Karlsruhe Institute of Technology

Institut für Astroteilchenphysik (IAP)

Bachelor

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Datenauswertung von Sensoren des atmosphärischen elektrischen Feldes am Pierre Auger Observatorium

Das Betreiben der Radiodetektoren am Pierre Auger Observatorium zur Messung von ausgedehnten Luftschauern erfordert es, das atmosphärische elektrische Feld permanent zu überwachen. Dadurch können Gewitter erkannt werden, die die Radioemission von Luftschauern beeinflussen und somit deren Rekonstruktion erschweren. Neben bestehenden Sensoren wurden vor Kurzem neue, sogenannte "Feldmühlen" am Pierre Auger Observatorium aufgebaut.

In dieser Bachelorarbeit sollen die ersten Daten der neuen Feldmühlen ausgewertet werden. Dazu können die Messungen mit meteorologischen Datenbanken von Blitzen, als auch mit Messdaten von Luftschauern der Radio- (und ggfs. Teilchen-) Detektoren des Pierre Auger Observatoriums korreliert werden.

Bachelor/Master

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Investigating the detectability of PeV-gamma rays with a very dense radio detector for air-shower emission

We routinely use radio detection of air showers to measure particle cascades initiated by charged nuclei at energies of 100 PeV (i.e., 10^{17} eV) or higher. At lower energies, the radio signals become very weak and thus hidden in the radio background from the Galaxy.

In the next years, however, very dense radio-antenna arrays such as the Square Kilometre Array will come online. By correlating signals measured by many antennas, such weak signals might then become measurable. A particularly interesting target would be photon-induced air showers at PeV energies, which could be associated with a high-energy photon flux from the Galactic center. In this project, we will undertake a simulation study to work out the detectability of such PeV-energy photon-induced air showers, and investigate a possible triggering strategy.

Master

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Revolutionizing Cosmic Ray Detection: ML-Powered Autonomous Radio Triggering

The Giant Radio Array for Neutrino Detection (GRAND) marks a significant advancement, spanning 200,000 km with wide-band radio antennas. To detect air-shower events effectively in such large-scale arrays, an efficient autonomous trigger system is crucial. Thus, a novel multi-level radio trigger is currently being developed. The first-level trigger identifies potential air-shower signals at a single antenna, while the true innovation lies in the second-level trigger using information for many antennas at the same time. By evaluating the energy distribution on ground level (i.e. radio footprint), it makes reliable event decisions based on scientific knowledge of radio emissions.

This project offers a master's thesis opportunity for students to explore machine learning in cosmic ray detection. Focused on enhancing the second-level trigger, the student applies image recognition to radio footprints. The application of machine learning will significantly advance the trigger development. It provides a unique experience for students to actively contribute to large-scale cosmic ray experiments, influencing the future of astroparticle research.