Comparison of fast electron fluxes generated in front of Passive-Active and Fully-Active Multijunction LH antennas in Tore Supra

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A Retarding Field Analyzer (RFA) was used during lower hybrid (LH) current drive experiments in the Tore Supra tokamak to characterize the supra-thermal particles emanating from the region in front of the C4 Lower Hybrid (LH) Passive-Active-Multijunction (PAM) grill [1]. This work is continuation of our previous measurements on Fully-Active-Multijunction (FAM) launchers C2 and C3 [2]. The RFA collects electrons that flow along field lines from the outboard side of the tokamak. The measurements were performed when wave-guide rows of the C4 launcher were magnetically connected to the RFA. The RFA is mounted on a vertically reciprocating probe drive, situated on top of the torus. The analyzer is biased to collect only supra-thermal electrons with energy greater than 200 eV.

Comparison of the fast electron beam from C3 and C4 on the same plasma

The maximum power reached in the C3 and C4 comparison experiments was 1.4 MW.

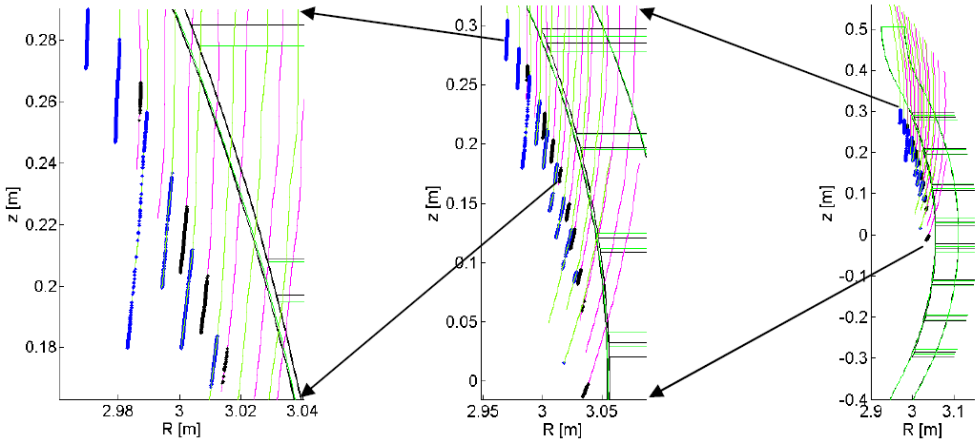

Fig. 1. Schema of individual RFA plunges mapped to in front of the grill (magenta lines) for C3 in shot #46465 (blue dots denote measured collector current I_{co} <10 μA , green C3 grill drawing) and C4 in shot #46463 (black dots I_{co} <10 μA, black C4 drawing). The LH power is 1.5 MW.

We compare three similar shots: shot #46462, 63 and 65, with C4, C4 and C3 active, power 1.4, 1.4 and 1.3 MW, line averaged density 5.1, 4.0 and 4.9x $10^{19}m^{-2}$, limiter position 3.044, 3.045 and 3.044 m, respectively, and the same antenna position 3.055 m.

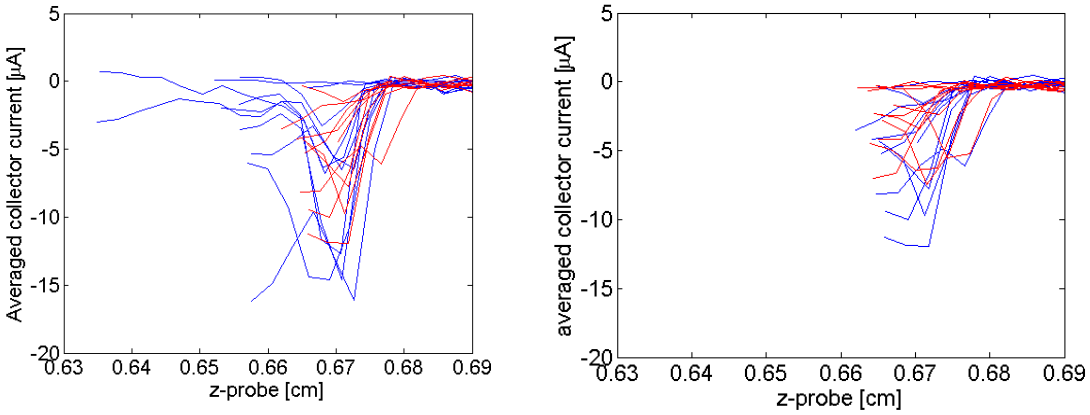

Fig. 2 (left). Averaged collector current, C3 blue, C4 red, for individual plunges of Figure 1.
Fig. 3 (right). Averaged collector current, 46462 blue, 46463 red, for individual plunges similarly as in Figure 1; the scale is the same as in Figure 2.

While Fig. 2 shows the averaged collector current in the shots 46465 and 46463 for C3 and C4 active, the next Fig. 3 compares the averaged collector current for shots with lower (#46463) and higher (#46462) densities, C4 launcher active. It is obvious that the averaged collector current is in magnitude higher for C3 then for C4 both for the same plasma density and also for the lower density for the C4 shots, and that the averaged C4 collector current grows for growing plasma density. Even if the averaged collector current is in magnitude lower for C4 then for C3 at the same conditions, the individual bursts of collector current may be comparable or even higher for C4 then for C3,

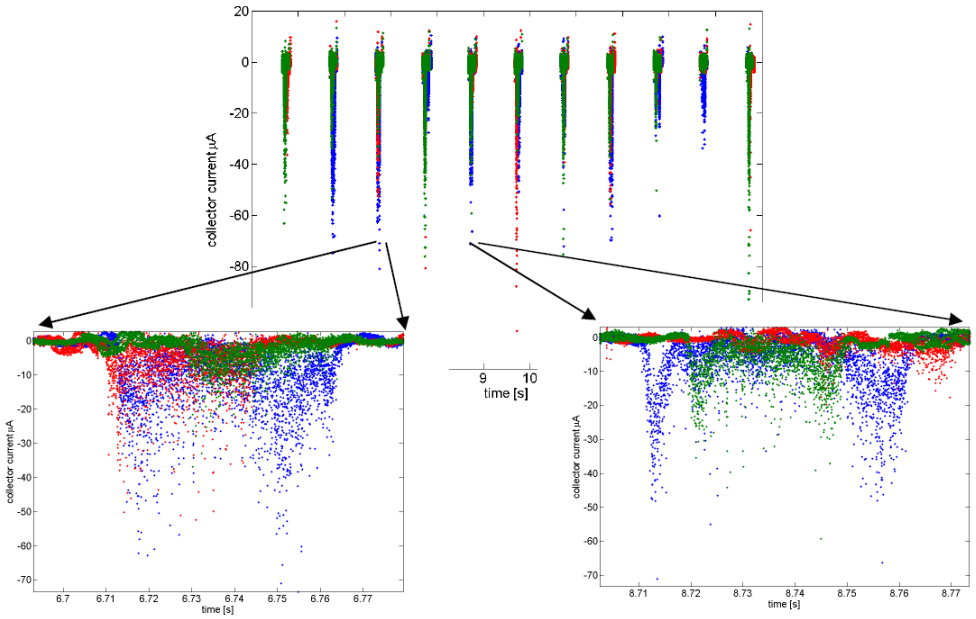

Fig. 4. Upper figure: Time dependence of the collector current I_{co} (not averaged) C3 active, (#46465, blue, minimum I_{co} =-114 μA in plunge 2) and for C4 active (#46463, red, minimum I_{co} =-105 μA in plunge 6, and #46462, green, minimum I_{co} =-117 μA in plunge11); Bottom: Details of plunges 3 and 5.

cf. Fig. 4. For completeness, Fig. 5 shows time dependence of the averaged collector currents also for all 3 shots 46462, 63, and 65discussed in this section.

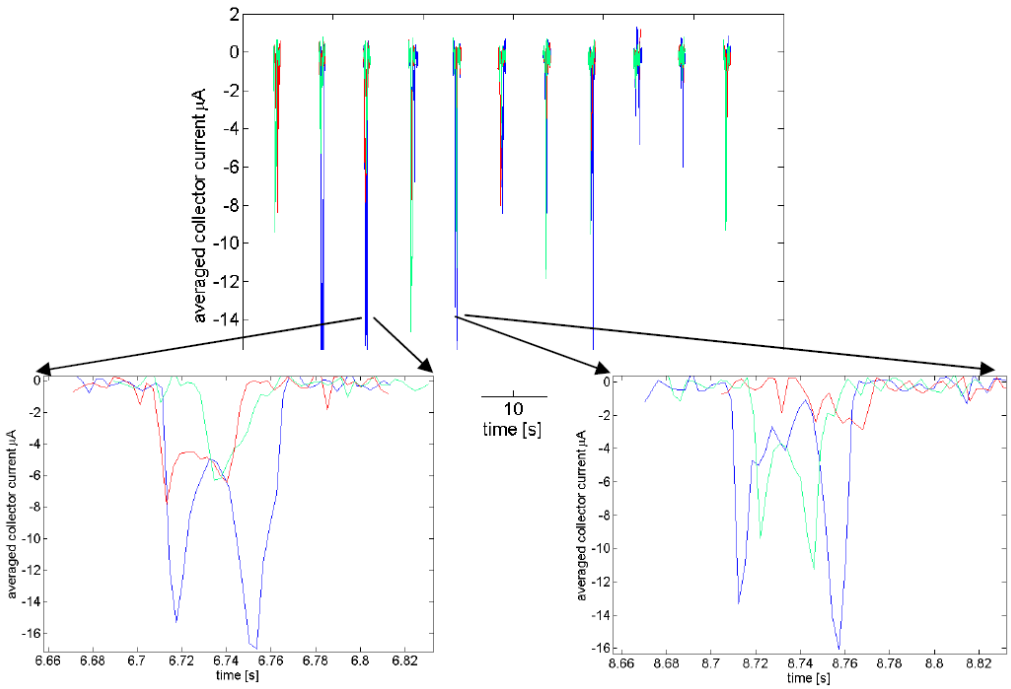

Fig. 5. Upper figure: Time dependence of averaged collector current for C3 active, (#46465, blue, minimum averaged I_{co} =-17.5 µA in plunges 2 and 8) and for C4 active (#46463, red, minimum averaged I_{co} =-8.5 µA in plunge 1 and #46462, green, minimum averaged I_{co} =-14.7 µA in plunge 4); Bottom: Details of plunges 3 and 5.

Energy distribution in the C4 fast beam

Fig. 6 shows measured collector currents I_{co} less then 10 µA in all RFA plunges mapped in front of the C4 grill in shots #44168,69,70, in which the voltage of the RFA electron repulsing grid Ug2 was varied from shot to shot, Ug2 = -200 V (blue, #44168), -400V (red, #44169),-600V (green, #44170).

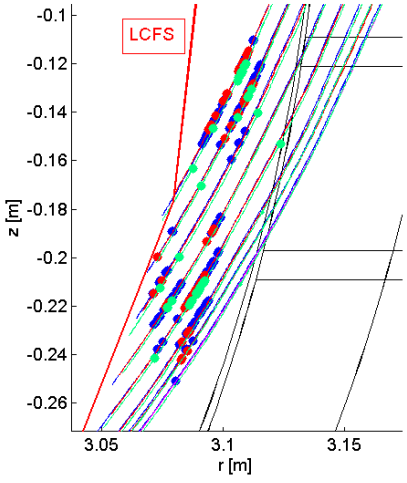

Fig. 6. Show measured values of I_{co} less than 10 µA in all plunges of shots #44168,69,70, Ug2 = -200 V (blue), -400V (red),-600V (green).

The following Fig. 7, left, shows the collector current for PLH=1.5 MW as a function of Ug2, in plunge 2 of shots #44168,69,70, while the right Fig. 7 shows the sum of bursts of collector current smaller then the value on the x-axis.

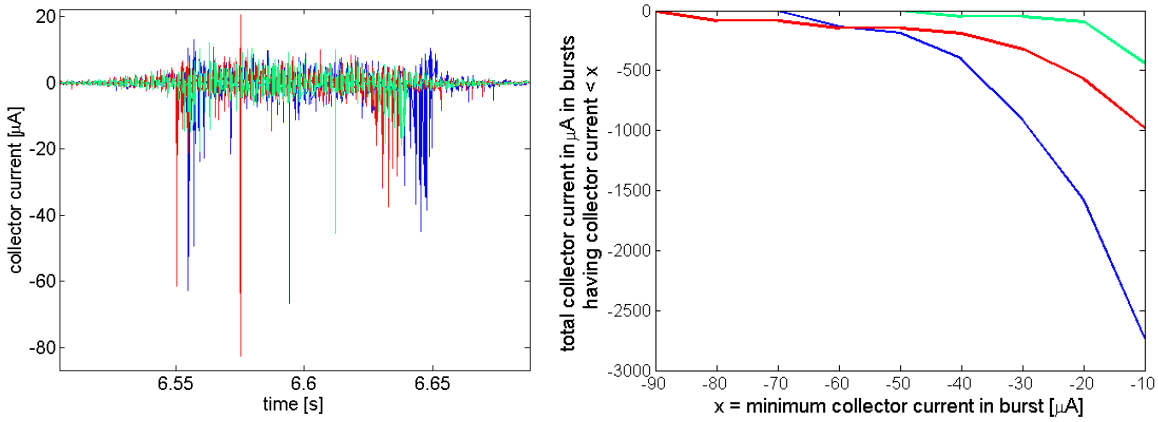

Fig. 7. Collector current as a function of the electron energy in the beam: Ug2 = -200 V (blue), -400V (red), -600V (green)

Discussion and Conclusion. In the comparison of the C3 and C4 fast beam in the three shots #46462, 46463 and 46465, the RFA slit did not penetrate (with exception of two plunges for C3) deep enough to measure the fast electrons generated in the so called 2nd beam [3] several cm radially distant form the grill mouth. This was caused by problems with determination of the LCFS position in the chosen shot configuration with wide SOL. As we observed in shots #44130 and #44133, the 2nd beam becomes to be well developed for C4 power of 0.85-0.9 MW. As can be seen from Fig. 6, the probe penetrated into the 2nd beam in C4 beam energy distribution measurements in shots #44168,69,70. The energy distribution measurement shows that, also for the RFA electron repelling grid voltage -600V, there is still enough electrons with energy larger then 600 eV producing collector current (green dots and curves for Ug2 = -600V in Figs. 6 and 7). As it is also obvious from Figures, the main conclusion of our contribution is that the PAM (C4) grill generates lower averaged supra-thermal electron fluxes than the FAM (C3) grill for identical SOL plasma conditions.

This work was supported by EURATOM and carried out within the framework of the European Fusion Development Agreement. The views and opinions expressed herein do not necessarily reflect those of the European Commission. The coauthors V.P. and V.F. acknowledge partial support of the Czech Science Foundation Grants GACR 202/07/0044 and 205/10/2055.

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