A Sustainable High Power Density (SHPD) Tokamak to Enable a Compact Fusion Pilot Plant

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Design parameters, key physics missions and engineering issues are identified for a new high power density tokamak to develop and test predicted sustainable plasma operating scenarios for a low capital cost 'compact' fusion pilot power plant (CFPP). Analysis highlights that low cost requires advanced plasma scenarios with high confinement and capable power handling (Fig 1). Key gaps arise with present devices in fusion power density, bootstrap fraction, heat flux, field and particle density (Fig 2) leading to phase transitions in underlying physics; SHPD must access the reactor side of these transitions to resolve the pilot physics. Pedestal calculations indicate an optimal aspect ratio ~2.3-2.7, consistent with engineering optimizations, with strong shaping to enable high bootstrap operation. Self-consistent transport, current drive, pedestal, and equilibrium simulations show a modest scale SHPD tokamak can meet these challenges, operating with high field, broad current profiles and reactor-like heat fluxes (Fig 3). With suitable wall and divertor choices, this would pioneer solutions to enable a compact fusion pilot plant.

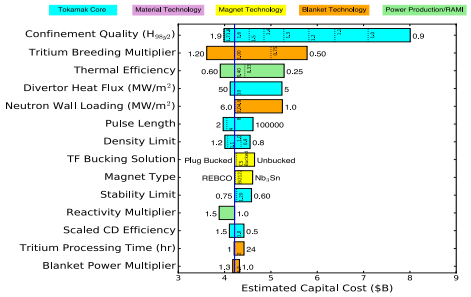

Fig 1: System analysis identify the most important parameters governing capital cost of 4m radius 200MWe fusion pilot.

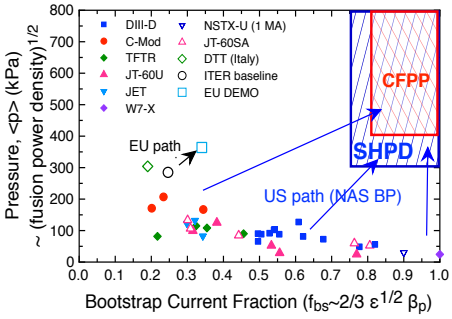

Fig 2: Comparison of pilot with present devices (achieved=solid).

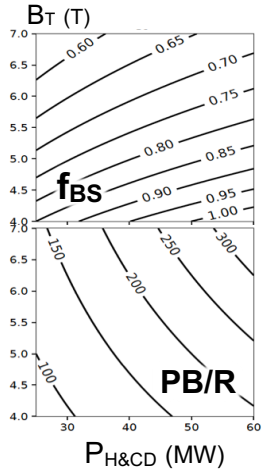

Figure 3: SHPD solutions with H_{98}~1.5 R=1.25m, A=2.5, q_{95}=8 and f_{padGW}=0.8.

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