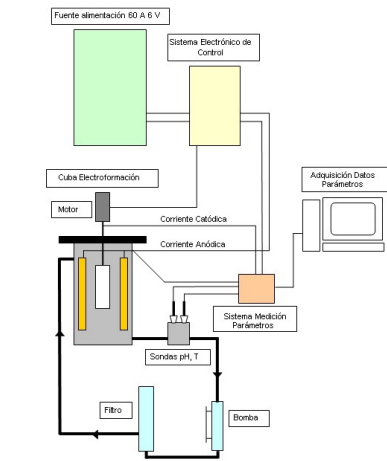
## Material:

- Steel AISI 316L / CuCrZr



# Research Activities & Case Studies

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

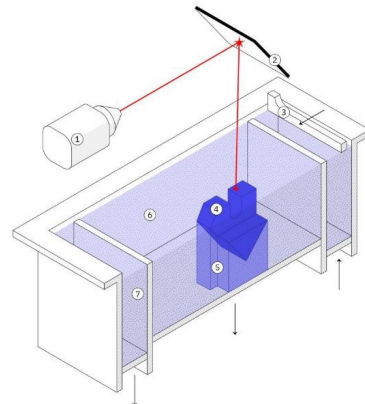
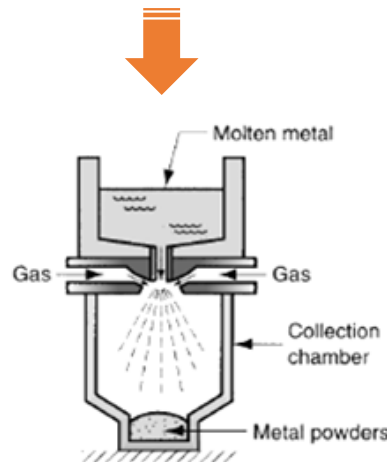


## Objectives:

- Realization of complex components using SLM technology
- By atomizing Electroformed Copper

## Material:

- EF Copper from LSC (see Eric's talk)



Laboratorio Subterráneo Canfranc



**Thanks for your attention**  
**(and you're welcome at LNGS Mechanics Service)**

