

Structure dynamics associated with temperature fluctuations in the magnetised plasma of the Thorello device

R. Barni¹, C. Riccardi¹, A. Fredriksen²

¹*Dipartimento di Fisica Occhialini, Universita' degli Studi di Milano-Bicocca,
p.zza della Scienza, 3 I-2016 Milano, Italy*

²*Dep. Physics, University of Tromsø, N-9037 Tromsø, Norway*

Experimental investigation of magnetised plasma turbulence is actively pursued in fusion aimed as well as in basic plasma physics toroidal devices [1-3]. The experimental study of the turbulence in low beta, low temperature magnetised plasmas has demonstrated the presence of spatially localized density fluctuation structures propagating in the background plasma [4,5]. Such structures are usually associated to a local modification of the electric field. Their formation and evolution are actively investigated. In particular such structures contributes to the anomalous transport and constitutes an efficient mechanism for the ejection of particles and energy from a plasma column towards the edge region, across the magnetic field lines. This topic is a major issue affecting basic plasma physics understanding yet. It is also relevant in connection with the physics of the edge region of fusion aimed devices [6]. Experiments reported here have been performed in the Thorello device, operating at the University of Milano-Bicocca [7]. Here a low temperature, high density steady plasma column can be produced and maintained in a hydrogen low pressure discharge. The plasma column shows a rather high level of fluctuations which have been studied by means of multiple pin electrostatic probes: fairly long time series of fluctuating plasma parameters have been obtained and correlated. Here electron temperature fluctuations have been measured by means of a double probe. A conditional sampling analysis was then performed in order to detect and study the spatiotemporal evolution of structures in a 2D section of the device in the turbulent state [8,5]. We report results obtained by the selection of events connected with enhanced temperature fluctuations at the edge of the plasma column. The detected structures are compared with those observed in connection with density and potential fluctuations confirming the role of such structures in the energy as well as particle flux.

The device consists of a toroidal vessel, major and minor radius respectively 40 and 8 cm. A simple toroidal magnetic field (up to 0.2 T) is provided by 59 closely packed coils. Plasma in Thorello is produced in low pressure hydrogen by a steady hot cathode discharge. Electrons are thermo-ionically emitted by a tungsten filament, wrapped in a spiral, 2 cm in diameter and located in correspondence of the center of the poloidal cross-section.

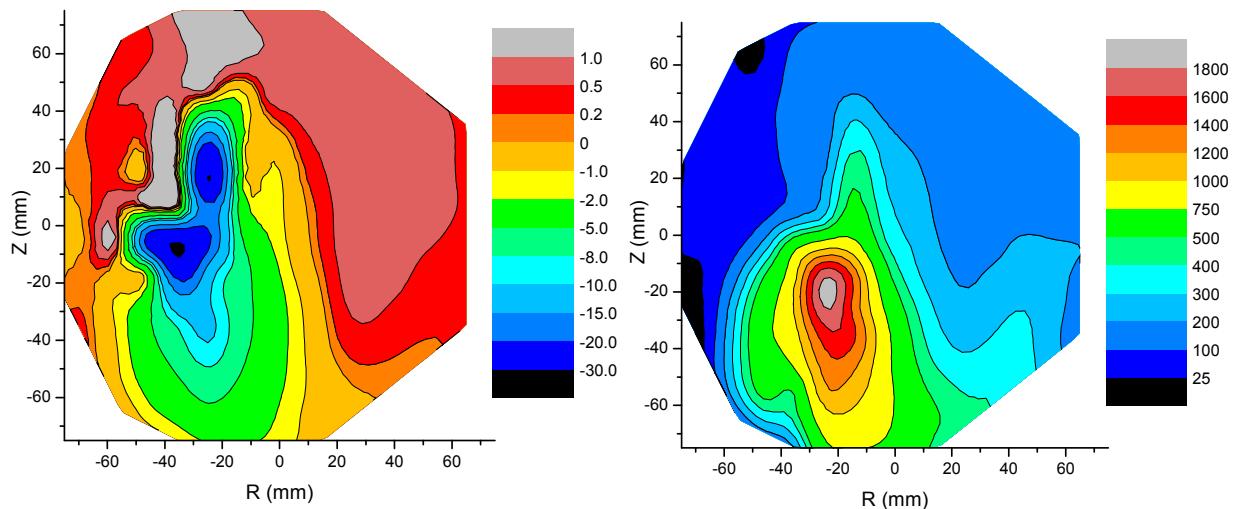


Fig.1 - 2D profiles of the floating potential and of the ion saturation current in the experiment.

Discharge is ignited by imposing a negative bias to the filament respect to the vacuum chamber. A quite stable and steady discharge current can be maintained almost indefinitely in the device. Electrostatic probes have been employed to characterise the plasma filling the device. A movable probe, with a tungsten tip (5 mm long, 0.3 mm diameter) scans the 2-D poloidal section of the device, allowing the reconstruction of the average profiles of plasma parameters as well as to measure time series at each different position. Another probe, with three parallel tips in a triangular array of 3 mm size, is held at a fixed position. The probe is used as a double probe to measure the electron temperature [9]. The experiment we report was performed in a discharge at 4×10^{-2} Pa, with a filament current of 70 A and a bias of -100 V. The magnetic field was 250 Gauss. 2D profiles of the ion saturation current and of the floating potential are shown in Fig.1. One could notice that the reference probe location lays just outside the main plasma column, at the edge of the potential well. We discuss results concerning a conditional sampling analysis, which was previously applied to spot density blobs dynamics [5]. At first, we select as a trigger condition, the time when we observe a relative maximum in the positive fluctuations of the electron temperature at the reference probe location, extracting and averaging 200 μ s time windows. Here the electron temperature was 1.98 ± 0.33 eV. A threshold in the event amplitude, at the level of 2σ was applied.

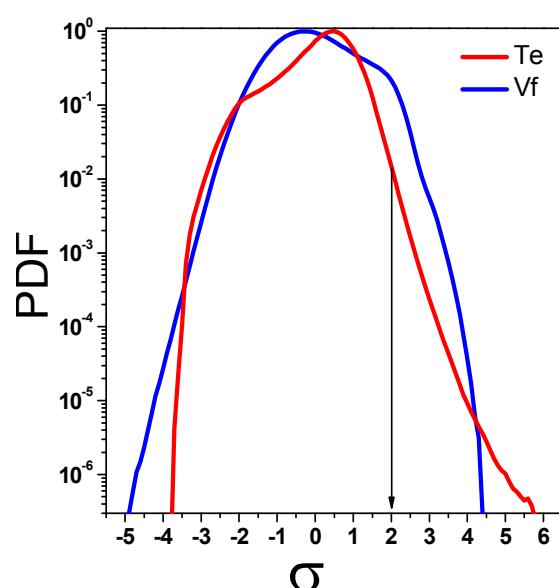


Fig.2 - PDF of electron temperature fluctuations.

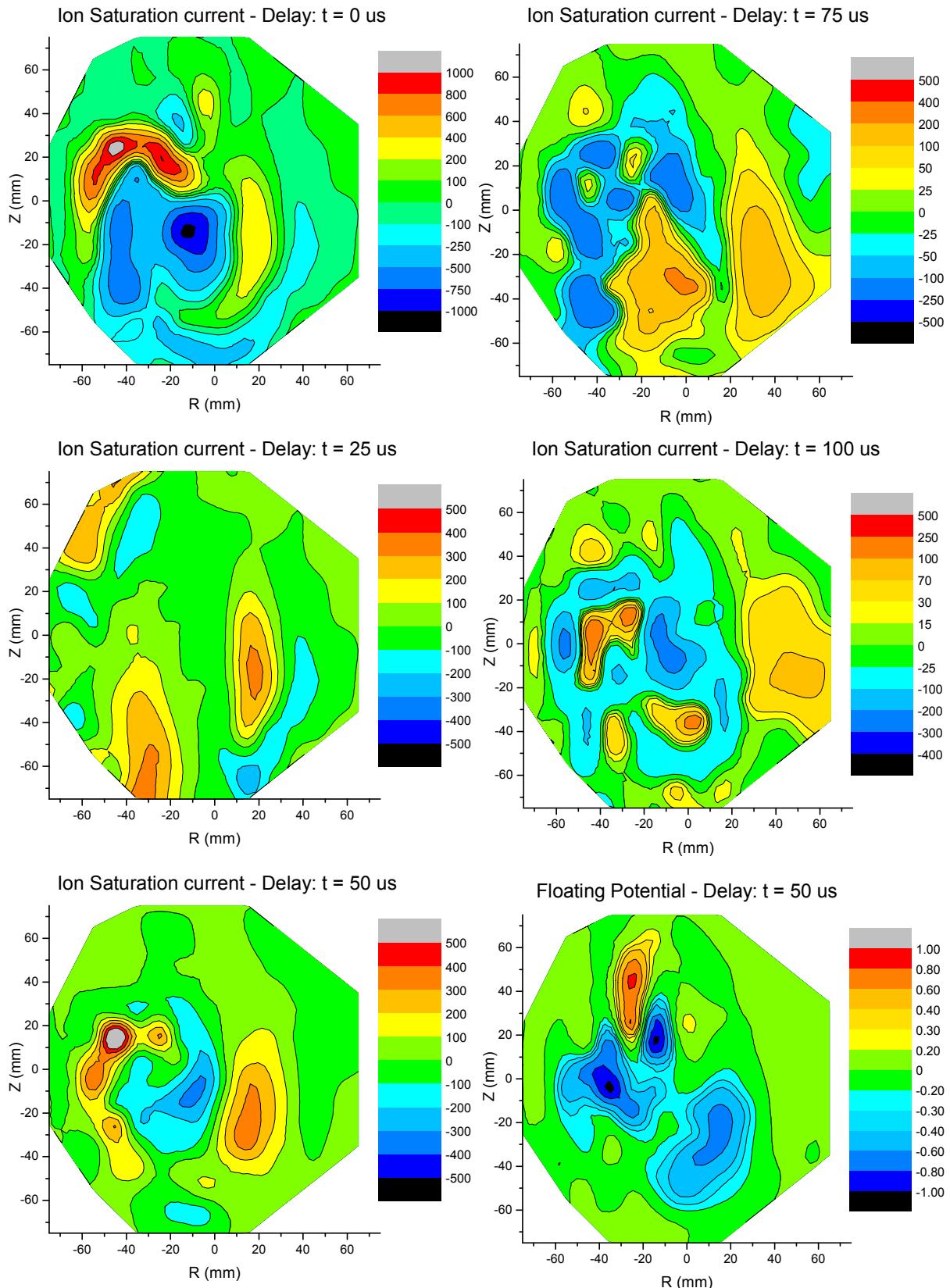


Fig.3 - Conditionally sampled signal of the ion saturation current and of the floating potential in the 2D poloidal cross-section at different delays from the trigger condition.

We eliminated overlapping events as was done in [8]. The mean number of events exceeding threshold was 359 ± 48 over the whole data-set of position scanned. We started looking at the

evolution of the ion saturation current fluctuations in the poloidal section. A few snapshots are shown in fig.3. At first we can look at the plasma state in the poloidal section at the trigger time, fig.3 at the upper left corner. The structure triggering the conditional sampling appears at the edge of the main plasma column, where an $m=1$ poloidal mode is rotating. Trigger happens when the positive fluctuation lobe (that is corresponding to an increased plasma density) reaches the reference probe region. The plasma density in the central part of the column appears depleted too. Afterwards in the edge region, outside the main column, a broad positive blob propagates outwards reaching the limiter shadow after about 100 μ s. Blob is elongated along the motion line, with dimensions respectively of 2-4 cm. The blob motion follows rather closely the pattern of the average floating potential line separating the potential well (closed lines) and the edge region (open lines). We have also applied the conditional sampling, with the same triggering condition, at the floating potential time series. So we have reconstructed its evolution in the whole poloidal section. First of all the level of potential structure fluctuations is a few volts. Then the overall perturbation of the mean potential well happens to be small and it has effects only at the borders and in the edge region. A snapshot is shown in fig.3 at the lower right corner. At that time the potential perturbation is extending into the edge region. It looks like a shallow bump just disconnecting from the main potential well, somewhat larger than the associated density blob. The potential structure fades progressively, like it happens for the blobs, in about 100 μ s. This behaviour closely resembles that already discovered, associated with ion saturation current structures [5]. This enforce evidence that density blobs are associated also with electron temperature fluctuations and their motion contributes not only to particle but also to energy transport the edge regions of magnetised plasmas in turbulent regime.

References

- [1] 1] G.R. Tynan, A. Fujisawa and G. McKee, *Plasma Phys. Control. Fusion* 51, 113001 (2009).
- [2] S.J. Zweben, J.A. Boedo, C. Hidalgo et al., *Plasma Phys. Control. Fusion* 49, S1 (2007).
- [3] S.H. Muller, C. Theiler, A. Fasoli et al., *A, Plasma Phys. Control. Fusion* 51, 055020 (2009).
- [4] G.Y. Antar, S. Krasheninnikov, P. Devynck et al., *Phys. Rev. Lett.* 87, 065001 (2001).
- [5] R.Barni and C.Riccardi, *Plasma Phys. Control. Fusion* 51, 085010 (2009).
- [6] G.Y. Antar, G. Counsell G, Y. Yu, B. LaBombard and P. Devynck, *Phys. Plasmas* 10, 419 (2003).
- [7] C. Riccardi, R. Barni, M. Arosio and M. Fontanesi, *Europhys. Conf. Abstr.* 32, P2.027 (2008).
- [8] H.L. Pecseli and J. Trulsen. *Phys. Fluids B* 1, 1616 (1989).
- [9] C.Riccardi, G. Longoni, G. Chiodini and M. Fontanesi, *Rev. Sci. Instr.* 72, 461 (2001).