Integrated performance and critical issues towards steady-state operation in JT-60U

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Steady-state operation in tokamak requires full non-inductive current drive. Therefore efficient operation should be compatible with a large fraction of bootstrap current (f_{BS}) in order to minimize re-circulating power for external current drive. The f_{BS}~50% is expected in the ITER steady state operation scenario, while f_{BS}>75% in a fusion reactor. In these cases, weak or reversed shear plasmas are envisaged. Furthermore, a fusion reactor requires simultaneous achievement of high confinement, high β_N, high f_{BS}, full non-inductive current drive, high fuel purity, high radiation fraction and high density at medium q_{95}~5 regime. Moreover profiles of pressure, current and rotation should be optimized to keep stable sustainment under highly self-regulating system. JT-60U has been optimizing a weak shear plasma (WS) and a reversed shear (RS) plasma towards steady-state operation with integrated performance.

One of the critical issues in WS plasma regime is avoidance of NTMs. Optimizing pressure and current profiles or adjusting ECCD successfully avoided the NTMs. As a result, high integrated performance was achieved near the steady state current profile solution with full non-inductive current drive at q_{95}~4.75 [1]. Furthermore, higher density by pellet injection and higher β_N by wall stabilization were demonstrated.

In RS plasma regime, large f_{BS}~75% was successfully sustained for 7.4s under nearly full non-inductive current drive condition so far [2], while β_N was limited ~1.7. Therefore one of the critical issues in RS plasma is improvement of beta limit. Recently, the beta limit is significantly improved by wall stabilization. As a results, high confinement RS plasmas exceeding non-wall beta limit with large f_{BS} are obtained in reactor relevant regime at q_{95}~5.3. Achieved integrated performance in both regimes is shown in figure together with the target values in the ITER steady-state scenarios.

[1] Y. Kamada and the JT-60U team, Nucl. Fusion **41** (2001) 1311.
[2] Y. Sakamoto, et al., Nucl. Fusion **45** (2005) 574.

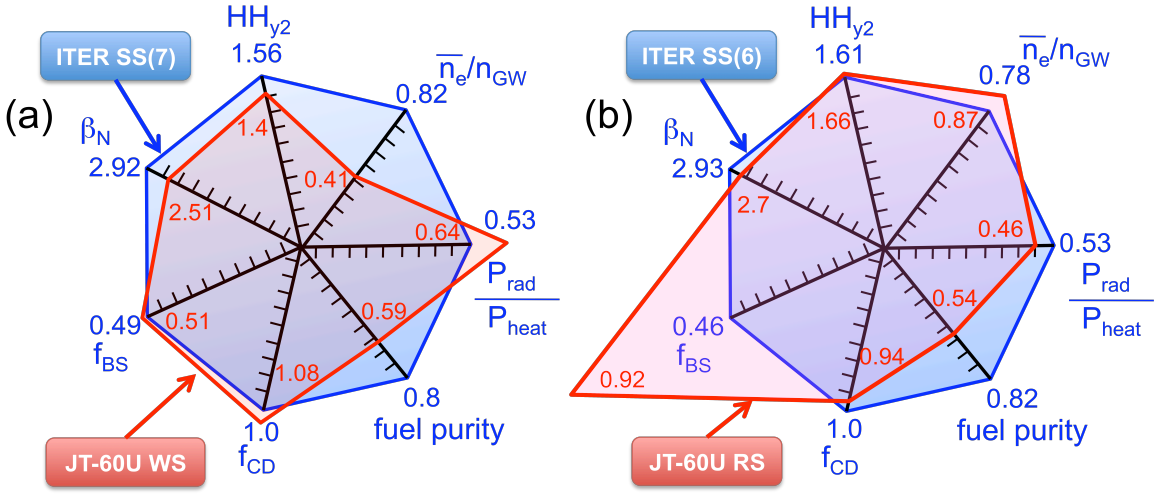

Figure: Achieved integrated performances in (a) weak shear plasma and (b) reversed shear plasma together with target values in the ITER steady-state scenarios.