Present Status of the Laser Charge Exchange Test Using the 3-MeV Linac in J-PARC

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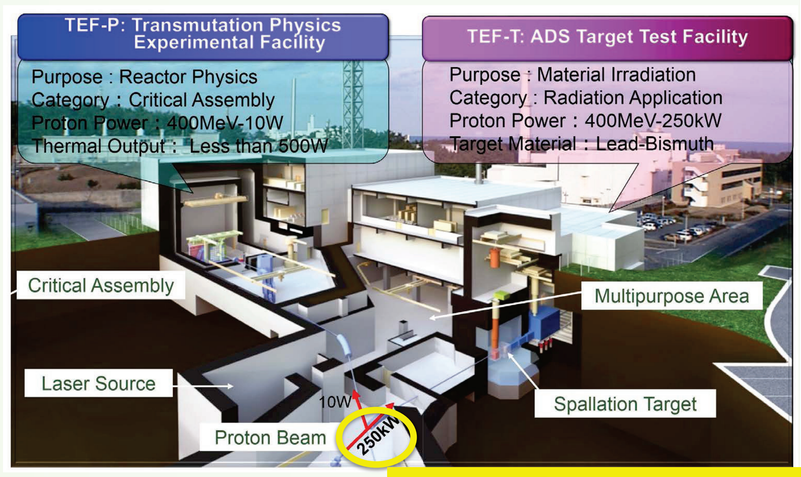
Introduction

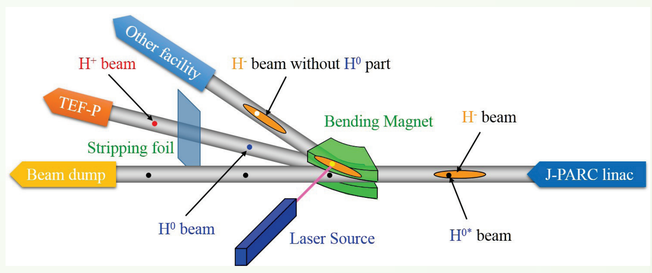
- In the framework of J-PARC project, JAEA plans to be built a Transmutation Experimental Facility (TEF), which consists following two buildings;
  - ADS target test facility (TEF-T) for material irradiation tests using 250kW Pb-Bi spallation target, and
  - Transmutation Physics Experimental Facility (TEF-P), which set up a fast critical/subcritical assembly.
- Since the TEF-P requires a stable proton beam with a power of less than 10W, a stable and meticulous beam extraction method is required to extract a small amount of the proton beam from the high power beam using 250kW.
- To fulfil this requirement, the Laser Charge Exchange (LCE) method has been developed. The LCE strips the electron of the H^- beam and neutral protons will separate at the bending magnet in the proton beam transport.
- To demonstrate the charge exchange of the H^-, a preliminary LCE experiment was conducted using a linac with energy of 3MeV in J-PARC.
- In this paper, present status of LCE tests is presented.

Transmutation Experimental Facility (TEF)



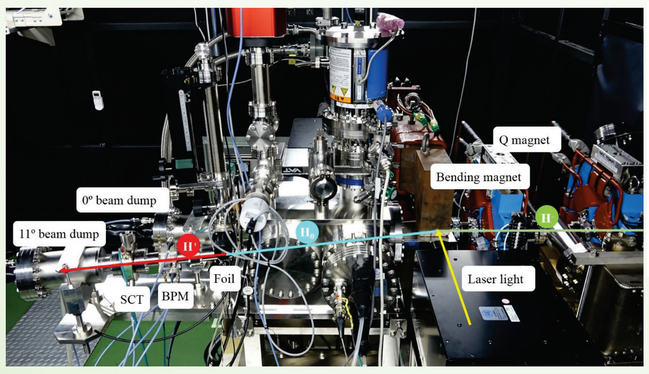
Laser Charge Exchange (LCE) Method to extract a small amount of the proton beam

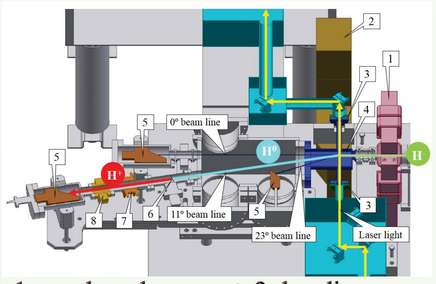
- TEF-P Critical Assembly simulates neutronic performance in very low thermal power.
- To simulate ADS neutronics very low power proton beam should be extracted from J-PARC intense proton accelerator.
- Using Laser Charge Exchange (LCE) Method, low power beam can be easily extracted by no influence of J-PARC accelerator operation.
- Since the outer electron of the H^- is very weakly bound to the atom, it can easily be stripped by a laser light in the wavelength range of 800~1100nm.
- To eliminate the pre-neutralized protons, we were trying to perform laser injection and beam bending simultaneously in one magnet.



Laser Charge Exchange (LCE) Devices

LCE devices of the 3 MeV, 0.45kW linac



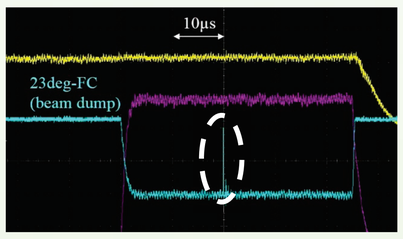


1- quadrupole magnet, 2- bending magnet, 3- quartz viewing port, 4- vacuum chamber, 5- beam dump, 6- stripping foil, 7- BPM, 8- SCT

- Beam width and emittance of the H^- beam were obtained with the beam emittance monitor placed 30 cm downstream of the quadrupole magnet by using Q-scan technique.
- As a result of the measurement, the RMS width in the vertical direction (σ_v) at the collision point was estimated as about 2.8 mm.

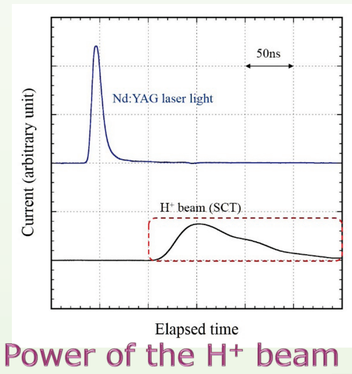
Preliminary results

To confirm the lack of the H^- beam caused by the LCE



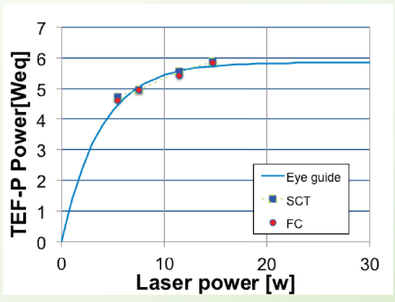
- The rapid rise and fall part surrounded by the white dotted circle is due to the lack of the H^- beam caused by the LCE.
- This lack was observed from the first shot of the Nd:YAG laser light after beginning the LCE experiment.

To measure the power of the stripped H^+ beam



- Power of the H^+ beam was 0.026W from the time integral of the H^+ beam current inside the dotted-red rectangle.
- If the laser light from this Nd:YAG laser system collided with the H^- beam delivered from the J-PARC linac, a stripped H^+ beam with a power of about 5W would be obtained.

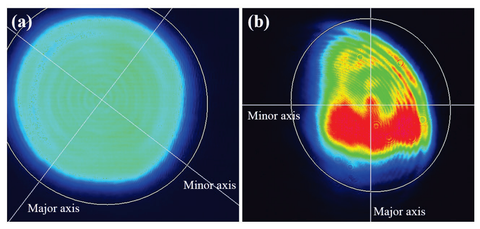
Change of the stripped H^+ beam power as a function of the Nd:YAG laser power



The stripped H^+ beam with a power of about 5W equivalent was expected even if the laser power of the present Nd:YAG laser system was set to the lower value of 5W.

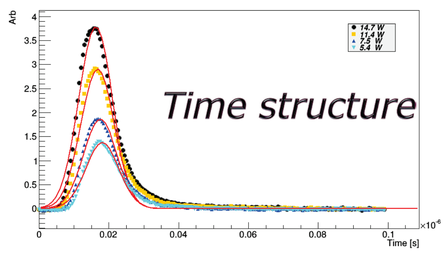
Nd:YAG Laser

- The commercial high power Q-switched Nd:YAG laser (Continuum, Powerlite DLS 9025, 1.6 J/pulse, 25 Hz) was located on an anti-vibration table.
- The laser light was reflected by ten plane mirrors and transmitted through one quartz viewing port from the laser main body to the collision point. This optical path length was 4.25 m.
- After the collision with the H^- beam, the laser light was propagated to the termination point in the light-blocking box used for the laser light diagnostics. During the propagation, which was 3.16 m in length, there were five reflections by the plane mirror and one transmission through the quartz viewing port.
- Quartz viewing ports (effective diameter: φ35.6mm, thickness: 3.2mm, laser damage threshold for 1064nm Nd:YAG laser: 10 J/cm^2 for 10ns pulse) were fitted to the vacuum chamber.



Two-dimensional profile of the Nd:YAG laser light at (a) the exit of the laser main body and (b) the termination point.

The diameter of the Nd:YAG laser light could be estimated as 9.3mm (FWHM) at the collision point with the H^- beam



The time profile of the Nd:YAG laser light with a power of 14.7W was about 4.8ns (1σ).

CONCLUSION

- For the extraction of the low power H^+ beam (less than 10W) from the high power H^- beam (400MeV, 250kW) by the LCE technique, a preliminary LCE experiment to measure the power of the stripped H^+ beam was conducted using the H^- beam with energy of 3MeV from the RFQ linac in J-PARC.
- As a result of this experiment, the stripped H^+ beam with a power of about 5W equivalent was obtained under the J-PARC linac beam condition, and **this value almost satisfied the power requirement (less than 10W) of the proton beam for the TEF-P**.
- In this experiment, we focused on the power of the stripped H^+ beam. We will conduct a further experiment to confirm the beam quality of the laser and the H^-, as well as the long-term power stability of the stripped H^+ beam.