Development of an automatized method for in-situ measurement of the geometrical properties of the ITER bolometer diagnostic

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In order to derive the local emission profile of the plasma radiation in a fusion device using the line-integrated measurements of the bolometer diagnostic, tomographic reconstruction methods have to be applied to the measurements from many lines-of-sight. A successful reconstruction needs to take the finite sizes of detectors and apertures and the resulting non-ideal measurements into account. The geometrical properties have been characterized and measured for the JET bolometer diagnostic in a laboratory environment previously [1]. However, in ITER, the international fusion research facility being built in France, a method for in-situ measurement of the geometrical properties of the various components of the bolometer diagnostic is required [2]. The bolometer diagnostic in ITER will feature many detectors in various locations distributed over the whole vacuum vessel. Always the viewing cones have to pass through narrow gaps between components (e.g. for shielding). Therefore, an in-situ measurement of the geometric properties after installation of all components is the only viable procedure.

The method proposed to be used for ITER uses the parallel beam of a blue laser (wavelength: 405 nm) with high intensity to illuminate the bolometer assembly from many different angles ξ (poloidal direction) and θ (toroidal direction). A light-weight robot from Kuka Robotics is used to efficiently position the laser on many points covering the complete viewing cone of each line-of-sight and to direct the beam precisely into the entrance aperture of the bolometer. Measuring the response of the bolometer allows for the calculation of the transmission function $t(\xi,\theta)$, the angular etendue and finally the geometric function in reconstruction space, which is required for the tomography algorithms.

Measuring the transmission function for a laboratory assembly demonstrates the viability of the proposed method. Results for a typical pin-hole camera used in ASDEX Upgrade are presented, as well as results for a collimator-type camera from a prototype envisaged for ITER. The implemented procedure is discussed in detail, in particular with respect to the automization applied which takes the achievable positioning and alignment accuracies of the robot into account. This discussion is extended towards the definition of requirements for a remote-handling tool for ITER. The final proof of the applicability for in-situ calibration in ITER will be demonstrated by the in-situ determination of the geometric properties of the ASDEX Upgrade bolometer diagnostic.

[1] L.C. Ingesson et al., Rev. Sci. Instrum., Vol. 71, No. 3 (2000), pp 1370–1378

[2] H. Meister et al., Rev. Sci. Instrum., Vol. 79, No. 10F511 (2008), pp 10F511-1 – 10F511-5