A010 Family of Time Interval Counters Adapted to SLR Applications

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Our location

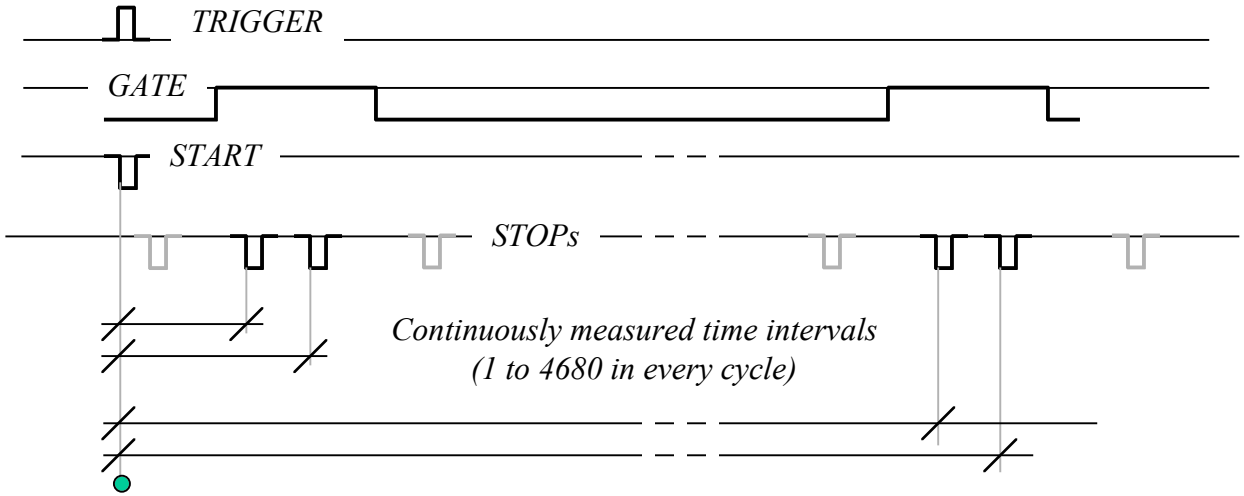
The A010 family includes three models of high-precision PC-based time interval counters which differ mainly by the offered single shot RMS resolution:

Model A011 (<40 ps RMS) - easy-to-use counter covering the most typical requirements of SLR applications

Model A012 (<20 ps RMS) - is competitive with the counters currently most popular for SLR applications (SR620, HP5370B)

Model A013 (<10 ps RMS) - is capable of supporting millimeter accuracy

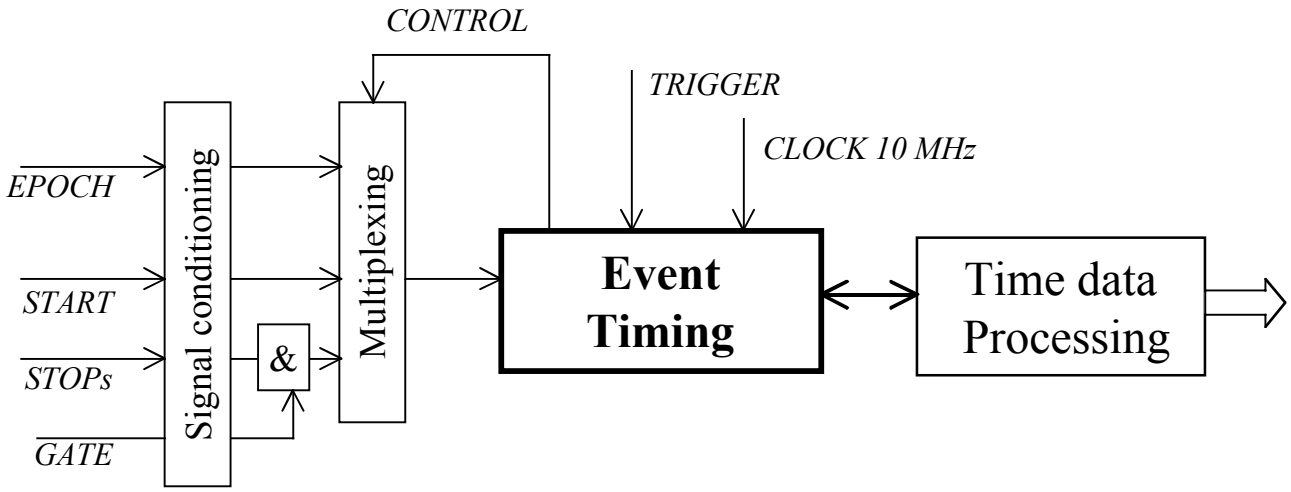
All models are similar in functionality, capable of measuring continuously a sequence of time intervals and Start pulse timing relative to the internal real time clock.



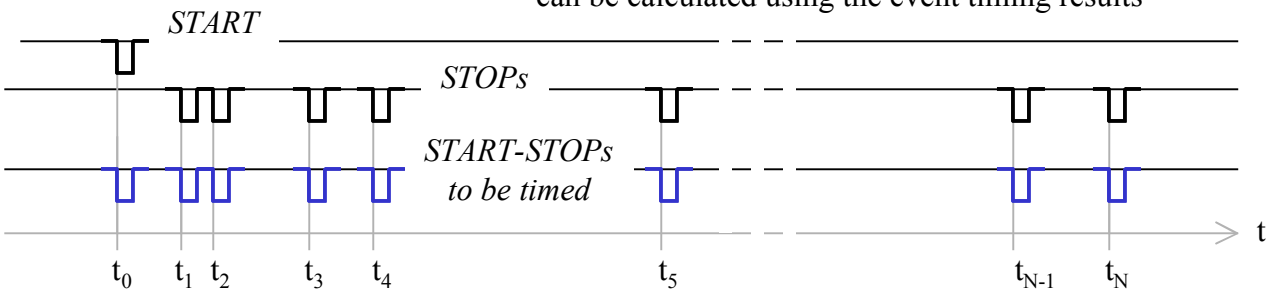
Time of START
(12.5 ns LSB size)

209 ms maximum time interval between adjacent pulses
Single shot RMS resolution:
A011 <40 ps
A012 <20 ps
A013 <20 or <10 ps depending on the operating mode

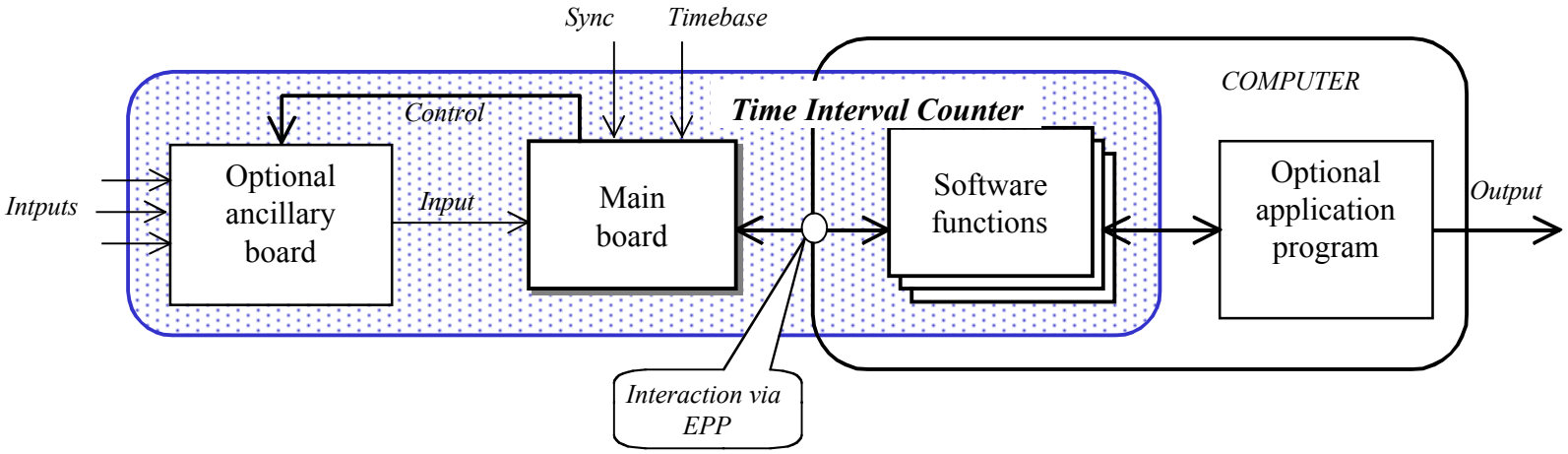
The time interval measurement is based on high-speed single-channel event timing, resulting in high linearity and temporal stability of the measurement



Any one time interval between any two of the input pulses can be calculated using the event timing results

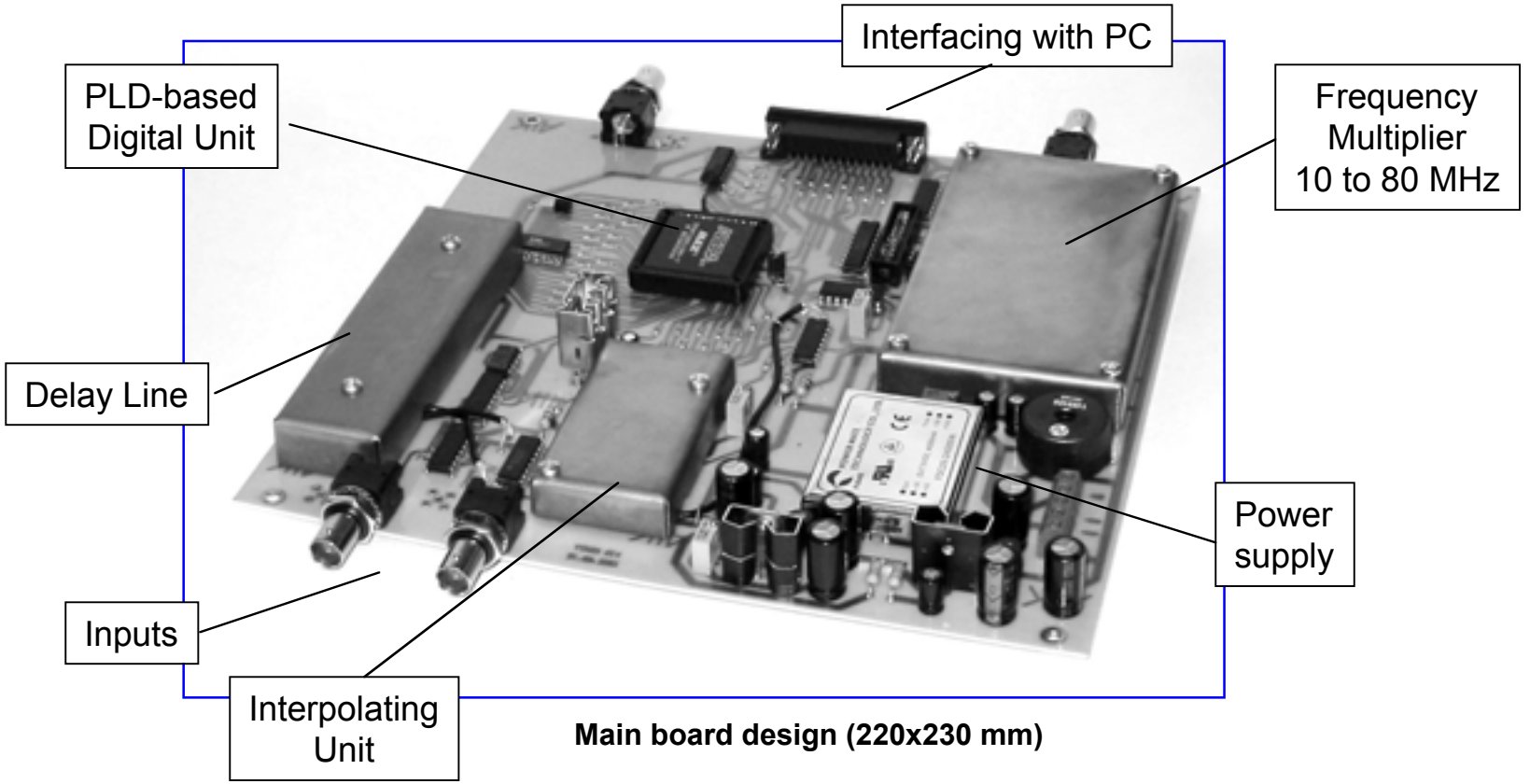


Each counter represents a virtual instrument which performs the most of the specific measuring functions by a program. It is available both as a ready-to-use instrument (including custom-made options) and a set of the firmware tools for embedding the counter in more complex system.



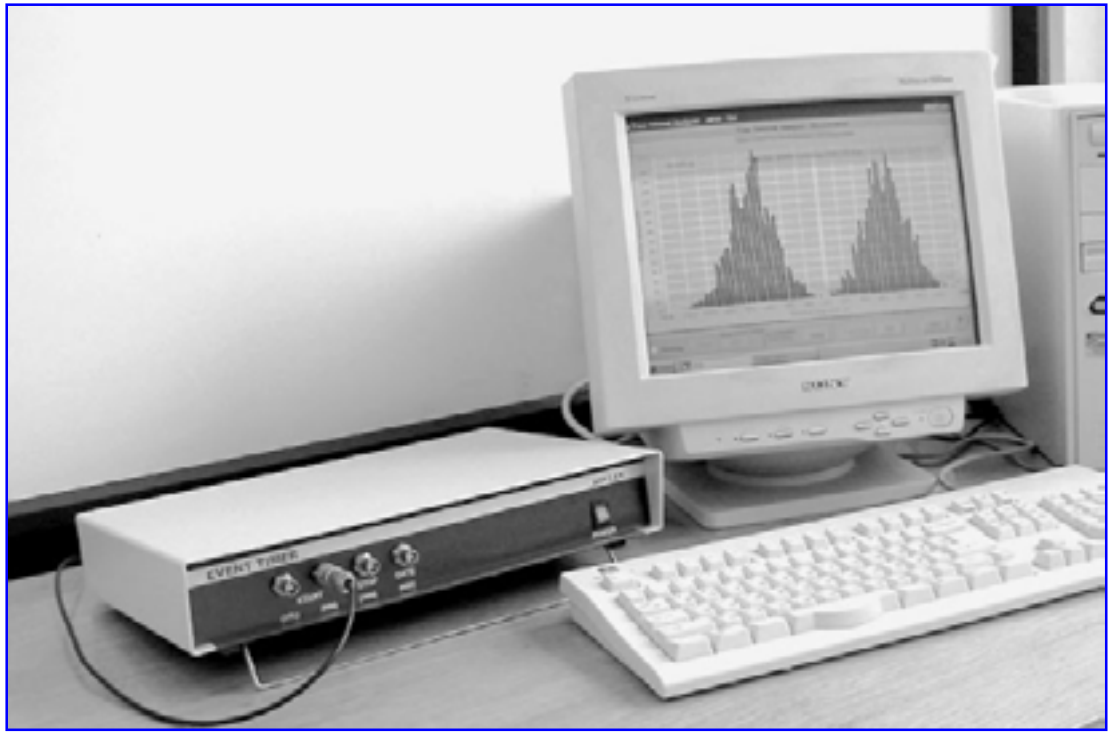
Fundamental architecture

Hardware core of the counters (main board) has the compact form, resulting in space-saving design of the counters as a whole



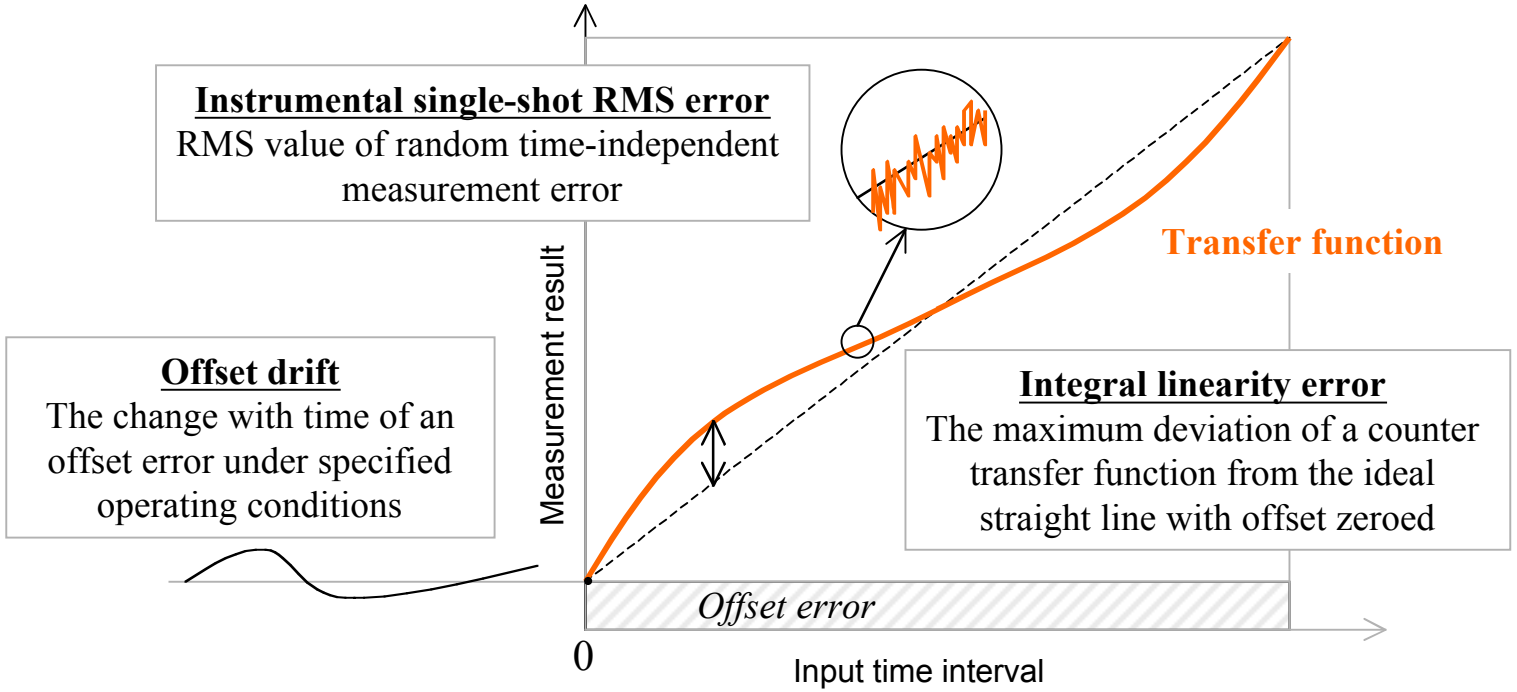
Main board design (220x230 mm)

All counter's models have similar hardware design and differ mainly by the type of the ancillary board and software.



The general view of the time interval counter

Experimentally evaluated parameters of the counters



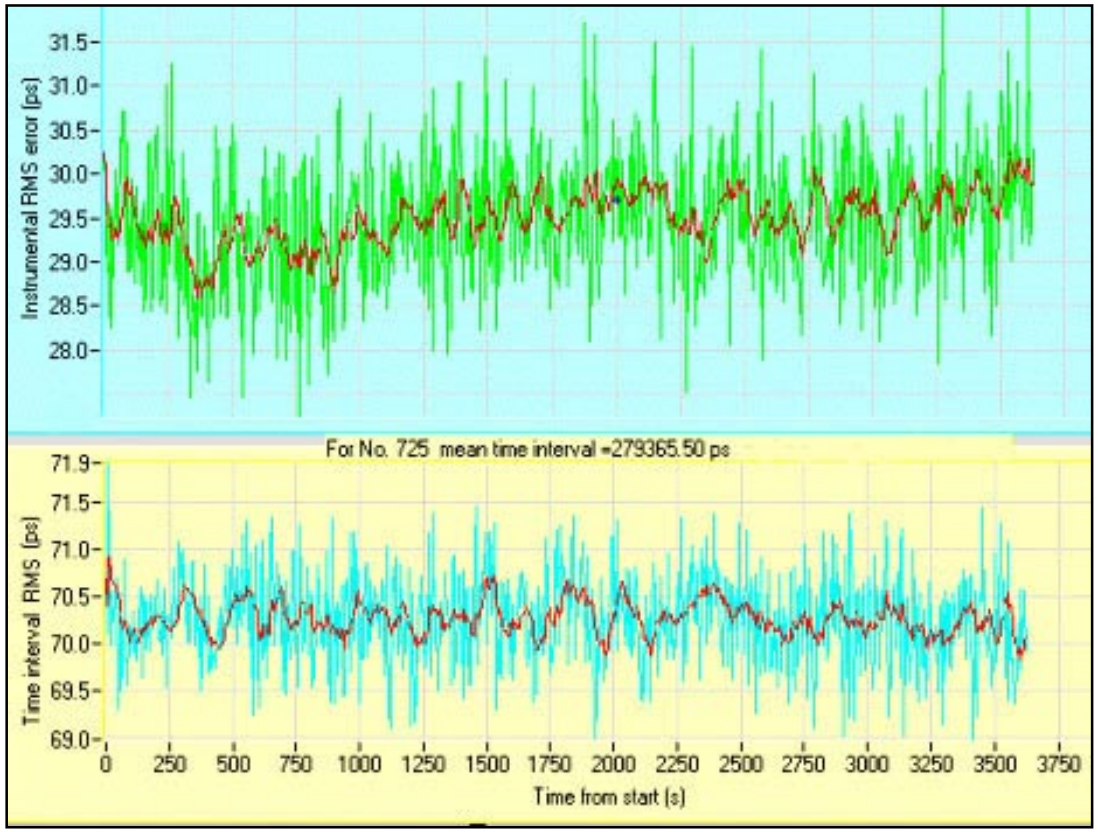
Instrumental RMS error automated testing. Testing method.

To evaluate the instrumental RMS error, a special test method is used. This method is based on comparison between several independent results of timing the same events, resulting in non-sensitivity to the test signal jitter. It gives slightly overstated estimates of the instrumental RMS error (corresponded to the worst case of time interval measurement).

The many times repeated test shows (see related slides):
<u>At the top</u> - Instrumental RMS error of time interval measurement versus testing time.

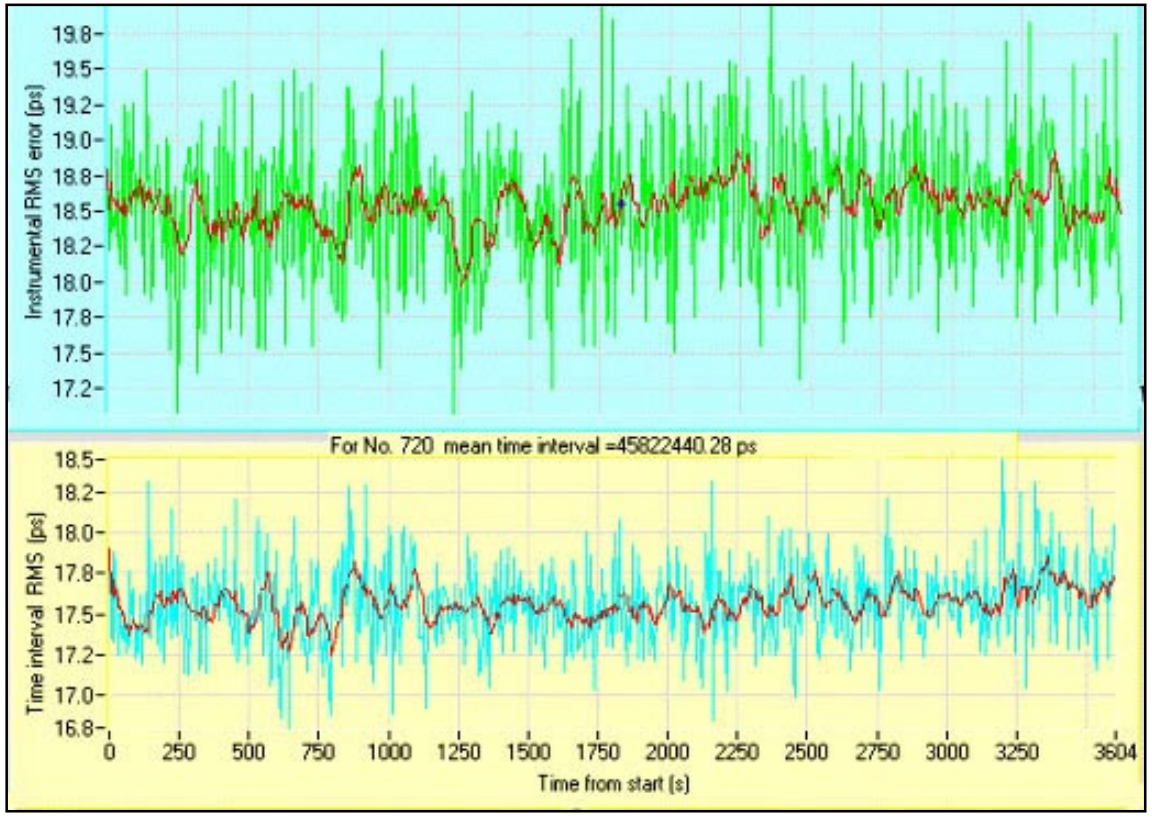
<u>At the bottom</u> - RMS deviation of measurement results versus testing time. It includes both the instrumental error and jitter of time intervals have been measured.

Instrumental RMS error automated testing. Testing results for A011



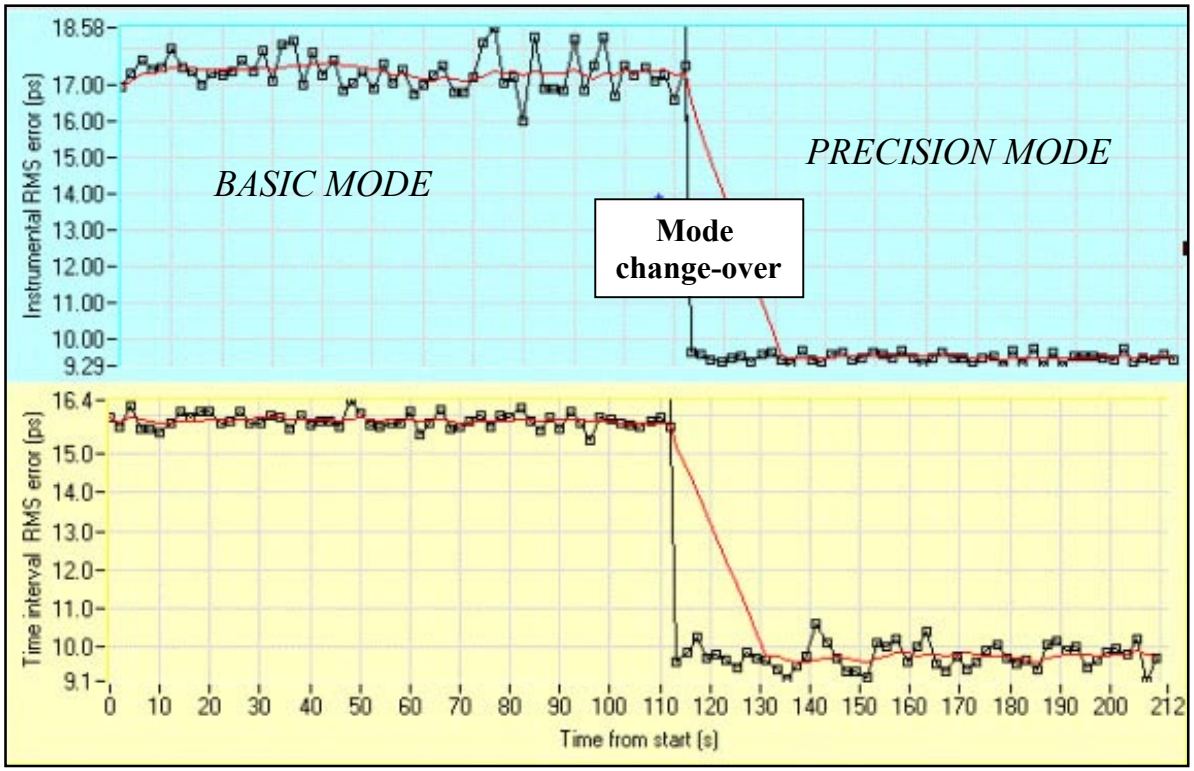
Test signal jitter is greater than the instrumental error

Instrumental RMS error automated testing. Testing results for A012



Test signal jitter is less than the instrumental error

Instrumental RMS error automated testing. Testing results for A013



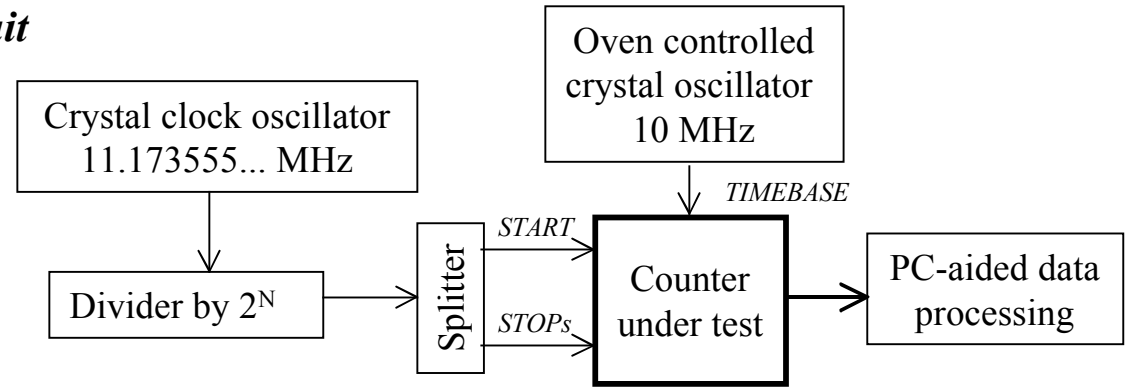
Test signal jitter is less than the instrumental error

Conclusions from the instrumental RMS error automated testing

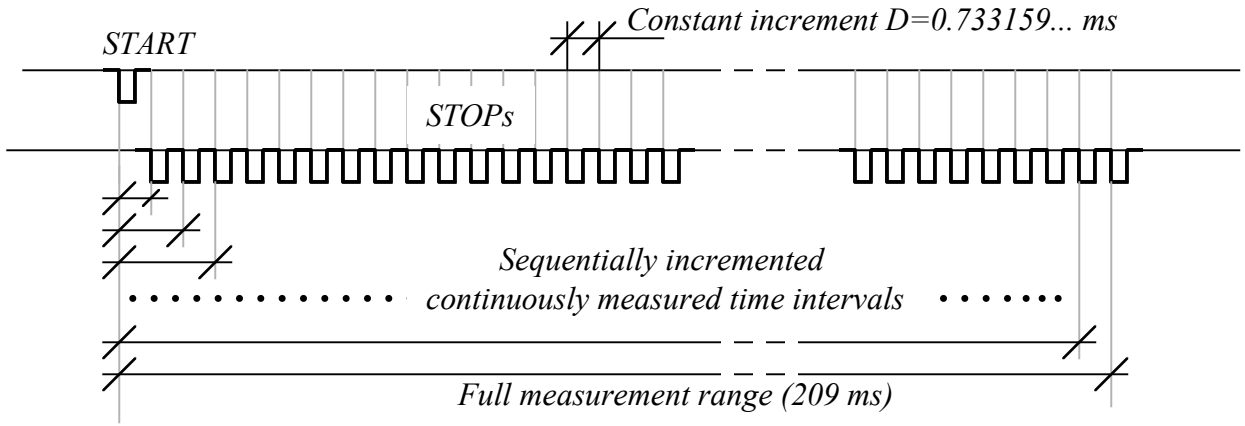
- **The counter A011 ensures the instrumental RMS error less than 40 ps**
- **The counter A012 ensures the instrumental RMS error less than 20 ps**
- **The counter A013 ensures the instrumental RMS error less than 20 ps in the "Basic mode" and less than 10 ps in the "Precision mode"**

Integral linearity automated testing. Testing method

Test circuit

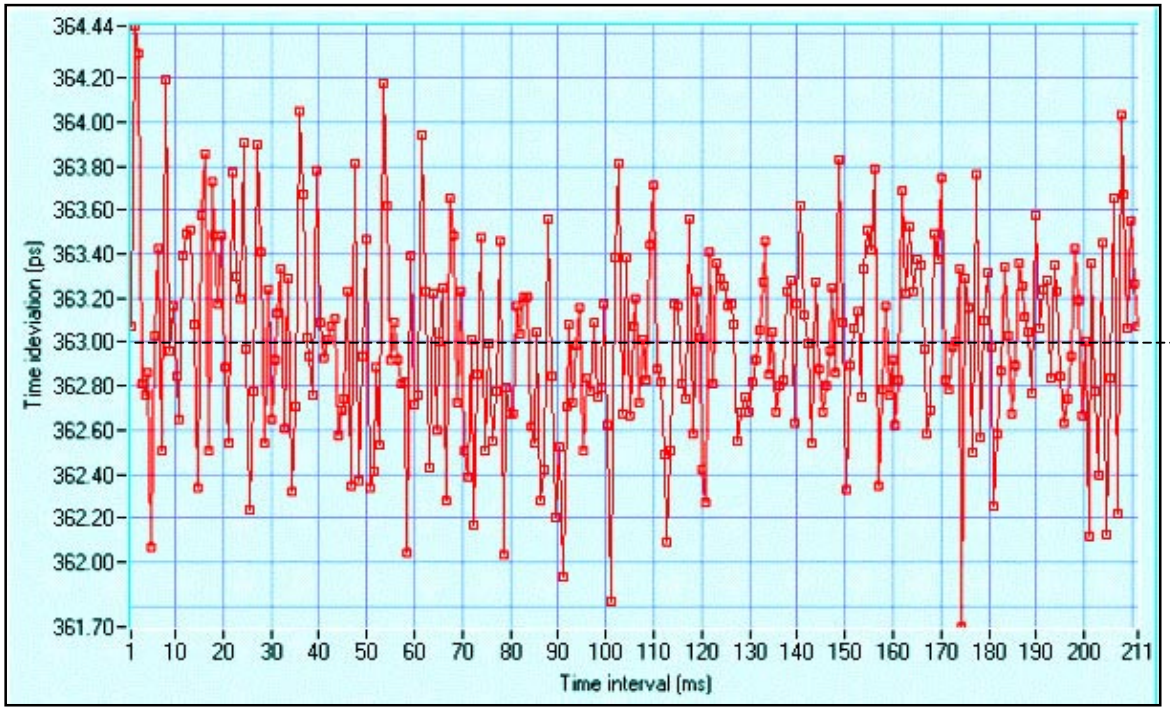


Timing diagram for testing



Integral linearity automated testing. Testing result.

Displacement of measurement results (mean of 1000 readings)
versus time interval has been measured

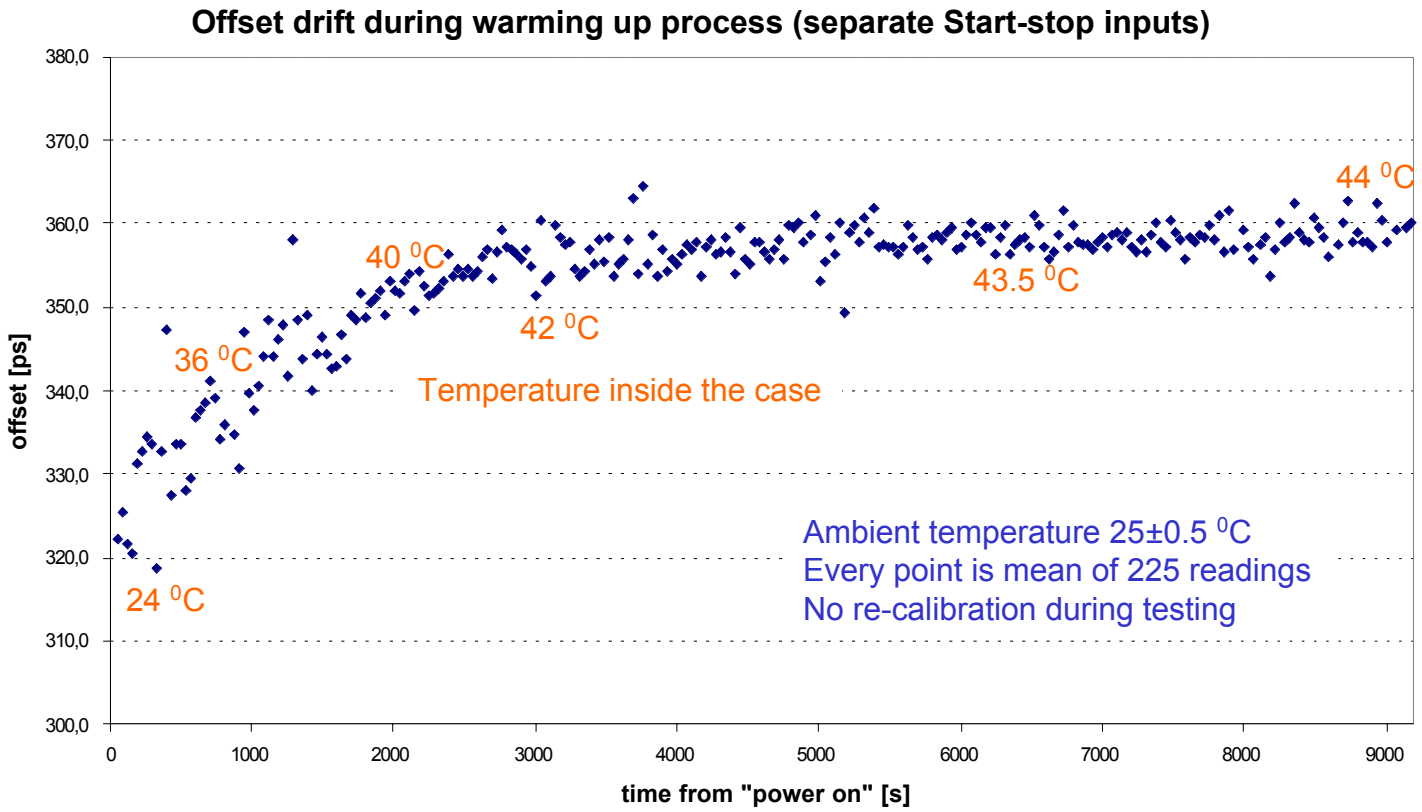


Conclusions from the integral linearity automated testing

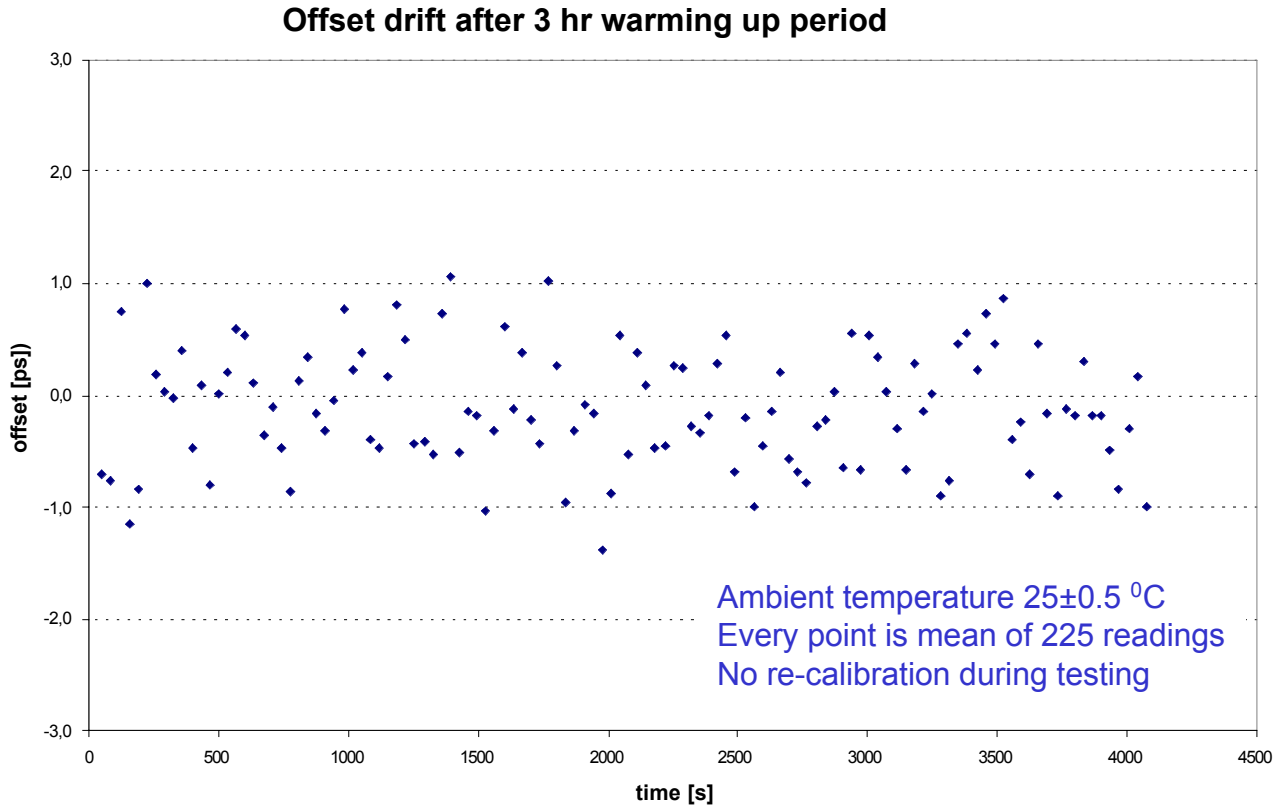
• Theoretically the integral linearity error should be negligible small due to the applied principle of the time interval measurement. In general the testing results confirm this fact and show that for times greater than 500 μs the linearity error is much less (<±1 ps) than the random errors of its estimation.

• For time intervals smaller than 500 μs some linearity error (up to 10 ps for the smallest intervals) is possible. It is caused by the finite recovery time of the event timer after every event timing.

Offset drift automated testing. Testing results.



Offset drift automated testing. Testing results.

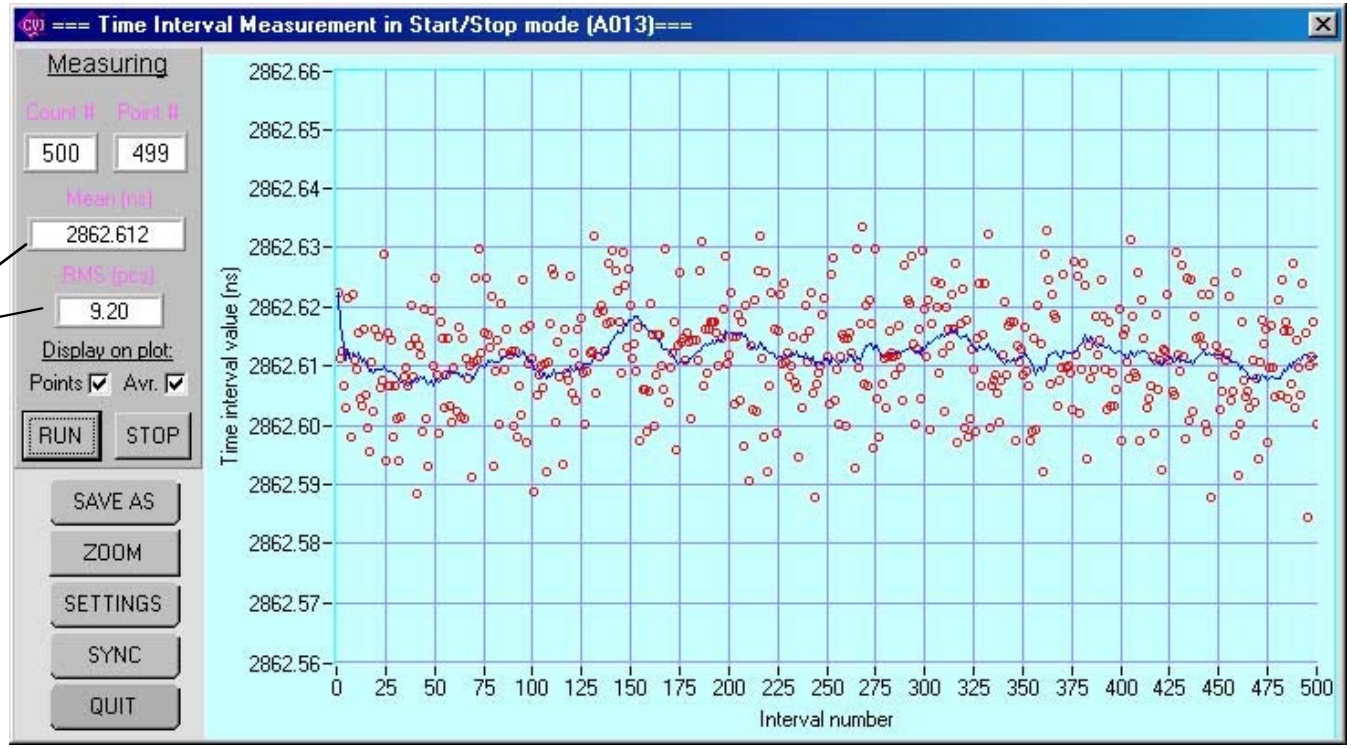


Conclusions from the offset drift automated testing

- **After an initial warming-up period (about 3 hr) the offset drift is much less than ±1 ps under stable in temperature (±1^{0}C) operating conditions.**
- **The offset drift is caused mainly by the temperature instability of throughput delays of START and STOP pulses to the point of their logical combining. The drift is not observed when Start-stop pulses come to the common input of the counter.**

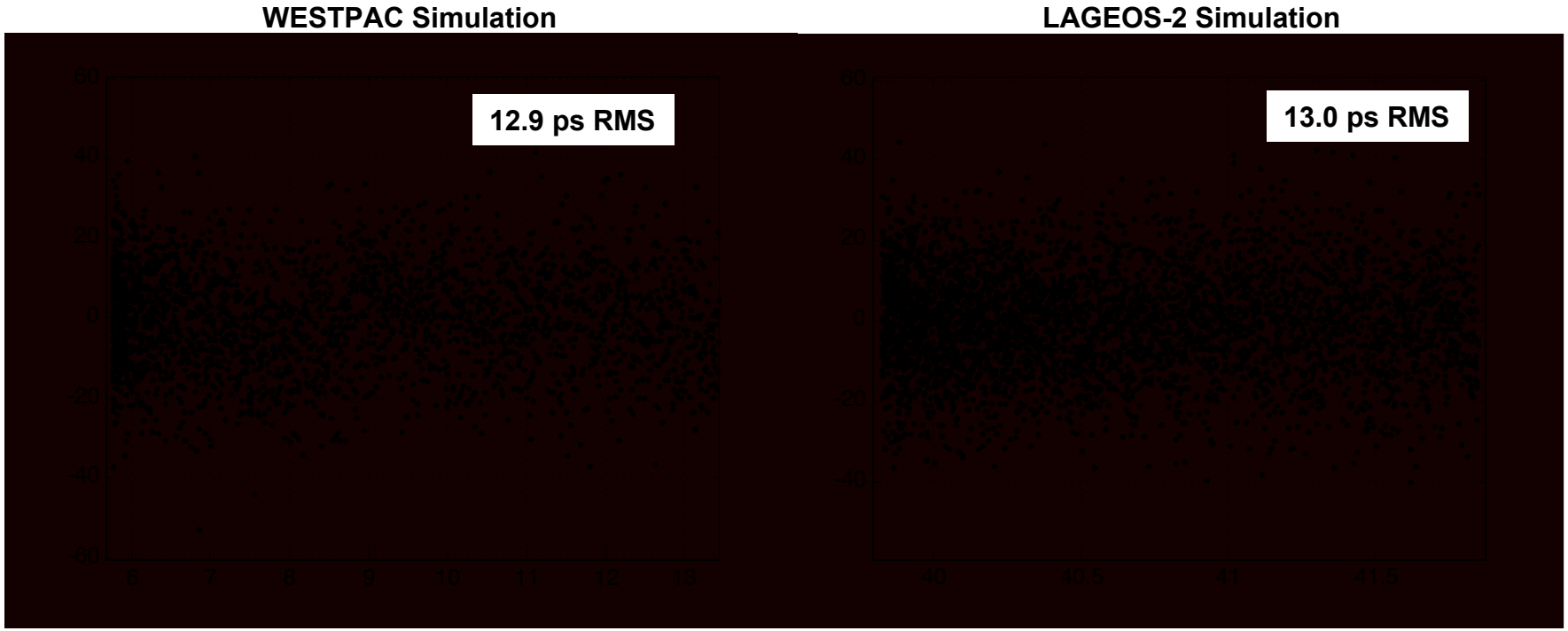
Example of A013 application. Virtual Time Interval Counter A013-TIC

Mean and RMS variation of measurement results



Results of high-stable time interval measurements at10 Hz repetition rate (circle - single-shot reading, line - sliding mean of 10 readings)

A comparison of A013 and PET (Wettzell)



<u>Conclusion.</u> A013 and PET appear to be closely allied in single shot resolution and linearity error.

A010 family specifications

Inputs (50 Ohm): Start (Start-stop)	NIM pulses (falling edges)	
Stop	NIM pulses (falling edges)	
Gate	NIM pulses (high level)	
Epoch	TTL pulses (rising edges); 1 pps	
Sync	TTL pulses (rising edges)	
	Basic mode (all models)	*Precision mode (*A013 *only)*
Time interval range	100 ns to 209 ms	5 μs to 209 ms
Time interval RMS resolution	< 40 ps (A011) < 20 ps (A012 & A013)	<10 ps
Sample number in one cycle	1 to 4680	1 to 520
Integral linearity error	< ± 1 ps (for measurement range from 500 μs)	
Offset drift	<±0.2 ps/^{0}C (common input); <± 0.5 ps/^{0}C (separate inputs)	
Warm-up time	3 hr	
Measurement cycle control	By user program or externally by Sync pulse	
Application software	Windows based "Time Interval Counter"	
Software support	Example program in C	
Special feature	Start pulse timing with 12.5 ns LSD resolution	
Timebase	External - 10 MHz; internal - 10 MHz/100 ppm	
Hardware connection to PC	Via PC parallel port operating in EEP mode	
Hardware dimension	375_60x233 mm	
Power supply	100 – 240 VAC	