Identifying Single Retro Tracks With A 2 kHz SLR System:

Simulations and Actual Results

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San Fernando, June 2004
Most satellites have more than 1 retro;
Most times more than 1 retro is seen;
LAGEOS gives Single Photon-Electrons (max. return rate most times < 15 %)
LEOs usually give Multi-PE, BUT:
  - Big Fluctuations in Return Energy;
  - Always considerable amount of SPEs;
Topex: Retros

- Big ring of retros:
  - Always multiple retros visible;
  - Satellite is stabilized; so:
    - Slow changes of visible retros;

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Topex: Return Pulse Shapes (simulated) and Retros

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Vertical axis: 550 to 1188 mm (two-way);

Laser Pulse: 10 ps, but:

40 ps FWHM assumed to simulate receiver noise;

24° rotation of the satellite about the symmetry axis;
Topex: Graz Data

Fit to ALL Points | Fit to MARKED Points | Y-Limits Min/Max | Sigma Reject | Degree: 11

21.0° TOP01210 28.5° Topex CG 12.3°
428277 Pts; RMS (11p) = 76.3 mm; Time Bias: -5.4 ms; Range Bias: 0.3 m
ERS-2, Envisat: Retros

- Satellites are stabilized;
- Slow changes of visible retros;
- ERS and ENVISAT: Identical arrays
- Always 2 retros visible at least;

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ERS-2, Envisat: Simul. Return Pulse Shapes

Incidence angle: 40°

- Retros; Middle dot is actually 2 retros at same distance;
- Simulated Return Pulse Shape

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Horizontal axis is from 0° to 360° => one full revolution;
We usually see only a fraction of this full revolution;
Vertical axis is from 46 to 119 mm (73 mm);
At the mm-level: CoM correction is NOT CONSTANT !!!

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Envisat: 300 k Returns

~ 1/8 of simulated full revolution (as in previous image)

2nd Track: shows max. offset of up to ~ 2 cm

For NP generation: 2nd track returns omitted

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LAGEOS

Lageos 1:
- VERY slow rotation only;
- Slow changes of retro visibility;
- Allows detection of tracks of different retro clusters;

Lageos 2:
- Rotates significantly faster;
- Not easy to detect tracks of single retros or retro clusters

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LAGEOS: Retro Visibility, Sim. Return Pulse Shapes

- Retros;
- Simulated Return Pulse Shape

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LAG-1: Simul. Return Signal

- 90° angle with spin axis
- 30° angle with spin axis
- 0° angle with spin axis

Horizontal: 1 complete revolution (360°)
Vertical: 280 to 550 mm (two-way).

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Lageos 1: Multiple tracks

- Lageos-1 Pass
- Night time
- ~ 500 k Returns
- Slow rotation
- ~ 160 mm vertical
- Several tracks
- NP: Track 1 only
- 400 k remaining

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Other Satellites: GFO

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Other Satellites: Jason-1

<table>
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<tr>
<th>Fit to ALL Points</th>
<th>Fit to MARKED Points</th>
<th>Y-Limits Min/Max</th>
<th>Sigma Reject</th>
<th>Degree: 8</th>
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0.062 in

19.5° JA101417
37.6° Jason1 KG 45.0°
53663 Pts; RMS (8p) = 13.3 mm; Time Bias: -1.9 ms; Range Bias: 4.6 m

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Even Stella shows it ...
Conclusions

The Graz 2 kHz SLR system resolves:
- single retro tracks;
- and / or tracks of retro clusters on most satellites;
- Exceptions: LaRetC, Champ (?), Panels only on Glonass sats;
- Lageos: Single PE returns only, due to low energy (400 mJ/shot);
- LEOs: Multi-PEs, but also significant fraction of SPEs;
- NP Generation: Secondary tracks omitted, only nearest retro used;
- Consequence for CoM corrections at mm-level:
  - Even with secondary tracks removed:
    - CoM correction: NOT ALWAYS CONSTANT!
  - For stabilized satellites: Chance to increase SLR accuracy!

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Be aware …

… of these things also in YOUR system:

- With kHz  =>  We now can show it;
- With 10 Hz  =>  You just don’t know it ….