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Novel multi-energy x-ray cameras for magnetically confined fusion plasmas

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A compact multi-energy soft x-ray (ME-SXR) camera has been developed for time, energy and space-resolved measurements of the soft-x-ray emissivity in magnetically confined fusion (MCF) plasmas. Multi-energy x-ray imaging provides a unique opportunity for measuring, simultaneously, a variety of important plasma properties (T_e, $n_e^2 Z_{eff}$, n_Z, ΔZ_{eff} and $n_{e,fast}$). Selecting an appropriate detector response eliminates the contamination introduced by the low- and high-energy line-emission from medium- to high-Z impurities facilitating temperature measurements in Ohmic and RF-heated scenarios (e.g. ICRH and LHCD) in agreement with conventional ECE and Thomson scattering systems. Impurity density measurements are also possible using the line-emission from medium- to high-Z impurities to separate background as well as transient levels of metal contributions. This novel imaging system developed at PPPL and tested first at Alcator C-Mod tokamak at MIT, combines the best features from both pulse-height-analysis (PHA) and multi-foil methods, and represents a very large improvement in throughput and spatial resolution thanks to present state-of-the-art pixelated PILATUS detectors with nearly 100k pixels. Being the first of its kind, this novel diagnostic will be used to resolve the impurity emission, study impurity transport and impurity-induced MHD and will become an essential part of a control algorithm coupled to physics and engineer actuators for minimizing impurity accumulation in tokamaks. This technique should be explored also as a burning plasma diagnostic in-view of its simplicity and robustness. Recent results from a detector sensitivity study including its response at high magnetic fields (up to 3.4 T and 3.0 T/s) and ITER-like neutron fluences (up to $10^{15} - 10^{16}$ n_{eq}/cm^2) will be presented.

Eligible for student paper award?

No

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