Water Tank R&D

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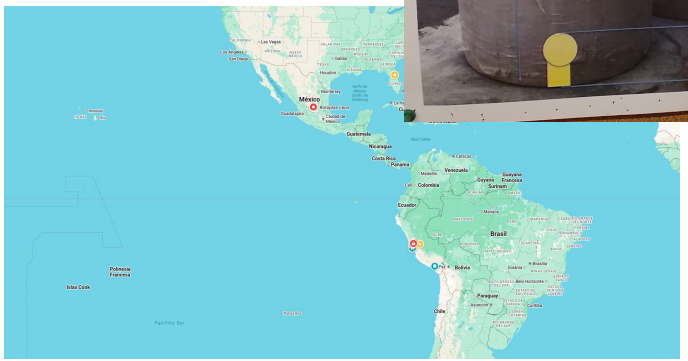
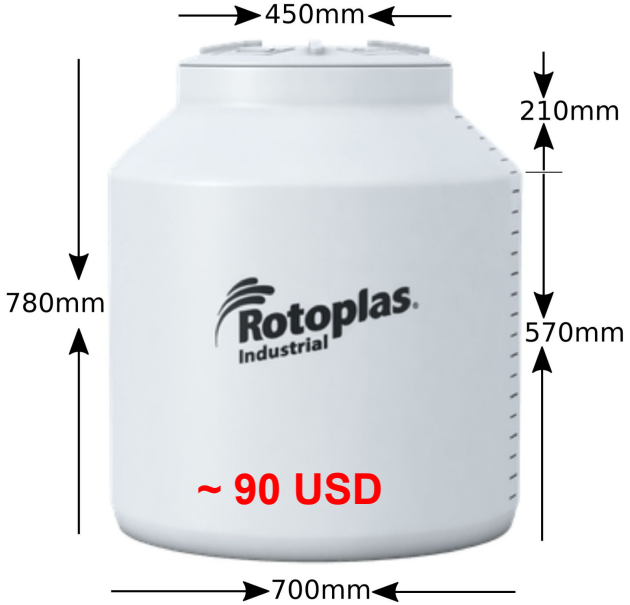
Why?

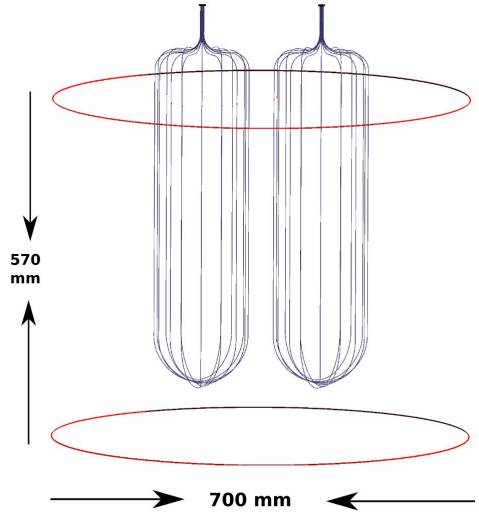


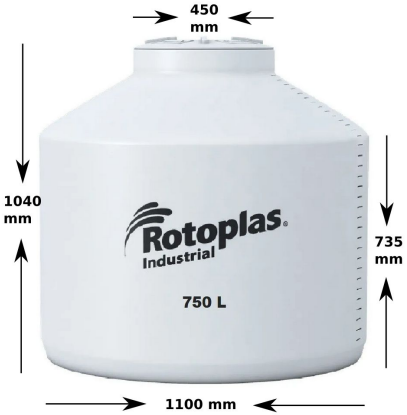


https://www.rotoplas.com.pe/tanque-250l-pisco-vino-sin-conexion/p

G4 Simulation / Corsika Simulation

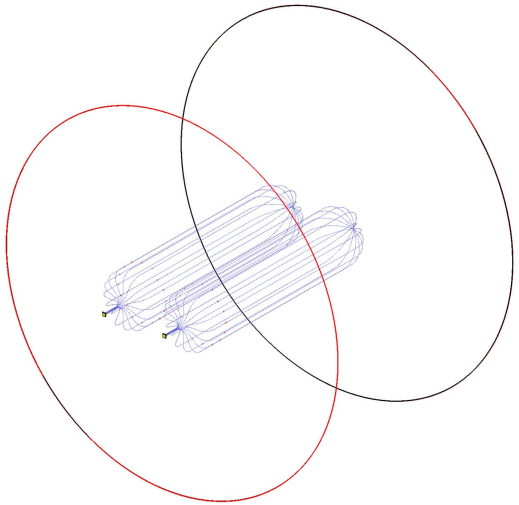
Geometry





8 fibers

Simulation Description



Two groups of two fibers array with 1 SiPM at the ends of each fiber.

Water properties:

- **n = [1.3455 - 1.3608] for energy [2.177 - 4.136] eV - Reference from Meiga - LAGO**
- **Attenuation length = 10 m.**
- **Production of scintillation light = 0%**

Tyvek properties:

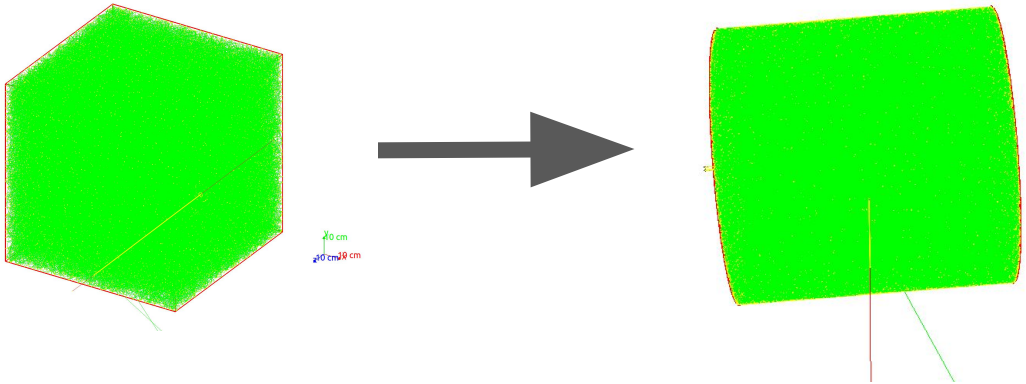
- **Composition C2H4**
- **Thick = 0.4 mm**
- **Density = 0.93 g/cm3**
- **roughness = 5 deg**
- **n = 1.5**
- **Attenuation length = 0.01 * mm**
- **Reflectivity = Taken from GODDESS files for Tyvek**

Fiber Model: (From GODDESS files)

- **Saint-Gobain_BCF-92_round_1mm.properties**

Using GODDESS 4.3 at Geant4 v10.05.0

Based on GODDESS Simulation



G4Box (const **G4String** &pName, **G4double** pX, **G4double** pY, **G4double** pZ)

G4EllipticalTube (const **G4String** &name, **G4double** theDx, **G4double** theDy, **G4double** theDz)

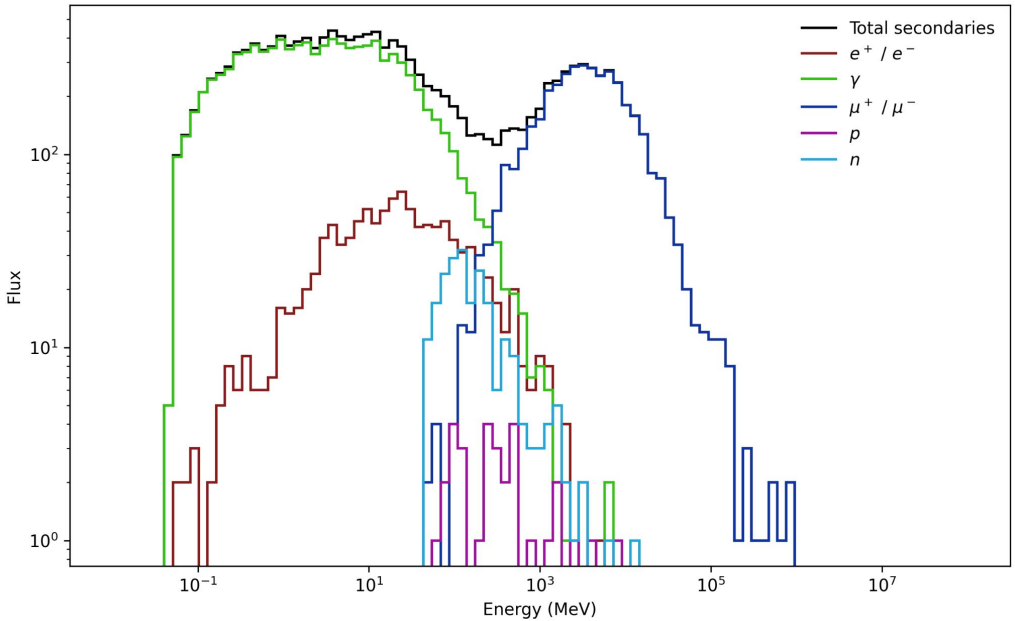
Modified classes:

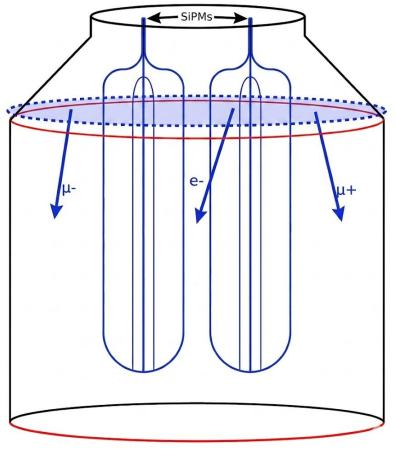
G4ScintillatorTile

G4Wrapping

Merge the two options currently in progress!

Background of secondaries - Lima

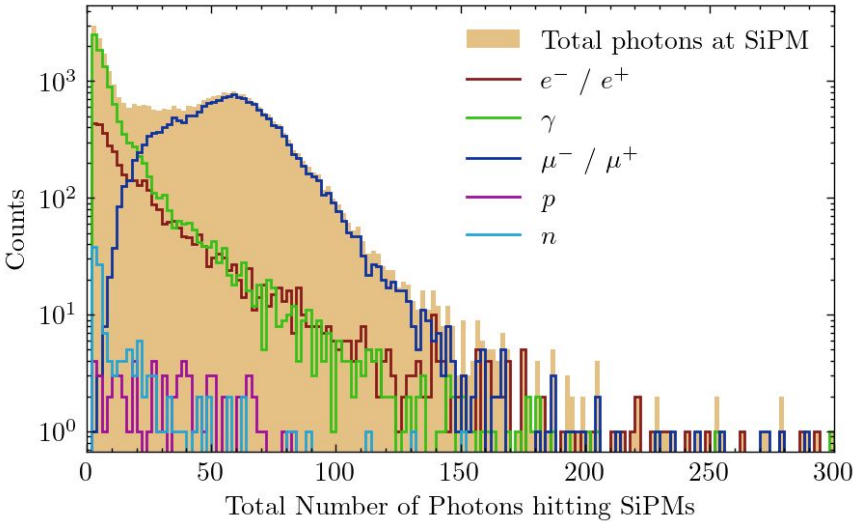




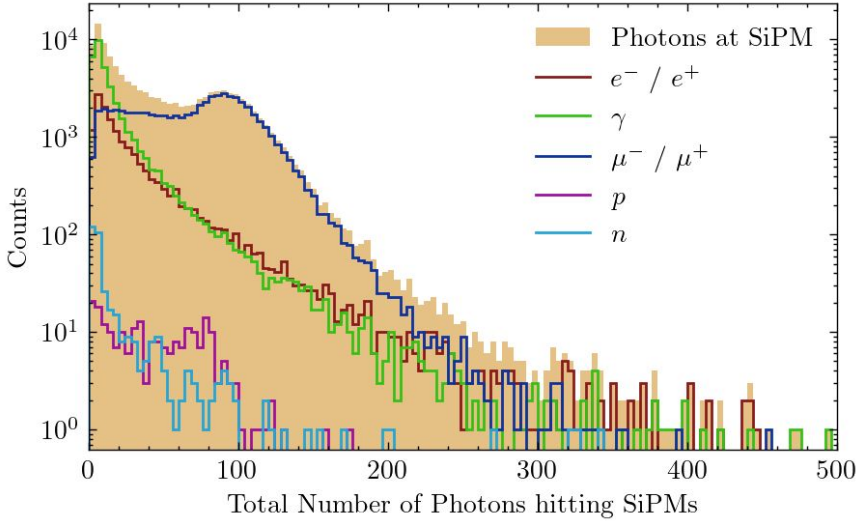
Sarmiento-Cano, C., Suárez-Durán, M., Calderón-Ardila, R., Vásquez-Ramírez, A., Jaimes-Motta, A., Núñez, L. A., ... & LAGO Collaboration. (2022). The ARTI framework: cosmic rays atmospheric background simulations. *The European Physical Journal C*, *82*(11), 1019.

Expected photon hits at SiPM spectrum

750 L.



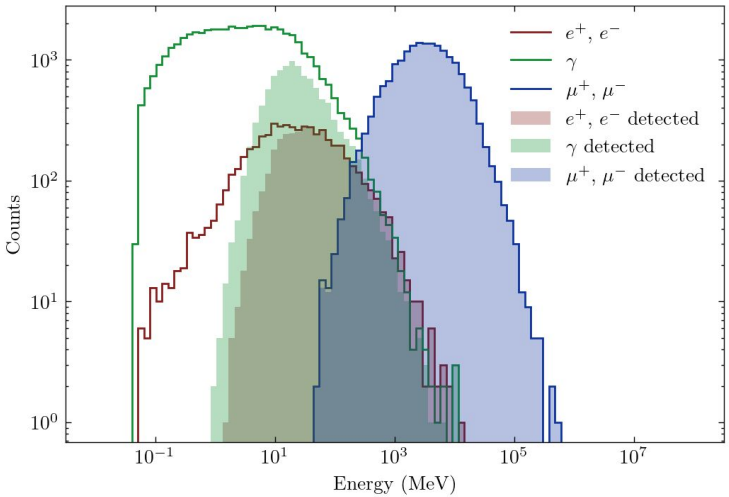
250 L.



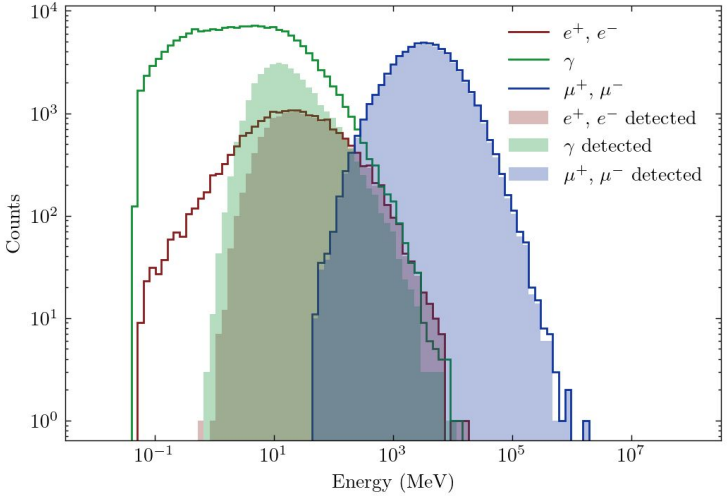
- **Few numbers of photons are hitting the SiPMs. This suggests that we need more fibers in order to improve the signal.**
- **This histograms are similar in form to histograms from simulations of WCDs using PMTs as photodetectors.**

Results - Simulated and detected particles

750 L



250 L

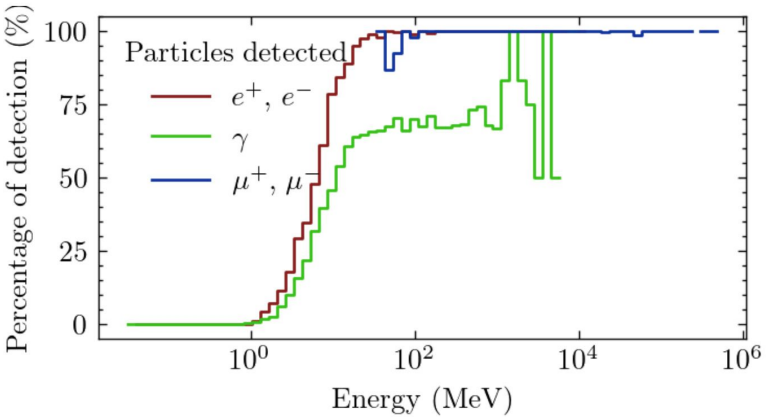


Energy threshold around 10 MeV.

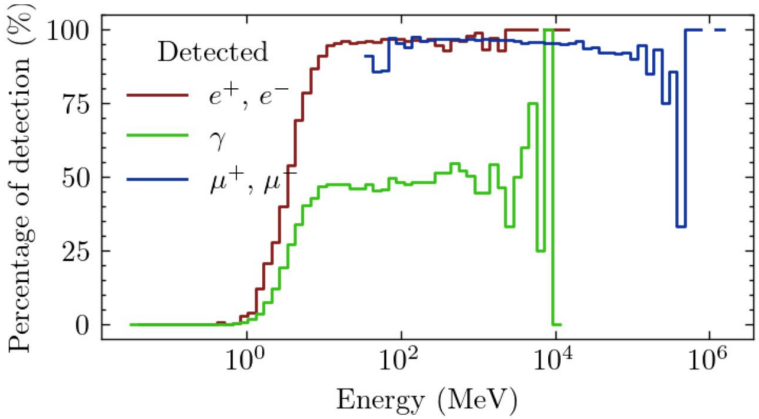
15000 particles in 6h.

Results - Simulated and detected particles

750 L.



250 L.



For this simulation setup, we can see a energy threshold (10 MeV) for particles to be detected by our array.

We expect a lower threshold by adding more fibers for future simulations.

Time Simulation: 15000 particles in 6h.

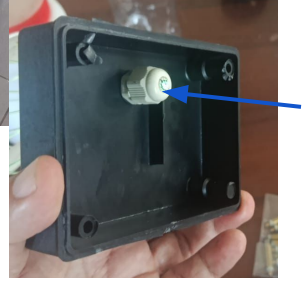
Toy detector

Toying around

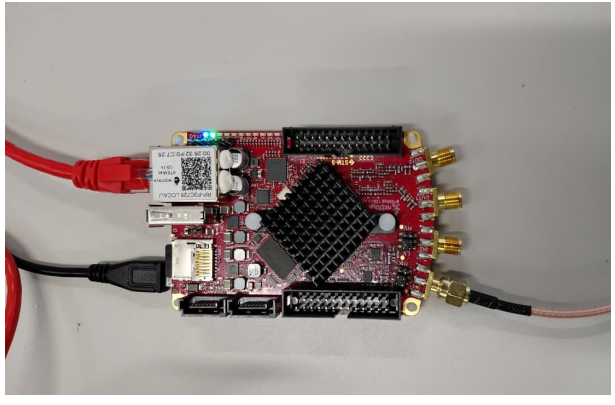
Optical
Fiber:
BCF99-29AMC
1.25 ia x 400MD

Tyvek
Bag

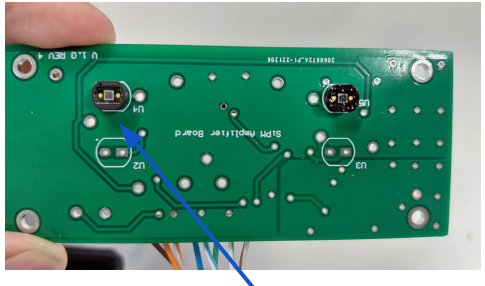
20 L
Bucket

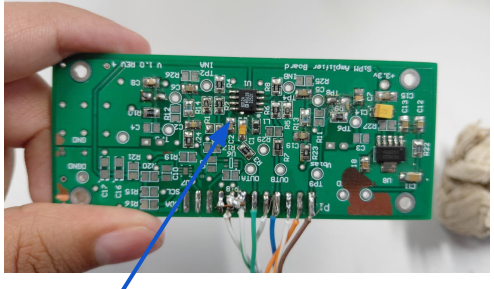


Electric
connector



RedPitaya Board: 2 analog
channel bandwith 40 MHz.





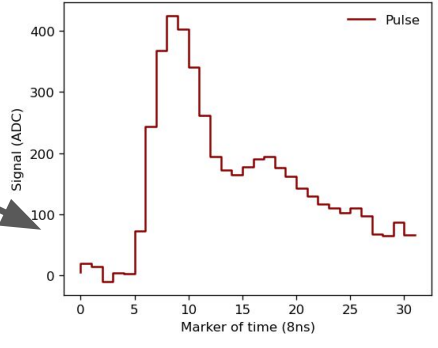
Silicon Photomultiplier
Hamamatsu 3x3mm with
AD8012A AMPLIFIER

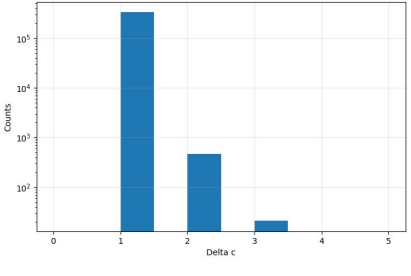
Data acquisition from LAGO project.

Arnaldi, L. H., Cazar, D., Audelo, M., & Sidelnik, I. (2020, February). The new data acquisition system of the LAGO Collaboration based on the Redpitaya board. In *2020 Argentine Conference on Electronics (CAE)* (pp. 87-92). IEEE.

```
# #
# # This is a LAGO raw data file, version 5
# # It contains the following data:
# #   <N1> <N2>        : line with values of the 2 ADC for a triggered pulse
# #   # t <C> <V>      : end of a trigger
# #                      gives the channel trigger (<C>: 3 bit mask) and 125 MHz clock count (<V>) of the trigger time
# #   # c <C>          : internal trigger counter
# #   # x f <V>        : 125 MHz frequency
# #   # x t <V>        : temperature value
# #   # x p <V>        : pressure value
# #   # x r1 <V>       : pulse rate at channel 1
# #   # x r2 <V>       : pulse rate at channel 2
# #   # x h <HH:MM:SS> <DD/MM/YYYY> <S> : GPS time (every new second, last number is seconds since EPOCH)
# #   # x s <T> C <P> hPa <A> m : temperature <T>, pressure <P> and altitude (from pressure) <A>
# #   # x g <LAT> <LON> <ALT>   : GPS data - latitude, longitude, altitude
# #   # x v <HV1> <HV2>         : HV voltages for channels 1 and 2
# #   # x b <B1> <B2> <B3>      : baselines (NOT IMPLEMENTED IN LAGO)
# # In case of error, an unfinished line will be finished by # E @@@
# # Followed by a line with # E <N> and the error message in human readable format, where <N> is the error code:
# #   # E 1 : read timeout of 2 seconds
# #   # E 2 : too many buffer reading tries
# #   # E 3 : unknown word from FPGA
# #
# # Current registers setting
# #
# x c T1 300
# x c T2 8190
# x c HV1 7.7 mV
# x c HV2 7.7 mV
# x c SC1 1
# x c SC2 1
# # This file was started on red-pitaya
```

```
  6    1
 20   -2
 14    1
-10   -2
  4    0
  3    5
 73    1
244    4
368    2
425    2
403    1
341   -3
262   -5
194    7
173  -13
165   -4
177    1
190    1
195    1
176   -3
162    0
142   -2
130    3
117   -2
110    5
103    0
110   -2
 97    0
 68    1
 65    2
 87    2
 66   -1
# t 1 259239
# c 436857
```

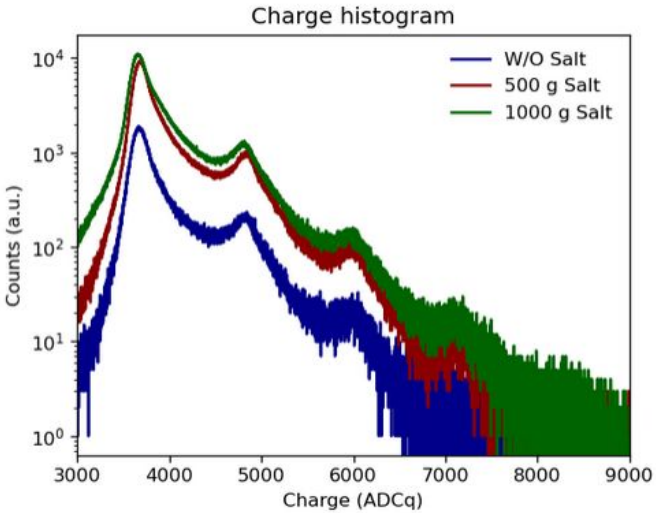


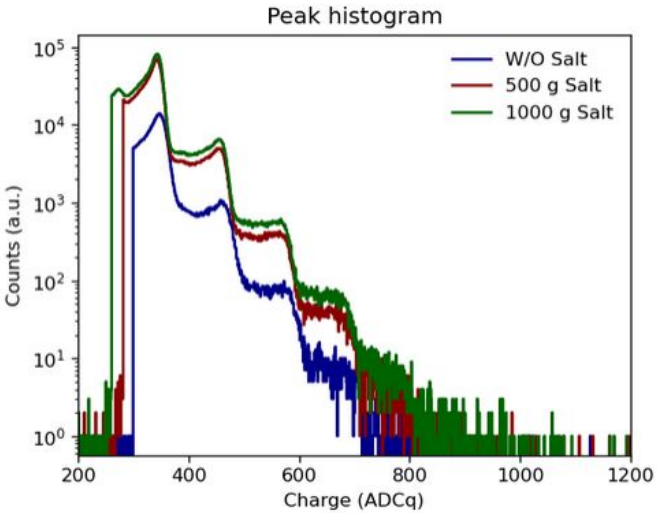


Time

Counter

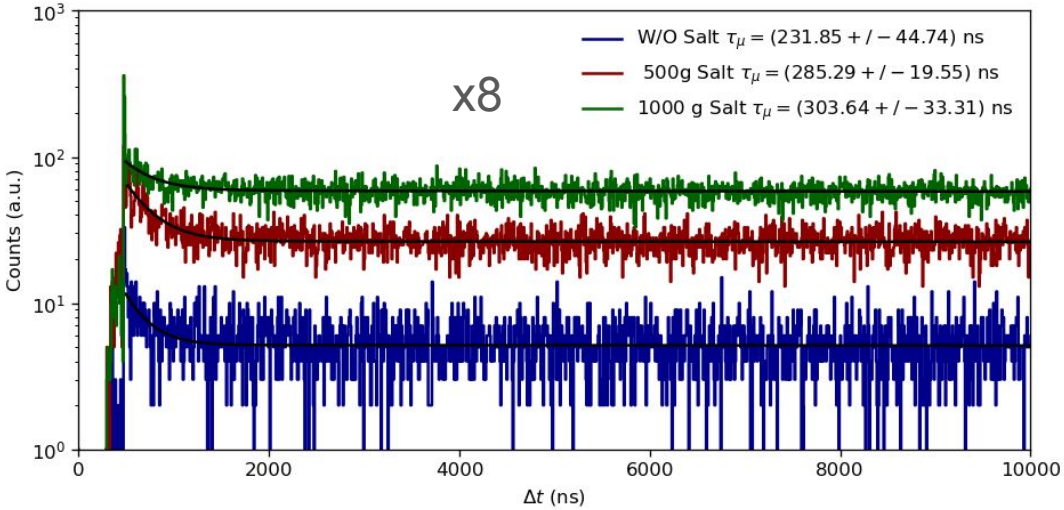
Histograms - Charge and Peak doped with salt

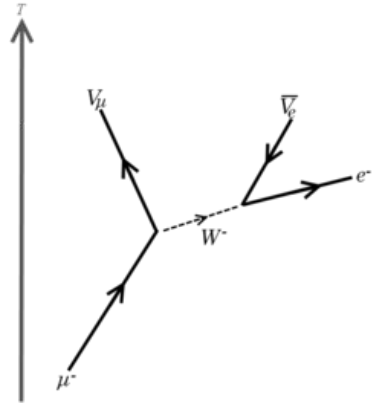




Quishpe, R., Audelo, M., Calderon, M., Carrera, E., Cazar, D., Guerrero, D., ... & LAGO Collaboration. (2015). “Panchito” Water Cherenkov Detector Water Studies for the LAGO Collaboration. *Nuclear and Particle Physics Proceedings*, *267*, 433-435.

Time difference histogram





Quispe, D., Sarmiento, C., Otiniano, L., Asorey, H., Castromonte, C., Yanyachi, R., ... & LAGO Collaboration. (2026). Decaying muon charge spectra as a robust long-term calibration tool for water cherenkov detectors. *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*, 171415.

Issues

- Slow component acquisition times due to Peruvian procedures.

- A favorable but slow response from Rotoplas Peru and regarding its communication with Rotoplas México.

Next steps

- **Make an advance prototype with the 250 L commercial detector (both already purchased) and trying to observe Michel spectrum from muon decay.**

- **Finalize negotiation with Rotoplas for prototyping acquisition and get better idea of overall cost per unit.**

Thank you!

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