LA-UR -84-4015

LA-UR--84-4015

DE85 005557

TITLE: STATUS OF THE LOS ALAMOS FREE ATOMIC TRITIUM BETA-DECAY EXPERIMENT

AUTHOR(S): J. F. Wilkerson, T. J. Bowles, J. C. Browne, T. H. Burritt, J. S. Cohen, J. A. Helffrich, D. A. Knapp, M. P. Maley, R. L. Martin, and R. G. H. Robertson

SUBMITTED TO: The Proceedings of the American Physical Society Division of Particles and Fields Fall Meeting, Santa Fe, New Mexico, October 31 - November 3, 1984.

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

STATUS OF THE LOS ALAMOS FREE ATOMIC TRITIUM BETA-DECAY EXPERIMENT

J.F. Wilkerson, T.J. Bowles, J.C. Browne, T.H. Burritt, J.S. Cohen, J.A. Helffrich, D.A. Knapp, M.P. Maley, R.L. Martin, and R.G.H. Robertson

Los Alamos National Laboratory
Los Alamos, New Mexico, USA

An experiment to study the beta-decay of tritium using a gaseous source of free (unbound) atomic tritium is currently underway in the Physics Division at Los Alamos. The use of free atomic tritium along with careful design of the measurement scheme should allow a definitive determination for an electron antineutrino mass ~10 eV.

Measurements of the beta-decay spectrum of tritium in a solid source (tritiated valine) by Lyubimov et al.[1] indicate a non-zero electron-antineutrino mass. However, complications inherent in a complex tritiated source raise concerns about the validity of ITEP results. An experiment to study the beta-decay of tritium using a gaseous source of free (unbound) atomic tritium is currently underway at Los Alamos. The use of free atomic tritium should yield the most unambiguous results possible. We will now describe the experiment and point out a few of its characteristics important to making an accurate measurement.

The apparatus, shown in Fig. 1, consists of three principal sections: a source region, a pumping restriction and extraction region, and a toroidal magnetic spectrometer. The basic concept of the experiment is to measure the beta-decay spectrum of an intense gaseous atomic tritium source. An extended source is required to reach a sufficient source intensity. Placing this source in a strong axial magnetic field with a pinch at one end allows one to extract most of the betas from the tritium decays into the extraction region. The pumping restriction and extraction region serves two purposes: to stop tritium molecules from reaching the spectrometer and to focus the betas emerging from the source region into the spectrometer. The toroidal spectrometer analyzes the momentum of the betas, allowing a precise measurement of the tritium energy spectrum near the endpoint.

The source region consists of a 4 m long 3.8 cm diameter highly polished aluminum tube which is pumped by Hg diffusion pumps located at both ends. An RF dissociator produces the atomic tritium gas which enters the tube at the midpoint between the two pumps. The tube is cooled to a temperature of about 120 Kelvin to minimize recombination of the atomic gas. The expected integrated source intensity will be 10^{15} - 10^{16} tritium atoms/cm^2 of 85-90% pure atomic tritium.

Sapphire standoffs allow the aluminum tube to be thermally regulated but electrically isolated, so that the potential of the tube can be varied up to 20 kV. This is one of the critical features of the experiment. By biasing the source tube, the betas that decay in the source region are accelerated when they emerge into the extraction region. Hence, the betas from the source region can be differentiated from background tritium decays that occur elsewhere in the system. Another advantage of varying the source potential is that it is possible to step the source voltage

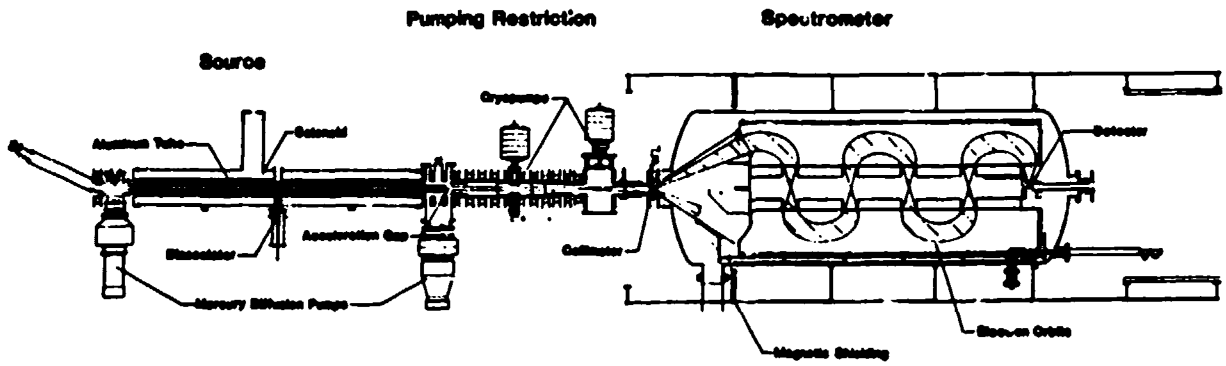

Fig. 1. Cross section of experimental apparatus. The overall length of the apparatus is 16 m.

instead of the spectrometer magnetic field.

The source tube is enclosed in a magnetic solenoid which produces a field on the order of 1.5 kG with a small axial gradient. The electrons are constrained to spiral about the field lines, allowing 93% of the betas from tritium decays in the source region to enter the extraction region.

The pumping restriction and extraction region is a differential pumping system which allows a windowless source while limiting tritium contamination of the spectrometer to 2.5 mCi/day. The accelerated beta particles from the source are focused to a collimator located at the object of the spectrometer. The collimator limits the acceptance of the spectrometer so that no betas that emerge from or strike the source walls enter the spectrometer. The extraction efficiency has been measured to be 25% with a ^{169}Yb source and is in good agreement with ray-tracing calculations.

The design parameters of the toroidal spectrometer, an improved version of an earlier design by Tret'yakov[2], have been described previously[3]. The resolution of the spectrometer is determined mainly by source diameter and is calculated to be about 30 eV FWHM for 25 keV electrons and a 1 cm diameter source. A two axis cosine coil active magnetic shielding system surrounds the spectrometer and cancels the ambient magnetic field to the necessary 20 milligauss level. The detector is position and energy sensitive.

Understanding the system's characteristics and behavior is critical to obtaining unambiguous results. There is a variety of both offline and online diagnostics to ensure that we understand our system. Offline diagnostics include an electron gun to study orbits, wall effects, and resolution parameters. Several solid sources and a gaseous ^{83m}Kr line source will also be used to study system resolution and extraction. Online diagnostics include a detector to monitor total source activity, a UV laser to determine the molecular fraction of the source gas, and a residual gas analyzer to monitor gas composition.

The construction of the experimental apparatus is nearly complete. Data taking should commence within the next year. We expect a count rate of 1 Hz in the last 100 eV below endpoint and an ultimate sensitivity to neutrino mass better than 10 eV.

1. V.A. Lyubimov et al., Zh. Eksp. Teor. Fiz. 81 1158 (1981); V.A. Lyubimov et al., to be published.

2. E.F. Tret'yakov, Izv. Akad. Nauk. SSR, Ser. Fiz. 39, 583 (1975).

3. T.J. Bowles et al., AIP Conference Proceedings 99 (1983) p 17-24.