Abstract

by Joost Pieter Veenkamp

IceCube is a cubic kilometer neutrino detector in the Antarctic ice. With the detection of high energy neutrinos many scientific goals are being pursued. The Precision IceCube Next Generation Upgrade, with an energy threshold of a few GeV, will detect atmospheric neutrinos with high statistics. With this detector, the Neutrino Mass hierarchy can be determined, among other goals. Building on experience gathered with the successful IceCube detector, improvements are made to all elements of the PINGU design with respect to IceCube. Among these is the calibration system, in which the Precision Optical CALibration Module (POCAM) will be implemented. The POCAM illuminates all PINGU optical modules isotropically with short pulses of light. This enables verification of the energy scale and energy resolution of PINGU, and enhancement of the ice models. To introduce the POCAM, this thesis starts with a discussion of (atmospheric) neutrino physics, the IceCube and PINGU detectors and the respective calibration systems, after which the design study of the POCAM is discussed. An inverted integrating sphere isotropizes photons emitted from an internal, appropriately placed matrix of LEDs. The resulting emission from the POCAM consist of short, isotropic light pulses. A diode on the integrating sphere enables in-situ monitoring of the emission. The emission characteristics have been optimized by studying the geometry in a Geant4 simulation. Simulations of configurations varying the properties in the design are presented. With the acquired knowledge a baseline geometry is proposed. As a next step the functionality of the POCAM inside PINGU and IceCube is tested with ray tracing simulation, of which the first promising results are discussed.