T 75: Neutrino Astronomy IV

Time: Thursday 16:15–18:30 Location: VG 1.105

T 75.1 Thu 16:15 VG 1.105

Recent Developments in RNO-G — •Zeynep Su Selcuk[1] and Anna Nelles[1,2] — [1]DESY, Platanenallee 6, 15738 Zeuthen — [2]ECAP, Friedrich-Alexander-University Erlangen-Nuremberg, 91058 Erlangen, Germany

Astrophysical neutrinos and their origins are the focus of the Radio Neutrino Observatory Greenland (RNO-G). Due to their electrically neutral nature and low cross-section, neutrinos from astronomical sources travel without being attenuated or deflected by electromagnetic fields. The observation of highly energetic neutrinos is particularly interesting since these can bring light to some of the most extreme objects in the Universe. Studying these neutrinos also provides the opportunity to test fundamental physics at energy scales far beyond those achievable by current particle accelerators. RNO-G is currently under construction and aims to become the world's most sensitive ultra-high energy (E > 10 PeV) neutrino detector. It searches for radio signals emitted through the Askaryan mechanism after neutrinos interact with the dense Greenlandic ice sheet, which provides a large effective volume to compensate for the low neutrino flux. The ice sheet is transparent to radio emission and thanks to the large attenuation length of the radio waves, a large volume can be observed with a relatively low number of stations. RNO-G plans to cover an area of approximately 50 km^2 with 35 stations and each station consists of 24 receiver antennas. 7 of these 35 stations are already operational. The data taken from these first 7 stations will help shape the future of the project. This talk gives an update on the latest developments in RNO-G.

T 75.2 Thu 16:30 VG 1.105

Updates on the optical module for IceCube-Gen2 — •Markus Dittmer and Alexander Kappes for the IceCube-Gen2-Collaboration — Universität Münster, Institut für Kernphysik

As part of the further development of IceCube, an innovative optical module (OM) was developed for IceCube-Gen2, which builds on the successful features of the mDOMs and D-Eggs of IceCube Upgrade, but also adapts to the limitations of the smaller borehole diameter. This new OM design, which will be tested in IceCube Upgrade, will serve as a prototype for the planned mass production of 10,000 OMs for IceCube Gen2. To simplify the assembly processes, important changes had to be made to the design, especially to integrate the gel pad concept. In this presentation, the design philosophy will be reviewed and various performance metrics will be presented.

T 75.3 Thu 16:45 VG 1.105

Discrimination of Muon Bundles from Single Muons in IceCube — •Alexandra Scholz and Cristina Lagunas Gualda for the IceCube-Collaboration — Technical University of Munich, Germany

The detection of neutrino events from astrophysical sources is one of the main goals of the IceCube Neutrino Observatory, which is located at the geographic South Pole. Atmospheric muons and neutrinos produced in the interaction of cosmic ray particles with the atmosphere build a large background for such events. Atmospheric neutrinos are irreducible background and cannot be directly filtered out. Nevertheless, for IceCube's northern sky the Earth serves as a shield for atmospheric muons, which often reach the detector in bundles. However, it also filters ultra-high energy (UHE) neutrino events. In order to detect UHE events, the whole sky has to be considered, leaving us with the problem of the enormous background of atmospheric muons. The strategy of this project is to discriminate muon bundles from single muons above 100 TeV, as single muons are the signature of astrophysical neutrino events in the detector. A graph neural network (GNN) will be used to classify the events based on CORSIKA simulations.

T 75.4 Thu 17:00 VG 1.105

Improving Track Reconstruction with Direct Muon Signals in IceCube Upgrade Modules — •Simon Pick — Ruhr-Universität Bochum — DESY, Zeuthen

One of the main constraining factors in IceCube's ability to detect neutrino point sources is angular resolution. Muon track reconstruction is limited by the knowledge of the optical properties of ice and detector responses. With the addition of multi-PMT optical modules in the upcoming upgrade of the existing detector, new calibration methods will be possible.

A promising approach for an improved track reconstruction is the measurement of a direct muon signal in multiple PMTs of separate modules. This may present a technique to confine the muon track with unprecedented accuracy treating the PMTs as anchor points and thus, by using those tracks as calibration sources, enabling a general improvement for all reconstructed tracks. This talk discusses the feasibility of the idea and presents the progress of its investigation through laboratory measurements.

T 75.5 Thu 17:15 VG 1.105

Advanced Northern Tracks Selection using a Graph Convolutional Neural Network for the IceCube Neutrino Observatory: Event classification — •Shuyang Deng, Philipp Behrens, Jakob Böttcher, Lasse Düse, Philipp Fürst, Leon Hamacher, Michael Handt, Lars Marten, Philipp Soldin, and Christopher Wiebusch for the IceCube-Collaboration — III. Physikalisches Institut B RWTH Aachen University, Aachen, Germany

The IceCube Neutrino Observatory is a large neutrino detector built deep in the Antarctic ice at the South Pole. The Advanced Northern Track Selection (ANTS) framework uses a graph convolutional neural network to select neutrino-induced muon tracks. These events have different topologies and signatures within the detector, such as through-going, starting, skimming tracks as well as remaining background from cosmic-ray induced muons and cascades e.g. related to electron neutrinos. In this work, we perform the classification of these event topologies using the ANTS framework, providing an event-wise probability for each topology. This classification enables dedicated handling of these topologies in further analyses.

T 75.6 Thu 17:30 VG 1.105

Advanced Northern Tracks Selection using a Graph Convolutional Neural Network for the IceCube Neutrino Observatory: Background Rejection — •Philipp Behrens, Jakob Böttcher, Shuyang Deng, Lasse Düser, Philipp Fürst, Leon Hamacher, Michael Handt, Lars Marten, Philipp Soldin, and Christopher Wiebusch for the IceCube-Collaboration — III. Physikalisches Institut, RWTH Aachen University, Aachen, Deutschland

The IceCube Neutrino Observatory is a large neutrino detector located in the ice at the geographic South Pole. It detects atmospheric and astrophysical neutrinos by Cherenkov radiation emitted by secondary particles with more than 5000 photomultipliers. A main challenge is the efficient distinction between neutrinos and air-shower-induced muons. The Advanced Northern Tracks Selection (ANTS) improves this classification using a deep graph convolutional neural network, capturing the node-like structure of the geometric arrangement of the photomultipliers inside the detector, as well as the raw sensor data. Using this architecture, both local and global features are learned. This work focuses on the evaluation and enhancement of the neural network architecture with respect to the background rejection of air-shower-induced muons.

T 75.7 Thu 17:45 VG 1.105

Advanced Northern Tracks Selection using a Graph Convolutional Neural Network for the IceCube Neutrino Observatory: Energy Reconstruction — •Lasse Düser, Philipp Behrens, Jakob Böttcher, Shuyang Deng, Philipp Fürst, Leon Hamacher, Michael Handt, Lars Marten, Philipp Soldin, and Christopher Wiebusch for the IceCube-Collaboration — III. Physikalisches Institut, RWTH Aachen University, D-52056 Aachen, Germany

The IceCube Neutrino Observatory is a detector located at the geographic South Pole, consisting of more than 5000 photomultipliers (PMTs). These PMTs detect Cherenkov radiation, produced by muons induced by charged current neutrino interactions, within the instrumented ice. The identification of neutrino-induced through-going muon tracks is performed by the newly developed Advanced Northern Tracks Selection (ANTS) using a graph convolutional neural network that encodes the spatial geometry of the PMTs. A significant advantage of this network architecture is utilizing the full event information, enabling an improved reconstruction of event features like neutrino energy. This talk discusses the network's performance and compares it to existing energy reconstruction methods. The reconstruction is evaluated with respect to resolution, direction, and computational efficiency across various event topologies.

T 75.8 Thu 18:00 VG 1.105

Using CRPropa to reconstruct the high energy neutrino emission of NGC 1068 * — •Alexander Kazatsky, Julia Becker Tjus, Björn Eichmann, and Julien Dörner — Theoretical Physics IV, Faculty of Physics and Astronomy, Ruhr-University Bochum, Universitätsstraße 150, 44801 Bochum

The Seyfert 2 galaxy NGC 1068 (also known as Messier 77) is one of the closest active galaxies for which a high energy neutrino flux has been detected by the IceCube Neutrino Observatory. Previous works have concluded that the neutrino emission is likely to originate from a region of the active galactic nucleus (AGN) called the AGN corona. In this work, this neutrino emission is calculated by developing a threedimensional model for the corona of NGC 1068 using a modified version of the publically available CRPropa propagation framework. The diffusive transport of the underlying cosmic rays is solved via stochastic differential equations in 3D space and different hadronic processes are taken into account for the generation of the overall non thermal emission. The resulting neutrino flux is compared to the available IceCube data to optimise the model of the AGN environment. * Supported by SFB 1491

T 75.9 Thu 18:15 VG 1.105

Hadronic Modelling of the TXS 0506+056 2017 Flare Using CRPropa* — •Vladimir Kiselev[1,2], Leander Schlegel[1,2], Julien Dörner[1,2], and Julia Becker Tjus[1,2] — [1]Theoretische Physk IV, Fakultät für Physik, Ruhr-Universität Bochum, Universitätsstraße 150, 44801 Bochum — [2]RAPP Center, Ruhr-Universität Bochum, Universitätsstraße 150, 44801 Bochum

TXS 0506+056 is a well-studied blazar that, in 2017, was associated with a high-energy neutrino detection by IceCube during a gamma-ray flare. This event marked the first indication of detection in multi-messenger astrophysics, highlighting the need for robust theoretical models. In response, several attempts have been made to model the multi-messenger emission from this flare. Here, we present our approach to modelling the 2017 neutrino and gamma-ray flares using a modified version of CRPropa. Compared to other models, we adopt a hadronic model to explain both the Very High-Energy gamma-rays and neutrinos, incorporating particle propagation in a fully three-dimensional environment with turbulent magnetic fields. Furthermore, we validate the result using both the SED and the lightcurve of the flare.

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