DPP15-2015-001721

Abstract Submitted
for the DPP15 Meeting of
The American Physical Society

Sorting Category: 6.23 (E)

Physics of Plasma Cathode Current Injection During LHI[1] E.T. HINSON, J. BARR, M. BONGARD, M.G. BURKE, R. FONCK, J. PERRY, UW-Madison — Localized helicity injection (LHI) ST startup employs current sources at the tokamak edge. Max $I_{\rm p}$ in LHI scales with injection voltage $V_{\rm inj}$, requiring an understanding of injector impedance. For the arc-plasma cathode electron injectors in Pegasus, impedance is plasma-determined, and typically $V_{\rm inj}$>1kV for $I_{\rm inj}$ =2kA. At low $I_{\rm inj}$, $I_{\rm inj} \propto V_{\rm inj}^{3/2}$, an indication of a double layer (DL) common to such devices. However, at $I_{\rm inj}$>∼1kA, $I_{\rm inj} \propto V_{\rm inj}^{1/2}$ occurs, a scaling expected for limited launched beam density, $n_b \equiv I_{inj} \Big/ (e\sqrt{2eV_{inj}/m_e}A_{inj}) \sim I_{\rm inj}/V_{\rm inj}^{1/2}$. An ohmic discharge injection target was created to test this hypothesis. Langmuir probe data showed $I_{\rm inj}/V_{\rm inj}^{1/2} \propto n_{\rm edge}$ at low $n_{\rm edge}$, consistent with a limit ($n_{\rm edge} \geq n_{\rm e,b}$) imposed by quasineutrality. If edge fueling maintained $n_{\rm edge} \geq n_{\rm e,b}$, spectroscopic measurements of source density $n_{\rm arc}$ indicated $I_{\rm inj}/V_{\rm inj}^{1/2} \propto n_{\rm arc}$, as expected from DL expansion. Thus $n_{\rm b}$ established by $n_{\rm arc}$ or $n_{\rm edge}$ determines $V_{\rm inj}$ up to the onset of cathode spot (CS) arcing. Technology development has increased obtainable $V_{\rm inj}$ and reduced CS damage using new ring shielding and a cathode design drawing CS's away from insulators. This involved a novel optimization of conical frustum geometry. Finally, consistent with NIMROD predictions of coherent streams in the edge during LHI, pairwise triangulation of outboard Mirnov data assuming beam m=1 motion has allowed an estimate of beam R(t), Z(t) location that is near the injector R, and consistent across the array.

[1]Supported by U.S. DOE Grant DE-FG02-96ER54375

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Date submitted: 24 Jul 2015

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