Positioning the U.S. to Play a Leading Role in and Benefit from a Successful ITER Research Program

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Burning Plasma Physics in ITER: "*The study of burning plasmas, in which self-heating from fusion reactions dominates plasma behavior, is at the frontier of magnetic fusion energy science. The next major step in magnetic fusion research should be a burning plasma program, which is essential to the science focus and energy goal of fusion research… ITER offers an opportunity for the study of burning plasma physics in conventional and advanced tokamak configurations for long durations with steady state as the ultimate goal, and would contribute to the development and integration of plasma and fusion technology*." [2002 Snowmass meeting press release; later endorsed by FESAC]. The U.S. Domestic Fusion Program must prepare for a successful ITER Research Program by:

1. **Supporting ITER design decisions**
   The U.S. is a strong contributor, and in some areas a clear leader, in ongoing research supporting ITER's design during construction. These activities are supported by ongoing U.S. tokamak research, but rely the availability of adequate resources and run-time. Some of these areas are:
   - Disruption prediction, avoidance, and mitigation (U.S. clear leader)
   - ELM control and ELM-free operating scenarios (U.S. clear leader)
   - Plasma control (U.S. clear leader)
   - Error field measurement and control (U.S. clear leader)
   - Materials issues, in particular interactions of helium plasmas with the tungsten divertor
   - Qualification of candidate heating and current drive upgrades for ITER steady-state scenario
2. **Preparing for leading roles in the ITER research program**
   The U.S. is among the leaders in ongoing fusion science research that will prepare scientists to play leading roles in scientific exploitation of ITER, and U.S. tokamak capabilities are world-leading in increasing fidelity to expected burning plasma conditions. Areas for potential leadership include:
   - Model validation and integrated simulation of tokamak plasmas in support of ITER research (U.S. clear leader)
   - Energetic particles and energetic particle driven instabilities (U.S. clear leader)
   - Plasma control (U.S. clear leader)
   - SOL heat flux control via divertor seeding and geometry (within ITER's hardware restrictions) (U.S. clear leader)
   - Development and qualification of ITER inductive and noninductive operating scenarios
   - U.S. work is also underway to develop self-consistent core-edge integration
3. **Positioning the U.S. to benefit from the results of the ITER research program**
   A successful ITER research program along with progress in fusion nuclear science will provide much of the needed basis to proceed to a fusion DEMO. To position the U.S. to benefit from ITER and proceed toward energy development requires continued strong domestic programs in tokamak physics, materials, and fusion nuclear science.

The U.S. is a major participant in the International Tokamak Physics Activity (ITPA) due in large part to technical contributions from C-Mod, DIII-D, NSTX, and our theory program. Research leading toward and beyond ITER should take advantage of the complementary nature of U.S. facilities and those of our international partners. For example, the long-pulse superconducting tokamaks can work together with the more flexible, but shorter-pulse, U.S. devices to develop and qualify long pulse operating scenarios. Our participation in international collaborations, including ITER, will have the largest impact and benefit when leveraged from a position of strength provided by our domestic research program.

Our present domestic program is already addressing most of these issues. It is vital that we continue to make resources available in the form of run-time on and upgrades to our major tokamaks, diagnostics, computational tools, and perhaps most importantly, continued development of our strong scientific workforce.