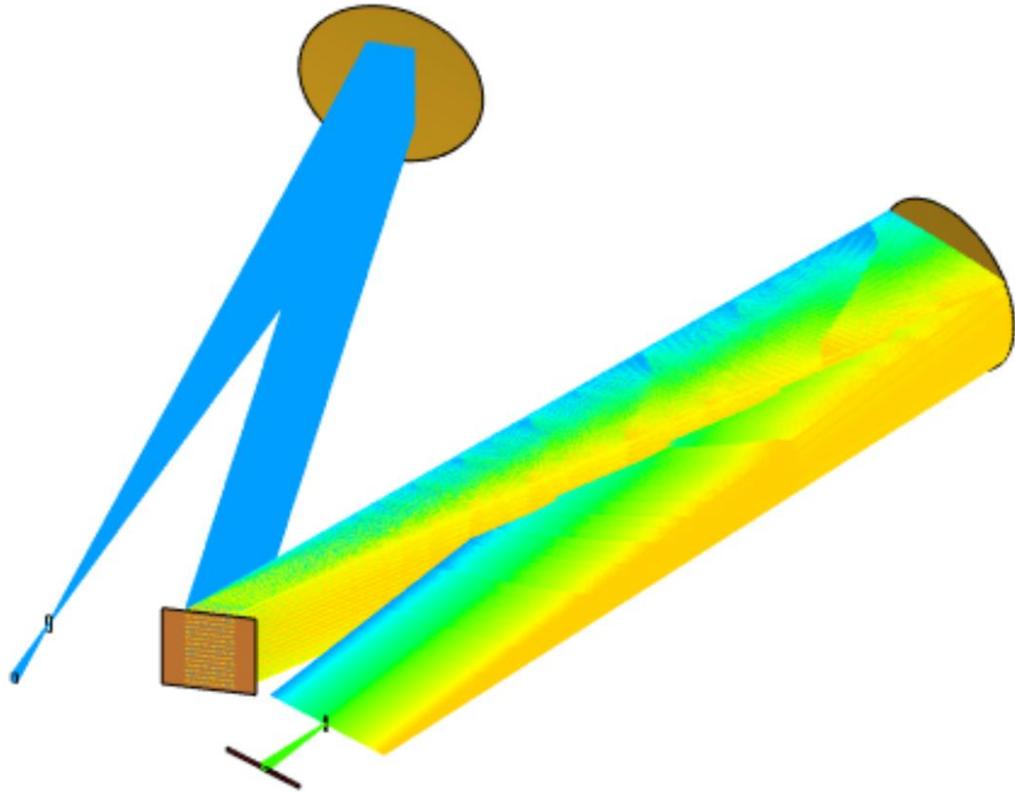


Czerny-Turner Setup

Abstract



Czerny-Turner setups are widely used to measure the spectral information of light sources. Typically, a parabolic mirror is used to collimate the source first, and then a diffraction grating will spatially separate the wavelengths. A second mirror can be employed to refocus each of the now separate wavelength components. By positioning an exit aperture properly, a specific wavelength can be selected. A simulation of the complete Czerny-Turner setup, including real reflective mirrors and a diffractive grating is presented in this use case using, first, a continuous spectrum, and then the discrete example of the sodium doublet.

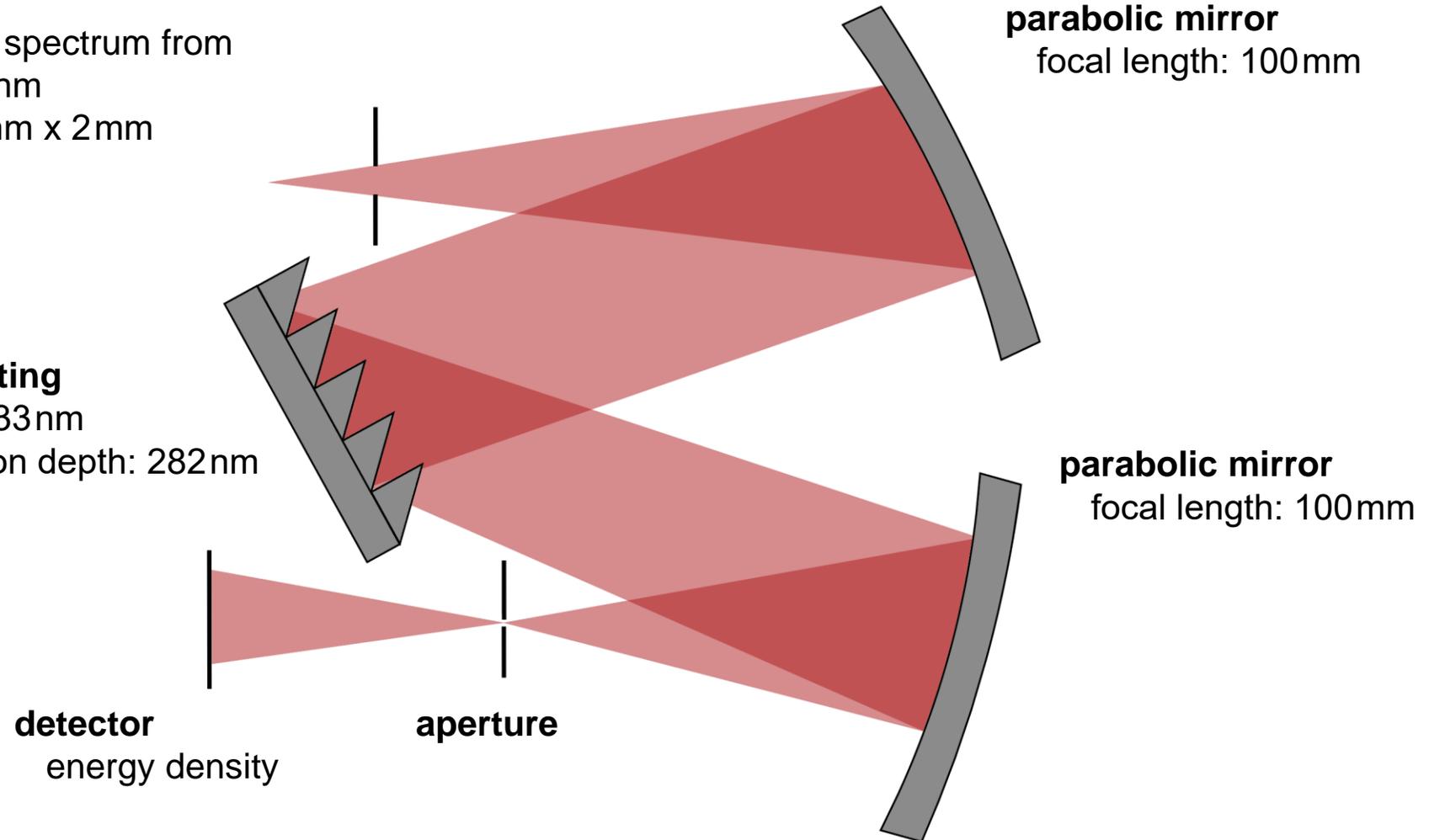
Modeling Task

spherical wave

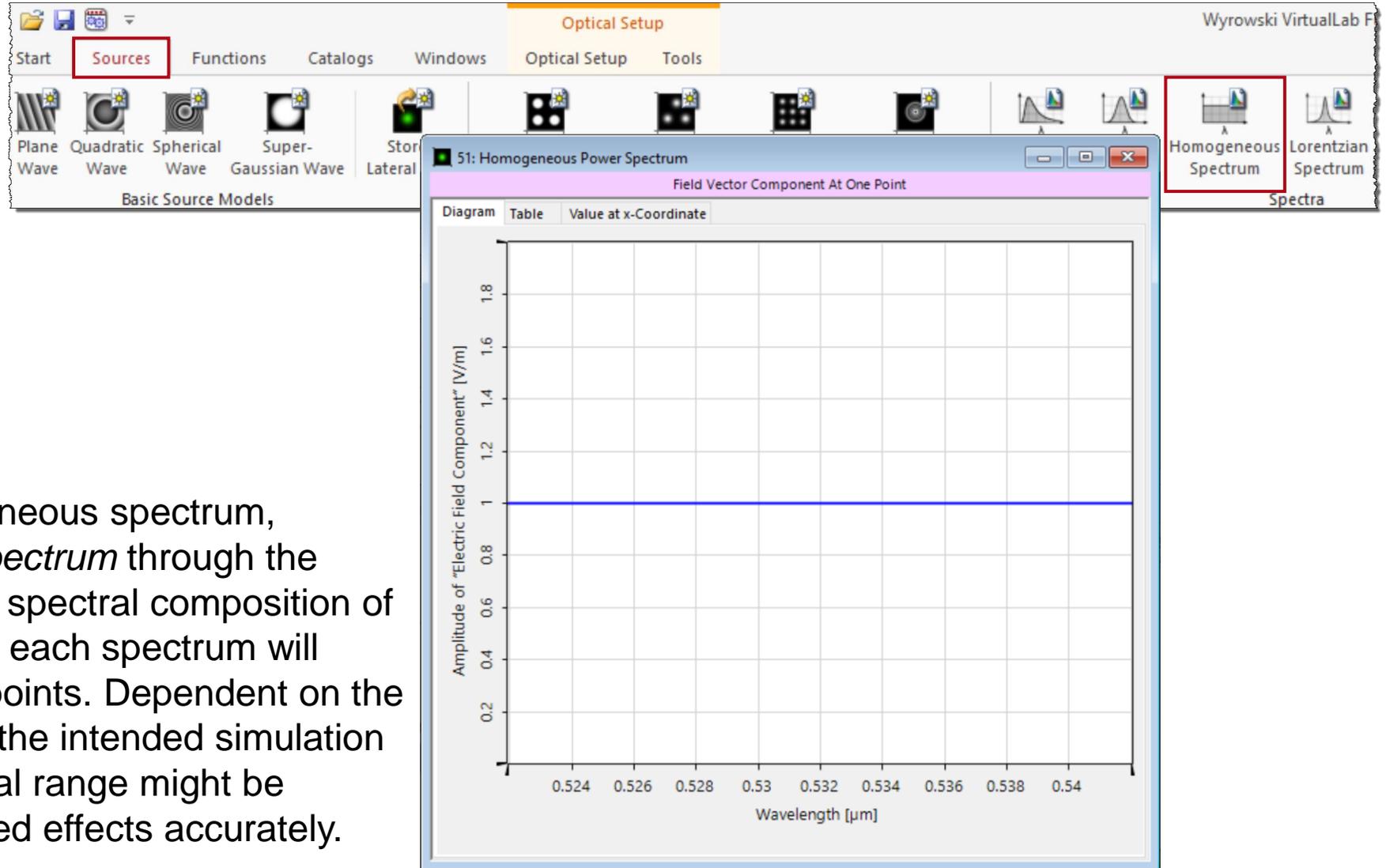
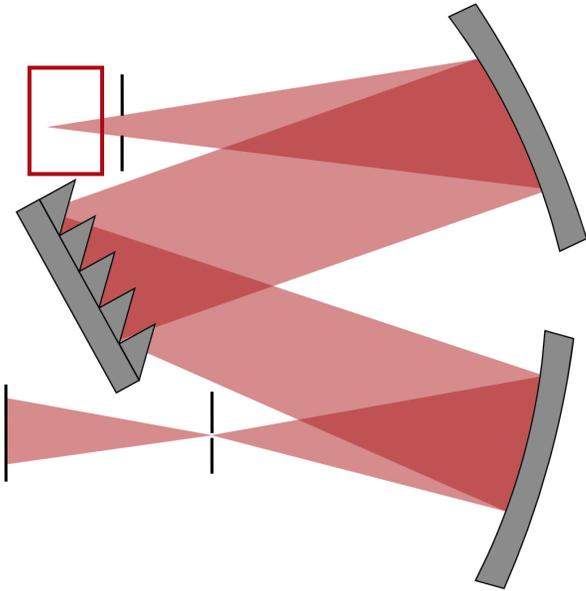
- homogeneous spectrum from 512nm to 552nm
- aperture: 500nm x 2mm

sawtooth grating

- period: 833nm
- modulation depth: 282nm

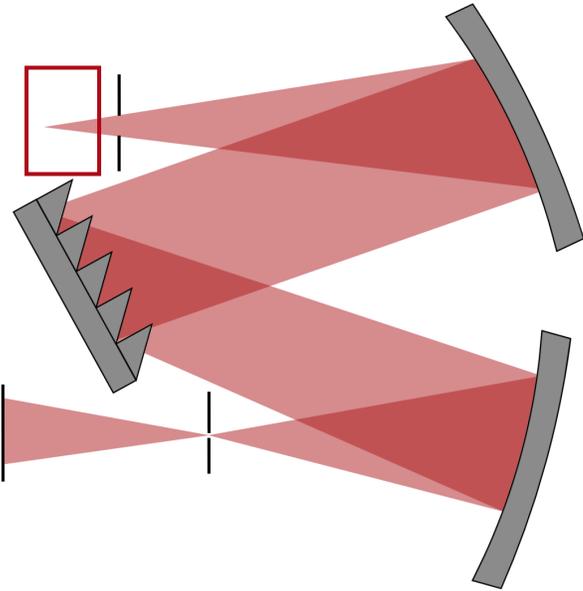


System Building Blocks – Homogeneous Power Spectrum



To model light with a homogeneous spectrum, generate a *Homogeneous Spectrum* through the *Sources* tab and use it as the spectral composition of the source. Keep in mind that each spectrum will consist of discrete sampling points. Dependent on the particular optical system and the intended simulation a finer sampling of the spectral range might be necessary to model the desired effects accurately.

System Building Blocks – Homogeneous Power Spectrum



Alternatively, a *Parameter Run* can be applied instead, to vary the wavelength in a specific range. This technique benefits from the option offered by the *Parameter Run* to retroactively add more wavelength samples to the spectrum, without the need to repeat the simulation with previous ones.

43: Parameter Run*

Parameter Specification

Set up the parameter(s) to be varied.

You can select one or more parameters which shall be varied as well as the resulting number of iterations. Several [modes](#) are available specifying how the parameters are varied per iteration.

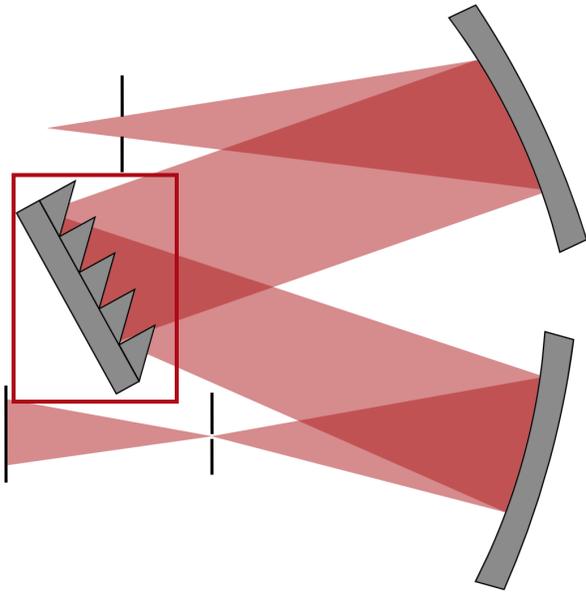
Usage Mode: Standard

Filter by... Show Only Varied Parameters

1	2	*	Object	Category	Parameter	Vary	From	To	Steps	Step Size	Original Value
			Optical Setup Parameter	Simulation Settings	Oversampling Fact...	<input type="checkbox"/>	0.01	1000	1	999.99	1
				Simulation Settings	Oversampling Fact...	<input type="checkbox"/>	0.01	1000	1	999.99	1
				Simulation Settings	Fourier Transform...	<input type="checkbox"/>	0.001	1000	1	1000	1
				Environment	System Temperature	<input type="checkbox"/>	-273.15 °C	1E+100 °C	1	1E+100 °C	20 °C
				Environment	Air Pressure	<input type="checkbox"/>	0 Pa	1 GPa	1	1 GPa	101.33 kPa
			"Spherical Wave" (# 0)	Medium at "...	Material (Air) Con...	<input type="checkbox"/>	0	1E+300	1	1E+300	0
					Wavelength	<input checked="" type="checkbox"/>	512 nm	552 nm	801	50 pm	518 nm
				Weight	<input type="checkbox"/>	0	1E+300	1	1E+300	1	
				Polarization Angle	<input type="checkbox"/>	0°	360°	1	360°	0°	
				Distance to Input P...	<input type="checkbox"/>	-1E+303 mm	1E+303 mm	1	2E+303 mm	-10 mm	
				Lateral Offset X	<input type="checkbox"/>	-1E+303 mm	1E+303 mm	1	2E+303 mm	0 mm	
				Lateral Offset Y	<input type="checkbox"/>	-1E+303 mm	1E+303 mm	1	2E+303 mm	0 mm	
				Number of Rays X	<input type="checkbox"/>	1	2E+09	1	2E+09	31	
				Number of Rays Y	<input type="checkbox"/>	1	2E+09	1	2E+09	31	
				Oversampling Factor	<input type="checkbox"/>	1E-300	1E+300	1	1E+300	1	

< Back Next > Show ▾

System Building Blocks – Sawtooth Grating



Grating structures, such as a sawtooth or blazed grating, are modeled by defining appropriate surfaces and media in a *Stack*. This *Stack* can then be imported into a variety of different components, depending on the intended use. In this case we investigate the overall wavelength dependency in a grating-specific optical setup, which can be accessed by *Start, Gratings*. Afterwards the *Stack* can be loaded into a *Grating Component* in a normal *Optical Setup* to simulate the entire system.

The screenshot shows the 'Edit Grating Component' window in a software application. The window is divided into several sections:

- Coordinate Systems:** A 3D coordinate system icon.
- Position / Orientation:** A 3D coordinate system icon with a rotation handle.
- Structure:** A magnifying glass icon over a grating structure.
- Solver:** A 3D grating structure icon.
- Channel Configuration:** A 3D grating structure icon with arrows indicating light paths.
- Fourier Transforms:** A 3D grating structure icon with arrows and labels \mathcal{F} and \mathcal{F}^{-1} .

The main configuration area includes:

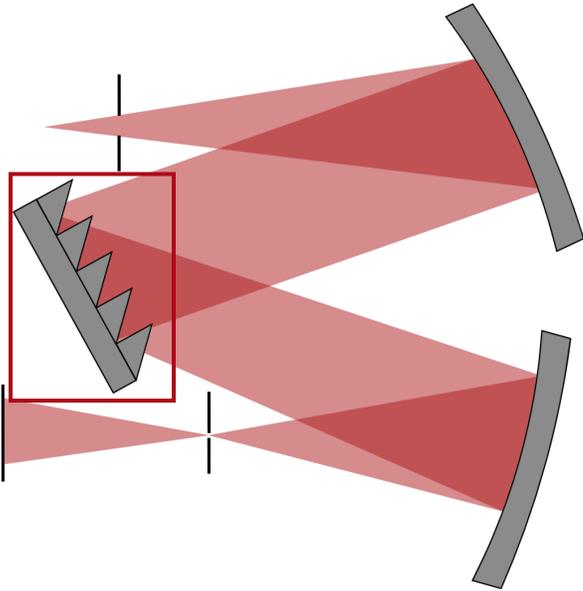
- Component Size:** 20 mm x 20 mm.
- Reference Surface (all Channels):** Plane Surface.
- Aperture:** Preview for Czerny Turner Sawtooth Grating.
- Grating:** 1D-P.
- Grating F:** Czerny T.
- On Fr:** On Fr.
- Homoge:** Homoge.
- Air in Ho:** Air in Ho.

A table below the configuration area shows the grating structure details:

Index	z-Distance	z-Position	Surface	Subsequent Medium	Comment
1	0 mm	0 mm	Sawtooth Grating Interface	Air in Homogeneous Medium	Enter your comment here

At the bottom, the **Periodic Stack; Stack Period** is set to 833 nm x 833 nm. The window includes 'Close' and 'Help' buttons.

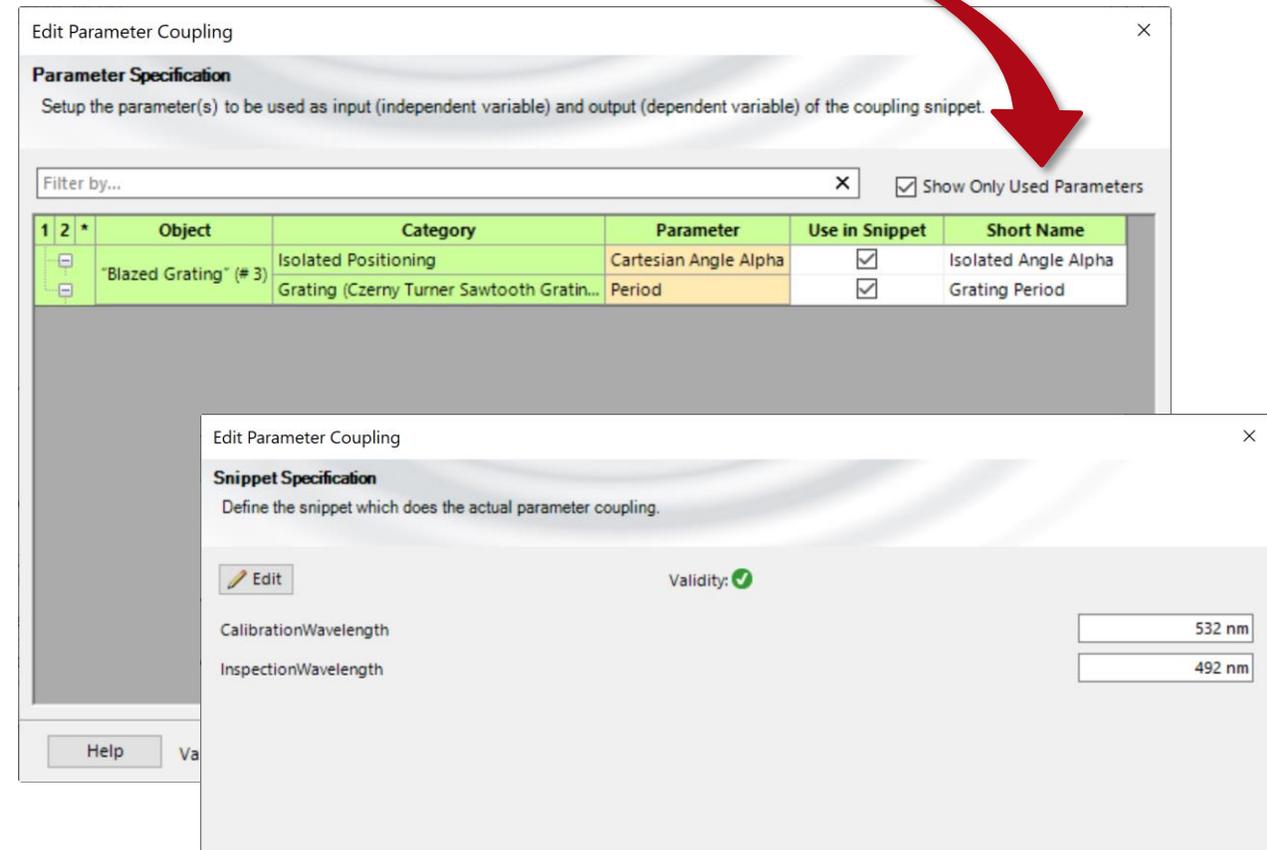
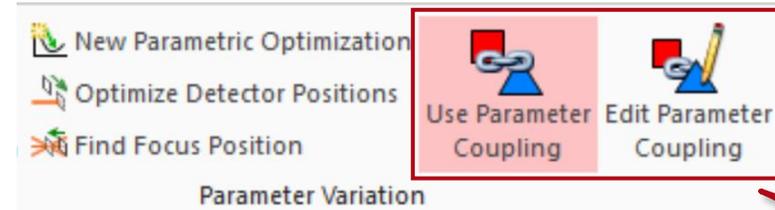
Parameter Coupling



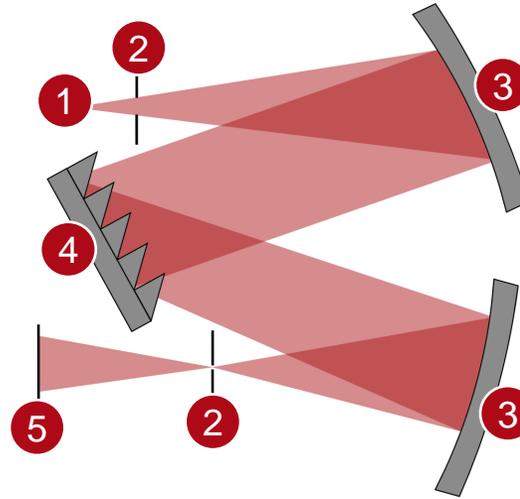
The *Parameter Coupling* feature can be used to link parameters of the system, so that a certain relationship between them is maintained. In this use case we want to adjust the angle of the grating automatically, depending on the which wavelength is investigated .

More information about the *Parameter Coupling* under:

[Coupling of Parameters in VirtualLab Fusion](#)

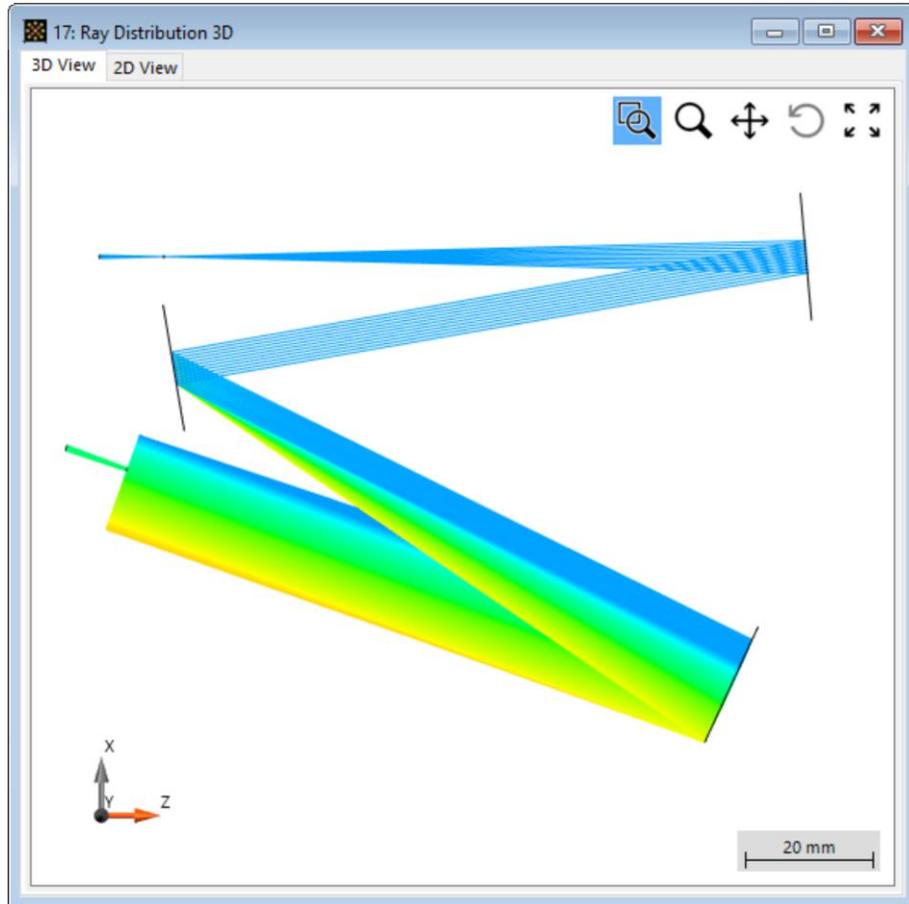


Summary – Components...

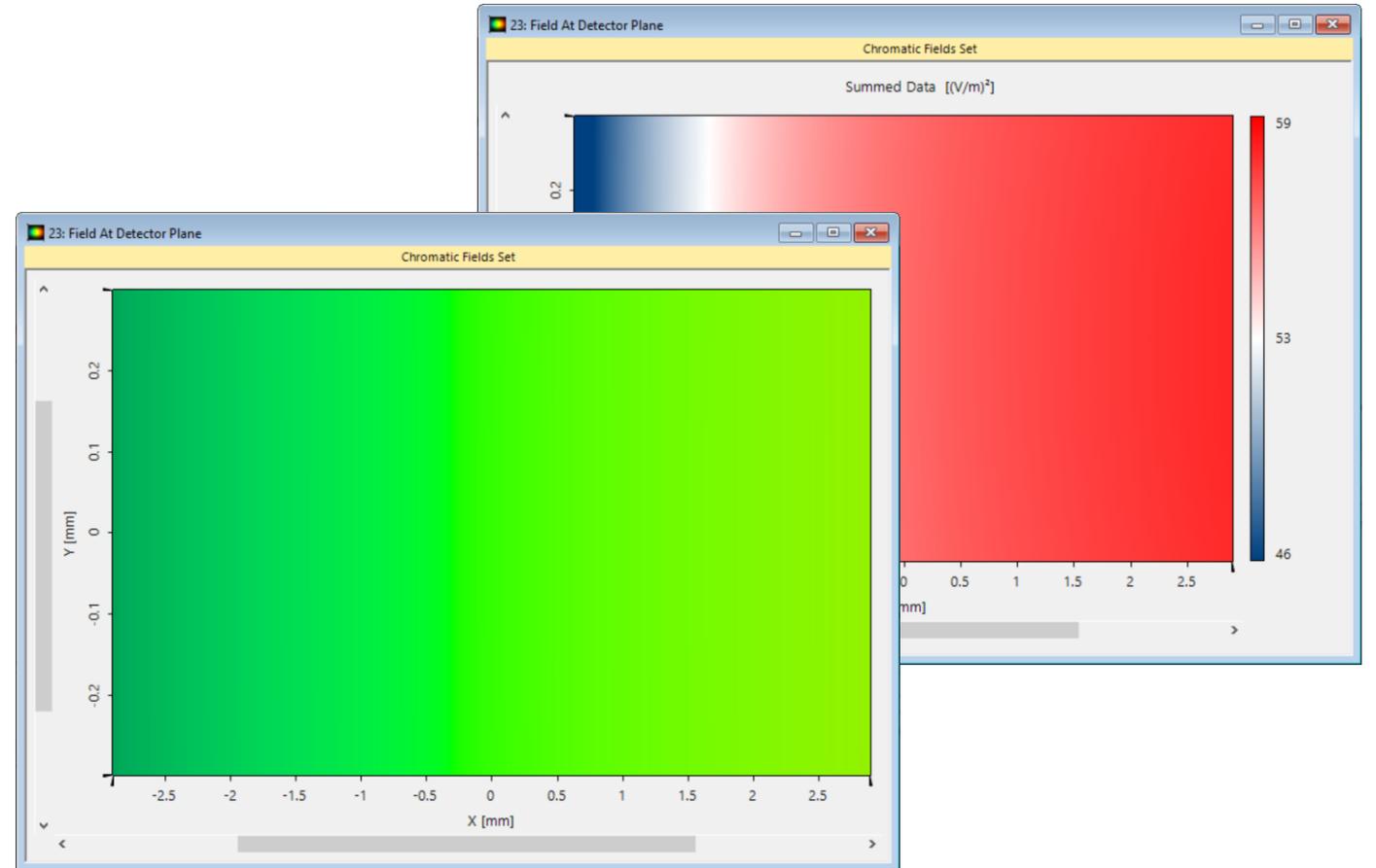


... of Optical System	... in VirtualLab Fusion	Model/Solver/Detected Value
1. source	<i>Spherical Wave (with Homogeneous Power Spectrum)</i>	point source (with homogeneous spectrum)
2. aperture	<i>Aperture</i>	transmission function
3. parabolic mirror	<i>Parabolic Mirror Component</i>	Linear Plane Interface Approximation (LPIA)
4. sawtooth grating	<i>Grating Component</i>	FMM/RCWA
5. detector	<i>Camera Detector</i>	energy density measurement

System Impressions



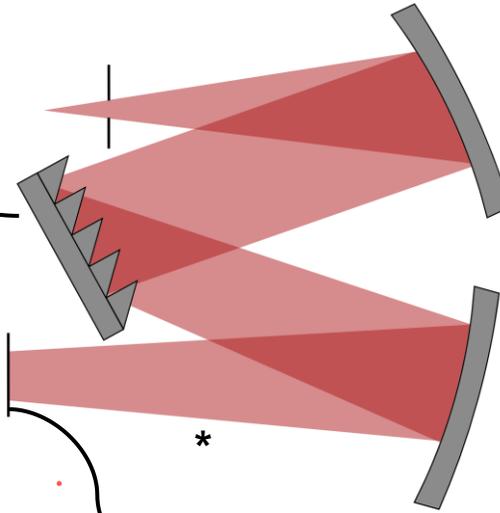
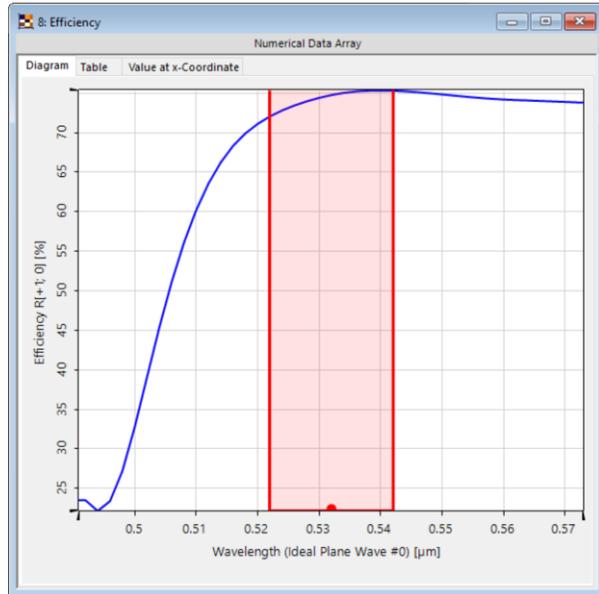
3D Ray Tracing visualization



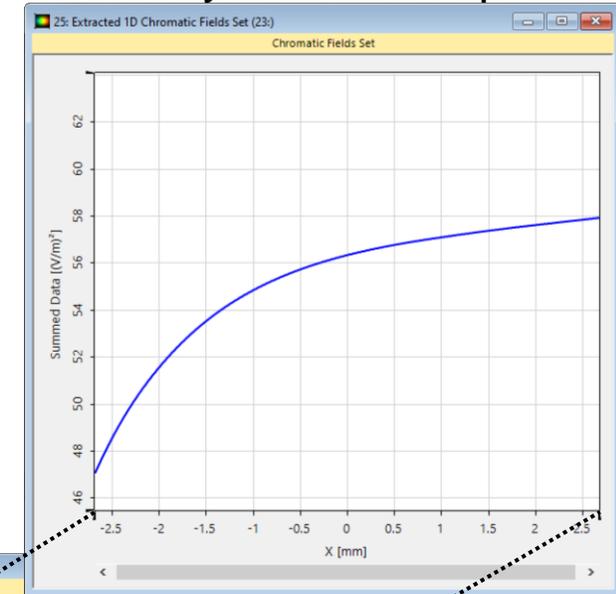
field visualization at detector plane in real and false color (without exit aperture)

Grating Efficiency Calculation

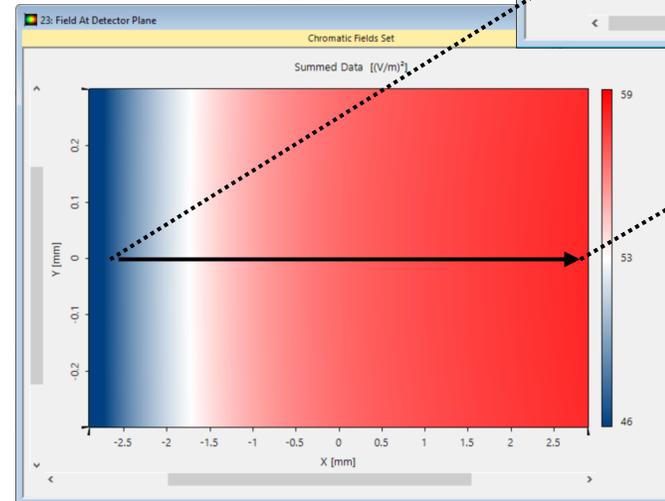
calculated diffraction efficiency



intensity at detector plane



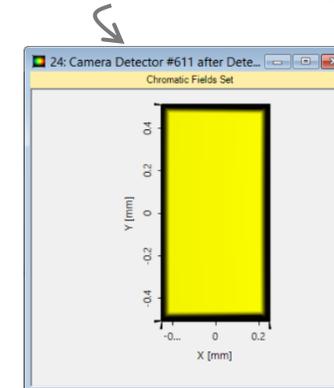
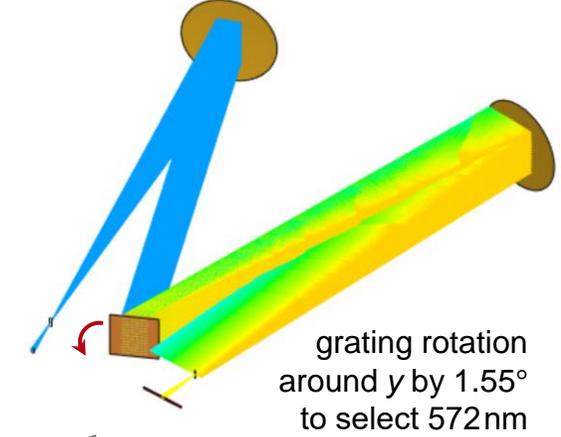
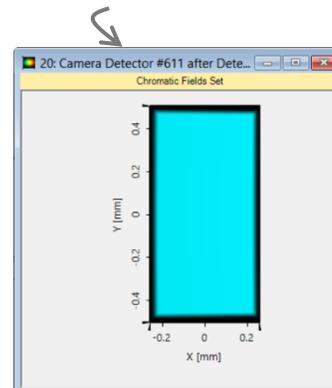
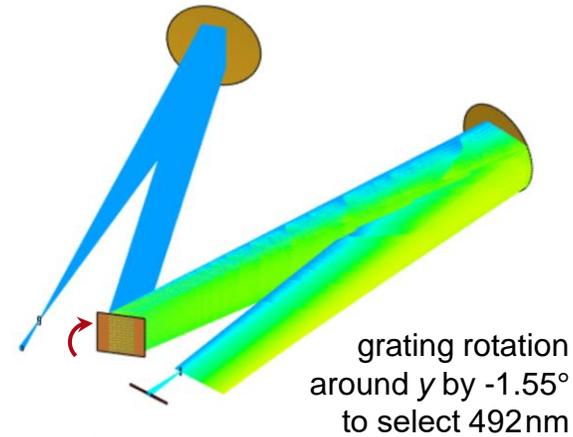
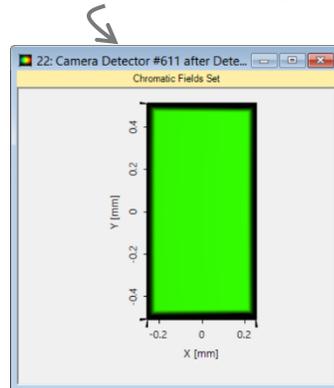
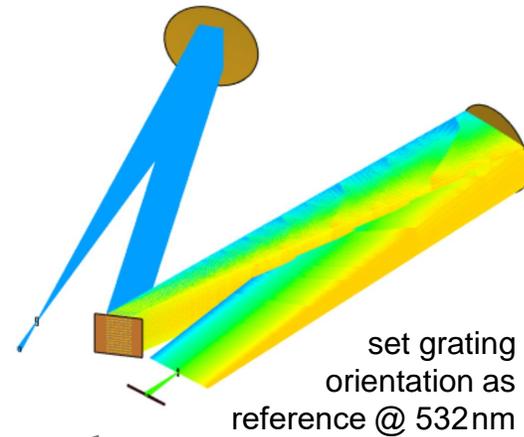
The FMM (“Fourier Modal method”) algorithm calculates the diffraction efficiency of the sawtooth grating rigorously. As the setup translates wavelength into spatial information, the same behavior is expected of the energy density distribution at the detector plane.



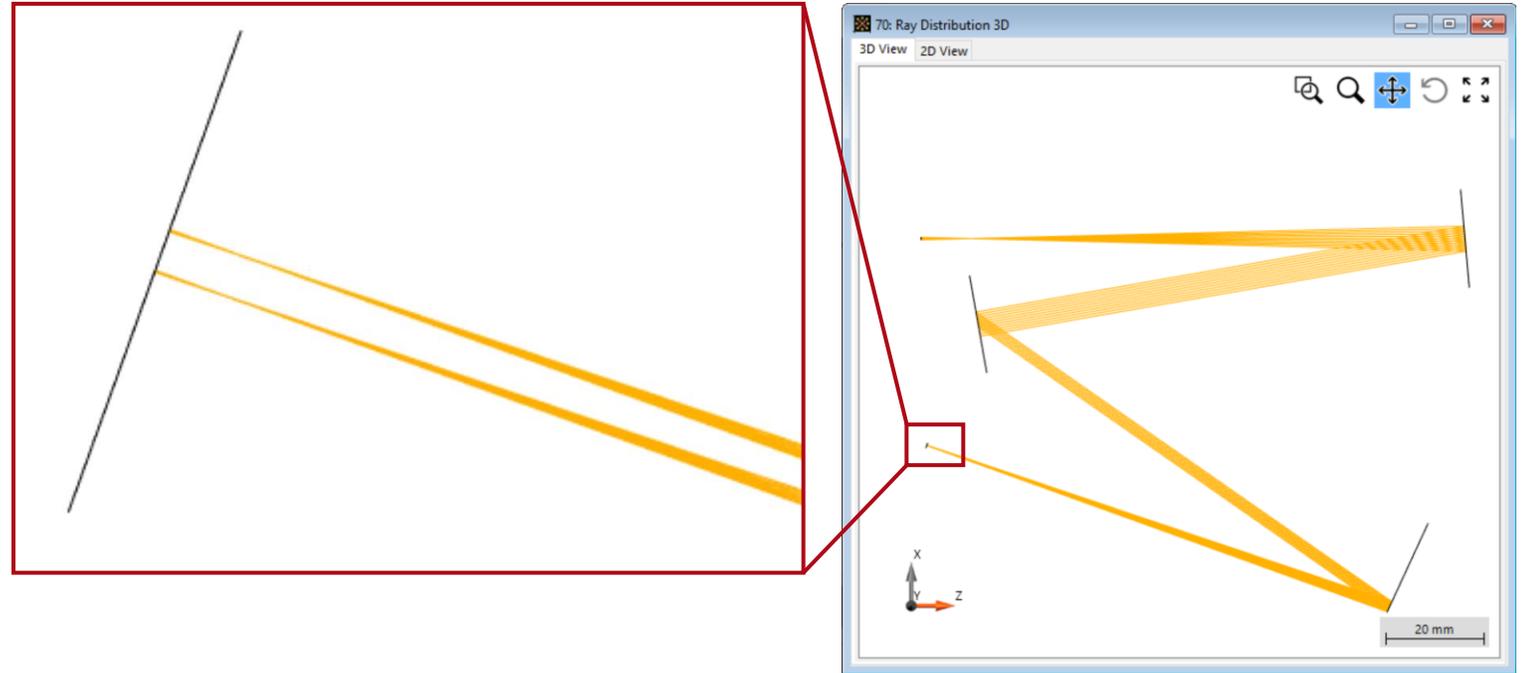
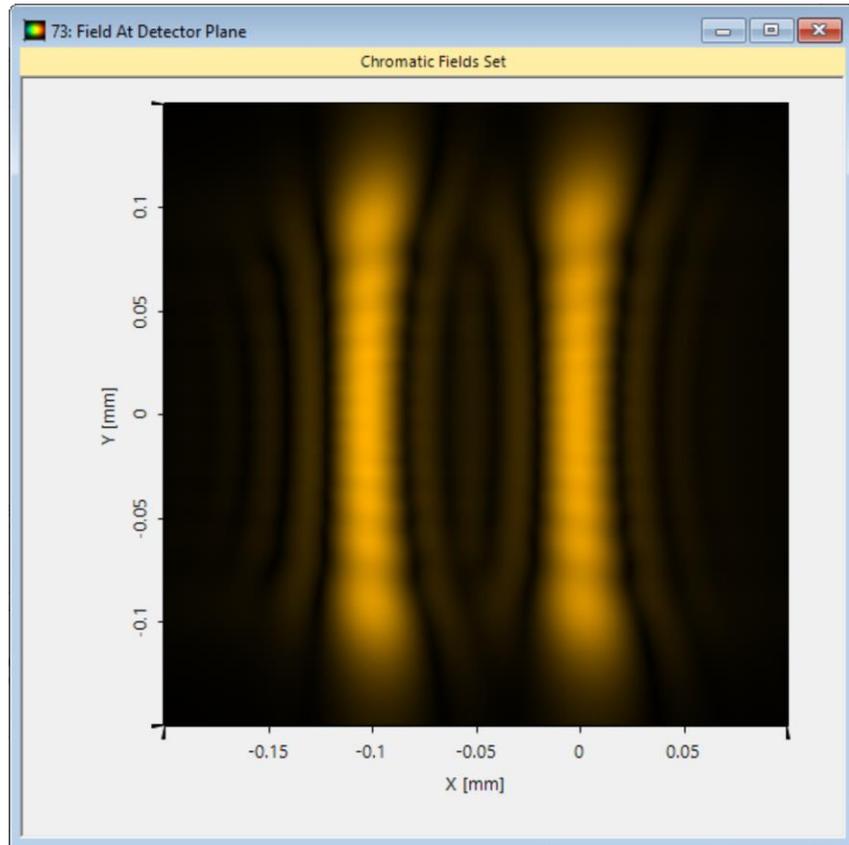
**Note: to demonstrate the wavelength depended behavior of the efficiency, the aperture has been removed for this experiment.*

Automatic Rotation of Grating

By using *Parameter Coupling*, the system will automatically adjust to facilitate the detection of the intended wavelength.



Application Example: Sodium Doublet Resolution



When propagating into the focus of the second mirror, the separation between the two wavelengths can be visualized. Depending on the simulation settings, diffraction effects caused by the apertures can be included in the simulation. For more details see:

[Resolving Sodium Doublet by Using a Czerny-Turner Setup](#)

Document Information

title	Czerny-Turner Setup
document code	GRT.0030
document version	2.0
software edition	VirtualLab Fusion Advanced
software version	2021.1 (Build 1.180)
category	Application Use Case
further reading	<ul style="list-style-type: none">- <u>Grating Component</u>- <u>Coherence Measurement Using Michelson Interferometer and Fourier Transform Spectroscopy</u>- <u>Resolving Sodium Doublet by Using a Czerny-Turner Setup</u>