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Signal Differentiation

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The task of finding a feeble 0.005 to 1 Hz photoelectron pulses amid tens and hundreds of thousands of stellar light created photoelectrons is a a multi-step process. As has been discussed in other sections, the initial rendering is done by minimizing the detection interval whereby most of the random stellar photons can be discarded. This leaves us with near zero to as many as 20 pulses per second of residual noise. Potentially buried in this is our hoped for detectable laser signal. Clearly if the random noise pulses were well below the laser signal rate, that signal could be more easily be ferreted out. But how does one distinguish signal from noise pulses a hundred or more times more frequent?

For several years I applied Fast Fourier Transform (fft) software to the problem (as described in other sections). However, after much deliberation and many calculations, it seemed more likely that the sought after pulsed laser signal would have much lower pulse rates than 0.1 to 10 Hz. And, at rates lower than about 0.05 Hz, fft software was not found to be very useful, i.e., the detectable limit was not low enough. Bruce Howard and I deliberated about this in early 2017 and decided our best bet would be to develop our own specialized software to detect periodicities out to one pulse in 500 seconds (to 0.002 Hz) or so. At first blush the solution to the problem seemed obvious, but it became more complicated as reality set in. We did, however, succeed with this little project and have since retired the fft software. Out of various practical considerations we limit most stellar observations to 15 to 20 minutes. Within that constraint, the software is capable of detecting as few as three periodic pulses (periodicities as long as 400 seconds). More realistically five pulse periods, with one or two missing pulses, sets a periodicity limit of about 200 seconds per pulse. Using the LED pulser and a wide range of simulated stellar backgrounds, the effectiveness is routinely confirmed.

Oscilloscope displays also confirm periodic detections of as few as two photons within 50 ns, yet with stellar background counts of more than 100 kcps. Considering the various factors affecting the detection efficiency, two photon detections with the 0.5 meter telescope corresponds to a detection limit as low as 60 photons per sq. meter.