

GPS Time Corrections at FD

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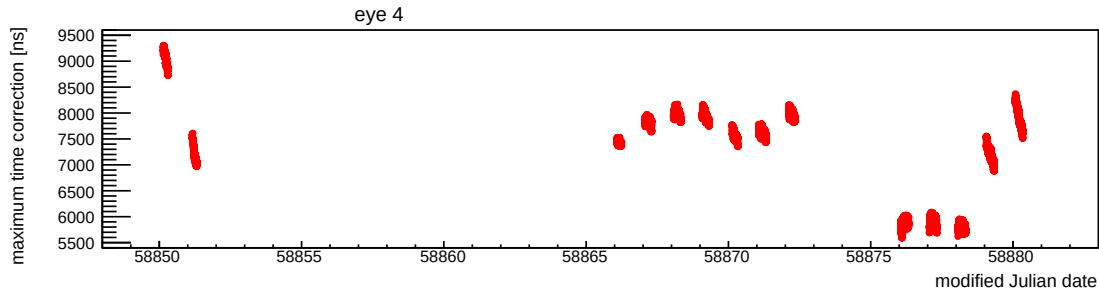
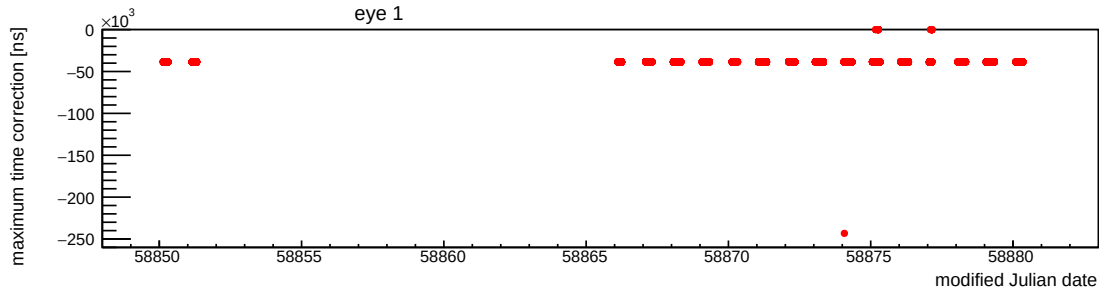
Timing at FD (simplified)

- FD electronics runs with 1 Hz (in sync with 1 PPS) and 10 MHz clocks
- 10 MHz crystal oscillator has error of few $\times 10^{-5}$
- GPS timing system with
 - Oncore UT+ receiver
 - 1 PPS signal only estimated
 - corrections (negative sawtooth) only available in next second
- period of 10 MHz clock must be corrected (T10)
- sawtooth parameters give offset -127 ... + 128 ns (roughly)

References:

- F. Meyer, F. Vernotte, Time Tagging Board Tests at Besancon Observatory, 2001, GAP 2001-050
- M. Kleifges, D. Tcherniakovski, GPS Module, Documentation of Firmware Implementation & Communication, 2006, CERN EDMS

Time correction 2020-01



Plotted quantities

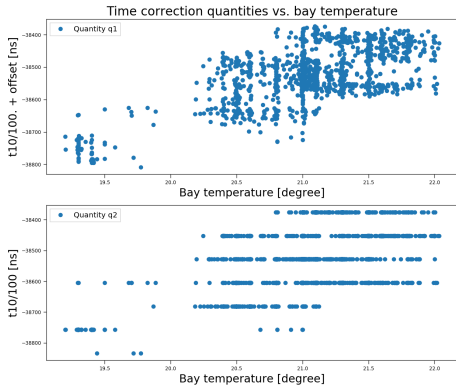
$$q1 = 1 * 10^9 * \frac{T_{10}}{100.} + offset - 1 * 10^9$$

$$q2 = 1 * 10^9 * \frac{T_{10}}{100.} - 1 * 10^9 \quad (= q1 - offset)$$

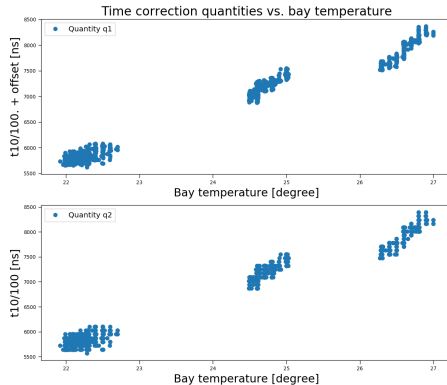
Time correction is maximal at the end of a second (after $1 * 10^9$ ns).

Time correction 2020-01 - temperature dependence

Los Leones



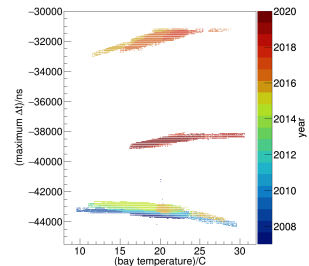
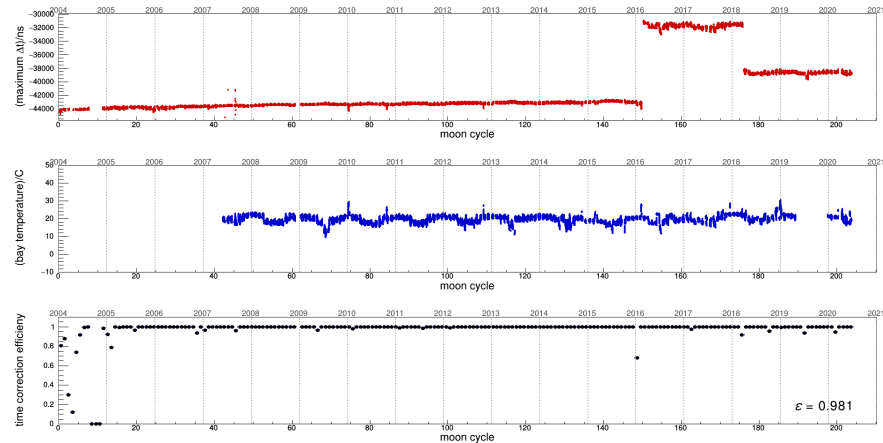
Coihueco



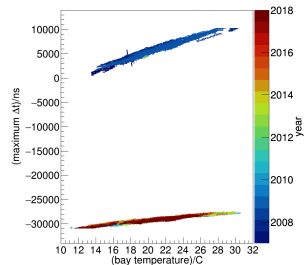
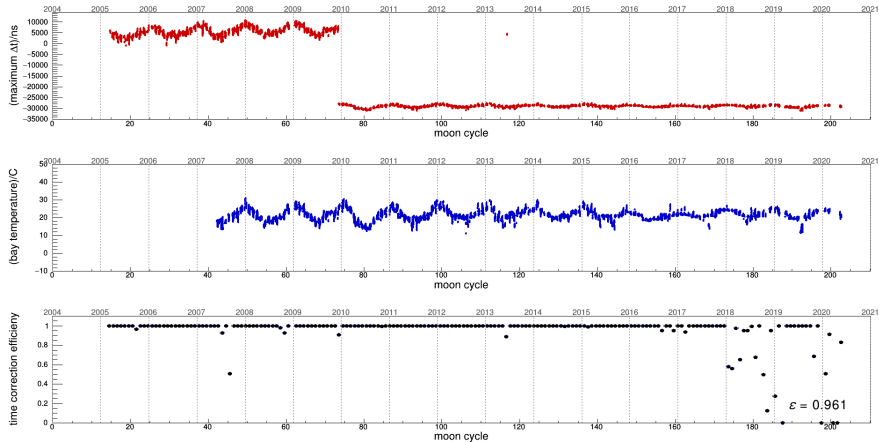
FD DAQ: Error handling during timing correction

- status of time correction by DAQ in TEyeEventHeader:
 - kCorrectionNotSet - missing link to GPS
 - kUnknownQuality - invalid/wrong data from GPS
 - kAveragedPeriod - took some average value for T10
doesn't take temperature and/or time dependence into account
 - kFullQuality - the best we can do in online system
- wrong or incomplete error handling in DAQ (next plot):
 - sometimes flag set falsely to kFullQuality
 - T10 set to nominal value (100.0)
 - or T10 too much off from nominal value, reason not clear

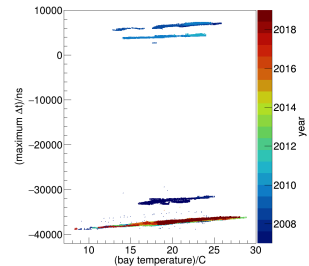
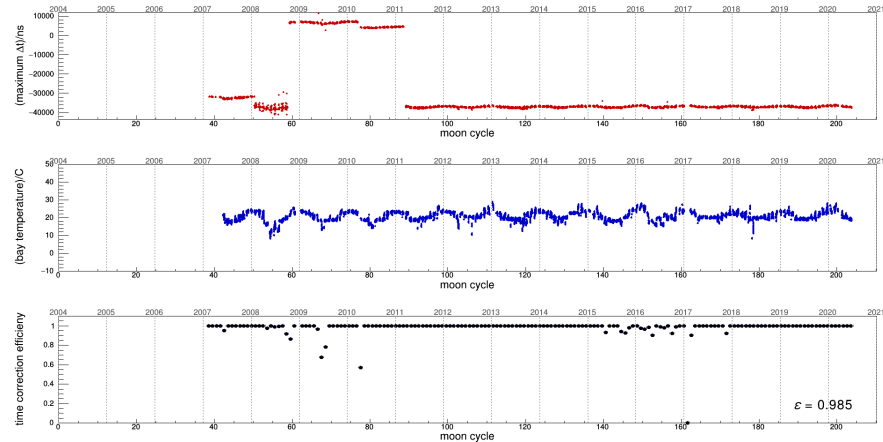
Los Leones



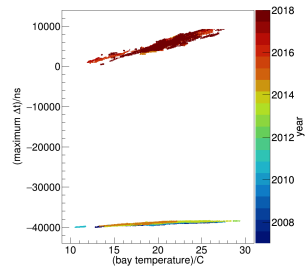
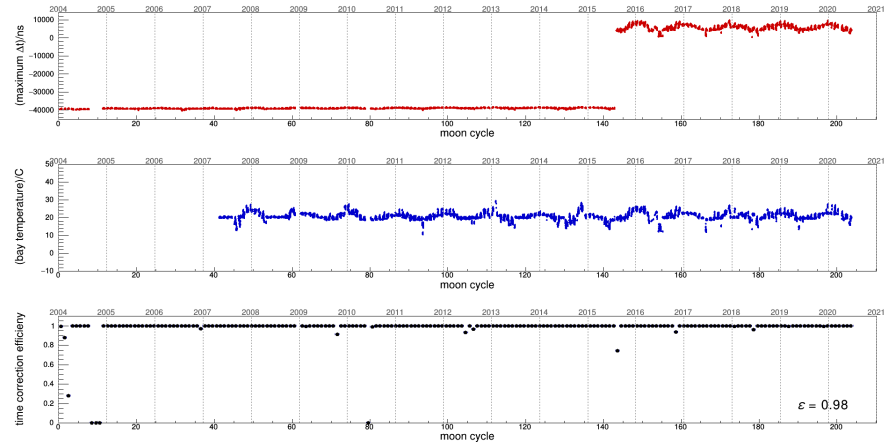
Los Morados



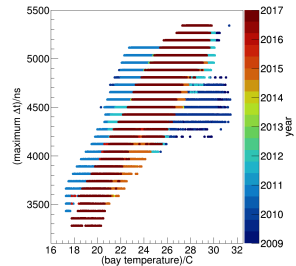
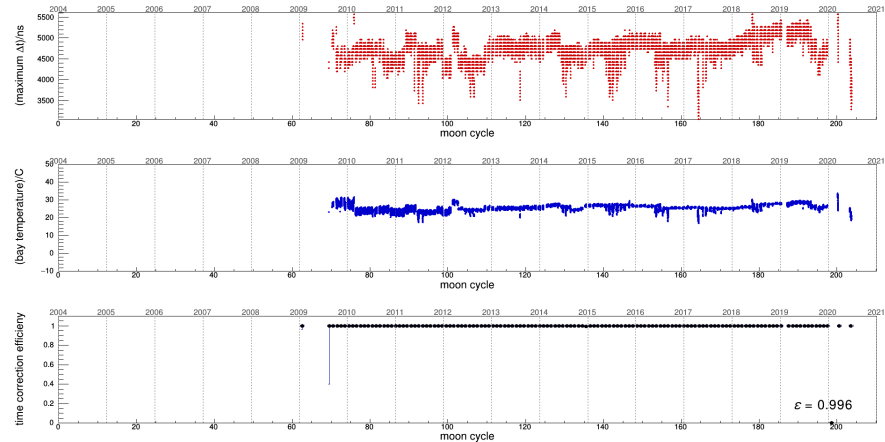
Loma Amarilla



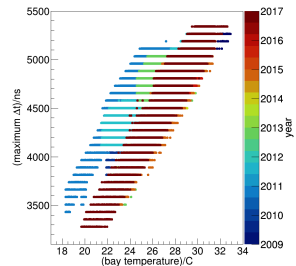
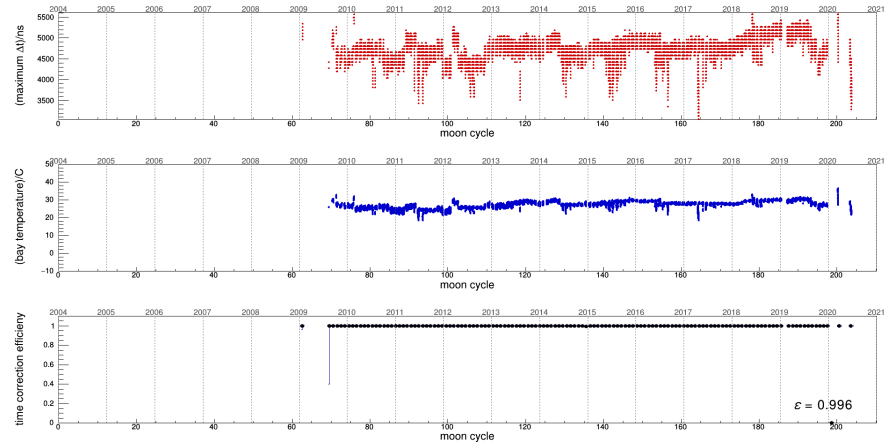
Coihueco



Heat - DAQ temperature



Heat - Rack temperature



Analysis and Offline

- time correction within Offline could (should?) be done, if
 - T10 has unplausible values (too much off or too precise)
 - kAveragedPeriod set in FD raw data
- final precision not better than $\pm 128\text{ns}$
- loss of events is uncorrelated with showers, thus no effect on X_{max}
- take into account corresponding flag in exposure calculation

Conclusions

- $\sim$ linear correlation of oscillator frequency with bay temperature
- overall event loss due to bad-quality time correction: 1.9%
- offline correction for these 1.9% worth the effort?
- T-freq correlation tight enough for a precise offline correction?
- track hardware & software (software/firmware revisions, serial numbers) in data or database ?