QA/QC During the Construction of a Modular Neutrino Detector, NOvA

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on behalf of the NOvA collaboration

Frontier Physics for Frontier Detectors
La Biodola, Isola d'Elba, Italy
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Outline

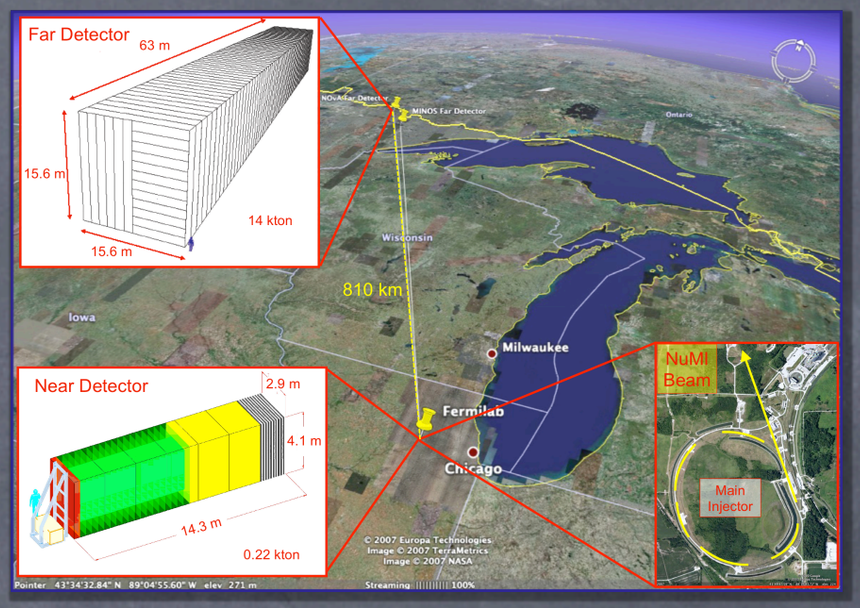
Quality Assurance/Quality Control System

- NOvA Detector at Ash River
- Ensuring Quality of Construction
- Higher Quality Measurements
- Acknowledgements

NuMI Off-axis Neutrino Appearance (NOvA) Experiment

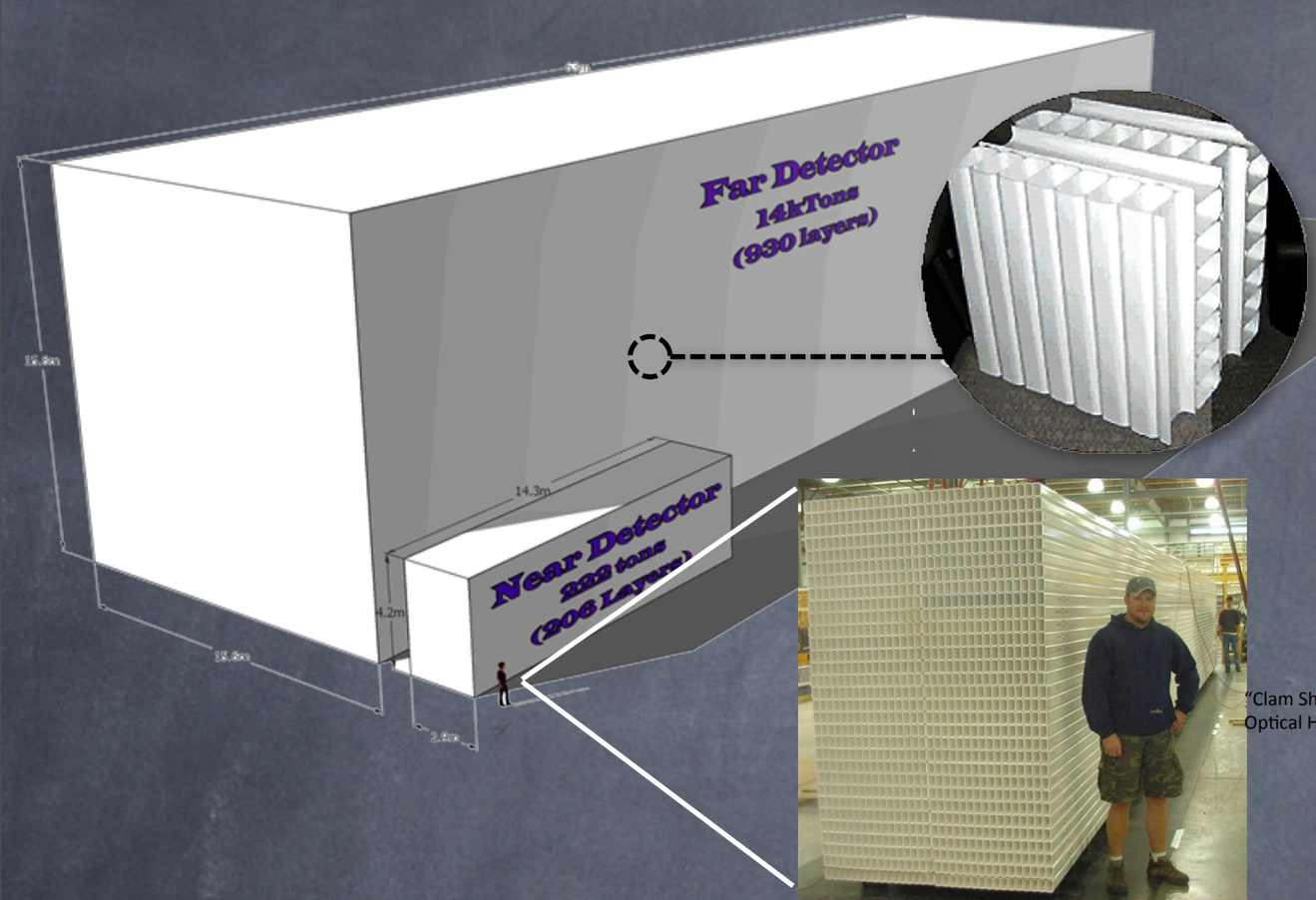
A 15 kTon detector is being built at Ash River, MN to record particle interactions from neutrinos generated in a 700kW beam located 810 km away at Fermilab, near Chicago, IL. Assembly of this massive PVC detector is tracked via an enterprise level software system (Java EE) designed to ensure high quality construction. Each of the dozen client stations are located throughout the detector hall to track one of inventory, testing, assembly, filling, and outfitting tasks using a bar code scanner system coupled to a central database. The business logic resides in its own tier where it ensures procedures are correct and restricts failed processes. Remote monitoring and reporting is provided via a web-interface. A crew of forty will work in either of two ten hour daily shifts, four days per week through 2014 when the installation of the NOvA Far Detector is scheduled for completion. In this poster the QA/QC system is described.

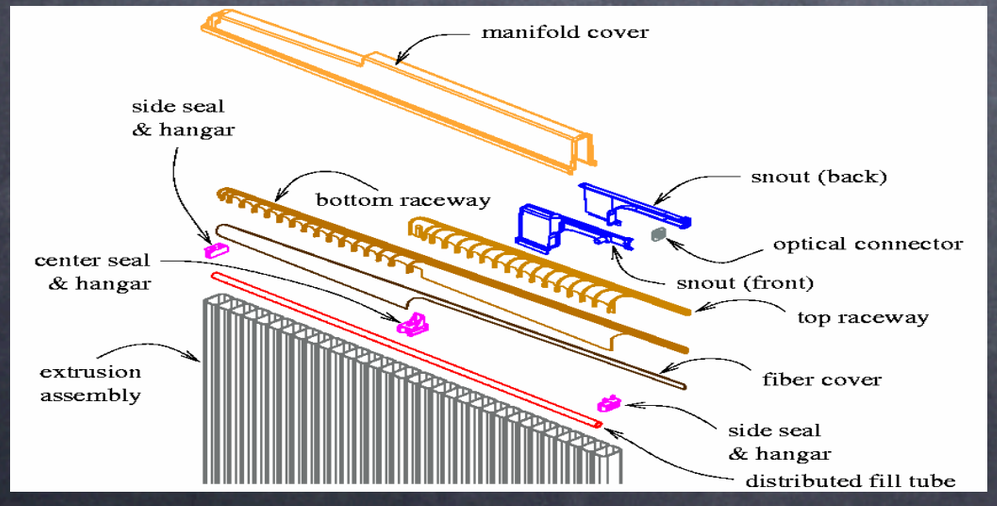
Reference: http://www-nova.fnal.gov



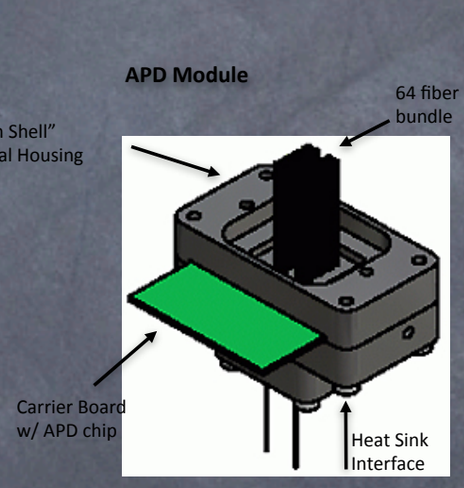
NOvA Detector Components

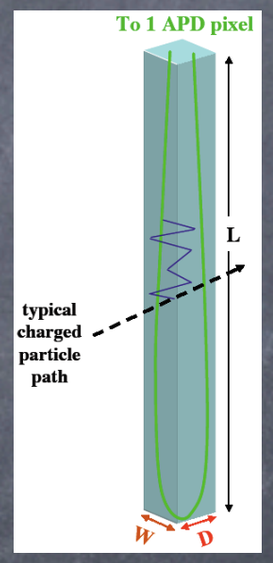
The detector is constructed from 11,520 modules (30, 384 module, 200 ton blocks), each extruded from a high reflectivity PVC, strung with 0.7 mm fibers, then filled with liquid scintillator. Once complete, the detector will hold 14,000 km of fiber and 3 million gallons of liquid scintillator.

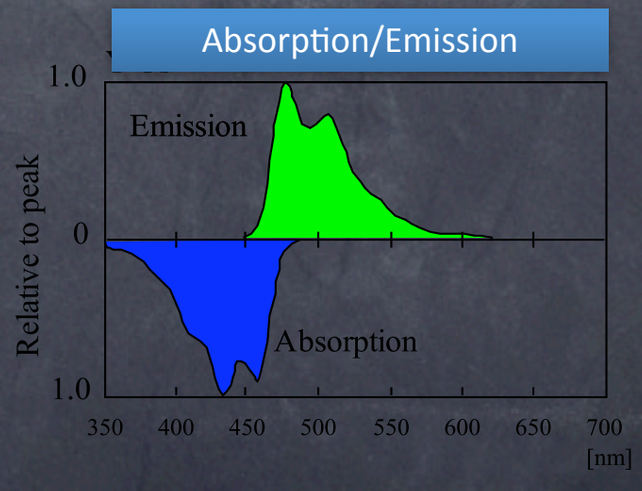




Modules are first assembled in factory, passing QA/QC there, then shipped to Ash River, testing again before installation as a 384 module block, one of 30.



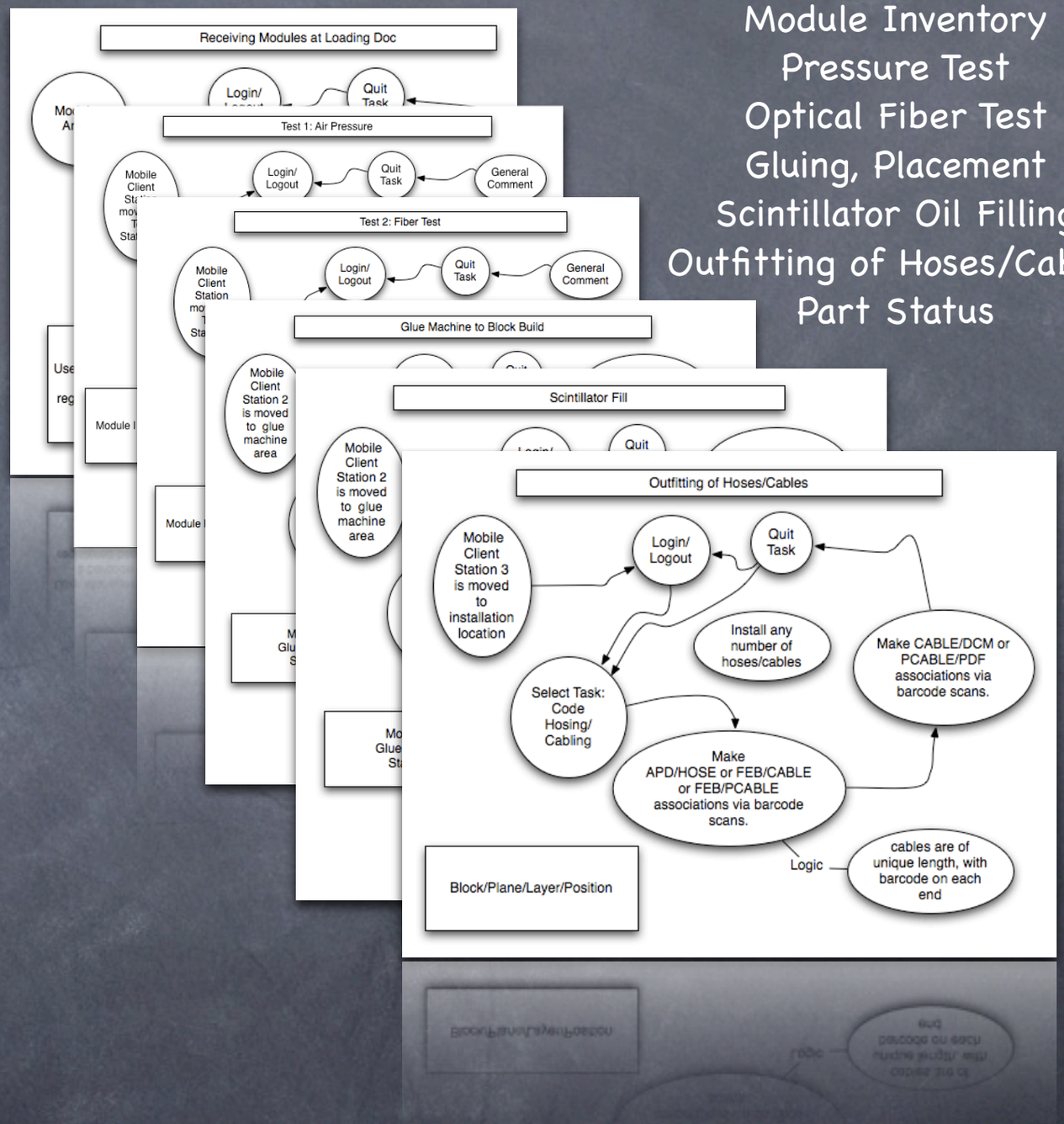




Cooled avalanche photo-diode systems will be coupled to each module via 64 looped wavelength shifting fiber bundles, forming 32 channels per module, with readout via a custom ASIC amplifier tuned to the long (~102 ft) fibers and ADC; an installation process requiring detailed inventory, testing, and parts associations.

Quality Assurance Processes

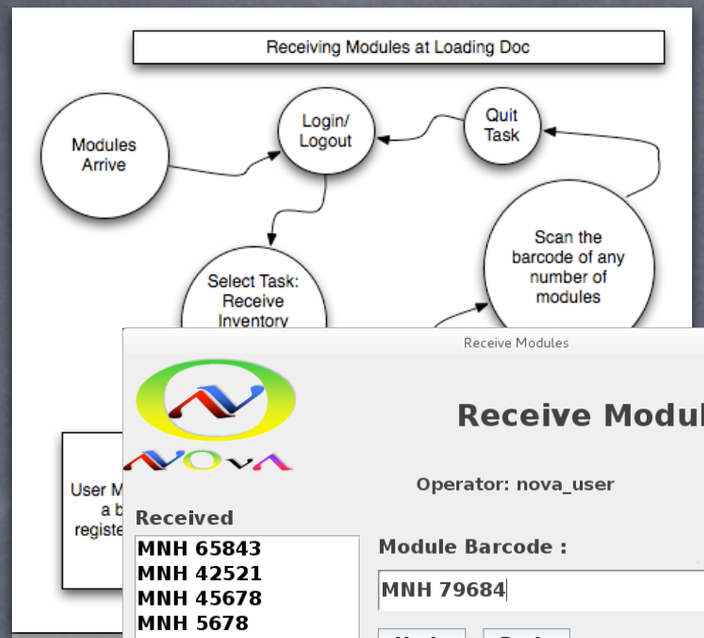
The numerous components of the detector and the long timeline of its installation require detailed inventory management, testing data, and part associations be recorded directly to database, a task, in days of old, reserved for a clip-board and/or spreadsheet.



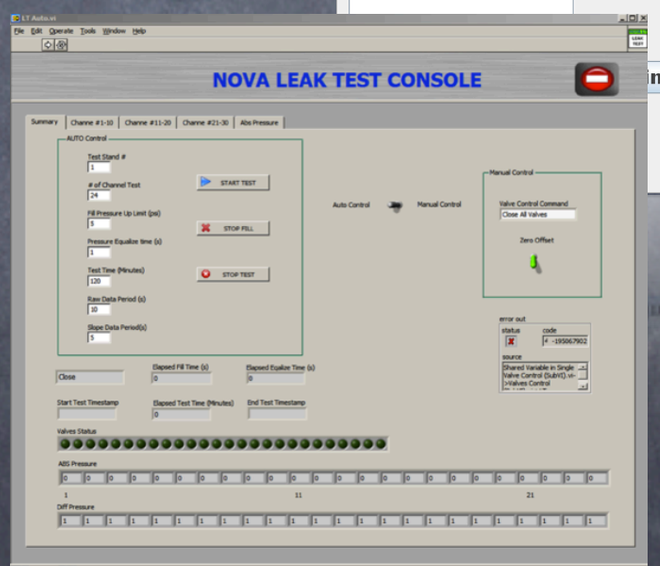
Module Inventory
Pressure Test
Optical Fiber Test
Gluing, Placement
Scintillator Oil Filling
Outfitting of Hoses/Cables
Part Status

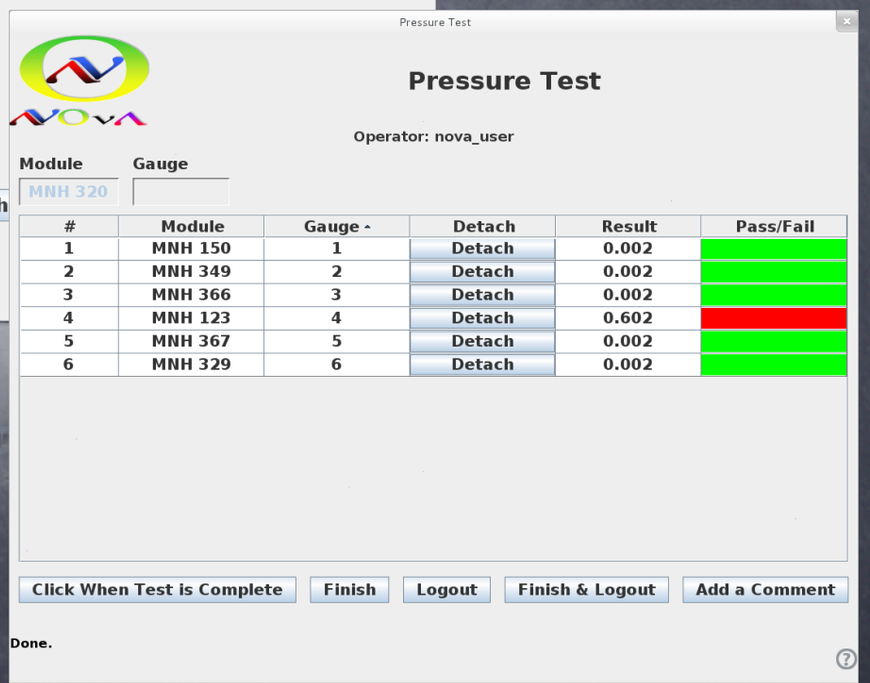
Receiving and Testing Modules at Ash River

For example, after a truckload of modules are received at Ash River, the 24-module stack is tested for pressure leaks using a multi-channel rig built at Argonne National Laboratory. A barcode system is used to associate module serial numbers with the corresponding gauge of the pressure tester. Upon completion of the four hour test, data is exchanged between systems and recorded to a PostgreSQL database



Modules Arrive
User Login
Select Task
Scan Barcodes
Add Comment (Optional)
Quit Task
User Logout



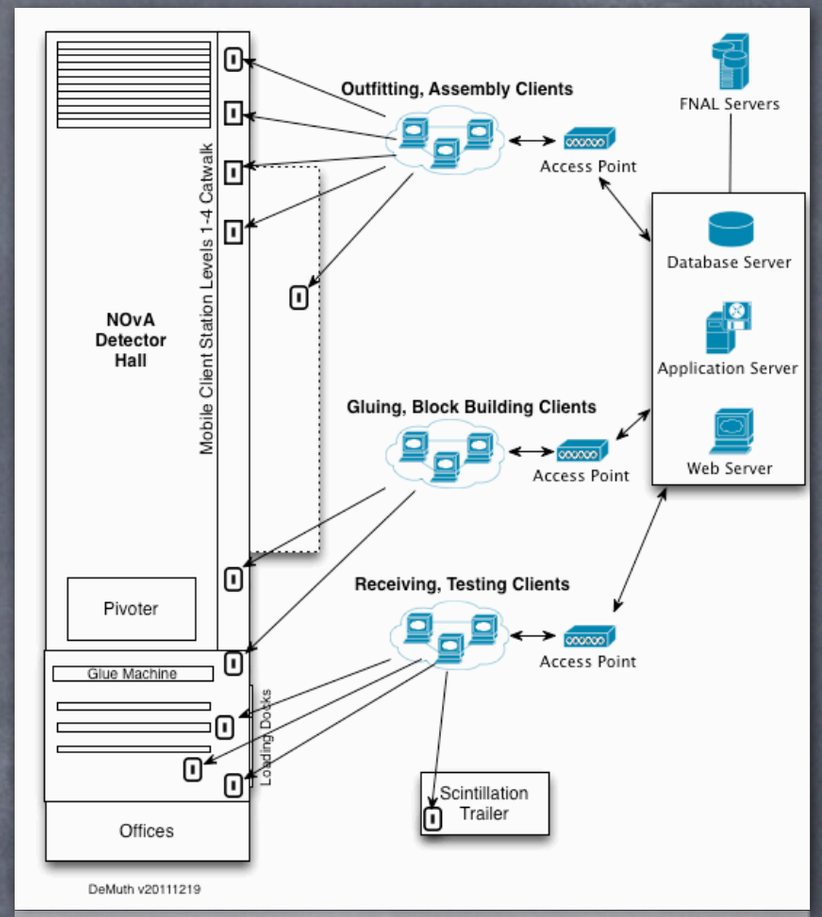


Two pressure leak and one fiber continuity tests are employed before filled with scintillator fluid. On occasion modules will fail and decommissioned in what is anticipated to be an infrequent event.

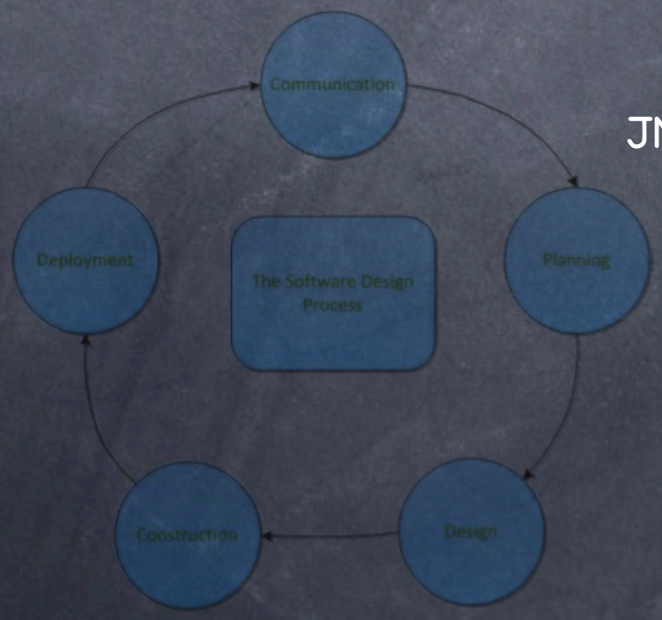
Client Stations

Twelve WiFi-enabled client stations (CS) each connected to its own bluetooth barcode scanner are distributed throughout the installation area.

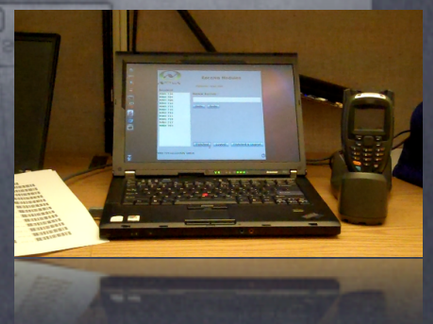
CS1: Receiving
CS2: Pressure Testing
CS3: Fiber Testing
CS4: Gluing
CS5: Building/Placement
CS6-CS9: Outfitting Catwalks
CS10: APD Assembly
CS11: Scintillator Trailer
CS12: Spare



All processes recorded via barcode scanner, design must be highly reliable and robust to failure and following a sanctioned software design process.



Client
Basic Laptop Ubuntu Linux
Motorola Barcode - MT2090
JNLP (WebStart) Software Distribution
SSID on Fermilab Network



Server
Debian Linux Virtual Machine
Glassfish 3.1.X Application Server
PostgreSQL Database

Web Admin Dashboard

User Management, Module Monitoring & Tracking

Remote users access a web console to track and monitor modules.

Module Listing

Module Barcode	Current Location	
MNH 349	Factory[Mpls]	Get Process
MNH 350	Truck[1]	Get Process
MNH 351	Loading Dock[AshR]	Get Process
MNH 352	Assembly[AshR]	Get Process

click

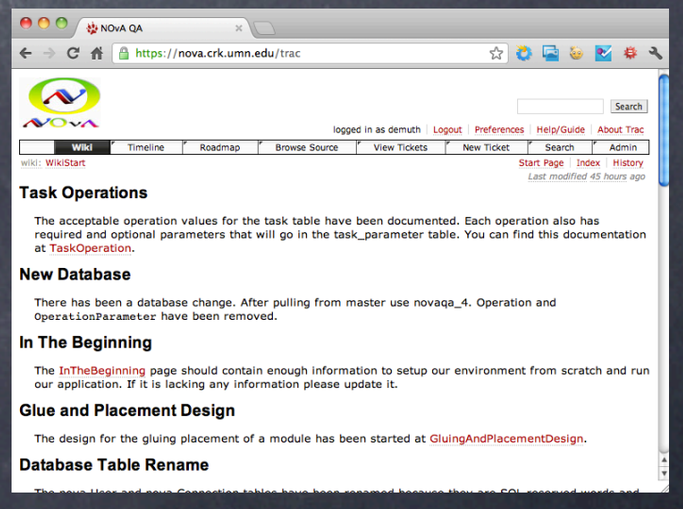
Installation Process

Location	Arrival	Departure
Factory[Mpls]	Thu Nov 17 08:05:35 CST 2011	Thu Nov 17 08:05:35 CST 2011
Truck[1]	Thu Nov 17 08:05:35 CST 2011	Thu Nov 17 08:05:35 CST 2011
Loading Dock[AshR]	Thu Nov 17 08:05:35 CST 2011	Thu Nov 17 08:05:35 CST 2011

Reports are customized to needs, requirements and are critical for informing remote site managers of status and progress of the installation.

We use web-based software management and bug/issue tracking system used to accommodate communication between team of developers, stakeholders, and users.

Integrated Wiki, Git (version control) using Python, PostgreSQL, preserving an open source BSD License model.



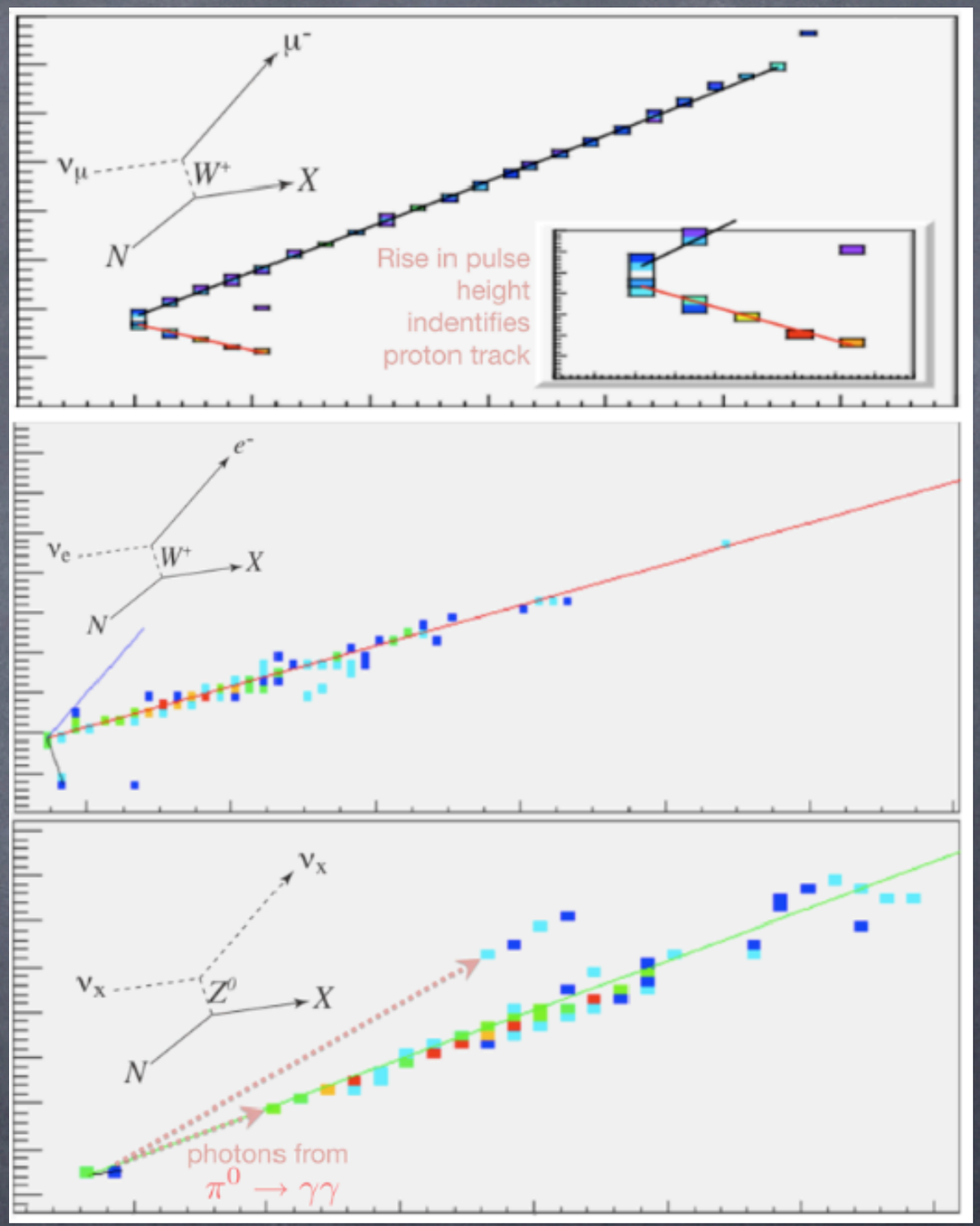
Higher Precision Measurements

Managing quality in construction contributes to the precision we require to obtain our objectives:

Electron appearance is directly related to $\sin^2\theta_{13}$ and an an aim of NOvA is to improve this measurement by an order of magnitude beyond the current limit.

Pursuing a goal of resolving the mass hierarchy by running a beam of neutrinos and anti-neutrinos.

A goal to evidence CP violation via a measurement of muon neutrino disappearance and $\sin^2 2\theta_{13}$



Team NOvA

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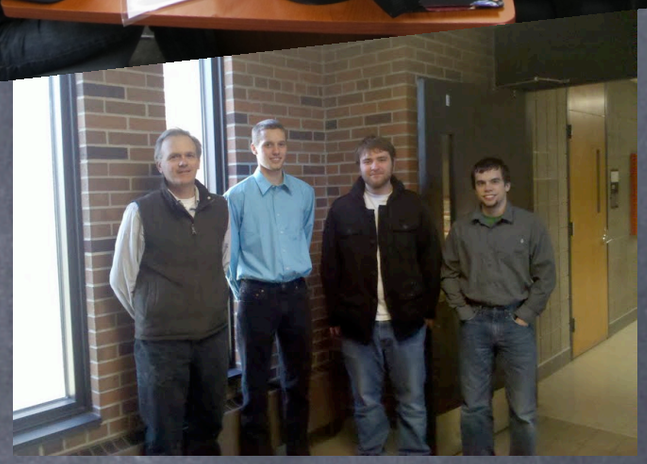
- Barcode: Kurt Prudhomme prud0042@crk.umn.edu
- Testing: Adam Hoff hoffx128@crk.umn.edu



What pleases us most about this project is that software engineering students at an undergraduate-only institution are the key designers to this QA/QC system.

Acknowledgements

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