



## **RADIOMETRIC ANALYSIS FOR REMOTE FLUORESCENCE SPECTROSCOPY – PROGRAM SUMMARY**

OPTRA has been contracted by the Defense Science and Technology Laboratory of the United Kingdom Ministry of Defense to perform a radiometric study comparing the relative sensitivities and capabilities of three spectroscopic approaches for fluorescence discrimination. The application is remote Light Detection and Ranging (LIDAR) of biological materials. The three approaches are listed below.

- a. Fourier transform spectroscopy
- b. Dispersive (i.e. grating) spectroscopy
- c. Non-dispersive (i.e. cascaded filters) spectroscopy

The spectral range of interest for each case is 300 to 500 nm (excited by a 15 to 18 mJ, frequency quadrupled Nd:YAG laser at 266 nm with 4.5 ns pulses at a PRF of 20 Hz). Dstl has specified eight spectral bands for the first two approaches evenly spaced in 25 nm increments. The third approach will use the following five bands (achieved with four cascaded filters): 300-325 nm, 325-350 nm, 350-400 nm, 400-450 nm, and 450-500 nm. For each approach DSTL will average over 10 to 100 pulses, depending on the amplitude of the return. The geometry of the measurement is standoff at an unspecified range. Dstl intends to use a 10-inch f/5.7 Cassegrain telescope to collect the fluorescent light and deliver it to one of the three spectroscopic systems listed above.

The analysis results were as follows. From a purely radiometric standpoint, for equal integration times, the cascaded filter approach offers the greatest sensitivity. The FTS offers the second best with the dispersion system close behind. The cascaded filters do come at the cost of spectral resolution, however. Given these results, we conclude that all three approaches are viable, but we encourage the sponsor to consider a number of other factors as part of the decision making process. One factor is the cost of each system, particularly with respect to the number of detector elements required if PMTs are used. There is also an issue with the spectral purity of each channel or how well the spectral bands are isolated from each other. This may become an issue for the cascaded filters with insufficient spectral rejection and/or a PMT array suffering from cross-talk in the case of the dispersive system. The sponsor may also consider whether they may require higher spectral resolution in the future (for a Raman measurement, for example); this will be reflected in the radiometry and instrument requirements. We note that the throughput dictated by the measurement geometry ( $1.75 \times 10^{-4}$  cm<sup>2</sup>ster) is getting pretty close to the grating spectrometer throughput limit; an increase in spectral resolution will likely put the grating spectrometer at its limit while the FTS and cascaded filters both still have some margin with respect to their throughput limits. This means that the FTS and cascaded filters will have a sensitivity benefit for higher resolutions. As a general recommendation, we would advise some sort of range gating or synchronous detection scheme using the laser pulse as a clock to enhance background rejection. This could be implemented in any of the three spectrometers. We believe any of the three approaches can be implemented in a compact, rugged format for field operation.