8. PARTICIPATION IN THE ITER PROJECT

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8.1. INTRODUCTION

The Portuguese participation in the ITER project included in 2004 activities on microwave diagnostics related with the design analysis of the position reflectometer, development of an advanced FM-CW coherent reflectometer and demonstration experimental studies on ASDEX-Upgrade of plasma position/shape measurements in ITER relevant scenarios.

Prof. Carlos Varandas participated in 2004 in two meetings of the ITER negotiations.

Concerning the *design analysis of the position reflectometer,* the Association EURATOM/IST has led a Physics Integration Task of the Fusion Technology Programme (TW3-TPDSUP). CATIA models have been developed for the draft design of the waveguide routing of gaps 3, 4 and 5 (Figure 8.1). First simulation studies of the performance of the waveguide routing using HFSS have been performed. The assessment of the possibility to locate the electronics in the port cells has been initiated.

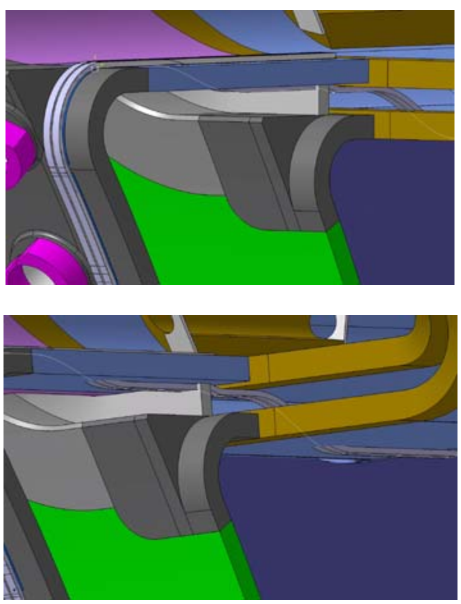

Figure 8.1 –3D Catia models of waveguide routing (gap 4) for the ITER position reflectometer

Regarding the *development of a prototype of a coherent reflectometer*, the basic concept has been developed. The design of the sources and subsequent determination of the operation frequency bands have been finalized. The design of the sweep and digital control has been initiated as well as the study of an integrated FPGA based approach for linear control and frequency synthesis.

Concerning *plasma position/shape measurements,* automatic density have been obtained in ASDEX Upgrade in ITER relevant scenarios, namely in ELMy H modes, demonstrating clearly the possibility to use reflectometry for plasma position/shape measurements in ITER.

8.2. COHERENT REFLECTOMETER

This diagnostic (Figure 8.2.) will be capable of performing both profile and turbulence measurements at very high plasma densities. The use of synthesized sources along with frequency conversions leading to a full coherent system allows both fast sweeps and fixed frequency operation with low phase noise signals. The system is capable of withstanding the long distances from diagnostics to the vessel while using a locally generated reference.

8.3 PLASMA POSITION/SHAPE MEASUREMENTS IN ITER RELEVANT SCENARIOS

ASDEX Upgrade standard ELMy H-mode scenario provides an abundant source of repetitive type I ELMy discharges on which position measurements can be performed. Figure 8.3 shows the positions of densities corresponding to several possible n_{sep}/n_{e_med} ratios after removal of measurements obtained during ELM onset and MHD phases where microwave signals are scattered and cannot be used for data analysis.

The proximity of time traces of position of different tracked layers indicates the location of the ETB (in the steep region of the profile, different density layers are very close in radial distance). Consistently, in both HFS and LFS, after the L-H transition ($t \approx 1.85$ s) and during the initial density ramp up, curves corresponding to a ratio n_{sep}/n_{e_med} of 30% and 40% are closer. Afterwards, the density drops with the increase of ELM frequency but the ratios of curves at the steep region rise to 40-50%. The injection of more 2 MW of neutral heating and a strong fueling gas puff leads to a higher density steady state phase, with higher frequency higher density ELMs (f_{ELM}>200 Hz after $t\approx 5$ s). Again, the proximity of the curves suggests a rise of densities at the ETB, corresponding to 50-60% n_{sep}/n_{e_med} values. During this phase, rapid ELM recovery results in oscillations of the positions in the steep gradient region of less than 0.5 cm when compared to the magnetic separatrix changes (black curve).

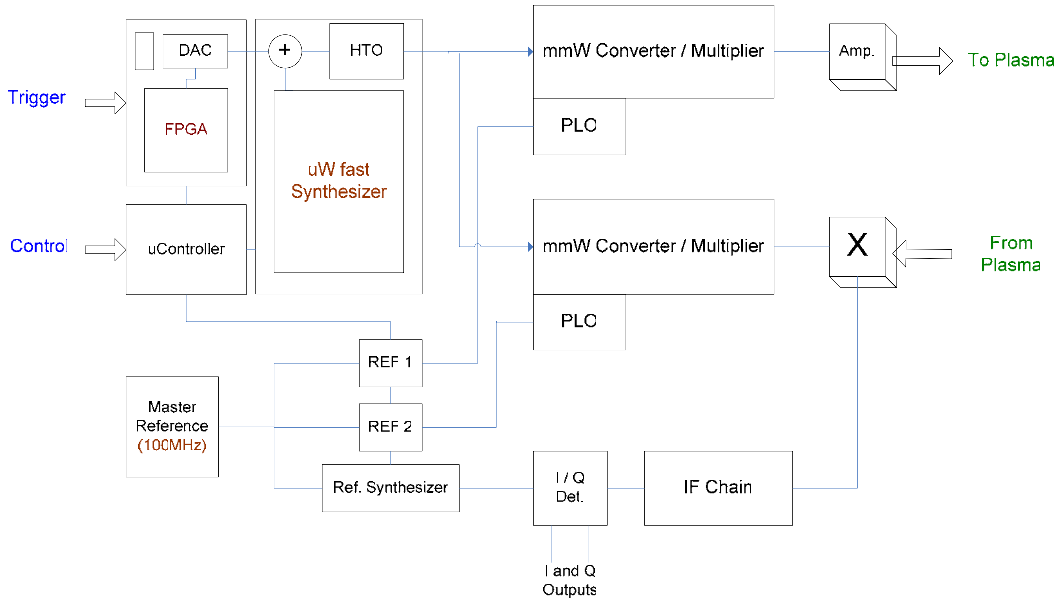

Figure 8.2 – Reflectometer using coherent signal generation and IQ detection

For the profiles that correspond to t=2.66 and 3.76 s, the pedestal is still within the measuring range. For t=6.02 s the edge profile changes considerably, exhibiting higher densities up to the density barrier foot, typical of a gas puffed, non-detached H-mode plasma. In this phase, similar to the foreseen ITER higher density regimes, the pedestal is no longer within the measuring range of the reflectometer. The increase of the density at the barrier foot is consistent with the observed increase of the ratio values of the closest curves. In these circumstances, an alternative n_{sep}/n_c scaling (where n_c is the pedestal density) cannot be used to estimate the density at the separatrix without the upgrading of the ASDEX Upgrade reflectometer to probe higher densities.

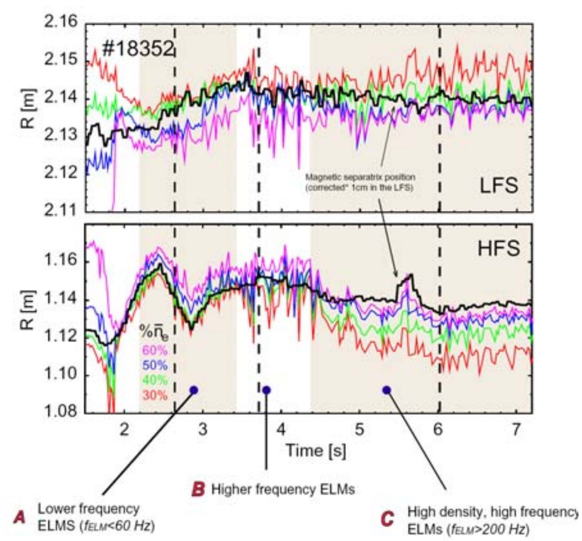

Figure 8.3 - Temporal evolution of edge plasma layers with plasma densities according to the time trace of the magnetic separatrix position.