1 Argentina

1.1 Bariloche

The site is located at the Centro Atómico Bariloche at 41.15°S, 71.30° W and an altitude of 850 MAMSL. The Bariloche group has developed the electronics for the LAGO project in collaboration with the Mexico group. The detectors are used to test and improve the data acquisition software and hardware since 2006.

1.1.1 Detectors description

Three different WCD have been constructed. Nahuelito was the first detector build in 2006 and together with Boyita are made of commercial plastic water tanks. Recently a stainless steel commercial water tank has been used in the construction of Sputnik. The latter will serve as a prototype for the Antarctic site detector. Geometry and dimensions details are shown on figure 1.

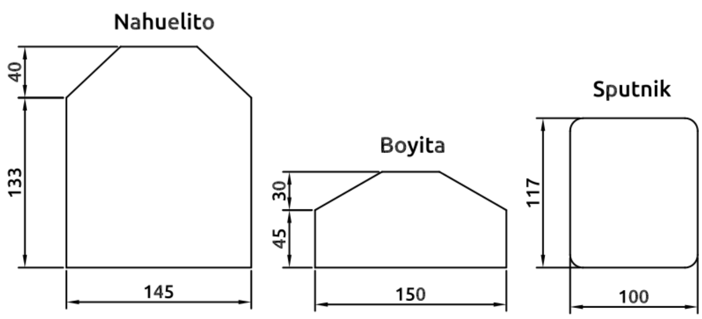

Figure 1: Geometry and dimensions of the Bariloche site detectorsi (All units in cm).

All detectors have an inner liner made of Tyvek^{TM}and one PMT mounted on top. Both Nahuelito and Boyita have 8 inches Hamamatsu R5912 PMTs while Sputnik has an 8 inch Electron Tube Limited 9353KB PMT. Because of the good water quality of Bariloche no purification process was implemented and tap water is used directly. The possibility of doping the water with amino-G ($NH_2C_{10}H_5(SO_3H)SO_3Na$) as wavelength shifter to improve the signals has been explored in all the Bariloche detectors.

1.1.2 Detectors performance

During the last years the use of the detectors has been shared with experimental physics courses for Balseiro Institute undergraduate students. Currently Nahuelito is exclusively used for the LAGO project. In this section different results are presented using the three detectors to showcase their performance.

Muon decay can be observed using WCD by looking at the histogram of time difference between consecutive events as shown on figure 2. Two different regions can can be seen. At large time differences the exponential distribution corresponding to the arrival of uncorrelated particles from the background of secondary cosmic rays. At small time differences another exponential distribution with a characteristic time $\approx 2\,\mu$s corresponding to muon decay.

Charge and amplitude histograms are used in order to calibrate the detectors. The maximum of the muon hump, corresponding roughly to verticals muons, can be used to define the VEM (Vertical Equivalent Muon). 1 VEM is the average signal of a vertical and central muon. The final energy calibration of the detectors can be done knowing the average energy deposited by a vertical muon. A typical charge histogram of Boyita can be seen in figure 2.

During the construction of Sputnik the improvements on the signals due to the inner Tyvek$^{\mathrm{TM}}$liner and the addition of amino-G to the water was checked. Comparison of average signals taken with the stainless steel tank only and the addition of the inner liner and amino-G (6 mg/l) can be seen in figure 2. All the signals were taken using an oscilloscope with a trigger rate of approximately 100 Hz. Using the LAGO data acquisition electronics with a sampling rate of 40 MHz the charge-amplitude ratio goes from 1 in the case of bare stainless steel to approximately 1.5 with the addition of the Tyvek$^{\mathrm{TM}}$liner and to approximately 2 doping the water with amino-G.

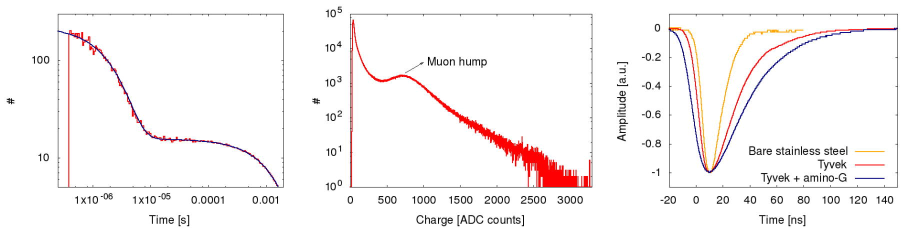

Figure 2: Left: histogram of time difference between consecutive events using Nahuelito. A fit of the sum of two exponential functions corresponding to muon decay and the arrival of uncorrelated particles of the background can be observed. Center: one hour typical charge histogram using Boyita. Right: Comparison of average traces with the stainless steel tank only and after the addition of the Tyvek$^{\mathrm{TM}}$liner and amino-G. A significant improvement of the signal is observed.

The addition of amino-G as wavelength shifter significantly improves the signals of WCD. However a systematic study of the aging of amino-G doped water would be necessary before deciding on its use in all LAGO detectors.