ALCATOR C-MOD AND ADX: RESEARCH ON THE HIGH-FIELD PATHWAY TO FUSION ENERGY

B. LaBombard and the Alcator Team
MIT Plasma Science and Fusion Center
175 Albany St., Cambridge, MA 02139
labombard@psfc.mit.edu

Because fusion power density scales as plasma pressure squared, $-\langle\beta_N/q\rangle^2 B^4$, high field tokamaks can have tremendous economic and practical advantages, as seen in the ARC (affordable, robust, compact) fusion pilot plant design study [1] – a device the size of JET that produces 270 MW of electrical power. ARC exploits new magnetic technology – high-temperature, high-field (9.25 tesla on axis), demountable superconductors – attaining excellent core performance without pushing on core confinement, beta, or proximity to disruptive operational limits. With this vision in mind, critical research on the high-field pathway to fusion energy shifts away from enhancing core performance (e.g., increasing beta) and more towards finding viable physics/engineering solutions for the support systems of a high field fusion power plant: (1) advanced divertors for heat exhaust/erosion control that handle order-of-magnitude increases in power density over present experiments, (2) efficient (i.e., wall-plug to plasma) RF systems for steady-state current drive and heating that survive the onslaught of plasma-material interactions in a reactor.

Alcator C-Mod and ADX [2] directly target this vision. Both are prototypical for an ARC concept: compact, high power density, high field with demountable toroidal field magnets, high absolute plasma pressure but moderate plasma beta. C-Mod is an essential research platform for first-generation divertor and RF systems: high-Z, vertical target plate divertor at ITER-level parallel heat fluxes and divertor conditions; RF current drive wave physics and technologies at ITER B-fields and plasma densities.

ADX is proposed as a follow-on experiment, able to implement game-changing improvements in divertor and RF systems informed by C-Mod. It is a fully-integrated, high-performance tokamak, specifically designed to develop and test next-generation divertor/material innovations for power/PMI handling at reactor-level power densities, such as super-X and X-point target divertor concepts, and advanced LHCD and ICRF concepts, including the unprecedented ability to perform high-field-side launch – exploiting excellent RF wave physics and substantially reduced plasma-antenna interactions, particularly in double-null configurations. Using the same class of external actuators available to a power plant, ADX will explore core/pedestal plasma performance at world-record breaking plasma pressures, in physics regimes prototypical of a reactor (equilibrated electrons/ions, no external torque, no fueling from heating/current drive actuators), and investigate access to enhance confinement via current profile control and the attainment of advanced, ELM-suppressed confinement modes, such as I-mode [3].