

7. PARTICIPATION IN THE TCV PROGRAMME¹

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7.1. INTRODUCTION

The Portuguese participation in the TCV² programme has included the development, operation and scientific exploitation of:

- Three X-ray diagnostics: two pulse height analysis (PHA) diagnostics for implementation on an horizontal and a vertical TCV port and a rotating crystal spectrometer;
- An advanced plasma control system (APCS).

7.2. X-RAY DIAGNOSTICS

7.2.1. Horizontal PHA diagnostic

The routine operation of this diagnostic (Figure 7.1), based on a Germanium detector and on a CFN interface amplifier timing generator, has been assured by Portuguese staff.

Software tools for data analysis have been improved, mainly related with the calculation and interpretation of spectra with permanent non-Maxwellian behaviour. Two modified Maxwellian distribution functions were independently tested, accounting for respectively magnetic trapping and anisotropy. The results permit to conclude that, for most of the analysed spectra, only the anisotropy function accounts the observed effects.

Plasma physics studies related with the influence of auxiliary heating on the plasma electron distribution function have been carried out. Results obtained with a bi-Maxwellian function (Figure 7.2) have started to be compared with those provided by other diagnostics.

7.2.2. Vertical PHA diagnostic

7.2.2.1. Introduction

This diagnostic was conceived aiming at providing very high throughput by using a new type of detector and real-time electron temperature and impurity content measurements that might be also used for feedback control by using a CFN multi-DSP-based VME module.

The compact design of the diagnostic has allowed its implementation along a vertical line of sight, in a narrow space between port 14b and a TCV coil. This diagnostic is equipped with a set of DuraBe windows and a variable aperture (Figure 7.3), each one arranged on separate disks actuated by two independent step motors, which are presently remotely controlled by a CRPP master/slave unit.

In 2004, the diagnostic was dismantled from TCV for inspection and repair of some malfunctions, alignment of the detector, replacement of viton rings, calibration of the filters and aperture positions and repair of one motor.



Figure 7.1 – View of the horizontal PHA diagnostic on TCV

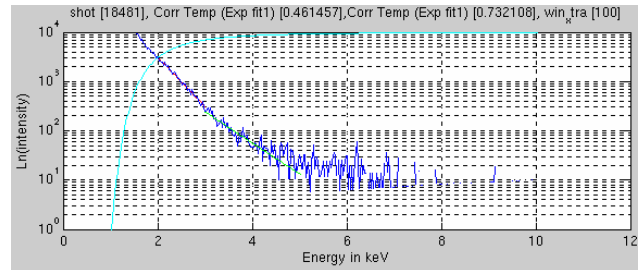


Figure 7.2 - Bi-Maxwellian fit to a spectrum exhibiting a tail

The variable aperture has been redesigned in order to have the correct curvature and gradient. The interface master/slave that actuates the motors has been redesigned aiming at avoiding saturation. A commercial CAMAC data acquisition board (XIA) has been tested, proving not to be stable for X-ray sources of variable flux. A commercial multi-channel analyser board (MCA3-FastComTec) has been installed. Two input channels of this module have been activated to survey the signal coming from the detector pre-amplifier and detection and suppression of the noise sources. The diagnostic has been re-implemented on TCV. The hardware and software for

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² TCV is a tokamak of the Association EURATOM/Suisse Confederation

the calculation of the electron temperature using the CFN real-time multi-DSP-based VME module have been developed, tested and improved.

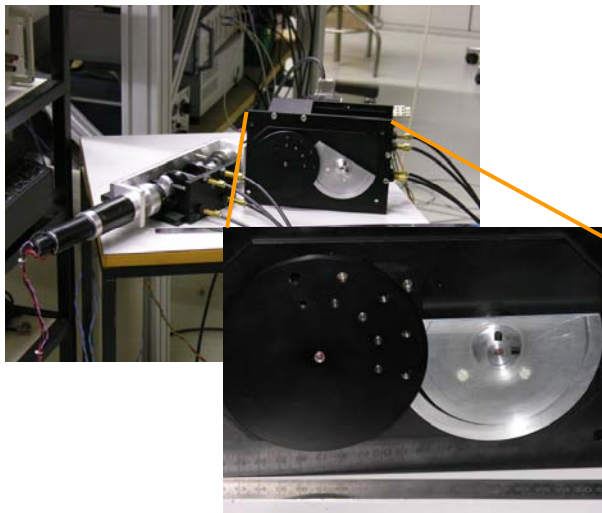


Figure 7.3 - Detail of the filters and aperture holders of the vertical PHA

7.2.2.2. Real-time diagnostic

The real-time diagnostic is being implemented through parallel processing of the acquired data by several digital signal processing algorithms, distributed by the DSPs of the above mentioned CFN module, which construct a sequence of histograms corresponding to the X-ray spectra during a TCV discharge. Each histogram is obtained using the following algorithms: moving average, triangular or trapezoidal filter and custom algorithms that detect the amplitude of the signals and eliminate those that correspond to pile-up. Adequate processing of these histograms, using a custom algorithm to find the linear zone of the histogram data and a linear regression fitting algorithm, allows not only to compute the temperature of the plasma electrons during the discharge, but also to detect and identify the impurities in the central plasma region. An appropriate real-time feedback control algorithm permits to actuate on the gyrotrons of the electron cyclotron heating system in order to avoid disruptions in the plasma due to either excess or missing of the injected power.

7.2.3. Rotating crystal spectrometer

This diagnostic, based on a twenty years old apparatus loaned by the Plasma Physics Princeton Laboratory, has been envisaged to record the soft-X-ray line radiation from highly charged ions of low to medium Z elements from the hot core of the TCV plasma, along a horizontal line of observation.

During the last trimester of 2004, the calls for tenders for the micro-channel plates and crystals have been made. The electronic devices of the diagnostic have been tested. The programmes for the step motor have been revised and

improved. The signals that will be provided by TCV system to the diagnostic and from the diagnostic to the TCV data acquisition system have been identified and characterized.

7.3. ADVANCED PLASMA CONTROL SYSTEM

This new digital system for the control of the TCV plasma (Figure 7.4) is based on the CFN real-time multi-DSP-based VME (RTPROV) module.

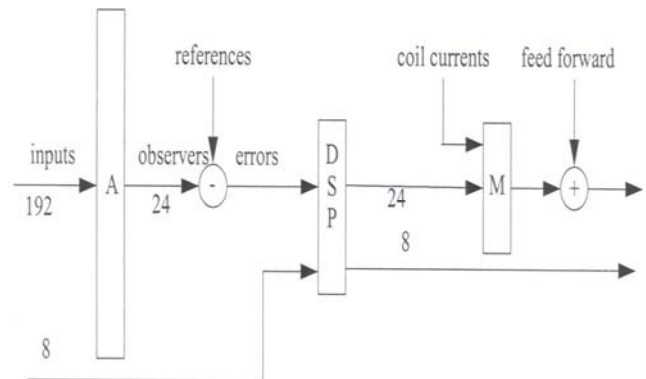


Figure 7.4 – APCS functional diagram

In 2004, the commissioning and testing of twelve RTPROV modules were finalized. The tests of the simultaneous operation of these modules in a VME crate (Figure 7.5) have been initiated. The development and testing of the data mover bus (DMBUS) have been finalized. The DMBUS and XIO VME modules have been commissioned and tested. Software for MACH programming and DMBUS management has been developed and tested. The APCS operation system has been developed and tested. Software for the APCS integration in the TCV control and data acquisition system is under development.

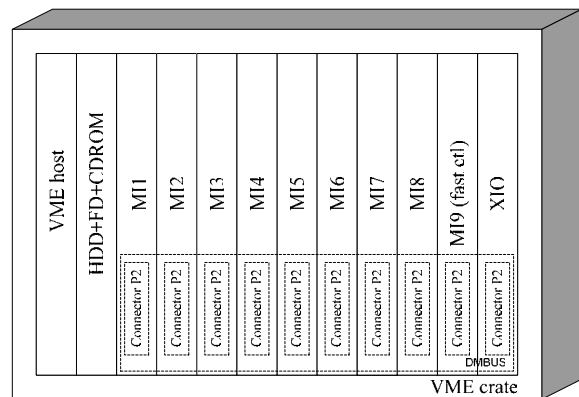


Figure 7.5 – Overview of the APCS hardware