Contribution ID: **114** Type: **Poster + Flashtalk**

Exploiting the latent space of deep AutoEncoders for the identification of signal pulses in noisy time-series

In this contribution we propose a data-driven technique based on self-supervised deep neural networks, specifically convolutional and variational autoencoders (AE), developed to improve the sensitivity to signal pulses over a significant background in long waveforms.
The dataset consists of synthetic waveforms with around 10,000 samples; each time-series is composed of non-gaussian noise, with the addition of a log-normal shaped signal pulse in a fraction of the events. The AE model is set up to heavily compress the input waveform in a 4-dimensional latent space, allowing a direct study of the features in such a reduced representation.
After a training of about 100 epochs on 7000 waveforms, a region in the latent space where the network encodes time-series presenting only background noise clearly emerges, allowing in turn to tag as signal candidates those falling outside this range. When applied on a test dataset of freshly generated waveforms, such a procedure correctly labels 100% of the events with a large signal, and the fraction of successful identifications only decreases for signal peak amplitudes comparable with the accidental pulses in the background.
This approach was designed to fully exploit the measurements in dual-phase Liquid Argon Time Projection Chambers, as the one of the Recoil Directionality (ReD) experiment, a R&D apparatus built in the context of the Darkside project. The goal is the identification of delayed electroluminescence (S2) signals in gas, produced by very low energy (~ a few keV) nuclear recoils, with a sensitivity at least comparable to the conventional reconstructions. Furthermore, we aim to export this technique to other distinct experimental settings in the field of astroparticle physics.

This work is supported by ICSC –Italian National Research Centre for High Performance Computing, Big Data and Quantum Computing, funded by European Union –NextGenerationEU, and it has been carried out within the Spoke 2 ("Fundamental Research and Space Economy") as part of the activities in the Working Group 3 ("Applications for experimental astroparticle physics and gravitational waves experiments") under the use-case DAIDREAM ("DAta-driven IDentification of Rare Events in Astroparticle physics through Machine learning techniques").

AI keywords

autoencoders; time-series; latent space; unsupervised learning; pulse identification

Primary authors: ANASTASI, Gioacchino Alex (Università di Catania & INFN Catania); ALBERGO, Sebastiano (Istituto Nazionale di Fisica Nucleare); DE NAPOLI, Marzio (Istituto Nazionale di Fisica Nucleare); Dr PINO, Noemi (Istituto Nazionale di Fisica Nucleare - Laboratori Nazionali del Sud); PUGLIA, Sebastiana Maria (Istituto Nazionale di Fisica Nucleare); TRICOMI, Alessia Rita (Istituto Nazionale di Fisica Nucleare); ZAKHARY, Paules (Università di Catania & INFN Catania & CSFNSM)

Presenter: ANASTASI, Gioacchino Alex (Università di Catania & INFN Catania)

Track Classification: Explainability & Theory