T 37: Cosmic Rays II

Time: Tuesday 16:15–17:45 Location: VG 3.102

T 37.1 Tue 16:15 VG 3.102

Measuring the Cosmic Ray Sun Shadow with IceCube* — •Niclas Krieger[1,2], Jonas Hellrung[1,2], Lukas Merten[1,2], Julia Becker Tjus[1,2,3], and Paolo Desiati[4] for the IceCube-Collaboration — [1]Ruhr-Universität Bochum, Fakultät für Physik und Astronomie, Institut für Theoretische Physik IV, Universitätsstraße 150, 44780 Bochum, Germany — [2]Ruhr Astroparticle and Plasma Physics Center (RAPP Center), Bochum, Germany — [3]Chalmers University of Technology, Department of Space, Earth and Environment, 412 96 Gothenburg, Sweden — [4]Department of Physics and Wisconsin IceCube Particle Astrophysics Center, University of Wisconsin-Madison, Madison, Wisconsin 53706, USA

With the IceCube Neutrino Observatory atmospheric muons are detected that are produced when cosmic rays interact with the Earth's atmosphere. On their way to Earth, cosmic rays are blocked by the Sun and the Moon. While the Moon shadow serves as an absolute pointing calibration, the Sun shadow enables an indirect observation of the Solar magnetic field since this deflects cosmic rays on their way and thus leaves its footprint in the temporal variation of the cosmic-ray shadow with the 11-year solar cycle. In this talk the methods of measuring the shadows of these celestial objects will be reviewed. Furthermore, it will be shown how these observations help to understand the Solar magnetic field better.

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T 37.2 Tue 16:30 VG 3.102

Towards a Directional Search for Ultra-High-Energy Photons Using the Surface Detector of the Pierre Auger Observatory — •Tim Fehler, Marcus Niechciol, and Markus Risse for the Pierre-Auger-Collaboration — Experimentelle Astroteilchenphysik, Center for Particle Physics Siegen, Universität Siegen

In addition to its capabilities for precise measurement of ultra-high-energy (UHE, $E \gtrsim 10^{17}$ eV) cosmic rays through the observation of extensive air showers, the Pierre Auger Observatory also offers the potential to effectively detect UHE photons. Their connection to UHE cosmic rays is manifold; constraints on their flux provide valuable hints on the elusive nature of the UHE cosmic rays. Contrary to charged cosmic rays, which are deflected by magnetic fields, UHE photons carry the inherent advantage that their origin can be traced back directly, which promotes the search for directional excesses of photon-like events in the sky. This contribution details the developments for a new direction-dependent search for UHE photons, based on the paradigm of air-shower universality. With this approach, data from the Surface Detector (SD) array of the Pierre Auger Observatory can be used to reconstruct key quantities such as the primary energy and the atmospheric depth of the shower maximum $X_{\max}$, which are essential for primary particle classification, with significantly improved precision. Furthermore, with sole dependence on the SD, one is able to take advantage of its $\sim 100\%$ duty cycle.

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T 37.3 Tue 16:45 VG 3.102

Inferring the Ultra-High-Energy Cosmic Ray Flux Prior to Deflections in the Galactic Magnetic Field Using Information Field Theory — Martin Erdmann, •Frederik Krieger, Josina Schulte, Michael Smolka, and Maximilian Straub — III. Physikalisches Institut A, RWTH Aachen University

Ultra-high-energy cosmic rays (UHECRs) are assumed to be charged nuclei with energies exceeding 10^{18} eV, whose origins and acceleration mechanisms are still not discovered. Upon entering the Earth's atmosphere, UHECRs interact with air molecules, initiating extensive particle showers that can be observed by cosmic ray observatories. However, as UHECRs traverse the Galactic magnetic field (GMF), they are deflected, changing their trajectories and causing the measured arrival directions to no longer point back to their sources. To address this challenge, we present a novel approach combining forward modeling and information field theory to reconstruct the UHECR flux before deflection in the GMF. We apply this method to an astrophysical model, demonstrating its potential to improve the estimation of the UHECR source distribution.

T 37.4 Tue 17:00 VG 3.102

A novel approach for air shower profile reconstruction using radio measurements with Information Field Theory — •Keito Watanabe[1], Tim Huege[1,2], Mitja Desmet[2], Stijn Buitnik[2], and Torsten Ensslin[3,4] for the LOFAR-Cosmic ray key science project-Collaboration — [1]Institute for Astroparticle Physics, Karlsruhe Institute of Technology, Eggenstein-Leopoldshafen, Germany — [2]Vrije Universiteit Brussel, Astrophysical Institute, Brussels, Belgium — [3]Max Planck Institute for Astrophysics, Garching, Germany — [4]Ludwig-Maximilians-Universität, Munich, Germany

Reconstructing the profile of extensive air showers, generated from the interaction of cosmic rays in the Earth's atmosphere, is crucial to understanding their mass composition, which in turn provides valuable insight on their possible source of origin. However, current frameworks can only recover shower parameters that provide limited information on the composition and relies on computationally expensive simulations. In this work, we develop a novel framework to reconstruct the longitudinal profile of air showers using measurements from radio detectors with Information Field Theory, a state-of-the-art reconstruction framework based on Bayesian inference. We utilise prior knowledge about the physical process of radio emission to generate a fast-forward model based on template synthesis and incorporate realistic response and noise models to produce voltage traces at each antenna. We apply our framework with simulated datasets based on the LOFAR detector layout and analyse the reconstruction efficiency to highlight the performance of our framework.

T 37.5 Tue 17:15 VG 3.102

Identifying Ultra-High-Energy Photons with a Convolutional Neural Network on the Basis of Surface Detector Measurements at the Pierre Auger Observatory — •Tim Fehler, Eleonora Guido, Marcus Niechciol, Markus Risse, and Daniel Steiniger for the Pierre-Auger-Collaboration — Experimentelle Astroteilchenphysik, Center for Particle Physics Siegen, Universität Siegen

Towards ultra-high energies (UHE, $E \gtrsim 10^{17}$ eV), the expected flux of cosmic photons becomes so small that only the indirect detection via extensive air showers remains feasible. The quest to identify ultra-high-energy photons then fundamentally boils down to a classification problem, in which photon-induced air showers must be distinguished from the vast background of hadron-induced showers, utilizing only the limited data provided by detector sampling on an individual event basis. This work explores the application of a convolutional neural network (CNN) to this task, considering the full temporal evolution of the signal in surface-detector stations of the Pierre Auger Observatory as input. We show that with this approach, high levels of accuracy in classifying simulated shower events can be reached, providing a promising tool for future searches for UHE photons.

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T 37.6 Tue 17:30 VG 3.102

Investigating the Expected Flux of GZK Photons — •Chiara Papior, Marcus Niechciol, and Markus Risse — Experimentelle Astroteilchenphysik, Center for Particle Physics Siegen, Universität Siegen

It is expected that charged cosmic rays produce ultra-high-energy (UHE, here beyond 10 PeV) photons during their propagation over extragalactic distances via photo-pion production with the cosmic microwave background. This effect is also known as the Greisen-Zatsepin-Kuzmin (GZK) effect and the photons produced via this interaction are termed GZK photons. The flux of GZK photons depends on the parameters of the emitted cosmic-ray spectrum such as the spectral index or a potential cutoff, as well as other parameters depending on the sources, including their distances, and the composition of the cosmic rays themselves. Simulations based on different input parameters have been performed, and the expected GZK photon flux will be presented. The goal is to update the allowed range of the expected GZK photon flux based on current measurements of cosmic-ray observatories at ultra-high-energy.

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