SCIENCES & BIOENGINEERING SCIENCES

The Research Group
High-Energy Physics

has the honor to invite you to the public defence of the PhD thesis of

Simon De Kockere

to obtain the degree of Doctor of Sciences

Title of the PhD thesis:

Observation of Neutrino-Induced Cascades via Radio Detection Techniques

Promotors:
Prof. dr. Nick van Eijndhoven
Prof. dr. Krijn de Vries

The defence will take place on

Tuesday, October 29 2024 at 4 p.m. in U-residence, Green Room

The defence can also be followed through a live stream.

Members of the jury

Prof. dr. Jorgen D'Hondt (VUB, chair)
Prof. dr. Stijn Buitink (VUB, secretary)
Prof. dr. Michael Tytgat (VUB)
Prof. dr. Dominique Maes (VUB)
Prof. dr. Ioana Maris (ULB)
Prof. dr. Anna Nelles (DESY Zeuthen and Friedrich-Alexander Universität Erlangen, DE)

Curriculum vitae

Simon obtained his MSc in Physics & Astronomy at the University of Ghent in 2018. The MSc thesis had a focus on the optimization of a search for double bang topologies in the IceCube detector, which is a key signature for tau neutrino events.
At the VUB-IIHE, Simon has been working in the astropartice physics group as part of the Askaryan Radio Array (ARA), Radio Neutrino Observatory Greenland (RNO-G) and Radar Echo Telescope (RET) collaborations. The main topic of his thesis is the simulation of the radio emission of cosmic-ray particle cascades propagating through both air and ice, as observed by in-ice radio detectors. As part of his PhD, Simon was member of the RNO-G and RET field teams sent to Summit Station, Greenland in 2023 and 2024. Furthermore, he was highly involved in the teaching activities provided by the department of Physics and Astronomy, supervised BSc./MSc. students and presented results at scientific conferences and through peer-reviewed articles.

Abstract of the PhD research

Several neutrino observatories, such as the IceCube Neutrino Observatory at the South Pole, have successfully demonstrated the viability of using optical modules to detect neutrino interactions in ice or water, instrumenting volumes as large as 1 km^3. At energies of 10 PeV and above, even such impressive detection volumes prove insufficient to observe the extremely low flux of these very energetic neutrinos, calling for new detection techniques suited to cover even larger volumes in a practical and cost-efficient way. A neutrino interacting in ice will create a particle cascade developing a net negative charge, leading to so-called Askaryan radio emission, which has an attenuation length of the order of ~ 1 km. Next-generation neutrino observatories are exploring the feasibility of detecting radio emission from neutrino interactions in ice, using the polar regions as detector sites. Although Askaryan radiation from particle cascades in dense media has been observed in controlled environments, no proof of its detection in nature has been presented yet.

However, radio emission from cosmic-ray air showers has been observed by several ground-based radio observatories. Furthermore, at high altitudes typical for polar ice sheets, cosmic-ray air showers reaching the ice surface still contain a large fraction of the energy of the primary particle. This energy is mostly concentrated around the shower core, which propagates into the ice and leads to the development of an in-ice cascade, similar to neutrino-induced particle cascades. Cosmic rays are however much more likely to interact and the corresponding observed flux is significantly higher. Therefore, detecting cosmic-ray events with in-ice radio neutrino detectors would serve as a valuable proof-of-concept. Additionally, these events also form an important background, which has to be identified in the search for neutrino signals.

The thesis presents the first Monte-Carlo simulation framework developed to simulate the radio emission from cosmic-ray showers for in-ice radio detectors, including both the in-air and in-ice component of the cascades. It relies on an existing Monte Carlo code for the simulation in air, and uses a module developed with the GEANT4 simulation toolkit for the simulation in ice, both applying ray tracing for the propagation of the radio emission. Key features of the in-ice particle shower as well as the radio emission from both the in-air and the in-ice cascade components for in-ice observers are discussed.