WP3: Muon g-2 Calibration System Update

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Summary

- Update SiPM gain drop (double pulse meas.)
- Update laser jitter measurement
- Update laser Control Board and monitor electronics

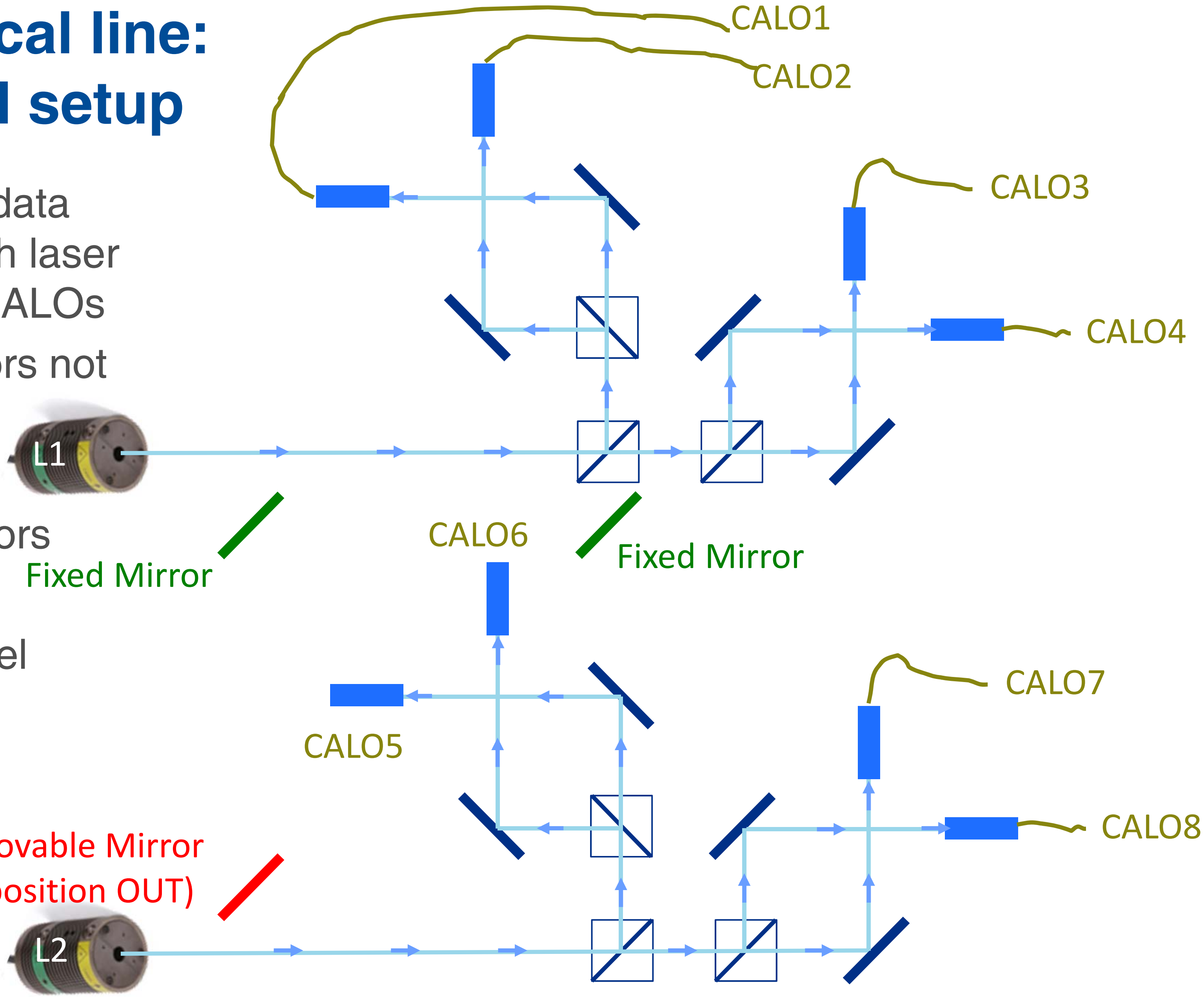
SiPM gain drop

- **Short time constant (about 30 ns)**
- SiPMs gain can decrease by as much as 4% after a positron signal, as measured with a LED in lab – NEW DATA
- **Long time constant (about 65 μs)**
- Within a muon fill (700 μm duration) the overlap of about 100 signals in a crystal due to muon decay, together with the power supply recovery time, can cause a gain drop of about 1% (as estimated by simulation)

The optical line: standard setup

- In normal data taking each laser pulses 4 CALOs
- extra mirrors not used
- each laser

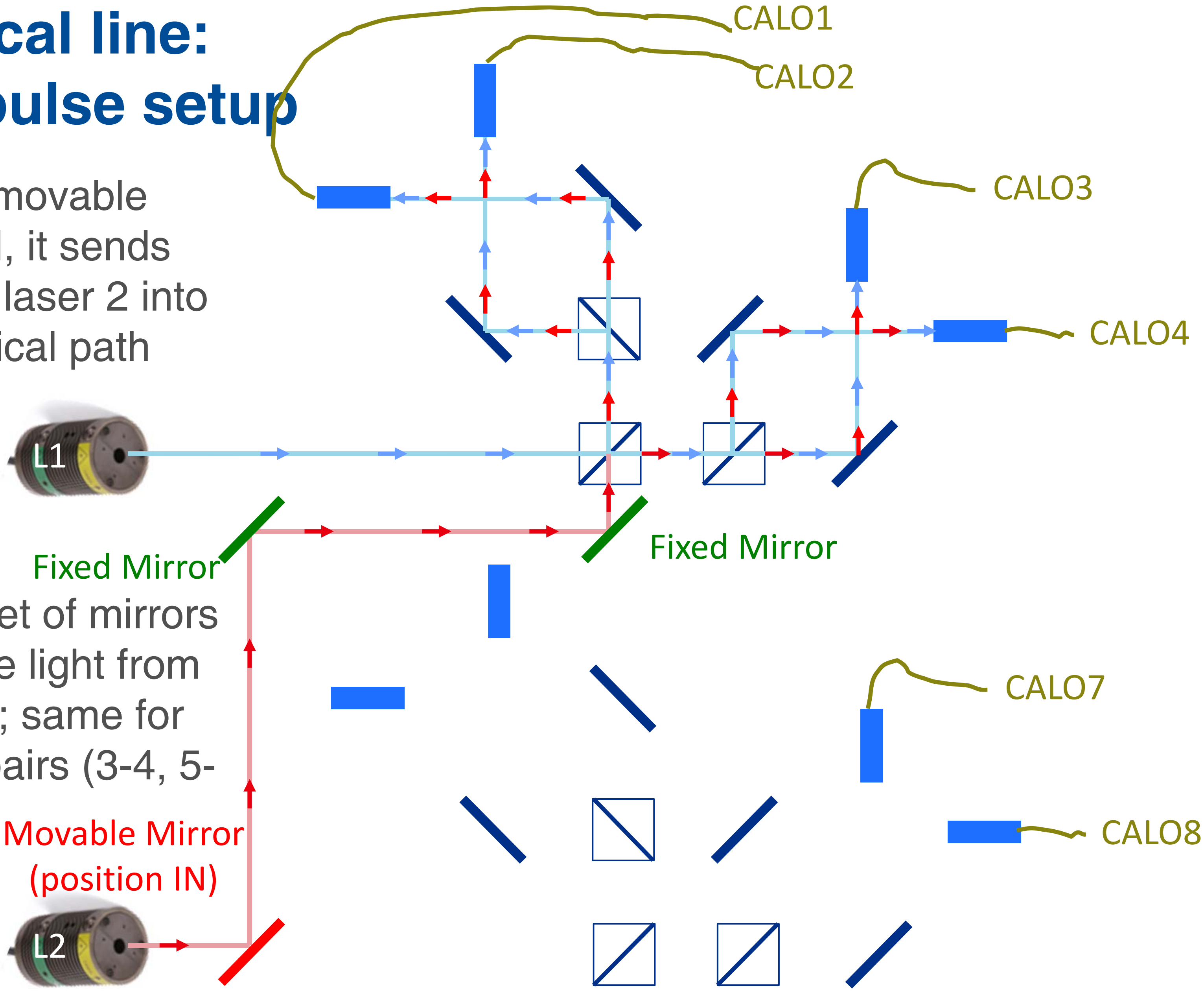
has its monitors (not plotted) and filter wheel



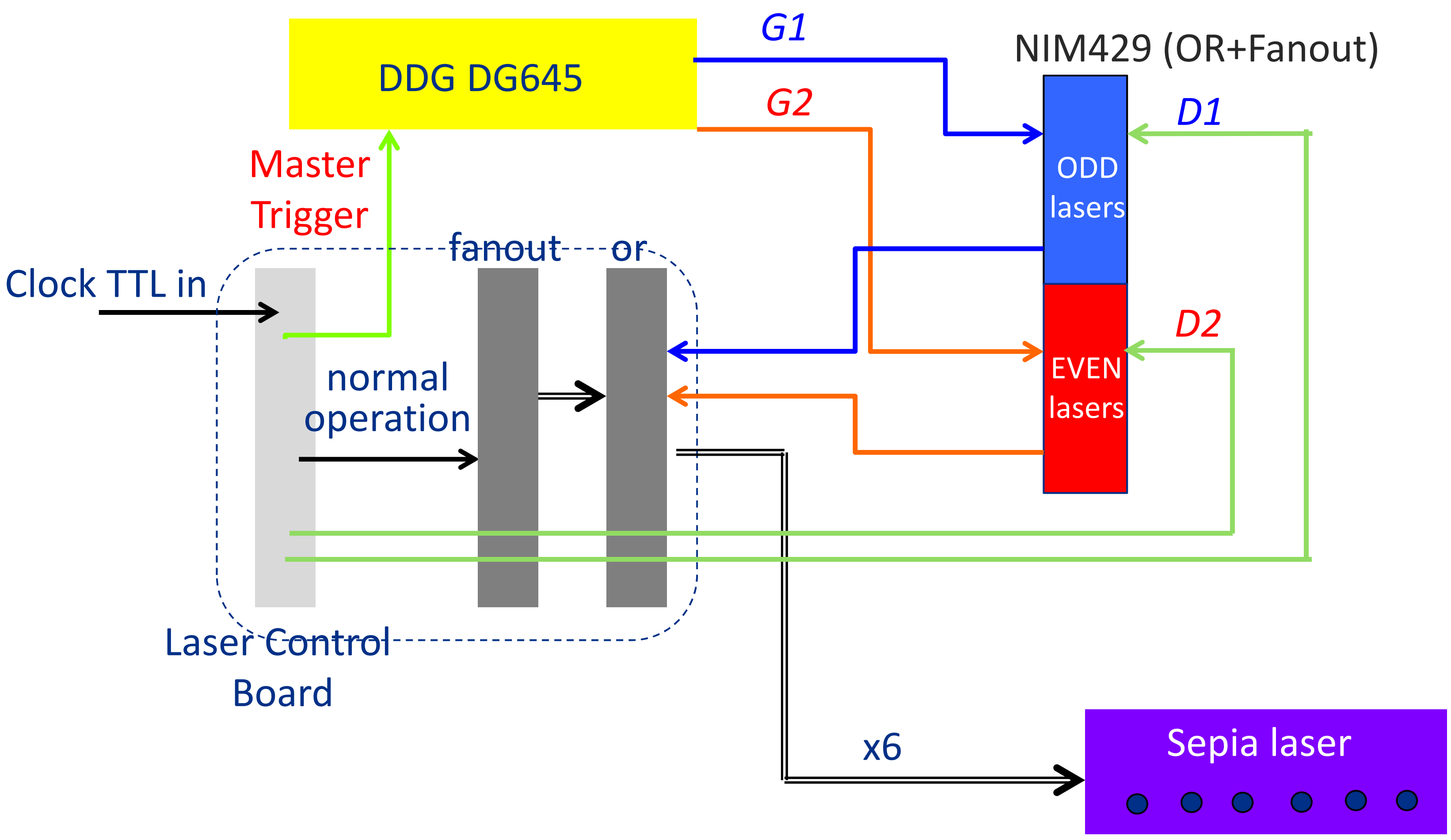
The optical line: double pulse setup

- When the movable mirror is IN, it sends the light of laser 2 into laser 1 optical path

- A similar set of mirrors deflects the light from L1 into L2 ; same for the other pairs (3-4, 5-6)

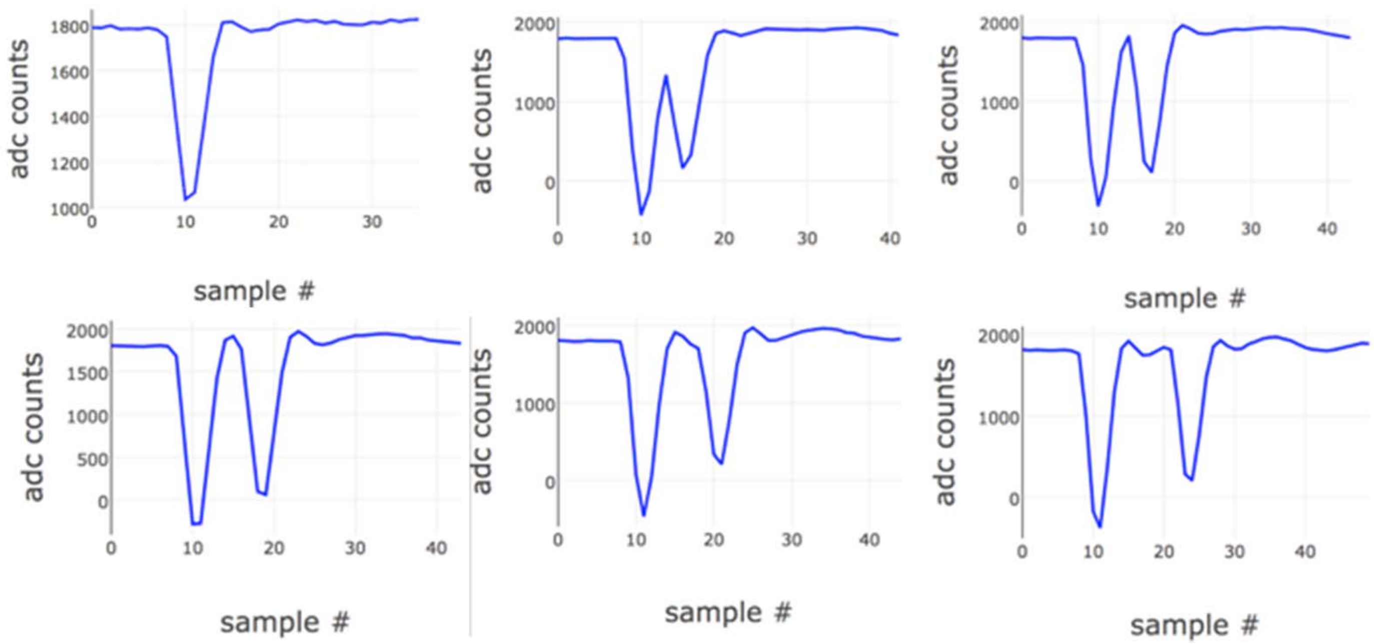


Logical scheme for Normal Data Taking and Double Pulse



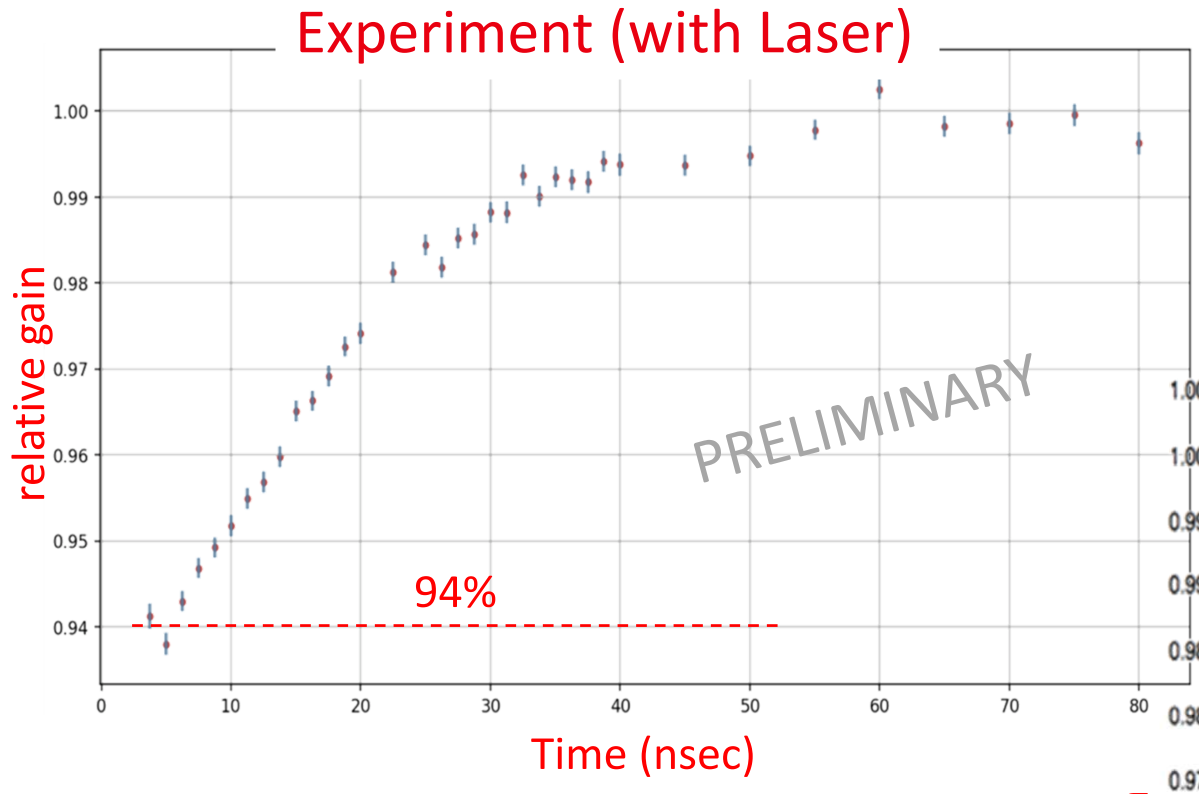
Double Pulse signal on the crystal

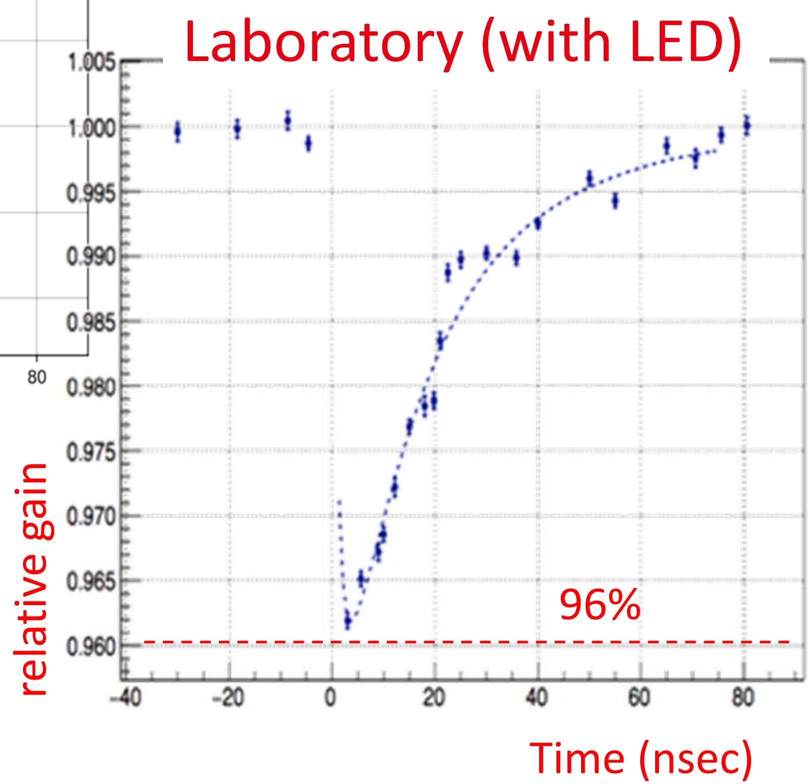
- runs 2663-2684: second laser delayed in steps of 2 nsec
  0-40 ns



- x-axis : 1 *sample* = 1.25 nsec

Preliminary gain function determination: crystal 23 of calo 17





- The behavior is well reproduced
- The gain losses seem slightly larger than expected
- Large fluctuation among crystals/SiPM

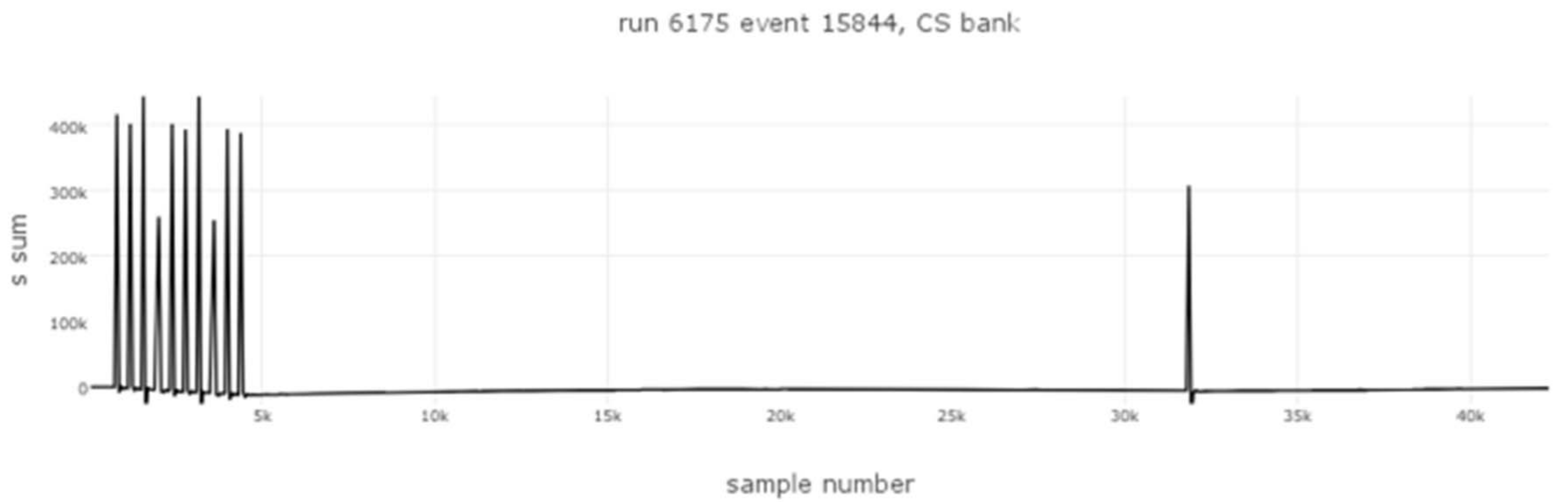
Long Term gain calibration

1. The Laser Control Board (LCB) sends a trigger to the Delay Generator (DG); this Master Trigger (MT) is a replica of the CCC input signal
2. The DG sends a *burst of triggers* to Laser1 (L1)
3. The LCB sends a *delayed* signal to Laser2 (L2) which triggers the test pulse

example:

L1: *burst* of 10 signals with a 0.5 μsec spacing at MT

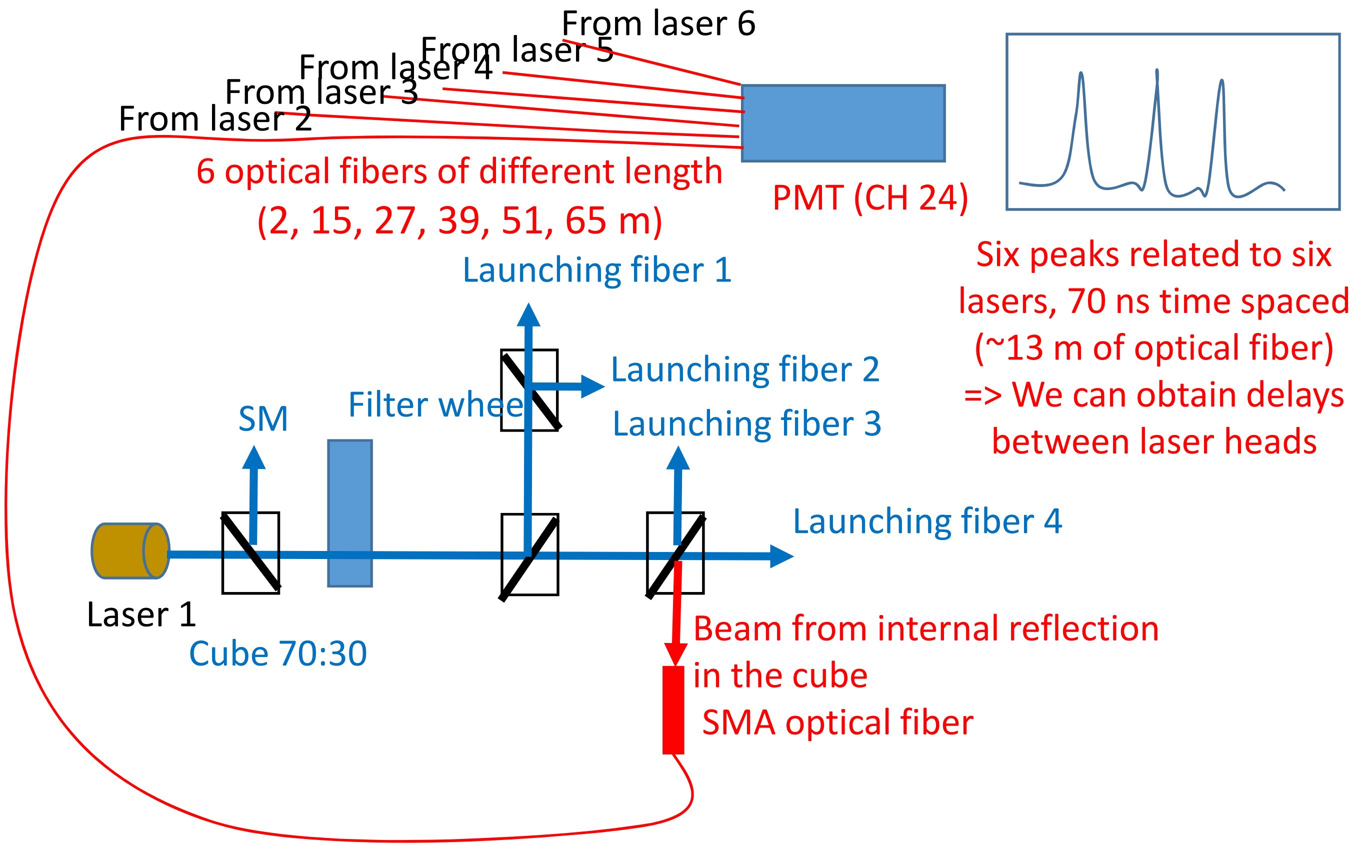
L2: *test signal delayed* by 5, 6, ..., 250 μsec wrt to MT



Results not yet analyzed

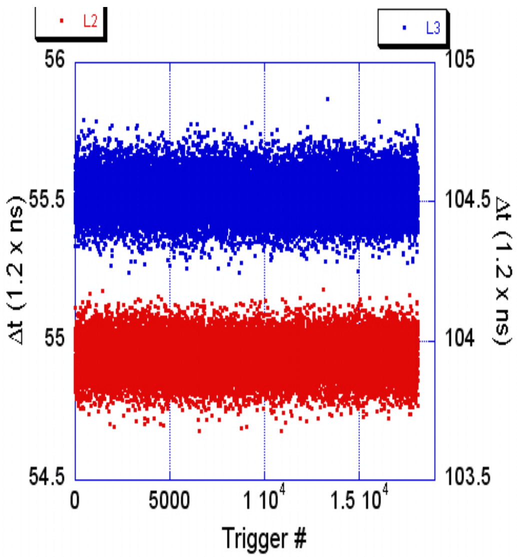
Laser jitter measurement setup

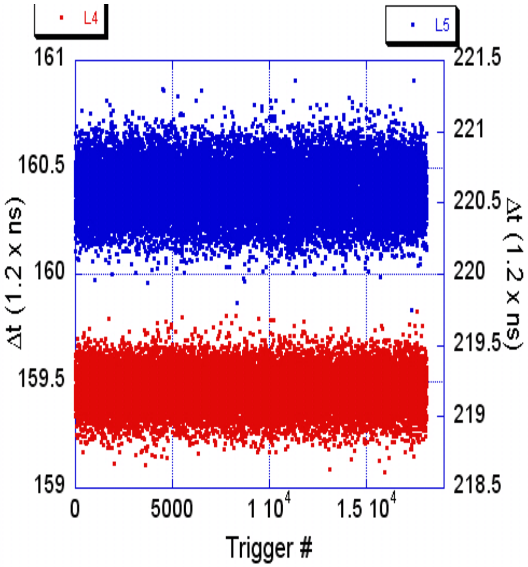
We use the spare channel in the front end board, 1 PMT, 1 CH of the uTCA

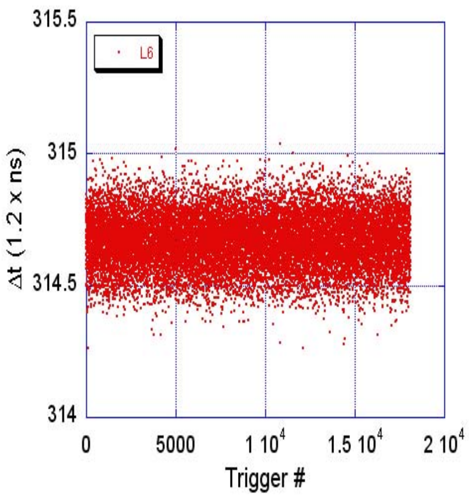


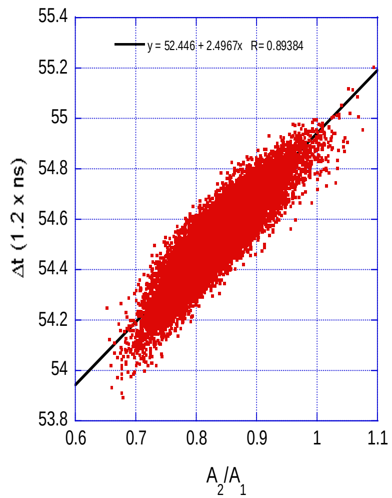
Preliminary results: run 5755

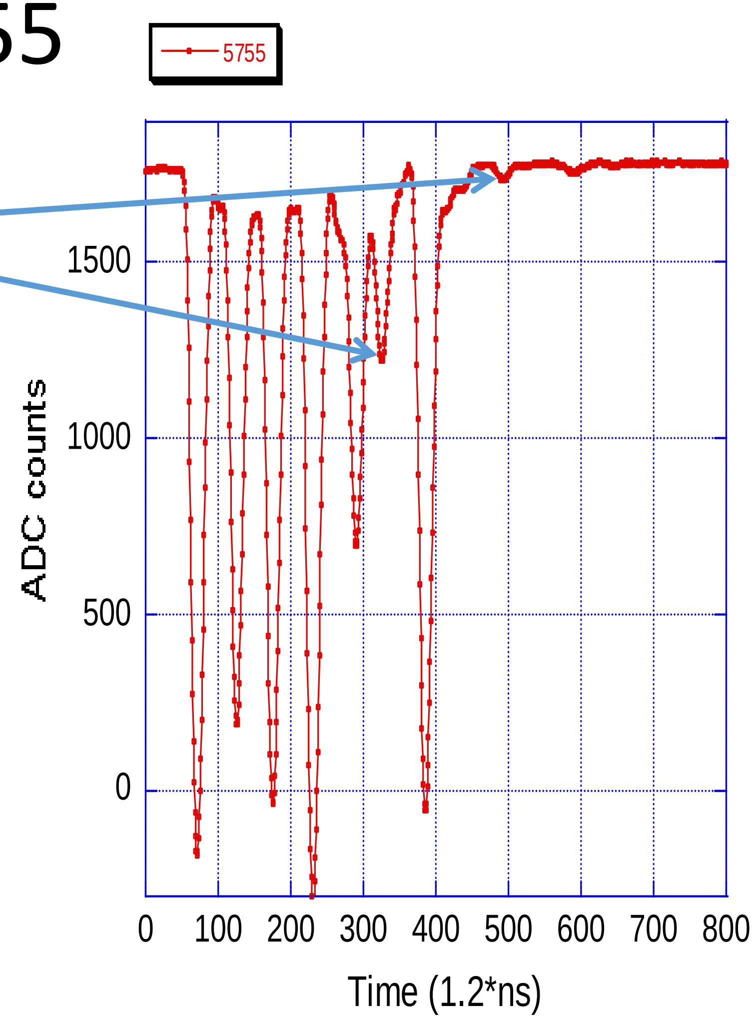
Unwanted reflection at the end of the launching fibers









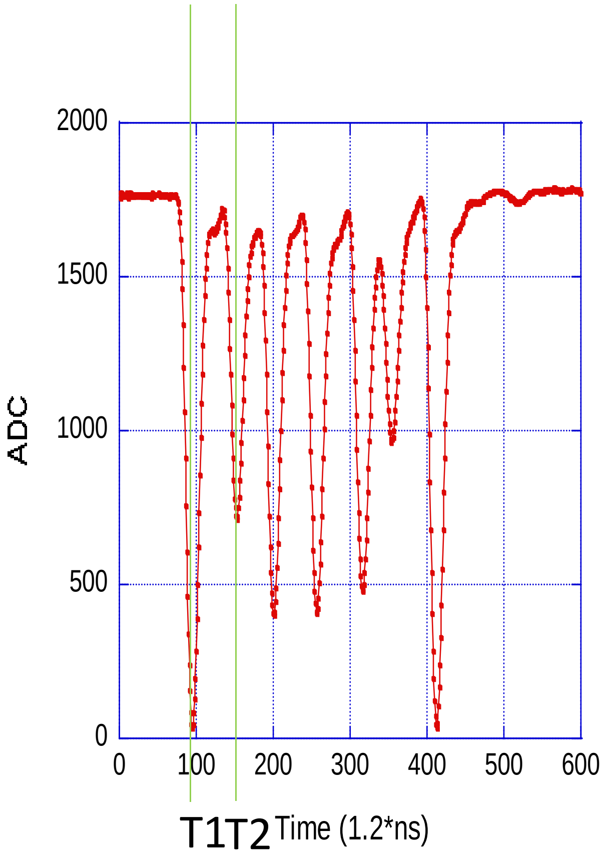


Spread > 0.6 ns

Jitter ~ 0.1 ns ?

Exploitation of the double pulse configuration

It is possible to cancel the contribution of the optical fiber length: beam from laser head 2 is delivered through optical fiber 1



	STD config.	Double pulse config.
T1 = delay peak fiber 1	$\delta t1+L1/v$	$\delta t2+L1/v+\delta L_{1-2}$
T2 = delay peak fiber 2	$\delta t2+L2/v$	$\delta t1+L2/v+\delta L_{2-1}$
Δt_{2-1} = T2 – T1	$(\delta t2-\delta t1)+(L2-L1)/v$	$(\delta t1-\delta t2)+(L2-L1)/v$

$$(\Delta t_{2-1})_{STD} - (\Delta t_{2-1})_{DP} = 2*(\delta t2-\delta t1)$$

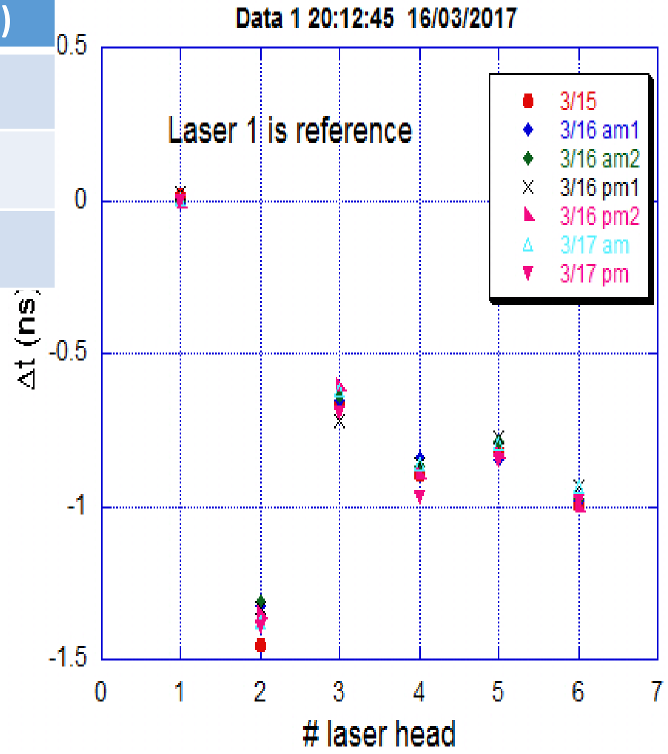
$$(\Delta t_{4-3})_{STD} - (\Delta t_{4-3})_{DP} = 2*(\delta t4-\delta t3)$$

$$(\Delta t_{6-5})_{STD} - (\Delta t_{6-5})_{DP} = 2*(\delta t6-\delta t5)$$

Jitter of the laser heads

Comparison with previous measurement

Laser	$(\Delta t_{x-(x-1)})_{STD}$	$(\Delta t_{x-(x-1)})_{DP}$	$(\Delta t_{STD}-\Delta t_{DP})/2$ (1.25 ns)	Delay laser (ns)	Delay laser DRS4 (ns)
2 – 1	54.534	57.833	-1.65	-1.98	-1.4
4 – 3	55.459	55.816	-0.18	-0.21	-0.25
6 – 5	95.113	96.240	-0.56	-0.68	-0.15



Improvements (next summer?):

- New sampling optics (to avoid unwanted reflections)
- Long fibers made of silica (better photostatistic)
- New front-end electronics (without shaper)
- Better fit procedure

Measurement with old PMT,
DRS4 digitizer (5 GS/s) , without front-end
and different trigger electronics

Deliverable D1.1

The Naples crew is currently writing the report requested for the deliverable D1.1, due in month 24.

Also, a paper is ready to be published, regarding the laser control board

The laser control of the muon g-2 experiment at Fermilab

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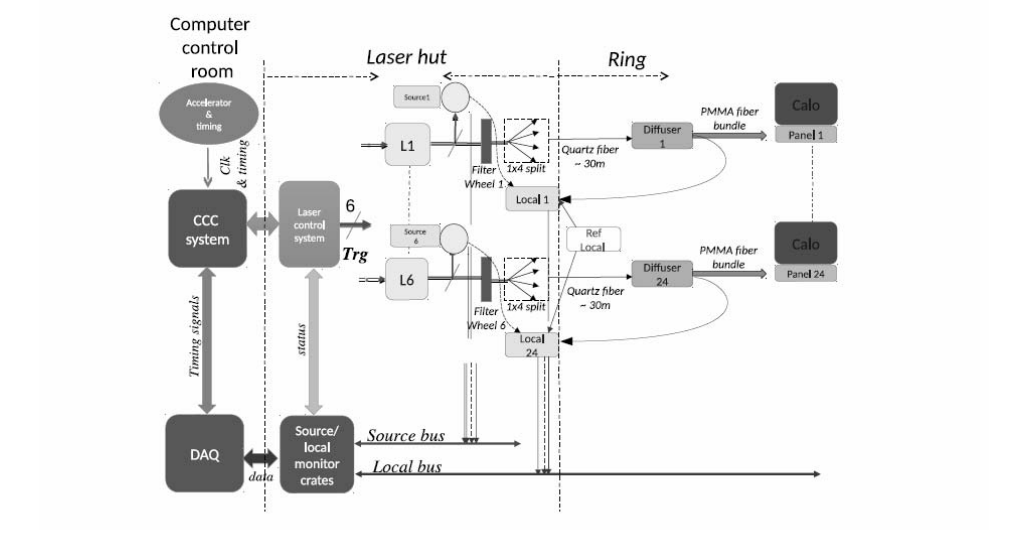

Figure 1: Schematic drawing of the laser calibration to provide light calibration pulses to the calorimeters. The light pulses are monitored through the monitoring electronics both at the source, or at laser output, Source Monitor, and at the end of the distribution system, Local Monitor, before delivery to the calorimeters.

Abstract

The Muon g-2 E ... s magnetic moment, $a_\mu = (g_\mu - 2)/2$ to an unprecedented precision: the goal is 0.14 parts per million (ppm). The new experiment will require upgrades of detectors, electronics and data acquisition equipment to handle the much higher data volumes and slightly higher instantaneous rates. In particular, it will require a continuous monitoring and state-of-art calibration of the detectors, whose response may vary on both the millisecond and hour long timescale.
The calibration system is composed of six laser sources and a light distribution system will provide short light pulses directly into each crystal (54) of the 24 calorimeters which measure energy and arrival time of the decay positrons.
A Laser Control board will manage the interface between the experiment and the laser source, allowing the generation of light pulses according to specific needs including detector calibration, study of detector performance in running conditions, evaluation of DAQ performance.
Here we present and discuss the main features of the Laser Control board.

Keywords: Laser Calibration, FPGA