6 - 43 Status of Intense Proton Source for C-ADS Injector

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Two compact and intense 2.45 GHz permanent proton sources and their corresponding low energy beam transport(LEBT) systems were developed successfully for China Accelerator Driven Sub-critical system (C-ADS) in 2014, one of which was built at IMP, Lanzhou and the other at IHEP, Beijing. Both proton sources can deliver stable 10 mA/35 keV proton beams at CW mode to the entrances of the downstream RFQs. As shown in Fig. 1, the beams extracted by a 3-electrode extraction system are transported by the LEBT system, which is composed of 2 identical solenoids, and into the 3.2 or 2.1 MeV radio-frequency quadrupole (RFQ). In order to ensure superconducting cavities commissioning and protection, an electrostatic-chopper has been designed and installed in the LEBT line that can chop the cw beam into a pulsed one. The achieved fall/rise time of the chopper is less than 20 ns.

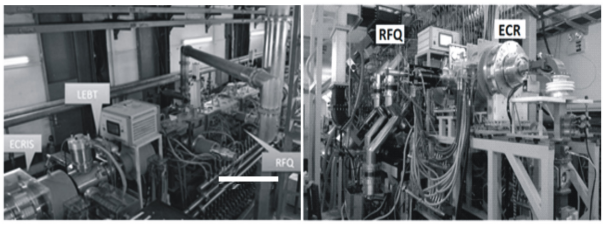

Fig. 1 (a) Layout of the low energy 2.1 MeV injector II at IMP, including ECR(left), LEBT and RFQ units.
(b) Layout of the low energy 3.2 MeV injector I at IHEP, including ECR, LEBT and RFQ units(right).

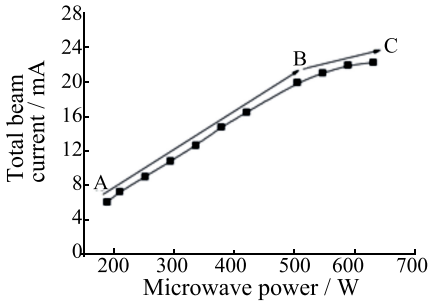

Fig. 2 Total hydrogen ion beam current versus input power.

At IMP, the ECR proton source and LEBT platform were operated as the injector of the 2.1 MeV RFQ from Jun. 6, 2014 to Jan.31, 2015. The ECR ion source can deliver proton beams with different duty factor by means of the microwave generator operated with pulsed mode or chopper unit into the RFQ. For the RFQ and superconducting cavities commissioning, the ECR ion source was operated for 837 h and met the requirements of the accelerators.

As shown in Fig. 2, as the source was operated in CW mode at 35 kV with an extraction hole of $\varnothing = 4.0$ mm, the total hydrogen ion beam current varied linearly with the input power (A-B) . The beam current increased from 6 to 20 mA with the input power increasing from 200 to 500 W. If the power is higher than 500 W, the increasing trend of the beam current with the increasing power becomes slow. For CADS injector I, the ECR ion source and RFQ was integrated at IHEP in May, 2014. Reliability and emittance of ECR ion source are key points to meet Injector I requirement and commissioning. For intense proton sources, spark occurred frequently between the electrodes due to high electric field and secondary electrons. To test the reliability of the ion source and its LEBT, a uninterrupted 15 h reliability test has been done with the beam energy of 40 keV and the current intensity of

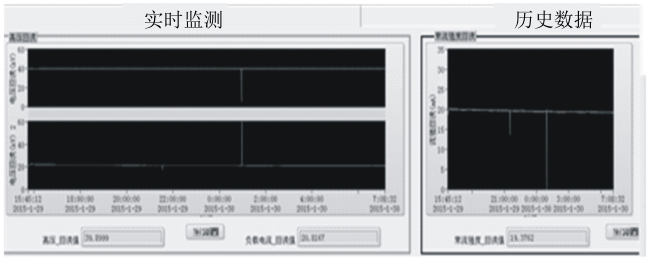

Fig. 3 Spark test for extracted beam 40 keV, 20 mA from LEBT downstream.

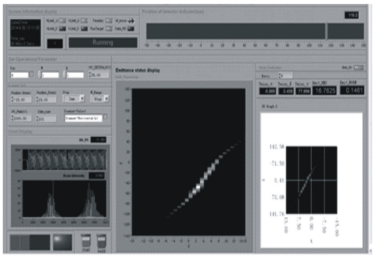

Fig. 4 Measured phase space distribution at beam energy of 35 keV, proton current of 11.3 mA.

20 mA at the exit of LEBT and the result is shown in Fig. 3. After a few hours' commissioning, the source and the LEBT ran for 15 h with one spark induced interval and the interval was shorter than 1 s. After the spark, the whole system recovered automatically. About 11.3 mA proton beam was measured at the test chamber-2 under vacuum of the order of 10^{-3} Pa in the beam line and the measured phase space distribution is shown in Fig. 4. Test results showed that the normalized rms emittance is 0.14 πmm·mrad and there is no aberration.