T 46: Calorimeter / Detector Systems II

Time: Tuesday 17:00–18:30 Location: WIL/C133

T 46.1 Tue 17:00 WIL/C133

Fast Hadron Shower Simulation Methods with the CALICE AHCAL Prototype — •André Wilhahn, Julian Utehs, and Stan Lai for the CALICE-D-Collaboration — II. Physikalisches Institut, D-37077, Göttingen

Extensive simulations of particle showers are crucial for high energy physics experiments, since they allow for a sensible interpretation of recorded calorimeter data. As many calorimeters are designed with increasing granularity, while having to cope with higher energy deposits and higher luminosity conditions, the accurate simulation of particle showers in a computationally efficient manner is of utmost importance. This talk describes preliminary investigations into a data-driven fast calorimeter simulation that is meant to describe particle showers accurately, without simulating every individual particle interaction with the calorimeter material.

We start by investigating pion showers in the CALICE AHCAL (Analog Hadron Calorimeter) prototype, which is a highly granular hadronic calorimeter comprising a total of 38 active layers embedded in a stainless-steel absorber structure. Each active layer contains a grid of 24×24 scintillator tiles that are read out individually via silicon photomultipliers. Longitudinal energy distributions and correlation factors between these detector layers have been simulated with the help of kernel density estimators and compared with data. The results of this procedure are presented in this talk. In particular, current developments will be discussed and future plans for improving and expanding the fast calorimeter simulation will be outlined.

T 46.2 Tue 17:15 WIL/C133

Data-driven Fast Calorimeter Simulation with the CALICE AHCAL Prototype — •Julian Utehs, André Wilhahn, and Stan Lai for the CALICE-D-Collaboration — II. Physikalisches Institut, Georg-August-Universität Göttingen

High granularity calorimeters are foreseen to be an integral part of future particle physics detectors, for instance in detectors at a future e^+e^- collider. Therefore, there is an extensive research program dedicated to understanding how high granularity calorimeters can be exploited. For this purpose, the CALICE collaboration has developed a prototype, the Analog Hadron Calorimeter, which uses SiPM technology to read out highly granular scintillator tiles. The combination of highly granular calorimetry with a foreseeable higher luminosity will significantly increase the calculation time for MC simulations that simulate all particle interactions with the calorimeter material (as in GEANT4). Therefore fast simulation methods are also important, allowing the reduction of computational resources, while accurately describing the shape and correlations of the showers.

The aim is to parameterize showers in order to describe them via a probability density function, that can be used for the simulation of particle showers. This talk will focus on the description of radial and angular distributions of pion showers, based on test beam data taken with the AHCAL Prototype. The combined description of longitudinal, radial, and angular distributions is also discussed.

T 46.3 Tue 17:30 WIL/C133

Shower Separation in Five Dimensions using Machine Learning — •Jack Rolph and Erika Garutti — University of Hamburg, 22761, Luruper Chaussee 149, Hamburg, Germany

To fulfil the requirements for BSM physics searches and Higgs precision measurements at future linear colliders, a final state jet-energy resolution of 3-4 % for jet energies in the range 150-350 GeV is mandatory. Particle Flow Calorimetry (PFC) is a method expected to provide this resolution, which relies upon highly granular sampling calorimeters and sophisticated clustering techniques. In addition, the PFC technique requires excellent separation of single particles. This study presents the performance of three published neural network models to separate the energy deposited by a single charged and single pseudo-neutral hadron estimated from a charged shower, observed with the highly granular CALICE Analogue Hadronic Calorimeter (AHCAL). The neural networks use spatial and temporal event information from the AHCAL and energy information, which is expected to improve sensitivity to shower development and differences in the time development of the hadron shower. Neutral hadron showers with energy 5-120 GeV were separated from charged showers at a variable distance of 0.2-658 mm by the neural networks. It is found that the best-performing network reconstructed events with a Mean90 energy in agreement within 5% of the known shower energy and with an average RMS90 of 1.6 and 1.4 GeV without and with 100 ps timing information from AHCAL, respectively. The improvement due to timing information is attributed to the superior clustering of the hadron shower core.

T 46.4 Tue 17:45 WIL/C133

Track reconstruction of charged particles using a 4D quantum algorithm — Arianna Crippa[1,2], Lena Funcke[3,4], Tobias Hartung[5], Beate Heinemann[1,6], Karl Jansen[1], Annabel Kropf[1,6], Stefan Kühn[1], Federico Meloni[1], •David Spataro[1,6], Cenk Tüysüz[1,2], and Yee Chinn Yap[1] — [1]Deutsches Elektronen-Synchrotron DESY — [2]Humboldt-Universität zu Berlin — [3]Universität Bonn — [4]Massachusetts Institute of Technology — [5]Northeastern University, London — [6]Albert-Ludwigs-Universität Freiburg

Reconstructing tracks in future colliders can be challenging for several reasons. For example, there may be a large number of particle tracks or a high background rate. Therefore, new reconstruction techniques need to be developed and existing ones refined. Quantum algorithms are believed to offer an advantage in computation time in combinatorial tasks such as track reconstruction. By formulating the tracking task as Quadratic Unconstrained Binary Optimization (QUBO), the task can be solved with quantum computers. For the first time, a time component is integrated into QUBO to enable 4D tracking, reducing background rates effectively. Results of an initial implementation are presented for a setup similar to the positron tracking system of LUXE, an experiment planned at DESY and Eu.XFEL. Peak occupancies of up to 100 hits/mm^2 are expected in the initial phase of LUXE. To demonstrate the transferability of this approach, results are also presented for a barrel-shaped muon collider detector geometry, where lower peak occupancy but large background is expected.

T 46.5 Tue 18:00 WIL/C133

QUBO partitioning and choice of quantum device for charged particle track reconstruction at LUXE — •Annabel Kropf[1,2], Arianna Crippa[1,3], Lena Funcke[4,5], Tobias Hartung[6], Beate Heinemann[1,2], Karl Jansen[1,3], Stefan Kuehn[1], Federico Meloni[1], David Spataro[1,2], Cenk Tüysüz[1,3], and Yee Chinn Yap[1] — [1]DESY — [2]Albert-Ludwigs-Universität Freiburg — [3]Humboldt-Universität zu Berlin — [4]Universität Bonn — [5]MIT — [6]Northeastern University, London

LUXE (Laser Und XFEL Experiment) is a proposed experiment at DESY using the electron beam of the European XFEL and a high-intensity laser. The experiment's primary aim is to investigate the transition from the well-probed perturbative to the non-perturbative Quantum Electrodynamics regime. In LUXE's initial phase, positrons are produced that impinge on a four-layered pixel detector with occupancies of up to 100 hits/mm^2. Reconstructing positron trajectories is a combinatorial problem challenging for a classical computer to solve. Our group explores the novel approach of expressing the track pattern recognition problem as a quadratic unconstrained binary optimization (QUBO), allowing the algorithm to be mapped onto a quantum computer. Splitting the QUBO term into mappable subQUBOS is required because the size of the QUBO exceeds the number of qubits of state-of-the-art quantum computers. This talk investigates the influence of the QUBO splitting algorithm on the final track reconstruction efficiency. Additionally, the effectiveness of a gate-based quantum computer and a quantum annealer for applying the QUBO approach will be compared.

T 46.6 Tue 18:15 WIL/C133

Beam induced background identification in ATLAS by tracking system — •Marzieh Bahmani for the ATLAS-Collaboration — Humboldt-Universität, Berlin, Germany

It is important to study Beam Induced Background (BIB) since the BIB can significantly affect the data from ATLAS detector. Events with a large BIB component can produce a large hit occupancy in the sub-detectors and can affect the track reconstruction in the Inner Detector. The hits pattern in the Inner detector has been studied which allows to distinguish electronic noise hits form those generated by BIB and provides information on BIB characteristics at different locations in barrel and end-caps. For this study unpaired isolated bunches are exploited using BCM unpaired triggers. The ATLAS Run-II dataset has been used for this study.