T 44: Experimentelle Methoden der Astroteilchenphysik II

Zeit: Dienstag 16:30–19:00 Raum: Z6 - SR 2.013

T 44.1 Di 16:30 Z6 - SR 2.013

mDOM - a multi-PMT optical module for future upgrades of IceCube — •Lew Classen, Tabea Eder, Daniel Gude-rian, Alexander Kappes, Cristian Lozano, Florian Sprenger, Florian Trittmaack, and Martin Unland for the IceCube-Collaboration — Institut für Kernphysik, Westphälische Wilhelms-Universität Münster

Following the discovery of a high-energy astrophysical neutrino flux by IceCube research and development for a next-generation neutrino observatory in Antarctica is under way. A significant relative enhancement in sensitivity for the envisionend detector is expected from novel optical sensors. Among the most promising new designs is the so-called mDOM, a multi-PMT Digital Optical Moule. Optical modules based on this concept feature an array of several small photomultipliers (PMTs) housed inside a transparent pressure vessel, resulting in several advantages with respect to the conventional single-PMT design, such as a larger sensitive area, a uniform solid angle coverage as well as enhaced intrinsic directional senisitivity. The contribution will introduce the sensor concept and provide an overview of the current status of development of the device.

T 44.2 Di 16:45 Z6 - SR 2.013

The Wavelength-Shifting Optical Module for IceCube - Status and Performance — •Peter Peiffer for the IceCube-Gen2-Collaboration — Universität Mainz, Deutschland

The Wavelength-shifting Optical Module (WOM) is a single photon sensor developed in the context of the IceCube neutrino telescope. It provides a large photosensitive area with low detector noise and improved UV sensitivity. This is achieved by combining a wavelength-shifter coated tube with two small, low-noise PMTs. Incident UV photons are absorbed by the wavelength-shifter and are re-emitted isotropically. We show that on average $\sim$40% of the re-emitted light is captured by total internal reflection and guided to the PMTs at the ends of the 90 cm tube. Compared to the IceCube DOM, the noise is a factor 10 lower, while the effective area is up to a factor of 2 higher. This leads to a factor 20 improvement in the S/N ratio. Apart from IceCube, this sensor can also be employed in other experiments, that aim at the detection of UV photons with a high S/N ratio. (e.g. SHiP) In this contribution the performance characteristics of the WOM and an update of the current status of the prototype development are discussed.

T 44.3 Di 17:00 Z6 - SR 2.013

In situ calibration of multi-PMT optical modules in the deep ice at the South Pole — •Tabea Eder, Lew Classen, and Alexander Kappes for the IceCube-Collaboration — Institut für Kernphysik, Westfälische Wilhelms-Universität Münster

Based on the discovery of high-energy cosmic neutrinos by the IceCube Neutrino Observatory, a next-generation neutrino telescope at the South Pole is in the planning phase. The utilization of new detector module concepts are being considered to further increase the detector sensitivity. A promising candidate is the multi-PMT Digital Optical Module (mDOM), which provides a larger effective photocathode area and information on the photon arrival direction due to 24 3-inch PMTs in one module, in comparison to the standard single-PMT DOMs currently used in IceCube. A critical aspect of this design is the monitoring of the time calibration between the PMTs within an mDOM module after deployment in the ice. For such an in-situ measurement, the time differences between correlated signals in two PMTs caused by radioactive decays in the pressure vessel can be utilized. In the talk, the calibration method will be introduced and the current status of the studies presented.

T 44.4 Di 17:15 Z6 - SR 2.013

Dark rates from radioactive decays in the multi-PMT digital optical module — •Martin Antonio Unland Elorrieta, Lew Classen, and Alexander Kappes for the IceCube-Collaboration — Institut für Kernphysik, Westfälische Wilhelms-Universität Münster

In the framework of a planned upgrade of the IceCube Neutrino Observatory and a next-generation neutrino telescope at the South Pole, new optical modules are being developed, which are expected to significantly increase the detector sensitivity. One such concept is the multi-PMT Digital Optical Module (mDOM) which features 24 three-inch PMTs inside a pressure vessel pointing in all directions. This design provides i.a. an almost uniform angular acceptance, an increased effective area and the possibility of using local coincidences between PMTs of the same module. As the deep ice at the South Pole has a very low optical activity, light produced by the mDOM itself represents the dominant background source. Two major sources are Cherenkov and scintillation light produced by radioactive decays inside the module's pressure vessel. After an introduction, the talk presents detailed investigations of the underlying production mechanisms and their parameter, as well as results from a Geant4 simulation of the module response to this background.

T 44.5 Di 17:30 Z6 - SR 2.013

Background light sources in photomultiplier tubes operated at negative HV — •Florian Trittmaack, Lew Classen, and Alexander Kappes for the IceCube-Collaboration — Westfälische Wilhelms-Universität Münster, Institut für Kernphysik, Deutschland

A significant sensitivity gain for future neutrino telescopes at the South Pole is anticipated to come from new optical sensor designs. One such design is the Multi-PMT Digital Optical Module (mDOM), which incorporates 24 3" photomultipliers (PMTs). Due to the low level of optical background in the deep ice, the dominant background is produced by the optical modules themselves with the PMTs being major sources. After an introduction to mechanisms of dark rate production inside a PMT, the talk presents investigations to characterize and identify the major sources for the 3 PMTs operated with negative high volatge used in the mDOM and possible ways to reduce it.

T 44.6 Di 17:45 Z6 - SR 2.013

Sensitivity of multi-PMT optical modules to the energy spectrum of MeV supernova neutrinos — •Florian Sprenger, Cristian Jesús Lozano Mariscal, Lew Classen, and Alexander Kappes for the IceCube-Collaboration — Westfälische Wilhelms-Universität Münster, Institut für Kernphysik, Münster

Within the efforts for the next generation neutrino observatory at the South Pole, new optical modules like the multi-PMT optical module (mDOM) are being developed, which are expected to significantly increase the detector sensitivity to high energy astrophysical neutrinos. On the other hand, neutrinos from core-collapse supernovae with energies as low as few MeVs can reveal a detailed picture of the events that accompany the collapse of the core and verify and enhance our picture of these powerful explosions. With its unique features like local coincidences and information on the arrival direction of detected photons, the mDOM may allow for event-by-event detection of MeV neutrinos with a single module while at the same time keeping the background sufficiently low. The talk presents the first study on the energy sensitivity for SNe by using local coincidences in the mDOM.

T 44.7 Di 18:00 Z6 - SR 2.013

Measurement of luminescence spectra of ultra-purified water and ice — •Sarah Pieper — Bergische Universität Wuppertal, Deutschland

Luminescence is the phenomenon of a medium emitting photons as a deexcitation mechanism, that is exceeding thermal radiation and is delayed concerning the time of excitation. It can be characterized by parameters such as light yield, emission spectrum, and decay times.

It was proposed that luminescence of water and ice can be used as a new detection method at particle detectors that use water or ice as their target medium. These detectors use directly or indirectly produced Cherenkov light as a detection method. Therefore the detection of particles is restricted by their velocities using this method.

Luminescence light, on the other hand, is produced by particles due to their energy transfer to the medium. Therefore particles with a large energy transfer can be detected even below velocity ranges detectable due to Cherenkov light emission. In order to use luminescence light, the characteristics, mentioned above, need to be known for the properties given in these detectors.

As a first step, the characteristics are determined for ultra-purified water and ice. Light yield of ultra-purified water and ice and its temperature dependance in a temperature range from $-40°$C to $20°$C has already been measured. Measurements of the emission spectrum are ongoing, using different types of radioactive sources for excitation. The present status of this investigation will be presented.

T 44.8 Di 18:15 Z6 - SR 2.013

Logging device for in-situ measurements of luminescence in ice — •Anna Pollmann for the IceCube-Collaboration — Bergische Universität Wuppertal

Luminescence is induced by highly ionizing particles passing through matter due to excitation of surrounding atoms. In particular, this mechanism is present also in pure H_2O ice, which was irradiated by ionizing radiation.

The production of luminescence light is not constrained by a minimal speed threshold of the incident particle as in contrast to Cherenkov light. Thus, slow particles can be detected by utilizing luminescence in large water-Cherenkov detectors with high sensitivity such as IceCube. These particles are highly ionizing, heavy particles proposed beyond the Standard Model of particle physics, such as magnetic monopoles.

The observables of luminescence, such as wavelength spectra and decay times, are highly dependent on the properties of the medium. The usage of luminescence at the IceCube neutrino telescope will therefore be prepared by an in-situ measurement within a deep bore hole which is close to IceCube.

A logging device will be presented that is currently under development in order to measure the depth dependent properties of luminescence in the South Pole ice. A radioactive source will be attached to the ice within the bore hole and the backwards scattered luminescence light will be collected and analyzed.

T 44.9 Di 18:30 Z6 - SR 2.013

Entwicklung einer Sonde zur Messung der Ausbreitungseigenschaften ultravioletten Lichts im antarktischen Eis — •Jannes Brostean-Kaiser für die IceCube-Gen2-Kollaboration — DESY Zeuthen

Das weltweit größte Neutrinoteleskop IceCube soll in den nächsten Jahren zu IceCube Gen2 erweitert werden. Zur Steigerung der Sensitivität wurden für diese Erweiterung neue optische Module entwickelt. Eines der neuen Module (WOM) vergrößert den sensitiven Wellenlängenbereich des Teleskops in das Ultraviolette. Für eine Abschätzung der Sensitivitätssteigerung durch die neuen Module wurde eine Sonde entwickelt, welche die Absorptions- und Streulängen von Ultraviolettem Licht in Südpoleis messen kann. Desweiteren wurden erste Tests und Simulationen zu der Messung durchgeführt. In diesem Vortrag wird die Entwicklung der Sonde, sowie die Vorhersagen der Simulation dargestellt.

T 44.10 Di 18:45 Z6 - SR 2.013

The IceCube Neutrino Observatory as an instrument for glaciology — •Martin Rongen and Christopher Wiebusch for the IceCube-Collaboration — III. Physikalisches Institut B, RWTH Aachen University

The IceCube Neutrino Observatory instruments about 1 km^3 of deep, glacial ice at the geographic South Pole with 5160 optical modules to detect Cherenkov light of passing particles. After discovering a diffuse flux of high-energy cosmic neutrinos, there is an on-going search to identify their astrophysical sources. This effort relies heavily on an ever more precise understanding of the optical scattering and absorption properties of the instrumented ice. In turn, IceCube can now provide a unique insight into the glacier which, due to the large distances observed, is in many ways complementary to ice cores. We observe a direction-dependent extinction length, with the direction of least extinction being aligned with the local flow direction of the ice. In this talk, a depth-dependent measurement of the strength of this anisotropy will be presented. Possible explanations of the effect are going to be discussed.