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Configuration Studies for an ST-Based Fusion Nuclear Science Facility

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A Fusion Nuclear Science Facility (FNSF) could play an important role in the development of fusion energy by providing the nuclear environment needed to develop fusion materials and components. The spherical tokamak (ST) is a leading candidate for an FNSF due to its potentially high neutron wall loading and modular configuration. A key consideration for the choice of FNSF configuration is the range of achievable missions as a function of device size. Possible missions include: providing high neutron flux (1-2MW/m2) and fluence (3-6MWy/m2), demonstrating tritium self-sufficiency (tritium breeding ratio TBR ≥ 1), and demonstrating electrical self-sufficiency. All of these missions must also be compatible with a viable divertor, first-wall, and blanket solution. During the past two years, U.S. studies have for the first time developed ST-FNSF configurations simultaneously incorporating: (1) a blanket system capable of TBR ˜ 1, (2) a poloidal field (PF) coil set supporting high elongation and triangularity for a range of li and normalized beta values consistent with NSTX/NSTX-U previous/planned operation, (3) a long-legged / Super-X divertor analogous to the planned MAST-U divertor which substantially reduces projected peak divertor heat-flux and has all outboard PF coils outside the vacuum chamber and as superconducting to reduce power consumption, and (4) a vertical maintenance scheme in which blanket structures and the centerstack (CS) can be removed independently. Progress in these ST-FNSF mission vs. configuration studies including dependence on plasma major radius R0 for a range R0 = 1 − 1.6m will be described. TRANSP/NUBEAM calculations of negative neutral beam heating and current drive scenarios will also be described.

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