THE HIE-ISOLDE SUPERCONDUCTING CAVITIES: SURFACE TREATMENT AND NIOBIUM THIN FILM COATING

Giulia Lanza, Sergio Calatroni, Leonel Marques Antunes Ferreira, Anna Gustafsson, Mats Lindroos, Matteo Pasini, Philippe Trilhe (CERN, Geneva), Vincenzo Palmieri (INFN/LNL, Legnaro, Padova)

BACKGROUND

HIE ISOLDE LINAC

A major upgrade is planned to take place in the next 4-5 years for the post-accelerator of radioactive ion beams at CERN. The upgrade consists in boosting the energy of the machine from 3MeV/u up to 10 MeV/u with beams of mass-to-charge ratio 2.5<A/q<4.5 by replacing parts of the existing normal conducting linac.

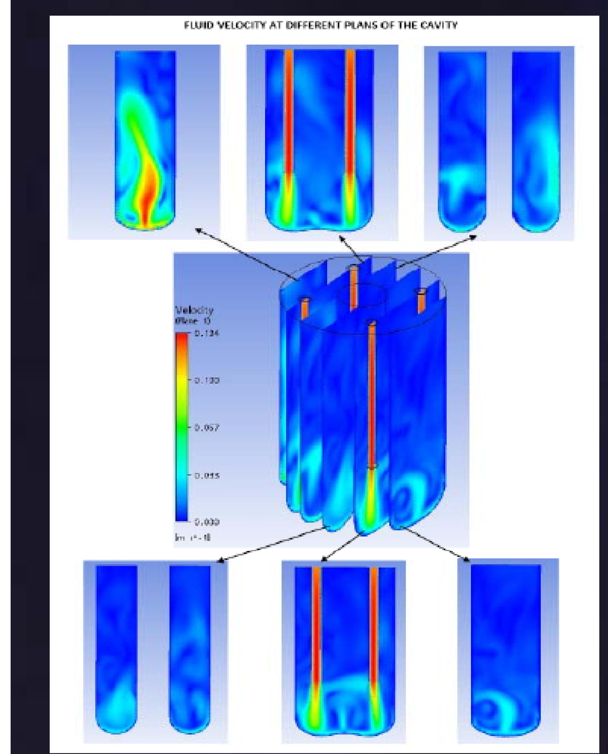
QWR R&D ACTIVITY PROGRAM

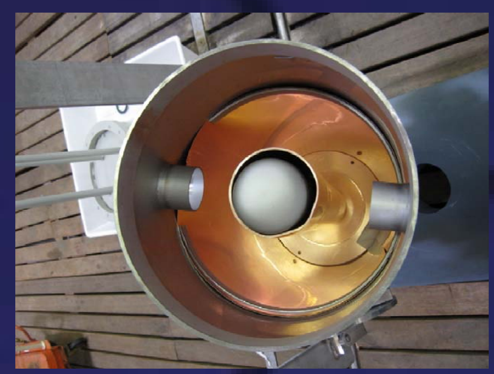
The new accelerator is based on independently phased 101.28MHz, niobium sputtered superconducting two gap Quarter Wave Resonators (QWRs). Two cavity geometries, "low" and "high" β, have been selected for covering the whole energy range. An R&D program has started at CERN in 2008. CERN has designed and prepared new facilities for the surface treatment and the niobium coating of the HIE-ISOLDE superconducting cavities. We describe here the design choices, as well as the results of the first surface treatments and test coatings.

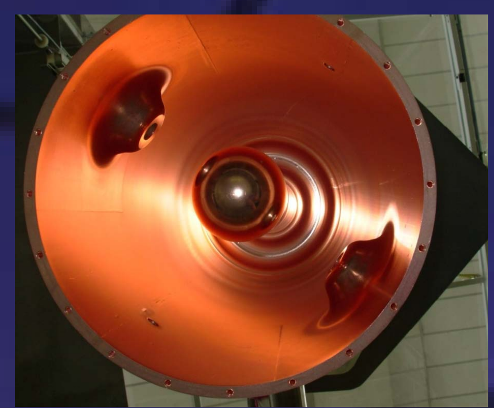
SURFACE TREATMENTS

QWR cavities production sequence:

- Machining and EB welding
- Warm RF test for frequency measurement
- Chemical polishing (SUBU) and passivation
- Low pressure ultrapure water rinsing
- Coating
- Low pressure ultrapure water rinsing
- RF warm and cold test (TRIUMF, later on at CERN)







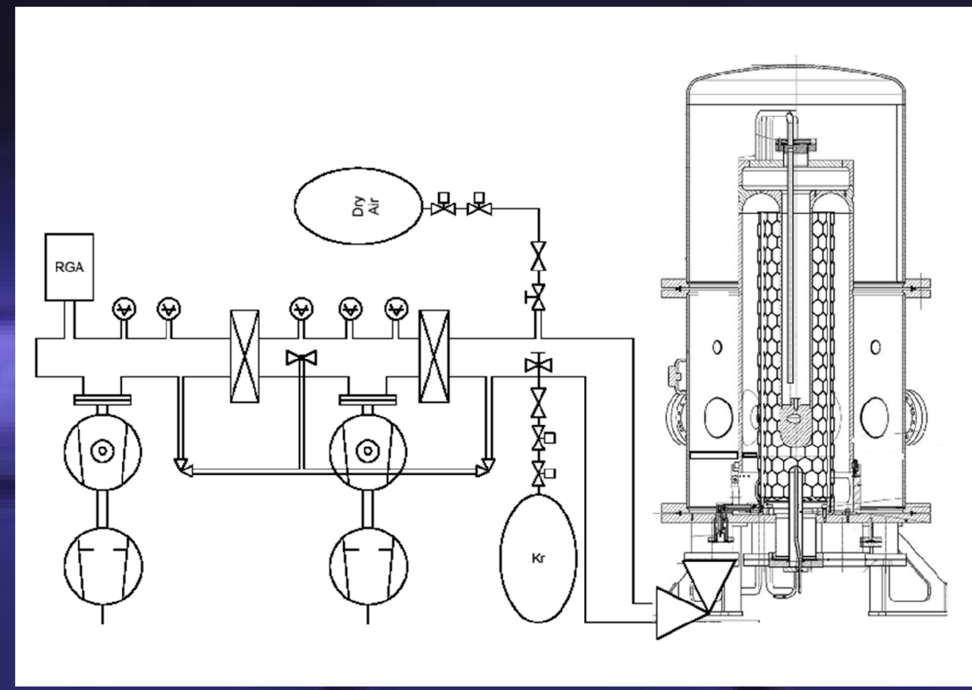
Simulations of the fluid velocity of the SUBU injected into the cavity by four tubes, have shown that the velocity of the fluid close to the bottom wall of the cavity is uniformly distributed: the values obtained vary between 0.04 m/s and 0.06 m/s. Since they are lower than the calculated Reynold number no turbolent motion is expected.

A closed circuit system with dedicated tubes and pump has been built for the cavity treatment. Three tanks in line are made of stainless steel and polypropylene for respectively the SUBU (thermo controlled tank), the passivation and the final rinsing.

SUBU: Sulfamicacid (H_3NO_3S) 5 g/L, H_2O_2 5% vol, n-butanol$C_4H_{10}O$ 5% vol, di-ammonium citrate ($C_6H_{14}N_2O_2$) 1 g/L.
Chemical polishing is carried out at 72 °C and is preceded and followed by washing with H_3NO_3S

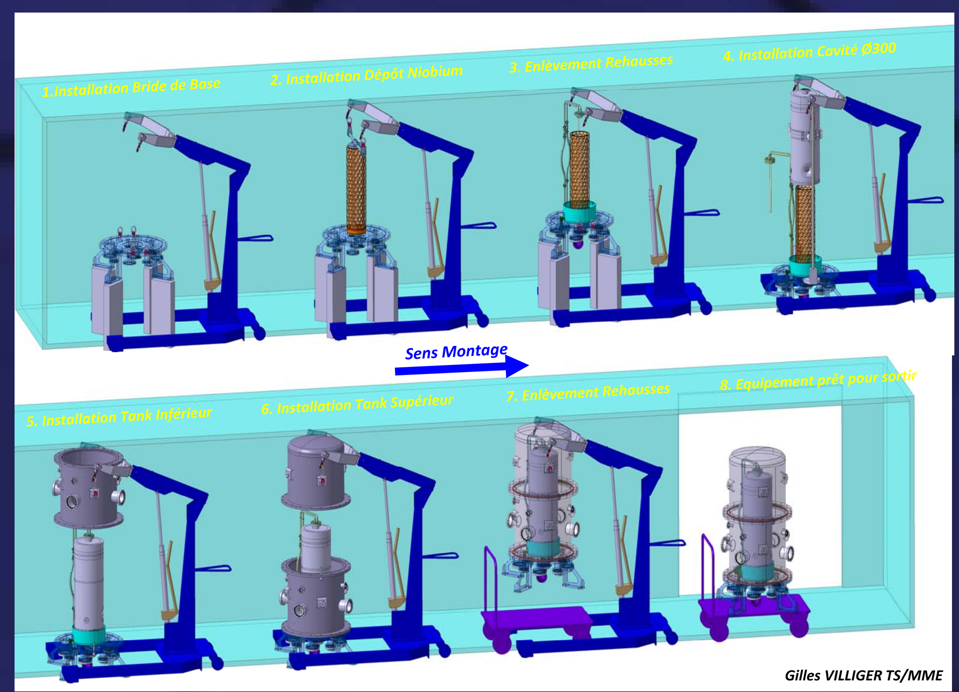
The first chemical treatment was tested on copper plates placed into the dummy stainless steel cavity. After a visual inspection of the samples the treatment procedure was approved and the first copper cavity was chemical treated. The rinsing was performed in a class 100 clean room with ultrapure water at 6 bar. At the moment one copper cavity is stored in a class 10 clean room, it is ready to be coated.

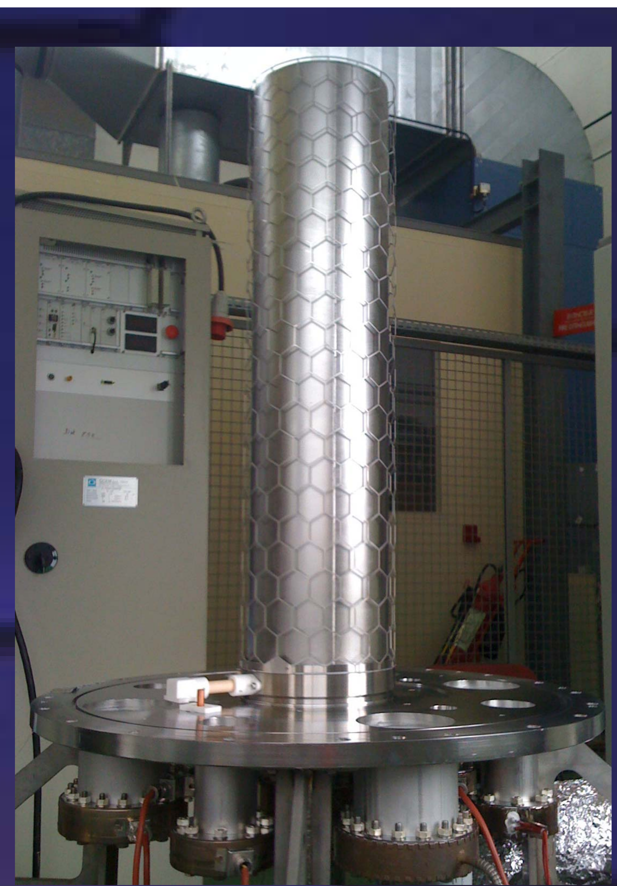
NEW FACILITY FOR QWR COATING



The coating system is designed for Bias Diode Sputtering. Inside a class 10 clean room the cathode-grids structure and the cavity and the vacuum chamber are assembled. The closed chamber is then connected to the pumping system outside the clean room.

Cathodes and grids are easily demountable as coating is foreseen for both high β and low β cavities.





Bias Diode Sputtering:

On the basis of the LNL experience with heavy ion cavities for LINAC ALPI, the technology for niobium on copper QWRs was developed using the DC Bias Diode Sputtering technique.

Outcomes:

- Unstable plasma: after 20-40 min the plasma disappeared from the outer part of the cathode. Non homogeneous distribution of the plasma.
- As a consequence a different sputtering rate was measured: after 2 hours of sputtering 250nm on the inner antenna and nothing measurable on the outer wall of the cavity.
- Too low sputtering rate.

Magnetron Sputtering:

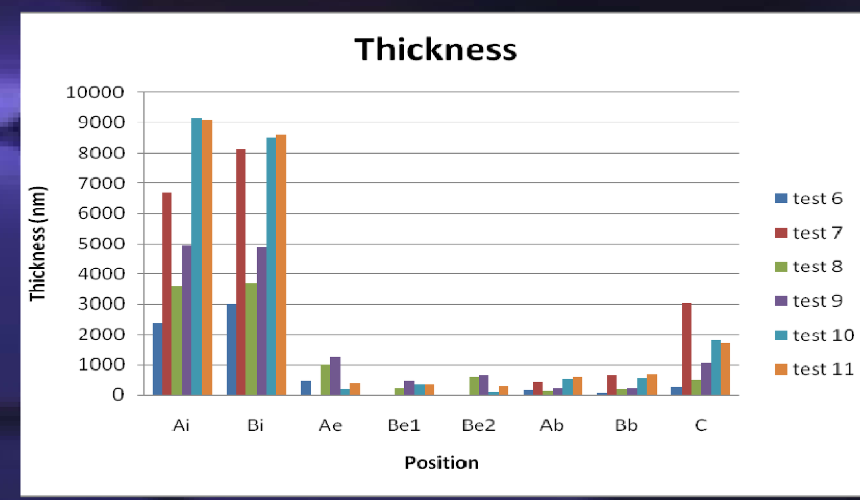
Two coating test, developed in a smaller coating system, confirmed the homogeneous coating on both sides of the cathode with magnetic field. Calculations were run to simulate the magnetic field. A multilayer coil, 1m diameter, was built and 6 tests were run with it

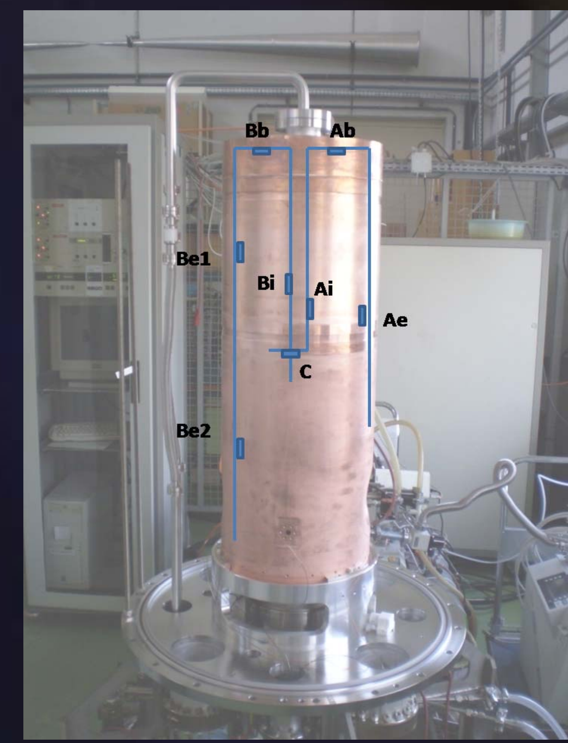
Outcomes:

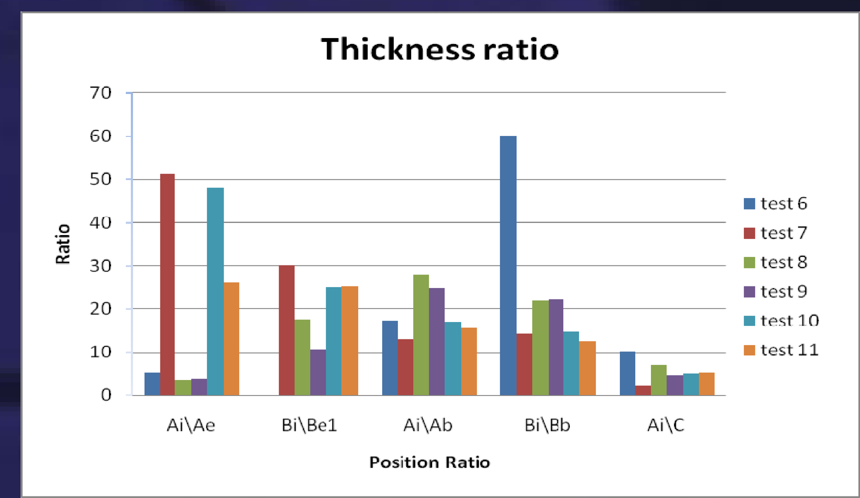
- Stable plasma
- Improvements on the thickness
- More homogeneous distribution of the plasma between outside and inside

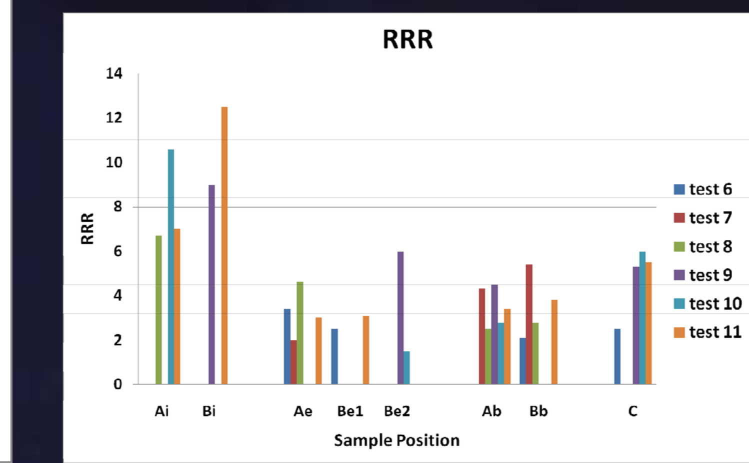
FIRST COATING RESULTS

Parameters	test 6	test 7	test 8	test 9	test 10	test 11
Pressure (mbar)	0.01	0.008	0.015	0.015	0.01	0.008-0.015
Cathode I (A)	1.8	3	3	3	3	3
Coil I (A)	30	40	50	40	40	40
Time (min)	340	360	240	410	420	420









The base pressure of the chamber after baking is on the order of 10^{-9} mbar. To explore different coating conditions the plasma at different pressures and coil currents was characterized.

Even if the magnetron sputtering guarantee a constant outer plasma, the ratio of the film thicknesses of the inner and the outer wall is still higher then the expected and acceptable value. The problem of the coating on the bottom part of the cavity is, on the other hand, magnified due to the magnetic field, perpendicular to the cavity surface.

Several solutions for balancing the film thickness are under test. Solutions to modify the magnetic field shape or the cathode structure are under development.

CONCLUSIONS

An R&D program to design and prepare new facilities for the surface treatment and the niobium coating of the HIE-ISOLDE superconducting cavities has started at CERN in 2008. Up to now the first copper QWR prototype was chemically treated and it is ready to be coated.

The DC Bias Diode Sputtering and the Magnetron Sputtering configurations were tested and niobium on quartz samples were characterized with thickness and RRR measurements. Still the sputtering conditions have to be optimized to obtain a homogeneous coating. Solutions to modify the cathode structure and to balance the film thickness are under development.

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