T 56: Data, AI, Computing, Electronics VI

Time: Wednesday 16:15–17:45 Location: KH 02.014

T 56.1 Wed 16:15 KH 02.014

How to make artificial intelligence more sustainable and precise? - Introducing the project PEARLS — •Simran Gurdasani[1], Valerie Lang[2], Pardis Niknejadi[1], and Naman Kumar Bhalla[2] — [1]DESY — [2]Albert-Ludwigs-Universitaet Freiburg

Artificial intelligence (AI) is increasingly applied in scientific research, but its growing computational demands raise concerns regarding reliability, transparency, and environmental impact. The PEARLS project: Precision in Energy-aware AI Research for Low-carbon Solutions, is an ErUM-Data consortium between DESY and the University of Freiburg and aims to address these challenges. Within PEARLS, we are developing tools to measure the Carbon footprint of Machine Learning applications, evaluate algorithm efficiency and precision, and improve the processing of data in ML workflows. In this talk, I will introduce the PEARLS project, report on the current progress from DESY and Freiburg, and outline plans for the future.

T 56.2 Wed 16:30 KH 02.014

b-hive: a CMS wide Machine Learning Framework — Niclas Eich, Alexander Jung, Alexander Schmidt, and •Ulrich Willemsen — III. Physikalisches Institut A, RWTH Aachen

b-hive is a state of the art machine learning framework with wide adaptation in various working groups in CMS. It is a pipeline for training and testing of machine learning algorithms allowing for a modular approach to developing and deploying ML models in high-energy physics applications. The framework provides standardized interfaces for data preprocessing, model training, validation, and inference, enabling researchers to efficiently prototype and compare different algorithms for jet identification and analysis tasks. This presentation will demonstrate the current capabilities of b-hive, showcase recent applications in b-tagging and discuss future development plans.

T 56.3 Wed 16:45 KH 02.014

Foundation Model Based Approaches to Jet Tagging Using JEPA — Mirac Noyan Özdemir, Alexander Schmidt, •Sergio Schöneberg, and Ulrich Willemsen — III. Physikalisches Institut A, RWTH Aachen University

Foundation Models have gained significant traction in Natural Language Processing and Computer Vision and have recently become the focus of intensive research in the field of high-energy physics as they provide highly adaptable models that require less task-specific training and data. Moreover, their ability to leverage unlabelled data and their capacity to derive meaningful representations are promising opportunities for improving model robustness.

This talk presents the application of the Joint-Embedding Predictive Architecture (JEPA) to jet physics, capabilities of few-shot learning are demonstrated and the viability for jet flavor tagging is discussed. Finally, the broader implications for AI safety within high-energy physics are addressed.

T 56.4 Wed 17:00 KH 02.014

Cross-Geometry Transfer Learning in Fast Electromagnetic Shower Simulation — •Lorenzo Valente[1], Gregor Kasieczka[1], and Frank Gaede[2] — [1]Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22607 Hamburg, Germany — [2]Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, 22607 Hamburg, Germany

Fast and accurate particle shower simulation is essential for high-energy physics, but traditional Monte Carlo methods like Geant4 are computationally expensive, while machine learning alternatives typically require complete retraining for each detector geometry. We present a transfer learning approach for generative calorimeter simulation using point cloud representations and diffusion/flow models. By pretraining on detector configurations and fine-tuning with limited target data, our method enables efficient adaptation across diverse geometries without geometry-specific preprocessing. We demonstrate significant performance improvements with minimal training samples through both full fine-tuning and parameter-efficient adaptation strategies. This work establishes transfer learning as a practical technique for geometry-flexible fast simulation, reducing computational requirements for detector design studies and physics analyses.

T 56.5 Wed 17:15 KH 02.014

Agents of Discovery — Sascha Diefenbacher[1], Anna Hallin[2], Gregor Kasieczka[1], Michael Krämer[1], Anne Lauscher[3], and •Tim Lukas[1] — [1]University of Hamburg, Hamburg, Germany — [2]Lawrence Berkeley National Laboratory, Berkley, USA — [3]RWTH Aachen University, Aachen, Germany

Particle physics is becoming more and more data intensive, requiring increasingly complex analysis methods. Large parts of these methods belong to standard procedures which have to be implemented by hand, taking time away from more innovative work. With the rise of agentic AI systems other approaches become feasible: Tasking AI agents with implementing those known parts, making workflows more efficient.

In this work we present a framework allowing a team of AI Agents to work autonomously on a given task, including capabilities for writing code, code execution, error correction and logic checks. The setup uses state-of-the art OpenAI LLMs and has been tested in the realm of anomaly detection. The performance was monitored throughout many different technical and physical metrics, allowing us to draw detailed conclusions on the capabilities of the different LLMs: Most are capable of solving the given task, while the best were able to match human level performance.

T 56.6 Wed 17:30 KH 02.014

Development of Exclusive Tagging Algorithms for b-hadrons at FCC-ee — •Elgi Orozi[1], Florian Bernlochner[2], Valerio Bertacchi[2], Thomas Kuhr[1], Markus Prim[2], and Slavomira Stefkova[2] — [1]Ludwig-Maximilians-Universität München (LMU), München, Germany — [2]Rheinische Friedrich-Wilhelms-Universität Bonn, Bonn, Germany

The FCC-ee physics programme will feature operations at energies ranging from $\sqrt{s} = m_Z$ up to the $t\bar{t}$ production threshold. The enormous statistics of Z-boson decays will allow the study of beauty-quark electroweak precision observables with exceptional statistical precision. Identifying b-hadrons in high-statistics $Z \to b\bar{b}$ events is therefore crucial for probing small deviations from the Standard Model. While existing exclusive tagging approaches, such as the Belle II FEI, provide a conceptual framework, they must be adapted to the high-multiplicity environment at FCC-ee, where hadronisation, initial- and final-state radiation, and track densities are significantly more complex.

In this work, we develop and assess the performance of an exclusive B-tagging algorithm for FCC-ee, based on hierarchical decay reconstruction combined with gradient-boosted decision tree classifiers. This configurable framework performs track combination, vertex fitting, feature extraction, and multivariate classification. As a benchmark, we reconstruct the decay channel $B^+ \to \bar{D}^0[\to K^+\pi^-]\pi^+$ from simulated $Z \to b\bar{b}$ events, using the IDEA detector concept. This talk will provide insight into the feasibility of exclusive B-tagging at FCC-ee and outline future developments of advanced tagging strategies.