

## On the Strategy and Requirements for Neutronics Testing in ITER

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Neutronics testing is among the several types of fusion technology testing scheduled to be performed in a test facility such as ITER. The three ports assigned for testing in ITER will test several blanket concepts proposed by the various parties with test blanket modules (TBM) that utilize different structural materials, breeders, and coolants. Nevertheless, neutronics issues to be resolved in ITER-TBM are generic in nature and are important to each TBM type. Dedicated neutronics tests specifically address the accuracy involved in predicting key neutronics parameters such as tritium production rate, TPR, volumetric heating rate, induced activation and decay heat, and radiation damage to the reactor components. In addition, neutronics analyses are required to provide input support for other tests (e.g. heating rates for thermo-mechanics tests).

In this paper, we address some strategies for performing the neutronics tests. Tritium self-sufficiency for a given blanket concept can only be demonstrated in a full sector, as envisioned in a Demo reactor, including a closed tritium fuel cycle with its components such as tritium separation and clean-up systems. However, testing in ITER TBM can provide valuable information regarding the main parameters needed to assess the feasibility of achieving tritium self-sufficiency. Unlike the case of using engineering scaling to reproduce demo-relevant parameters in an “Act-alike” test module, dedicated neutronics tests require a “Look-alike” test module for a given blanket concept. This is due to the desire to quantify realistic error bars associated with various neutronics parameters when predictions with various codes/nuclear data are compared to measured data. Furthermore, it is strongly desired to perform neutronics tests on as “cold” module as possible to allow accurate measurement of tritium production. It is therefore recommended to perform these tests as early as possible during the DD operation phase (year 4) or the low duty cycle DT operation phase (years 5 and 6).

The paper also addresses the operational requirement (i.e. fluence requirement) as well as the geometrical requirement of the test module (i.e. minimum size) in order to have meaningful and useful tests. For example, TPR, neutron and gamma spectrum measurements, etc., require fluence in the range of  $1-10^6$  Ws/m<sup>2</sup>. Any linear combination of neutron wall loading and operating time in this range is acceptable, e.g., 400 s (ITER pulse) at  $2.5 \times 10^{11}$  n/cm<sup>2</sup> is adequate. Measured neutronics data requires high spatial resolution. This requires the measured quantity to be as flat as possible in the innermost locations inside the test module both in the poloidal and toroidal direction. This sets, in turn, certain geometrical requirement on the size of the TBM. In this paper, we discuss the minimum test module size that makes the predicted data, whose measurements are intended in ITER (e.g. TPR), not to deviate by more than 5% (for improved simulation) relative to the full coverage case found in a Demo or a power reactor. Preliminary results show that a test module of ~45 cm in the poloidal direction and ~60 cm in the toroidal direction may achieve this accuracy goal. The impact of the frame thickness of the test port (cooled with water) on these measurements is also investigated and the results will be reported in this paper.