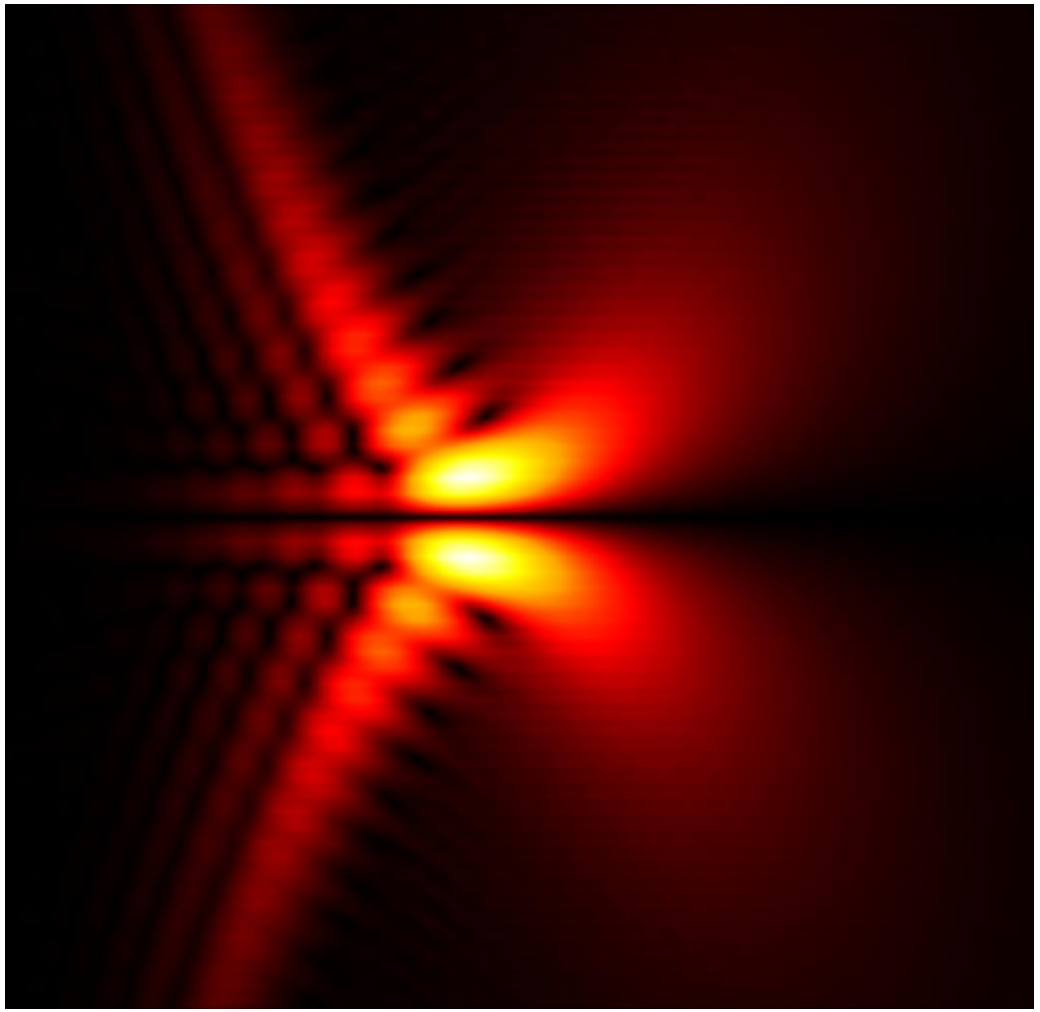
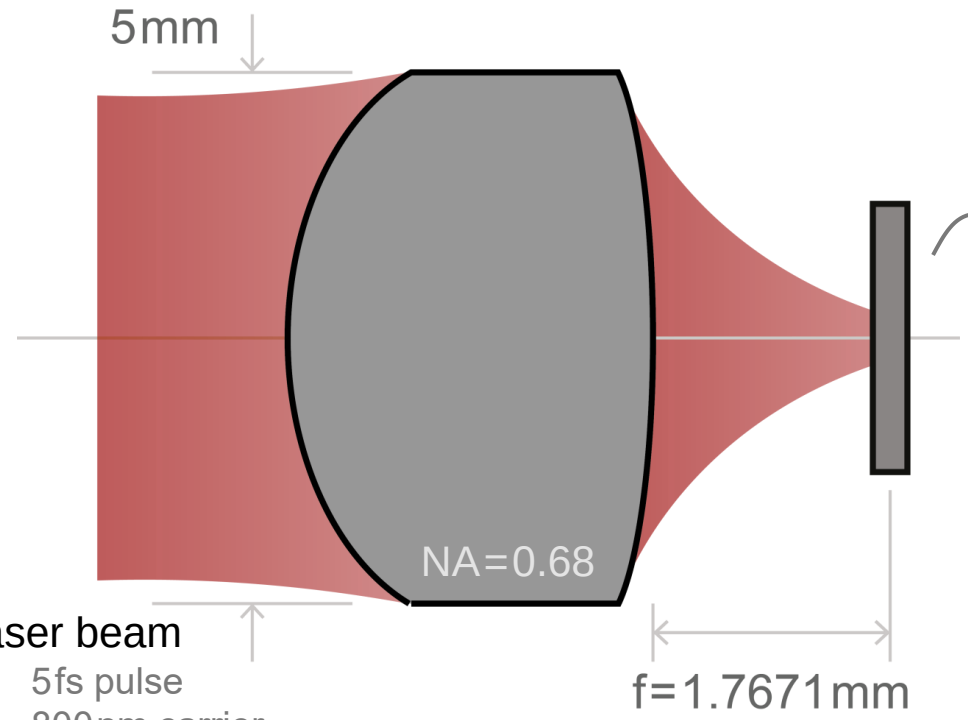
Pulse Focusing with High-NA Lens

Abstract

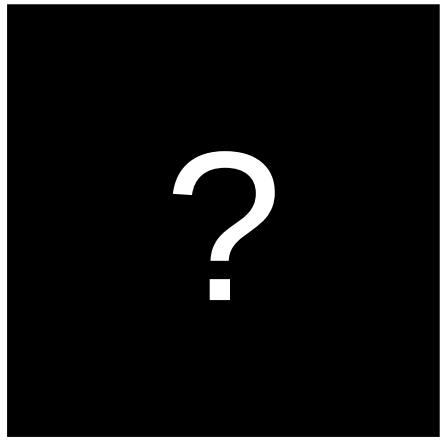


While for most other types of sources it is often accurate enough to labour under the stationary approximation, ultra-short pulses require a somewhat more nuanced approach, where the correlation between the different spectral modes is taken into account. We investigate here the effects of subjecting one such pulse to propagation through a lens with high numerical aperture, in terms of its spatial, as well as of its temporal, profile.

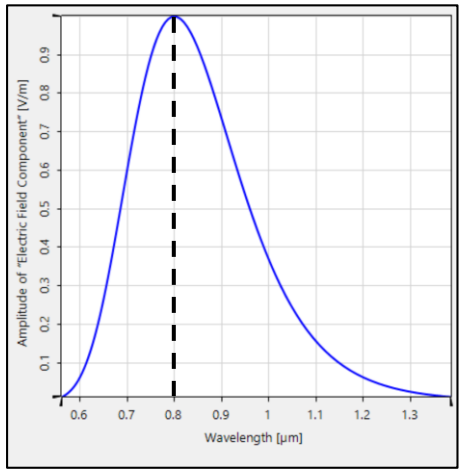
Modeling Task



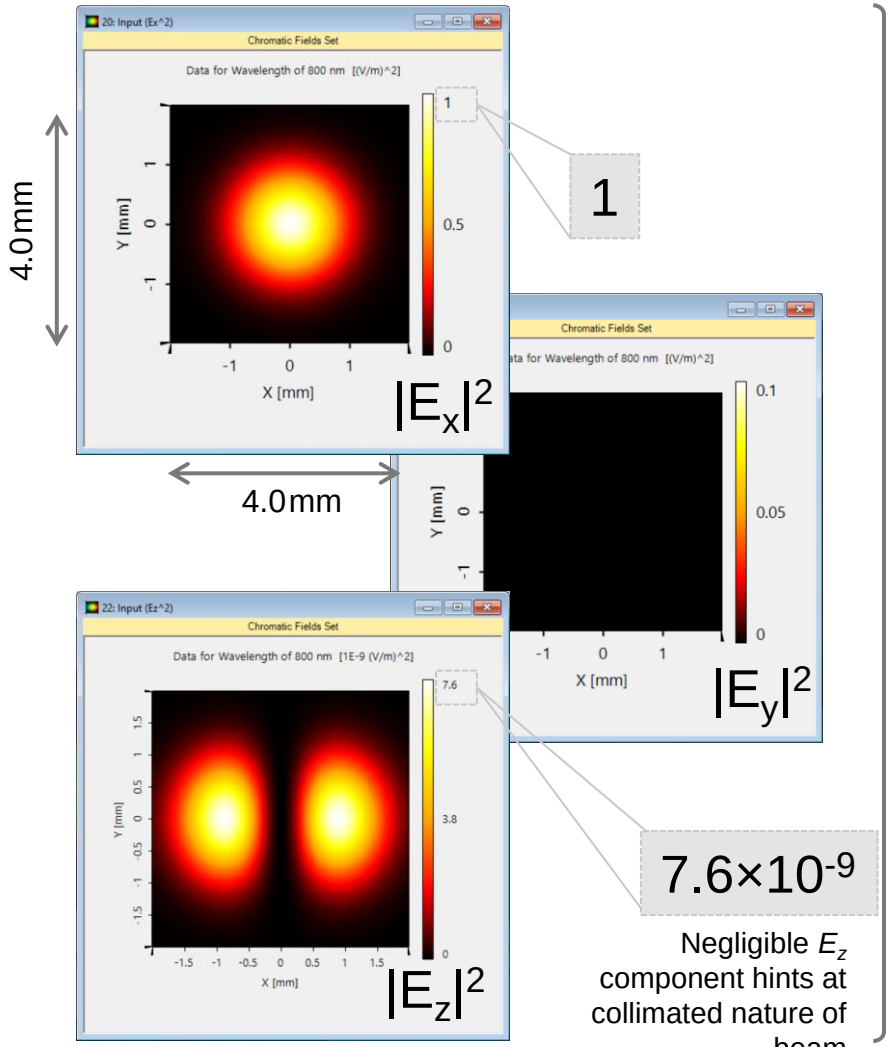
laser beam
- 5fs pulse
- 800nm carrier wavelength
- linearly polarized along *x*

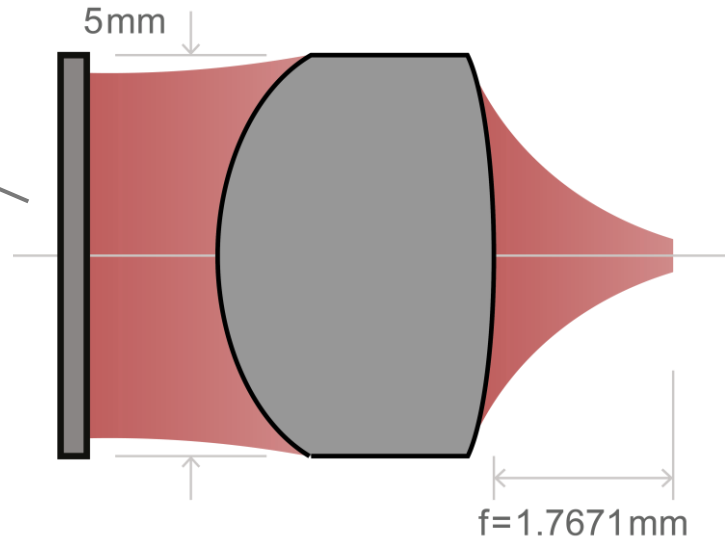


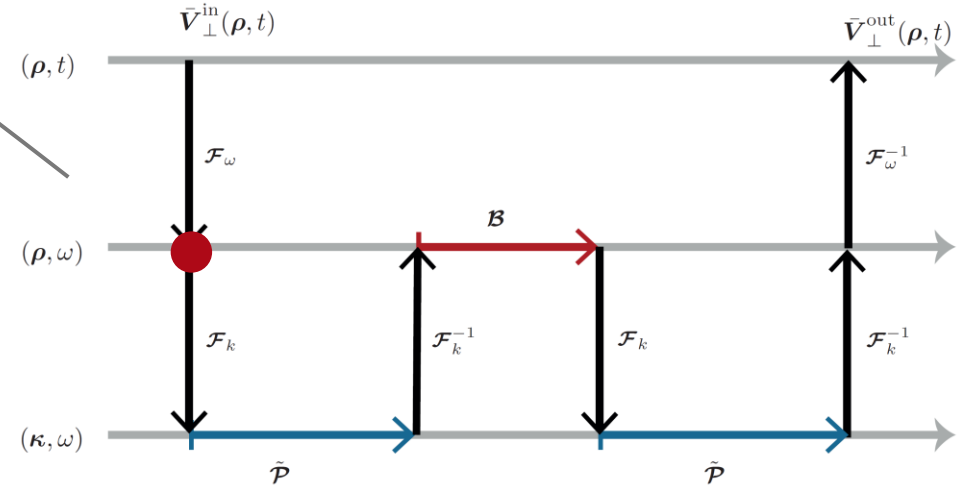
pulse evaluation
- spatial
- temporal



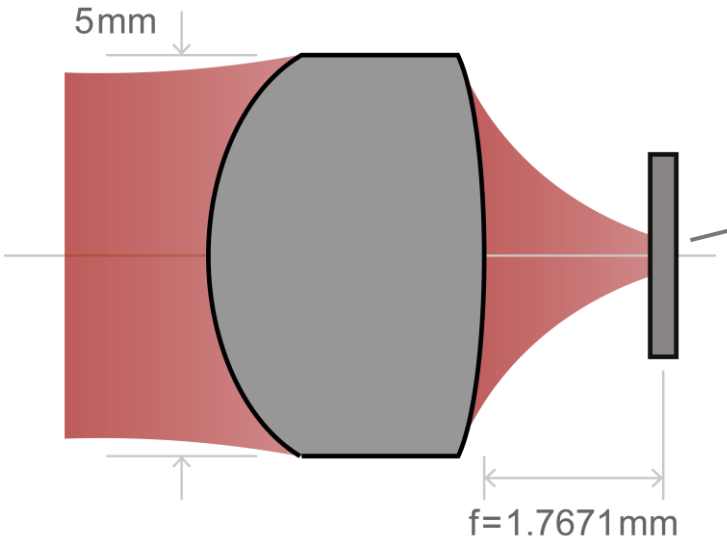
Purely Spatial Analysis: Input Field (Carrier λ)



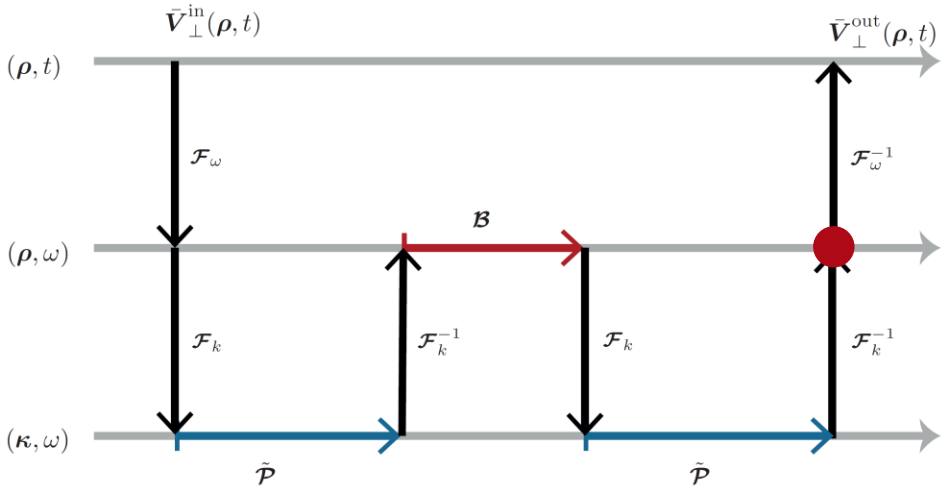




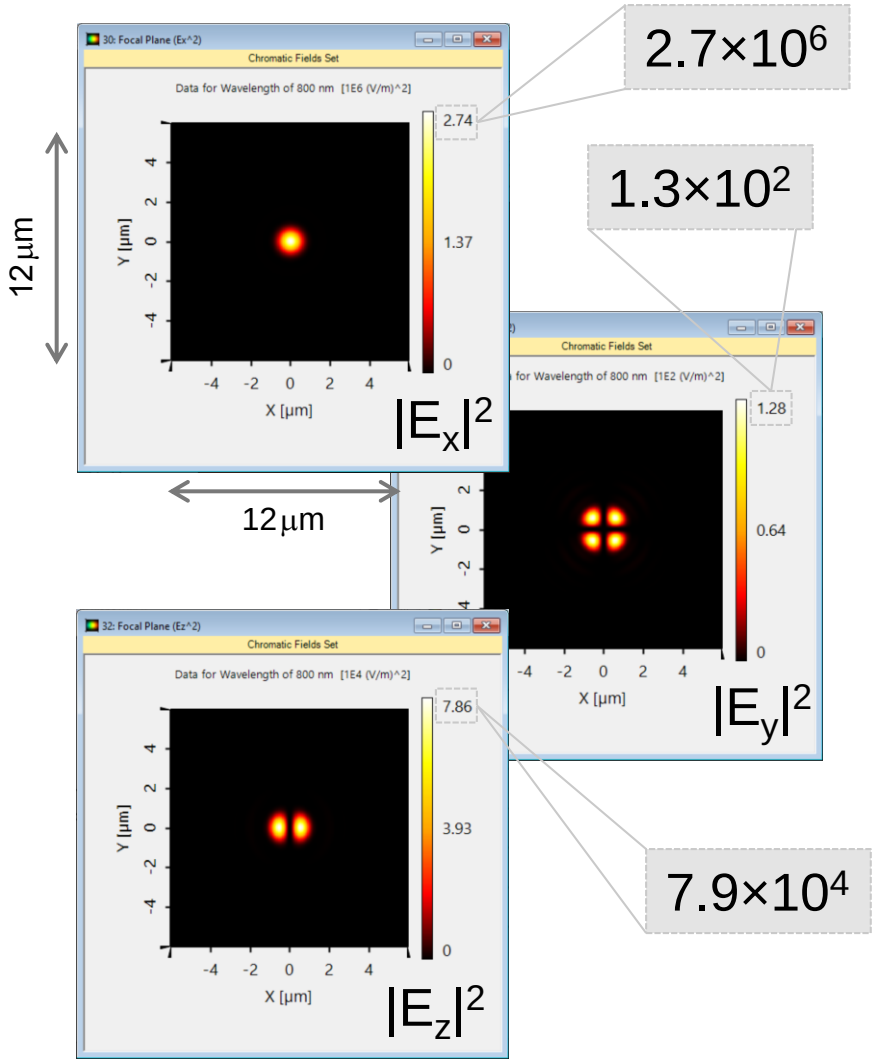
Purely Spatial Analysis: Field at Focal Plane (Carrier λ)



Note focusing effect on the size!

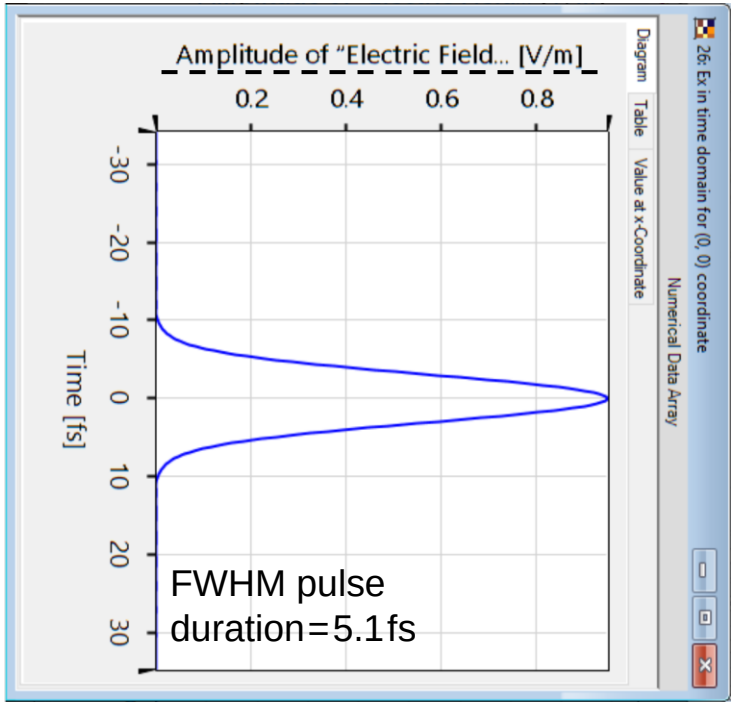


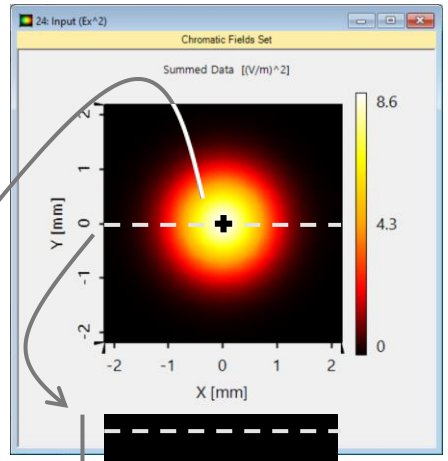
A small E_y component appears from the cross-talk effected by the surfaces of the lens. The tangible E_z component is the result of the high focusing of the beam

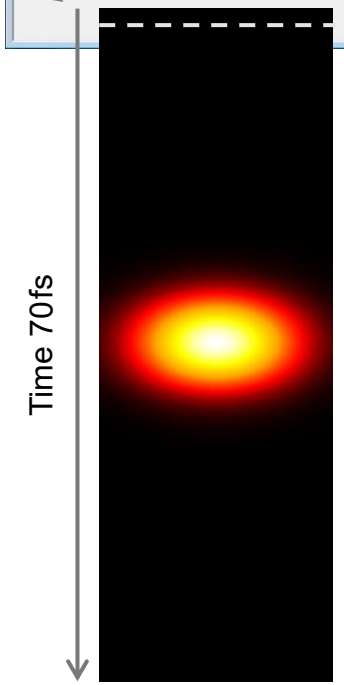


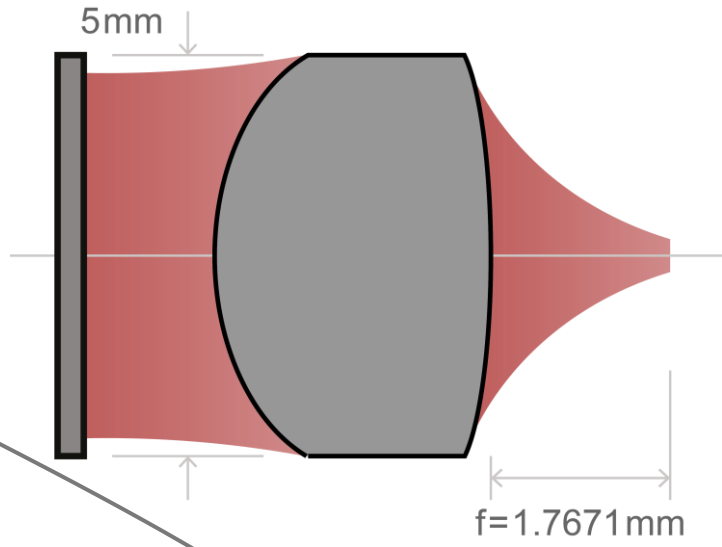
Spatio-Temporal Analysis: Input Field (E_x Component)

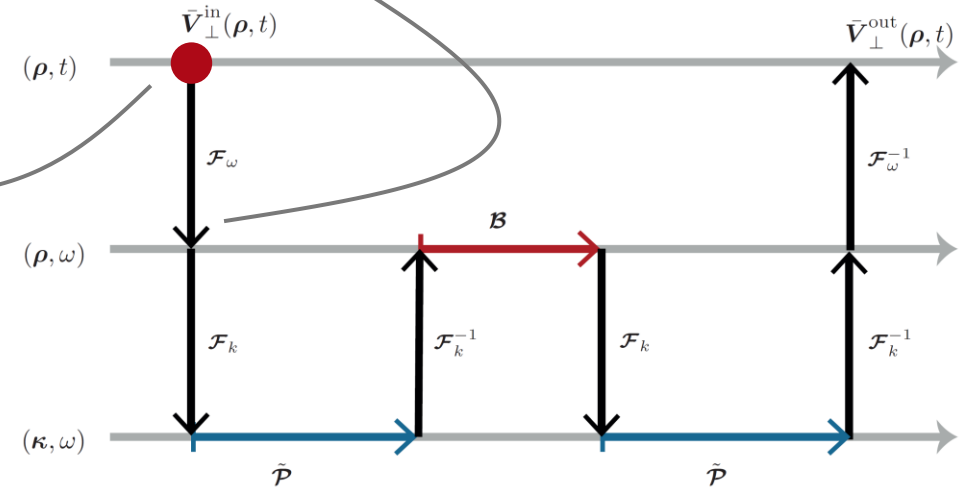
The Pulse Evaluation detector in VirtualLab facilitates the visualization of the pulse properties in different domains





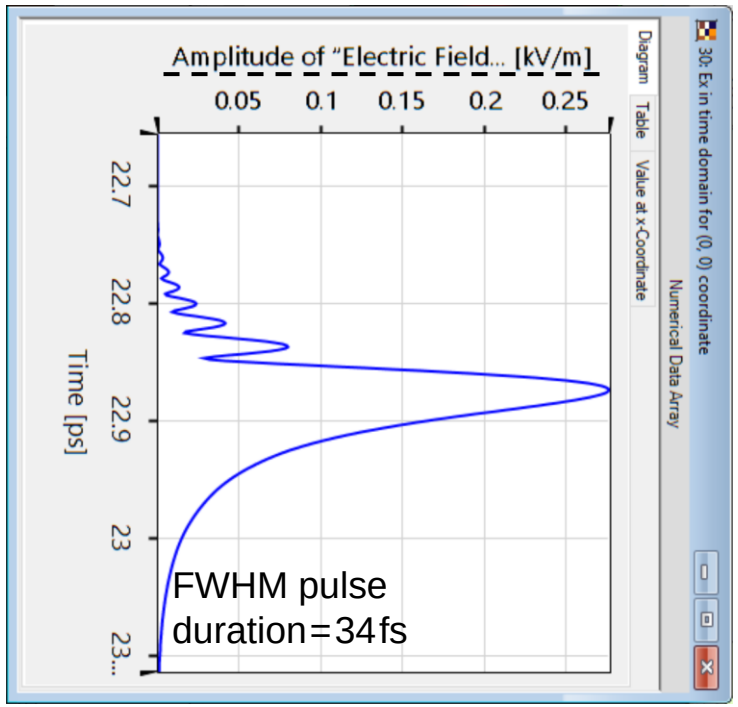


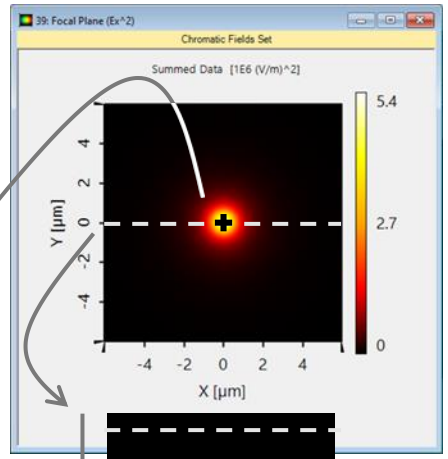


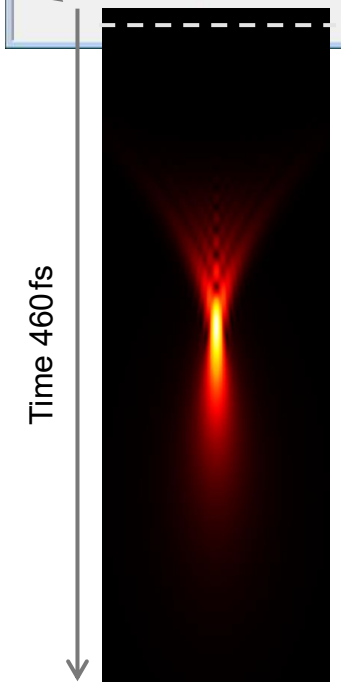


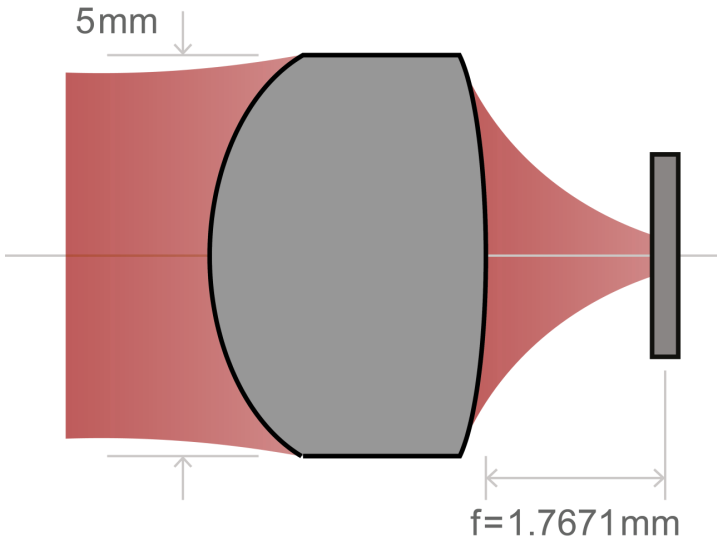
Spatio-Temporal Analysis: Focus (E_x Component)

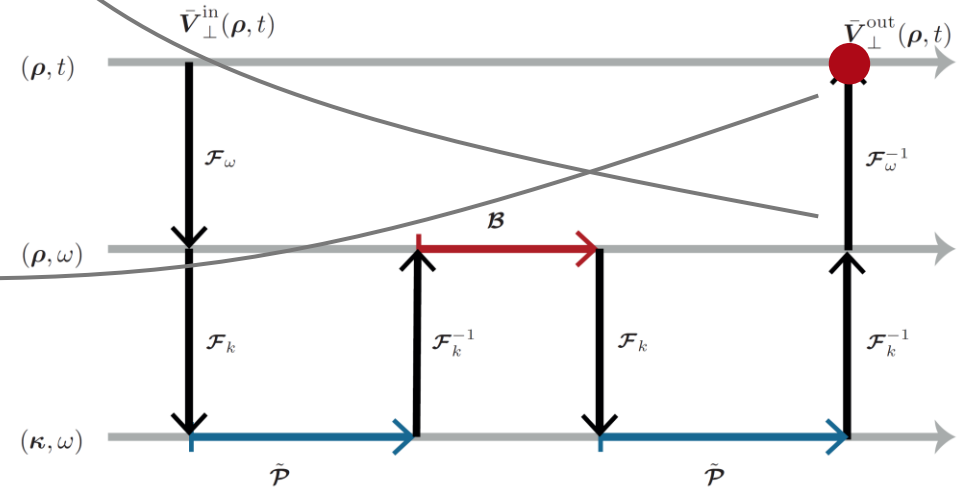
The Pulse Evaluation detector in VirtualLab facilitates the visualization of the pulse properties in different domains



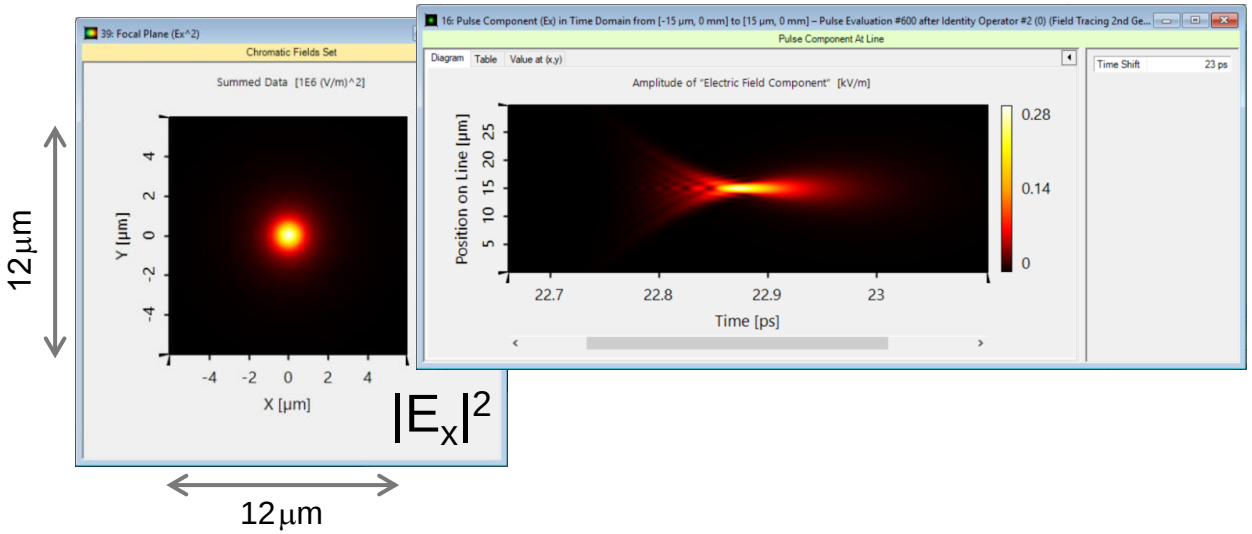


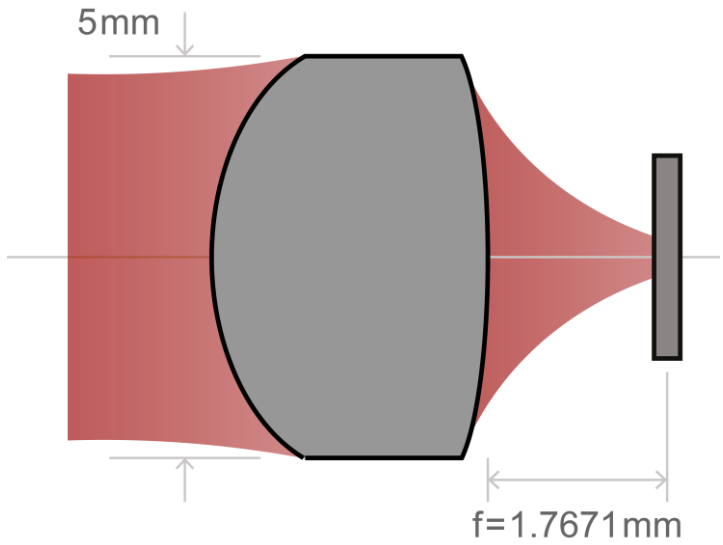


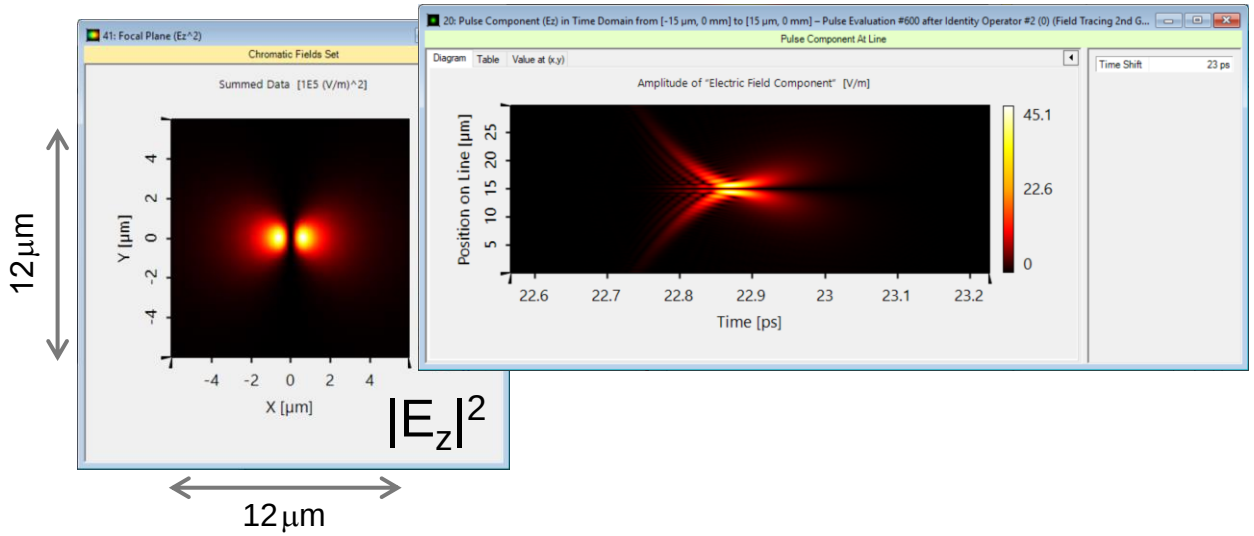




Spatio-Temporal Analysis: Focus (E_x and E_z)

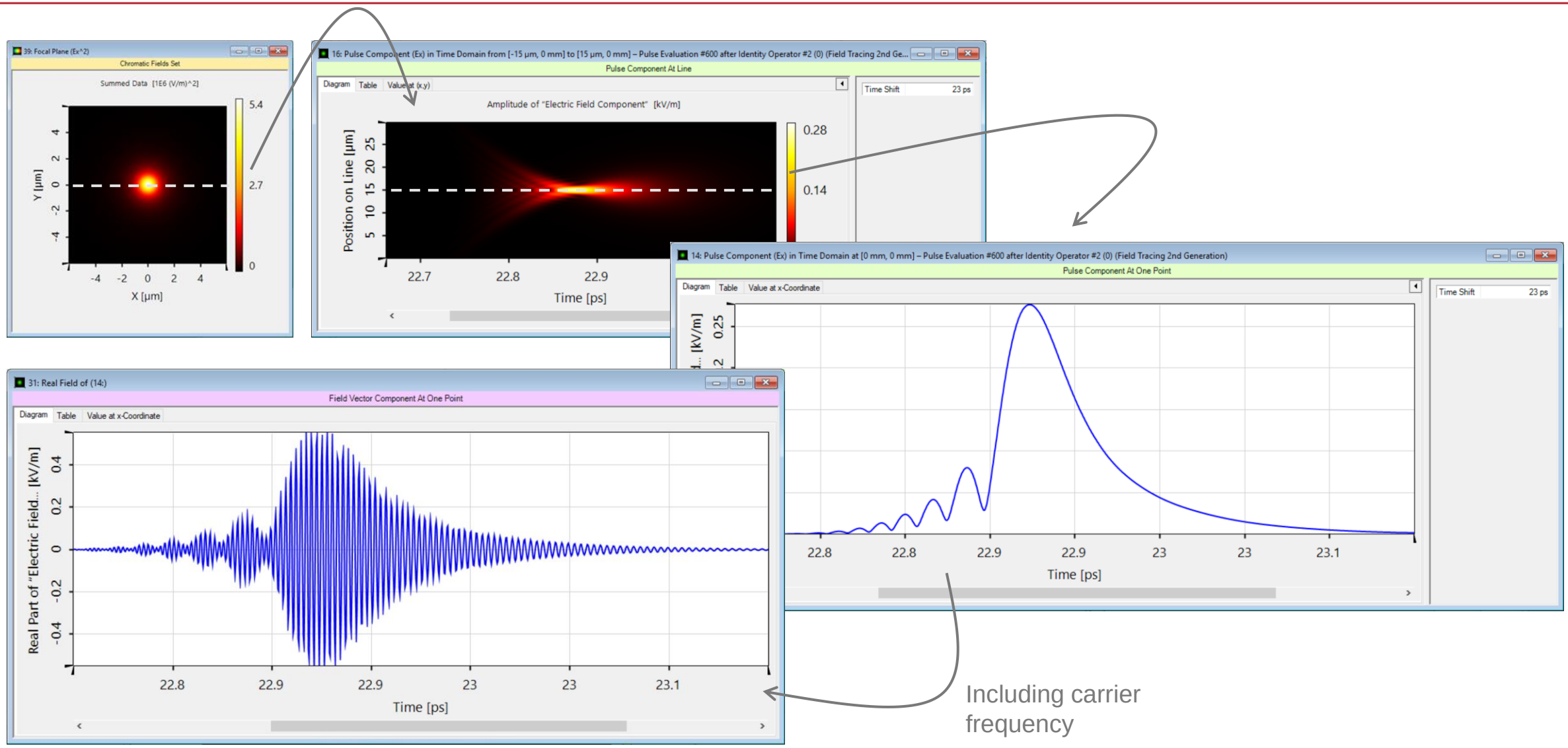




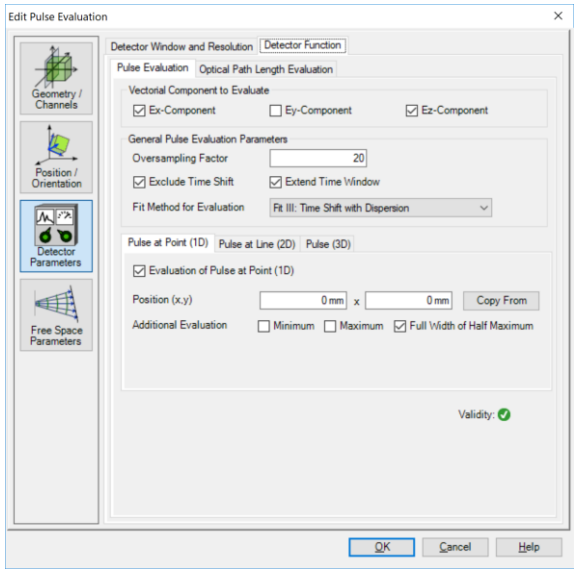


As always, consistent electromagnetic treatment in VirtualLab Fusion allows for the analysis of vectorial effects, also for ultra-short pulses

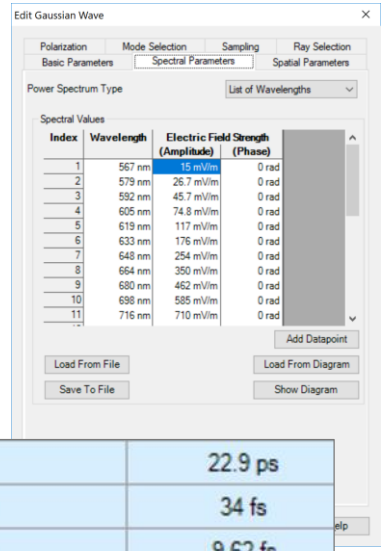
Temporal Analysis: E_x Component with Carrier Frequency



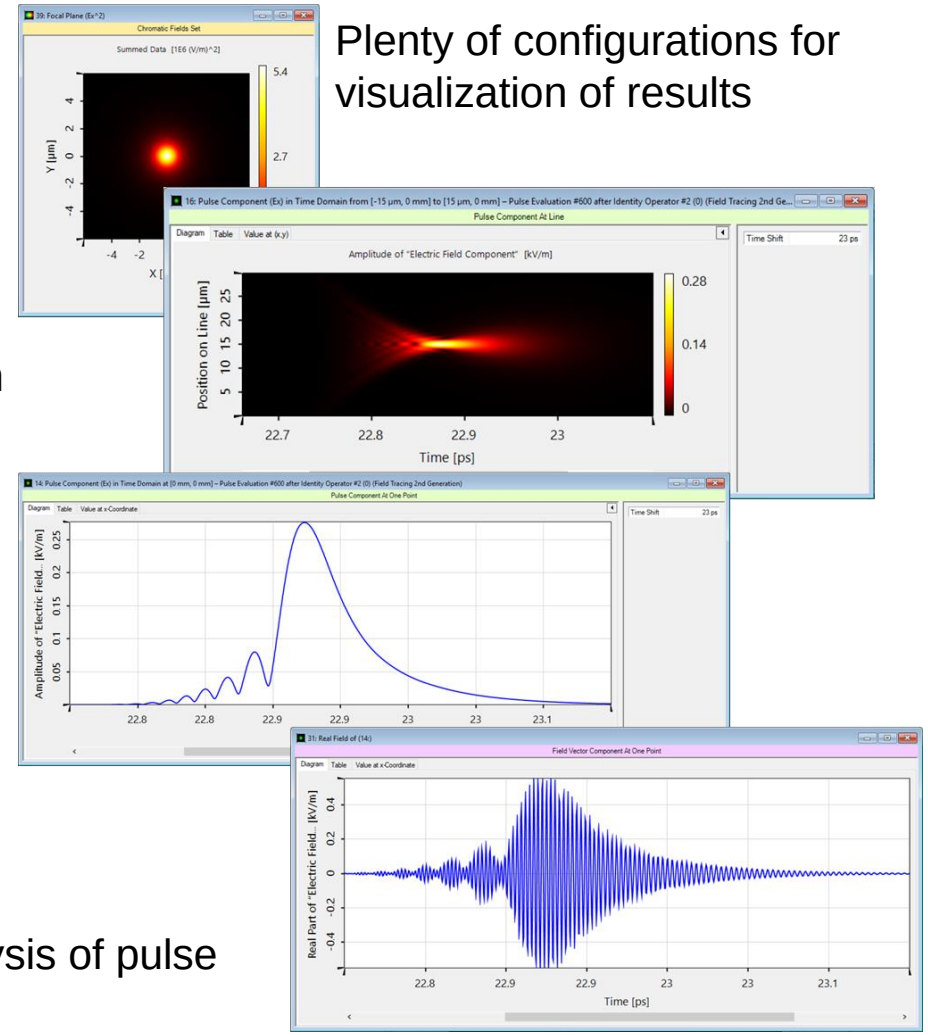
Peek into VirtualLab Fusion



Pulse Evaluation detector to comprehensively analyze properties of pulsed light



Pulse spectrum definition



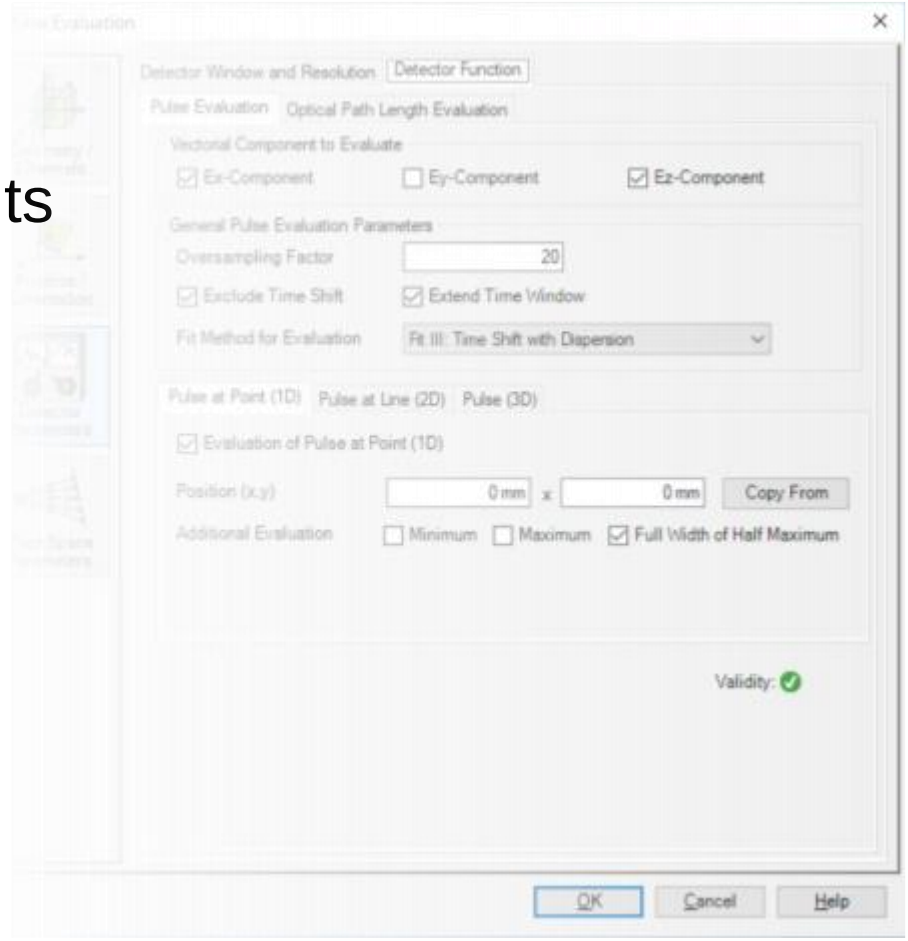
Plenty of configurations for visualization of results

Linear Fit III: Time Shift with Dispersion	22.9 ps
FWHM (Time) of Squared Amplitude (Ex)	34 fs
FWHM (Time) of Squared Amplitude (Ez)	9.62 fs
Linear Fit III: Time Shift with Dispersion	0 s
FWHM (Time) of Squared Amplitude (Ex)	5.09 fs
FWHM (Time) of Squared Amplitude (Ez)	0 s

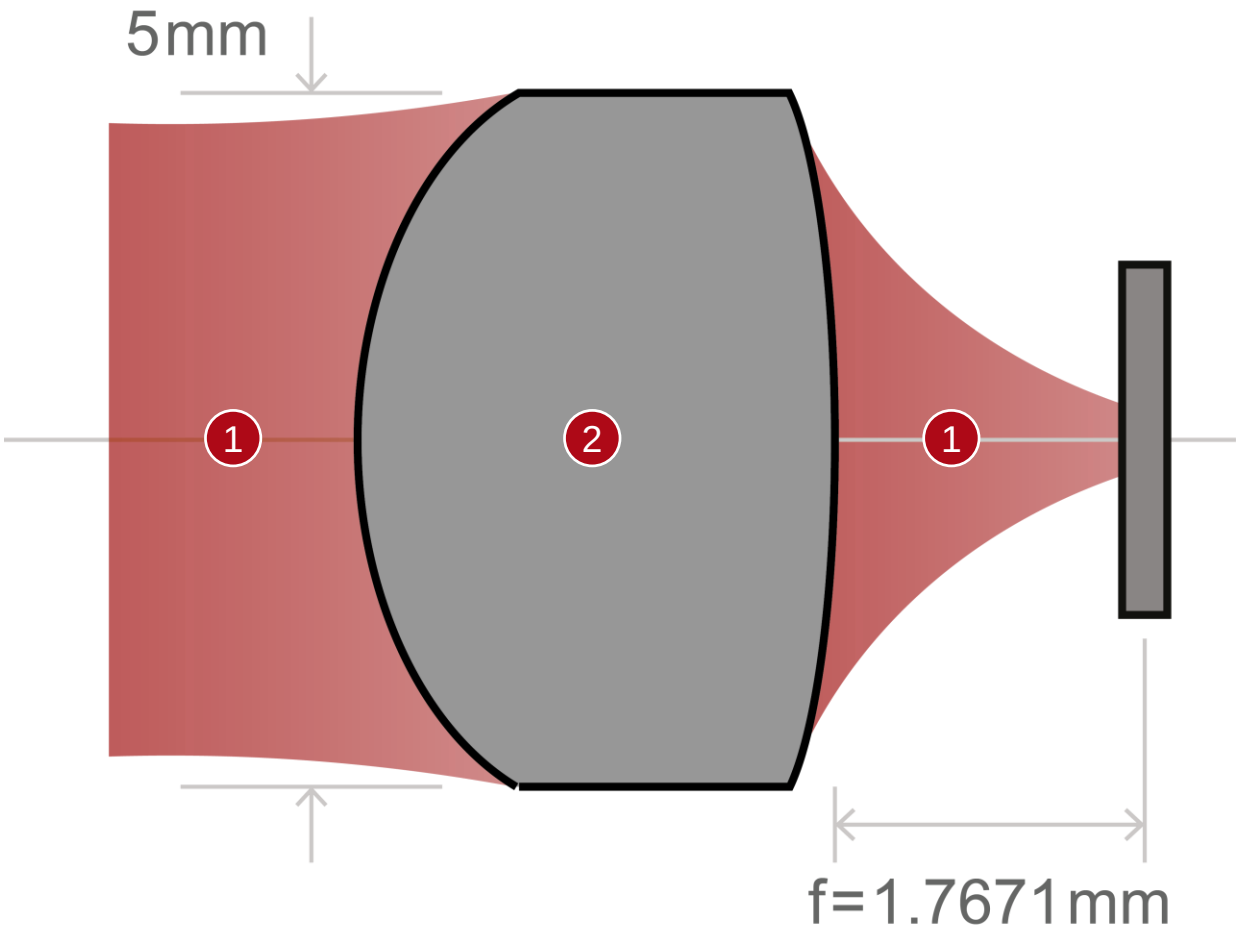
Quantitative analysis of pulse properties

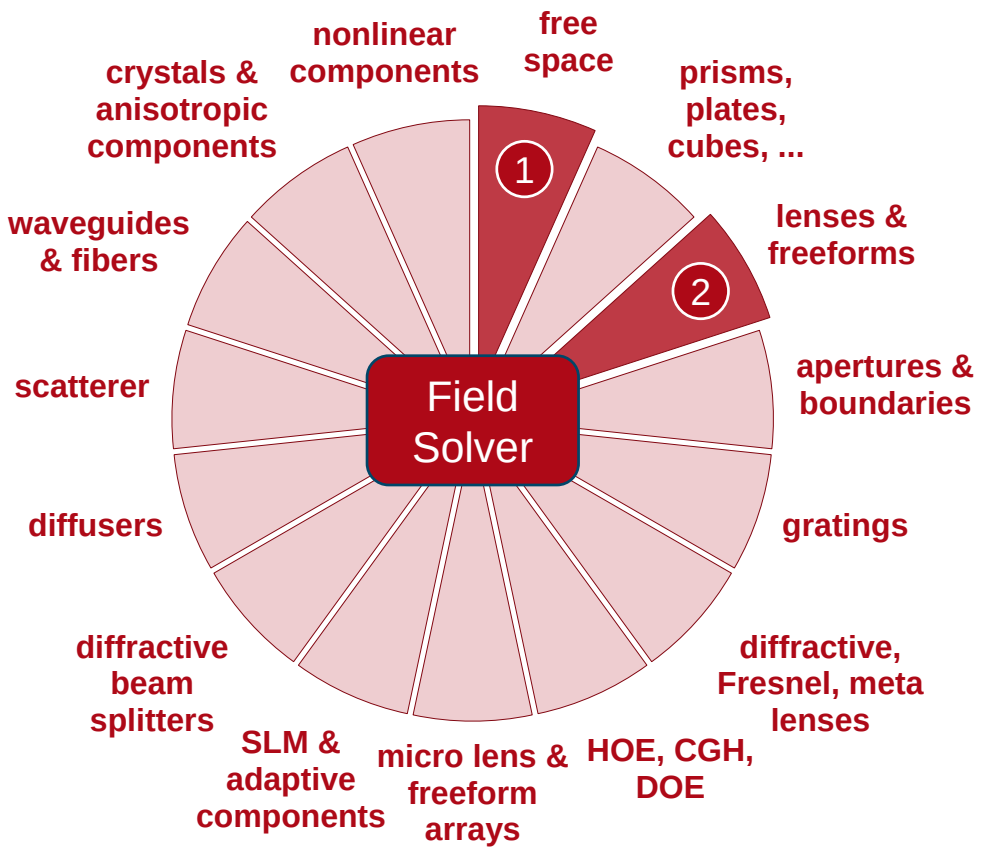
Workflow in VirtualLab Fusion

- Set up source
  - Basic Source Models [Tutorial Video]
- Set the position and orientation of components
  - LPD II: Position and Orientation [Tutorial Video]
- Configure the Pulse Evaluation detector



VirtualLab Fusion Technologies





Document Information

title	Pulse Focusing with High-NA Lens
document code	MISC.0073
version	1.0
toolbox(es)	Starter Toolbox
VL version used for simulations	7.5.0.158
category	Application Use Case
further reading	- Femtosecond Pulse Propagation through Dispersive Seawater - Focusing of Femtosecond Pulse by Using a high-NA off-Axis Parabolic Mirror