CEROS - National Defense
Center of Excellence for Research in Ocean Sciences

CEROS Project Description

Project: ***Deep-Ocean Anti-Neutrino Detector*** [1]

Contractor: **Makai Ocean Engineering, Inc., Kailua HI**
with the University of Hawaii, Department of Physics and Astronomy

Summary: Detection and measurement of electron anti-neutrinos offers the potential for remote monitoring of nuclear reactors and clandestine nuclear weapons testing. This project comprises a pilot study to develop technology and ascertain engineering design parameters for a deep-ocean anti-neutrino detector located near the Hawaiian Islands.

Description: Anti-neutrinos arise from radioactive decay occurring naturally from the Earth's crust and mantle, or from a hypothetical natural reactor at the Earth's core, or from man-made nuclear reactors or nuclear weapons testing. Figure 1 shows a color coded world map of the expected flux of geo-neutrons (electron anti-neutrinos from natural radioactivity), mostly due to decay of naturally radioactive Uranium and Thorium. The deep oceanic basins are relatively free of terrestrial sources of radioactive decay products, and with a sufficient depth of water to shield a detector from cosmic ray background radiation. Hawaii provides a desirable test site for an anti-neutrino detector because of the lack of signal contamination by radioactive decay products from the continental crust.

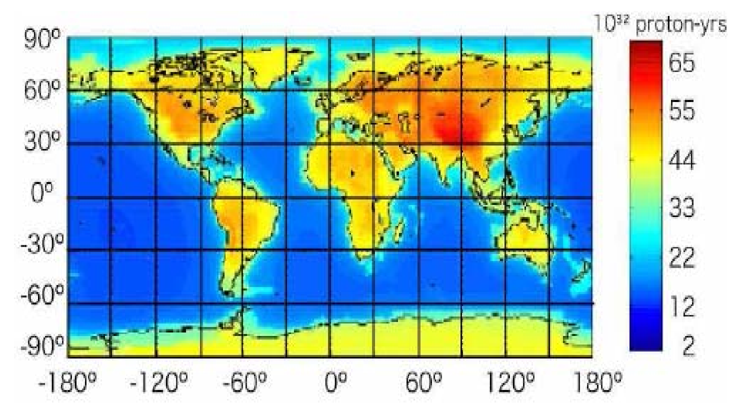

Figure 1. The predicted geo-neutrino yield (events per 10^{32} free protons per year) on the Earth's surface. The yield on continental land masses is dominant because of crustal radioactive decay. Oceanic areas have relatively little activity, due primarily from mantle radioactivity.

The long-range technical problem addressed in this work is the challenge of designing, manufacturing, and installing deep ocean detectors which could monitor nuclear reactors and nuclear bomb tests throughout the world. Anti-neutrinos pass freely through shielding materials, and thus any reactor or bomb test could not be hidden from the proposed detector.

This effort is the first step of building a 4,000 ton prototype detector to be located in deep ocean waters offshore of Hawaii. If successful, the detector could lead to monitoring nuclear reactors around the earth, and detecting clandestine fission weapons tests down to useful levels. Subsequent nuclear detectors would be much larger than the prototype design that will result from this work, and a large number of multiple detectors (as many as 500) would be distributed

[1] CEROS FY04 contract 53439, initiated 15 June 05 and entitled *A Deep-Ocean Anti-Neutrino Detector near Hawaii*.

at various locations. In addition to monitoring nuclear reactions, the detector will also provide measurements of the earth's total radioactivity and basic crustal characteristics – the initial objective of the first detector.

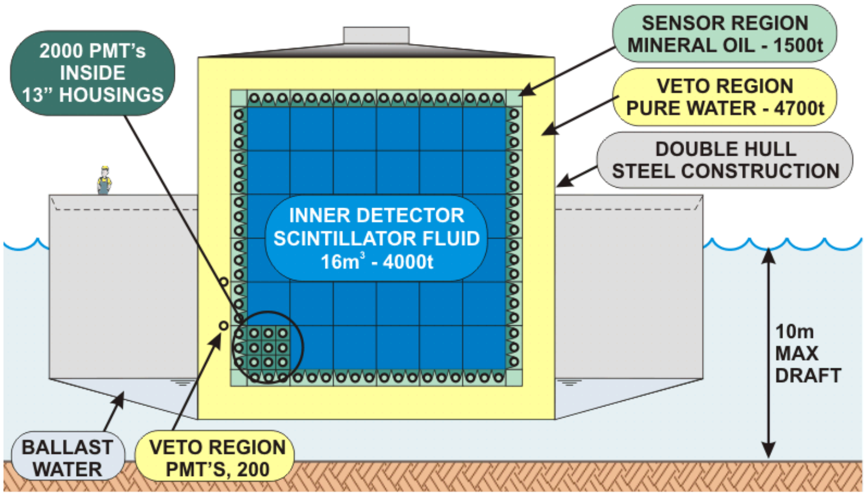

Figure 2: Conceptual design of a 4 kiloton anti-neutrino detector. This is a barge-shaped hull with a cubic reactor capable of both floating in a harbor and of submerging to 5000 m water depth.

Based on both engineering and physics considerations, the design is converging on that shown in Figure 2. The core is a large target mass (4 kton) of scintillating liquid in a transparent cube surrounded by about 2000 light sensors. The scintillator fluid provides an environment for particle collision and the resulting generation of unique light signatures; these light signals are detected by the surrounding light sensors (photo-multiplier tubes contained in glass pressure housings, as shown in Figure 3). The frequency of neutrino detections is proportional to the target mass, and the energy resolution is a function of the number of light sensors.

In addition to the stringent requirements of the physics (low radiation materials, 5000m depth, unique fluids, 2000 photo tubes, massive electronics), this design includes the practical considerations such as outfitting in Honolulu harbor, USCG safety considerations, conventional building codes (the team is using ABS codes for LNG tankers), as well as the requirements for submergence and recovery. Simulation studies of the marine engineering aspects of lifting, towing, floating, lowering, and bottom placement of the detector will be done using 3D dynamic software programs.

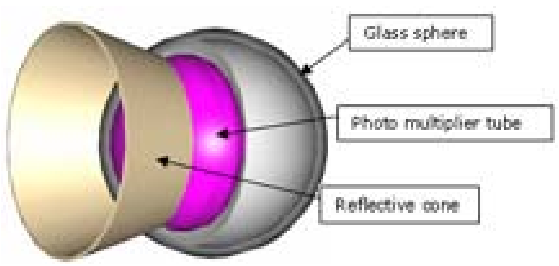

Figure 3. Photomultiplier tubes will be mounted inside glass pressure housings.

This effort does not include the construction of an actual anti-neutrino detector, but will address key design and cost estimation problems that must be resolved before requesting follow-on funding from other organizations such as the National Science Foundation (NSF) or the Defense Threat Reduction Agency (DTRA). The initial detector to be proposed to NSF and DTRA will be a geo-detector (shown above) that can measure basic radiation measurements from the earth's crust and core - measurements that are important for the background radiation in a nuclear deterrence detector and of vital interest to basic geophysical science.

This contract was performed under the sponsorship of the Defense Advanced Research Projects Agency. The content of this document does not necessarily reflect the position of the Federal Government, and no official endorsement should be inferred.