Progress with QPR at CERN

Lorena VEGA CID

Section: BE/RF/SRF

Supervisors: G. Vandoni, W. Venturini

On behalf of all the colleagues from BE-RF, TE-VSC and TE-CRG contributing to the QPR studies.

Outline

1. Thin film studies on 2019
2. Commissioning of new QPR
3. Future work

Thin film studies on 2019

Type of test
- QPR
- New QPR
- 1.3 GHz cavity

Thin film research lines
- Nb
  - ECR
  - HiPIMS
- Nb_3Sn
- Bulk Nb

Institutes
- CERN
- Jlab
- HZB

Test	Starting date	Type of test	Type of coating	Fabrication
1	24 January	1.3 GHz cavity	HiPIMS Nb	CERN
2	08 March	1.3 GHz cavity	HiPIMS Nb	CERN
3	20 March	New QPR	Bulk Nb	JLab
4	05 June	QPR	Nb_3Sn	CERN
5	18 June	QPR	ECR Nb	JLab
6	17 July	QPR	HiPIMS Positive pulse Nb	CERN
7	24 July	New QPR	Bulk Nb	HZB
8	08 August	QPR	HiPIMS Positive pulse Nb (second part)	CERN
9	11 September	QPR	Nb_3Sn	CERN
10	17 October	QPR	Bulk Nb	HZB
11	21 November	1.3 GHz cavity	HiPIMS Nb	CERN+JLab

Commissioning of new QPR

Main design modifications

In 2017 a new version of the QPR was built: An electromagnetic and mechanical re-design of the existing QPR to optimize the measurement range and resolution

Figure	*Original design*	*New design*
Res. Freq. [MHz]	399.7 / 803.3 / 1211	398.1 / 806.2 / 1224
H_{ss}/H_{pk}	0.87	0.91
B_{ss}/E_{pk} [mT/MV/m]	4.00 / 4.00 / 4.22	5.28 / 5.28 / 5.40
Av. field on surface [mT]	16.4	22.5
B_{edge} [mT]	1.5	2.5

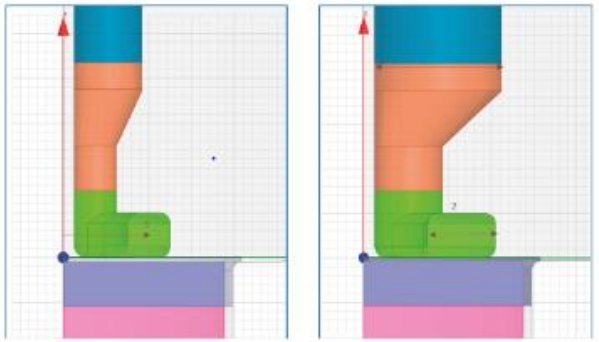
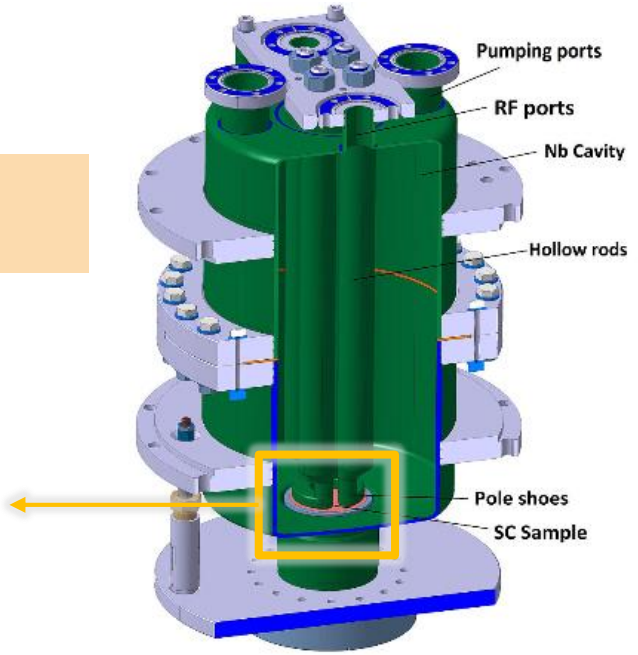


Figure 6: Original and new pole shoe geometry.



Modification	Impact	Benefits
↓ gap	↑ Hs/Hpk	Higher field is illuminated in the sample: More homogeneus field distribution over the sample, better resolution
↑ diameter of rods	↑ Bs/Epk	Electric field is reduced in the rod's surface: Lower risk field emission
↑ width of rods	↑ Average Bs	More homogeneus field distribution over the sample: Better resolution
Material	↑ RRR	Better cooling: Lower the risk of thermal breakdown

V. del Pozo Romano et al, "Redesign of CERN's Quadrupole Resonator for Testing of Superconducting Samples", in *Proc. 18th Int. Conf. on RF Superconductivity (SRF'17)*, Lanzhou, China, July 2017, https://doi.org/10.18429/JACoW-SRF2017-TUPB016, 2018.

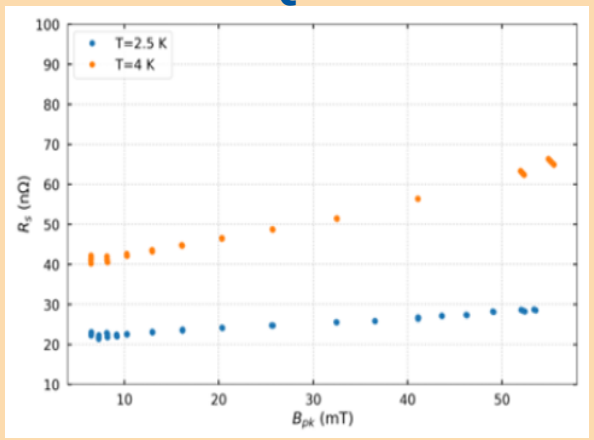
Commissioning of new QPR

First benchmark with bulk Nb sample

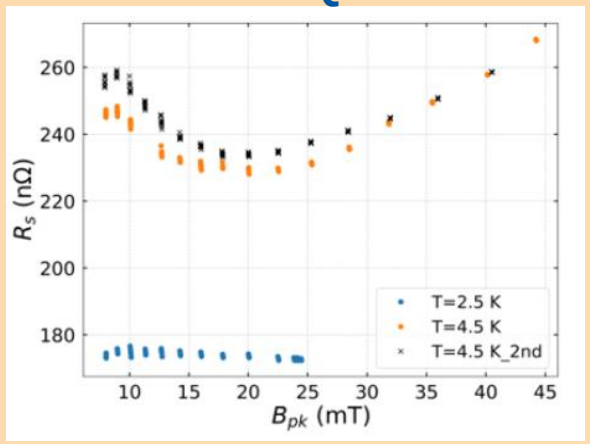
A bulk Nb sample RRR>100 (JN1) was tested with old and new QPR for commissioning (April 2019).

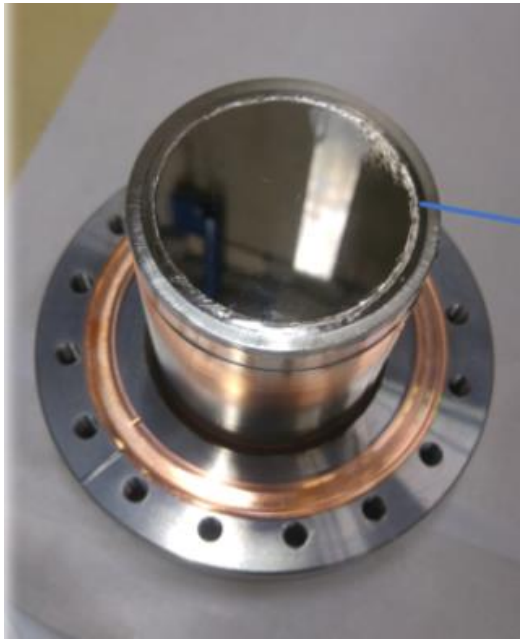
Rs vs Bpk @400MHz

Old QPR



New QPR





General comments (*courtesy: M. Arzeo*):

- *Output:* Overestimation of surface resistance with new QPR.
- *Possible cause*: In new QPR the magnetic field is more distributed in the sample surface. The weld might be affecting the dissipation.
- *To do next*: Measure another bulk Nb sample without welds on the top surface to confirm the theory.

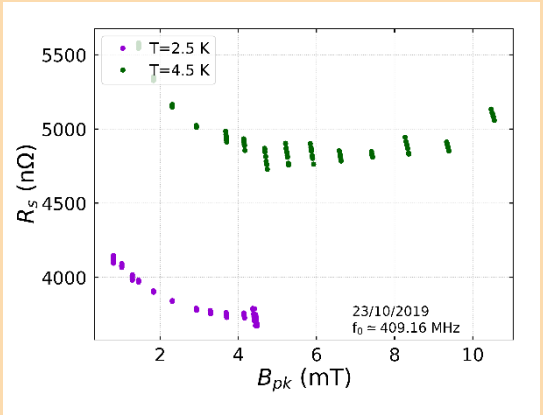
Commissioning of new QPR

Second benchmark with bulk Nb sample

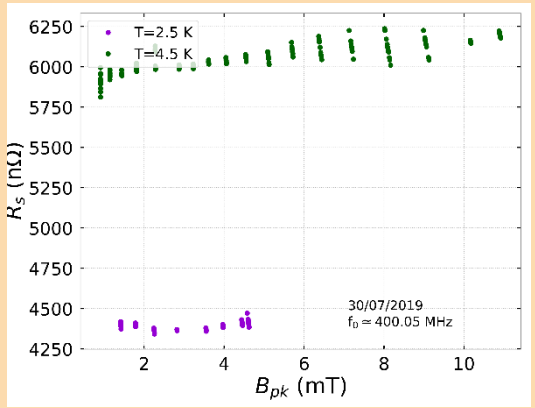
- A second bulk Nb sample has been tested with old and new QPR.
- The sample was produced in HZB and it was e-beam welded on the Nb cylinder support.

Rs vs Bpk @400MHz

Old QPR



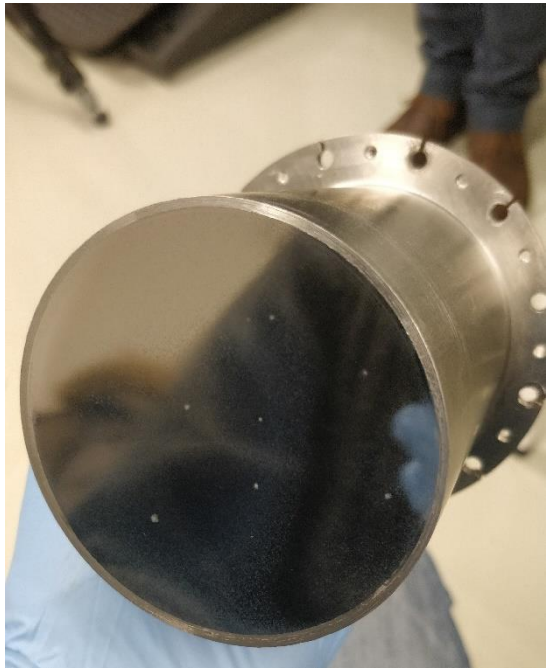
New QPR



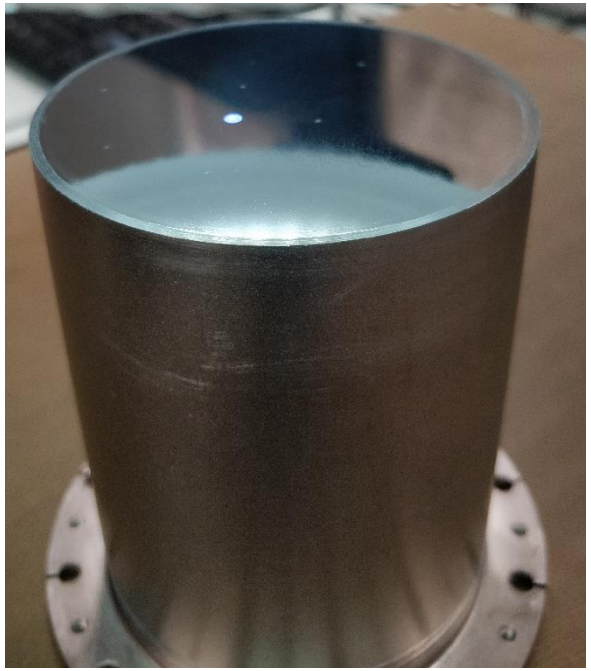
- *Output:* Discrepancies in the results with old and new QPR.
- *Possible cause*: The sample quality was very low, which could be attributed to the high roughness of the surface (Ra~30-40 um). Dissipation was evident even at low fields. Results cannot be fully trusted as there might be heat leaks.
- *To do next*: Repeat process using a good sample for benchmarking.

Preparation of a HZB QPR sample within EASITrain program

Defects observation

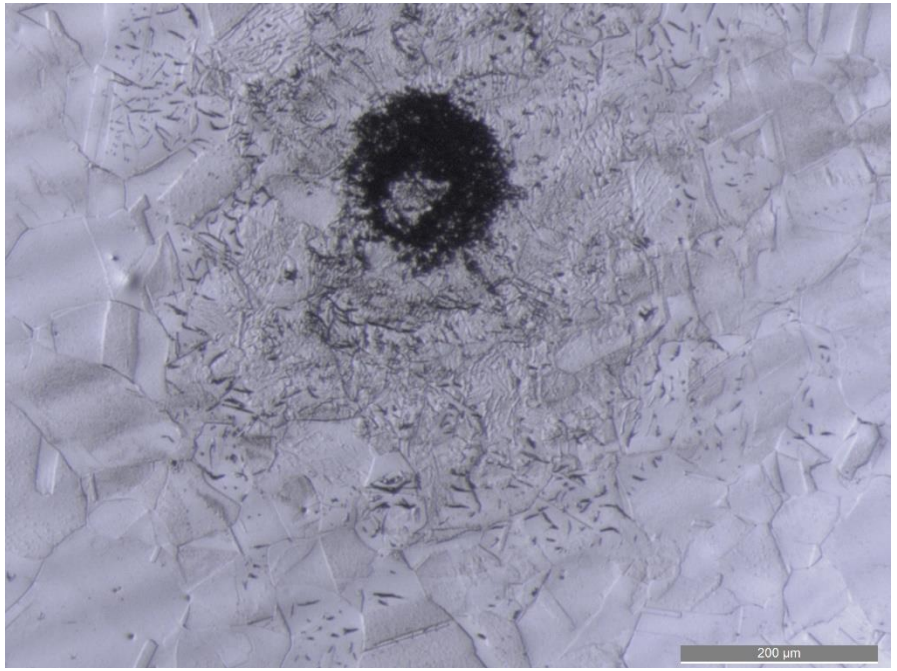


Few bright spots observed



Optical microscopy

Courtesy of A.-T. Fontenla

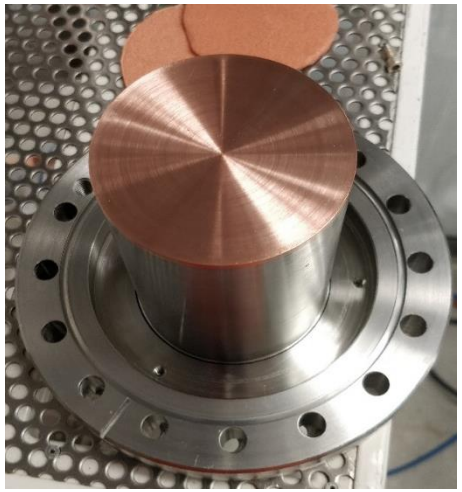


Massive defects. Covered by the coating.

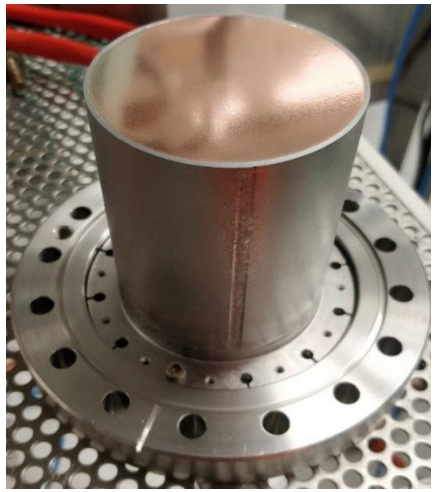
Courtesy of G. Rosaz

Preparation of a HZB QPR sample within EASITrain program

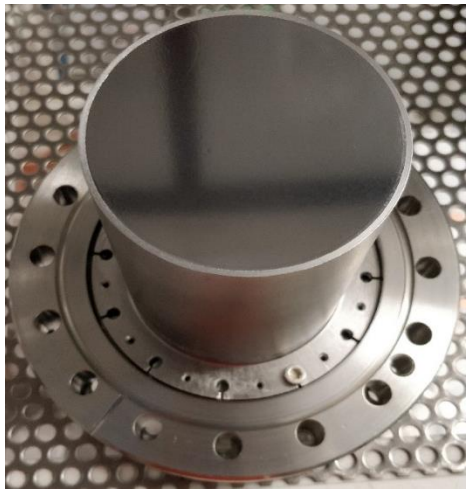
Coating



QPR sample holder



QPR sample mounted



After coating

A happy ESR ☺

- Sample striped
- SUBU (20min)
- HPWR
- Coating – HiPIMS / -50V bias. Final thickness ~ 8um

- Ready for RF testing (planned at CERN beginning 2020)
- It will be used for benchmarking of old and new QPR as part of the commissioning campaign.

Courtesy of G. Rosaz

Future work

	December	January	February	March
HiPIMS coated 1,3 GHz cavity				
QPR Nb coating (JLab)				
QPR Nb coating (HZB)				
New QPR commissioning				
To be added…				

Conclusions

- Several QPR measurements have been performed during 2019.
- New QPR commissioning is ongoing.
- Next sample for benchmarking has been prepared within the EASITrain program.
- We are ready to measure one sample for ARIES.
- Busy schedule, so it is useful to have sufficient notice time to be prepared for the test.