The Neutrino Comes Into Its Own: How Gas Analysis Aids Neutrino Research

By Paul Nesdore

A neutrino walked into a bar and asked, "How much for a beer?" The bartender looked at the neutrino and said, "No charge."

The existence of the electrically-neutral neutrino was reported in the July 20, 1956 issue of Science, by Clyde Cowan, Frederick Reines, F. B. Harrison, H. W. Kruse, and A. D. McGuire. The neutrino has long borne the moniker of "ghost particle." Neutrinos are generated from the sun at the rate of billions per second. Most go through the earth (and your body) and never collide with another particle. This is, of course, the reason they are so hard to analyze. A 2003 Scientific American article stated that if you could construct a block of lead a light-year long (9.4 x 1015 meters), almost all of the neutrinos that impinged on the lead block would come out the other side, untouched. Here's another mind-blowing statistic: five million high-energy solar neutrinos pass through every square centimeter of your body every second. To add to the complexity, neutrinos come in three flavors and can change flavors in flight.

Recently this "ghost particle" has even taken on more allure. Experiments performed just last September measured the time-of-flight of the neutrino from CERN in Switzerland to the Gran Sasso National Laboratory in Italy. First results showed that these elusive particles appeared to travel faster than the speed of light—62 billionth of a second faster. If this were true, it would stand Einstein on his head, and suggests that his Special Relativity theory is flawed. Although one subsequent experiment confirmed this result, a recent experiment conducted at Gran Sasso laboratory, the ICARUS experiment, reported that the neutrinos did not, in fact, exceed the speed of light.

One of the beauties of gas technology is that it has so many uses in so many applications, from measuring complex gas mixtures in flue stacks at chemical and gas processing plants, to examining the neutrino. The Fermi National Accelerator Laboratory in Illinois monitors the level of oxygen and moisture in the detector medium that is used to capture neutrinos. The lab is using Tiger Optics' LaserTrace+ gas analyzer for detection of H_2O and O_2 in the detector medium (a later model, the LaserTrace 3, was a recent winner of the 2012 Gases & Instrumentation International Golden Gas Award). The neutrino detection method involves the use of a large vessel containing a network of detector wires surrounded by an electric field. All this is immersed in liquid argon. As particles pass through the medium, an ionization path is recorded as they are received by the wire network. These "liquid argon time-projection chambers" (LArTPC) are placed underground with the intention of reducing interference from cosmic rays and background radiation. The reason that oxygen and moisture need to be monitored closely at the parts-per-trillion level is that water and oxygen will absorb- the ionization electrons and thereby destroy the attempt to trace the particles.

This is just another example of how leading edge gases technology aids advanced research projects.

"We're honored that the neutrino research pioneers have chosen the most advanced instrumentation to protect the integrity of their work. It's great to be in a position to help them blaze the frontiers of science," said Dr. Graham Leggett, product manager of Tiger Optics' environmental division.