Operating experience with the laser ion source relevant the HIF application

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Since March 2014, a laser ion source (LIS) has been used to provide high brightness low charge state heavy ion beams for regular routine operation of the hadron accelerator complex in Brookhaven National Laboratory (BNL)[1]. The peak current and pulse width of the typical beams from the LIS are several hundreds of microampere and about 200 microseconds, respectively. Of course, these specifications cannot be directly applied to the HIF. However, only by reducing the plasma drift distance to one tenth, the beam current and pulse width will become 1000 times and 1/10 respectively and these values are not far from the HIF's requirements. Therefore, it would be useful to discuss some operational difficulties and to investigate what should be improved in the existing LIS in BNL toward the HIF application.

The LIS, nicknamed as "LION," was designed to provide multiple ion species to the electron beam ion source (EBIS) where the charge state of the injected ions are multiplied to meet the acceptance of successive linear accelerator chain ($q/m > 6$)[2]. The front-end radio frequency quadrupole (RFQ) accelerates the beams up to 300 keV/u and the following interdigital π mode linear accelerator (IH-LINAC) increases the energy to 2.0 MeV/u. Then, by passing a 275 degree bending section, the undesired charge state beams are scraped and the only purified beams are injected to the booster synchrotron which accelerates the beams around 1 GeV/u. The accelerated beams are guided to two destinations, NASA space radiation laboratory (NSRL) and relativistic heavy ion collider (RHIC). The NSRL requires various species to simulate the cosmic rays and operates in day time. The RHIC accelerate gold beam provided through alternating gradient synchrotron (AGS). The RHIC runs 24 hours for 6 months a year for gold ions from the LIS and protons from the optically pumped polarized ion source (OPPIS). Therefore, the LIS is intensively used to provide heavy ions to two user facilities simultaneously.

Through the long time none stop operation of the LIS, we have experienced some troubles including mechanical failures of the motorized target scanner, built up debris on the vacuum window for the laser beams, suspected accretion on the beam extraction electrodes and energy degradation of the laser systems. Those occurrences were investigated and the structure of the LIS was updated.

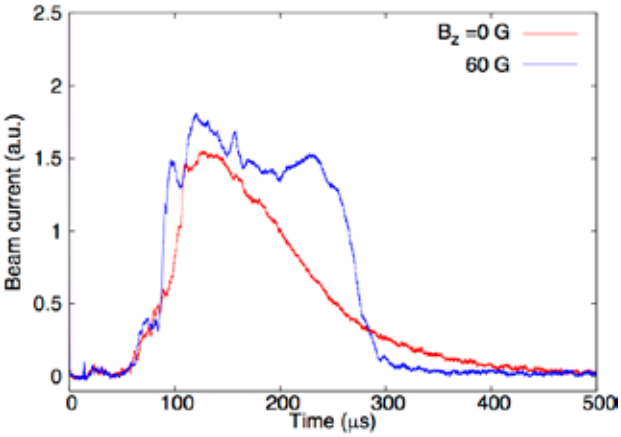

Figure 1. Beam current profile of Fe^{1+} from the LION. The red curve shows the original shape due to thermal distribution in the ablation plasma and the blue curve indicates the modified profile by the pulsed coil.

In addition, recently we have tested a pulsed solenoid in the LIS. This is the new device to tailor the beam current profile. As shown in Figure 1, we could obtain a flat top beam by applying pulsed magnetic field. It is very important to achieve constant current with the minimized variation of the beam emittance.

In the conference, we will explain the details of the difficulties and discuss how we approach to the ideal laser ion source for the HIF application.

References

[1] Kanesue, T. et al. (2014) Proc. IPAC2014, WEAB01
[2] Alessi, J. et al. (2010) Rev. Sci. Instrum. 81, 02A509