

Physics monitor

The chemical plant at the SAGE Gallium Germanium Neutrino Telescope, Baksan, Caucasus mountains.

Atmospheric neutrinos

Since 1961 physicists have known that neutrinos exist in several varieties, each associated with a different type of weakly interacting particle, electron, muon, or tau. However new results continue to suggest that neutrinos, long thought to be massless, have mass and can change their allegiance, or 'oscillate'.

Primary cosmic rays from outer space crashing into the Earth's atmosphere produce showers of particles which eventually decay via weak interactions, producing 'atmospheric' neutrinos. Both muon-like and electron-like neutrinos are produced, the former via pion decays into muons and from subsequent muon decay, the latter only from muon decay (a negatively-charged muon decays into an electron accompanied by an electron antineutrino and a muon neutrino). Thus detectors expected to see about twice as many muon neutrinos as electron neutrinos.

In the 1980s, a new generation of large underground experiments began to search for signs of proton decay, predicted to occur at a very low rate by 'grand' unified theories. However when these experiments saw no signs of proton decay, they turned their attention to neutrinos, and the observations of the 1987A supernova marked the advent of a new branch of physics - neutrino astronomy.

Atmospheric neutrinos might appear less intriguing than their cosmic counterparts, but soon several experiments reported a dearth of muon-like atmospheric neutrinos, some 40% down on the expected level.

This puzzle is now underlined by initial results from second generation studies, the Japanese Super-Kamiokande detector with 50,000 tonnes of water monitored by 11,000 large photomultipliers (July 1996, page 22), and the Soudan-II (Argonne/Minnesota/Oxford/Rutherford Appleton/Tufts) with a 960 tonne tracking calorimeter.

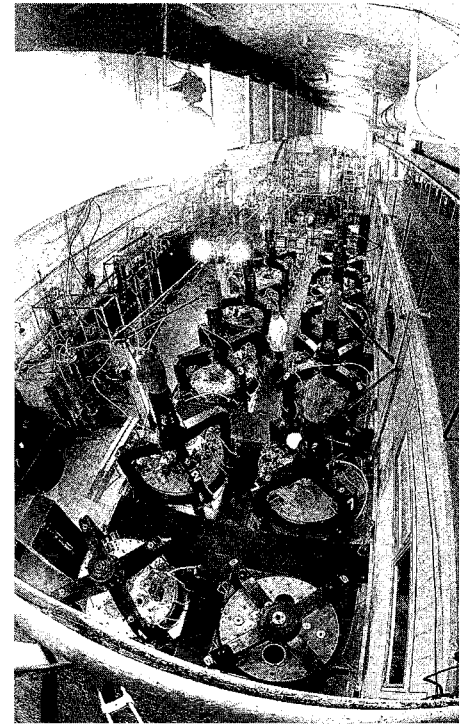
The signals picked up by these deep underground detectors are subject to a variety of background effects, including neutron production by muons in the intervening rock, and a new CERN experiment (June 1996, page 1) is setting out to better measure this.

However it is tempting to see such consistent deficiency of muon neutrinos as evidence for their oscillation into electron-like neutrinos en route. For Super-Kamiokande, the suggestion is amplified with a directional dependence observed by the smaller initial Kamiokande experiment now looking to be underlined by its big brother, with the deficiency most marked for particles entering the detector from below. Neutrinos can fly right through the Earth before hitting the detector, but these have travelled much further than those arriving from above, and have a correspondingly higher probability of converting if neutrino masses are around 0.1 eV.

While there is much speculation in the courtroom, the atmospheric neutrino jury is still out.

Particles and cosmology at Baksan

The international schools organized by the Institute for Nuclear Research of the Russian



Academy of Sciences (INR) at Baksan Valley, Kabardino Balkaria, provide an unusual slant on particles and cosmology.

The Baksan Valley in the Caucasus mountains is the home of the Baksan Neutrino Observatory of INR with underground installations including the Gallium-Germanium Neutrino Telescope (SAGE), the Underground Scintillation Telescope and other low background facilities, as well as the Carpet and Andyrchi surface extensive cosmic ray air shower arrays.

The Baksan talks traditionally emphasize solar neutrinos. With the results of ongoing experiments, presented by V.Vermul (SAGE), J.Kiko (GALLEX) and K.Lande (Homestake), pointing to a particle physics solution of the solar neutrino problem, urgent need for fresh data on various parts of solar neutrino