

counters  $6 \times 12 \times 10$  meters (PHYSICS TODAY, May 1966, page 88).

The only known ways to make large amounts of high-energy muons are from the decay of pions or kaons. Pions or kaons have relatively long lifetimes; accordingly, they need time (and consequently a long mean free path) to decay. Tangential pions and kaons stay longer in the rare portions of the atmosphere, so it was expected that the muon flux would be much greater tangential to the earth's atmosphere than perpendicular. Since the Utah experimenters see almost no variation, they conclude that the majority of cosmic-ray muons with energies greater than 1000 GeV are produced either directly or as the progeny of a parent that decays copiously into muons with a lifetime much shorter than that of the kaon.

The experiment has excited considerable interest. One intriguing candidate for parenthood is the long-sought intermediate boson (W particle), which might be the carrier of the weak interaction. Keuffel and his collaborators suggest that experimenters should now look in emulsions for high-energy muons and electrons, which would be expected if a W particle was being produced.

# IN BRIEF

On 7 Dec. the National Bureau of Standards Reactor (PHYSICS TODAY, November 1966, page 38) went critical. The heavy-water-moderated reactor, intended primarily for materials research, will be tested at low power until money to run it at 10 MW is available.

The Graphite Low Energy Experimental Pile (GLEEP) at Harwell celebrated its 20th anniversary in August, and is now the world's oldest operating reactor. The graphite reactor at Oak Ridge ran for 20 years, also, but was shut down on its birthday in 1963. GLEEP is currently being used for materials testing at a low operating power of 3 kW; it has been run at 80 kW.

A spacecraft should rendezvous with Halley's Comet on its next appearance (in 1985-86), according to Herman Michielson of Lockheed. He says it may even be possible to land on the comet's solid nucleus.

Meanwhile the Utah experimenters are adding additional muon detectors along the tunnel. By measuring the transverse momentum that muon pairs have with respect to each other, the group hopes to find out if the parent or parents are very heavy.

Results were reported in *Phys. Rev. Letters* 19, 1487 (1967).

## Deuteron D-State Helps Explain J Dependence in p,d Reaction

The type of spin dependence in direct nuclear reactions that was found in 1964 by Rubby Sherr, Ernest Rost and Martin Rickey appears to be explained well by some recent calculations of R. C. Johnson and Filipe D. Santos of the University of Surrey (reported at the Tokyo Nuclear Structure conference). The theorists, using the distorted-wave Born approximation, calculated cross section as a function of angle for p,d and d,p reactions. They found that, although the deuteron wave function is predominantly S-state, one must also include D-state contributions in the calculation to account for the forward-angle variation of deuteron angular distributions with the spin J of the final nucleus. Large-angle spin dependence, also discovered in 1964 by Linwood Lee Jr and John Schiffer, awaits explanation.

The midlatitude auroral red arc, a faintly glowing toroid that encloses the earth, will be studied by a new observatory being built at the University of Michigan.

Bunching of Van Allen electrons has been discovered by a Bell Labs experiment aboard ATS-1, a communications satellite in synchronous orbit. Irregular fluctuations in the solar wind apparently cause the bunches, which can be followed through several transits through the belt. Distortions of the belt by solar wind cause a day-to-night variation by factors of 10 to 100.

A nuclear-powered heart pacemaker expected to last ten years is being tested by AEC. Although the present model is electrically powered, eventually the device will use the heat from  $\text{Pu}^{239}$  decay to produce electricity.

Neptunium isotopes now number 13 with the discovery of  $\text{Np}^{229}$  and  $\text{Np}^{230}$  at Oak Ridge by R. L. Hahn, M. F. Roche and K. S. Toth. □

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