

UseCase.0053 (1.0)

### **Pulse Simulation – Temporal Dispersion**

**Keywords:** pulse, bandwidth handling, temporal dispersion

### **Description**

- The use case demonstrates the effect of material dispersion on pulse propagation.
- Specifically it presents the modeling of a pulse through 100 mm in BK7 vs Air.
- The central wavelength of the pulse is 800 nm.
- Different pulse lengths are evaluated: 5, 10, 15 fs.
- Goal:
  - Show effect on pulse by temporal dispersion
  - Different ways for visualization of pulses
  - Smart sampling handling within spectral domain

### **Important Reminder!**

Global Options ×				
Fields and Sampling Operations View Parameters Performance Other Settings				
View Performance				
✓ Disable Light View				
Use Standard Range for Complex Amplitude View				
Maximum Number of Table Cells for Data Arrays 100000				
Array Size and Handling				
Default Precision of Arrays Double Precision V				
Swap Large Field Data on Hard Disc				
Field Size Warnings				
✓ Warn Before Exceeding Specified Limits				
Waming Levels				
✓ Maximum Number of Sampling Points per Field 1E+09				
Maximum Number of Fields Set Members 400				
Guaranteed Amount of Remaining Physical Memory 1 GB				
Multi Core Processing				
✓ Use Multiple Cores Number of Cores To Use				
Use Multiple Cores for Parameter Run Loop				
FFT Algorithm				
Intel Math Kernel Library FFT     O VirtualLab FFT				
Reset All 🚰 🛃 Ok Cancel Help				

- Make sure, that for pulse modeling you have chosen Double Precision BEFORE pulse specification!
- The global options can be edited by the menu item "Global Options" in the file menu.

### **Sample System**



Filename: UseCase.0053\_SampleSystem.lpd

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### Sample System (3D View with Rays)



## **Result Simulation 5 fs Pulse After Source**



- The pulse (1D) is located centered around the time of **0 s**.
- The pulse duration is
   **5.2239 fs** (measured by FWHM detector).
- The time window of the pulse is as large as necessary. The information displayed is numerically correct.

# **Result Simulation 5 fs Pulse in 100 mm Air**



- The pulse (1D) is located centered around the time of **333.66 ps**.
- The pulse duration is
   **5.3376 fs** (measured by FWHM detector).
- The time window of the pulse is as large as necessary. The information displayed is numerically correct.

# **Result Simulation 5 fs Pulse in 100 mm BK7**



- The pulse (1D) is located centered around the time of **509.43 ps**.
- The pulse duration measurement makes no sense.
- The time window of the pulse is too small. The information displayed is numerically not correct.

# Initial Time Window Size?

Gaussian Pulse Spectrum				
Pulse Specification				
Definition by FWHM     O Definition	on by 1/e Diameter	r		
Pulse Duration	5 fs			
Carrier Wavelength	800 nm			
Carrier Frequency	374.74 THz	:		
Estimated Increase of Time Window	100			
Numerical Settings				
Squared Amplitude Truncation (Frequency Domain)	0.01 %			
Resulting Size of Angular Frequency Window	2.0213 PHz			
Squared Amplitude Truncation (Time Domain)	0.01 %			
Resulting Size of Time Window	1.8226 ps			
Resulting Samples	587	J		
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- In this example the resulting pulse has a size of several ps (we will see that soon).
- Preparation in the initial time window would require more than 550 harmonic fields!

Not practical for fast simulation!

## **Smart Inclusion of Material Dispersion**

- VirtualLab offers a smart solution to this problem.
- The pulse evaluation detector provides the change of phase due to material dispersion: phase residual
- That can be calculated for an arbitrarily fine frequency sampling.
- Smart processing allows increase of time window in order to house pulse without increase of initial time window.
- This option can be enabled by selecting extend time window option within the pulse evaluation detector.

<ul> <li>Exclude Time Shift</li> </ul>	Extend Time Window	
Fit Method for Evaluation	Fit III: Time Shift with Dispersi	on 🗸

# **Result Simulation 5 fs Pulse in 100 mm BK7**



- By applying the VirtualLab algorithm to automatically enlarge the time window, the pulse can be reconstructed, without using more frequency samples as before.
- The pulse duration is
   2.3721 ps (measured by FWHM detector).

## **Result Simulation 10 fs Pulse After Source**



- The pulse (1D) is located centered around the time of **0 s**.
- The pulse duration is 10.448 fs (measured by FWHM detector).

# **Result Simulation 10 fs Pulse in 100 mm Air**



- The pulse (1D) is located centered around the time of **333.66 ps**.
- The pulse duration is 10.462 fs (measured by FWHM detector).

# **Result Simulation 10 fs Pulse in 100 mm BK7**



- The pulse (1D) is located centered around the time of **509.33 ps**.
- The pulse duration is
   1.1962 fs (measured by FWHM detector).
- These values can be calculated efficiently by using the algorithm to include the material dispersion smart

## **Result Simulation 15 fs Pulse After Source**



- The pulse (1D) is located centered around the time of **0 s**.
- The pulse duration is 15.672 fs (measured by FWHM detector).

# **Result Simulation 15 fs Pulse in 100 mm Air**



- The pulse (1D) is located centered around the time of **333.66 ps**.
- The pulse duration is
   15.676 fs (measured by FWHM detector).

# **Result Simulation 15 fs Pulse in 100 mm BK7**



- The pulse (1D) is located centered around the time of **509.43 ps**.
- The pulse duration is 800.83 fs (measured by FWHM detector).
- These values can be calculated efficiently by using the algorithm to include the material dispersion smart



- VirtualLab enables the evaluation of pulses using the pulse evaluation detector.
- Material dispersion is included within the simulation of pulses using VirtualLab.
- Temporal dispersion leads to extension of the time window of the propagated pulse. This would typically result in an oversampling in frequency domain.
- With the smart sampling techniques of VirtualLab it is not necessary to trace significantly more frequencies, but to use the optical path length information of the system for a smart interpolation technique.