Twin synthetic diagnostic for the design and exploitation of the WEST high-resolution Thomson Scattering diagnostic.

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WEST is a medium-size tokamak which is relevant for the ITER project. One purpose is to test and assess the behavior and ageing of components ahead of ITER divertor installation [1,2].

Detailed characterisation of edge kinetic profiles is important to understand the physics of power load distribution, coupling of Radio-frequency heating systems and confinement properties of the plasma.

Precise measurement of the density and temperature profiles are required in the pedestal and scrape of layer regions (SOL) to evaluate and investigate the heat flux (HF) deposited on the divertor target. Precise temperature and density profiles are also needed in the plasma core to characterize the confinement regime and evaluate the upstream fluxes.

For this purpose, a new High Resolution Thomson scattering (HRTS) diagnostic is being developed for determining the electron density n_e and temperature T_e.

In the plasma edge, the HRTS will probe 18 cm at the plasma top with 6 mm vertical resolution, corresponding to 3.5 mm resolution once remapped to midplane (corresponding to approximately 10 radial positions across the pedestal). To achieve such resolution a water cooled in-vessel endoscope will be implemented [3].

In the plasma core, the resolution requirement is less stringent. The optical system is thus outside the vacuum vessel 20 vertical positions will be probed with a 25 mm spatial resolution from the equatorial plane. Owing to an overlap with the edge system, the HRTS will offer a full coverage of the plasma upper half.

To prepare the operation of the HRTS and evaluate its performance, a synthetic diagnostic has been developed to model the complete transmission function of the system from the laser up to the polychromators signal in order to validate the system.

More specifically, the model includes Thomson scattering processes, laser characteristics and system geometry, Monte Carlo rendering of photon statistics through optics of the telescopes, optical fibres, and finally the instrument transfer functions of the detector, i.e the polychromators channels.

Thanks to this synthetic diagnostic, one verify that the photonic budget of the final optical design fulfils the requirements for precise measurements of electron temperature and density. Namely, for standard plasma parameters of $n_e = 10^{19}\ m^{-3}$ and $T_e = 1\ KeV$, about 5000 photo-electrons are generated by polychromators with an error of 2 % on the electron temperature estimate. We have also verified that SOL measurements were possible :

for SOL parameters $n_e = 10^{18}\ m^{-3}$ and $T_e = 10\ eV$, about 500 photo-electrons are generated by polychromators leading to an error of 15 % on the electron temperature.

Note that the background signal is also evaluated using a Bremsstrahlung emission model and experimental conditions from previous WEST experiments.

Twofold objectives are followed :

1) quantifying the impact on temperature and density estimates through sensitivity analysis of the signal to noise ratio,

2) addressing the possibility to measure the effective charge (Z_{eff}) of the background plasma through Bremsstrahlung inversion.

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[2] Bucalossi J and al, 2022, Operating a full tungsten actively cooled tokamak :overview of WEST first phase of operation, doi 10.1088/1741-4326/ac2525

[3] Colledani G, 2023, this conference