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Advanced density profile reflectometry; the state-of-the-art and measurement prospects for ITER[1]

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Dramatic progress in millimeter-wave technology has allowed the realization of a key goal for ITER diagnostics, the routine measurement of the plasma density profile from millimeter-wave radar (reflectometry) measurements. In reflectometry, the measured round-trip group delay of a probe beam reflected from a plasma cutoff is used to infer the density distribution in the plasma. Reflectometer systems implemented by UCLA on a number of devices employ frequency-modulated continuous-wave (FM-CW), ultrawide-bandwidth, high-resolution radar systems. One such system on DIII-D has routinely demonstrated measurements of the density profile over a range of electron density of 0-6.4×10^{19} m^{-3}, with $\sim$25 μs time and $\sim$4 mm radial resolution, meeting key ITER requirements. This progress in performance was made possible by multiple advances in the areas of millimeter-wave technology, novel measurement techniques, and improved understanding, including: (i) fast sweep, solid-state, wide bandwidth sources and power amplifiers, (ii) dual polarization measurements to expand the density range, (iii) adaptive radar-based data analysis with parallel processing on a Unix cluster, (iv) high memory depth data acquisition, and (v) advances in full wave code modeling. The benefits of advanced system performance will be illustrated using measurements from a wide range of phenomena, including ELM and fast-ion driven mode dynamics, L-H transition studies and plasma-wall interaction. The measurement capabilities demonstrated by these systems provide a design basis for the development of the main ITER profile reflectometer system. This talk will explore the extent to which these reflectometer system designs, results and experience can be translated to ITER, and will identify what new studies and experimental tests are essential.

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