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KATRIN - DIRECT MEASUREMENT OF NEUTRINO MASSES IN THE SUB-EV REGION

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ABSTRACT

The KArlsruhe TRItium Neutrino Mass Experiment is a next generation tritium beta decay experiment designed to reach a sensitivity of 0.2 eV/c^2. KATRIN will allow to investigate the role of the neutrino hot dark matter in the evolution of large scale structures of the universe and will also allow to discriminate between so-called hierarchical and quasi-degenerated neutrino mass models. The status of the first components of the final KATRIN setup will be shown.

1 Introduction

Recent ν-oscillation experiments (e.g. [1]) give compelling evidence that neutrinos have nonzero mass from the observation of neutrino flavor changes. However, these experiments are only sensitive to differences between squared neutrino masses. Neutrinos with masses in the sub-eV range could play an important role as hot dark matter in the evolution of large scale structures of the universe. A measurement of the absolute masse scale of neutrinos could also be decisive in selecting different neutrino mass models. The most stringent model independent upper limits on the neutrino mass are given by recent tritium β decay experiments [2, 3] which are so called "direct mass measurements". Since these experiments have reached their sensitivity limit, it is necessary to investigate which sensitivity could be achieved by a new tritium β decay endpoint experiment (KATRIN).

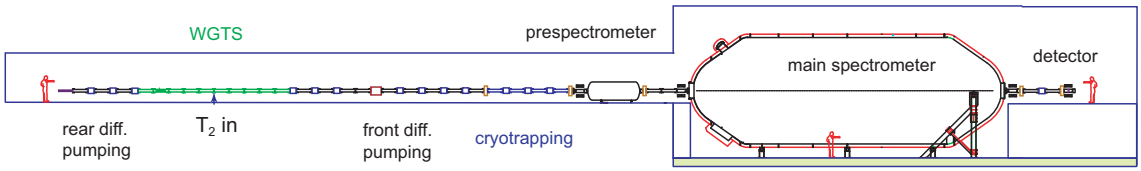

Figure 1: *Sketch of the KATRIN experiment setup (side view).*

2 The KATRIN experiment

The KATRIN experiment is based on the well proven concept of recent tritium β decay experiments. A sketch of the side view is shown in Figure 1. The key components are a Windowless Gaseous molecular Tritium Source (WGTS), differential pumping sections at the front and rear side, a cryotrapping section, a system of a pre- and a main spectrometer and a segmented detector. The KATRIN collaboration has improved the proposed setup compared to its Letter of Intent [4]: A larger source diameter (90 mm) combined with a larger main spectrometer diameter (10 m), a higher tritium purity (95 %), an optimized measurement point distribution and improved systematics. Recent simulations for 3 years of data taking result in a neutrino mass sensitivity of 0.2 eV/c^2 (90% C.L.) with statistical and systematic uncertainties contributing about equally. A non-zero neutrino mass of 0.35 eV/c^2 would be detected with a 5 σ significance.

3 The status of first components for the final KATRIN setup

Exemplary for the ongoing work of the KATRIN setup, the status of the source and transport system and the pre-spectrometer - two of the first components for the final KATRIN setup - shall be shown.

The WGTS will allow to determine the neutrino mass with a minimum of systematic uncertainties from the tritium source. The transport system will guide the β decay electrons adiabatically from the source to the spectrometer, while at the same time eliminating any tritium flow towards the spectrometer, which has to be kept practically free of tritium for background reasons. This will be done by a combination of differential (DPS-F) and cryogenic (CPS-F) pumping sections (Figure 2). A decision of the reference setup of the source and transport system for KATRIN has been made in February 2003. The specification of the DPS2-F has been completed in June 2003 and the tender action has been started. The specification of the WGTS and the rest of the transport system is in progress.

The main duty of the pre-spectrometer in the final KATRIN setup is to

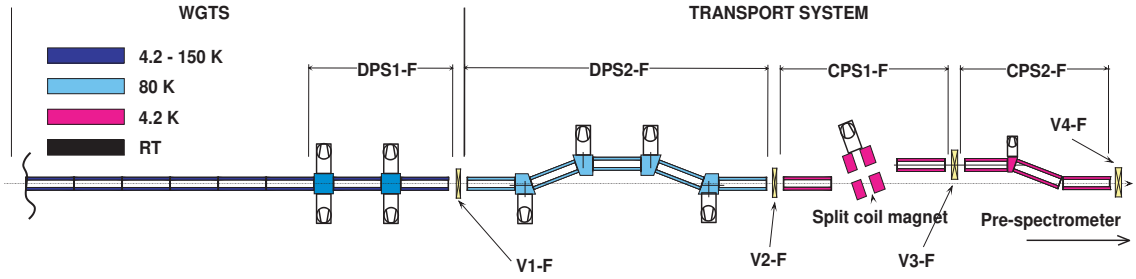

Figure 2: *Reference setup for the KATRIN source and transport system*

reject low energy β decay electrons, thus limiting the number of β electrons in the main spectrometer, which reduces background levels. In the current phase, the pre-spectrometer will help to verify features of the main spectrometer design: The vacuum characteristics, the novel concept of putting the whole spectrometer on retarding potential (18.6 keV) and the electro magnetic design. For background reasons the final pressure in the spectrometers has to be below $1 \cdot 10^{-11}$ mbar and the outgassing rate has to be below $1 \cdot 10^{-13}$ $\frac{\text{mbar} \cdot \text{l}}{\text{s} \cdot \text{cm}^2}$. These requirements have recently been met with a vacuum test chamber. The pre-spectrometer is currently manufactured by the company SDMS and will be delivered in September 2003. A substantial test programme will start directly thereafter.

4 Summary

KATRIN is a next generation direct neutrino mass experiment with a sensitivity on the neutrino mass of 0.2 eV/c^2. This allows to distinguish between different neutrino mass models and to check the role of the neutrinos in structure formation. The installation of the first components of the final setup is under way: The reference setup for the source and transport system has been approved, the tender action for the first parts has been started. The pre-spectrometer will be delivered in September 2003 and the vacuum requirements have been met with a test chamber. Tests with the pre-spectrometer concerning the design of the main spectrometer will start soon.

References

1. K. Eguchi et al., Phys. Rev. Lett. **90** (2003) 021802.

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3. V.M. Lobashev et al., Nucl. Phys. B (Prec. Suppl.) **91** (2001), 280.

4. A. Osipowicz et al. (KATRIN collaboration), hep-ex/0109033.