# T 77: Deep Learning III

Zeit: Donnerstag 16:00–18:15 Raum: H06

T 77.1 Do 16:00 H06

**Studies of Energy Reconstruction with Deep Learning at the LHC** — •Simon Schnake, Hartmut Stadie, and Peter Schleper — Institut für Experimentalphysik, Uni Hamburg

The higher energies and luminosities in the up coming LHC phases are increasing the requirements on detector and analysis methods. One way to achieve this is to apply deep learning to different areas of the data analysis. The recent developments in the field make it a suitable candidate for exploration. This could significantly increase the accuracy and precision of the experiment. In this talk different approaches of energy reconstruction with deep learning are shown. Also some techniques to tackle distribution problems are presented.

T 77.2 Do 16:15 H06

**Deep Learned Calorimetry with the CALICE AHCAL Technological Prototype** — •Erik Buhmann and Gregor Kasieczka for the CALICE-D-Collaboration — Universität Hamburg, Institut für Experimentalphysik, Luruper Chaussee 149, 22761 Hamburg

The Analog Hadron Calorimeter (AHCAL) Technological Prototype 2018, developed by the CALICE collaboration for a future linear collider experiment, is a highly granular calorimeter consisting of roughly 22,000 individual scintillator tiles. The prototype underwent test beam in May, June and October 2018 at the SPS. Hit energies and hit times in each individual channel are recorded and can be processed into 3D images of single events. In this study we use Deep Learning algorithms to analyze those images.

Convolutional Neural Nets (CNNs) are used for two separate tasks, for energy reconstruction as well as for particle classification. The training of the neural networks are performed with test beam data as well as using a Monte Carlo simulation. Studies of the energy reconstruction performance with different CNN architectures, preprocessing and data augmentation are presented. A comparison between a cut based approach and the CNN performance for particle classification is discussed.

T 77.3 Do 16:30 H06

**A Neural Network Approach to Estimate the Mass of Resonances decaying to $\tau^+\tau^-$ with the ATLAS Detector** — •Martin Werres, Philip Bechtle, Klaus Desch, Christian Grefe, Michael Hübner, Lara Schildgen, and Peter Wagner — Physikalisches Institut, Uni Bonn, Deutschland

This study investigates the predictive power of deep neural networks (DNN) in the task of mass reconstruction in ditau events with simulated ATLAS data at the LHC. The ditau mass has a large discriminating power in distinguishing between $Z \to \tau\tau$ and $H \to \tau\tau$ events. A strategy how to design a DNN training environment is presented. The performance is compared to the Missing Mass Calculator tool [arXiv:1012.4686] which is currently used in analyses. The conditions under which a competitive mass reconstruction can be achieved are presented. The influence of the environment of the individual event in the training of the DNN, such as the tau decay mode, the rest of the event, the pileup conditions and other influences on the reconstruction are studied.

T 77.4 Do 16:45 H06

**Investigation of the top-quark mass precision using machine-learning techniques at the ATLAS experiment** — •Steffen Ludwig, Andrea Knue, and Gregor Herten — University of Freiburg, Institute of Physics

The top quark is the heaviest known elementary particle in the Standard Model (SM) and its mass is a fundamental parameter. Its value is close to the scale of electroweak symmetry breaking and hence the top quark might serve as a window to physics beyond the SM.
Due to the high collision rate of the LHC, the ATLAS collaboration was able to measure the top-quark mass at subpercent level at $\sqrt{s} = 8$ TeV. Removing badly reconstructed events has shown to reduce the dominant signal modelling uncertainties using $t\bar{t}$ events in the lepton + jets channel.
Exploring this decay channel using $pp$ collision data at $\sqrt{s} = 13$ TeV, the talk focuses on the influence of deep neural networks in comparison to boosted decision trees on the event reconstruction and selection purity, while studying the impact on the total systematic uncertainty of the top-quark mass.

T 77.5 Do 17:00 H06

**A deep learning based search for a heavy CP-even Higgs boson in dileptonic H → WW decays with the CMS experiment** — •Peter Fackeldey[1] and Dennis Roy[2] — [1]III. Physikalisches Institut A, RWTH Aachen University — [2]III. Physikalisches Institut B, RWTH Aachen University

A promising model beyond the Standard Model is the Minimal Supersymmetric Standard Model (MSSM), which is commonly parameterized in the Higgs sector by $\tan\beta$ and $m_A$. As in every 2HDM, five different Higgs bosons are predicted. Especially the decay of the heavy scalar Higgs boson into two W bosons is very sensitive to low values of $\tan\beta$ and $m_A$. Standard Model background processes are a challenge in this region. These backgrounds are modelled using data driven methods, whose performances heavily rely on the purity of their associated control regions. In the last few years Deep Learning showed remarkable progress and success in high energy physics. We present a multi-class classification strategy with deep neural networks, which increases the purity in the signal regions and in control regions for SM background processes. This strategy minimizes systematic uncertainties and thus improves the limits in an unexplored region of the MSSM parameter space in the search for H → WW.

T 77.6 Do 17:15 H06

**tt$\gamma$ topology training through neural network** — •Binish Batool — binish.batool@cern.ch

The study of the process of production of Top Quarks in association with Photon ( tt$\gamma$ ) is done as an handle to study the electroweak coupling. It is being studied with full run2 data at the centre of mass of 13 TeV of LHC for higher precision. The usage of advance techniques is being done in this analysis which include the analysis independent approach to distinct the real prompt photon from hadron-fakes and an analysis dependent approach which employs the tt$\gamma$ topology. This talk will cover the later one. This approach takes the form of neural network (NN) and its architecture is chosen to provide best suppression for signal and background. The tt$\gamma$ topology for single and the dilepton channel has been implemented in NN in separate mode.

T 77.7 Do 17:30 H06

**Trennung von Signal und Untergrund in $t\bar{t}\gamma$-Prozessen durch Nutzung eines neuronalen Netzes in leptonischen Endzuständen bei $\sqrt{s} = 13$ TeV in ATLAS** — •Steffen Korn, Thomas Peiffer, Arnulf Quadt, Elizaveta Shabalina, Royer Edson Ticse Torres und Knut Zoch — II Physikalisches Institut, Georg-August-Universität Göttingen

Durch die assoziierte Produktion von Top-Quark-Paaren und Photonen ($t\bar{t}\gamma$) kann die Stärke der elektromagnetischen Kopplung des Top-Quarks an das Photon gemessen werden. Die Messung dieses fundamentalen Parameters des Standard Modells (SM) ermöglicht des Weiteren Einsicht auf Physik jenseits des SM. Evidenz dieses Prozesses wurde zuerst bei CDF am Tevatron mit $\sqrt{s} = 1,96$ TeV erbracht. Die Beobachtung des Prozesses erfolgte am LHC mit $\sqrt{s} = 7$ und $\sqrt{s} = 8$ TeV mit erhöhter Präzision. Aufgrund der ähnlichen Topologie von Untergrund und Signal sowie einem Verhältnis zwischen Untergrund und Signal von ungefähr 1:1 im leptonischen Kanal bieten sich neuronale Netze (NN) zur Separation von Signal und Untergrund an. Die Trennung von Signal und Untergrund im $t\bar{t}\gamma$-Endzustand aus Proton-Proton-Kollisionen aus den Jahren 2015 bis 2018, die mit dem ATLAS-Detektor bei einer Schwerpunktsenergie von 13 TeV gemessen wurden, werden präsentiert. Neuronale Netze werden genutzt, um Signal und Untergrund in unterschiedliche Klassen zu gruppieren. Die Leistungsfähigkeit verschiedener NN-Architekturen und ihr Effekt auf die Ereignisselektion werden vorgestellt.

T 77.8 Do 17:45 H06

**A DeepWWTagger for CMS** — Paolo Gunnellini, Johannes Haller, Roman Kogler, and •Andrea Malara — Institut für Experimentalphysik, Universität Hamburg

In this talk, we will present an overview for a new tagger that, using deep learning technique and investigating jet-substructure variables as well as sub-particles information, aims for both a high background

rejection and a large selection efficiency of boosted Higgs bosons, decaying into two hadronic W bosons. In an environment of increasingly highly-energetic events, and therefore more and more collimated heavy objects, this tagger can help to discriminate jects characterised by a different number of sub-jets.

T 77.9 Do 18:00 H06

**Multi-Class Boosted Object Tagger for Reclustered Jets at the ATLAS Experiment** — •Elena Freundlich, Olaf Nackenhorst, Johannes Erdmann, and Kevin Kröninger — TU Dortmund, Experimentelle Physik IV

The identification of boosted objects is a key element of many analyses targeting the search for new physics at high energies. At the ATLAS experiment, a multi-class boosted object tagger for reclustered (RC) jets is developed as a novel tool to identify $W/Z$ bosons, $H$ bosons and $t$ quarks unambiguously. A clear advantage of this tagger is the possibility to propagate the systematic uncertainties of small-R jets.

As input, RC jet properties and constituent information are used to train a deep neural network in order to obtain a four-dimensional output and differentiate between boosted objects and multijet events. The performance for each of the three signal classes $W/Z$, $H$ and $t$ can be adapted according to the needs of an analysis. Different studies about the performance of such a tagger are shown.