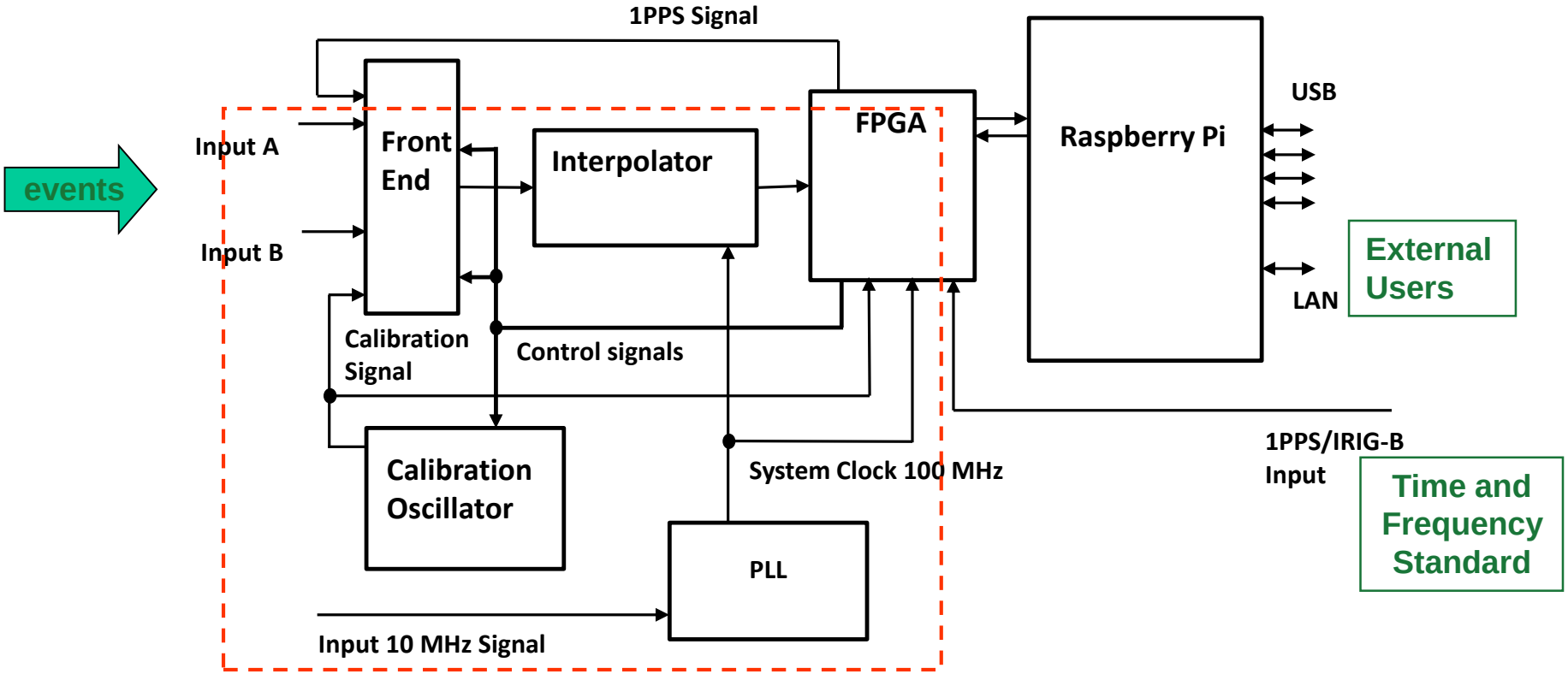
Eiropas Reģionālās attīstības fonda līdzfinansēts projekts Nr.1.1.1.1/16/A/174
„Laika sinhronizācija ar augstu precizitāti
sadalītai zinātnisku mērījumu sistēmai (DaLaS)”.

Taimera izstrāde JUNO projekta vajadzībām un tā parametru novērtēšana

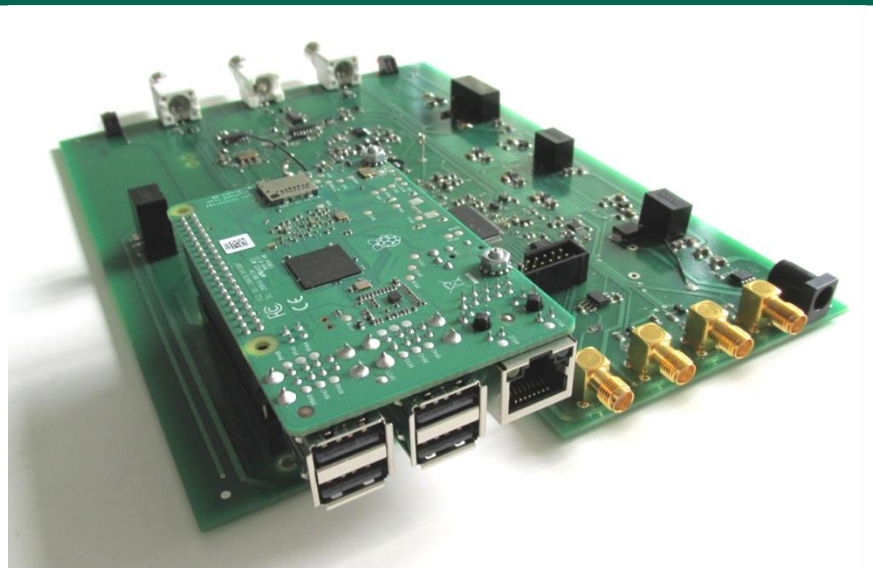
Architecture and operational principles of the TET
TET implementation and housing
An example of application software for the TET
Estimation of the TET performance parameters:
- **Interval non-linearity errors**
- **Interpolator nonlinearity estimation**
- **Measurement uncertainty for short and long intervals**
- **TET precision dependence on temperature without calibration**
- **TET precision stability in temperature with recalibration**
- **ADC values deviation in temperature**
- **Input to input offset drift in temperature**
- **Single-input offset drift in temperature**

TET full specification

Block diagram of the True Event Timer (TET)

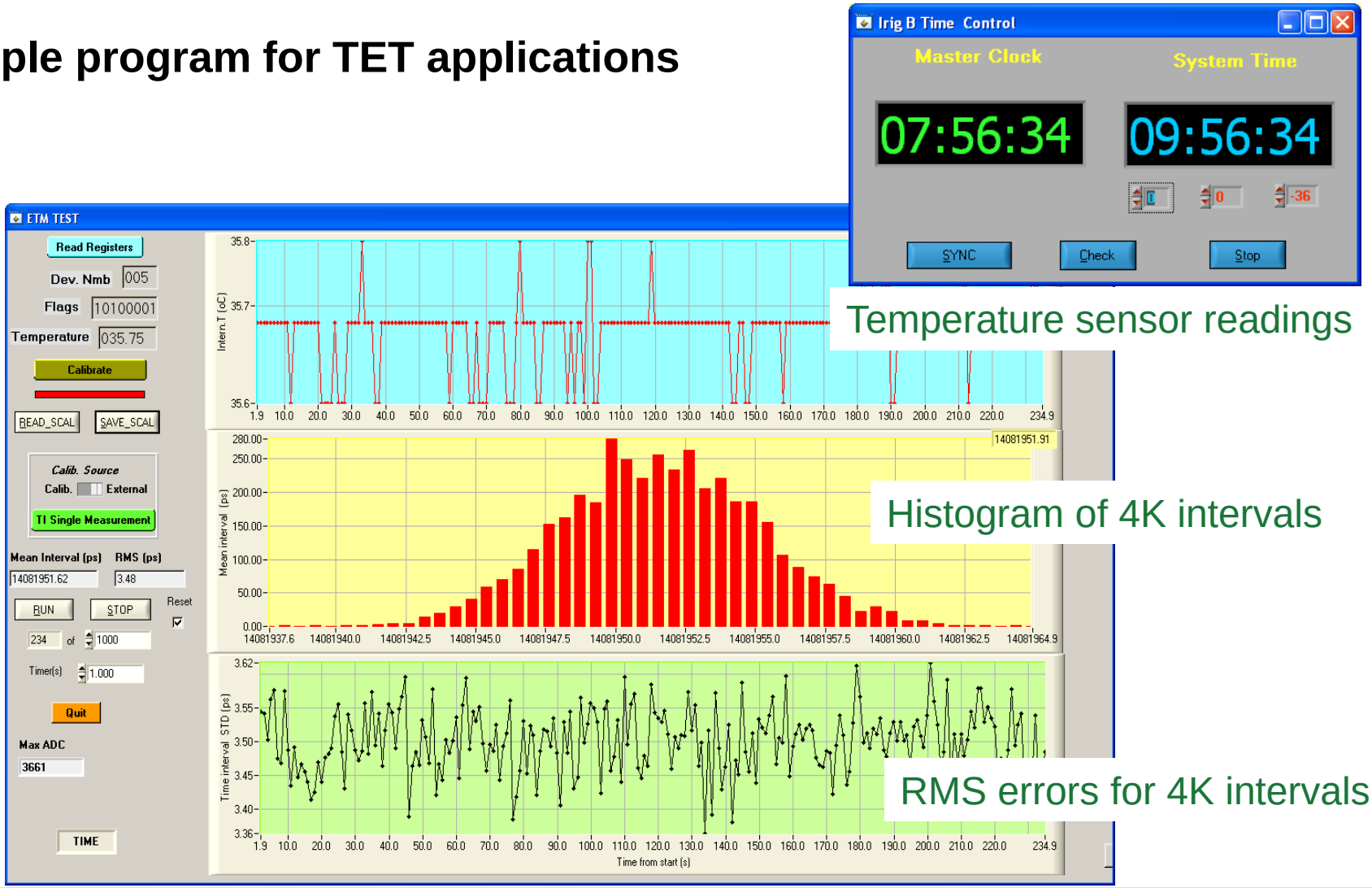


The timing module board with on-board computer Raspberry



Assembled True Event Timer in the Hammond enclosure

Sample program for TET applications

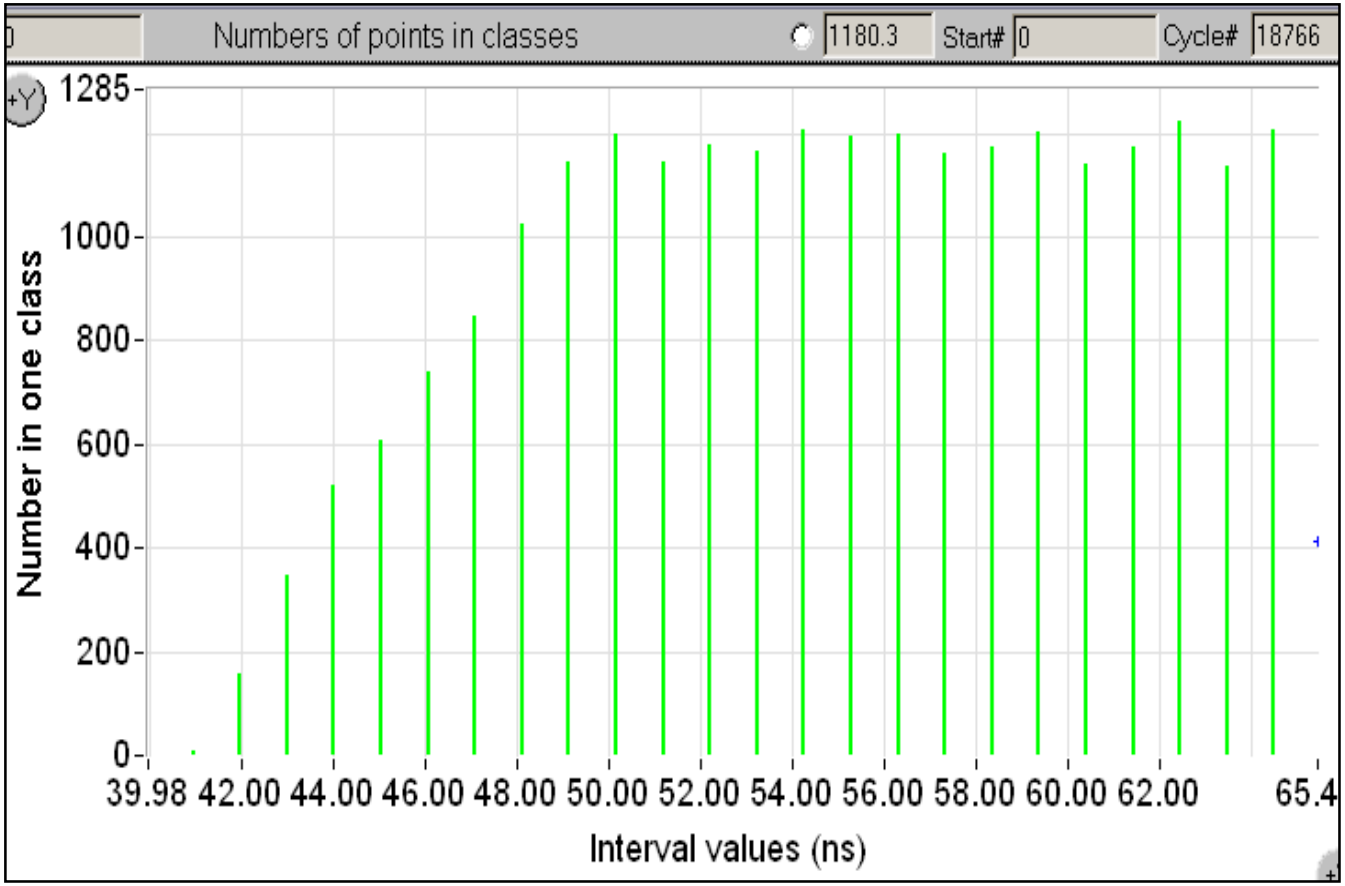


Temperature sensor readings

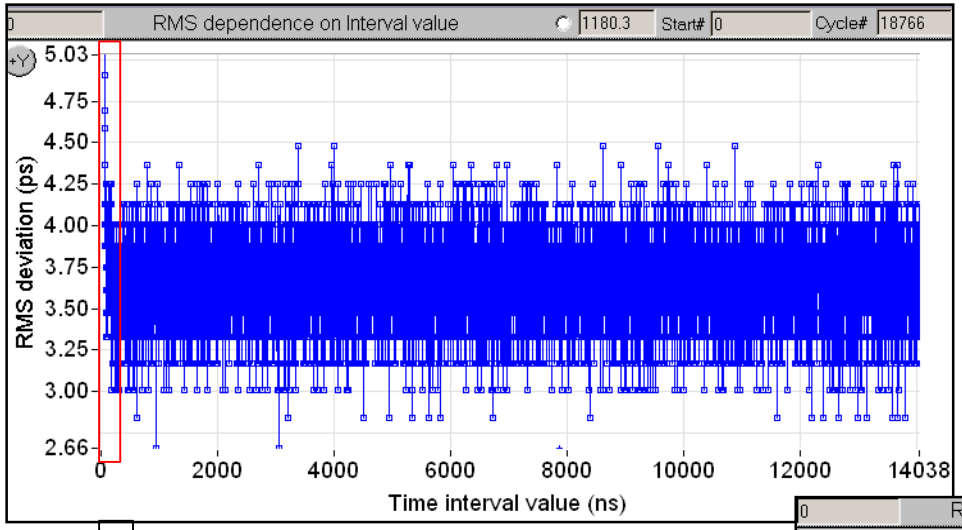
Histogram of 4K intervals

RMS errors for 4K intervals

Dead-time estimation

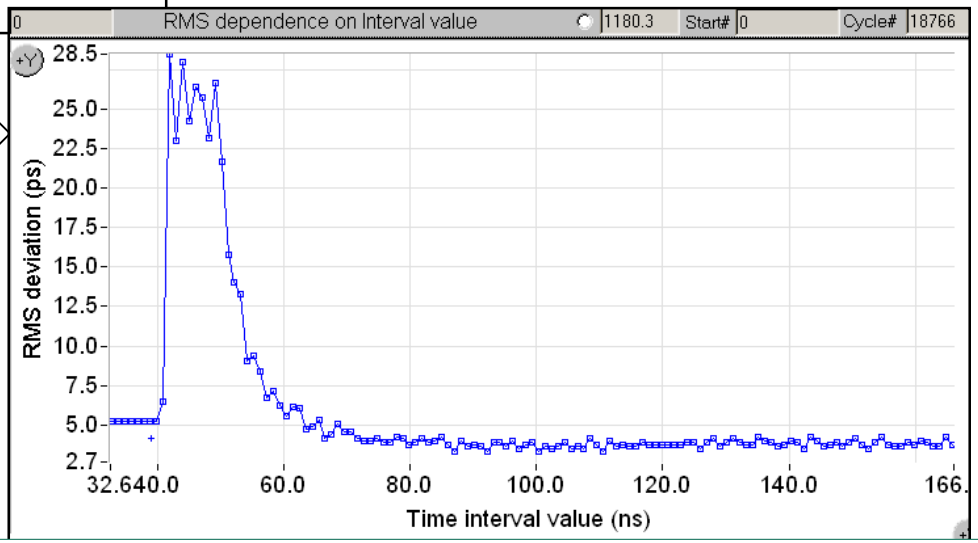


Measurement uncertainty dependence on interval value

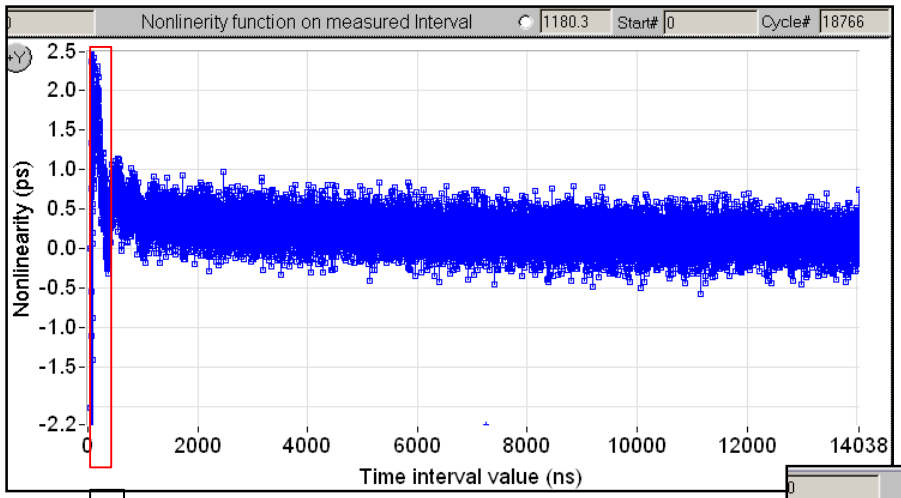


For events after 150 ns the measurement uncertainty is less than 4.5 ps

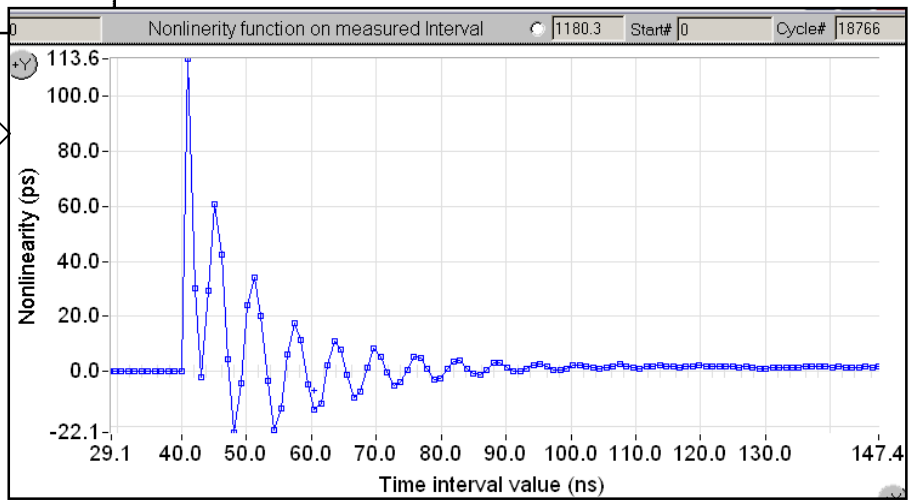
Measurement uncertainty for events close to the “dead time”



Interval non-linearity estimation

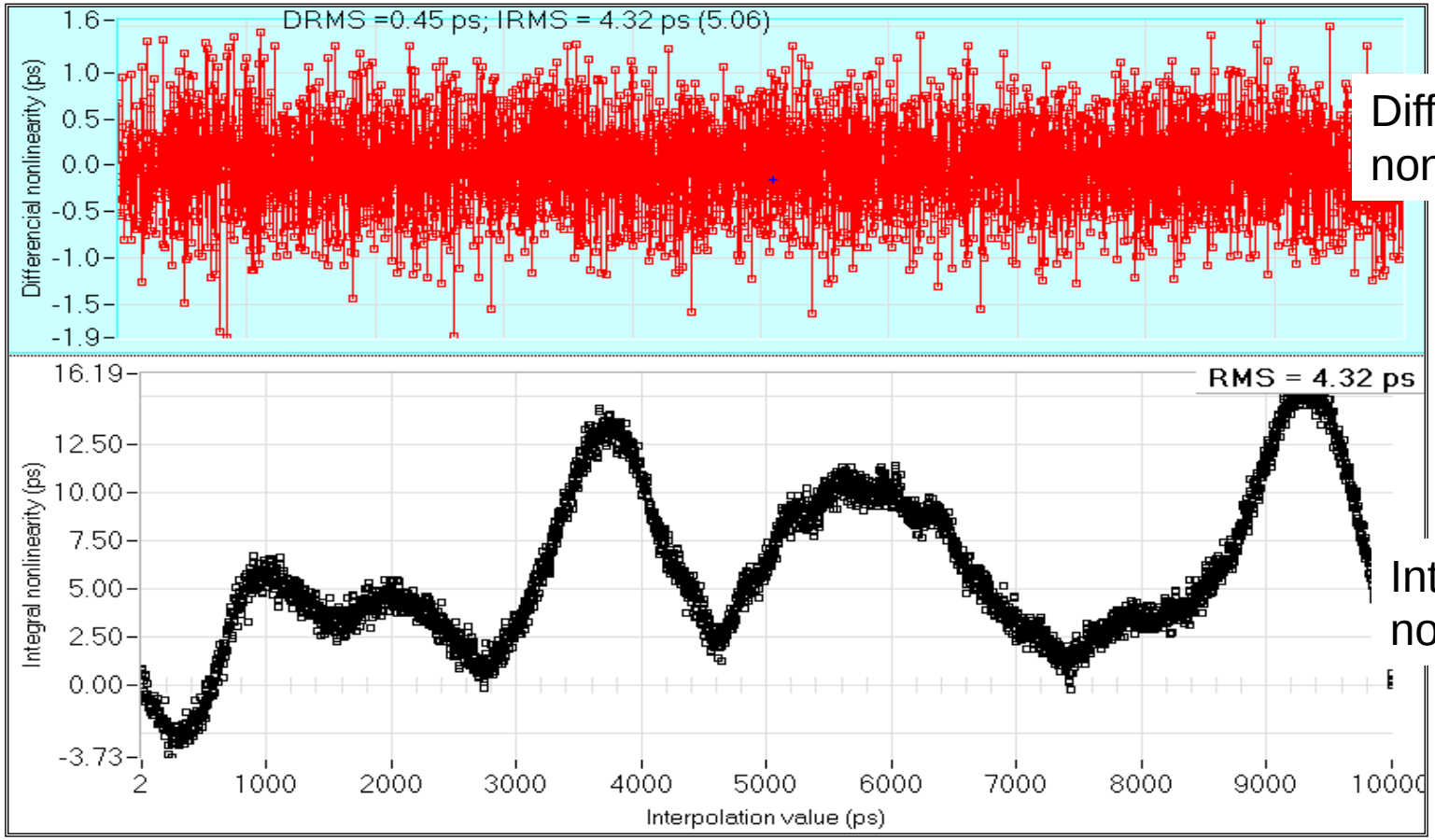


Interval nonlinearity for events after 150 ns is less than 1 ps



Interval nonlinearity for events close to the “dead time”

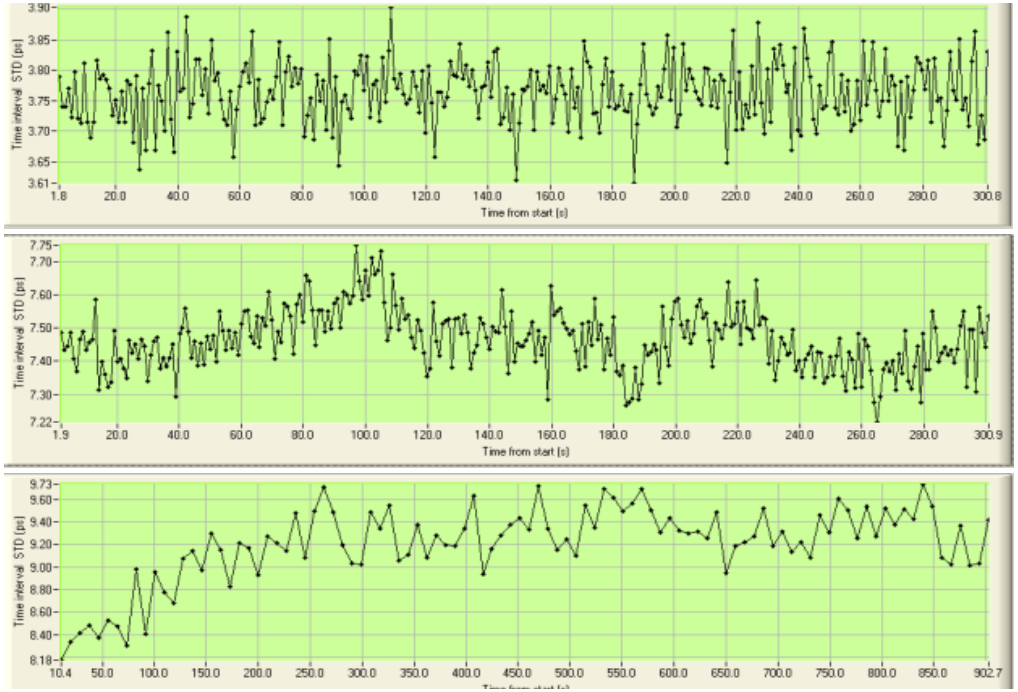
Differential and integral nonlinearities statistical estimation



Differential nonlinearity

Integral nonlinearity

Measurement uncertainty depending on intervals (asynch)

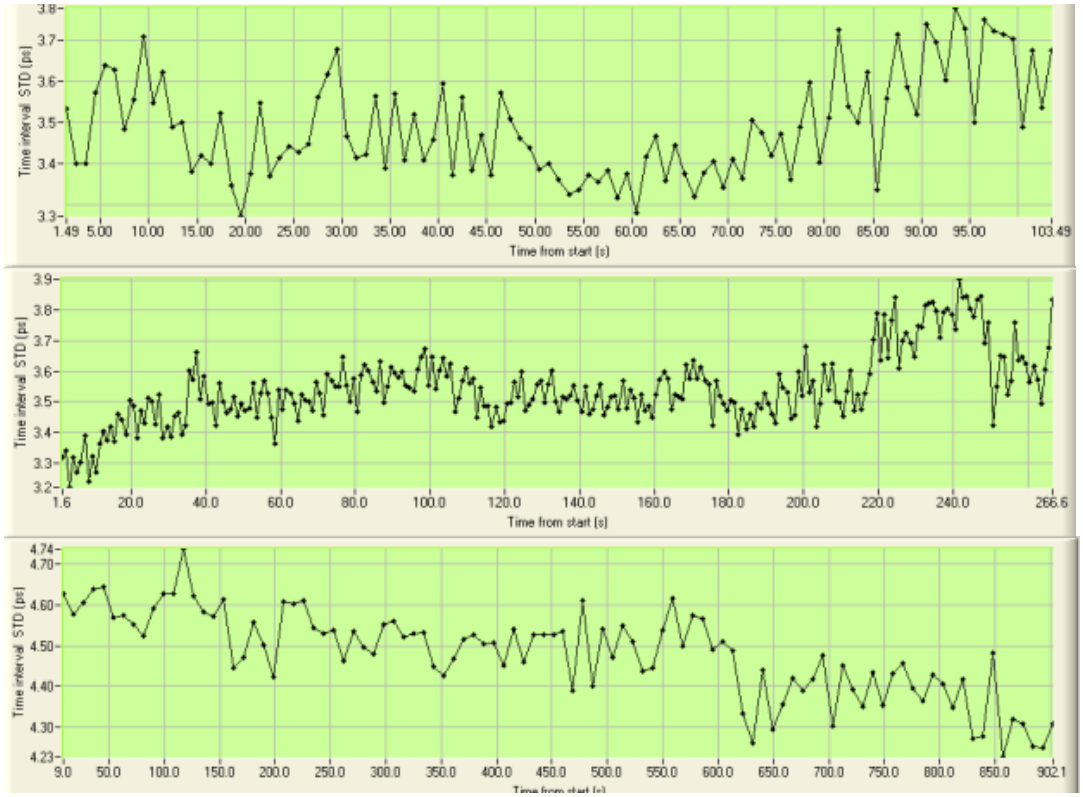


T=199.97 ns
RMS = 3.8 ps

T=19996.95 ns
RMS = 7.5 ps

T=1999694.69 ns
RMS = 9.3 ps

Measurement uncertainty depending on intervals (synch)

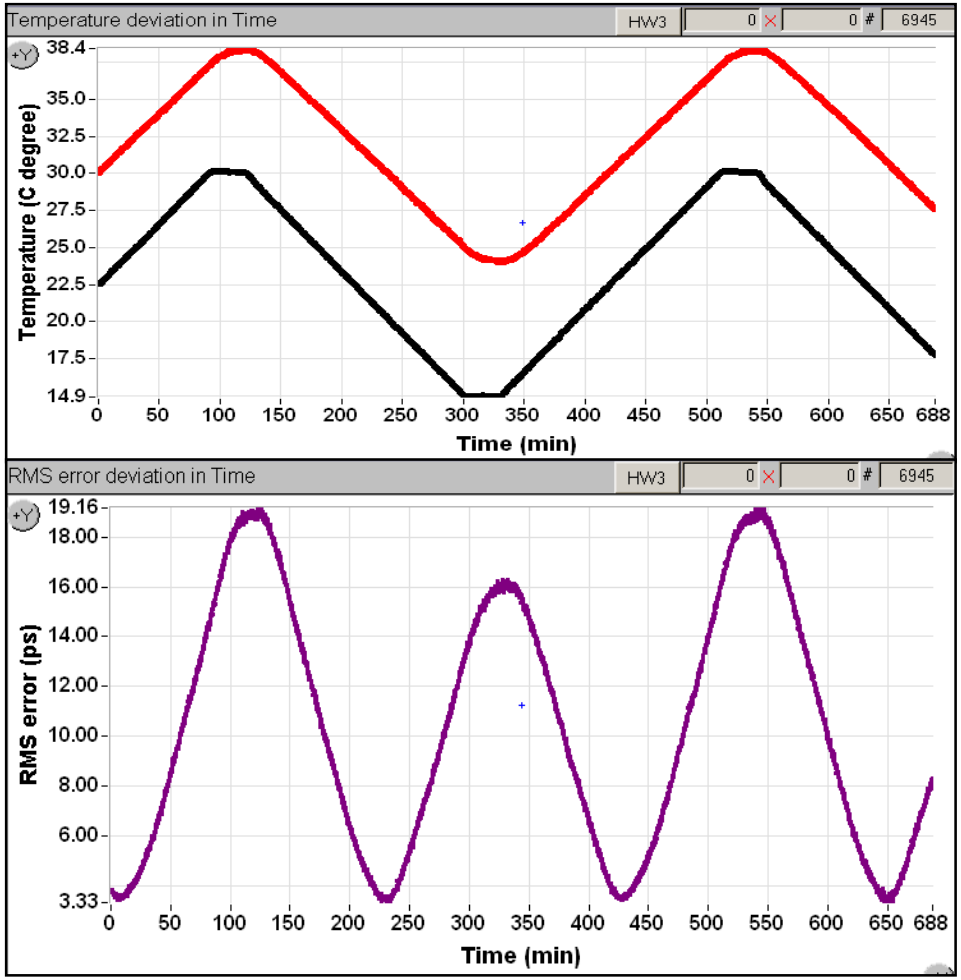


T=200.00 ns
RMS = 3.5 ps

T=20000.00 ns
RMS = 3.6 ps

T=2000000.00 ns
RMS = 4.5 ps

Measurement uncertainty changes together with change of temperature (without recalibration)

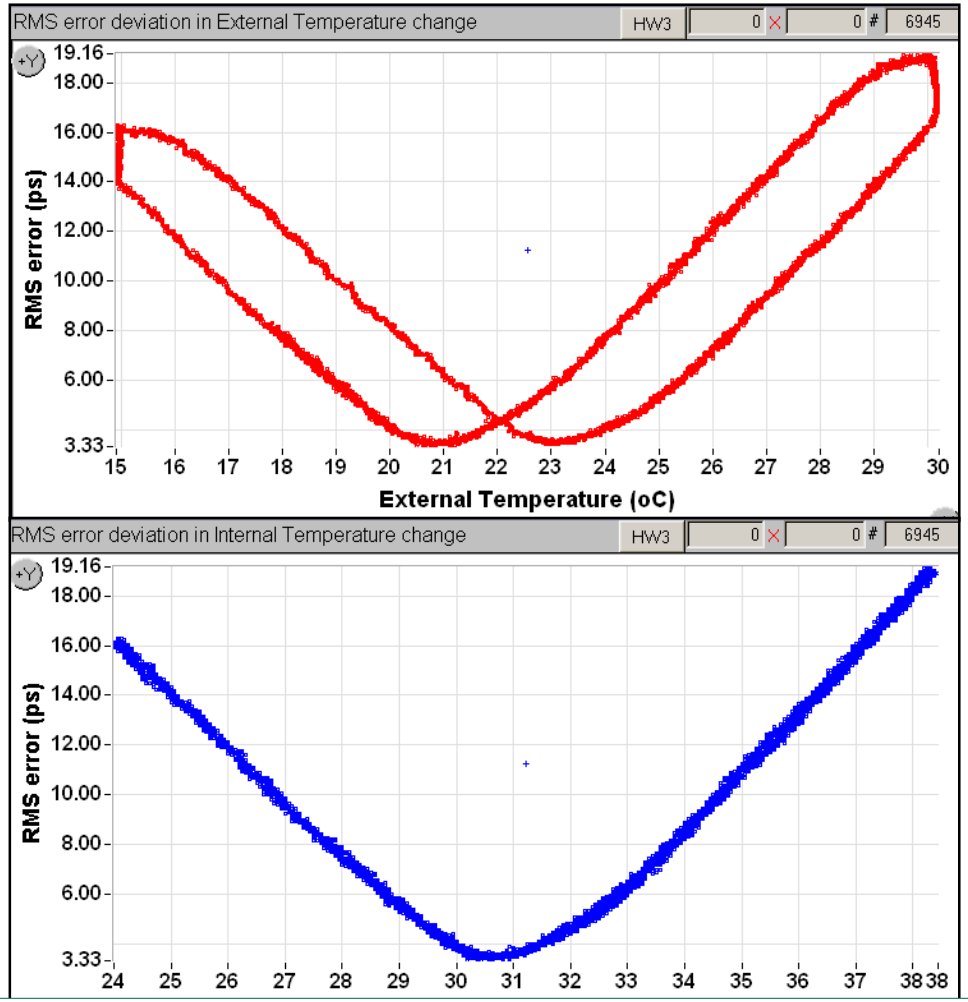


Internal temperature

External temperature

Measurement uncertainty

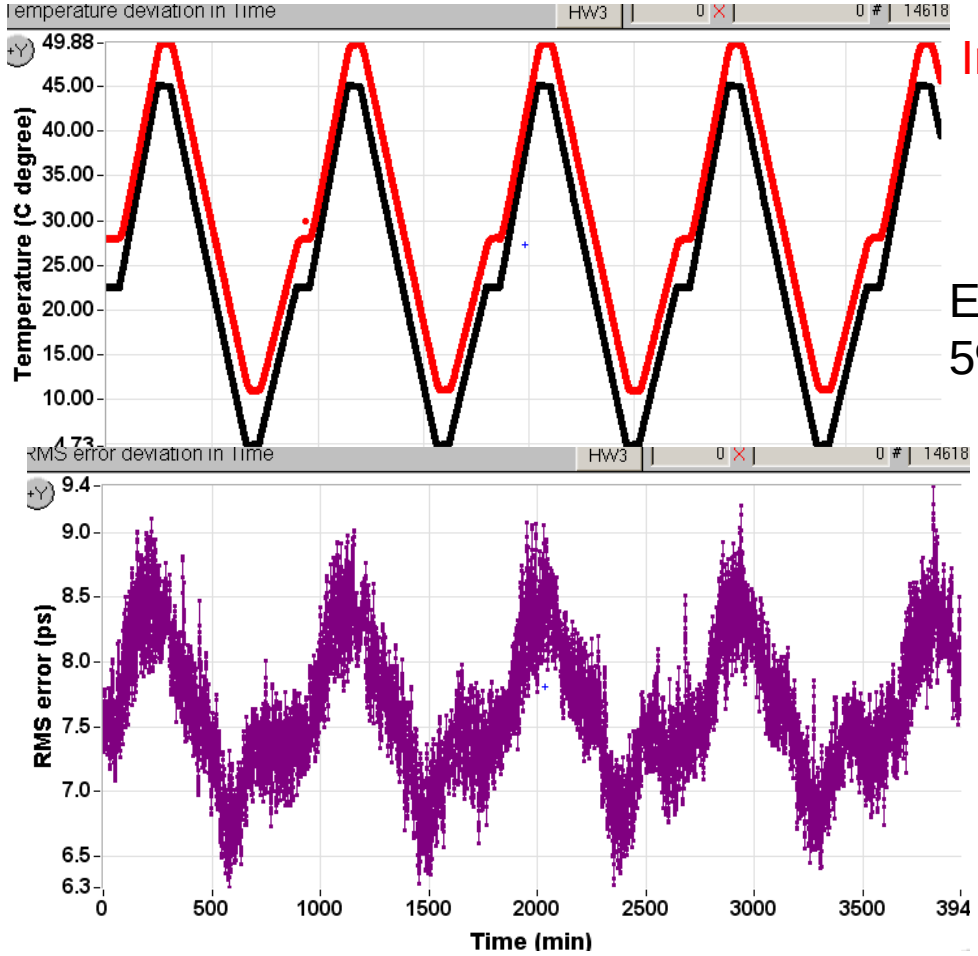
Measurement uncertainty dependence on temperature without recalibration



Uncertainty as function of the external temperature

Uncertainty as function of the internal temperature

Measurement uncertainty change together with change of temperature with regular recalibration

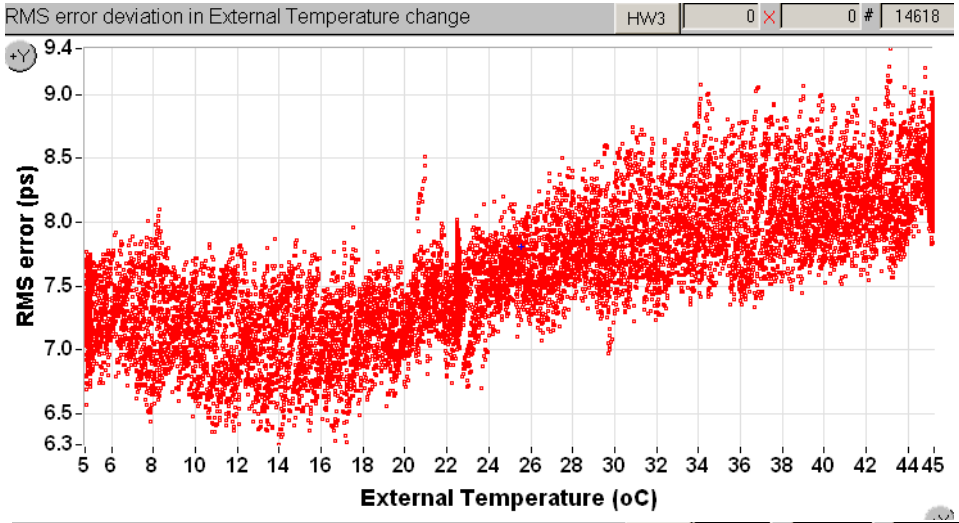


Internal temperature

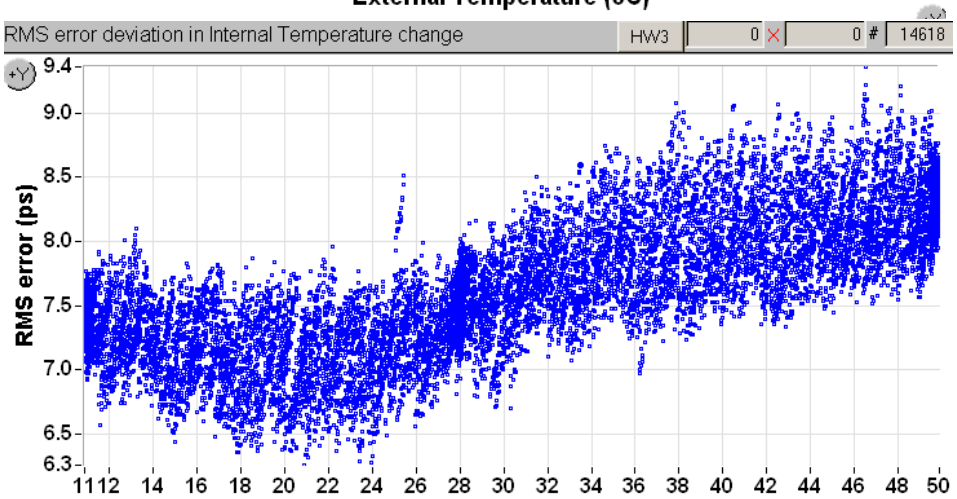
External temperature from 5°C up to 45°C

Measurement uncertainty

Measurement uncertainty dependence on temperature with regular recalibration

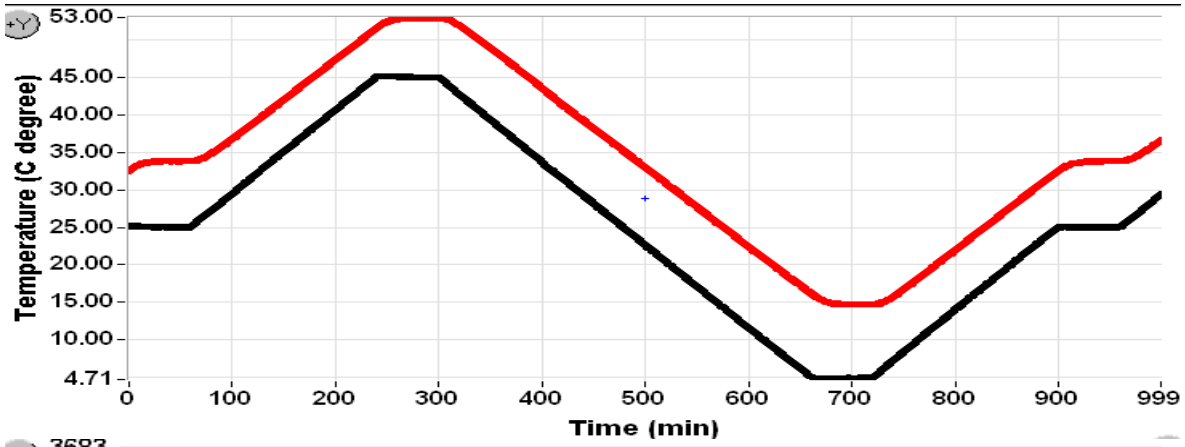


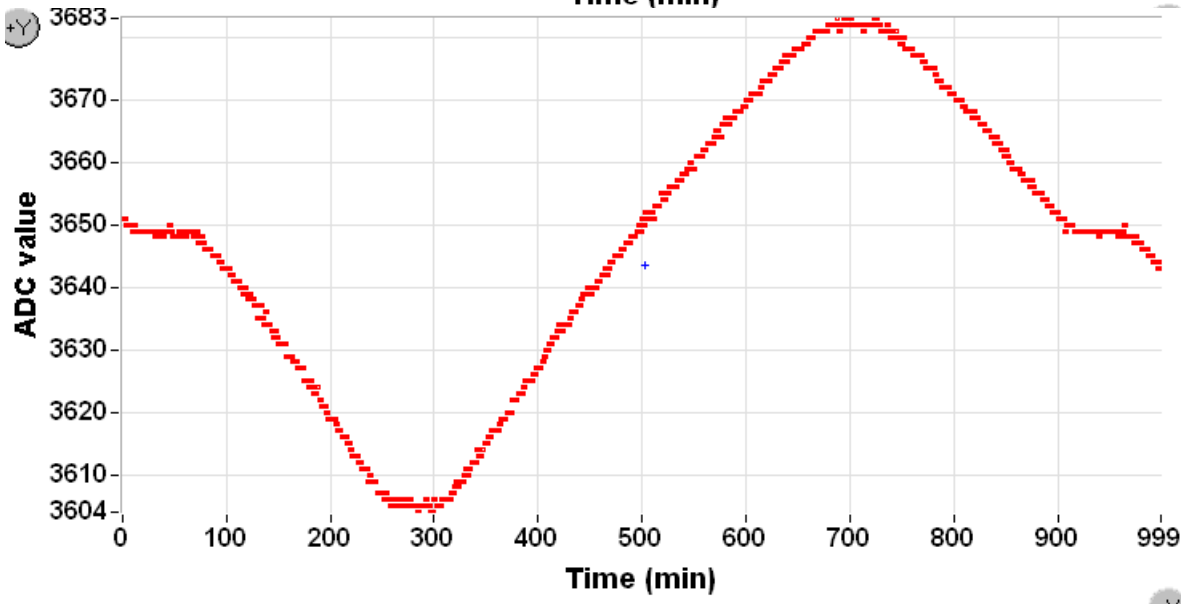
Uncertainty as function of the external temperature



Uncertainty as function of the internal temperature

Changes in temperature of ADC maximal values

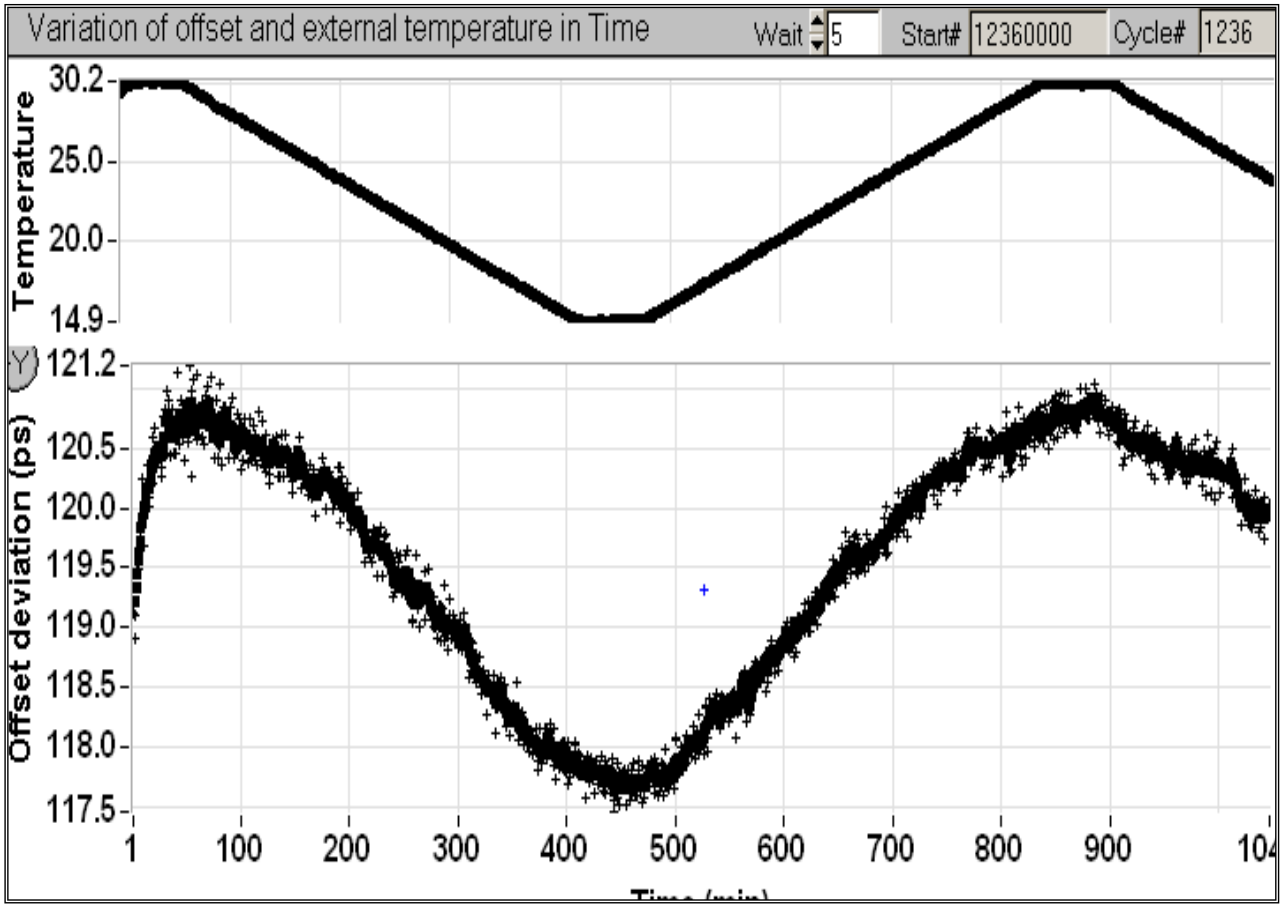




External temperature changes in the range from 5°C up to 45°C

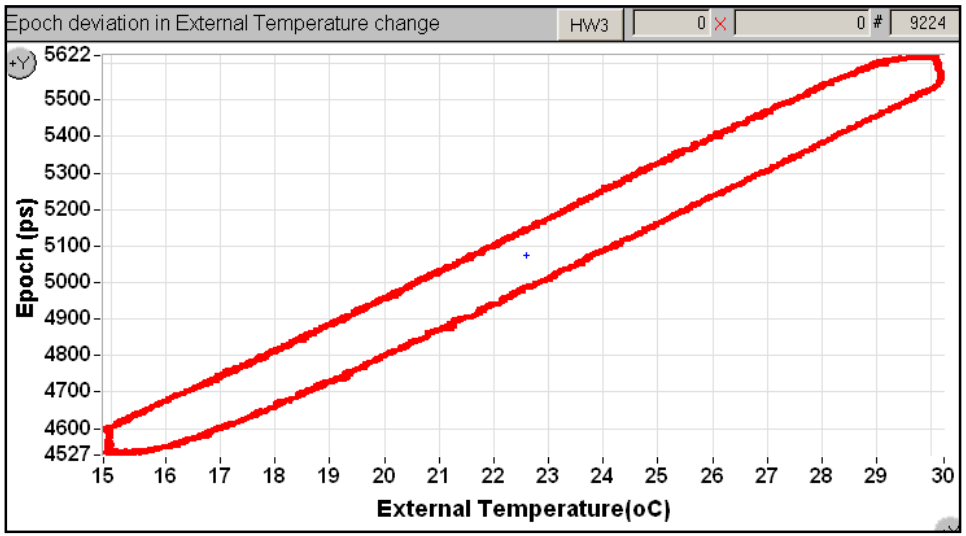
ADC values range changes in the range from 3683 down to 3604

Input to input offset drift in temperature

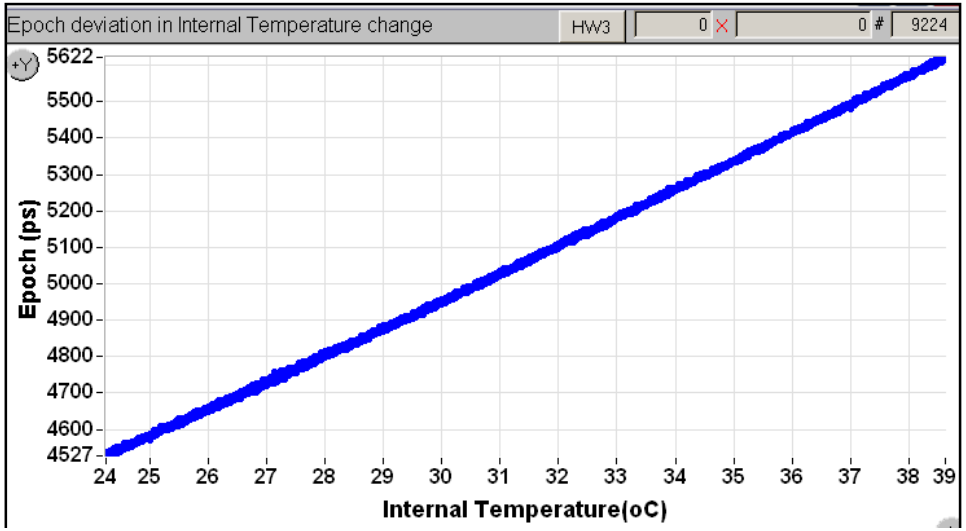


For temperature change from 15 ^{o}C up to 30 ^{o}C
the input-to-input drift is about 3 ps or 0.2 ps/^{o}C

Single-input drift in temperature



Epoch value as a function of the external temperature



Epoch value as a function of the internal temperature

Specification parameters of the True Event Timer

Specification parameters of the True Event Timer		
Circuit defined parameters:		Comments
time measurement range: from up to	49 ns unlimited	Timing module has upper limit 343.6 s and can be increased.
least significant bit	2.5 ps	
dead-time	50 ns	
buffer memory (time-tags)	4K	Can be increased
Precision specifying parameters:		
Measurement uncertainty for intervals: including: Integral nonlinearity Interval nonlinearity	9.3 ps 4.3 ps < 1 ps	To be eliminated To be eliminated For intervals > 200 ns
Result dependence on temperature:		
Input-to-input offset drift	0.2 ps/^{o}C	
Single input deviation	73 ps/^{o}C	To be eliminated