September 2023, Release of VirtualLab Fusion 2023.2

The New VirtualLab Fusion 2023

Overview of new features of version 2023.2

General Information

| Version	2023.2 (Build 1.242)
Update Service	3rd quarter of 2023 is required.
Install Type	Standalone Installation VirtualLab Fusion 2023.2 is installed in parallel to your existing VirtualLab Fusion installations.

The New VirtualLab Fusion 2023.2

Major development directions

Major Development Directions of VirtualLab Fusion 2023.2

- VirtualLab Fusion enables optical modeling by combining different modeling techniques on one software platform.

- The development of VirtualLab Fusion never stops. VLF 2023.2* provides:
    - Higher Speed
    - Easier Use
   - More Physics
    - Deeper Transparency
    - Better Control
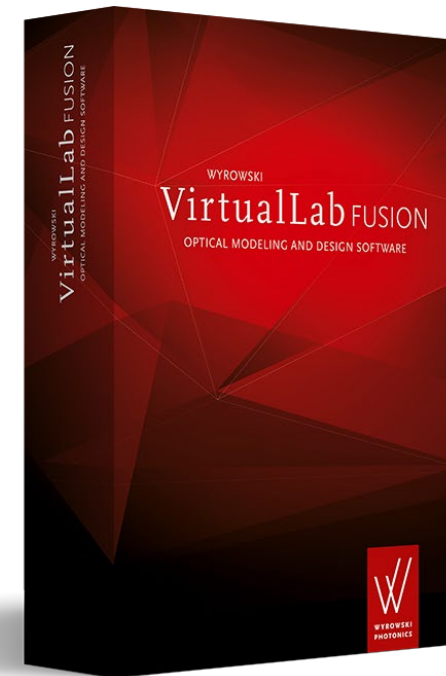
*Our customers often refer to VirtualLab Fusion as VLF. Therefore, in this feature overview we use VLF 2023.2 for VirtualLab Fusion 2023.2.

Higher Speed

Major development directions of VirtualLab Fusion 2023.2

Higher Speed by VirtualLab Fusion 2023.2

- With VLF 2023.2 the **Distributed Computing Package** is released as a new member of the VirtualLab Fusion product family.
  This package enables the use of computers in a network and the automatic distribution of simulation tasks. Depending on the task, the time required to obtain the results is significantly reduced.
  The workflow to configure your simulation in VirtualLab Fusion is unchanged.
  Simply define the clients on available computers in your network and get your results much faster.

- VLF 2023.2 also makes better use of **multicore processors** for parallel calculations.

- In addition, the **visualization** of large 2D as well as 3D data is improved, to provide a more performant and fluid user experience.
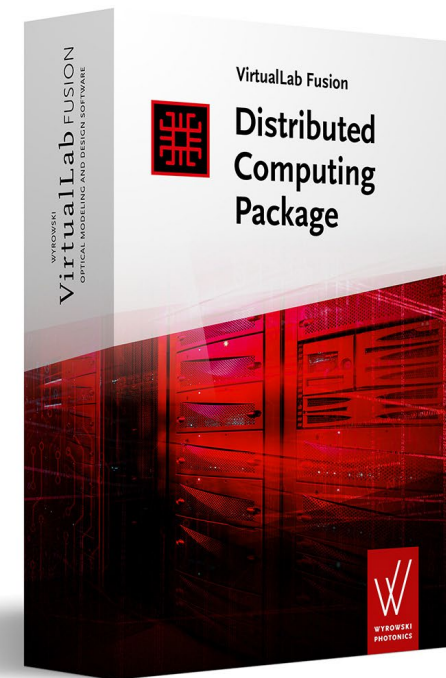
Easier Use

Major development directions of VirtualLab Fusion 2023.2

Easier Use of VirtualLab Fusion 2023.2

- VLF 2023.2 comes with a variety of improvements for our **Data Views**. This includes new features for the visualization of 1D and 2D data as well as the 3D system data.

- **Regions** are a central data object in VirtualLab Fusion. With VLF 2023.2 we enable new options for editing polygon regions and also make the usage of regions (e.g., in the surface layout of the lightguide component) more user-friendly.

- Isotropic as well as anisotropic **Coatings** are defined by a sequence of layers. In VLF 2023.2, the layer sequences can be adapted even more user-friendly.

- VLF 2023.2 enables an easier usage of **Detector Add-ons** inside the universal detector as well in the main window of VirtualLab Fusion.
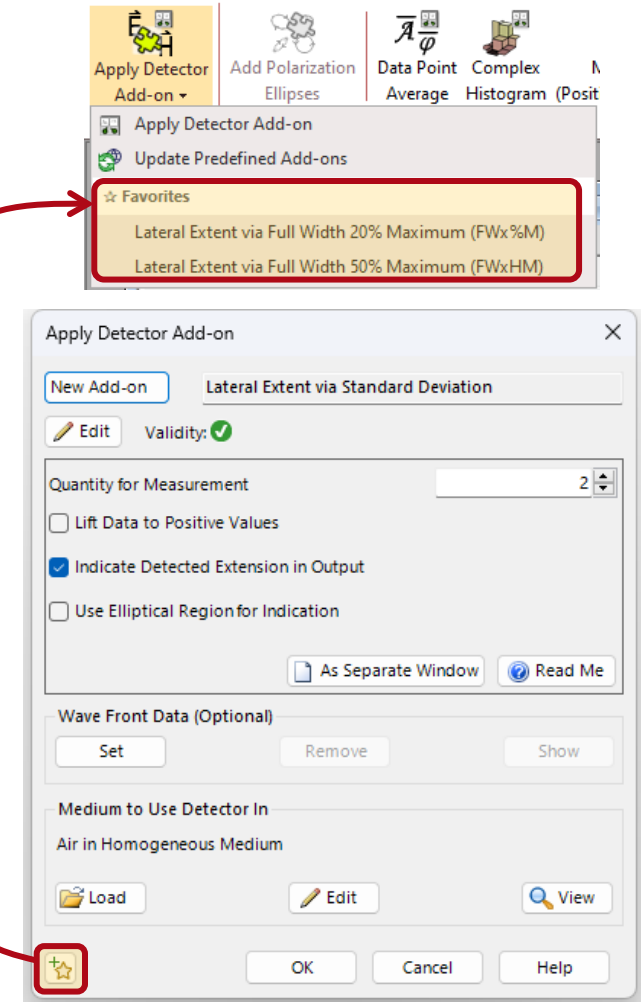
More Physics

Major development directions of VirtualLab Fusion 2023.2

More Physics in VirtualLab Fusion 2023.2

- VirtualLab Fusion provides an ever-growing number of physical optics models with emphasis on:
  - sources with models for light radiation
  - components with models for light interaction
  - detectors with models for light evaluation
  - models for propagation of light from sources to components and to detectors
- In VLF 2023.2, the **Parameter Variation Analyzer** is available, which allows to configure an internal parameter sweep and to evaluate the combined result for the analysis of multi configurations.
- The **Field Inside Grating Analyzer** now supports the evaluation of 2D periodic grating structures, too.
- The **Multimode Fiber Coupling Detector** also provides the efficiency per mode in VLF 2023.2.
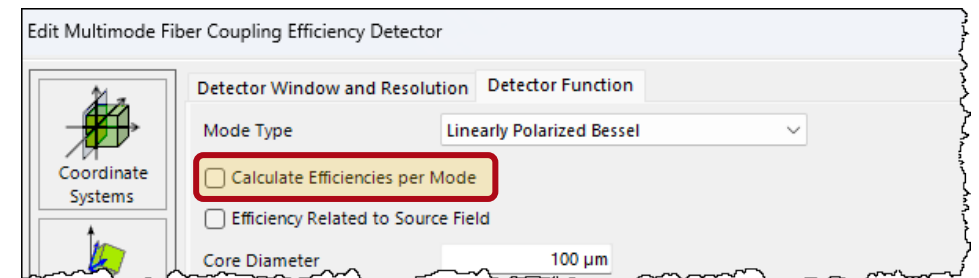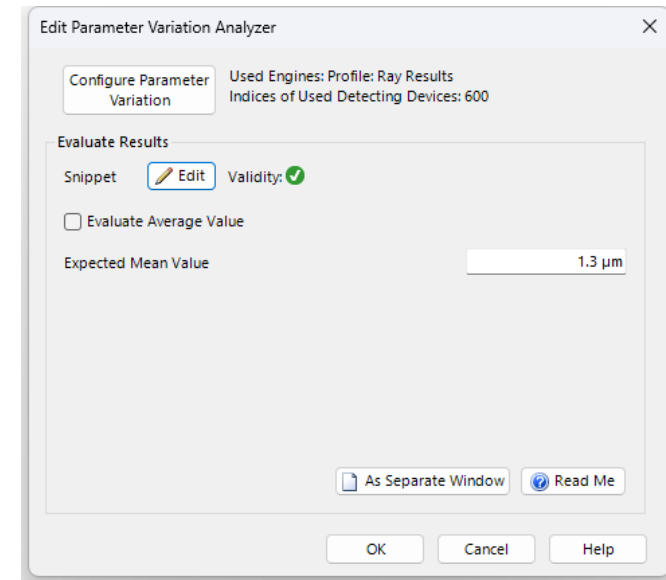
Deeper Transparency

Major development directions of VirtualLab Fusion 2023.2

Deeper Transparency of VirtualLab Fusion 2023.2

- The **Process Logging** in VirtualLab Fusion now provides much more detailed information about the process during the simulation of an optical setup.

- The user gets details about both the decision and the decision criteria (PTI) of the automatic Fourier transform selection during propagation.

- In addition, the logging provides information about the selected sampling and the calculation times per algorithm step.

- VLF 2023.2 enables the following features to access and control the process logging:
  - option to temporary suspend the logging during simulation
  - select the logging level directly on the logging tab
  - option to search within a specific logging information using a full text search

Better Control

Major development directions of VirtualLab Fusion 2023.2

Better Control of VirtualLab Fusion 2023.2

- In VLF 2023.1, we have already introduced the **Profile Editing Tools** to more conveniently configure the modeling parameters of a complex system.

- The layout of the profile editing tool has been further optimized to provide a more intuitive overview of the various parameters that can be adjusted.

- In addition, the tool for **Paraxial Assumptions** has been simplified and the application to detectors within the underlying systems is more clearly communicated.

- Moreover, new parameters for the **Parameter Extraction** (e.g., parameters of the GRIN media and more parameter for the volume grating medium) are available, which allow their use in a parameter run or parametric optimization.
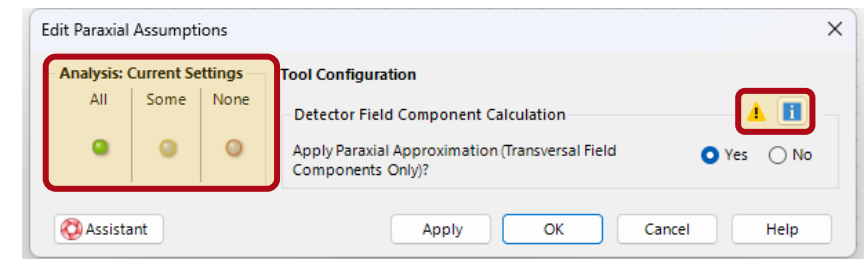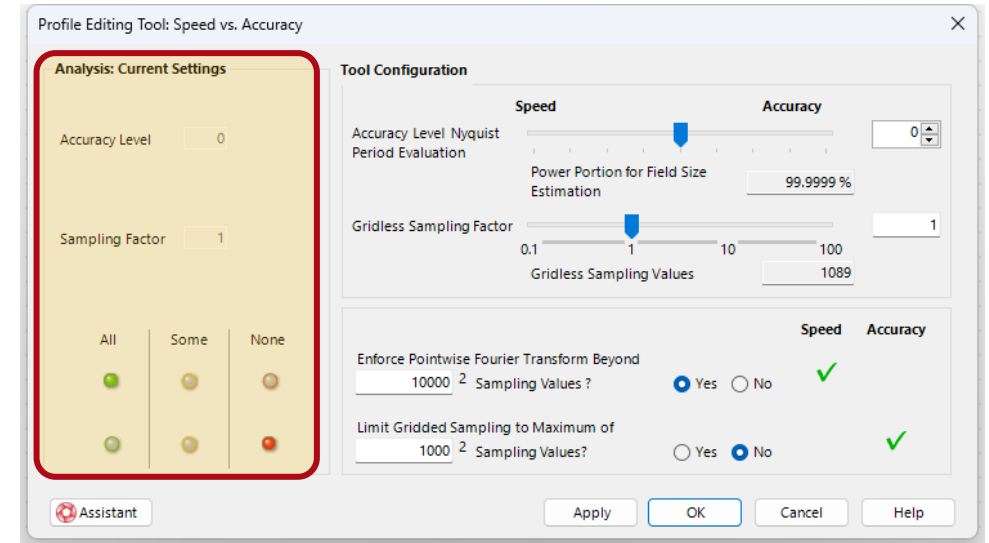
New VirtualLab Fusion Product Family

New VirtualLab Fusion Product Family - General

- With VLF 2023.2 we offer different configurations of VirtualLab Fusion. We distinguish between the platform (**VirtualLab Fusion Standard**) and additional packages, which can be combined as needed.

- The following packages are available:

  ➡ **Grating Package**

  ➡ **Diffractive Optics Package**

  ➡ **Flat Lens Package**

  ➡ **Light Shaping Package**

  ➡ **AR/VR/XR Package**

  ➡ **Distributed Computing Package**
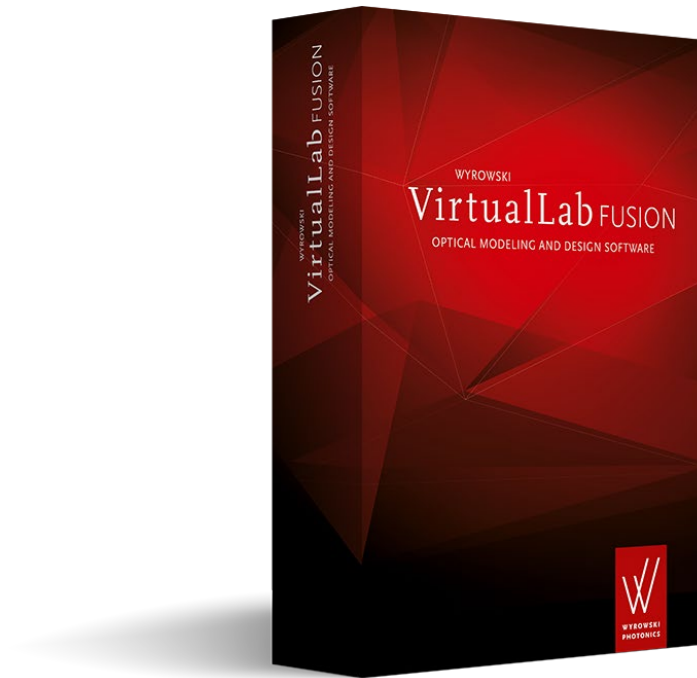
VirtualLab Fusion – Grating Package

- Previously, the VirtualLab Fusion platform was offered in two editions:
    - VirtualLab Fusion Basic
    - VirtualLab Fusion Advanced
- With VLF 2023.2, all VirtualLab Fusion Advanced features are now included in the **Grating Package**.
- This includes:
    - Fourier Modal Method (FMM aka RCWA), which is a rigorous vectorial solver to analyze 1D and 2D-periodic structures
      This modeling technique is also used for grating components in VLF, as well as diffractive lenses.
    - Advanced simulation of micro lens arrays (MLA), including channel decomposition techniques
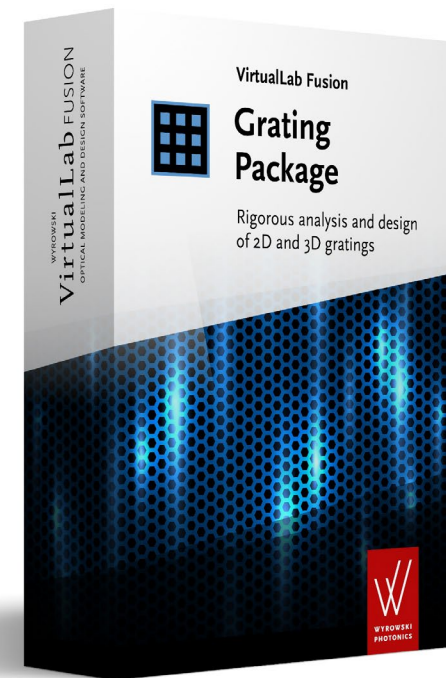
VirtualLab Fusion – Diffractive Optics & Flat Lens Package

- In previous versions, we offered the Diffractive Optics Toolbox in silver and gold version.

- With VLF 2023.2 the Diffractive Optics Toolbox Silver is renamed to **Diffractive Optics Package**.

- The **Diffractive Optics Package** provides the iterative Fourier transform algorithm (IFTA) for designing beam splitters and diffusers.

- The **Flat Lens Package** includes all additional features of the old Diffractive Optics Toolbox Gold, i.e. the modeling of diffractive lenses by local linear grating approximation and the modeling of meta-lenses by specialized solvers.

- The **Flat Lens Package** can be ordered independently of the Diffractive Optics Package.

VirtualLab Fusion – AR/VR/XR Package

- For modeling and designing waveguides (or lightguides) with grating couplers (i.e. surface relief and holographic gratings), the Light Guide Toolbox has been provided so far.

- This toolbox was offered as silver and gold edition.

- In VLF 2023.2, the Light Guide Toolbox is renamed to the **AR/VR/XR Package** which contains all features of the silver and the gold edition of the former toolbox*.
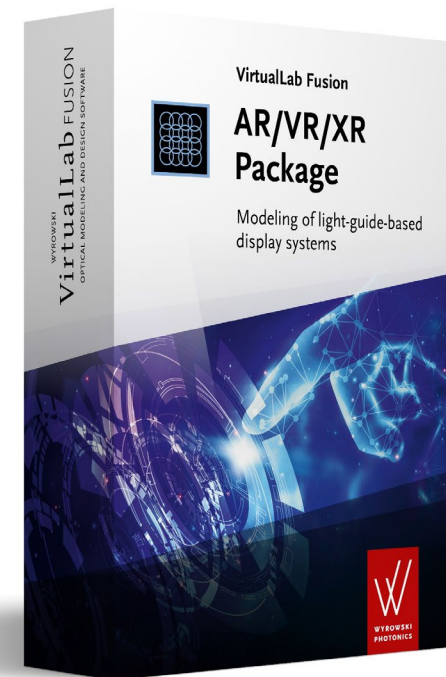
Note: All users of the previous Light Guide Toolbox silver will automatically receive the new AR/VR/XR Package as well.

VirtualLab Fusion – Distributed Computing Package

- With VLF 2023.2 we release the Distributed Computing Package as a new member of the VirtualLab Fusion product family.

- The **Distributed Computing Package** allows you to use network resources to speed up your simulations.

- Your workflow for modeling remains unchanged – the time for complex simulations is just shortened.
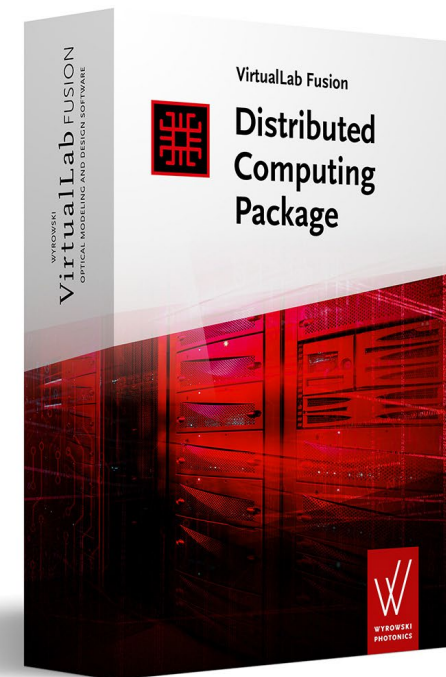
The All-new VirtualLab Fusion 2023.2

Feature Overview

Distributed Computing with VirtualLab Fusion

VirtualLab Fusion 2023.2 feature overview

Distributed Computing with VirtualLab Fusion

- With VLF 2023.2 we release the Distributed Computing Package as a new member of the VirtualLab Fusion product family.

- The **Distributed Computing Package** allows you to use network resources to speed up your simulations.

- In VLF 2023.2, we mainly distribute individual iterations of parameter runs via the network.

- The user only needs to configure the number of clients on computers in the network before starting the parameter run.

- In the user interface of the parameter run, the currently configured execution location is displayed and in case of enabled distributed computing, the user can also see how many clients are used for calculation.
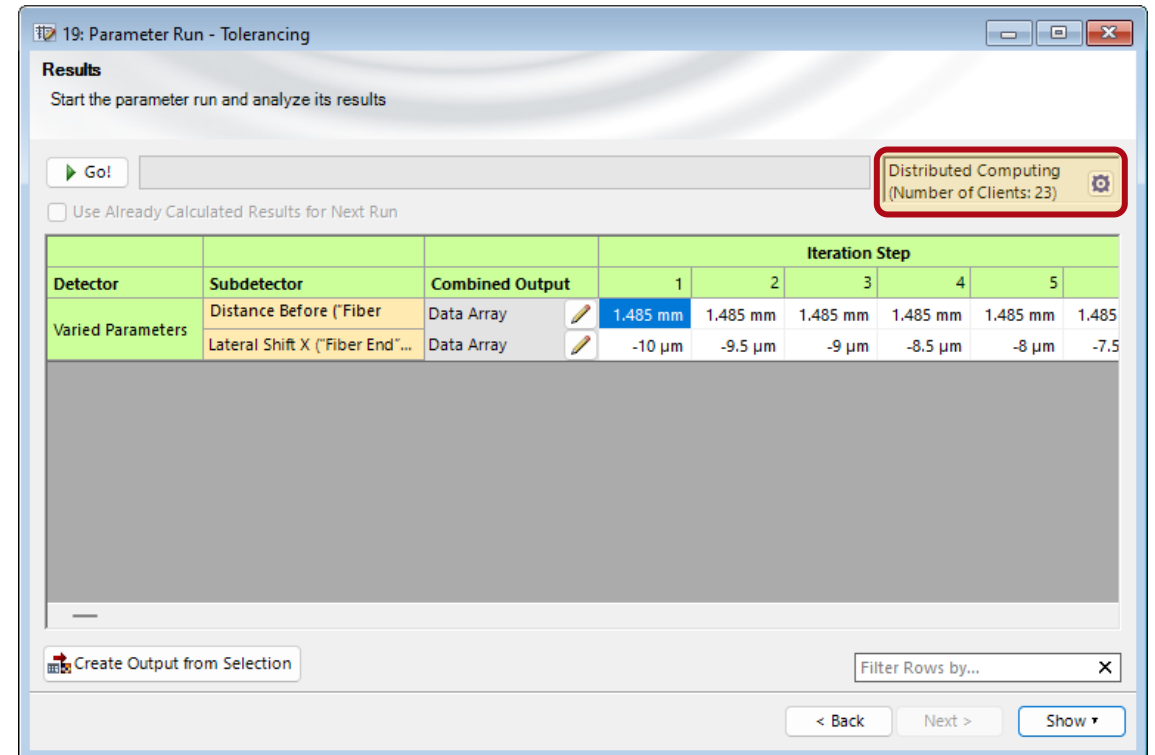
Distributed Computing with VirtualLab Fusion

- VLF 2023.2 provides an intuitive user interface to start a server for distributed computing and configure the clients on the network.

- A single click on "Start Server" will start the server in your VLF instance.

- You can easily launch an arbitrary number of clients on multiple machines simultaneously by using a tool provided in the user interface.

- In addition, the user interface provides a tabular listing of all connected clients and their current status.

- It is even possible to add and remove clients during a running simulation.

- For transparency, VLF 2023.2 also provides a logging window where the user can see which simulation was run on which client and when the results were returned.

Learn More About Distributed Computing with VirtualLab Fusion

Use Cases

- Usage of Distributed Computing

- Test Image Simulation of an AR Waveguide

- Coherence Measurement with White Light Interferometry

- Investigation of Diffraction in Interferometer Caused by Sharp Relief– Analysis by Using Distributed Computing
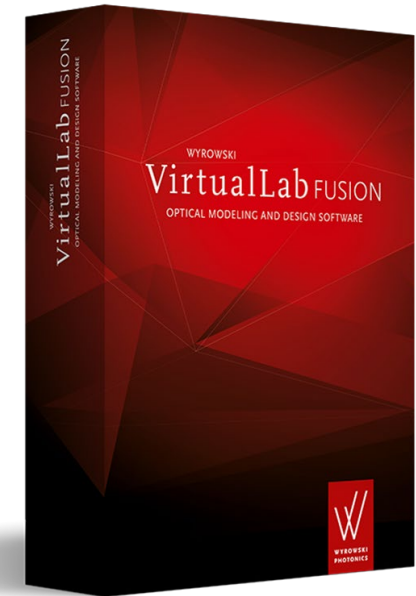
More examples & use cases coming soon!

Higher Modeling Speed

VirtualLab Fusion 2023.2 feature overview
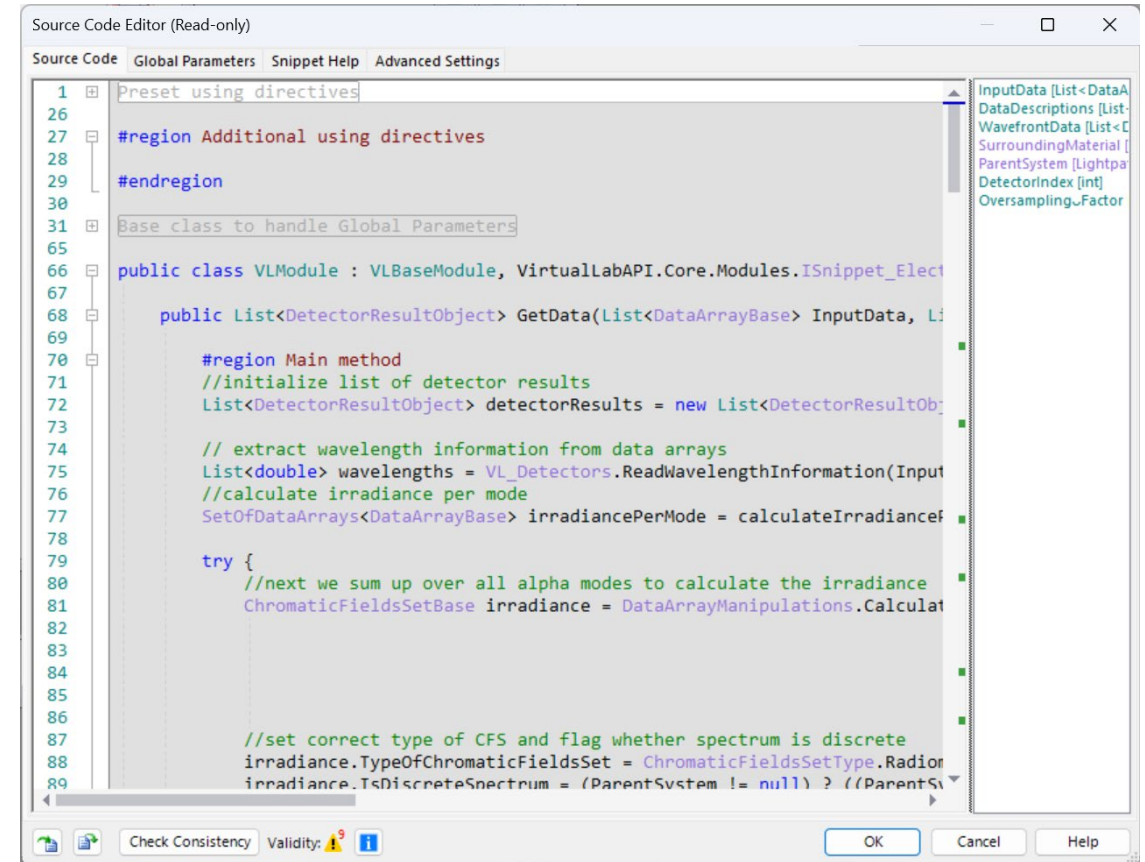
Higher Modeling Speed in VLF 2023.2

- The modeling algorithms in VLF 2023.2 are further optimized and deliver higher modeling speed.

- VLF 2023.2 makes better use of multicore processors for parallel computing.

- In addition, the performance of visualization of large 2D data is improved.

- The 3D system view now uses a smarter and less demanding surface representation, which enables a higher performance for visualization and reduces file sizes if the CAD data is exported.

- In VLF 2023.2, the performance of the S-Matrix solver for evaluation the effect of anisotropic coating was improved.
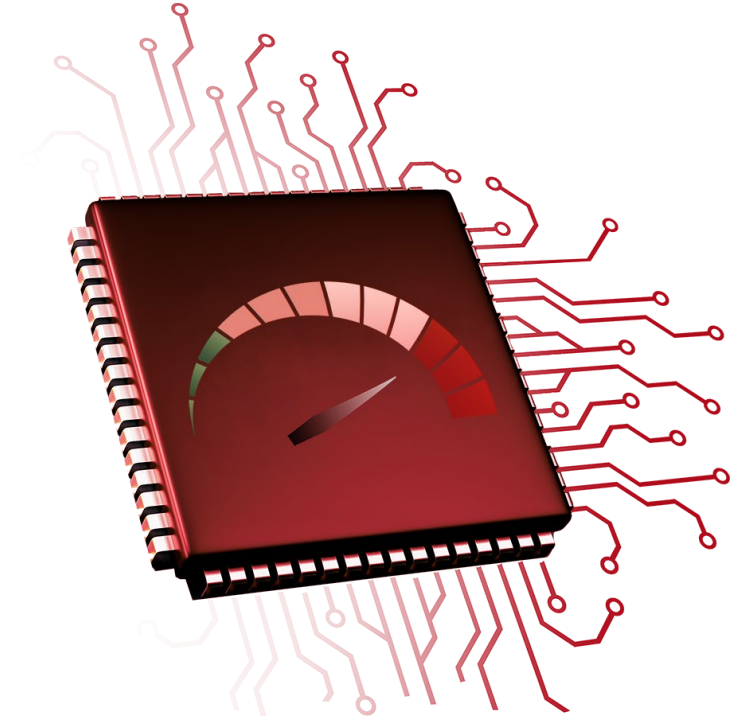
Higher Modeling Speed in VLF 2023.2

- VirtualLab Fusion provides customization of system building blocks via the build-in snippet technology.

- Here, the user only needs to implement a small piece of source code to realize the structure he like to have, in case it is not available as a built-in definition.

- With VLF 2023.2 the just-in-time compilation of such snippets is much more performant.

- This results in an increase in speed and a decrease in physical memory when such a custom system building block is used in your simulation.

Data Views

VirtualLab Fusion 2023.2 feature overview

Selected Data Views in VirtualLab Fusion 2023.2
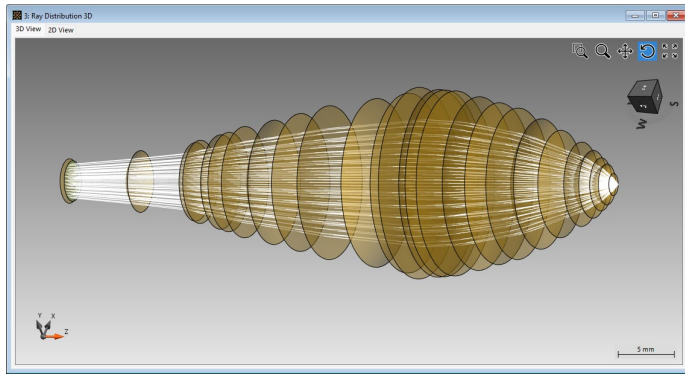
3D System View
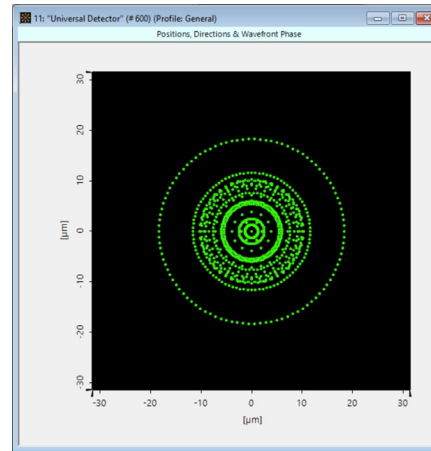
Data Array (gridless):
positions only
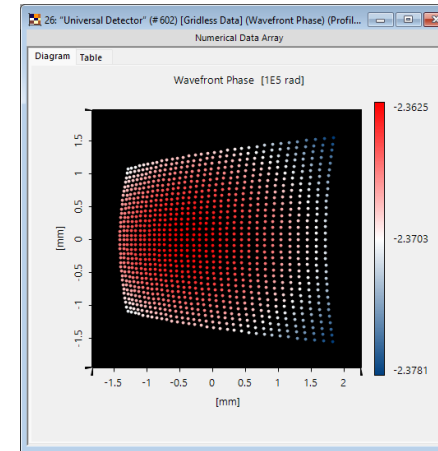
Data Array (gridless):
field values
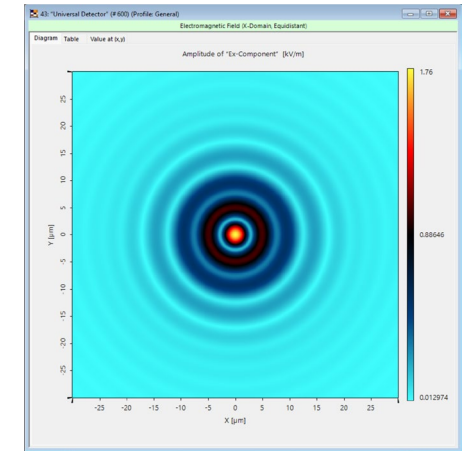
Data Array (gridded):
field values
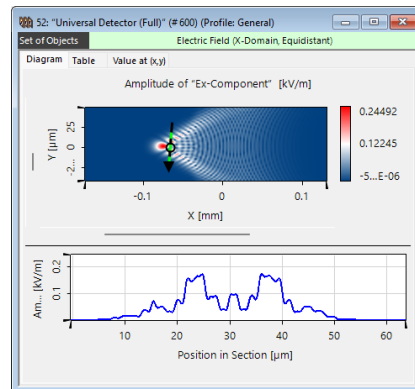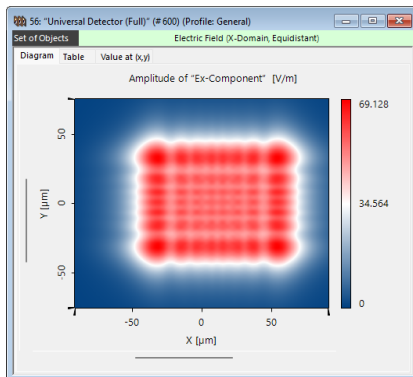
Set of Data Arrays (gridded):
field values
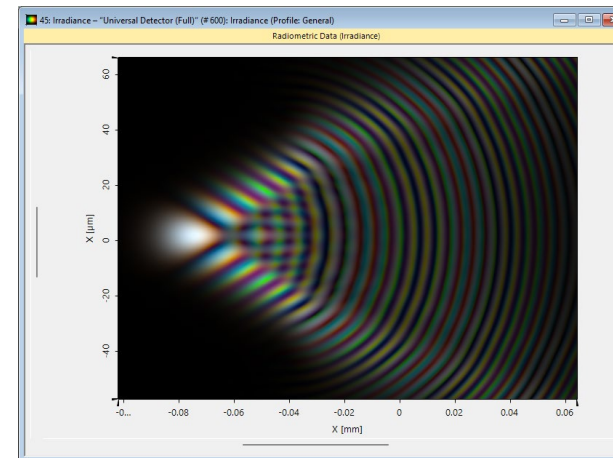
Radiometric Data View

Selected Data Views in VirtualLab Fusion 2023.2
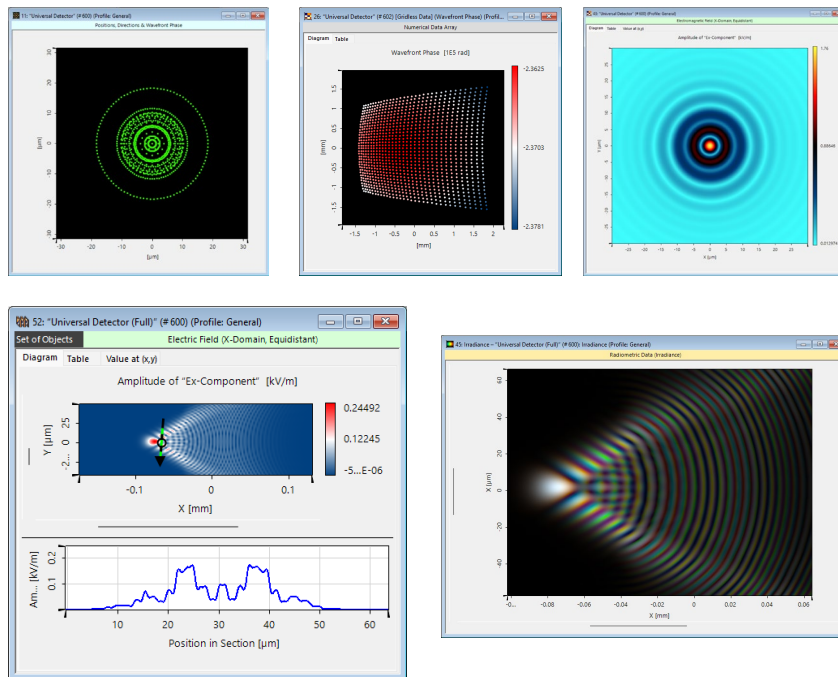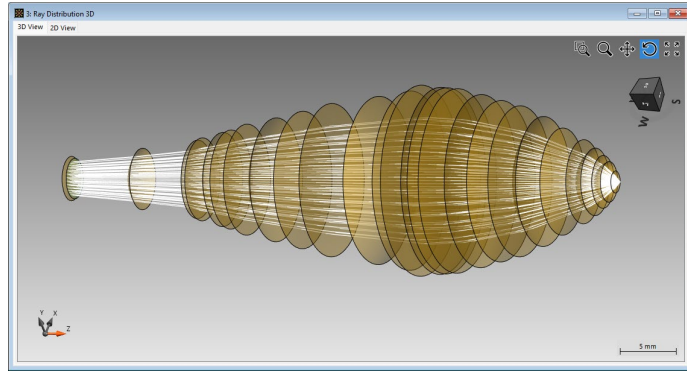
- In most cases, optical simulations produce 1D or 2D result data. VLF 2023.2 applies data view windows to provide the results to the user.

- **System 3D**: Used to illustrate the coordinate mapping of pointwise physical optics modeling, which provides results similar to ray optics.

- **Data Array**: The universal visualization tool for 1D and 2D gridded and gridless data.

- **Set of Data Arrays**: In optical modeling, we often deal with multiple modes and wavelengths. In this case, several Data Arrays are combined in one Set of Data Arrays.

- **Radiometric Data**: Energy quantities, e.g., irradiance, can be visualized according to the color perception of the human eye by the concepts of colorimetry.

System 3D View: Length Measurement Tool

- VLF 2023.2 provides a new tool to measure lengths in the *System 3D* view.

- In order to use this feature, the new *Full-Size Rulers* have to be activated in the view setting. Then the measuring tool becomes available in the toolbar of the 3D view.

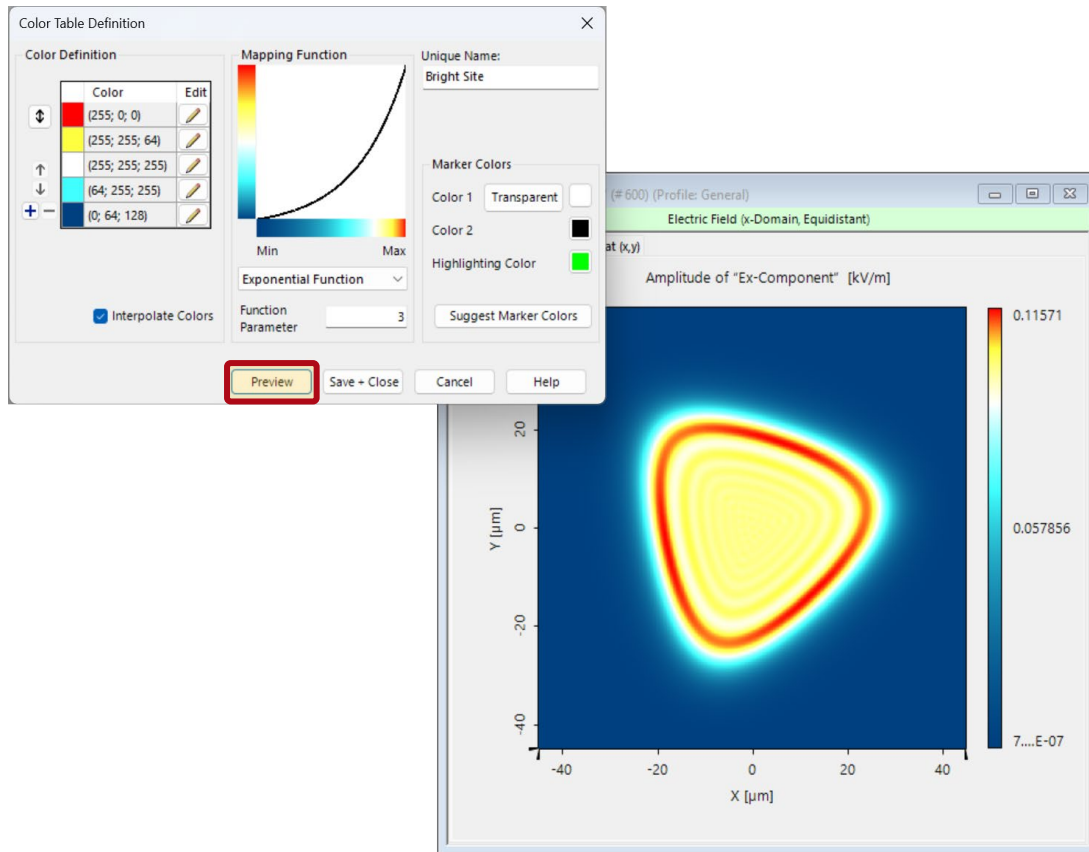- The measuring tool can be easily controlled with the mouse.
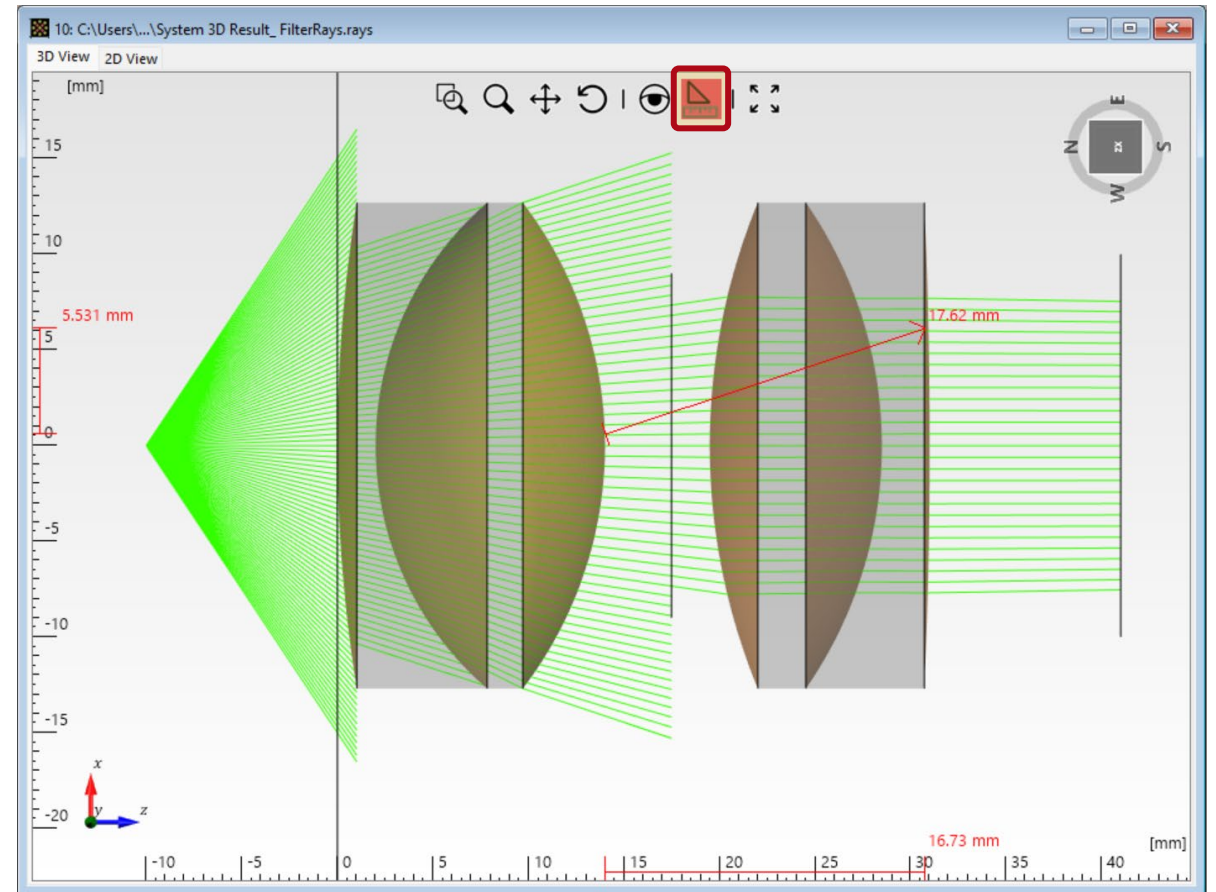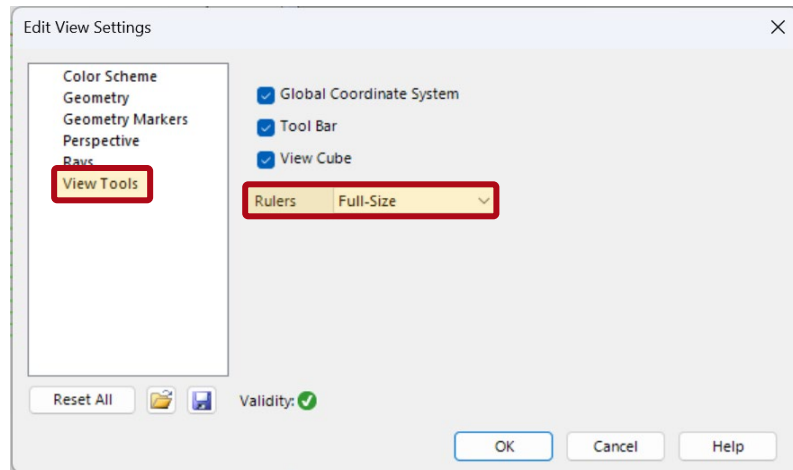
System 3D View: Tool to Filter Blocked Rays

- In the *System 3D* view, the rays are typically drawn until they are blocked.

- VLF 2023.2 provides a new option to filter rays that are blocked by an aperture of the system, what results in a more descriptive result.
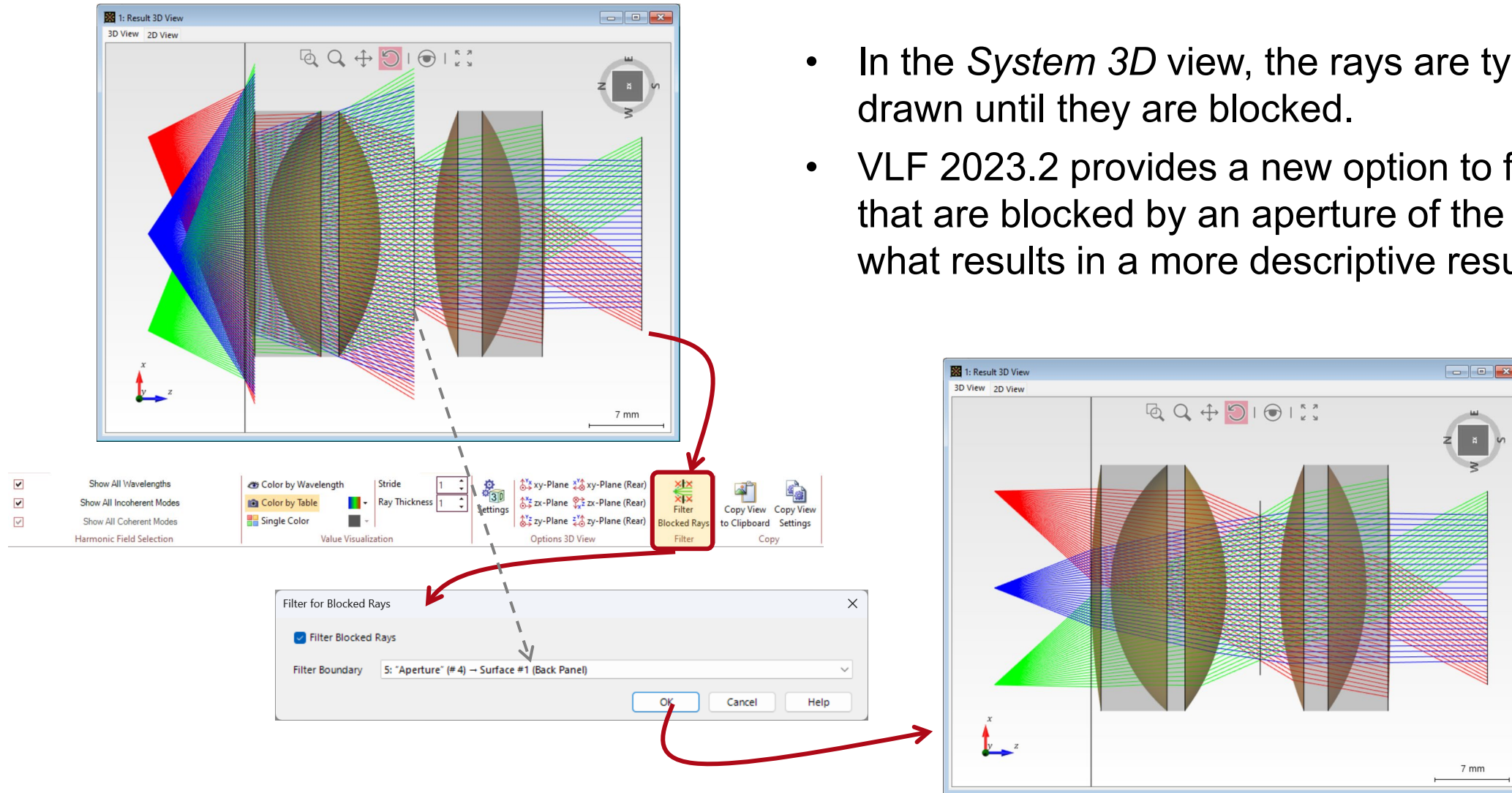
Data Array View: Preview Option for Color Lookup Tables

- For the display of 2D data, VLF uses color lookup tables (LUTs) to encode the values of the data in the view.

- A lot of pre-defined color lookup tables are available, and in addition, the user can also customize existing color LUTs or even define new LUTs.

- In former version it was necessary to save a LUT after editing in order to apply it to the underlying data.

- With VLF 2023.2, we provide a preview within the edit dialog of the LUTs, which applies the adapted configuration directly to the underlying view.

Data Array View: Hide Numerical Artifacts
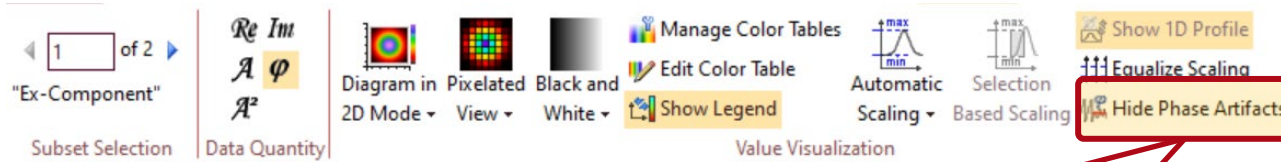
Off

On

Phase with artifacts

Phase without artifacts
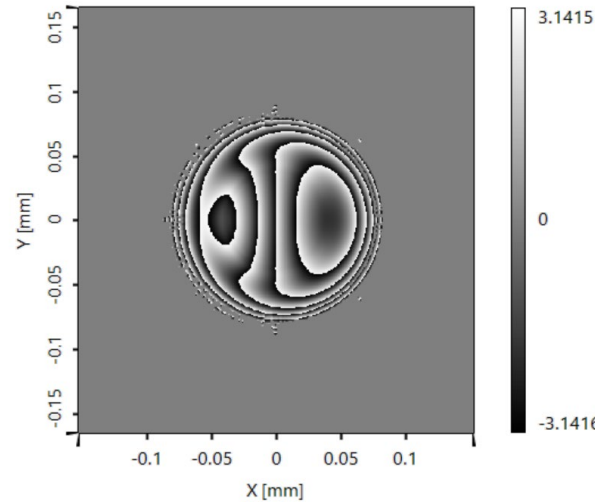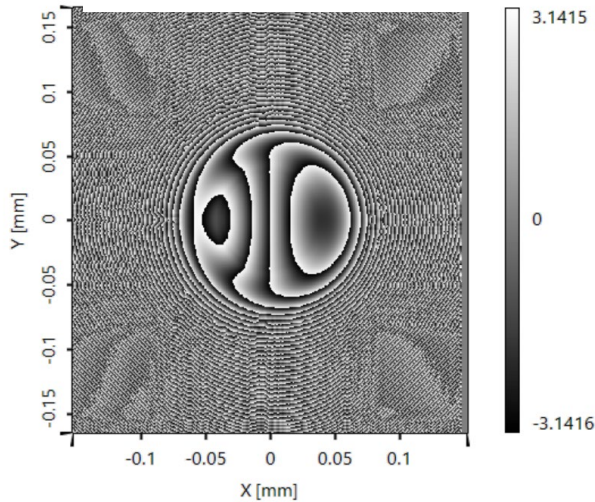
- VLF 2023.2 provides a new view option to hide numerical artifacts for the visualization of phase values of complex-valued 1D and 2D data.

- The option can easily be activated in the view ribbon of the data array.

- The threshold for the detection of artifacts can be set in the property browser.
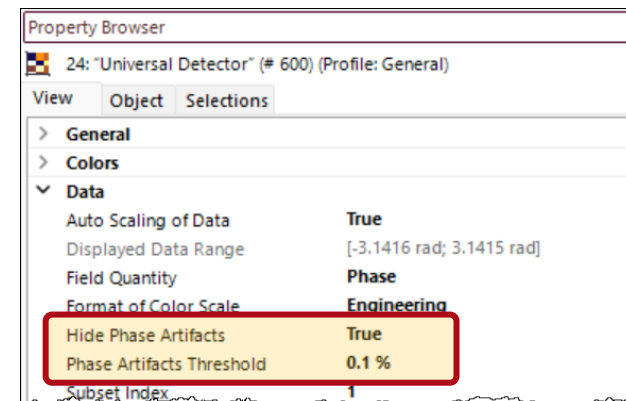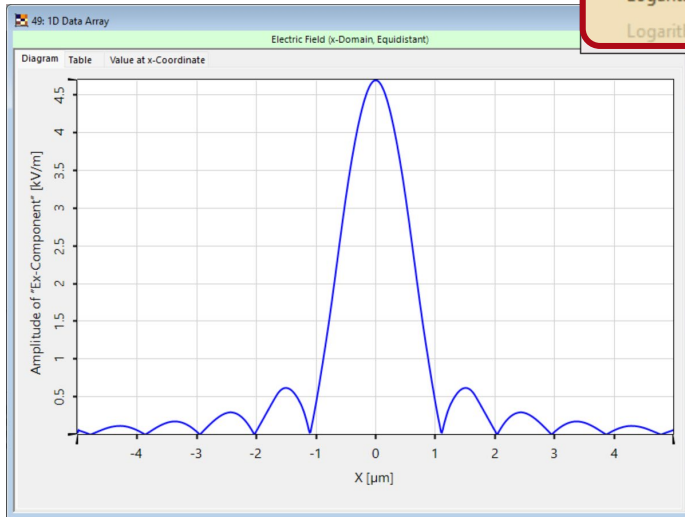
Data Array View: New Zoom Options

- VLF 2023.2 provides an option to automatically center the view for Data Arrays and Set of Data Arrays.

- For a Set of Data Arrays, it is now also possible to display the various data on a uniform maximum extension without any problems.
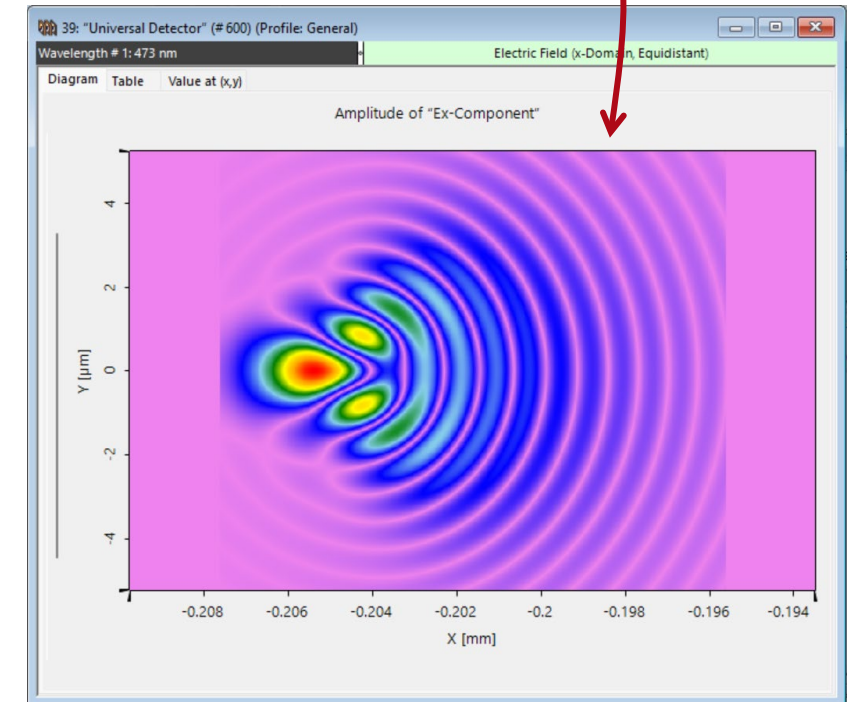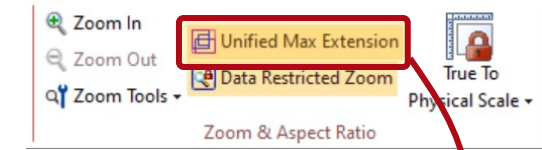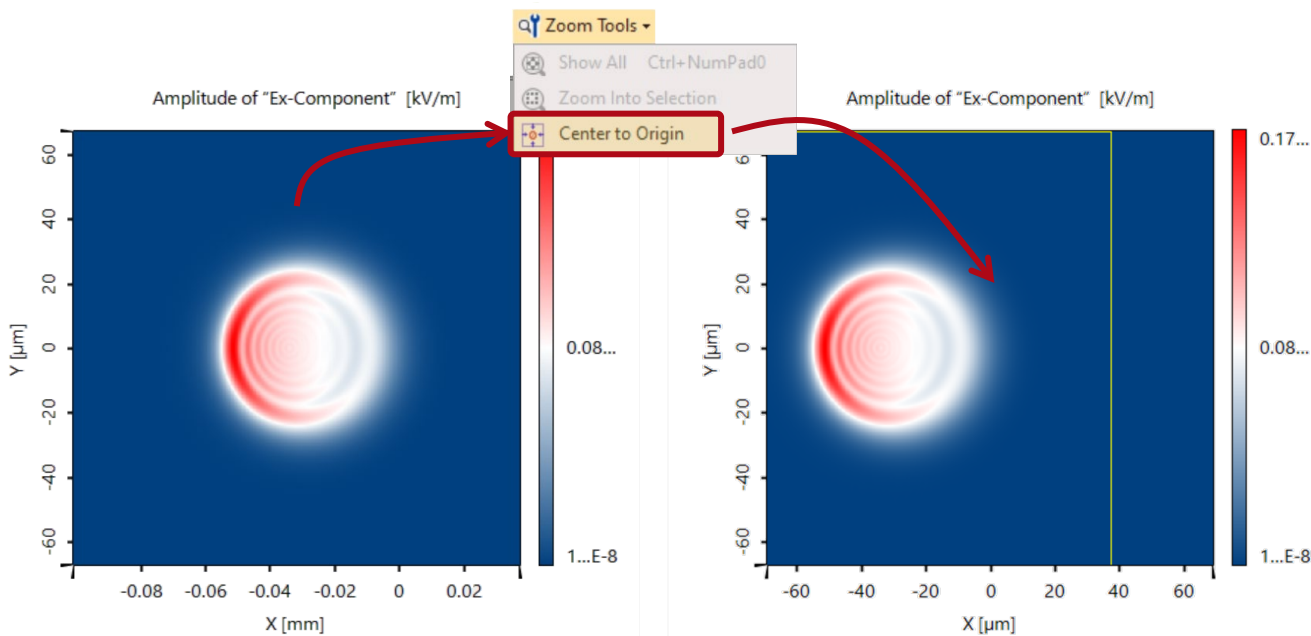
Data Array View: Improved Configuration of Axis Options

- VLF 2023.2 now allows you to change axis labels for data fields directly via the property browser.

- For 1D data arrays, there are now new options to configure the axis options directly via corresponding buttons in the view ribbon.
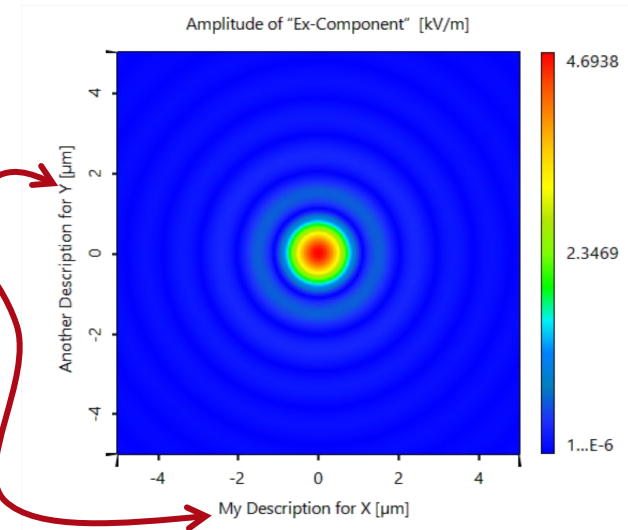
Data Array View: New Global Options for Markers

- The 1D/2D data view in VirtualLab Fusion allow the usage of
  - Point Marker
  - Line Marker (only for 2D data)
  - Rectangle Marker
- These tools are used to highlight parts of the data and measure values or quantities at specific points or in highlighted areas.
- With VLF 2023.2, the thickness of the markers can be adapted via global settings.
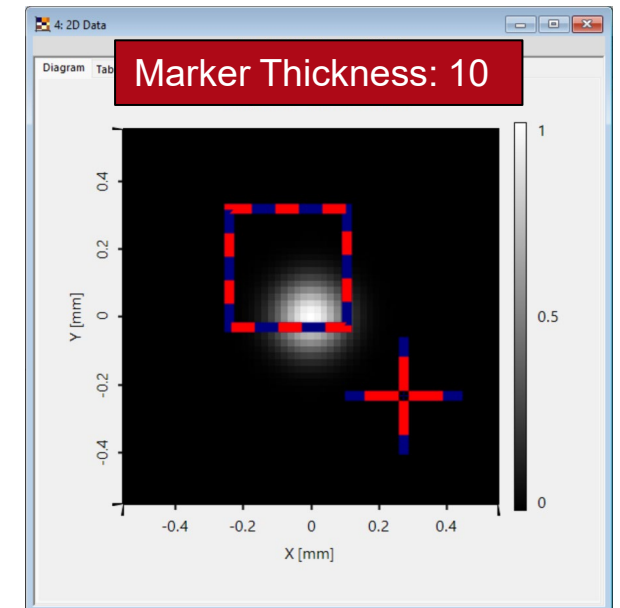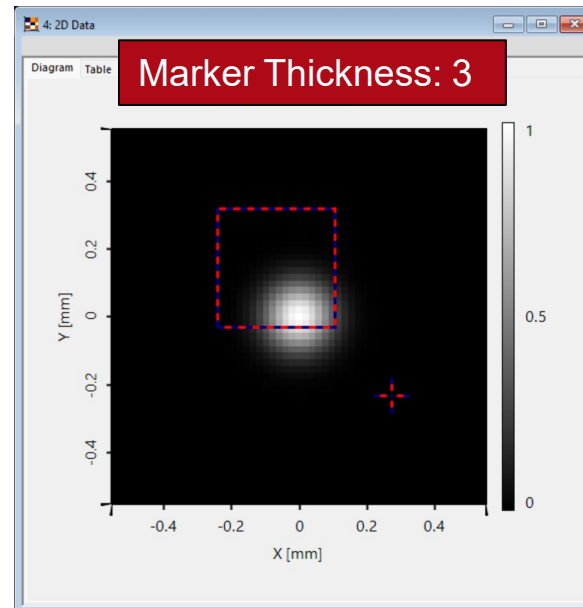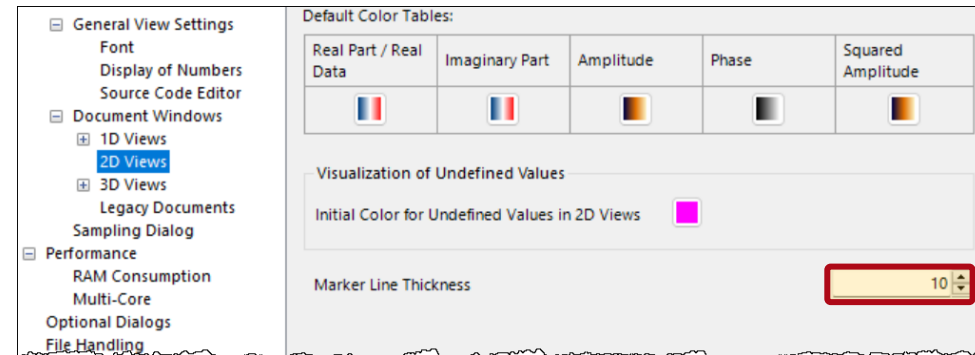
Data Array View: Revised Multigraph Options
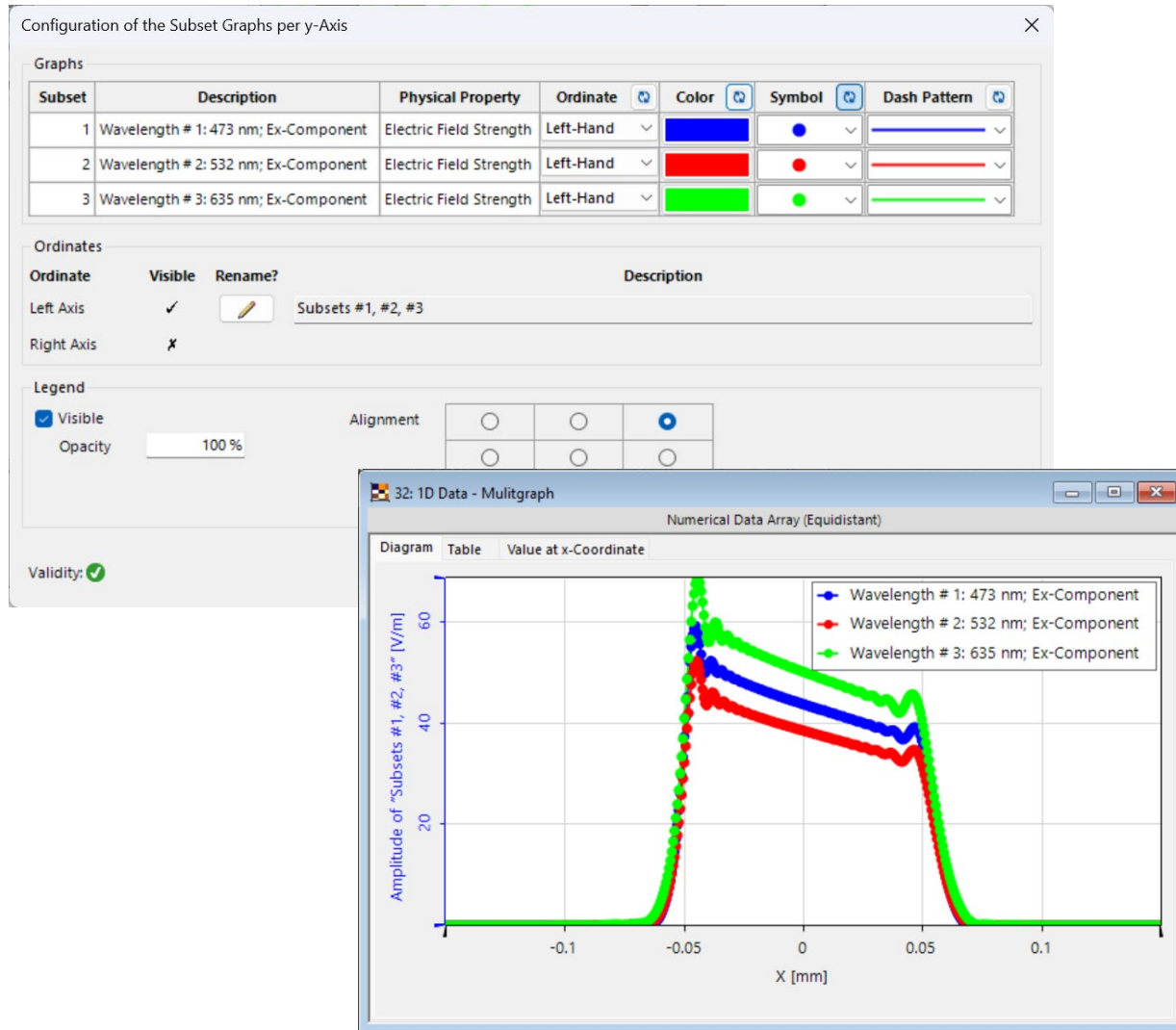
- For the display of different 1D curves in a single view VLF offers the multi graph.

- The dialog to configure the options for the view was improved and now provides a more user-friendly interface to all important view options.

- Within the new dialog for the multi graph view options, the user can now easily synchronize colors, dash patterns, symbols and more.

- In addition, the appearance (position and transparency) of the legend can be customized directly.
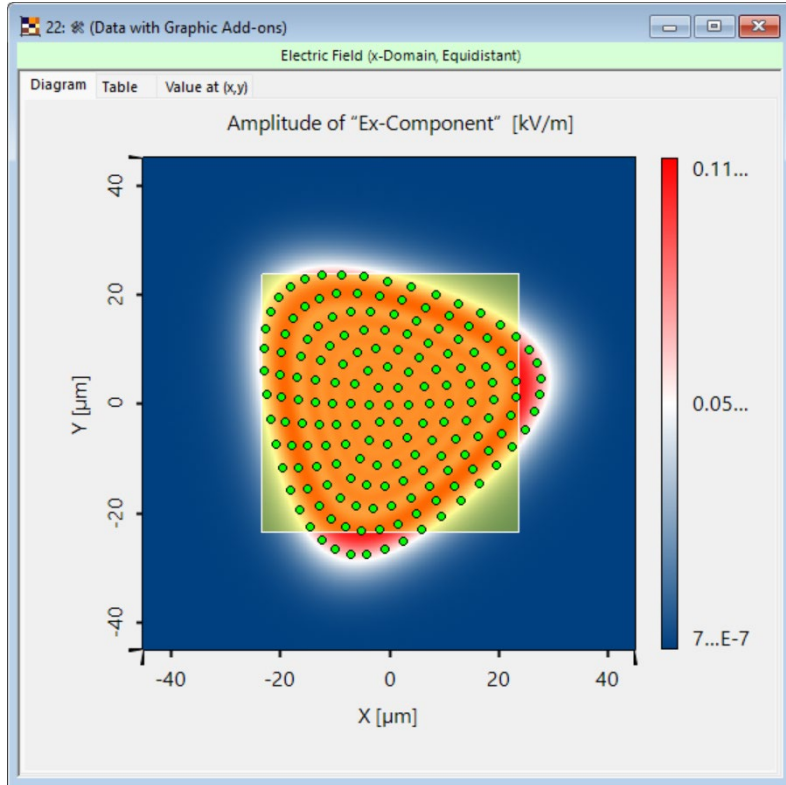
Data Array View: Improvements 1D View

- VLF 2023.2 allows to zoom directly into the profile line extracted from 2D data.

- For 1D data views, the rectangle marker provides a new option to highlight the center of the selected range. This option can be activated in the property browser.
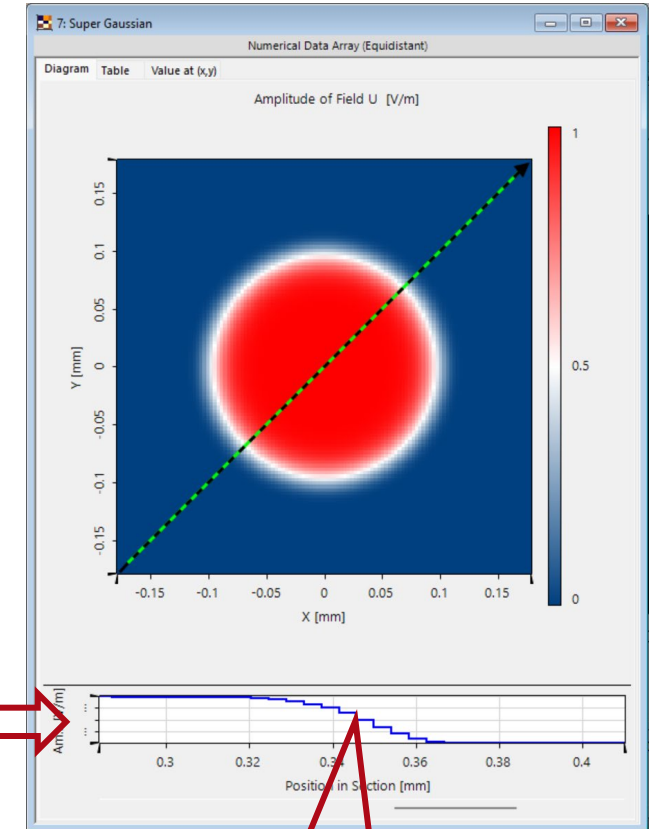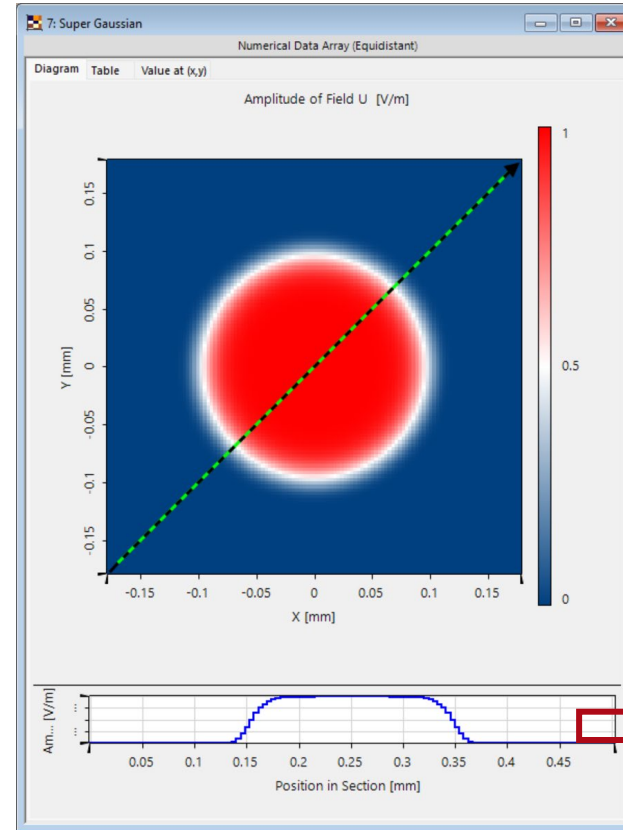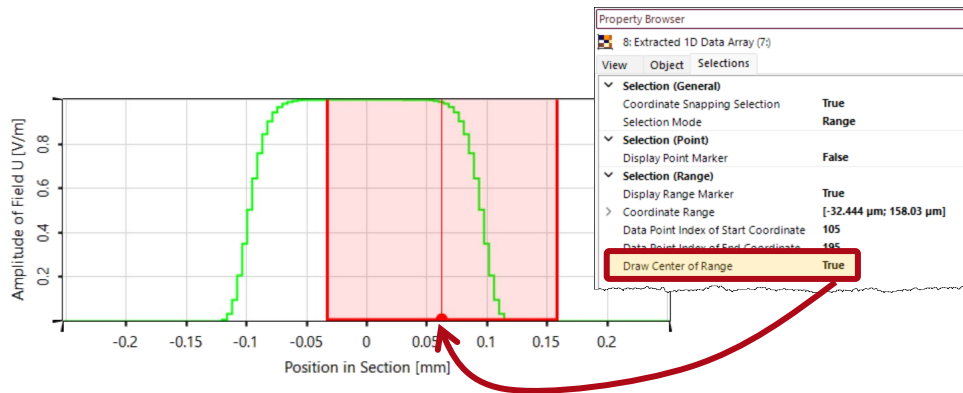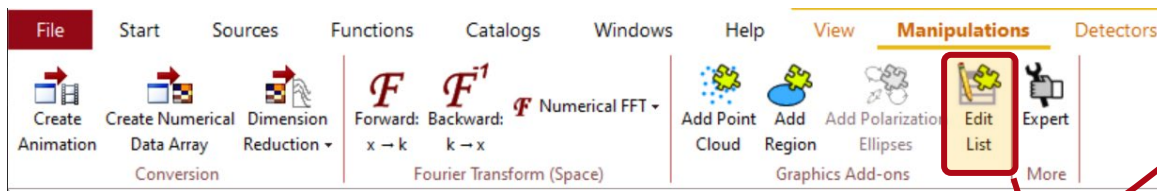

Zoom directly in1D profile
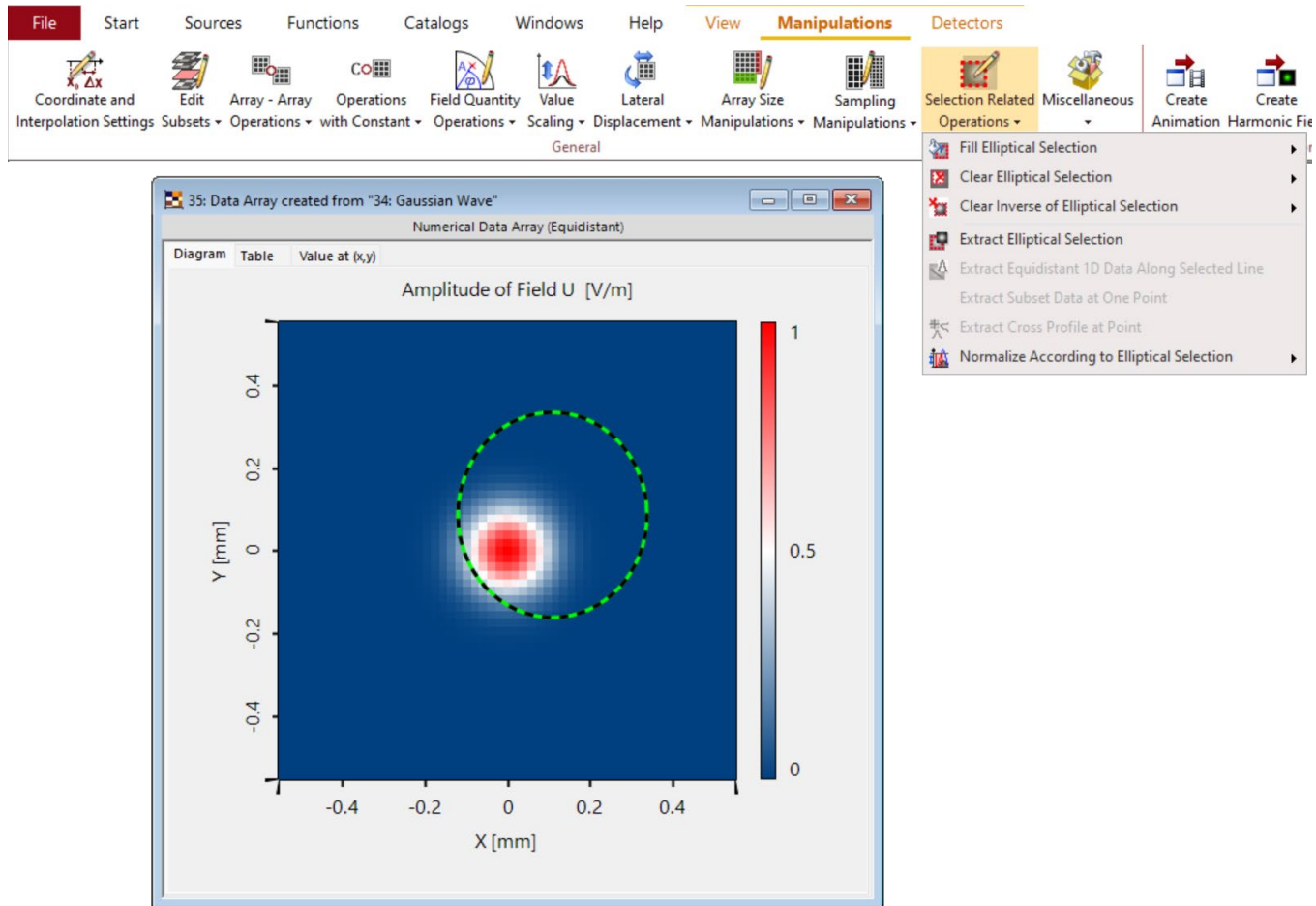
Data Array View: Configuration of Graphic Add-ons

- In VLF 2023.1 we have introduced the graphic add-ons to the data visualization for 1D and 2D data.

- There can be any number of graphic add-ons per data array.

- With VLF 2023.2, the user can now edit the list of graphic add-ons, i.e., rearrange and also delete graphic add-ons from the list.

Data Arrays: New Manipulation Actions

- The manipulation of data is an important step in VLF.

- In VLF 2023.2, we provide a set of new manipulation tools for 1D and 2D data arrays:
  - Selection related operations work now also for elliptical markers
  - Remove numerical artifacts from the data (not only in the display)
  - Convert real valued data to complex valued data
  - Extrude 1D data arrays to 2D data arrays

Preview of Isotropic Media

- VLF provides a preview for all available system buildings.

- In VLF 2023.2, we re-developed the preview for isotropic media (distribution of refractive index in xyz).

- The new preview provides the distribution of the refractive index over the screen pixels automatically, i.e. it is no longer necessary to specify sampling parameters.

- It also enables mouse-controlled zoom into the data.

- Additionally, the user can also easily select the quantity as well as the view range to be displayed.

Old Media Preview

New Media Preview
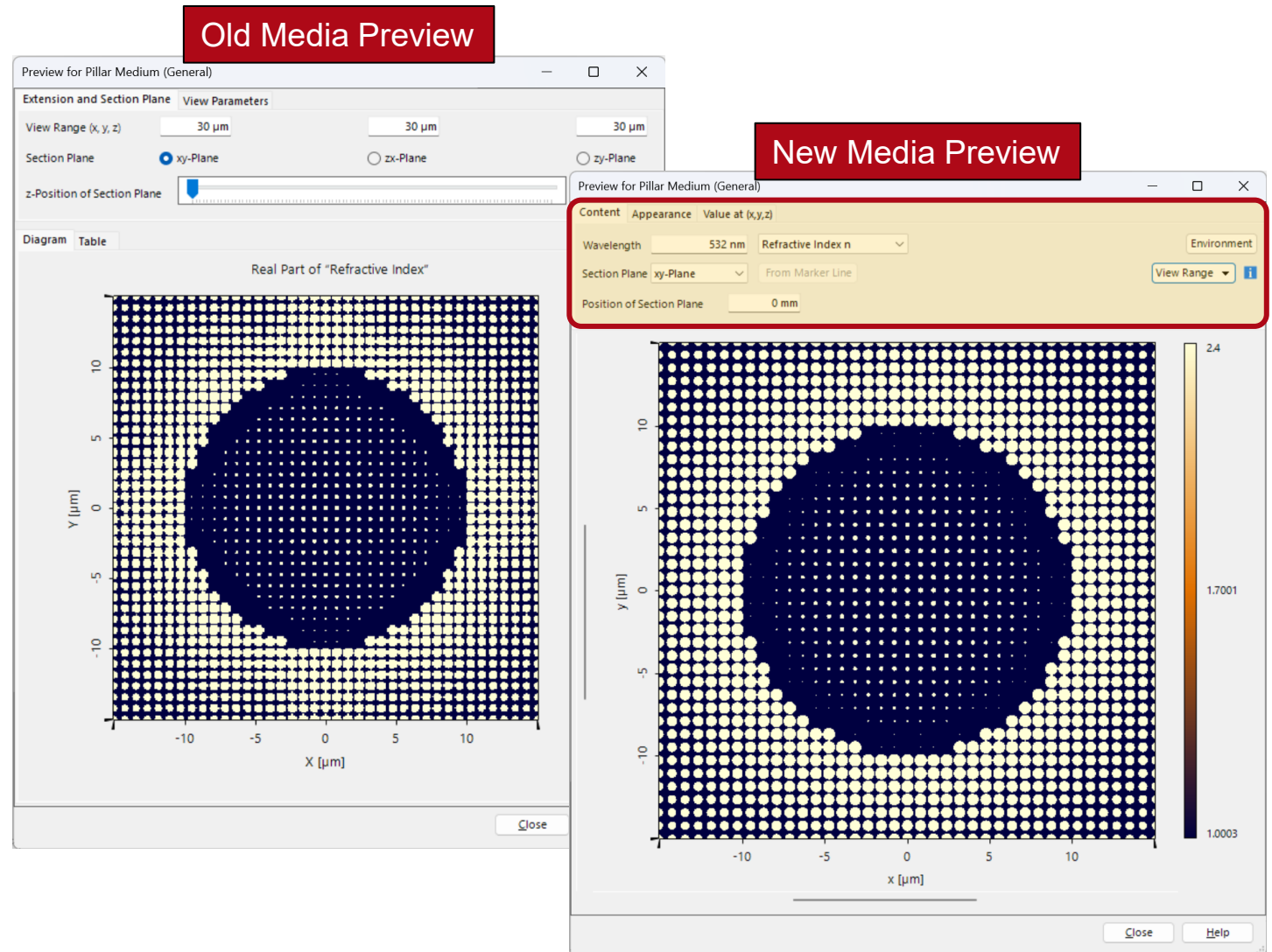
# Preview for Stacks and Lens System Component
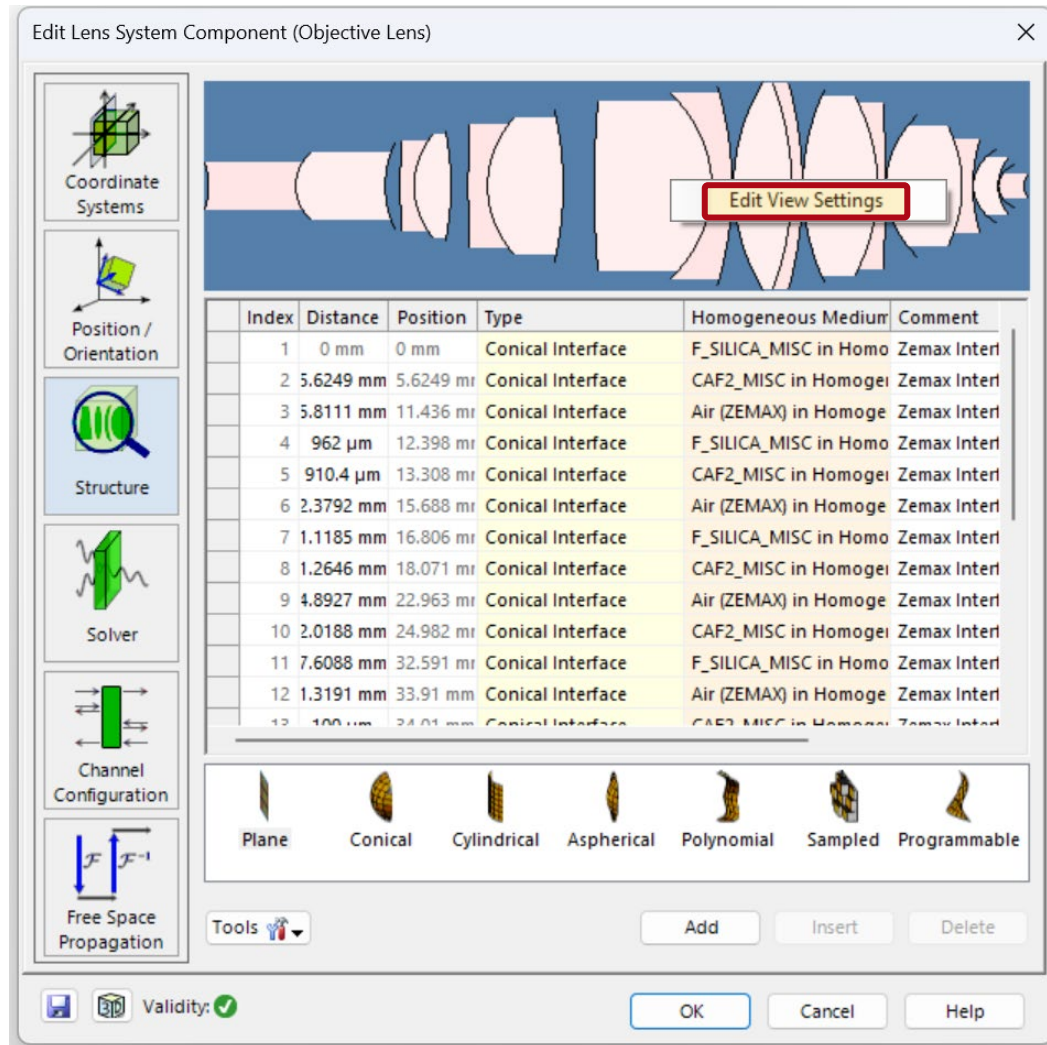
- In VLF 2023.2, the user can easily change the color lookup table for the structure preview of stacks and the preview included in the Lens System Component.
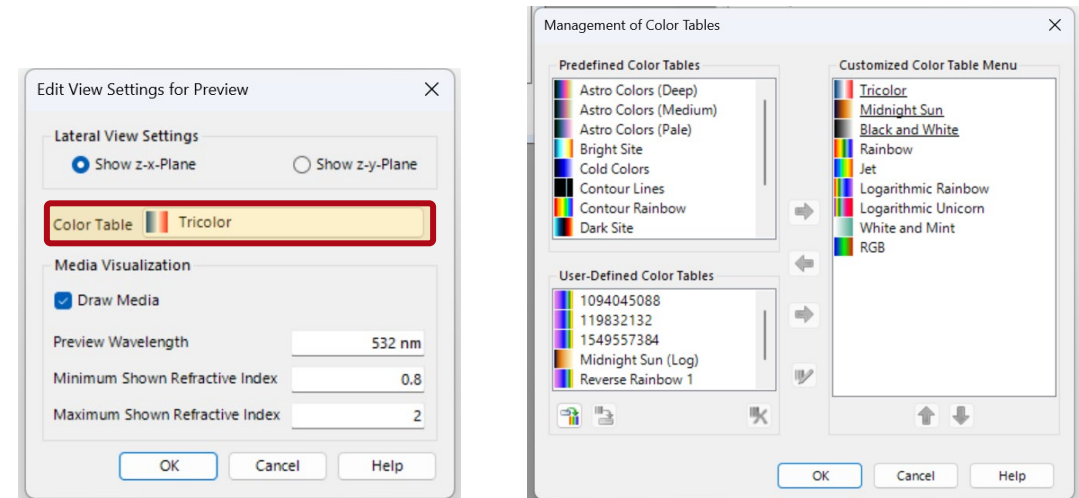
Improvements Physical Properties

- In VLF 2023.2, the concept of physical properties is completely re-implemented.

- The user directly benefits from a categorized selection of physical properties provided in the corresponding dialogs.

- In addition, it is now possible to define your own physical properties within snippets and modules and assign it to a data array.
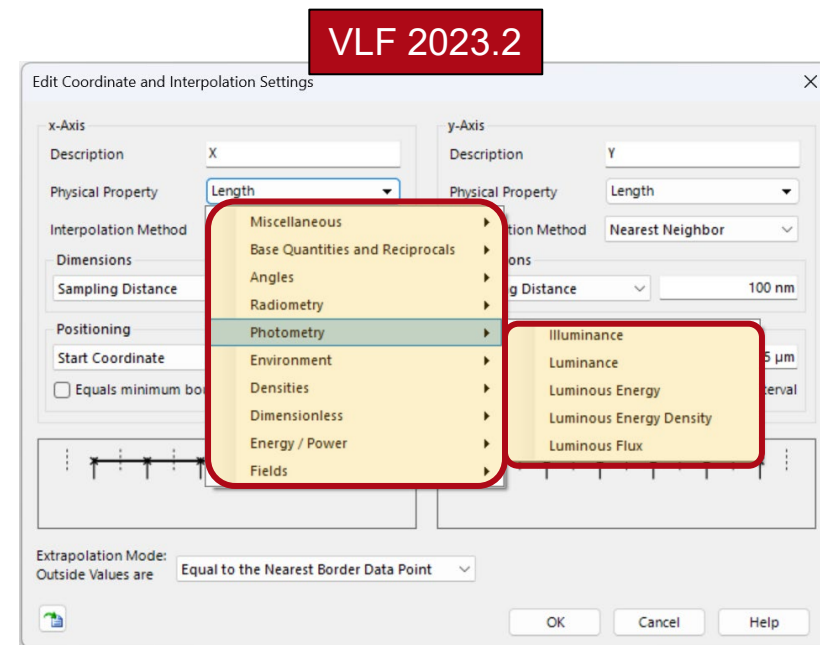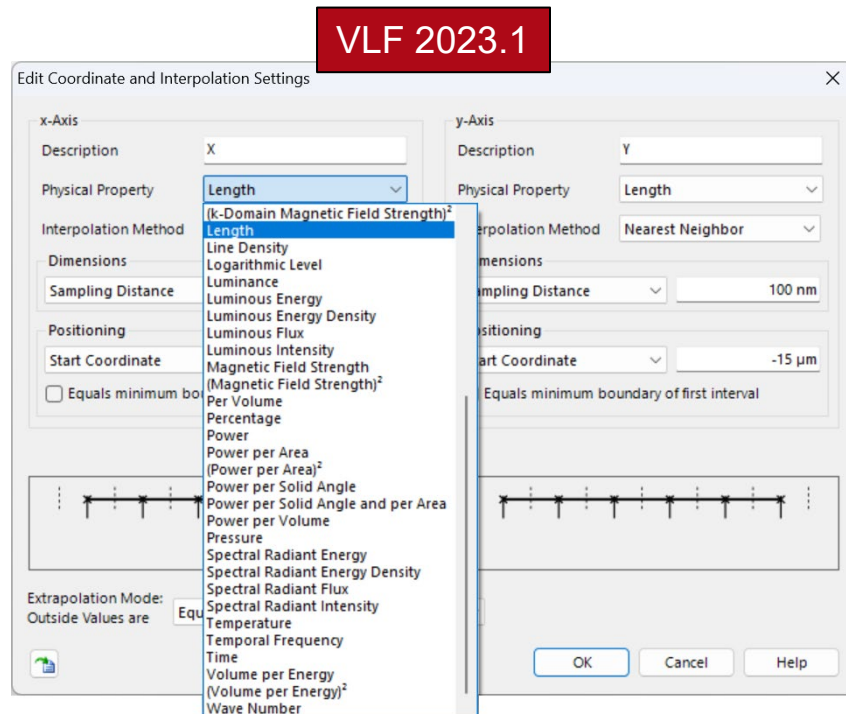
Learn More About Data Views in VirtualLab Fusion
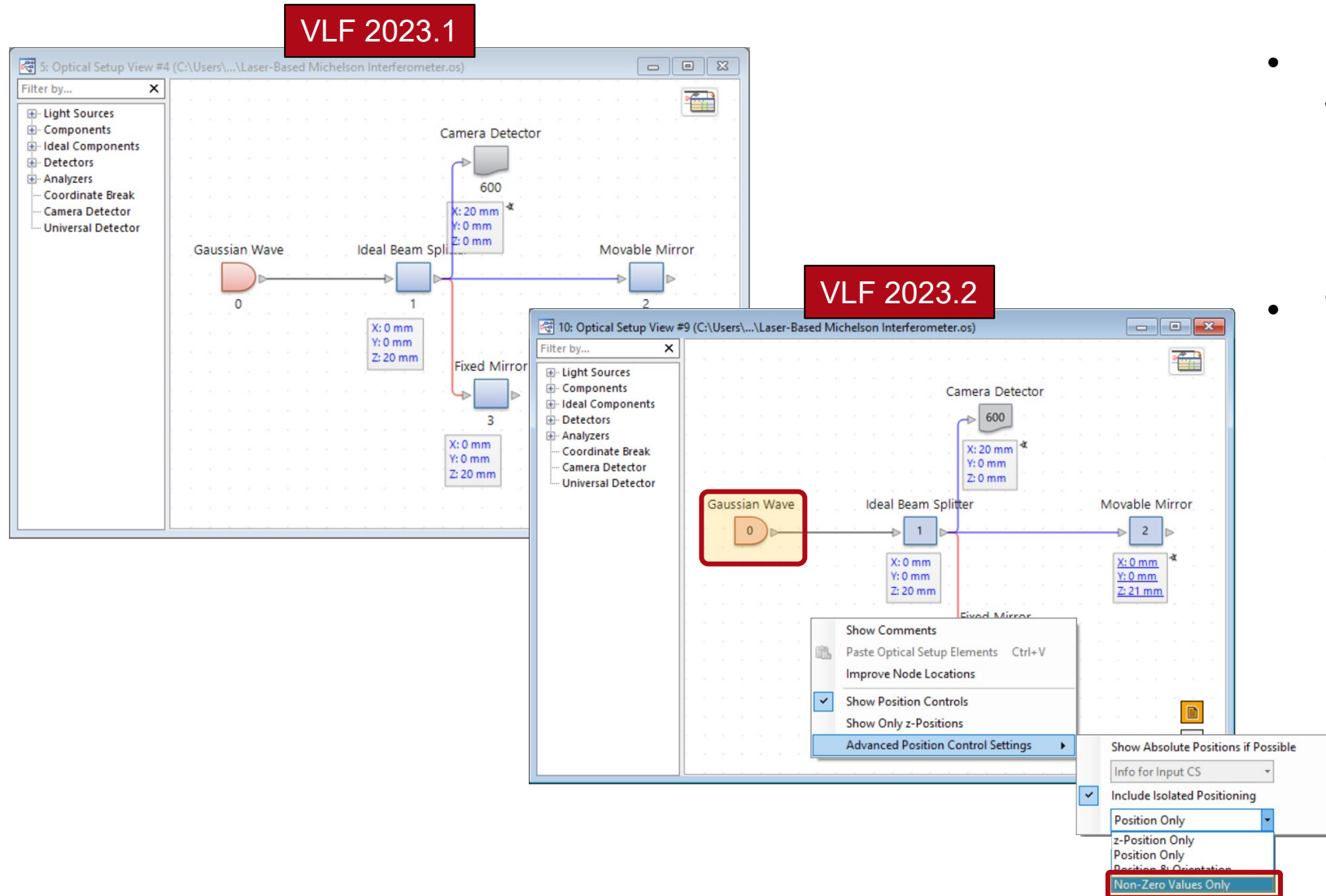
Use Cases

- Introduction to Data Arrays
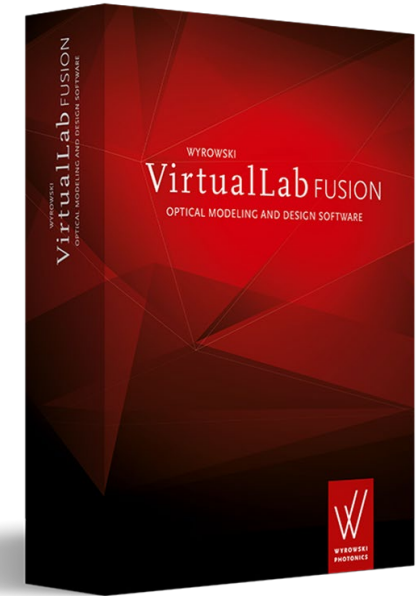
More examples & use cases coming soon!

Optical Setup

VirtualLab Fusion 2023.2 feature overview

Optical Setup View – Changes of User Interface

VLF 2023.1

VLF 2023.2

- In VLF 2023.2, the visualization within the optical system view has been improved to give a more compact overview about elements and their positions.

- There is a new option for the advanced position control setting that causes the optical setup view to display position controls only when the position settings are different from zero.

Optical Setup Tools – Combine Components
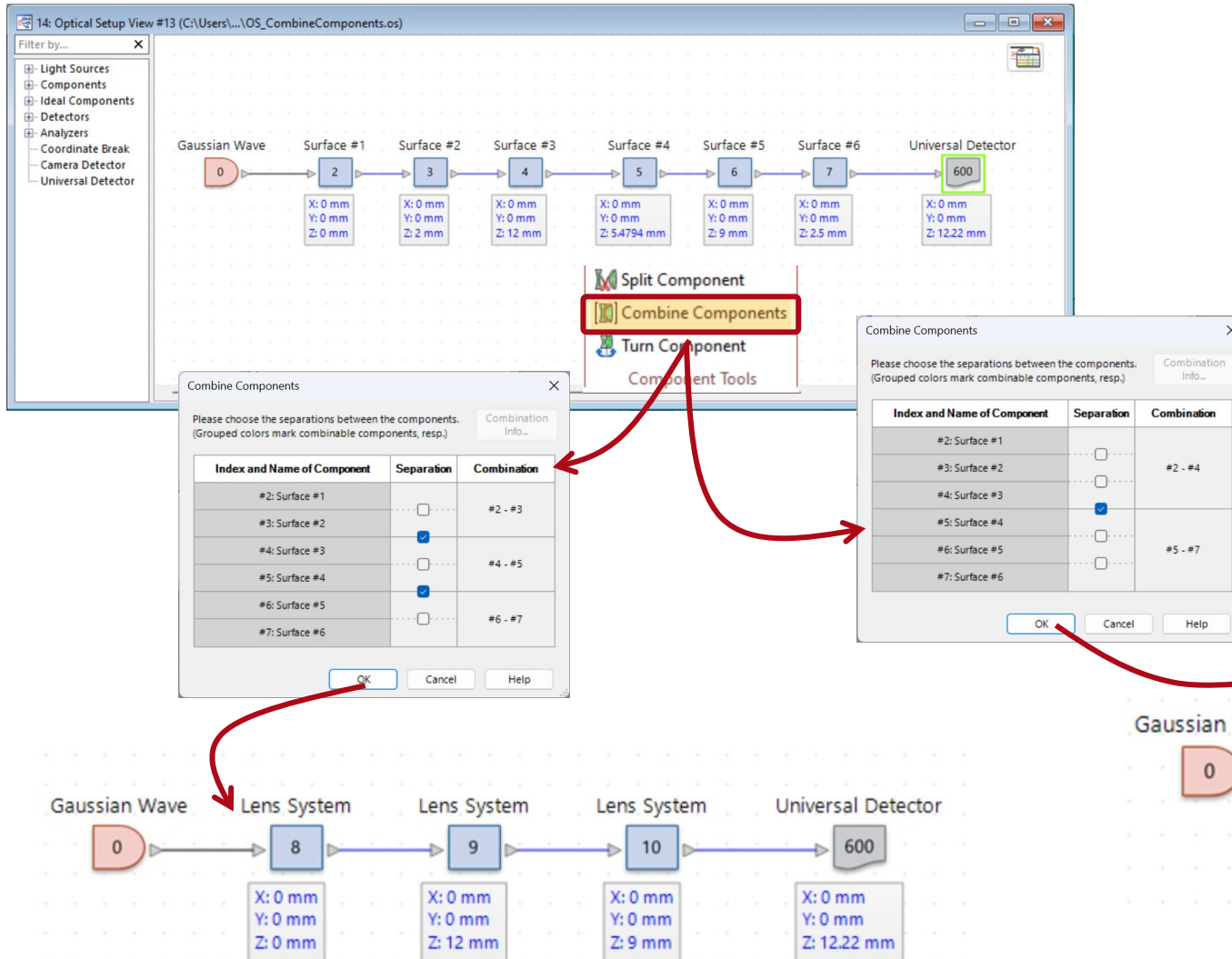
- In VLF 2023.2, a new option in the context menu of components allows combining multiple surfaces and lens systems to a single component.

- The user can select which component is to be combined into a lens system component via a user-friendly edit dialog.

Components

VirtualLab Fusion 2023.2 feature overview

# Duplicate Surface(s) @ Lens System & Light Guide Component
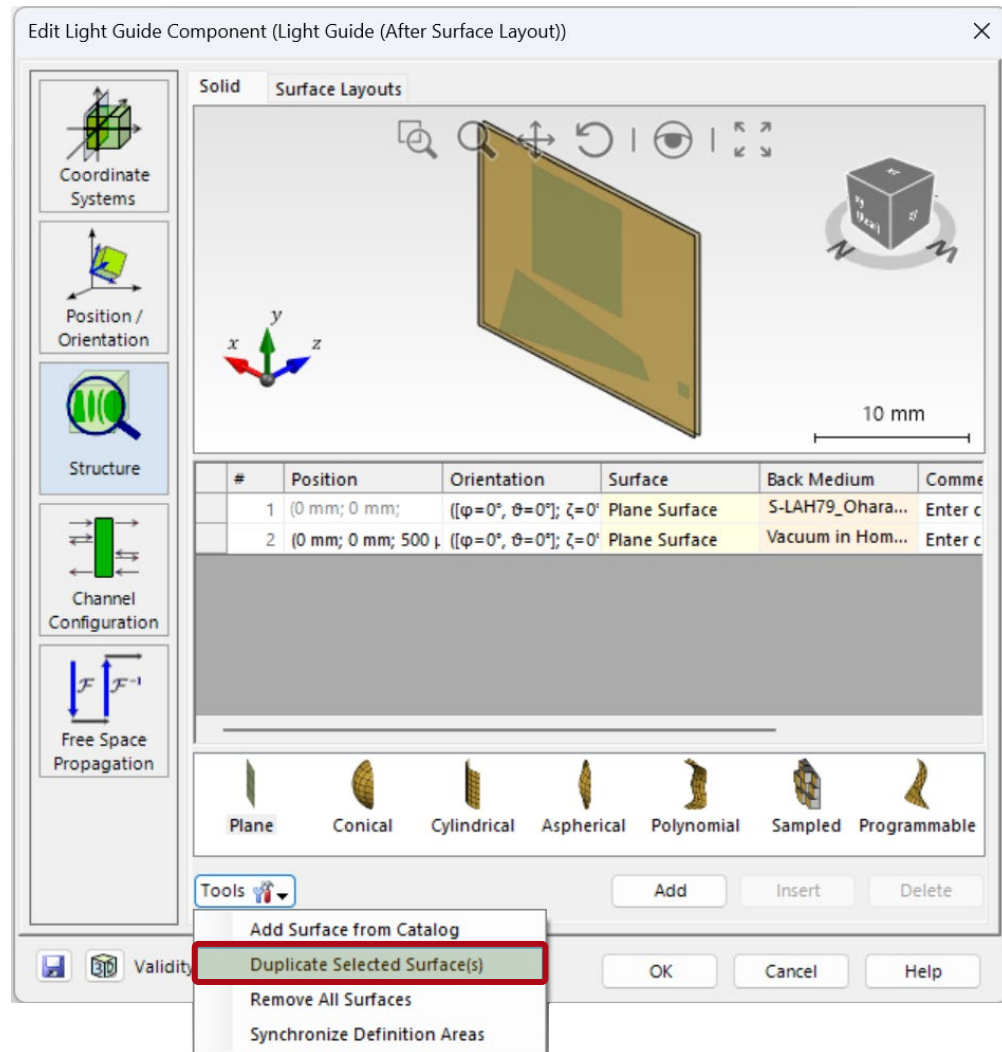
- The configuration of components is an important step when setting up an optical system.

- With VLF 2023.2, we provide a new tool for the lens system and light guide component, which allows to duplicate selected surface(s).

- For light guide components also the surface layout is duplicated (i.e. configured regions).
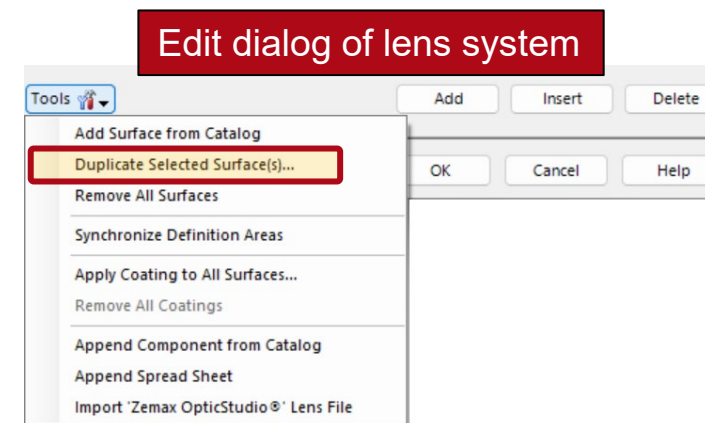
Improved Edit Options for Isotropic and Anisotropic Coatings

- In VLF an optical coating is described by a sequence of coating layers.

- Further, it is distinguished between isotropic and anisotropic coating layers.

- In VLF 2023.2, the user can change the position of a layer in the edit dialogs of the coatings by simply clicking the newly introduced "up" or "down" buttons.

- The selected layer will be reordered according to your action.
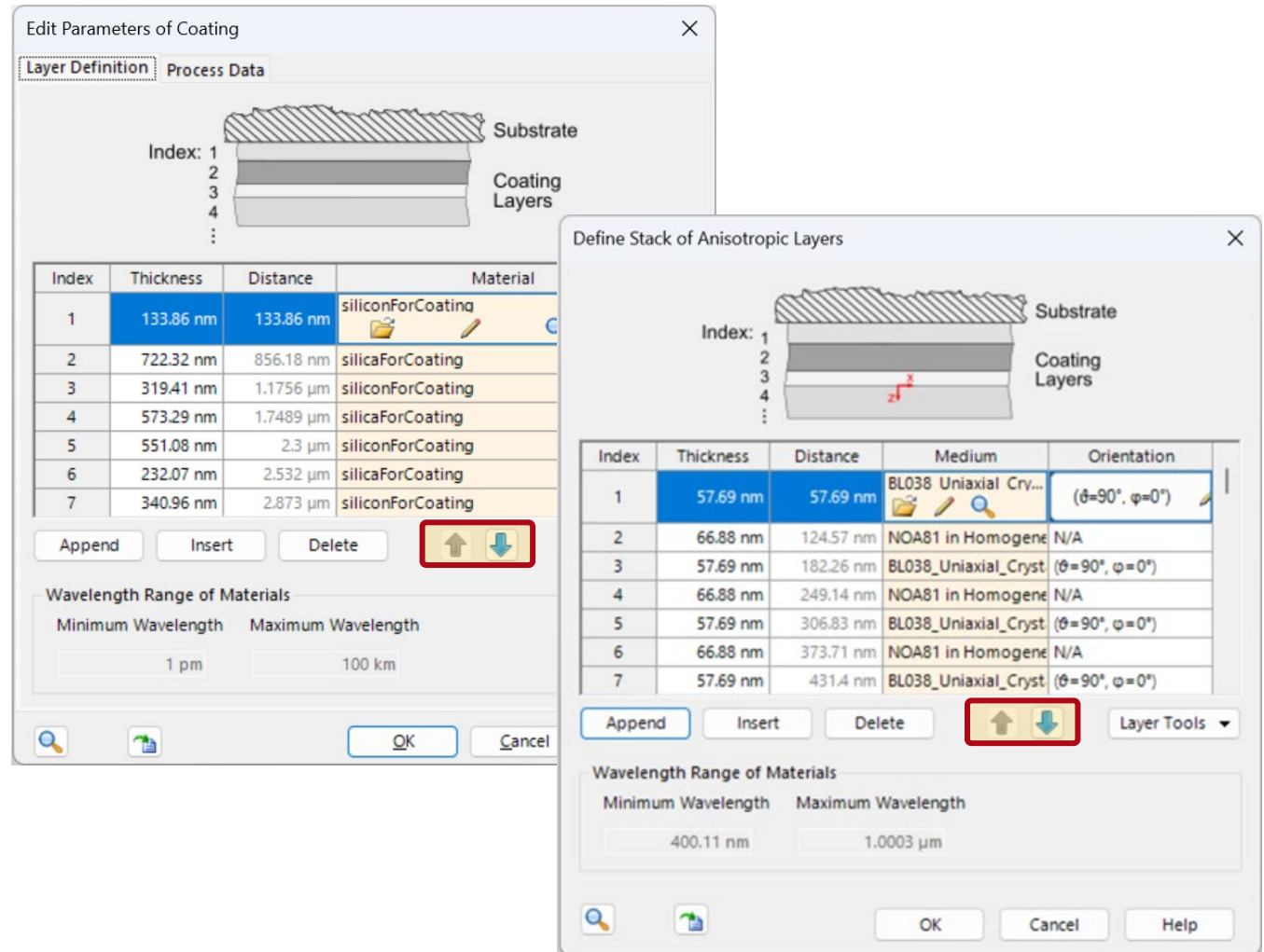
GRIN Medium: New GRIN Profile Definitions
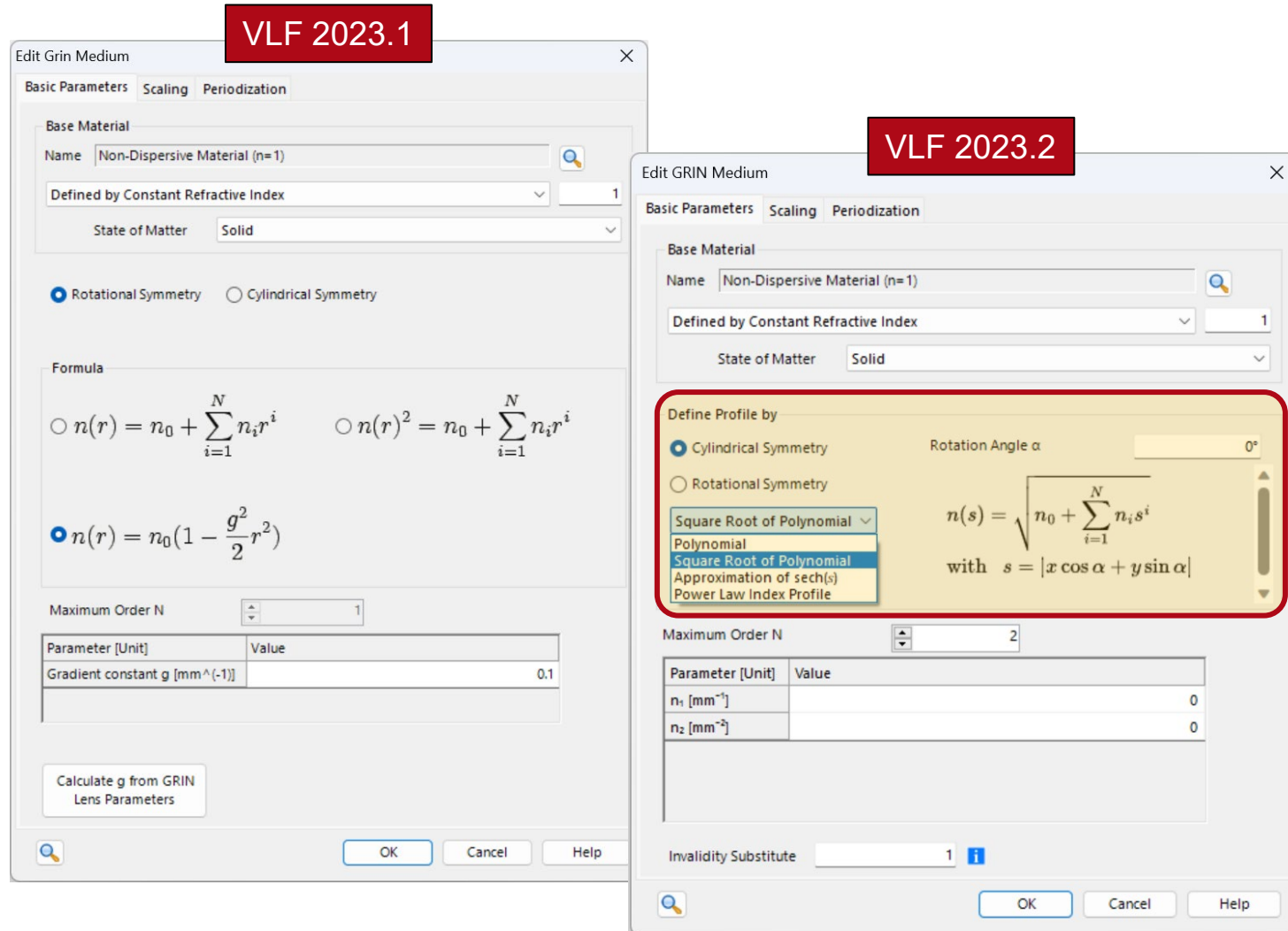
- The GRIN medium offers several possibilities to define the profile of the refractive index distribution.

- In VLF 2023.2, we have added new formulas to describe the refractive index distribution of a GRIN fiber.

- In addition, the edit dialog of the GRIN medium has been restructured and now offers a more intuitive selection of available profiles.

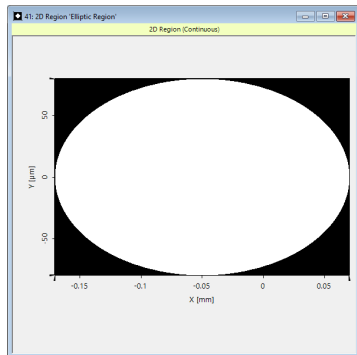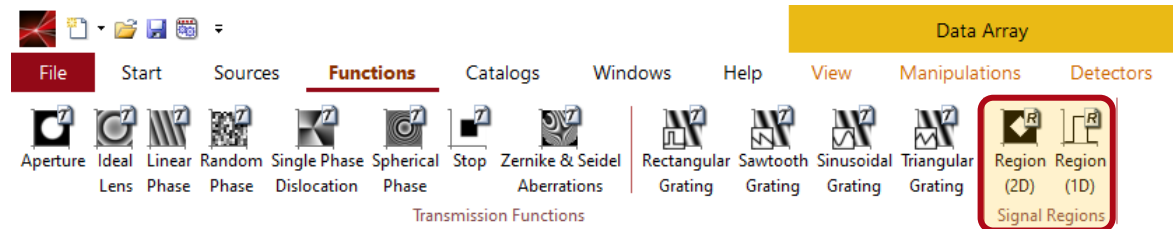# Learn More About Components in VirtualLab Fusion

Use Cases

- Construction and Modeling of a Graded-Index Lens

- Modeling of Graded-Index (GRIN) Multimode Fiber

- Stratified Media Component

- Absorption in a CIGS Solar Cell

Regions

VirtualLab Fusion 2023.2 feature overview

Regions in VirtualLab Fusion
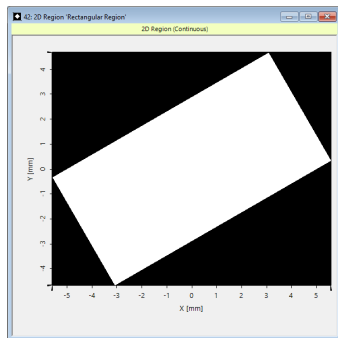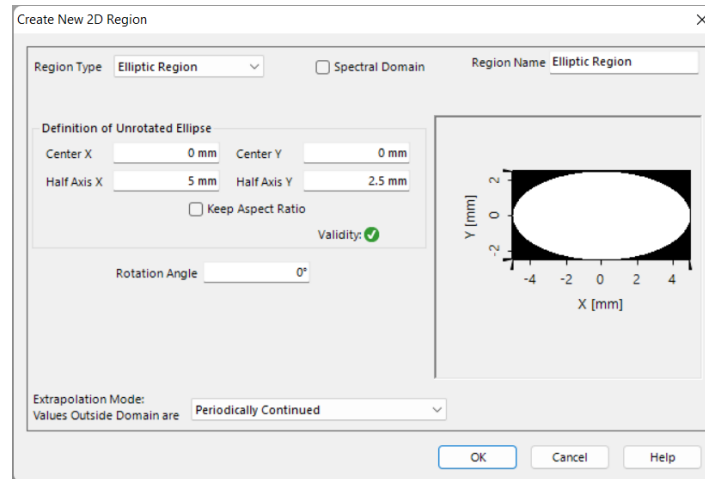
- In VLF, Regions are used to define areas with various shapes, e.g., to define signal windows in diffractive optics designs.

- In VLF 2023.1 we have started to apply the region concept in many more scenarios.

- Regions define 1D and 2D areas where certain operations are to be performed, e.g., evaluation area of a detector or definition area of a grating.
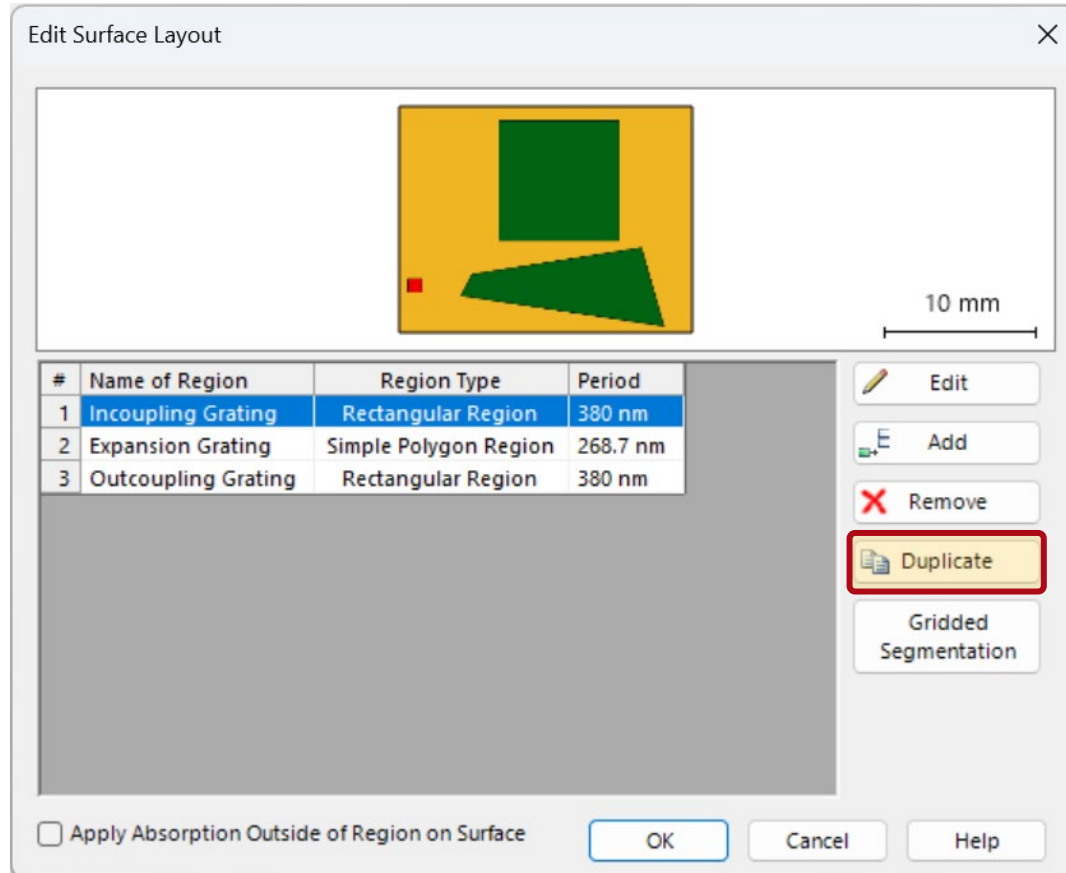
Improved Editing of Polygon Regions

- In the editing dialog of polygon regions in VLF 2023.2 there is a new collection of tools that allow to transform this type of regions.

- The offered tools enable an easy scaling, rotation and translation of a given polygon.
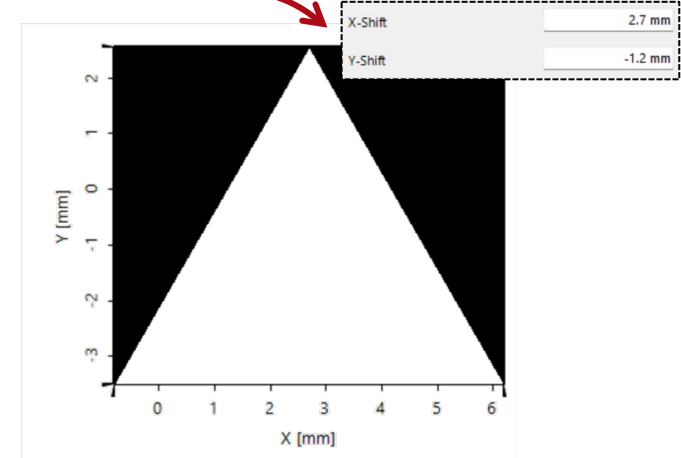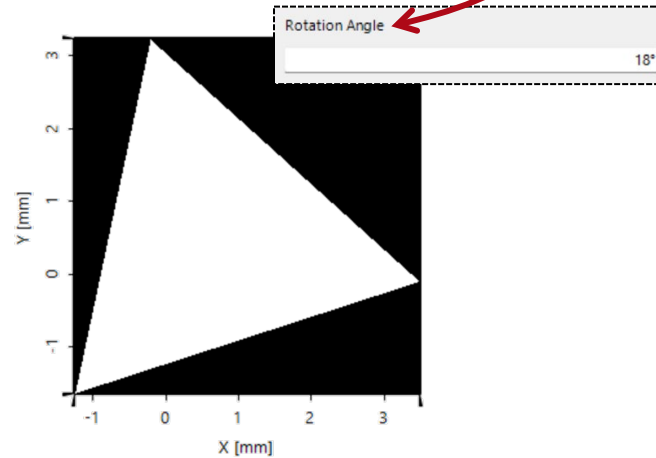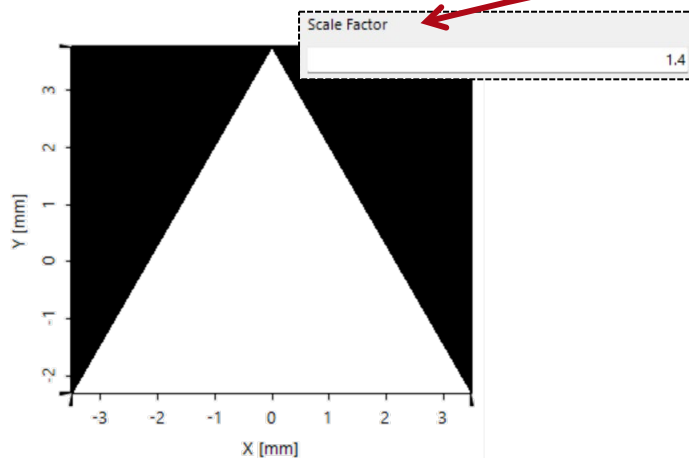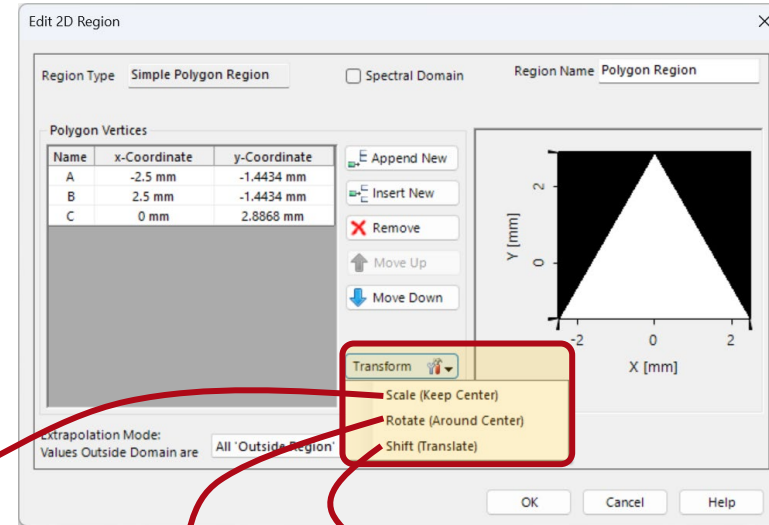
Duplicate (Grating) Region in Surface Layout

- Within the light guide components of VLF, the user can specify the layout of the surfaces, which contain all the grating regions that are used for guiding the light through the component.

- The user can add new regions, edit existing regions or delete a grating region.

- In VLF 2023.2, a new option enables a simple duplicate function for a selected region.

- The duplication, copies the shape and size of the region together with all other setting, like configured grating structures, channels and diffraction orders.

Learn More About Regions in VirtualLab Fusion

Use Cases

- Flexible Region Configuration

- Add Region to Data Array

- Lightguide with Butterfly Eye-Pupil Expander based on Patent by Microsoft
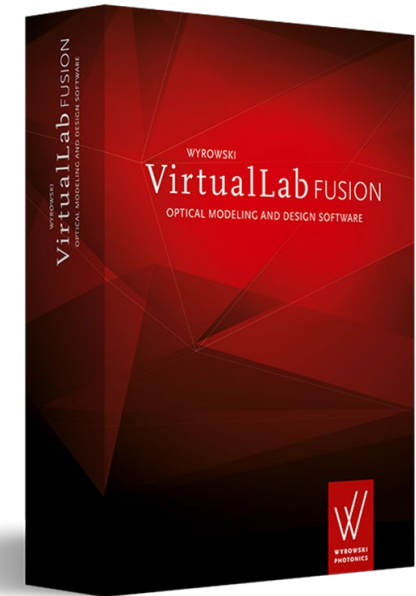
Parametric Optimization

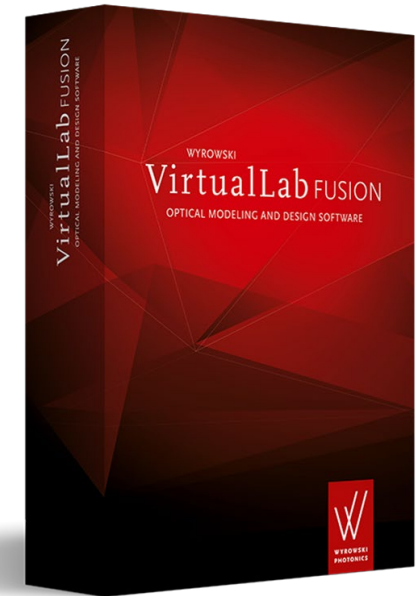VirtualLab Fusion 2023.2 feature overview

Parametric Optimization

- In parametric optimization of VLF, all intermediate results of the optimization process are provided in tabular form.

- In VLF 2023.2, values in the table are highlighted by color, if the merits or constraints are (not) fulfilled:
  - red: parameters constraints are not fulfilled
  - green: merit constraints are fulfilled
  - orange (filled): optimum result

- In addition, the user can select via the property browser that only the valid optimization steps are shown (e.g. ranges of parameters are not violated).

Learn More About Parametric Optimization in VirtualLab Fusion

Use Cases

- Introduction of the Parametric Optimization Document

- Parametric Optimization of Slanted Grating

- Rigorous Analysis and Design of Anti-Reflective Moth-Eye Structures

- Optimization of Lightguide with Continuous Modulated Grating Region

More examples & use cases coming soon!

Detector Add-ons

VirtualLab Fusion 2023.2 feature overview

Universal Detector – Detector Add-ons
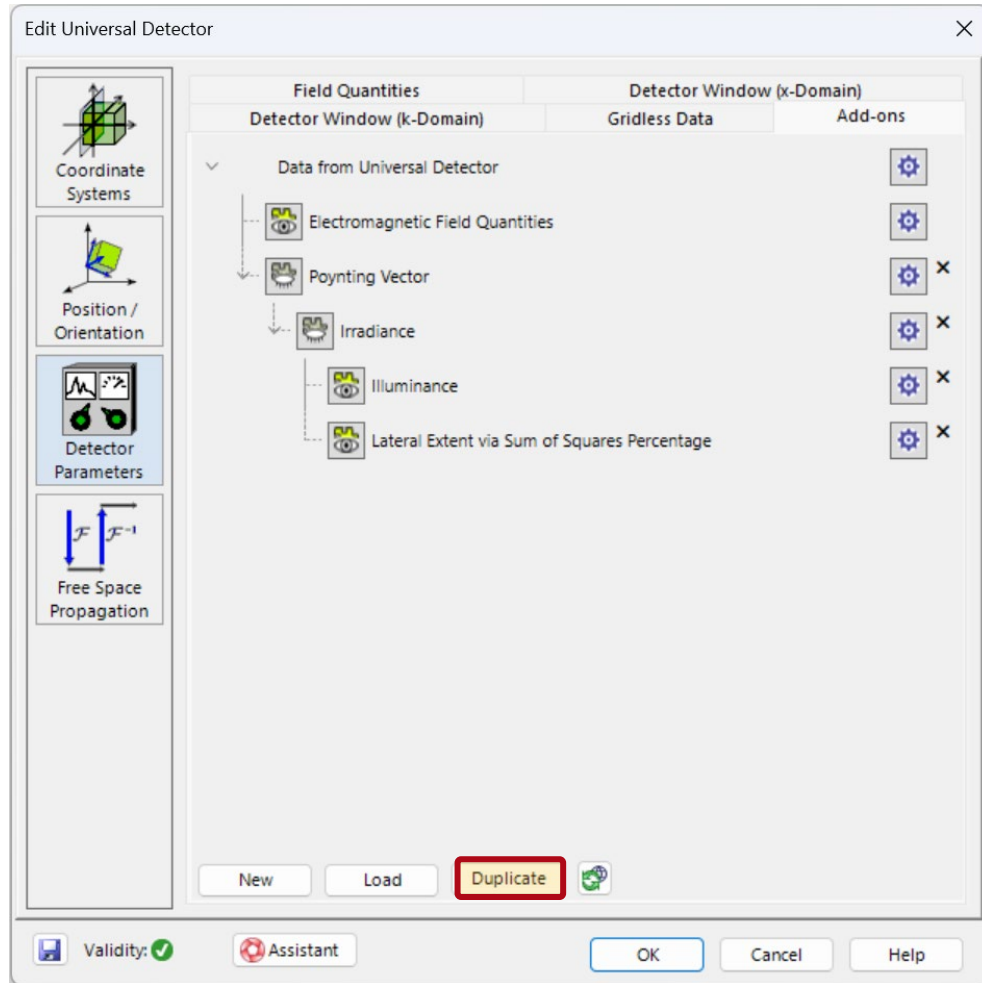
- Detector add-ons can be used for further evaluations inside the universal detector.

- VLF provides a set of pre-defined detector add-on that can be updated via internet, triggered by the synchronize button in the universal detector.

- In VLF 2023.2, a new category for export add-ons is provided, which enable the export of results to the following formats:
  - text (CSV)
  - picture (BMP, PNF, TIFF)
  - raw data (VLF formats)

- VLF 2023.2 also offers a new option to duplicate a selected detector add-on, which simplifies the workflow for the user.

Post-Processing: Application of Detector Add-Ons

- Detector add-ons can be used either in the universal detector or in post-processing.

- To simplify the use of detector add-ons in the main window, VLF 2023.2 now offers the possibility to define favorites for detector add-ons.

- This way you can facilitate the access to the detector add-ons with a concrete preset for your daily work.
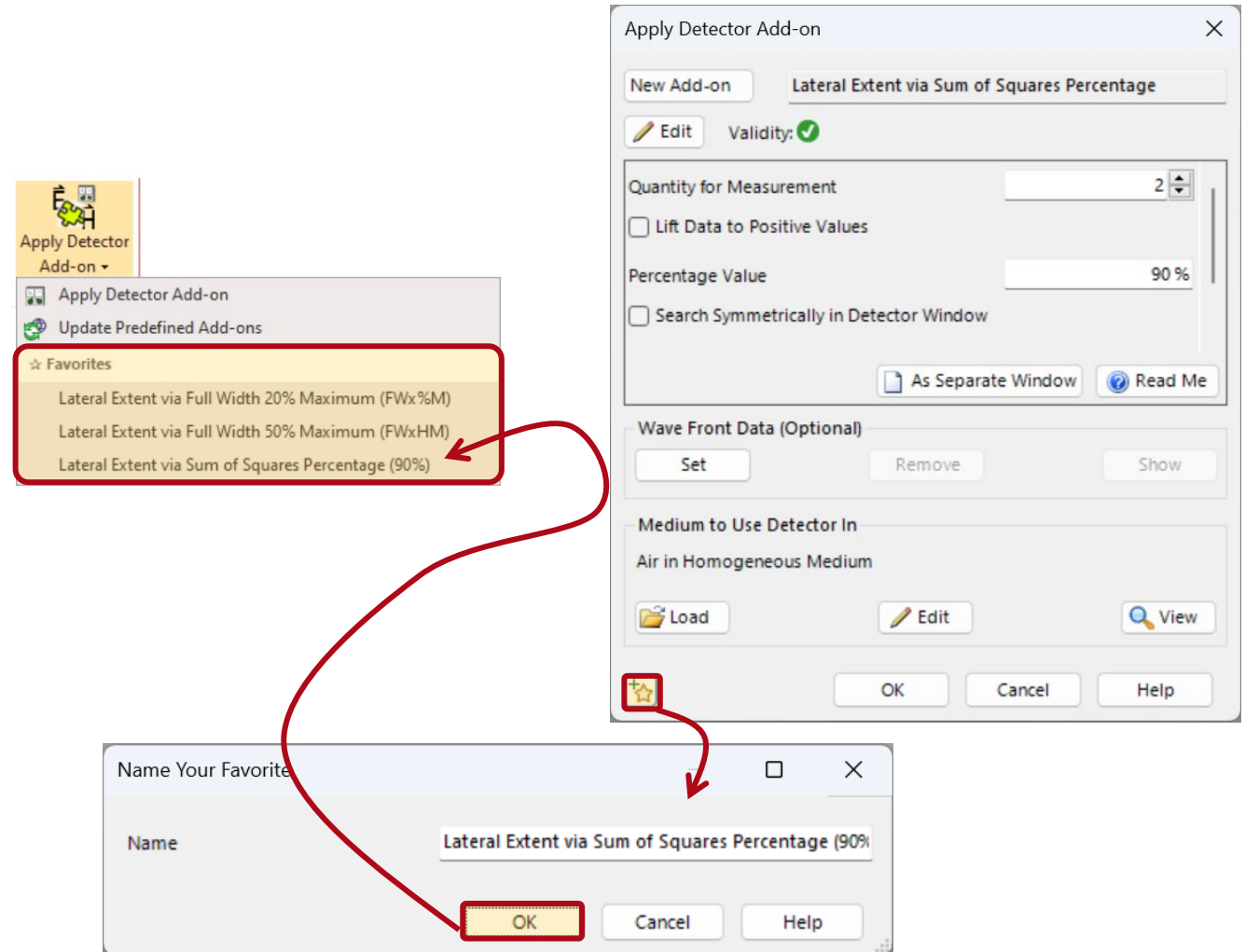
Learn More About Detector Add-ons in VirtualLab Fusion

Use Cases

- Universal Detector

- Design and Analysis of Intraocular Diffractive Lens

- Visualize Grating Regions in Lightguide Results
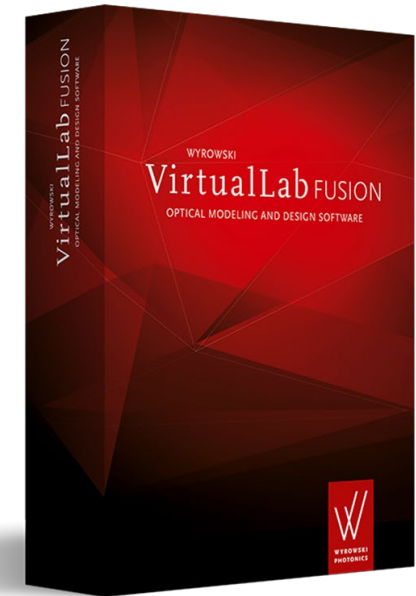
Customization (Modules & Snippets)

VirtualLab Fusion 2023.2 feature overview

Improvements for Customization (Modules & Snippets)
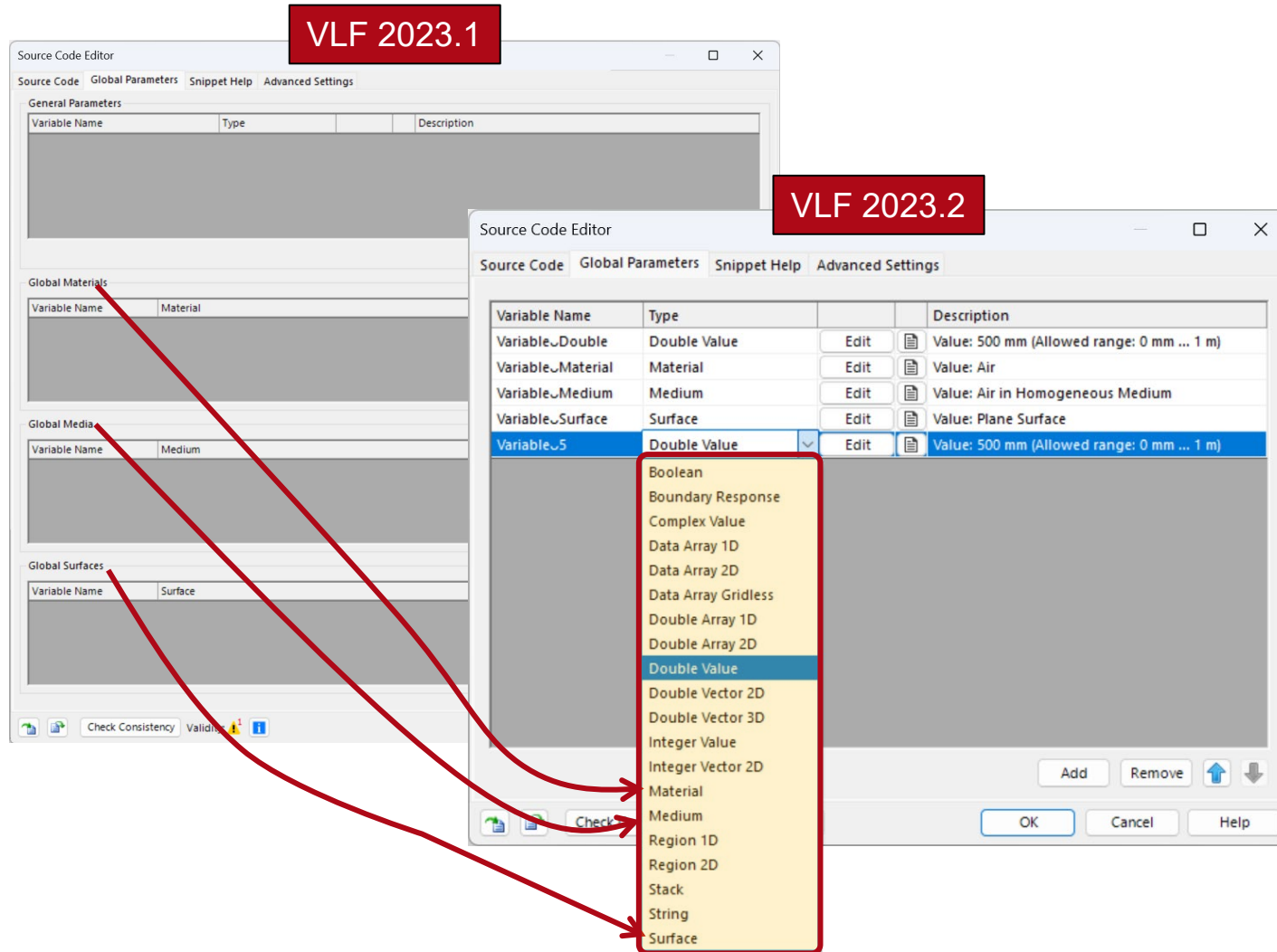
- In VLF 2023.2, the handling of global parameters in snippets was unified.

- All snippets now have access to all type of VLF data (like surfaces and materials).

- The user interface offers these data types similar to the basic data types (like double or int) by selection in a dropdown menu.

- With VLF 2023.2, the VirtualLab.Progamming.dll provides the new class `VL_OpticalSetups` which enables an easy access to parameter of optical setups and results of parameter runs.

Detectors & Analyzers

VirtualLab Fusion 2023.2 feature overview

New: Parameter Variation Analyzer

- In VLF 2023.2, the all-new **Parameter Variation Analyzer** can be added to any system.

- This analyzer internally performs a user-configured parameter run, and via a snippet the user can access the results of the parameter run and perform user-defined evaluations on them.

- This enables advanced multiple configuration and tolerance analysis for your optical setup.

- The Parameter Variation Analyzer benefits from the distributed computing techniques of VLF.
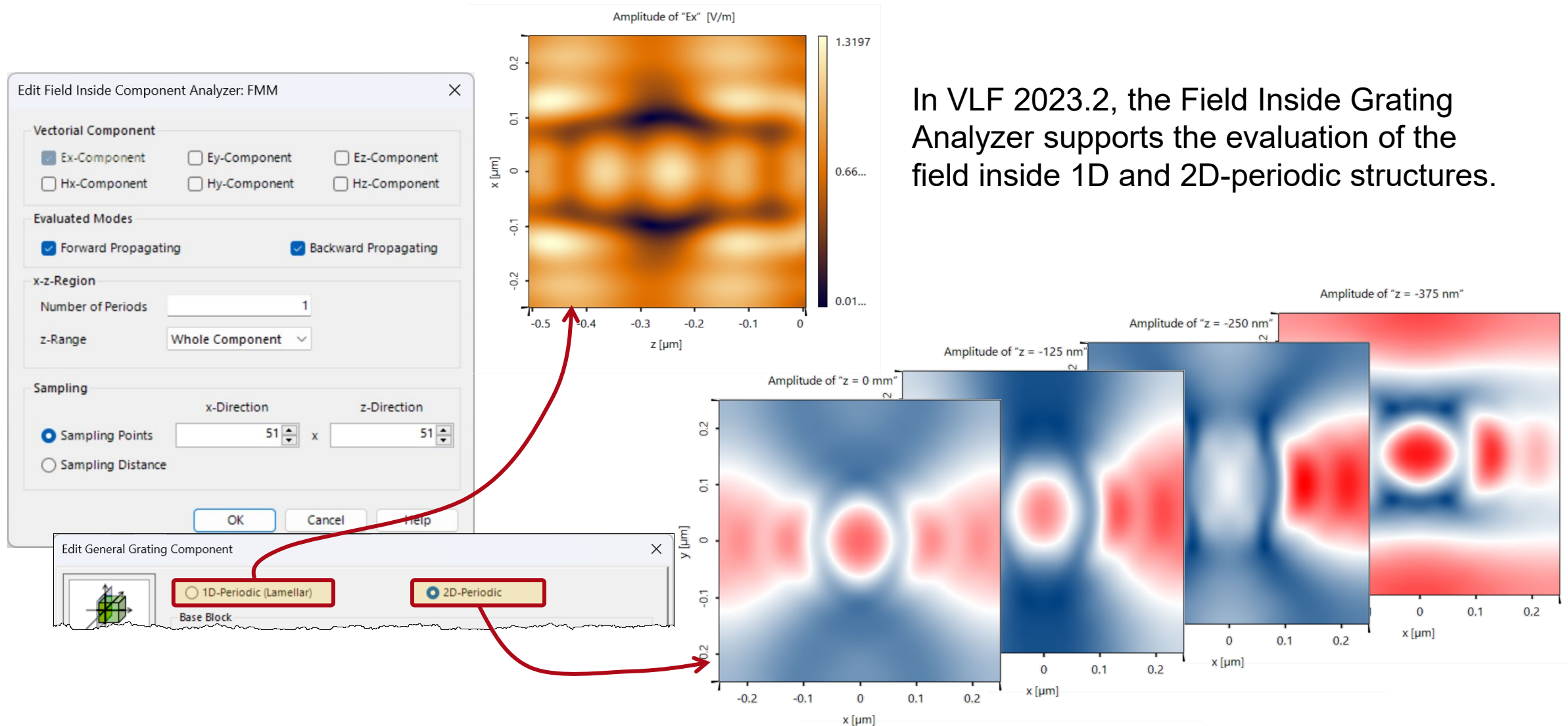
Improvements Multimode Fiber Coupling Detector

- In VLF 2023.2, the Multimode Fiber Coupling Detector offers the option to detect the efficiency per fiber mode as well.

- The total fiber coupling efficiency as well the fiber coupling efficiency per single mode are logged to the detector result table.

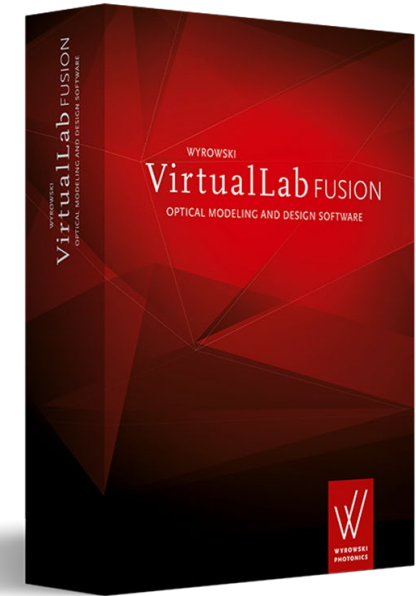# Field Inside Component Analyzer: FMM

In VLF 2023.2, the Field Inside Grating Analyzer supports the evaluation of the field inside 1D and 2D-periodic structures.

Learn More About Detectors & Analyzers in VirtualLab Fusion
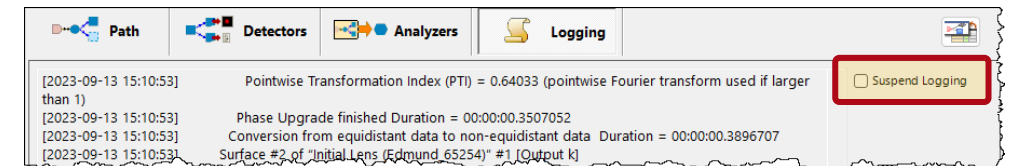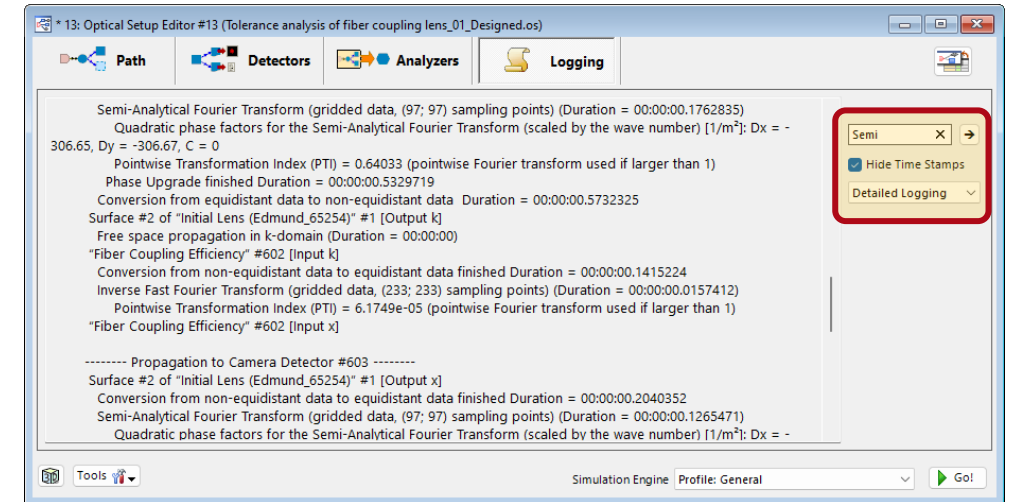
Use Cases

- Parameter Variation Analyzer

More examples & use cases coming soon!

Process Logging

VirtualLab Fusion 2023.2 feature overview

Process Logging During Simulation

- The process logging in VirtualLab Fusion now provides much more detailed information about the process during the simulation of an optical setup.

- The user gets details about both the decision and the decision criteria (PTI) of the automatic Fourier transform selection during propagation.

- In addition, the logging provides information about the selected sampling and the calculation times per algorithm step.

- VLF 2023.2 enables the following features to access and control the process logging:
  - option to temporary suspend the logging during simulation
  - select the logging level directly on the logging tab
 - option to search within a specific logging information using a full text search

Profile Editing Tools

VirtualLab Fusion 2023.2 feature overview

Improved Layout of Profile Editing Tools

- In VLF 2023.1, we introduced the profile editing tools.

- The configuration dialog was redesigned in VLF 2023.2 which results in a more logical organization of the information of parameters that are currently present in the optical system and the setting which shall be applied.

- In addition, the option to neglect diffraction-induced divergence was removed.
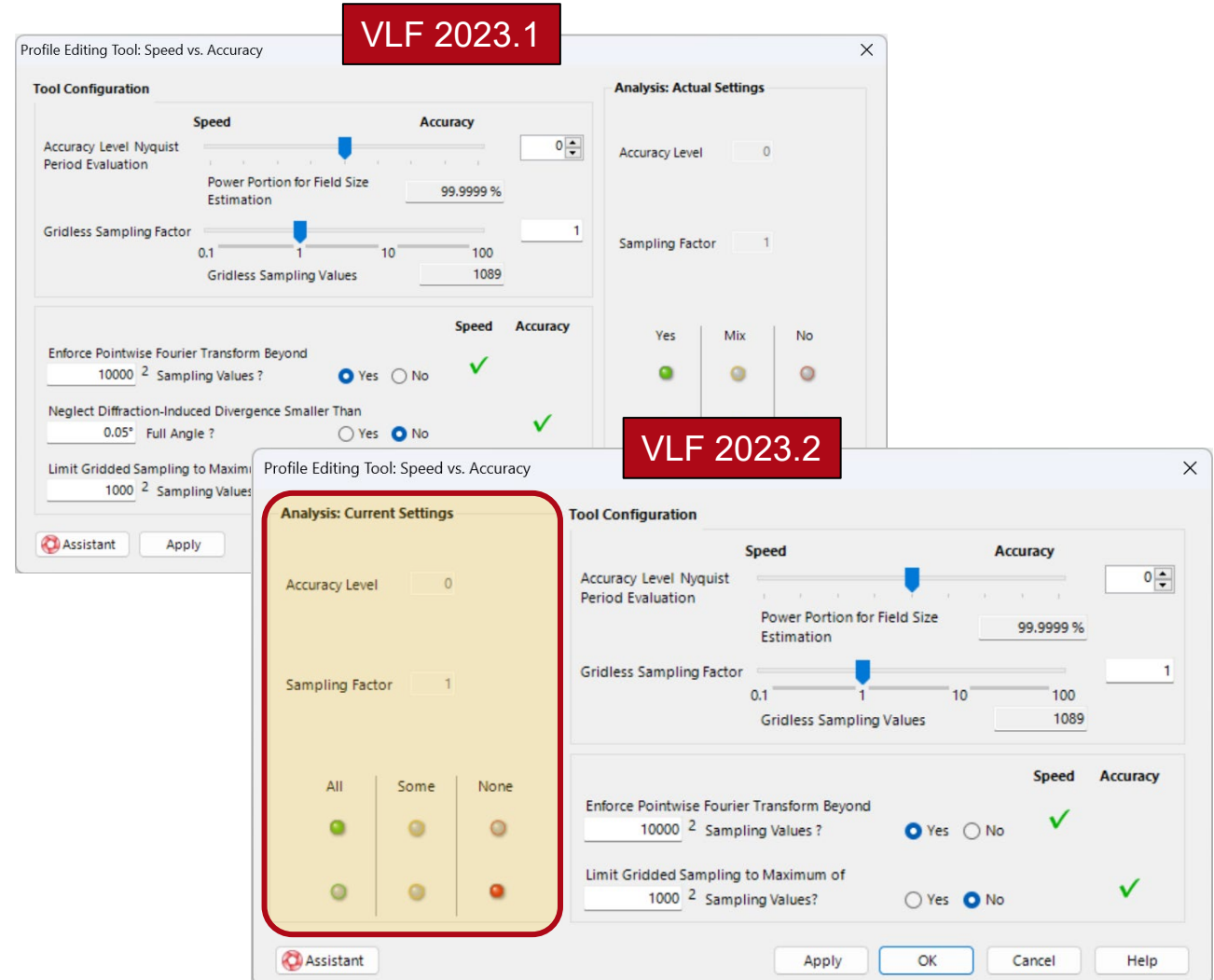
Improved Layout of Profile Editing Tools
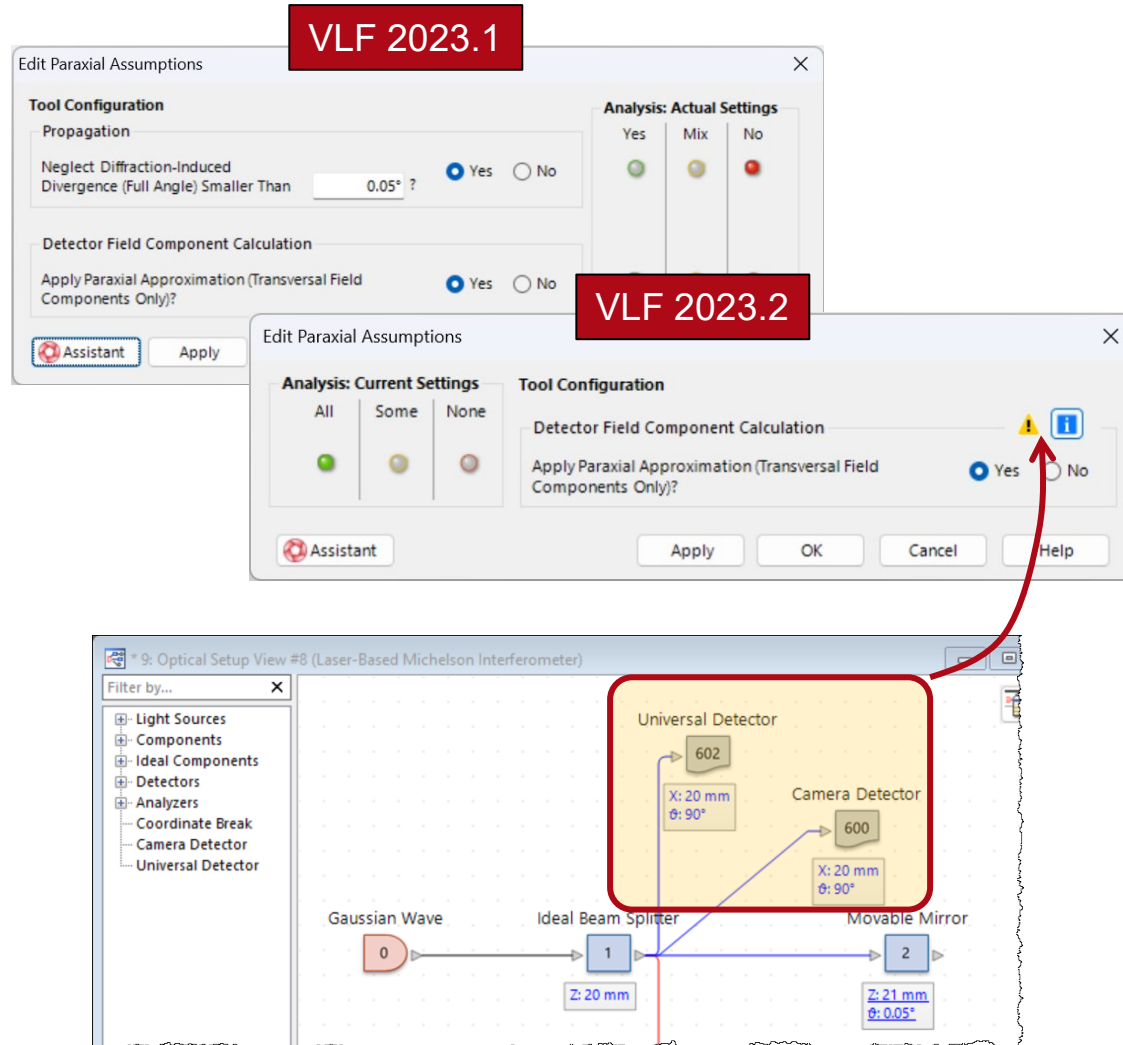
- In VLF 2023.2, the tool for paraxial assumptions was improved and simplified.

- The option to neglect diffraction-induced divergence was removed.

- Furthermore, there are now additional identifiers for the field component calculation settings.

- This option affects only universal detectors, and if other detectors are present, a warning for paraxial assumptions is displayed in the profile editing tool.

Learn More About Profile Editor And Profile Editing Tools in VirtualLab Fusion

Use Cases

- Profile Editor

- Configuring Your Simulation in VirtualLab Fusion
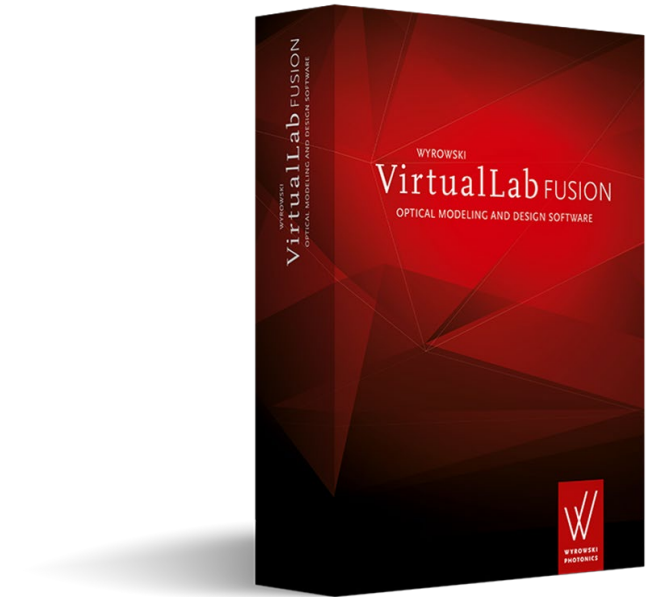
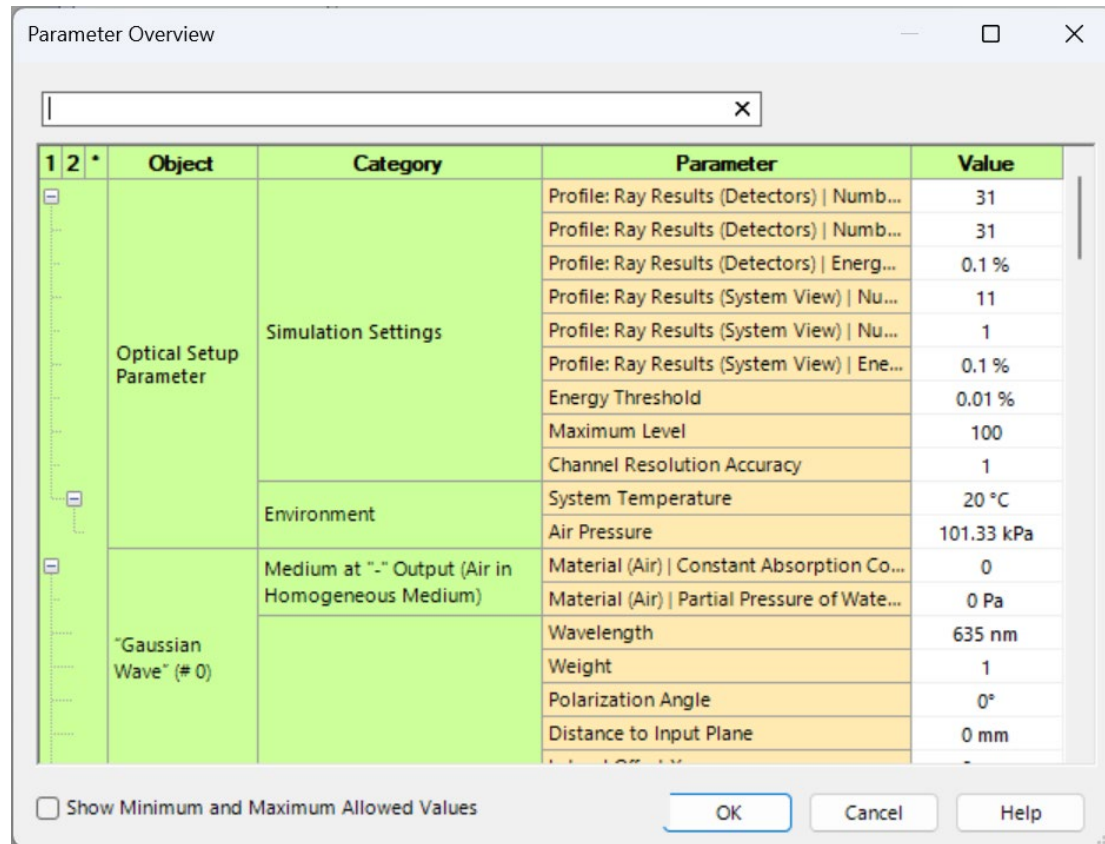**More examples & use cases coming soon!**

Miscellaneous

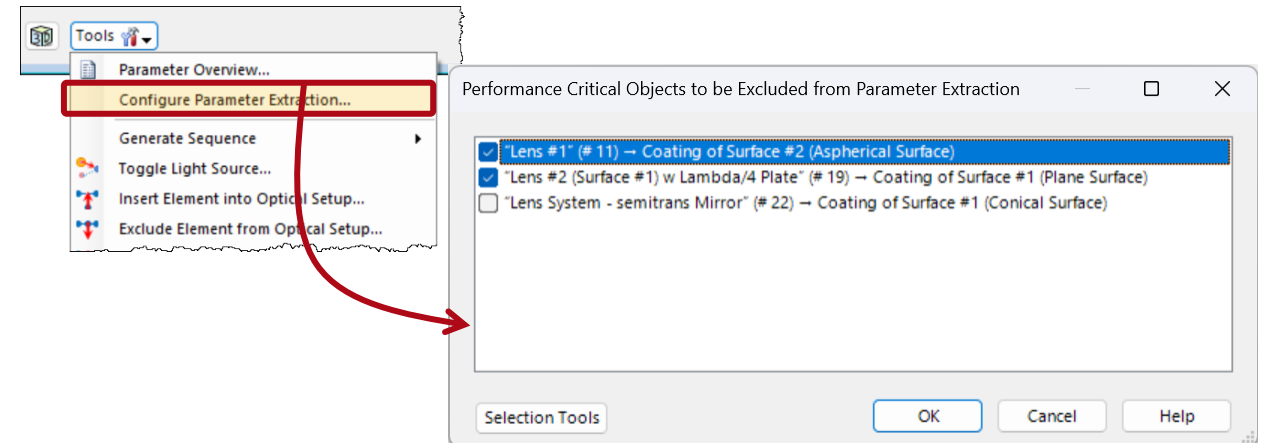VirtualLab Fusion 2023.2 feature overview

Parameter Extraction


- New parameters are available for parameter overview and parameter run:
  - parameters of GRIN media
  - additional parameters for volume grating
  - diffraction orders of grating component
- VLF 2023.2 enables the deactivation of parameter extraction* for all kind of coatings.

*Note: In case, the number of extracted parameter is large, the performance in parameter run is maybe reduced.

New XML Format for Files Generated by VirtualLab Fusion

- In VLF 2023.2, a new file format is available for saving VirtualLab Fusion files to disk.

- In previous VLF versions, the files were stored using external technology. In VLF 2023.2, our own technology was implemented, which is exactly tailored to our needs.

- Now, files can be saved in both formats. The new format can be activated in the *Global Options* dialog.

- Saving in the new file format is a preview feature for upcoming versions of VLF. Try it out and contact support@lighttrans.com or your local distributor for feedback and questions.
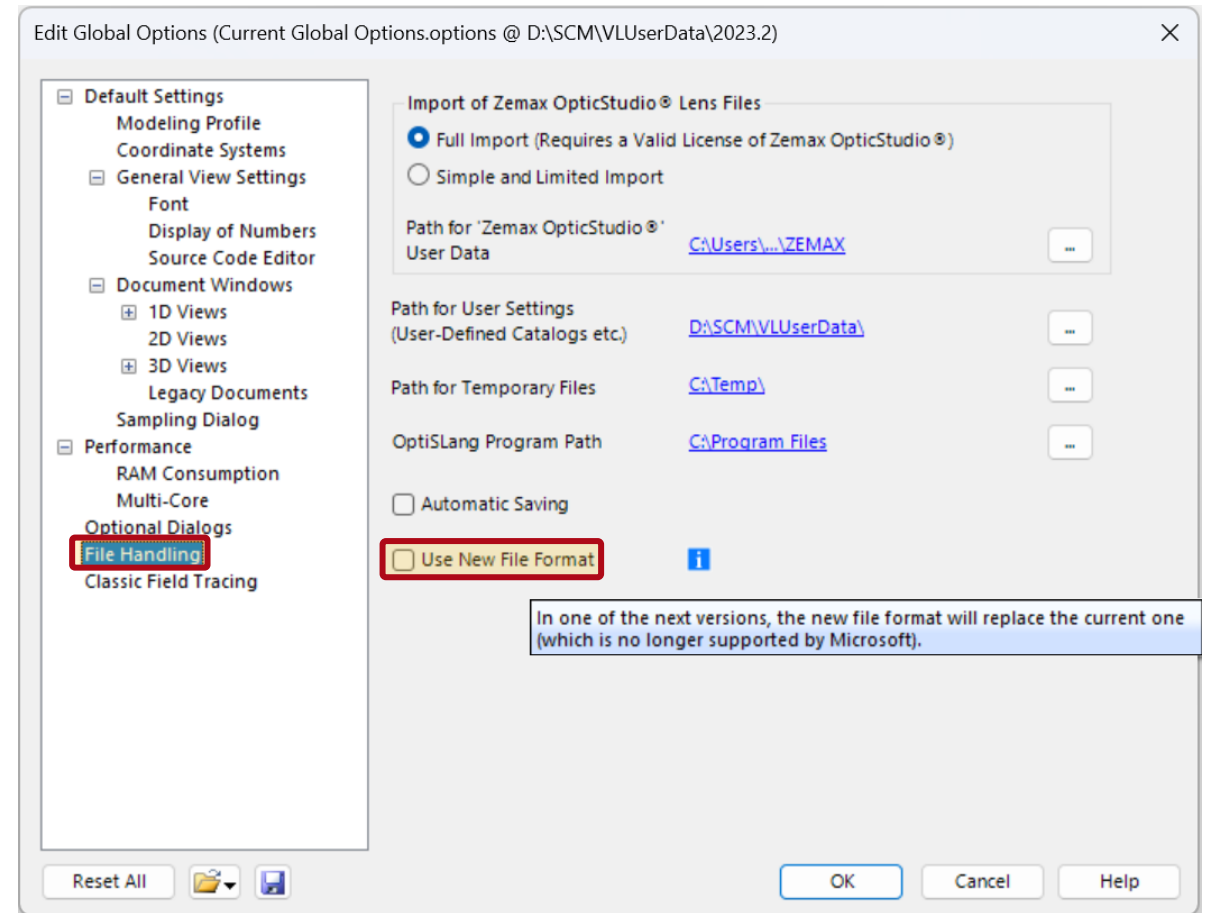
VirtualLab Fusion 2023.2 – The Feature Firework

- VirtualLab Fusion 2023.2 provides amazing new features for:

  - Higher Speed

  - Easier Use

  - More Physics

  - Deeper Transparency

  - Better Control