ISBN: 978-3-95450-194-6 ISSN: 2226-0366 doi:10.18429/JACoW-LINAC2018-THPO006

STATUS OF 650 MHz SRF CAVITY FOR ERHIC SRF LINAC*

W. C. Xu†, [1], I. Ben-Zvi[1, 2], Y. Gao[1], D. Holmes[1], P. Kolb[1], G. McIntyre[1], R. Porqueddu[1], K. Smith[1], R. Than[1], F. Willeke[1], Q. Wu[1], A. Zaltsman[1],
[1]Collider-Accelerator Department, Brookhaven National Laboratory, Upton, NY, 11790, USA
[2]Physics & Astronomy Department, Stony Brook University, Stony Brook, NY, 11794, USA

Abstract

A 5-cell 650 MHz SRF cavity was design for eRHIC high current SRF linac. One Cu cavity was fabricated for HOM damping study, and one Nb cavity was fabricated for SRF performance study with various post-processing procedures. The SRF performance study includes both high Q-value study (at gradient of 15 ~ 18 MV/m) and high gradient study (> 26 MV/m). This paper reports the HOM measurements results on Cu cavity and first result of vertical test on the Nb cavity.

INTRODUCTION

Collider-Acceletaor Department at Brookhaven National Laboratory (BNL) has been actively working on R&D of an electron-ion collider for more than a decade. This collider, named eRHIC, aims to collide electron beam that is from a new electron accelertor, with proton beams that is provided by existing RHIC [1]. The new electron accelerator will be placed in the RHIC tunnel, and most of components of RHIC will be reused for eRHIC. The layout of eRHIC is shown in Figure 1. To make sure we get the best machine performance with reasonable cost, both ERL-Ring [2] and Ring-Ring eRHIC [3] were studied. However, either design requires high performance SRF cavities.

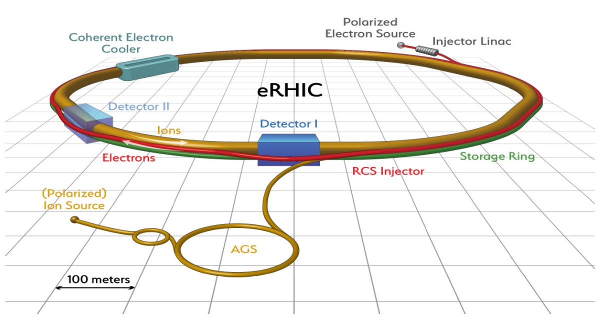

Figure 1: eRHIC layout.

Although the design of 5-cell 647 MHz cavity was aimed for high current ERL-Ring eRHIC[4-5], the cavity will be used for performance study for Ring-Ring SRF as well. A Cu prototype cavity was fabricated for HOM damping study, and an Nb cavity was fabricate for performance study. This paper will report the HOM measurement results, plan of the performance study, and first vertical test result.

* Work supported by LDRD program of Brookhaven Science Associates, LLC under Contract No. DE-AC02-98CH10886 with the U.S. DOE.
† wxu@bnl.gov

HOM MEASUREMENT ON CU CAVITY

The cavity fabrications contract was awarded to RI [6], which we have weekly telephone meeting to discuss the progress and resolve different issue during cavity fabrication. As we expect to have tons of R&D on the cavity, we asked for 4.5 mm cavity wall thickness. However, the geometry deformation tolerance is not allowed to be higher than +/- 0.3mm. To meet the tolerance, RI had to do at least once reshaping of each half cell. The beampipe of the cavity was design to be detachable so that we can study HOM damping in the future, as shown in Figure 2.

The spectrum measured in the Cu cavity matches very well with simulation results, which Figure 3 shows the spectrum comparision of the first HOM passband. This is also benefitted from tight geometry control during cavity fabrication. Due to the large cell-to-cell coupling and tight cavity shape tolerance, the cavity's field flatness is 89% as fabricated, and it required little tuning to reach 98.2% of field flatness.

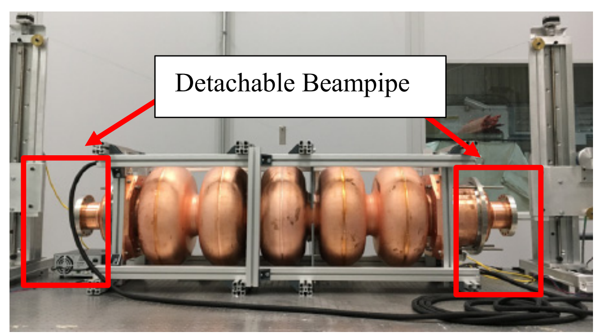

Figure 2: Bare 650 MHz Cu cavity with detachable beampipe.

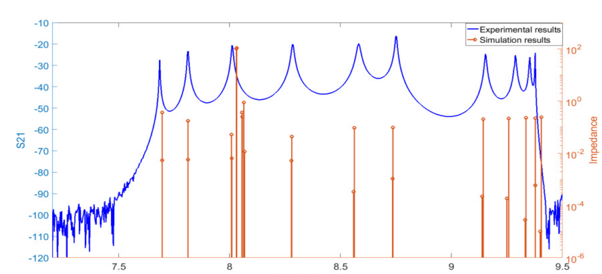

Figure 3: Simulated HOM spectrum and measured HOM spectrum.

NB CAVITY

Cavity fabrication and processing

Cu cavity is kind of a dry-run of the tooling for the Nb cavity fabrication, which made the Nb cavity fabrication much smoothly. However, a lot of dents and scratches were

ISBN: 978-3-95450-194-6 ISSN: 2226-0366 doi:10.18429/JACoW-LINAC2018-THPO006

discovered in the inspection of the cups and dumb-bells. Cratex was used to grind the local defects found during inspection. Figure 4 shows example of grinded half –cell and beampipe.

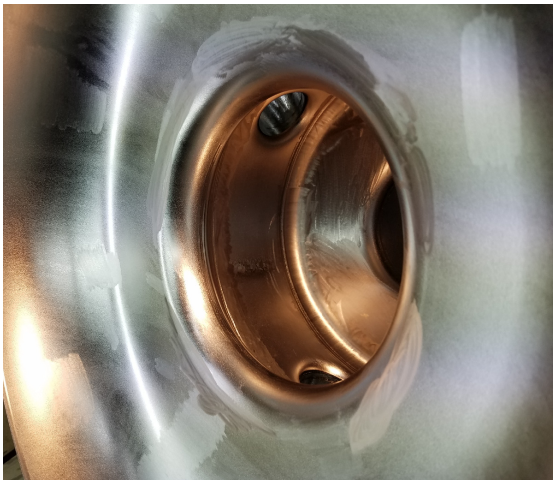

Figure 4: Nb inner surface after ginding with Cratex.

The last weld is done RI's EB-welder vertically because of the cavity is too long for horizontal welding. Following the last welding, the cavity was carried out pressure test up to 26 psia, to satisfy the ASME code.

As shown in Figure 5, the Nb cavity's field was initially tuned up to 99% flatness in the RI, which re-measured as 98 % flatness after shipping to BNL.

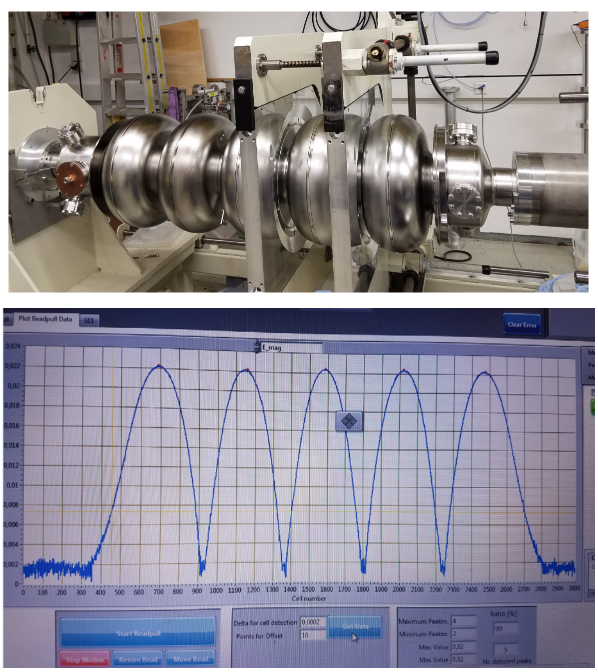

Figure 5: Nb cavity tuned in RI.

The post processing of the 650 MHz cavity is done with combination effort between ANL and BNL. ANL took care of the BCP part, and BNL took care of HPR and 600 C bake. The BCP removed Nb in amount of 115 µm (heavy BCP) and 36 µm (light BCP). Between the heavy and light BCP, the cavity was baked at 600 C for 10 hours. Prior to shipping to ANL for light BCP, the field flatness was measured again, which reduced slightly to 95 %. The field flatness and first passband comparison before and after BCP and bake is shown in Figure 6. One important feature that has to be point out is that the grinding marks from the cavity fabrication were gone after BCP, which can be seen in Figure 7.

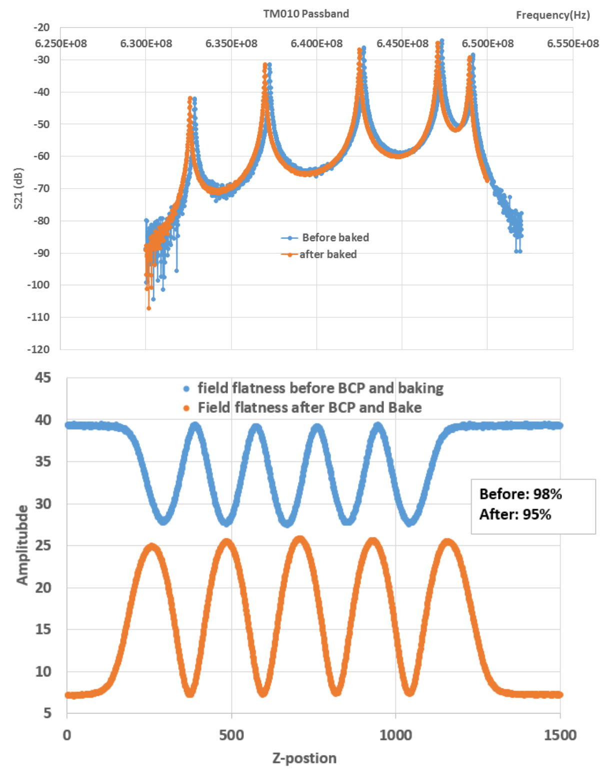

Figure 6: Nb cavity's fundamental sprectrum (Top) and the field flatness (Bottom) before and after heavy BCP and bake.

Figure 7: No grinding marks after BCP.

Preparation for Vertical Test

The vertical test of the 650 MHz cavity is to carry out in the Large Vertical Test Facility (LVTF) at Bldg.912 in BNL. In Figure 8, it shows the 650 MHz cavity in Class 10000 clean room for installation of instrumentations (temperature, helium level and RF) for vertical test. To minimize the RF loss, all HOM ports and beam pipe ports are

ISBN: 978-3-95450-194-6 ISSN: 2226-0366 doi:10.18429/JACoW-LINAC2018-THPO006

sealed with Cu disc gaskets, with a venting hole. The estimated total RF loss on the all ports @ 20 MV/m is about 0.2 watt. The liquid helium is provided with a Helium refrigerator. A fixed FPC antenna is used to couple the RF power into the cavity, and Qext of the FPC is 8E9, and a pick up antenna with external Q of 7E10 is used. The maximum available RF power source is 500 W in CW mode.

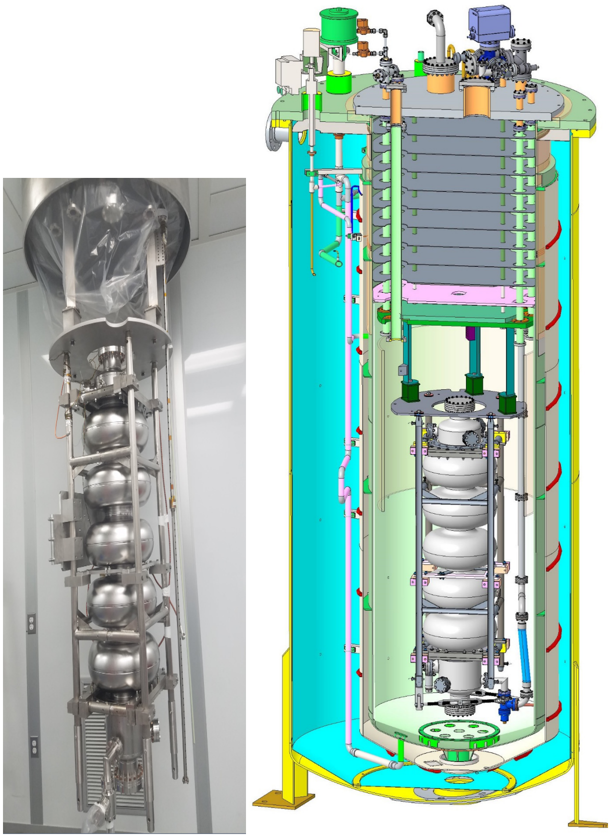

Figure 8: Configuration of the vertical test.

Plan of Study

The SRF performance study includes both high Q-value and high gradient with various post-processing. The first round of post processing (heavy BCP, 600 C bake and light BCP) is to create a baseline for the future reference. Also, it is the first time for using BNL's new-built HPR on an Nb cavity, so commissioning the HPR is a side purpose. The high-Q study goal of the cavity processing is to study various post-processing methods to reach 18 MV/m with Q_0~$2x10^{10}$, which is the goal for the ERL-Ring eRHIC SRF linac. The further processing will be based on the results of the first test. As EP has been proved to be beneficial for cavity gradient, and cavity gradient of 25 MV/m is required for Ring-Ring eRHIC SRF linac, we will try to do EP on the cavity later on.

SUMMARY

A 650 MHz high current SRF cavity has been designed, prototyped, went through first round of post-processing, and ready for vertical test. Various post-processing steps will be carried out for high Q studies for the ERL-Ring SRF linac and for high gradient study for Ring-Ring eRHIC SRF linac.

ACKNOWLEDGEMENGT

The authors would like to thank Michael Pekeler, Aliaksandr Navitski and other experts for useful discussion and resolving the issues that appeared during cavity fabrication.

The authors would like to thank Michael Kelly and Thomas Reid for helping on cavity BCP.

REFERENCES

[1] RHIC, https://www.bnl.gov/rhic/
eRHIC, "eRHIC Design Study: An Electron-Ion Collider at BNL", December 2014, arXiv:1409.1633.

[2] C. Montag *et al.*, "Overview of the eRHIC Ring-Ring Design", in *Proc. 8th Int. Particle Accelerator Conf. (IPAC'17)*, Copenhagen, Denmark, May 2017, paper WEPIK049.

[3] W. Xu *et al*, "Frequency choice of the eRHIC SRF linac", BNL-111776-2016-IR.

[4] W. Xu *et al.*, "RF and Mechanical Design of 647 MHz 5-Cell BNL4 Cavity for eRHIC ERL", in *Proc. 7th Int. Particle Accelerator Conf. (IPAC'16)*, Busan, Korea, May 2016, paper WEPMR041.

[5] W. XU *et al.*, "Progress of 650 MHz SRF cavity for eRHIC SRF linac", in *Proc. 18th Int. Conf. RF Superconductivity (SRF'17)*, Lanzhou, China, Jul. 2017, paper WEPMR041.

[6] RI, http://www.research-instruments.de