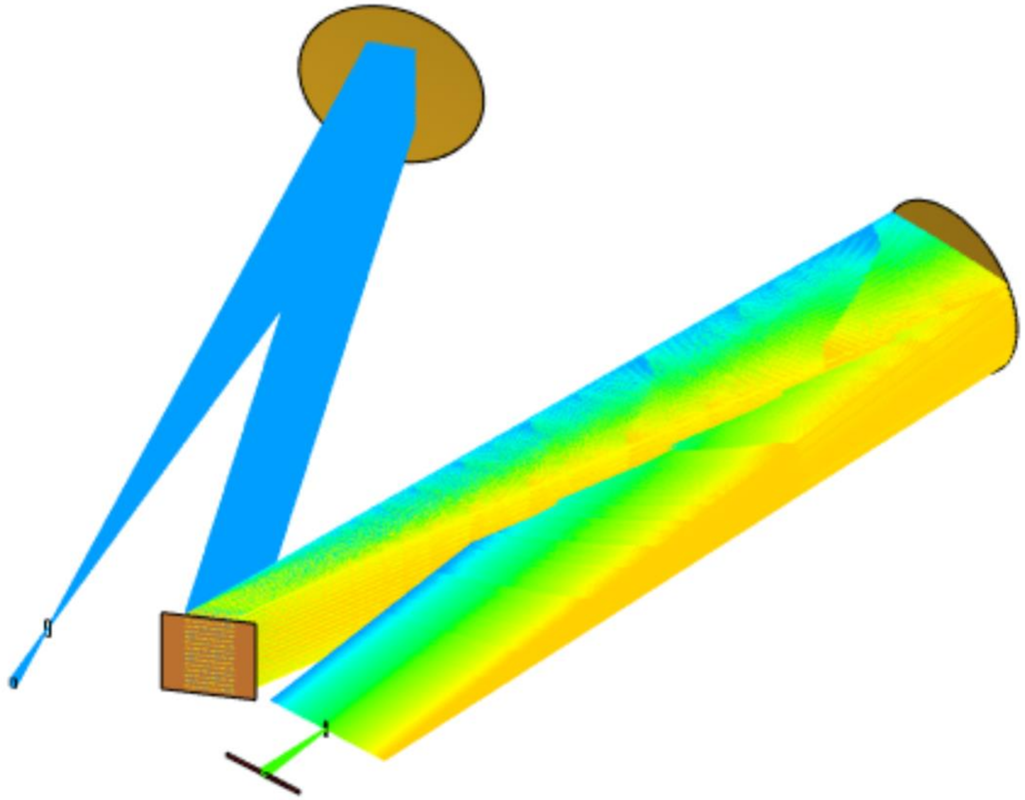
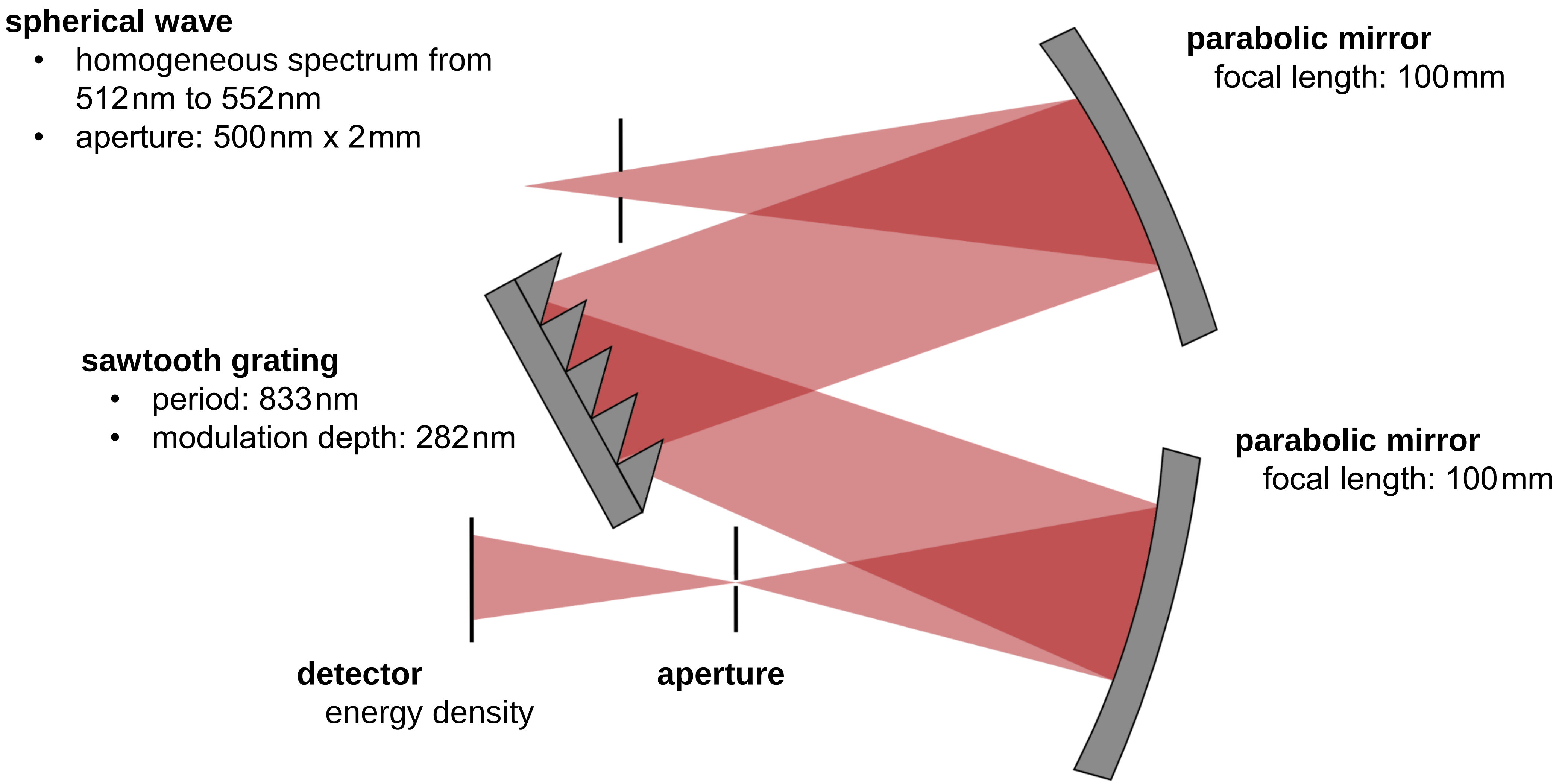
Czerny-Turner Setup

Abstract

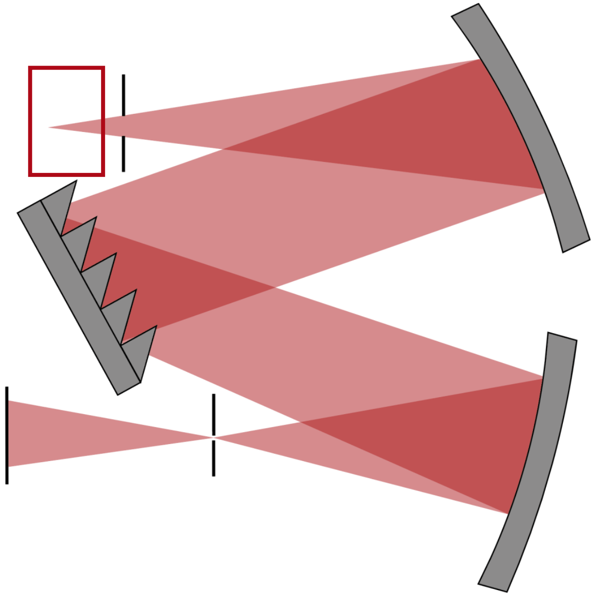


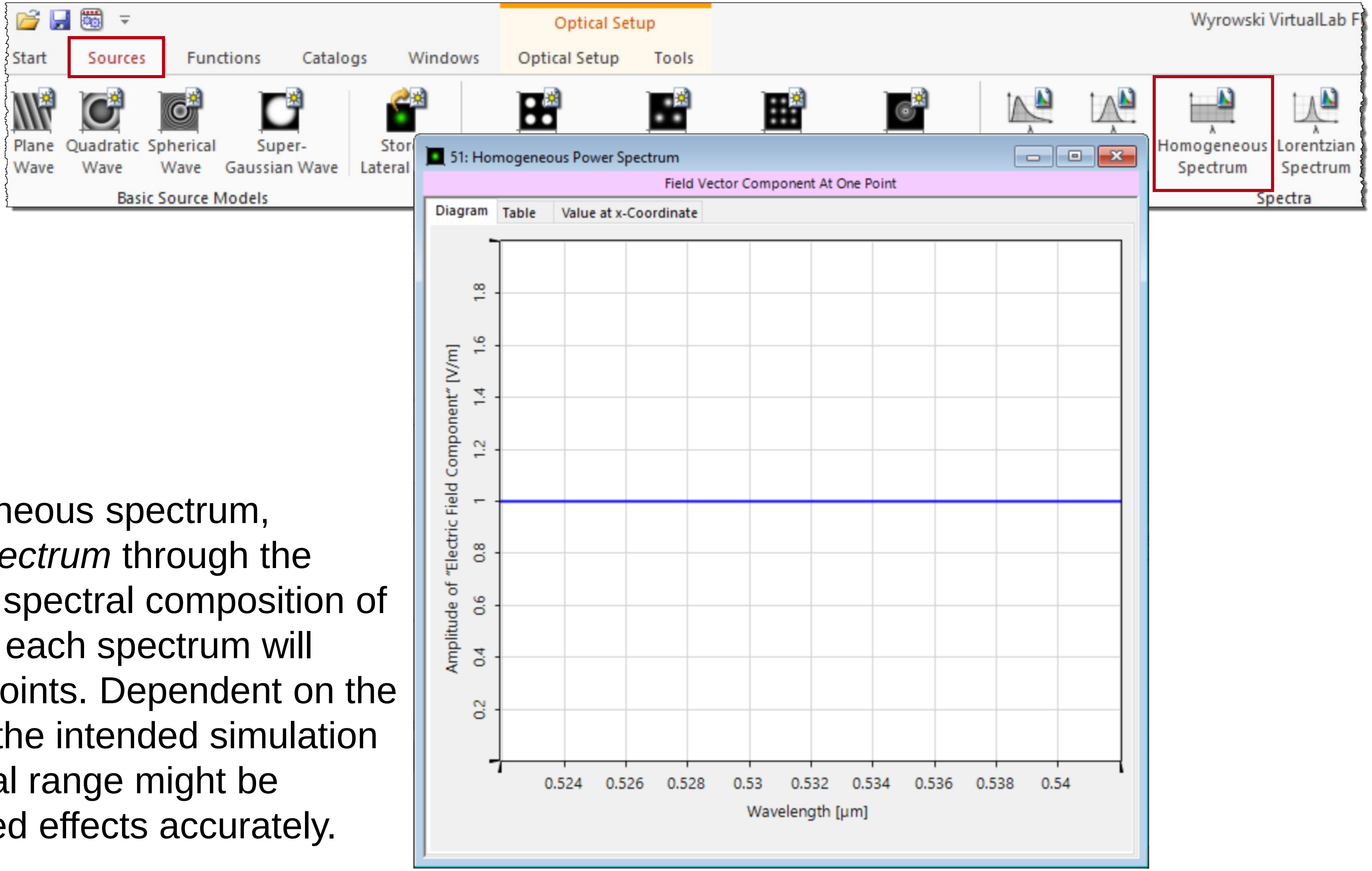
Czerny-Turner setups are widely used to measure the spectral information of light sources. Typically, a parabolic mirror is used to collimate the source first, and then a diffraction grating will spatially separate the wavelengths. A second mirror can be employed to refocus each of the now separate wavelength 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



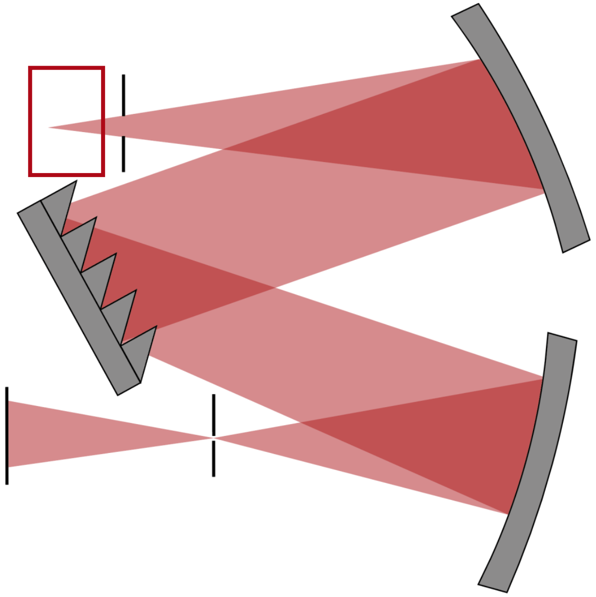
System Building Blocks – Homogeneous Power Spectrum



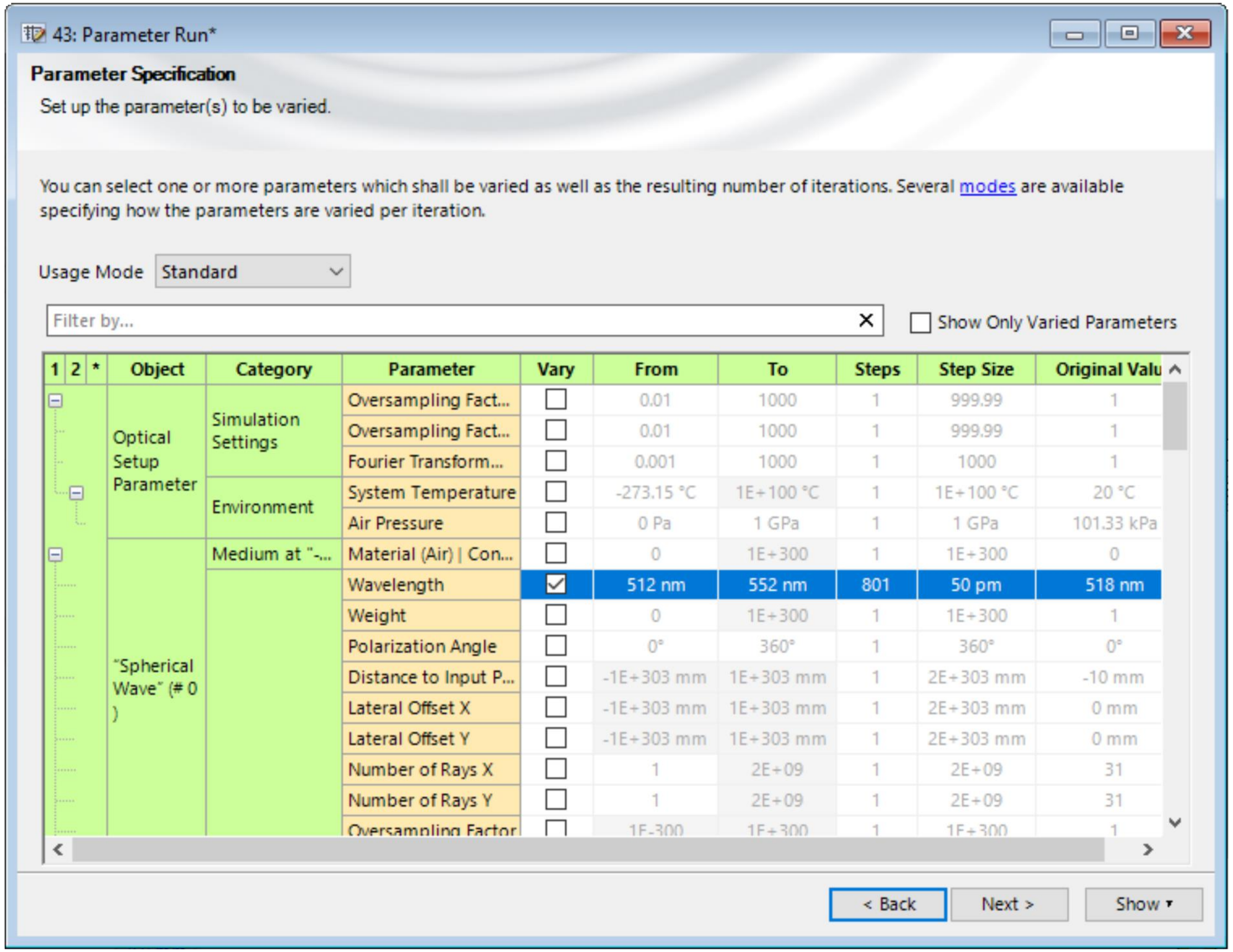


To model light with a homogeneous spectrum, generate a *Homogeneous Spectrum* through the *Sources* tab and use it as the spectral composition of the source. Keep in mind that each spectrum will consist of discrete sampling points. Dependent on the particular optical system and the intended simulation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

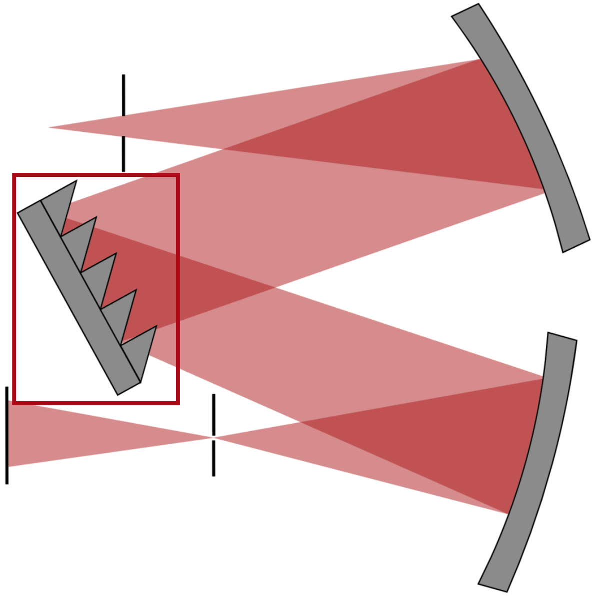
System Building Blocks – Homogeneous Power Spectrum

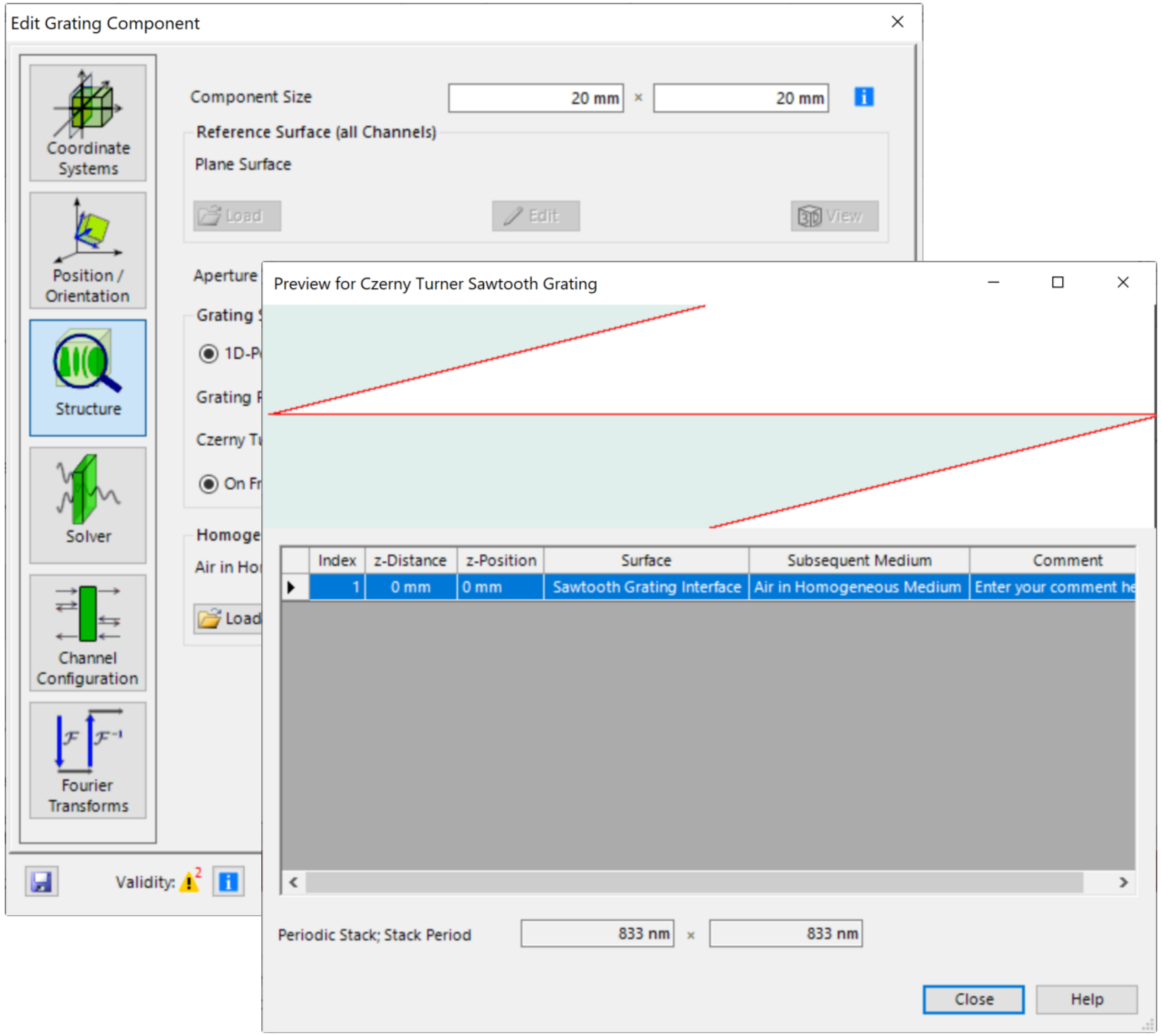


Alternatively, a *Parameter Run* can be applied instead, to vary the wavelength in a specific range. This technique benefits from the option offered by the *Parameter Run* to retroactively add more wavelength samples to the spectrum, without the need to repeat the simulation with previous ones.



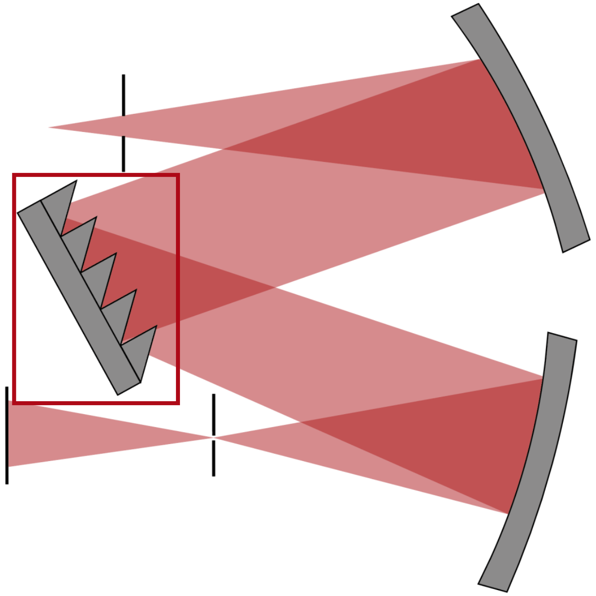
System Building Blocks – Sawtooth Grating

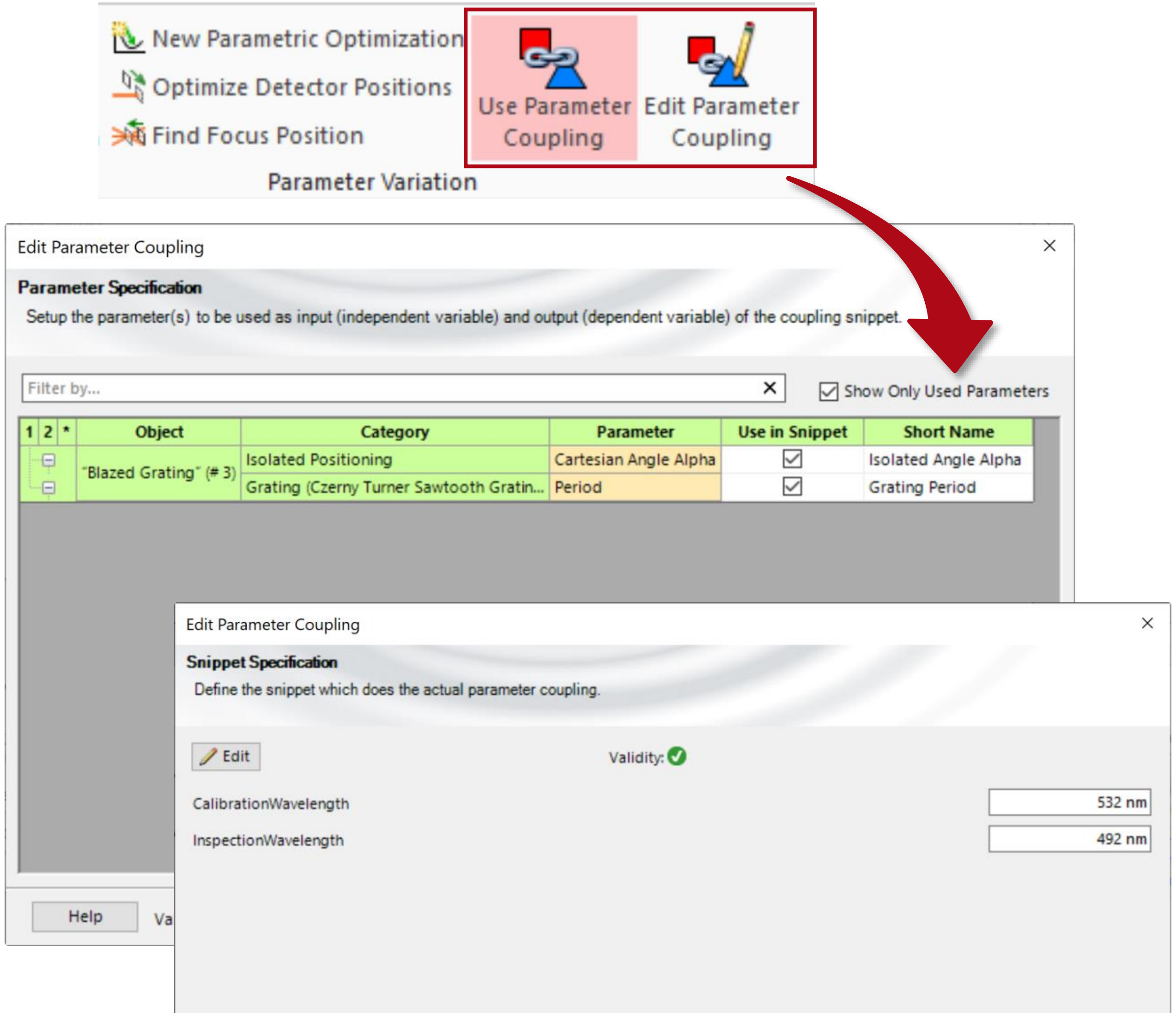




Grating structures, such as a sawtooth or blazed grating, are modeled by defining appropriate surfaces and media in a *Stack*. This *Stack* can then be imported into a variety of different components, depending on the intended use. In this case we investigate the overall wavelength dependency in a grating-specific 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.

Parameter Coupling



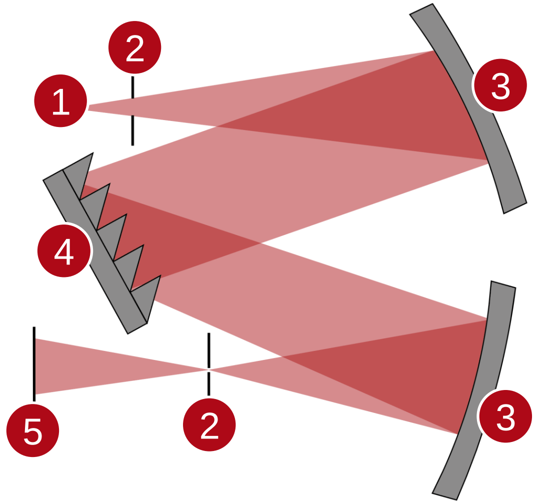


The *Parameter Coupling* feature can be used to link parameters of the system, so that a certain relationship between them is maintained. In this use case we want to adjust the angle of the grating automatically, depending on the which wavelength is investigated .

More information about the *Parameter Coupling* under:

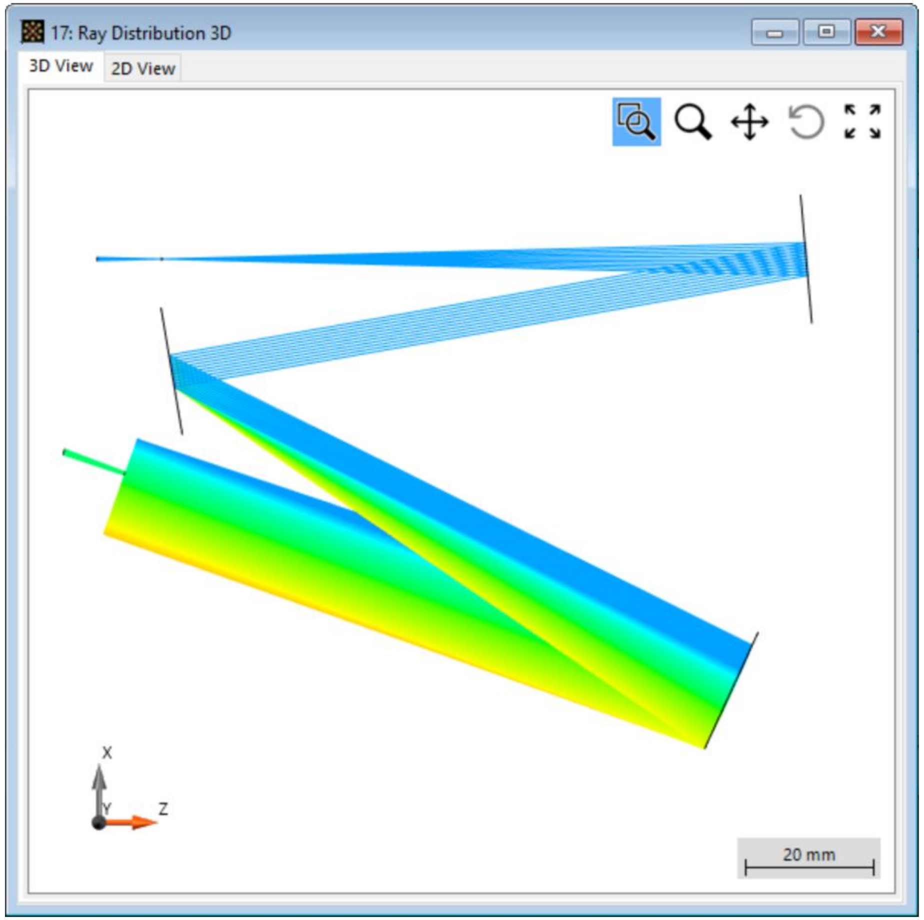
Coupling of Parameters in VirtualLab Fusion

Summary – Components...

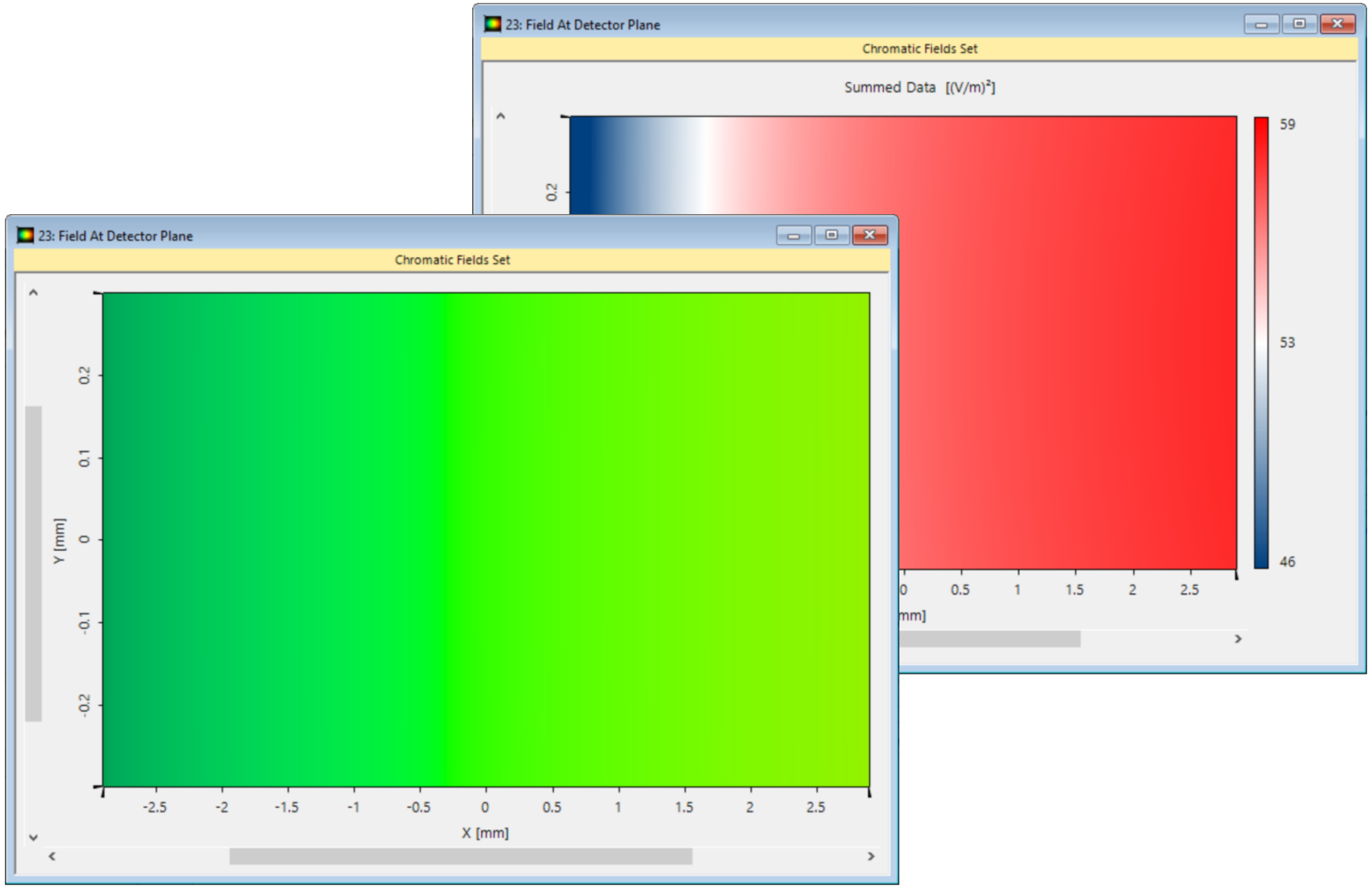


… of Optical System	… in VirtualLab Fusion	Model/Solver/Detected Value
1. source	*Spherical Wave* (with *Homogeneous Power Spectrum*)	point source (with homogeneous spectrum)
2. aperture	*Aperture*	transmission function
3. parabolic mirror	*Parabolic Mirror Component*	Linear Plane Interface Approximation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

System Impressions



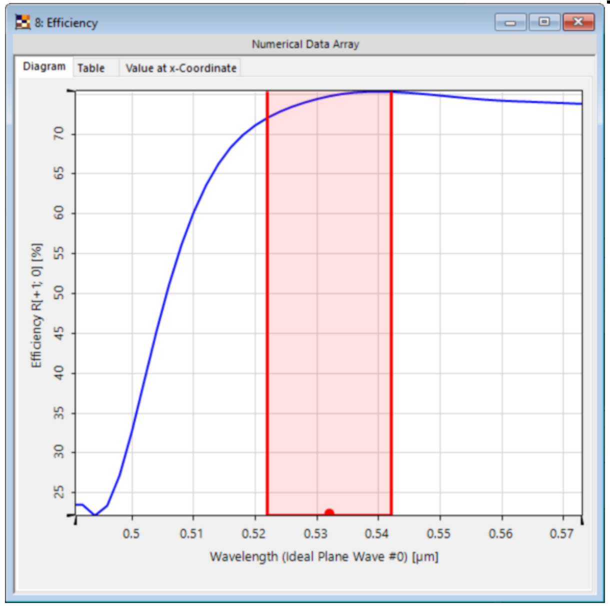
3D Ray Tracing visualization

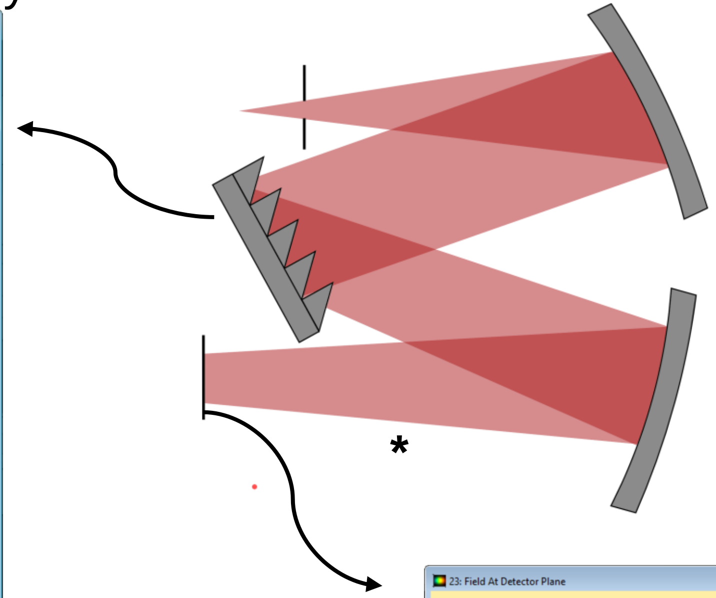


field visualization at detector plane in real and false color (without exit aperture)

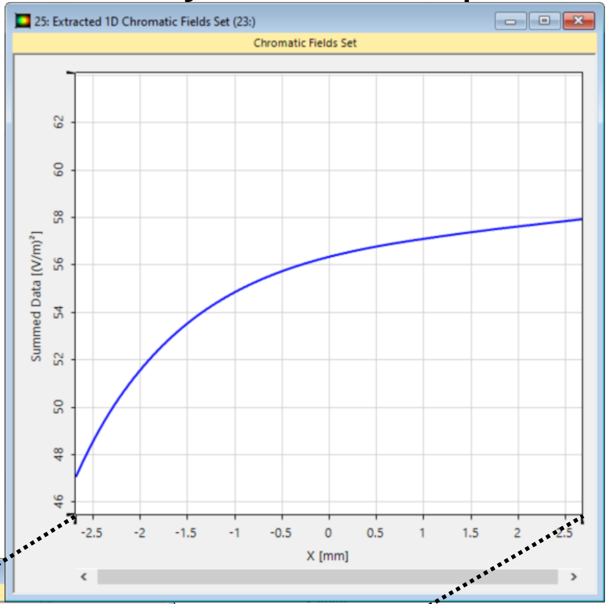
Grating Efficiency Calculation

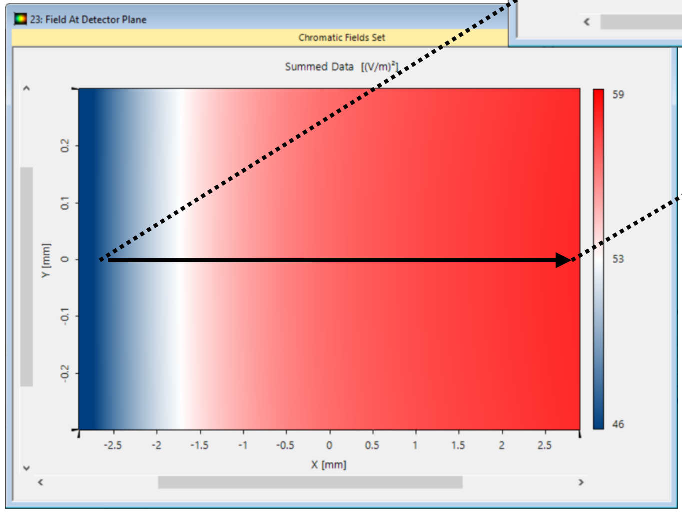
calculated diffraction efficiency





intensity at detector plane



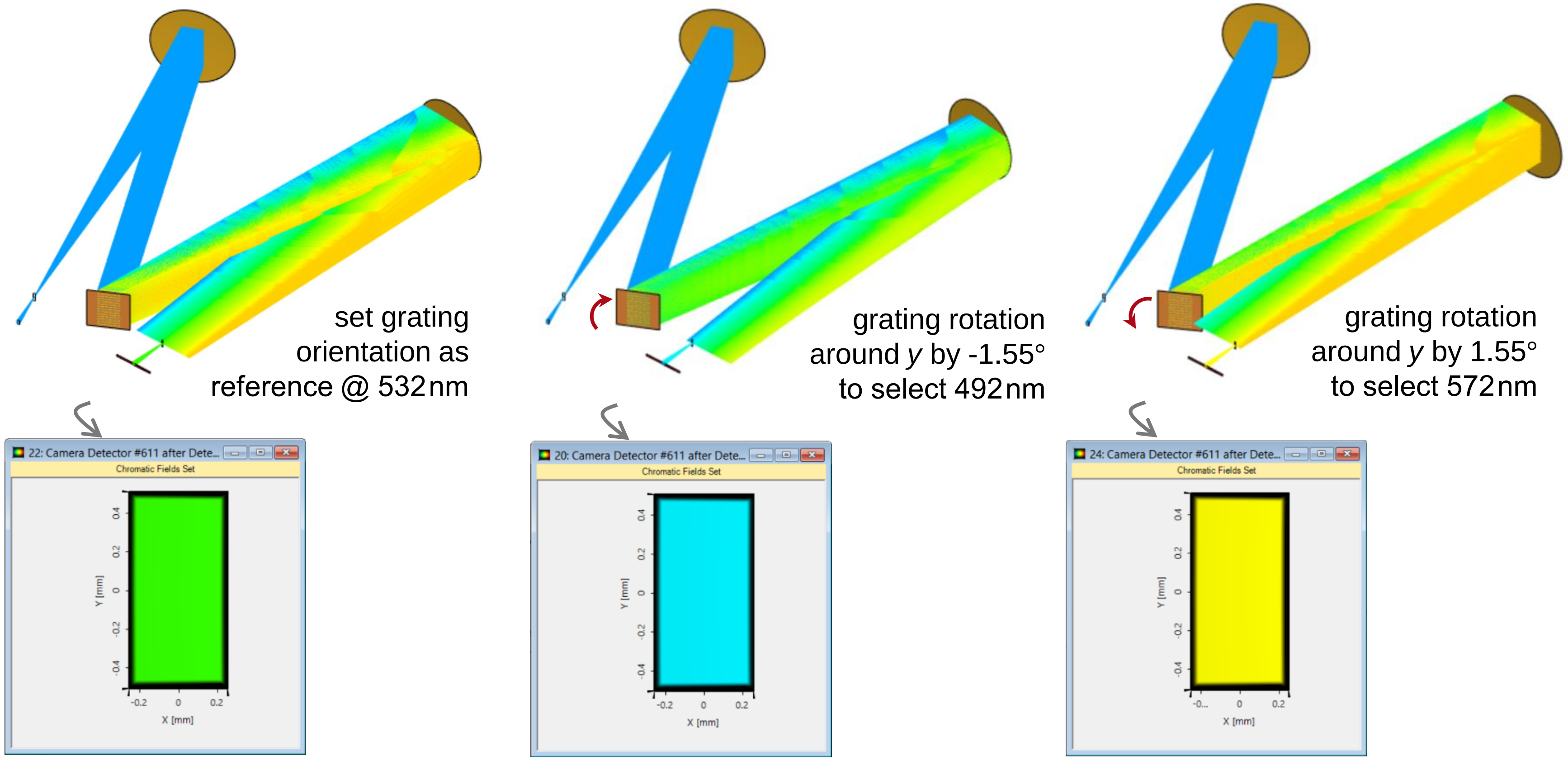


The FMM (“Fourier Modal method”) algorithm calculates the diffraction efficiency of the sawtooth grating rigorously. As the setup translates wavelength into spatial information, the same behavior is expected of the energy density distribution at the detector plane.

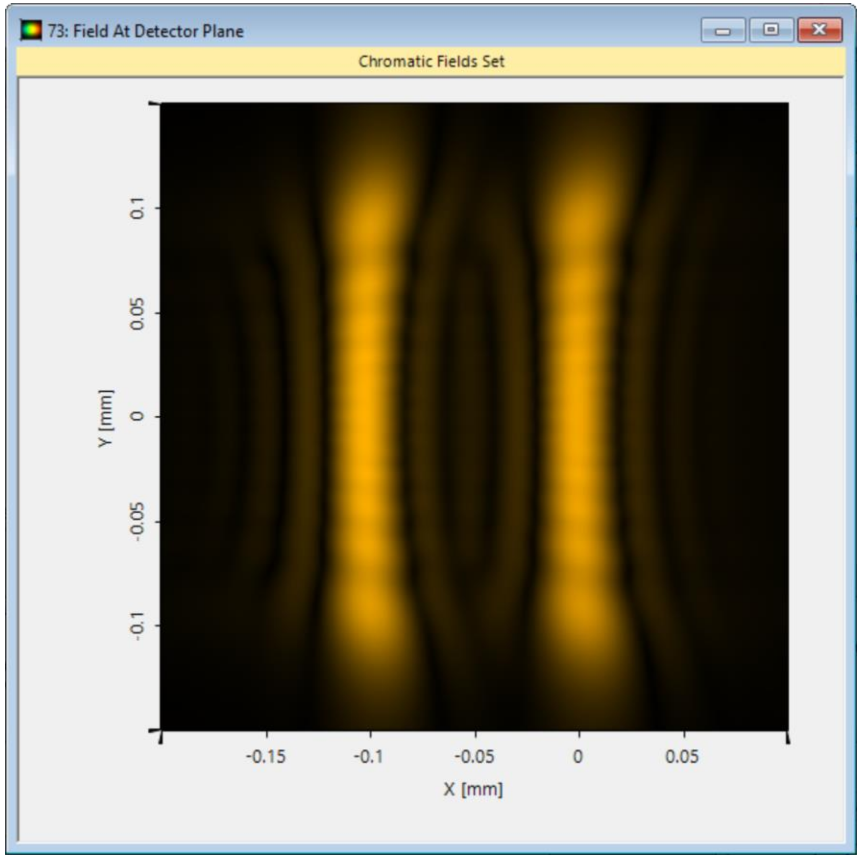
**Note: to demonstrate the wavelength depended behavior of the efficiency, the aperture has been removed for this experiment.*

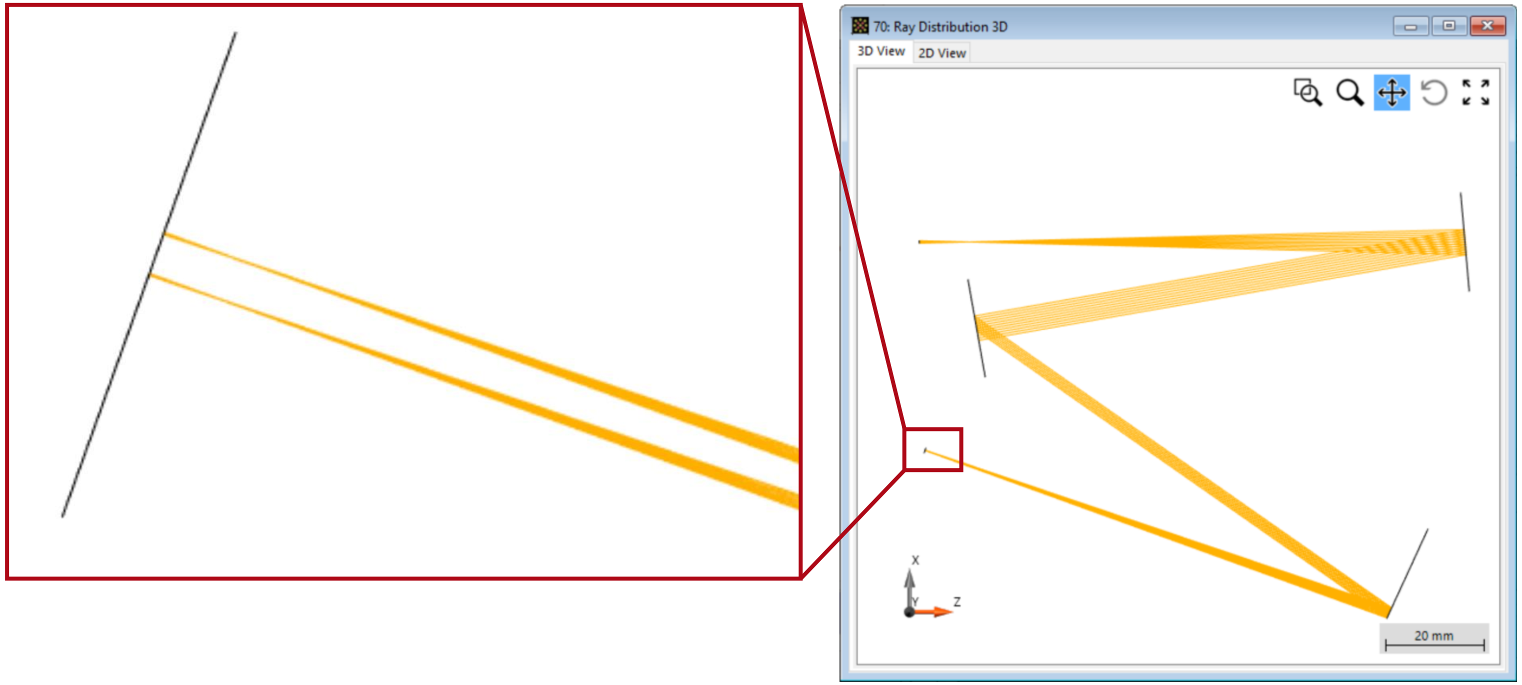
Automatic Rotation of Grating

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	- Grating Component - Coherence Measurement Using Michelson Interferometer and Fourier Transform Spectroscopy - Resolving Sodium Doublet by Using a Czerny-Turner Setup