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Assessment of environmental effects on the ITER FOCS operating in reflective scheme with Faraday mirror

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Plasma current measurements will play an important role in ITER to provide real-time plasma control and machine protection. Fiber Optics Current Sensors (FOCS) with the sensing fiber installed on the external surface of the vacuum vessel is a system intended to perform this task. The FOCS signal is proportional to the current and is more suitable for the steady-state operation as compared to today's standard electromagnetic sensors. However, the intrinsic and extrinsic linear birefringence significantly degrade the sensor performance. Recent numerical simulations demonstrated that operating FOCS in reflection with an ideal Faraday mirror (FM), i.e. the rotation angle is exactly 90°, can significantly improve the measurement accuracy. Unfortunately, FM detuning above 0.3° gives unacceptable error, while the tolerance of commercial FMs is ±0.5°, at best. The FM calibration offers only a partial solution due to uncontrolled detuning of the FM under external perturbations. This problem is the subject of the presentation.

An ideal FM can be located far from the vacuum vessel (in the cubicle area) because it fully compensates the linear birefringence in the link between the sensing fiber and the FM. For a non-ideal FM this link gives additional errors and should be avoided. When located near the vacuum vessel the FM will be exposed to thermal and radiation fields which will influence the FM rotation. We have investigated these effects experimentally and found that the thermal detuning sensitivity is ~0.12°/K, i.e. temperature stabilization better than ±2.5K is necessary. Radiation-induced detuning saturates at ~1.2° for gamma-doses of 12.5kGy@520Gy/h. Saturation indicates that pre-irradiation may be a way of radiation hardening.

In the presentation we will also discuss the physical background for the temperature and radiation sensitivity and show that our experiential results agree well with the theoretical models assuming that the FM uses Bismuth-Iron Garnet as the Faraday rotator.

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