T 93: Data, AI, Computing, Electronics VIII

Time: Friday 9:00–10:15 Location: KH 00.024

T 93.1 Fri 9:00 KH 00.024

Electromagnetic Shower Shape Correction using Normalizing Flows — •Marius Melcher, Arno Straessner, and Asma Hadef — Technische Universität Dresden

The interplay between data and simulation is essential for precision measurements at the ATLAS experiment. The Geant4-based simulation of electromagnetic showers in the calorimeter, however, exhibits notable discrepancies with data, particularly in derived shower-shape variables used for electron and photon identification. These mismatches can impact the efficiency and background rejection of identification algorithms, making corrections to simulated showers crucial for physics analyses.

This talk presents a machine-learning-based approach using normalizing flows to correct shower-shape variables in simulation. This model is applied to electron shower-shapes measured by ATLAS during LHC Run 3. Resulting improvements in data-simulation agreement are discussed.

T 93.2 Fri 9:15 KH 00.024

Speeding up the MC Background Simulation at Belle II — •Oliver Schumann, Nikolai Krug, Thomas Kuhr, and Thomas Lück — Ludwig-Maximilians-Universität München (LMU), München, Germany

By striving for ever-higher luminosities, the Belle II detector is set to observe rare decay signals. However, these high luminosities correspond to an increased demand for MC-generated background. Therefore, an efficient algorithm to simulate background events for the detector in large quantities is vital for the successful interpretation of Belle II's data. While the generation and skimming of events in the MC simulation chain are quick and easy to compute, the detector simulation and reconstruction of these particles are a slow task. A neural network (NN) is introduced into the chain to classify skim-passing events and discard those which fail to pass the NN before the detector response simulation, thereby saving valuable computing resources and time.

This work explores a new approach for parallelisation of the NN training process, in hopes of achieving convergence with the resources available in less (real) time. It involves an on-the-fly training pipeline on multiple machines, retrieving the updated NN, and redistributing it to the clients. This talk aims to provide an overview of the current work in progress and to give an outlook on future prospects.

T 93.3 Fri 9:30 KH 00.024

CaloHadronic: review and updates — •Martina Mozzanica[1], Gregor Kasieczka[1], Frank Gaede[2], and Katja Krüger[2] — [1]University of Hamburg — [2]DESY, Hamburg

Simulating showers of particles in highly-granular calorimeters is a key frontier in the application of machine learning to particle physics. Achieving high accuracy and speed with generative machine learning models can enable them to augment traditional simulations and alleviate a major computing constraint. Recent developments have shown how diffusion based generative shower simulation approaches that do not rely on a fixed structure, but instead generate geometry-independent point clouds, are very efficient. We present CaloHadronic: a diffusion model for the generation of hadronic showers in both the highly granular electromagnetic and hadronic calorimeters of the International Large Detector, ILD. In addition, we detail several updates to the dataset and architectural design.

T 93.4 Fri 9:45 KH 00.024

OmniJet-alpha for Calorimeters - Autoregressive generation of Calorimeter Showers — Joschka Birk[1], Frank Gaede[2], Anna Hallin[1], Gregor Kasieczka[1], Martina Mozzanica[1], and •Henning Rose[1] — [1]Institute for Experimental Physics, Universität Hamburg Luruper Chaussee 149, 22761 Hamburg, Germany — [2]Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, 22607 Hamburg, Germany

We present an autoregressive approach for the generation of high-granularity calorimeter showers based on the OmniJetAlpha architecture. The proposed method directly embeds individual calorimeter shower hits, enabling end-to-end autoregressive generation without relying on discrete tokenization or vector-quantized codebooks. To model hit features efficiently, the architecture employs separate prediction heads for each feature dimension, allowing the overall model size to remain compact even at very high spatial and energy granularities, while avoiding codebook collapse and related representational bottlenecks. This design facilitates stable training and scalable generation in regimes where traditional token-based approaches become impractical. Our results demonstrate that generative pre-training can be performed directly at the data level for calorimeter shower modeling, removing the need for intermediate representations. This is a significant step toward leveraging transformer-based foundation models in high-energy physics, as autoregressive pre-training has proven exceptionally effective in generative modeling, as evidenced by recent advances in large language models.

T 93.5 Fri 10:00 KH 00.024

PanShower: One model for all calorimeter showers — •Thorsten Buss[1,2], Henry Day-Hall[2], Frank Gaede[2], Gregor Kasieczka[1], and Katja Krüger[2] — [1]Universität Hamburg, Hamburg, Germany — [2]Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany

Accurate and efficient detector simulation is essential for modern collider experiments. To reduce the high computational cost, various fast machine learning surrogate models have been proposed. Traditional surrogate models for calorimeter shower modeling train separate networks for each particle species, limiting scalability and reuse. We introduce PanShower, a unified generative model that simulates calorimeter showers across multiple particle types using a single generative model. PanShower is a continuous normalizing flow model with a Transformer architecture, enabling it to generate complex spatial and energy correlations in variable-length point cloud representations of showers. Trained on a diverse dataset of simulated showers in the highly granular ILD detector, the model demonstrates the ability to generate realistic showers for electrons, photons, charged and neutral hadrons over a wide range of incident energies and angles without the need for retraining.