Upgrade of the Nuclotron Extracted Beam Diagnostic Subsystem.

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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.

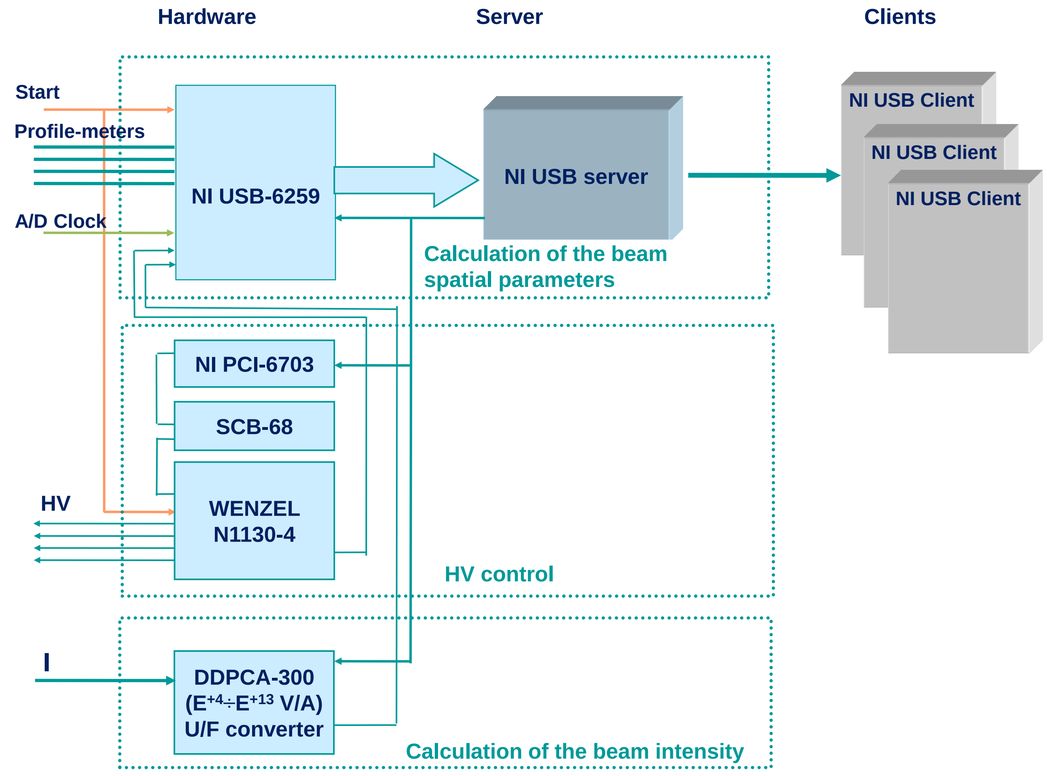

Figure 1: Extracted beam diagnostics subsystem structure.

HARDWARE

Advantech industrial PC.

National Instruments acquisition modules **NI USB-6259 BNC** with 16 16-bit analog Inputs, 4 16-bit analog outputs, 2 32-bit counters, 48 bit digital I/O;
NI PCI-6703, **NI SCB-68** with 16 16-bit analog outputs, 8-bit digital I/O.

WENZEL Elektronik high voltage power supplies **N1130-4**, high voltage is regulated in 0÷6 kV range, 4 channels

FEMTO variable gain sub femto ampere amplifier **DDPCA-300** with trans-impedance gain from 10^{+4} to 10^{+13} V/A. The gain can be controlled remotely.

Custom voltage-to-frequency converter to convert a voltage level signal from current amplifier to a frequency signal suitable for transfer over long cable.

Custom calibration module emulating signals from 32x32 multiwire proportional chamber.

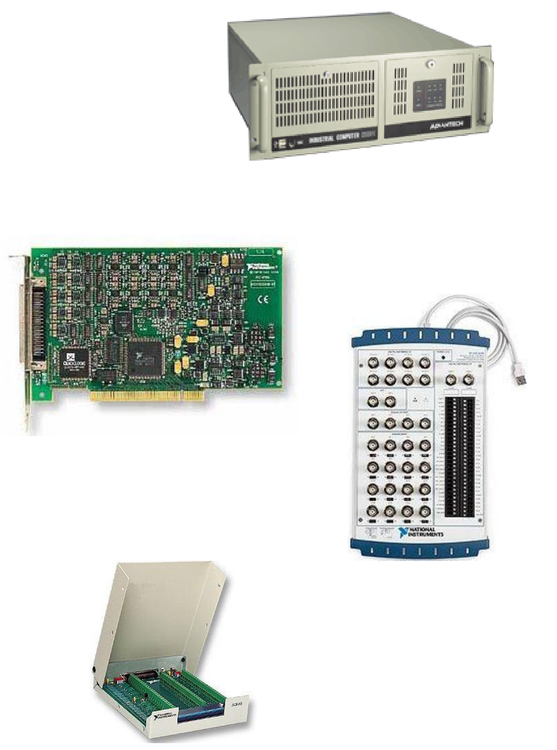

Figure 2: Hardware used in the diagnostic subsystem

SOFTWARE COMPLEX

The software have been developed in National Instruments LabVIEW development system. The server application and client applications interchange data using DataSocket server via Data Socket Transfer Protocol (DSTP).

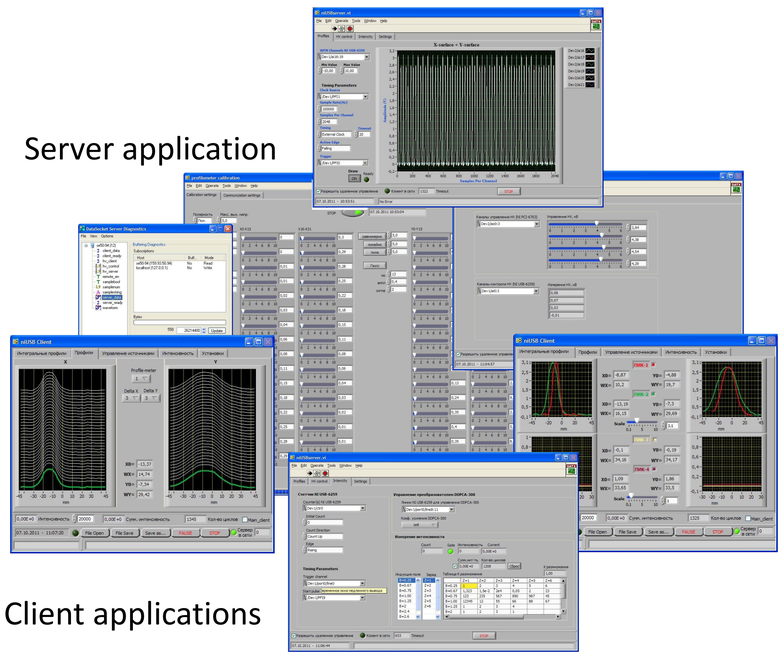

Figure 3: Software developed in Labview

CONCLUSION

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.

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.

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.

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.

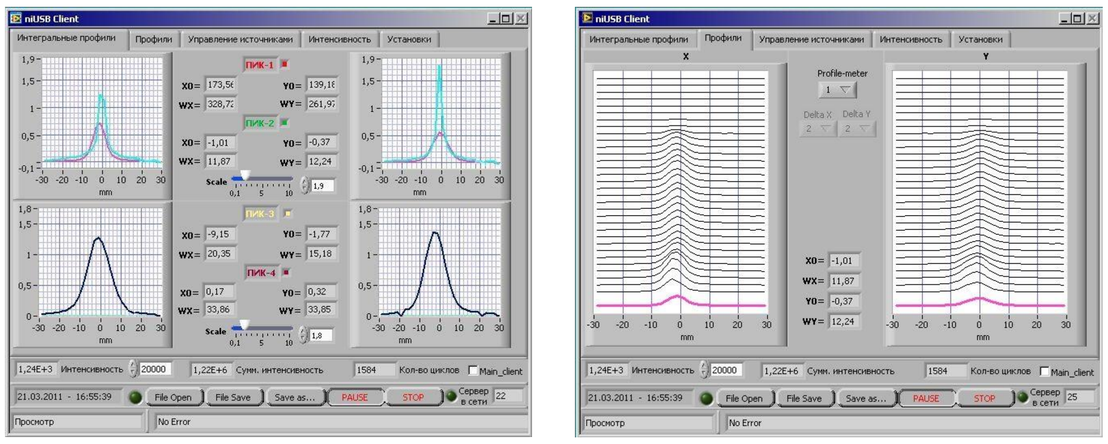

Figure 4: Measured Integral and momentary transversal beam profiles.