

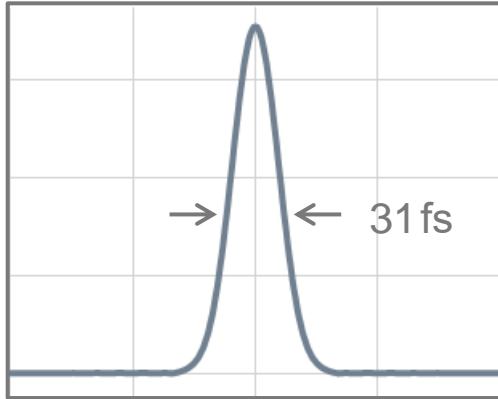
# Grating Stretcher for Ultrashort Pulses

# Abstract



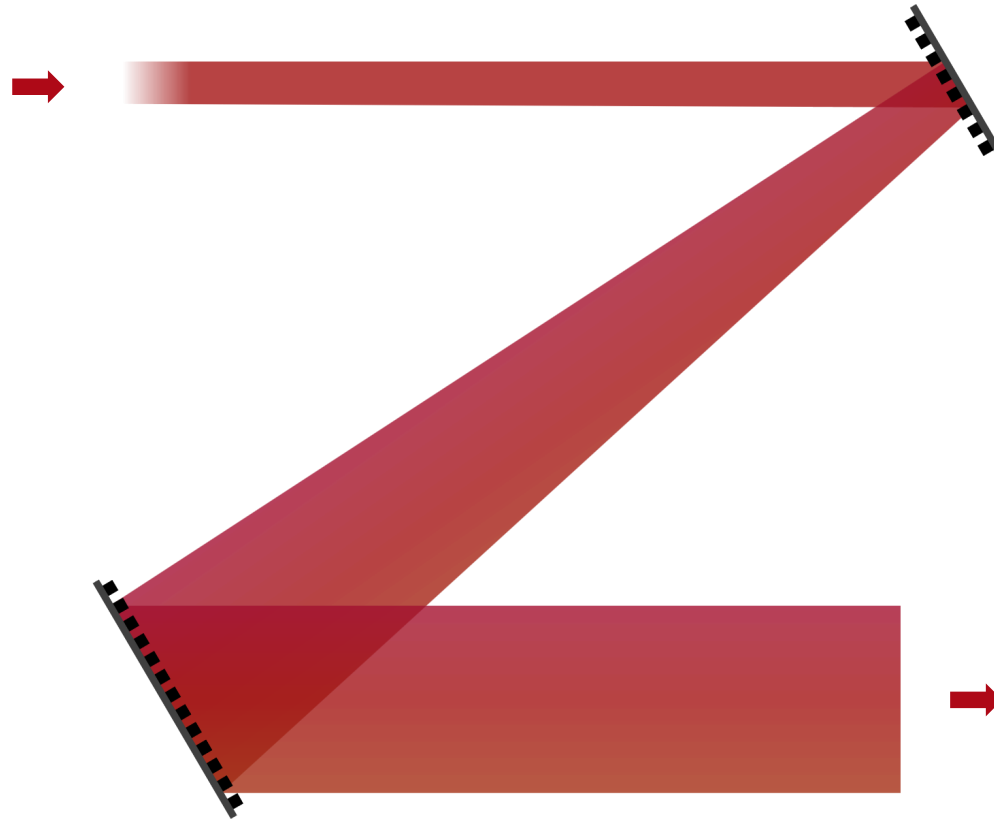
The role of ultrashort pulses is growing in modern optical applications. For example, they can be found in the fields of laser material processing, medical imaging, optical communication and so on. Prisms and gratings are typical optical components that are used for manipulating the temporal behavior of optical pulses. In this example, a pulse stretcher consisting of two diffractive gratings are constructed and the pulse broadening effect after propagation through them is demonstrated.

# Modeling Task



input pulse

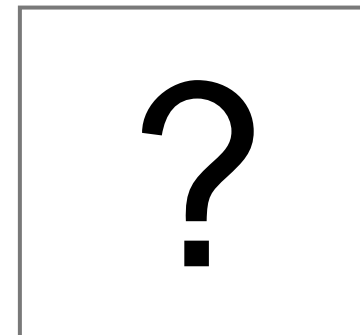
- carrier wavelength 619nm
- temporal duration 31 fs
- Gaussian spatial profile [collimated]



gratings pair

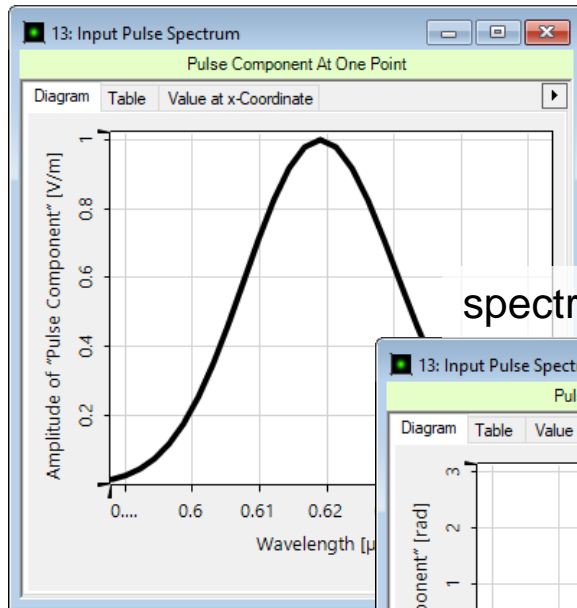
- period  $1.667 \mu\text{m}$
- rotation angle  $30^\circ$
- diffraction order  $R+1$
- distance between two gratings 64 mm

How does the two diffraction gratings changes the ultrashort pulse that propagates through them?

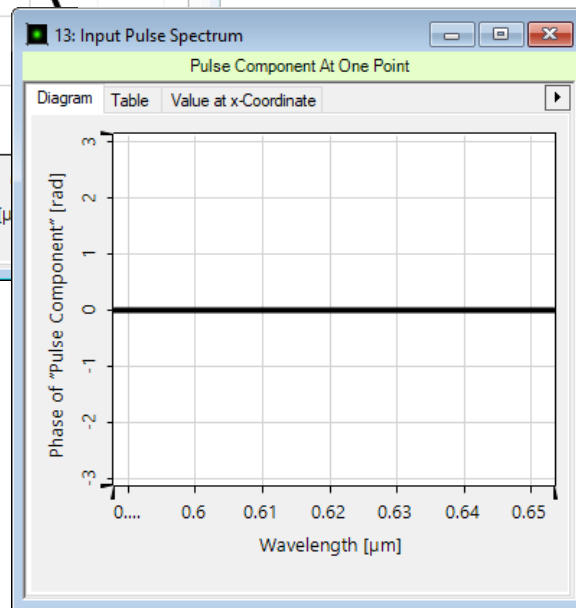


# Input Pulse in Both Domains

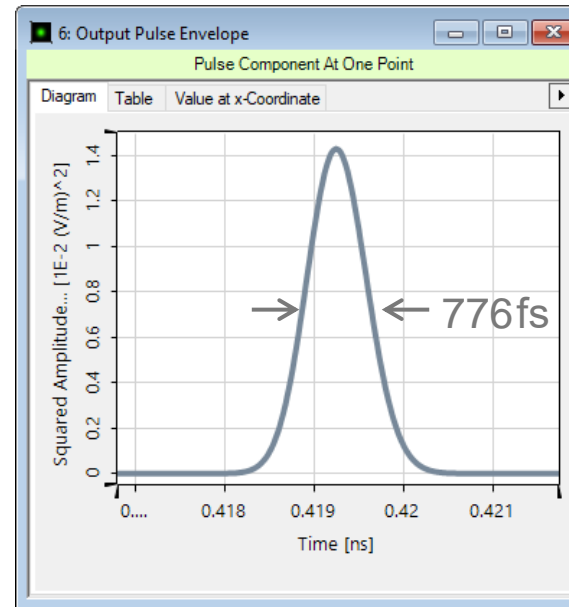
spectrum domain (amplitude)



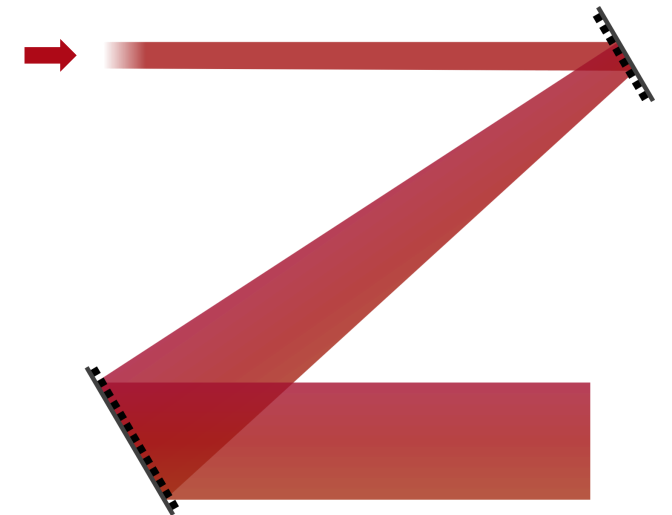
spectrum domain (phase)



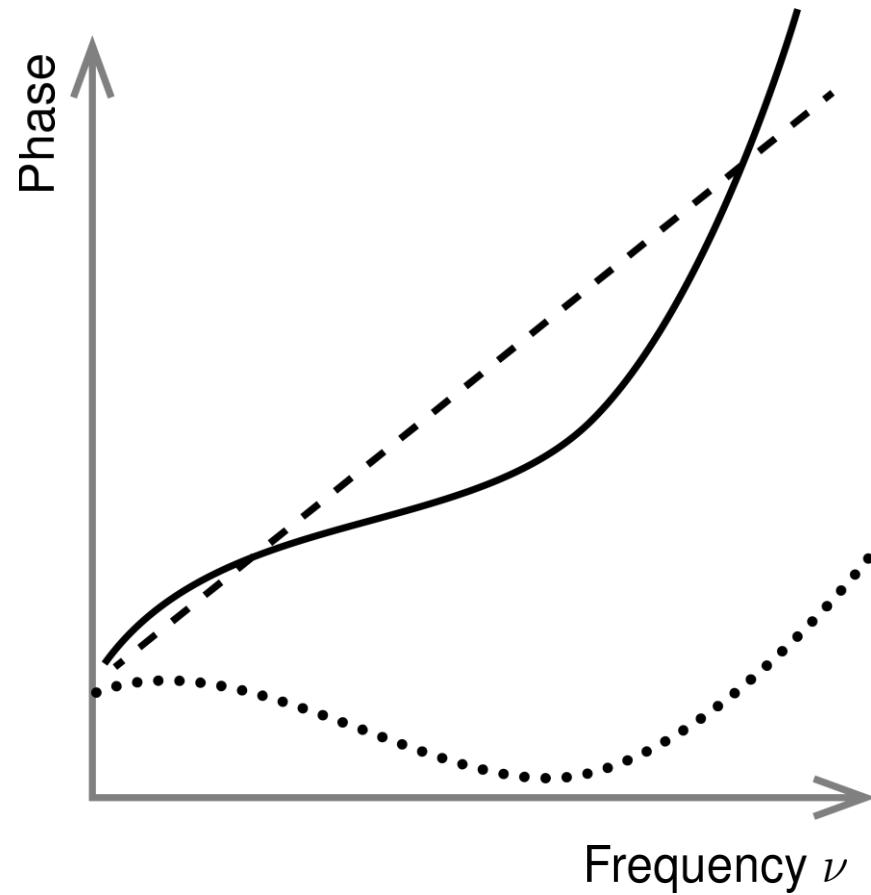
time domain  
(squared amplitude)



Nonlinear spectral phase leads to broadening of the temporal pulse envelope.



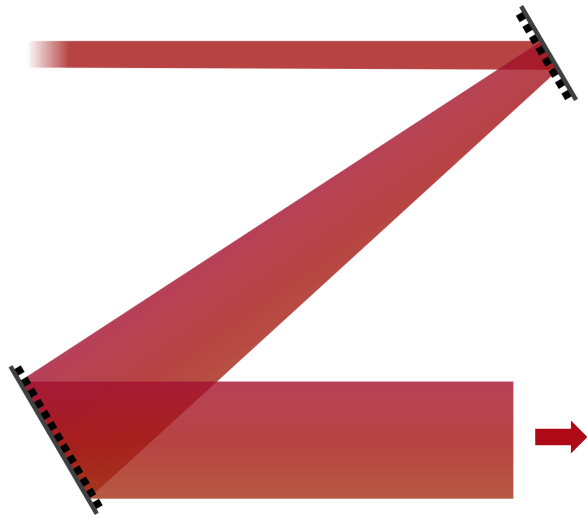
# Analysis of Phase over Frequency



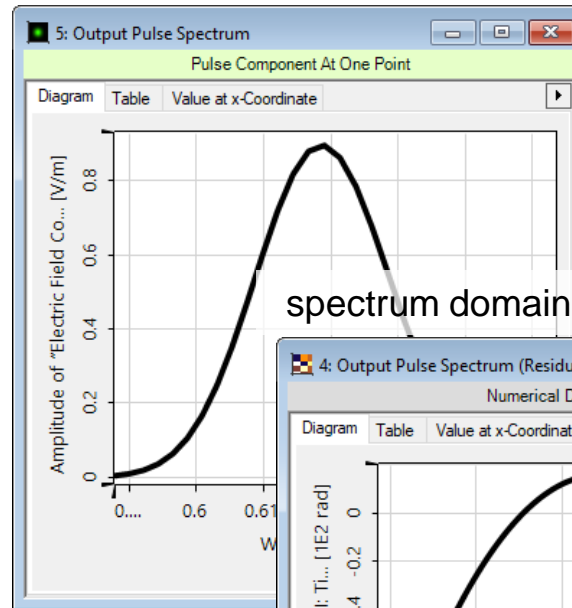
- complete phase
- - - linear fit phase
- ..... residual phase  
(complete phase – linear fit phase)

- Complete phase v.s. frequency can be analyzed at a given spatial position.
- A linear fitting of phase over frequency gives information on temporal shift.
- The residual phase (extracting linear fit from complete phase) determines the temporal pulse profile.

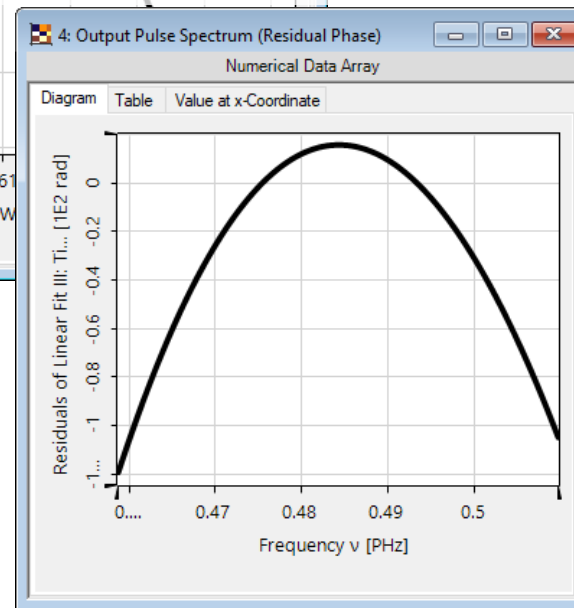
# Output Pulse in Both Domains



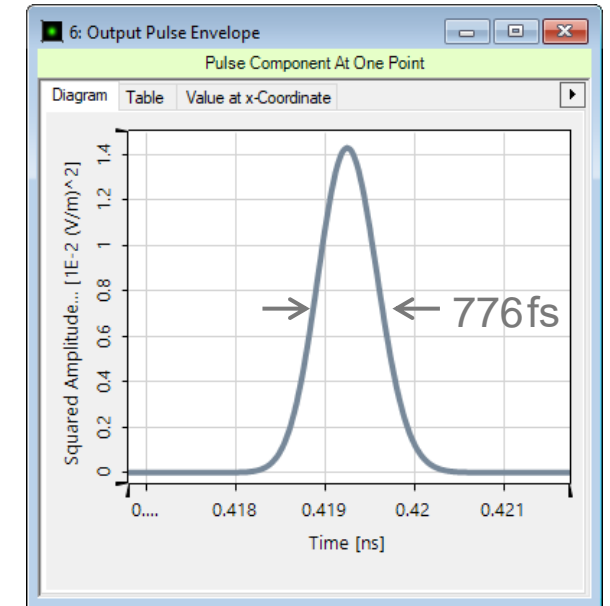
spectrum domain (amplitude)



spectrum domain (residual phase)



time domain  
(squared amplitude)



Higher-order spectral phase leads to broadening of the temporal pulse envelope.

# Peek into VirtualLab Fusion

Edit Gaussian Wave

Polarization Mode Selection Sampling Ray Selection  
Basic Parameters Spectral Parameters Spatial Parameters

Power Spectrum Type List of Wavelengths

Spectral Values

Index	Wavelength	Electric Field Strength (Amplitude)	Electric Field Strength (Phase)
1	587.92 nm	14.987 mV/m	0 rad
2	590.03 nm	26.731 mV/m	0 rad
3	592.17 nm	45.678 mV/m	0 rad
4	594.31 nm	74.779 mV/m	0 rad
5	596.48 nm	117.28 mV/m	0 rad
6	598.65 nm	176.23 mV/m	0 rad
7			
8			
9			
10			
11			

Gaussian Pulse Spectrum

Pulse Specification

Definition by FWHM  Definition by 1/e Diameter

Pulse Duration 31 fs

Carrier Wavelength 619 nm

Carrier Frequency 484.32 THz

Estimated Increase of Time Window 5

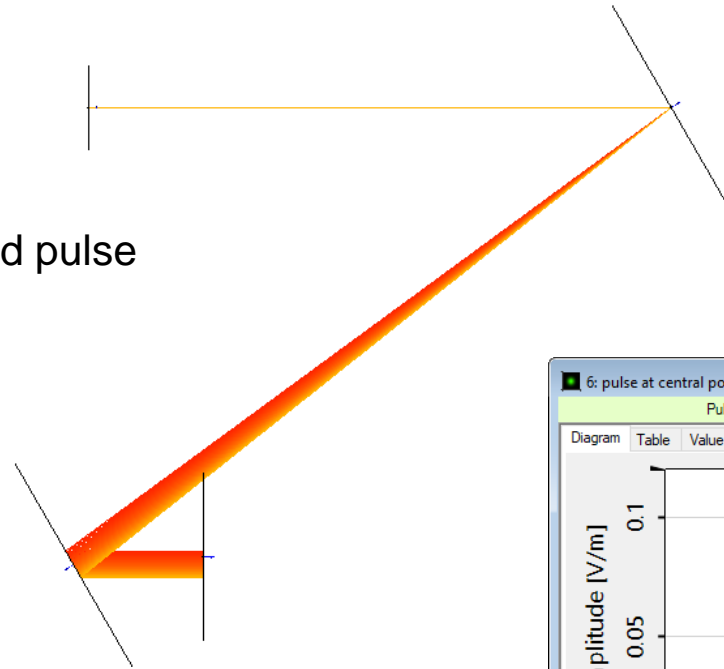
Numerical Settings

Squared Amplitude Truncation (Frequency Domain) 0.01 %

Resulting Size of Angular Frequency Window 326.02 THz

Squared Amplitude Truncation (Time Domain) 0.01 %

customized pulse spectrum



Edit Pulse Evaluation

Detector Window and Resolution Detector Function

Pulse Evaluation Optical Path Length Evaluation

Vectorial Component to Evaluate

Ex-Component  Ey-Component  Ez-Component

General Pulse Evaluation Parameters

Oversampling Factor 10

Exclude Time Shift  Extend Time Window

Fit Method for Evaluation Fit III: Time Shift with Dispersion

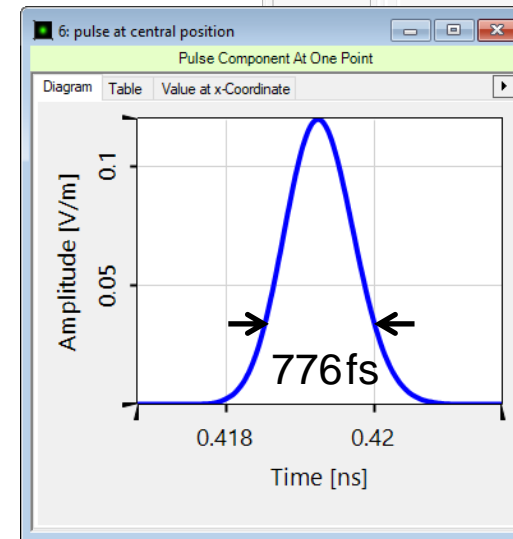
Pulse at Point (1D) Pulse at Line (2D) Pulse at (3D)

Evaluation of Pulse at Point (1D)

Position (x,y) 0 mm x 0 mm Copy From

Additional Evaluation  Minimum  Maximum  Full Width of Half Maximum

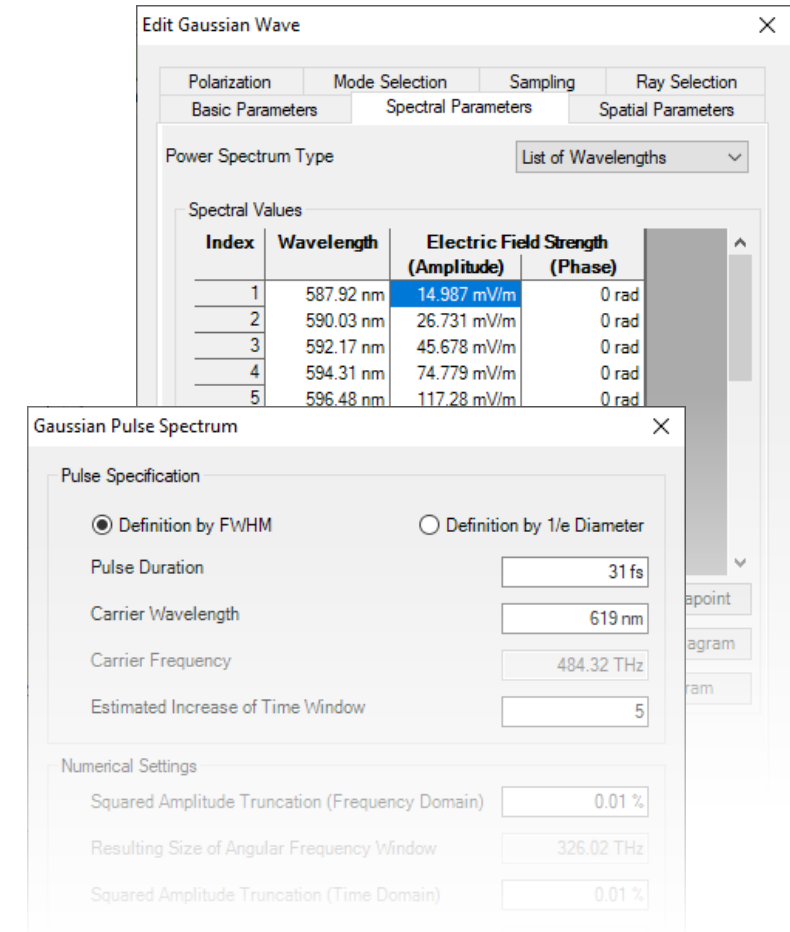
Validity: ✓



pulse evaluation detector

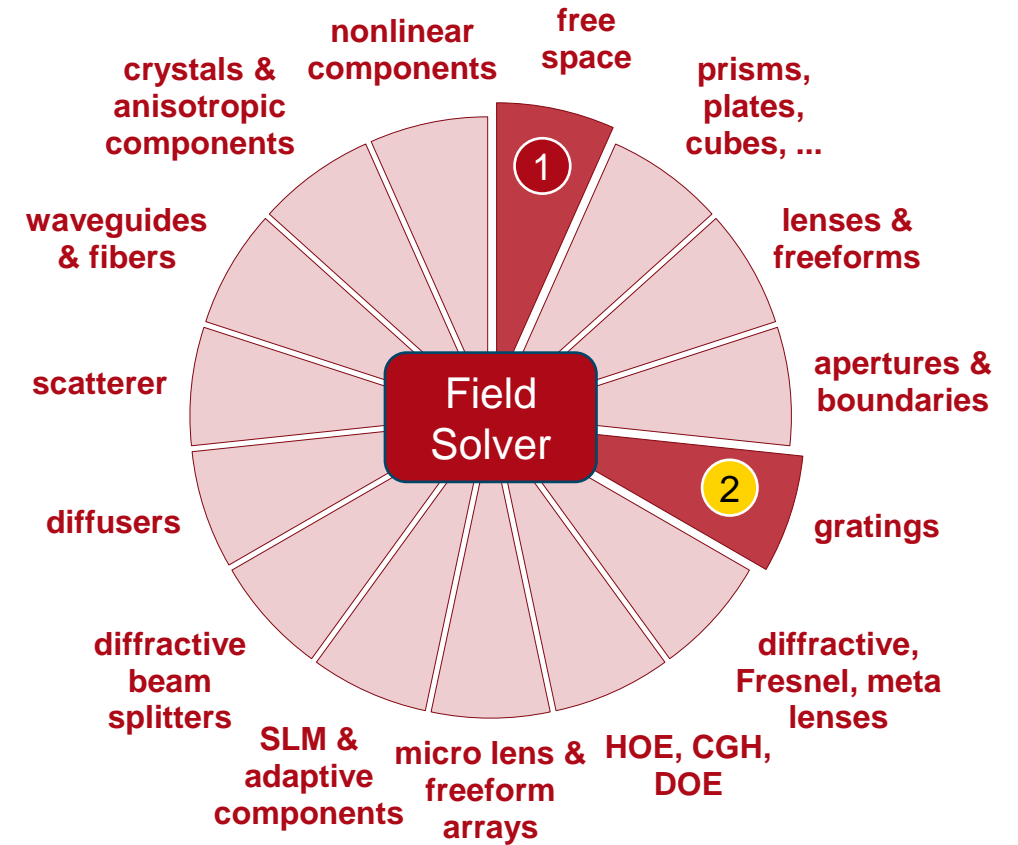
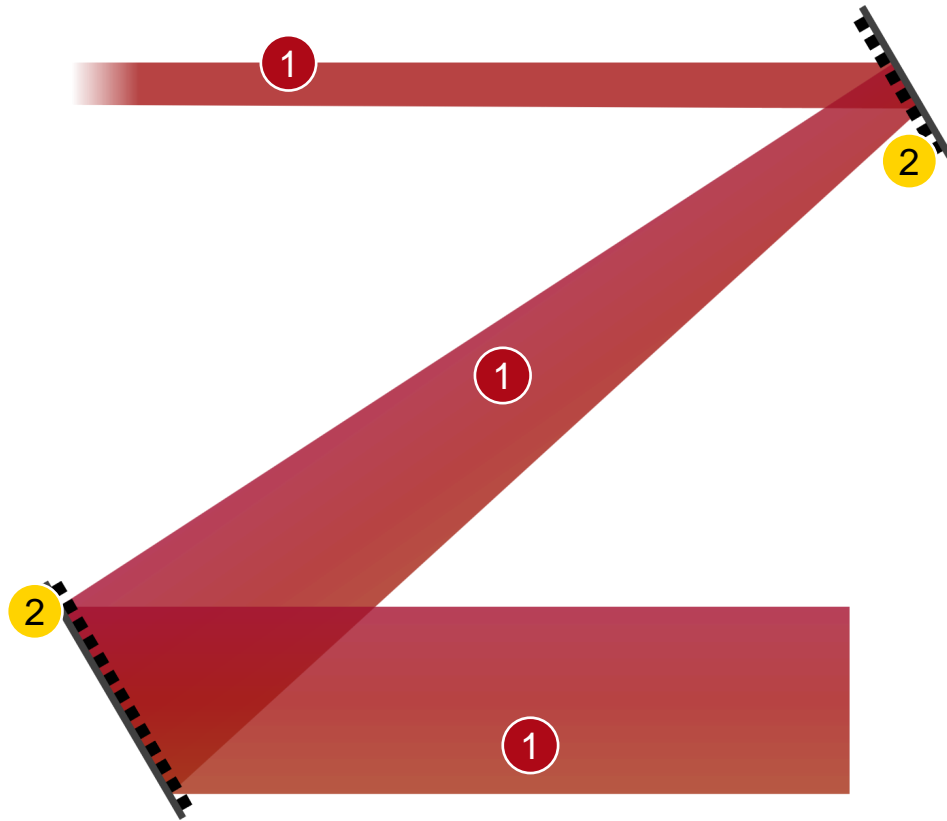
# Workflow in VirtualLab Fusion

- Set up input Gaussian field
  - [Basic Source Models](#) [Tutorial Video]
- Set up an ideal grating and select the working diffraction order
- Select and set up the pulse evaluation detector





# VirtualLab Fusion Technologies



# idealized component

# Document Information

title	Grating Stretcher for Ultrashort Pulses
document code	USP.0002
document version	1.1
software version	2023.1 (Build 1.556)
software edition	VirtualLab Fusion Basic
category	Feature Use Case
further reading	<ul style="list-style-type: none"><li>• <a href="#"><u>Focusing of Femtosecond Pulse by using a High-NA Off-Axis Parabolic Mirror</u></a></li><li>• <a href="#"><u>Pulse Focusing with High-NA Lens</u></a></li><li>• <a href="#"><u>Pulse Broadening in Dispersive Media</u></a></li></ul>