Talk 2: The Advanced Tokamak Path to a Compact Fusion Power Plant (04/07)

Development of an efficient fusion reactor requires the simultaneous optimization of the plasma operating scenario and underlying hardware. These are inextricably linked; an effective operating scenario reduces demand on key components. The critical challenge is to reduce recirculating power; if significant auxiliary heating or current drive is needed, this drives up required fusion power to run these systems, and thus size, heat flux, neutron load, and cost. The Advanced Tokamak concept addresses this through a fortuitous alignment of high plasma pressure operation with strong self-driven 'bootstrap' current and low turbulent transport. Here, research into transport, stability and energetic particle interactions has identified the key principles behind a solution. New integrated "full physics" simulations show the various trade-offs and path to optimize the approach. Higher pressure of course increases fusion performance. But increasing the density has greater leverage, raising the self-driven bootstrap current and thus decreasing demand for auxiliary current drive systems. Potential solutions are indicated at ~4m radius and ~6T using conventional superconductors. However, higher field, high Tc superconductors provide greater margin in attainable beta, density, safety factor and neutron load, as well as easier maintenance and thus higher duty cycle. The plasma exhaust is managed by a combination of core radiation, flux expansion and radiative divertor, tuned to ensure H mode sustainment. Divertor solutions similar to ITER are possible, but continuous operation may require a more advanced configuration to reduce erosion. Overall, studies show that well targeted research in the coming years could provide the basis to proceed with a compact Advanced Tokamak power plant – this talk will set out the key physics and hardware considerations behind its design.