Supercontinuum Generation Software Manual

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Introduction: The Supercontinuum Generation software is a useful tool that allows the user to simulate the supercontinuum generation based on different step index fiber designs and parameters. With this software it is possible to specify basic optical parameters e.g. peak power, pulse width, fiber length, etc… as well as dispersion, where the effective index is a function of wavelength, and attenuation and raman gain as a function of wavelength and frequency offset, respectively. The software has 2 built-in libraries that set appropriate parameters so that the user may compare simulation results to results from the respective paper. The software may also import and export user parameters into an excel spreadsheet and export data from result figures. This manual will cover how to use find and use features associated with the Photopica Supercontinuum Generation software.

Getting Started: When the Photopica Supercontinuum Generation software is first opened, the main screen of the user interface will be displayed as shown in Fig. 1. At this time the software verifies that the user license is up to date and hasn't been modified. The main screen displays UI buttons and a display panel:

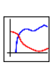
The import button allows the user to import input parameters from either of the two built-in libraries, or from a user generated sheet created by the Photopica Supercontinuum Generation software from a previous session.

The save button allows the user to save all parameters used to create the current simulation.

The  button represents all the optical properties to be set in the simulation. This button contains most of the functionality with the Photopica Supercontinuum Generation software. It is here where all basic optical parameters are set, as well as, dispersion, raman gain, and attenuation.

The  button contains simulation parameters not directly related to optical properties such as space and time discretizations.

The  button contains the execution button, the checklist for setting the simulation, and more advanced features such as specifying the number of samples to display in results and toggle of the spectrogram flag.

The  button toggles all results of the simulation in the display panel.

The display panel shows relevant figures and information about the simulation based on the current menu the user has selected, such as the results, index curves, raman gain, and loss curve.

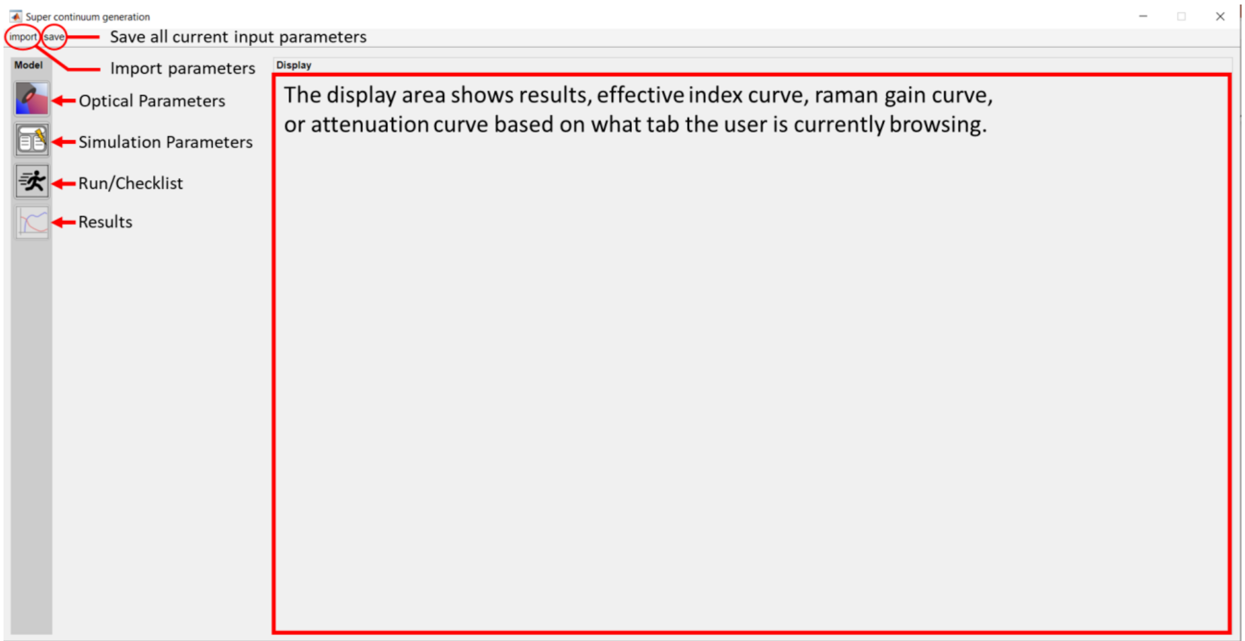


Figure 1: Main screen

Setting Optical Parameters: To set optical parameters click on the  button. When the optical parameters button has been selected by the user a new panel appears, as seen in Fig 2, with vertical tabs labeled: Optical, Dispersion, Raman, Attenuation. Description of the contents for each tab is listed below.

> Optical: Includes user input boxes to set the fiber length, peak power, pulse width, FR factor, pump wavelength, and gamma.
>
> Dispersion: Allows the user to create the dispersion curve based on three methods which are: Import GVD curve, create dispersion curve, or user defined Betas.
>
> Raman: Allows the user to create the raman gain curve by either importing the raman gain curve or creating one with the Lorentz approximation.
>
> Nonlinear: Gives the user the option to select either a constant nonlinear index for all wavelengths, or to import a nonlinear index curve as a function of wavelength.
>
> Attenuation: Allows the user to create the attenuation curve by either importing the attenuation curve or by specifying the loss at specific wavelengths and performing an interpolation.

When either the Optical, Dispersion, Raman, Nonlinear or Attenuation vertical tab is selected, the selected tab will be highlighted to notify the user which tab is currently active. The example in Fig. 2 shows the Optical menu, and the accompanied highlight of the Optical tab.

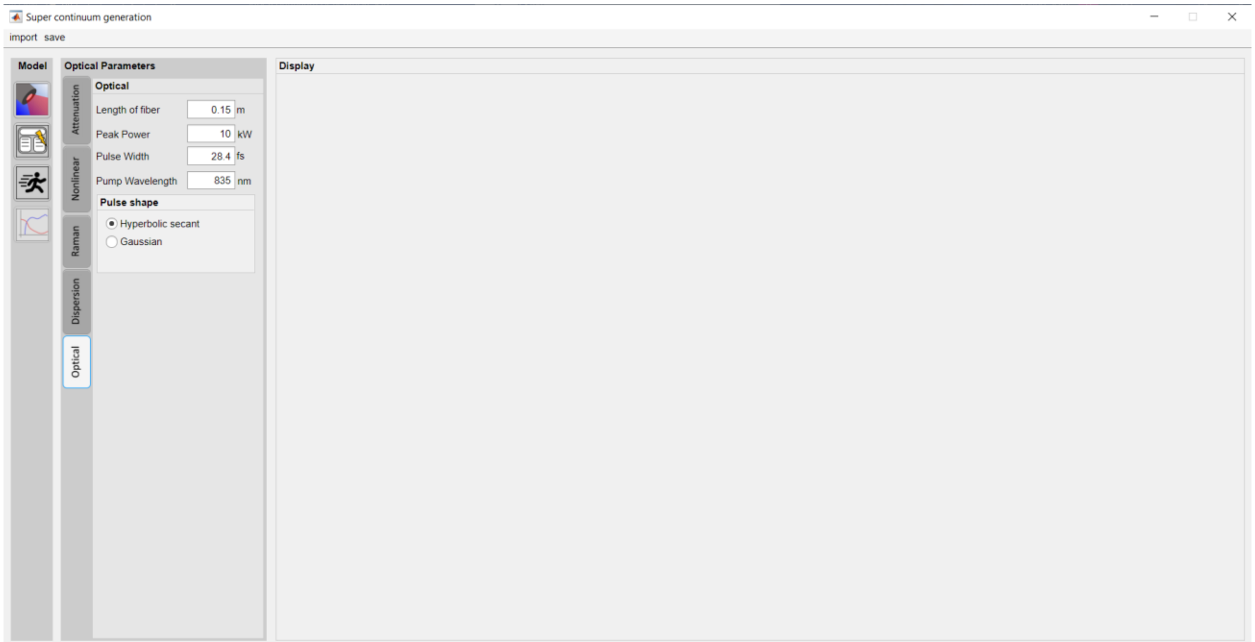


Figure 2: Optical tab selected

Optical: Figure 2 shows the screen when the vertical Optical tab has been selected. Basic optical parameters to set for the simulation are in this tab such as the pulse shape, fiber length, and wavelength.

Dispersion: When the user selected the Dispersion vertical tab, the menu panel updates as shown in Fig. 3. The user has three options for setting the dispersion curve: import GVD curve, create the dispersion curve, or User defined Betas.

User defined Betas: When this option is selected, the user may define up to beta 10 as seen in Fig. 3. Index curve is not plotted when this option is selected.

Create dispersion curve: The most advanced feature. This setting allows the user to create the core and cladding refractive indices by approximating the refractive indices using Sellmeier coefficients where:

$$n \approx \sqrt{1 + \sum_{k=1}^{m} \frac{A\lambda^2}{\lambda^2 - B}}.$$

Up to five m-terms may be defined. A and B should correspond to μm and λ is the wavelength in μm. The core diameter is defined, and the Photopica Supercontinuum Generation software calculates the effective index as a function of wavelength based on user input. The dispersion is then extracted from the effective index curve. Figure 4 shows the screen when this option is selected. Starting and ending wavelength and core size are given in μm. The Plot indices button will set and plot the core and cladding indices based on user input and is required to be pressed for the Calc eff. index button to be active.

Import GVD curve: This option loads the effective index as a function of wavelength, extracts the dispersion from effective index, and plots the effective index and dispersion curves as a function of wavelength on the display panel.

Figure 3: Vertical Dispersion tab selected with beta option.

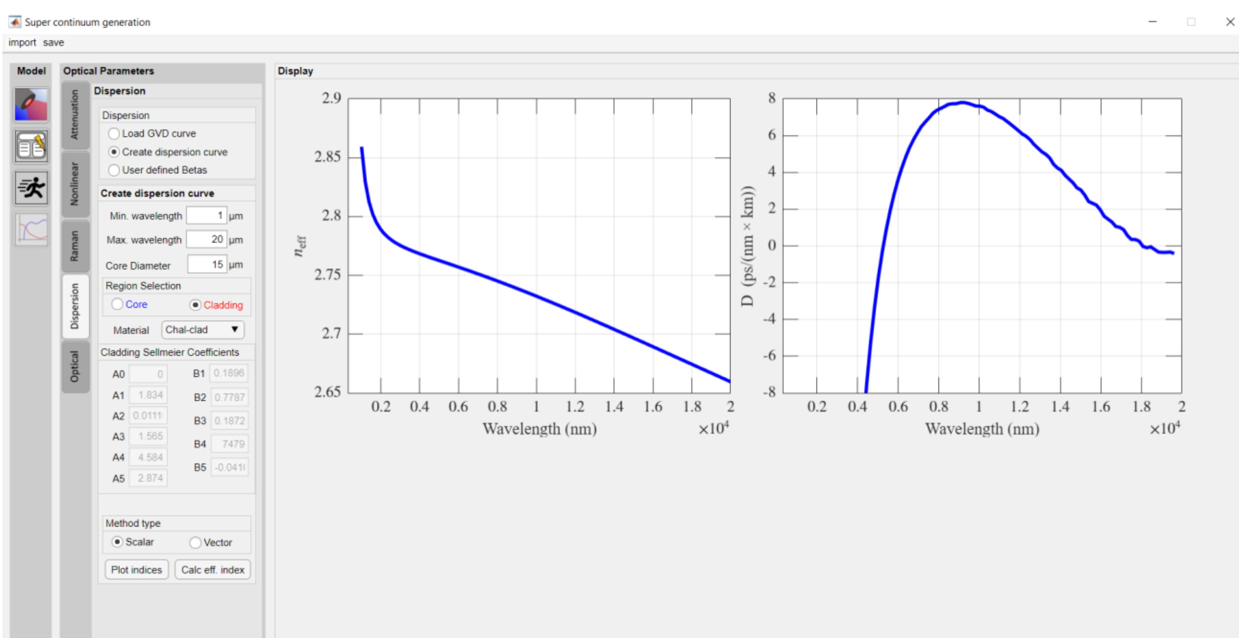


Figure 4: Create dispersion curve with Sellmeier coefficients

Raman: When the user selects the vertical Raman tab, the menu panel updates to the Raman parameters panel as shown in Fig. 5. Within the Raman parameters menu, there are two methods for setting the Raman gain: Import raman gain curve and create raman response.

Import raman gain curve: This setting allows the user to import the raman gain as a function of frequency offset.

Create raman response: This setting allows the user to approximate the raman response using the damped oscillator approximation where the time response is given by:

$$h_a = \tau_1 \left(\frac{1}{\tau_1^2} + \frac{1}{\tau_2^2}\right) e^{\frac{-\tau}{\tau_2}} \sin\left(\frac{\tau}{\tau_1}\right),$$

τ_1 and τ_2 are the oscillation and decay constants, and the raman gain is given by:

$$R_a = \mathrm{imag}\big(\mathrm{FT}(h_a)\big),$$

where FT denotes the Fourier transform.

No raman response: Alternatively, the user may also choose to zero out the raman gain.

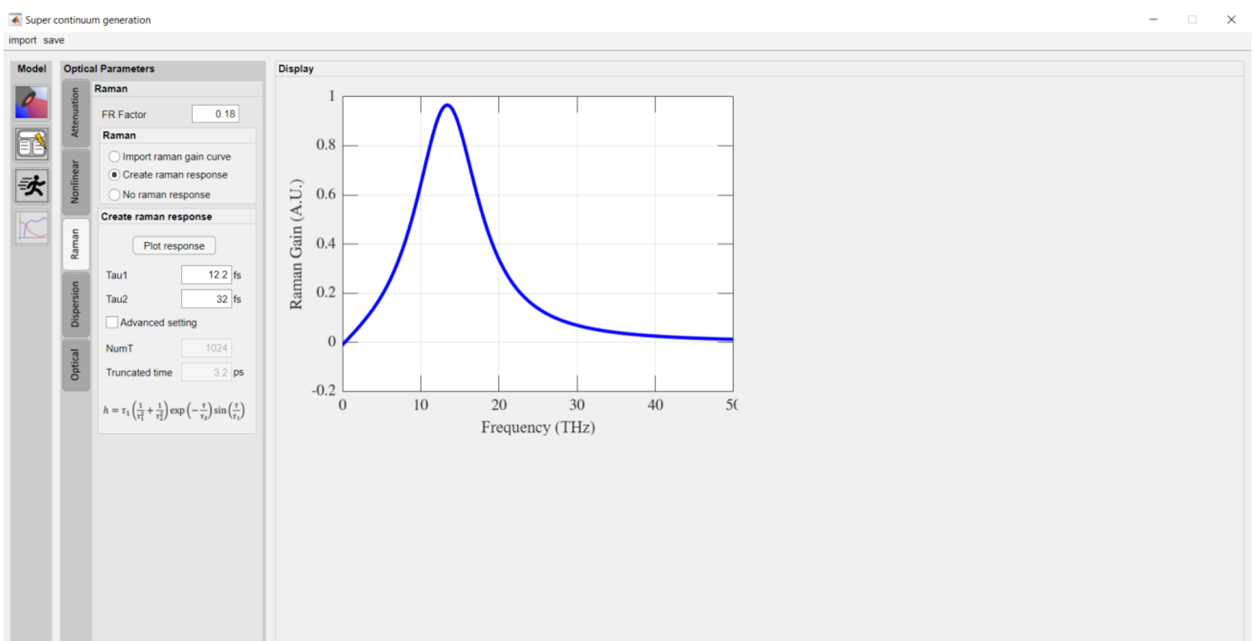


Figure 5: Vertical Raman tab selected

Nonlinear: When opening the nonlinear tab, the user has the option of either using a constant nonlinear index or importing a nonlinear index curve as a function of wavelength. When the user is supplying the value for the nonlinear index, gamma, the User defined gamma toggle switch is facing left, and the n_2 and Effective Area boxes are disabled. The gamma may also be calculated by disabling the User defined gamma toggle switch and giving the n_2 and Effective Area. When the User defined gamma switch is on, the value in the gamma box may not correspond to the gamma that would be calculated from the n_2 and Effective Area values. Figure 6 shows the nonlinear tab selected and a nonlinear index curve loaded.

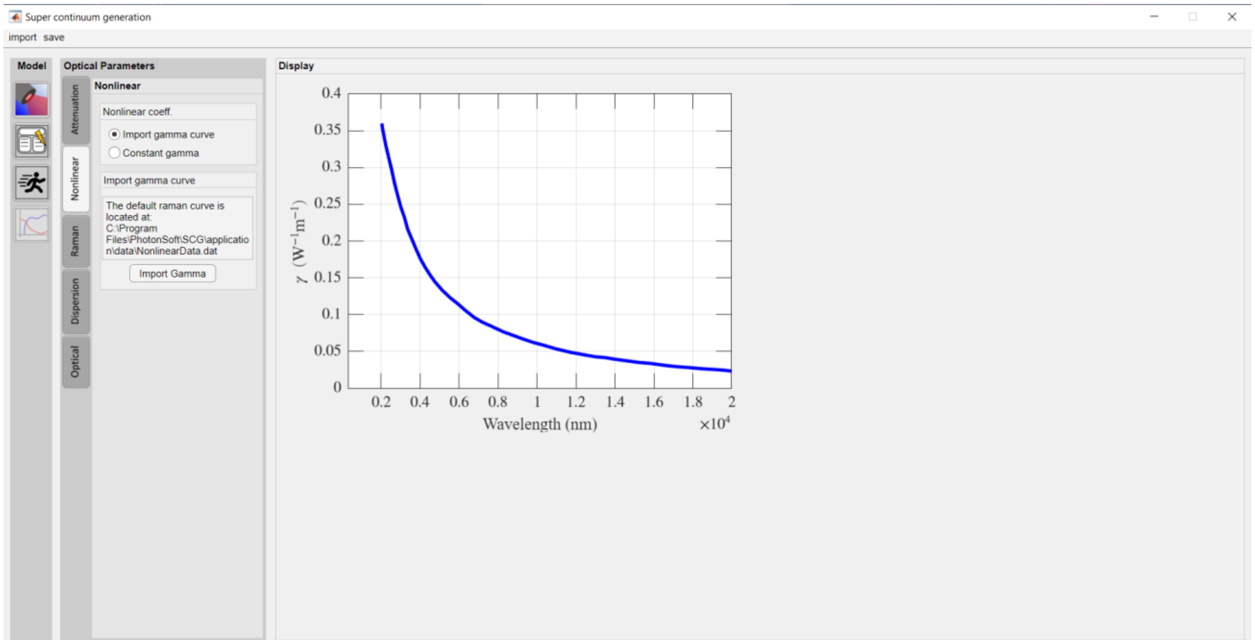
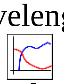


Figure 6: Import nonlinear index curve

Attenuation: When the vertical Attenuation tab is selected, the Attenuation parameters panel will be made visible as seen in Fig. 7. The user has two options for setting the attenuation: Import attenuation curve and create loss curve.

Import attenuation curve: This option loads the attenuation curve as a function of frequency from file.

Create loss curve: This option lets the user create the loss curve by specifying the loss at particular wavelengths (max of 10 losses may be specified). The loss curve may then be linearly or  spline interpolated. The button plots the loss curve based on user input. Figure 8 shows the screen with this option selected. When the loss curve is created the loss at the largest specified wavelength will be the loss for all wavelengths greater than those specified. Similarly, for wavelengths smaller than those specified, the loss will be that of the smallest wavelength specified.

In addition to the attenuation curve options, the user also has the option to set the loss boundaries. By enabling ☑ Manually set boundaries , the user may select the beginning and ending wavelength values where the loss exponentially increases which reduces the chance of a failed simulation.

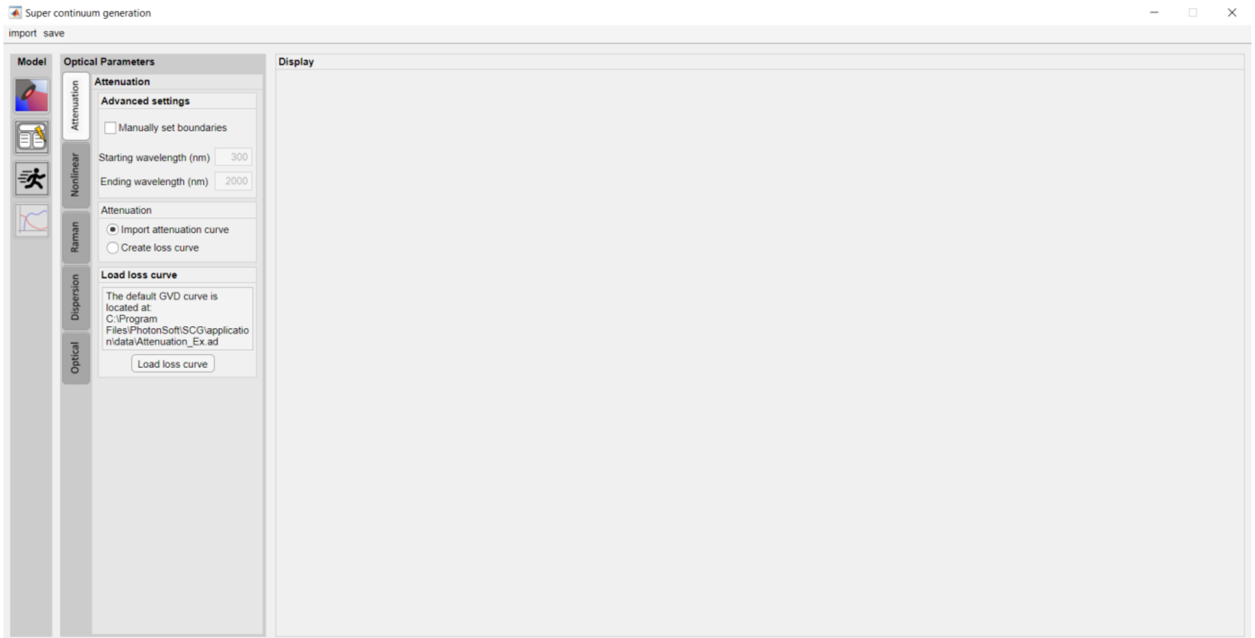


Figure 7: Vertical Attenuation tab selected

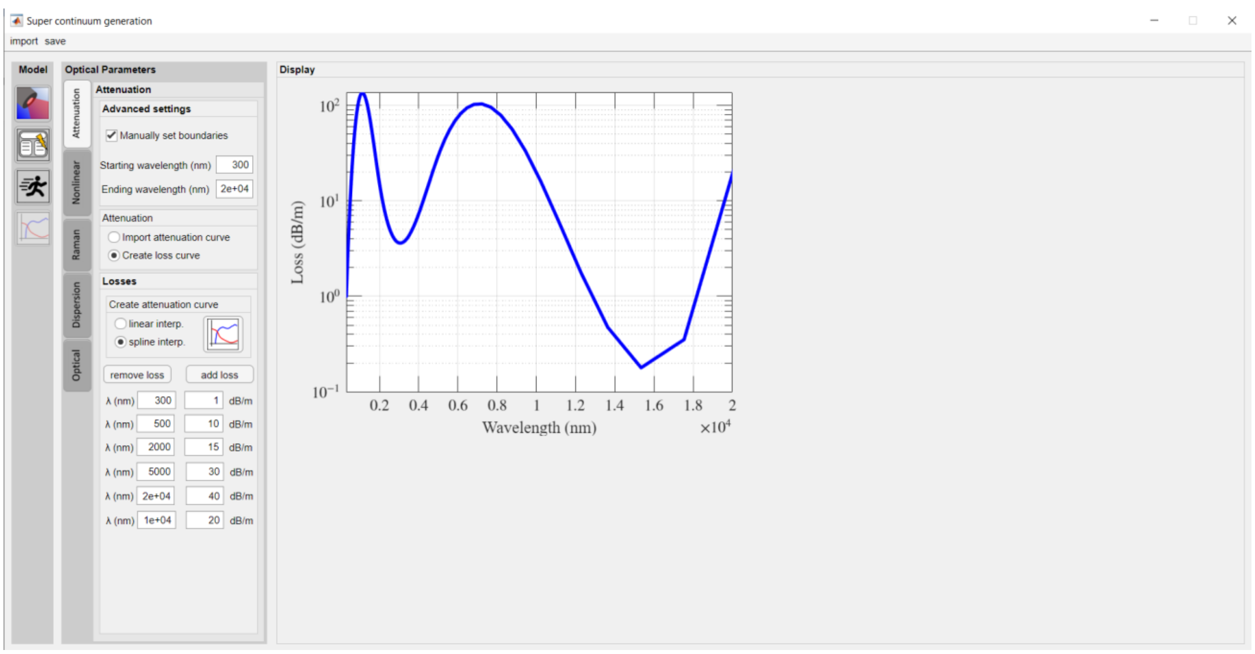


Figure 8: Creating the loss curve

Setting Simulation Parameters: To set simulation parameters click on the  button. When the simulation parameters button has been selected by the user a new panel appears, as seen in Fig 9, with vertical tabs labeled. Embedded in the simulation parameters menu is a secondary vertical tab menu that includes Discretization, Sampling, and Spectrogram.

Discretization: The Discretization menu allows the user to change the discretization for space and time used in the simulation as shown in Fig. 9. Both the spatial and temporal parameters have a preset discretization for coarse, fine, and super fine. If the user selects User defined, then the number of points and step may be defined. The length of fiber shown in the spatial parameters panel is copied from the value listed in the optical parameters.

Sampling: There are four settings within the sampling tab: display samples, num λ, num t, and num z. Display samples sets the number of horizontal slices in the power-time/wavelength contours the user wishes to view. num λ, num t, and num z set the number of interpolated points to plot. These parameters do not directly affect the simulation, only what gets plotted for results.

Spectrogram: The spectrogram tab includes a toggle switch to enable or disable the spectrogram. When enabled, a panel appears which displays parameters related to the spectrogram which are: min and max wavelengths to set limits on spectrogram contour, number of wavelengths between the min and max to plot, number of time points, and the bandwidth of the filter used.

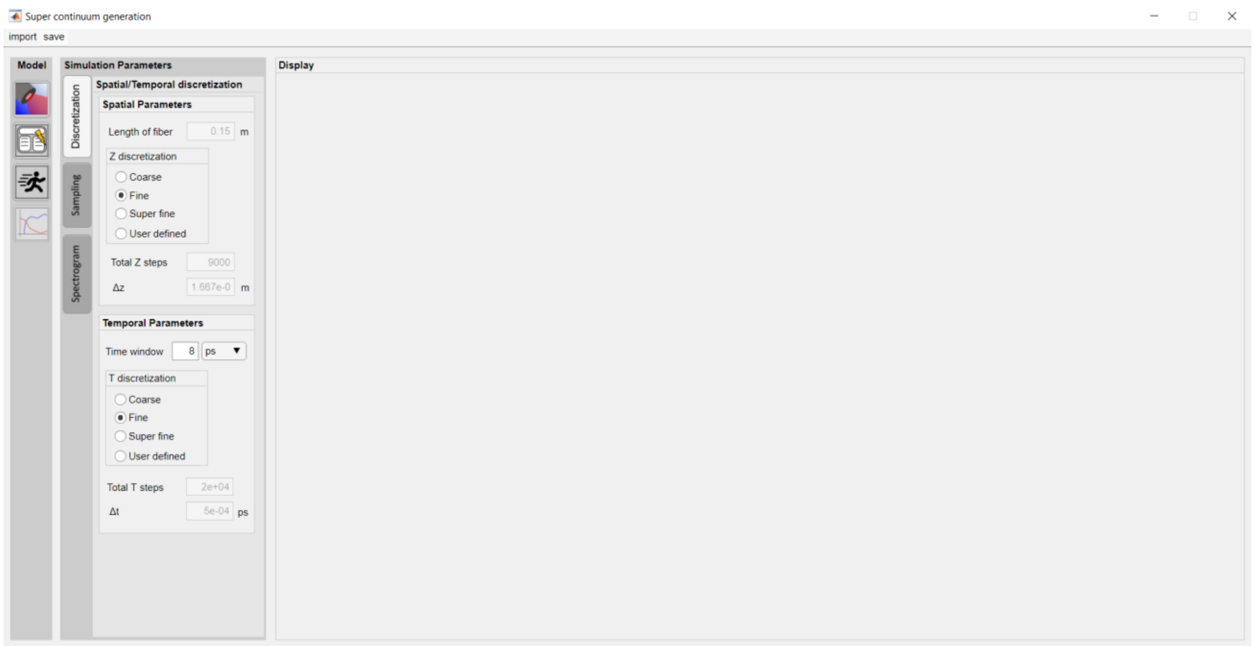


Figure 9: Simulation button selected

Run simulation and checklist: Clicking the  button will pull up the run simulation menu as shown in Fig. 10. This menu shows the user the run button and status lights for dispersion, raman, nonlinear and attenuation. If any of these terms has yet to be defined by the user, the light will remain red, and the run button disabled. Once all terms are defined, all corresponding lamps will turn green and the run button will be enabled as shown in Fig. 10.

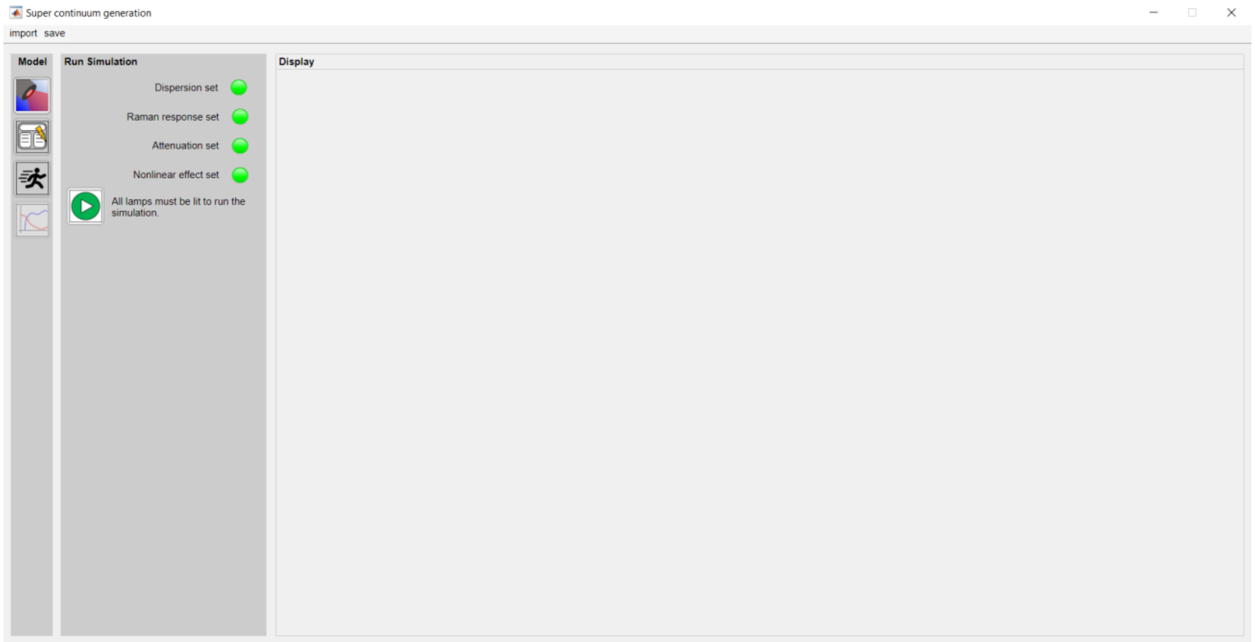


Figure 10: Run button selected

Simulation results: Once the simulation has finished running, the software will automatically begin displaying results. To manually view results after the simulation has finished select the button. Figure 11 shows an example of results with the spectrogram active. The scroll bar at the bottom of the Display panel may be used to step through the different slices in the power vs distance and time/wavelength contours in the second column where the slice is plotted on the first column. The last column is reserved for the spectrogram if the user enabled it before the simulation began. Changing the limits and y scaling of the plots on the results page may be done using the settings contained within the time plot limits and wavelength plot limits followed by clicking the embedded button as shown in Fig. 11. Clicking the will save the results currently displayed on the display to the user specified directory.

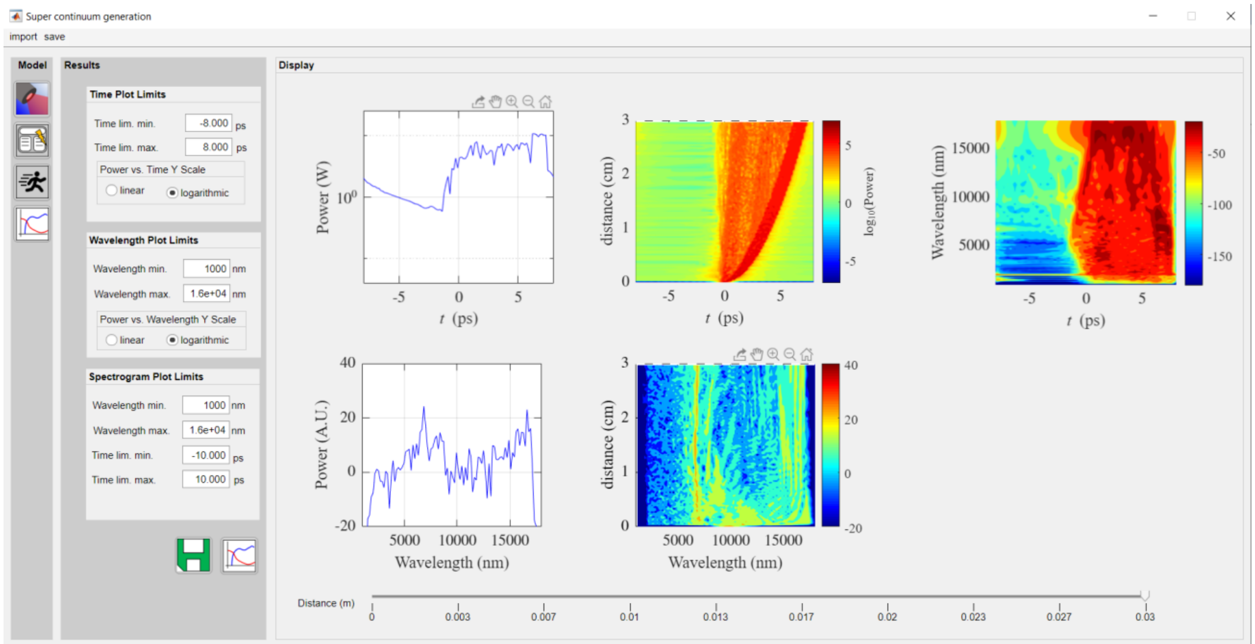


Figure 11: results