§23. High Resolution X-Ray Imaging Crystal Spectrometer (XICS)

Pablant, N. (PPPL), Morita, S., Yokoyama, M., Bitter, M. (PPPL), Hill, K. (PPPL), Gates, D. (PPPL), Goto, M., Lazerson, S. (PPPL), Oishi, T., Roquemore, A. (PPPL), Seki, R.

The high resolution x-ray imaging crystal spectrometer (XICS)[1] has been upgraded from its initial installation configuration. An analysis program has been developed allowing complete spectral analysis and tomographic inversion of the measured data. The resulting ion temperature profiles have been integrated into the TASK3D transport code, allowing for the first time a complete static transport analysis of ECH heated discharges without NBI injection.

A major upgrade was undertaken for the XICS diagnostic that expanded the view of the Ar^{16+} (helium-like) system to include the full plasma profile (Fig. 1), and added a completely new Ar^{17+} (hydrogen-like) system.[2] The upgraded Ar^{16+} system now includes a water cooled Pilatus 300K-W detector which allows for operation on every discharge as well as during long pulse discharges. The expanded view range, from -0.50 m $< z <$ 0.51 m, allows the measurement of poloidal rotation (Fig. 2) and improves the accuracy of the tomographic inversion procedure. The newly installed Ar^{17+} system allows the measurement of the ion temperature profile in plasmas with 3 keV $\leq T_e \leq$ 10 keV, providing a significantly expanded range for the XICS diagnostic.

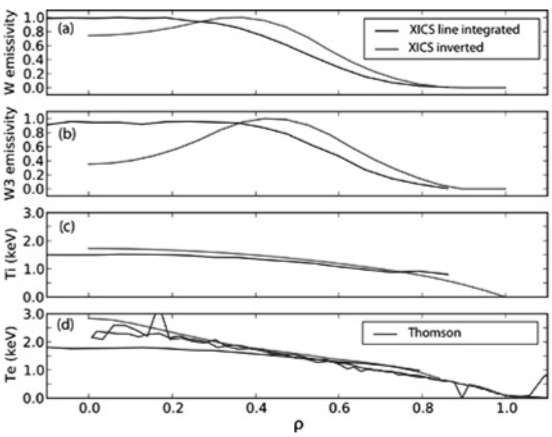

Fig.1 Line-integrated (black) and inverted (red) XICS measurements from shot 114206. In (d) the XICS measurement of T_e is compared with Thomson scattering (blue).

A full acquisition and analysis package is now complete for both the Ar^{16+} and Ar^{17+} XICS systems. This package includes: data acquisition, spectral fitting using an atomic physics based spectral model, and tomographic inversion based on a known plasma equilibrium. A new inversion procedure has been developed that allows constraints to be enforced as part of the inversion process. These constraints ensure that the inverted profile is realistic, and allow inversions to be done with low signal levels or an incomplete viewing range. Both the STELLOPT equilibrium reconstruction code[3] and the TSMAP equilibrium lookup system[4] have been integrated into the inversion procedure.

XICS measurements of the poloidal rotation profiles and ion temperature have been applied to the transport study of pure ECH heated high-T_e plasmas. Ion temperature profiles from XICS have been integrated into the TASK3D transport analysis code[5]. This allows a complete static transport analysis in the absence of NBI injection. Measured temperature profiles from the XICS and Thomson scattering systems are shown in Fig. 3 along with the calculated power density from electrons to ions, assuming a pure hydrogen plasma.

The evolution of the poloidal rotation for shot 114722 is shown in Fig. 2. As the plasma enters the high-T_e regime around 3.6s the poloidal rotation is seen to increase, indicating the development of a strong radial electric field.

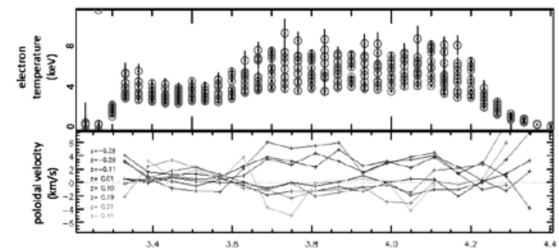

Fig.2 a) Time evolution of the electron temperature for shot 114722 as measured by Thomson scattering and b) line-integrated poloidal rotation as measured by the XICS diagnostic. Each line corresponds to a different viewing height in the plasma. Views above and below the magnetic axis measure opposite flow velocities, indicating a clear poloidal rotation.

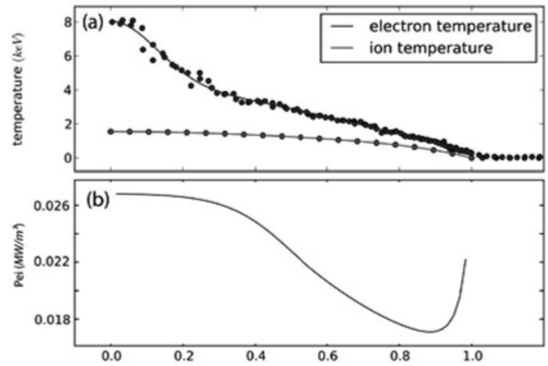

Fig.3 a) Measured ion and electron temperatures for shot 114722 at 4000ms and b) power density from electrons to ions as calculated using the TASK3D analysis suite.

1) Pablant, N. et al., Rev. Sci. Instr. **83** (2012) 083506.
2) Pablant, N. et al., to be submitted (2013).
3) Lazerson, S. et al., Europhys. Conf. Abstr. **35G** (2011).
4) Suzuki, C. et al., Plasma Phys. Contr. Fus. **55** (2013) 014016.
5) Yokoyama, M. et al., Plasma Fus. Res. **8** (2013) 2403016.