STUDY OF EDGE ELECTROSTATIC BIASING ON TOKAMAK TCABR

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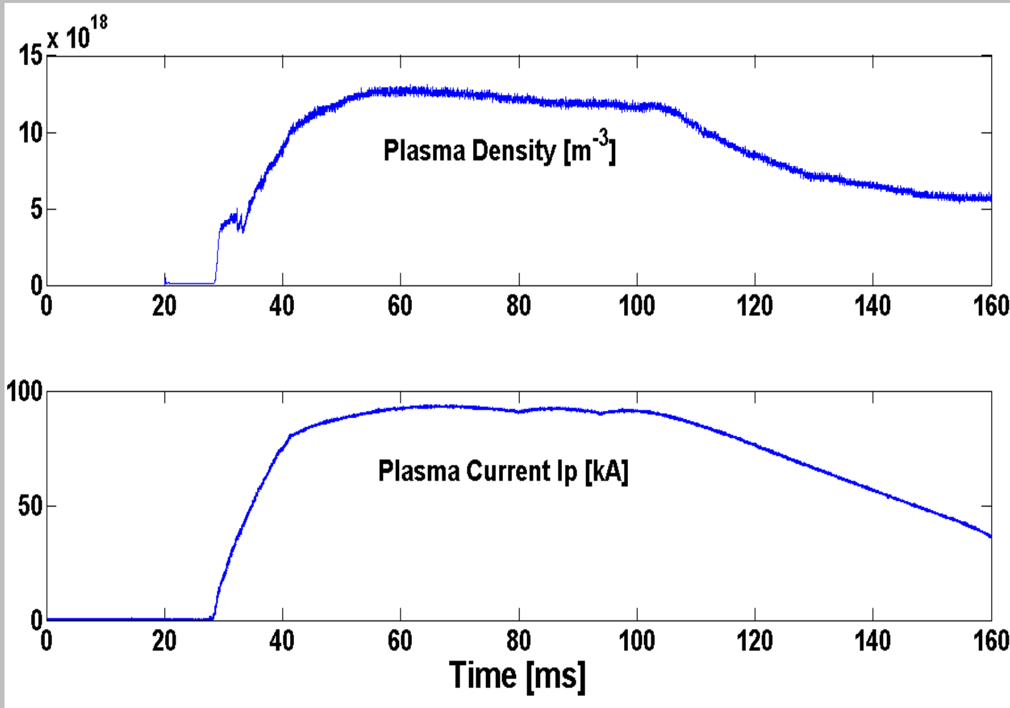
TCABR parameters

- Minor radius: $a = 0.18\,\mathrm{m}$
- Major radius: $\mathrm{R} = 0.61\,\mathrm{m}$
- Maximum plasma current: $\mathrm{I_p} \approx 90\,\mathrm{kA}$
- Toroidal magnetic field: $\mathrm{B_T} = 1.1\,\mathrm{T}$
- Maximum average density: $\mathrm{n_e} \approx (1.0 - 4.5) \times 10^{19}\,\mathrm{m^{-3}}$
- Circular hydrogen plasma, with ohmic heating

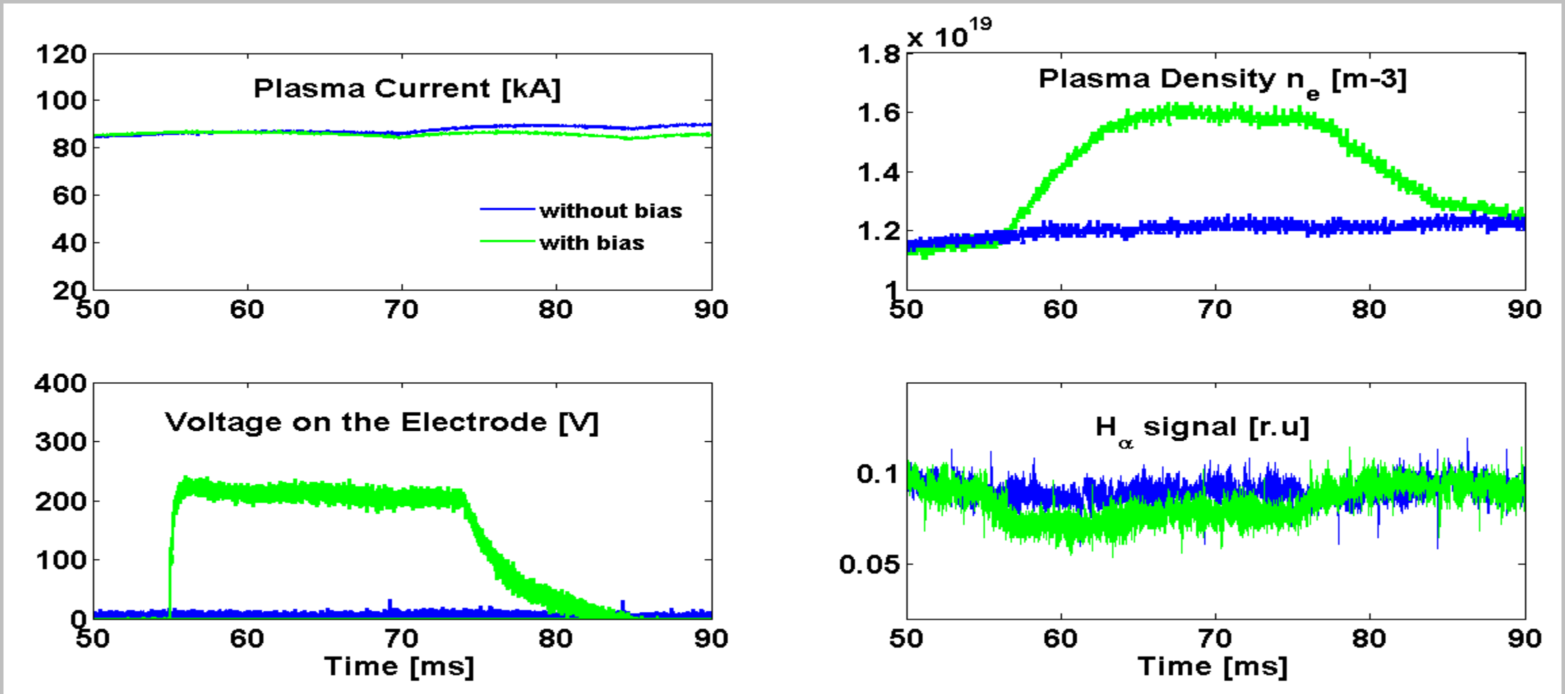


Improvement in the plasma confinement biased by an external electrode

It is widely accepted that the shear of the plasma flow due to ∇E_r at edge drives a reduction in plasma turbulence and transport, creating a change of plasma density profile near the edge, resulting on appearance of a transport barrier.

Ref: Connor J.W. et al 2000 Plasma Phys. Control. Fusion 42 R1

- **Movable Electrode:** made of hard graphite with 20 mm diameter and 8 mm thickness. The power supply can provide current and voltage of up to 300 A and 750 V, with positive or negative polarities. It is inserted vertically from the bottom of the TCABR vessel.



Previous results in biasing experiments in TCABR

- Improvement in confinement using biased electrode at edge of TCABR, with decrease of turbulence and particle transport .

  Ref: Nascimento I.C. et al 2005 Nucl. Fusion 45 796

- MHD instabilities induced or suppressed by electrode biasing. Negative influence of magnetic island (3,1) in the plasma confinement.

  Ref: Nascimento I.C. et al 2007 Nucl. Fusion 47 1570

- Long distance correlation of plasma potential fluctuations at the edge of TCABR and existence of zonal flows (ZFs).

  Ref: Kuznetsov Yu. K. et al 2012 Nucl. Fusion 52 063004

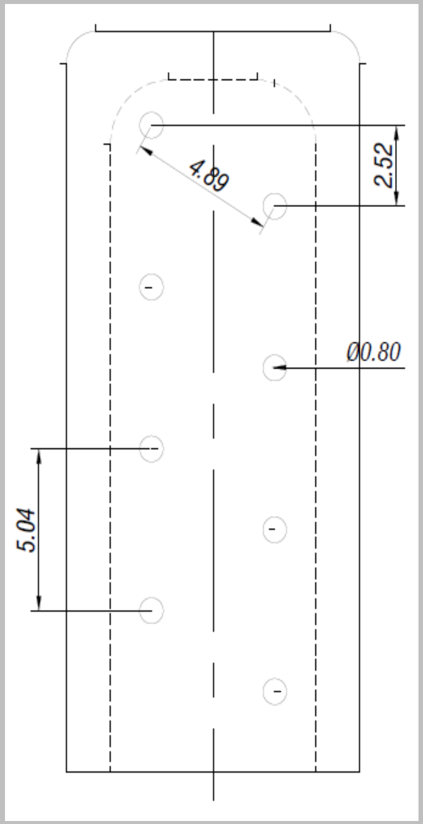
Objectives of this project:

- Measurement of plasma parameters in the SOL and plasma edge using Langmuir probes with improved time and spatial resolution to try to detect the trigger of the confinement improvement in the TCABR, mainly electron density and temperature, fluctuations, radial electric field, turbulence and particle transport.

- What is the role of temperature in the process and how its correction in plasma parameters, like the radial electric field and the electron density, as well as the particles transport, affects the results.

Electrostatic Probes

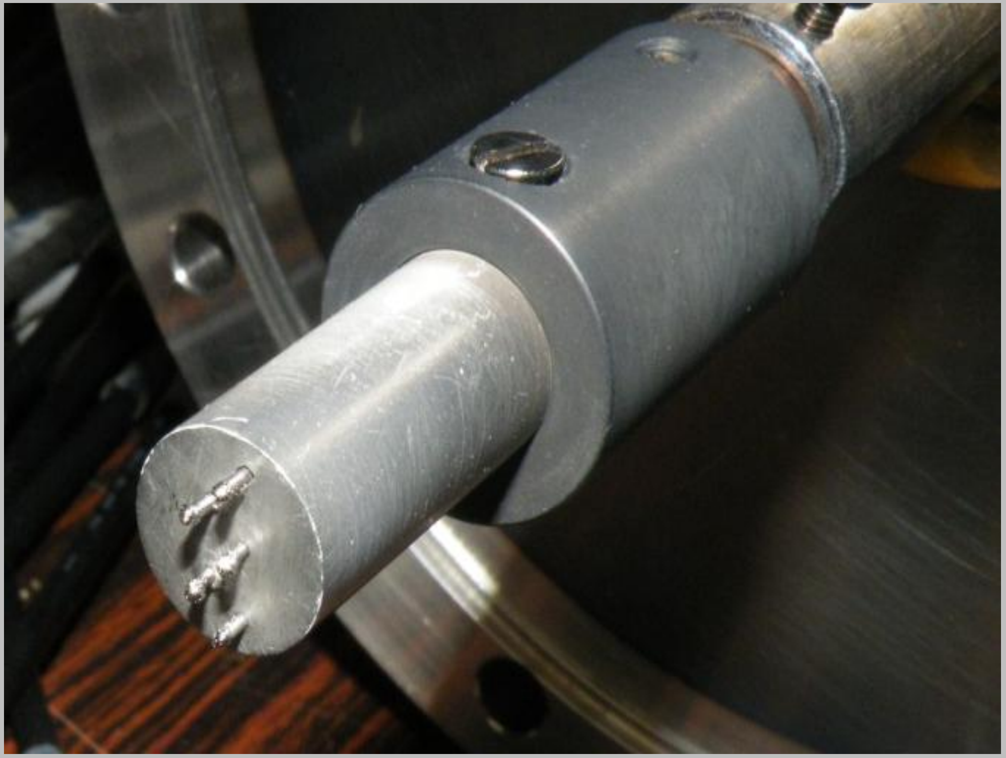
- **Rake Probe**: There are 18 pins of tungsten each one with 3 mm length and diameter of 0.8 mm, inserted in a body of boron nitride.



- Datas are acquired with 2M samplings/s

Electrostatic Probes

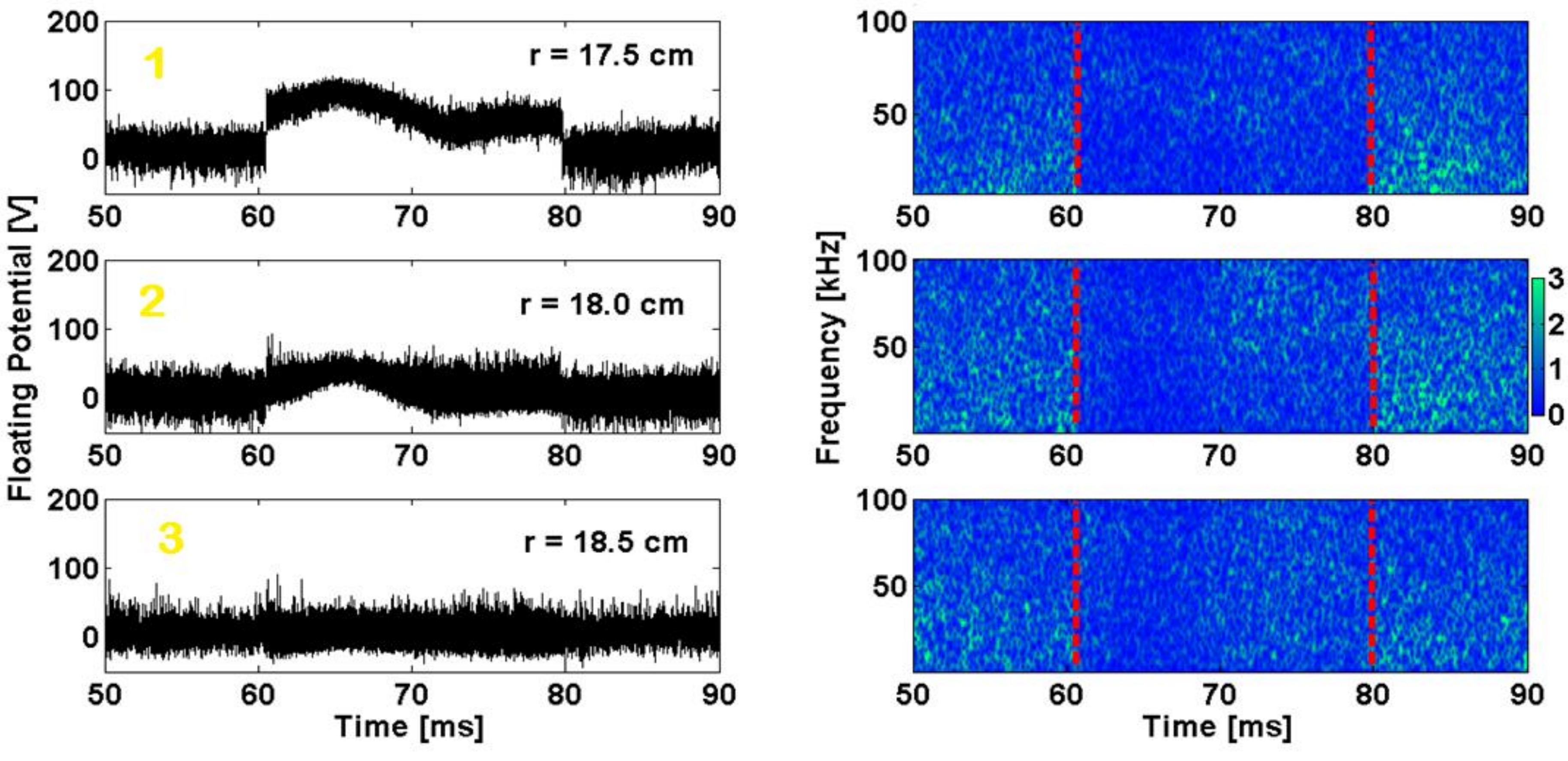
- **5 – pins Probe:** The five pins are in the same radial position, but in different poloidal and toroidal positions. The distance between pins is 5 mm.



The probes were installed in the equatorial plane of TCABR. Each probe has a movable system that allows to put it in different radial positions (shot by shot) in a range of [+2.0 to -3.0] cm, or $r/a \approx$ [0.9 , 1.2], with respect to the limiter.

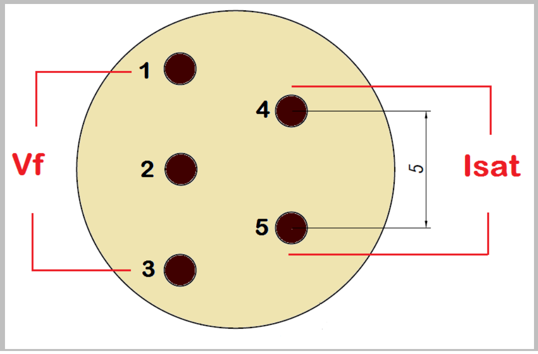
Power spectrum variation when electrode is biased

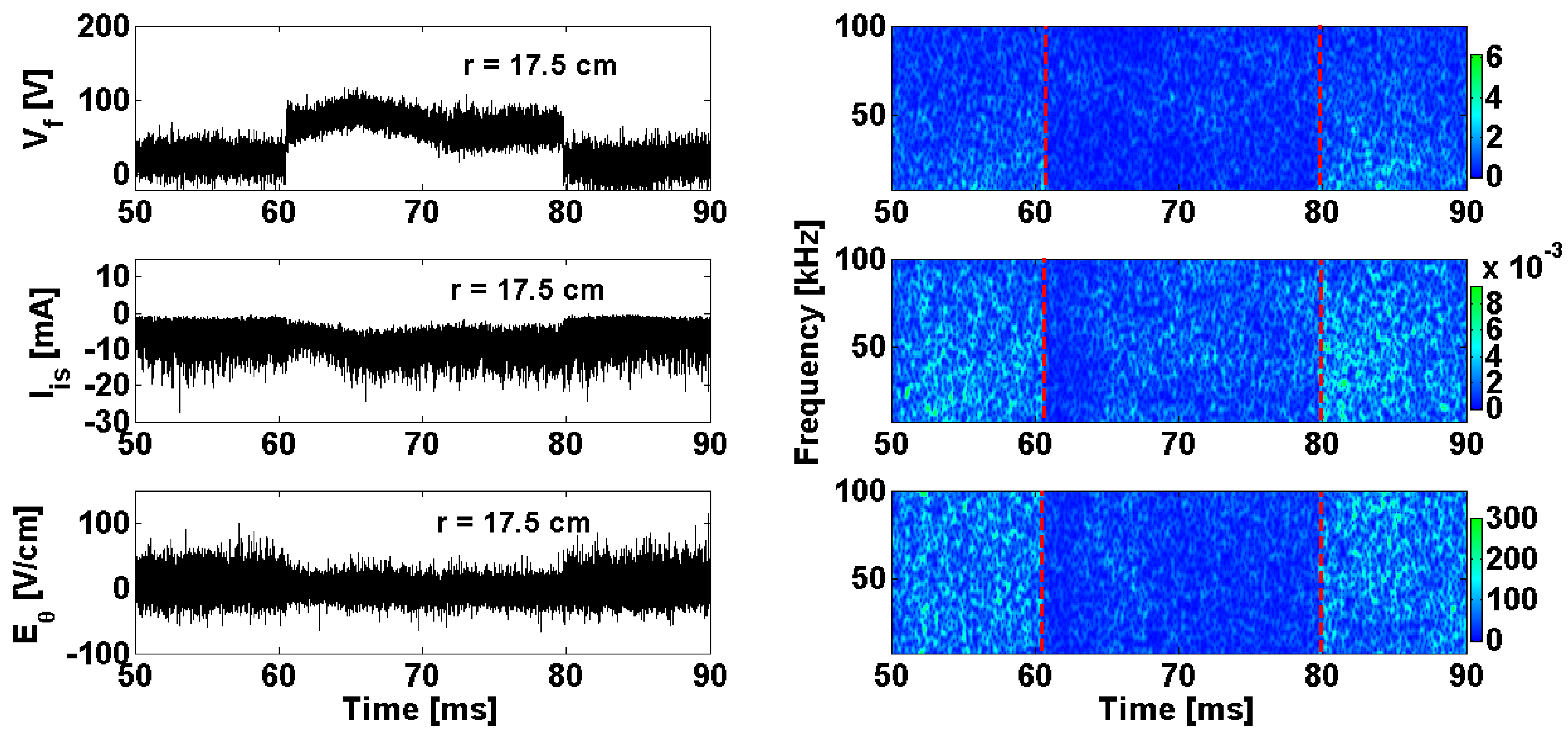
- Rake Probe (radial variation of floating potential, $V_b = +300\ \mathrm{V}$)



Power spectrum variation when electrode is biased

- 5-pins probe (variation of parameters at the same radial position)





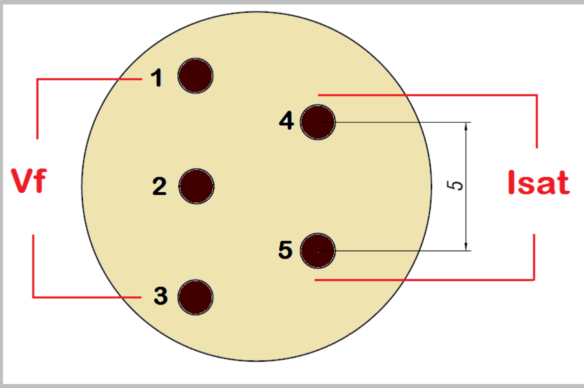
Particle Transport

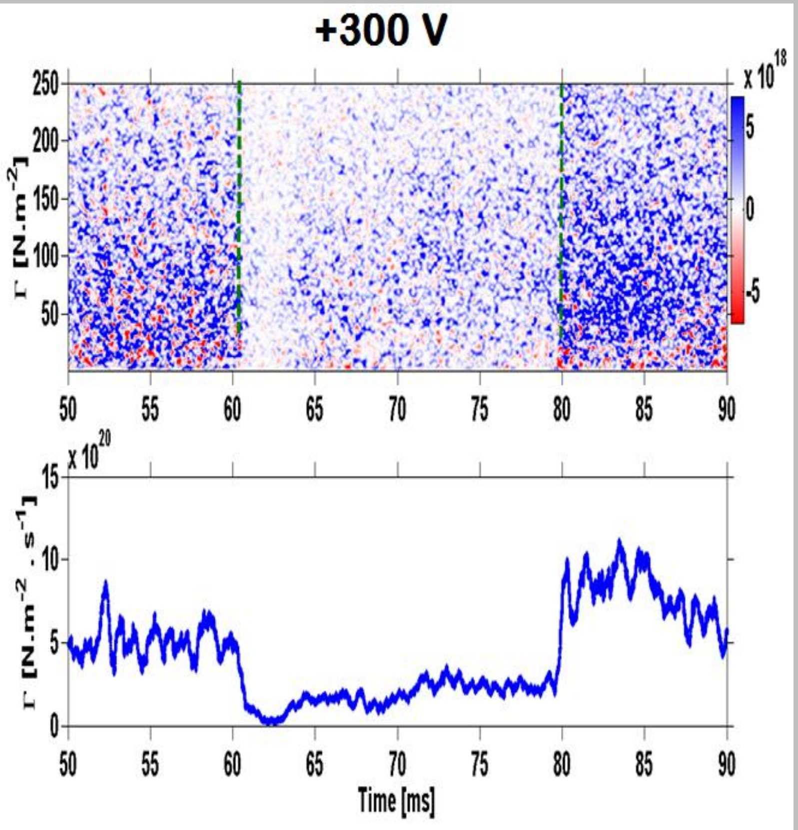
$$\Gamma_r = \langle \tilde{n}_e . \tilde{v}_r \rangle = \langle \tilde{n}_e \cdot \tilde{E}_\theta \rangle / B_t$$

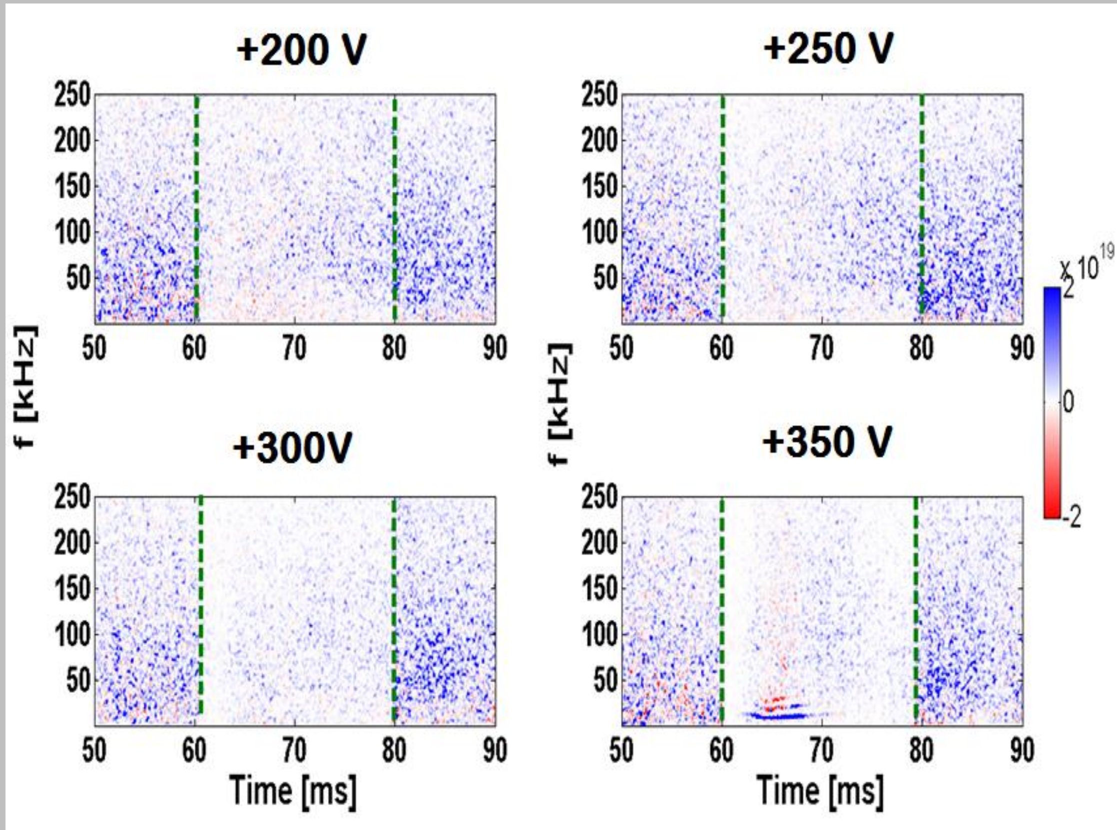
$$\vec{v}_E = \frac{\vec{E} \times \vec{B}}{B^2}$$

$$T(f) = \frac{2}{B_t} \mathrm{Re}\{S_{nE}(f)\}, \mathrm{f} \geq 0$$

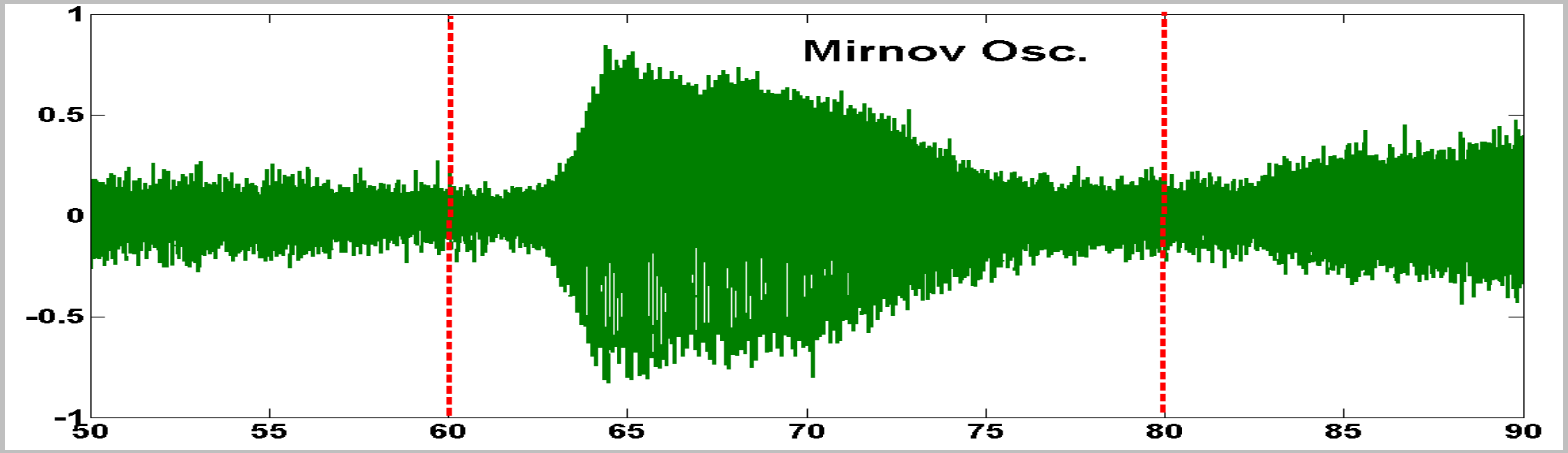
$$\Gamma = \int_0^\infty T(f) df$$

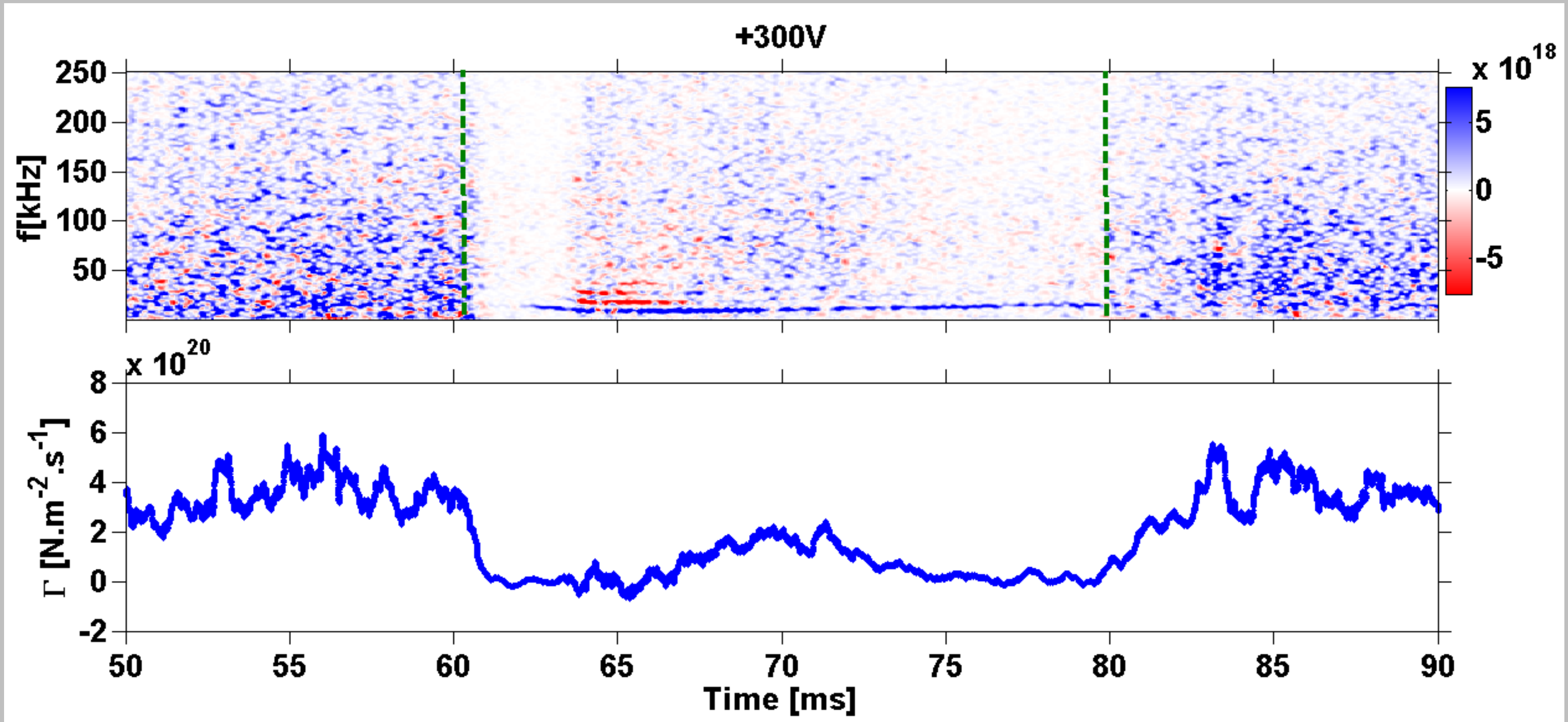




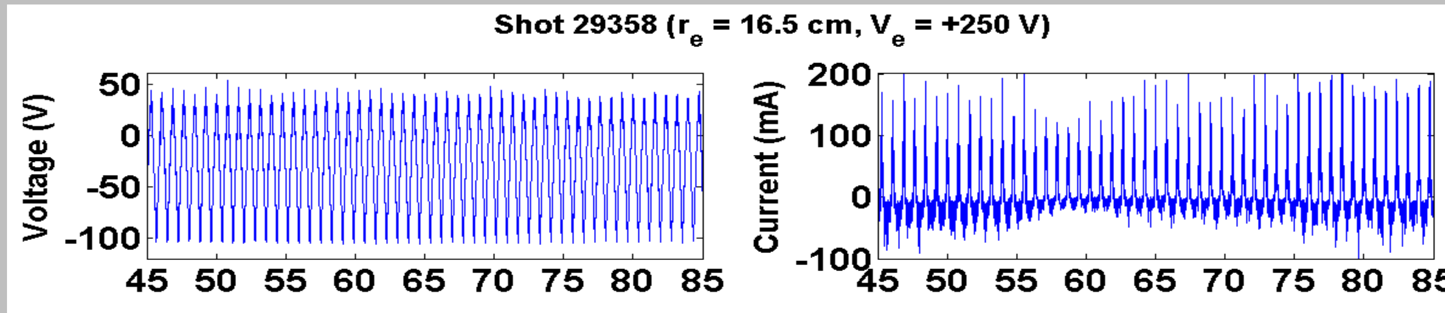


Particle Transport with high MHD activity





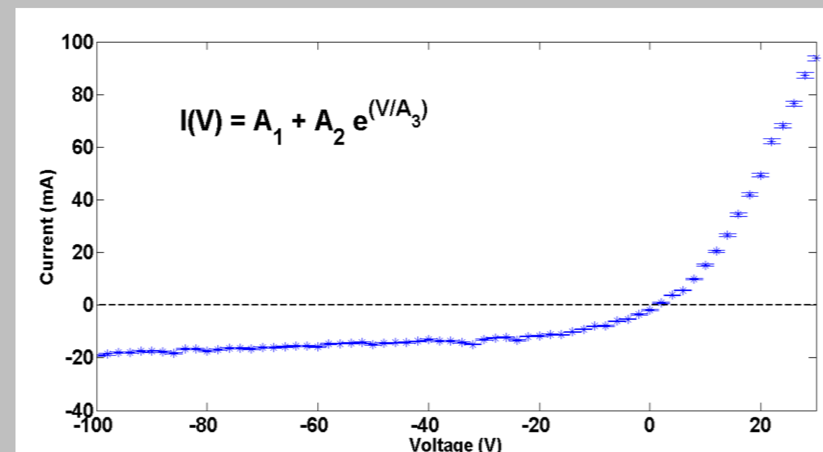
Average temperature and density of electrons

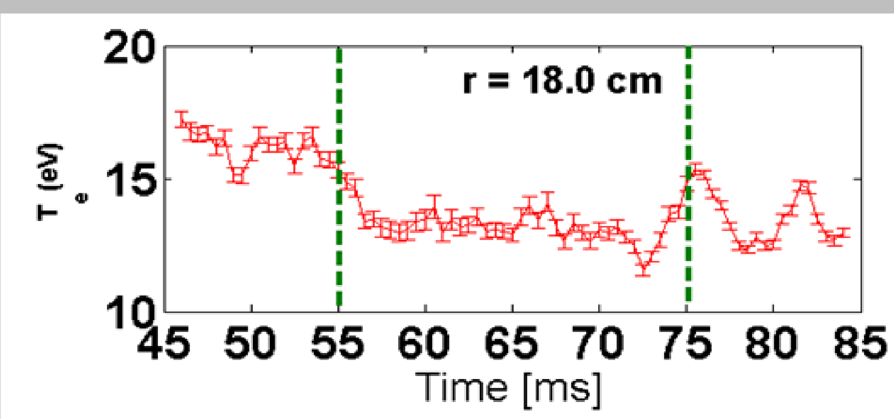


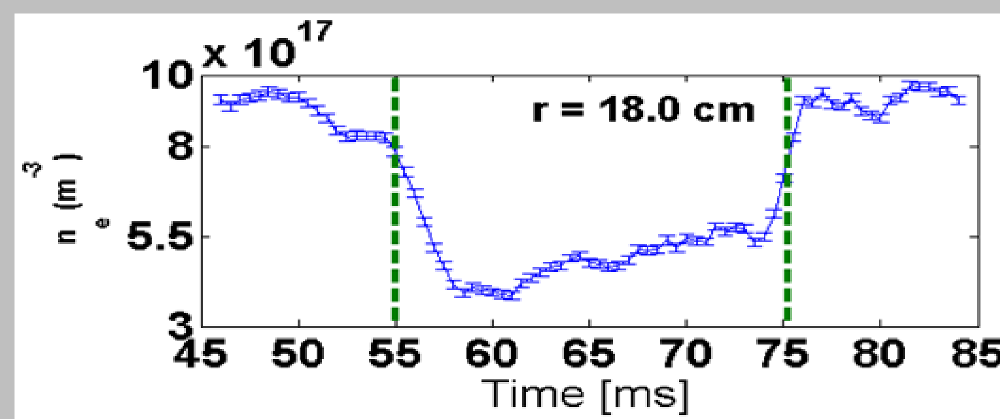
$$I(V) = A_1 + A_2 e^{\frac{V}{A_3}}$$

$$A_3 \rightarrow \text{Electron temperature}\,(T_e)$$

$$n_e = \frac{I_{is}}{\sqrt{T_e}}\sqrt{\frac{4m_i}{k_b A^2 e^2}}, \quad V_p \approx V_f + 3\frac{k_B T_e}{e}$$



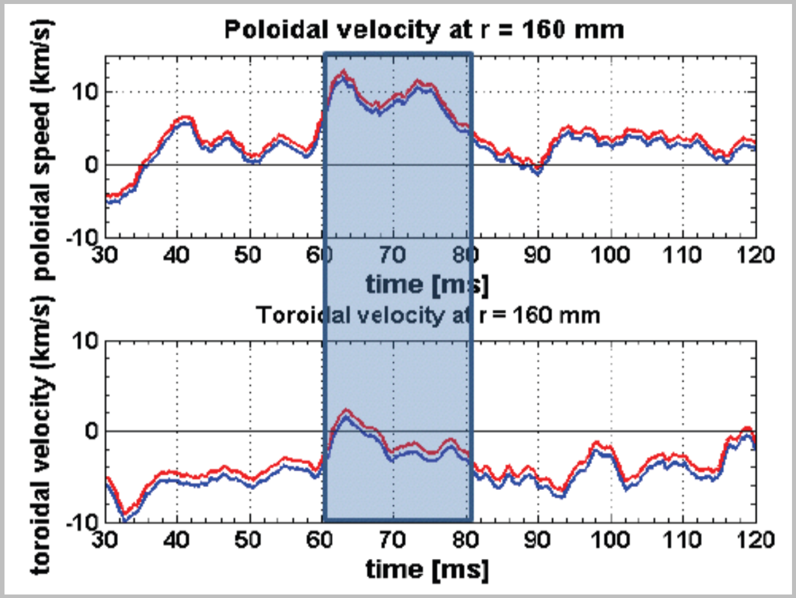




Recent plasma rotation measurements with biasing in TCABR

- **Plasma rotation:** Measurements are performed using Doppler shift of carbon spectral lines

  Ref: Severo J.H.F et al Nucl. Fusion 43 1047



The figure on the right side shows a recent measurement of poloidal and toroidal rotation with biasing

The spectrogram of the floating potential bellow shows a peak at ≈60kHz presently under investigation