T 93: Neutrino physics without accelerators IV

Time: Thursday 16:00–18:30 Location: Tr

T 93.1 Thu 16:00 Tr

Charge-carrier collective motion in germanium detectors for $\beta\beta$-decay searches — •Tommaso Comellato, Matteo Agostini, and Stefan Schönert — Physik-Department, Technische Universität München, Garching

The state-of-the-art technology in germanium crystals allows the production of detector blanks with lengths and diameters of 10 cm, and a level of impurities in the range of 10^{10} atoms/cm^3. Such crystals can be converted into High Purity Germanium (HPGe) detectors. In such devices, the time structure of the signal can be used to discriminate the topology of the energy deposition. This is exploited in the search for neutrinoless double beta decay ($0\nu\beta\beta$) of ^{76}Ge, where HPGe detectors enriched in ^{76}Ge are used simultaneously as source and detector (Gerda, Legend). In the effort to enlarge the detector dimensions, new geometries such as the Inverted Coaxial have been recently developed [1]. In this new type of detectors the time needed to collect charge carriers is much larger than the detectors used in the current $0\nu\beta\beta$ experiments. Longer collection times lead to the observation of subleading effects in the signal formation due to the self-interaction of the charge-carriers' clusters during their migration. In this talk I will present the impacts that such effects have on signal shape and on pulse shape discrimination performance, as we describe in [2]. This work has been supported in part by the ERC (Grant agr. No. 786430 - GemX) and by the SFB1258 funded by the DFG.

[1] R. J. Cooper et al., Nucl. Instrum. Meth. A665 (2011) 25

[2] T. Comellato et al., arXiv: 2007.12910 (2020)

T 93.2 Thu 16:15 Tr

Search for light exotic fermions in double beta decay — •Elisabetta Bossio[1], Matteo Agostini[1,2], Alejandro Ibarra[1], and Xabier Marcano[1] — [1]Physik-Department, Technische Universität München, Garching, Germany — [2]Department of Physics and Astronomy, University College London, UK

Double beta decay is predicted in the Standard Model with the emission of two active neutrinos. Models in which light exotic fermions are emitted, replacing one or both the neutrinos in the final state, could be tested through the search for spectral distortions in the electron spectrum with respect to the Standard Model expectations.

In this contribution, the discovery potential of selected neutrinoless double beta decay experiments will be presented, under two concrete scenarios: the single production of a light sterile neutrino in double beta decay and the pair production of light Z_2-odd fermions. It will be shown that future searches allow to test for the first time a new part of the parameter space at the MeV-mass scale[1]. This work has been supported in part by the German Federal Ministry for Education and Research (BMBF) and the German Research Foundation (DFG) via the SFB1258.

[1]M. Agostini, E. Bossio, A. Ibarra, X. Marcano, arXiv:2012.09281

T 93.3 Thu 16:30 Tr

Detection prospects for the double-beta decays of ^{124}Xe — •Christian Wittweg[1], Brian Lenardo[2], Alexander Fieguth[2], and Christian Weinheimer[1] — [1]Institut für Kernphysik, Westfälische Wilhelms-Universität Münster, 48151 Münster, Germany — [2]Physics Department, Stanford University, Stanford, CA 94305, USA

The isotope ^{124}Xe is exceedingly rare and long-lived. Still, its slow neutrinoless double-beta decays could be a key to understanding the mass and nature of the neutrino as well as the dominance of matter over antimatter in the Universe. Its double-beta decays with neutrinos could provide constraints for nuclear matrix element calculations in the neutron-poor region of the nuclear chart [C. Wittweg et al., EPJ C 80 (2020) 1161]. What makes ^{124}Xe special among double-beta emitters is the theoretical possibility of three different neutrinoless decay modes – either via double-electron capture in a nuclear resonance, or involving the emission of one or two positrons. Together with the observation of neutrinoless double-beta decays in other isotopes, ^{124}Xe could also allow to disentangle the underlying decay mechanism. The talk will introduce the neutrinoless and two-neutrino decays of ^{124}Xe and discuss the detection prospects with upcoming experiments such as XENONnT, nEXO and DARWIN.

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T 93.4 Thu 16:45 Tr

Sensitivity of the DARWIN observatory to the neutrinoless double beta decay of ^{136}Xe — •Fabian Kuger for the DARWIN-Collaboration — Albert-Ludwigs-Universität, Freiburg, Germany

The DARWIN observatory is a proposed next-generation experiment to search for particle dark matter and other rare processes of nuclear or astrophysical origin. Its time projection chamber will instrument 40 t of natural liquid xenon containing about 3.6 t of ^{136}Xe. The combination of ultra low background levels, very good energy resolution and large target mass predestines DARWIN to search for the neutrionless double beta decay of ^{136}Xe.

We present a Monte Carlo simulation study of the background and event topologies resulting in a projected half-life sensitivity of 2.4×10^{27} yr after 10 yr of DARWIN operation, a comparable science reach to dedicated double beta decay experiments using xenon targets enriched in ^{136}Xe.

T 93.5 Thu 17:00 Tr

Background characterization for the COBRA experiment — •Juliane Volkmer — IKTP, TU Dresden

In 2011 the COBRA demonstrator was built with the objective of investigating the practicability of using CdZnTe semiconductor crystals for the investigation of double beta decays.

The CdZnTe crystals contain nine isotopes capable of different $\beta\beta$ decay modes, can be operated at room temperature and are commercially available. Additionally, the versatile detector material offers the possibility of investigating physics besides the $\beta\beta$ decay, like a potential quenching of g_A in nuclear processes – by measuring the spectrum shape of the strongly forbidden ^{113}Cd β decay – and exotic $\beta^+\beta^+$ decay modes.

One of the main challenges of investigating such extremely rare processes is the detector's background, potentially occurring at much higher rates than the searched-for signal itself. The background can be reduced by using ultra-pure materials and great care during the experiment's construction, a shielding system, as well as analysis cuts on the data.

However, a certain fraction of the background still passes through the shielding and survives the analysis cuts. For this remaining background it is important that it is well understood and characterized.

In this talk an overview of the background present for the COBRA demonstrator is given. The focus lies especially on the results of investigating the background with the help of coincidence analyses.

T 93.6 Thu 17:15 Tr

Measurement of the neutrino mixing angle θ_{13} with the Double Chooz experiment — •Philipp Soldin, Markus Bachlechner, Lars Heuermann, Achim Stahl, and Christopher Wiebusch — RWTH Aachen University - Physics Institute III B, Aachen, Germany

Double Chooz is a reactor neutrino disappearance experiment that was operating between 2011 until the end of 2017. Its main purpose was the precise measurement of the neutrino mixing angle θ_{13}. The experimental setup consisted of two identical liquid scintillator detectors at average baselines of about 400 m and 1 km to two nuclear reactor cores in Chooz, France. The neutrinos were detected by measuring the signature of the inverse beta decay (IBD), which consists of a prompt positron annihilation and a delayed neutron capture signal. We perform a measurement of θ_{13} using a Poisson based likelihood fit of the energy dependent flux of the two detectors. This requires the consideration of the simultaneous measurement of the energy dependent neutrino rates in two detectors, all relevant backgrounds and systematic uncertainties, resulting in more than 300 partly correlated model parameters. In this talk we present the challenging fit method and the experimental result from the full data set of Double Chooz.

T 93.7 Thu 17:30 Tr

Likelihood-based searches of sterile neutrino signals in Double Chooz. — •Lars Heuermann, Markus Bachlechner, Philipp Soldin, Achim Stahl, and Christopher Wiebusch — RWTH

Aachen University - Physics Institute III B, Aachen, Germany

Double Chooz is a reactor neutrino disappearance experiment with the main goal to measure the neutrino oscillation. The setup consists of two identical detectors at baselines of 1050 m and 400 m, optimized for the neutrino mixing angle θ_{13}. Additional, hypothetical sterile neutrino flavours, which do not participate in weak interactions, still might contribute to anti-electron-neutrino disappearance and thus could be measurable in Double Chooz. In this search, we test the data in a maximum likelihood analysis with respect to the parameters of a model with one additional sterile neutrino flavour (3+1 model). A particular challenge is that Wilks' theorem is not fulfilled and the parameter scan is computationally expensive. An initial analysis has been performed with a subset of the data. Here we extend the analysis to the full available data set. We will present the analysis method, study of systematic uncertainties and conclude with upper exclusion boundaries for the sterile mixing parameters Δm^2_{41} and $\sin^2(2\theta_{14})$ through likelihood based scans.

T 93.8 Thu 17:45 Tr

Vertex Reconstruction using Graph Convolutional Networks in Double Chooz — •Markus Bachlechner, Thilo Birkenfeld, Philipp Soldin, Achim Stahl, Alexandros Tsagkarakis, and Christopher Wiebusch — RWTH Aachen University - Physics Institute III B, Aachen, Germany

Double Chooz is a reactor anti-neutrino disappearance experiment, which took data from 2011 until the end of 2017. The main purpose was the precise measurement of the neutrino mixing angle θ_{13} with two identical liquid scintillator detectors. Neutrinos are detected via the signature of the inverse beta decay (IBD), which is characterized by a prompt signal from a positron and a delayed signal from neutron capture. The random association of uncorrelated events caused by natural radioactivity and the β-n decay of ^{9}Li produced by atmospheric muons are two major backgrounds. The discriminations between signal and background are based on either the spatial distance between the prompt and delayed like events or the proximity to a preceding muon track. A precise vertex reconstruction is thus important for reducing the background and improving the measurement of θ_{13}. In this talk an approach via Graph Convolutional Networks (GCNs), which can adapt to the complex geometry and specific physical features of the detector, is presented. By using such versatile deep learning technique, the current maximum likelihood based reconstruction is outperformed.

T 93.9 Thu 18:00 Tr

The Taishan Antineutrino Observatory — •Hans Steiger — Cluster of Excellence PRISMA+, Johannes Gutenberg University Mainz (JGU), Staudingerweg 9, D-55128 Mainz

The TAO (Taishan Antineutrino Observatory) detector is aiming for a measurement of the reactor neutrino spectrum at very low distances (< 30 m) to the core with a groundbreaking resolution better than 2 % at 1 MeV. The TAO experiment will realize the unprecedented neutrino detection rate of about 2000 per day, which is approximately 30 times the rate in the JUNO main detector. In order to achieve its goals, TAO is relying on yet to be developed, cutting-edge technology, both in photosensor and liquid scintillator (LS) development which is expected to have an impact on future neutrino and Dark Matter detectors. In this talk TAO's design, physics prospects as well as the status of its construction will be presented, together with a short excursion into its rich R&D program with a special focus on the German contribution to the development of the novel gadolinium-loaded liquid scintillator. This work is supported by the Cluster of Excellence PRISMA+ at the Johannes Gutenberg University in Mainz.

T 93.10 Thu 18:15 Tr

Looking for sterile neutrinos and new physics using the solar ^{8}B neutrino spectrum — •Simon Appel, Lothar Oberauer, and Birgit Neumair — Physik Department, TU München

Solar ^{8}B neutrinos are detected via elastic scattering on electrons in large radiopure detectors. The expected upturn in the survival probability of solar ^{8}B neutrinos is still not detected. Current generation detectors struggle with several challenges. Cosmic muons produce radiogenic isotopes that mimic the ^{8}B neutrino shape. Especially the long lived ^{10}C and ^{11}Be isotopes are problematic. External gamma background limits the fiducial volume. Future detectors may improve these limitations. Besides the MSW effect there is more physics beyond the standard model that could affect the neutrino survival probability. Light sterile neutrinos $\Delta \mathrm{m}^2_{01} \simeq (0.7-2)\cdot 10^{-7}\mathrm{eV}^2$ and flavour changing ν_e-ν_τ interactions affect the survival probability in the same energy region as the MSW effect. This talks focuses on the ability of future detector generations exploring this parameter space.