The ITER Research Plan and supporting R&D in present experiments

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The primary aim of the ITER Research Plan (IRP) is to define the plan of research and development and of the exploitation of the facility necessary to meet the ITER mission goals.

The IRP is divided into two main phases after first plasma demonstration: operation in H/He plasmas (Pre-Fusion Plasma Operation (PFPO)) and in DD/DT plasmas (Fusion Plasma Operation (FPO)). These two main phases are subdivided into experimental campaigns, separated by further assembly phases, in which the tokamak ancillary systems (heating and current drive, fuelling, etc.) are progressively implemented to their baseline configurations to be completed before FPO (“Staged Approach”). The IRP describes the objectives of each operational campaign consistent with the available tokamak systems, details the experimental plan to achieve them (including options), and identifies the main risks of the experimental plan to achieve the objectives of each phase and corresponding mitigation actions.

The main physics objectives of the two initial experimental campaigns (PFPO-1 and PFPO-2) are the achievement of high confinement plasmas (H-mode) and the demonstration of plasma operation up to the ITER design values for plasma current (15 MA) and toroidal field (5.3T) in L-mode plasmas. These experiments will characterize for the first time energy and particle confinement in a tokamak plasma at the reactor scale, to compare with the extrapolations made on the basis of present experiments that have been used for the ITER design. This will determine the operational range for H-mode operation in H/He plasmas in ITER and allow an initial assessment of core-edge integration and plasma-wall interactions in ITER. It is anticipated that operation will be limited to plasma currents/fields ~50% of the design values in H mode. Important issues for these initial phases concern the demonstration of disruption mitigation by shattered pellet injection, H-mode operation at low values of current and field (5 MA/1.8T to 7.5 MA/2.65T) and the optimum plasma species to perform the H-mode experiments (H, He or mixed H-He); the required R&D to address the open issues will be described.

The FPO campaigns cover a long operational period from the start of DD plasma operation, with the principal objectives being the demonstration of the $Q = 10$ inductive operation and $Q = 5$ operation with in-principle steady-state conditions. The experimental plan to proceed from DD towards DT plasmas builds on the results expected to be achieved in PFPO. It includes a verification of the L-mode 15 MA development path demonstrated in PFPO and the initial expansion of the H-mode operational space in DD plasmas from low values of current and toroidal field. This is followed by a gradual evolution toward DT plasmas with increasing T content plasmas leading to a demonstration of $Q = 10$ operation for a duration of 50 s. The details of the experimental path depend on the changes of plasma parameters with increasing currents, fields and T concentration with the optimum path providing a gradual assessment of physics and resolution of integration issues and tuning of plasma control schemes as the fusion power builds up, for which R&D is required. This initial phase is then followed by experimental campaigns focused on increasing the burn length of the inductive $Q = 10$ scenario towards the objective of 300-500s and the development of the in-principle stady-state $Q = 5$ scenarios where the optimization of the pressure and plasma current profiles will be a main focus of the experimental programme. In both cases, scenario integration issues associated with high Q operation will explore the new regime of dominant self-heating for the first time. The open R&D physics and operational issues regarding the achievement of high Q fusion performance for pulse durations from 300 s up to 3000s will be discussed.