APR13-2013-000505

Abstract for an Invited Paper
for the APR13 Meeting of
the American Physical Society

Bonner Prize Talk – First Laboratory Observation of Double Beta Decay

MICHAEL MOE, University of California, Irvine

Although we are awash in neutrinos, we remain ignorant of some of their fundamental properties. We don't know their masses. We don't know whether "anti-neutrinos" are really distinct particles. Double beta ($\beta\beta$) decay offers a handle on these questions if we can observe the energy spectrum of the two emitted electrons, and determine whether or not they share their energy with two neutrinos. Seeing neutrinoless (0ν) decay would solve some enduring puzzles. The power of the process to elucidate the neutrino was recognized in the 1930's, but $\beta\beta$ decay would be exceedingly rare and difficult to detect. Unsuccessful laboratory searches had been going on for 25 years when the UC Irvine group began its first experiment with a cloud chamber in 1972. After some background for the non-expert, and a snapshot of the theoretical and experimental milieu at the time, the talk will begin with the reasons for choosing a cloud chamber, and the taming of its balky and idiosyncratic behavior. The talk will end with the first definitive observation of two-neutrino $(2\nu)\beta\beta$ decay of ^{82}Se in the vastly superior time projection chamber (TPC) in 1987. Discouragement through the tortuous 15-year interval was relieved by occasional victories. Some I will illustrate with revealing cloud-chamber photographs. We learned many things from this primitive device, and after seven years we isolated an apparent $\beta\beta$ decay signal. But the efficiency of the trigger was small, and difficult to pin down. Estimating 2.2%, we were way low. The resulting "short" ^{82}Se half-life of 1 x 10^{19} years was suspect. New technology came to the rescue with the invention of the TPC. Experience with the cloud chamber guided our design of a TPC specifically for $\beta\beta$ decay. The TPC was built from scratch. Its long, steep learning curve was also punctuated with little triumphs. A memorable moment was the first turn-on of a portion of the chamber. So long ago, this all seems rather quaint, but through ample use of photographs and anecdotes it makes and interesting story. As a digital device, the TPC made data acquisition and analysis orders of magnitude simpler and faster. After seven years of massage, the TPC yielded good evidence for 2ν decay of ^{82}Se with a half-life near 10^{20} years. While the 0ν mode was not in evidence, finally seeing $\beta\beta$ decay in the laboratory created optimism about an eventual 0ν discovery.