Auger Youngsters Meeting 2024 (Siegen)

Report of Contributions

https://indico.physik.uni-siegen.de/e/augeryoungsters2024

Contribution ID: **3** Type: **not specified**

Adding interferometric lightning detection to the Pierre Auger Observatory

Friday 6 September 2024 10:00 (20 minutes)

The Pierre Auger Observatory has detected downward terrestrial gamma-ray flashes (TGFs) with its Surface Detector. A key to understanding this high-energy radiation in thunderstorms is to combine such measurements with measurements of lightning processes in their earliest stages. With eleven modified Auger Engineering Radio Array (AERA) stations we can build an interferometric lightning detection array working in the bandwidth range 30 - 80 MHz inside the Surface Detector array to precisely measure lightning stepped leaders in 3D. These measurements allow us to decipher the cause of TGFs and clarify the reason for the observed high-energy particles in thunderstorms.
We will present the current status of the detection plans including the configuration of the interferometric lightning detection array, together with future steps and the reconstruction characteristics obtained with AERA.

Primary author: WEITZ, Melanie Joan (Bergische Universität Wuppertal)

Presenter: WEITZ, Melanie Joan (Bergische Universität Wuppertal)

Session Classification: Main session

Contribution ID: **4** Type: **not specified**

Graph neural networks for photon search at tens of PeV

Thursday 5 September 2024 09:50 (20 minutes)

The contributions focus on the implementation of graph neural networks to search for photons using the SD-433 and the Underground Muon Detector.

Primary author: RODRIGUEZ, Ezequiel (ITeDA-KIT)

Presenter: RODRIGUEZ, Ezequiel (ITeDA-KIT)

Session Classification: Main session

Contribution ID: **5** Type: **not specified**

Directional search for UHE photons using the surface detector of the Pierre Auger Observatory

In addition to its capabilities for precise measurement of ultra-high-energy (UHE, $E > 10^{17}$ eV) cosmic rays with the observation of extensive air showers, the Pierre Auger Observatory also encompasses the potential of effectively detecting UHE photons. These are closely connected to the origin or propagation of hadronic cosmic rays. Moreover, such UHE photons are also theorized to be emitted during transient events, offering an additional channel in the context of multimessenger astronomy. Several efforts by the Pierre Auger Collaboration have utilized the Observatory's various detector systems to search for UHE photons. Although no UHE photons have been unambiguously identified so far, stringent upper limits have been established on both the diffuse photon flux and the flux from specific arrival directions, including near source candidates. During my PhD studies, I aim to design a new direction-dependent UHE photon search, based on air-shower universality. With this approach, data of the Surface Detector (SD) can be used to reconstruct central quantities like primary energy and atmospheric depth of the shower maximum, which are essential for primary particle classification, with a significantly improved precision. Moreover, with sole dependence on the SD, one can take advantage of its extensive duty cycle for a UHE photon search. The ongoing work and forthcoming steps involved in constructing such an analysis will be discussed in this contribution.

Primary author: FEHLER, Tim (Experimentelle Astroteilchenphysik, Universität Siegen)

Presenter: FEHLER, Tim (Experimentelle Astroteilchenphysik, Universität Siegen)

Contribution ID: **6** Type: **not specified**

Investigating the Elemental Spectra and Arrival Directions of UHECRs

Thursday 5 September 2024 13:50 (20 minutes)

The origin of the UHECRs remains unknown. Yet the properties of the detected spectra can provide us with useful clues. We aim to study the features of the energy spectra in dependence on arrival air showers using artificial neural network mass estimators. Obtaining the elemental group of the primary particle on a single-event basis allows for the separation of the lightest particles which are minimally deflected on the extragalactic magnetic fields. We are searching for small- and large-scale correlation patterns in the sky in comparison with existing object catalogs.

Primary author: ČERMÁKOVÁ, Berenika (KIT)

Presenter: ČERMÁKOVÁ, Berenika (KIT)

Session Classification: Main session

Contribution ID: **7** Type: **not specified**

GMFs and UHECR arrival and anisotropy

Wednesday 4 September 2024 14:20 (20 minutes)

We investigate the energy dependent residence time of extragalactic cosmic rays entering our Galaxy using CRPropa and current galactic magnetic models. With our simulation setup, we see the onset of diffusive propagation starting below ankle energies, and a strong suppressing of extragalactic cosmic rays entering our Galaxy below 0.1 EeV. We investigate anisotropy in this framework.

Primary author: MEINERT, Janning (Bergische Universität Wuppertal)

Presenter: MEINERT, Janning (Bergische Universität Wuppertal)

Session Classification: Main session

Contribution ID: **8** Type: **not specified**

Estimating the secondary photon flux produced during the propagation of primary cosmic rays

In this contribution, a simulation based method to estimate the flux of secondary photons produced during the propagation of primary cosmic rays is presented. During their propagation cosmic ray particles interact with photon background fields such as the cosmic microwave background (CMB). Through photo-pion production and the subsequent decay of neutral pions, secondary photons are created. The overall number of photons produced in these interactions varies depending on different parameters, like the propagated distance, the energy of the initial cosmic ray particle and overall cosmic ray composition. These dependencies are evaluated here in order to investigate a maximum or also minimum possible photon flux.

Primary author: PAPIOR, Chiara (Universität Siegen)

Presenter: PAPIOR, Chiara (Universität Siegen)

Contribution ID: **9** Type: **not specified**

Lightning Broadband Radio Interferometry at the Pierre Auger Observatory

Friday 6 September 2024 10:20 (20 minutes)

Previous efforts at the Pierre Auger Observatory have shown that lightning related phenomena can be picked up by, and affect, each of its detector systems. Therefore as part of its monitoring, a system has been rolled out to detect thunderstorm conditions, enabling the investigation of thunderstorms and lightning using the Observatory's hybrid detectors.

As a successful testbed for air shower measurements using radio detectors, the Auger Engineering Radio Array (AERA) is a direct precursor to the Radio Detector package of the AugerPrime upgrade that is currently in deployment. To expand the existing lightning detection infrastructure, we aim to repurpose a subset of AERA stations and strategically redistribute them within the Auger field to establish a precision interferometric lightning physics facility.

In this contribution, I will present the interplay between thunderstorms and air shower physics and the motivation for further developing such lightning facilities.

Primary author: DE BOONE, Eric-Teunis (Universität Siegen)

Presenter: DE BOONE, Eric-Teunis (Universität Siegen)

Session Classification: Main session

Contribution ID: **10** Type: **not specified**

Drone-Based Calibration of AugerPrime Radio Antennas

Thursday 5 September 2024 15:00 (20 minutes)

Radio emissions of extensive air showers can be observed at the Pierre Auger Observatory with the AugerPrime radio detector (RD). As part of the AugerPrime upgrade, RD is being installed on 1660 water-Cherenkov detectors on an area of about 3000 km^2 and consists of dual-polarized Short Aperiodic Loaded Loop Antennas (SALLA). To achieve high measurement precision, RD needs to be well-calibrated, which requires the antenna response pattern to be well-known. We introduce a method to measure the directional response of the SALLA using a well-defined biconical antenna mounted to a drone. The drone-based setup possesses active stabilization and precise pointing with the use of a gimbal. Additionally, the drone's position is tracked using differential GPS with $\mathcal{O}$(cm) precision. This setup allows us to precisely extract the antenna response pattern from any direction in the frequency range of $30 - 80$ MHz. In a recent in-situ campaign, calibration measurements of the AugerPrime radio detector have been performed. First results of these measurements are presented and compared to simulations.

Primary author: REUZKI, Alex (RWTH Aachen University)

Presenter: REUZKI, Alex (RWTH Aachen University)

Session Classification: Main session

Contribution ID: **11** Type: **not specified**

Photon-hadron discrimination with CNNs

Thursday 5 September 2024 10:10 (20 minutes)

In this contribution we study the performance of convolutional neural networks discrimination of photon induced events from the hadronic background. We use simulated showers for the SD-1500 detector. We also investigate the influence of different input information and try to understand of which information the network is making use of.

Primary author: ELLWANGER, Fiona (Karlsruhe Instiute of Technology - Institut für Astroteilchenphysik)

Co-authors: Dr VEBERIC, Darko (Karlsruhe Instiute of Technology - Institut für Astroteilchenphysik); Dr SCHMIDT, David (Karlsruhe Instiute of Technology - Institut für Astroteilchenphysik); Dr ROTH, Markus (Karlsruhe Instiute of Technology - Institut für Astroteilchenphysik); Prof. ENGEL, Ralph (Karlsruhe Instiute of Technology - Institut für Astroteilchenphysik)

Presenter: ELLWANGER, Fiona (Karlsruhe Instiute of Technology - Institut für Astroteilchenphysik)

Session Classification: Main session

Contribution ID: **12** Type: **not specified**

Application of Information Field Theory to UHECR Deflections in the Galactic Magnetic Field

Information Field Theory (IFT) offers a powerful framework for the analysis of experimental data. The fundamental objective of IFT is the reconstruction of continuous fields from noisy and sparse data. By combining Bayesian probabilities with computational techniques from quantum field theory and statistical mechanics, IFT allows for efficient inference in high-dimensional problems.

In this talk, we discuss the application of IFT to the arrival directions of ultra-high-energy cosmic rays (UHECRs). We introduce a forward model that connects the extragalactic illumination map of UHECRs to the observed arrival directions, accounting for deflections caused by the Galactic magnetic field. We apply the model to simulated arrival directions, demonstrating the capabilities and possibilities that IFT can provide.

Primary authors: KRIEGER, Frederik (RWTH Aachen University); ERDMANN, Martin; SMOLKA, Michael

Presenter: KRIEGER, Frederik (RWTH Aachen University)

Contribution ID: **13** Type: **not specified**

A search for neutron fluxes from Galactic candidate sources

Wednesday 4 September 2024 15:30 (20 minutes)

Neutral particles, whose arrival directions directly indicate their origin, are valuable for investigating sources of ultra-high-energy cosmic rays (UHECRs). We expect that sources emitting UHECRs also produce neutrons through nuclear interactions and photo-pion production in their vicinity. These free neutrons, which undergo β-decay, can travel a mean distance of $9.2\times(E/\mathrm{EeV})$ kpc. As a result, neutron fluxes in the EeV range could be detectable on Earth from UHECR sources within our Galaxy. We explore potential neutron fluxes from various Galactic candidate sources, focusing on objects of astrophysical interest, including pulsars, microquasars, and magnetars, as well as the Galactic center, the Crab Nebula, and a subset of gamma-ray emitters identified by LHAASO. Since air showers initiated by protons and neutrons are indistinguishable, we identify a possible neutron flux by detecting an excess of cosmic ray events near the direction of a candidate source. We compare the observed signal against the expected background to identify such excesses. Our analysis considers cosmic ray events with declinations between -90° and $+45^\circ$ and energies starting from 0.1 EeV.

Primary author: DE OLIVEIRA FRANCO, Danelise (University of Hamburg)

Presenter: DE OLIVEIRA FRANCO, Danelise (University of Hamburg)

Session Classification: Main session

Contribution ID: **14** Type: **not specified**

Current status of Pythia 8 for air shower studies

Thursday 5 September 2024 11:00 (20 minutes)

- Introduce Pythia 8 model for hadronic interactions
- Motivate using Pythia 8 alongside the current state-of-the-art hadronic interaction models for (extensive) air shower simulations
- Discuss cross-sections among models and compared to Auger (p-air and pp)
- Discuss tune of Pythia 8 for air showers
- Discuss (status of) interface between Pythia 8 and Corsika 8
- Outlook on global tune for air showers

Primary author: GAUDU, Chloé (Bergische Universität Wuppertal)

Presenter: GAUDU, Chloé (Bergische Universität Wuppertal)

Session Classification: Main session

Contribution ID: **15** Type: **not specified**

Measuring the delayed neutron component in extensive air showers

Thursday 5 September 2024 11:40 (20 minutes)

The study of ultra-high-energy cosmic rays allows for the probing of hadronic interactions at energies far exceeding those achievable by human-made accelerators.
Different models can be tested by measuring the electromagnetic or muonic signal in air showers.
In the Scintillator Surface Detectors (SSDs), we observe subluminal pulses that could originate from a late neutron component.
This opens up a new possibility of testing hadronic interaction models through the hadronic component of air showers.
In this talk, we will examine the measurements of subluminal pulses and make a first attempt to compare them to predictions of dedicated neutron simulations.

Primary author: SCHULZ, Tobias (KIT)

Presenter: SCHULZ, Tobias (KIT)

Session Classification: Main session

Contribution ID: **16** Type: **not specified**

Deflection direction reconstruction using normalizing flows with an AGN-catalog

Wednesday 4 September 2024 15:10 (20 minutes)

Ultra high energy cosmic rays (UHECRs) coming from many different sources are deflected by the galactic magnetic field (GMF) before arriving at Earth. Every source type emits cosmic rays (CRs) with unique energies and compositions which are not known yet. This contribution focuses on UHECRs originating from positions of active galactic nuclei (AGN). Because of uncertain existing GMF models, a GMF model based on spherical harmonics is established. In order to find coherent deflection directions of UHECRs, here normalizing flows are used. The goal of this work is to find the optimal hyperparameters with which the network can reconstruct the GMF model best. Currently the results show that a big network with a higher maximum degree of spherical harmonic expansion, and therefore more trainable parameters, has a good performance. The next steps are the addition of background CRs to better mimic real data. Together with taking the exposure of the Pierre Auger Observatory into account, it will be seen which cINN works best for the purpose of finding the best reconstruction of the GMF.

Primary author: WIRTZ, Dominik (RWTH Aachen)

Presenter: WIRTZ, Dominik (RWTH Aachen)

Session Classification: Main session

Contribution ID: **17** Type: **not specified**

Studying effects of Lorentz violation in the photon sector using extensive air shower simulations

Thursday 5 September 2024 11:20 (20 minutes)

The effects of isotropic, non-birefringent Lorentz violation in the photon sector can be studied with air showers induced by ultra-high-energy cosmic rays.
Using the 1-dimensional air shower simulation program CONEX, bounds on the studied Lorentz violation were set based on the significant reduction of the average atmospheric depth of the shower maximum $\langle X_{\mathrm{max}} \rangle$ and its shower-to-shower fluctuations $\sigma(X_{\mathrm{max}})$.
In order to improve the search for the Lorentz violation, these modifications, which achieve Lorentz violation, have been implemented in the 3-dimensional air shower simulation program CORSIKA. This allows the inclusion of observables unavailable to a 1-dimensional simulation such as those connected to the lateral particle distribution.
Preliminary results from the 3-dimensional shower simulations will be presented.

Primary author: SPORNHAUER, Nico (Universität Siegen)

Presenter: SPORNHAUER, Nico (Universität Siegen)

Session Classification: Main session

Contribution ID: **18** Type: **not specified**

Gravitational Wave Follow-up of Ultra-High Energy Neutrinos with the Pierre Auger Observatory

Friday 6 September 2024 11:10 (20 minutes)

Primarily designed to detect ultra-high energy (UHE) cosmic rays, the Pierre Auger Observatory also possesses excellent sensitivity to UHE neutrinos. The Surface Detector array is used to search for highly inclined neutrino-induced air showers, which, though not observed yet, have clear characteristic signatures. Follow-up searches of UHE neutrinos in Gravitational Wave (GW) events are of unique scientific interest.

The fourth observational run (O4) by the gravitational wave network LIGO-Virgo-KAGRA of interferometric detectors started in May 2023. With the substantial increase in sensitivity in the O4 run, a higher frequency of GW alerts is expected. This creates a need for the development of software to reply to the General Coordinates Network (GCN) circulars. This talk presents the work being done by the Pierre Auger Collaboration to get an automated response to these GCN notices. Following the alerts, a specific analysis is conducted to calculate a one-day fluence limit for a point source, in the case no neutrino candidate was identified.

Primary author: PAULSEN, Therese (Bergische Universität Wuppertal)

Presenter: PAULSEN, Therese (Bergische Universität Wuppertal)

Session Classification: Main session

Contribution ID: **19** Type: **not specified**

Absolute energy calibration of the Fluorescence Telescopes at the Pierre Auger Observatory with a roving laser system

Thursday 5 September 2024 14:10 (20 minutes)

The Fluorescence Detector (FD) of the Pierre Auger Observatory provides energy measurements of primary cosmic rays that are largely independent of specific models. These FD energy measurements are crucial for calibrating the energy reconstruction process of the Surface Detector. Consequently, the accuracy of the FD energy calibration plays a significant role in the systematic uncertainties associated with nearly all scientific results from the Observatory. To achieve high precision in calibration, a laser with a well-defined energy output is fired in front of the FD telescopes. This method has the advantage that the camera's response to the laser closely simulates its reaction to an actual cosmic ray air shower, something that is difficult to achieve with other calibration methods.

The system, originally developed by Alina Esfahani, was designed with special attention given to the depolarization of the laser beam to ensure a consistent relationship between energy output and directional light emission. Additionally, the use of a telescope mount allows laser shots at various angles. This presentation covers the ongoing development of the mobile laser system and outlines plans for upcoming measurement campaigns.

Primary author: UZEIROSKA, Rukije (Bergische Universität Wuppertal)

Presenter: UZEIROSKA, Rukije (Bergische Universität Wuppertal)

Session Classification: Main session

Contribution ID: **20** Type: **not specified**

Measurement of the Cosmic Ray Spectrum with the Pierre Auger Observatory's Surface Detector

Thursday 5 September 2024 13:30 (20 minutes)

In this study, we measured the cosmic ray energy spectrum at the Pierre Auger Observatory using a surface detector array composed of Water-Cherenkov detectors, with the energy scale calibrated by a fluorescence detector. This contribution presents the spectrum measured with the 433 m array, which lowers the energy threshold from previous measurements to 63 PeV, enabling the characterization of the flux steepening around 230 PeV, a feature known as the "second knee."

Primary author: BRICHETTO ORQUERA, Gabriel (KIT - ITeDA)

Presenter: BRICHETTO ORQUERA, Gabriel (KIT - ITeDA)

Session Classification: Main session

Contribution ID: **23** Type: **not specified**

Closing the meeting

Friday 6 September 2024 11:50 (10 minutes)

Contribution ID: **24** Type: **not specified**

Organizational matters regarding evening activities

Thursday 5 September 2024 15:40 (20 minutes)

Contribution ID: **25** Type: **not specified**

Opening talk

Wednesday 4 September 2024 14:00 (20 minutes)

Contribution ID: **26** Type: **not specified**

Estimating the secondary photon flux produced during the propagation of primary cosmic rays

Wednesday 4 September 2024 15:50 (20 minutes)

In this contribution, a simulation based method to estimate the flux of secondary photons produced during the propagation of primary cosmic rays is presented. During their propagation cosmic ray particles interact with photon background fields such as the cosmic microwave background (CMB). Through photo-pion production and the subsequent decay of neutral pions, secondary photons are created. The overall number of photons produced in these interactions varies depending on different parameters, like the propagated distance, the energy of the initial cosmic ray particle and overall cosmic ray composition. These dependencies are evaluated here in order to investigate a maximum or also minimum possible photon flux.

Presenter: PAPIOR, Chiara (Universität Siegen)

Session Classification: Main session

Contribution ID: **27** Type: **not specified**

Directional search for UHE photons using the surface detector of the Pierre Auger Observatory

Friday 6 September 2024 11:30 (20 minutes)

In addition to its capabilities for precise measurement of ultra-high-energy (UHE, $E > 10^{17}$ eV) cosmic rays with the observation of extensive air showers, the Pierre Auger Observatory also encompasses the potential of effectively detecting UHE photons. These are closely connected to the origin or propagation of hadronic cosmic rays. Moreover, such UHE photons are also theorized to be emitted during transient events, offering an additional channel in the context of multimessenger astronomy. Several efforts by the Pierre Auger Collaboration have utilized the Observatory's various detector systems to search for UHE photons. Although no UHE photons have been unambiguously identified so far, stringent upper limits have been established on both the diffuse photon flux and the flux from specific arrival directions, including near source candidates. During my PhD studies, I aim to design a new direction-dependent UHE photon search, based on air-shower universality. With this approach, data of the Surface Detector (SD) can be used to reconstruct central quantities like primary energy and atmospheric depth of the shower maximum, which are essential for primary particle classification, with a significantly improved precision. Moreover, with sole dependence on the SD, one can take advantage of its extensive duty cycle for a UHE photon search. The ongoing work and forthcoming steps involved in constructing such an analysis will be discussed in this contribution.

Presenter: FEHLER, Tim (Center for Particle Physics Siegen, Universität Siegen)

Session Classification: Main session