T 56: Experimental methods III

Time: Wednesday 16:30–18:45 Location: H-ÜR 1

T 56.1 Wed 16:30 H-ÜR 1

Background reduction in KATRIN by induced de-excitation of Rydberg atoms with terahertz radiation — •Enrico Ellinger for the KATRIN-Collaboration — Bergische Universität Wuppertal

A major background in the neutrino mass experiment KATRIN is supposed to originate from the ionization of Rydberg atoms within the main spectrometer (MS) volume. In Rydberg atoms one or more electrons have a high principal quantum number n resulting in a large orbital radius and long decay periods in the ms range. Once produced in radioactive processes in the surface of the MS vessel wall the neutral Rydberg atoms can travel through the whole MS before they get ionized by thermal radiation and finally accelerated towards the main detector producing the background. Terahertz radiation can be used to stimulate Δn= $\pm$ 1 transitions to states from where spontaneous de-excitation to ground state is faster (μs range). This approach was pioneered by the anti-hydrogen community at CERN. However, due to the very different environment in comparison to atomic trap experiments the feasibility at KATRIN must be examined. This study is presented as well as the first draft of an experimental set-up for testing this new method.

T 56.2 Wed 16:45 H-ÜR 1

Pile-up in the Borexino experiment — •Alexandre Göttel[1,2], Zara Bagdasarian[1], Mariia Redchuk[1,2], Sindhuja Kumaran[1,2], Livia Ludhova[1,2], Ömer Penek[1,2], Giulio Settanta[1], and Apeksha Singhal[1,2] — [1]IKP-2, FzJ — [2]RWTH Aachen University

In particle physics, pile-up refers to recorded physics events in which two or more uncorrelated physical processes occur so close in time that the detector is unable to correctly distinguish between them. The Borexino Detector is a liquid scintillator detector located at the Laboratori Nazionali del Gran Sasso (LNGS) in Italy. It was built with the primary goal of detecting solar neutrinos, with an unprecedented sensitivity below 2 MeV. Because of similarities in the rate and spectral shape of pile-up events and low-energy solar neutrino events, pile-up is one of the most crucial backgrounds in the energy range of Borexino's solar neutrinos measurement (e.g. neutrinos from the pp-chain, and from the CNO-chain). Therefore it is extremely important to tightly constrain the spectral shape and rate of pile-up events for different energy estimators. In this talk the methods used to estimate pile-up in Borexino will be presented, and the results will be discussed alongside the different sources of statistical and systematic uncertainty.

T 56.3 Wed 17:00 H-ÜR 1

Data-driven Continuum Monte Carlo Corrections for Belle and Belle II — •Lena Feld[1], Florian Bernlochner[2], Pablo Goldenzweig[1], and Markus Prim[1] for the Belle II-Collaboration — [1]Karlsruher Institut für Technologie — [2]Rheinische Friedrich-Wilhelms-Universität Bonn

The Belle and Belle II experiments record BB decays at the Y(4S) resonance. For background determination, continuum data without B meson decays is recorded 60 MeV below the resonance. We present a method to improve the simulation of the continuum in a data-driven way. For this purpose, a multivariate classifier is trained to distinguish the Monte Carlo prediction from the continuum data. The classification is used to reweight the individual events of the Monte Carlo prediction. We present early studies on the improvability of the continuum Monte Carlo sample.

T 56.4 Wed 17:15 H-ÜR 1

Bias mitigation in Selective Background Monte Carlo Simulation at Belle II — •Yannick Bross[1], Thomas Kuhr[1], Andreas Lindner[1], and James Kahn[2] for the Belle II-Collaboration — [1]Ludwig-Maximilians-Universität München — [2]Karlsruhe Institute of Technology

The Belle II experiment is expected to collect a total of 50 ab^{-1} in its lifetime. Considering the focus of measurements on rare processes with a small branching fraction, a strong statistical understanding of the background is required. However, a significant portion of the simulated data is discarded trivially in the first stage of analysis, warranting a better method of simulation to keep up with the amount of data. For this purpose a neural network is implemented to select the relevant data after the Monte Carlo event generation and then only simulate selected events. Existing methods have shown great success with graph neural networks, but lack a good understanding and control of any biases they introduce during selection. Therefore carefully controlling any biases that arise is an important task to improve the network. In this work we introduce methods of checking and further mitigating potential biases.

T 56.5 Wed 17:30 H-ÜR 1

Selective background simulation using graph neural networks at Belle II — •James Kahn[1], Andreas Lindner[2], Emilio Dorigatti[2], and Thomas Kuhr[2] for the Belle II-Collaboration — [1]Karlsruher Institut für Technologie — [2]Ludwig-Maximilians-Universität München

The large volume of data expected to be produced by the Belle II experiment presents the opportunity for studies of rare, previously inaccessible processes. Investigating such rare processes in a high data volume environment necessitates a correspondingly high volume of Monte Carlo simulations to prepare analyses and gain a deep understanding of the contributing physics processes to each individual study. This resulting challenge, in terms of computing resource requirements, calls for more intelligent methods of simulation, in particular for background processes with very high rejection rates. This work presents a method of predicting in the early stages of the simulation process the likelihood of relevancy of an individual event to the target study using graph neural networks. The results show a robust training that is integrated natively into the existing Belle II analysis software framework.

T 56.6 Wed 17:45 H-ÜR 1

Pixel Detector Background Generation using Generative Adversarial Networks at Belle II — Matej Srebre, Thomas Kuhr, •Hosein Hashemi, and Martin Ritter for the Belle II-Collaboration — Ludwig-Maximilians-Universität München

The pixel detector (PXD) is an essential part of the Belle II detector recording particle positions. Data from the PXD and other detectors allow us to reconstruct particle tracks and decay vertices. The effect of background noise on track reconstruction for measured data is emulated for simulated data by a mixture of measured background noise and easily-simulated particle decays. This model requires a large set of statistically independent PXD background noise samples in order to avoid the systematic bias of reconstructed tracks. However, data from the fine-grained PXD requires a substantial amount of storage. As an efficient way of producing background noise, we explore the idea of an on-demand PXD background generator using Generative Adversarial Networks (GANs).

T 56.7 Wed 18:00 H-ÜR 1

Accuracy and performance of Geant4 in background simulations for rare event searches — •Holger Kluck[1,2], Robert Breier[3], Alexander Fuss[1,2], Valentyna Mokina[2], Veronika Palušová[3], and Pavel Povinec[3] — [1]Atominstitut, Technische Universität Wien, A-1020 Wien, Austria — [2]Institut für Hochenergiephysik der Österreichischen Akademie der Wissenschaften, A-1050 Wien, Austria — [3]Comenius University, Faculty of Mathematics, Physics and Informatics, 84248 Bratislava, Slovakia

Searches for rare events depend crucially on an accurate prediction of the background. Depending on the type of search, the energies of interest go from the MeV regime, e.g. for neutrinoless double-beta ($0\nu2\beta$) decay, down to the sub-keV regime, e.g. for coherent elastic neutrino-nucleus scattering (CEνNS) and dark matter-nucleus scattering. A widespread Monte Carlo code to model the background is Geant4. It gives its users great freedom of configuration, i.a. by choosing the actual model for the particle interactions, the so-called physics list, and by setting the production threshold for secondary particles.

In this contribution, we assess the dependency of the obtained background spectra on the chosen Geant4 configuration for radioactive decays in Ge and $CaWO_4$ targets. First, a potential most accurate reference configuration is infered based on literature research. Afterwards we systematically scan the configuration space and compare the simulated spectra with the reference both in the MeV and in the sub-keV regime. Lastly, for configurations with a similar accuracy as the reference, we identify the one with the highest performance.

T 56.8 Wed 18:15 H-ÜR 1

Background rejection with the Liquid Argon Veto System of LEGEND-200 — •Patrick Krause[1], Maria Fomina[2], Konstantin Gusev[1,2], Jozsef Janicsko-Csathy[3], Oskar Moras[1], Stefan Schönert[1], Mario Schwarz[1], Egor Shevchik[2], and Christoph Wiesinger[1] — [1]Technische Universität München, Garching, Germany — [2]Joint Institute for Nuclear Research, Dubna, Russia — [3]Leibniz-Institut für Kristallzüchtung, Berlin, Germany

A discovery that neutrinos are Majorana fermions would have profound implications for particle physics and cosmology. The Majorana character of neutrinos would make possible the neutrinoless double-beta (0nbb) decay, a matter-creating process without the balancing emission of antimatter. The LEGEND Collaboration aims to develop a phased, ^{76}Ge-based double-beta decay experimental program with discovery potential at a half-life beyond 10^{28} years. The first Phase, LEGEND-200, aims for a discovery potential of 10^{27} years and a background index of 0.6 cts/(ROI t yr). Based on the success in GERDA a liquid argon veto system will be deployed in LEGEND-200 to actively suppress background events. It utilizes the property of liquid argon to scintillate upon the interaction with ionizing radiation. The emitted vacuum ultraviolet light is shifted to the optical spectrum and read out by silicon photomultipliers mounted to the end of optical fibers. This talk will give an insight into the design considerations of the LEGEND-200 liquid argon veto system, driven by the performance of the GERDA liquid argon veto system. This work has been supported in part by the German Federal Ministry for Education and Research.

T 56.9 Wed 18:30 H-ÜR 1

An embedding technique to determine genuine $\tau\tau$ backgrounds from CMS data — Janek Bechtel, •Sebastian Brommer, Artur Gottmann, Oliver Kuntze, Günter Quast, and Roger Wolf — Karlsruhe Institut für Technologie, Karslruhe, Deutschland

The τ-embedding technique is a data-driven method, where dimuon events are selected from data, and the muons are replaced by simulated τ lepton decays. In this way, a hybrid event is created, which only relies on the simulation for the well understood τ lepton decay. The remainder of the event, by construction, provides a better description of the data than full simulation, especially for challenging simulation tasks, such as the underlying event or multijet production.

The τ-embedding technique is actively used by CMS to estimate standard model backgrounds that contain genuine τ decays.

The current status of the technique, as well as studies on polarization effects in embedded events are presented.