

### Effect of High Energy Electrons on H<sup>-</sup> Production and Destruction in a High Current DC Negative Ion Source for Cyclotron

M. Onai<sup>1</sup>, H. Etoh<sup>2</sup>, Y. Aoki<sup>2</sup>, T. Shibata<sup>3</sup>, S. Mattei<sup>4</sup>, S. Fujita<sup>1</sup>, A. Hatayama<sup>1</sup>, J. Lettry<sup>4</sup>

<sup>1</sup> Faculty of Science and Technology, Keio University, Yokohama 223-8522, Japan

<sup>2</sup> Sumitomo Heavy Industries, Ltd., ThinkPark Tower, Tokyo 141-6025, Japan

<sup>3</sup> High Energy Accelerator Research Organization (KEK), Ibaraki, Japan

<sup>4</sup> CERN Rte de Meyrin, 1200 Geneva – Switzerland

Corresponding Author: Moriaki Onai, e-mail address: onai@ppl.appi.keio.ac.jp

In cyclotron used for medical application, negative hydrogen ions (H<sup>-</sup>) are commonly injected and accelerated to obtain higher extraction efficiently [1]. In such application of H<sup>-</sup> ions, it is highly required to enhance the H<sup>-</sup> production in ion sources and for obtaining high H<sup>-</sup> beam current. In this study, we focus on the multi-cusp DC arc-discharge source [2]. A systematic study of the EEDF (Electron Energy Distribution Function) in the arc-discharge plasma has been conducted. Especially, the effect of the EEDF on the efficient H<sup>-</sup> production has been studied by the KEIO-MARC code (Kinetic modeling of Electrons in the IOn source plasmas by the Multi-cusp ARC-discharge) [3].

By using the results of the EEDF from the code, H<sup>-</sup> production rate/destruction rate is calculated by a system of zero-dimensional (0D) rate equations. Effects of 1) filter magnetic configuration, and 2) arc-discharge power, on the EEDF and on the resultant H<sup>-</sup> production/destruction have been studied systematically. In addition, their optimizations are being carried out. Furthermore, some improvements of the KEIO-MARC code regarding neutral reactions and transport are being conducted. The results of those improvements will also be reported.

#### References

- [1] M. E. Phelps, “Electronic Generators,” in *PET: Molecular Imaging and Its Biological Applications*, (Springer, New York, 2004), pp. 227–229.
- [2] H. Etoh *et al.*, *Rev. Sci. Instrum.* **85**, 02B107 (2014).
- [3] T. Shibata *et al.*, *J. Appl. Phys.* **114**, 143301 (2013).