



# Niobium welding tests at CERN

Thomas Demazière

04-09-2018

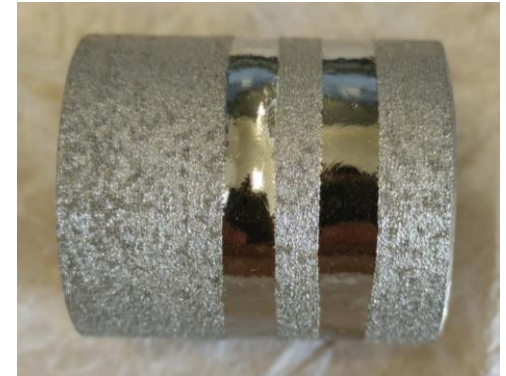
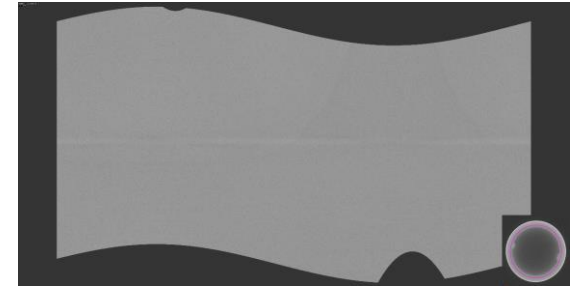
# Weldability of Nb

## Niobium welded at CERN :

- RRR300 (99%)
- RRR40 for RFD welding tests to come
- 3D printed Niobium (1 test only)

## Niobium welding processes :

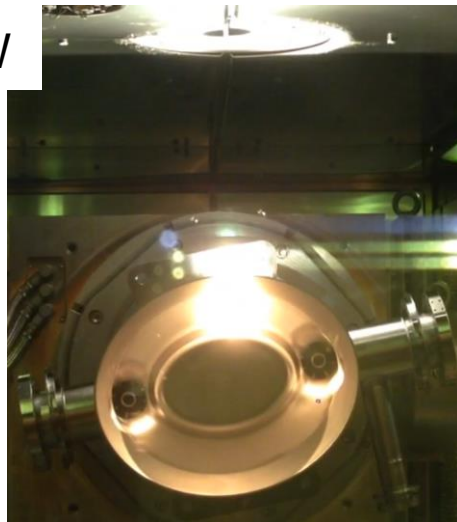
- EBW
- Manual TIG in glove box (sputtering cathodes,...)



Properties	Niobium	Nb45Ti55	Copper
Thermal conductivity (W.m <sup>-1</sup> .K <sup>-1</sup> )	54	10	400
Melting temperature (°C)	2500	1900	1080
Density (g.cm <sup>-3</sup> )	8.57	5.7	8.96
Linear energy to weld 3 mm (J/mm)	225		300
plasma color during welding	bright white (RRR300) bright red (500 ppm)		green

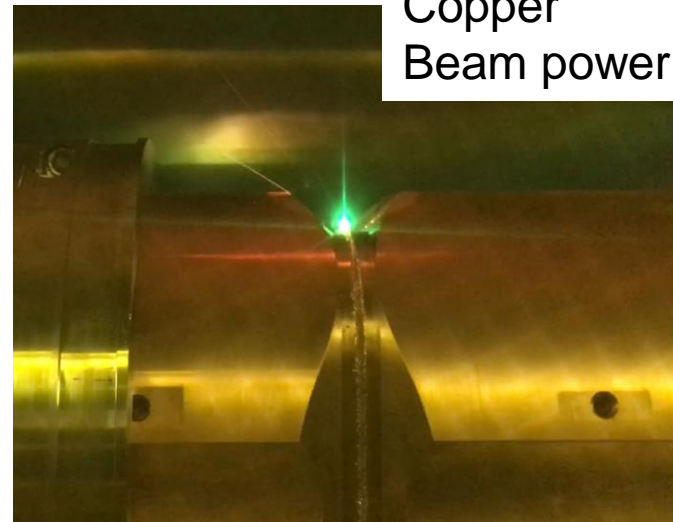
Niobium

Beam power : 5 kW



Copper

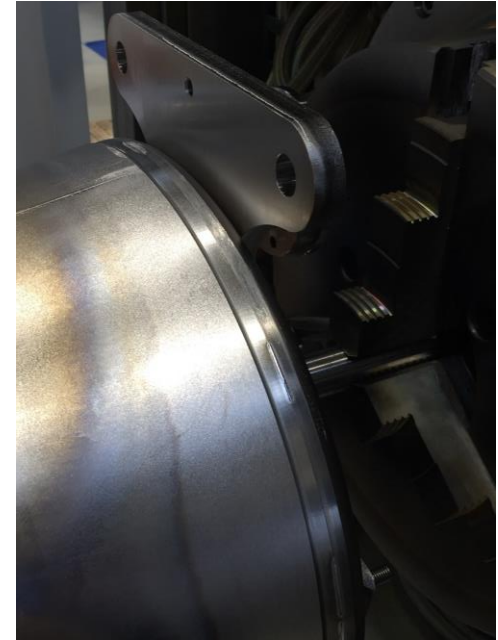
Beam power : 10 kW



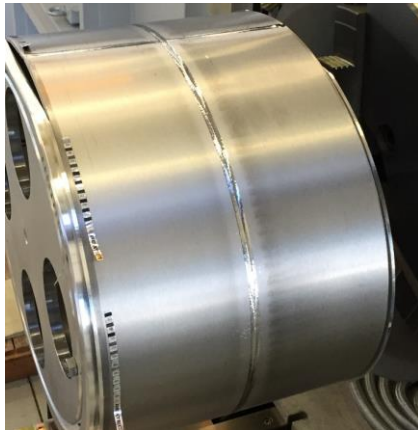
# Weldability of Nb RRR300

## Typical joint preparation :

- Machined welded interface
- Butt weld (square edges, with or without backing)
- BCP 5-25  $\mu\text{m}$  less than 8hrs before welding
- Assembly of the parts under laminar flow
- Vacuum below  $5 \cdot 10^{-5}$



# Weldability of Nb RRR300

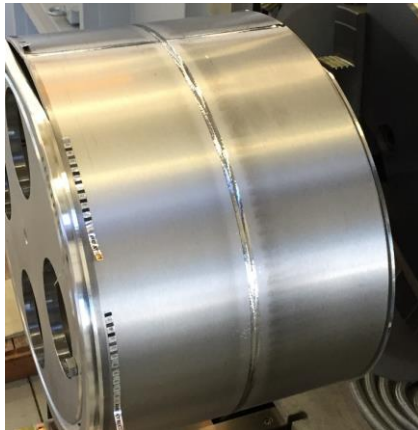
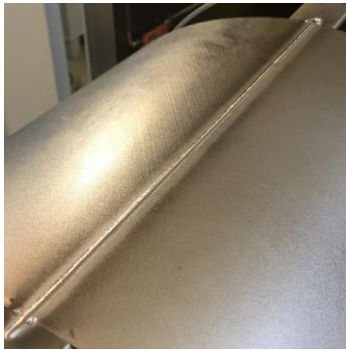


## 3 main types of parameters :

- Full penetration weld with focused beam
  - Lowest distortion
  - Root concavity → smoothing mandatory
- Smoothing pass
  - Necessary for proper surface finish
  - Adds shrinkage
- Full penetration weld with under focused beam
  - Largest distortion
  - Parameters challenging to control (risk of lack of fusion or burn through is significant)
  - Smooth surface finish, no spatter



# Weldability of Nb RRR300



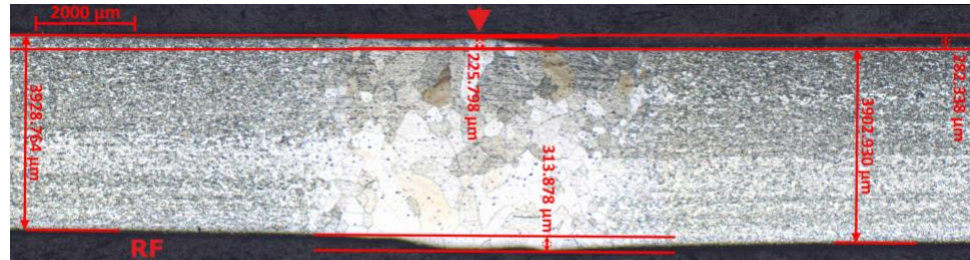
X-ray results :



# Weldability of Nb RRR300

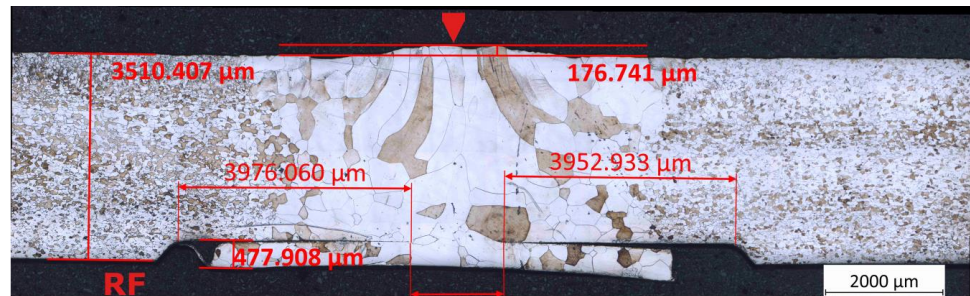
## 4 mm / 2 passes

- Energy : 315-350 J/mm per pass
- $R_{p0.2}$  : 71 Mpa
- $R_m$  : 170 Mpa
- A% : 36%



## 3 mm / 1 pass (with backing)

- Energy : 340 J/mm
- $R_{p0.2}$  : 57 Mpa
- $R_m$  : 180 Mpa
- A% : 61%



## 3 mm / 1 pass

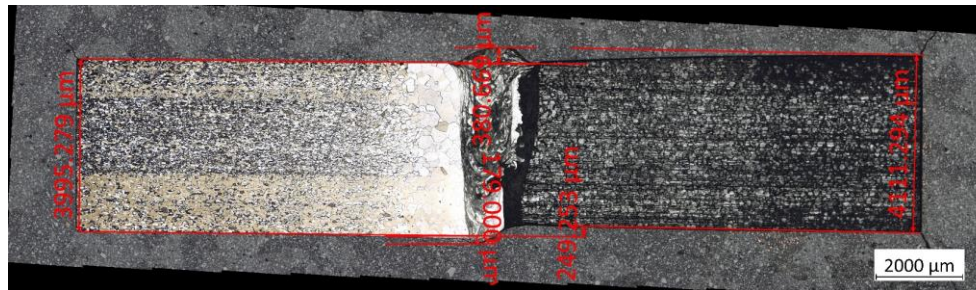
- Energy : 605 J/mm
- $R_{p0.2}$  : 70 Mpa
- $R_m$  : 144 Mpa
- A% : 23%



# Weldability of Nb45Ti55

Welded only in dissimilar joints (for Crab Cavities project)

- Nb to NbTi (EBW)



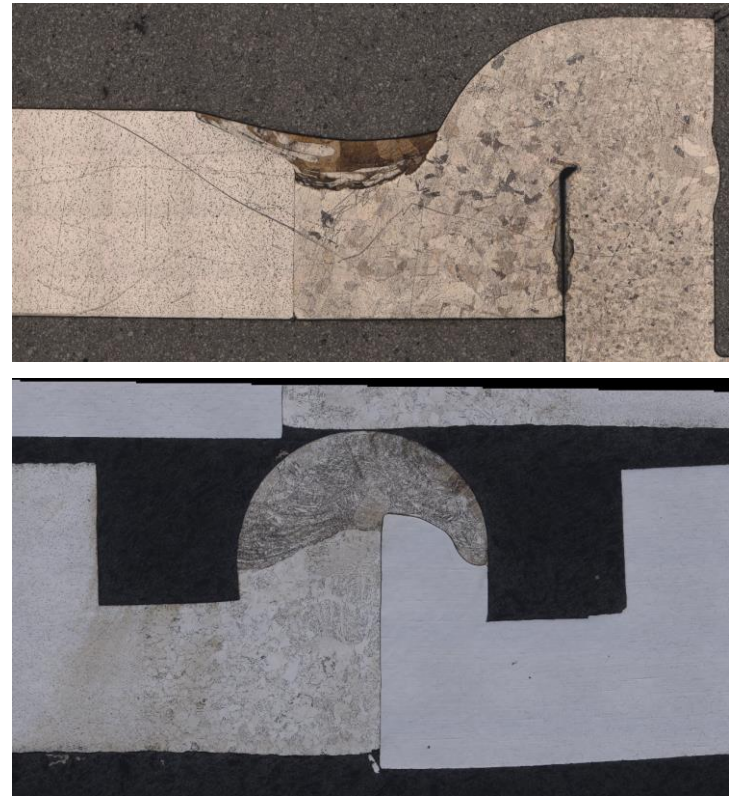
The beam is focused on the Nb to compensate for the lower energy required to melt NbTi



# Weldability of Nb45Ti55

Welded only in dissimilar joints (for Crab Cavities project)  
Ti Gr.2 to NbTi (manual TIG)

- More challenging to accommodate the difference in melting point
- Requirements less stringent than for EBW (partial penetration joints, only leak tightness is required)



# Conclusion

**Niobium and NbTi welded at CERN :**

- No particular defects observed
- Easier parameter setting than with copper
- Difficulties come mostly with the high quality requirement and complicated design and tooling assemblies



***Thank you for your attention***