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A New Method for noise rejection in the Water Cherenkov Detectors of the LAGO project through Muon Decay measurement

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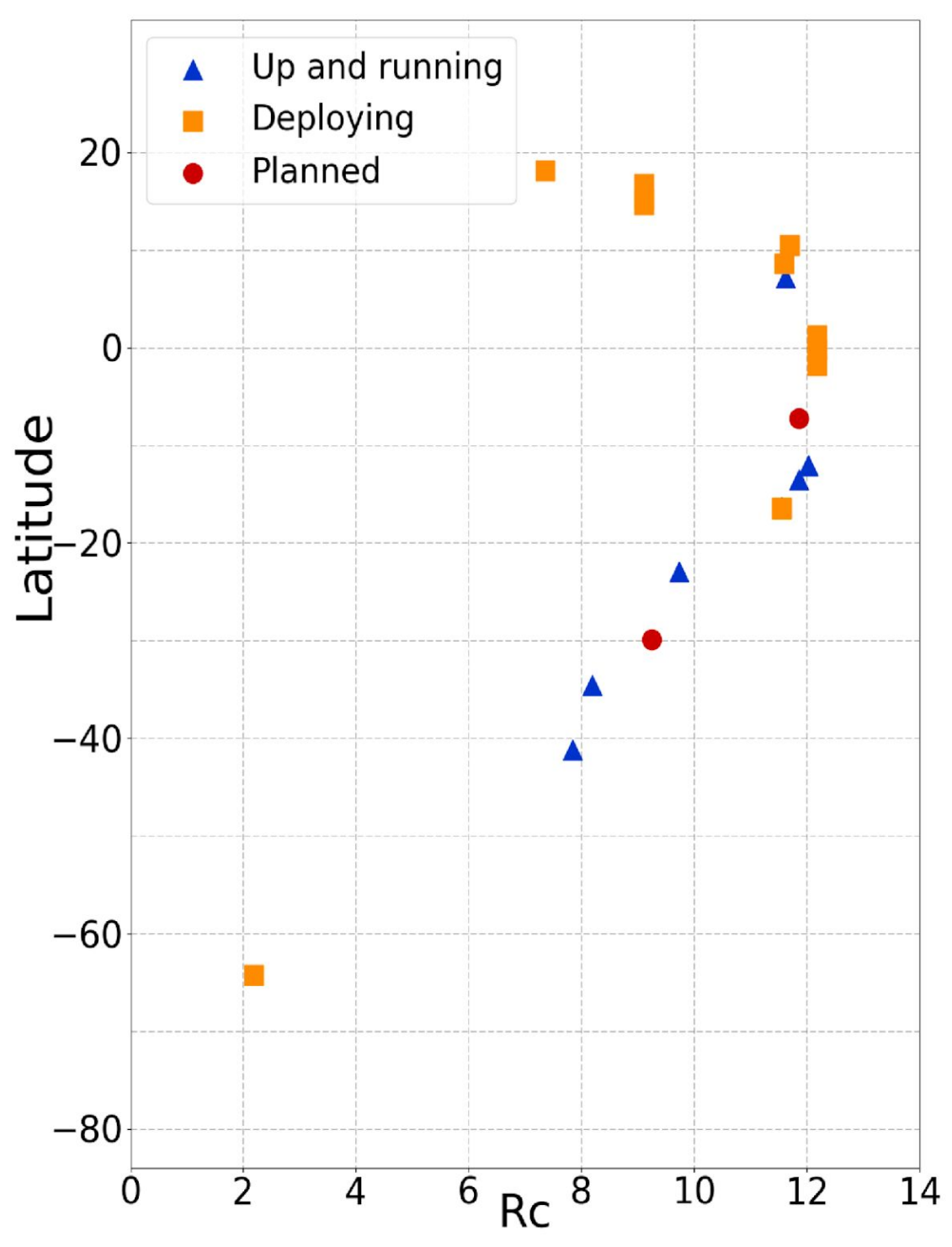
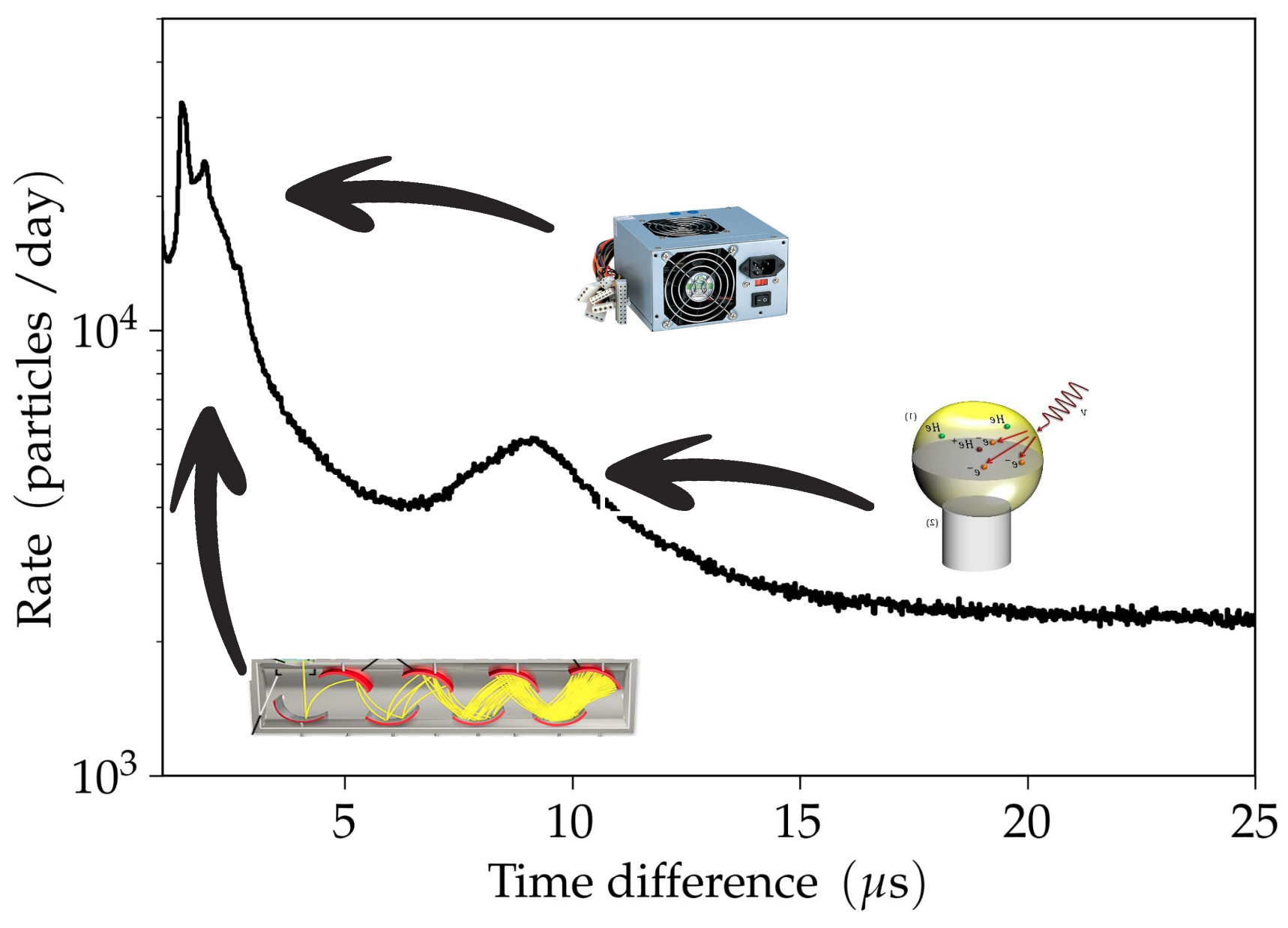
1 LAGO WCD Network



The Latin American Giant Observatory (LAGO) constitute a **Water Cherenkov Detector (WCD) network** through Latin America, with large variation altitudes and rigidity cutoffs and **different Detector geometries.**

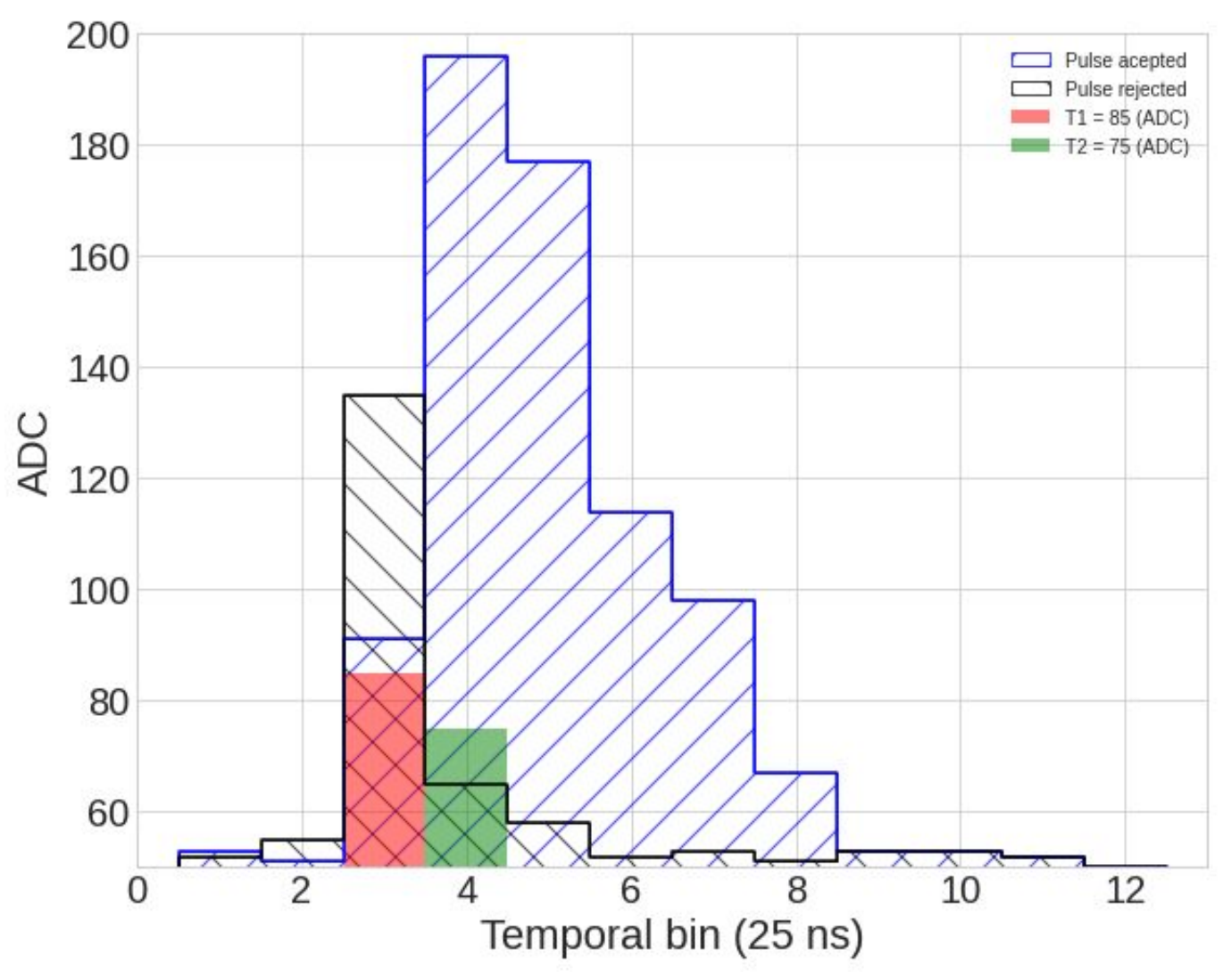
Two WCDs of the LAGO project: one in Bariloche (Nahuelito, left) the other in Peru's Antarctica Camp (ANTAR, center). The Cherenkov light produced in purified water by air showers entering the detector is measured by a 9” photomultiplier tube (PMT) centered at the top of the detector (right).

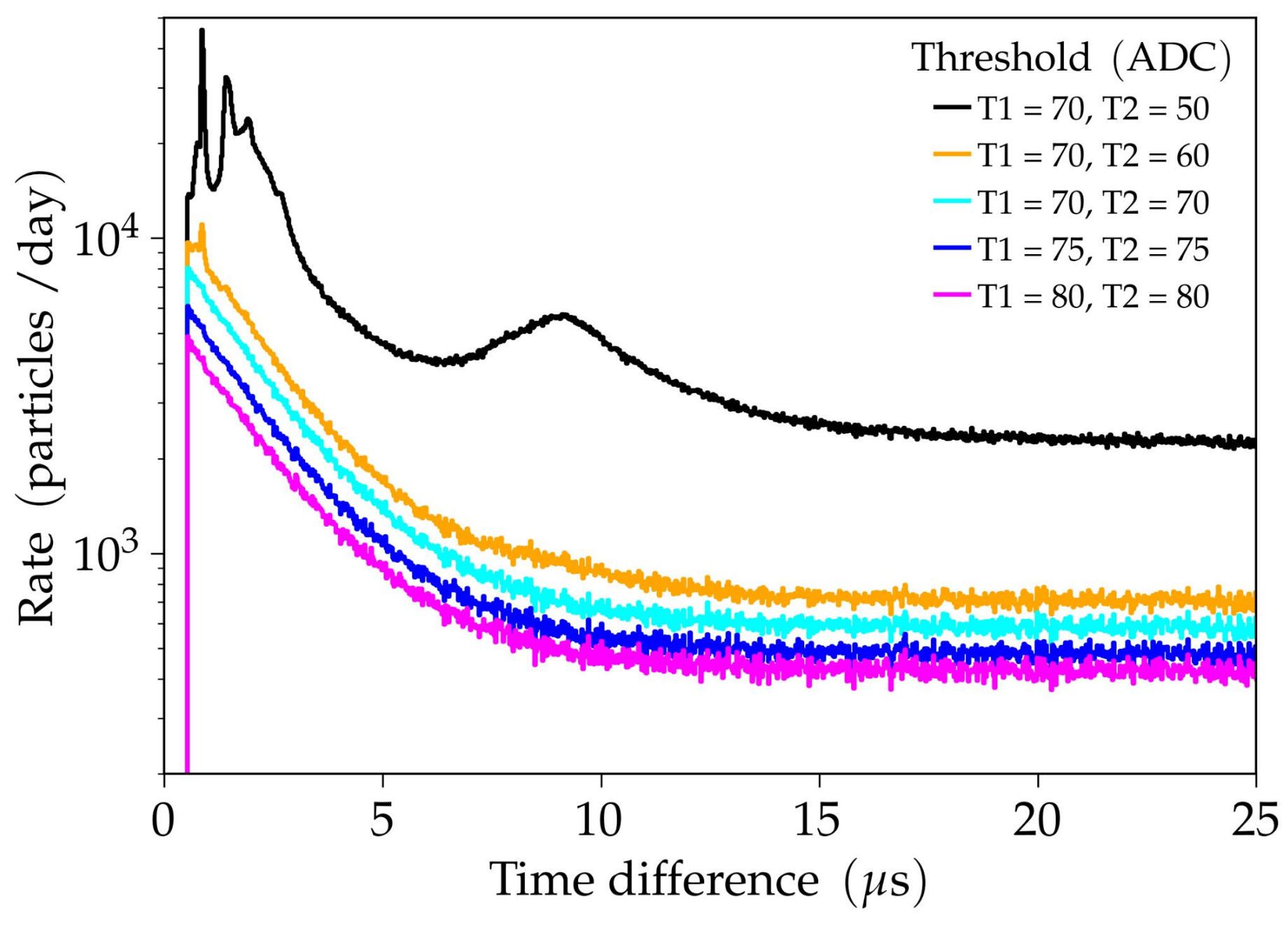
2. Noise Rejection Method in WCD



Sources of **noise in a LAGO’s WCD** come from light leakage, electronic noise, thermionic emission and after-pulses; **noise signals are expected to present a short pulse width** (few nanoseconds) and **characteristic differential time spectrums signal below 5 μs.**

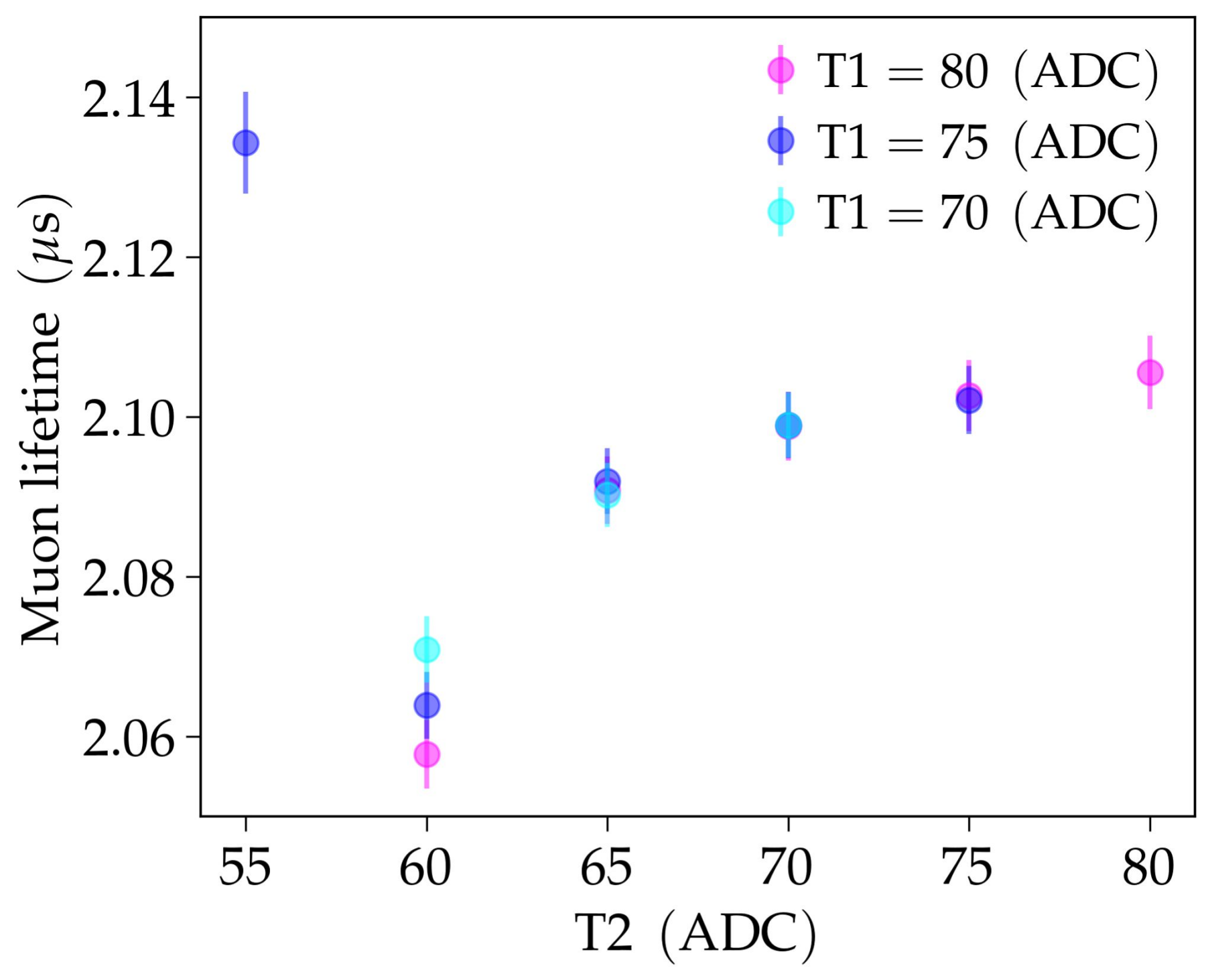
LAGO DAQ digitizes **pulses** at 25 ns sampling rate on windows of 300 ns. Also uses a single threshold-based trigger in the **3rd temporal acquisition bin (T1)**. **We implement secondary trigger threshold at the 4th bin (T2) to improve noise (short pulses) rejection.**



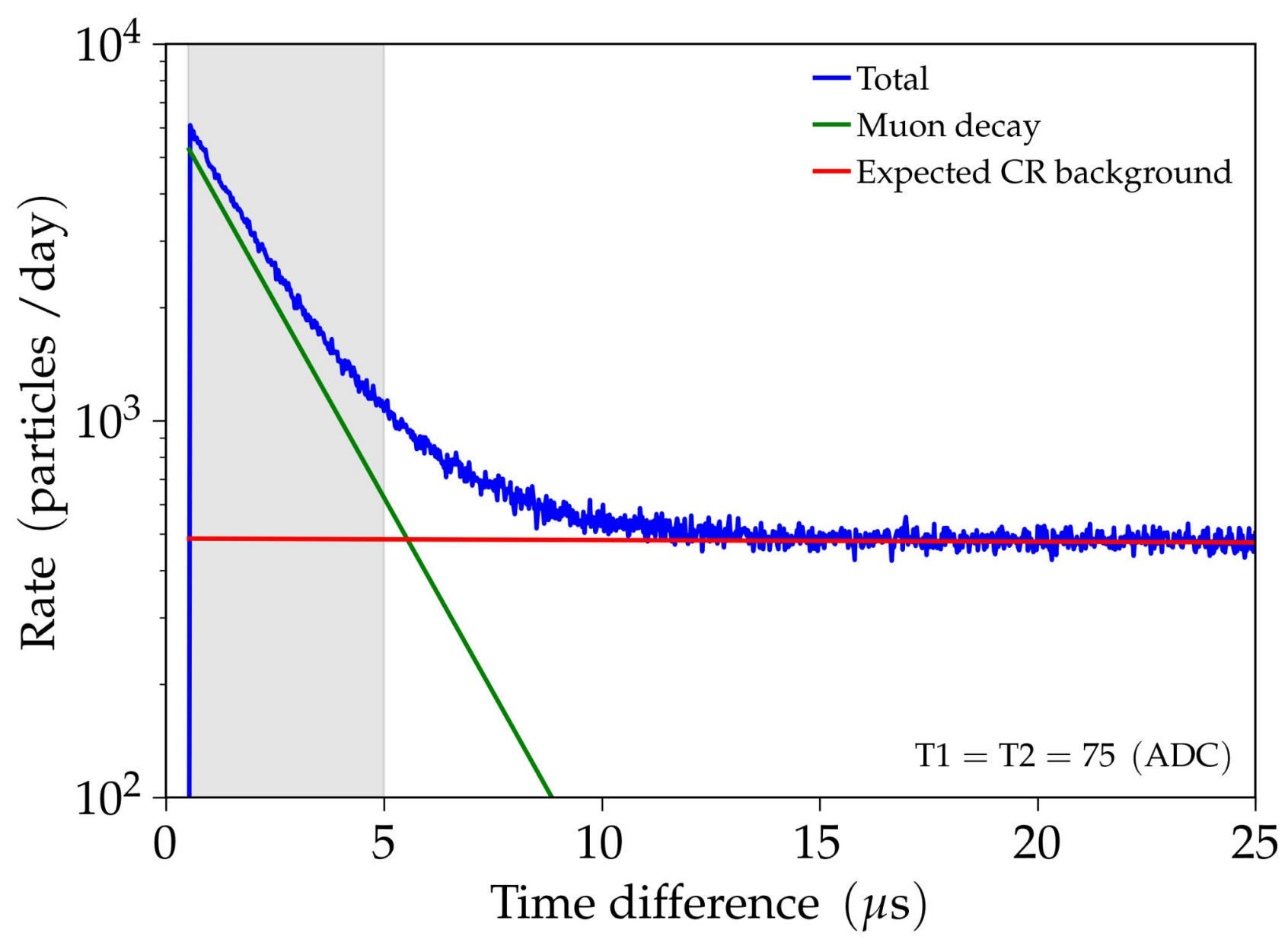


We **vary trigger** levels searching for expected **two exponential behavior of time difference histogram** of signal in the WCDs (from secondary cosmic radiation and muon decay inside WCDs)

From the data we calculate the **muon lifetime (< 2.2 μs) as a function of the trigger level** and search for stable values.

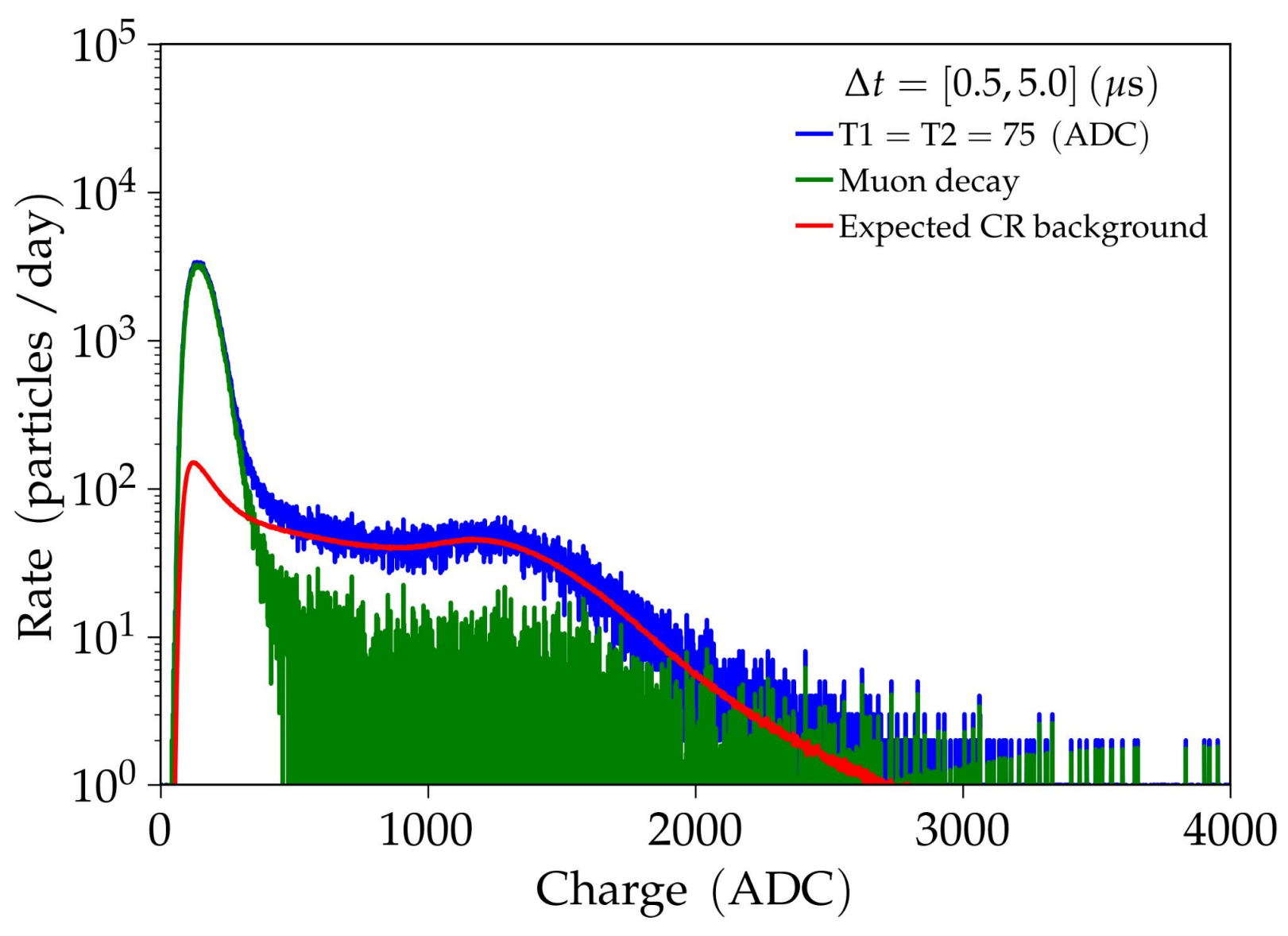


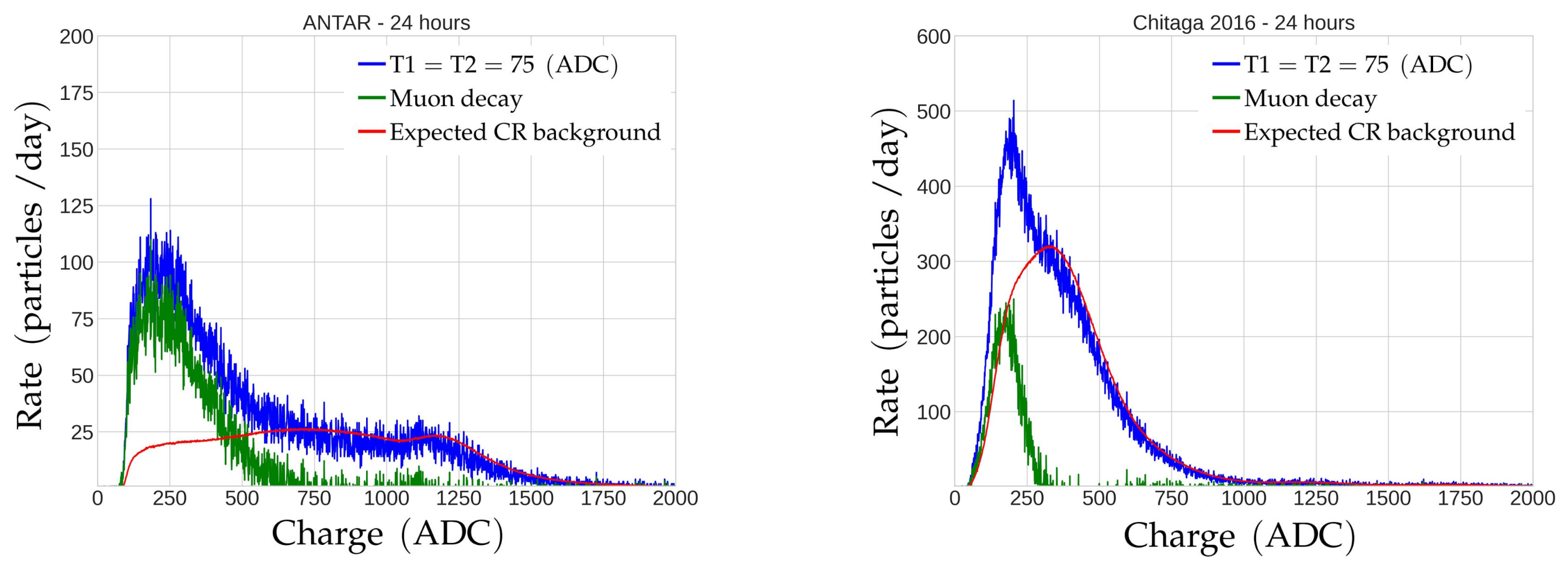
3. Michel Electron Spectrum



We fitted the **time difference histogram** with two exponentials, one corresponding to the **cosmic ray background** and the other to the **muon decay**. From this we estimate cosmic ray content on **0.5 - 500 μs band.**

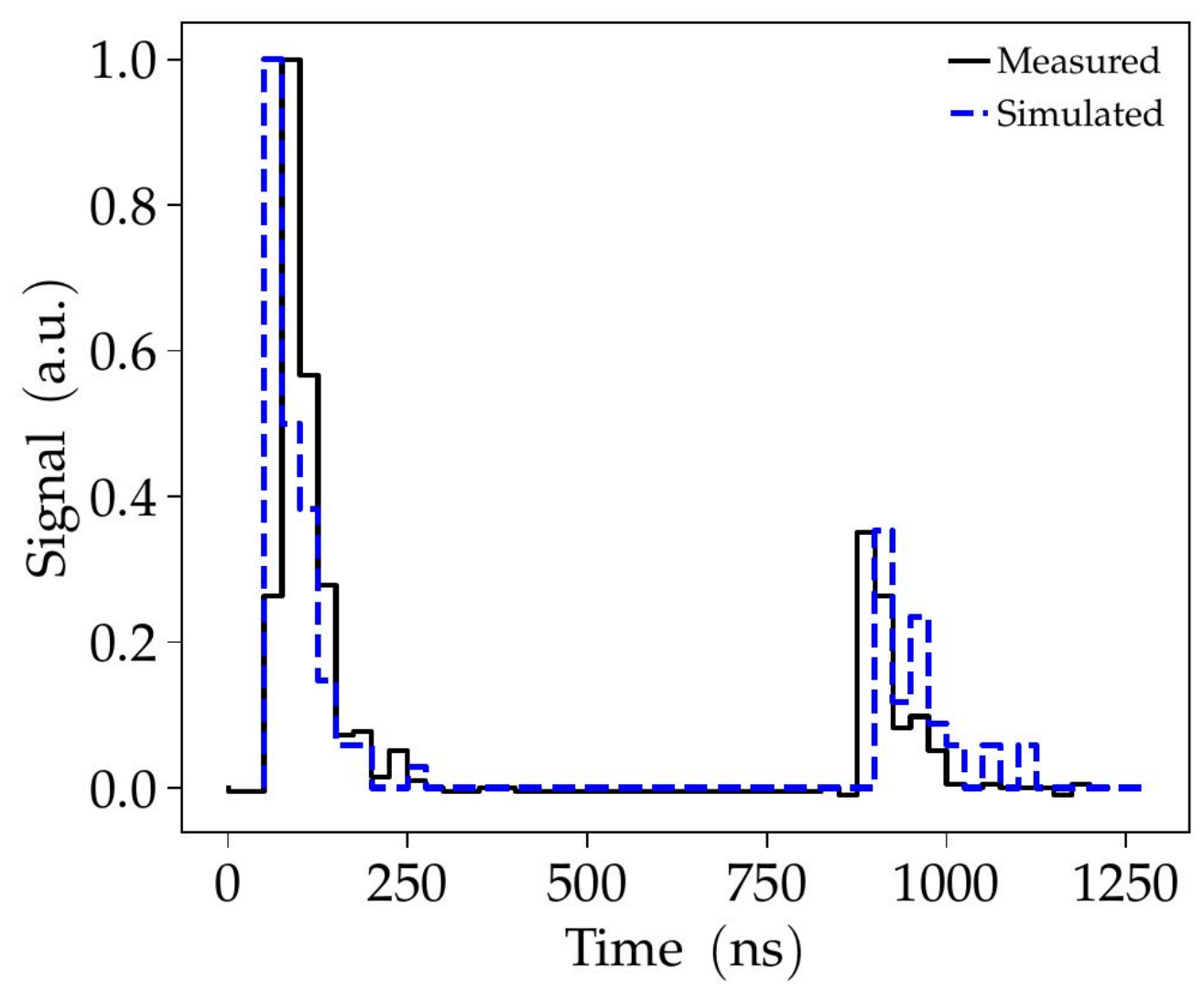
Charge spectrum of Michel electrons is estimated by selecting the pulses with a time difference between **0.5 and 5 μs** subtracting from the **expected charge histogram of cosmic ray content**.





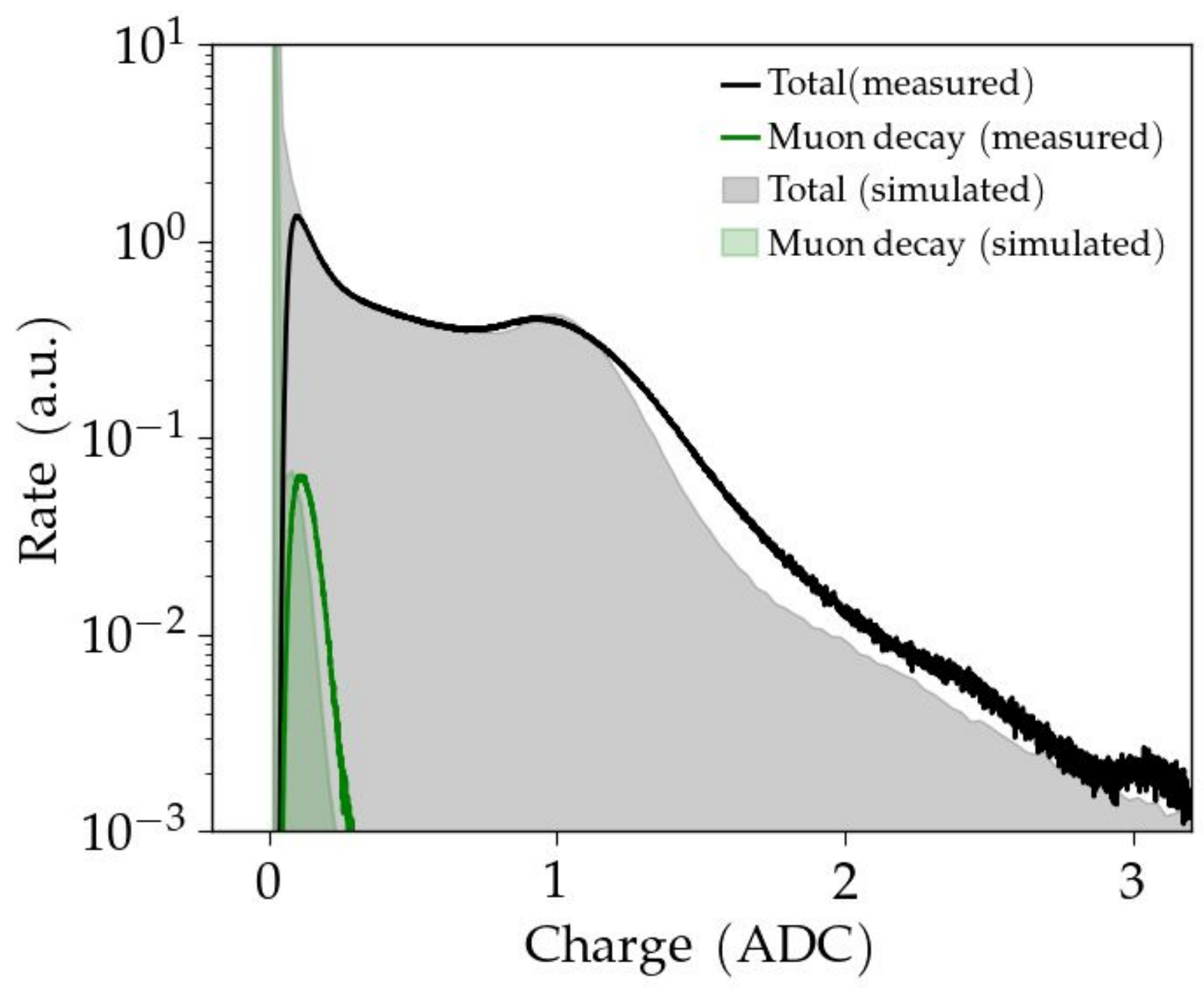
The process is used in the data set of two other LAGO WCDs located in other sites: ANTAR (left) and Chitaga (right).

4. Simulation



We performed simulations in order to compare the results with the measured data. The response of a WCD to the flux of secondary particles was simulated using Geant4. A comparison between a **measured** and a **simulated** time trace of a decayed muon is shown in the left.

The integral of the time trace results in the total charge collected at the PMT. A comparison between the **charge spectrum** of the measured and simulated flux is shown in the right. The shapes of both distributions (also for the **muon decay**) are in good agreement.



5. Conclusions

We have developed a method to reject noise in WCDs of LAGO by implementing a secondary trigger based on the calculation of the muon lifetime in water. Currently, we are in process of improving our simulation to take into account the particularities of each LAGO WCDs. Our method could be implemented at the DAQ level of our WCDs. Evenmore, by taking advantage of the precise determination of the Michel spectrum we are able to improve the energy calibration of the detector and establish an energy threshold for particle detection.