

Progress in sub-picosecond event timing

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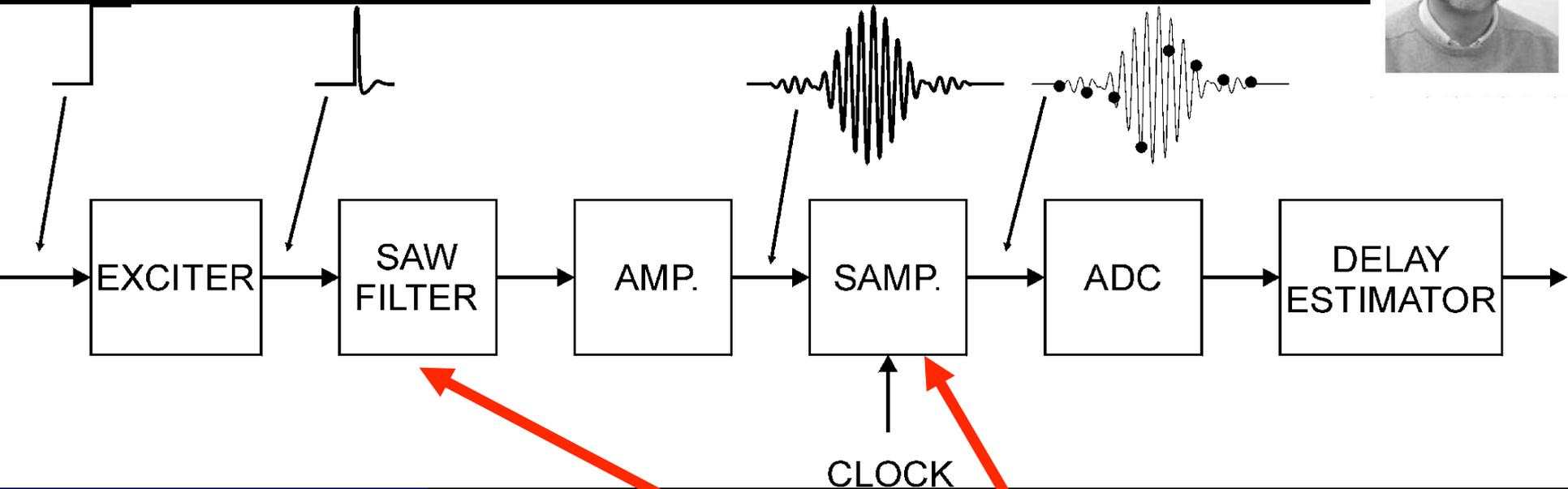
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Outline

- Novel timing principle of sub-ps event timing
- New technologies in electronics
(SiGe ultrafast logic, “no ground”, SAW filters,..)
- First device design and construction
- Timing results : jitter, linearity, stability
- First field test results

New timing principle theory by Petr Panek

US Patent, 2005

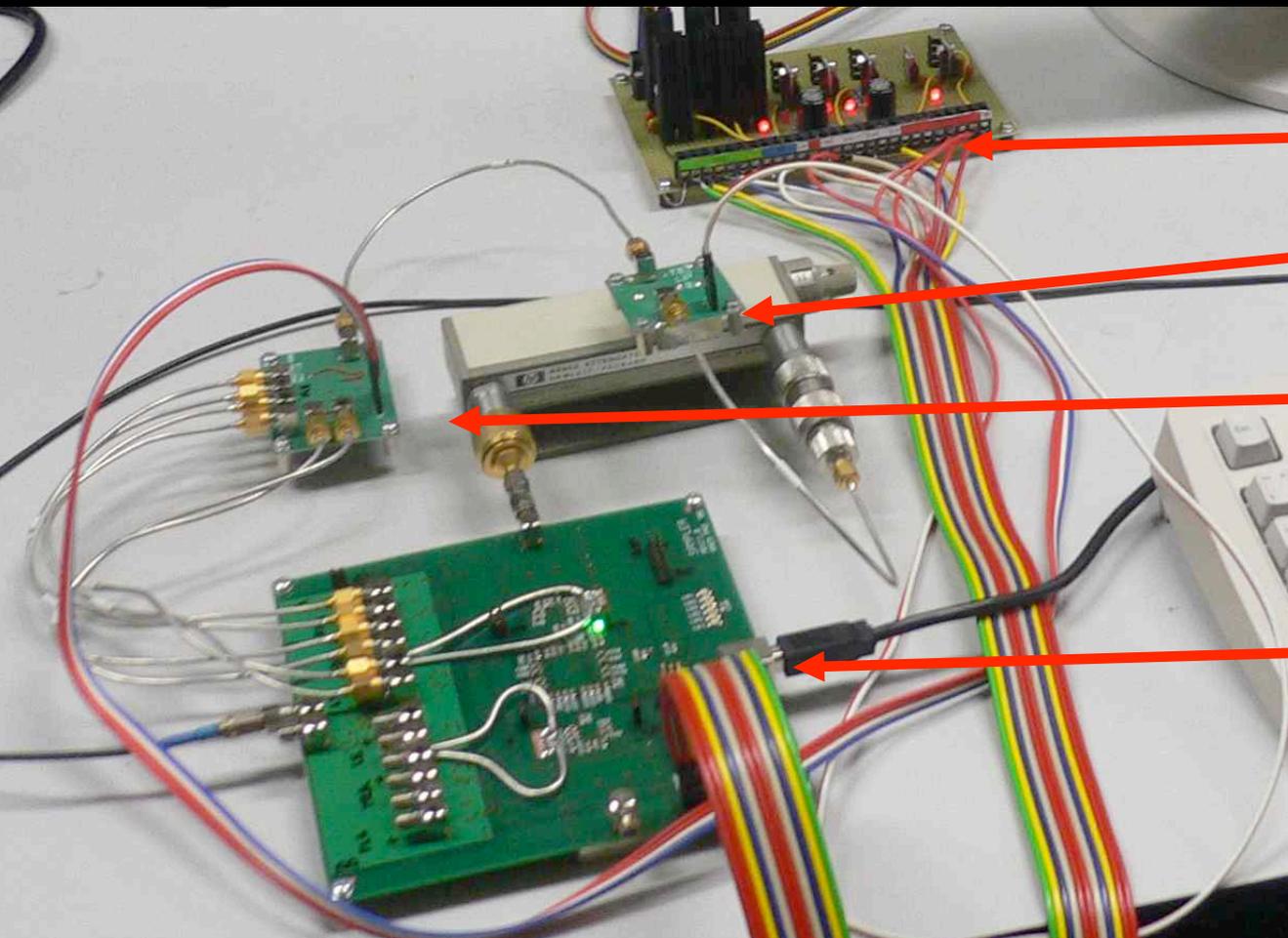


- Time measurement is carried out in a FREQUENCY DOMAIN
- The time-interpolation by the SAW filter
- The SAW filter output synchronously sampled & digitized
- Time / epoch is computed using the reverse FFT

New technologies employed

- Ultrafast SiGe 10 GHz logic 35 ps slopes
50 Ohms lines matched
drift ~ 0.5 ps / K 
- logical gain 1
high costs, limited availability
PCB design, soldering problems 
- SAW filters used as time interpolators
- 200 MHz Module, J.Kolbl and P.Sperber, Deggendorf, 2005
extreme spectral purity
- Circuit design complementary signals only
=> "NO GROUND"
maximum design symmetry
 ~ 10 ps delay matched cables

First sample construction



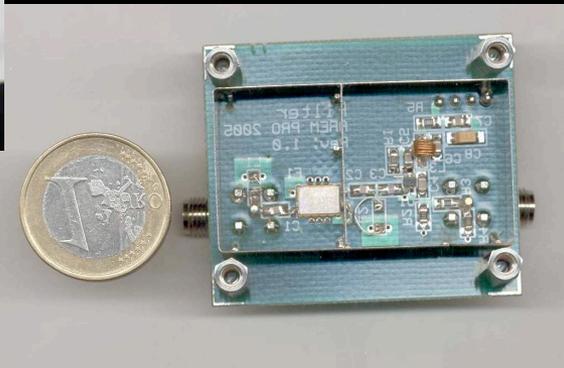
Power supply

SAW filter

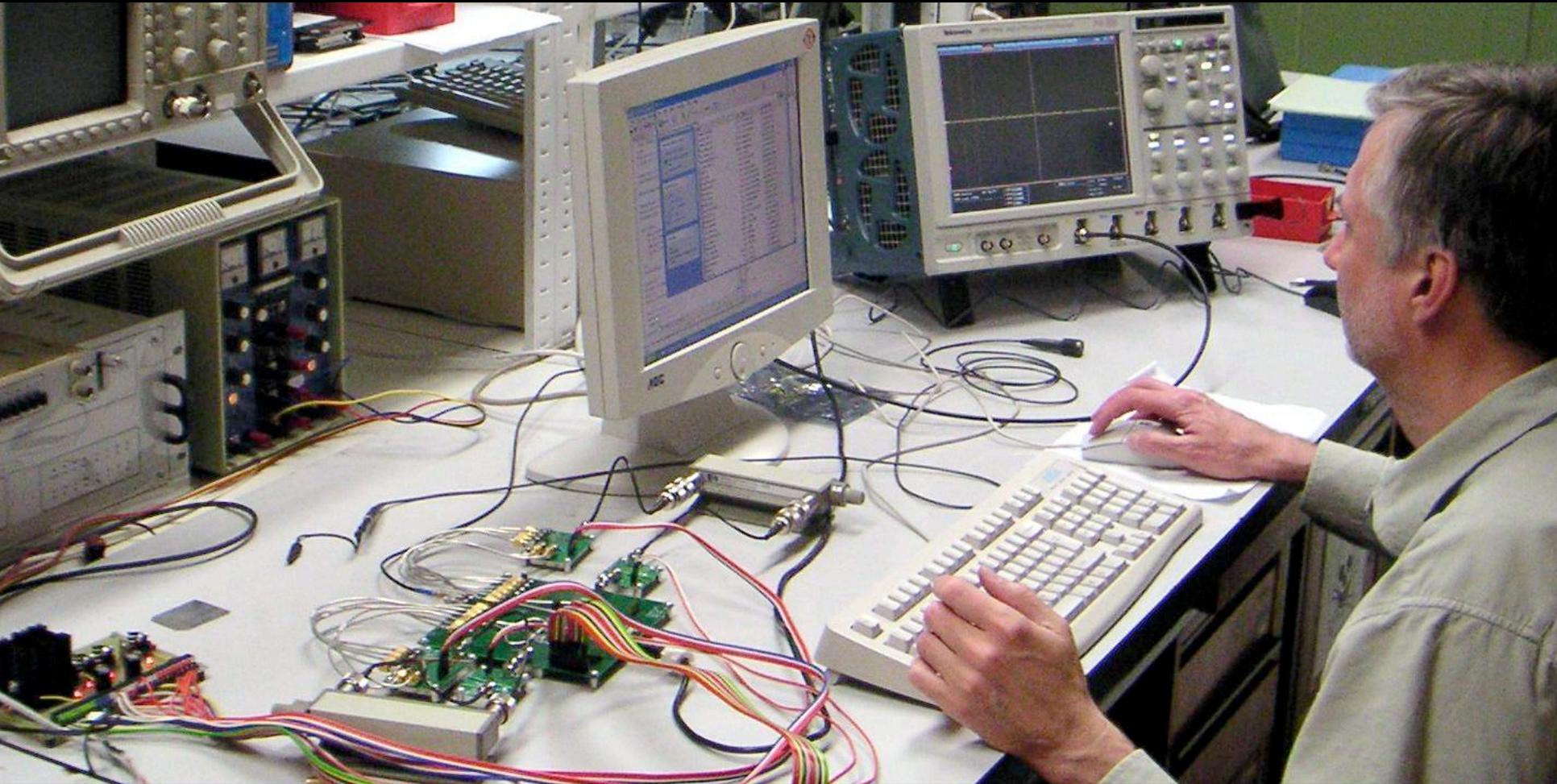
Exciter

Sampler & A/D
data interface

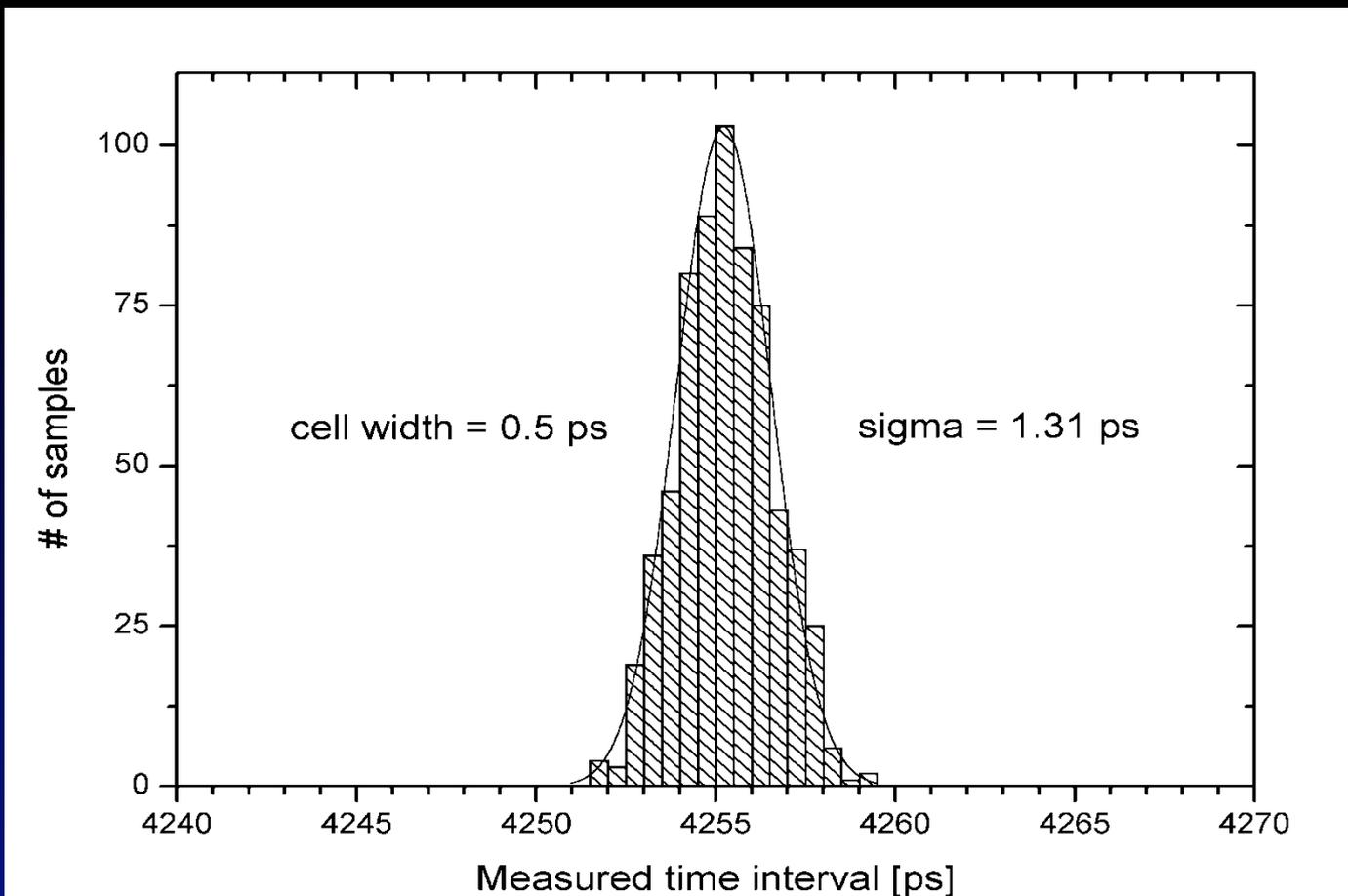
Interpolator based on SAW filter



Device operational test – full configuration



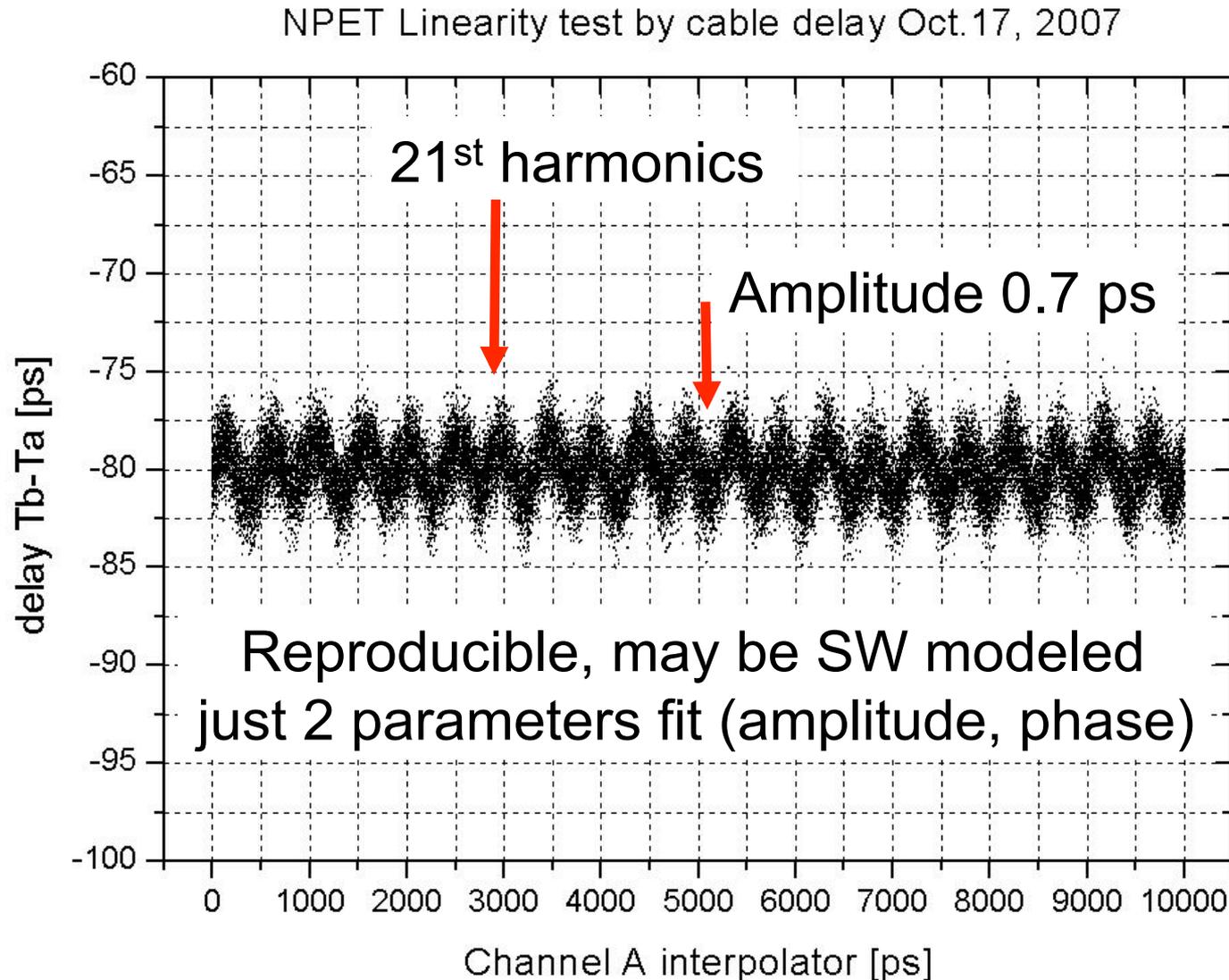
Timing jitter - cable delay test



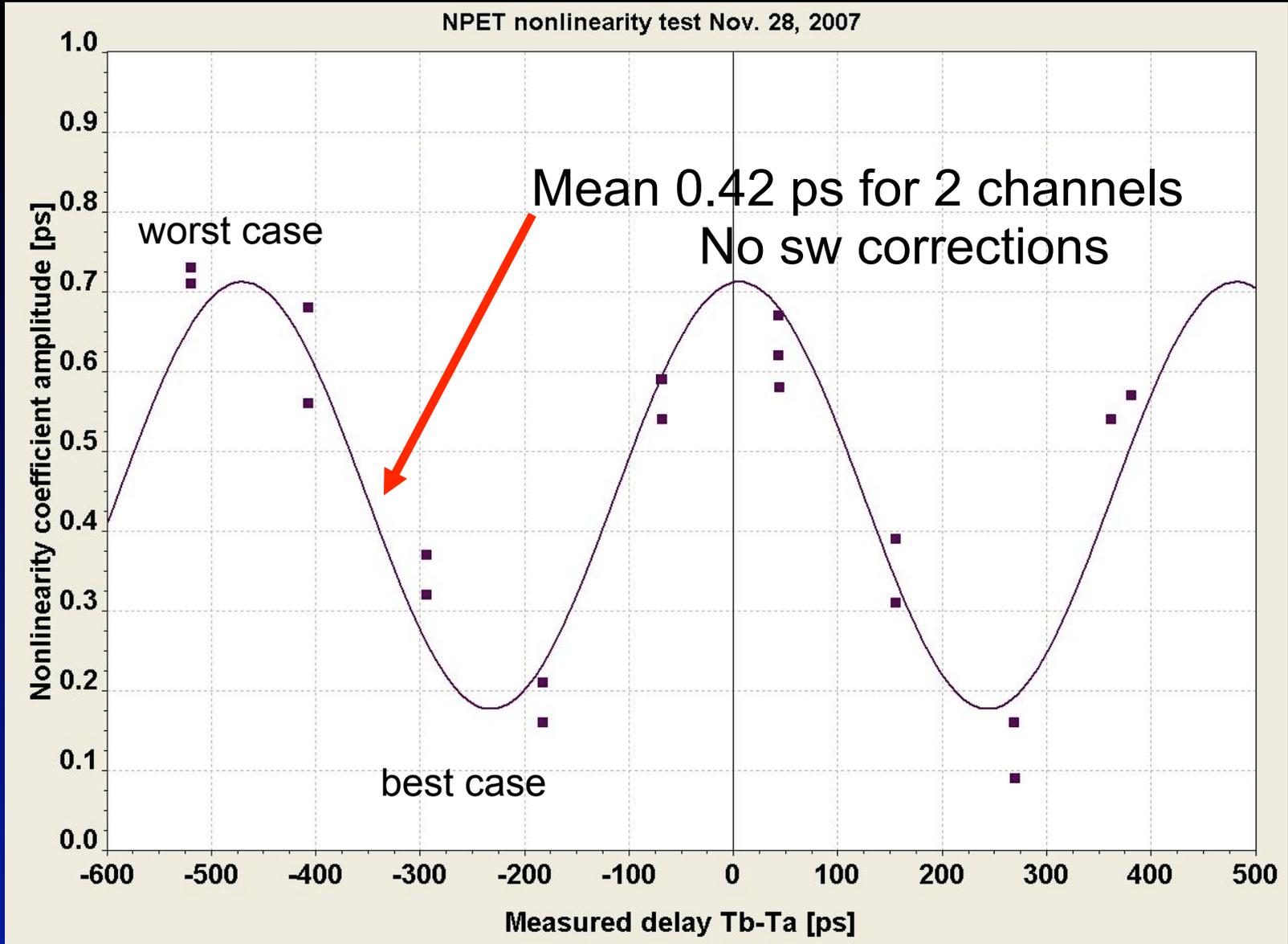
Jitter per channel ~ 920 fs, normal distribution

Review of Scientific Instruments, 78,1 (2007)

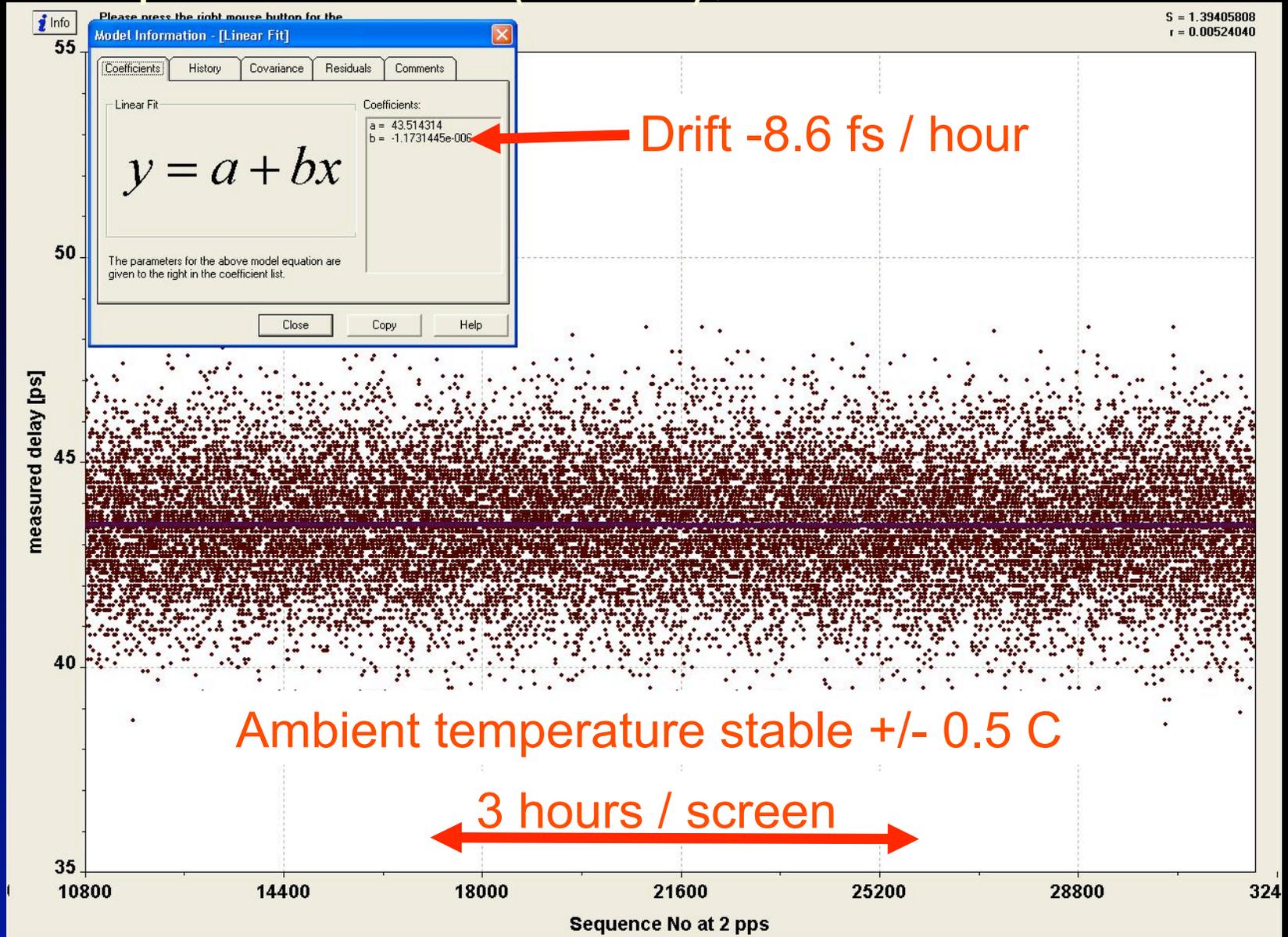
Timing linearity - the worst case phase



Timing linearity – dependence on Tb-Ta phase

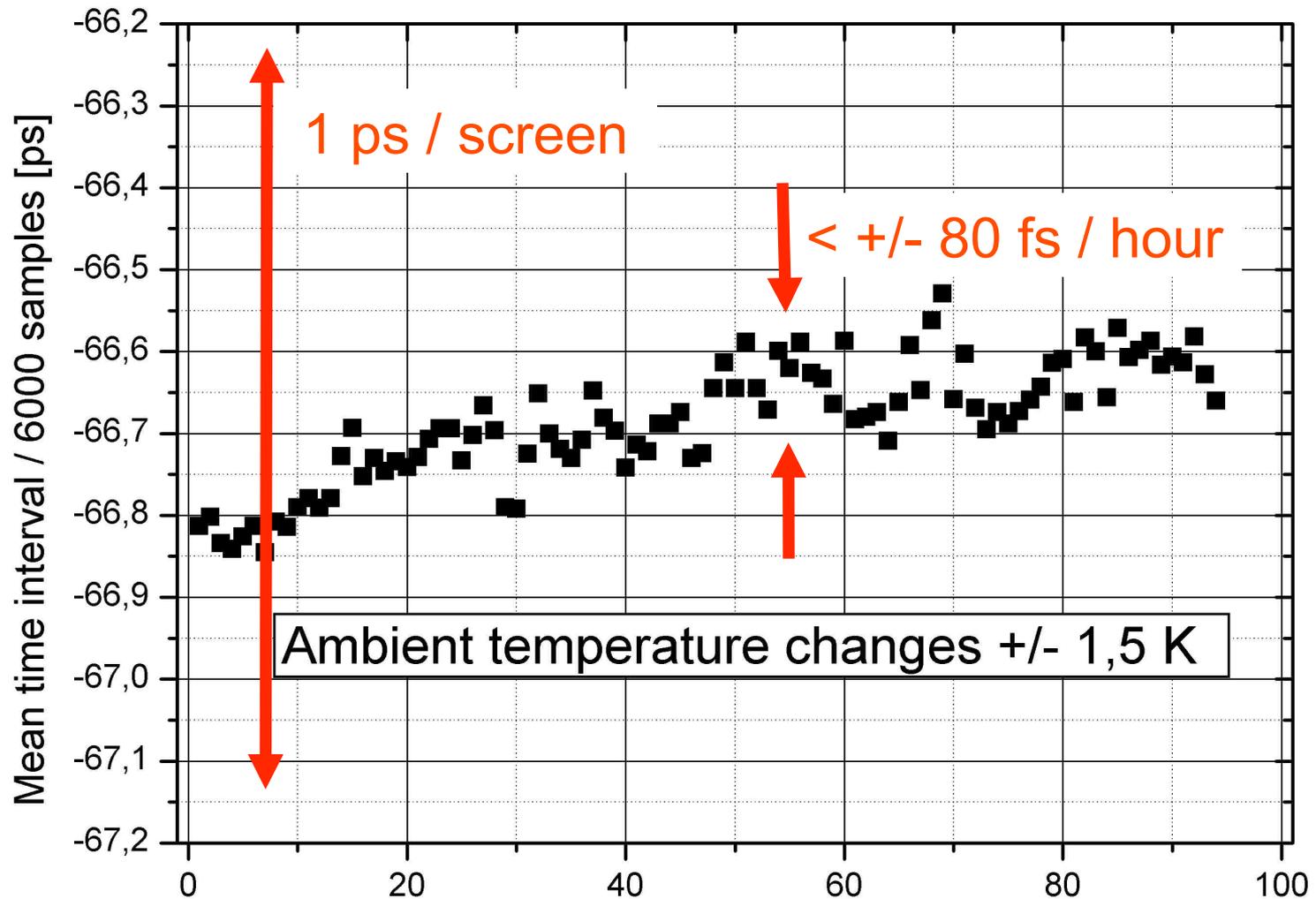


Temperature drift (Tb-Ta), channel to channel



Temperature drift (Tb-Ta), channel to channel

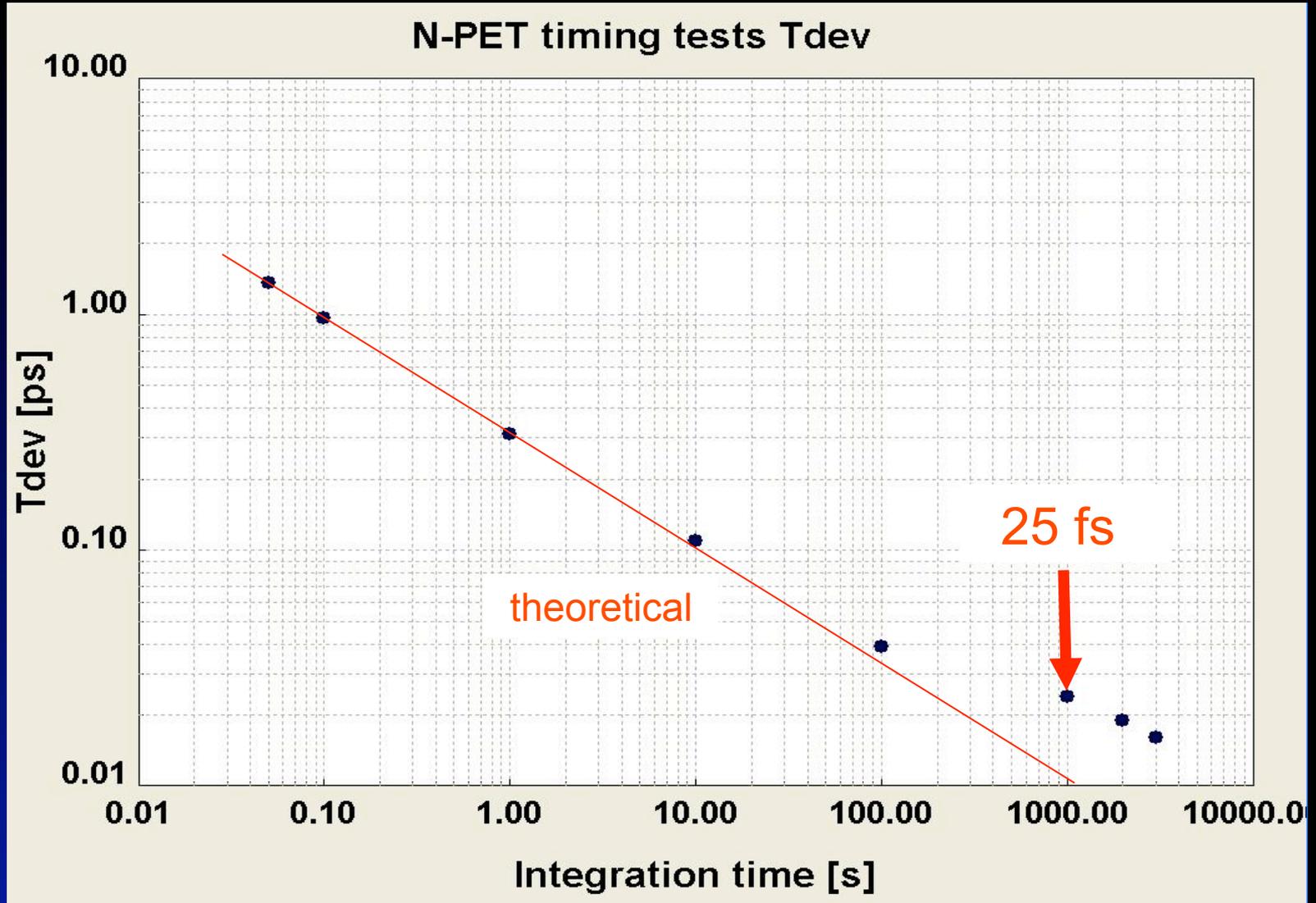
N-PET timing stability - cable delay test



Measurement series No., 300s each, 8 hours / screen

Tdev test

25 Hz repetition rate

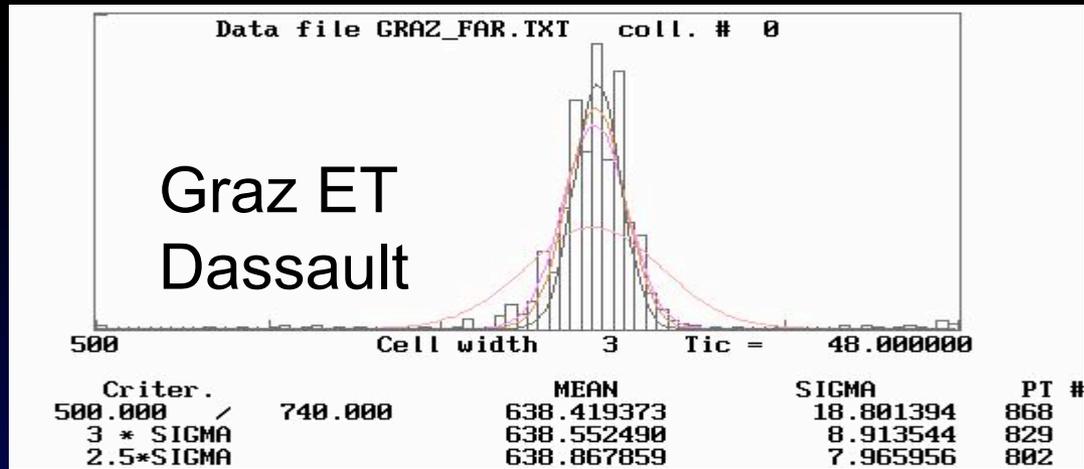


Epoch timing device

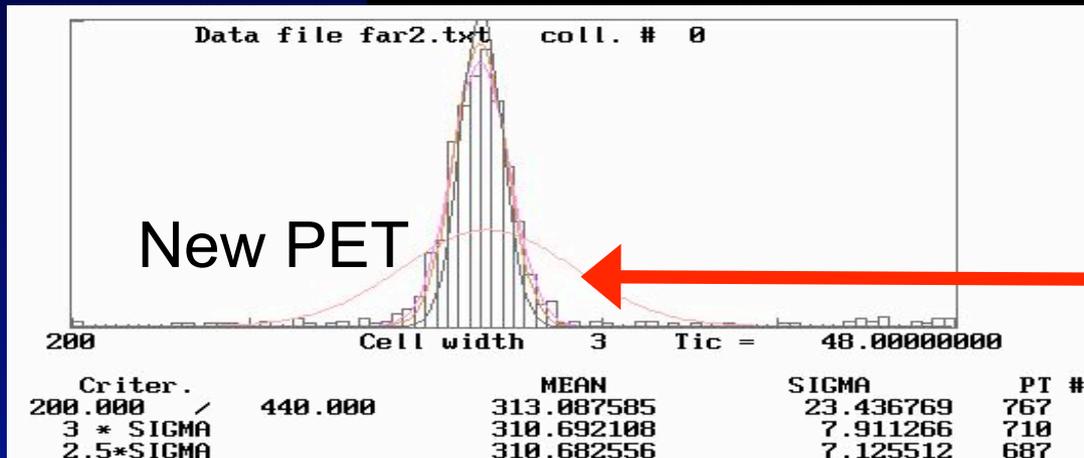


- Epoch timing system, Two independent channels
- Inputs NIM 2 x
clock 200MHz
- Jitter 0.9 ps / ch
- Non-linearity < 0.2 ps
- Stability < +/- 0.1 ps
- Power < 15 Watts
- Interface USB 1
- Dead time 10 us
- Repetition rate 2.5 kHz CW

SLR tests in Graz, 4.3 km ground target



8.0 ps jitter



7.1 ps jitter

Normal distribution (!!)

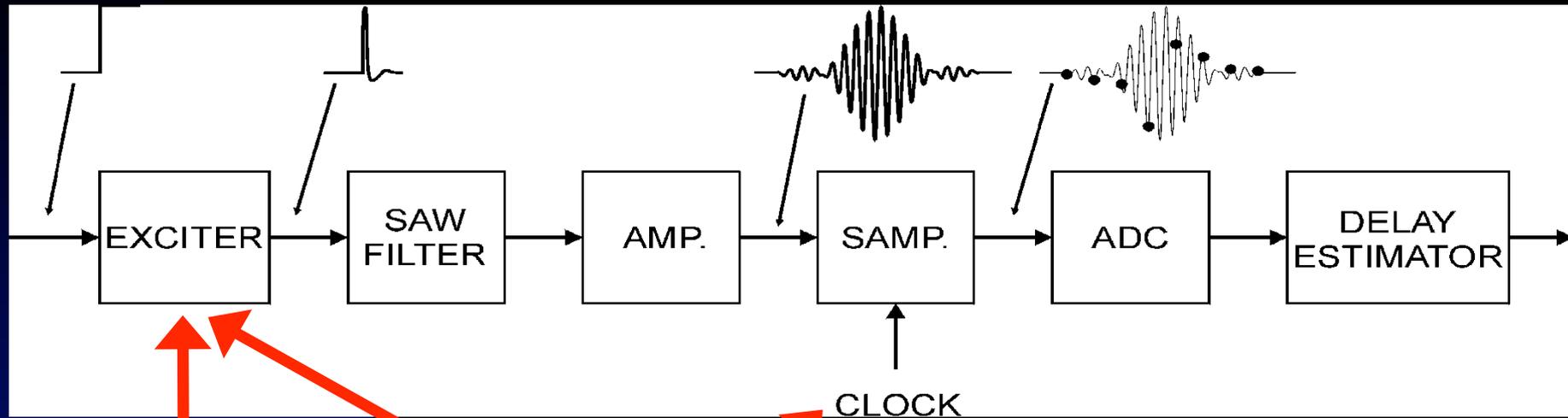
The difference corresponds to 2.5 ps versus 0.9 ps for Dassault and NPET timing jitters

Conclusion

- Sub – picosecond event timing device is existing
- “plug and play” device
- Novel timing principle was verified for the first time
New technologies appreciated
- Extreme stability and linearity of the order of ~ 100 fs
- Self - calibrating no adjustment or calibration needed ever
- Applications: basic metrology, laser time transfer
next generation SLR ...(?)..

Future vision ALL OPTICAL EVENT TIMING

Ulrich Schreiber, Ivan Prochazka, Petr Panek



- Optical detectors are incorporated into the Exciter
- The “laser comb” optical clock used as a reference
- NO cables involved for critical signals !
- All the technology is available
- fs stability and reproducibility 10^{-15} is achievable

