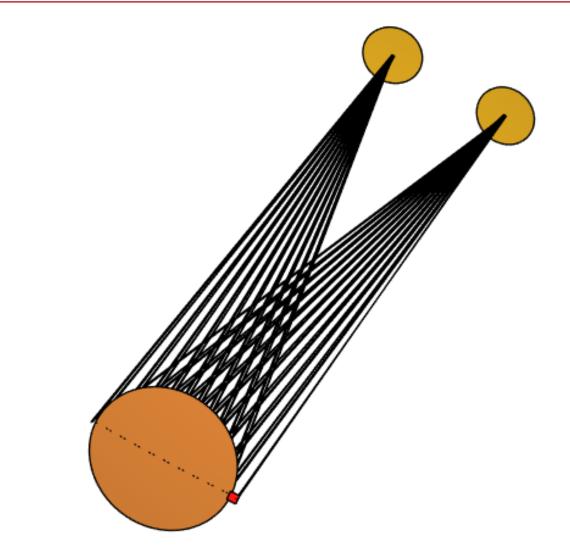


Modeling of Multi-Pass White Cell

Abstract



Multi-pass cells are widely used in gas spectroscopy, offering a compact design that achieves extended optical path lengths through multiple internal reflections. VirtualLab Fusion's nonsequential simulation engine streamlines this process by automatically finding and handling all necessary propagation steps, enabling optical engineers to focus on system design. This Use Case demonstrates this capability in the context of CO_2 absorption measurement.

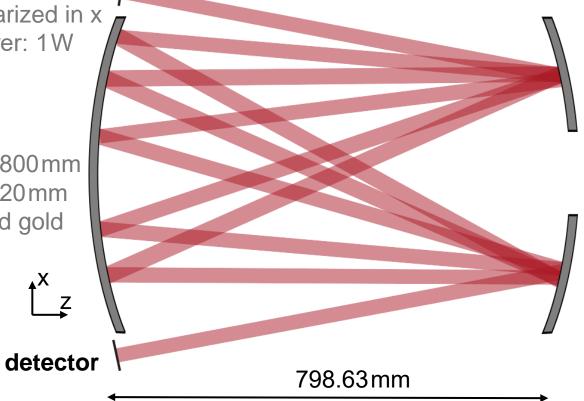
Modeling Scenario

plane wave

- wavelength: 900nm
- linearly polarized in x
- source power: 1W

spherical mirror #2

- radius of curvature: -800mm
- diameter: 120mm×120mm
- coating: HR protected gold



spherical mirror #1

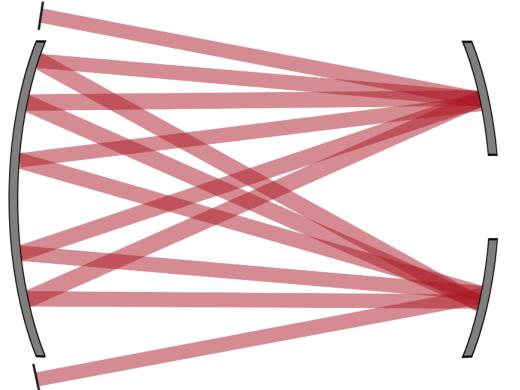
- radius of curvature: -800mm
- diameter: 47.5mm×47.5mm
- coating: protected gold

spherical mirror #3

- radius of curvature: -800mm
- diameter: 47.5mm×47.5mm
- coating: HR protected gold

system parameters: Yin Guo and Liqun Sun, "Biconic White multipass cell design based on a skew ray-tracing model," Appl. Opt. 56, 7586-7595 (2017).

Modeling Tasks



Tasks:

- calculate the total beam path
- calculate irradiance and radiant flux when the cell is filled with:
 - air
 - CO₂* (n=1.00044, absorption coefficient 0.1 1/m)

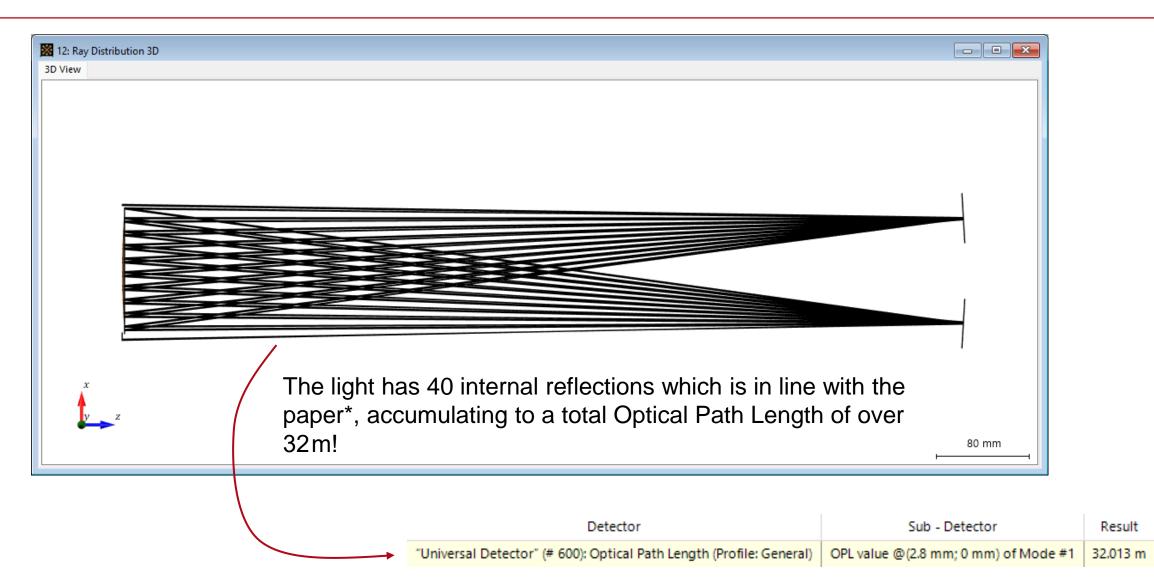
detector

- optical path length
- irradiance
- radiant flux

* Values from: Old, J. G., K. L. Gentili, and E. R. Peck. "Dispersion of carbon dioxide." JOSA 61.1 (1971): 89-90.

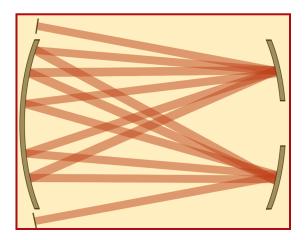
Simulation Results

System Overview – OPL Detection

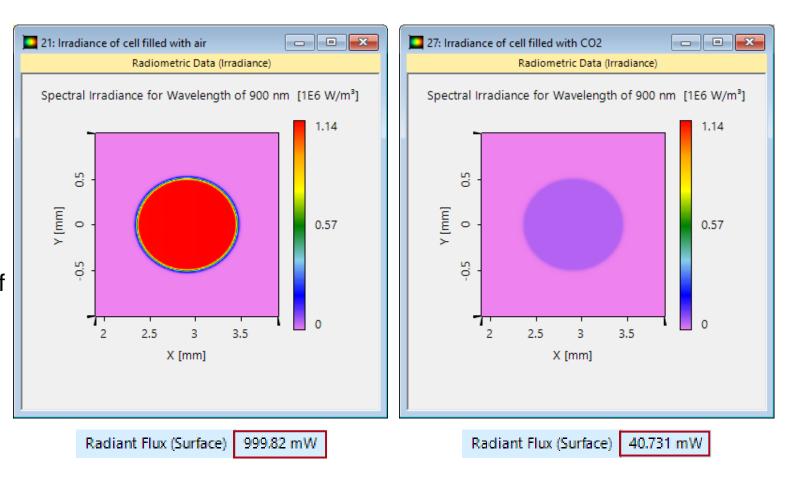


6 * Yin Guo and Liqun Sun, "Biconic White multipass cell design based on a skew ray-tracing model," Appl. Opt. 56, 7586-7595 (2017). www.LightTrans.com

Physical Optics Results – Irradiance & Radiant Flux

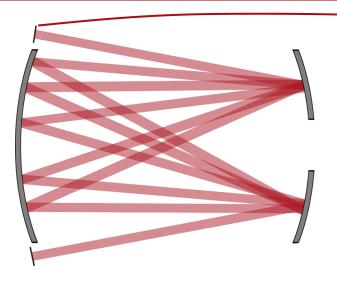


When the White cell is filled with an absorptive gas (such as carbon dioxide for a beam with wavelength of 900 nm) the decrease in energy can be measured after the resonator. Due to the high number of passes over a long distance in such configuration, the loss of radiant flux over 32.021 m is noticeable, as can be observed from the figures on the right.



Workflows

Power Management

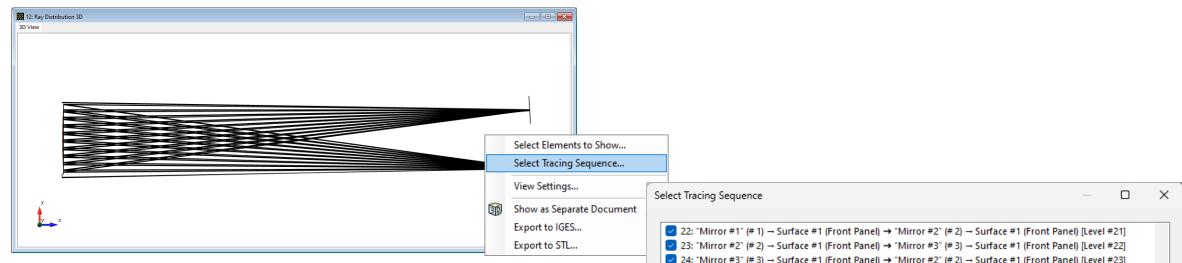


1				
Profile Editor (Mod	deling Profile: General)			×
*	Parameter Overview Position & Size P	'ower Management		
Sources	Type of Power Spectrum	O Discrete	○ Continuous	
C M.	Source Power Management	Source Modeling Power	1 W	
Components & Solvers				
Visualization & Detectors				

In VirtualLab Fusion, it is possible to define the power of the source. This can be done via the Power Management in Profile Editor. For more information:

Profile Editor

Non-Sequential Tracing



Selection Tools

With the non-sequential approach in VirtualLab Fusion, it is possible to follow the multiple-passes the light will make until it reaches the detector. This can be seen via the "Select Tracing Sequence" by right-clicking on the System 3D Result.

For more information regarding the non-sequential configuration in VirtualLab Fusion:

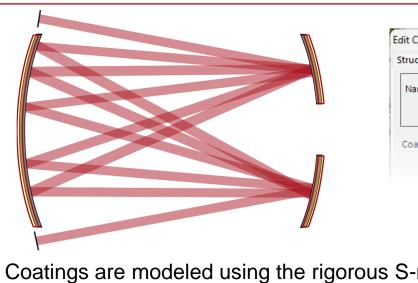


lect Tracing Sequence				
22: "Mirror #1" (# 1) → Surface #1 (Front Panel) → "Mirror #2" (# 2) → Surface #1 (F		•	-	
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✓ 35: "Mirror #2" (# 2) → Surface #1 (Front Panel) → "Mirror #3" (# 3) → Surface #1 (F	ront Panel)	[Level	#34]	
✓ 36: "Mirror #3" (# 3) → Surface #1 (Front Panel) → "Mirror #2" (# 2) → Surface #1 (F	ront Panel)	[Level	#35]	
37: "Mirror #2" (# 2) → Surface #1 (Front Panel) → "Mirror #1" (# 1) → Surface #1 (F	ront Panel)	[Level	#36]	
✓ 38: "Mirror #1" (# 1) → Surface #1 (Front Panel) → "Mirror #2" (# 2) → Surface #1 (F	ront Panel)	[Level	#37]	
39: "Mirror #2" (# 2) → Surface #1 (Front Panel) → "Mirror #3" (# 3) → Surface #1 (F	ront Panel)	[Level	#38]	
40: "Mirror #3" (# 3) → Surface #1 (Front Panel) → "Universal Detector" (# 600) [Lev	el #39]			

Cancel

Help

Coatings



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	Edit Conical Surface			×				
	Structure Height Discontinuities Scaling	Coating Periodiza	tion					_
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	Name Protected Gold		Structur	e Height Discontinu	ities Scaling Coatin	9 Periodization		
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Coatings are modeled using the rigorous algorithm, optimized for x,y-invariant laye	ered structures. In this		Depend	lent on Wavelength				
case, actual coatings were used on the r	mirrors, which can be							
built from scratch or imported into VirtualLab Fusion. For further				Variable	Parameter			
information:			Reflectance	1 (

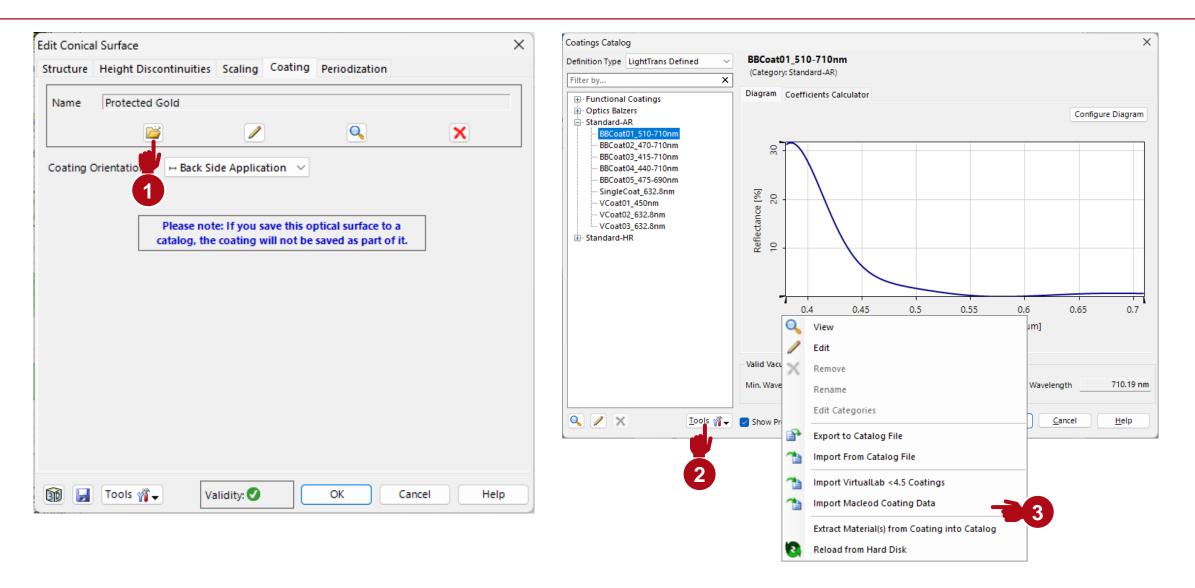
Import Coating into VirtualLab Fusion

Alternatively, coating functionalities can also be defined using Functional Coatings within the software. For more information: **Functional Coatings**

Dependent on P	plarization	Phase Change Δφ	Absorption	
Dependent o	on Incidence Angle			
Dependent on Wavelength				
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Reflectance	1			
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information:

Import Coatings into VirtualLab Fusion



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The total Optical Path Length (OPL) information can be extracted from the smooth wavefront phase per source mode and position in the *Universal Detector*. More information under: <u>Universal Detector</u>

Edit Universal Detec	ctor		×	
Coordinate Systems	Field Quantities Detector Window (k-Domain) ✓ Data from Universal Detector •••	Detector Window Gridless Data	Add-ons	
Orientation	Poynting Vector	e) Name Position	ctor Add-on Optical Path Length of OPL Evaluation C Edit Validity:	X @ Read Me 2.8 mm 0 mm OK Cancel Help
Validity:	New Load Duplicate	OK Car	cel Help	

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Universal Detector – Optical Path Length Add-on

title	Modeling and Evaluation of Multi-Pass White Cell
document code	USC.0412
document version	1.0
required packages	_
software version	2024.1 (Build 1.132)
category	Use Case
further reading	 <u>Modeling of a Herriot-Cell</u> <u>Functional Coatings</u> <u>Universal Detector</u> <u>Programming Detector Add-ons in VirtualLab Fusion</u>