Notes on Single and Multi-Detector Timing

LSC 2002 Spring Meeting

LIGO Livingston Observatory

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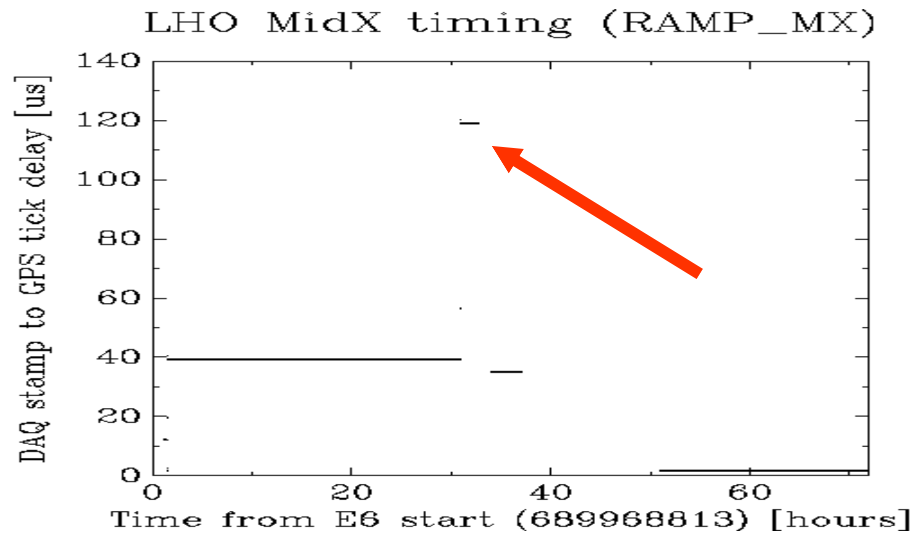
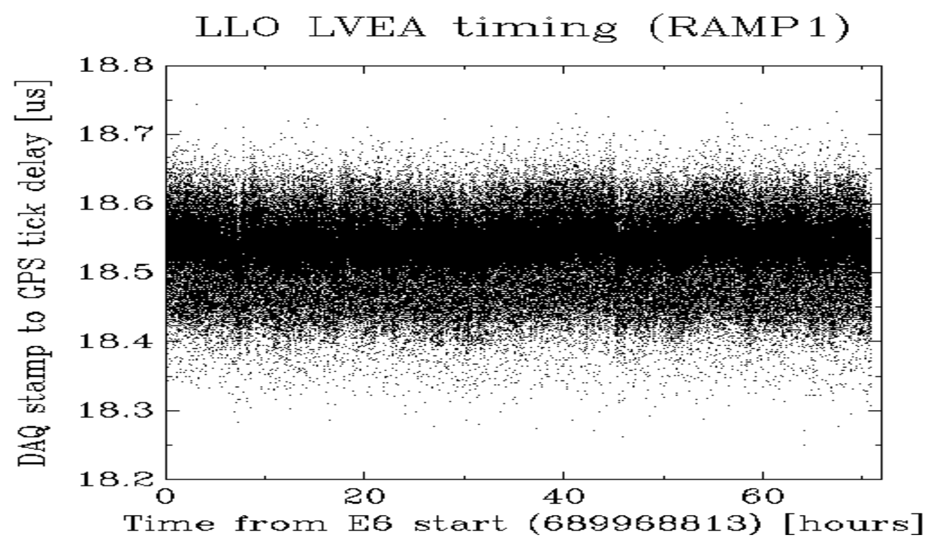
March 2002

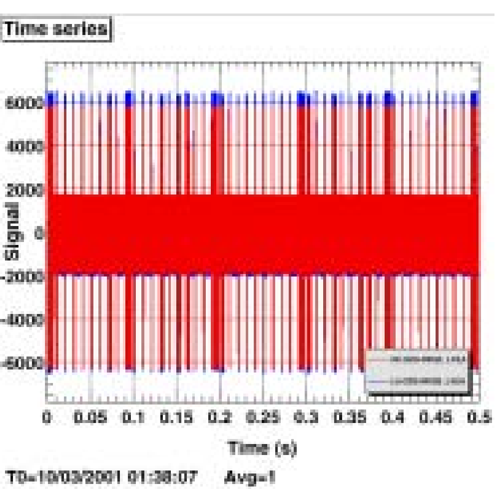
LIGO-G020143-00-D

E6 Notes on E6 timing

- **IRIG-B signals**
  - No problems during the run
  - Large shifts were observed before and after the run in LHO
- **Slope indicates timing differences below 120 μs**
  - Still have old timing cards
    - Shifts of ~O(10 μs) coinciding with reboots
    - One large 120 μs was quickly corrected
  - Scatter is sub μs between jumps
  - “Double bands” observed – might be software related
    - Will investigate with new timing cards

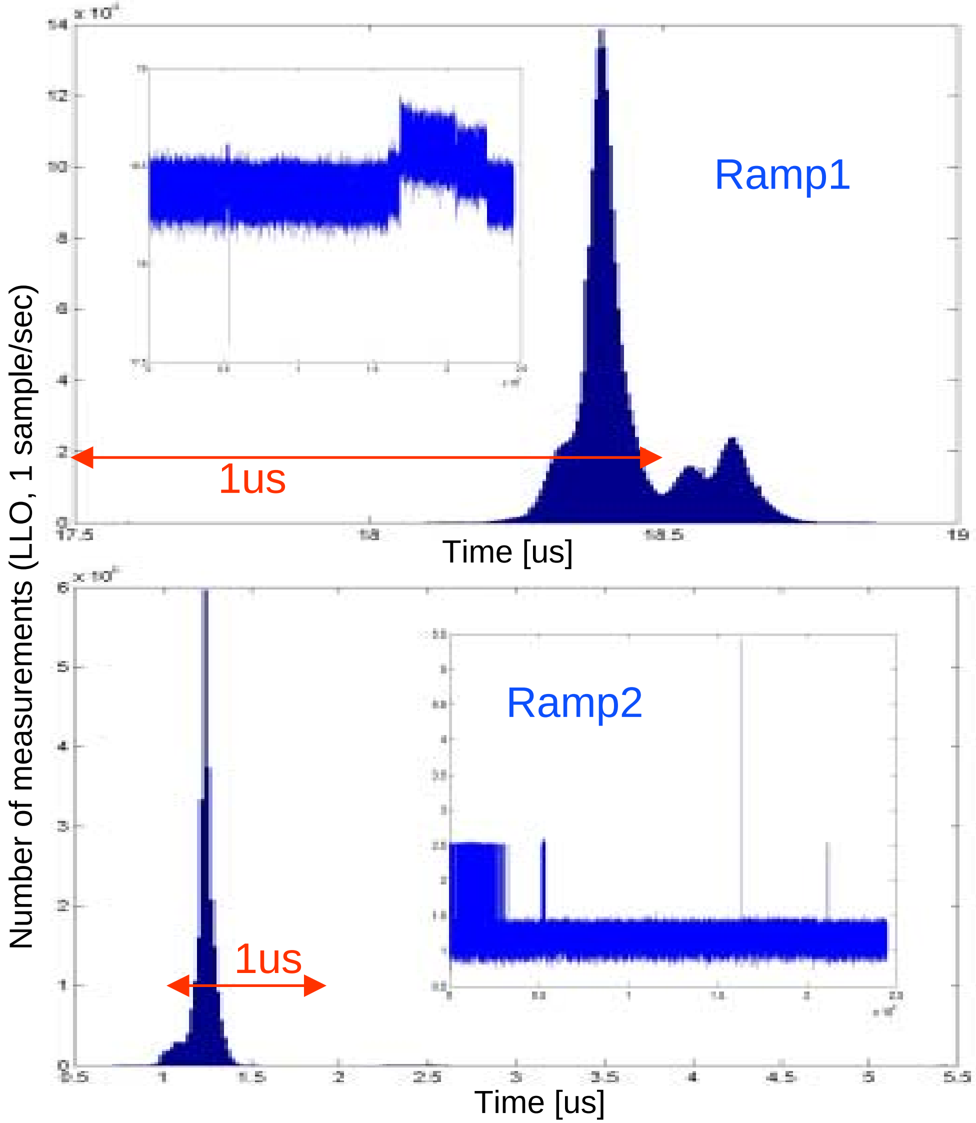






Notes on E7 timing

- IRIG-B signals
  - No problems at LLO
  - Some problems in LHO
    - **… at the beginning of the year**
      - **01/01/02!!, 01/02/02, 01/04/02,…**
- Ramps indicate the “usual” jumps
  - Between jumps the stability is good
- Only 2 signals at LLO and 1 in LHO
  - **Ideally, there should be more than 10 signals monitored to cover all LVEs, subsystems and crates.**
- New timing board are here.
  - They should be installed for E8



LIGO-VIRGO Timing Test

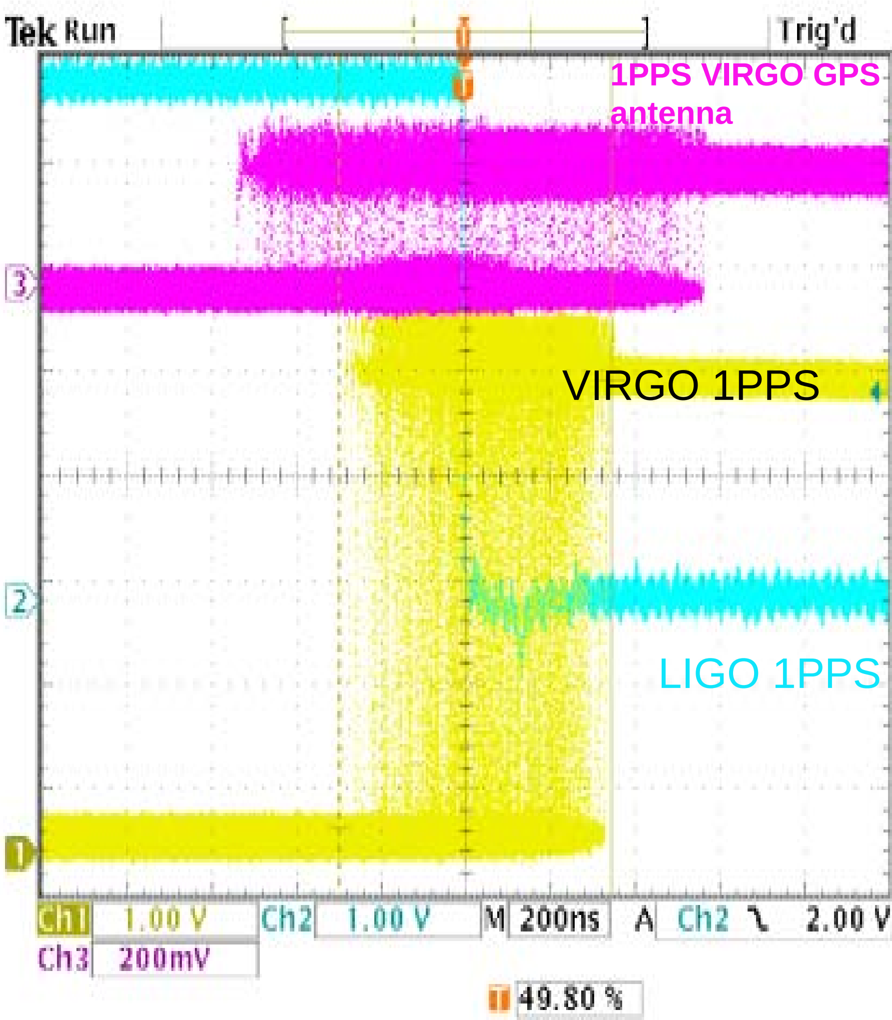
- **For coincidence analysis accurate relative and absolute timing is a necessity**
  - » **Is it wise to solely rely only on the GPS system?**
  - » **Delays on the signal path?**
  - » **Are we synchronized to the word? (e.g. external triggers)**
  - » **Are we running in sync? How much in sync?**
  - » **Does boards from different manufacturers give us the same time?**
  - » **Do we ALWAYS get the right time from the GPS?**
  - » **GPS is complicated -> are there firmware bugs?**

Can we make measurements or systems, which can answer such troubling questions?

1. **Validate the relative performance of our GPS boards**
2. **Prototype and evaluate a simple system to correlate relative/absolute time stamping of data between sites (preferably GPS independent !)**
3. **Propose an affordable, GPS independent solution for redundancy**
4. **… will continue**

GPS board validation

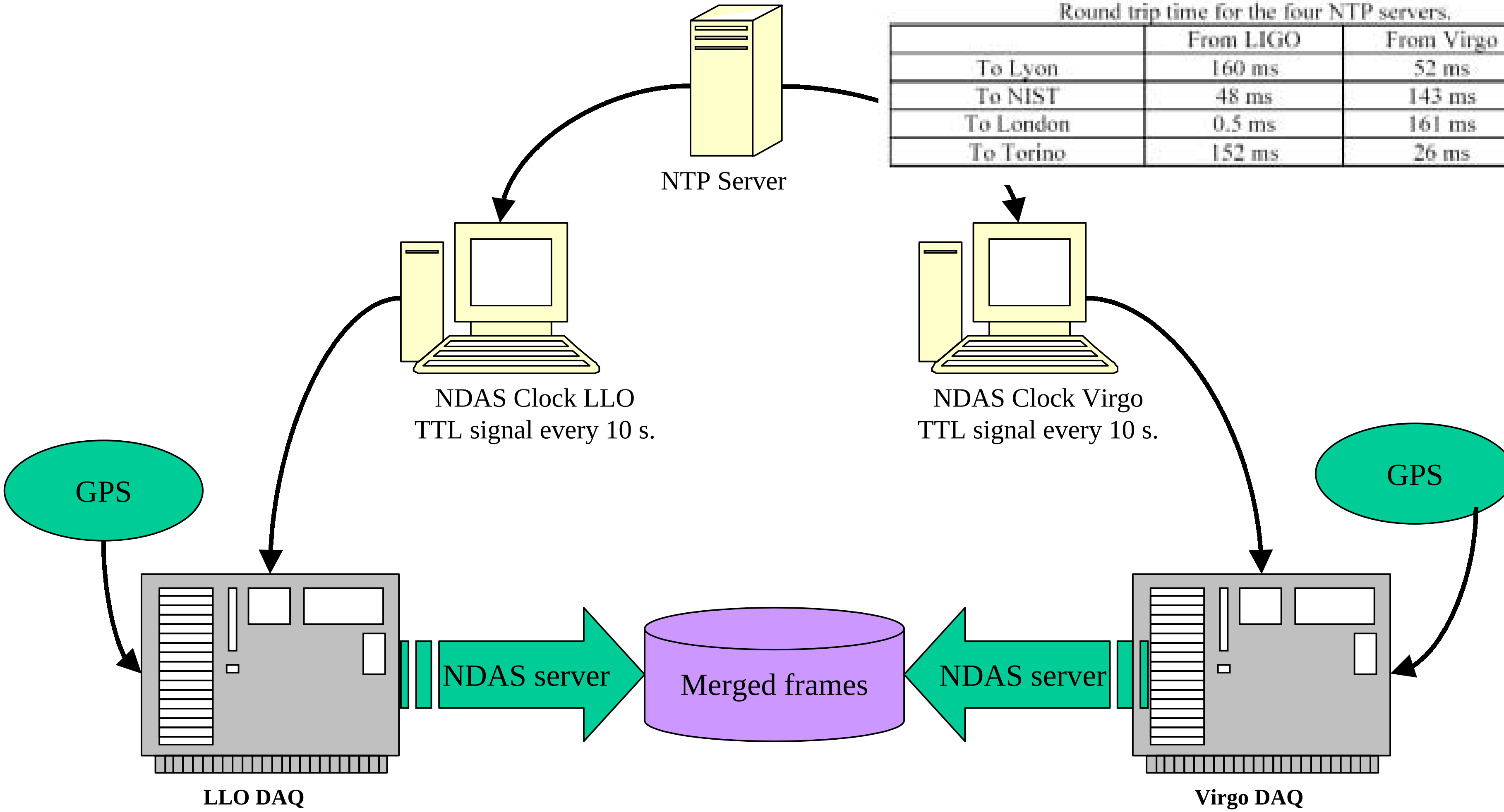
- **LIGO and VIRGO use different GPS boards**
- **Is there a systematic or random difference?**
- **Measure the relative 1 PPS jitter**



Experimental Setup/Conclusion

- A VIRGO GPS antenna was installed outside the building and connected to a VME crate were the VIRGO VME GPS board was installed.
- The LIGO 1PPS signal source was the LIGO GPS board installed in the mass storage room
- 1 µs relative accuracy for the GPS boards used is a fair assumption
- No significant systematic offset is observable

Global timing test



Round trip time for the four NTP servers.

	From LIGO	From Virgo
To Lyon	160 ms	52 ms
To NIST	48 ms	143 ms
To London	0.5 ms	161 ms
To Torino	152 ms	26 ms

Accuracy of signal generation

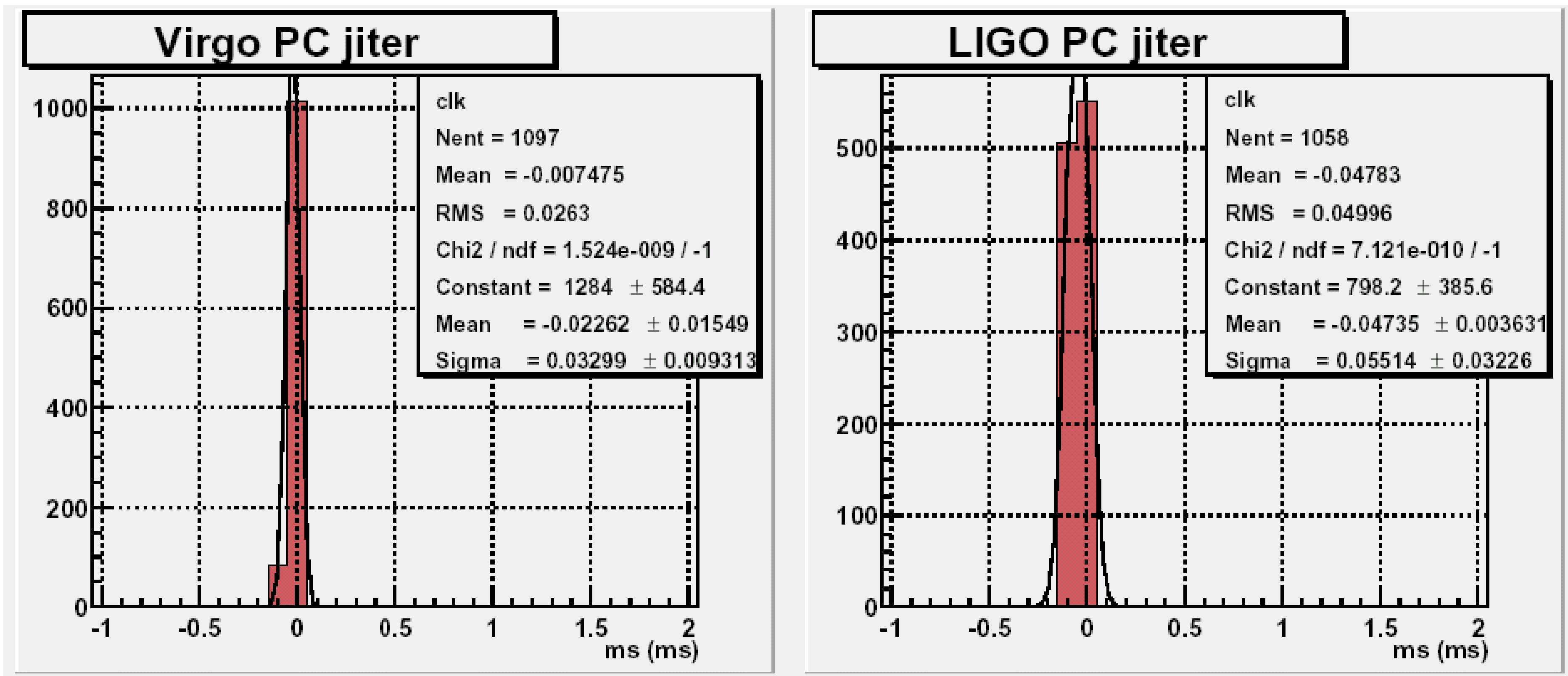


Figure 4: Event arrival time resolution: arrival time relative to the previous pulse measurement without updating the PC clock. The two measures are separated by 10 seconds.

Arrival times (Torino server example)

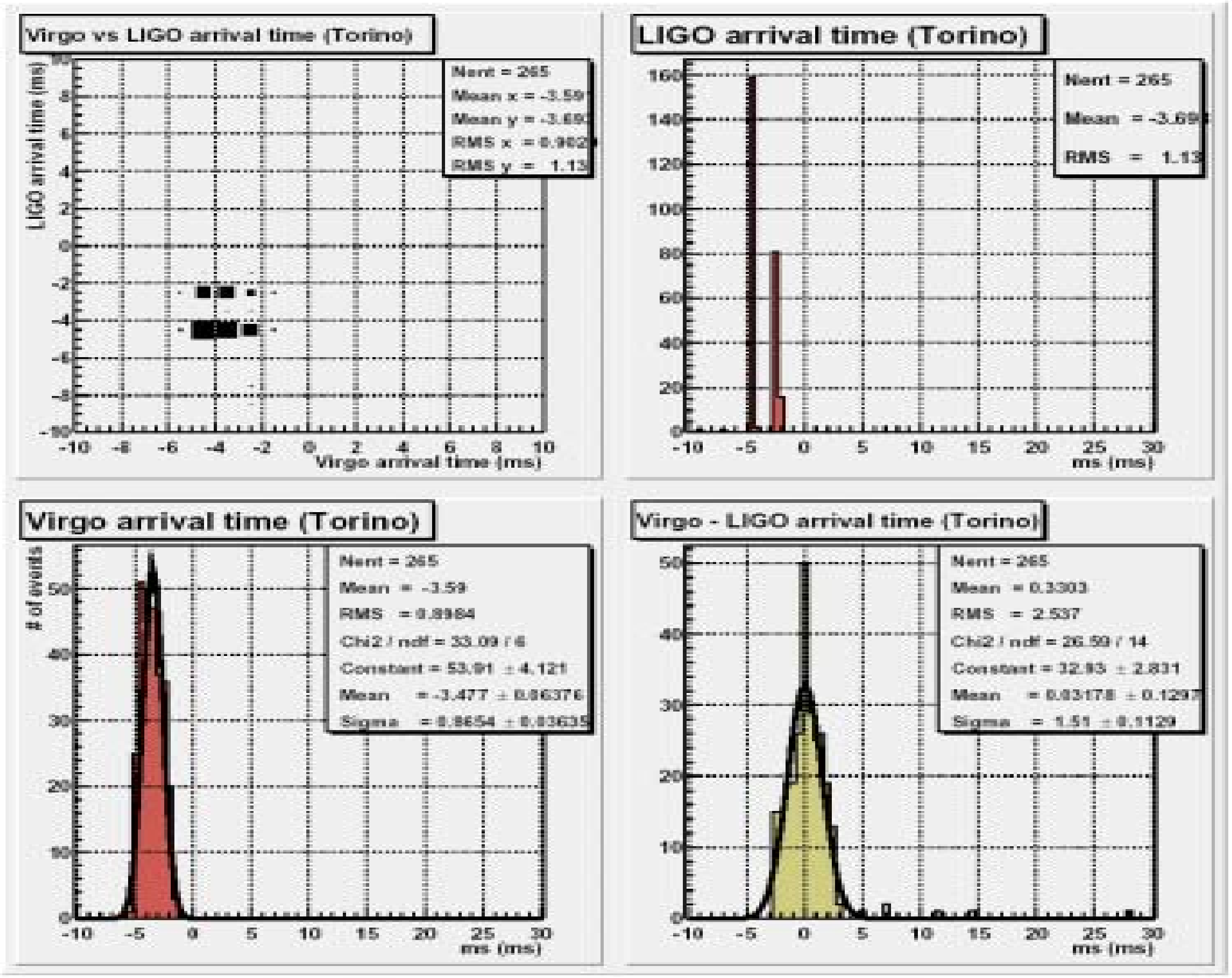


Figure 10: Arrival times when the PC clocks are set using the Torino server.

Arrival time trends

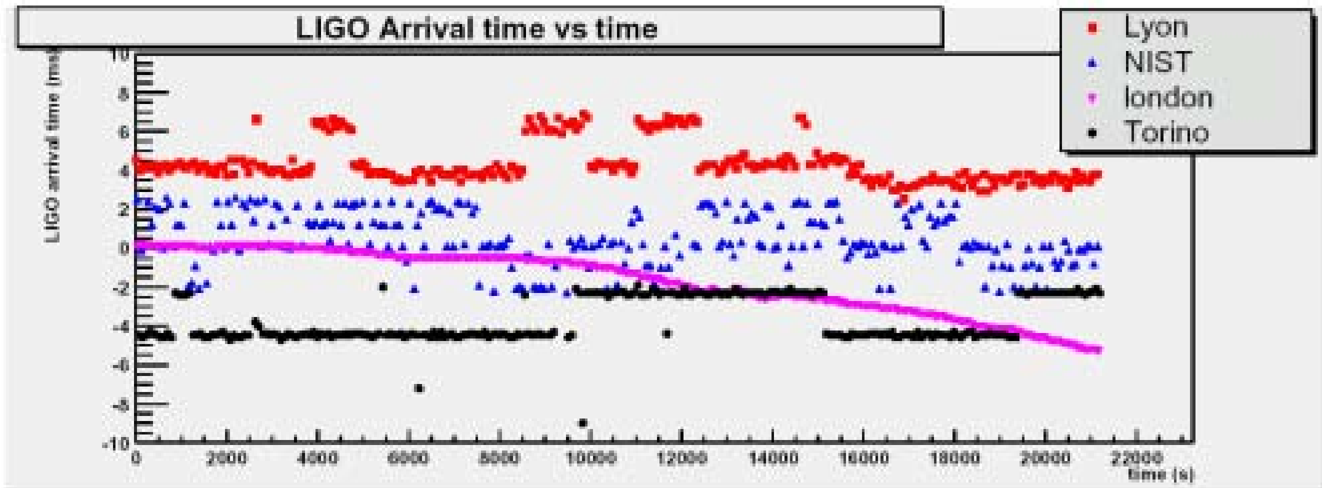


Figure 5: Arrival time at the LIGO site. The drift of the LIGO NTP server (london) is visible.

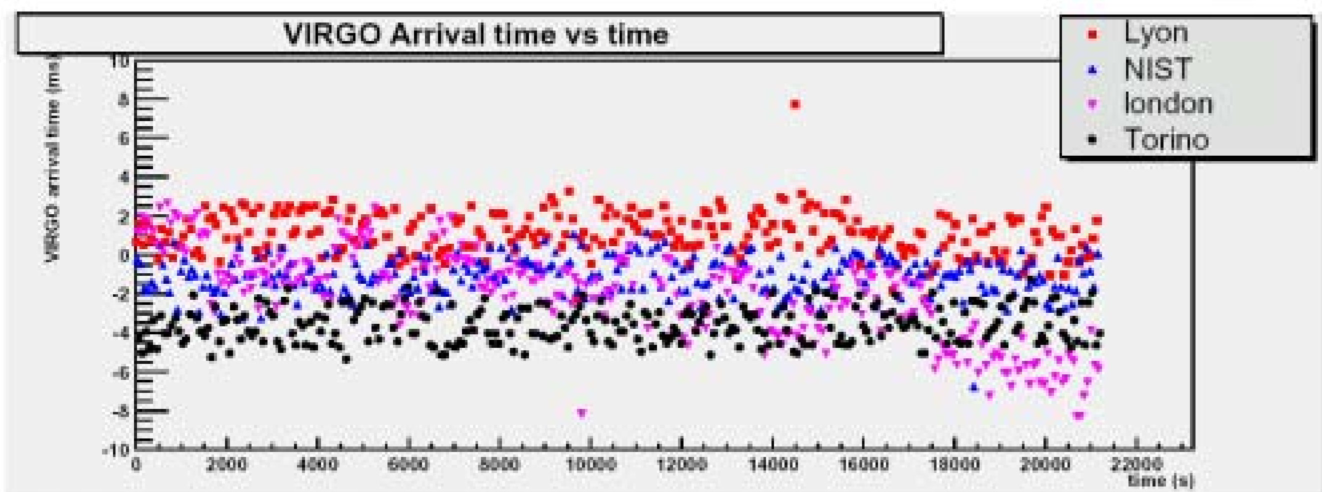
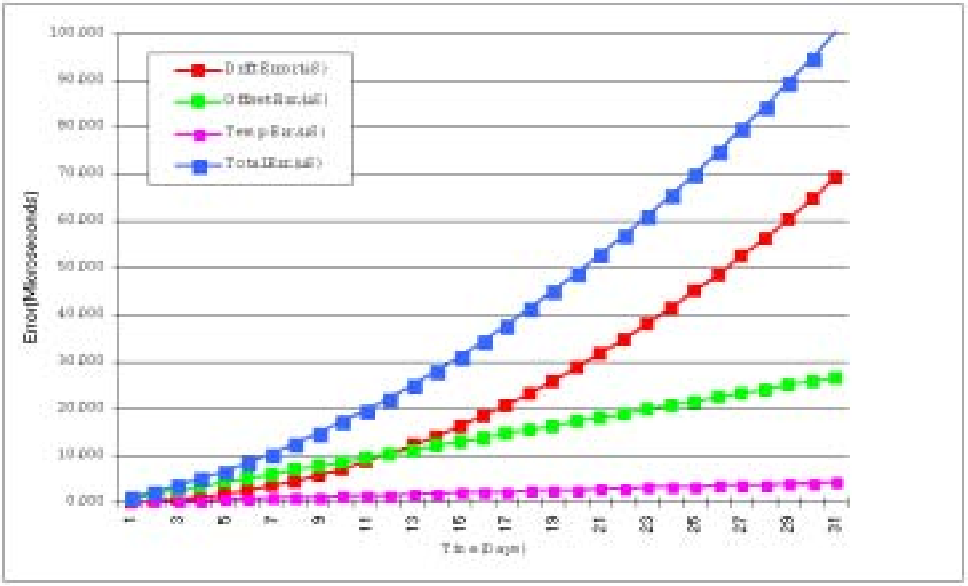


Figure 6: Arrival time at the VIRGO site.

Viable(?) atomic clock based solution



Simple assumptions:

•Clocks can be disciplined to a master source at the same location 4 times a year.

• No collaboration will be willing to invest more than ~10K$

• It is sufficient to maintain the relative accuracy between any two sites within 20% of the expected accuracy of the matched filtering (0.2 * 100us ~ 20us) for the free running periods (~90 days).

- NO - Baked precision crystals
    - ~150 ms for the 90 day interval
- NO - Cesium clocks
    - better than ~20us for the 90 days
    - However, a 25K$/unit is pricey
- Maybe – a small rubidium based clock
    - 1.5K$/unit + work
    - ~700us for 90 days
        - Software correction to ~20us