COMMISSIONING STATUS OF THE 3 MEV RFQ FOR THE COMPACT PULSED HADRON SOURCE (CPHS) AT TSINGHUA UNIVERSITY*

Q.Z. Xing#, J.C. Cai, C. Cheng, L. Du, Q. Du, T.B. Du, X.W. Wang, Z.F. Xiong, H.Y. Zhang, S.X. Zheng, Key Laboratory of Particle & Radiation Imaging (Tsinghua University), Ministry of Education, Beijing 100084, China
Y.J. Bai, X.L. Guan, C. Jiang, D. Wang, S.Y. Yang, Department of Engineering Physics, Tsinghua University, Beijing 100084, China
W.Q. Guan, Y. He, J. Li, NUCTECH Co. Ltd., Beijing 100084, China
J. Billen, J. Stovall, L. Young, USA

Abstract

The 3 MeV Radio Frequency Quadrupole (RFQ) accelerator for the Compact Pulsed Hadron Source (CPHS) is in its initial stage for the commissioning at Tsinghua University. Braze of the flanges was completed in January, 2012. The RFQ cavity has been delivered to Tsinghua University after the final field tuning. In 2012 the 3-meter-long RFQ is expected to deliver 3 MeV protons to the downstream High Energy Beam Transport (HEBT) with the peak current of 50 mA, pulse length of 0.5 ms and beam duty factor of 2.5%. The initial commissioning is now underway.

INTRODUCTION

Four neutron beam lines are planned in the Compact Pulsed Hadron Source (CPHS) project at Tsinghua University, among which two lines are being constructed for the Small Angle Neutron Scattering (SANS) and neutron imaging [1]. The neutron will be generated by the proton beam bombarding a Beryllium target. The 13 MeV proton linac contains the ECR ion source, LEBT, RFQ, DTL and HEBT. The layout of the CPHS project is shown in Fig. 1. The main parameters of the accelerator system are listed in Table 1. The present status and commissioning plan of the RFQ accelerator are presented in this paper.

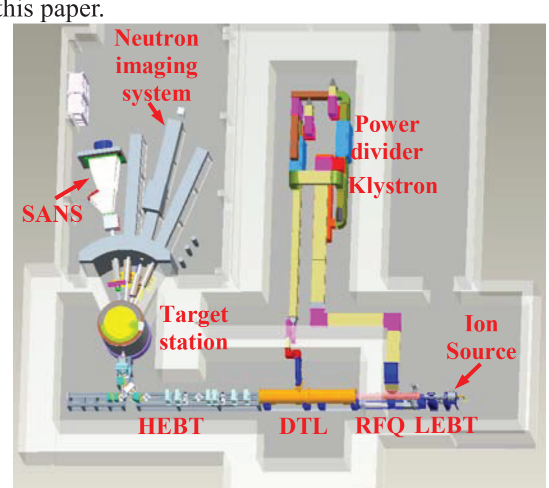

Figure 1: CPHS layout.

*Work supported by the "985 Project" of the Ministry of Education of China.
#xqz@tsinghua.edu.cn

Table 1: Main parameters of the CPHS accelerator system

Parameters	Value	Unit
Ion type	Proton	
Beam power	16	kW
Beam energy	13	MeV
Average current	1.25	mA
Pulse repetition rate	50	Hz
Protons per pulse	1.56×10^{14}	
Charges per pulse	2.5×10^{-5}	C
Pulse energy	0.325	kJ
Pulse length	500	µs
Peak current	50	mA
Beam duty factor	2.5	%
RF frequency	325	MHz
Output energy of the ion source	50	keV
Output energy of the RFQ	3	MeV

RFQ CONFIGURATION AND STATUS

The 3-meter-long RFQ accelerates a 50 keV proton beam from the ECR source to 3 MeV. To facilitate the machining and brazing, the whole RFQ cavity is separated longitudinally into three segments. Each segment contains two major vanes and two minor vanes [2~4]. Fig. 2 shows the RFQ mounted on the support stand at the campus of Tsinghua University.

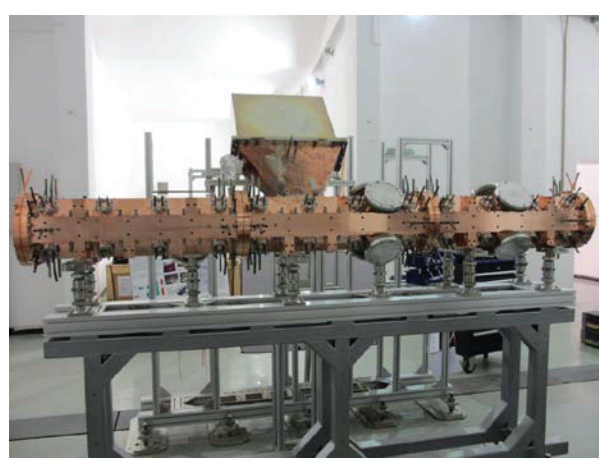

Figure 2: RFQ mounted at the campus of Tsinghua University.

ISBN 978-3-95450-115-1

The three segments are aligned together by the laser tracker. After the alignment the maximum magnetic field was measured longitudinally by the bead-pull method. As shown in Fig. 3, the quadrupole field is within 3% of the designed value, and the admixture of the two dipole modes are less than 4% of the quadrupole mode. The result is almost the same as the measurement just after the re-braze of the copper flanges.

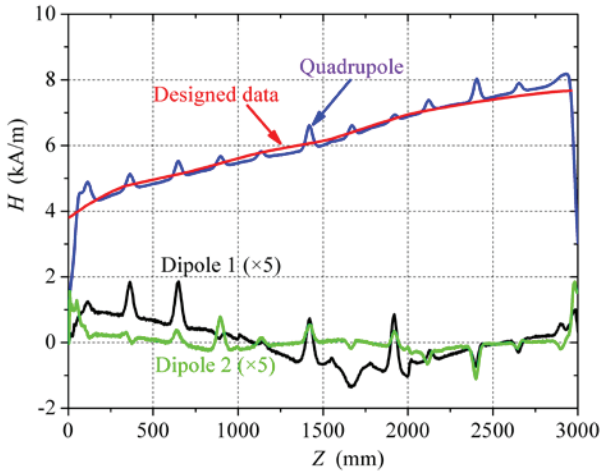

Figure 3: Field distribution measured at Tsinghua University.

Five pickups are adopted which are located in the middle of five tuners separately. The attenuation of the pickups has been adjusted to be near -60 dB. Fig. 4 shows the S21 curve measuring between the coaxial-waveguide adapter and the pickup in the tuner of C11. The frequency interval between the TE_{210} mode (Q0 in Fig. 4) and its neighboring dipole modes (TE_{111} and TE_{112}) is larger than 5.0 MHz.

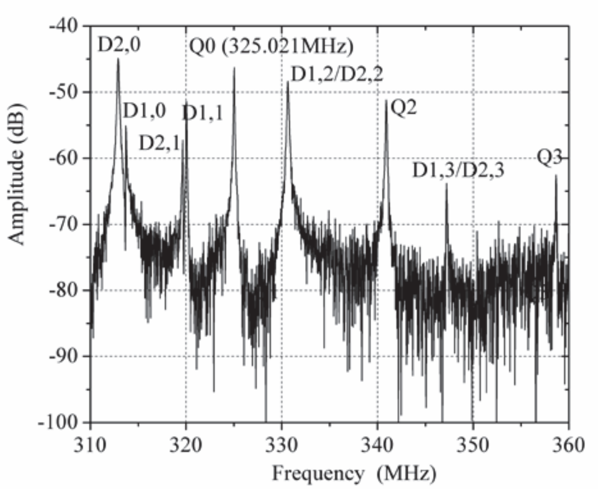

Figure 4: Frequency spectrum measured at the cavity temperature of 21 ℃ and humidity of 80%.

While the construction of the DTL will be completed in 2013, the 3 MeV proton beam will be adopted to produce the neutron this year. Five quadrupoles have been positioned instead of the DTL. After the field measurement, the RFQ cavity is now waiting for the alignment with the HEBT first. Then the high-vacuum test of the RFQ will be carried out, and the cooling water system will be mounted.

HIGH VACUUM SYSTEM

Eight ion pumps (pumping speed of 200 l/s for each pump) are adopted to obtain the high vacuum with the designed dynamic vacuum degree of 4×10^{-5} Pa inside the CPHS RFQ. Pre-pumping will be carried out by one oil-free molecular pump (700 l/s). There is another oil-free molecular pump (100 l/s) and one ion pump (50 l/s) located at the side of the power coupler. The high vacuum test will be performed soon.

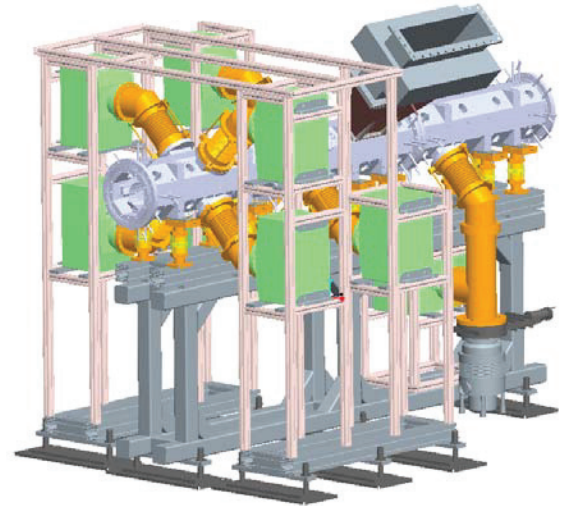

Figure 5: Layout of the high-vacuum system.

RFQ COOLING SYSTEM AND LOW LEVEL CONTROL

Two cooling units are ready for the CPHS RFQ. One serves for the cooling of all the vane tips, 32 tuners and the end flanges. The other is for the cooling of the wall inside, 15 tuners, 8 vacuum flanges and the power coupler. The total consumption of the cooling water will be about 770 l/min. The field amplitude will be monitored through five pickups, which are located in the middle of five tuners. The low level RF phase will be monitored and controlled via the EPICS database through Ethernet [5].

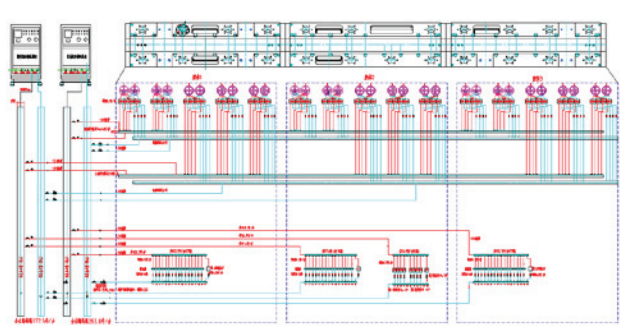

Figure 6: Layout of the cooling system.

BEAM DIAGNOSTICS

At the exit of the CPHS RFQ, the beam current will be measured by one ACCT and one faraday cup. Then the transmission rate can be obtained. One set of TOF will be adopted in the HEBT to measure the beam energy. Measurement of the maximum inter-vane voltage is planned by the characteristic X-ray emissions [6], as shown in Fig. 7. The glass vacuum window is at the right side with the gate valve between the window and the RFQ.

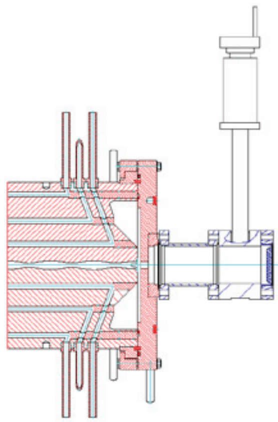

Figure 7: Setup of the measurement of the maximum inter-vane voltage.

ION SOURCE & LEBT/HEBT STATUS

The ECR proton source (2.45 GHz, 1.5 kW) and the LEBT are under conditioning to deal with the sparking problem, as shown in Fig. 8. The typical phase space and proton pulse measured at the end of the LEBT are presented in Fig. 9. The measurement position is not at the entrance of the RFQ exactly. Therefore, the transverse profile is larger than expected. The maximum output proton beam reaches 60 mA.

As shown in Fig. 10, the target station is now being built. The magnets for the HEBT are ready for alignment. One uniform round beam spot with the diameter of 5 cm on the target is designed.

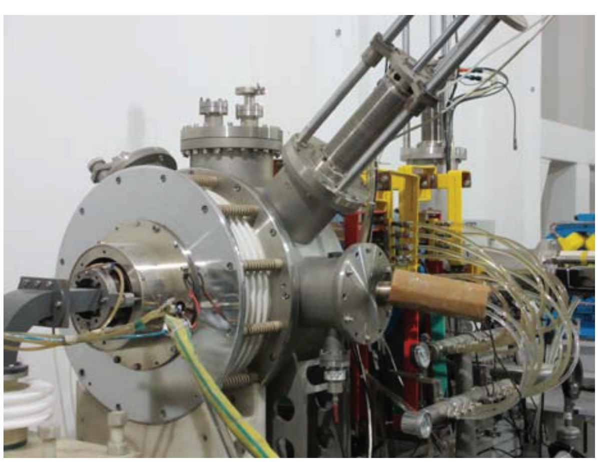

Figure 8: ECR proton source and LEBT.

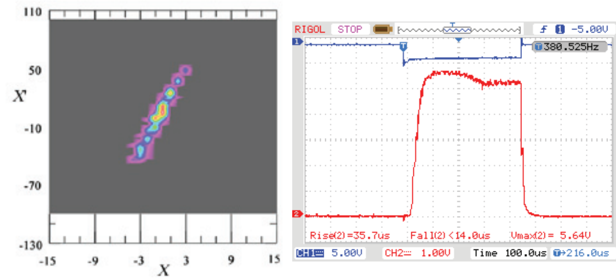

Figure 9: Phase space (left) and proton pulse measured at the end of the LEBT.

Figure 10: HEBT and the target station.

ACKNOWLEDGMENT

Special thanks should be given to Shanghai Institute of Applied Physics for the help in the field tuning. This work has been supported by the “985 Project” of the Ministry of Education of China.

REFERENCES

[1] J. Wei, et al., “The Compact Pulsed Hadron Source Construction Status”, IPAC’10, Kyoto, May 2010, MOPEC071, p. 633 (2010), http://www.JACoW.org

[2] Q.Z. Xing, et al., “Design of the CPHS RFQ Linac at Tsinghua University”, IPAC’10, Kyoto, May 2010, MOPD047, p. 792 (2010), http://www.JACoW.org

[3] Q.Z. Xing, et al., “Development of the 3MeV RFQ for the Compact Pulsed Hadron Source at Tsinghua University”, LINAC’10, Tsukuba, September 2010, TUP046, p. 509 (2010), http://www.JACoW.org

[4] Q.Z. Xing, et al., “Construction Status of the CPHS RFQ at Tsinghua University”, IPAC’11, San Sebastian, September 2011, MOPC024, p. 122 (2011), http://www.JACoW.org

[5] Q. Du, et al., “Control and Timing System Design of CPHS”, PCaPAC’10, Saskatoon, October 2010, WEPL025, p. 79 (2010).

[6] G.O. Bolme, et al., “Measurement of RF Accelerator Cavity Field Levels at High Power from X-ray Emissions”, LINAC’90, Albuquerque, September 1990, p. 219 (1990).

[7] L. Young, “Tuning and Stabilization of RFQ’s”, LINAC’90, Albuquerque, September 1990, p. 530 (1990).

ISBN 978-3-95450-115-1