

PROFILES AND INTENSITIES MEASUREMENTS IN THE DIAGNOSTIC SYSTEM OF THE EXTRACTED BEAMS OF THE U-70 ACCELERATOR

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Abstract

Diagnostic system for the extracted beams of the U-70 accelerator is a hardware-software complex with profilometers, intensimeters and electronic crates at the lower level, VME-crates with ADC-modules and MVME-167 processors (vxWorks operating system, basic EPICS tools, home made software) at the middle level, personal computers used as workstation at the upper level.

In this report we consider:

- The approaches to the system adaptation problems during the U-70 runs and solutions to these problems
- Data acquisition and hardware-software levels of data processing for non-standard profilometers
- The tools for the beam intensity measurement and presentation, the intensimeter calibration procedure.

INTRODUCTION

The diagnostic system for the extracted beams of the U-70 was operated since the 2001. The basic principles of the system and its original structure were described in [1].

The main tasks of the system are:

- the acquisition of beam related data and its primary processing;
- various on-line and off-line presentation of the information;
- data archiving and access to data.

The system does have a flexible adjustment mechanism, but it cannot solve all the problems. Since physicists and beam specialists are doing scientific research, an alteration of the software and hardware is sometimes needed. We will consider the ways of the non-standard measurement hardware integration into the system as well as the system adaptation to special operation modes.

LOWER AND MIDDLE LEVELS OF THE DIAGNOSTIC SYSTEM

The diagnostic system is a three-level hardware-software complex. The software for the upper and middle levels is based on the EPICS toolkit [2].

The layout of the middle and lower levels is shown in Figure 1. The signals related to beam particles are registered at the lower level. VME-crates with crate controllers and ADC-modules make up the middle level. This is the IOC (Input-Output Controller) in EPICS terms. In the considered configuration IOC consists of VTG, VSA, VCT modules and Motorola MVME-167 controller. VTG is the timing module, VSA is 12-bit ADC for 16 channels and VCT is 8-channel counter module.

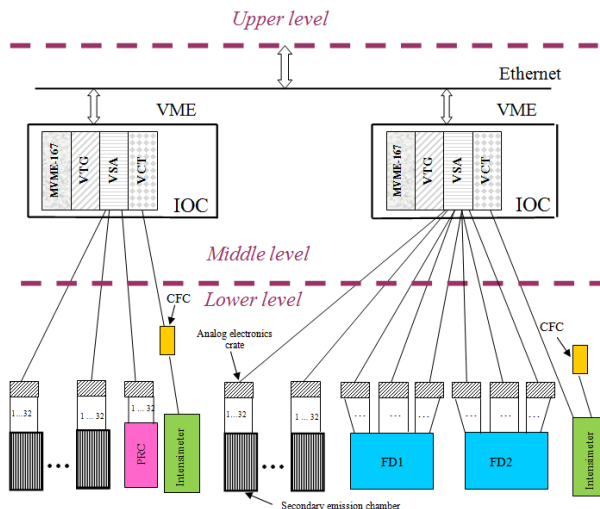


Figure 1: The layout of the lower and middle levels of the diagnostic system. The new components are marked by colors. PRC – the proportional chamber before beamstopper. FD1 and FD2 – the ionization chambers in the area of FODS setup.

IOC operates in the real time mode in accordance with the U-70 accelerator supercycles which are 8-9 seconds long. Within this time interval data should be acquired and processed and transferred to the upper level.

For IOC start-up one needs to load several files from the upper level via Ethernet. The files contain vxWorks operating system [3], EPICS base software, developed in IHEP special software and various setup parameters.

THE NONSTANDARD HARDWARE IMPLEMENTATION

All “standard” diagnostic system profilometers have 16 measurement channels in the horizontal plane and 16 – in the vertical one. The chambers are connected to the analog electronic crates.

The profilometer located before the beamstopper which is needed for OKA setup has a different structure. It is a proportional chamber with 32 signal electrodes in the particle separation plane. In order to make usage of this chamber as close as possible to the standard way the first 16 channels were connected to analog electronics as correspondent to the horizontal plane, and the other 16 channels – as correspondent to the vertical plane. This prevents any changes on the IOC level. The transfer of the information and its processing were the same as for the “standard” orthogonal chambers.

The ionization chambers located in the FODS setup area have 40 channels for the beam profile measurement in each plane. Also, these chambers have different distances between electrodes, in contrast to the other profilometers which have the constant distances. This is why the standard method for the integration in the diagnostic system was not suitable. At first the connection of these chambers to new electronics was performed merely by hardware. Only the central parts of the chambers were employed. It was a good decision for the quick implementation. The next iteration involved the complete solution of the problem, when all channels were connected and data presentation was made by software in IOC.

The beam profiles measuring devices are linked to the system through the analog electronics. But diagnostic system allows for the other method of connection, too. Figure 1 shows the intensimeter implementation: it connects to VCT via current-frequency convertor (CFC).

INTENSITY MEASUREMENT

The intensity value detection of the slowly extracted beams is performed by the intensimeter, which is a secondary emission chamber or a gas-filled ionization chamber. The intensimeter has one output channel for connection to the VCT module of the VME crate. The readings of this device are relative, so it needs calibration.

The activation foil methods were used for the absolute calibration of the intensimeter. During the specified time periods for each accelerator cycle the value of the intensity measured by the intensimeter was fixed. By summarizing these values the total charge of the beam was calculated. At the same time the foil was irradiated by this beam. Then the charge of the foil cumulated during the exposition time was found by means of dosimetry. Thereby there were two sets of measurements. Assuming that the dosimetry data were “true” (with an error of 5%) the proportionality coefficient was calculated by the formula of the least square method :

$$K = \frac{\sum X_i Y_i}{\sum X_i} \quad (1)$$

where K represented the needed coefficient; X_i – sum of intensimeter data values, Y_i – total charge of the protons passed through the foil for the i -th time period respectively.

The comparison of the intensimeter measurements and the dosimetry measurements make it possible to detect only the compliance of the cumulative charges. However, the important device characteristic is the dynamic correspondence of its measurements and the real value of intensity. Such comparison may be carried out by using the common charge of one of the planes of the profilometer that is the first in the beam course. This charge gives the approximate estimate of the current

intensity with some coefficient. Fig. 2 shows the intensimeter data (the upper graph) and total charge of all the channels of the first profilometer in the vertical plane (the lower graph). It is seen that the graphs' shapes are very similar. This method of comparison was used for the preliminary estimation of the workability of the implemented device.

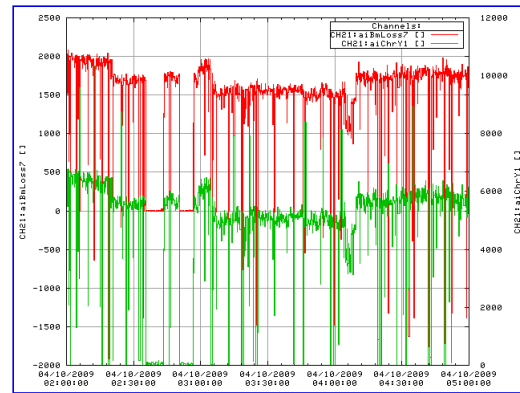


Figure 2: The comparison of the intensimeter measurements and the common charge of the Y-plane of the first profilometer.

SOFTWARE FOR IOC AND PROCESS DATABASE

Software for the middle and upper levels was developed by means of EPICS tools. The main program components of the middle level are shown in Fig. 3. They are Channel Access (CA), the process database, the means for database maintenance and the driver for hardware and software interface. CA provides the communication between IOC and the middle level support.

CA and the process database maintenance are the “staff” parts of EPICS. Besides these, the IOC software includes a process database and a driver-program both developed in IHEP. The process database contains the results of the current measurements and specifies the algorithms for data processing and control. Record is the database element. When implementing new devices in the diagnostic system one or several records for parameters setup are always added to database – ao-records (analog output). For each profilometer, these parameters are orientation and “step”, and for the intensimeter, it is the proportionality coefficient (1). For the data acquired by profilometers the wf-records (waveform) and ai-records (analog input) were added to database. wf-records contain the arrays of profile measurements, ai-records contain the calculated beam characteristic. ai-record for the intensimeter data was added to the database too.

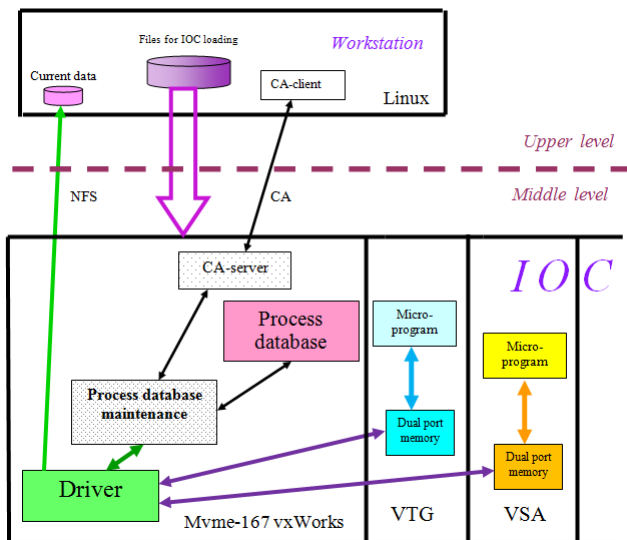


Figure 3: Some parts of IOC software and their links. The homemade components are colored.

In the recent accelerator runs there were two IOCs in operation, both designed for the beam profiles and intensity measurements. The separate databases were composed for each IOC. The total number of records for each IOC is about 900.

DRIVER FOR HARDWARE SUPPORT IN IOC

Driver is a multifunctional homemade program which provides the software support for all VME-modules and complicated data processing in IOC.

The driver functions include data reading from VSA, VTG and VCT and their processing, communication with database maintenance software, initializing and reconfiguration of the VME modules, data transfer to the upper level, etc.

When driver designing the special attention was paid to the data organization. The data were put in the hierarchical structures (in the sense of C language) that are common for all parts of the driver. In line with the diagnostic system logic, the structures contain measurements, descriptions of devices, processing parameters, current states of the diagnostic system components.

The vxWorks operating system ensures the parallel running of several tasks. It gives the driver functions the possibility to work simultaneously and independently. So the driver guarantees regular data refreshing and data presentation at the same time.

The driver performs the data transformation for the non-standard ionization chambers.

CONCLUSION

The diagnostic system is used in the U-70 accelerator runs for the tuning of the channels' magnetic optics in order to deliver beams to the experimental setups.

The generally accepted hardware design and software orientation on the EPICS allow rather quick and effective adaptation of the diagnostic system to the various requirements of the physics experiments.

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