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DEVELOPMENT PROGRESS OF THE H^+/H^- LINEAR ACCELERATORS AT TSINGHUA UNIVERSITY*

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Abstract

We present, in this paper, the development progress of the 13MeV proton linac for the Compact Pulsed Hadron Source (CPHS), and the 7MeV H^- linac injector for the synchrotron of the Xi'an 200MeV Proton Application Facility (XiPAF).

INTRODUCTION

One proton and one H^- linear accelerators are being constructed. The Compact Pulsed Hadron Source (CPHS) project is aimed at becoming an experimental platform for education, research, and innovative applications at Tsinghua University. The facility will provide the proton beam, together with the neutron beam by delivering the proton beam to bombard the beryllium target. The designed parameters for the proton beam is 13 MeV/50 mA with the pulse length of 500 μs and repetition rate of 50 Hz [1][2]. The Xi'an 200MeV Proton Application Facility (XiPAF) project was launched in the year of 2014 for the research of the single event effect. The facility is mainly composed of one 7 MeV H^- linac injector, one 200 MeV six-fold synchrotron and two experimental stations. The designed parameters for the H^- beam of the linac injector is 7 MeV/5 mA with the pulse length of 10-40 μs and maximum repetition rate of 0.5 Hz [3].

13 MeV PROTON LINAC FOR CPHS

CPHS project consists of a high-current proton linac (13 MeV, 16 kW, peak current 50 mA, 0.5 ms pulse width at 50 Hz), a neutron target station, a small-angle neutron scattering instrument and a neutron imaging/radiology station. The accelerator system consists of the 50 keV ECR Ion Source (IS), Low Energy Beam Transport line (LEBT), 3MeV four-vane Radio Frequency Quadrupole (RFQ) accelerator, 13 MeV Alvarez-type Drift Tube Linac (DTL), RF power supply and distributor, and High Energy Beam Transport line (HEBT). Figure 1 presents the latest layout of the linac of the compact pulsed hadron source.

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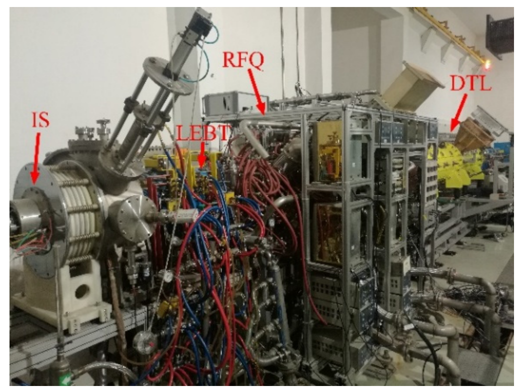

Figure 1: Layout of the linac of the compact pulsed hadron source.

CPHS has provided ~2000 hrs beam time since 2013 to the users with the neutrons produced by the 3 MeV proton beam from the RFQ bombarding on the beryllium target [4]. The application of the neutrons mainly consists of the neutron imaging [5], and the test of the neutron detectors including the B_4C-coated straw-tube [6] and the gadolinium-doped micro-channel plate (MCP) [7].

DTL

The 4.3-meter-long Alvarez-type DTL accelerates the 3 MeV proton beam to 13 MeV. The final tuning of the DTL cavity is completed and it is being installed in the beam line (Fig. 2).

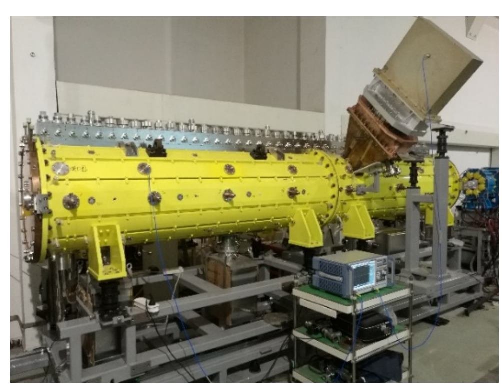
Figure 2: Assembled CPHS DTL for RF measurement.

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Figures 3 and 4 illustrate the field distribution of the DTL cavity and the tilt sensitivity after the final tuning, respectively. The relative error of the field between the designed and measured distribution is within 1.6%, and the tilt sensitivity is tuned to be within ±33%/MHz in all cells.

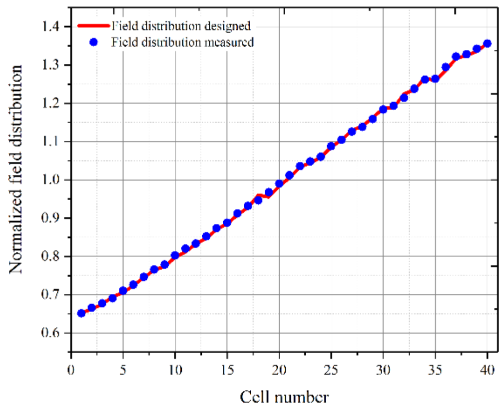

Figure 3: Field distribution of the CPHS DTL after the final tuning.

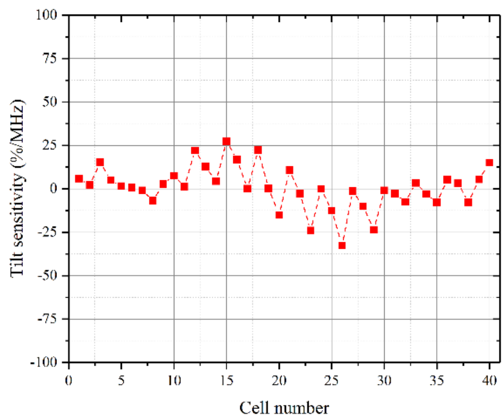

Figure 4: Tilt sensitivity of the CPHS DTL after the final tuning.

RF Power System

The DTL will share with the RFQ the same klystron, which can supply the peak RF power of 3.0 MW with a maximum duty factor of 3.33%. The RF transmission system is being installed, as shown in Fig. 5.

Figure 5: RF power system for the CPHS RFQ and DTL.

7 MeV H$^-$ LINAC INJECTOR FOR XiPAF

The 7 MeV H$^-$ linac injector for the synchrotron of the XiPAF project is composed of the 50 keV H$^-$ ECR source, LEBT, 3 MeV four-vane RFQ accelerator, 7 MeV KONUS-IH-DTL, and the corresponding RF power source system.

ECR Ion Source

The H$^-$ source has been assembled as in Fig. 6 and the maximum current of 5.8 mA has been measured by the Faraday cup at the exit of the source (Fig. 7).

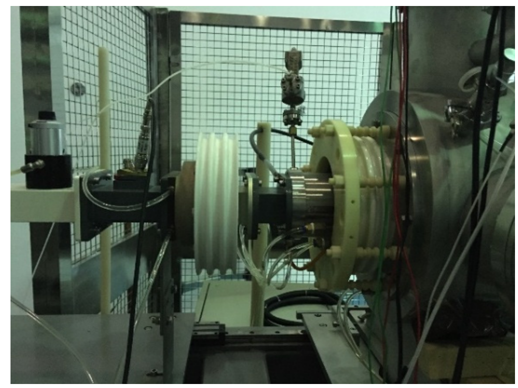

Figure 6: Assembled H$^-$ ECR source at site for XiPAF.

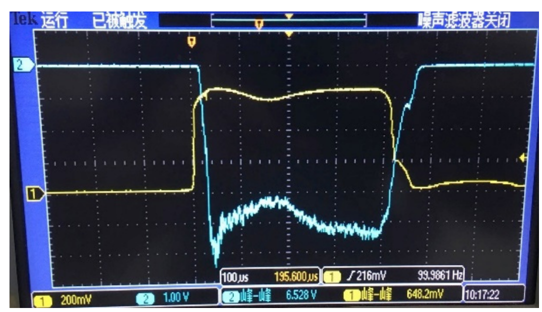

Figure 7: Beam current measured by the Faraday cup at the exit of the H$^-$ source.

LEBT

The LEBT will steer and match the beam from the ion source to the RFQ by two solenoids and two steering magnets. The LEBT has been assembled and is under beam conditioning (Fig. 8).

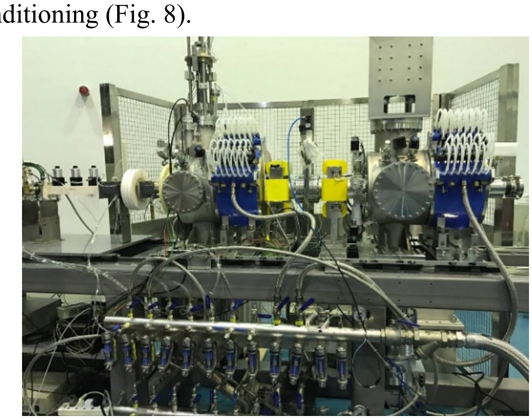

Figure 8: Assembled XiPAF LEBT at site.

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RFQ

The four-vane RFQ has been assembled (Fig. 9) and tuned. The relative error between the measured field distribution and the designed curve for the operating quadrupole mode is within ±2.7%, and the dipole component is within ±1.9%, as shown in Fig. 10.

Figure 9: Assembled XiPAF RFQ for the tuning.

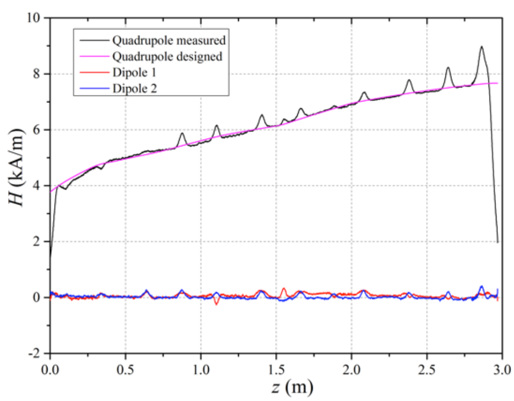

Figure 10: Field distribution of the quadrupole and dipole modes after the tuning.

IH-DTL

The machining of the one-meter-long KONUS-IH-DTL cavity has been completed and the cavity is under tuning. Figure 11 shows the central frame of the cavity.

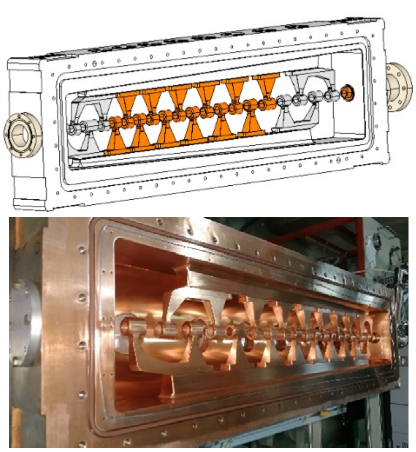

Figure 11: Central frame of the IH-DTL cavity.

RF Power System

The RFQ and DTL will be powered by two 4616V4 tetrode amplifiers. The RF power source has been assembled and successfully produced RF power for 8 hrs at 325 MHz with a peak power up to 500 kW, a repetition rate of 1 Hz, and a pulse width of 150 µs (Fig. 12).

Figure 12: Tetrode-based RF system at site for XiPAF.

CONCLUSION

The assembly of the 13 MeV H^+ linac for CPHS and the 7 MeV H^- linac injector for XiPAF is expected to be completed in this year and the beam conditioning and commissioning are foreseen.

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