# §1. Conceptual Design Studies towards LHD-type DEMO Reactors

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On the basis of a steady progress in the LHD experiment, a lot of achievements have been made in terms of refinement of the database, physics analysis, and engineering R&D for the helical system. This study advances conceptual design activity of the helical DEMO reactor FFHR-d1 by utilizing these achievements and wide-ranged researches including the core plasma physics and the reactor technology through cooperative researches in NIFS. This study also aims at establishing an engineering basis that enables engineering demonstration for the helical DEMO and contributing to a progress in nuclear fusion research by clarifying issues and prospects of each research field.

This study has been conducted under the Fusion Engineering Research Project, launched at the beginning of FY2010. Conceptual design activity for FFHR-d1[1)] and related engineering R&D have been conducted by 3 research groups (superconducting magnets, in-vessel components, reactor system design) that consist of 13 task groups. In this fiscal year, primary design parameters of FFHR-d1 are set. The detailed examination of the core plasma and 3-D design of in-vessel components are in progress.

The design integration task group performed design window analysis based on the direct profile extrapolation (DPE) method[2)] proposed by the core plasma task group using the system design code HELIOSCOPE. The design point having $R_c$=15.6m, $B_c$=4.7T and $P_{fus}$=3GW was selected as a candidate for FFHR-d1[3)]. The feasibility of this design point is validated thorough the detailed analysis by the related task groups: radial-build design by the in-vessel component task group[4)], evaluation of tritium breeding and neutron shielding performance through neutronics calculations by the blanket task group[5)], and evaluation of coil cooling performance through thermo-hydraulic calculations by the superconducting magnet and cryogenic system task groups[6)].

After the decision of the primary design parameters, detailed consideration of the core plasma design is in progress by the core plasma task group in cooperation with the Numerical Experiment Research Project. Calculations of the high-beta equilibrium, neo-classical transport and alpha particle behavior are being performed. The results will be fed back to the LHD experiment. In parallel, detailed consideration for a 3-D shape of main components is in progress. A basic shape of in-vessel components (vacuum vessel, blanket and divertor plates) is set by the design integration task group using the result of a magnetic field line tracing calculation. Neutronics calculations with the 3-D geometry are underway by the blanket task group. Consideration for the shape and location of divertor components and exhausting ports is in progress by the in-vessel component task group. In addition, detailed considerations of the development issues of FFHR-d1 are underway by other task groups including consideration for the shape of heating ports by the heating task group.

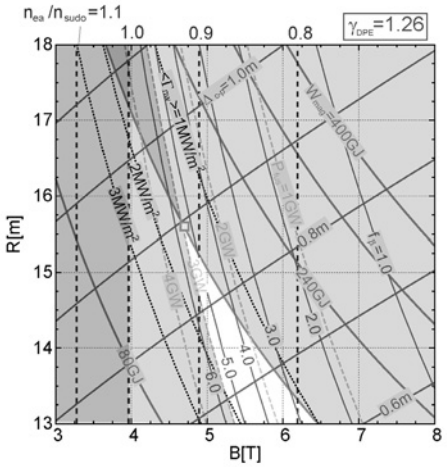


Fig. 1. Design window analysis for FFHR-d1.

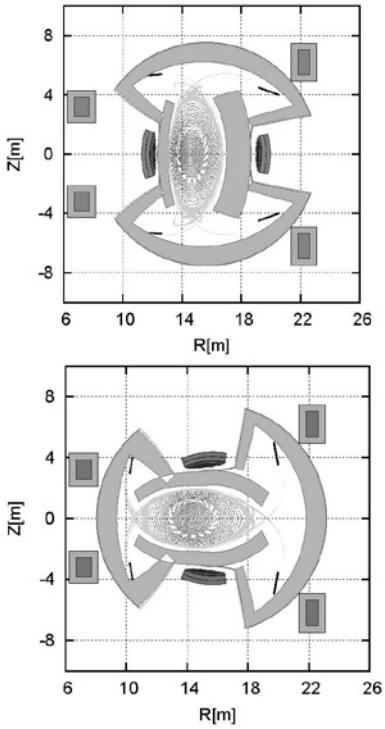


Fig. 2. Proposed shape of in-vessel components on the vertically- and horizontally-elongated cross section.

1) A. Sagara et al., Invited talk on the 10th International Symposium on Fusion Nuclear Technology (ISFNT-10), 11-16 September, 2011, Portland, Oregon, US, O38, to be published in Fusion Eng. Des. (2012).
2) Miyazawa, J. et al.: Fusion Eng. Des. **86** (2011) 2879.
3) Goto, T. et al.: Proc. of ITC-21, Toki, Japan, Nov. 28-Dec. 1, 2011, P2-94, to be published in PFR (2012).
4) Tamura, H. et al.: 21st International Toki Conference (ITC-21), Toki, Japan, Nov. 28-Dec. 1, 2011, P2-23.
5) Tanaka, T. et al.: 21st International Toki Conference (ITC-21), Toki, Japan, Nov. 28-Dec. 1, 2011, P2-95.
6) Hamaguchi, S. et al.: 21st International Toki Conference (ITC-21), Toki, Japan, Nov. 28-Dec. 1, 2011, P2-21.