TIMER ACCURACY ESTIMATION FOR THE FRENCH TRANSPORTABLE LASER RANGING STATION (FTLRS)

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Abstract

Timer accuracy estimation is fundamental to reduce station bias. This study is evaluation and modelling of FTLRS Stanford chronometer for different time intervals (linearity), and in time evolution (long-lasting effect)

Method:

To evaluate our timing system accuracy, we use two timing systems and compare results of each. We dispose of

- Two Dassault Timers *as the reference*, and
- The FTLRS Stanford chronometer (temperature controlled).

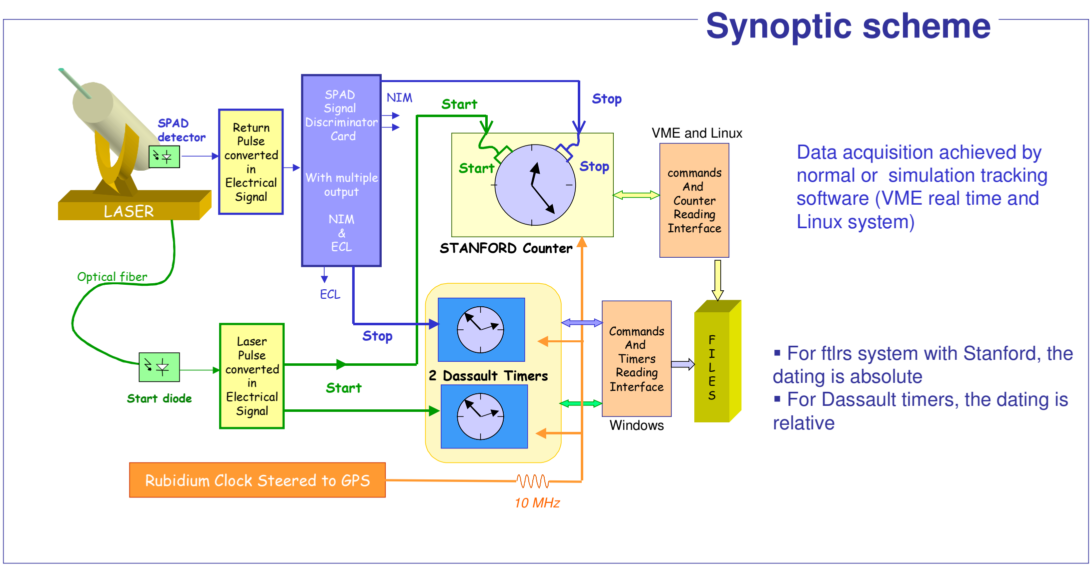

Figure 1: hardware configuration

As shown on Figure 1, the context is identical and these measures are done *on the same events* which are echo or noise.

- The laser pulse is distributed to one Dassaut timer, and is the start signal for Stanford counter.
- The return pulse is detected with a SPAD and distributed, via a SPAD Signal Discriminator Card, to the second Dassaut Timer and the Stanford Counter stop signal.

The important item is to note that *these measurements are achieved without mutual perturbation.*

Dating storage:

The two dating system's results are saved on files.

For the same event, FTLRS timing system (including Stanford chronometer) save absolute date, but Dassaut timers timing system save relative dates.

To determine which record in each file correspond to the same event (we have just to determine the first correspondence), we have compared on each file the difference between two consecutive laser pulse date, and this method was very efficient.

First result: time stability evaluation

We evaluated the stability of Stanford counter by tracking during one or two hours different targets, from very near (some meters) to 10 000km.

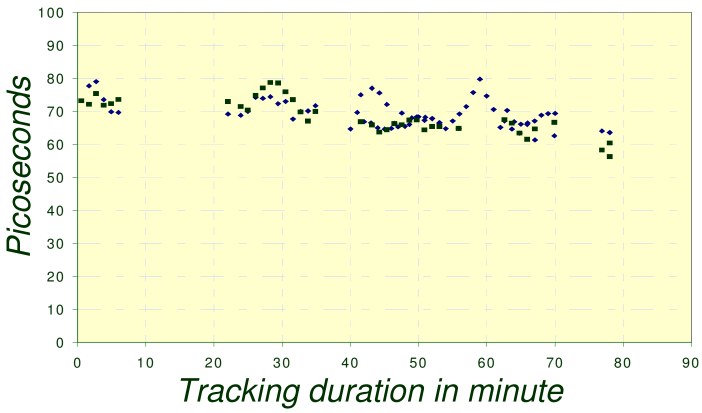

Figure 2: timing systems difference, LONG-LASTING EFFECT

As shown on Figure 2 (Y_axis is difference between the 2 timing systems), stability is satisfactory, and not range depending at 10 ps level.

Results for internal calibration: from 15ns to 55ns

For this test, and to obtain different roundtrip times, we changed the size of an optical cable; The 2 timing systems difference (in picoseconds) evaluation is on Figure 3. When roundtrip time is less than 33 nanoseconds, this timing difference seems unpredictable: look at Figure 3 After 34 ns, results are repetitive but complementary measurements are to achieve if we want use it as internal calibration

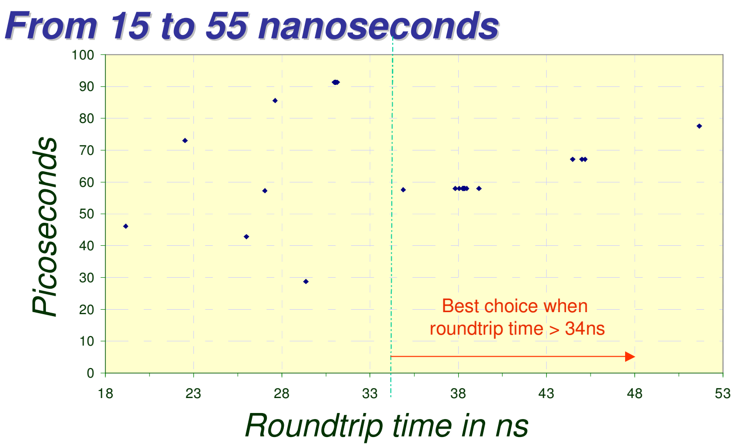

Figure 3: timing systems difference close INTERNAL calibration

Results for target from 100 meters to 1 km:

At different days, we did a lot of measures and observe always the same behaviour of curve. So, range near external calibration is easy to model. The best result is done when target is between 100 to 500 meters as shown on Figure 4

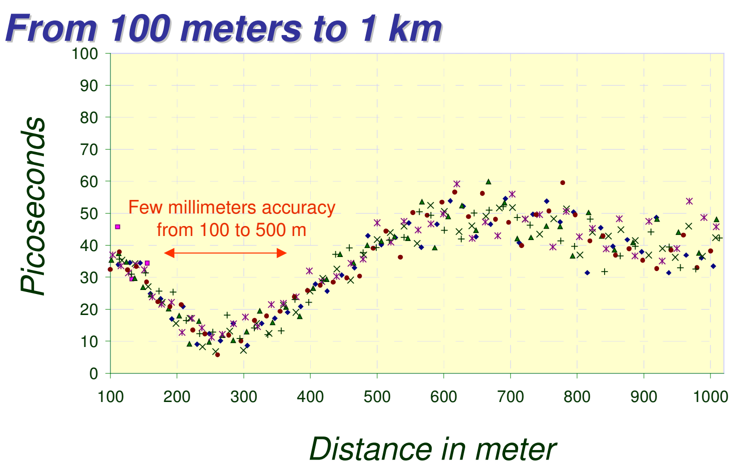

Figure 4: timing systems difference close EXTERNAL calibration

Results for satellite tracking range:

For satellite tracking range, the difference between the 2 timing systems is less than 25 picoseconds.
On Figure 5 we link all the results. The difference between satellite and external calibration is between 30 and 60 picoseconds. This can explain a part of data range bias during Crete campaign (from the analysis, we had about 40 ps).

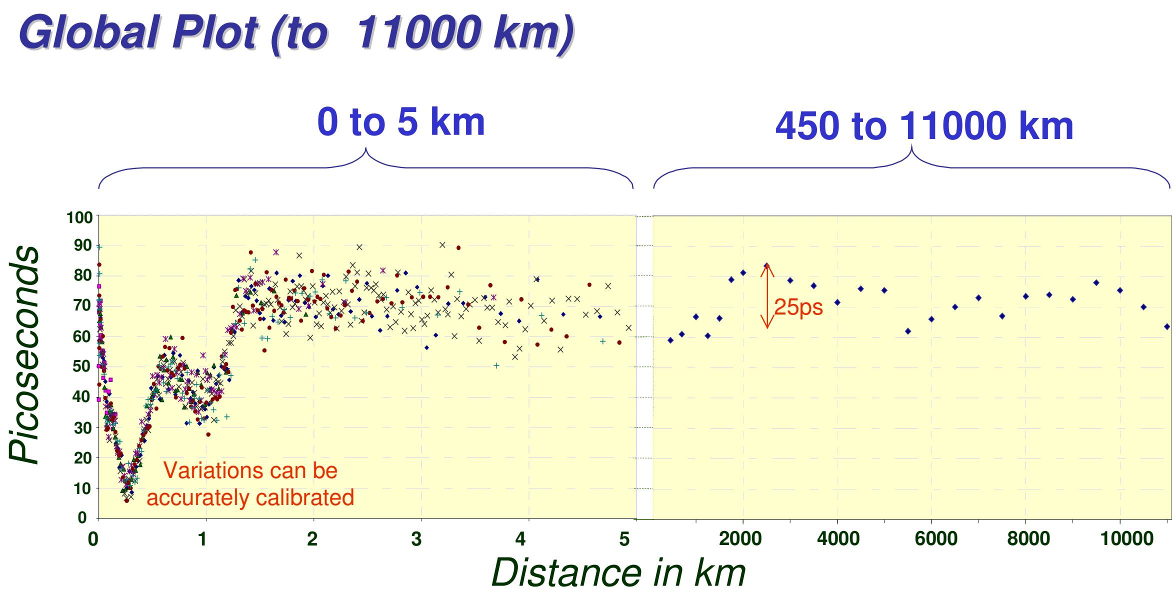

Figure 5: global result for calibration and satellite ranging

Conclusion:

It is very important to model chronometry behaviour at different ranges, and to process the calibration value accordingly.

- Stanford Chronometer can achieve *few millimetres accuracy during satellites tracking* (from 400 to 10 000km).
- Range near external calibration is easy to model; *the correction to achieve for this external calibration can be tuned to 30/60 ps depending on the target's range.*
- Values near internal calibration range are more difficult to evaluate, except when the roundtrip time is longer than 34 ns. *The difference between external and internal calibrations is about 50 ps (7.5mm).*