



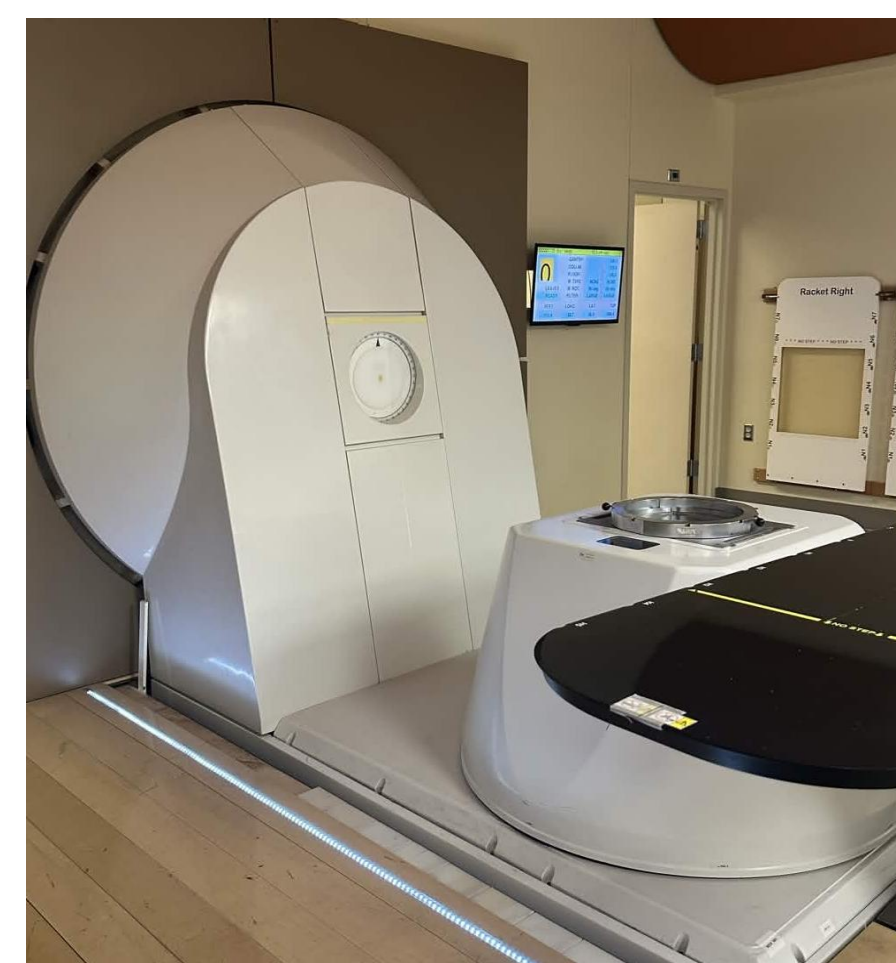
# PLC Testbench For Continuous Hardware Development Standard Operating Procedure



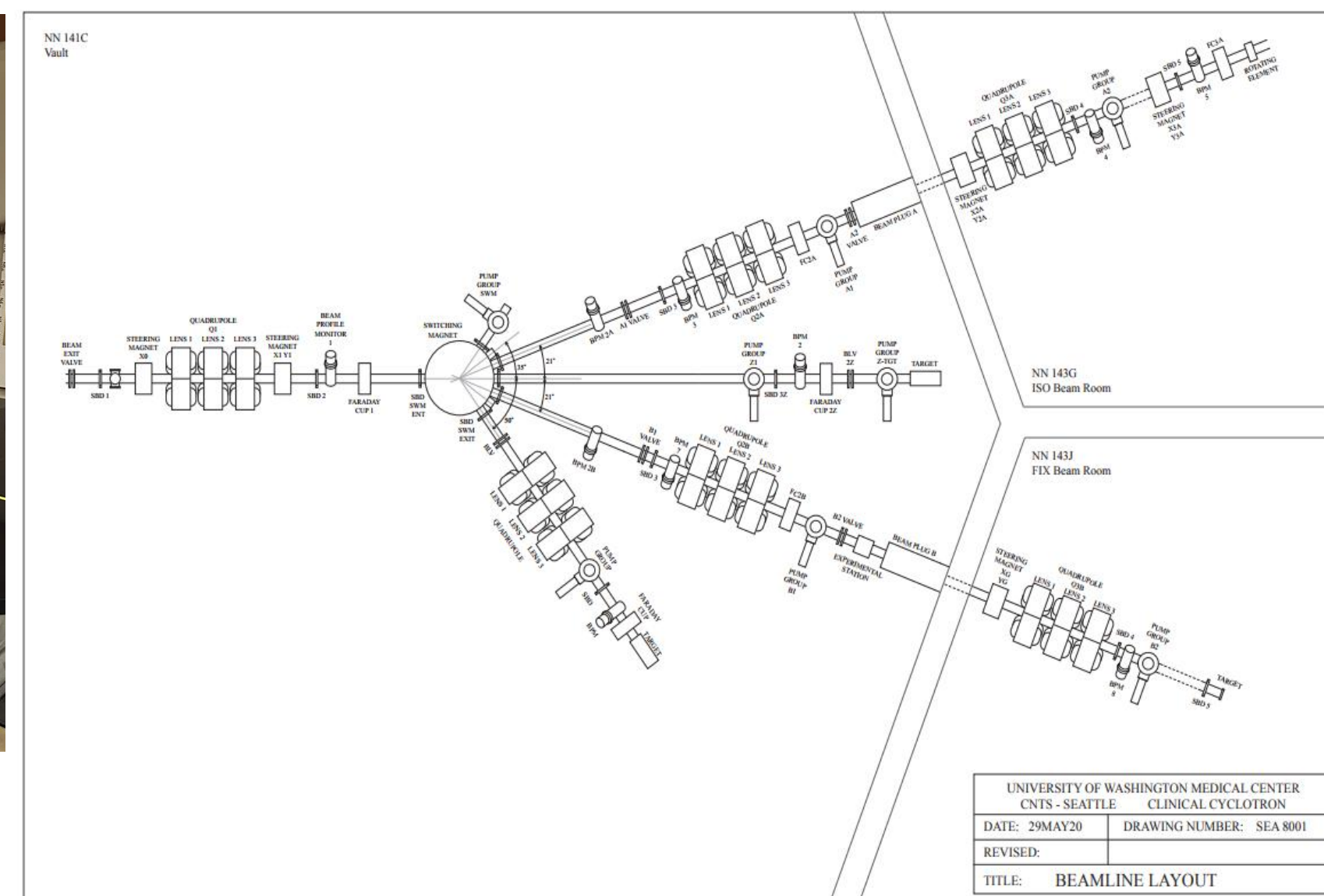
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## Motivation and Background

- The UW Medical Cyclotron Facility (UWMCF) is home to a hospital grade multi-particle variable energy cyclotron, the only facility in the world to provide Fast Neutron Therapy for radiation treatment.
- It is imperative to the UWMCF to have minimal downtime to maximize treatment time and stay on treatment schedules.
- UWMCF's control circuitry runs on Programmable Logic Controllers (PLCs). A PLC testbench and trained staff allows hardware and software updates to be tested for reliability before being pushed to the main system.



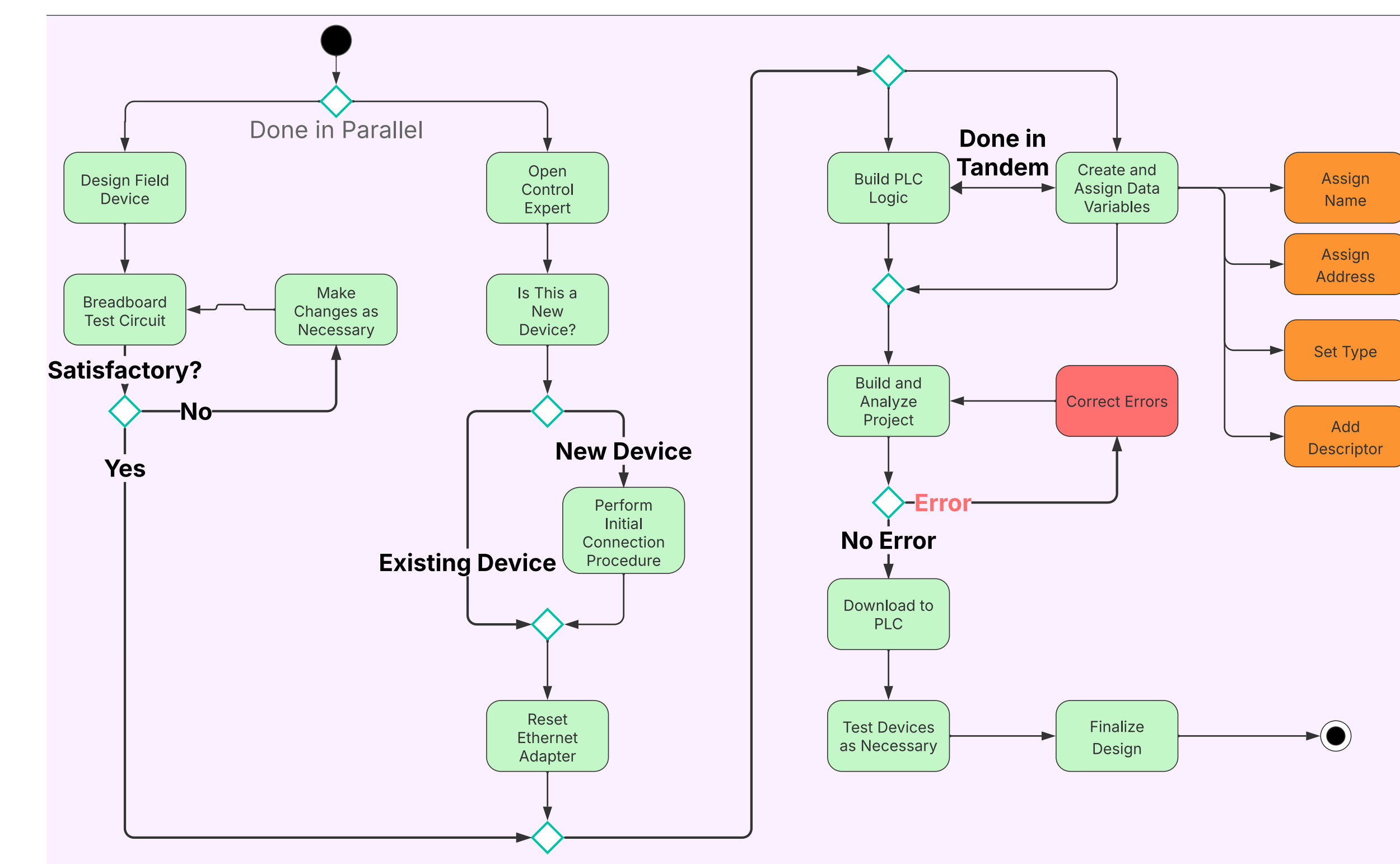
Gantry & Treatment Bed



Beamline Diagram

## General Design Requirements and Objectives

- To ensure minimum downtime, an easy to use and readily accessible testbench was required.
- Along with the testbench, a Standard Operating Procedure (SOP), which is easy to understand and train on, was developed and refined. This SOP covered startup, shutdown, reset, and building an example program.
- Along with the actual testbench and SOP, multiple rounds of training were conducted to ensure staff understanding and the ability to train future staff.



## Procedure Development

### Reference modeling from operational systems

- Used a live cyclotron vacuum pump subsystem as the primary design reference
- Grounded procedure scope in real facility workflows rather than theoretical assumptions

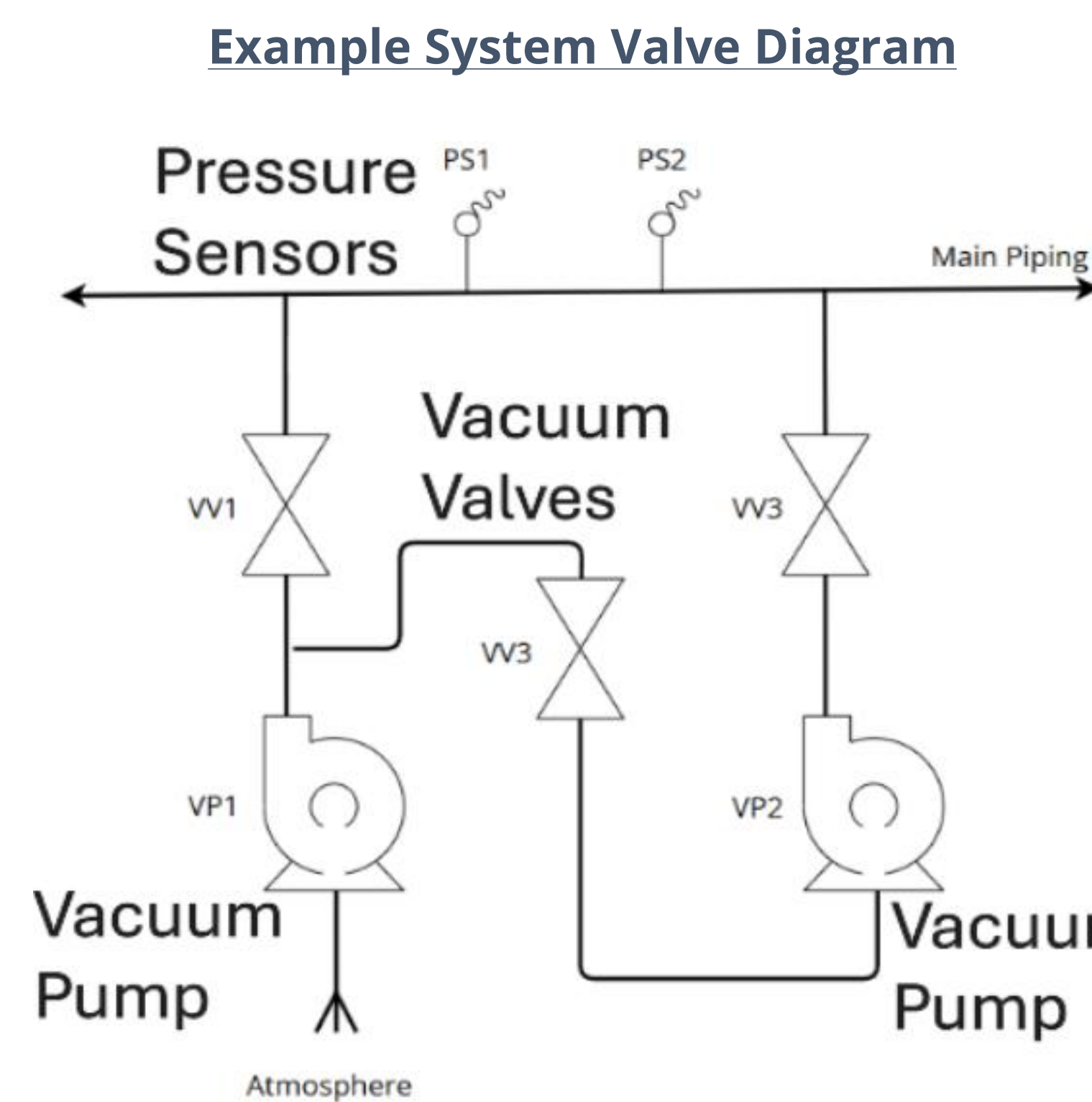
### Incremental prototyping to identify procedure requirements

- Built sample PLC systems and prototype hardware iteratively to expose testbench operation gaps
- Each iteration defined specific decision points requiring standardized guidance

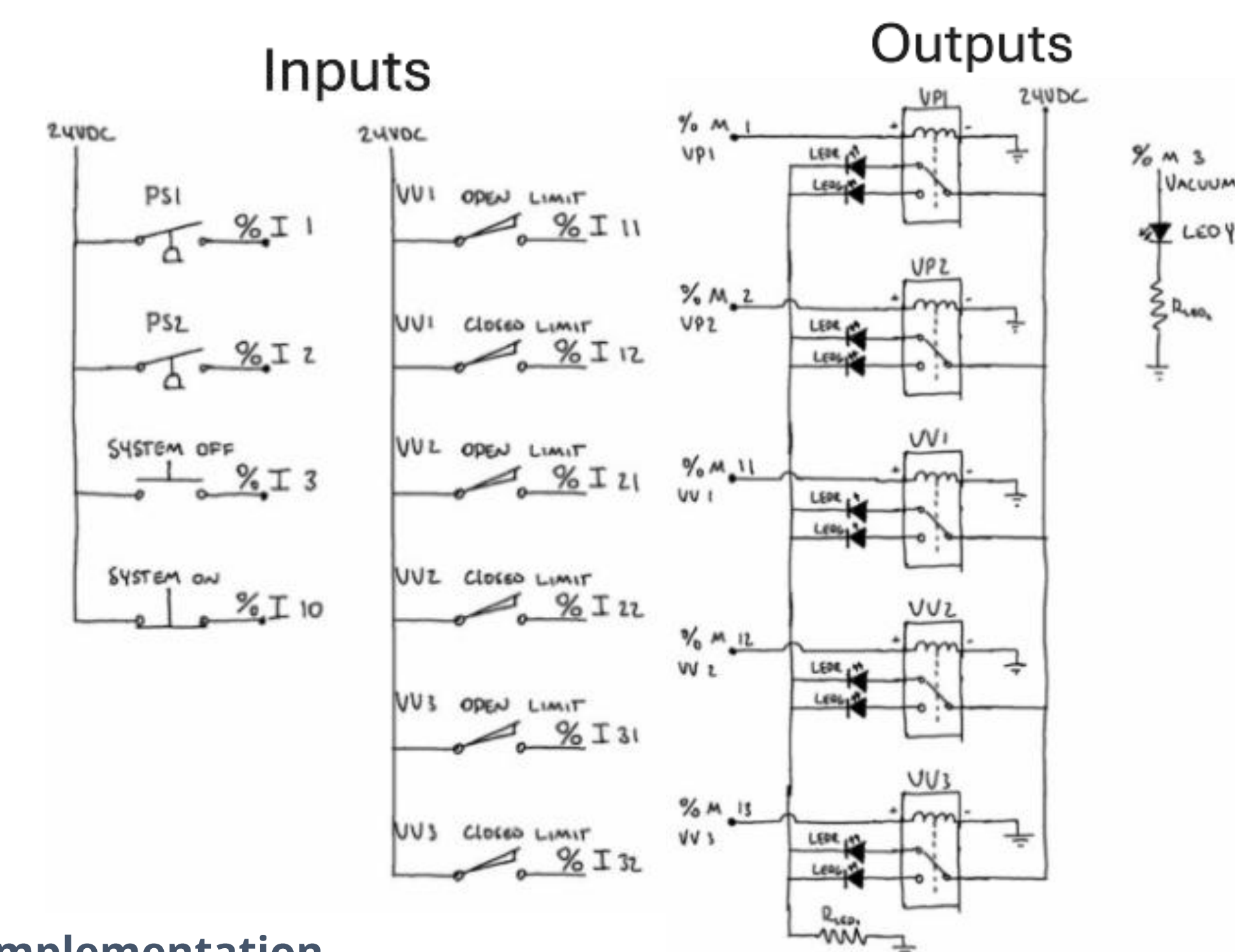
### Facility-integrated validation

- Procedures were tested and refined through direct staff interaction prior to formal facility review
- Ensured SOPs were operationally accurate and repeatable under real conditions

## Hardware Testbench



### Example System Wiring Diagram



### Hardware Implementation



## Results

### Standard Operating Procedures

- Developed and facility-reviewed 6 SOPs (39 pages): startup & shutdown, Ethernet communication, hardware connection, project configuration, backplane module swapping, and existing project access
- Provides a reusable framework for future hardware validation and development

### Example Training Program

- Developed a 17-page PLC ladder logic training program based on a cyclotron vacuum pump tree system, providing both a realistic sequential control logic example and a functional platform for PLC training, workflow validation, and testbench demonstration.

### Staff Training

- Conducted facility staff walkthrough sessions covering SOP workflow and guided hands-on testbench operation
- SOP and training resources reduce dependence on individual knowledge. Standardized onboarding ensures operational continuity

### Testbench as an Independent Test Environment

- Provides a fully isolated environment for validating hardware and software changes before deployment to the operational cyclotron system
- Eliminates unvalidated modifications as a source of unplanned downtime, directly supporting the facility's need for continuous treatment availability

## Future Work

- Support for multiple PLC platforms
- Incorporate real industrial process simulation
- Operator Development and Instructional Integration
- Continue refinement of EcoStruxure Control Expert project organization
- Support future cyclotron beam line expansions
- Improve scalability of the testbench for larger and more complex systems

## Conclusion and Contribution

This project successfully developed a fully operational PLC testbench and Standard Operating Procedures for the UW Medical Cyclotron Facility. The primary technical contribution of this project was the development and implementation of a functional test environment. The system provides a safe and controlled environment separate from the actual cyclotron system for testing hardware configurations, validating software changes, and training facility personnel before applying to the operational cyclotron systems.

This project reduces operational risk and minimizes facility downtime. The testbench establishes a foundation for continuous hardware development and future system expansion within the facility through the development of standardized procedures, ladder logic programs, and staff training resources.