T 11: Neutrinophysik 1 (Neutrinomassen)

Zeit: Montag 16:45–19:05 Raum: VSH 17

Gruppenbericht T 11.1 Mo 16:45 VSH 17

Status of the KATRIN Experiment — •Fabian Harms for the KATRIN-Collaboration — Karlsruhe Institute of Technology (KIT), Institute for Nuclear Physics (IKP)

The KArlsruhe TRItium Neutrino (KATRIN) Experiment is a large-scale experiment for the model independent determination of the effective mass of the electron-antineutrino with a sensitivity of 200 meV/c^2 (90% C.L.). It investigates tritium β-decay close to the kinematic endpoint of the energy spectrum with a high-resolution electrostatic spectrometer (ΔE = 0.93 eV at 18.6 keV).

The KATRIN experimental setup consists of a high luminosity windowless gaseous tritium source (WGTS), a magnetic electron transport system with differential and cryogenic pumping for tritium retention, a series of two electrostatic spectrometers (pre-spectrometer and main spectrometer) for energy analysis, and a detector system based on a segmented silicon PIN diode detector for efficient counting of transmitted β-electrons.

With all main components on site at KIT, the experiment celebrated 'FirstLight' on 14$^{\text{th}}$ October 2016 by successfully transmitting electrons through the 70-m long experimental setup. The talk will present the current status of the experiment and give an overview on the results of the recent FirstLight measurement campaign.

We acknowledge the support by KSETA, BMBF (05A14VK2), HAP and the Helmholtz association.

T 11.2 Mo 17:05 VSH 17

Project 8: Towards measuring the neutrino mass using CRES — •Christine Claessens and Sebastian Böser — Institut für Physik, Johannes Gutenberg-Universität Mainz

The Project 8 collaboration seeks to measure the absolute electron neutrino mass by investigating the endpoint of the tritium beta decay spectrum using a frequency based method. To this purpose the collaboration has recently established Cyclotron Radiation Emission Spectroscopy (CRES) as a new method to determine the energy of relativistic electrons. By trapping electrons from krypton decay in a magnetic field to increase the integration time, the detection of single electrons and the reconstruction of their kinetic energy from the measured cyclotron frequency has successfully been demonstrated (Phys. Rev. Lett. 114, 162501). In this talk the proof of principle prototype design and current results are presented. Furthermore, insight on one of the main challenges for the forthcoming scale-up of the experiment, the development of a fast frequency based trigger, is given.

T 11.3 Mo 17:20 VSH 17

The Electron Capture in ^{163}Ho experiment — •Federica Mantegazzini for the ECHo-Collaboration — Kirchhoff-Institute for Physics, Heidelberg University, Germany

The Electron Capture in ^{163}Ho (ECHo) experiment is designed to investigate the electron neutrino mass with sub-eV sensitivity by the analysis of the electron capture spectrum of ^{163}Ho. The sensitivity on the electron neutrino mass is crucially related to the energy available for the decay $Q_{\mathrm{EC}} = 2833(30_{\mathrm{stat}})(15_{\mathrm{sys}})$ eV, which has been precisely determined by the ECHo collaboration. Accordingly, a sensitivity below 10 eV at the end of the present phase of the experiment, ECHo-1k, is expected. During this phase about 1 kBq of high purity ^{163}Ho source will be implanted in arrays of low temperature metallic magnetic calorimeters operated in a reduced background environment. The goals of the current phase are the precise characterization of the parameters describing the spectrum, the optimization of the detectors production and the identification and reduction of the background sources. These results will pave the way to the second phase of the experiment, ECHo-1M, where an activity of 1 MBq will be used, in order to reach a sub-eV sensitivity on the electron neutrino mass. Furthermore, the high statistics and high resolution measurement of the ^{163}Ho electron capture spectrum will allow the investigation of the existence of sterile neutrinos at the eV- and keV-scale up to a mass value of Q_{EC}. In this contribution, a general overview of the ECHo experiment is presented and the current status as well as the future perspectives are discussed.

T 11.4 Mo 17:35 VSH 17

Description of the calorimetrically measured Ho-163 spectum — •Dorothea Fonnesu for the ECHo-Collaboration — Kirchhoff-Institute for Physics, Heidelberg University

The study of the end-point region of calorimetrically measured Ho-163 electron capture spectrum will allow, in the next future, to achieve sub-eV sensitivity on the electron neutrino mass. Within the ECHo experiment, first high statistics Ho-163 spectra have been measured with very high energy resolution. Such precise measurements allowed the identification of structures in the Ho-163 spectrum which are not described if only first order excited states, consisting in a hole in the electronic shells of the daughter atom left by the captured electron, are considered. Second order excited states in the daughter dysprosium atoms characterized by two holes in the atomic shells could be the reason of the additional structure in the spectrum. We present the comparison of the high statistics Ho-163 spectra acquired in a low background environment with theories including second order excited states. At the present status there is not a clear agreement between theory and data. We discuss how new high statistic measurements of the Ho-163 spectrum and new experiments could provide inputs to better understand the role of higher order excited states occurring after electron capture processes.

T 11.5 Mo 17:50 VSH 17

FirstLight measurements of the KATRIN experiment — •Moritz Hackenjos — Karlsruhe Institute of Technology (KIT), Institute for Technical Physics (ITEP)

The KArlsruhe TRItium Neutrino (KATRIN) experiment aims to determine the effective mass of the electron-antineutrino with an sensitivity of 200 meV/c^2 (90% C.L.) by the investigation of the endpoint energy-region of the tritium β-spectrum in a direct and model-independent way. Therefore, Molecular tritium gas will be injected continuously in the center of a Windowless Gaseous Tritium Source (WGTS). β-electrons from tritium decay are then guided via superconducting solenoids along the 70-m long experimental beamline towards two electrostatic spectrometers used for high-precision energy analysis. A segmented detector at the end of the beam line efficiently counts those electrons which overcome the retarding potential of the spectrometers.

With only 2×10^{-13} β-electrons found in the last 1-eV region of the tritium β-spectrum, it is of utmost importance to use most of the WGTS high luminosity. Therefore an adiabatic guidance of the β-electrons along the experimental setup without energy or statistics loss is crucial to reach the KATRIN design sensitivity.

In fall 2016 the full KATRIN beamline was run in joint operation for the first time during a FirstLight commissioning measurement campaign. This talk will focus on the overall beam line alignment of KATRIN which was studied in a series of dedicated measurements during FirstLight.

T 11.6 Mo 18:05 VSH 17

Simulation of global beamline alignment of the KATRIN experiment — •Marco Deffert for the KATRIN-Collaboration — Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen

The KArlsruhe TRItium Neutrino (KATRIN) experiment aims to determine the effective mass of the electron anti-neutrino with a sensitivity of 200 meV/c^2 (90 % C.L.) by investigating the kinematics of tritium β-decay. For this purpose it uses a high luminosity windowless gaseous tritium source ($A = 10^{11}$ Bq) combined with a high resolution electrostatic spectrometer ($\Delta E = 0.93$ eV at 18.6 keV). In fall 2016 First Light measurements were performed with the full KATRIN beamline when electrons were guided magnetically through the 70-m long setup for the first time.

In order to simulate the electron transport and interactions in KATRIN the KASSIOPEIA particle tracking framework has been developed. This talk will focus on the implementation of the full KATRIN beamline into KASSIOPEIA and first results on simulations of the electron transport with regards to the First Light measurements.

We acknowledge the support by KSETA, BMBF (05A14VK2), HAP and the Helmholtz association.

T 11.7 Mo 18:20 VSH 17

First results of the commissioning of the Windowless Gaseous Tritium Source of the KATRIN experiment — Moritz Hack-

enjos, Alexander Marsteller, and •Hendrik Seitz-Moskaliuk for the KATRIN-Collaboration — Karlsruher Institut für Technologie, Institut für experimentelle Kernphysik, Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen

KATRIN will perform a direct, kinematics-based measurement of the neutrino mass with a sensitivity of 200 meV (90 % C. L.) reached after 3 years of measurement time. The neutrino mass is obtained by determining the shape of the spectrum of tritium beta decay electrons close to the endpoint of 18.6 keV with a spectrometer of MAC-E filter type. Important requirements to achieve this goal are the temperature stability and homogeneity of the beam tube of the Windowless Gaseous Tritium Source (WGTS). The temperature stability is specified to be within ±30 mK/h and the temperature homogeneity is specified to be within ±30 mK along the 10 m long WGTS beam tube.

During the first light measurement campaign in fall 2016, the cryogenic performance of the WGTS was tested in detail. This talk presents the results of this first cryo-test of the source cryostat showing that the WGTS is ready for standard KATRIN operation.

This work is supported by BMBF (05A14VK2) and the Helmholtz Association.

T 11.8 Mo 18:35 VSH 17

Project 8: Atomic Tritium Motivation and Source Design — •Alec Lindman, Sebastian Böser, and Peter Peiffer — Institut für Physik, Johannes Gutenberg Universität Mainz

Project 8 is a phased approach to measuring the absolute neutrino mass with Cyclotron Radiation Emission Spectroscopy (CRES) of tritium beta decay electrons. This talk will discuss the motivations for an atomic T source and the supporting apparatus design in light of engineering feasibility and the design sensitivity. All existing T β-decay m_ν measurements use molecular T_2, which has a relatively broad final states spectrum. An atomic T source and a few cubic meter trap volume will enable the target sensitivity. Parallel technology development efforts in Project 8 aim to deliver a trap with magnetic field uniformity of 10^{-7}, filled with tritium having a T_2 contamination less than 10^{-6} and instrumented with a spatially resolving phased antenna array to measure the femtowatt CRES signals. In such a trap, one year of runtime with 10^{18} T atoms should provide 40 meV sensitivity to the neutrino mass.

T 11.9 Mo 18:50 VSH 17

Production, Separation and Implantation of ^{163}Ho for Electron Neutrino Mass Measurements — •Tom Kieck[1], Holger Dorrer[1], Christoph E. Düllmann[1], Klaus Eberhardt[1], Raphael Haas[1], Ulli Köster[2], Christoph Mokry[1], Jörg Runke[1], Sebastian Schmidt[1], Fabian Schneider[1], Leonard Winkelmann[1], and Klaus Wendt[1] for the ECHo-Collaboration — [1]Johannes Gutenberg-Universität, Mainz, Germany — [2]Institut Laue-Langevin, Grenoble, France

The ECHo collaboration aims at measuring the electron neutrino mass by recording the spectrum following electron capture of ^{163}Ho using metallic magnetic calorimeters (MMC). Presently kBq amounts of the radioisotope ^{163}Ho were produced from enriched ^{162}Er in the ILL high flux nuclear reactor, chemical and mass spectrometric separated and embedded into 250x250 μm^2 Au-absorbers.

The application of resonance ionization at the RISIKO mass separator provides optimum elemental and isotopic selectivity for ultra-pure ^{163}Ho ion implantation. After improvement of efficiency and stability of laser ion source and mass separator, post focusing ion optics were installed and characterized for minimum loss implantation with sub millimeter beam spot size. An in-situ deposition of gold using the technique of pulsed laser deposition (PLD) generates a homogeneous ^{163}Ho/Au layer as absorber of the MMC.