T 41: Cosmic Ray II

Time: Tuesday 17:00–18:30 Location: POT/0013

T 41.1 Tue 17:00 POT/0013

Determination of the Energy Spectrum of UHECRs using Air Showers Detected by the Fluorescence and Surface Detector of the Pierre Auger Observatory — •Kathrin Bismark for the Pierre Auger-Collaboration — Karlsruher Institut für Technologie (KIT)

The origin, propagation and mass composition of ultrahigh-energy cosmic-rays (UHECRs) are still open questions. A precise measurement of the spectral features of the UHECR energy spectrum provides important clues to answer these questions.

In this contribution, we present an analysis of air shower data using a hybrid technique, i.e. the combination of surface (SD) and fluorescence detector (FD) measurements from the Pierre Auger Observatory. The high statistics of hybrid data available after more than 15 years of UHECR observations enable us to evaluate environmental influences on detection capabilities as well as to optimize selection criteria using measured rather than simulated data. We will show how previous estimates of the hybrid spectrum can be improved and present a preliminary calorimetric measurement of the energy spectrum of UHECRs.

T 41.2 Tue 17:15 POT/0013

Depth of Maximum of Air-Shower Profiles at the Pierre Auger Observatory — •Thomas Thomas for the Pierre Auger-Collaboration — Karlsruhe Institute of Technology, Institute for Astroparticle Physics, Karlsruhe, Germany

The Pierre Auger Observatory is the largest ultra-high energy cosmic ray observatory in the world. Using a hybrid technique (fluorescence telescopes and surface detectors) it is possible to estimate the mass composition of cosmic rays. The main mass-sensitive observable measured with fluorescence telescopes is the depth of maximum of air-shower profiles called X_{max}.

In this presentation, we will present the analysis of the most recent datasets for the standard eyes and also for the low energy measurements performed with the High Elevation Auger Telescope (HEAT). This low energy measurements allow to study the energy region where the transition between Galactic and extragalactic cosmic rays is expected.

T 41.3 Tue 17:30 POT/0013

A machine learning approach to mass composition studies of ultra-high energy cosmic rays with the AugerPrime upgrade of the Pierre Auger Observatory. — •Akash Parmar, Paulo Ferreira, and Thomas Hebbeker — RWTH Aachen University, Aachen, Germany

The Pierre Auger Observatory is the world's largest experiment to observe the extensive air showers produced by ultra-high energy cosmic rays. The observatory uses a hybrid detection method that combines 1600 ground-based water Cherenkov detectors covering an area of more than 3000 km^2 and 27 fluorescence detectors at four sites. The efficiency and measurement techniques of the Pierre Auger observatory are improved by the ongoing upgrade called AugerPrime. A part of the upgrade consists of deploying a scintillator detector on top of each water Cherenkov detector which provides additional information about the composition of the extensive air showers.

Currently, the understanding of cosmic rays at ultra-high energy is limited by low incoming flux and the available theoretical models for hadronic interactions. Precise measurement of the composition can help us understand the sources of cosmic rays and improve the current models.

The additional information provided by the combination of water Cherenkov detectors and scintillator surface detectors has been explored with a machine learning algorithm called random forest, to analyze the measurable properties of the shower and infer the mass composition of the primary particle.

T 41.4 Tue 17:45 POT/0013

Inferring Properties of Ultra-High-Energy Cosmic Ray Sources from Surface Detector Data of the Pierre Auger Observatory — Teresa Bister, Martin Erdmann, Merlin Klein, •Frederik Krieger, and Josina Schulte — III. Physikalisches Institut A, RWTH Aachen University

With the Pierre Auger Observatory, the energy spectrum and the distributions of the depths of the shower maximum X_{max} of ultra-high-energy cosmic rays (UHECRs) can be measured. The latter is correlated to the mass of the primary cosmic ray and can be directly measured by the fluorescence detector (FD). Using deep learning, X_{max} can also be extracted from the surface detector (SD) data which has the benefit of high event statistics. With these observables, characteristics of the sources of UHECRs can be inferred. Owing to the stochastic nature of interactions during propagation, simple inversion of the process from source to Earth is not possible. To this end, different inference methods can be used.

We present and compare two different inference methods and apply them to actual astrophysical scenarios: the Markov Chain Monte Carlo (MCMC) method and conditional invertible neural networks (cINNs). It has already been shown that cINNs perform similarly well to the frequently used MCMC method. We show the results of both methods on SD data of X_{max} and the energy spectrum.

T 41.5 Tue 18:00 POT/0013

Studying the properties of bursting UHECR sources in a multi-messenger approach* — •Leonel Morejon — Bergische Universität Wuppertal, Gaußstr. 20, 42119 Wuppertal

The study of Ultra-High Energy Cosmic Rays (UHECRs) via the multi-messenger approach is reaching a level that requires going beyond steady state sources. The exploration of bursting sources and the implications for multi-messenger detection is the goal of the French-German research project MICRO. Meeting this challenge requires improvements of the existing tools and defining new methods to accelerate the computations related to the propagation of UHECRs in extragalactic space and within the sources. The progress of MICRO in these aspects will be presented by discussing: a) a module to compute hadronic interactions within CRPropa, b) tools to fit the UHECR spectrum and composition with precomputed propagation tensors and corresponding propagation matrices, and c) the estimation of the impact that uncertainties of the latest models of Extragalactic Background Light (EBL) have on the precision in UHECR propagation.

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T 41.6 Tue 18:15 POT/0013

Numerical investigation of bursting sources as potential accelerators of ultra-high-energy cosmic rays — •Leander Schlegel[1,2], Julia Becker Tjus[1,2], and Marcel Schroller[1,2] — [1]Theoretische Physik IV, Ruhr Universität Bochum, Bochum, Germany — [2]RAPP-Center at Ruhr Universität Bochum, Bochum, Germany

Since their discovery over a century ago, the origin of cosmic rays of the highest energies is still widely uncertain. While the observed constant flux suggests at first sight to analyze primarily steady state source models, the needed magnetic luminosities for potential sources seem to favor bursting sources, that appear in quiescent and flaring states, like the class of Active Galactic Nuclei (AGN). The goal of this work is trying to understand the detailed behaviour of bursting sources and their possible contribution to the UHECR flux, by simulating the time resolved propagation of a plasma blob inside the jet of an AGN and accounting for a temporal variability of the source. For this purpose, a tool for cosmic-ray propagation in relativistic plasmoids of AGN jets implemented into the open-source code CRPropa 3.1, is further improved. With this framework, we will predict the multimessenger signatures of flaring sources that are active for certain intervals in time, representing a flaring behaviour. With this investigation we aim to help providing a numerical AGN model, that can finally be tested against other source models by fitting to observed UHECR data.