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The NOνA Experiment - Present and Future

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The NOνA experiment is a next generation long-baseline, accelerator-based neutrino oscillation experiment, currently under construction at Fermilab and northern Minnesota. Using a totally active liquid scintillator detector, positioned off the NuMI neutrino beam axis, NOνA will improve the existing constraints on electron neutrino appearance by more than an order of magnitude. Running a NuMI facility upgraded to 700 kW of beam power in neutrino and anti-neutrino modes, on an 810 km long baseline, NOνA is sensitive to the neutrino mass hierarchy and will pioneer searches for CP violation in the leptonic sector. We present the expected neutrino physics sensitivities of NOνA and report on the ongoing installation of the prototype Near Detector and construction at the Far Detector site, as well as on the future prospects for the experiment.

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The **Nu**MI **O**ff-Axis ν_e **A**ppearance project [1], the flagship of the Intensity Frontier initiative at Fermilab, is a next generation long-baseline accelerator neutrino oscillation experiment. NOνA will use the **Neu**trinos from the **M**ain **I**njector facility at Fermilab to produce a very intense neutrino beam measured in two locations, a 0.22 kton Near Detector (ND), 1 km downstream of the beam target at Fermilab, and a very large 14 kton Far Detector (FD), 810 km away in Ash River, northern Minnesota. Comparisons of the observed neutrino energy spectrum in the FD with the expectation from the ND measurement allows NOνA to search for ν_e appearance and measure θ_{13}; possibly determine the neutrino mass hierarchy and constrain δ_{CP}; and make precision measurements of the neutrino and antineutrino oscillation parameters Δm^2_{32}, θ_{23}, $\Delta\bar{m}^2_{32}$, $\bar{\theta}_{23}$.

During 2012, several programmed upgrades to the accelerator complex at Fermilab will increase the NuMI beam power from the present $\sim$ 300 kW to a nominal 700 kW. The tertiary muon neutrino beam, produced from collisions of 120 GeV protons with a graphite target, will be sampled by both detectors placed 14 mrad off the beam axis. This off-axis positioning results in a very narrow beam spectrum peaked at $\sim$2 GeV, tuned to the maximum probability for muon to electron neutrino transitions expected for an 810 km baseline. The narrow band beam drastically reduces the contamination from neutral current interactions with energies above the maximum of the $\nu_\mu \to \nu_e$ oscillation probability, the dominant background in ν_e appearance searches.

The NOνA detectors are functionally identical, allowing for cancellation of systematic errors due to beam flux and cross-section uncertainties. Both are composed of highly reflective (15% TiO_2) PVC cells filled with liquid scintillator (mineral oil infused with 5% pseudocumene). The scintillation light is collected by wavelength shifting fibers and read out by 32-pixel avalanche photo-diodes. The detectors are optimized for detection of ν_e charged-current interactions, with fine sampling of the characteristic electromagnetic showers (1 plane=0.15 X_0, Molière radius=10 cm).

The NOνA physics program requires running for three years with a ν_μ beam and three years with a $\bar{\nu}_\mu$ beam. The sensitivity to nonzero θ_{13} is shown in Fig. 1 as a function of δ_{CP} and is one order of magnitude below the present best limits. Due to NOνA's long baseline, matter-induced oscillations affect $\nu_\mu \to \nu_e$ and $\bar{\nu}_\mu \to \bar{\nu}_e$ oscillation probabilities by $\sim$ 30%, granting NOνA its unique ability of resolving the mass hierarchy if θ_{13} is sufficiently large. NOνA has already begun data taking with the ND placed on the surface. The data will be valuable for testing the detector components, as well as for calibration of the detector response and tuning of the Monte Carlo simulation using cosmic-ray and neutrino-induced events. Construction at the Ash River site is well underway, with FD assembly starting in the Spring of 2011. Full operations using the upgraded NuMI beam, the completed FD, and the ND underground are expected to begin in September 2013.

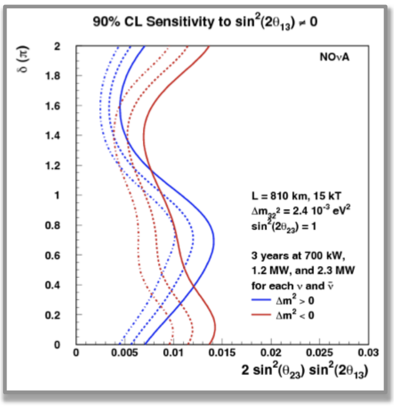

Figure 1: NOνA's sensitivity to ν_e appearance as a function of δ_{CP} and mass hierarchy. The regions to the right of the curves are excluded at 90% C.L.

References

[1] D. S. Ayres *et al.*, The NOνA Technical Design Report, FERMILAB-DESIGN-2007-01(2007).