Input on Steady State Issues for DEMO

Further comments on White Paper Submitted by
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- Fusion Power Density: $P \sim \beta^2 B_T^4 = (\beta/\varepsilon)^2(\varepsilon B_T^2)^2$
- **Higher beta-normal (4-5) can give higher bootstrap current fraction (90%) and reduced current drive requirement (10%, mostly far off axis, at r/a=0.8)**
- **Aries-RS (B_T=8.0T) should be revisited by adopting Aries-AT's (B_T=5.8T) optimized features, in particular $q_{min} > 2.0$, with optimized pressure profile alignment to achieve 90% bootstrap fraction and 10% off-axis LHCD with ≤ 40 MW of RF power**
- **Higher field offers many physics advantages, including higher current drive efficiency and better accessibility for far off-axis current drive (LHCD) and for ECH/ECCD at lower frequency (220-250 GHz, see RF presentation)**
- **More stable MHD operation for Aries RS at lower elongation, lower triangularity and somewhat higher q_{95} (as compared to Aries-AT)**
- **Magnet technology is improving rapidly and ITER RS (B_T=8.0T, 16 T on coil) appears technologically feasible for DEMO (see magnet presentation by MIT)**

The Steady State (SS) Mission of ITER will likely Not Address Important Physics/Technology Questions for SS Operation of DEMO

- **Baseline density for the ITER SS (7×10^{19} m^{-3}) may be too low to be compatible with divertor power handling.**
- **β and β_N in the ITER SS will not be DEMO – relevant (i.e., the values needed for high fusion output).**
- **Flat H-mode like density profiles assumed for ITER SS operation are only compatible with $f_{BS} \approx 50\%$, which seriously impacts the achievable values of Q.**
  - **Flat density profile may not be realistic – need to do the experiment !**
- **Optimal mix and timing of the H&CD systems for ITER SS is still unclear:**
  - **Additional 20 MW of ECRF power may be added in place of NBI**
  - **LHRF power for far off-axis current profile control is still not included in "Day 1" power complement.**

Noninductive Current Drive Complement Planned for ITER SS will not Extrapolate to DEMO

- **NBI provides half of the noninductive current in ITER SS, but the high energy beams (multi-MeV) needed to penetrate in DEMO ($\sim 3 \times 10^{20}$ m^{-3}) are not considered to be realistic.**

- **Need $f_0 \geq 5$ GHz LHRF sources for DEMO to avoid parasitic absorption via Parametric Decay Instability (PDI) and α-particle interaction:**
  - **3.7 – 4.6 GHz sources may be adequate for ITER SS.**

- **Need (≥ 220) GHz ECRF sources for DEMO, assuming on-axis absorption with fundamental O-mode at 8.0 T.**

Status of Existing / Planned SS Tokamaks in the World Fusion Program

- **EAST, KSTAR, JET, JT60-SU, and Alcator C-Mod all have significant SS missions.**
- **But none of these devices can address the question of whether or not attractive SS plasma can be maintained with significant self-heating from α-particles.**
- **Recommend an interim device (perhaps at higher B_t) be considered with DEMO scalable RF technologies:**
  - **Revisit ARIES RS (B_0=8 T) with optimized features of ARIES AT (B_0=5.8 T)**
- **Higher B_t has a number of benefits:**
  - **More stable MHD operation at higher fusion power output.**
  - **Better LH and EC wave accessibility.**
  - **Higher LHCD efficiency.**
- **Advances in predictive simulation capabilities achieved through SciDAC and FSP Initiatives will help to assess many of these issues for ITER – and for DEMO.**