

Wavefront Error Detector

Abstract



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Wavefront Error [Wavelength]

Wavefront error is defined as the difference between the reference wavefront phase, which is a constant phase or spherical phase, and the detected wavefront phase of one optical system. It is a very important criterion for the quality of the system, which can be used as merit functions for parametric optimization. In VirtualLab Fusion, users can detect such errors by using specific detector. This use case shows how to handle a wavefront error detector in VirtualLab Fusion.

Modeling Task

how to handle a Wavefront Error Detector. ۲



Wavefront phase: The phase distribution in detector plane, which results in one wavefront. Wavefront error: Deviation between detected and reference wavefront phase.

Sub - Detector

Peak-to-Valley Wavefront Error [λ] RMS [\] of Wavefront Error

Peak-to-Valley and RMS of wavefront error

Result

19.397

5.5807

5.2113

4,4873

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System Construction

For illustration purposes, we work with an optical system, which includes a plane wave, an aspherical lens and the wavefront error detector.



System Construction

For illustration purposes, we work with an optical system, which includes a plane wave, an aspherical lens and the wavefront error detector.



Edit Wavefront Erro	Detector Window and Resolution Detector	ector Function	×
	Reference Wavefront		
Geometry / Channels Position / Orientation	 Constant Phase 	○ Spherical Phase	
00	Output		
Detector Parameters	🗹 Data Arrays		
	Peak-to-Valley		
	RMS		

Detector Function: Reference Wavefront

The reference wavefront can be

- Constant Phase results in planar reference wavefront.
- Spherical Phase results in spherical reference wavefront, whose radius and origin can be set by the user or optimized by VirtualLab.

Detector Window and Resolution Detector Function Reference Wavefront Image: Constant Phase Image: Constant Phase) Spherical Phase				
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	Fit M	lethod Optimize Optimize User-Det User-Det	d Radius and Origin d Radius and Origin fined Radius and Orig fined Radius at Optimi	in ized Origin	

Results: Constant vs Spherical Reference

• Simulation is demonstrated using Ray Tracing.

Detector Wind	ow and Resolution	Detector Function				
Reference	Wavefront					
Const	ant Phase	ar Tanan Sura (Data) a	O Spherical Phase	e	NH-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1	
	Output					
Reches Barres Brong	Data Array	6				
	Peak-to-Va	lley				
	RMS					
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Detector Window an	d Resolution Detector Function		
Reference Wave	front		
Constant Ph	lase	Spherical Phase	
Fit Method	Optimized Radius and Origin	~	
·	Output		
الموداديرين الراجري الر	🗸 Data Arrays		
	Peak-to-Valley		
	RMS		
	Phase Radius & Origin	والمهر والمالي الماركي والمراجع والمراجع المراجع المراجع والمراجع والمراجع والمراجع والمراجع والمراجع والمراجع	المداخلين التوين عدور ، وزوع عرف دونو الارام ورد.



Data Arrays give the distribution of wavefront error in the detector plane.

Phase Radius & Origin gives the position of

spherical center of the reference spherical wavefront optimized by VirtualLab



Simulation Results: Const. v.s. Spherical

- Simulation is demonstrated using Ray Tracing.
- In this example, the detected wavefront should be spherical. Therefore, when we use Spherical Phase as reference, the wavefront error is smaller (~20λ).





Data Arrays give the distribution of wavefront — error in the detector plane.

Phase Radius & Origin gives the position of spherical center of the reference spherical wavefront optimized by VirtualLab



Spherical Phase: Fit Method

- Fit Method
 - Optimized Radius and Origin: The reference spherical wavefront is optimized/fitted from detected wavefront. The position of spherical center is shown when Phase Radius & Origin is checked.

Detector Window and Resolution	Detector Function	
Reference Wavefront		
O Constant Phase	Spherical Ph	ase
Fit Method Optimiz Optimiz User-De User-De	ed Radius and Origin ed Radius and Origin fined Radius and Origin fined Radius at Optimized Origin	~
Output		
🗹 Data Arrays		
Peak-to-Valley		
RMS		
Phase Radius & Origin		



wavefront error

Spherical Phase: Fit Method

- Fit Method
 - Optimized Radius and Origin
 - User-Defined Radius and Origin: The position of sperical center of the reference wavefront, i.e. radius and x,y coordinates are given by the user.



D	etector Window and Re	esolution Detector Function
	Reference Wavefront	
	Constant Phase	Spherical Phase
	Fit Method	User-Defined Radius and Origin $\qquad \checkmark$
	Phase Radius	-30.45 mm
	Origin (x, y)	0 m × 0 m
	Dutput	
	Data Arrays	
/	Peak-to-Valley	
	RMS	

wavefront error



Spherical Phase: Fit Method

- Fit Method
 - Optimized Radius and Origin
 - User-Defined Radius and Origin
 - User-Defined Radius at Optimized Origin: x,y coordinates are optimized by the VirtualLab.



D	etector Window and R	lesolution	Detector Function		
	Reference Wavefrom	nt			
	O Constant Phase	e		Spherical Phase	
	Fit Method	User-De	fined Radius at Opti	mized Origin V	
	Phase Radius		-30.45 mm		
	Origin (x, y)	◯ Defir	ned by Centroid	Defined by Chief Ray	
	Dutput				
	🗹 Data Arrays				
/	Peak-to-Valley				
	RMS				
	Origin				

wavefront error



Detector Function: Output

- Output:
 - Data Arrays give the distribution of wavefront error in the detector plane.



Detector Window and Resolution Detector Function Reference Wavefront Constant Phase Spherical Phase Fit Method Optimized Radius and Origin \sim Output Data Arrays Peak-to-Valley RMS Weighting None None Phase Radius & Origin by Amplitude by Squared Amplitude

Detector Function: Output

- Output:
 - Data Arrays
 - *Peak-to-Valley*: maximum value minus minimum value of wavefront error.



De	etector Window and Re	esolution	Detector Function			
	Reference Wavefront	t				
	O Constant Phase	;		Spherical I	Phase	
	Fit Method	Optimized	d Radius and Origin		~	
	Output					
	🗹 Data Arrays					
	Peak-to-Valley					
	RMS \	Weighting	None	\sim		
	Phase Radius &	Origin	None by Amplitude			
			by Squared Amplit	ude		

Sub - Detector	Result
Peak-to-Valley Wavefront Error [λ]	19.397

Detector Function: Output

- Output:
 - Data Arrays
 - Peak-to-Valley
 - RMS: The roof mean square of the wavefront error. User can either apply a Weighting by Amplitude or by Squared Amplitude to avoid phase from almost dark regions.

Weighting	RMS [λ]
None	5.5824
by Amplitude	5.5816
by Squ. Ampl.	5.5807

Detector Window and Resolution	Detector Function
Reference Wavefront	
O Constant Phase	Spherical Phase
Fit Method Optimiz	ed Radius and Origin V
Output	
🗹 Data Arrays	
Peak-to-Valley	
RMS Weightin	Ig None ~
✓ Phase Radius & Origin	None by Amplitude
	by Squared Amplitude

small differences due to almost uniform amplitude at detector position

Document Information

title	Wavefront Error Detector
version	1.0
VL version used for simulations	7.0.3.4
category	Feature Use Case