DEVELOPMENT OF CW HEVY ION LINAC AT IMP

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29th Linear Accelerator Conference

Spetember16-21,2018
Beijing | China

Abstract

A new heavy ion linac as the injector for the Separated Sector Cyclotron (SSC), named SSC-Linac, is being under constructed at the national laboratory Heavy Ion Research Facility in Lanzhou (HIRFL). The SSC-Linac mainly consists of a 4-rod RFQ and three IH-DTL cavities which can accelerate ion of $A/q \leq 7$ from 3.73 keV/u to 1.025 MeV/u. Both of them operating at 53.667MHz had been developed. In the commissioning, ions were successfully accelerated to 0.295 MeV/u by IH-DTL1. The beam commissioning of the IH-DTL2 which can accelerate the ion to 0.586 MeV/u will come soon. In this presentation, the recent R&D progress of the SSC-Linac including the development of key components and the beam commissioning results are presented.

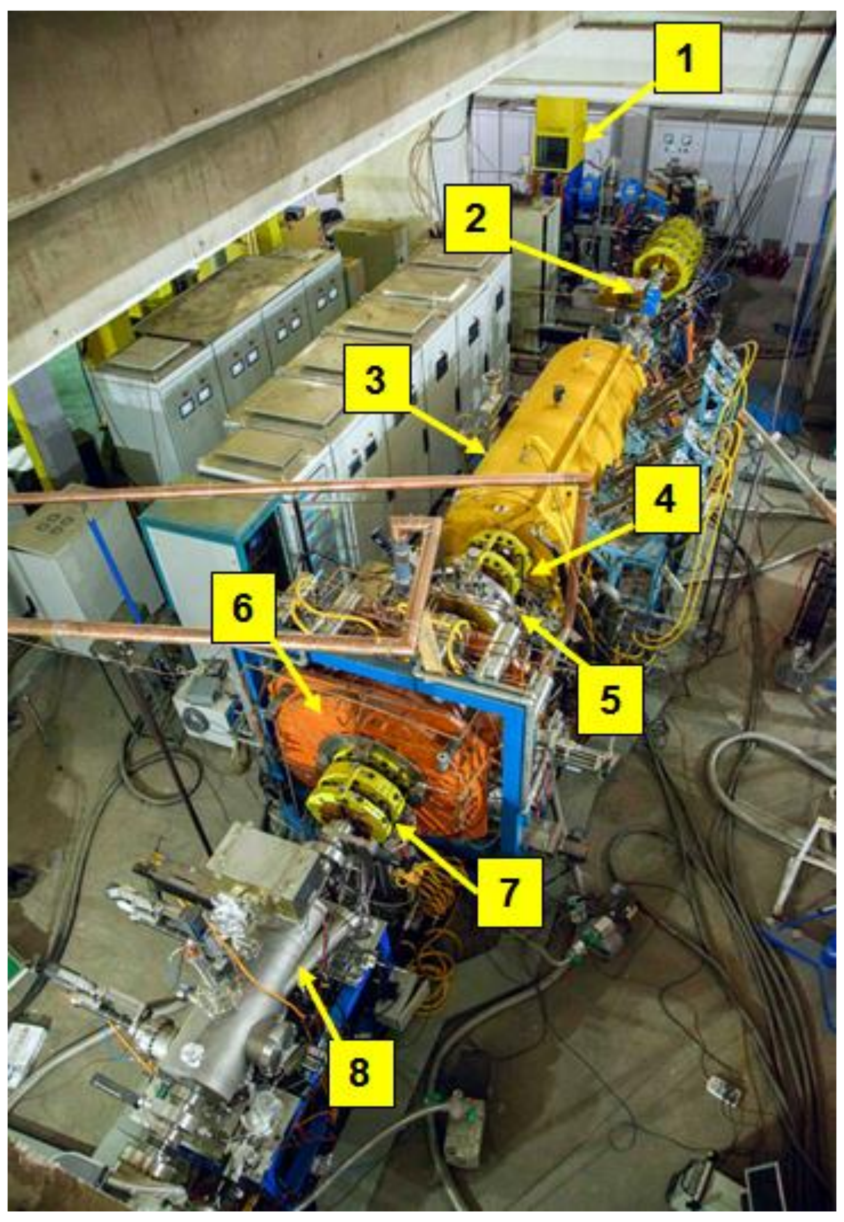

Figure 1:General view of the SSC_Linac front end

As the main part of the upgrade project of HIRFL, a new heavy-ion linac which operated at Continuous Wave (CW) mode was designed and constructed as the injector for the SSC. The main design parameters of SSC-Linac was listed in Table 1. There are two stages for the energy upgrade project. In the first stage, the ion particles will be accelerated to 0.586 MeV/u using two IH-DTL cavities. And then they will be further injected and accelerated to 6 MeV/u by the SSC facility. In the second stage, the particle will be accelerated to 1.025 MeV/u by adding the DTL3. Finally, the particles will be accelerated to 10.7 MeV/u also by the SSC facility. Fig. 1 shows the layout of the front end section of the SSC-Linac.

Figure 1: General view of the SSC-Linac. 1-ECR ion source; 2-LEBT section; 3-RFQ; 4-MEBT section; 5- Re-buncher cavity; 6- IH-DTL1; 7-Foucsing triplets; 8-Beam diagnostics system.

Tabl 1: SSC_Linac main parameters

Design ion	$^{238}U^{34+}$
ECR ion source	
Extraction voltage	25kV
Mass analyzer	90° dipole magnet
Frequency	18GHz
Focusing element	solenoid
RFQ	
Type	4-rod
Frequency	53.667MHz
Input energy	3.728keV/u
Output energy	143keV/u
Inter-electrode voltage	70kV
RF power	35kW
Max.current	0.2emA
Operation mode	CW
Length	2.52m
Max.modulation	1.996
IH-DTL	
Frequency	53.667MHz
Input energy	0.143MeV/u
Output energy	1.025MeV/u
Length	4.4m
Operation mode	CW

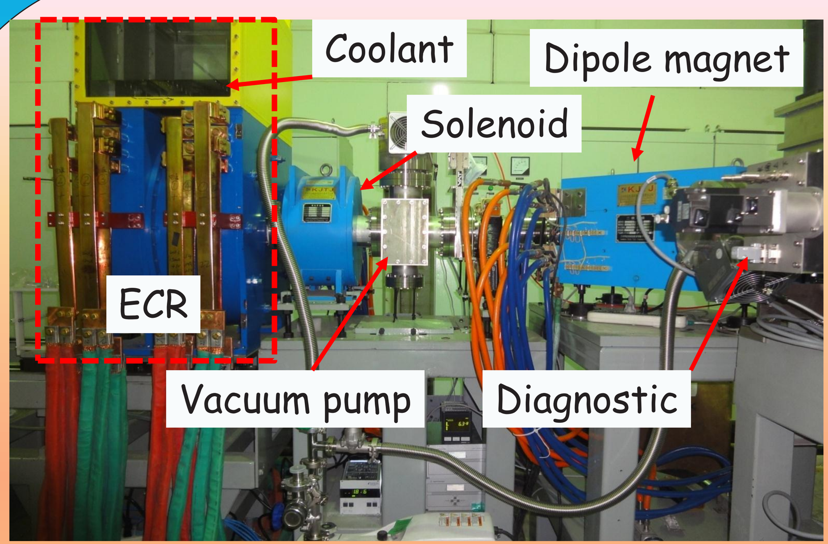

Figure 2:ECR ion source

The high charge state room temperature ECR Ion Source has been developed. This source magnet coils are cooled through evaporative cooling technology. The maximum mirror field is 2.3T (with iron plug) and the effective plasma chamber volume is Ø76mm×260mm.

The transverse emittances were measured by the emittance scanners located at downstream of the dipole magnet. The measured normalized rms emittances at 200eμA beam current for $^{16}O^{5+}$ were πmm·mrad and 0.15πmm·mrad in horizontal and vertical plane, respectively.

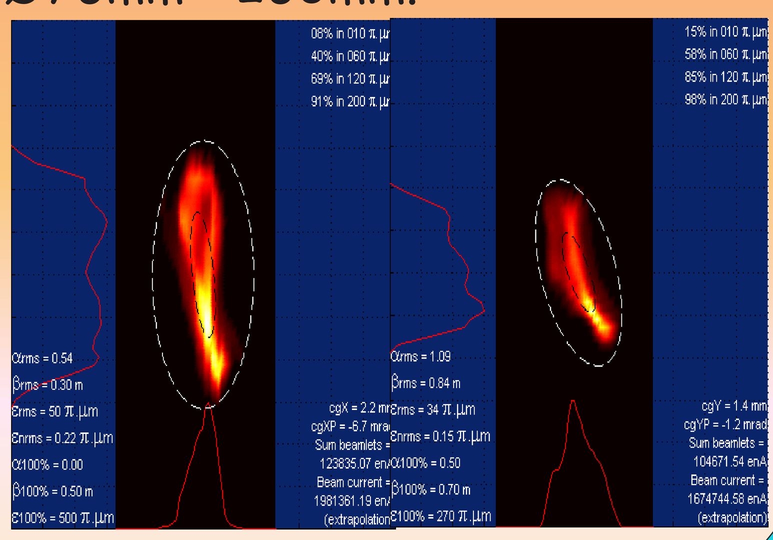

Figure 3:Measured transverse emittance

CW 4-rod RFQ had been developed under the successful cooperation between Peking University and IMP as shown in Fig.4. The first beam ($^{16}O^{5+}$) 149.5eμA was successfully accelerated to 141.9 keV/u in April 2014. The beam energy was measured using the time of flight (TOF) method with two FCTs installed after the RFQ exit.

Figure 4:CW 4-ROD RFQ

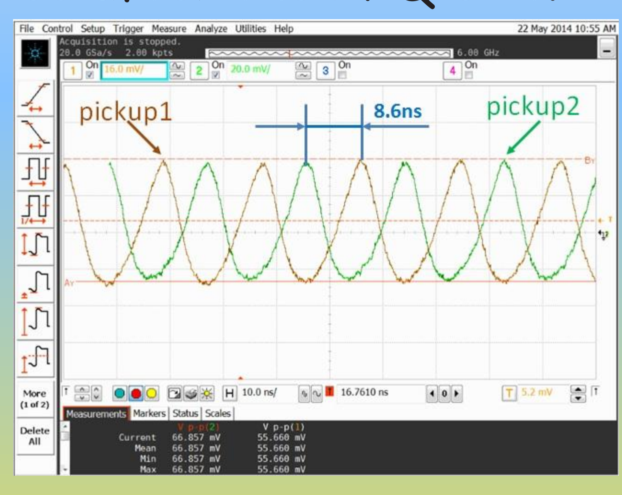

Figure 5:Beam single detected by FCTs

The distance of two FCTs is 240.7mm and the corresponding time of flight is 8.6ns. Figure 5 shows the $^{40}Ar^{8+}$ ion beam signals detected by FCTs. With the 94% transmission, the measured beam energy and beam current are 142.8±0.21keV/u and 198eμA, respectively

Figure 6: The second IH-DTL cavity

In the final design, the high energy section of the SSC-Linac adopted three IH-DTL cavities insteading origin design within four cavties and obtaining the same energy. At the same time, the total linac length was shorten 1.3m. The first cavity DTL1(295keV/u) had been installed and beam commissioning was successfully. The second cavity DTL2(586keV/u) will come soon for beam commissioning as shown in Fig.6.

Figure 7 shows the measured transverse emittances at DTL1 exit. The measured transverse normalized rms emittances were 0.18πmm·mrad and 0.14πmm·mrad in horizontal and vertical plane, respectively. Both of them were in good agreement with the simulation results. After then, more beam test were carried out using some other spiece ions such as $^{12}C^{4+}$, $^{40}Ar^{8+}$, $^{209}Bi^{30+}$.

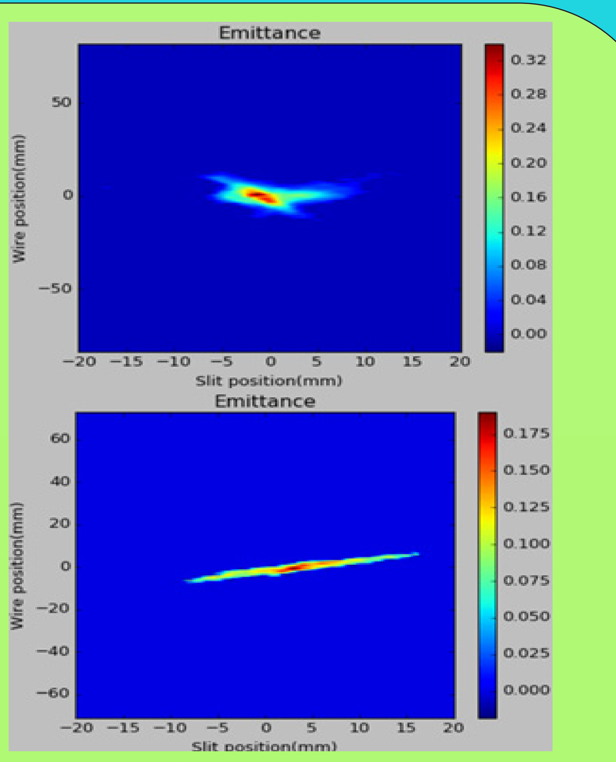

Figure 7: Measured transverse emittances at DTL1 exit.

SUMMARY: The front end section of the SSC-Linac has been fabricated and commissioned successfully with various specie ions. The measured particle energy was in good agreement with design value. But he match input would be studied carefully for improving the beam transmission efficiency. Furthermore, the higher power conditioning and beam commissioning of IH-DTL2 will be carried out in the near future.