WYROWSKI PHOTONICS

Feature.0029

# Wavefront Error Detector

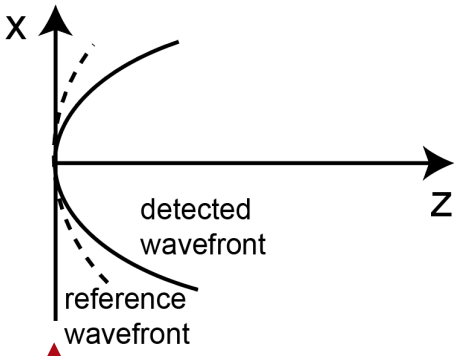
One very important criteria for the quality of imagine system is the wavefront error. We will show how wavefront errors can be measured using VirtualLab.

# About This Use Case

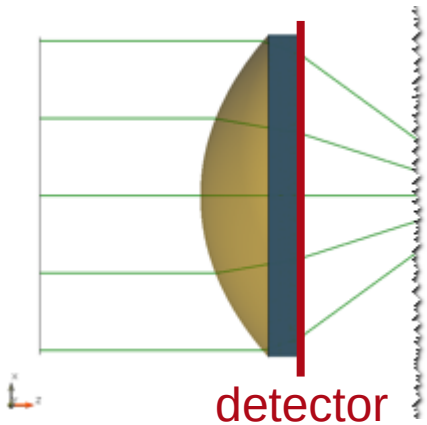
- The following toolbox is required
  - Starter toolbox
- This use case was produced with VirtualLab Fusion (Build 7.0.0.35).
- Get your free Trial Version here!

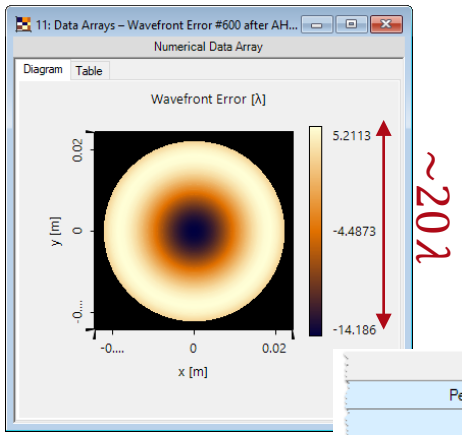
# This Use Case Shows...

- how to handle a Wavefront Error Detector.




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



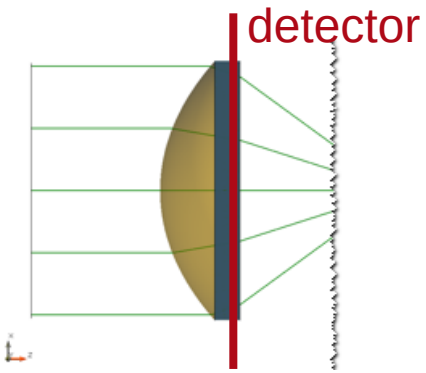

wavefront error
(Data Arrays)

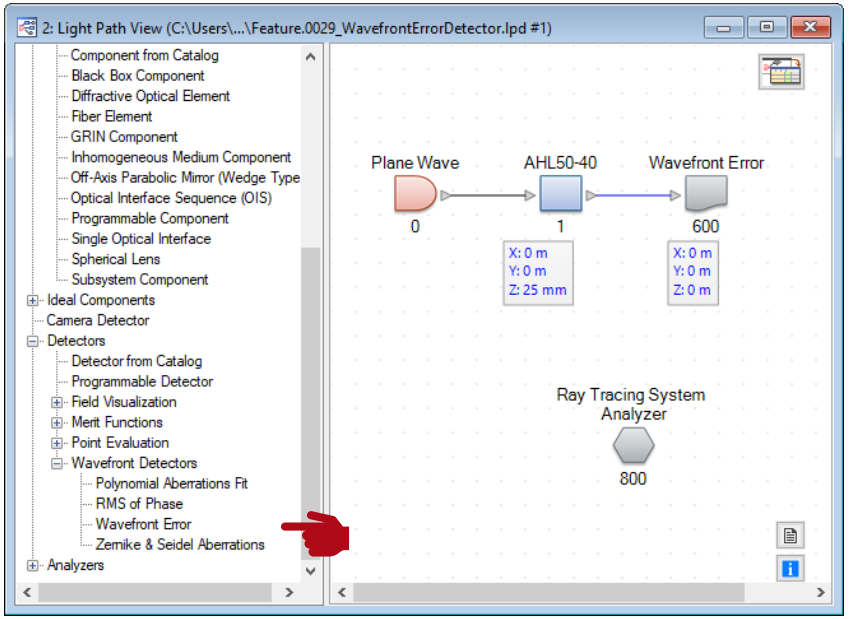
Peak-to-Valley and RMS of wavefront error

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

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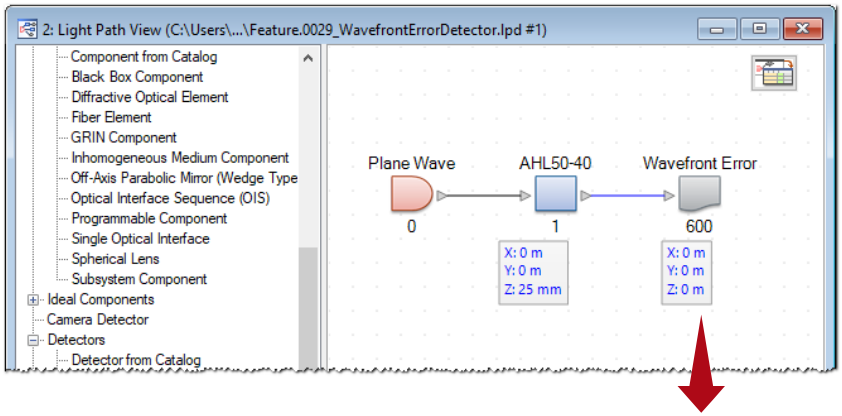
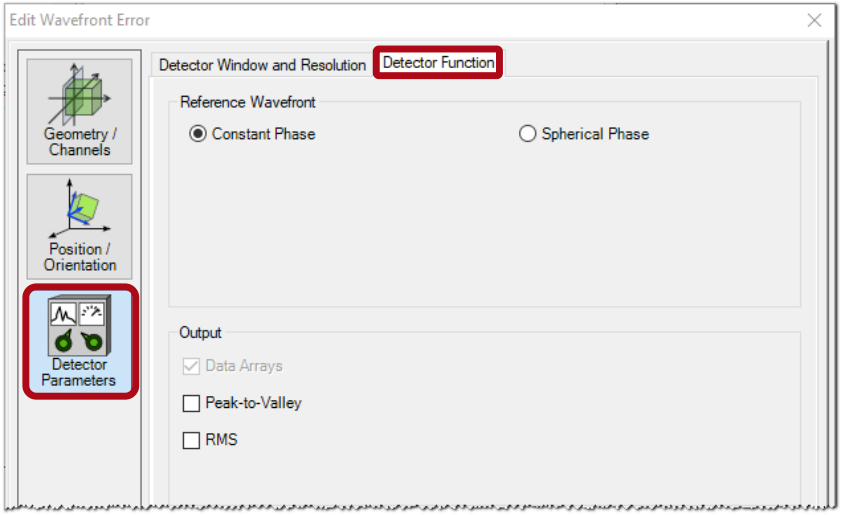
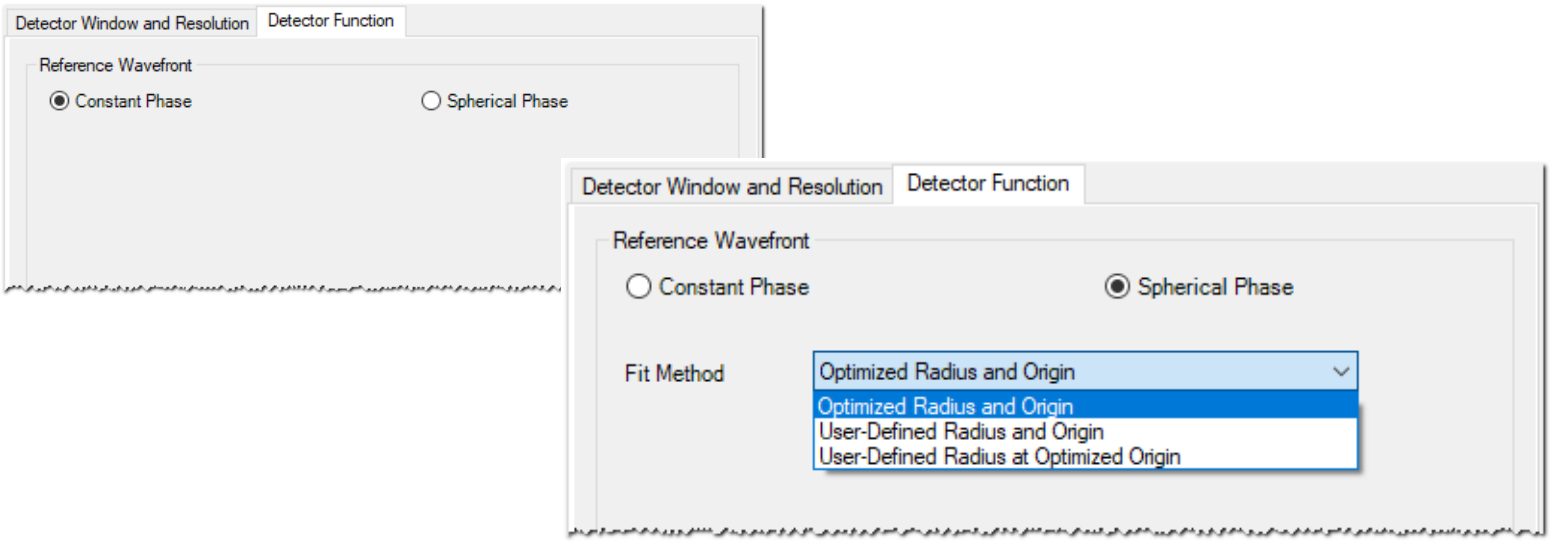


# Detector Function: Reference Wavefront

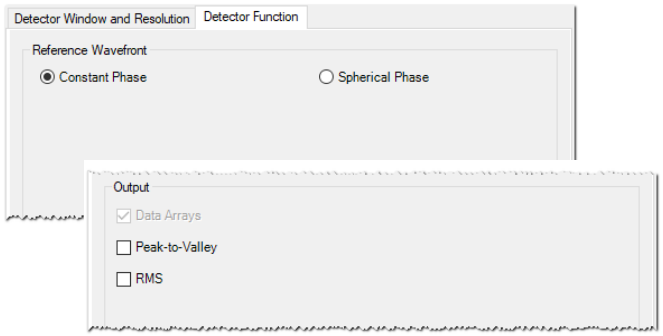
The reference wavefront can be

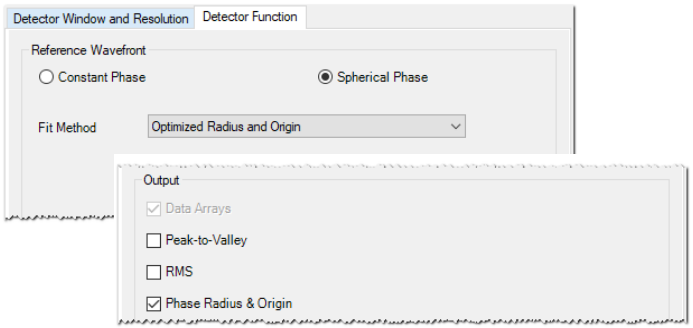
- *Constant Phase* results in planar reference wavefront.
- *Spherical Phase* results in spherical reference wavefront, whose radius and origin can be set by the user or optimized by VirtualLab.

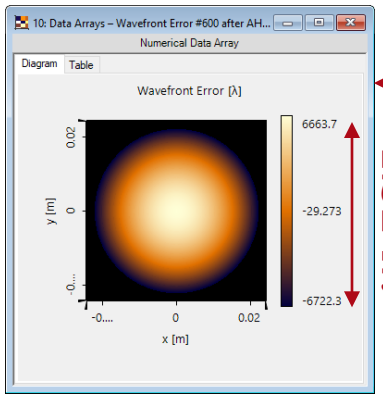


# Results: Constant vs Spherical Reference

- Simulation is demonstrated using Ray Tracing.



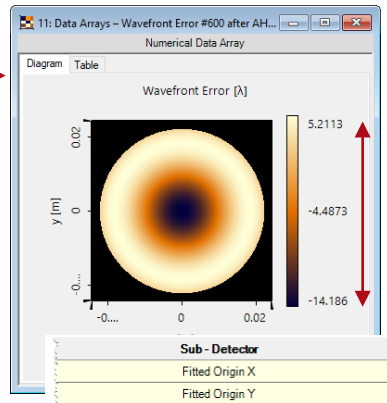




~1.3E4λ

*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

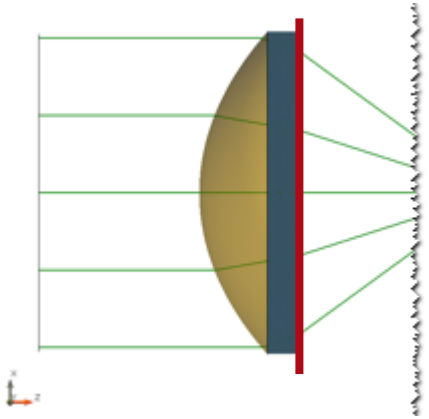


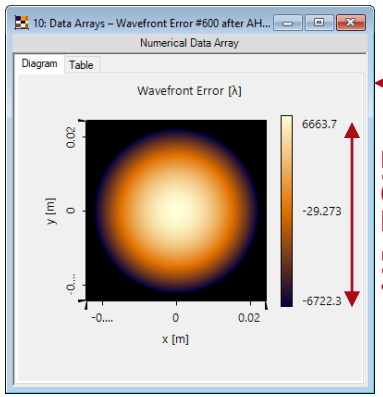

~20λ

| Sub - Detector | Result |
|---|---|
| Fitted Origin X | 0 m |
| Fitted Origin Y | 0 m |
| Fitted Phase Radius | -30.39 mm |

# 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 ($\sim 20\lambda$).

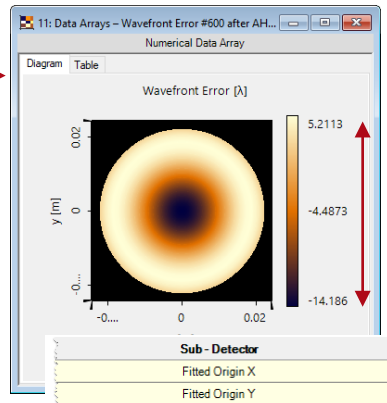





$\sim 1.3E4\lambda$

*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

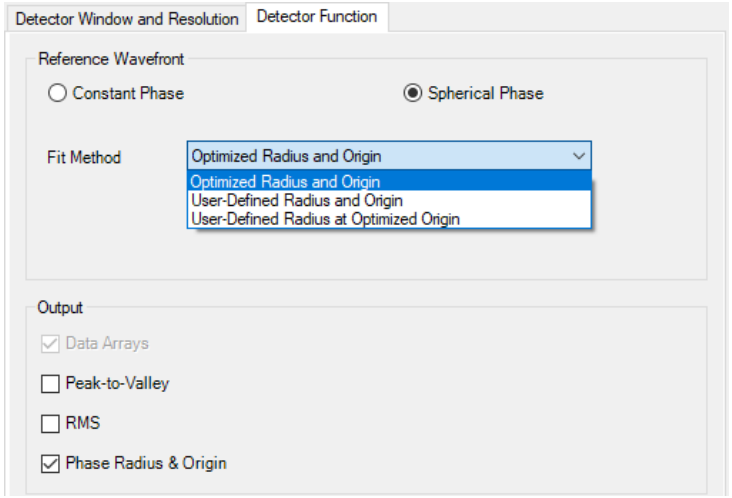


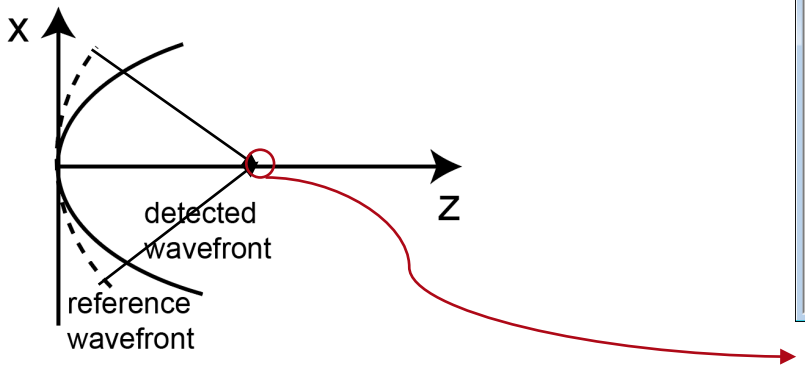

$\sim 20\lambda$

| Sub - Detector | Result |
|---|---|
| Fitted Origin X | 0 m |
| Fitted Origin Y | 0 m |
| Fitted Phase Radius | -30.39 mm |

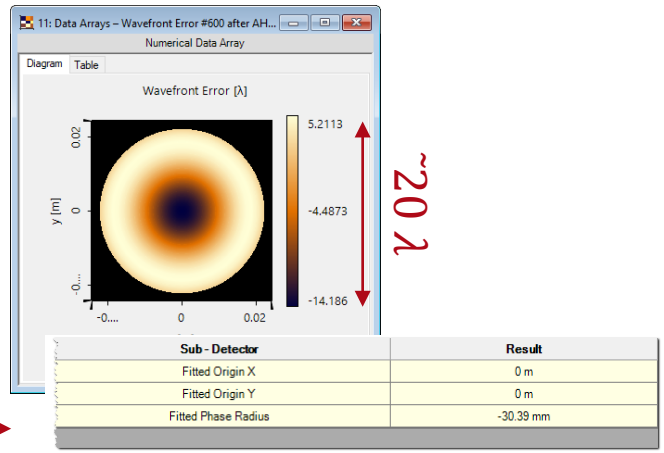
# Spherical Phase: Fit Method

- 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.



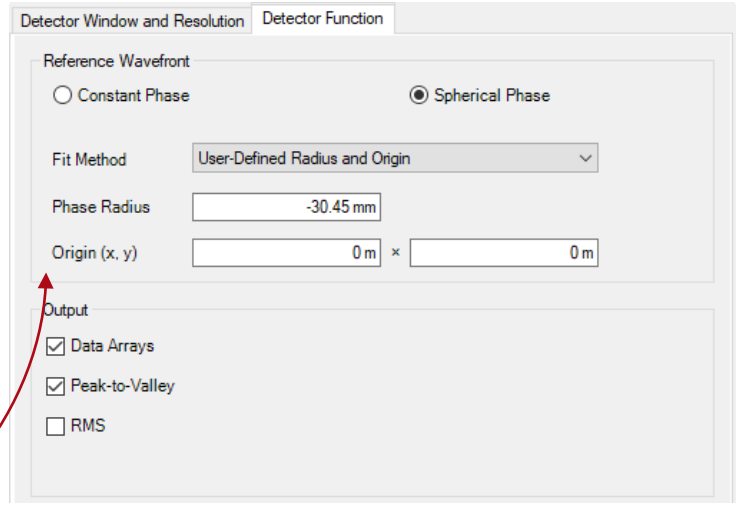

wavefront error

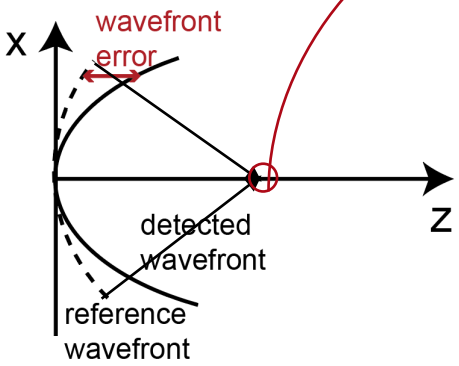



phase radius and origin

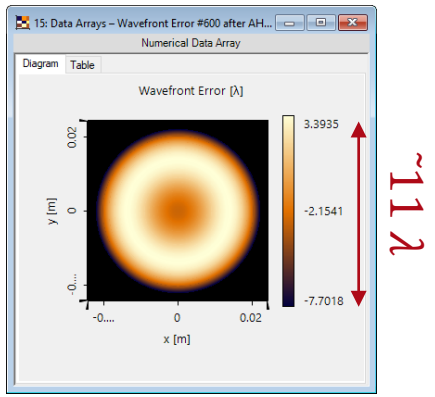
# Spherical Phase: Fit Method

- 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.



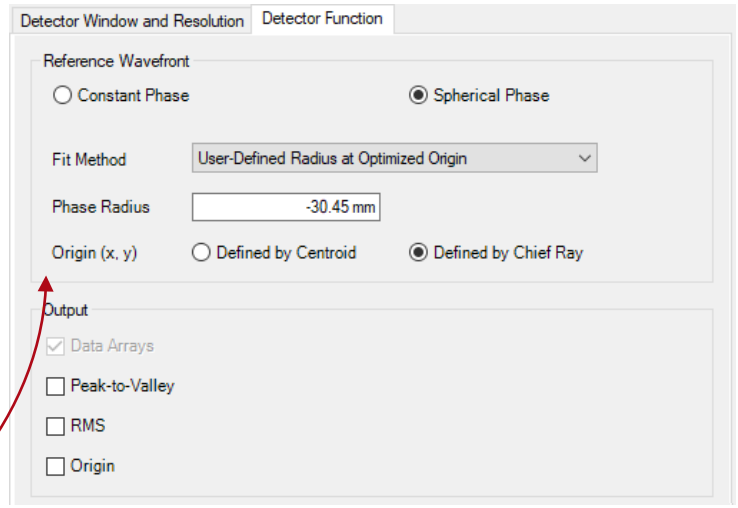



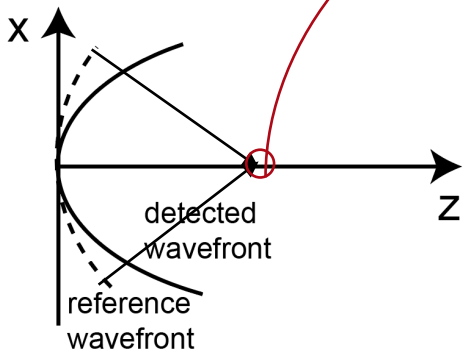

wavefront error



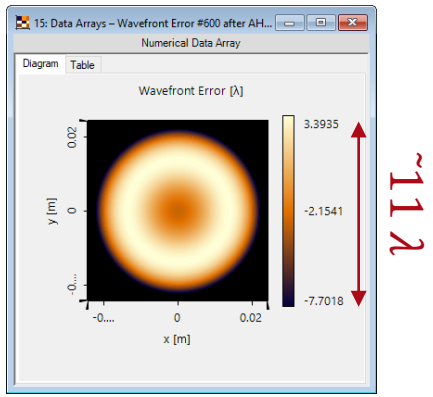
# Spherical Phase: Fit Method

- 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.




wavefront error

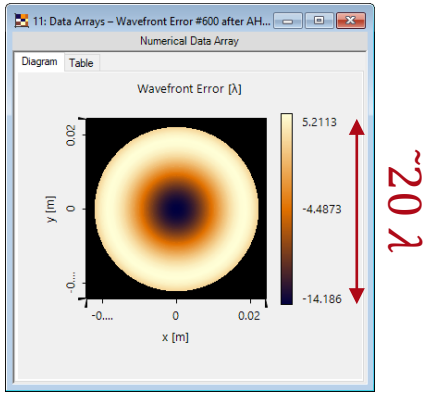



~11 λ

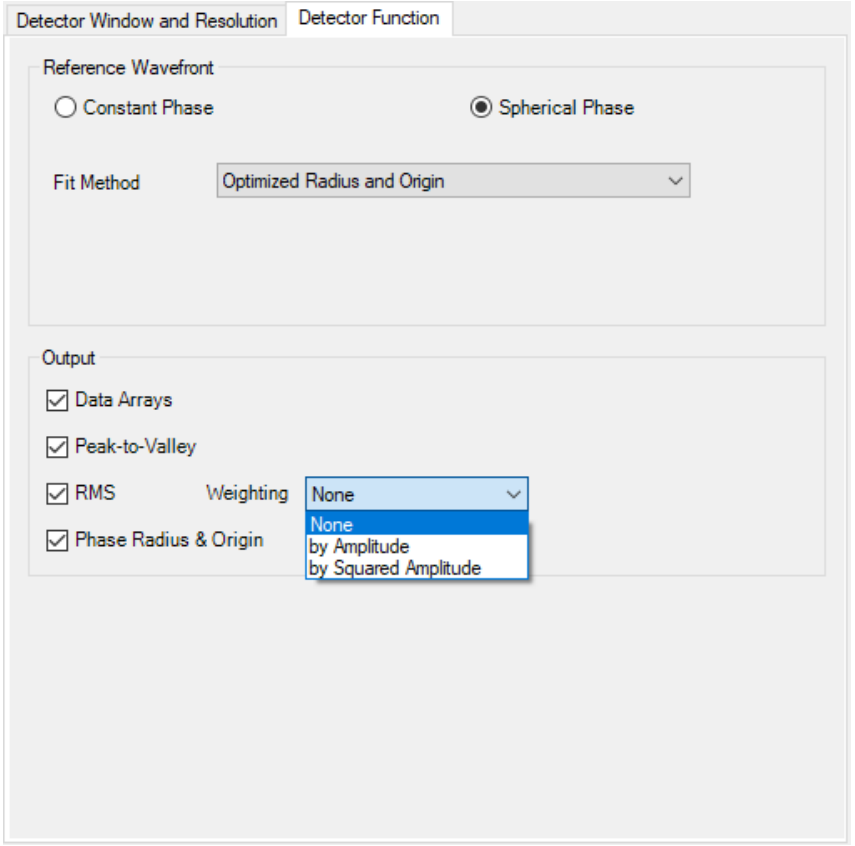
# Detector Function: Output

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

wavefront error



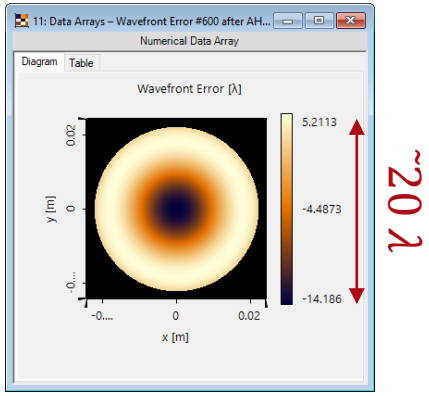

~20 λ

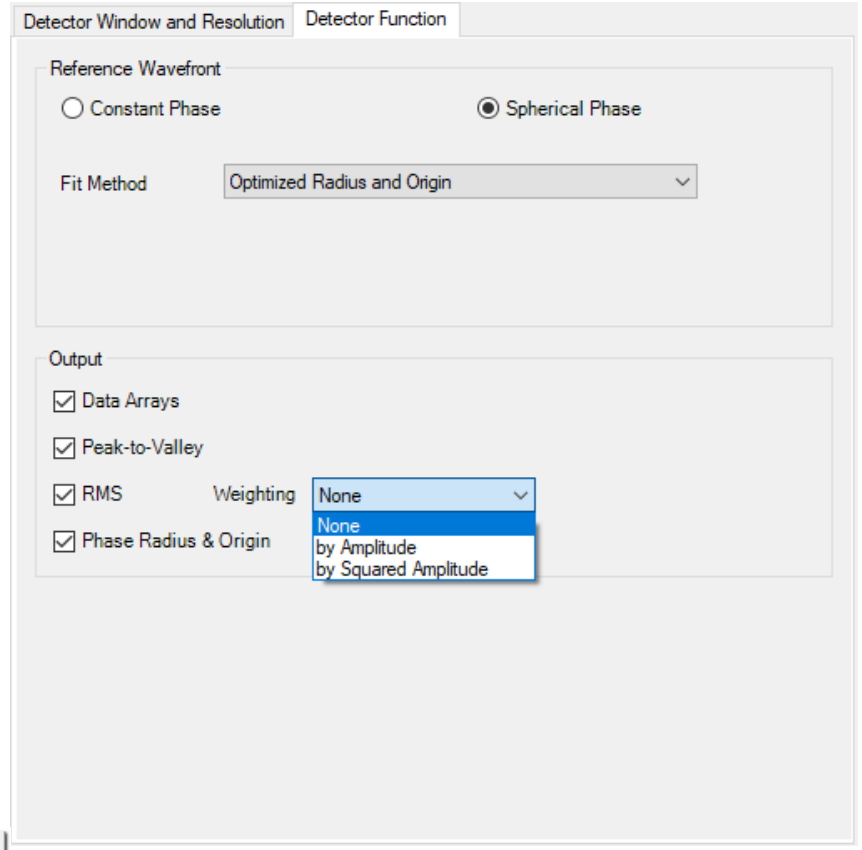


# Detector Function: Output

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

wavefront error

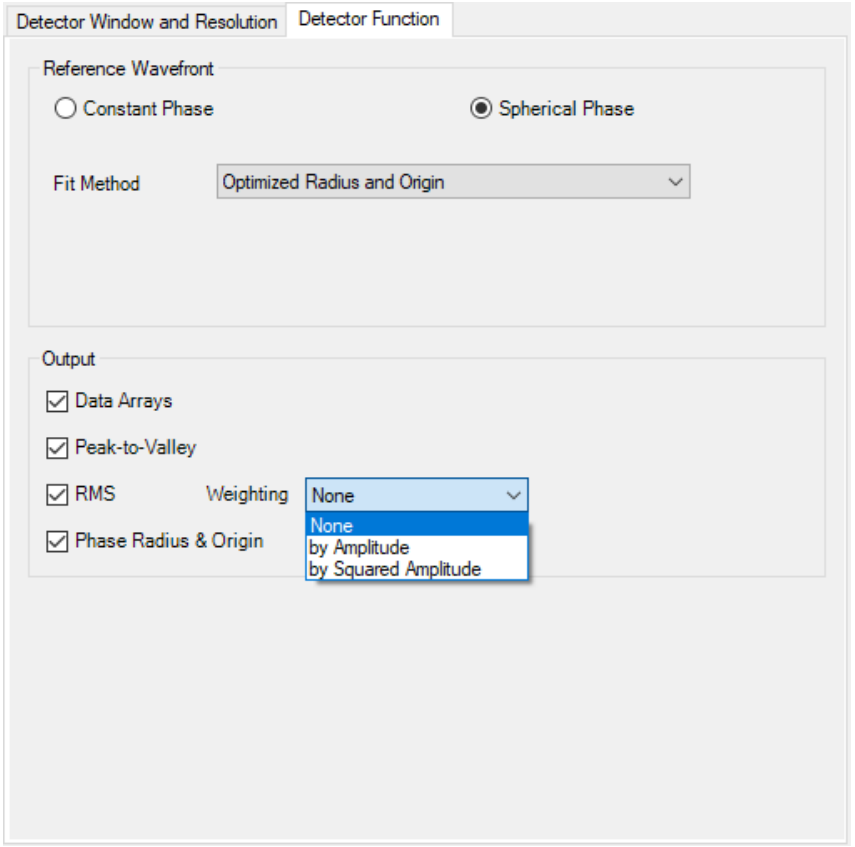



| Sub - Detector | Result |
|---|---|
| Peak-to-Valley Wavefront Error [λ] | 19.397 |

# 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 [$\lambda$] |
|---|---|
| None | 5.5824 |
| by Amplitude | 5.5816 |
| by Squ. Ampl. | 5.5807 |

*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 |