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Using X-ray measurements to assess uncertainties in plasma temperature and impurity profiles in tokamaks

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In tokamaks, the local X-ray plasma emissivity is a complex quantity resulting from the contribution of several plasma parameters, i.e. electron temperature, density and concentration of impurities in multiple ionization states. In particular, the impurity core concentration can be estimated from the emissivity in the soft X-ray (SXR) range 0.1 – 20 keV, while information about the superthermal electron population can be obtained in the hard X-ray (HXR) range 20 keV – 200 keV [1]. The estimation of the tungsten concentration profile is subject to many uncertainties, in particular it requires accurate knowledge of plasma temperature, magnetic equilibrium, atomic processes leading to its cooling factor and the spectral response of the diagnostic [2]. A global W concentration can, for example, be inferred with integrated simulation codes in order to match the total radiated power. When all other plasma parameters are well-known, the impurity density profile can be reconstructed in the core with the help of SXR tomographic tools [3]. Nevertheless, in the case of a significant fraction of superthermal electrons e.g. due to RF heating, accurate estimation of electron temperature from ECE measurements can become a challenging task [4].

Therefore, the goal of this contribution is to establish a methodology to assess the uncertainty in the core electron temperature and impurity concentration profiles based on X-ray measurements. The proposed strategy is to define a grid of candidates (T_e, c_W) scenarios and identify the ones having the highest consistency with respect to multiple line-integrated measurements. In order to determine the capabilities and limitations of such an approach, the method is first tested on well-known synthetic profiles in an arbitrary tokamak geometry. In a second step, first experimental tests are presented for some selected WEST discharges.

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