Commissioning of the Laser Ion Source for RHIC EBIS †

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The electron beam ion Source (EBIS)-based heavy ion preinjector (RHIC-EBIS) served for RHIC and NASA Space Radiation Laboratory (NSRL) at Brookhaven National Laboratory (BNL)[1]. The NSRL is a facility that simulates the effect of galactic cosmic radiation (GCR), which consists of highly energetic heavy ions of various kinds in space. The RHIC-EBIS is required to provide fast switching between heavy-ion species for this purpose. A new laser ion source (LIS), named "LION," is funded by NASA to expanding the range of ion species available for fast switching. Fast switching can be accomplished by switching the laser-irradiation position on different target materials[2,3].

LION consists of a high-power pulsed laser, a target chamber, a 3-m-long plasma drift region with a solenoid magnet, and an extraction chamber. The ion extraction voltage may be up to 40 kV. The laser is equipped with two identical Q-switched Nd:YAG laser oscillators (850 mJ/6 ns at FWHM, 1062 nm wavelength). A built-in laser combiner merges the two laser beams into one laser path to aim at the same position. The laser is focused on a solid state target plate. The laser spot on the target is 5 mm in diameter. Different laser energies in the range 500 ~ 700 mJ is used depending on the species to achieve singly charged ions. In a target chamber, several targets are held on a tungsten target holder, as shown in Fig.1, which is mounted on an x-y linear stage. The stage allows the laser to irradiate different positions on different target materials. The solenoid magnet is used to reduce the diverging angle of the expanding plasma. The typical magnetic field to be used is only several Gauss. With this drift length, an ion beam with a pulse width of a few hundred microseconds is achieved.

The commissioning of the beam was started on March 7, 2014 with an Fe target. LION was isolated from the EBIS beam line to prevent RHIC gold run as a precaution. The platform voltage was set to 12 kV for the first beam test. The Fe beam extracted from the LION was very close to what we expected. No breakdown caused by the generated plasma was observed.

From March 14, the operation mode of EBIS was adjusted for LION. The transport line and the EBIS injection timing were investigated to capture ions. The first beam extracted from the EBIS was observed on March 16.

On March 26, the first beam at the NSRL target room was observed with a Ta beam. The beam intensity was sufficiently high for an NSRL run. Hence, we decided to use the LION for an NSRL run.

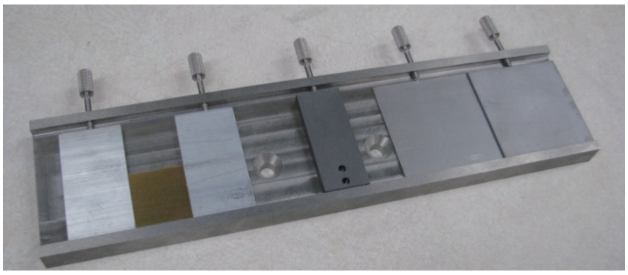

Fig. 1 Target holder with Au, C, Fe, and Ta targets from left to right. Aluminium plates are used to hold the Au target.

The user operation with LION was started from March 27, and it was very successful. Since then, LION has provided most of beams for NSRL. This is beyond our initial plan to use the LIS for several days for commissioning. After all, C, Si, Ti, Fe, Ta, and Au beams are provided for NSRL user runs.

As predicted, lighter species show less tolerance of the number of shots on a single spot to maintain long-term stability. The target scan step of 0.1 mm / 80 s was used for C while 0.1 mm / 540 s was used for Fe. These numbers are conservative and should be investigated further for efficient use of target materials.

The EBIS injection efficiency and the EBIS setting had been improved continuously. Since June 3, LION with a platform voltage of 18 kV started to provide Au beams for RHIC instead of providing beams for NSRL. Until the end of the run, LIS has been working continuously. The target scan step for the Au target was set at 0.5 mm / 20 s. The target was 1-mm thick with 25 mm x 25 mm area, and the target consumed approximately 50% of its life.

LION was used to provide C, Si, Ti, Fe, Ta, and Au beams for NSRL and RHIC user operation. This is the first LIS for low-charge-state ion production to be combined with an EBIS-type heavy-ion source for long term user operation.

References

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