



# Laser Interferometer Gravitational-Wave Observatory (LIGO)

---

## Engineering Run 2. LHO

### Detector Timing

Related LIGO technical note number: LIGO-T010034-00D

*LSC 2001 Spring Meeting*

*Baton Rouge, LIGO Livingston Observatory*

**Szabolcs Márka, Daniel Sigg and Akiteru Takamori**

*March 15 2001*



# How can we measure ...?

- **Special signal to measure DAQ timing**

- » **GPS TRIG**

- 1 ms long square wave

- » **GPS RAMP**

- 1 ms long steep ramp

- » **The GPS second tic is aligned with**

- the rising edge of the square wave
- the zero crossing of the ramp

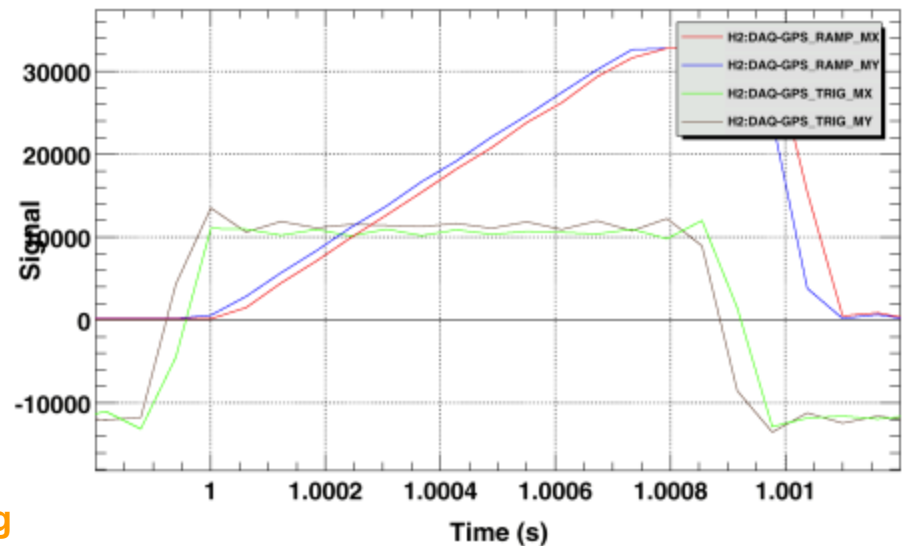
- » **Fit the RAMP and compute the zero crossing**

- » **Determine delay between GPS tic and DAQ time stamp**

- Practical experience:  $O(100\text{ns})$  measurements are achievable!

- » **DMT monitor exist!**

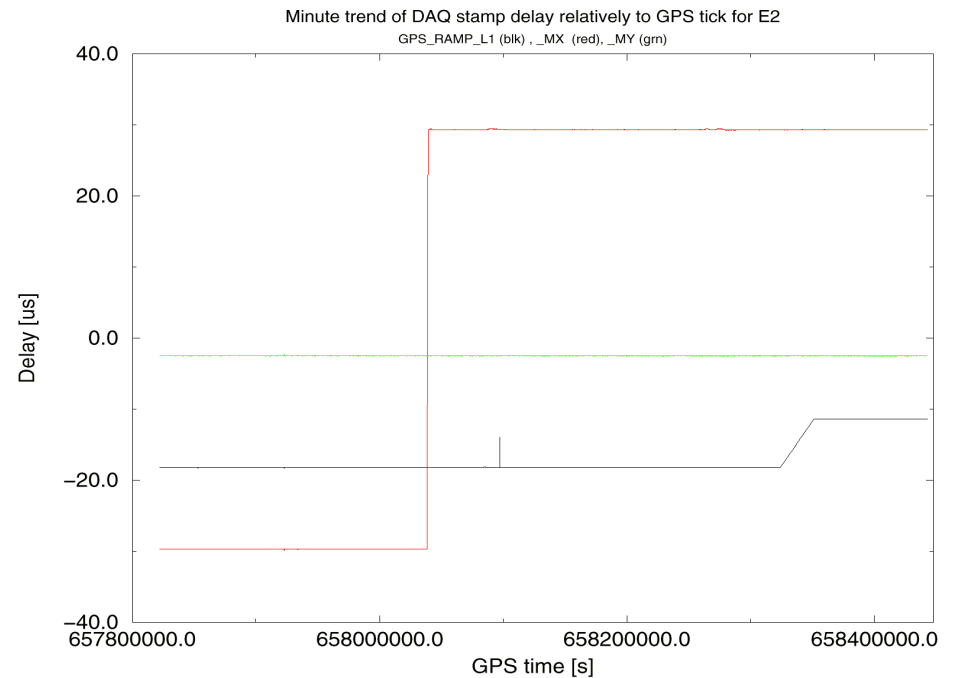
- Thanks for John Zweizig for his help!





# and ... did we measure?

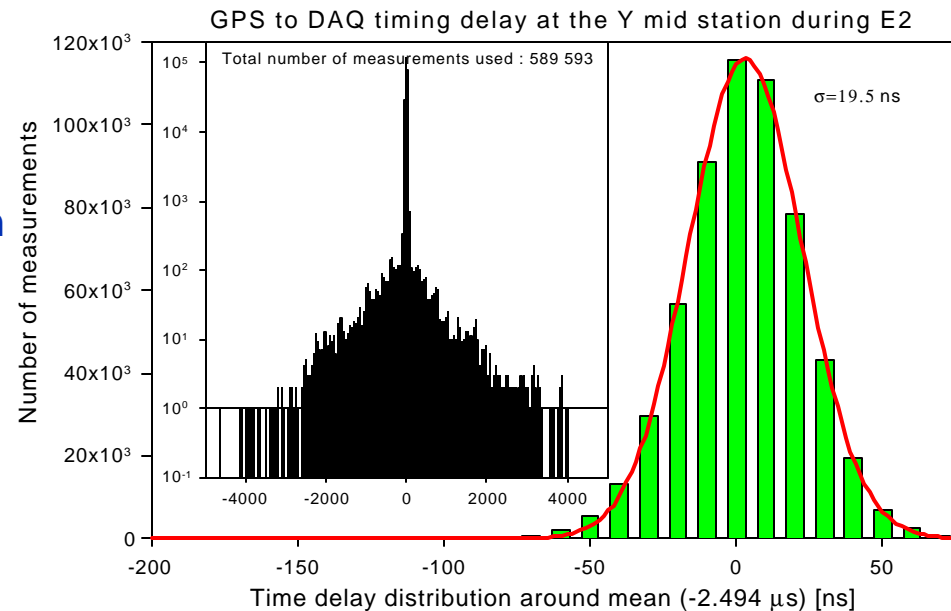
- We monitored the timing of the
  - » Corner station
  - » Both midstations
- DMT monitor (TimeMon)
  - » Second trend
  - » Minute trend
  - » Hour trend
  - » Output for DMT Viewer (on DTT)
- the overview ...





# Accuracy Measurement

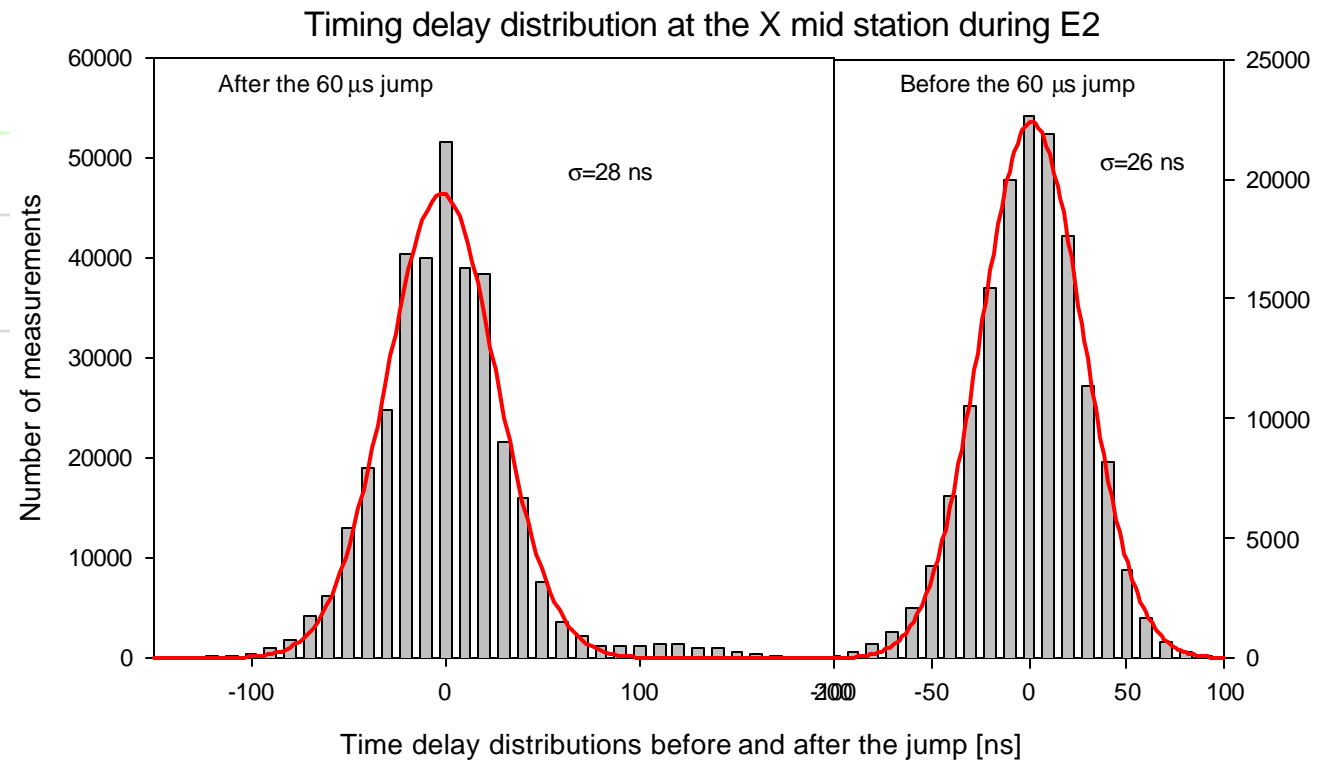
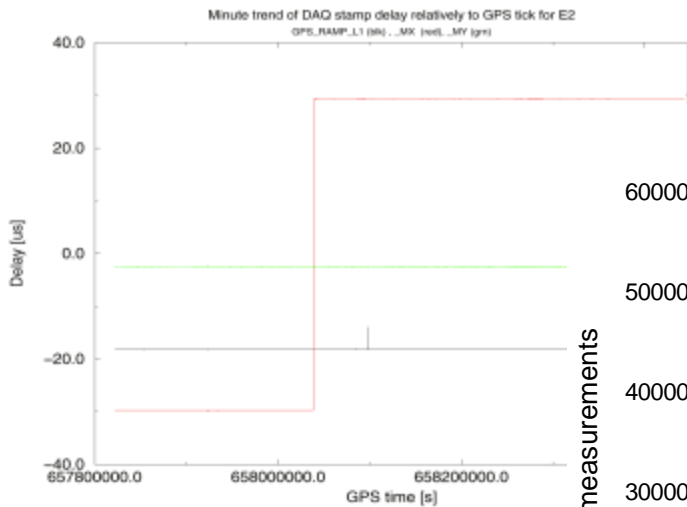
- The timing stability is very good (unless DAQ rebooted)
- We only observed excess noise on the Y-mid station signal





# Accuracy before and after the jump

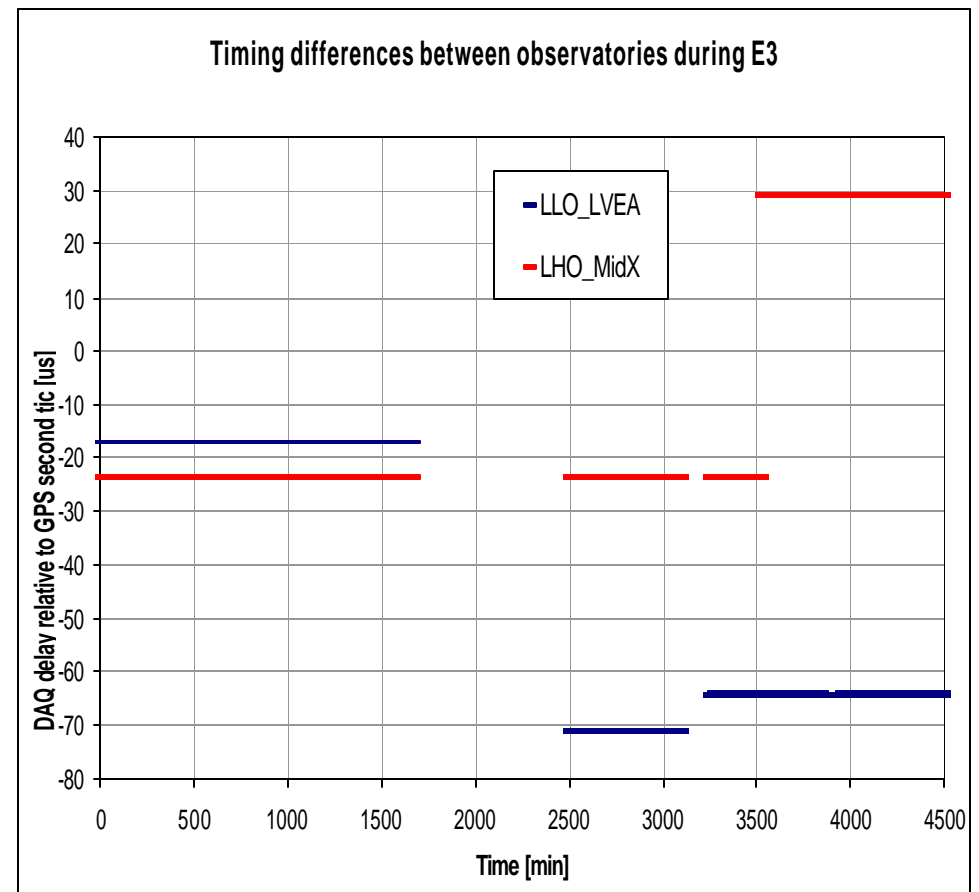
- No significant difference between distributions !





# Next step: Preliminary E3 results...

- **IRIG-B signals**
  - Codes agree
  - Phases coincide
- **Indicates site to site timing difference of less than 100 ns**
  - Shifts of  $O(10 \mu\text{s})$  coincide with reboots
  - Scatter is sub  $\mu\text{s}$  between jumps
- **To fix or monitor these jumps...**





# Conclusions

- A LIGO technical note is available (LIGO-T010034-00D)
- We are able to measure the timing delay
  - » Less than 100 ns between the GPS tic and DAQ time stamp
  - » from test mass...  $O(100\mu s)$
- Things to do (on the short run)
  - » Track down and fix reboot related jumps
  - » Analyze E3 data
  - » Include more versatile (real time) error reporting (to operators)
  - » Improve RAMP signal shape (hardware)
  - » Include (multi site?) IRIG-B signal comparison/error detection
  - » Investigate, propose and implement GPS independent timing method(s)
  - » Investigate timing methods suitable for inter(national)-site timing
- A lot to do, let's go ahead!