

The NERC Space Geodesy Facility: Return Energy Estimates derived from normal point and full rate laser data.

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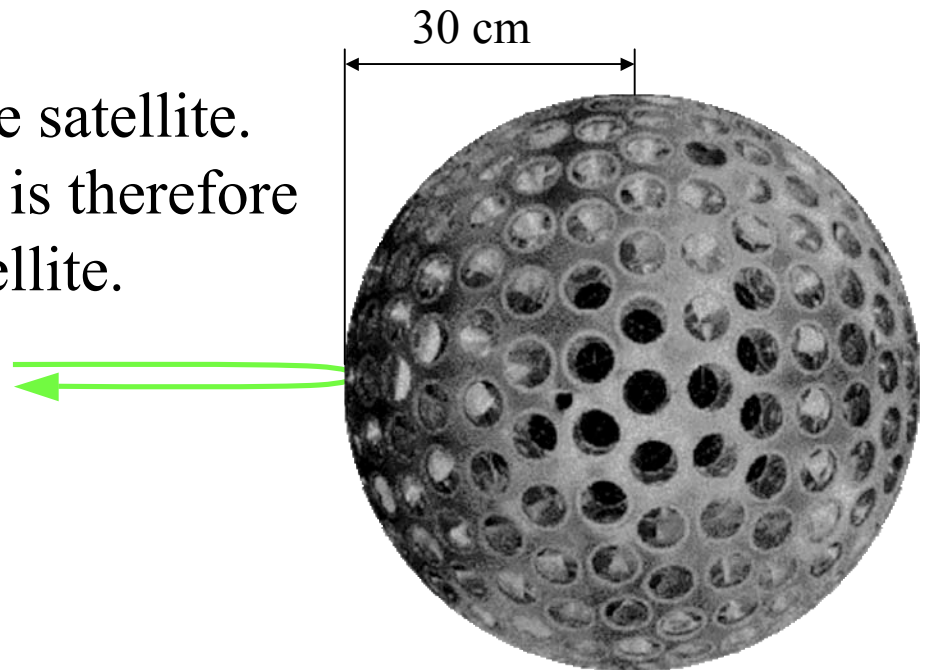


Introduction

- We have been investigating variation of laser return rate and its effect on range accuracy.
- We have experimented at Herstmonceux (C-SPAD detector) with a number of satellites by including periods of high and low return rate over a pass.
- We have analysed return rates from the full-rate data for the Lageos and Etalon satellites for all ILRS contributing stations.

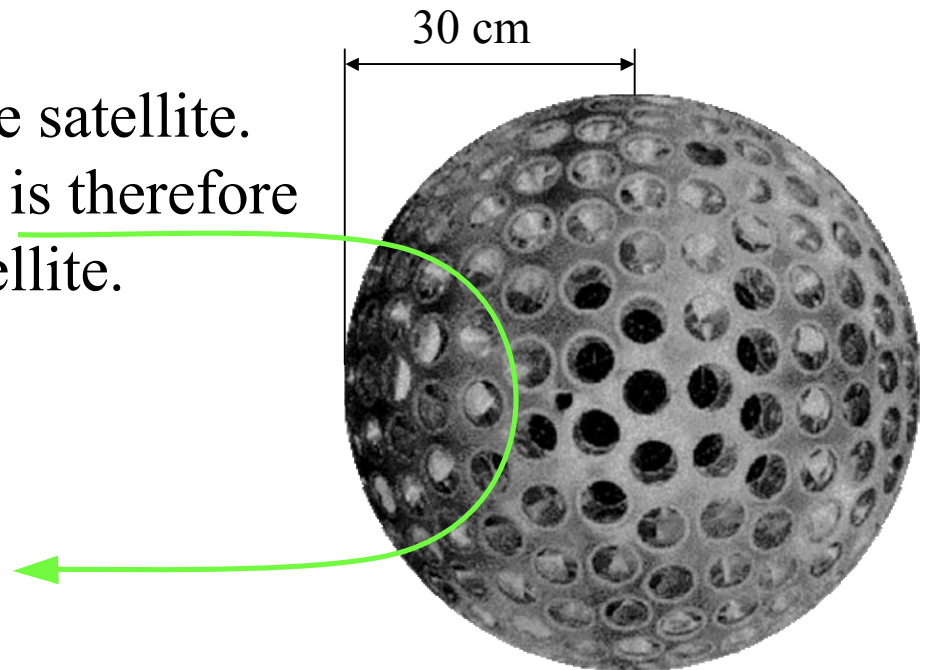
Effect of return rate

- A range measurement is dependent upon the strength of the return signal.
- The effective reflection point for a high return rate is closer to the front of the satellite.
- Low rates of return provide measurements from across the satellite. The effective reflection point is therefore closer to the centre of the satellite.
- Different corrections to refer the measurement to the centre of mass are needed for different return rates.

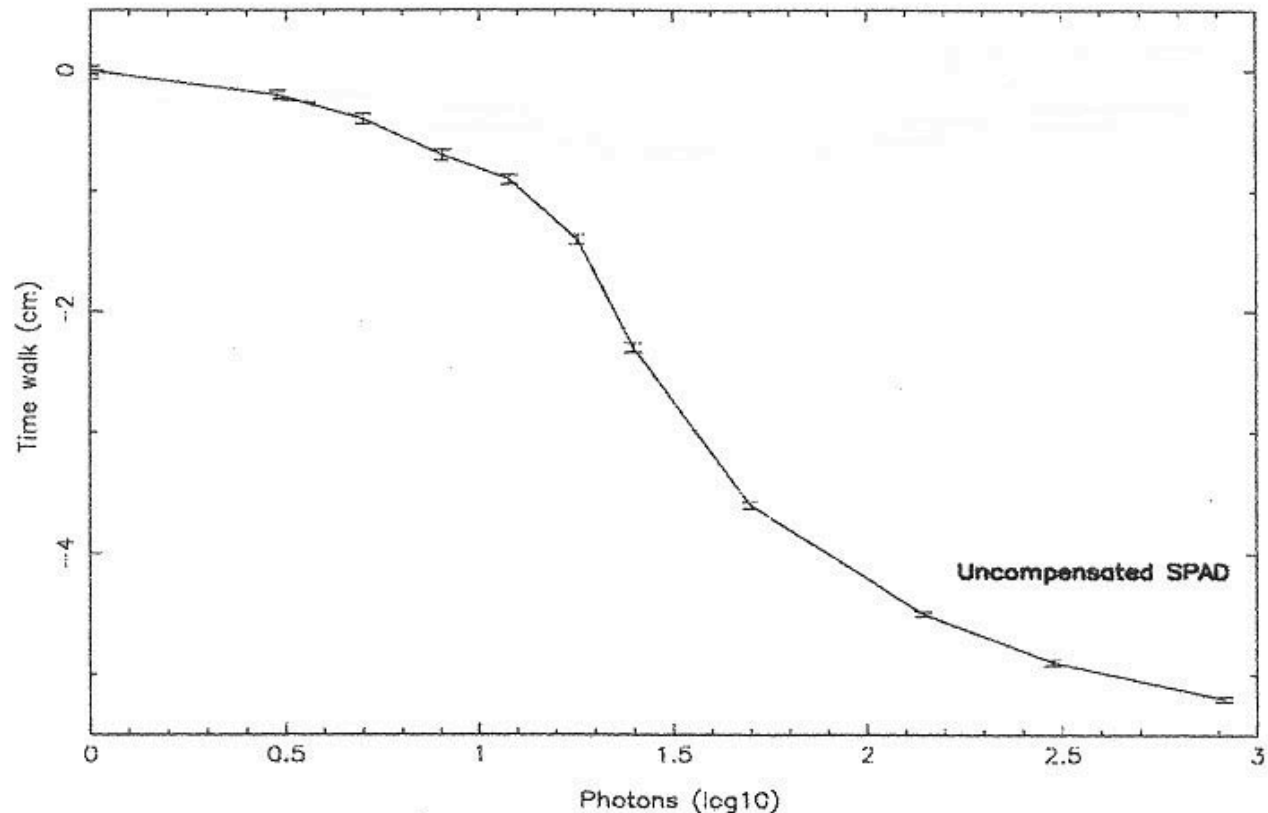


Effect of return rate

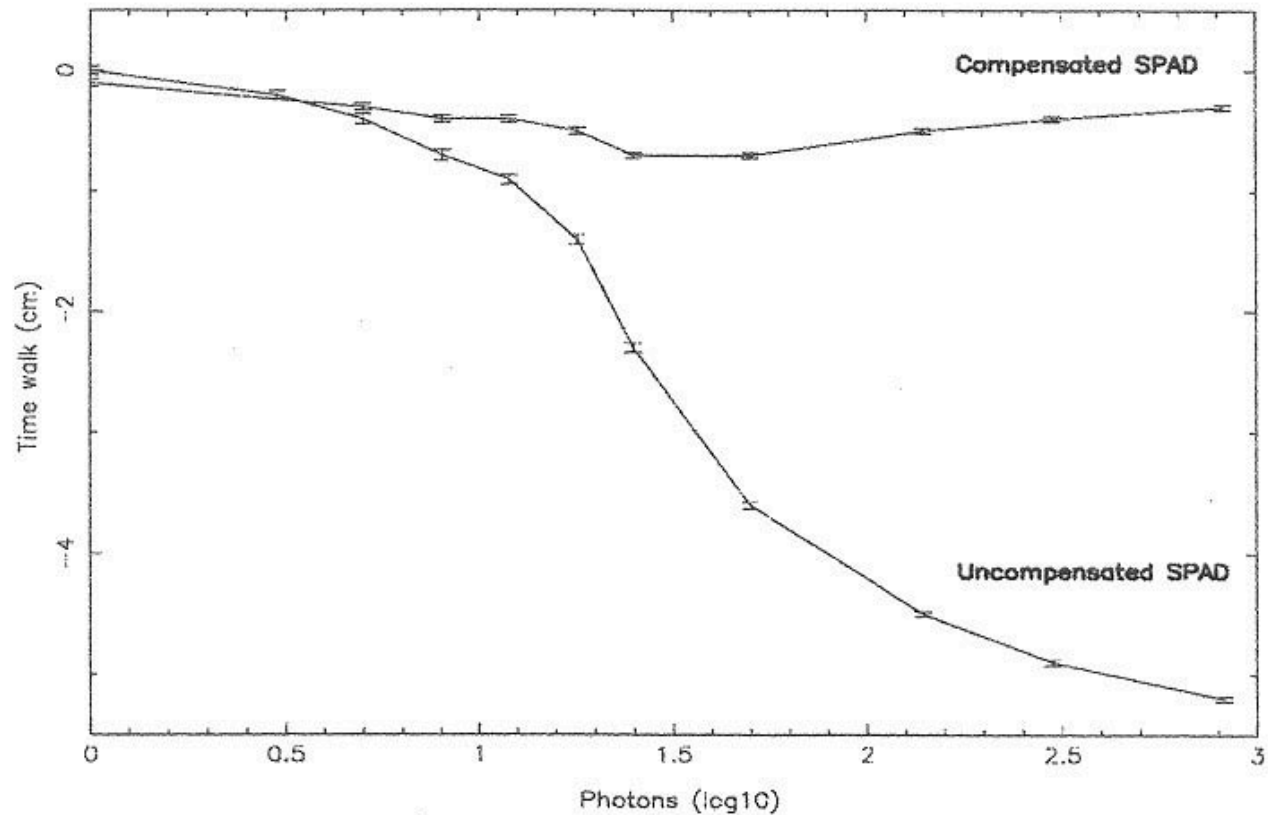
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- SPAD detectors experience ‘Time Walk’ with return rate.
- A calibration range measurement using an uncompensated SPAD channel changes by a few centimetres between low and high return rates.
- A compensated SPAD reduces this variation to less than a few millimetres.
- Different return rates result in different values of time walk. (Experimental results from Herstmonceux. 100ps laser)



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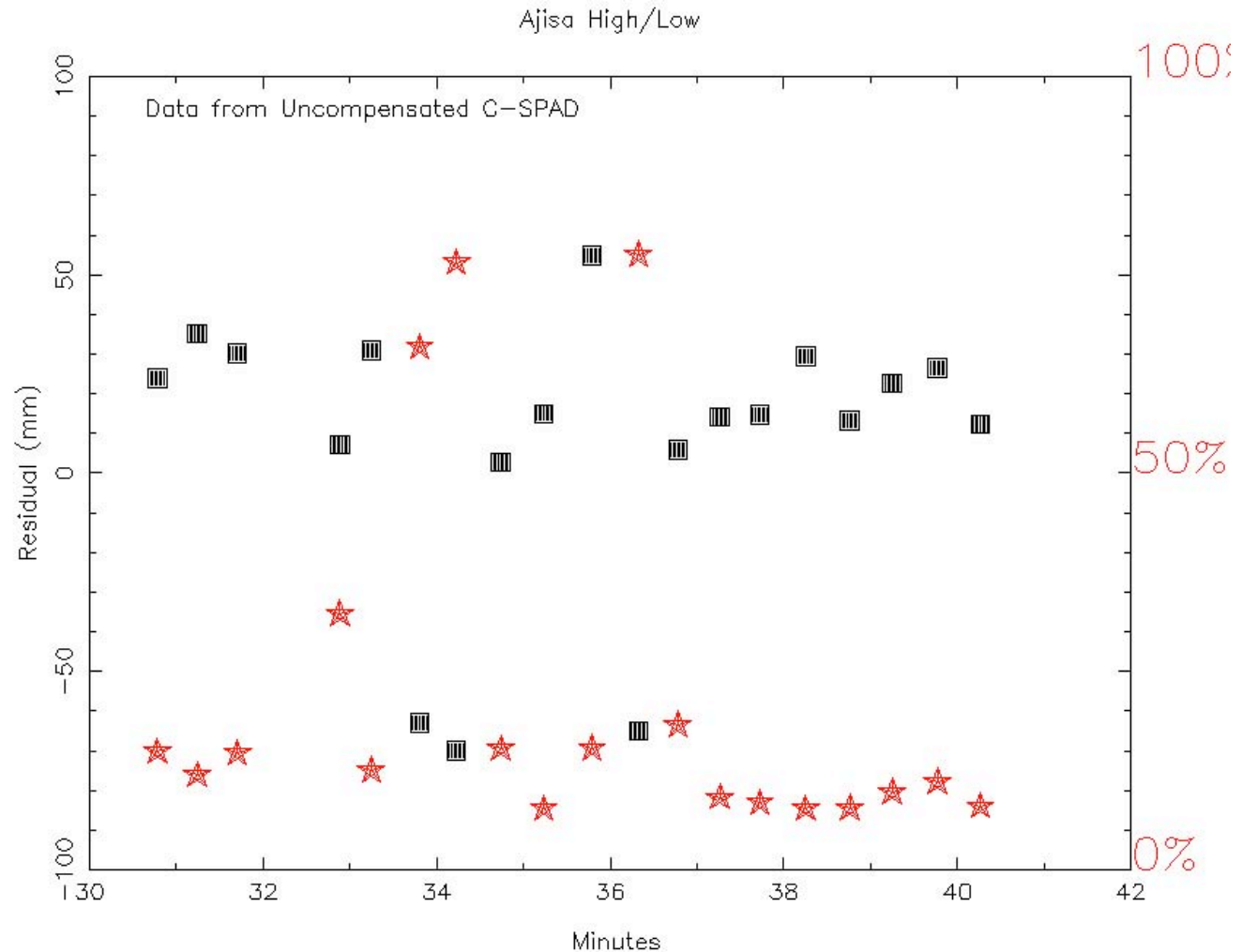


High/Low Return Rates

- These effects can be quantified by taking high and low return rate measurements across a pass.
- The high/low process uses neutral density filters to control to the number of photons reaching the detector.
- The pass is observed predominantly at low return rate. By removing all ND filters, the system is forced to observe at high return rate.
- The residual plots from the resulting orbit solution show the high rate data standing off from the low rate solution.

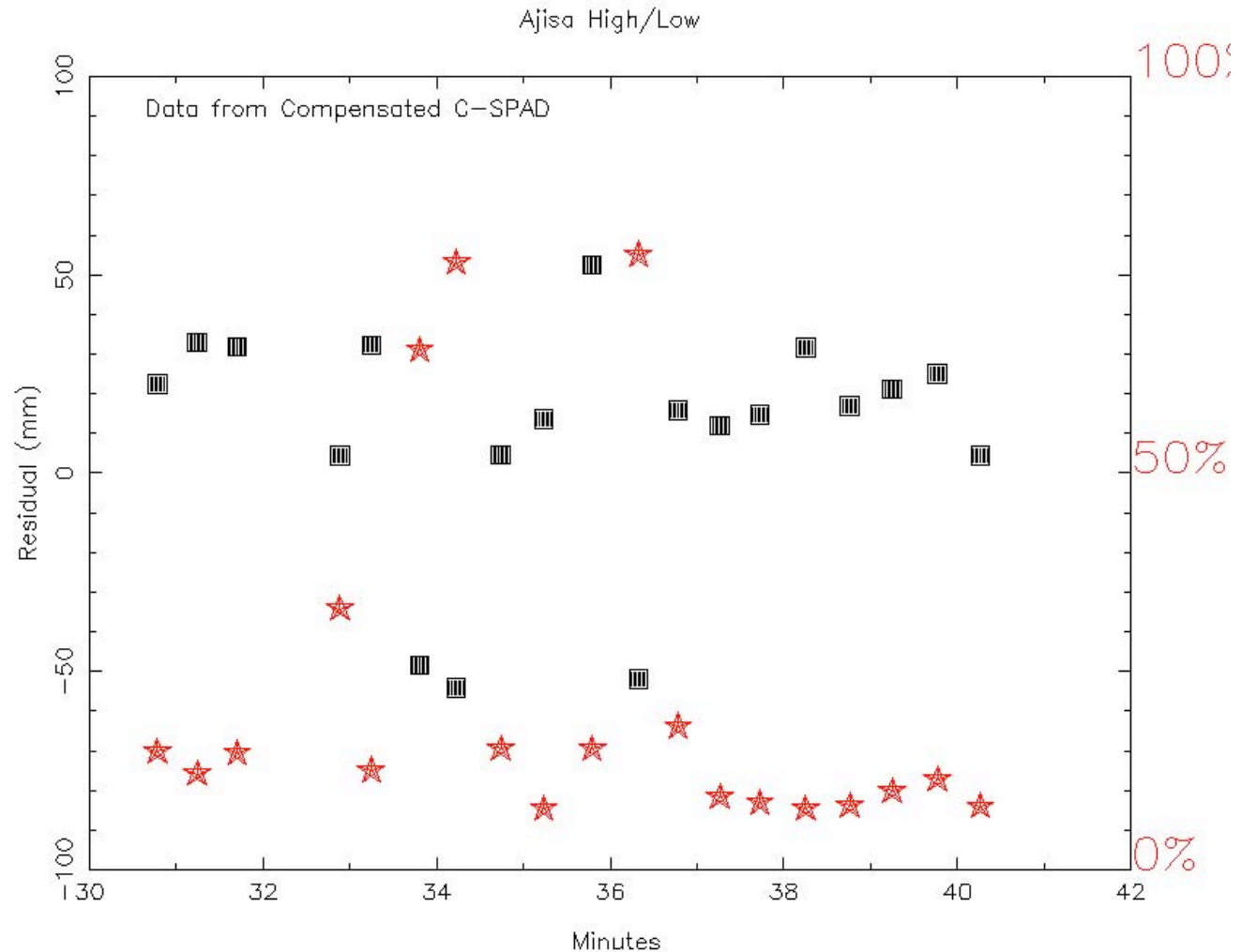
Ajisai -uncompensated

- Data offset at high return rate.
- Offset includes satellite, detector and laser pulse effects.
- Solution maintains a zero mean.



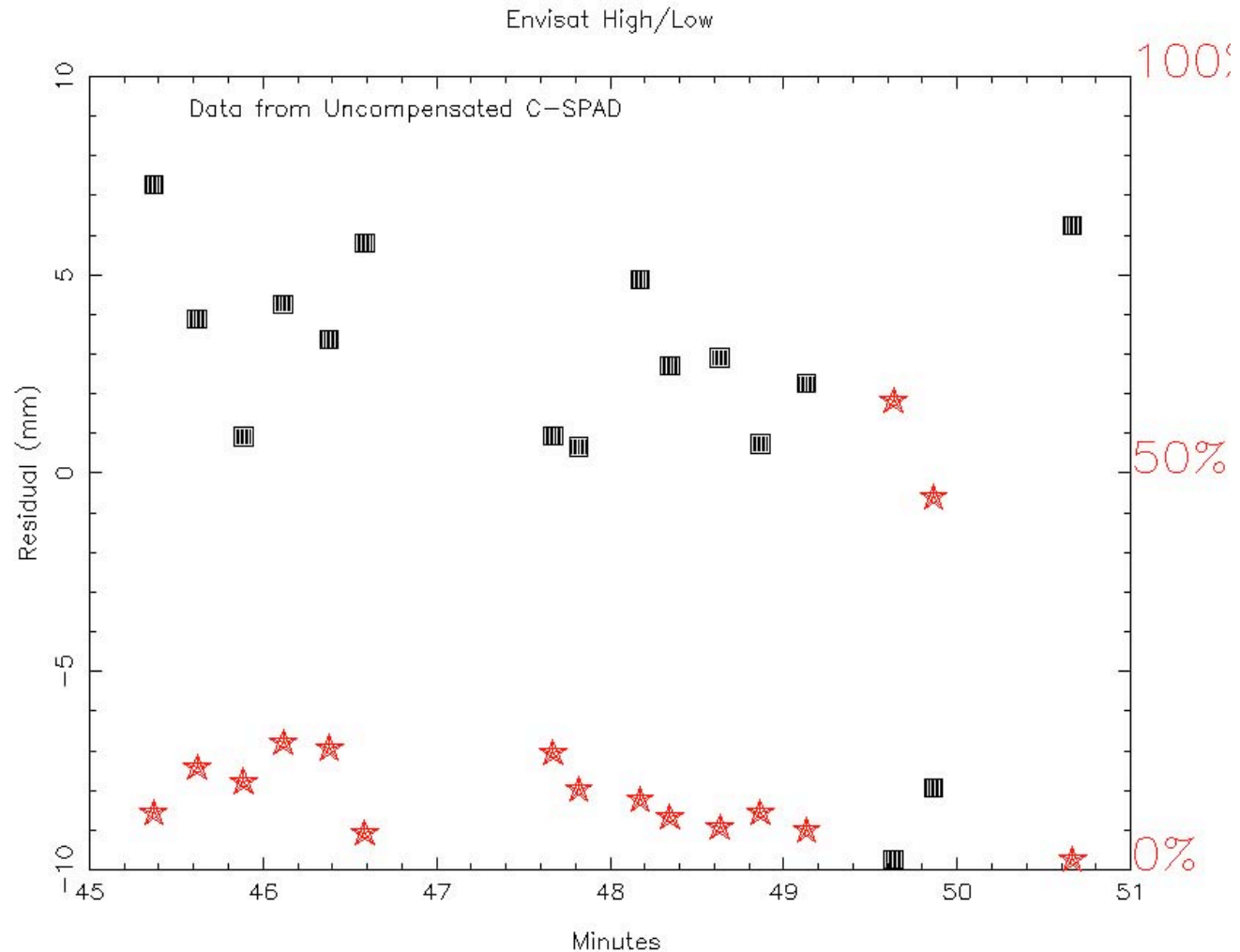
Ajisai -compensated

- Data offset at high return rate.
- Offset only includes satellite effects.
- Solution maintains a zero mean.



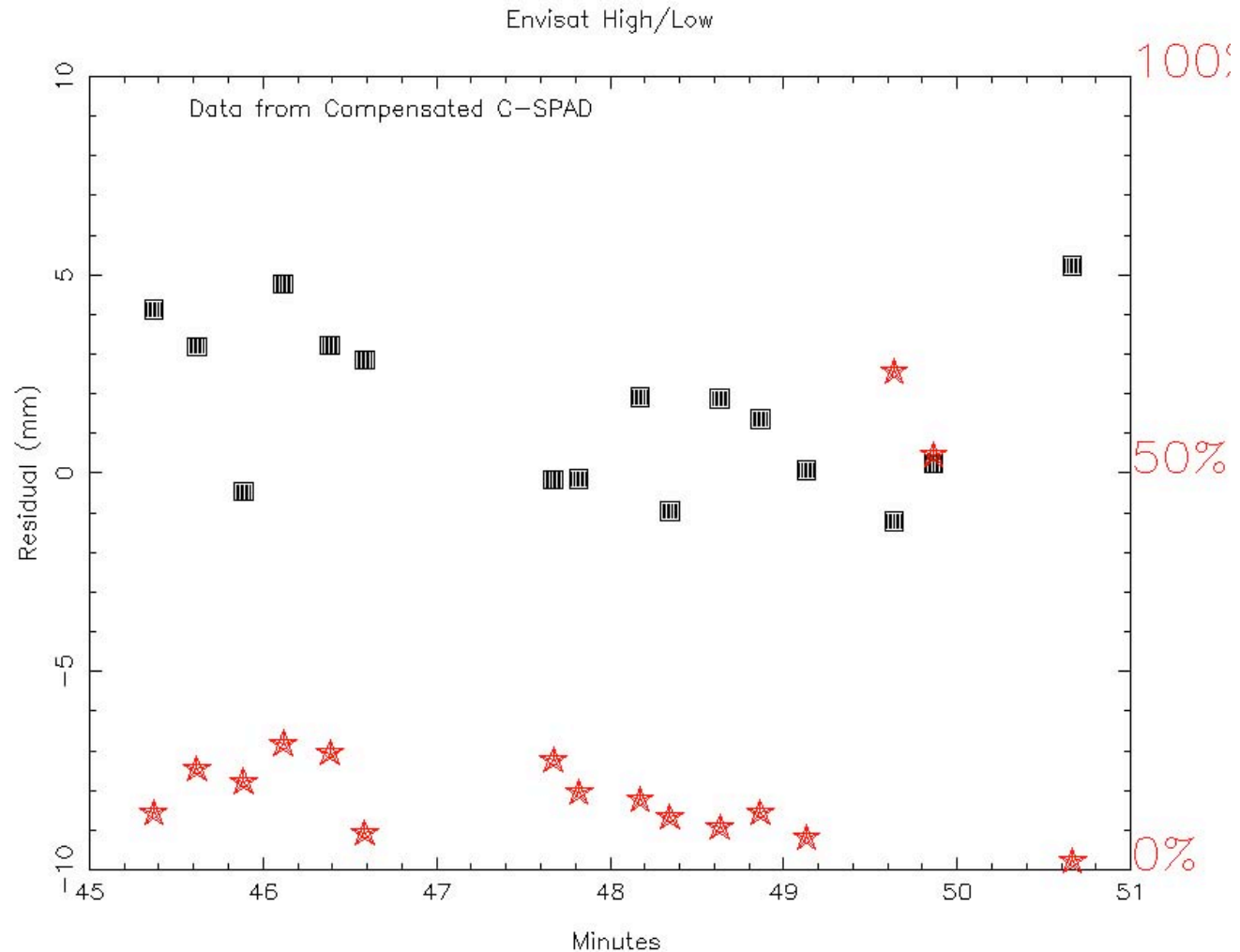
Envisat -uncompensated

- Data offset at high return rate.
- Offset includes satellite, detector and laser pulse effects.
- Solution maintains a zero mean.



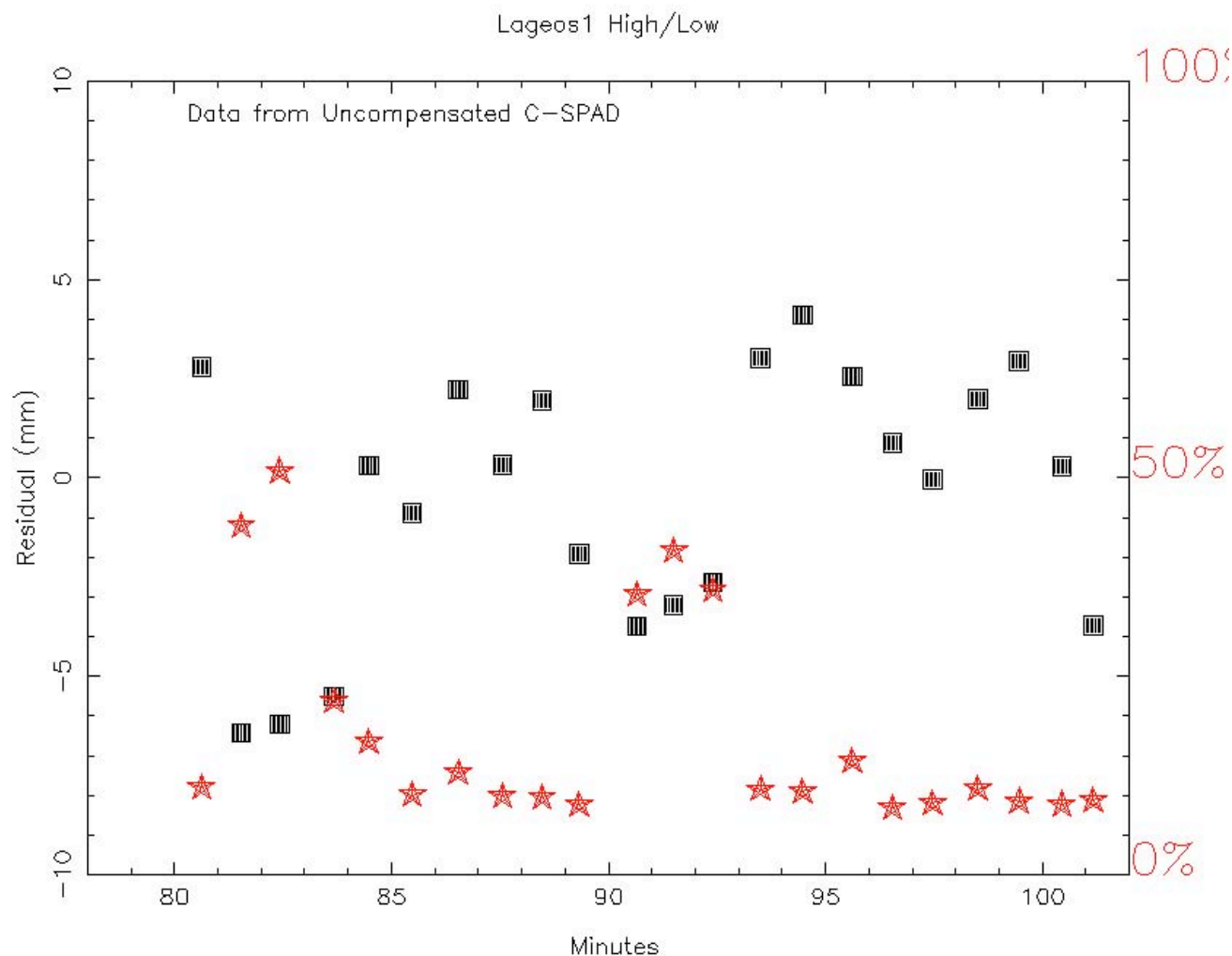
Envisat -compensated

- No detectable data offset at high return rate.
- Offset only includes satellite effects.
- Solution maintains a zero mean.



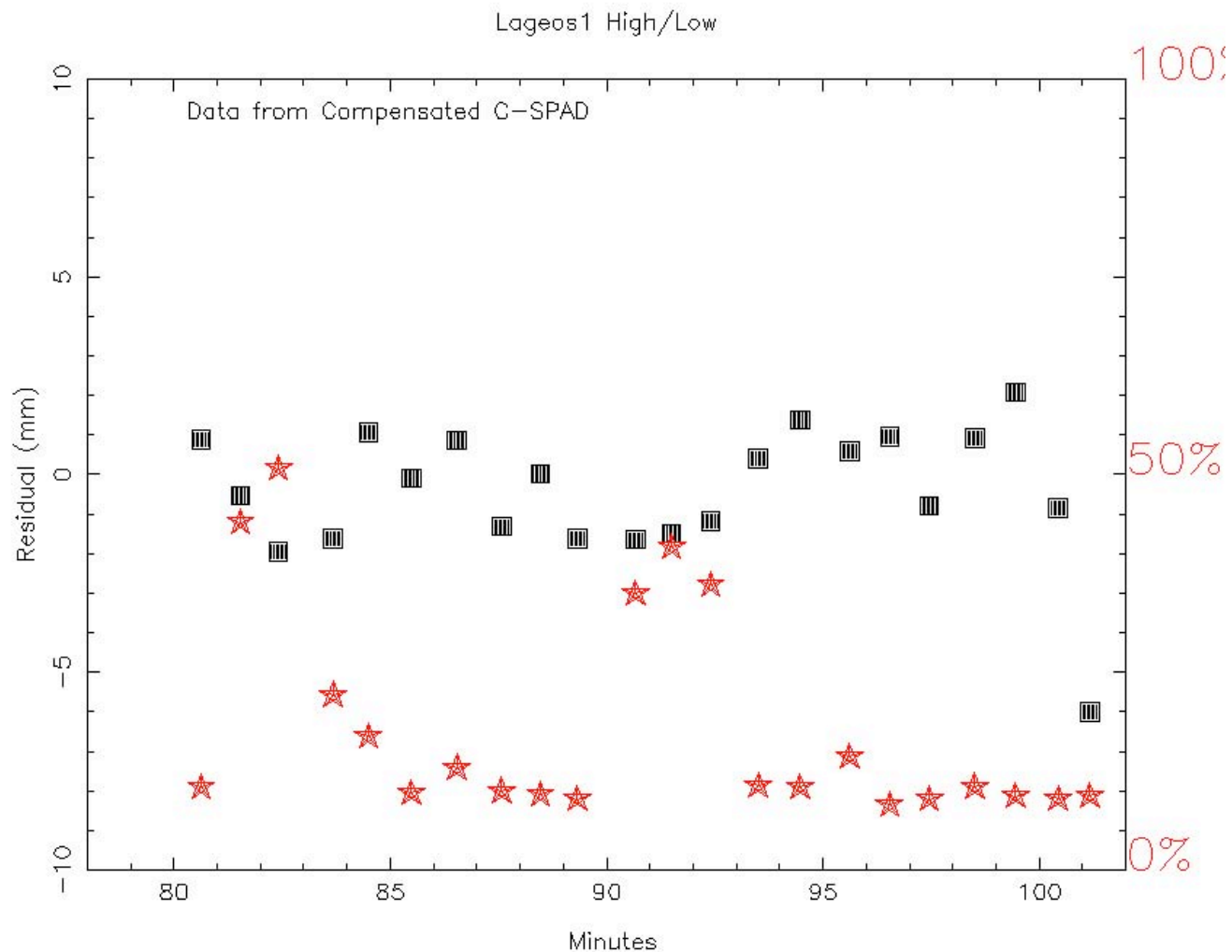
Lageos 1 -uncompensated

- Data offset at high return rate.
- Offset includes satellite, detector and laser pulse effects.
- Solution maintains a zero mean.



Lageos 1 -compensated

- No detectable data offset at high return rate.
- Offset only includes satellite effects.



Satellite	Uncompensated offset	Compensated offset
Ajisai	80+ mm	60+ mm
Envisat	10+ mm	~ 0 mm
Lageos	~ 5 mm	~ 0 mm

- The plots show range measurement differences at high and low levels of return rate.
- The differences contains effects from the shape of the satellite and uncompensated detector time walk.
- The ongoing experiments show that Lageos behaves as a small target for return rates less than 40%.

Varying Return Rates

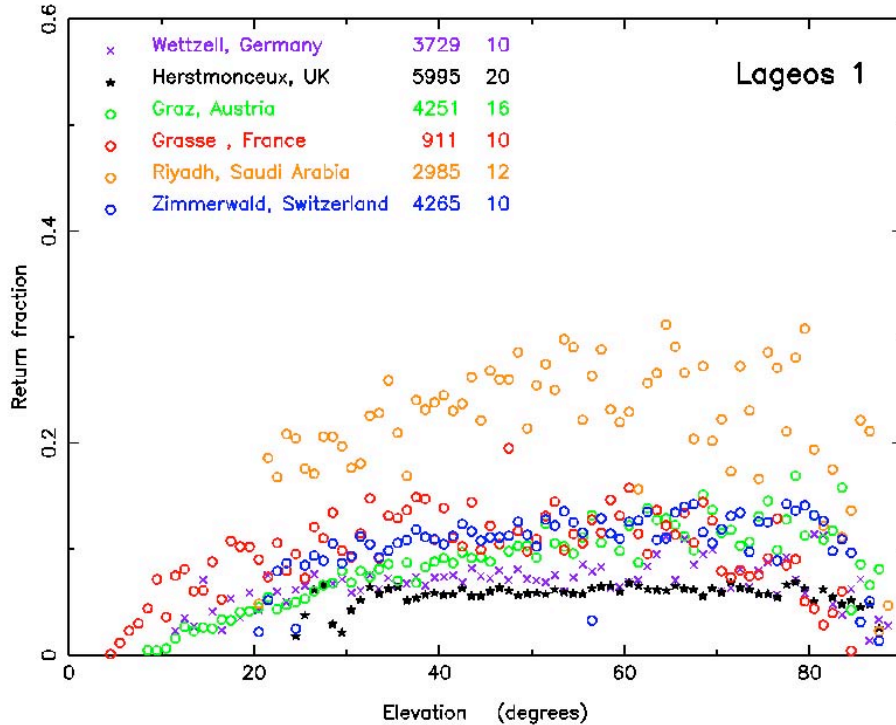
- We now attempt to characterise the return rate behaviour of the major ILRS stations. In the following we assume:
 - An estimate of the return rate can be made from the ratio of the number of range measurements to the number of shots fired.
 - The effective number of shots depends on the firing rate, the use of the semi train and the use of an event timer.
 - The return rate during a satellite pass can be estimated using the full rate data volume.
- From the 2003 full rate data a variation of return signal strength is evident with changes in satellite, station and elevation.

Lageos 1 and 2

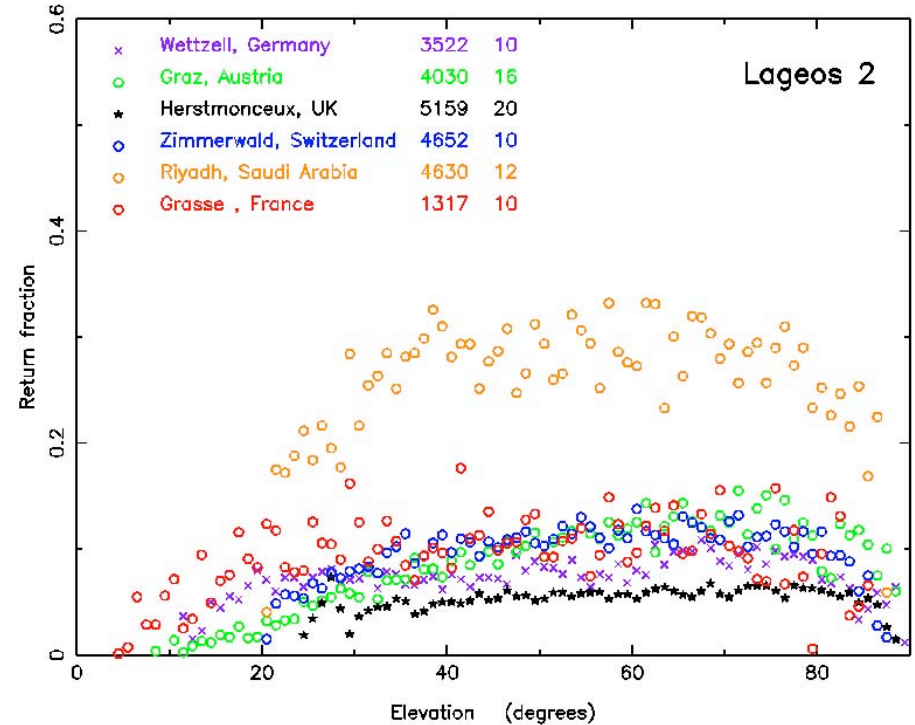
C-SPAD systems

- Similarity between satellites
- Similarity between stations

Fraction of returns to shots fired varying with elevation



Fraction of returns to shots fired varying with elevation

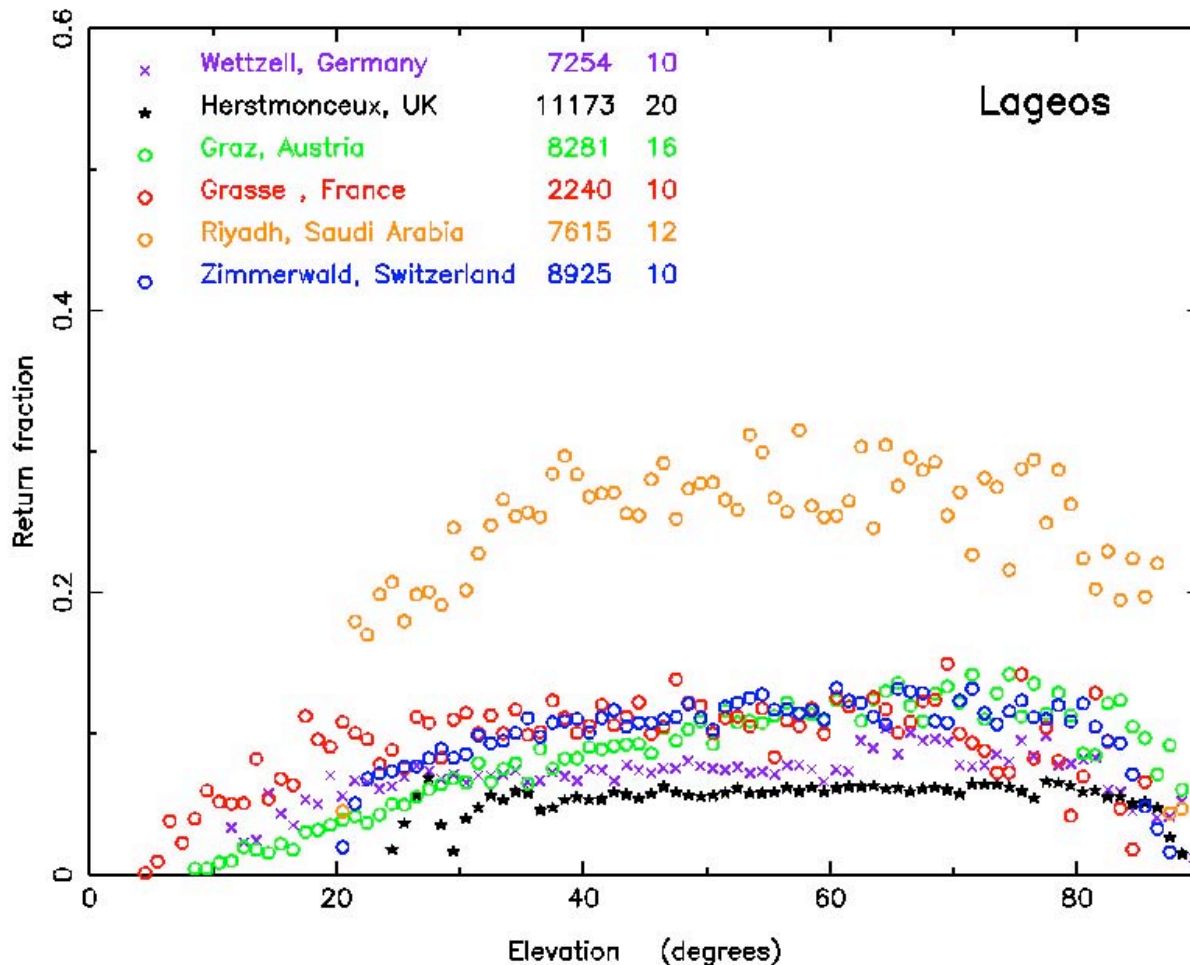


Plots contain: No. of NPs; Fire rate

Lageos 1 and 2 combined

C-SPAD systems

Fraction of returns to shots fired varying with elevation



- Mostly operating at low return rate.

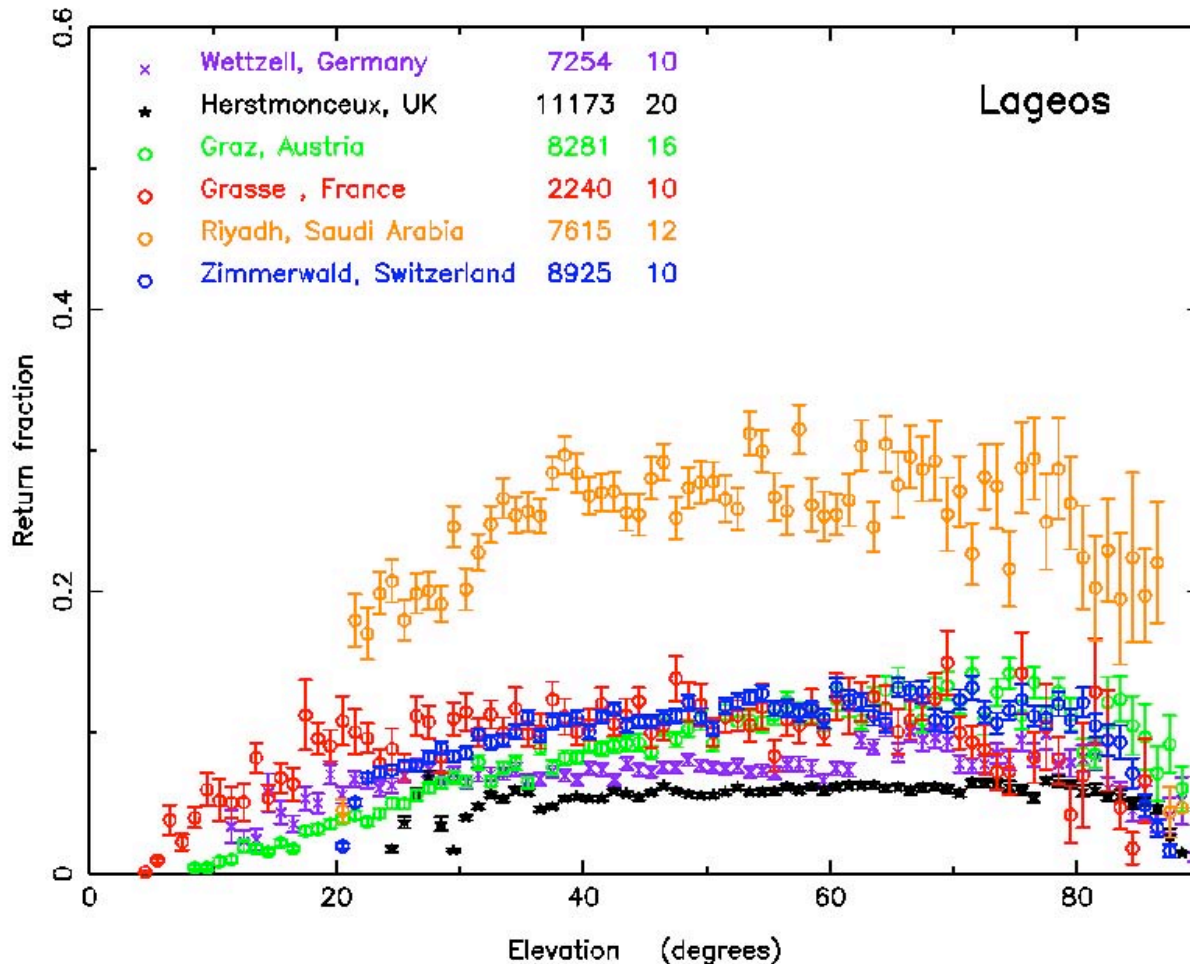
- Return rate consistent at low level with increasing elevation.

- Lower levels of return rate at high and low elevation

Lageos 1 and 2 combined

C-SPAD systems

Fraction of returns to shots fired varying with elevation



- Mostly operating at low return rate.

- Return rate consistent at low level with increasing elevation.

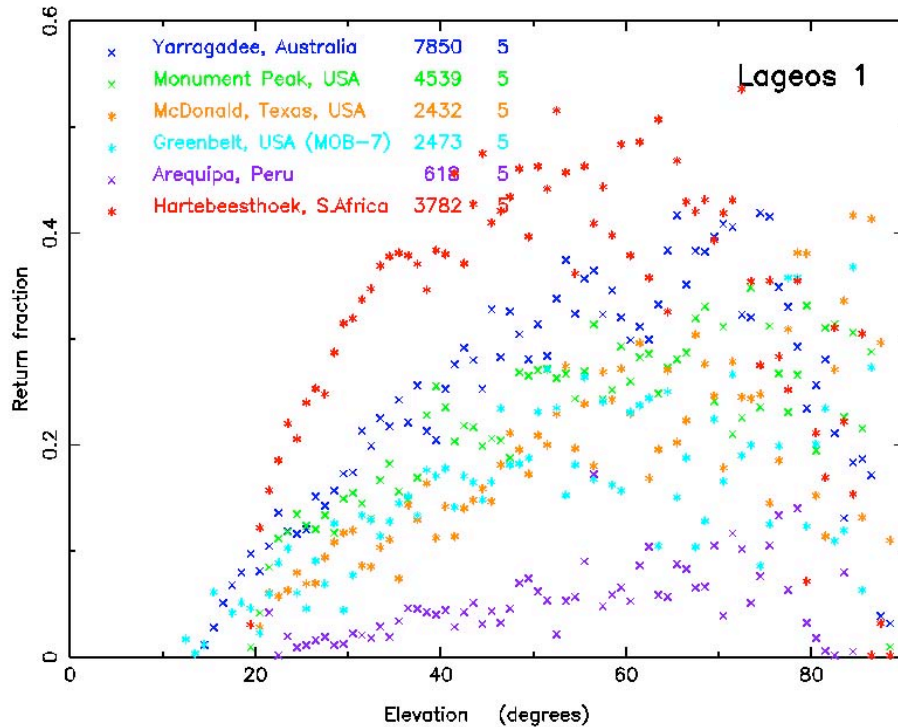
- Lower levels of return rate at high and low elevation

Lageos 1 and 2

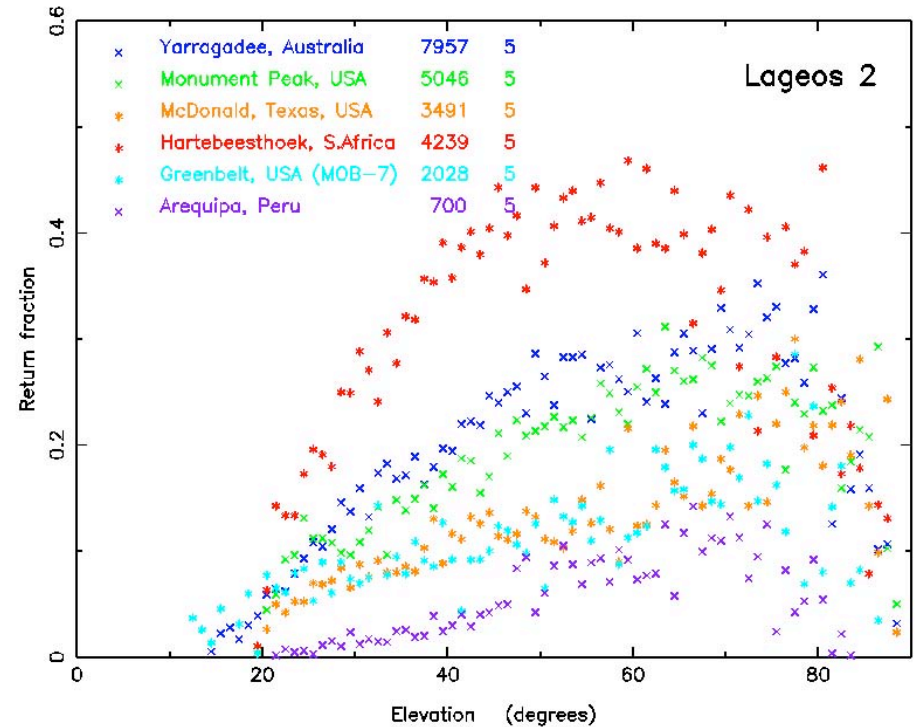
NASA MCP systems

- Similarity between satellites
- Dissimilarity between stations

Fraction of returns to shots fired varying with elevation



Fraction of returns to shots fired varying with elevation

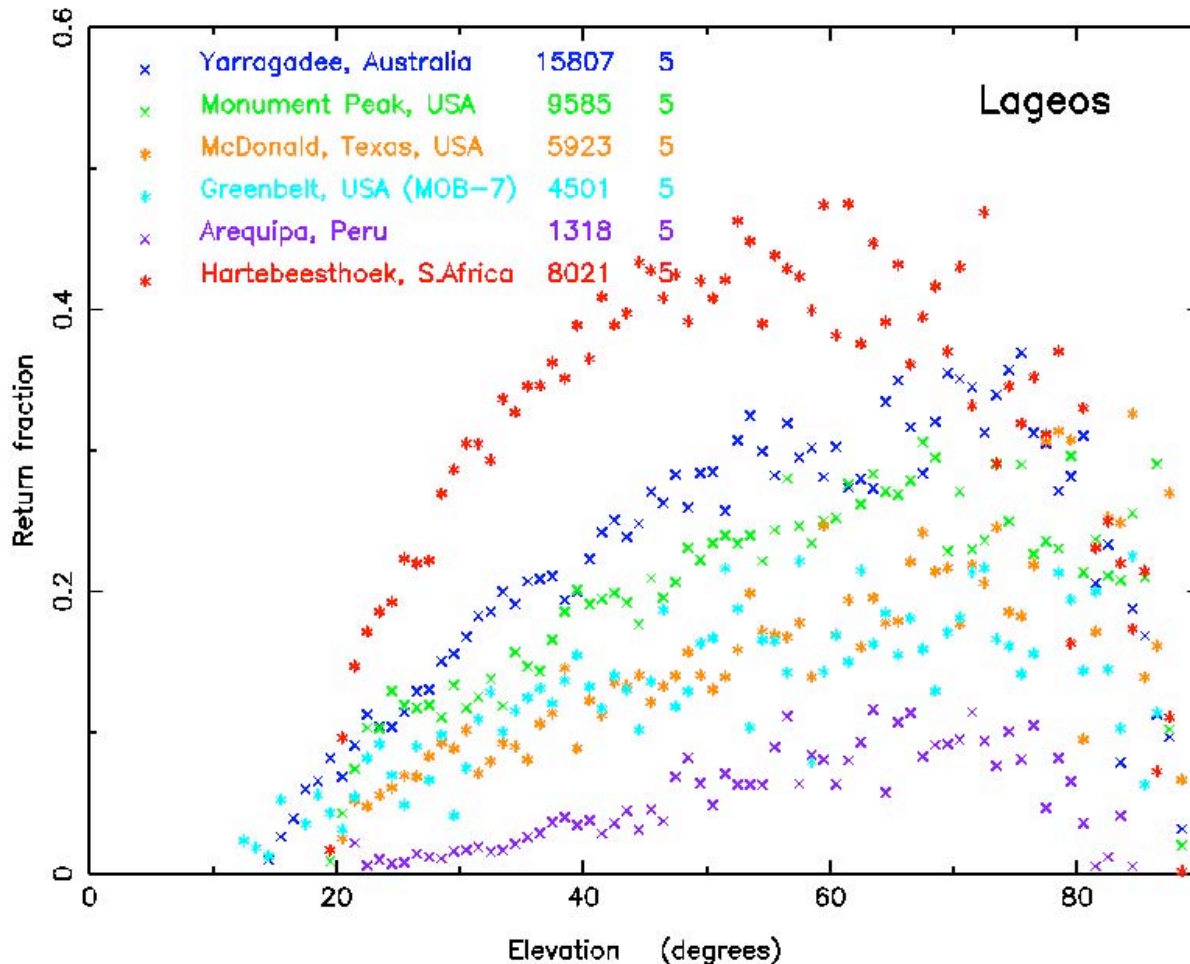


Plots contain: No. of NPs; Fire rate

Lageos 1 and 2 combined

NASA MCP systems

Fraction of returns to shots fired varying with elevation



- Variation in return rate between stations.

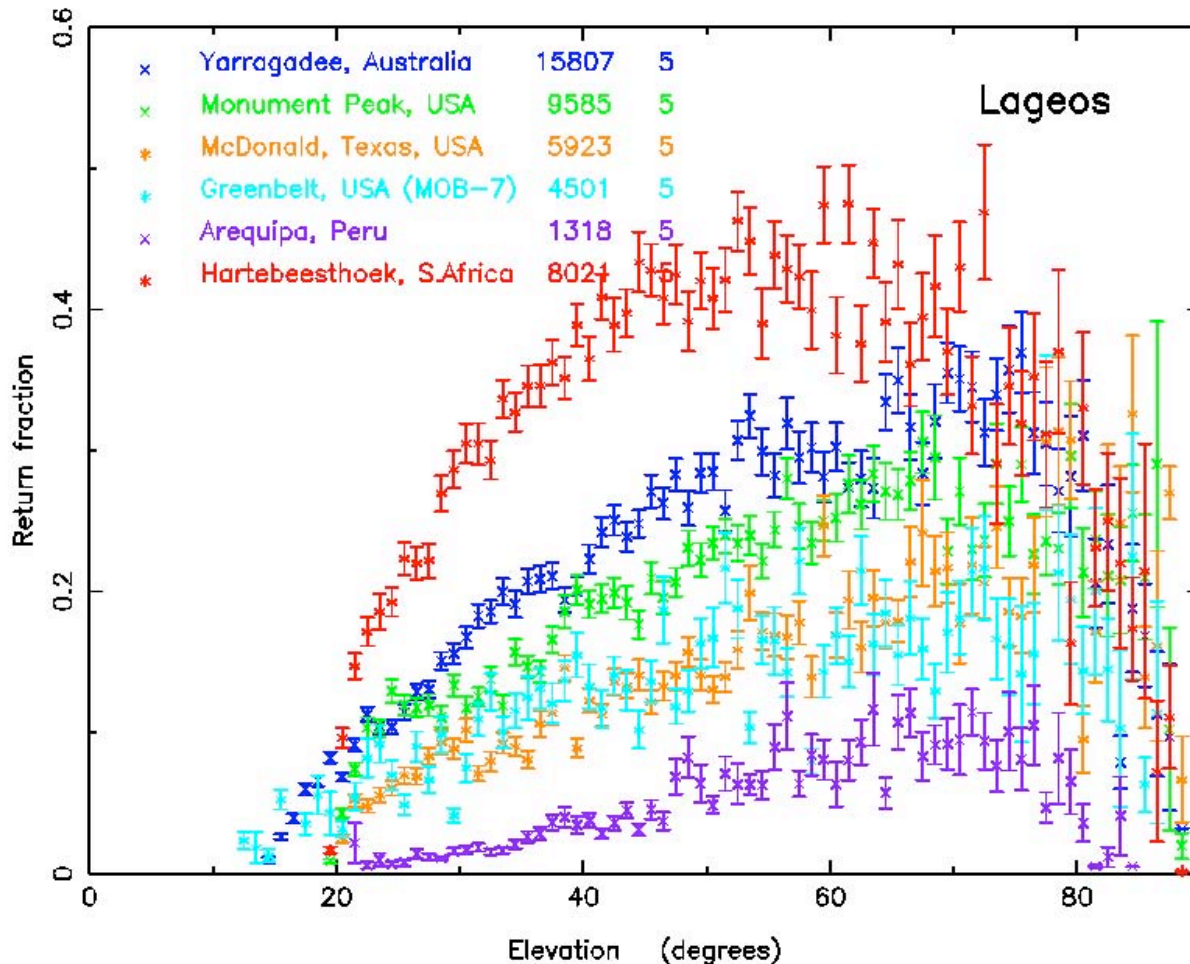
- Varying level of return rate with elevation.

- Lower levels of return rate at high and low elevation.

Lageos 1 and 2 combined

NASA MCP systems

Fraction of returns to shots fired varying with elevation



- Variation in return rate between stations.

- Varying level of return rate with elevation.

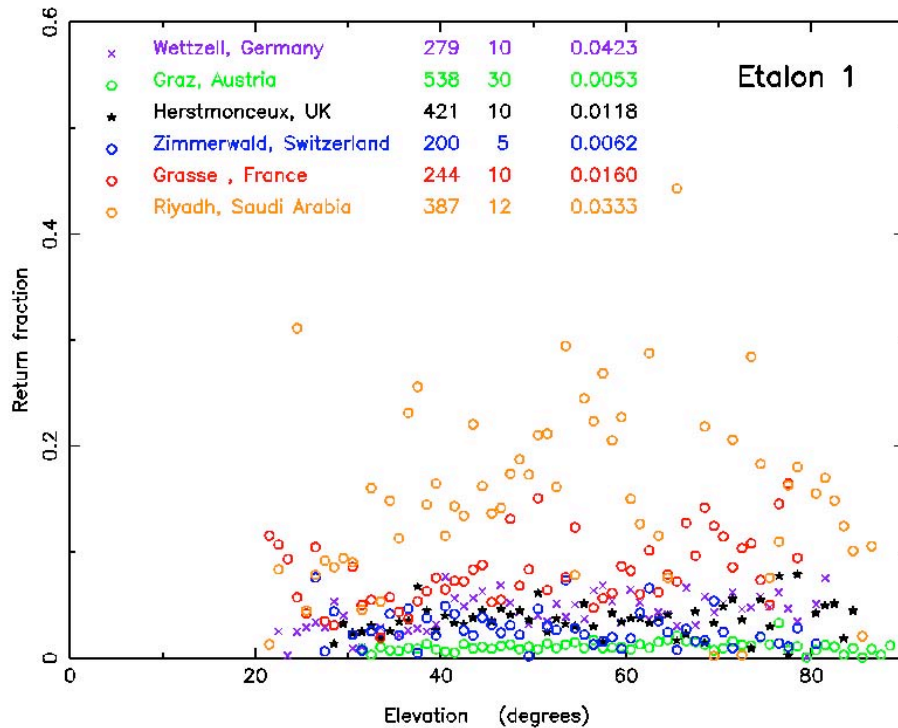
- Lower levels of return rate at high and low elevation.

Etalon 1 and 2

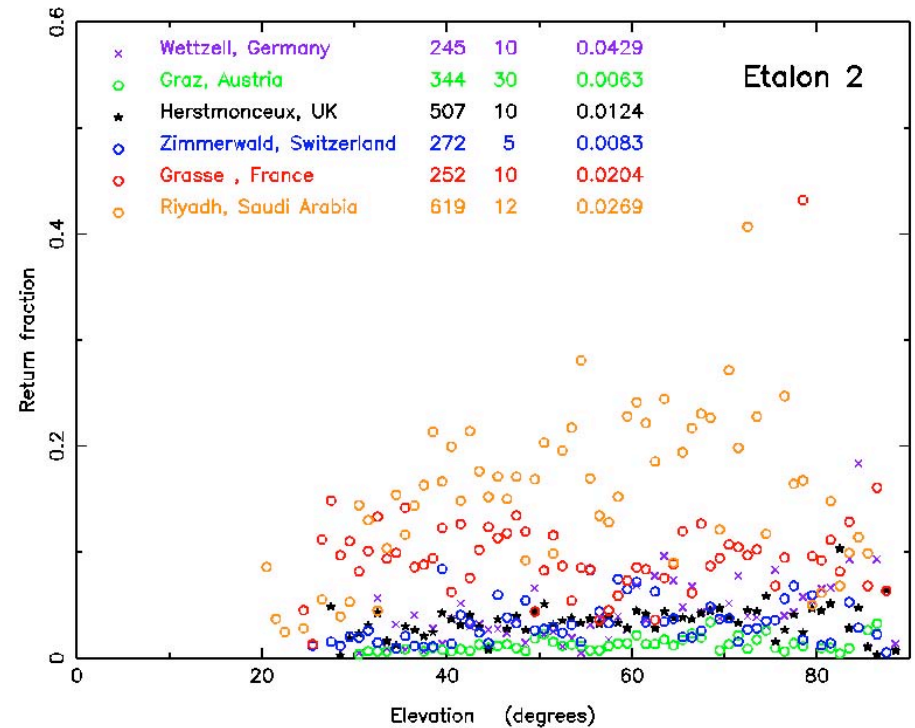
C-SPAD systems

- Similarity between satellites
- Similarity between stations

Fraction of returns to shots fired varying with elevation



Fraction of returns to shots fired varying with elevation



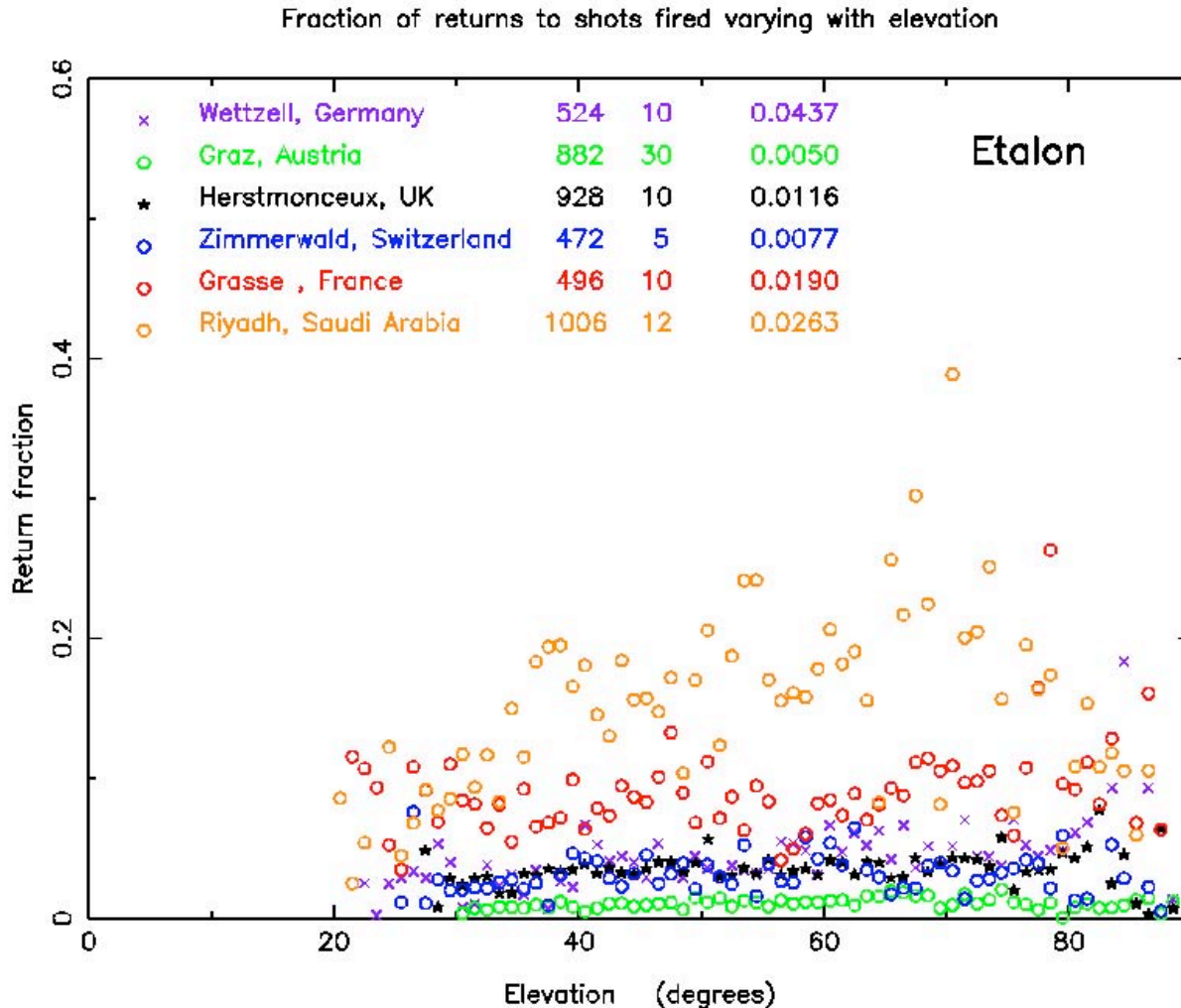
Plots contain: No. of NPs; Fire rate; Average return efficiency

Etalon 1 and 2 combined

C-SPAD systems

- Mostly observed at low return rate

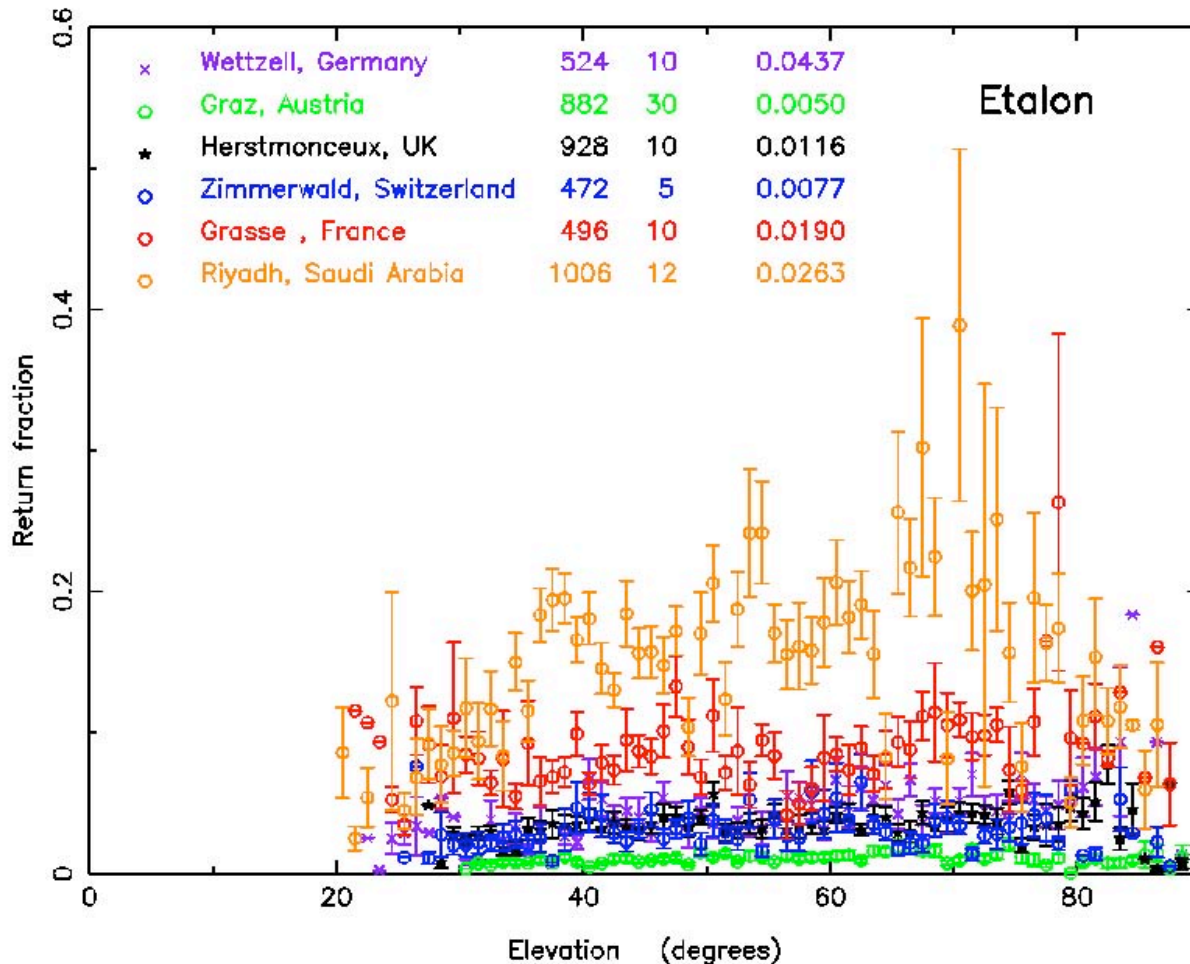
- Return rate consistent at low level with increasing elevation.



Etalon 1 and 2 combined

C-SPAD systems

Fraction of returns to shots fired varying with elevation



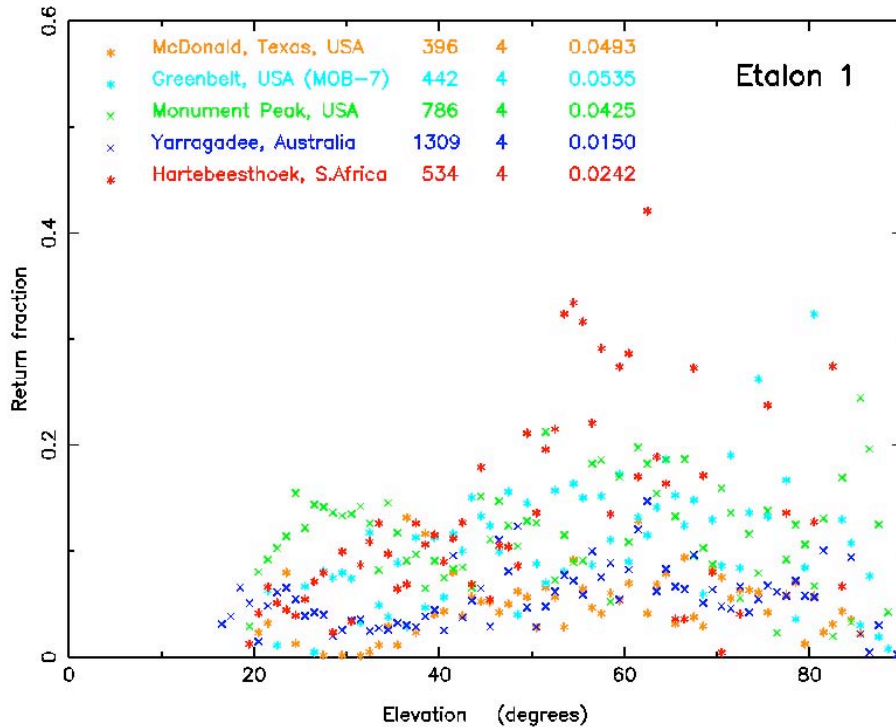
- Mostly observed at low return rate
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Etalon 1 and 2

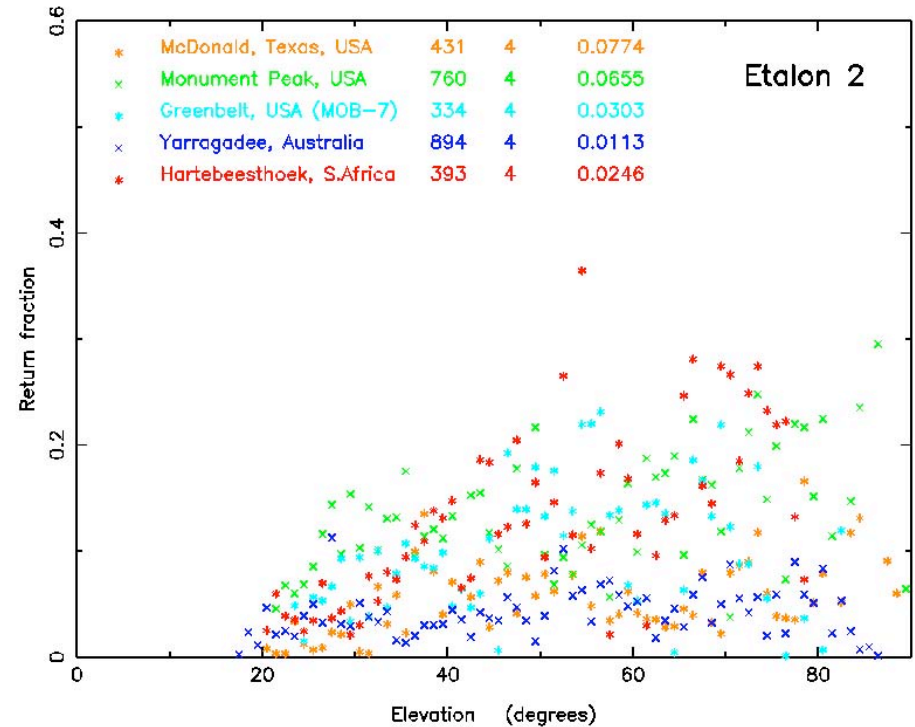
NASA MCP systems

- Similarity between satellites
- Slight similarity between stations

Fraction of returns to shots fired varying with elevation



Fraction of returns to shots fired varying with elevation

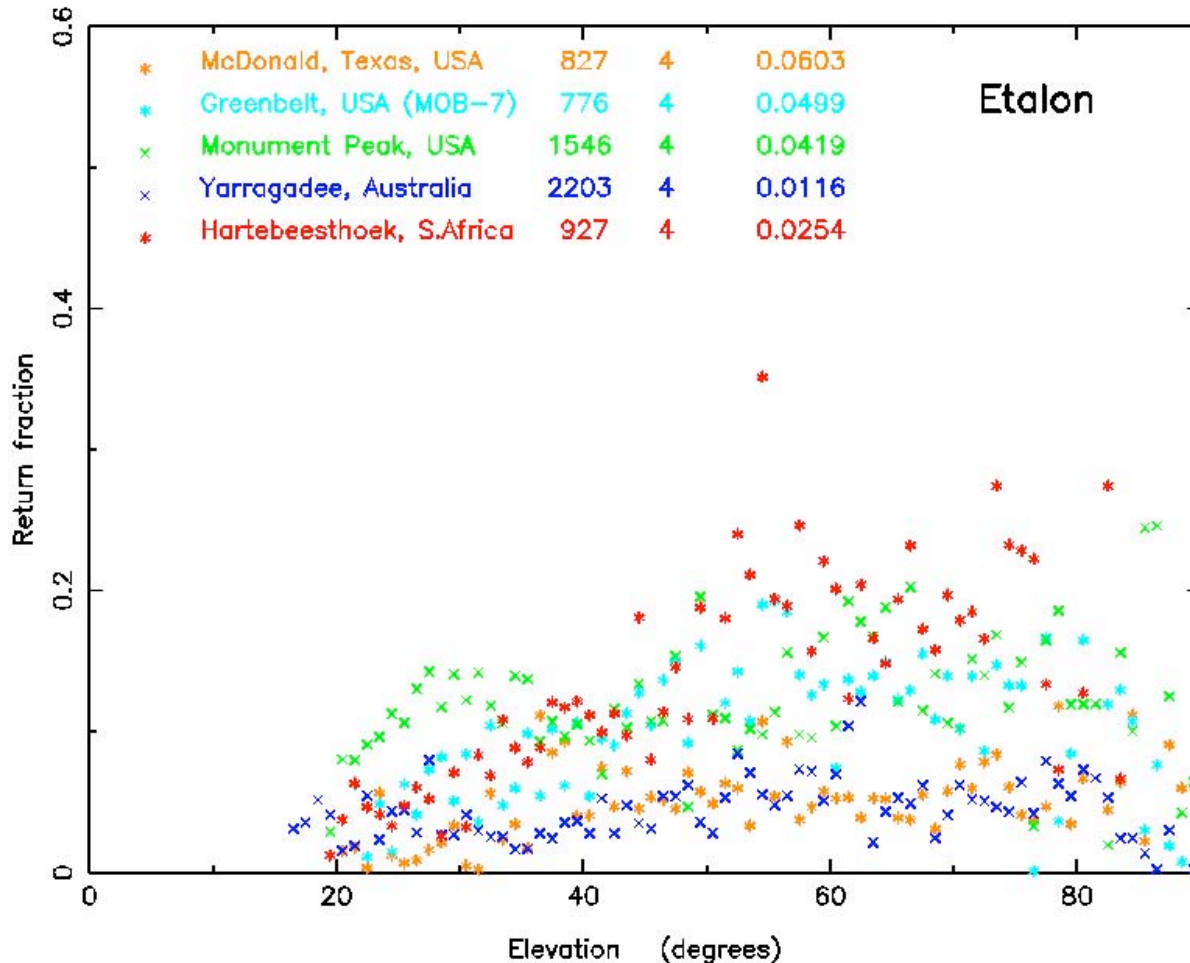


Plots contain: No. of NPs; Fire rate; Average return efficiency

Etalon 1 and 2 combined

NASA MCP systems

Fraction of returns to shots fired varying with elevation

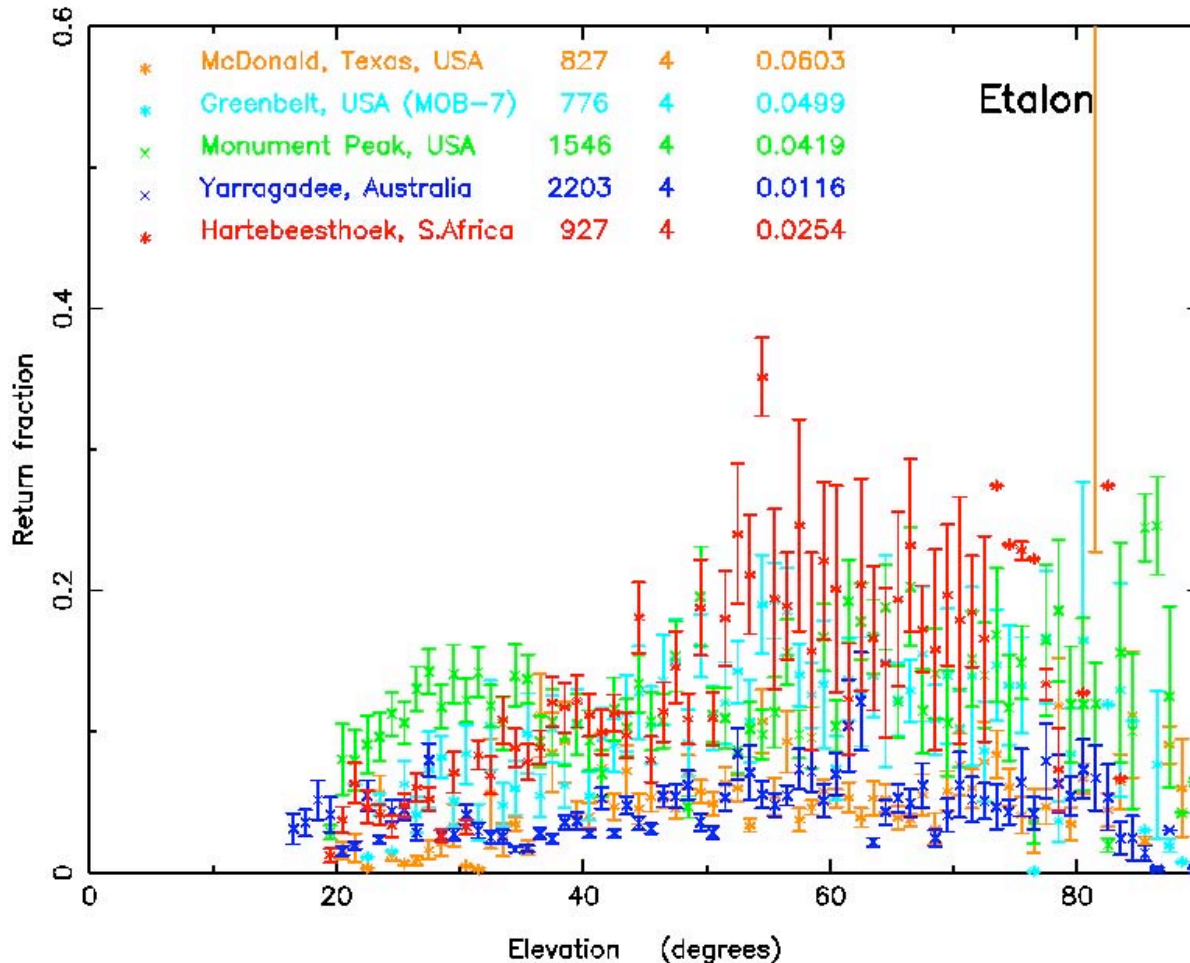


- Mostly observed at low return rate.
- Difference in return rate between stations.
- Return rate consistent at low level with increasing elevation.

Etalon 1 and 2 combined

NASA MCP systems

Fraction of returns to shots fired varying with elevation



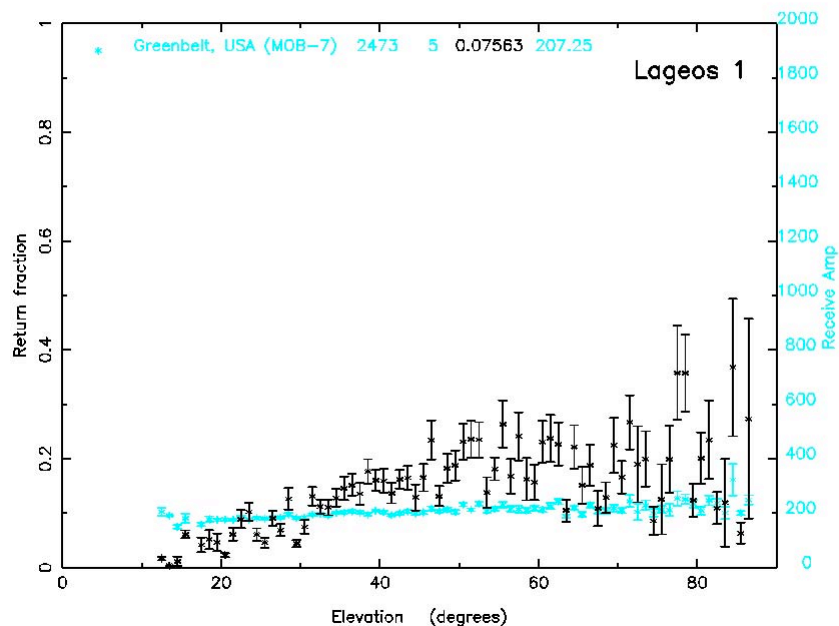
- Mostly observed at low return rate.
- Difference in return rate between stations.
- Return rate consistent at low level with increasing elevation.

- The estimated return rate is greater for the nearer Lageos satellites than for the more distant Etalon satellites.
- The return rate varies between stations. This is particularly true between MCP and C-SPAD stations and also between MCP stations.
- The return rate varies with elevation. This is shown in the Lageos return rate plots and is greater for the NASA MCP systems.

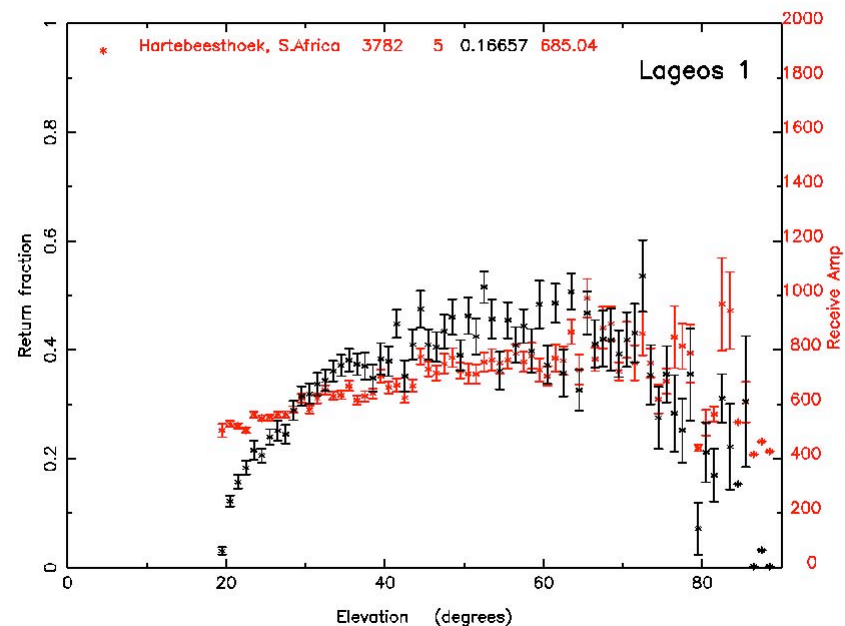
Receive Amplitude

- The full-rate archive contains an entry called ‘receive amplitude’ which is used by NASA MCP stations. It is a linear scale varying from 0 to 2000.
- This value is related to the true return rate and could be used as a substitute in analyses.
- However, the information is supplied by only a few stations and we believe it is incorrectly scaled for Yarragadee, Australia.

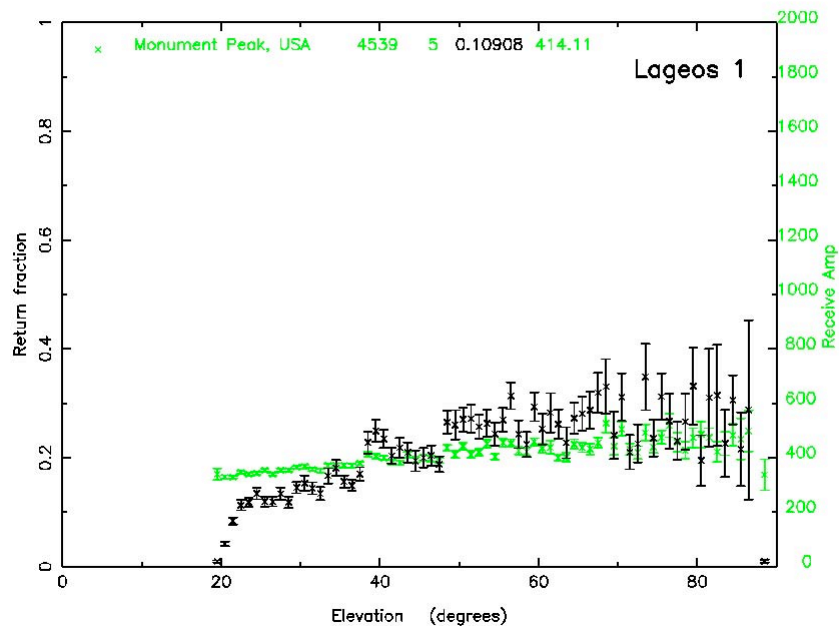
Return and Receive signals varying with elevation



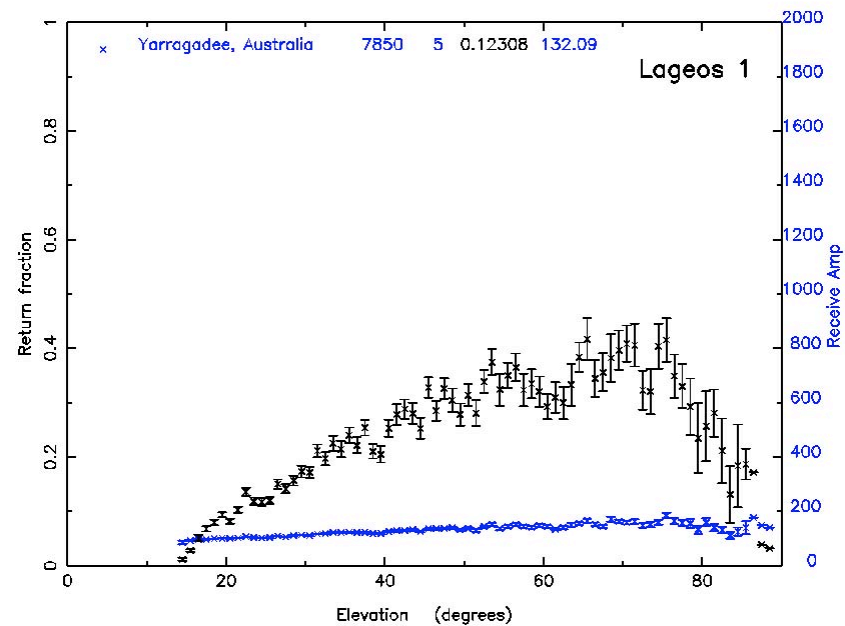
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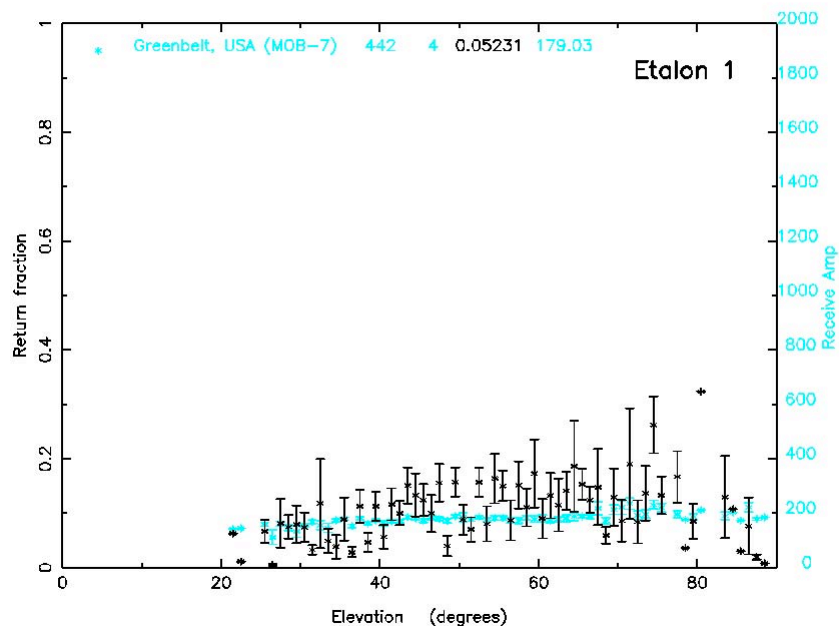
Return and Receive signals varying with elevation



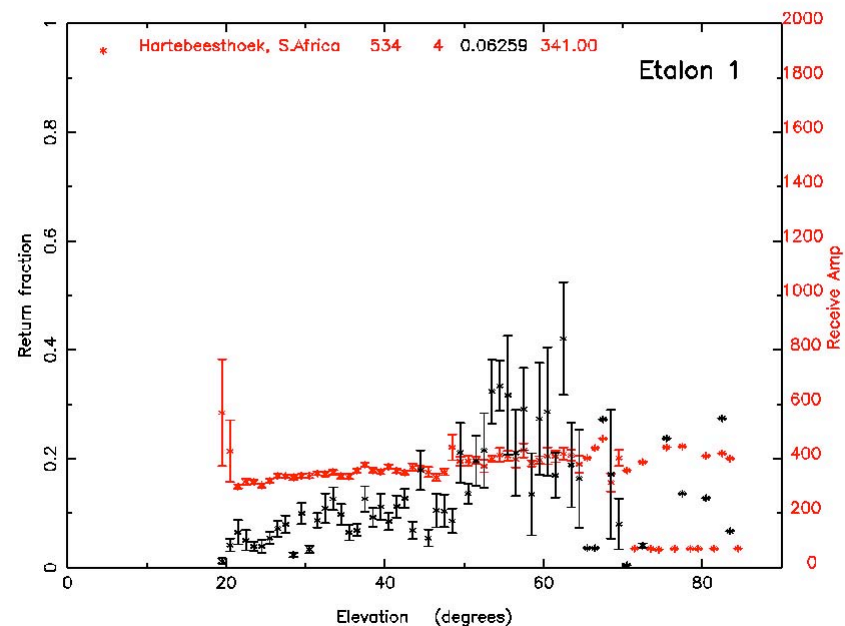
Return and Receive signals varying with elevation



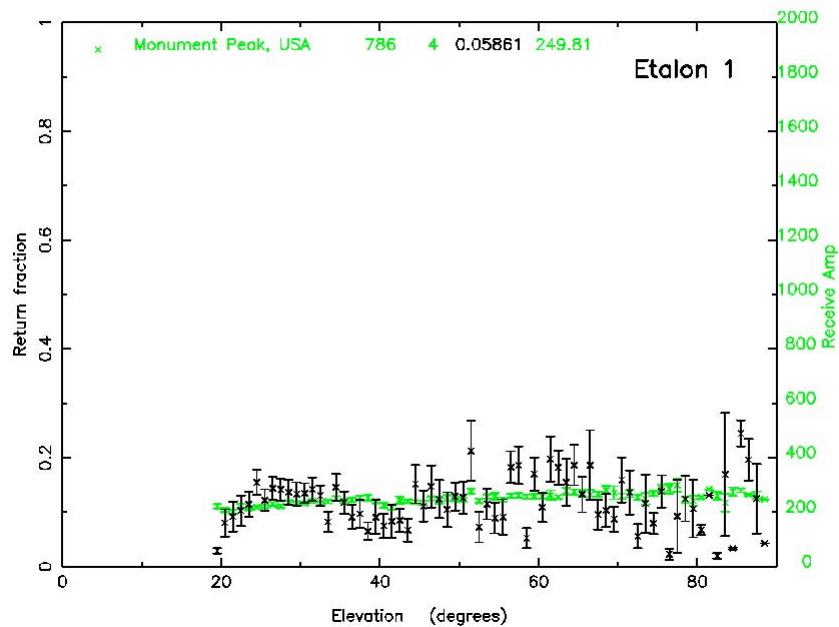
Return and Receive signals varying with elevation



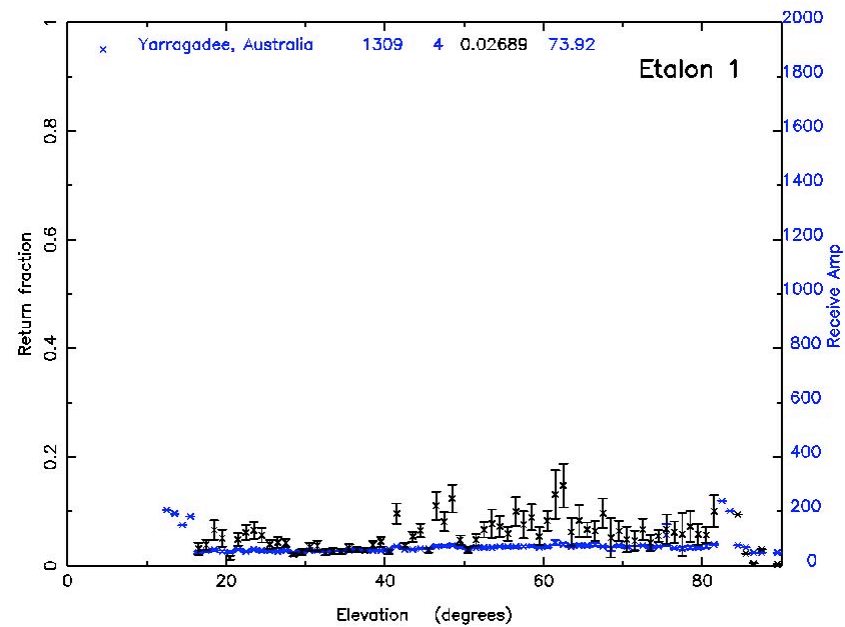
Return and Receive signals varying with elevation



Return and Receive signals varying with elevation



Return and Receive signals varying with elevation



Conclusion

The strength of the return signal from a satellite can effect the accuracy of the resulting range measurement.

This difference can (*and should*) be quantified in high/low return rate experiments at each station.

Conclusion

Return rate varies between stations.

Return rate varies between satellites.

Return rate varies with elevation.

Maintaining a consistent return rate during all observations will provide more consistent measurements.