DEVELOPMENT OF THE NEW CONTROL SYSTEMS FOR JINR e- LINAC ACCELERATOR TEST-BENCH

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Abstract

Linear accelerator test-bench in the Joint Institute for Nuclear Research is based on the part of the accelerator complex which was transferred to the possession of JINR by The National Institute for Subatomic Physics (NIKHEF, Amsterdam). Analysis of the transferred accelerator equipment has shown that full re-engineering is required for its control systems; all other systems are in good condition and have considerable endurance. Results of development and creation of the Electron Gun Control System (EGCS), Video and Analog Signals Control System (VASCS) and Automatic System of Radiation Safety Control (ASRSC) are presented. These systems allowed achieving a commissioning of the first accelerator section of the bench with current of 3 mA in 1 μs pulse and at beam energy of 23-25 MeV.

INTRODUCTION

JINR linear accelerator test-bench is based on the so-called Medium Energy Accelerator (MEA) equipment. MEA [1] was developed by Haimson Research Corporation (USA) in 1969-1974, built in 1975-1978 and put into operation in 1978. In the end of 1990s the accelerator complex was transferred to JINR.

A set of projects for realization of the base of the test-bench is proposed:

- Free electron lasers (FEL) complex. Test-bench construction allows beam extraction with energy of 15 to 200 MeV. Beam with such energy can be used for infrared to ultraviolet FEL radiation generation with wavelength of 300 μm to 200 nm. First undulator of the IR range (transferred to JINR by NPO of automatic systems, Samara; E = 25 MeV, λ = 18.7 μm) is going to be installed.
- Testing of the accelerating structures and diagnostics, e.g. intensity monitors for short-pulse facilities like ILC [2]. This issue may require replacement of the current gun by the photocathode gun.
- Volume FEL with centimetric to infrared energy range creation [3].
- Experiments with RF gas discharge in quasi-optical cavity to confirm nuclear fusion in resonant streamer. [4]

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. Schematic view of this setup is presented in Fig. 1.

Most of the transferred control systems were obsolete and complete renewal of control equipment was needed. Results of the development of the new control systems are described in this paper.

ELECTRON GUN CONTROL SYSTEM

Triode type DC electron gun [5, 6] with an impregnated thermionic cathode (W with 20% Ba, Ca and Al oxides) is being used at the test-bench. 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. Electron gun control system (Fig. 2) consists of following components:

- ICT (Insulating Core Transformer) power supply unit provides cathode voltage of -400 kV with stability of $10^{-4} – 10^{-5}$.
- Cathode electronics unit allows remote control of the gun.
- Computer with the GunCtrl program provides interface with the cathode electronics.
- Communication line consists of protocol converters and fibre-optic cables.

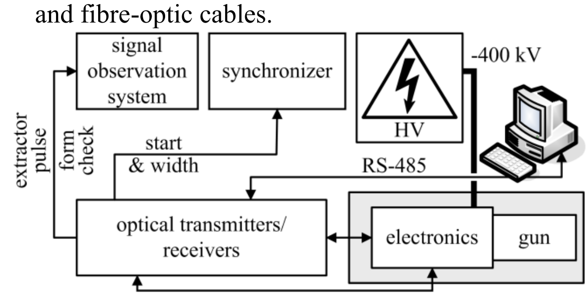

Figure 2: Scheme of the Electron Gun Control System.

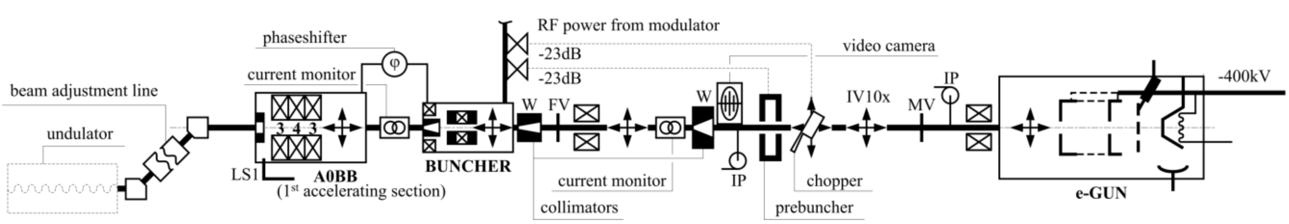

Figure 1: Schematic view of the injector and 1st accelerating section.

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Cathode Electronics

Cathode electronics comprises:

- Gun controller board designed for connection with control computer, 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. 3) 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.

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.

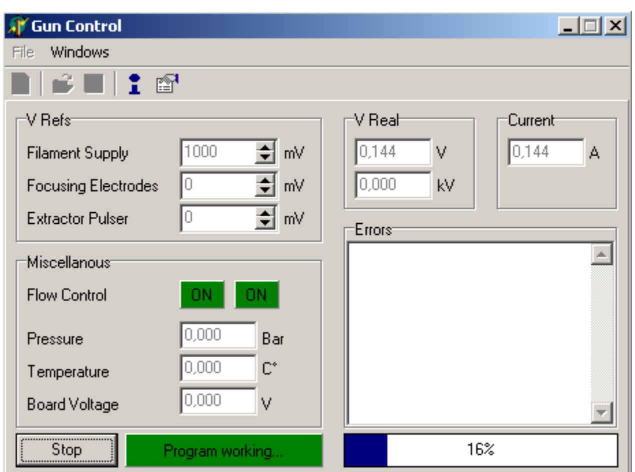

Fig. 3: Main window of GunCtrl software.

VIDEO AND ANALOG SIGNALS CONTOL SYSTEM

Video control system consists of four cameras:

- IP-camera Aviosys 9060 A is used for accelerator room general surveillance.
- IP-camera Aviosys 9000 is installed next to the prebuncher to observe initial beam profile. The screen position in the beamline can be controlled remotely from the control room. IP-cameras are connected to the video control system computer by LAN. Aviosys Surf16Ch software is used for imaging.
- Sun Kwang SK-2005 PH analog camera is installed next to the first bending magnet.
- Q-cam QM-68PAT analog camera is installed next to the second bending magnet, just before the position where the undulator is going to be installed. Both analog cameras are connected to the video control system computer using BeholdTV 409 FM TV-tuner (with manual switching so far).

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.

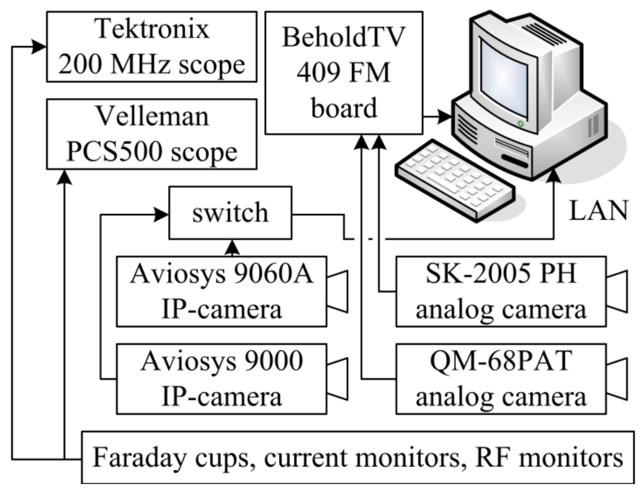

Fig. 4: Scheme of the Video and Analog Control System.

AUTOMATIC SYSTEM OF RADIATION SAFETY CONTROL

This system is designed to ensure radiation safety for test-bench personnel during regular operations and in emergency cases. The radiation control devices of the MEA accelerator were not transferred to JINR since that equipment had not been certified for use in Russia. More detailed information on system requirements and setup can be found in [6].

The main source of radiation during bench operation is background and emergency losses of an electron beam, which generate the bremsstrahlung with a wide energy spectrum. In addition, if the photon energy is higher than the reaction threshold (12-14 MeV), secondary neutrons (photoneutrons) appear. Beyond the biological shielding of the accelerator room, the radiation environment will be determined by long-range radiation: high energy photons and photoneutrons.

During accelerator shutdown the radiation environment for the personnel will be determined by the induced gamma and beta activity of the equipment exposed to high-energy photons and neutrons. The formation of loose contamination on the equipment and of radioactive aerosols in the air is also probable.

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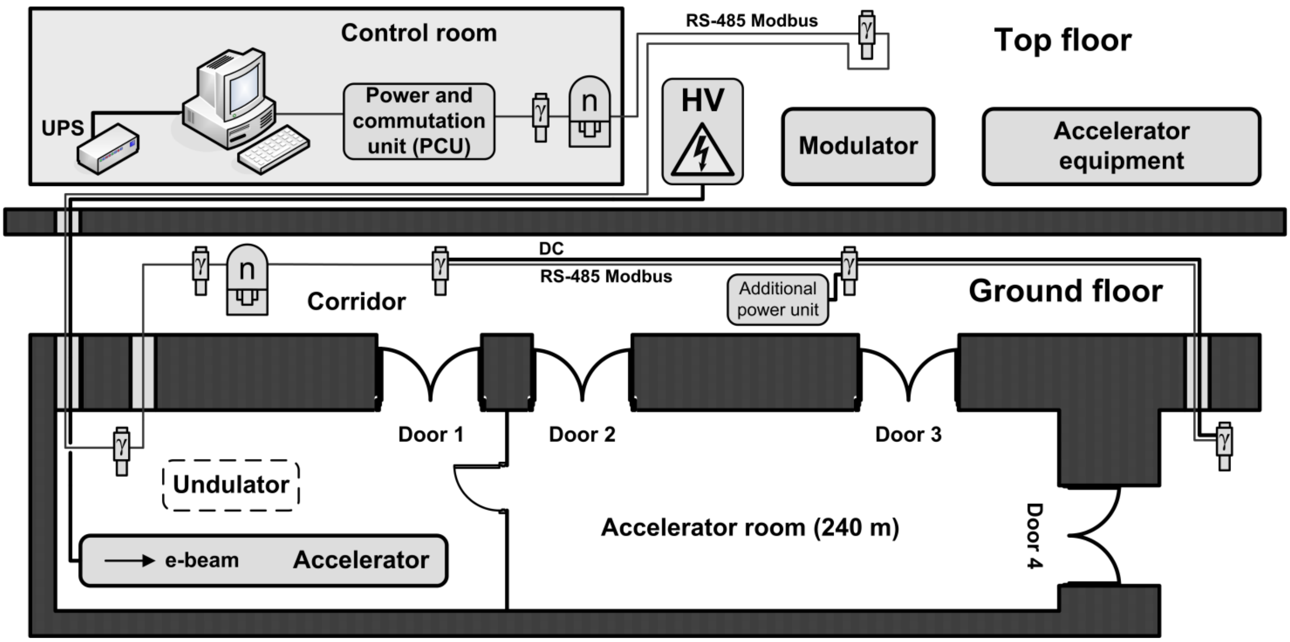

Fig. 5: Scheme of the Radiation Control System.

Radiation Control System Hardware

Main devices of the Radiation Control System are 7 scintillation detector units and 2 neutron radiation detectors. Scheme of the detectors layout is presented in Fig. 5. All this detectors are connected among themselves and with the Power and Commutation Unit (PCU) by the serial RS-485 communication link supporting the Modbus RTU communication protocol. PCU is connected to the control computer by the serial RS-232 communication link.

Owing to the pulse character of the accelerator operation (a relative pulse duration of $1 \times 10^4 – 3 \times 10^5$ at a pulse duration of 1 – 10 µs) it will be necessary to correct the indications of the gamma-detectors on the basis of the readout of the DKS-AT1123 portable X-ray and gamma-radiation dosimeter, which is capable of adequately measuring the dose rate of pulse radiation with a minimal pulse duration of 10 ns.

RadCtrl Software

This software (Fig. 6) 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).

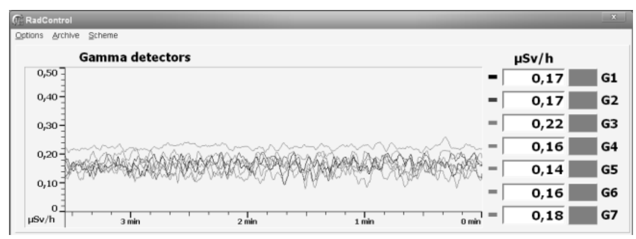

Fig. 6: Part of the main window of RadCtrl software with gamma-detectors readout (background radiation).

CONCLUSION AND OUTLOOK

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 energy of 23-25 MeV. All control systems worked in normal mode.

At the present time the IR undulator is going to be installed. It will provide first bench capabilities for users. All described control systems are mature and ready for the operation in regime of the FEL radiation generation.

REFERENCES

[1] Kroes F.B., Electron linac MEA, Compendium of scientific linacs, LINAC'96, 1996, p. 151.
[2] N.I. Lebedev, A.A. Fateev, Physics of Particles and Nuclei Letters, Volume 5, Number 7 (2008), 609-611.
[3] V.G. Baryshevsky et al., Nuclear Instruments and Methods in Physics Research B 252 (2006) 86-91.
[4] V.S. Barashenkov et al., Technical Physics, Volume 45, Number 11 (2000), 1406-1410.
[5] Kroes F.B. et al., Improvement of the 400 kV linac electron source of AmPS, Proc. of EPAC'92, p. 1032.
[6] N.I. Balalykin et al. Physics of Particles and Nuclei Letters. Volume 7, Number 7 (2010), 525-528.
[7] N.I. Balalykin et al. Physics of Particles and Nuclei Letters, Volume 9, Number 4-5 (2012), 452-455.

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