Advantages of the Braidwood Experiment

Goal: Implement a multi-detector, reactor neutrino experiment with sensitivity below the $\sin^2 2\theta_{13} = 0.01$ level with cross checks and redundancy. The purpose is to assure a convincing 3 to 5 σ signal if $\sin^2 2\theta_{13}$ s above 0.02. This sensitivity is achieved by searching for a signal using both relative rate and relative energy shape measurements in a set of detectors about 200m and 1500 m from a nuclear reactor.

We believe The most cost and time-effective approach to address the next steps in a long-term neutrino program is to develop a convincing reactor experiment that has discovery (3 to 5 σ) potential to $\sin^2 2\theta_{13} = 0.02$, and limit sensitivity at the $\sin^2 2\theta_{13} = 0.006$ level. The Braidwood Experiment provides this opportunity, with two modes of signal detection (rate and energy spectrum), multiple measurements of major backgrounds, and multiple constraints on the other significant systematic errors. The use of identical detectors at near and far locations from the reactor detector and flux systematic uncertainties to first order. It is an experiment that can be mounted in a timly fashion, has a strong collaboration, and is supported strongly by the Exelon Corporation, the owners of the Braidwood Nuclear Power Station.

Baseline Design:

The following design will permit the definitive search described above:

- Near and far detector stations under identical 450 mwe flat overburden shielding
- Two near and two far 65 ton fiducial mass spherical detectors using Gd-loaded liquid scintillator.
- Simultaneous filling of scintillator in near and far detectors to ensure identical composition
- Active muon veto system for background tagging and event identification
- Innovative two-region detector design
- Movable detectors that can be cross calibrated at the near location
- A multiple source calibration system

Advantages of Braidwood:

- Multiple identical near and far detectors
  - Increased fiducial target mass and event statistics
  - Reduction of detector systematic uncertainties through direct comparisons
- The geology and overburden has been determined by digging bore holes to the full 450 mwe depth at the actual locations on the Braidwood reactor site.
  - Results showed that the rock and water characteristics were as expected, and that the overburden at the two locations is identical better than 2%.
- Flat overburden
  - Better shielding for large angle cosmic-ray muons
  - Capability to put near and far detector at the same depth
  - Capability to have a deep near detector with significant shielding
  - Allows simple method for transporting modules between near and far sites for cross calibration
- Near and far detector at the same depth
  - Allows the use of ^{12}B to perform a relative efficiency and energy calibration between the near and far detectors
  - Measurement of near detector background in the far site.
- Deep near detector
  - Cosmic-ray rates at a level that allows muon tagging of the ^{12}B for near/far cross calibration
  - Neutrino-electron elastic scattering events can be isolated in the near detector allowing a measurment of the weak mixing angle
- Large (6.5 m diameter) spherical detectors
  - Increased fiducial volume
  - Reduced surface area to volume ratio reducing edge effects (e.g., energy tails resulting from lost particles)
  - Insensitivity to neutrino wind effects compared to cylindrical detectors

- Two zone detectors with Gd loaded scintiallator inner region surrounded by pure oil buffer region.
  - Increased fiducial volume for a given detector radius
  - Minimal surfaces that need to be understood for light transmission
  - Easier calibration using sources than three zone systems
- Active veto system for reducing and measuring spallation backgrounds
  - Most spallation backgrounds from neutrons and radioactive isotopes are tagged for study and removed from event sample
  - Muon shower veto can identify muons that undergo catastrophic interactions. Most of the backgrounds are from these types of muon interactions which happen at low rates and can, therefore, be vetoed.
- Direct cross calibration of detectors at the high rate near site by judicious moving of detectors during the experimental running period.
- The Exelon reactor company is anxious and willing to work with collaboration in developing, deploying, and running the experiment.
  - Company claims that security issues are not an issue with the detector locations being proposed
  - The use of outside subcontractors for construction and operations is allowed and encouraged. This was tested during the recent bore hole construction project that we set up and carried through using several subcontracting firms.

Cross Checks and Redundancies to Establish a Convincing Measurement

Multiple cross checks on the backgrounds and relative acceptances for the detectors are necessary to establish a convincing measurement, should a signal be observed. The list of cross checks built into the Braidwood Design includes:

1. Multiple methods to determine the relative fiducial volume and efficiency of the detectors
   - Direct measurements of the detector mass and composition during common filling of the detectors
   - Direct measurements of spallation isotope production by muons in the detectors
   - Cross calibration of far and near detectors by movement to the high rate near site

2. Multiple measurements of the backgrounds using muon tagging and event isolation

3. Multiple detectors at each

   - Direct cross check of rates at a given site
   - Stationary detectors during moving provide a direct monitor of units that are moved
   - Very high statistics samples to compare reactor neutrino response with other calibration methods