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Neutral Beam Injection System For the C-2-Upgrade Field Reversed Configuration Experiment

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Tri Alpha Energy, Inc. is a privately funded company pursuing research of Field Reversed Configuration (FRC) plasmas for fusion reactor applications. Over the past decade, TAE has brought together world-class technical specialists in such fields as FRC plasma science, magnets, neutral and neutralized beams, pulsed power, diagnostics, controls, electronics and fabrication, and has well over 500 years of combined fusion research experience. This group of scientists, engineers and technologists is working at TAE's state-of-the-art plasma research facility in Orange County, California.

The core of the facility is the world's largest FRC plasma device named C-2,[1] in which neutral beams (20 - 40 keV hydrogen, ~ 4 MW total)[2] were injected tangentially to produce a significant fast-ion population. In the C-2 experiment, neutral beam injection (NBI), coupled with electrically-biased plasma guns at the plasma ends, magnetic end plugs, and advanced surface conditioning, led to dramatic reductions in turbulence-driven losses and greatly improved plasma stability.[3] Under such conditions, highly reproducible, macroscopically stable, hot FRCs with total plasma temperature of ~ 1 keV and record lifetimes were achieved.[4]

The C-2 device has been recently upgraded with a new NBI system, which was designed and built in collaboration with the Budker Institute of Nuclear Physics (Novosibirsk, Russia). The C-2-Upgrade NBI system consists of six highly reliable and robust injectors based on positive ion technology. The system can deliver up to a total of 10 MW of hydrogen beam power (15 keV, 8 ms pulse), by far the largest ever used in compact toroid plasma experiments. The injectors feature flexible, modular design based on a triode ion optical system with slitted multi-aperture inertially cooled grids and geometrical beam focusing. The cold-cathode arc discharge plasma sources[5] generate up to 180 Amps of extracted ion current.

The NB injectors were commissioned in the on-site test facility that allows a complete characterization of the injector performance, including measurements of the beam divergence and focal length, and determination of the beam composition. In my talk, I will briefly describe the C-2U device and main aspects of the TAE experimental effort. The primary focus of the talk will be on the TAE NBI program, specifically: 1) the development of the NB injectors in a collaborative effort with Budker Institute, 2) test facility, diagnostics, and associated components and infrastructure, 3) integration with the C-2U machine, 4) results of acceptance tests and operating experience.

References

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