Contribution ID: **52** Type: **Contributed Oral**

Disruption Event Characterization and Forecasting Results and Initial Real-Time Application

Wednesday, 20 July 2022 11:55 (25 minutes)

Disruption prediction and avoidance is critical for ITER and reactor-scale tokamaks to maintain steady plasma operation and to avoid damage to device components. Physics-based disruption event characterization and forecasting (DECAF) research determines the relation of events leading to disruption, and forecasts event onset. The analysis has access to data from multiple tokamaks to best understand, validate, and extrapolate models. Recent code improvements allow fully automated analysis spanning an entire device run campaign or even the entire device database. Such analysis is showing very high true positive success rates, in some cases over 99% with early forecasting (on transport timescales) well before the disruption. While this result is very encouraging over broad ranges of shots, analysis continues to ensure causality of the computed DECAF events with the detected disruption, rather than just correlation. This is a critical question to be answered for any disruption prediction analysis. Significant new hardware and software for real-time data acquisition and DECAF analysis are being installed on the KSTAR superconducting tokamak. Real-time magnetics, electron temperature, Te, profiles from electron cyclotron emission (ECE), 2D Te fluctuation data from ECE imaging, and velocity and Ti profiles show excellent agreement with offline data/analysis. An MHD mode locking forecaster has been developed for off-line and real-time use using a torque balance model of the rotating mode. Early warning forecasts on transport timescales potentially allow active profile control to avoid the mode lock. Mode stability alteration by ECCD is examined and recent experiments have shown the ability to avoid mode lock-induced disruption by applying rotating 3D fields. Innovative counterfactual machine learning is used to examine hypothetical RWM stabilization scenarios with rotating MHD. An ELM identification event module includes the ability to distinguish localized and global MHD events. Fully non-inductive current scenarios in KSTAR are examined by "predict-first"analysis of already highly (~75%) non-inductive plasmas. Resistive stability analysis including delta'computed by DCON is evaluated with comparison to experiment examining sensitivity to localized variations of kinetic equilibrium reconstructions of the q profile using MSE magnetic pitch angle data.
Supported by US DOE Grants DE-SC0016614 and DE-SC0018623.

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Session Classification: Prediction & Avoidance

Track Classification: Prediction and Avoidance