The Heavy Ion Beam Diagnostic For Plasma Fluctuation Studies At The Tokamak ISTTOK

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Enhanced transport and energy loss due to turbulence can significantly reduce the efficiency of a fusion reactor. Therefore fluctuation studies for turbulence control and mitigation are very important in order to improve plasma confinement and performance. Plasma density, temperature and electric potential turbulent fluctuations are responsible for the anomalous transport, while the Magneto-Hydrodynamic (MHD) activity affects the equilibrium for instance through fluctuations of the plasma pressure.

The Heavy Ion Beam Diagnostic (HIBD) at the tokamak ISTTOK (a=8.5cm, R=46cm, B_T=0.5T, I_p=5kA, $\langle n_e \rangle = 5\text{x}10^{18}\text{m}^{-3}$ and $T_e(0)$ ~ 120-150eV) has recently been improved to allow the experimental studies of turbulence in the frequency range of interest. It operates by injecting a primary Xe^+ ion beam (18-25keV) and collecting the secondary Xe^{2+} ions generated from the ionisation process of Xe^+ ions collisions with the plasma electrons. The HIBD improvement includes a low noise Multiple Cell Array Detector (MCAD) [1] and a home-made amplification system, to measure the detected ion current fluctuations with wide frequency bandwidth (up to 400 kHz at -3dB of gain) and high signal to noise ratio.

Previous HIBD results have demonstrated that, for ISTTOK plasma density and temperature ranges, the measured Xe^{2+} ion current fluctuations are weakly affected by the integral path effects. This means that the measured generation factor $n_e\sigma_{eff}(T_e)$ (a function of plasma density and temperature) fluctuations (relative values) can be obtained directly from the Xe^{2+} ion current intensity. For absolute values of $n_e\sigma_{eff}(T_e)$ fluctuations, a reconstruction algorithm taking into account the beam attenuation effects [2] should be used. The fluctuation measurements of the $n_e\sigma_{eff}(T_e)$ generation factor are performed simultaneously at twelve different sample volumes (with a maximum delay time of 1μs) along the tokamak minor radius ($-0.7a < r < 0.7a$) with a spatial resolution defined by the primary beam size and trajectory (roughly vertical path across the plasma) and the secondary MCAD cell dimensions.

A preliminary analysis of the HIBD signals has demonstrated high correlations with the signals from Mirnov coils and Langmuir Probes in the range of MHD frequencies. Using filtering techniques, the typical signature from a tearing mode was observed. Statistical analysis of signals from a HIBD periphery sample volume and a Langmuir probe (both measurements located at the equivalent radial position) have shown some similar properties, namely, high values of skewness and kurtosis, a typical characteristic of turbulent fluctuations.

This work presents the current status of the HIBD at ISTTOK and its capabilities for plasma spatial and temporal fluctuation studies.

[1] R.B. Henriques, et. al., *Review Scientific Instruments* **83**, 10D705 (2012).
[2] A. Malaquias, et. al., *Review Scientific Instruments* **70**, 947 (1999).