Graz: 4 Years of kHz SLR

Advantages

Problems / Solutions

Additional Results

G. Kirchner, F. Koidl, D. Kucharski

a kHz advertisement ☺ ☺ ☺

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# Graz 2-kHz Laser Specs …

- 2 kHz Repetition Rate   => High Data Density;
  => Increased NP accuracy;

- 0.4 mJ / Pulse   => Sending out 0.8 W average Power;

- 10 ps Pulse Width   => about 3 mm „long" pulses;

- Sesam Oscillator / Regenerative Amp / Double Pass Amp:
  => MUCH better Stability etc.

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kHz SLR: Advantages in Accuracy

- Improved Single Shot RMS: Shorter / more uniform pulses
  - Example: GRACE: From ≈ 3.0 mm to ≈ 2.5 mm

- Improved NP RMS: Much higher data density;
  - Each NP: > 100 Single Measurements MINIMUM (Graz)
  - NPs are much better defined with some 10.000 Pts / NP
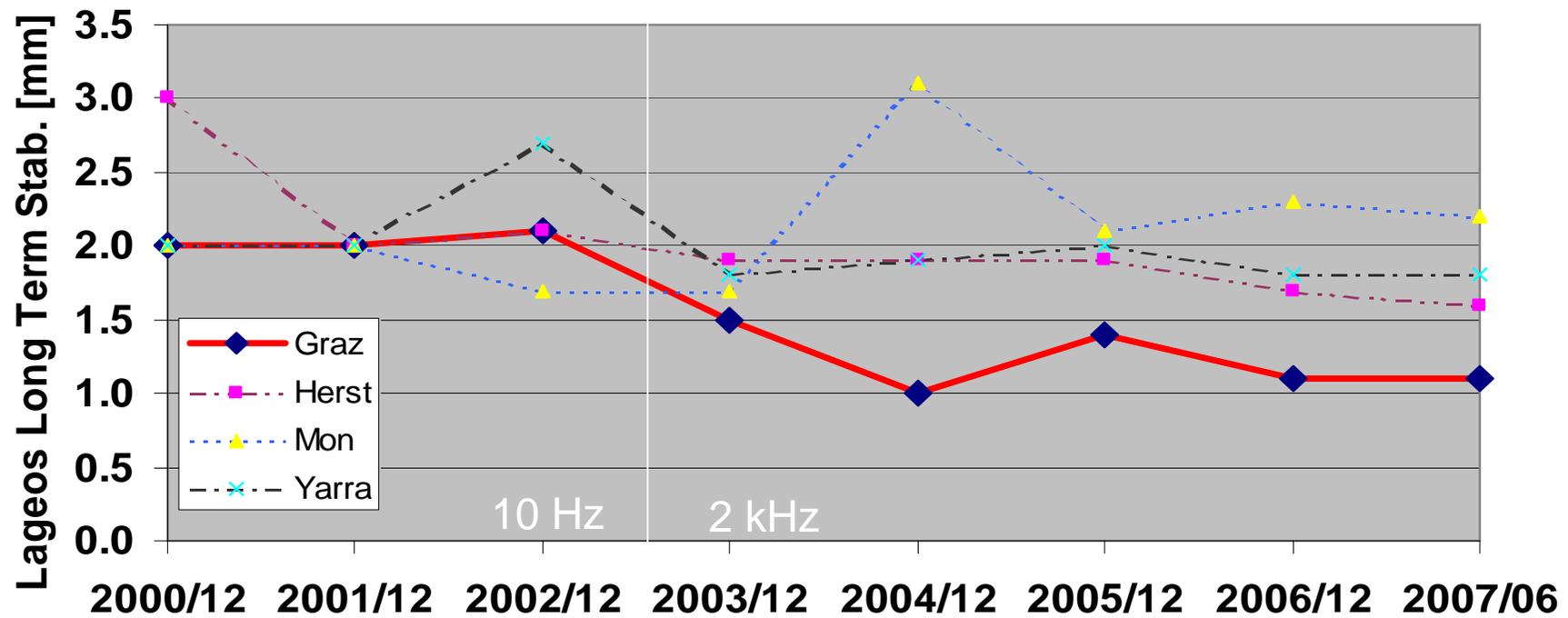
- Effects visible in analysis results:

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kHz SLR: Small Improvement in SS RMS

GRAZ: GRACE 2003-2007: SS RMS:
3.0 mm @ 10 Hz; 2.5 mm @ 2 kHz
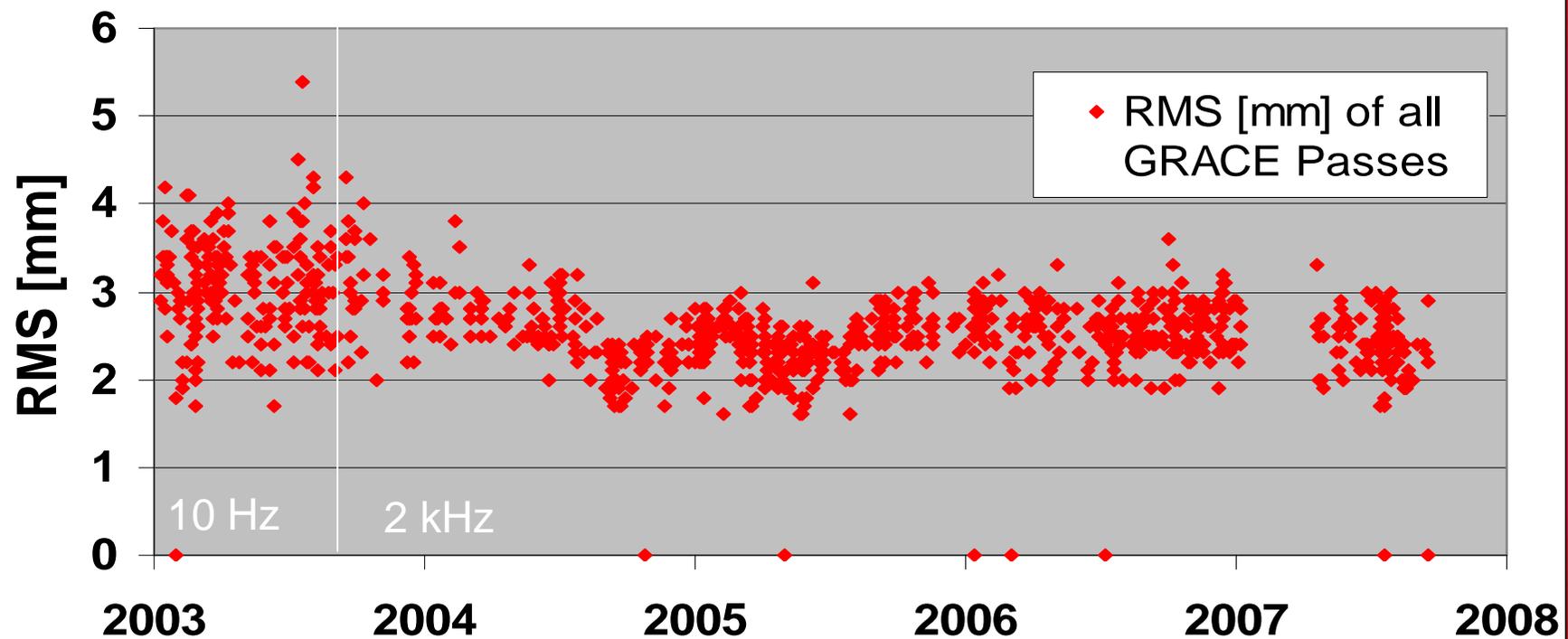
kHz SLR: Low Elevation Pass Example

Example: SLR Graz, at 500 m altitude ...

- CHAMP Pass of 2007-07-15 / Night Time:
  - 11.5°Maximum Elevation;   8.0° - 11.5° - 5.9°
  - About 50 K Returns, within 4 minutes
  - 2.5 mm Single Shot RMS

- Good to study atmosphere, refraction, ...

kHz SLR: Advantages in Stability
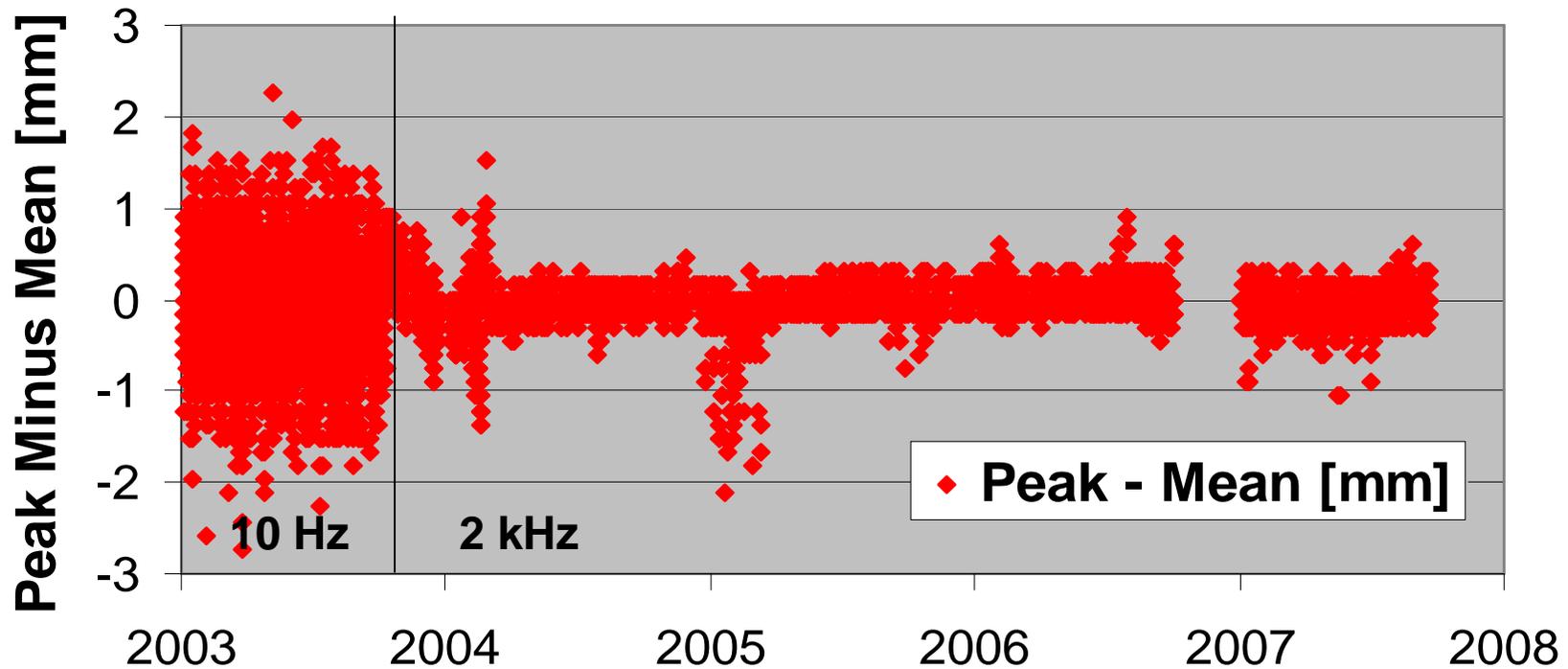
- Diode Pumped Solid State Lasers:
  - ➤ Much better Stability / Repeatability of Laser Pulses
  - ➤ Laser Parameters are much more constant (shot to shot), and for months instead for a few days ....

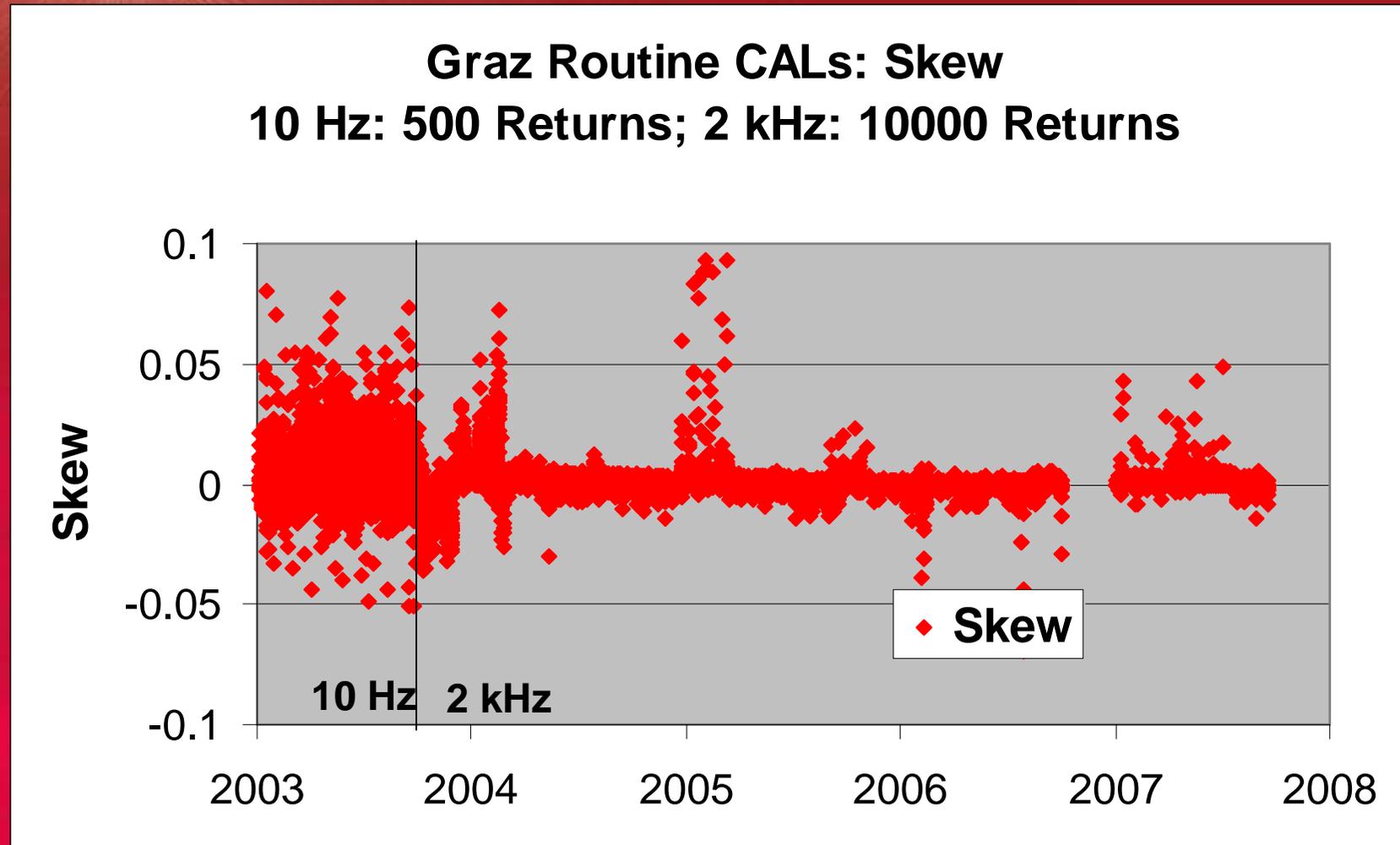- CAL values are much more stable / better defined:
  - ➤ Few ps (= sub-mm) differences between consecutive cals NEEDED for mm accuracy SLR ! ! !
  - ➤ Much better statistical CAL values:
    RMS, Peak minus Mean, Skew etc.

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kHz SLR: Advantages in CAL Stability

Graz Routine CALs: Peak Minus Mean [mm]:
10 Hz: 500 Returns; 2 kHz: 10000 Returns

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kHz SLR: Advantages in CAL Stability

Graz Routine CALs: Skew
10 Hz: 500 Returns; 2 kHz: 10000 Returns

Skew

0.1
0.05
0
-0.05
-0.1

◆ Skew
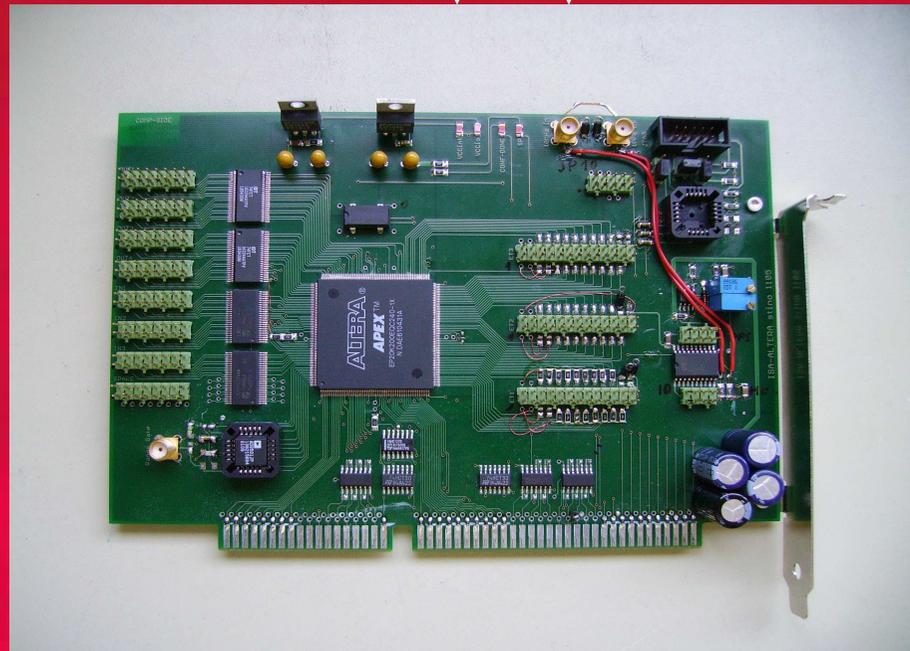
10 Hz   2 kHz

2003   2004   2005   2006   2007   2008

kHz SLR: Advantages in Operation

Faster / Easier Acquisition of Passes

Much less maintenance work ☺ ☺ ☺
- Average in Graz: Once per month short realignments;
- No leakages, no damages, no HF noise
- No flash lamp problems anymore !!!

CHEAPER in operation: After 4 years of EXTENSIVE SLR, we still use the SAME set of Pump Diodes ...

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kHz SLR: Problems / Solutions: Examples:

■ Change from Time Intervall to Event Timing necessary:
  ➢ Easy with Riga ET; fast (some kHz), stable, linear …

■ Programming / Operating Systems: Various Choices:
  ➢ DOS   => Graz; operational;
  ➢ DOS + Linux   => NERC: operational;
  ➢ Windows / LabView   => Potsdam: kHz demonstrated;
  ➢ Others possible   => Shown within this session

■ Range Gate: Needs kHz update rates; a simple solution:
  ➢ Graz FPGA board: 5-ns-Event-Timing now included:
  ➢ Within few µs: Read Event Time, program RG Event Time;
  ➢ Independent of the actually used Event Timer:

Example for Simple RG Generation:

Start Event ——— ps Resolution ———→ RIGA ET; or GRAZ ET; or… ⟷ Windows PC,

Stop Event ————————————————→ Linux, etc…

5 ns Resolution

=> Read Event Time

<= Set Range Gate

(5 ns Resolution)

DOS PC:

Any Compiler

Graz FPGA board: 5 ns E.T. now included

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kHz SLR: Additional Results, By-Products

- kHz Scanning of Satellite Surface => Spin Determination;
- Atmospheric Seeing Measurements along Laser Beam;
- kHz Time Transfer via AJISAI: Work in Progress (Graz);
- kHz LIDAR: Implementing it now in Graz:
  - ➢ SPCM detects backscatter of Laser Beam;
  - ➢ FPGA board counts Photons within 15-m-Bins;
  - ➢ 4096 Bins cover Distance up to 61 km;
  - ➢ Integration of e.g. 200 Shots in each bin: Within 0.1 s @ 2 kHz;
  - ➢ Detects atmospheric layers, clouds, aircraft vapour trails;
- etc. etc. (work in progress ☺)

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kHz SLR: Conclusion after 4 Years

- **More accurate, more stable results ...**
- **Less maintenance work ...**
- **Offers new possibilities, new by-products**

It is the

MOST PROMISING

(if not only) way to mm-SLR ☺

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