Advanced uses of a current transformer and a multi-wire profile monitor for online monitoring of the stripper foil degradation in the 3-GeV RCS of J-PARC

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Abstract
We have established an advanced and sophisticated uses of a current transformer and a multi-wire profile monitor for accurate measuring as well as online monitoring of the waste beam so as to know the stripper foil degradation during user operation of the J-PARC 3-GeV RCS. The sensitivity of both monitors are good enough for measuring a change of the foil thickness of 1% or even less. Foil degradation such as, foil thinning and pinhole formation are believed to be the signs of a foil breaking. A sudden foil breaking is not only decreases accelerator availability but also raises maintenance issues. A proper monitoring system of the foil degradation is thus important in order to avoid any such issues by replacing the foil with a new one in the scheduled maintenance day. A foil was used for a continuous last 7 months operation with an extracted beam power of 300 kW (18 kW injected beam). The integrated irradiated particles (only injected H) were $8 \times 10^{21}$ but there was no foil degradation so far. Surprisingly, an increase of the foil thickness of around 10% was observed.

Introduction
In order to increase circulating beam intensity, multi-turn H-charge exchange injection is performed. Nearly 99.7% of the H-beam is stripped to proton beam by using an HBC (Hybrid type Boron doped Carbon) stripper foil placed in the middle of chicane bump magnets. Remaining 0.3% is called waste beam and mainly it is partially stripped H+, where un-stripped H+ is ideally negligible. The H+ and un-stripped H- (if any) are stripped to H+ and transported to the injection beam dump.

P.M.F. 

Accelerators at J-PARC facility: 
- 400 MeV (181 MeV at present) LINAC
- 3-GeV 25 Hz Rapidly Cycling Synchrontron (RCS)
- 30-GeV (30-GeV at present) Main Ring (MR)

Beam power for user operation at the latest was 300 kW and feasibility of more than 500 kW has also been demonstrated recently.

Measurement principle and Validity

Online trend of the foil thickness

In addition to the H0CT data taken online, waste beam was in detail measured almost every maintenance day

Clear reduction of the H+ yield obtained by both H0CT and MWPM7

For a continuous 7 months operation

Extracted beam power: 300 kW (injected beam power: 18 kW)

Total integrated inj. particles, (Ibeam) : $4 \times 10^{21}$ pp

Injected beam (Ibeam): $8 \times 10^{21}$

Due to transverse painting

Thicker foil: winding beam loss also increases.

Thinner foil: waste beam increased.

No need lower capacity dump.

Required space and money.

Summary
An accurate measurement of even a small fraction of the waste beam has been successfully done. Online monitoring of the waste beam and recognizing any change of the foil thickness during RCS operation has also been demonstrated. An HBC foil used for a continuous 7 months operation did not show any foil degradation but a linear increase of the thickness as much as 10% from it’s initial value has been measured. More repeated and further longer time range experimental data might be necessary for detail explaining the present data.