T 15: Cosmic Rays I

Time: Monday 16:45–18:15 Location: VG 3.102

T 15.1 Mon 16:45 VG 3.102

Beamforming with the SKA-Low array for detection of gamma rays at PeV energies. — •Subhadip Saha[1,2] and Tim Huege[1] for the SKA High-Energy Cosmic Particles Science Working Group-Collaboration — [1]Institute for Astroparticle Physics, Karlsruhe Institute of Technology, Karlsruhe, Germany — [2]Indian Institute of Technology Kanpur, Kanpur, India.

SKA-Low (Square Kilometer Array) is globally recognized as the next-generation radio-astronomical observatory at frequencies below 350 MHz. We are focusing on its dense core region and aim to perform beamforming with thousands of antennas to detect the radio emission from particle showers initiated by cosmic or gamma rays in the atmosphere. Beamforming is expected to lower the radio-detection threshold for air showers considerably. With thousands of these antennas, the beamforming approach has significant potential to lower the detection threshold down to as low as 1 PeV. The strength of the beamformed signal can be scaled with the number of antennas and energy to estimate the number of antennas required to detect these low-energetic energetic air showers. We are investigating how far the detection threshold can essentially be brought down with the beamforming application and if the detection of PeV gamma rays would be possible.

T 15.2 Mon 17:00 VG 3.102

Advancing Cosmic-Ray Studies with LOFAR and the LORA Scintillator Array — •Stuti Sharma[1] and Anna Nelles[1,2] for the LOFAR-Cosmic ray key science project-Collaboration — [1]ECAP, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany — [2]Deutsches Elektronen-Synchrotron DESY, Zeuthen, Germany

The Low Frequency Array (LOFAR) is a radio telescope with antenna fields across Netherlands and Europe. Designed to observe the radio sky at low frequencies, it also provides precision measurements of the radio emission of cosmic-ray air showers in the range of 30-80 MHz. Central to LOFAR's cosmic-ray key science project is the LOFAR Radboud Air Shower Array (LORA), an array of 40 scintillation detectors in LOFAR's dense core. LORA measures particle densities from air showers, serving as a trigger for the LOFAR antennas and providing initial estimates of shower direction, energy, and core position. It detects cosmic rays above 1e16 eV, with nanosecond timing ensuring precise reconstruction of shower geometry and radio footprint. The LORA upgrade doubled the detector count, expanding the effective area and increasing trigger rates for high-energy events by 45%. This enhancement reduces composition bias and improves sensitivity to proton and iron primaries, essential for exploring the galactic-to-extragalactic cosmic-ray transition. Our goal is to incorporate data from LORA into the radio reconstruction framework, facilitating both standalone and integrated analyses of cosmic ray in particle and radio data.

T 15.3 Mon 17:15 VG 3.102

Monitoring Large-Scale Radio-Detection Arrays with Machine Learning — •Johann Luca Kastner for the GRAND-Collaboration — Karlsruher Institut für Technologie, Institut für Astroteilchenphysik

In recent years, radio-detection techniques, such as those employed in the GRAND experiment, have emerged as a promising method for detecting ultra-high-energy cosmic rays (UHECRs). One of the key advantages of radio detection is its cost-effectiveness, allowing for the deployment of large arrays that can cover vast areas necessary for measuring the low fluxes of UHECRs. However, this comes with the challenge of monitoring the functionality of a massive number of antennas (up to tens of thousands) over a vast area (tens of thousands of km^2). In this talk, we will present an approach to addressing this challenge using a combination of dimensionality reduction (UMAP) and clustering (DBSCAN) algorithms applied to periodically triggered monitoring data of a GRAND prototype setup. Our method aims to identify malfunctions and periods of poor operation, enabling efficient maintenance and optimization of the radio-detection system.

T 15.4 Mon 17:30 VG 3.102

The holy grail of air shower triggers: Tests towards a self-standing radio trigger at the Pierre Auger Observatory* — •Jannis Pawlowsky and Julian Rautenberg for the Pierre-Auger-Collaboration — Bergische Universität Wuppertal, Wuppertal, Germany

The Pierre Auger Observatory is the largest facility for the detection of ultra-high-energy cosmic rays. Key aspects to achieve the highest sensitivity are the particle triggers, which are responsible for maximizing station data read-out of reconstructable air showers within limited communication bandwidth. This system works excellent for the majority of hadron-induced air showers. However, it can be improved for air showers induced by neutral primaries such as photons and neutrinos. A radio trigger implemented for the AugerPrime Radio Detector provides an alternative when particle detectors become less efficient. The feasibility of such a radio trigger is heavily dependent on the noise environment, dominated by anthropogenic sources.

This work presents the efforts made to develop a bandwidth-compatible trigger. The design of the trigger is discussed, which was also employed in multiple field tests. The results of these tests are shown, yielding conclusions on the radio noise environment at the Observatory and the compatibility of the trigger with the communication bandwidth. Furthermore, planned improvements are discussed.

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T 15.5 Mon 17:45 VG 3.102

Status of the antennas at the IceCube Surface Array Enhancement — •Megha Venugopal for the IceCube-Collaboration — Institute of Astroparticle Physics (IAP), Karlsruhe Institute of Technology, Germany

IceCube is a cubic km detector at the South Pole comprising two main components, the neutrino detector that measures neutrinos in-ice, the IceCube Neutrino Observatory and IceTop, a surface cosmic-ray detector constituting 81 pairs of ice-filled Cherenkov tanks. An extension with multiple stations, each station equipped with 8 elevated scintillators and 3 antennas, was planned on the IceTop footprint to complement existing measurement methods and to serve as part of a larger surface array for IceCube-Gen2. In early 2023, the scintillators of the single deployed station of the IceCube Surface Enhancement were upgraded, increasing the dynamic range and enabling the reconstruction of more coincident air showers. An updated dataset combining data from radio and IceTop detectors is presented. Additionally, the current status of the deployment of new stations is discussed.

T 15.6 Mon 18:00 VG 3.102

Status and Performance of the Scintillation detectors of the IceCube Surface Array Enhancement — •S Shefali for the IceCube-Collaboration — Institut für Astroteilchenphysik, Karlsruher Institut für Technologie (KIT), Karlsruhe, Germany

The IceCube Neutrino Observatory is a multipurpose detector which includes a unique surface array, IceTop, highly instrumental for cosmic-ray studies in addition to its capability of vetoing for astrophysical neutrino searches for the IceCube in-ice instrumentation. An enhancement of the surface array, with scintillation and radio detectors, in order to facilitate multi-component cosmic ray studies, as well as improving the IceTop detectors calibration by accounting for the snow accumulation on them, has been ongoing. The existing prototype station was upgraded with improved Scintillation detectors at the beginning of January 2023. This contribution will discuss the performance of the scintillation detectors following the 2 years of successful air shower measurements with this upgrade.