Collaboration research of Compact Toroid Injection Experiments

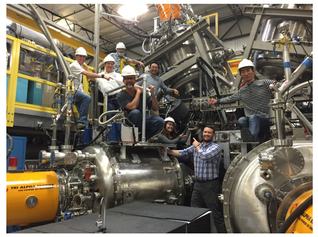
Tomohiko Asai[1], Tadafumi Matsumoto[2,3], Thomas Roche[2], Hiroshi Gota[2], Toshiki Tajima[2,3]

[1] *Nihon University,* [2] *TAE Technologies, Inc.,* [3] *University of California at Irvine*

Collaboration Research

- Integral partnership (started 2012)
- Development of a compact toroid (CT) injector for FRC particle refueling
- *MOU research cooperation (started 2014)

Nihon Univ. — TAE Technologies, Inc. — University of California, Irvine



Group photo with CT injector on the C-2U

Primary Contributors and Collaborators

Nihon University[1]

- Tomohiko Asai
- Fumiyuki Tanaka
- Takahiro Edo
- Akiyoshi Hosozawa

TAE[2] and UCI[3]

- *Tadafumi Matsumoto; Graduated from Nihon University in March 2017 under the MOU, and working as an employee at TAE/UCI.
- Hiroshi Gota[2]
- Ian Allfrey[2]
- Thomas Roche[2]
- Toshiki Tajima[2,3]

Recent Researches and Studies

1. Iron-core bias coil to make a stationary bias field and improve CT performance
2. Pre-ionization system to reduce initial neutral gas
3. CT's behavior in the magnetic field
4. CT collision and merging experiment

Publications and Presentations

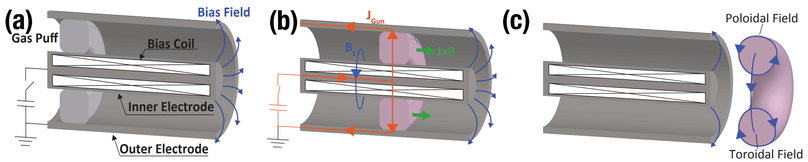
Papers

- T. Matsumoto *et al.*, "Development of a magnetized coaxial plasma gun for compact toroid injection into the C-2 field-reversed configuration device", Rev. Sci. Instrum. 87, 053512 (2016)
- T. Matsumoto *et al.*, "Characterization of compact-toroid injection during formation, translation, and field penetration", Rev. Sci. Instrum. 87, 11D406 (2016)
- T. Asai *et al.*, "Compact toroid injection fueling in a large field-reversed configuration", Nucl. Fusion 57, 076018 (2017)
- T. Edo *et al.*, "Performance improvement of a magnetized coaxial plasma gun by adopting iron-core bias coil and pre-ionization systems", 26th International Toki Conference Proceeding (December 2017), (Submitted)

Conference Presentations

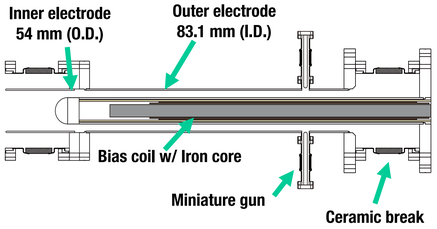
- T. Edo *et al.*, 26th ITC, Japan (December 2017)
- A. Hosozawa *et al.*, PLASMA2017, Japan (November 2017)
- T. Matsumoto *et al*, CT-Workshop, Japan (November 2017)
- T. Edo *et al.*, 59th APS-DPP, USA (October 2017)
- I. Allfrey *et al.*, 59th APS-DPP, USA (October 2017)
- T. Matsumoto *et al.*, 58th APS-DPP, USA (October 2016)
- T. Edo *et al.*, 58th APS-DPP, USA (October 2016)
- T. Asai *et al* ., 26th IAEA, Japan (October 2016)
- T. Matsumoto *et al.*, US-Japan CT2016 Workshop, USA (August 2016)
- T. Matsumoto *et al.*, HTPD2016, USA (June 2016)
- T. Matsumoto *et al.*, 57th APS-DPP, USA (November 2015)
- T. Roche *et al.*, 57th APS-DPP, USA (November 2015)
- I. Allfrey *et al.*, 57th APS-DPP, USA (November 2015)
- T. Matsumoto *et al.*, 56th APS-DPP, USA (October 2014)

Compact Toroid (CT) Injector

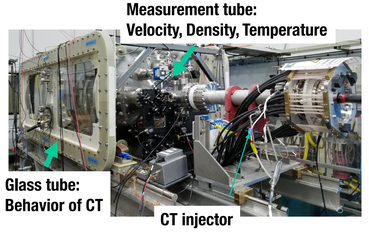


Typical CT formation process by MCPG. (a) Gas inlet (b) apply high-voltage to generate the plasma (c) accelerated plasma is captured by bias filed and eject a magnetized plasmoid

Developed CT Injector and Test Stand



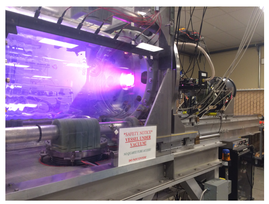
Schematic view of our CT injector



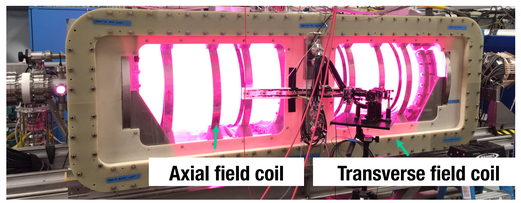
Test stand for CT injector

Table. Comparison of plasma parameters between FRC and CT

	Particles ($\times 10^{19}$)	Temperature (eV)	Poloidal flux (mWb)	Energy (kJ)
FRC	1.0 – 1.5	600 – 800	5 – 7	5 – 7
CT	0.5 – 1.0	20 – 30 (electron)	0.4	0.1 – 0.3

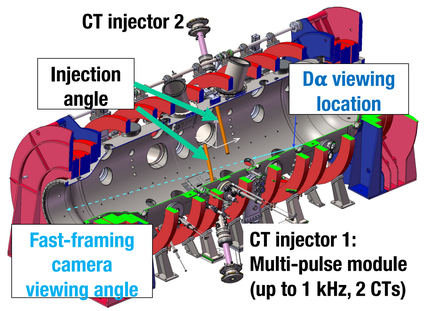


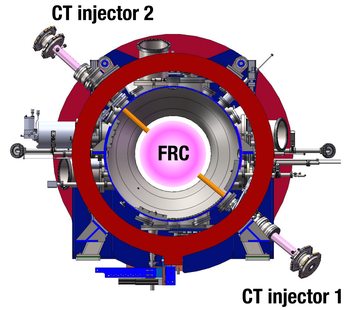
CTI test stand in 2014



CT collision and merging experiment in 2017

Installation of CT Injector

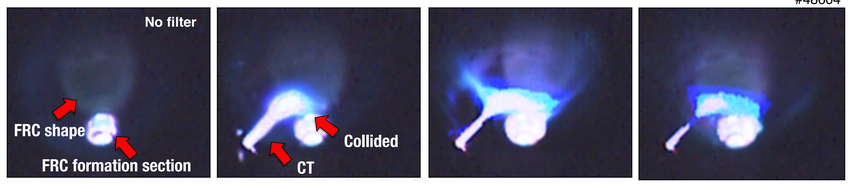




End-view of the C-2U vessel

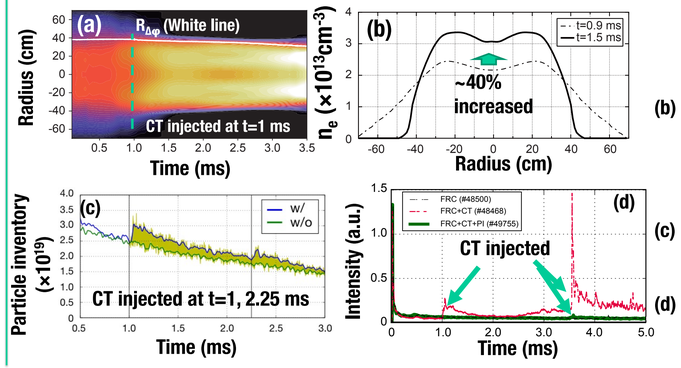
Results of CT injection

Fast-framing camera Images



τ=0 (relative time to CTI) | τ=40 μs | τ=120 μs | τ=200 μs

Change in FRC parameters by CT Injection



(a) Time evolution of the electron density distribution using Abel inversion technique.
(b) Time slice of the density distribution at t=0.9 ms (Dotted line) and t=1.5 ms (Solid line).
(c) Total particle inventory of C-2U FRC
(d) Time evolution of the Dα emission by CT injection.