

License agreement and manual¹

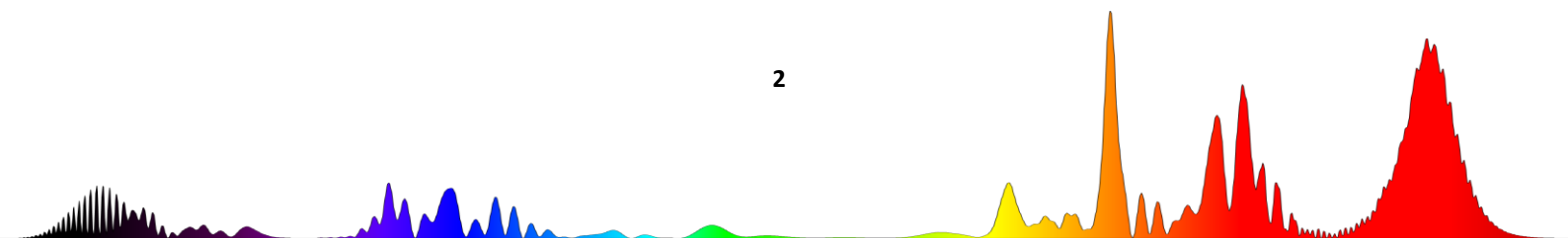
fiberdesk™

last update 23.11.2025

¹ some functions might be restricted to higher versions, appearance of graphics user interface depends on actual fiberdesk version and operating system

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1. General

1.1 System requirements

1.1.1. Software requirements

fiberdesk works stable on the following operating systems:

Microsoft® Windows® 7 / 8 / 8.1 / 10 / 11

In addition, because *fiberdesk* uses the Thales Sentinel USB Protection System, its drivers for the usage of the USB hardware lock are also required for dongles purchased before 2019. Later ones are driverless, the driver is included in the Windows system.

1.1.2. Hardware requirements

Required processor: Intel Pentium or compatible

Required/Recommended RAM: 1 GB or more

1.2 Software license

This program is **NOT** freeware, please see end-user license below. This means that you are not allowed to distribute it anywhere or to modify the executable or any data files within this program. Furthermore, you are not allowed to place this program on a Web Site, but you could place a link to the official website of this program. This program is provided as is. There are no guarantees for you about the safety of your data. Any suggestions and bug reports are welcome. To ask questions, get answers or report bugs visit the official web site.

Official web-site: www.fiberdesk.com

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To ensure that the software functions properly, the Licencor / fiberdesk publishes **updates** (by sending it to you by email or putting it on the official webpage). If the Software is an update, you must possess a valid license to its version to use this update. Updates improve the workings of the software, i.e. remove bugs. The user is responsible for proper configuration of the software updating process to provide for the highest possible level of functional reliability. Updates may be licensed to you by fiberdesk with additional or different terms, please see comments e.g. in the corresponding blog on the webpage.

Updates are distinguished from **Upgrades**: Upgrades to a new version, which includes new features that were not available in Your version, require a new license that must be purchased (please contact fiberdesk for a quote to Upgrades). However, upgrades are free if released within one year after purchase of Your license but this time period of one year is then not extended.

If a new version is available, updates to previous versions are not guaranteed after one year after purchase of Your license. In that case you need to purchase a new license for an upgrade and update.

Updates and Upgrades may have different behaviors, for instance in terms of dialogs or file format. The change must not be tracked within fiberdesk, so that there is no liability of fiberdesk to read files saved with a previous version. The customer might keep the older version in order to be able to read files.

7. FURTHER LIMITATIONS / SCIENTIFIC BUGS

The Licensor is not responsible for any mistakes in the documentation or scientific errors arising from the results the software produces. However, any of such mistakes can be reported to the licensor and can be updated, if possible and necessary.

8. Support

Technical support is given for any software bug or technical question concerning the functionality of the software. Scientific support, which means that scientific question or problems are solved by the fiberdesk support, are not included in the license. The Licensor may ask such questions, however, the decision for answering is done by fiberdesk. Likewise, no consulting about scientific topics is included in the license.

9. Referencing Fiberdesk

If a scientific citation of fiberdesk is possible use a phrase similar to the following:

[X] simulations done using fiberdesk, www.fiberdesk.com

More specifically, if the predefined dispersion values are used for any kind of publication, please contact the author (webmaster@fiberdesk.com) for information on copyright and citation.

10. General Terms

If any part of this agreement is found to be invalid, illegal or unenforceable, it will not affect the validity of the balance of this agreement, which will remain valid and enforceable according to its terms. This Agreement sets out the entire understanding between You and the Licensor and may only be amended in writing in a document signed by both parties.

2. Software Interface: Overview

The general graphical layout of **fiberdesk** is shown in Fig. 2.1.

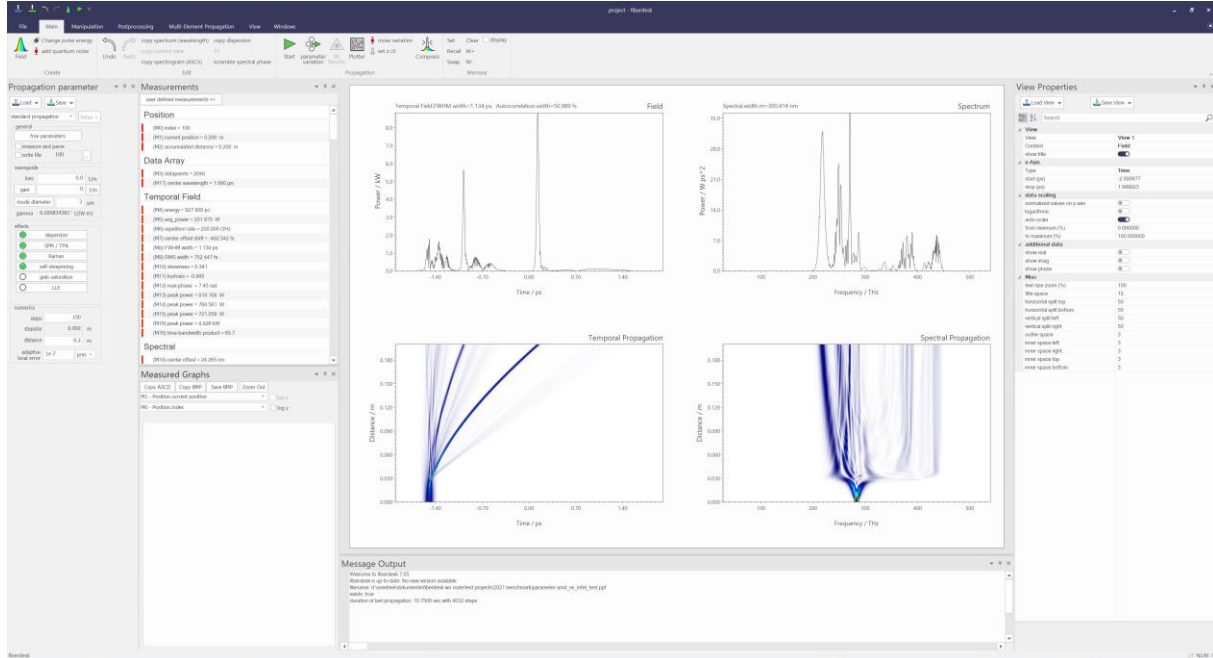


Fig. 2.1: Graphical User Interface (GUI).

fiberdesk uses a ribbon menu (with advanced features and easier access to the command structure. It is explained in section 3.1.

Beside the main view, additionally information and parameter setups are displayed in four attachable windows (dockable panes). These four windows are:

- the propagation parameter pane
- the measured value pane
- the output pane
- graph pane

More details can be found in section 3.2.

2.1 File Menu

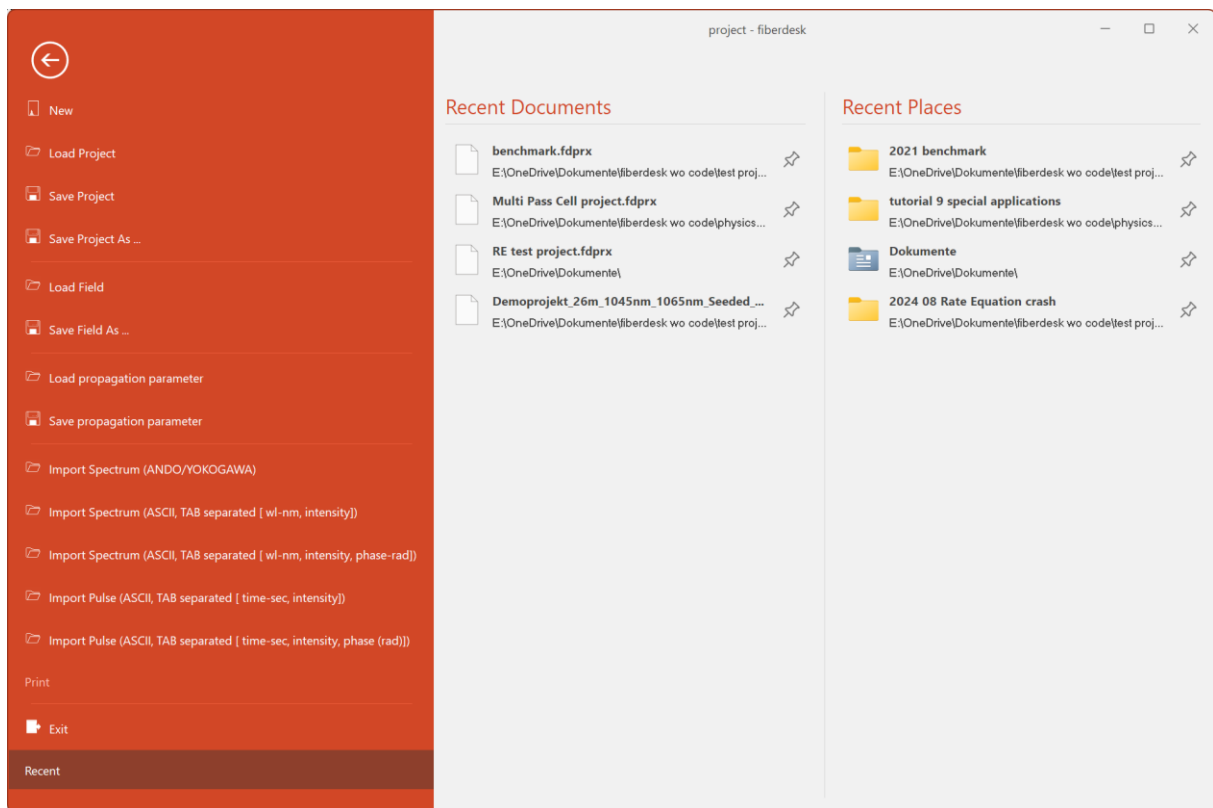


Fig. 2.2: The file menu.

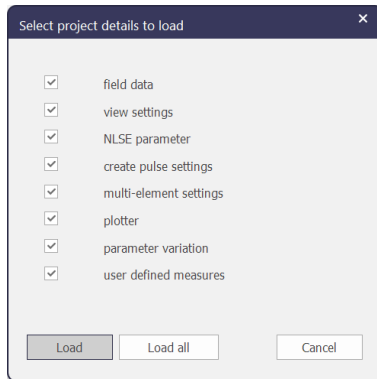
The file menu (Fig. 2.2) includes all command to control data connected to a file.

New

Creates a new project and sets most controls to standard values.

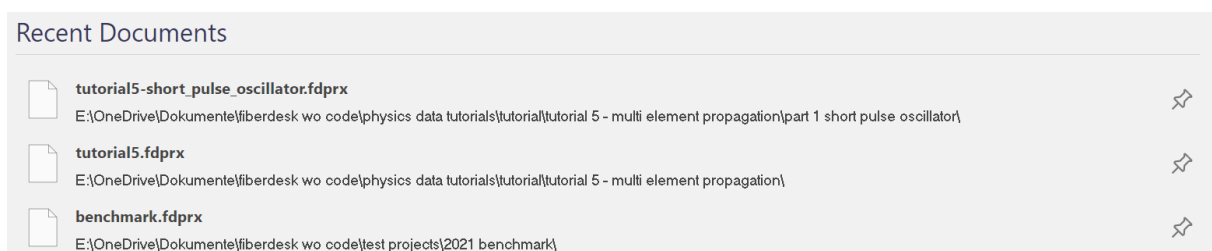
Load/Save Project

Opens/Saves a project. When attempting to open a project file, the following dialog box will appear:



The *file* includes the *data array* that samples the electric field, as well as the element container (see File Description), propagation parameter, view definitions, and dialog parameters. You can choose which parameters to reload, allowing you to retain certain parameters that you have already set or need to reuse. This provides you with control over maintaining specific settings.

Recent Documents contain recent project files.



Save Project As ...

Saves the current project with all settings to a different file name.

Load/Save Field

Loads or Saves the field information only.

Load propagation parameters ...

Loads the propagation parameters from a specific file.

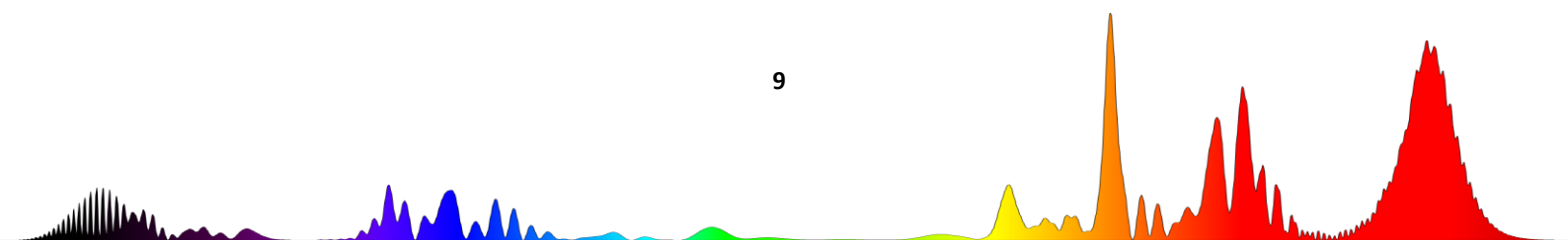
Export propagation parameters ...

Saves the propagation parameters to a specific file.

Import spectrum (ANDO)

Imports an ANDO spectrum file and sets the phase to zero.

Important for ASCII/ANDO imports: The actual data array dimensions are kept constant, thus, be sure to provide enough datapoints and the right spectral range for the given file. This means, first “create a pulse” with the right bandwidth and central wavelength.

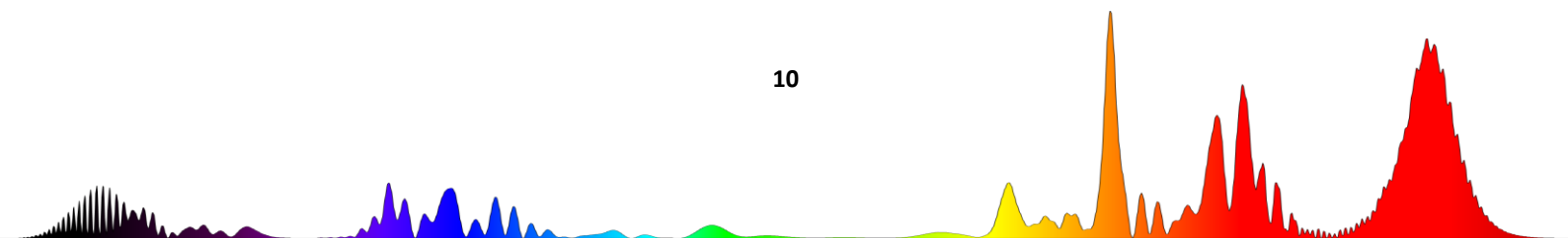


Close

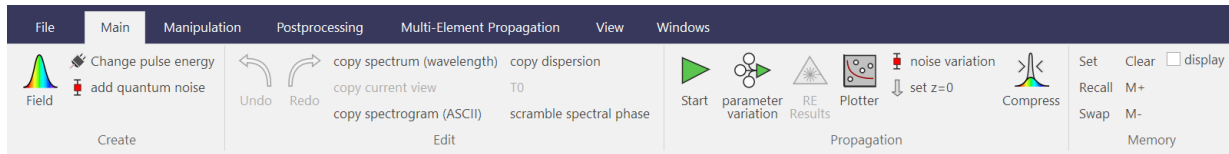
Closes the current document file.

Exit

Quit fiberdesk.



2.2 Main



2.2.1. Create

Field

This calls the main dialog for setting up a simple pulse and the corresponding temporal and spectral parameters for the simulations.

Size (DP)

number of data points of the field

Type

shape of the temporal pulse intensity (Gauss, sech², Parabolic, Rect) Additionally, one can select a specific spectral shape

from file .. select a specific field file that has been saved before (menu File>Save Field) in the *.fieldx format.

Half interval (HI)

Half of the temporal width of the complete field. The dwell time is therefore given by $t_{DW} = 2 * HI / DP$. Of course, this sets the spectral width and resolution due to Fourier theorem.

Pulse duration (FWHM)

full width at half maximum of the pulse width

TempShift

offset of the position of the pulse center τ

Double pulse separation τ_{dp}

- Relative magnitude R

- Center wavelength: central wavelength of the pulse spectrum

- Chirp: linear spectral chirp in fs² with its definition:

The 'Pulse Profile and Data Array' dialog box is shown. It has a 'data array setup' section with a 'Size' dropdown set to '2k (2^11)'. Below this are input fields for 'array center wavelength' (1060 nm), 'half interval' (1.5 ps), and 'vacuum length (full interval)' (0.000899377374 m). A checkbox 'fit all parameters to the closest value of the array' is checked. The 'Type' dropdown is set to 'Gauss'. Below this are fields for 'pulse duration (FWHM)' (0.1 ps), 'TempShift' (-1 ps), 'phase' (0 rad), 'wavelength' (1060 nm) with a 'same as array' checkbox, '2nd order spectral phase' (0 fs²), and '3rd order' (0 fs³). There are checkboxes for 'energy' (checked, 1e-09 J), 'average power' (unchecked, 333.333 W), and 'repetition rate' (3.33333e- Hz, checked 'cw'). There are also checkboxes for 'scramble spectral phase (random phase)', 'phase diffusion modell with given linewidth', and 'add quantum noise (one photon per spectral node)' (checked). A 'double pulsing' section has 'separation' (0 ps) and 'relative magnitude' (0). At the bottom, there are checkboxes for 'create field in data array 1' (checked) and 'add field to data array 1' (unchecked), and buttons for 'OK', 'Apply', 'Cancel', and 'reset'.

$$A(T) = \dots e^{-\frac{C}{2}(\omega - \omega_0)^2 - i\frac{C_3}{6}(\omega - \omega_0)^6}$$

The double-pulse separation, temporal shift and relative magnitude is calculated from the complex single-pulse field amplitude $A(T)$ by

$$A_{new}(T) = \frac{(1-R)A(T - \tau_{dp} + \tau) + (1+R)A(T + \tau_{dp} + \tau)}{2}$$

Scramble spectral phase (random phase)

It sets a random (uniform distribution) phase in the spectral domain, thus, the spectral lineshape is maintained, but the temporal domain does not contain pulse information anymore.

Phase diffusion modell with given linewidth

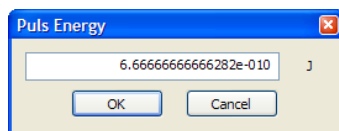
It randomizes the spectral phase according to Ref. 11.

Add Quantum Noise (one photon per spectral node)

Adds the energy of one photon in the spectral domain with random phase. Thus, energy might not be conserved due to the complex addition of the values.

Change pulse energy

Changes the pulse energy of the current pulse.



Add quantum noise

Adds one photon per spectral mode with random phase.

Use second field

Enables or disables the second data array for a second field that can be coupled through the NLSE by XPM or birefringence.

Please ask webmaster@fiberdesk.com for details, currently not contained in commercial versions.

2.2.2. Edit

Undo

Undo last change in the dataarray. The selected area is set to the full size of the dataarray.

Redo

Restore last undo step.

Copy spectrum (wavelength axis)

Copy spectrum to clipboard as ASCII. The wavelength axis is obtained by linear interpolation from the frequency axis.

Copy current view

Copy current view to clipboard as enhanced metafile (EMF).

Copy spectrogram as ASCII matrix

If spectrogram view is active, copy all values to clipboard as ASCII matrix.

2.2.3. Propagation

Start

Start the propagation using the current settings.

Parameter variation

Vary one or two parameters of a propagation using the dialog in Fig. 2.3.

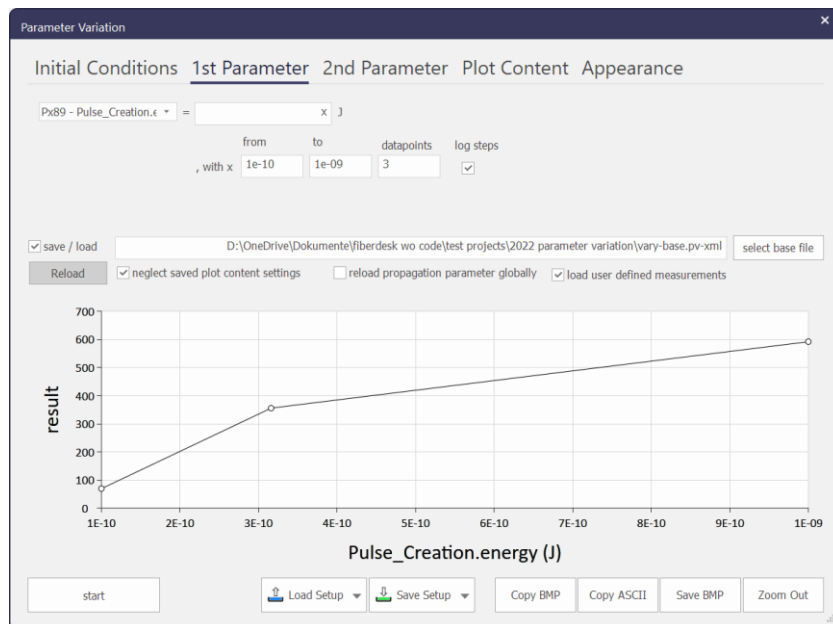


Fig. 2.3: Parameter Variation Dialog.

Depending on the parameter to vary, the field is create with the new parameter and propagated using the parameters set up so far. All measurements are done after propagation so that the results can be displayed without a new calculation.

The parameters are varied linearly or with equal logarithmic setup, if “log steps” is chosen.

A second parameter can be varied if selected.

The resulting fields of the parameter variation propagation can be saved or reloaded by choosing a base file:

☒ save / load

☒ neglect saved plot content settings

☐ reload propagation parameter globally

☒ load user defined measurements

The following files are saved for example:

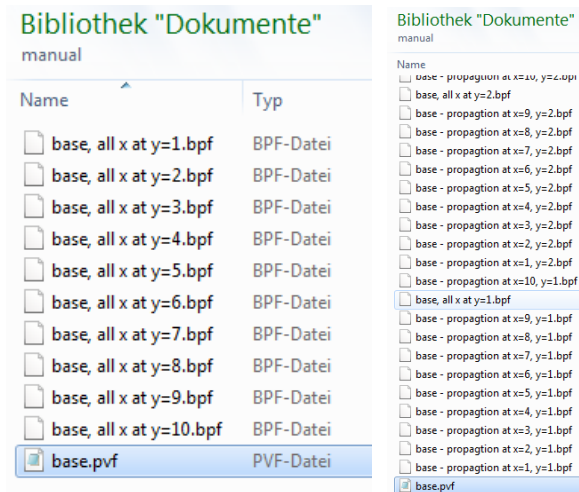


Fig. 2.4: File structure in the parameter variation dialog (left) without and (right) with individual propagation saved.

Each individual propagation can also be saved by combining the “save to file” option with the “write file” option in the general setup for the propagation parameter outside this dialog.

Set $z=0$

Set propagation position to zero.

include noise (deprecated, you should use the parameter variation tool)

Starts a propagation multiple times by adding specific noise sources on the initial pulse. The number of propagation is given by “Number of simulations”.

- input phenomenological quantum noise: one photon with random phase is added per frequency intervall
- shot noise (each time intervall): Poisson noise on each temporal datapoint
- shot noise overall energy: poisson noise variation of the pulse energy

×

Number of simulations

input energy fluctuations

 %

input phenomenological quantum noise

☐

shot noise (each time intervall)

☐

shot noise (total energy)

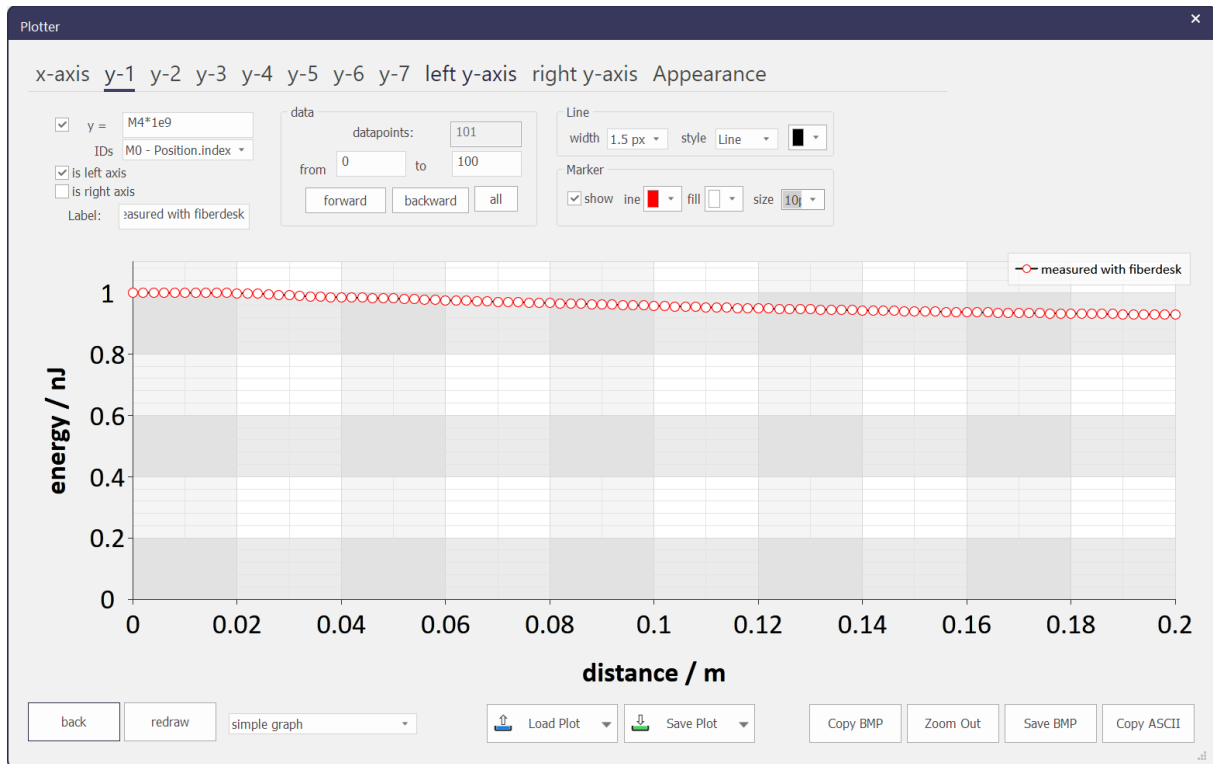
☐

☒ save last slices in bpfx

If the option “save last slice in bpf” is chosen, the result of each propagation is saved in a file for further processing and analysis, see menu “postprocessing”. In combination with the usual “write file” option, each full propagation is saved in a file array.

Plotter

The plotter allows to plot the measurement results in a more customized way. The x and y axis can be scripted and the design in detail configured.



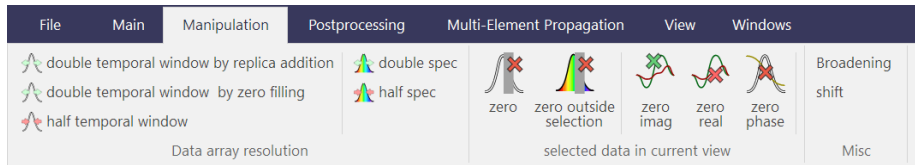
Compress

Minimizes the autocorrelation FWHM by a linear propagation (dispersion only) using the dispersion values given in the dialog.

The Initial Parameter dialog box contains the following fields and options:

- Initial Step size:** 0.05 m
- wavelength:** 1060
- Beta2:** 0.2 ps²/m
- Beta3:** 0 ps³/m
- Beta4:** 0
- Grating Compressor:** (checkbox)
- Prism pair:** SF18
- Buttons:** OK, Cancel

2.3 Manipulation



2.3.1. Data array resolution

double temporal window by replica addition

Doubles the number of points by increasing the temporal range and copies the field to that areas. Resets the selection as well.

double temporal window by zero filling

Doubles the number of points by increasing the temporal range and set the new datapoints to zero. Resets the selection as well.

Half temporal window

Halves the temporal windows symmetrically.

Doubles the number of points by increasing the spectral range. Resets the selection as well.

Double / half spec

Doubles / Halves the number of points by decreasing the spectral range. Resets the selection as well.

2.3.2. selected data in current view

Zero

Set field to zero for all data points inside the selection.

Zero outside selection

Set field to zero for all data points outside the selection.

Zero phase / real / imag

Set values to zero in the whole selection.

Panel: Misc

exchange fields

If two fields are used, its content is exchanged.

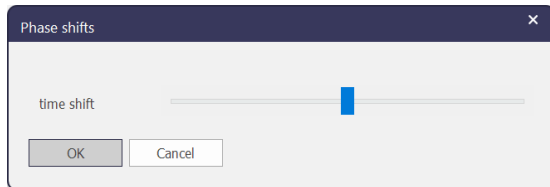
merge fields

If two fields are used, its content is merged in the first field.

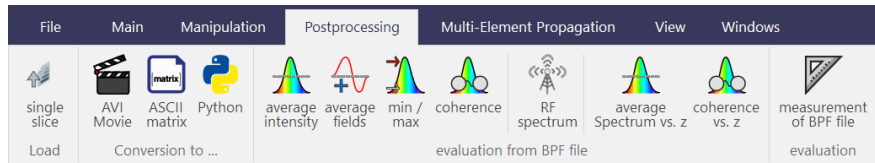
2.3.3. Misc

shift

Allows to shift the field in time.



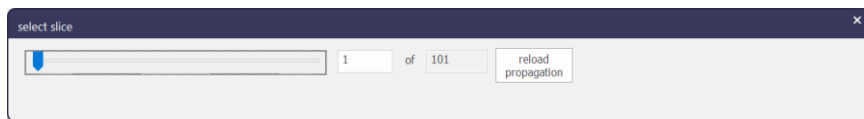
2.4 Postprocessing



2.4.1. Panel: Load

single slice

Reload a previously saved slice from a beam propagation file. Choose the slice number by using the following slider control or manually type the requested slice:



During this slice selection, every view control (e.g. data selection and zoom) can be used. Use this function in prior to following visual post-processing tools (e.g. movie creation) or to check the slice from a long term propagation.

Reload propagation to recreate 2D propagation views.

Panel: Conversion to ...

AVI movie

The movie is created by using the current view. The following steps have to be done:

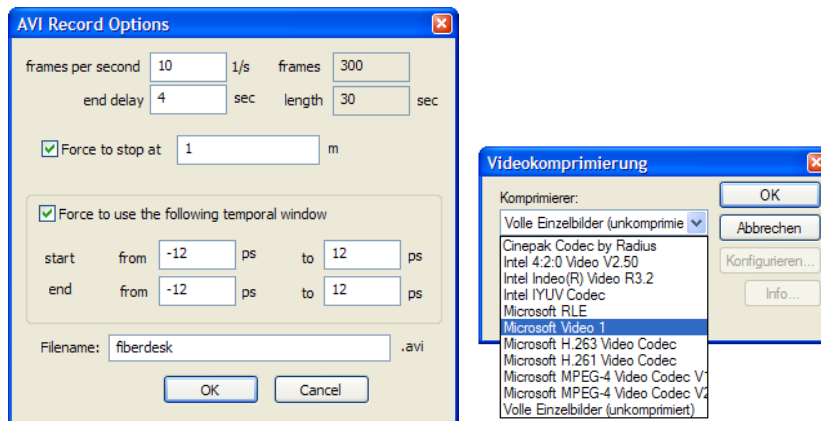
Select a previously saved propagation file.

Using the AVI creation dialog, one can specify the number of frames per second and an end delay, which shows the last frame for that time.

If the propagation is longer than required for the AVI use the option “force to stop at”.

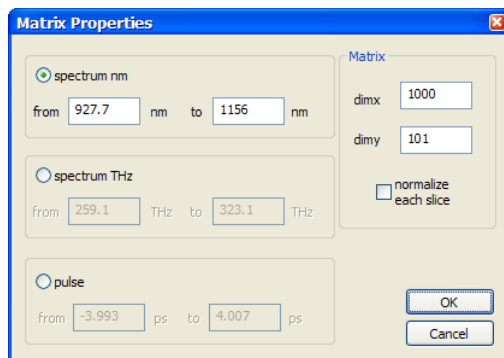
If a specific temporal window is given, the current selection is overwritten and the values of the dialog are used. This can be used to create an artificial co-moving time frame.

Choose a name for the AVI file, and then press OK to accept the settings. After the first screen is saved to the AVI file, select a compression scheme. The recommended scheme is “MS Video 1”.



ASCII matrix

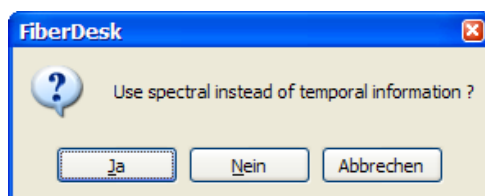
Chose a previously saved propagation file. An ASCII copy of the temporal or spectral evolution is copied to the clipboard for further processing in other softwares, e.g. ORIGIN™. In the corresponding dialog, please chose the content, which is to copy and the dimensions of the ASCII matrix. Choose “normalize each slice” to do so.



2.4.2. Panel: Noise evaluation

mean and variance

Especially, if the propagation file contains data from the noise variation simulation, this function helps you to calculate the mean (average value) and the variance of the data. Decide if the spectrum or temporal field should be used for the evaluation. The result is copied to the clipboard in a three-column ASCII format.



min/max

The minimum and maximum values in the spectral or temporal domain are calculated from a previously saved propagation file. The result is copied to the clipboard in an ASCII format.

coherence

Calculates the coherence (see [4]) from a single propagation file according to the

following equation: $|g_{12}(\lambda)| = \frac{\left| \langle E_1^*(\lambda) E_2(\lambda) \rangle \right|}{\sqrt{\langle |E_1(\lambda)|^2 \rangle \langle |E_2(\lambda)|^2 \rangle}}$

RF spectrum

Calculates the radio frequency spectrum of a series of pulses S_i by taking the Fourier transform of the array $|S_i|^2$. The temporal spacing $t_{i+1}-t_i$ is given by the current repetition rate setting f_R , thus, the radio frequency range is $-f_R/2 \dots f_R/2$. The result is copied to the clipboard in ASCII format.

<RIN> vs. z

Calculates the average relative intensity noise (RIN) along a previously saved propagation distance. A number of propagation files are required for this function. Each propagation file contains a single propagation. The propagations just differ in their noise properties.

<Spectrum> vs. z

Calculates the average spectrum along a previously saved propagation distance. A number of propagation files are required for this function. Each propagation file contains a single propagation. The propagations just differ in their noise properties.

coherence vs. z

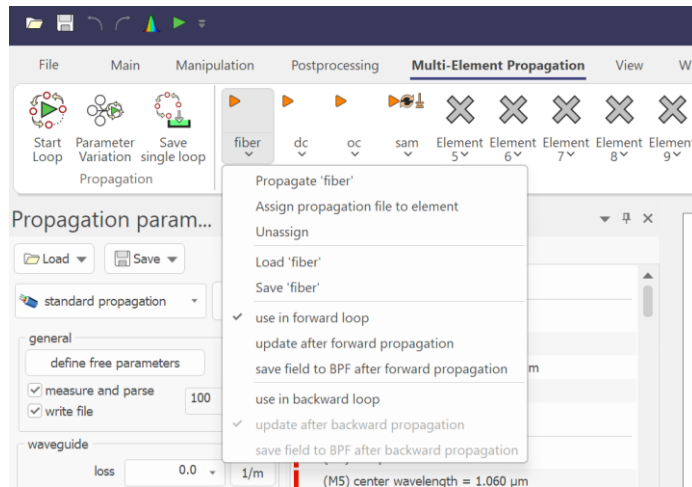
Calculates the coherence along a previously saved propagation distance. A number of propagation files are required for this function. Each propagation file contains a single propagation. The propagations just differ in their noise properties.

Panel: Misc

Measurement of BPF file

This function measures all values along a previously calculated and saved propagation file (*.bpf).

2.5 Multi-Element Propagation



Within this category previously saved propagation files can be assigned to a button (in the Element Container) for fast (or often required) propagations. Additionally, all propagation files can be used in a loop in “forward” and “forward and backward” direction. One can also directly load and save the assigned propagation parameter file. Use this panel for e.g. simulating short pulse resonators.

The buttons icon is changed to represent the possible usage:



Upper row:

- forward propagation,
- update after forward propagation
- save field after forward propagation

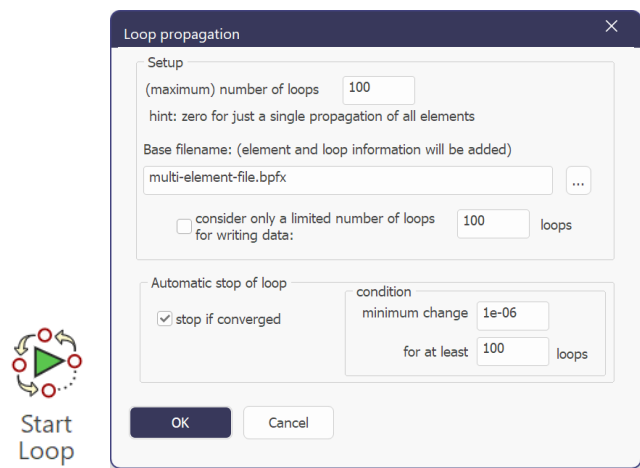
Lower row:

- backward propagation,
- update after backward propagation
- save field after backward propagation

2.5.1. Panel: Propagation

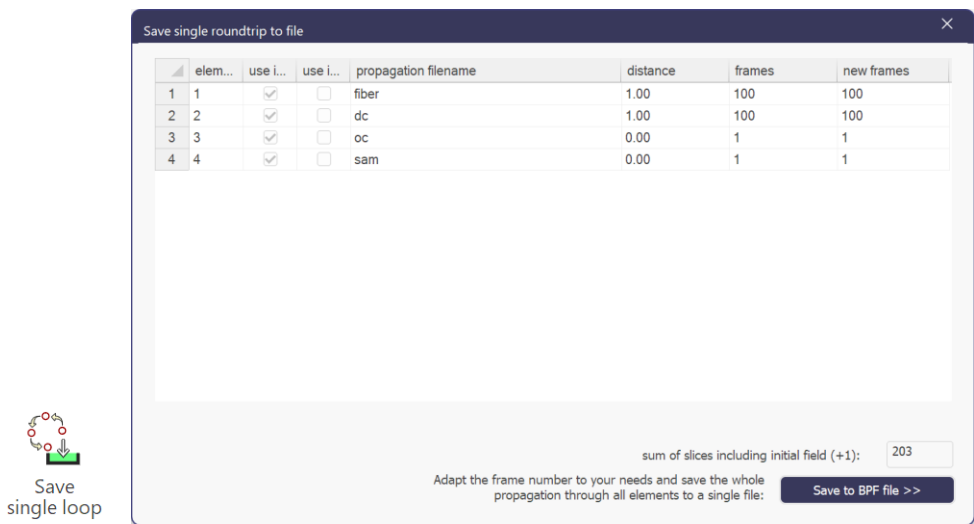
Start Loop

Executes the loop propagation, type the number of loops and start by pressing “OK”. The options “write to a propagation file” and “measure values” are switched off during a loop propagation. After each round trip the field can be saved to a *.bpf file with the option “write slice to bpf file”.

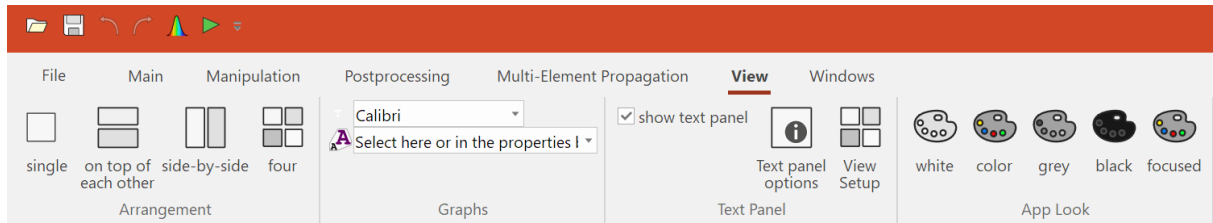


save single loop

The propagation within one roundtrip can be saved to a file by using this panel entry. The corresponding dialog resembles the loop structure and one has to specify the slices belonging to each segment.



2.6 View



This manages the configuration and presentation of the view.

However, the main setup is done using the attached window “**View Properties**” described in the next section.

2.6.1. Panel: Arrangement

Select between one and four views simultaneous on the screen as indicated by the icons.

2.6.2. Panel: Font

You can choose to display different main fonts and its relative size.

Panel: Text

Select “Text Panel” to show a summary of the main variables, like distance and energy.

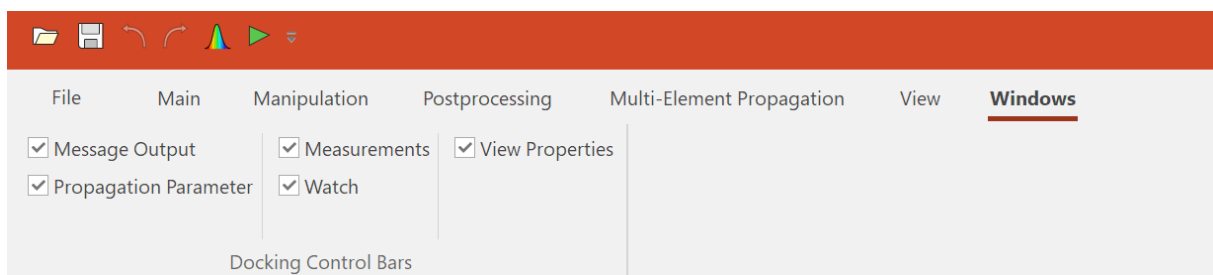
Text Panel options

Select the information that should be shown in the “Text Panel”.

View Setup

Set up the measured variables for each view and other details.

2.7 Attached Windows

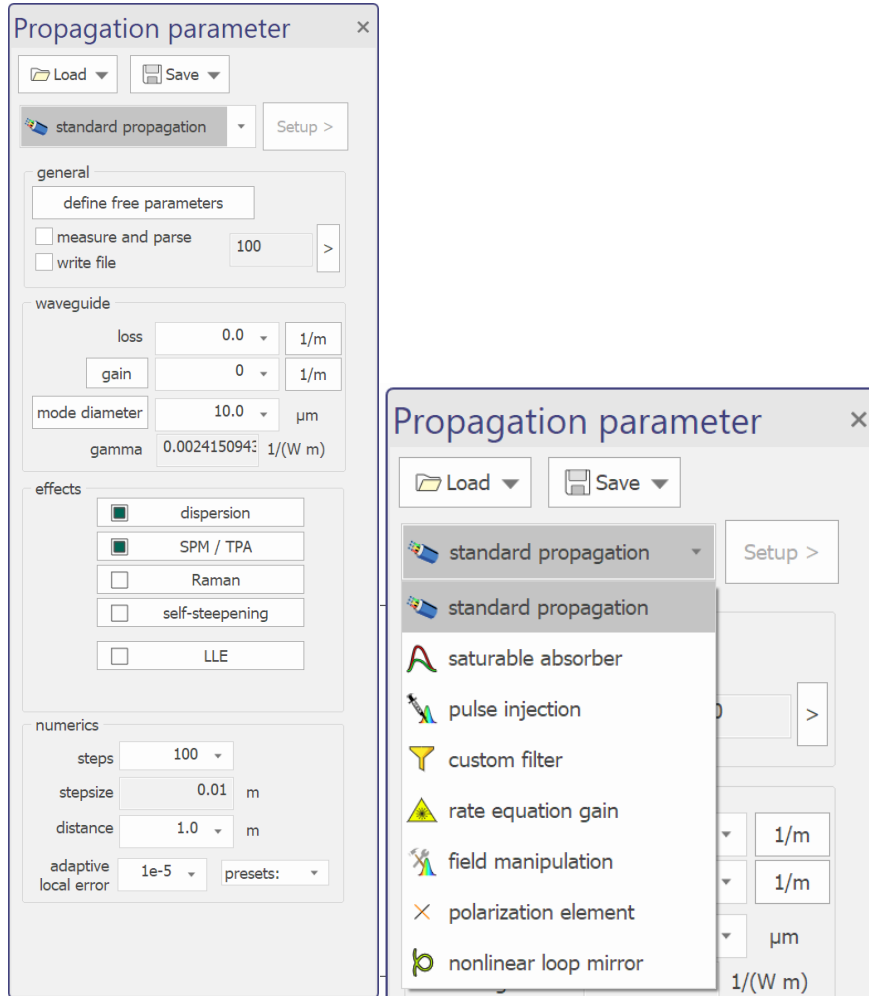


Each docking control bars can be switched on or off using the windows category. They are described in the following:

2.7.1. Propagation parameter

The propagation parameter window shows most parameters required to setup your simulation and are related to the equations that are numerically solved.

There are six different propagation methods available: “**standard fiber**”, “**saturable absorber**”, “**pulse injection**”, “**custom filter**”, “**rate equation gain**”, “**polarization manipulation**” and “**nonlinear loop mirror**”. They can be chosen within the propagation parameter window, see next figure.



Standard Propagation

This propagation is based on solving the nonlinear Schrödinger equation. If all effects are considered, it has the following form:

$$\frac{\partial A}{\partial z} = -\frac{\alpha}{2}A + \int_{-\infty}^{\infty} \frac{g(\omega)}{2} \tilde{A}(\omega) e^{-i\omega T} d\omega + \sum_{n \geq 1} \beta_n \frac{i^{n+1}}{n!} \frac{\partial^n}{\partial T^n} A + i\gamma \cdot \left(1 + i\tau_{shock} \frac{\partial}{\partial T}\right) \left(A(T) \int_{-\infty}^{\infty} R(\tau) |A(T-\tau)|^2 d\tau \right) \quad 2.1$$

The normalized functional form $R(t)$ includes the vibrational contribution of the delayed Raman responds to a fraction of f_R and the instantaneous electronic contribution to a fraction of $(1-f_R)$.

$$R(t) = (1 - f_R)\delta(t) + f_R h_R(t)$$

The shock term is described by a single time scale τ_{shock} , which is defined as [6]:

$$\tau_{\text{shock}} \cong \tau_0 + \tau_A = \frac{1}{\omega_0} - \left[\frac{1}{n_{\text{eff}}} \frac{dn_{\text{eff}}(\omega)}{d\omega} \right]_{\omega_0} - \left[\frac{1}{A_{\text{eff}}} \frac{dA_{\text{eff}}(\omega)}{d\omega} \right]_{\omega_0}$$

The parameter τ_A can be changed in the “**self-steepening**” dialog, see below.

To change the parameters in this equation, the propagation parameter window is usually used.

There you can directly edit the following parameters as they appear directly or indirectly:

linear loss / gain

waveguide

loss	0.0 ▾	1/m
gain	0 ▾	1/m

- in [1/m] or [dB/m], Click on the unit to change it.
- Click the button [gain] to choose:



Gain

steady state gain (long pulses to cw)

☐ saturate gain with Esat = J

$$g = g_0 / (1 + \frac{E}{E_{sat}})$$

profile

gain profile

Center nm Width nm
shape

add second peak

Center nm Width nm
shape

ratio of second to first peak (set to zero for only one peak):

user defined gain file

☐ use ASCII file for gain profile given in g(1/m) vs. wavelength (separator TAB)

temporal gain saturation (pulses shorter than population relaxation time)

☐ use temporal gain saturation instead of steady state gain and profiles, with

saturation fluence F J/cm²

$$g(T) = g_0 \exp\left(-\frac{1}{E_{sat}} \int_{-\infty}^T |A(t)|^2 dt\right)$$

with $E_{sat} = F \cdot A_{eff}$

saturation energy with current MFD: J

gain profile: The gain profile can also be an addition of two different profiles.

The profiles have the following analytical forms, which are normalized and multiplied by the gain value. The parameters are converted to frequency domain for the calculation (center wavelength~ ν_c , width~ $\Delta\nu$).

Lorentz	$\frac{1}{\pi} \frac{\Delta\nu}{\Delta\nu^2 + (\nu - \nu_c)^2}$
Parabolic	Positive values of $1 - 2\left(\frac{\nu - \nu_c}{\Delta\nu}\right)^2$
N-th order Gauss (supergauss2: N=2 ...)	$4 \cdot \ln(2) \left(\frac{(\nu - \nu_c)^2}{\Delta\nu^2}\right)^N$
Asymmetric sech (reverse frequency axis for Asymmetric Lorentz)	$\nu < \nu_c: \cosh\left(\frac{\nu - \nu_c}{0.45 \cdot \Delta\nu / 2.041475}\right)^{-1}$ $\nu > \nu_c: \left(1 + \frac{2 \nu - \nu_c }{0.55 \cdot 3.5 \cdot \Delta\nu}\right)^{-2}$

--	--

Select a **gain profile from file**, an ASCII file, created by yourself in a separated dialog.

The ASCII file has to have the structure: <wavelength in nm> [TAB] <positive gain in 1/m>, e.g.

1000	0
1010	0.5
1020	0.6
1030	0.4
1040	0

- It includes setting **total gain saturation** – check this to simulate gain saturation effects.
- Alternatively, choose **temp gain saturation** – check this to approximately simulate the temporal gain saturation effects meaning that the front depletes the gain and is amplified more than the pulse trail. This can be observed for long pulses with a pulse energy close to the saturation energy of the fiber E_{sat} , which is calculated automatically (for details see [2]).

MFD

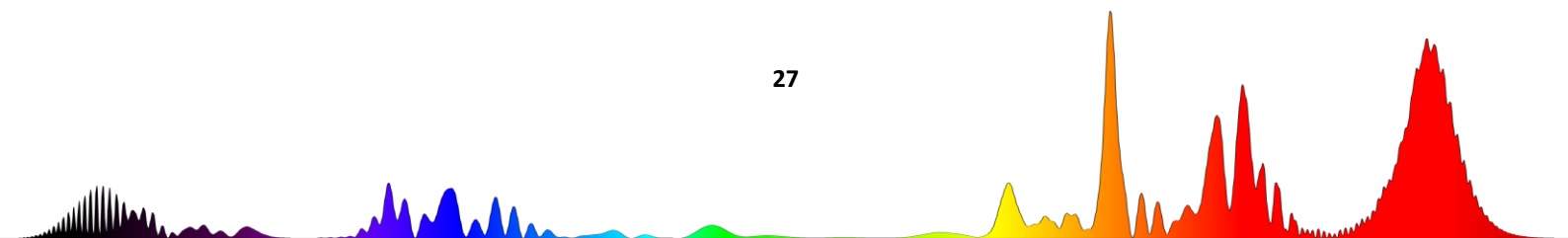
mode diameter	10.0 ▾	μm
---------------	--------	---------------

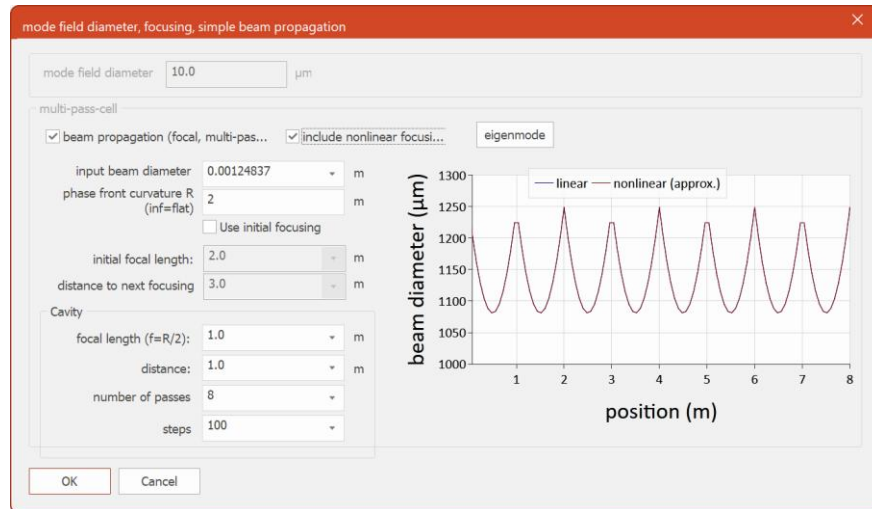
- Sets the **mode field diameter** of the propagation mode in [μm]. It is used to calculate the nonlinear coefficient g by $\gamma = \omega/c \cdot n_2/A_{\text{eff}}$ with $A_{\text{eff}} = \pi \cdot \text{MFD}$. Also it determines the saturation energy E_{sat} (see also [temp gain sat] below and [2]). The parameter n_2 can be changed in the “fiber parameter” dialog. For an advanced setup, especially using the mode diameter setup for simultaneous **Gauss BPM simulation**, see below.

Gauss Beam Propagation (Multi-Pass-Cell)

mode diameter	10.0 ▾	μm	converts to	using BPM	μm	if selected
---------------	--------	---------------	-------------	-----------	---------------	-------------

- click the “mode diameter button” to access the dialog. See tutorial on Multi-Pass-Cell for more information.





SPM

- check this to use the SPM term in the NLSE.

If the shock term is not used (self-steepening), the algorithm to solve the nonlinear Schrödinger equation needs to know, what the field center frequency is, as it might be different to the data array center (spectral grid shift > see “Create Pulse Dialog” where you can offset the wavelength compared to the array center wavelength).

self phase modulation / two photon absorption term

$$\frac{\partial A}{\partial z} = \dots + i\gamma(1 - f_R)|A(T)|^2 A(T)$$

$$\gamma = \frac{\omega_0}{c} \frac{n_2}{A_{\text{eff}}} \text{ and } A_{\text{eff}} = \frac{\pi}{4} MFD^2$$

n_2 m^2/W

without shock term (self-steepening), calculate gamma by:

☒ use pulse create wavelength nm

☐ use fixed wavelength: nm

f_R

TPA m/W

☐ saturate SPM

saturation power GW/cm^2

☒ use SPM and TPA ☐ exclude SPM

self steepening

- check this to simulate the self-steepening effect.

- it includes the (linear) dependence of the effective area with wavelength though an **additional shock term**, please see Ref. 6 for details.

term self steepening

$$\frac{\partial A}{\partial z} = \dots + i\gamma \left(1 + i\tau_{\text{shock}} \frac{\partial}{\partial T} \right) \left(A(T) \int_{-\infty}^{\infty} R(\tau) |A(T - \tau)|^2 d\tau \right)$$

$$\tau_{\text{shock}} = \tau_0 + \tau_A = \frac{1}{\omega_0} - \left[\frac{1}{n_{\text{eff}}} \frac{dn_{\text{eff}}(\omega)}{d\omega} \right]_{\omega_0} - \left[\frac{1}{A_{\text{eff}}} \frac{dA_{\text{eff}}(\omega)}{d\omega} \right]_{\omega_0}$$

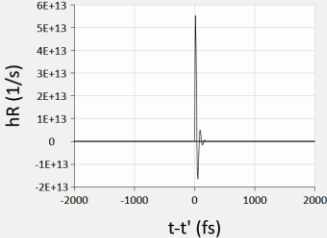
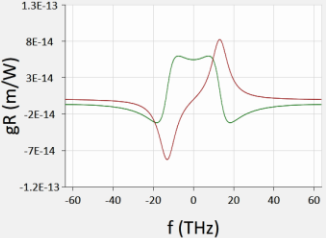
additional shock time fs

☒ use self steepening term
☐ exclude self steepening

Raman response

- check this to simulate the delayed Raman response.
- The dialog allows for a detailed setup of the function $h(t)$ or scripting your own.

term delayed Raman response

$$\frac{\partial A}{\partial z} = \dots + i\gamma \left(1 + i\tau_{\text{shock}} \frac{\partial}{\partial T} \right) \left(A(T) \int_{-\infty}^{\infty} R(\tau) |A(T - \tau)|^2 d\tau \right) \text{ with } R(\tau) = (1 - f_R)\delta(\tau) + f_R h_R(\tau)$$

f R hR(t) = 1/fs

n2 m/W

☒ use term
☐ exclude term
☐ convolve with current spectrum

steps, stepsize, distance

- Set the distance to propagate and the corresponding stepsize by these values. It determines the accuracy of the Split-Step algorithm. Even if the adaptive step size option help to avoid numerical errors, decrease the step size to ensure the numerical result.

stepsize adaption

- Options: **none/rough/normal/precise/accurate** – This determines the adaptive stepsize control by means of the local error. The stepsize is reduced until the local error is below the given value. The smallest stepsize is 1 μm and therefor the highest precision used by the software. Set the stepsize adaption to “none” to control stepsizes smaller than 1 μm .

numerics

steps

stepsize m

distance m

adaptive local error presets:

Measure and parse

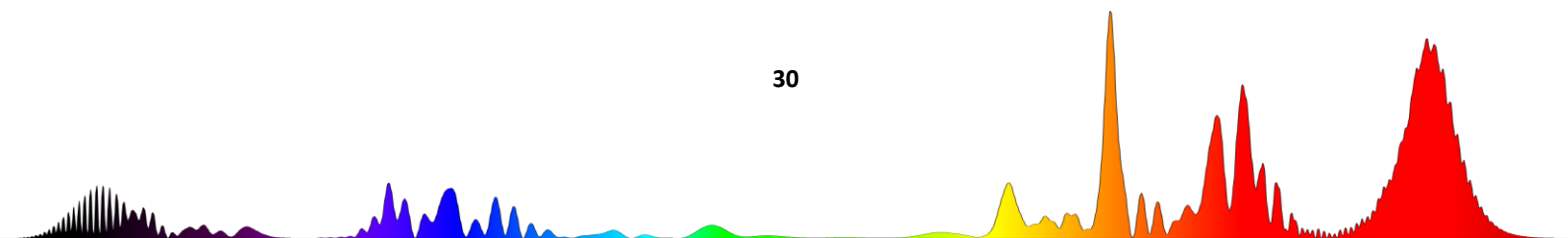
- Select this option to measure and parse strings that you might have set variable during propagation. It will reinitialize the parameter of the NLSE. Set also the number of how many times you want to update these during the propagation.

write file

Select this option to write a specific number of slices of the propagation to a propagation file (*.bpfx). Use this to write files that are required for most post-processing functions. If no filename is given, a fallback filename in the %APPDATA% directory is taken.

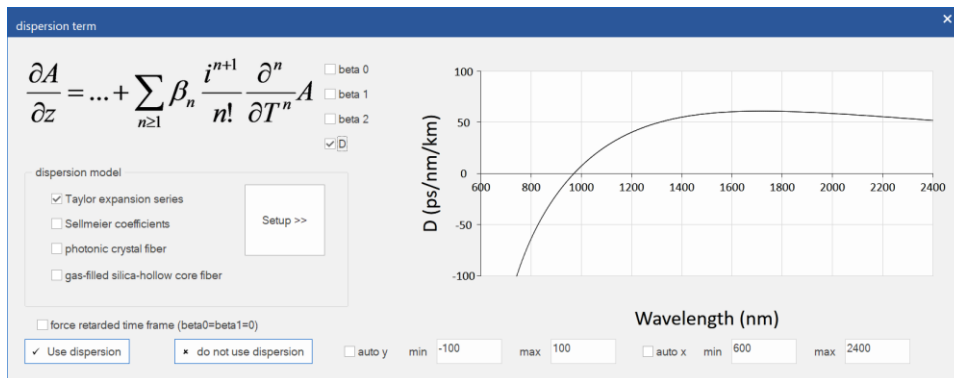


There are also several dialogs available to change additional parameters:



Dispersion

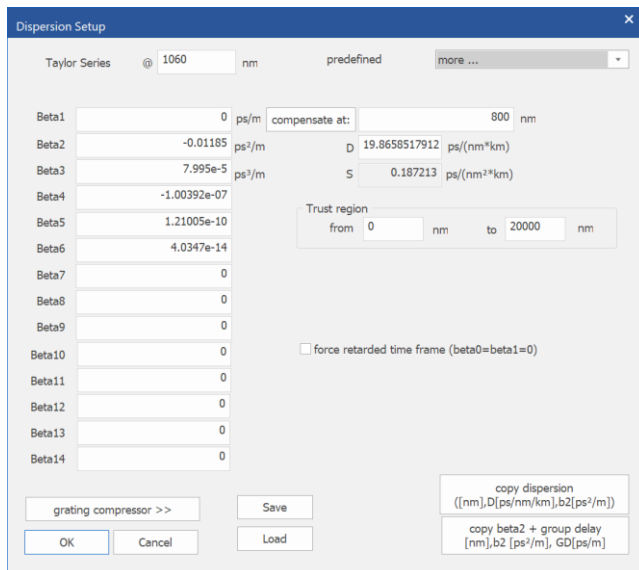
- is changed in the “Dispersion dialog” by using the following options:



- Taylor expansion series

It is specified by the coefficients β_n according to the following equation (Taylor series expansion):

$$\beta(\omega) = n_{eff}(\omega) \frac{\omega}{c} = \beta_0 + \beta_1(\omega - \omega_0) + \frac{1}{2} \beta_2(\omega - \omega_0)^2 + \frac{1}{6} \beta_3(\omega - \omega_0)^3 \dots$$



The center wavelength/frequency of this Taylor series expansion ω_0 is also required. Specify a trust region. It determines in which wavelength range the Taylor series generates values, which are physically right. Outside this region, the dispersion is set to zero. If the range is set to zero, the full range is used for evaluating the Taylor series.

Additionally, it is possible to select several fibers from the pre-settings as well as to save or load the dispersion settings.

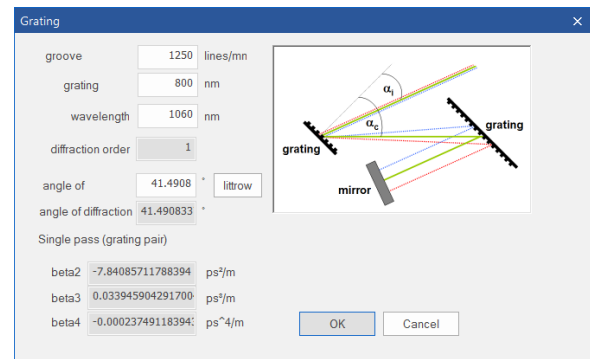
Automatically, the parameters of β_2 and β_3 are converted to the dispersion parameter D and its slope $S = dD/d\lambda$ according to:

$$D = -\frac{2\pi c}{\lambda^2} \beta_2$$

$$S = -\frac{2\omega^3}{(2\pi)^2} \beta_2 + \frac{\omega^4}{(2\pi)^2} \beta_3$$

If the center wavelength of the current spectral domain does not correspond to the Taylor series expansion wavelength of the dispersion, the Taylor series is automatically recalculated (internal). During this operation, a group delay (and fast varying amplitude due to the offset frequency) usually appears at the center wavelength of the pulse. To compensate for that, the option “always use retarded time frame” is used to set both values to zero ($\beta_0^{\text{new}} = \beta_1^{\text{new}} = 0$). Thus, the retarded time frame is always at the center wavelength of the spectral domain and the most slowly varying amplitude envelope is used.

- grating compressor
- In the Taylor series expansion dialog, the dispersion of a typical grating compressor in single pass can be calculated. The drawing in the dialog visualizes the parameters (m = diffraction order).
- The dispersion is calculated according to:



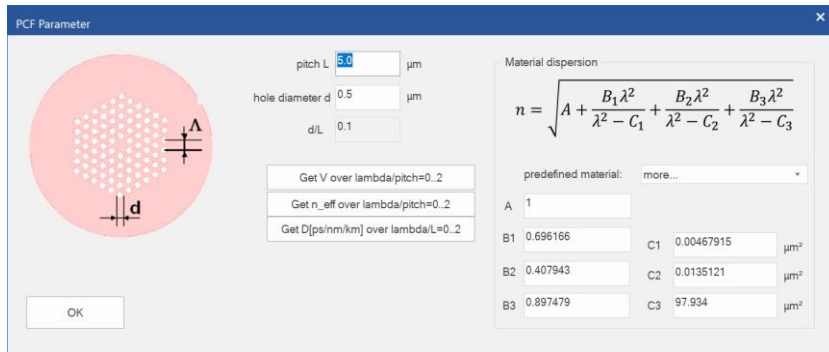
$$\sin(\alpha_c) + \sin(\alpha_i) = m \frac{\lambda}{\Lambda}$$

$$\beta_2 = -\frac{1}{c} \frac{m^2}{\omega^3} \left(\frac{2\pi c}{\Lambda} \right)^2 \frac{1}{\cos(\alpha_c)^3}$$

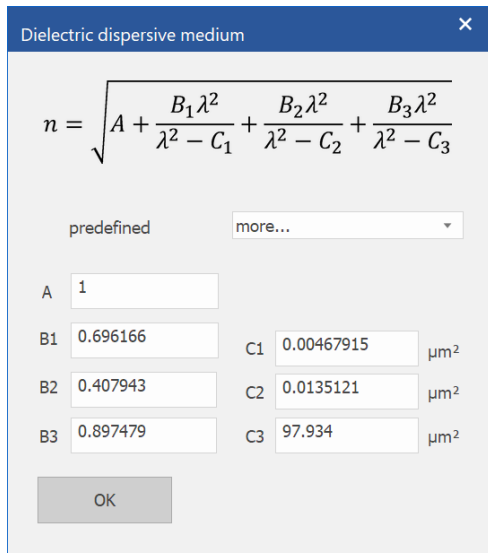
$$\beta_3 = -3\beta_2 f \quad \text{with} \quad f = \frac{1}{\omega} + \frac{m}{\omega^2} \frac{2\pi c}{\Lambda} \frac{\sin(\alpha_c)}{\cos(\alpha_c)^2}$$

$$\beta_4 = \beta_2 \left(12f^2 + 3 \frac{m^2}{\omega^4} \left(\frac{2\pi c}{\Lambda} \right)^2 \frac{1}{\cos(\alpha_c)^4} \right)$$

- **fused silica photonic crystal fiber:** By specifying the hole to hole distance (pitch) and the hole diameter, the dispersion of a one missing hole solid core photonic crystal fiber can be used. The background material is assumed to be fused silica. Please see [3] for details.



- Sellmeier coefficients
- The well-known Sellmeier coefficients can also be used to describe the dispersion of a material. Several predefined materials are available. Please take a look at <http://refractiveindex.info> for more material data.
- Please also keep in mind that there are other definitions of the sellmeier equation, which might explain differences for coefficients.



Rate Equation gain

The propagation solves the NLSE similarly to “standard fiber” but includes the gain by solving the stationary rate equations. This can be used to model cw and quasi-cw amplification including ASE.

Background: The theoretical description of the laser process in fiber amplifiers is done by combining the local rate equation for the laser process and the power flow (propagation equation) for the fields along the fiber. They have been developed to predict and optimize Erbium-doped fiber amplifiers used for telecommunication application [7].

The local rate equation describes the dynamic of the emission and absorption processes of the rare earth ion within its host material by using its spectroscopic properties. A simple model for the energy level system for the Ytterbium-ion is shown in Figure 2.1 and shows some of the most important emission and absorption lines, which result from the Stark splitting of the upper and lower energy lines. It has been argued that for Erbium and Ytterbium fibers, a reduced two level model for the emission and absorption process can be used so that the effective emission and absorption cross section include the population density and cross section values [7, 8]. As an example, the effective cross sections of a typical Yb-doped fiber is shown in Figure 2.2.

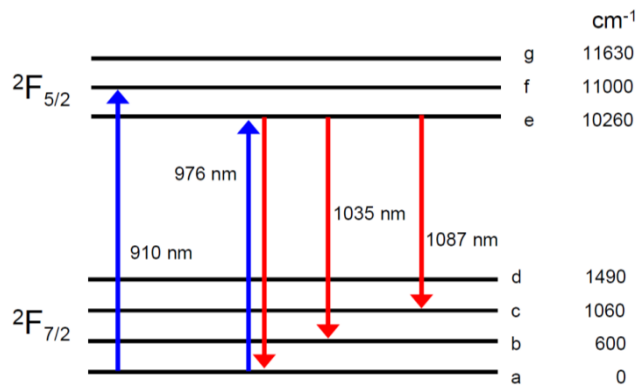


Figure 2.1: Energy level model for Ytterbium-ion in fused silica.

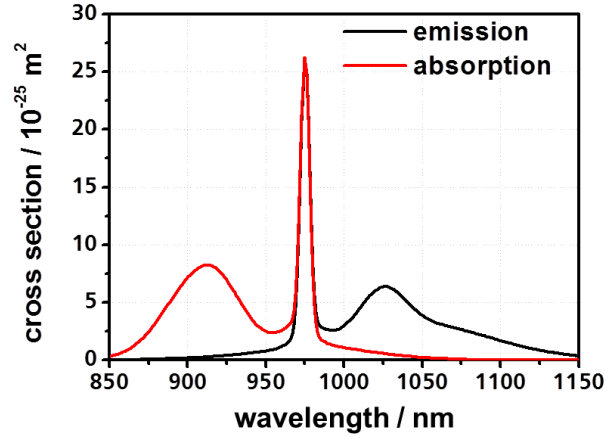


Figure 2.2: Typical emission and absorption cross section of an Yb-doped fiber.

The approximated system used in fiberdesk leads to the following equations for the forward (+) and backward (-) propagating signal (S) and pump powers (P) including spontaneous emission (SE)²

$$\frac{dP_{S/P}^{\pm}}{dz} = \Gamma^{S/P} (\pm \sigma_{\text{em}}^{S/P} N_2 \mp \sigma_{\text{abs}}^{S/P} N_1 + \alpha_{S/P}) P_{S/P}^{\pm} + SE_S \quad 2.2$$

with

$$SE_S = \pm 2 \cdot h\nu \cdot \Delta\nu \cdot \sigma_{\text{em}}^S N_2$$

where the total ion density $n_0 = n_1 + n_2$ is the sum of upper and lower population density and $\alpha_{P/S}$ is an additional loss (background loss) for the fields. It is assumed that the pump absorption can be described by a simple overlap factor Γ_p , which is the ratio of doped core area to pump core area. The upper population density for steady-state conditions is

$$n_2(z) = n_0 \frac{\sum_{k=S,P} \frac{\sigma_{\text{abs}}^k}{h\nu_k} \Gamma^k \frac{P^k(z)}{A_c}}{\sum_{k=S,P} \frac{\sigma_{\text{abs}}^k + \sigma_{\text{em}}^k}{h\nu_k} \Gamma^k \frac{P^k(z)}{A_c} + \frac{1}{\tau}} \quad 2.3$$

with τ as the upper state lifetime and the total power at a given position $P(z) = P^+(z) + P^-(z)$. The inversion level is defined as n_2/n_0 . The solution of Eq. 2.2 and 2.3 and can be made

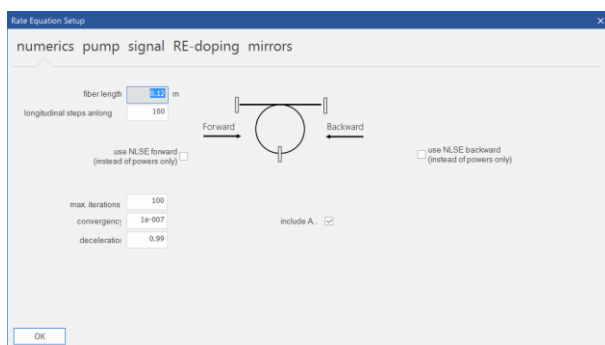
² for the signal only

for fiber amplifier but also for laser, if the boundary conditions at the laser mirrors (typically $z=0, L$) are included in the description for forward and backward propagating fields.

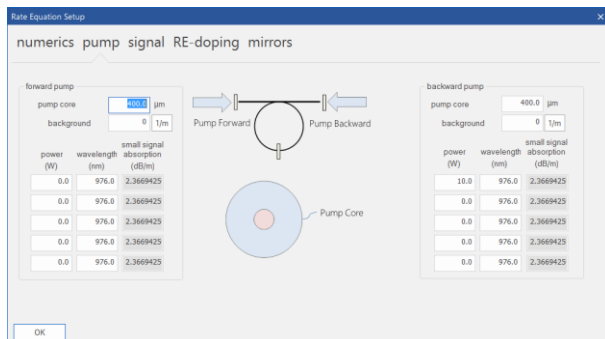
For ultra-short pulse propagation, the rate equations are combined with the nonlinear Schrödinger equation (Eq. 2.1) by calculation the spectral gain $g(\omega, z) = dP(\omega)/dz \cdot 1/P(\omega)$ with the results of the rate equation and then propagating the NLSE with that gain. However, the spontaneous term is added to the complex field by photons of random phase in that case.

In the main dialog, all parameters are set in various tabbed property pages including:

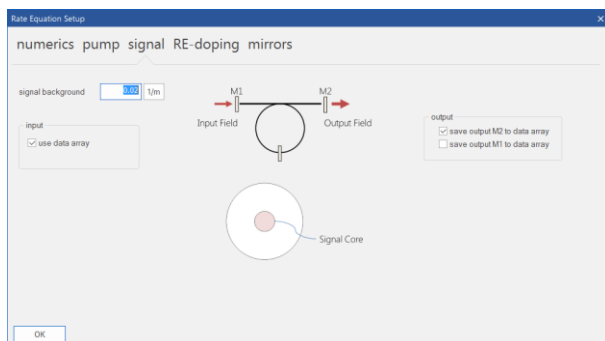
- Numerics



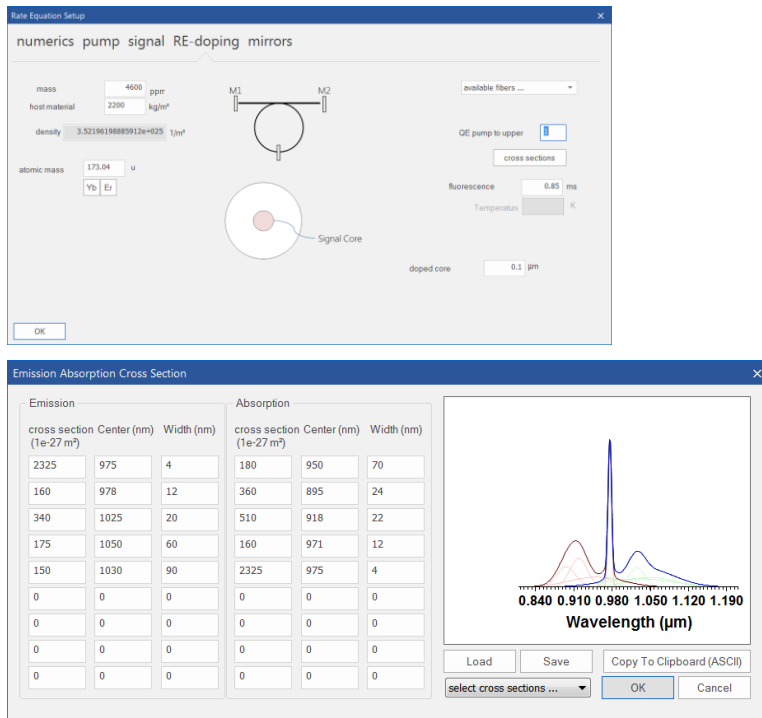
- Pump



- Signal



- Doping, with its sub-menu for cross section setup. There, the cross sections can be included using a simple multi-Gaussian peak fit.



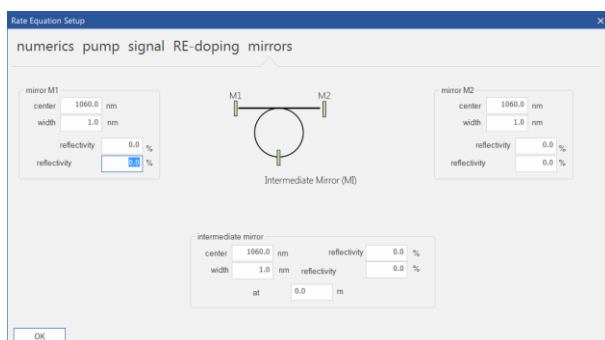
The equation for the cross-section fit is:

$$\sigma(\nu) = \sum_j \sigma_j e^{-\frac{1}{2} \left(\frac{\nu - \nu_0}{\Delta \nu} \right)^2}$$

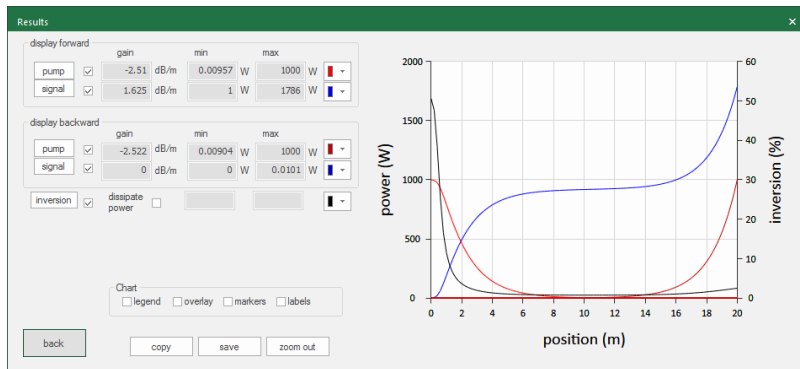
With ν as the frequency, ν_0 the center frequency of the cross-section peak, both expressed as wavelength ($\nu = c/\lambda$) as well as $\Delta \nu$ given by

$$\Delta \nu = 1.0 / (2 * \text{sqrt}(2.0 * \log(2))) * |c/(\nu_0 + \Delta \lambda / 2) - c/(\nu_0 - \Delta \lambda / 2)|$$

- where $\Delta \lambda$ is the FWHM of the contributing peak.
- Mirrors



After propagation, the total powers and inversion can be accessed in the “main” section, “propagation”->”RE Results”.



The options “live” is disabled during the calculation. However, you can “write to a propagation file” and measure or display afterwards (“Post Processing”).

Saturable Absorber

You can choose between instantaneous saturation and a saturable element.

The first action of this element is to center the field temporally.

You can choose between an instantaneous saturation and a saturable element with a saturation that is decaying with a specific time constant.

All models change the field according to an intensity or peak power depending reflectivity³ R changing the existing field envelope A_{in} to the reflected output field A_{out} :

$$A_{out} = R A_{in}$$

With the unit of A being $J^{1/2}$ the peak power P_P for each datapoint of the field is obtained by division to the dwell time τ_{dw} (time between the temporal field datapoints)

$$P_P = |A(T)|^2 / \tau_{dw}$$

Usually, there is a reflectance R_0 , which cannot be saturated and is the reflectance at low power levels. The saturable reflectance ΔR (also called modulation depth) depends on peak power and might be time dependent. R_0 and ΔR do not need to add up to 100% because the saturable absorption might not be completely saturable.

Here are the models implemented in fiberdesk:

Fast Saturable Absorber

³ R can also be the transmission, the models apply accordingly

The reflectance of the first model is an instantaneous saturation according to:

$$R = R_0 + \Delta R \left(1 - \left(1 + \frac{P_p}{P_{sat}} \right)^{-1} \right)$$

Time depending saturable absorber with one time constant

The time dependent saturable absorption modifies the field according to the following excitation equation and the resulting reflectivity

$$\frac{du}{dt} = \frac{P_p}{A \cdot F_{sat}} (1 - u) - \frac{u}{T_1}$$

$$R = R_0 + \Delta R \cdot u$$

where $u(t)$ is a dimensionless excitation level of the saturable absorber between 0 (unexcited) and 1 (fully saturated). Furthermore, A is the effective beam area on the saturable absorber and F_{sat} the saturation fluence in J/cm^2 . The recovery time of the absorber is T_1 .

The unsaturable and saturable reflectivity can be controlled directly in the dialog. The saturation energy E_{sat} is controlled by controlling the focal spot and the saturation fluence (as known from semiconductor saturable absorber mirrors).

Fast saturable absorber with roll-off

The model has a $\sin^2$ behaviour so that for a peak power above PA the reflectivity drops.

$$R = R_0 + \Delta R \cdot \sin^2 \left(\frac{\pi P_p}{2 P_A} + \varphi_0 \right)$$

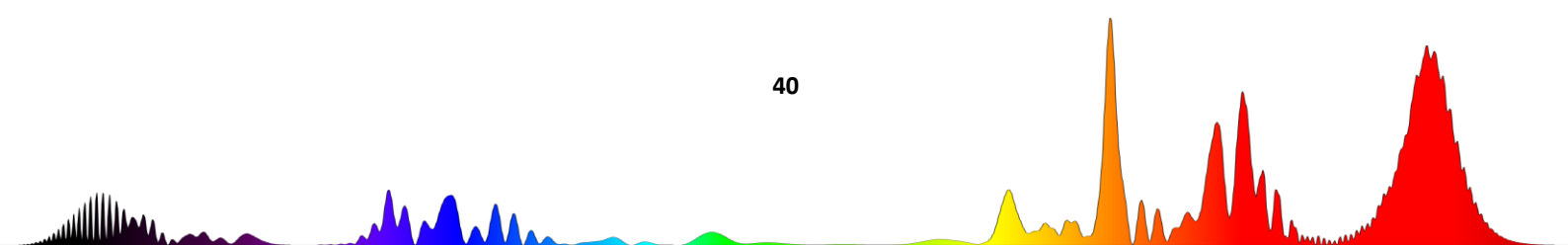
Saturable absorber with two-photon absorption

The last model is using a saturation fluence and values for two photon absorption that lets the reflectivity saturate⁴. It takes the pulse duration (rms measurement of the fields duration times 2.355⁵) as t_p . The total energy of the field is E so that the fluence F is E/A .

$$R = R_0 + \Delta R \cdot \left(1 - \frac{F_{sat}}{F} + \frac{F_{sat}}{F} e^{-F/F_{sat}} \right) - \frac{\beta \cdot F \cdot d}{t_p}$$

⁴ https://www.batop.de/products/laser/fiber-laser/data-sheet/ps-fiber-laser-evaluation-kit_PSFL1030.pdf, downloaded 07.10.2025

⁵ This is the conversion of the rms value to the FWHM assuming a Gaussian pulse shape

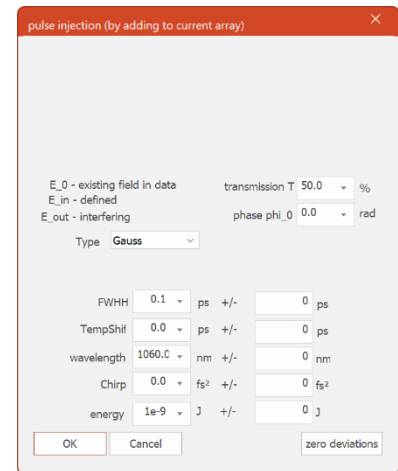


Pulse Injection

This method adds a pulse to the current data array, causing interference with the existing field. You must set a transmission parameter and phase.

The parameters can vary randomly based on the uncertainty parameter set in the setup dialog.

Tip: For an interference-free pulse, use multi-element propagation. You can either add a high loss before this element to zero out the existing array and then inject a pulse, or achieve absolute zero by multiplying with zero using "manipulation" propagation.



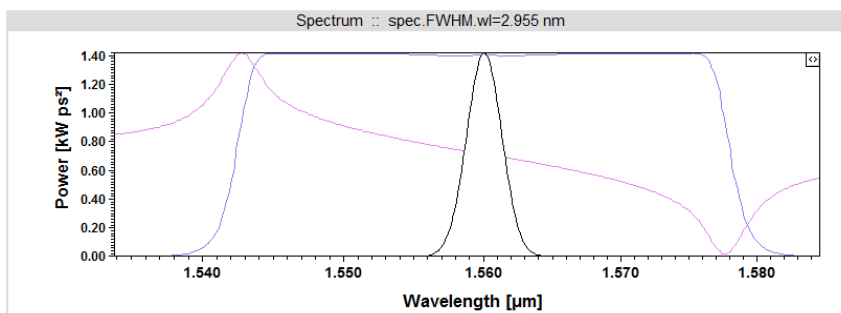
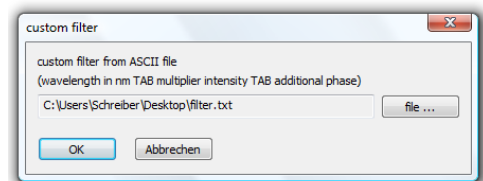
Custom Filter

This allows to select an ASCII file with a custom defined transmission $T(\omega)$ for the spectral intensity and an additional spectral phase $\phi(\omega)$. It is combined with the spectral field amplitude as follows:

$$\tilde{A}(\omega) \rightarrow \sqrt{T(\omega)} \cdot \tilde{A}(\omega) \cdot e^{i\phi(\omega)}$$

The ASCII file has to contain three columns with the values of the wavelength in nm, the transmission T and the phase in rad. The values have to be separated by "TAB" or ",".

The imported data are displayed in the main view (normalized).



Nonlinear Loop Mirror

This allows to define a nonlinear loop mirror consisting of several elements that are previously saved as ppfx files. The current field is the input and the output is the coherent superposition of the results of the left and right clockwise propagating field.

If you need to setup a non-reciprocal element, use it only either in cw or ccw direction.

See [tutorial 8](#) for details and examples.

2nd output
input

output

2nd input

coupler

R

1

2

3

4

5

1-R

transfer parameter
variation to element

☐ yes, to

element 1

☐ yes, to

element 2

☐ yes, to

element 3

☐ yes, to

element 4

☐ yes, to

element 5

non-reciprocal? select if to use in clockwise and/or
counter clockwise propagation

	cw	ccw
select >>	☒	☒
select >>	☒	☒
select >>	☒	☒
select >>	☒	☒
select >>	☒	☒

output field

☒ use output port
 ☐ use 2nd output port (same as input)

both only possible with second field enabled, then first field output will be the input port

OK

cancel

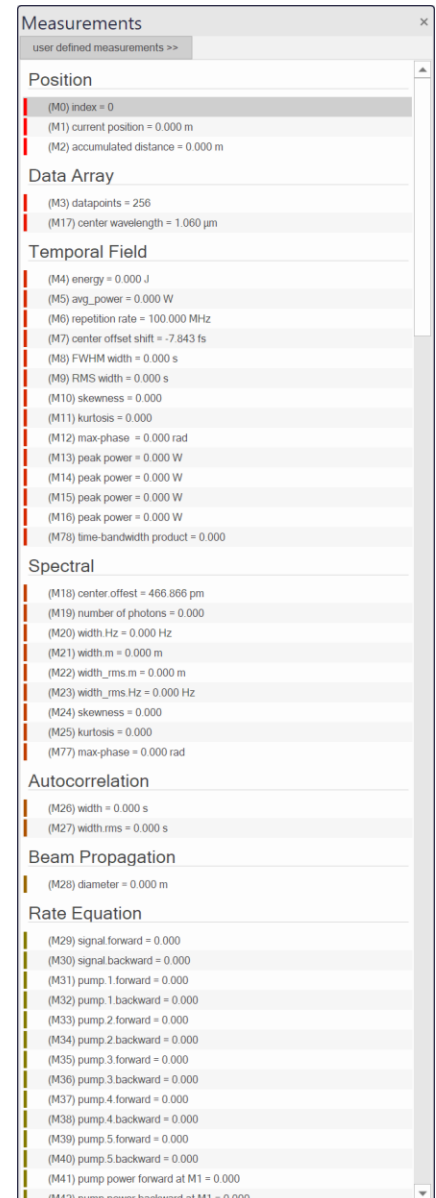
R = 0.5

with 0.5 = 50:50

2.7.2. Measurements

The current dataarray is analysed almost after each modification. The results are displayed in this separate window. SI units are used. The description is usually intuitive and displayed in the bottom of the windows when clicked on a specific measurement. To keep it short, here is a description for some of the values:

- datapoints – number of datapoints in current data array
- position – current propagation position
- FWHM – full width at half maximum
- rms – root mean square (second momentum)
- ac. – values belonging to the autocorrelation
- pulse. – values belonging to the temporal field intensity
- spec. – values belonging to the spectral field intensity
- theory. – parameters of the current propagation according to usually used normalization parameters (change is by “menu->manipulation->change T0”)
- t.b. product – time-bandwidth product
- Q – quality factor in time and spectral domain (FWHM/RMS/2.0) [1]
- (for more information ask webmaster @ fiberdesk.com)



To see a description for other parameters, click the parameter and a description is shown in the information window at the bottom of the control:

Spectral

(M20) center.offest = 466.866 pm

(M21) number of photons = 0.000

(M22) width.Hz = 0.000 Hz

(M23) width.m = 0.000 m

(M24) width_rms.m = 0.000 m

spectral width as second central momentum (deviation) given in dimensions of a wavelength difference

2.7.3. Measurement graphs

If the measurement is switch on (see propagation parameter window) during propagation, all measured value from the measurement result window are show with respect to the propagation distance in the “Graph” window.

general

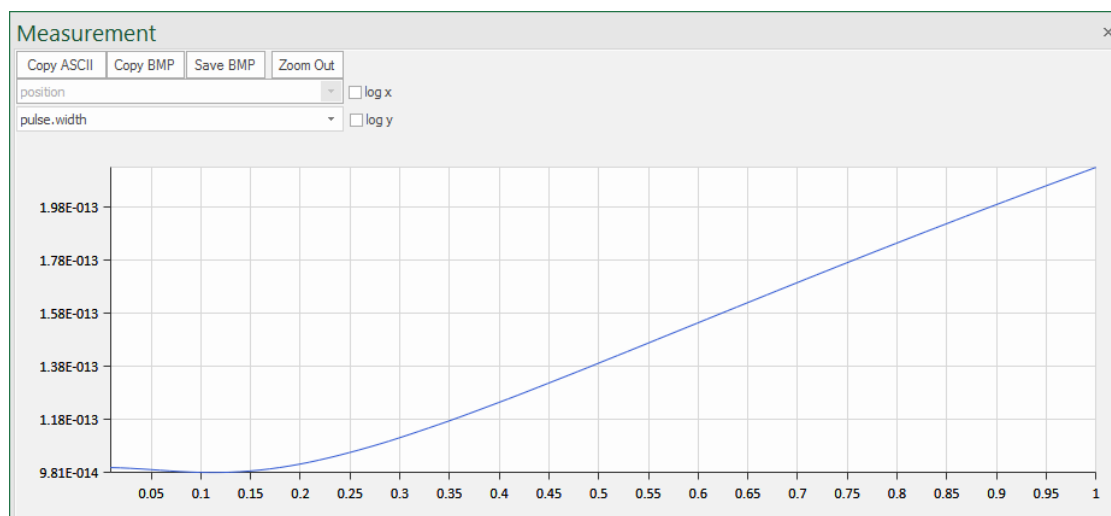
define free parameters

☒ measure and parse

100

>

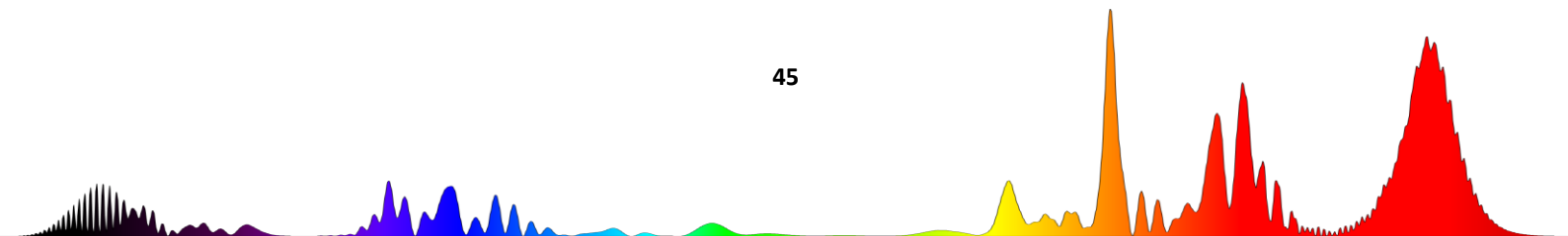
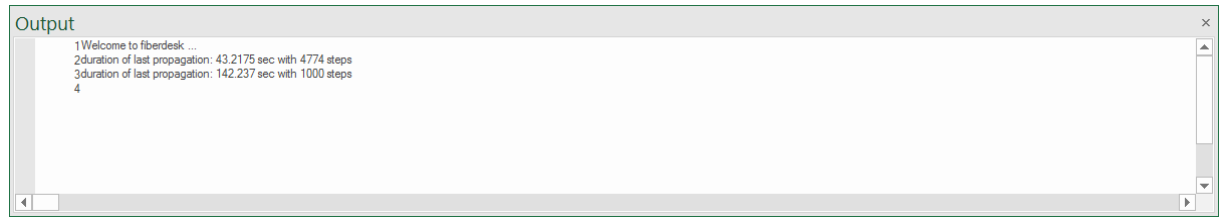
☐ write file



Use the buttons on top to copy the content of the current graph to the clipboard in ASCII or BMP format or save it to a file. Zoom in to the values by moving to mouse onto the data and click left. Zoom out by the button on top.

2.7.4. Output

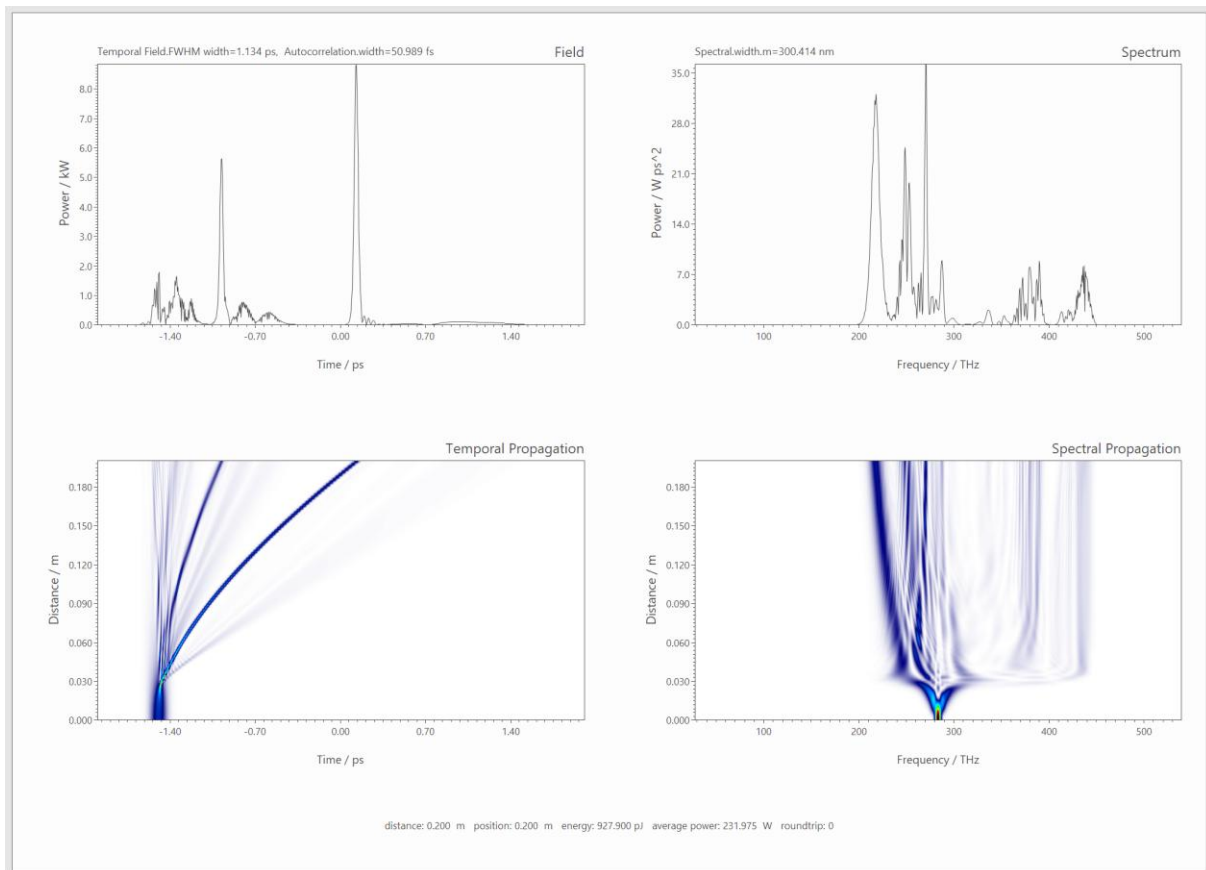
Several important information or results of the propagation are displayed in the output window.



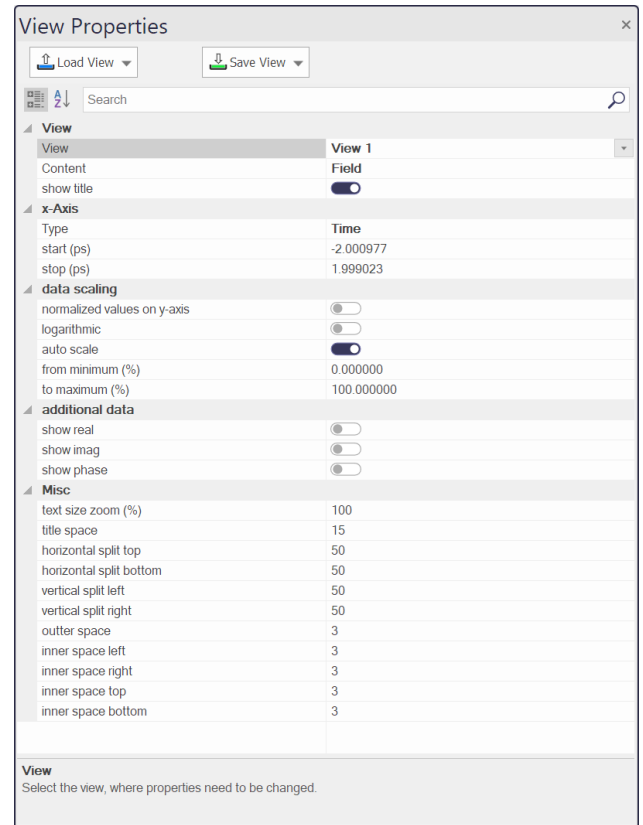
2.8 View interface

2.8.1. View

The general view can contain different views of the current electric field: the temporal field, its Fourier transformation as the spectral field and the autocorrelation. The number of views can be chosen in the ribbon menu (see ribbon control “View”).



The control of the view is done in the view setup pane and is related to the selected view (e.g. simply by clicking into the view) In the bottom of the pane, a description of each property item is displayed – click on a specific item to read its description.



View Properties

Load View Save View

Search

View

View 1

Content Field

show title ☒

x-Axis

Type Time

start (ps) -2.000977

stop (ps) 1.999023

data scaling

normalized values on y-axis ☐

logarithmic ☐

auto scale ☒

from minimum (%) 0.000000

to maximum (%) 100.000000

additional data

show real ☐

show imag ☐

show phase ☐

Misc

text size zoom (%) 100

title space 15

horizontal split top 50

horizontal split bottom 50

vertical split left 50

vertical split right 50

outer space 3

inner space left 3

inner space right 3

inner space top 3

inner space bottom 3

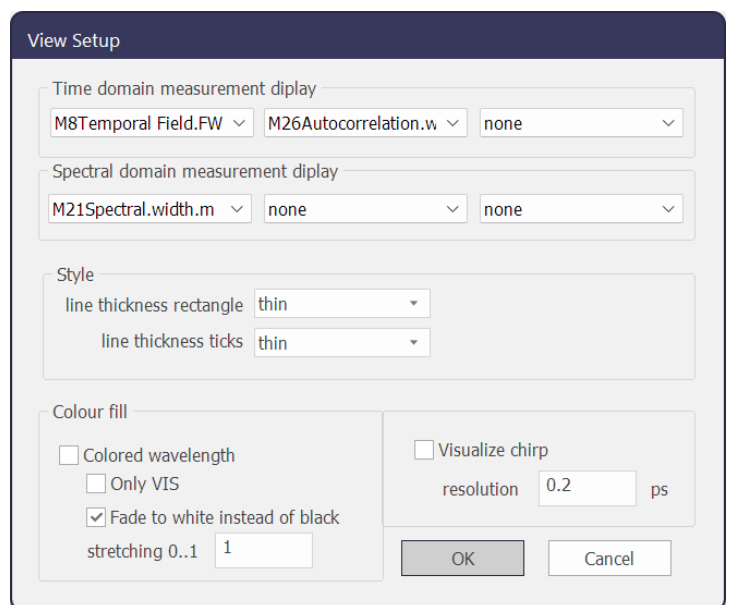
View

Select the view, where properties need to be changed.

There it is possible to select up to three different measured values displayed in the view for a quick access.

If the option “colored wavelength” is chosen, each wavelength is colored individually. The colors are controlled by the options “only VIS” to highlight the visible wavelength (otherwise the whole current spectral range is used) and the option “Fade to white ...” to choose the colors of the wavelength that are out of the visible region.

Additionally, a fast algorithm is implemented to visualize the temporal position of the spectral components (chirp).



View Setup

Time domain measurement display

M8Temporal.Field.FW M26Autocorrelation.w none

Spectral domain measurement display

M21Spectral.width.m none none

Style

line thickness rectangle thin

line thickness ticks thin

Colour fill

☐ Colored wavelength

☐ Only VIS

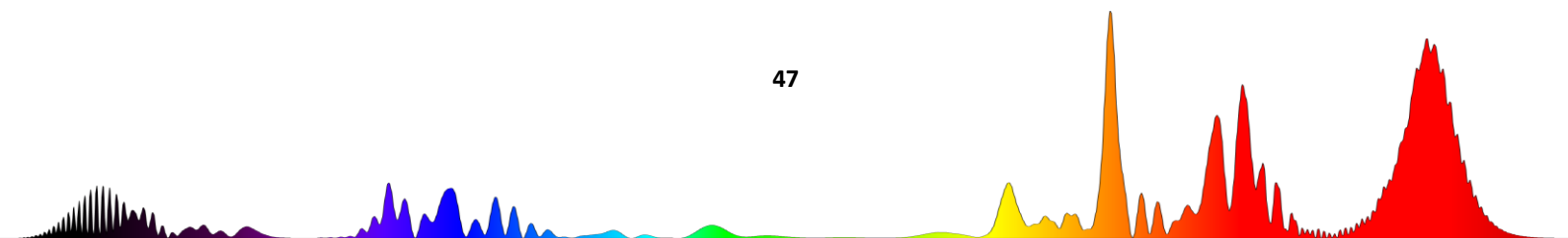
☒ Fade to white instead of black

stretching 0..1 1

☐ Visualize chirp

resolution 0.2 ps

OK Cancel



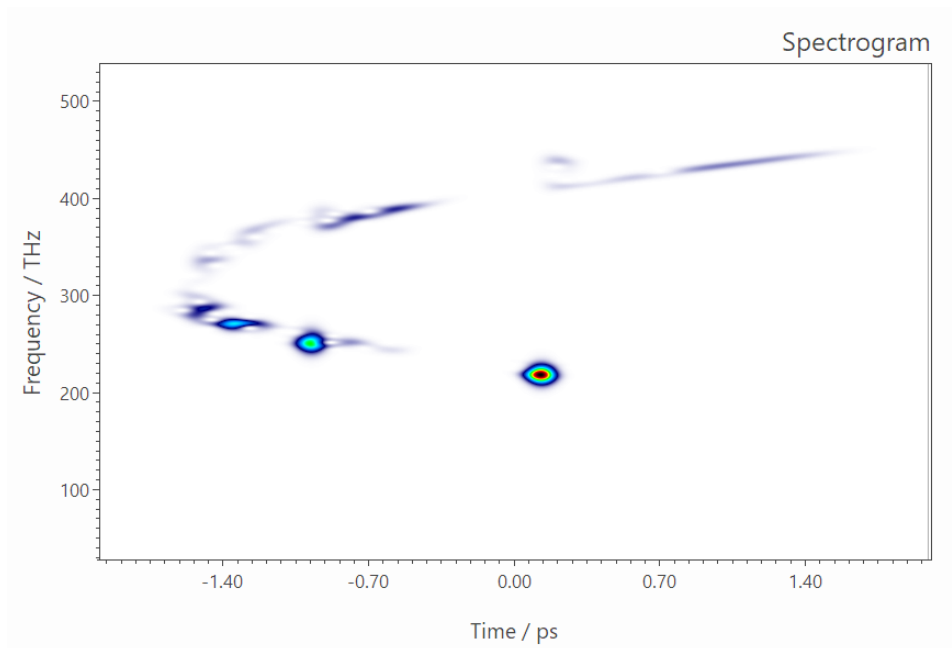
2.8.2. Spectrographic content

The spectrographic view shows a spectrally (wavelength) resolved temporal map of the electric field. This view is well known from the measurement technique of ultrashort pulse known as frequency resolved optical gating (FROG) [5]. It is calculated by the following equation:

$$S(t, \lambda) = \left| \int_{-\infty}^{\infty} e^{-i\frac{c}{\lambda}\tau} e^{-i(\tau-t)^2/T_{BW}^2} A(z, \tau) d\tau \right|^2$$

If the axis of the spectrum in the normal view is set to any of the frequency axis, the spectrogram is also calculated in time-frequency domain.

$$S(t, \omega) = \left| \int_{-\infty}^{\infty} e^{-i\omega\tau} e^{-i(\tau-t)^2/T_{BW}^2} A(z, \tau) d\tau \right|^2$$



In the view properties pane, the temporal resolution T_{BW} can be chosen.

2.9 References

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