TIME OF FLIGHT MEASUREMENTS WITH SCINTILLATORS♪

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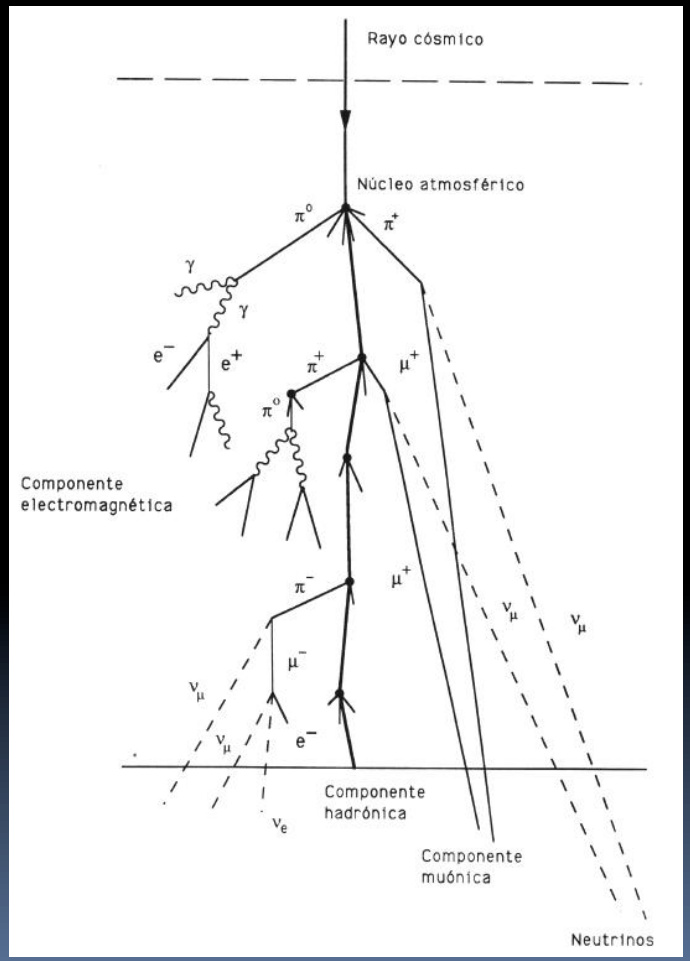
Contents

- Introduction
- Experiment with scintillators
  - Plastic Scintillators
  - Electronic (PMT, FC,TAC, ADC)
  - Construction of the experiment
  - Time Calibration
  - Analysis and Results
  - Velocity measurement
  - Angular distribution
  - Analysis and Results
- Conclusions

Introduction

COSMICS RAYS



- Muons (μ)
- The muon is an unstable subatomic particle with a mean lifetime of 2.2 μs.
- Mass of 105.7 MeV/c2, which is about 200 times the mass of an electron
- Muons have a very large mass and energy compared with the decay energy of radioactivity, they are never produced by radioactive decay

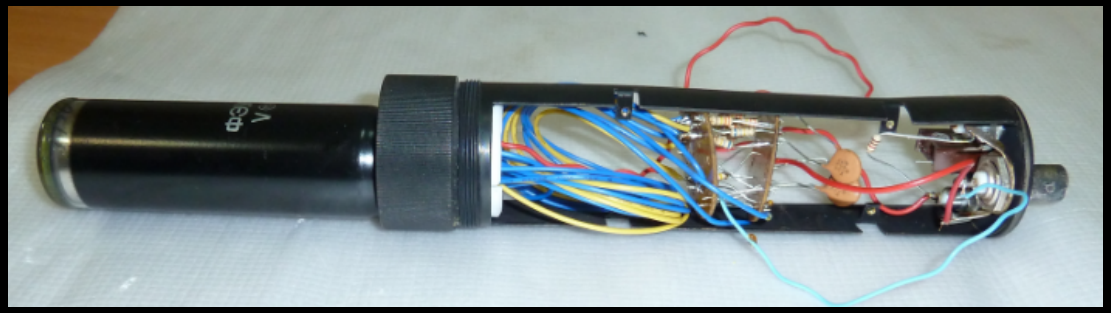
Experiments with Scintillators

Plastic scintillators

Scintillators are usually divided into three types, crystalline, liquid, and plastic, which utilize the ionization produced by charged particles to generate optical photons, typically in the blue to green wavelength regions.

- Very short response times and are extensively utilized for experiments where accurate measurements of very short time intervals (ns) must be obtained in spite of extremely high counting rates
- Detection of charged particles with minimal response to gamma-rays

Photomultiplier (PMT)

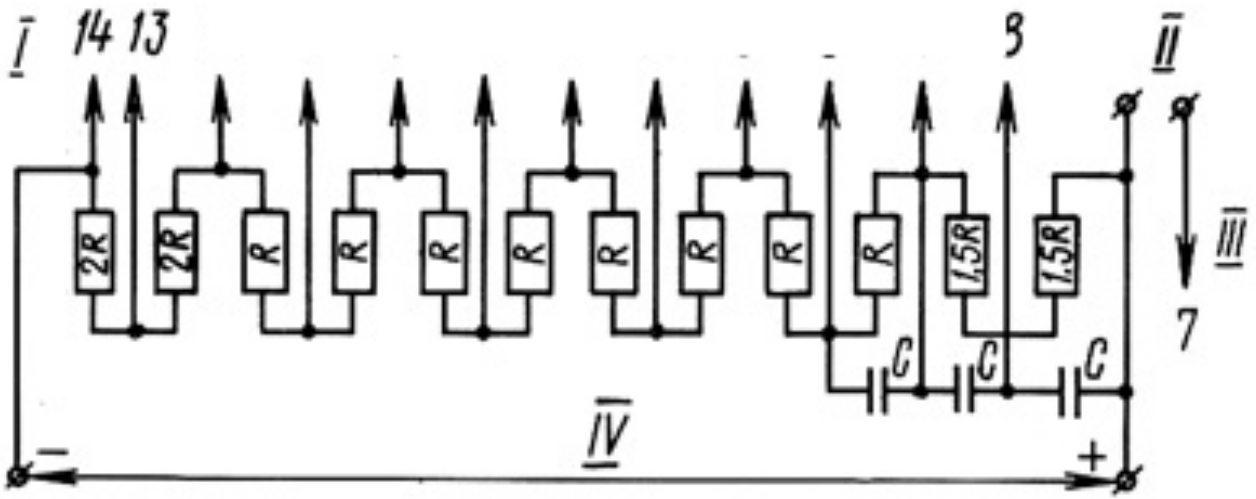


Multiply the charge produced by incident light (photoeffect) by as much as 100 million times

Capable of resolving single photoelectrons of a light pulse

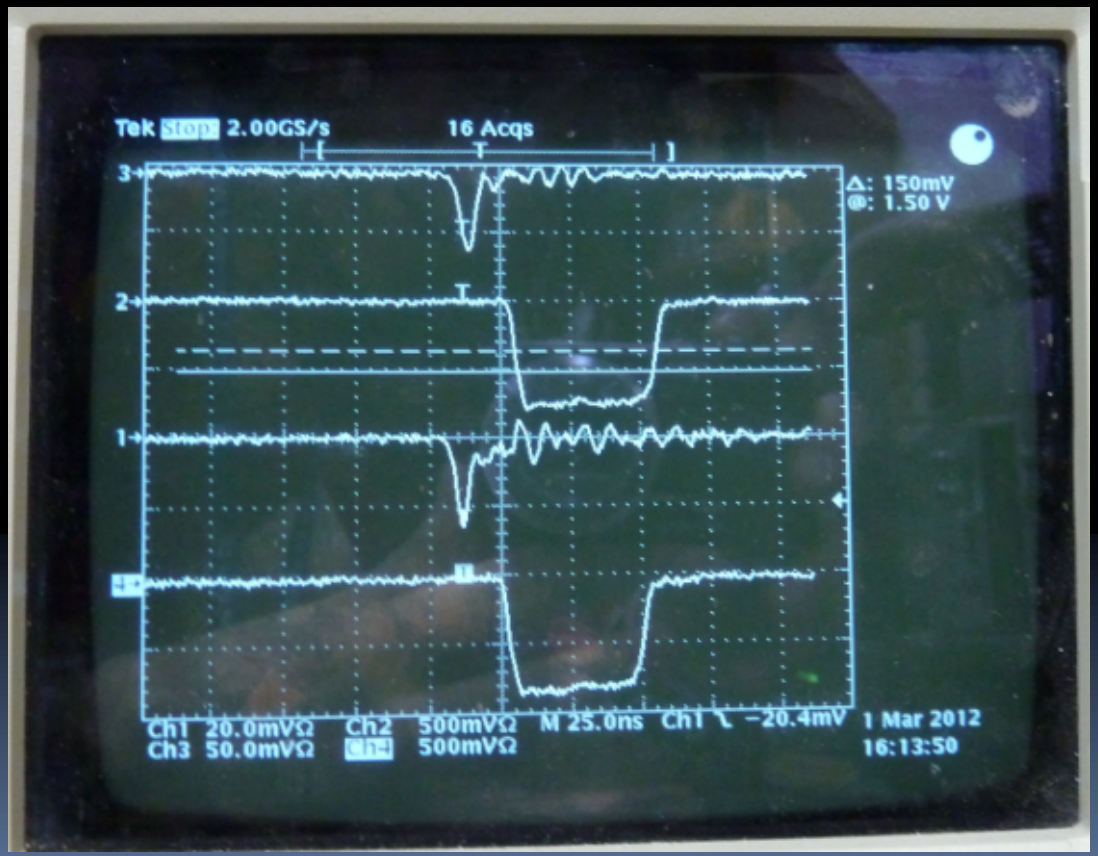
illator

R = 330 kOhm, C = 680 pF



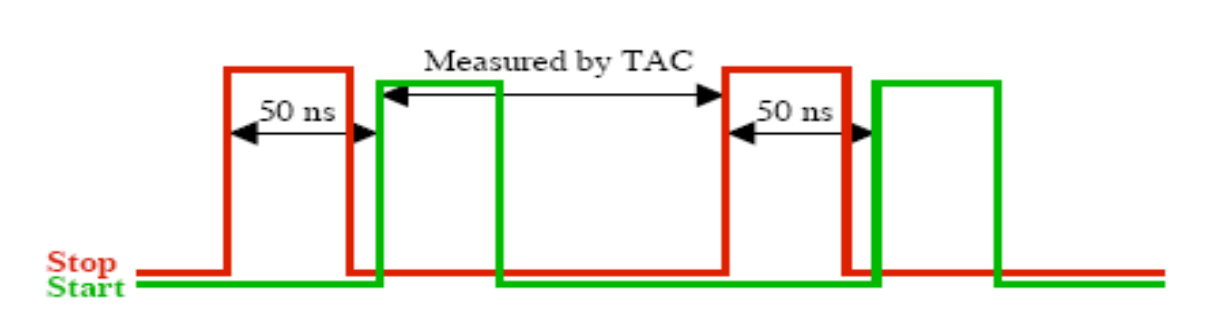
Constant fraction discriminator (CFD)

Is an electronic signal processing device, designed to mimic the mathematical operation of finding a maximum of a pulse by finding the zero of its slope



Time to amplitude converter (TAC)

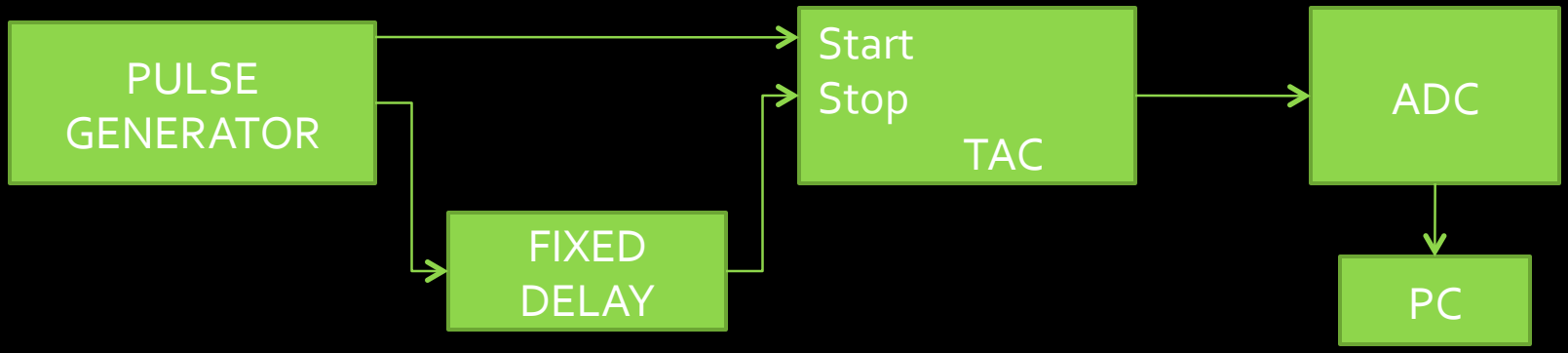
Generates a rectangular output pulse whose peak amplitude is linearly proportional to the time interval between a START and STOP input pulse pair



Analogic to Digital Converter (ADC)

An analog-to-digital converter (ADC) is a device that converts a continuous quantity to a discrete time digital representation

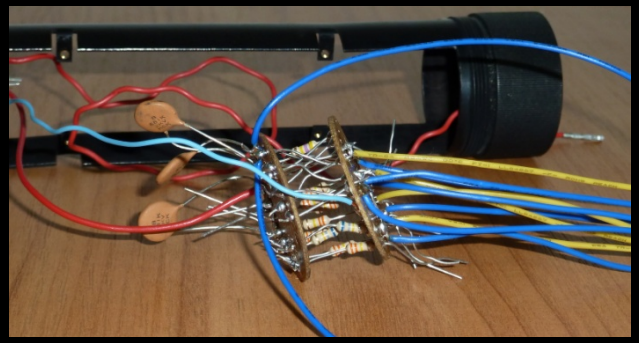
BASIC SCHEME OF CALIBRATION



We calibrate our setup by feeding it START and STOP pulses of known separations in time delays, measured by an osciloscope. A callibration is done at the beginning of the data taking

Construction of the experiment

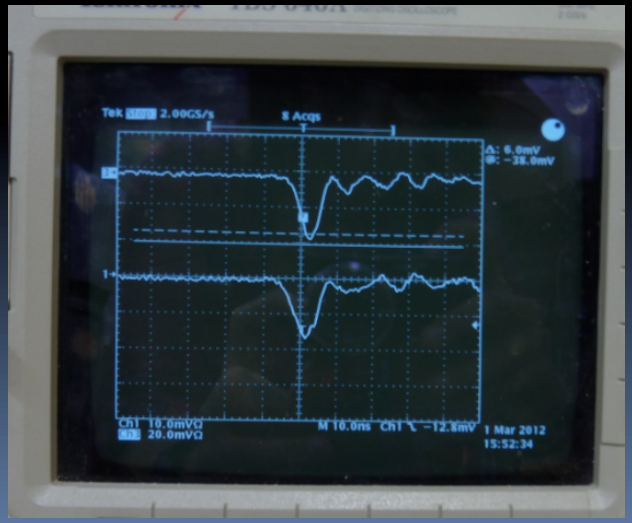
1. Assemble PMT



3. Cabling

2. Black tape

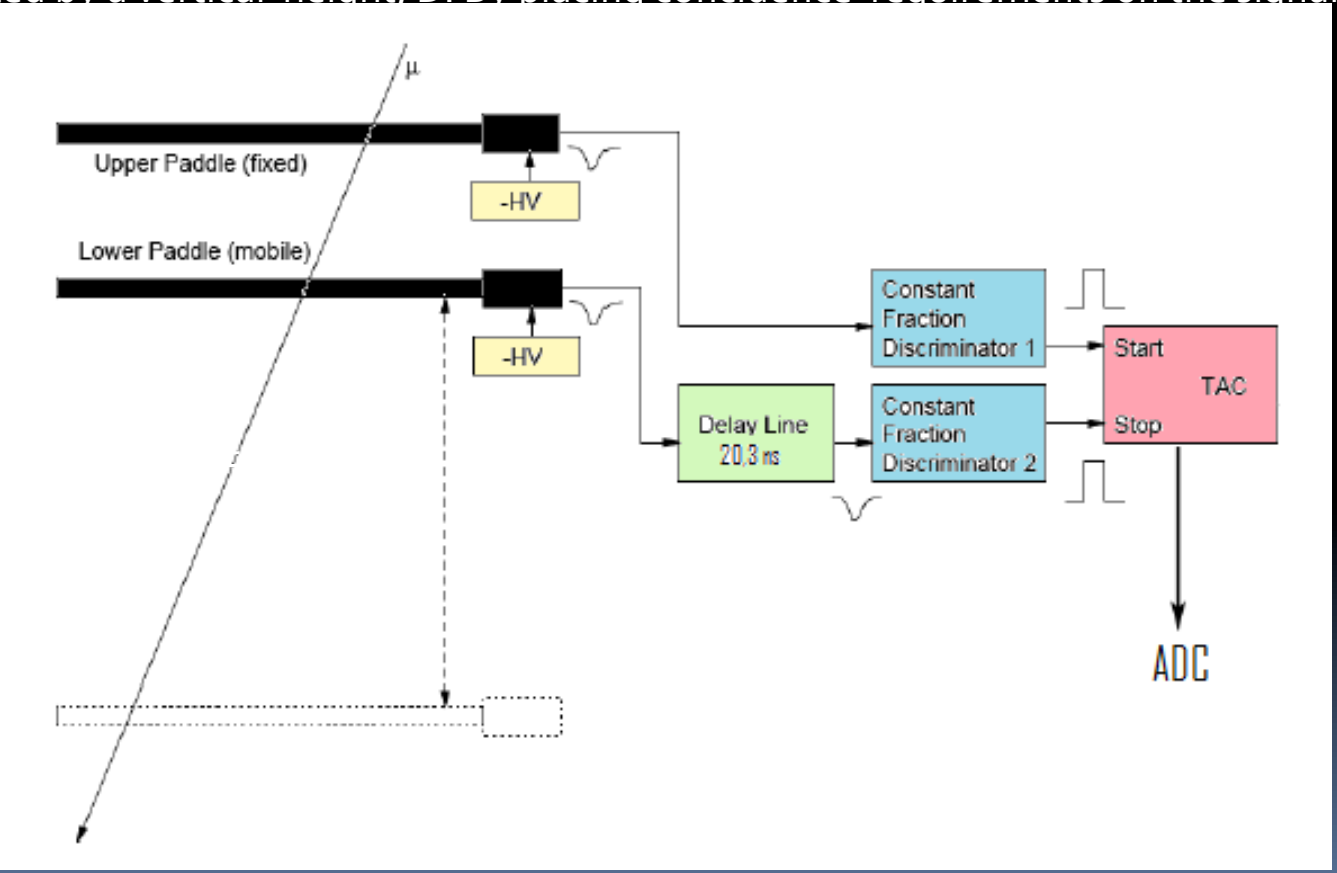
4. First signals ☺



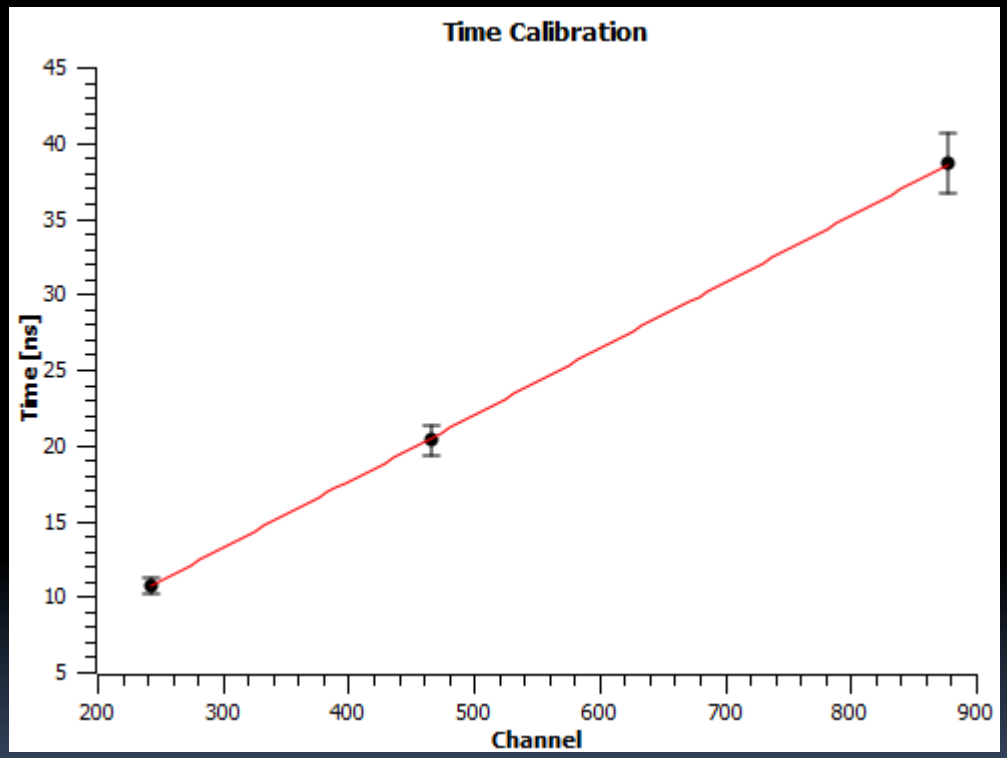
Construction of the experiment

- Theory and Metod

We determine the mean speed of muons by using two flat, broad scintillator pads separated by a vertical height, D. By placing concidence requirements on the signals from th
passed
events,



Time Calibration



This calibration corresponds to a resolution of :
- Cable 1: 10,70 ± 0,5 ns
-Cable 2: 20,45 ± 1 ns
-Cable 3: 38,6 ± 2 ns

-One and two parameter linear fit checked

$$T = kA$$

K= constant fraction
A= nº channel

k= (0.0439 ± 0.0005) ns/channel

Analysis and Results

- **Muons velocity**

Time is a function that depends on Δt1 and Δt2 → $T = T\ (\Delta t_1, \Delta t_2)$

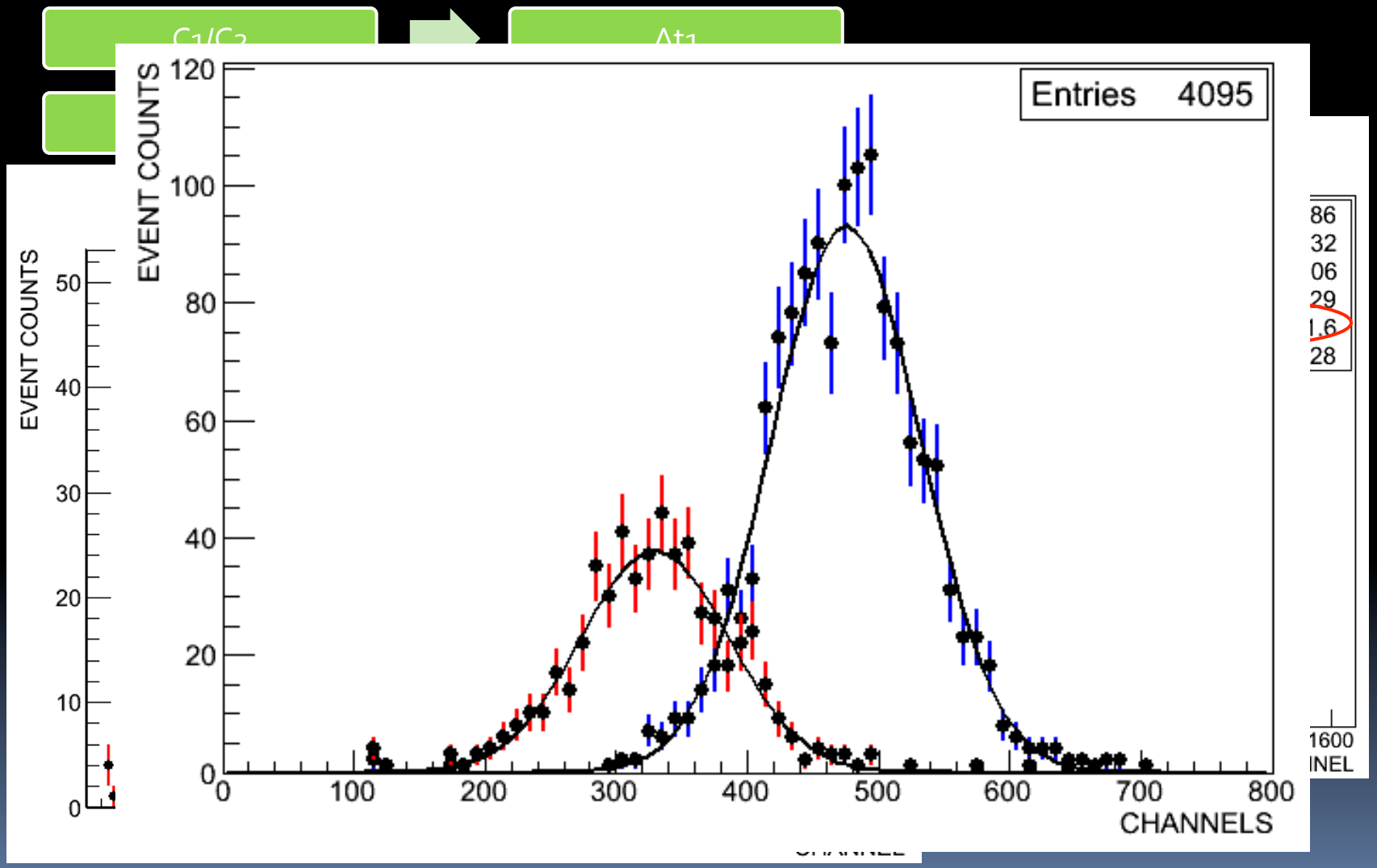
We obtain the following equation → $T = \frac{(\Delta t_1 - \Delta t_2)}{2}$

Calibration according to obtain → $T = kA$

Velocity is a function that depends on the distance between detectors, Δt1 and Δt2 → $V = V(d, \Delta t_1, \Delta t_2)$

$V = \frac{d}{T}$ → $V = \frac{2d}{k(\Delta t_1 - \Delta t_2)}$

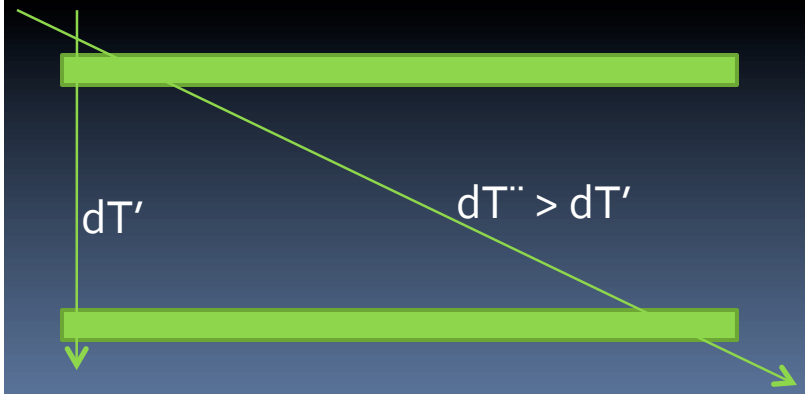
Analysis and Results



Velocity measurement

$$V = \frac{2d}{k(\Delta t_1 - \Delta t_2)}$$

Effect	Correction	Error contribution [*10^8 m/s]
Time 12 (stat)	0	0.036
Time 21 (stat)	0	0.055
External optical light *(syst)*	0	0
Scintillator area	0.08	0.08
Calibration	0	0.03
Distance uncertainty	0	0.031
Threshold value	Included in sc. area	0



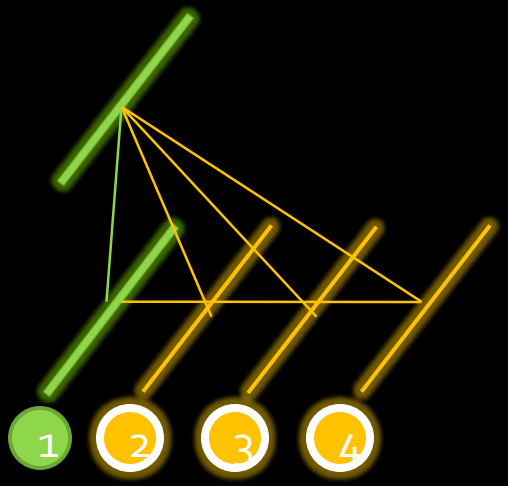
Muons velocity that we have obtained is:

$$V = (2{,}71 \pm 0{,}066_{\,stat} \pm 0{,}091_{syst}) \cdot 10^8 m/s$$

$$V = (2{,}71 \pm 0{,}11) \cdot 10^8 m/s$$

Angular distribution

Events on each position of the detectors:



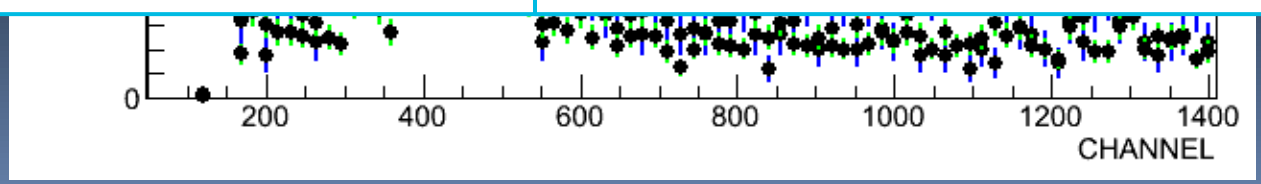
Comments:
-Background position
-Last measurement

1st position:
-Number of event s in the pick : 878
-Total random events: 2036
-Number of backgrounds per bin: 10,4
-Total number of background events:

2nd position:
-Number of event s in the pick : 2979
-Total random events: 12885
-Number of backgrounds per bin: 66,42
-Total number of background events:

3rd position:
-Number of event s in the pick : 1010
-Total random events: 4236
-Number of backgrounds per bin: 21,8
- Total number of background events:
-Number of muon events: 530±33

4th position:
-Number of event s in the pick : 5621
-Total random events: 36468
-Number of backgrounds per bin: 188
- Total number of background events: 4135,55
-Number of muon events: 1485±78



Analysis and Results

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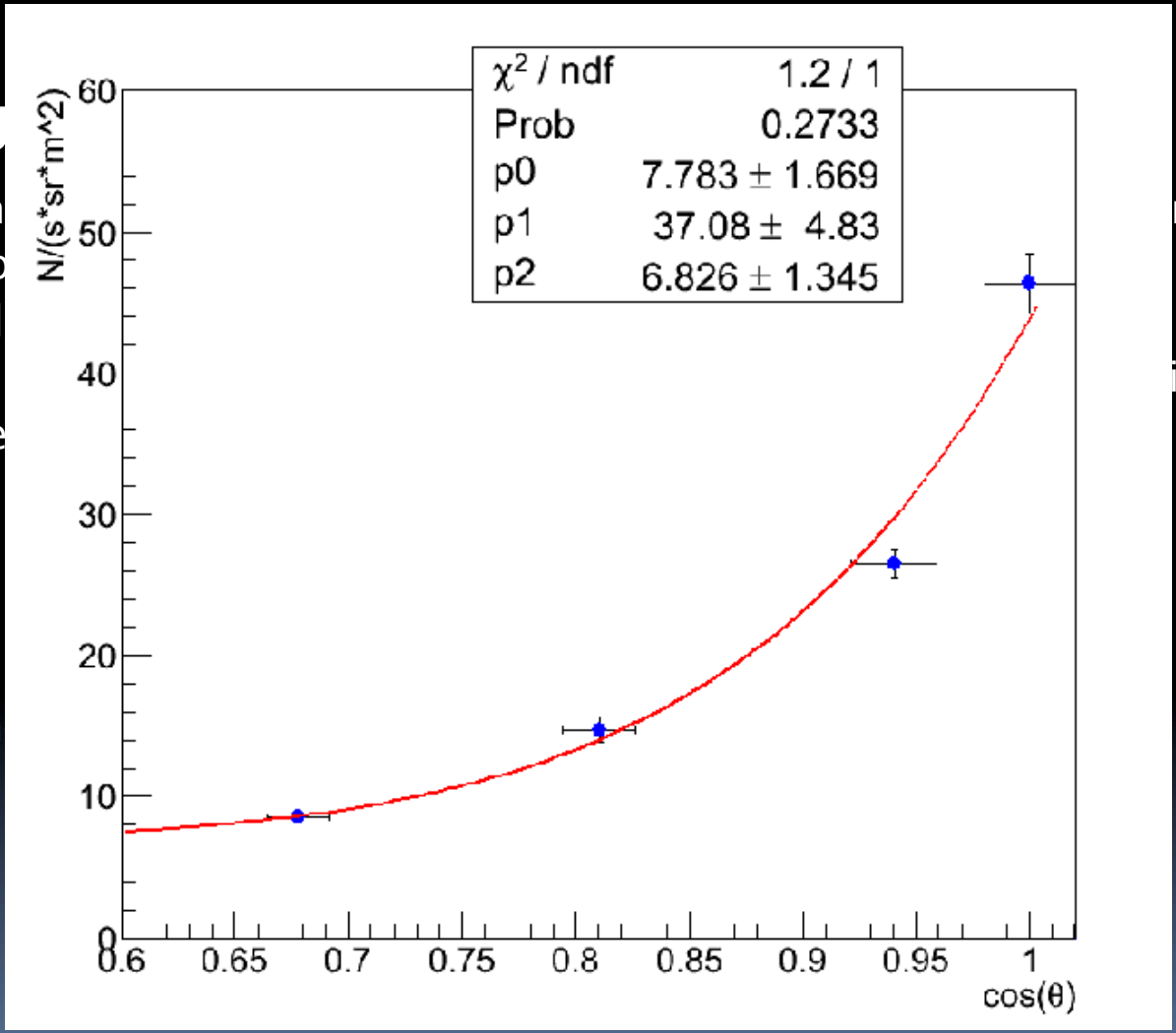


Results

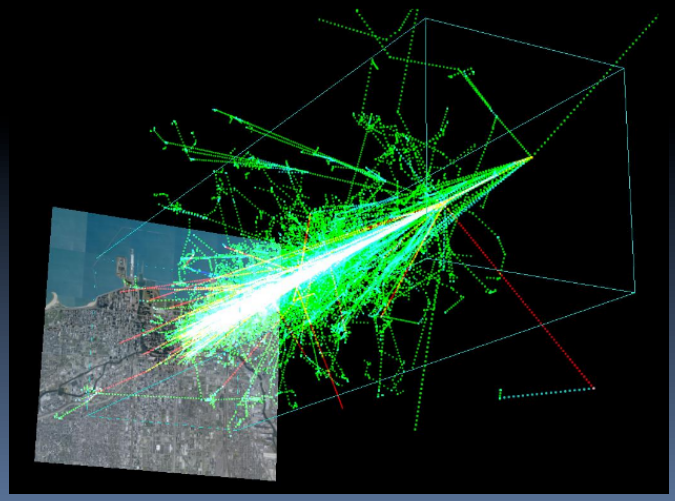
Flux of single muon at zero degree azimuthal angle: **37± 5 μ / s/sr/m²**

Power of the angular spectrum: **7,8± 1,7**

Cosmic ray broad shower

This effect is independent on the different angles

The amount of cosmic ray broad showers was obtained to be: **15%**



Conclusions

- A PMT HV divider has been constructed
- Two plastic scintillator counters were assembled
- A data acquisition system was setup
- The velocity of the muons was measured
- The angular distribution was obtained
- Few unexpected effects were observed

Thank you for your attention!!!

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