7. PARTICIPATION IN THE TCV PROGRAMME

C. Varandas (Head), A.P. Rodrigues P. Amorim, L.A. Pereira, T.I. Madeira

7.1. INTRODUCTION

This project had in 2005 two research lines:

- X-ray diagnostics
- Advanced plasma control system (APCS)

7.2. X-RAY DIAGNOSTICS

7.2.1. Introduction

This research line included in 2005 activities related with:

- The operation and scientific exploitation of the horizontal pulse height analysis (PHA) diagnostic;
- The commissioning, testing and implementation on TCV of the vertical PHA diagnostic;
- The transformation of the vertical PHA diagnostic into a real-time system;
- The commissioning and testing of the rotating crystal spectrometer.

7.2.2. Analysis of the data from the horizontal PHA diagnostic

Since its commissioning, the horizontal PHA diagnostic has provided data which has contributed to many experimental studies particularly in the fields of impurity injection aided particle confinement and plasma heating scenarios: mild (Figure 7.1) to strong (Figure 7.2) deviations of the electron populations from a thermal distribution when additional heating is applied have been observed, and impurities resulting from the erosion of the plasma vessel walls during ECRH have been identified (Figure 7.3). The impurity identification is straightforward as long as the system calibration is known, but to determine the electron temperature, some situations have been treated by employing a single maxwellian fit (Figure 7.4), others are addressed by a bi-maxwellian model (Figure 7.1) in cases of strong non-Maxwellian behavior (Figure 7.2) the approximation of a Maxwellian distribution no longer holds and leads to erroneous results without physical meaning as there is no longer a correspondence between the observed photon energy and the electron energy. A qualitative interpretation of the experimental results is being investigated.

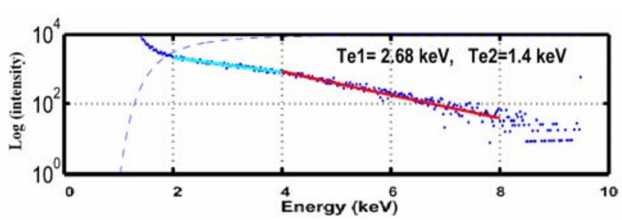

Figure - 7.1 - Example of mild non-maxwellian behavior observed during ECRH

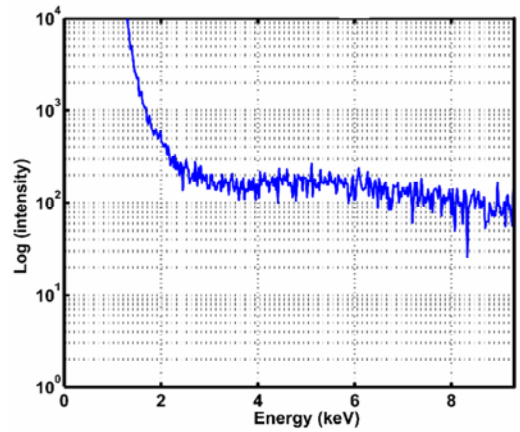

Figure 7.2 - Example of strong non-maxwellian behavior observed during ECRH

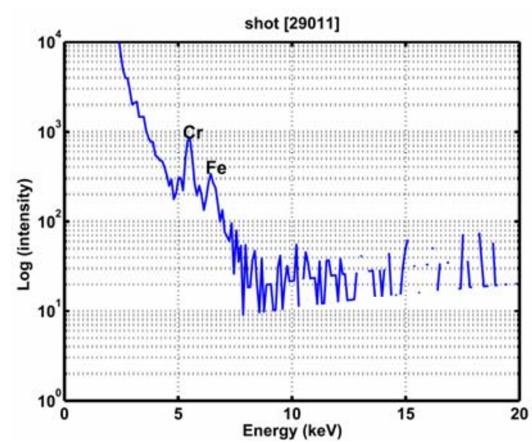

Figure 7.3 - Impurities resulting from erosion of the plasma vessel walls during ECRH.

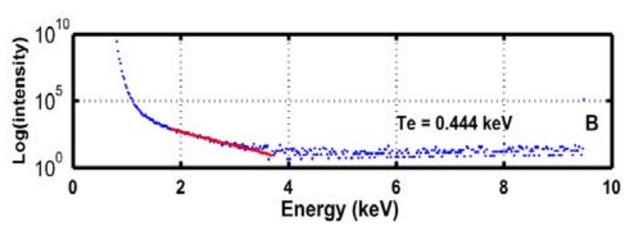

Figure 7.4 - Electron temperature measurement using single Maxwellian fit

7.2.3 Vertical PHA diagnostic

The vertical PHA diagnostic is a modern upgrade of the “classical” horizontal PHA system that has been designed aiming at demonstrating an extremely low *étendue* X-ray spectral measurement of a hot plasma with a regulated flux permitting real-time measurements of plasma parameters for a wide range of plasma conditions and real-time diagnostic feedback control.

This diagnostic comprises a compact Silicon Drifted Detector (SDD) Peltier cooled diode and two independent systems for signal conditioning and processing: a commercial multiple-frame multichannel analyser (MCA3) with post acquisition analysis and a CFN designed VME hosted DSP card which will provide real-time analysis of the X-ray emission. Both system are designed to remote actuate the stepper motors whilst simultaneously regulating the system *étendue* to maintain an optimal throughput during a single discharge: the analogue system employs an integrator (sensor) together with a comparator that when the throughput limits are surpassed, gives out a signal that actuates the motors and change the position of the aperture. For the DSP system the pre-amplifier pulses are fed into a subsystem with a DAC that supplies the appropriate voltage to actuate the stepper motor. With a regulated input rate, a spectrum, with spectroscopic quality, may be obtained every 100 ms during a 2 s TCV discharge.

Measurements of the central electron temperature have already been obtained with the MCA3 card for some TCV operation regimes (Figures 7.5), with an average throughput of 300 kHz. The DSP algorithms employed to make the histogram and calculate the electron temperature are still being essayed for performance during TCV operation. A set of beryllium filters of 50, 100 and 150 μm are also employed to reduce the dominant lower energy X-ray photon rate and a low power ^{55}Fe source occupies one of the filter holder positions and can be used to diagnose and calibrate the system *in situ*.

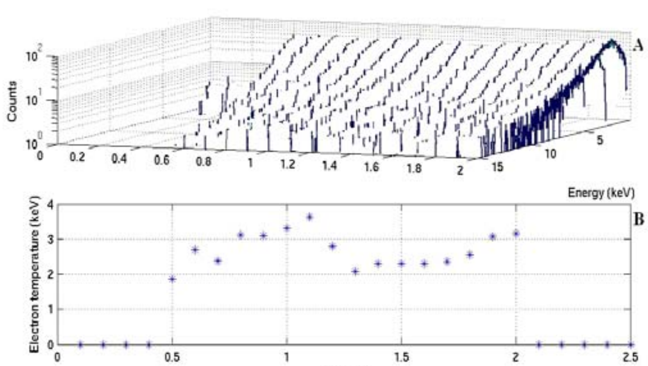

Figure 7.5 - Results obtained with the MCA3. (A) soft x-ray spectrum and (B) Electron temperature, temporal evolution.

7.2.4. Real-time diagnostic

The research and theoretical development of the histograms construction algorithms were carried out. These algorithms, that give real-time results, were implemented using C language and the specific DSP Assembler. The debug and optimization were initially done using a simulation setup with data from the old PHA diagnostic and later with real-time data from the detector system in shot conditions. The synchronization of these algorithms with those that make the data acquisition and the electron temperature calculation has been also tested.

The DSPs system in the TCV control was integrated with the data acquisition system and the detector system was connected with the DSPs module. The TCV trigger and timing system was also connected to the DSP module in order to get external synchronized triggers. These timing signals were programmed in the TCV main database and used to synchronize the real-time electron temperature calculation with the shot of the TCV.

Implementation and test of the VME host CPU software were done. This software configures the DSPs module, gets the histograms and the electron temperature values, calculated during the shot.

The control of the count rate in real-time is absolutely necessary in order to avoid saturation of the acquisition system and to maintain a minimum count rate that gives a minimum statistical error that enables the calculation of the electron temperature of the plasma in real-time. To overcome this need the development and implementation of the diaphragm real-time control algorithm which controls the X-ray count rate were done. The control algorithm must yet be tested in good shot conditions. This task should be concluded during 2006 when the shots of TCV will be stable. Then, the real-time electron temperature calculation can be achieved.

7.2.5. Rotating Crystal Spectrometer

All parts of the diagnostic (the new microchannel plates, new pre-amplifiers and master/slave unit that actuates the stepper motor) have been assembled. The tests to the hardware have been initiated. First essays have shown that the pre-amplifiers were not working properly, their design had to be revised but every new adaptation did not succeed so far. The design of the holding structure at the horizontal port has started but had to be interrupted because the port was attributed to another device. No decisions have been taken so far in what concerns the new localization of the diagnostic.

7.3. ADVANCED PLASMA CONTROL SYSTEM

After some preliminary tests, the main objective of the 2005 activity in this Project was the decrease of the control cycle. Aiming at having a transfer time in the DMBUS less then 10 μs, the control programming logic device (CPLD) that controls the DMBUS was replaced by a faster version. This change has originated the need of the reprogramming of the CPLD with another software tool and a different language.

In parallel, a support library, a set of utilities and test scripts have been developed.