Tutorial 504 (1.0)

Manipulations of Numerical Data Arrays

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Related Tutorials: Tutorial.337

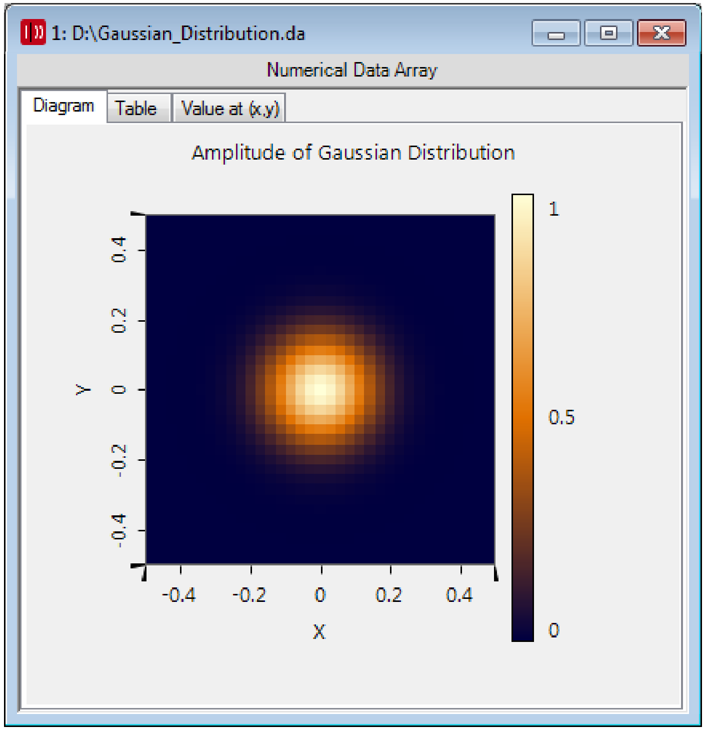
Requirements: VirtualLab™ 5.5 – Starter Toolbox

Task

- For several purposes, it is useful to manipulate the data contained within a Numerical Data Array.
- This tutorial demonstrates the usage of some of these manipulations including resampling, replication or changing physical units and the interpolation method.

Starting Object

At first, the Numerical Data Array contained in the related file **`Gaussian_Distribution.da`** has to be loaded into VirtualLab™.

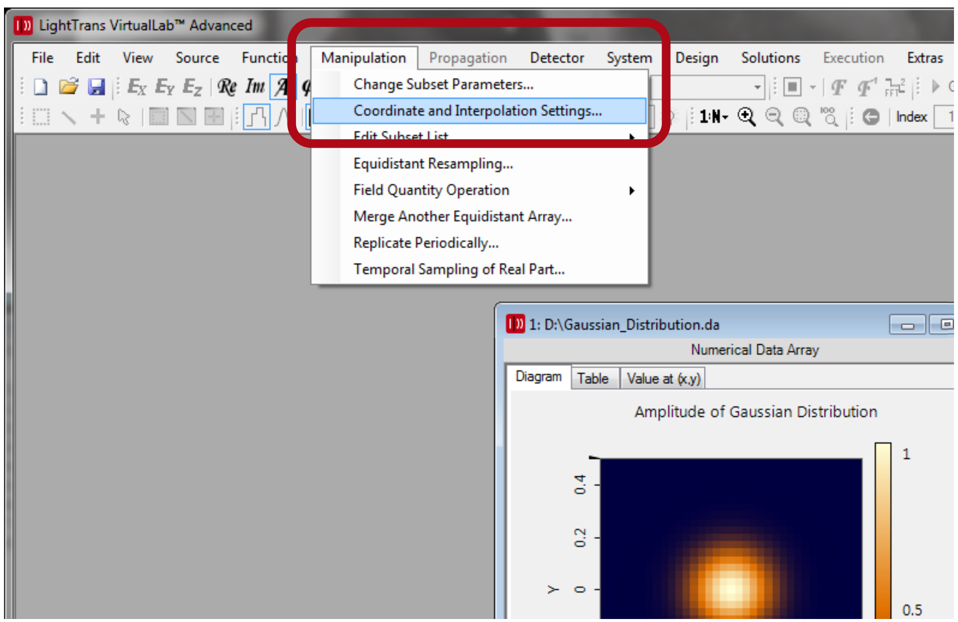


Change Coordinate and Interpolation Settings

Since we want the Numerical Data Array

- to be defined in length coordinates and
- to use a smooth interpolation method,

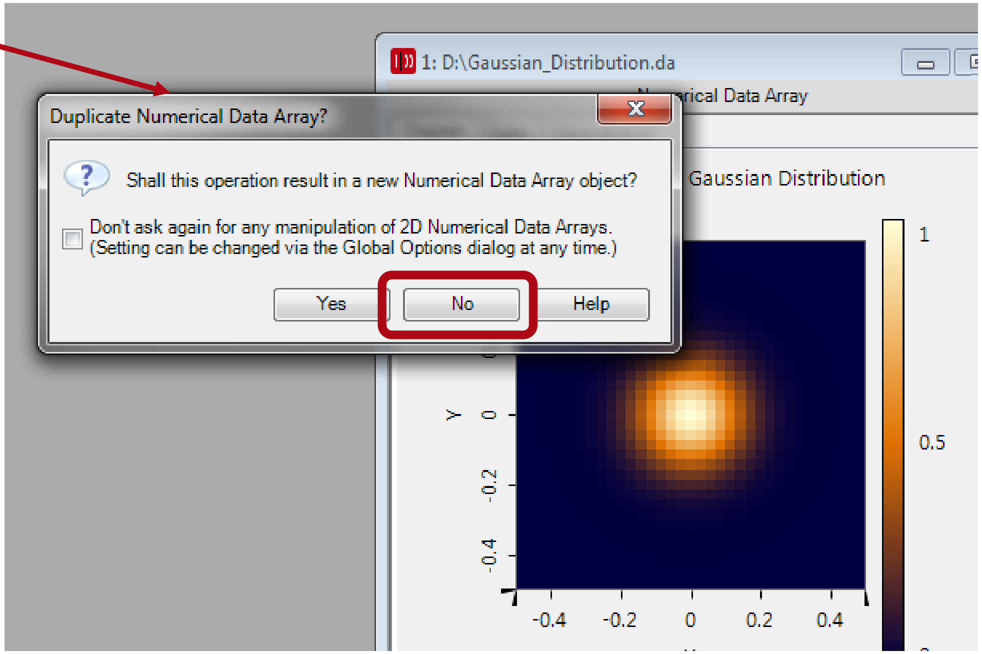
we use the manipulation operation **Coordinate and Interpolation Settings**



Results in

Duplication or no Duplication

- No we are asked whether we want to create a duplicate of the Numerical Data Array as result of the current operation.

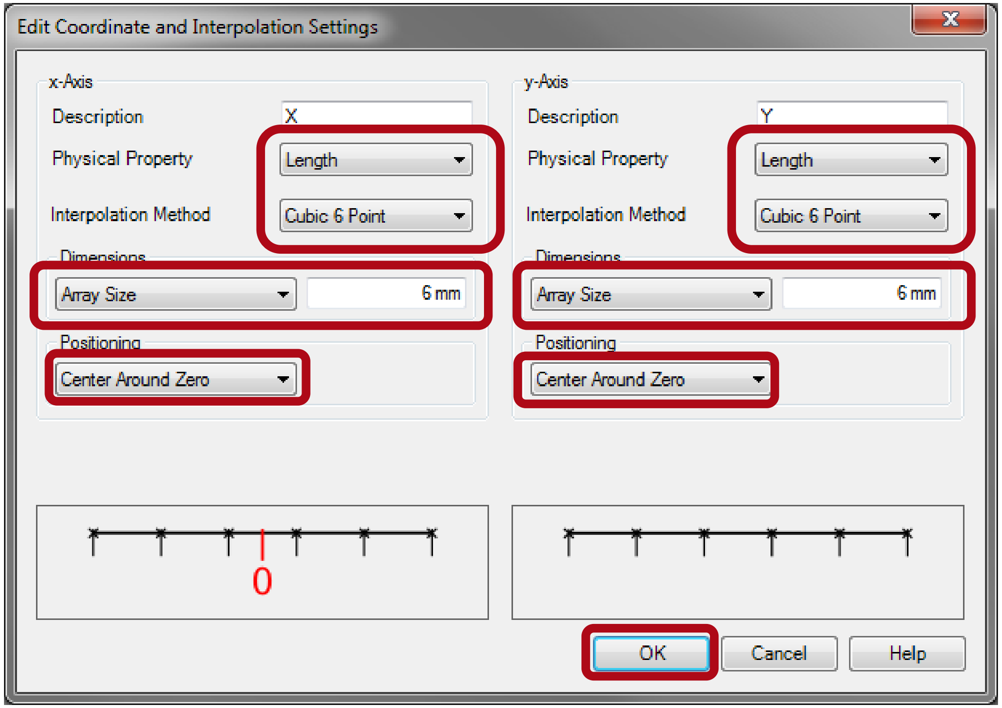


- This question is asked for each manipulation operation, unless the „Don‘t ask again…“ option is chosen.
- We select *No* in order to operate on the same Data Array for the moment.

Results in

Edit Coordinate and Interpolation Settings

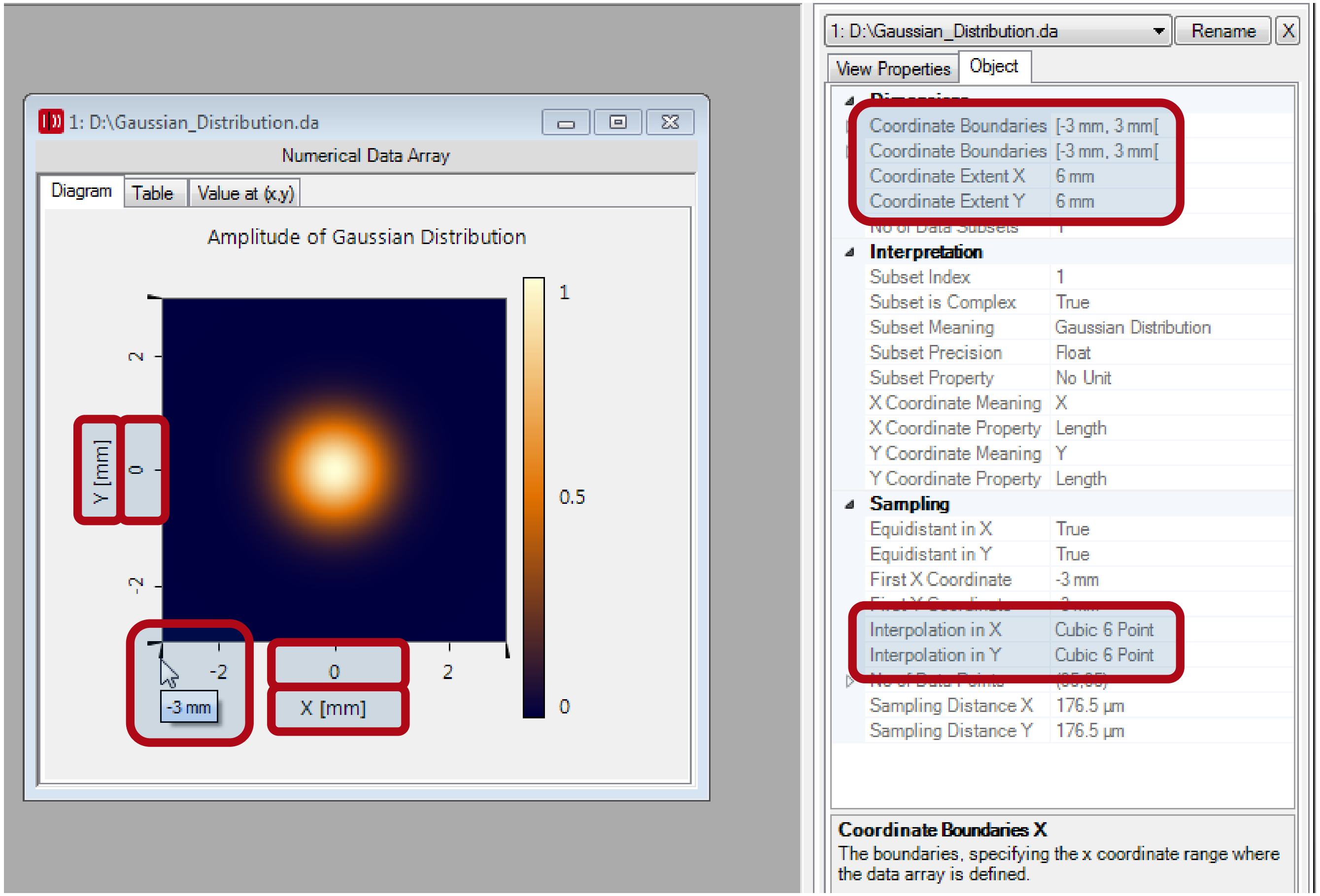
- A settings dialog appears.



- We choose *Length* as Physical Property for both dimensions.
- The *Array Size* has to be set to *6 mm* in x and y, the positioning has to be done by centering the coordinate ranges around zero.
- Then we proceed with *OK*.

Results in

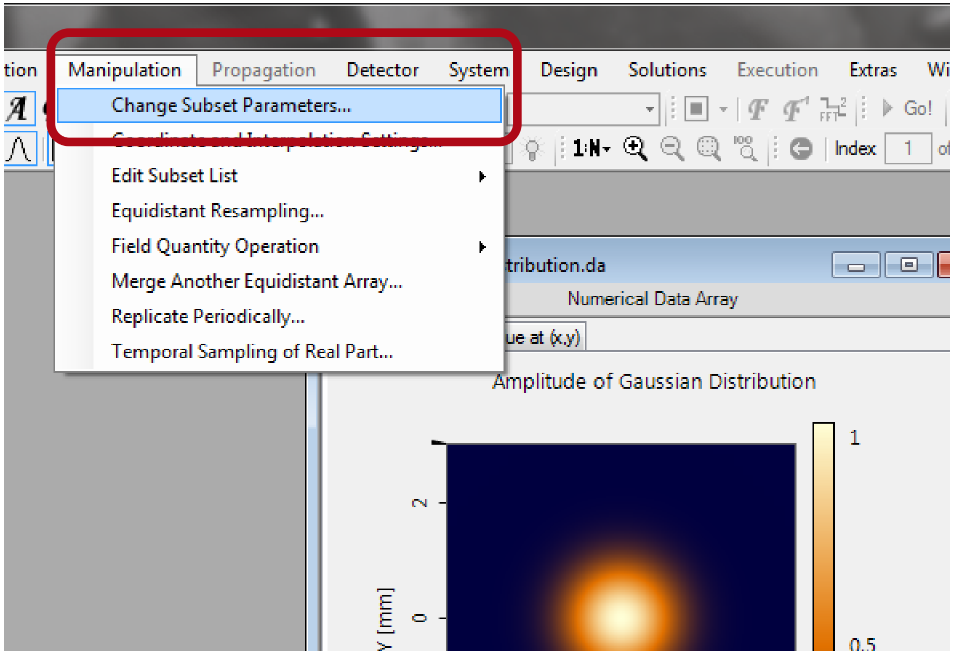
Operation Result



The changes are done on the same object. The changes can be seen at the labels in the view and at the values in the Property Browser at the right.

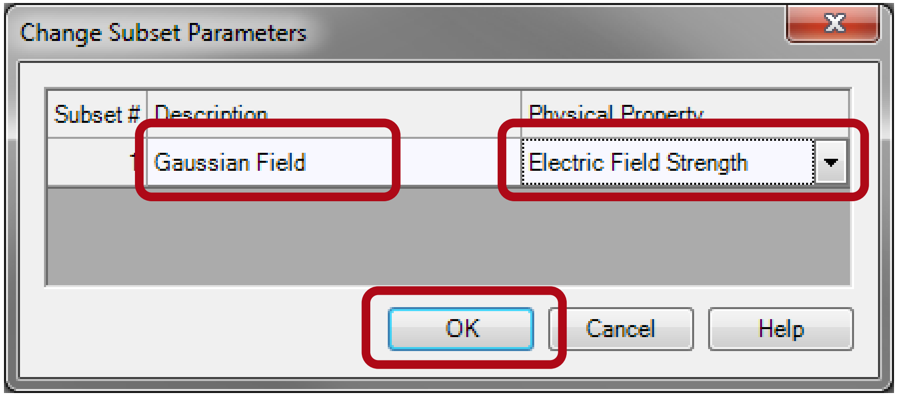
Change Subset Parameters

- Now we want to give the data in the Numerical Data Array some kind of physical meaning, which is done via **Change Subset Parameters.**
- Again, we do not duplicate the Numerical Data Array for the operation.



Results in

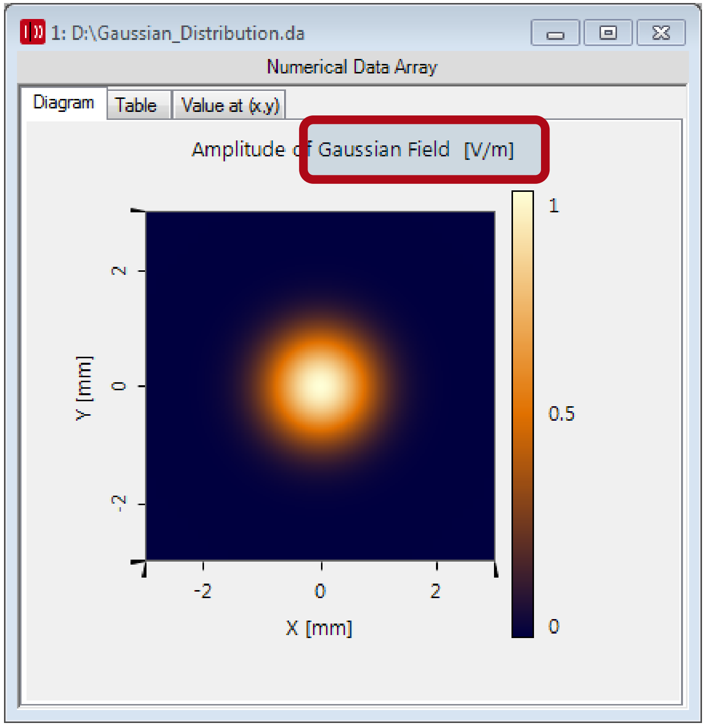
Changing the Subset Parameters



- Since there is only one subset contained at the moment, the table has one row only.
- Here we enter *Gaussian Field* as Description of the subset and *Electric Field Strength* as its Physical Property.
- *OK* closes the dialog.

Results in

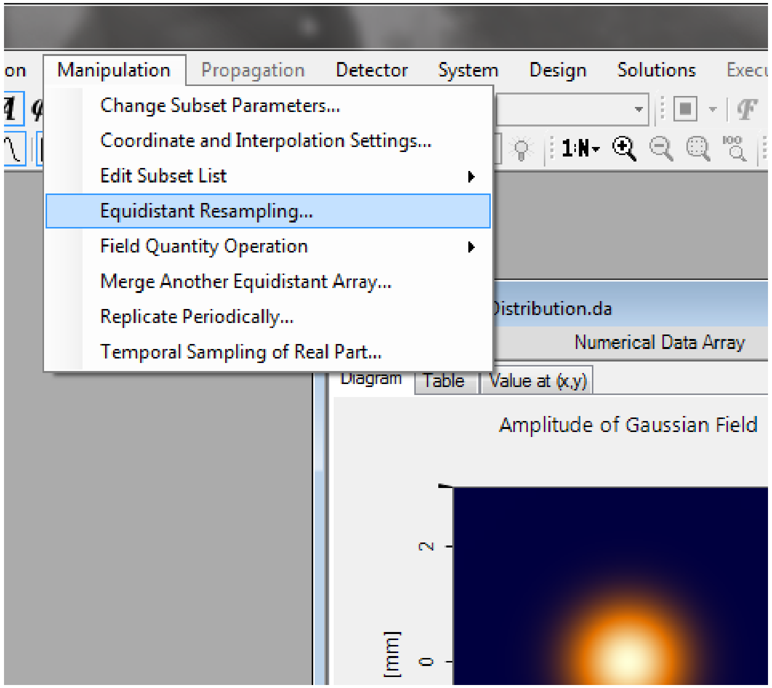
Operation Result



The name and unit of the data subset have changed, as indicated by the label.

Equidistant Resampling

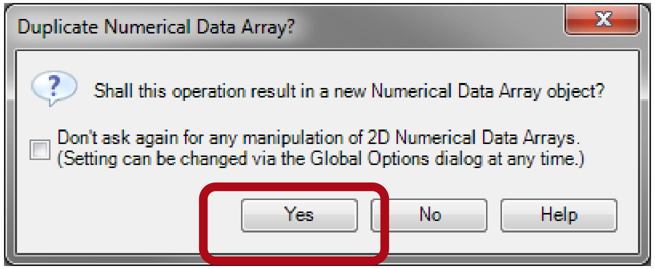
Numerical Data Arrays which are equidistantly sampled can be resampled leading to a new number of sampling points. This operation is called via Equidistant Resampling.



Results in

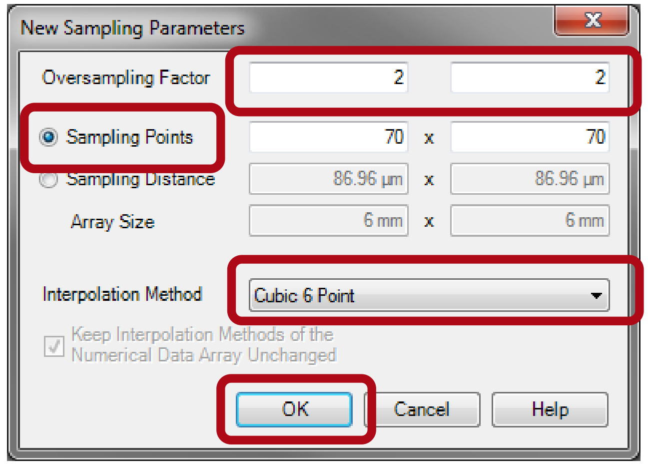
Duplication or no Duplication

When asked for duplication, we answer *Yes* now, since resampling can lead to a loss of information. So we keep the original object in case the operation does not meet our expectations.



Results in

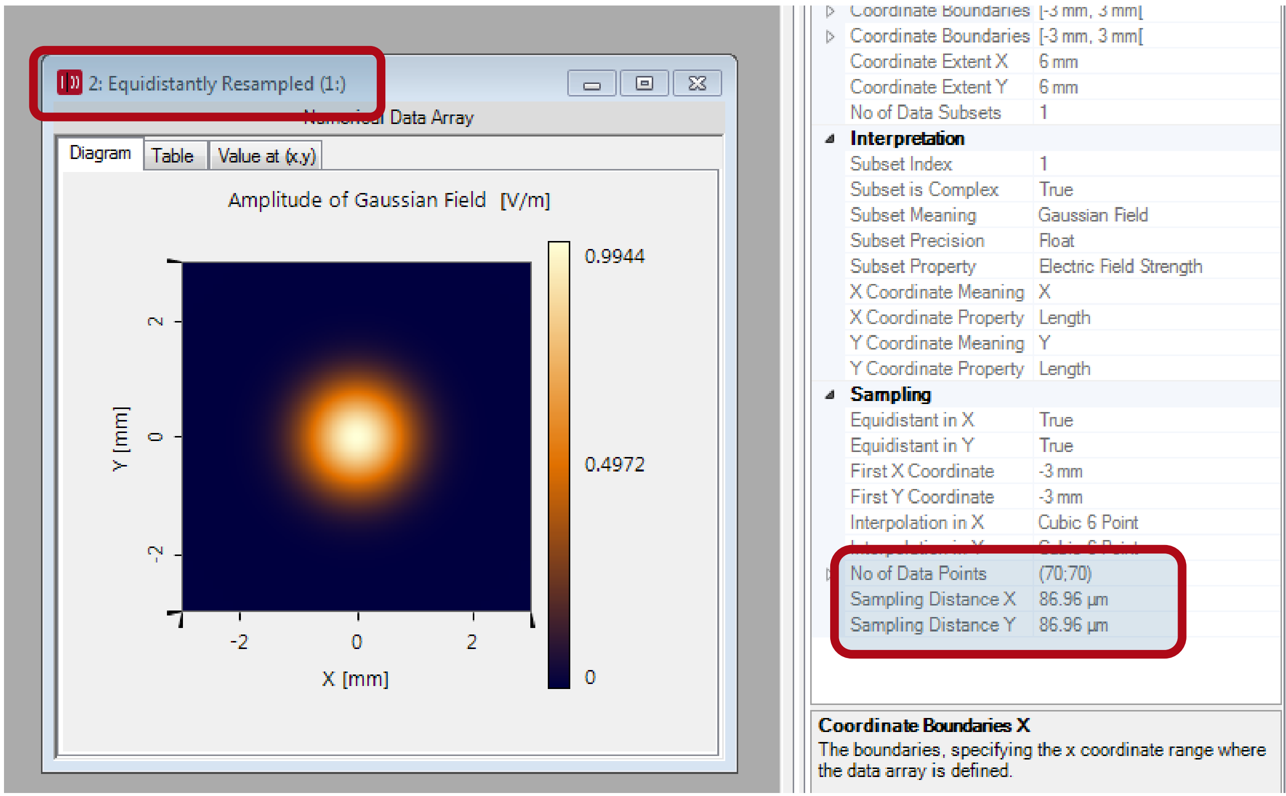
New Sampling Parameters



- We enter a resampling factor of *2* for each dimension.
- This setting refers to the number of *Sampling Points*, instead of the Sampling Distance.
- The interpolation has to be done using the Data Array's own method, *Cubic 6 Point* interpolation.
- *OK* closes the dialog.

Results in

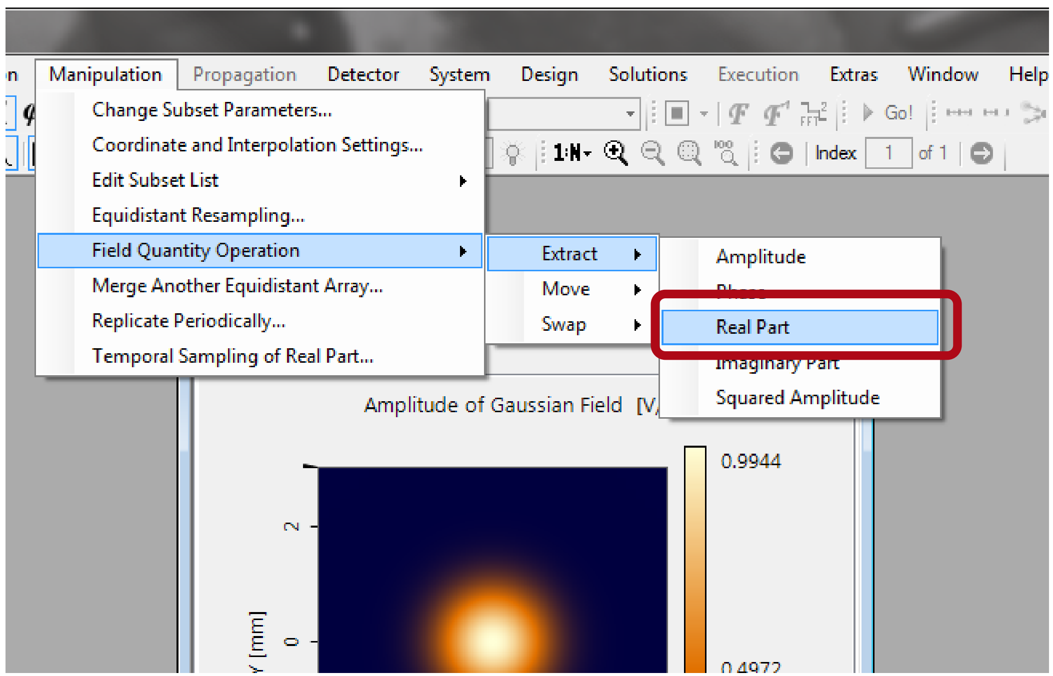
Operation Result



The result is a new Numerical Data Array with changed sampling parameters: 70 × 70 sampling points (35 × 35 before) and a sampling distance of 86.96 µm × 86.96 µm (176.5 µm × 176.5 µm before).

Extracting the Real Part

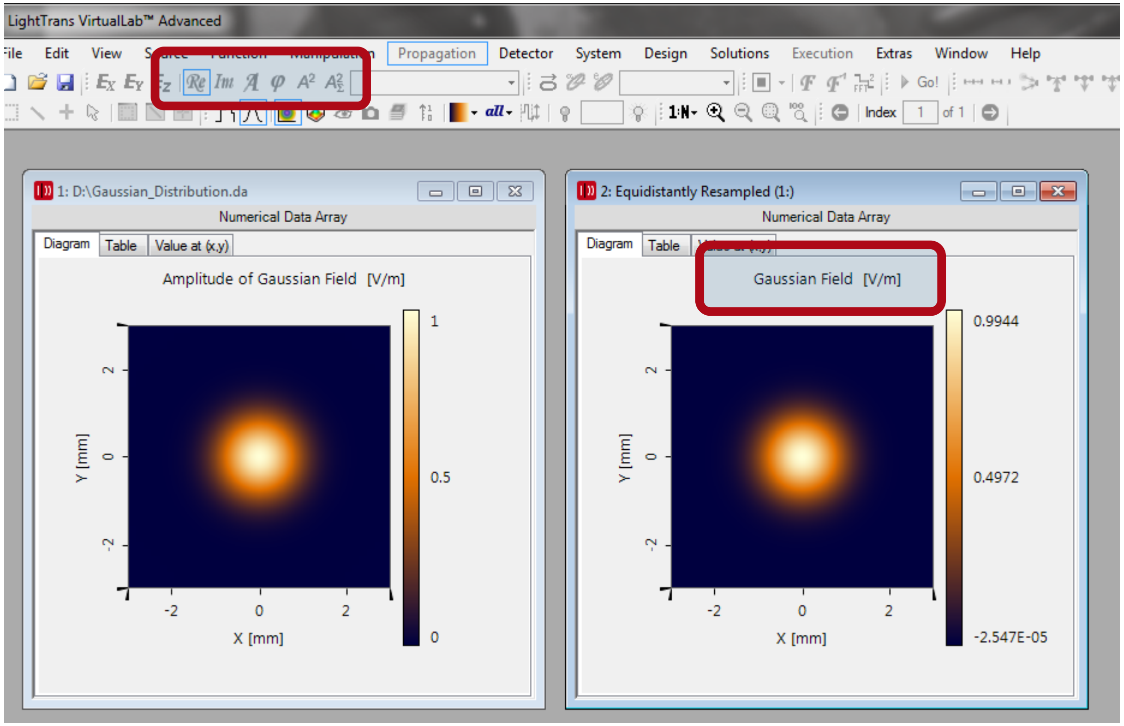
Now we want to convert the complex data of the new object to real values. This can be done e. g. by extracting the real part, an operation that can be accessed via Field Quantity Operation > Extract > Real Part.



Results in

The question for duplication we answer with *No* this time.

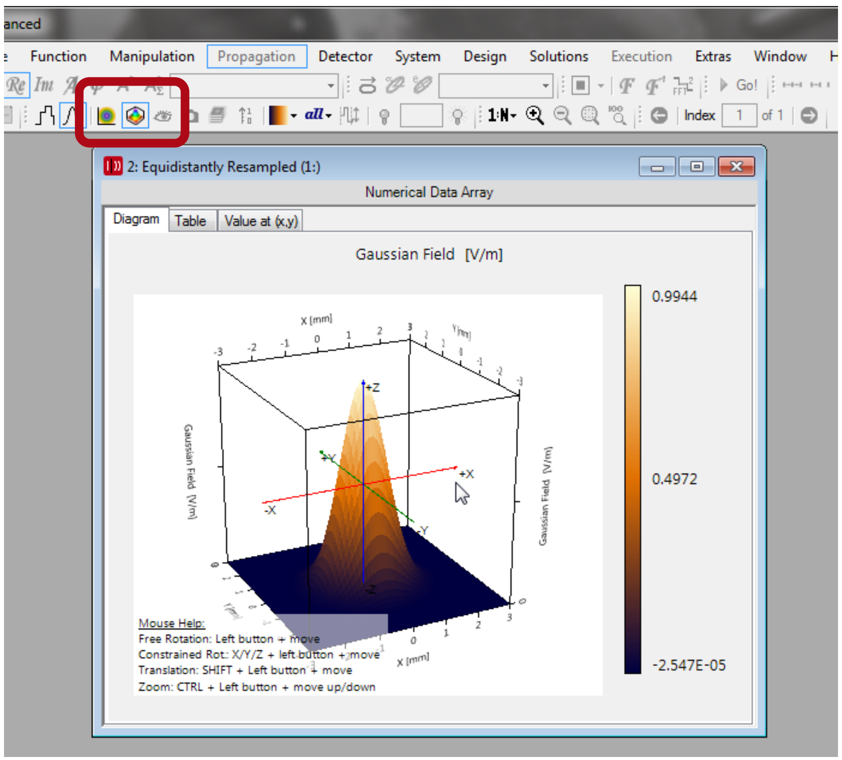
Operation Result



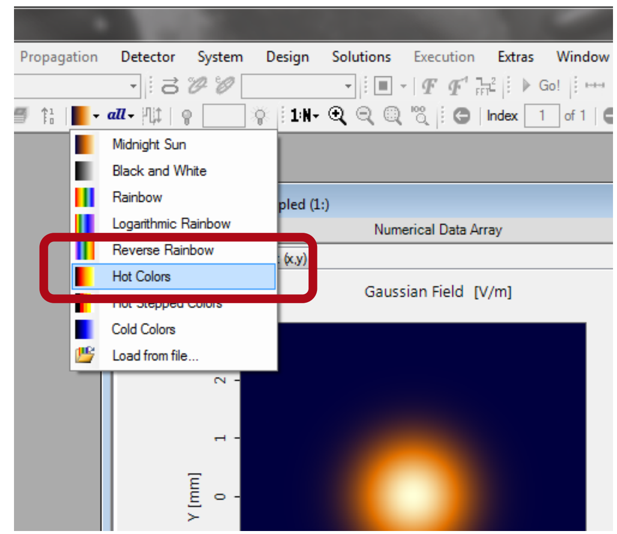
Comparing the result of this operation (right side) with the original Data Array we loaded (left side) shows that there are no other complex parts (field quantities like phase or amplitude) left.

Some View Options

If one wants to have a different kind of view at the data, it can be switched to 3D mode (left side) or the color lookup table can be changed (right side).



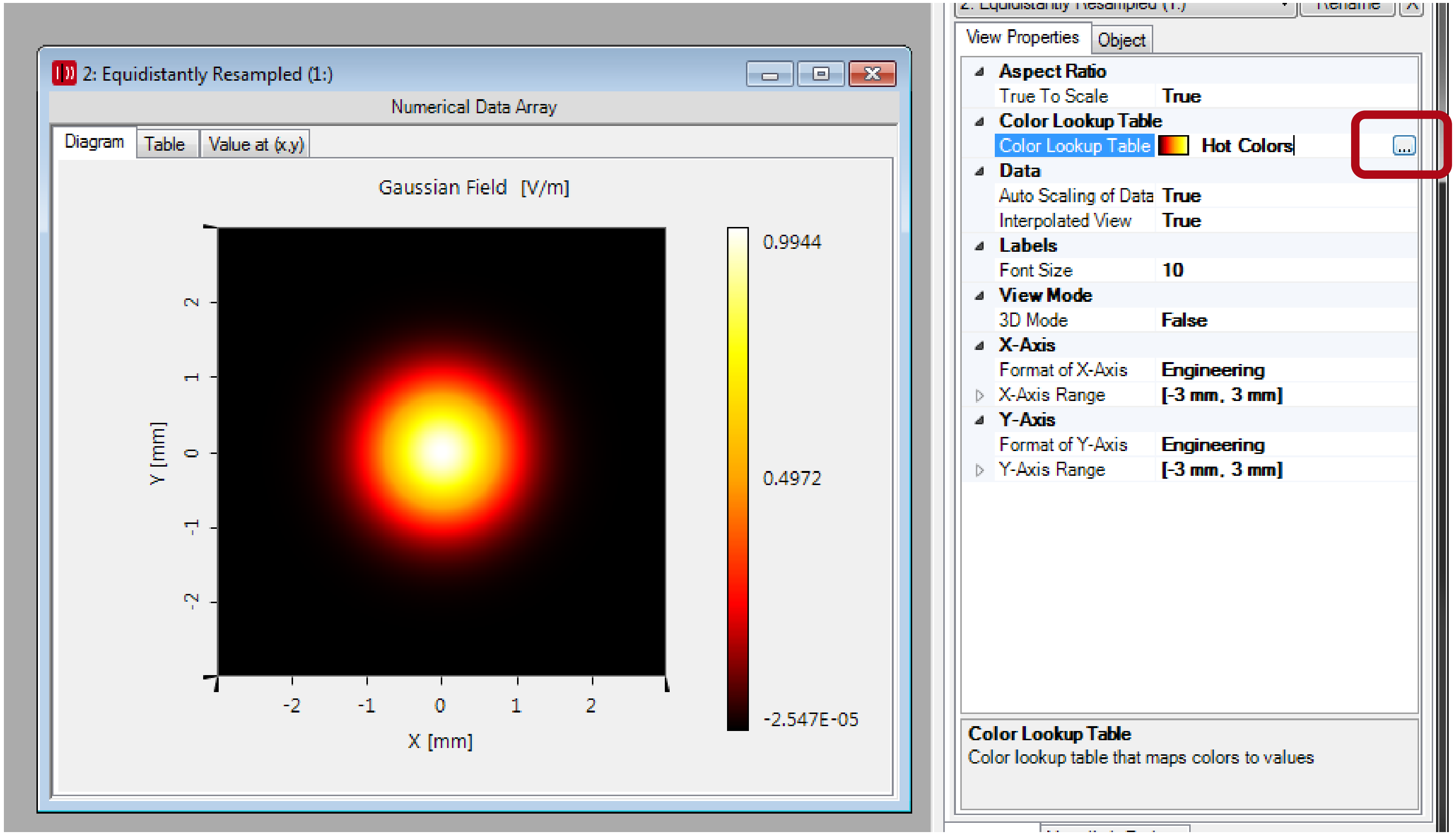
AND / OR



Here, we decide just to use **Hot Colors**.

Results in

Changed View

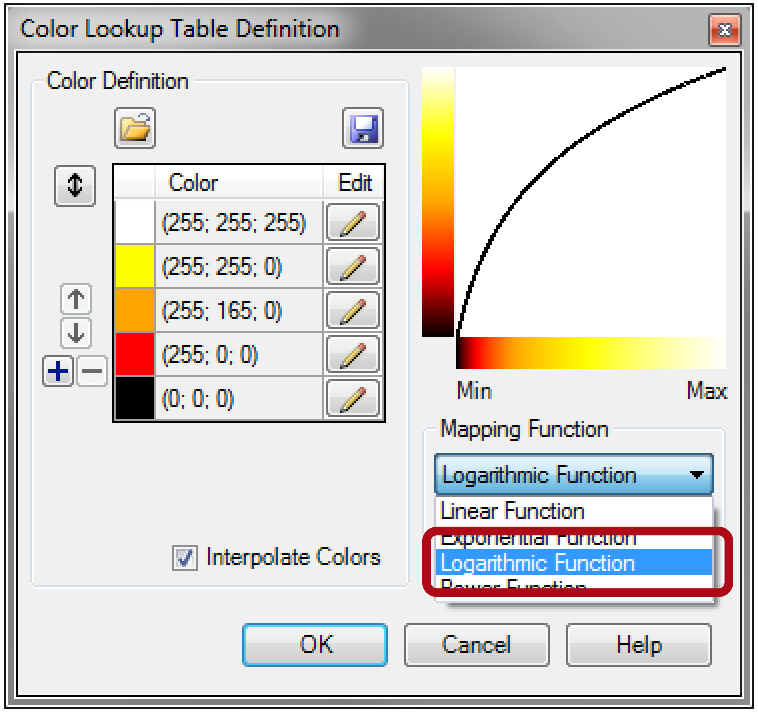


Since we want to have a better impression of the more faint regions we decide to edit the current color lookup table via Property Browser.

Results in

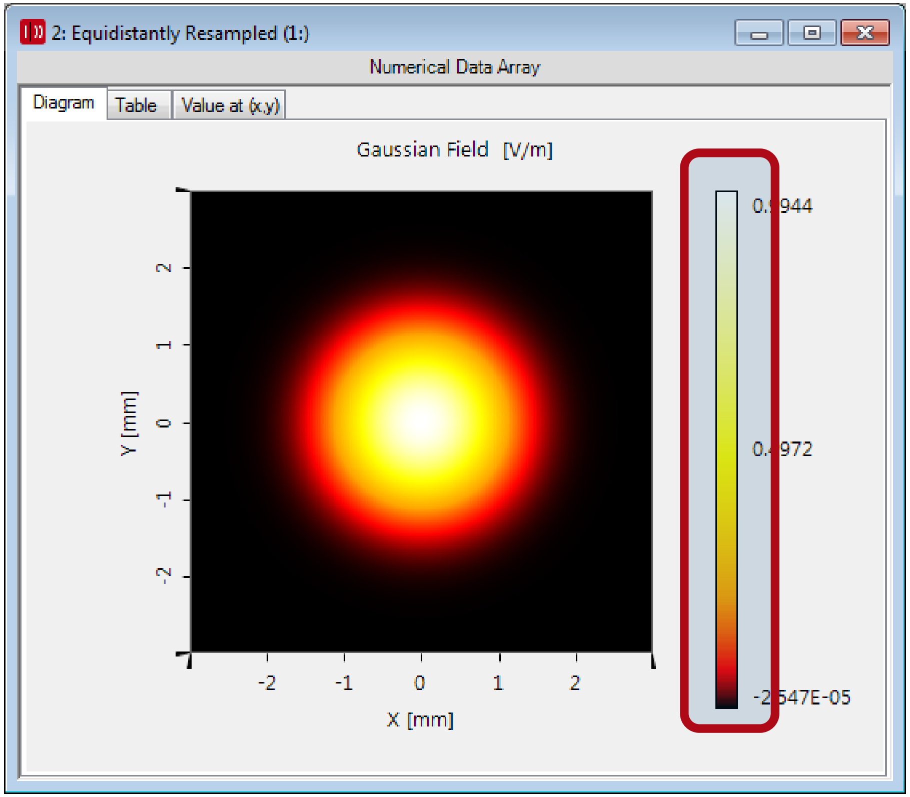
Editing a Color Lookup Table

We change the Mapping Function to **Logarithmic Function**.



Results in

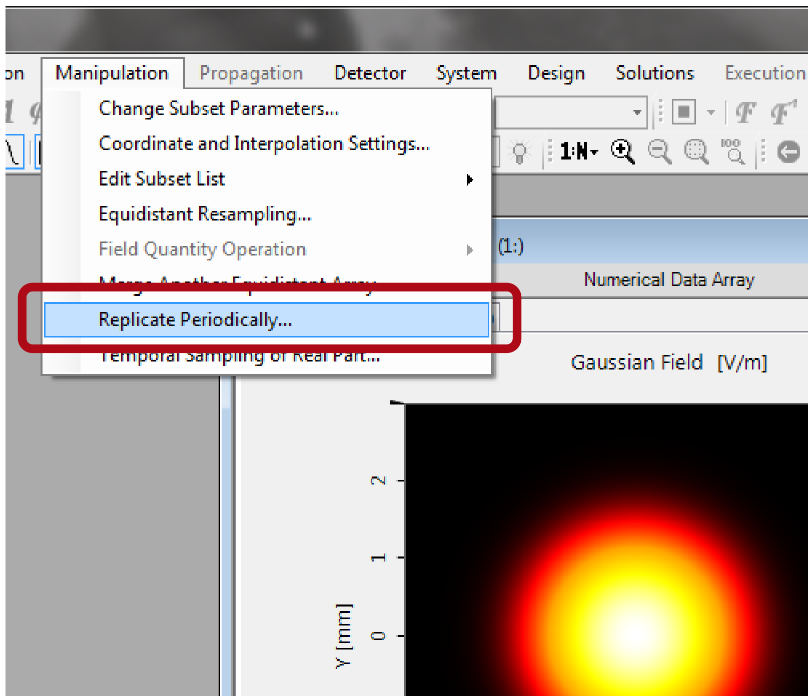
Changed View



In the result, the color mapping is not linear anymore and the outer regions of the Gaussian can be seen better.

Periodic Replication

Next, we want to Replicate Periodically the Data Array's lateral data distribution.

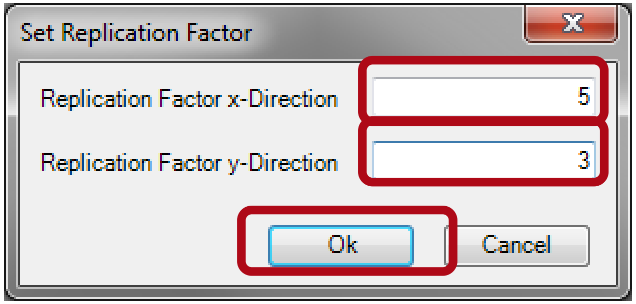


The question for duplication we answer with *Yes*.

Results in

Setting the Replication Factor

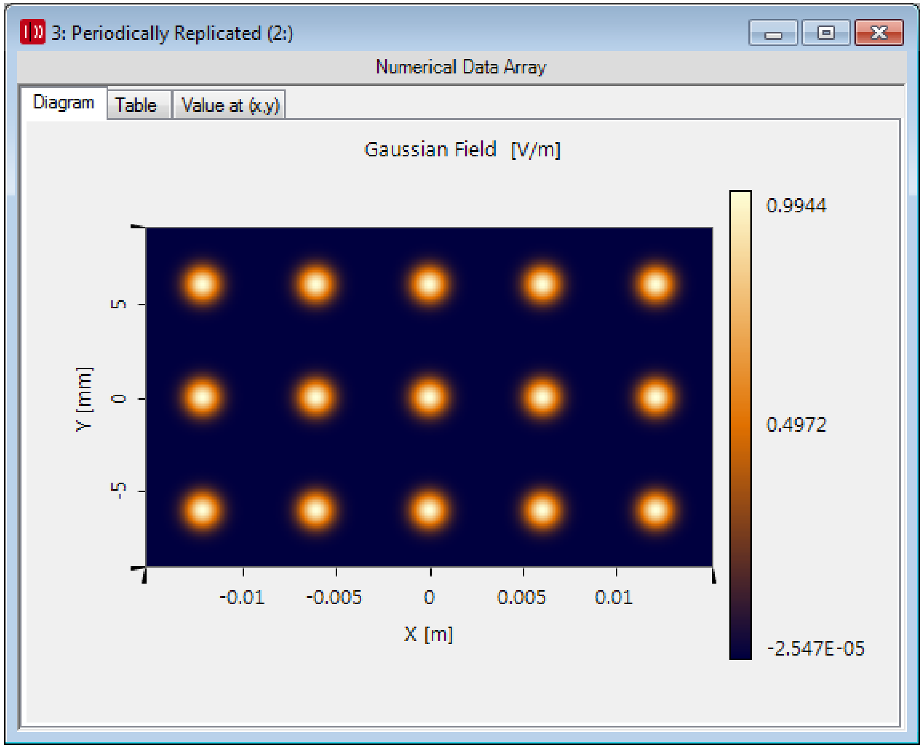
We want to replicate the current data *5* times in x-direction and *3* times in y-direction.



We proceed with *Ok*.

Results in

Operation Result



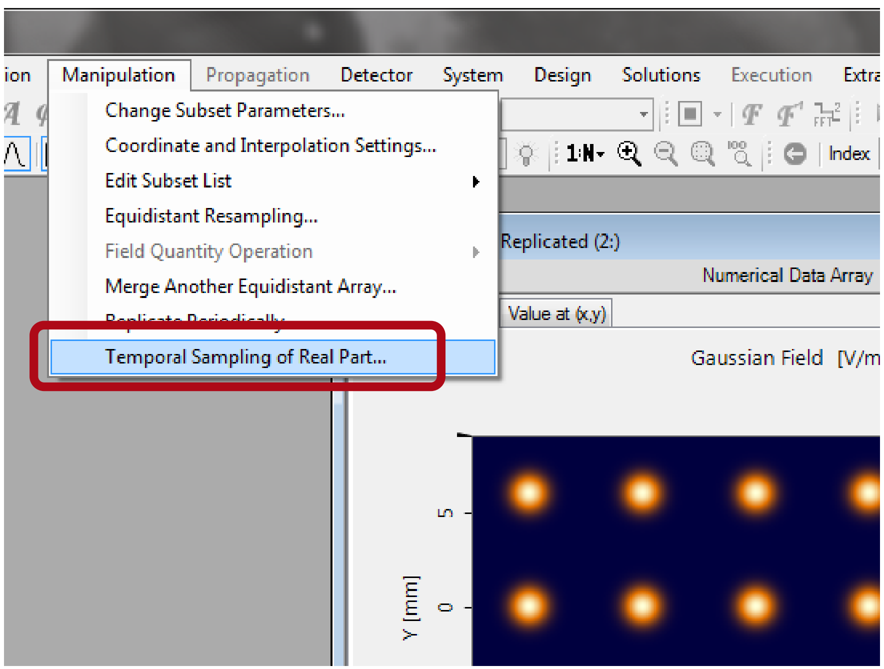
In the result, we can see the desired number of replications in each of the dimensions, respectively.

Temporal Sampling

For the moment, we consider the Numerical Data Array to be a representation of an electric field $\boldsymbol{E}(\boldsymbol{r})$. Now, we want to evaluate its temporal oscillating field strength which can be calculated via

$$\boldsymbol{E}(\boldsymbol{r}, t) = 2\,\mathrm{Re}\left[\boldsymbol{E}(\boldsymbol{r})\exp(-\mathrm{i}\omega_0 t)\right].$$

In order to do that calculation, we call Temporal Sampling of Real Part.

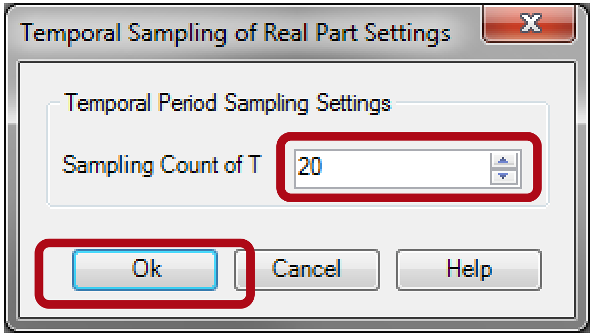


The question for duplication we answer with *Yes*.

Results in

Temporal Sampling Steps

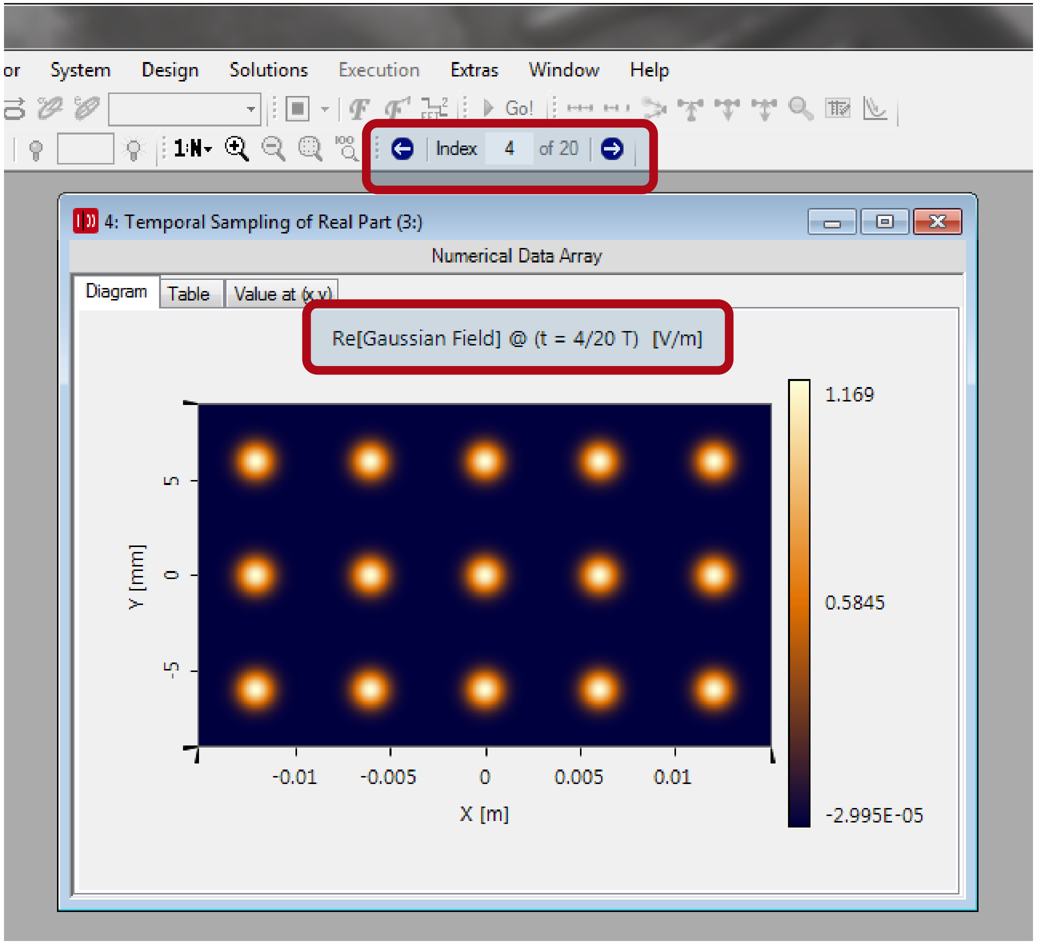
A dialog asks for the number of temporal sampling steps, i. e. the number of steps one oscillation period is decomposed to.



We enter *20* and proceed with *Ok*.

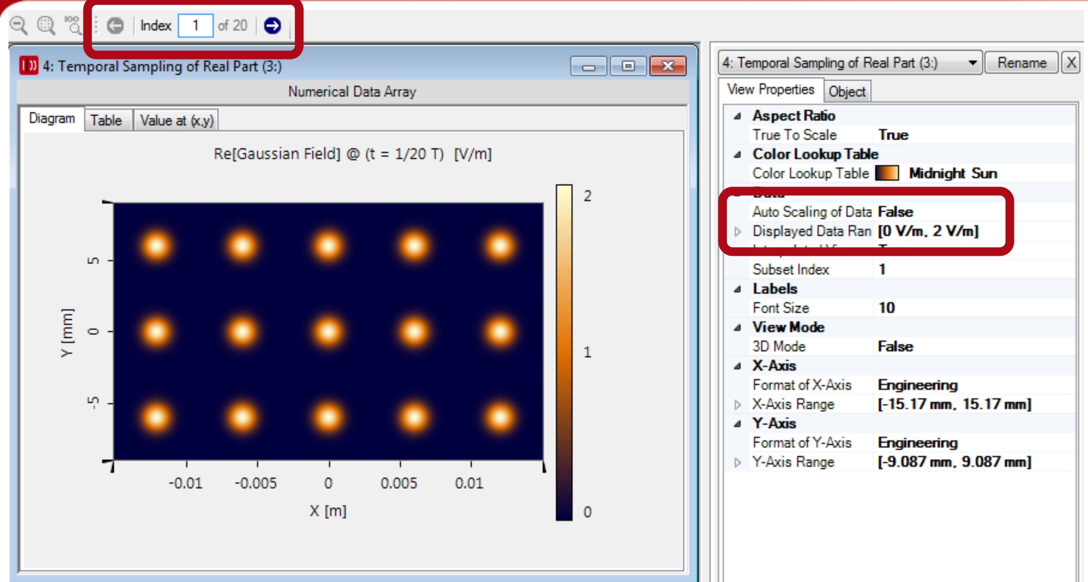
Results in

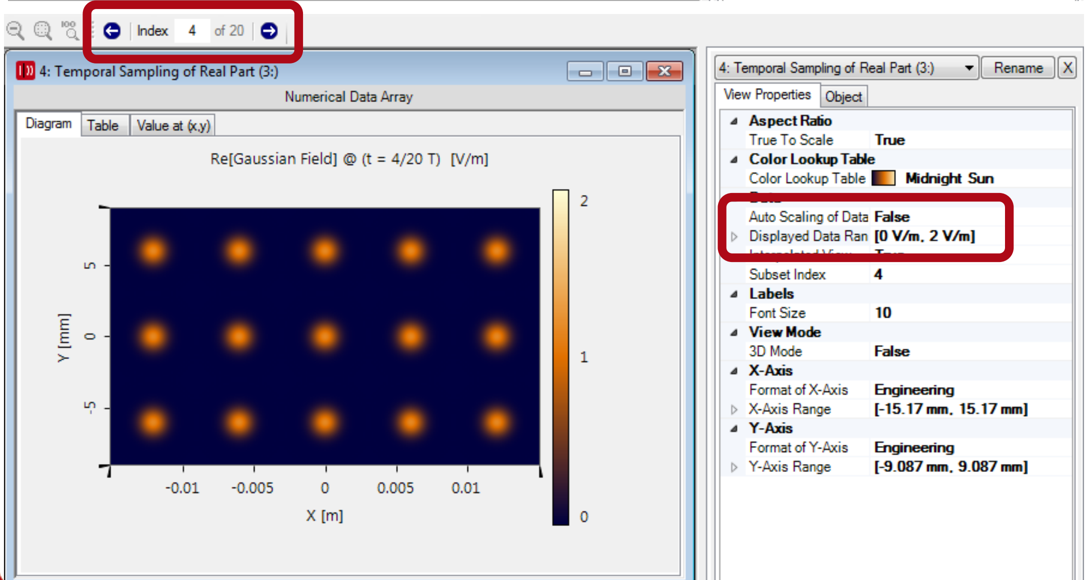
Operation Result



We obtain a new Numerical Data Array, holding 20 subsets, one for each temporal sampling step.

Changing View Options

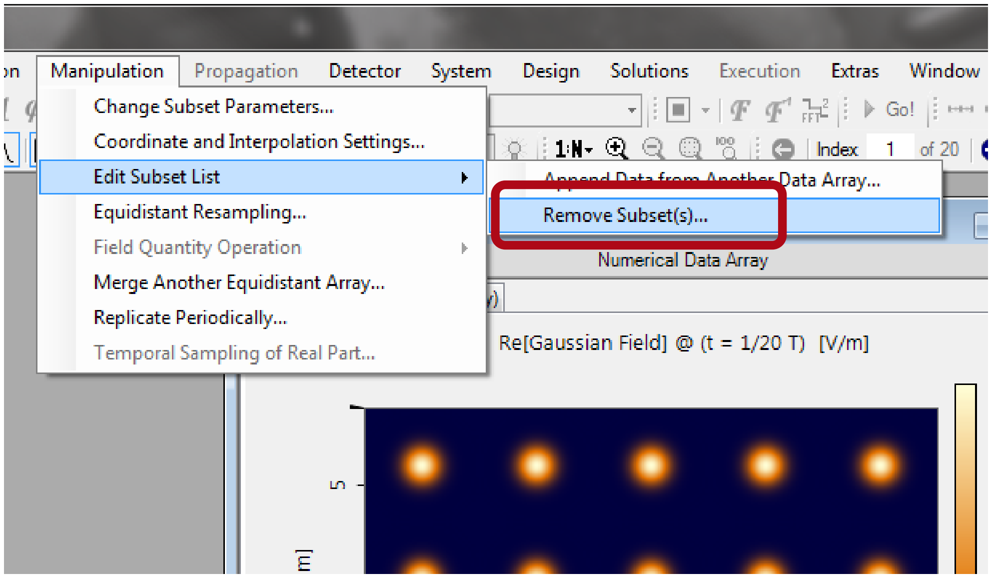




- In order to see the oscillating effect, we have to change the scaling of the data in the view.
- This is done via Property Browser, where the *Auto Scaling of Data* has to be set to *False* and the *Displayed Data Range* has to be set to *[0 V/m, 2 V/m]*.

Removing Subsets

Now we want to reduce the number of subsets hold in the Numerical Data Array. This can be obtained via Edit Subset List > Remove Subset(s).

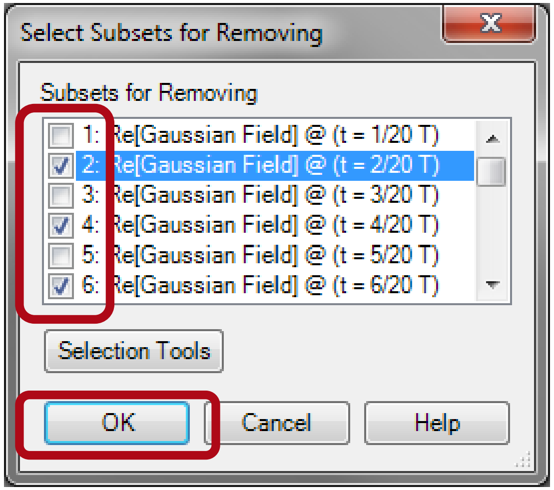


The question for duplication we answer *No* this time.

Results in

Selecting Subsets for Removing

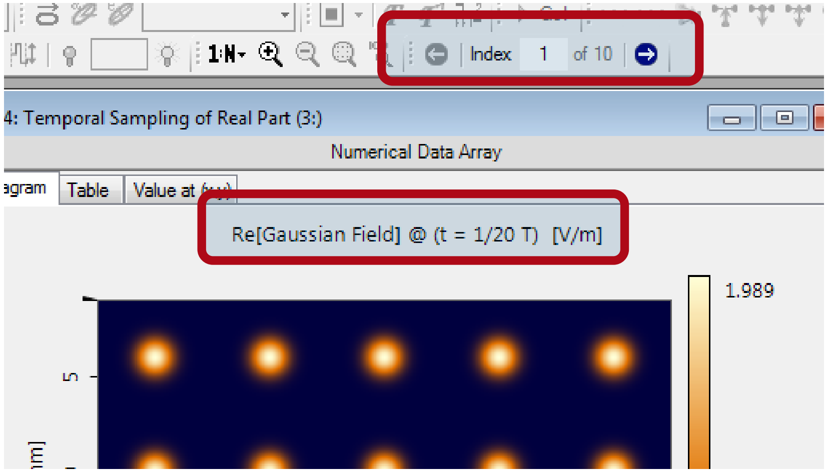
The next dialog asks for the selection of that subsets which shall be removed. Each single subset can be chosen, except one (because at least one subset has to remain within the Data Array).



We want to halve the number of subsets, so we *mark every second subset* and proceed with *Ok*.

Results in

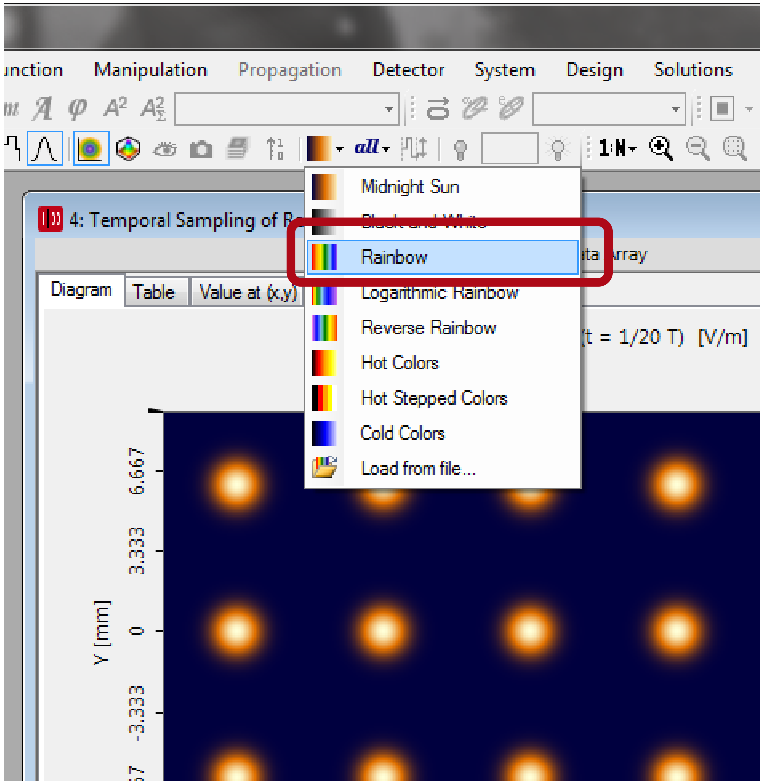
Operation Result



- The Numerical Data Array will have half the number of subsets now, i. e. 10.
- The label „…t = 1/20 T…“ is correct anyway, since the remaining temporal sampling steps are 1/20 T, 3/20 T, 5/20 T and so on, now.

Visualizing the Temporal Dependency via Animation

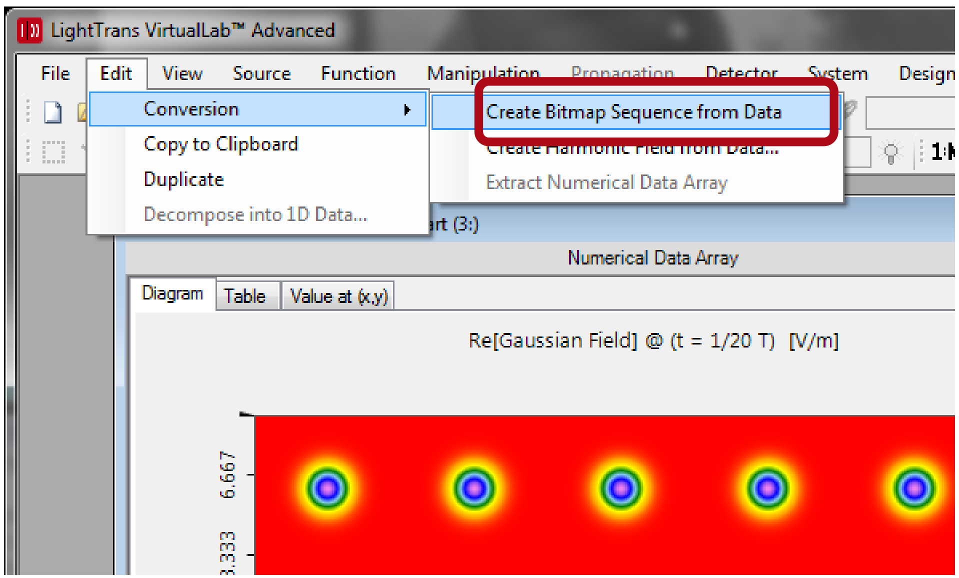
- The most impressive way to visualize the temporal dependency of the electrical field strength, is to create an animation or so called bitmap sequence.
- At first, we change the color lokup table to *Rainbow*.



Results in

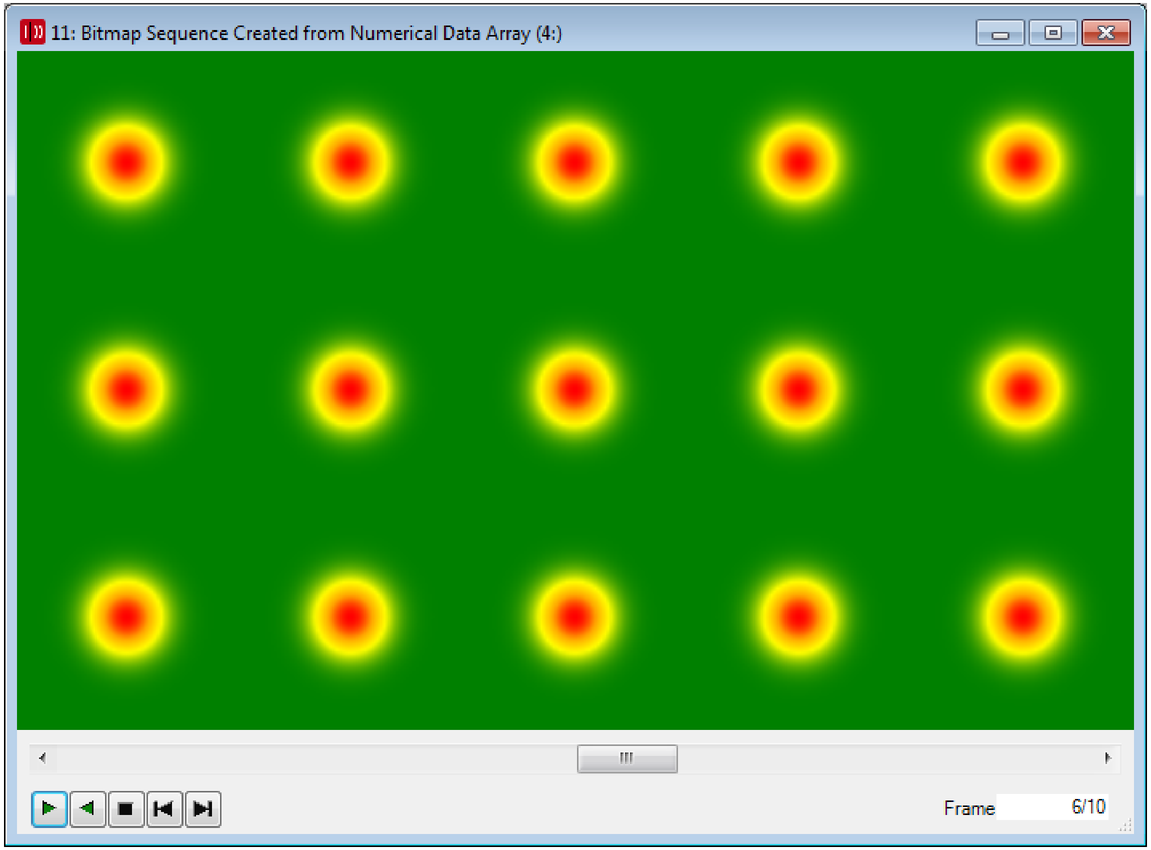
Visualizing the Temporal Dependency via Animation

Now we do the conversion from Numerical Data Array to the animation via *Edit > Conversion > Create Bitmap Sequence from Data*.



Results in

Operation Result



The result is an animation which shows the temporal oscillation of the electric field strength.

Conclusion

- There are numerous ways of manipulating Numerical Data Arrays which can be combined for a very flexible handling of almost any kind of 1D or 2D data.