WP 4.1: Additive Manufacturing for accelerator components

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WP 4.1: Status

Task 1: *Definition of powder specification and property requirements for optimised parts - report based on a literature review and discussion with industry.*

Task 2: *Developement and characterisation of High Conductivity powder for additive Manufacturing*

- *Supplier benchmarking*
- *Niobium powder development*
- *Powder characterisation (size, chemical composition and flow properties)*

Task 3: *Fabrication of test parts.*

- *Design and fabrication of test parts for analysis of mechanical, conductivity, RRR and UHV properties.*
- *Each parameter could be analysed individually allowing for a steady flow of test pieces.*

Task 4: *Selection of design and fabrication parameters for optimised part.*

- *Pieces will be built incorporating the learnings from previous milestones.*
- *Various simple shapes will be built and tested.*

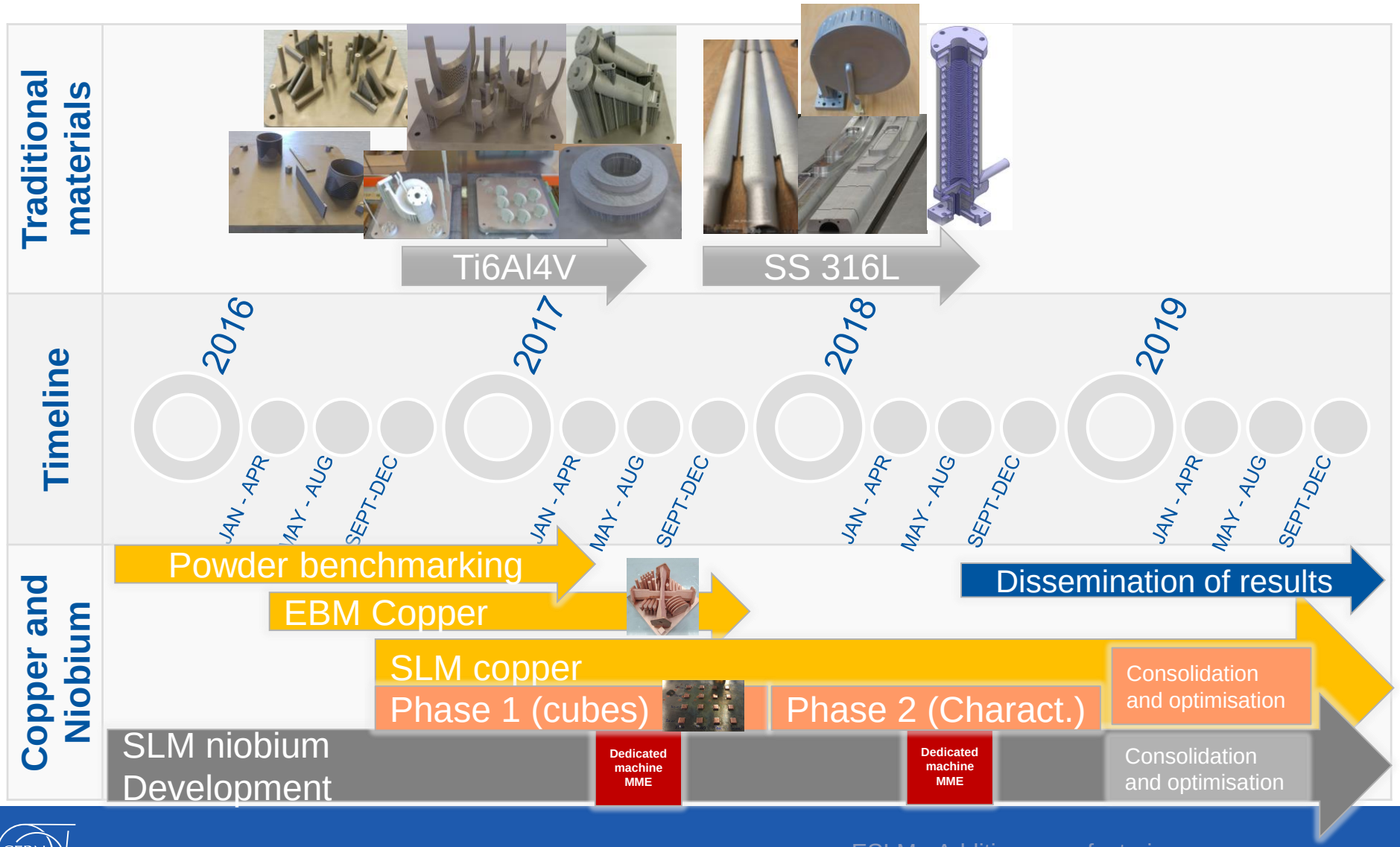
Task 5: *Fabrication of final prototype.*

- *Final complex geometry component built with optimised properties.*

Deliverables	Month
D1. Report: mechanical properties of copper parts (mechanical, conductivity, suitability for UHV applications).	M24
D2. Report: powder development and benchmarking.	M24
D3. Report: mechanical properties of niobium parts (mechanical, conductivity, suitability for UHV applications).	M36
D4. Dissemination of results through journal paper(s) and conference presentation(s).	M48

Status
Task1: Powder specification defined (Size, flow, chemistry)
Task 2: for SLM: characterisation and benchmarking performed for 5 suppliers (4 Cu powder and 3 Nb powders).
Task 3: EBM copper: OK SLM Cu and Nb underway
Task 4: EBM: waveguides were built and analysed SLM Cu and Nb: not started
Task 5: Not started
D1: EBM Cu: OK SLM Cu: initial characterisation underway – Extension of deadline to M36
D2: OK
D3: First trial underway
D4: - Poster at FCC Week 2016 - Presentation at Workshop AM for RF (European Space Agency

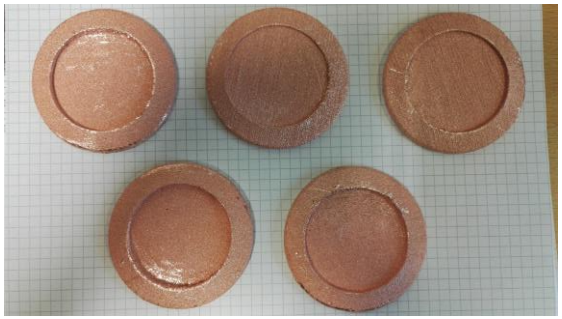
Timeline: WP 4.1 and SLM Machine



Annex : Results and pictures

Electron Beam Melting: Copper

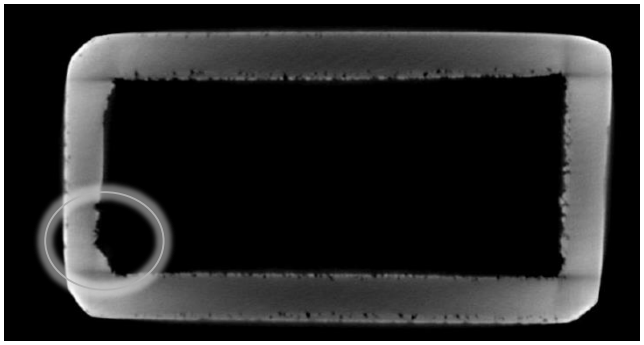
Wall thickness	He leak tightness UHV Detector limit 10^{-10} mbar
0.75 mm	KO (10^{-3} mbar)
1 mm	KO (10^{-3} mbar)
1.5 mm	KO (10^{-9} mbar)
2 mm	KO (10^{-9} mbar)
2.5 mm	KO (10^{-9} mbar)



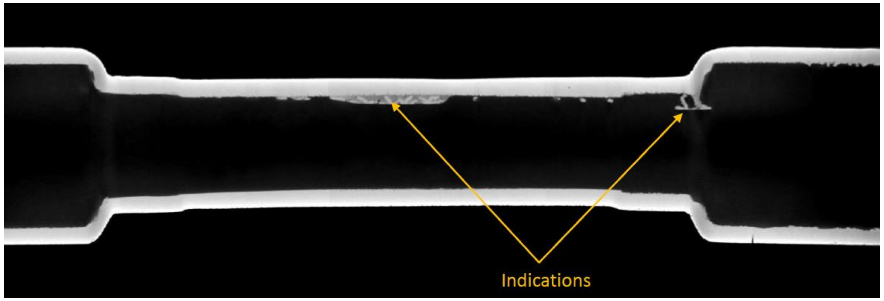
Scattering parameters far from the simulation (Due to large shape deviation)

Electron Beam Melting: Copper

Scattering parameters far from the simulation
Due to large shape deviation and macro-defects inside the channel

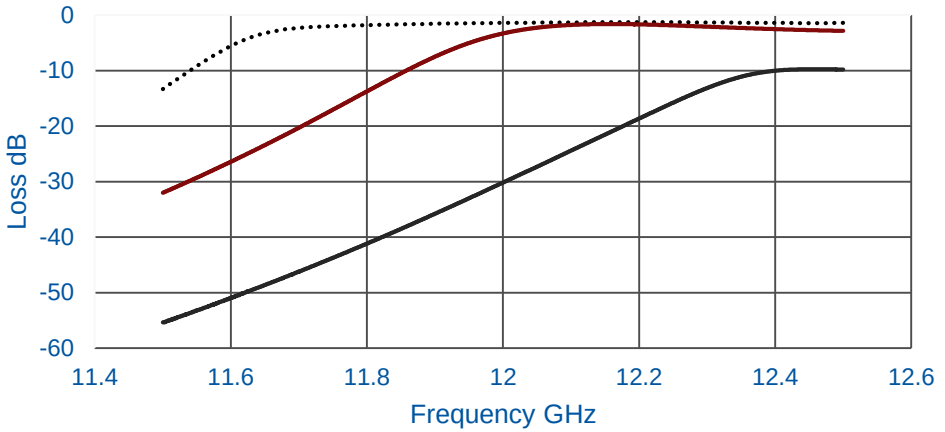


WG1

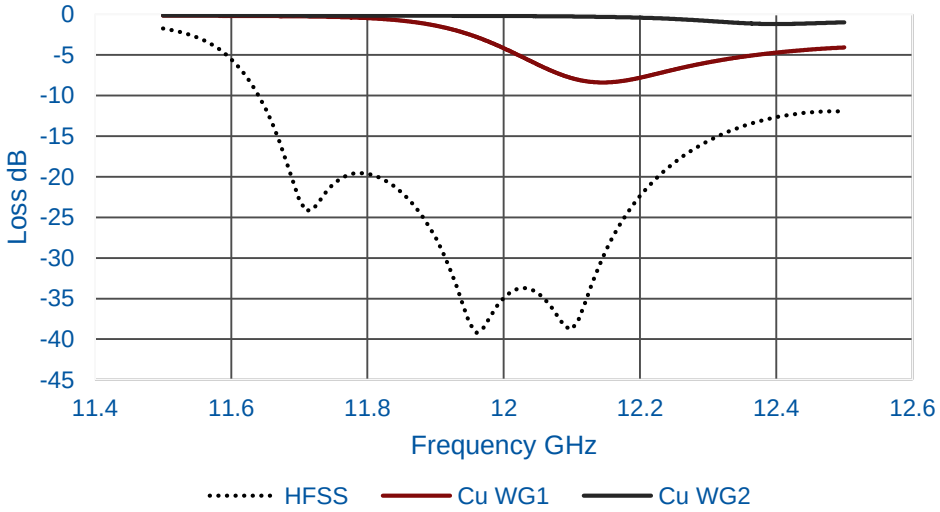


WG2

Injection Loss S12

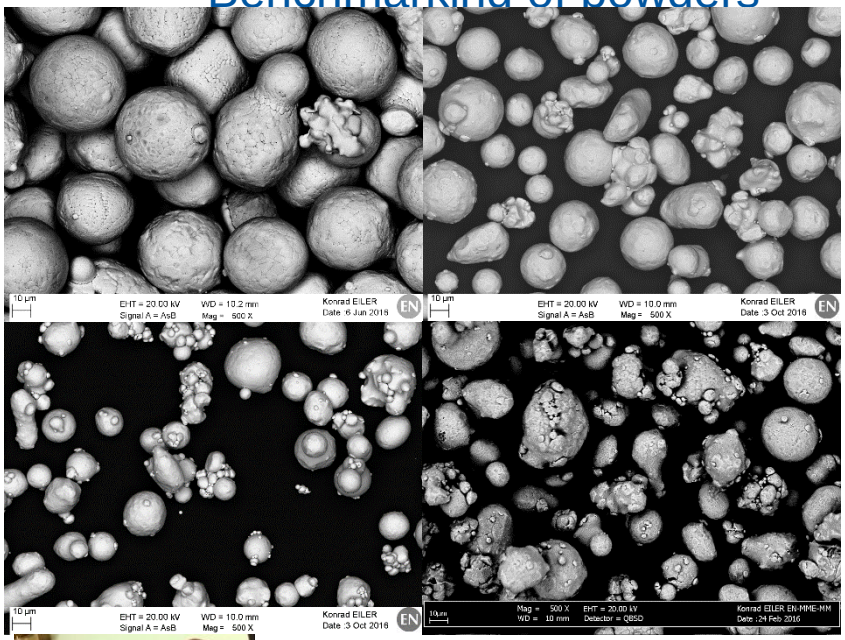


Return loss S11



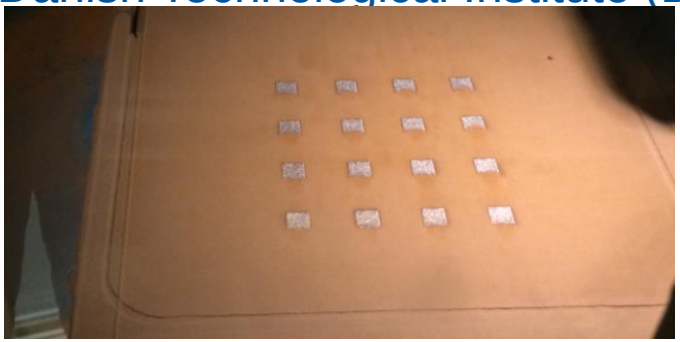
Selective Laser Melting of copper

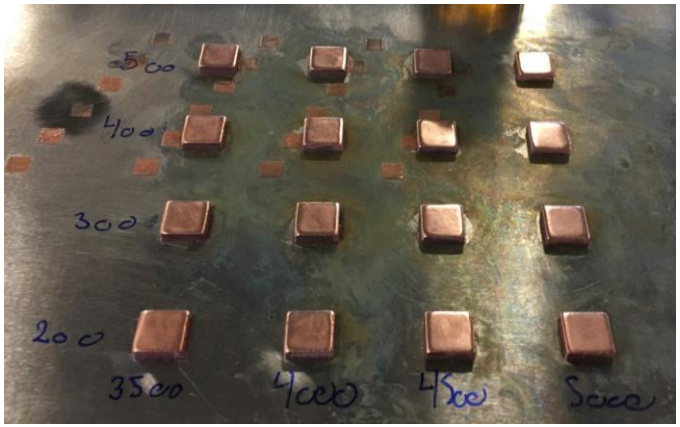
Benchmarking of powders



- Chemical composition
- Flow test (hall flow and avalanche angle)
- Shape and size characterisation

First trials at Danish Technological Institute (DK)



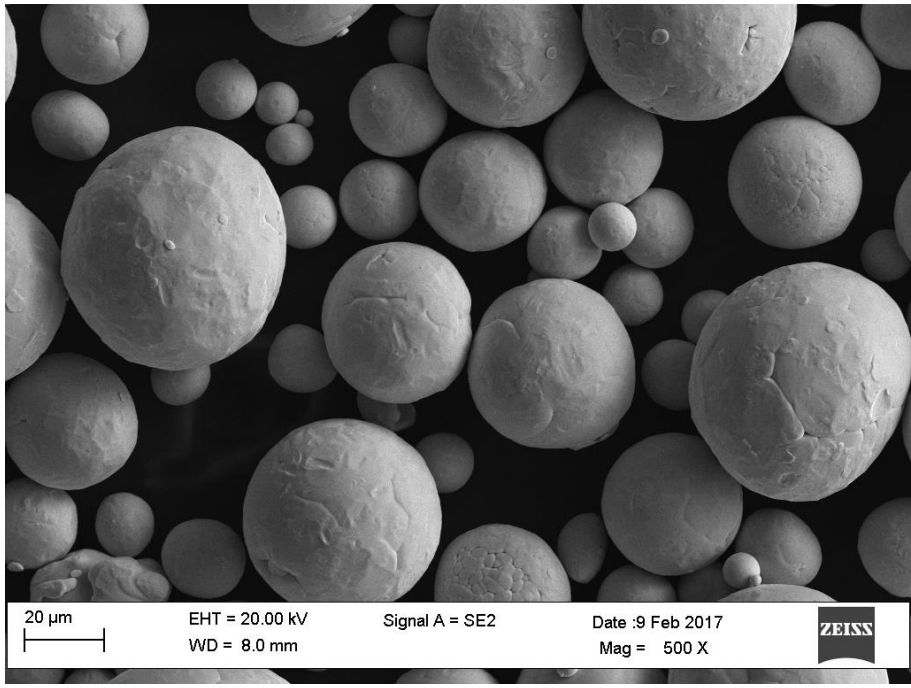


Test specimens being built with different parameters

Selective Laser Melting of niobium

Commercial Niobium spherical powder (H.C. Starck):

- Flow properties better than current Titanium powder
- Size distribution similar to Titanium powder
- Chemical composition: Oxygen content: <500 ppm
- 20 kg purchased



Kick off of the processing phase at CERN in June

With the objective to reach >99.5% density and characterise the physical properties.

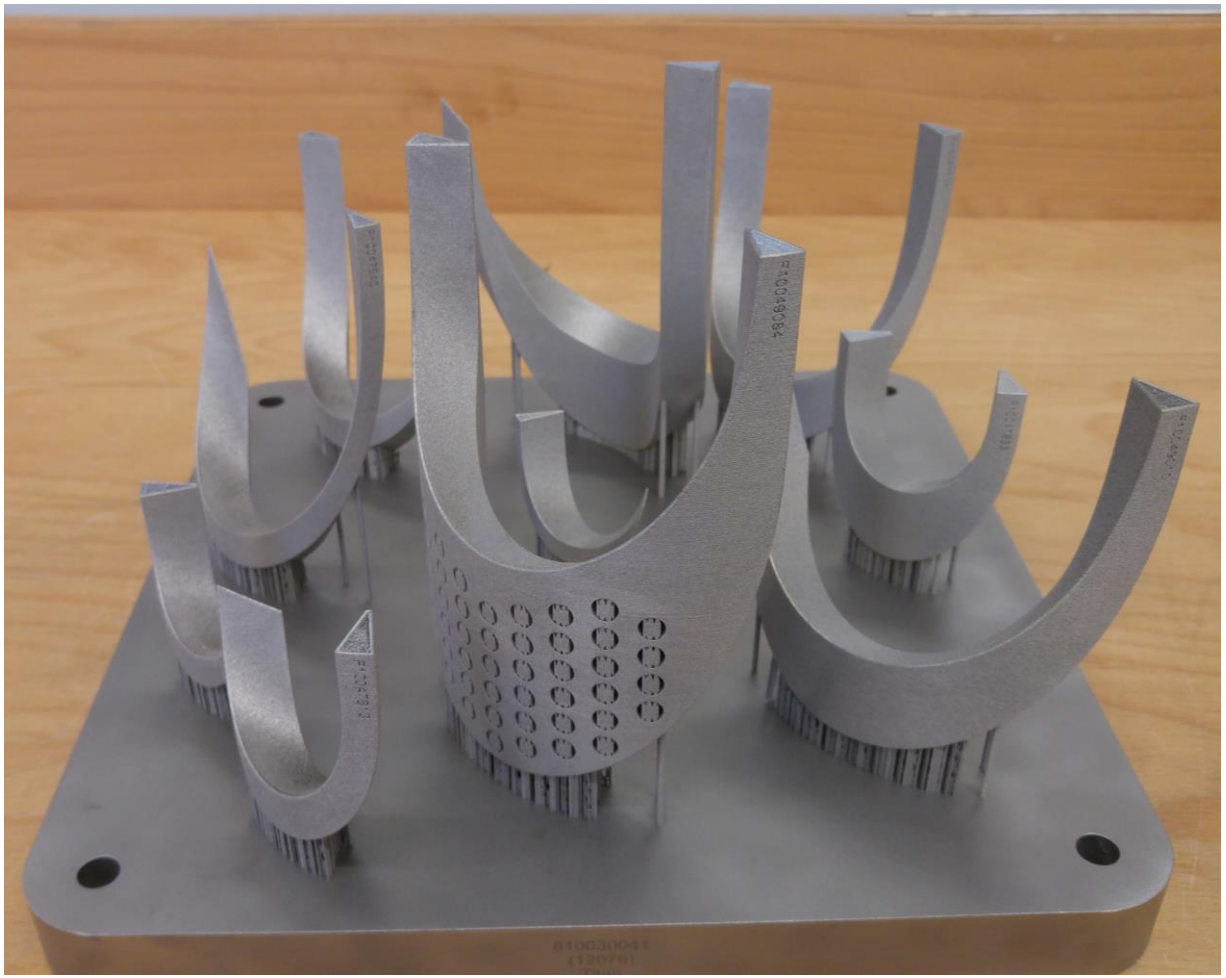
Titanium parts for FNAL 15T dipole demonstrator manufactured at CERN

End Spacers for

FNAL 15T dipole demonstrator

40 units (4x10)

Optimisation of supports and laser scanning strategy to achieve the geometrical tolerances



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