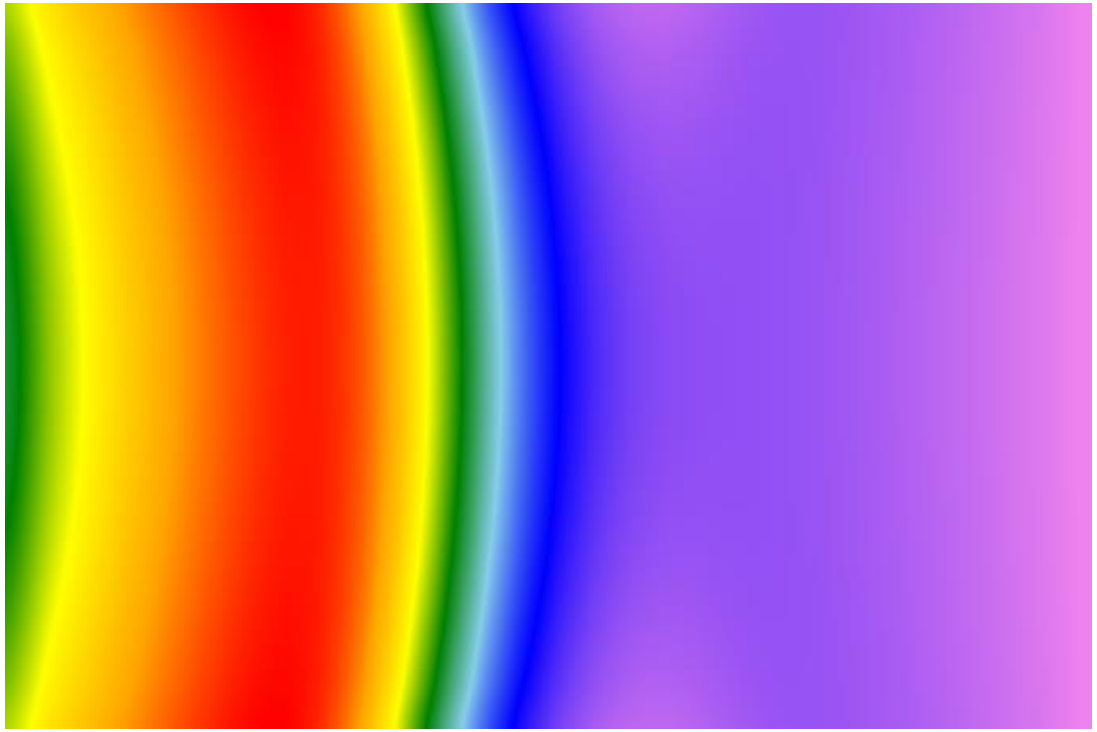
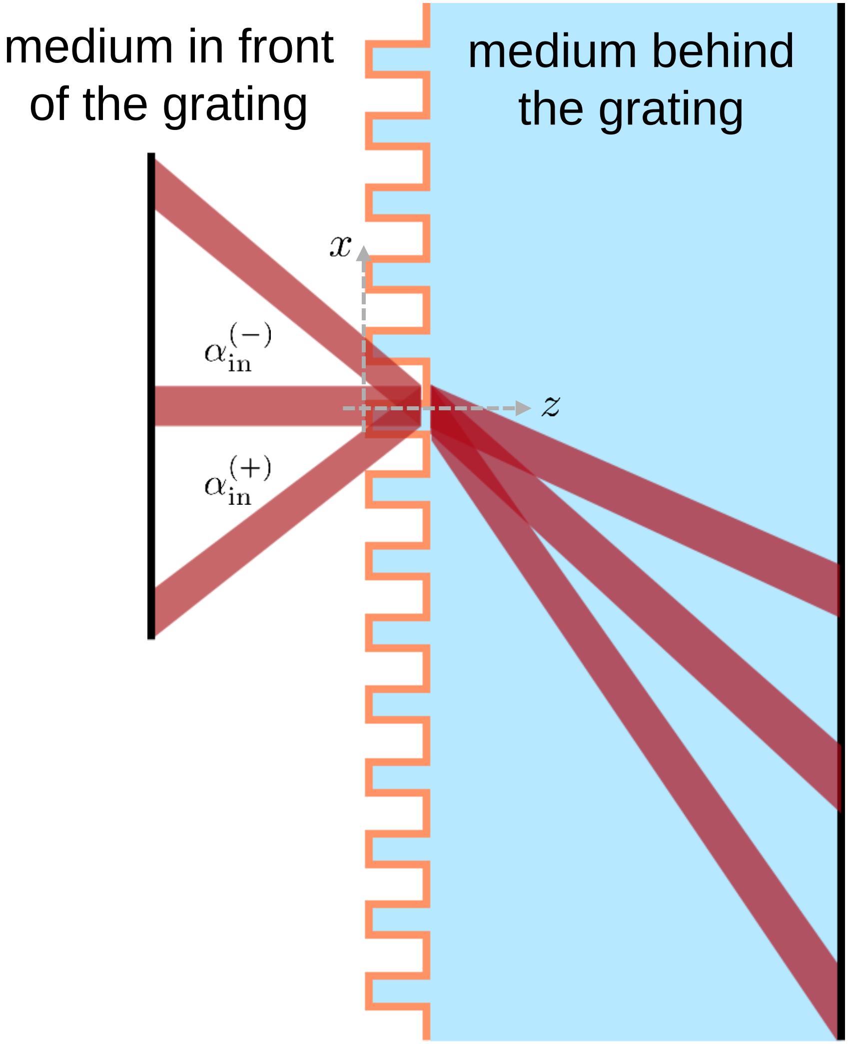
Customized Detector for Lightguide Coupling Grating Evaluation

Abstract



A customized detector is generated to calculate the diffraction efficiencies of a one-dimensional periodic structure, as a function of the incident directions over a user-defined range. From the efficiencies the mean value and the contrast of the diffraction efficiencies can be evaluated within the defined field of view, and can be used to define a merit function for further possible parametric optimization.

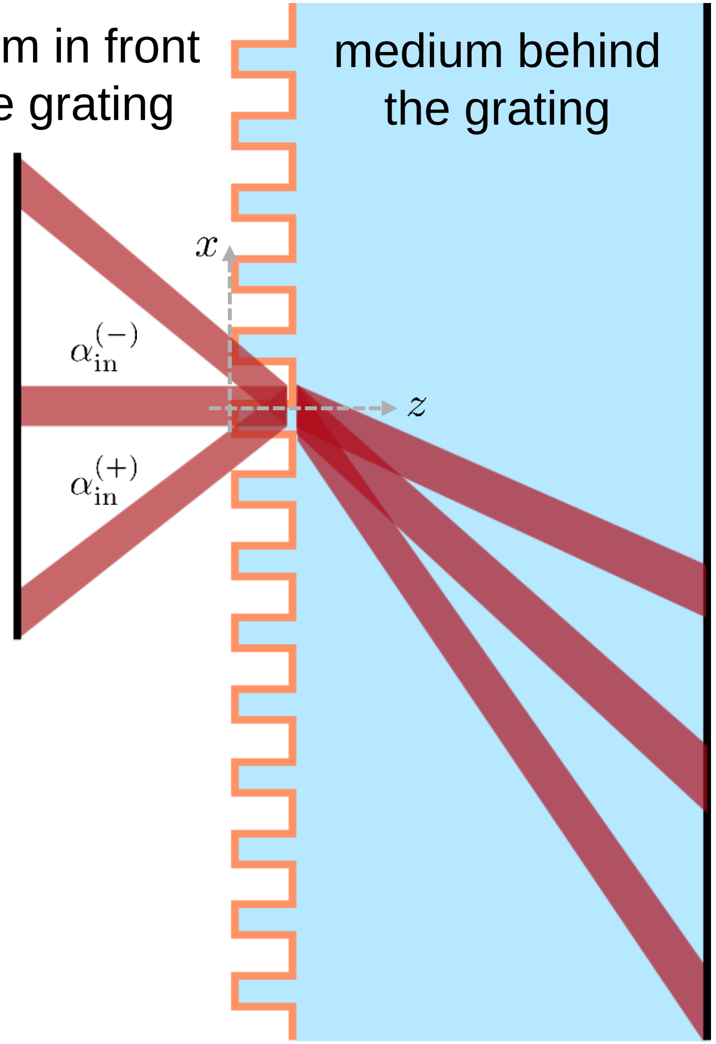
Modeling Task



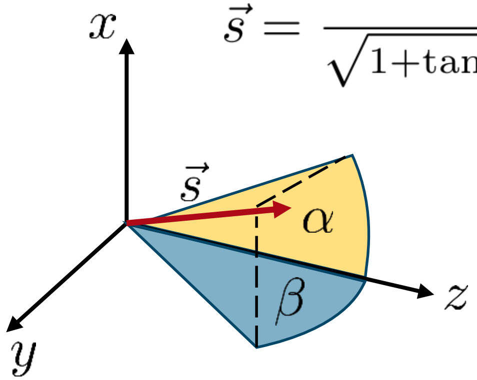
Task:
Generate a detector to evaluate the performance (mean efficiency, uniformity) of waveguide coupling grating for a given field of view (FOV).

The detector can be used to analyze a specified diffraction order, either in transmission or reflection mode.

Definition of Field of View (FOV)



$$\vec{s} = \frac{1}{\sqrt{1+\tan^2\alpha+\tan^2\beta}}(\tan\alpha, \tan\beta, 1)^T$$

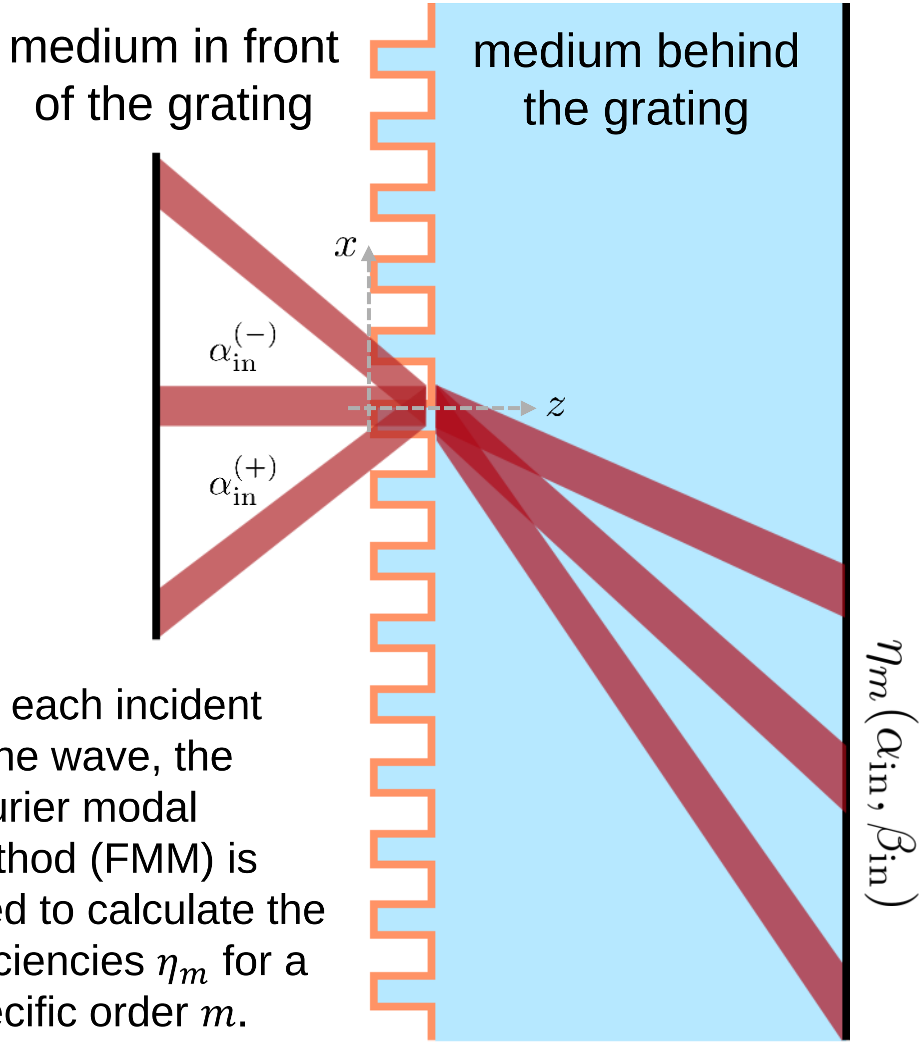


The field of view is defined as a set of plane waves with certain incident directions specified by Cartesian angles.

```
// calculate unit vector from cartesian angle definition
Vector3D incidentDirectionForGratingAnalysis;
DirectionConversion.UnitVectorFromCartesianAngles(
     currAngleX,
     currAngleY,
     out incidentDirectionForGratingAnalysis);
```

Variable	Value	Allowed range
VectorD currAngleX	(-15,15)°	[-90,90]°
VectorD currAngleY	(-10,10)°	[-90,90]°

Calling Fourier Modal Method (FMM)



For each incident plane wave, the Fourier modal method (FMM) is used to calculate the efficiencies η_m for a specific order m.

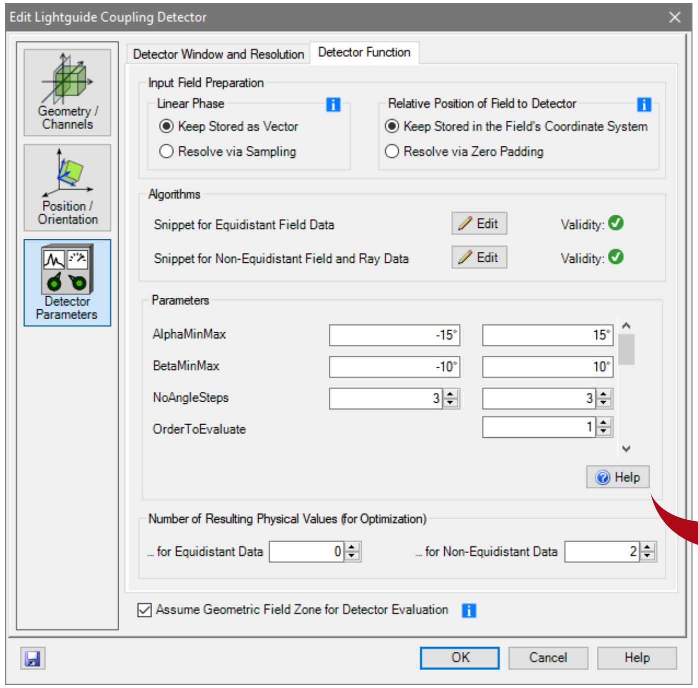
```
//perform Fourier modal methods
RigorousSimulationResult1D FMMResults = GetRayleighCoefficents(
         wavelength,
         incidentDirection,
         stack,
         mediumBefore,
         mediumBehind);

//extract order information from FMM result
OrderInfo currOrder = FMMResults.GetOrder(OrderToEvaluate);

//extract the efficiency data
currEfficiency = currOrder.Efficiency;
```

Variable	Comment
double currWavelength	wavelength in [m]
Vector3D incidentDirection	calculated from FOV
OpticalStack stack	1D-periodic grating
HomogeneousMedium mediumBefore	medium in front of the grating
HomogeneousMedium mediumAfter	medium behind the grating
int OrderToEvaluate	specified diffraction order m

Overview of the Input Parameters using the Detector Help



Lightguide Coupling Detector

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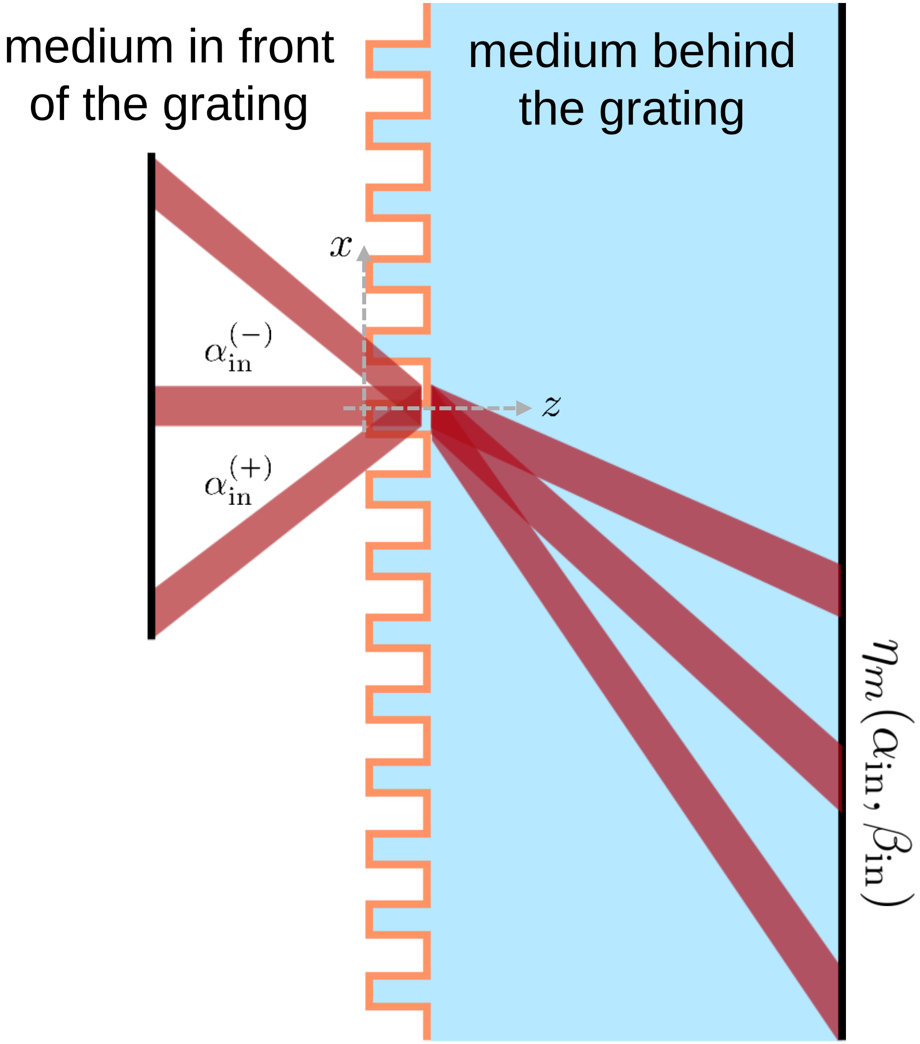
Version: 2.2
Last Modified: Wednesday, November 28, 2018

This detector calculates the diffraction order efficiency for a user-specified field of view defined by a set of plane waves with different incident directions represented by the cartesian angles alpha and beta. Please note that the polarization and the incident field of view is defined in the detector settings. A one-dimensional periodic stack is defined to represent the structure, which is evaluated. The detector calculates the uniformity error (contrast) and the mean efficiency. These parameters can be used within the parameter run or for parametric optimization.

PARAMETER	DESCRIPTION
AlphaMinMax	Field of view specification for the Cartesian angle alpha. The first value of the vector defines the minimum. The second value defines the maximum value.
BetaMinMax	Field of view specification for the Cartesian angle beta. The first value of the vector defines the minimum. The second value defines the maximum value.
NoAngleSteps	The number of steps that shall be used to analyze the specified field of view. The first value defines the number of steps for alpha, the second value the number of steps for beta.
OrderToEvaluate	The order number to be evaluated during the FOV analysis.
Transmission	Boolean flag whether transmission (true) or reflection (false) shall be evaluated.
ShowEfficiencyDistribution	Boolean flag whether the detector also shall plot the 1D or 2D efficiency distribution evaluated for the given field of view. For optimization we recommend to turn of the output to save time.
Ex	The value of the Ex component of the illuminating field vector. The field vector is given with respect to the coordinate system of the incident FOV angle.
Ey	The value of the Ey component of the illuminating field vector. The field vector is given with respect to the coordinate system of the incident FOV angle.
NumberOfEvanescentOrders	Numerical control parameter of the Fourier modal method to control the calculation accuracy.
AccuracyLayer	For the Fourier modal method the geometry (stack) is converted into transition points and layers. This accuracy factor controls the number of layers.
StackOnFrontSide	If activated, the stack is placed on front side of the component otherwise it is place at the back side.
ShowDecompositionPreview	If activated, the preview of the layer decomposition is shown.
MediumBefore	The medium in front of the grating.
MediumBehind	The medium behind the grating.
Grating_Stack	The stack that defines the grating structure. (can be loaded from catalog)

Evaluation of the Detector Results

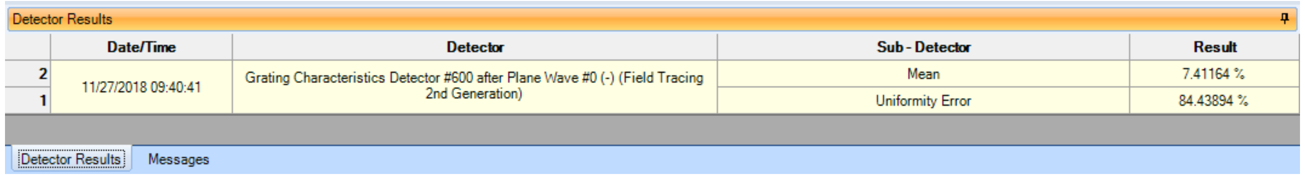


As a result, the detector calculates the mean efficiency and the uniformity contrast according to the efficiencies as a function of the incident directions of a set of plane waves for a specific diffraction order m.

The uniformity contrast (or error) is calculated as

$$u_e = \frac{\eta_m^{\max} - \eta_m^{\min}}{\eta_m^{\max} + \eta_m^{\min}}.$$

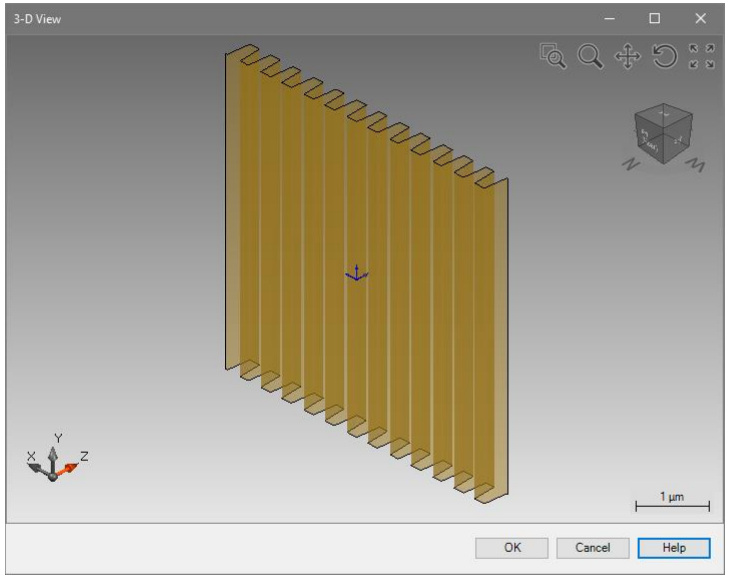
The calculated values are shown in the Detector Results tab of VirtualLab Fusion.


Detector Results

	Date/Time	Detector	Sub - Detector	Result
2	11/27/2018 09:40:41	Grating Characteristics Detector #600 after Plane Wave #0 (-) (Field Tracing 2nd Generation)	Mean	7.41164 %
1			Uniformity Error	84.43894 %

Detector Results Messages

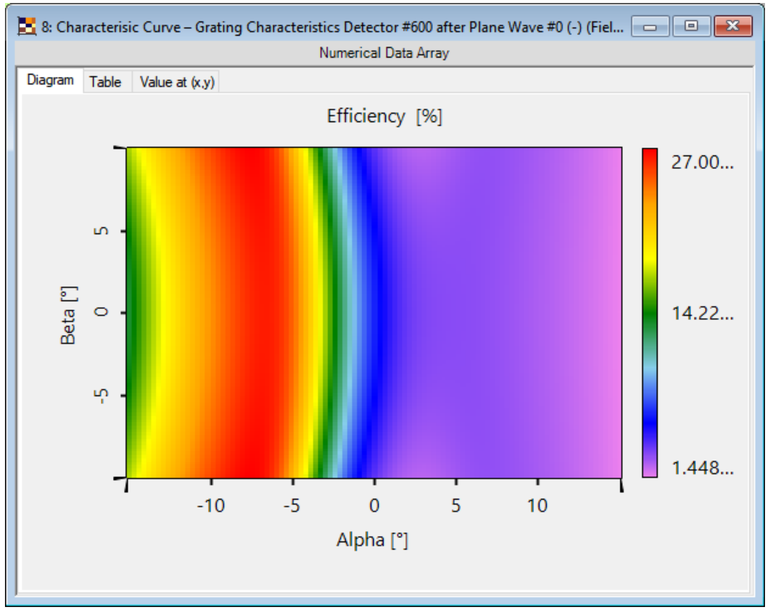
Lightguide Coupling Analysis of a Rectangular Grating

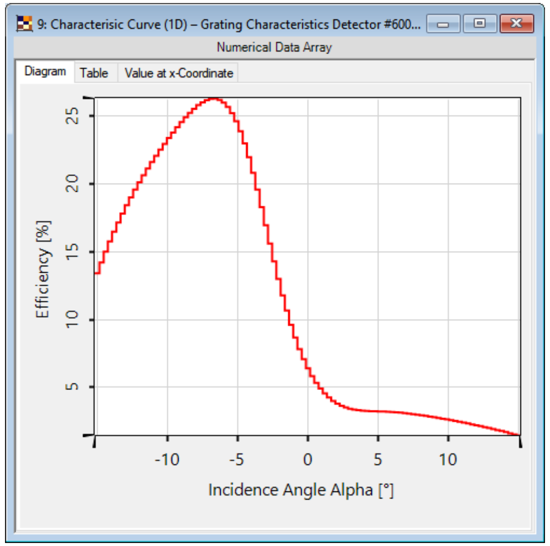


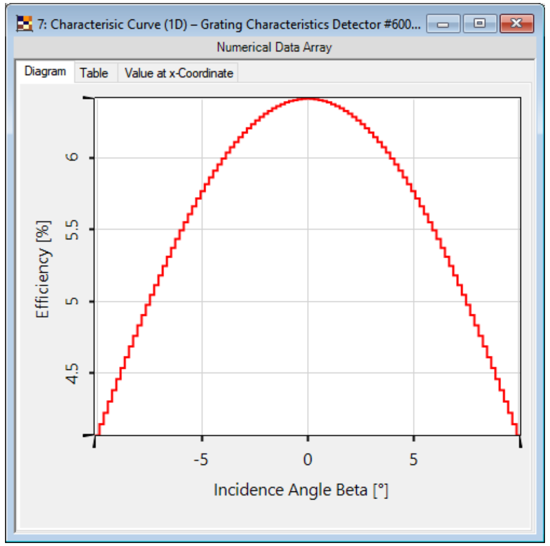
wavelength	532 nm
field of view	(±15°, ±10°)
grating type	rectangular grating
grating period	410 nm
modulation depth	400 nm
fill factor	50%
diffraction order	transmission +1st

The detector enables the evaluation of the efficiency distribution for a specific field of view interacting with a rectangular grating structure.

mean efficiency	11.2 %
uniformity contrast	89.8 %







Document Information

title	Customized Detector for Lightguide Coupling Grating Evaluation
document code	CZT.0107
version	1.0
toolbox(es)	Starter Toolbox, Grating Toolbox
VL version used for simulations	7.4.0.49
category	Feature Use Case
further reading	- How to Work with the Programmable Detector and Example (Minimum and Maximum Wavelengths) - Programming a Degree of Coherence Detector