

# Development of Compact Toroid Injection System for the GAMMA 10/PDX Device

T. Seki<sup>a</sup>, M. Mizuguchi<sup>a</sup>, Y. Miyamoto<sup>a</sup>, T. Asai<sup>ab</sup>, M. Sakamoto<sup>ac</sup>

<sup>a</sup>*LINEA Innovations, Inc.*

<sup>b</sup>*College of Science and Technology, Nihon University*

<sup>c</sup>*Plasma Research Center, University of Tsukuba*

In magnetically confined plasma heating through neutral beam injection (NBI), it is important that the injected neutral particles are ionized and trapped in the magnetic field as charged particles. When the target plasma density is low, leading to decrease particle collision, injected neutral particles pass through the plasma without interaction (shine-through). This phenomenon reduces the heating efficiency of NBI. On the tandem mirror device, GAMMA 10/PDX at the University of Tsukuba [1], NBI heating is applied utilizing ~25 keV beams. In the previous experiment on GAMMA 10/PDX [2], NBI heating performance was evaluated under two operation modes: high-density mode and hot-ion mode. Increases in both line-integrated electron density and diamagnetic signal were observed. The heating effect in high-density mode was more pronounced.

Compact toroid (CT) injection is considered a particle fueling method for magnetically confined plasmas [3,4]. Prior studies by TAE Technologies successfully demonstrated CT injection into field-reversed configurations (FRCs) with external open field lines. They achieved successful CT injection into a target plasma with a confinement field strength of ~0.1 T and a density of  $\sim 10^{19} \text{ m}^{-3}$ , confirming a particle number increase of 20-30% [5]. Therefore, further improvement of NBI heating efficiency by increasing plasma density is expected through the CT injection into the mirror plasma generated in GAMMA 10/PDX.

To inject CTs into the mirror plasma, a CT injection system utilizing a magnetized coaxial plasma gun has been developed. This system is designed to inject a CT perpendicularly to the mirror magnetic field, which has a strength of ~0.5 T in the central mirror section of the GAMMA 10/PDX device. The system consists of a magnetized coaxial plasma gun, which generates and accelerates CT using coaxial cylindrical electrodes, and a high-voltage pulsed power supply to drive it. This system is capable of ejecting CTs with a density of  $\sim 10^{21} \text{ m}^{-3}$ , a temperature of ~30 eV, and a velocity of ~100 km/s.

- [1] Y. Nakashima *et al.*, AIP Conf. Proc. **1771**, 020002 (2016)
- [2] H. Ozawa *et al.*, Plasma Fusion Res. **5**, S2084 (2010).
- [3] M. Nagata *et al.*, Nucl. Fusion **45**, 1056 (2005).
- [4] C. Xiao *et al.*, Phys. Plasmas **11**, 4041 (2004).
- [5] T. Asai *et al.*, Nucl. Fusion **57**, 076018 (2017).