Our sun provides a local laboratory to test various astrophysical mechanisms such as particle acceleration. During some powerful solar events high-energy particles are expelled into the interplanetary medium. Upon entering the Earth’s atmosphere they will lead to an increase of particle flux at the ground level. The resulting spectrum will deviate from the steady galactic spectrum, so that various characteristics of the event can be studied.

In the tanktop simulation, solar events high energy particles are produced by various astrophysical mechanisms such as neutron stars. In air-shower mode, tanks are deployed close to the geographical South Pole. Water is filled into the tanks and allowed to freeze under controlled conditions to ensure bubble-free, clear ice. In simulation, we can study the light output from different types of particles in the tank. This is important to understand at which PE level to search for a change in rate. Especially at lower energies, gamma rays produce the dominant contribution, followed by electrons and positrons. Muons start to play the major role at about 200 PE, allowing for calibration of the tank. Other particles, such as neutrons, protons and various mesons, contribute by about 1%. Comparing the simulation to measurements at an artificial tank (DOM 63 of station 29) we find that the simulation describes the experiment sufficiently well.

The IceTop tanks are deployed close to the geographical South Pole. Water is filled into the tanks and allowed to freeze under controlled conditions to ensure bubble-free, clear ice. In simulation, we can study the light output from different types of particles in the tank. This is important to understand at which PE level to search for a change in rate. Especially at lower energies, gamma rays produce the dominant contribution, followed by electrons and positrons. Muons start to play the major role at about 200 PE, allowing for calibration of the tank. Other particles, such as neutrons, protons and various mesons, contribute by about 1%. Comparing the simulation to measurements at an artificial tank (DOM 63 of station 29) we find that the simulation describes the experiment sufficiently well.

Simulations are done using the FLUKA\(^2\) package (“ABC”, [3]) and a combination of CORSIKA\(^4\)/GEANT4\(^5\) (“tanktop”).

The secondary particle flux is dominated by electrons and gammas produced by the electromagnetic part of the cascade. We show here the flux of secondary particles expected by our calculations and compare to some experiments. The calculations are in reasonable agreement with the experiments.

The light yield in the tank for various particles is a function mainly of energy for electrons and gammas. Above 1 GeV most muons have enough energy to pass through the full detector volume depositing a constant amount of energy whereas below these energies the tank operates in calorimeter mode. The slight rise in light production is due to the increasing number of secondaries produced by the muon at higher energies.

The IceTop tanks are sensitive to low energy particles produced in cascades by cosmic radiation. The response of the IceTop detectors is understood reasonably well in terms of the simulation. This allows predictions of rate changes induced by changes in the primary particle spectrum. We expect count rate drops beyond variations induced by atmospheric variations, leading to good detectability of solar events.

The yield function \( N(P; z) \) describes the primary cosmic ray detection efficiency of a full sky illumination of particle averaged over all arriving angles (uniform in \( \cos \theta \)). It is related to the count-rate \( N(P; z, t) \) by

\[
N(P; z, t) = \sum_{j=0}^{\infty} S_j(P; z) \lambda_j(t) \frac{dP}{dt}
\]

where \( \lambda \) is the primary particle rate, \( S_j \) is the cosmic ray spectrum, \( \lambda_j(t) \) is a function of time, \( t \) is the rigidity of the primary particle, \( P \) is the energy of the primary particle, and \( z \) is the atmospheric depth.