

Fermilab Laser Calibration System For The Muon $g-2$ Experiment

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On behalf of the Italian collaboration

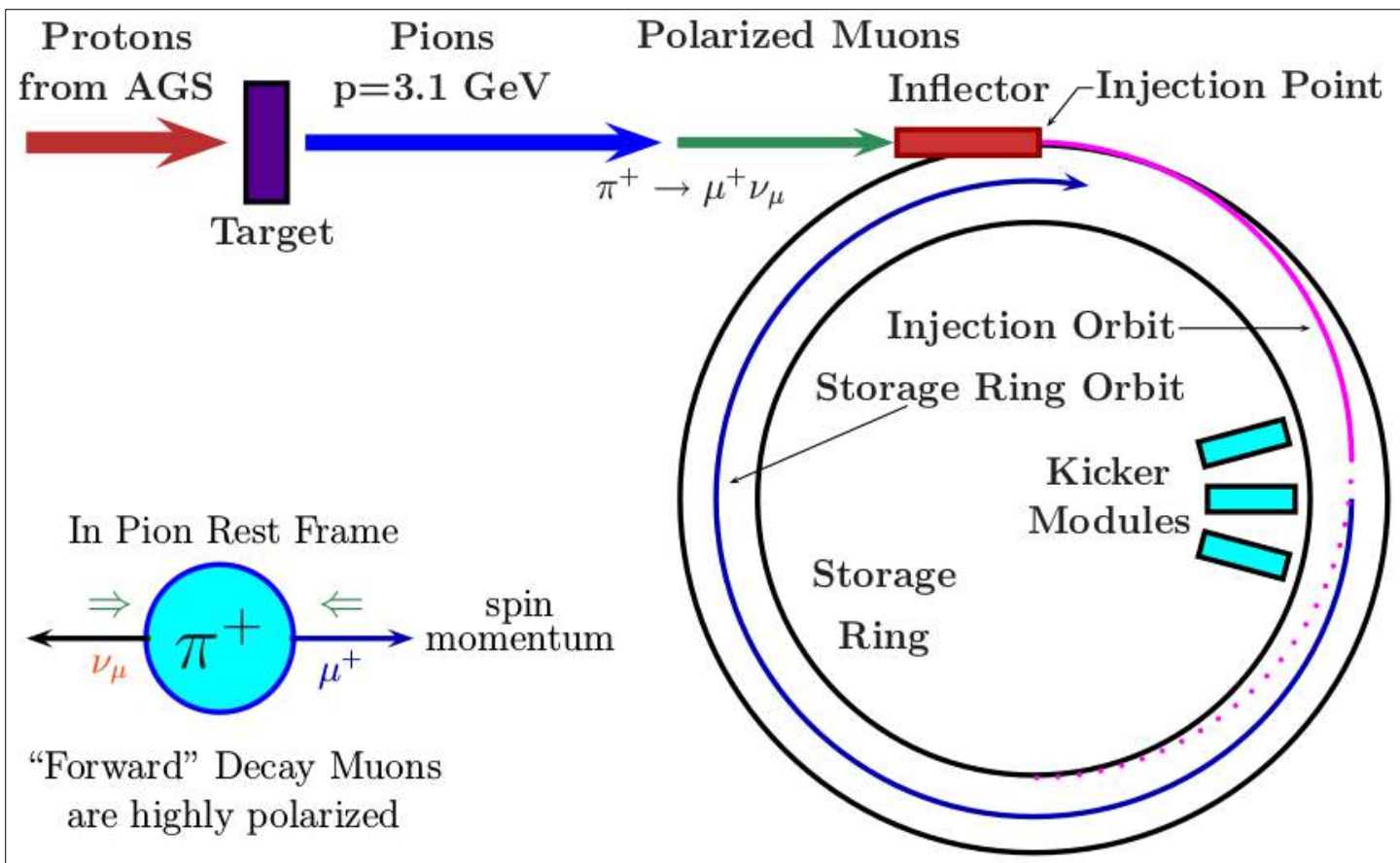
MUSE

INFN

GENERAL $g-2$ EXPERIMENT BACKGROUND

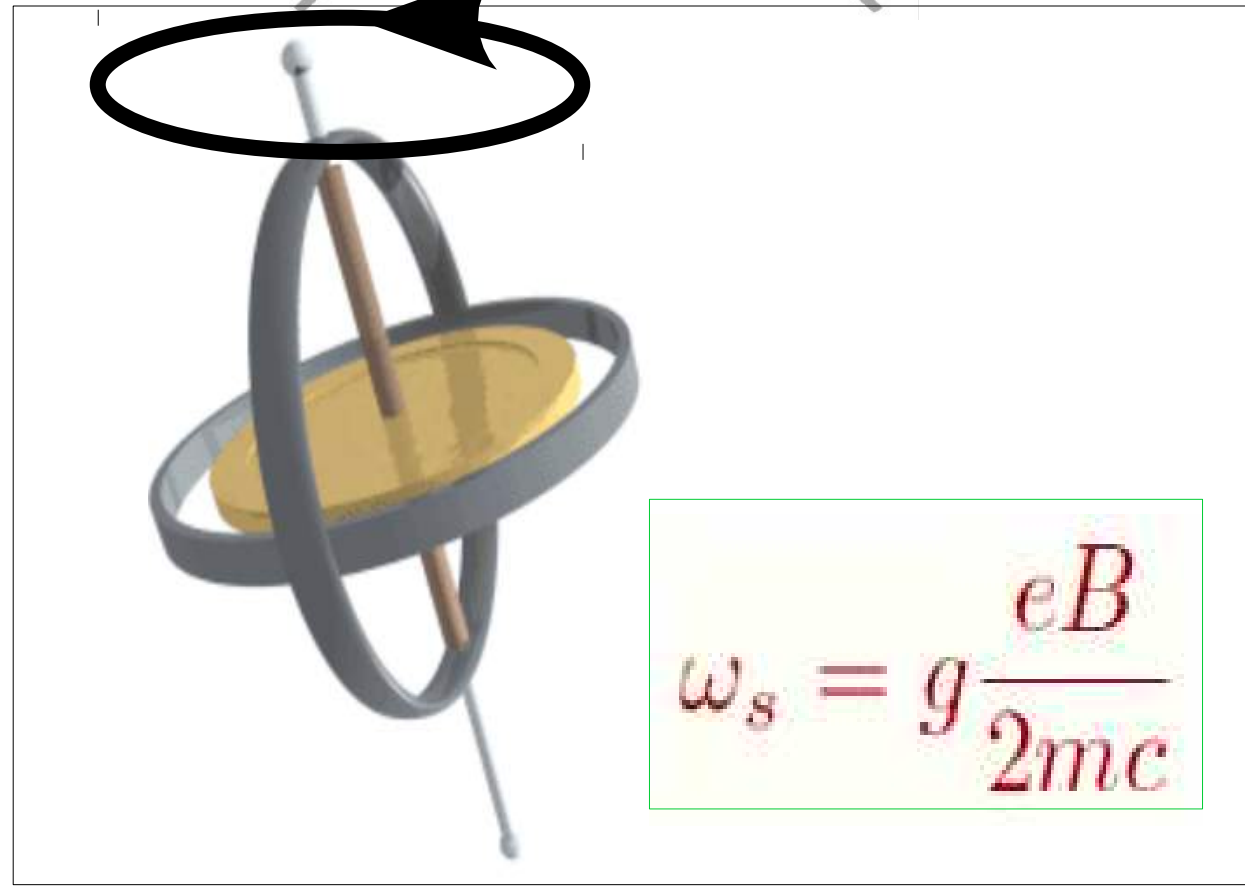
Spin and magnetic moment

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

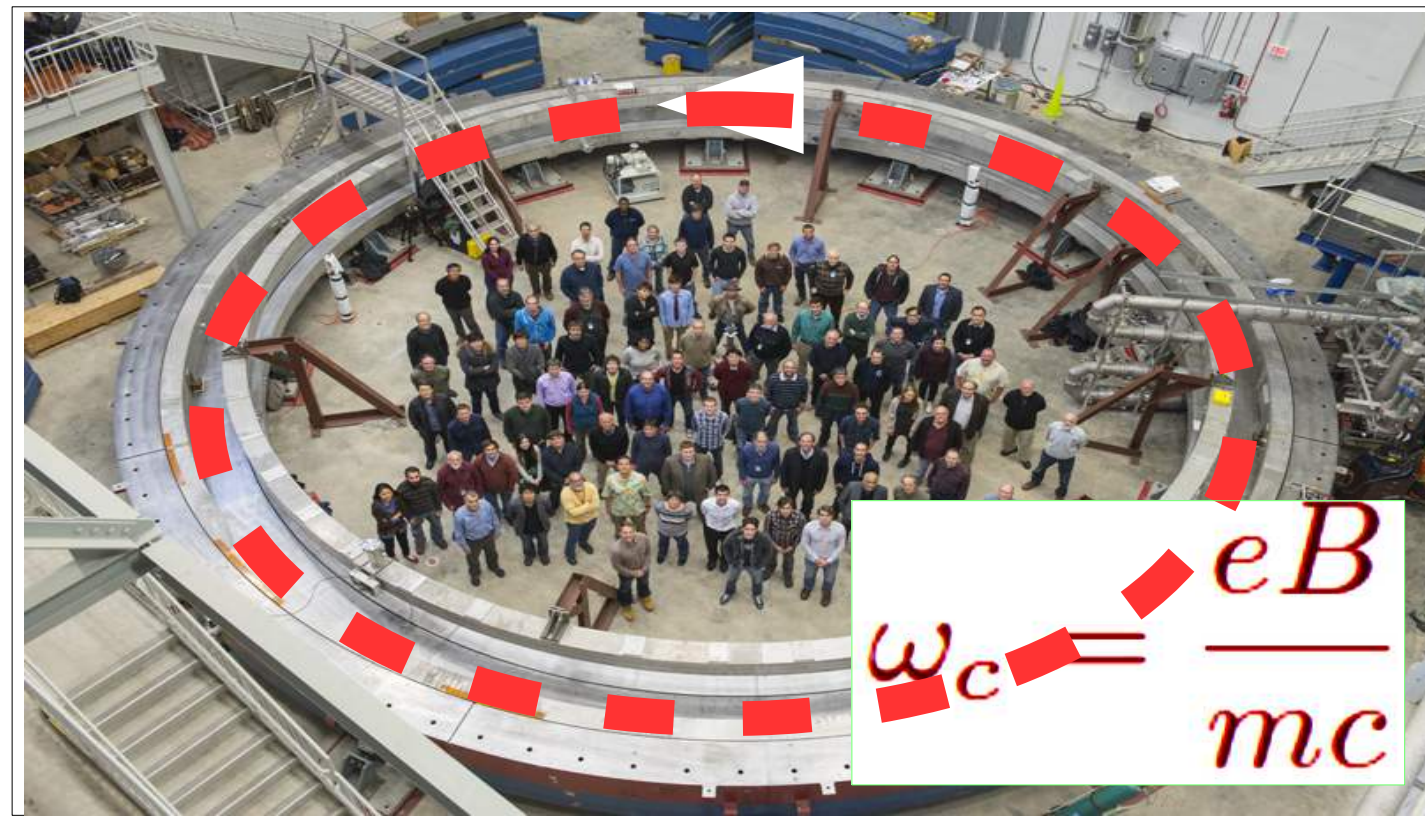


The basic working principle of the experiment.

$$g = 2_{Dirac} + \mathcal{O}(10^{-3})_{QED} + \mathcal{O}(10^{-7})_{QCD} + \mathcal{O}(10^{-9})_{EW} +$$

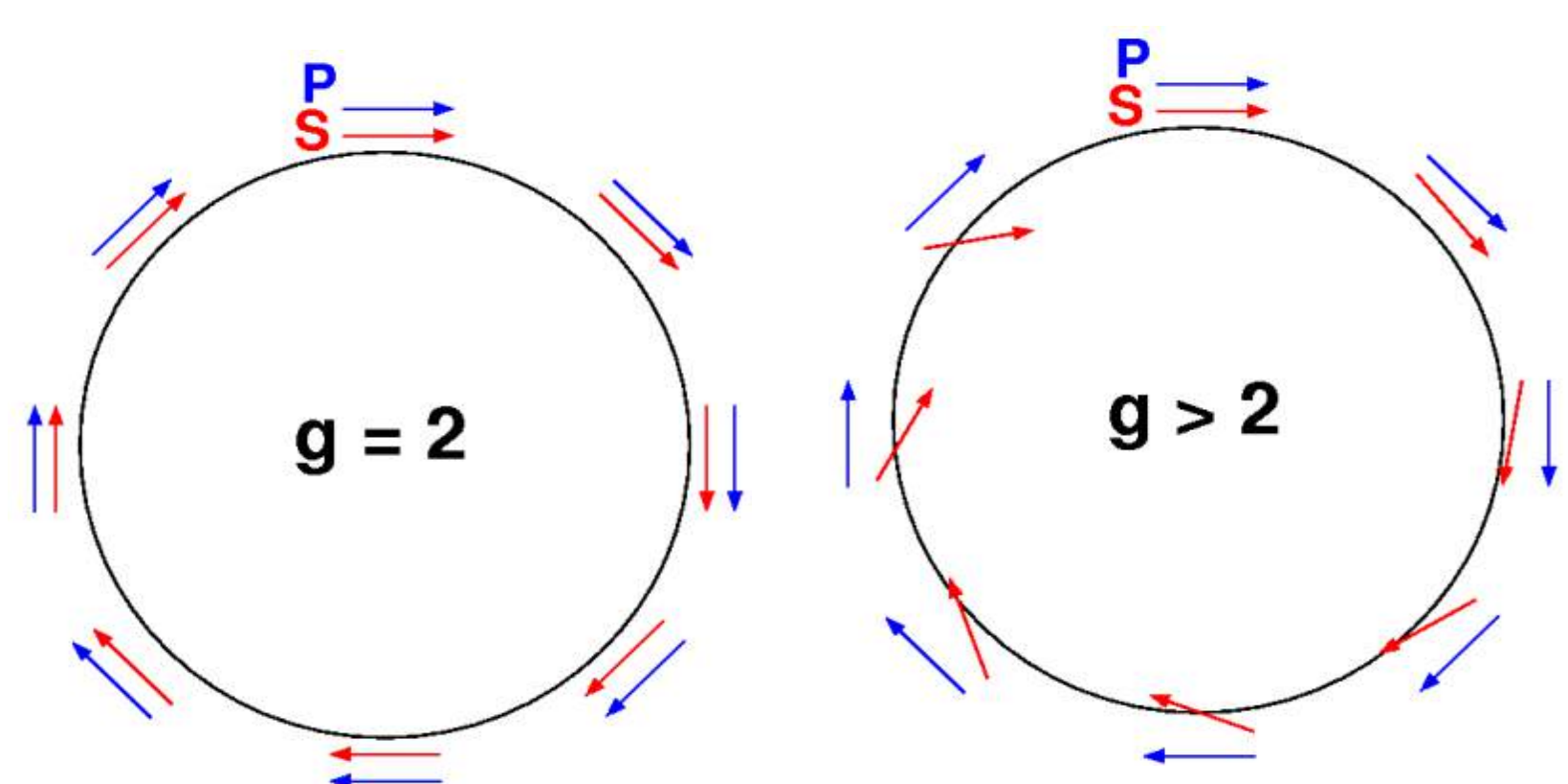


Larmor precession frequency.

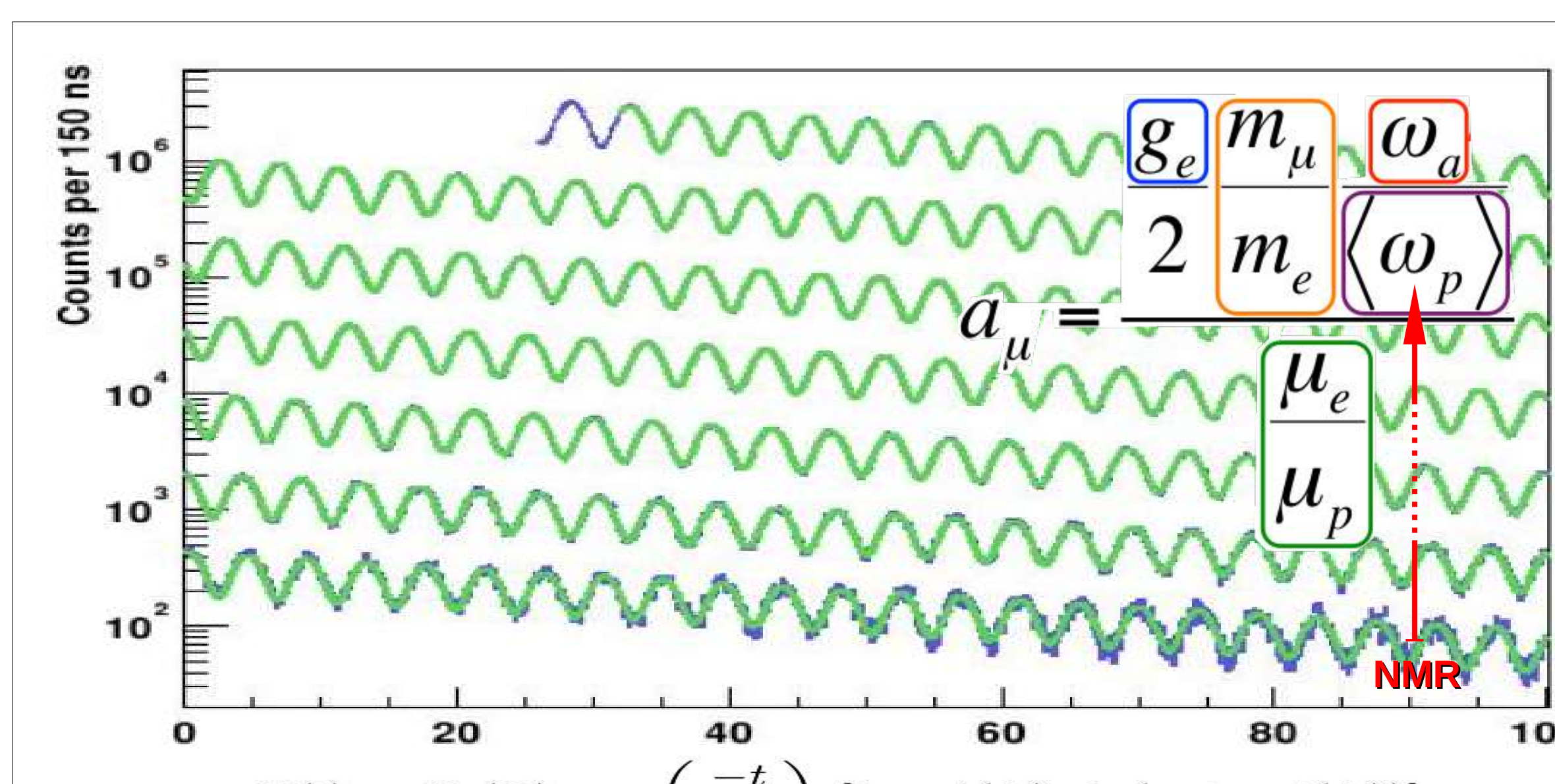


Cyclotron frequency.

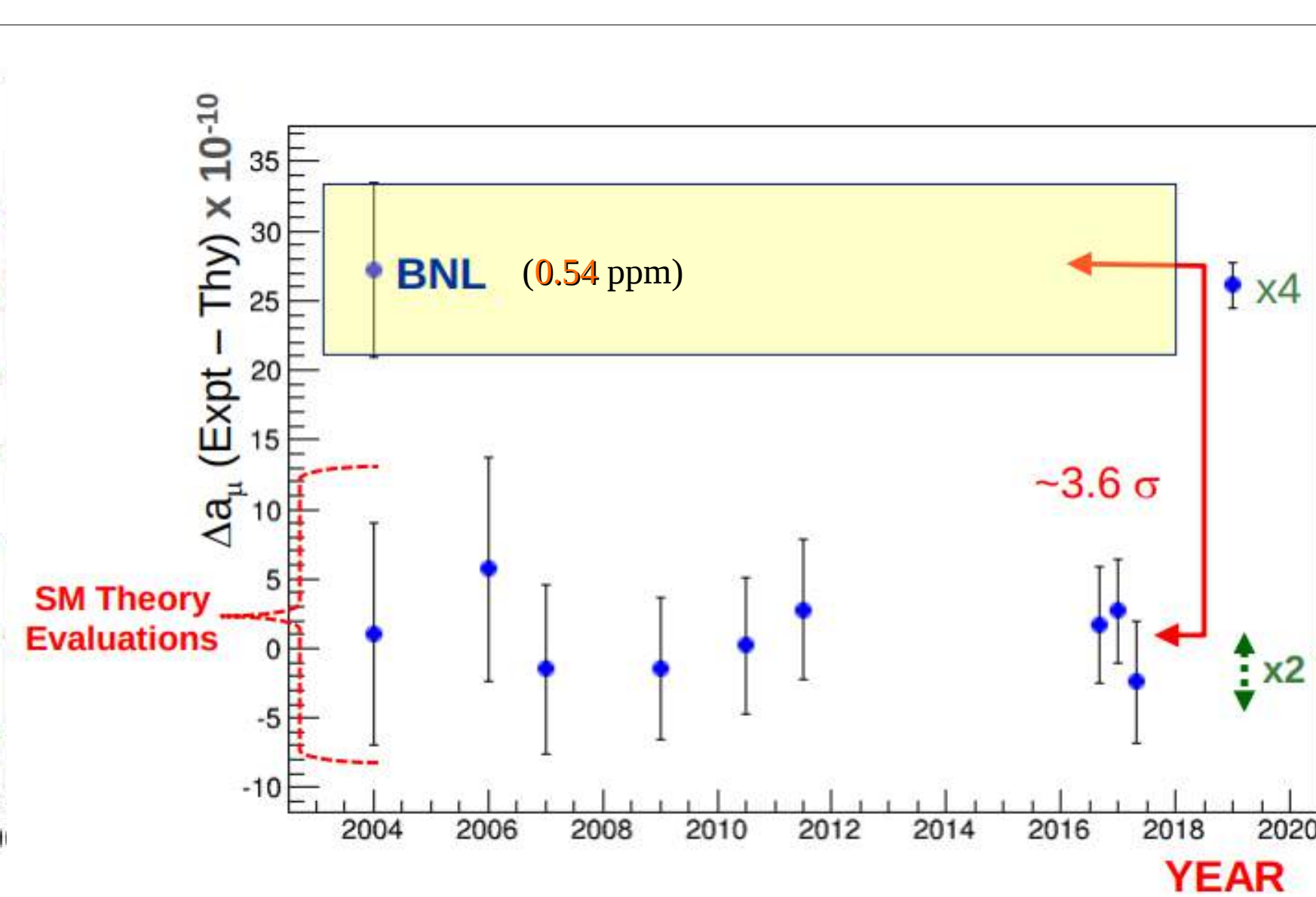
$$\omega_a = \omega_s - \omega_c = a_\mu \frac{eB}{mc}$$
$$a = (g-2)/2$$



Difference of the two frequencies $\sim g-2$ hence perfect match when $g=2$, otherwise $g \neq 2$



Positron counts and the 5-parameter-fit



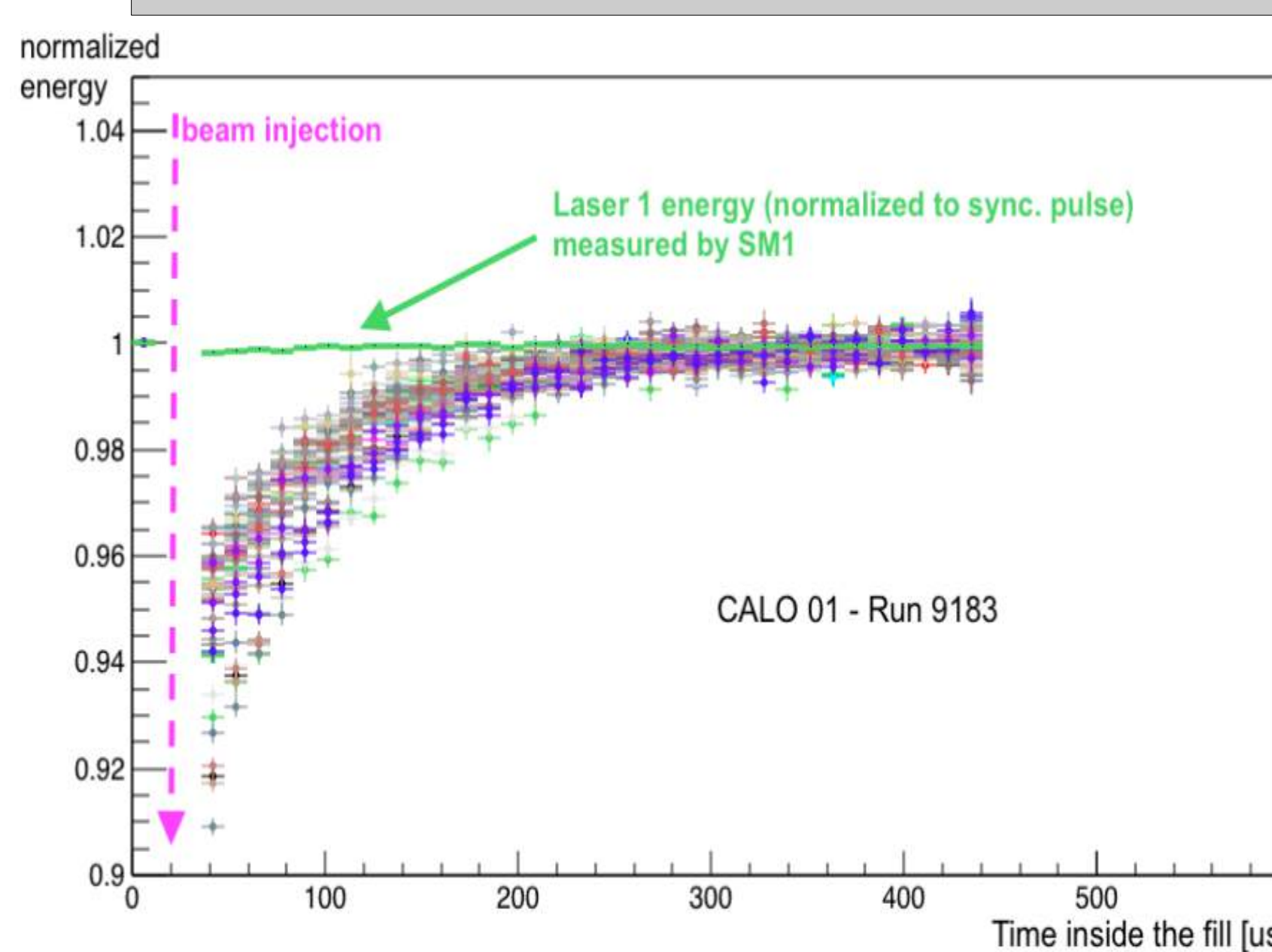
SM: 116 591 828 \pm 50, (E821 - SM) = (287 \pm 80) $\times 10^{-11}$ ($\sim 4 \sigma$)

E821 Error	Size [ppm]	Plan for the New $g-2$ Experiment	Goal [ppm]
Gain changes	0.12	Better laser calibration and low-energy threshold	0.02
Lost muons	0.09	Long beamline eliminates non-standard muons	0.02
Pileup	0.08	Low-energy samples recorded; calorimeter segmentation	0.04
CBO	0.07	New scraping scheme; damping scheme implemented	0.04
E and pitch	0.05	Improved measurement with traceback	0.03
Total	0.18	Quadrature sum	0.07

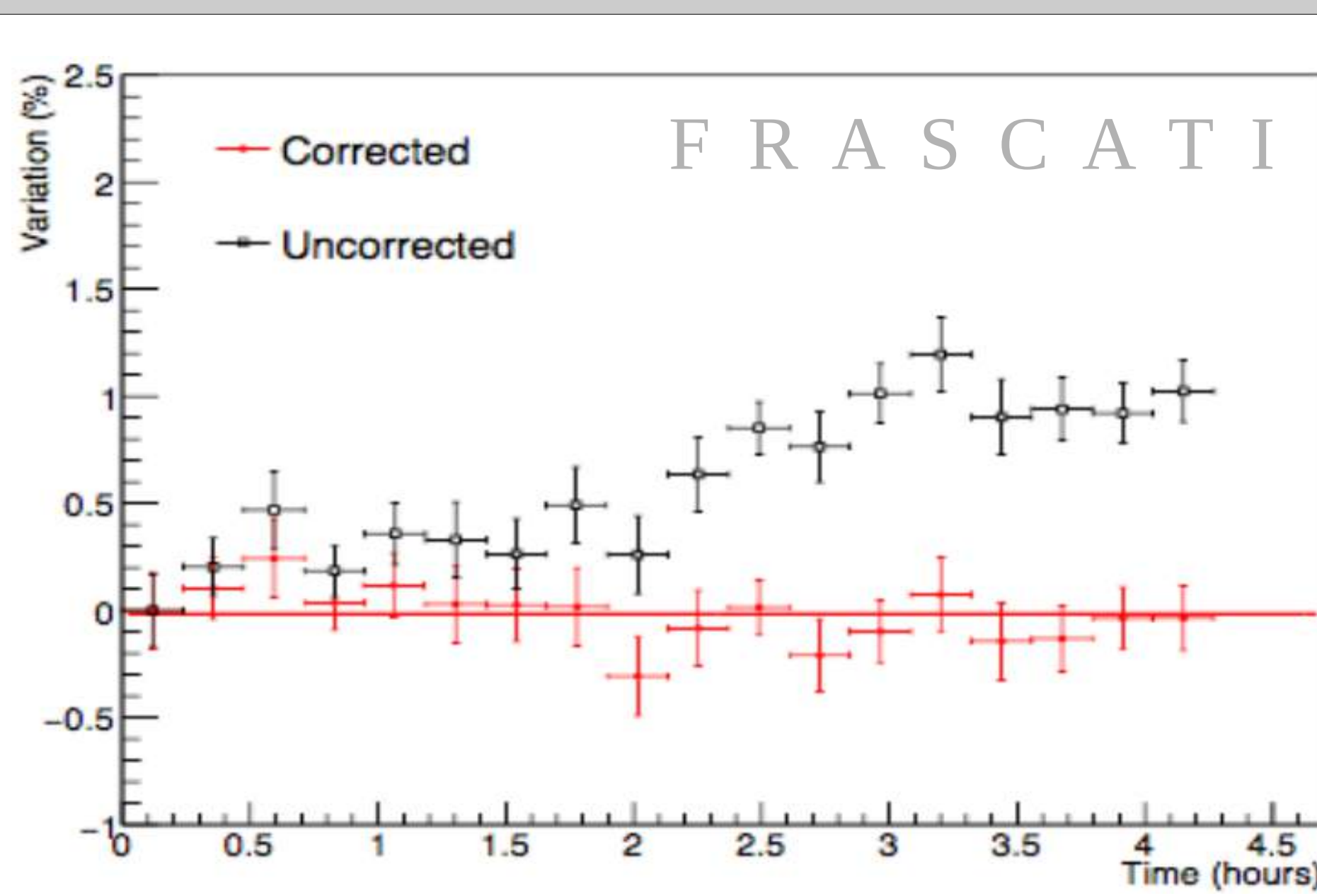
Precision goals of Fermilab E989 experiment.

GAIN SAG AND THE LASER CALIBRATION SYSTEM

SHORT TERM AND LONG TERM GAIN CHANGE

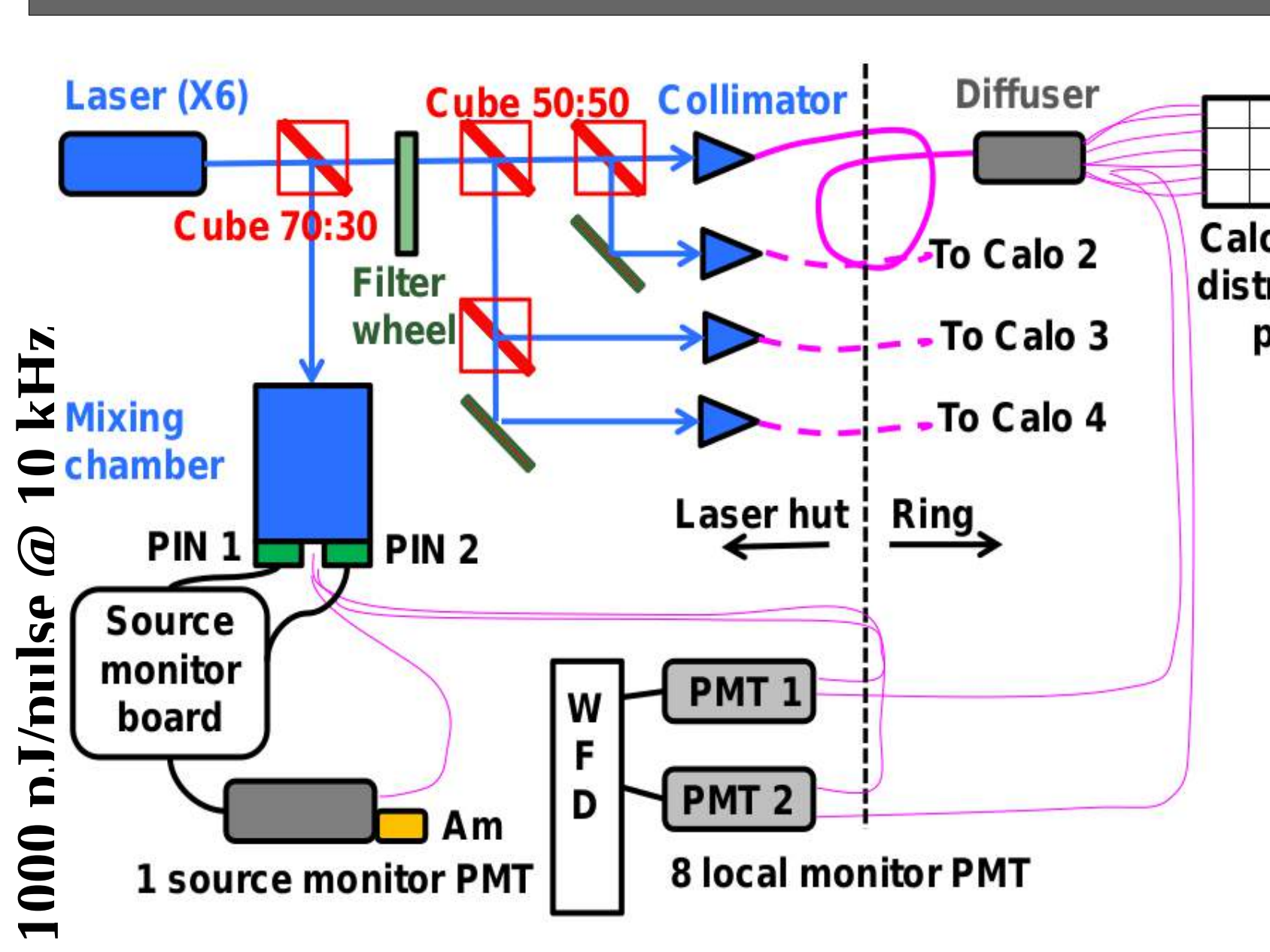


Calorimeter gain-sag function obtained using laser pulses that simulate positrons.

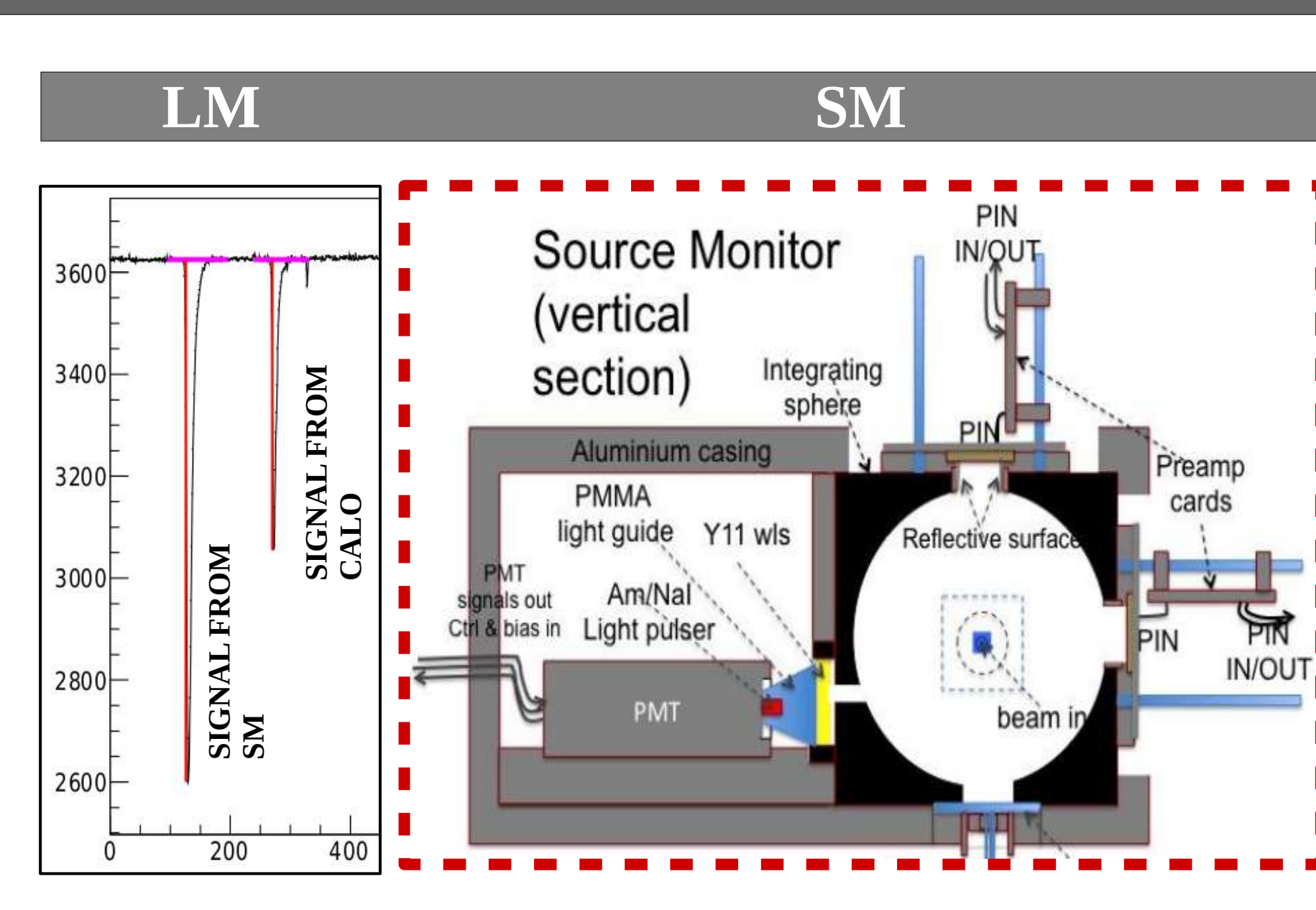


For long term stability of the calorimeter gain, laser pulses are used to correct it.

MONITORING SYSTEM: SOURCE AND LOCAL MONITORS



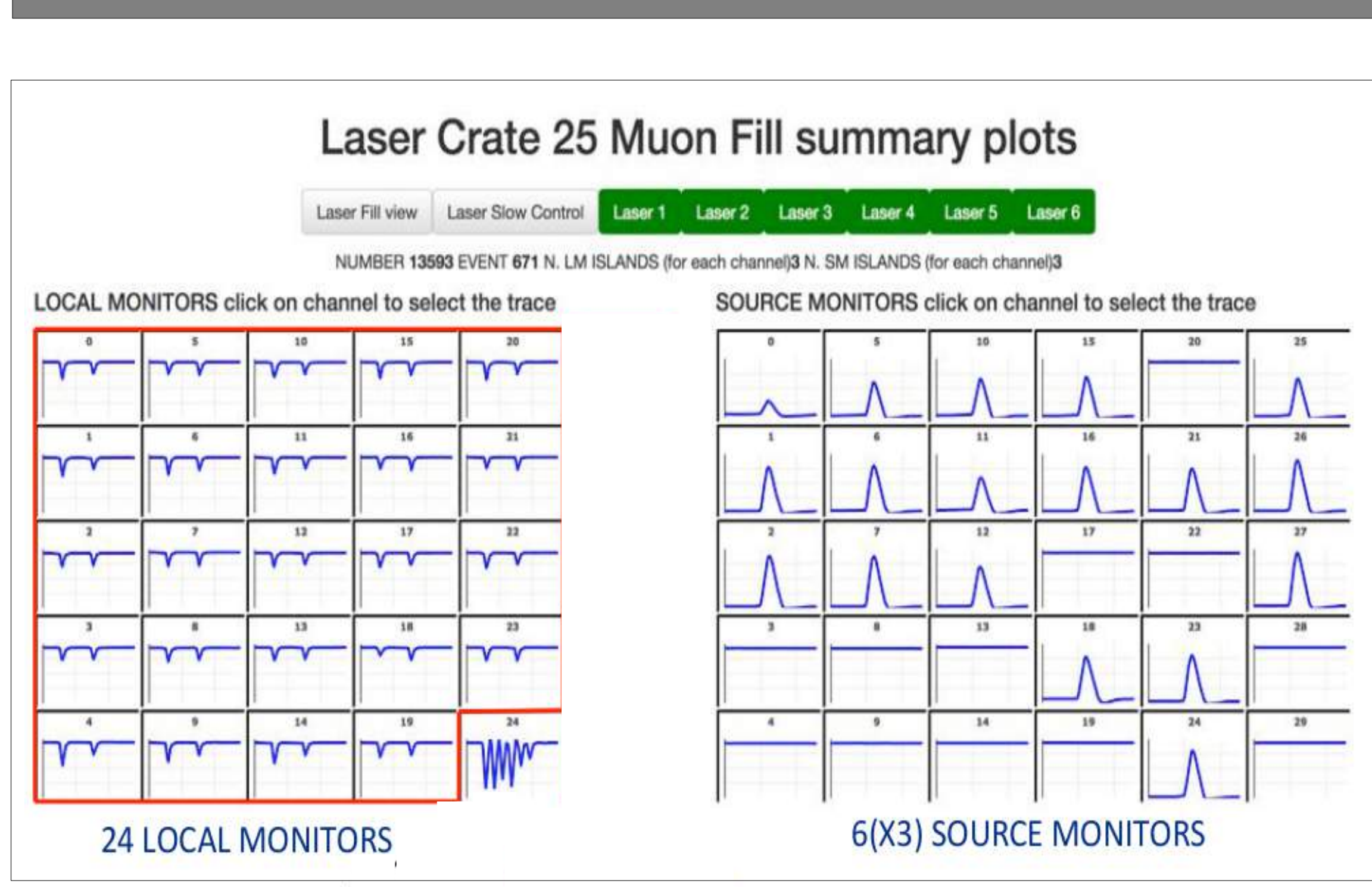
Schematics of the laser calibration system.



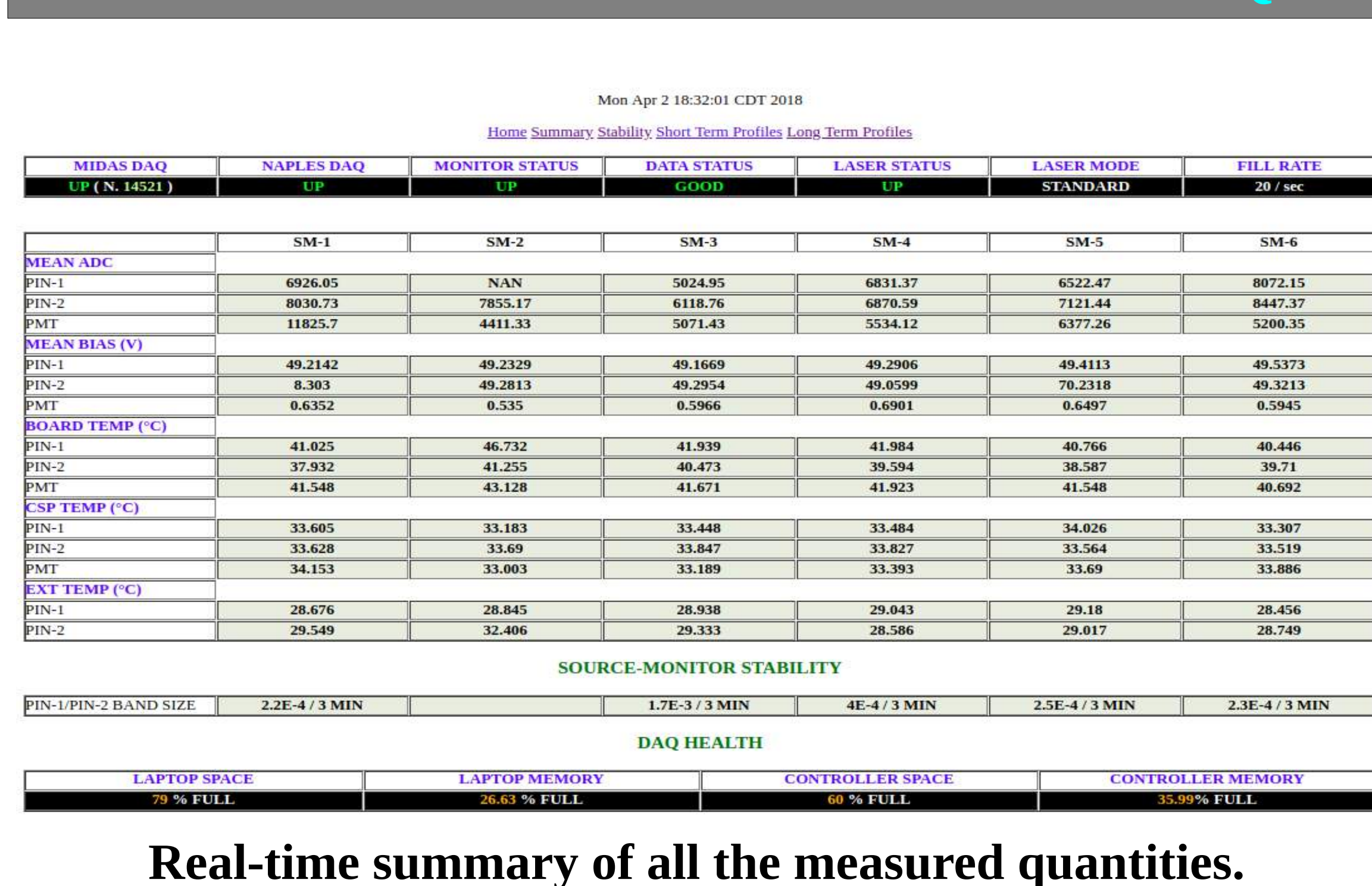
Local (LM) and Source Monitors (SM) are used to monitor the stability of the calorimeters.

LASER CALIBRATION MONITORING SYSTEM & PERFORMANCE

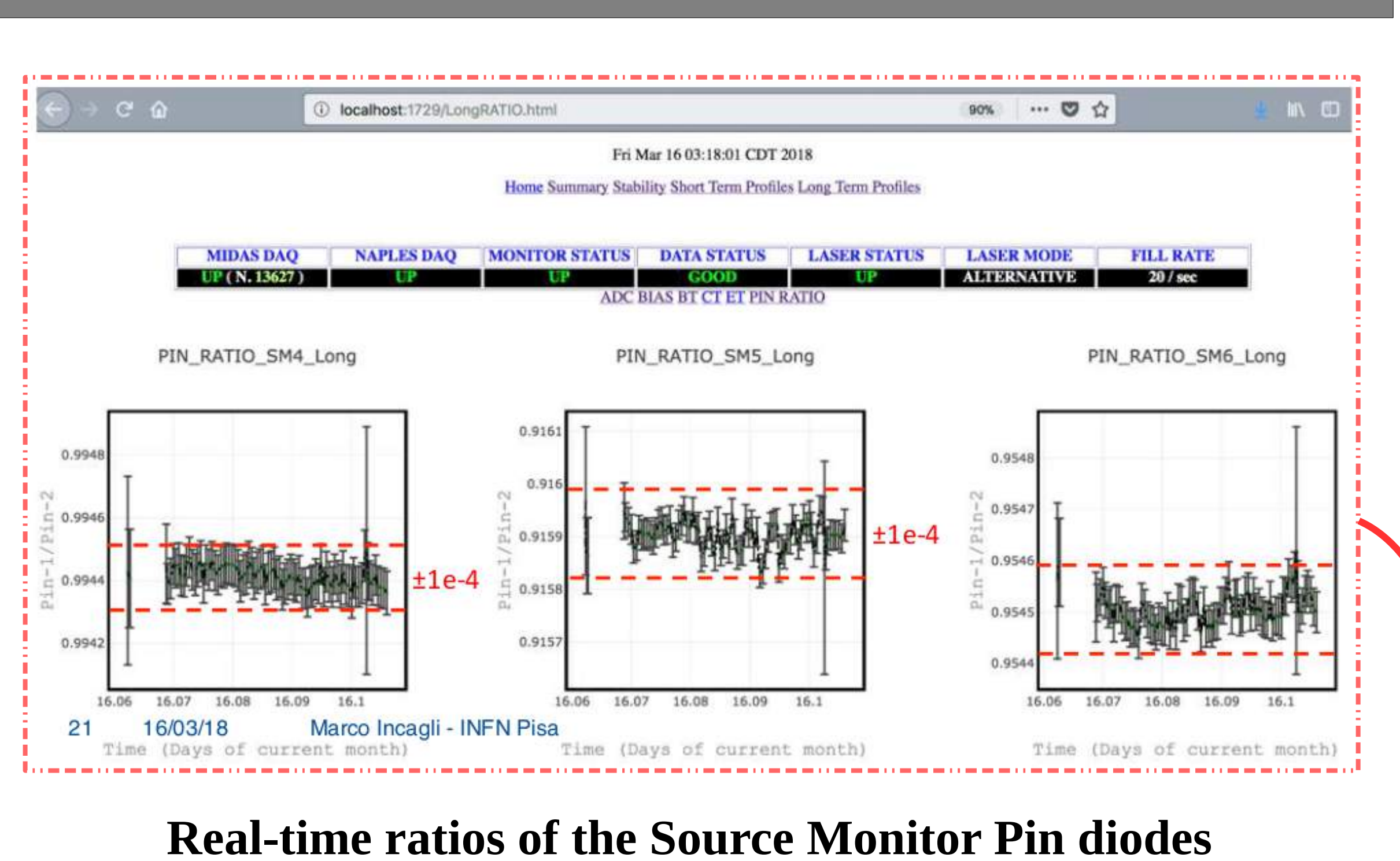
ONLINE SM AND LM TRACES



NAPLES DAQ SM MONITORING PAGE

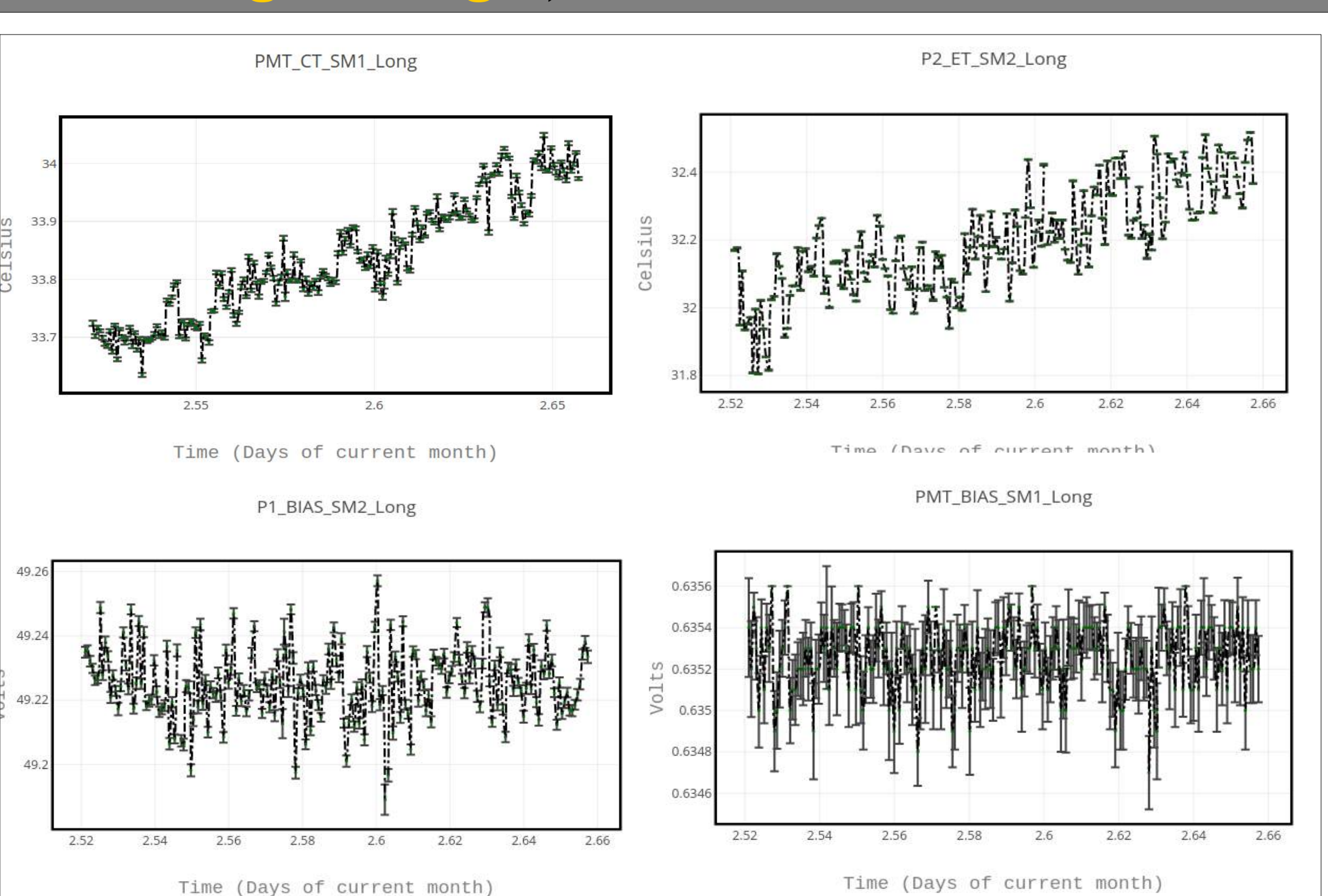
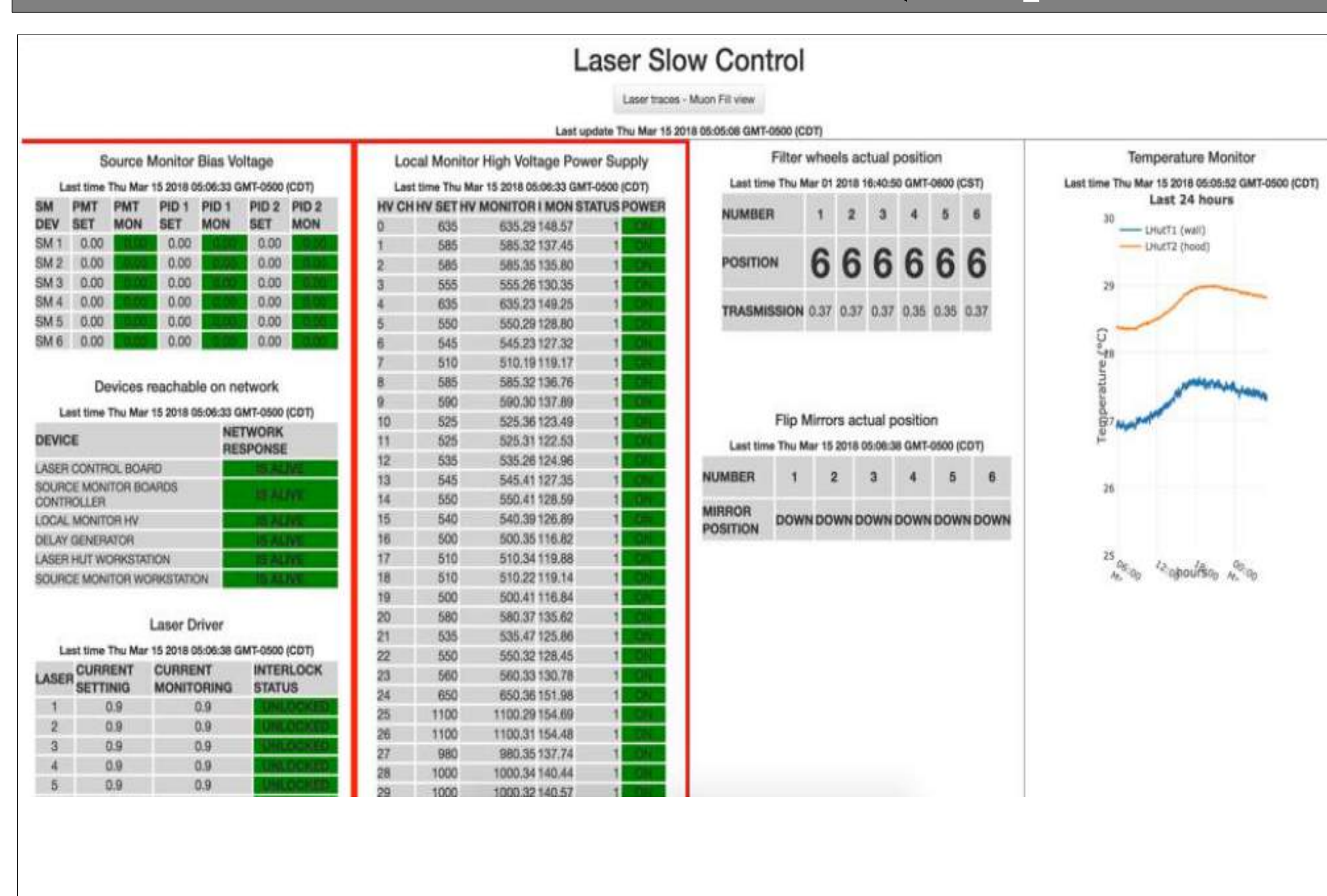


Real-time summary of all the measured quantities.

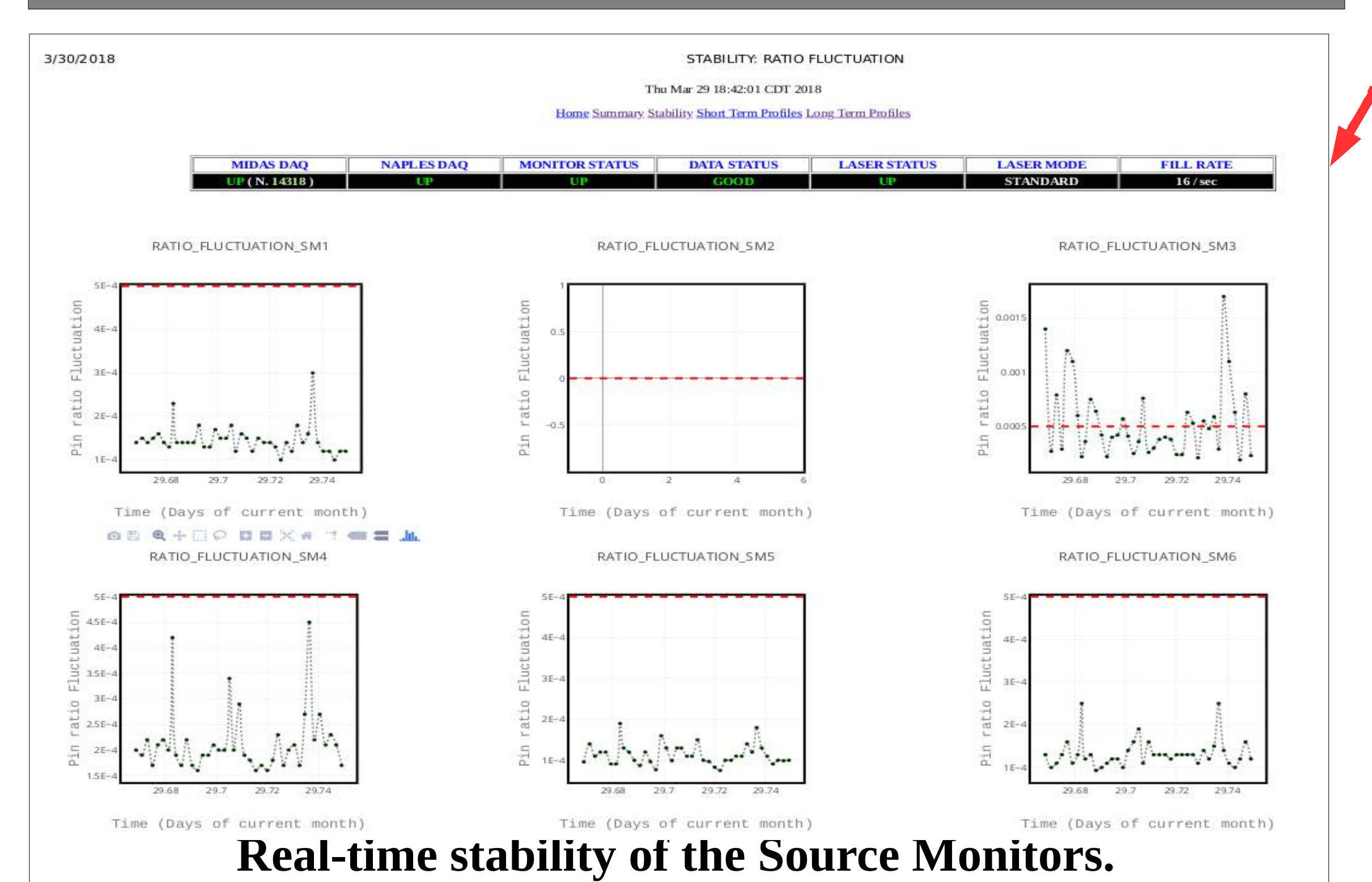


Real-time ratios of the Source Monitor Pin diodes

SLOW-CONTROL (Temperatures, Biases and High Voltages) MONITORING



STABILITY OF SM



Real-time stability of the Source Monitors.