



# **Experimental Operation Plan**

## **NOvA Experiment (E-929)**

### **Fermi National Accelerator Laboratory**

#### **v 1.1: October 24, 2014**



# Experimental Operations Plan for the NOvA Experiment

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## 1 INTRODUCTION

Fermilab experiment E929, the NuMI Off-Axis  $\nu_e$  Appearance Experiment (NOvA) is the second generation experiment on the NuMI beam line. It seeks to make significantly more precise measurements of neutrino oscillations than the first generation MINOS experiment, with particular emphasis on the  $\nu_\mu \rightarrow \nu_\mu$  and  $\nu_\mu \rightarrow \nu_e$  channels. The elements that allow it to make significantly more precise measurements include

- roughly three times the detector mass,
- roughly twice the beam power,
- a detector optimized for electron identification with roughly an order of magnitude finer longitudinal segmentation, and
- on off-axis detector siting, which provides a narrow-band beam producing more neutrino flux in the region of the oscillation maximum and lower backgrounds from neutral current feed-down from higher energy neutrino events.

To accomplish its goals, NOvA will study the interactions of the NuMI neutrino beam in two locations: the NOvA underground cavern at Fermilab, about 1 km from the NuMI target and the NOvA Far Detector Laboratory near Ash River, Minnesota, 810 km from the NuMI target. Both of these locations are located approximately 14 mrad off the NuMI beamline. The neutrino oscillations over the long baseline are studied by comparing the differing observed interactions in the two detectors.

## 2 SCEINCE

The NOvA experiment is designed to address the remaining questions in neutrino oscillations. Recent results from experiments using neutrinos from the Sun, the atmosphere, reactors, and accelerators have shown that neutrinos have a non-zero mass and that the flavor eigenstates are composed of admixtures of the mass eigenstates with the superposition given by the PMNS matrix,

$$\begin{pmatrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{pmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & c_{23} & s_{23} \\ 0 & -s_{23} & c_{23} \end{bmatrix} \begin{bmatrix} c_{13} & 0 & s_{13}e^{-i\delta} \\ 0 & 1 & 0 \\ -s_{13}e^{i\delta} & 0 & c_{13} \end{bmatrix} \begin{bmatrix} c_{12} & s_{12} & 0 \\ -s_{12} & c_{12} & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{pmatrix} \nu_1 \\ \nu_2 \\ \nu_3 \end{pmatrix}$$

where the elements  $c_{ij}$  and  $s_{ij}$  are the sines and cosines of angles  $\theta_{ij}$  and  $\delta$  is a CP-violating phase. It is now known that the angles  $\theta_{ij}$  are all reasonably large with  $\theta_{12} \approx 33^\circ$ ,  $\theta_{23} \approx 45^\circ$ , and  $\theta_{13} \approx 9^\circ$ .

Remaining questions are

- What is the neutrino mass ordering? That is, is the electron neutrino flavor mostly associated with the lowest two mass eigenstates or the highest two mass eigenstates? The result speaks not only to models of neutrino mass, but to the Dirac or Majorana nature of neutrinos as knowledge of the mass ordering will be an important input to the interpretation of future neutrinoless double beta decay experiments.

- Is the angle  $\theta_{23}$  maximal? If not maximal, is it larger or smaller than  $45^\circ$ , that is, is the  $\nu_3$  state more associated with the muon or tau neutrino flavor?
- What is the value of  $\delta$ ? Do the neutrinos violate CP symmetry?
- Is the PMNS matrix sufficient to explain neutrino oscillations or is there new physics to be found in the neutrino sector?

NOvA will answer these questions through measurements of the  $\nu_\mu \rightarrow \nu_\mu$  neutrino survival channel and  $\nu_\mu \rightarrow \nu_e$  appearance channel using the two detectors discussed above. The measurements will be made using beams of both neutrinos and antineutrinos as the effects of the neutrino mass hierarchy and CP violating phase is enhanced by the comparison of neutrino to antineutrino oscillation rates.

Figure 1 shows the reach of the NOvA experiment to determine the mass hierarchy and constrain the CP violating phase for a nominal 6-year run of  $36 \times 10^{20}$  protons-on-target. NOvA will provide discrimination between the two mass orderings at the 2-sigma level over 40% of the possible  $\delta$  values. NOvA is not powerful enough to discover CP violation, but can provide important constraints on the CP violating phase  $\delta$  particularly in combination with reactor experiments and T2K.

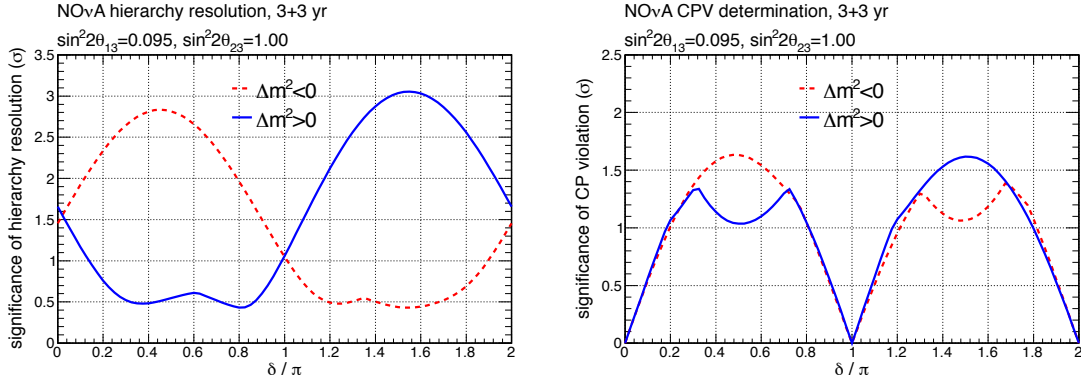


Figure 1: Left, the significance of hierarchy determination as a function of the CP phase  $\delta$  for in the NOvA experiment. Right, the significance for observing CP violation in neutrino oscillations in the NOvA experiment.

Figure 2 demonstrates the capabilities of the experiment in the muon-neutrino channel. The highly segmented detector provides excellent resolution in the muon neutrino channel and very good rejection of neutral-current interactions. This high resolution makes the experiment able to distinguish values of  $\sin^2(\theta_{23}) = 0.4$  from maximal mixing,  $\sin^2(\theta_{23}) = 0.5$ . Figure 2 only uses muon neutrino disappearance data. By combining it with electron neutrino appearance data, the correct lobe in Figure 2 right can be determined with between 2 and 3 standard deviations, depending on the value of  $\delta$  and the mass ordering.

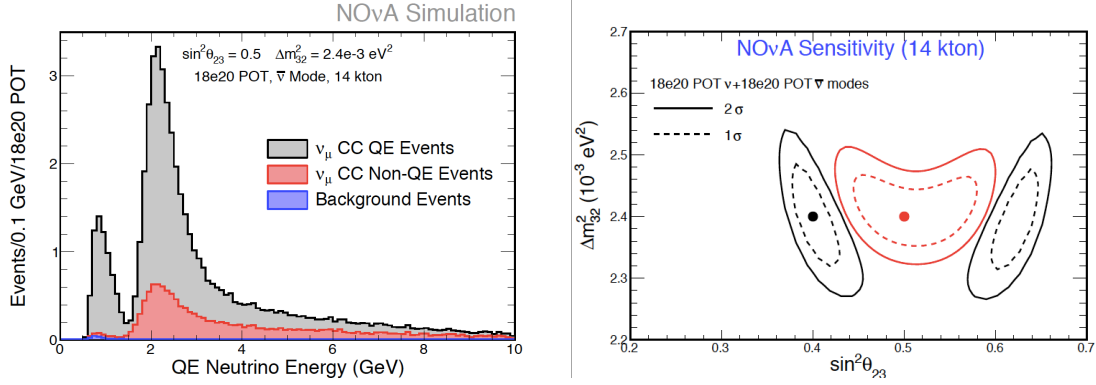


Figure 2: Left, a sample spectrum for muon neutrino events seen at the NOvA far detector. The excellent energy resolution of the experiment in the quasi-elastic and non-quasielastic channels makes the oscillation dip at 1.8 GeV very apparent leading to excellent resolution for the mixing angle  $\theta_{23}$ . Right, the  $\theta_{23}$  contours for a 6-year NOvA run for two test points having maximal and non-maximal values of  $\theta_{23}$ .

### 3 EXPERIMENTAL DESIGN

#### 3.1 NuMI Beam

The NuMI beam is produced by extracting protons from the Main Injector and transporting them down the NuMI beamline. The protons are focused onto a production target. A set of magnetic horns focuses the secondary particles, mainly pions and kaons, into a decay pipe 677 m long. The meson decays in this region produce a neutrino beam comprised of mostly muon-type neutrinos. A hadron absorber and rock barrier upstream of the NOvA underground cavern absorb the charged particles, leaving a beam composed only of neutrinos.

#### 3.2 NOvA Detectors

The two NOvA detectors are of an identical “totally active” design, consisting of PVC extrusions filled with liquid scintillator. The extrusion cells are 6.6 cm thick in the beam direction and have transverse dimensions of 4 cm by 15.4 m for the far detector and 4 cm by 3.85 m for the near detector. The cells are arranged in planes with the long direction alternating between vertical and horizontal orientation. The far detector consists of 896 planes, with each plane containing 384 cells. The near detector consists of 192 planes with each plane containing 96 cells. In addition, the downstream end of the near detector contains a “muon catcher” consisting of a ten-layer sandwich of 10 cm iron plates, each followed by a vertical and horizontal layer of liquid scintillator cells.

Light emitted by ionizing charged particles in the liquid scintillator cells are collected by a U-shaped wavelength shifting fiber in each cell. Light from each fiber is detected by an avalanche photo diode (APD). Signals from the APDs above an adjustable threshold are continuously output to the data acquisition system (DAQ), which sends them to a

computer farm where beam, data-driven, and random triggers select segments of the data to be written to permanent storage.

### 3.3 Data Acquisition and Detector Controls Systems

An outline of the DAQ system is shown in Figure 3. The APDs are cooled to  $-15^{\circ}\text{C}$  by a thermoelectric cooler (TEC), which is controlled by a controller (TECC) on the front-end board (FEB). The APD signals are amplified and shaped by an ASIC, which sends to signals to an ADC operating at 2 MHz in the far detector and 8 MHz in the near detector. The digitized signals are sent to an FPGA, which sends pulse heights over a programmable threshold to the data concentrator modules (DCMs). Currently, once a threshold is crossed, the highest pulse height after threshold and the three previous pulse heights are output to a DCM. The number of output pulses is programmable. The pulse train is accompanied by a time stamp, which derives from time signals distributed by time distribution units (TDUs), which derive time signals from the GPS system.

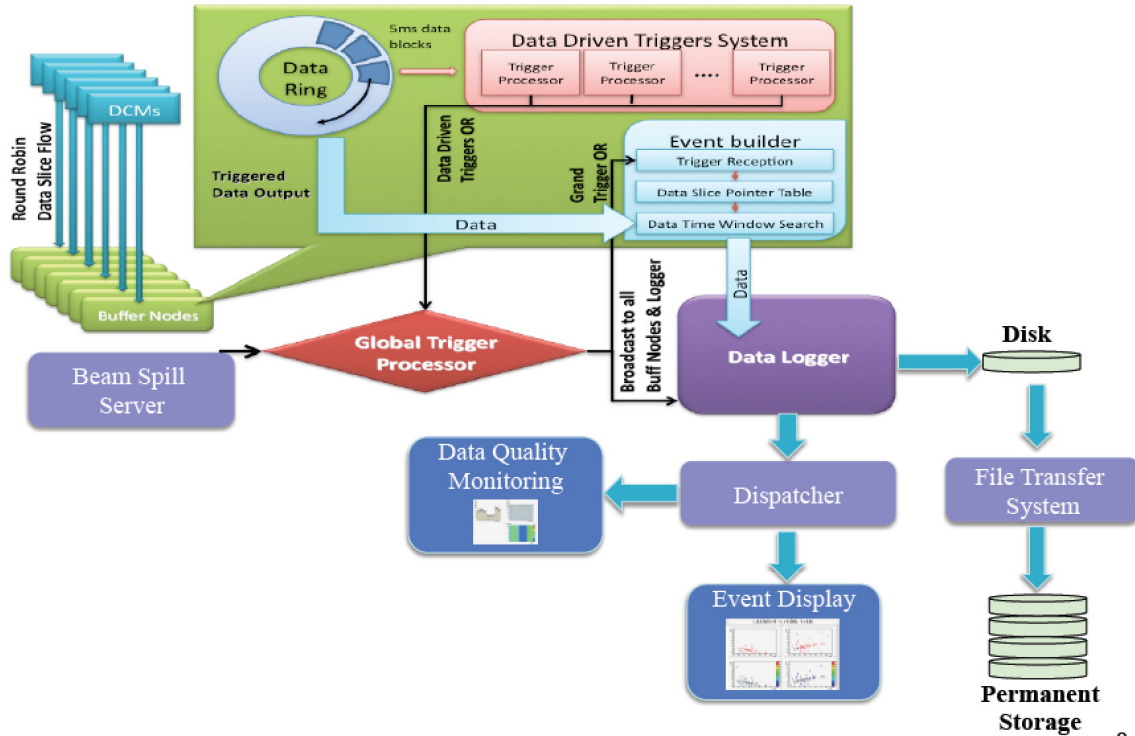


Figure 3: Cartoon of the DAQ system. FEBs and TDUs are not shown.

The DAQ modules organize the data and send them to a buffer node. Each buffer node uniquely receives 5 ms of data. The buffer ring is very deep, allowing up to 20 minutes of stored data. The global trigger processor issues a trigger based on one of three inputs: a beam spill trigger, a data-driven trigger, or a random trigger. The data-driven triggers are derived from the data in the buffer nodes. Once a global trigger is issued, the data is extracted from the buffer node, sent to the event builder to be organized and then to the data logger and dispatcher to be sent to local disk pending transfer to permanent storage

at Fermilab, to the online data quality monitoring program, and to the online event display.

The detector controls system (DCS) controls and/or monitors the low and high voltage, the APD cooling system, the dry-gas and water-cooling systems, and environments.

## **4 THE NOvA COLLABORATION**

### **4.1 Organization and Governance**

The NOvA collaboration presently consists of 130 Ph.D. physicists and 50 graduate students from 38 institutions in 7 countries, Brazil, the Czech Republic, Greece, India, Russia, the United Kingdom and the United States. The collaboration members from institutions outside the United States consist of 35 Ph.D. physicists and 13 graduate students from 17 institutions.

NOvA has an Institutional Board consisting of one representative from each collaboration institution. The Institutional Board approves and modifies the collaboration bylaws,[1] admits new institutions and senior members to the collaboration, and sets shift, authorship, and publications policies.

The scientific leadership of the NOvA collaboration consists of two co-spokespersons, who are elected for staggered two-year terms by the entire collaboration.

The co-spokespersons are advised by an Executive Committee, which has 9 members elected by the entire collaboration for two-year staggered terms and a number of ex-officio members.

To carry out the mission of the experiment, the spokespersons have appointed several working groups charged with detector operations, data processing and physics analysis as outlined in Figure 4. Going from right to left at the top level in Figure 4, the working groups are

- Detector operations, which is outlined in more detail below.
- Data Driven Triggers, which is charged with the development, maintenance, and deployment of the software framework supporting data-driven triggers, facilitating the development and deployment of trigger instances, and monitoring and reporting the trigger performance to the spokespersons.
- Calibration and alignment, which is responsible for the time and energy calibration of the near and far detector and for alignment of the detector elements.
- Computing, which is responsible for maintenance of NOvA software and execution of data production for calibration and analysis. The group acts as a liaison between the experiment and the Fermilab Computing Sector and consults with it to develop annual budget plans to support NOvA computing. Fermilab support for NOvA computing is covered in a TSW.[2]
- The Physics and Analysis Coordinator, who is charged with oversight of the physics working groups to coordinate among the groups and identify areas of common



## Experimental Operations Plan for the NOvA Experiment

interest. The Physics and Analysis coordinator works with the working group leaders to set and facilitate progress towards analysis milestones.

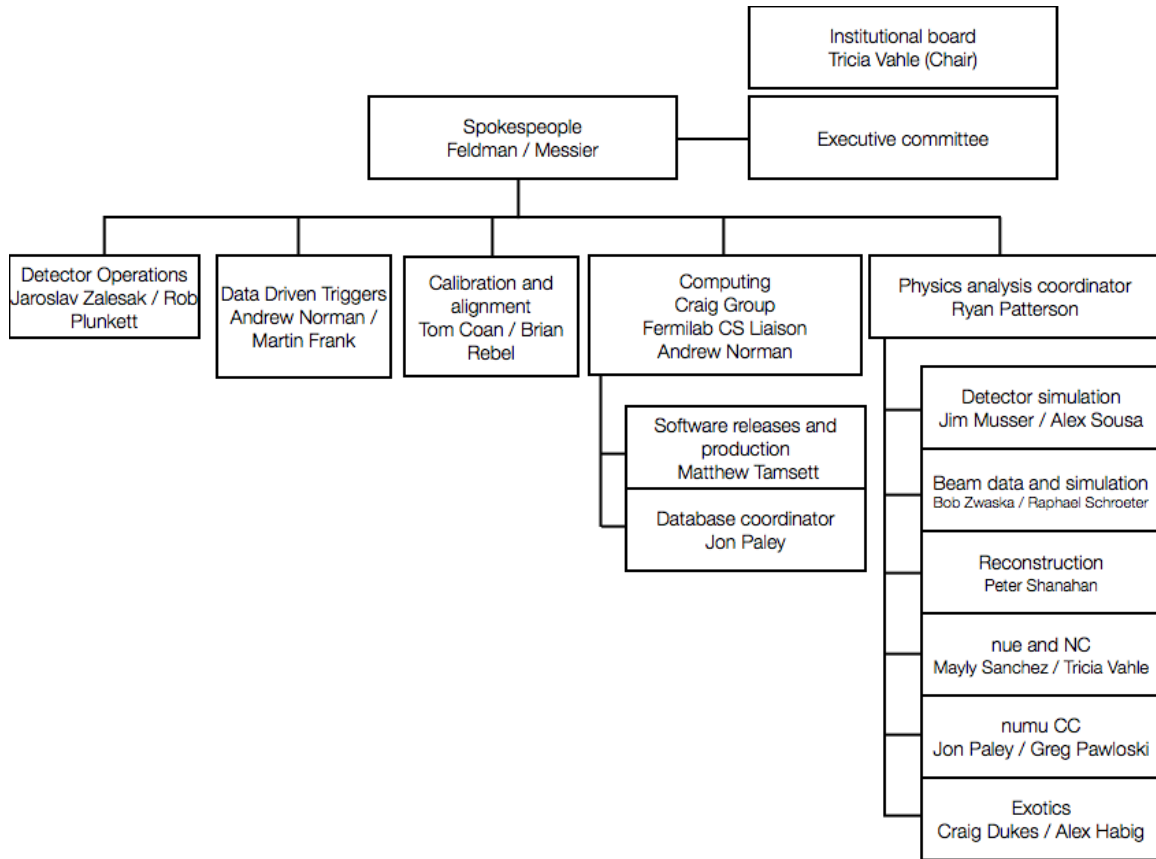


Figure 4: The NOvA Collaboration Organization Chart

## 4.2 Operations Group

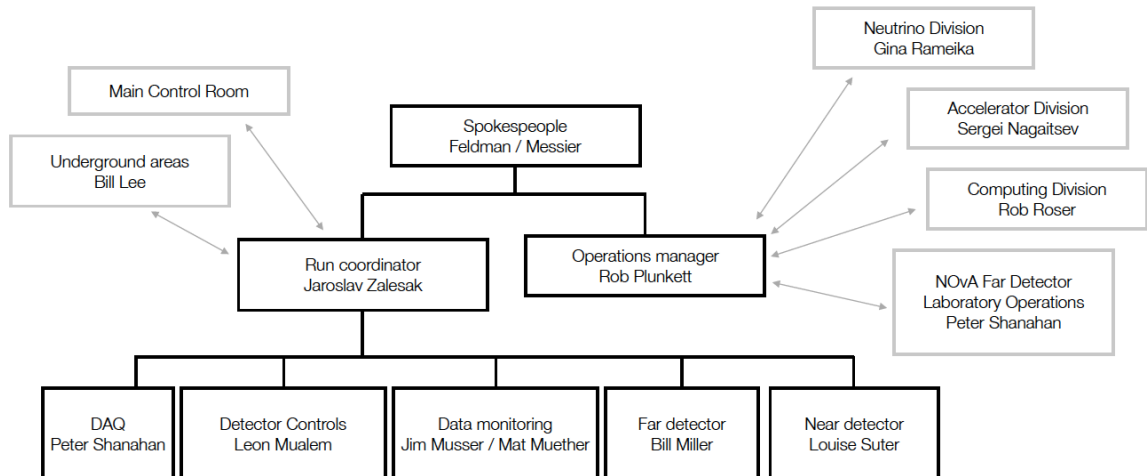


Figure 5: NOvA Operations Group Organization chart



Figure 5 shows the organization of the NOvA operations group. It is led by a Run Coordinator and an Operations Manager, who report to the experiment spokespersons.

The Run Coordinator is charged with optimizing the use of the near and far detectors to meet the physics goals of the experiment. In consultation with the spokespersons, the Run Coordinator will direct and decide the priority and scheduling of detector systems development and maintenance. The Run Coordinator has responsibility for scheduling shifts, maintaining shift procedures, and maintaining the systems expert on-call list. The Run Coordinator will be the primary contact between the experiment and the Fermilab Main Control Room and NuMI Underground Areas group and will be responsible for reports to the weekly All Experimenters' Meeting.

In executing the run plan, the run coordinator will be assisted by a rotating team of Deputy Run Coordinators chosen in consultation with the spokespersons. It is expected that the Run Coordinator will delegate much of the day-to-day responsibilities to the Deputy Run Coordinators so that they bear primary responsibility for shifter on-call support, control room maintenance, and reporting to the weekly All Experimenters' Meeting. Deputy Run Coordinators will serve in overlapping two-week terms acting as a secondary contact in their first week and primary contact in their second week.

The Operations Manager is responsible for oversight of NOvA operations and assisting the Run Coordinator with long-term planning of NOvA operations. The Operations Manager serves as a liaison between the NOvA Operations group and the Fermilab operations support groups inside the Neutrino Division, Scientific Computing Division, and the NOvA Far Detector Laboratory Operations Manager. The operations manager is charged with maintaining the agreements between the experiment and University and Fermilab support groups for operation, maintenance, and repair of equipment required for NOvA operations. The operations manager is charged with writing the operations budgets in consultation with the Run Coordinator and experiment spokespersons.

The Run Coordinator and Operations Managers are expected to serve 12-18 month terms followed by a 6-month overlap period with their successors. The exact lengths of these periods will be dictated by circumstances.

Five working groups report to the Run Coordinator:

- The DAQ working group is charged with development, maintenance, and online support of the data acquisition systems
- The DCS group is charged with development, maintenance, and online support of the detector controls hardware and software.
- The Data Monitoring group is charged with development, maintenance, and online support of tools to monitor data quality and with giving regular feedback on the performance of detector hardware.
- The Far Detector group is responsible for executing maintenance and repair work scheduled by the Run Coordinator on the far detector.

- The Near Detector group is responsible for executing maintenance and repair work scheduled by the Run Coordinator on the near detector.

### 4.3 Shifts

Shifts running the NOvA experiment are shared equally by all of the Ph.D. physicists and graduate students. In addition to regular shifters, both DAQ and DCS experts run on-call shifts to provide assistance when problems arise that are beyond the expertise of the shifters. The shifters' responsibilities are to follow the run plan set out by the Run Coordinator, to see that the detectors are running properly, and to see that the data is of high quality, as determined from the diagnostic online monitoring.[3]

Shifts are run 24/7 regardless of whether the beam is on or off. Currently, two shifters are assigned to day and swing shifts and one shifter is assigned to the night shift. Starting in November 2014, after the retrofit is completed, the Institutional Board has approved remote shifts with one shifter at Fermilab in the ROC-West and one shifter at a remote site. It is anticipated that the shift policy will evolve as the running becomes more routine.

## 5 FERMILAB

Figure 6 shows the high level Fermilab organization. The NOvA experiment gets support mainly from the Accelerator Division (AD), the Computing Sector (CS), and the Neutrino Division (ND).

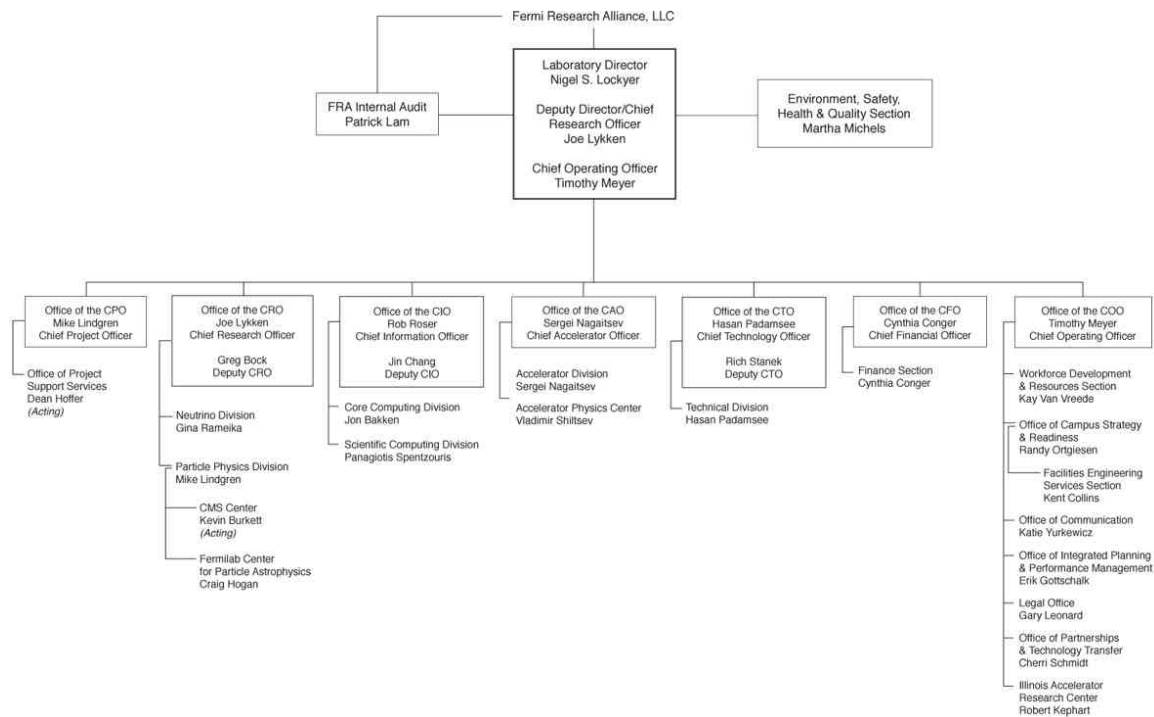


Figure 6: The Fermilab high-level organization chart.

## **5.1 Accelerator Division**

The Accelerator Division is responsible for commissioning, operation and maintenance of the primary proton beam line, the target station and the hadron absorber. The line of demarcation between Accelerator Division and Neutrino Division responsibilities is, unless otherwise noted, the large doors just upstream of the MINOS shaft.

The Accelerator Division will also be responsible for monitoring intensity and beam quality of the primary proton beam. Overall monitoring of the primary proton beam intensity within 3% is required by the experiment.

The NOvA Experiment depends on support from a number of departments within AD. AD provides a liaison to the NOvA. The deliverables and services expected from each of these groups are described below.

### **5.1.1 External Beams Department**

The External Beams Department is the proprietor of the NuMI beamline from the Main Injector to the hadron absorber and controls access to the muon alcoves. The department provides a Machine Coordinator who is in charge of beamline operations and serves as the point of contact for NOvA questions involving the beam. The Machine Coordinator's responsibilities concern both operational status and requests from NOvA for changes in the beamline, target station or hadron absorber. The department also provides a Beamline Physicist who aids in day-to-day operational issues and assists the Machine Coordinator as required. The External Beams Department contains personnel expert in various elements of the design, operation and troubleshooting of any beamline, and are called upon by the Machine Coordinator as needed. In addition, budgeting and purchasing of spare equipment and changes to equipment in the NuMI target hall is coordinated by this department.

### **5.1.2 Controls Department**

The Controls Department is responsible for the front-end computers, links, crates and control cards for the operation of all equipment from the Main Injector to the hadron absorber. These responsibilities include the hardware and software of the Beam Permit System. The Department maintains several pieces of application software for controlling beamlines, specific instances of which are used by NuMI/NOvA. It is responsible for the maintenance of the accelerator consoles in the NOvA Control Room (ROC-West) and NuMI service buildings. It installed and maintains several Programmable Logic Controllers dealing with target chase cooling and various water systems including beamline LCW, target hall and absorber RAW and near detector cooling. The computer networking in the NuMI underground and above ground installations is also the responsibility of Controls. The Controls Department is also responsible for the support of the ACNET system, which is used by the NOvA Detector Controls System.

#### 5.1.3 Electrical Department

The Electrical Department is responsible for all of the power supplies needed to run the magnets of the primary beamline. It is responsible for the NuMI extraction kicker and its power supply, the large pulsed power supply of the NuMI focusing horns and the electronic control of beamline vacuum.

#### 5.1.4 ES&H Department

The AD ES&H Department has ES&H oversight responsibility for the AD areas of the NuMI facility. In addition, the ES&H Department coordinates underground safety training for all NuMI/NOvA areas. The department oversees access control to the pre-target beamline enclosure, target hall, decay pipe region, absorber hall and muon alcoves. Oversight is also provided for radiation and electrical safety in the region of the primary proton beam through various access control keys, enclosure interlocks, electrical permits to power supplies, interlocked radiation detectors, and beam inhibit critical devices.

#### 5.1.5 Instrumentation Department

The Instrumentation Department is responsible for the maintenance and calibration of primary beamline monitoring devices – loss monitors, total loss monitors, BPMs and toroids.

#### 5.1.6 Main Injector Department

The Main Injector Department is responsible for providing beam with appropriate parameters on NuMI timeline cycles. Such parameters include, but are not limited to, intensity, emittance and orbit stability. The Booster Department is responsible for supplying proper beam to the Main Injector. The Mechanical Support Department is responsible for operational support and maintenance, including magnet changes, of all the mechanical equipment in the Accelerator Division controlled areas. This includes vacuum and water systems throughout the beamline as well as the decay pipe region and the hadron absorber. The department has responsibility for technical support of equipment in the target hall and associated areas, including horns, targets, RAW systems, target pile cooling and dehumidification.

#### 5.1.7 Operations Department

The Operations Department is responsible for accelerating and extracting 120 GeV primary protons into the NuMI Primary Proton beamline and for maintaining the beam parameters throughout the line and onto the NuMI target. The primary beamline is controlled from the AD Main Control Room. The Operations Department is responsible for the administration of accesses to MI65 areas, the Muon Alcoves and the Absorber, and for resecuring these areas after a Supervised Access. AD provides first response to alarms in these areas.

## **5.2 Computing Sector**

The Fermilab Computing Sector supports the needs of the NOvA experiment computing through provision, maintenance and support of common, and in some cases experiment specific, core and scientific services and software.

Andrew Norman is the Computing Sector Liaison. His responsibilities include maintaining excellent communications between the experiment and CS as well as attention to ensuring the computing needs, agreements, issues and any other relevant items between the experiment and the computing sector are addressed in a timely and mutually agreed upon manner. The services CS provides to NOvA are detailed in the NOvA computing TSW.<sup>2</sup>

The tables below gives the list of the services supported for NOvA computing operations.

<b>Core Services:</b>	
Authentication and Directory Services	Standard KCA and DNS services provided both for Ash River as well as at Fermilab.
Central Web Hosting	Support for the NOvA central web server and NOvA DocDB.
Database Hosting	Database hosting and database infrastructure used by NOvA at Fermilab.
Desktop Services	Windows and Mac desktop support for the computers covered by the Managed Services contract. (Sparing for the Ash River and Fermilab IFIX computers is under discussion).
Fermilab (Data Center) Facilities	Laboratory space for DAQ test stands and buffer test facility remaining at Fermilab.
Network Services	Standard support for both near and far detector facilities. Essential NOvA related network devices are supported for 24x7 service. It is understood that the network installation at Ash River and Fermilab has sufficient redundancy and failover such that the standard support level is sufficient to allow data taking and recording to continue in the event of failures.
Networked Storage Hosting	Support for BlueArc home area and data disks; Part of the data processing, simulation and analysis scientific computing system support
Service Desk	Issue and notification reporting, handling and tracking.

<b>Scientific Services</b>	
DAQ & Controls	Run control, resource management, event builder, application manager, EPICS and other software developed and supported by the Computing Sector for NOvA DAQ. Artdaq, including custom input drivers, for the trigger system software. Data Concentrator Modules (DCM), Timing Distribution Units (TDUs) and other customer front end electronics firmware.
Grid and Cloud Computing	Batch processing on Grid accessible systems at Fermilab as well as offsite through the Open Science Grid. Jobsub, GlideinWMS and other software for processing and analysis.
Scientific Collaboration Tools	NOvA code repositories hosted through cdcvs.fnal.gov, redmine, and the electronic log-book application.
Scientific Computing Systems	Control Room computing system and workstation administrative support. Support for interactive, batch processing, simulation and analysis computing systems at Fermilab. Hosting of some scientific databases.
Scientific Data Management	SAM, IFDH, FTS and other data handling software and systems.
Scientific Data Storage and Access	Enstore based tape storage services. Tape handling and curation. dCache based data disk services and systems.
Scientific Databases	Applications and database infrastructure for identified NOvA online and offline databases
Scientific Frameworks	The art offline framework
Scientific Software	SoftReltools, ROOT, and other software tools.
Simulation Software	Support for Geant4.

### **5.3 Neutrino Division**

The newly formed Neutrino Division is responsible for the operation of the NOvA experiment and experiment-related activities at Fermilab. Figure 7 shows the Neutrino Department organization chart.

The Neutrino Division provides an administrative organization for the Fermilab staff working on NOvA, as well as a center for experimental operations, data analysis and future planning. It also provides the funds for the operation and maintenance needs of the NOvA Detectors and those parts of the NuMI/NOvA facility for which it is the landlord and the operations and maintenance needs of the NOvA Far Detector Laboratory at Ash River, MN.

## NEUTRINO DIVISION

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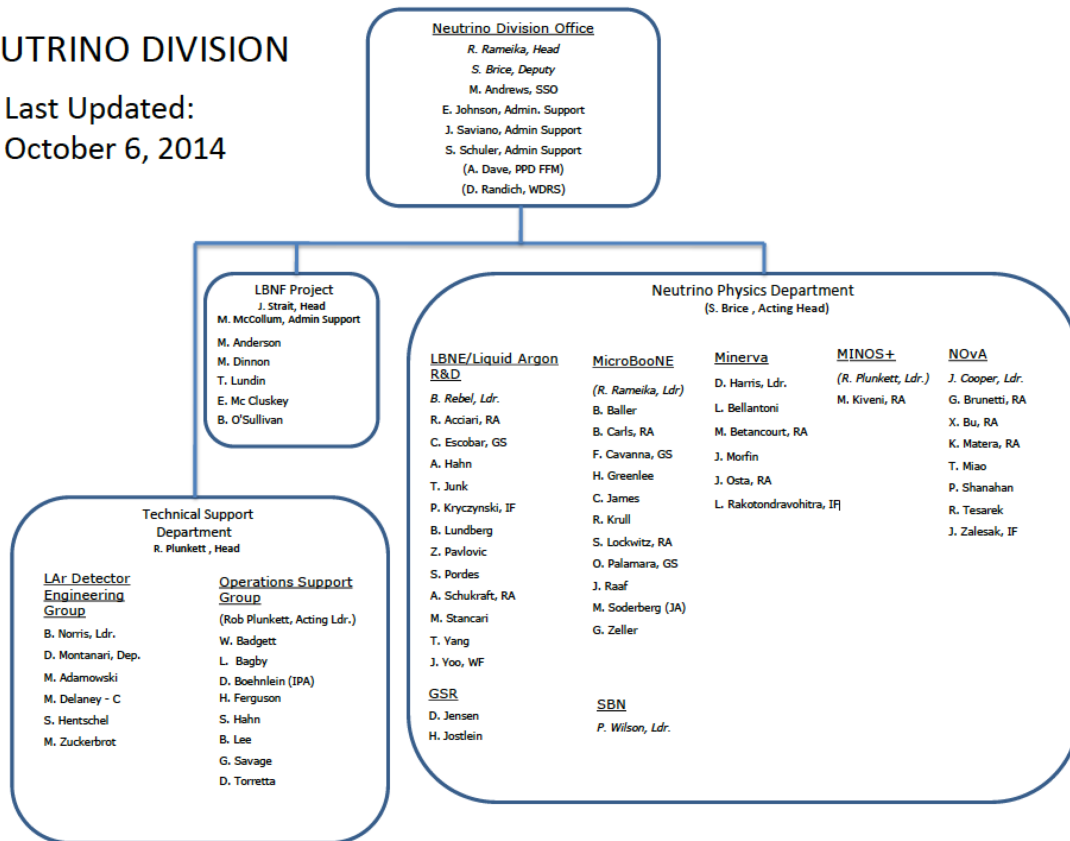


Figure 7: Neutrino Division Organization Chart

The Neutrino Division provides an administrative organization for the Fermilab staff working on NOvA, as well as a center for experimental operations, data analysis and future planning. It also provides the funds for the operation and maintenance needs of the NOvA Detectors and those parts of the NuMI/NOvA facility for which it is the landlord and the operations and maintenance needs of the NOvA Far Detector Laboratory at Ash River, MN. The Ash River laboratory is run by the University of Minnesota under an MOU with Fermilab.[4]

The Neutrino Division provides office space for both resident and visiting NOvA collaborators. Office space provided is commensurate with the amount of time spent at Fermilab.

The head of ND's Operations Support Group is the liaison to the NOvA experiment.

### 5.3.1 Operations Support Group

The ND Operations Support Group (OSG) is responsible for the maintenance and repair of the NOvA water-cooling and dry air systems in the Near Detector Hall at Fermilab, including interlocks that talk to the NOvA controls system. The OSG provides maintenance and support for the NOvA underground cavern. The NOvA experiment may request additional services including rigging of items down the MINOS shaft or in



the NOvA underground cavern. These requests are coordinated through the Experiment Liaison Officer (ELO) and the Underground Area Coordinator (UAC).

Technicians in OSG are also responsible for repair services for mechanical systems in the ND-controlled areas of the NuMI facility. The systems include the ND LCW water system. The OSG will change de-ionization bottles and conduct preventive maintenance as necessary, as well as performing repair work as needed. The UAC coordinates this work.

### 5.3.2 ES&H

The Neutrino Division has ES&H oversight responsibility for the ND areas of the NuMI facility.

The NOvA experiment shares ND underground space with various tests and other experiments. Access to the underground areas is controlled via training, access keys, limited occupancy and badging in and out when entering or exiting the areas, respectively. Designation of rules and procedures for access to the underground areas and coordination of permits for work to be performed in the ND underground areas are the responsibility of the UAC.

### 5.3.3 Responsibilities for NOvA Electronics

The table below lists the current responsibilities for maintenance of NOvA electronics components

<b>System</b>	<b>Responsibilities</b>
High Voltage Supplies	Repair or replacement by Fermilab.
Low Voltage Supplies	Repair or replacement by Fermilab.
Power Distribution System	Repair and maintenance by University of Virginia
APDs	Testing and evaluation by Caltech
Thermal Electric Coolers (TEC)	Repair of controllers by Fermilab. Technical assistance by Indiana.
TEC Cooling System	Maintenance by Fermilab.
Front End Boards	Repair by Fermilab. Technical assistance and firmware by Harvard.
Data Concentrator Modules	Repair by Fermilab .
Timing Distribution Units	Repair by Fermilab. .
Detector Control System	Repair and maintenance by Fermilab. Technical assistance by Tennessee.
Data Acquisition System	Maintenance by CS with assistance from several collaborating institutions.

## 6 SPARES

The following table lists current spares and anticipated FY15 purchases.

Item	Spares	# used in NOvA	Anticipated purchases FY15	Comments
ND APDs	>2000	631		
FD APDs	300	10,752	750	
ND FEBs	70	631		~100 more can be repaired
FD FEBs	~1000	10,752		
TECCs	~1000	11,383		
TECs	1000	11,383	1000	
DCMs	31	182		
TDUs	15	31		
PDBs	6	182		
HV main frame	3	3		
HV controllers	2	3		
HV PS	5	13		
LV Chassis	7	61		
LV PS	6	61		
700 kW Targets	2	1	1	1 in 2016s
Horn 1	1	1		1 in 2016
Horn 2	1	1	1	1 in 2016

## 7 BUDGETS AND RESOURCES

### 7.1 NOvA Operations Budget

The FY15 budget for the Far Detector Laboratory is given in the following table.

Item	Cost	Comments
Crew labor	\$705,484	9.75 FTE -> 7.75 FTE in Q2
Utilities	\$461,542	85% electricity
Other M&S	\$135,033	>30% for safety
26% Overhead	\$338,536	
Total	\$1,640,595	

The FY15 operations budget request from the Neutrino Division is given in the following table.

Item	Cost	Comments
Travel to Ash River	\$4,500	
Design of overburden	\$50,000	To FESS
ND dry gas and water cooling maintenance	\$47,000	

Purchase of 750 spare APDs	\$271,875	
Purchase of 500 spare TECs	\$5,190	
Repair of ND APDs	\$50,000	To Harvard
M&S for FD dry gas and water cooling maintenance	\$70,750	
FD computing upgrades	\$185,000	
FD spare scintillator storage	\$24,000	
Test beam preparation and operation	\$30,000	
Total	\$738,815	

## **7.2 Common Fund**

NOvA will follow the Fermilab policy on common funds.

## **8 RUN PLAN**

The first phase of NOvA is defined as  $36 \times 10^{20}$  protons on target (POT). This is a 6-year run at the nominal rate of  $6 \times 10^{20}$  POT/yr. Approximately half of this running will be with a neutrino-enhanced beam and half with an antineutrino-enhanced beam, although the exact division will depend on an optimization of the physics based on the intermediate results.

Normalized to a full 14 kt detector, NOvA collected about  $0.7 \times 10^{20}$  POT during FY14. It is anticipated that the FY15 run will collect between 2 and  $3 \times 10^{20}$  POT.

The first analysis results, which will include some FY15 data, are expected in early CY15. For the principal oscillation analyses, we expect that the time period between the end of data taking and the results will be three months.

## **APPENDIX: GLOSSARY**

ACNET	Accelerator Control Network
AD	Accelerator Division
ADC	Analog to Digital Converter
APD	Avalanche Photodiode
ASIC	Application-Specific Integrated Circuit
BlueArc	Name of a computer network storage device manufacturer
CC	Charge Current
CCD	Core Computing Division
CIO	Chief Information Officer
CRO	Chief Research Officer
CS	Computing Sector (the union of CCD and SCD)
CY	Calendar Year
DAQ	Data Acquisition System

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dCache	A disk-based front-end data buffering for the Enstore mass storage system
DCM	Data Concentrator Module
DCS	Detector Controls System
DNS	Domain Name System
DocDB	Document Database
EC	Executive Committee
Enstore	A tape storage access and management system
EPICS	Experimental Physics and Industrial Control System
ES&H	Environment. Safety, and Health
FD	Far Detector
FEB	Front-End Board
FPGA	Field-Programmable Gate Array
FTS	File Transfer System
FY	Fiscal Year
GPS	Global Positioning System
HV	High Voltage
IB	Institutional Board
IFDH	Intensity Frontier Data Handling
IFIX	Proprietary name of supervisory monitoring and control program
KCA	Keon Certificate Authority
LCW	Low-Conductivity Water
LV	Low Voltage
M&S	Materials and Supplies
MINOS	<b>Main Injector Neutrino Oscillation Search</b>
MOU	Memorandum of Understanding
NC	Neutral Current
ND	Neutrino Division or Near Detector
NOvA	<b>NuMI Off-axis <math>\nu_e</math> Appearance Experiment</b>
NuMI	<b>Neutrinos from the Main Injector</b>
OSG	Operation Support Group
PDB	Power Distribution Boards
PMNS	Pontecorvo–Maki–Nakagawa–Sakata
POT	Protons on Target
PS	Power Supply
PVC	Polyvinyl Chloride
RAW	Radioactive Water
ROC	Remote Control Room
SAM	Sequential Access with Metadata
SCC	Scientific Computing Division
T2K	Tokai to Kamioka Experiment
TDU	Time Distribution Unit
TEC	Thermoelectric Cooler
TECC	Thermoelectric Cooler Controller
TSW	Technical Statement of Work (formerly MOU)
UAC	Underground Area Coordinator

## **REFERENCES**

1. NOvA Collaboration Bylaws,  
[http://www-nova.fnal.gov/NOvA\\_Collaboration\\_Information/index.html](http://www-nova.fnal.gov/NOvA_Collaboration_Information/index.html)
2. NOvA Computing TSW, <http://nova-docdb.fnal.gov:8080/cgi-bin/ShowDocument>
3. NOvA Shift Handbook, <http://nova-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=10512>
4. MOU between The University of Minnesota and Fermilab for Operation of the NOvA Far Detector Laboratory and the NOvA Far Detector, <http://nova-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=11785>