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Measurements and Modeling of Fast Ion Losses in JET Deuterium Plasmas in Preparation for DT

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With burning reactor plasmas, such as ITER, looming in the future, there exists a strong need for fully developed, predictive, energetic particle transport models. JET's recent 2019-2020 deuterium campaign provides an excellent testbed for examining fast ion confinement and transport under plasma conditions similar to future tokamak reactors. MeV scale ICRH heated deuterium NBI ions, as well as DD-fusion products, act as a proxy for DT-fusion born alpha particles in preparation for JET's upcoming DT-campaign in 2021. This presentation details the development of a predictive model for fast ion losses in JET deuterium plasmas supported by measurement.

Fast ion loss measurements are reported via an array of Faraday cup fast ion loss detectors, a scintillator probe fast ion loss detector, gamma ray spectroscopy, and neutron diagnostics.

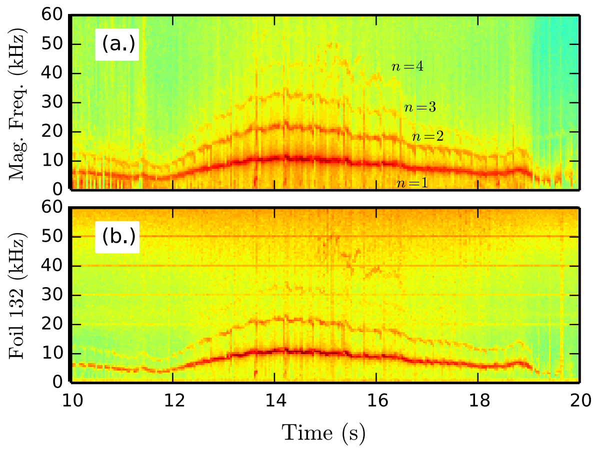

Fig. 1. Spectrograms from JET shot 96133 produced from a magnetic Mirnov coil, (a.), and fast ion loss Faraday-foil 132, (b.). Toroidal mode numbers, n, are labeled in (a.) for each respective kink mode.

In particular, focus has been placed on the Faraday cup fast ion loss detector array which has undergone upgrades resulting in enhanced measurements [1]. Losses have been recorded due to a wide variety of MHD activity, including: neoclassical tearing modes, kink modes, sawteeth, fishbone modes, and edge-localized modes. Figure 1 presents an example of measured losses due to kink modes and intermittent sawteeth suitable for modeling efforts. Analytic representations for the perturbations are used as input into the ORBIT-kick model [2] which calculates transport matrices for input into TRANSP/NUBEAM [3]. The computed fast ion distributions are related to that produced from reverse-orbit integrating ions from a synthetic Faraday cup loss detector such as that shown in Figure 2. The synthetically biased loss distributions are translated to a flux and compared to measurement.

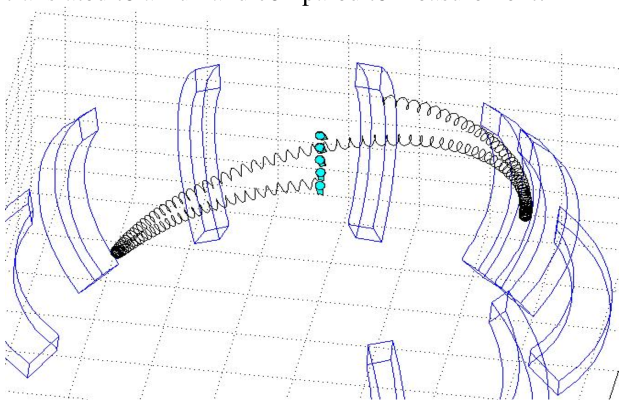

Fig. 2. A representative lost deuteron orbit calculated from revere orbit integrating from the Faraday cup detector (turquoise) until contact with the limiter (blue).

We will present our complete methodology along with initial results of our integrated model. The model will be extended to predict other loss mechanisms, such as Alfven eigenmodes, and alpha particle losses in next year's DT-campaign. Additionally, the model will be employed on the scintillator fast ion loss detector.

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