T 7: Data, AI, Computing, Electronics I

Time: Monday 16:15–18:15 Location: KH 00.024

T 7.1 Mon 16:15 KH 00.024

Understanding and Expanding the Transformer-Based Neural Network to Analyze Extensive Air Showers at the Pierre Auger Observatory — •Ronja Westphalen, Maximilian Straub, Alex Reuzki, Niklas Langner, Josina Schulte, and Martin Erdmann — RWTH Aachen University, Aachen, Germany

Determining the mass of ultra-high-energy cosmic rays is crucial to understanding their origin. Ground-based detectors, such as the Pierre Auger Observatory, measure extensive air showers and collect multidimensional, time- and location-dependent signals that contain information on the primary particle. Analyzing these complex signals with a Transformer-based neural network to reconstruct mass-dependent observables, such as the depth of the shower maximum $X_{\max}$ and the muon content R_{μ}, from surface detector (SD) measurements at the Pierre Auger Observatory has been shown to be successful.

This study investigates the working principle of the Transformer in detail. We examine the attention mechanism in the time trace and in spatial analysis to understand how effectively features are reconstructed from these complex measurements. Additionally, we assess the agreement between the data and simulations in the latent network space to determine whether known discrepancies of hadronic interaction models are inherently apparent in the network response. Finally, we want to extend the network by the radio detector, enabling the evaluation of SD measurements in combination with the radio signal for the AugerPrime setup.

T 7.2 Mon 16:30 KH 00.024

Reconstruction and Identification of Atmospheric Neutrino Events at JUNO Using Machine-Learning Methods — •Milo Charavet, Caren Hagner, Daniel Bick, and Mikhail Smirnov — University of Hamburg, Hamburg, Germany

The Jiangmen Underground Neutrino Observatory (JUNO) is a next-generation multipurpose liquid scintillator detector with a 20-kiloton target mass, located in southern China. One of its primary goals is to determine the neutrino mass ordering (NMO) with a significance of at least 3σ by precisely measuring the oscillation pattern of reactor antineutrinos over a 53 km baseline. While JUNO's NMO sensitivity primarily comes from reactor neutrinos, atmospheric neutrino oscillations provide complementary sensitivity via matter effects and can enhance the overall performance in a joint analysis. The construction of the detector has been completed, and JUNO has already started physics data taking since August 2025. Detecting atmospheric neutrinos in a liquid scintillator detector poses several challenges, such as the reconstruction of complex event topologies and the separation of interaction channels. Advanced machine learning methods, in particular deep-learning based reconstruction techniques, offer promising solutions to address these difficulties. This talk will present recent progress in using such methods to reconstruct the energy, direction, and vertex of atmospheric neutrino events, as well as their performance in particle identification from Monte Carlo studies, highlighting both the challenges and the advantages of these innovative approaches.

T 7.3 Mon 16:45 KH 00.024

Particle Identification in OSIRIS using Deep Learning — •Martin Kandlen, Elisabeth Neuerburg, Achim Stahl und Christopher Wiebusch — RWTH Aachen

In August 2025, the filling of the 20-kton liquid scintillator based Jiangmen Underground Neutrino Observatory (JUNO) was finished. The radiopurity of the liquid scintillator (LS) was monitored by the Online Scintillator Internal Radioactivity Investigation System (OSIRIS). OSIRIS has a cylindrical acrylic vessel for 20-ton batches of LS observed by 64 20" PMTs. The Uranium and Thorium impurities are measured via Bismuth-Polonium coincidence decay signals. I use attention-based deep learning methods for particle identification, where the input consists of the scintillation time profile. Simulation-data-mismatches are overcome by domain adaptation; the model is trained using both simulated and real detector data. In this talk, I present the methodology and performance of the classification.

T 7.4 Mon 17:00 KH 00.024

Self-Supervised Pretraining of HPGe Waveforms for Pulse-Shape Discrimination for LEGEND — •Niko Lay[1], Christoph Vogl[1], Tommaso Comellato[1], Konstantin Gusev[1], Brennan Hackett[2], Baran Hashemi[1], Lukas Heinrich[1], Patrick Krause[1], Andreas Leonhardt[1], Béla Majorovits[2], Moritz Neuberger[1], Nadezda Rumyantseva[1], Mario Schwarz[1], Michael Willers[1], and Stefan Schönert[1] — [1]Technical University of Munich, Garching, Germany — [2]Max Planck Institute for Physics, Garching, Germany

LEGEND searches for ($0\nu\beta\beta$)-decay using HPGe detectors enriched in ^{76}Ge and operated in instrumented LAr. For LEGEND-1000, underground-sourced Ar, depleted in ^{42}Ar, constitutes the baseline choice. In the event that such argon is unavailable, a well-established and experimentally validated mitigation strategy is under preparation. Using HPGe detectors operated in ^{42}Ar-enriched LAr at the SCARF test facility at TUM, we compare three self-supervised pretraining objectives: a transformer-based autoencoder, an autoregressive objective, and masked contrastive modeling. We finetune the pretrained models to classify signal-proxy vs. background, and bulk vs. surface interaction. The resulting pretrained backbones provide a basis for future likelihood-amortization and simulation-based inference workflows, while this talk focuses on their impact on these two PSD tasks. We acknowledge support from the DFG under Germany's Excellence Strategy – EXC 2094 (ORIGINS), through the Sonderforschungsbereich SFB 1258, and by TUM MDSI Seed Funds.

T 7.5 Mon 17:15 KH 00.024

ML-based LAr classification in LEGEND-200 — •Jonas Schlegel and Christoph Wiesinger for the LEGEND-Collaboration — Max-Planck-Institut für Kernphysik, Germany

LEGEND-200 uses the scintillation properties of liquid argon (LAr) to suppress backgrounds in the search for neutrinoless double beta decay of ^{76}Ge. The LAr is instrumented with wavelength-shifting fibers coupled to arrays of silicon photomultipliers. The current veto implementation relies on a global threshold and is limited by random coincidences, as it does not exploit spatial information. We implement a machine-learning (ML) based topology-aware LAr veto that combines the photoelectron pattern with the relative angular position of the triggering high-purity germanium detector. The network is trained on samples of true and random coincidences and outputs an event-by-event veto probability. This implementation achieves improved background discrimination and serves as a proof-of-concept for further improvements, including timing information and alternative neural network architectures.

T 7.6 Mon 17:30 KH 00.024

Application of FiLM Neural Networks for π/K Separation in the PANDA Barrel DIRC — •Daniel Markhoff[1,2], Roman Dzhygadlo[2], Jochen Schwiening[2], and Yannic Wolf[2,3] — [1]University of Edinburgh, Edinburgh, United Kingdom — [2]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany — [3]Goethe-Universität Frankfurt, Frankfurt, Germany

Machine learning techniques were investigated as an alternative approach to PID in the PANDA Barrel DIRC at FAIR. FiLM neural-network models were trained on simulated Geant4 photon-hit patterns and achieved $>2\sigma$ π/K separation at 3.5 GeV/c. The models provide a significant reduction in computation time compared to the conventional time-based imaging reconstruction, while retaining competitive classification performance. These results indicate that ML-based PID has strong potential to complement or accelerate traditional DIRC reconstruction methods.

T 7.7 Mon 17:45 KH 00.024

LSTM Networks for Enhanced Signal Efficiency in the CRESST Experiment — •Praveen Murali for the CRESST-Collaboration — Kirchhoff-Institut für Physik, Heidelberg, Germany

Cryogenic experiments, such as CRESST (Cryogenic Rare Event Search with Superconducting Thermometers), frequently encounter time-series pulses from recoil events that are corrupted by distorting artefacts. These artefacts mandate data quality cuts, resulting in a drop in desired signal efficiency. This talk will introduce an application of Long Short-Term Memory (LSTM) networks to solve this problem. More specifically, it will illustrate how LSTM networks can be used to accurately "resurrect" these previously discarded pulses. This method represents a significant opportunity to enhance both the overall signal efficiency and the data yield in these highly sensitive, low-background experiments. Moreover, this method's applicability extends beyond CRESST to encompass other experiments exhibiting similar pulse and noise characteristics.

T 7.8 Mon 18:00 KH 00.024

Machine learning based Particle Identification in a Diffusion Cloud Chamber. — •Benjamin Rosendahl, Jasper von Lepel, Mario Schwarz, and Stefan Schönert — Department of Physics, TUM School of Natural Sciences, Technical University of Munich, 85748 Garching b. München, Germany

We present a work on a diffusion cloud chamber, which establishes quasi-stationary alcohol vapor diffusion through air by a temperature gradient, generating a supersaturated layer (S) in which ions seed droplet formation. By measuring the vertical temperature profile $T(y)$ and applying heat and diffusion equations as well as nucleation theory, we characterize local supersaturation and growth kinetics during vapor condensation on ions. Together with a camera setup, a U-Net based machine learning pipeline performs segmentation of particle tracks, followed by skeletonization and vectorisation. The live time setup enables joint thermodynamic and particle physics analyses: Mapping $T(y)$ and $S(y)$, quantifying fluxes of charged particles by both cosmic and ambient radiation (e.g., muons, betas and alphas) calibrated by comparison to radioactive sources and identifying phenomena such as radon decay. Beyond measurement, the instrument functions as an exhibit with high educational value, translating otherwise abstract concepts into observable events. We acknowledge support from the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany's Excellence Strategy - EXC 2094 - 390783311 and through the Sonderforschungsbereich (Collaborative Research Center) SFB 1258 'Neutrinos and Dark Matter in Astro- and Particle Physics'.