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Plans to Develop Integrated Core-Edge-Wall Plasma Solutions for a Fusion Pilot Plant with DIII-D

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A critical challenge for a compact fusion pilot plant is to resolve the path to a high fusion performance core with a dissipative divertor approach, finding solutions that are mutually compatible to marry them together. This must also be integrated with surrounding plasma interacting technologies and materials. An upgrade to DIII-D is proposed to close gaps on reactor physics regimes in divertor, SOL, wall, pedestal and core to test critical physics, pioneer solutions and resolve their mutual compatibility.

The key to developing an integrated solution is to raise pressure. This enables high density to be sustained at low collisionality to achieve the high dissipation divertor and at the same time a high-performance low collisionality core. On DIII-D this is achieved through a rise in shaping, current, volume and power, exploiting the natural properties of improved pedestals at high shape to close gaps and push limits. Upgraded flexible heating and current systems (electron cyclotron and neutral beam power rises) enable development of a range of pulsed and steady state core solutions at the higher densities needed for core-edge integration. Integrated modelling projects betaN's up to 5, with unique access to low collisionality, thermalized, peeling limited reactor-like regimes, and short neutral penetration depths into the core to study relevant particle and impurity transport. The resulting increased parallel heat flux and density raise opacity and shorten mean free paths to access reactor relevant physics in the divertor.

A staged divertor program is underway to explore the development of advanced closure schemes and to isolate divertor physics mechanisms, before proceeding to a core-edge optimized configuration for integrated solutions. This will be combined with a new reactor relevant wall, where final choice of material and missions are still being discussed with the community. Also planned are tests of a further change to pumped high power closed divertor for negative triangularity operation. Passive coil runaway electron dissipation and high speed pellet disruption mitigation schemes will also be tested, while the EC power rise will be used to resolve mitigated ELM solutions in conjunction with DIII-D flexible 3D and profile control capabilities. Spin polarized fusion concept tests are also being explored.

These exciting developments will enable DIII-D to pioneer integrated core and edge solutions, their materials compatibility and required control to resolve and project the approach for the pilot. Community input is sought on how best this might complement international facilities to close gaps on fusion energy.

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