Recent Progress on Ion Source of SC200 Cyclotron

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Abstract A 200MeV compact superconducting cyclotron, named SC200, for proton therapy is under development by collaboration of ASIPP (Hefei, China) and JINR (Dubna, Russia). The ion source is a significant subsystem of the cyclotron. A hot cathode internal ion source has been designed and tested for SC200 cyclotron. The ion source has been successfully arc discharged on the test bench. The extracted beam current has been measured over 100 μA and filament lifetime of ion source exceeded 100 h, which indicated that the ion source meets the design requirements. The stability of the filament under strong magnetic field has also been tested and the differences between the two kinds of filament are compared.

INTRODUCTION

Per end of 2018 more than 220000 patients have been treated worldwide with particle therapy. The SC200 superconducting cyclotron for hadron therapy is under development by collaboration of ASIPP (Hefei, China) and JINR (Dubna, Russia). Superconducting cyclotron SC200 will provide acceleration of protons up to 200 MeV with maximum beam current of 400 nA in 2020. Internal ion source of PIG type will be used. The Penning ion source is perfectly suitable for the accelerator, as the structure of it is simple, compact, and discharging-efficient. The penning ion source produces plasma by heating cathode which will release thermoelectron. Under the effect of arc voltage electric field, the accelerated electron will collide hydrogen, then produces plasma. The proton of plasma will be extracted and then be accelerated to form proton beam.

EXPERIMENTAL PROCEDURES

We established a test bed to carry out experiment so as to verify the proper functioning of ion source. The structure is shown as below Fig. 1. It includes six sections: magnet system, vacuum system, water cooling system, power system, data-collecting system and gas injection system. We went to the high magnetic field laboratory of the Chinese Academy of Science and carried out repeated experiments under the 3T magnetic field generated by their equipment.

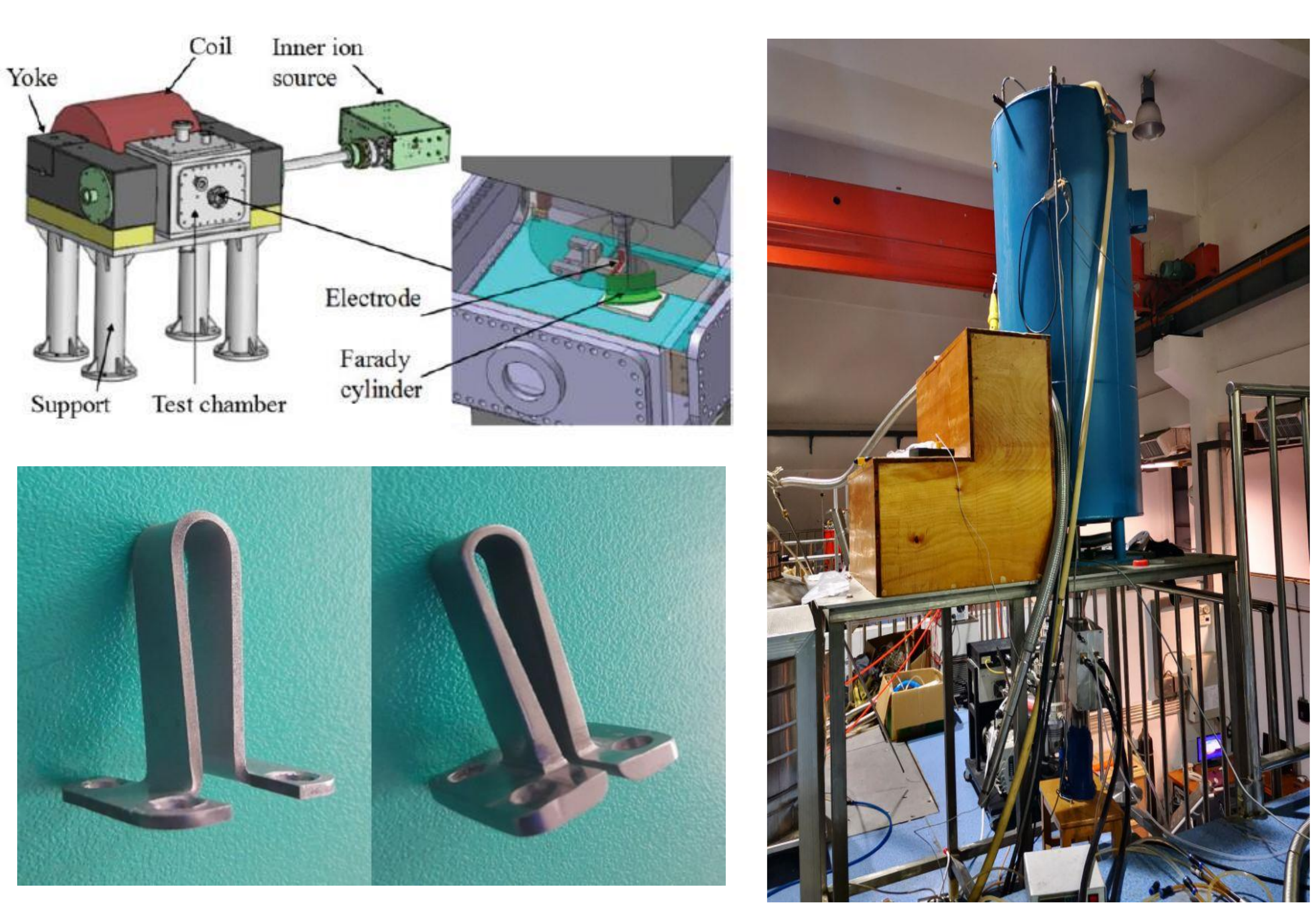

Figure 1. Fundamental structure of test bench and filament.

RESULT AND DISCUSSION

Figure 2(a) shows the value and variation trend of the measured arc current under different filament current. The other general conditions were: gas flow 2 sccm, magnetic field 1 T and arc voltage 170 V. A thick filament requires a larger filament current to produce the same amount of arc current as a thin filament. With the increase of filament current, arc current rises rapidly in both thick filament and thin filament.

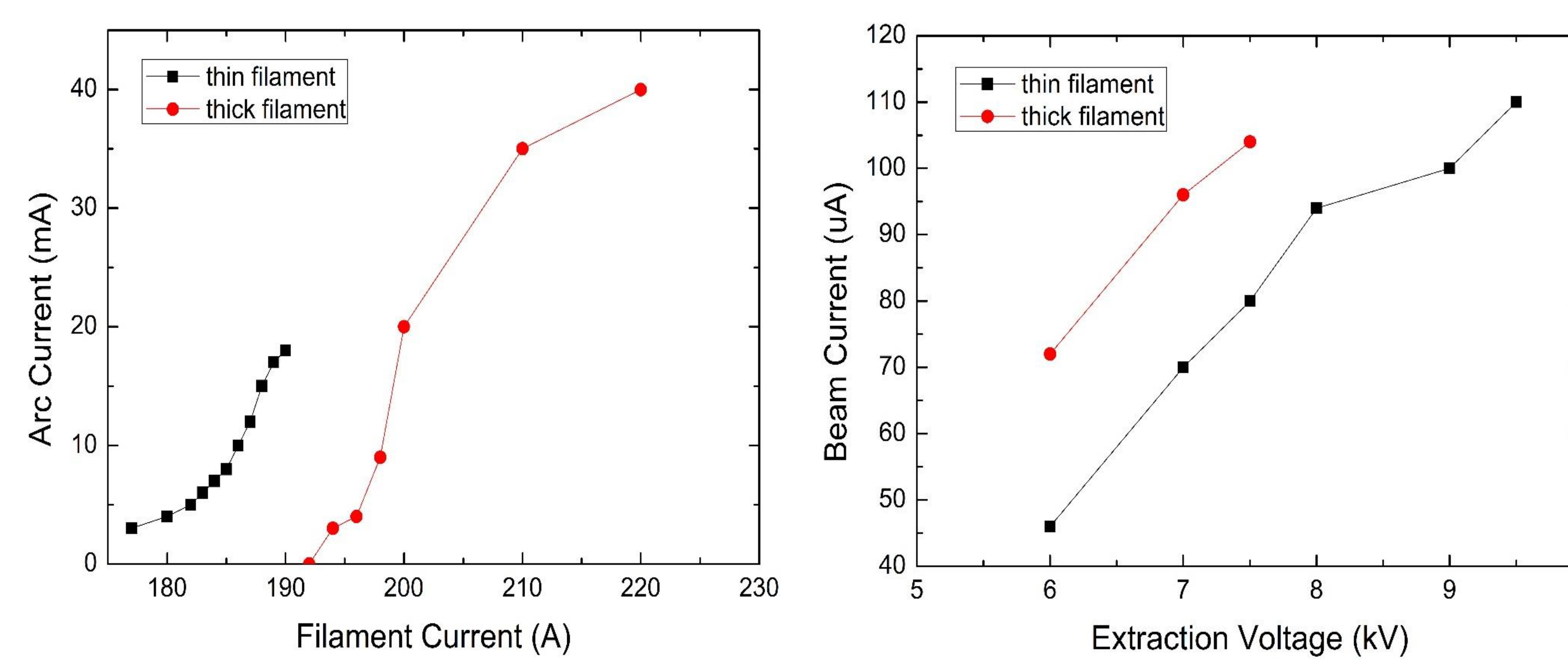

Figure 2 . (a) (b)

The extracted beam intensity at various extraction voltage was measured under a magnetic field of 1 T, an arc voltage of 170 V and a gas flow of 2 sccm. The results are shown in Fig. 2(b). The thin filament current is set to 175 A, while the thick filament current is set to 215 A. With a current of more than 100 μA, we chose the thin filament as the final filament of our ion source, which will reduce the load on the filament power supply. In addition, high current will cause permanent damage to the filament and more easily cause the filament to break. Figure 3 shows that the discharge is extremely stable for 1 h and the beam extraction for 0.5 h. The beam extraction strength exceeds the accelerator requirement of 100 μA.

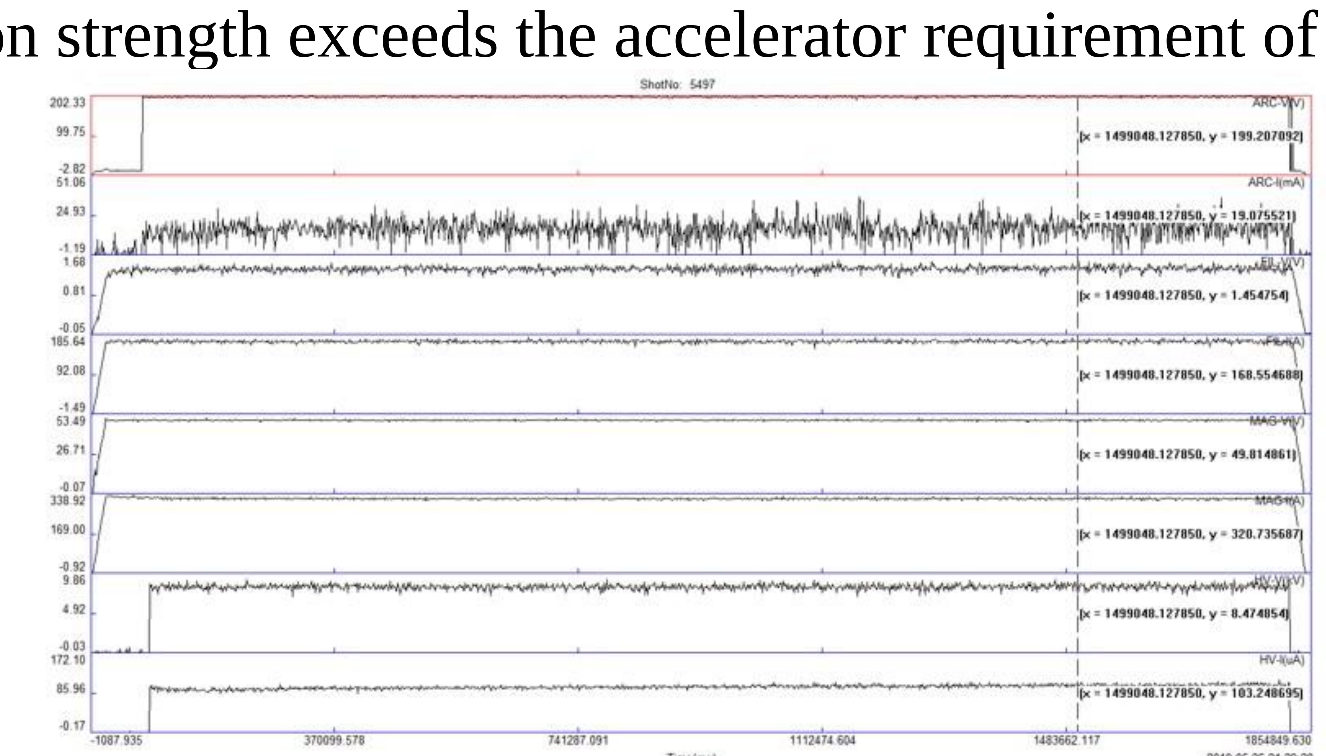

Figure 3. Waveform collected of the stable ion source discharge.

Conclusion

The hot cathode Penning inner ion source plays a very important role for the whole proton superconducting cyclotron system. The results obtained on our test bench confirm that the structure and operation state of the designed ion source is suitable for long pulses at high beam current. Thin filament can well meet the design requirements of the SC200 cyclotron. After extensive testing, the ion source is capable of generating beams of more than 100 μA and of stable operation for a long time. The integrated commissioning of the SC200 cyclotron will begin at the end of this year. The ion source will then be tested with other subsystems.