MUSE

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WP3: Muon g-2 Calibration System Update

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MUSE Scientific Board Meeting

Apr 24th 2017

Outline

- HW frozen, there have been no major changes in recent months
- Slow control and DQM completed
- Gain stability monitor: the first significant result
- The main area of work concerns the development of data analysis software

Slow control of the system

Source Monitors settings

Local Monitors settings

Filters setting

Laser hut temperature detectors monitor

Laser Slow Control

Laser traces - Muon Fill view

Last update Mon Apr 23 2018 15:57:56 GMT+0200 (CEST)

Source Monitor Bias Voltage

Last time Mon Apr 23 2018 15:57:05 GMT+0200 (CEST)

SM DEV	PMT SET	PMT MON	PID 1 SET	PID 1 MON	PID 2 SET	PID 2 MON
SM 1	0.63	0.63	49.14	49.22	7.80	8.30
SM 2	0.54	0.53	49.14	49.21	49.14	49.28
SM 3	0.60	0.60	49.14	49.18	49.14	49.29
SM 4	0.69	0.69	49.14	49.27	49.14	49.04
SM 5	0.65	0.65	49.14	49.43	70.00	70.25
SM 6	0.60	0.59	49.14	49.57	49.14	49.35

Devices reachable on network

Last time Mon Apr 23 2018 15:57:30 GMT+0200 (CEST)

DEVICE	NETWORK RESPONSE
LASER CONTROL BOARD	IS ALIVE
SOURCE MONITOR BOARDS CONTROLLER	IS ALIVE
LOCAL MONITOR HV	IS ALIVE
DELAY GENERATOR	IS ALIVE
LASER HUT WORKSTATION	IS ALIVE
SOURCE MONITOR WORKSTATION	IS ALIVE

Laser Driver

Last time Mon Apr 23 2018 15:57:09 GMT+0200 (CEST)

LASER	CURRENT SETTINIG	CURRENT MONITORING	INTERLOCK STATUS
1	0.9	0.9	UNLOCKED
2	0.9	0.9	UNLOCKED
3	0.9	0.9	UNLOCKED
4	0.9	0.9	UNLOCKED
5	0.9	0.9	UNLOCKED
6	0.9	0.9	UNLOCKED

Local Monitor High Voltage Power Supply

Last time Mon Apr 23 2018 15:57:30 GMT+0200 (CEST)

HV CH	HV SET	HV MONITOR	I MON	STATUS	POWER
0	635	635.33	148.59	1	ON
1	585	585.36	137.47	1	ON
2	585	585.38	135.80	1	ON
3	555	555.28	130.36	1	ON
4	635	635.29	149.29	1	ON
5	550	550.35	128.82	1	ON
6	545	545.26	127.33	1	ON
7	510	510.30	119.20	1	ON
8	585	585.34	136.78	1	ON
9	590	590.35	137.91	1	ON
10	525	525.38	123.50	1	ON
11	525	525.34	122.54	1	ON
12	535	535.33	124.98	1	ON
13	545	545.48	127.38	1	ON
14	550	550.45	128.60	1	ON
15	540	540.45	126.91	1	ON
16	500	500.37	116.82	1	ON
17	510	510.40	119.90	1	ON
18	510	510.26	119.15	1	ON
19	500	500.38	116.84	1	ON
20	580	580.42	135.63	1	ON
21	535	535.51	125.87	1	ON
22	550	550.35	128.47	1	ON
23	560	560.34	130.80	1	ON
24	650	650.40	152.00	1	ON
25	1100	1100.31	154.70	1	ON
26	1100	1100.34	154.50	1	ON
27	980	980.39	137.75	1	ON
28	1000	1000.38	140.45	1	ON
29	1000	1000.36	140.58	1	ON
30	0	2.66	0.07	0	OFF
31	0	2.59	0.03	0	OFF
32	0	1.15	0.03	0	OFF

Filter wheels actual position

Last time Thu Mar 01 2018 23:40:50 GMT+0100 (CET)

NUMBER	1	2	3	4	5	6
POSITION	6	6	6	6	6	6
TRASMISSION	0.37	0.37	0.37	0.35	0.35	0.37

Flip Mirrors actual position

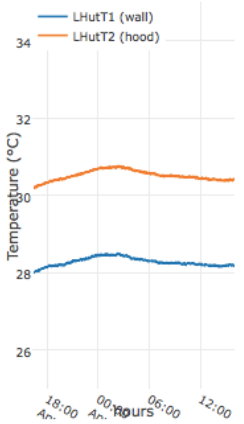
Last time Mon Apr 23 2018 15:57:10 GMT+0200 (CEST)

NUMBER	1	2	3	4	5	6
MIRROR POSITION	DOWN	DOWN	DOWN	DOWN	DOWN	DOWN

Mirrors for double pulse

Temperature Monitor

Last time Mon Apr 23 2018 15:57:11 GMT+0200 (CEST)
Last 24 hours



Laser heads setting

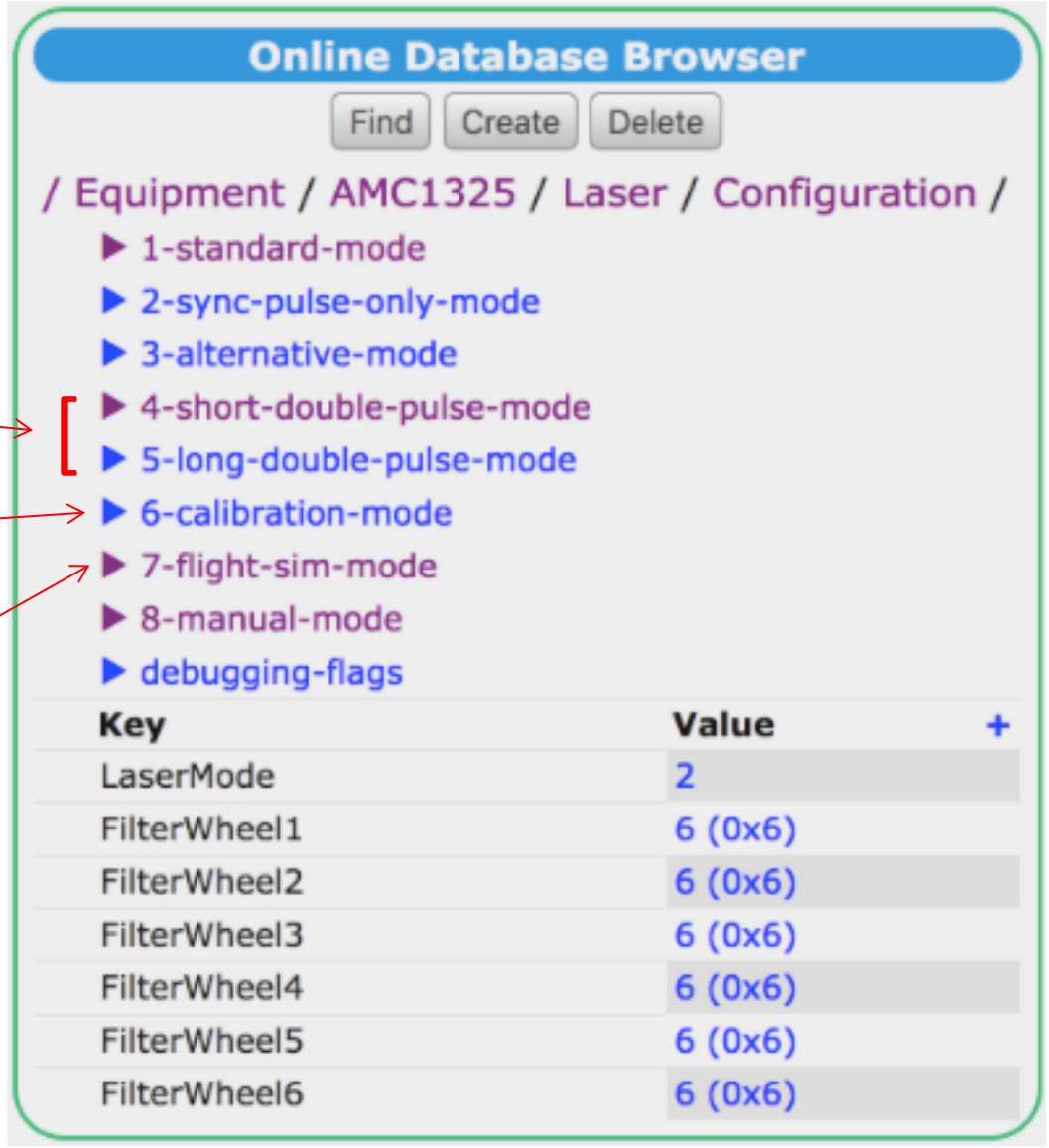
Network connectivity

Laser operation modes

Double pulse studies

Calorimeters SiPMs calibration

Muon beam simulation



Laser system wiki pages

Muon g-2

Search:

+ Overview Activity Roadmap Issues Calendar News Documents Wiki Forums Files Repository HTML

Wiki »

Watch History

Laser WIKI page

Introduction

This page contains stable and reliable enough information on the Muon g-2 laser calibration system.

For transient on-the-spot information please use the elog sites:

- https://muon.npl.washington.edu/elog/g2/Laser+Calibration+System/ for analysis related logs
  - ask UW people for an account, otherwise use G2Muon...
- http://dbweb5.fnal.gov:8080/ECL/gm2/E/index?category_id=21 for operational & shift logs
  - must use your FNAL services password, it is part of FNAL logbook services

Information

- how to edit and contribute
- General instruction for New Users

Software

- Offline
- Online and ODB
- Calibration
- Database and Slow Control

https://cdcvs.fnal.gov/redmine/projects/g-2/wiki/Laser

Hardware

- Hardware maps
- High Voltage System (Local Monitor and Source Monitor)
- Laser related hardware (laser control i.e. Sepia II, ...)

Procedures and Plots

- Laser System for Shifters
- Procedure for Double Pulse
- Procedure for Filter Wheel Calibration
- Procedure for Flight Simulator
- Laser performance plots

Laser system importance

Category	E821 [ppb]	E989 Improvement Plans	Goal [ppb]
Gain changes	120	Better laser calibration	
		low-energy threshold	20
Pileup	80	Low-energy samples recorded	
		calorimeter segmentation	40
Lost muons	90	Better collimation in ring	20
CBO	70	Higher n value (frequency)	
		Better match of beamline to ring	< 30
E and pitch	50	Improved tracker	
		Precise storage ring simulations	30
Total	180	Quadrature sum	70

Laser System Role:

Key element

Helps (timing)

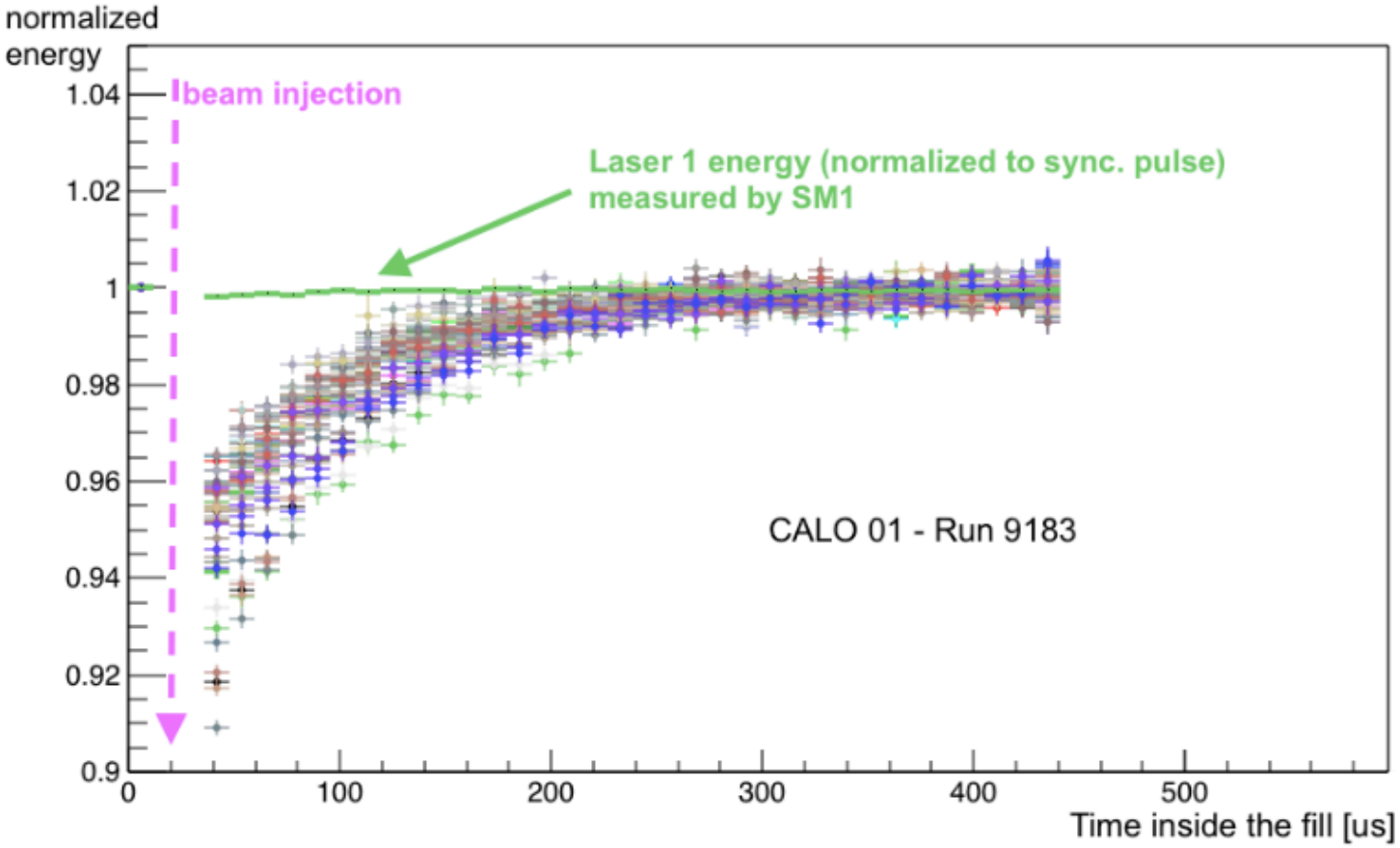
Helps (timing)

Beam related effects

- The Laser is the key element in reducing the *overall (including effects on B, not listed here)* largest systematic error and it contributes to the reduction of 2nd and 3rd largest effects on ω_a

Gain stability over a fill

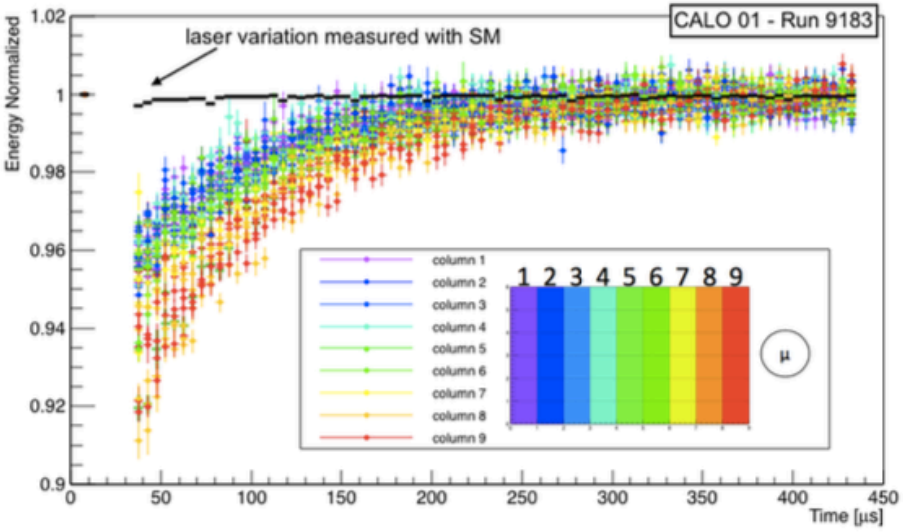
- Jan 2018: first measurement of the gain sag due to beam
- Done by pulsing the laser during muon fills
- Measured an effect much larger than anticipated: ~8% vs. <1%



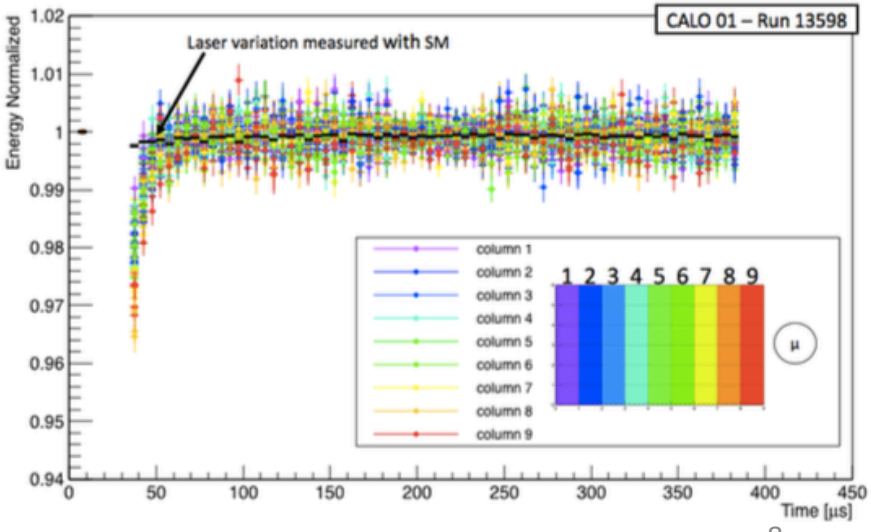
Gain stability over a fill

- Two main effects:
  - Splash at beam injection causing a bigger drop in the calorimeters near injection site
  - Power supply recovery over the fill
- Three laser studies to characterize them
  - Flight simulator
  - Flight simulator with splash
  - Long-time double pulse with splash
- A HW fix was devised and mounted on the calorimeter power supplies: MegaBoxes
- The laser studies were extended to the case of beam present, to check the effectiveness of the MegaBoxes: MegaBoxes do mitigate the gain sag due to the splash

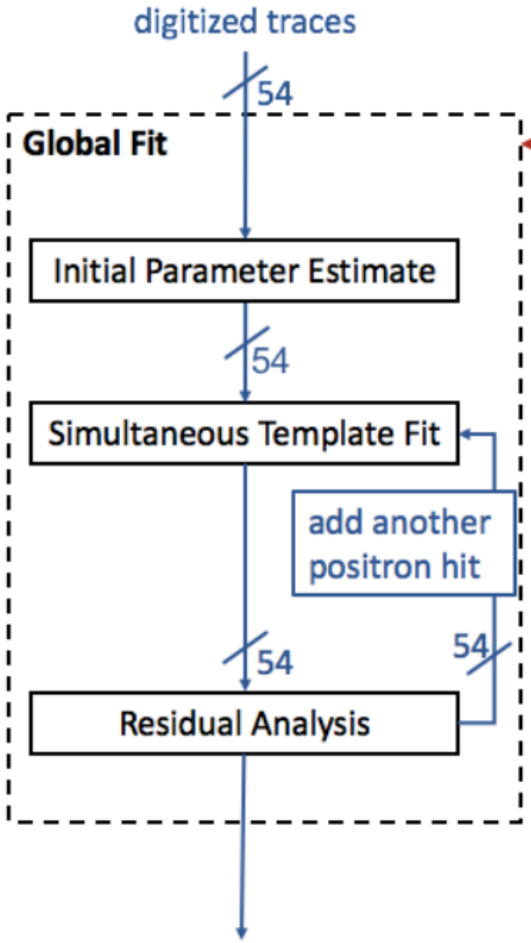
Sans Megaboxes:



With Megaboxes:



Gain corrections in reconstruction



Energy calibration
Gain corrections
Time correction

- the global fit considers multiple crystals simultaneously ⇒ crystal-to-crystal variations needs to be accounted for before fitting;
- corrections (time and gain) and energy calibration are input parameters of the Simultaneous Template Fit step.

$$\chi^2 \sim \sum_s \sum_c \left[y - \sum_p E_c(E_p, t_p, \vec{x}_p, \vec{\theta}_p) \cdot S(t - T_c(E_p, t_p, \vec{x}_p, \vec{\theta}_p)) - P_c \right]^2$$

Laser system update summary

- In operation and stable since April 2017
- No laser failure until now
- Uptime almost 100% since commissioning run (few drawbacks with the interlock system or trigger misalignment)
- Very important for debugging and event reconstruction
- Minor HW upgrades foreseen during next shutdown:
  - LM extended to 48 PMTs
  - Upgrade of Naples electronics
  - Implementation of asynchronous trigger for Am signals
  - Assessment of the actual delays between the sync pulses sent to the calorimeters
- Pull gain corrections to get requested accuracy