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Denoising Signals from a High-Purity Germanium Detector using Generative Adversarial Networks with Convolutional Autoencoders

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High-purity germanium detectors are used in the search for rare events such as neutrinoless double-beta decay, dark matter and other beyond Standard Model physics. Due to the infrequent occurrence of signal events, extraordinary measures are taken to reduce background interactions and extract the most information from data. An efficient signal denoising algorithm can improve energy resolution and background rejection techniques, and help classify signal events. It can also help identify low-energy events where the signal-to-noise ratio is small. In this work, we demonstrate the application of generative adversarial networks with deep convolutional autoencoders to remove electronic noise from high-purity germanium p-type point contact detector signals. Built on the success of denoising using a convolutional autoencoder, we investigate generative adversarial network applied on autoencoders to further improve denoising and enable more realistic model training conditions. This includes training with unpaired simulation and real data, as well as training with only real detector data without the need of simulation. Our approach is not limited to high-purity germanium detectors; it is broadly applicable to other detector technologies in the particle astrophysics community and beyond.

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