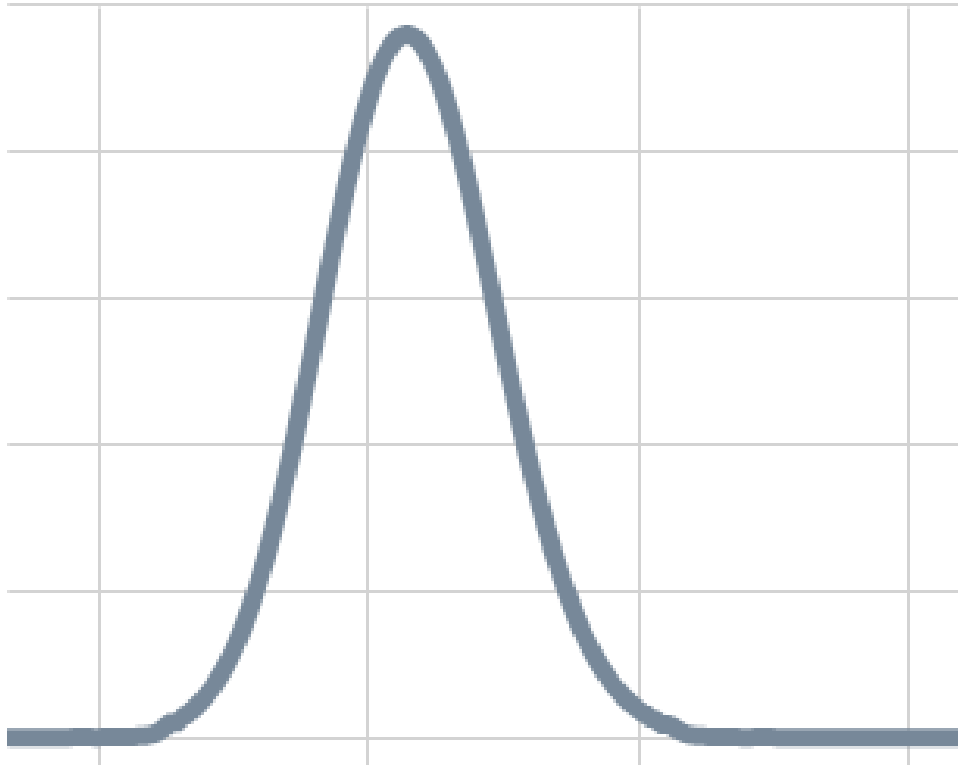


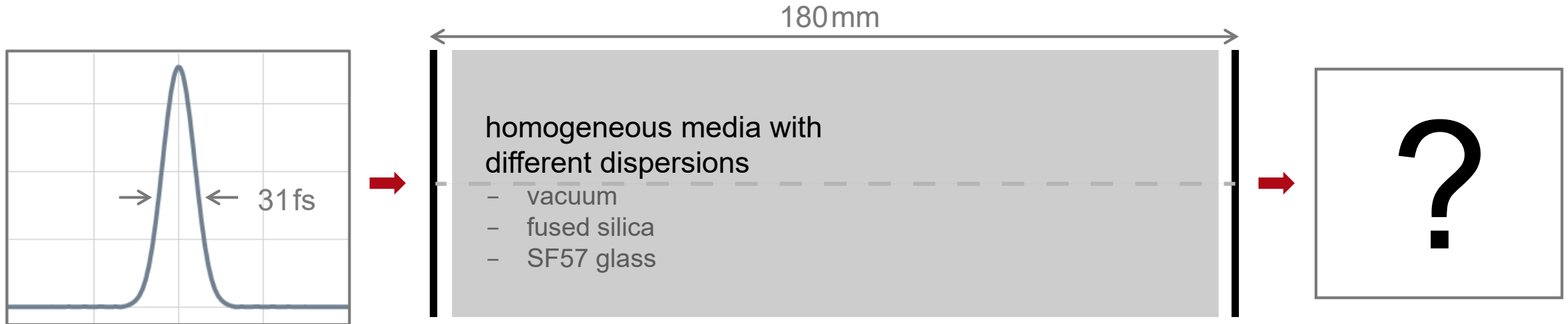
# **Pulse Broadening in Dispersive Media**

# Abstract



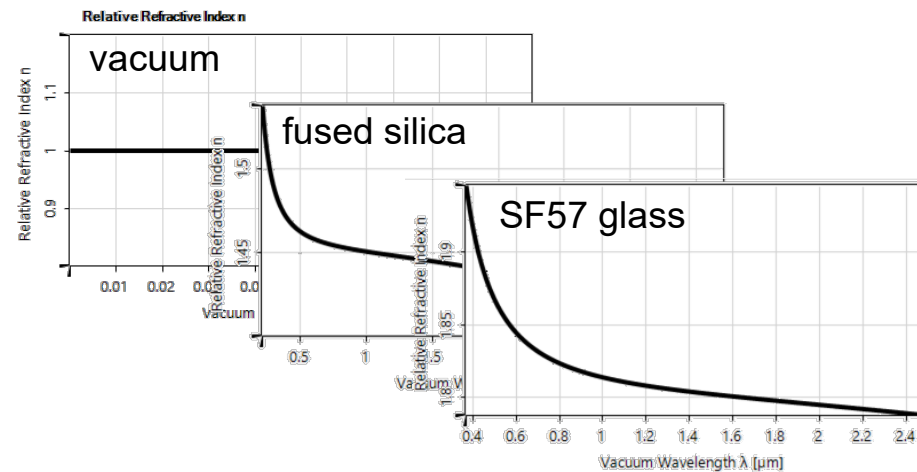
Ultrashort pulses turn out to be a promising tool for laser material processing applications. On the one hand, ultrashort pulses often shows superiority in e.g. heat control and precision; on the other hand, due to dispersive effect, it can be challenging to maintain the pulse duration after propagating through a complete optical system. In this example, we investigate the relation between pulse broadening and material dispersion, based on selected examples.

# Modeling Task



input pulse

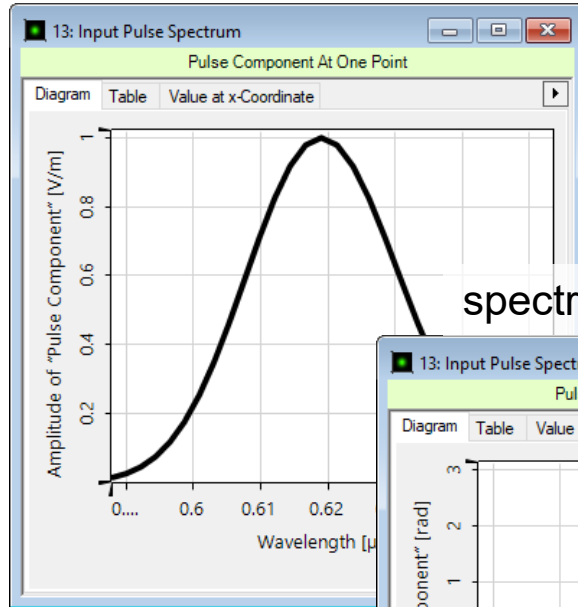
- carrier wavelength 619nm
- temporal duration 31 fs
- Gaussian spatial profile [collimated]



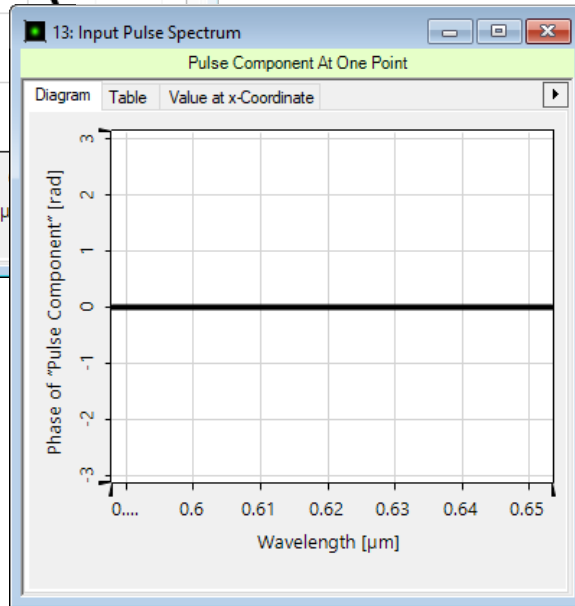
How does different dispersive media affect the pulse after propagation for a certain distance?

# Input Pulse in Both Domains

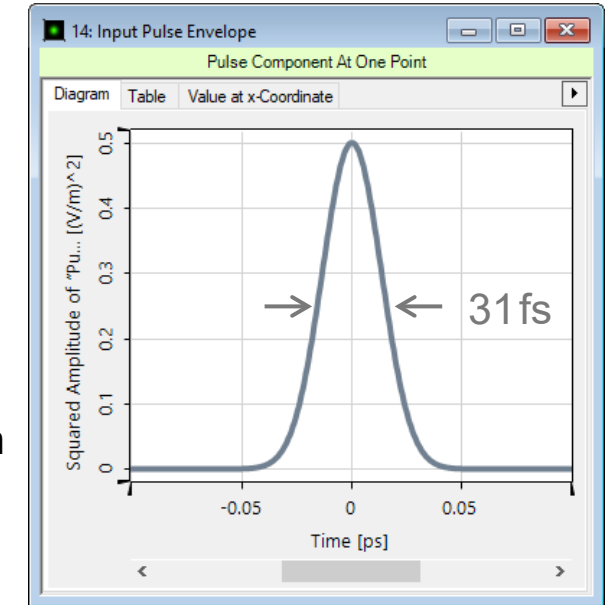
spectrum domain (amplitude)



spectrum domain (phase)

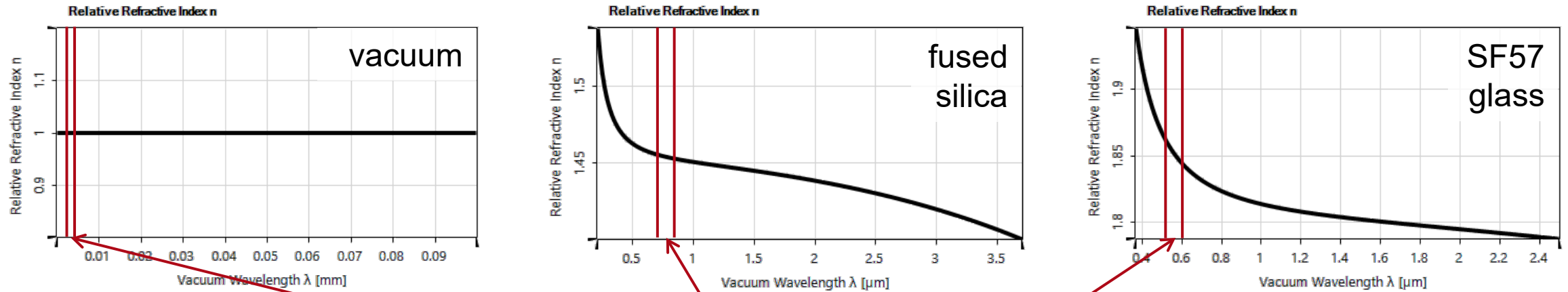


time domain  
(squared amplitude)



Constant phase over wavelength  
implies transform-limited pulse,  
with the minimum possible  
temporal duration.

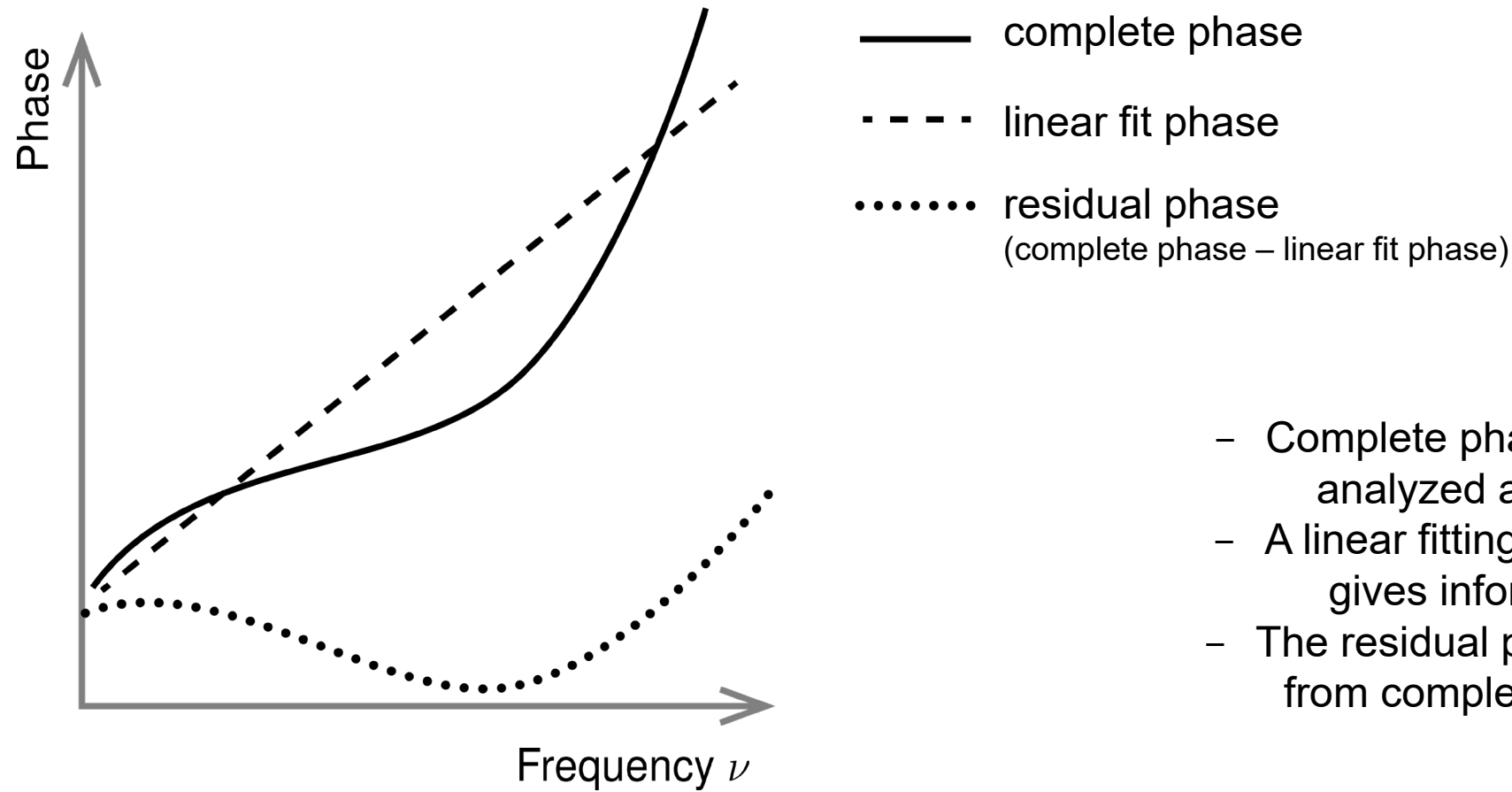
# Dispersion Properties of Different Materials



pulse spectrum range from 588nm to 653nm

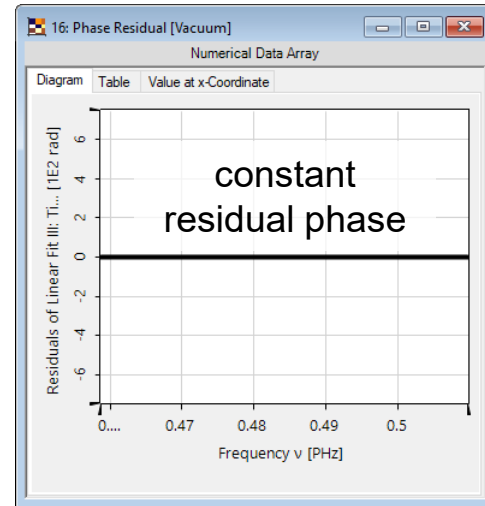
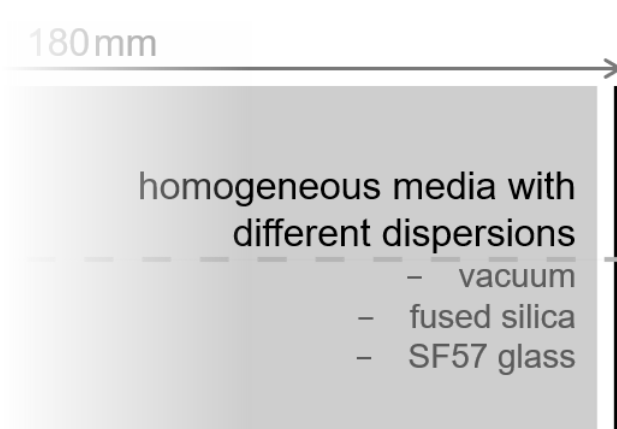
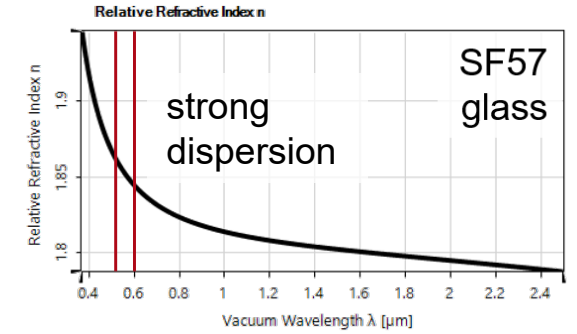
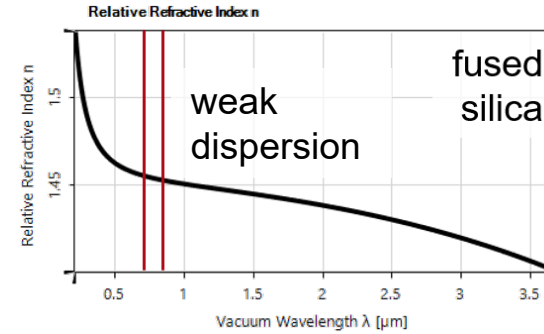
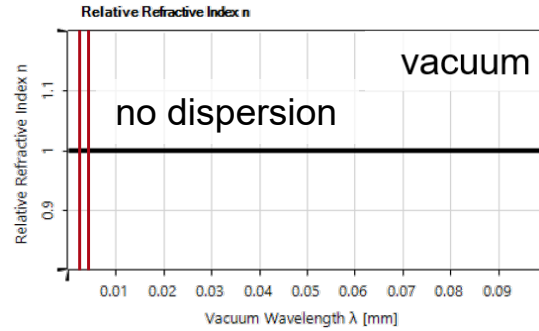
|                                   | <b>vacuum</b> | <b>fused silica</b>  | <b>SF57</b>          |
|-----------------------------------|---------------|----------------------|----------------------|
| $n@588\text{nm}$                  | 1             | 1.4585               | 1.8466               |
| $n@653\text{nm}$                  | 1             | 1.4565               | 1.8369               |
| $\Delta n (588\sim 653\text{nm})$ | 0             | $2.0 \times 10^{-3}$ | $9.1 \times 10^{-3}$ |

# Analysis of Phase over Frequency

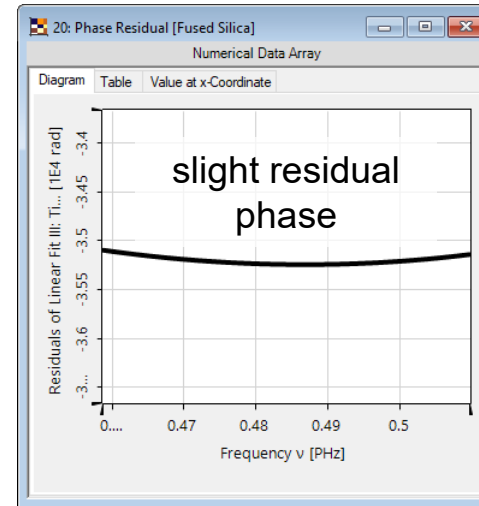


- Complete phase v.s. frequency can be analyzed at a given spatial position.
- A linear fitting of phase over frequency gives information on temporal shift.
- The residual phase (extracting linear fit from complete phase) determines the temporal pulse profile.

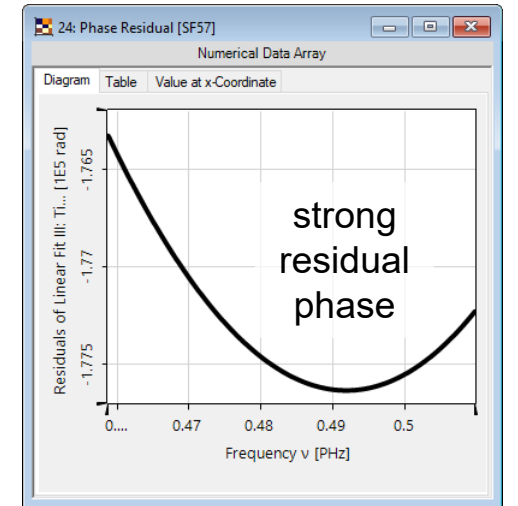
# Output Pulse – Residual Phase over Frequency



vacuum

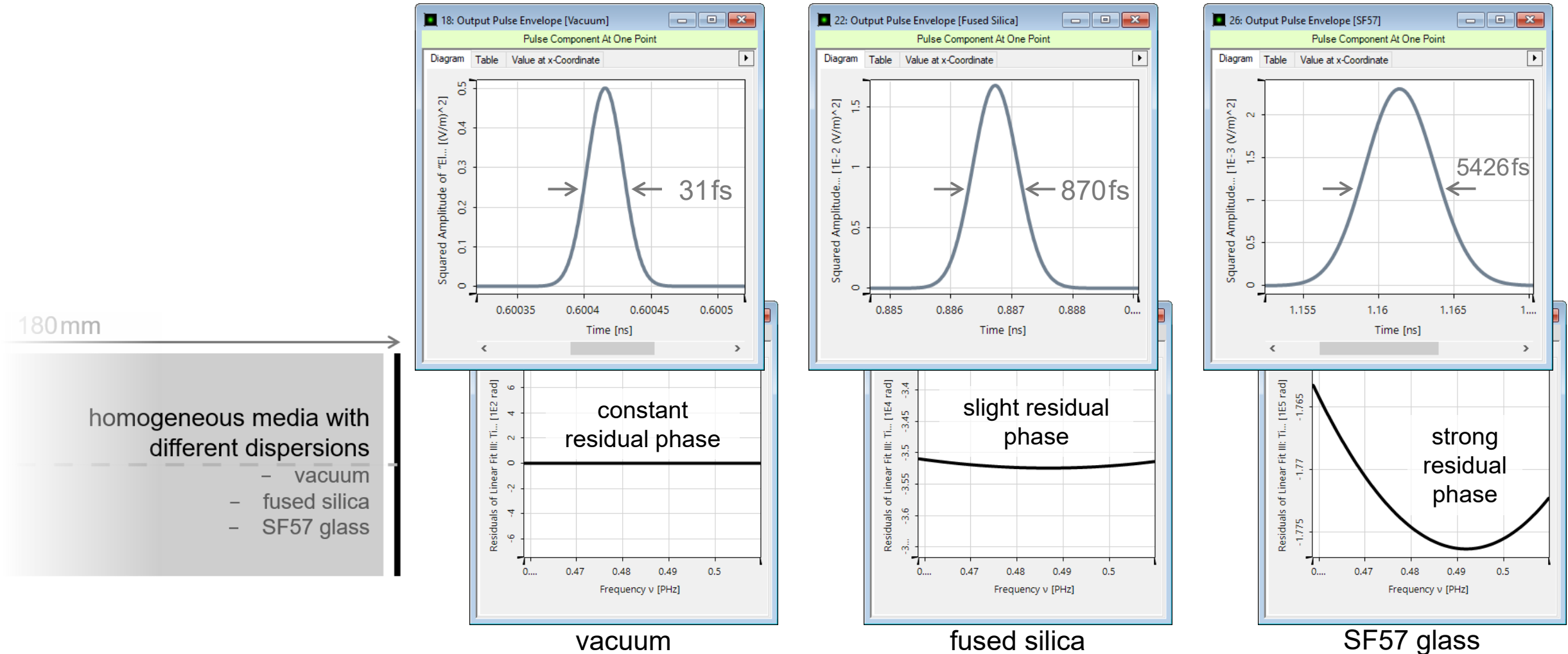


fused silica



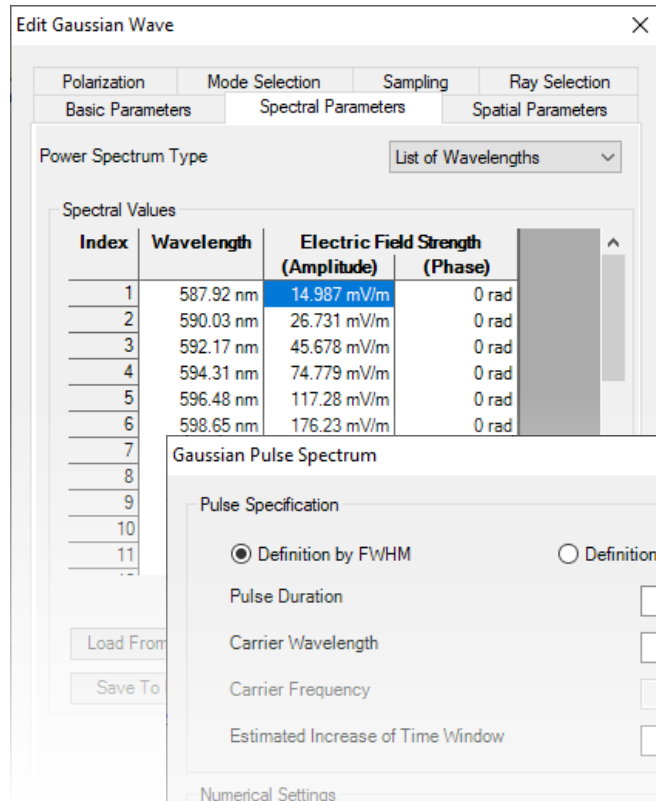
SF57 glass

# Output Pulse – Temporal Pulse Envelope

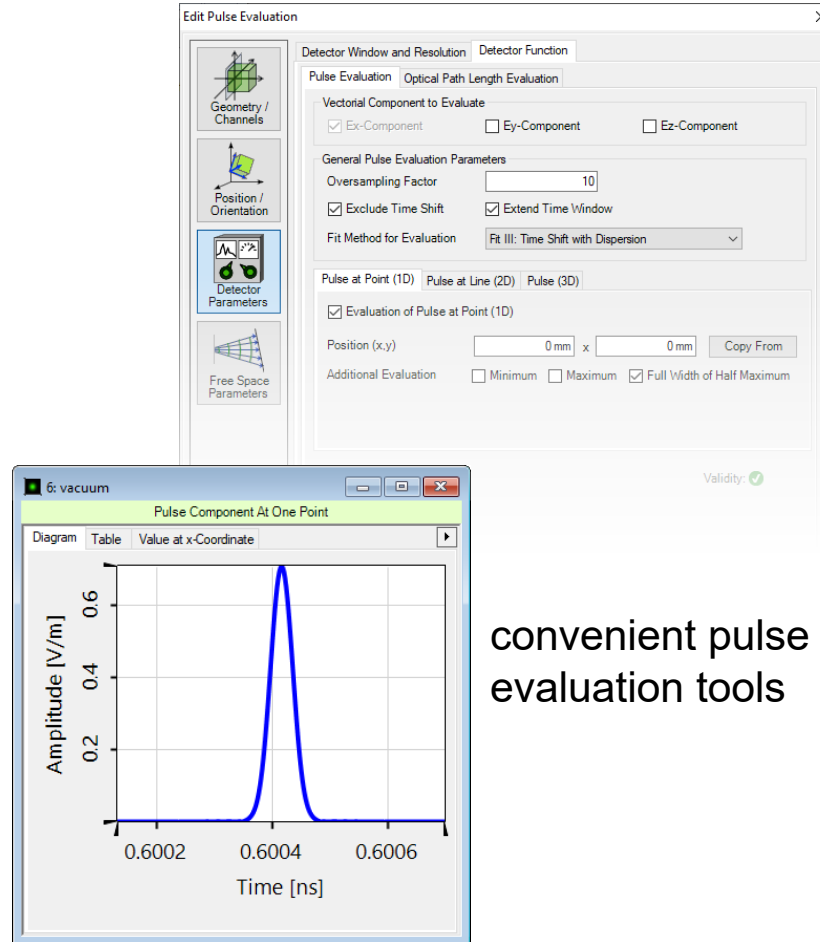




# Peek into VirtualLab Fusion



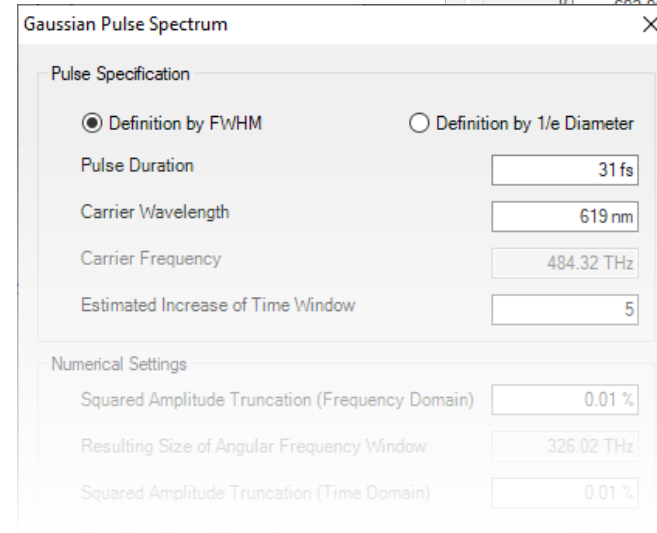
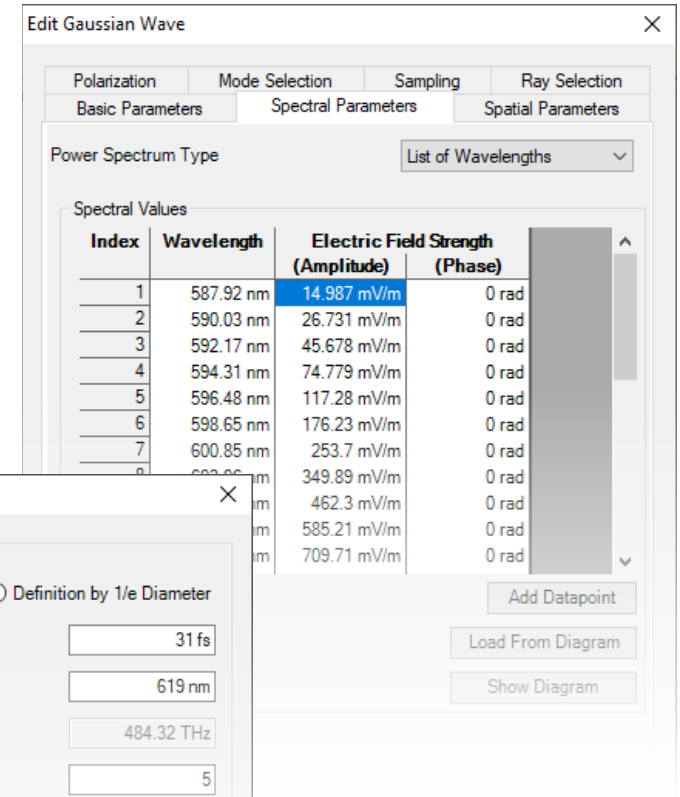
customizable pulse spectrum



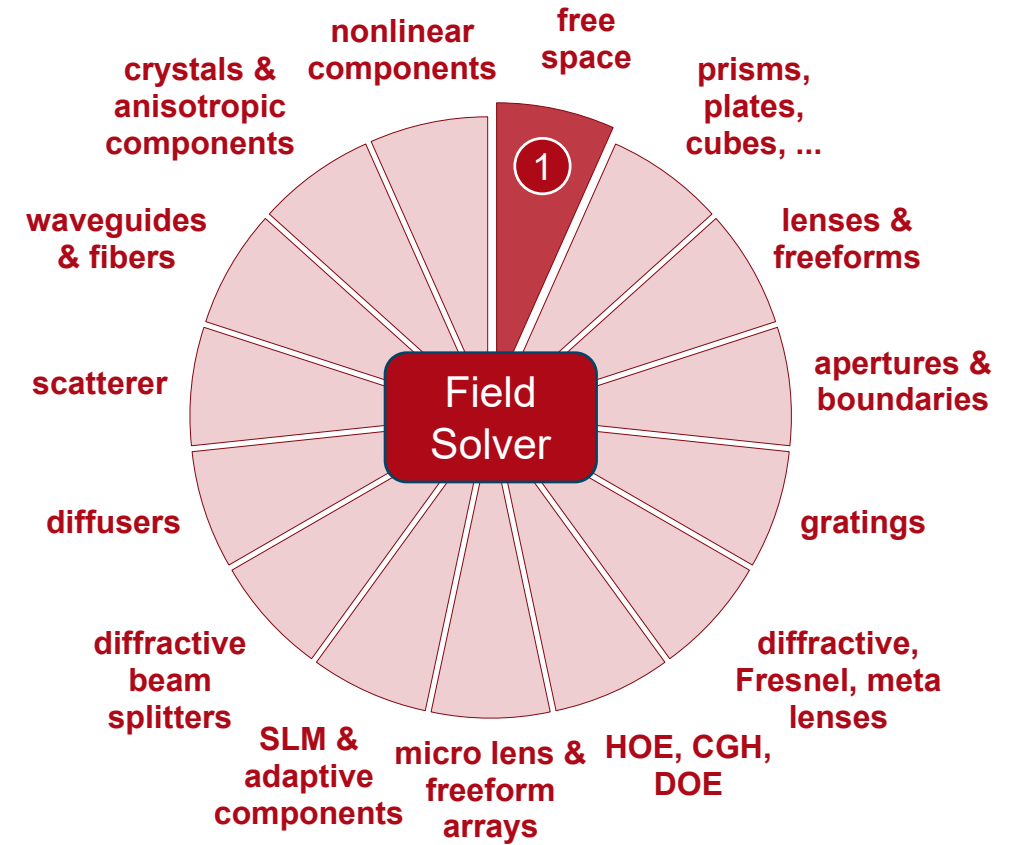
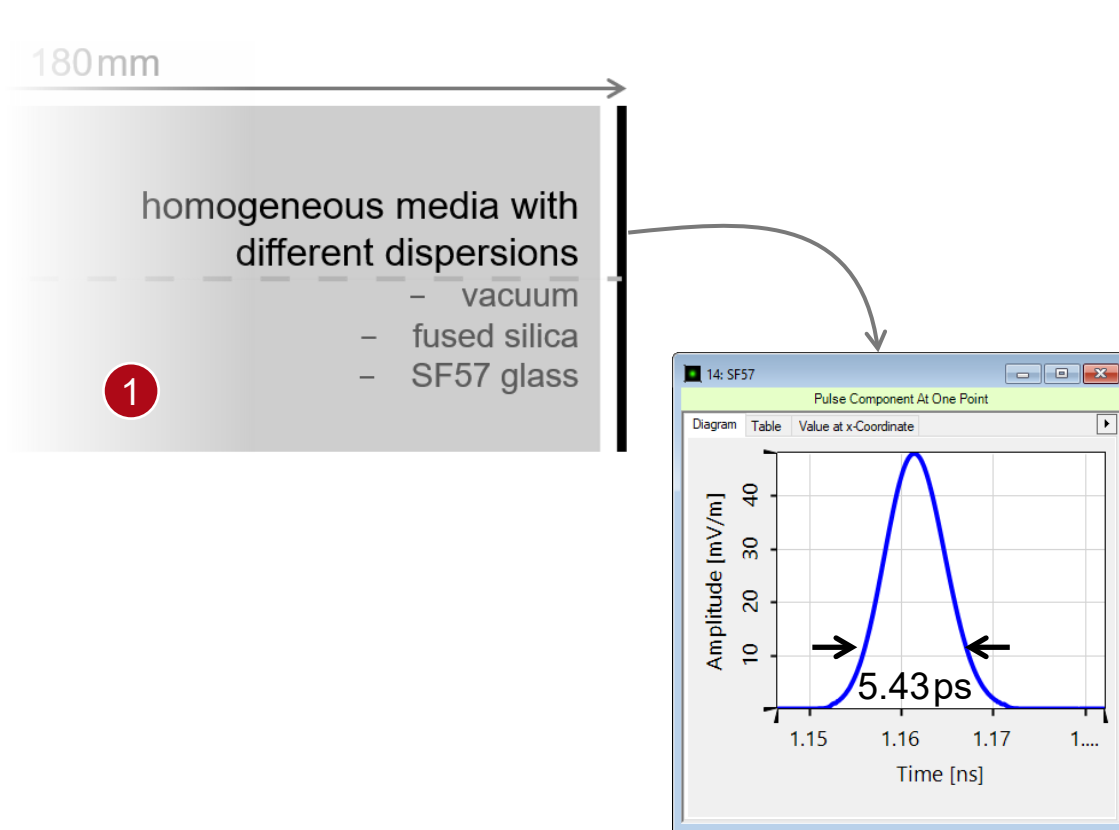
convenient pulse evaluation tools

# Workflow in VirtualLab Fusion

- Set up pulse spectrum
  - [Basic Source Models](#) [Tutorial Video]
- Select material from Material Catalog
  - [Catalogs IV: Materials Catalog](#) [Tutorial Video]
- Select and set up the pulse evaluation detector



# VirtualLab Fusion Technologies



# Document Information

|                                 |  |
|---------------------------------|--|
| title                           | Pulse Broadening in Dispersive Media   |
| document code                   | MISC.0074  |
| version                         | 1.0  |
| toolbox(es)                     | Starter Toolbox  |
| VL version used for simulations | VirtualLab Fusion Spring Release 2019  |
| category                        | Application 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>Grating Stretcher for Ultrashort Pulses</u></a></li></ul> |