ISTITUTO NAZIONALE DI FISICA NUCLEARE
LABORATORI DI SUPERCONDUCTIVITA
UNIVERSITY OF FERRARA
DEPARTMENT OF PHYSICS
"Technologies for accelerator and targets in nuclear physics"

Construction of an innovative cylindrical magnetron sputtering source for HIE-ISOLDE superconductive Nb/Cu QWRs

Ph.D. student: Daniel A. Franco Lespinasse
Internal tutor: Prof. G. Fiorentini
External tutor: Prof. E. Palmieri

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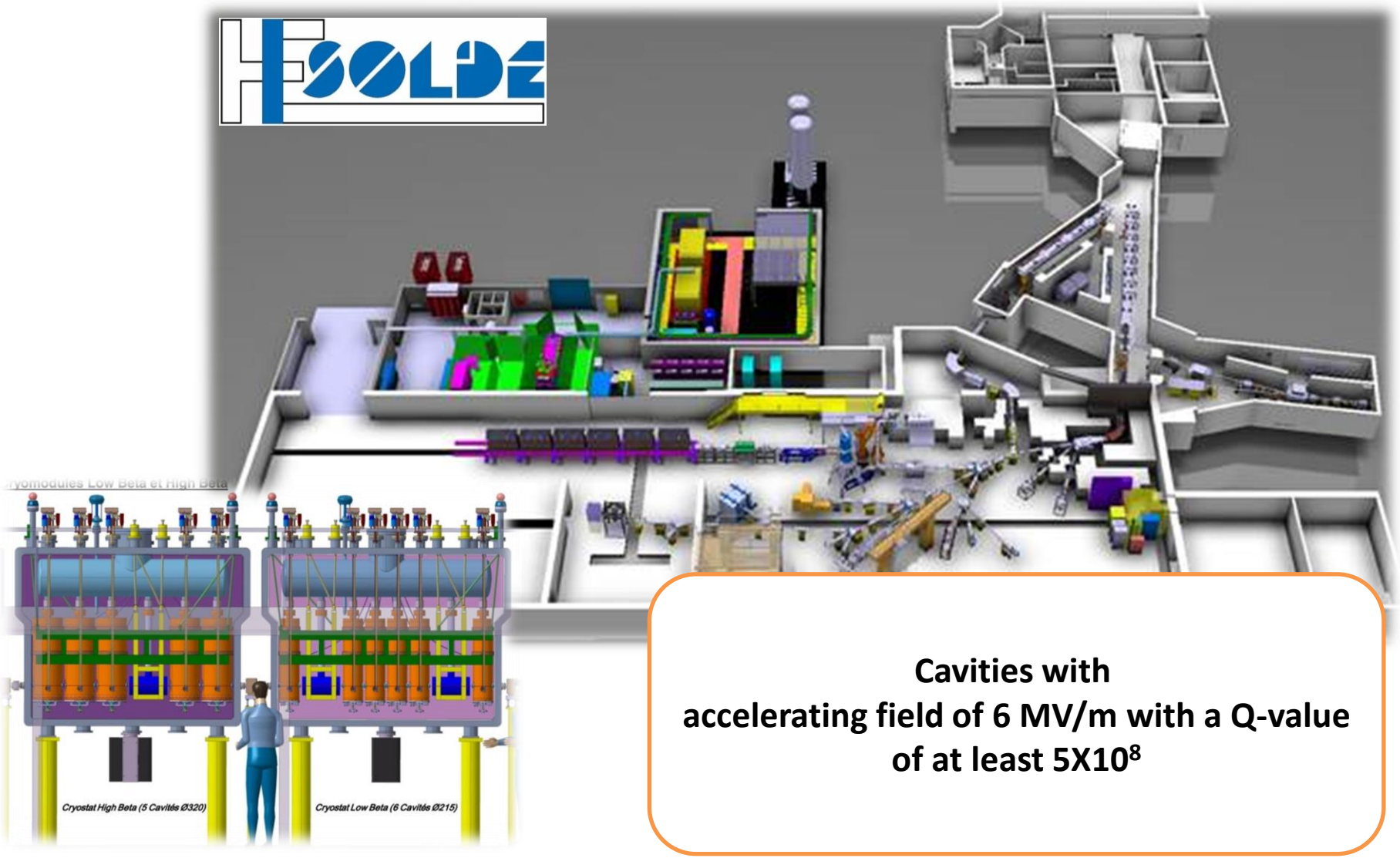
Content

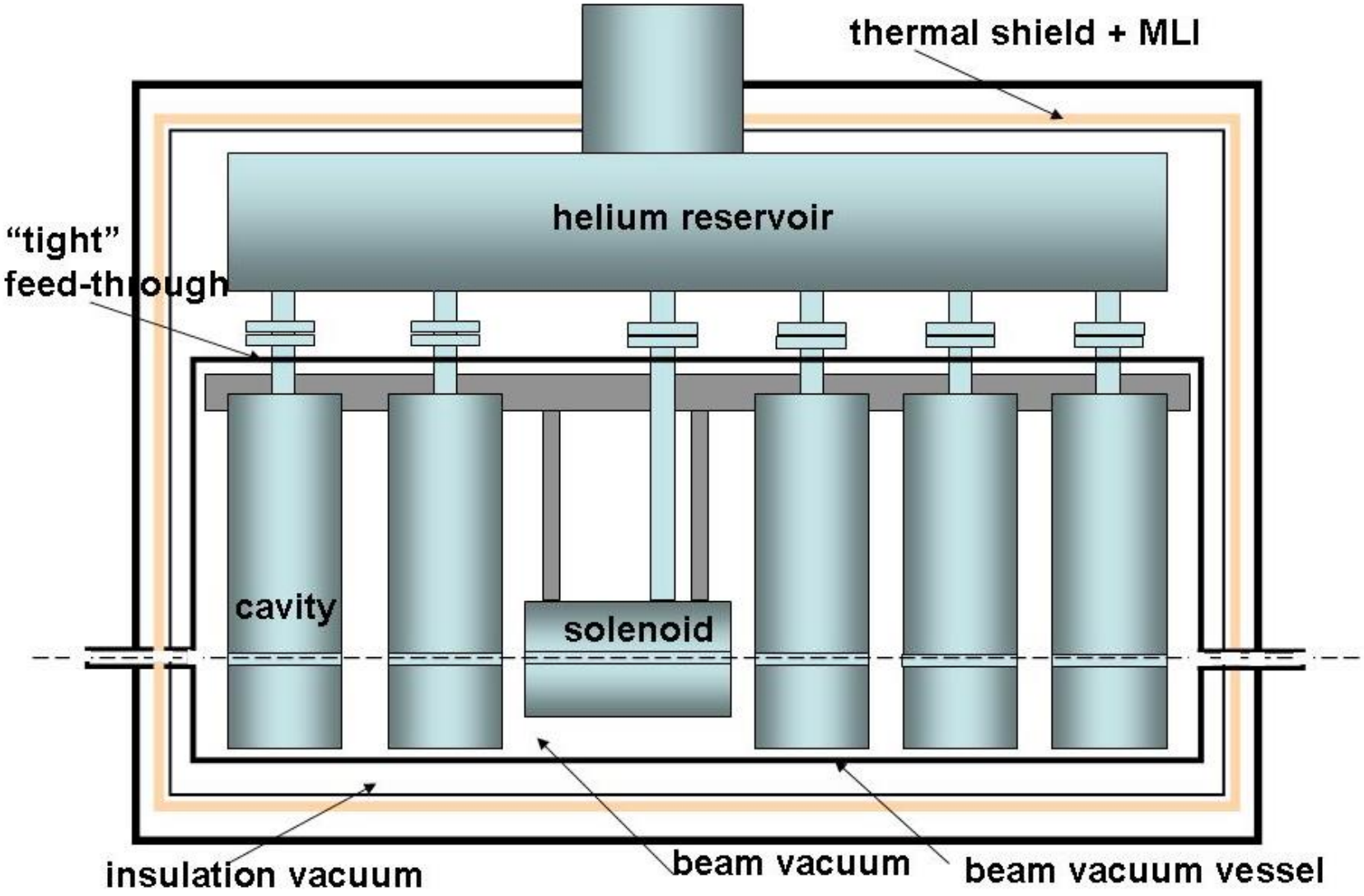
- HIE ISOLDE project
- Quarter wave resonator cavity (QWR) for ISOLDE project
- The aim of the phD Project
- Development at LNL (2012-2013) and last results
- Conclusions and further work

HIE ISOLDE project

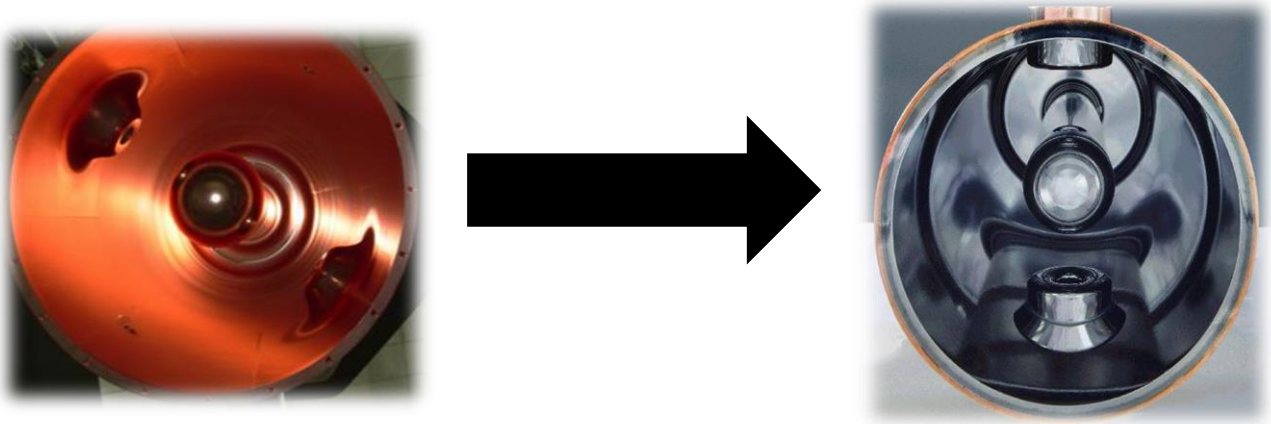


Cavities with
accelerating field of 6 MV/m with a Q-value of at least $5X10^8$

QWRs cavities



The aim of the PhD. project



Coat Copper Quarter Wave Resonator Cavities with Nb thin film

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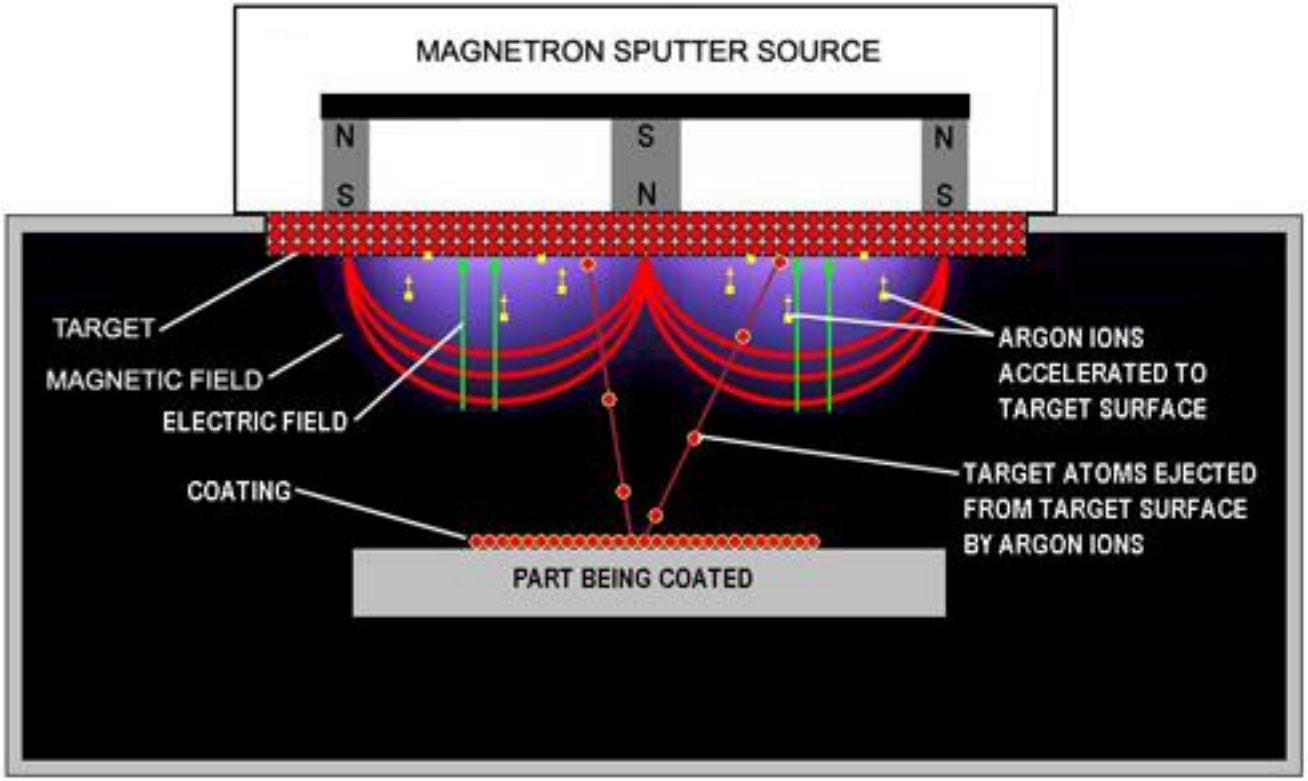
Magnetron sputtering technique

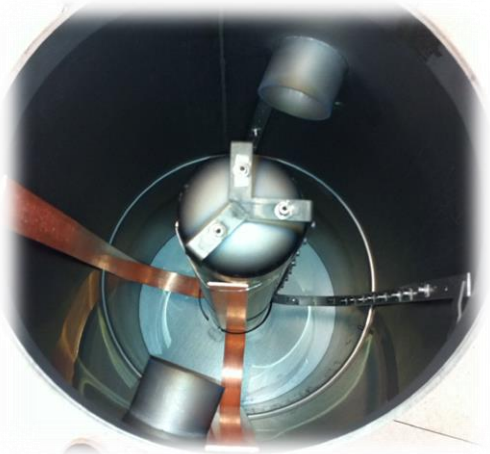


Developments of last year

- Assembly of the system

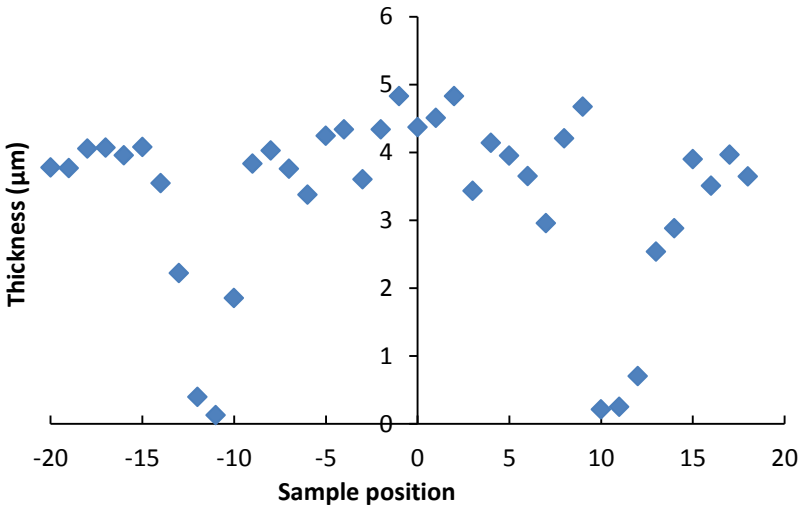
Developments of last year

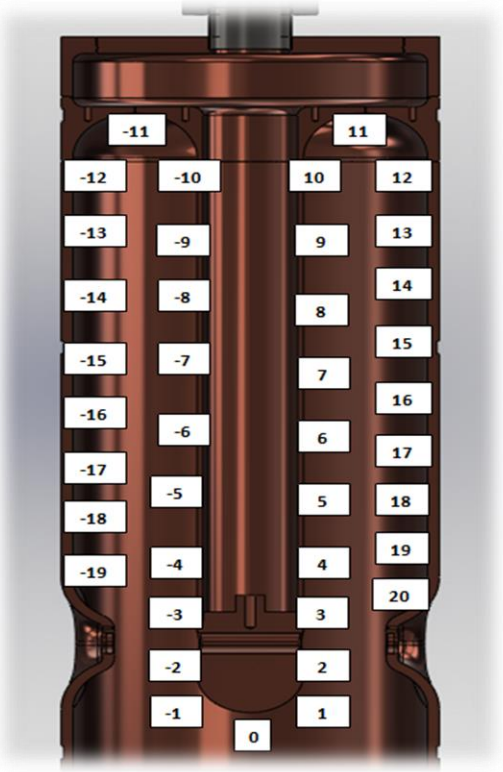
- Sputtering depositions



Developments of last year

- Sputtering depositions





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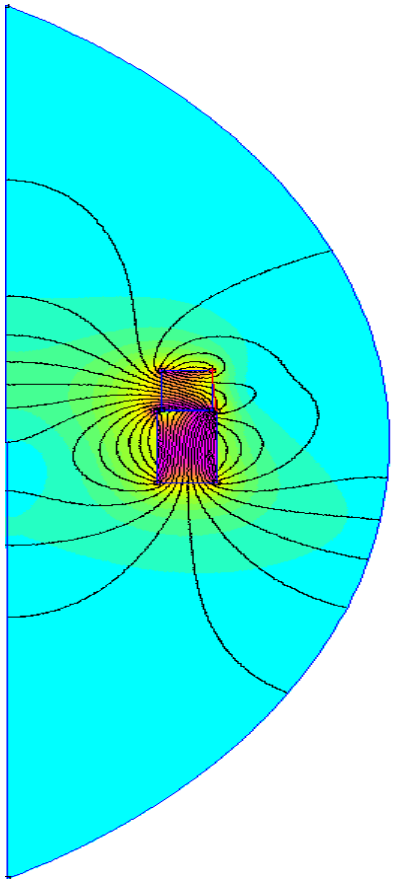
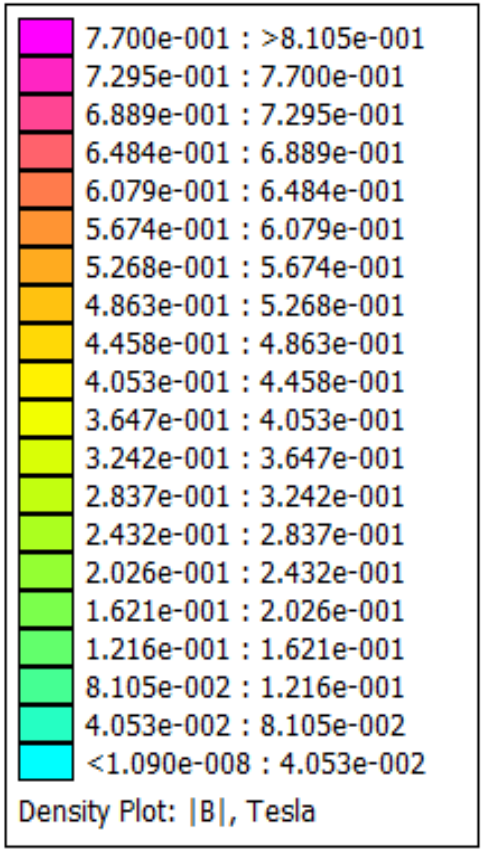
Developments of last year

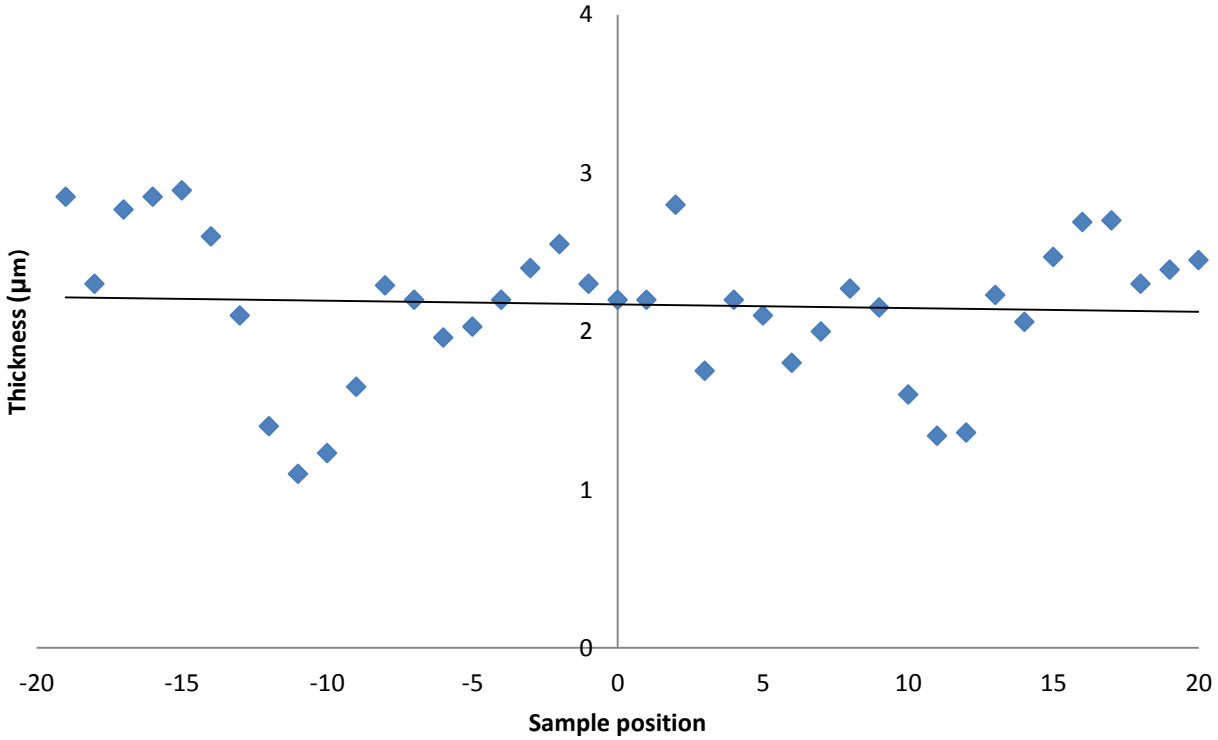


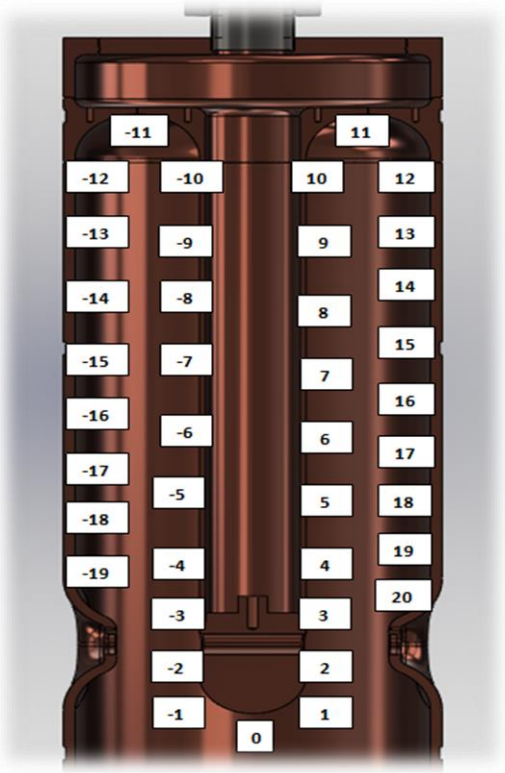


Simulation of magnetic field FEM

Developments of last year

- The results





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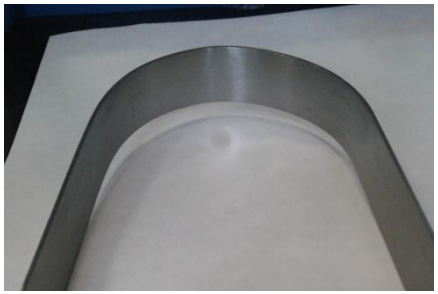
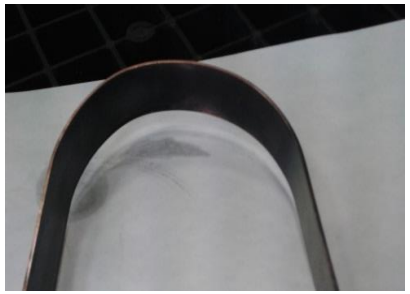
Developments of last year

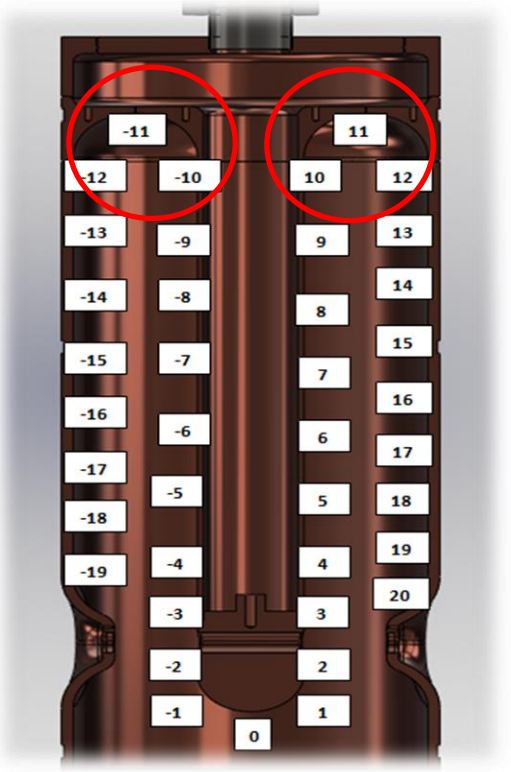
- The results

t=0

t=3H







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Nb Depositions

- The aim for the 2nd year

- Perform the deposition of Nb over the cavity. Moreover, measure the superconductive properties (RRR, Tc)

Nb Depositions

- The aim for the 2nd year

Nb Depositions

- The Results

The deposition was performed with a base vacuum of $4{,}2 \times 10^{-8}$ mbar using the following parameters:

Power= P 1*

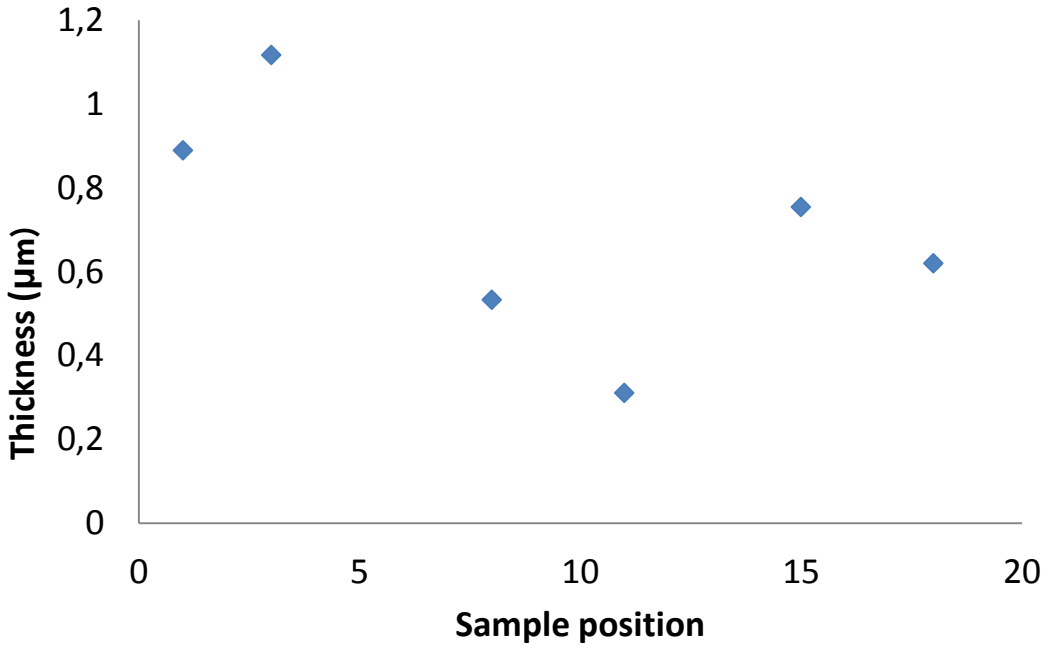
Sputtering pressure= p1*

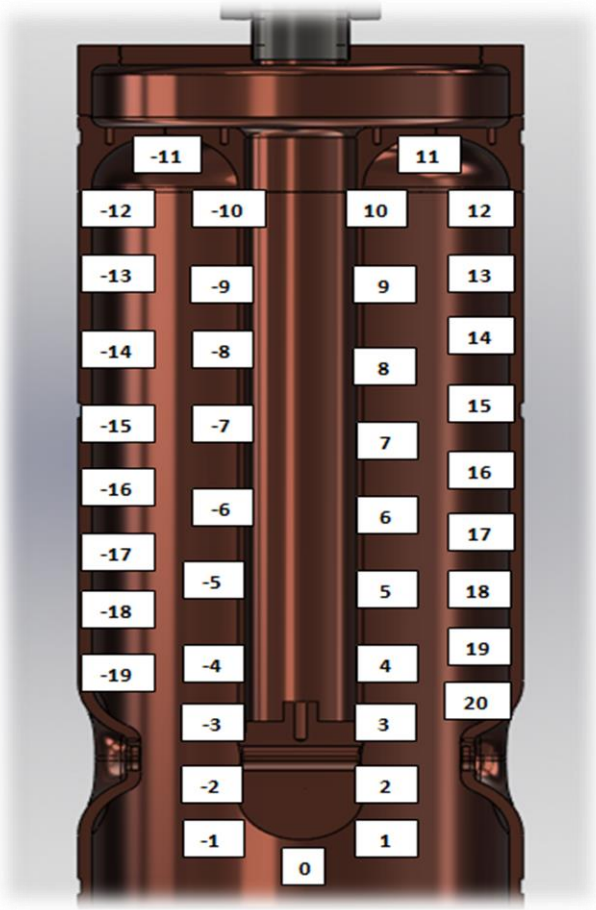
Time: 25 min, time intervals of 5

(*)Reserved for privacy INFN

Nb Depositions

- The Results





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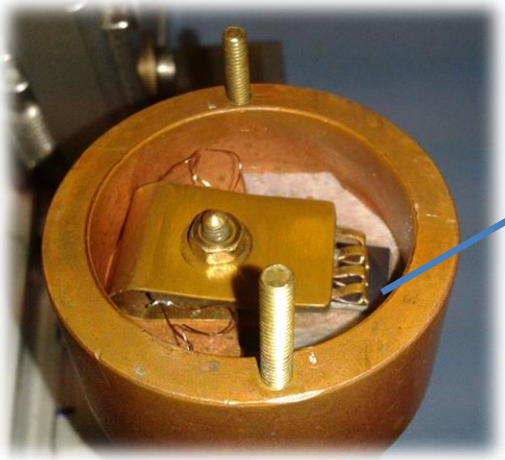
Nb Depositions

- Residual resistance ratio (RRR) and Critical temperature (Tc)

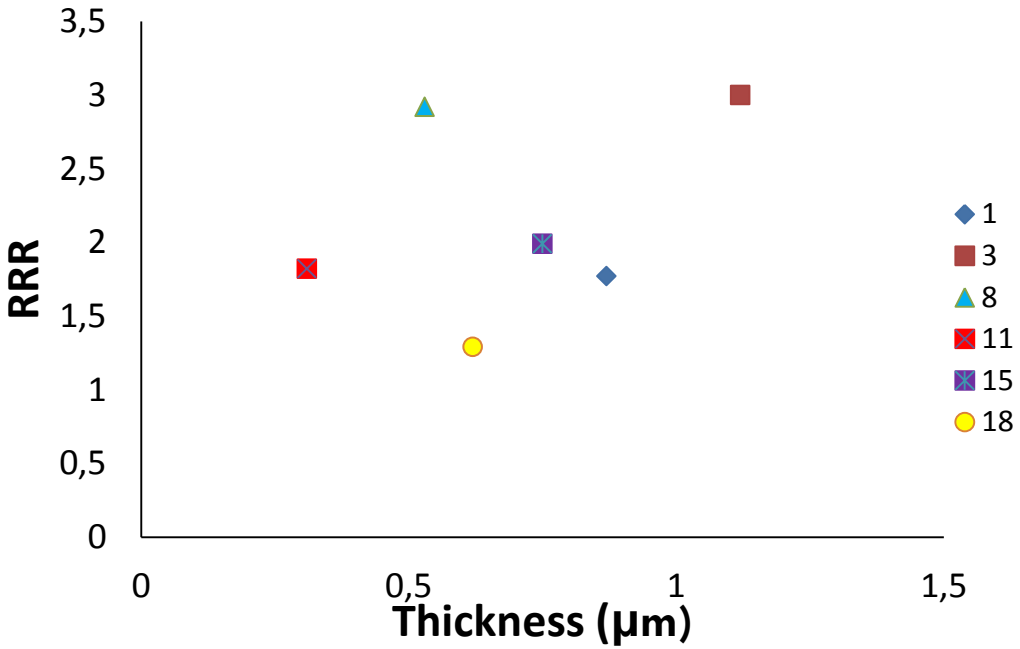


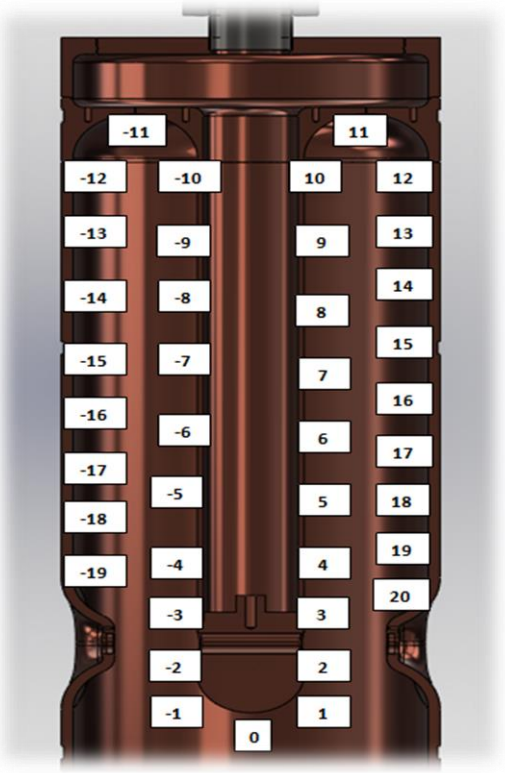
Quartz sample

$$RRR = \frac{R(300K)}{R(10K)}$$

Nb Depositions

- The Results





Sample	1	3	8	11	15	18
Thickness (µm)	0,88	1,12	0,53	0,31	0,75	0,62
Tc (K)	7,44	8,7	8,7	7,6	7,7	5,8
RRR	1,77	3	2,92	1,82	1,99	1,29

Nb Depositions

- The Results

Sample	1	3	8	11	15	18
Thickness (µm)	0,57	0,58		0,86	0,62	0,33
Tc (K)	8,2	8,8		7,05	8,51	8,32
RRR	2,18	2,89		1,03	2,07	2,02

Nb Depositions

- The Results

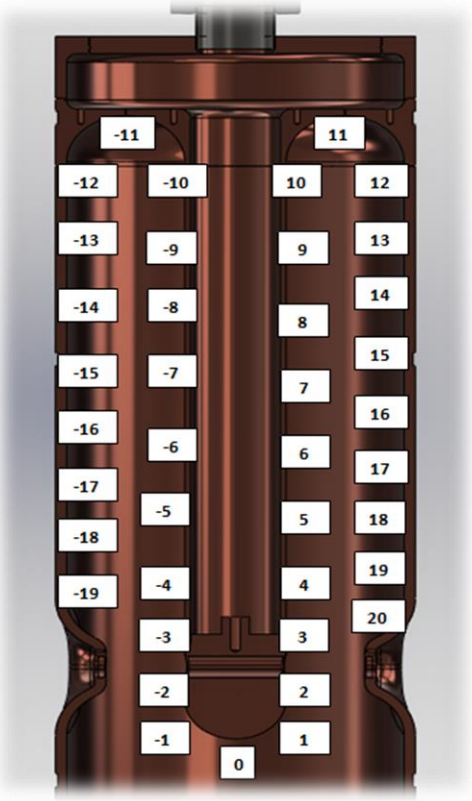
A new deposition was performed a deposition using the following parameters:
Psputtering= p 2*
Power= P2*
Sputtering time: 30 min with intervalous of time

We took the 15th position as a parameter to understand the behavior of the procces, in order to improve the RRR value.

Nb Depositions

- The Results

Sample	-11	1	3	8	11	**15**	18
RRR	X	X	3,3	3,73	X	**3,4**	3,6
Tc (K)			8,76	8,72		**8,81**	8,78



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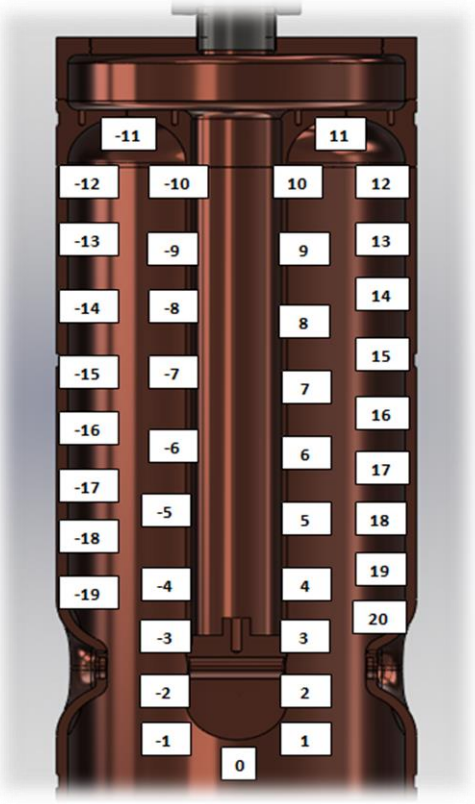
Nb Depositions

- The Results

Psputtering= p 3*
Power = P3*
Sputtering time: 30 min with intervalous of time of 5 min



Sample	-11	1	3	8	11	**15**	18
RRR	X	3,2	X	X	X	**5,2**	6
Tc(K)		8,84				**9,1**	9,17

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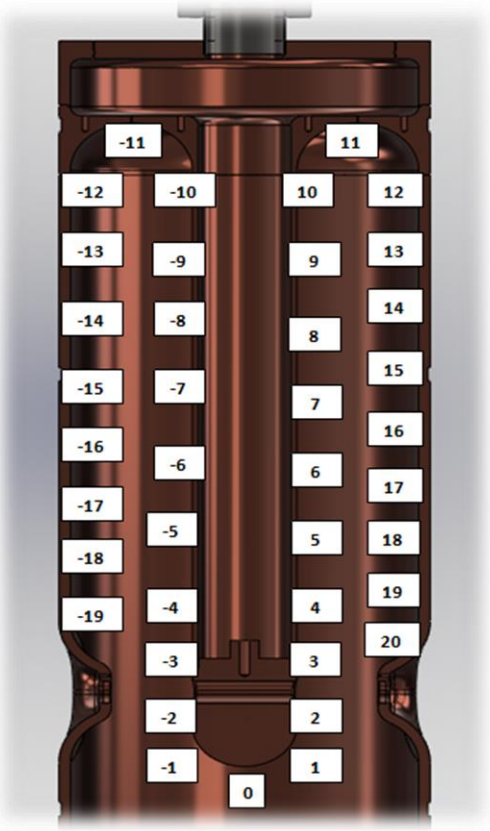
Nb Depositions

Was performed another deposition with the following parameters:
Psputtering= p4*
Power = P4*
Sputtering time: 30 min with intervalous of time of 5 min.

As we saw in the previous deposition the RRR value is increasing while the power is higher



Sample	-11	1	3	8	11	**15**	18
RRR	X	X	X	X	X	**9,24**	X
Tc (K)						**9,34**	

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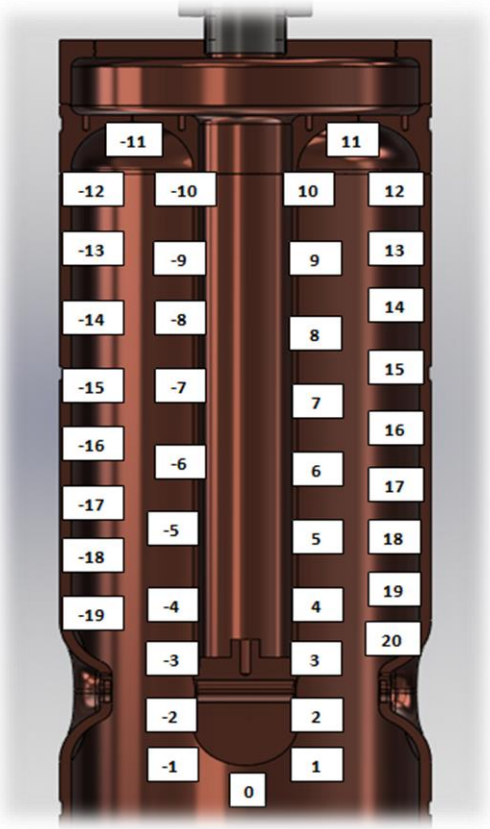
Nb Depositions

In order to improve the vacuum, was placed on the top of the chamber a Nb magnetron to be used as a getter. Also was performed a new
deposition keeping the same parameters used before:
Power= P5*
Psputtering= p5*
Time: 30min
The deposition was done heating the cavity @350°C.



Sample	-11	1	3	8	11	**15**	18
RRR	X	X	X	X	X	**10,41**	X
Tc (K)						**9,3**	

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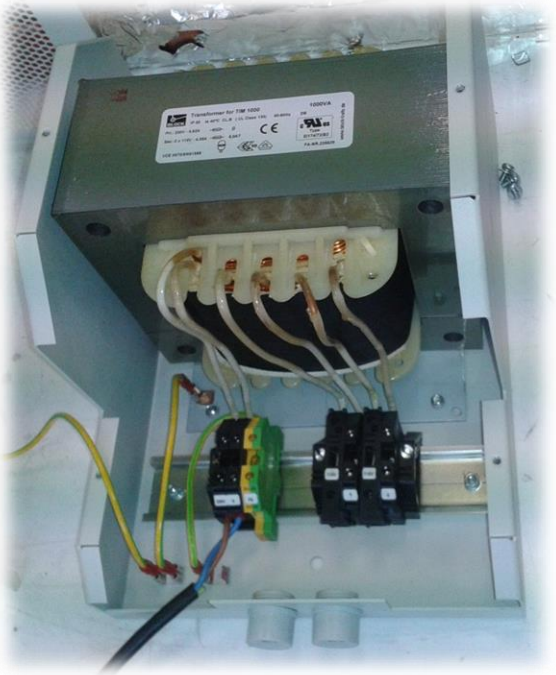
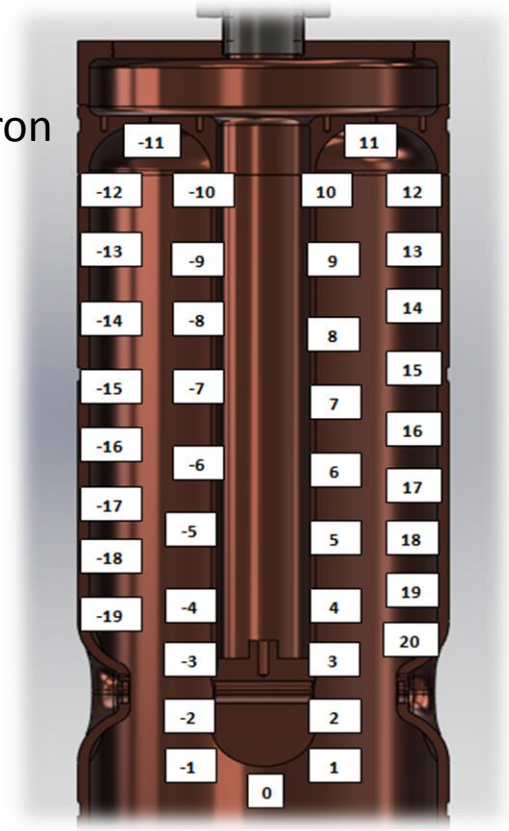
Nb Depositions



Nb Depositions

After was done the deposition inside the cavity, using the Magnetron Sputtering Power supply, with g the following parameters:

Initial Vacuum Pressure: $4x10^{-8}$ mbar
Power = P6*
Sputtering pressure = p6*
Time: 30 min
Cavity temperature: 380°C



Sample	-11	1	3	8	11	**15**	18
RRR	X	X	12,9	**19,6**	X	**12,7**	13,4
Tc (K)			9,13	**9,21**		**9,4**	9,33

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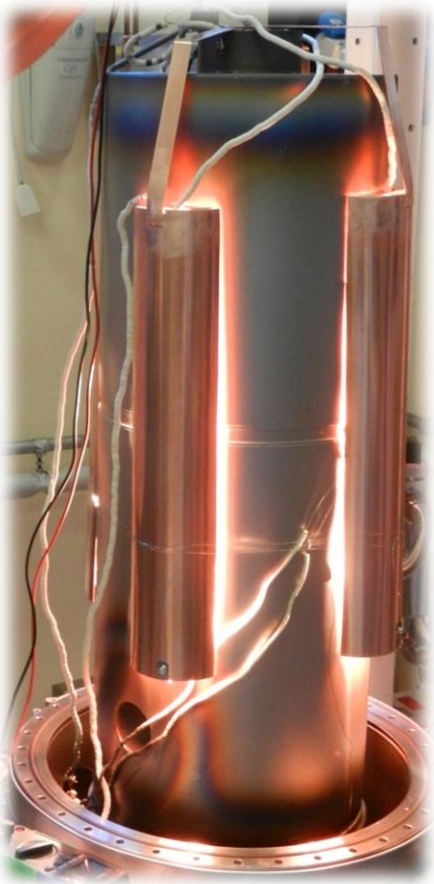
Nb Depositions

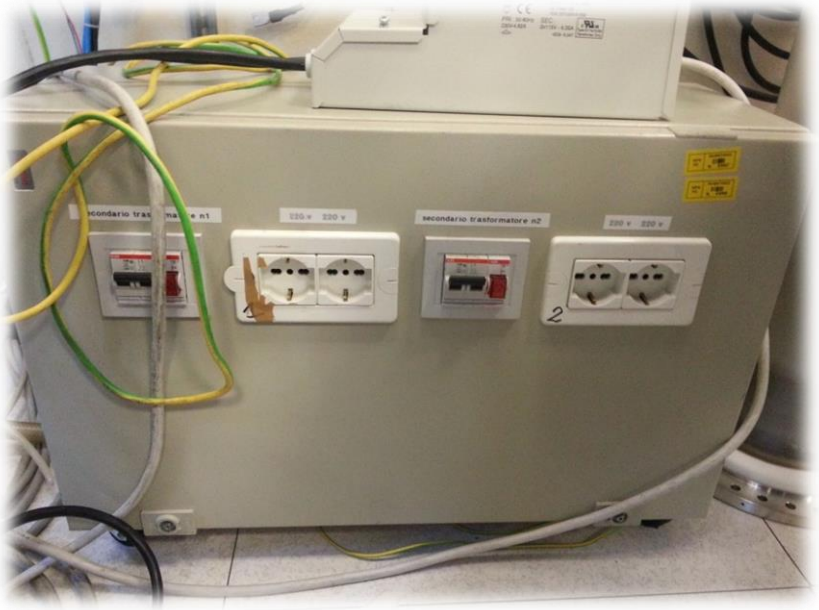
2 Power supply will be connected in order to increase the power during the deposition. The highest power that we can reach is P6*.

Also will be added to the system 4 more lamps outside the cavity to improve the uniformity of the heating along the cavity during the sputtering process.

Nb Depositions

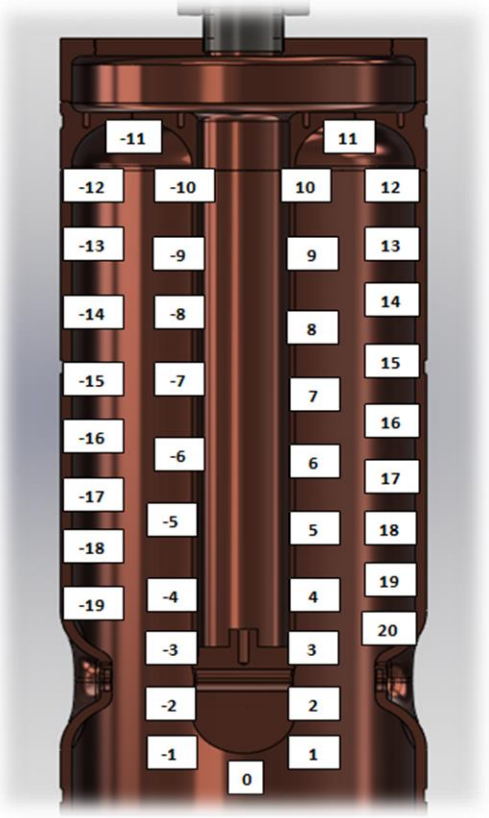


Nb Depositions



Nb Depositions

Initial Vacuum Pressure: $4x10^{-8}$ mbar
Power = P7*
Sputtering pressure = p7*
Time: 30 min
Cavity temperature: (inside and outside the cavity)
300°C



Sample	-11	1	3	8	11	15	18
RRR	X	X	12,9	14	X	22	27
Tc (K)			9,13	9,19		9,33	9,28

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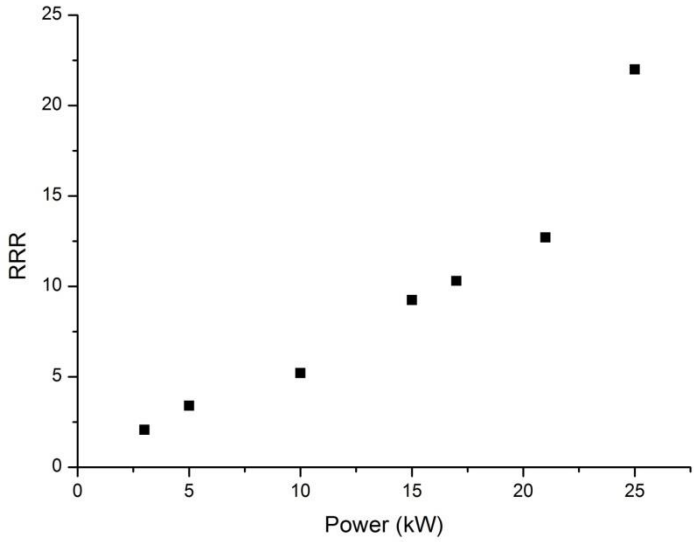
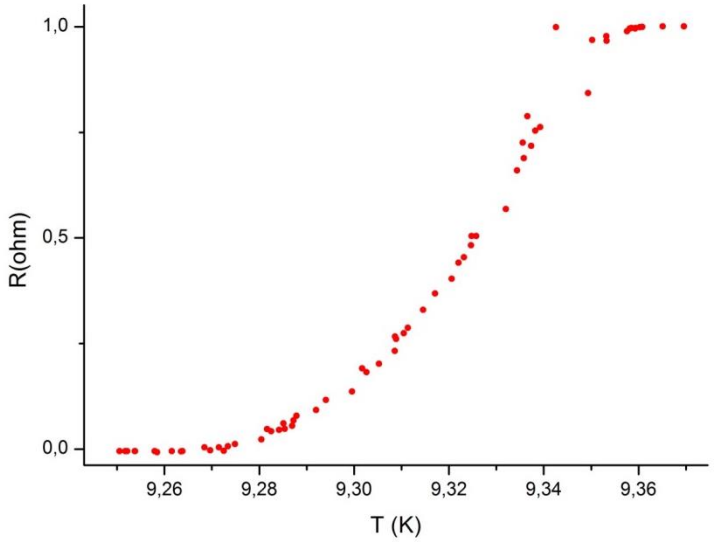
Nb Depositions





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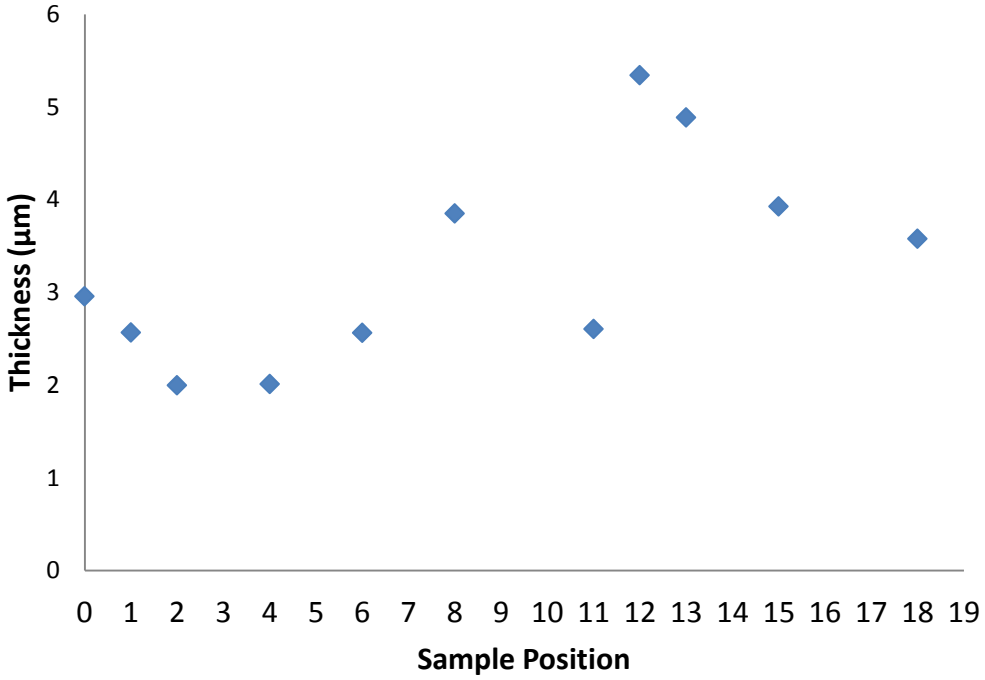
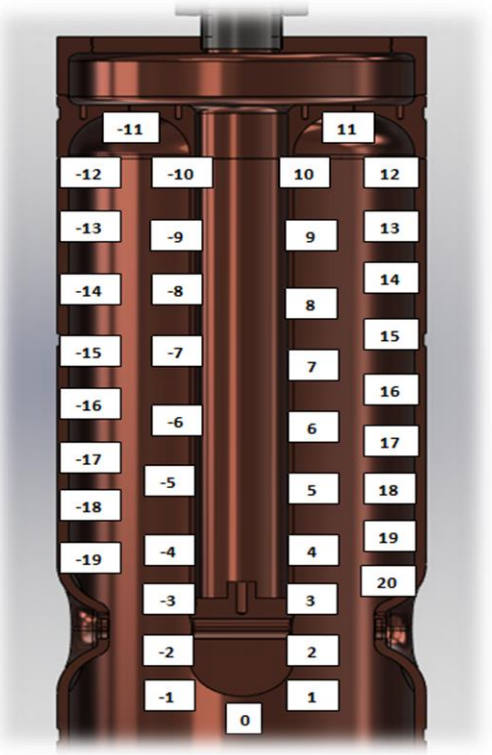
Nowadays





Power= P8*

Sputtering pressure= p8*

Time: 30 min

Cavity temperature: (inside and outside the cavity) 300°C

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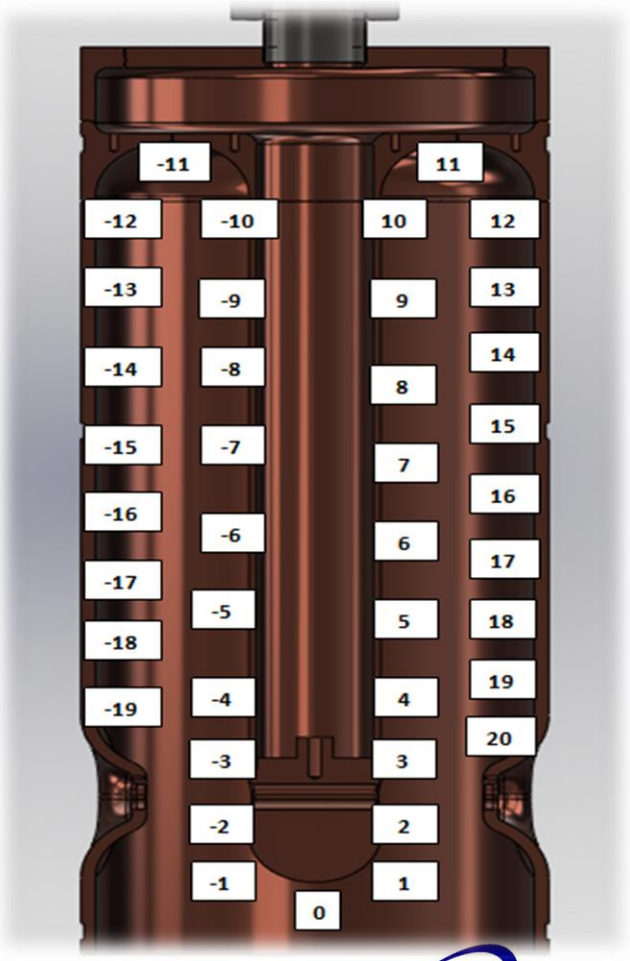
Nowadays

Sample	-11	1	3	8	11	15	18
RRR				61			
Tc (K)				9,3			



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Conclusions

-The vacuum system was successfully assembled and is available for thin film deposition.

- The uniformity of the Nb thin film along the cavity is quiet good, however we are trying to improve this results with another magnetic field source

- The RRR is higher if the substrate is heated during the sputtering process

-Increasing the power of deposition the RRR values are higher along the cavity

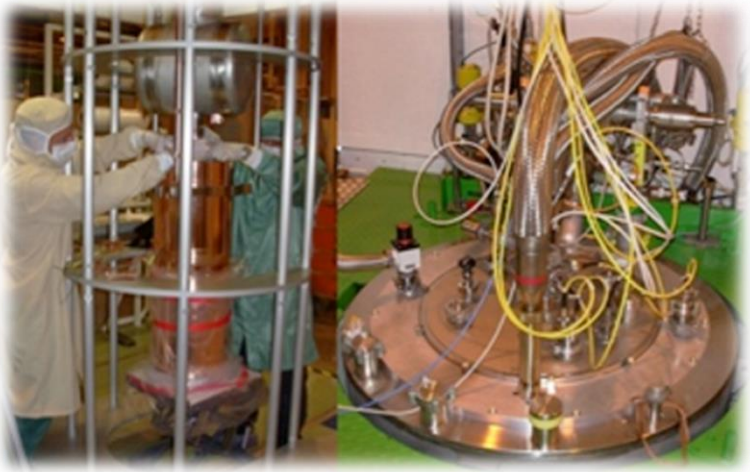
Further works

-Deposit the niobium film onto copper plates in order to close the QWR cavity.

-Perform the deposition directly with the Niobium cathode onto copper cavities.

-Design the cryostat and the RF system in order to measure the superconductive properties of the cavities

-Perform the measure of superconductive properties (Tc ,RRR and Q value)



Thanks for your attention

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