

	WCD1	WCD2 & WCD3
Diameter	1.4 m	2.2 m
Water depth	1.4 m	1.5 m
Water volume	2200 l	5300 l
Amino G	yes	only in WCD2
Tank material	plastic	fiberglass
Liner material	Tyvek®	vinyl
Liner reflection coefficient	0.8	0.9
Photomultiplier	9353KB 8"	9353KB 8"

Table 1: Relevant characteristics of each WCD operating on mount Chacaltaya.

Three WCD are operating, since 2009, at the cosmic ray laboratory on mount Chacaltaya, near the city of La Paz, Bolivia. The laboratory is located at $16^{\circ} 21' S$ latitude and $68^{\circ} 8' W$ longitude, corresponding to a geomagnetic rigidity cutoff of 12.5 GV. The elevation of the laboratory is 5240 m.a.s.l., at an atmospheric depth of 530 g/cm². The atmospheric mass burden corresponds to ~ 6.6 nuclear mean free paths or to ~ 14.1 radiation lengths. The high elevation of the laboratory improves the sensitivity of a WCD to low energy showers with respect to a WCD with similar characteristics operating at sea level.

Each of the WCD operating on mount Chacaltaya has a volume of pure water contained in a cylindrical tank made of either plastic or fiberglass. The volume of water is observed from above by an 8 inch Electron Tubes photomultiplier that collects Cherenkov photons emitted by the medium when charged energetic particles hit the detector. Moreover, the water has been mixed with Amino G, a chemical compound that acts as a wave length shifter, thus effectively increasing the number of photons collected by the photomultiplier. The walls of each tank are internally covered with a reflective liner. Two different materials were used as reflective liners, and their reflection coefficients have been measured employing a violet led. Table 1 contains some of the characteristics for each of the WCD operating at the laboratory. The configuration of the WCD at the laboratory is sketched in figure 1.

Data acquisition is performed by means of a local station (LS), designed and implemented at the Bariloche Atomic Center in Argentina (CAB, from its name in Spanish), based on the data acquisition electronics from the Pierre Auger Observatory. The LS is basically built from a digitizer, a

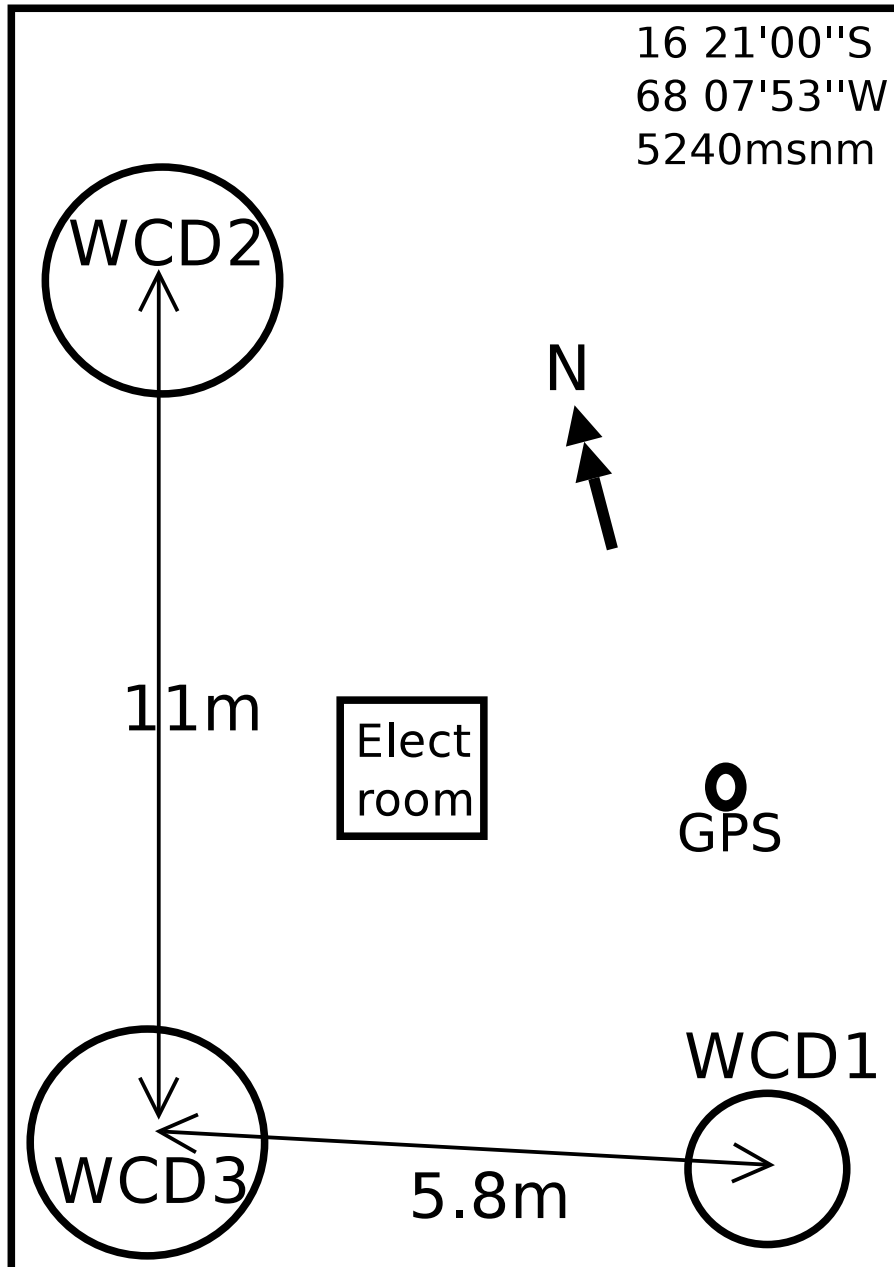


Figure 1: Location of the WCD at a room of the laboratory on mount Chacaltaya.

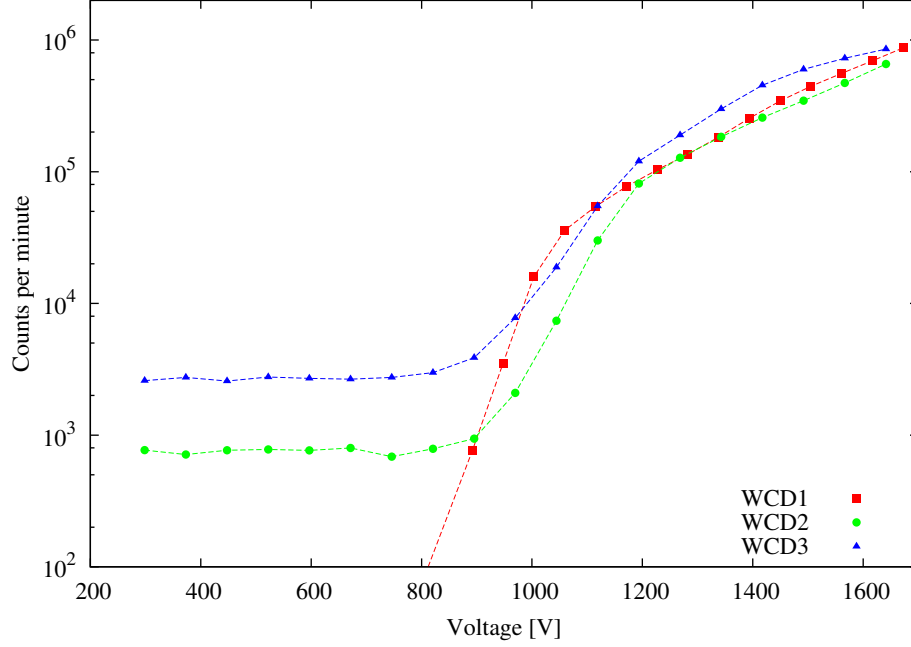


Figure 2: The plateaus of the photomultipliers for each of the WCD operating on mount Chacaltaya.

Nexys2 FPGA and a GPS clock. The digitizer has three input channels for analog signals ($50\ \Omega$ impedance), an amplifier and a 10 bit ADC with a sampling rate of 40 MHz, that receives the signal coming from the photomultipliers. The sampling rate corresponds to a sampling period of 25 ns. By means of the FPGA it is possible to connect the LS to pressure and temperature sensors, but this feature is not exploited at the laboratory on mount Chacaltaya at the time of writing. The FPGA operates at a rate of 40 MHz and it communicates with a standard PC running a Linux version. The communication between the LS and the PC takes place via the USB port employing the USB 2.0 protocol, achieving a transmission rate of 400 Mb. The high voltage required for the operation of the photomultipliers is controlled employing a DAC and a pulse width modulation technique. The plateaus for each of the photomultipliers operating are displayed on figure 2. A typical pulse obtained from a WCD is shown in figure 3.

Two histograms are filled on a minute basis on each of the WCD. The first histogram is filled with entries corresponding to the peaks (i.e. highest pulse value) of the pulses received during a minute. The second histogram

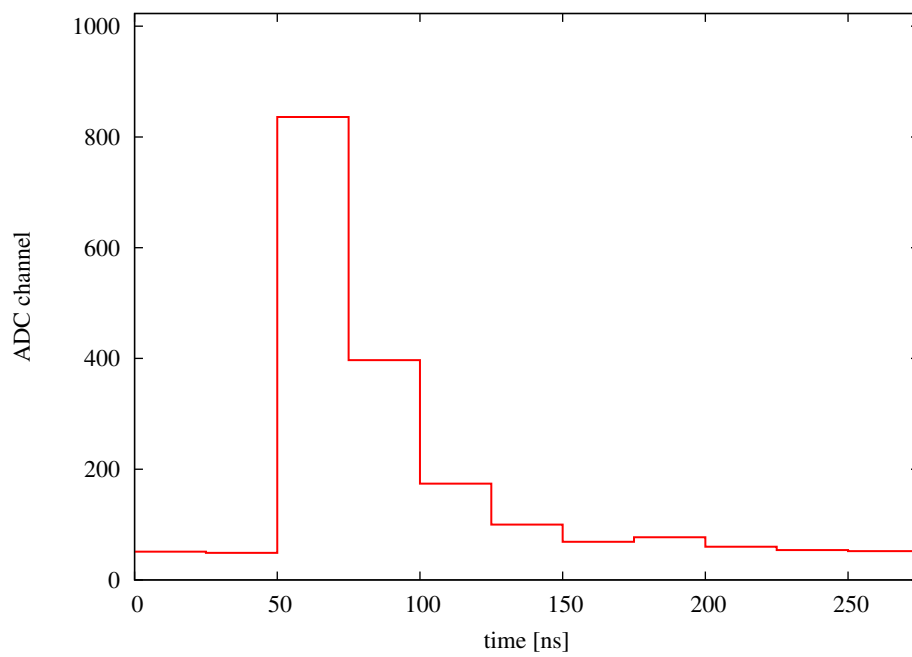


Figure 3: A typical pulse shape obtained from a WCD.

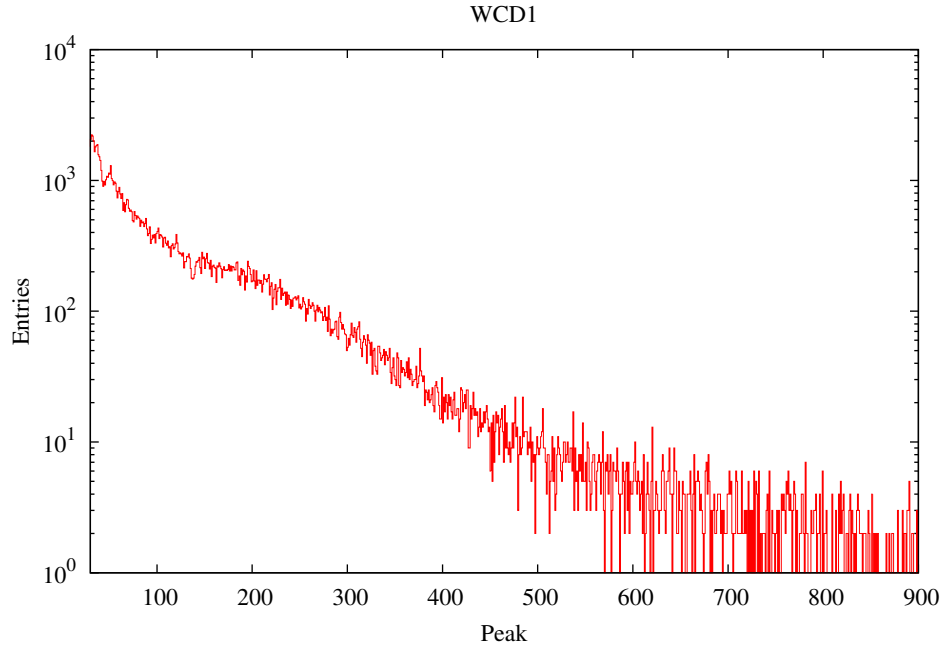


Figure 4: Typical peak histogram from a WCD.

is filled with entries corresponding to the charge (i.e. the integrated signal) of the pulses received. Two sample histograms are shown in figures 4 and 5 for WCD1.

As already noted, there are three WCD currently operational on the laboratory at mount Chacaltaya and it is expected to have a new WCD operating at the Higher University of San Simón in the near future, at the city of Cochabamba, located on a valley with an elevation of almost 2600 m.a.s.l.

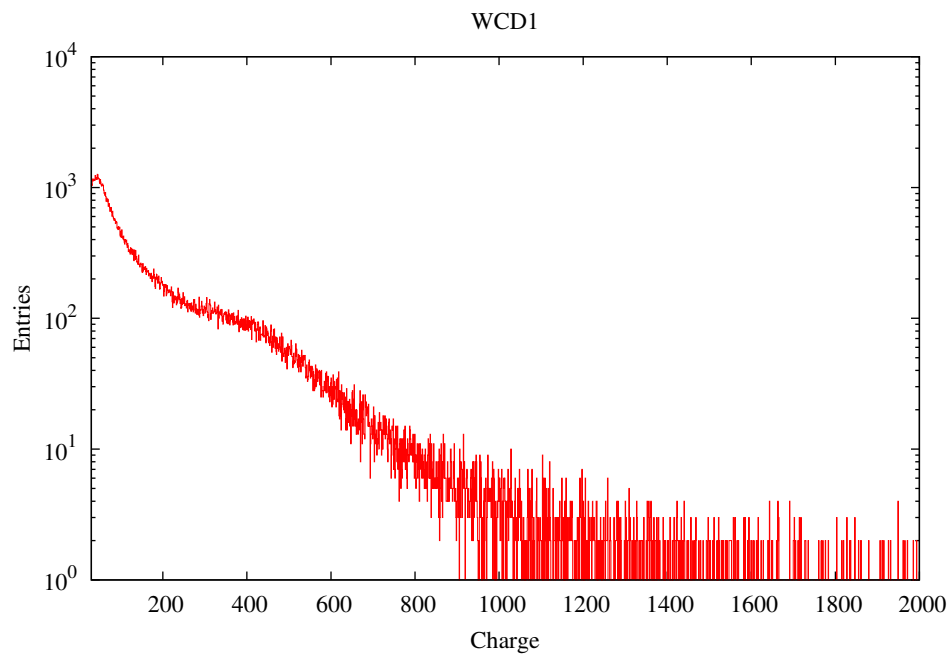


Figure 5: Typical charge histogram from a WCD.