**Guide to Running EO Scenario Analysis using the photonics projects toolset**

 The photonics project toolset are a conglomeration of python based jupyter notebooks that can be downloaded from the GitHub, or run as a Voila instance on the website in a point and click fashion with the supporting IT infrastructure transparent to the user. The tools can be run one at a time as needed, but run in conjunction with each other form the basis of a powerful analysis capability. The following document describes the process for doing this. Primarily, the output of each tool is used at the inputs in the next. This information is also taught in several online and in person classes. These can be seen on the resources page, or by contacting the authors per below.

Step by step process:

1. Blackbody calculator – the tool will launch and display a room temperature (300K) plot. You can update parameters in the boxes, by dragging the sliders – **AND ALSO by typing values into the area at the end of the slider for higher precision**. Preliminary conclusions about the scenario from this tool would be simply the peak wavelength for the temperature and energy in specific wavebands of possible interest. For the experienced user, if you know your temperatures and atmosphere you can go directly to step 3.
2. Atmospheric Transmission – this tool will generate plots of the atmospheric transmission for a variety of selected conditions. Again, the wavebands can be set by dragging the sliders, but also by inputting the value directly at the end of the slider. The sub-band atmospheric transmission and description are given by the tool. This can be used to evaluate the impacts of the various parameters in the inputs (Distance, Humidity, and Aerosol levels) in the different bands.

Starting on step 3 is where the tools can be chained together to perform a scenario analysis. This is primarily done by copying the output values of one tool into the clipboard for input values in the next tool. An automated overall tool to do this seamlessly is in development and will be posted in the GitHub. All sliders can be over-ridden by the text at the right end of the slider.

1. Blackbody through Atmosphere – once a target temperature and relevant atmosphere have been chosen, the radiance for any given sub-band from 1um to 15um can be calculated by the tool. This is output in text above the graph and can be copied for pasting into the next tool. Watts or photon units can be used here, but for the final detector and ROIC calculations only photon units can be used. A 300K target through a 0.5Km atmosphere in the 3-5um band is used for a starting example. These case results are propagated through the tools as default values.
2. Flux on Detector – the next step is to calculate the flux incident on the detector for the case of interest. The radiance value in photons from the last step is pasted into the first box, and then the relevant optical parameters. A default case of f/2.0 is used for the baseline. The output in photons/sec on the detector is given above the graph and can be copied for pasting into the next tool. If Watts units are input, the same ratio of values is computed, and the output can be taken as Watts on detector.
3. Detector Performance – the tool calculates the detector photo current and dark current for the given case. It is important to have cut on and cut-off wavelengths that are consistent with the values from step 3. The 50% cutoff wavelength is normally used for Rule’07 (see references) based calculations. This is likely to be 10 to 15% higher than the bandpass number used in step #3. Some margin should also be used on the cut-on side, although it is not as critical to performance. The third box down is the flux on detector in photon units from the last step. The dark current scale factor defaults to 1.0 but can be much lower for modern low noise material. This can be set to correspondingly lower numbers if data is available from the detector source. The primary operational variable for the detector is the temperature and this can be set by the slider or the value at the end of the slider. The key results are the dark current and the photo current printed over the plots. These can be copied (one at a time) for use in the ROIC SNR tool.
4. ROIC SNR – A digital readout circuit noise model is presented in tool #6. The outputs from above, photocurrent and dark current, are input into the first two boxes Isig and Idark respectively. Operating parameters for the ROIC are needed from the designers, but some reasonable default values are given. The primary design performance drivers are capacitor size, bit depth, and amplifier noise. The key operational variable is the integration time. This can be swept with the slider or typed in the box at the end of the slider. Key outputs are given above the graph.
5. NETD – Noise Equivalent Temperature Difference – This calculator tool uses a variety of the parameters from the earlier tools which will need to be input to the corresponding boxes. Notably, the wavelength should be the median of the band, most accurately in terms of the photon flux. For instance, for a 3-5um band at 300K, the median photon wavelength (where half the photons are above and half below) is well over 4um (more towards 4.5um). This can make a large difference in the resulting NETD calculation. These values are band center approximations.