Glove Box LightGuide optiSLang Optimization Tutorial

Task Description

- This tutorial looks deeper into:
  - Workflow automation of Ansys SPEOS
  - Sensitivity Analysis
  - Optimization
- An optical analysis of a light guide is performed in Ansys SPEOS with Ansys optiSLang
- The aim is to optimize the light guide in order to achieve all requirements:
  - homogeneous lit appearance by minimizing RMS contrast and maximizing average luminance

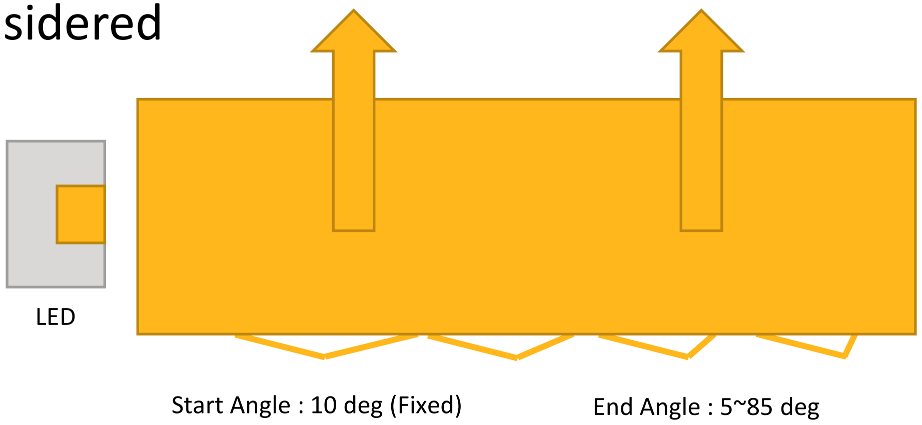
Pre-requisites

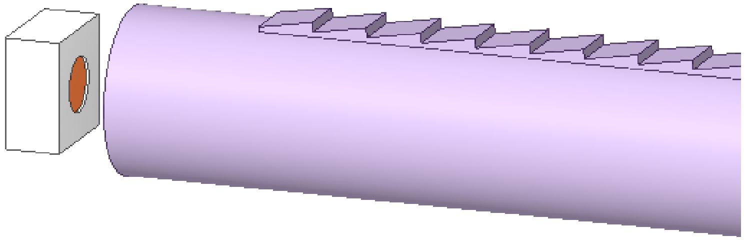
- ANSYS License Manager 2023 R2 or later (optional)

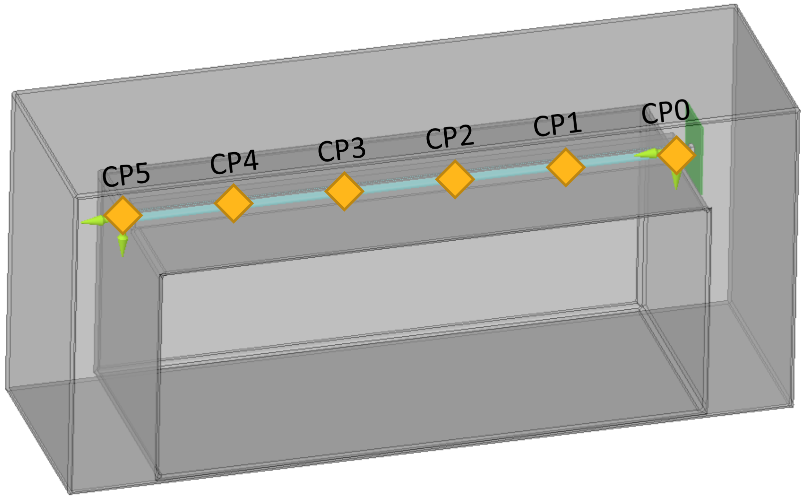
- ANSYS SPEOS 2023 R2 or later
- ANSYS optiSLang 2023 R2 or later

Light Guide Parameters

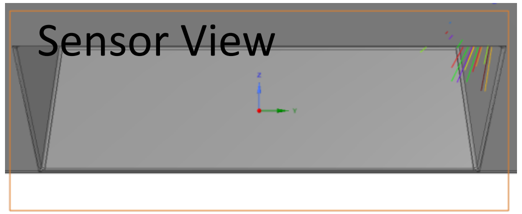
- For the Optimization, the end angle of the prisms at 6 control points on the lightguide are considered







- Further possible parameters could be:
  - Profile geometry (type / profile)
  - Prism geometry (start and end angle, number of prisms by step value, offset, width,…)
  - Prism milling (bottom, top)
  - …

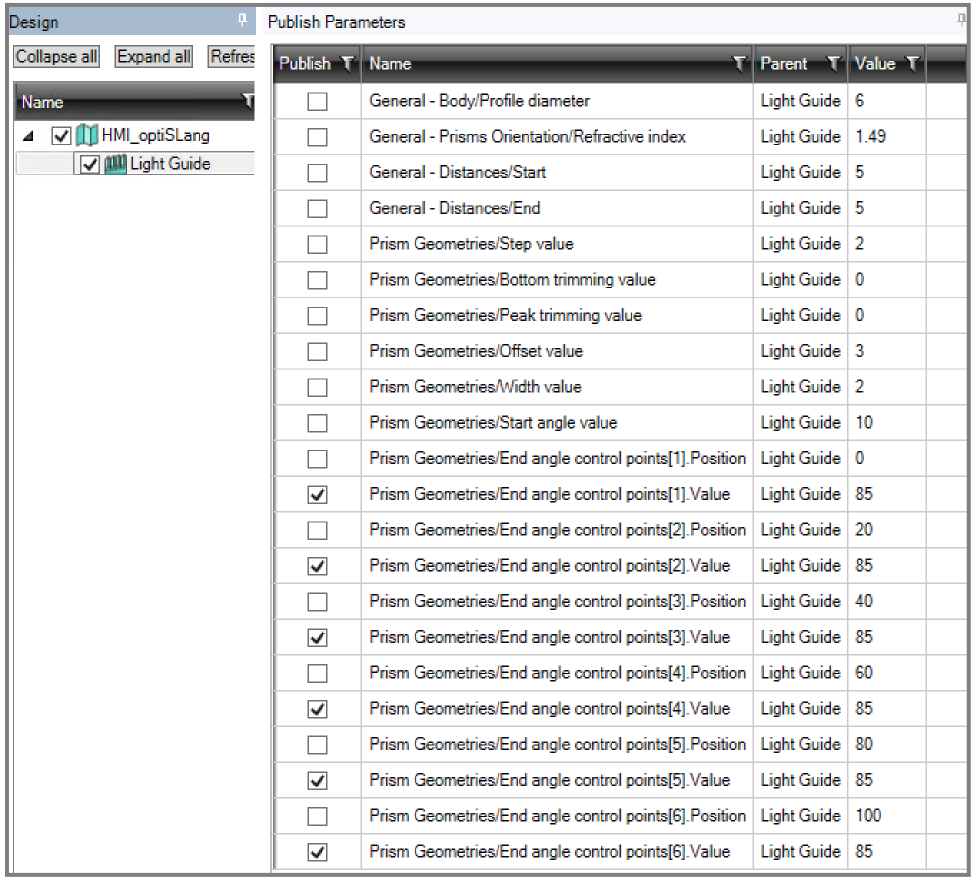


Model preparation in Ansys Speos

Ansys SPEOS Setup

For variation analyses with optiSLang it is necessary to publish parameters in the Speos simulation model:

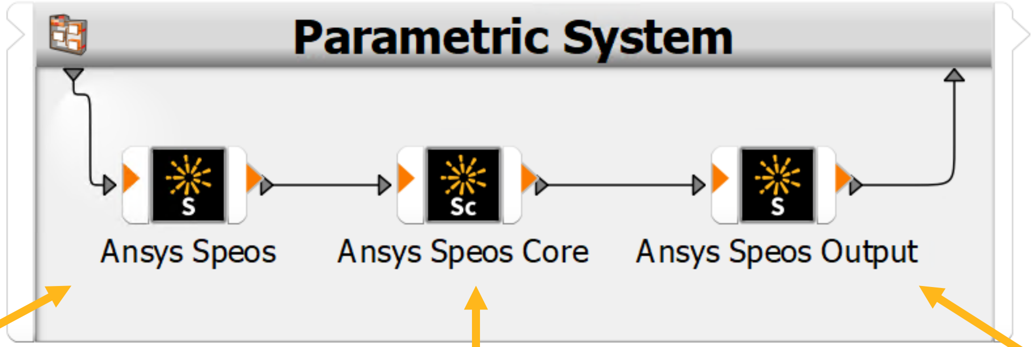
1. Open the Ansys Speos project (HMI_optiSLang.scdocx)
2. Select the ***Workbench tab***
3. Click ***Publish Parameters***
4. Select an Optical Part Design feature or a Light Simulation feature (Material, Source, Sensor, Simulation).
5. In the Publish Parameters panel, a list of the possible parameters you can use in optiSLang appears.
6. Check the parameters to be used in optiSLang.
   (**For this tutorial, all necessary parameters are already selected**)
7. Save your *.scdocx project.



Workflow creation and parameterization in optiSLang

Speos workflow in optiSLang

For variation analyses (e.g. optimization) it is necessary to automate your Speos project including geometry creation and simulation. The Speos workflow in optiSLang consists of 3 nodes:



Ansys Speos node:
- updates the geometry based on SpaceClaim & Speos parameter values
- exports the Speos Simulation file (*.speos)

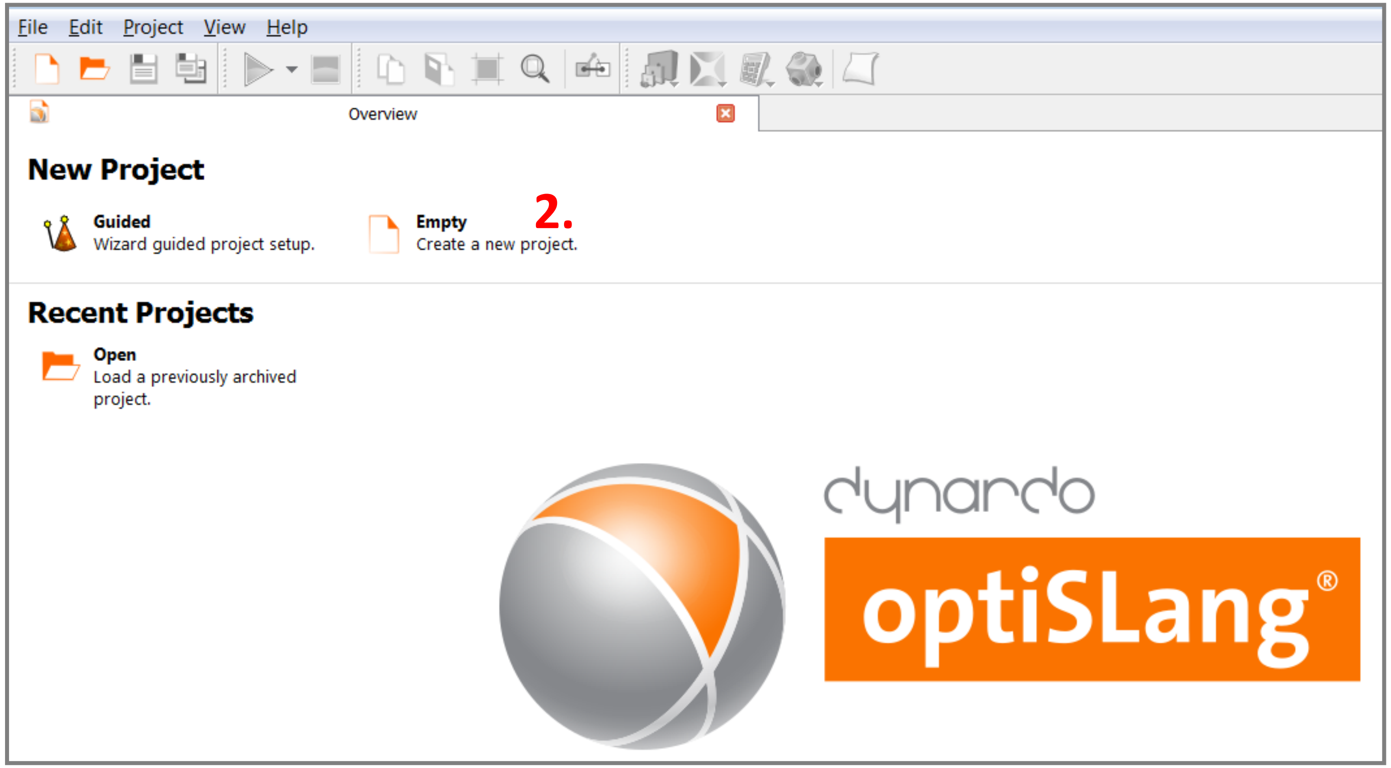
Ansys Speos Core node:
- launches and processes the simulation

Ansys Speos Output node:
- extracts response values from the Speos simulation report

Workflow creation

How to create the automated tool chain for a Speos analysis is shown in the following section:

1. Open Ansys optiSLang
2. Create a new ***Empty*** project

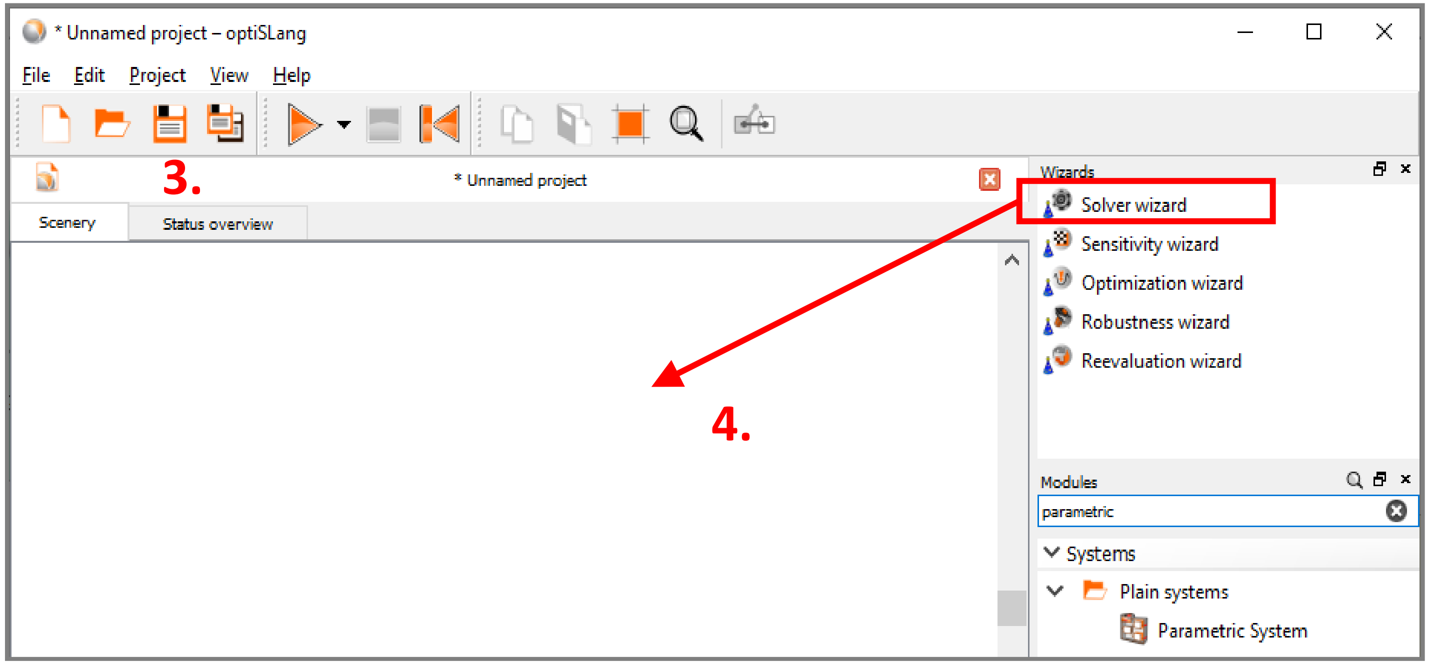


Ansys

Workflow creation

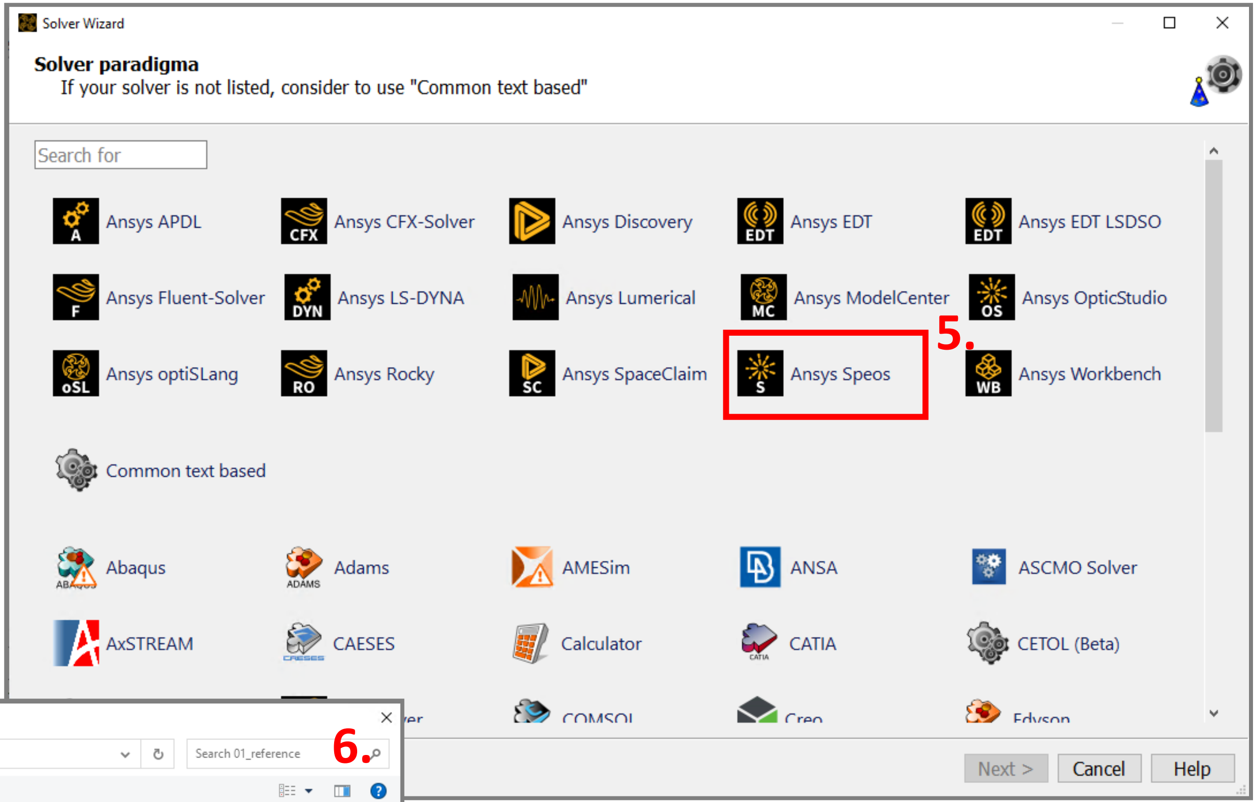
3. **Save** the optiSLang project
   Best practices: save the project next to the reference folder to allow relative path in optiSLang

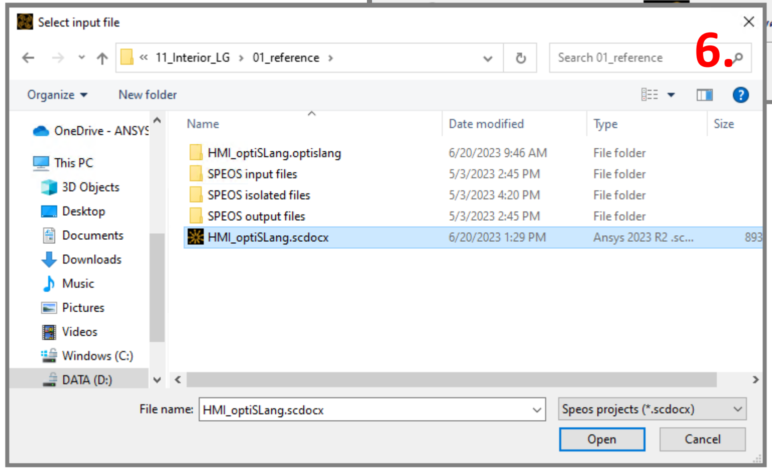
4. Drag and Drop the ***Solver Wizard*** it into the scenery



Workflow creation

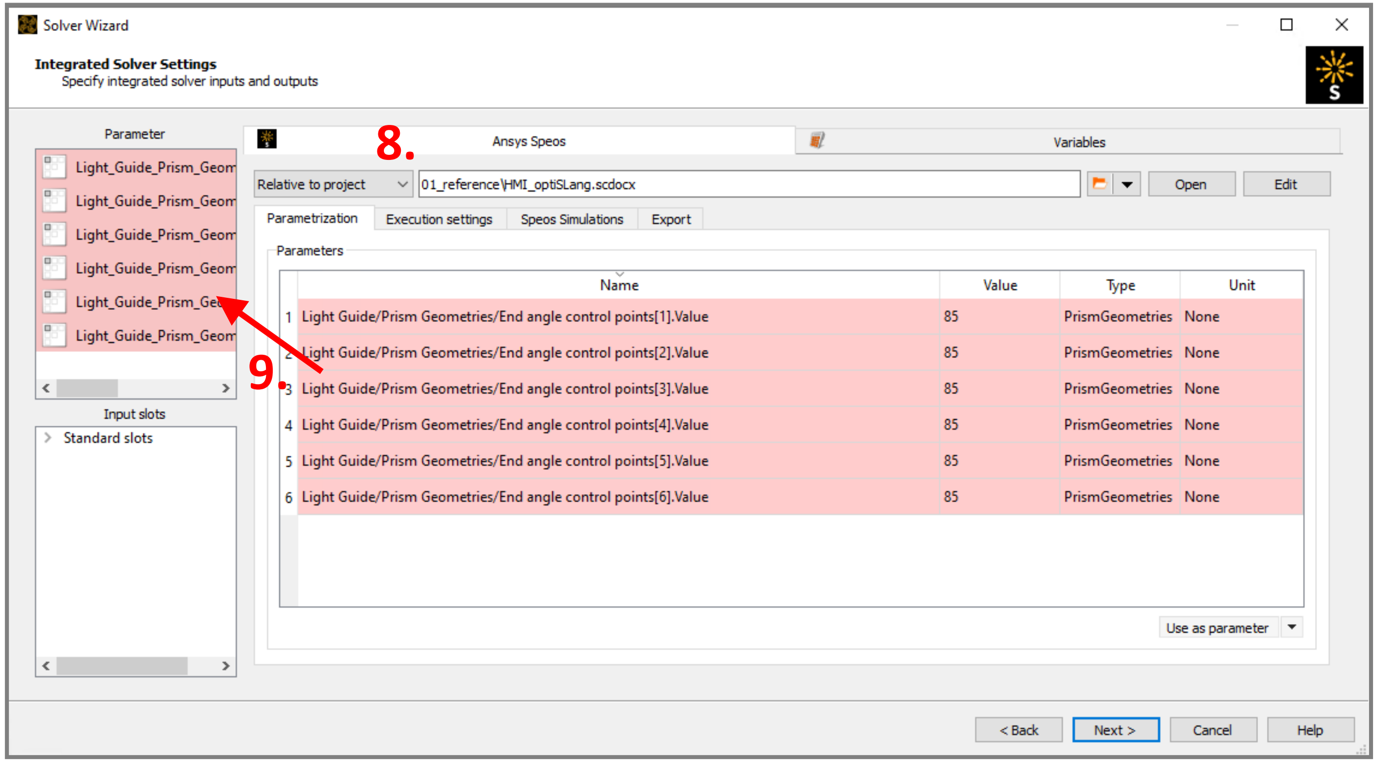
5. Click on ***Ansys Speos*** to start the solver wizard
6. Select Speos input file and click on ***Open***
7. Wait until optiSLang have extracted the published parameter (can take 1-2 minutes)





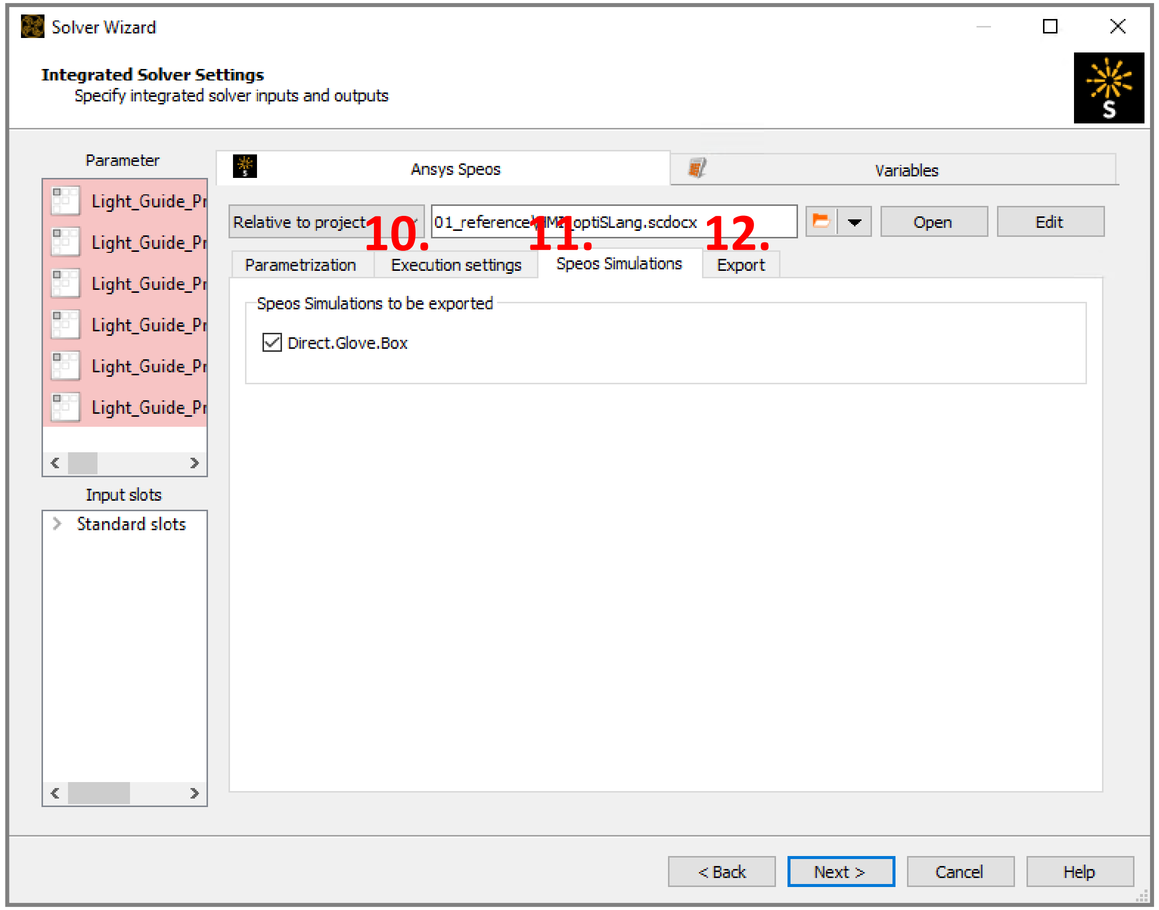
Workflow creation

8. Optional: Change path to "Relative to Project"
   →This allows for easy transfer of the project to different locations
9. Drag and Drop the parameter to the ***Parameter*** pane to consider them in the variation analysis



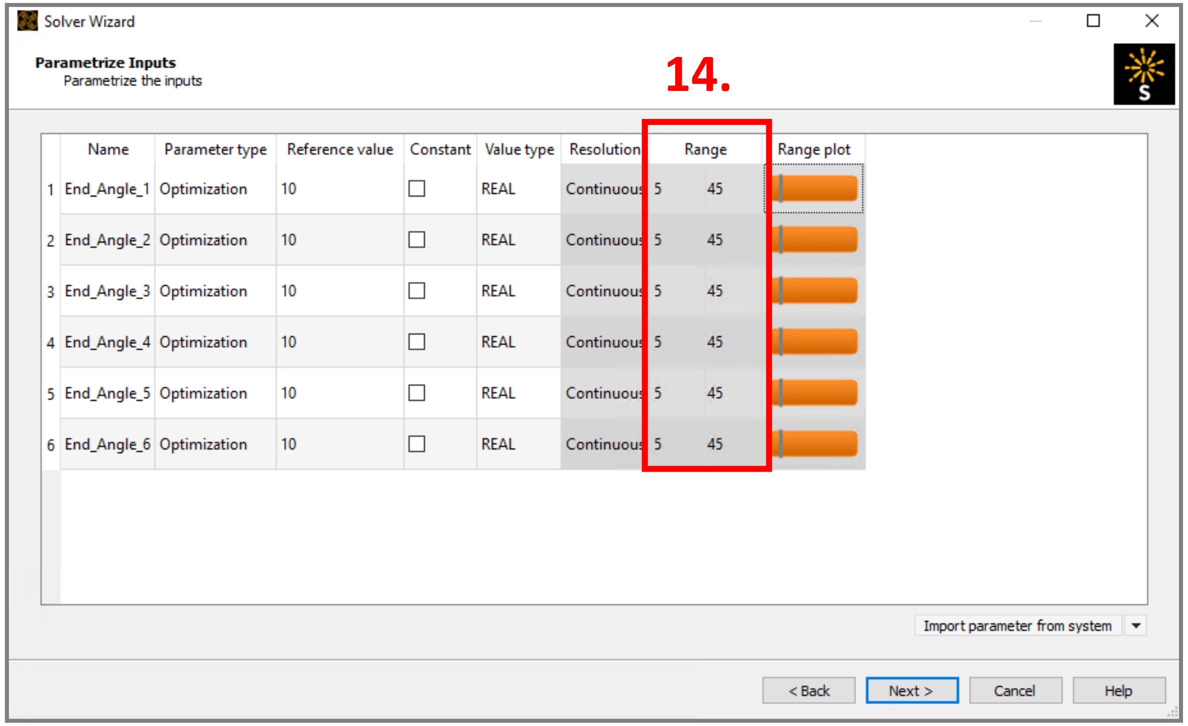
Optional: Workflow creation

10. Optional: Under ***Execution settings*** you can add python scripts for pre or post update →*not mandatory for this tutorial*
11. Optional: Under ***Speos Simulation*** you can select which Speos simulation should be exported for the simulation →*preselected and mandatory for this tutorial*
12. Optional: Under ***Export*** you can choose an additional export (e.g. an image from the geometry)
13. Click on ***Next***



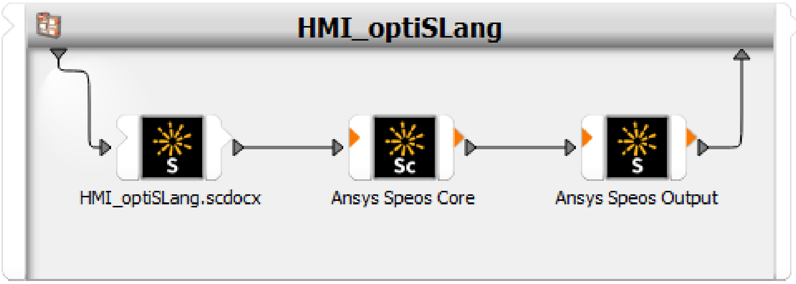
Workflow creation

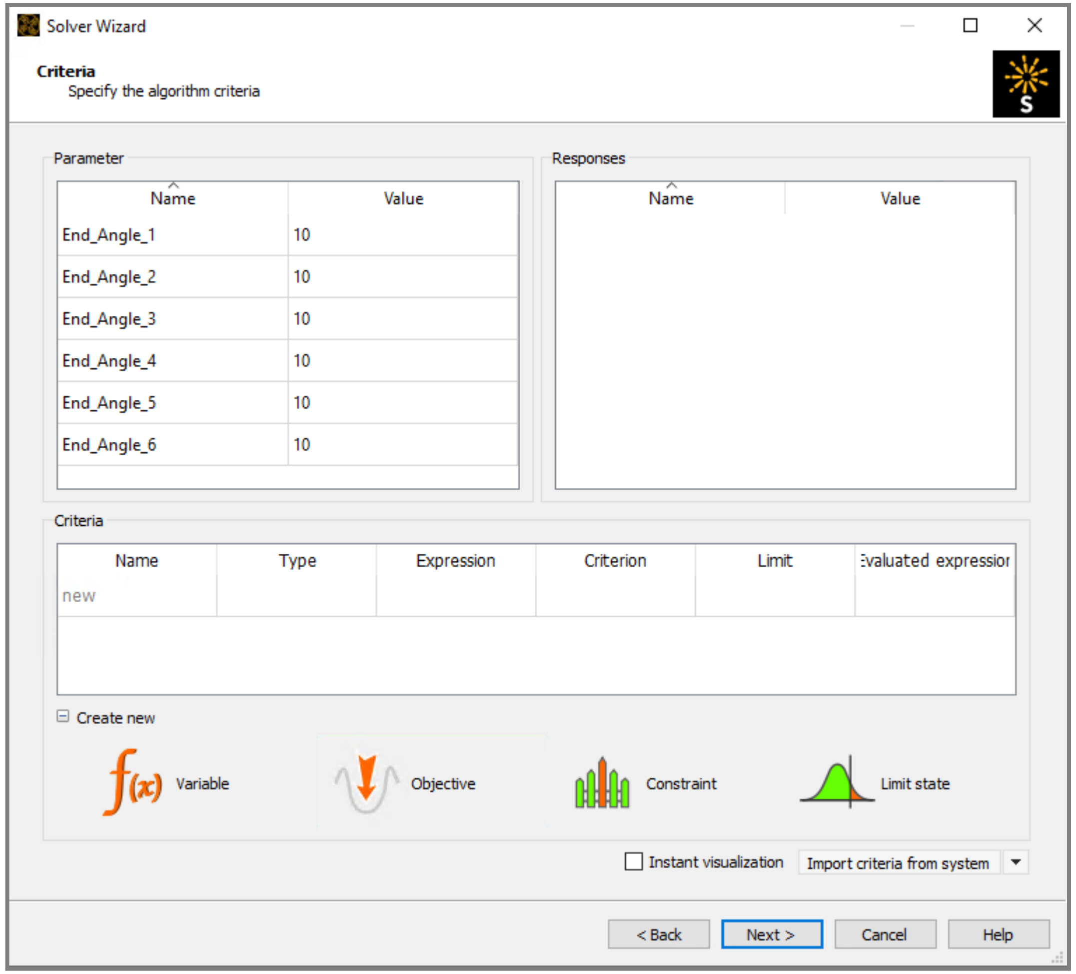
14. Adjust the parameter ranges in the parameter table
    (In variation analysis, the parameters are varied within the parameter range)
15. Use F2 to rename the parameters to End_Angle_x
16. Click on ***Next***



Workflow creation

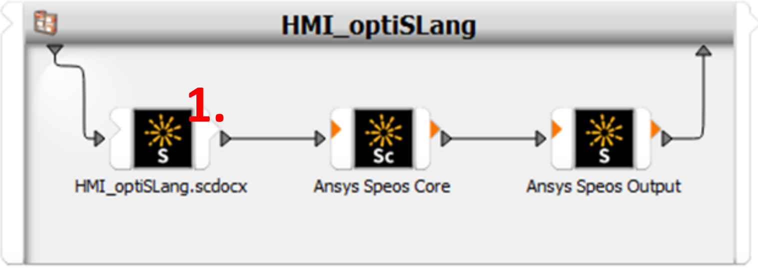
16. Skip the criteria definition
    (Responses and criteria's will be defined in the next steps)
17. Click on ***Next***
18. Then Click ***Finish*** in the next window
19. The Speos workflow will automatically be created:

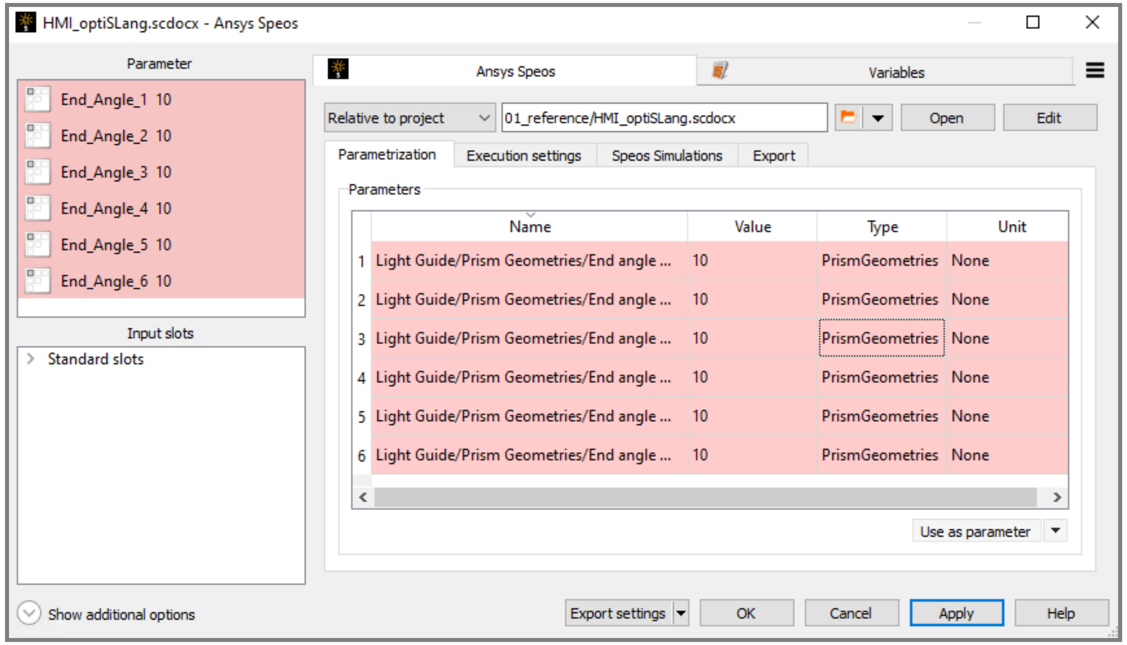




Ansys Speos Node

Optional: All settings made in the wizard can be reviewed and adjusted by double-click on the Speos node

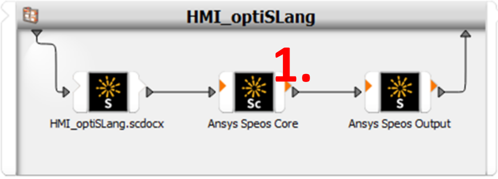


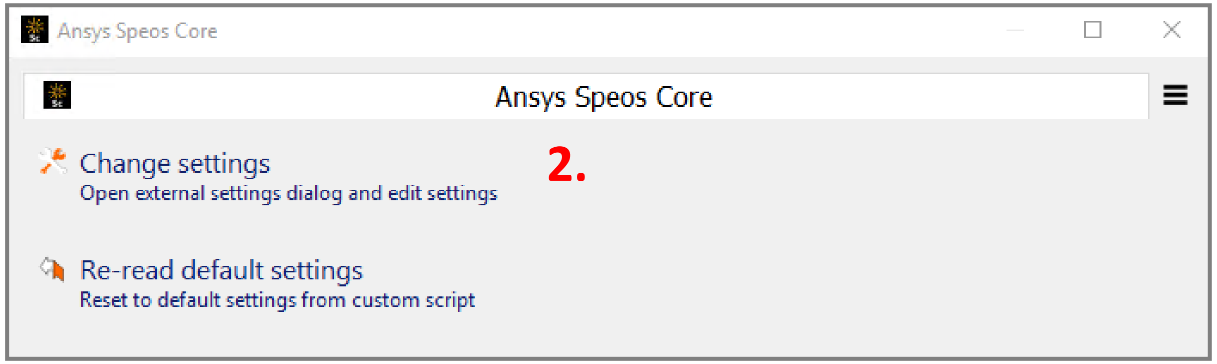


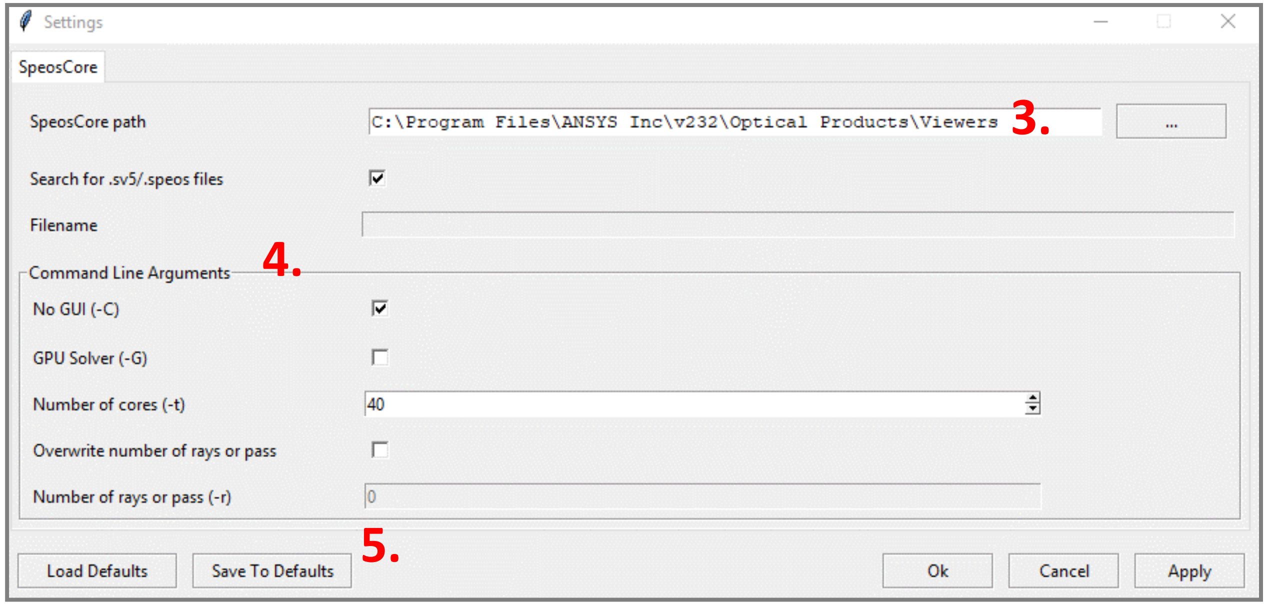
Ansys Speos Core node

Optional: The default solver settings for the Speos simulation can be reviewed and adjusted:

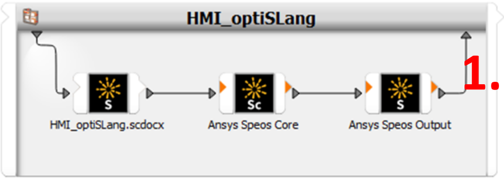
1. Double-click on the ***Ansys Speos Core*** node
2. Click on ***Change Settings***
3. Check the SpeosCore path
4. adapt Command line arguments
5. Click on ***Save to default***
6. Click ***Apply*** and ***OK***





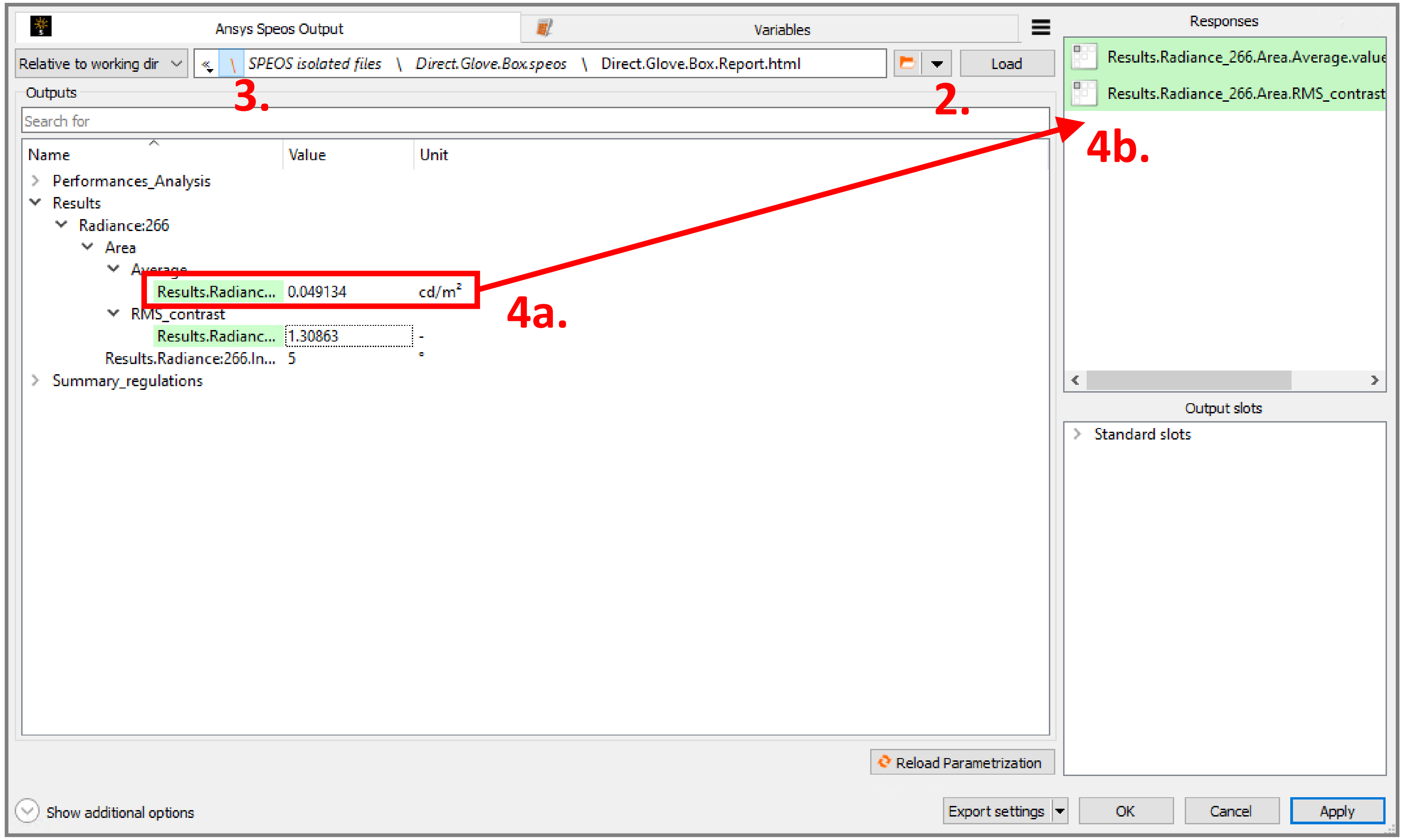


Ansys Speos Output node



Set up the Speos Output node in order to extract the simulation results:

1. Double-click on the ***Ansys Speos Output*** node
2. Browse for the file "**Direct.Glove.Box.Report.html**" in the reference files folder ("01_reference\SPEOS isolated files\Direct.Glove.Box.speos\")
3. Set the path to ***Relative to working dir*** and set the orange path split position
4. Define the responses via drag and drop and rename them



Optimization Criteria Definition

In the next step the wizard asks for the optimization criteria definition.

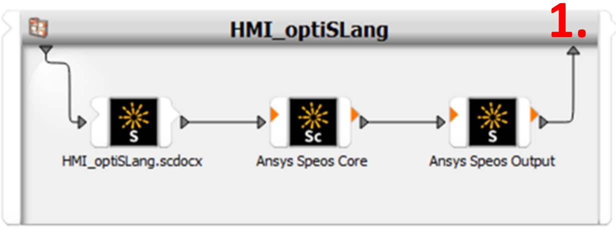
For the **Optimization goal of the Glove box Lighting** is to:

- obtain a **homogeneous lit appearance**

The best practice to achieve this goals is to:

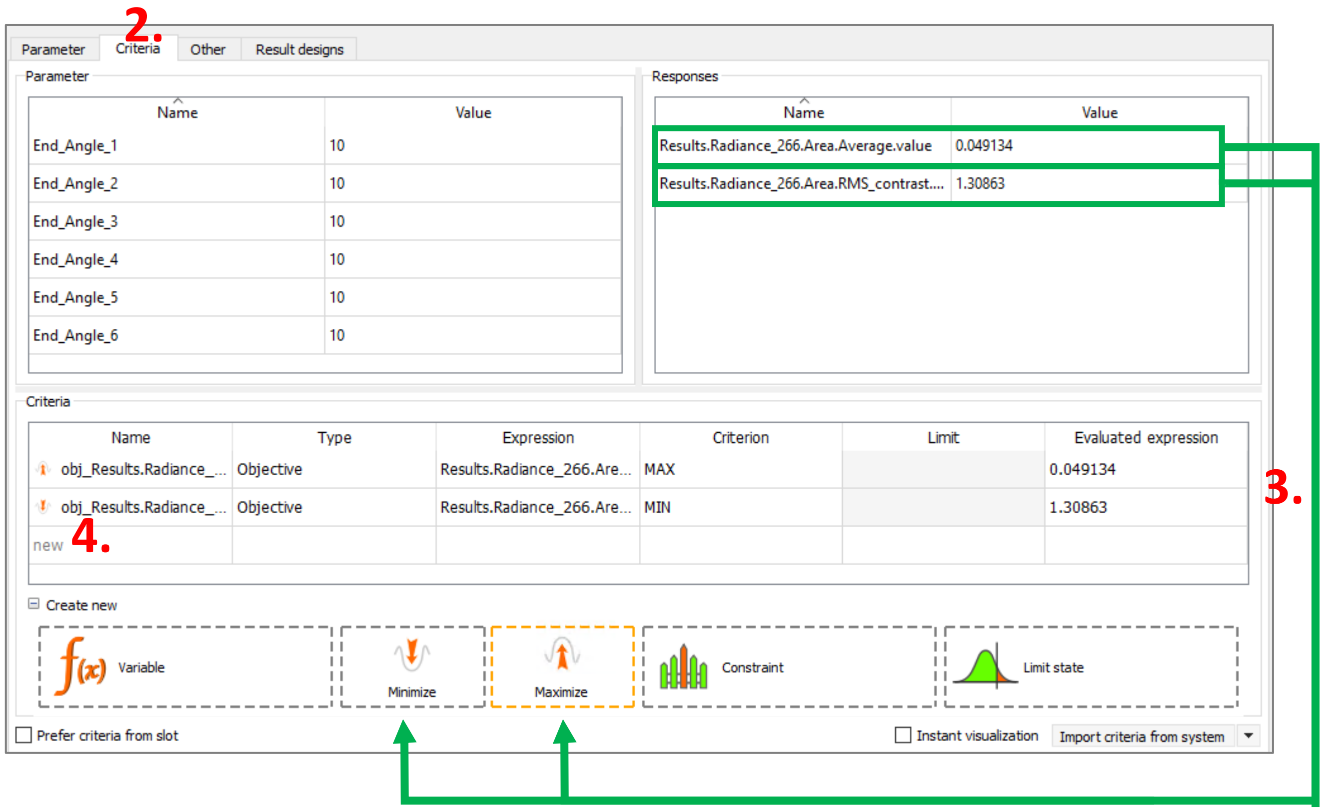
- **Minimize the RMS-contrast** (this is a measure of homogeneity: the smaller the value, the more homogeneous is the lit appearance).
- **Maximize the average luminance** (to avoid that the optimizer optimizes in the direction of no lighting, as this would mean the best homogeneity)

Criteria Definition



Define Optimization criteria's as follow:

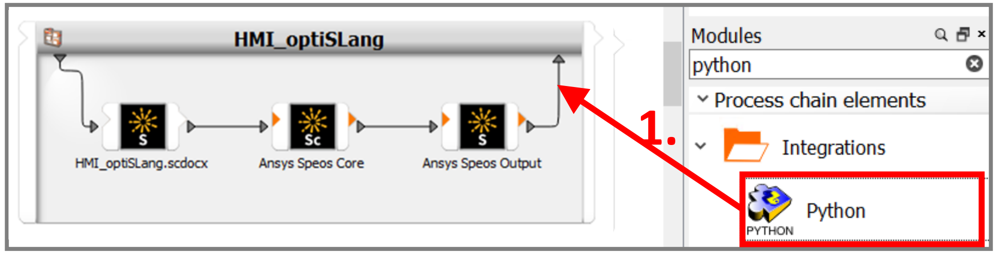
1. Double click on the systems head
2. Go to the ***Criteria*** tab
3. Drag the responses onto the ***Objective field***:
   - "RMS_Contrast" (Minimize)
   - "Average" (Maximize)
4. The new criterions appears in the criteria list.
5. Click ***Apply*** and ***OK***

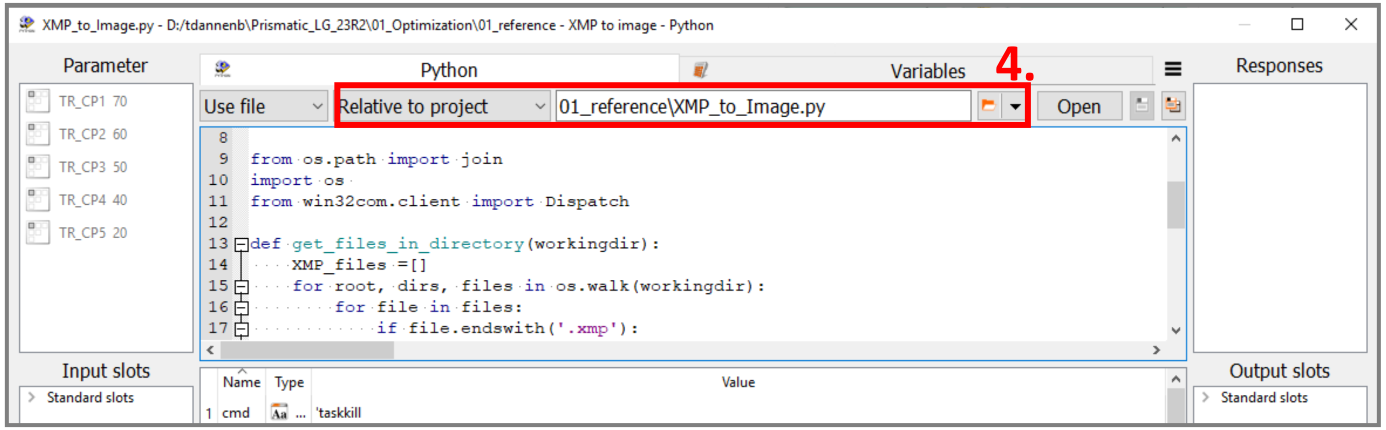


Workflow Extension

Optional: In order to increase the design understanding, export an image from the XMP-Viewer and add it into the optiSLang postprocessing

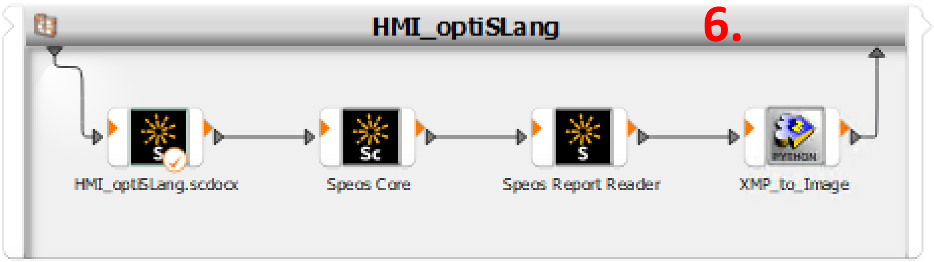
1. Filter for ***Python*** under ***Modules*** and drag and drop it onto the green arrow in the parametric system
2. Rename the Python-node with F2 to "XMP to image"
3. ***Double-click*** on the Python-node
4. Browse for the Python script „XMP_to_Image.py" in the reference files folder ("01_reference")
5. Click ***Apply*** and ***OK***

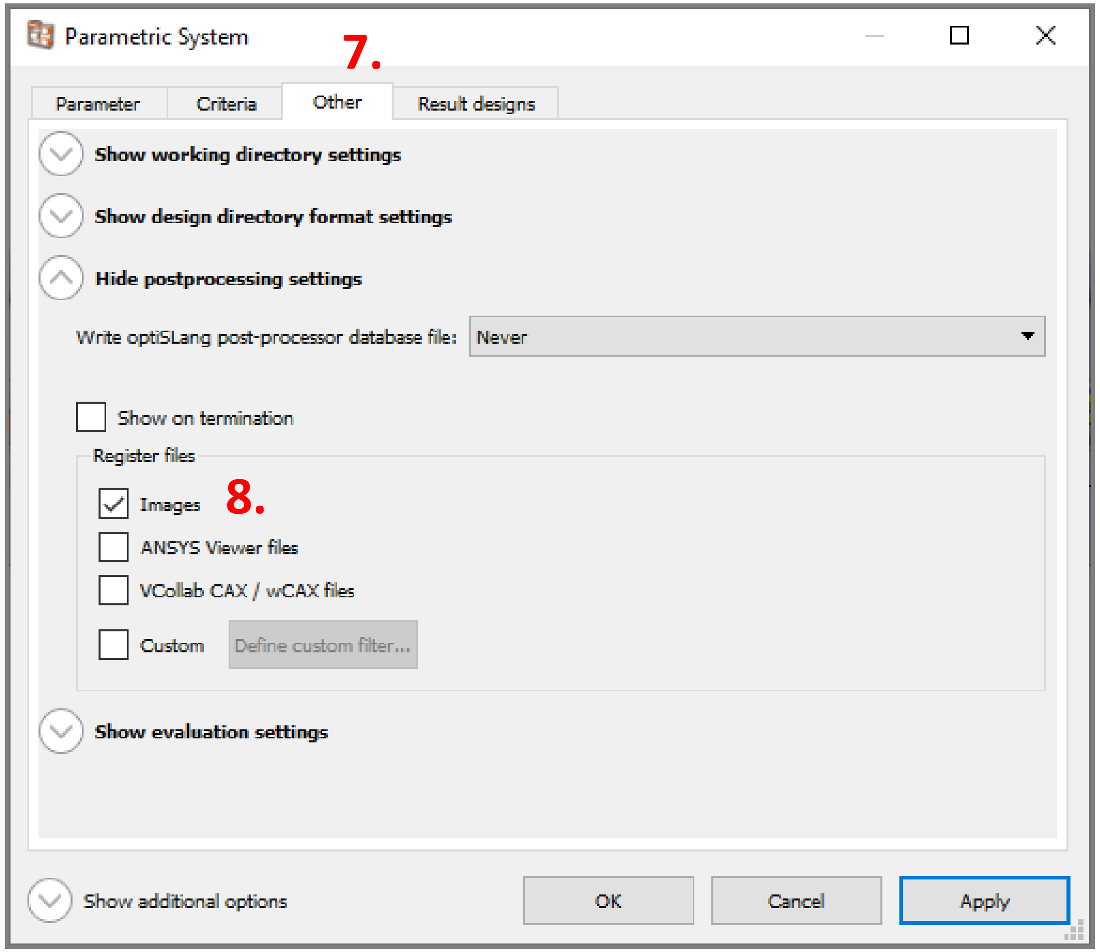




Workflow Extension

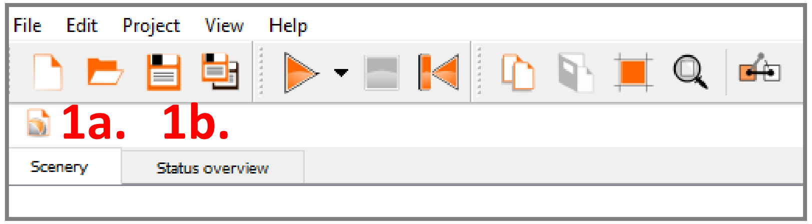
6. ***Double click*** on the systems head
7. Go to the ***Other*** tab
8. Change the postprocessing settings to import the images into the optiSLang Postprocessing automatically
9. Click ***Apply*** and ***OK***

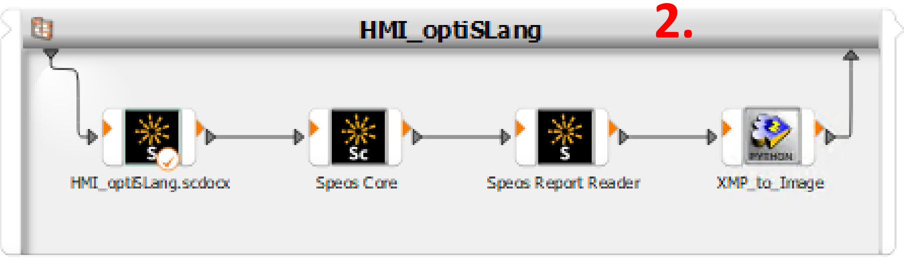


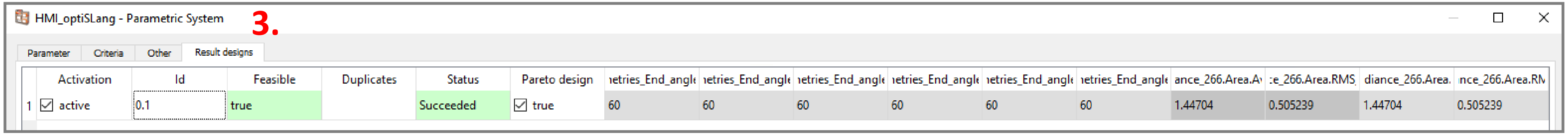


Test Run

1. Save and execute the project
2. Open the executed system by double click on the systems head
3. Check the results of the initial Design in the **Result designs** tab







	Activation	Id	Feasible	Duplicates	Status	Pareto design	ietries_End_angl	ietries_End_angl	ietries_End_angl	ietries_End_angl	ietries_End_angl	ietries_End_angl	ance_266.Area.A	:e_266.Area.RMS	diance_266.Area.	ince_266.Area.RN
1	☑ active	0.1	true		Succeeded	☑ true	60	60	60	60	60	60	1.44704	0.505239	1.44704	0.505239

NOTE: If the Python node fails, please check the trouble shoot on the next slide

Troubleshooting: Python node

- If the COM server for the XMP-Viewer is not registered in the windows registry, then the following

ERROR

```
Python interpreter error:
Traceback (most recent call last):
  File "C:\Program Files\ANSYS Inc\v231\optiSLang\lib\python3.7\lib\site-packages\win32com\client\dynamic.py", line 81, in _GetGoodDispatch
    IDispatch = pythoncom.connect(IDispatch)
pywintypes.com_error: (-2147221005, 'Invalid class string', None, None)

During handling of the above exception, another exception occurred:

Traceback (most recent call last):
  File "<string>", line 29, in <module>
  File "C:\Program Files\ANSYS Inc\v231\optiSLang\lib\python3.7\lib\site-packages\win32com\client\__init__.py", line 95, in Dispatch
    dispatch, userName = dynamic._GetGoodDispatchAndUserName(dispatch,userName,clsctx)
  File "C:\Program Files\ANSYS Inc\v231\optiSLang\lib\python3.7\lib\site-packages\win32com\client\dynamic.py", line 98, in _GetGoodDispatchAndUserName
    return (_GetGoodDispatch(IDispatch, clsctx), userName)
  File "C:\Program Files\ANSYS Inc\v231\optiSLang\lib\python3.7\lib\site-packages\win32com\client\dynamic.py", line 83, in _GetGoodDispatch
    IDispatch = pythoncom.CoCreateInstance(IDispatch, None, clsctx, pythoncom.IID_IDispatch)
pywintypes.com_error: (-2147221005, 'Invalid class string', None, None)
```

- **Solution: Set up the windows registry correct:**
  - **Open „Virtual Photometric Lab“ with admin rights manually in the used Ansys Speos version**
  - **reopen optiSLang and try again**

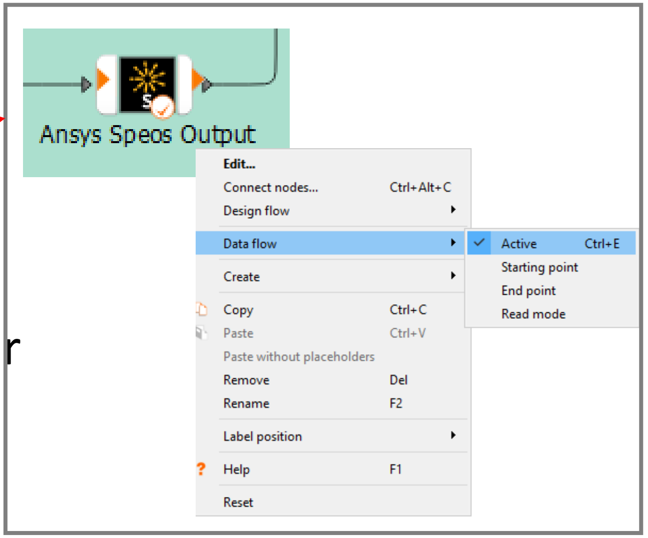
Troubleshooting: Ansys Speos Output node

Location of the Speos report (.html file):

1. With a **manual solve** of the simulation in Speos, the Speos report (.html file) will be written into the “**SPEOS output files**” folder
2. With the **automatic solve** using the Speos integration in optiSLang the Speos report will be written into the “**SPEOS isolated files” folder**

For new projects, this report might not be existing in the “SPEOS isolated files” folder.
The best practices is:

1. Setup the workflow via wizard
2. Deactivate Ansys Speos Output Node
   (right click on the node and click on “Active”)
3. Run the workflow
4. Copy the generated Speos report (.html file) into your reference folder
5. Setup the Speos output node
6. Activate the Speos Output node and run the workflow



Troubleshooting: Solver Noise

- For variation analysis like Optimization, it is important to have a high simulation quality in order to minimize the solver noise. Small Solver noise means that if the same simulation is run multiple times, the variations in the responses should be small.

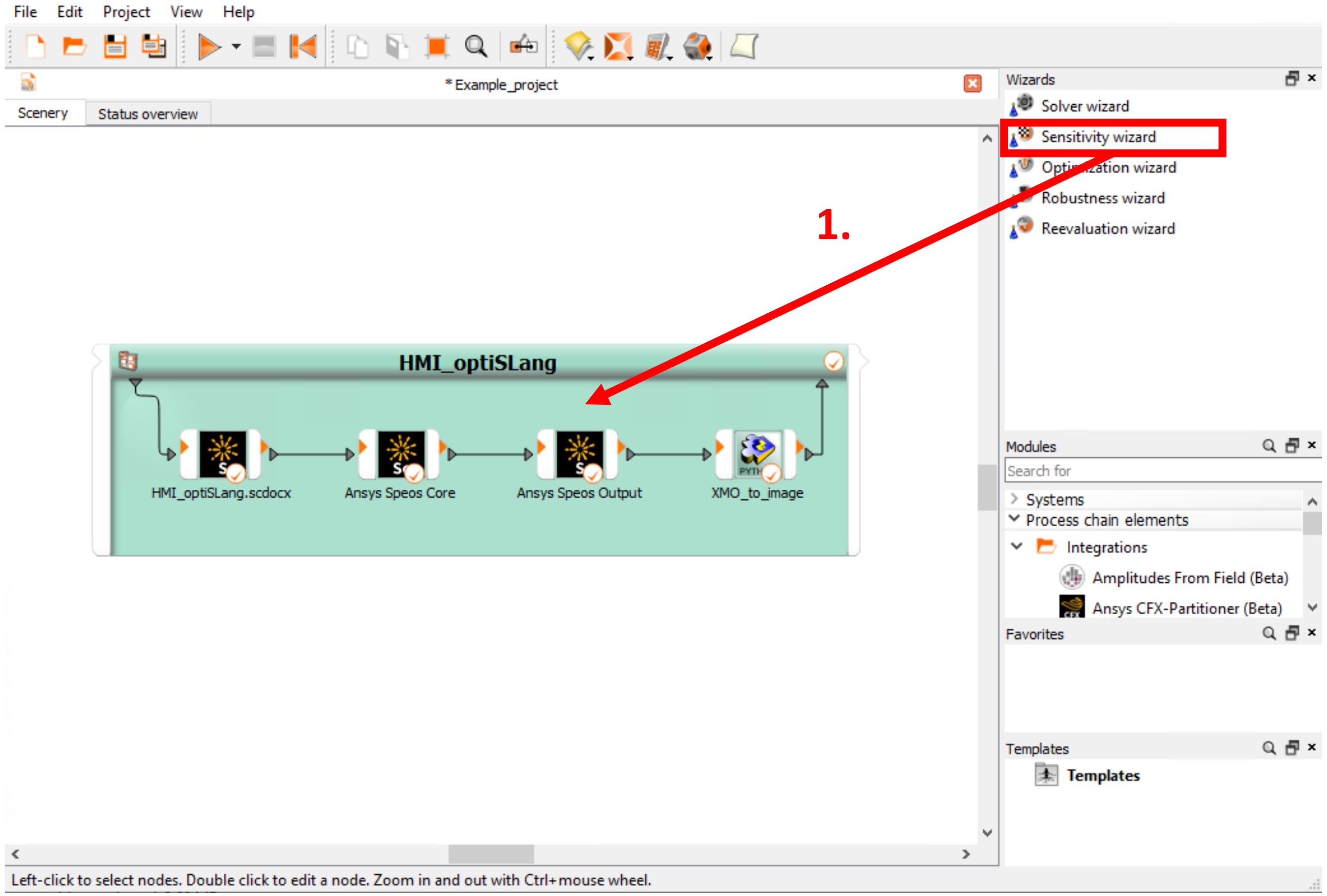
- Optional: There is an easy solution to fast check the solver noise within optiSLang. How to do is shown at the End of the Presentation in the Section “Check Solver Noise”

Sensitivity Analysis

Ansys

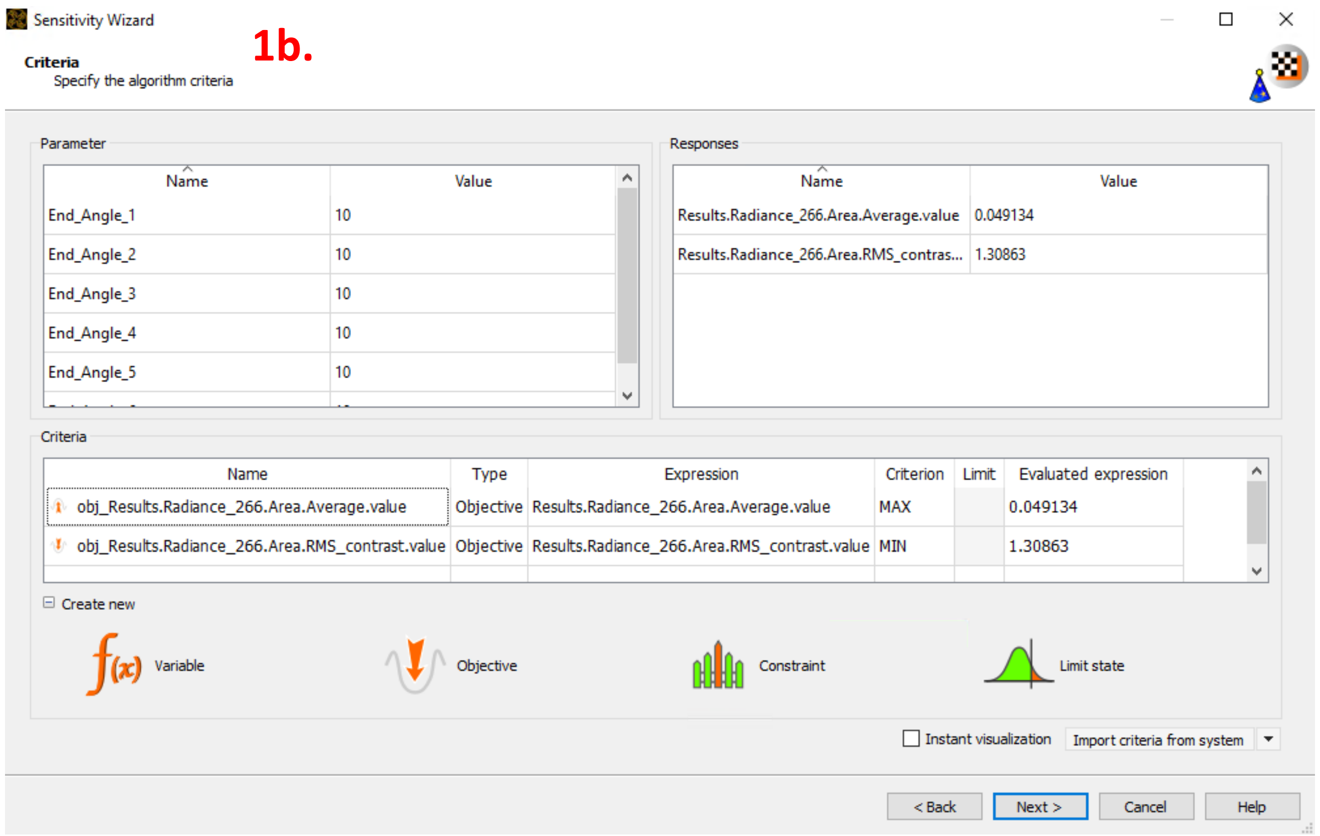
Sensitivity Analysis

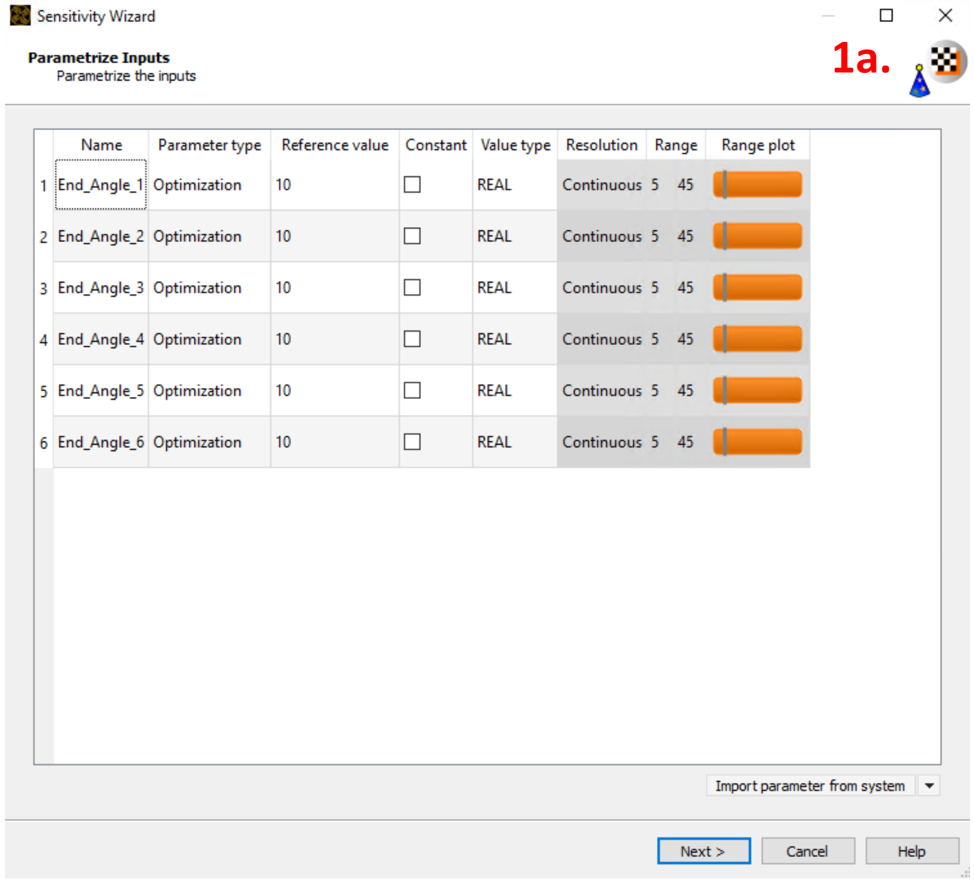
1. Drag the sensitivity wizard onto the head of the solver chain



Sensitivity Analysis

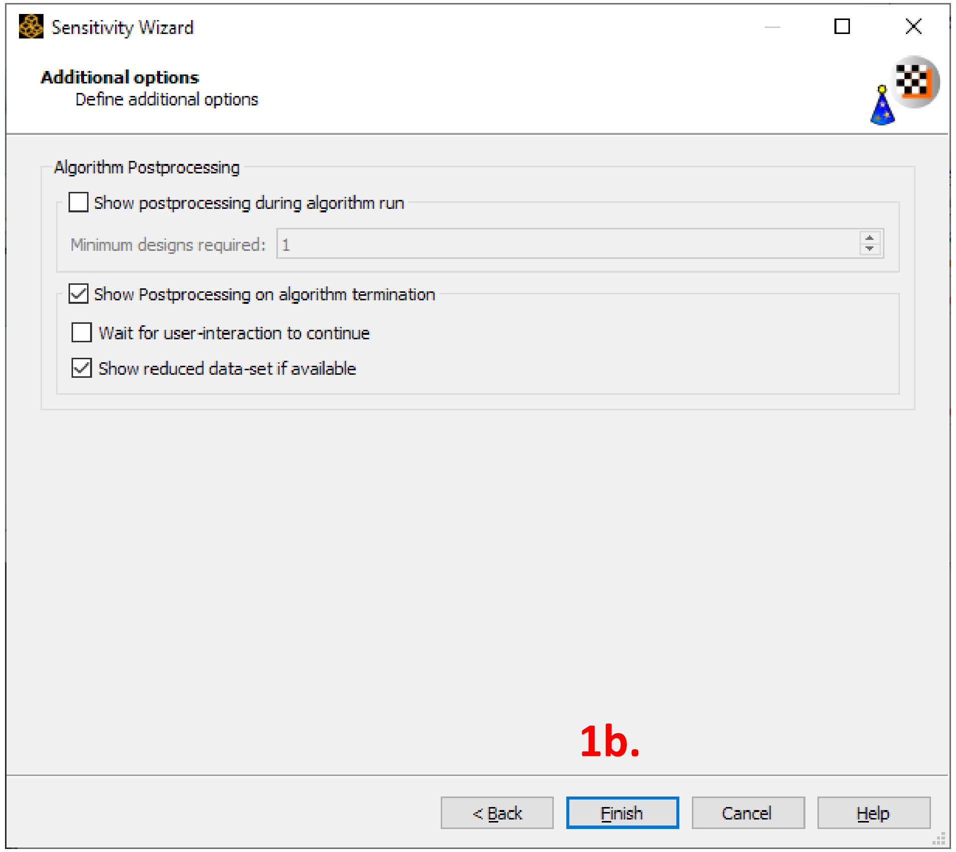
1. Keep the ranges and criteria

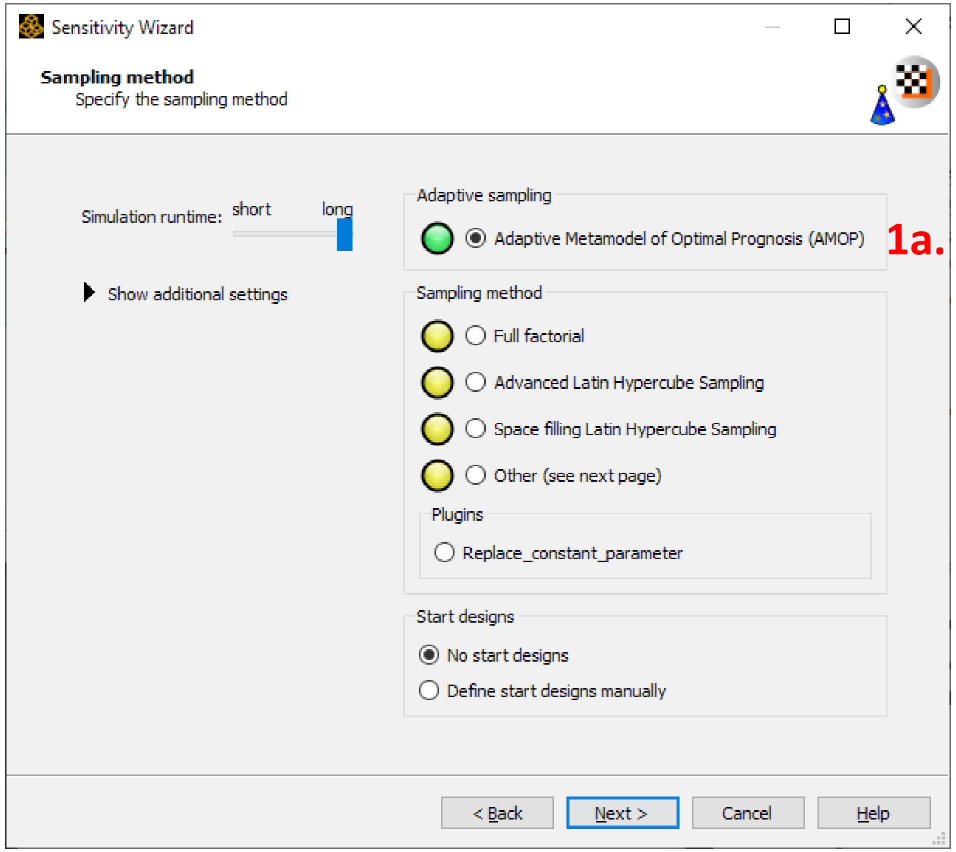




Sensitivity Analysis

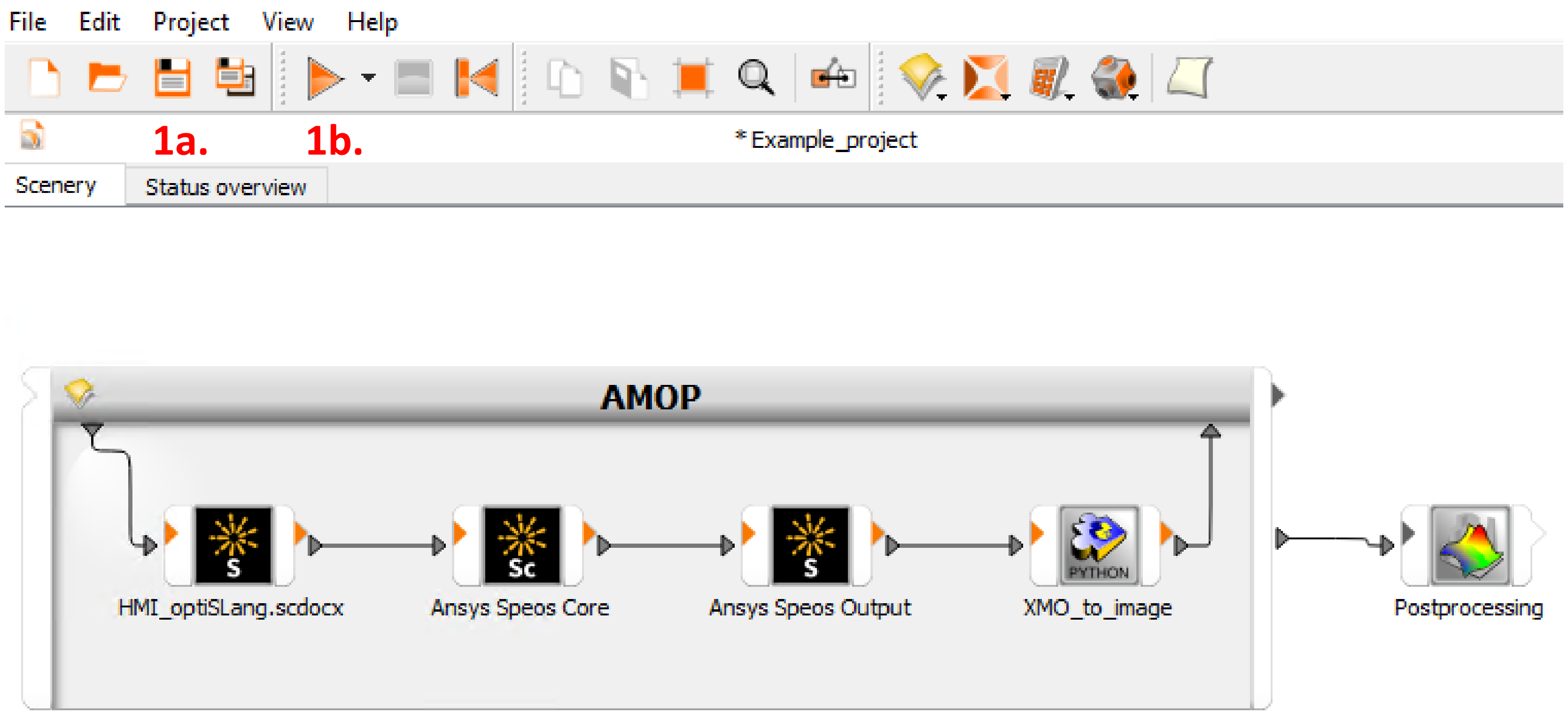
1. Keep all settings and finish the wizard





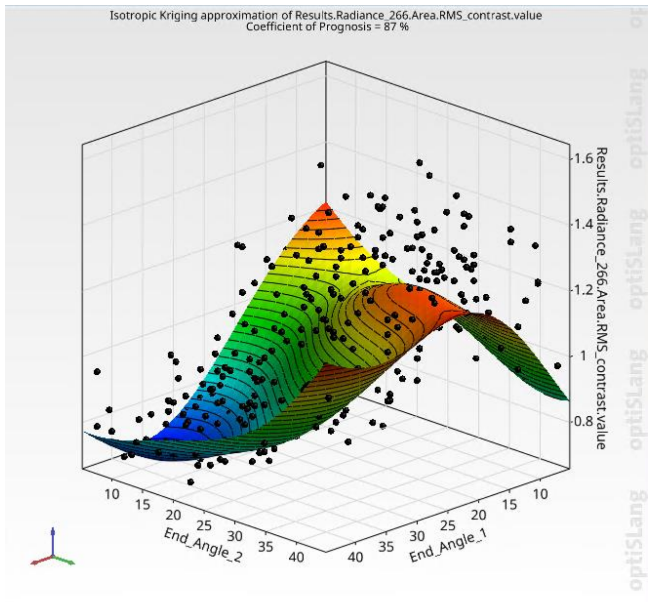
Sensitivity Analysis

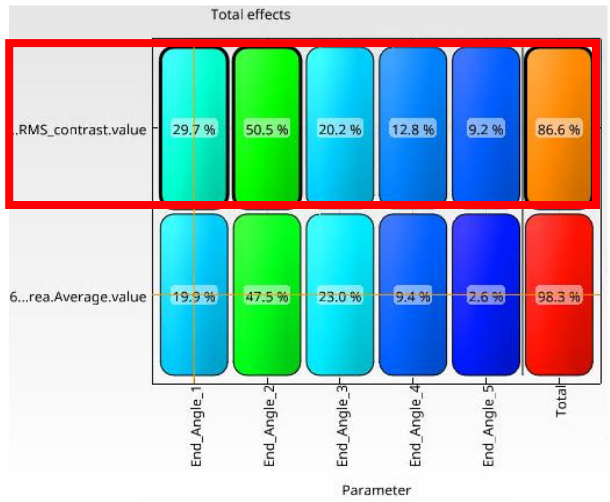
1. Save and execute the project



Result of Sensitivity Analysis

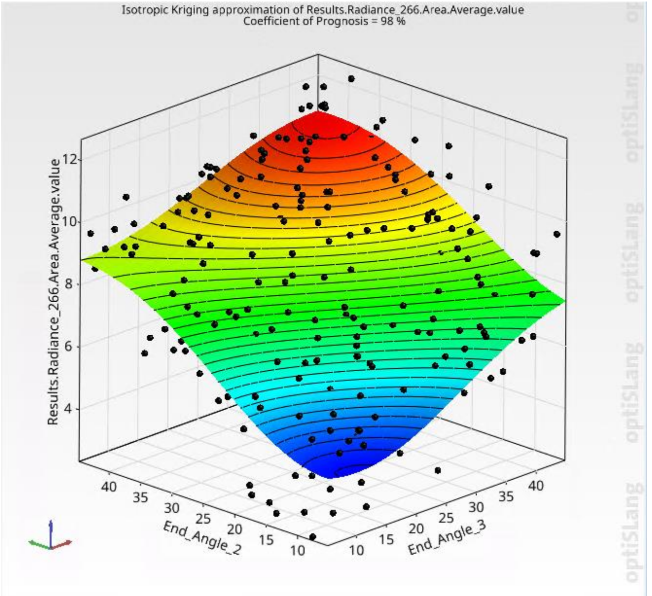
- The approximation quality is good for RMS contrast (87%).
- The most important inputs for RMS contrast are end angle at control point 2 (50.5%), control point 1 (29.7%) and control point 3 (20.2%).
- The end angles at control point 4, 5 and 6 have less influence.
- A non linear dependency of the End angles to the RMS contrast can be identified.

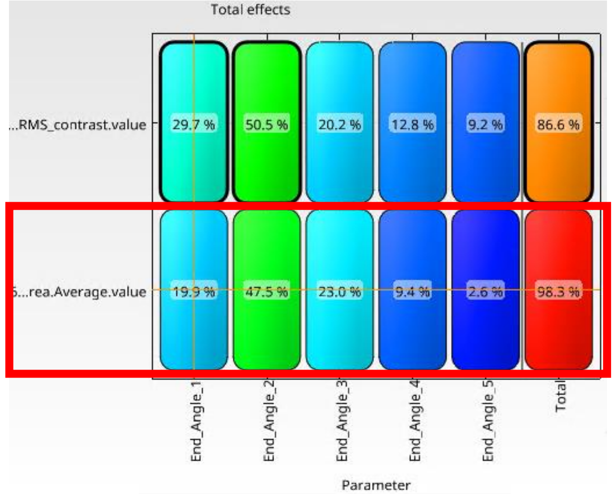


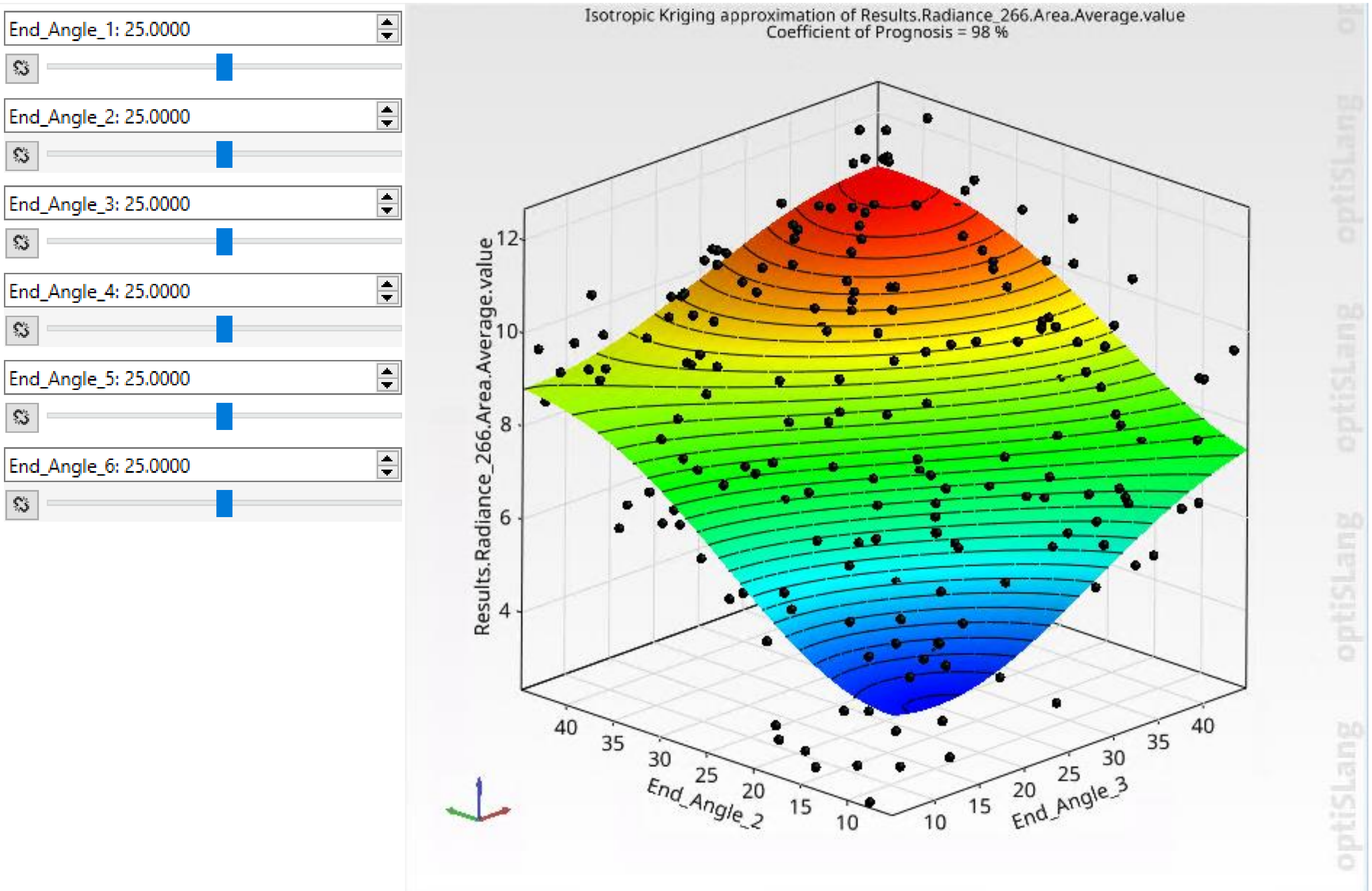


Result of Sensitivity Analysis

- The approximation quality is excellent for average luminance (98.3 %).
- The most important inputs for average luminance are end angle at control point 2 (47.5%), control point 3 (3.0%) and control point 1 (19.9%).
- The end angles at control point 4, 5 and 6 have less influence.
- A non linear dependency of the End angles to the average luminance can be identified.



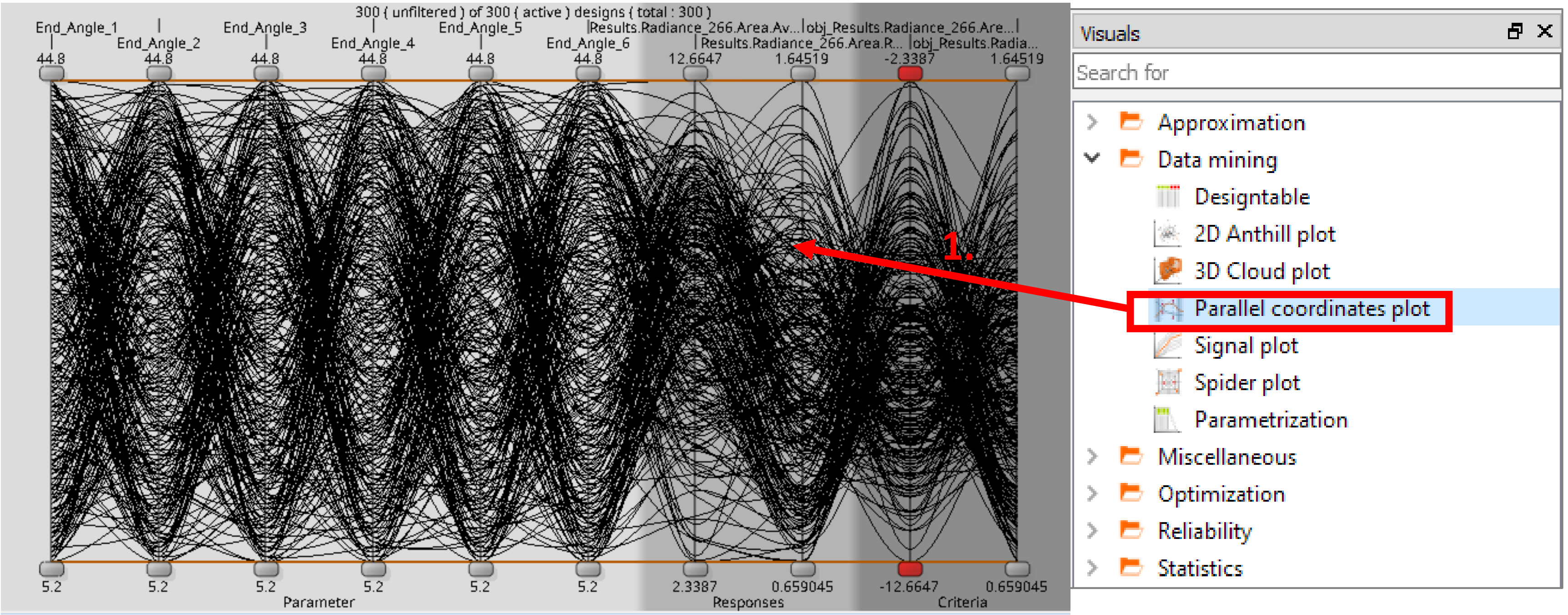




End_Angle_1: 25.0000
End_Angle_2: 25.0000
End_Angle_3: 25.0000
End_Angle_4: 25.0000
End_Angle_5: 25.0000
End_Angle_6: 25.0000
Isotropic Kriging approximation of Results.Radiance_266.Area.Average.value
Coefficient of Prognosis = 98 %
Results.Radiance_266.Area.Average.value
12
10
8
6
4
End_Angle_2
40
35
30
25
20
15
10
End_Angle_3
10
15
20
25
30
35
40

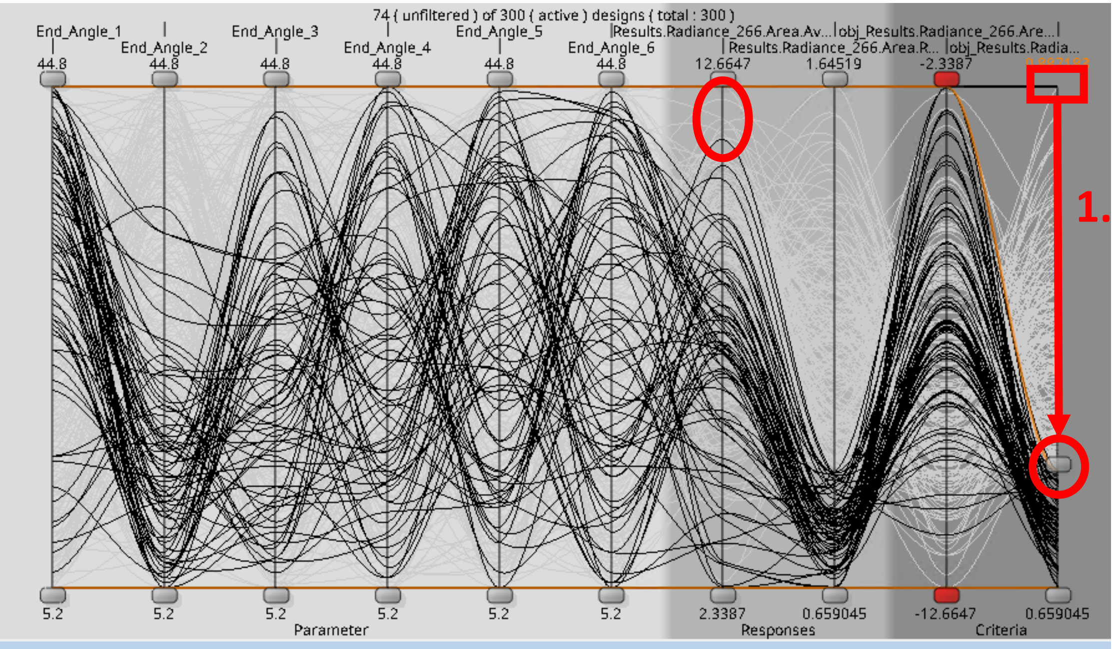
Result of Sensitivity Analysis

1. Drag the “Parallel coordinates plot” into the Postprocessing



Result of Sensitivity Analysis

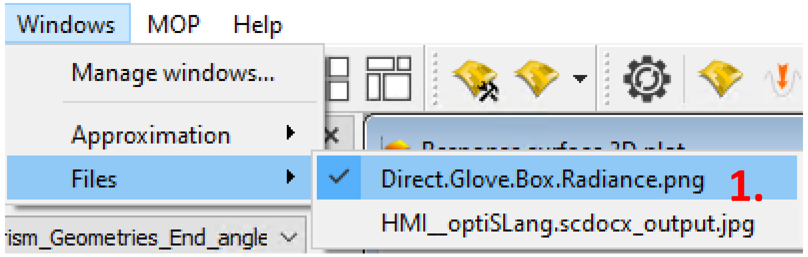
1. Move down the slider for RMS contrast to filter out designs which have a low value for RMS contrast
   - Check the ranges of the input parameters that lead to a low RMS contrast
   - Check the relation between RMS contrast and average
     - → The applied filtering filters designs having a high average luminance
     - → Trade off between RMS contrast and average luminance

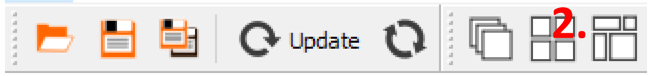


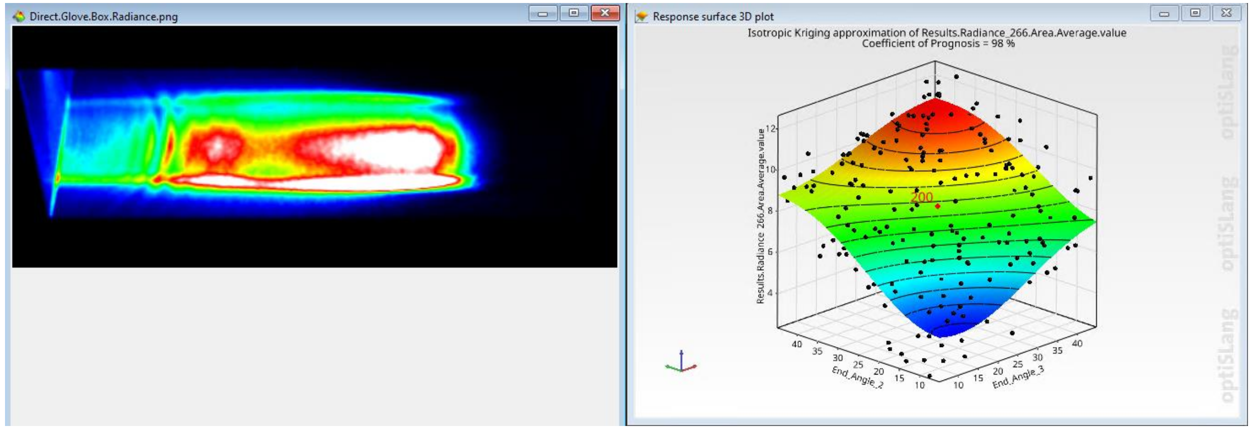
Result of Sensitivity Analysis

1. Select in “Windows”, “Files” the “Direct.Glove.Box.Radiance.png” file in order to display the light distribution in the postprocessing
2. Select “Tile subwindows ” in the postprocessing tool bar

- All plots are connected, and pictures are updated by clicking on a new design
- Check physical phenomena appearing in the design space



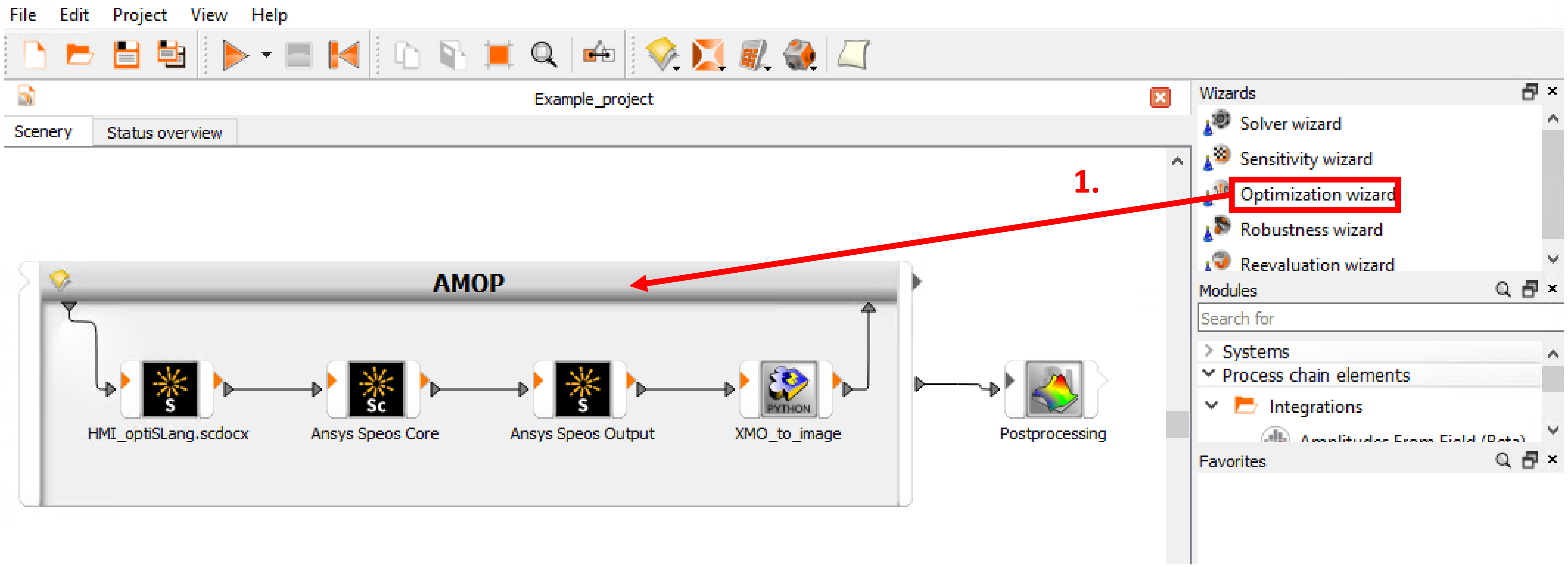




Optimization on Metamodel of Optimal Prognosis (MOP)

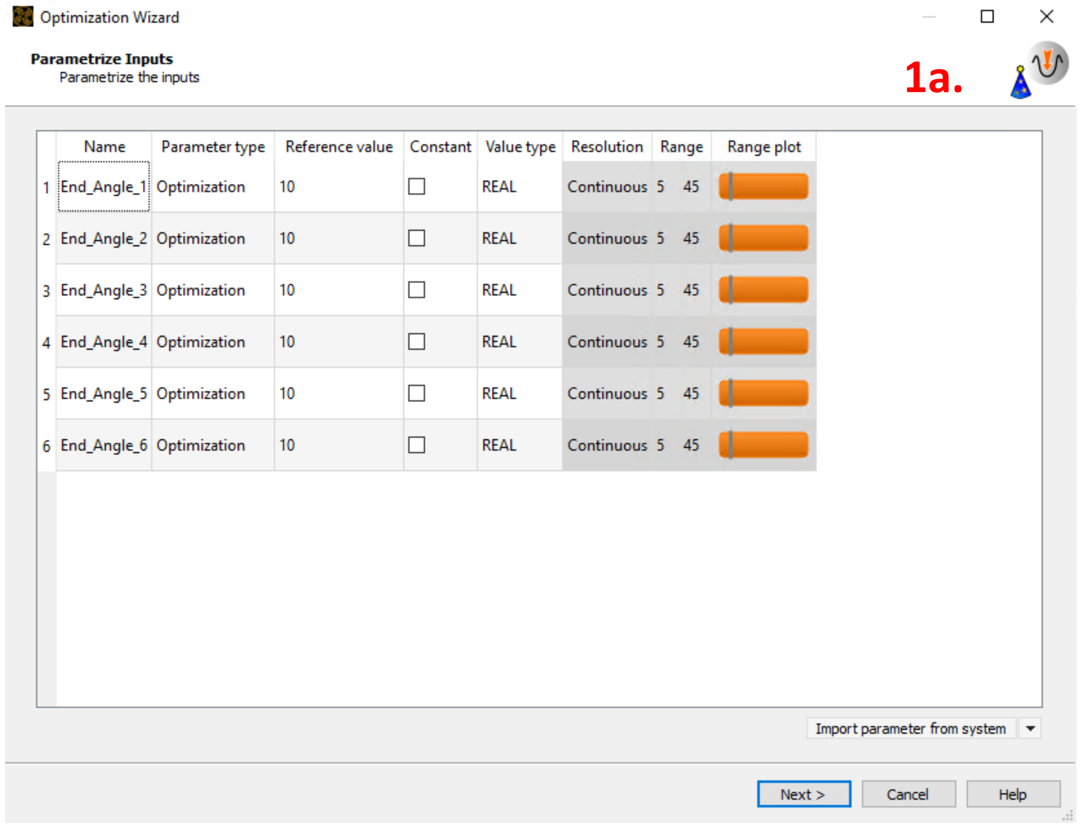
Optimization using the MOP

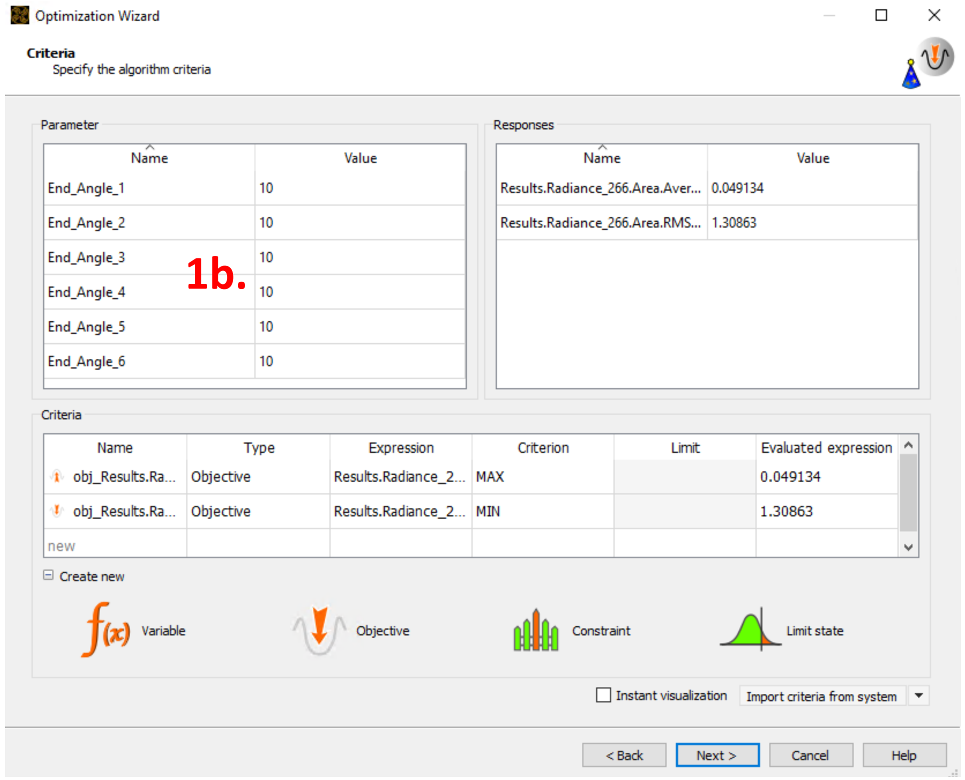
1. Drag the optimization wizard onto the head of the sensitivity system



Optimization using the MOP

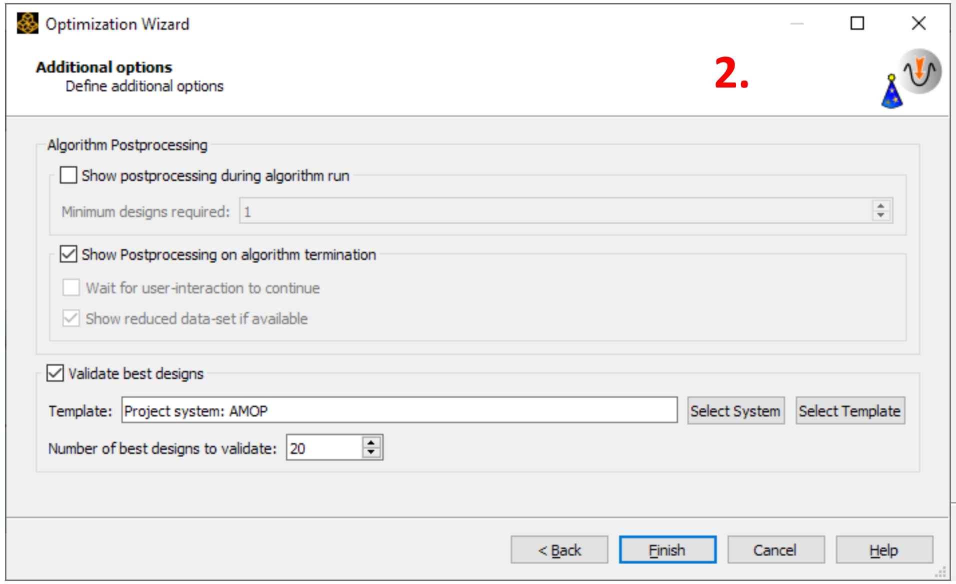
1. Keep the parameter ranges and criteria definition

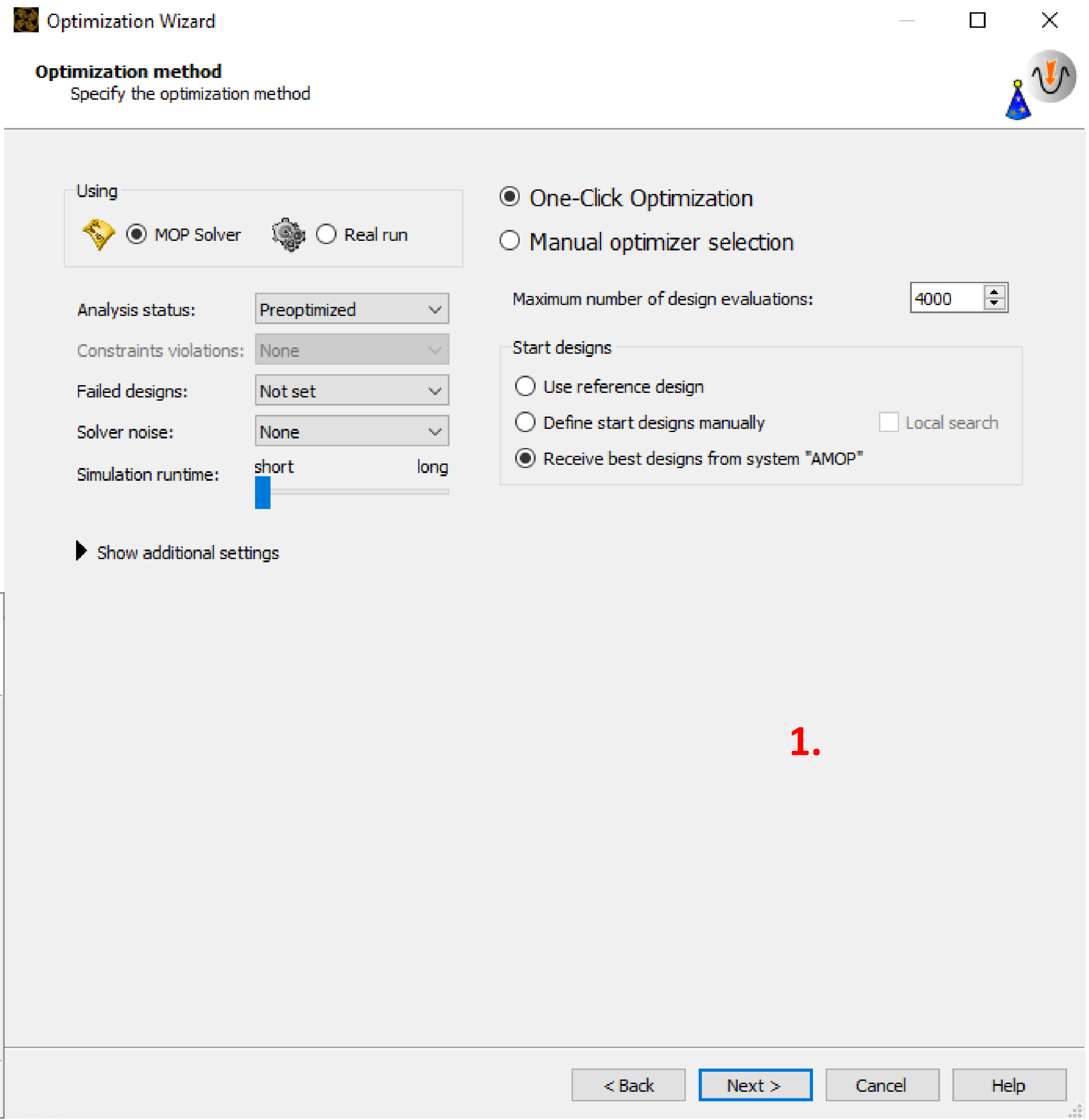




Optimization using the MOP

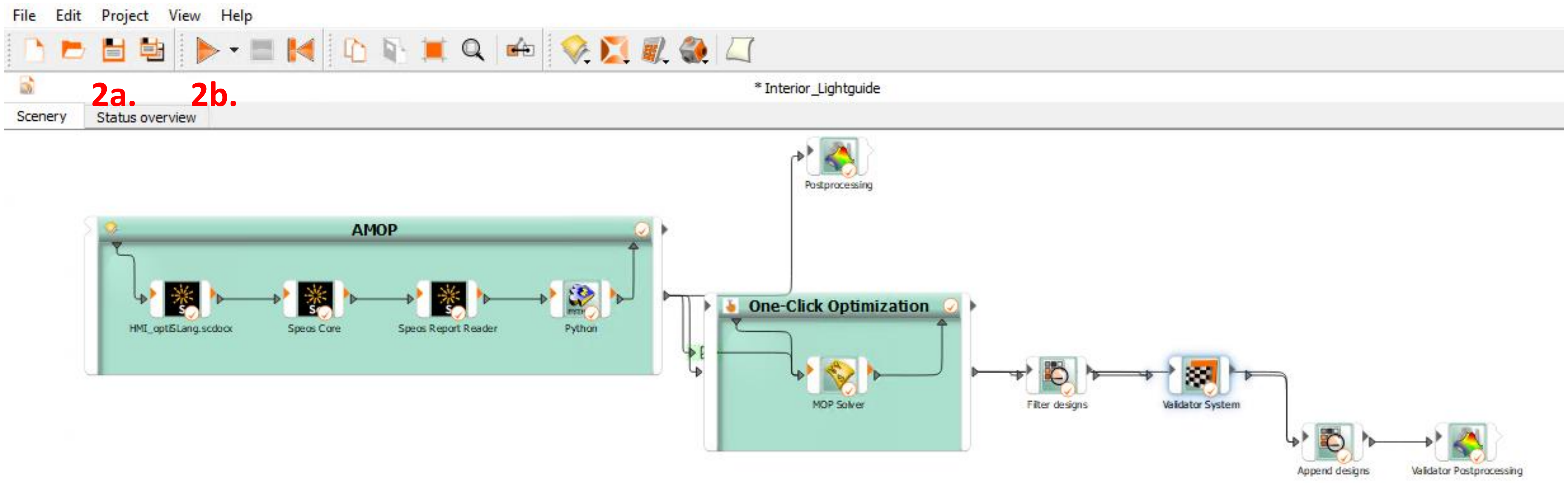
1. The One-Click Optimization is recommended as optimizer
2. Keep the defined “Additional options” and finish the optimization wizard





Optimization

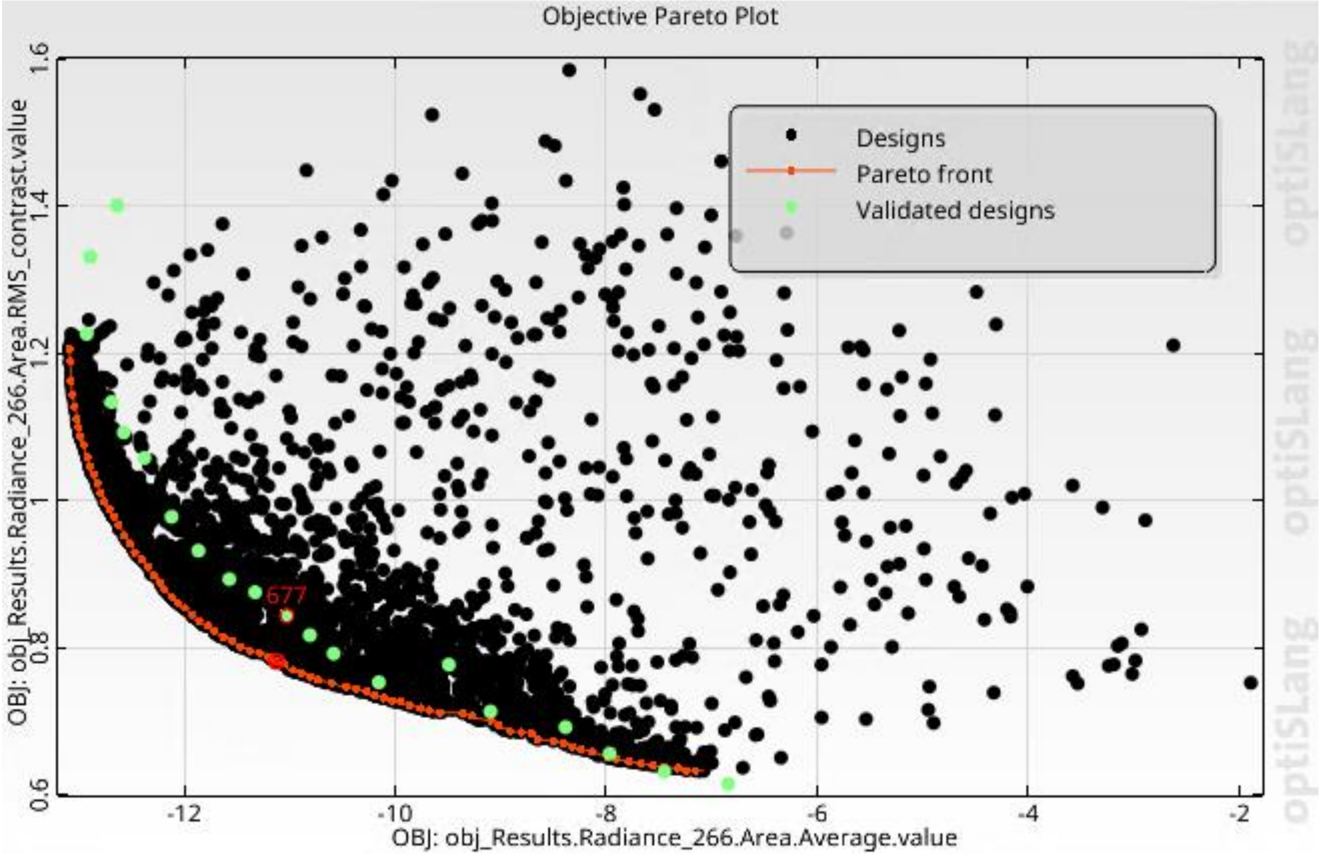
1. The Evolutionary Algorithm appears in the workflow
2. Save and execute the project
3. After the Optimization has finished the Postprocessing opens automatically



Results of Optimization using the MOP

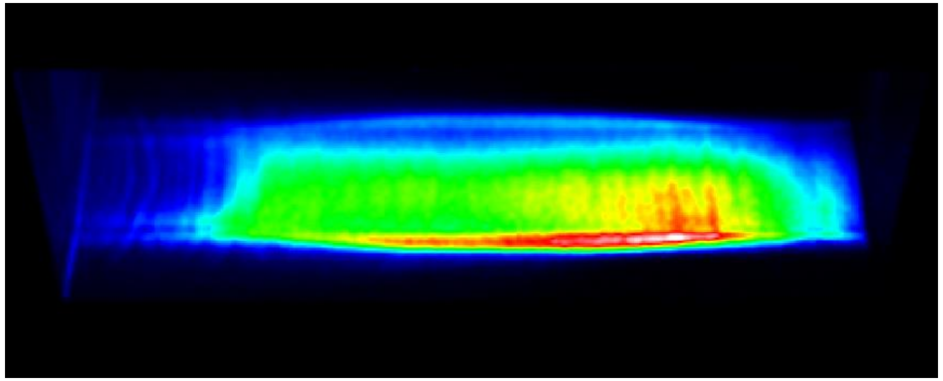
- **Fast Optimization** on Metamodel
- **Trade off** between RMS contrast and average gets visible
- The pareto front shows all best designs.
- The responses and objective of 20 best designs on the pareto front are validated by a solver call.

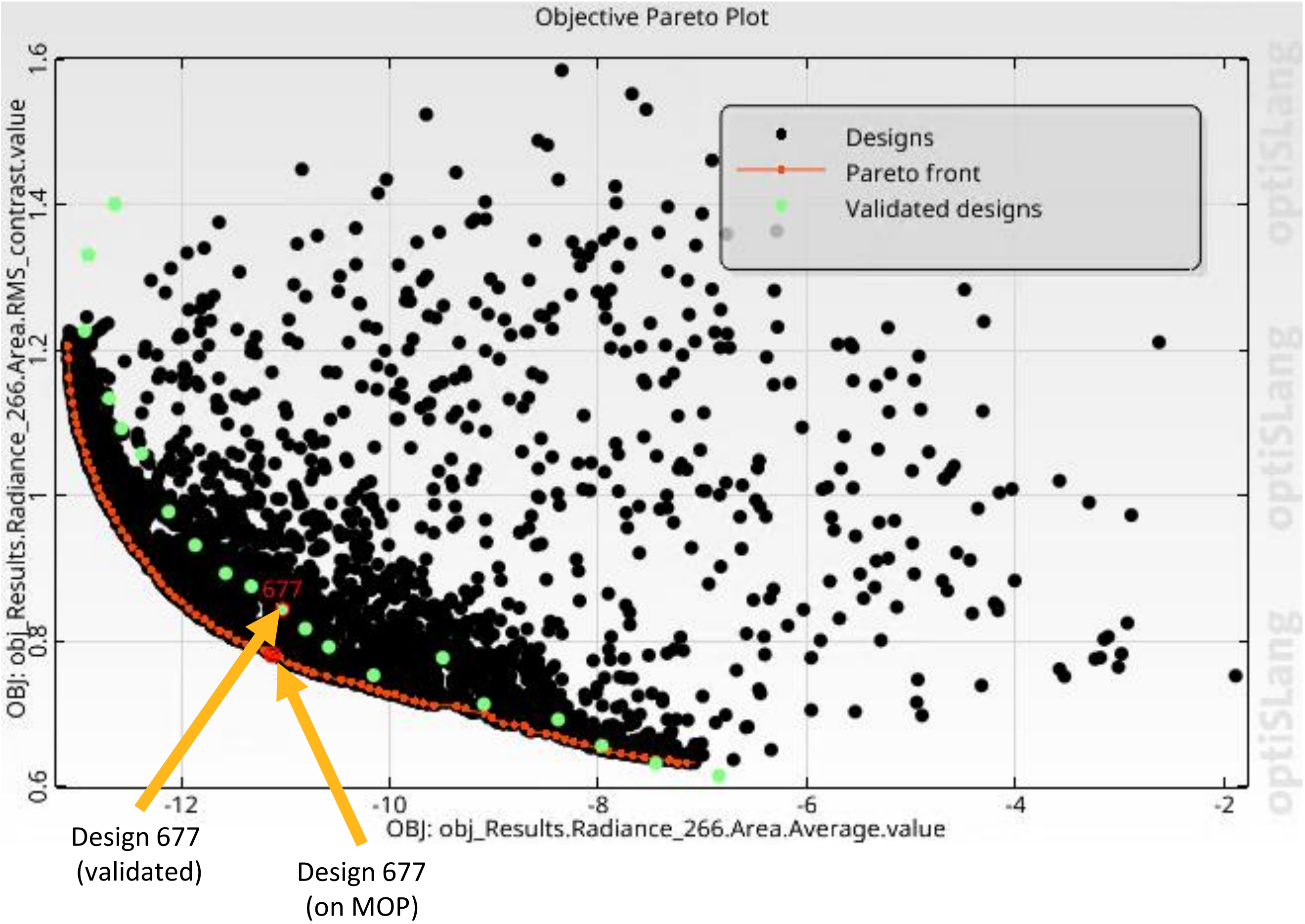
→ Due to local approximation errors the estimated response value may differ from the solver result (validation of the best design is necessary).



Results of Optimization using the MOP

- Choose the best design (in this case Design 677)





Summary

- Due the Sensitivity Analysis and Optimization:
  - the best possible trade off between RMS contrast and average luminance could be found
  - the average luminance could be significantly improved

	Initial Design	Best trade off (from optimization on MOP)
RMS Contrast	0.785	0.844
Average luminance(cd/m2)	1.830	11.03