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The Importance of Turbulence Measurements to Burning Fusion Plasmas

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The fusion science community is actively preparing for the "burning plasma era" epitomized by ITER – an international collaboration to construct, operate and study the "next-step" fusion device. Performance projections for the device currently rely on empirical scaling of the confinement properties of existing fusion devices. This is not entirely satisfactory, and advances in computational power have resulted in the ability to predict transport/confinement properties based on first-principles nonlinear gyrokinetic turbulence models. This talk will describe the role of turbulence measurements in validating such predictions and, thereby, enhancing confidence in the ability to project fusion performance. Since the predicted transport is determined by the turbulence physics inherent in the code, performing comparison and obtaining agreement with the measured turbulence properties is essential to establishing confidence in extrapolating to "next-step" devices. Measurements have advanced considerably and are able to locally monitor turbulence at all relevant spatial scales and in multiple fields. Such measurements will be described, together with comparison with code predictions in existing fusion plasmas. Burning plasmas will provide some unique challenges (e.g. role of alphas, low collisionality, high neutron and thermal fluxes) which will potentially modify the range of validity of code predictions while also constraining measurement capabilities. There is, therefore, an urgent need to develop diagnostic techniques suitable for the burning plasma environment, since measurement of the turbulence properties will be essential to provide the necessary information to guide future modifications to the simulations. Some of the challenges and possible solutions will be described. *Supported by the US DOE under DE-FG03-01ER54615 and DE-FG02-08ER54984.