Small particle means big research for international physics project

February 17 2011

As part of a global physics project, a team of Kansas State University physics researchers is starting small.

They're looking at neutrinos, tiny particles with a major influence on physics research.

Glenn Horton-Smith, associate professor of physics, is leading the K-State exploration on the Double Chooz neutrino detector, located in the Ardennes region of northern France. The detector measures neutrinos from the nearby Chooz nuclear power plant.

More than 38 universities and research institutes from eight countries are working on the neutrino detector. K-State is one of 14 U.S. organizations involved.

Neutrinos are neutral elementary particles that come from nuclear reactions or radioactive decay, and large detectors are needed to capture and measure them.

The detector is buried more than 300 feet inside a hill a little more than a half of a mile away from the nuclear reactor and is the site of a previous neutrino experiment. Construction on the first of two new neutrino detectors finished in late 2010.

"It's exciting because we're in a data-taking stage right now," Horton-Smith said. "We're looking at the first data that is coming out and making sure everything is working correctly."

K-State scientists, along with K-State's Electronics Design Lab, designed and built the hardware for the detector's monitoring system, which measures the magnetic field and temperature throughout the detector. Horton-Smith wrote the first computer simulation of the detector, and he leads the group of researchers who work on offline data processing and simulation software.

The hardware and software help the detector measure neutrino oscillations, which are the transformations of neutrinos into different types. Neutrinos come in three different types, each an overlapping of three different mass states. As these states oscillate, a neutrino's type changes.

"It is very analogous to a musical chord, where you hear two or three frequencies at the same time," Horton-Smith said.

While two mass states have been detected in the neutrinos from reactors, the third state is either weak or absent. Researchers in the Double Chooz collaboration want to discover more about this third mass state.

To capture and measure neutrinos, the detector includes a central cylinder 10.5 cubic meters in size that is surrounded by larger cylinders. The cylinders are filled with a clear liquid scintillating oil that glows when neutrinos interact and measures energy deposited by radiation and subatomic particles. Several layers of buffer liquid and steel act as protection.

"We're really checking to see whether all three mass states are in the electron neutrino, or if one of them is missing," Horton-Smith said. "If one of them is missing, there are all sorts of theories about why that may be."

Researchers will collect data throughout the year from the first detector. The second detector, scheduled to be completed in 2012, will be even closer to the nuclear reactor -- more than 1,300 feet. By comparing data from both detectors at two different distances, researchers hope to have more accurate measurements of neutrino oscillations.

Provided by Kansas State University