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The Muon g-2 Experiment

Temperature dependence of the laser calibration signals

Francesco Carnevali

Introduction

A particle with spin has a magnetic moment $\vec{\mu}$ directed along its spin $\vec{S}$,

$$\vec{\mu} = g\frac{e}{2m}\vec{S}$$

the g-factor relates the magnetic moment to the spin.

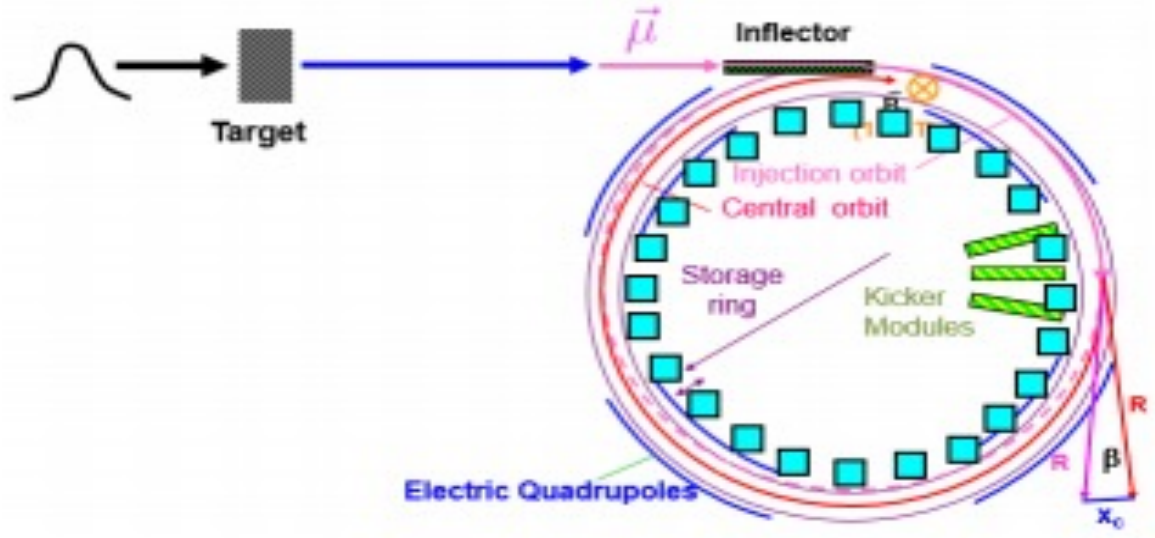
Dirac's equation predicts g=2 but quantum fluctuations produce an anomaly

$$a = \frac{g-2}{2}$$

The g-2 experiment goal is to reduce the anomaly's error from 0.54 ppm (BNL E821) to 0.140 ppm and keep the calorimeters gain's fluctuation at 0.04%.

$$a_\mu^{EXP} = a_\mu^{SM} + a_\mu^{NewPhysics}$$

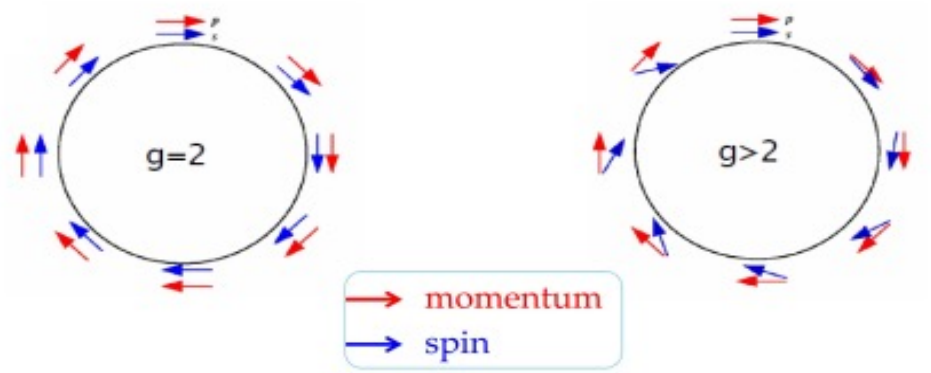
The g-2 Experiment



Store longitudinally polarized muons in a ring and observe their decay product (positrons). If g≠2 then the spin rotates faster than momentum.

- measure the uniform magnetic field $\vec{B}$
- measure the "anomalous" precession $\omega_a = \omega_s - \omega_c$

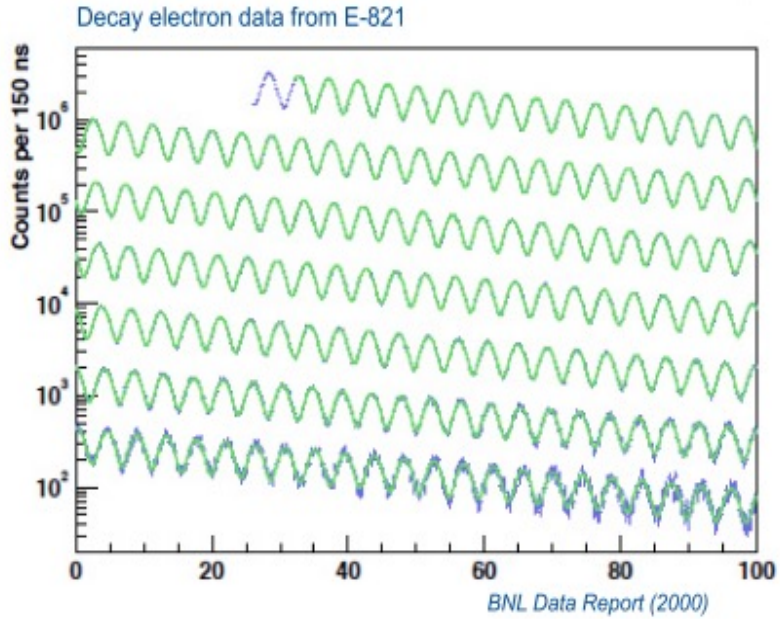
The g-2 Experiment



$$\omega_c = \frac{eB}{\gamma m}$$

$$\omega_s = g\frac{eB}{2m} + (1-\gamma)\frac{eB}{\gamma m}$$

$$a_\mu = \omega_a \frac{m}{eB}$$

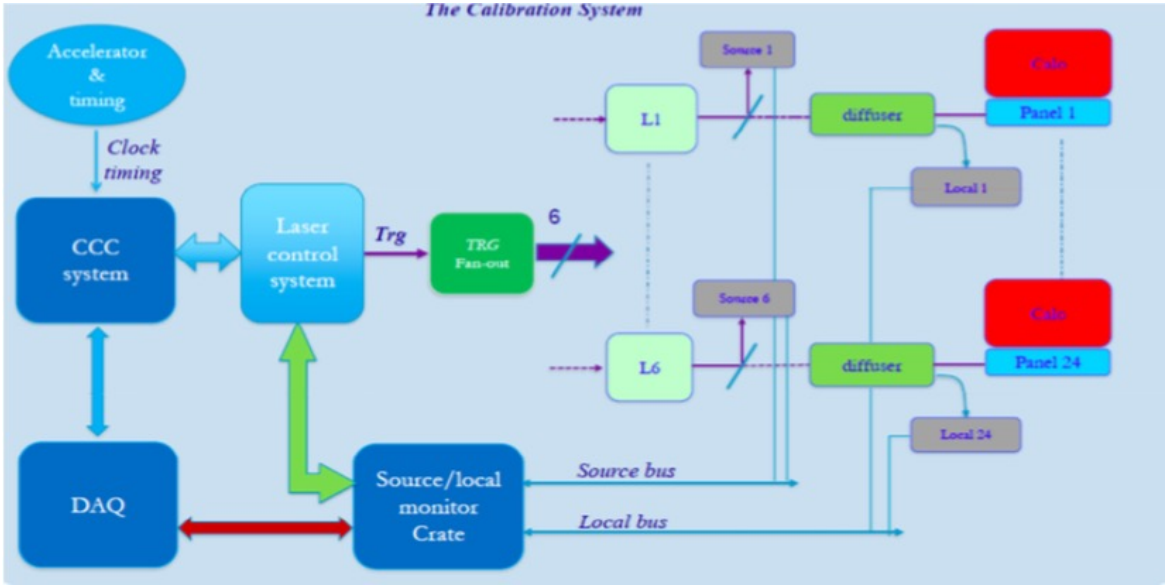


$$f(t) = N_0 e^{-\lambda t}\left[1 + A\cos(\omega_a t + \phi)\right]$$

The Laser Calibration System

Idea:

- **Send trains of laser pulses on known intensity synchronously on all calorimeters' channels**



Goals:

- **Absolute calibration of the SiPMs response**
- **Provide short term and long term (bias and temperature variations) calibration of the of the SiPM gain function.**

Time[Days]

The Laser Calibration System

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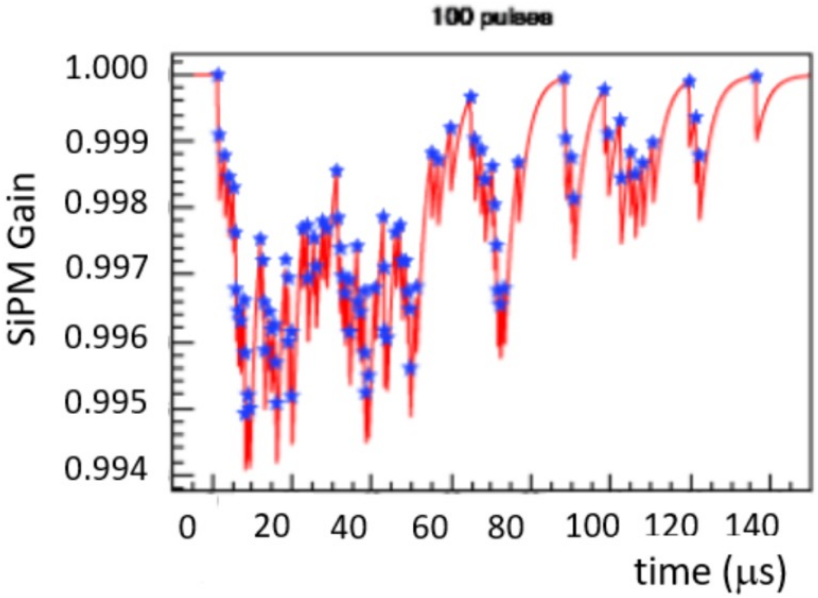
- **Send trains of laser pulses on known intensity synchronously on all calorimeters' channels**



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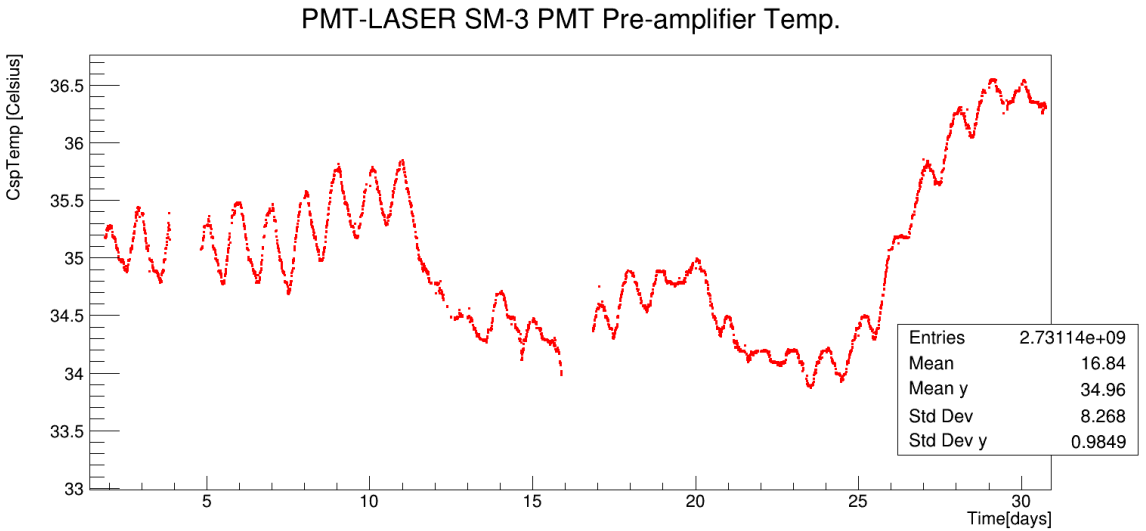

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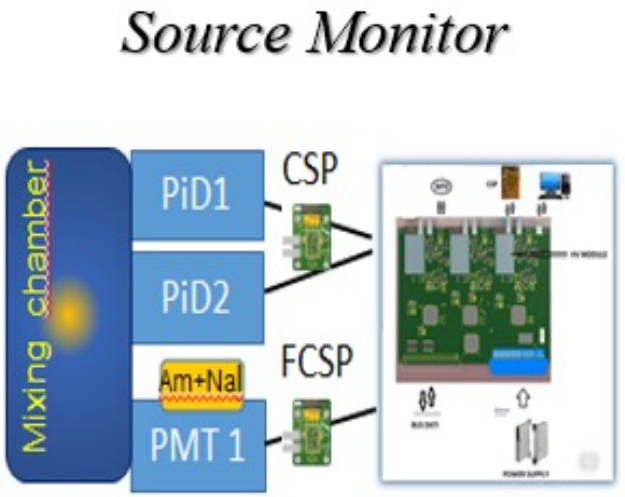
Source Monitor

The laser calibration system is made up of six Source Monitors.
They are used to check for any fluctuations in the laser source.

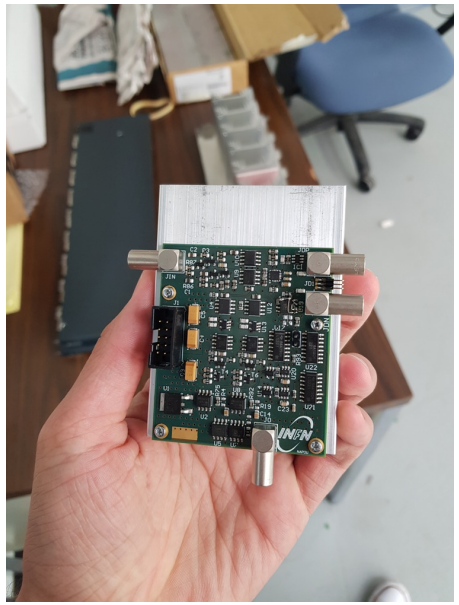


The Source Monitor are made up of:

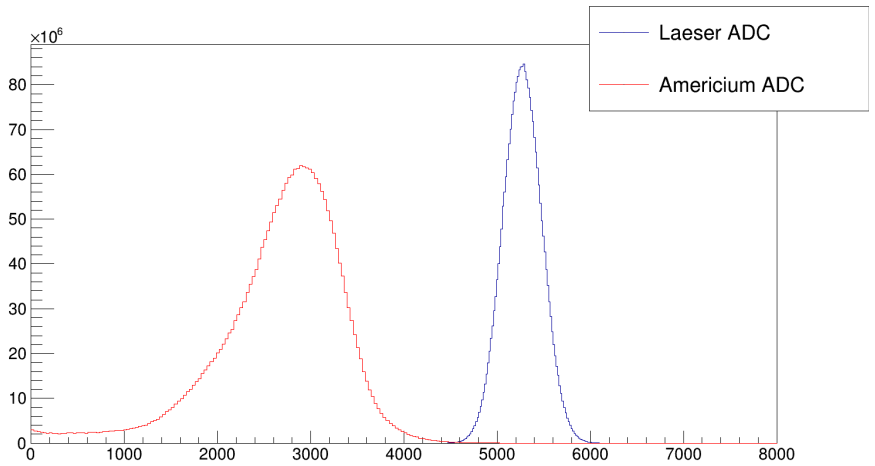
- Mixing chamber
- Two PinDiodes
- One Pmt
- Three Csp
- A source of Americium+NaI

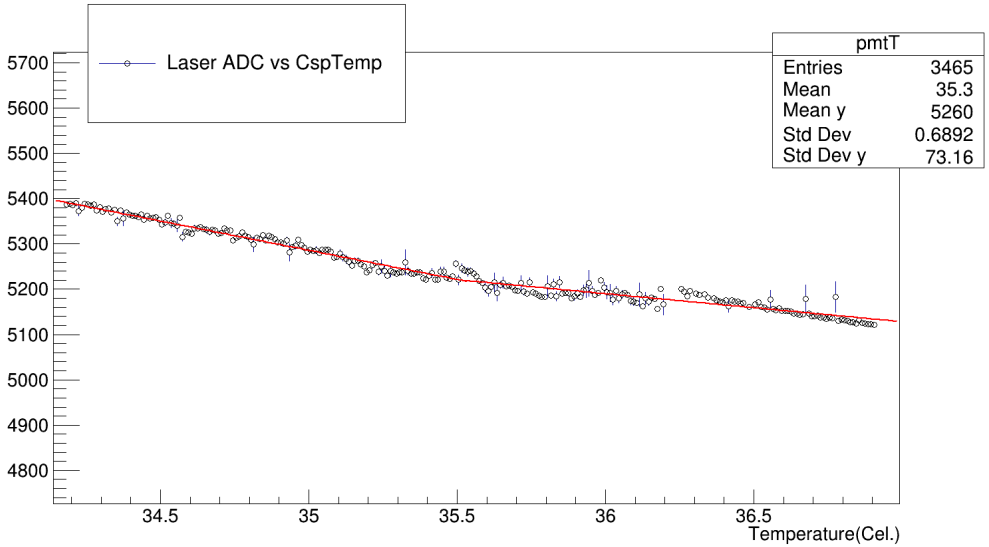
What I have done

- Installation of a new Local Monitor crate.
- Testing 24 new preamplifier.
- Analysis of the temperature-signals correlation and signals corrections of May 2018's data.
- Analysis of ω_a .

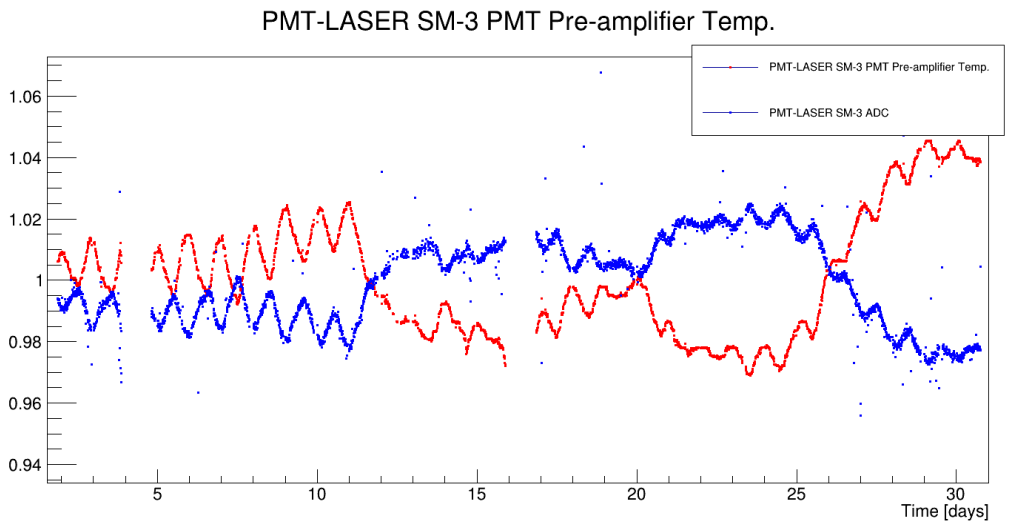


Source Monitor 3



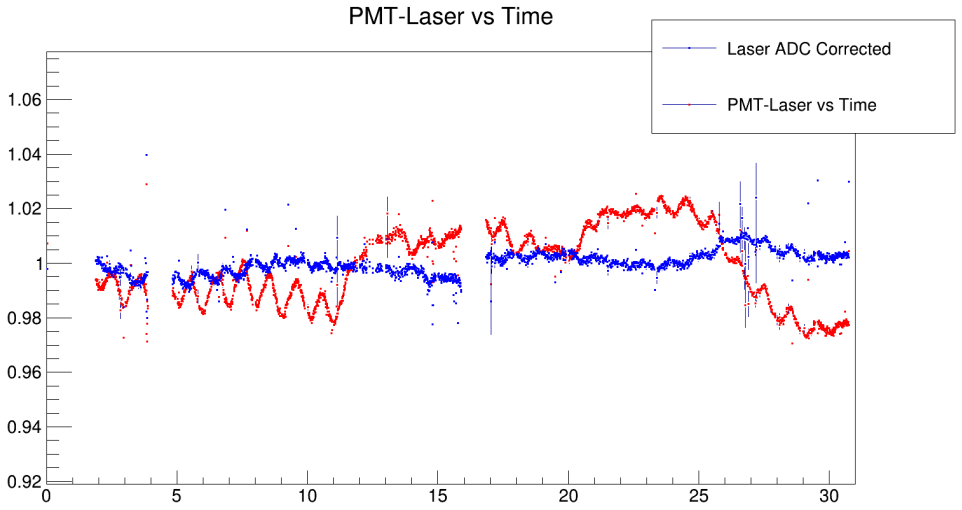


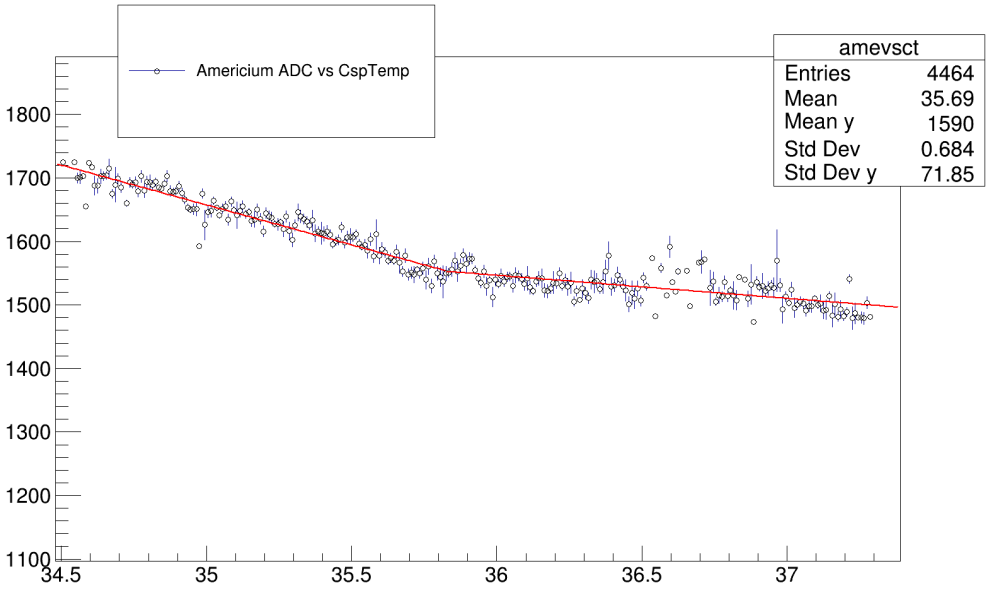
$$ADC'(t) = ADC(t) + p_1 * (T(t^*) - T(t))$$



Source Monitor 3

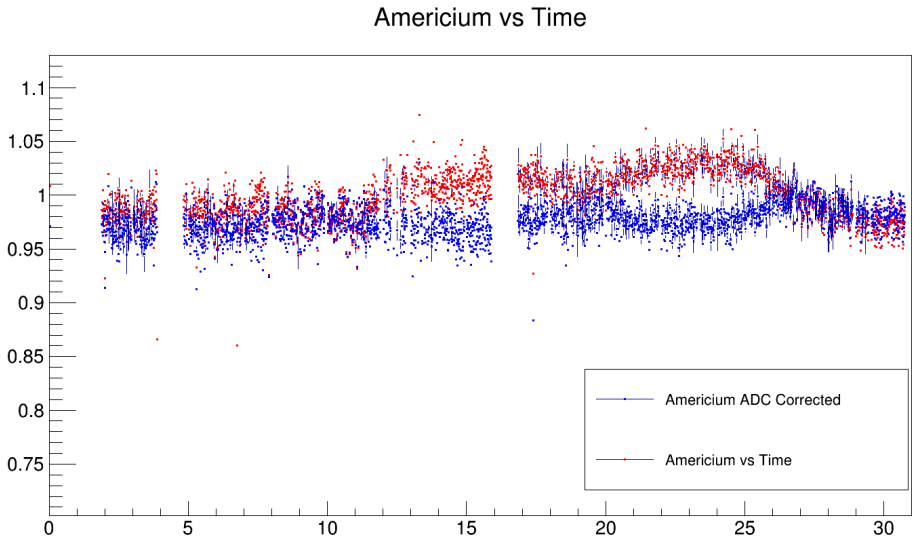
p_1[LowTemp]	P_1[HighTemp]
-132,9± 0,2	-61,2± 0,3





Source Monitor 3

p_1[LowTemp]	P_1[HighTemp]
-94,4± 0,2	-20,6± 0,2



$$p_1(Laser) = p_1(Source) + p_1(Electronics)$$
$$p_1(Americium) = p_1(Electronics)$$

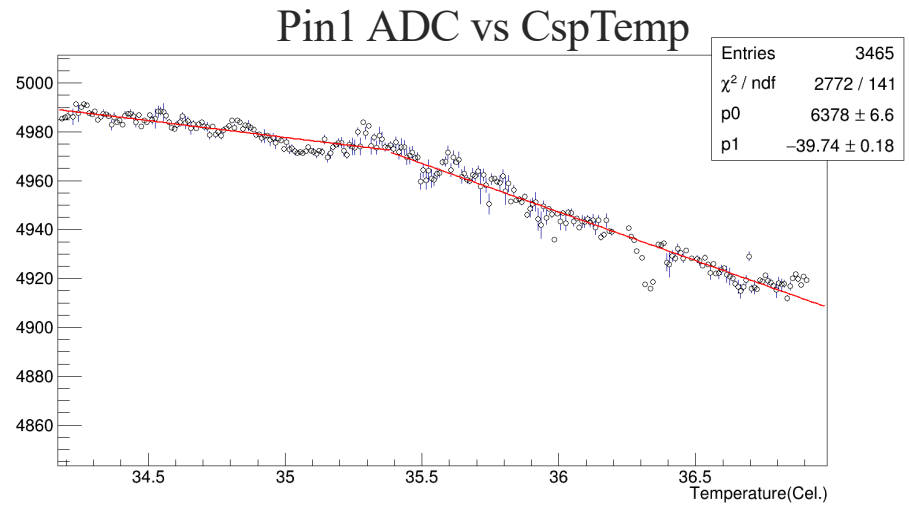
$$\frac{\Delta G}{G} = \frac{p_1(Electronics)}{ADC^*(Laser)}$$

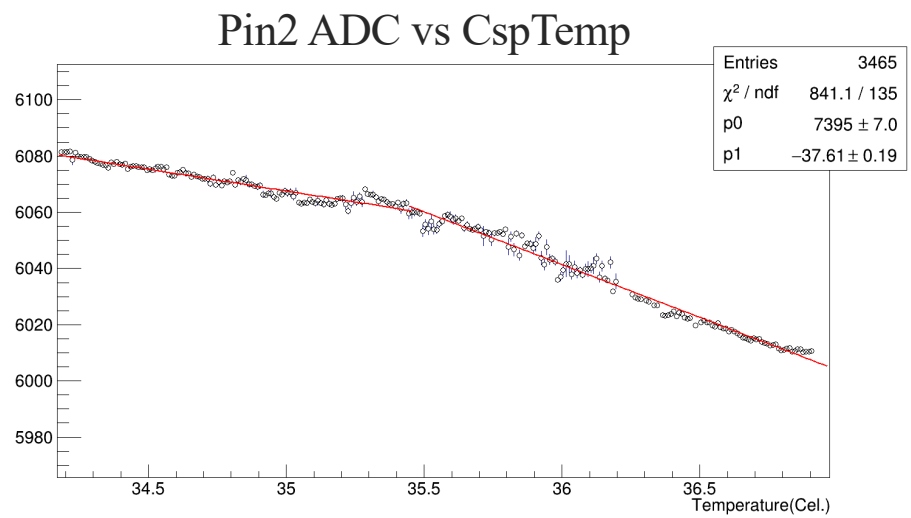
$$\frac{\Delta C(Source)}{T} = \frac{p_1(Source)}{ADC^*(Laser)}$$

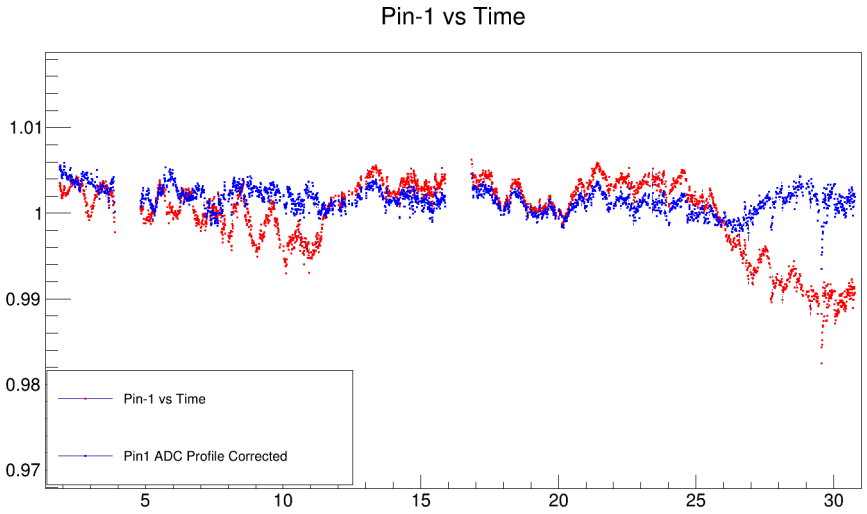
$$\frac{\Delta C(Source)}{T} = 0,75\%$$

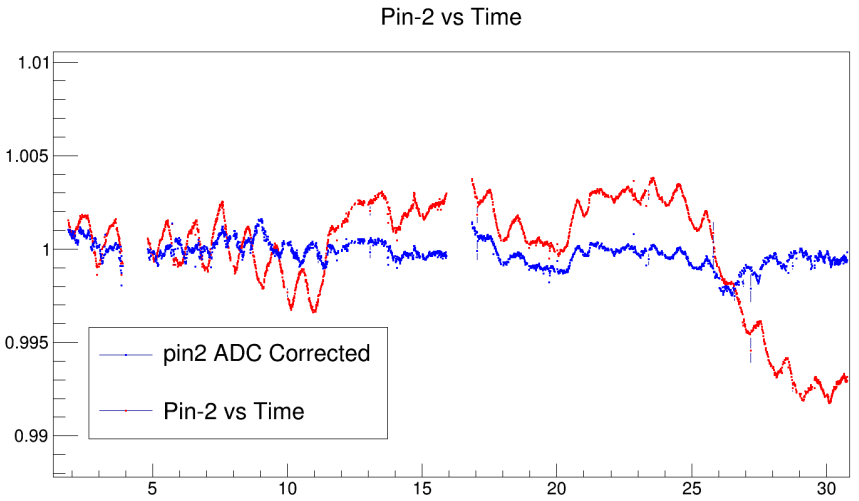
$\frac{\Delta G}{G}$ [LowTemp]	$\frac{\Delta G}{G}$ [HighTemp]
1,8%	0,4%

Source Monitor 3









Source Monitor 3

P_1 [#Counts/°C]	P_1 [LowTemp]	P_1 [HighTemp]
Pin1	-13,6±0,2	-38,9±0,2
Pin2	-15,5±0,2	-37,6±0,2
Laser	-132,9±0,2	-61,2±0,3
Americium	-94,4±0,2	-20,5±0,2

$\frac{\Delta G}{G}$ [LowTemp]	$\frac{\Delta G}{G}$ [HighTemp]
1,8%	0,4%

$$\frac{\Delta C(Source)}{T} = 0,75\%$$

Source Monitor 1

P_1 [#Counts/°C]	P_1 [LowTemp]	P_1 [HighTemp]
Pin1	-22,2±0,2	-80,0±0,2
Pin2	-29,3±0,3	-73,7±0,2
Laser	-195,7±0,2	-302,7±0,2
Americium	-14,1±0,1	

$\frac{\Delta G}{G}$ [LowTemp]	$\frac{\Delta G}{G}$ [HighTemp]
0,15%	

$$\frac{\Delta C(Source)}{T} \approx 2\%$$

Source Monitor 6

P_1 [#Counts/°C]	P_1 [LowTemp]	P_1 [HighTemp]
Pin1	-24,4±0,2	-68,1±0,2
Pin2	-32,0±0,2	-72,7±0,2
Laser	-167,4±0,1	
Americium	-125,6±0,3	-36,3±0,2

$\frac{\Delta G}{G}$ [LowTemp]	$\frac{\Delta G}{G}$ [HighTemp]
2,4%	0,7%

$$\frac{\Delta C(Source)}{T} \approx 1,6\%$$

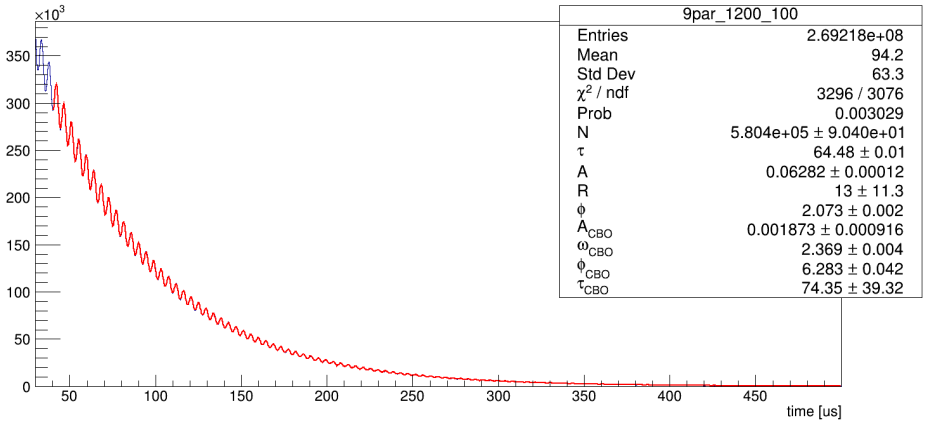
Analysis of ω_a

- Selection of events in an energy range between 1200 and 2900 MeV, with energy bins of 100 Mev.
- In each energy bin we fit wiggle plot with a 9-parameter function.
- Estimation of the R parameter.

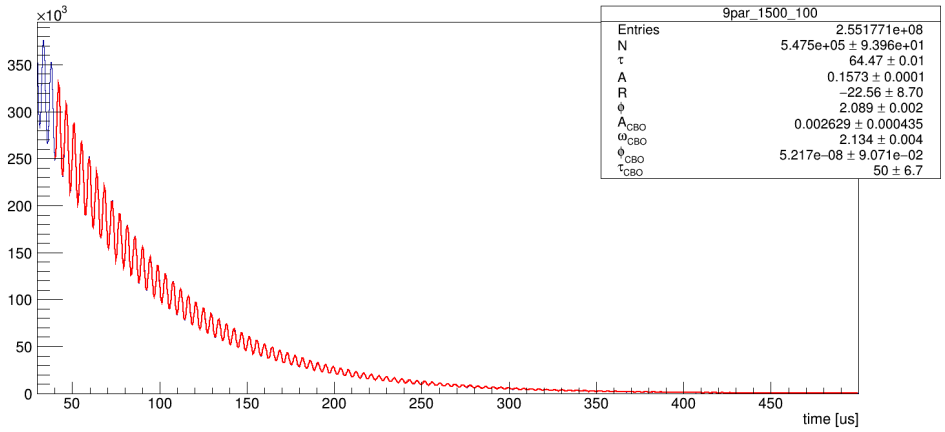
$$R = \frac{\omega - \omega_{ref}}{\omega_{ref}}(ppm)$$

Analysis of ω_a

$$f(t) = Ne^{-\frac{t}{\tau}}[1 + Acos(\omega t + \Phi)]^*[1 - e^{\frac{t}{\tau_{CBO}}} A_{CBO} cos(\omega_{CBO} t + \Phi_{CBO})]$$



1200<E(MeV)<1300



1500<E(MeV)<1600

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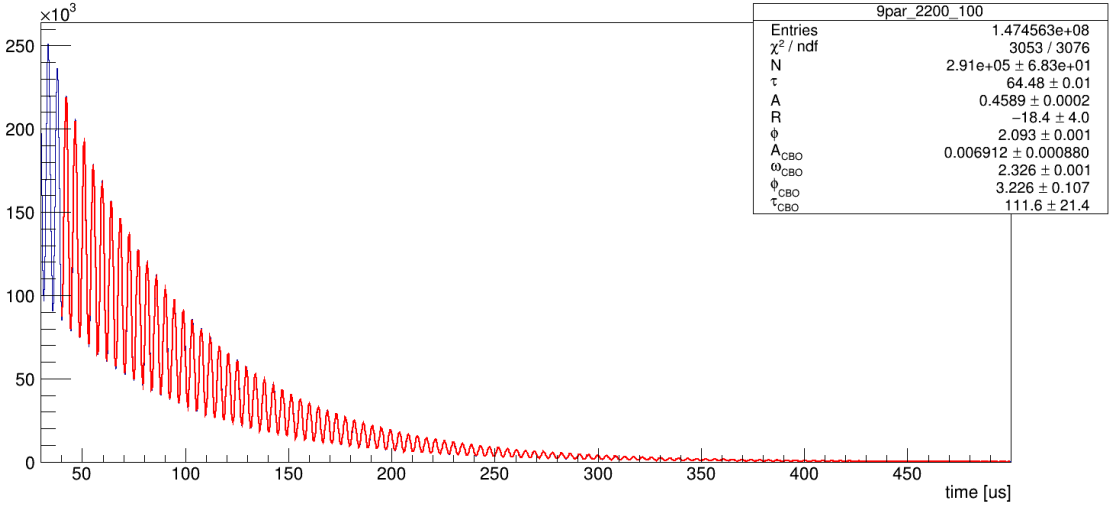
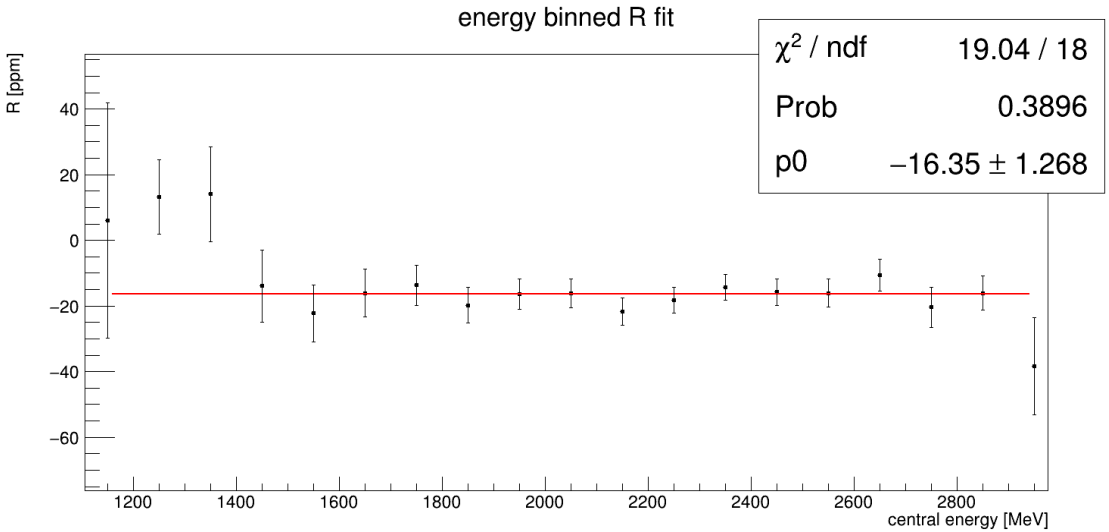
Analysis of ω_a

2200<E(MeV)<2300





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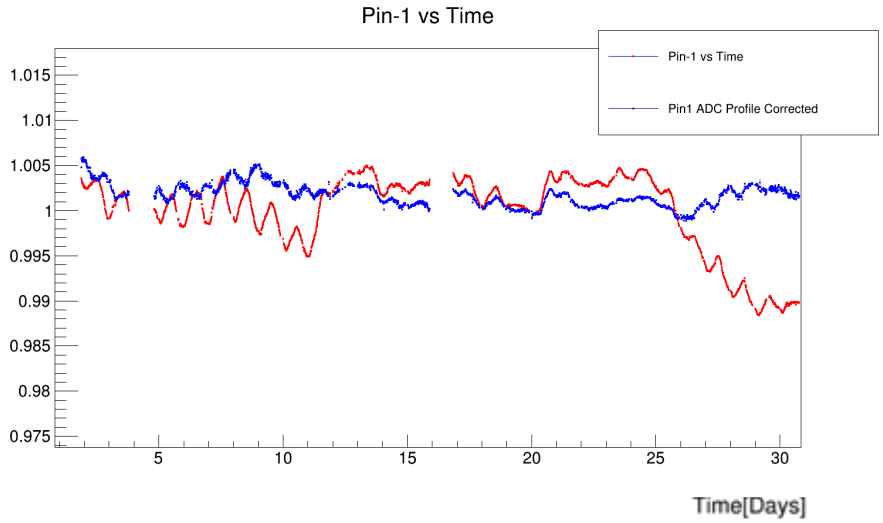
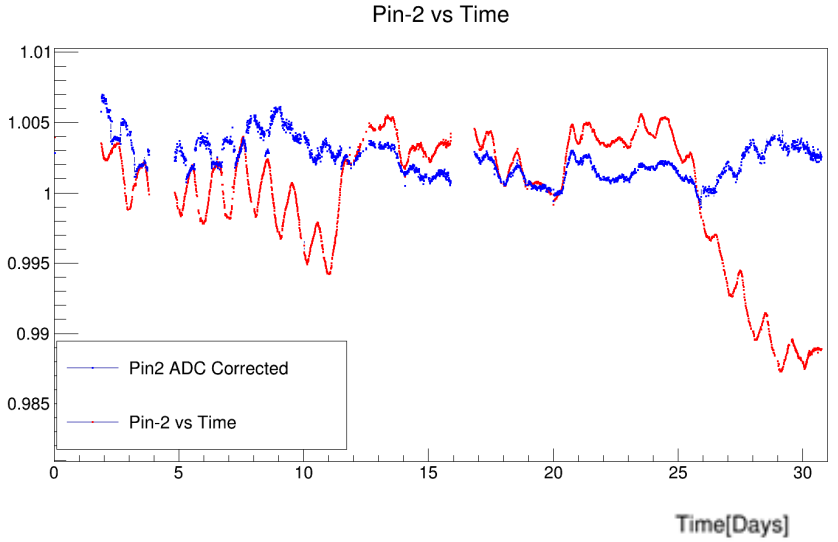
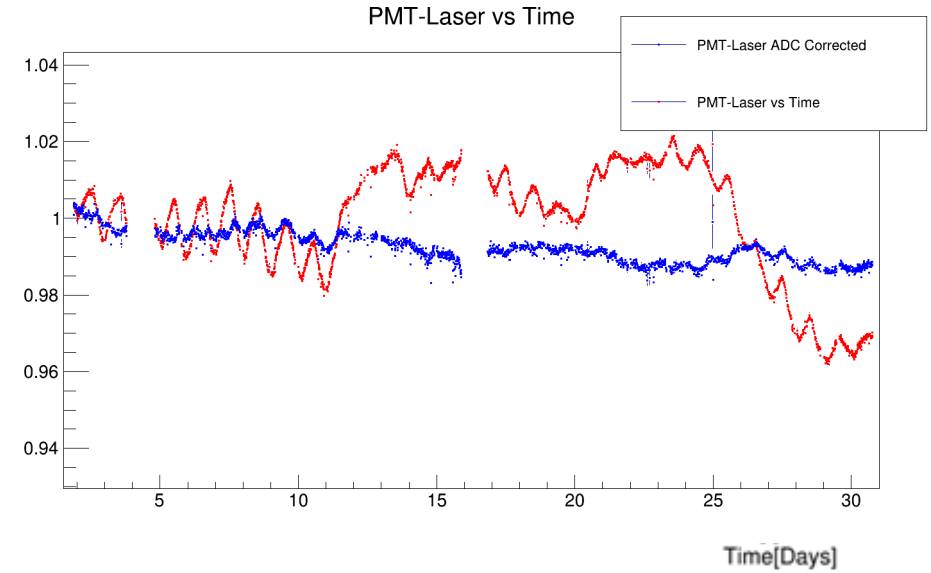
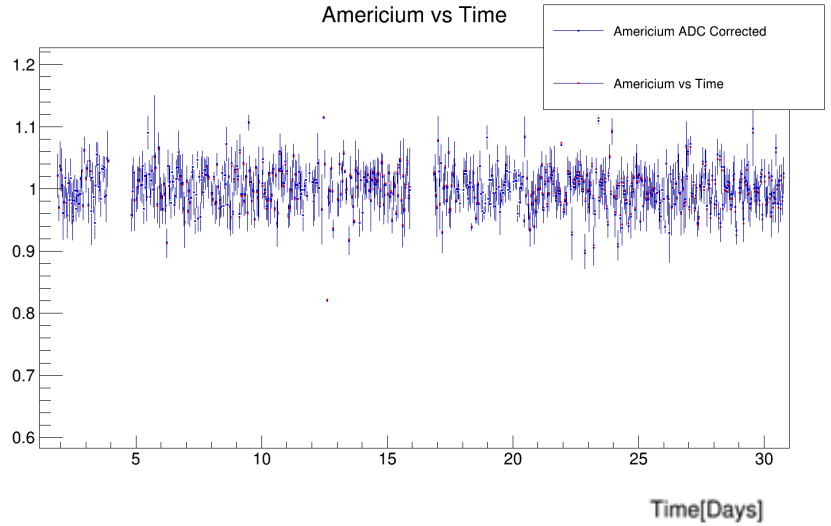
Backup

Source Monitor 1









Source Monitor 6