Kristofer Ogren, University of Michigan
Title: Development of Calibration Sources for a Large Gd-Doped Water Cherenkov Detector

Abstract
The detection of antineutrinos from nuclear reactors is of great interest for nuclear security and nonproliferation, as antineutrino signatures are impossible to shield and may provide information on the presence of undeclared reactors or the operation of known reactors, which would be useful for verification applications. One prominent detector design, now under consideration by the WATCHMAN-AIT collaboration, relies on a multi-kiloton tank of gadolinium-doped water to detect inverse beta-decay (IBD) events caused by antineutrino interactions. In such large-volume detectors, calibration is a considerable challenge, and carefully designed sources are needed which can both mimic the expected response to IBD events at various locations inside the detector volume. One proposed calibration source is 16N, which emits a beta-correlated gamma-ray with an energy of 6.1 MeV. The 16N gamma-ray is interesting because it is near the high-energy range of the gamma-ray cascade produced by neutron captures on gadolinium, and the correlated beta particle allows the gamma-rays to be time-tagged. Current designs for the 16N calibration source involve the production of 16N by irradiating CO2 gas with 14.1 MeV neutrons from a DT generator, which is then transferred to a small decay chamber inside the detector volume. Another little-considered feature of this design is that by substituting CO2 gas enriched with 17O, 17N can be produced using the same mechanism. 17N may also be interesting as a potential calibration source, as it emits beta-correlated delayed neutrons. We present initial studies on the production of 16N and 17N using a DT generator neutron source, as well as the design, construction, and initial tests of a specialized beta-tagging detector for conducting time-correlated measurements of 16N and 17N. We also report on the exploration of 241Am13C as a potential alternative source of neutrons and 6.1 MeV gamma-rays.