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# CONTROL SYSTEMS OF DC ACCELERATORS AT KAHVELab

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*Abstract*

KAHVE Laboratory has two functional particle sources: thermal electrons and ionized hydrogen. Each of these are followed by DC acceleration sections, for obtaining an electron beam to accelerate electrons MeV energy level and for providing protons to the radio frequency quadrupole accelerator which are being built. So far both systems have keV energy levels. Both systems employ LabVIEW based GUIs to interact with the user and to control and monitor the DC power supplies. The vacuum gauges, turbomolecular pumps, stepper motors and high voltage power supplies are all controlled with PLCs. The equipment under high voltage, are monitored and controlled via Arduino based wifi and bluetooth wireless communication protocols. The proton beamline has additional devices for beam diagnostics which are being commissioned like pepper pot plate, scintillator screen and faraday cup. Both systems are being standardize before MeV energy level for generalize to national labs which are working on detectors and accelerators. We believe such a setup could be a low budget control and readout example for modern small experiments and educational projects.

## INTRODUCTION

The proton accelerator at KAHVELab utilizes a 20 kV high voltage power supply units (PSU), two low voltage PSUs, one four-channel low voltage PSU, two turbomolecular pumps, two vacuum gauges, three pneumatic cylinders with PLC and PC control combined all in one LabVIEW GUI as shown in Fig. 1. The system extracts 20 keV proton beam from microwave discharge ion source. Upgrade process of the ion source with permanent magnets and the addition of a 800 MHz RFQ is on going. After the RFQ, the beam energy will be 2 MeV.

The electron accelerator at KAHVELab uses 60 kV high voltage PSU, two four-channel low voltage PSUs, one low voltage PSU, two turbomolecular pumps, two vacuum gauges, two stepper motors, PLC and PC control combined, all in one LabVIEW GUI as shown in Fig. 2. It produces a 50keV electron beam using thoriated tungsten thermionic cathode. This project was supported by TUBITAK Project No: 117F462. Different cathode types, welding and hardening processes are successfully tested.

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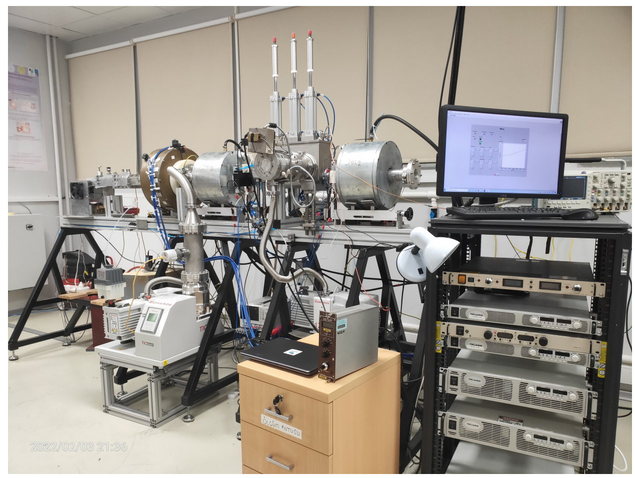

Figure 1: The Proton Accelerator at KAHVELab.

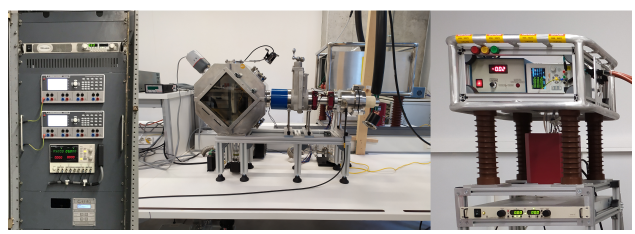

Figure 2: The Electron Accelerator at KAHVELab.

## CONTROL SYSTEM DEVELOPMENT OF PROTON ACCELERATOR

The system [1] employs PLC and PC for controlling devices and automation at the moment. PC used for user interface and serial communication with devices which can not be controlled directly with PLC yet. Devices like vacuum gauges and pneumatic cylinders need digital and analogue signals for control. Also, PLC's have the ability to serial control of devices like turbomolecular pumps and power supplies. While developing a control system for these accelerators we found out LabVIEW is very easy for testing an instrument but not so much to build a stable control system. We therefore implemented a LabVIEW GUI controlled PLC system which is more stable than pure LabVIEW option. PLC's also has the benefit of providing digital and analogue signals. Unfortunately devices like PSUs or vacuum pumps do not have drivers for PLC's and we had to write one for each such device.

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In Fig. 3 the automation panel of the proton beam line is shown. There are different types of PLC modules (Digital IO, Analog IO, Communication Modules etc.). In future we are planing to build different automation panels for each section of the beamline and develop main control system(like SCADA) to observe all beam parameters and accelerator status.

Figure 3: Automation Panel of the Proton Beamline

In Fig. 4, the proton beamline control GUI is shown. Recent system changes (Changing Ion Source from electromagnets to permanent magnets) forced us to make changes on the GUI. It is currently under development.

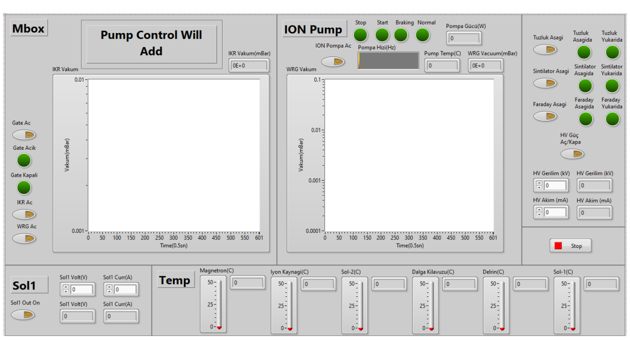


Figure 4: LabVIEW GUI of Proton Accelerator.

## CONTROL SYSTEM DEVELOPMENT OF ELECTRON ACCELERATOR

The control system is similar to the Proton beamline with GUI and PLC-PC combined solution. In this system, fully control of an accelerator setup is archived [2]. All PSUs and controllers are fitted in a single rack as seen in Fig. 2. WiFi and Bluetooth wireless communication solutions are used for floating ground (HV) case. High Voltage Deck is upgraded with a safety case for avoiding electrical accidents. The target system was also upgraded to 2 axis (R-Z) motion for better target manipulation. Saving & Loading the beam configuration, data logging of vacuum measurements and beam parameters were added to GUI (see Fig. 5).

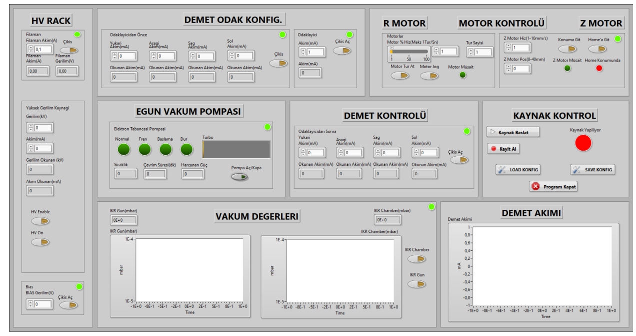


Figure 5: LabVIEW GUI of Electron Accelerator.

## EXPERIMENTS

In the Fig. 6, focused 20 keV proton beam is shown. Once the 800 MHz RFQ production is completed, this beam will enter the RFQ to reach 2 MeV exit energy. Most of the devices on this beamline can be controlled with the LabVIEW GUI. Due to recent upgrades of some devices, the system development is still ongoing. In the next phase, all vacuum devices, beam production, measurement and cooling systems will be automatically controlled & monitored.

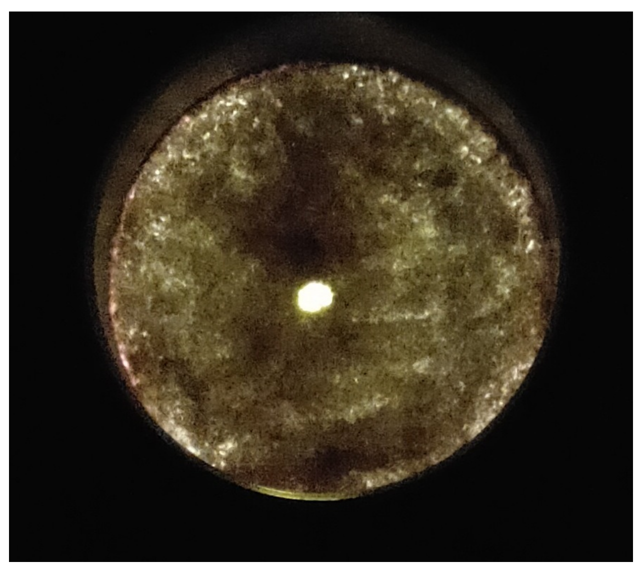

Figure 6: 20 keV Proton Beam [3].

Electron beam can be used for welding. In the Fig. 7, two stainless steel pipes with 0.4 mm thickness welded by an electron beam at 20 keV are shown. Such processes have been automated with a single weld button. In the background, PLC-PC combination with electrical signals, serial communication and wireless communication used together for this process. PID control for constant beam current will be added in future. After that this device can be used as an industrial Electron Beam Welding Machine or X-Ray generator.

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In Fig. 7, rastering test with an electron beam is shown. With rastering of the electron beam one can build a scanning electron microscope. Beam optimization, calibration and automation of rastering is under further development.

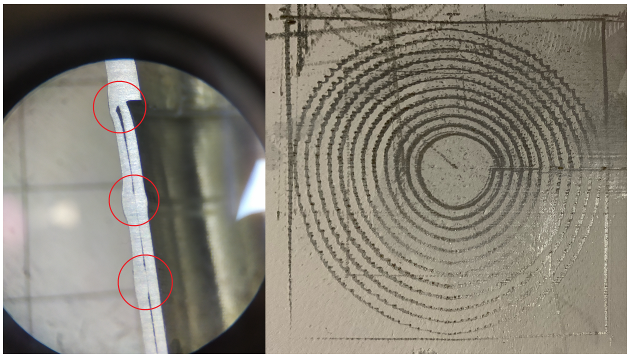

Figure 7: eBeam Welding and Rastering Tests.

## WIRELESS SOLUTIONS

In Figs. 8 and 9, our WiFi and Bluetooth solutions are shown. Since some parts of accelerators should be on HV and sparks can damage most electrical devices we had to use wireless communication solutions. In Fig. 8's left side a WiFi controlled current meter is shown. This lab-made device can measure microampere and milliampere inputs from two different ports. In Fig. 8's right side, a Bluetooth controlled analogue output circuit with Arduino micro controller board is shown. This device can produce –10 to 10 V DC analogue output. In Fig. 9 our WiFi thermometer solution is shown. These devices are designed and assembled by our team. The external cases are made with a 3D printer when possible. These devices can be useful and cheap solutions for special cases. In the future we are planning to add temperature and humidity measurements in beam areas.

## RESULT AND OUTLOOK

In the last three years, as KAHVELab, we managed to control different type devices (Turbomolecular pumps, vacuum gauges, low voltage PSUs, HV PSUs, pneumatic valves, sensors, motors) with different type of communications (TCP/IP, RS232, RS485, Analogue etc.). In the next three years, we are planning build systems which has multiple safety controls and can be controlled anyone who has a short training. We also plan to prepare control systems for these accelerators which will reach MeV energy level.

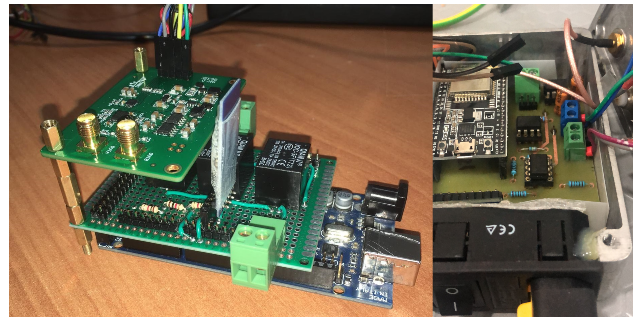

Figure 8: WiFi and Bluetooth Controllers.

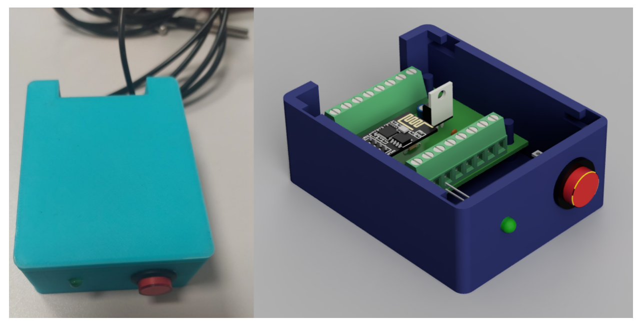

Figure 9: WiFi Thermometer Box.

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