

Lecture 1 - Overview

- Graphical User Interface
- Parameter Access
- Setting up a propagation
- Setting up a view
- Loading / Saving field, projects, components

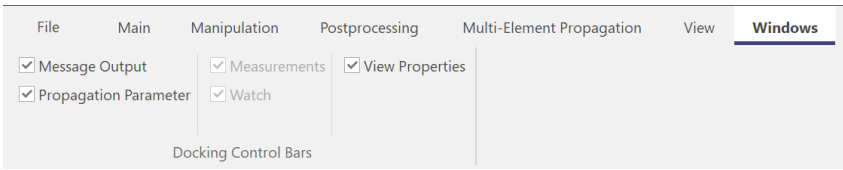
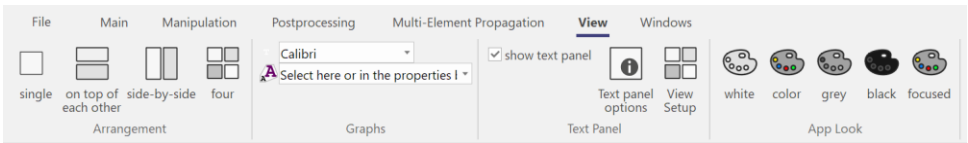
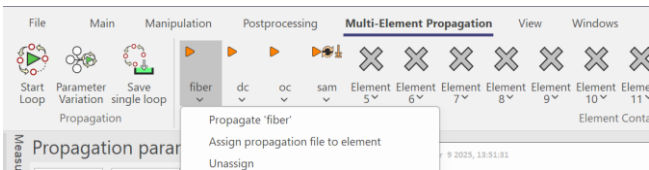
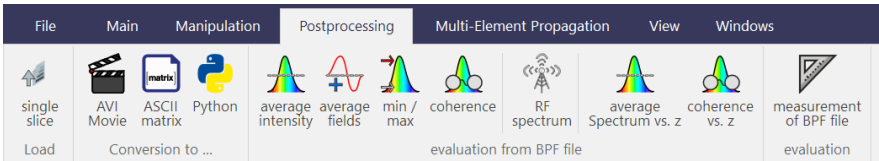
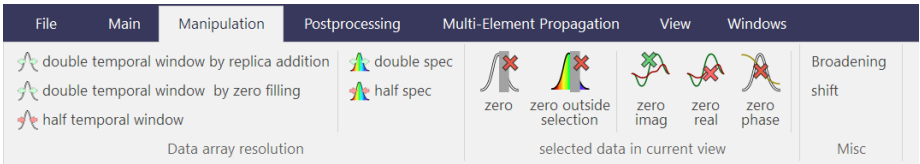
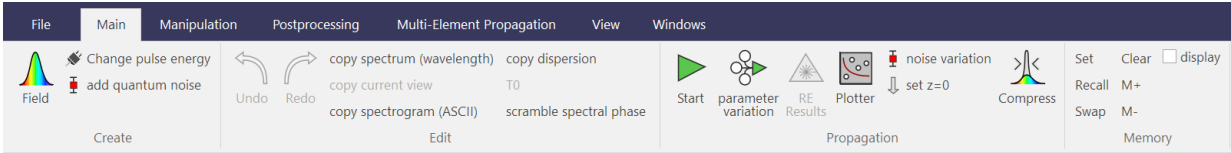
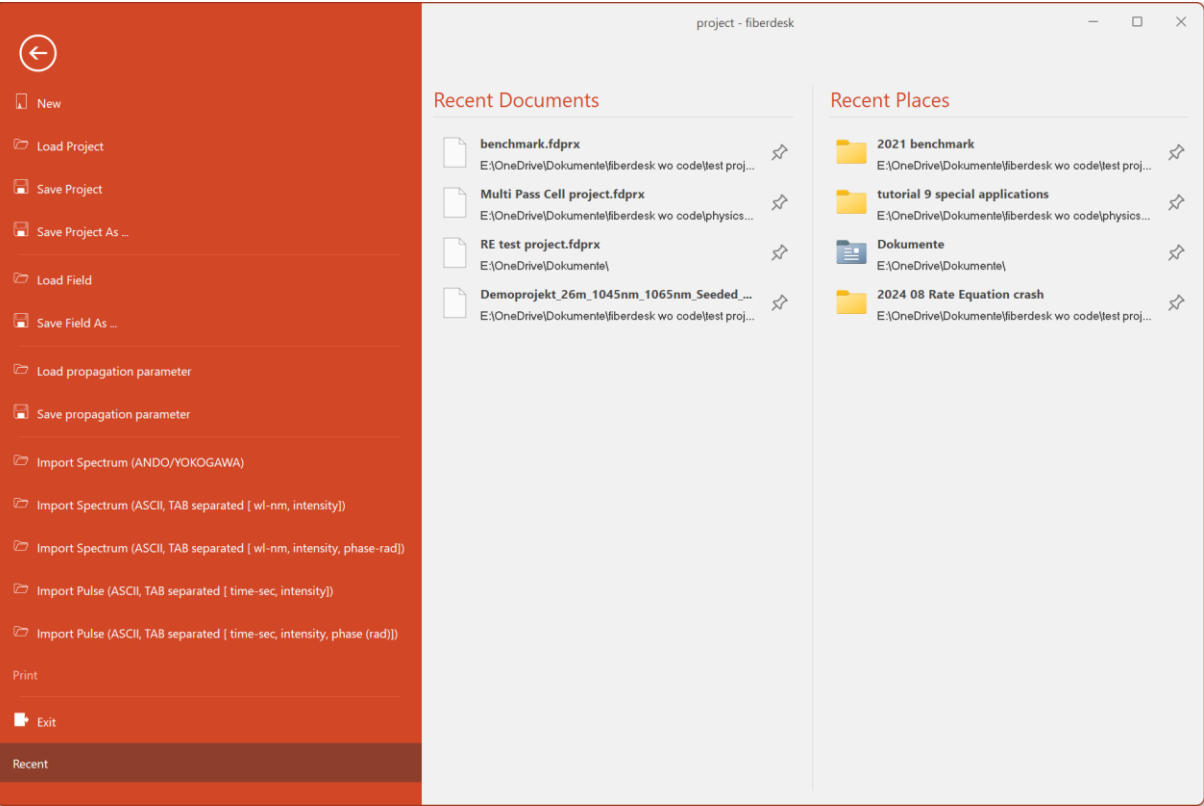


fiberdesk – graphical user interface (GUI)



fiberdesk – graphical user interface (GUI)

File menu



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fiberdesk – NLSE parameter setup

Parameter access in detail:

The parameters of the underlying equations are shown for the nonlinear Schrödinger equation as an example:

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

The screenshot shows the 'fiberdesk' software interface. On the left is the 'Propagation parameter' window, and on the right is the 'Gain' window.

Propagation parameter window:

- general:** 'define free parameters' button, 'measure and parse' checked, 'write file' unchecked, '100' in a box.
- waveguide:** 'loss' set to 0.0 with unit 1/m (highlighted with a green box), 'gain' set to 0 with unit 1/m (highlighted with a yellow box), 'mode diameter' set to 3 μm, 'gamma' set to 0.035555555 1/(W m).
- effects:** 'dispersion', 'SPM / TPA', 'Raman', 'self-steepening' are checked; 'LLE' is unchecked.
- numerics:** 'steps' set to 7500.

Gain window (highlighted with a red box):

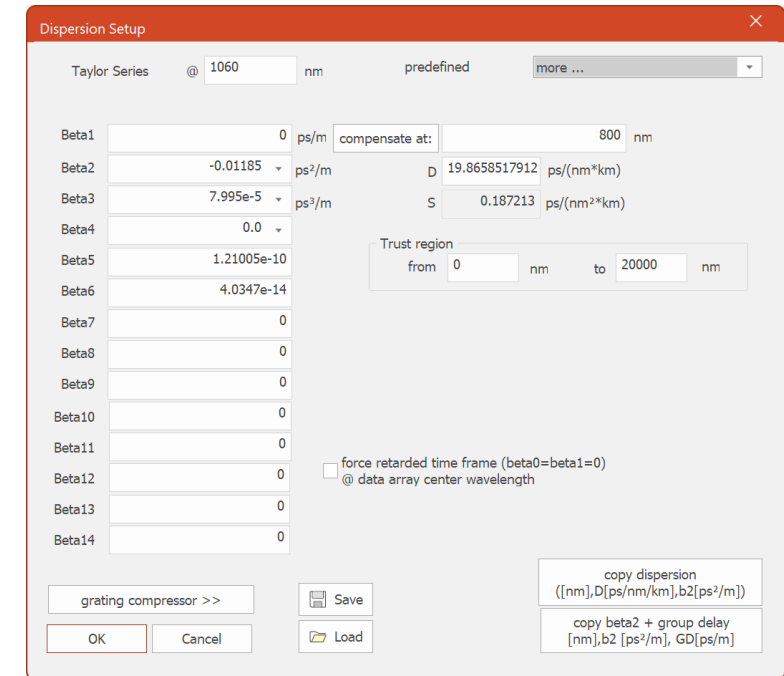
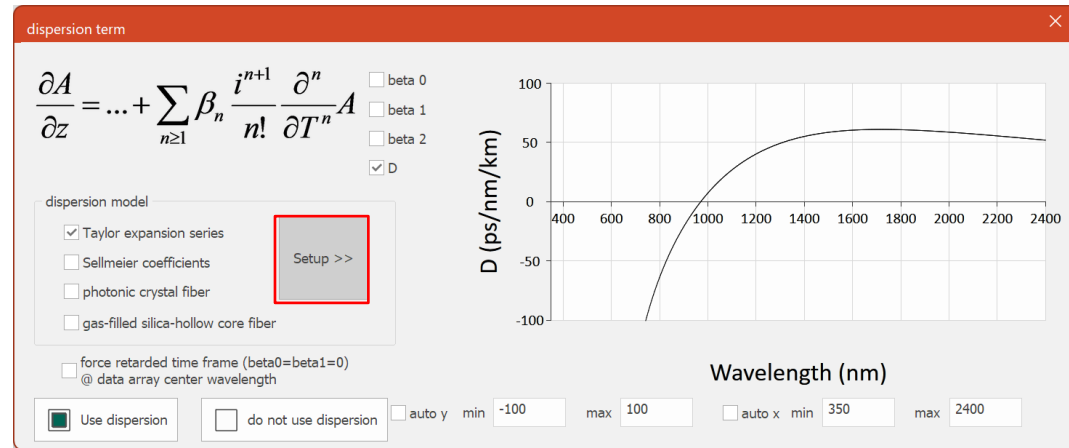
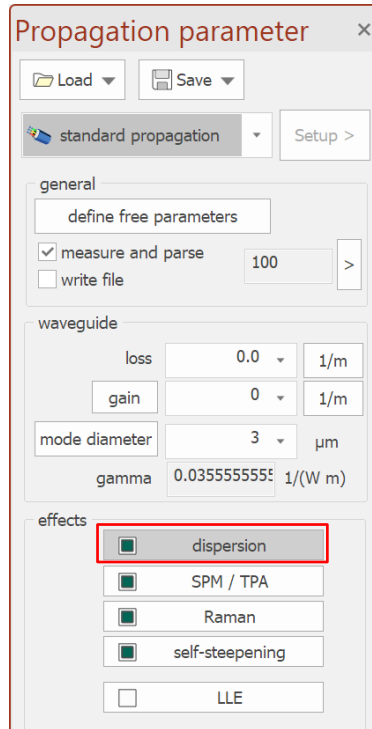
- steady state gain (long pulses to cw):** 'saturate gain with Esat = 1e-9 J'. Formula: $g = g_0 / (1 + \frac{E}{E_{sat}})$.
- profile:** 'gain profile' and 'add second peak' sections. Both have 'Center' 1060 nm, 'Width' 40 nm, and 'shape' 'const'.
- ratio of second to first peak (set to zero for only one peak):** 0.
- user defined gain file:** 'use ASCII file for gain profile given in g(1/m) vs. wavelength (separator TAB)' unchecked. 'file ...' button.
- temporal gain saturation (pulses shorter than population relaxation time):** 'use temporal gain saturation instead of steady state gain and profiles, with' unchecked. 'saturation fluence F' 30 J/cm². Formula: $g(T) = g_0 \exp\left(-\frac{1}{E_{sat}} \int_{-\infty}^T |A(t)|^2 dt\right)$ with $E_{sat} = F \cdot A_{eff}$. 'saturation energy with current MFD:' box.
- Back** button.

fiberdesk – NLSE parameter setup

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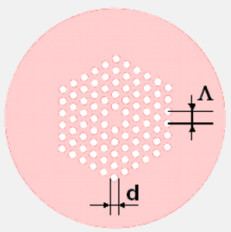


fiberdesk – NLSE parameter setup

Parameter access in detail:

$$\frac{\partial A}{\partial z} = -\frac{\alpha}{2} A + \int_{-\infty}^{\infty} \frac{g(\omega)}{2} \tilde{A}(\omega) e^{-i\omega T} d\omega + \sum_{n \geq 1} \beta_n \frac{i^{n+1}}{n!} \frac{\partial^n}{\partial T^n} A +$$

PCF Parameter



pitch 5.0 μm
hole diameter d 0.5 μm
d/Λ 2.9209714

Copy values to clipboard
lambda = pitch/10 .. pitch * 2.0
V and W parameter n_eff
dispersion D[ps/nm/km]

Material dispersion
$$n = \sqrt{A + \frac{B_1 \lambda^2}{\lambda^2 - C_1} + \frac{B_2 \lambda^2}{\lambda^2 - C_2} + \frac{B_3 \lambda^2}{\lambda^2 - C_3}}$$

predefined more...
A 1
B1 0.696166 C1 0.00467915 μm²
B2 0.407943 C2 0.0135121 μm²
B3 0.897479 C3 97.934 μm²

OK

Propagation parameter

Load Save

standard propagation Setup >

general
define free parameters
☒ measure and parse 100
☐ write file

waveguide
loss 0.0 1/m
gain 0 1/m
mode diameter 3 μm
gamma 0.035555555 1/(W m)

effects
☒ dispersion
☒ SPM / TPA
☒ Raman
☒ self-steepening
☐ LLE

dispersion term

$$\frac{\partial A}{\partial z} = \dots + \sum_{n \geq 1} \beta_n \frac{i^{n+1}}{n!} \frac{\partial^n}{\partial T^n} A$$

☐ beta 0
☐ beta 1
☐ beta 2
☒ D

dispersion model
☒ Taylor expansion series
☐ Sellmeier coefficients
☐ photonic crystal fiber
☐ gas-filled silica-hollow core fiber
Setup >>

☐ force retarded time frame (beta0=beta1=0) @ data array center wavelength
☒ Use dispersion ☐ do not use dispersion ☐ auto y

Gas filled silica hollow core fiber (fundamental mode)

predefined more...

$$n = \sqrt{A + \frac{B_1 \lambda^2}{\lambda^2 - C_1} + \frac{B_2 \lambda^2}{\lambda^2 - C_2} + \frac{B_3 \lambda^2}{\lambda^2 - C_3}}$$

T0 0 K P0 0 Pa
B1 0 C1 0
B2 0 C2 0
B3 0 C3 0

actual
T 273.15 K P 101325 Pa

fiber
inner structure thickness 100 nm
core diameter 2*R 80 μm

OK

Dielectric dispersive medium

$$n = \sqrt{A + \frac{B_1 \lambda^2}{\lambda^2 - C_1} + \frac{B_2 \lambda^2}{\lambda^2 - C_2} + \frac{B_3 \lambda^2}{\lambda^2 - C_3}}$$

predefined more...
A 1
B1 0.696166 C1 0.00467915 μm²
B2 0.407943 C2 0.0135121 μm²
B3 0.897479 C3 97.934 μm²

OK

fiberdesk – NLSE parameter setup

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Propagation parameter

Load Save

standard propagation Setup >

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define free parameters

☒ measure and parse 100

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waveguide

loss 0.0 1/m

gain 0 1/m

mode diameter 3 μm

gamma 0.035555555 1/(W m)

effects

☒ dispersion

☒ SPM / TPA

☒ Raman

☒ self-steepening

☐ LLE

self phase modulation / two photon absorption term

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

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

n2 3.2e-20 m²/W

f R 0.18

TPA 0.0 m/W

TPA is experimental so far

☐ saturate SPM

saturation power 1.0 GW/cm²

☒ use SPM and TPA

☐ exclude SPM

fiberdesk – NLSE parameter setup

Parameter access in detail:

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Propagation parameter [X]

Load [v] Save [v]

standard propagation [v] Setup >

general

define free parameters

☒ measure and parse 100 >

☐ write file

waveguide

loss 0.0 1/m

gain 0 1/m

mode diameter 3 μm

gamma 0.035555555 1/(W m)

effects

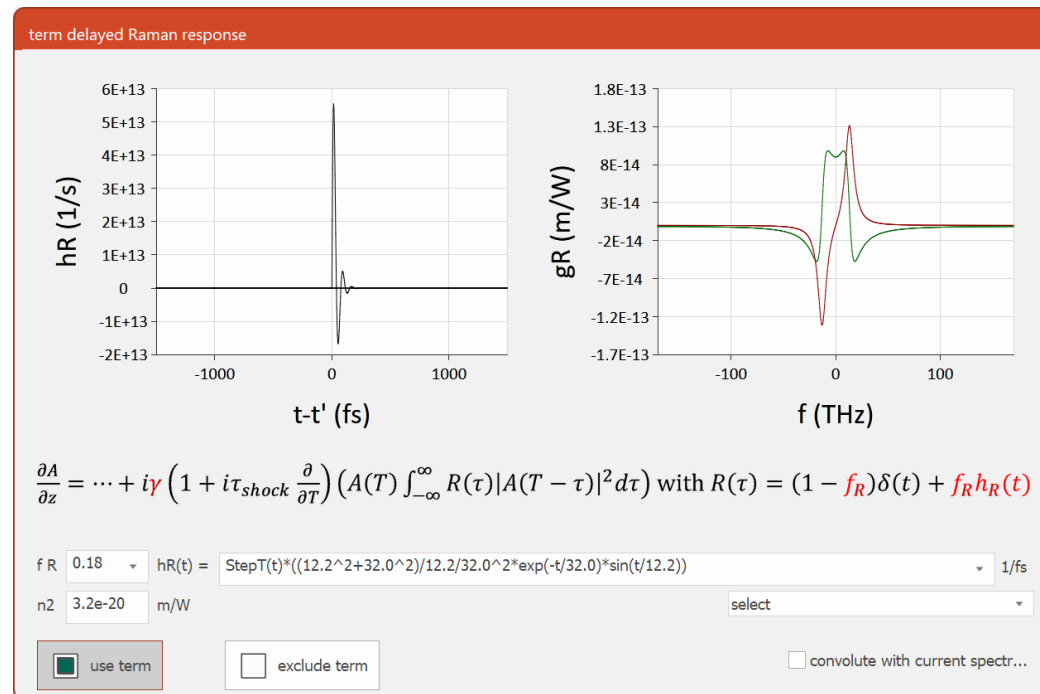
☒ dispersion

☒ SPM / TPA

☒ Raman

☒ self-steepening

☐ LLE



fiberdesk – NLSE parameter setup

Parameter access in detail:

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

Propagation parameter

Load Save

standard propagation Setup >

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waveguide

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mode diameter 3 μm

gamma 0.035555555 1/(W m)

effects

☒ dispersion

☒ SPM / TPA

☒ Raman

☒ self-steepening

☐ LLE

term self steepening

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

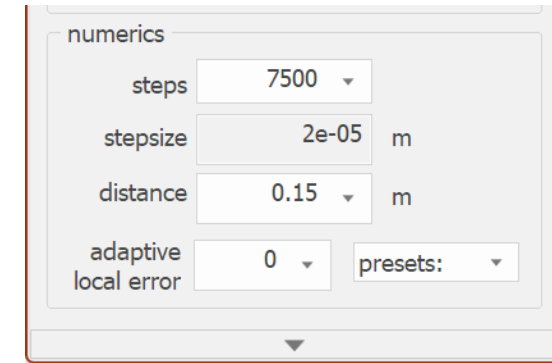
$$\tau_{shock} = \tau_0 + \tau_A = \frac{1}{\omega_0} - \left[\frac{1}{n_{eff}} \frac{dn_{eff}(\omega)}{d\omega} \right]_{\omega_0} - \left[\frac{1}{A_{eff}} \frac{dA_{eff}(\omega)}{d\omega} \right]_{\omega_0}$$

additional shock time 0.0 fs

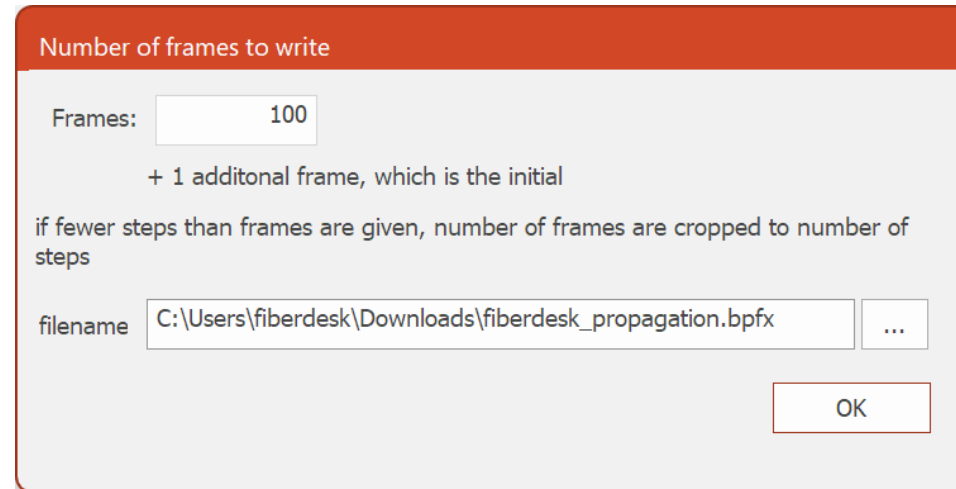
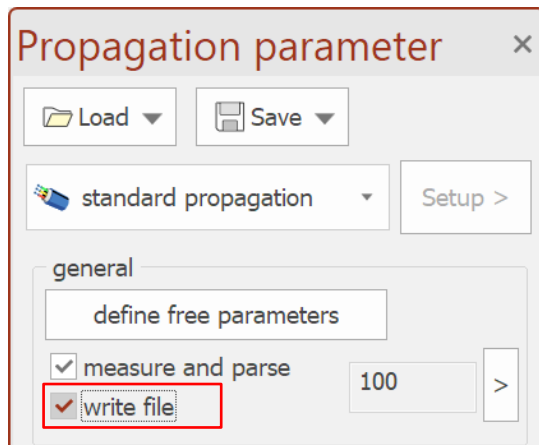
☒ use self steepening term ☐ exclude self steepening

fiberdesk – NLSE parameter setup

Propagation setup: distance, stepsize, numerical accuracy etc.



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



file contains the initial field plus 100 fields from the calculated propagation for later analysis

file extension: ***.bpfx**

Lecture 1 - Overview

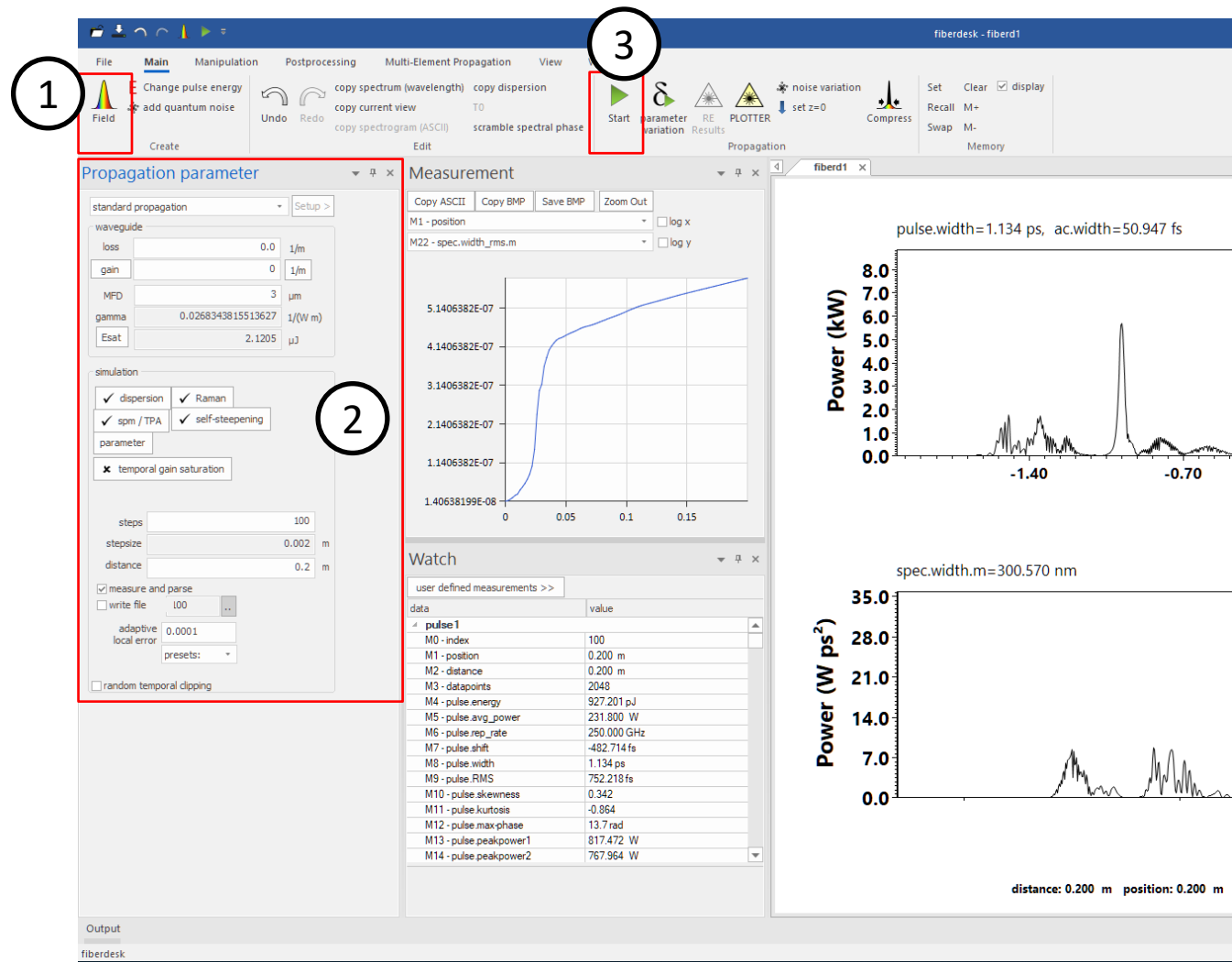
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Setting up a propagation

Learn the most simple workflow

- (1) Create the initial field
- (2) Setup propagation parameter
- (3) Start the simulation

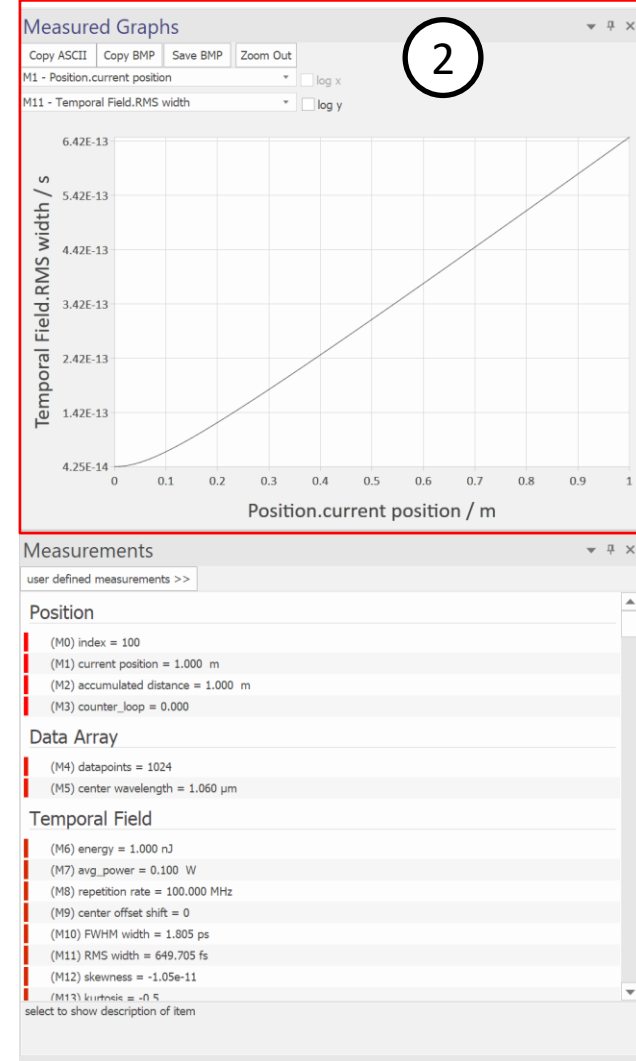
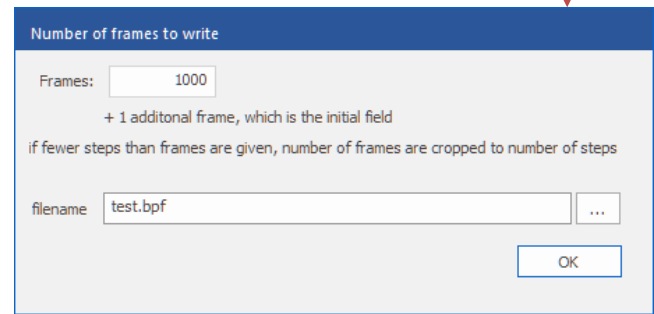
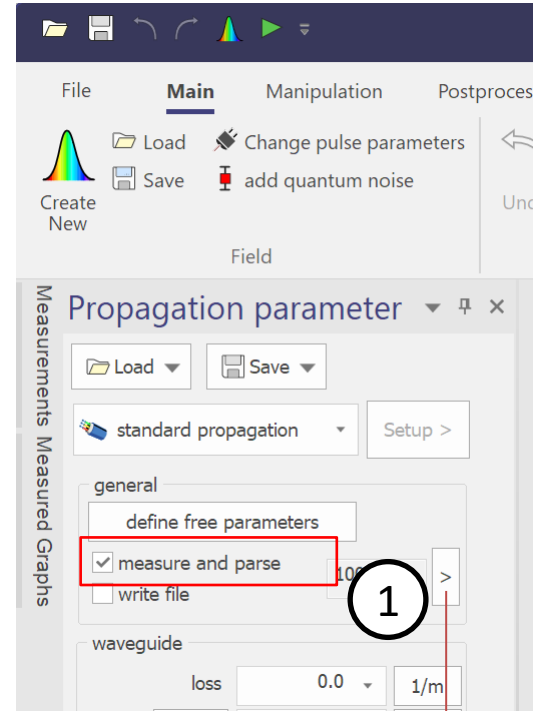


Setting up a propagation

Measure something along z

To measure different values of the numerical field that fiberdesk is propagating:

1. choose „measure and parse“ and setup the number of measurement points along z, which should be equal or less than the number of steps. (change with setup button to access dialog)
2. After propagation, you will see the measured values as instantaneous values or graphs along the propagation.



Setting up a propagation

User defined measures

You can also define your own measurement in addition to the pre-defined options.

You need to:

1. Open the dialog „user defined measurements >>“
2. Script your own function by either using values measured before or math expressions with variables

M90 = log2(M4) (just an example for M4 = datapoints)

1

Watch	
user defined measurements >>	
data	value
pulse1	
M0 - index	100
M1 - position	0.200 m
M2 - distance	0.200 m
M3 - datapoints	2048
M4 - pulse.energy	927.201 pJ

user defined measurements

M87		0
M88		0
M89	M4	1024
M90	log2(M4)	10
M91		0
M92		0

☒ measure and parse not switched on during propagation, no evaluation of measured values along the propagation length is done

datapoints: from to forward backward all

back Test

2

Setting up a propagation

User defined measures

Real example:

How to measure the B-Integral?

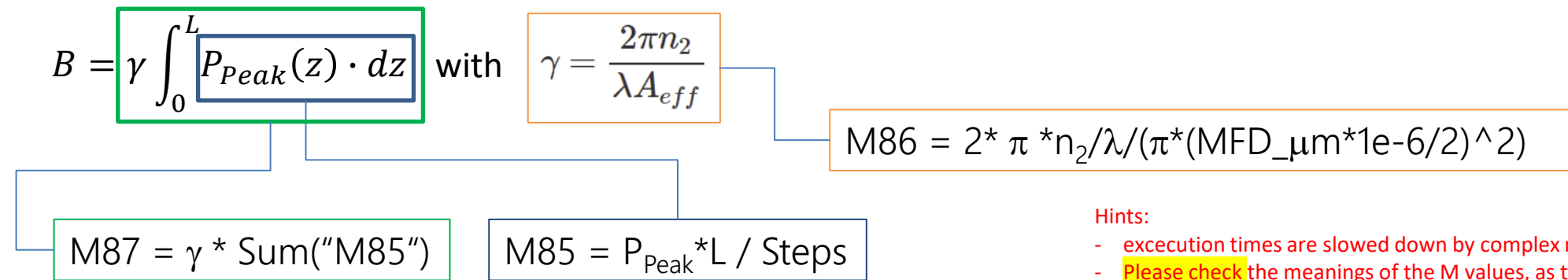
(shown by several user defined measurements for educational reasons)

We translate the equation to measured values and a function that integrates (summation) along z.

user defined measurements		
M84	$(M10 * M11)^2$	1.54365569478842e-09
M85	$M13 * P3 / P4$	3.9668238857714
M86	$2 * \pi * P5 / M17 / (\pi * (P7 * 1e-6 / 2)^2)$	0.0268343815513627
M87	$M86 * \text{Sum}("M85")$	10.7510217188675
M88		0
M89		0

Extended Syntax:

datapoints: from to



Hints:

- execution times are slowed down by complex measurements.
- Please check the meanings of the M values, as they might have changed in their number, depending on the actual version of fiberdesk

Setting up a propagation

Change parameters during propagation

For example, if you script the mode field diameter (MFD) like this, the MFD will change quadratically with propagation, because M1 is the current position.

You need to have “measure and parse” switched on!

waveguide

loss

0.0

1/m

gain

0

1/m

mode diameter

10-5*M1^2

μm

gamma

0.0024150943

1/(W m)

general

define free parameters

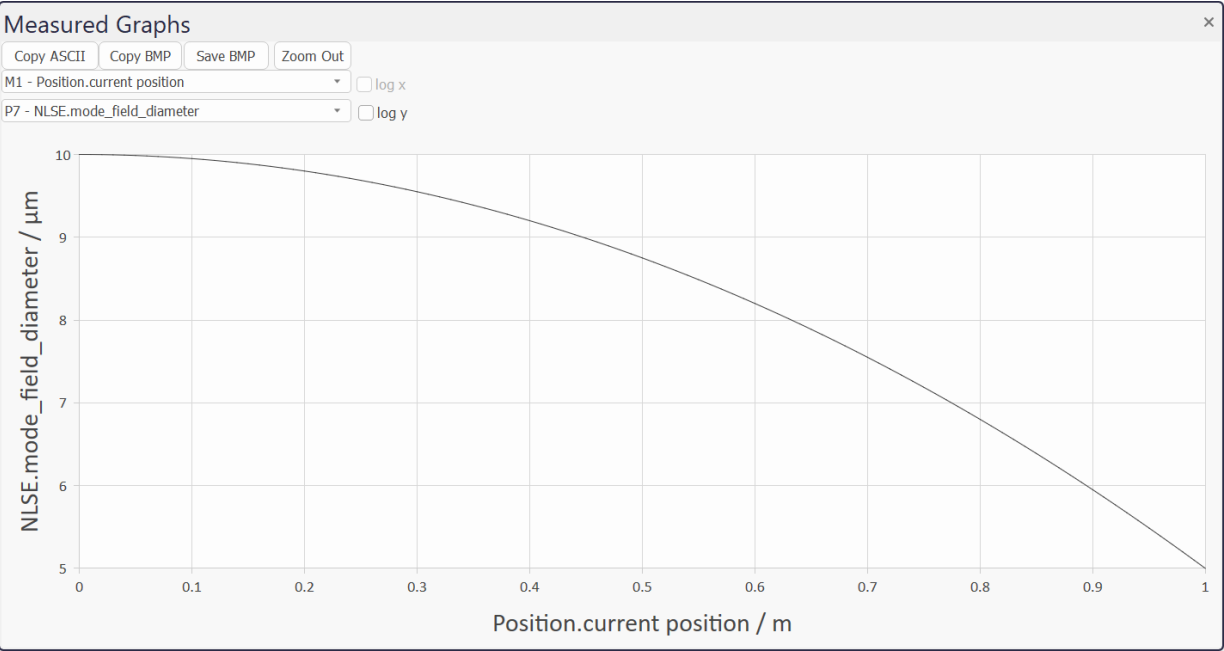
☒ measure and parse

☐ write file

100

>

To check the success, the measured parameter is show in the measurement windows:



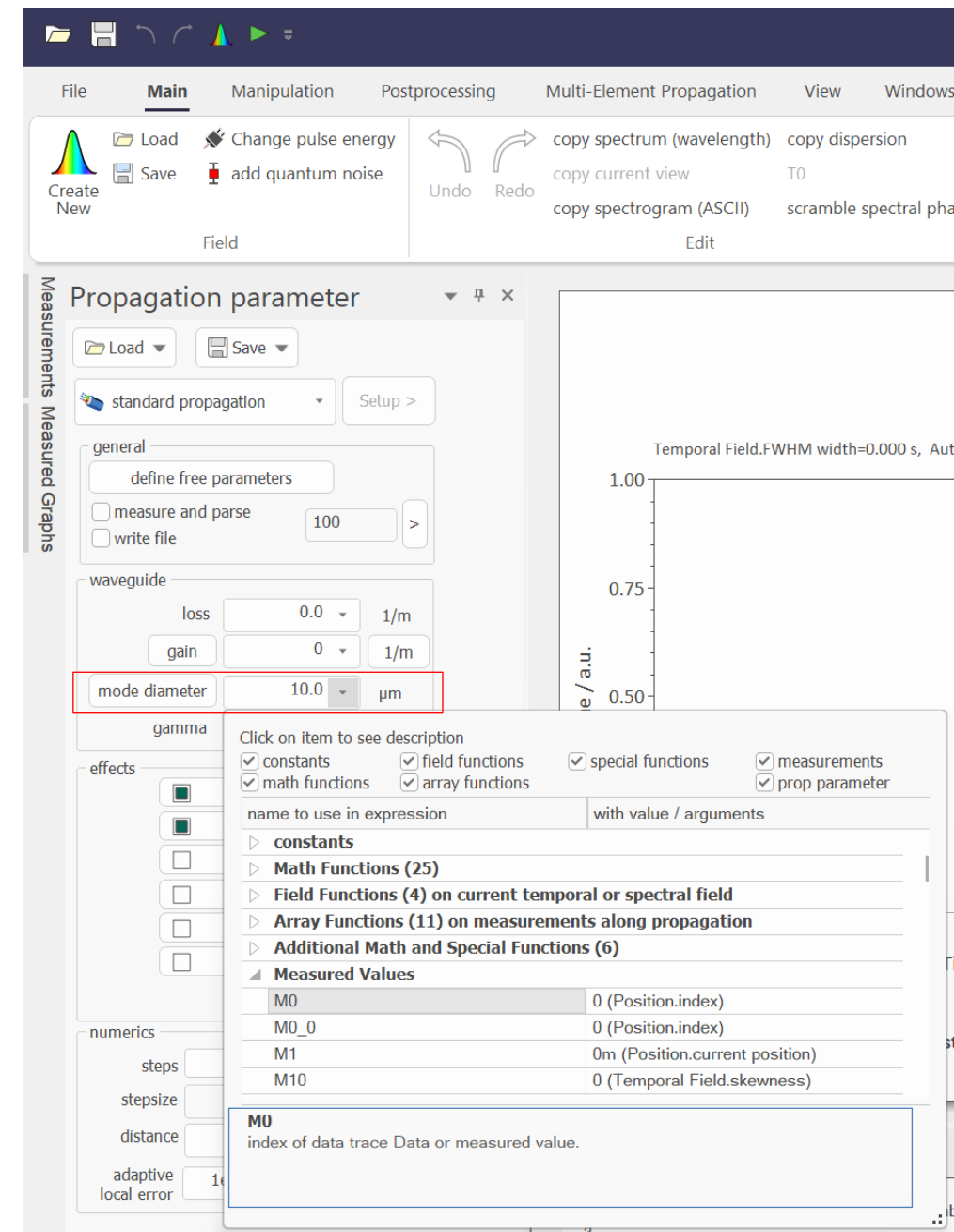
Setting up a propagation

Change parameters during propagation

Changing parameters along the propagation can be made for any parameter, where **a symbol (button) appears in the input line**, if in focus, see for instance the mode field diameter prompt.

If you click on the symbol, a dialog appear with **all available variables**, functions etc.

Click on any of the entries, and a **short help** will appear in the lower part of the dialog

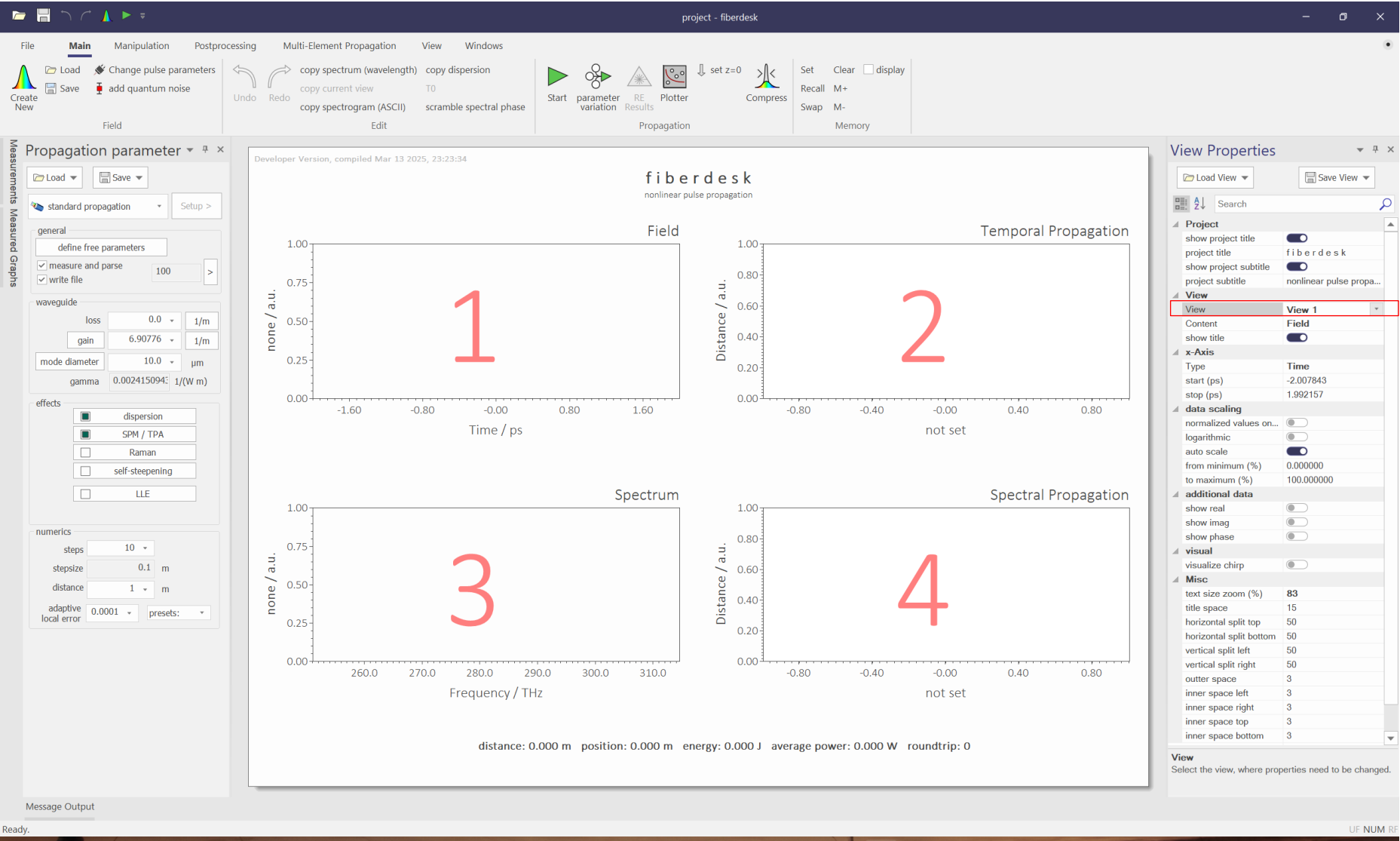
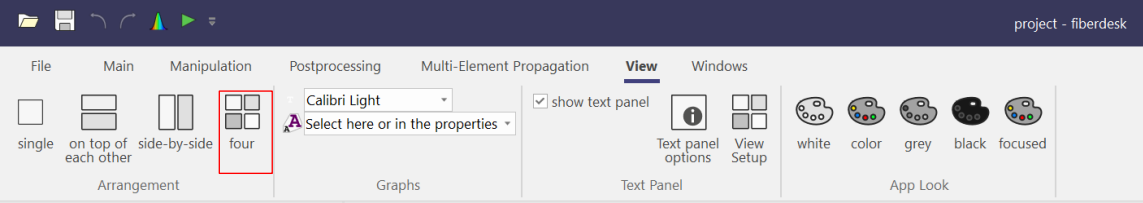


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Setting up a view



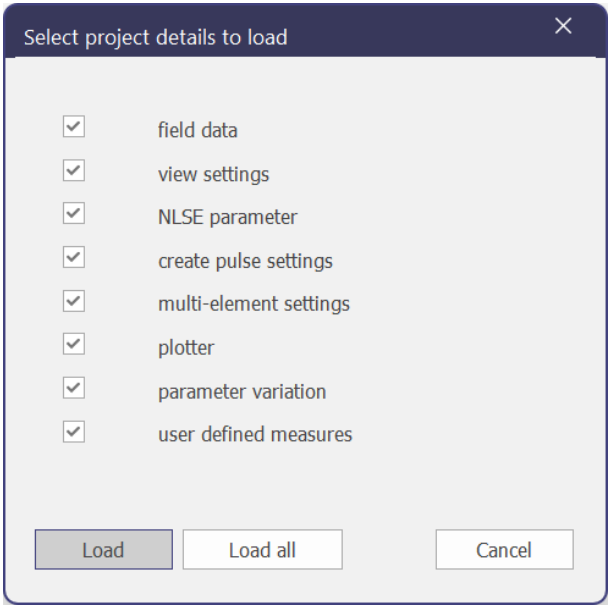
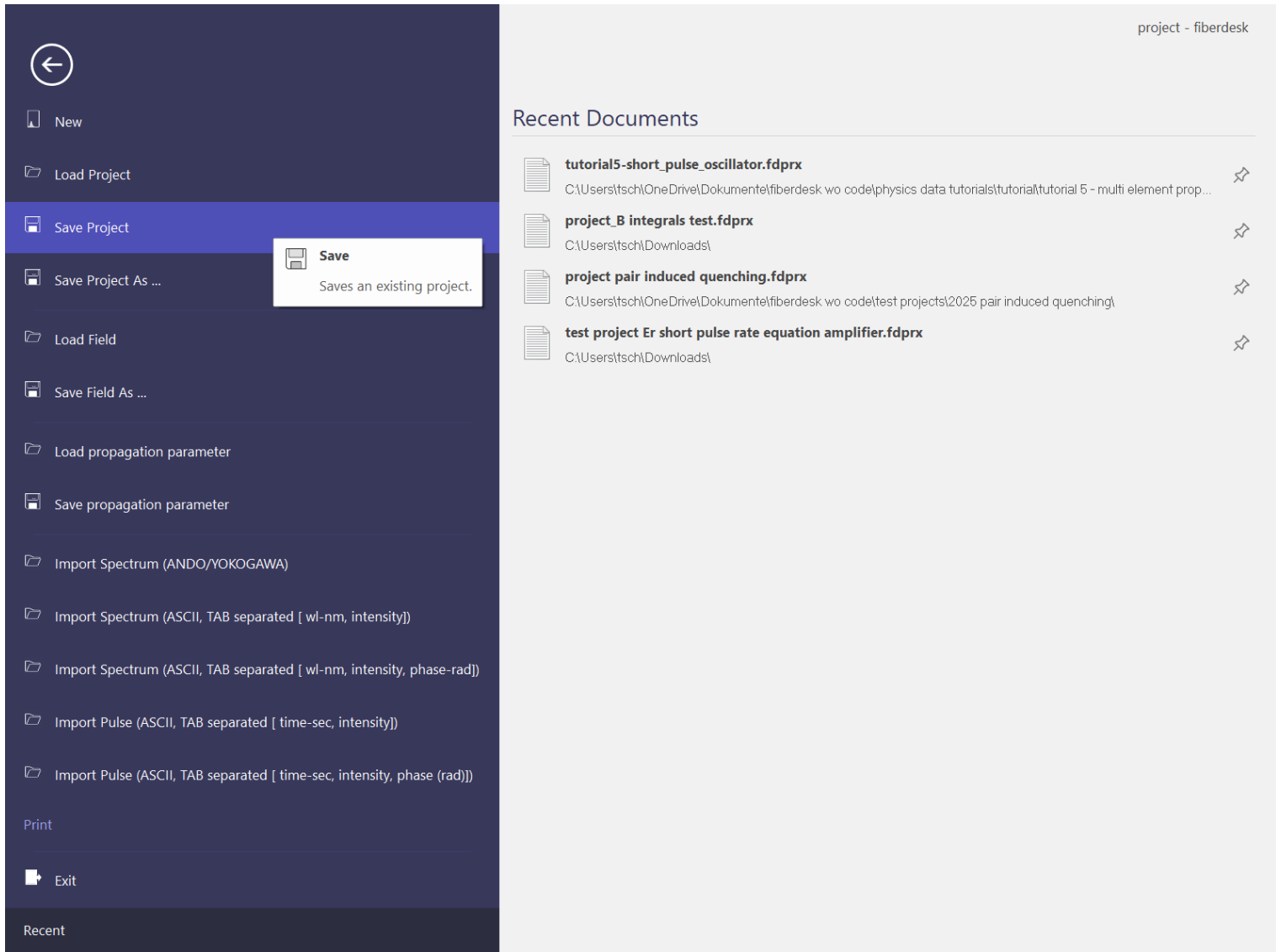
Click here to select the view to set up

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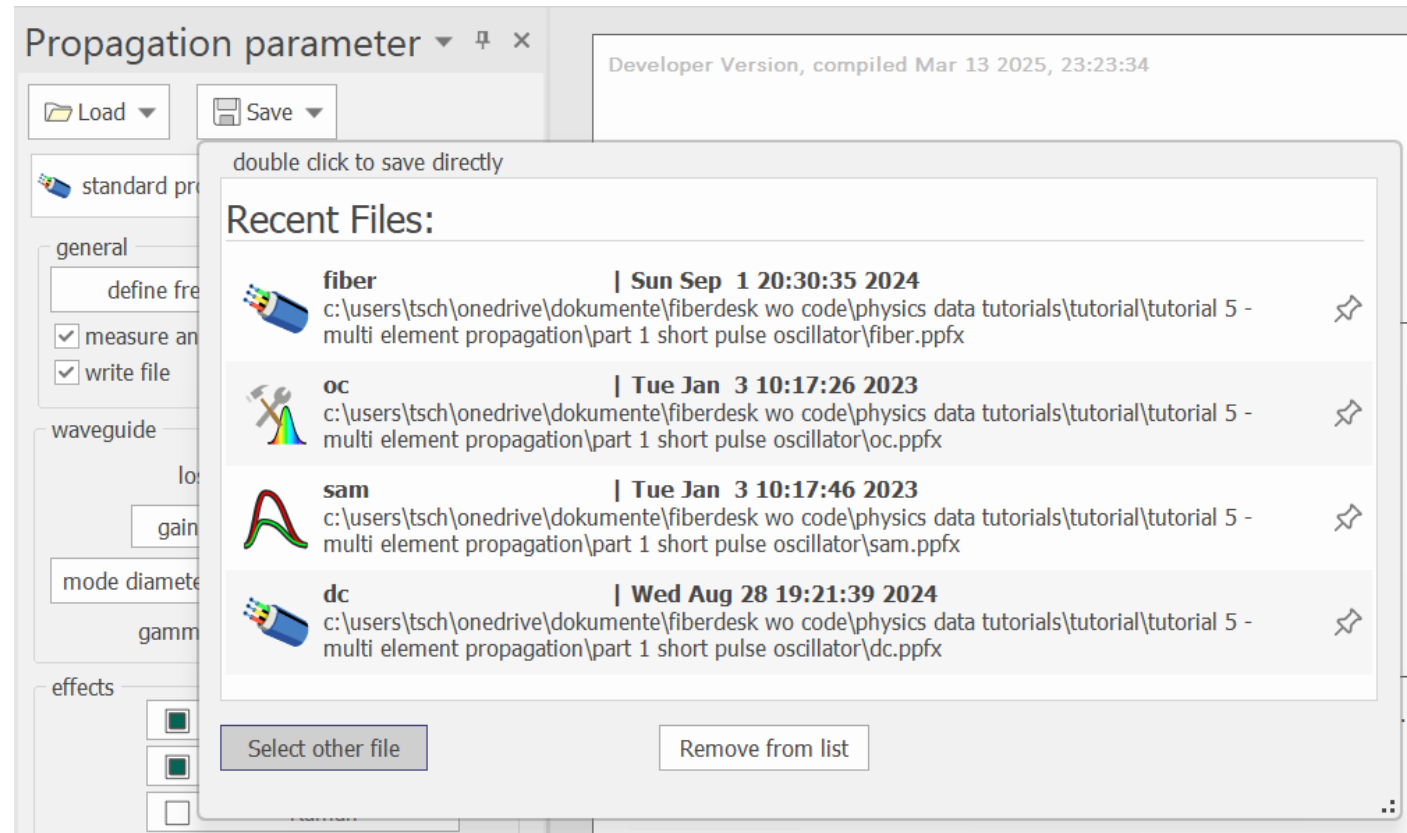
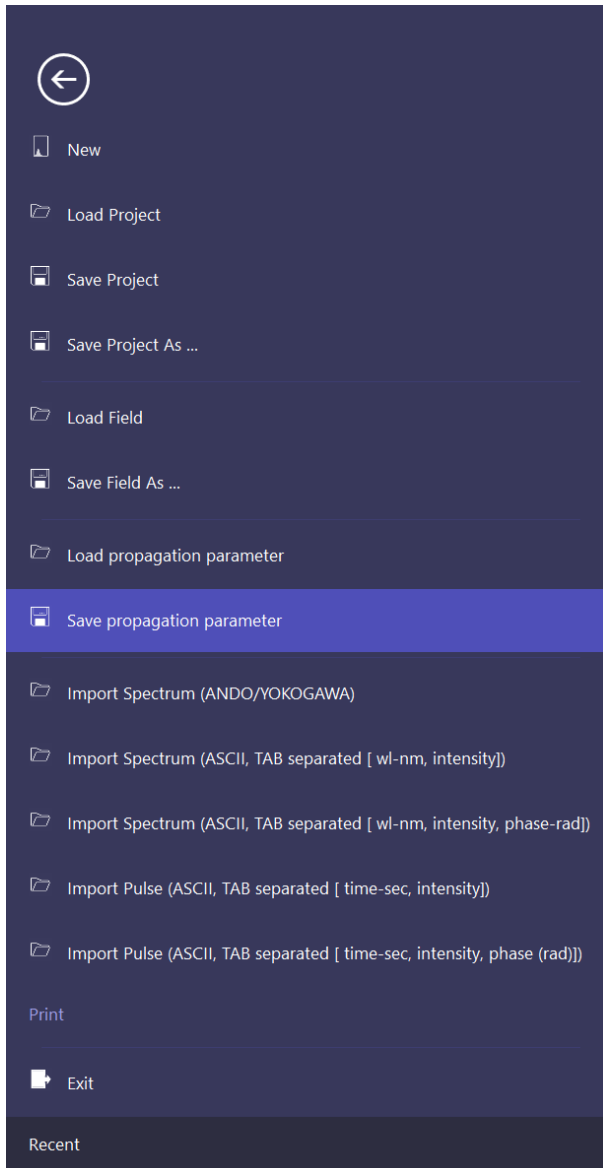
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Loading / Saving field, **projects**, components

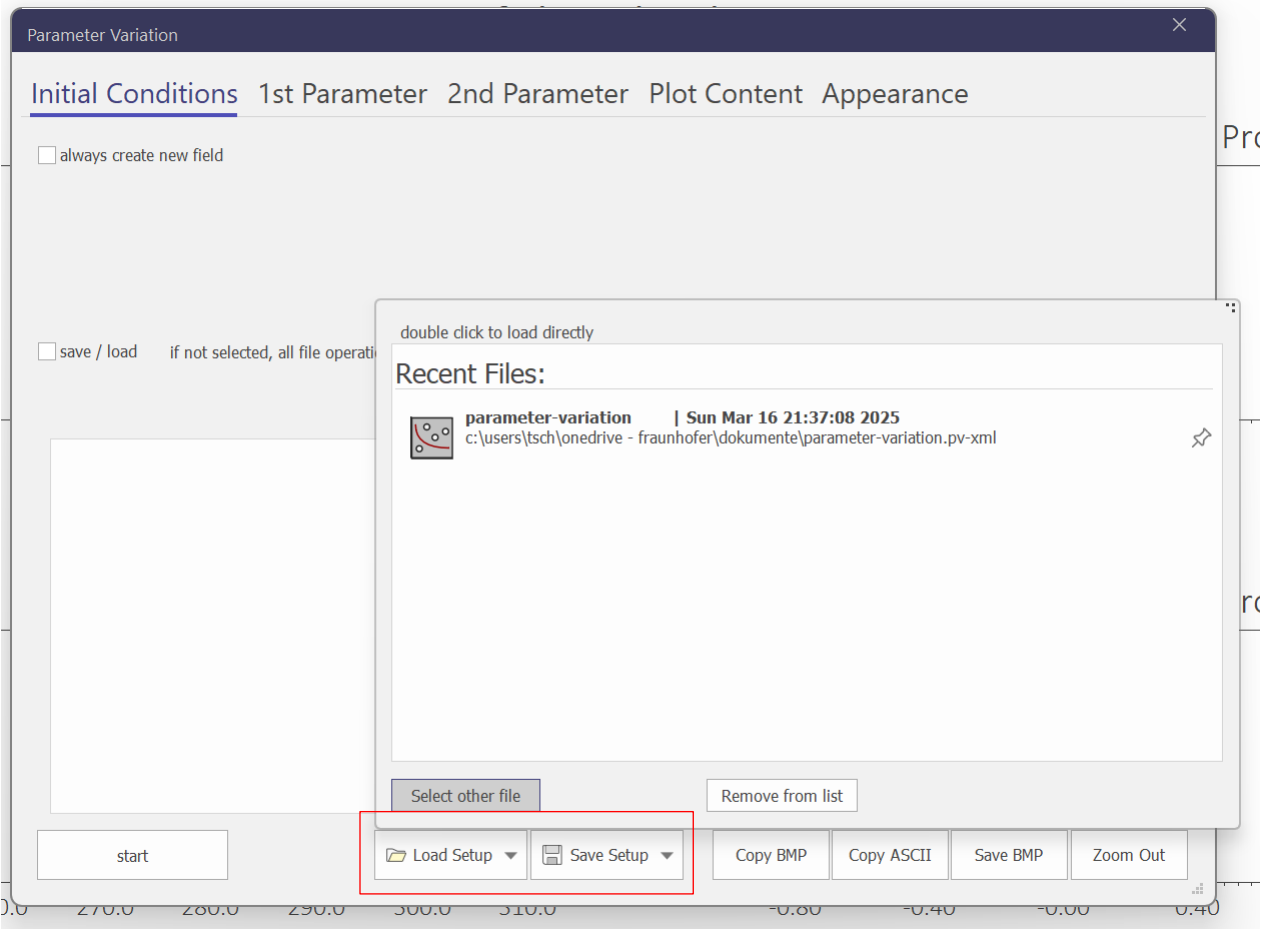


Loading / Saving field, projects, components



Loading / Saving field, projects, components

Saving dialog content



Saving view content

