ARENA 2016

Tuesday 07 June 2016 - Friday 10 June 2016

Groningen, Netherlands

Book of Abstracts

my abstract book

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A Study of radio frequency spectrum emitted by high energy air showers with LOFAR

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The LOw Frequency ARay (LOFAR) is a multipurpose radio antenna array aimed to detect radio signals in the frequency range 10-240 MHz, covering a large surface in Northern Europe with a higher density in Northern Netherlands. The high number density of radio antennas at the LOFAR core in Northern Netherlands allows to detect radio signals emitted by cosmic ray induced air showers, and to characterize the geometry of the observed cascade in a detailed way.
A study of several geometrical parameters of radio signals emitted by extensive air showers propagating in the atmosphere, and their correlation with the observed radio frequency spectrum in the 30-70 MHz regime is here presented.
In order to find the best parameters which describe the correlation between primary cosmic ray information and the emitted radio signal, a cross-check between real data and simulations has been done. Regarding real data, cosmic ray radio signals detected by LOFAR since 2011 have been analysed. For the simulation of radio signals, the CoREAS code, a plug-in of the CORSIKA particle simulation code, has been used.
Preliminary results on how the frequency spectrum changes as function of distance to the shower axis, and as function of primary particles mass composition are shown.
The final aim of this study is to find a method to infer information of primary cosmic rays in an independent way from the well-established fluorescence and surface detector techniques, in view of affirming the radio detection technique as reliable method for the study of high energy cosmic rays.

Summary:

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A large fiber sensor network for an acoustic neutrino telescope

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The scientific prospects of detecting neutrinos with an energy close or even higher than the GKZ cut-off energy has been discussed extensively in literature. It is clear that due to their expected low flux, the detection of these ultra-high energy neutrinos ($E_\nu > 10^{18}$ eV) requires an telescope larger than 100 km^3. Acoustic detection [1, 2] may provide a way to observe these ultra-high energy cosmic neutrinos, as sound induced in the deep sea by their loss travels undisturbed for many kilometers so that a large neutrino telescope can be established. To realize such a telescope, acoustic detection technology must be developed that allows for a large deep sea sensor network.

Fiber optic hydrophone technology is a promising means to establish large a scale sensor network [3] with the proper sensitivity to detect the small signals from the neutrino interactions. In this talk we present an update of the research and development of the fiber hydrophone technology at TNO. We report on the recent progress related to sensor developement as well as R&D on sensor networks.

[1] G. A. Askaryan. Acoustic recording of neutrinos. Zemlia i Vselennaia, 1:13–16, 1979.
[2] J. G. Learned. Acoustic radiation by charged atomic particles in liquids: An analysis. Phys. Rev. D, 19:3293–3307, June 1979.
[3] E. J. Buis et al. Fibre laser hydrophones for cosmic ray particle detection. Journal of Instrumentation, 9(03):C03051, 2014.

Summary:

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ANITA: Current Status and Future Plans

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The ANtarctic Impulse Transient Antenna (ANITA) collaboration deploys balloon-borne interferometric antenna payloads that fly at 37 km above Antarctica. The primary goal is detection of Askaryan emission from cosmogenic neutrinos interacting in the ice sheet. In addition, ANITA has proven sensitive to ultra-high-energy cosmic rays.

This talk will provide an update on ongoing analyses of the most recent ANITA flight, which launched December 2014. I will also discuss upgrades and plans for the upcoming ANITA-4 mission.

Summary:

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Acoustic detection of UHE neutrinos in the Mediterranean sea: status and perspective.

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In recent years the astro-particle community is involved in the realization of experimental apparatuses for the detection of high energy neutrinos originated in cosmic sources or produced in the interaction of Cosmic Rays with the Cosmic Microwave Background.
For neutrino energies in the TeV-PeV range, kilometre square optical Cherenkov detector, that has been so far positively exploited by IceCube and ANTARES, is considered optimal. For higher energies, three experimental techniques are under study: the detection of radio pulses produced by showers following a neutrino interaction, the detection of air showers initiated by neutrinos interacting with rocks or deep Earth's atmosphere and the detection of acoustic waves produced by deposition of energy in the interaction of neutrinos in acoustically transparent mediums. The potential of the acoustic detection technique, first proposed by Askaryan in 1957, to build very large neutrino detectors is appealing, thanks to the optimal properties of mediums such as water or ice as sound propagator.
Though the studies on this technique are still in an early stage, acoustic positioning systems used on optical Cherenkov detectors, like AMADEUS and NEMO, give the possibility to study the ambient noise and provide important information for the future analysis of acoustic data. KM3NeT with its equipment of acoustic sensors will monitor the underwater acoustic signals; its infrastructure could be used for the implementation of dedicated array of acoustic sensors namely for the acoustic neutrino detection.
Results obtained by AMADEUS and NEMO in the Mediterranean will be summarised and perspectives of acoustic detection of UHE neutrinos will be discussed.

Summary:

The acoustic detection of astrophysical neutrinos with energies exceeding 100 PeV will be discussed.
The potential of the acoustic detection technique, first proposed by Askaryan in 1957, to build very large neutrino detectors is appealing, thanks to the optimal properties of mediums such as water or ice as sound propagator.
Results obtained by AMADEUS and NEMO in the Mediterranean will be summarised and perspectives of acoustic detection of UHE neutrinos will be discussed.

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Acoustic detection of high energy neutrinos in Fresh water

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The features, advantage and difficulties of acoustic detection of high energy neutrinos in Fresh water are discussed. The status and perspectives of the feasibility study to detect high energy cosmic neutrinos acoustically in Lake Baikal is presented. A concept of acoustic array as a part of Baikal Gigaton Volume Neutrino Telescope NT1000 based on results of simulation and background measurements is described.

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Acoustic detection of high energy neutrinos in Sea Water: Status and Prospects

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The acoustic neutrino detection technique is a promising approach for future large-scale detectors with the aim of measuring the small expected flux of cosmogenic neutrinos at energies in the EeV-range and above. The technique is based on the thermo-acoustic model, which implies that the energy deposition by a particle cascade - resulting from a neutrino interaction in a medium with suitable thermal and acoustic properties - leads to a local heating and a subsequent characteristic pressure pulse that propagates in the surrounding medium. The main advantage of using sound for the detection of neutrino interactions, as opposed to Cherenkov light, lies in the much longer attenuation length of the former type of radiation - several kilometers for sound compared to several tens of meters for light in the respective frequency ranges of interest in sea water.

Current or recent test setups for acoustic neutrino detection have either been add-ons to optical neutrino telescopes or have been using acoustic arrays built for other purposes, typically for military use. While these arrays have been too small to derive competitive limits on neutrino fluxes, they allowed for detailed studies of the experimental technique. In particular with the AMADEUS acoustic array of the Cherenkov neutrino telescopes ANTARES in the Mediterranean Sea, long term measurements of the acoustic ambient noise and transient background were performed. These allowed for Monte Carlo simulations of potential future neutrino telescopes.

With the advent of the research infrastructure KM3NeT in the Mediterranean Sea, new possibilities will arise for acoustic neutrino detection. A point in time has been reached where preexisting test setups for acoustic neutrino detection in sea water can be denoted "first generation setups". In this presentation results from these acoustic arrays will be summarized and prospects and implications for the future of acoustic neutrino detection will be discussed.

Summary:

In this presentation, results from test setups for acoustic neutrino detection in sea water will be summarized and prospects and implications for the future of acoustic neutrino detection will be discussed.

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Acoustics in water: synergies with marine biology

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The ANTARES project, in addition to optical detectors, includes an array of 36 hydrophones that was installed with the aim of acoustic neutrino detection. The acoustic data stream has been active since 2008 and is managed under AMADEUS. Coincidentally, ANTARES is installed in the Pelagos marine sanctuary, home to many marine mammals species, both whales and dolphins, all of which are acoustically active. The fact that ANTARES is cabled (providing real-time access to data) makes it a unique observation platform for the local marine fauna. The LAB has been analysing the acoustic data, relayed through AMADEUS, since 2010 with a focus especially on sperm whales and dolphins. Presented here are some of the signal processing techniques that have been used for the sperm whale detection and classification algorithms. In addition a study was done to relate background noise levels to animal presence. The ability to study trends in animal presence and a possible relationship with anthropogenic activities for such a long and continuous time frame is unique and is impossible as a purely biological initiative; the costs for installing such a platform just to measure sound levels and to monitor the environment are too high. Opening up platforms such as ANTARES, and for example Neptune from the ONC, to marine researchers will not only help to improve marine research but may also help to obtain funding by widening the scope of applications. In that sense, it would be advantageous to take into account design requirements of other fields when deploying new monitoring platforms (e.g. KM3). For example, for acoustics it would be preferred not to use hardware high-pass filters and to store or transfer the raw data.

Summary:

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Analysis updates for ARA

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The Askaryan Radio Array (ARA) is a neutrino telescope array under phased deployment near the South Pole. The array aims at discovering and determining the ultra-high energy neutrino flux via detection of the Askaryan signal from neutrino-induced showers. This novel detection channel makes ARA the most cost-effective neutrino observatory in probing the neutrino flux from ~ 100PeV – 10EeV. Currently three stations are operational, with two more stations to be added in the 2017-2018 Pole season.

This contribution will discuss various new analysis techniques developed for the ARA, including an interferometric reconstruction taking into account the curved paths traveled by EM radiation in inhomogeneous ice. Preliminary results of diffuse neutrino search using 2013-2014 data from 2 stations using the background rejection and interferometric reconstruction techniques discussed here and earlier will also be presented.

Summary:

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Background Rejection in the ARA Experiment

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The Askaryan Radio Array (ARA) is a radio frequency observatory under construction at the South Pole that is searching for ultrahigh energy neutrinos via the Askaryan effect. Thermal fluctuations currently dominate the trigger-level background for the observatory and anthropogenic sources also introduce a significant source of noise. By taking advantage of the observatory's regular geometry and the expected coincident nature of the RF signals arriving from neutrino-induced events, this background can be filtered efficiently. This contribution will discuss techniques developed for the ARA analyses to reject these thermal signals, to reject anthropogenic backgrounds, and to search for neutrino-induced particle showers in the Antarctic ice. The results of a search for neutrinos from GRBs using the prototype station using some of these techniques will be presented.

Summary:

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Circular polarization of radio emission from air showers in thundercloud conditions.

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When a high-energy cosmic-ray particle enters the upper layer of the atmosphere, it generates many secondary high-energy particles and forms a cosmic-ray-induced air shower. In the leading plasma of this shower electric currents are induced that emit electromagnetic radiation. These radio waves can be detected with LOw-Frequency ARray (LOFAR) radio telescope. Events have been collected under fair-weather conditions as well as under atmospheric conditions where thunderstorms occur.

For the events under the fair weather conditions the emission process is well understood by present models. For the events measured under the thunderstorm conditions, we observe large differences in intensity, linear polarization and circular polarization from the fair-weather events. This can be explained by the effects of atmospheric electric fields in thunderclouds. Therefore, measuring the intensity and polarization of radio emission from cosmic ray extensive air showers during the thunderstorm conditions provides a new tool to probe the atmospheric electric fields present in thunderclouds.

Summary:

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Constraining ultra-high-energy cosmic ray models with cosmogenic neutrino predictions

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With our newly-developed code for ultra-high-energy cosmic ray (UHECR) propagation, CRPropa, the flux of neutrinos due to interactions of UHECRs with extragalactic background light can be predicted. These cosmogenic neutrinos cover a wide energy range, from below PeV energies up till 100 EeV. The recent measurements in the PeV range and limits at higher energies from IceCube are starting to constrain UHECR models. When combined with predicted secondary photon fluxes and photon background measurements by, e.g., Fermi LAT even stronger constrains can be obtained. In this way the source evolution and UHECR composition can be investigated.

Summary:

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Construction and test of a multi-purpose deep sea hydrophone array in KM3NeT-Italia

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Acoustic neutrino detectors in water may complement the Cherenkov arrays now under construction (KM3NeT and Baikal) extending the sensitivity of such apparatuses to the Ultra high energy regime.
In such view the KM3NeT-Italia project has developed acoustic sensors and read-out electronics sensitive to micro-Pascal scale acoustic pulses in the range 5-70 kHz. Read-out and data transmission electronics is completely embedded in the Cherenkov detector one, making the array acoustic time synchronised with the Cherenkov one. The acoustic arrays streams the acoustic data flow continuously from all the sensors to shore. Each sensor has a standard and a high (+30 dB gain) to match three main field of science and technology: detector positioning system, bioacoustics and oceanography, study for acoustic neutrino detection.
The same hydrophone, with proper modifications of the front-end electronics, is used in the KM3NeT ARCA detector.
The first KM3NeT Italia tower-structure will be deployed in May 2016. The tower is composed by 14 floors, each being a 8 m long bar structure, vertically spaced by 20 m. Hydrophones are placed close to the end of each floor and one hydrophone is placed on the tower base at about 3 m from the seafloor. Results on system qualification, test and calibration will be presented together with first acoustic data from deep sea.

Summary:

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Cosmic-ray mass composition with LOFAR

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In the dense core of LOFAR individual air showers are detected by hundreds of dipole antennas simultaneously. We reconstruct Xmax by using a hybrid technique that combines a two-dimensional fit of the radio profile to CoREAS simulations and a one-dimensional fit of the particle density distribution. For high-quality detections, the statistical uncertainty on Xmax is <20 g/cm^2.

We present results of cosmic-ray mass analysis in the energy regime of 10^{17} - $10^{17.5}$ eV. This range is of particular interest as it may harbor the transition from a Galactic to an extragalactic origin of cosmic rays.

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Data acquisition system for the hydrophone array of KM3NeT-Italia: quest for acoustic UHE neutrino searches

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In the framework of the KM3NeT-Italia activities, 8 towers, each equipped with 84 large area PMTs for neutrino Cherenkov detection and 29 hydrophones, will be installed. Hydrophones are fully embedded in the electronics and data transport system of the Cherenkov array and are time-synchronised. A data acquisition system (DAQ) on shore has been developed to receive the acoustic stream from sea and search on-line for a number of known signals i.e. the acoustic pulses emitted from the long baseline array of beacons used for acoustic positioning. Together with this principal goal, the DAQ system has a flexible design capable to recognise biological signals and neutrino-induced acoustic pulses. Continuous monitoring of acoustic background and unfiltered data storage - under proper conditions - is also implemented. The system is designed to scale in view of possible extensions of the acoustic array.

Summary:

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Development of an acoustic sensor for the future IceCube-Gen2 detector for neutrino detection and position calibration

Author(s): Stefan Wickmann[1]

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In the planned high-energy extension of the IceCube Neutrino Observatory in the deep ice at the geographical South Pole the spacing of detector modules will be increased with respect to IceCube. Because of these larger distances the quality of the optical geometry calibration is expected to deteriorate. To counter this an independent acoustic geometry calibration system based on trilateration is introduced. Such an acoustic positioning system (APS) has already been developed for the Enceladus Explorer Project (EnEx), initiated by the DLR Space Administration. In order to integrate such APS-sensors into the IceCube detector the power consumption needs to be minimized. In addition, the frequency response of the front-end electronics is optimized for positioning as well as the acoustic detection of neutrinos. The new design of the acoustic sensor and results of test measurements with an IceCube detector module will be presented.

Summary:

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Development of an array emitter for acoustic neutrino detection calibration

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Acoustic detection is a promising technique for the detection of Ultra High Energy (UHE) neutrinos. It is based on the detection of the short bipolar pressure pulse with very directive pattern (pancake) generated after the neutrino interaction with a nucleus of the water. The acoustic sensors could be implemented in the optical-based deep-sea neutrino telescope under construction (KM3NeT telescope), working then as a complementary hybrid detector. Acoustic emitters able to imitate the signal are needed to calibrate the sensors and to study the viability of the technique. For this purpose, a compact calibrator composed of few piezo-ceramic transducers emitting in axial direction and structured in an array system has been designed. The array is operated at high-frequency (hundreds of kHz) and, by means of the parametric effect, the emission of the low-frequency (tens of kHz) acoustic bipolar pulse is generated permitting to mimic the UHE neutrino acoustic pulse. Electronics have been developed as well for the signal amplification to assure the power needed and for the control operation and monitoring of the emitter. In this paper, the design, development and characterization of the acoustic array emitter is presented, showing the results obtained in the involved processes, such as, parametric emission studies, ceramic design optimization through backing and heading, electronics design, multi-element array design and tests in the lab and for long distances in the sea.

Summary:

Presentations / **55**

EnEx-RANGE - Robust autonomous Acoustic Navigation in Glacial icE

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Within the Enceladus Explorer Initiative of the DLR Space Administration navigation technologies for future space mission are in development. Those technologies are the basis for the search of extraterrestrial life on the Saturn moon Enceladus. An autonomous melting probe, the EnEx-Probe, aims to extract a liquid sample from the ocean below the icy crust.

A first EnEx-Probe was developed and demonstrated in a terrestrial scenario. At the Bloodfalls, Taylor Glacier, Antarctica a clean subglacial liquid sample was extracted in November 2014. To enable navigation in glacier ice two acoustic systems were integrated into the probe in addition to conventional navigation technologies. The first acoustic system determines the position of the probe during the run based on propagation times of acoustic signals from emitters at reference positions at the glacier surface to receivers in the probe. The second system provides information about the forefield of the probe. It is based on sonographic principles with phased array technology integrated in the probe's melting head. Information about obstacles or sampling regions in the probe's forefield can be acquired. The development of both systems is now continued in the project EnEx-RANGE. The emitters of the localization system are replaced by a network of intelligent acoustic enabled melting probes. These localize each other by means of acoustic signals and create the reference system for the EnEx-Probe.

This presentation includes the intelligent acoustic network, the acoustic navigation systems of the EnEx-Probe and results of terrestrial tests.

Summary:

Presentations / **36**

Estimation of the composition of cosmic rays from radio measurements with the Auger Engineering Radio Array.

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One of the current methods to estimate the mass of a cosmic ray is the measurement of the atmospheric depth of the shower maximum (X_{max}). This depth is strongly correlated to the mass of the primary because it depends on the interaction cross section of the primary with the constituents of the atmosphere. The radio-electric field emitted by the secondary particles of an atmospheric air shower is known to contain information on the depth of the air shower maximum. Measuring the electric field with the Auger Engineering Radio Array (AERA) in the 30-80 MHz band allows the determination of the depth of shower maximum on the basis of the good understanding of the radio emission mechanisms. The duty cycle of radio detectors is close to 100%, making possible the statistical determination of the cosmic ray mass composition through the study of a large number of events above 10^{17} eV. In this contribution, X_{max} reconstruction methods based on the study of the radio signal with AERA will be detailed.

Summary:

Presentations / **23**

Experimental calibration of the ARA neutrino telescope with an electron beam in ice

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Askaryan Radio Array (ARA) is being built at the South Pole aiming for observing high energy cosmogenic neutrinos above 10 PeV. The ARA detector identifies the radio emissions from the excess charge in a particle shower induced by a neutrino interaction. Such a radio emission was first predicted by Askaryan in 1962 and experimentally confirmed by Saltzberg et al. using the SLAC accelerator in 2000. We also performed a similar experiment using 40 MeV electron beams of the Telescope Array Electron Light Source, aiming to verify our understanding of the Askaryan emission and the detector responses used in the ARA experiment. Clear coherent polarized radio signals were observed with an ice target. On the other hand, clear signals were also observed without any target due to the sudden appearance of the beam. We performed a detailed simulation to understand our data. The final results of the experiment will be presented in the conference.

Presentations / 24

In-situ absolute calibration of electric-field amplitude measurements with the radio detector stations of the Pierre Auger Observatory

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With the Auger Engineering Radio Array (AERA) located at the Pierre Auger Observatory, radio emission of extensive air showers is observed. To exploit the physics potential of AERA, electric-field amplitude measurements with the radio detector stations need to be well-calibrated on an absolute level. A convenient tool for far-field calibration campaigns is a flying drone. Here we make use of an octocopter to place a calibrated source at freely chosen positions above the radio detector array which allows different types of calibrations to be performed. Special emphasis is put on the reconstruction of the octocopter position and its accuracy during the flights.

The directional antenna response pattern of the radio detector stations was measured in a recent calibration campaign. Results of these measurements are presented and compared to simulations. It is found that measurements and simulations are in agreement except for small frequencies and small zenith angles.

Summary:

Presentations / 39

Influence of atmospheric electric fields on air-shower radio emission measured with AERA

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The Auger Engineering Radio Array (AERA) at the Pierre Auger Observatory with its 153 antenna stations distributed over 17 km2 is the largest experiment to measure the radio emission of extensive air showers.
The radio emission is known to be influenced by strong atmospheric E-fields such as those in thunderstorm conditions. Based on the measurement of the atmospheric E-field on the ground, criteria for the selection of affected events have been derived. A corresponding event selection has been studied with respect to the amplitude and polarization in comparison with simulations. In addition, selected events have been simulated with a two-layered atmospheric E-field model and compared with the measurements.

Summary:

poster / **27**

LORA: trigger studies and hardware upgrades for the LOFAR Radboud air shower array

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LORA (LOFAR Radboud Air shower array) is a particle detector build around the LOFAR core to complement radio detection of cosmic rays. The LORA instrument has been critical in determining the arrival direction, energy, and core location of cosmic rays detected with LOFAR. LORA detects particles from a cosmic ray induced extensive air shower and triggers the LOFAR antennas to read out relevant data. A radio-particle hybrid trigger may allow for further studies of parameters of cosmic rays in an interesting regime of the spectrum where a source transition is expected (above 10^{16} eV). The current LORA experimental set-up is described along with plans for hardware upgrades, and different triggering scenarios are discussed.

poster / 57

Lightning stepped leaders; LOFAR data and simulations

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The initial and yet fundamental process in a typical cloud-to-ground lightning strike includes the propagation of a very faint and charged channel which is called stepped leader. The exact mechanism for the step leaders is not understood. The reason for this is that the temporal and/or spatial resolution of the devices exploited for observing this phenomenon has not been sufficient. The radio interferometric array of LOFAR however is capable to measure radio signals with 1 ns temporal resolution. Thus LOFAR can measure the radio pulses emitted by stepped leaders at multiple times during the formation of the steps and locate the positions of the pulses with sub-meter accuracy. This provides with new possibilities to test and probe the theories explaining the propagation of a stepped leader. We are currently processing the data measured by LOFAR, and in addition, are preparing a simulation tool to calculate the radio signals expected on the basis of current models. By comparing the simulation and experimental data, we aim to determine the characteristics of stepped leader formation.

Summary:

Presentations / 22

Measurement of horizontal air showers with the Auger Engineering Radio Array

Olga Kambeitz[None]

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The Auger Engineering Radio Array (AERA), located at the Pierre Auger Observatory in Argentina, measures the radio emission of extensive air showers in the 30-80 MHz frequency range. AERA consists of more than 150 antenna stations distributed over 17 km^2. Together with the Auger surface detector, the fluorescence detector and the muon detector (AMIGA), AERA is able to measure cosmic rays with energies above 10^17 eV in a hybrid detection mode. AERA is optimized for the detection of air showers up to 60° zenith angle, however, using the reconstruction of horizontal air showers with the Auger surface array, also very inclined showers are measured. In this contribution the analysis of the AERA data in the zenith angle range from 62° to 80° will be presented. CoREAS simulations predict radio emission footprints of several km^2 for horizontal air showers, which are confirmed by AERA measurements. The first results on radio-based composition measurements of horizontal showers and an outlook of the radio detection of neutrino-induced showers will be given.

Summary:

Presentations / 19

Modeling of radio emission from a particle cascade in magnetic field and its experimental validation

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The SLAC T-510 experiment was designed to compare controlled laboratory measurements of radio emission of particle showers
to that predicted using particle-level simulations, which are relied upon in ultra-high-energy cosmic-ray air
shower detection.
Established formalisms for the simulation of radio emission physics, the "end-point" formalism and the "ZHS"
formalism, lead to results which can be explained by a superposition of magnetically induced transverse current radiation and a charge-excess radiation due to the Askaryan effect.
Here, we present the results of Geant4
simulations for the SLAC T-510 experiment, taking into account the details of the experimental setup (beam energy, target geometry and material, magnetic field configuration, and refraction effects) and their comparison to measured data with respect to e.g. signal polarisation, linearity with magnetic field, and angular distribution. It shows that the macroscopic models reproduce the measurements within
uncertainties and give a very good description of the data.

Summary:

Presentations / **28**

Nanosecond-level time synchronization of AERA using a beacon reference transmitter and commercial airplanes

Tim Huege[1]

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Radio detection of cosmic-ray air showers requires time synchronization of detectors on a nanosecond level, especially for advanced reconstruction algorithms based on the wavefront curvature and for interferometric analysis approaches. At the Auger Engineering Radio Array, the distributed, autonomous detector stations are time-synchronized via the Global Positioning System which, however, does not provide sufficient timing accuracy. We thus employ a dedicated beacon reference transmitter to correct for event-by-event clock drifts in our offline data analysis. In an independent cross-check of this "beacon correction" using radio pulses emitted by commercial airplanes we have shown that the combined timing accuracy of the two methods is better than 2 nanoseconds. We present the concept, experimental setup and results of both the beacon and airplane timing calibration approaches.

Summary:

Presentations / **11**

Neutrino Astronomy: What did we learn, Where should we aim?

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Icecube's discovery of an extra-terrestrial high energy neutrino flux marks the beginning of a new era in neutrino astronomy. I will discuss the what we have learned from this discovery, what the main open questions are, and the way forward towards answering these open questions.

poster / 13

Nuclear Emulsions for WIMP Search (NEWS)

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Nowadays there is compelling evidence for the existence of dark matter in the Universe. A general consensus has been expressed on the need for a directional sensitive detector to confirm, with a complementary approach, the candidates found in "conventional" searches and to finally extend their sensitivity beyond the limit of neutrino-induced background. We propose here the use of a detector based on nuclear emulsions to measure the direction of WIMP-induced nuclear recoils. The production of nuclear emulsion films with nanometric grains has been recently established. Several measurement campaigns have demonstrated the capability of detecting sub-micrometric tracks left by low energy ions in such emulsion films with nanometric grains. Innovative analysis technologies with fully automated optical microscopes have made it possible to achieve the track reconstruction for path lengths down to one hundred nanometres and there are good prospects to further exceed this limit. The detector concept we propose foresees the use of a bulk of nuclear emulsion films surrounded by a shield from environmental radioactivity, to be placed on an equatorial telescope in order to cancel out the effect of the Earth rotation, thus keeping the detector at a fixed orientation toward the expected direction of galactic WIMPs. We report the performances and the schedule of the NEWS experiment, with its one-kilogram mass pilot experiment, aiming at delivering the first results on the time scale of five years.

Summary:

Presentations / 40

On the radar detection of neutrino induced particle cascades in ice

Aongus O'Murchadha[1] ; Kael Hanson[2] ; Krijn de Vries[3] ; Simona Toscano[3] ; Thomas Meures[4]

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A detailed model for the radar reflection of in-ice particle cascades is presented. This allows us to determine the effective area and sensitivity for a typical bi-static radar set-up. It follows that the radar technique is a promising method to probe the currently existing energy gap between several PeV where IceCube runs low in statistics and a few EeV where the Askaryan radio detectors become sensitive. However, the feasibility of the method crucially depends on the plasma properties such as its lifetime, free charge collision rate and density. These parameters are not well known, and therefore experimental verification is needed.

Summary:

A detailed model for the radar reflection of in-ice particle cascades is presented. This allows us to determine the effective area and sensitivity for a typical bi-static radar set-up. It follows that the radar technique is a promising method to probe the currently existing energy gap between several PeV where IceCube runs low in statistics and a few EeV where the Askaryan radio detectors become sensitive. However, the feasibility of the method crucially depends on the plasma properties such as its lifetime, free charge collision rate and density. These parameters are not well known, and therefore experimental verification is needed.

Presentations / **5**

Overview of lunar detection of ultra-high energy particles and new plans for the SKA

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The lunar technique is a method for maximising the collection area for
ultra-high-energy (UHE) cosmic ray and neutrino searches. The method uses either ground-based radio telescopes or lunar orbiters to search for Askaryan emission from particles cascading near the lunar surface. While experiments using the technique have made important advances in the detection of nanosecond-scale pulses, only at the very highest energies has the lunar technique achieved competitive limits. This is expected to change with the advent of the Square Kilometre Array (SKA), the low-frequency component of which (SKA-LOW) is predicted to be able to detect an unprecedented number of UHE cosmic rays.

In this talk, the status of lunar particle detection is reviewed, with particular attention paid to outstanding theoretical questions, and the technical challenges of using a giant radio array to search for nanosecond pulses. The activities of SKA's High Energy Cosmic Particles Focus Group are described, as is a roadmap by which this group plans to incorporate this detection mode into SKA-LOW observations. Estimates for the sensitivity of SKA-LOW phases 1 and 2 to UHE particles are given, along with the achievable science goals with each stage. Prospects for near-future observations with other instruments are also described.

Presentations / **4**

Phased arrays: A strategy to lower the energy threshold for neutrinos

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In-ice radio arrays are optimized for detecting the highest energy, cosmogenic neutrinos, expected to be produced though cosmic ray interactions with background photons. However, there are two expected populations of high energy neutrinos: the astrophysical flux observed by IceCube (\~1 PeV) and the cosmogenic flux (\~10^{18} eV or 1000 PeV). Typical radio arrays employ a noise-riding trigger, which limits their minimum energy threshold based on the background noise temperature of the ice. Phased radio arrays could lower the energy threshold by combining the signals from several channels before triggering, thereby improving the signal-to-noise at the trigger level. Reducing the energy threshold would allow radio experiments to more efficiently overlap with optical Cherenkov neutrino telescopes as well as more efficient searches for cosmogenic neutrinos. I will discuss the proposed technique and prototypical phased arrays deployed both at Greenland's Summit Station and in an anechoic chamber.

Summary:

Presentations / 21

Phenomenology of transition radiation at radio frequencies from ultrahigh-energy showers

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Co-author(s): Enrique Zas [2] ; Paolo Privitera [3] ; Pavel Motloch [4]

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We explore transition radiation at MHz-GHz frequencies as a possible way to detect ultrahigh-energy (UHE) particles. We have developed a general method to calculate transition radiation that extends the well-known Zas-Halzen-Stanev (ZHS) algorithm. We have applied it to the characterization of the frequency and angular properties of the electric field from high-energy showers crossing the boundary between two media. We discuss the potential of transition radiation for the detection of UHE particles in different situations of experimental interest.

Summary:

Presentations / 48

Proposal for a Giant Radio Array for Neutrino Detection

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?

Summary:

The Giant Array for Neutrino Detection (GRAND) is a proposal for a giant array of radio antenna aiming primarily at studying high energy (E>3 10^{16}eV) neutrinos of cosmic origin, through the detection of air showers induced by the decay in the atmosphere of tau leptons produced by the interaction of the cosmic neutrinos under the Earth surface.
GRAND will aim at a neutrino sensitivity of 2 10^{-11} GeV/cm^2/s/sr above 3 10^{16} eV, which should allow for example the detection of up to 150 cosmogenic neutrinos per year for "reasonable" UHECRs models.
We show how an array of ~200'000 antennas deployed over a total area of ~200'000km² on appropriate mountainous locations should allow reaching this goal.
Such a detector would also certainly be a very interesting tool for UHECR physics, and possibly to other science cases (study of the Epoch of Reionization for example). We also discuss technological options for the detector and the steps to be taken to achieve this project.

Presentations / **8**

Radio Detection of UHE Neutrinos in Ice at the South Pole: The ARA Experience and New Ideas

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Abstract TBD

Presentations / **6**

Recent results from CODALEMA and the Nan\c cay radio facilities related to cosmic-ray measurements

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Since 2003, the Nançay Radio Observatory hosts the CODALEMA experiment, dedicated to radio detection of cosmic ray induced extensive air showers. Several instrumental upgrades have been made up to the current setup. CODALEMA is now composed of:

- 57 self-triggering radio detection stations working in the 20-250 MHz band and spread over 1 km^2;
- a 13 scintillator array acting as a particle detector;
- a compact array made of 10 cabled antennas, triggered by the particle detector, and whose role is to figure out the capabilities of a phased antenna cluster to cleverly select air shower events.

In addition, CODALEMA hosts the R&D EXTASIS project, aiming at detecting the low-frequency signal (below 9 MHz) produced at the sudden disappearance of the air shower particles hitting the ground. All these antenna arrays present different antenna density and extent, and can be operated in a joint mode to record simultaneously the radio signal coming from an air shower. Therefore, the Nançay facilities may offer a complete description of the air shower induced electric field at small, medium and large scale, and over an unique and very wide frequency band (from ~2 to 250 MHz). The use of multi-band detectors combined with sophisticated composite trigger algorithms could help boosting the radio detection technique as a candidate for a further very large cosmic ray observatory. We will describe the current instrumental set-up and the last science results that have been obtained, together with the prospective developments of the radio detection technique.

Presentations / **3**

Recent results from the ARIANNA neutrino experiment

Anna Nelles[1]

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The ARIANNA experiment is currently taking data in its pilot-phase on the Ross ice-shelf. Nine fully autonomous stations measure radio signals in the frequency range from 100 MHz to 1 GHz. The seven station HRA was completed in December 2014, and augmented by two special purpose stations with unique configurations. In its full extent ARIANNA is targeted at detecting interactions of cosmogenic neutrinos in the ice-shelf. Downward-pointing antennas installed at the surface will record the radio emission created by neutrino-induced showers in the ice and exploit the fact that the ice-water surface acts as a mirror for radio emission. ARIANNA stations are independent, low-powered, easy to install and equipped with real-time communication via satellite modems.

We will report on detailed measurements of the radio quiet environment at the ARIANNA site, as well air shower detections that have been made over the past years. Furthermore, we will discuss the search for neutrino emissions, future plans and sensitivities of the experiment.

Presentations / **30**

Results and Perspectives of the Auger Engineering Radio Array (overview talk)

Christian Glaser[1]

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The Auger Engineering Radio Array (AERA) is an extension of the Pierre Auger Cosmic-Ray Observatory. It is used to detect radio emission from extensive air showers with energies beyond 10^{17} eV in the 30 - 80 MHz frequency band. After three phases of deployment, AERA now consists of more than 150 autonomous radio stations with different spacings, covering an area of about 17 km². It is located at the same site as other Auger low-energy detector extensions enabling combinations with various other measurement techniques. The radio array allows different technical schemes to be explored as well as to cross calibrate our measurements with the established baseline detectors of the Auger Observatory. We will report on the most recent technological developments and give an overview of the experimental results obtained with AERA. In particular, we will present the measurement of the radiation energy, i.e., the amount of energy that is emitted from the air shower in the form of radio emission, and its dependence on the cosmic-ray energy by comparing with the measurement of the the well-calibrated Auger surface detector. Furthermore, we outline the relevance of this result for the absolute calibration of the energy scale of cosmic-ray observatories.

Summary:

Presentations / **26**

SLAC T-510: Accelerator measurements of radio emission from particle cascades in the presence of a magnetic field

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Cosmic ray induced particle cascades radiate in radio frequencies in the Earth's atmosphere. Geomagnetic and Askaryan emission provide an effective way to detect ultra-high energy cosmic rays. The SLAC T-510 experiment was the first to measure magnetically induced radiation from particle cascades in a controlled laboratory setting. An electron beam incident upon a dense dielectric target produced a particle cascade in the presence of a variable magnetic field. Antennas covering a band of 30-3000 MHz sampled RF emission in vertical and horizontal polarizations.
Results from T-510 are compared to particle-level RF-emission simulations which are critical for reconstructing the energy and composition of detected ultra-high energy cosmic ray air showers. We discuss the experimental set up, the data processing, the systematic errors and the main results of the experiment, which we found in a good agreement with the simulations.

Summary:

Presentations / **25**

Search for Cosmic Particles with the Moon

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The low flux of the ultra-high energy cosmic rays (UHECR) at the highest energeis provides a challenge to answer the long standing question about their origin and nature. A significant increase in the number of detected UHECR is expected to be achieved by employing Earth's moon as detector, and search for short radio pulses that are emitted when a particle interacts in the lunar rock. Observation of these short pulses with current and future radio telescopes also allows to search for the even lower fluxes of neutrinos with energies above 10^{22} eV, that are predicted in certain Grand-Unifying-Theories (GUTs), and e.g. models for super-heavy dark matter (SHDM). In this contribution we present the initial design for such a search with the LOFAR radio telescope.

Summary:

Presentations / **34**

Search for Cosmic Ray real-time identification with Radio antennas

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Cosmic rays entering the Earth's atmosphere will produce Extensive Air Showers, which emit a radio signal in the 10-200 MHz frequency region through Geo-synchrotron and Askaryan emission.
In the last years the Radio detection technique for observing Cosmic rays made huge developments. It has been recently proven that, by using the Radio footprint at the ground-level, the primary particle properties (arrival direction, energy, mass composition) can be reconstructed with an accuracy comparable to the current experiments. Moreover, the Radio detection technique has a very high duty cycle and shows a substantial reduction in construction and operational costs.
At the present time, one of the biggest challenges for assessing the Radio detection as a valuable technique for Cosmic-ray observation is to identify on real-time the very fast (less than 100 ns) radio signals over the background noise. As consequence, the detection of Extensive Air Showers with standard particle detectors is usually used as trigger for the Radio data acquisition. Anyhow, this procedure limits strongly the efficiency and exploitability of Cosmic-ray Radio detection technique.
In this work, we will present the latest updates on the real-time identification of the Radio signal from Extensive Air Showers by using the data from LOFAR Low Band Antenna stations, which are sensitive in the 30-80 MHz region.

Summary:

Presentations / **47**

Sensitivity of lunar particle-detection experiments

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The use of the Moon as a detector volume for ultra-high-energy neutrinos and cosmic rays, by searching for the Askaryan radio pulse produced when they interact in the lunar regolith, has been attempted by a range of projects over the past two decades. In this presentation, I will discuss some of the signal-processing considerations relevant to an experiment of this type, with reference to these past experiments, and the consequent effects on their sensitivity. I will also discuss the merits of different approaches for future experiments, and highlight their potential.

Summary:

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Signal classification and event reconstruction for acoustic neutrino detection in sea water with KM3NeT

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The research infrastructure KM3NeT will comprise a multi cubic kilometer neutrino telescope that is currently being constructed in the Mediterranean Sea. The telescope will be composed of several detection units anchored at the sea bed, which are kept taut vertically by a buoy. Each detection unit has a length of about 700 hundred meters. Modules with optical and acoustical sensors are mounted every 36 meters on each line. While the main purpose of the acoustic sensors is the position calibration of the detection units, they can be used as instruments for studies on acoustic neutrino detection, too. In this presentation, methods for signal classification and event reconstruction for acoustic neutrino detectors will be presented, which were developed using Monte Carlo simulations. The signal classification uses the disk-like emission pattern of the acoustic neutrino signal, which is often called "pancake". For the classification, a set of features is calculated from the signature in the detector. These are used as the input for the machine learning algorithms that perform the classification. This approach improves the suppression of transient background by several orders of magnitude. Additionally, an event reconstruction is developed based on the signal classification. The direction of the incident neutrino can be derived from a fit of the "pancake" plane, while the event vertex can be reconstructed from the timing of the hits. The energy reconstruction however requires a combined fit of all these parameters for an accurate result. An overview of these algorithms will be presented and the efficiency of the classification will be discussed. The quality of the event reconstruction will also be presented.

Summary:

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Simulation of the Radiation Energy Release in Air Showers

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Co-author(s): Johannes Schulz [2] ; Jörg Hörandel [3] ; Martin Erdmann [4] ; Tim Huege [5]

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A simulation study of the energy released by extensive air showers in the form of MHz radiation is performed using the CoREAS simulation code. We develop an efficient method to extract this radiation energy from air-shower simulations. We determine the longitudinal profile of the radiation energy release and compare it to the longitudinal profile of the energy deposit by the electromagnetic component of the air shower. We find that the radiation energy corrected for the geometric dependence of the geomagnetic emission scales quadratically with the energy in the electromagnetic component of the air shower with a second order dependency on the atmospheric density at the position of the maximum of the shower development $X_{\max}$. In a measurement where $X_{\max}$ is not accessible, this second order dependence can be approximated using the zenith angle of the incoming direction of the air shower with only a minor deterioration in accuracy. This method results in an intrinsic uncertainty of 4% which is well below current experimental uncertainties.

Summary:

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Simulation study on high-precision radio measurements of the depth of shower maximum with SKA1-low

Author(s): Anne Zilles[1]

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As LOFAR has shown, using a dense array of radio antennas for detecting extensive air showers initiated by cosmic rays in the Earth's atmosphere makes it possible to
measure the depth of shower maximum for individual showers with a statistical uncertainty less than $20\,\mathrm{g/cm^2}$. This allows detailed studies of the mass composition in the energy region around 10^{17}eV where the transition from a galactic to an extragalactic origin could occur.
Since SKA1-low will provide a much denser and very homogeneous antenna array with a large bandwidth of $50 - 350\,\mathrm{MHz}$ it is expected to reach an uncertainty on the X_{max} reconstruction of less than $10\,\mathrm{g/cm^2}$.
We present first results of a simulation study with focus on the potential to reconstruct the depth of shower maximum for individual showers to be measured with SKA1-low. In addition, possible influences of various parameters such as the numbers of antennas included in the analysis or the considered frequency bandwidth will be discussed.

Summary:

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Sources of high-energy neutrinos

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We present a bottom-up and a top-down model that can produce high-energy neutrinos.

Gamma rays bursts (GRBs) are flashes of gamma rays which are associated with extremely high energetic explosions in distant galaxies. The relativistic fireball is the most popular model to explain the GRBs. Within the fireball model ultra-high energetic cosmic rays can be produced. It is also likely that neutrinos are produced at high energies, which should be detectable with the IceCube detector.

In a top-down approach ultra-high energetic cosmic rays are produced through the decay of super-heavy dark matter (SHDM), particles with masses above 1013 GeV. SHDM can be formed in the early universe directly after the era of inflation following the instant preheating process by Felder, Kofman, and Linde. Annihilation of these SHDM particles inside the galactic DM halo could produce ultra-high energetic cosmic rays with energies above the GZK-cutoff.

Summary:

Presentations / **2**

Status of air-shower measurements with sparse radio arrays

Frank Schröder[1]

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Current radio arrays like AERA or Tunka-Rex have demonstrated that areas of several km² can be instrumented for reasonable costs with antenna spacings of the order of 200 m. This finally fulfills the promise that radio detection of air showers can be relatively cheap – at least when radio antennas extend existing arrays. Recent results indicate that for the reconstruction of the energy of the primary particle the radio technique can already compete in absolute accuracy with other precise techniques, like the detection of air-fluorescence or air-Cherenkov light. Moreover, it has been demonstrated that radio arrays provide information on the mass-composition of the primary cosmic-rays above 100 PeV by their sensitivity to the position of the shower maximum. Although sparse arrays have not yet achieved the same precision for the shower maximum as dense arrays like LOFAR, or as the established detection techniques, radio measurements can be used to increase the total accuracy of observatories containing antennas among other detectors. In particular the combination of radio and muon measurements is expected to yield higher accuracy for the type of primary particle initiating the air shower, and this around the clock and not limited to clear nights as the light-detection methods. This talk will summarize the latest results and plans of several radio experiments, in particular LOPES, AERA, and Tunka-Rex.

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TEC, Trigger and Check: preparing LOFAR for Lunar observations

Author(s): Sander ter Veen[1]

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One of the main ways to use radio to detect Ultra High Energy Neutrinos and Cosmic Rays is the Lunar Askaryan technique, that uses the Moon as a target and searches for nanosecond pulses with large radio telescopes. To use low frequency aperture arrays, such as LOFAR and the SKA, pose new challenges and possibilities in detection techniques of short radio pulses and an accurate measurement of the Total Electron Content (TEC). As a prepatory work, we have used other measurements that use similar techniques, or that can answer a specific question, with the LOFAR radio telescope. In this contribution I will report on our work on triggering on short radio signals, post-event imaging of radio signals from buffered data and methods to determine the TEC-value.

Summary:

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The ExaVolt Antenna: Concept and Development Updates

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A flux of ultrahigh energy neutrinos is expected both directly from sources and from interactions between ultrahigh energy cosmic rays and the cosmic microwave background. Using the cost-effective radio Cherenkov technique to search for these neutrinos, the ExaVolt Antenna (EVA) is a mission concept that aims to build on the capabilities of earlier radio-based balloon-borne neutrino detectors and increase the sensitivity to lower energies and fluxes. The novel EVA design exploits the surface of the balloon to provide a focusing reflector that aims to provide a signal gain of ~30 dBi (compared to 10 dBi on ANITA). This increase in gain when combined with a large instantaneous viewing angle will yield a 10-fold increase in sensitivity and will allow this balloon-borne experiment to probe the expected low neutrino fluxes even at energies greater than 10^{19} eV. This contribution will present an overview of the mission concept, recent technology developments, and the results of a hang test of a 1:20-scale model which demonstrates the effectiveness of the design.

Summary:

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The cosmic-ray air shower signal in Askaryan radio detectors

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We discuss the radio emission from different parts of the cascade development for a cosmic-ray induced air shower hitting an ice surface. The in-air emission, in-ice emission, as well as the transition radiation are included in to the calculation. The induced signal should be detectable by the currently operating Askaryan radio detectors searching for the GZK neutrino flux. Where on one side the signal poses a possible background, if detected such a signal would immediately proof the on-site feasibility of the detection technique.

Summary:

We discuss the radio emission from different parts of the cascade development for a cosmic-ray induced air shower hitting an ice surface. The in-air emission, in-ice emission, as well as the transition radiation are included in to the calculation. The induced signal should be detectable by the currently operating Askaryan radio detectors searching for the GZK neutrino flux. Where on one side the signal poses a possible background, if detected such a signal would immediately proof the on-site feasibility of the detection technique.

Presentations / **20**

The influence of the atmospheric refractive index on radio measurements of extensive air showers

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Measurements of radio emission from extensive air showers, together with air shower simulations, have allowed to infer the height of maximum emission (X_{max}) for individual air showers to a precision of 18 g/cm^2, important for composition studies.

In this procedure, one of the major systematic uncertainties arises from variations of the refractive index in the atmosphere. The refractive index n varies with temperature and humidity, and the variations can make on the order of 10 % difference in (n-1).
Using CoREAS simulations, we have evaluated the systematic error arising from the uncertainty in the refractive index.
Also, we give an interpretation in terms of a simple, physical model.

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Towards a cosmic-ray mass-composition study at Tunka Radio Extension

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The Tunka Radio Extension (Tunka-Rex) is a radio detector at TAIGA facility located in Siberia nearby the southern tip of Lake Baikal. Tunka-Rex measures air-showers created by high-energy cosmic rays, in particular the lateral distribution of the radio pulses produced during the development of the air-shower. The depth of the air-shower maximum, which statistically depends on the mass of the primary particle, is determined as function of the slope of the lateral distribution. Starting from 2015, Tunka-Rex acquires data jointly with Tunka-Grande, which adds a measurement of the muonic shower component to the calorimetric radio measurements, and gives complementary information about air-shower. To interpret these measurements, one has to take into account systematic uncertainties given by hadronic models. Furthermore, it is important to investigate different shower geometries, since the received signal depends on the inclination and dimensions of cascade. In the frame of this study we perform simulations using the CONEX and CoREAS software packages of the recently released CORSIKA v7.5 including the modern high-energy hadronic models QGSJet-II.04, EPOS-LHC, and SIBYLL 2.3. We report the last results on this study, and discuss the prospects of future improvements based on these simulations.

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Tunka-Rex: Status, Plans, and Recent Results

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Tunka-Rex, the Tunka Radio extension, meanwhile consists of 44 SALLA antennas at the TAIGA facility (Tunka Advanced Instrument for cosmic ray physics and Gamma Astronomy) in Siberia, and soon will be extended to a total of 63 antennas, most of them distributed on an area of one square kilometer. In the first years of operation, Tunka-Rex was solely triggered by the co-located air-Cherenkov array Tunka-133. The correlation of the measurements by both detectors has provided direct experimental proof that radio arrays can measure the position of the shower maximum. The precision achieved so far is 40 g/cm², and several methodical improvements are under study. Moreover, the cross-comparison of Tunka-Rex and Tunka-133 shows that the energy reconstruction of

Tunka-Rex is precise to 15 %, with a total accuracy of 20 % including the absolute energy scale. By using exactly the same calibration source for Tunka-Rex and LOPES, the energy scale of their host experiments, Tunka-133 and KASCADE-Grande, respectively, can be compared even more accurately with a remaining uncertainty of about 10 %. The main goal of Tunka-Rex for the next years is a study of the cosmic-ray mass composition in the energy range above 100 PeV: For this purpose, Tunka-Rex now is triggered also during daytime by the particle detector array Tunka-Grande featuring surface and underground scintillators for electron and muon detection.

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Tunka-Rex: energy reconstruction with a single antenna station

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The Tunka-Radio extension is a radio detector for air showers in Siberia.
It currently consists of 44 antennas, distributed over 3 square kilometer, and co-located with Tunka-133, a non-imaging air-Cherenkov detector for air showers.
From 2012 to 2014 on, Tunka-Rex operated exclusively together with its host experiment, Tunka-133, which provided a trigger,
data acquisition and an independent air-shower reconstruction.
It was shown that the air-shower energy can be reconstructed by Tunka-Rex with a precision of 15% for events with signal in at least 3 antennas,
using the radio amplitude at a distance of 120m from the shower axis as an energy estimator.
Using the reconstruction from the host experiment for the air-shower geometry (shower core and direction),
the energy estimator can in principle already be obtained with measurements from a single antenna, close to the reference distance.
We present a method for event selection and energy reconstruction, requiring only one antenna, and achieving a precision of about 20%.
This method enables energy reconstruction with Tunka-Rex for three times more events than the standard reconstruction.
The effective detector area is tripled for high energy events, vertical events are already observed at lower energies, and
the energy threshold decreases to by about 40%.

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Ultimate precision in cosmic-ray radio detection - the SKA

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As of 2023, the low-frequency part of SKA-1 will go online in Australia. It will constitute the largest and most powerful low-frequency radio-astronomical observatory to date, and will facilitate a rich science programme in astronomy and astrophysics. With modest engineering changes, SKA-1 low

will also be able to measure cosmic rays via the radio emission from extensive air showers. The extreme antenna density and the homogeneous coverage provided by more than 60,000 antennas on an effective area of one km^2 will push radio detection of cosmic rays in the energy range around 10^17 eV to ultimate precision, with superior capabilities in the reconstruction of energy, depth of shower maximum and arrival direction. We will discuss the status of the project and outline the scientific potential of cosmic-ray detection with the SKA.

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Validating a fast analytic code for radio emission calculations from parametrized air showers

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Extensive air showers are an interesting phenomena because they can provide information about, among many other things, the electric fields present in the atmosphere, an understanding of which is necessary to understand the concept of lightning.
To be able to deduce the electric fields from the radio footprint we have developed a macroscopic code that uses a parametrized shower profile. We compare the results for radio emission of microscopic CORSIKA/CoREAS simulation with those of the macroscopic calculation to optimize the parametrization. Particular attention is given to polarization observables, characterized by the Stokes parameters.

Summary:

Extensive air showers are an interesting phenomena because they can provide information about, among many other things, the electric fields present in the atmosphere, an understanding of which is necessary to understand the concept of lightning.
To be able to deduce the electric fields from the radio footprint we have developed a macroscopic code that uses a parametrized shower profile. We compare the results for radio emission of microscopic CORSIKA/CoREAS simulation with those of the macroscopic calculation to optimize the parametrization. Particular attention is given to polarization observables, characterized by the Stokes parameters.

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