

Cremlin+ Detector

Workshop: Cosmo-Boxes

Hands-On Review

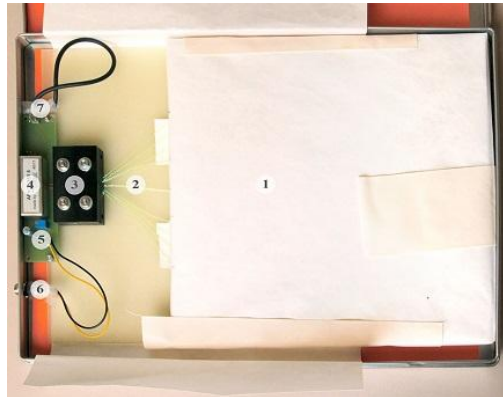
Cosmo-Box Setup

Complete Set:

1x Laptop
3x Cosmo-Boxes
1x DAQ-Card
(4 input channels)
Lemo-Cables and
USB cable



More information:
https://www.desy.de/school/school_lab/zeuthen_site/cosmic_particles/experiments/cosmo_experiment/index_eng.html



Cosmo-Box Setup

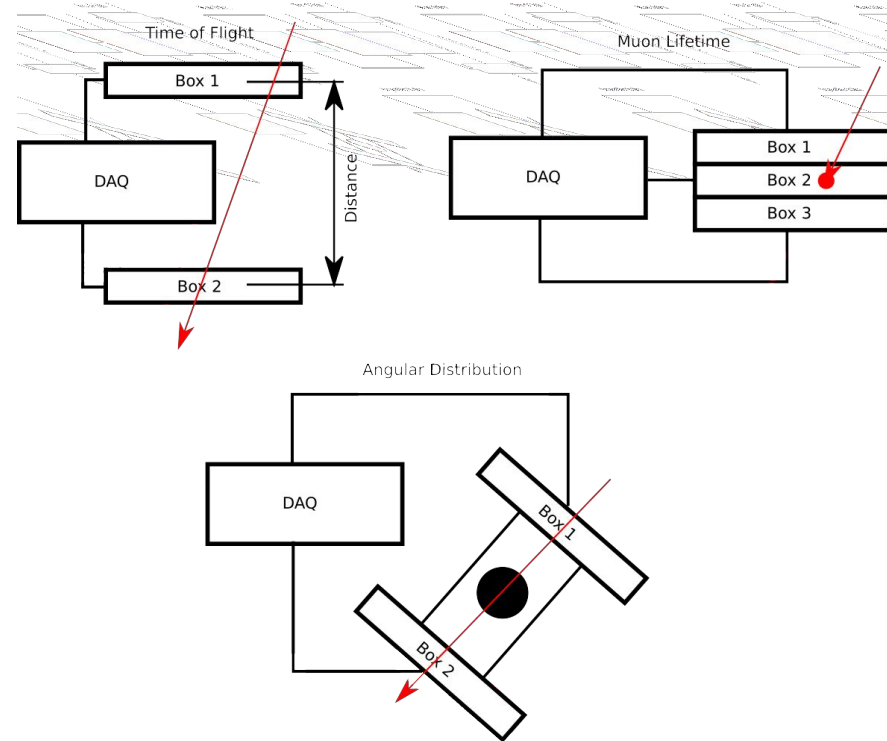
Time of Flight measurements and muon rate with 2 boxes at various distances

Muon lifetime measurements with 3 boxes in stack

Angular distribution with 2 boxes in rotatable system

Measuring showers with 3 boxes scattered on ground

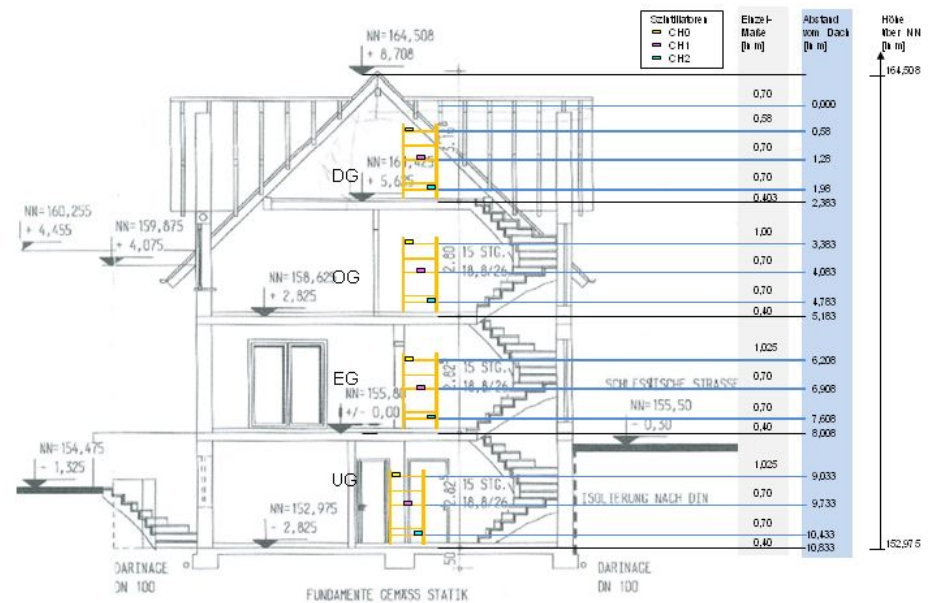
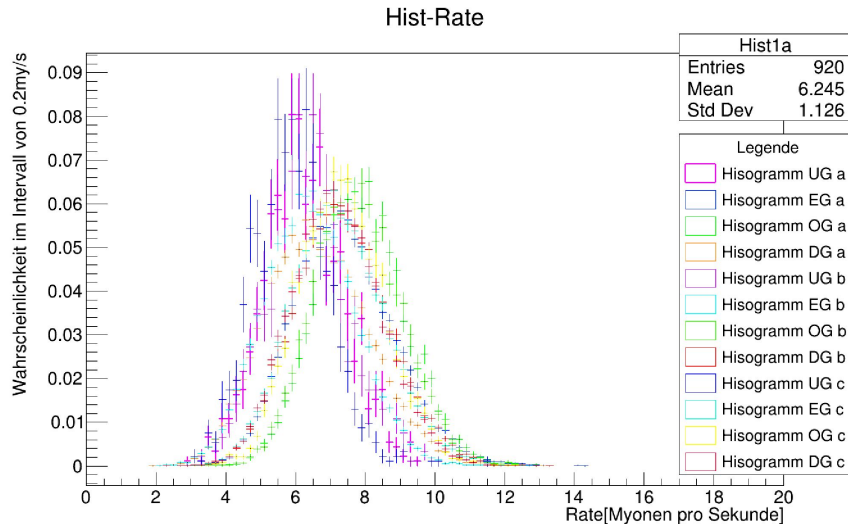
Presented results created by internship student



Muon Rate

Measuring and calculating muon rate => comparing with literature

Measurement in different building levels possible



[Abb. 3] Skizze Aufbau M-Rate: Abstand vom Dach bei 3 Szintillatoren diagonal im Regal auf 4 Hausebenen

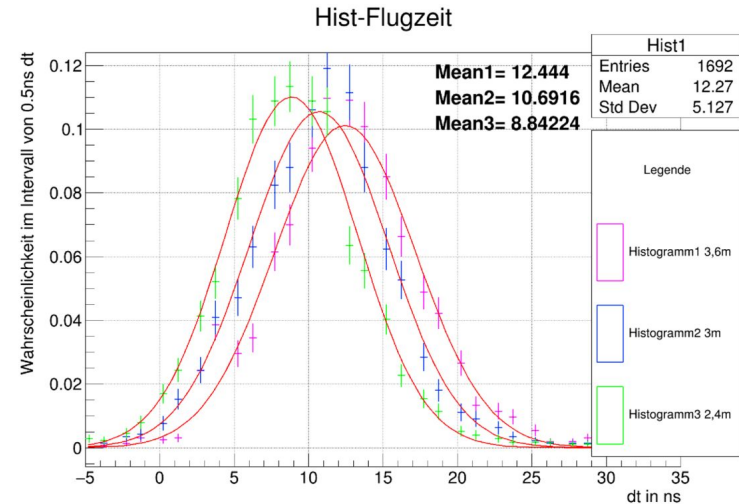
Time of Flight

Measuring Time of Flight of muons at different heights

Recommendation : Distance > 3 m because of time resolution

Analysis with ROOT, PyPlot, Gnuplot etc

Higher statistics => better results



Time of Flight

Measurement	Distance [m]	Time of Flight [ns]	Speed [km/s]	Part of vacuum speed of light
1	3,01	10,6916	281529,424	93,91%
2	3,62	12,444	290903,246	97,03%
3	2,39	8,84224	270293,500	90,16%

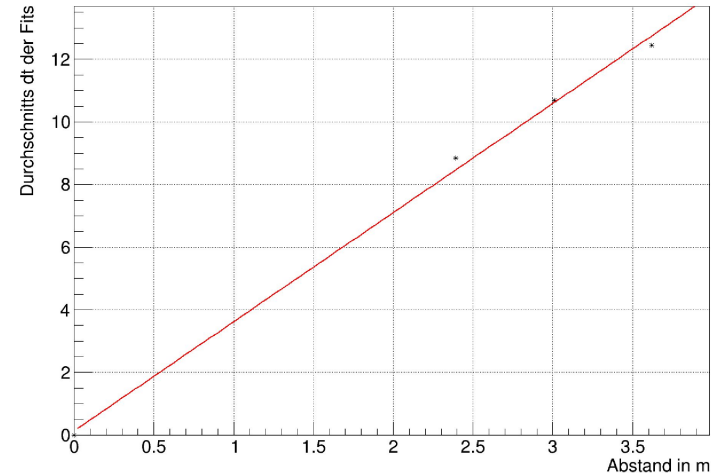
Results match very well with predictions

Linear fit for obtaining better results

Obtained speed: 287100 km/s (95.77% of c)

Estimation of further statistical and systematic errors

Graph

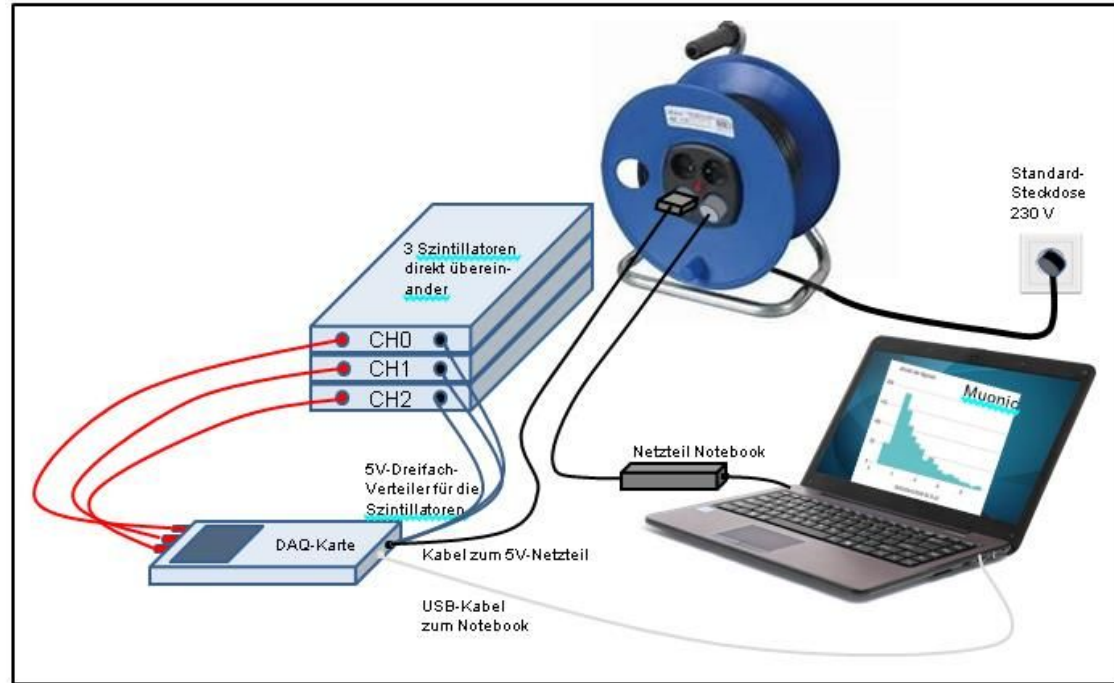


Muon Life Time

Placing all boxes in
one stack

Only considering
muons sticking in
plate 1

Two signals required
(muon and electron)



[Abb. 10] Skizze Aufbau Myonen Lebensdauer

Muon Life Time

Fitting exponential function to data

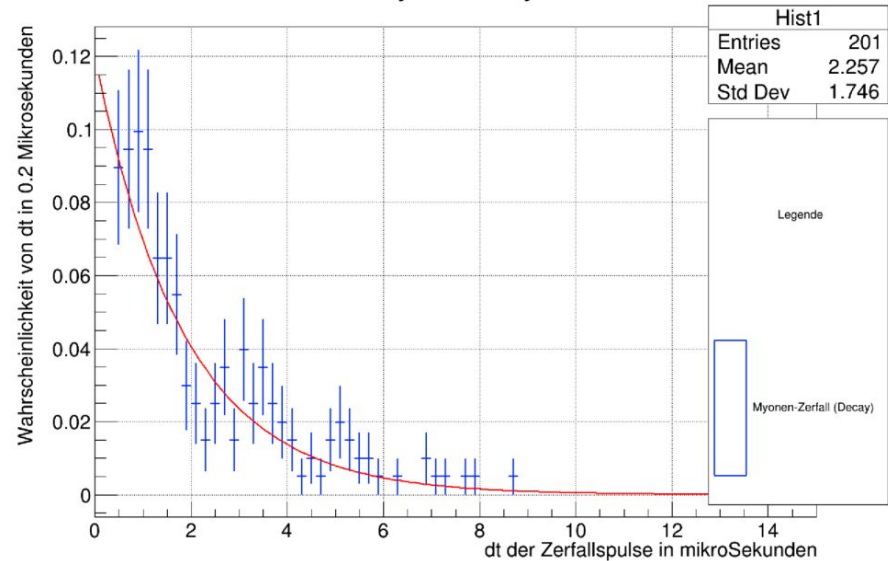
Alternative: Plotting data logarithmically and making a straight line fit

Measured value: $2.02 \mu\text{s}$

Literature value: $2.19 \mu\text{s}$

```
EXT PARAMETER      ED=3.70470e-09  STRATEGY= 1  ERROR MATRIX ACCURATE
NO.  NAME          VALUE          ERROR          STEP          FIRST
 1  Constant      -2.12341e+00  1.57365e-01  1.97590e-04  -1.02639e-03
 2  Slope         -5.40948e-01  6.07447e-02  8.37749e-05  1.76478e-03
FCN=27.4599 FROM MINIMAD  STATUS=CONVERGED  135 CALLS  136 TOTAL
EDM=3.46639e-09  STRATEGY= 1  ERROR MATRIX ACCURATE
EXT PARAMETER      STEP          FIRST
NO.  NAME          VALUE          ERROR          SIZE          DERIVATIVE
 1  p0             1.19626e-01  1.87746e-02  2.36504e-05  8.59654e-03
 2  p1             5.40957e-01  6.65677e-02  8.38483e-05  -1.68699e-03
root [2] Info in <TCanvas::Print>: pdf file /home/jannik/Praktikum/PraktikumMyonen/Bilder/DecayMtfFtV2.pdf has been created
c1_n2
```

Myon-Decay



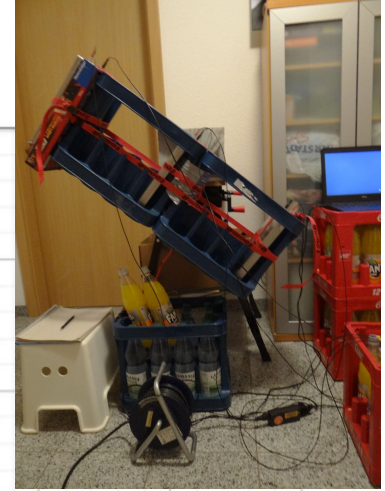
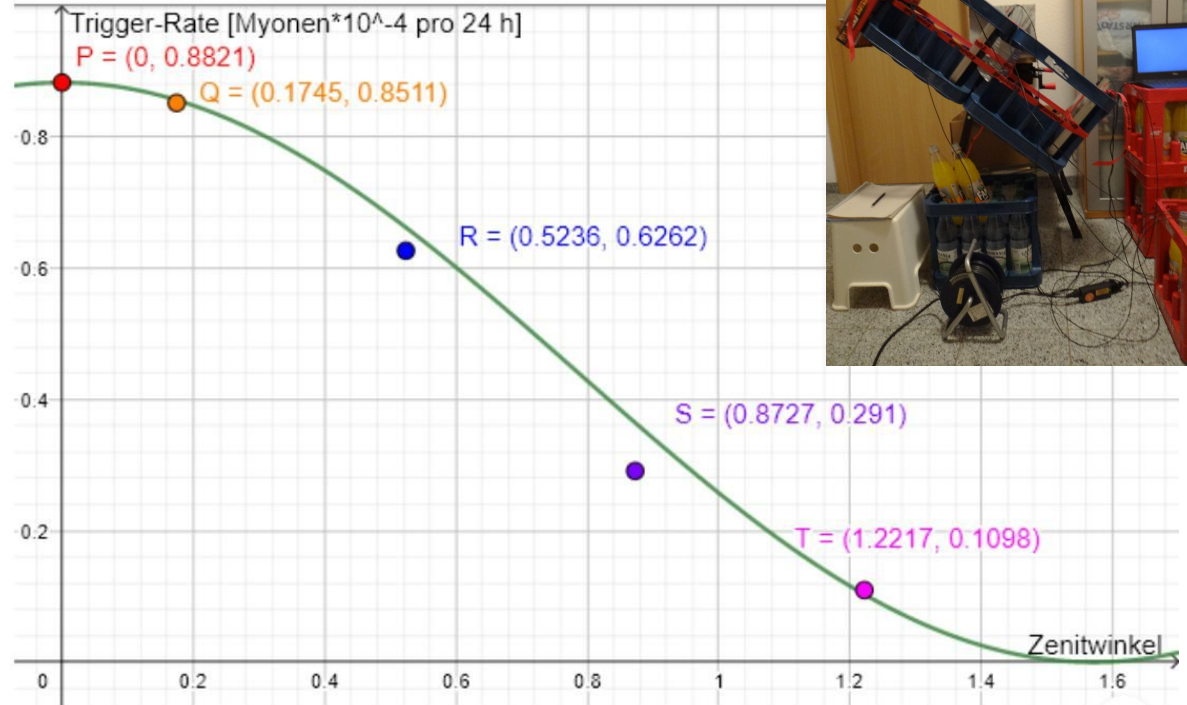
Angular Distribution

Measuring angle dependency

Cos-Square dependency clearly visible

Measurements for 0° and 90° polar angle

Zenitwinkel	$70^\circ = \frac{7 \cdot \pi}{18}$ =1,2217	$50^\circ = \frac{5 \cdot \pi}{18}$ =0,8727	$30^\circ = \frac{3 \cdot \pi}{18}$ =0,5236	$10^\circ = \frac{\pi}{18}$ =0,1745	0°
Rate [in Myonen pro 24 h]	1098	2910	6262	8511	8821
Punkt in Graph	T	S	R	Q	P



Learning Goals

Principles of particle absorption, Time of Flight, particle lifetime

Taking data from real-life experiment

Preparation of data for further analysis

Writing scripts to analyze large data sets

Relationship between statistics and errors

Estimating additional statistical and systematic errors