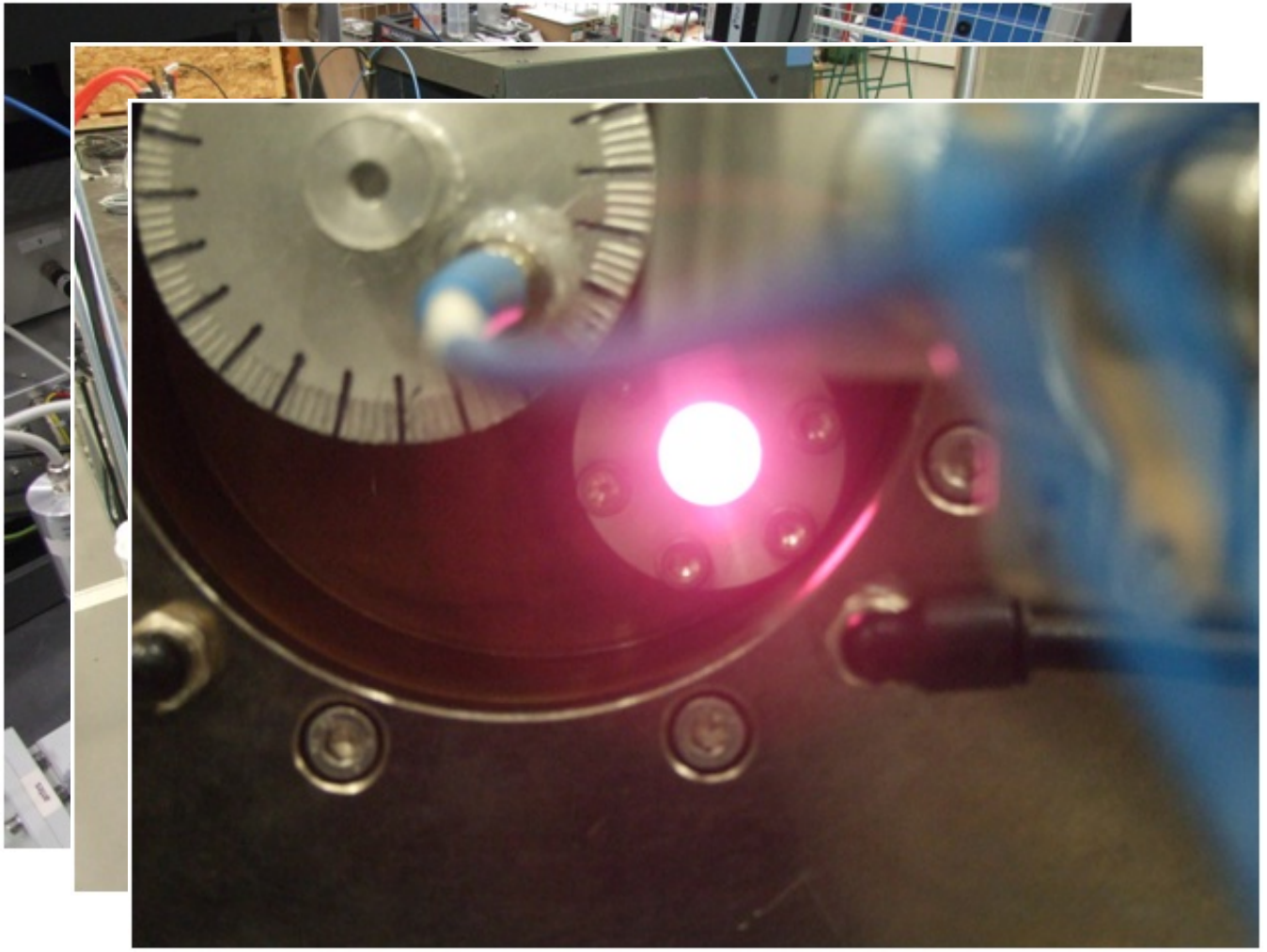
Experimental Study of Temperature and Density Evolution During Breakdown in a 2.45 GHz ECR Plasma

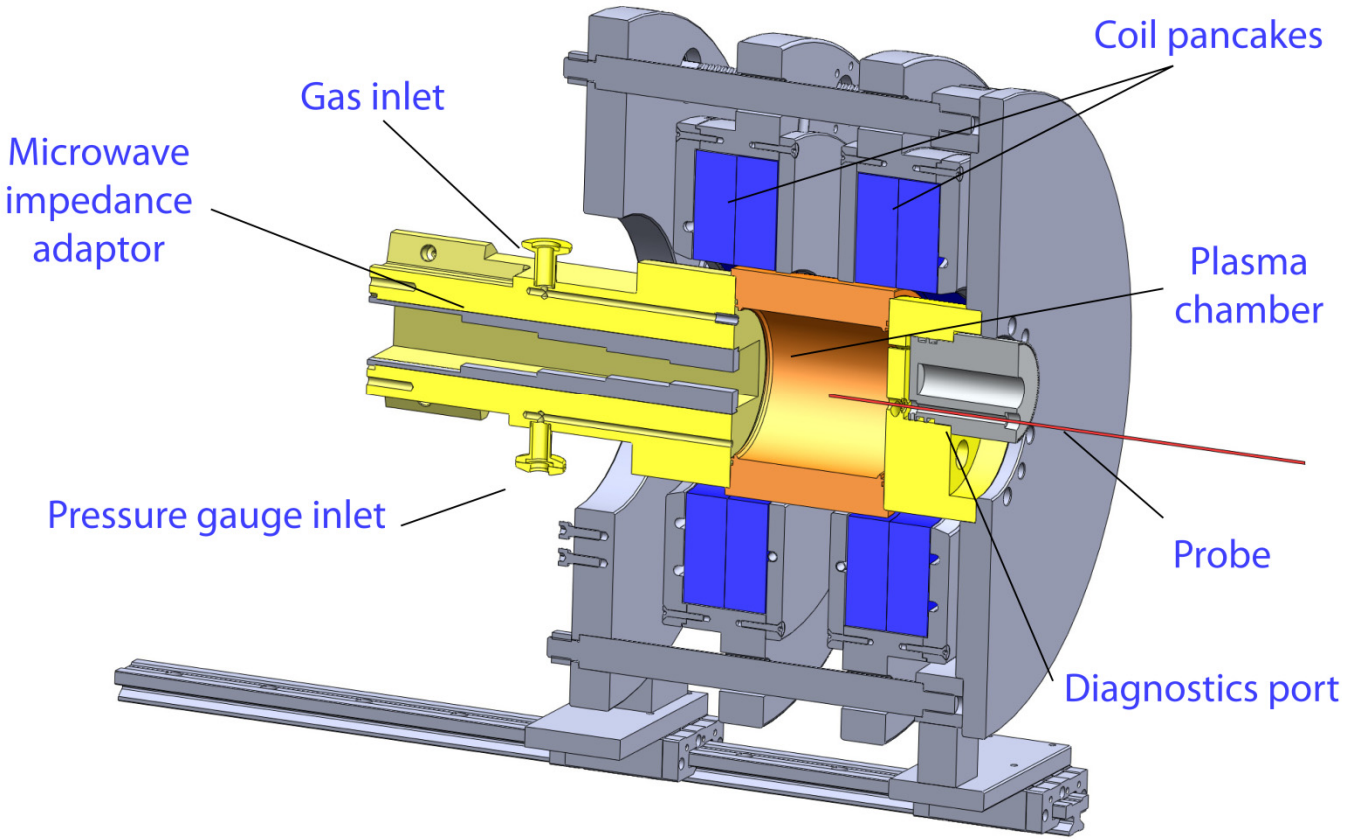
O. D. Cortázar, A. Megía-Macías & A. Vizcaíno-de-Julián.

2.45 GHz Plasma Reactor

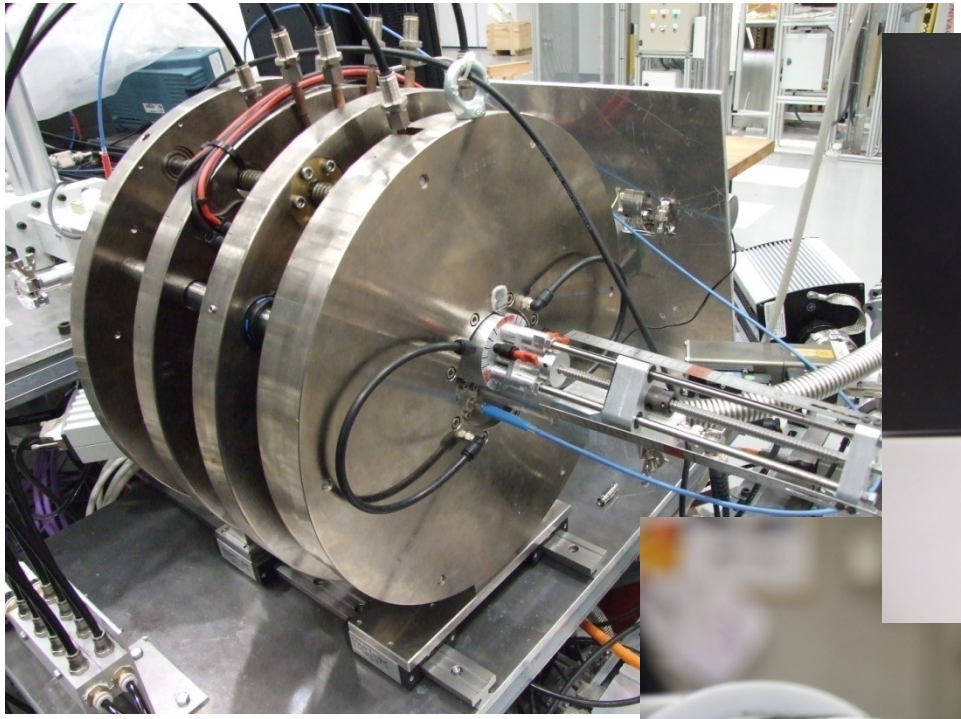
Starting tests: February 2011.

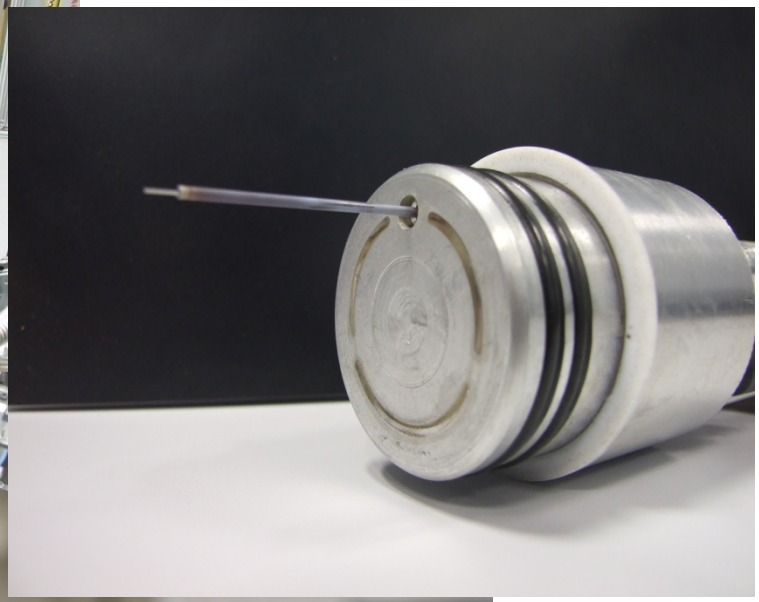


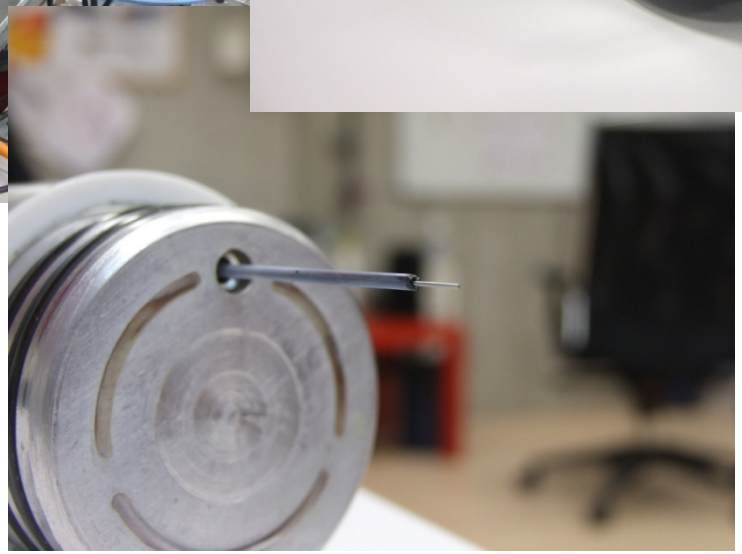
2.45 GHz Plasma Reactor



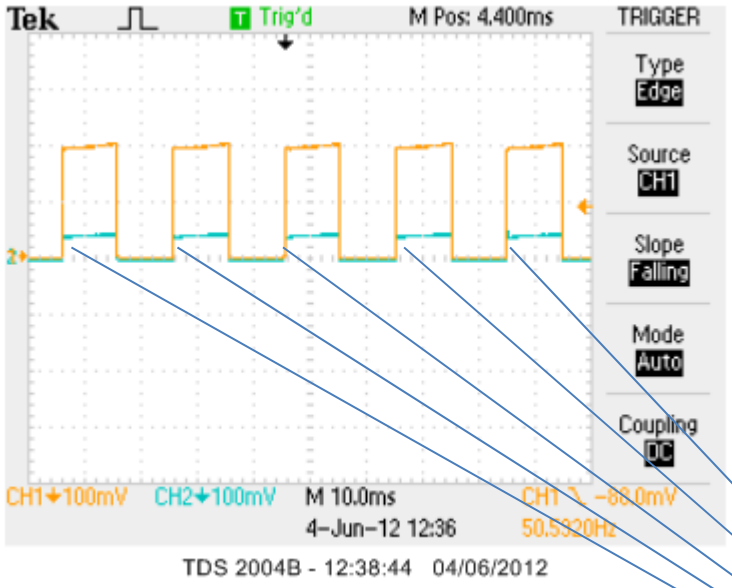
Temperature and density measurements set-up.



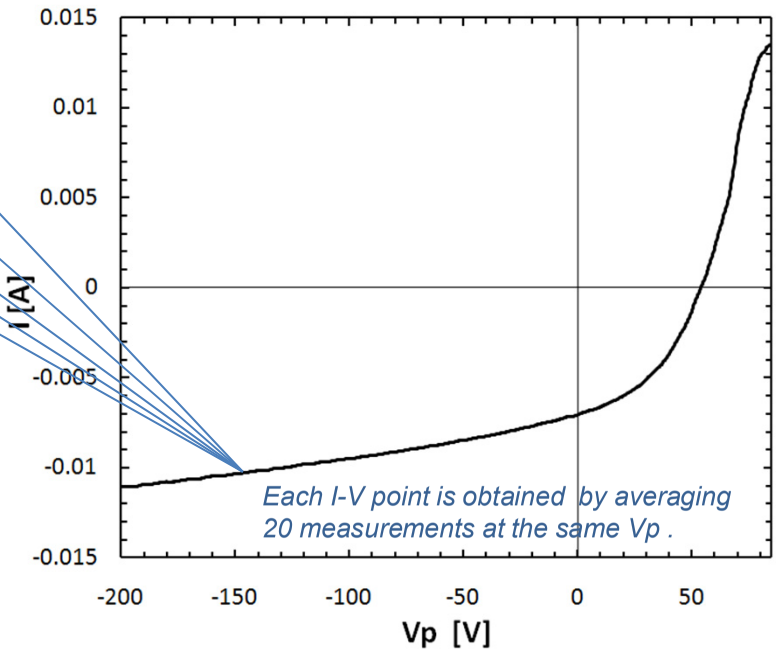




I-V curve from Langmuir probe with temporal resolution



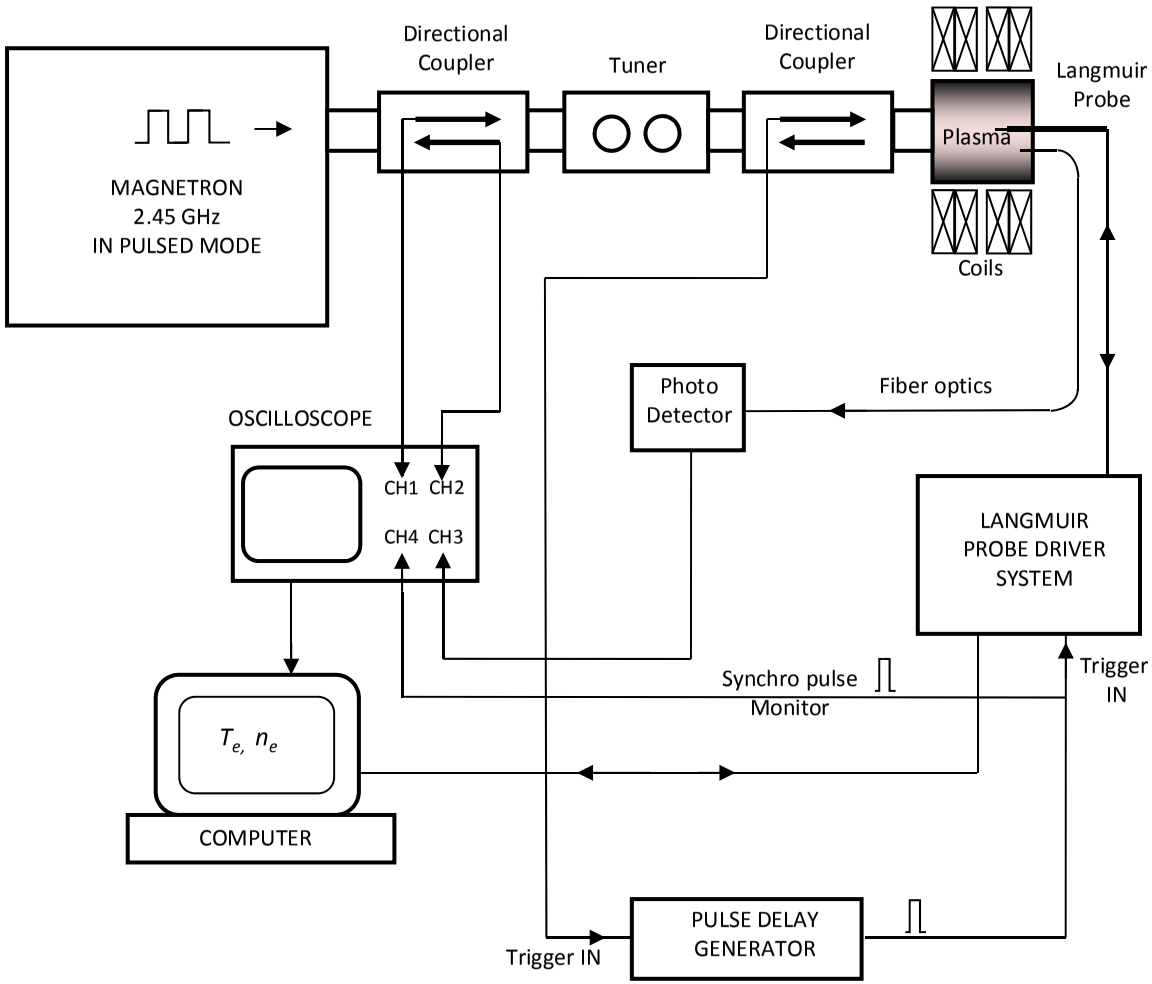
I-V points are measured from different pulses.

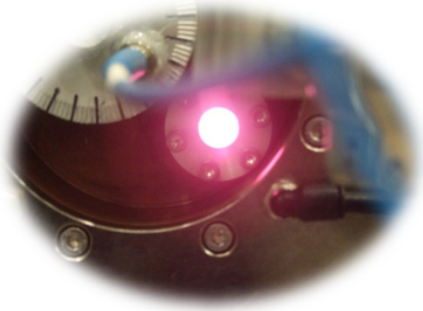


Acquisition time = 62.5 ns
Dig. Time = 14.6 µs

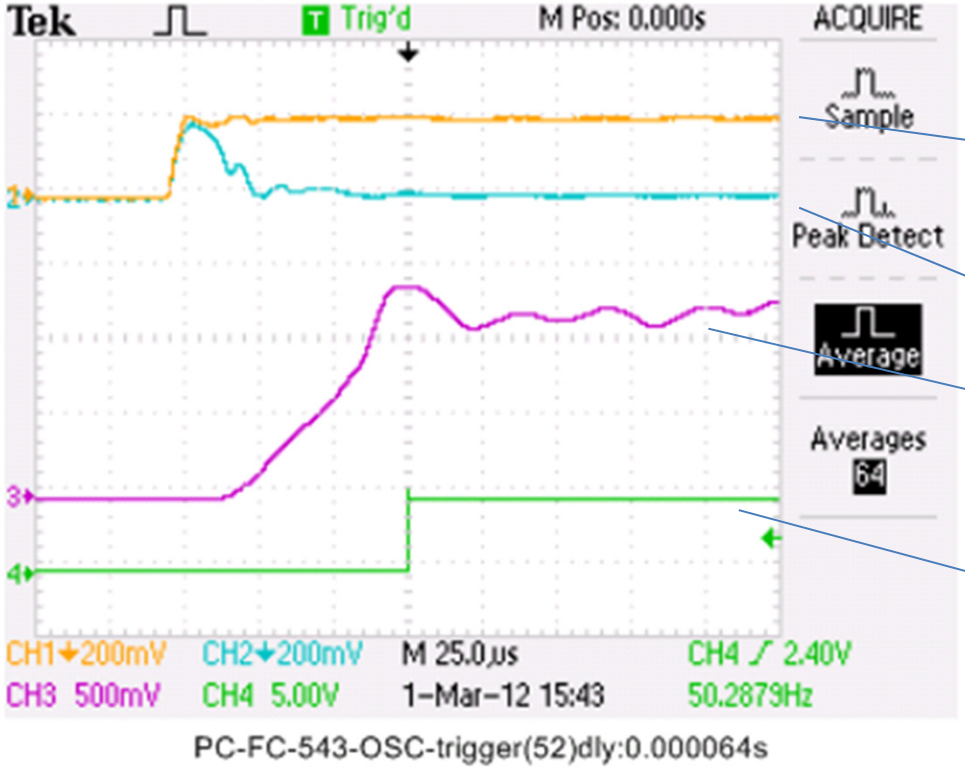
Jitter ≤ 200 ns

Temperature and density measurements set-up.





Breakdown study



Incoming Power

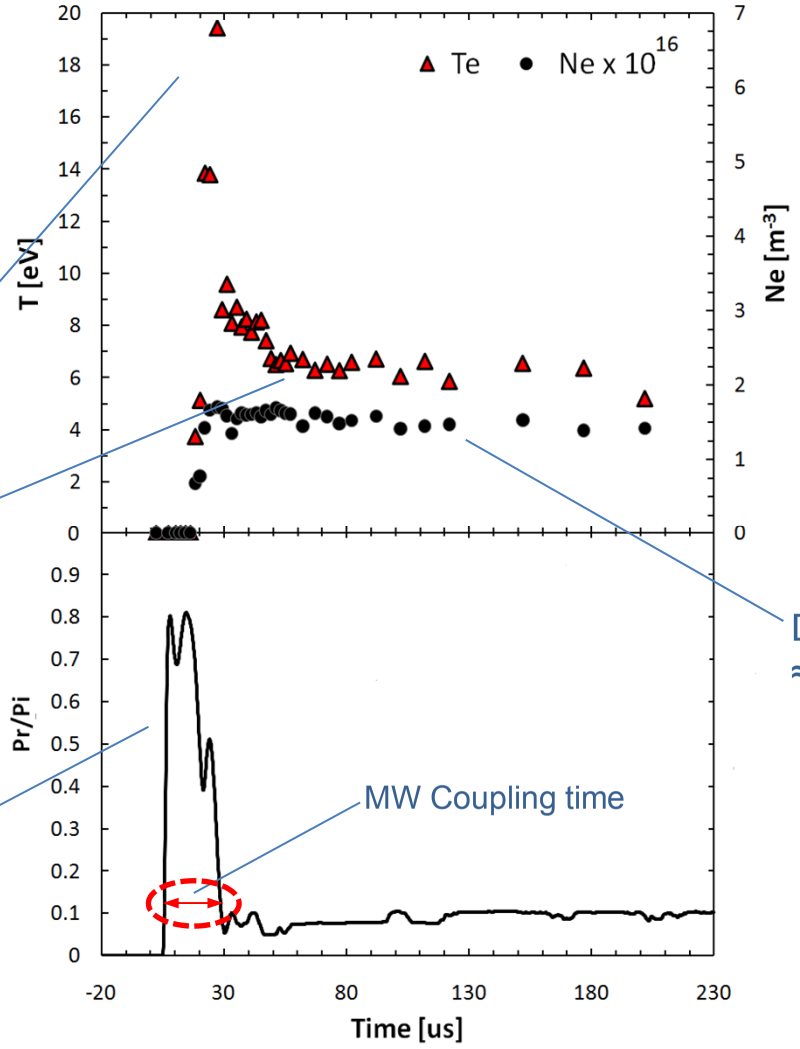
Reflected Power

Visible Light

Trigger Langmuir probe

Example of temperature and density evolution

P = 1500 W
p = 3.8 x 10^{-3} mb
DC = 90 %



Temperature ;

Peak @ 20 eV

Decay @ 4 - 6 eV

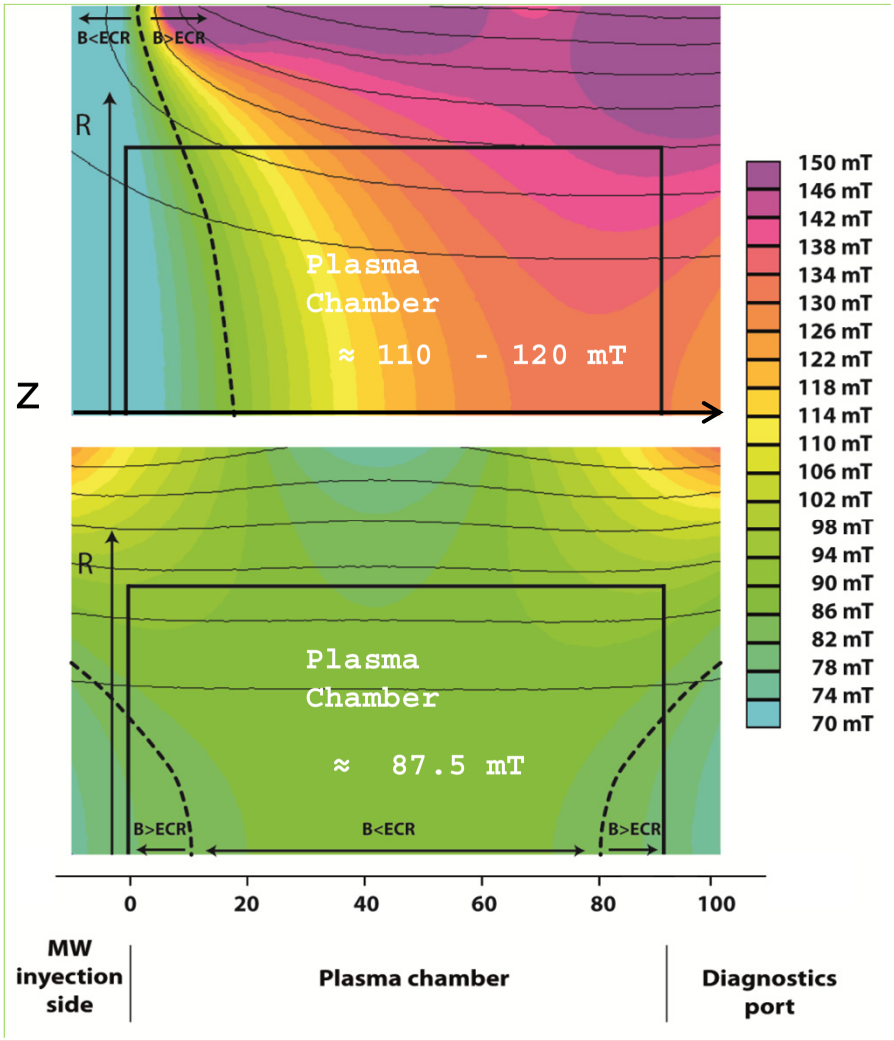
Density
≈ 1.5 x 10^{16} m^{-3}

Ratio *Pr/ Pi*

MW Coupling time

We study the plasma parameters evolution and microwave coupling times for:

✓ Two magnetic fields profiles



✓ Two neutral gas pressures

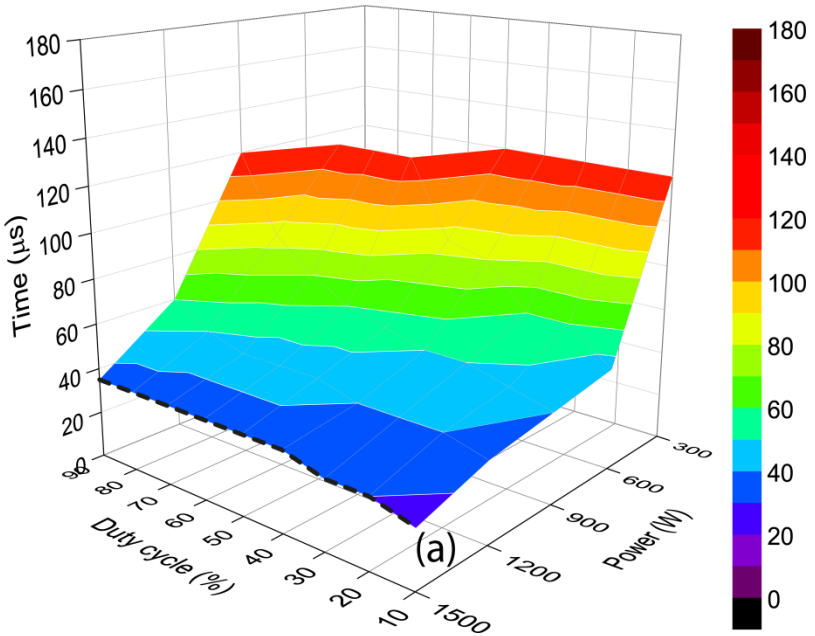
H_2 @ 3.8×10^{-3} mb

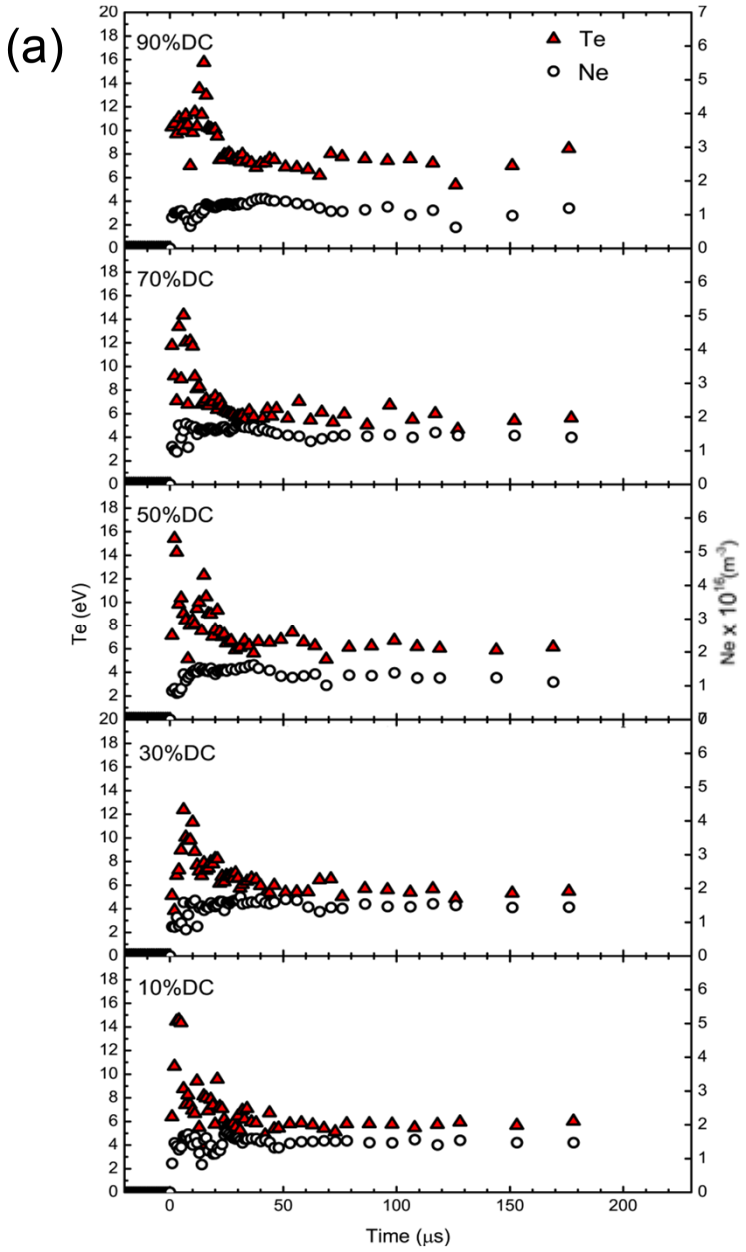
H_2 @ 6.2×10^{-3} mb

Microwave coupling time ;

Temperature and density evolution at B > ECR

P = 3.8 x 10^{-3} mb @ 1500 W

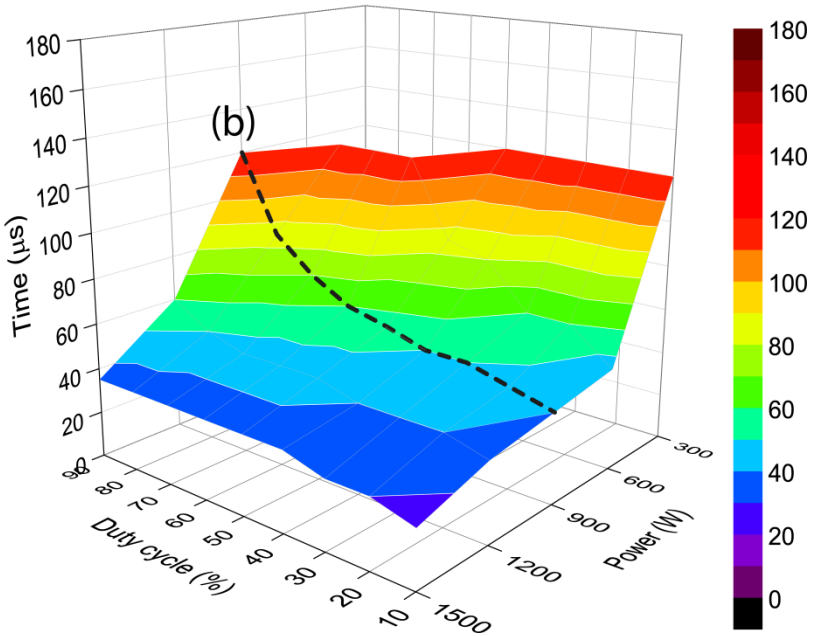


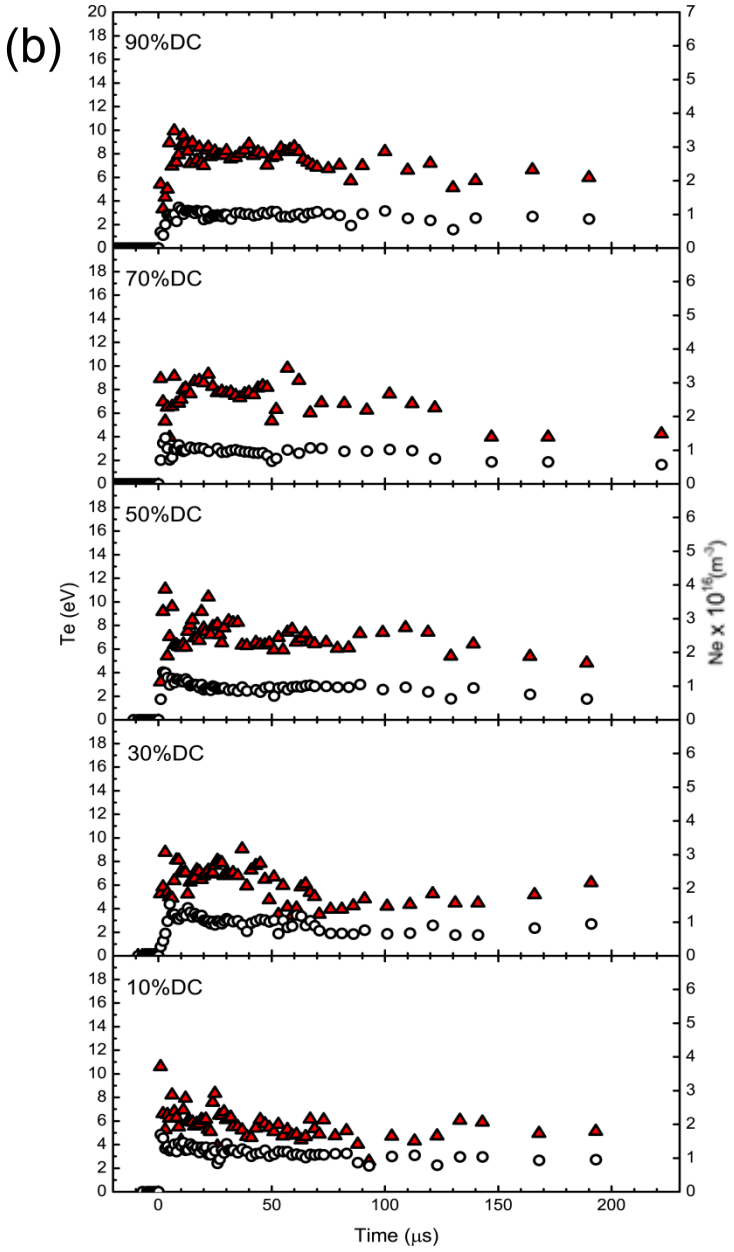


Microwave coupling time ;

Temperature and density evolution at B > ECR

P = 3.8 x 10^{-3} mb @ 900 W

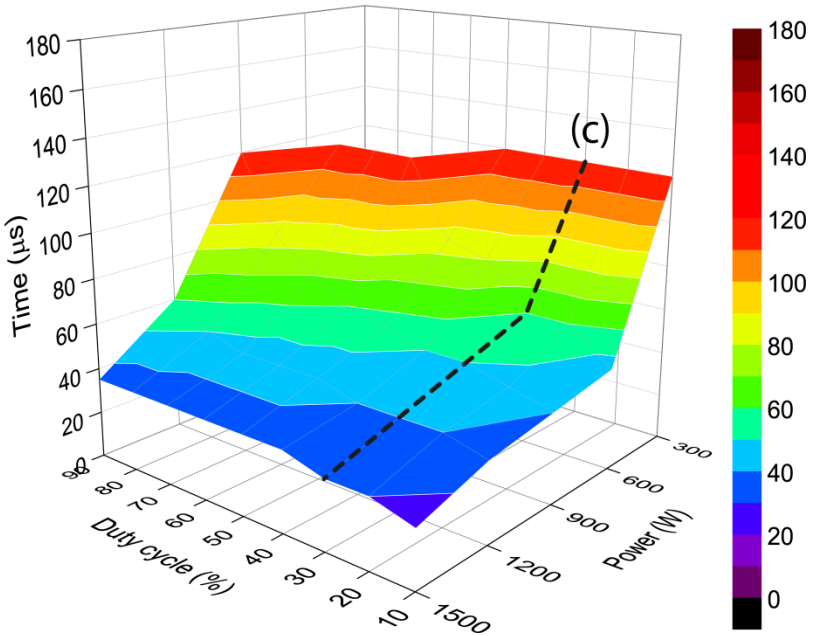


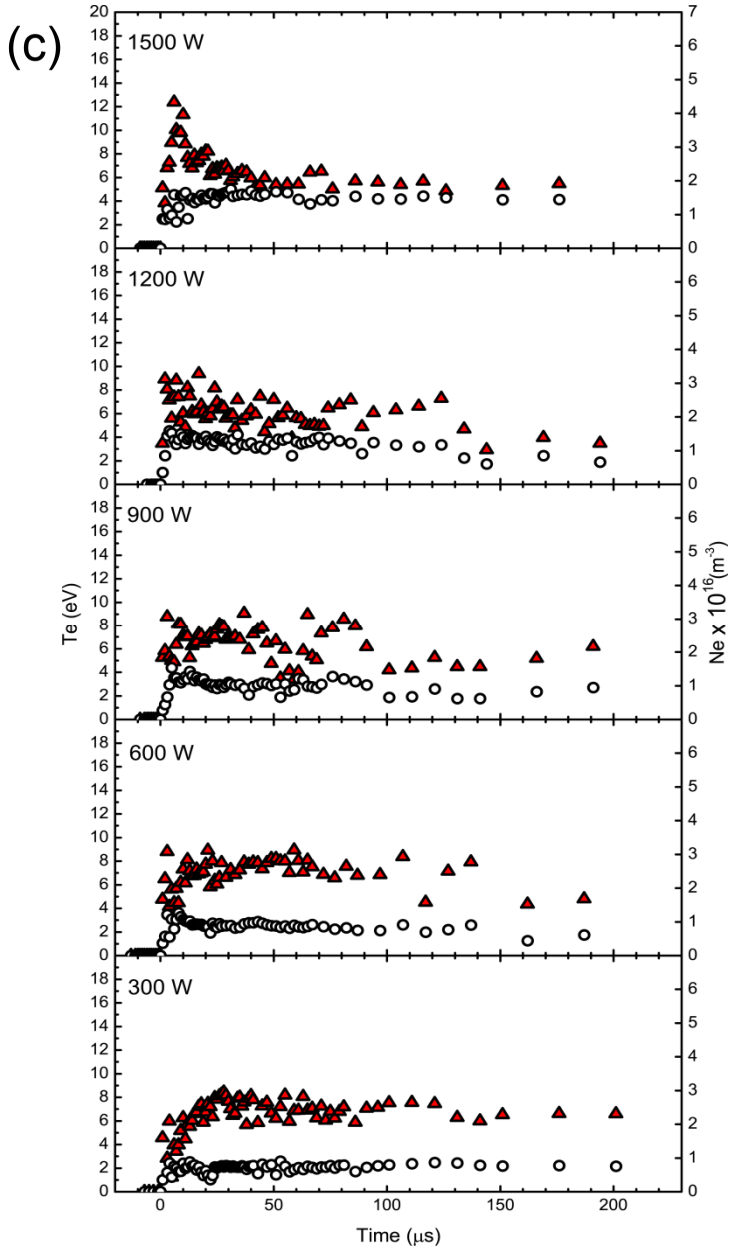


Microwave coupling time ;

Temperature and density evolution at B > ECR

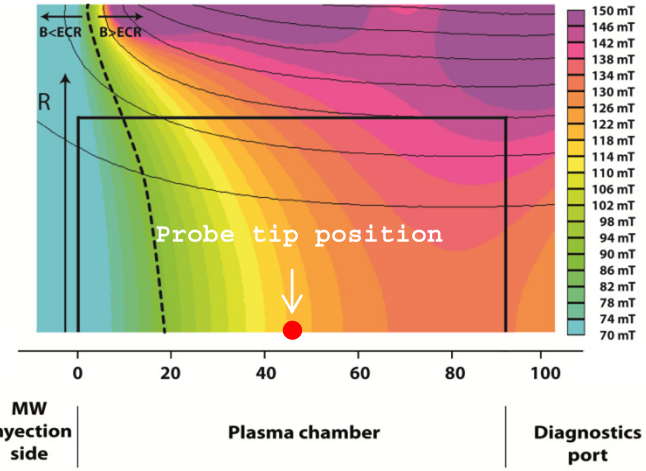
P = 3.8 x 10^{-3} mb @ DC 30%

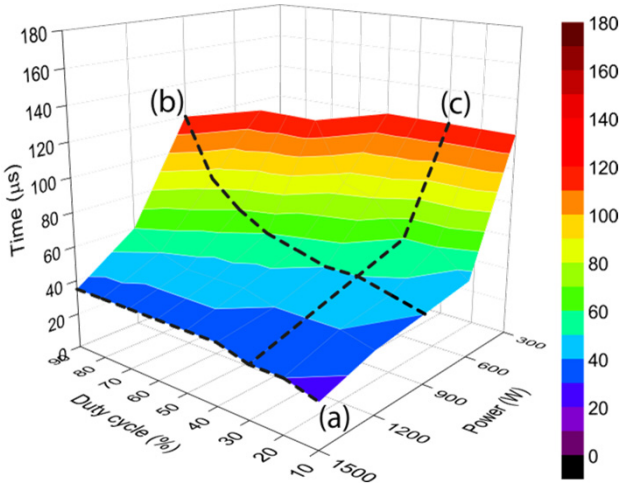


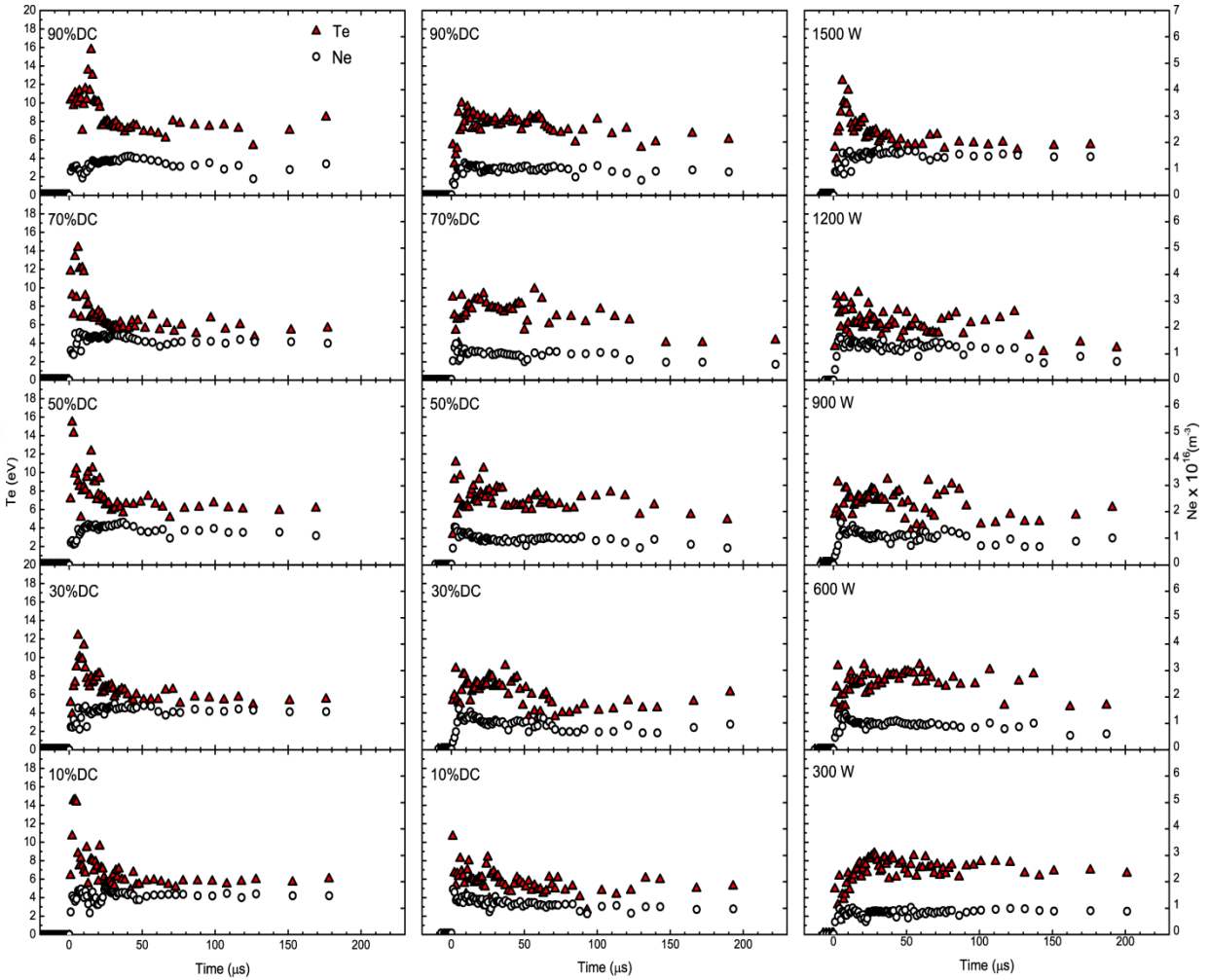


B > ECR (B ≈ 120 mT)

H_2 @ 3.8 x 10^{-3} mb



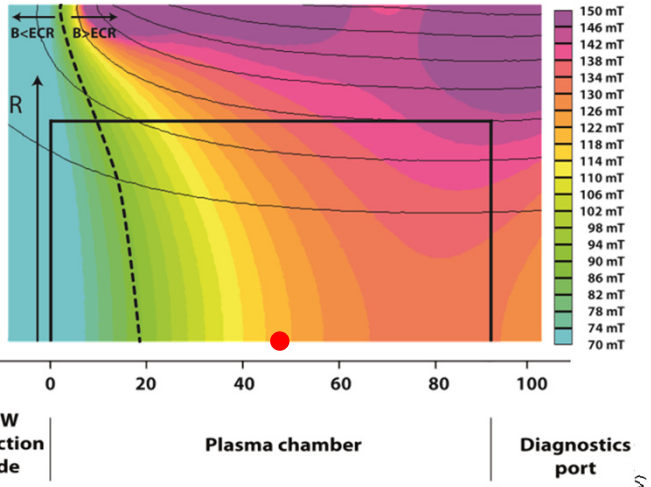


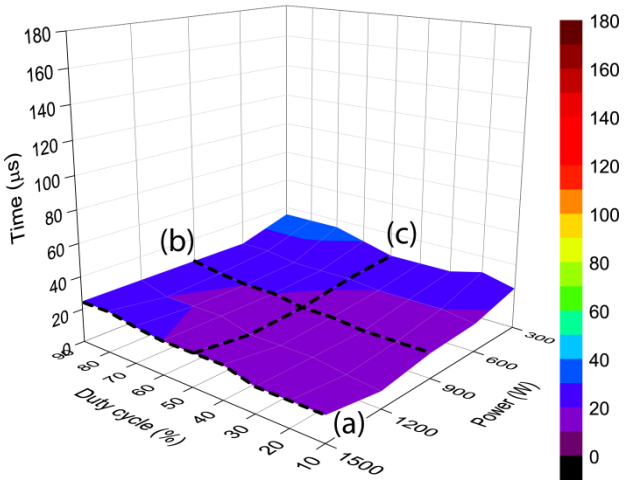


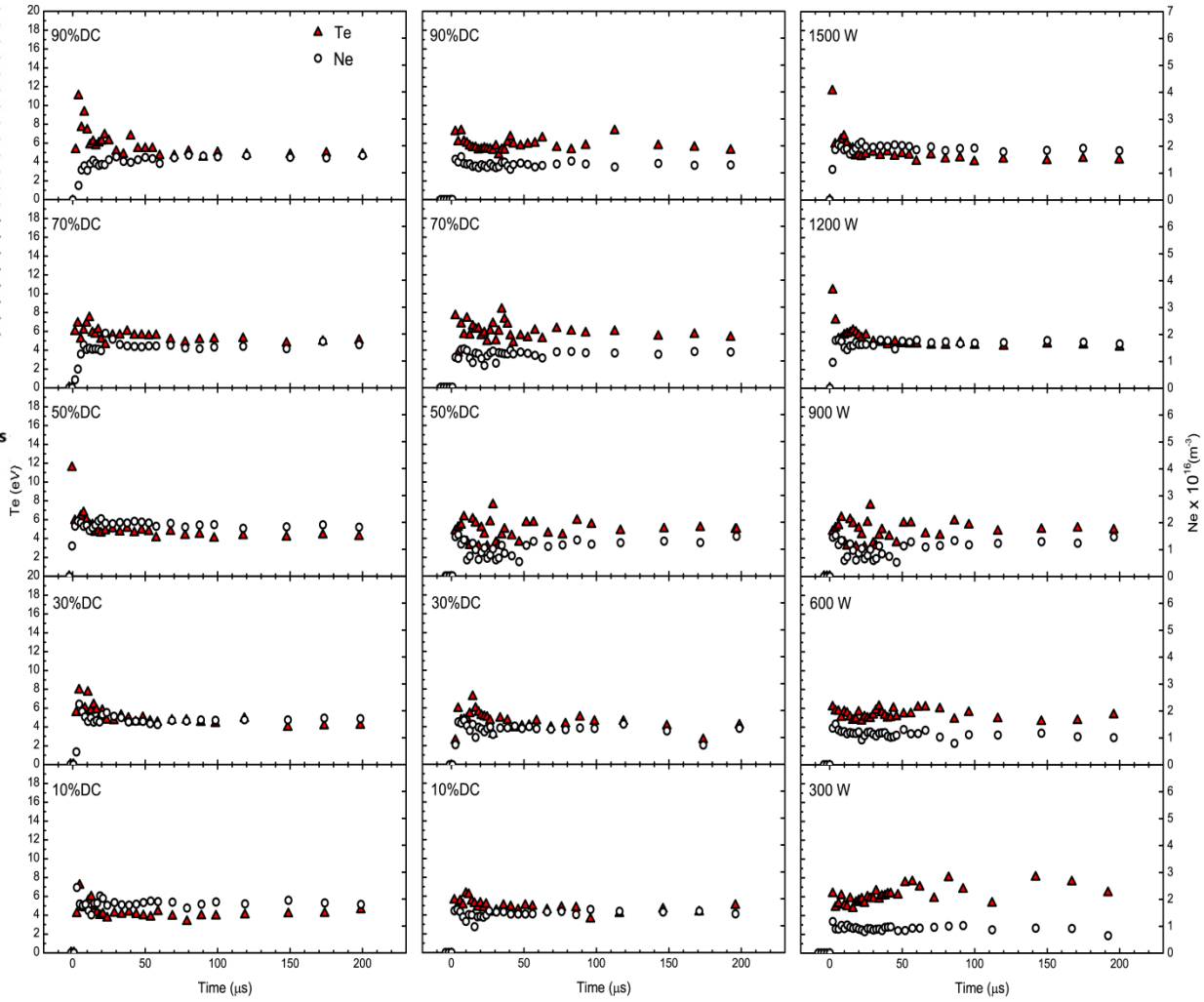
(a) 1500W (b) 900W (c) 30% DC

B > ECR (B = 120 mT)

H_2 @ 6.2 x 10^{-3} mb



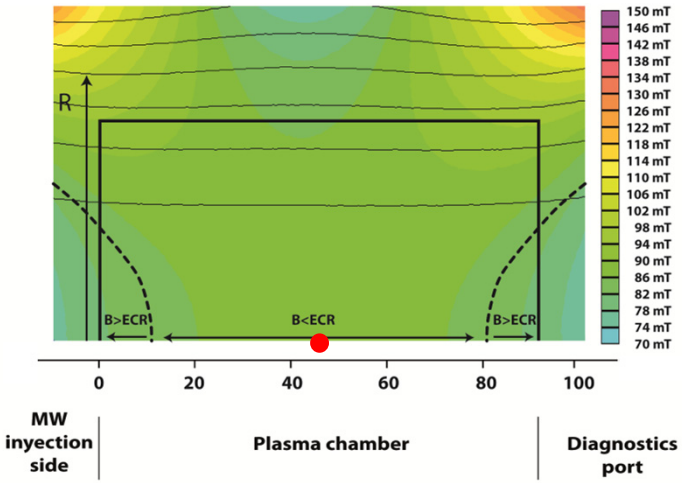


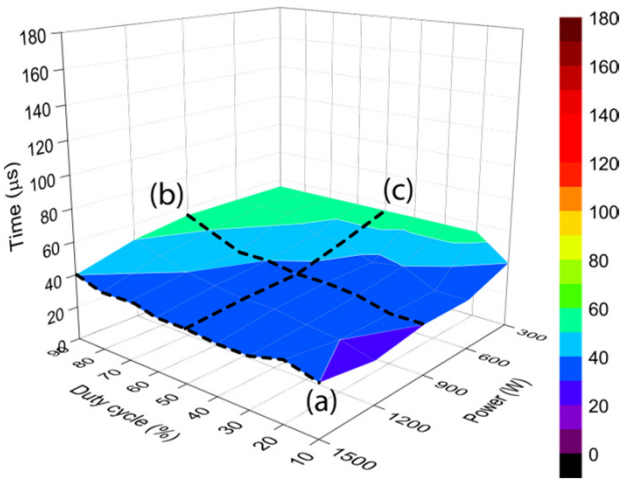


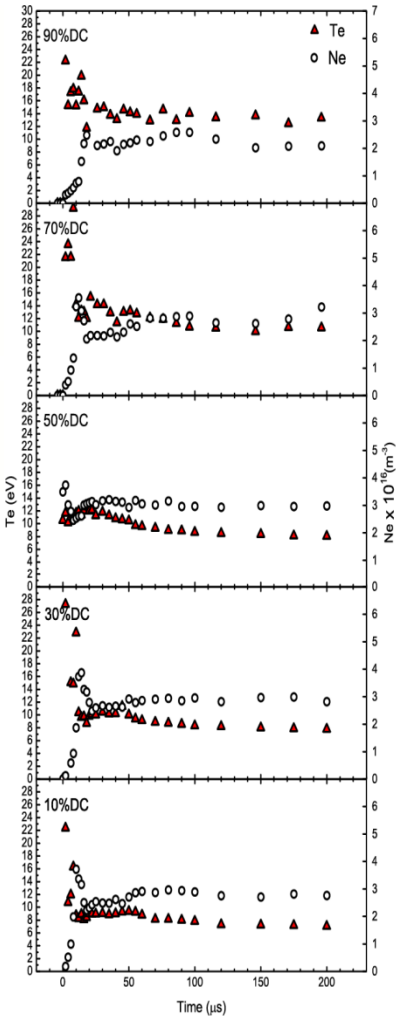
(a) 1500W (b) 900W (c) 50% DC

B = ECR = 87.5 mT

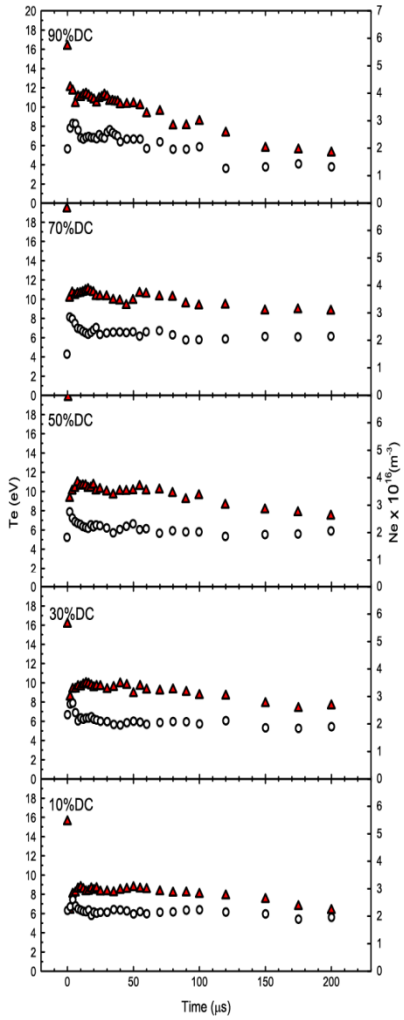
H_2 @ 3.8 x 10^{-3} mb



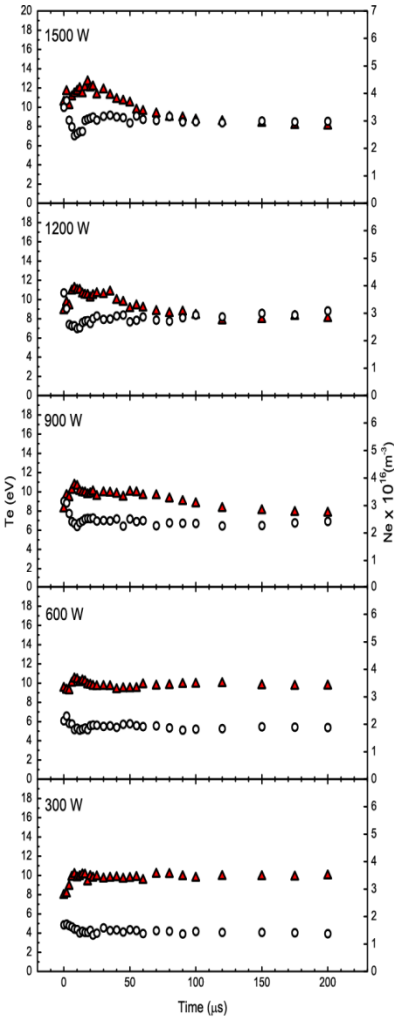




(a) 1500W



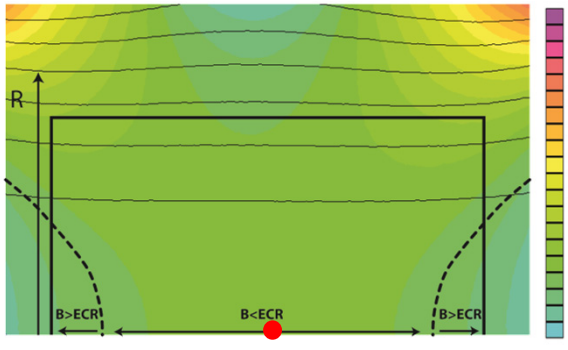
(b) 900W

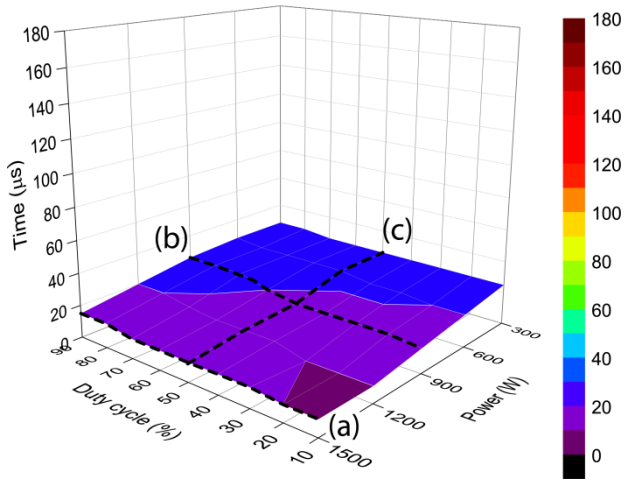


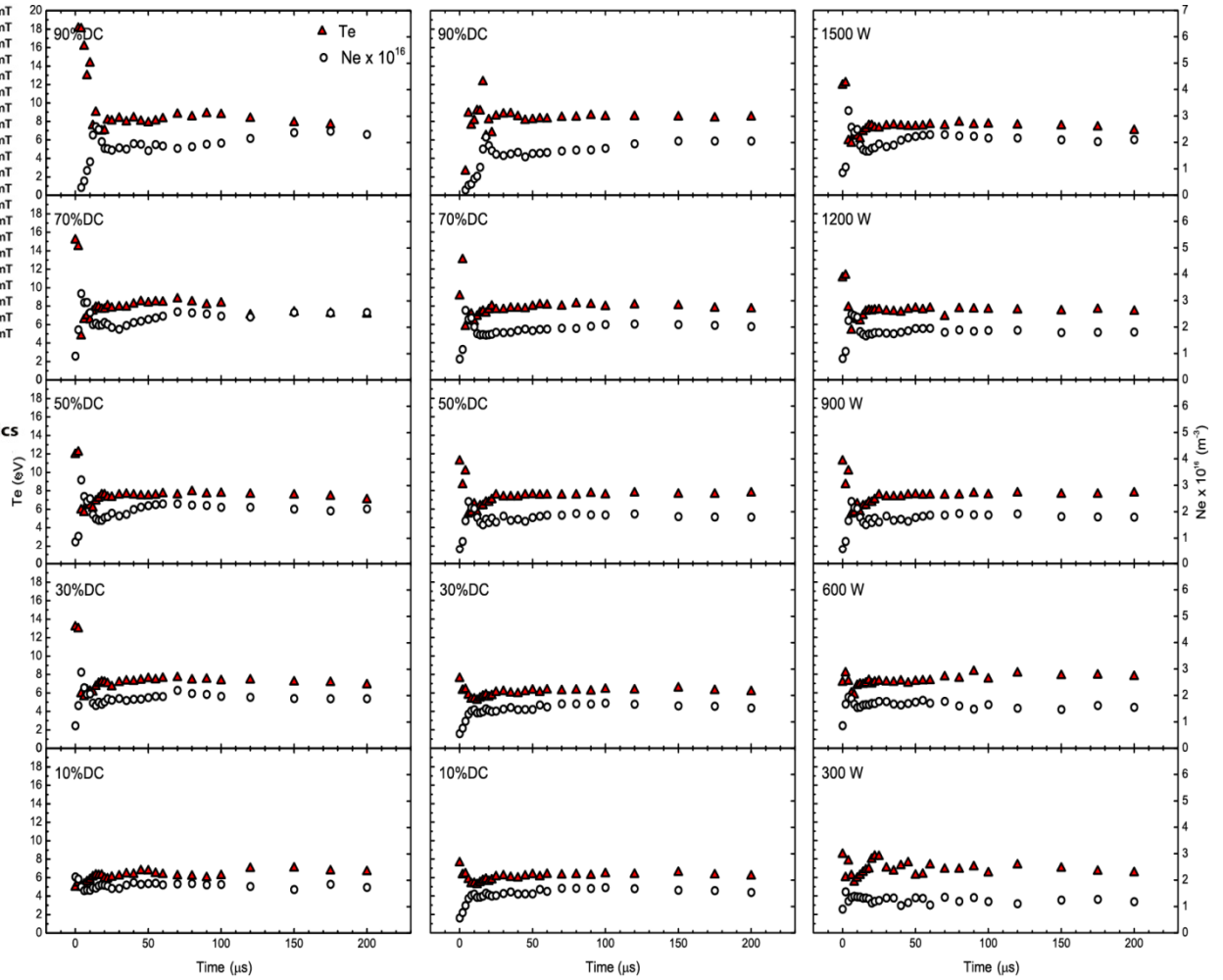
(c) 50% DC

B = ECR = 87.5 mT

H_2 @ 6.2 x 10^{-3} mb

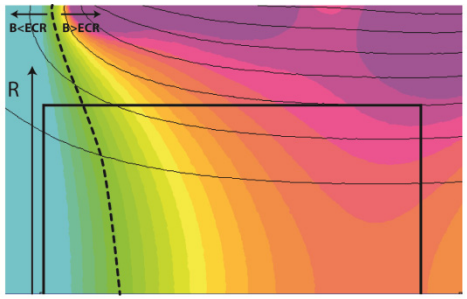


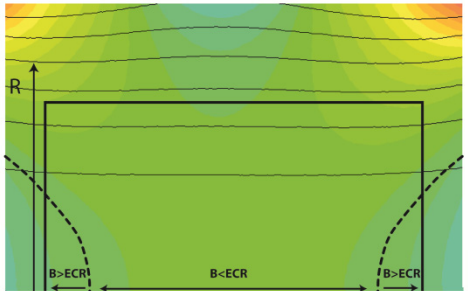




(a) 1500W (b) 900W (c) 50% DC

Remarks:





Pressure x 10^{-3} mb	Te peak (eV)	Te steady-state (eV)	Ne x 10^{16} m^{-3}
B > ECR (≈ 120 mT @ z)			
3.8	16 - 18	6 - 7	1 - 2
6.2	8 -12	4 - 5	1 - 2
B = ECR (≈ 87.5 mT @ z)			
3.8	24 - 16	8 - 10	2 - 3
6.2	18 - 12	5 - 7	2 - 3

Summarizing:

The evolution of plasma parameters during breakdown in a 50 Hz pulsed ECR hydrogen plasma excited at 2.45 GHz is presented.

Two pressure regimes and two magnetic field profiles were studied as a function of incoming microwave power and duty cycle.

Microwave coupling times have been also measured for the same range of parameters and related to plasma temperature and density evolution.

Temperature peaks at very beginning of breakdown, in coincidence with the drop of reflected power are reported.

In general terms the temperature values seem to be related with incoming power.

The highest temperatures both during breakdown transient and final steady-state are reached for the B = ECR magnetic field profile.

Drop of electric field inside the plasma chamber during breakdown may give an explanation of peak temperature. See poster session: WEPP01 (Wednesday 16:00).

Thank you for your attention.