COSMIC-RAY INDUCED 'μ-e' EVENTS

T.B. Novey,
Argonne National Laboratory.

We were interested in looking for these neutral cosmic-ray induced 'μ-e' events reported by Cowan and started to do this about a year ago.

This work was done by R.A. Lundy and D.D. Yovanovitch. Now the main thing is to decide, do you have a neutrino plus a nucleon producing a muon, or do you have cosmic-ray muons, which then come into equilibrium with neutrons from muon stars, which then produce pions in these large liquid scintillator detectors and lead to the 'μ-e' decay chain? You can see the neutral produced 'μ-e' decay in this way. This is what we set out to test because we suspected that perhaps this might be the case.

We built a 2½ ft cube of liquid scintillator surrounded by plastic sheets which fit together very closely making a tight anticoincidence shield, and we then began to look for neutral induced 'μ-e' decays. The electronics system is triggered by a self-coincidence with a delay from 0.05 to 2 μsec. If there is no signal from the anticoincidence, the tank signal is displayed on an oscilloscope. You should see then, two pulses indicated a μ produced and μ decaying into an electron or it could be a pion produced stopped and decayed to a muon and then to an electron. We cannot distinguish the π-μ decay in this large size detector. So then you look at this rate. Well, we saw plenty of these, of course, as there is known to be a considerable neutron intensity at ground level and we began to put concrete around the detector. Eight feet of concrete around this entire assembly is sufficient so that the muons are now in equilibrium with neutrons which they produce, and so this rate no longer drops off rapidly with absorber. At this point, we obtained 0.5 events per hour in a half ton of liquid scintillator, or one event per-ton-per-hour at 8 m water equivalent. Now this is to be compared with Cowan's one event per hour in a ¼ ton of liquid scintillator at 200 m water equivalent underground, or four events per-ton-per-hour, so our rate is already considerably lower even at near ground level. One can calculate the rate of these events expected from the known cosmic-ray muon spectrum and it agrees closely with the observed event rate. Now the last point to prove is - are these pion produced? This was checked by placing scintillator up on top of the shielding and photographing its signal on the oscilloscope also. Then, when you see one of the 'μ-e' events, you look to see if a charged particle came in through the top. The results show that about 40% of the 'μ-e' events were associated with a charged particle coming in the top counters. This area sees about 40% of the incoming cosmic-ray flux. It seems therefore that for > 10 m water equivalent absorber, all of the neutral induced 'μ-e events that we see can be associated with neutrons produced by electromagnetic interaction of muons.