High Power Test of RF Separator for 12 GEV Upgrade of CEBAF at Jefferson Lab

S. Ahmed

M. Wissmann

J. Mammosser

M. Spata

C. Hovater

See next page for additional authors

Original Publication Citation

Ahmed, S., Wissmann, M., Mammosser, J., Spata, M., Hovater, C., Krafft, G., & Delayen, J. R. (2012). High power test of RF separator for 12 GEV upgrade of CEBAF at Jefferson Lab. In *IPAC 2012: Proceedings of the International Particle Accelerator Conference 2012* (pp. 4032-4034). JACoW.
https://accelconf.web.cern.ch/ipac2012/papers/thppr030.pdf

HIGH POWER TEST OF RF SEPARATOR FOR 12 GEV UPGRADE OF CEBAF AT JEFFERSON LAB *

S. Ahmed†, M. Wissmann, J. Mammosser, M. Spata, C. Hovater,
Thomas Jefferson National Accelerator Facility, Newport News, VA 23606, USA
G.A. Krafft, J.R. Delayen,
Thomas Jefferson National Accelerator Facility, Newport News, VA 23606, USA
Center for Accelerator Science, Old Dominion University, Norfolk, VA 23529, USA

Abstract

CEBAF at Jefferson Lab is in the process of an energy upgrade from 6 GeV to 12 GeV. The existing setup of the RF separator cavities in the 5th pass will not be adequate to extract the 11 GeV beam to any two existing experimental halls (A, B or C) while simultaneously delivering 12 GeV beam to the new hall D. To restore this capability, we are exploring the possibility of using existing normal conducting 499 MHz TEM-type rf separator cavities. Detailed numerical studies suggest that six 2-cell normal conducting structures meet the requirement. Each 2-cell structure will require up to 4 kW RF input power in contrast with the current nominal operating power of 1.0 to 2.0 kW. A high power test at 4 kW confirmed that the cavity can meet the requirement.

INTRODUCTION

The Continuous Electron Beam Accelerator Facility (CEBAF) at Jefferson Lab is in the process of an energy upgrade from 6 GeV to 12 GeV. Beam extraction in the existing setup is done with a system consisting of ten normal conducting RF separator cavities. Each structure consists of two cells (see Fig. 1) – details are very well discussed in [1]. RF is powered from one end using a loop coupler which couples to the other cell via two holes in the central plate. The parameters of the cavity are summarized in Table 1. In the current setup, a series array of three cavities on the 5th pass is capable of sending highest energy (6 GeV) beams to the three existing experimental halls A, B, and C simultaneously. For 12 GeV operation of CEBAF, the RF separator cavities are supposed to provide deflections of ∼ ±452 μrad for 11 GeV beams traveling to halls A and C. The RF kick is determined by the requirement to have the beams to halls A and C vertically separated by ±17 mm relative to hall B at the entrance of the existing extraction magnet (Lambertson-style) in the beam switchyard located 43 m downstream from the start of the separator cavity. Beam dynamics simulations suggest the use of six 2-cell normal conducting cavities [2] in order to restore this capability. Each 2-cell system needs to operate at the power level of ∼ 4 kW in contrast with the current nominal power of 1.0-2.0 kW [3]. This increase in RF power can increase heat load which may detune the cavity – leading to instabilities. It is therefore important to confirm the cavity's operating ability at the elevated power level.

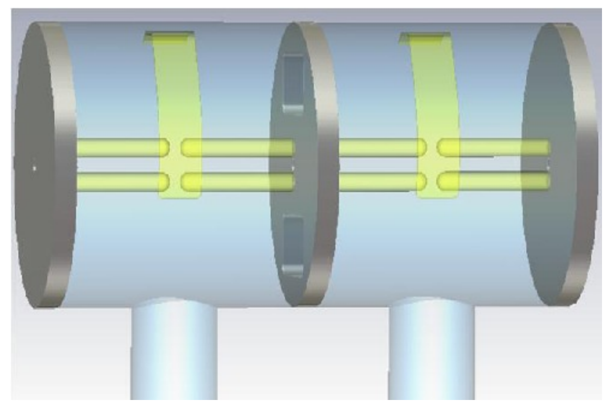

Figure 1: Schematic of normal conducting RF separator.

Table 1: Parameters of Cavity

Parameters	Unit	Value
Operating Mode		TEM
R/Q	MΩ	210
Q_L		2500
Q_0		5000
Operating Frequency	MHz	499
Rod Separation	mm	14.3

EXPERIMENTAL SETUP

To assemble a new separator cavity, end and central copper plates were taken from an existing prototype structure and assembled on a new stainless steel body. The stainless steel bodies and other components were cleaned for ultra high vacuum. The cavity was then assembled in a clean room – see Fig. 2. The S_{21} measurement for critical coupling of power gives Q_L ∼ 2600 – see Fig. 3. In this transmission measurement, field probe coupler was set to -40 dB. A helium leak test was performed to confirm

* Authored by Jefferson Science Associates, LLC under U.S. DOE Contract No. DE-AC05-06OR23177. The U.S. Government retains a non-exclusive,paid-up, irrevocable, world-wide license to publish or reproduce this manuscript for U.S. Government purposes.
† sahmed@jlab.org

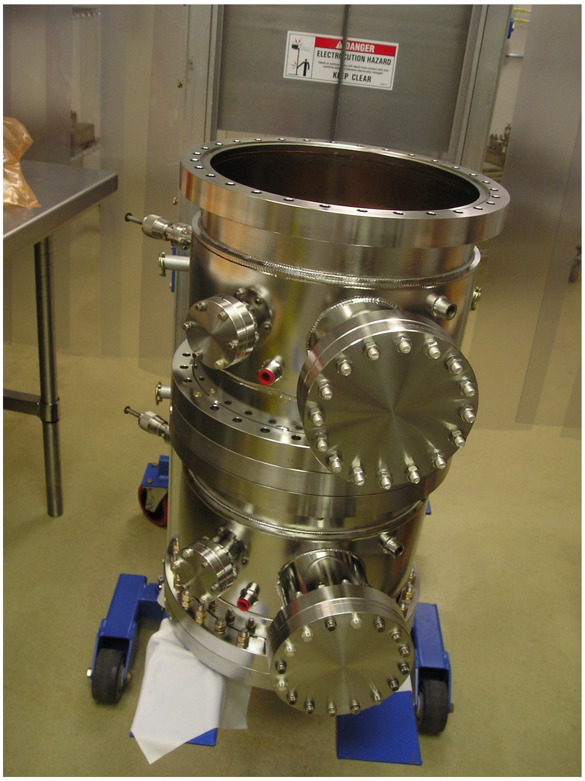

Figure 2: Clean room assembly of separator cavity.

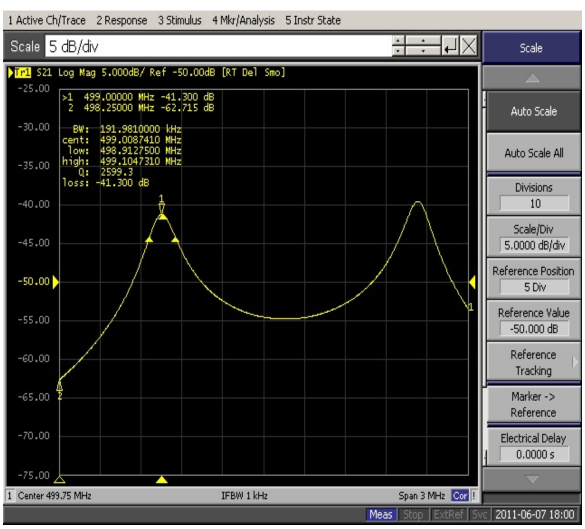

Figure 3: Low level measurement for critical coupling.

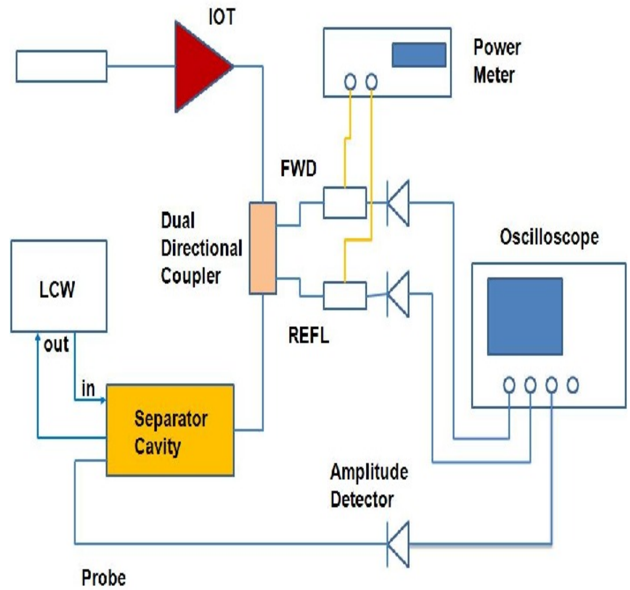

Figure 4: Schematic of high power test.

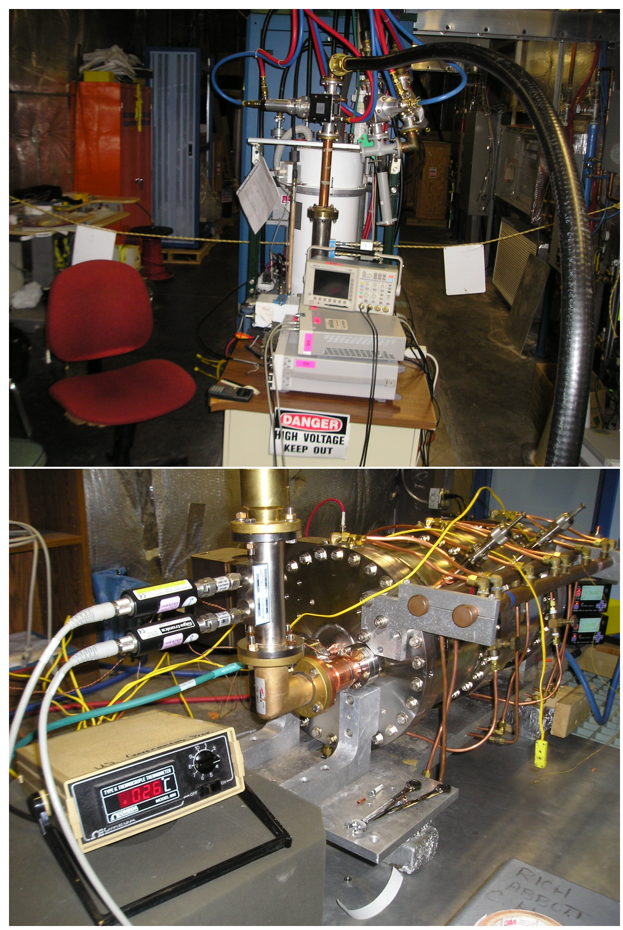

Figure 5: Experimental setup for high power test.

that the cavity is leak tight. We connected the scroll and turbo pumps to the cavity which pumped down to 10^{-6} torr. The ion pump was started with 4 kV and then turned to 7 kV when the pressure reached to $6{\times}10^{-8}$ torr. Running the ion pump for two days brought down the pressure to 4×10^{-9} torr. The cavity was then moved to the accelerator site where an rf power source and water cooling setup were available. The water cooling manifold used in this experiment conforms to a parallel configuration of water distribution through different sections of the cavity. A schematic of high power test is shown in Fig. 4 and the real experimental setup following the schematic is illustrated in Fig. 5.

ISBN 978-3-95450-115-1

RESULTS AND DISCUSSION

The following results show performance for almost 2.5 hours of steady state operation. Cavity can be operated at 4 kW – see Fig. 6, reflection is negligibly small. The high power drifts the frequency and vacuum up by about 400 kHz and 2-10 μA of ion pump current as shown in Figs. 7 and 8 respectively, due to heating illustrated in Fig. 9.

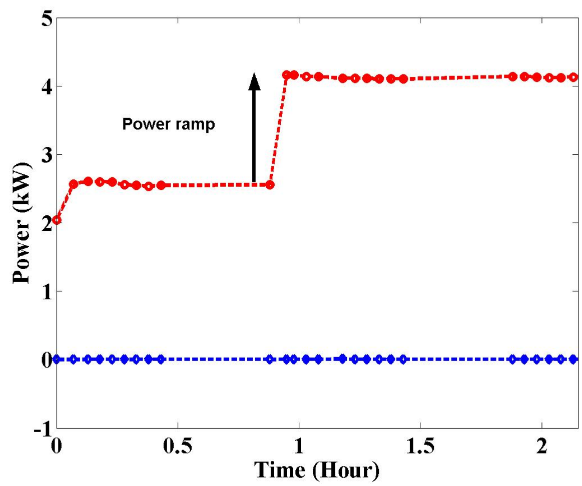

Figure 6: Temporal evolution of forward (FWD) and reflected (REF) power.

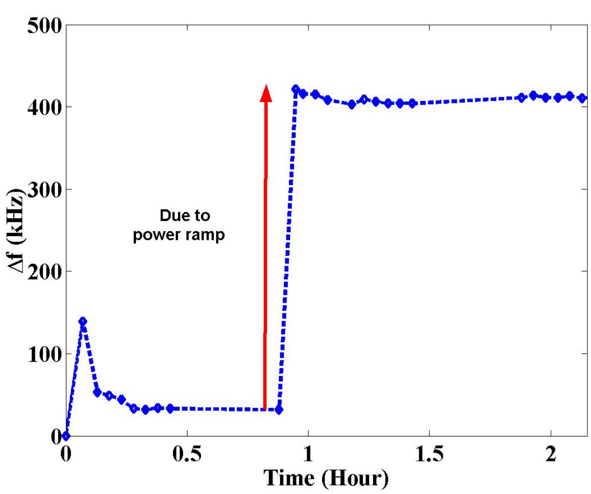

Figure 7: Temporal evolution of frequency shift during the process of operation.

CONCLUSION

We have performed a high power test (4 kW or higher) of a separator cavity with the objective to confirm its suitability for restoring the capability of extracting 5th pass (11 GeV) beams to the three experimental hall A, B and C simultaneously in the case of the proposed 12 GeV upgrade of CEBAF. The cavity met the requirements, however, we have to learn how to control the frequency shift due to heating for the stable operation. Work is in progress and we expect to finish sometime in summer 2012.

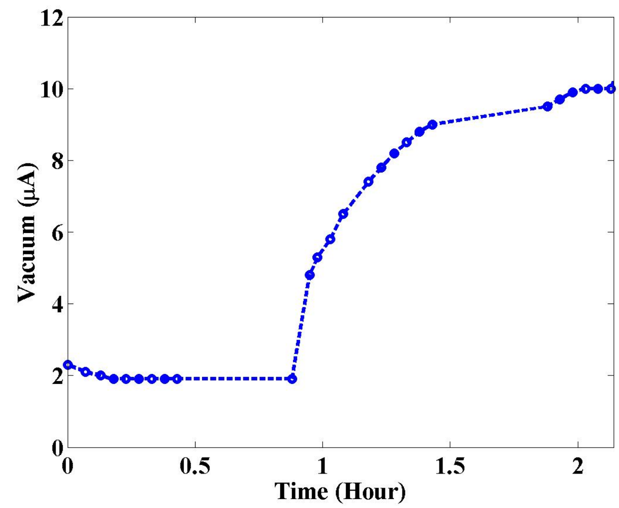

Figure 8: Cavity vacuum rise during operation.

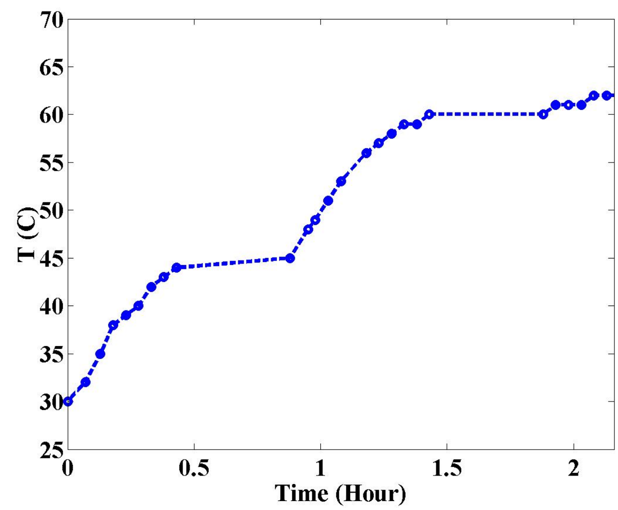

Figure 9: Steady increase in probe temperature during operation due to direct RF heating.

REFERENCES

[1] C. Leemann and C.G. Yao, in JLab Technical Note No. CEBAF-TN-90-217, 1990.

[2] S. Ahmed, G.A. Krafft, K. Deitrick, S.U. De Silva, J.R. Delayen, M. Spata, M. Tiefenback, A. Hofler, and K. Beard, Phys. Rev. ST. Accel. Beams, 15, 022001 (2012).

[3] J.R. Delayen, M. Spata, and H. Wang, in Proceedings of PAC 2009, Vancouver, BC, Canada, 2009.