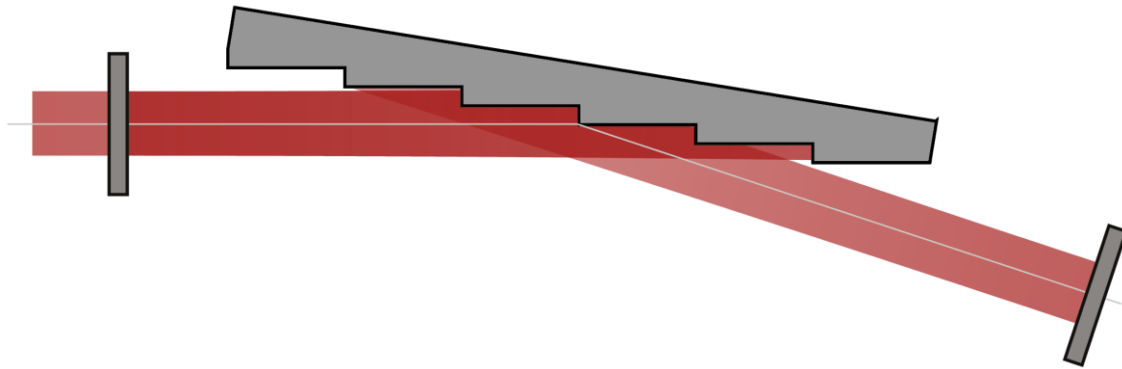


# Littrow Configuration for Blazed Gratings

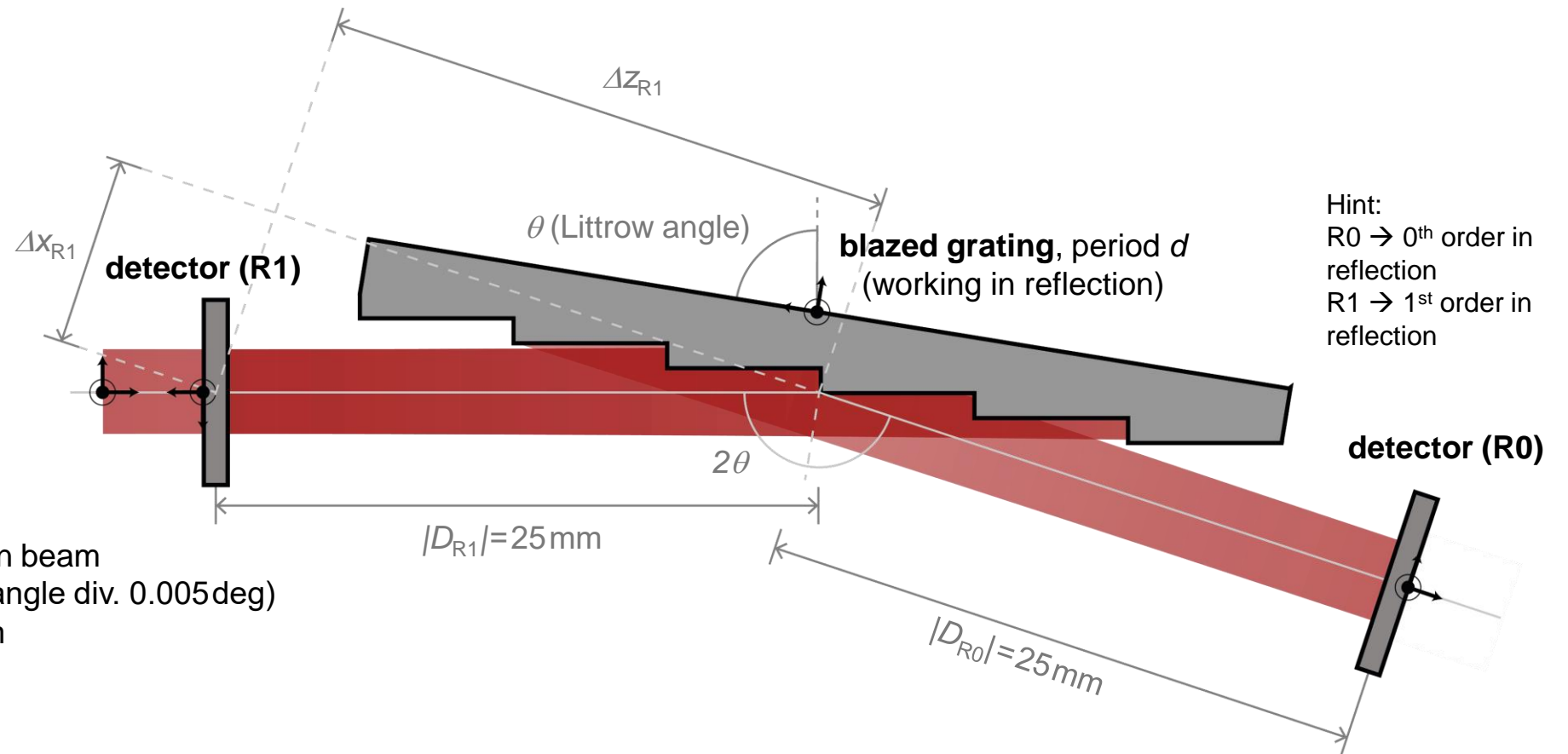
# Abstract



Littrow configuration is the chosen denomination for a very commonly used way of orientating a blazed grating in monochromators, spectrometers & resonators, with the aim of obtaining maximum efficiency for the order with a diffraction angle equal to the angle of incidence. Needless to say, this type of system is extremely sensitive to the positions of the different elements, with the additional caveat that these optimal positions depend strongly on both the wavelength, and the period of the grating. We offer here an optical setup configured according to Littrow, which furthermore, via some programming, maintains those optimal positions even under a change of wavelength or grating period.

# Modeling Task

The *Parameter Coupling* feature in VirtualLab Fusion can help configure the system so that both the grating and the detectors are automatically positioned according to Littrow.



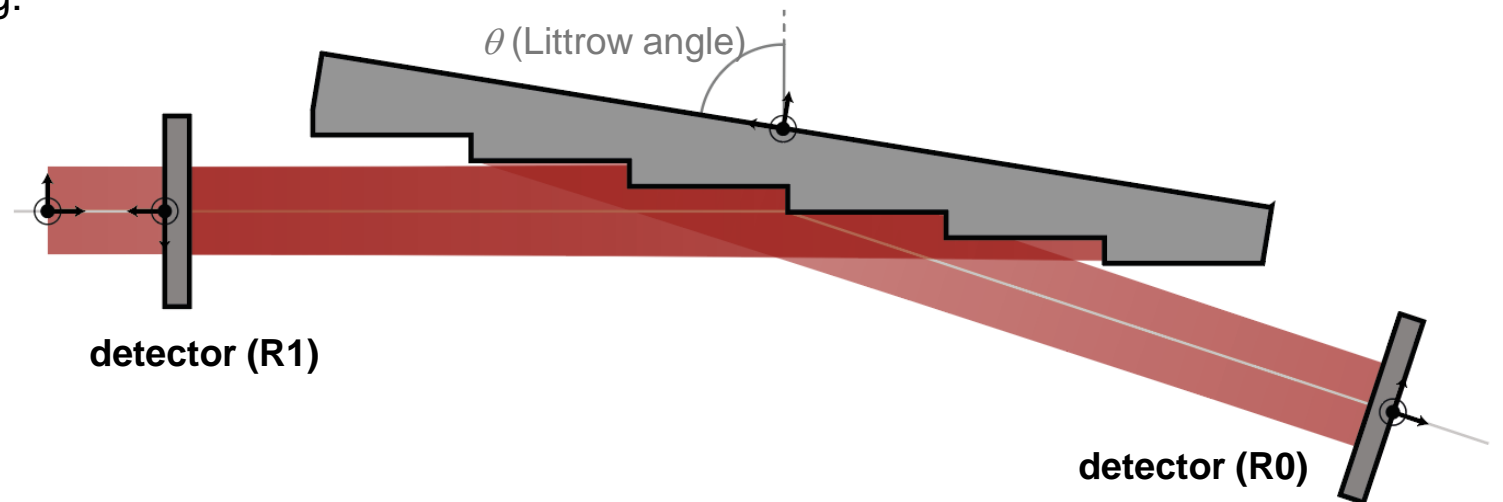
## source

- fundamental Gaussian beam
- low divergence (half-angle div. 0.005deg)
- wavelength  $\lambda=488\text{nm}$

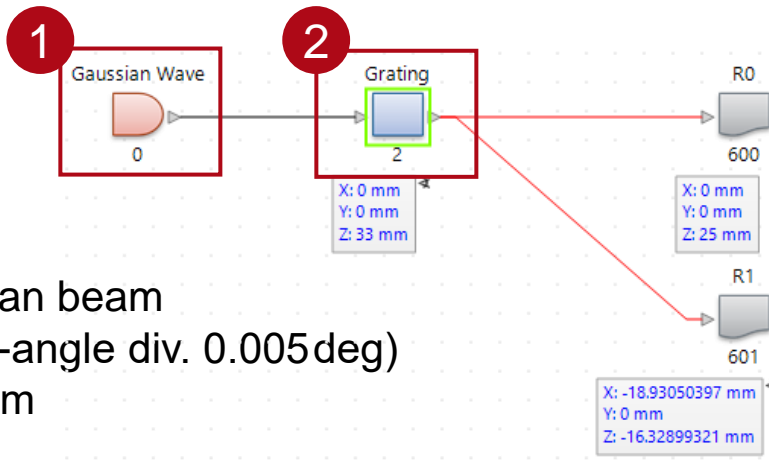
# Littrow Configuration

- The so-called “Littrow” configuration is a special setup of the grating orientation with the aim of ensuring a diffraction angle of the reflected 1<sup>st</sup> order (R1) equal to the impinging beam.
- The grating equation for reflection in air yields:  $d(\sin\theta_\alpha + \sin\theta_\beta) = m\lambda$  with  $\alpha, \beta$  and  $m$  represent the incidence angle, diffraction angle and the diffraction order, respectively.
- In order to obtain a diffraction angle for the 1<sup>st</sup> reflected order, that equals the angle of incidence, the grating equation becomes:
$$2d\sin\theta_{\text{Littrow}} = \lambda$$
- Hence, the rotation angle of the grating (the so-called Littrow angle) can be calculated by using the wavelength of the incident beam and the period of the grating:

$$\theta_{\text{Littrow}} = \arcsin\left(\frac{\lambda}{2d}\right)$$

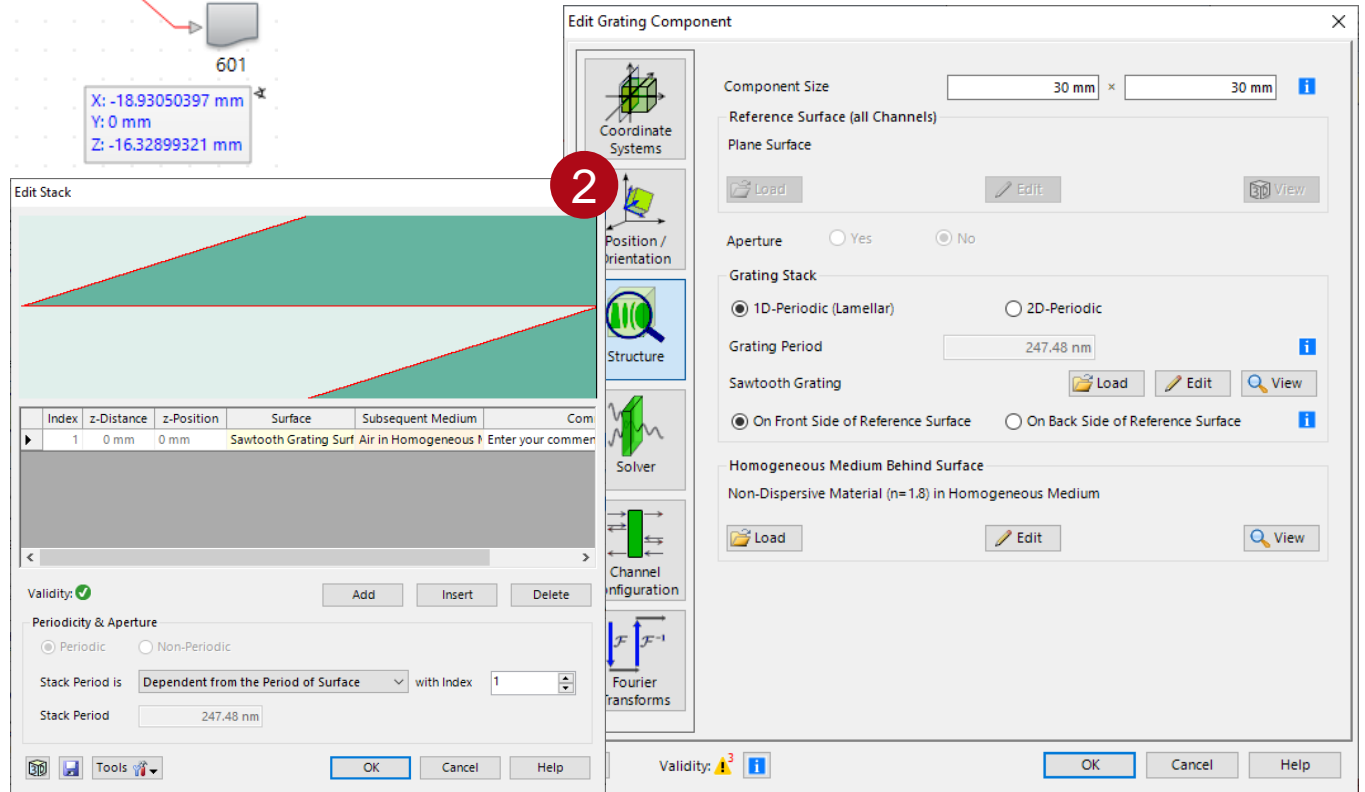
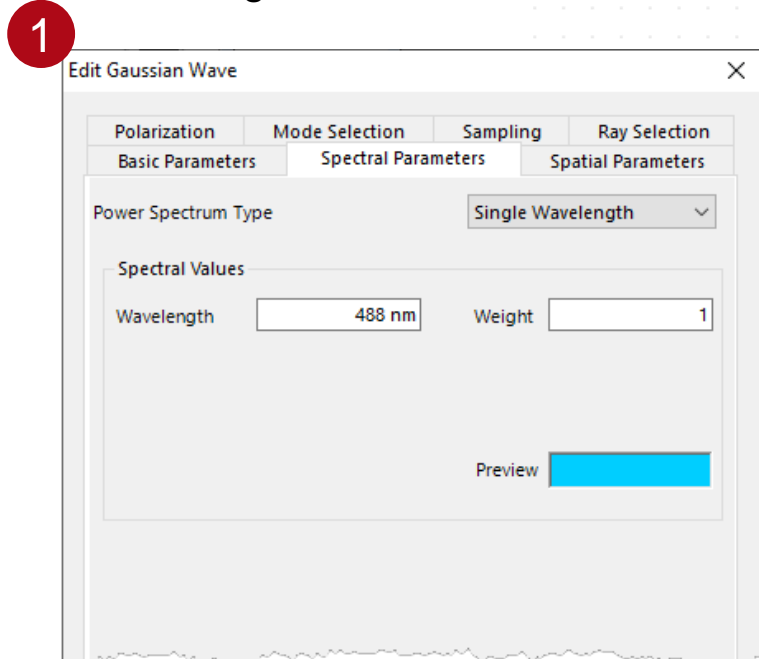


# System Building Blocks – Source and Component

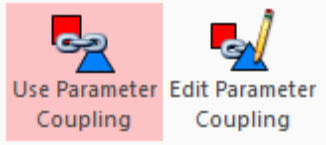


A sawtooth grating is modeled by using the Grating component in a general optical setup.

- fundamental Gaussian beam
- low divergence (half-angle div. 0.005deg)
- wavelength  $\lambda = 488 \text{ nm}$



# Use Parameter Coupling



This Optical Setup has been built up using the *Parameter Coupling* feature, which allows the user to link several parameters and variables of the system via some programming.

In this case, the rotation of the grating, as well as the orientation and position of both detectors (one for the 0th order, R0, another one for the 1st order, R1, both in reflection), will be automatically determined via the *Parameter Coupling*.

Edit Parameter Coupling

**Parameter Specification**  
Setup the parameter(s) to be used as input (independent variable) and output (dependent variable) of the coupling snippet.

Filter by...  Show Only Used Parameters

1	2	*	Object	Category	Parameter	Use in Snippet	Short Name
			"Gaussian Wave" (# 0)		Wavelength	<input checked="" type="checkbox"/>	Wavelength
			"Lightguide" (# 1)	Basal Positioning (Relative)	Rotation #1 (about Y-Axis)	<input checked="" type="checkbox"/>	GratingRotationY
				Surface #1 (Plane Interface)	Surface Region #1 (Square Region)   Period	<input checked="" type="checkbox"/>	GratingPeriod
			"R0" (# 600)	Basal Positioning (Relative)	Distance Before	<input checked="" type="checkbox"/>	R0DetectorDistance
			"R1" (# 601)		Distance Before	<input checked="" type="checkbox"/>	R1DetectorDeltaZ
				Basal Positioning (Relative)	Lateral Shift X	<input checked="" type="checkbox"/>	R1DetectorDeltaX
					Rotation #1 (about Y-Axis)	<input checked="" type="checkbox"/>	R1DetectorRotationY

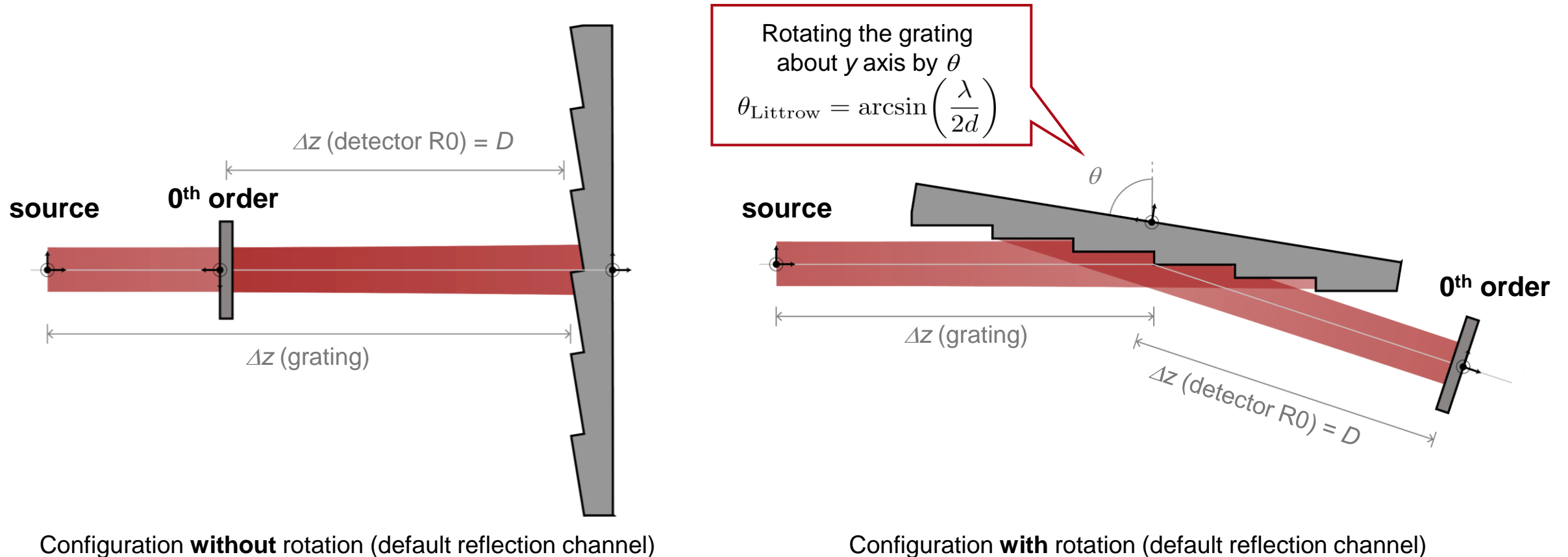
Help Validity:

given parameters:

- wavelength  $\lambda$ ,
- grating period  $d$ ,
- detector distance  $|D|$

# Rotating the Grating & Positioning Detector for 0<sup>th</sup> Order (R0)

Upon rotating an element in an optical system in VirtualLab Fusion, the default reflection channel (which coincides with the 0<sup>th</sup> order of a grating) will get assigned a coordinate system which matches Snell's law.



# Positioning the Detector for 1<sup>st</sup> Reflected Order (R1)

Steps to position detector R1:

1. Rotate  $-2\theta$  around  $y$  axis

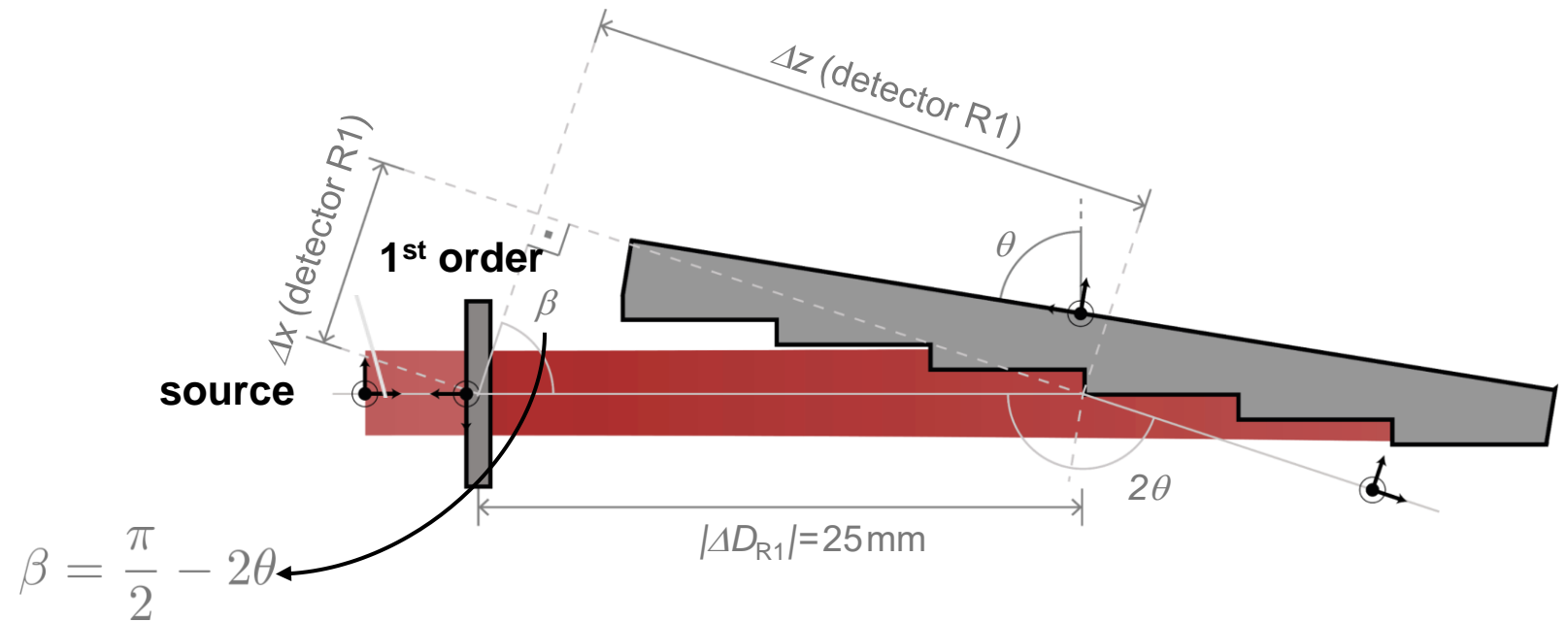
$$\theta_{\text{Littrow}} = \arcsin\left(\frac{\lambda}{2d}\right)$$

1. Shift detector along  $x$ ,  $\Delta x_{R1}$

$$\Delta x_{R1} = -D \cos(\beta)$$

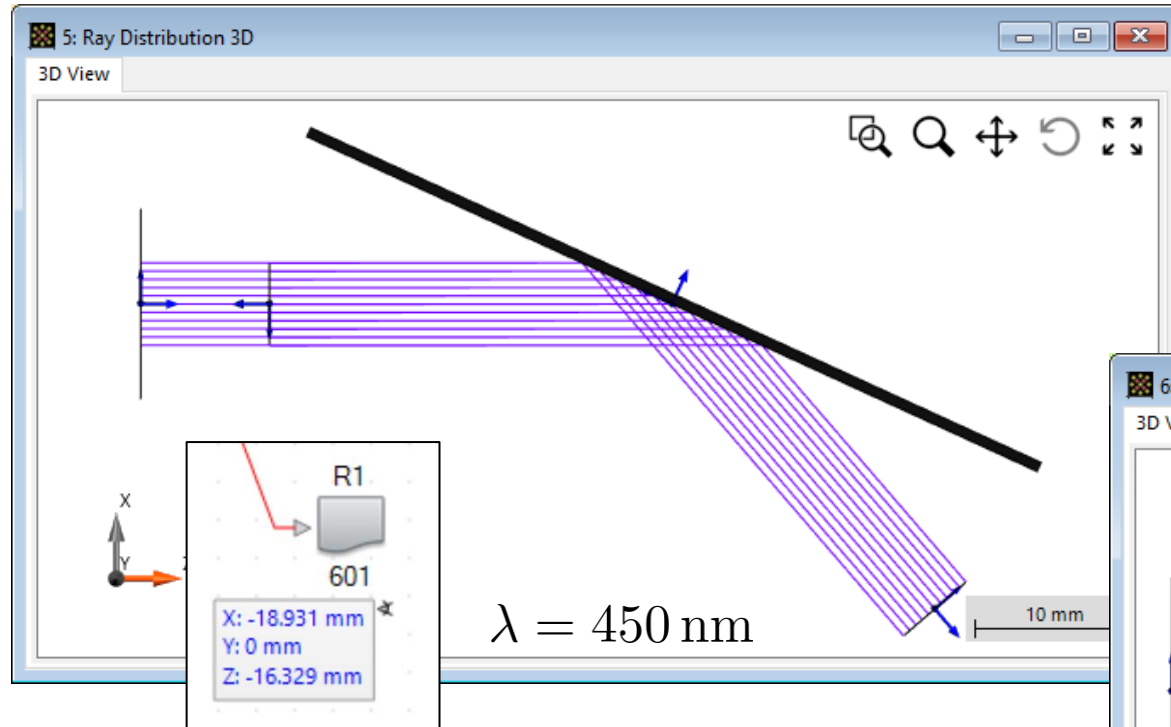
3. Shift detector along  $z$ ,  $\Delta z_{R1}$

$$\Delta z_{R1} = D \sin(\beta)$$

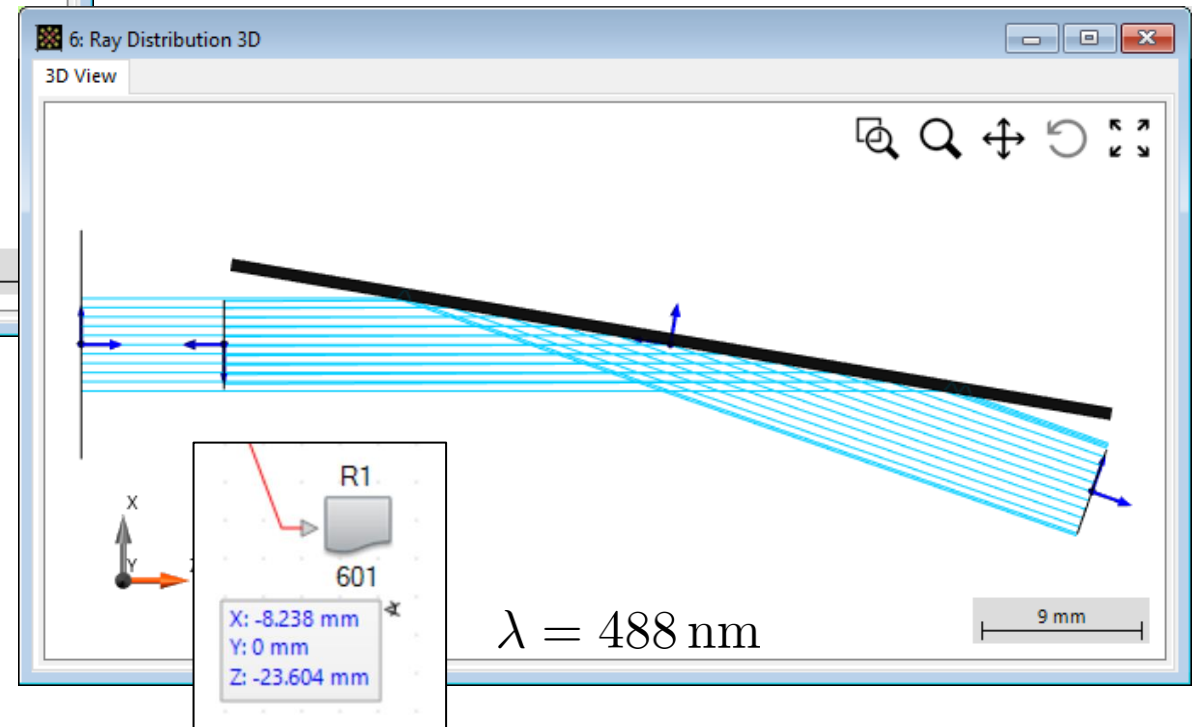




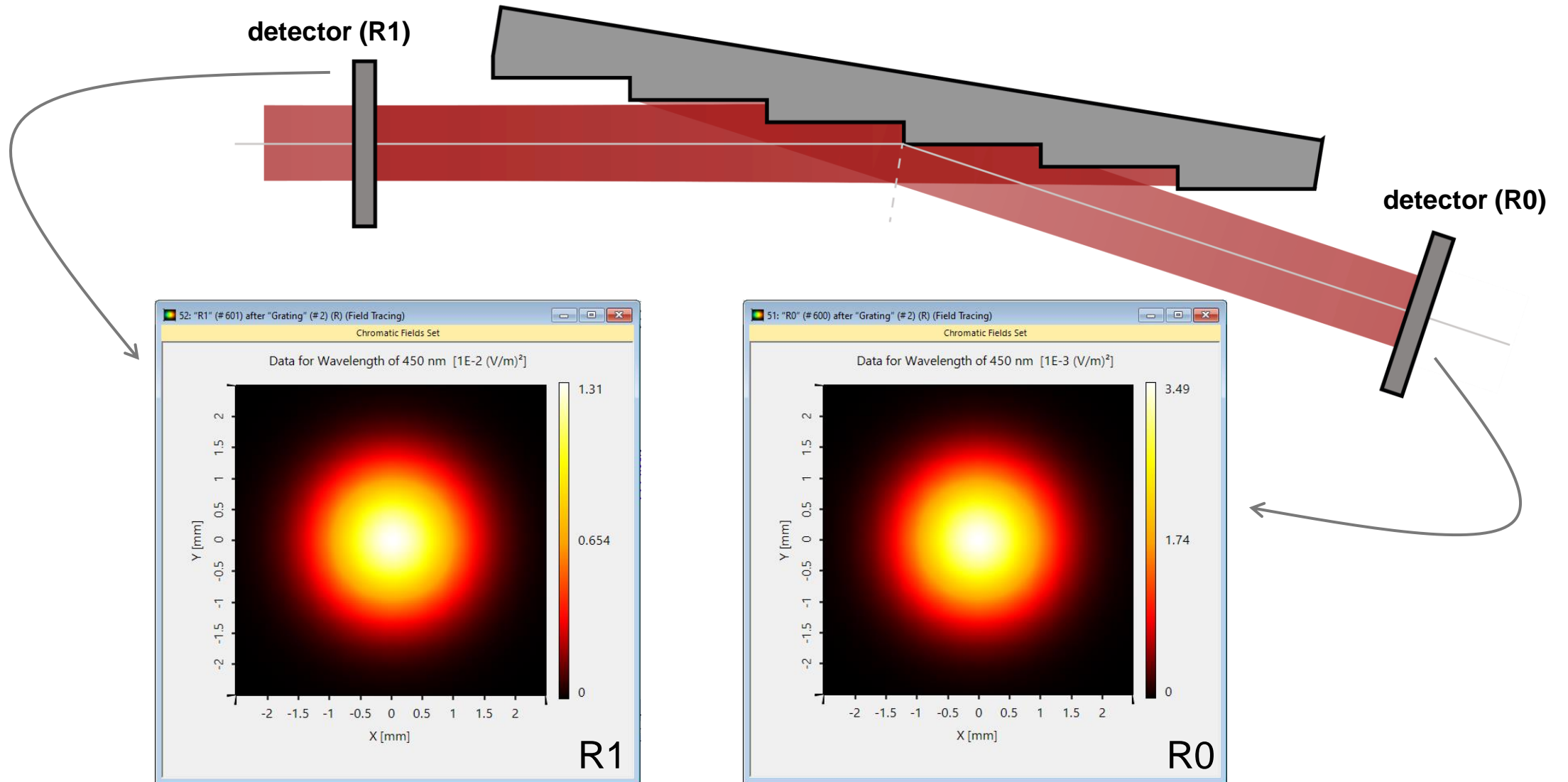
# Position Configured Automatically



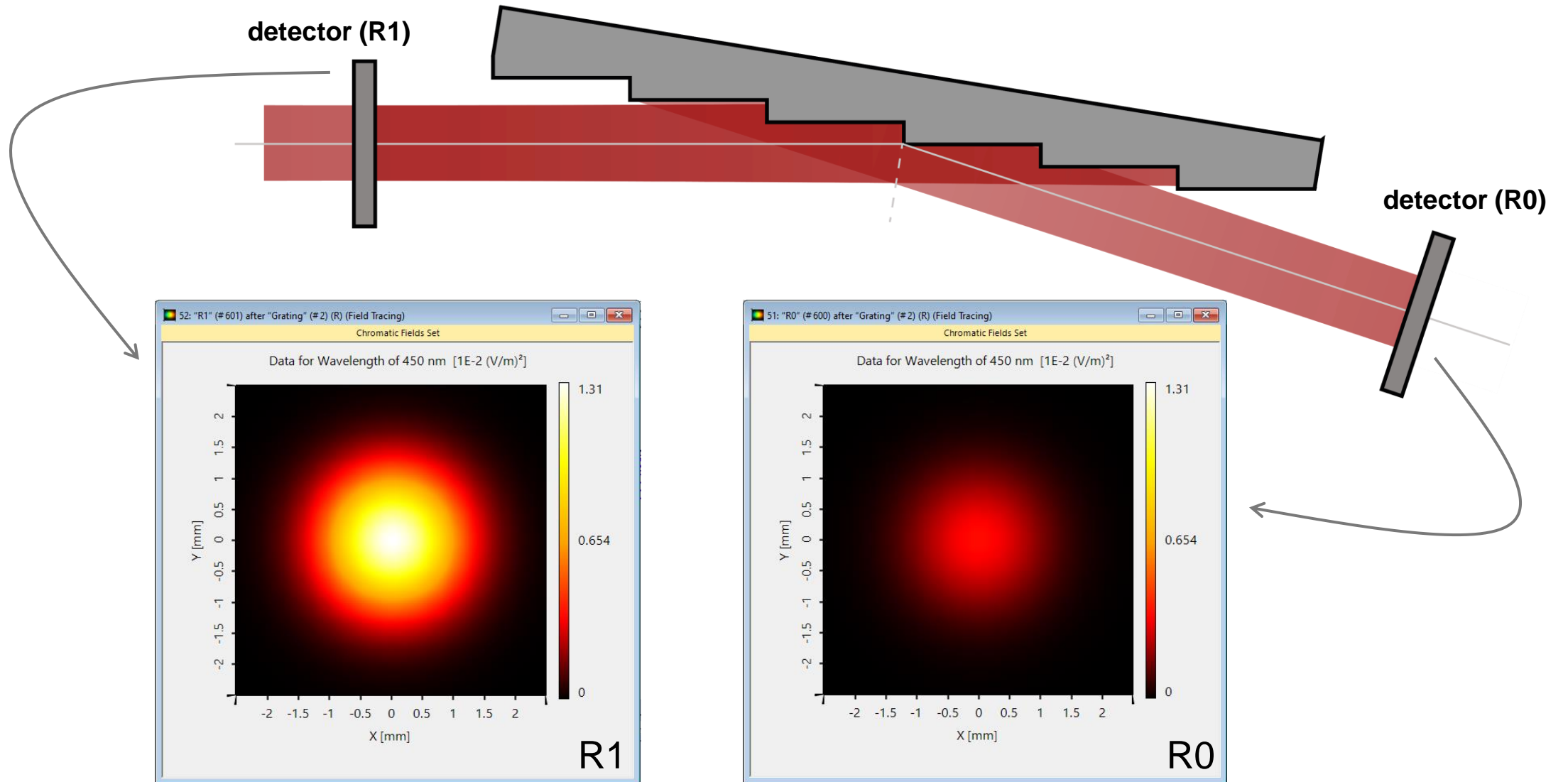
Rotation of the grating and positioning of detectors R0 and R1 is performed automatically by VirtualLab via the programmable Parameter Coupling.



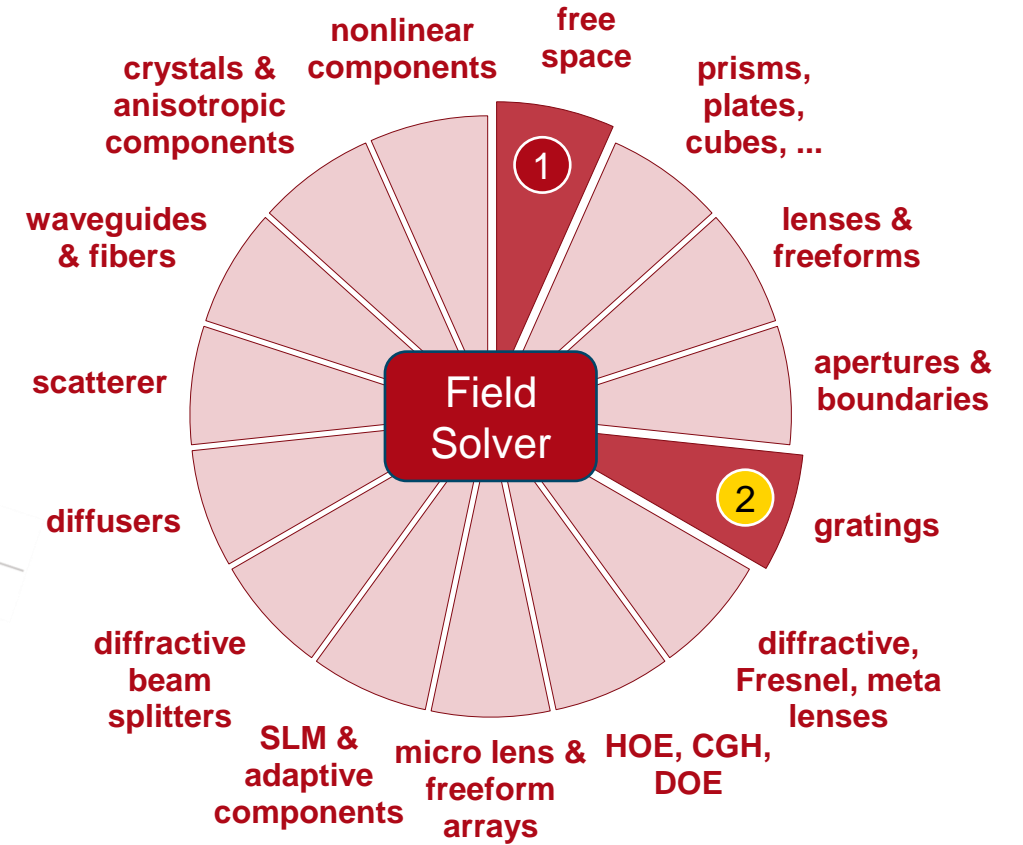
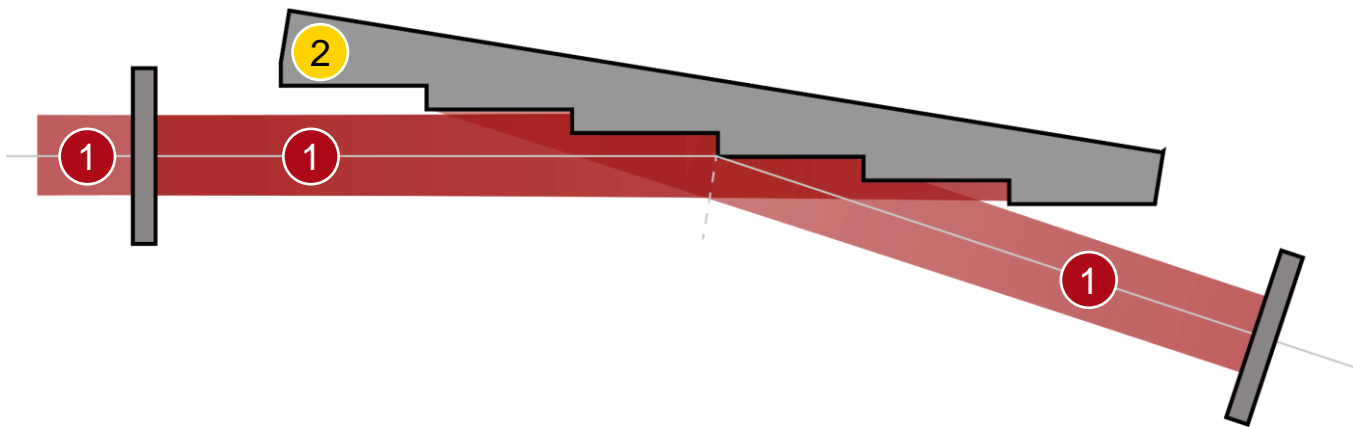
# Physical Optics Simulation Results (Normalized)



# Physical Optics Simulation Results



# VirtualLab Fusion Technologies



# idealized component

# Document Information

title	Littrow Configuration for Blazed Gratings
document code	GRT.0029
document version	1.1
software edition	VirtualLab Fusion Basic
software version	2021.1 (Build 1.180)
category	Application Use Case
further reading	<ul style="list-style-type: none"><li>- <a href="#"><u>Analysis of Blazed Grating by Fourier Modal Method (FMM)</u></a></li><li>- <a href="#"><u>Configuration of Grating Structures by Using Interfaces</u></a></li><li>- <a href="#"><u>Configuration of Grating Structures by Using Special Media</u></a></li></ul>