Comparisons of a single SR620 timer against a variety of timers from the Eurolas network.

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ABSTRACT

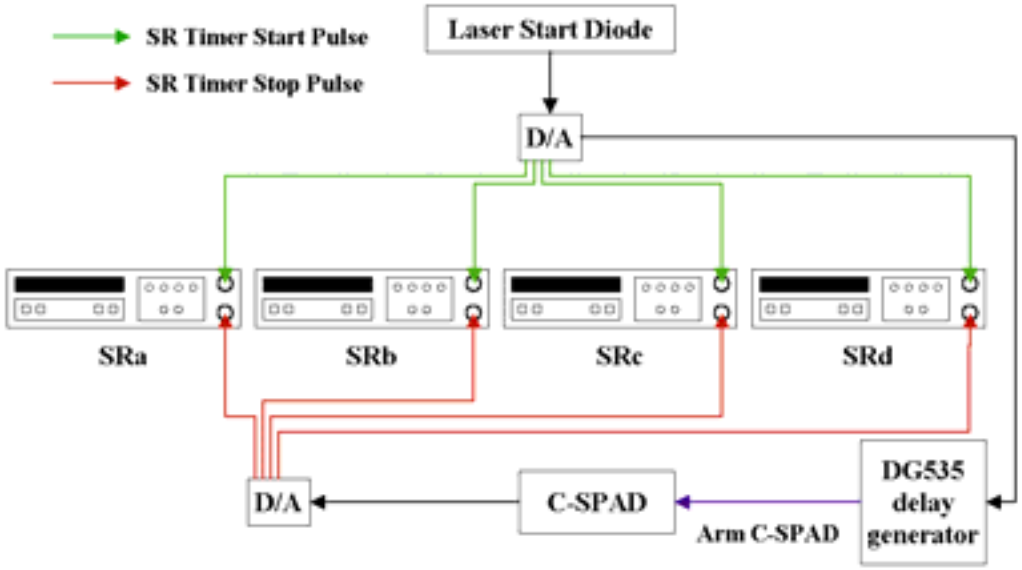
The non-linearity of the SR620 interval timer is a potential source of bias in the SLR system. At the Eurolas workshop held at Herstmonceux in March 2002 several stations brought their SR620 timers for comparison tests against a single SR timer (Hx-D). Range measurements were made for the full range of ranges required by SLR. The results from these tests give the relative behaviour of the devices but not an absolute correction. A brief review of previous experiments using PPET and HP timers is included to show why we believe Hx-D is a linear timer with biases of only a few pico-seconds. Also included are the results of comparisons made at the Graz SLR station for all the timing devices within their cluster.

1. Experience at Herstmonceux

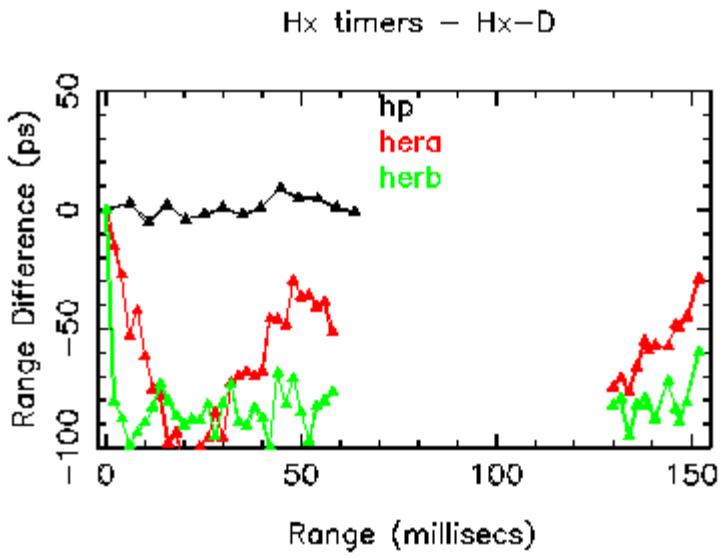
We have made regular comparison tests over many years and found that the results we get are very stable. We have done these tests using a variety of detectors, many different cable configurations and different threshold levels and we always get the same results.

The laser is fired at 10Hz and this in turn triggers the start diode. The start pulse is then sent to the start for each timing device and a DG535 time interval generator. The DG535 is fed with delays of 0-150ms in units of 2ms. This then delays the arming of the detector, which is exposed to daylight. For each 2ms range we collect 500 noise readings which are spread randomly over some 10microseconds depending on the daylight. Collecting data in this way minimises any effects caused by the internal 90mHZ oscillator of the SR620. The detector sends a stop pulse to all the timing devices. As each device has small differences in the cables used, each data set must have the current calibrations for the timer removed before comparison.

A schematic of the system used for these tests and normal observing is shown below.

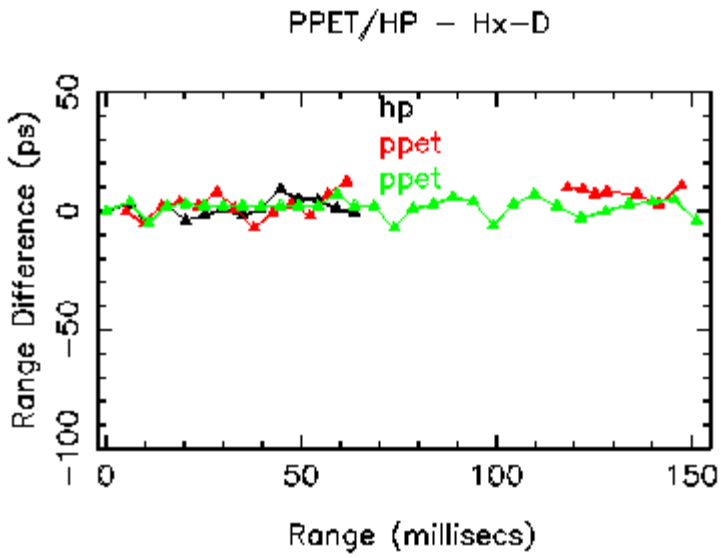


Early results for two SRs and an HP5370A were first published in the proceedings of the 9th Workshop in Canberra[1]. Typical results for two SRs and the HP are given below.



These results only tell us the relative behaviour of our timers and tell us nothing of the accuracy. To try to understand the accuracy of our system we compared all of our devices against PPET. Full details of the results can be found in the Florence proceedings[2].

Plotted below are the results of PPET, HP and Hx-D. These results persuaded us that Hx-D is an accurate linear device to ~10ps.

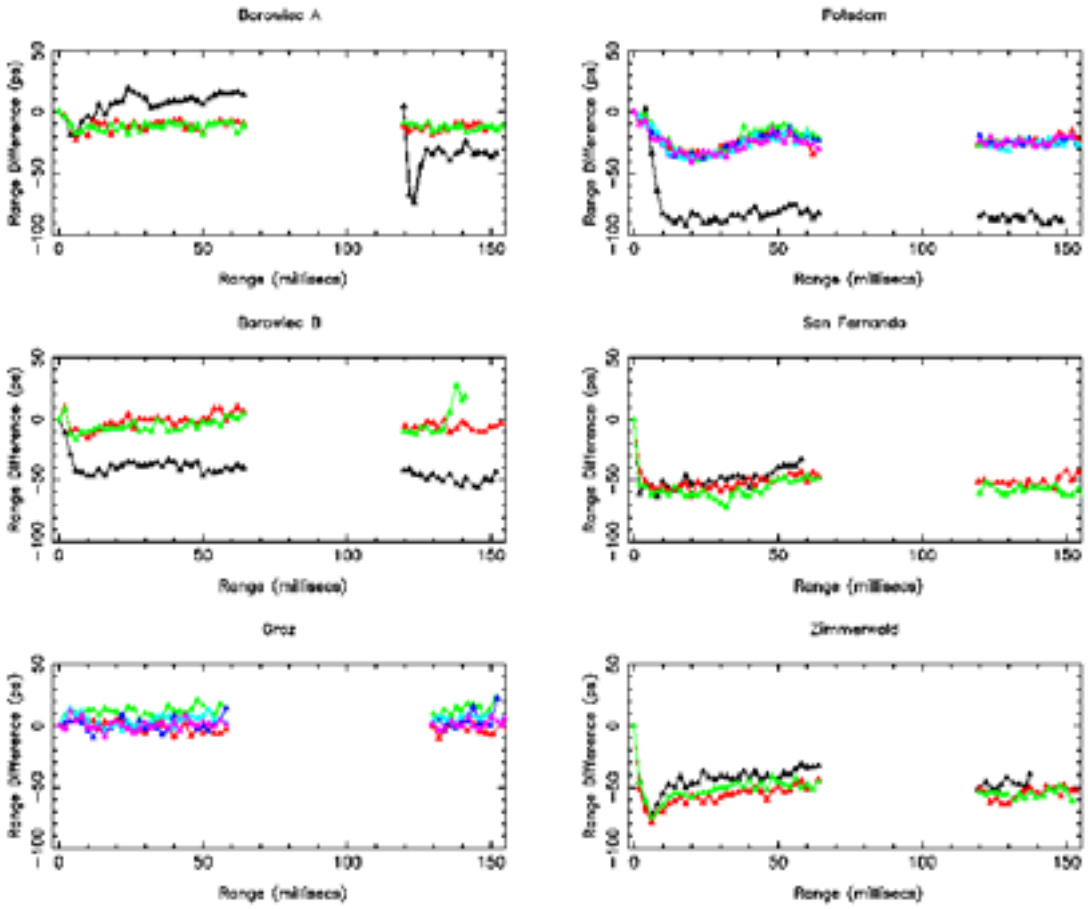


However our HP broke and the PPET had to go back and so we had no way to confirm these results over time. Late in 2001 we purchased two second-hand HP5370B timers and were able to repeat the tests. The "new" HPs gave the same results as the old one.

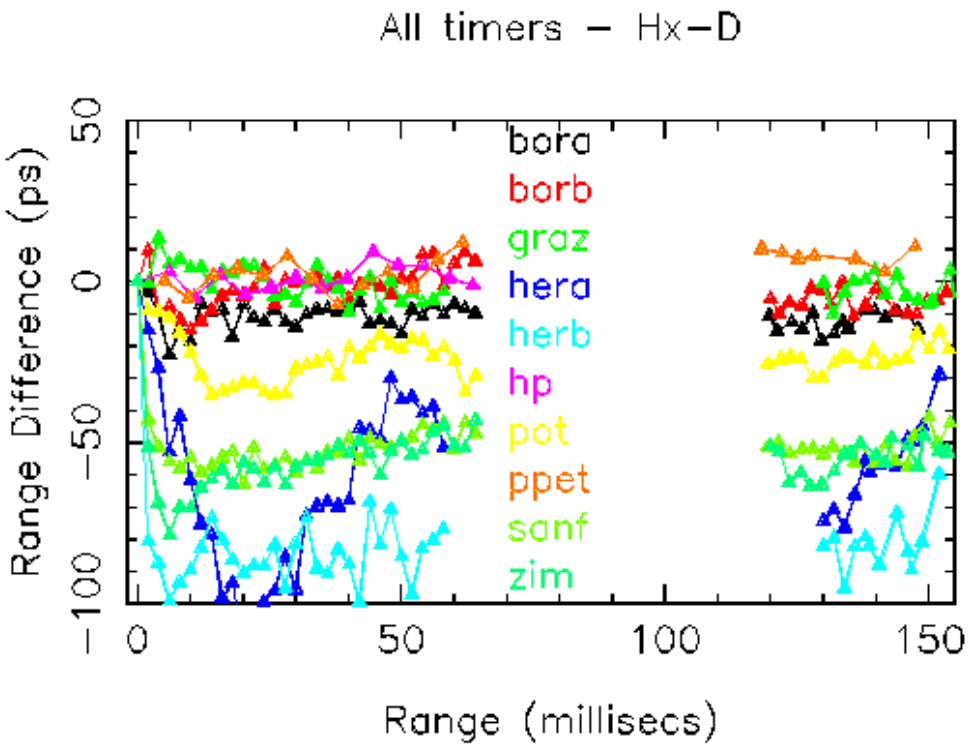
Given the stability of these results it was decided that we should in fact publish all our data (which was on Hx-A system) on the Hx-D system. Full details of this were announced in SLRMAIL 0891

2. Comparison of Eurolas timers with Hx-D

The Eurolas workshop at Herstmonceux was held in March 2002, shortly after the announcement that Herstmonceux was going to publish all new data on the Hx-D (PPET) system. It was decided to try to extend these tests and all stations were asked to bring their SR timers to Herstmonceux for comparison to Hx-D. Borowiec, Potsdam, San Fernando and Zimmerwald all brought timers. Graz sent their SR timer after the meeting. Including the Herstmonceux timers, eight SR timers were compared with Hx-D. As these tests were being carried out at the same time as the workshop there were limitations on the number of tests we were able to carry out. However each timer always had one warm-up test and then at least two proper tests. The warm-up tests were never used as they stood off from the other tests. These have been plotted for both Borowiec timers and the Potsdam timer to show the sort of errors that can occur if SR timers are not given sufficient warm-up time. (Our advice is **never** turn a SR timer off). Each test is plotted in a different colour on the plots. The black data sets for Borowiec A & B and Potsdam are the warm-up tests.

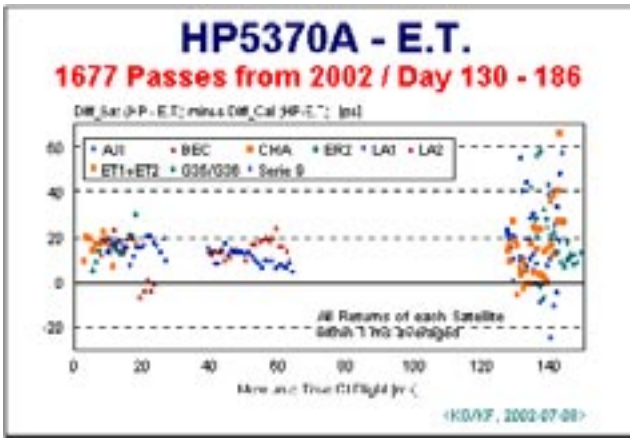


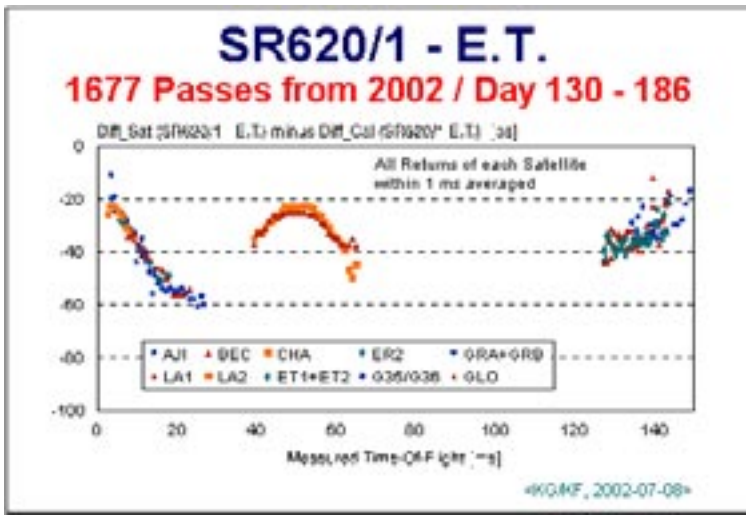
As can be seen from the diagrams above and the Herstmonceux results, SR timers can vary by up to 100ps but experience at Herstmonceux and the repeatability of the results obtained in these tests would imply that these behaviours are very stable for each timer. The plot below summarizes the results of all the comparisons carried out against Hx-D.

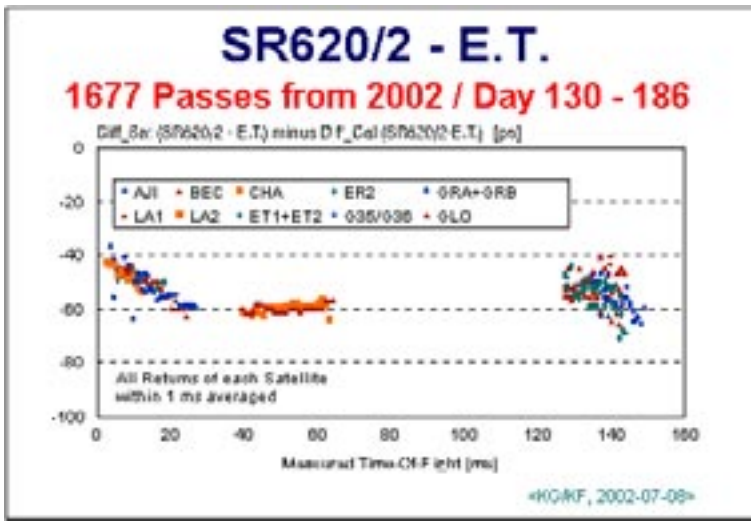


3. Results from Graz

Although Graz has not carried out the same tests, they have collected simultaneous data when ranging to satellites. They have taken this calibrated data for their two SR timers and HP and compared the results with the event timer designed and built at Graz.







4. Conclusions

- SR620 interval timers have range dependent biases of up to 100ps.
- These biases are very stable over a long period of time.
- To reach mm accuracy we need to measure these biases.
- We need a co-ordinated campaign to measure the biases for all SR timers relative to some standard device.
- The ultimate goal should be to calibrate all timing devices against some standard device.

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Borowiec, Graz, Potsdam, San Fernando and Zimmerwald SLR stations.

6. References

1 Gibbs, P. & Sinclair, A.T., 1994, "*Investigation of a small range-dependent bias of two SR620 Time Interval counters",* Proceedings of 9th International Workshop on Laser Ranging Instrumentation, pp 274-276.

2 Appleby, G.M., Gibbs, P., Sherwood, R.A., & Wood, R., 1999, "*Achieving and maintaining sub-centimetre accuracy for the Herstmonceux single-photon SLR Facility*", Proceedings of, Florence.