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Studies of Laser Power Reduction for the Laser Stripping of 400 MeV H^- beam at J-PARC RCS

Pranab Kumar SAHA[1*], Hiroyuki HARADA[1], Michikazu KINSHO[1], Hitoki YONEDA[2], Yurina MICHINE[2], Aoi FUCHI[2], Atsushi SATO[3] and Yong LIU[4]

[1]Japan Atomic Energy Agency, J-PARC Center, Tokai, Naka, Ibaraki 319-1195, Japan
[2]The University of Electro-Communications, Chofu, Tokyo 182-8585, Japan
[3]Nippon Advanced Technology Co., Ltd., Tokai-mura, Naka-gun, Ibaraki 319-1112, Japan
[4]High Energy Accelerator Research Organization, Tsukuba, Ibaraki 305-0801, Japan

*E-mail: saha.pranab@j-parc.jp

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The H^- (negative hydrogen) stripping to proton by using a solid stripper foil for charge-exchange injection is only an established way to achieve high-intensity proton beam in circular accelerators. However, a short and unexpected lifetime of the stripper foil, as well as uncontrolled beam losses and the corresponding residual radiation at the injection area, are two serious issues even with a moderate beam power. To avoid the realistic issues associated with foil, we proposed an alternative method of H^- stripping by using only lasers. To establish our method, we are preparing for a Proof-of-Principle demonstration of 400 MeV H^- stripping to proton by using lasers at Japan Proton Accelerator Research Complex (J-PARC). However, to achieve a higher stripping efficiency, the laser power is the most concerning issues in this case. To overcome this difficulty, we have studied both an extensive manipulation of the H^- beam and advanced uses of the laser. These include utilizing a dispersion derivative of the H^- beam to cope with its large momentum spread, while multi-pass laser system for multiple interactions of the H^- beam with lasers. We have found that the laser power can be reduced to more than an order of magnitude by applying a combination of the two methods.

KEYWORDS: High-intensity proton beam, charge-exchange injection, laser stripping, laser power reduction

1. Introduction

The multi-turn charge-exchange injection (CEI) of H^- (negative hydrogen) is an effective way to increase the proton (p) beam intensity in synchrotrons or storage rings [1-2]. Solid stripper foils are usually used to strip two electrons from the H^- leaving only p to inject into a circular accelerator. However, a short and unexpected lifetime of the stripper foil as well as uncontrolled foil scattering beam losses and the corresponding residual radiation are two serious issues even with a moderate beam power [3, 4].

Figure 1 shows a typical RCS stripper foil before (left) and after (right) only 244 C injection charge via the foil at 150 kW beam power operation. Although the foil did not break, severe foil deformation due to beam irradiation can easily be seen. To obtain the