Compact Toroid Injection into C-2U FRCs for Particle Refueling

Tadafumi Matsumoto,[1] Thomas Roche,[2] Ian Allfrey,[2] Tomohiko Asai,[1]
Hiroshi Gota[2], Toshiki Tajima[2,3] and the TAE Team[2]

[1]*Nihon University, Chiyoda-ku, Tokyo 101-8308, Japan*
[2]*Tri Alpha Energy, Inc., P.O. Box 7010, Rancho Santa Margarita, CA 92688, USA*
[3]*University of California, Irvine, Irvine, CA 92697, USA*

The compact toroid (CT) injector system [1] has been developed for the C-2U device [2] under the joint collaboration between Nihon University and Tri Alpha Energy (TAE) for several years. The first CT injector for a field-reversed configuration (FRC) particle refueling was deployed on the C-2 device at TAE.

Sustainment times of the FRC have exceeded 5 ms in C-2U. In long-lived FRCs, particles loss becomes a problem. Thus, the FRC needs a particle refueling system. As a particle refueling system, we have been developing the magnetized coaxial plasma gun (MCPG), which has coaxial electrodes. The MCPG accelerates the CT/plasmoid by Lorentz-force **J**×**B**. The CT reaches velocities such that it has a higher kinetic energy density than C-2U's magnetic field energy density; i.e., $\frac{1}{2}\rho v^2 \geq \frac{1}{2}B^2/\mu_0$, where ρ, v, and B are mass density of the CT, velocity, and magnetic field inside the C-2U confinement vessel. We have 2 CT injectors mounted on the confinement vessel around mid-plane, and they can be operated independently. They are installed on C-2U 180 degrees apart, slightly off-axis, and angled such that the injected CTs' trajectories intersect at the center of the confinement vessel. In order to refuel the FRC intermittently, a multi-pulse CT injection system is needed. Therefore, we have started to develop such system over the previous year [3]. Our multi-pulse CT injection system can inject 2 CTs with as little as 1 ms delay between them by using two capacitor banks on the MCPG. Using this technique, we are able to inject 3 CTs in a single shot. Furthermore, the CT injector needs a large amount of neutral gas to breakdown, and the neutral gas becomes a trailing gas that enters the confinement vessel; Thus, FRC is cooled down by the neutral gas. Therefore, we have developed a Pre-Ionization (PI) system to reduce the neutral gas as well as to improve a reliability of the MCPG breakdown.

In this talk, we will present the result of CT injection into C-2U, and the new techniques developed for the CT injector.

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[3] I. Allfrey *et al*., Bull. Am. Phys. Soc. **60**, BP12.00024 (2015).