



Building a Remote-Controlled Valve and Pump Module for Performing Multi-Column Extraction Chromatographic Separations

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Motivation and Objectives

Cancer is one of the leading causes of death worldwide. Terbium (Tb) isotopes stand out with great potential for use in both cancer therapy and imaging. Specifically, ^{161}Tb , which exhibits beta particle and Auger-electron emissions, has shown the potential to replace ^{177}Lu in targeted radionuclide therapy. A challenge in production of the ^{161}Tb isotope lies in its isolation from neighboring lanthanides Gadolinium (Gd) and Dysprosium (Dy). A recent study conducted at the University of Wisconsin by Peikin et al. showed promise in using LN2 extraction chromatography (EXC) resin to isolate the Tb isotope from Gd¹. The focus of this study is to build a remote-controlled valve and pump module to automate the multi-column extraction chromatographic separation performed in this study from commercially available systems.

Chemical Process Summary

- Dissolve 100 mg Gd_2O_3 , 50 μg in $\sim 2\text{ mL}$ $[\text{HNO}_3]_{\text{conc}}$, evaporate to dryness, reconstitute in 5.6 mL 0.1 M HNO_3
- Column 1 (100.60 mm x 8.00 mm \varnothing , 2.7 g LN2 resin 20 – 50 μm)
 - Load** Gd, Tb in 0.1 M HNO_3 to column
 - Rinse** with 100 mL 0.2 M HNO_3 to remove Gd
 - Elute** 10 mL 1 M HNO_3 , collect **Tb** in 4 mL fraction
- Dilute Column 1 elute to 0.1 M HNO_3
- Column 2 (30.00 mm x 5.50 mm \varnothing , 300 mg LN2 resin, 20 – 50 μm)
 - Load** Gd, Tb in 0.1 M HNO_3 to column
 - Rinse** with 13 mL 0.2 M HNO_3 to remove Gd
 - Elute** Tb with 1 mL 1 M HNO_3
- Column 3 (40.85 x mm x 4.00 mm \varnothing , 100 mg bDGA resin, 50 – 100 μm)
 - Load** Tb in 1 M HNO_3 to column
 - Rinse** with 10 mL 2 M HNO_3 , 2 mL 0.5 M HNO_3 to remove Fe, Cu, Zn
 - Elute** Tb with 1 mL 0.01 M HCl

Materials & Methods

Framework Construction: Utilized ready-made plastic enclosures modified to accommodate the attachment of hardware (PTR-28487-C/PW-12850-T, Bud Industries).

Fluidic Logic and Flow Rate: Serial configuration of solenoid flipper valves (6724, Bürkert Fluid Control System) and variable voltage peristaltic pumps (WPM1-P3AA-WP/ WPM1-P3BA-WP, Welco).

Valve/Pump Control Method: Transistor-Transistor Logic (TTL) signals generated by a National Instruments USB-6008 Multifunction I/O device, coupled with a custom designed circuit².

Data Acquisition: Two custom radiation detection systems consisting of a CsI scintillator (1 x 1cm, Hilger Crystal Ltd) coupled to a photomultiplier tube (E849-35, Hamamatsu Photonics) powered and processed with bench-top electronics (925-SCINT, Ortec)³. One custom Geiger-Mueller radiation detector modified from the open-source design on MightyOhm. Data was acquired and logged through use of the digital counter inputs of the USB-6008s⁴.

Software: LabView software was written to automate control of hardware components and perform the acquisition and analysis of chromatogram data.

Acknowledgments

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Fluidic Logic Control Custom IC

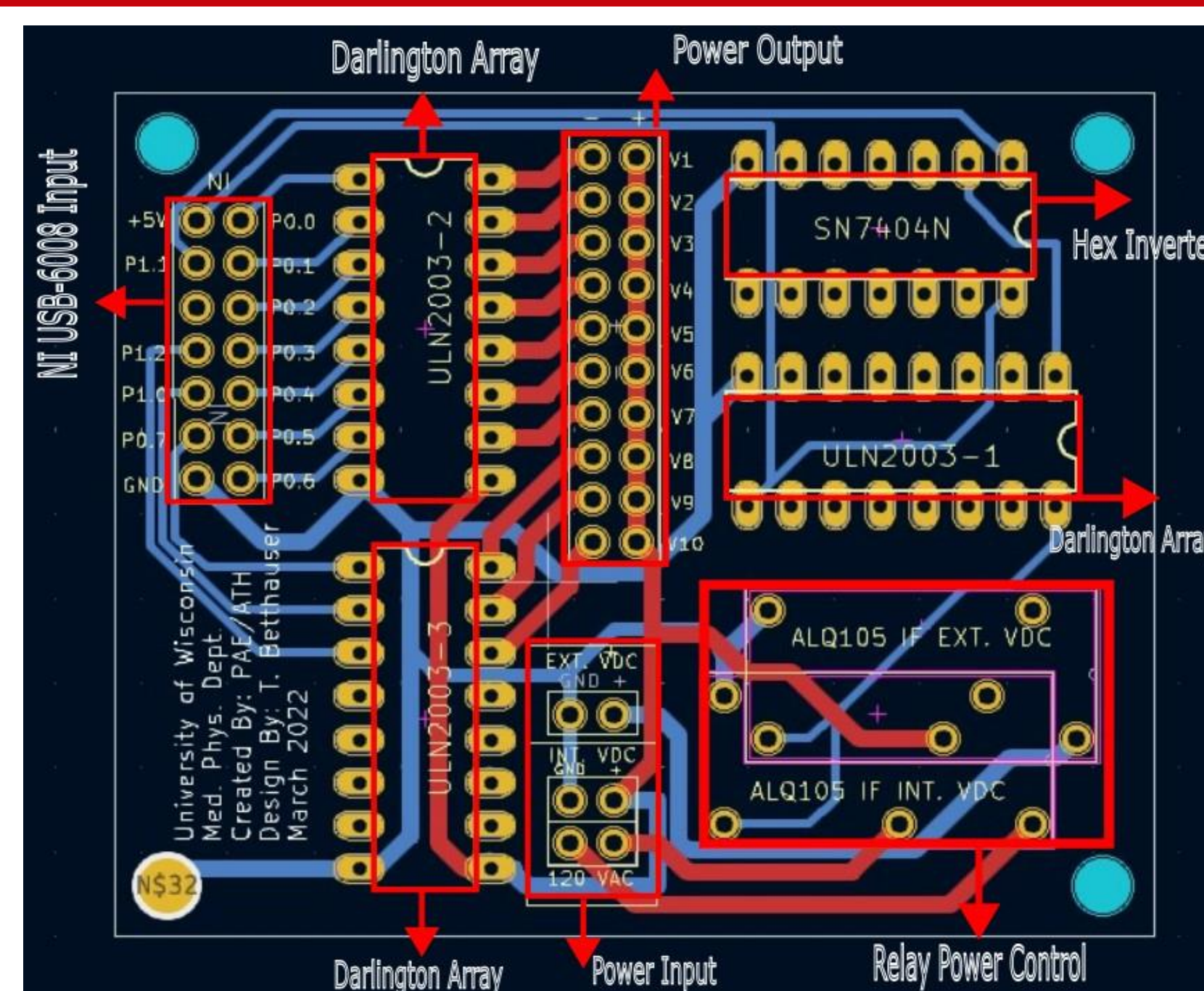


Figure 1. Diagram of Fluidic Logic Control board.

Custom Menu-Driven Interface

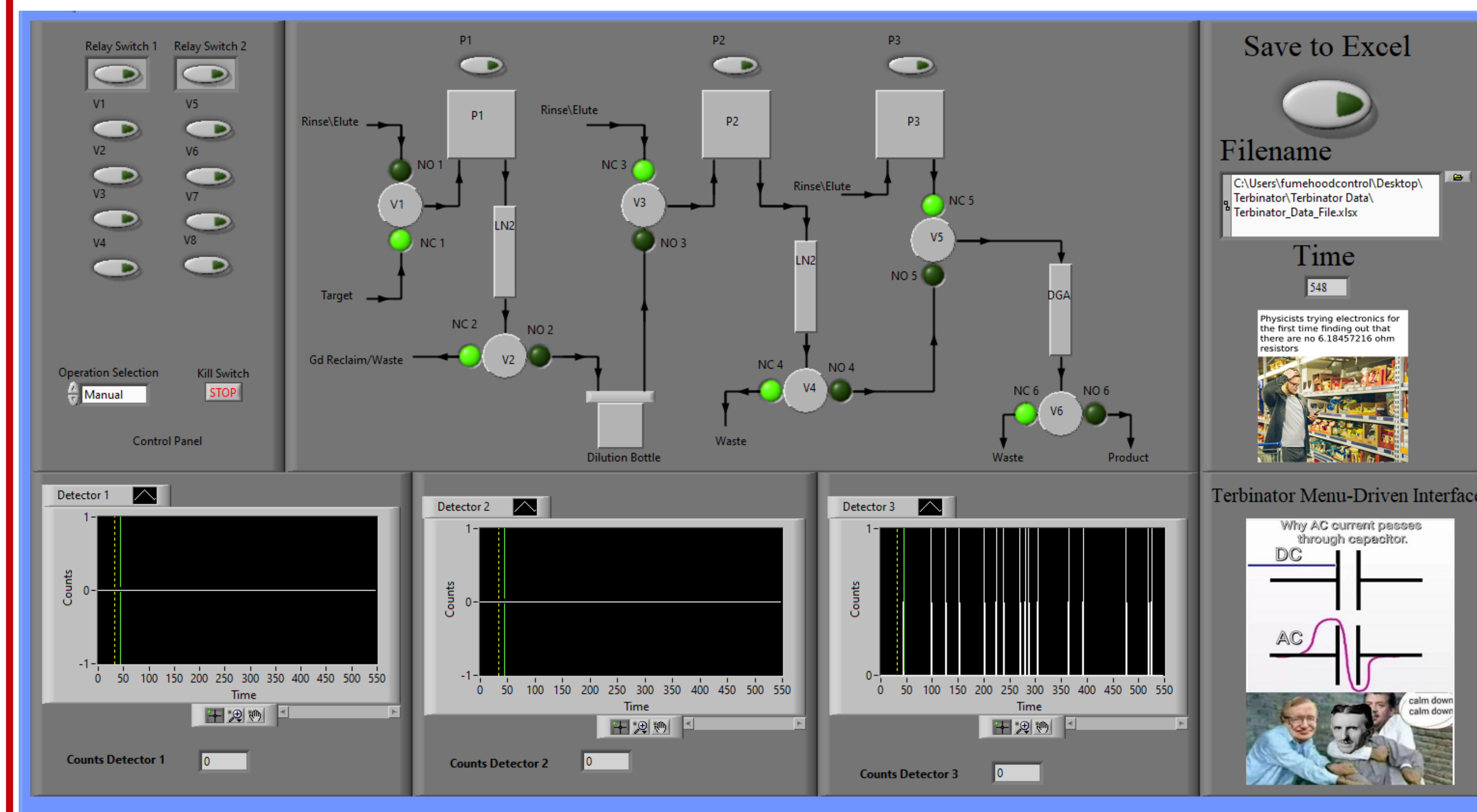


Figure 3. Image of Custom Programmed LabVIEW Menu-Driven Interface

Valve and Pump Module

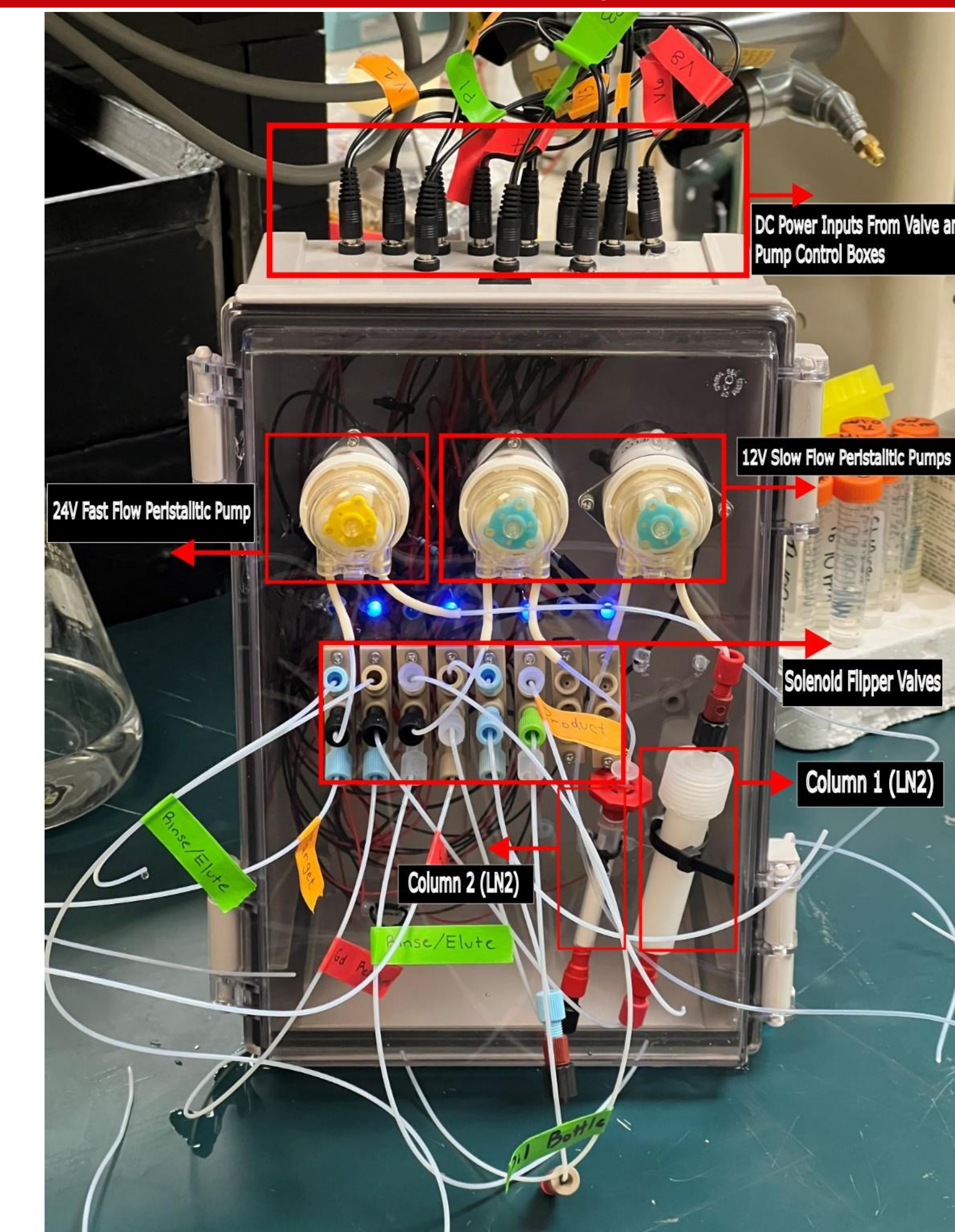


Figure 2. Diagram of Built Valve and Pump Module.

Valve and Pump Control Modules

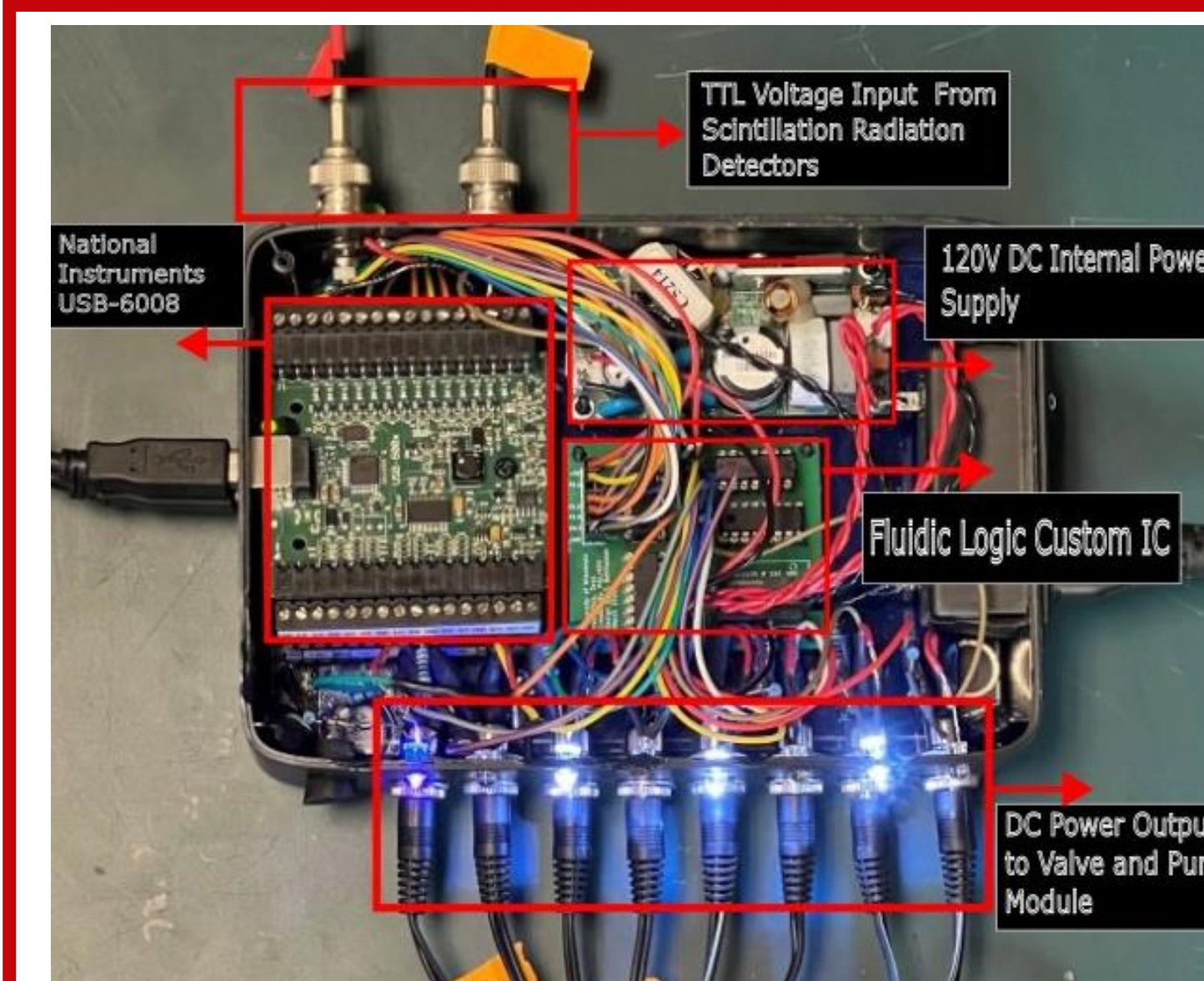


Figure 4. Diagram of Built Valve Control Box.

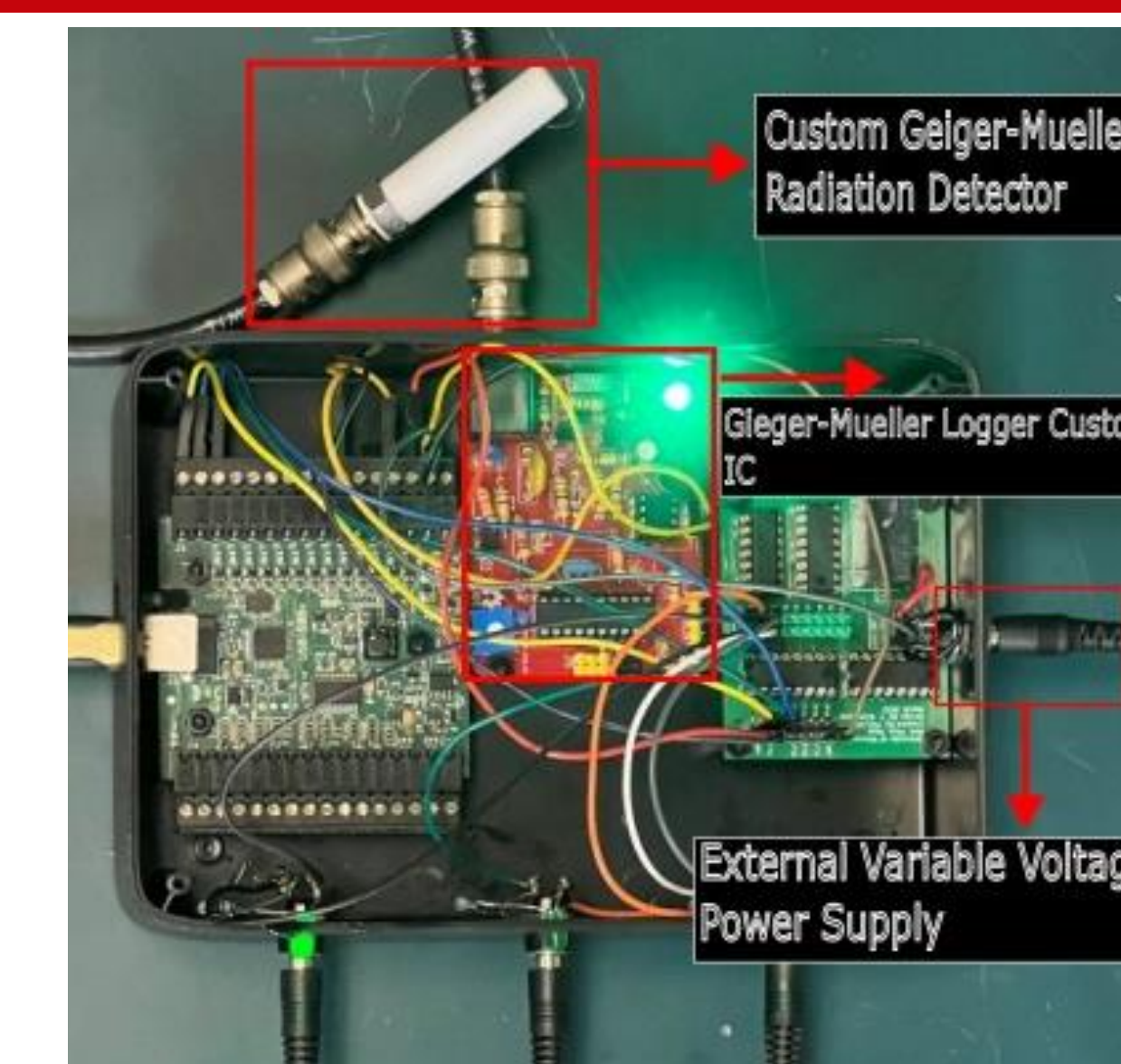


Figure 5. Diagram of Built Pump Control Box.

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