

LAB

What's new v5.13

Optimizer enhancements

Optimizer enhancements

LAB has received some new optimizer modes to allow a more efficient and less time-consuming optimization.

- Multi-Level Single-Linkage (MLSL) + Subplex
- NLOpt

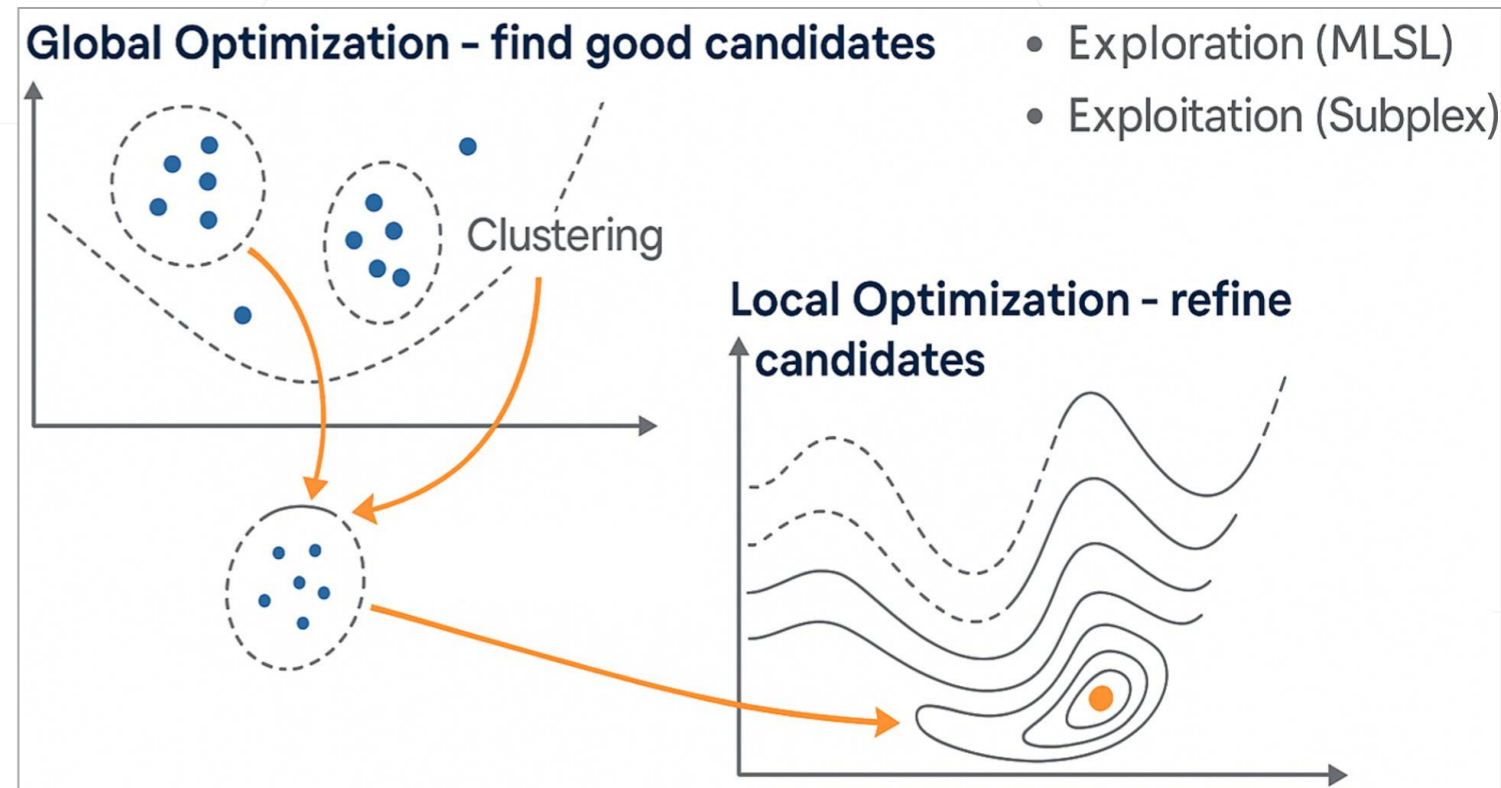
In addition to the new models also some enhancements have been made to improve the user experience of the Calibration module.

- Update Optimizer Start Parameters
- Safety Measures for Calibration Crashes

New Optimization Method MLSL + Subplex

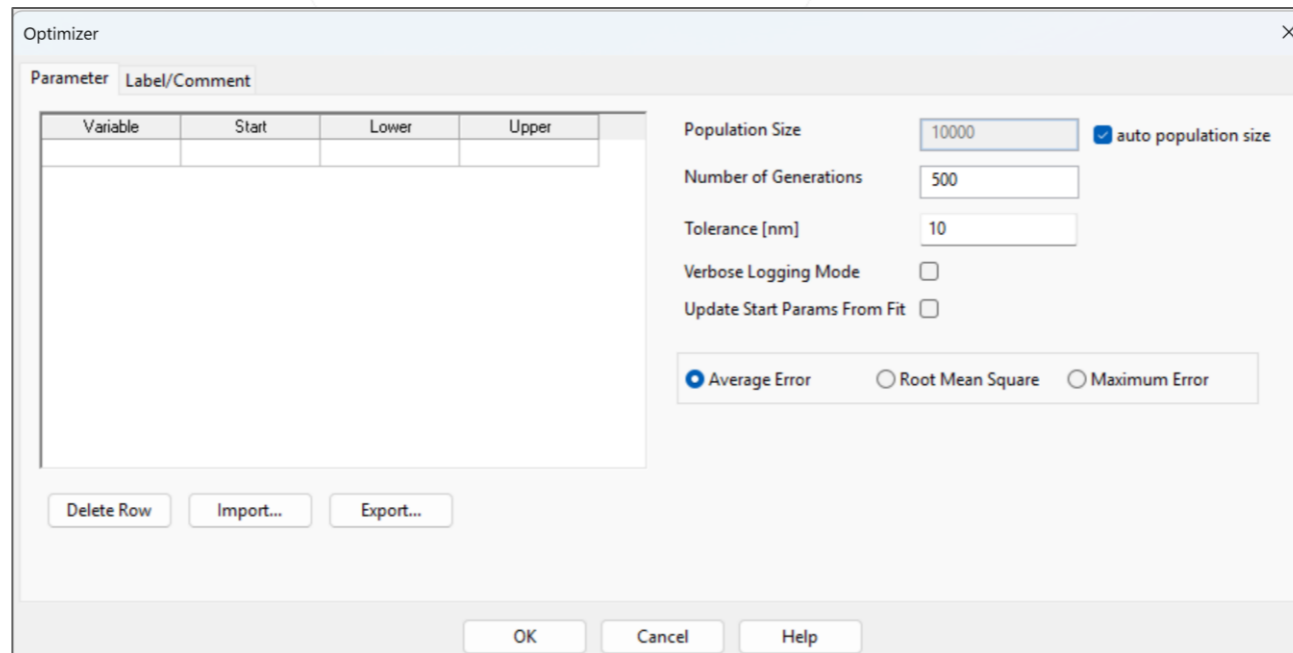
- Until now optimization used only the "Differential Evolution" optimizer algorithm, the superior "**MLSL + Subplex**" optimization method has been implemented into the *Calibration* and *Optimizer Modules* and is now the default setting
- **MLSL + Subplex** Optimizer is a **Multi-Start** optimization strategy that combines:

- **MLSL**: Multi-Level Single-Linkage — a **global** optimization algorithm
- **Subplex**: a derivative-free **local** optimization algorithm



New Optimization Method MLSL + Subplex

- **Multi-Start MLSL** algorithm performs global optimization by sampling start points in the search space, clustering nearby points, merging close clusters — then runs a **local optimizer (Subplex)** from a promising point in each cluster.
- Key Features:
 - Global optimizer
 - Once a good start point is found ("semi-random process"), local optimization runs fast



The screenshot shows the 'Optimizer' dialog box with the following settings:

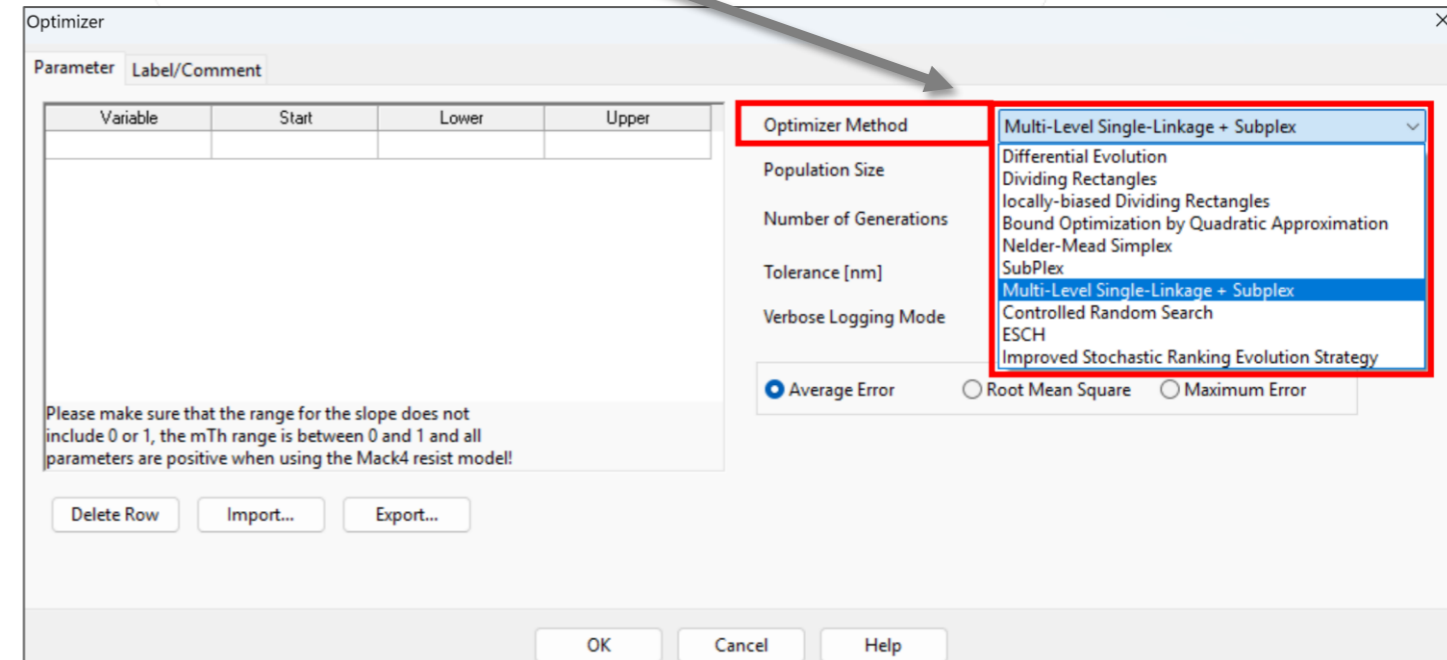
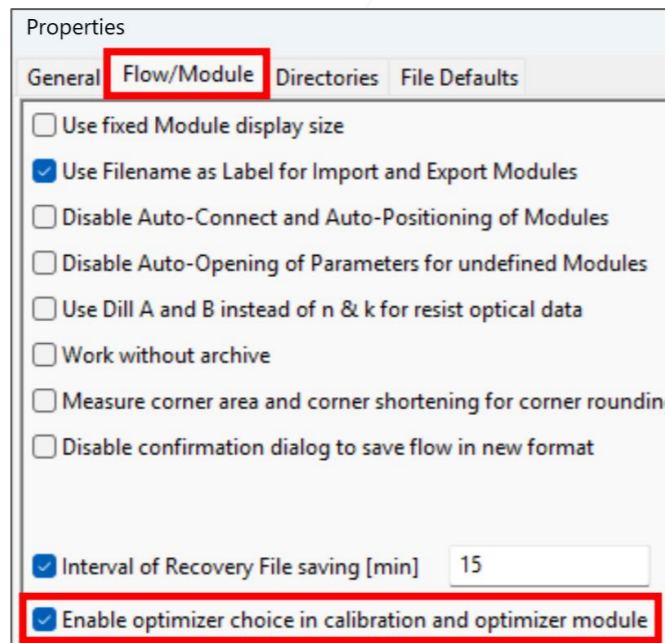
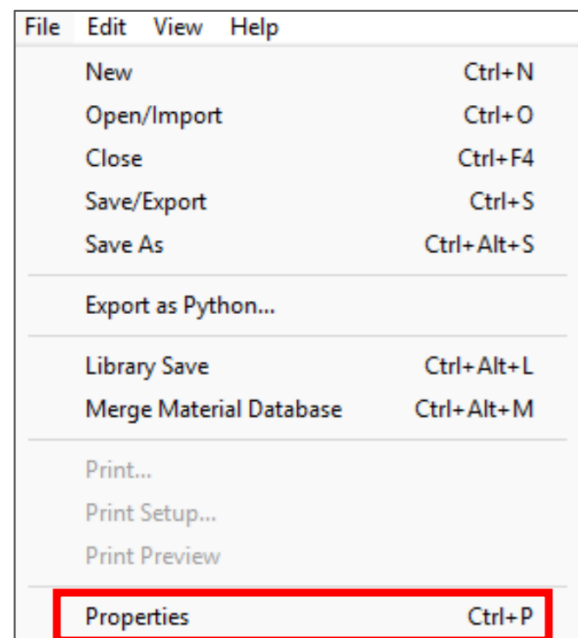
Variable	Start	Lower	Upper

Population Size: 10000 ☒ auto population size
Number of Generations: 500
Tolerance [nm]: 10
Verbose Logging Mode: ☐
Update Start Params From Fit: ☐
☒ Average Error ☐ Root Mean Square ☐ Maximum Error
Buttons: Delete Row, Import..., Export..., OK, Cancel, Help

The optimizer uses MLSL + Subplex by default

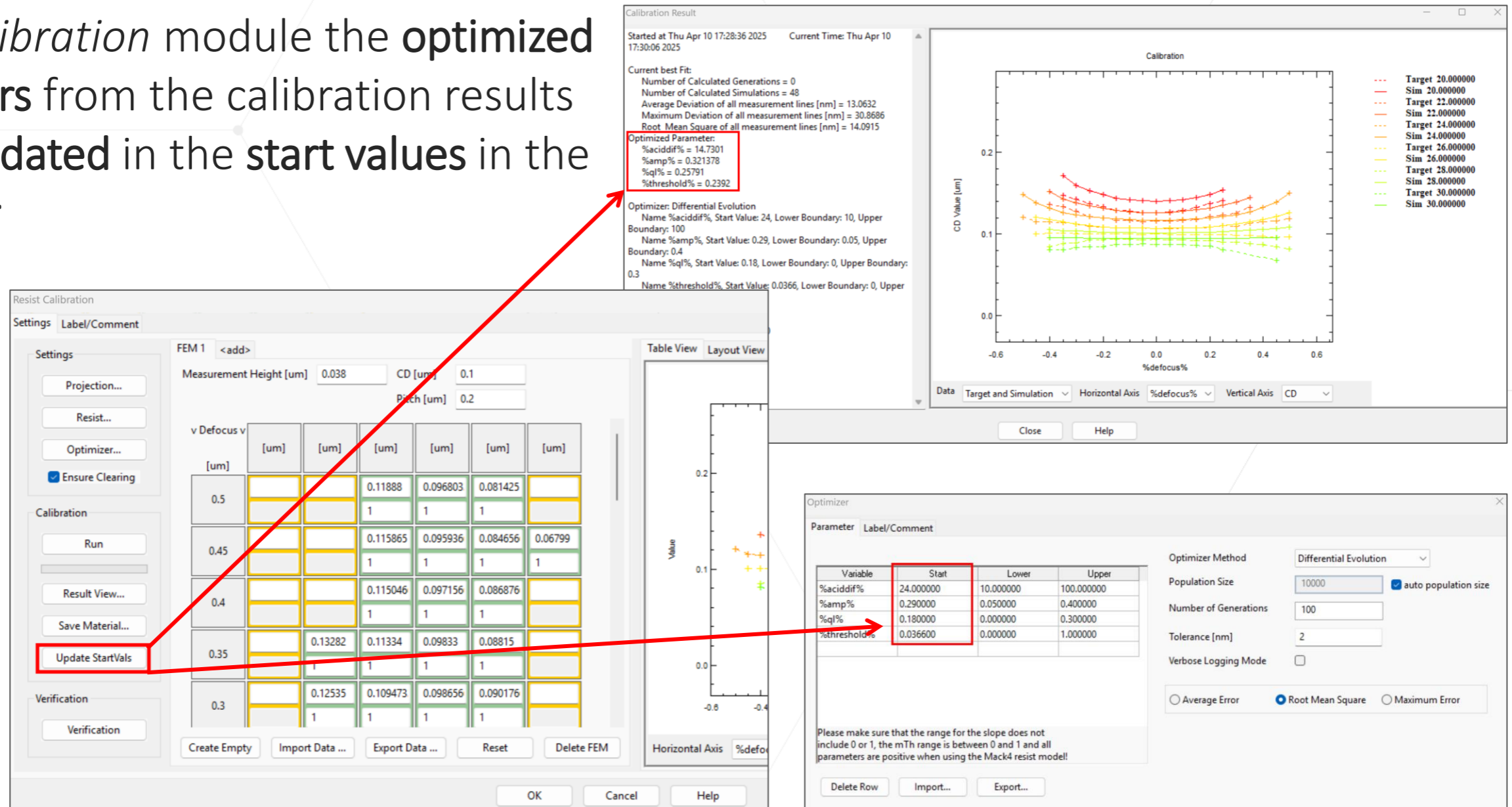
NLopt Optimization Methods

- Other **NLopt** (nonlinear optimization library) optimization methods are also added to the *Calibration* and *Optimizer* Modules.
- Based on testing, **MLSL + Subplex** was chosen as the default due to its speed and performance, though other methods can still be enabled
- Optimizer selection can be enabled in Properties under Flow/Module
- A drop-down of available methods is shown in the optimizer model



Update Optimizer Start Parameters

1. In the *Calibration* module the **optimized parameters** from the calibration results will be updated in the **start values** in the **Optimizer**



The image shows a workflow in the GenISys software to update optimizer start parameters. It includes three main windows: 'Resist Calibration', 'Calibration Result', and 'Optimizer'.

Resist Calibration Window: This window contains a table of calibration data. A red box highlights the 'Update StartVals' button in the bottom left corner.

v Defocus v [um]	[um]	[um]	[um]	[um]	[um]
0.5			0.11888	0.096803	0.081425
0.45			0.115865	0.095936	0.084656
0.4			0.115046	0.097156	0.086876
0.35		0.13282	0.11334	0.09833	0.08815
0.3		0.12535	0.109473	0.098656	0.090176

Calibration Result Window: This window displays the results of the calibration. A red box highlights the 'Optimized Parameter' section, which lists the following values:

- %aciddif% = 14.7301
- %amp% = 0.321378
- %ql% = 0.25791
- %threshold% = 0.2392

Optimizer Window: This window allows for setting the optimizer parameters. A red box highlights the 'Start' column in the parameter table, which is being updated with the values from the 'Calibration Result' window.

Variable	Start	Lower	Upper
%aciddif%	24.000000	10.000000	100.000000
%amp%	0.290000	0.050000	0.400000
%ql%	0.180000	0.000000	0.300000
%threshold%	0.036600	0.000000	1.000000

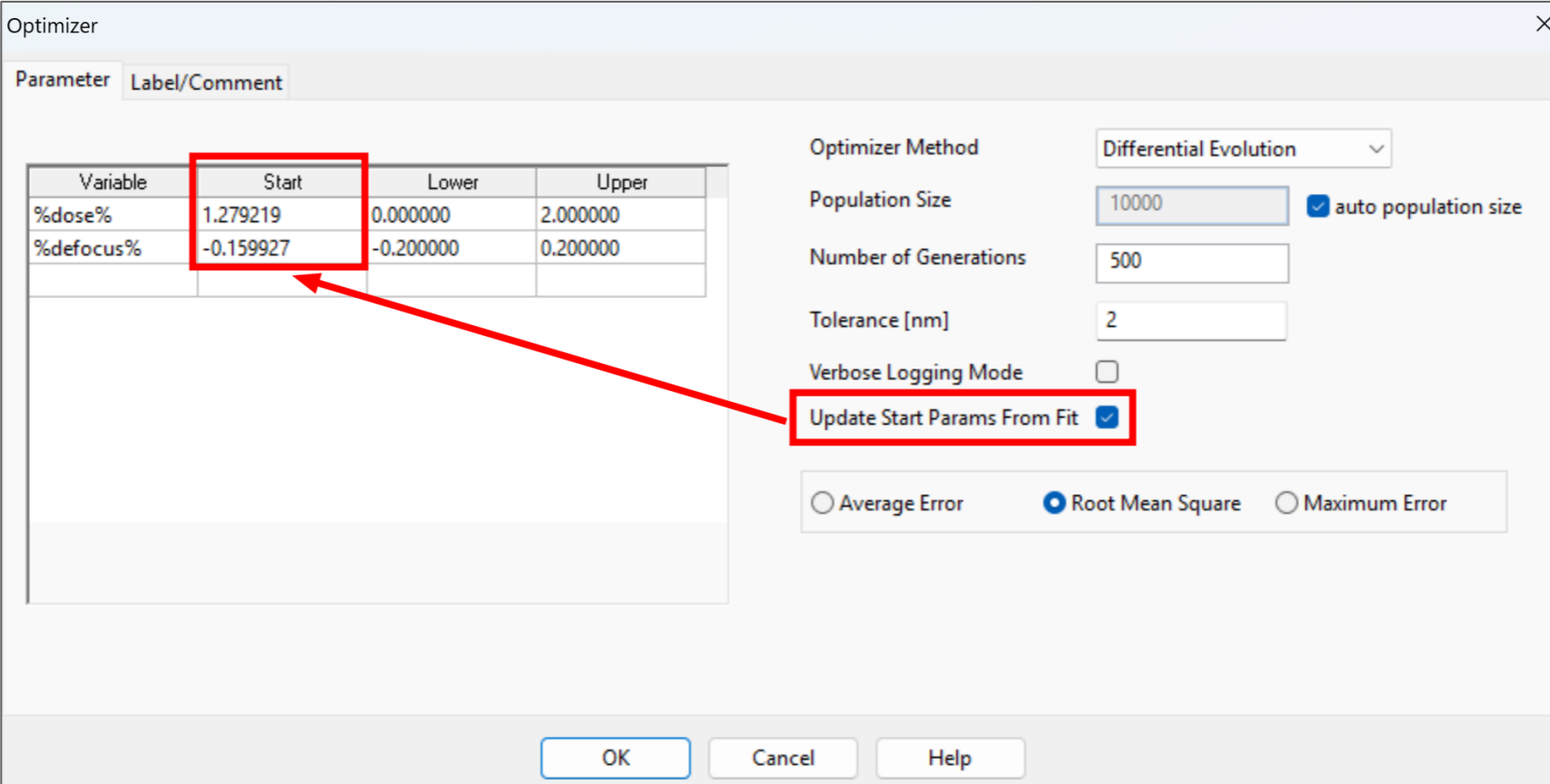
The 'Optimizer' window also shows the 'Optimizer Method' set to 'Differential Evolution' and the 'Population Size' set to '10000'.

"Update StarVals"

Update Optimizer Start Parameters

2. In *Optimizer* module :

- "Update Start Params From Fit": to automatically update start values in the optimizer



Optimizer

Variable	Start	Lower	Upper
%dose%	1.279219	0.000000	2.000000
%defocus%	-0.159927	-0.200000	0.200000

Optimizer Method: Differential Evolution

Population Size: 10000 ☒ auto population size

Number of Generations: 500

Tolerance [nm]: 2

Verbose Logging Mode: ☐

☒ Update Start Params From Fit

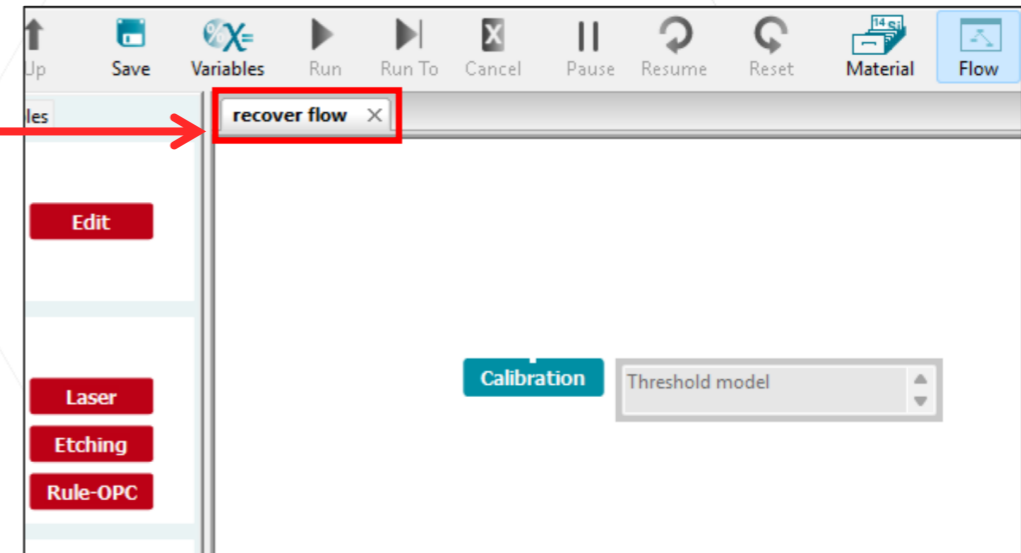
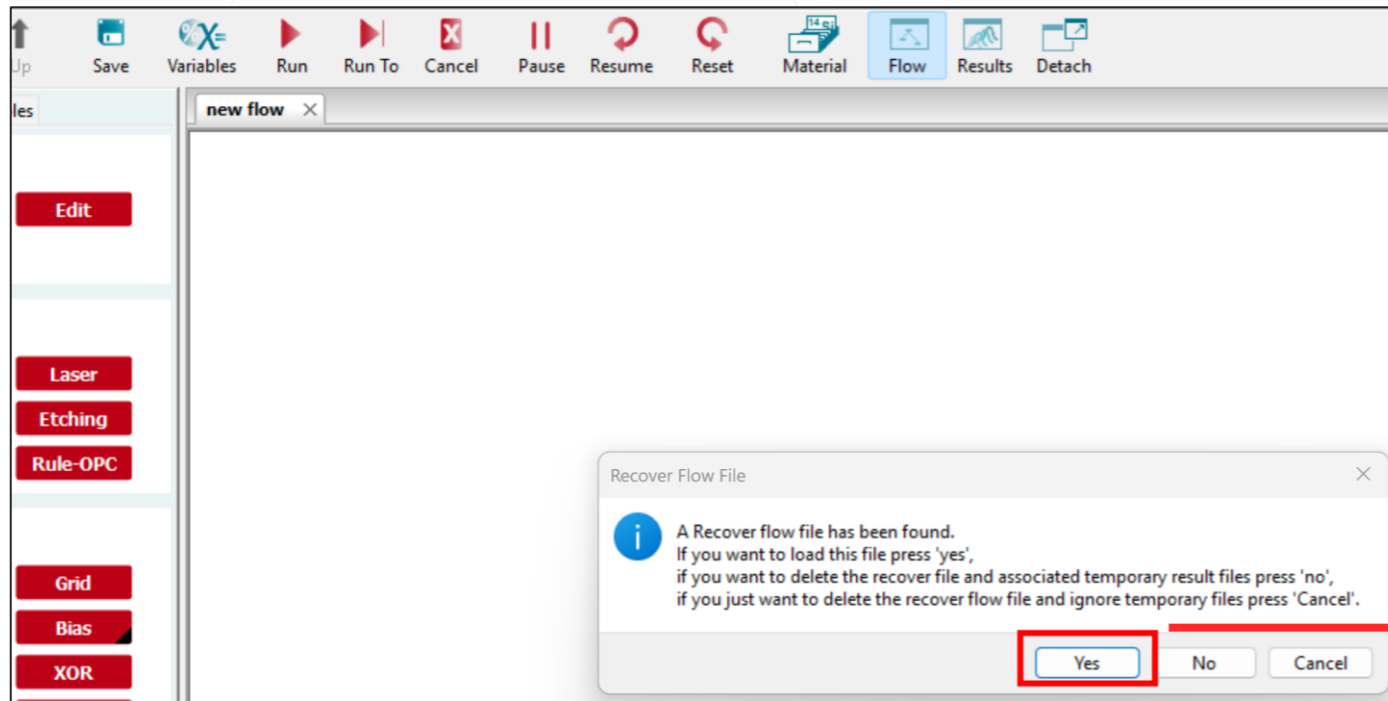
☐ Average Error ☒ Root Mean Square ☐ Maximum Error

OK Cancel Help

Safety Measures for Calibration Crashes

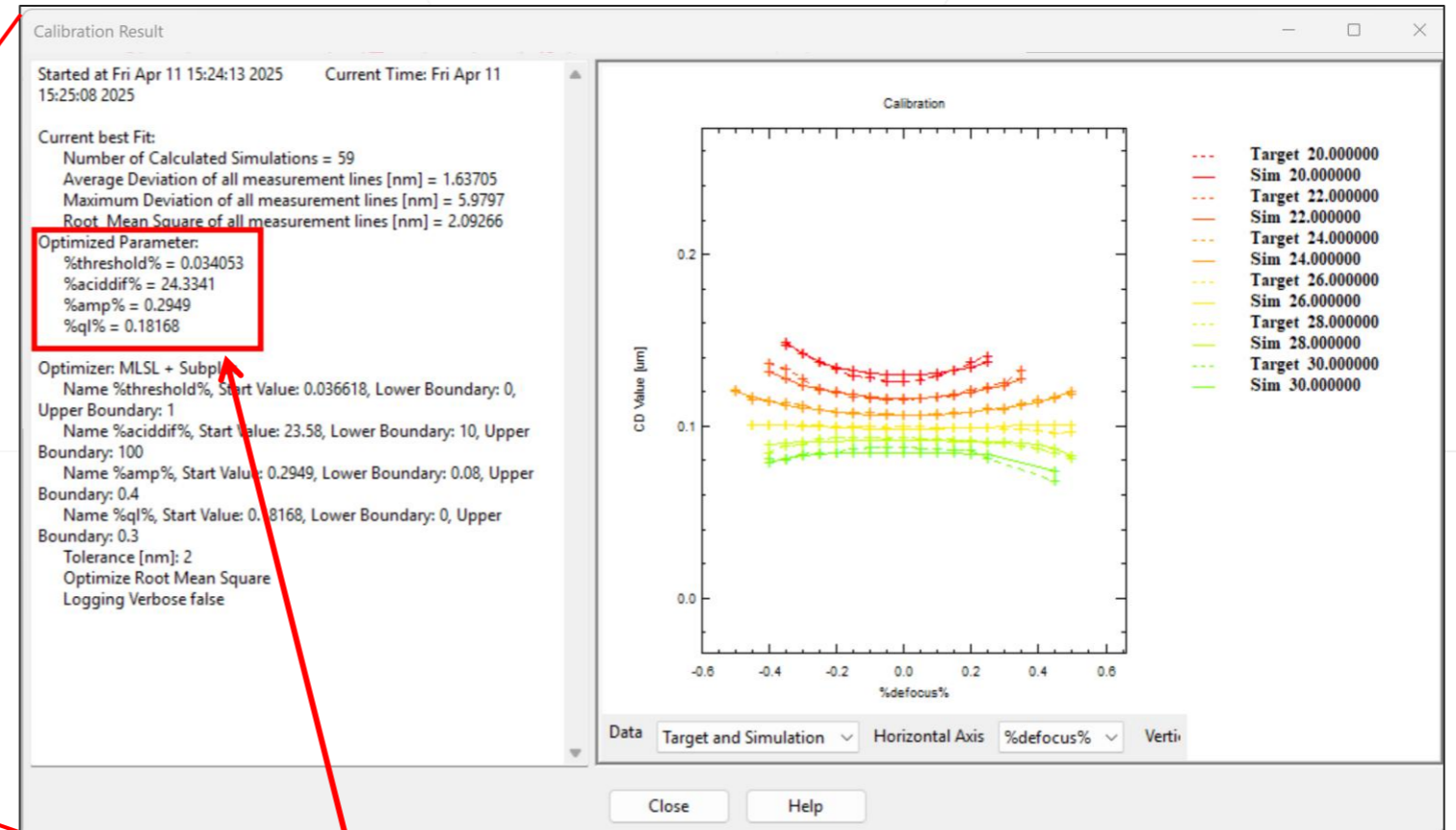
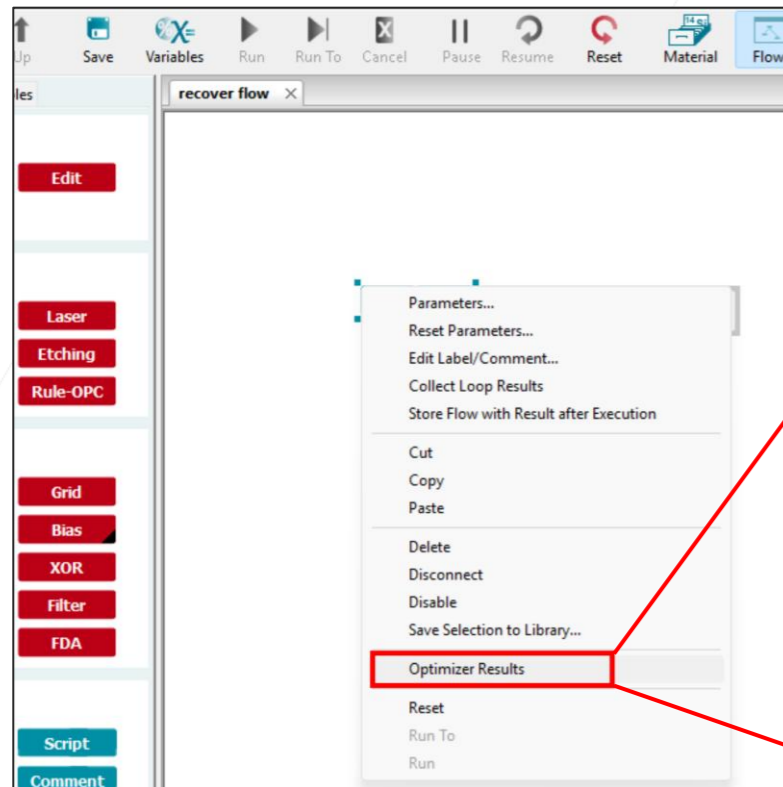
If LAB crashes while the calibration is running:

1- Open LAB again



2- Load the recover flow

Safety Measures for Calibration Crashes



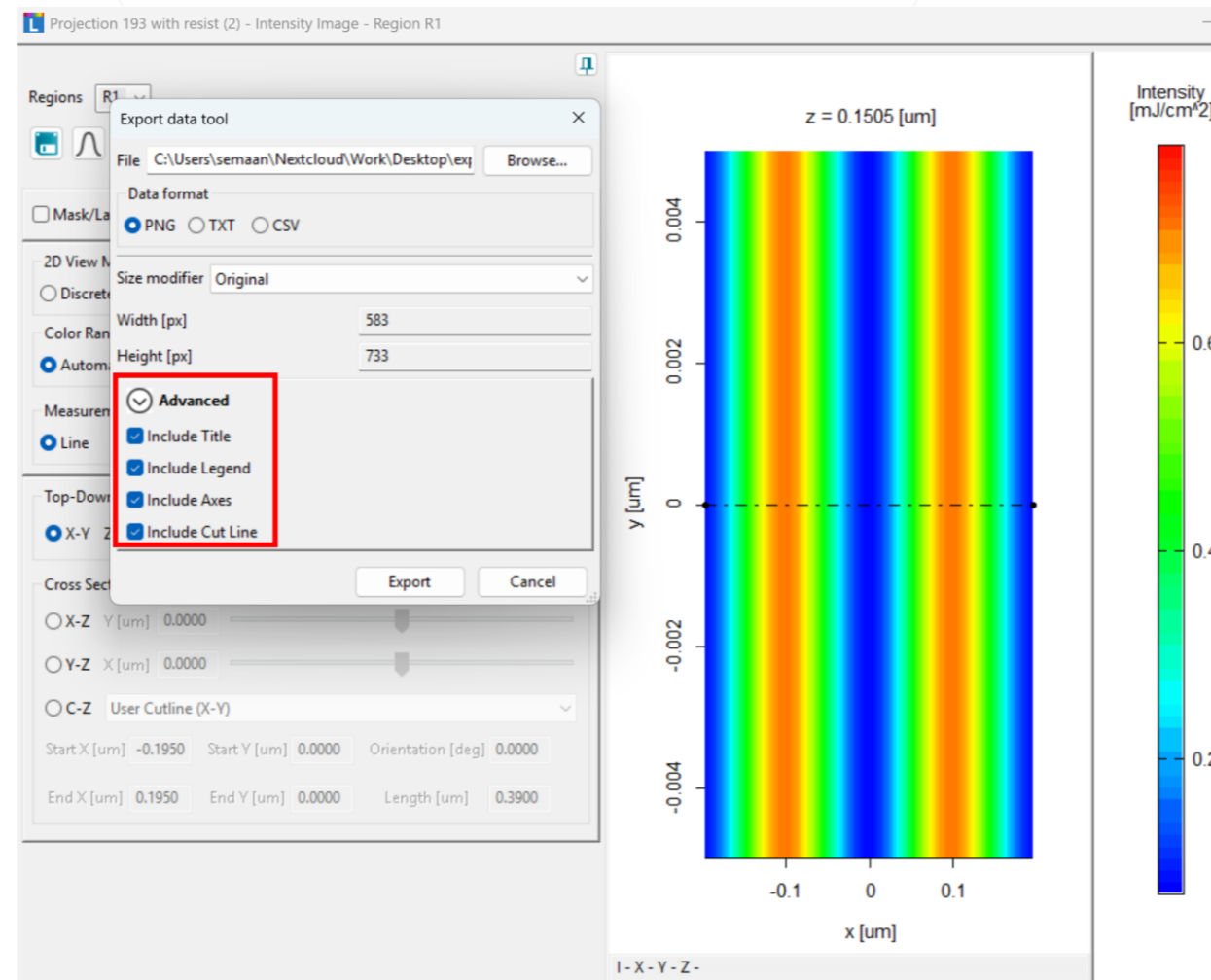
- 3- Right-click on the calibration model
- 4- Choose "Optimizer Results"

- 5- The window shows you the last optimized parameters before crashing

Image Information Export

Image Information Export

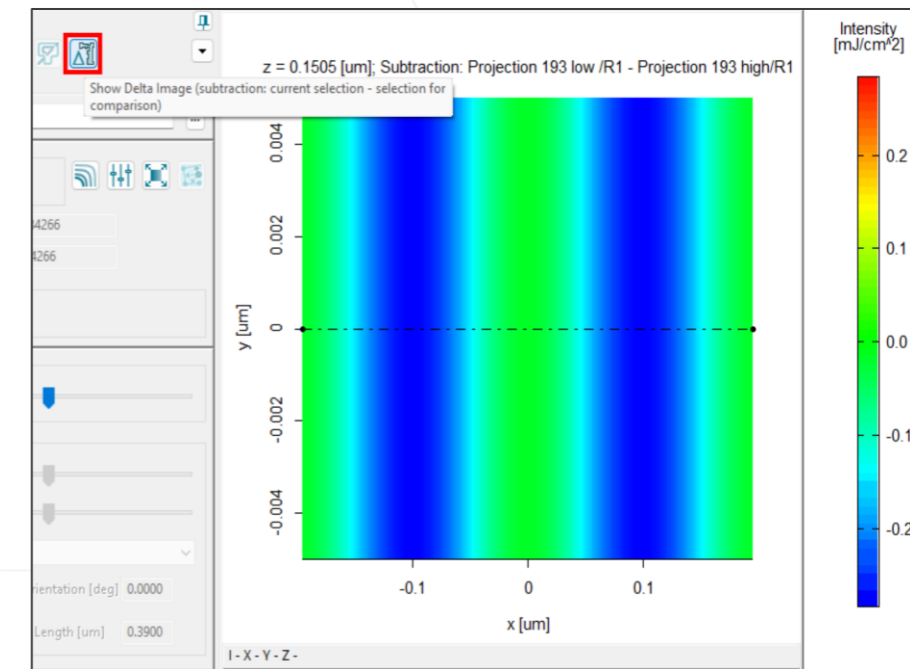
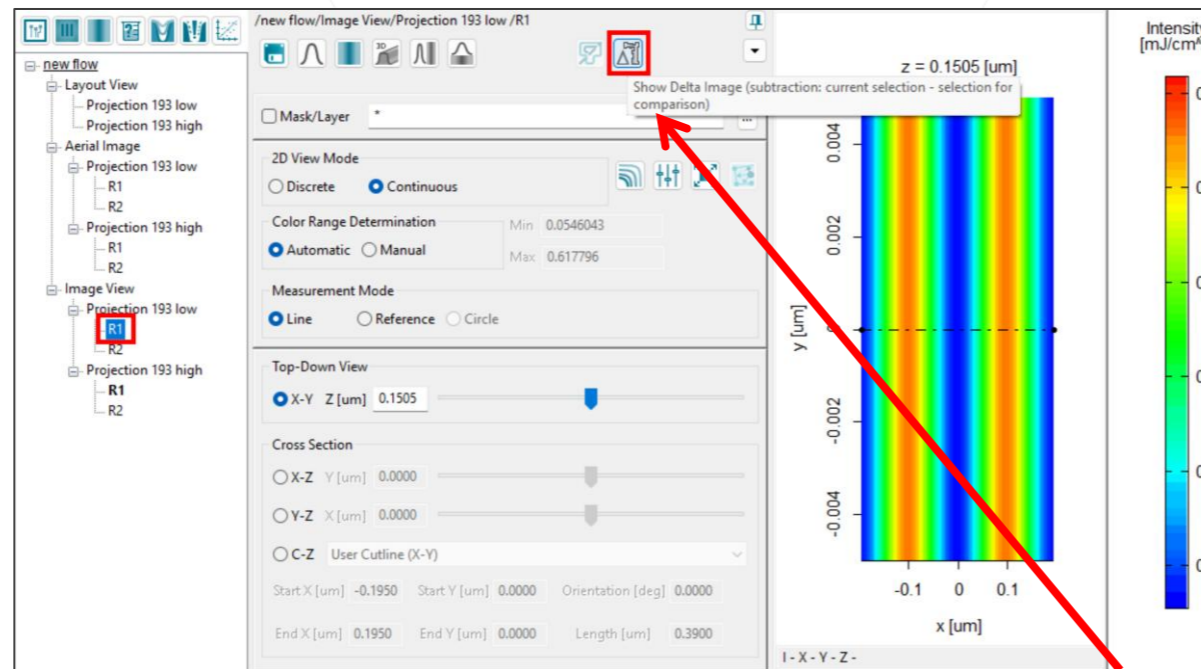
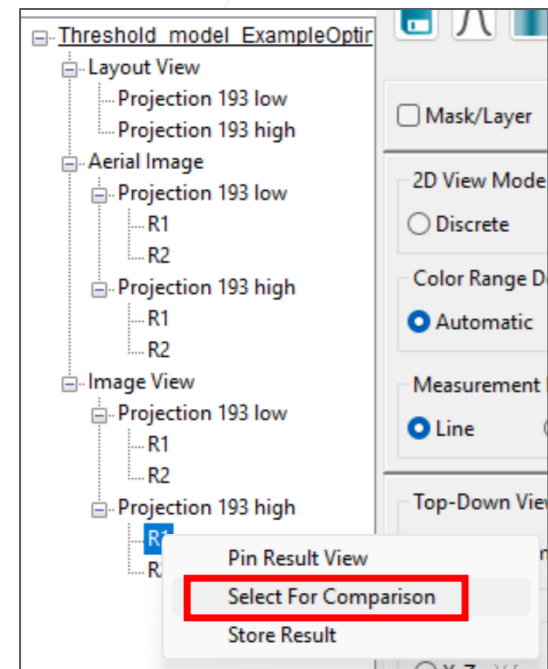
- When exporting a plot as a PNG file, the export dialog now offers **check boxes** where the visibility of the **plot title**, **legend**, **axes**, and **cut-line** can be **adjusted** for the **export** without affecting the plot window



Intensity subtraction between two simulations

Intensity subtraction between two simulations

- In the result tree, there is a new button "Show Delta Image" to compare two image results, it supports:
 - Cut views – XY, XZ, YZ and CZ
 - 1D, 2D and 1D-2D views



1- Select the subtracted image

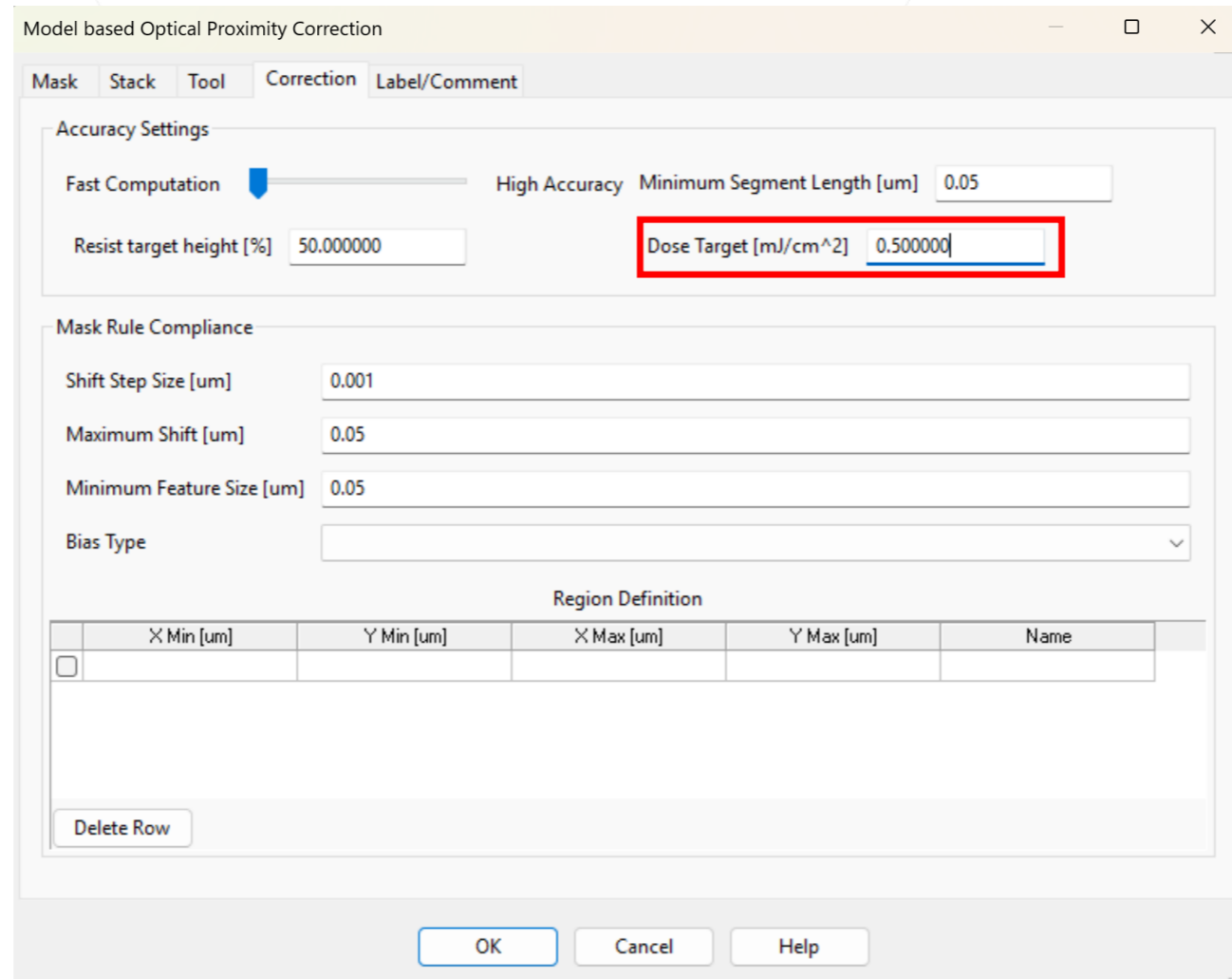
2- Select the second result and press the "Delta"

3- The Intensity subtraction results will be displayed

Model OPC Improvement

User-defined Intensity Threshold

- User can specify the target intensity threshold [mJ/cm²] in the resist for the model OPC correction. The intensity threshold was previously assumed to be 0.5 mJ/cm².



Model based Optical Proximity Correction

Mask Stack Tool Correction Label/Comment

Accuracy Settings

Fast Computation ☐ High Accuracy Minimum Segment Length [um] 0.05

Resist target height [%] 50.000000 Dose Target [mJ/cm²] 0.500000

Mask Rule Compliance

Shift Step Size [um] 0.001

Maximum Shift [um] 0.05

Minimum Feature Size [um] 0.05

Bias Type

Region Definition

	X Min [um]	Y Min [um]	X Max [um]	Y Max [um]	Name
<input type="checkbox"/>					

Delete Row

OK Cancel Help

Python API

LAB object method: LAB.e_beam()

- LAB.e_beam() is a method for performing E-Beam simulations
- It contains all the E-Beam parameters as a Python dictionary (not all shown here)

```
EBeamResults = LAB.e_beam(InputLayout,  
    {'StackEntries' : [['Resist', 'PMMA350k'],  
    'ResistStack' : [],  
    'BaseDose' : 260,
```

The InputLayout is the result of the previous LAB.import_gds() function

LAB object method: LAB.get_measure_value()

- The **LAB.get_measure_value()** method returns lithography line-based measurements, such as CD, NILS, Intensity Contrasts, etc.

Example: returning the line CD at the center of the stack

```
# CD Measurements: can be performed for ("Top", 'Center', 'Bottom', "Aerial")  
Line1CenterCD = LAB.get_measure_value(EBeamResults, "CD", "Center", "Line1")  
print(Line1CenterCD)
```

The EBeamResults is the output of the previous LAB.e_beam() method

Metrology line name

LAB object method: LAB.get_measure_value()

- The **LAB.get_measure_value()** method returns lithography corner-based measurements, such as Corner Radius and Mean Radius of All Corners.

Example: returning the corner radius at the center of the stack

```
# Corner measurements can be performed for ("Top", 'Center', 'Bottom')
C1CenterRadius = LAB.get_measure_value(EBeamResults, "Corner Radius", "Center", "C1")
print(C1CenterRadius)
```

The EBeamResults is the output of the previous LAB.e_beam() method

Metrology corner name

Example: returning the Mean Radius of All Corners at the bottom of the stack

```
# Additional corner measurement if more than one corner is to be measured, for ("Top", 'Center', 'Bottom')
CornerMeanBottomRadius = LAB.get_measure_value(EBeamResults, "Corner Radius", "Bottom", "Mean Radius of ALL Corners")
print(CornerMeanBottomRadius)
```

Thank You!

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