6 - 9 CW Beam Test of the Injector II RFQ for ADS Project

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As one of the main components of the injector II of China ADS LINAC project, an RFQ working at 162.5 MHz is used to accelerate proton beams of 15 mA from 30 keV to 2.1 MeV. The four vane RFQ has been designed in collaboration with Lawrence Berkeley National Laboratory and built at the workshop of the Institute of Modern Physics, Chinese Academy of Sciences (IMP, CAS).

Low power test of the injector II RFQ was carried out after fabrication in a room with constant temperature which was 20 °C. All the tuners were inserted into the cavity by 20 mm before measurement, and in the initial condition the field flatness was within ±0.039 as the black line shown in Fig. 1. Due to the large number of tuners of the cavity a tuning program was developed to simplify the tuning procedure, and the field flatness reached ±0.015 after four times tunings of the tuners. The final field flatness was within ±0.01 (as the grey line shown in Fig. 1) by adjusting the two gaps sizes between the endplates and vanes. The cavity frequencies and Q value were measured after the tuning, and it showed the quadrupole frequency was 162.46 MHz and the adjacent dipole frequency was 183.4 MHz respectively, and the unloaded Q value was 12 600.

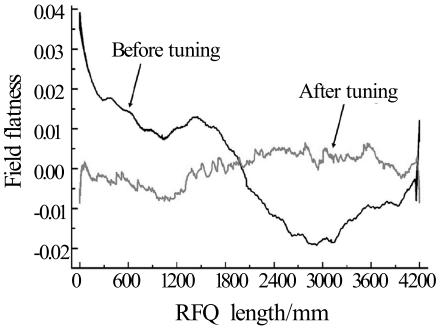

Fig. 1 Field flatness before and after tuning.

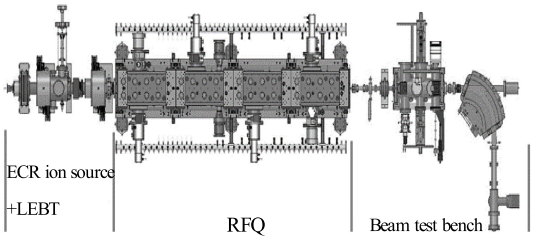

Fig. 2 The injector II RFQ acceleration system.

One set of RF system was used to provide RF power for the RFQ, which consisted of a RF amplifier of 200 kW, several segments of coaxial transmission lines, a power splitter, a phase shifter and two high power couplers. RF conditioning started with a CW power of about 2 kW and then was conducted hard because electric sparking happened frequently. Therefore, RF power in CW mode and pulse mode were fed into the cavity alternately, and it finally took one and a half month to reach the CW power of 92.7 kW which corresponds the cavity voltage of 65 kV that was calibrated by X-ray end point method. The RFQ acceleration system is shown in Fig. 2, which mainly includes an ECR ion source, a low energy beam transport (LEBT) line, the RFQ and a beam test bench. Two ACCTs (AC current transformer) located at the entrance and exit of the RFQ are used to measure the transmission efficiency, two BPMs (beam position monitor) in the test bench are used to measure the beam energy, and a dipole magnet is used to measure the beam energy spread.

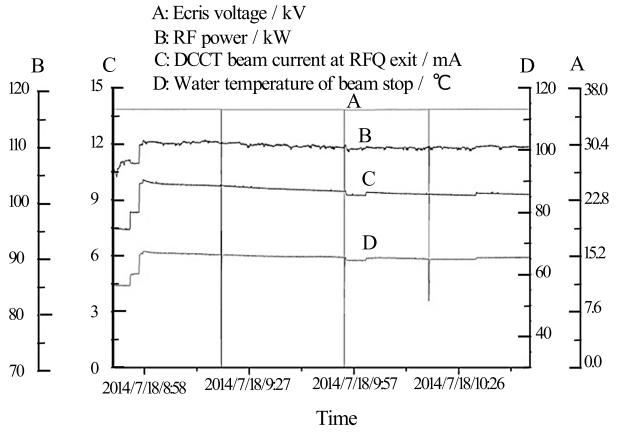

Fig. 3 Time record of acceleration of 10 mA beam.

The first acceleration of pulse beam was carried out at the beginning of June in 2014, and at the end of the month CW beam of 10 mA had been accelerated successfully for 4.5 h. Beam parameters of 10 mA were measured in June and July, and the results demonstrated that the transmission efficiency was 95.3%, output energy was 2.165 MeV, energy spread was 1.9%, horizontal and vertical emittances were all 0.33 πmm·mrad. All the parameters well meet the design specifications of the RFQ. Here, the time record of 2 h with 10 mA in July 18$^{\text{th}}$ is exhibited as shown in Fig. 3.