T 93: Search for New Particles 6

Time: Thursday 16:15–18:45 Location: T-H24

T 93.1 Thu 16:15 T-H24

Symmetries, Safety, and Self-Supervision — Barry M. Dillon[1], Gregor Kasieczka[2], Hans Olischläger[1], Tilman Plehn[1], Peter Sorrenson[1,3], and •Lorenz Vogel[1] — [1]Institut für Theoretische Physik, Universität Heidelberg, Germany — [2]Institut für Experimentalphysik, Universität Hamburg, Germany — [3]Heidelberg Collaboratory for Image Processing, Universität Heidelberg, Germany

Collider searches face the challenge of defining a representation of high-dimensional data such that physical symmetries are manifest, the discriminating features are retained, and the choice of representation is data-driven and new-physics agnostic. We introduce JetCLR (Contrastive Learning of Jet Representations) to solve the mapping from low-level jet constituent data to optimized observables through self-supervised contrastive learning. Using a permutation-invariant transformer-encoder network, physical symmetries such as rotations and translations are encoded as augmentations in a contrastive learning framework. As an example, we construct a data representation for top and QCD jets and visualize its symmetry properties. We benchmark the JetCLR representation against other widely-used jet representations, such as jet images and energy flow polynomials.

T 93.2 Thu 16:30 T-H24

Searching for Jet Pairs with Anomalous Substructure in CMS — Gregor Kasieczka, Louis Moureaux, Tobias Quadfasel, and •Manuel Sommerhalder — Institut für Experimentalphysik, Universität Hamburg

Despite compelling experimental and theoretical motivation as well as extensive new physics searches at the Large Hadron Collider, there have been no discoveries of physics beyond the standard model (BSM) so far. One potential reason for this is that the common search strategy relies on selecting BSM signal candidate events based on specific signal and background models. Such a dedicated search cannot be performed for every possible BSM theory and phase space region. Thus, model-independent anomaly detection methods are an important addition to existing search methods. These algorithms aim to select signal candidates in a data-driven manner based on anomalous phase space signatures.

One such anomaly detection method is CATHODE. It detects resonant signal peaks by combining neural density estimation in a sideband region with a weakly supervised classification task of disinguishing real data from synthetic background-like samples. We present the first application of CATHODE in a search for BSM physics in the CMS experiment targeting a dijet final state.

T 93.3 Thu 16:45 T-H24

Autoencoders and k-Means for unsupervised anomaly detection in high energy physics — Thorben Finke, Michael Krämer, Alessandro Morandini, Alexander Mück, and •Ivan Oleksiyuk — Institute for Theoretical Particle Physics and Cosmology (TTK), RWTH Aachen University, D-52056 Aachen, Germany

Unsupervised anomalous jet tagging based on low-level observables has recently gained popularity in the high energy physics community. The main goal here is to be as efficient and model-independent as possible. We scrutinize a widely used anomaly detection method based on the reconstruction loss of a deep autoencoder to show its capabilities, but also its limitations. Although we reproduce the positive results from the literature, we show that the standard autoencoder setup cannot be considered as a model-independent anomaly tagger by inverting the task: the autoencoder fails to tag QCD jets if it is trained on top jets. We improve the capability of the autoencoder to learn non-trivial features of jet images, such that it is able to achieve both top jet tagging and QCD jet tagging with the same setup. We propose an alternative machine learning approach using k-Means and Gaussian Mixture Model to construct anomaly scores. We show that these methods, albeit simple, have several benefits and may also be regarded as promising anomaly detection tools.

T 93.4 Thu 17:00 T-H24

How to Identify Anomalies at the LHC — •Thorsten Buss[1], Barry Dillon[1], Thorben Finke[2], Michael Krämer[2], Alessandro Morandini[2], Alexander Mück[2], Ivan Oleksiuk[2], and Tilman Plehn[1] — [1]Institut für Theoretische Physik, Universität Heidelberg, Germany — [2]Institute for Theoretical Particle Physics and Cosmology (TTK), RWTH Aachen, Germany

Searches for anomalous events are the main motivation for the LHC and define key analysis steps, including triggers. We discuss how LHC anomalies are defined through probability density estimates evaluated through an appropriate latent space. Different approaches, like invertible networks, and Dirichlet latent spaces are illustrated for the especially challenging scenario of dark matter jets. Finally, we present benchmark results for unsupervised top vs QCD jet tagging.

T 93.5 Thu 17:15 T-H24

Better latent spaces for better autoencoders — Barry Dillon[1], Tilman Plehn[1], Christof Sauer[2], and •Peter Sorrenson[1,3] — [1]Institut für Theoretische Physik, Universität Heidelberg, Germany — [2]Physikalisches Institut, Universität Heidelberg, Germany — [3]Heidelberg Collaboratory for Image Processing, Universität Heidelberg, Germany

Autoencoders as tools behind anomaly searches at the LHC have the structural problem that they only work in one direction, extracting jets with higher complexity but not the other way around. To address this, we derive classifiers from the latent space of (variational) autoencoders, specifically in Gaussian mixture and Dirichlet latent spaces. In particular, the Dirichlet setup solves the problem and improves both the performance and the interpretability of the networks.

T 93.6 Thu 17:30 T-H24

Development of a new trigger for exotic particle searches with IceCube — •Timo Stürwald for the IceCube-Collaboration — Bergische Universität, Wuppertal, Deutschland

The IceCube Neutrino Observatory is a cubic kilometer scale Cherenkov light detector that also searches for signatures of particles beyond the standard model. The upcoming IceCube Upgrade and IceCube-Gen2 extension will improve the sensitivity for these searches due to an increased and partly denser instrumented sensitive volume. The better sensitivity allows for the detection of signatures of exotic particles including fractionally charged particles, which directly and indirectly produce light.

In this talk results of adjusted IceCube standard triggers applied on simulated fractionally charged particles are presented. Furthermore, the development of a new trigger is presented. This new trigger includes the analysis of isolated single hits that so far are not included in any IceCube trigger, because a large fraction of them originates from well understood noise sources. For simulated faint exotic signatures these isolated single hits become the dominant hit type.

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T 93.7 Thu 17:45 T-H24

Simulation of the WOM in IceCube Gen2 for the detection of exotic particles — •Nick Jannis Schmeisser[1], Anna Pollmann[1], and John Rack-Helleis[2] for the IceCube-Collaboration — [1]Bergische Universität Wuppertal — [2]JGU Mainz

The IceCube Neutrino Observatory is a cubic kilometer scale Cherenkov light detector located at the geographic South Pole. Besides the detection of neutrinos, it is used for searches for particles beyond the Standard Model. One kind of these exotic particles are fractionally charged particles which carry a fraction of the electron charge. The IceCube detector will be enhanced first by the IceCube Upgrade and then by IceCube Gen2 in the next years. The Wavelength-shifting Optical Module (WOM) is a newly developed sensor that is going to be deployed in the IceCube Upgrade amongst other sensors. The WOM achieves an improved signal to noise ratio and UV-sensitivity in comparison to the sensors deployed in the original IceCube detector via wavelength shifting and light guiding. In this presentation the results of simulations with the WOM in IceCube Gen2 investigating the efficiency of the WOM in detecting fractionally charged particles in comparison to the optical modules used in the original IceCube detector is shown. These simulations show that the WOM has a higher efficiency than the original sensors.

T 93.8 Thu 18:00 T-H24

Search for heavy neutral lepton production and decay with the IceCube Neutrino Observatory — •Leander Fischer for the IceCube-Collaboration — DESY Zeuthen

We investigate the ability of IceCube DeepCore to reconstruct low-energy (GeV) double-cascade topologies, which can be produced through Beyond Standard Model interactions. In particular, we consider Heavy Neutral Leptons (HNLs) in the mass range of 0.1-3 GeV that are produced from up-scattering of atmospheric tau-neutrinos. The sensitivity to HNL interactions, where the production and subsequent decay happen inside the detector volume, is investigated using 8 years of atmospheric data from IceCube DeepCore.

T 93.9 Thu 18:15 T-H24

Search for Sub-Relativistic Magnetic Monopoles in IceCube — •Christian Dappen[1], Jakob Böttcher[1], Sukeerthi Dharani[2], and Christopher Wiebusch[1] for the IceCube-Collaboration — [1]RWTH Aachen University - Physics Institute III B, Aachen, Germany — [2]Universität Hamburg

The IceCube Neutrino Observatory detects high energy neutrinos through their interaction in the Antarctic ice while also searching for more exotic particles such as magnetic monopoles. These hypothetical particles are predicted by Grand Unified Theories as relics from the very early Universe. For masses on the GUT-scale (10^{14} GeV - 10^{17} GeV) those monopoles would move at sub-relativistic speeds ($\beta < 10^{-2}$) through IceCube. A subrelativistic monopole in matter may catalyze nucleon decays via the Rubakov-Callan effect. This results in Cherenkov light from small particle showers along the trajectory of the monopole with separations of centimeters up to tens of meters. This pattern is recorded by a dedicated slow particle trigger at a rate of ≈ 10 Hz. For the separation of signal from background events, we have developed a chain of boosted decision trees (BDTs) which are trained with simulated monopole signal and data-driven background events. In each level of the BDT, a background rejection of about 99% is achieved which allows a more efficient training of the subsequent BDT for rare backgrounds. Based on the final selection, the sensitivity is estimated and the analysis is evaluated with an experimental dataset of five months.

T 93.10 Thu 18:30 T-H24

Searching for axion-like particles via ultra-high-energy photons — •Chiara Papior, Markus Risse, and Philip Ruehl — Center for Particle Physics Siegen, Experimentelle Astroteilchenphysik, Universität Siegen

As axion-like particles (ALPs) provide solutions for several questions that current models leave unanswered, it is of great interest to study them experimentally. A potential coupling of ALPs to photons can be probed by large scale cosmic ray detectors like the Pierre Auger Observatory which are sensitive to ultra-high-energy (UHE) photons. After the hypothetical production of high energy ALPs in the environment of e.g. a flaring blazar or a binary neutron star merger, ALPs may propagate over cosmological distances through the intergalactic medium without attenuation. Back-conversion into UHE photons may happen via the Primakoff effect in the magnetic field of the local cluster or the Galaxy itself. A high-confidence detection of an UHE photon from a transient source well beyond the megaparsec scale would be a strong indicator for the presence of ALPs due to the opaqueness of the cosmic microwave background towards photons at these energies. The probability of the ALP-photon conversion depends on several parameters such as the magnetic field in the intergalactic medium, the distance of propagation and the mass and coupling of the ALPs themselves. The work presented in this contribution aims to evaluate the possibility to probe the phase space of UHE ALPs by using the functionality of the gammaALPs python package.