# Control Systems of DC Accelerators at KAHVELab

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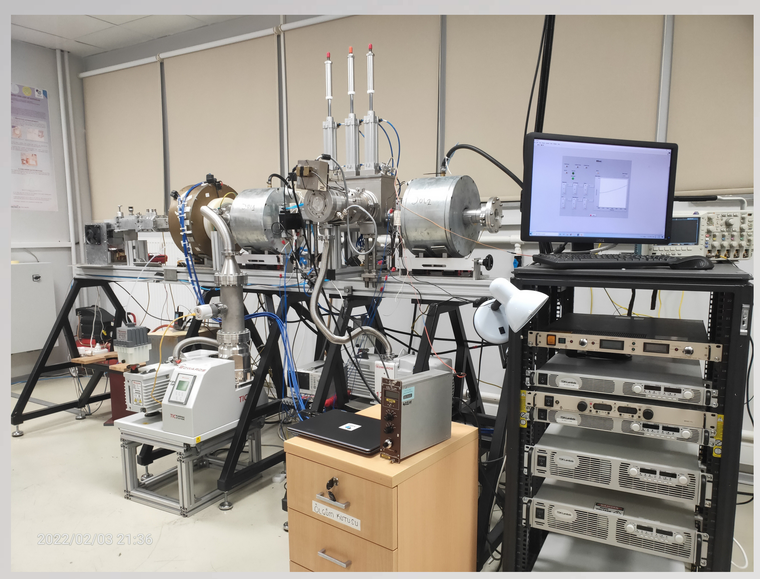
KAHVE Laboratory has two functional particle sources: thermal electrons and ionized hydrogen. Each of these are followed by DC acceleration sections, for obtaining an electron beam to accelerate electrons MeV energy level and for providing protons to the radio frequency quadrupole accelerator which are 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.

## The Proton Accelerator

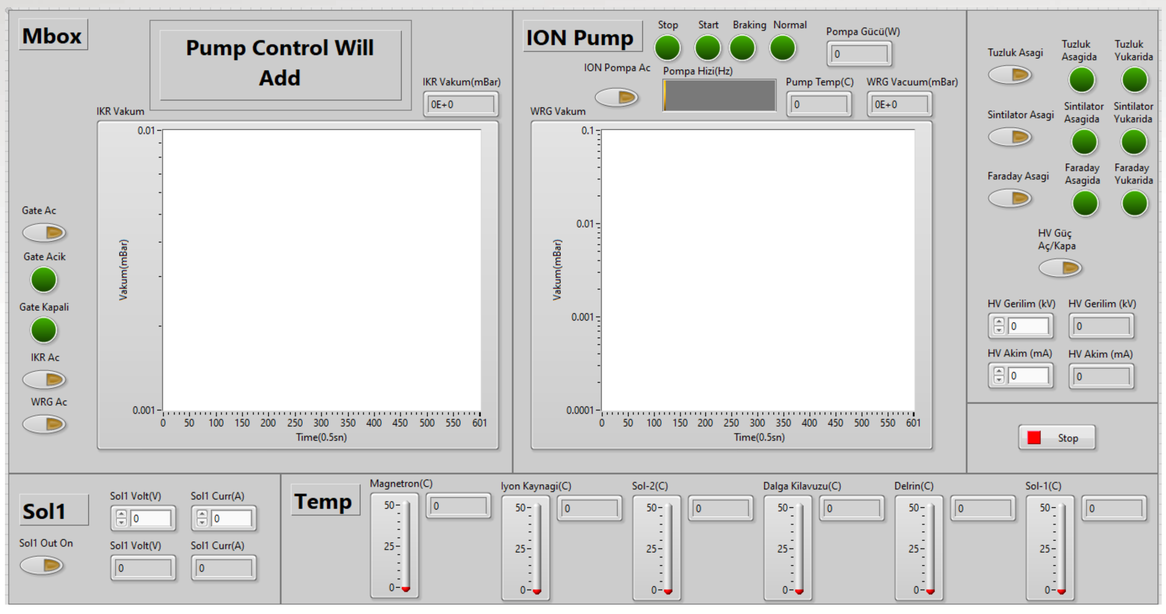


Produces 20 keV proton beam. As source microwave discharge ion source used.

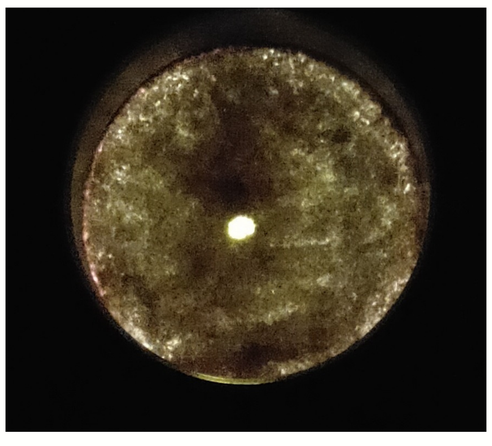
Upgrade process of ion source with permanent magnets and 800 MHz RFQ under commissioning.

20 kV High Voltage PSU
2x Low Voltage PSU
1x 4ch Low Voltage PSU
2x Turbomolecular Pump
2x Vacuum Gauge
3x Pneumatic Cylinder
PLC and PC control combined
All in one LabVIEW GUI

Both systems are using PLC and PC for controlling devices and automation at the moment. PC is for user interface and serial communication with devices which can not be controlled with PLC at the moment. Devices like vacuum gauges and stepper motors need digital and analog signals to control them. 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 LabVIEW GUI controlled PLC system which is more stable than pure LabVIEW. It also has benefit of providing digital and analog 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.




In the right figure, focused 20 keV proton beam is shown. After 800 MHz RFQ production is completed this beam will enter RFQ to reach 2 MeV energy. Most of the devices 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 automated.



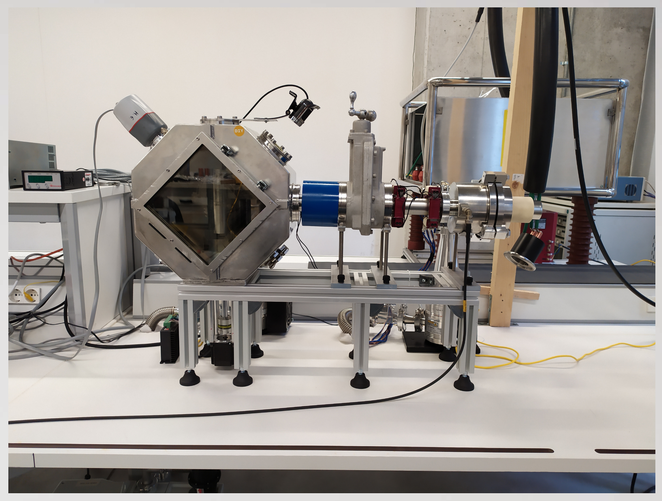
## The Electron Accelerator

Produces 50kV electron beam from thoriated tungsten thermionic cathode.

Upgraded to 2 axis(R and Z) motion control and vacuum automation with pneumatic vacuum valves

This project supported by TUBITAK Project No: 117F462.

60 kV High Voltage PSU
2x 4ch Low Voltage PSU
1x1ch Low Voltage PSU
2x Turbomolecular Pump
2x Vacuum Gauge
2x Stepper Motor
PLC and PC control combined
All in one LabVIEW GUI

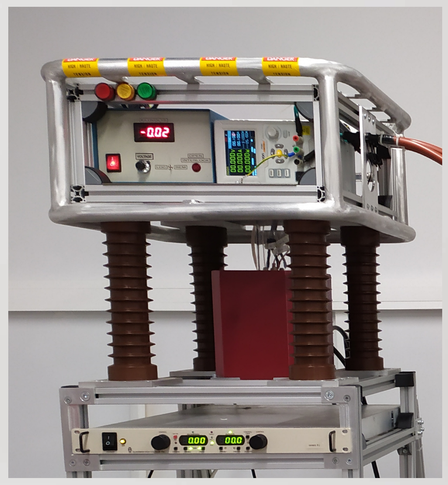


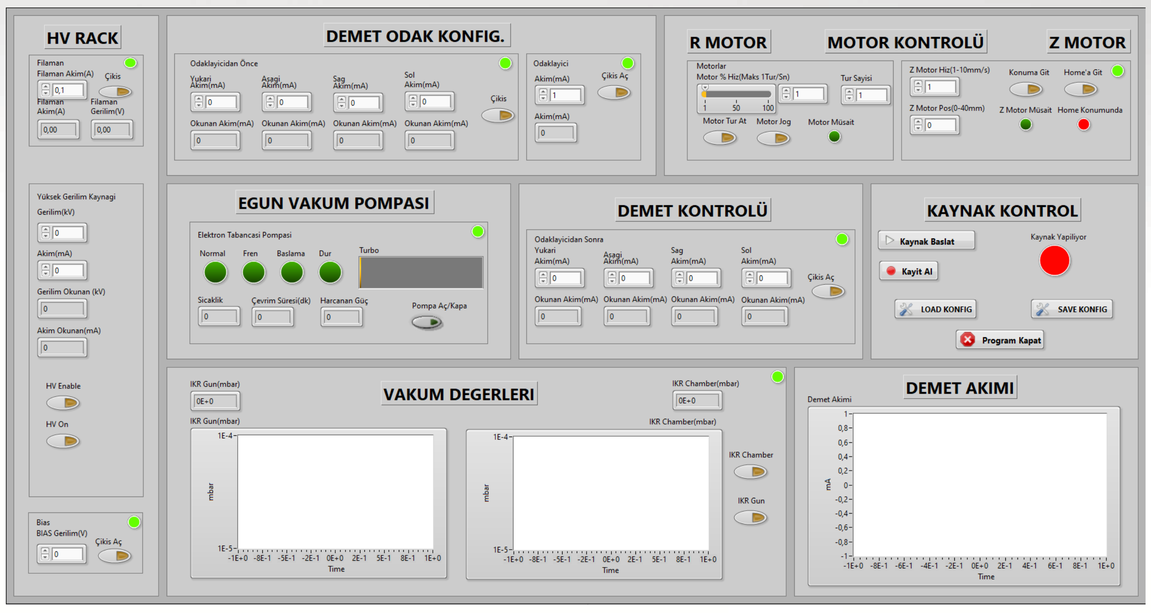
All PSUs and controllers are fitted in a single rack

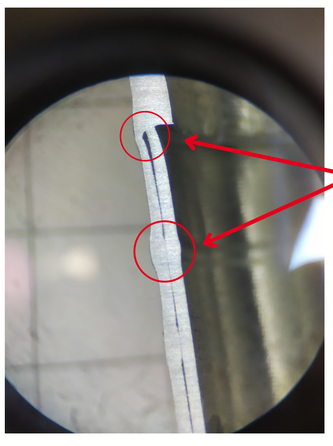
WiFi and Bluetooth wireless communication solutions are used for floating ground (HV) case .

High Voltage Deck upgraded with a safety case for avoiding electrical accidents.

Save-Load beam config, data-logging of vacuum and beam parameters added to GUI.

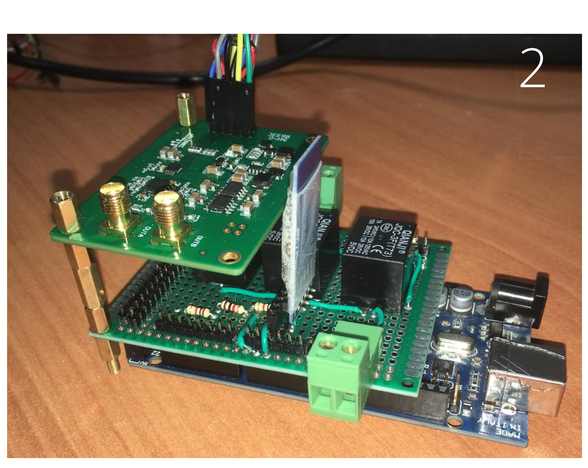




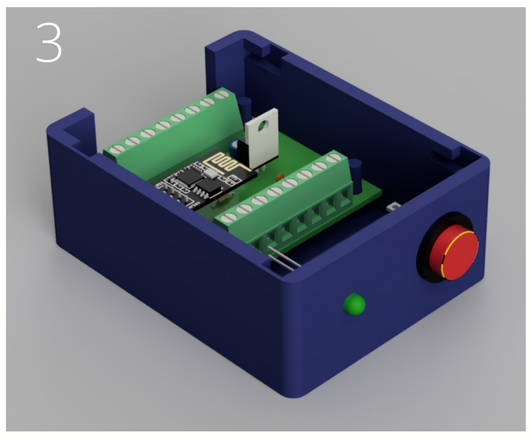



Welded Points

Electron beams can be used for welding. In the left figure, two stainless steel pipes with 0.4 mm thickness welded by an electron beam at 20 keV are shown. All 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 beam calibration will be added in future. After that this device can be converted a commercial Electron Beam Welding Machine or X-Ray generator.

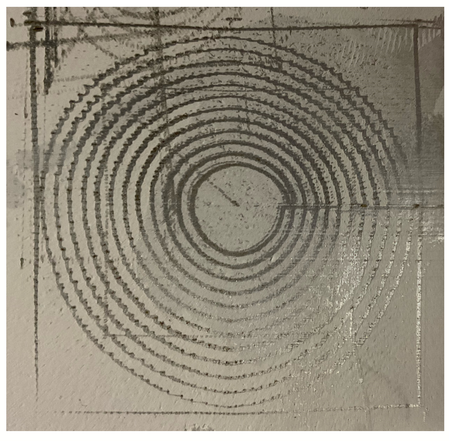




In the left figures, our wifi and bluetooth solutions are shown. Since some parts of accelerators should be on HV or sparks can damage devices we had to use wireless solutions. In figure 1 a wifi controlled current meter is shown. This lab-made device can measure microampere and milliampere inputs from different ports. In figure 2, a bluetooth controlled an analog output circuit with Arduino are shown. This device can give -10 to 10V DC analog output. In figure 3 and 4 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 accelerator areas.





In the right figure, rastering test with an electron beam is shown. With rastering of electron beam we will able to build our scanning electron microscope. Beam optimization, calibration and automation of rastering is under process.



## Results 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, Analog). 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. Also control systems for accelerators which has MeV energy level.

## References

[1]Ilhan, T. B., "Electron Beam Welding Device Control System Design", Istanbul University-Cerrahpasa, Istanbul, Turkey.
[2] Halis D., et al., "Diagnostic Station of Proton Beam at KAHVELab (PTAK)", IBIC2022.
[3]Adiguzel, A., et al., "Ion source and LEBT of KAHVELab proton beamline", arXiv 2208.00529, 2022.