

Preliminary tests with GPS

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The *GPS (Global Positioning System)* is a satellite system which provides real time information on

position (latitude, longitude, altitude) of the user receiver

Local time synchronization with respect to UTC (Universal Coordinated Time)

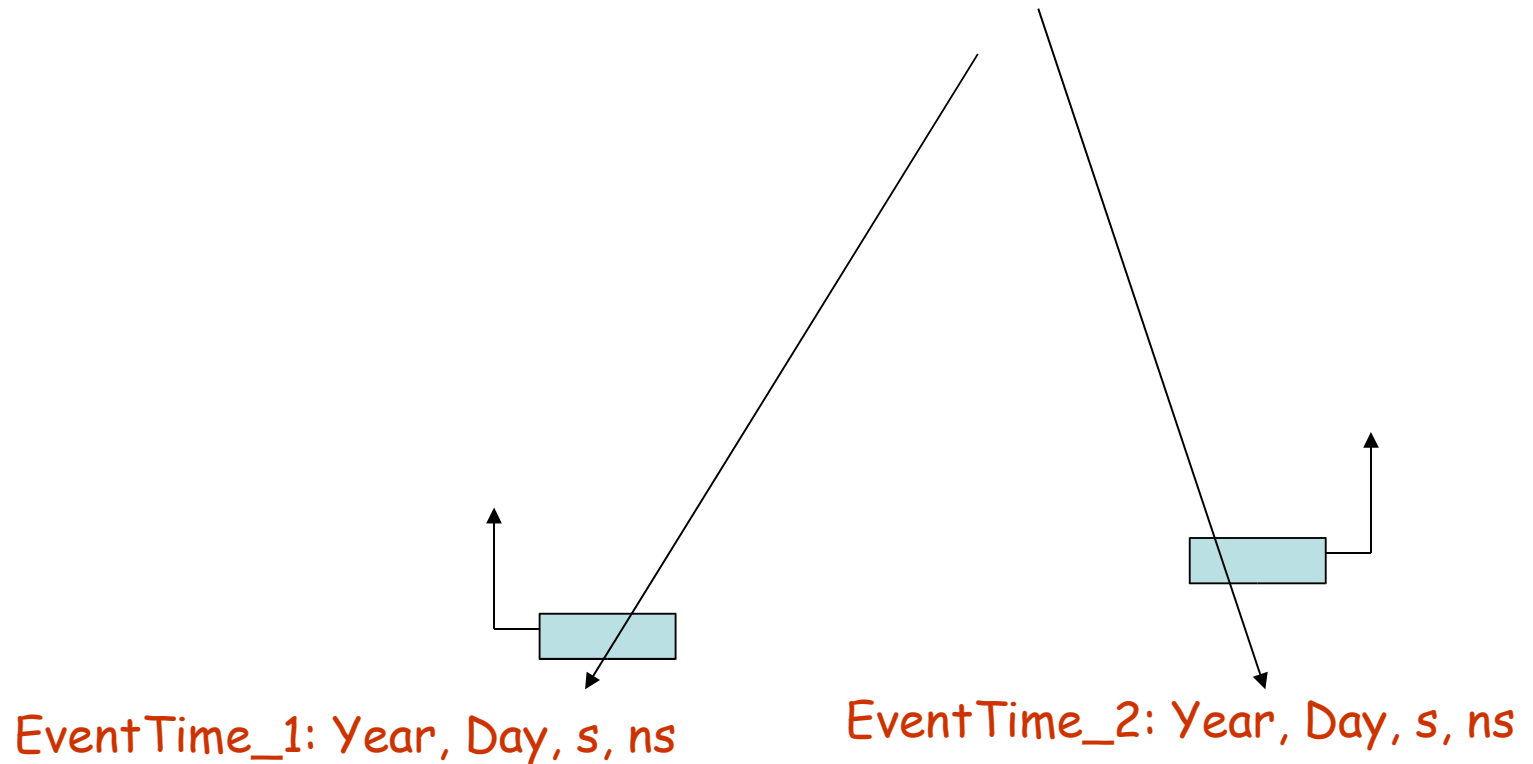
Based on

Space Segment: a set of (24+3) satellites, located in 6 orbital planes with 55° inclination to the horizon

Control Segment: Earth stations to control proper functioning and to send corrections

User Segment: user receiver, using the informations from visible satellites

For distant detectors (as for the EEE telescopes), time synchronization may be achieved in principle within 100 ns by the use of GPS receivers (one for each telescope), in order to correlate off-line the events measured by different telescopes.



Some tests of the GPS system are actually on-going in Catania, with the following hardware

2 GPS92 units : Modules GPS in standard CAMAC from HYTEC

1 GTS8000 unit: Additional GPS module, with 1 PPS (1 Pulse Per Second)

Detectors for cosmics (Geiger, scintillators)

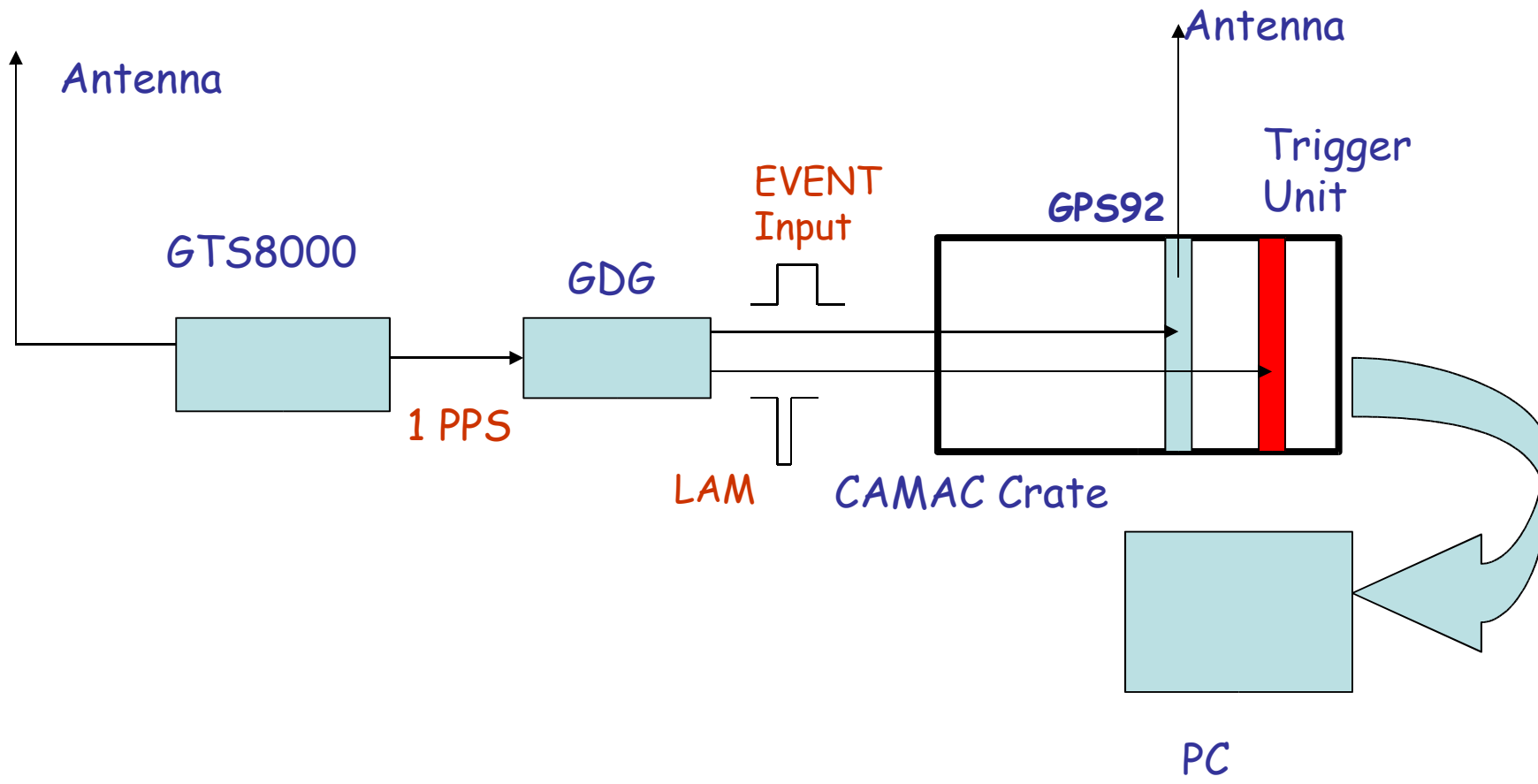
Some preliminary results:

Position measurements: resolution and short/long term variations

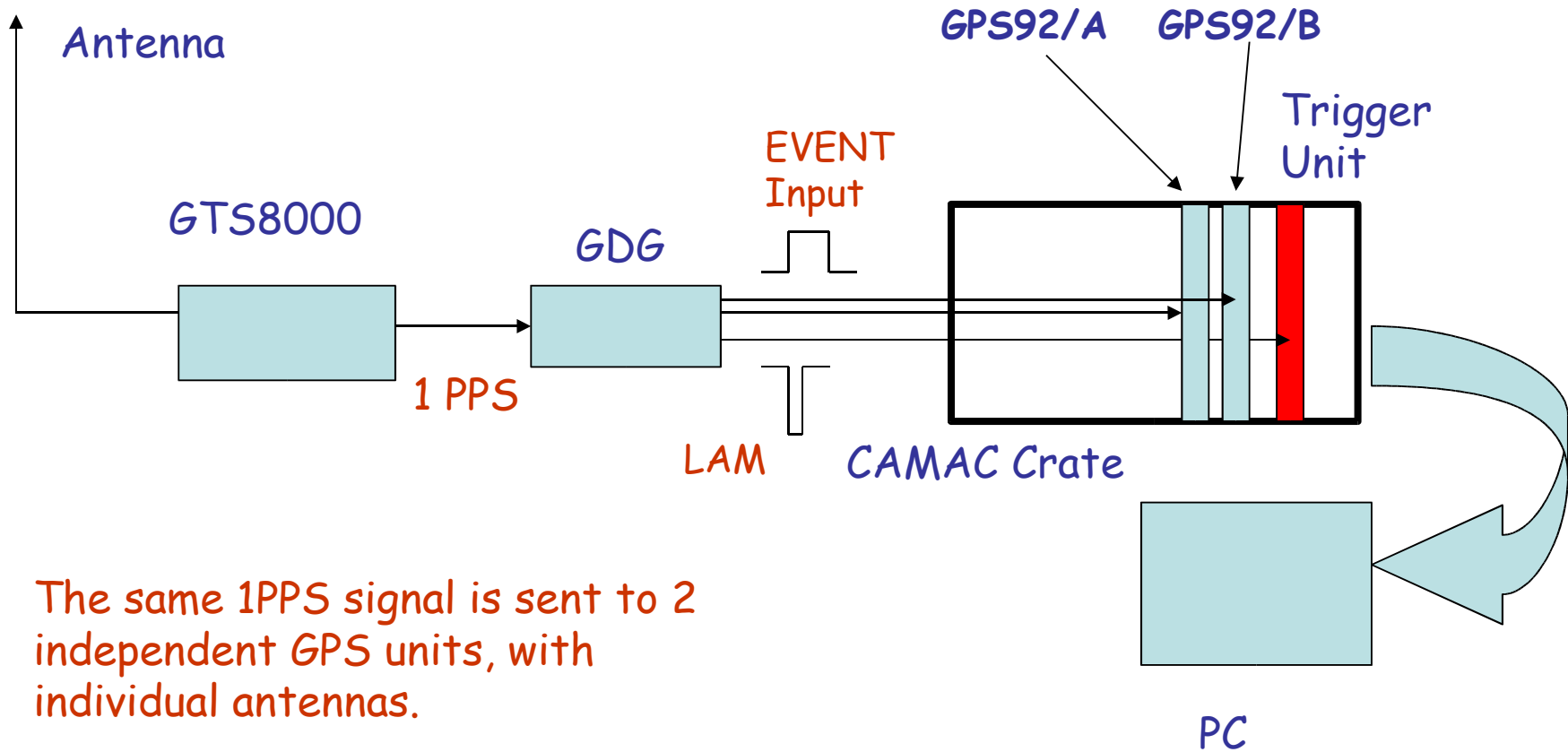
Time resolution of the individual GPS unit

Correlation between the informations provided by 2 independent GPS

Hardware configuration for tests with 1PPS signals from GPS



Hardware for tests with 2 GPS92 modules



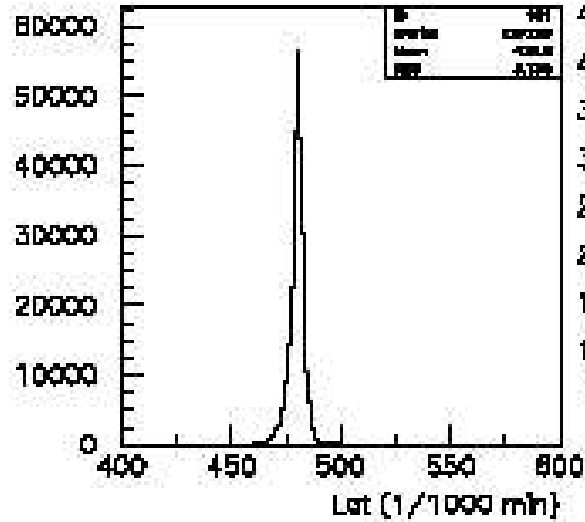
The same 1PPS signal is sent to 2 independent GPS units, with individual antennas.

Time information provided by the
GPS92 unit (available both in CAMAC
and VME)

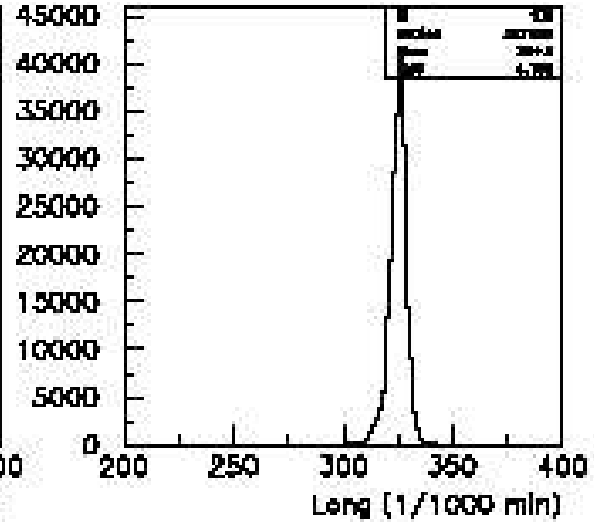
| Word | Bits | Content |
|------|-------|---|
| 2 | 0-15 | Low 16 bits 10 ns increments into seconds |
| 3 | 0-10 | High 11 bits |
| | 11-15 | Low 5 bits of seconds into day |
| 5 | 0-11 | High 12 bits |
| | 12-15 | Low 4 bits of day into year |
| 7 | 0-4 | High 5 bits |
| | 5-9 | 5 bits of year (starting from 1996) |
| | 10-15 | Status bits |

4 additional CAMAC words provide
geographical informations

Latitude

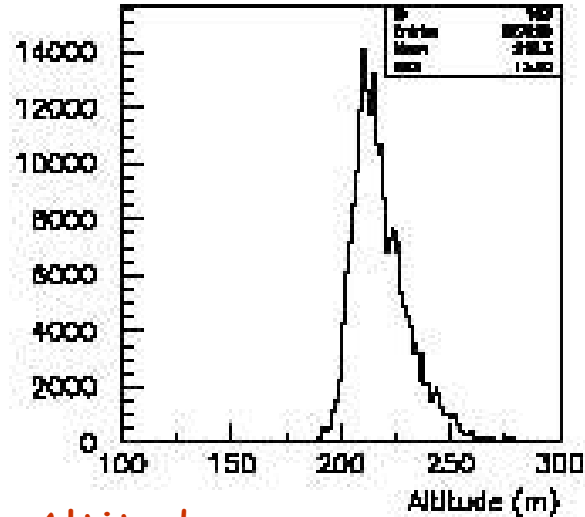


Longitude



Position measurements
($\approx 3 \times 10^5$ events)

Period:
December
2004



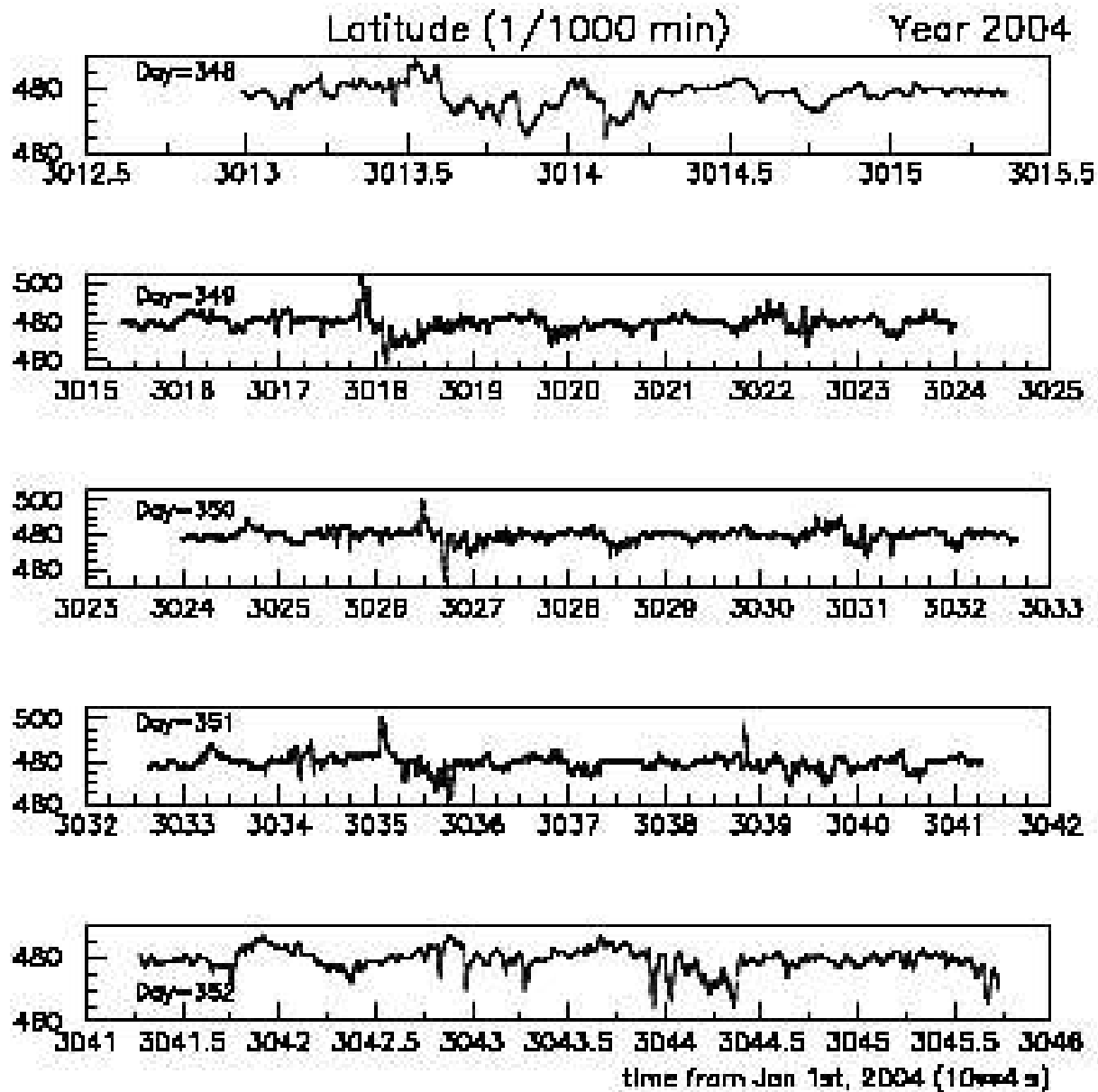
Altitude

Latitude = 37 deg N 31.4798 min
Longitude = 15 deg E 04.3248 min
Altitude = 218.3 m a.s.l.
4-days survey with 1PPS signal

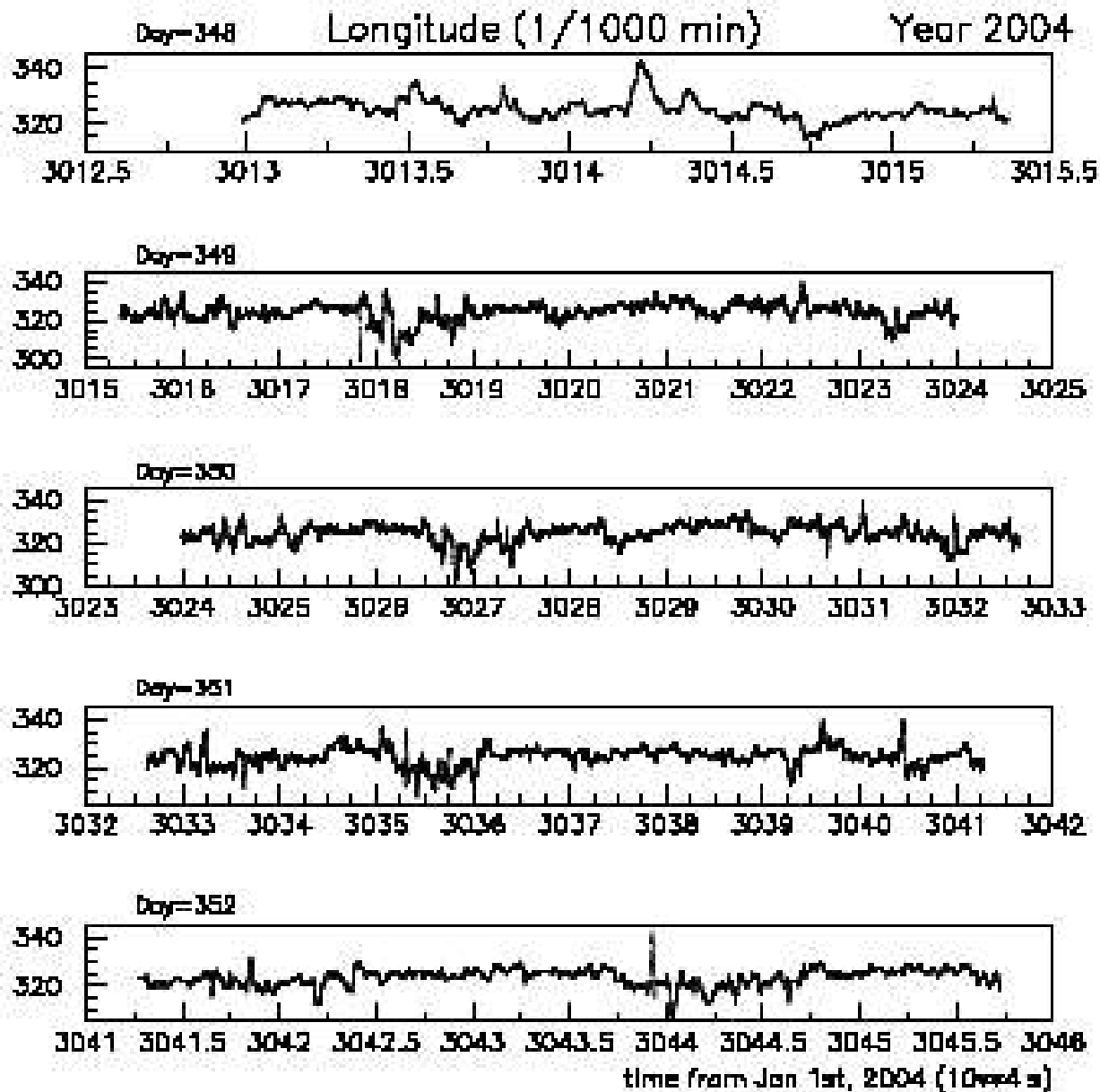
Average values

0.001 min Long ≈ 1.5 m

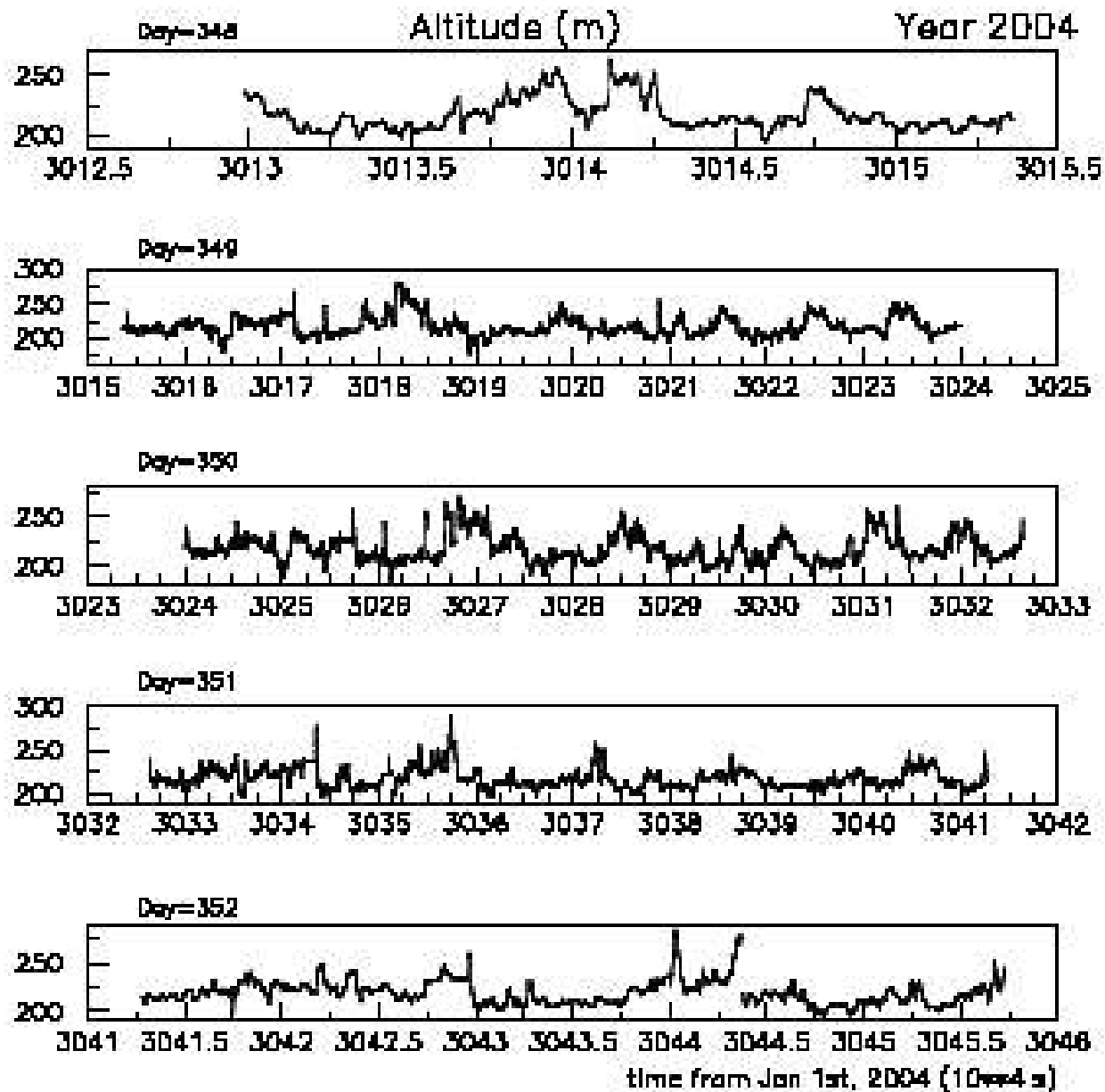
0.001 min Lat ≈ 1.9 m



Variations of the position information (latitude) over 4 days

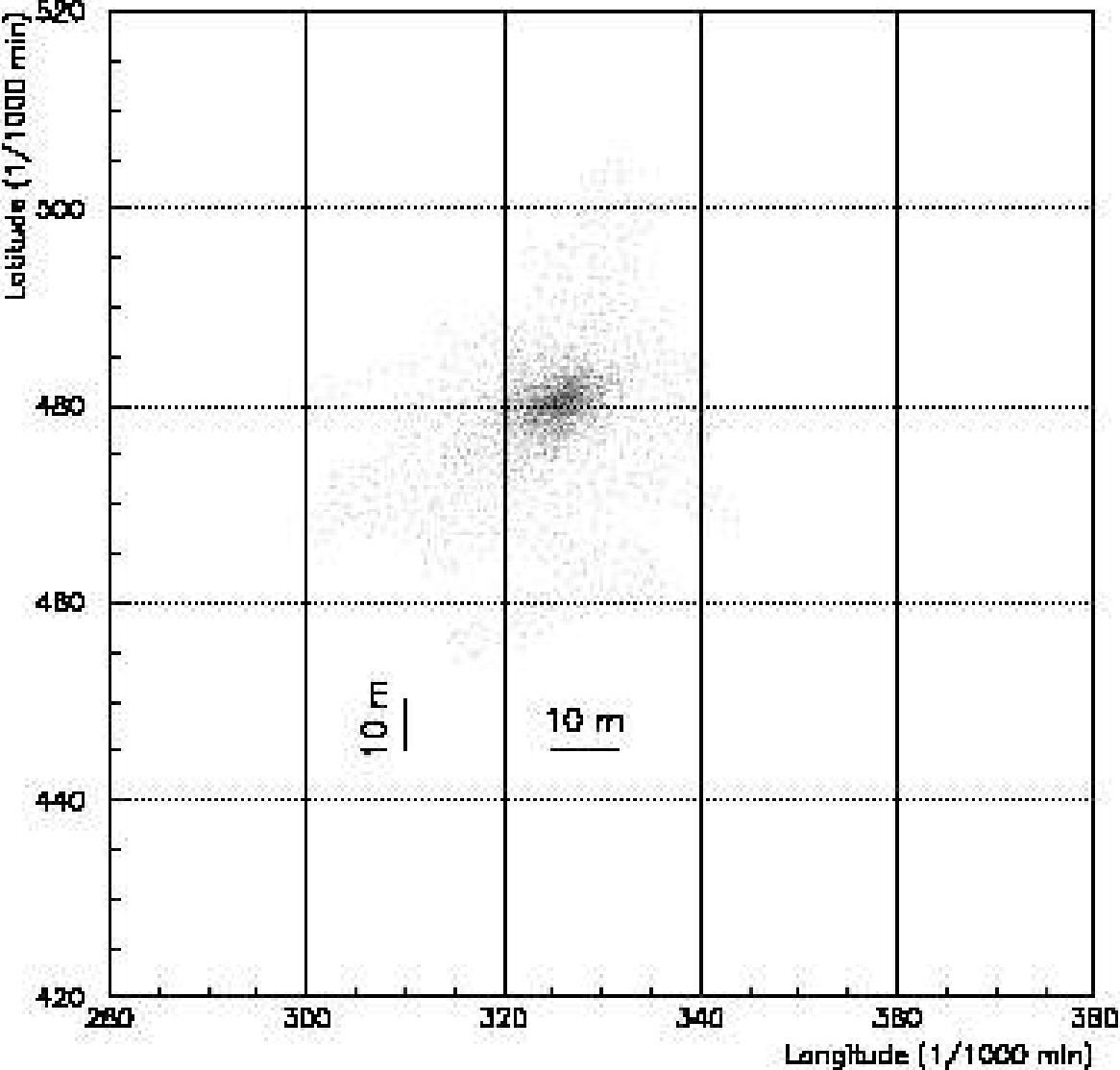


Variations of the position information (longitude) over 4 days

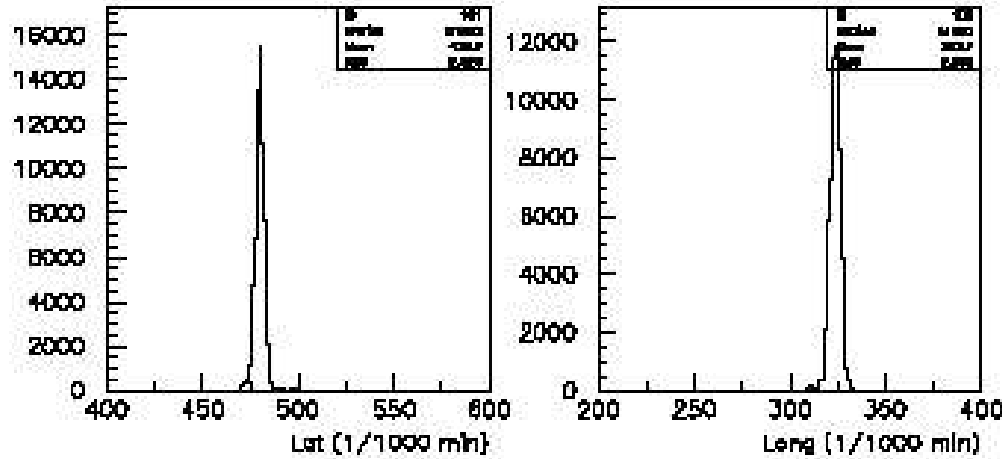


Variations of the position information (altitude) over 4 days

Scatter plot of the position measurements



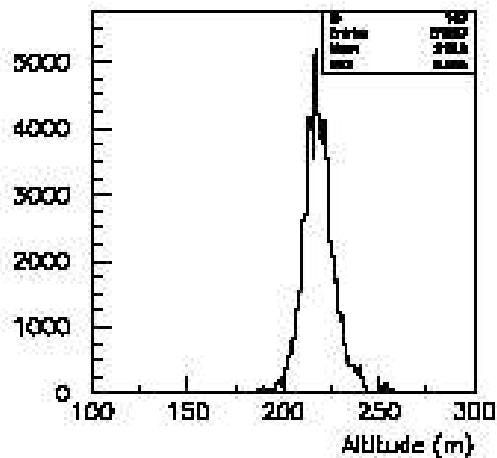
Position measurements after about 6 months (July 2005, 10^5 events),
with antenna located in the same position



Differences observed w.r.t.
December 2004:

0.001 minutes on Lat, Long
0.5 m in altitude

Compatible with resolution

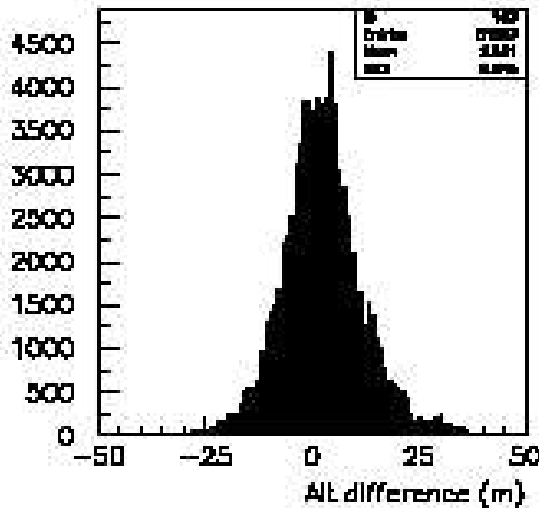
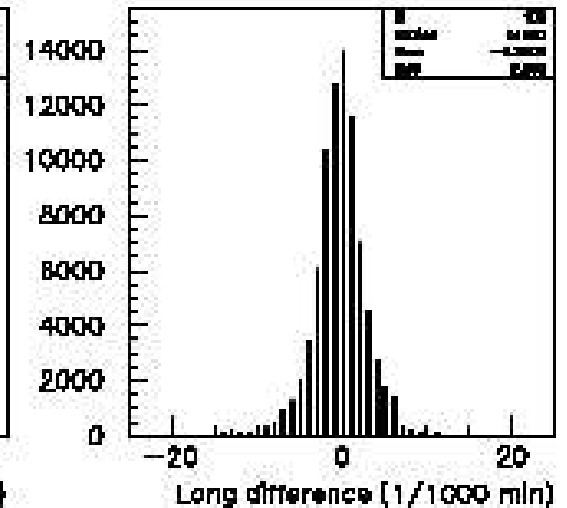
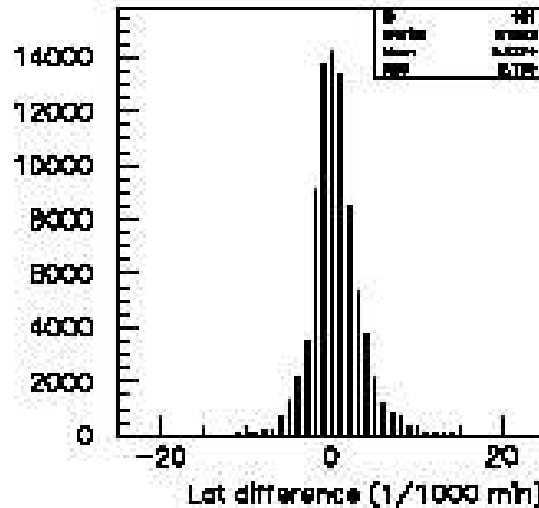


1-day survey with 1PPS signal

July 2005

Differences between the positions provided by 2 independent GPS with antennas in the same location:

Centred on zero, with dispersions compatibles with the expected ones.



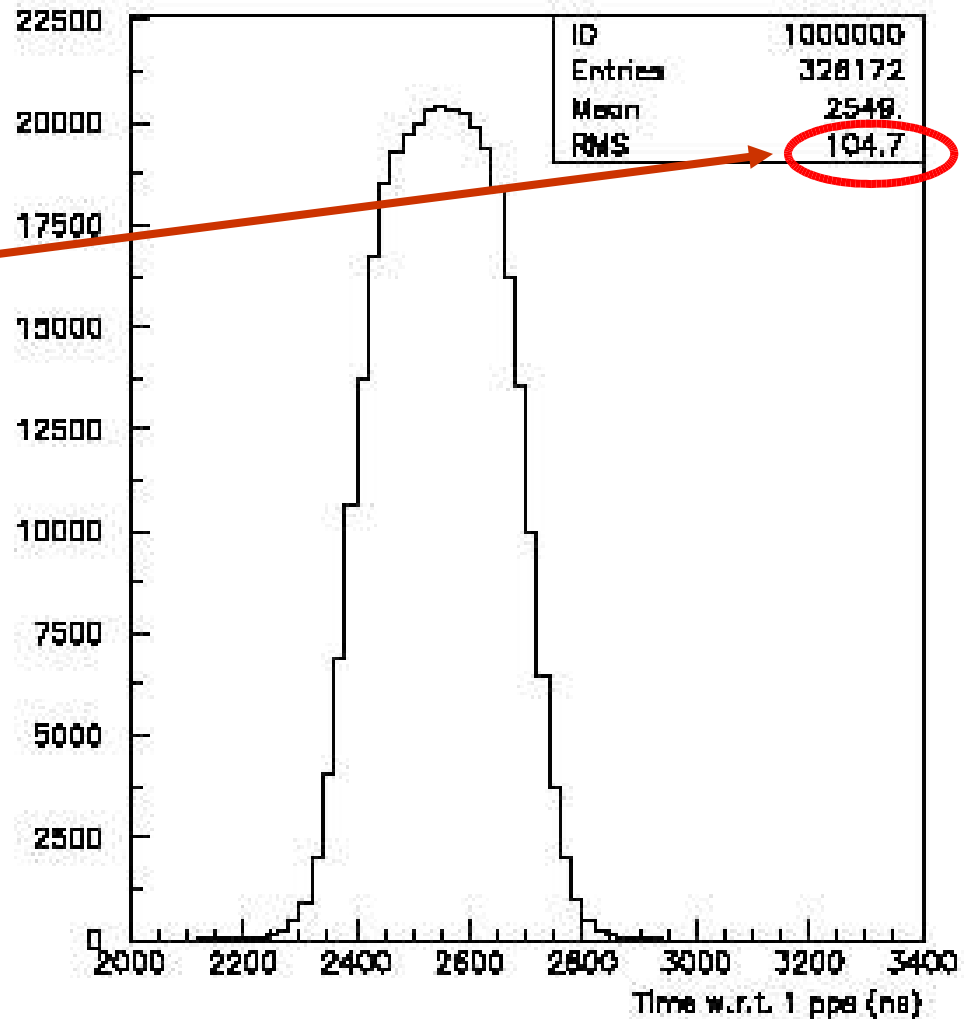
Geographical location as seen by 2 close GPS

Timing of the individual GPS92 unit w.r.t. 1PPS signal generated by an additional GPS

RMS \approx 105 ns

99.7% of events has a correct timing

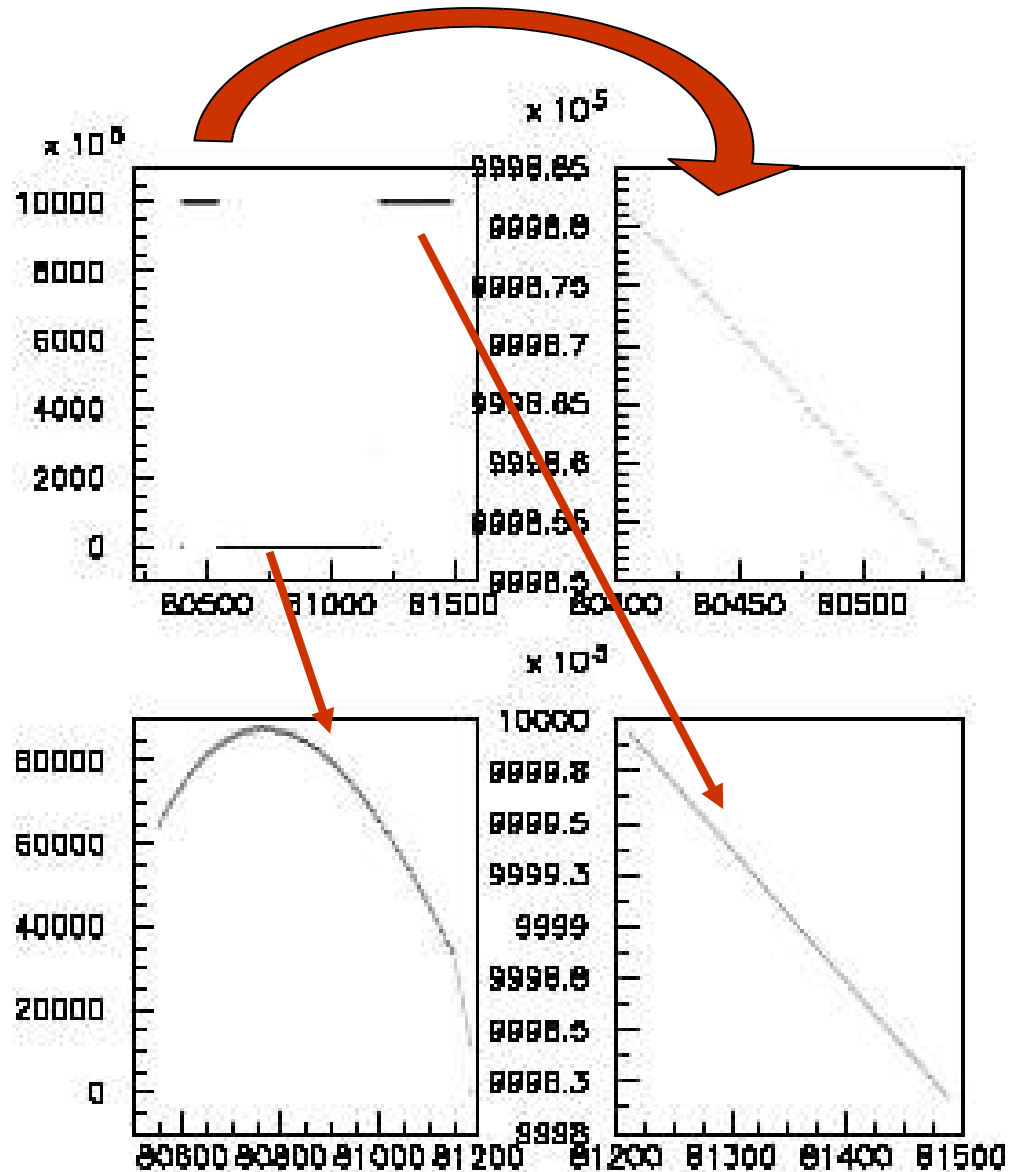
A set of events (0.3 %) shows drift effects, with timing shifted by several microseconds w.r.t. 1 PPS



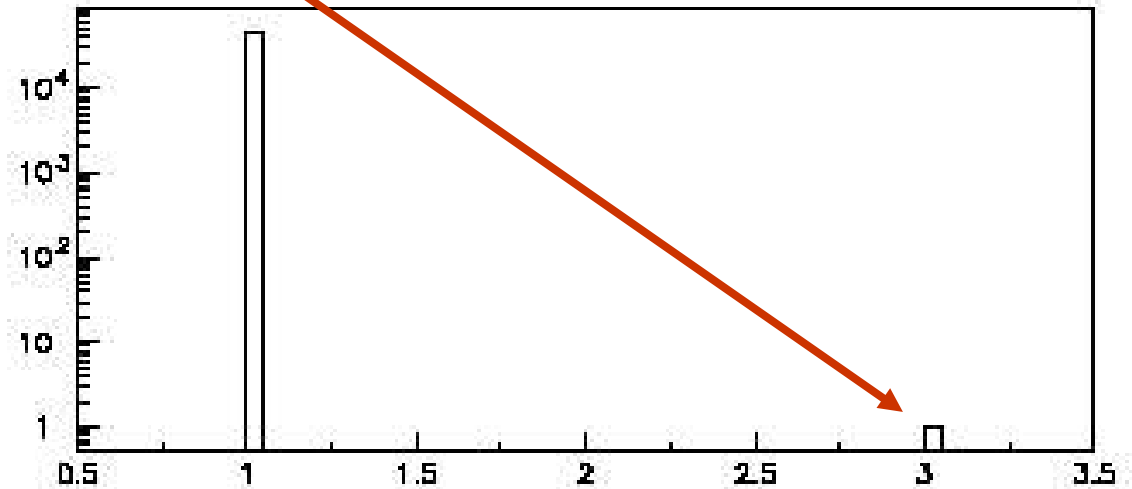
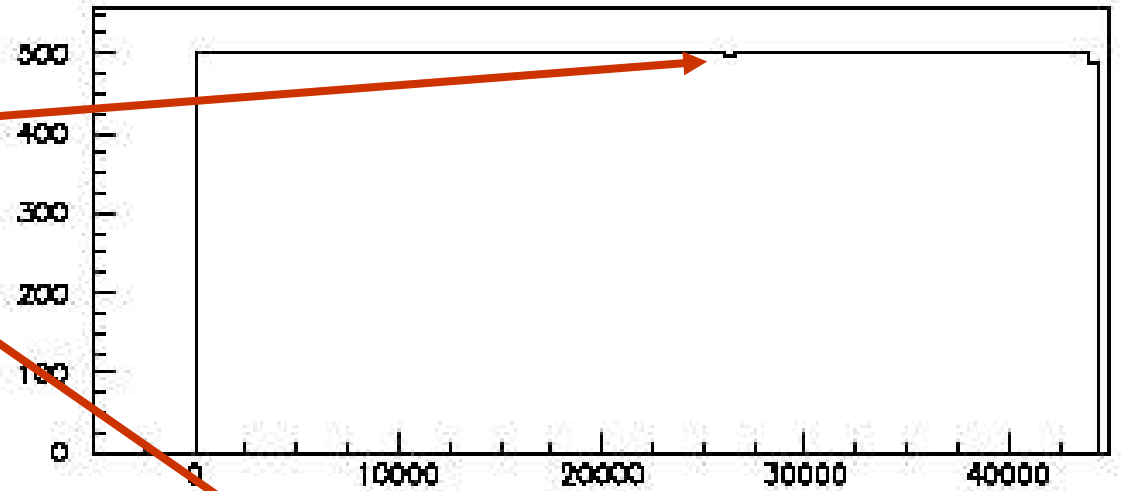
Such effects however occurred in a well definite period (about 15 minutes over 4 days)

During this period we observed time drift effects of about 300 ns/s.

At the end of such period everything was again correctly working in synchronism with the 1 PPS.



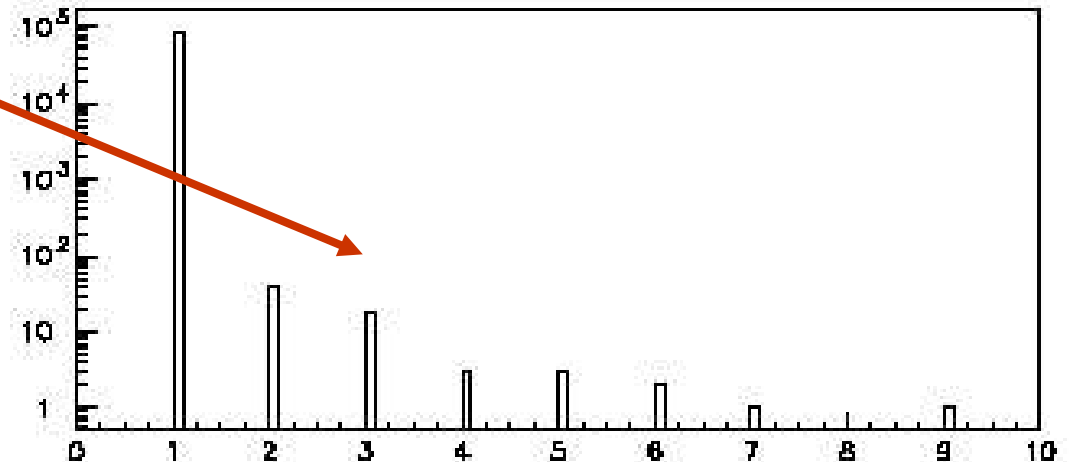
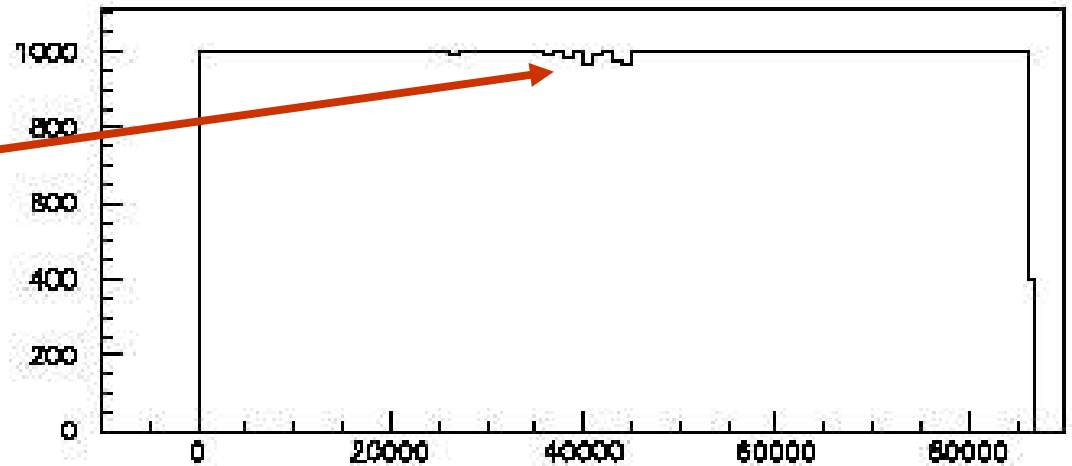
Some loss of the 1PPS signal was occasionally detected.



Difference (s) between consecutive events.

Sometimes such loss of 1PPS cycles is more consistent

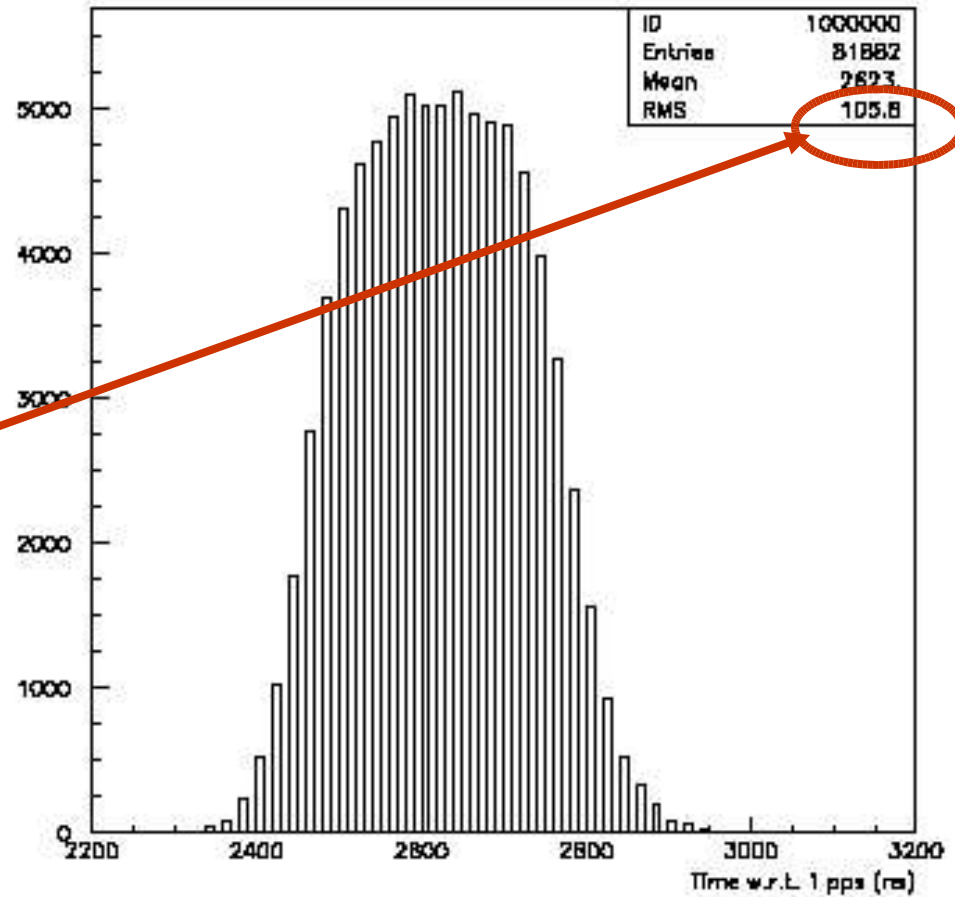
And the signal may disappear for a few seconds



Difference (s) between consecutive events.

In a different set of events (about 10^5) measured 6 months later, only 1 event was found outside the correct timing

RMS consistent with that obtained 6 months before.



VERY PRELIMINARY

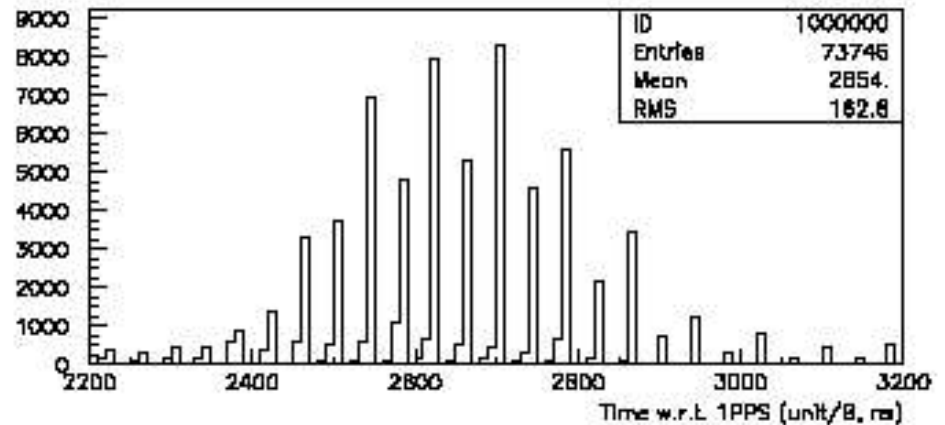
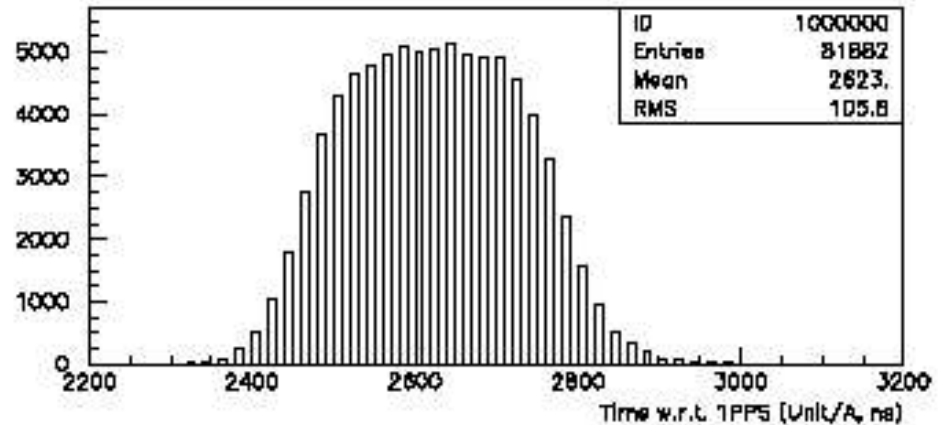
Correlation between timing informations provided by 2 GPS92 independent modules w.r.t. the same external 1PPS signal

The second GPS92 unit (only recently installed) shows a different behaviour (Hardware problems with comparators?)

→ Small shift (30 ns)

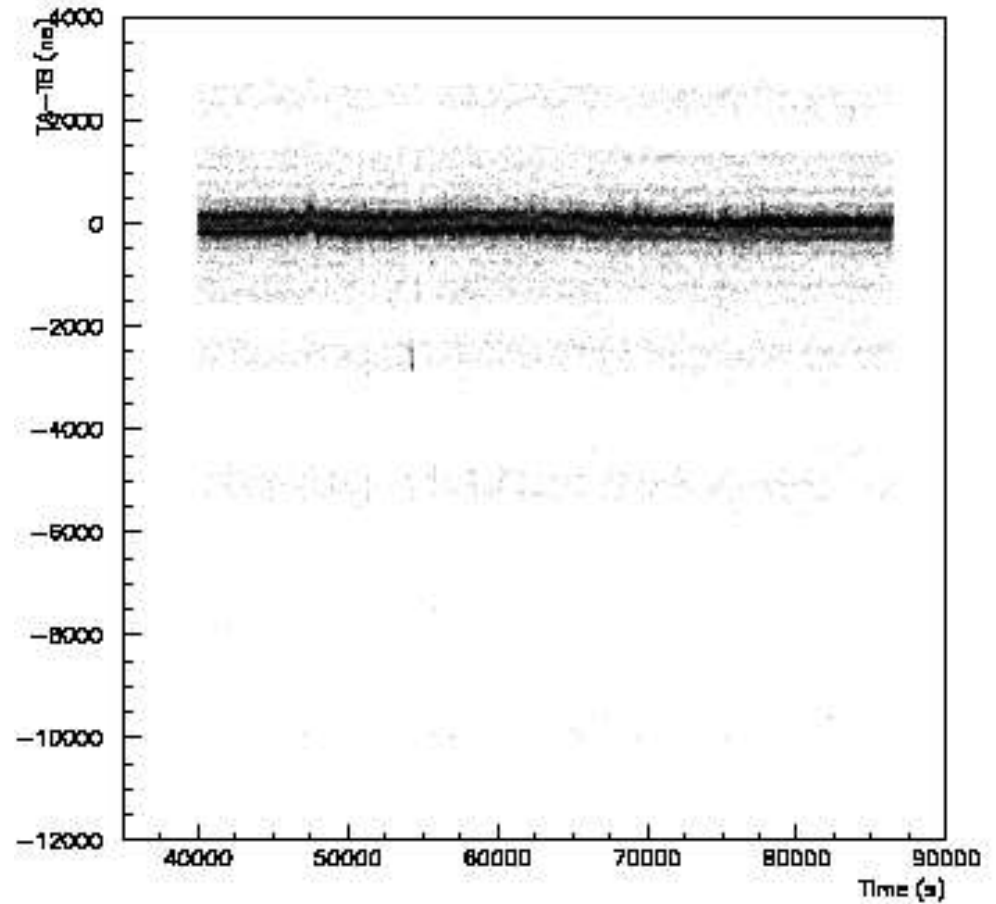
→ RMS larger

→ Many events outside the correct timing



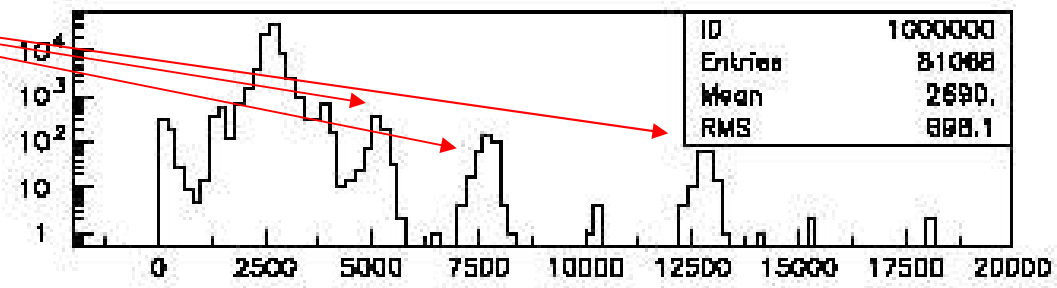
VERY PRELIMINARY

The events outside the correct timing are not concentrated in a single period, but rather uniformly distributed over the measurement.

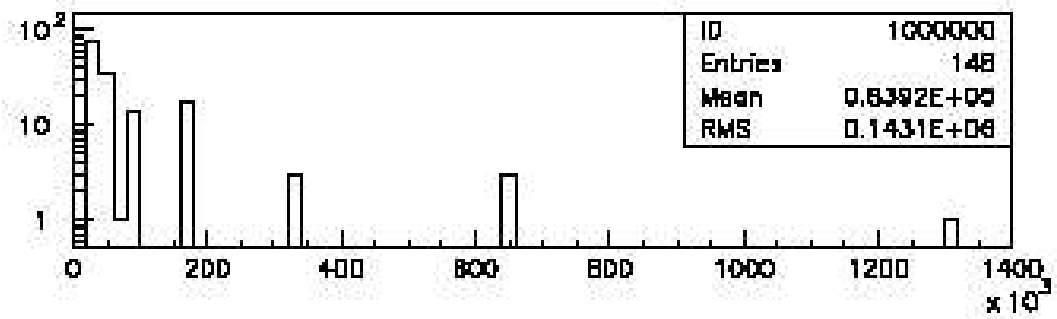


VERY PRELIMINARY

Among the events outside the correct timing, most of them is located in several peaks, shifted by about 2.5 μs , between 0 and 20 μs



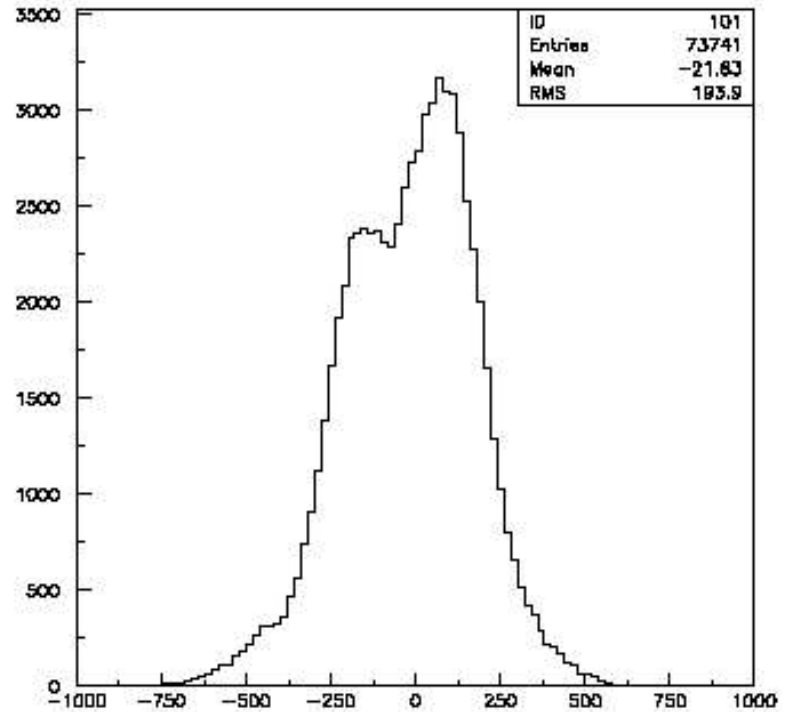
Some events even between 20 e 20000 μs



VERY PRELIMINARY

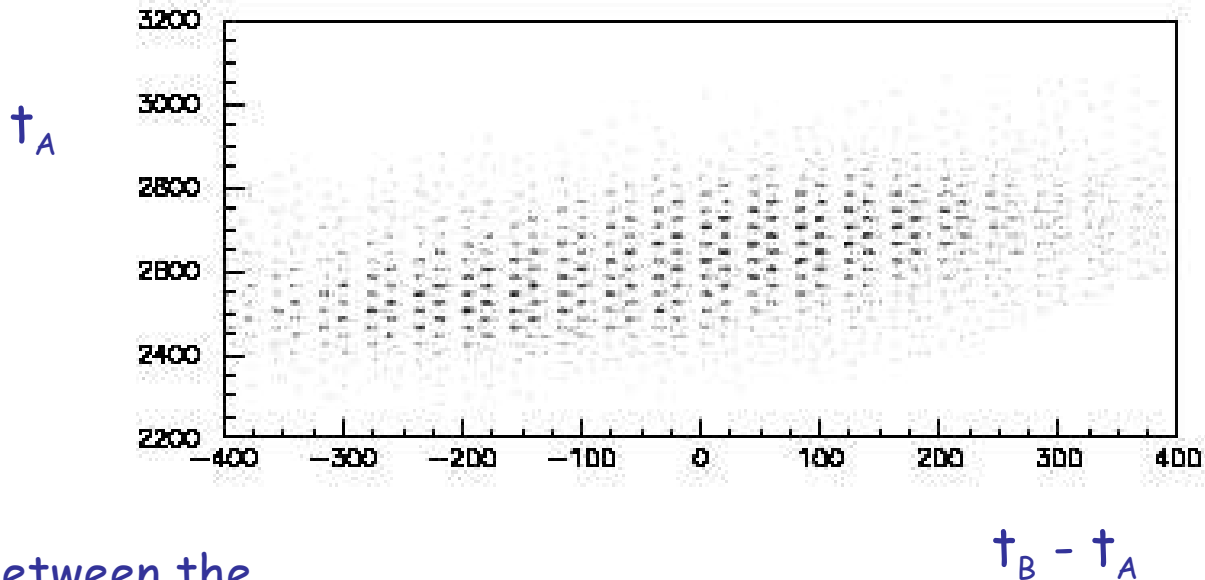
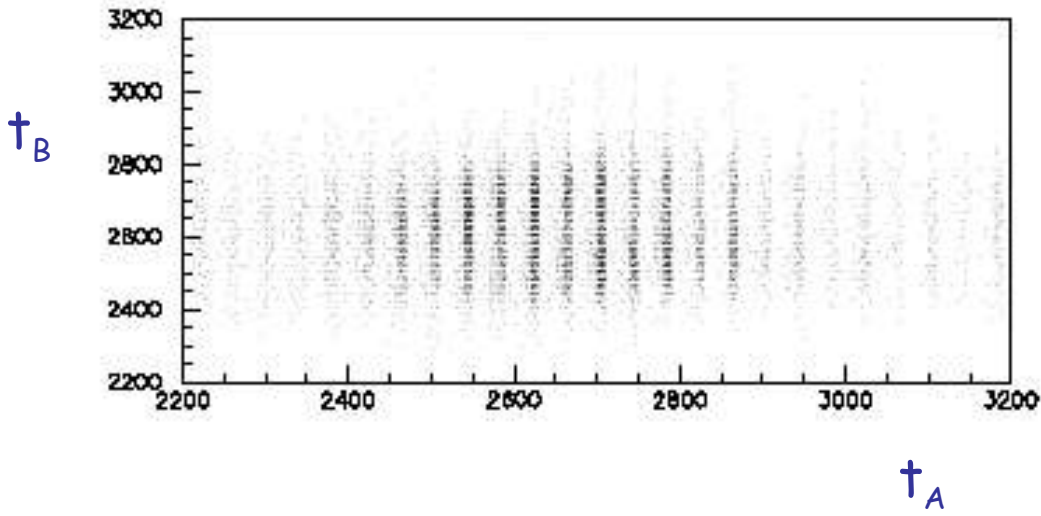
The time difference between the information provided by the two units shows 2 peaks and a relatively large RMS

This is consequence of the fact that the two timing are not exactly correlated



$t_B - t_A$

VERY PRELIMINARY



The difference between the two timing depends on t_A .

Conclusions and future activity

For optimal conditions, the timing may be obtained within resolutions in the order of 100 ns.

Checks over long periods are however important to investigate and quantify possible causes of loss of the correct timing as well as possible drift effects for short periods.

Additional measurements planned to

- Compare time information provided by twin units in the same location

- Employ physical signals from detectors (random arrival)