

#### Visualize Time Dependency of a Propagating Field

#### Abstract



While complex fields and amplitudes are commonly used to represent electromagnetic fields, the actual field propagates along time. This tutorial explores methods for visualizing real-time field propagation in VirtualLab Fusion, demonstrating the concept through two distinct examples.

## **Temporal Sampling of Real Part**

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2D Harmonic Fields with a single subset can have a time dependency added by the *Temporal Sampling of Real Part* functionality under *Manipulations/Miscellaneous*. This function will multiply  $e^{i\omega_0 t}$  onto the data array, with  $\omega_0$  calculated from the temporal period via  $T = 2\pi/\omega_0$  and then extract the real part at  $t = \frac{1}{n}T, \frac{2}{n}T, ..., T$  with n being the parameter defined by *Sampling Count of T*.

If the *Treat the Data as Electric Field* flag is active it additionally multiply the extracted real part by 2.



#### **Create Animation**

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Conversion Settin	gs					×
Bitmap Size						
Aspect Ratio	True to Physical Scale	~				
Width	200 🜩	Height		200 🜩		
Scale Frames to	Common Value Range	~				
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The new document can then by turned into a movie by the *Create Animation* button in *Manipulations*. More information about animation generation under: <u>Overview Image</u>



# Example 1 – Propagation of an Inclined Plane Wave over a Distance of 10 mm

### **Modeling Scenario**



#### Set up Optical System

* 5: Optical Setup View #4 (Example System: Focus)          Default       Image: Components         ideal Components       Plane Wave         Ideal Components       0         Apertures and Lenses       1         Ideal Lens       2:10 mm         Spherical Phase       2:10 mm         Stop       Zernike & Seidel Aberrations	ersal Detector 600 2 10 mm Detector Window (k-Domain) Field Quantities Select Field Data Which Is Provided to Detector Add-Ons Select Field Data Which Is Provided to Detector Add-Ons Detector Window (x-Domain) Detector Window (x-Domain) Coordinate Systems	cor Window (k-Domain) Gridless Data Add-ons Field Quantities Detector Window (x-Domain) Vindow Centered Around O Detector Position Center of Field Mode
Set up the detector so that it only detects a single component and is one dimensional. Ensure sufficient sampling points to avoid Moiré effects.	Josethis   Josethis   Josethis   Josethis   Josethis   Domain   Space (x-Domain)   Configure Field Data Visualization by Electromagnetic Field   Quantity Add-On   Apply Paraxial Approximation for Component Calculation?   Yes   No   Sum Mutually Coherent Modes?   Propagation     Image: the space pagation     Image: the space pagation     Components     Ex   Ey   Ey   Ex   Ey   Ey <td>dow Position 0 mm × 0 mm Window Size Field Data (Per Mode) ● Manual Setting (All Modes) Iow Size 20 µm × 1 nm Grid Resolution Field Data (Per Mode) ● Manual Setting (All Modes) iet Grid Period ● Set Grid Points Grid Points User-Defined ✓ 501 ÷ 1 ÷</td>	dow Position 0 mm × 0 mm Window Size Field Data (Per Mode) ● Manual Setting (All Modes) Iow Size 20 µm × 1 nm Grid Resolution Field Data (Per Mode) ● Manual Setting (All Modes) iet Grid Period ● Set Grid Points Grid Points User-Defined ✓ 501 ÷ 1 ÷
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#### **Perform a Parameter Run**

131: Parameter Run         Parameter Specification         Set up the parameter(s) to be varied.		Perform a <i>Paran</i> <i>Before</i> parameter and 10.01 mm. Endirection through	<i>meter Run</i> , er from the Ensure suf h the <i>Step</i> s	, vary dete ficien s colu	ing the <i>l</i> ctor bet t sampli ımn.	Distance ween 9. ng poin <sup>:</sup>	€ 99mm ts in z-
Specifying how the parameters which shall be varied as well as the resulting humber of iterations, several modes       Usage Mode       Standard       Filter by       X       Show Only       1     2 *       Parameter     Vary       From     To       Steps     Step Size       Original Value	/ Varied Parameters	J					
Image: State of the state	10 * 131: Parameter Ru	1				F	- • •
	Results Start the parameter run	and analyze its results				/	
< Back Nex	Go!	ted Results for Next Run				Local Execution (Parallel Iteration	ons: 8)
					Itera	ition Step	
	Detector	Subdetector	Combined Output	198	199	200	201
	Varied Parameters	Distance Before ("Universal	Data Array	)97 mm	10.0098 mm	10.0099 mm	10.01 mm
Extract the output by double-clicking the <i>Universal Detector</i> – row. Ensure that the <i>Combined Output</i> is set to 2D Data Array.	Tuniversal Detector" (4	Selection	2D Data Array 🗸	a Array	1D Data Array Fil < Back	1D Data Array	1D Data Array

### **Temporal Sampling & Movie Generation**

#### result of the Parameter Run





Follow the workflow demonstrated on pages 3 and 4 to create a movie of the time dependent propagation of the field through the focal area.



#### **Example 2 – Field Inside Photonic Lattices**

### **Modeling Scenario**

#### source

- ideal plane wave
- wavelength: varies between 400nm and 2000nm
- linearly polarized (TE or TM depending on configuration)

#### photonic lattices

- 1D lamellar grating
- invariant in y-direction
- refractive index of cylinders: 3.5
- 3 configurations with different period  $\Lambda$ : 500 nm, 700 nm and 1100nm

Reference: Yeong Hwan Ko, Nasrin Razmjooei, Hafez Hemmati, and Robert Magnusson, "Perfectly-reflecting guided-mode-resonant photonic lattices possessing Mie modal memory," Opt. Express 29, 26971-26982 (2021)



#### **Scenario**



### **Field Inside Analyzer: FMM**



The sample files for this task can be found in the following use case: <u>Resonant Photonic Lattices</u>

For our demonstration we want to setup the *Field Inside Component Analyzer: FMM* in a way that it only detects one component and that efficient sampling is ensured. Then we simulate the system using the analyzer as *Simulation Engine*.

Ex-Component	Ey-Component	Ez-Component
Hx-Component	Hy-Component	Hz-Component
Evaluated Modes		
Forward Propagat	ing 🛛 🗹 B	ackward Propagating
x-z-Region		
Number of Periods	1	
z-Range	Whole Component $\sim$	
Sampling	<b>-</b>	<b>-</b>
Sampling Points	x-Direction	z-Direction
Sampling Distance	2	



## **Temporal Sampling & Movie Generation**

#### result of the Field Inside generated movie Analyzer: FMM on Related Miscellaneous Create Create Dim Animation Harmonic Field Red rations -137: Animation 🛃 150: "Field Inside Component Analyzer:... 📼 📼 🎫 M Savitzky-Golay Filter Cr Create aneous Numerical Data Array (Equidistant) Temporal Sampling of Real Part Animation Harmo Diagram Table Value at (x,y) Quantization Amplitude of "Ey" [V/m] Hard Ouantization 3.68... Soft Quantization Floyd-Steinberg Quantization 0.5 Follow the workflow demonstrated on page 3 and 4 to create a movie of the × [hm] 0 1.84... time dependant propagation of the field through the focal area. 0.5 0.00... 5 -0.6 -0.4 -0.2 z [µm] H 4 II F H Frame

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further reading	<ul> <li><u>Overview Image</u></li> <li><u>Resonant Photonic Lattices</u></li> </ul>

#### **Marketing Picture**

