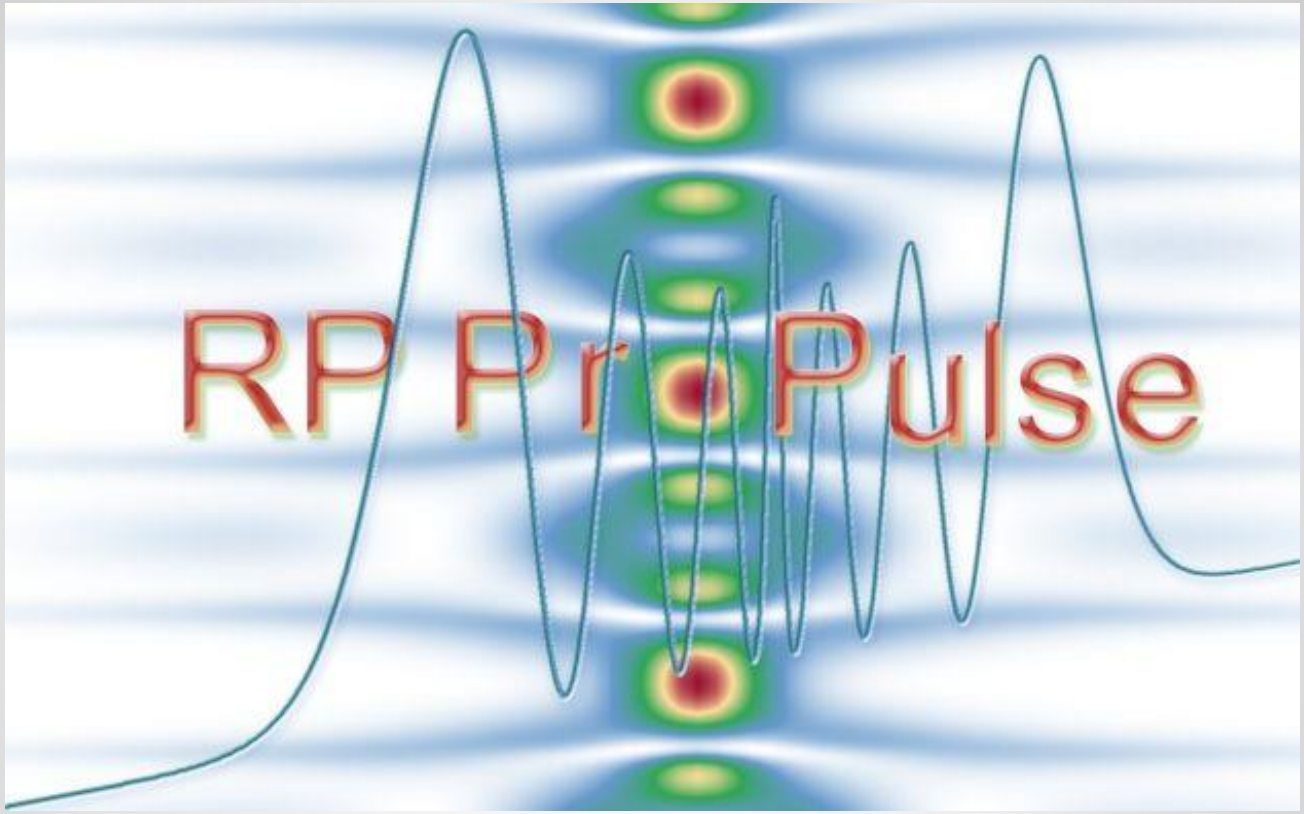
RP ProPulse V4



a software product of

RP Photonics Consulting GmbH

www.rp-photonics.com/propulse.html

Why are Simulations of Pulse Propagation so Important?

- Pulse propagation in mode-locked lasers or synchronously pumped OPOs is a **highly nonlinear process** – in most cases hard to properly describe with analytical means or even just understood with intuitive reasoning.
- However, it is essential to understand that quantitatively: understanding is the key to **good product designs**, delivering optimum performance and reliability while not requiring more expensive parts than necessary.
- A simulation tool must offer **a high degree of flexibility** to be useful; it should allow you to
  - conveniently implement different kinds of setups
  - quickly get a comprehensive characterization of any design
  - generate any plots which may be helpful in your case

What is Special about the **RP ProPulse** software?

- You can define laser setups, additional calculations or optimizations, graphical diagrams etc. in text form – i.e., as **script code**.
- This approach is **far more flexible** than working with forms or pop-up menus:
  - can easily describe laser resonators containing many optical components
  - simple copy & paste e.g. for parts of resonators, diagrams etc.
  - can **define your own diagrams**, containing any curves and additional elements – no limitation to predefined types of diagrams!
  - program any calculations, optimizations etc. just as needed
- **Note: flexibility is not just nice to have, but essential for sophisticated analysis and design tasks!**

Scripting is Easy!

Example 1: definition of a passively mode-locked laser:

```
resonator: linear
* OC: T_out = T_oc
* Crystal:
    gain(l) = 4.34 * 0.5 { single pass } * g0(l)
     [P_sat_av = P_sat_g],
    SPM = SPM_g
* SESAM:
    satloss = dR_a [E_sat = E_sat_a, tau = tau_a],
    loss = loss_a, GDD = GDD_tot,
    center [N = 500]
resonator end
```

(Some variable values with system parameters such as the output coupler transmission T_oc have been defined beforehand, not shown here.)

Scripting is Easy!

Example 2: get the pulse evolution visualized:

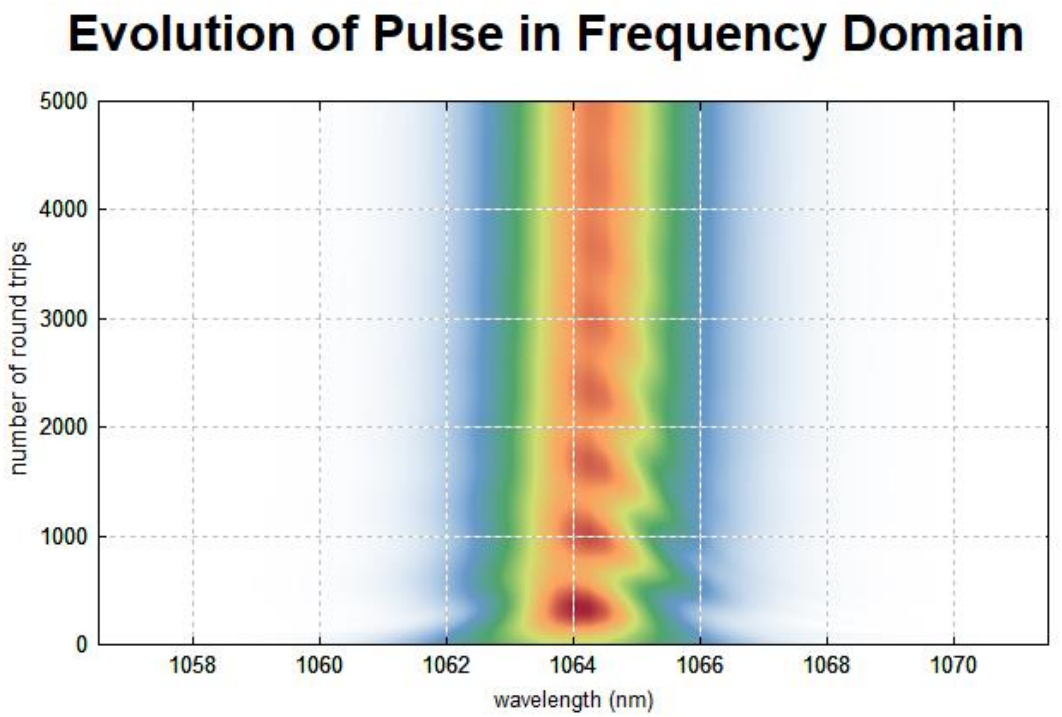
```
diagram 3:

"Evolution of Pulse in Frequency Domain"

x: (lambda_ref - dlambda_g / 4) / nm,
   (lambda_ref + dlambda_g / 4) / nm
"wavelength (nm)", @x
y: 0, N_rt
"number of round trips", @y
frame
hx
hy

! f := 0.8 / P_l(lambda_ref)

cp: color_I((getpulse(y, 0); f * P_l(x * nm))),
  order = xy
```



Scripting is Enormously Flexible!

Many tasks can easily be accomplished with a few lines of script code – for example:

- Let the software automatically compute as many resonator round-trips as required to **reach the state steady**, where pulse parameters don't change any more.
- Send the laser output pulse through additional components (e.g. a nonlinear fiber and a dispersive pulse compressor).
- Generate tailored **graphical diagrams** for visualizing properties of your pulses or whatever else.
- Save any calculated data in a **text file or binary file**.

You don't depend on which details the software developer has anticipated: put together yourself what you need! You can even do full-blown programming for most sophisticated calculations.

How to Get Scripts Developed?

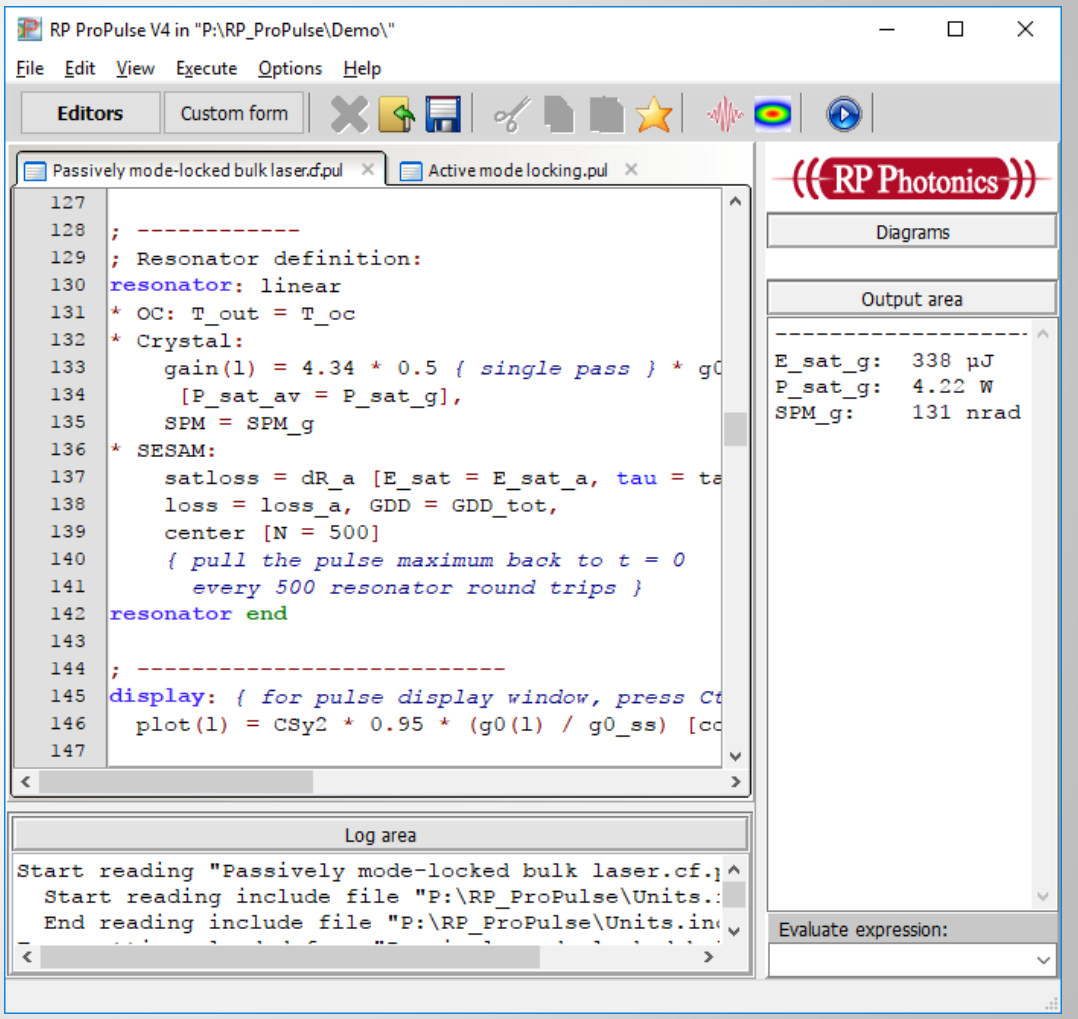
There are different approaches:

- Copy one of the **demo scripts** and modify it according to your needs.
- Adapt a **previously developed script** to the new requirements.
- Use the **code snippets library** for getting frequently used parts of script code. (Also add your own code snippets to that!)
- Get help within the **technical support**. Describe your needs, and we send you a script as a starting point for your development.

The User Interface (1)

Powerful script editors and editing tools:

- **Code snippet library** for frequently used parts of code
- **Parameter hints** for predefined functions
- **Multilevel undo/redo**
- **Syntax highlighting** for good readability of code
- **Integrated syntax checker**
- **Automatic code formatting** for consistent formats
- Setting of **breakpoints** for easy debugging



The User Interface (2)

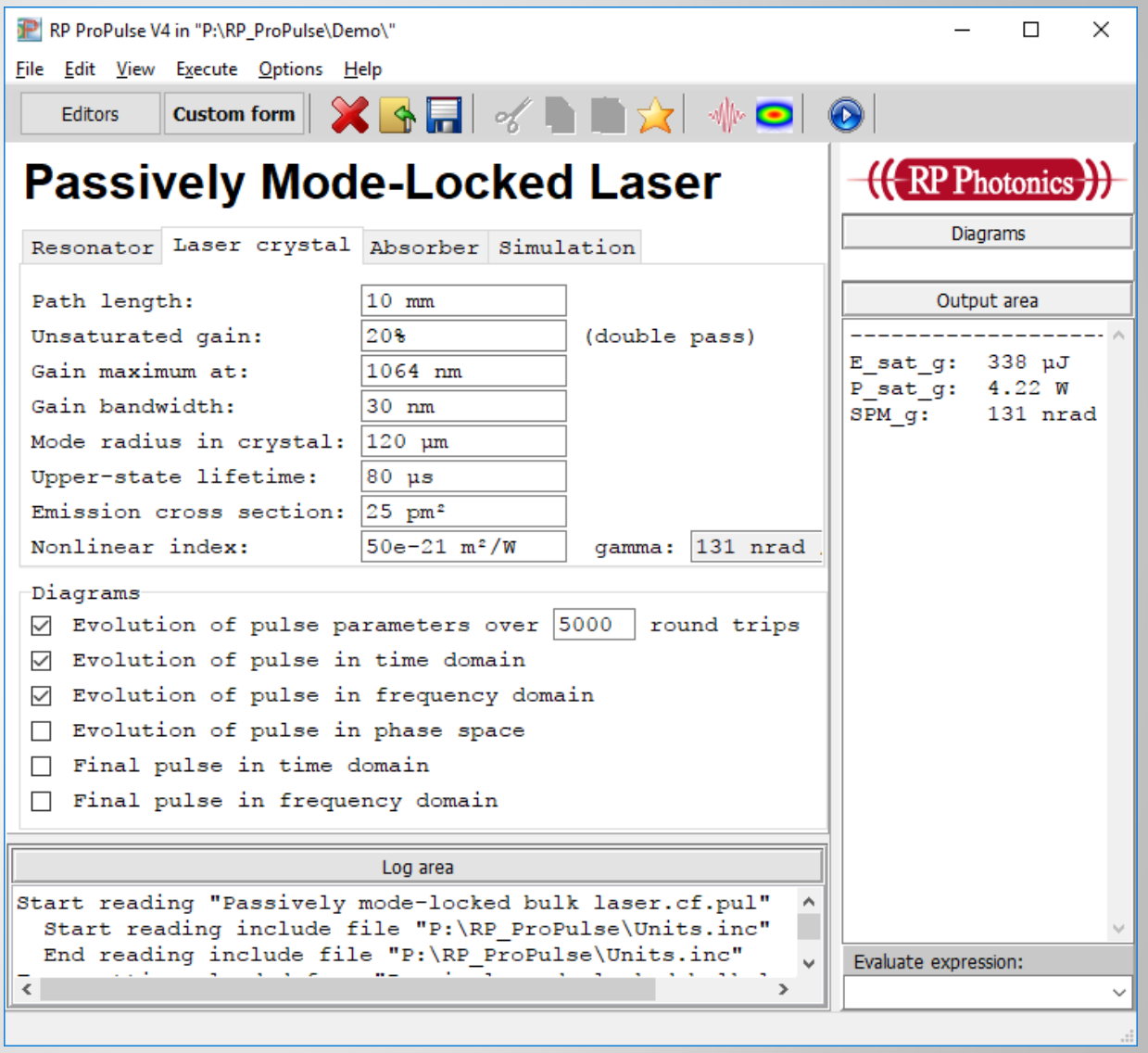
Custom forms: get any tailored forms you need!

- Such forms **can be made for *any* simulation**!
- **Very easy to use:** just fill out the input fields and execute to see the output values as well as created graphical diagrams.
  (See the example on the next page.)
- You can either **make such forms yourself or get them made** within the technical support. (A custom form is defined quite simply in text form within a script.)
- Ideal combination of flexibility and ease of use!
- Consequently, **RP ProPulse** becomes more suitable also for those who need to get certain designs recalculated **without spending much time on technical details**.

The User Interface (3)

Simple example for custom forms:

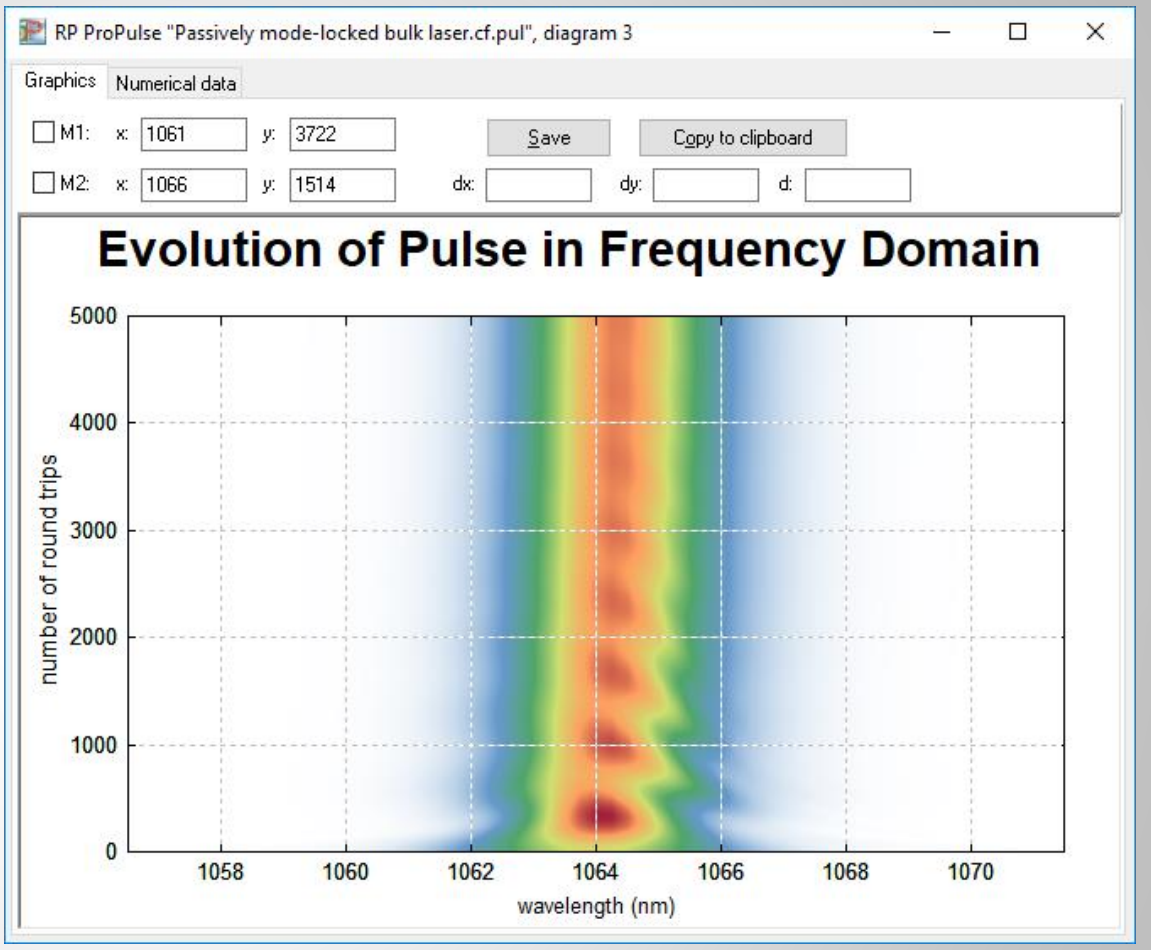
Passively mode-locked laser model, where one can simply enter a few parameters and select some of the offered diagrams.



The User Interface (4)

Graphical output windows

- high-quality graphics, directly usable for publications: copy to clipboard or save to file
- can make animated graphics
- adjustable resolution
- markers for doing measurements
- export numerical data

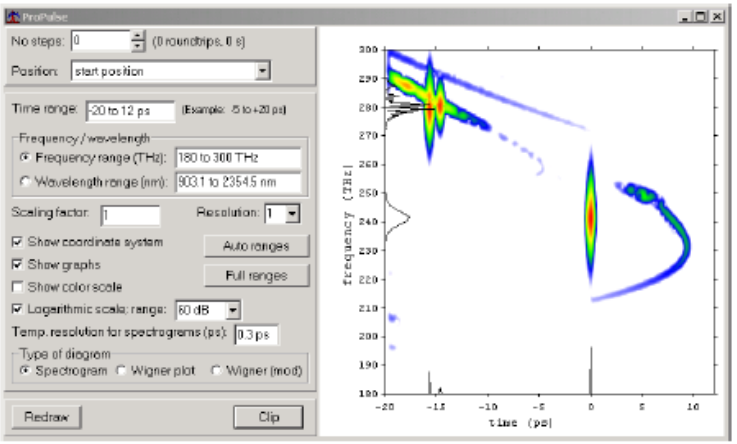


Also have flexible options for generating output in text form!

Put that into diagrams or files as you like.

Documentation

- comprehensive **PDF manual** with of the used physical model, details of the script language, etc.
- various **demo files**, demonstrating many different possibilities



The adjustable parameters are:

- **No steps**: number of steps after which the pulses are displayed. Each step means a number of round trips in the resonator, determined by the variable `rt_per_step` (section 4.3).
- **Position**: location in the laser resonator (or after some external elements) where the displayed pulse is taken.
- **Time range**: range for the horizontal axis.
- **Frequency range** and **wavelength range**: the selected one determines the vertical axis.
- **Scaling factor**: a factor with which the calculated function is multiplied after normalization to the maximum value.
- **Resolution**: number of pixel steps when the diagram is made. Small values give nicest results but make the drawing slower.
- **Show coordinate system**: switch on or off the display of the coordinate system.
- **Show graphs**: determine whether the additional graphs along the axes are shown: optical power versus time and spectral density.
- **Show color scale**: determine whether the used color scale is also displayed.
- **Logarithmic scale**: when this is checked, the scaling of the plotted function values (not of the axes) is logarithmic. The field behind the check box allows to specify over how many decibels (dB) the range extents. For example, if this is 60 dB, the plotted intensities can range from the maximum value down to 10^{-6} times this value. Logarithmic scaling is appropriate when weak background structures are of importance.
- **Temporal resolution for spectrograms**: see below for explanations on spectrograms.
- **Type of diagram**: choose between three different types (see below).

The buttons below are:

- **Redraw**: redraw the graphics (e.g. after changing the frequency range).

Technical Support

Any remaining technical issues can be addressed with the technical support:

The price for a **commercial user license** contains **8 support hours** (non-commercial licenses: 4 hours).

The support is done by Dr. Paschotta himself, who is a distinguished expert in this area and has developed **RP ProPulse**. He will make sure that you become another very satisfied user of the software!

Dr. Rüdiger Paschotta,
founder and managing director
of RP Photonics,
developer of RP ProPulse

Note that RP Photonics also offers consultancy on laser technology.

Can I Afford This Software?

Sure, a high-quality software product including competent support from a top expert costs some money.

Anyway, the better question is:

Can I afford *not* to have a powerful software tool, i.e.,

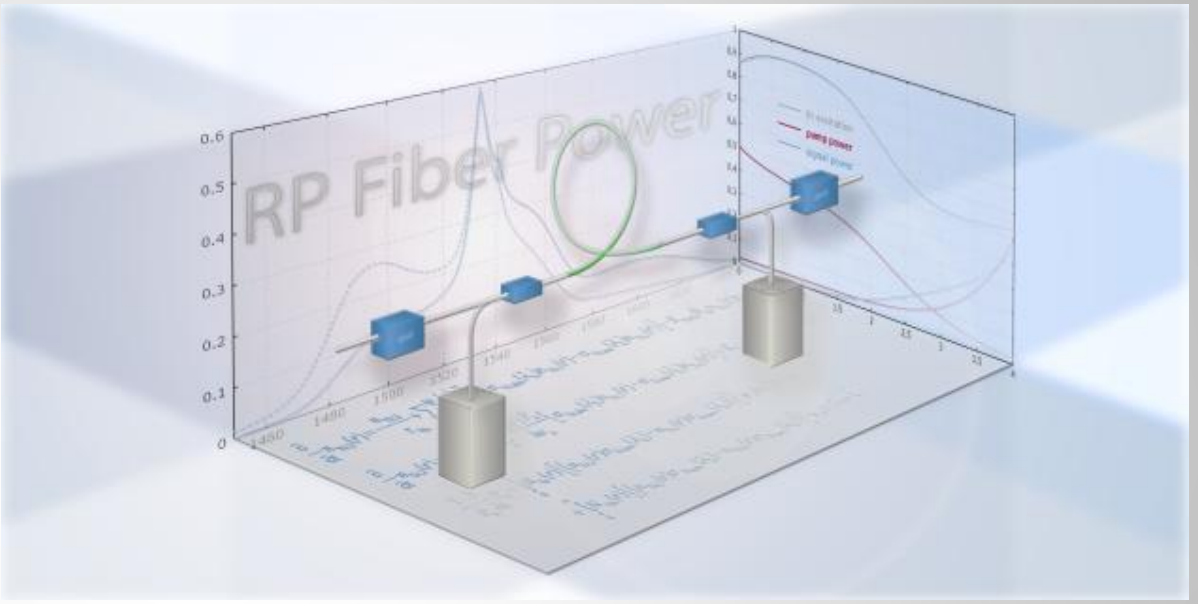
- to muddle through with insufficient tools?
- to use trial & error, wasting time and materials?
- to let customers wait while my competitors sell their products?

The **RP ProPulse** software will give a boost to your productivity! Also, your employees or students will become productive sooner when they acquire a deep understanding by playing with this software.

Other Software from RP Photonics

RP Fiber Power:

- design of fiber amplifiers, fiber amplifiers, double-clad fibers, multi-core fibers, fiber couplers, etc.
- powerful script language for an enormous flexibility
- can do most sophisticated analysis and optimizations



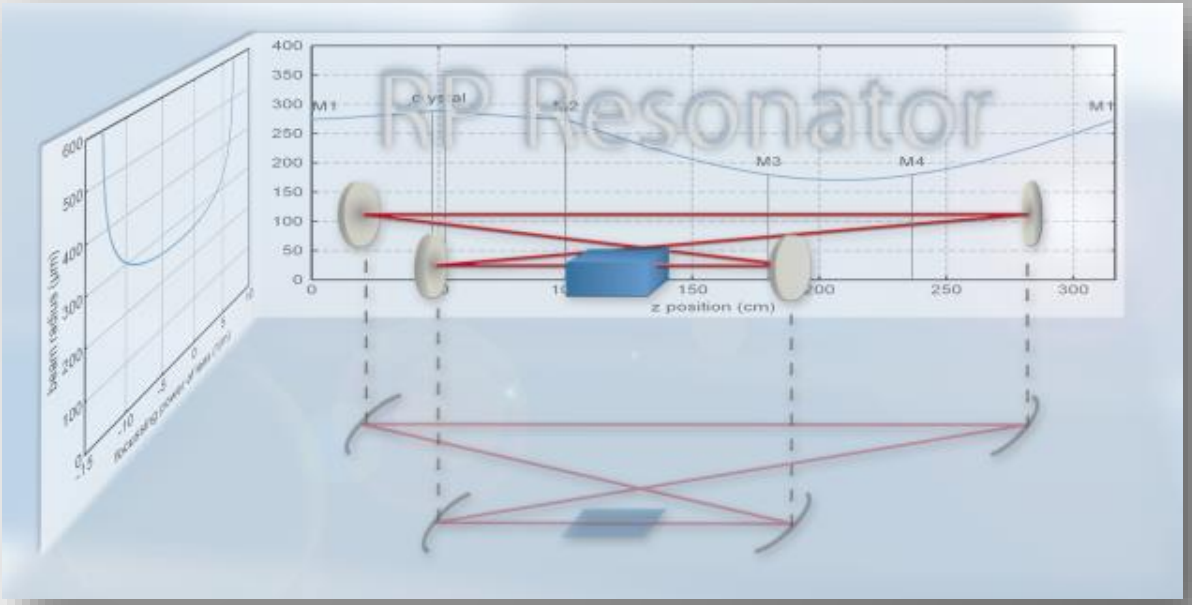
See a detailed description: www.rp-photonics.com/fiberpower.html

Note: **RP Fiber Power** can also simulate pulse evolution – not only in fiber devices, but also in many other components. For fiber laser and amplifier simulations, it may be better suited than **RP ProPulse**.

Other Software from RP Photonics

RP Resonator:

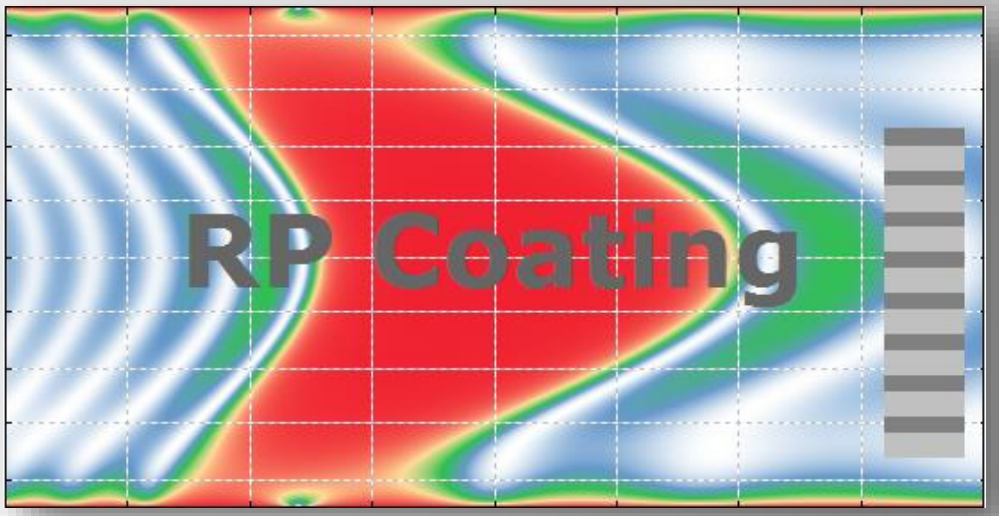
- design of optical resonators for lasers, OPOs, filters, etc.
- can fully parameterize the designs
- powerful script language for an enormous flexibility
- can do most sophisticated analysis and optimizations



See a detailed description: www.rp-photonics.com/resonator.html

Other Software from RP Photonics

RP Coating:



- analysis of multilayer thin-film devices: laser mirrors, filters, anti-reflection coatings, dispersive mirrors, polarizers, SESAMs, VECSELs, …
- can fully parameterize designs
- read / write data from or to text files or binary files with arbitrary formats: read transmission spectra from a spectrometer, control a coating machine, etc.
- can do most sophisticated analysis and optimizations

See a detailed description: www.rp-photonics.com/coating.html