Recent achievements in detector and timing technology for SLR and laser time transfer

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OUTLINE

- START detector
  long term performance in Graz
- SPAD detector package, 1-photon version with low temperature drift
- SPAD with high QE for space debris tracking
- NPET timing system upgrades & Two Way Time Transfer
- Conclusion

New Start detector + discriminator

- fully integrated solution
- minimizes drifts and RF inteferences
- APD + discriminator + output driver + trigger indication + power supply
- ultrafast (9 GHz) components
- Output fall times < 60 ps
- Jitter < 900 fs, 350 fs / K, Tdev < 60 fs

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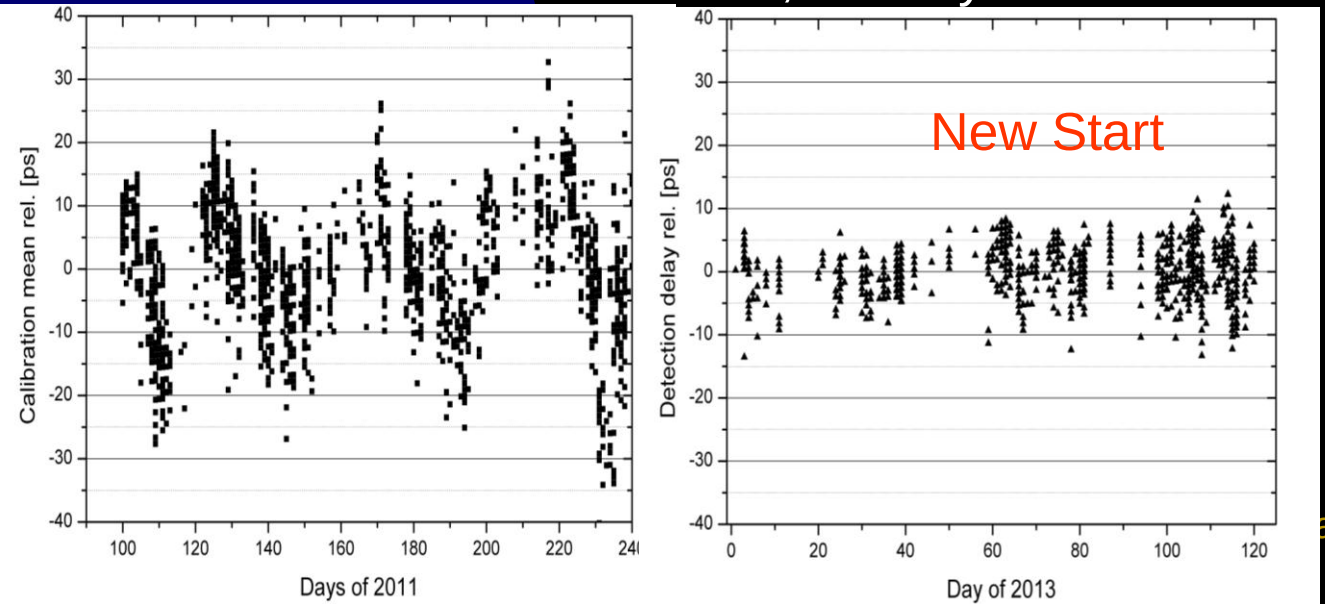
Graz SLR calibration mean,120 days each



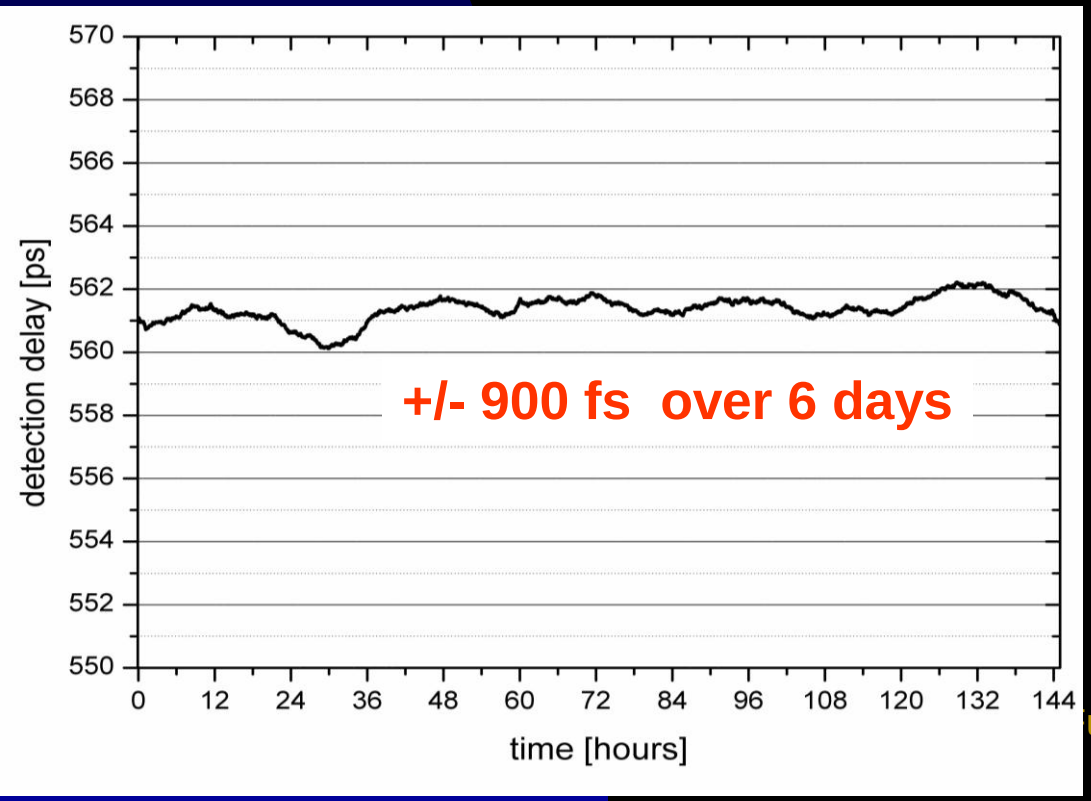
Single shot
16.5 ps =>13.2 ps

Stability
11 ps => 3.8 ps

an, Nov. 2013

SPAD detector package, 1- photon version
Low temperature drift

- SPAD 200 um, TE3, New control electronics,
- High BW and low temp. drift components
- Output NIM fall times ~ 100 ps
- = > jitter < 15 ps
- drift 260 fs / K



New SPAD + Start + NPET detection delay over 6 days,

Tdev 150 fs @ 100 s .. days

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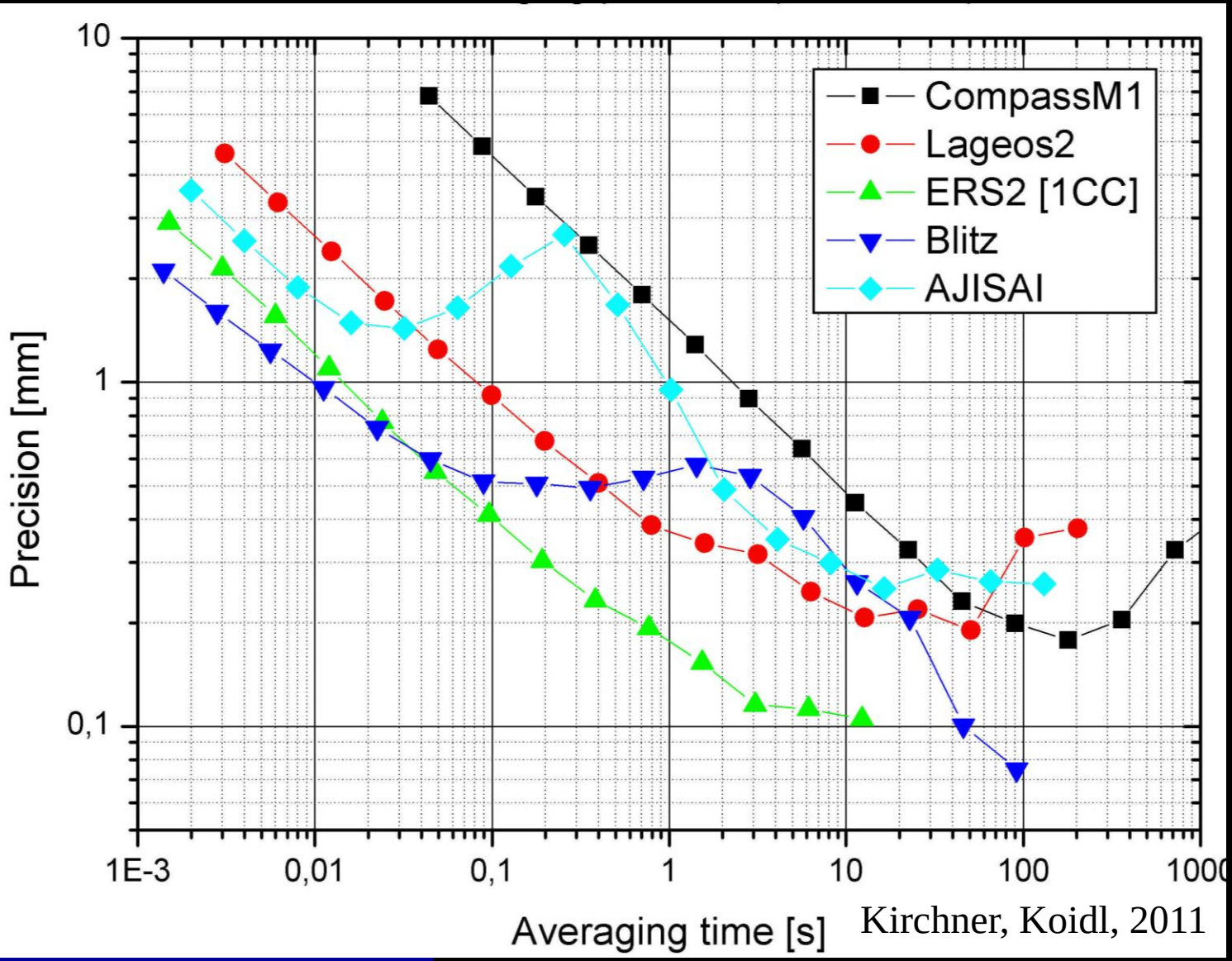
SLR using SPAD, 2kHz, Graz 2011



NPT
< 0.3 mm

All targets

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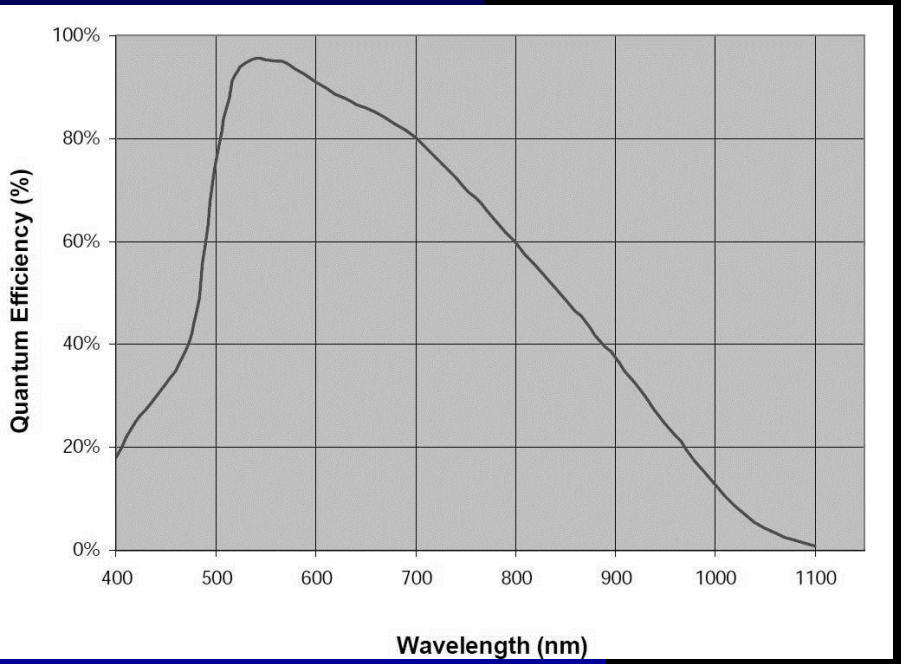
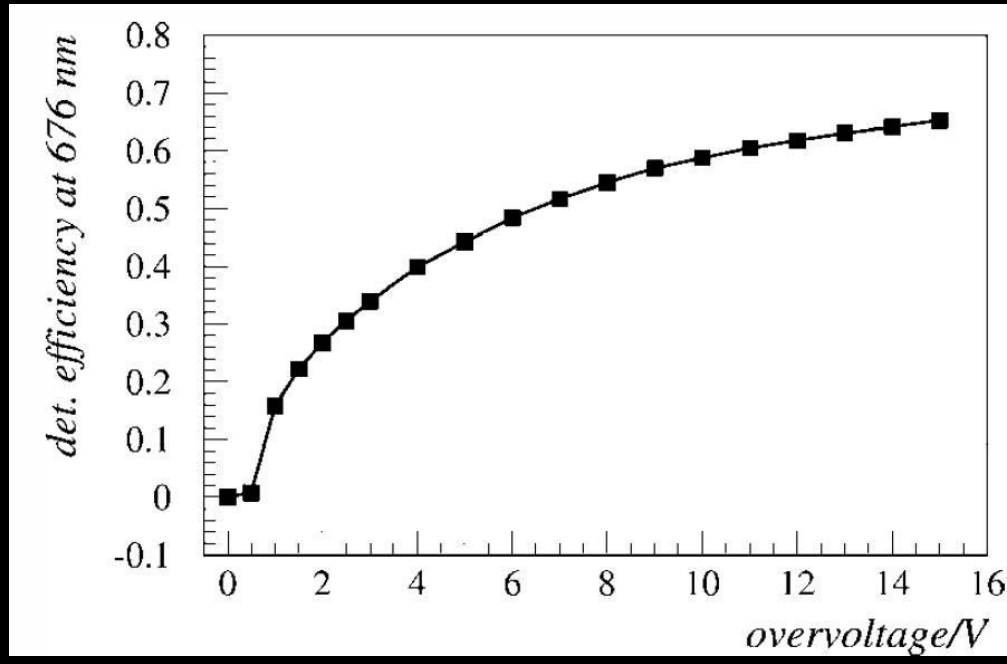
SPAD detector package with high QE for Lunar & space debris tracking

- High Photon Detection Efficiency PDE
- SAP500 detector by Laser Components
- APD on Si, 0.5 mm diameter, ~ 100 V break.
- PDE exceeds 60 % @ 532 nm @ 15V ab (M.Stipcevic, 2011)





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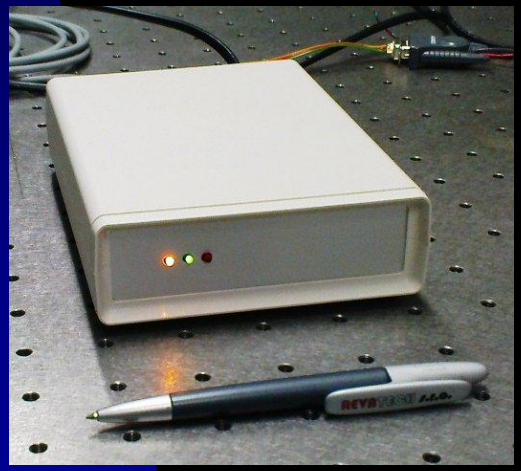
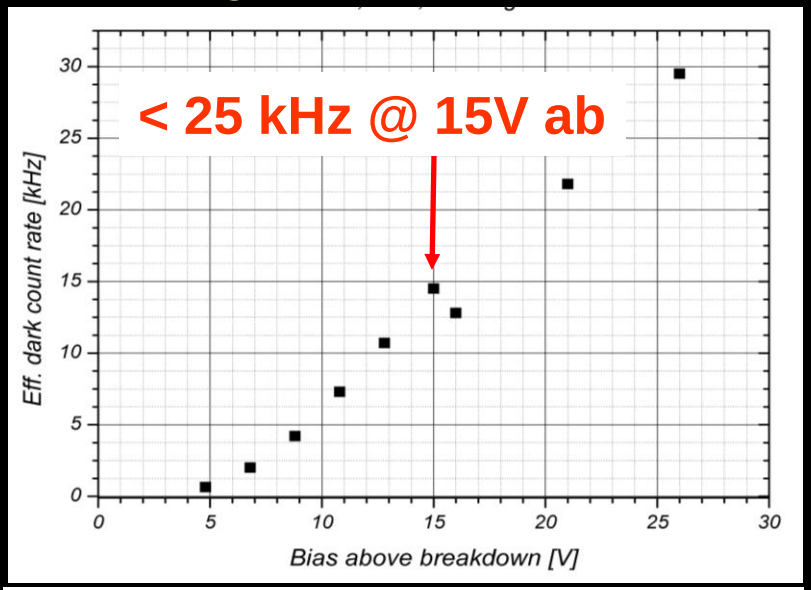
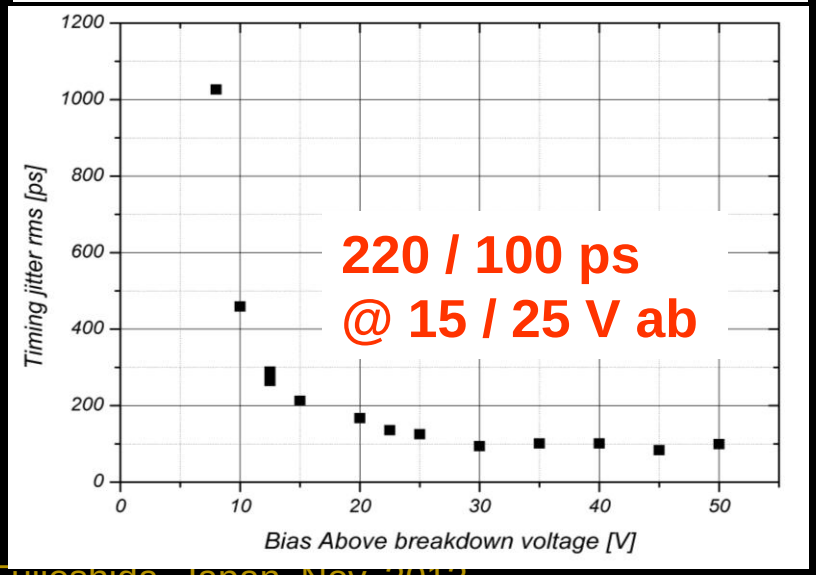
SPAD detector package with high QE
for space debris tracking

- HQE Detector package developed
- Standard SPAD housing & optics
- Single TE cooling to -8°C
- 1 : 1 replaceable to other SPADs mechanics / optics / signal cables







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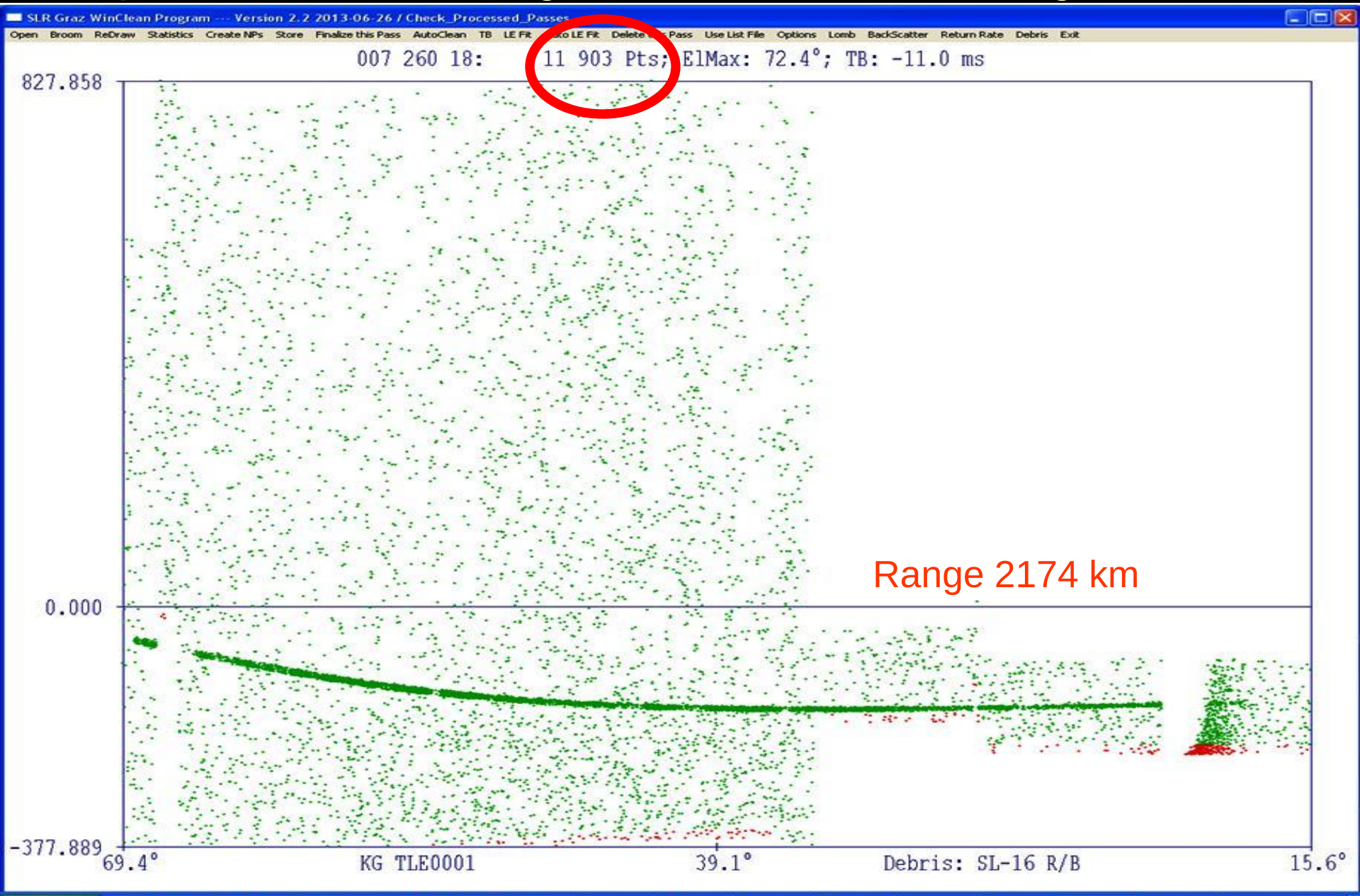
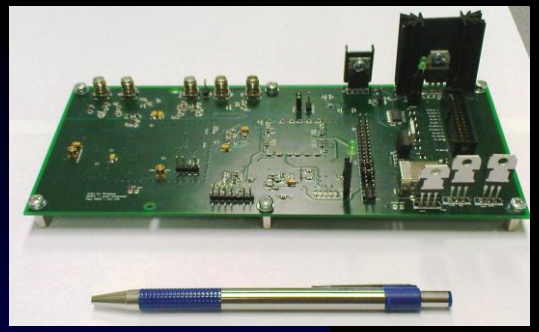
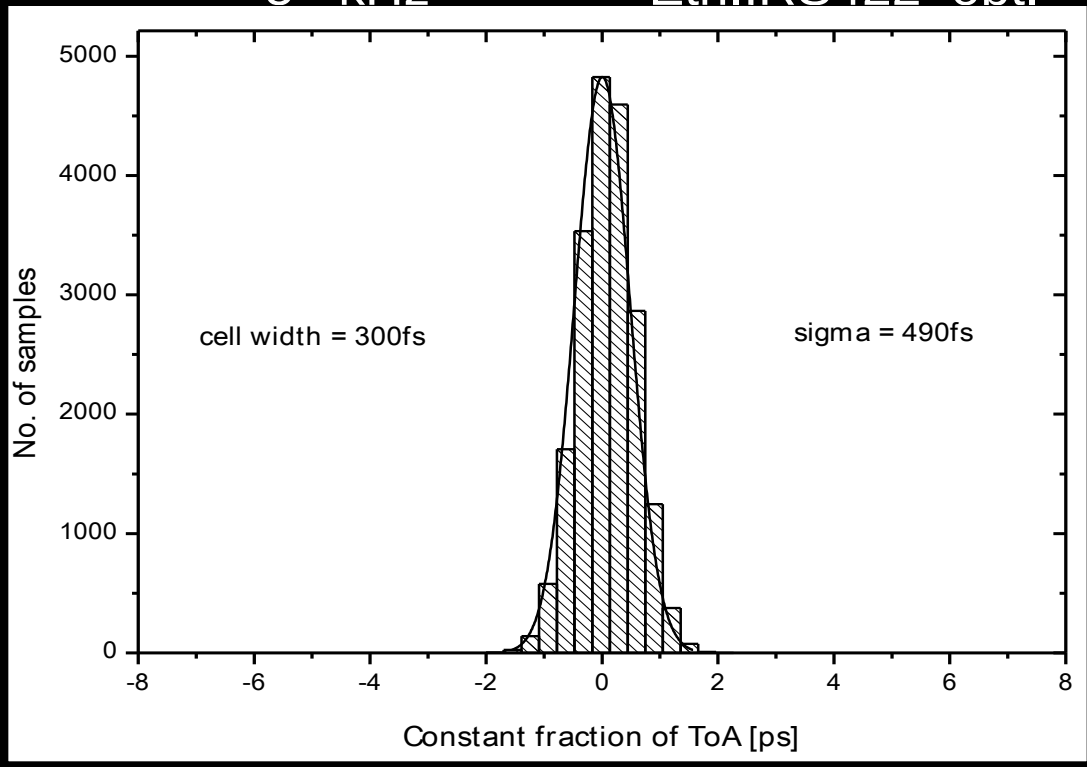
SPAD detector package with high QE
Space debris tracking, G.Kirchner, Graz August 2013



Sub-ps Timing System upgrades



- Compact & robust & user friendly
- On board computation of result (FPGA)
- jitter < 500 fs
- drift -70 fs / K (!!)
- Rates 2.2 kHz RS232
  5 kHz Eth..RS422 opt.



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Two Way Time Transfer via single coaxial cable

Single coaxial cable, variable delay

Time scale #1

Time scale #2

External events

External events

- Comparison of two independent time scales #1 and #2
- Sub-ps precision & few ps accuracy
- TWTT input boards

- Event timing function in parallel to TWTT in the same device

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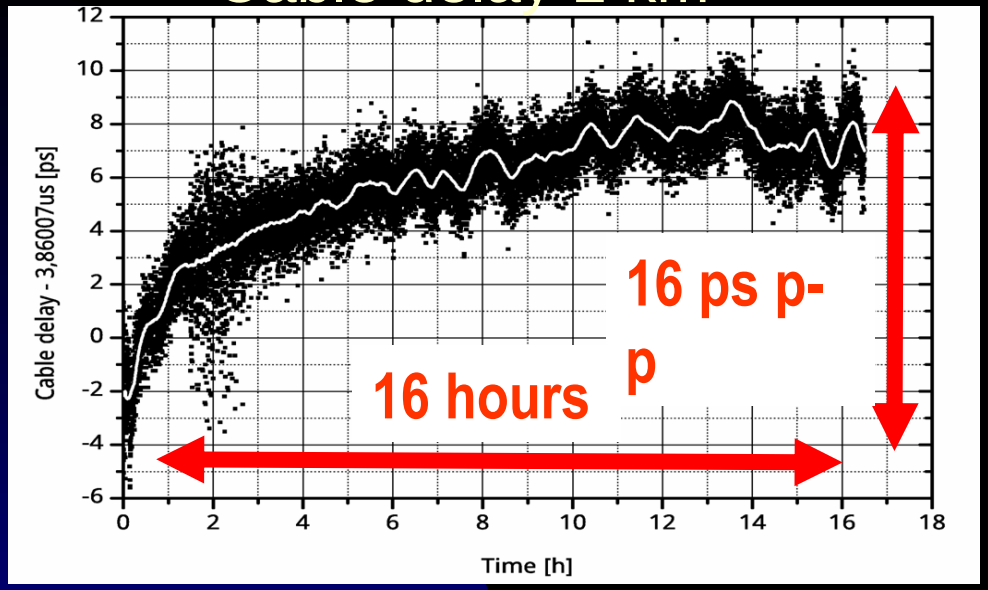
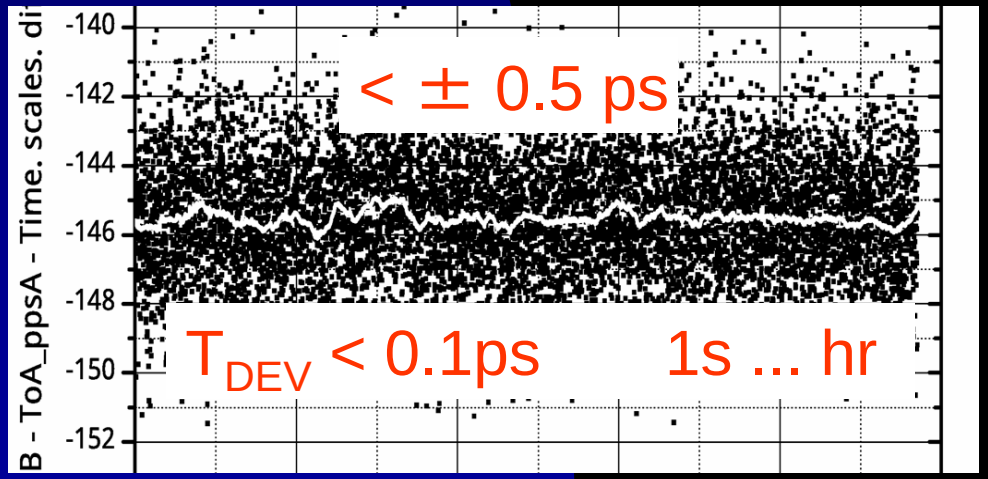
TWTT experiment PTB Braunschweig

Cable delay 1 km



Time scales difference



- Two TWTT timing systems
- Common frequency source
- Time transfer cable loops
  1 m ref.; 1 km, 2 km, 3 km

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Conclusion

- New Start detector improves the long term SLR system stability to a ps level
- Single Photon Avalanche Detector was optimized for long term stability of detection delay
- The SPAD detector with photon detection efficiency exceeding 60% at 532nm was constructed and tested in space debris tracking
- New sub-ps timing system was optimized for SLR and time transfer with kHz rates and fs stability
- Two way time transfer option was built in the timing system and tested at geodetic + SLR site
- Thanks for your attention