WP3: Muon g-2 Calibration System Update

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MUSE Scientific Board Meeting

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Laser Hut

- 6 lasers + 1 laser controller + 6 filter wheels + optics
- 24 optical fibers to the calorimeters
- 6 Source Monitors
- 24+24 Local Monitors NEW
- 3 laser-pair systems for double-pulse studies
- 1 PMT with one input for each of the 6 SMs for relative timing (to within 100 ps) and time-jitter studies
- 1 system for Fiber Harps and T0 synchronization

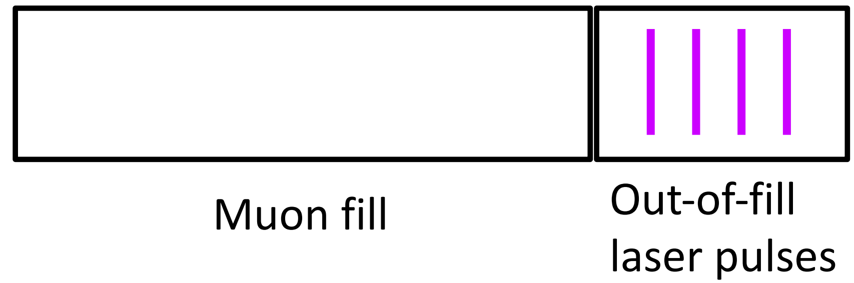
Local monitor upgrade NEW

- Doubling the LM system
- 24 new PMTs (Hamamatsu R1924A-100) read out by Corradi boards
- LM crate with 8 LM boards, 24 pre-amplifiers and a Crate Controller: completion of pre-ampl mount and board cabling underway

Asynchronous readout of SMs

- The absolute monitors, based on an Am source + NaI crystal + PMT must be read asynchronously wrt the muon events
- These signals are necessary for reliable long-term temperature corrections
- The inputs of the Rider crate 25 (devoted to the SMs signals) have been recabled to allow for asynchronous readout of the PMTs

Out-of-fill (OOF) gain corrections



Work ongoing

- Done using the OOF laser pulses for each subrun against a reference Run (n. 14395)
- Used to correct SiPM's gain fluctuations due to temperature variations

$$C \triangleq \frac{G}{G_0} = \left\langle \frac{L}{SM} \right\rangle_{subrun} \Big/ \left\langle \frac{L_0}{SM_0} \right\rangle_{run14395}$$

G: gain
L: SiPM response to laser pulses
SM: laser fluctuations (SM PINs)

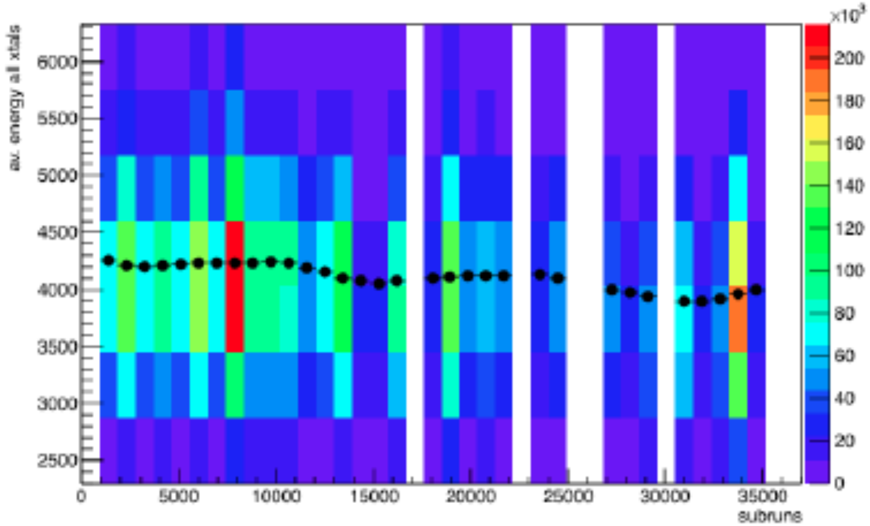
- Temperature differently affects the different SiPMs → 1296 factors, one for each of the calorimeter SiPMs

1 subrun = 2 GB ~ 5 s
1 run = 1 TB = 500 subruns

OOF corrections

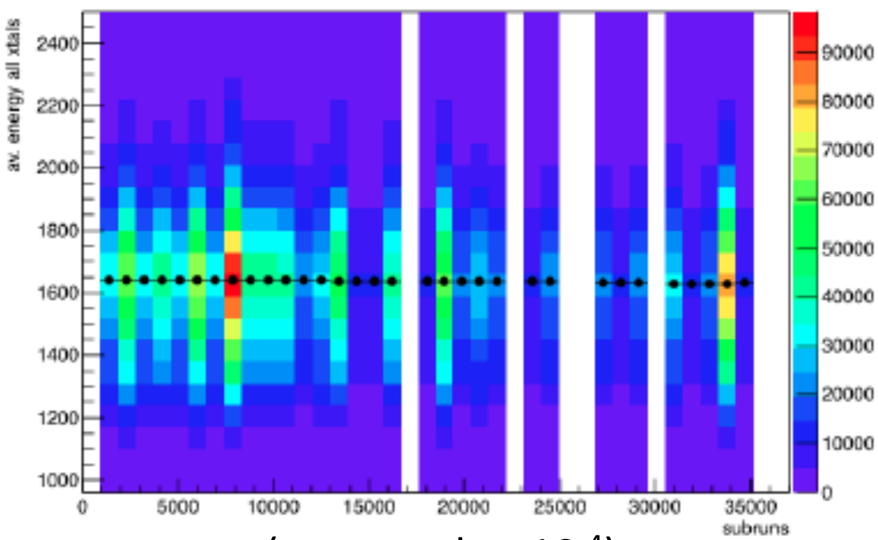
$$S_{sync}^{corr} = \frac{S_{sync}}{C}$$

- Sync. Pulse energy before the oof correction:



(Varies with temperature)

- Sync. Pulse energy after the oof correction:



(corrected to 10^{-4})

Slide courtesy of A. Driutti

In-fill (IF) gain corrections

Work ongoing

- IF gain software updated
  - InFillGainFunctionBuilder
  - InFillGainCorrector
  - LaserGain
- IF gain analysis
  - Done for most of run1 datasets
  - Tested two gain fit functions

$$f_1(t) = 1 - \alpha e^{-t/\tau}$$

$$f_2(t) = 1 - \alpha_1 e^{-t/\tau_1} - \alpha_2 e^{-t/\tau_2} \cos[\omega t - \phi]$$

  - Remaining structure in residuals at 10^{-4} level

Short-term double-pulse correction

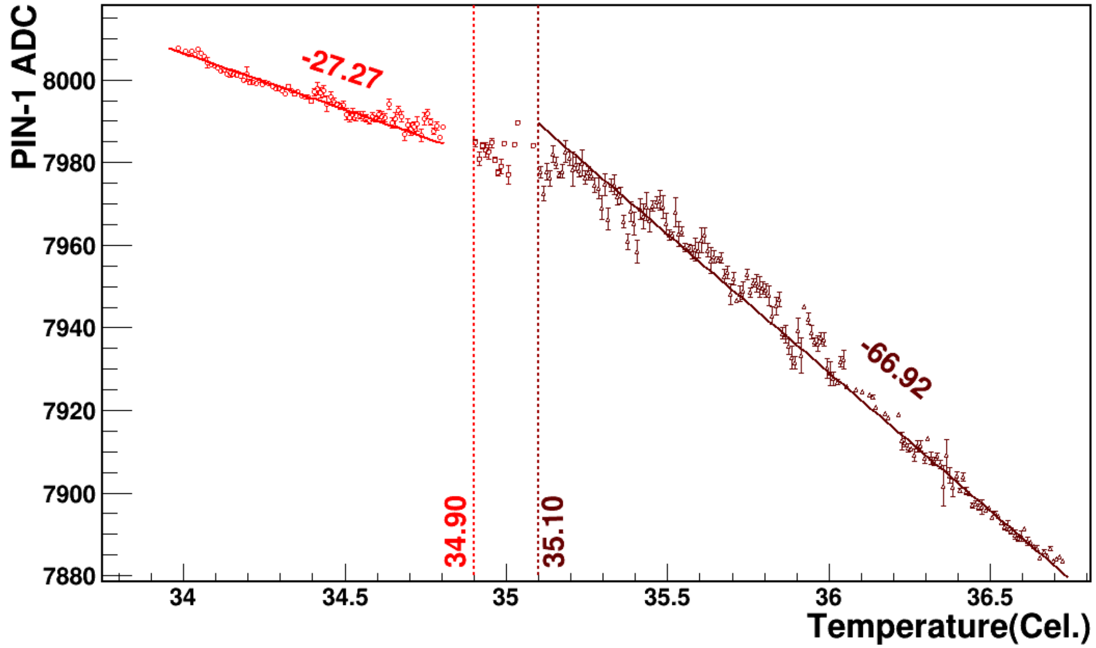
$$G(t) = N\left(1 - a\exp\left(-t/\tau\right)\right)$$

- To study how in-fill laser pulses perturb muon events
- 0^{th}-order approximation: one universal gain function
- 1^{st}-order: one function for each crystal
- 2^{nd}-order: dependence on the energy of the two pulses
- Pileup and lost muons must be accounted for, before estimating how important the STDP gain corrections are to the ω_a analysis

Slide courtesy of A. Nath

Long-term SM stability studies

Work ongoing

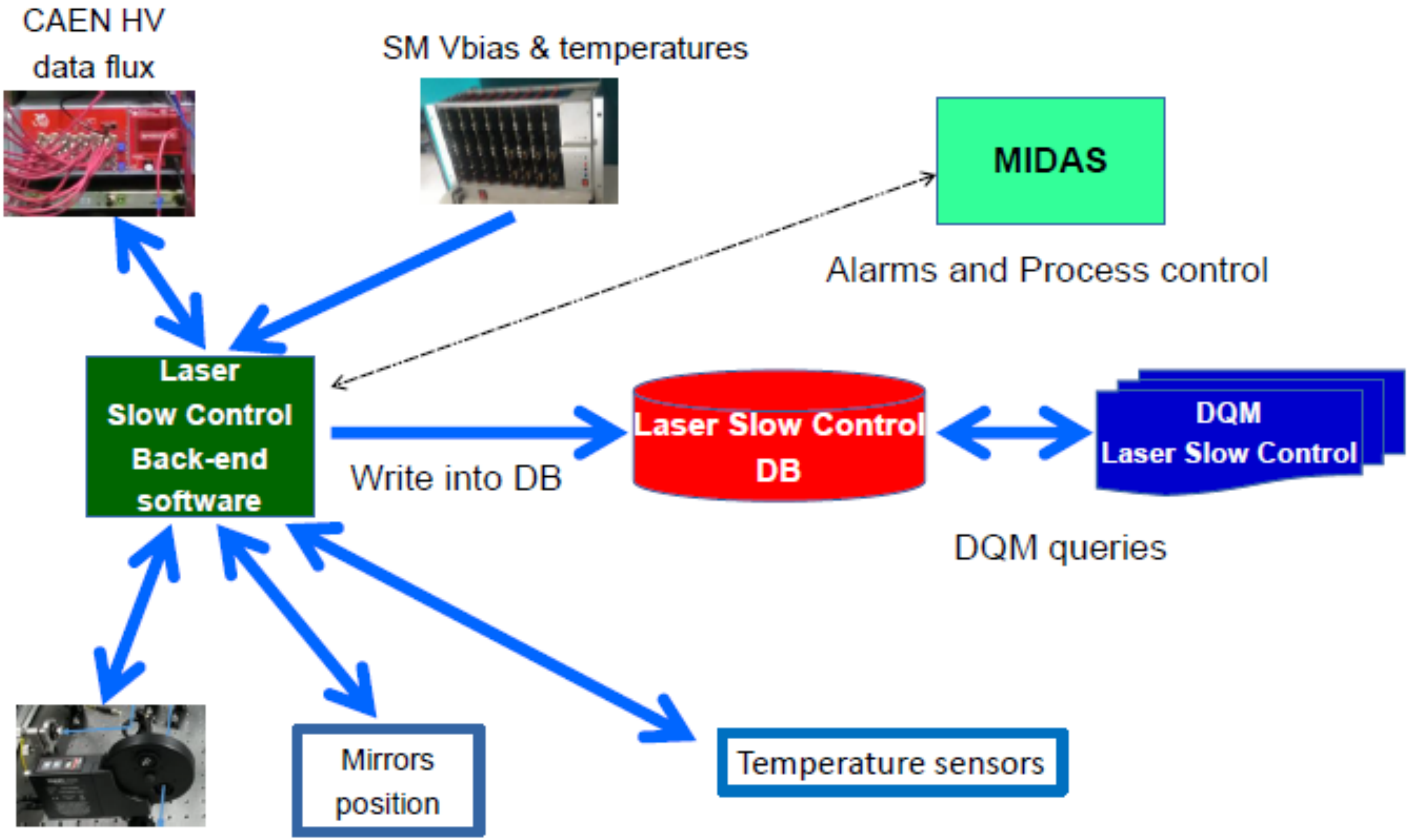


- The effects of temperature (T) and aging are noticeable on a time scale of a month or longer
- Looking for correlations: PIN-bias/T, PIN-ADC/T, PIN-ADC/PIN-bias
- A sudden change around 35 °C in the slope of the PIN-ADC/T graph for PIN1-SM6 was seen
- It does not look to be caused by temperature change
- Further investigations are being performed

Open problems: fix before resuming data taking

- PIN1 SM1, PIN1 SM3 signals are unstable: to be fixed
- Laser hut temperature too high and variable: stability to be improved
- The signals from the new LM PMT+Corradi boards show a ringing on the trailing edge, which negatively affects the energy reconstruction: studies ongoing
- Asynchronous readout: already tested, but needs to be checked after MIDAS update
- CCC prescale for laser triggering: needs testing
- Laser pulse amplitude varies with trigger rate: annoying but not really critical

Laser slow control and DB

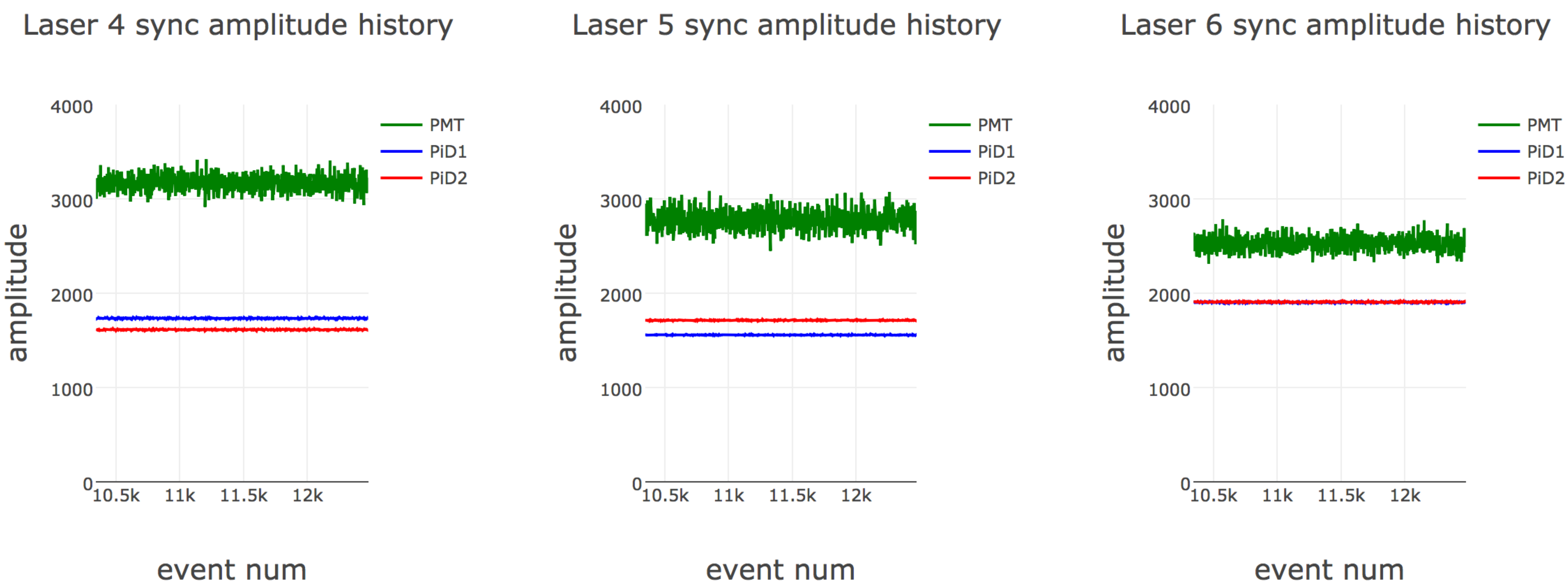


Slide courtesy of C. Ferrari

DQM for SM

NEW

- Plots for the amplitudes of the 6 SMs now online
- A plot is filled with 3 signals for each SM: PIN1, PIN2, PMT vs. event n.
- Helpful for debugging, checking stability



Slide courtesy of N. Raha

Functions of the Slow control & monitoring systems

- Monitor the status of Hardware and DAQ
- Monitor physical and environmental conditions
- Control data quality
- Control hardware equipment

Requirements for a good monitoring system

- Independent of a particular experiment
- Modular structure
- Access to data, both real-time and archived
- Different focus for shifters and experts
- Capability to control detector subsystems

Web-based approach

- Client-server architecture allows scalability and reliability
- Easy integration of experiment-specific tools
- No direct dependency on front-end electronics and data sources
- Cross platform compatibility
- Remotely accessible
- Rapid development thanks to lots of open-source web packages
- Customizable
- We would include all g-2 monitoring frameworks inside a single «Big Monitoring System»