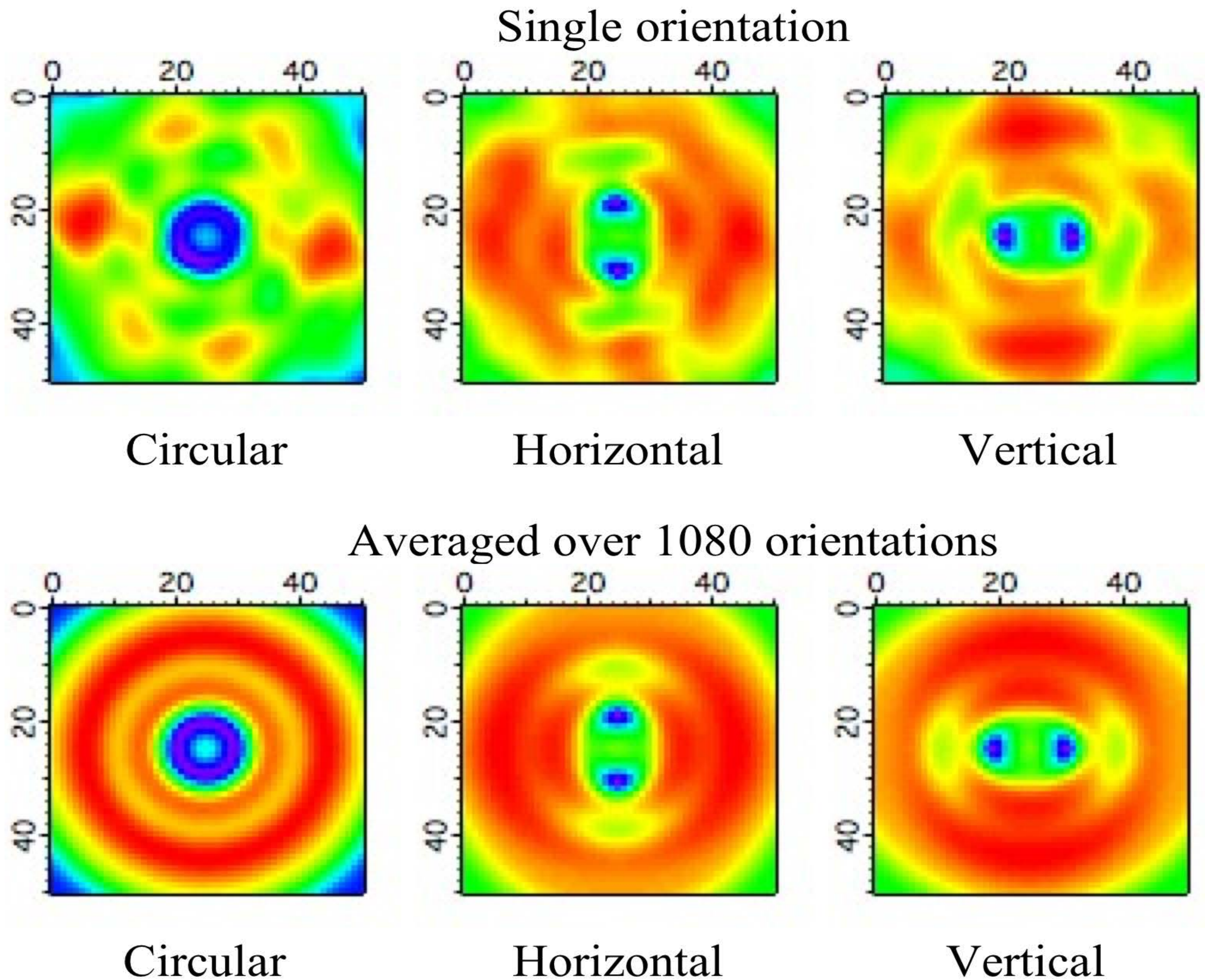
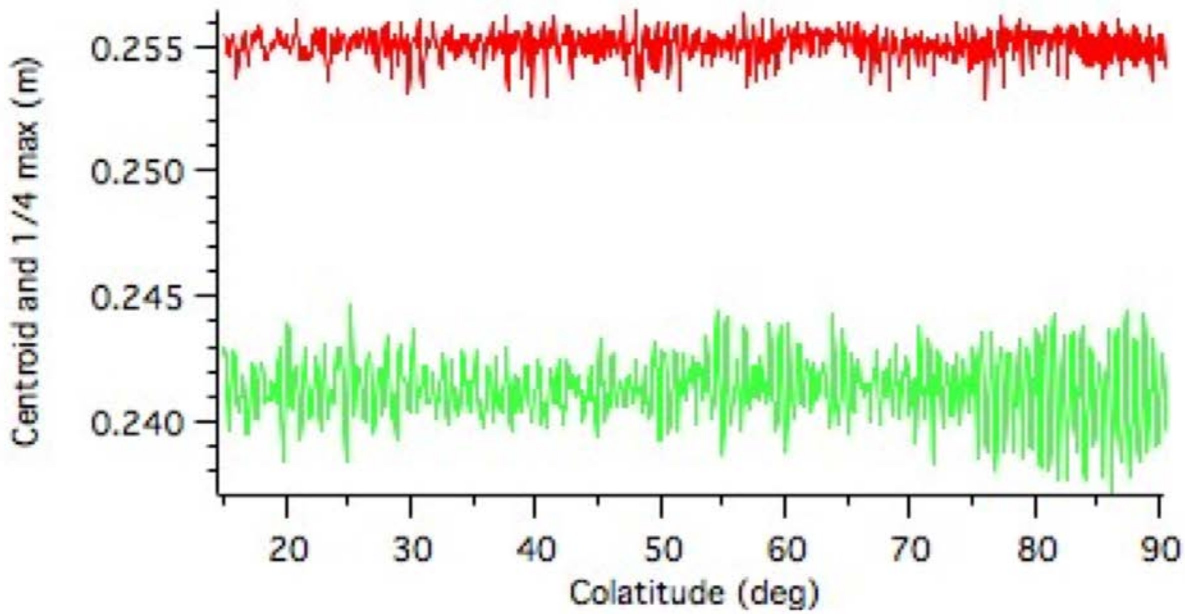
Lageos-2
Polarization Asymmetry
David Arnold

- Design goal for LAGEOS was 5 mm. Current goal is 1 mm.
- Polarization asymmetry is 2-3 mm with linear polarization
- Single photoelectron systems sensitive to polarization effects
- Asymmetry can be removed by using circular polarization
- Asymmetry depends on transmitted pulse length in constant fraction discriminator systems.
- Photon quantization can cause range changes in multi-photon systems.

Centroid range correction matrix



Range correction vs incidence angle
Pulse length .030 ns



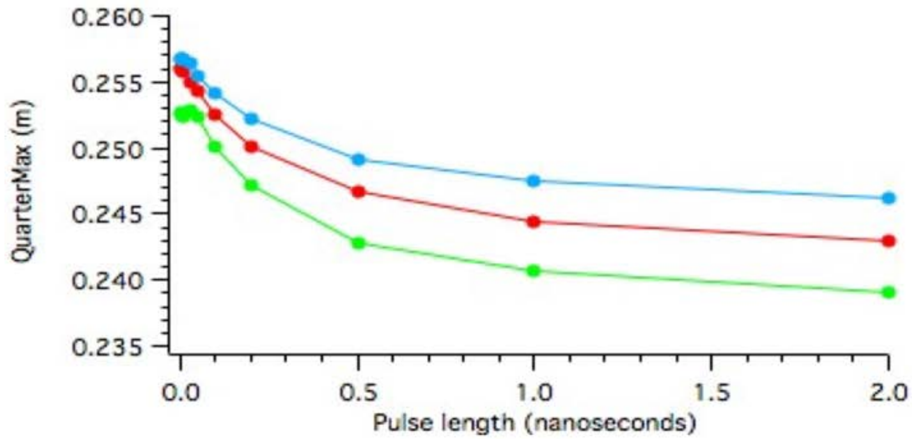
Red = 1/4 max, Green = centroid

Quantity	Min	Max	Max-Min	Average	r.m.s.
centroid	0.2371	0.2446	0.0075	0.2413	0.0012
1/4 max	0.2529	0.2564	0.0035	0.2550	0.0005
Crossec	13.267	19.957	6.690	16.431	1.3178

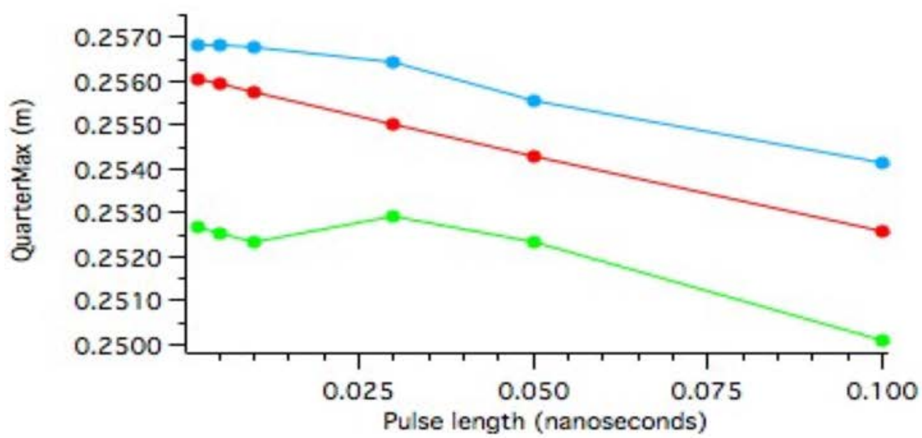
Statistics for 1080 incidence angles from 15 to 90 deg

1/4 Max range correction vs Pulse length

(each point averaged over 1080 incidence angles)

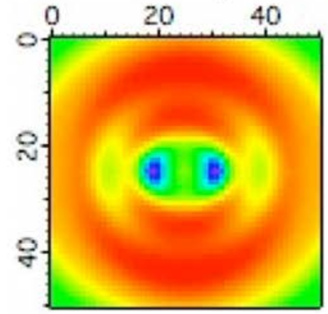


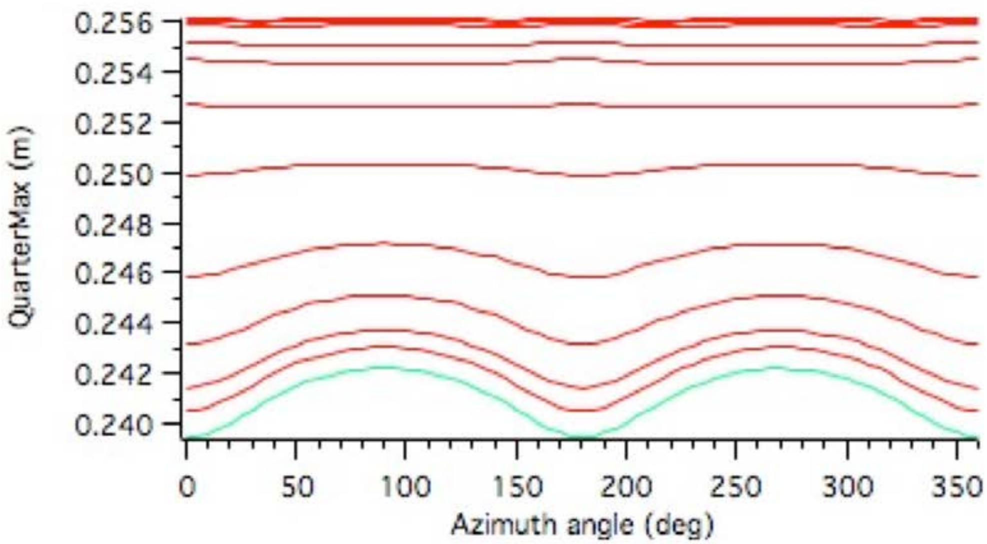
Average (red), minimum (green), maximum (blue)



Calculated maximum range correction is 0.25683 m.
Blue curve levels off at 0.256820.

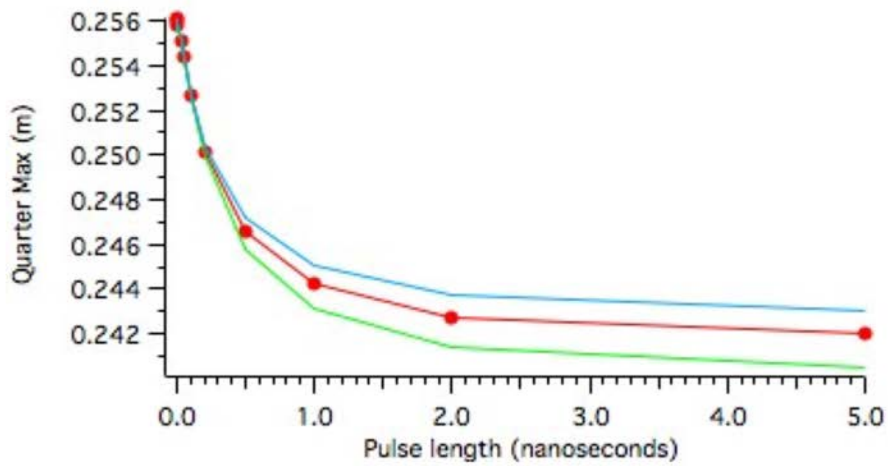
1/4 max (red) and centroid (green)
Range corrections around a circle in the far field
Linear vertical polarization.



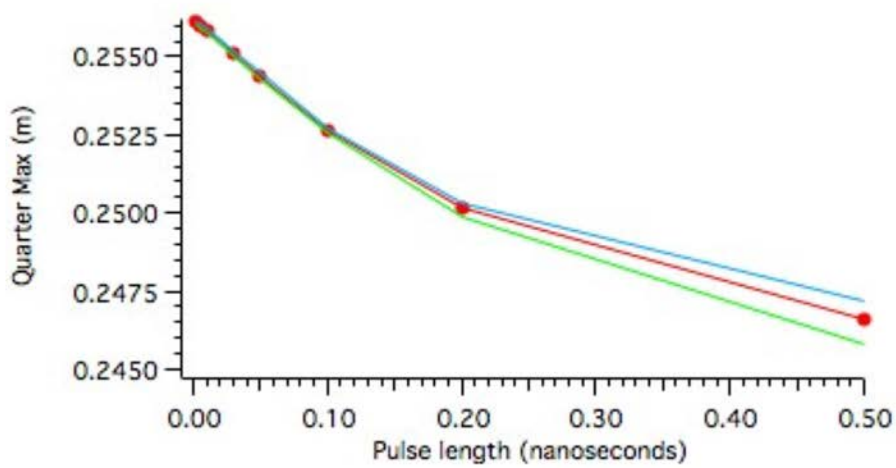


The pulse length of the red curves starting from the bottom
5.000, 2.000, 1.000, 0.500, 0.200, 0.100, 0.050, 0.030,
0.010, 0.005, 0.002 ns.
Centroid is independent of pulse length.

Asymmetry of 1/4 max range correction vs pulse length

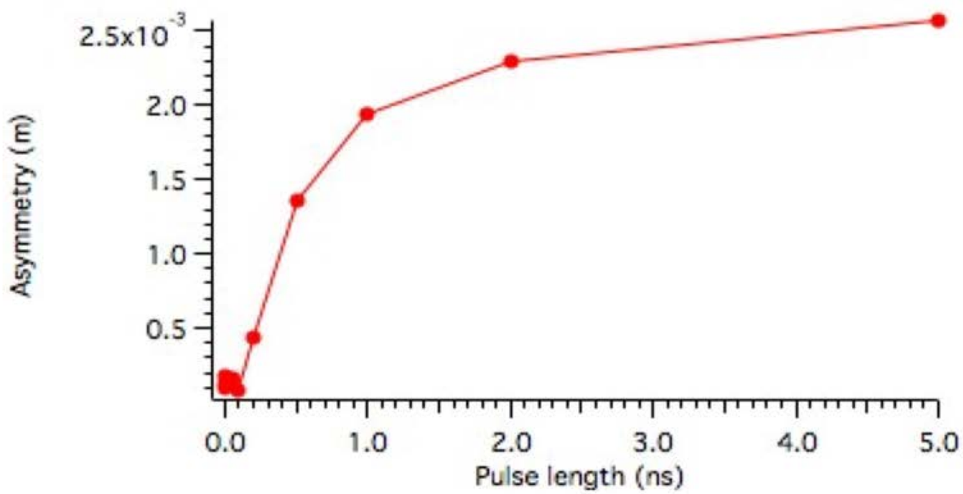


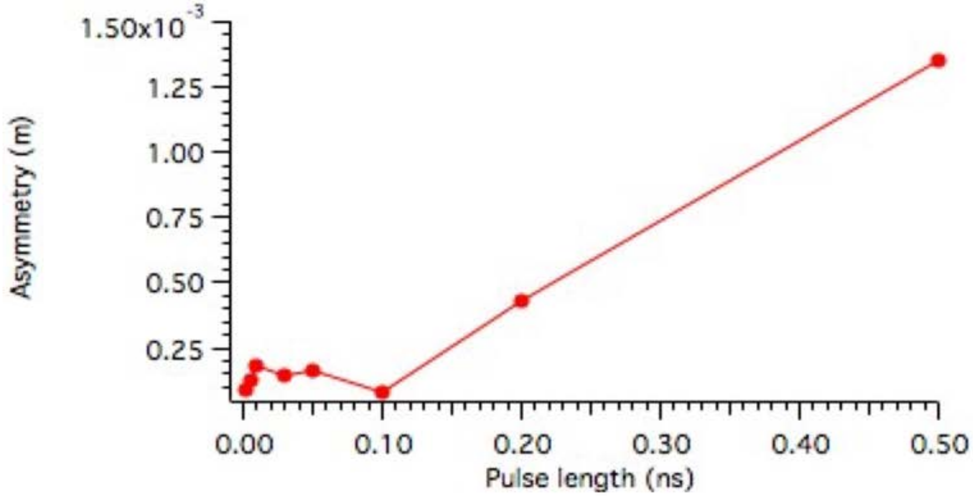
Average (red), minimum (green), maximum (blue) around circle in the far field



Asymmetry disappears below 0.100 ns

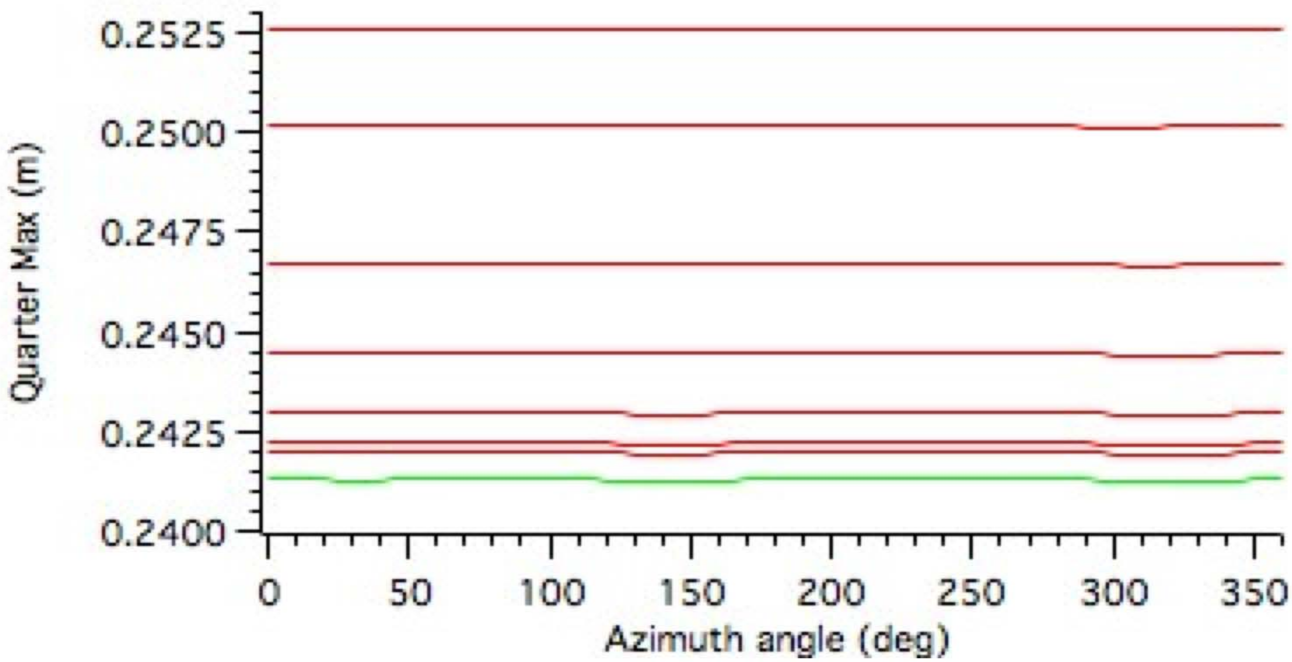
Asymmetry of the 1/4 max range correction (m) vs pulse length (ns)





The asymmetry decreases linearly from 0.500 to 0.100 ns
and virtually disappears below 0.100 ns.

Centroid and 1/4 max range correction vs azimuth angle for various pulse lengths with circular polarization



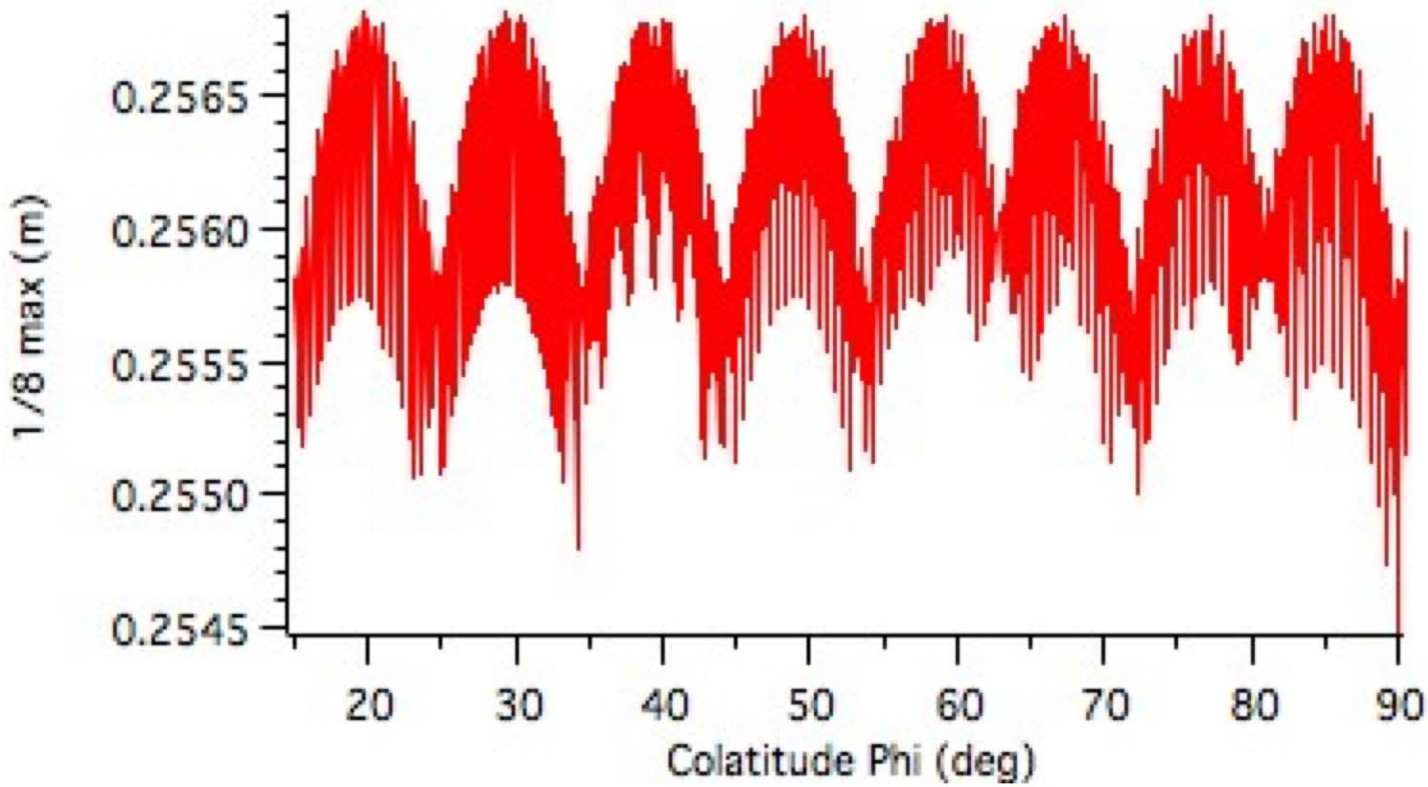
Centroid (green) and quarter max (red) range correction around a circle in the far field

Pulse lengths from bottom to top

10.000, 5.000, 2.000, 1.000, 0.500, 0.200, and .100 ns

The asymmetry disappears with circular polarization

1/8 max range correction vs incidence angle
Pulse length 0.002 ns

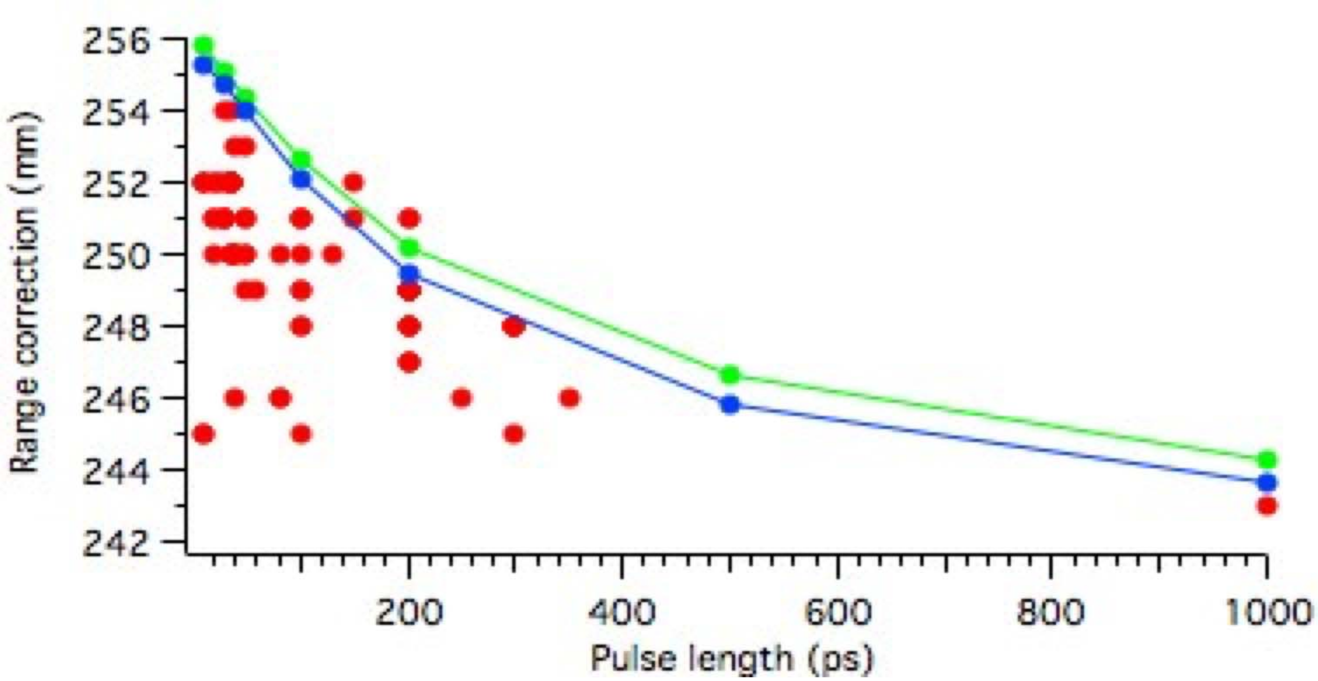


At normal incidence on a cube the range correction should be .25683 m.

Between cubes it should be .25569 m.

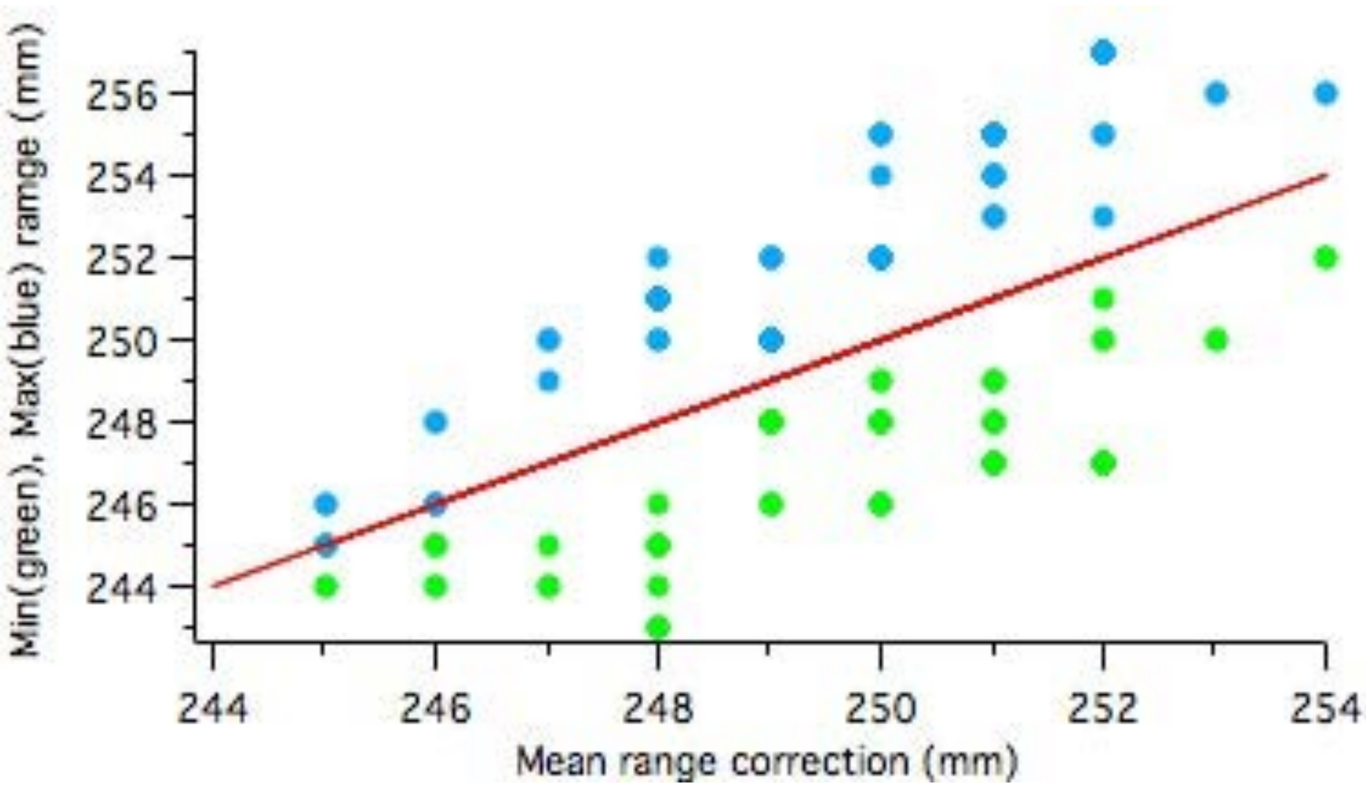
This agrees very closely with figure.

Comparison with range corrections computed for 82 stations

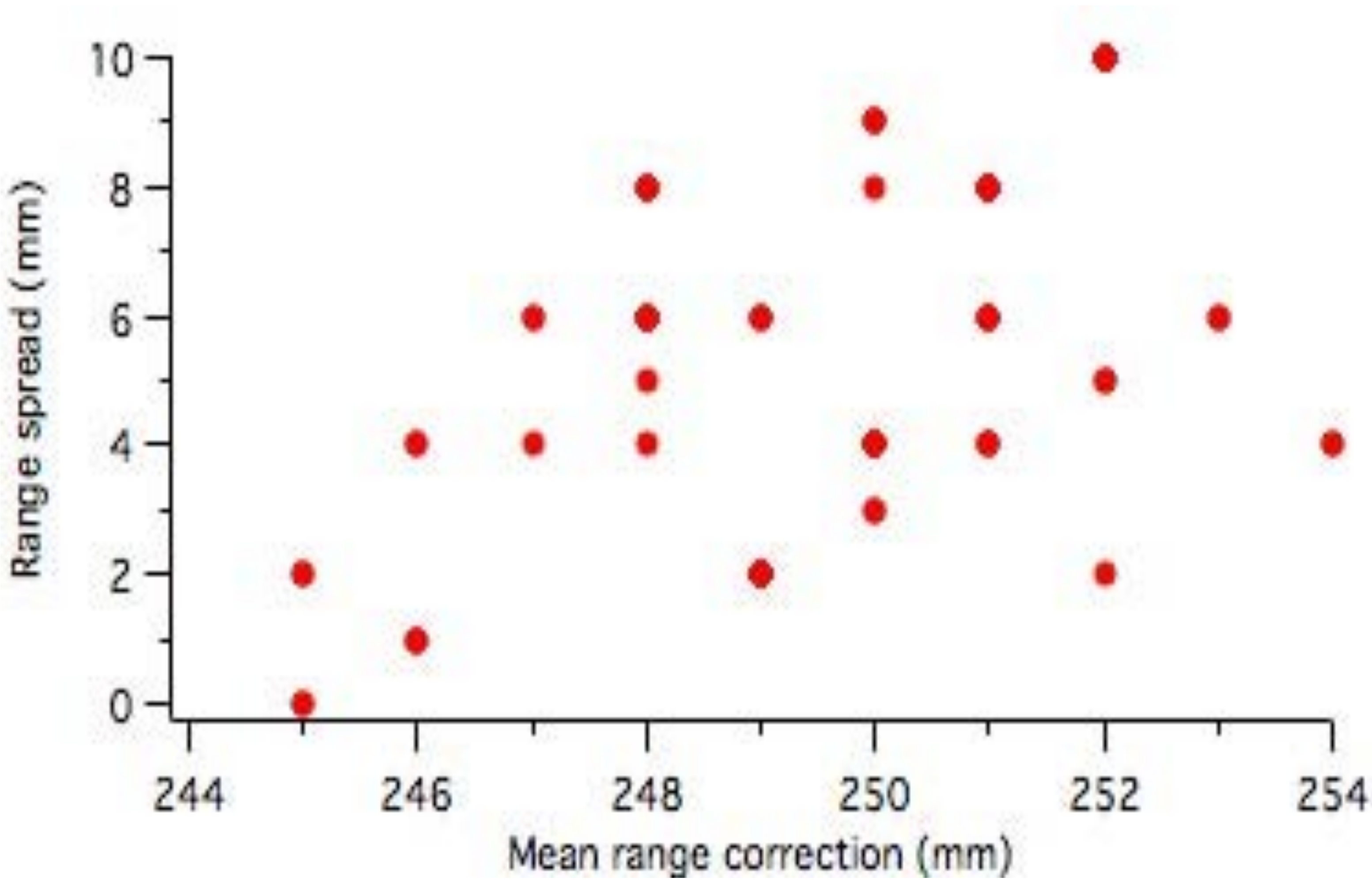


Green = 1/4 max correction (mm) vs pulse length (ps)
Blue = 1/2 max correction vs pulse length
Red = mean range corrections for the stations
(See http://ilrs.dgfi.tum.de/data_handling/com_lageos.txt)
Red dots lie between the centroid and the 1/4 and 1/2 max
(many of the dots overlap)

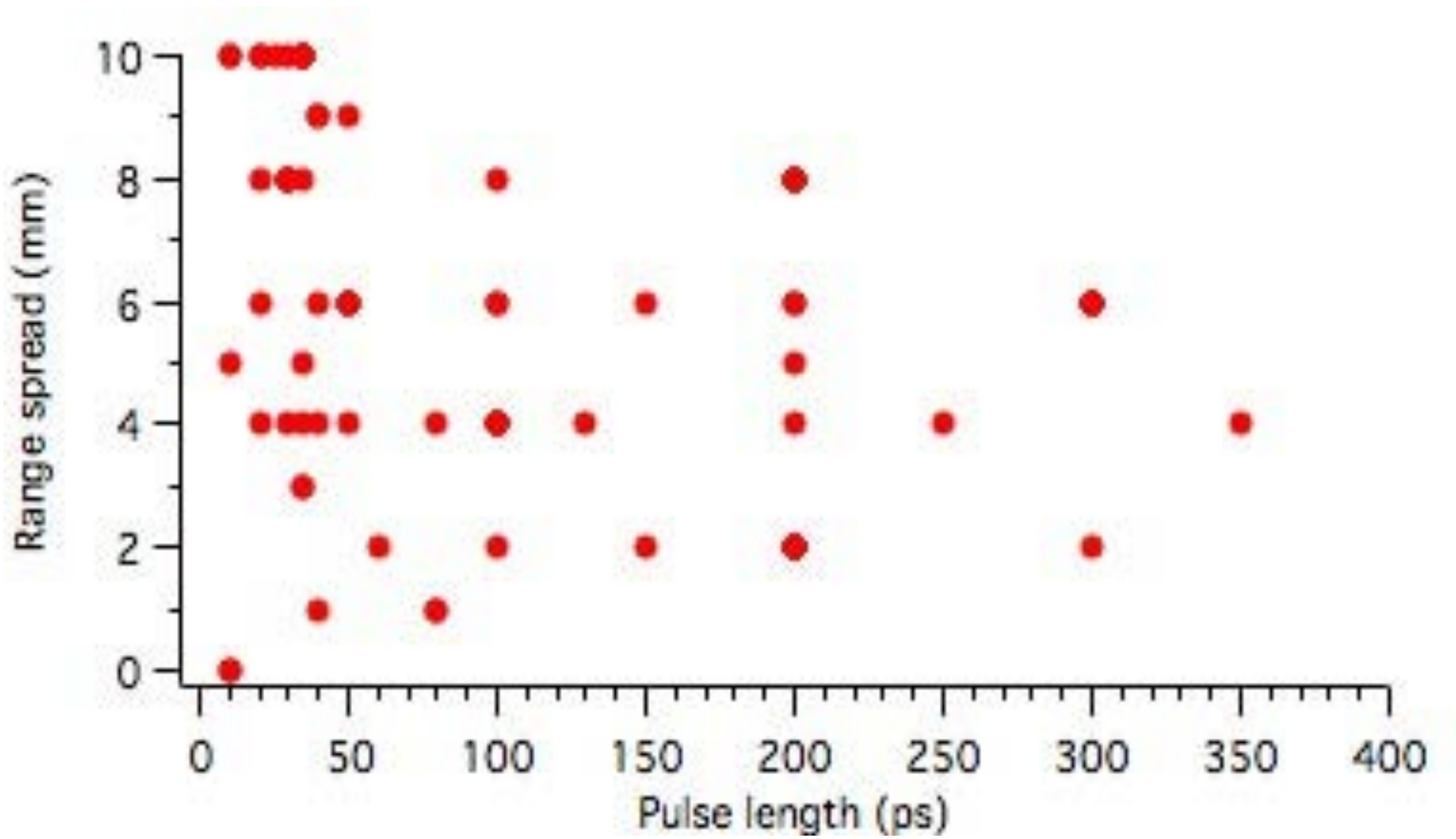
Uncertainty of range correction
Red = av, Green = min, Blue = max
Single p.e. = 245+/-1mm



Max-Min vs mean



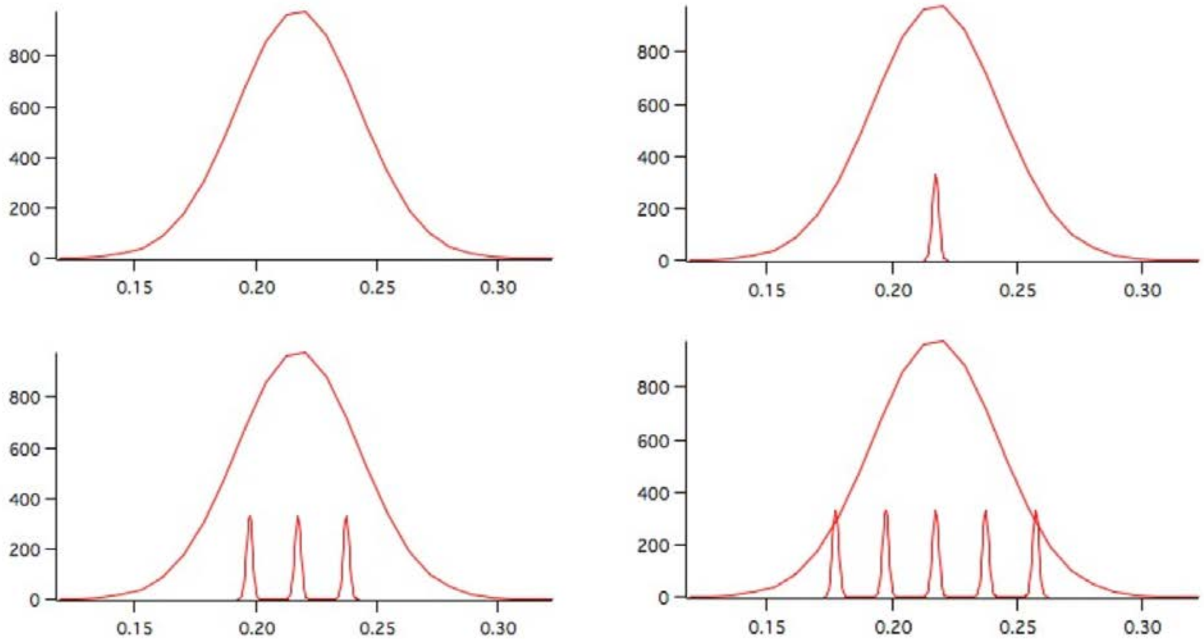
Max-Min vs pulse length



Small Max-Min

Sta							Pulse				Max	Min	Av	Max–Min
1831	1	10	1998	31	12	2050	150	2.0	20	40	253	251	252	2
7080	1	10	1985	31	12	2050	200	3.0	9	13	250	248	249	2
7090	1	7	1979	31	12	2050	200	3.0	4	10	250	248	249	2
7105	1	3	1981	31	12	2050	200	3.0	5	10	250	248	249	2
7110	15	8	1983	31	12	2050	200	3.0	5	10	250	248	249	2
7119	1	10	2006	31	12	2050	200	3.0	4	10	250	248	249	2
7124	1	8	1997	31	12	2050	200	3.0	6	10	250	248	249	2
7130	18	5	1998	1	3	2006	200	3.0	4	10	250	248	249	2
7210	1	3	1973	3	5	2004	200	3.0	5	8	250	248	249	2
7403	10	7	1992	31	12	2050	200	3.0	5	10	250	248	249	2
7405	18	4	2002	20	3	2006	80	2.5	15	20	246	245	246	1
7405	31	3	2006	31	12	2050	40	2.5	12	20	246	245	246	1
7594	1	1	1997	1	1	2002	80	2.5	15	20	246	245	246	1
7810	2	1	1996	9	3	2001	300	2.5	20	23	246	244	245	2
7810	4	3	2008	31	12	2050	60	2.5	15	10	250	248	249	2
7822	1	5	2011	31	12	2050	35	2.5	6	17	252	249	250	3
7823	1	6	2004	31	12	2050	35	2.5	6	17	252	249	250	3
7840	31	3	1992	31	12	2050	100	3.0	6	15	246	244	245	2
7840	1	2	2007	31	12	2050	10	2.5	3	9	245	245	245	0
7841	1	8	2011	31	12	2050	10	2.2	3	9	245	245	245	0
7845	1	9	1980	1	1	2005	200	2.5	20	24	250	248	249	2

Range bias due to quantization



- As the number of photoelectrons increases the range correction moves closer to the leading edge
- (Positions of photoelectrons are chosen for illustration - they can be any where under the pulse envelope)
- Range correction vs number of photoelectrons is listed on the website below for LAGEOS.
- http://ilrs.gsfc.nasa.gov/missions/satellite_missions/current_missions/lag1_com.html

Methods of eliminating polarization bias

- Use circular polarization
- Use a mixture of positive and negative offsets
- Eliminate the dihedral angle offset

A. LUNAR 1.5 inch (central peak)

B. GNSS 1.3 to 1.5 inch (first ring)

C. LAGEOS 1.0 in (first ring)

D. LEO 0.5 inch (central peak)

Signal strength bias

- Range correction for LAGEOS changes by up to one cm. Possible solutions:

▪ Limit signal strength to single photoelectrons

▪ Limit signal strength to strong signals

▪ Study range correction vs signal strength

Acknowledgement

- Many thanks to Reinhart Neubert for reviewing the analyses and providing very helpful references and suggestions.