Mt. Chacaltaya (5220 m.a.s.l) is the place where is located one of the most prestigious cosmic ray observatory since 1952. In 1947 the team conformed by Cecil Powell, Giuseppe Occhialini and Cesar Lattes announced the discovery of pion, the meson particle proposed by Hideki Yukawa in 1935. Few years latter, Cecil Powell in 1950 and Hideki Yukawa in 1949 were awarded with the Nobel Price in Physics. Encouraged by this remarkable finding, Ismael Escobar presented a proposal to the Universidad Mayor de San Andrés for the construction of a laboratory on Chacaltaya, which was immediately accepted. The laboratory officially began its activities on January 1st, 1952, having Escobar as its first director, and since then has hosted various experiments, mainly in the areas of cosmic ray physics and atmospheric physics. The laboratory on Chacaltaya is located at 16° 21' 0.5'" S latitude and 68° 7' 53.1'" W longitude. The geomagnetic rigidity cutoff at the site is 12.5 GV and its elevation is 5280 m.a.s.l. The atmospheric depth is 530 g/cm², corresponding to a mass burden of roughly 14 radiation lengths. An advantage of having a high-altitude site for time series recording of secondary particles at ground level is the increased sensitivity with respect to lower altitude sites. Given that Gamma Ray Bursts (GRB) and space weather monitoring are generally carried out by analyzing temporal count variations induced on different types of detectors, this advantage is a fundamental one for the scientific purposes of LAGO. Three water Cherenkov detectors (WCD) had been running intermittently on Chacaltaya, from 2009 to 2014, as part of LAGO. Nonetheless, a number of issues caused their stoppage in 2014, with the intention of replacing those detectors with new ones with better characteristics. In this document, we report the status of the ongoing work.

The water Cherenkov detector

We are developing a pilot WCD at the Universidad Mayor de San Andrés for a future implementation in the laboratory at Chacaltaya. Our research installations are located in the city of La Paz, Bolivia, at 3450 m.a.s.l., at the university campus of Cota Cota.

The detector itself is a cylindrical plastic tank, whose external surface has been covered with sheets of asphalt membrane in order to minimize light leakages from the outside to the inside. The tank dimensions are 87 cm of diameter and 100 cm of height. The detector is filled with pure water up to 78 cm, which we distill so as to increase the absorption length of Cherenkov photons. We measured the resistivity of water after the distillation process and it is around 1 MΩ cm.

The interface between pure water and the walls of the plastic tank is a Tyvek lining, which is commonly used in WCDs because of its high diffuse reflectance [1, 2, 3]. The body of water is observed from above by an 8 inch photomultiplier tube (PMT) made by THORN EMI, model 9350 KA, which we placed at the center of the tank.

We measured the charge spectrum for dark pulses produced in the photomultiplier operating at 1320 V. The resulting histogram is shown in figure 2. Part of the pulses recorded can be attributed to single electrons, spontaneously emitted by the photocathode through thermionic emission. These electrons arrive to the first dynode and start the current multiplication process, and are thus capable of emulating the signal produced by a single photon. The signals generated by single electrons show as a hump around 20 pC in the distribution.

As a first step to characterize the detector as a whole, we assembled a two-fold coincidence system to calibrate in energy the signals produced by a WCD. The signals generated by single electrons show as a hump around 20 pC in the distribution.

As a final remark, it is interesting to note that the mean value for VEM signals is 2.18 ± 0.05 nC, which approximately corresponds to 110 photoelectrons arriving to the first dynode of the PMT. This result is in good agreement with what has previously been found using Monte Carlo simulations of a WCD [5].

References:

Figure 1: The prototype WCD situated at the university campus in CotaCota. The PMT case can be seen at the top of the tank.

Figure 2: Charge histogram obtained for dark counts in the PMT used for the prototype WCD. The hump around 20 pC is caused by single electrons spontaneously produced at the photocathode by thermionic emission.

Figure 3: Signal recorded by the WCD, together with signals from two scintillators, in response to the passage of a vertical muon that interacts with the set of detectors. The time of flight measured by both scintillators (approximately 8 ns) corresponds to ~ 2.5 m, which is the distance that separates them.

Figure 4: The charge histogram for the prototype WCD for vertical equivalent muons (VEM).