

### **Assessing and enforcing single-photon returns: Poisson filtering**

An observation policy employed by some SLR stations is the so-called single-photon ranging. This consists in controlling the intensity of the retroreflected laser pulses so that, on average, no more than a single photon generates a detected photoelectron per returned pulse. This ensures that the optical spread of the laser light, caused by the size and shape of the in-orbit retroreflector arrays, is kept constant as seen by the detection unit. Thus, accurate centre-of-mass corrections can be derived for stations employing this mode of operation. The criteria used to control the intensity of returned pulses consists typically in setting a sufficiently low target detection rate (e.g. 10%). In the past, the low, but greater than zero probability of detecting multi-photon events at these modest rates was reasonably considered to have little impact on the quality of the observations. However, in the era of mm-level geodesy, every possible effect should be taken into account, and previous assumptions revisited. Here we add to the evidence showing that multi-photon detections, even at controlled, single-photon rates do occur and have a small, but quantifiable impact on the ranging measurements. We present a post-processing filter based on Poisson statistics that in our tests proved effective to remove this effect, bound by our results to less than 1 mm for LAGEOS/LARES and less than 3 mm for Ajisai. We discuss how a combination of the real-time energy control system plus a post-processing step makes of single-photon ranging an observation policy that enables sub-mm accuracy.