Millimeter Ranging to Centimeter Targets

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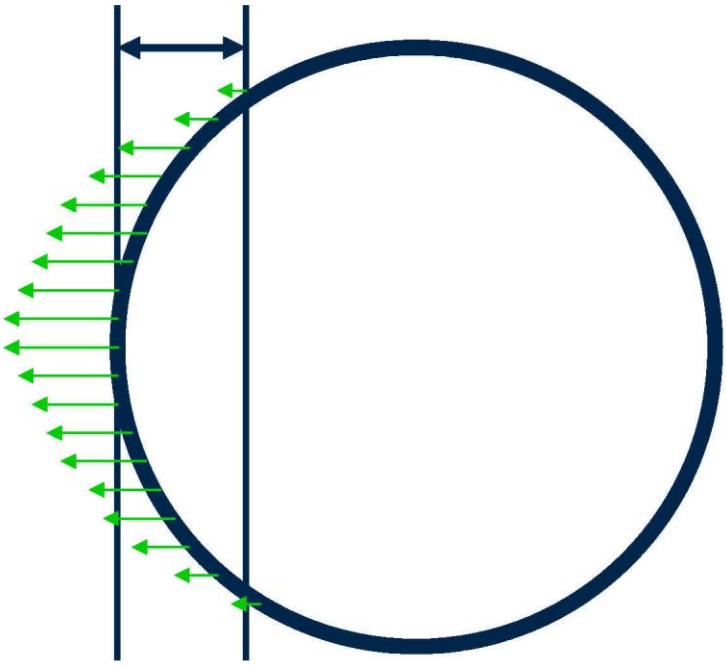
Abstract

Spherical satellites like LAGEOS-l, LAGEOS-2 or AnSAI introduce a significant satellite signature (> 300 mm for AnSAI, > 80 mm for LAGEOS) into SLR data, if the return signal cannot be kept at a constant level (which is difficult to achieve due to fast pointing fluctuations etc.). These variations cause a significant scatter of the NPs around any assumed mean reflection point.

kHz SLR however allows - due to its inherent data density - an easy and accurate determination of the "leading edge" (LE) of returns (those returns coming from the nearest retros). Using this LE as a reference line, and accepting only returns between LE and LE + 20 mm, the scatter of NPs is reduced from several em to less than 1 mm.



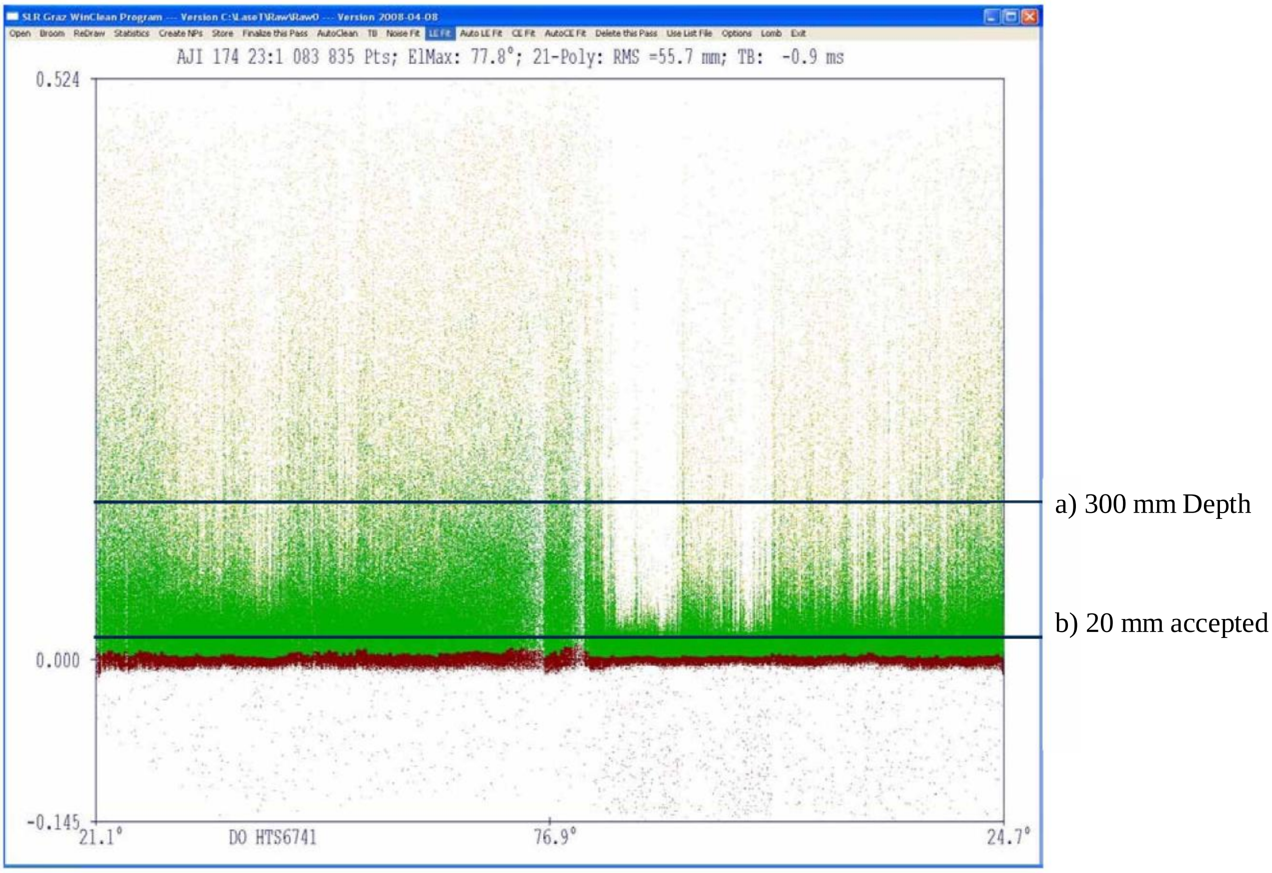
The Problem

The "reflective depth" of spherical satellites is up to 80 mm for LAGEOS, and up to 300 mm for AnSAI. This introduces a corresponding scatter of returns, potentially reducing the precision of SLR measurements.

One possible way to get better precision from such targets is to restrict return energy to single photons only; however, this requires a strict reduction of return rates (below the quantum efficiency of the detector) - which in tum requires additional hardware (ND filters), software (to keep returns rates within limits during ranging), observer training etc. However, this will reduce also significantly the number of returns per pass - loosing a major advantage of kHz systems - while still resulting in a certain amount of multi-photon returns within this SPE data set.

A possible solution

With the Graz 2 kHz SLR system, we are NOT controlling or limiting return signal energy; our observers are instructed only to achieve the maximum possible number of returns for each pass and each satellite. This results in a large amount of returns per pass (can be more than 1 million returns per pass for AnSAI and LAGEOS), but also produces large variations of data density, mean reflection points etc.; using such data sets to form Normal Points creates large scatter within the "reflective" depth of these satellites.



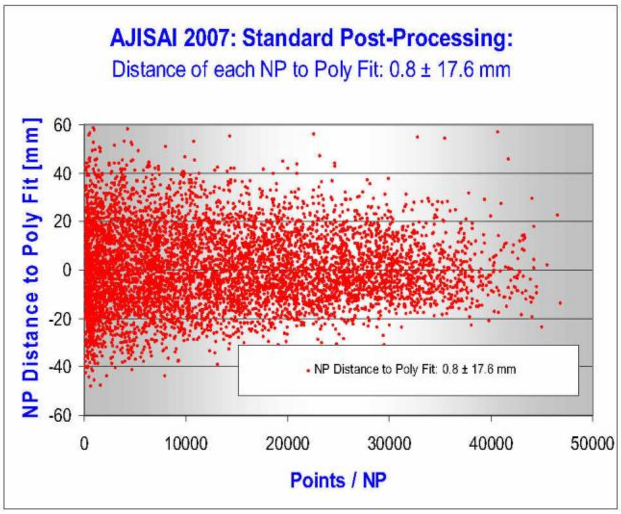
To use the inherent accuracy of our kHz system, but still keeping the operational simplicity and the high return rates, we are using now the "Leading Edge" (LE) of the returns as a reference line, and accept only returns from the first 20 mm reflective depth during post processing. Returns from behind this 20 mm limit are rejected. Although this method reduces the total amount of accepted returns (average reduction: about 30%), it offers significant improvements:

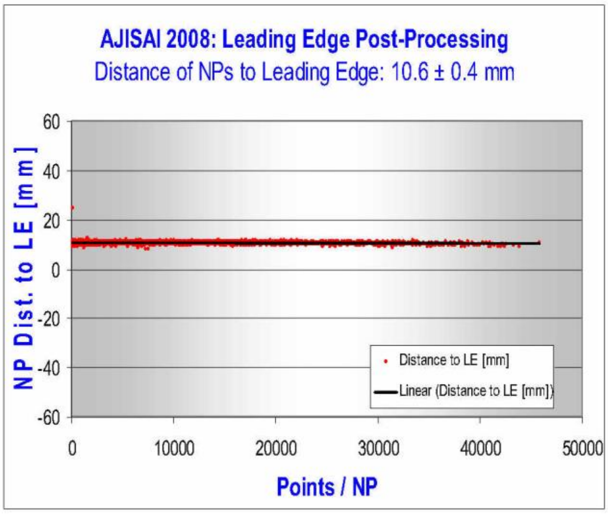
- Simple operation of the kHz system: Just try to get as many returns as possible ©
- ALL returns are accepted during tracking; no ND filters, no return rate reduction for SPE etc.
- Clearly visible "Leading Edge" line; used as reference line (e.g. for polynomial fits)
- 20 mm limit: Thus ALL NPs are located at a constant 10 mm distance from LE
- ALL NPs therefore need the same - CONSTANT - CoM correction;
- NP scatter is now significantly reduced: From ± 17 mm to ± 0.4 mm (AJISAI)

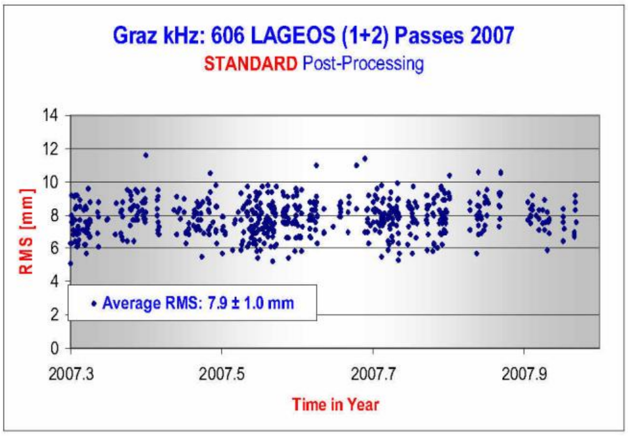
This method can be applied in principal for all spherical satellites; however, there are restrictions when using LE for post processing of other spherical satellites:

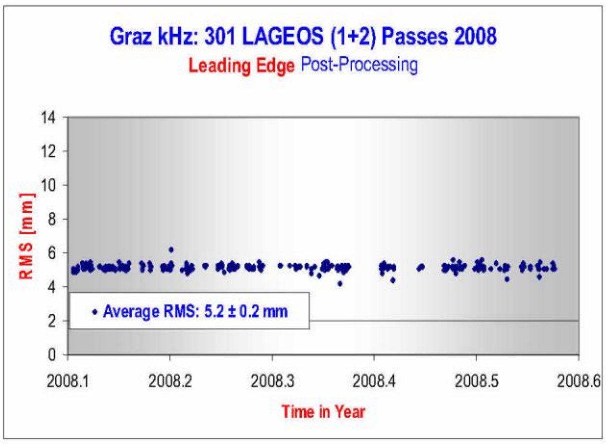
- Etalon: LE is applied, however there is no depth limit set (because anyway inherently SPE returns)
- Starlette / Stella: LE not applicable; although the satellites are now synchronized (no inertial spin), we still see the apparent spin; this causes bigger variations of nearest retro distances, and would affect NP positions if LE is applied.

With standard post processing (AJISAI, 2007, Graz), the NPs show large scattering of ± 17.6 mm due to big variations in data density. Since day 065 / 2008, we changed to "Leading Edge" post processing: All NPs are now at 10.6 mm ± 0.4 mm from LE.

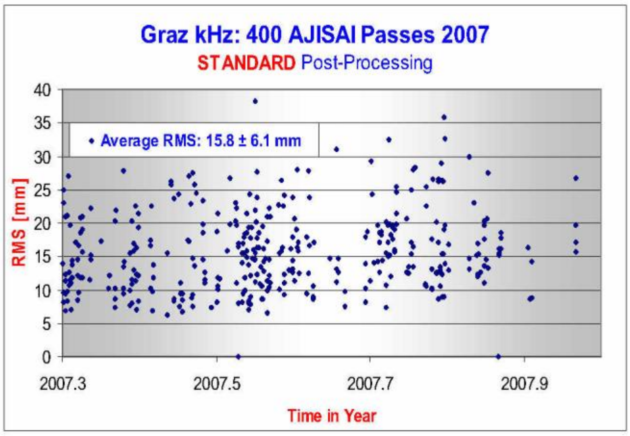


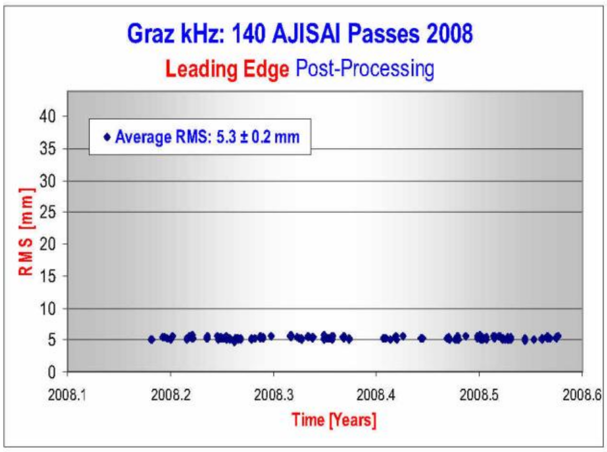






Similar effects can be seen for the resulting pass RMS: Large scattering of 15.8 ± 6.1 mm has been reduced now with the LE method to 5.3 ± 0.2 mm for AJISAI.





For LAGEOS, the LE has the same effects; shown here is the reduction of the pass RMS; from 7.9 ± 1.0 mm with standard post processing, to 5.2 mm ± 0.2 mm for the LE method.