Lageos 2 Spin and Orientation History from Herstmonceux Photometric Observations

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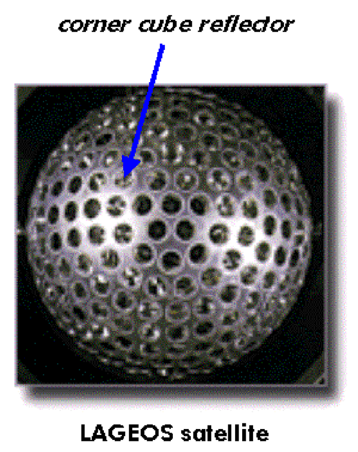
System Concepts

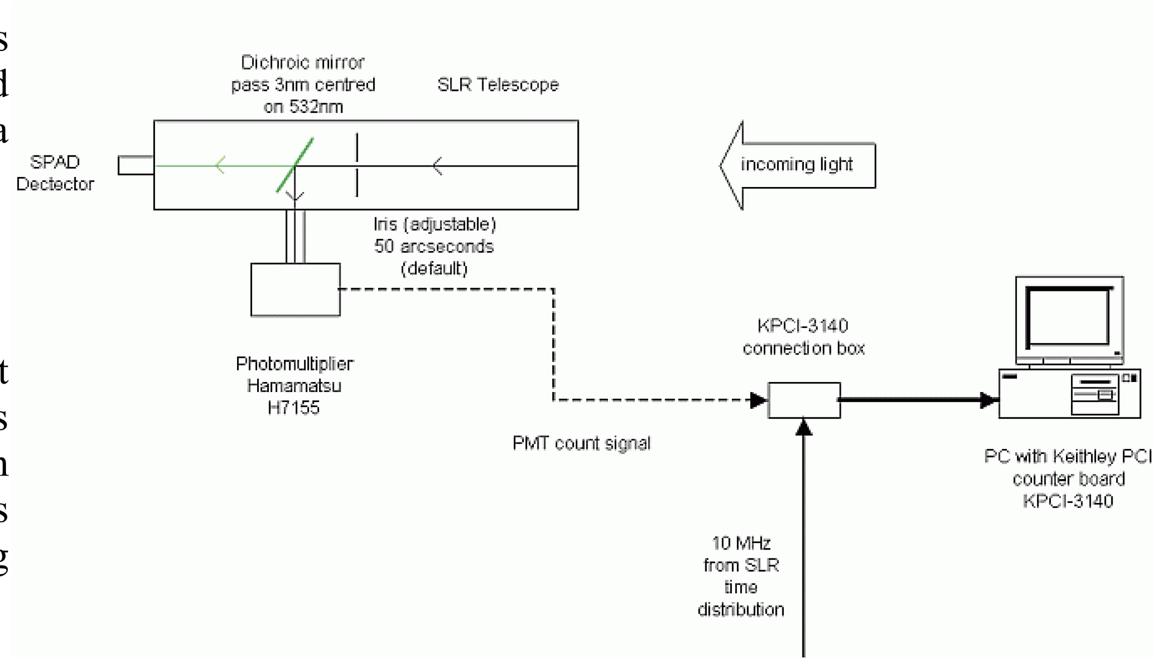


The Photometry system at Herstmonceux has been designed to allow easy operation and simultaneous SLR and photometry data collection.

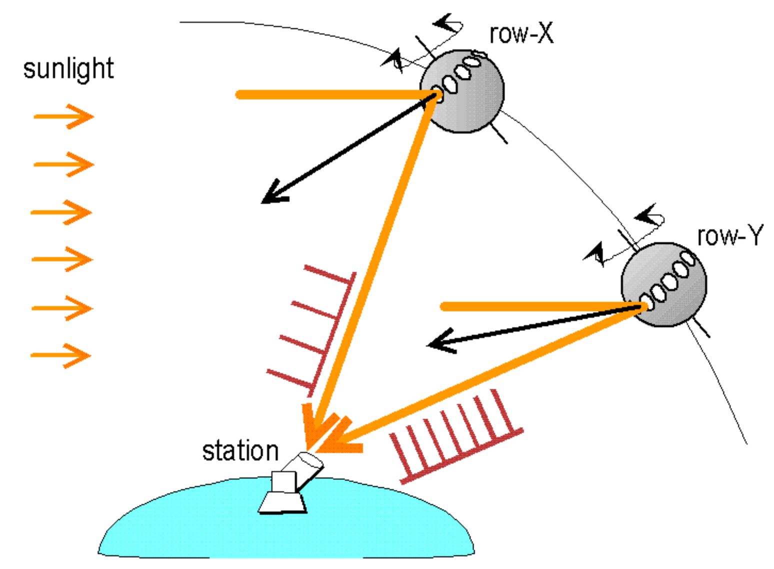
Development History

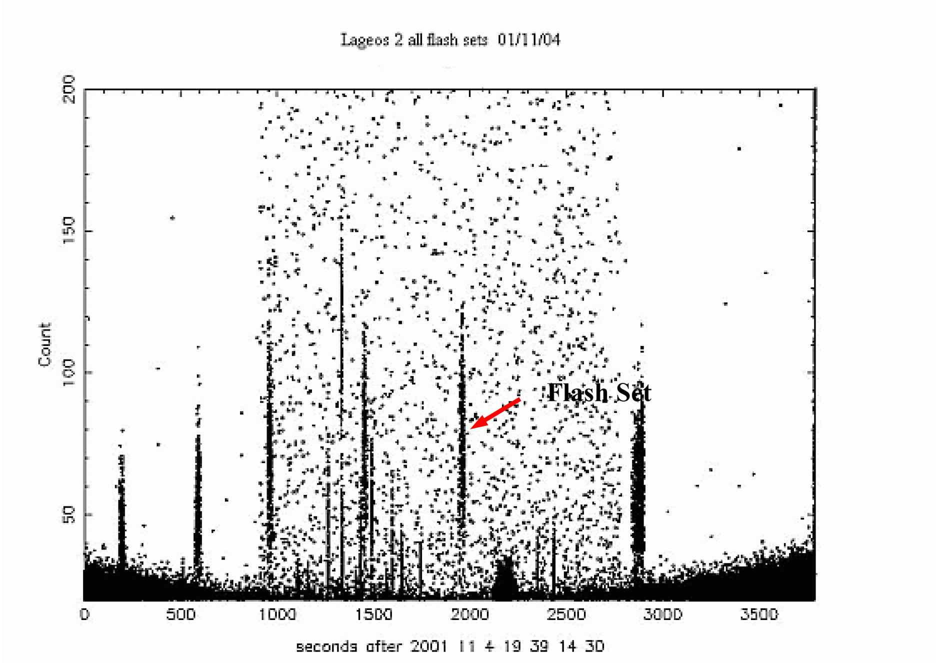
The first Lageos 2 photometry gathered at Herstmonceux was in March 2000 with 20ms time resolution. The system was upgraded in Nov 2001 to allow 1ms time resolution. This avoids confusion with laser pulses during simultaneous SLR observations.

NSGF Photometry System Schematic

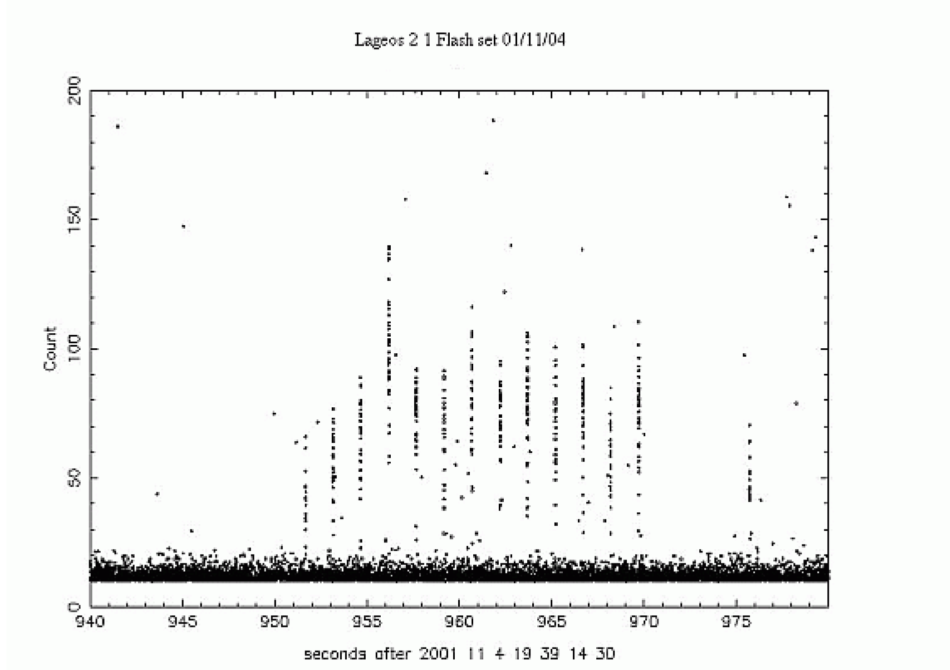


Formation of solar flashes

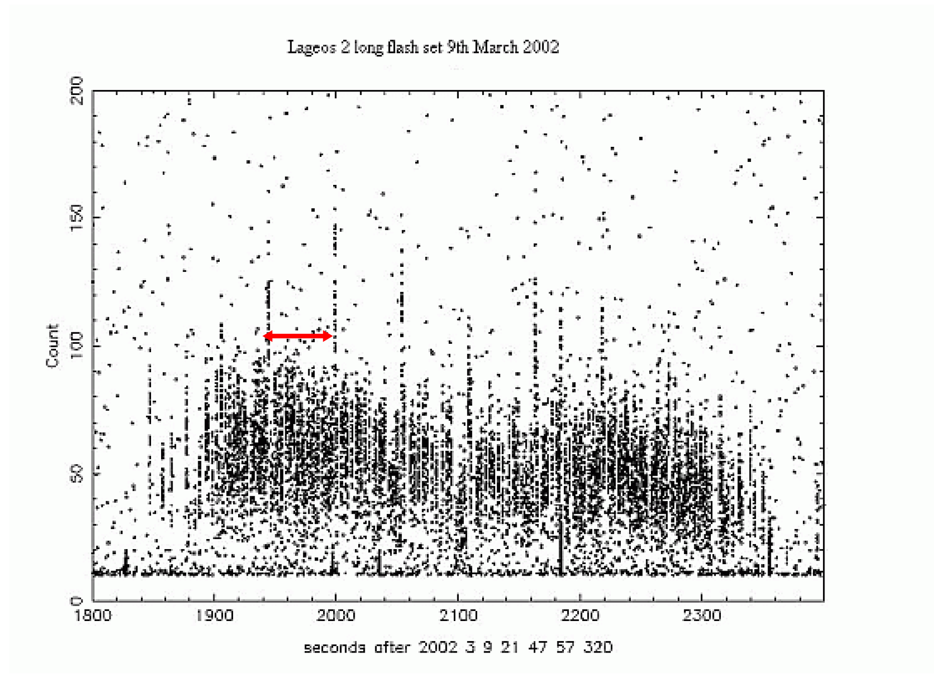




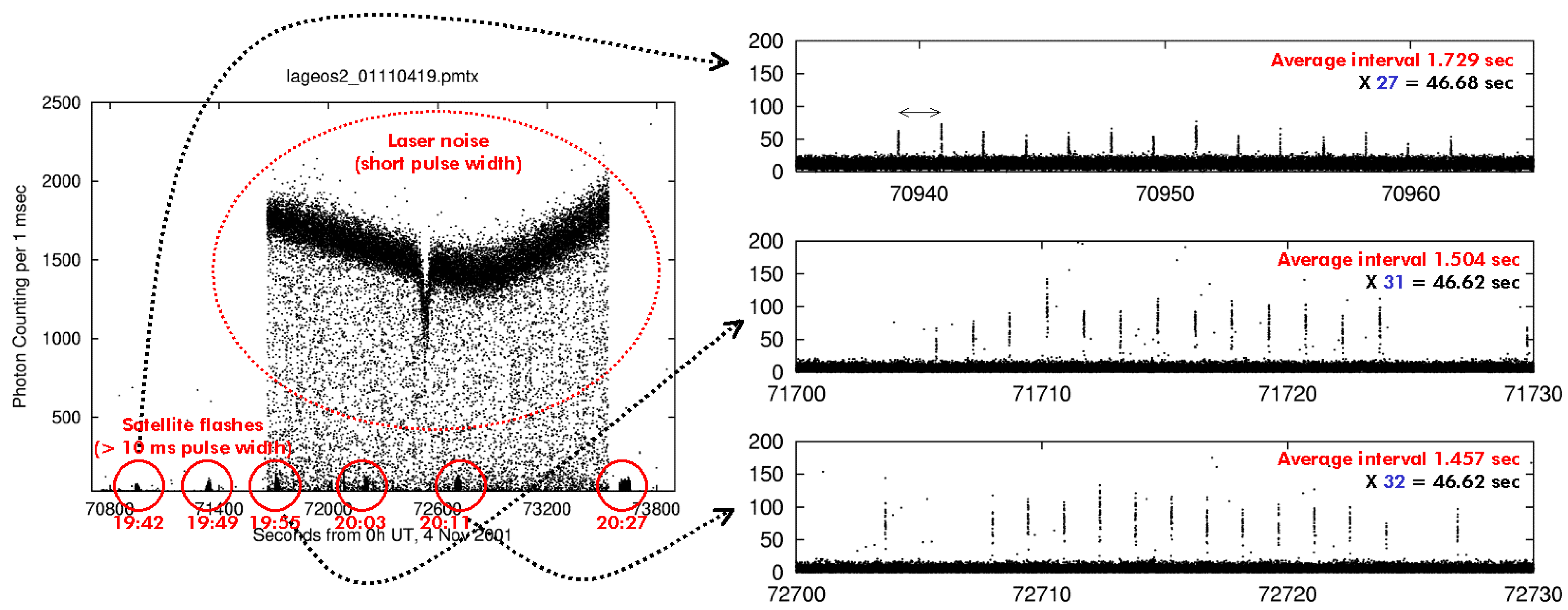
Raw data from a typical Lageos 2 observation. The area of higher noise density in the centre is when the laser is firing (when the satellite is above 30˚ elevation). The sets of Lageos flashes are the wider dense spikes. Stars passing through the iris show up as the narrow spikes.

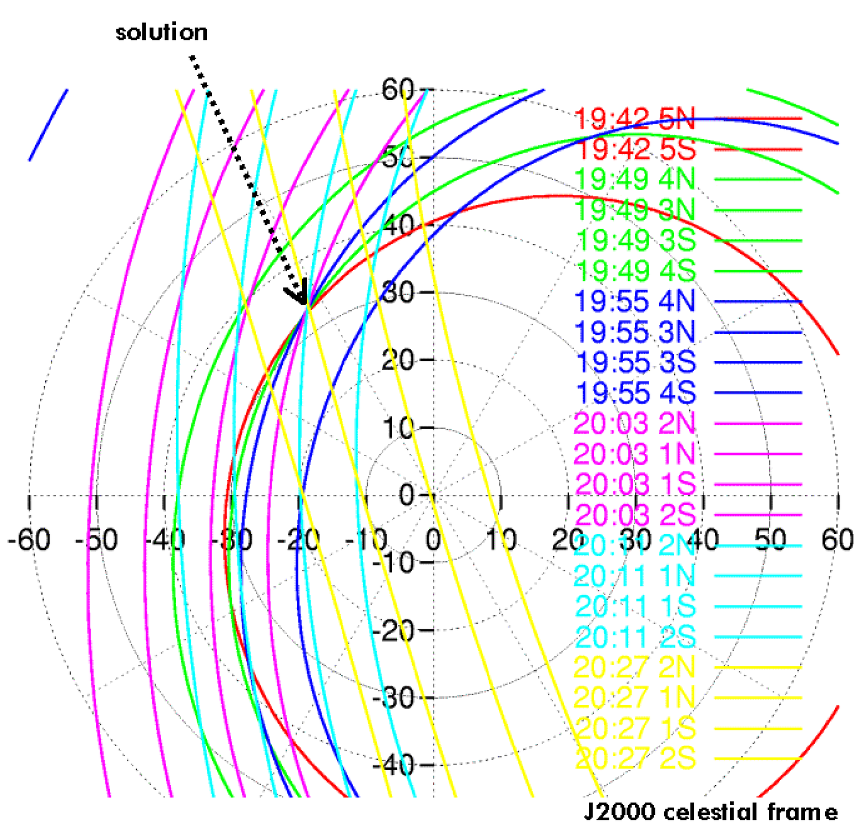


A magnified section of the plot to the left showing a single Lageos 2 flash set. The short duration flashes at regular intervals can be clearly seen. Each point represents a 1ms bin.



The plot above shows a more unusual case. Extended flashing comes from a single ring of CCR's when the correct geometry for flashing is maintained for an unusually long period, in this case a 31 CCR ring (later determined to be 3S). The repeat pattern can be clearly seen, as shown by the red arrow. All rings of reflectors are seen to have a distinctive pattern of flash intensities and timing due to slight CCR misalignment. These long sets of flashes help to show this and offer the possibility of mapping the orientation of individual reflectors in each ring.



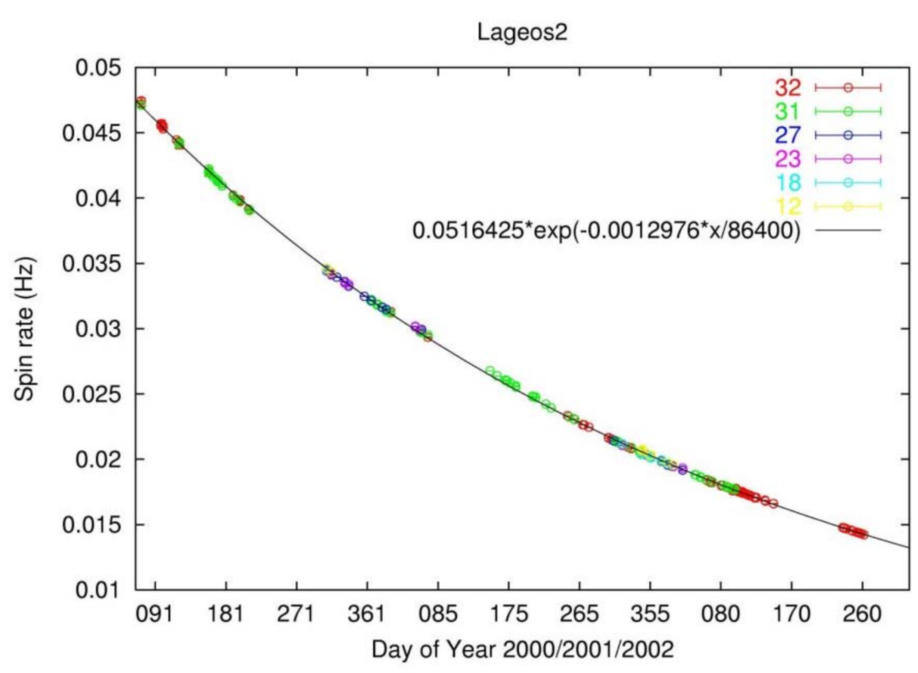


Analysis Procedure

The plot above shows the whole range of data present in a typical Lageos 2 data set. The laser spikes are easily distinguished from Lageos 2 flashes both by amplitude and their very short duration. Lageos 2 flashes are far longer > 10ms and can be distinguished from stars by their regular pattern. The satellite flashes are extracted by means of a median filter.

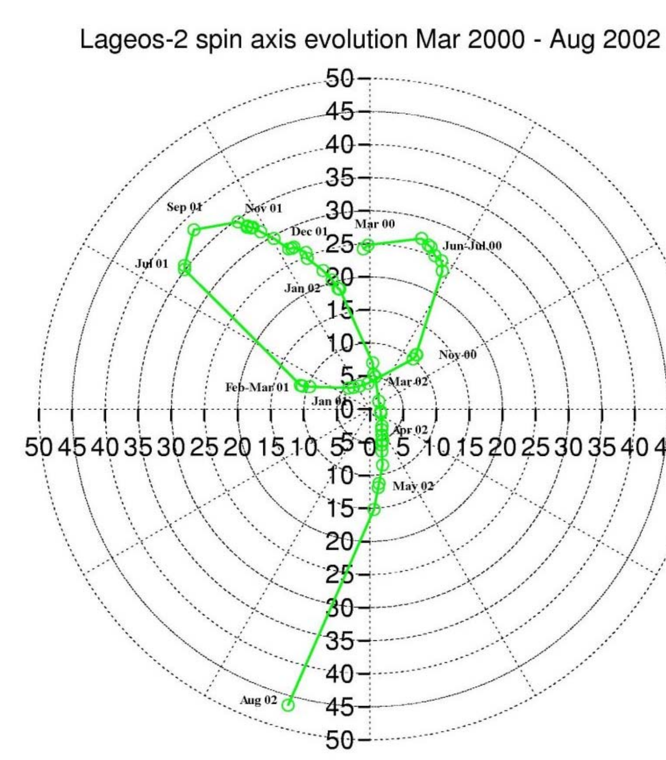
We can determine the average time between flashes for each set of flashes observed. This must be matched to the number of CCR's in the ring to give the spin period. Initially this can be done by matching the ratio between sets of flashes average spacing with the inverse of 32:31:27:23:18:12:6:1 (#CCR/ring). However once a function is established for the spin rate the #CCR/ring can be determined simply by fitting to the curve. The spin period is then simply the interval multiplied by the #CCR/ring.

Finally we can determine spin axis orientation by examining the relative positions of Sun, satellite and station. Flashes from a given ring can occur with the satellite axis anywhere on a cone centred on a radius vector through one of the reflectors. These possible axis positions trace a circle on the celestial sphere. Plotting all possibilities for all flash sets from one pass gives the above diagram and the true spin axis must be where the various circles intersect. This point also unambiguously identifies the actual ring of those with the correct number of CCR's responsible for each flash set.



Results

The plot to the left shows the complete history of Lageos 2 spin rate observations at Herstmonceux. The data follow a smooth approximately exponential curve, giving a slowdown rate of 37.4% per year. The colours show the different numbers of CCR's in the rings from which the flashes originated. The periods of no data correspond to times when Lageos 2 was only visible in the daytime from Herstmonceux. On the right is the spin axis history. The axis can be seen to trace a slow precession motion.



Future Study

Work is ongoing in trying to use the long period flash sets to map the detail of CCR misalignment, possibly enabling the unambiguous identification of a single CCR ring from a single flash set. This will become very important as the satellite's rotation continues to slow since the occasions on which 3 or more flash sets can be observed in a small time period will become fewer. This would seriously compromise our ability to make regular measurements of the spin axis orientation. A preferable solution would be to encourage other stations to start photometric observations of their own. Even a modest increase in data volume, in addition to the obvious benefits of wider global distribution of the observations, would enable us to maintain an axis history into the satellite's slow rotation phase (Lageos 1) and aid development of models to predict this behaviour in Lageos and other future geodetic missions.