Local effects of magnetic resonances in ECRH plasmas of the TJ-II Heliac

D. López-Bruna, J. A. Romero, A. López-Fraguas, J. M. Reynolds[a], E. Blanco, M. A. Ochando, T. Estrada, D. Tafalla, J. Herranz, F. Medina, R. Jiménez, E. Ascasíbar, V. I. Vargas[b], TJ-II Team

Laboratorio Nacional de Fusión, Asociación Euratom-Ciemat, Ciemat, Madrid 28040, Spain

[a] *Instituto de Biocomputación y Física de Sistemas Complejos, Zaragoza 50009, Spain*

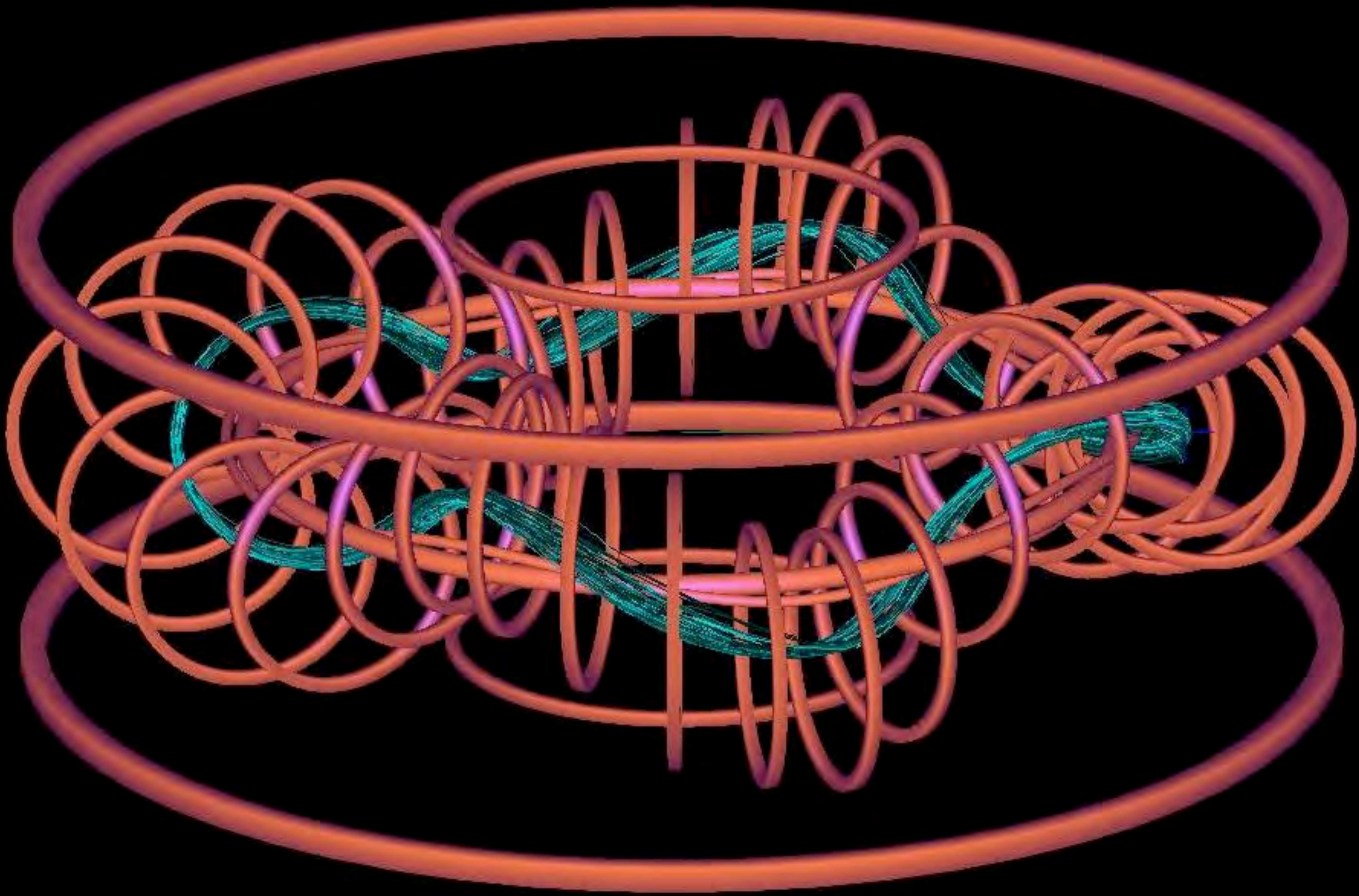
[b] *Instituto Tecnológico de Costa Rica, Cartago, Costa Rica*

Motivation

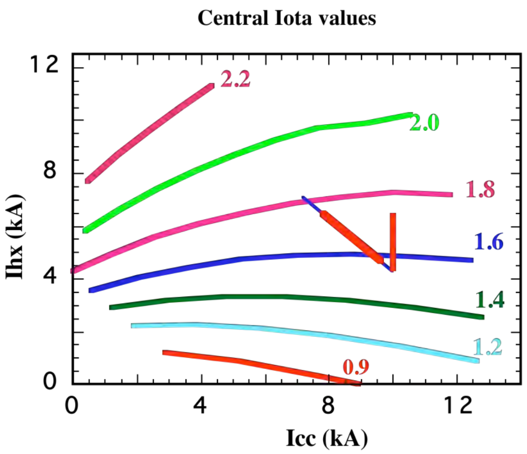
- How important is the 3D magnetic structure of S/H to evaluate transport?
- A fact: magnetic resonances *can* be deleterious for transport. What happens when they are not?
- In the absence of disruptions, are the magnetic resonances* practical control knobs for confinement?

* Magnetic resonance: short form for "low order rational value of the rotational transform", e.g. 3/2, 5/3, 7/4, 9/5

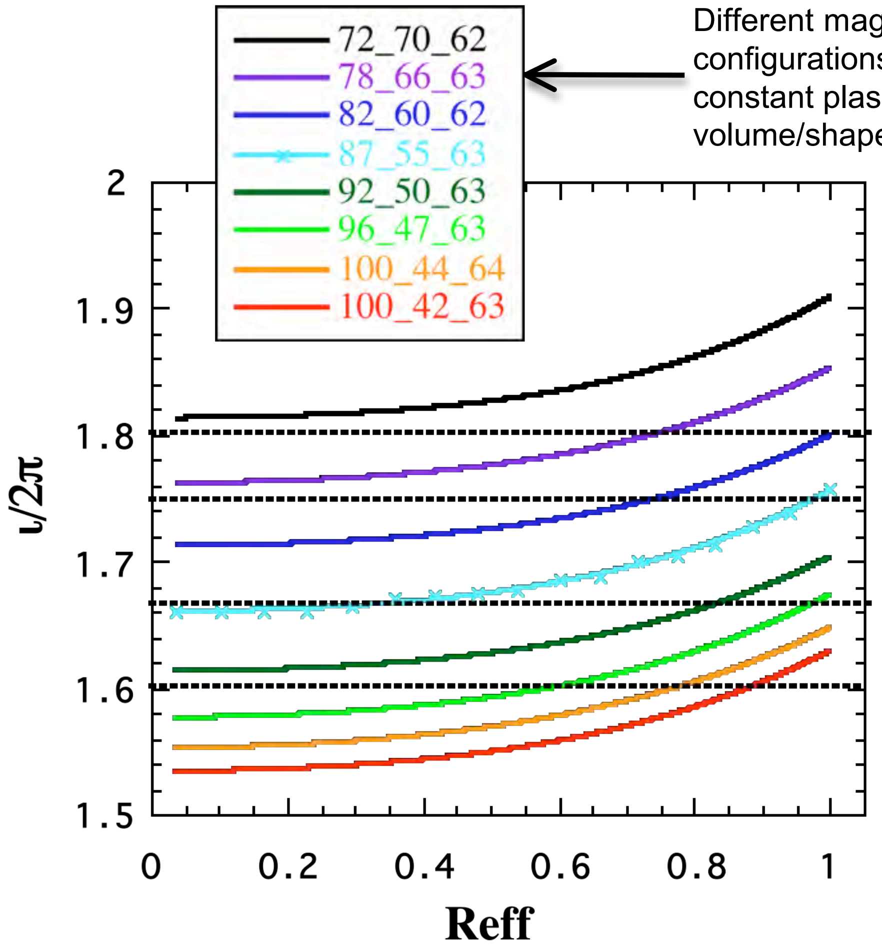
TJ-II Heliac



What is a ι-scan in the TJ-II?

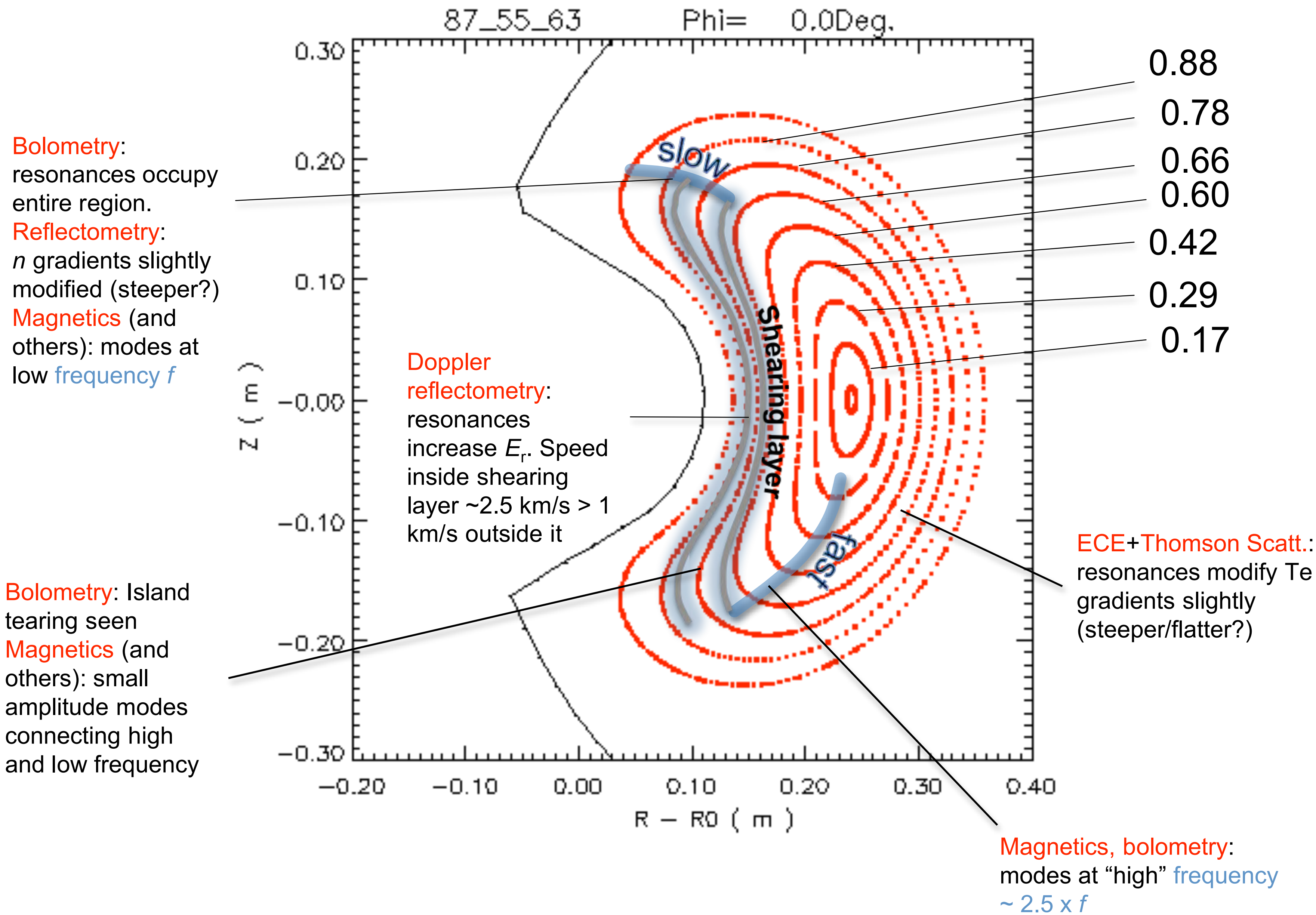


With proper combinations of I_{hx} and I_{cc}, the configuration map can be scanned



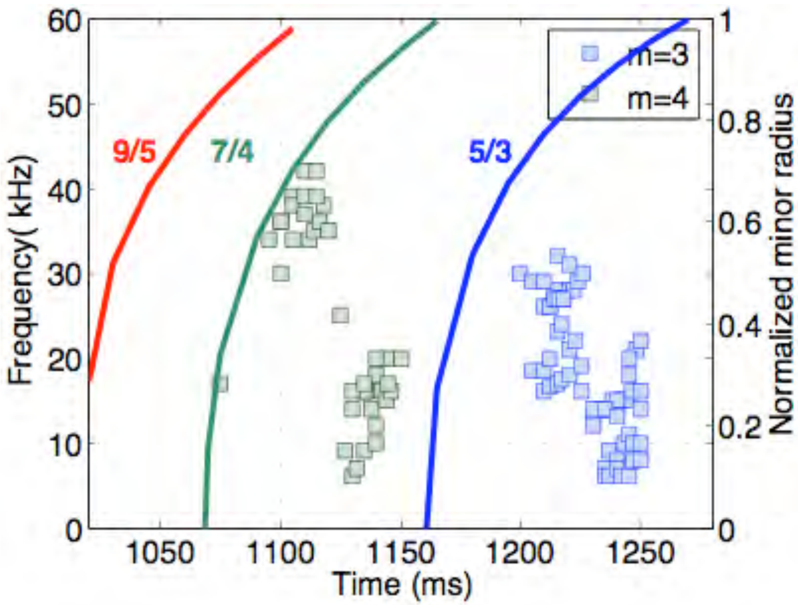
Different magnetic configurations at (practically) constant plasma volume/shape

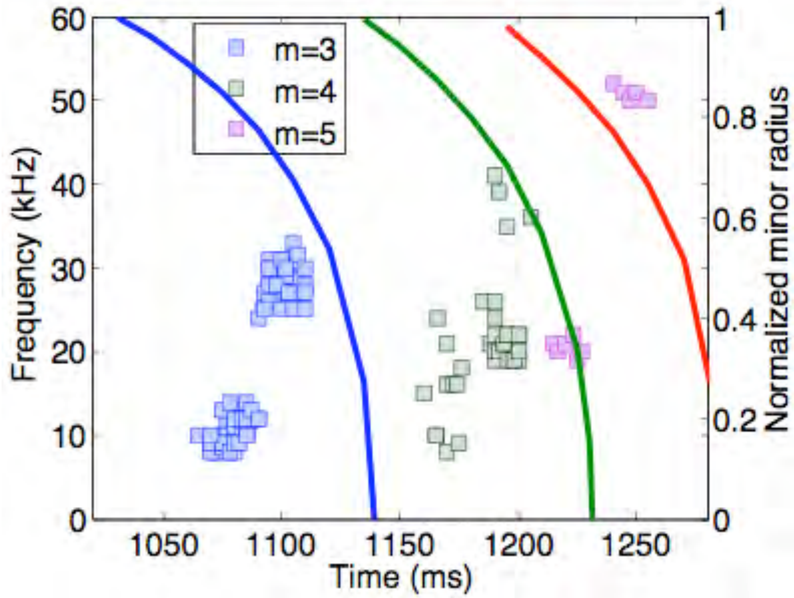
The scans can be done either statically –shot to shot– or dynamically –one shot at changing configuration.



Next: experimental support

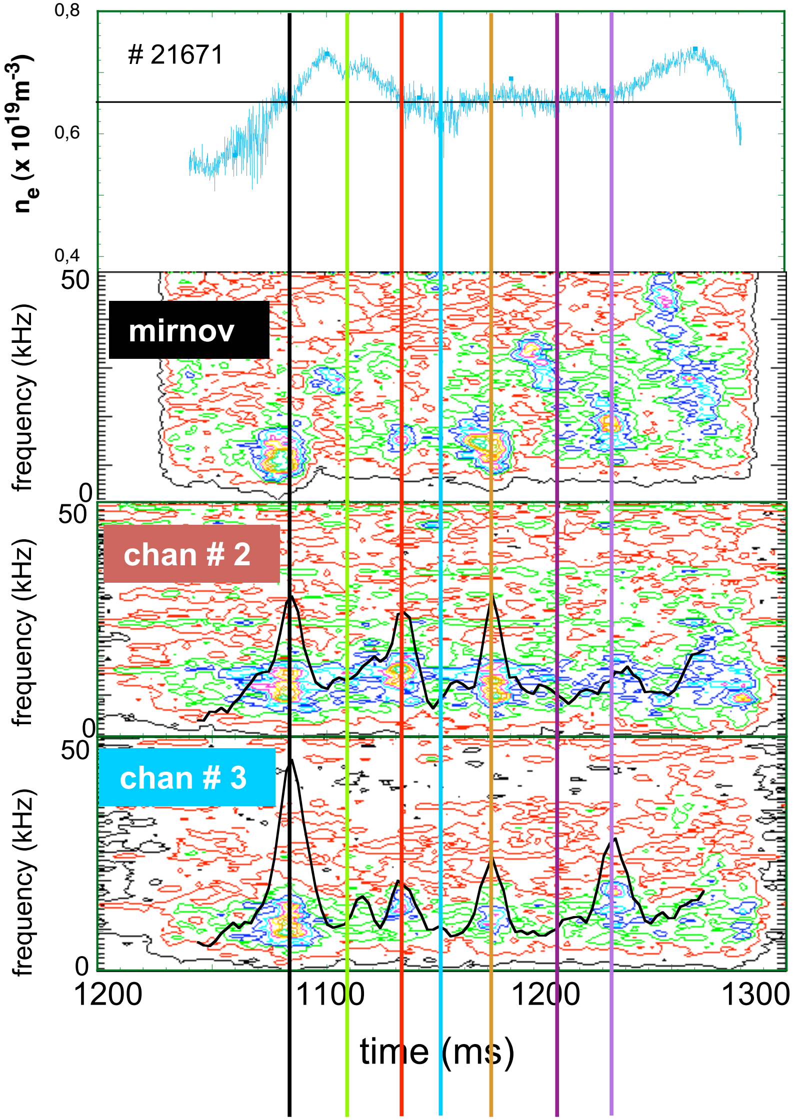
Data from **magnetics**

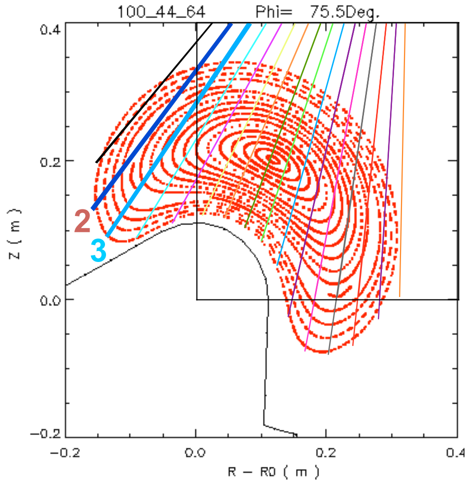


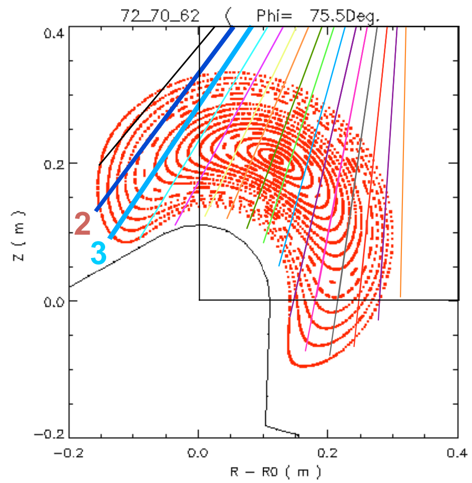


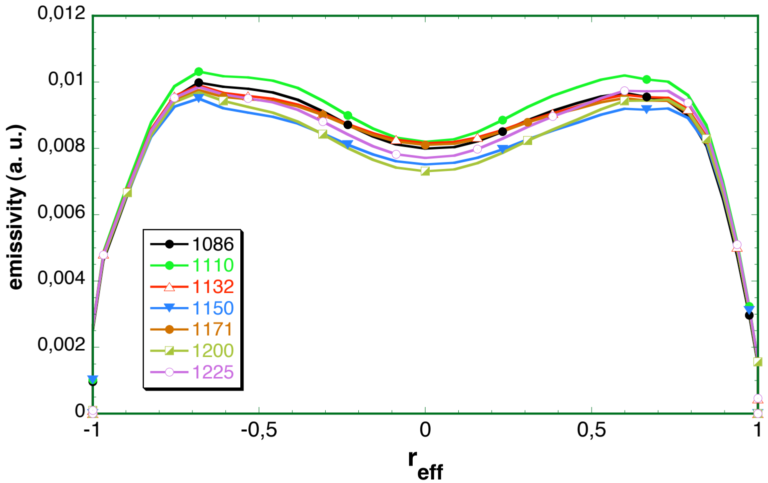
As the feeding currents in the central (circular and helical) conductors of the device are ramped in time, magnetic resonances move through the plasma. Mirnov coil arrays allow for obtaining mode numbers and associated frequencies. The lines represent the location of vacuum resonances 9/5, 7/4 and 5/3.

Data from **bolometry**

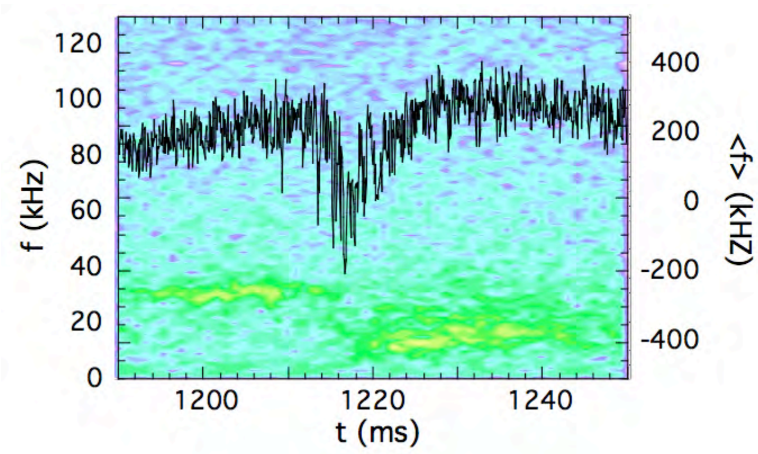




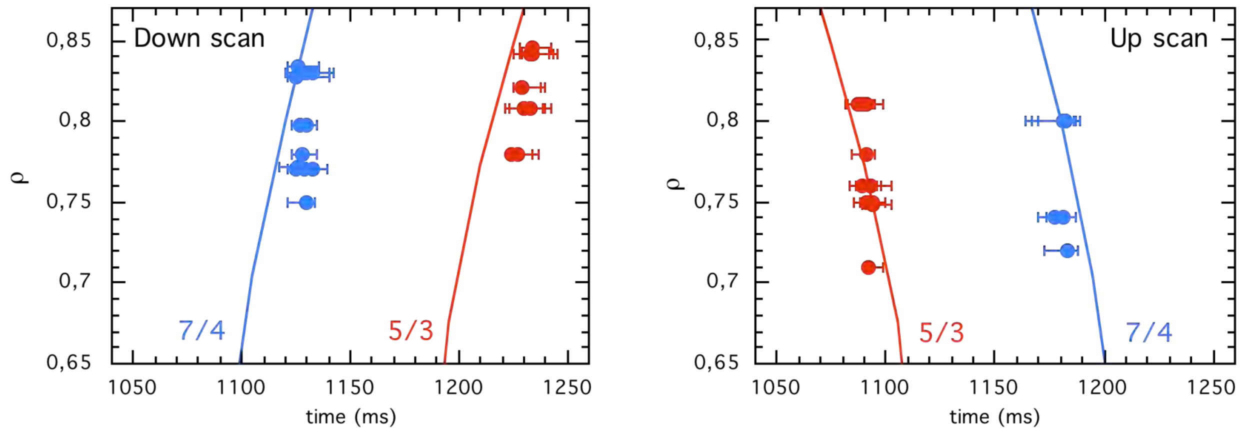




Data from **Doppler reflectometry**



Displacement of the main frequency of the density fluctuations at fixed radial position ($\rho \approx 0.8$) and mode frequency from magnetics at the passage of a resonance.

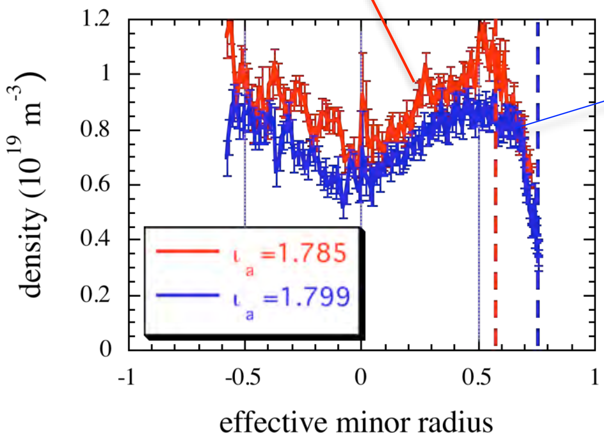


Radial (norm. flux surface coordinate) position of the vacuum resonances 7/4 and 5/3 and time laps during which a differential rotation is detected in the indicated radial positions. Data correspond to downwards (left) and upwards (right) moving rotational transform.

Data from **Thomson Scattering** in static scan

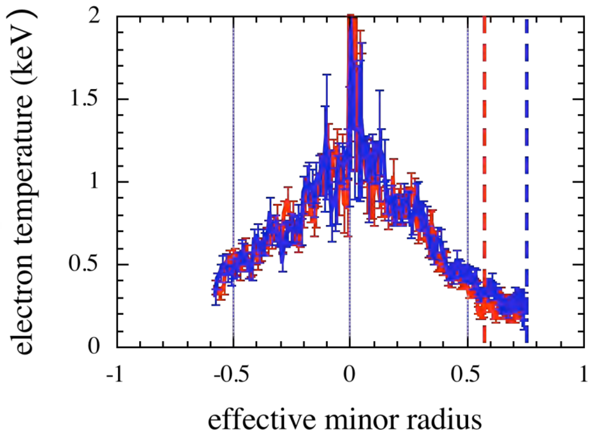
Average of T.S. Spectra, shots 16886, 16887 (I_{hx}=6.4 kA)

Average of T.S. Spectra, shots 16880, 16881, 16882(I_{hx}=6.2 kA)

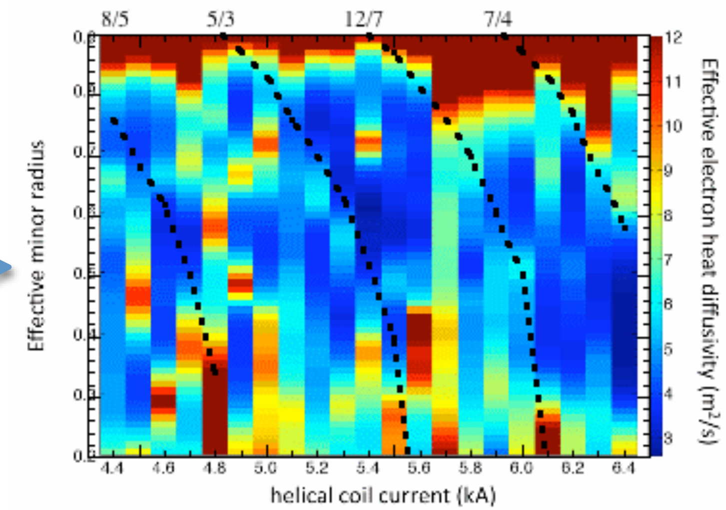


smoothing

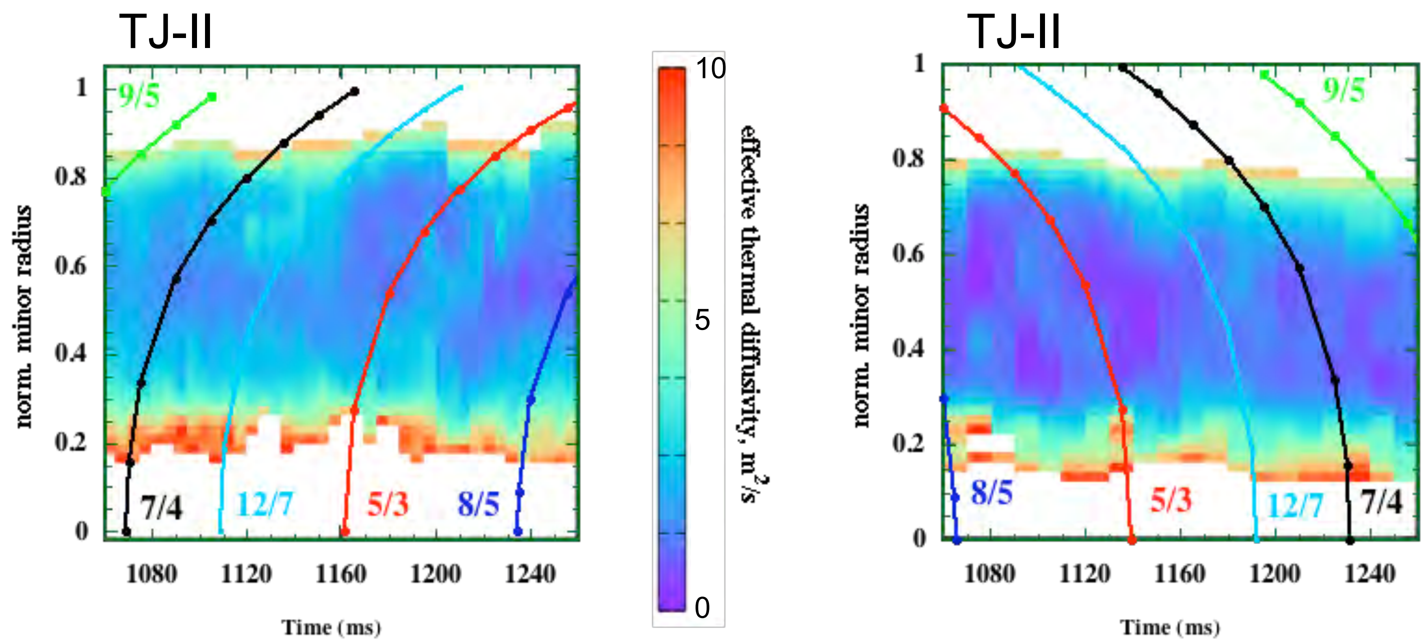
$$\chi_e \sim 1/nT_e'$$



Still, the analysis of 21 consecutive configurations (several discharges for configuration) yields a rough pattern of furrows apparently associated with the displacement of *vacuum* magnetic resonances.



Data from **ECE** in dynamic scans

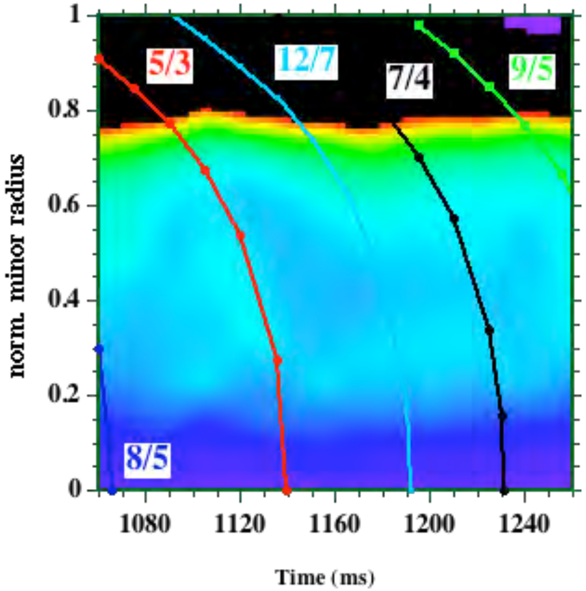


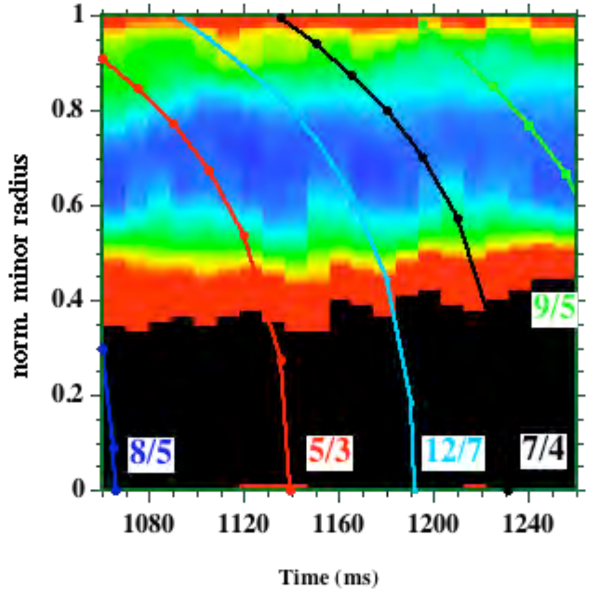
Same pattern as in static configuration scans but now found dynamically (single discharge sweeping). There is absolutely no doubt, afert many experiments of this kind, that the furrows and ridges in χ_e are lines of iso-“rotational transform”. Very important:

– Rather constant collisionality range: $\nu^*_e \sim 0.01$; $\nu^*_i \sim 0.1$

– Closeness between resonances and furrows/ridges => low magnetic shear (< 0.1) guaranteed

Data from **reflectometry**

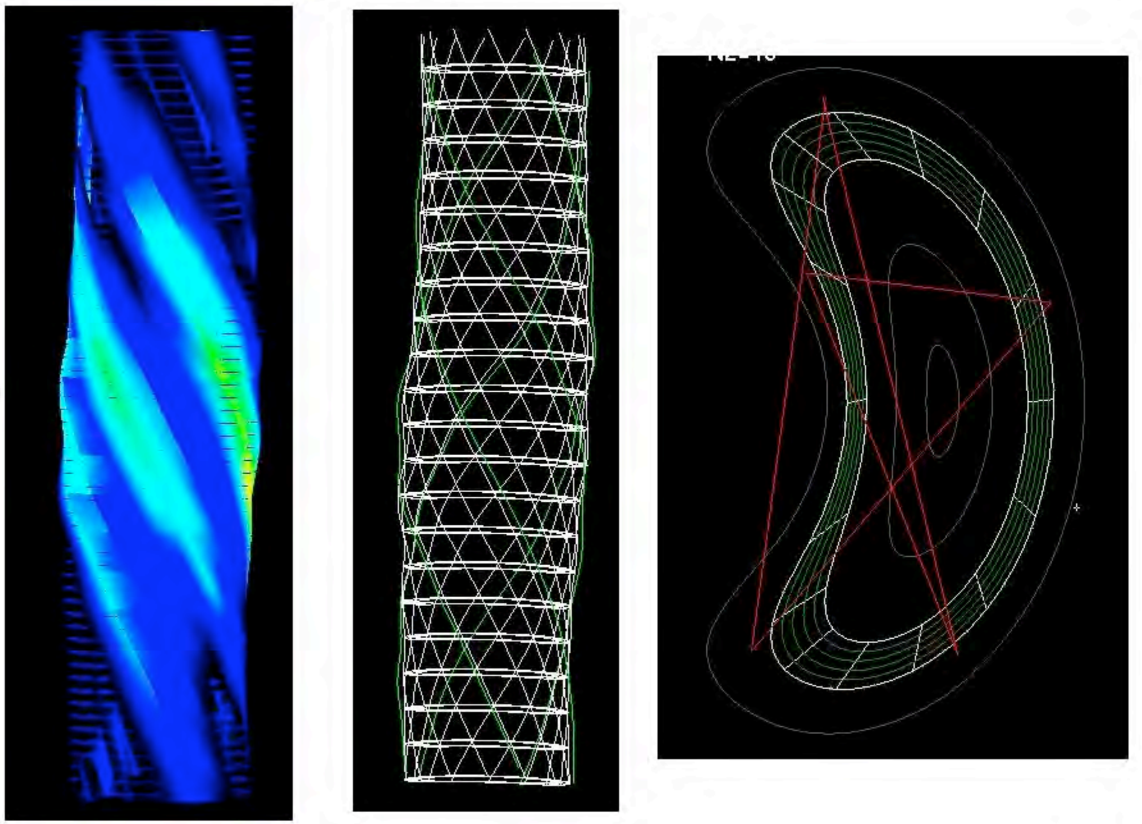




Electron temperature and density gradients (respectively obtained from ECE and reflectometry data) yield effective diffusivities that seem to move likewise through the plasma. Taking the paths of the resonances as a guide, ridges of χ_e and D_e follow the same lines.

DKE calculations (in progress)

Similar pattern is found for electrons, but with opposite sign: a current density is found with the helicity of the resonance



3-D ion velocity distribution obtained from the ion distribution function (left). The geometry of the TJ-II has been straightened (center) for clarity, where we can see the alignement of magnetic field lines –green– and calculation mesh –white. The results correspond to the plasma corona shown (right), which includes the 8/5 vacuum resonance

THE END