# Deep Learning Weeks

**week 12 (21. - 25.3)** + week 13 (28.3. - 1.4.)

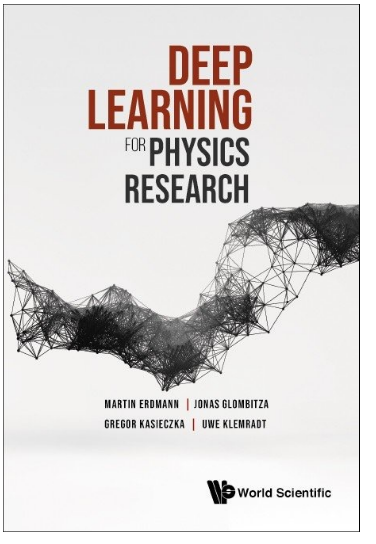
## **Week 12 (21.-25.3)** with Dr. Jonas Glombitza, RWTH Aachen

*Jonas is an expert in deep learning in physics research. He leads the machine-learning working group of the Pierre Auger Observatory (the largest cosmic-ray detector in the world located in Argentina), and is co-author of the recently published textbook "Deep Learning for Physics Research".*

**Workshop** Monday 13:00-17:00 and Wednesday 9:00-12:00

***Generative Adversarial Networks for Physics Research***

*Register here*: https://forms.gle/qgk1dMdqBAepKGAw9*




**: Due to seating capacity, the number of participants will be limited. The spots are given on a first-come, first-serve basis.*

Deep learning describes state-of-the-art machine learning techniques with deep neural networks, i.e., neural networks with many layers. Recently, significant progress has been made in the field of deep generative models using generative adversarial networks (GANs) and adversarial frameworks in general. These developments offer various applications in physics research. Besides the cost-effective generation of simulation data, adversarial frameworks can refine simulated detector data or provide powerful discrimination variables with reduced systematic uncertainties.

In this workshop, after a brief introduction into deep learning in general, an introduction to adversarial frameworks and especially GANs is given. Besides discussing the theory, hands-on sessions are included. During these sessions, you will learn how to implement and train GANs using TensorFlow/Keras. The workshop is divided into two parts. While we discuss and implement basic techniques of generative models on the first day, we turn to recent developments on the second day.

**Seminar** Thursday 10:30 - 11:15 (Å10238 Beurlingrummet or zoom)

***Deep Learning at the Pierre Auger Observatory***

*Zoom Meeting ID: 613 0593 4240 Passcode: 982066*

Ultra-high energy cosmic rays are the most energetic particles found in nature and induce extensive air showers when penetrating the Earth's atmosphere. By measuring these showers with a 3000 km² surface detector and fluorescence telescopes, the arrival directions and mass composition of the cosmic particles are studied at the Pierre Auger Observatory. The reconstruction of event-by-event information sensitive to the cosmic-ray mass is a challenging task and so far, mainly based on fluorescence detector observations with a duty cycle of about 15%. Recently, deep learning-based algorithms have shown to be extraordinarily successful across many domains. Applying these novel algorithms to surface-detector data allows for an event-by-event estimation of the cosmic-ray mass, exploiting the 100% duty cycle of the detector.

In this contribution, we discuss the application of deep learning at the Pierre Auger Observatory with a particular focus on the reconstruction of air showers. Furthermore, we show that machine learning algorithms and the extensive capabilities of the upcoming AugerPrime upgrade have enormous potential to deepen our understanding of UHECRs.

# Deep Learning Weeks

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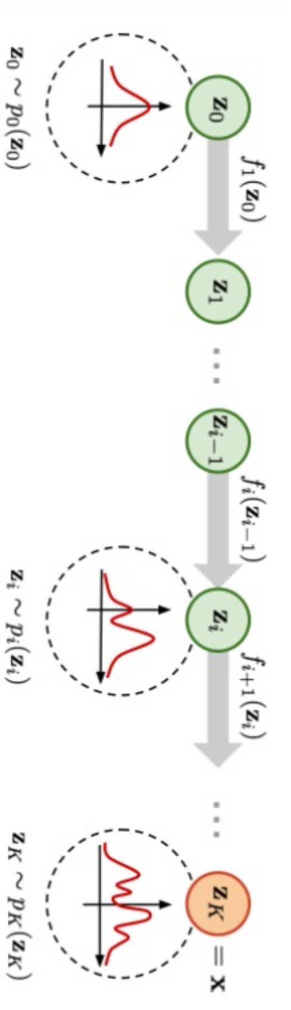
## **Week 13 (28.3. - 1.4)** with Dr. Thorsten Glüsenkamp, ECAP Erlangen

*Thorsten is an expert in deep learning in physics research. He leads the reconstruction/deep-learning working group of the IceCube Neutrino Observatory (the largest neutrino detector in the world located at the South Pole). He is pioneering novel approaches, in particular the usage of normalizing flows which allows to completely rethink data analysis in the 21st century.*




**Workshop** Monday 14:00-16:00 and Wednesday 9:00-11:00

***Normalizing flows - An overview and its revolutionary potential for high-energy physics when combined with deep learning***

*Register here*: https://forms.gle/3fJJyy2HreSzG8Lz9*

Modeling of probability distributions is ubiquitous in high-energy data analysis. Typical use cases involve modeling probability distributions of data for likelihood functions in the context of Frequentist or Bayesian analysis, or to directly parametrize probability distributions over the final parameters for variational Posterior inference. Traditional approximation of these PDFs reaches their limits when the involved dimensionality or complexity of the problem is large. Normalizing flows are a novel way to parametrize probability distributions, and their strength surfaces when combined with deep neural network architectures because they are not bound by traditional complexity bottlenecks.

This talk gives an introduction to normalizing flows, and then discusses its potential for both Frequentist and Bayesian data analysis in high energy physics. In particular, the possibility to re-interpret deep learning solely via normalizing flow inference is highlighted, which allows to completely rethink data analysis in the 21st century.

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**Seminar** Thursday 10:30 - 11:15 (Å10238 Beurlingrummet or zoom)

***Deep Learning in the IceCube Neutrino Detector - Status, Challenges, and Prospects***

*Zoom Meeting ID: 643 0039 1344 Passcode: 068393*

IceCube, the largest neutrino detector with 1 km3 instrumented Antarctic glacial ice volume, is currently the largest high-energy neutrino detector in the world. It has been operating for over 10 years in its full configuration and is continuing to take data and refine the data pipeline. This talk gives a brief overview of recent physics results, then shifts more to technical aspects and discusses the status, prospects, and challenges of the ongoing deep-learning efforts in the collaboration.

Any questions? Contact *Christian Glaser (christian.glaser@physics.uu.se)*