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Overview of Recent and Planned DIII-D Research to Develop Steady-State Tokamak Operation for Fusion Energy

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DIII-D is focused on providing the scientific basis of high fusion performance, noninductively-sustained tokamak operation in ITER and pilot plants that will set the stage for commercial energy production. This presentation will highlight recent DIII-D research progress investigating core plasma scenarios ranging from "high beta hybrid"to "high qmin". These studies have targeted improved understanding of limits to high normalized-beta steady-state operation, including ideal and resistive MHD instabilities, heat and particle transport, and current drive. For example, application of more off-axis NBI power to elevated-qmin discharges has in some cases produced broader profiles with higher ideal-MHD betaN limits and more classical fast ion transport. Studies have begun to push core scenarios to more reactor-relevant conditions, such as lower rotation, higher Te/Ti, higher density, lower collisionality, etc, and to assess compatibility and integration with boundary requirements such as no Type I ELMs and highly radiative detached divertors. High-betaN hybrid scenario plasmas are a case in point, where studies have shown that at high heating power lowering torque reduces normalized confinement but raising density can increase it. Plans to expand DIII-D's capabilities for reactor-relevant studies will be discussed. These include significant increases in heating and current drive power and flexibility in the form of new ECH lines, a high harmonic fast wave "helicon"system, a high-field-side launched lower hybrid system, and NBI upgrades. With these, operation at higher magnetic field (from 2.17 to 2.5 T), larger plasma volume and stronger shaping, and new advanced divertors is projected to enable access to sustained operation with many key normalized parameters matching those of compact fusion pilot plant design studies, thus permitting DIII-D to assess and inform such designs.

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