Status of the water-Cherenkov detector Tanca

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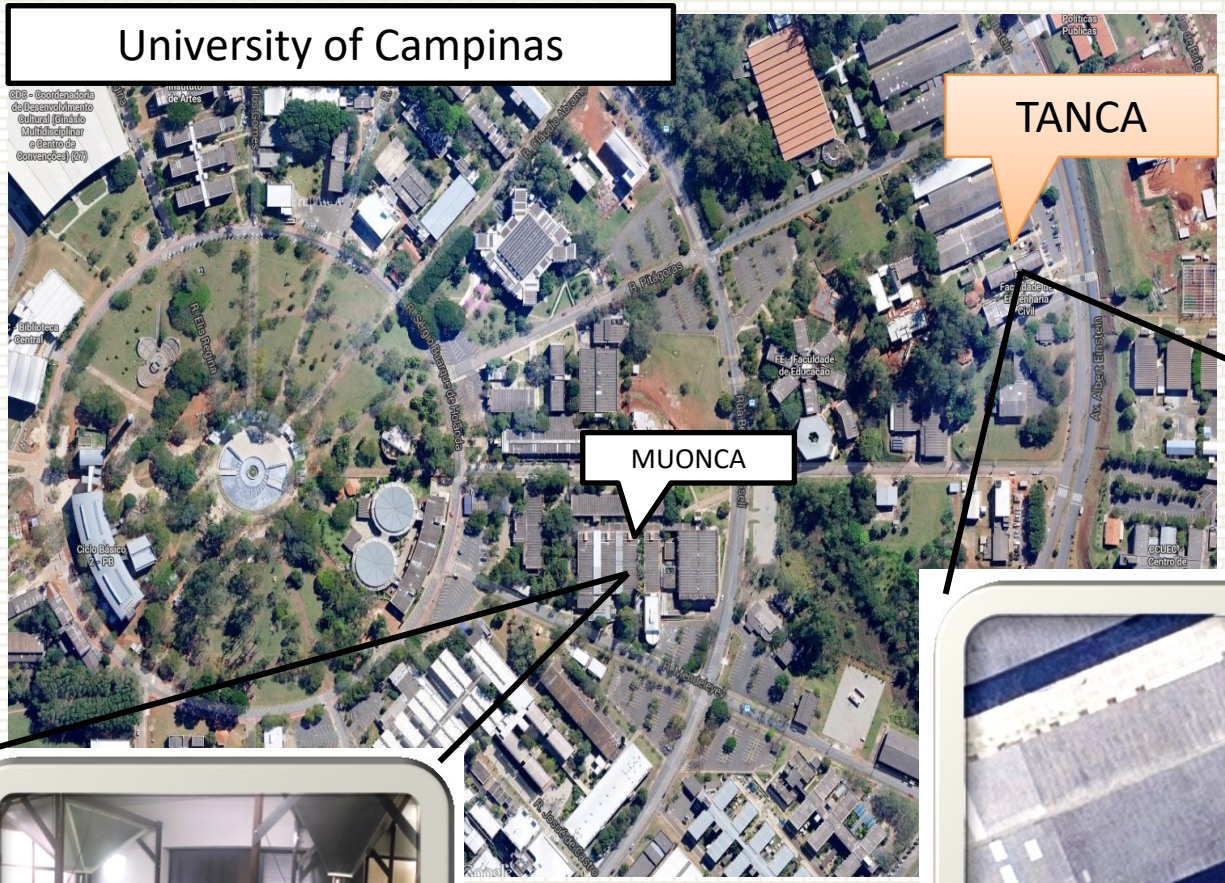
Esc Física Unìversidad Industrial de Santander, Bucaramanga, Colombia

The Tanca at Unicamp

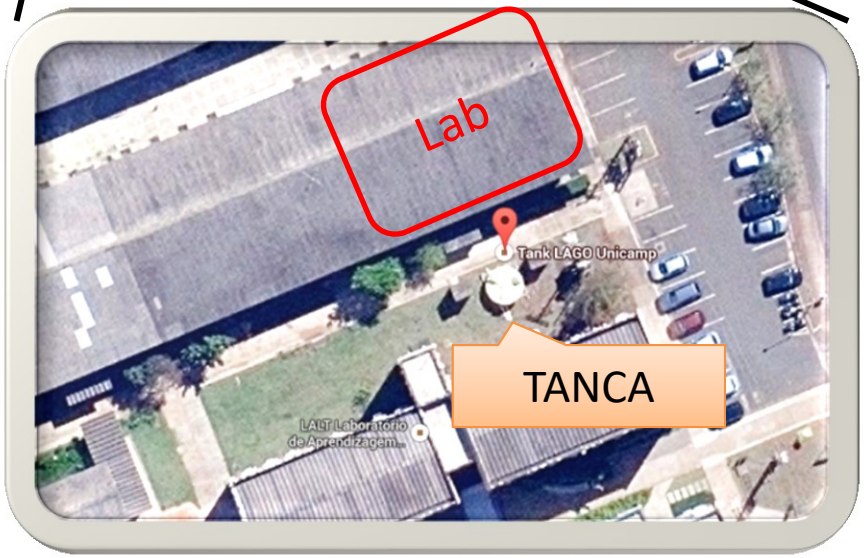
University of Campinas



Tanca is a nickname for the TANk detector of CAmpinas

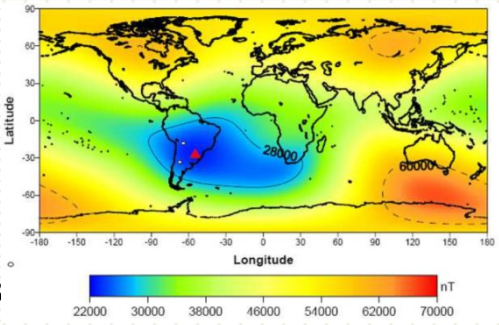
Campinas, SP, Brazil
22º 54’ S, 47º 03 N
640 meters a.s.l.

Muonca is a nickname for Muons in CAmpinas



The Tanca goals

- Uses the flux of galactic cosmic rays modulated by transient solar ejecta (CME) and changes in the global structure of the heliopheric and terrestrial magnetic fields to **study space weather**
- **Short-term modulations** are associated with interplanetary transient pertubations, causing phenomena like **Forbush Decrease**
- **Long-term modulations** in the cosmic ray flux are associated with the eleven years solar cycle
- Limits for the high-energy component of gamma-ray bursts at ground level
- Help to build a Brazilian network of **experimental Astroparticle researchers** (UNICAMP, UFABC, UFF, UFCG)
- **Academics**
  - **Muon decay, a real experiment for undergraduate students**
  - Detector physics
  - Interaction of radiation with matter
  - Construction and characterization of particle detectors
  - **Monte Carlo simulations of detectores and extensive air showers**

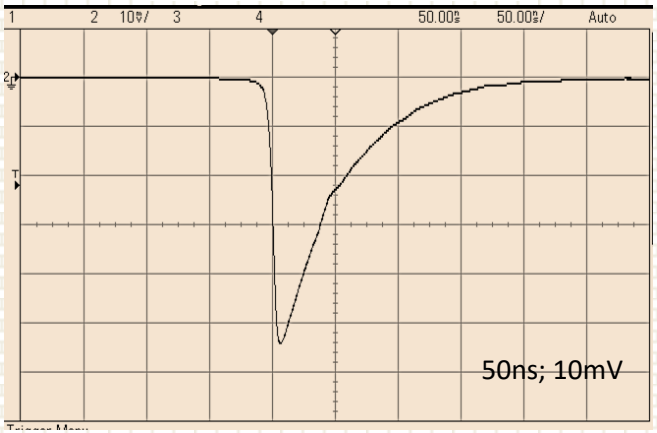


South Atlantic Anomaly

The Tanca detector

- The detector is a cylindrical polyethylene tank
- 3 PMT 9” Photonis XP1805
- Liner Tyvek
- 11400 liters of pure water
- **Cherenkov light**
- $Area_{vertical} = 10\ m^2$

Muon pulse

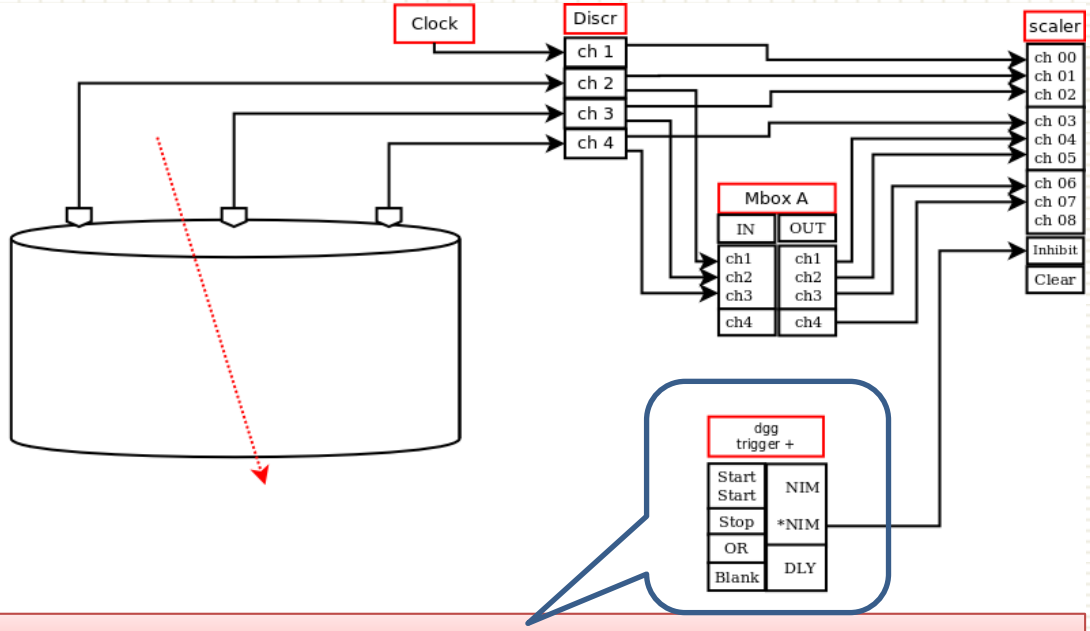


Photonis XP1805

Voltage-divider, HV power supply

The Tanca DAq using CAMAC

CAMAC/NIM modules: **LeCroy Scaler 2551 (100 MHz);** Logic Unit CAEN; Discriminator CAEN; Dual Gate Generator LeCroy 2323A; DAC CAEN



Precise (0.02sec) gate for the 1 sec time interval of the counts

Atmosferic date every 10 minutes

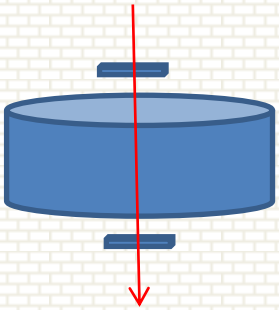
HV1=1075V HV2=1125V; HV3=1250V; Limiares: L=-22mV; TC=300ns
ms **CK S1 S2 S3 D12 D13 D23 TRI**
2016 08 30 00 00 00 039 1472515200039
M 2016 08 29 23 56 1 2016 08 29 20 50 941 23.1 48.8 0.0 23.9 135 0.0 01
1472515201125 **4996 2136 2174 2372 1860 1911 1924 1813**
1472515202170 4996 2024 2055 2263 1727 1768 1817 1682
1472515203215 4996 2143 2199 2404 1882 1902 1965 1830

Tanca muon count efficiency

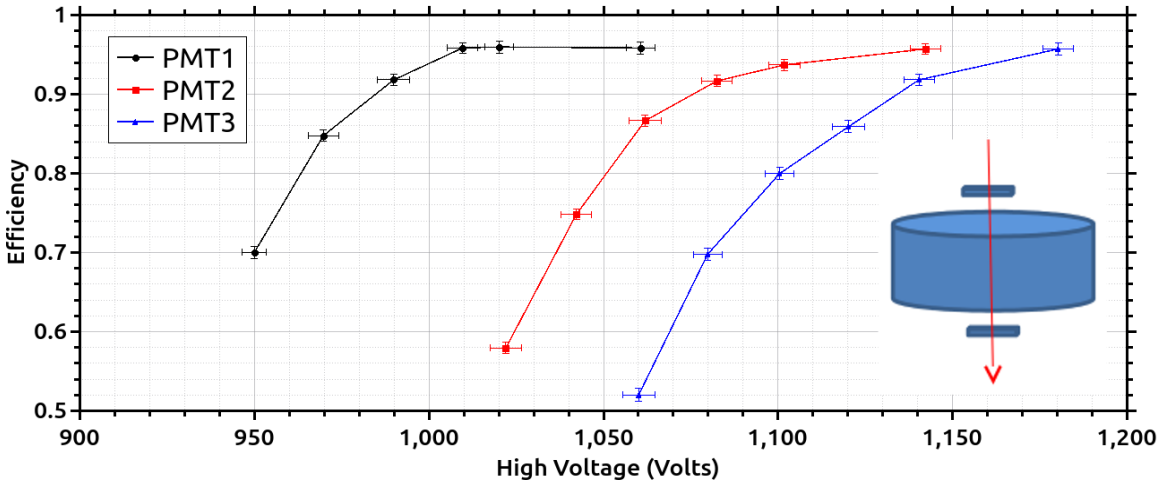
Two small, 40x38cm^2, plastic scintillators used to select vertical muons

(95.7 ± 0.8) %

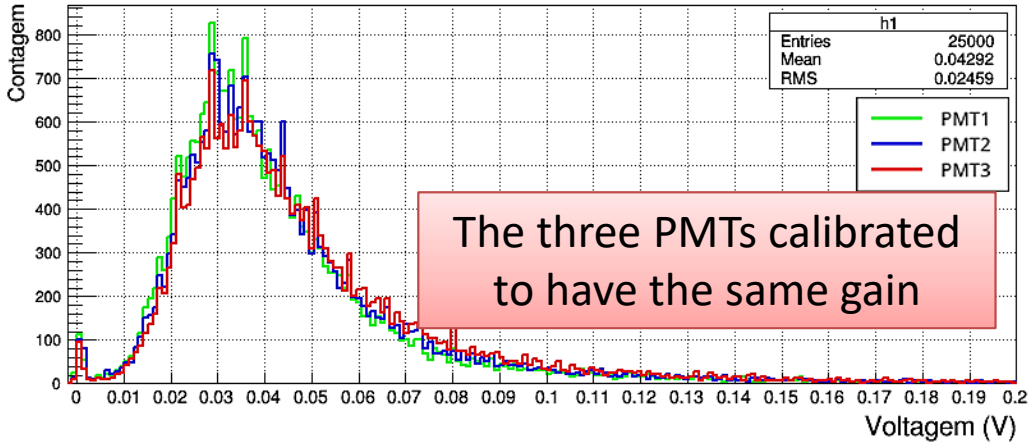
Vertical muon (VM)



$$\epsilon = \frac{VM + tank}{VM}$$



Pulse amplitude histogram



Trigger: an other PMT with a threshold of 15mV

Barometric coefficient

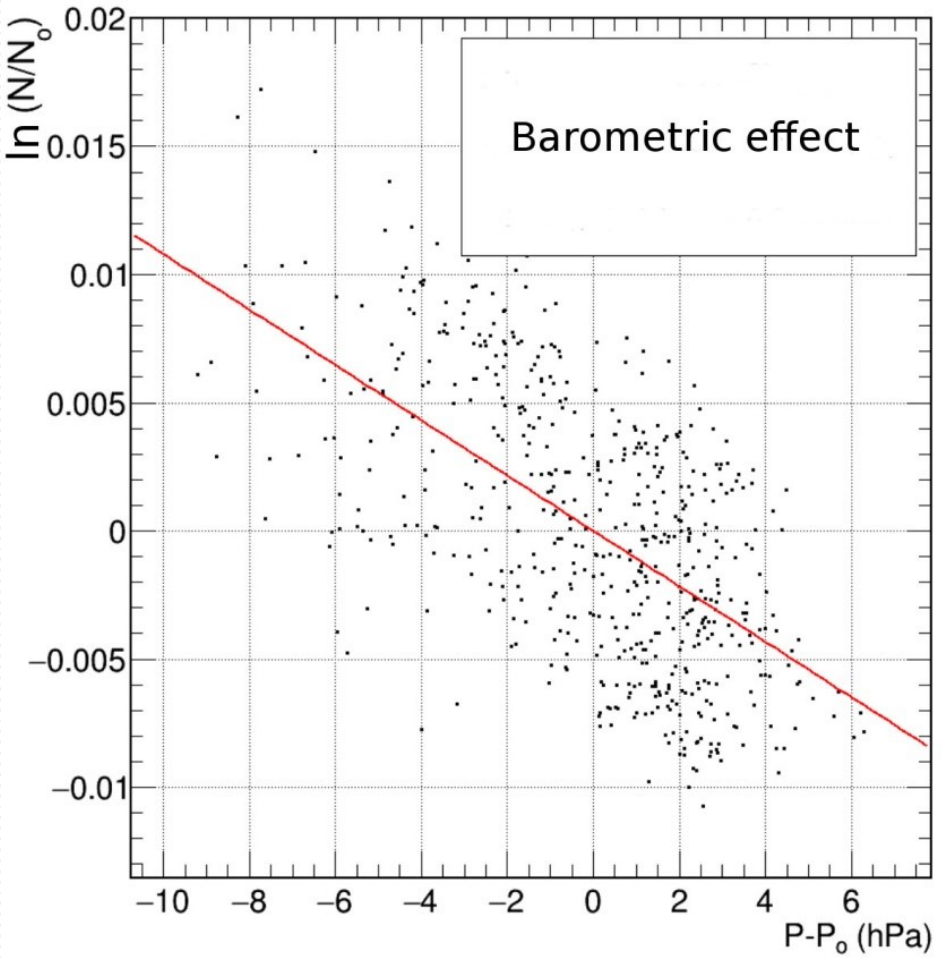
The flux of muons depends on the barometric pressure and this correlation can be approximated with an exponential behavior

$$I = I_0\, e^{-\beta(P-P_0)}$$

$$\frac{dN}{N} = -\,\beta\, dP$$

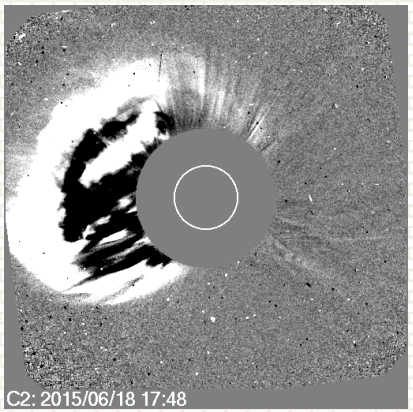
$$\ln\left(\frac{N}{N_0}\right) = -\,\beta(P - P_0)$$

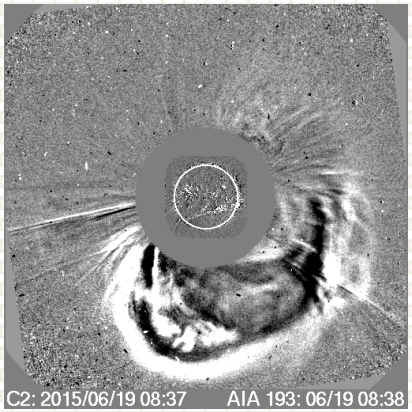
$$\boldsymbol{\beta = (0.108 \pm 0.06)\%/mbar}$$

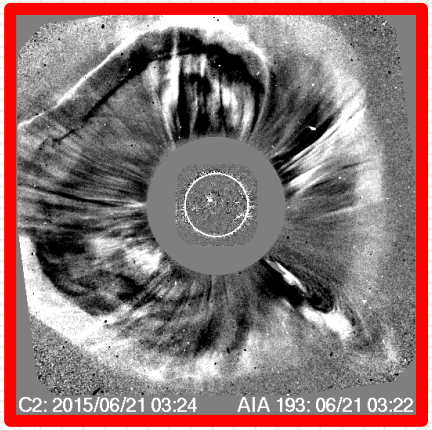


The Forbush analyses are done with data corrected by the barometric coefficient.

Coronal Mass Ejections in **June 2015**



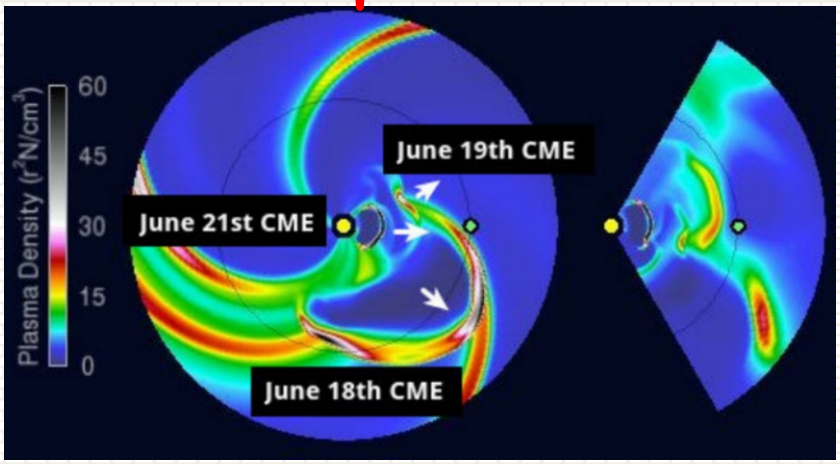




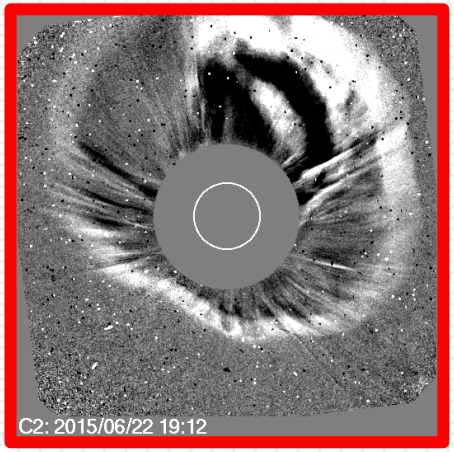
Forbush decrease

Toward the Earth

Five CMEs detected by **SOHO/LASCO**.



WSA-Enlil simulation **of the three first CMEs**.



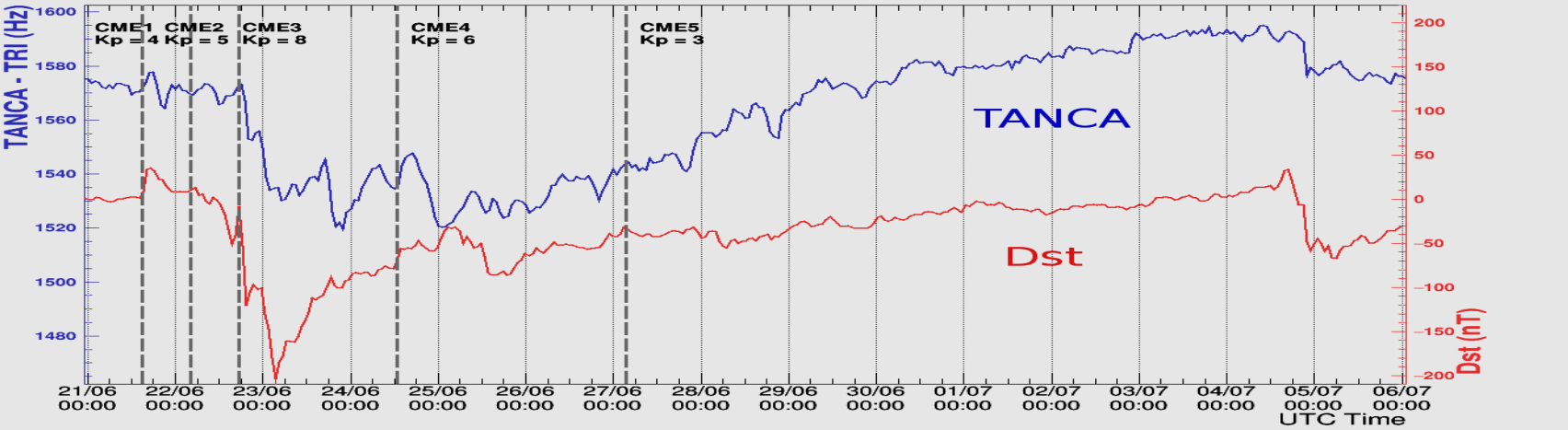
CME score board: NASA GSFC Community Coordinated Modeling Center (CCMC), https://kauai.ccmc.gsfc.nasa.gov/CMEscoreboard/

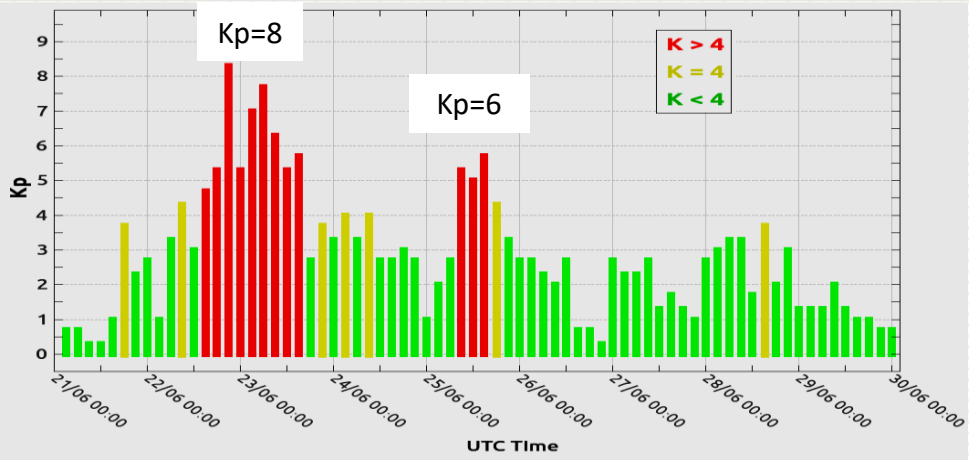
CME list: https://cdaw.gsfc.nasa.gov/CME_list/UNIVERSAL/2015_06/univ2015_06.html

Forbush event in June 2015
Dst, Kp and Tanca

The CMs and its magnetic interactions generated a strong geomagnetic storm

The dashed vertical lines shows the CMEs arrivel time on Earth.





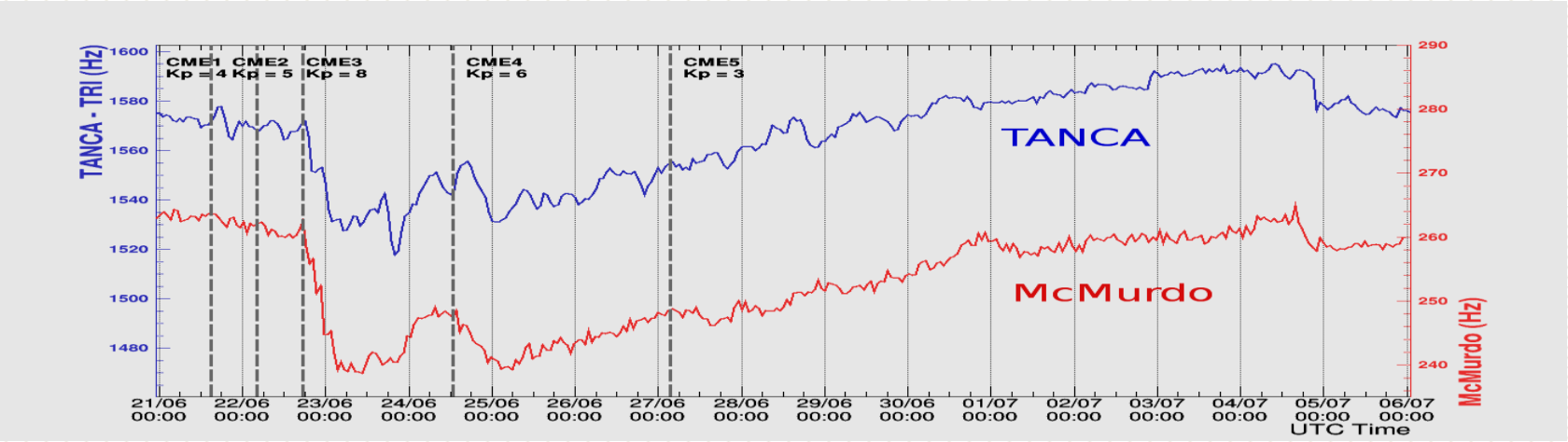
The Dst (Disturbance Storm Time) and Kp (Planetary K-Index) indices are used to quantify geomagnetic activity.

Dst measures the intensity of geomagnetic storms, reflecting variations in the Earth's magnetic field in equatorial regions.

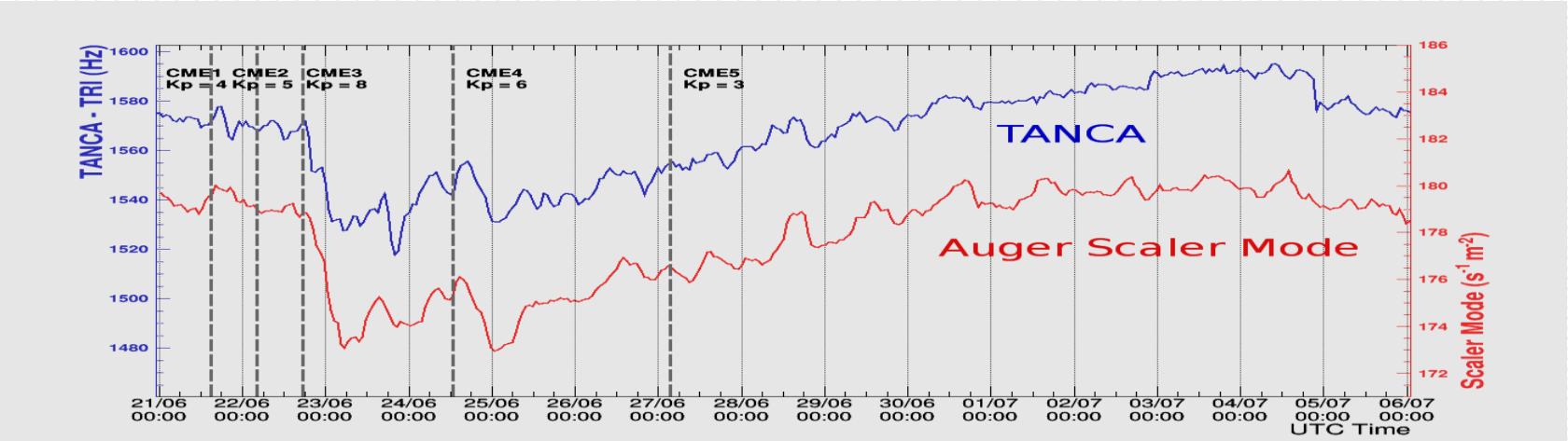
Kp quantifies geomagnetic activity on a scale from 0 to 9, representing an average of K indices measured at various stations around the globe.

Forbush event in June 2015
Tanca, McMurdo, Auger Scaler Mode

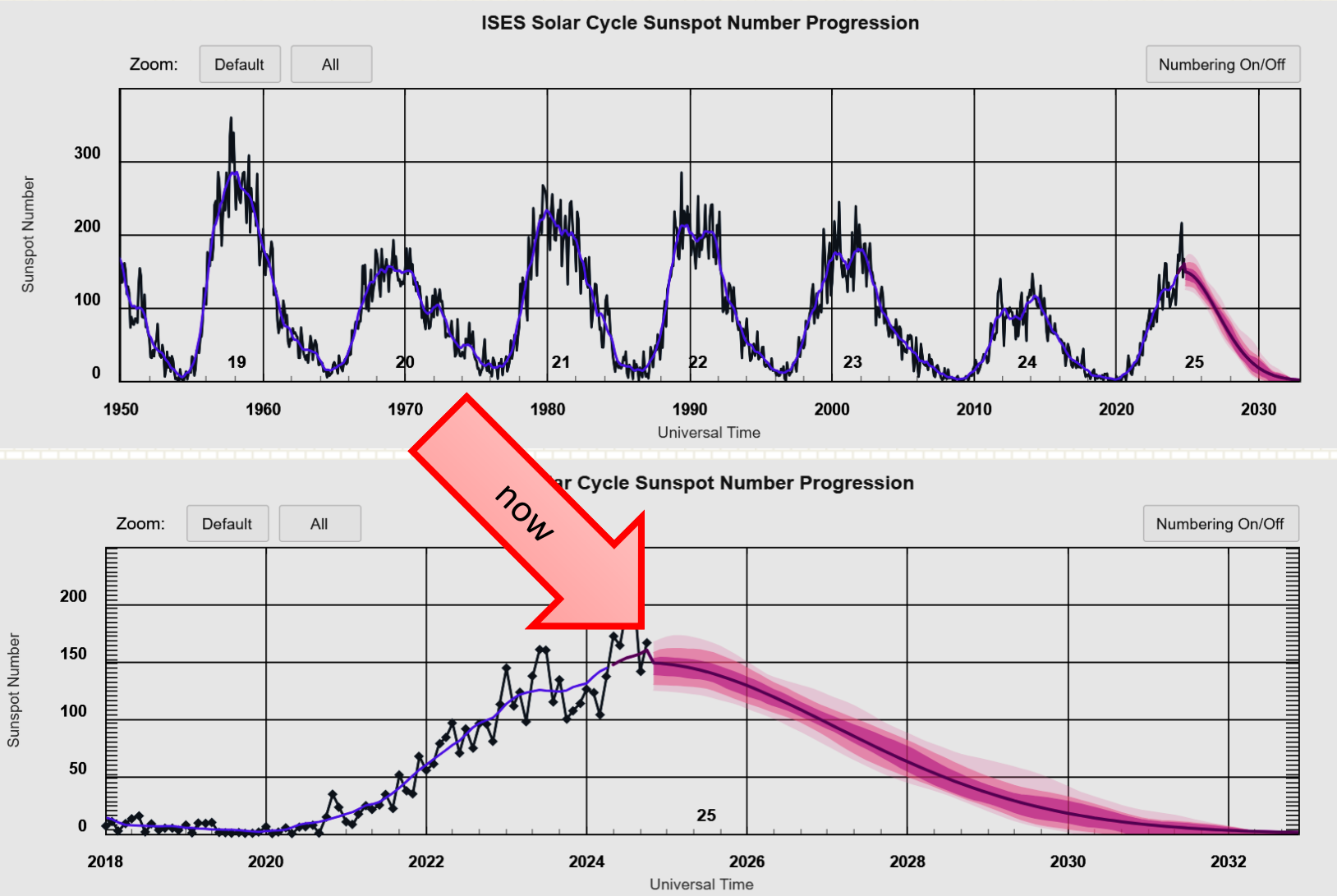
The McMurdo neutron monitor is located at the Southh Pole and has a very low geomagnetic cut-off.



The Auger Scaler Mode is 15 minutes time averaged data from the Pierre Auger Observatory, Malargue, Argentina



25th solar cycle

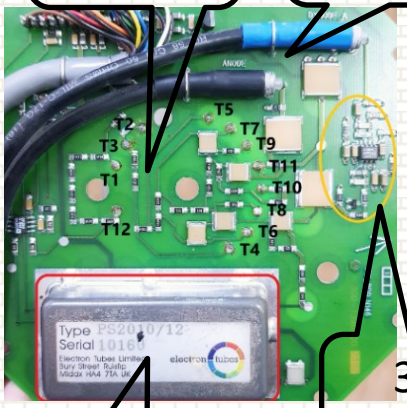


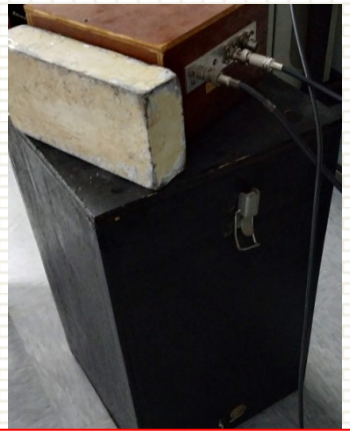
https://www.swpc.noaa.gov/products/solar-cycle-progression-updated-prediction-experimental

Tanca after Covid-19

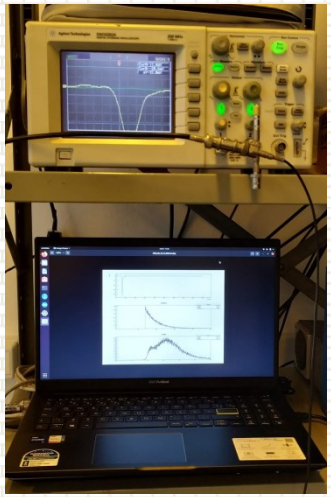
High humidity

front-end electronics not working



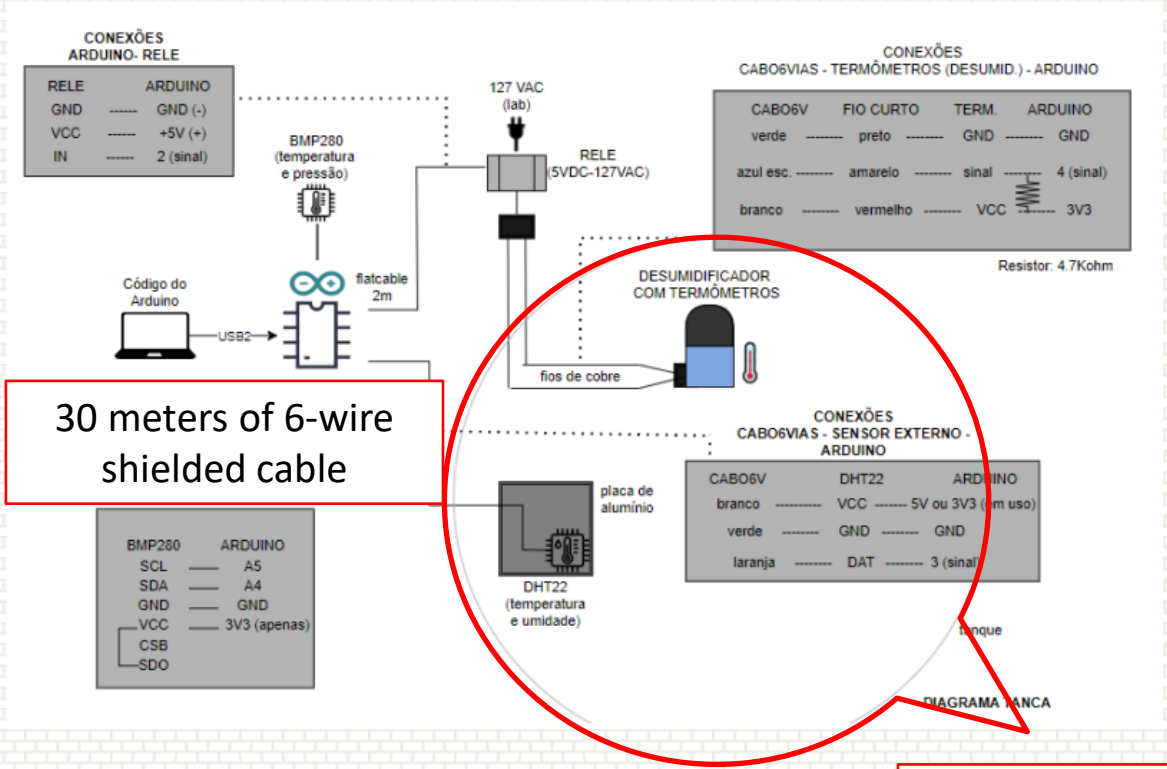


Black box with bue **LED**

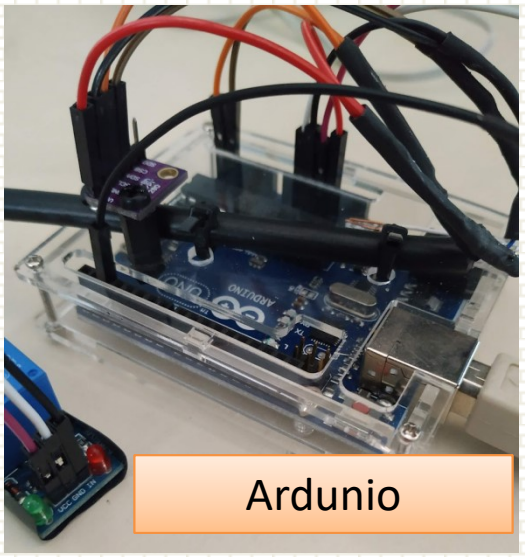


Humidity control

The humidity inside the Tanca reaches 100% RH. It is necessary to keep the RH below 70% to avoid damaging the electronics.



30 meters of 6-wire shielded cable



Ardunio

Inside Tanca

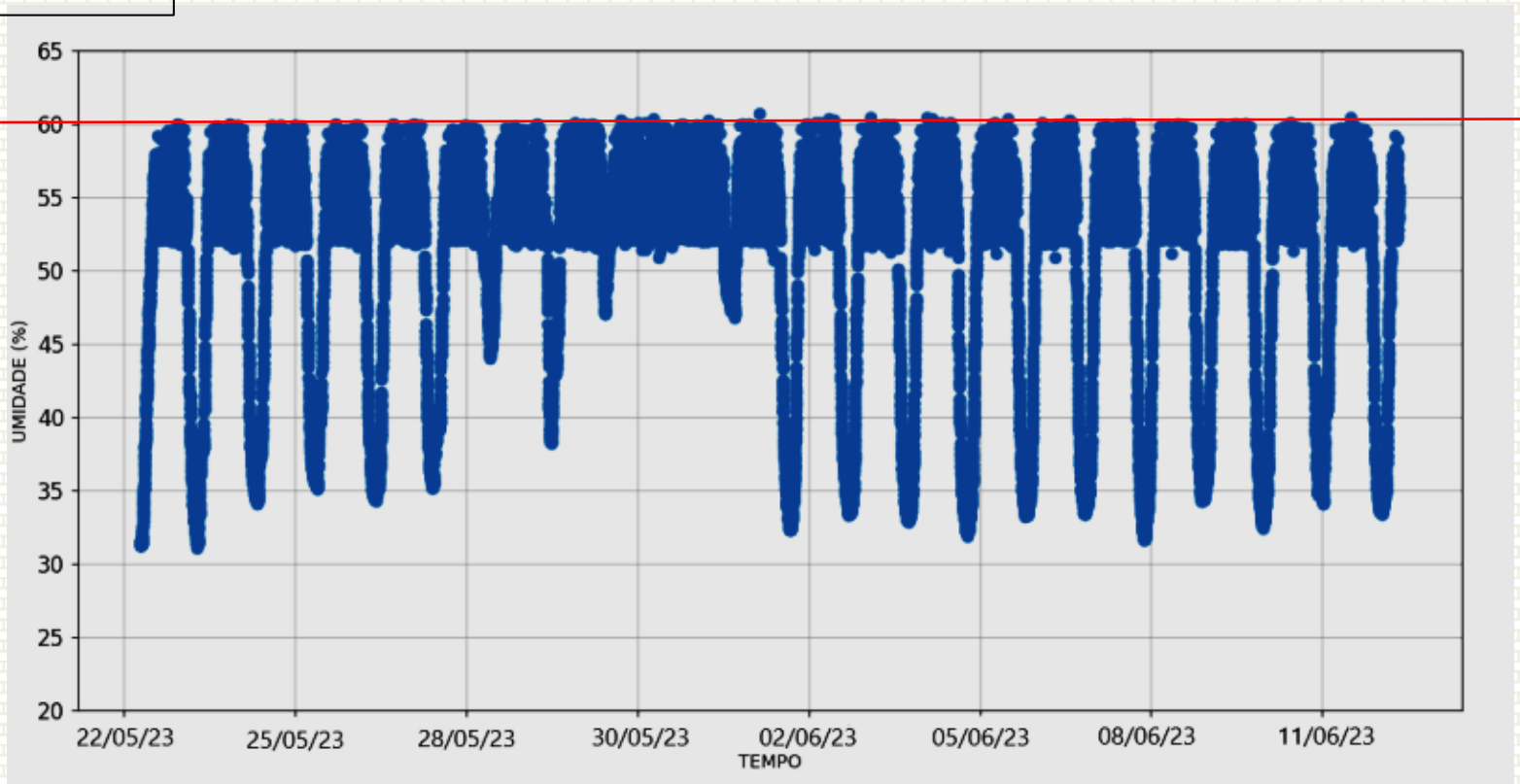
dehumidifier

Arduino:

- if RH > 60% turns on dehumidifier
- If Peltier temperature > 80oC turns off dehumidifier

Humidity control working

umidade **< 60%**

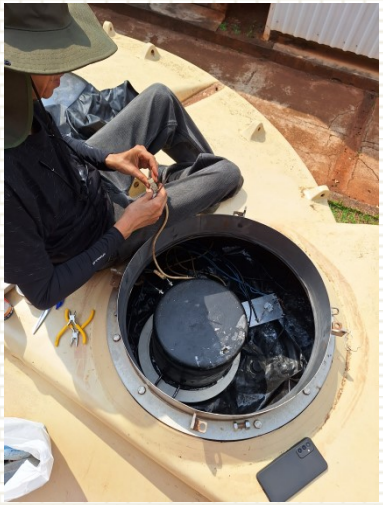


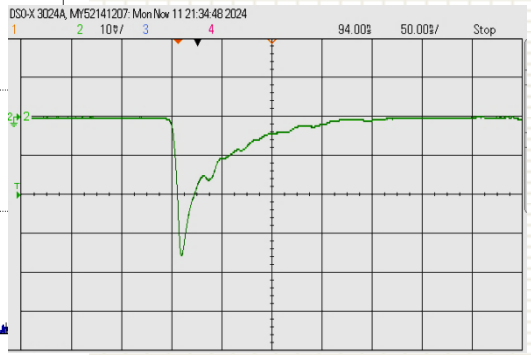
Mariana Guerra Mischieri (undergraduate student in 2023)

but in 2024 the dehumidifier broke! ☹

PMT#2 in November 2024

Muon pick, self trigger spectrum





Barometric pressure using Arduino

Arduino UNO

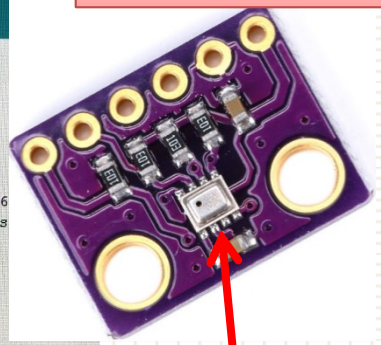
```
#include <Adafruit_Sensor.h> //INCLUSÃO DE BIBLIOTECA
#include <Adafruit_BMP280.h> //INCLUSÃO DE BIBLIOTECA

Adafruit_BMP280 bmp; //OBJETO DO TIPO Adafruit_BMP280 (I2C)

void setup(){
  Serial.begin(9600); //INICIALIZA A SERIAL
  if(!bmp.begin(0x76)){ //SE O SENSOR NÃO FOR INICIALIZADO NO ENDEREÇO I2C 0x76
    Serial.println(F("Sensor BMP280 não foi identificado! Verifique as conexões
    while(1); //SEMPRE ENTRE NO LOOP
  }
}

void loop(){
    //calcular um valor medio e depois fazer o Serial.print
    //ver quantos valores podem ser lidos em menos de 60 segundos
    Serial.print(bmp.readTemperature()); //IMPRIME NO MONITOR SERIAL A TEMPERATURA, em Gra
    Serial.print(" ");
    Serial.println(bmp.readPressure()); //IMPRIME NO MONITOR SERIAL A PRESSÃO, em Pascal
```

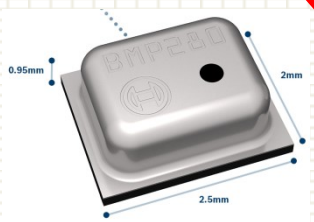
Relative accuracy pressure: ±0.12 hPA

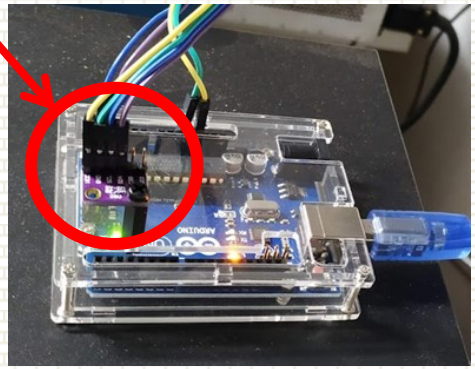


BMP280

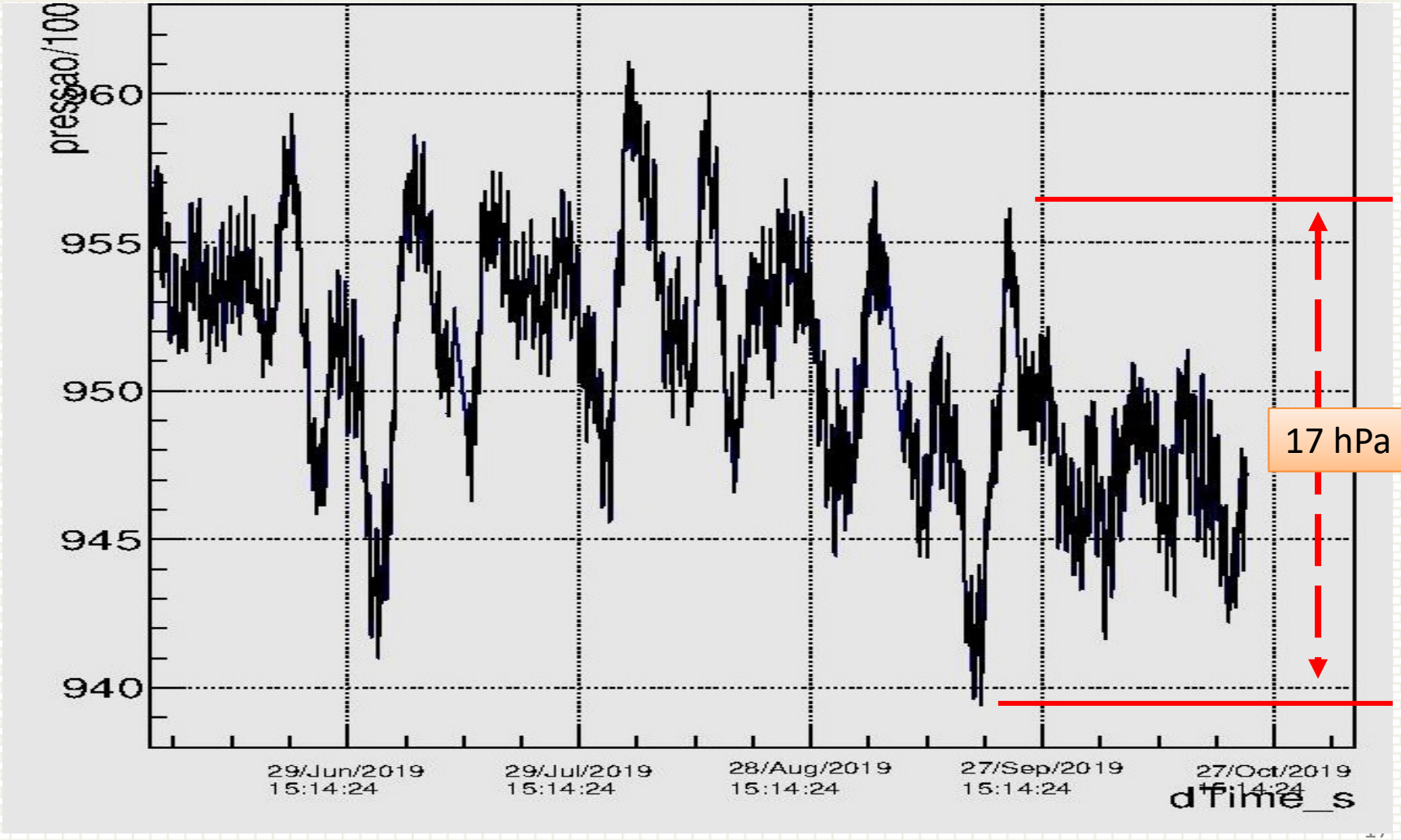
- **Bosh BMP280** absolute barometric pressure sensor
- Arduino UNO
- Python to write pressure to **ASCI file**

Python read USB port and write ASCI file





Daily variation of barometric pressure



Programa Move La América - CAPES

O Programa concederá **bolsas** para **estudantes** de **Mestrado** ou **Doutorado** vinculados a instituições de ensino e pesquisa estrangeiras da **América Latina e Caribe**, para realizarem estágio, pesquisas, atividades de extensão;

Benefícios
Mensalidade
Auxílio deslocamento
Auxílio instalação
Auxílio seguro-saúde

1000 (mil) bolsistas Mestrado
600 (seiscentos) bolsistas Doutorado

new DAq with digitizer
- **Digitizer** CAEN model DT5720B, 4ch 12bits, **250MS/s**
- Software C++ **saves .root TTree with waveform data**

Tanque Cherenkov situado na Anomalia Magnética do Atlântico Sul para estudo de eventos solares

Aluno: **Victor Clarizio**, Universidad Central de Venezuela, Caracas
Orientador no Brasil: Prof. Dr. Anderson Campos Fauth, UNICAMP
Three months at UNICAMP, March-May 2025

https://www.gov.br/capes/pt-br/acesso-a-informacao/acoes-e-programas/bolsas/bolsas-e-auxilios-internacionais/encontre-aqui/paises/multinacional/**programa-move-la-america**

Conclusion

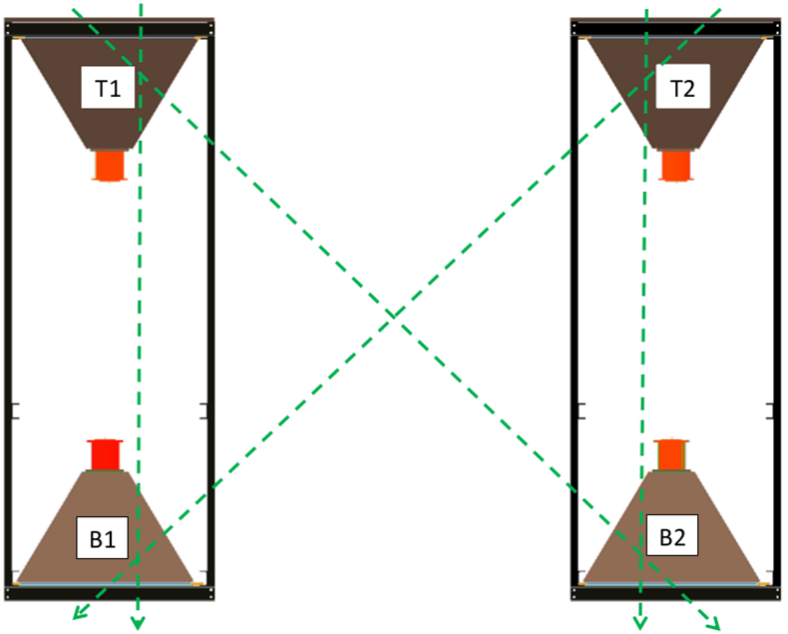
- We are working to reinstate the Tanca detector in continuous data acquisition mode.
- In December 2024, the front-end electronics maintenance for the three PMTs will be completed and installed.
- Continuous acquisition is expected to begin in January-February 2025 with the DAq CAMAC.
- The new DAq with waveform recording will be operational starting in March 2025.
- Thus, the Tanca will be fully operational during the peak of Solar Cycle 25.

Gracias

I would like to thank **Universidad Industrial de Santander** for their wonderful hospitality and the organization of the Encuentro CyTED LAGO INDICA, especially **Prof. Luis Nunes**.

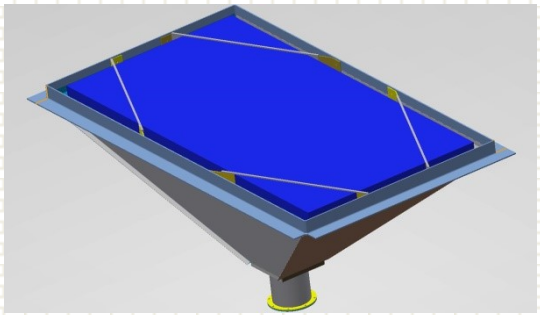
This work received support from the São Paulo Research Foundation (FAPESP), grant 2021/13538-5. ACF acknowledges the Brazilian National Council for Scientific and Technological Development (CNPq), grant 308231/2021-0. We thank Roberto F. dos Santos, Andre L. Pissolatti and Cezar R. A. dos Santos for their technical support

The MUONCA detector



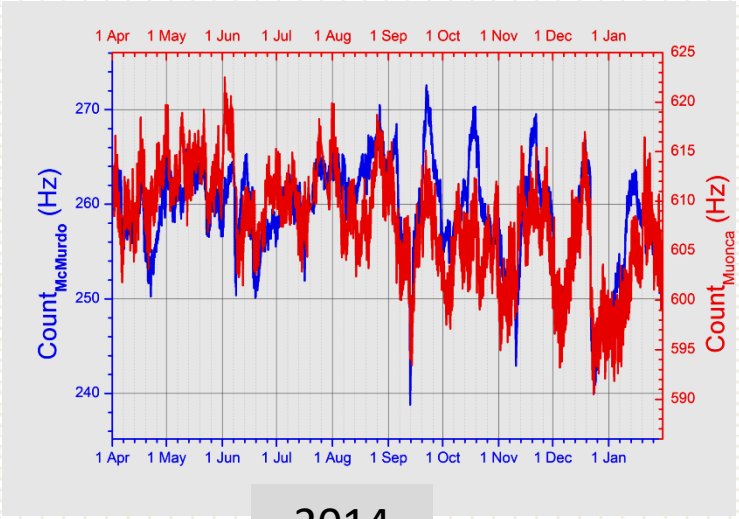
- The MUONCA is composed by four detectors.
- Three directions: vertical, East 45º and West 45º
- **Plastic scintillator** slab of 150 x 75 cm^2
- PMT 5” Hamamatsu
- Tyvek in the inner part
- $Area_{vertical}$ = (4 x 1,125) m^2
- CAMAC/NIM modules: LeCroy Scaler; Logic Unit; Discriminator ; Dual Gate Generator LeCroy

Hamamastu R877

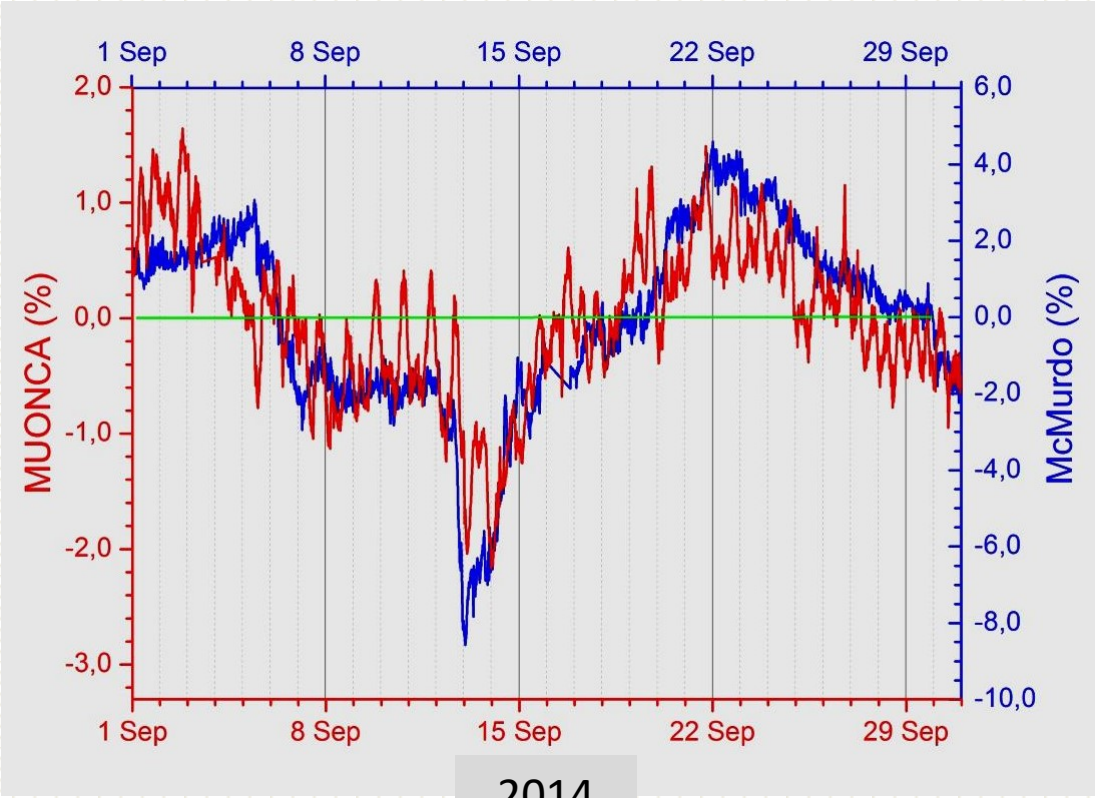


Forbush event Septemver 2014
Muonca and McMurdo

Muon telescope with four plastic scintillatores



2014



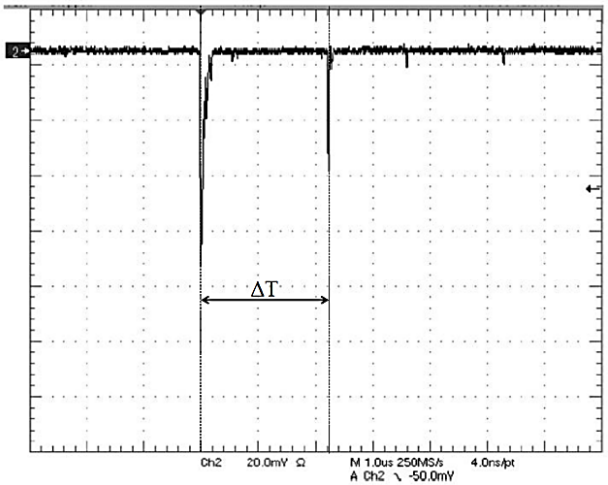
2014

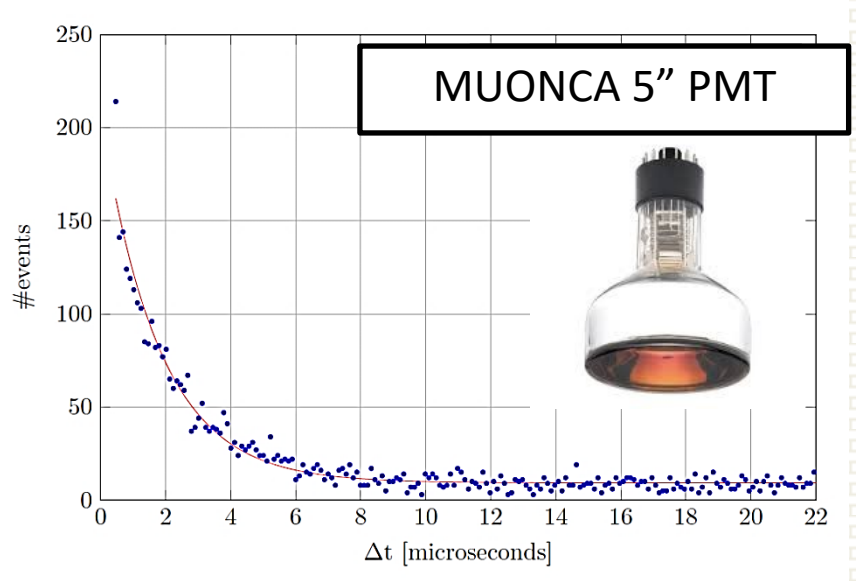
The academic muon decay

The study of the **muon lifetime** by looking the histogram of the time difference between successive pulses

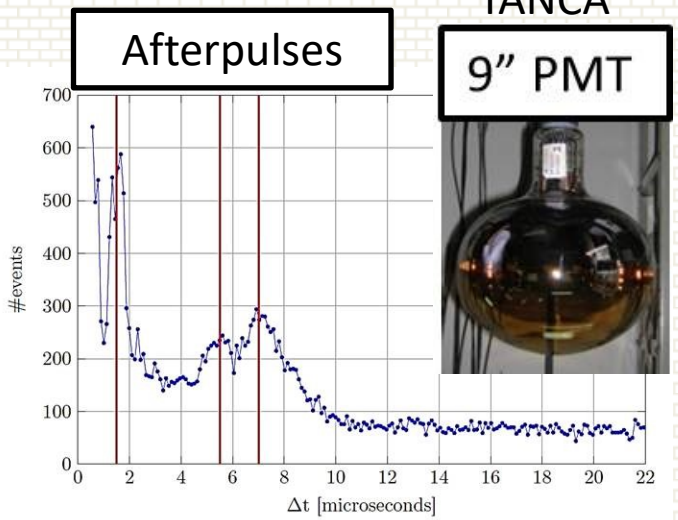
$$f(t) = A \cdot \exp\left(-\frac{t}{\tau}\right) + C$$

$$f(t) = 198 \cdot \exp\left(-\frac{t}{1.78 \cdot 10^{-6}}\right) + 9.25$$



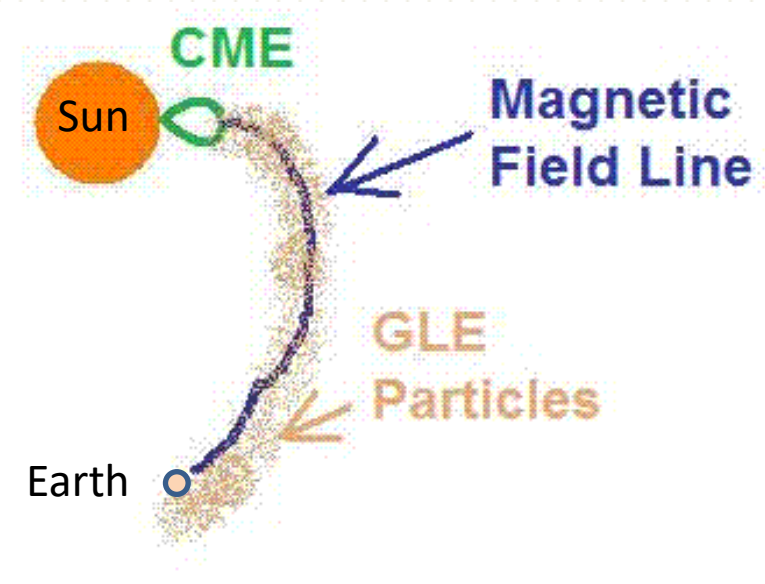


TANCA



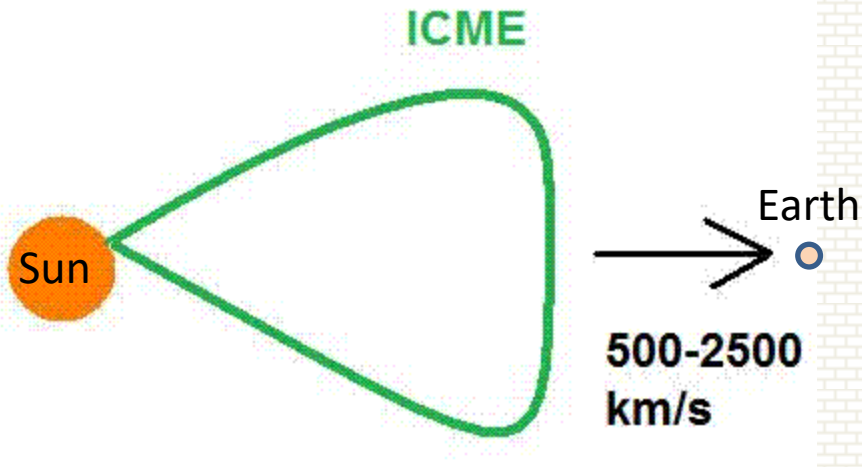
Coronal Mass Ejection Effects at Earth

Prompt Effect:
Energetic Particles (GLE)



- Energetic particles (~ 1 GeV) accelerated near Sun
- Charged particles follow magnetic field line
- Particles arrive at Earth 10-30 minutes later, if Earth is near the right magnetic field line

Delayed Effect:
Geomagnetic Disturbance



- *Interplanetary* CME arrives **20 hours to 4 days later**
- Impact of the ICME plasma with Earth's magnetic field causes a geomagnetic disturbance
- The ICME **suppresses** Galactic cosmic rays, an effect called a ***Forbush Decrease***