

Feature.0029

### **Wavefront Error Detector**

One very important criteria for the quality of imagine system is the wavefront error. We will show how wavefront errors can be measured using VirtualLab.

### **About This Use Case**

- The following toolbox is required
  - Starter toolbox
- This use case was produced with VirtualLab Fusion (Build 7.0.0.35).
- Get your free Trial Version <u>here</u>!

### This Use Case Shows...

how to handle a Wavefront Error Detector.  $\bullet$ 



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

4,4873



Peak-to-Valley and RMS of wavefront error

Result

19.397

5.5807

## **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 Fun	ction	<
Geometry / Channels	Constant Phase	O Spherical Phase	
Detector Parameters	Output 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 Reference Wavefront © Constant Phase	Detector Function				
		Detector Window and Reso	tion Detector Function		
				Calculation Rhouse	
, , , , , , , , , , , , , , , , , , ,	an de antille de source de la construir de la construit general de la construit general de la construit general		inited Dedition and Origin	Spherical Phase	7
		Fit Method U	imized Radius and Origin imized Radius and Origin er-Defined Radius and O er-Defined Radius at Opt	n National rigin imized Origin	
		رهر الوغر فرحندو ورغر منظر وورغرغ المصحر فرريا	مەسە قەلىر 5.5 كىر 5. تەسەر قرىز مەكىر بول	موادة فرد الرواد كركو والربور الري فرقندان	ر مر امو دو و الدو مدور دادمو م

## **Results: Constant vs Spherical Reference**

• Simulation is demonstrated using Ray Tracing.

Detector Windo	w and Resolution	Detector Function			
Reference \     Onsta	Navefront ant Phase		O Spherical Phase	e	
 Reception	Output	sers	ha bhann ba ba fa fi	1-9954-516-5599- 1-9954-516-5599-	1-5- <sup>3</sup> -1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1
	Peak-to-Va	lley			
,	سو دان دون ای دانو ساوه	والاشافرو فروشو مومو مواطع ال	ويتوجو ووافر ووالمتوقيق	ىلى الىروى كەرىيە بىلى بىرى بىرى بىرى	ورر وموجر مدومور موروع

Detector Window an	d Resolution Detector Function
Reference Wave	iront
O Constant Ph	ase
Fit Method	Optimized Radius and Origin
ľ.	Output
سورادو ورو سو سودو ور اس	🔽 Data Arrays
	Peak-to-Valley
	RMS
,	



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 Phase	
Fit Method Optimize Optimize User-Del User-Del	d Radius and Origin d Radius and Origin fined Radius and Orig fined Radius at Optin	çin nized Origin	
Output			
🗹 Data Arrays			
Peak-to-Valley			
RMS			
✓ Phase Radius & Origin			

wavefront error



### phase radius and origin

### www.wyrowski-photonics.com

# **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.



De	etector Window and Re	solution Detector Function
	Reference Wavefront	
	Constant Phase	Spherical Phase
	Fit Method	User-Defined Radius and Origin
	Phase Radius	-30.45 mm
	Origin (x, y)	0 m × 0 m
	Output	
	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	esolution	Detector Function	
	Reference Wavefrom	ıt		
	O Constant Phase	е		Spherical Phase
	Fit Method	User-De	fined Radius at Opti	mized Origin 🗸 🗸
	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		
O Constant Phase	Spherical Phase	
Fit Method Optimiz	zed Radius and Origin V	
Output ☑ Data Arrays		
Peak-to-Valley		
RMS Weightin	1g None ~	
✓ Phase Radius & Origin	None by Amplitude by Squared Amplitude	

### www.wyrowski-photonics.com

## **Detector Function: Output**

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



Detector Window and Resolution	n Detector Function
Reference Wavefront	
O Constant Phase	Spherical Phase
Fit Method Optim	ized Radius and Origin V
Output	
🔽 Data Arrays	
Peak-to-Valley	
RMS Weight	ing None 🗸
✓ Phase Radius & Origin	None by Amplitude
	by Squared Amplitude

## **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 Reso	lution Detector Function
Reference Wavefront	
O Constant Phase	Spherical Phase
Fit Method C	ptimized Radius and Origin V
Output	
Peak-to-Valley	
RMS We	ighting None V
✓ Phase Radius & Or	igin by Amplitude by Squared Amplitude

small differences due to almost uniform amplitude at detector position

### **Document & Technical Info**

code	Feature.0028
version of document	1.0
title	Wavefront Error Detector
category	Tools & Handling
author	Huiying Zhong(LightTrans)
used VL version	7.0.0.35
last modified on	August 28, 2017