7. PARTICIPATION IN THE TCV PROGRAMME[1]

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7.1. INTRODUCTION

The participation of the Association EURATOM/IST in the TCV programme has been focussed in three main research lines:

- Pulse Height Analysis (PHA) X-ray diagnostics;
- A X-ray rotating crystal spectrometer;
- Advanced plasma control system for TCV.

7.2. PHA DIAGNOSTICS

7.2.1. Main activities

The following main activities were carried out in 2002:

- Routine operation of the horizontal PHA diagnostic for the measurement of the electron temperature and analysis of the line radiation in the soft X-ray range from 1 to 10 keV;
- Elaboration of a Users Reference Guide for users of the horizontal PHA diagnostic;
- Finalization of the design of a vertical PHA diagnostic, including the issues related with its implementation on TCV;
- Definition of the tasks to be performed by the CRPP Technical Services;
- Purchase of some diagnostic components (detector, a CAMAC transient recorder and a DuraBe window);
- Improvement of a CAMAC DSP based algorithm aiming at meeting the experimental aims and performance;
- Beginning of the tests of the basic components of the diagnostic;
- Development of software for the utilization of a CFN DSP-based VME system on these diagnostics, aiming at achieving real-time operation for the feedback control of some TCV and diagnostic parameters.
- Development of a Linux based server and control program as well as a remote graphical user interface for the implementation of the CFN DSP-based VME system in the TCV control and data acquisition system.

7.2.2 Vertical PHA spectrometer

A new Pulse Height Analysis (PHA) diagnostic, to be implemented at a TCV vertical port with a central line of sight, has been developed aiming at to overcome three important limitations of the horizontal PHA diagnostic:

(i) To analyse the plasma is almost all the TCV configurations;
(ii) To increase the pulse processing and speed capabilities of the diagnostic;
(iii) To provide real-time data analysis allowing to use the results for feedback control of the tokamak operation.

Figure 7.1 shows the block diagram of this new diagnostic.

The detector (Figure 7.2) is a Roentec XFlash Silicon Drifted Detector (SDD) 1000B, which consists of a very thin (~ 300 μm) fully depleted silicon wafer, making it only sensitive in the soft X-ray range and fairly transparent to high X-ray energies (Figure 7.3). An electric field, with a strong component parallel to the surface, drives signal electrons towards a small-integrated collecting anode. The electric field is generated by a number of increasingly reverse biased field strips covering only one surface of the device. The radiation entrance side is a non-structured p+ junction, giving a homogeneous sensitivity over the whole detector's sensitive area (~5 mm^2).

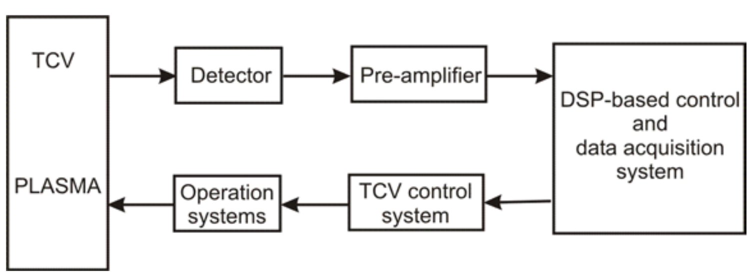

Figure 7.1 – Block diagram of the vertical PHA diagnostic

[1] Work carried out in collaboration with the TCV Team of the Association EURATOM/Confédération Suisse. Contact Person: Basil Duval.

Figure 7.2 - Photo of the SDD detector plus the electronic cooling system and its monitor.

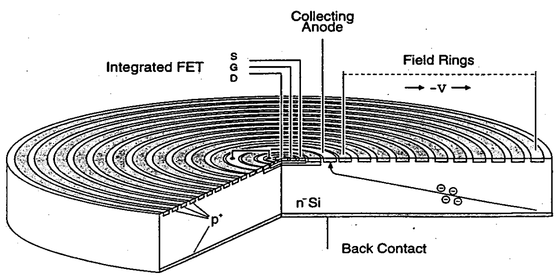

Figure 7.3 - Schematics of the SDD waffer

These detectors also feature an integrated thermally stabilised thermoelectric cooler, which can maintain the diode down to –10 °C. The power supply for the cooler and the diode can be located far from the diode itself, which permits more geometrical flexibility and installation freedom around the torus.

Data acquisition and processing is performed by a IST/CFN DSP-based VME system, which was specially designed for data acquisition, real-time parallel processing and feedback control. This system has four independent acquisition, processing and control channels, each one composed of: (i) one analog differential input for data acquisition with 12-bit resolution, +/- 5 V voltage range, independent software programmable sampling rate of up to 40 MSPS, and a FIFO memory of up to 32 kword; (ii) one 32-bit floating point DSP (TMS320C44) that can process up to 40 MIPS/80 MFLOPS; (iii) up to 128 kwords 32-bit wide SRAM for DSP program and data; (iv) one analog output for control with 14-bit resolution, +/- 5 V voltage range, independent software programmable update rate of up to 100 MSPS and a FIFO memory of up to 32 kword.

An application was developed to perform seven main tasks: (i) Data acquisition; (ii) Pile-up inspection and data acquisition control; (iii) Histogram construction, window correction and natural logarithmic application; (iv) Search of the histogram spectrum linear zone; (v) Fitting the data to a straight line and plasma electron temperature calculation; (vi) Feedback control and the remotely controllable X-ray PHA filters and apertures adjustment; (vii) Delivery of the acquired spectra to Host CPU on the VME bus and so to the main database of the TCV. These tasks are distributed by two of the four Acquisition, Processing and Control (APC) channels of the CFN module. The first three tasks of the list above are implemented in one APC channel and the last four tasks in the other one. The algorithm used to search the beginning of the histogram linear zone and the one to fit the data to a straight line are implemented and tested. The time spent by the DSP to find the first channel of the histogram where the fitting to the straight line should begin, is less than 250 μs.

Several algorithms to fit the histogram channels to a straight line were tried. The one that gave the best compromise between short calculation time and higher precision in the fitting calculation was the weighed linear regression algorithm. This algorithm is implemented in assembler language and takes 133 μs of the DSP processing time to fit 256 channels of the histogram to a straight line. The digital errors introduced by the DSP calculation are negligible and the overall error is within 2 % when compared to the off-line results, calculated using a more sophisticated procedure.

7.3 THE X-RAY ROTATING CRYSTAL SPECTROMETER

The following main tasks were performed in 2002:

- Cleaning up of the vacuum chamber, replacement of the gold O-rings by viton ones and test of its performance at high vacuum;
- Tests of the step motor support structure, CRPP manufactured amplifiers, crystals reflectivity and multichannel plates (MCPs) performance;
- Call for tender for a new set of crystals and MCPs.

7.4 ADVANCED PLASMA CONTROL SYSTEM FOR TCV

This is a new Project presently under discussion. In 2002 the following activities were made:

- Meetings between CRPP and IST staff to understand how the CFN DSP-based VME system could be used on the TCV real-time control;
- Elaboration of a proposal for the upgrading of the central analogue controller of the TCV plasma control system.