5. PARTICIPATION IN THE TJ-II PROGRAMME[1]

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5.1. INTRODUCTION

This project included in 2003 activities in the following areas:

- Microwave reflectometry;
- Heavy ion beam diagnostic;
- Plasma physics studies.

5.2. MICROWAVE REFLECTOMETRY

5.2.1 Introduction

The activities in this area were focused on the development of an advanced reflectometer for plasma fluctuation studies with increasing measuring capability, utilizing only one single frequency that can be hopped during the discharge.

The main activities performed in 2003 were:

- Finalization of the development and testing of the system at CFN;
- Implementation and testing of this reflectometer on the TJ-II stellarator.

5.2.2. Broadband fast hopping mm-wave reflectometer

The broadband fast hopping mm-wave reflectometer (Figure 5.1 and Table 5.1) employs dedicated fast frequency synthesizers and intermediate circuit designed by CFN. The operation bands of the synthesizer are 8–12 GHz and 12–18 GHz allowing any millimetre wave band to be covered with appropriate frequency multipliers and harmonic mixers.

Frequency	33.0 – 50.0 GHz
Intermediate Frequency	768 MHz
Waveguide type	WR22 - 33-50 GHz
Flange type	UG383/U
Power transmitted to plasma	7dBm (asdex) 16dBm (TJII)
Receiver sensitivity	-90 dBm
Dynamic range	>45 dB
IF gain control range	>40 dB
Output channels	I/Q 50 Ω/1 MΩ
Output bandwidth (base-band I/Q)	1 MHz
Control port	RS232c
Trigger input	TTL comp, falling edge
Switching time (to within 1%)	
To any frequency	<2 ms
Within 10% change	<1 ms

Table 5.1 - Main characteristics of the broadband fast hopping mm-wave reflectometer

Each synthesizer has a fast HTO oscillator and a PLL control board along with other auxiliary components implementing a fundamental dual loop multiple harmonic PLL scheme. The output and input components, the multiplier (output) and harmonic-mixer (input), interface directly the waveguides that connect to the antennas placed inside the TJ-II vessel.

The synthesized signal generators are based on HTOs controlled by a dual loop PLL with harmonic transfer technique. This synthesizer can employ HTOs operating at any frequency from 3 to 40 GHz although for millimeter wave generation the 8-12 GHz and 12-18 GHz bands are the most interesting.

The HTO is controlled by a digital-to-analog converter, in addition to the error voltage generated by the main PLL loop. In this way the error correction issued by the main loop acts only as a fine tuning, while the coarse tuning is performed by the DAC value. This ensures that the locking is made at the correct harmonic number of the PLL local oscillator (LO) and also keeps the lock time to a minimum.

Each system employs two identical frequency synthesizers: one is used for the plasma signal while the other serves as the LO for the plasma signal reception.

Both synthesizers are totally independent and can be controlled individually by the user.

This refletometer can be switched between frequencies in a very short time (sub millisecond) enabling to probe several plasma layers during the discharge to study the radial distribution of plasma fluctuations and to perform (with two identical systems) correlation measurements.

Tests of the fast frequency hopping reflectometer have confirmed its high performance.

5.3. HEAVY ION BEAM DIAGNOSTIC

5.3.1. Introduction

The TJ-II heavy ion beam diagnostic (HIBD) was designed to operate with two detectors for the

[1] Work carried out in collaboration with the TJ-II Team of the Association EURATOM/CIEMAT. Contact Persons: J. Sanchez and C. Hidalgo.

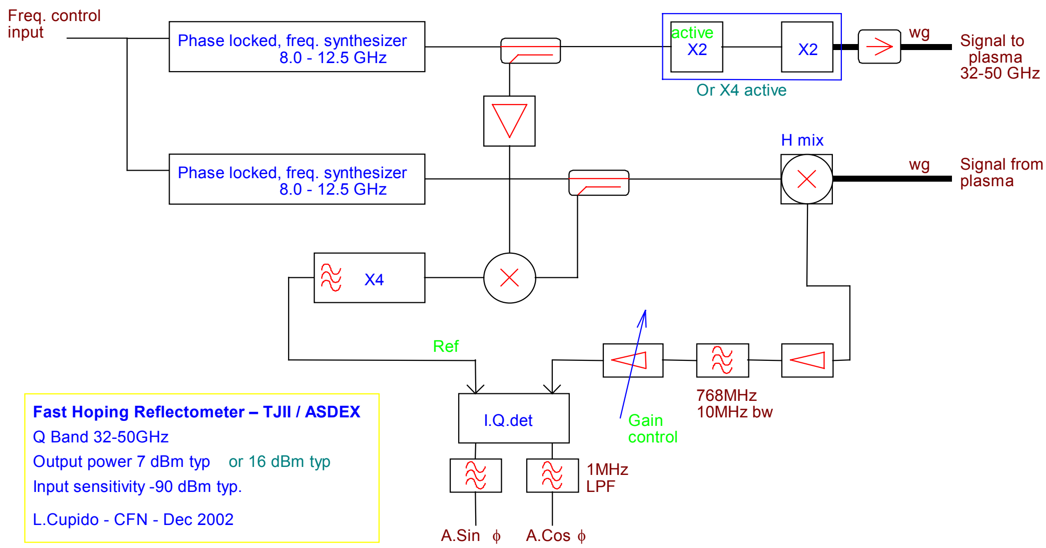

Figure 5.1 - Overall diagram Q band

secondary ions: (i) a 30^o Proca-Green electrostatic energy analyzer; and (ii) a multiple cell array detector (MCAD).

The following main activities were carried out in 2003:

- Finalization of the tests of the MCAD implemented in 2002. based on deep Faraday cup type cells;
- Operation of the multiple cell array detector;
- Improvement of the signal conditioning and data acquisition system.

5.3.2. Operation of the multiple cell array detector

Figure 5.2 shows that the plasma loading is strongly reduced in the Faraday cup type cells, since the photo-electrons are immediately collected on nearest inner surface inside the hole.

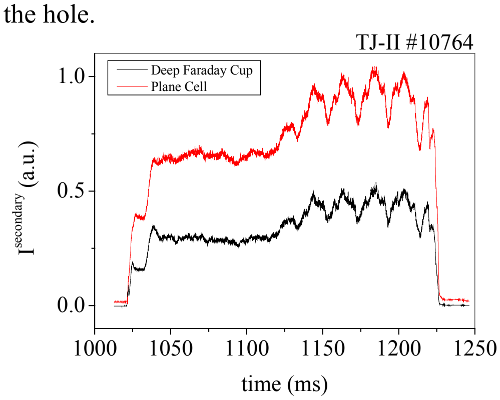

Figure 5.2 - Comparison of the plasma loading in a cell with and without Faraday Cup.

Both the primary and secondary beam signals have been observed in standard TJ-II regimes. Figure 5.3 presents the sweeping voltage on the toroidal and poloidal directions and secondary ions current detected at one of the MCAD Faraday cups. The spikes due to the secondary current are clearly seen above the plasma loading level when the secondary beams cross the detector due to the sweeping of the primary beam. The incident angles of a primary beam were carefully tuned to obtain maximal signals of secondary ions on the chosen cells. The signal-to-noise ratio for the secondary beam signal after crossing the plasma is now up to three times larger than in the old cells, allowing measurements of the electron density profiles. However, fluctuations studies will be only possible after improvement of the detector performance by inserting Nickel balls inside the cell holes.

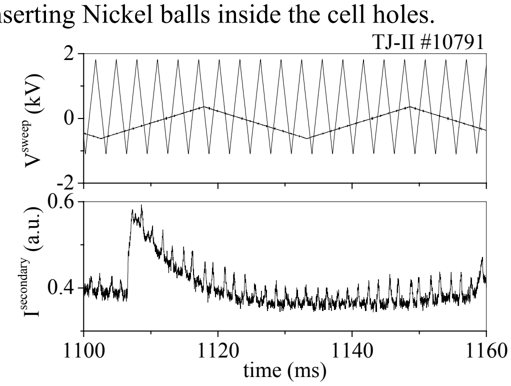

Figure 5.3 - Time evolution of the (a) sweeping voltage on the toroidal and poloidal direction; and (b) secondary ions current detected at one of the Faraday cups of the MCAD.

5.4. EDGE PLASMA PHYSICS

The following main activities were made in 2003:

- Continuation of the turbulent transport studies concerning the dynamic coupling between transport and parallel velocity;
- Continuation of the analysis of the effect of the shear layer on the radial correlation of transport;
- Construction at IST of a graphite electrode or edge biasing experiments on TJ-II to be performed in 2004.