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DISCLAIMER

COMMISSIONING OF THE 112 MHZ SRF GUN AND 500 MHZ BUNCHING CAVITIES FOR THE CeC PoP LINAC*

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Abstract

The Coherent electron Cooling Proof-of-Principle (CeC PoP) experiment at BNL includes a short electron linac. During Phase I, a 112 MHz superconducting RF photo-emission gun and two 500 MHz normal conducting bunching cavities were installed and are under commissioning. The paper describes the Phase I linac layout and presents commissioning results for the cavities and associated RF, cryogenic and other sub-systems.

INTRODUCTION

The CeC PoP experiment is under construction at BNL to demonstrate feasibility of this cooling scheme for future colliders [1, 2]. The experiment is aimed to cool only one bunch in RHIC. A 22-MeV high-bunch-charge beam will be delivered by a short linac [3, 4]. Phase I of the project includes installation and commissioning of a 112 MHz Quarter Wave Resonator (QWR) photoemission electron gun and two normal conducting bunching cavities as well as generating first beam. The Phase I linac layout is shown in Figure 1. The SRF gun cryomodule and bunching cavities were installed in the Interaction Region 2 (IR2) of RHIC tunnel during summer shutdown of 2014. The installed hardware is illustrated in Figure 2. In this paper we describe the first commissioning results for the 112 MHz SRF gun and two bunching cavities.

INSTALLATION AND COMMISSIONING OF THE 112 MHz QWR SRF GUN

The 112 MHz SRF QWR quarter-wave resonator was developed by BNL in collaboration with Niowave, Inc. [5-7]. It is designed to generate electron bunches with a charge range from 1 to 5 nC and repetition rate of 78 kHz, matching the RHIC revolution frequency. Multi-alkali photocathodes will be illuminated with a green (532 nm) light from a laser. More details of the gun design can be found in the cited references.

The gun operates at 4.3 K with liquid helium supplied from a so-called quiet helium source [8], which isolates the 112 MHz cryomodule from noise coming from the RHIC magnet supply line and the local helium compressor that processes the boil-off. The gun cryomodule together with associated sub-systems (cryogenics, RF, cooling water, vacuum, fundamental power coupler/tuner motion, cathodes insertion) was installed in RHIC during summer of 2014. Its commissioning began in the fall.

We started conditioning without a photocathode puck. Initially, numerous multipacting zones were encountered at very low cavity voltages. They have been cleaned out after several days of conditioning and never presented a problem afterwards.

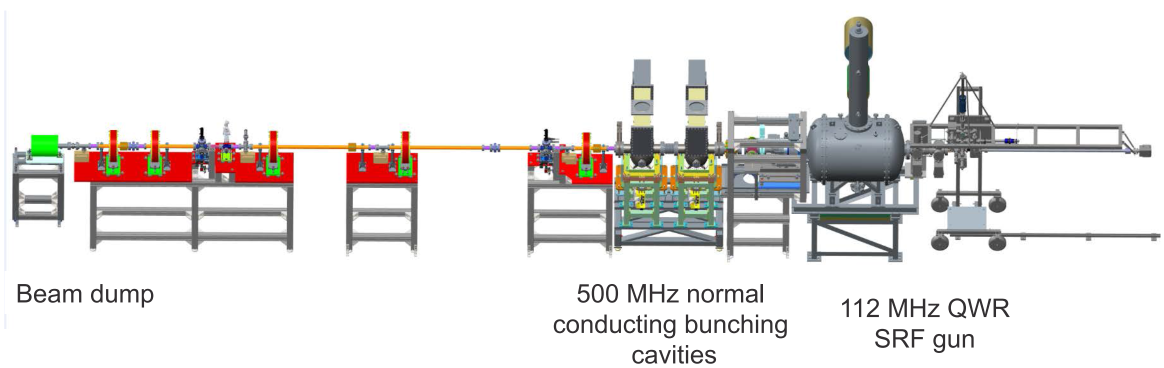

Figure 1: Layout of the Phase I of the CeC PoP linac installation.

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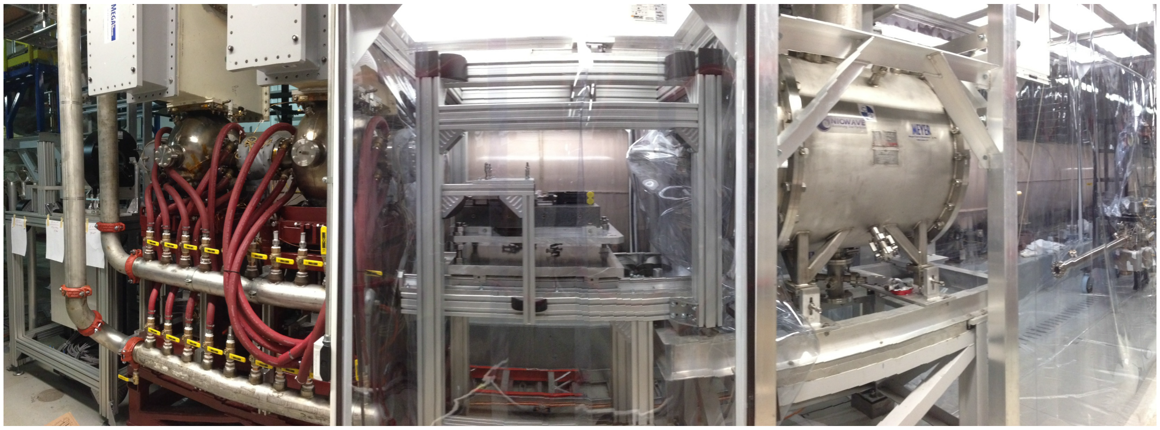

Figure 2: The 112 MHz SRF gun and two bunching cavities in the RHIC tunnel.

Further conditioning was easier, although we have found more multipacting inside the cavity, fundamental RF power coupler and cathode stalk as described in Ref. [9]. Eventually the gun reached the voltage level where its performance is limited by field emission (FE). High power pulsed processing allowed us to proceed and the gun has reached stable operation in CW mode at 1.3 MV, limited by a very high cryogenic load due to FE. A cavity voltage as high as 1.8 MV could be reached in pulsed mode. Figure 3 shows a photo of two active emitters taken during the cavity conditioning with a camera. An outline of the center conductor can be seen on the photo.

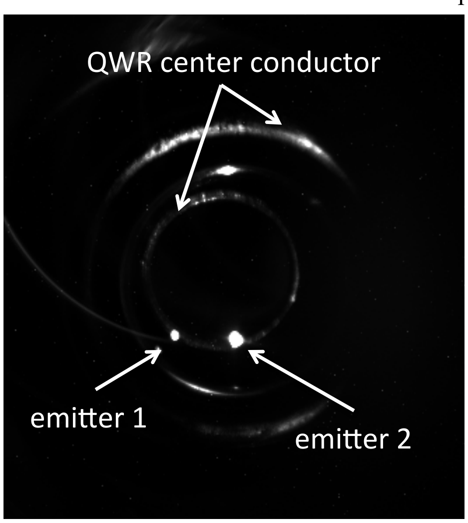

Figure 3: Two active field emitters inside the QWR center conductor.

Prior to the cryomodule delivery to BNL, it was tested at Niowave, where FE limited the cryomodule performance as well. Figure 4 compares the two test results. As we have reached the RF power amplifier limit, we plan to implement helium processing to condition FE further. The setup is complete and helium processing will begin soon. In the mean time preparations are under way to install the photocathode puck and try to generate first beam current from the gun.

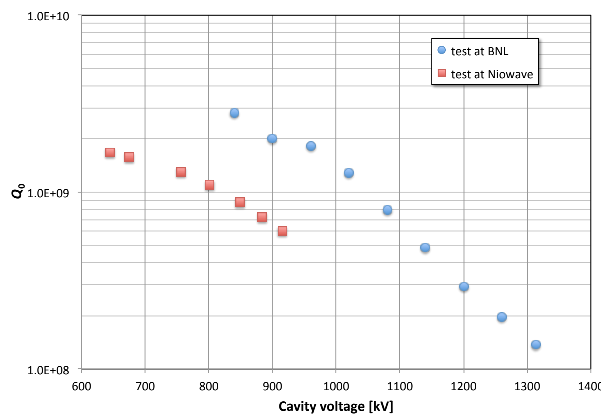

Figure 4: The 112 MHz cryomodule performance at Niowave and at BNL. FE limited the cavity voltage in both cases. Higher available RF power and better radiation shielding allowed reaching higher voltage at BNL.

INSTALLATION AND COMMISSIONING OF BUNCHING CAVITIES

Two 500-MHz bunching cavities are a contribution to the experiment from the Daresbury Laboratory, UK, where they were installed in the now decommissioned SRS light source [10]. The cavities routinely operated at an accelerating voltage of 300 kV.

The cavities were delivered from Daresbury Laboratory to BNL in early 2012. At BNL, the cavities were particulate-free cleaned and refurbished, vacuum baked. Following that they were installed in the RHIC tunnel as shown in Figure 5.

At first, the bunchers were conditioned individually. We have observed vacuum activity in the cavities due to multipacting. It was conditioned away and both cavities reached their design voltage of 300 kV. In the final configuration the cavities are powered in parallel form a 50-kW IOT amplifier via a 3-dB coaxial hybrid coupler. The RF power splitter layout is depicted in Figure 6.

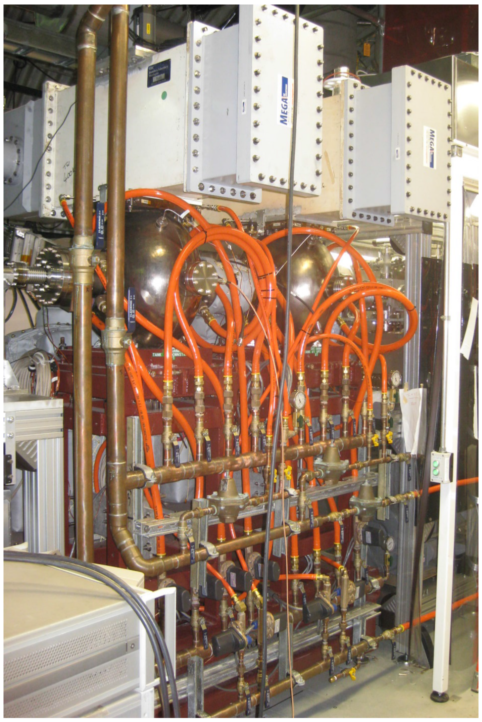

Figure 5: Two bunching cavities in the RHIC tunnel.

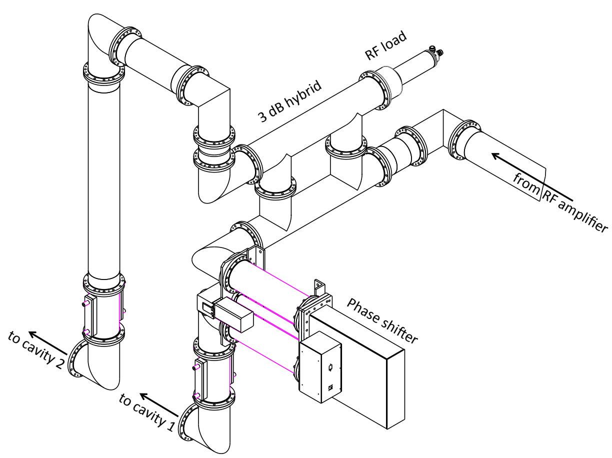

Figure 6: Layout of the 500 MHz RF power splitter.

SUMMARY

The Phase I of the CeC PoP electron linac was installed in the RHIC tunnel and is undergoing commissioning. The 112 MHz SRF gun cryomodule has been conditioned to 1.3 MV in CW mode, limited by field emission. Helium processing setup is complete with the goal to condition field emitters and increase the gun voltage to the design value of 2 MV. Preparations are under way for the first beam tests with a multi-alkali photoemission cathode puck. Two 500-MHz bunching cavities were installed in the tunnels and conditioned individually to their design voltage of 300 kV. The RF power splitting with a 3-dB hybrid coupler is installed and commissioning of the complete RF system has begun. Our goal is to generate the first photoemission beam from the gun before the summer RHIC shutdown of 2015.

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