New Underground Particle Detectors Proposed for Europe

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Three new giant underground particle detectors have been proposed for construction in Europe that could help achieve some major milestones in physics, such as verifying the decay of a proton, which has been theorized but never observed. In turn, this could lead to a new understanding of how our universe evolved.

A large group of European scientists makes the case for these "next generation" underground detectors and describes them in detail in a recent paper in the *Journal of Cosmology and Astroparticle Physics*.

In addition to searching for evidence of proton decay, the detectors could help scientists learn more about astrophysical neutrinos, those produced by supernovae, the Sun, and cosmic-ray interactions in our atmosphere. Particularly, gathering better data on the energy spectra of astrophysical neutrinos could help scientists better understand star evolution.

The detectors could also increase our understanding of geo-neutrinos, those in Earth's interior. Detecting neutrinos produced in the radioactive decay of heavy elements within Earth is an unexploited field of research that could open a rare window into Earth's inner environment.

The detectors all consist of giant cylinders, but will be filled with three different liquids as the detection media. As such, the detectors will, to some extent, complement each other, each having some capabilities the others do not.

The Giant Liquid Argon Charge Imaging ExpeRiment (GLACIER) is proposed for construction in a giant salt mine in Sieroszewice, Poland. GLACIER would consist of a vertical cylinder about 70 meters wide and 20 meters tall, filled with boiling liquid argon. When a particle enters the tank, it would interact with the argon and ionize some of the argon atoms. The interaction would also cause some of the argon atoms to "scintillate," or emit light. A second type of light, Cherenkov radiation, would also be emitted. This occurs when the particle entering the argon is traveling faster than the speed of light in argon. Both types of photons would be collected by photomultiplier tubes immersed in the liquid argon.

Along with the ionization data, scientists at GLACIER will be able to use the scintillation and Cherenkov light signals to work backward and determine what type of particle entered the tank.

Another experiment, the Low Energy Neutrino Astronomy (LENA) detector, would be a horizontal cylinder 100 meters long and 30 meters in diameter. An inner cylinder, about 13 meters in diameter, would contain a type of liquid scintillator, a cocktail that is especially good at absorbing high-energy electromagnetic or charged-particle radiation and almost instantly emitting the energy as photons.

LENA's outer cylinder would be filled with water to filter out muons, common particles that are like very heavy versions of electrons. Photomultipliers would line the cylinder to collect the scintillated light for analysis. The preferred location for LENA is the Center for Underground Physics in Pyhäsalmi, Finland.

The third detector is MEMPHYS, the MEgaton Mass PHYSics experiment. MEMPHYS would consist of between three and five cylinders, each 65 meters long and 65 meters wide. MEMPHYS would be filled with plain water and would detect fast-moving particles based on the Cherenkov radiation they produce as they interact with the water. This light would be collected by photomultiplier tubes lining the tank's inner wall. The proposed location for MEMPHYS is the Fréjus Underground Laboratory in Fréjus, France.

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