DPP16-2016-000548

Abstract for an Invited Paper
for the DPP16 Meeting of
the American Physical Society

C-2-Upgrade Field Reversed Configuration Experiment.

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In the C-2 field-reversed configuration (FRC) experiment, tangential neutral beam injection (20 - 40 keV hydrogen, 4 MW total), 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 [1,2]. Under such conditions, highly reproducible FRCs with a significant fast-ion population and total plasma temperature of about 1 keV were achieved [3]. The FRC's were macroscopically stable and decayed on characteristic transport time scales of a few milliseconds. In order to sustain an FRC configuration, the C-2 device was upgraded with a new neutral beam injection (NBI) system, which can deliver a total of 10+ MW of hydrogen beam power, by far the largest ever used in a compact toroid plasma experiment. Compared to C-2, the beam energy was lowered to 15 keV and angled injection geometry was adopted to provide better beam coupling to the FRC. The upgraded neutral beams produce a dominant fast ion population that makes a dramatic beneficial impact on the overall plasma performance [4]. Specifically: (1) high-performance, advanced beam-driven FRCs were produced and sustained for times significantly longer (5+ ms) than all characteristic plasma decay times without the beams, (2) the sustainment is fully correlated with neutral beam injection, (3) confinement of fast ions is close to the classical limit, and (4) new, benign collective fast ion effects were observed. Collectively, these accomplishments represent a dramatic advance towards the scientific validation of the FRC-based approach to fusion. This talk will provide a comprehensive overview of the C-2U device and recent experimental advances. [1] M. Tuszewski et. al, Phys. Rev. Lett 108, 255008 (2012). [2] H.Y. Guo et al., Nature Comm 6, 6897 (2015). [3] M.W. Binderbauer et al., Phys. Plasmas 22, 056110 (2015). [4] M.W. Binderbauer et al., AIP Conf. Proc. 1721, 030003 (2016).