PROGRESS OF THE JINR e-LINAC ACCELERATOR TEST-BENCH CONTROL SYSTEMS

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Abstract

Due to Joint Institute for Nuclear Research participation in ILC collaboration, e-linac accelerator test-bench is being created in the Laboratory of high energy physics of JINR. The bench is designed for several goals: accelerating structures and diagnostics testing, photoinjector prototype creation and investigation, radiation resistance studies of different materials etc. In addition, several proposals of FEL creation on the basis of the e-linac exist. Current setup, results of the test-bench control systems evolution since 2009 and future plans are presented. The most important updates include radiation control system calibration, verification and installation and an upgrade of the video control system.

INTRODUCTION

Linear accelerator test-bench in the Joint Institute for Nuclear Research is based on the so called MEA accelerator [1] – part of the accelerator complex which was transferred to the possession of JINR by the National Institute for Subatomic Physics (NIKHEF, Amsterdam).

In 2009 successful commissioning of the test-bench injector with beam energy of 400 keV was performed [2]. Since then a number of upgrades was done in bench control systems. Video and analog signals control system was substantially extended. Another major upgrade was calibration and verification of the Automatic system of radiation safety control gamma-detectors in JINR Radiation Safety Department and start of this system operational testing. The short description of non-upgraded since 2009 Electron gun control system is also given.

At the present time the injector (composed of electron gun, chopper, prebuncher and buncher) and the first accelerating section are assembled and put into operation. Estimated beam energy is about 25 MeV. In the short term it is planned to use the bench as a driver for the infrared FEL. The undulator of the IR range (transferred to JINR by NPO of automatic systems, Samara; E = 25 MeV, $\lambda = 18.7$ μm) is going to be installed.

VIDEO AND ANALOG SIGNALS CONTROL SYSTEM

While only electron gun was in operation, the video system was composed of two IP-cameras (both are still working at the same places):

- Aviosys 9060 A is used for bench room general surveillance;
- Aviosys 9000 is installed next to the prebuncher and used for observing initial beam profile. The screen position in the beamline can be controlled remotely from the control room.

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Both cameras are connected to the video control system computer by LAN. Aviosys Surf16Ch software is used for imaging.

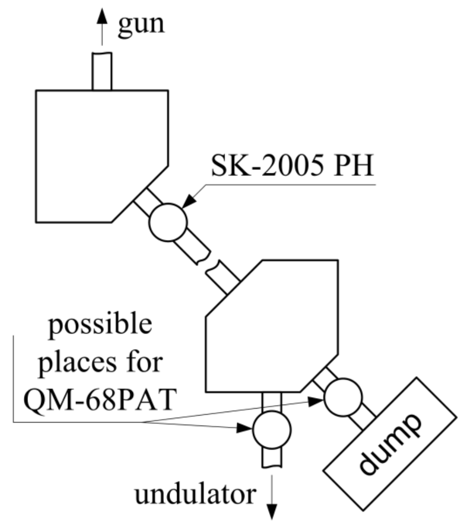

Figure 1: Analog cameras arrangement (top view).

After installation of the two bending magnets in 2012 two more cameras were installed:

- Sun Kwang SK-2005 PH analog camera is installed next to the first bending magnet;
- Q-cam QM-68PAT analog camera can be installed in two places (manually) which are shown in Fig. 1.

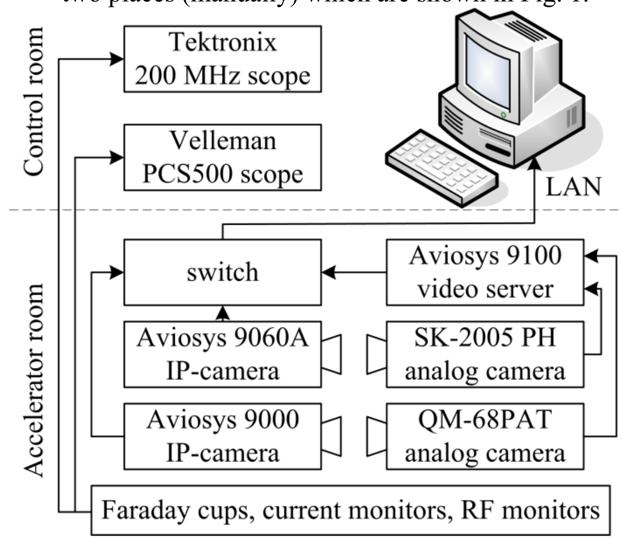

Figure 2: Scheme of the VASCS.

Until October 2012 both analog cameras were connected to the video control system computer using BeholdTV 409 FM TV-tuner (with manual switching between cameras). Now the video server Aviosys IP Video 9100 is being used. This server allows

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simultaneous watching of up to 4 analog cameras via LAN. Currently the built-in server web-interface is being used for imaging.

The video and analog signals control system also includes several current monitors, faraday cup and two oscilloscopes (200 MHz Tektronix and PC-scope Velleman PCS500) for their signals representation.

AUTOMATIC SYSTEM OF RADIATION SAFETY CONTROL

The radiation control system was assembled at the test stand in 2009. At that moment it was composed of:

- BDS-1M-63x63 gamma radiation detection units (with energy registration range of 0.16 to 5 MeV), seven pieces;
- UDBN-01-01 neutron radiation detectors (with minimum effective dose measurement range of 0.1 - 10^4 µSv/h and energy registration range of 0.025 - 14 MeV), two pieces;
- BPK-02 power supply and commutation unit (PCU);
- Computer with an uninterruptible power supply and RadCtrl software installed.

In summer 2010 calibration and verification of the above-mentioned gamma-detectors were conducted. The calibration was done in the Radiation Safety Department of JINR in the following way:

- Each detector was irradiated in the reference points with known dose rate. The count (amount of registered particles) was measured. The detector exposure time was set to 1 second.
- On the measurement results the piecewise-linear approximation of the dose rate to the count ratio function was done. The plot of the detectors-averaged function is presented in Fig. 3.
- Obtained coefficients for each of the linear parts of the function were put into the RadCtrl software.

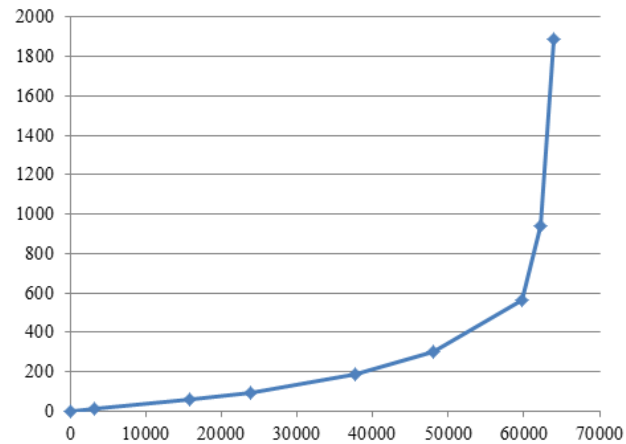

Figure 3: Detector-averaged dependence of the dose rate (y-axis) on the count (x-axis).

Verification of the correspondence between reference dose rate values and RadCtrl readout was performed after the calibration. The difference between measured and reference values has not exceed the admissible error.

Owing to the pulse character of the accelerator operation (a relative pulse duration of $1 \times 10^4 - 3 \times 10^5$ at pulse duration of 1 – 10 µs) it is necessary to correct the coefficients for the gamma-detectors. With this purpose system was complemented by the DKS-AT1123 portable X-ray and gamma-radiation dosimeter which is capable of adequately measuring the dose rate of pulse radiation with minimal pulse duration of 10 ns.

In 2011 ASCRC has been mounted at the accelerator bench and relating areas [4]. Currently the system is working in operational testing mode.

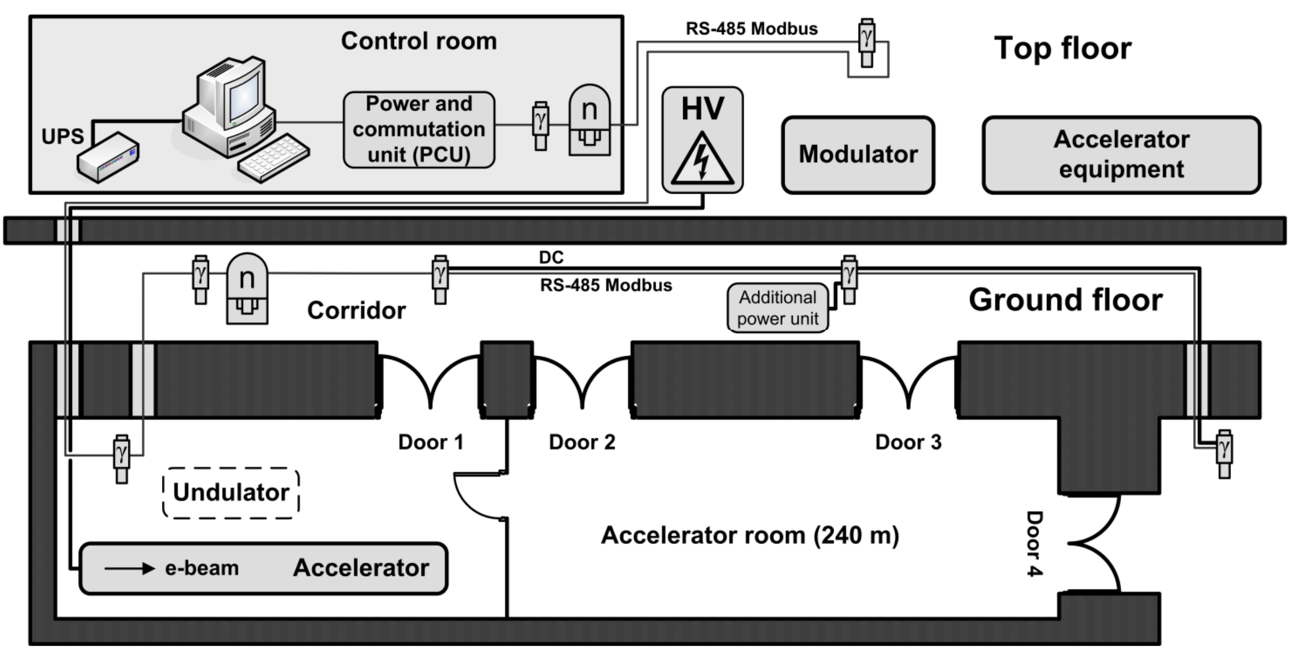

Figure 4: Scheme of the radiation control system.

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RadCtrl Software

This software (Fig. 5) is programmed in Object Pascal using Turbo Delphi software, runs on Windows XP operating system and performs the following functions:

- Displaying the current readout of all radiation detectors in both numeric and graphic representation.
- Signalization when one of the two threshold values ("yellow" and "red") is crossed.
- Signalisation when a detector is disconnected.
- Displaying the object's scheme as appropriate.
- Displaying the measurements archive for a chosen detector as appropriate (archive date can be saved in MS Excel format).
- Changing of the threshold values and the chart representation (linear/logarithmic).

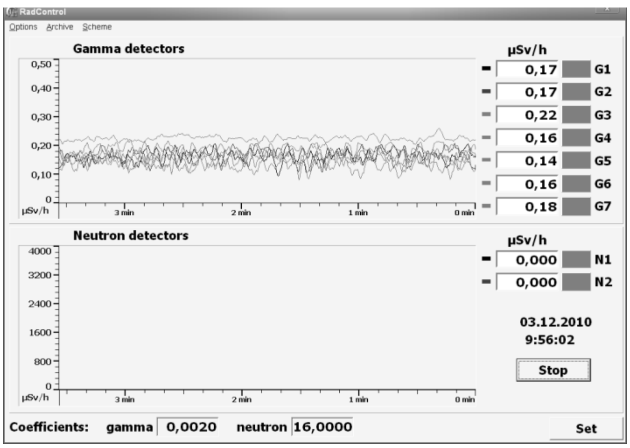

Figure 5: Main screen of the RadCtrl software showing background radiation.

ELECTRON GUN CONTROL SYSTEM

Triode type DC electron gun [2, 3] with an impregnated thermionic cathode (W with 20% Ba, Ca and Al oxides) is being used at the test-bench. This is a triode-type gun with a constant high voltage at the cathode, a grounded anode, and a control electrode. Gun focusing system consists of extractor electrode and 15 anodes with forced resistive (R = 200 MΩ) potential distribution (about 30 kV per interval). The voltage of the first focusing electrode can vary from 12 to 30 kV.

Cathode Electronics

Cathode electronics is the key component of the electron gun control system. It consists of:

- Gun controller board designed for connection with control computer with GunCtrl software installed on it, reference voltages assignment and main parameters of the gun control.
- 50 kHz supply board converts input AC voltage of 187 V (50 Hz) to AC voltage of 2x65 V (50 kHz). This board provides required supply voltages to all cathode electronics elements.
- Filament supply board controls cathode filament heating current.
- Extractor pulser module provides required gun unlocking pulse (from -400 V to +5 kV).
- Focusing electrodes board controls gun first focusing electrode voltage.

GunCtrl Software

GunCtrl (Fig. 6) is the software developed to provide a user with friendly interface between the gun controller and system operator. It is programmed in Object Pascal using Turbo Delphi software and runs on Windows XP operating system.

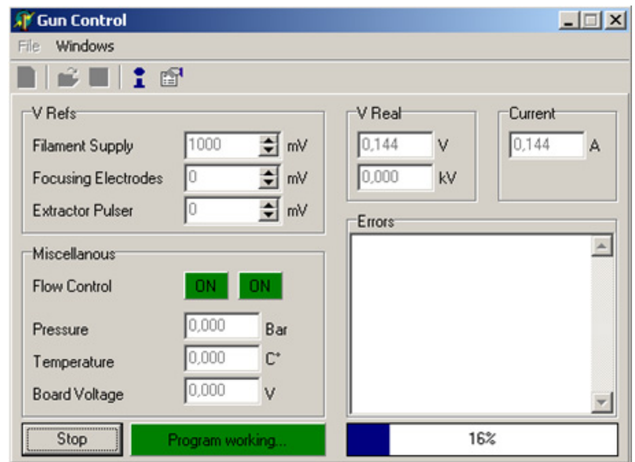

Figure 6: Main screen of the GunCtrl software

This software allows to set the reference voltages for filament heating, first focusing electrode and extractor.

Operator can also watch real voltage and current of filament heating, first focusing electrode voltage, pressure and temperature of the SF_6 insulating gas, cathode electronics board voltage and cooling system status.

CONCLUSION AND OUTLOOK

After modernization described control systems became more mature and at present fully cover the accelerator test-bench requirements (in particular, working in the FEL generation mode after undulator installation).

At the end of 2011 test launch of the accelerator was performed. The pulse current was 3 mA (with the pulse length of 1 μs) with the estimated energy of 23-25 MeV. All control systems worked in normal mode.

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