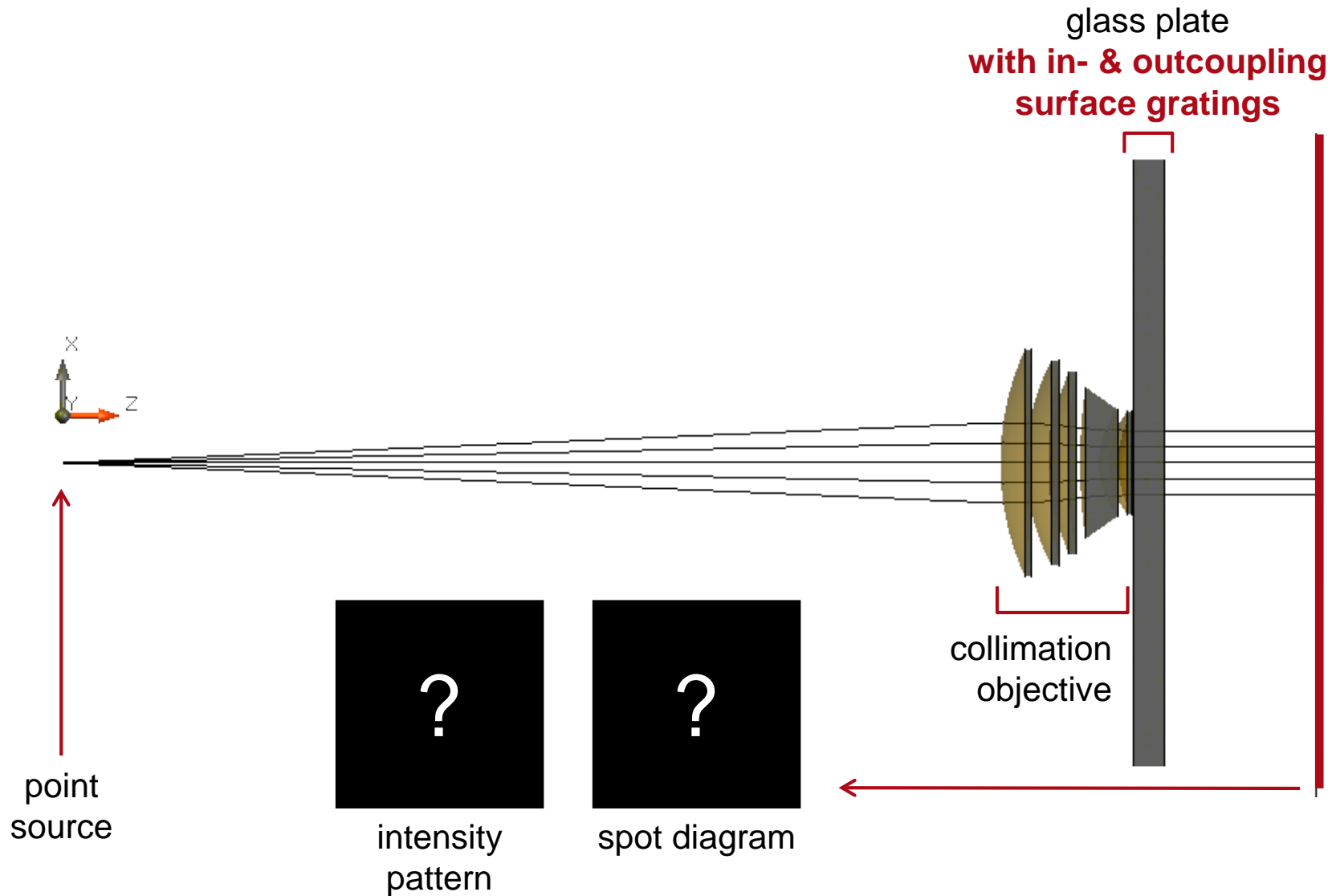


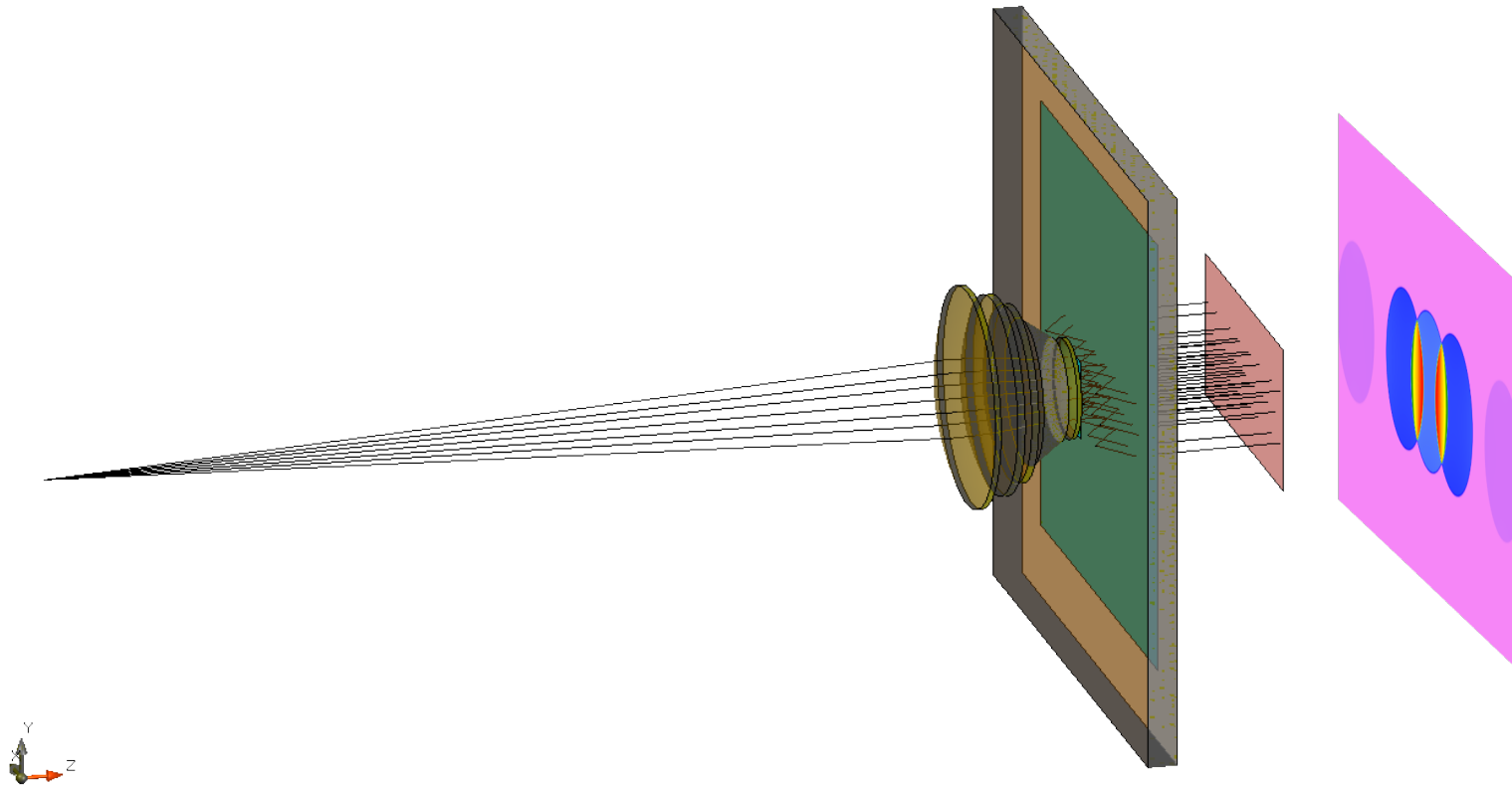
Virtual & Mixed Reality > Near-Eye Displays

# **Light Propagation through Waveguide with In- & Outcoupling Surface Gratings**

# Task/System Illustration

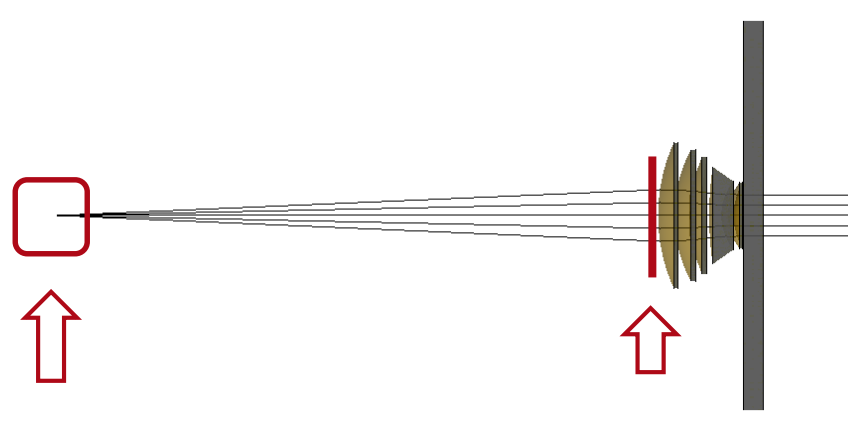


# Highlights



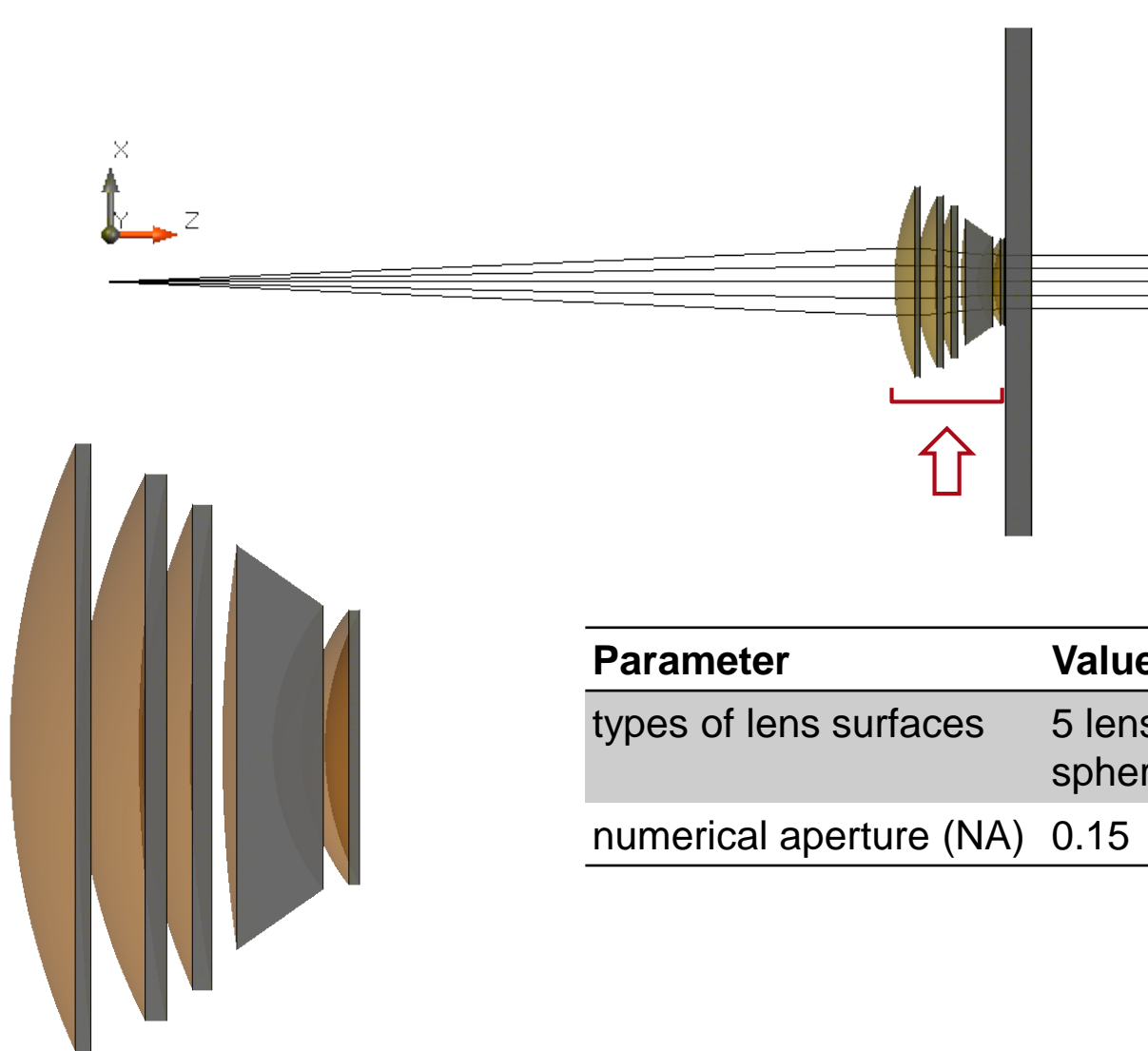
tailored light guiding within a waveguide  
using surface gratings

# Specification: Light Source



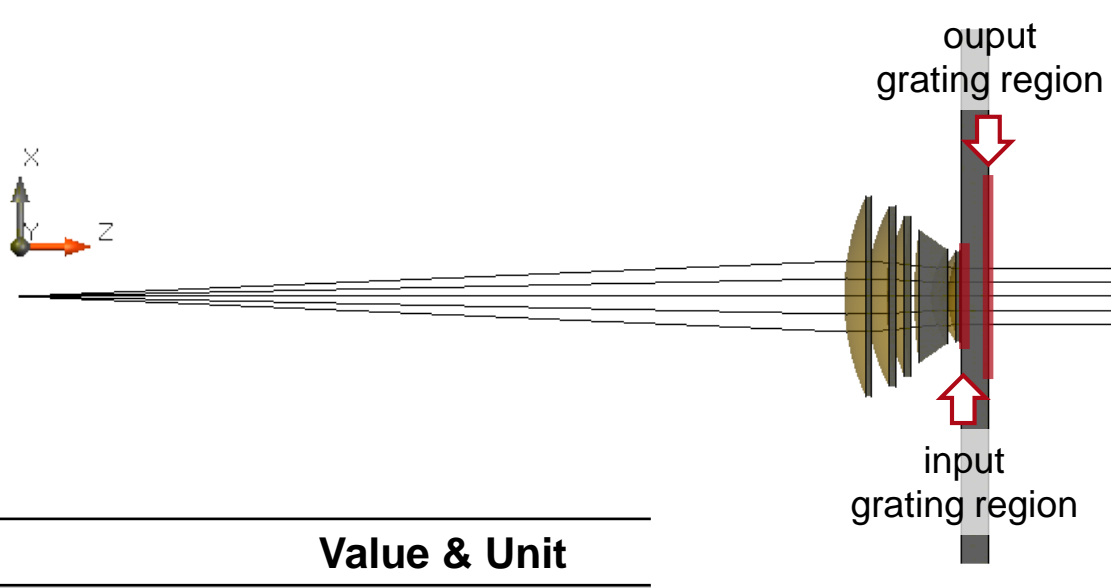
| Parameter                | Description / Value & Unit    |
|--------------------------|-------------------------------|
| type/number              | spherical wave (point source) |
| wavelength               | 532nm                         |
| polarization             | linear in x-direction (0°)    |
| lateral offset           | 0 × 0                         |
| distance to next surface | 30.955mm                      |
| aperture at next surface | 2.5mm × 2.5mm                 |

# Specification: Collimating Lens

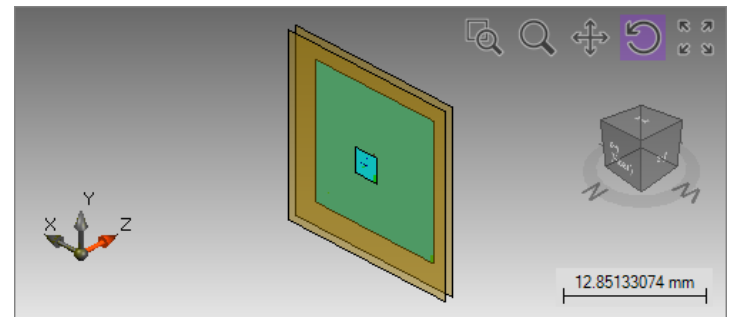


| Parameter               | Value & Unit                        |
|-------------------------|-------------------------------------|
| types of lens surfaces  | 5 lenses with 10 spherical surfaces |
| numerical aperture (NA) | 0.15                                |

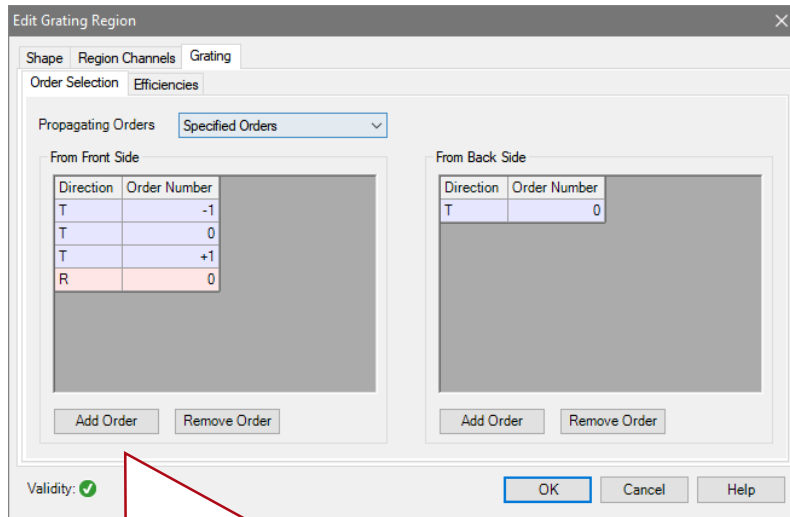
# Specification: Waveguide



| Parameter              | Value & Unit    |
|------------------------|-----------------|
| type                   | parallel planes |
| thickness              | 1 mm            |
| material               | fused silica    |
| input region size      | 2.7 mm × 2.7 mm |
| input region position  | 0 × 0           |
| output region size     | 15 mm × 15 mm   |
| output region position | 0 × 0           |

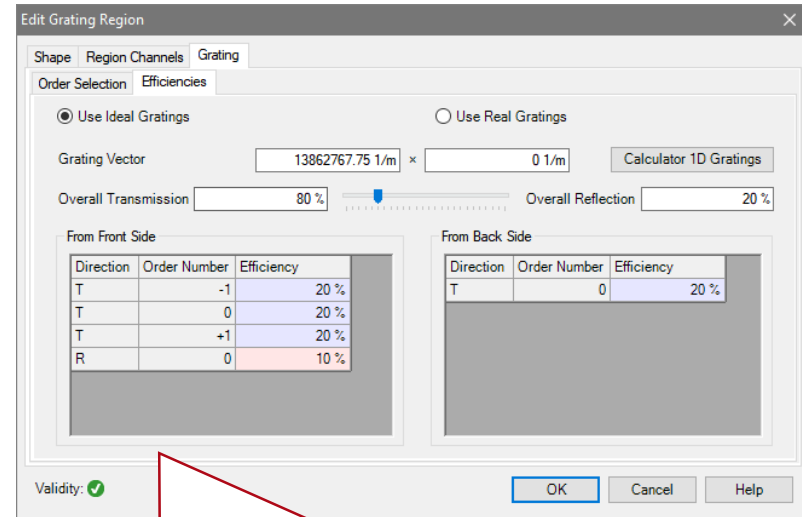


# Specification: Grating Surfaces



selection of regarded diffraction orders (... , -2, -1, 0, +1, +2, ... ) per

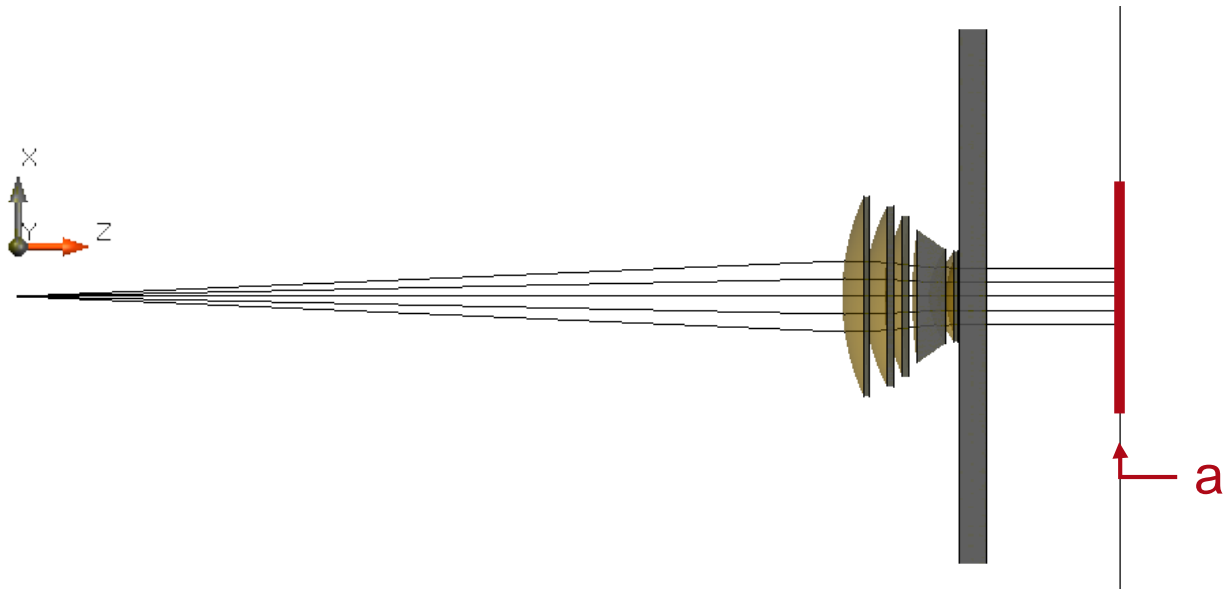
- grating region
- regarded incident direction (from front & back side)
- transmission (T) & reflection (R) channel



- specification of grating vector and period respectively
- specification of efficiency per diffraction order
- easy to use balance of overall transmission & reflection efficiencies

*Efficiencies impact the non-sequential ray and field tracing convergence (→ energy threshold).*

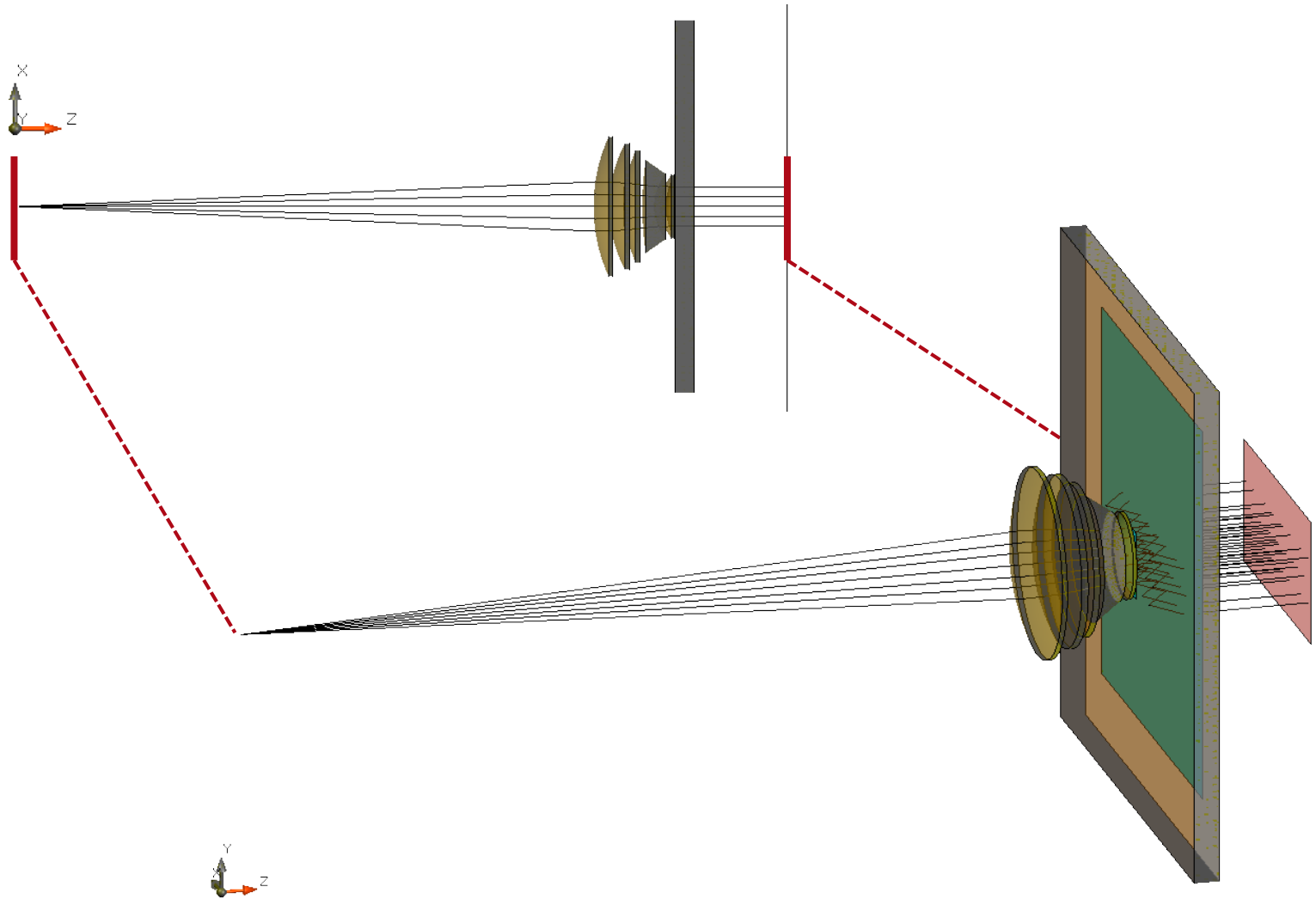
# Specification: Detectors



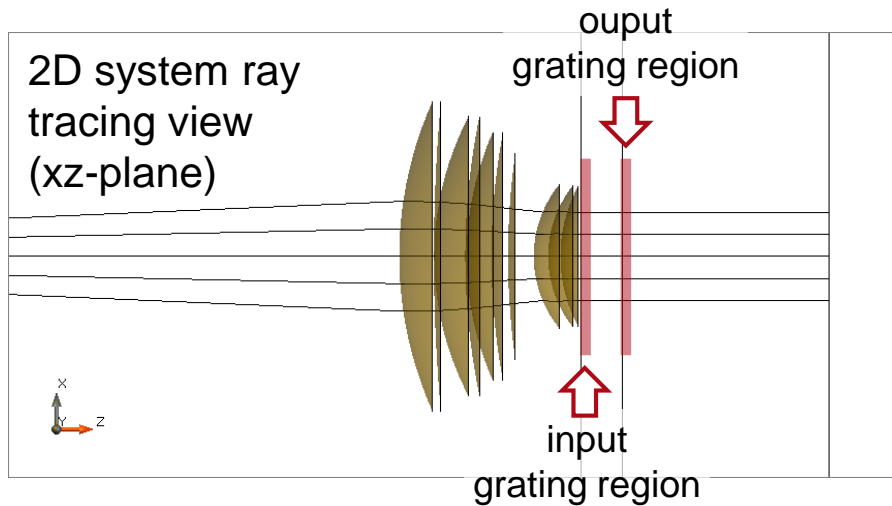
| Position    | Modeling Technique | Detector/Analyzer   |
|-------------|--------------------|---------------------|
| full system | 3D ray tracing     | 3D ray tracing view |
| a           | field tracing      | intensity pattern   |



# Results: 3D System Ray Tracing



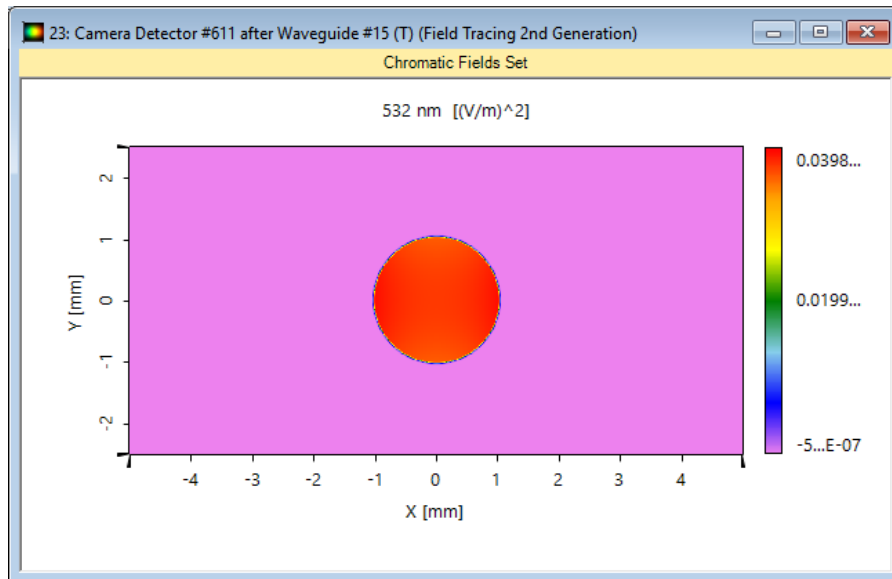
# Result I: Only 0<sup>th</sup> Non-Reflected Orders



## Highlights

tailored light guiding within a waveguide using surface gratings

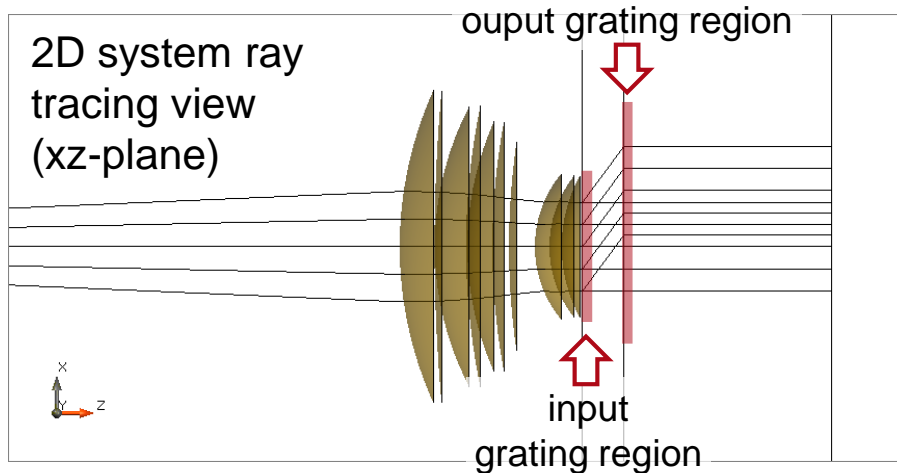
| Region | Channel | Order | Efficiency |
|--------|---------|-------|------------|
| input  | forward | T0    | 20%        |
| output | forward | T0    | 20%        |



individual specification option for simulated diffraction order for each region

intensity pattern (inverse rainbow colors) with modulation due to polarization effects from lens surfaces

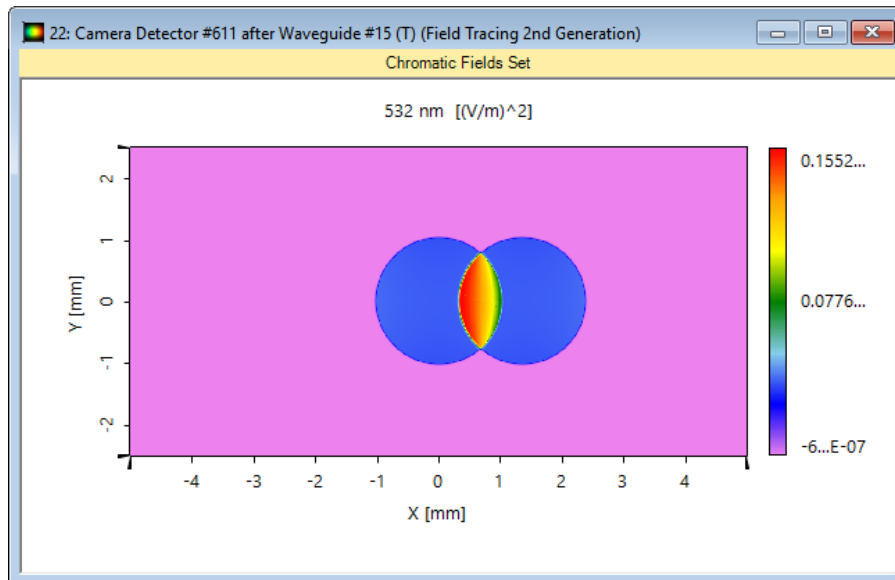
# Result II: Plus +1<sup>st</sup> Non-Reflected Orders



## Highlights

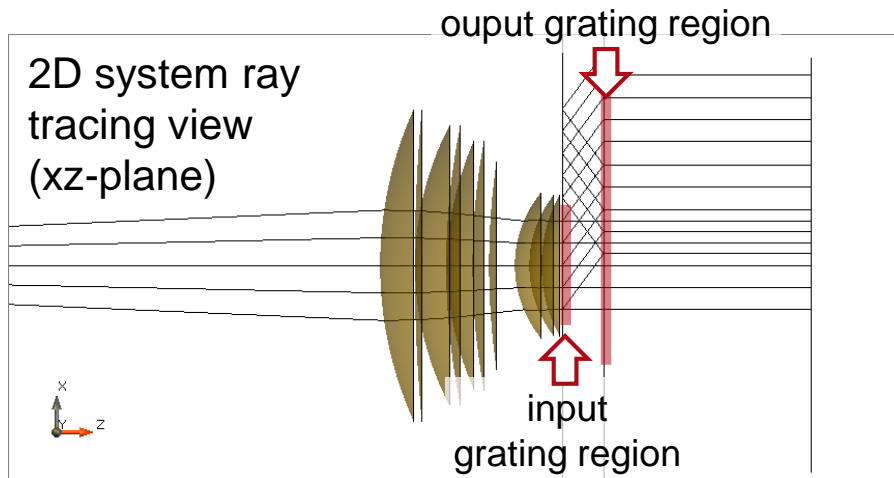
tailored light guiding within a waveguide using surface gratings

| Region | Channel | Order | Efficiency |
|--------|---------|-------|------------|
| input  | forward | T0    | 20%        |
| input  | forward | T+1   | 20%        |
| output | forward | T0    | 20%        |
| output | forward | T-1   | 20%        |



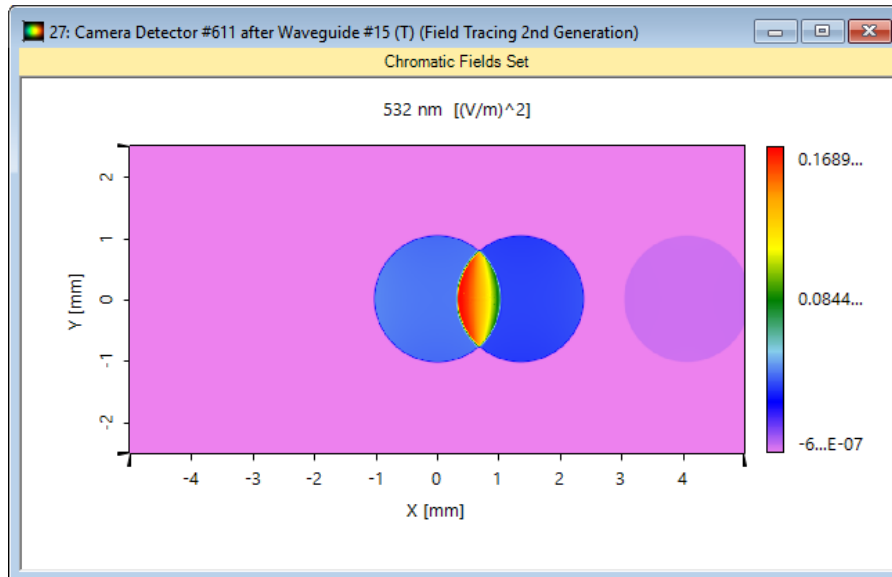
intensity pattern (inverse rainbow colors)  
different order modes are summed coherently

# Result III: Plus Back Reflections



## Highlights

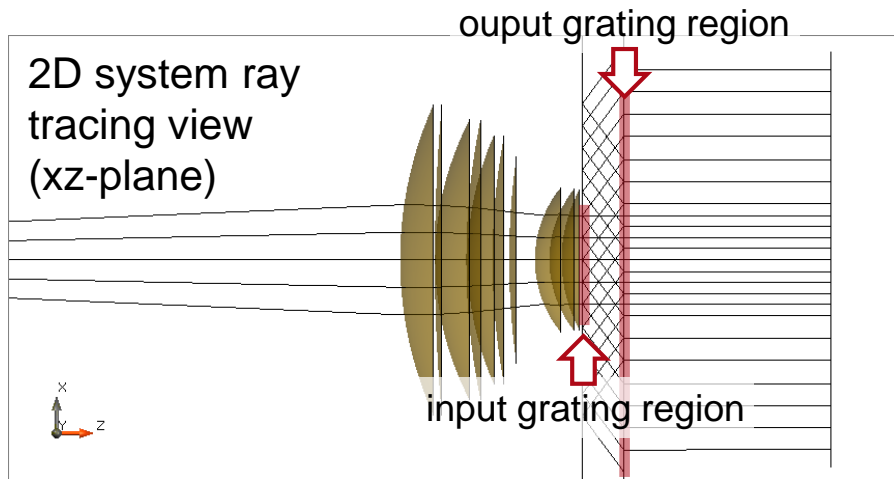
tailored light guiding within a waveguide using surface gratings



intensity pattern (inverse rainbow colors) with multiple reflected light modes

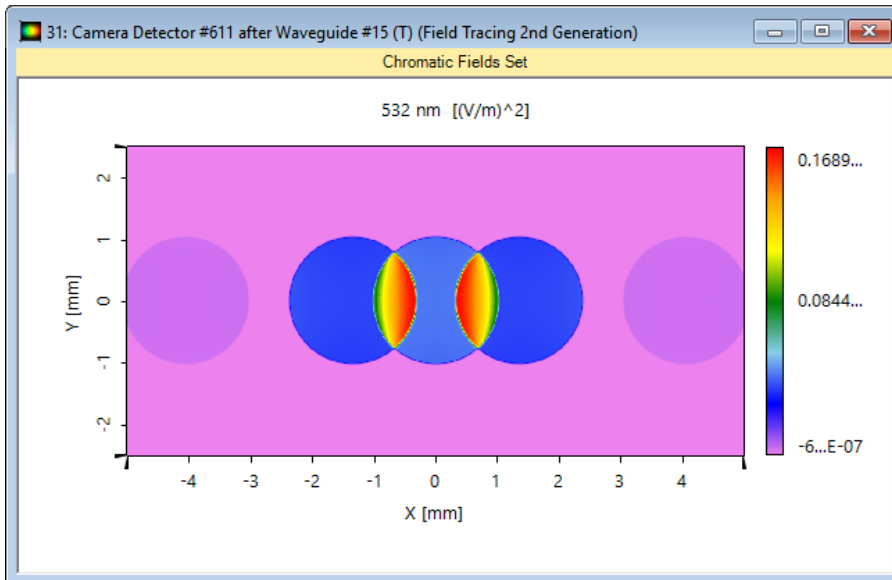
| Region | Channel  | Order | Efficiency |
|--------|----------|-------|------------|
| input  | forward  | T0    | 20%        |
| input  | forward  | T+1   | 20%        |
| input  | backward | R0    | 10%        |
| output | forward  | T0    | 20%        |
| output | forward  | R0    | 10%        |
| output | forward  | T-1   | 20%        |

# Result IV: Further Multi-Reflected Orders



## Highlights

tailored light guiding within a waveguide using surface gratings



| Region | Channel  | Order | Efficiency |
|--------|----------|-------|------------|
| input  | forward  | T0    | 20%        |
| input  | forward  | T+1   | 20%        |
| input  | forward  | T-1   | 20%        |
| input  | backward | R0    | 10%        |
| output | forward  | T0    | 20%        |
| output | forward  | R0    | 10%        |
| output | forward  | T+1   | 20%        |
| output | forward  | T-1   | 20%        |

intensity pattern (inverse rainbow colors) with further multiple reflected light modes

# Document & Technical Info

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|                     |   |
|---------------------|---|
| code                | NED.0005  |
| version of document | 1.0   |
| title               | Light Propagation through Waveguide with In- & Outcoupling Surface Gratings |
| category            | Virtual & Mixed Reality > Near-Eye Displays (NED)                           |
| author              | Roberto Knoth (LightTrans)  |
| used VL version     | 7.0.0.29  |

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## Specifications of PC Used for Simulation

|                  |                         |
|------------------|-------------------------|
| Processor        | i7-4910MQ (4 CPU cores) |
| RAM              | 32 GB                   |
| Operating System | Windows 10              |