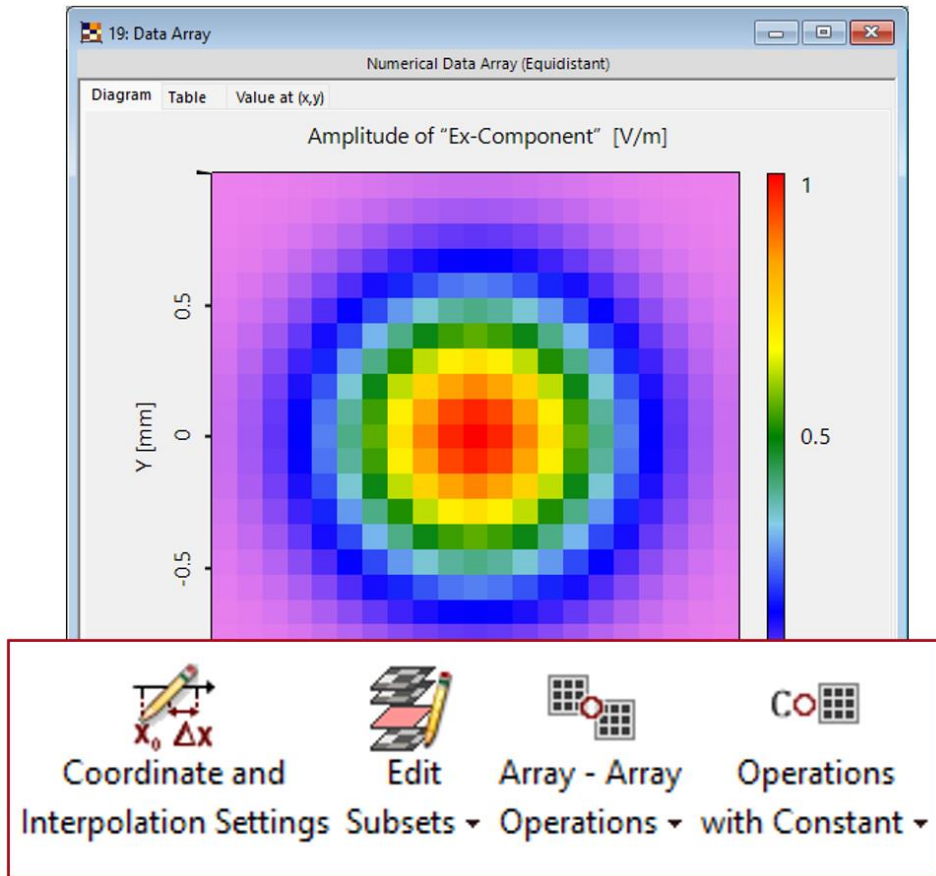# General Manipulation Tools for Data Arrays

Abstract

Data Arrays are the fundamental container in VirtualLab Fusion. There are a wide array of different tools to manipulate them to fit the form the user desires. In this tutorial we like to go over the most general ones, which include mathematical operations on the Data Array, the ability to change coordinate system and subset parameter as well as tools to adjust size and sampling parameters.
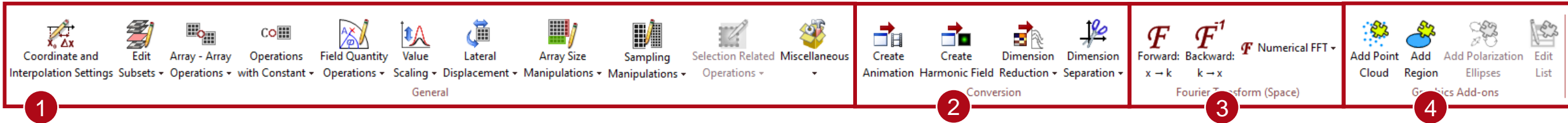
Data Arrays

Data Arrays can appear in the form of 2D or 1D documents. A yellow underlined sign will appear on the top of the main menu to indicate the current selected document is a *Data Array*. This is important as depending on the document class, different *Manipulations* and *View* settings are available.

While 1D and 2D documents may have drastically different *View* options, the general *Manipulations* tool – which are discussed in this tutorial – remain roughly the same for both types.
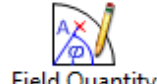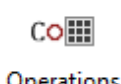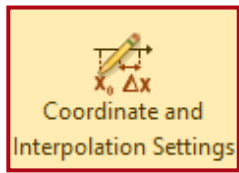
Manipulations

The *Manipulations* tab of the main menu ribbon allows for various customizations related to the actual data of the *Data Array*. It generally consists of 4 different sections, including:

1. *General*: Many different customization options including coordinate transformations, mathematical operations with single values or other arrays and sampling manipulation tools

2. *Conversion*: Transform *Data Array* to other objects

3. *Fourier Transform (Space)*: Apply *Fourier Transform* to the *Data Array*

4. *Graphics Add-ons*: Add additional information onto the Data Array as an overlay.

This tutorial focuses on the tools available in section 1. For more information about *Graphic Add-ons*, please see:
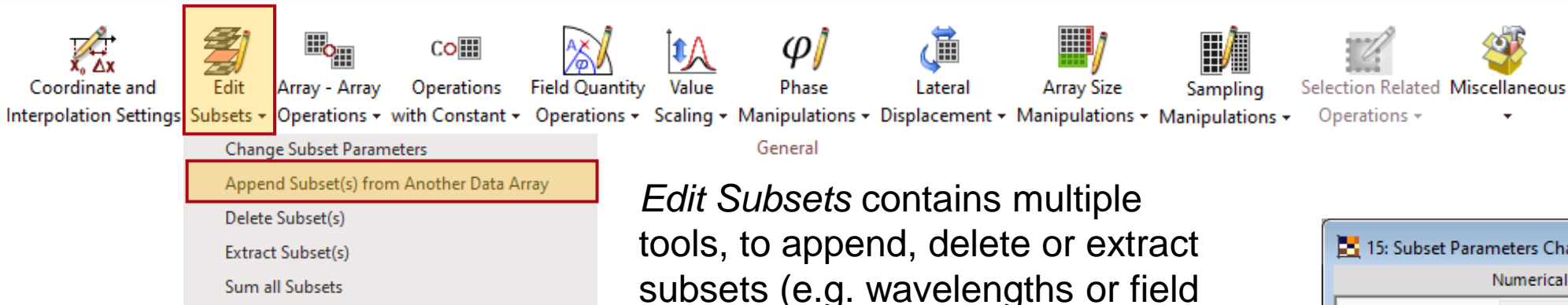- Graphics Add-on
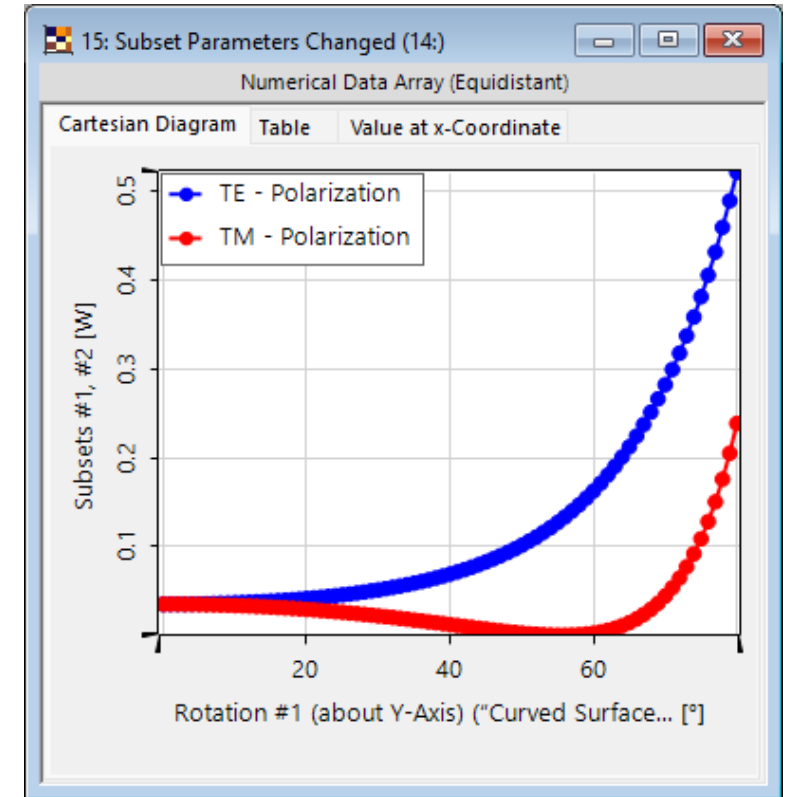
Coordinate and Interpolation Settings
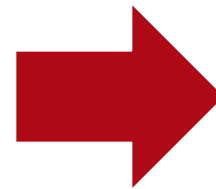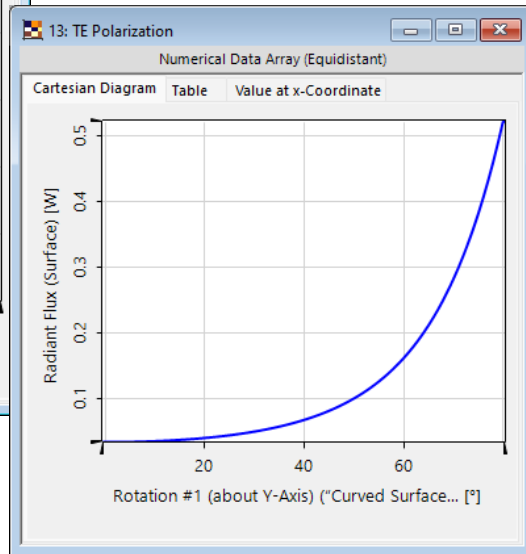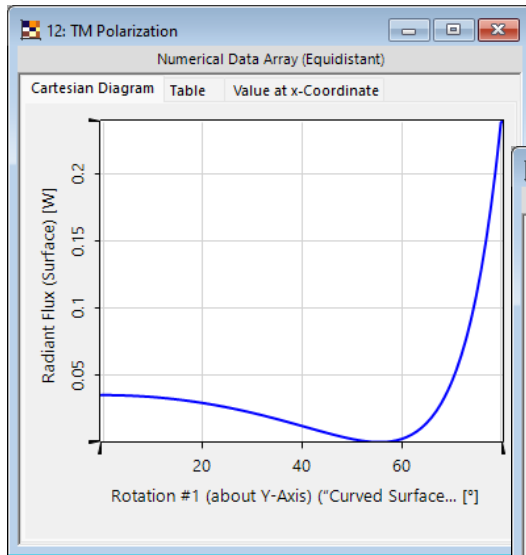

original detector result window
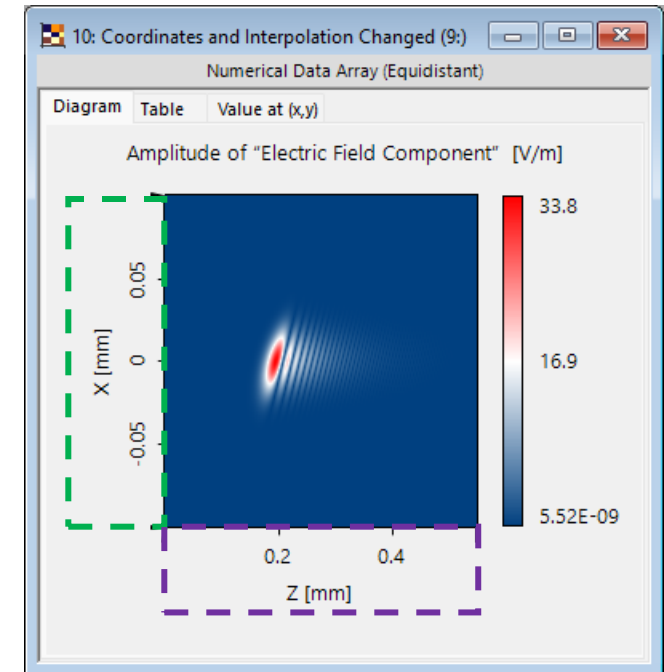
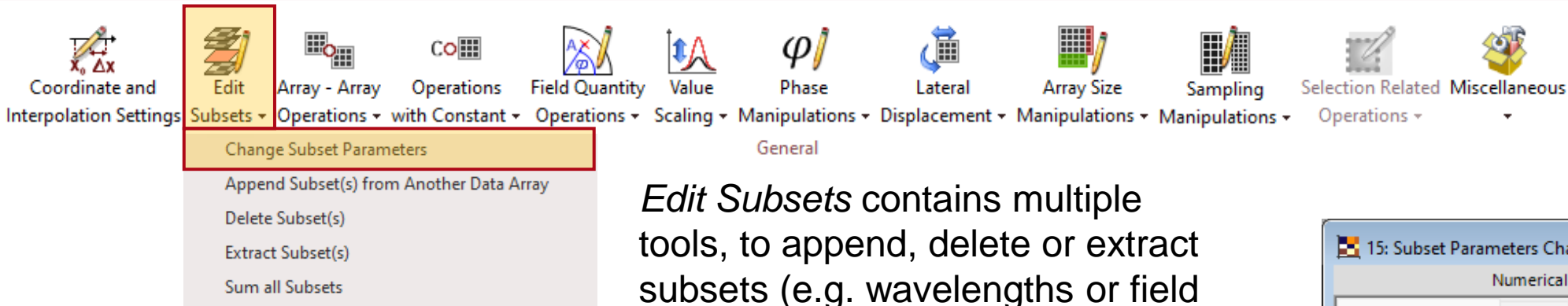detector result window after changing coordinate settings
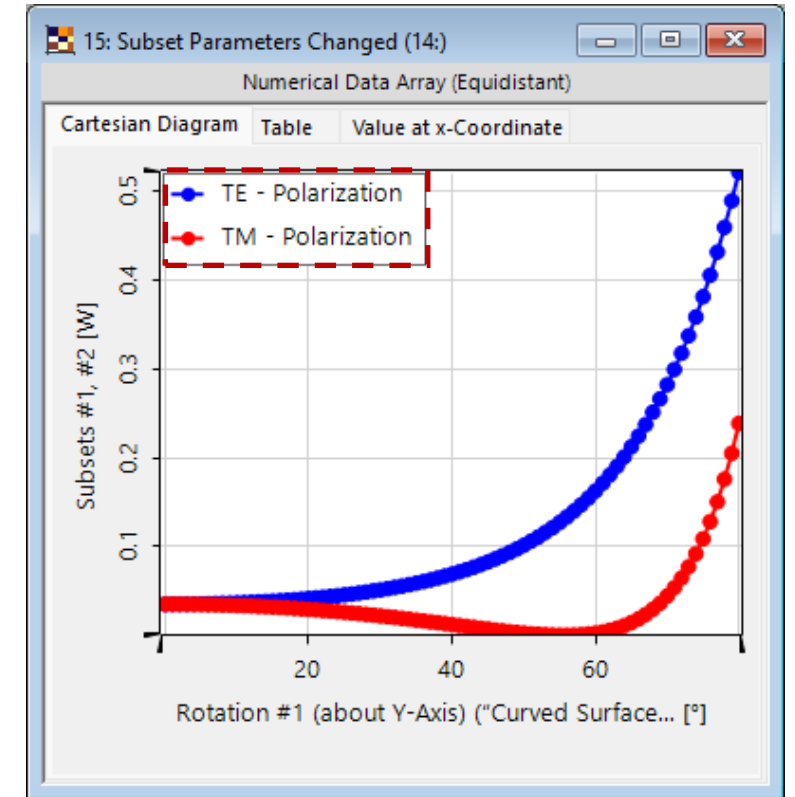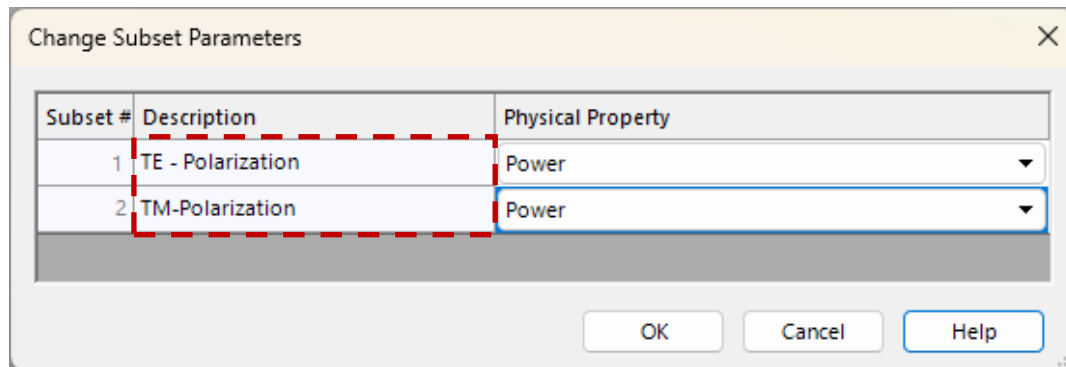
Edit Subsets

Edit Subsets contains multiple tools, to append, delete or extract subsets (e.g. wavelengths or field components) from *Data Arrays*.
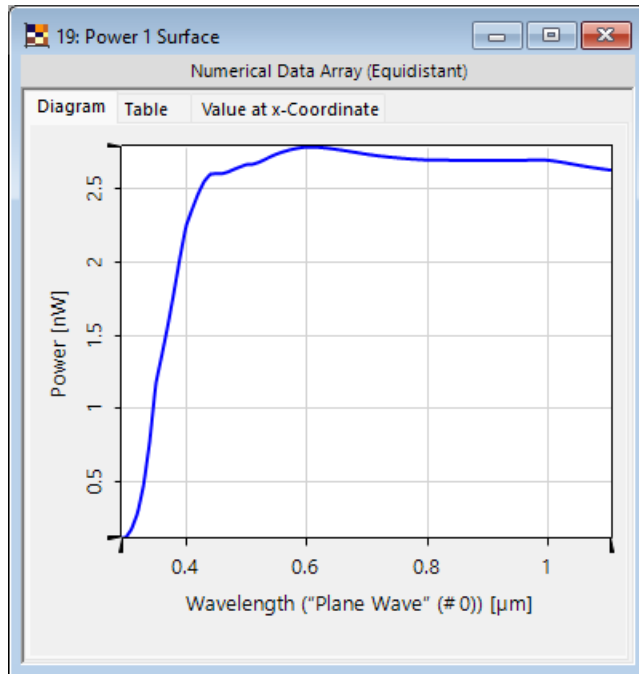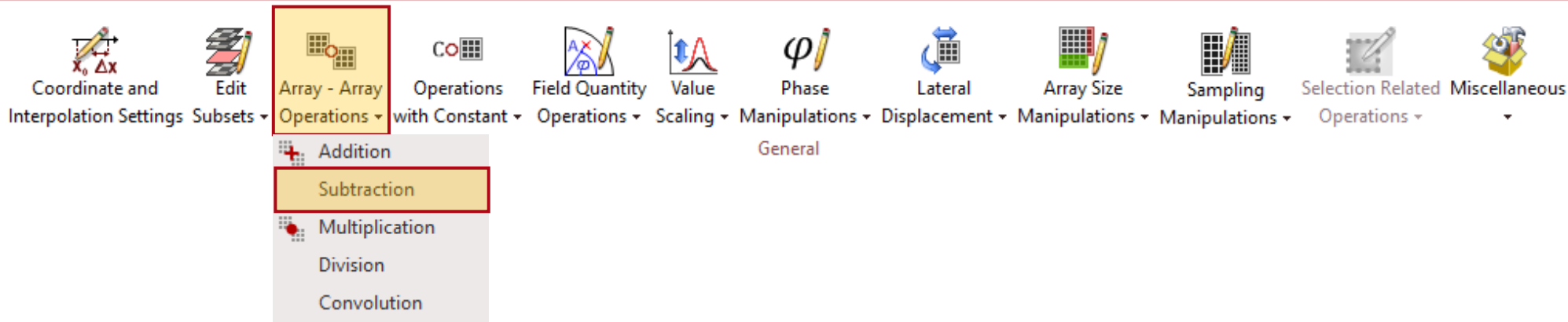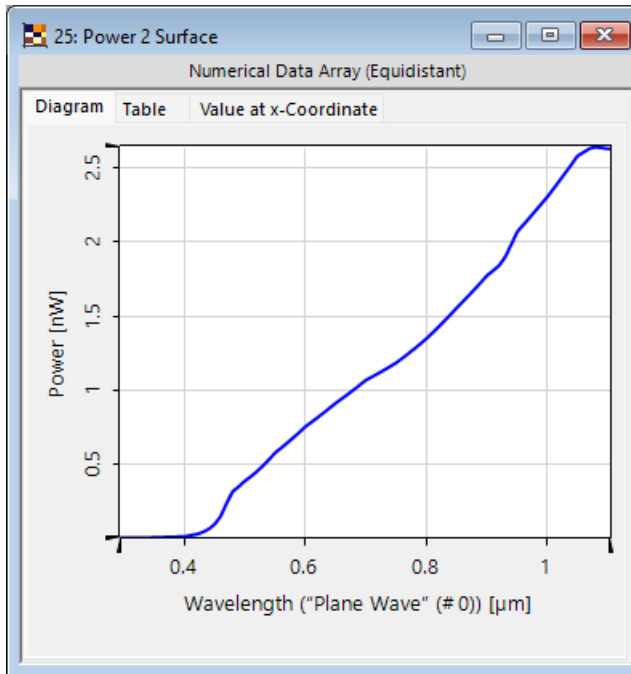
Change Subset Parameters

Edit Subsets contains multiple tools, to append, delete or extract subsets (e.g. wavelengths or field components) from *Data Arrays*.
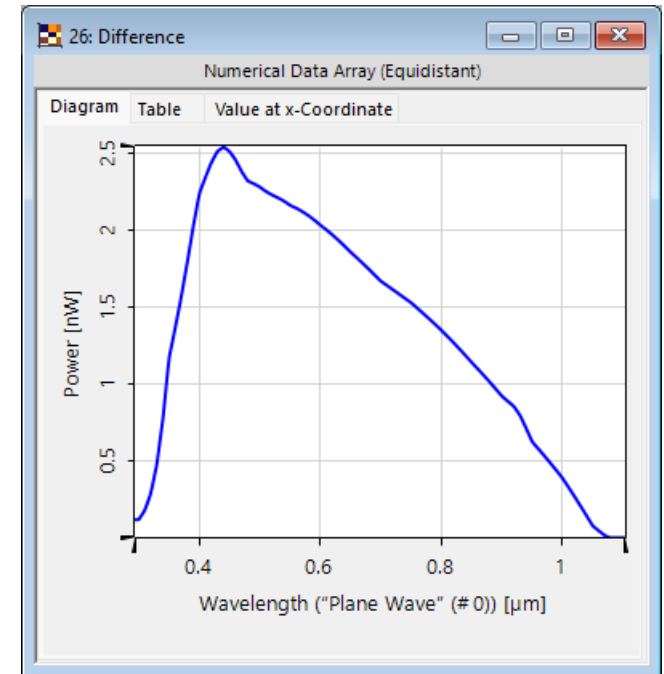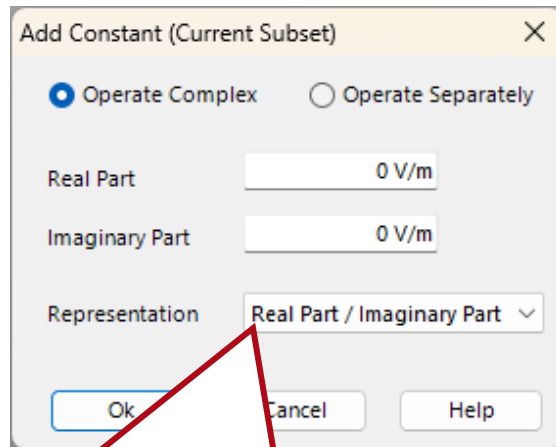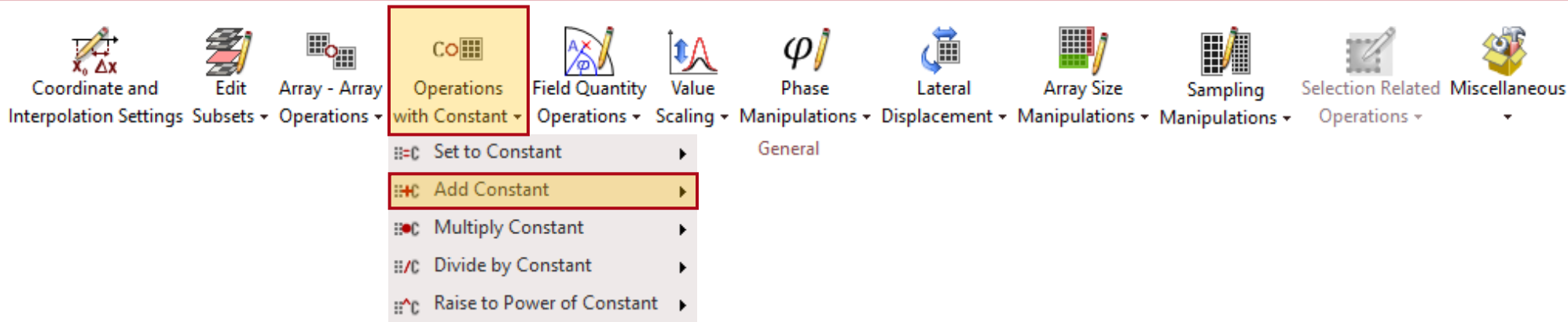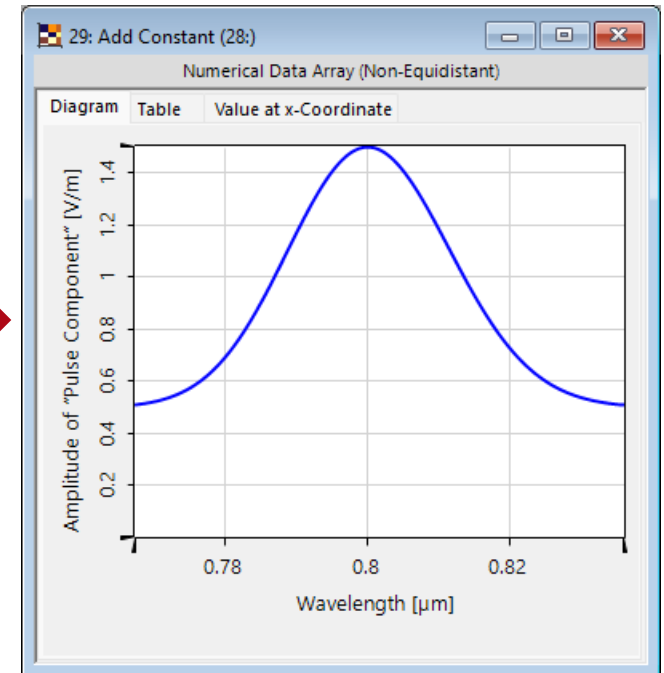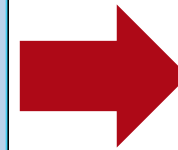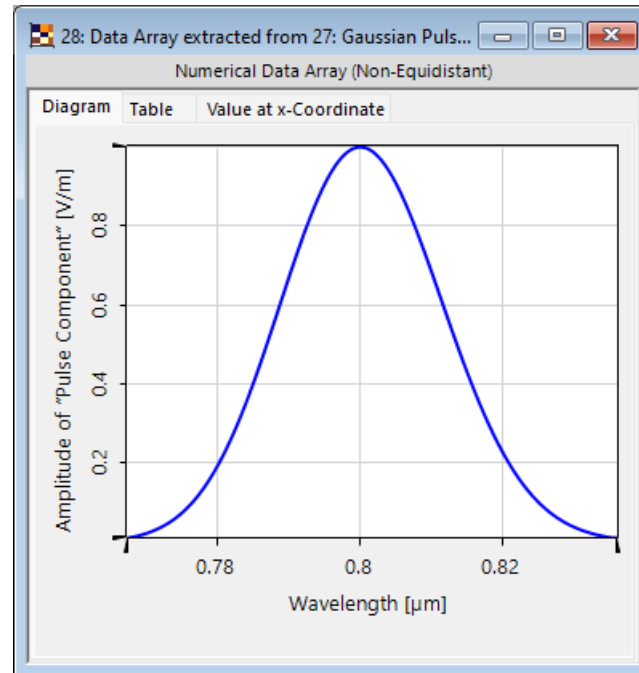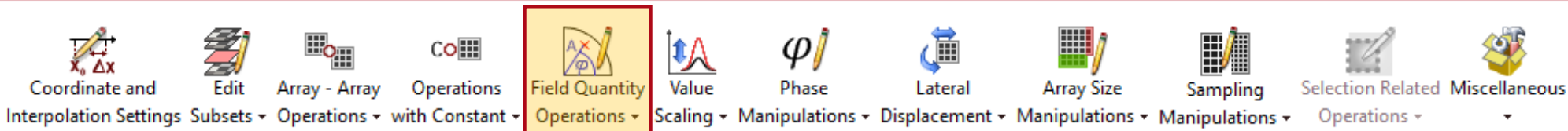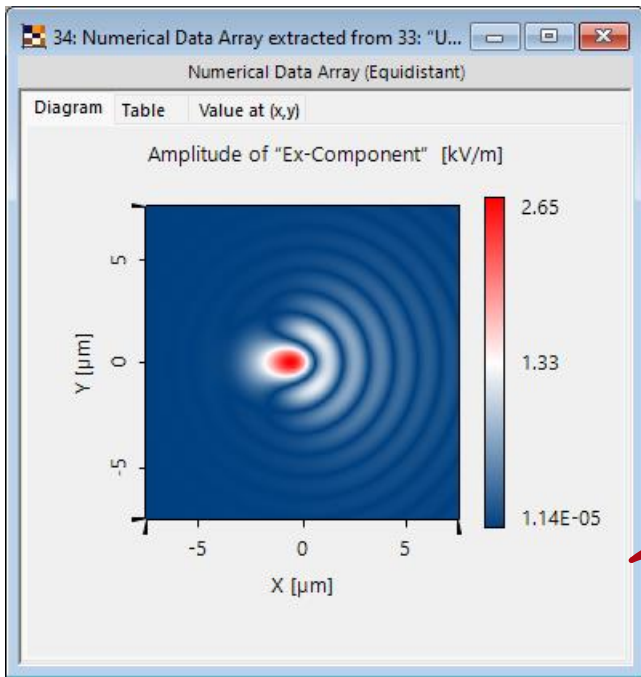
Array – Array Operations

Operations with Constant

Note: The constant can be defined by Amplitude/Phase or Real Part/Imaginary Part when the affected data array is complex.
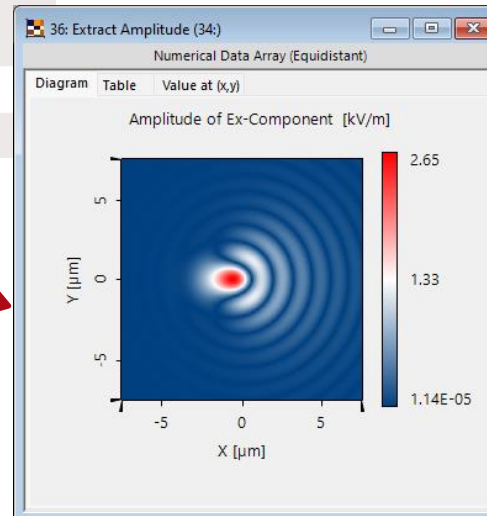
Array – Array Operations

Field Quantity Operations enables the extraction or internal shifting of complex quantities like amplitude and phase.
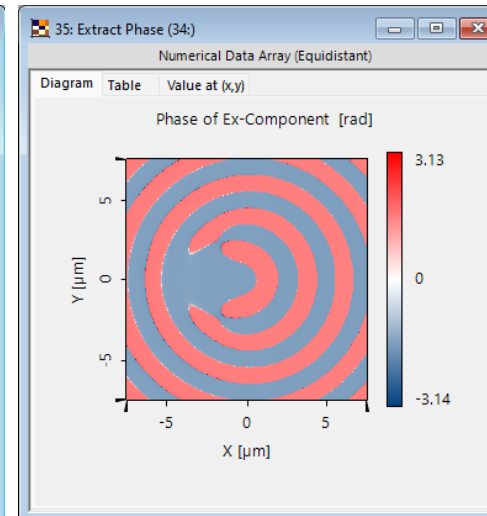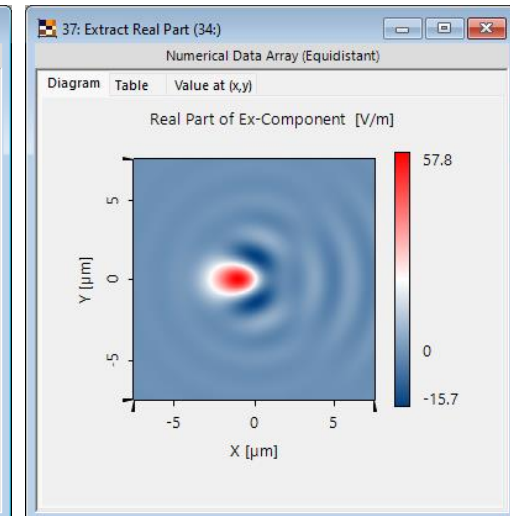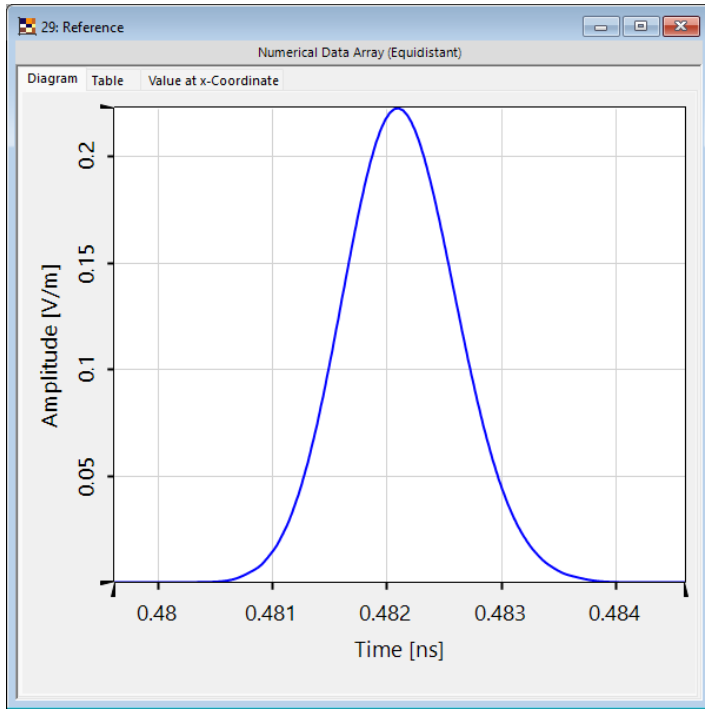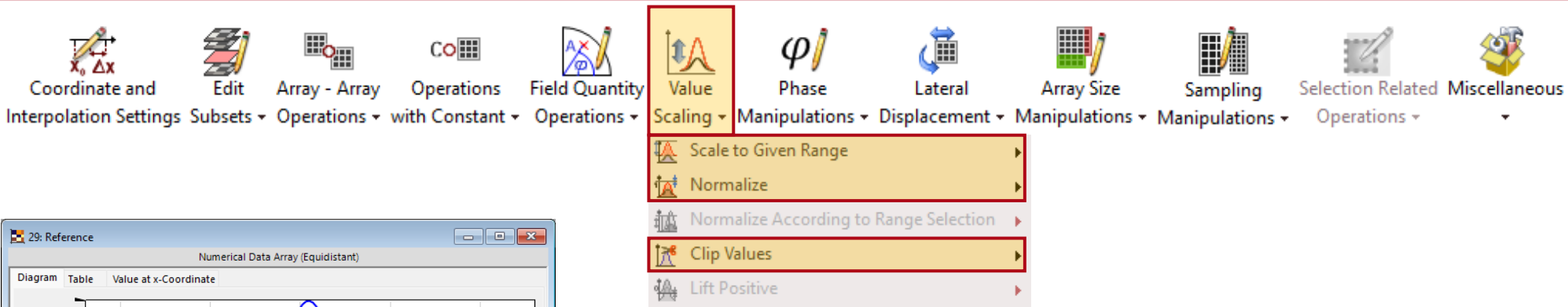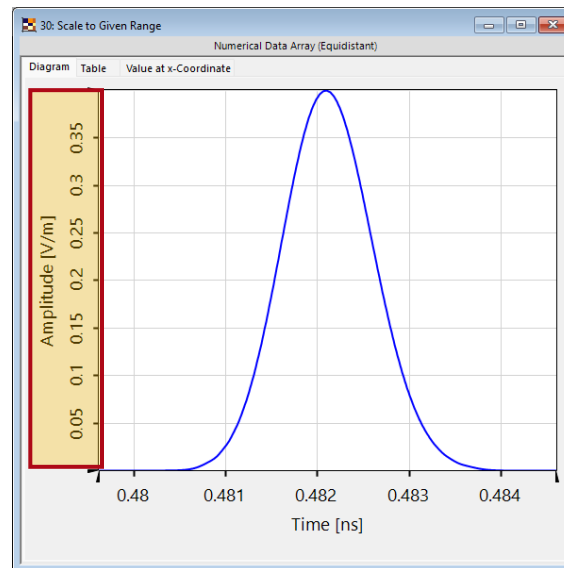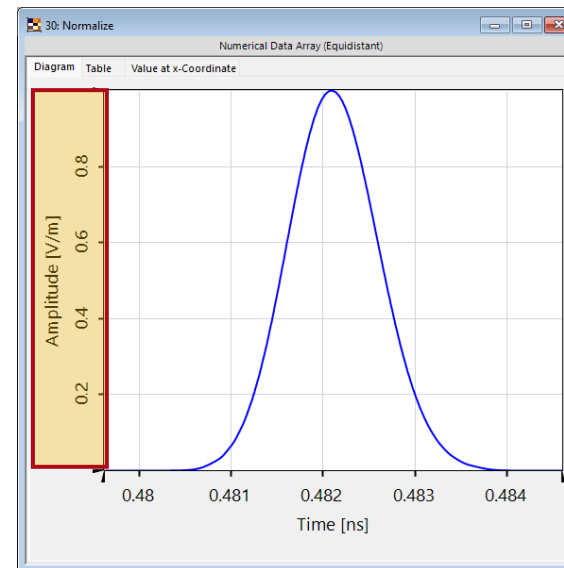
complex data array

amplitude

phase

real part

Value Scaling
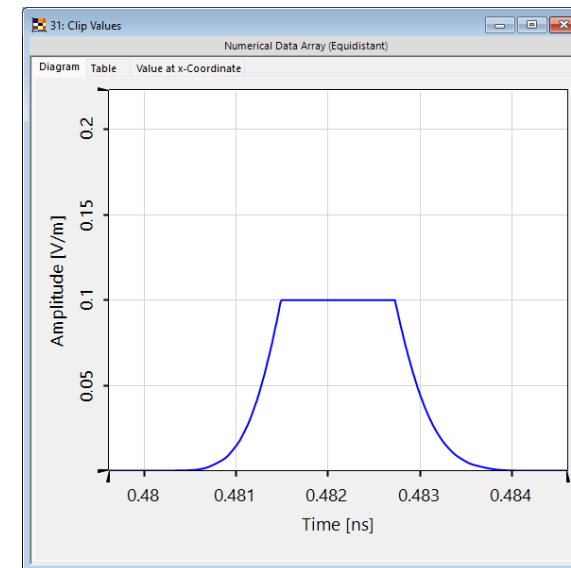

reference

Scale to Given Range
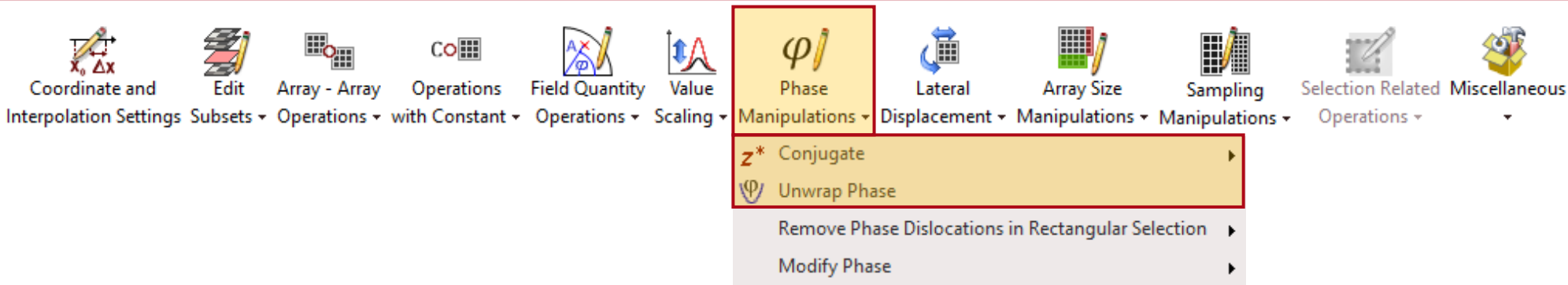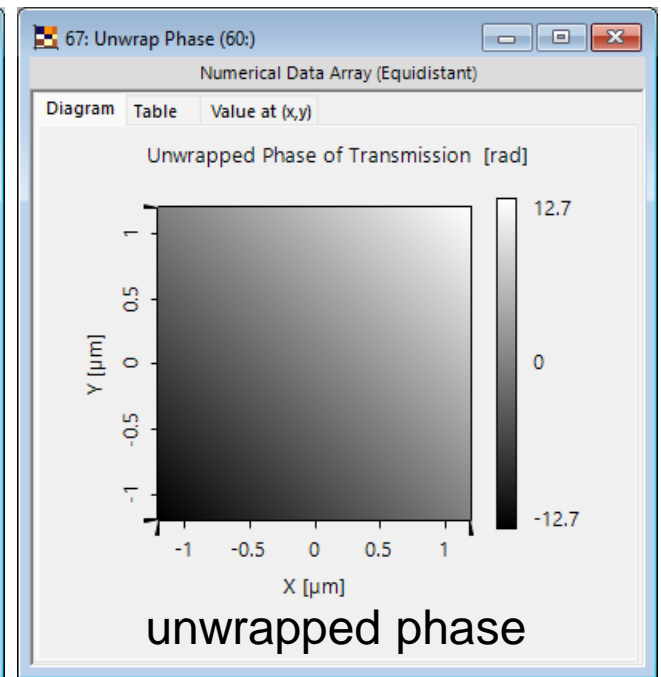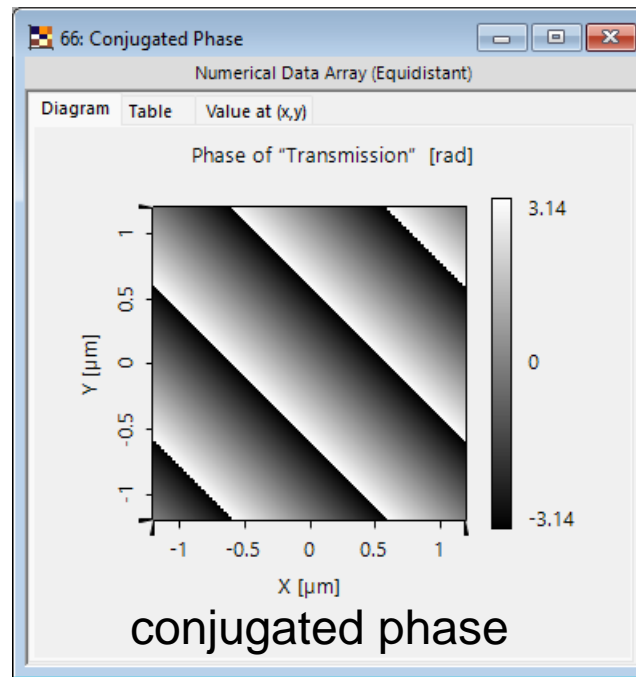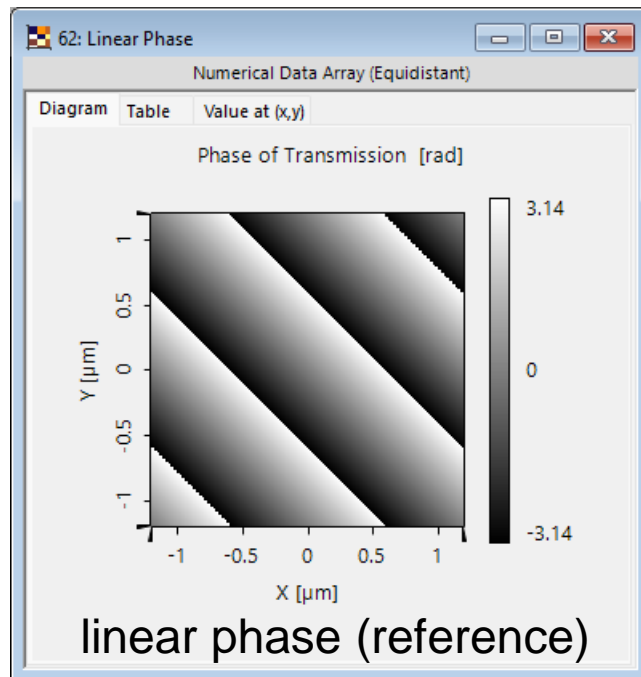(0 to 0.4 V/m)
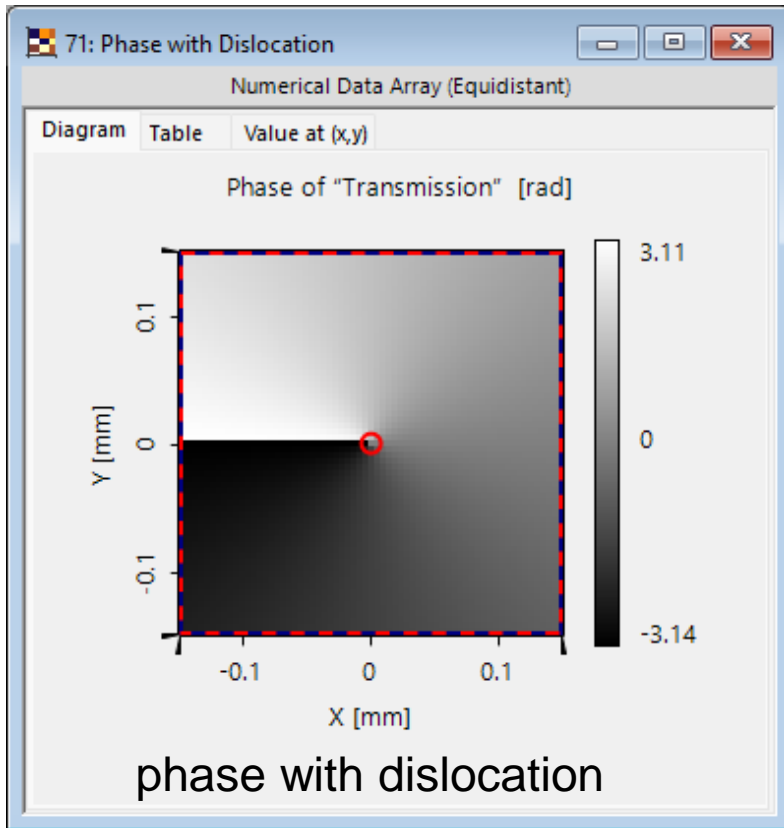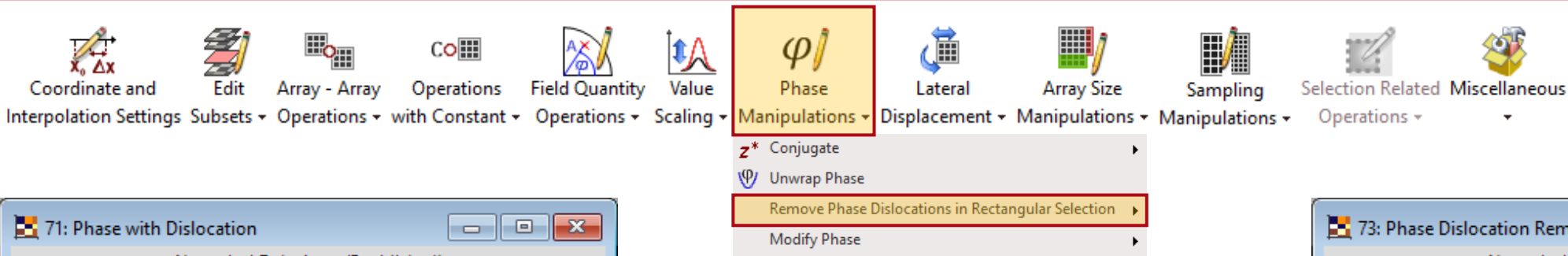
Normalize

Clip Values

Phase Manipulations

Phase Manipulations allows for various transformations of the phase, including conjugation and unwrapping. For this option to be visible, the *Data Array* needs to consist of complex data.

linear phase (reference)

conjugated phase

unwrapped phase

Phase Manipulations – Remove Phase Dislocations

When a rectangular marker is present in the Data Array, the tool Remove Phase Dislocations in Rectangular Selection can be used. The selection will then automatically be searched for phase dislocations. If one is found, it will be removed by multiplying it with a transmission function of a phase dislocation with its corresponding negative charge.

phase with dislocation

phase dislocation removed
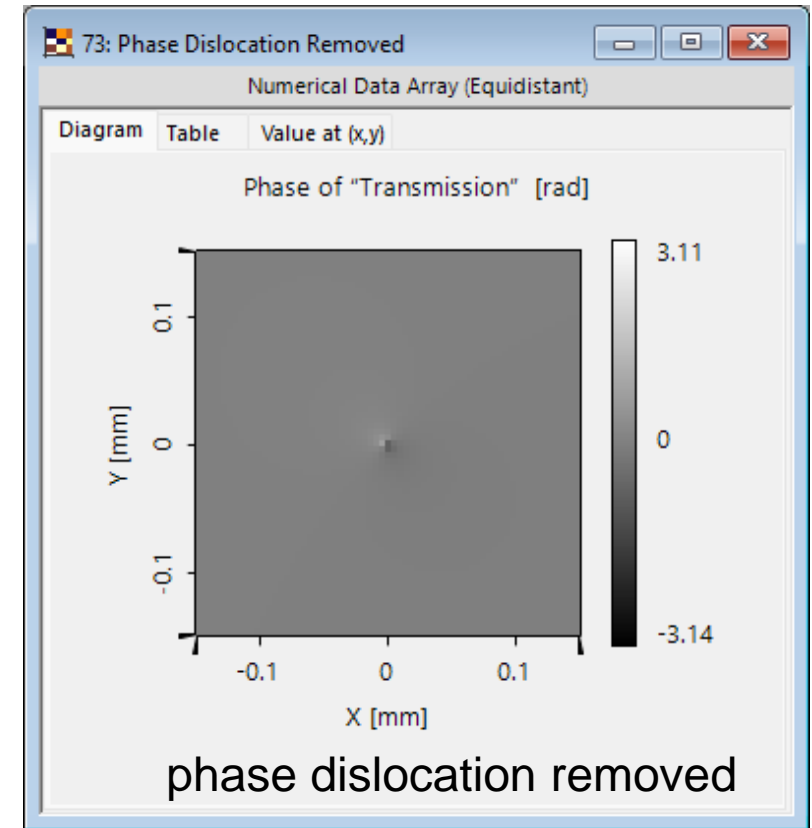
Phase Manipulations – Modify Phase
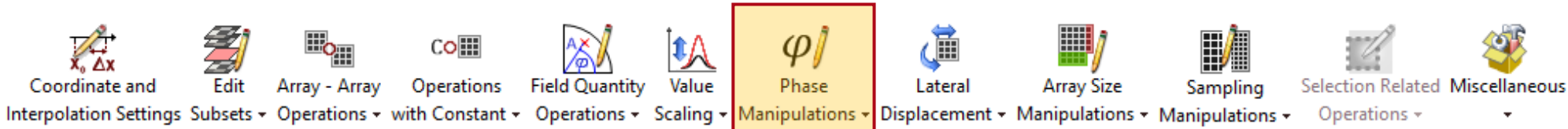
For *Data Arrays* only certain options are available in the *Modify Phase* tool, such as the generation of a random phase or the addition of a constant phase onto the result. To have all options available please use *Create Harmonic Field* in the *Conversion* area.
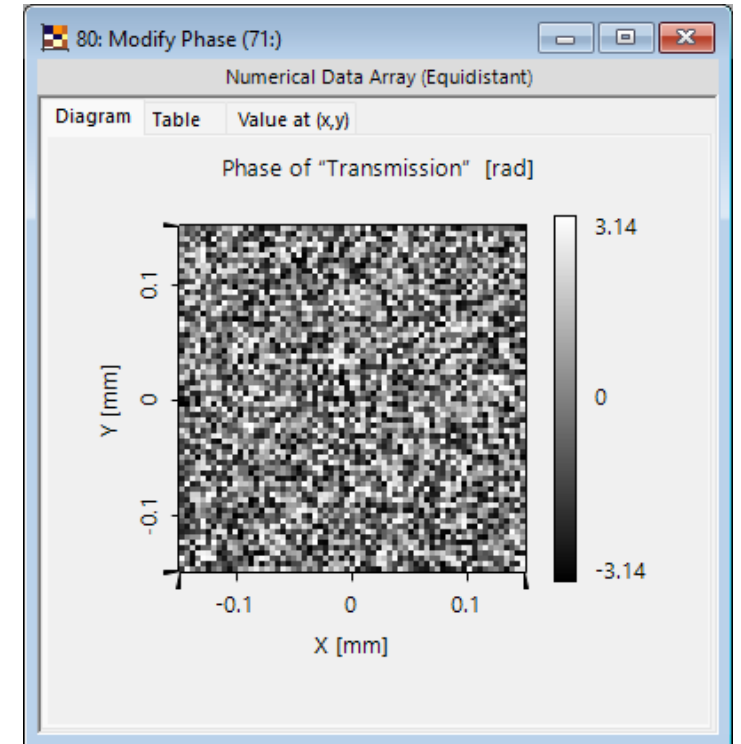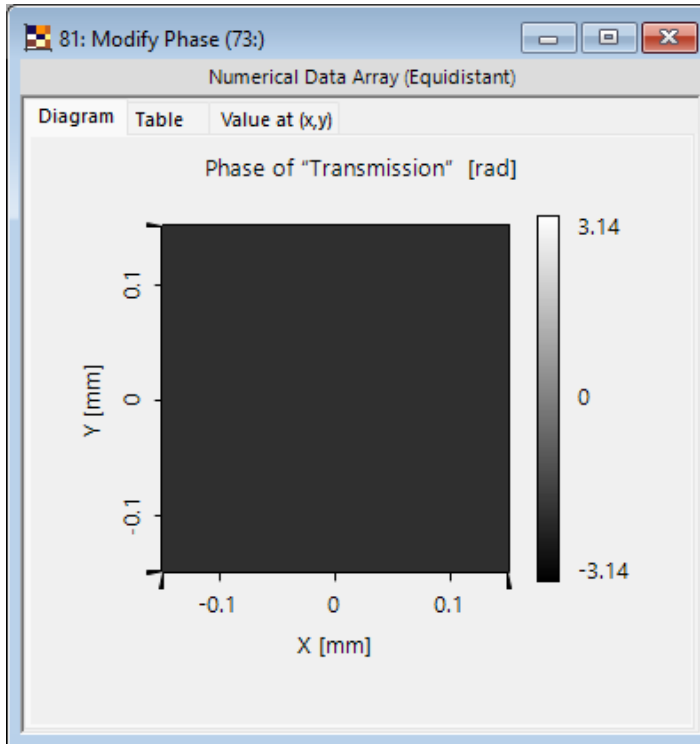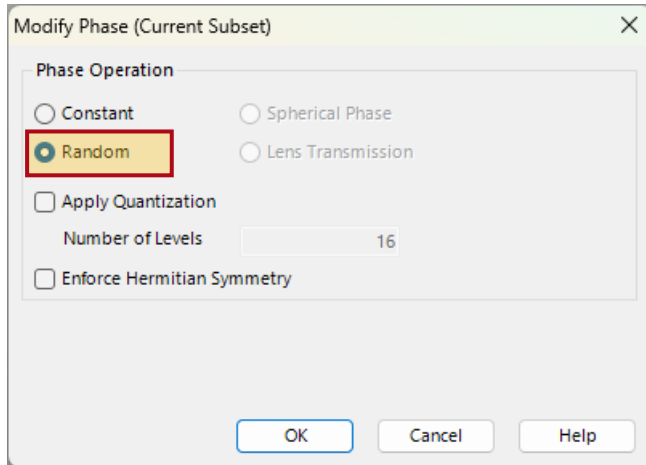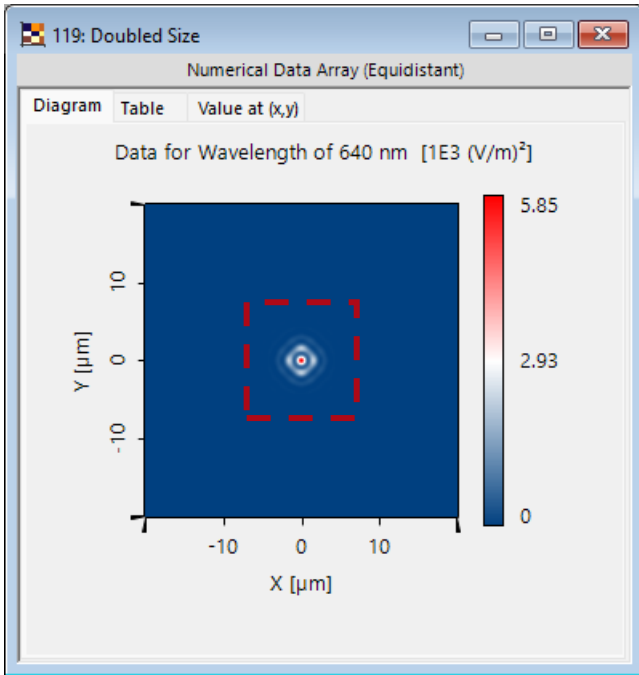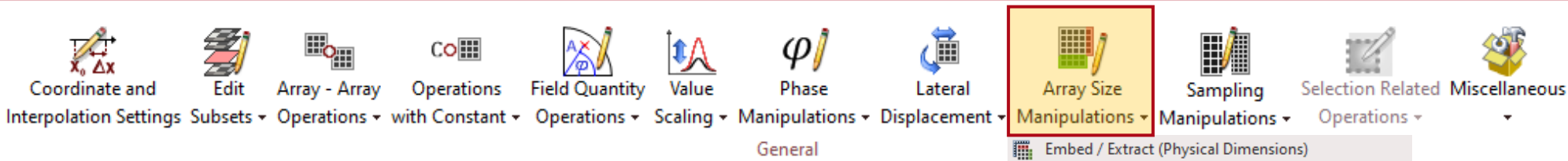
Lateral Displacement
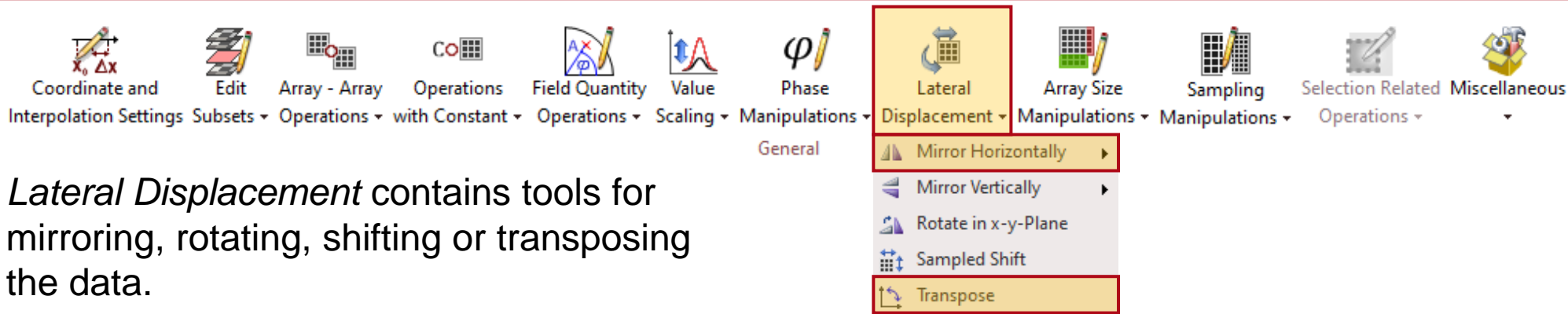
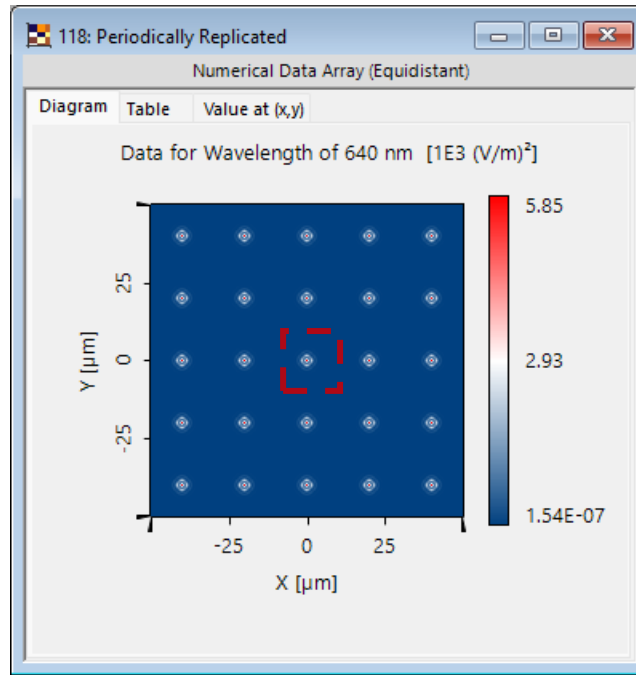*Lateral Displacement* contains tools for mirroring, rotating, shifting or transposing the data.
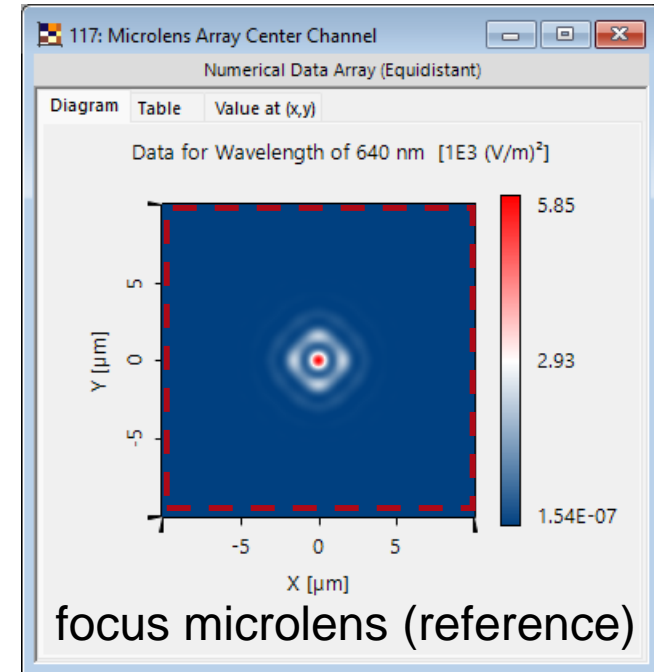
foci with coma (reference)

Mirror Horizontally

Transpose
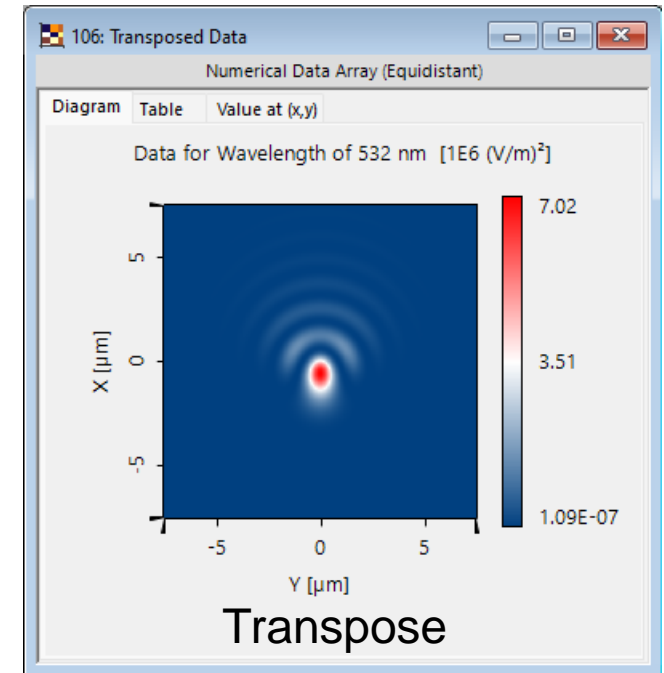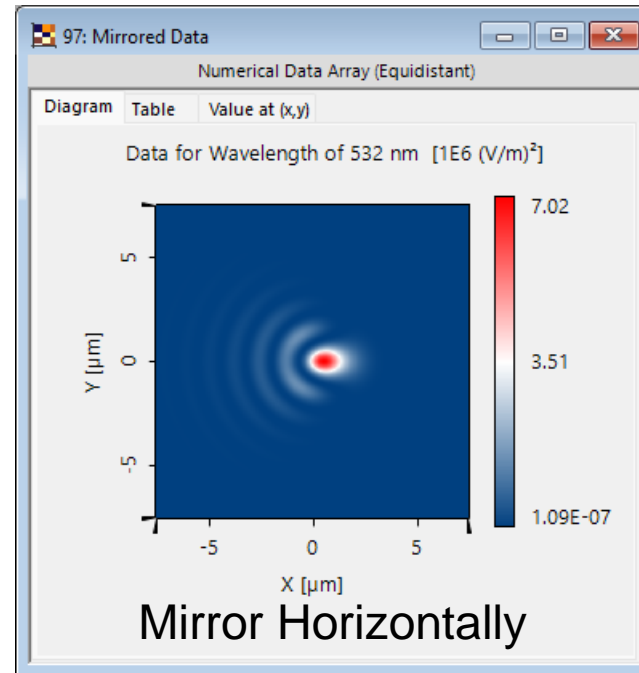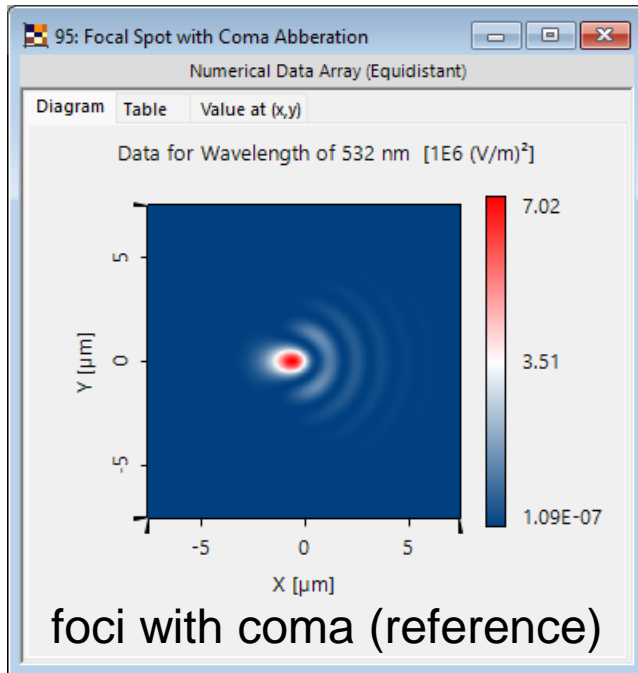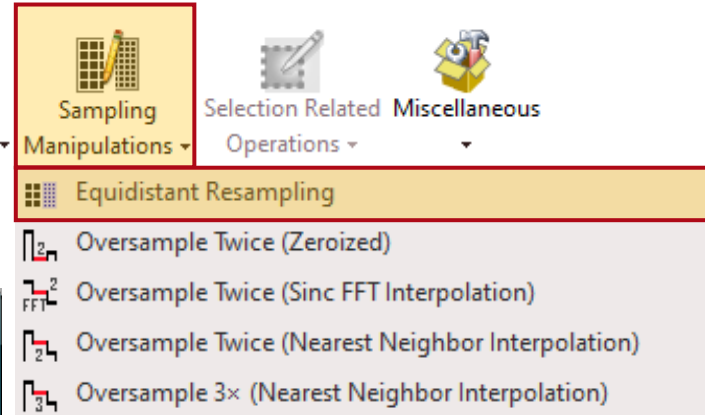
Array Size Manipulations

Embed in Double Sized Array (Center)

Replicate Periodically

focus microlens (reference)

Sampling Manipulation

In the Sampling Manipulation, the tool Equidistant Resampling allows the user to apply different interpolation algorithms to increase the sampling rate of the Data Array. In the dropdown menu, various shortcuts are implemented as well, in order to use the resampling tool in pre-defined specification with a click of a button.

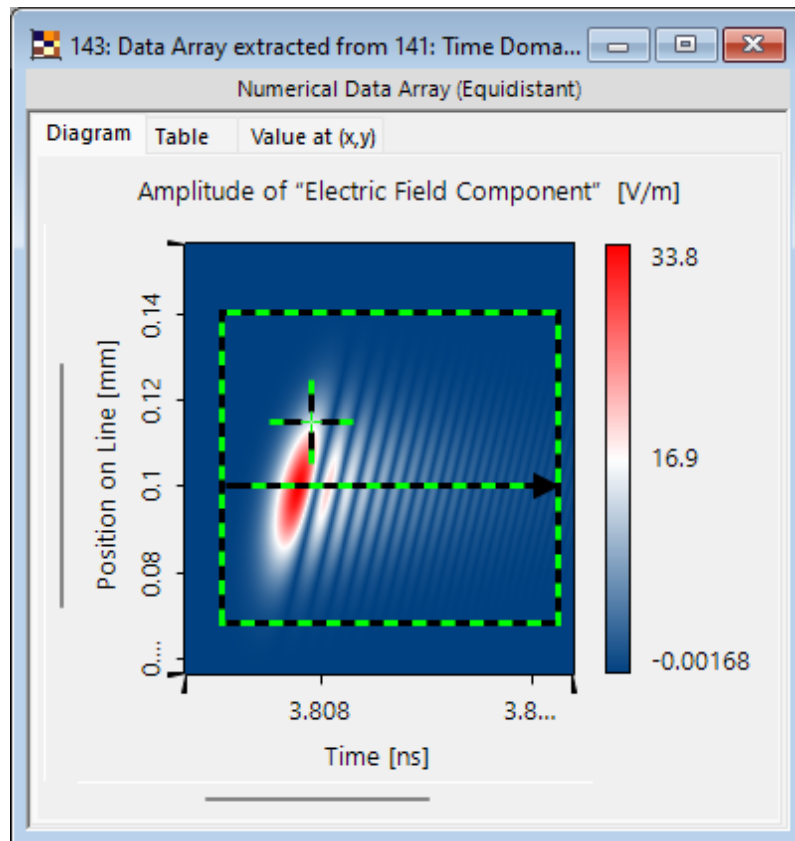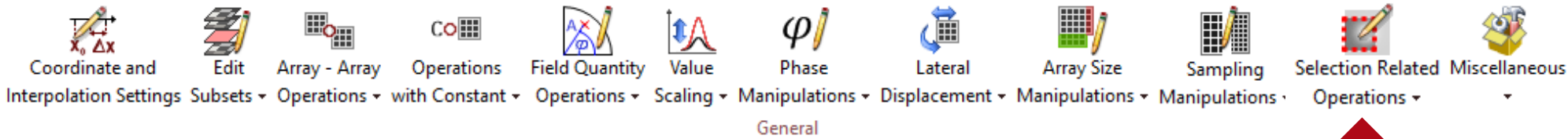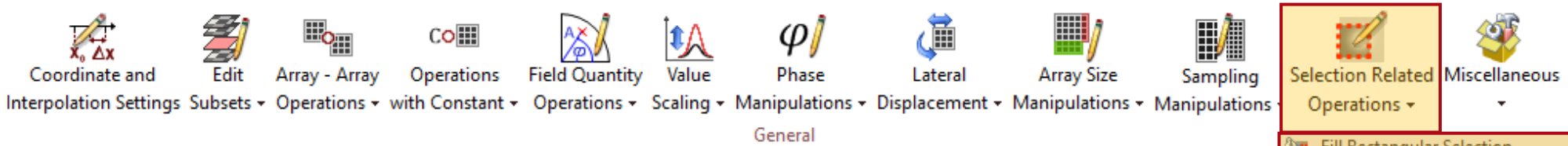# Selection Related Operations

The *Selection Based Operations* button only becomes available when at least one marker is active in the *Data Array.* Markers can be found in the *View* tab of the main menu. Each tool is related to a specific marker type and can only be used if the said marker is active in the *Data Array*.
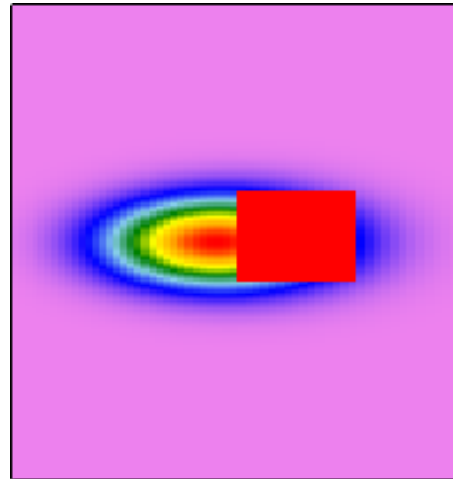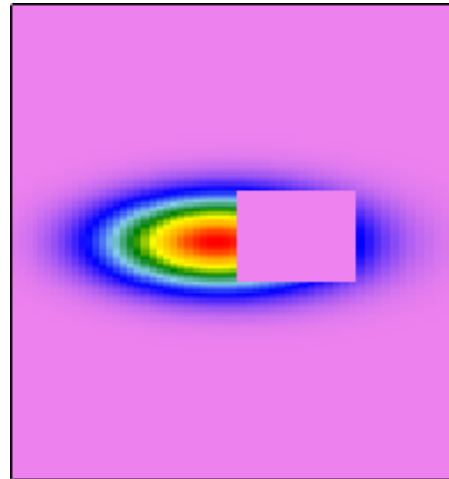
Operations for Rectangular Markers

Note: 1D Data Arrays have the same option available for the Range Marker
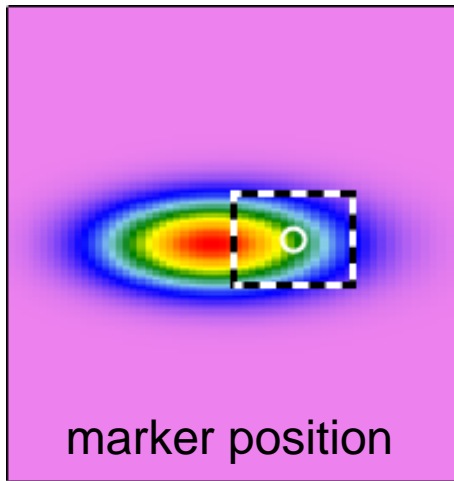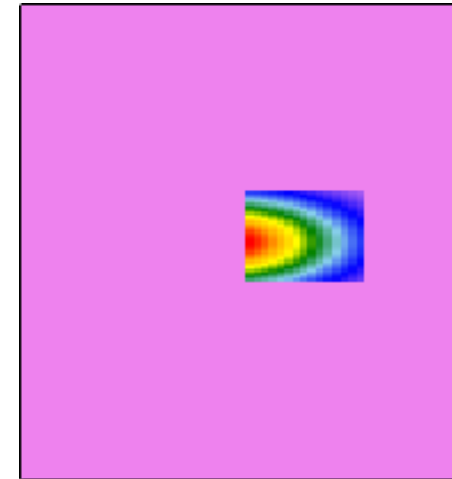
Selection Related Operations:
- Fill Rectangular Selection
- Clear Rectangular Selection
- Clear Inverse of Rectangular Selection
- Extract Rectangular Selection
- Extract Equidistant 1D Data Along Selected Line
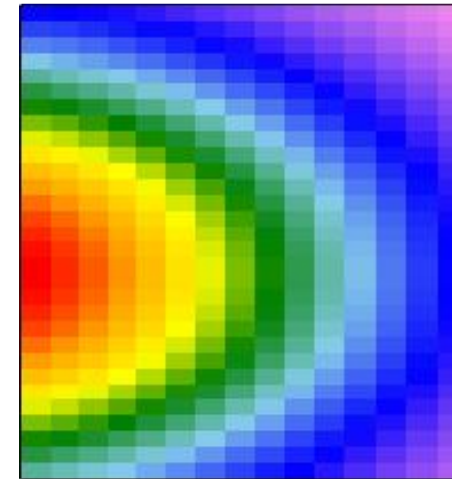- Extract Subset Data at One Point

marker position

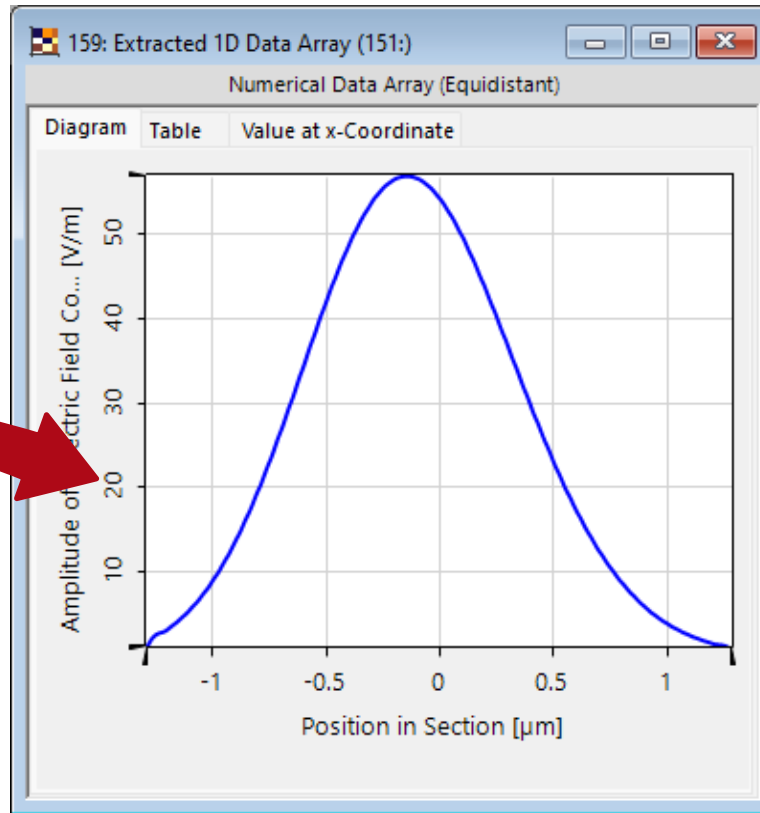Fill Rectangular Selection

Clear Rectangular Selection

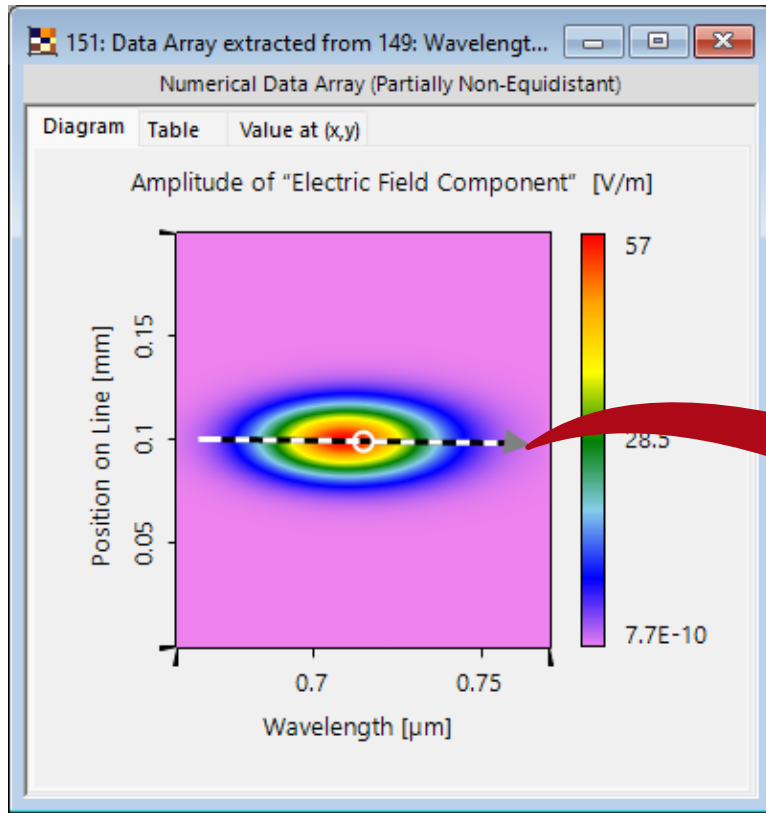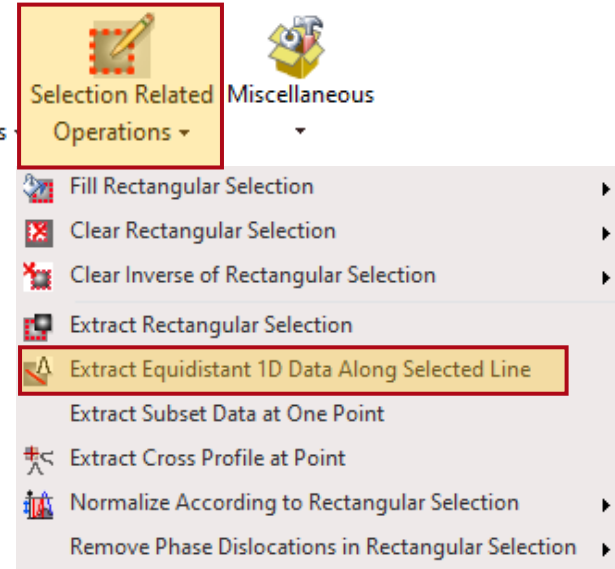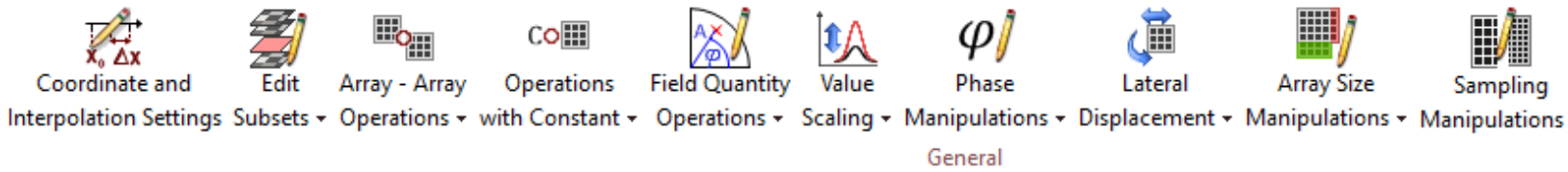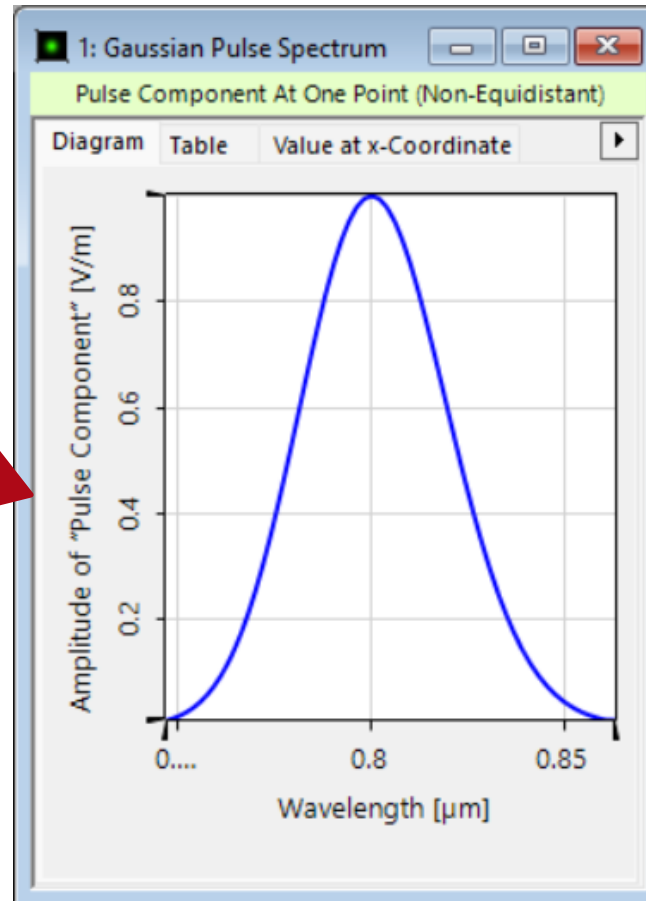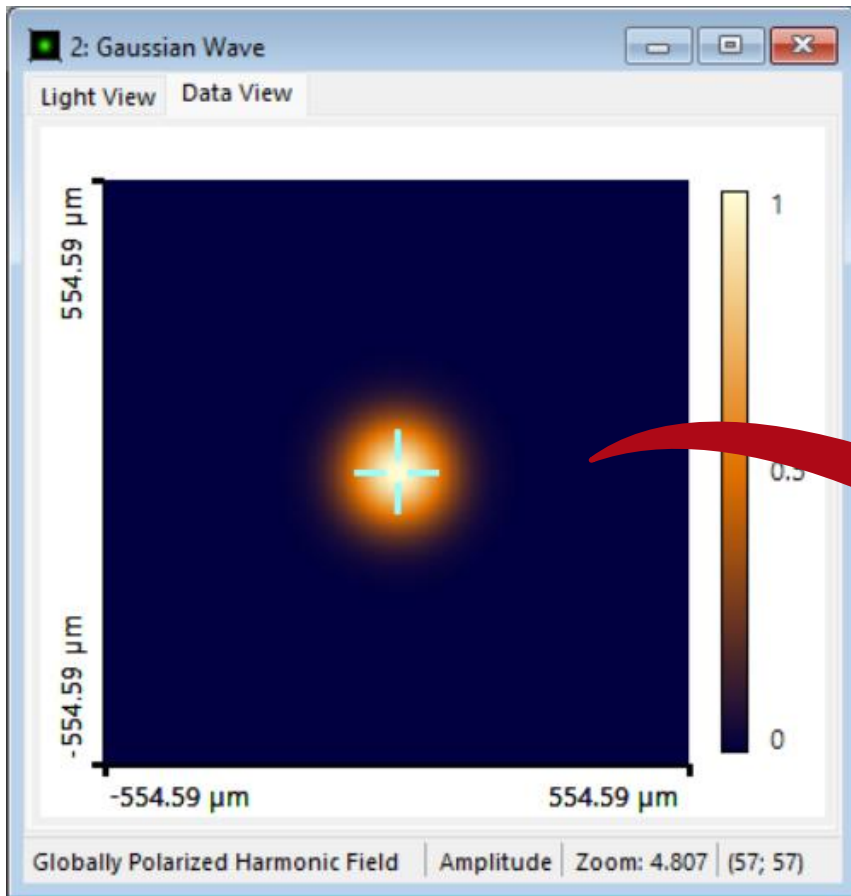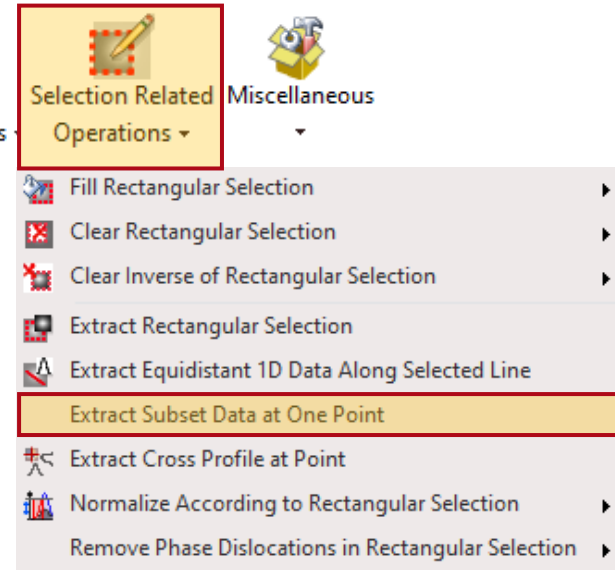Clear Inverse of Rectangular Selection
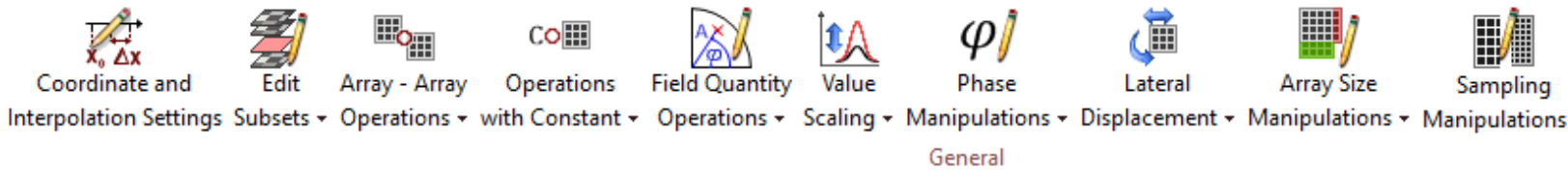
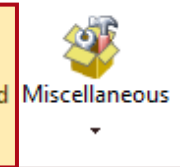Extract Rectangular Selection

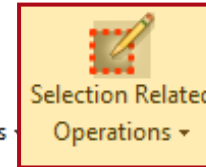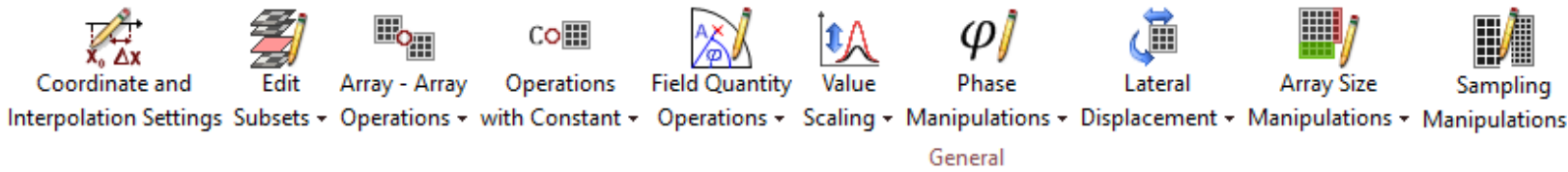# Operations for Linear Markers

Line marker can be used to generate 1D cross-sections of 2D Data Arrays.
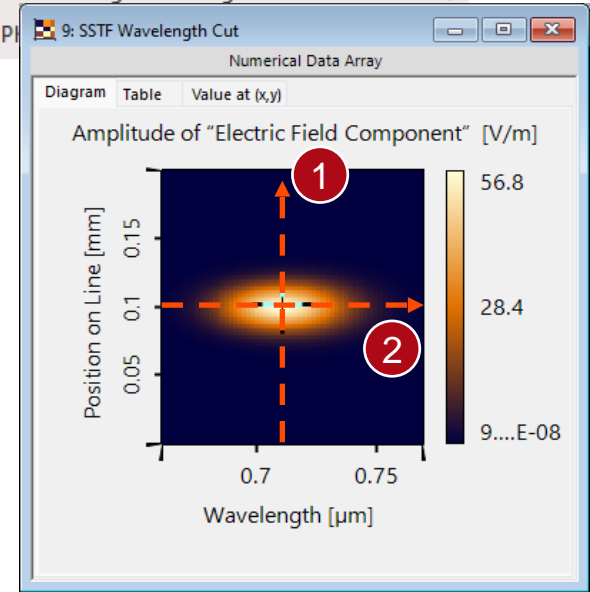
Extract Subset Data at One Point

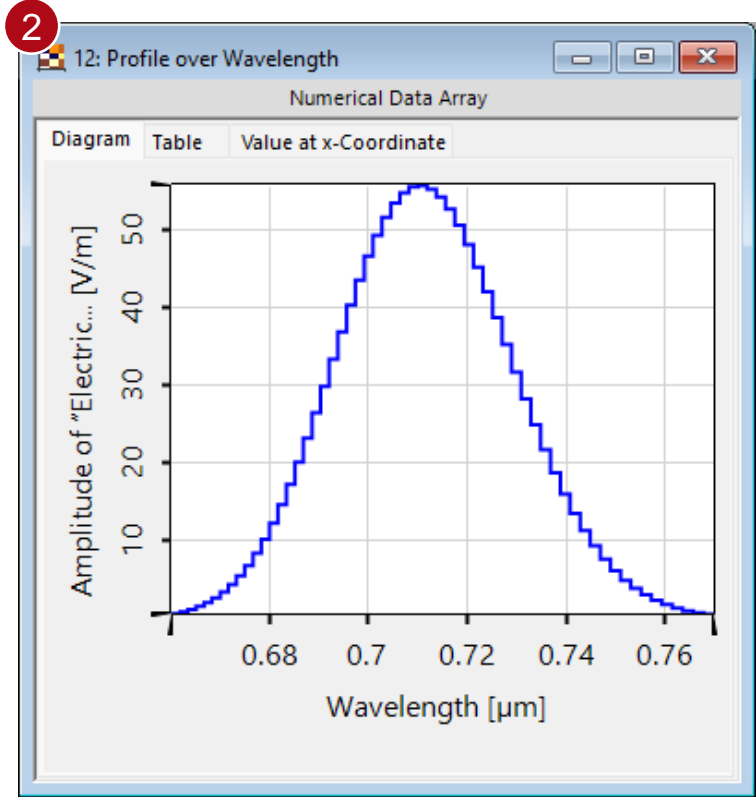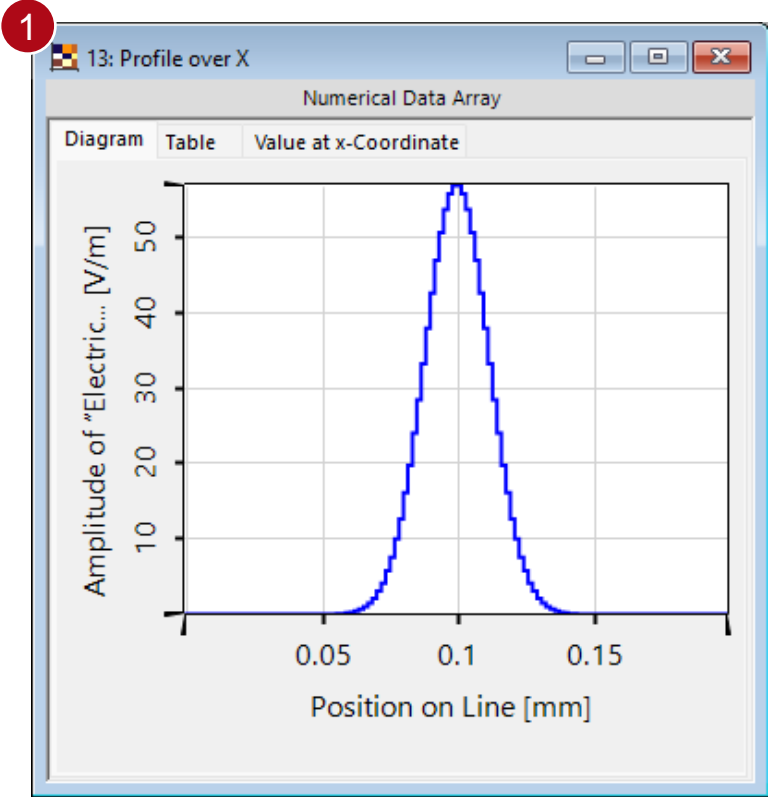There are multiple tools to extract information out of a *Point Marker*. If the field in question consists of multiple subsets (e.g. wavelengths), a cross-section of all subsets at the point in question can be generated.
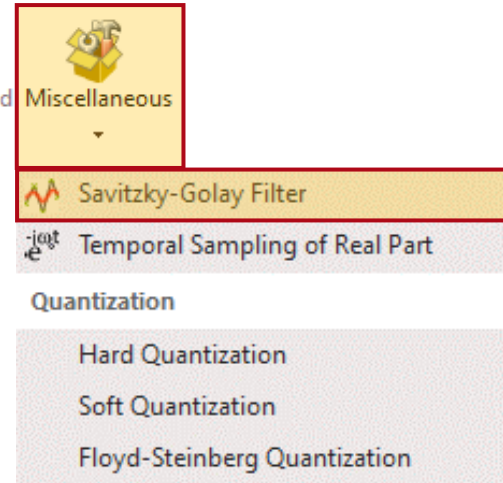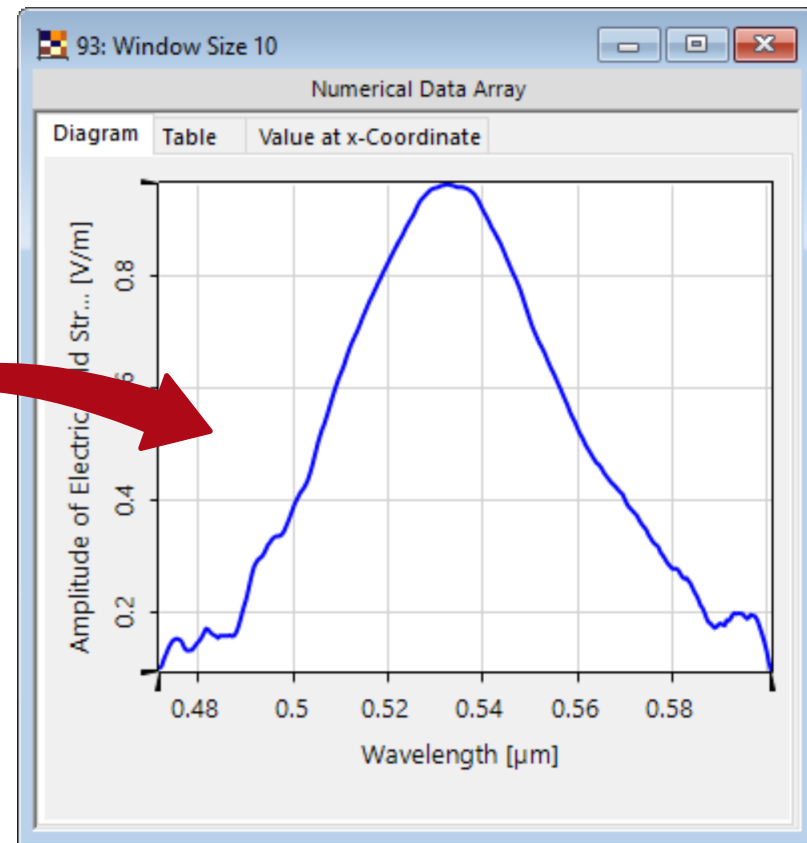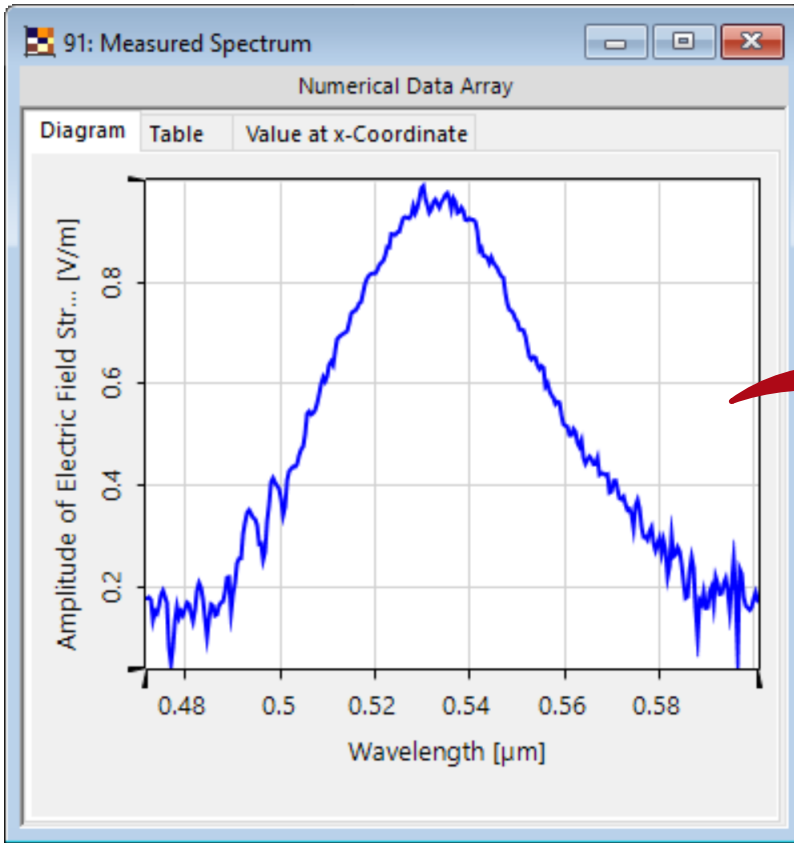
Extract Cross Profile At Point

Miscellaneous Functions
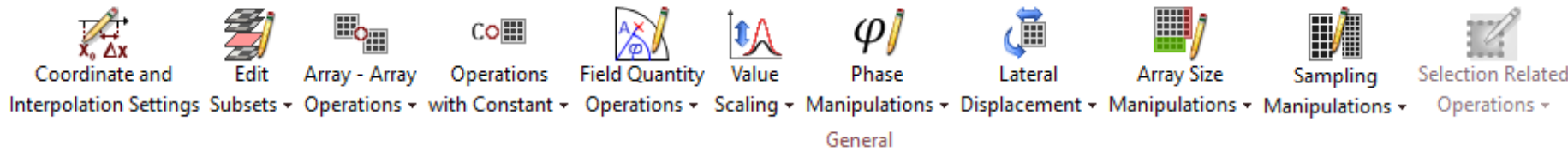
The *Savitzky-Golay Filter* performs regression algorithms to filter local noise. For more information:
Savitzky-Golay Filter Function

Miscellaneous Functions
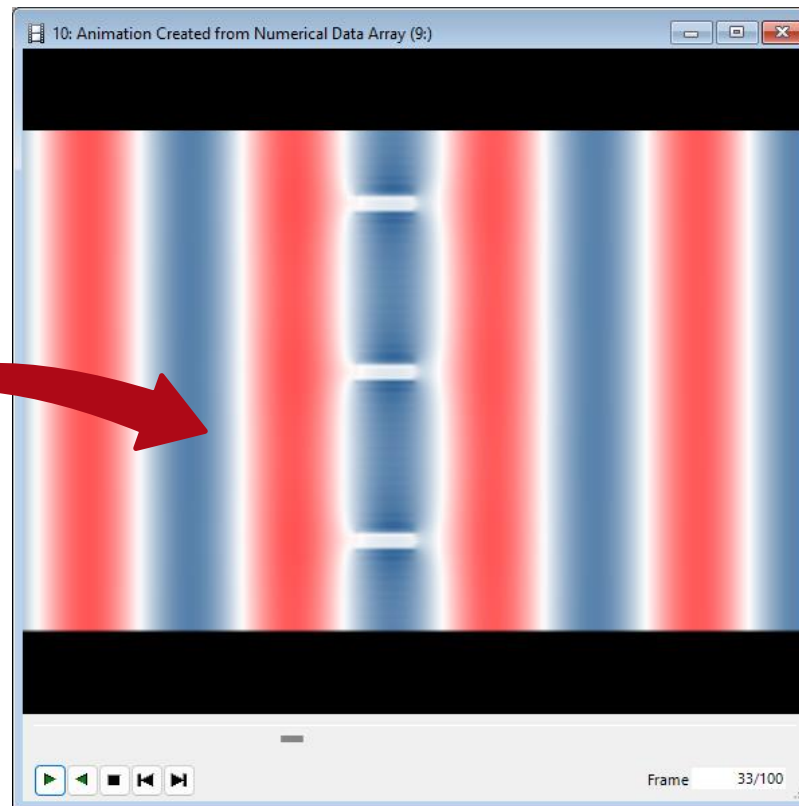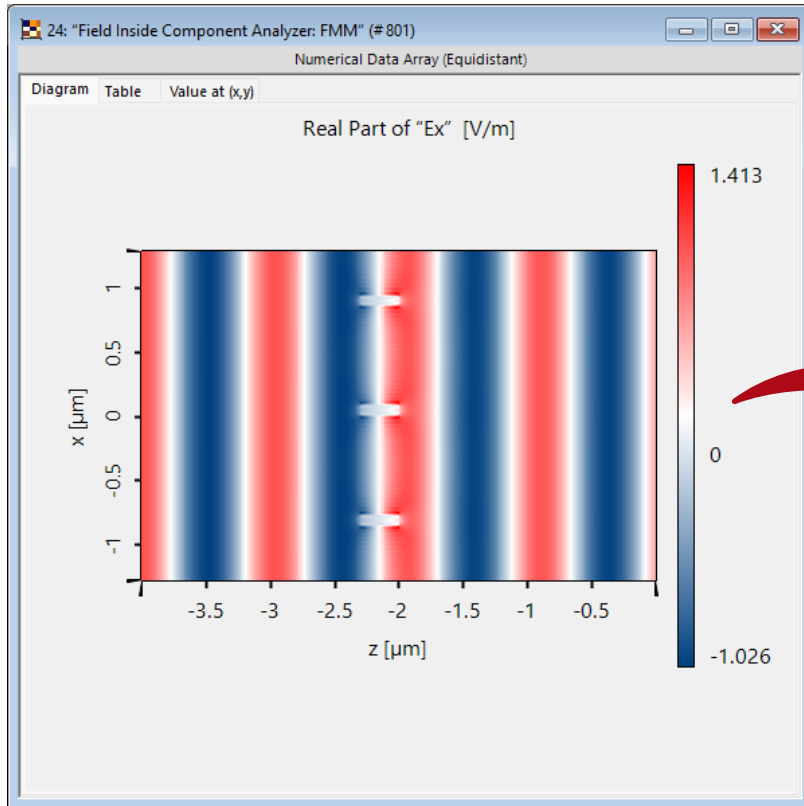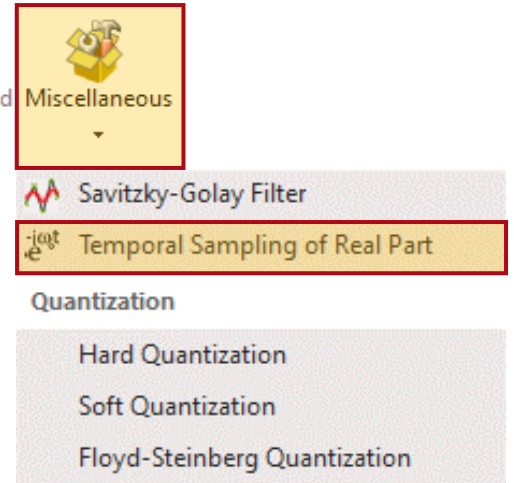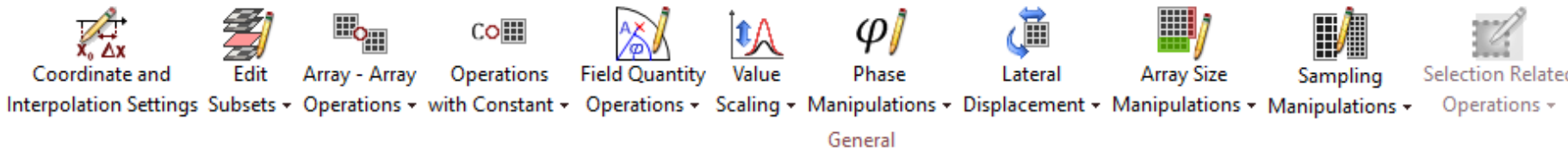
The *Temporal Sampling of Real Part* tool transforms field data into a series of *Data Arrays,* representing the field at different points in time. Which can then be transformed into an animation to visualize the moving field.

See example: Ultrasparse Dielectric Nanowire Grid Polarizers

Miscellaneous Functions

imported height profile

hard quantization

Savitzky-Golay Filter
Temporal Sampling of Real Part

Quantization

Hard Quantization
Soft Quantization
Floyd-Steinberg Quantization
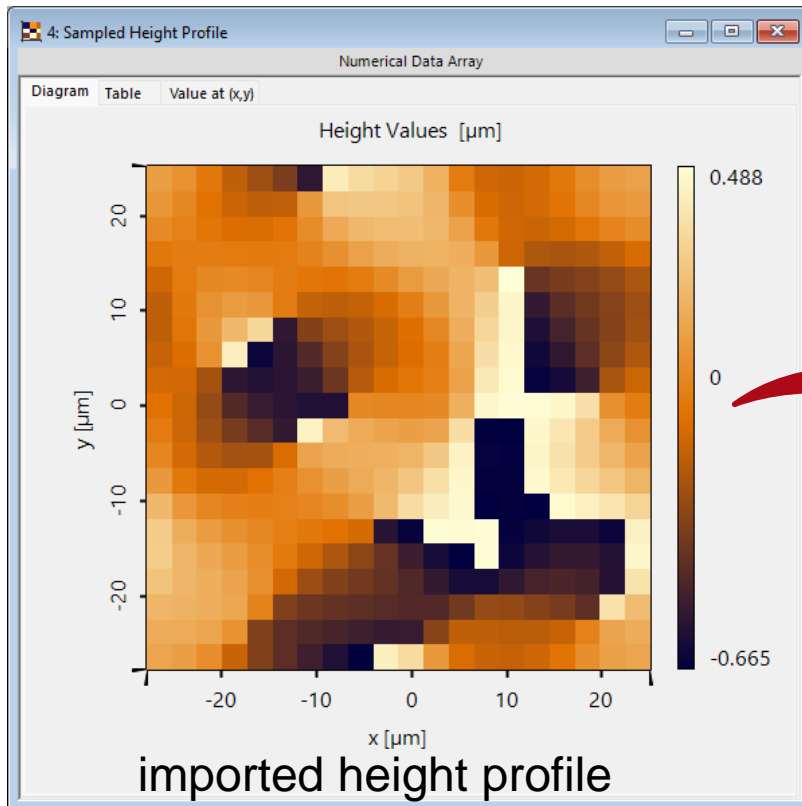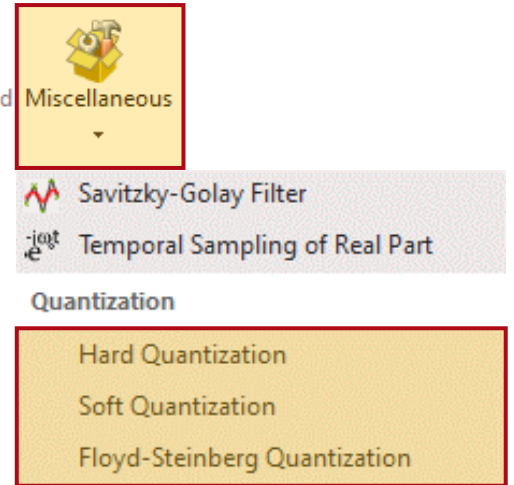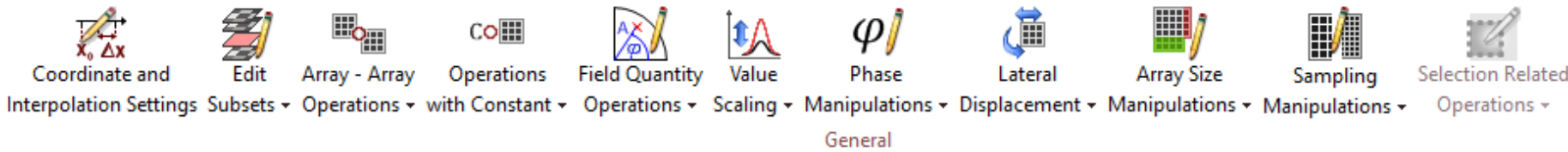
Lastly, there are different tools that allow for a *Quantization* of the given *Data Array*, which may be useful for fabrication.
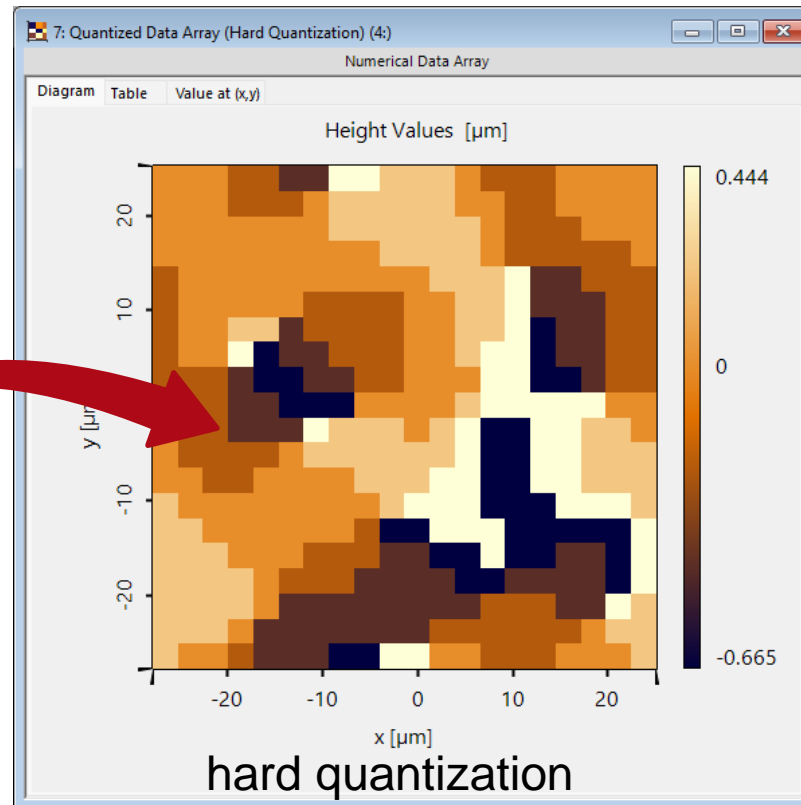
For exact definitions of the different quantization types, please see: VirtualLab Fusion Manual

Expert Mode

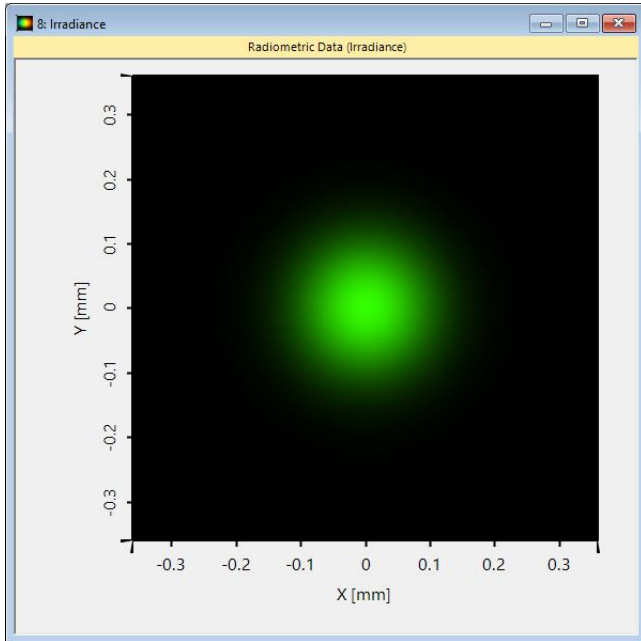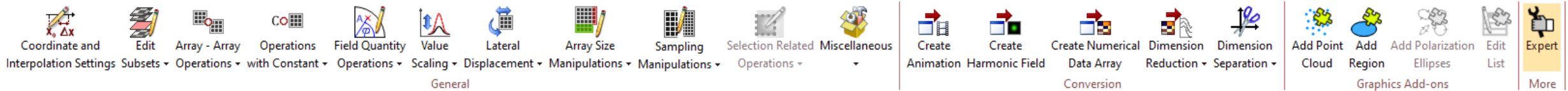This tutorial concentrates on manipulation tools for data arrays. However, we want to mention that most of these tools can also be accessed for other document types, such as *Chromatic Field Sets*, when the *Expert* mode is activated. The *Expert* mode can be found under the tab *Manipulations*.
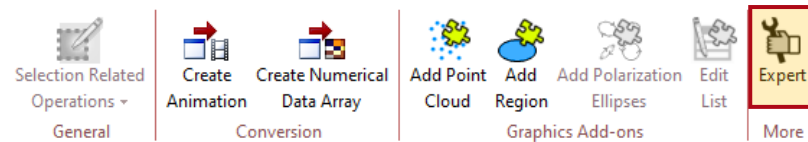
Document Information

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further reading	• Introduction To Data Arrays • Ultrasparse Dielectric Nanowire Grid Polarizers • Graphics Add-on • Savitzky-Golay Filter Function