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EX/9-2: Control and Dissipation of Runaway Electron Beams Created during Rapid Shutdown Experiments in DIII-D

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High-current (multi-MA) runaway electron (RE) beams could form in ITER during disruptions or rapid shutdowns. To avoid localized wall damage, it is crucial to understand how these RE beams are lost and how they can be controlled and dissipated. DIII-D dedicated experiments on rapid shutdown REs have improved understanding of the processes involved in RE formation, control, dissipation, and final impact with the vessel wall. Improvements in RE beam feedback control enabled stable confinement of RE beams out to the volt-s limit of the ohmic coil, as well as enabled a rampdown to zero current [1]. Collisional dissipation of RE beam current was studied by massive gas injection of different impurities into RE beams. RE current dissipation is shown to be more rapid than expected from avalanche theory [2,3] –this anomalous dissipation appears to be linked to the presence of high-Z impurity ions in plasma. It is not clear if the anomalous dissipation is due to radial diffusion of REs into the wall or an anomalously large collisional drag on the REs. Evidence for radial diffusion of REs is seen with diagnostic pellets, which show diffuse REs well outside the main RE beam [4]. Evidence for anomalous collisional drag on REs is seen in the RE energy distribution function, which shows a large increase in electrons at low energies, when compared with avalanche theory. Final RE-wall impact studies show that the REs are lost to the wall rapidly and with significant toroidal asymmetry once the beam radius touches the wall [5]. Significant (˜10x) apparent conversion of RE magnetic energy to kinetic energy [6] is observed in the final RE-wall impact for sufficiently slow impacts; for rapid impacts, the RE magnetic energy appears to go mostly into wall currents and ohmic plasma current.

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[4] A. James, et al., J. Nucl. Mater. 415, S849 (2011).
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[6] A. Loarte, et al., Nucl. Fusion 51, 073004 (2011).

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