WP3: Muon g-2 Calibration System Update

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MUSE Scientific Board Meeting

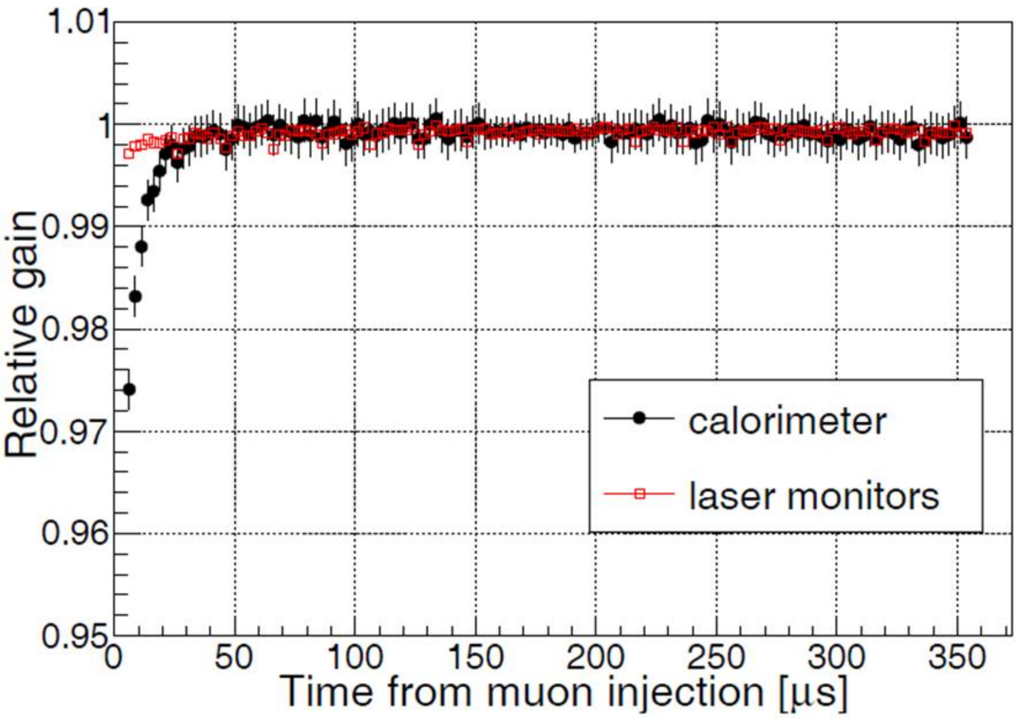
Jul 6th 2018

Gain stability

- To measure ω_a with the required accuracy, the gain stability of the crystals SiPMs must be guaranteed and the gain eventually corrected

Short-term gain stability

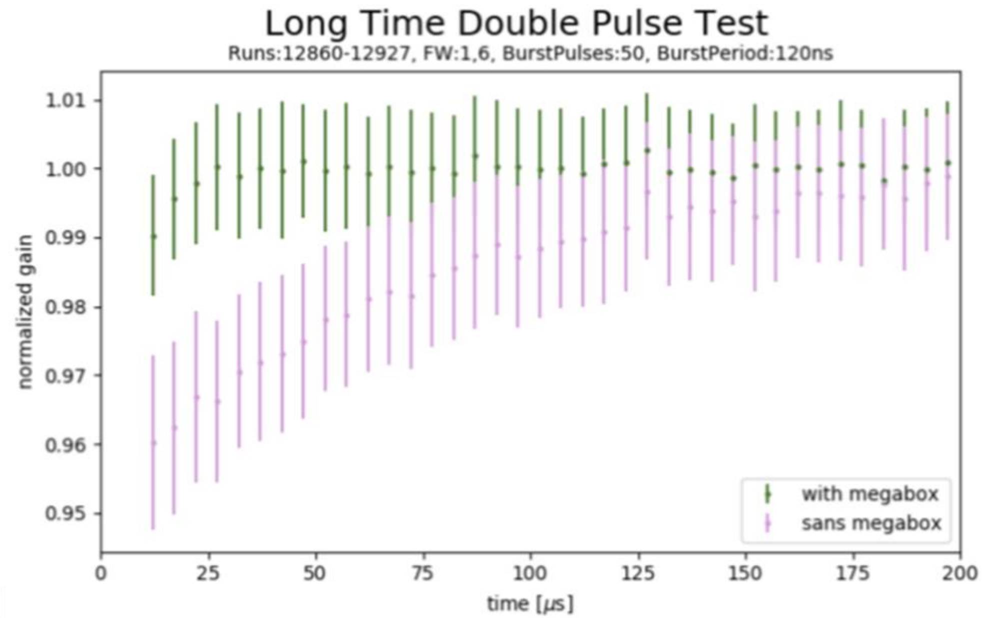
- Average gain with **in-fill laser pulses** during the first 400 μs of fill
- The 3% initial drop (black dots) is due to muon splash on injection, saturating the calorimeter
- Comparison with laser light fluctuations (red squares) from LCS monitor

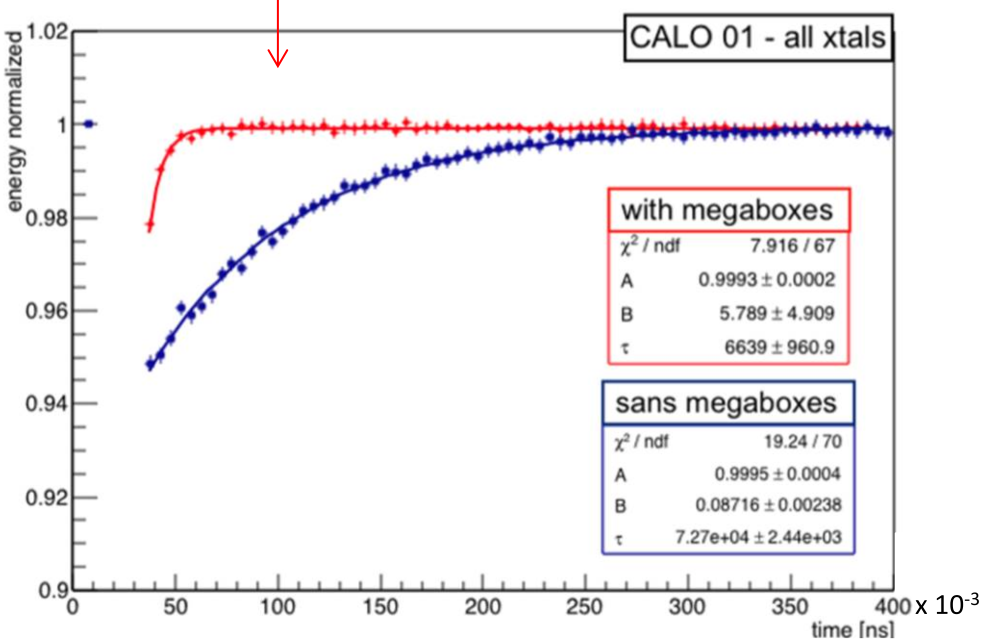


- For required precision: remove gain variations due to **double pulses**: a laser pulse preceded by a beam pulse within ~40 ns
- Effect estimated in the absence of beam, firing two lasers suitably delayed (scan up to 70 ns)
- Also important to **reduce pilup** effect (≥2 e^+ hitting the same crystal at the same time)

Short-term gain stability: reminder

- Splash effect HW-corrected with Megaboxes
- Test with no beam: laser system splash simulator of 50 pulses + 1 test pulse
- Test with beam





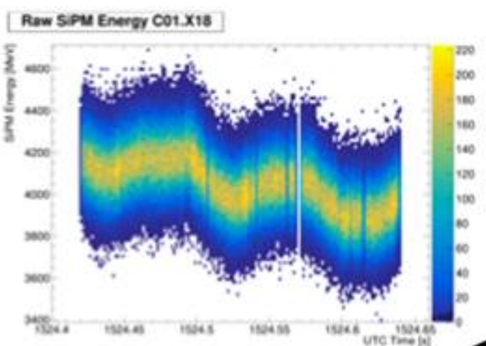
Improvements without and **with beam**

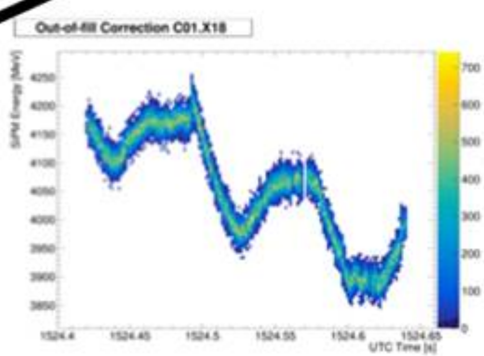
Long-term gain stability

- Calorimeter SiPMs are very sensitive to **temperature** and **bias voltage** variation
- Effect time scale >> 700 μs muon fills
- Correction done using **out-of-fill laser pulses**, a technique tested with mono-energetic electron beams in 2 test beam facilities
- Correction done every sub-run (1 sub-run ↔ 2 GB of data, ~5 seconds, 1 run ↔ 1000 GB of data)

In-fill gain function

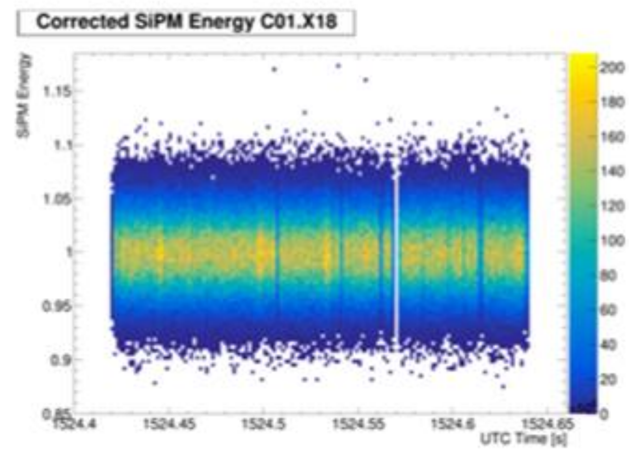
- To get in-fill gain function
  - Correct long-term drift with out-of-fill pulses
  - Correct laser shot-by-shot
  - Correct pileup from short-term double pulse study. To be done





Before correction: 3.7%

After correction: 2.8%



In-fill gain function

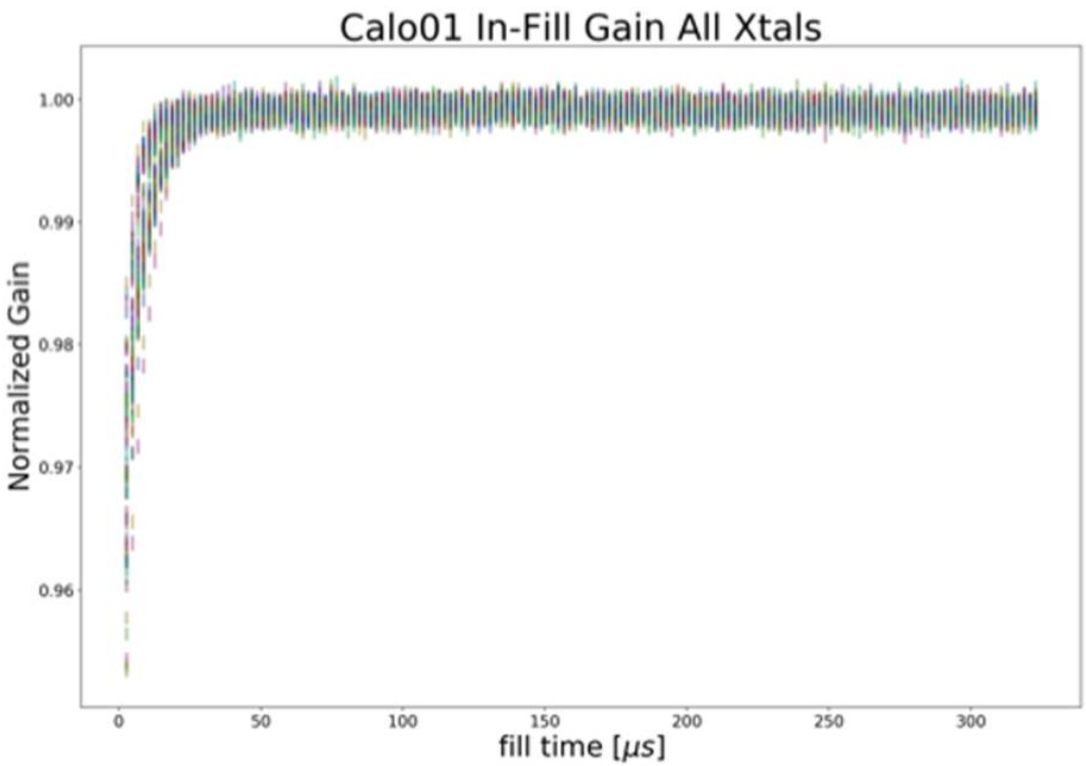
- To get in-fill gain function
  - Correct long-time drift with out-of-fill pulses
  - Correct laser shot-by-shot
  - Correct pileup from short-term double pulse study. To be done
- 1% fluctuations expected from laser specs
- First study shows the laser behaves much better → to be confirmed

In-fill gain function

- In-fill gain function differs from 1 for less than 3 x 10^{-4} after 30 μs
- Modeling function with exponential

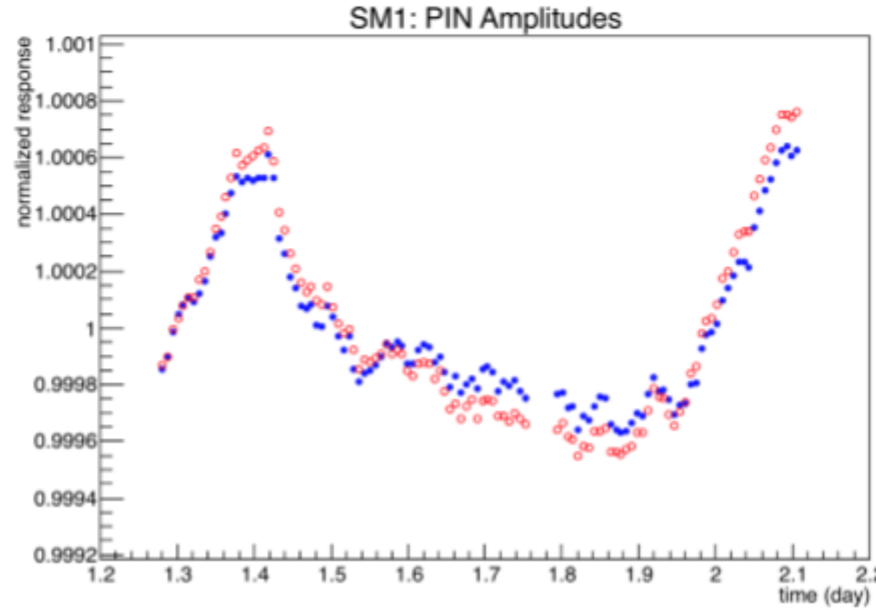
$$y = g\left[1 - a\exp\left(\frac{t - t_0}{\tau}\right)\right]$$

- In-fill gain correction maybe unnecessary after 30 μs



SM & LM temperature studies

- System performance depends on daily temperature variation
- Such a variation affects f. i. the PIN response at the per-mil level



- To reach the required accuracy this dependence has to be accounted for
- The challenge is to correctly disentangle the effects due to the laser source, the monitor and calorimeter sensors and electronics
- Studies are on going, more info in the next future...

Laser SLOW CONTROL, reminder

Sets & monitors:

SM V_{bias} ,

LM HV,

hardware parameters (filters, mirrors)**,**

Status of network devices,

Laser driver current and interlock status,

SM-related temperatures and storage in ODB New

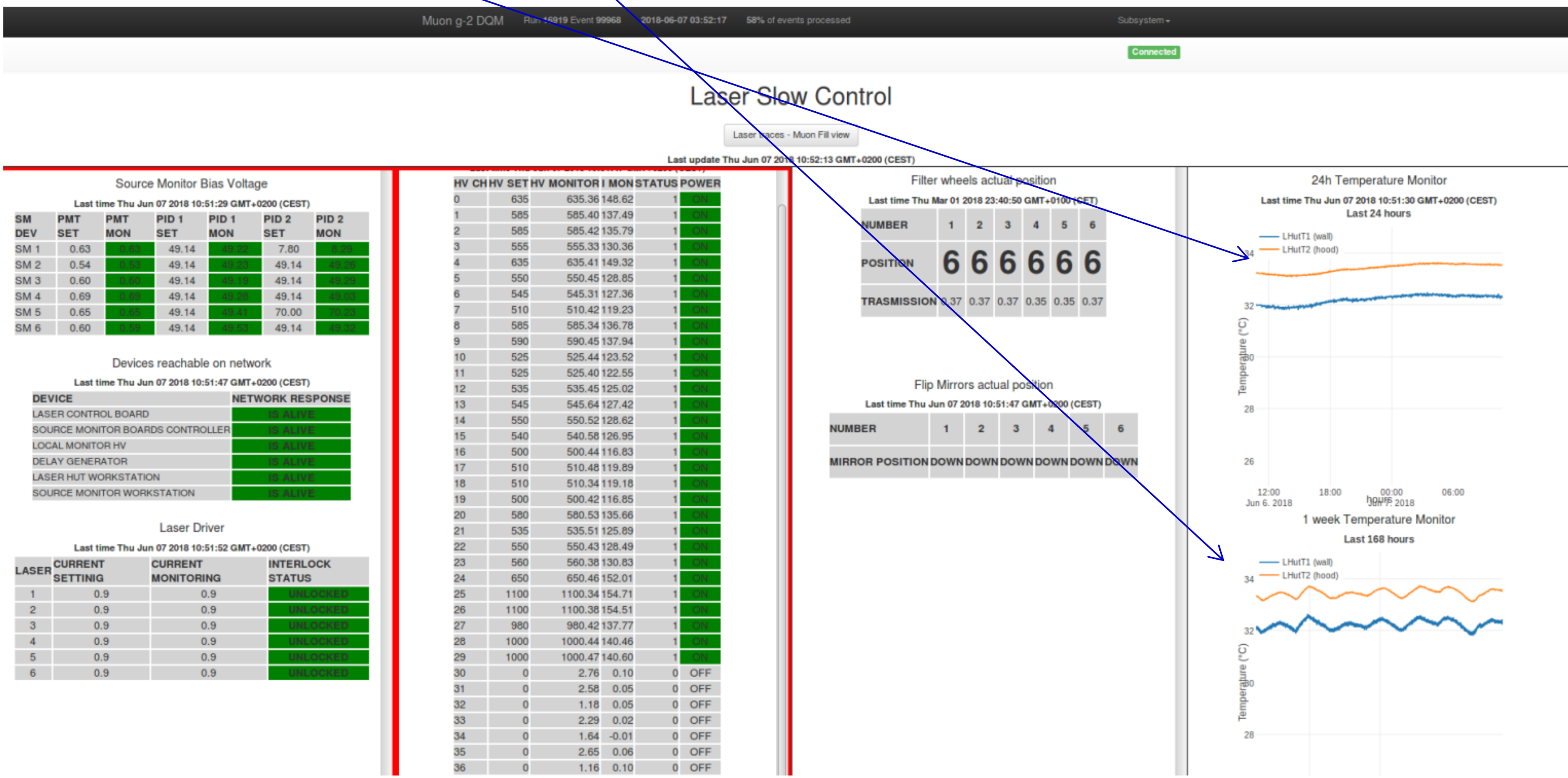
Example:

sm_temp_id	sm_description	sm_id_g2sc_laser_sm_device	sm_temp_time	board_temperature	ext_temperature	csp_temperature
1	PMT LASER 1	10	2018-06-20 04:13:35.020752	45.749001	0	38.890999
2	PID1 LASER 1	11	2018-06-20 04:13:35.020752	45.285999	33.117001	38.425999
3	PID2 LASER 1	12	2018-06-20 04:13:35.020752	42.133999	33.529999	38.396999
4	PMT LASER 2	20	2018-06-20 04:13:35.020752	47.301998	0	37.458
5	PID1 LASER 2	21	2018-06-20 04:13:35.020752	50.672001	33.026001	37.737999
6	PID2 LASER 2	22	2018-06-20 04:13:35.020752	45.505001	36.911999	38.304001
7	PMT LASER 3	30	2018-06-20 04:13:35.020752	45.945	0	37.789001
8	PID1 LASER 3	31	2018-06-20 04:13:35.020752	46.209999	33.518002	37.983002
9	PID2 LASER 3	32	2018-06-20 04:13:35.020752	44.609001	33.908001	38.376999
10	PMT LASER 4	40	2018-06-20 04:13:35.020752	46.240002	0	38.001999
11	PID1 LASER 4	41	2018-06-20 04:13:35.020752	46.240002	33.528	38.153999
12	PID2 LASER 4	42	2018-06-20 04:13:35.020752	43.688999	32.938999	38.386002
13	PMT LASER 5	50	2018-06-20 04:13:35.020752	45.887001	0	38.334999
14	PID1 LASER 5	51	2018-06-20 04:13:35.020752	45.062	33.634998	38.598999
15	PID2 LASER 5	52	2018-06-20 04:13:35.020752	42.941002	33.438999	38.133999

(15 rows)

Laser SLOW CONTROL, new

Displays last day and last week laser hut room temperatures



Muon g-2 DQM   Run 16919 Event 99968   2018-06-07 03:52:17   58% of events processed   Subsystem ▾

Connected

Laser Slow Control

Laser traces - Muon Fill view

Last update Thu Jun 07 2018 10:52:13 GMT+0200 (CEST)

Source Monitor Bias Voltage

Last time Thu Jun 07 2018 10:51:29 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	8.29
SM 2	0.54	0.53	49.14	49.23	49.14	49.26
SM 3	0.60	0.60	49.14	49.19	49.14	49.29
SM 4	0.69	0.69	49.14	49.28	49.14	49.03
SM 5	0.65	0.65	49.14	49.41	70.00	70.23
SM 6	0.60	0.59	49.14	49.53	49.14	49.32

Devices reachable on network

Last time Thu Jun 07 2018 10:51:47 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 Thu Jun 07 2018 10:51:52 GMT+0200 (CEST)

LASER	CURRENT SETTING	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

HV CH	HV SET	HV MONITOR	I MON	STATUS	POWER
0	635	635.36	148.62	1	ON
1	585	585.40	137.49	1	ON
2	585	585.42	135.79	1	ON
3	555	555.33	130.36	1	ON
4	635	635.41	149.32	1	ON
5	550	550.45	128.85	1	ON
6	545	545.31	127.36	1	ON
7	510	510.42	119.23	1	ON
8	585	585.34	136.78	1	ON
9	590	590.45	137.94	1	ON
10	525	525.44	123.52	1	ON
11	525	525.40	122.55	1	ON
12	535	535.45	125.02	1	ON
13	545	545.64	127.42	1	ON
14	550	550.52	128.62	1	ON
15	540	540.58	126.95	1	ON
16	500	500.44	116.83	1	ON
17	510	510.48	119.89	1	ON
18	510	510.34	119.18	1	ON
19	500	500.42	116.85	1	ON
20	580	580.53	135.66	1	ON
21	535	535.51	125.89	1	ON
22	550	550.43	128.49	1	ON
23	560	560.38	130.83	1	ON
24	650	650.46	152.01	1	ON
25	1100	1100.34	154.71	1	ON
26	1100	1100.38	154.51	1	ON
27	980	980.42	137.77	1	ON
28	1000	1000.44	140.46	1	ON
29	1000	1000.47	140.60	1	ON
30	0	2.76	0.10	0	OFF
31	0	2.58	0.05	0	OFF
32	0	1.18	0.05	0	OFF
33	0	2.29	0.02	0	OFF
34	0	1.64	-0.01	0	OFF
35	0	2.65	0.06	0	OFF
36	0	1.16	0.10	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 Thu Jun 07 2018 10:51:47 GMT+0200 (CEST)

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

24h Temperature Monitor

Last time Thu Jun 07 2018 10:51:30 GMT+0200 (CEST)

Last 24 hours

1 week Temperature Monitor

Last 168 hours

Laser SLOW CONTROL

NOW WE USE MIDAS ALARMS

- Program Alarm triggered when a SC Program is not running
- Evaluated Alarm on a threshold condition

↓

Alarm Message

- destination: (to system message log, to DB system)
- Alarm Alerts: visual, audial, email, SMS

Laser SLOW CONTROL

Midas alarms are enabled in laser slow control (LSC) software

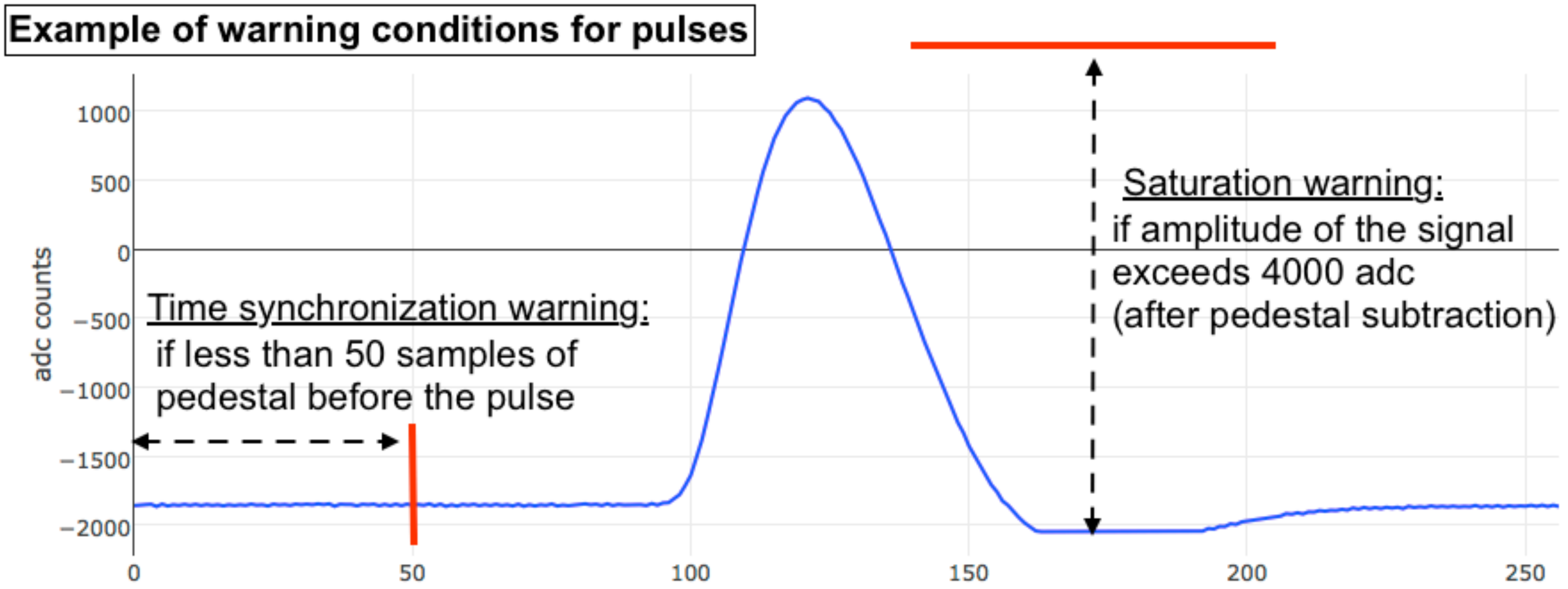
At moment the LSC sends the following warnings:

"Laser Slow Control DB CONNECTION FAILED"
"Laser Slow Control LOCAL MONITOR HV: DB DATA WRITE FAILED"
"Laser Slow Control NETWORK DEVICES PING: DB DATA WRITE FAILED"
"Laser Slow Control SOURCE MONITOR VBIAS: DB DATA WRITE FAILED"
"Laser Slow Control LASER DRIVER: DB DATA WRITE FAILED"
"Laser Slow Control LASER DRIVER LOCKED"
"Laser Slow Control LASER DRIVER NOT CONNECTED"
"Laser Slow Control FILTER WHEELS POSITIONS: DB DATA WRITE FAILED"
"Laser Slow Control FLIP MIRRORS POSITIONS: DB DATA WRITE FAILED"

Soon we will update MIDAS Program Page
adding the Slow Control software restart procedure

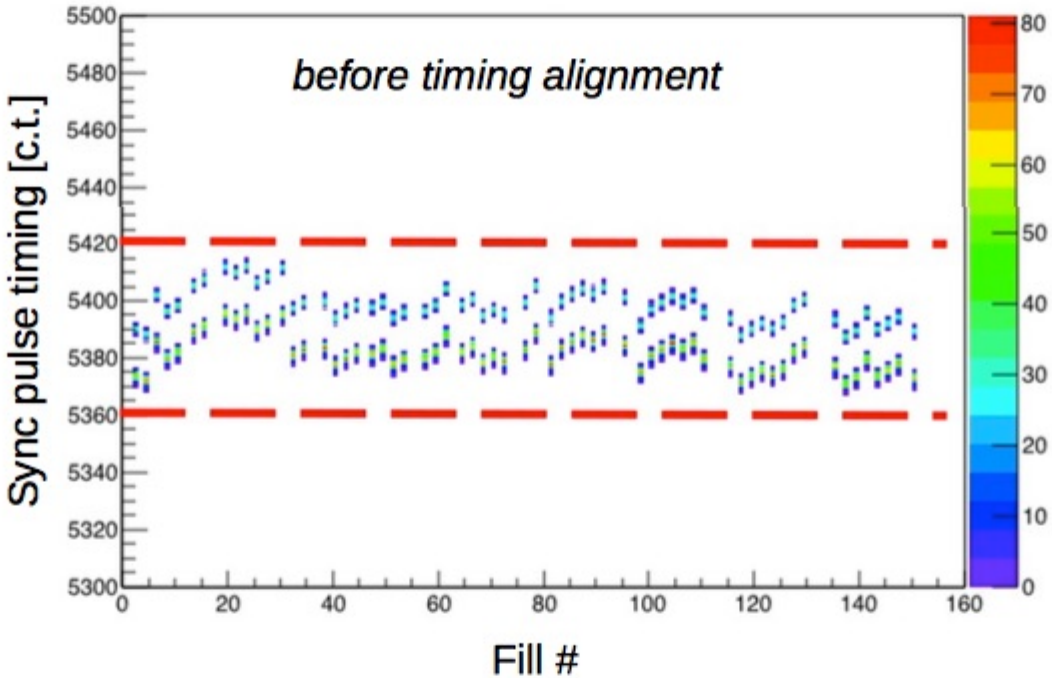
Online Data Quality Monitor

Now DQM Laser Monitors software (ART SIDE)
checks the quality of laser traces collected by DAQ



Offline Data Quality Monitor

- To make sure that the data is correctly acquired, we select offline the only fills which present both the
  - Sync pulse and the
  - End-of-fill pulse




```
======================
      Laser DQC
======================
good events      = 14
bad events       = 0
total events     = 14
--> 100 % passed DQC
======================
```