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

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***Abstract.*** *A critical challenge to develop a compact, low capital cost, fusion 'pilot' plant is to resolve the approach to a high fusion performance core with a dissipative divertor, and find solutions that are mutually compatible. This must also be integrated with surrounding plasma interacting technologies and materials, with relevant control techniques for plasma behaviour and instabilities, implemented. An upgrade to DIII-D is underway [Buttery 2023] to close these gaps in reactor physics regimes for divertor, SOL, wall, pedestal and core in order to test critical physics, pioneer solutions and resolve their compatibility.*

## Performance Upgrade through Increased Volume, Shaping, Heating and Current

The key to developing an integrated solution is to raise pressure. This enables high density to be sustained at low collisionality to achieve a 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, just implemented through a new divertor configuration, exploiting the natural properties of improved pedestals at high shape to close gaps and push limits. Upgraded flexible heating and current drive systems (doubling electron cyclotron heating and increasing neutral beam power with RF sources, and commissioning new helicon and LHCD systems) then enable development of a range of pulsed and steady state core solutions at the higher densities needed for core-edge integration.

For the pedestal, Fig. 1 shows projections with the proposed increased shaping and volume, and necessary heating. It is found that the usual limits (dotted line) are increased even with conventional pedestal techniques (dark arrow), enabling access to low collisionality regimes with low neutral penetration depth (just a fraction of the pedestal width), so pedestal structure becomes governed by transport, as in an FPP [Buttery 2021], rather than neutral deposition. With potential access to the improved stability valley (light arrow), even more exciting benefits to density and pressure may be possible, though our projections do not rely on this regime. Densities up to 1.6E20m$^{-3}$ are projected, similar to FPP and compatible with new higher frequency gyrotrons ordered, outside launch and present DIII-D field limits.

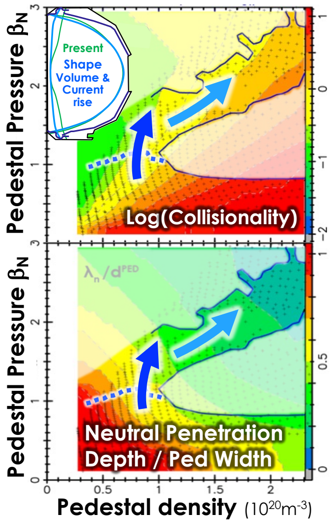


*Fig. 1: Pedestal parameters with EC and shape upgrade.*

Integrated modelling (Fig. 2 upper) [Park 2017] projects $\beta_N$'s up to 5, with unique access to low collisionality, thermalized, peeling-limited reactor-like regimes, and short neutral