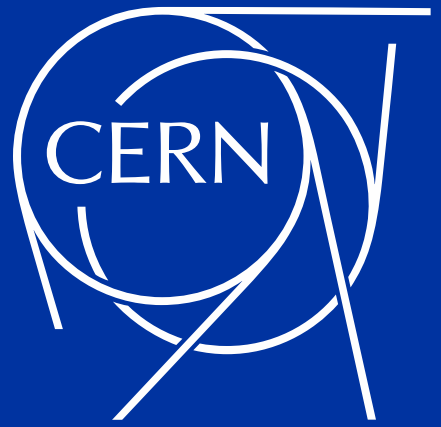


3D printing of HOM couplers

Sébastien Clément
TE-MSC-SMT
Polymer laboratory

PERLE collaboration meeting

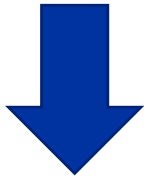
2023/06/23

Table of content

- 3D printing at CERN Polymer Lab
- Development of HOM couplers prototype for PERLE experiment
- Additive Manufacturing of NIOBIUM

3D printed polymer component requirements:

- **Radiation resistance**
- **High voltage insulation**
- **Compatible with cryogenic applications**
- **Accuracy**



- Stereolithography 3D printing process (SLA)
- Epoxy resins (Accura 25 and 48)

3D printing at Polymer lab

Viper Si2 since 2011

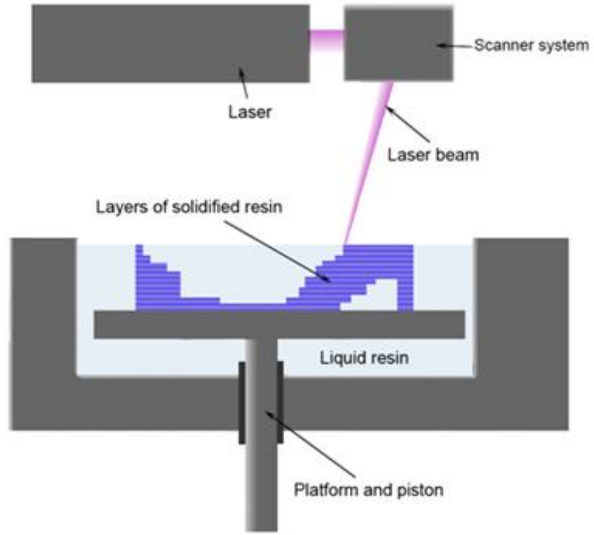
PROPERTIES	
Build volume	250 x 250 x 250 mm
Precision	± 0.1 mm
Layer thickness	MIN 0.08 mm, MAX 0.10 mm

ProJet 6000 HD since 2022

PROPERTIES	
Build volume	250 x 250 x 250 mm
Precision	± 0.1 mm
Layer thickness	MIN 0.08 mm

TECCAM 400 SLA since 2022

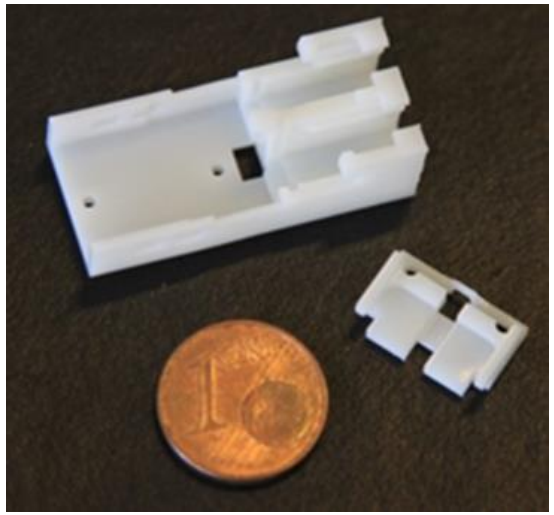
PROPERTIES	
Build volume	400 x 400 x 350 mm
Precision	Under evaluation
Layer thickness	Under evaluation



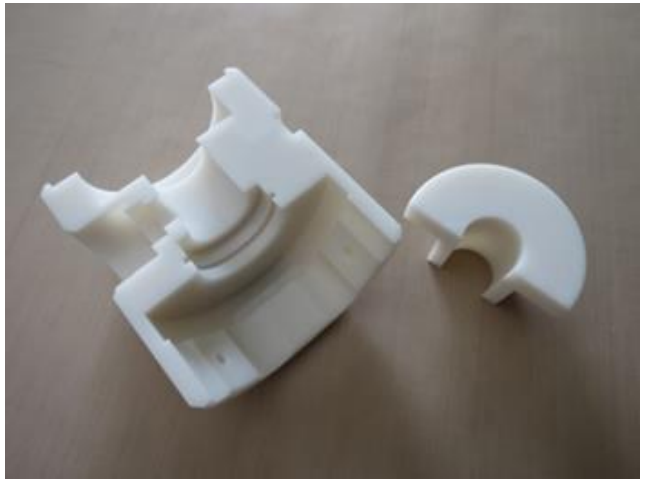
Stereolithography process

- Support grid dipped into liquid resin 0.1 mm
- Laser curing
- Postprocessing

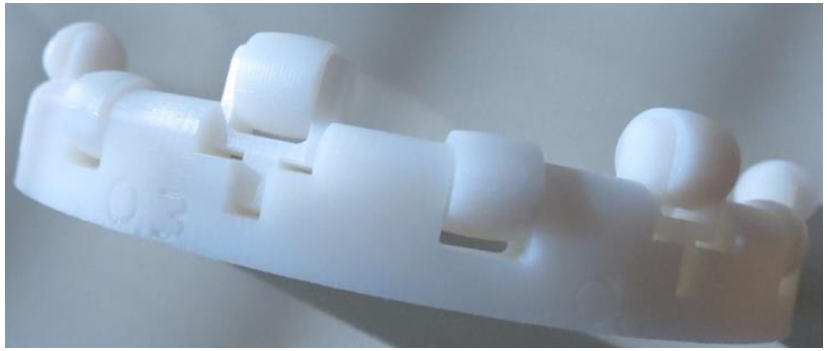
Functional parts for detectors and experiments printed in 3D



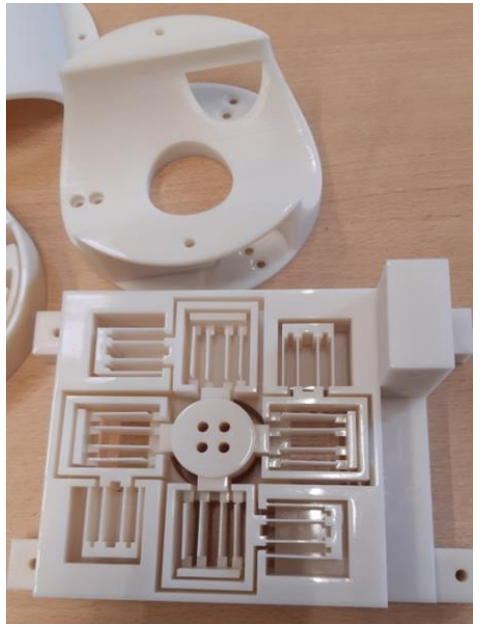
Irremovable plug (Atlas)



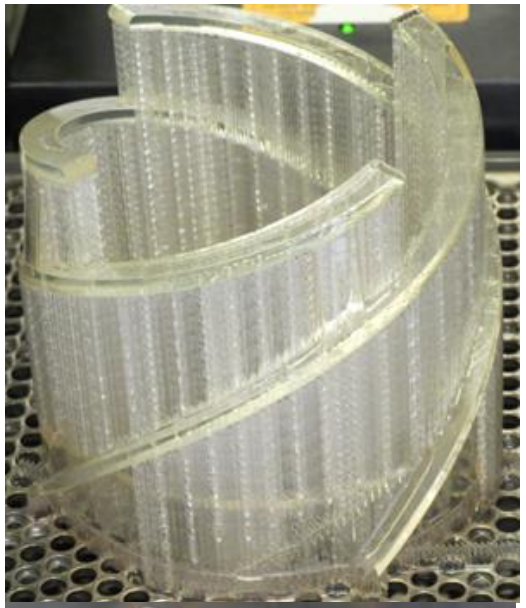
HV Connectors (NP02)



Ring with rolls systems in one parts for magnetics measurement (TE-MSC-MM)



Electronics cards Supports and instrumentations (FSI target)



Electric insulation(Alice)

What drives the development of metalized 3D printed parts

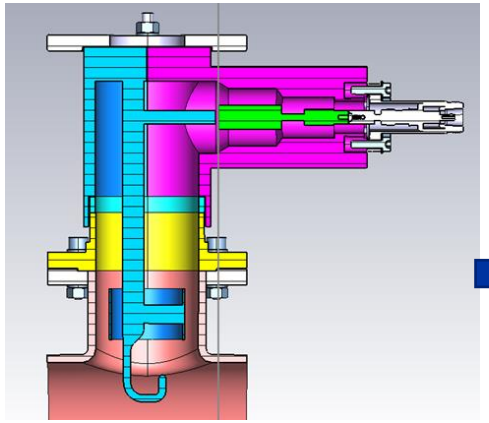
- Row material shortage and long lead time
- Price increase of row materials
- Light weight
- Short manufacturing time
- Highly complex geometries

RF coupler for PERLE Experiment in 5 steps

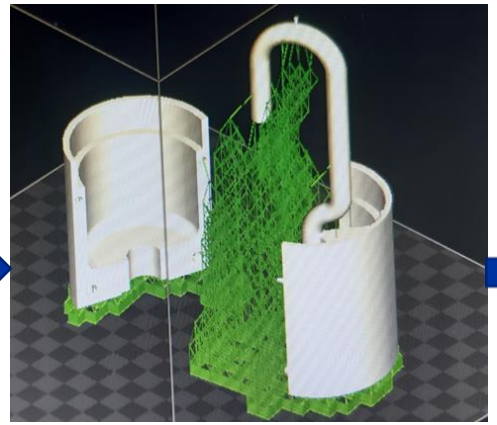
Coupler HOM for PERLE experiment (Powerful Energy Recovery Linac for Experiment)

This project consists of the development of a prototype RF coupler with copper coating

- Interaction with different groups (TE-VSC-SCC), (EN-MME-FW) and external laboratories IJCLAB (FR), JLAB (USA)
- We are investigating with the polymerlab team and the surface coating team the use of this technique to other applications



Design of the assembly



3D printing plateform preparation

Parts 3D printed

Parts with copper deposition by electroplated

Part tested in Jlab

ELECTROLYTIC COPPER PLATING ON EPOXY

Sandblasting

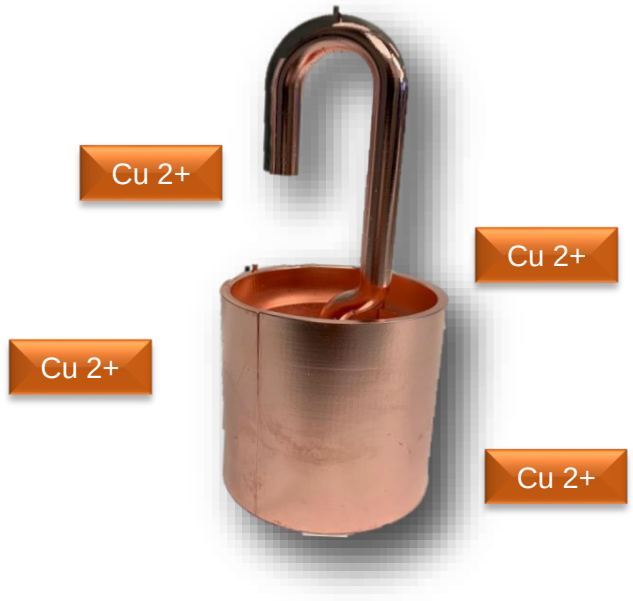
Sandblasting creates microporosities on the epoxy surface and improves adhesion

Carbon coating

Blackhole SP Replenisher is composed of miscible carbon particles in aqueous solution, giving them a negative charge

Negatively charged particles are electrostatically absorbed on the surface

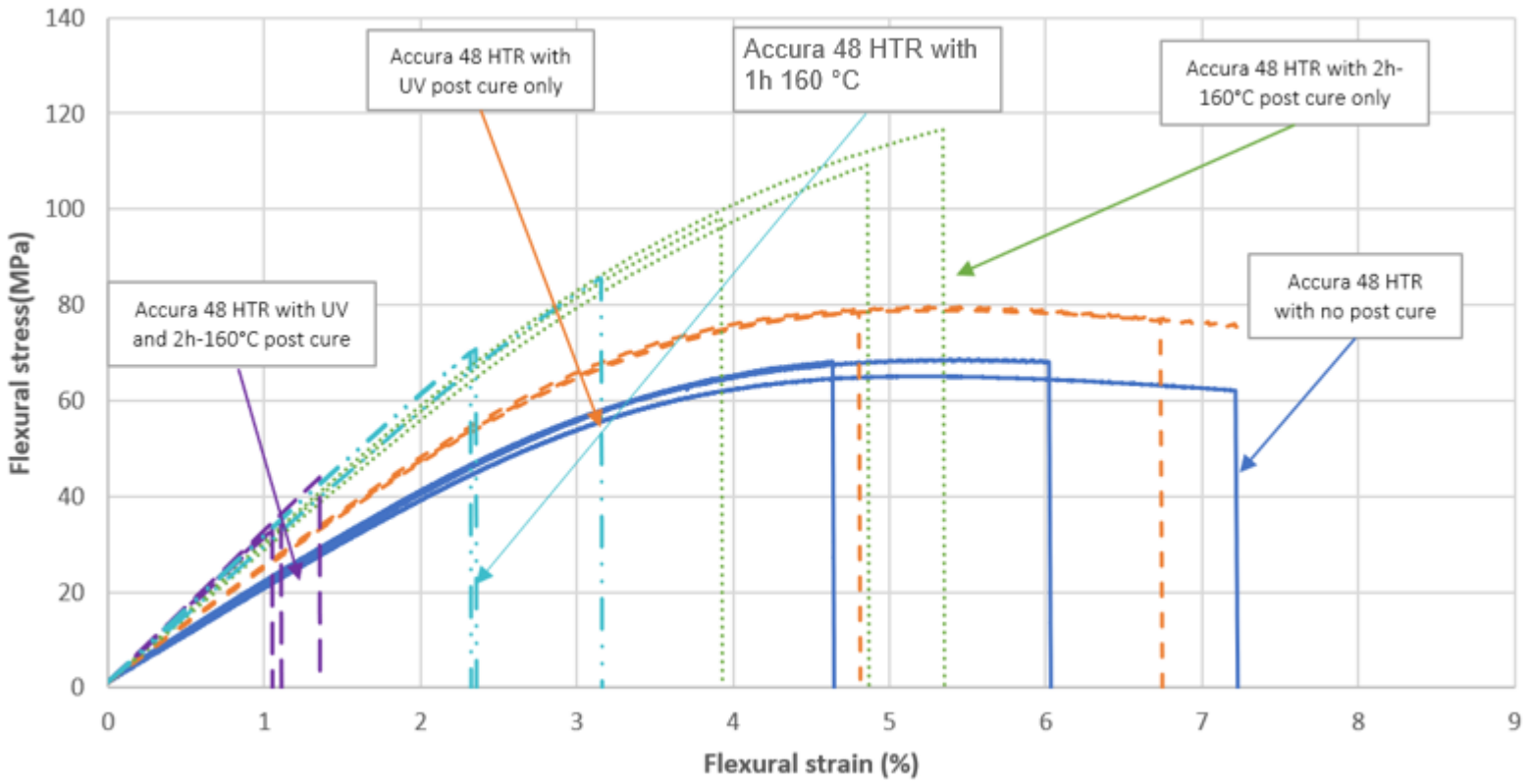
Electrolytic copper-plating



The electrical charge imparted to the epoxy enables electrolytic copper plating.

Copper plating is carried out in an electrolytic bath based on copper and sulfate

Optimization of Accura 48 post processing

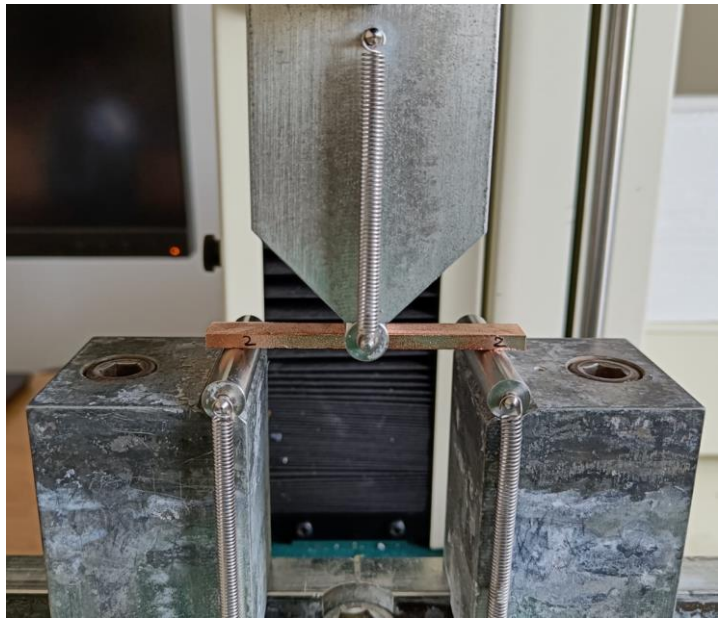


Comparison of RT flexural stress vs flexural strain curves for the four types of post cure Accura 48 HTR (J.-S. Rigaud, EDMS No. 2864019).

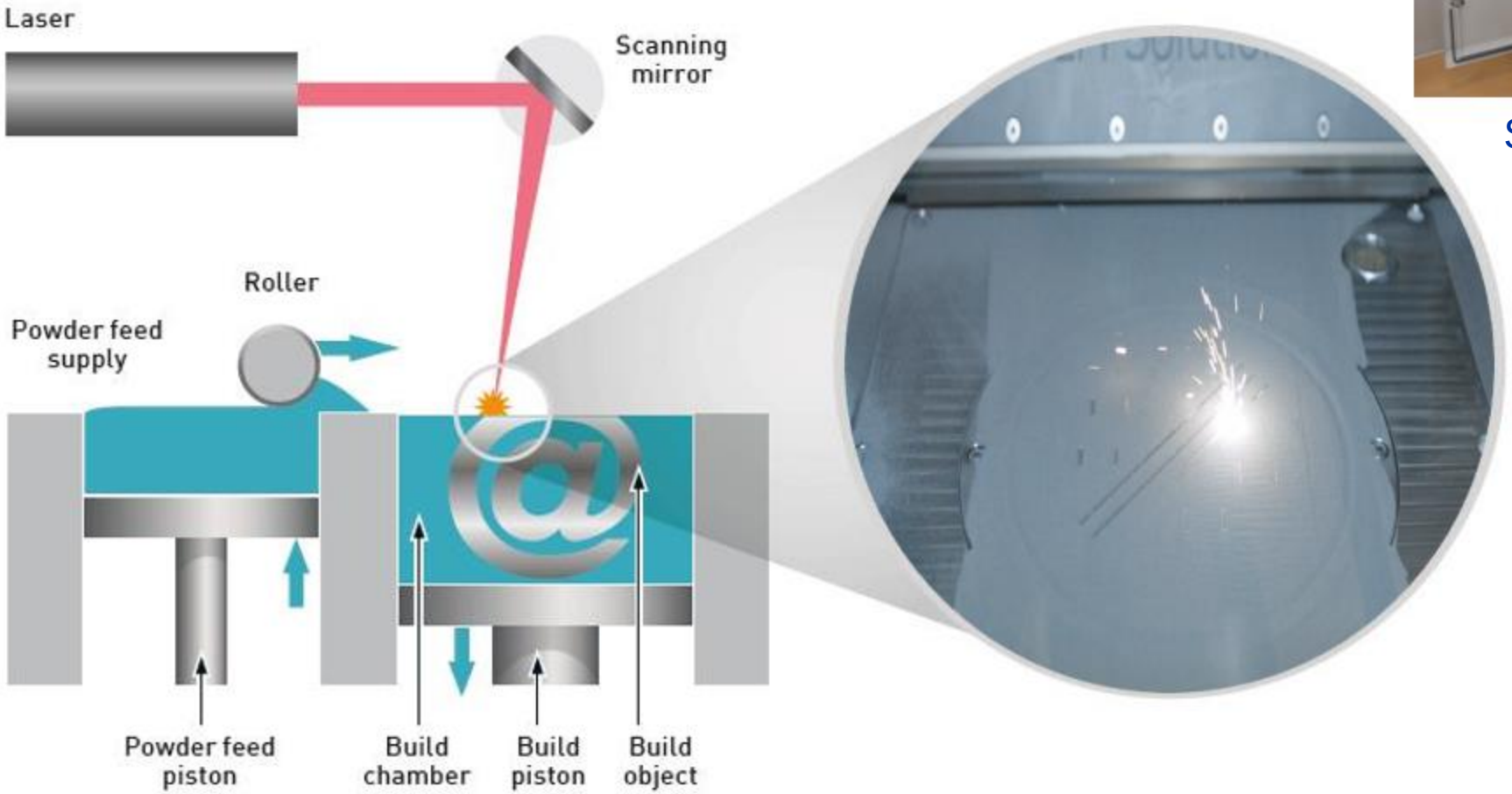
UV post processing chamber

Planned coating characterization

- Metrology and Cu coating thickness distribution
- Cu coating adhesion tests in accordance with ASTM D4541
- Tensile tests and flexural tests of Cu coated samples at RT and at 77K (effect of Cu coating thickness on mechanical properties)
- Thermal shock tests in liquid nitrogen
- Residual Resistivity Ratio (RRR) measurements of the Cu coating
- Tests of alternative coatings (nickel, silver and gold)



Additive Manufacturing of NIOBIUM superconducting applications



SLM solutions 280 HL

Information and contact: Romain.Gerard@cern.ch – EN/MME

Additive Manufacturing of NIOBIUM superconducting applications

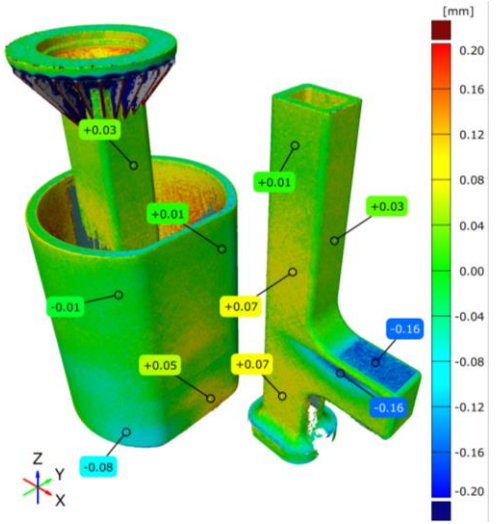
Additive Manufacturing opens the door to design freedom, bringing the cooling as close to the high field surfaces.

In EN/MME, this material was developed from the raw metal powder, to the process and post-manufacturing treatment.

It meets the strict requirements of UHV.

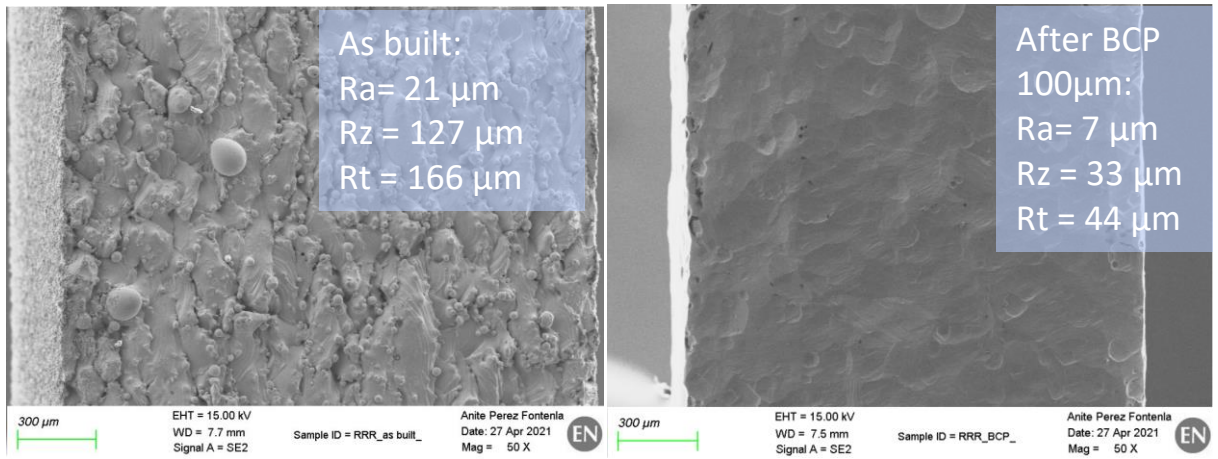
Build volume with niobium: Ø125 x H275 mm³

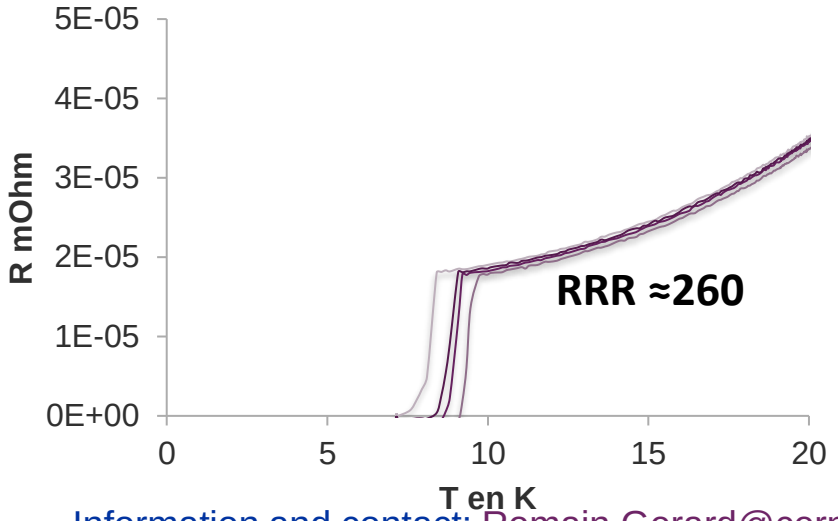
Geometry:
High precision 3D Scanning metrology.
Precision of +-0.2mm are readily achievable



Material purity:
Raw material improvement (Nb Powder)
Titanium Gettering TTH purification of the components

Surface: Chemical polishing and mechanical polishing studies





Information and contact: Romain.Gerard@cern.ch – EN/MME

Thank you

- **Carmelo Barbagallo, Patricia Duchesne, Walid Kaabi, Gilles Olivier, Guillaume Olry, Samuel Roset, Fabian Zomer (IJCLAB).**
- **James Henry, Sarah Overstreet, Gunn Park, Robert Alan Rimmer, Haipeng Wang (Jlab)**
- **Franck Gerigk SY-RF, Simon Barriere EN-MME, Romain Gerard EN-MME, Pierre Maurin TE-VSC, Mauro Taborelli TE-VSC, Ahmed Cherif EN-MME, Jean-Phillipe Rigaud EN-MME, Olivier Choisnet FSU ,Roland Piccin TE-MSC (CERN).**

Thank you for your attention