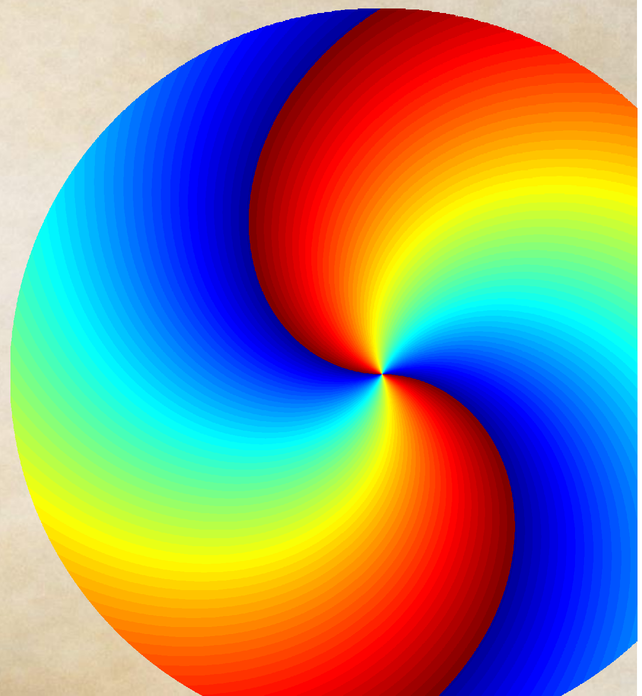
Polarisation at SGF, Herstmonceux

Matthew Wilkinson,
Toby Shoobridge

SGF, Herstmonceux. UK



“Improving support for GNSS and other challenging missions”
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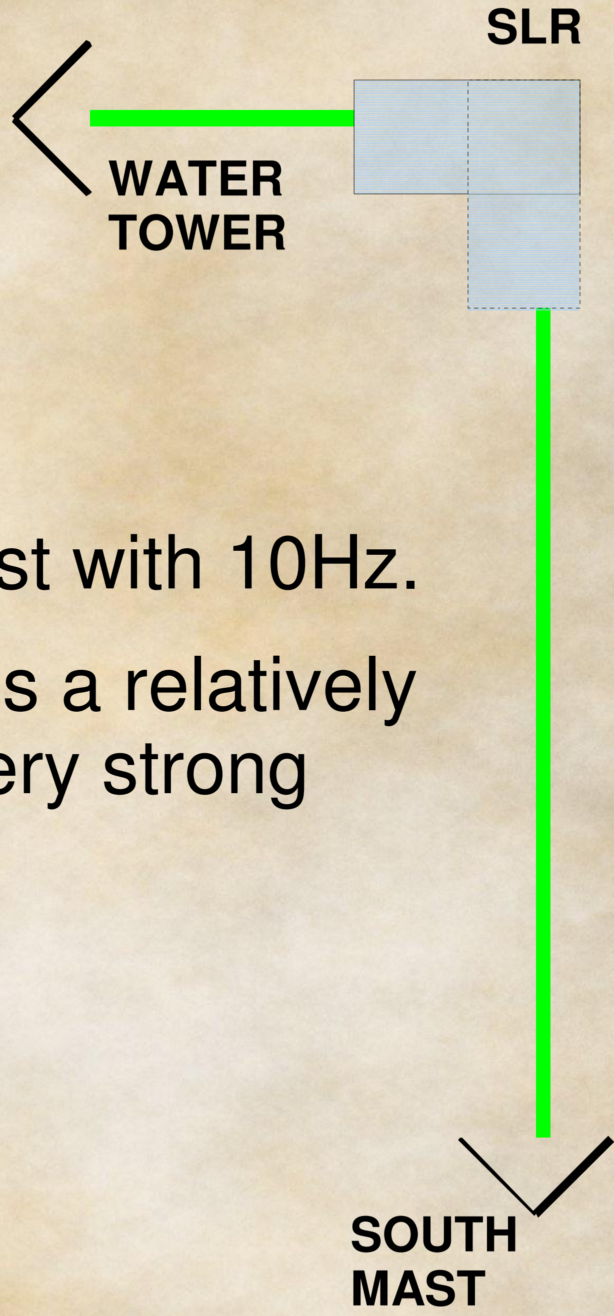
Introduction

Our interest began from observing phenomena thought to be caused by polarisation effects in the system.

This talk will describe:

- Tests designed to determine polarisation effects
- Cause and solutions
- Further investigations into polarisation
- Applications

First polarisation observation



Calibrating at two SGF SLR targets: one on the nearby **Water Tower** and a second, more distant target on the **South Mast**.

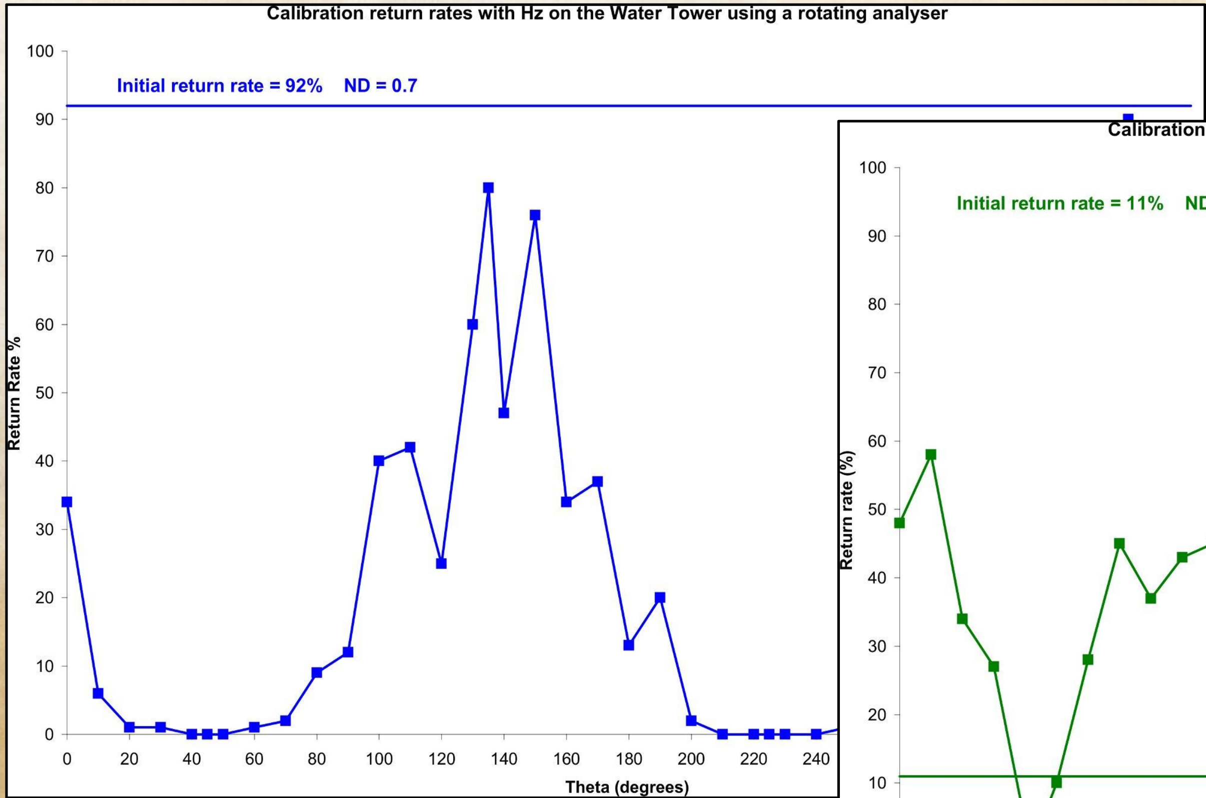
It was slow to calibrate on the South Mast with 10Hz.

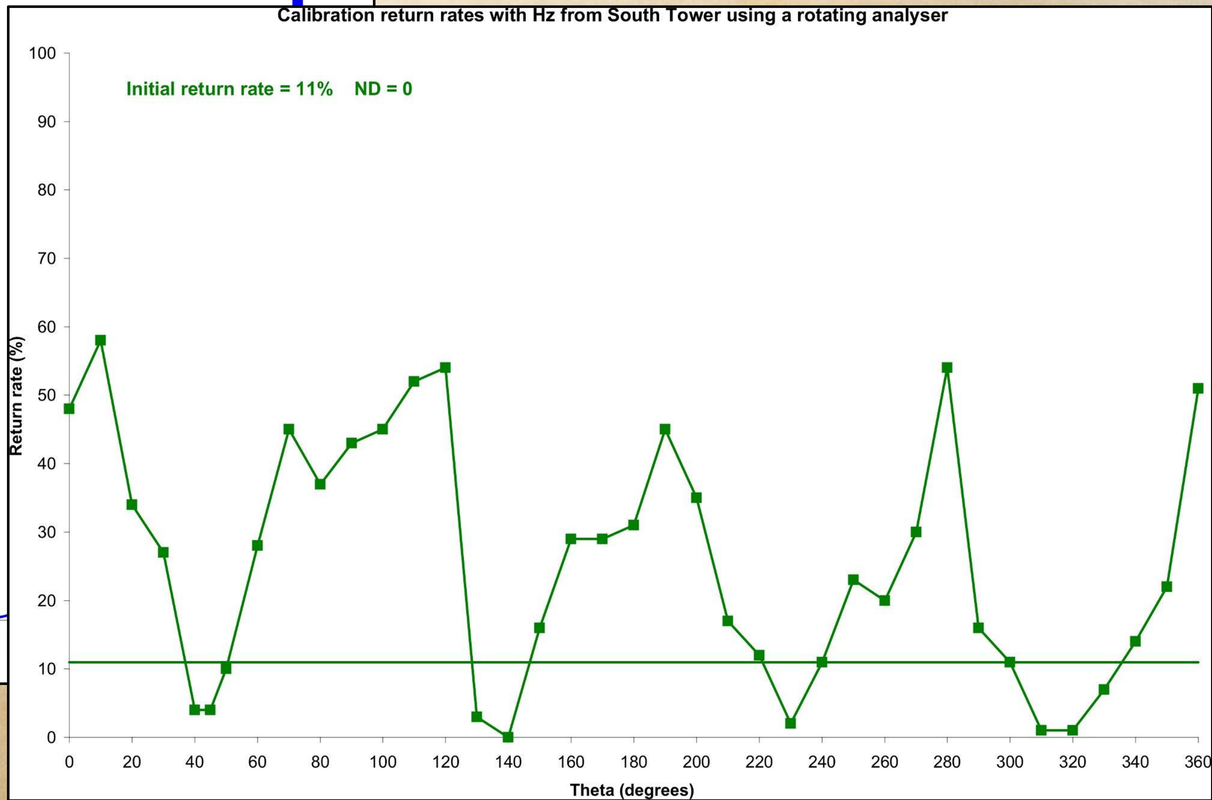
However, installing the kHz laser gave us a relatively weak signal on the West Tower and a very strong signal in the South.

Opposite to the 10Hz results!

First polarisation experiment

To observe the emitted polarisation orientation a polarising sheet 'analyser' was placed on the emitter window and rotated.



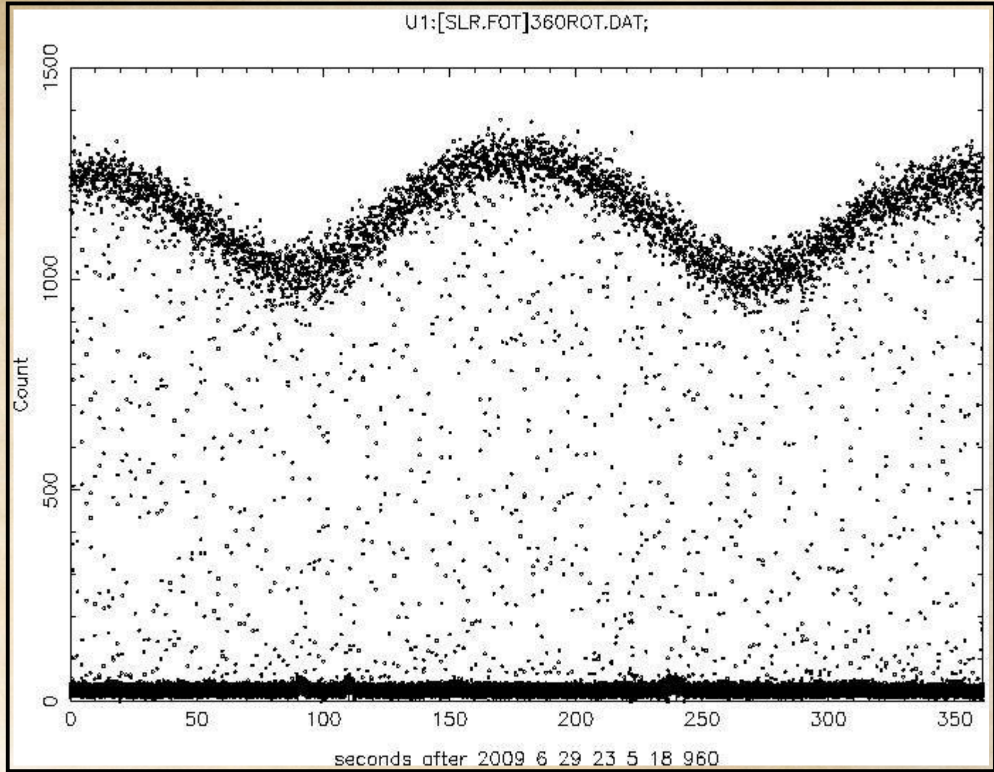


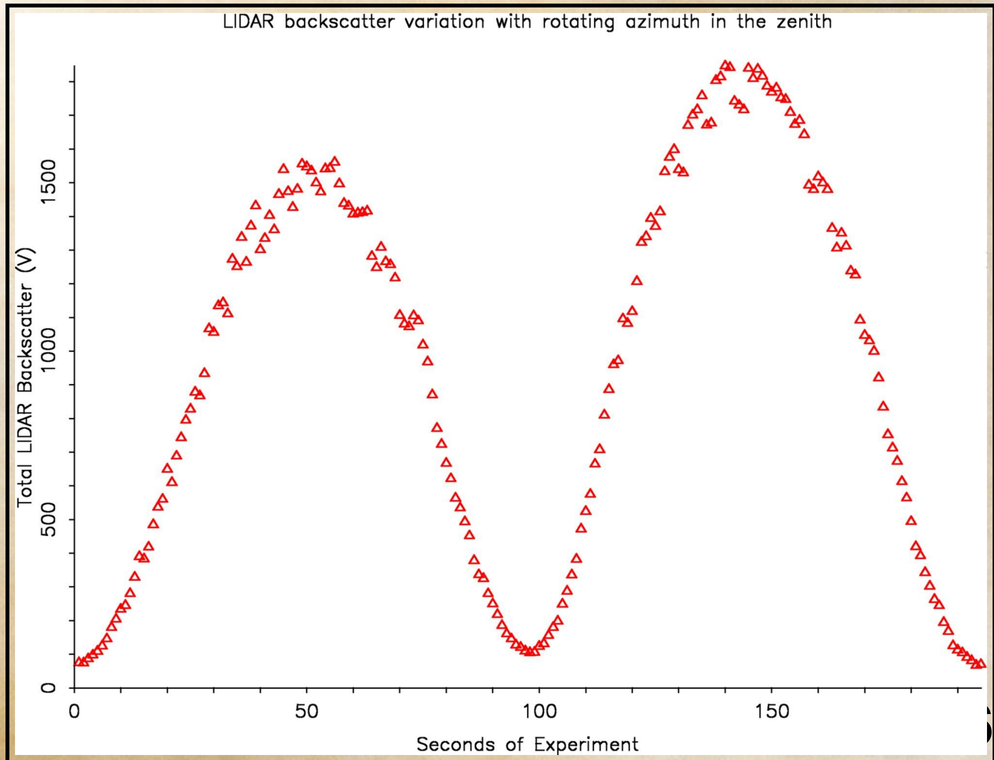
2nd polarisation observation

The beam as seen in the daytime camera would be invisible in certain parts of the sky.

The zenith backscatter was measured using a photon counter on the 2nd telescope port and a PMT on the 1st (SPAD) port and rotating the telescope in azimuth.

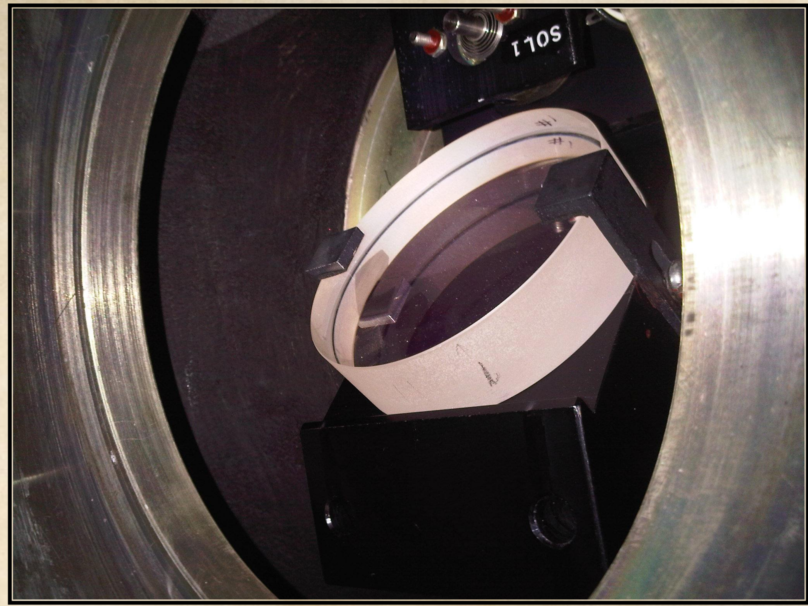
The opposite phases of the results indicated that the 45º **Dichroic Mirror** was the cause.

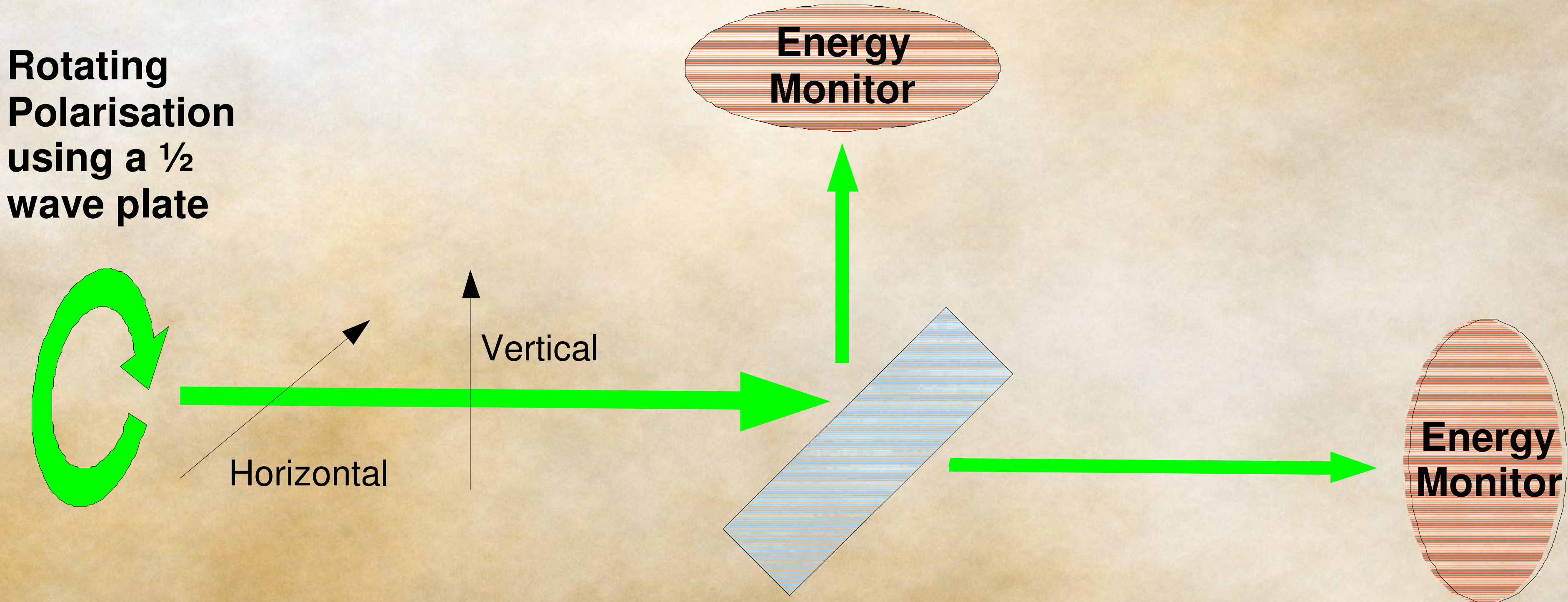




Standard Mirror test

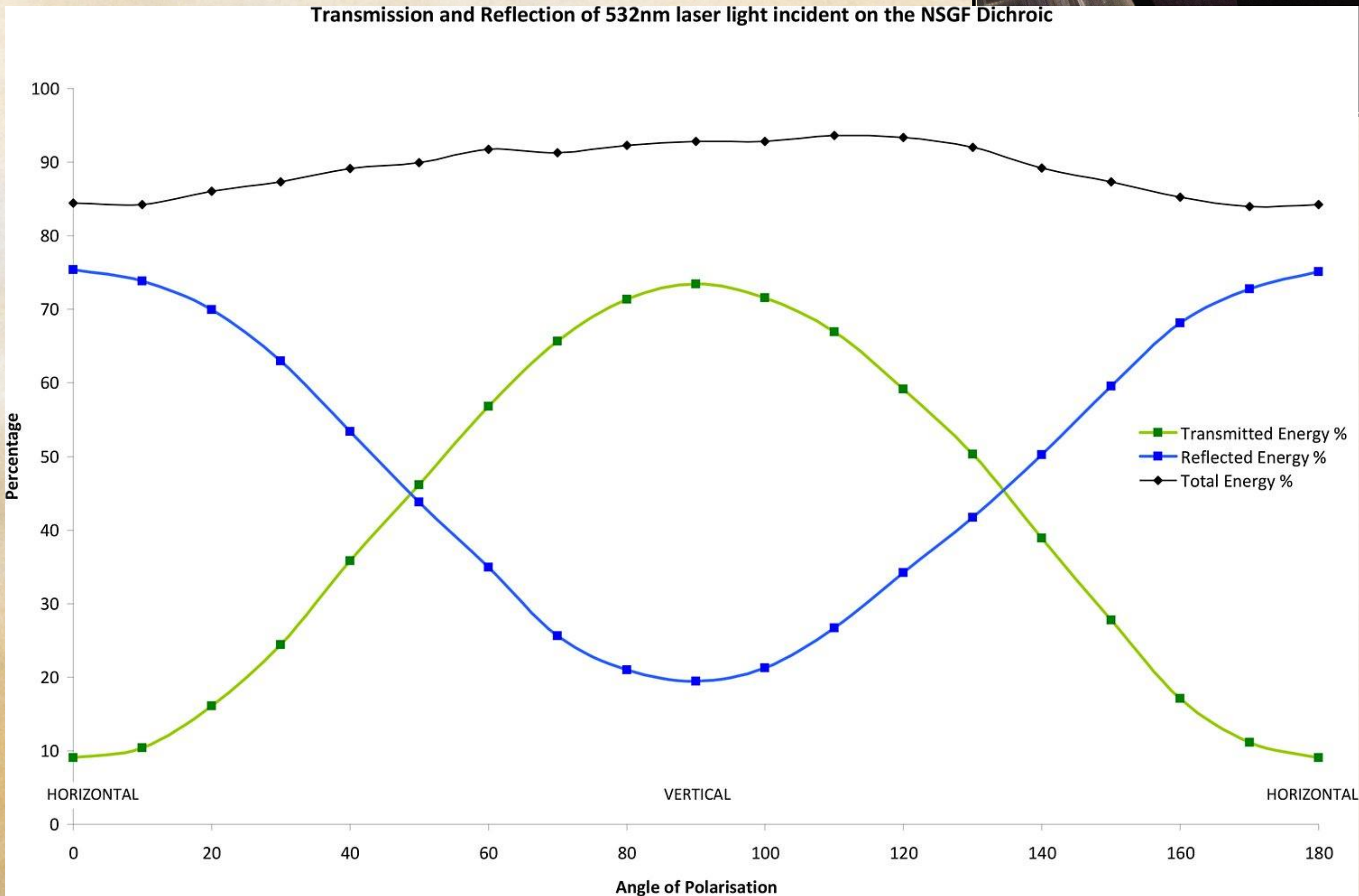
The dichroic was removed and a test was designed to establish its variation with polarisation.





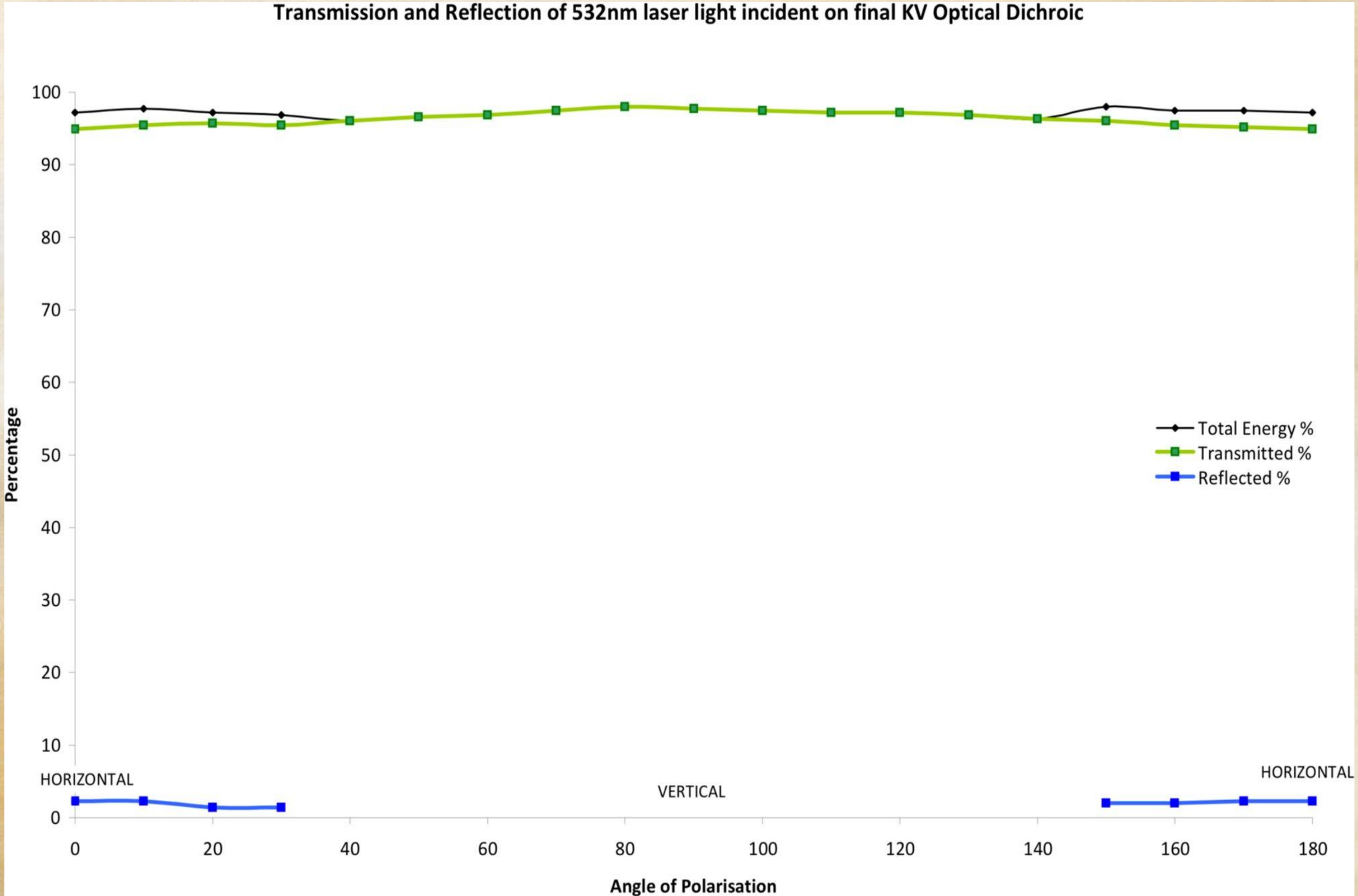
Dichroic

The dichroic was removed and a test was designed to establish its variation with polarisation.



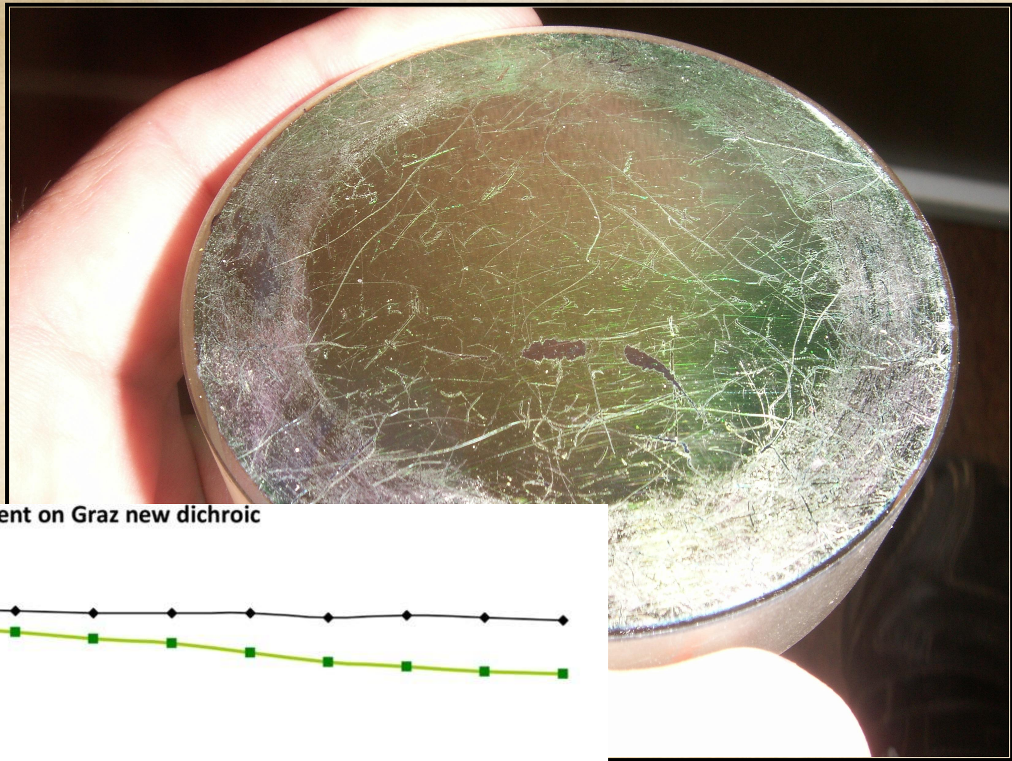
Dichroic

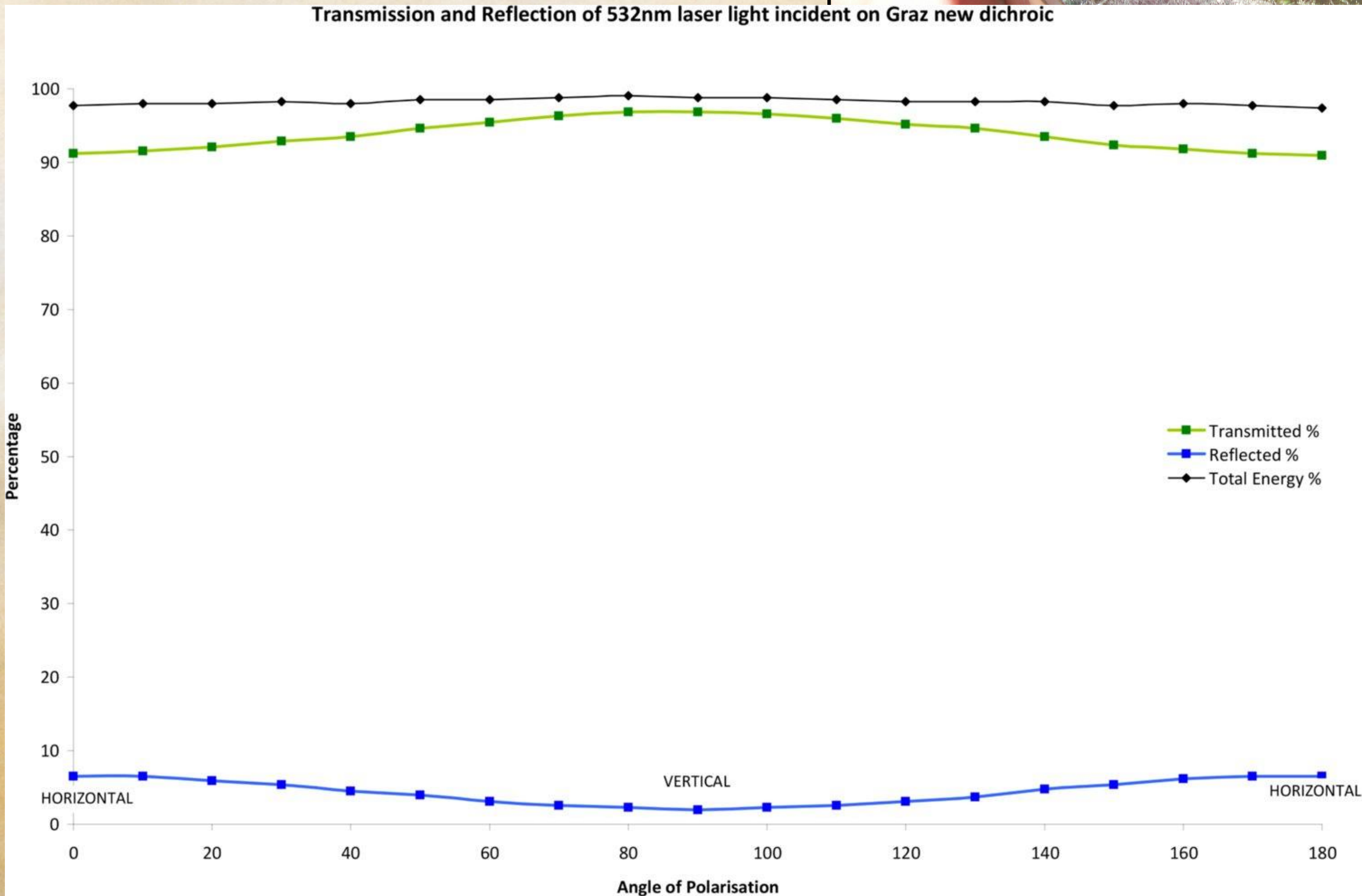
A UK company called **KV Optical** made a number of designs for an 'ideal' dichroic, each of which underwent our standardised test, until a final design was accepted.



Graz Dichroic

The Graz station now also benefits from a new dichroic.

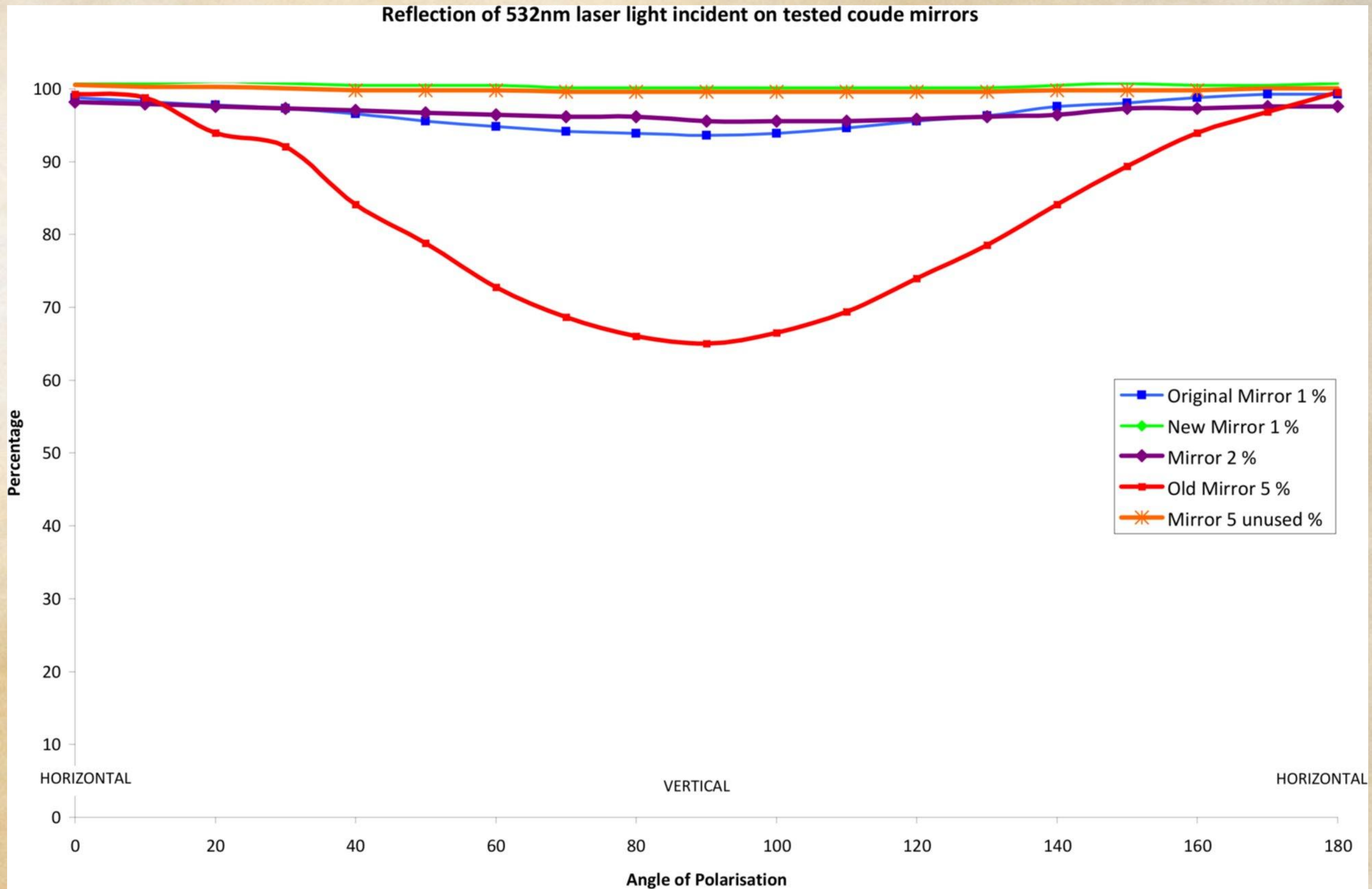




Testing Coudé Mirrors

The light leaving both lasers hits a chain of 5 mirrors before exiting from the emitter telescope.

Each of these mirrors needs to be as reflective as possible for 532nm light – **for all polarisations**.

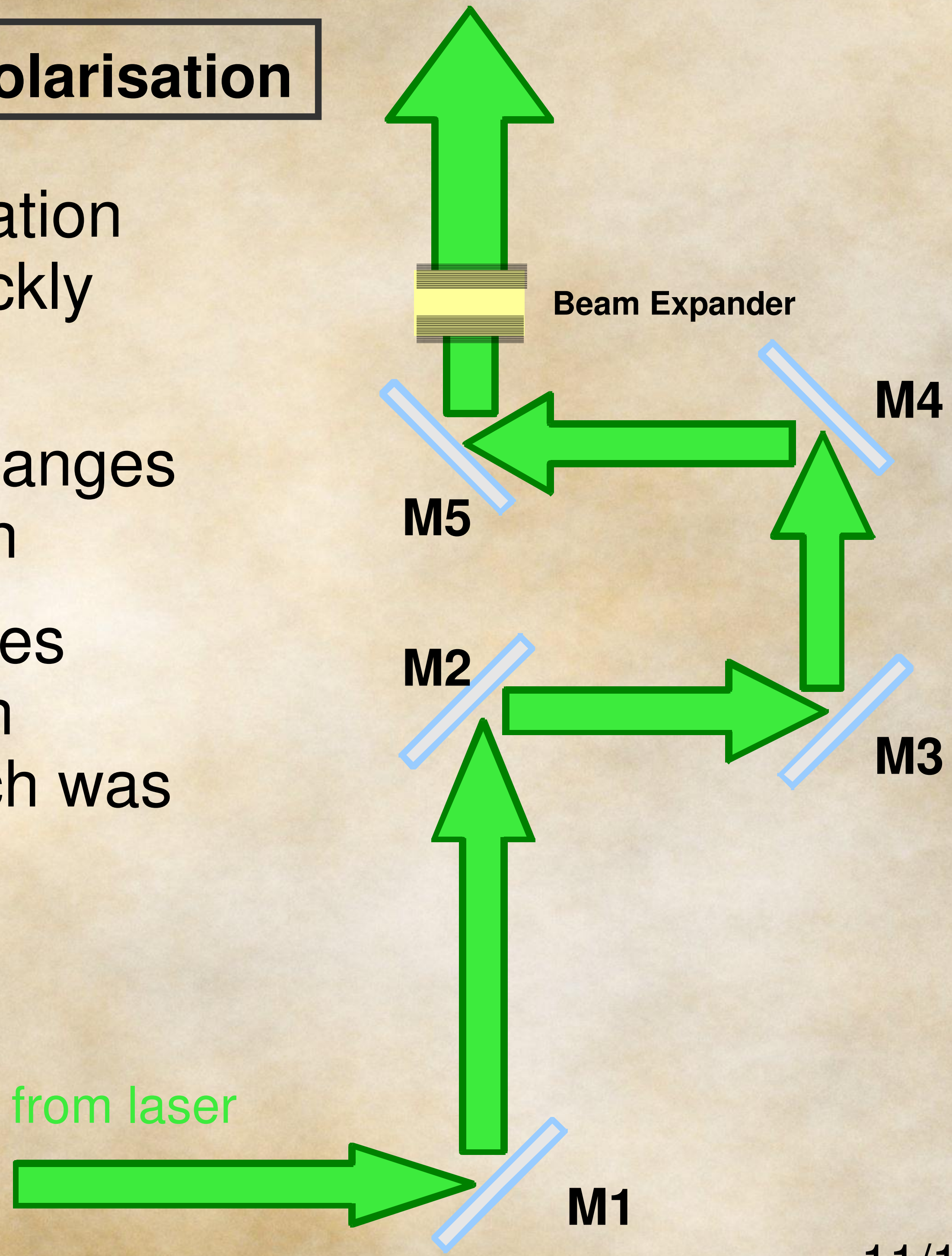


Testing Coudé Mirrors - Polarisation

From studying the polarisation through the coudé we quickly learnt:

Polarisation orientation changes with azimuth and elevation

Linear polarisation becomes **circular** in certain azimuth positions - due to M2 which was replaced.



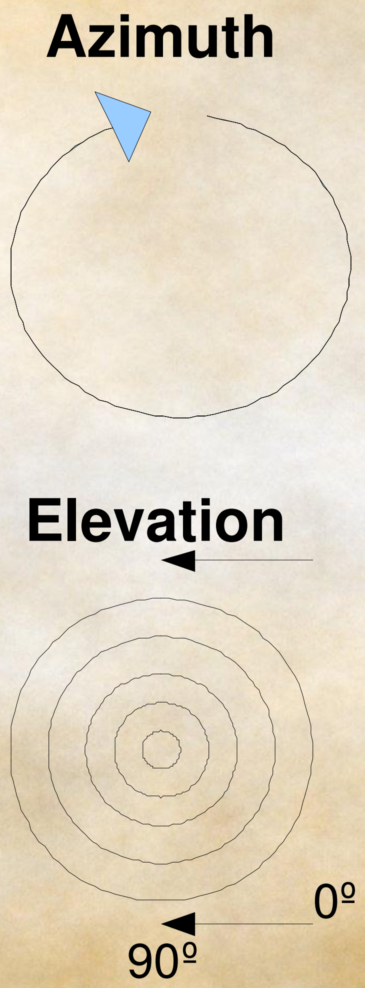
Testing Coudé Mirrors - Polarisation

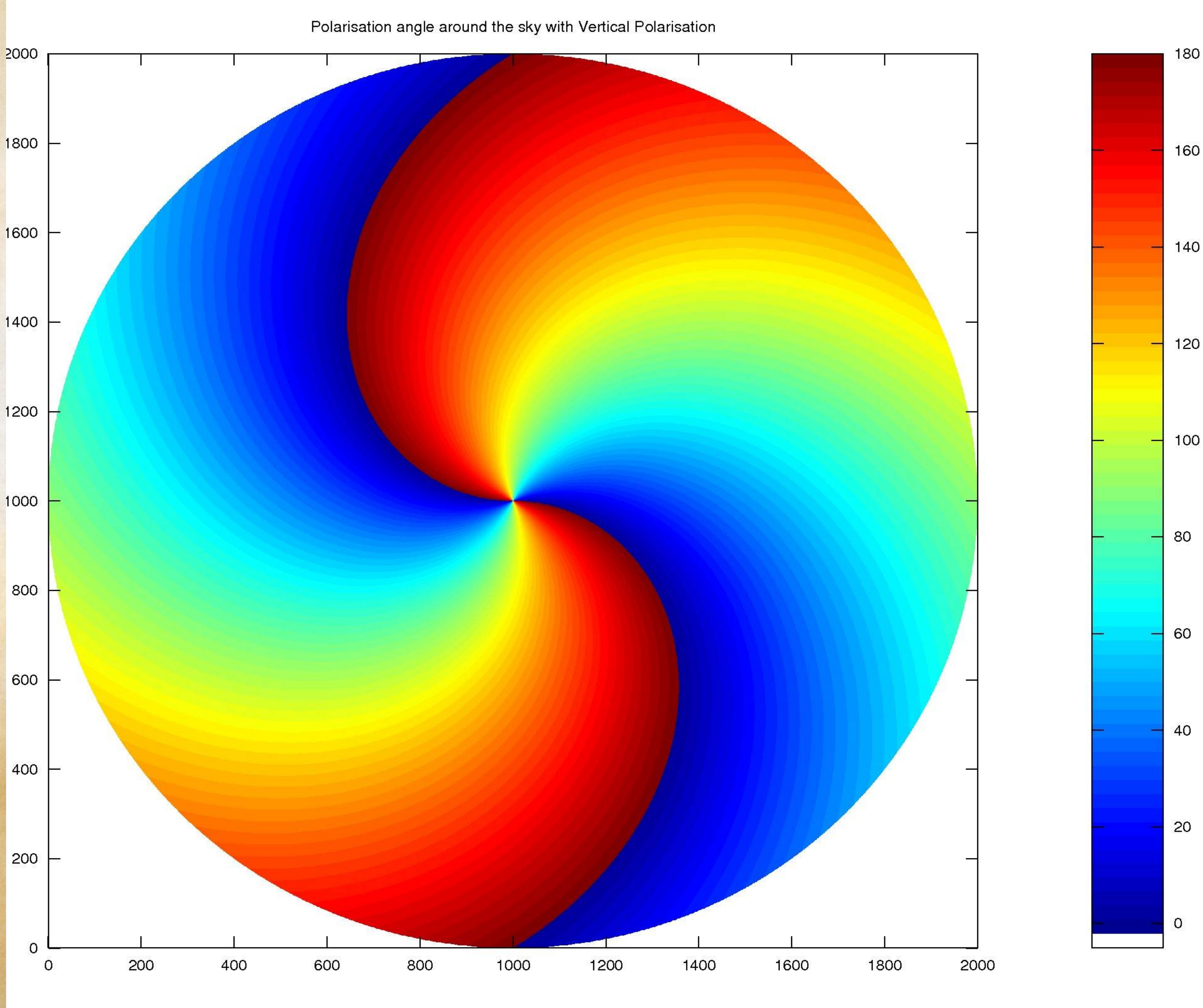
By considering the laser polarisation as linear and in two perpendicular components, perpendicular to the direction of the beam its orientation was modelled through each reflection.

This included non-planar reflections at M2 and M5, which were treated as transformations into different planes.

This was confirmed by prediction and testing using polarised sheet at different azimuths and elevations.

Modelling Polarisation





Controlling Polarisation

By reversing the modelled reflections and transformations, the input polarisation can be calculated to output a fixed polarisation.

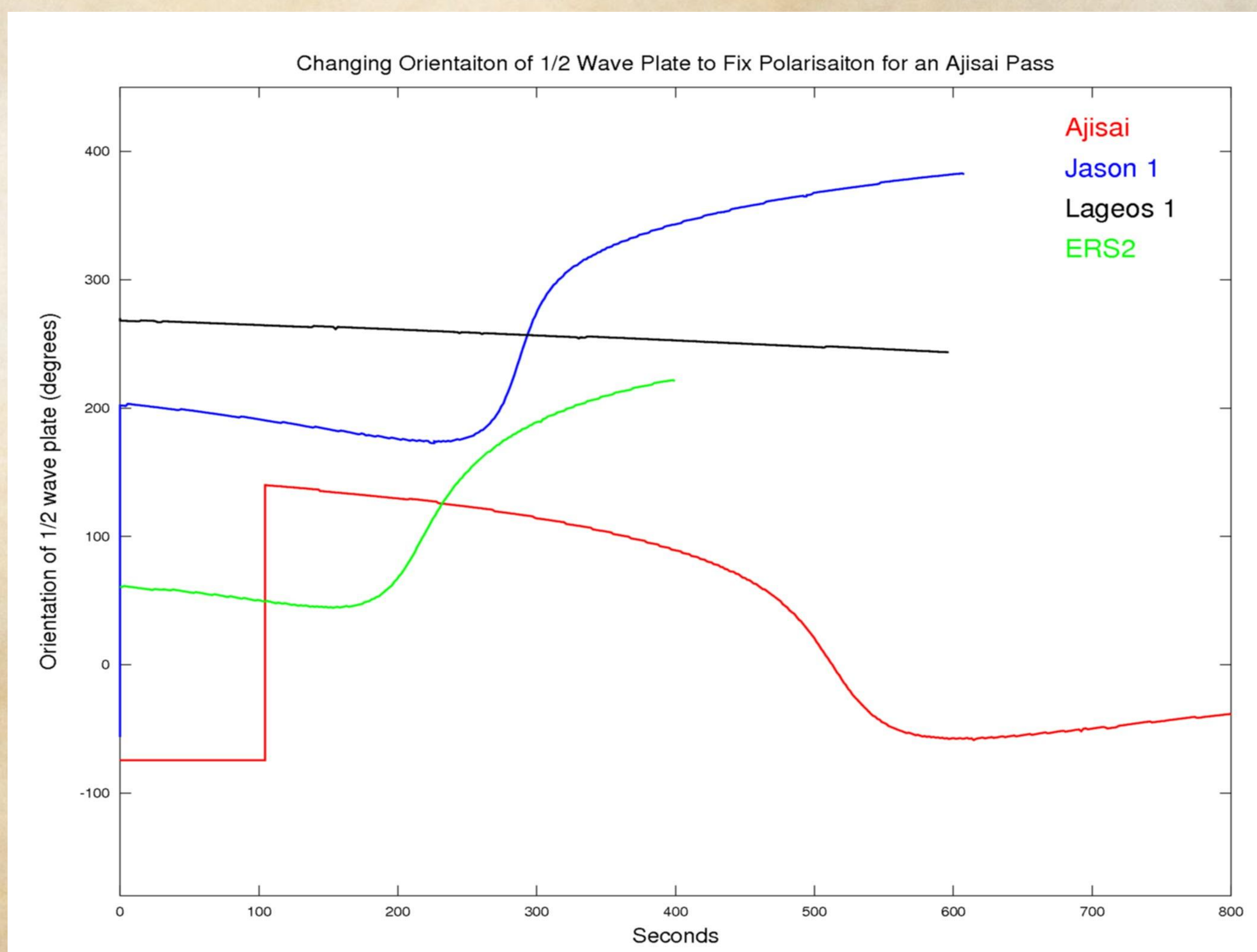
Using a 1/2-wave plate, the input polarisation was set to give an orientation parallel to the elevation axis.

This was confirmed again by prediction and testing at different azimuths and elevations.

Controlling Polarisation

Controlling the 1/2-wave plate in real-time would give a fixed chosen polarisation.

Taking some example passes the 1/2-wave plate would need only slow continuous adjustment to fix the polarisation to the elevation plane.



Conclusions

The Herstmonceux SLR station now has a far better understanding of the impact of polarisation in the system.

Replacing the dichroic mirror gave an improvement in return signal of more that 100%.

The polarisation orientation of the emitted laser beam varies across the sky.

Fixing the polarisation emitted is possible by controlling a 1/2-wave plate in real-time.

Conclusions

How does investigating polarisation help with the tracking of GNSS?

If satellite retro-reflector array response is dependent on incident polarisation then we could optimise for return rate in real-time.

If the polarisation of the returning laser light is known and preserved, then unpolarised noise could be filtered to improve the signal to noise ratio.