LAGEOS-2
Polarization, Pulse length, Signal strength, and detection system

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10. Summary

1. Average centroid range correction matrices.

The average centroid range correction matrix has good circular symmetry for circular polarization. The pattern for linear polarization is aligned with the polarization vector.
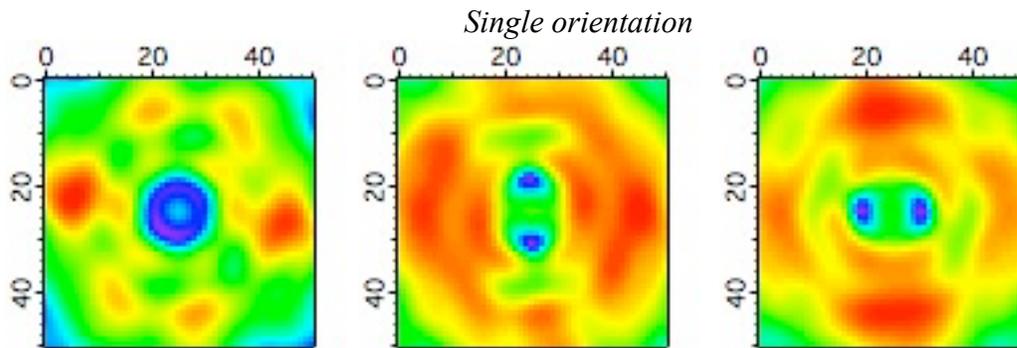
Single orientation

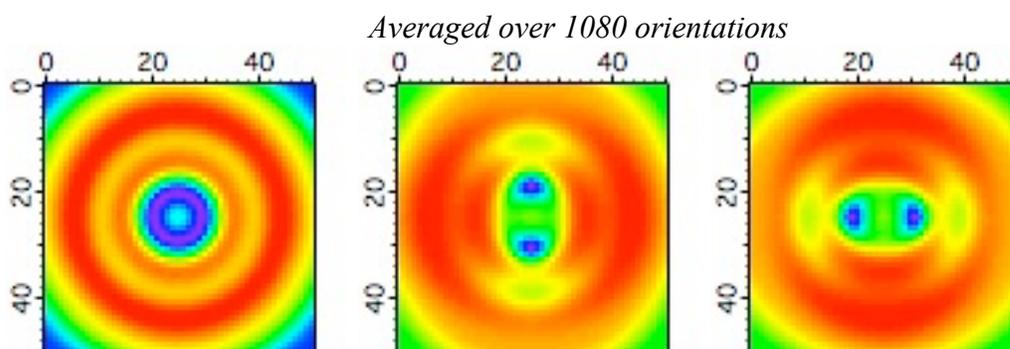| Fig 1(a) Circular | Fig 1(b) Horizontal | Fig 1(c) Vertical |

Averaged over 1080 orientations

| Fig 1(d) Circular | Fig 1(e) Horizontal | Fig 1(f) Vertical |

Figure 1. Centroid range correction at a single orientation and averaged over 1080 orientations for circular, horizontal, and vertical polarization. Red is larger values of range correction. The analyses in this report are average values over 1080 orientations.
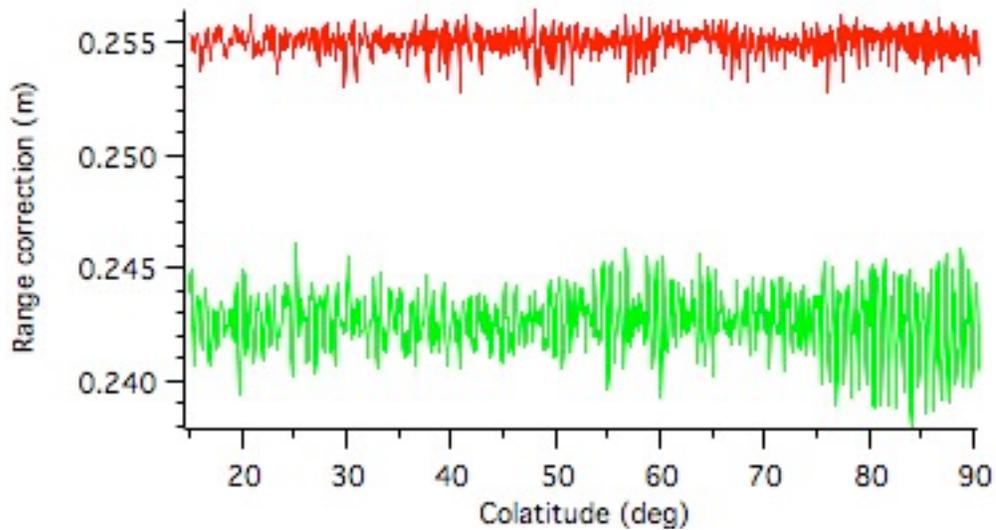
2. Range correction vs incidence angle

Figure 2. 1/4 max (red) and centroid (green) vs Colatitude (deg) for circular polarization. Simulations were done over 1080 incidence angles from colatitude (phi) = 15 to 90 deg. Spacing between points is Dtheta = 5 deg, Dphi = .07 deg. The transmitted pulse length is .030 ns. The simulations use phase index n = 1.461 and group index n = 1.484.

Quantity	Minimum	Maximum	Max-Min	Average	r.m.s.
centroid	0.238000	0.246070	0.008070	0.242660	0.001302
1/4 max	0.252870	0.256470	0.003600	0.255038	0.000529

Table 2. Statistics for the data plotted in Figure 2.

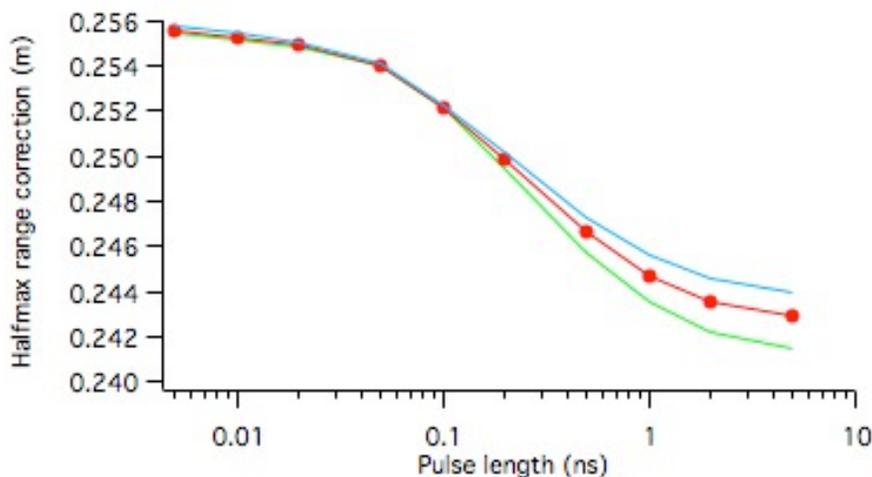## 3. Asymmetry of the range correction with linear polarization.

Figure 3.1. Halfmax range correction vs pulse length. The curves are the average (red), minimum (green) and maximum (blue) around a circle at radius 36 microradians. The data is averaged over 1080 orientations. The asymmetry is the blue minus the green.
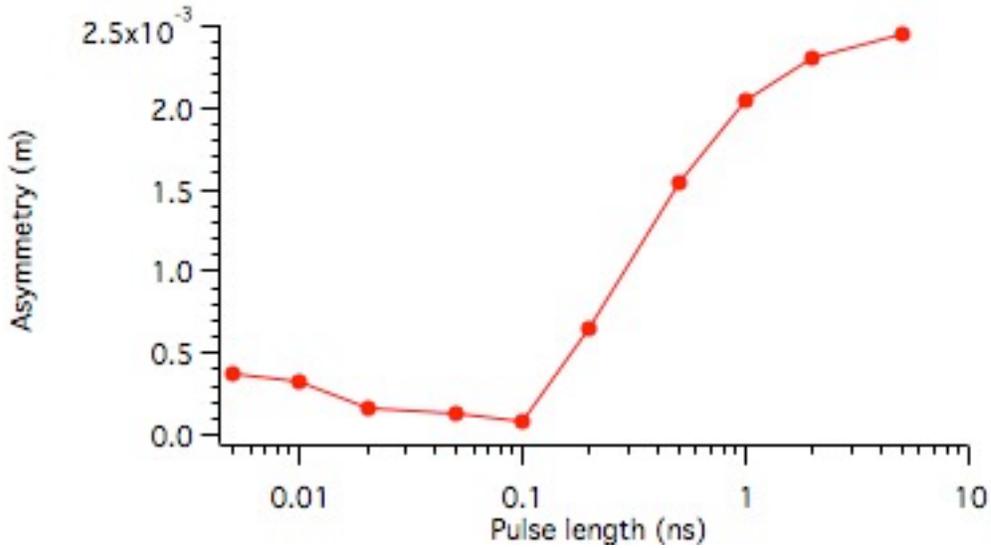

Figure 3.2. Asymmetry of the halfmax range correction (m) vs pulse length (ns).

4. Symmetry of the range correction with circular polarization

Circular polarization removes the asymmetry in the range correction.
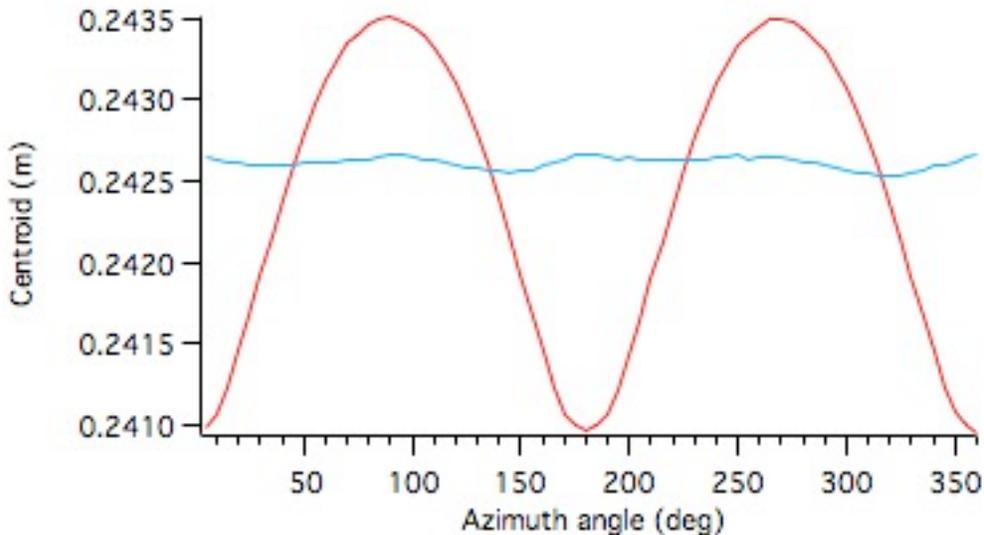

Figure 4. Centroid range correction for circular (blue) and linear vertical polarization (red) vs azimuth angle around a circle in the far field at velocity aberration 36 microradians. Figures 1(d) and 1(f) show the whole pattern.

5. Range correction vs pulse length
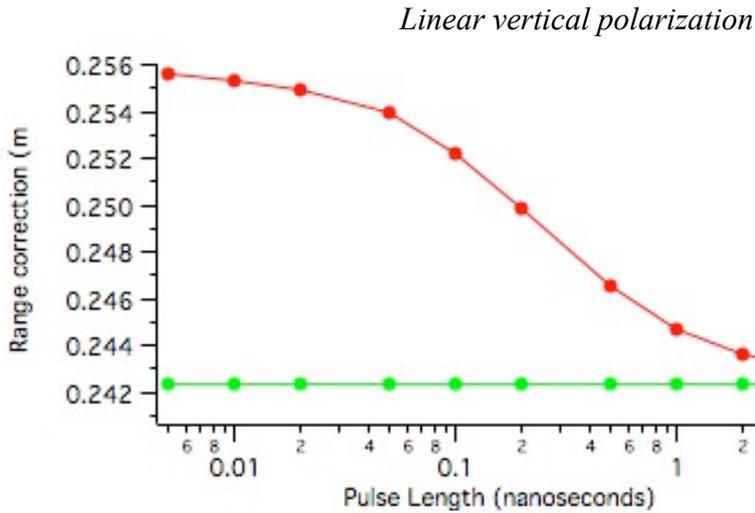
Linear vertical polarization

Figure 5. Halfmax range correction (red) and centroid (green) vs transmitted pulse length for linear vertical polarization. The data is averaged over 1080 orientations and around a circle of radius 36 microradians in the far field.

6. Range correction vs number of photoelectrons.

The rise time of the detector has been defined as the difference between the 10% and 90% points on the leading edge of a Gaussian pulse shape. The rise time = 1.6869224σ
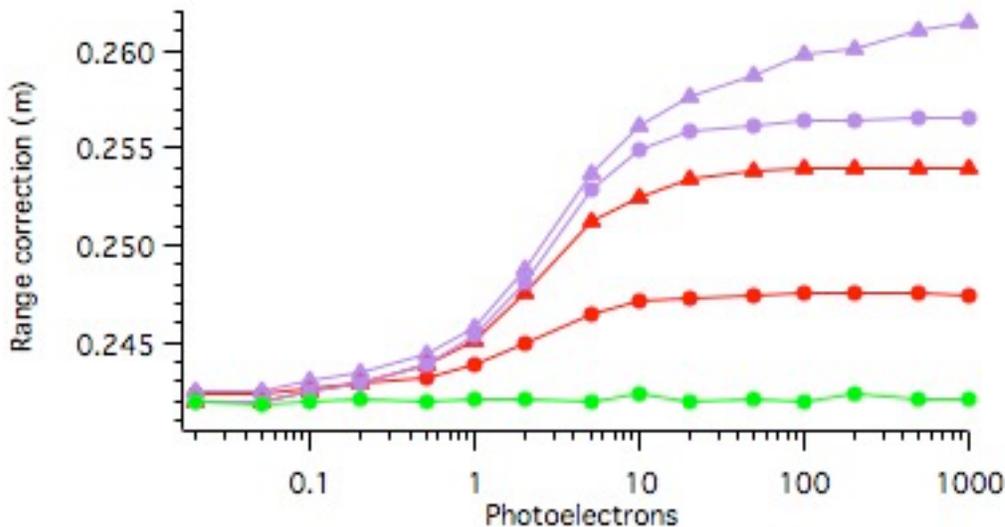

Figure 6.1. Centroid (green), HalfMax 0.300 ns rise time (red circles); .030 ns rise time (red triangles), first photoelectron (purple circles are zero ns transmitted pulse; purple triangles are 0.030 ns transmitted pulse). The calculation use a histogram averaged over 1080 incidence angles with incident pulse length 0.030 ns.
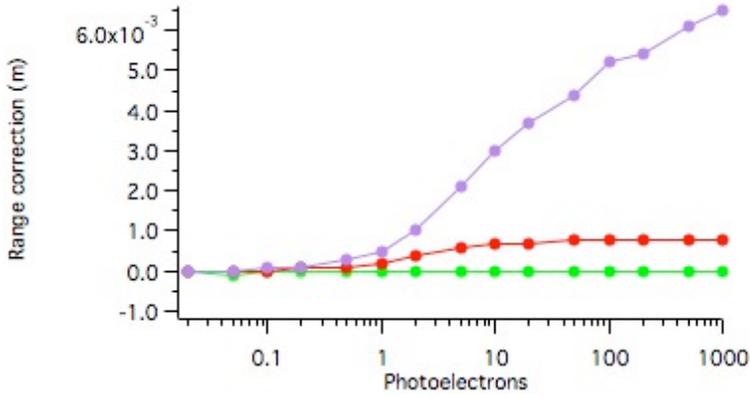
7. Target calibration

Figure 7.1. Target calibration (point reflector) with transmitted pulse length 0.030 ns and receiver rise time 0.030 ns, centroid (green), halfmax (red), first photoelectrons (purple).
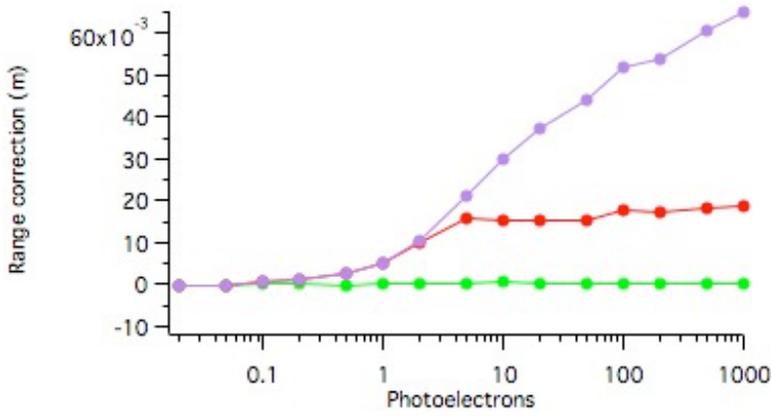

Figure 7.2. Target calibration with transmitted pulse length 0.300 ns and receiver rise time 0.030 ns, centroid (green), halfmax (red), first photoelectrons (purple).

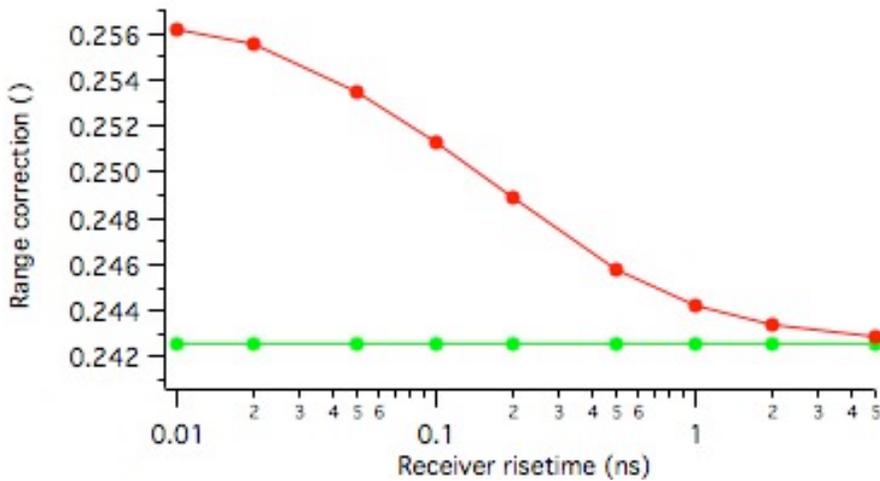## 8. Range correction vs receiver rise time

Figure 8. HalfMax range correction (red) and centroid (green) vs receiver rise time. The pulse shape is computed from a histogram with transmitted pulse width 0.030 ns. The average number of photoelectrons is 500.

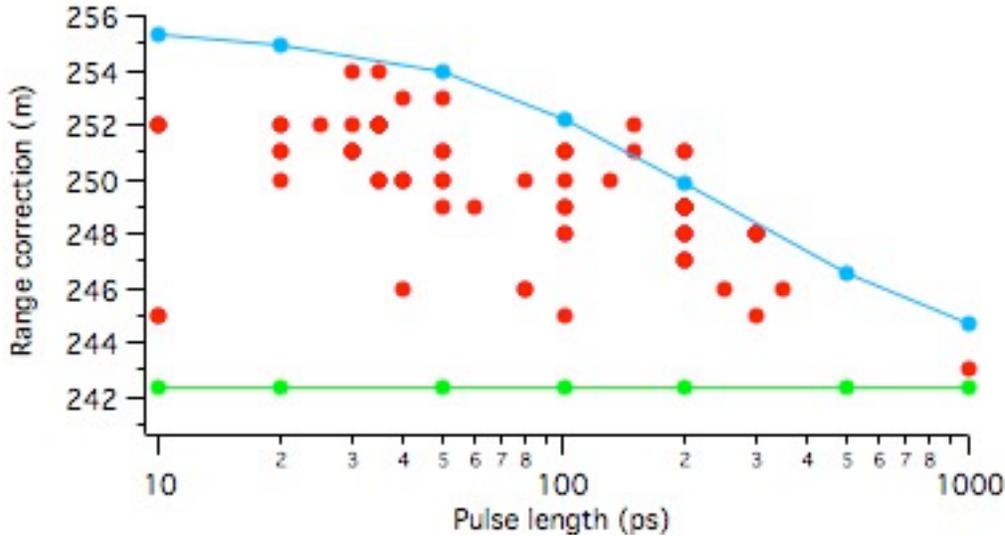## 9. Comparison with range corrections computed for each station.

Figure 9. Blue is half max range correction vs pulse length. Green is the centroid The red dots are the mean range corrections computed for the stations listed on the website below. Each red dot may represent many overlapping points.
http://ilrs.dgfi.tum.de/data_handling/com_lageos.txt .

10. Summary

The range correction for linear polarization depends on the angle between the transmitted polarization and the velocity aberration. The asymmetry can be removed by using circular polarization.

The range correction for multi-photoelectron systems depends on transmitted pulse length, signal strength, receiver rise time, and type of detection system (centroid, halfmax, or first photoelectron). The half max range correction reaches a plateau at around 10 or 20 photoelectrons. The leading edge of the return pulse is not sharply defined unless the incident pulse is very short. The position of the first photoelectron keeps increasing with signal strength for long pulse lengths. The range correction can be made independent of system parameters by using single photoelectron returns.

The target calibration is a function of signal strength. The halfmax range correction reaches a plateau. However, the position of the first photoelectron keeps moving further from the center of the satellite as the pulse length increases.

The mean range corrections determined using actual ranging data for the stations plotted in Figure 9 lie approximately between the range correction for halfmax (blue) and the centroid (green). This scatter appears to be the result of the dependence of the range correction on pulse length, signal strength, receiver rise time, and method of detection.