**Reactor Neutrino Detector (RND)**

**Status:** CD-0 Approved in November 2005

**Mission Need**

Neutrinos are elementary particles which were long thought to be massless, unlike other elementary particles such as quarks and electrons. However, one of the most significant developments in particle physics in the last several years has been the convincing evidence that neutrinos have mass. These masses are extremely small and have only been observed through a quantum mechanical phenomenon called neutrino oscillations. Oscillations can only occur if neutrinos have different masses and if the mass states of the neutrino are made up of a mixture of the various interaction states. The mixing of the neutrinos between mass and interaction states can be represented by 3 trigonometric angles called $\theta_{12}$, $\theta_{23}$, and $\theta_{13}$. Two of these mixing angles, $\theta_{12}$ and $\theta_{23}$, were measured with reasonable accuracy by various solar, atmospheric and accelerator based neutrinos experiments and are large. The third angle, $\theta_{13}$, is known only to be relatively small but has not been measured and could be zero.

Charge-Parity (CP) symmetry relates the properties of particles to their antiparticles and is usually conserved. However, CP symmetry has been discovered to fail in some limited circumstances. These violations of CP symmetry are very important to us. CP violation is required to explain why matter vastly outnumbers antimatter in the universe. CP violation was first observed in 1964, in the decay of particles that contain one strange quark. Since the early 1990s, experiments at the Stanford Linear Accelerator Center (SLAC) and the Japanese High Energy Accelerator Research Organization (KEK) have also observed CP violations from the rare decays of particles containing bottom quarks. However, the level of CP violation observed in these two cases is too small to explain the matter-antimatter asymmetry of the universe.

CP violation can also occur in the neutrino sector and discovering it would be a major addition to our understanding. Measurement of neutrino CP violation will, however, only be possible if the presently unknown neutrino mixing angle, $\theta_{13}$, is not zero. Therefore, the first step to determine the feasibility of measuring CP violation in the neutrino sector is to determine the magnitude of the neutrino mixing angle $\theta_{13}$.

In response to the many exciting possibilities arising from the discovery of neutrino oscillations, four divisions of the American Physical Society recently completed a year long study of the opportunities available in neutrino physics. Among their recommendations is "An expeditiously deployed multi-detector reactor experiment with sensitivity to $\nu_e$ disappearance down to $\sin^2 2\theta_{13}=0.01\ldots$"

The Reactor Neutrino Detector also supports the Department of Energy’s Science Strategic Goal within the Department’s Strategic Plan dated September 30, 2003: *To protect our National and economic security by providing world-class scientific research capacity and advancing scientific knowledge*. Specifically it supports the two Science strategies: 1. *Advance the fields of high-energy and nuclear physics, including the understanding of dark energy and dark matter, the*
lack of symmetry in the universe, the basic constituents of matter...and 7. Provide the Nation’s science community access to world-class research facilities...