UPGRADE OF THE NUCLOTRON EXTRACTED BEAM DIAGNOSTIC SUBSYSTEM.

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Abstract

The subsystem is intended for the Nuclotron extracted beam parameters measurements. Multiwire proportional chambers are used for transversal beam profiles measurements in four points of the beam transfer line. Gas amplification values are tuned by high voltage power supplies adjustments. The extracted beam intensity is measured by means of ionization chamber, variable gain current amplifier DDPCA-300 and voltage-to-frequency converter. The data is processed by industrial PC with National Instruments DAQ modules. The client-server distributed application written in LabView environment allows operators to control hardware and obtain measurement results over TCP/IP network.

THE PROBLEM STATEMENT

The project to construct a new accelerator complex NICA (Nuclotron-based Ion Collider fAcility) on the basis of the modernized existing Nuclotron accelerating facility is under active development at JINR. The modernization of the Nuclotron set the task to develop and put into operation a modern data acquisition and control systems. It is important to keep the existing functionality during accelerator runs while improving the graphic user interface, hardware control convenience, operation speed and stability. Fundamental principles of the control system organization are as follows:

- the client-server distributed model of data exchange,
- equipment operation reliability,
- applications operation stability in the long accelerator run.

The wide range of the acquisition electronics and software produced by National Instruments is quite satisfactory to solve the above tasks. A wide range of functions available in NI multifunction data acquisition modules allows to use only a few hardware modules to realize all necessary tasks. The software is based on .NET Framework, NI-DAQmx universal driver set and powerful graphics.

THE SUBSYSTEM STRUCTURE

The extracted beam diagnostics subsystem is intended to realize three features:

- to provide acquisition and remote observation of the extracted beam transversal profiles in four points of the transportation channel by means of proportional chambers;
- to measure the beam intensity using an ionization chamber;
- to control the gain of proportional chambers by means of their high voltage power supplies adjustment.

The equipment of the primary signal registration from the detectors is located on the beam transfer channel. The server computer and data acquisition modules are placed in the accelerator control room at about 400m distance from the detectors.

The subsystem structure is shown on Figure 1. The subsystem hardware has been made on the basis of Advantech industrial PC, multifunctional modules NI USB-6259 BNC, NI PCI-6703, NI SCB-68 produced by National Instruments [1], HV power supplies N1130-4 produced by WENZEL Elektronik and FEMTO variable gain sub femto ampere amplifier DDPCA-300 [3] with trans-impedance gain from 10^{+4} to 10^{+13} V/A. Additional custom voltage-to-frequency converter hardware to convert a voltage level signal from current amplifier to a frequency signal suitable for transfer of the data into the NI USB-6259 integration counter has been built.

HARDWARE OPERATION PRINCIPLES

Extracted beam intensity is calculated from measured ionization chamber current. The measured current is amplified by DDPCA-300 current amplifier and then converted to frequency signal by voltage-to-frequency converter. The signal is transferred over the long coaxial cable to 32-bit counter of USB-6259, synchronized by signal of extraction gate. The software allows to measure the cycle intensity and integral intensity of the extracted beam. The DDPCA-300 gain is controlled by 4 bit wide digital port of the USB-6259.

Beam transversal profiles are obtained by multiwire (32x32) proportional chambers. Signals from all 64 wires are multiplexed into a single analog line. Four ADC channels of USB-6259 are used to measure the analog signals from each proportional chamber. All ADCs are clocked by external clock signal formed by multiplexer thus allow deriving signals of each wire from the single line.

Proportional chambers gas amplification can be adjusted by means of high voltage power supplies which are controlled by NI PCI-6703 DACs. Adjusted high voltages are measured by four channels of USB-6259 ADCs.

SOFTWARE COMPLEX

The software complex consist of server application running on the server computer and few identical client applications which retrieve measurements data, visualize
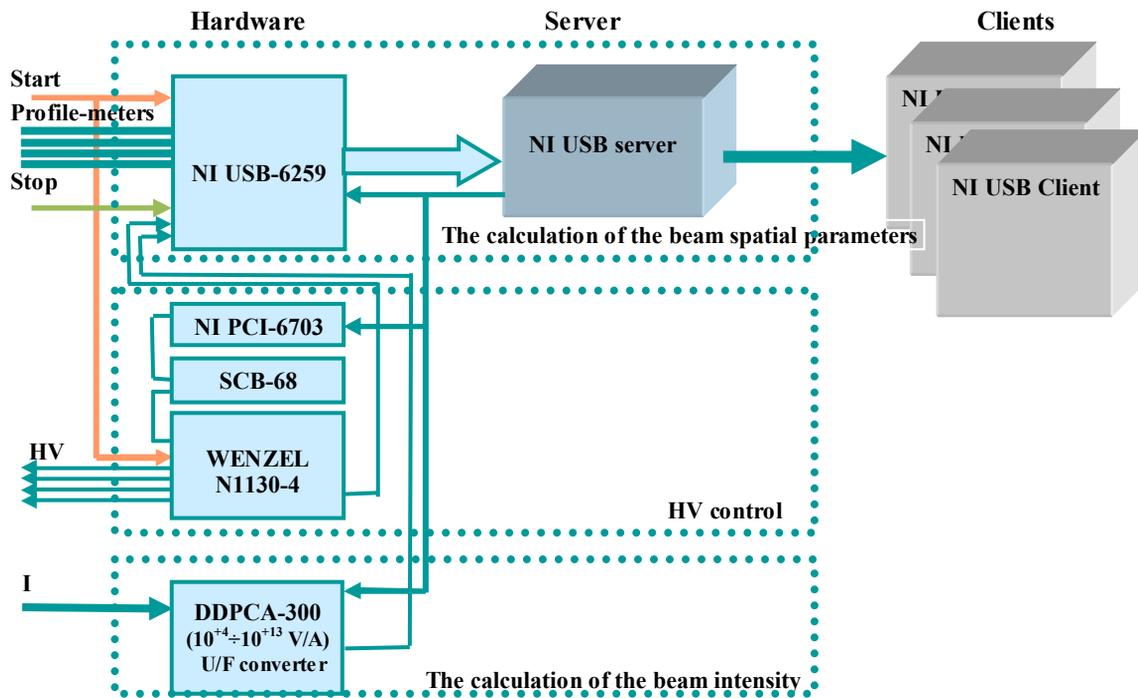
Figure 1: Extracted beam diagnostics subsystem structure.

it and allow an operator to control the hardware via TCP/IP network.

The server and clients applications are written in LabView development system for Windows. The data exchange between server and client applications are realized using LabView DataSocket server (DSS) running on the server computer. It realizes the application-layer DSTP transport protocol [2] operations and simplifies the task of organizing simultaneous interchange of data with many client applications connections in one cycle of the Server program. The publishing and subscribing of the data, located in the DSS URL-named memory, are preformed via a simple low-level interface of DataSocket Read and Write functions. These functions allow getting rid of the low-level TCP/IP programming and greatly simplify the server and client applications code. Besides, DataSocket server allows arranging data access permissions (write or read permissions) based on clients IP addresses. One of the client programs can be allowed to control the hardware, other are used only for the data visualization.

The server application consists of two continuously working cycles While and a Timed Loop cycle. In the first cycle, measurements of the beam spatial characteristics from proportional chambers and their power supplies voltages are acquired from NI USB-6259 module. The external ADC clock ensures correct timing of wires signals measurements. The second cycle reads-out the remote control DSS variables and makes a decision about hardware controls source - the server application or the controlling Client via DSS variables. The Timed Loop cycle is purposed to organize the start of the beam intensity measurements in a precisely given

moment of time: 32-bit counter of the NI USB-6259 module counts the number of pulses of the voltage-frequency converter between the signals of the beginning and end of the slow extraction gate. At the moment when the counting is finished, the value on the counter is read-out, summed up with stored integral value and sent to DataSocket server together with time stamp and other measurements and calculations of the beam intensity. The integral intensity and the number of completed measurements cycles can be reset remotely.

The client application is intended for on-line and off-line processing of the measured data, its visualisation and remote hardware control. It consists of the two program loops: the Event structure and a continuous working cycle While.

The first cycle treats the events from all application controls such as buttons, sliders, drop lists and xcontrols. According to controls values, it sets the operation regime (online processing or visualisation of the offline data collected before), proportional chambers and current amplifier parameters, graphics scales and colors. The working cycle While connects to DataSocket server in online mode or open a file with previously stored data in offline mode and read the acquisition data. The obtained data is then processed to calculate instantaneous and integral beam profiles spatial statistical parameters such as beam position and dispersion taking into account the chosen distance between the wires in each profile-meter. 32 instantaneous beam profile shots for chosen point of the transfer line allowing to see the beam profile time progression and the integral beam profile are displayed in the «Profiles» tab for both transversal coordinates. The tab «Integral profiles» shows the integral profiles of all
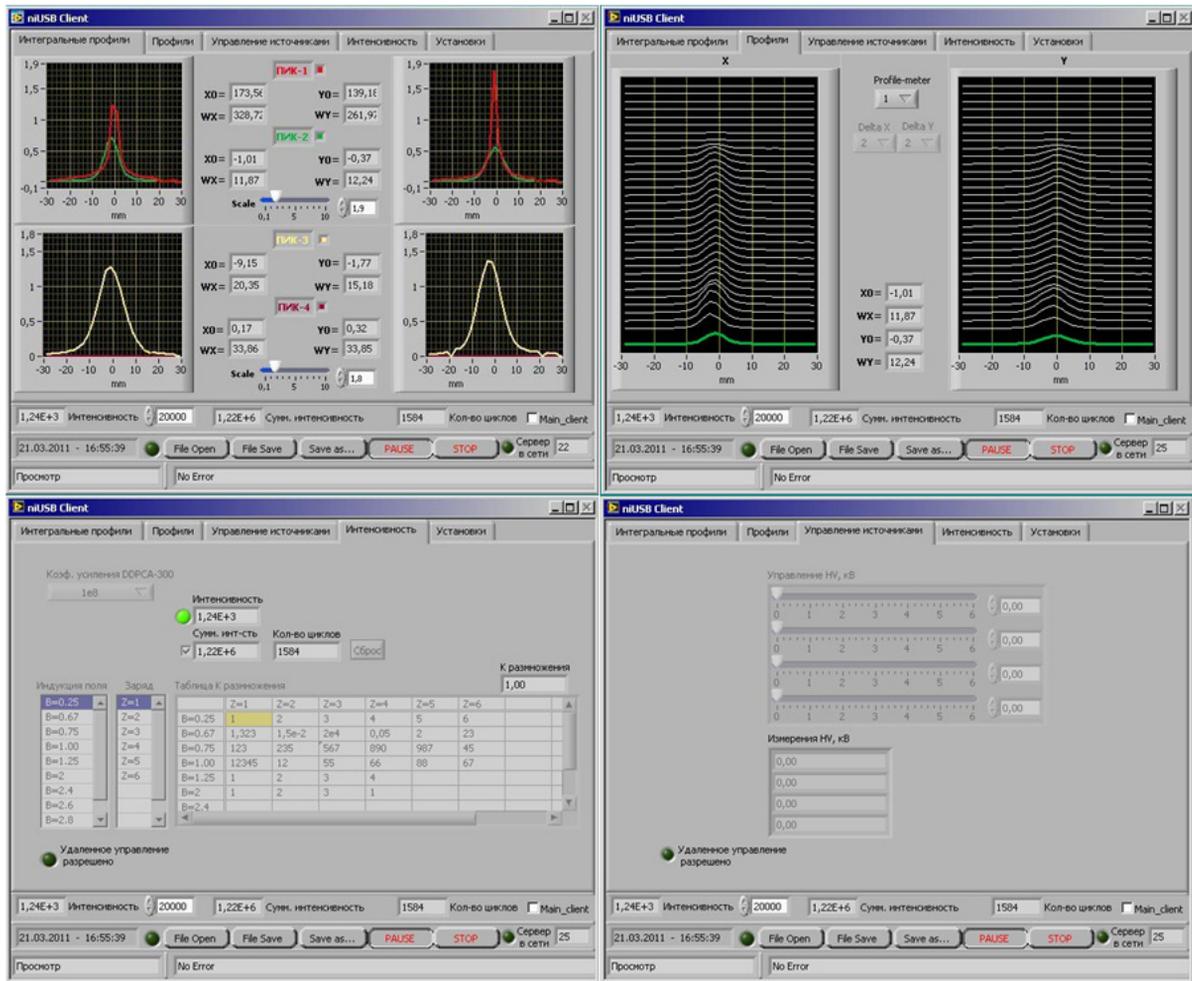
Figure 2: The beam tests of the subsystem to control extracted beam parameters (21.03.2011– 16:55). The Client window tabs: a) "Integral profiles", b) "Profiles", c) "Intensity". d) "HV supply control"

profile-meters simultaneously. Intensity and high voltage measurements are visualised as well on corresponding application tabs.

The client software allows operator to control remote hardware such as current amplifier and proportional chambers high voltage power supplies if it is allowed by server. Otherwise the corresponding controls are disabled.

EXTRACTED BEAM DIAGNOSTIC SUBSYSTEM BEAM TESTS

The beam diagnostics subsystem was tested on the extracted beam during March 2011 Nuclotron run. Figure 2 shows window tabs of the client application. The "Integral profiles" tab illustrates integral transversal beam profiles while "Profiles" tab shows 32 momentary profiles shots from the selected multiwire detector in both X and Y coordinates. The "Intensity" tab shows extracted cycle intensity and integral intensity over 1584 cycles. Since the screen tab with the integral profile values must be watched permanently, the values of the intensities are given also below all the screen tabs. The last tab "HV supply control" contains HV power supplies controls and

measurements. Hardware controls are disabled on all application window tabs as remote control was not allowed by the server.

CONCLUSIONS

The distributed subsystem to control parameters of the Nuclotron extracted beam was developed on client-server technology using National instruments acquisition modules, FEMTO current amplifier and LabView development system. Beam tests during March 2011 Nuclotron run showed the correct approach to the hardware-software selection and stable complex operation.

REFERENCES

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