

## **Impact of Faraday screen on ICRF antenna properties during experiments in different heating scenarios on TEXTOR**

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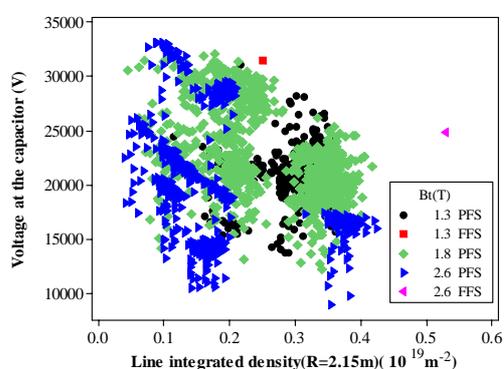
### **Introduction**

The RF launching system of TEXTOR consists of 2 different antenna pairs: the first one is tuned using a stub, a line stretcher and an autotuning system [1] and the second one is matched using a conjugate-T (CT) matching system [2]. The first antenna is not covered by a Faraday screen but is equipped with a graphite plate protecting the feeder area. The second antenna pair, which was previously equipped with a Partial Faraday Screen (PFS) covering the lower part of the antenna straps, is now equipped with 2 full Faraday screens (covering completely each strap). Observation of arcs starting at the limit of the metallic screen was the motivation to reintroduce a Full Faraday Screen (FFS) in front of the RF antenna. Measurements of the impact of this modification on the performance of the RF system and on the antenna distributed loading resistance are carried out at TEXTOR for various types of discharges and different heating scenarios.

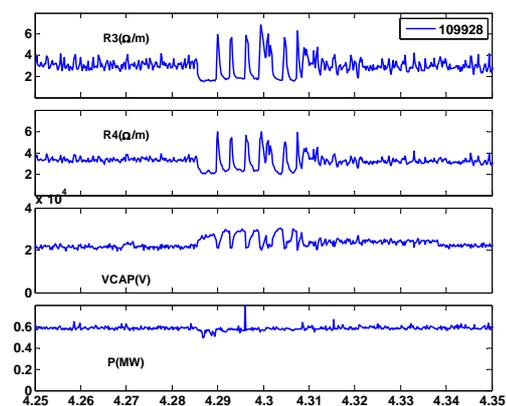
### **Operational limits**

During the operation with partial Faraday screen the maximum voltage measured at the end of one antenna strap shows a slow decrease as function of the line integrated density ( $n_{el}$ ) measured at  $R = 2.15\text{m}$  (0.06m from  $R_{\text{max}}$ ) when working at 38 MHz, the highest available frequency. Figure 1 shows the variations of this voltage versus  $n_{el}$  for 4 days of operation. Power varies between 300kW and 1MW. Results were obtained for different heating scenarios at magnetic field  $B_t=2.6\text{T}$  (minority heating),  $B_t=1.3\text{T}$  (2<sup>nd</sup> harmonic of H) and  $B_t= 1.8\text{T}$  (3<sup>rd</sup> harmonic of D). The maximum power sustained at the antenna and at the capacitor is decreased when the line integrated density at the edge of the plasma  $n_{el}(R=2.15\text{m})$  is increased. During the first days of operation with full Faraday screen at  $B_t=1.3\text{ T}$  the maximum voltage at the right strap of the antenna was slightly higher than the

values reached during the last campaign with partial screen (Fig. 1). When this value is reached an L-H transition occurred. The impact of a L-H transition on the antenna's electrical properties is illustrated in Fig. 2 for a discharge at lower power showing a strong drop of loading resistance and the subsequent increase of voltage at constant power. When working at the power limit in L mode, L-H transition will immediately cause a trip of RF power. For TEXTOR conditions of operation, maintaining the RF power during the L-H transition is only possible at approximately half the maximum power coupled in L mode. The relative drop of loading resistance is of same order for PFS and FFS antennas.



**Figure 1** Voltage measured at the capacitor (high voltage side of RF antenna) versus line integrated density at  $R=2.15m$ . ( $n_{el}$ ) : comparison of values obtained with partial Faraday screen (PFS) and Full Faraday screen (FFS).



**Figure 2** Time evolution of loading resistance ( $R_3$ ,  $R_4$ ) and voltage at the capacitor ( $VCAP$ ) during a L-H transition at  $t=4.285s$  followed by a back transition at  $4.308s$ . Loading resistance at strap 4 drops 45%, this corresponds, at constant power, to an increase of the voltage at the capacitor 4 by 35%, which is close to the measured increase.

At 2.6T we reached a maximum voltage of 24 KV at a very high  $n_{el}$  (rightmost magenta point on Fig.1).

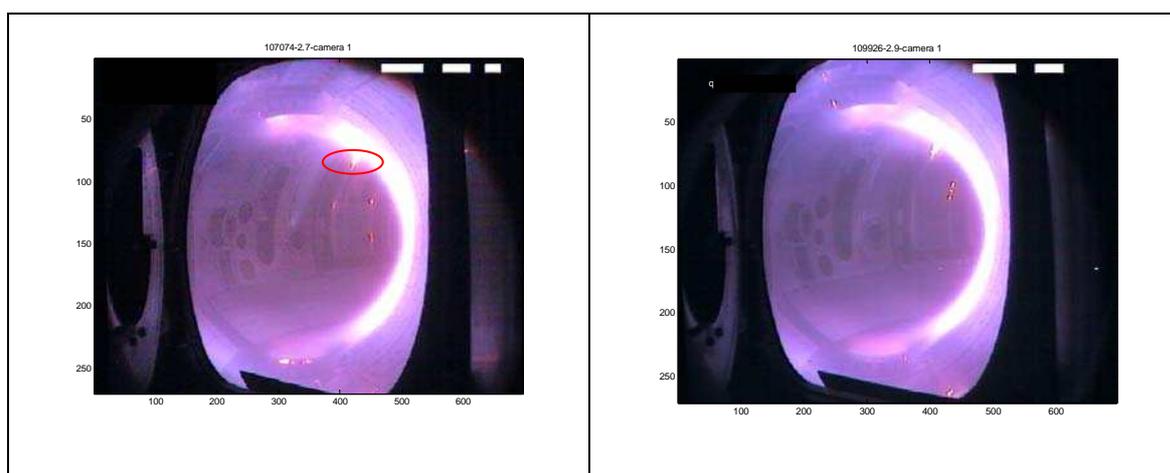
For PFS and FFS the trip is accompanied by a strong increase of iron emission probably due to an arcing in the antenna box.

### Impact of the Faraday screen on the bright spots at the antenna

The line of sight of a camera allows observing 1 strap of the antenna 2 and partly the other strap. At  $B_t=1.3T$  and RF heating at the 2<sup>nd</sup> harmonic of hydrogen several bright spots are observed around the antenna during RF heating. The strongest spot, also present at rather low power, is located at the top left of the left strap as shown in Figure 3. This bright spot is

also seen if a  $H_{\alpha}$  filter or a carbon line CIII filter is used. (There is also a hot spot occasionally visible at the same place after the RF pulse). This spot is probably due to excitation of atoms in the sheath produced by RF electric field in the antenna surroundings. There is no noticeable impact of the Faraday screen neither on the intensity nor on the localisation of this bright spot (when the voltage is below the arcing limit). The intensity of the light is more sensitive to changes of plasma position or intensity of beam heating power than changing PFS to FFS. The intensity of the light is strongly enhanced when the plasma is moved away from the antenna. It also increases when the beam power is decreased.

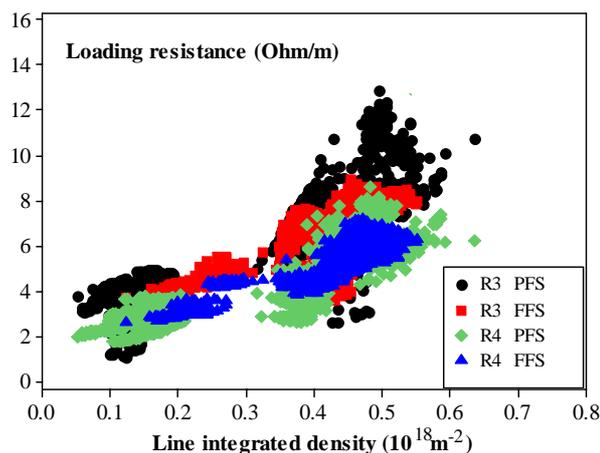
At the time of the trip, with PFS an intense bright spot was often observed at the border of the Faraday screen. With a FFS antenna at 1.3T a bright spot was observed at the bottom of the antenna (right side of the left strap). At  $B_t=2.6T$  many bright spots were also observed in the equatorial plane with FFS at the time of the trip.



**Figure 3** Bright spots are observed close to the antenna tip and are very similar without (left) and with (right) full Faraday screen.

### Impact of the Faraday screen on the antenna loading

The measurements of the antenna distributed loading resistances at TEXTOR are based on the determination of the standing wave pattern in the transmission lines between the ICRH generator and the RF antennae with voltage probes and directional couplers. The values of the loading resistance of the 2 straps are determined separately but are close to each other. The antenna loading resistance strongly depends on the density measured in the edge of the plasma. [3]



**Figure 4** Antenna distributed loading resistance versus mean line integrated densities for the two straps (3-4) of antenna 2 with partial (PFS) and full (FFS) Faraday screen –  $B_t=2.6T$  – Minority Heating.

In Fig. 4 the impact of the modification of the Faraday screen on the loading resistance as function of edge density is presented for series of discharges at high power for a minority heating scenario. At RF power close to the arcing limit with PFS the loading resistance of one strap (R3) strongly increases and the loading resistances of the straps become different; the distributed inductance decreases. This may be due to a coupling between the straps or to a local plasma in front of the antenna. With FFS those effects were never observed. Far from the arcing limit the impact of the Faraday screen is within the scatter of the measurements. Similar results are obtained for 2<sup>nd</sup> harmonic heating.

## Conclusions

No strong impact of the modification of the Faraday screen placed in front of the CT-antenna has been observed. The evolution of the distributed loading resistance with density in the edge is similar with PFS or FFS when the antenna is well conditioned and far from arcing conditions. The evolution of loading resistance during L-H transition or during the ELMs remains similar. The bright spots at the short circuit of the antenna have not been strongly affected. The decrease of the bright spots in the middle of the antenna observed at low magnetic field needs to be confirmed. The strong increase of distributed loading and decrease of inductance when approaching arcing limit have not been observed with FFS.

## References

- [1] F. Durodié, M. Vervier, Europhysics Conf. Abstracts, Vol. 16E, pp. 81-84, 1992.
- [2] F. Durodié et al., proceedings of 22nd SOFT, Helsinki 2002, pp. 509.
- [3] G. Van Wassenhove et al., 35<sup>th</sup> EPS Conf. on Plasma Phys. Hersonissos, 9-13 June 2008, Vol.32F, 1.104.