# DEVELOPMENT PROGRESS OF THE 7MeV LINAC INJECTOR FOR THE 200MeV SYNCHROTRON OF XI'AN PROTON APPLICATION FACILITY*

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*Abstract*

We present, in this paper, the development progress of the 7MeV Linac for the 200MeV synchrotron of the Xi'an Proton Application Facility (XiPAF). The 7 MeV linac injector is composed of the 50 keV negative hydrogen ion source, Low Energy Beam Transport line (LEBT), 3 MeV four-vane type Radio Frequency Quadrupole (RFQ) accelerator, 7 MeV Alvarez-type Drift Tube Linac (DTL), and the corresponding RF power source system. The 2.45 GHz microwave-driven Cesium-free Electron Cyclotron Resonance (ECR) source and LEBT will be commissioned in this year, and the peak current of the extracted H- beam at the exit of the LEBT is expected to be 6 mA, with the output energy of 50 keV, maximum repetition rate of 0.5 Hz, beam pulse width of 10~40 µs and normalized RMS emittance of less than 0.2 π mm•mrad. Furthermore, the construction status of the RFQ accelerator and DTL accelerator will be presented in this paper.

## INTRODUCTION

One 7 MeV $H^-$ linac injector is under construction for the 200 MeV synchrotron in the project of Xi`an Proton Application Facility (XiPAF) [1]. The parameter requirement of the linac injector is presented in Table 1.

Table 1: Requirement of the Linac Injector for XiPAF

| Parameter | Value | Unit |
|---|---|---|
| Ion type | H- | |
| Beam energy | 7 | MeV |
| Peak current | 5 | mA |
| Maximum repetition rate | 0.5 | Hz |
| Beam pulse width | 10~40 | µs |
| Normalized RMS emittance | <0.24 | π mm•mrad |

The 7 MeV linac injector is composed of the 50 keV negative hydrogen ion source, Low Energy Beam Transport line (LEBT), 3 MeV four-vane type Radio Frequency Quadrupole (RFQ) accelerator, 7 MeV Alvarez-type Drift Tube Linac (DTL), and the corresponding RF power source system. Main parts of the 2.45 GHz microwave-driven Cesium-free Electron Cyclotron Resonance (ECR) source and the LEBT have been manufactured and planned to be commissioned in the next half year of 2017. Mechanical design of the RFQ accelerator has been accomplished and the machining will be started in one month. Mechanical design of the drift tubes and cavity of the DTL accelerator has been finished while the auxiliary systems including the supporting system and cooling system are under design.

## ECR ION SOURCE

The discharge chamber of the ECR ion source has been manufactured and tested successfully at Peking University. Figure 1 shows the main part of the ECR ion source. The measured pulse of H- ion is presented in Fig. 2.

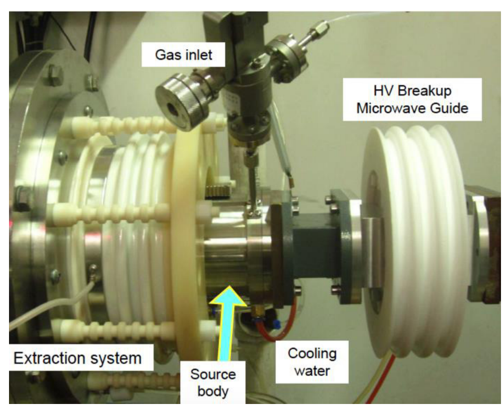


Figure 1: Main part of the ECR ion source for XiPAF.

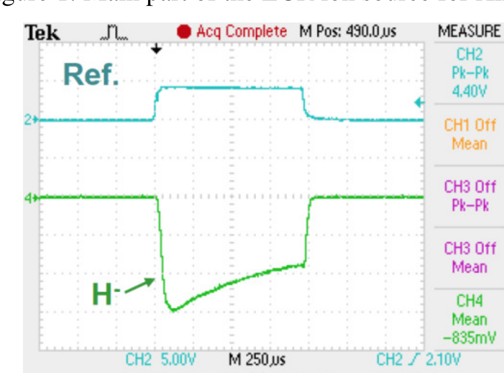


Figure 2: H- pulse profile measured at Peking University.

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With the RF power of 2.8 kW, beam pulse width of 1 ms, repetition rate of 100 Hz, extraction voltage of 50 kV, the current of the $H^-$ beam reached 12.4 mA. The measured normalized RMS emittance was 0.16 π mm•mrad.

## LOW ENERGY BEAM TRANSPORT LINE

The LEBT has been designed to match the beam and obtain the designed current of 6 mA at the entrance of the RFQ accelerator [2]. The two solenoids, two steering magnets and two chambers have been manufactured and assembled at Tsinghua University (Fig. 3). The excitation curve and the magnetic field distribution have been measured. Figure 4 shows the comparison of the simulation result of the longitudinal magnetic field on the mechanical axis for solenoid 1 and 2 with the corresponding measurement result. The relative error of the field integration along the longitudinal axis between the simulation and measurement result is less than 2%.

Figure 3: XiPAF LEBT section.

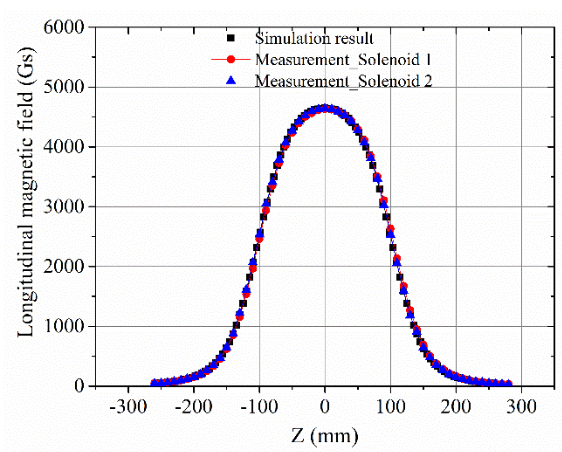


Figure 4: Simulation and measurement result of the longitudinal magnetic field on the longitudinal axis of Solenoid 1 and 2.

To guarantee that the first-order intrinsic frequency of the supporting system is not less than 30Hz, a simplified model has been set up and simulated by the ANSYS code, as shown in Fig. 5. The supporting structure has been machined according to the guaranteed model.

Figure 6 shows the full 3D layout of the ion source and LEBT for XiPAF. The whole system will be assembled and commissioned in the next half year.

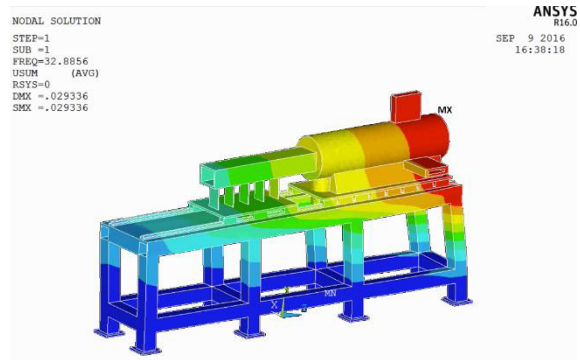


Figure 5: Simulation of the supporting system for LEBT.

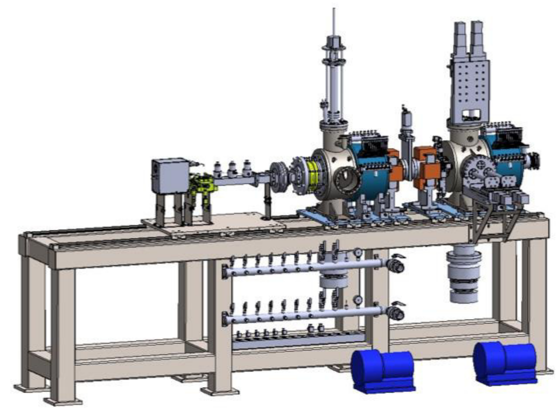

Figure 6: 3D layout of the ion source and LEBT.

## RFQ ACCELERATOR

The 3-meter-long four-vane Radio Frequency Quadrupole (RFQ) will accelerate $H^-$ from 50 keV to 3 MeV at an RF frequency of 325 MHz. Mechanical design of the RFQ accelerator has been accomplished (as shown in Fig. 7) and the machining will be started in one month.

Figure 7: 3D layout of the RFQ accelerator.

Two coaxial couplers for the RFQ accelerator has been machined. The couplers have been designed to afford at least 300 kW in maximum at 325 MHz with the RF pulse width of 150 μs [3]. To fulfil the need of the high power conditioning, a cavity has been prepared, as illuminated in Fig. 8.




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Figure 8: RF test for the two couplers of the XiPAF RFQ.

## DRIFT TUBE LINAC

Mechanical design of the drift tubes and cavity of the DTL accelerator has been finished (Fig. 9). The first-order intrinsic frequency of the supporting structure of the DTL cavity, together with that of the RFQ cavity, has been verified. The Alvarez-type DTL will accelerate $H^-$ from 3 MeV to 7 MeV at an RF frequency of 325 MHz, with the twenty-three accelerating cells in one single cavity.

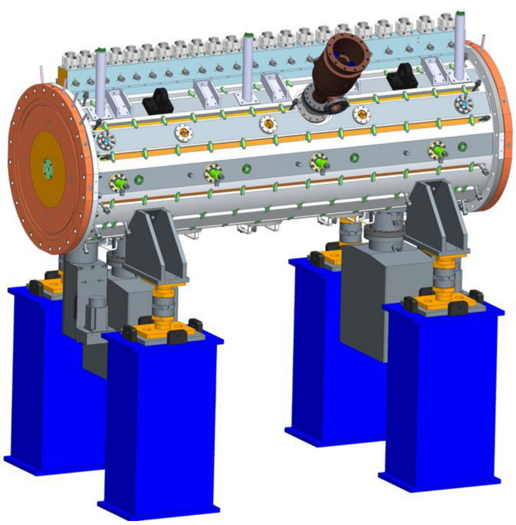

Figure 9: 3D layout of the DTL accelerator.

As the main parts of the DTL accelerator, the manufacturing progress of the drift tubes and the cavity will be proceeded while some auxiliary systems including the supporting system and cooling system are under design at the same time. The structure of the drift tubes are similar with that of the DTL linac for Compact Pulsed Hadron Source (CPHS), which is under construction at Tsinghua University aiming at providing 13 MeV proton beam and corresponding neutron beam to users [4]. The drift tubes for CPHS have been manufactured successfully (Fig. 10) and are expected to be aligned and mounted after the cavity is ready this year. Figure 11 shows the newly-machined drift tubes for CPHS mounted on one base plate.

Figure 10: Drift tube successfully manufactured for CPHS of Tsinghua University.

Figure 11: Drift tubes mounted on one base plate for CPHS.

The RFQ and DTL will be powered by two 4616V4 tetrode amplifiers. One of the amplifier has been conditioned to 500 kW/50 μs, with the target value of 500 kW/200 μs.

## CONCLUSION

Significant efforts have been placed on the construction of the 7 MeV linac injector for the project of Xi`an 200 MeV Proton Application Facility. The H- ion source and LEBT will be commissioned this year. Machining and assembling of the RFQ and DTL accelerators are expected to be accomplished in the next year.

## ACKNOWLEDGEMENT

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