Fast Ion Loss Diagnostics on DIII-D*

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Sawteeth and tearing modes affect fast ion confinement, while large fast ion densities can drive collective instabilities, including toroidicity-induced Alfvén eigenmodes. Losses of energetic alpha particles in ITER will reduce the alpha heating available to reach ignition, and have the potential to cause major damage to the first wall of ITER.

Measurements of the internal mode structures of the fast ion induced instabilities inside the DIII-D plasma are based on beam emisson spectroscopy, far infrared scattering, reflectometry, CO_2 interferometry, electron cyclotron emission, and magnetic fluctuation diagnostics. Measured profiles of the confined beam ions in DIII-D using the recently developed fast ion D_α spectroscopy (FIDA) show that instabilities redistribute fast ions radially. Thin foil Faraday collectors mounted near the midplane of DIII-D are used to measure fast ion losses. Modulation of the neutral beam sources has allowed observation of the prompt losses from each of the beam lines, and shows that the prompt losses are usually larger when the plasma current or toroidal field are low.

Interaction of the Alfvén eigenmodes with the fast ions is still poorly understood. Neither FIDA nor the existing energetic ion loss detectors on DIII-D have the fast time response needed to determine how the instabilities interact with the energetic ions. A new scintillator-based fast ion loss detector (FILD), based on the design used on ASDEX Upgrade, is being built to measure the beam ion losses on DIII-D with the needed time response (>100 kHz) and detection sensitivity. Based on the results we obtain with FILD, we plan to design and install additional fast ion loss detectors at a number of poloidal locations on the outside wall of DIII-D. By correlating the beam ion loss results from the fast ion loss detectors with the observations of the internal mode structures and the FIDA results, we hope to gain important information on the fast ion loss orbits and loss mechanisms involved in the instabilities.

*Work supported in part by the US Department of Energy under DE-FC02-04ER54698 and SC-G903402.