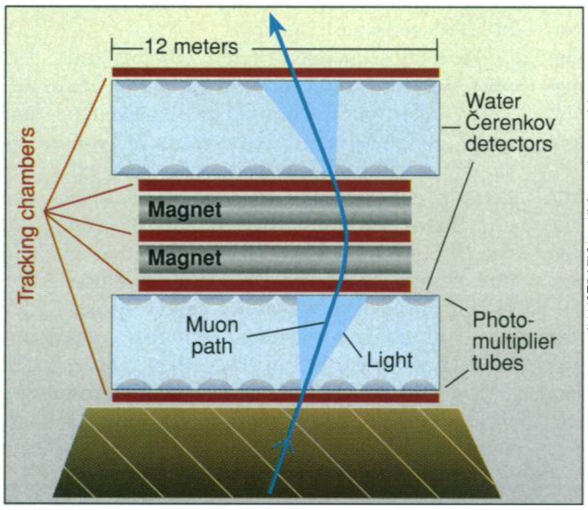
ASTRONOMY

Korea Makes a Bid to Catch Neutrinos From the Cosmos

SEOUL, SOUTH KOREA—Korean physicists are hoping that they will soon be in the thick of a global race to capture swarms of neutrinos from space. And they plan to do it by turning the logic of most other neutrino hunters on its head.

Physicists typically hunt for these elusive, little-understood particles by placing their detectors underground—in abandoned mines, deep underwater, or under antarctic ice—to screen out background signals. But a group of Korean physicists has proposed building a new neutrino telescope in a cheaper location, atop a hill. Instead of screening out background noise, the researchers are hoping to understand it so well that they can easily sift out the signals of the neutrinos they want to study.

If a prototype proves the concept, Korean science officials say that the government is likely to pony up the $10 million to $15 million required to build the telescope, called HANUL. Jewan Kim, a physicist at Seoul National University and a member of the president's science advisory council, notes that this would be the first time Korea has attempted an experimental facility of this scale and importance. "This is a real milestone for physics in Korea," he says.



Neutrino sandwich. By combining a magnetic spectrometer with detectors that register the flash from a muon, HANUL will discern the energy and other features of the original neutrino.

ILLUSTRATION: LIZ CARROLL SOURCE: HANUL

Some scientists caution that HANUL—which officially stands for High-Energy Astrophysics Neutrino Laboratory but also means "sky" in Korean—may be too small to gather a critical mass of data, and they warn that the above-ground approach is risky. "Ground level will be tough," warns John Learned, a particle physicist and veteran neutrino hunter at the University of Hawaii. But Wonyong Lee, the Columbia University physics professor heading the project, declares, "I am 100% persuaded that this can be done [above ground]." He notes that, as a bonus, the above-ground vantage will enable HANUL to pick up traces of another kind of signal from the distant universe, gamma rays.

The project grew out of discussions among Lee and Korean colleagues, who decided that an effort to build a leading-edge, large-scale experiment would help boost Korean physics to an international level. Last December, Lee and his colleague Yunsil Ho, a Columbia associate research scientist, won a 2-year, $260,000 grant from the Korea Science and Engineering Foundation to construct a proof-of-concept prototype. Lee and Ho, both native Koreans who are on leave from Columbia, hope it will lead to the construction of a full-sized detector on a hill overlooking Kangnung National University, in the northeast corner of South Korea.

The quest for neutrinos is a high-stakes and, by necessity, large-scale effort. These chargeless particles with little or no mass emanate from stars and exotic astrophysical objects, and also from cosmic rays striking Earth's atmosphere. But because they flow through matter like sunlight through glass, astrophysical neutrinos can only be captured in giant detectors. In or near the detector, an occasional neutrino sideswipes an atom, generating a muon—a charged relative of the electron—that continues in the same direction and emits a detectable flash of light known as Čerenkov radiation.

Many experiments, such as Japan's Super-Kamiokande (*Science*, 3 November 1995, p. 729), are primarily studying the neutrinos from Earth's atmosphere and the sun. HANUL would join a different group of experiments aiming to detect the higher energy neutrinos that carry clues about the distant universe. To catch these rare neutrinos, most of these experiments use long strings of photomultiplier tubes dangling in huge volumes of water or antarctic ice. They will rely on theory and simulations to separate astrophysical neutrinos from those that have closer sources.

Theoretical studies predict, however, that objects like exploding stars and black holes will produce neutrinos with distinctive energies. The distant sources will also produce different ratios of neutrinos to their antiparticles, antineutrinos. HANUL is designed to pick up these subtleties with the help of a magnetic spectrometer, paired with the Čerenkov detectors in tanks of water. By observing how a muon's trajectory curves as it passes through the magnetic field, scientists will be able to calculate whether it was spawned by a neutrino or an antineutrino and what the neutrino's energy was. That should let researchers quickly pick out the interesting signals and reject background noise, allowing HANUL to be built above ground.

If the prototype works as hoped, Lee and Ho hope to start building the full-sized detector in 2 years. As presently planned, it will be made up of 25 modules, each one a sandwich of magnets, Čerenkov detectors, and tracking chambers (see diagram). The modules would provide 1000 square meters of detector area. Says Ho, "It will then become possible to discover the high-energy neutrinos from new sources."

Ho and her colleagues hope that HANUL will also allow them to spot signs of a hypothetical massive particle called the neutralino, suggested by a speculative theory of fundamental particles and forces called supersymmetry, that might inhabit the halo of dark matter that apparently surrounds the Milky Way. Neutralinos, being slippery as well as heavy, might sometimes fall to Earth's core, where they would vanish in a flash of energy and a pulse of neutrinos. If so, HANUL might be able to pick out the stream of neutrinos emanating from a point source at Earth's center.

The biggest prize would be the detection of high-energy neutrinos from distant astrophysical sources. Catching such neutrinos may be a long shot for HANUL. Other experiments are being scaled up precisely because such events are believed to be so rare. AMANDA, an experiment in Antarctica, may eventually monitor a full cubic kilometer of ice, which would make its coverage area 1000 times larger than HANUL's. But Francis Halzen, a physicist at the University of Wisconsin who is involved in AMANDA, says he is a "big fan" of HANUL, noting that it will monitor an energy range covered by no other detector. "You create your window of opportunity, and there is something there to see that nobody has seen before."

Even without the prize of neutrinos from distant sources, HANUL would be a proud symbol of Korea's growing scientific abilities. Seoul National's Kim says that the facility will allow graduate students and even undergraduates to "learn cutting-edge techniques first-hand." He says it could also inspire millions of young people to consider becoming scientists. "That could be the biggest benefit to Korea."

–Dennis Normile