optiSLang

Tutorial: Optimization of a prismatic light guide (headlamp)

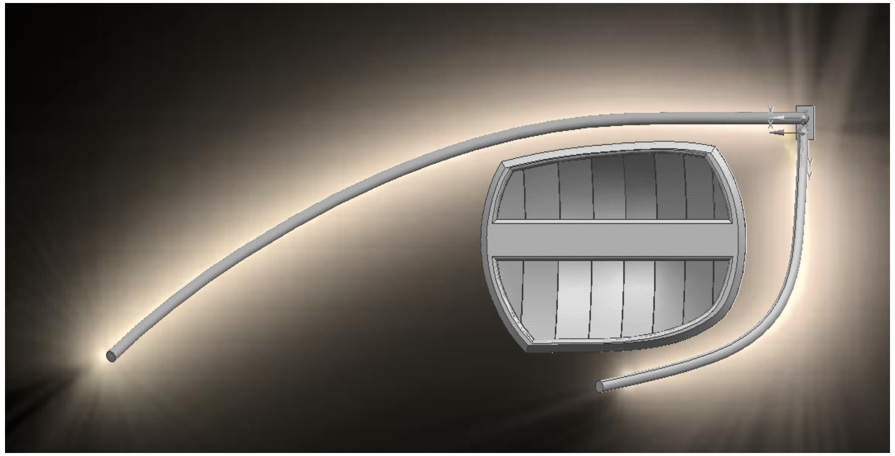
Release 2023 R2

Ansys

Task Description

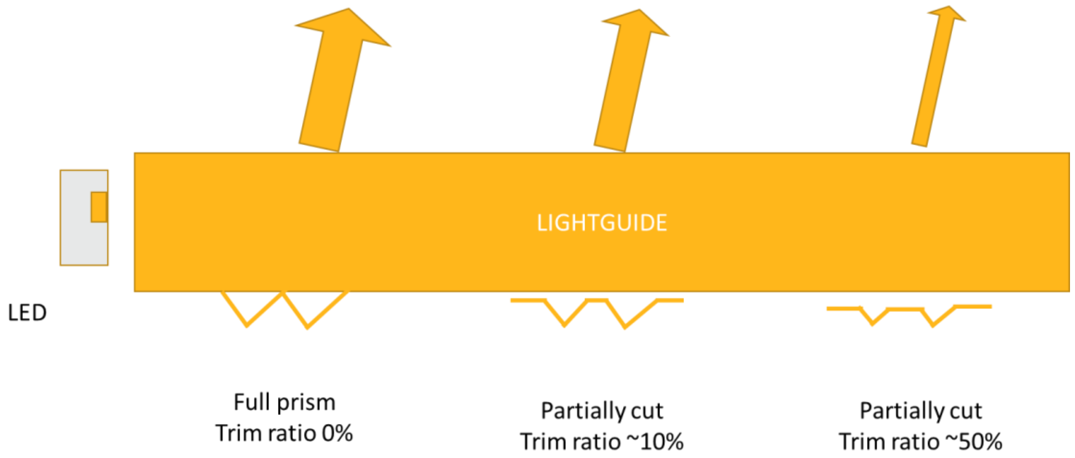
- In this example, we will use **Ansys Speos and Ansys optiSLang to optimize a prismatic lightguide** to **fulfill** the automotive Day-Time-Running-Lights **regulation** (42 rules) and **improve the homogeneity** of the lightguide to achieve a better lit appearance in an automated way.

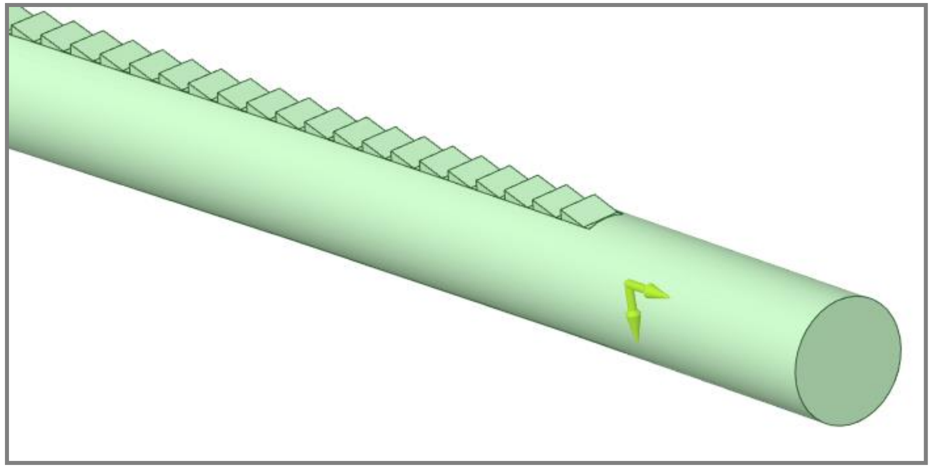
- This tutorial looks deeper into:
  - **Workflow automation of Ansys Speos**
  - **Sensitivity Analysis**
  - **Optimization**

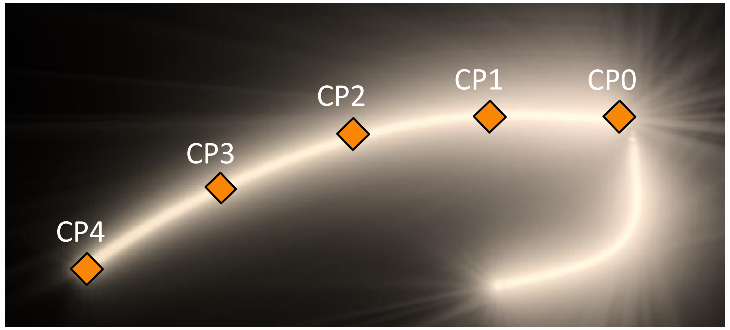


Light Guide Parameters

- For the Optimization the trimming ratio of the prisms at 5 control points on the lightguide are considered







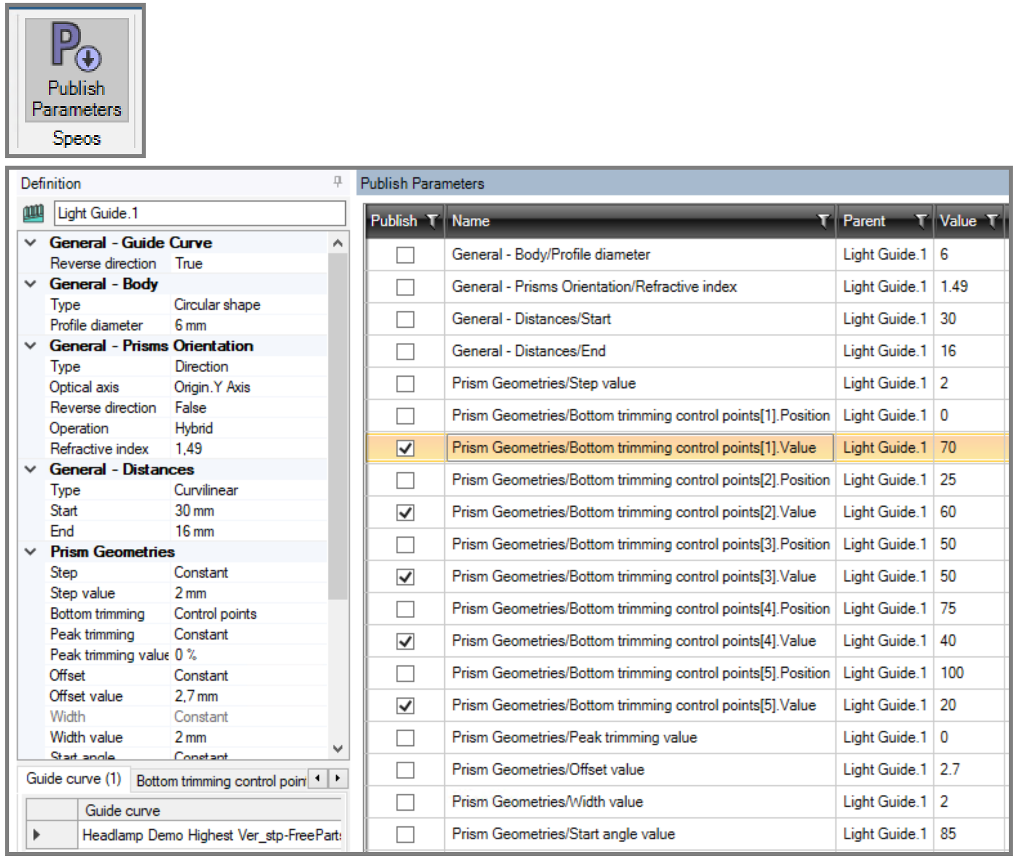
- Further possible parameter could be:
  - Profile geometry (type / profile)
  - Prism geometry (start and end angle, number of prisms by step value, offset, width,…)
  - Prism milling (bottom, top)
  - …

Setup in Ansys Speos

Ansys SPEOS Setup

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

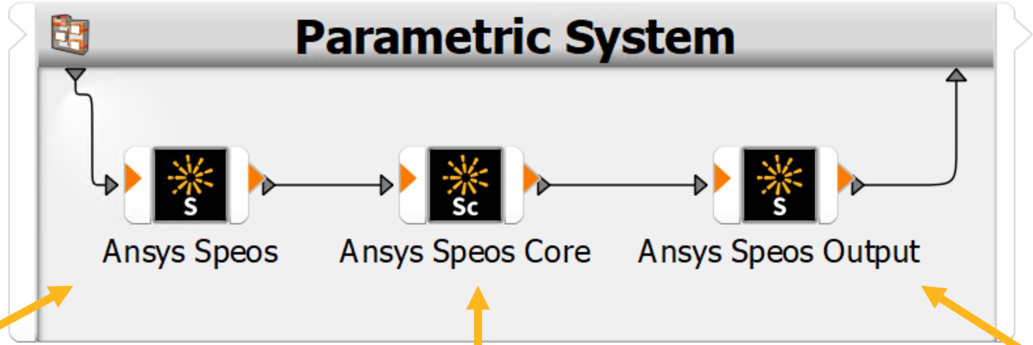
1. Open the Ansys Speos project (**Headlamp_LightGuide.scdocx**)
2. Select the ***Workbench tab***
3. Click ***Publish Parameters***
4. Select an Optical Part Design feature or a Light Simulation feature (Material, Source, Sensor, Simulation).
5. In the Publish Parameters panel, a list of the possible 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 Ansys 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)

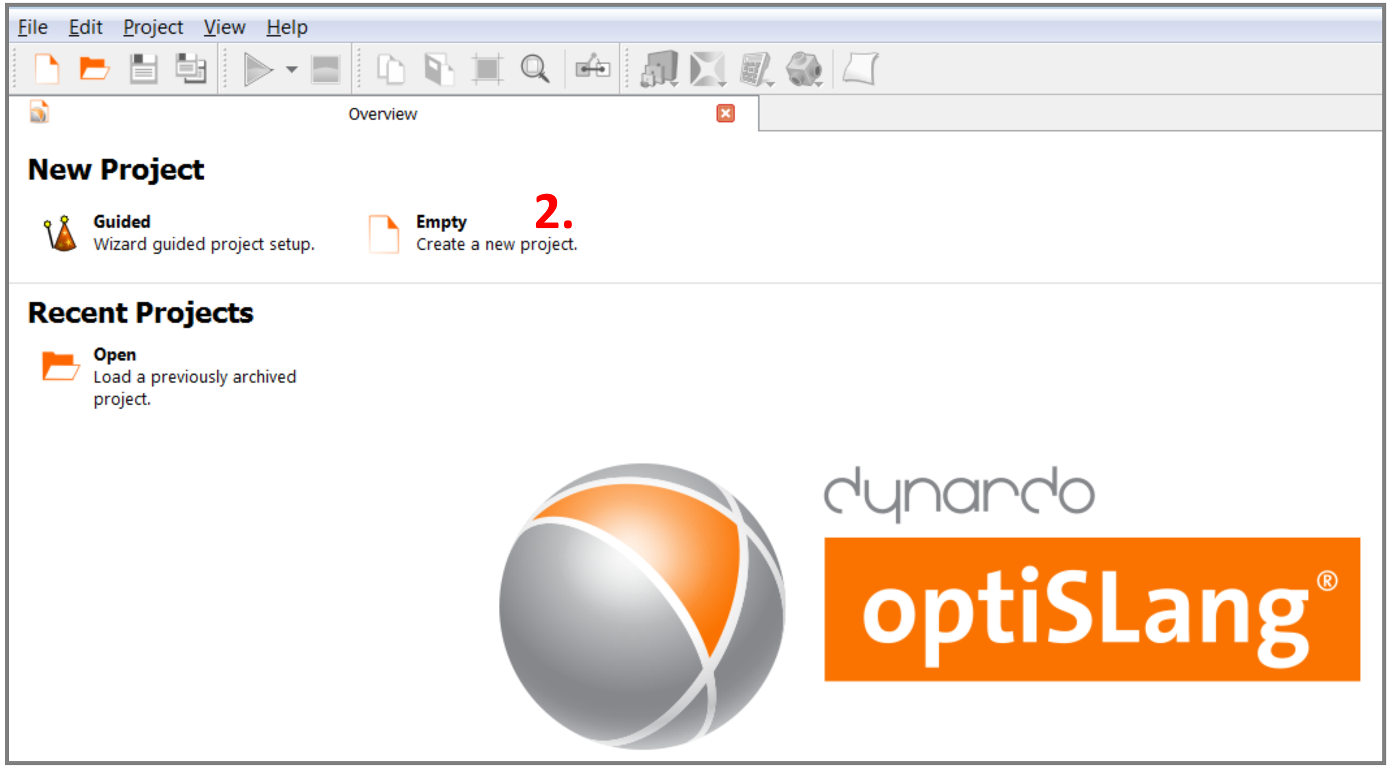
Ansys Speos Core node:
- launches and processes the simulation

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:

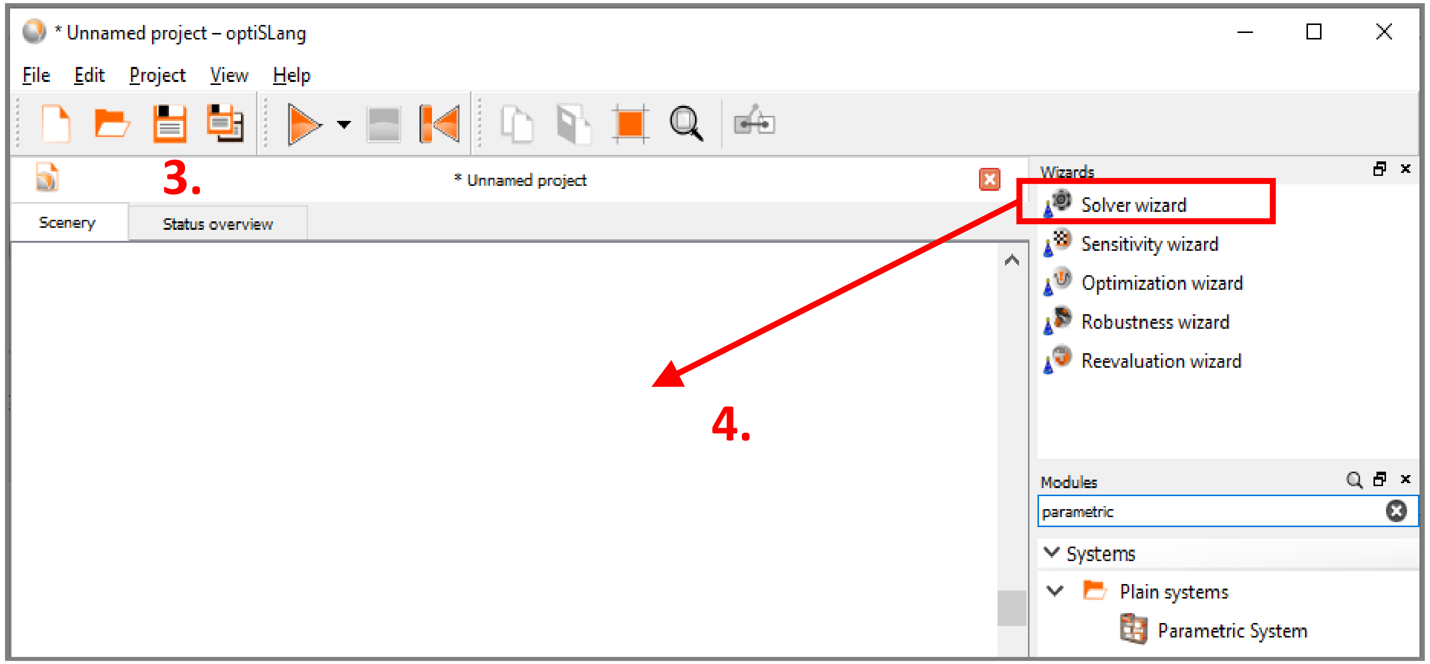
1. Open Ansys optiSLang
2. Create a new ***Empty*** project



Workflow creation

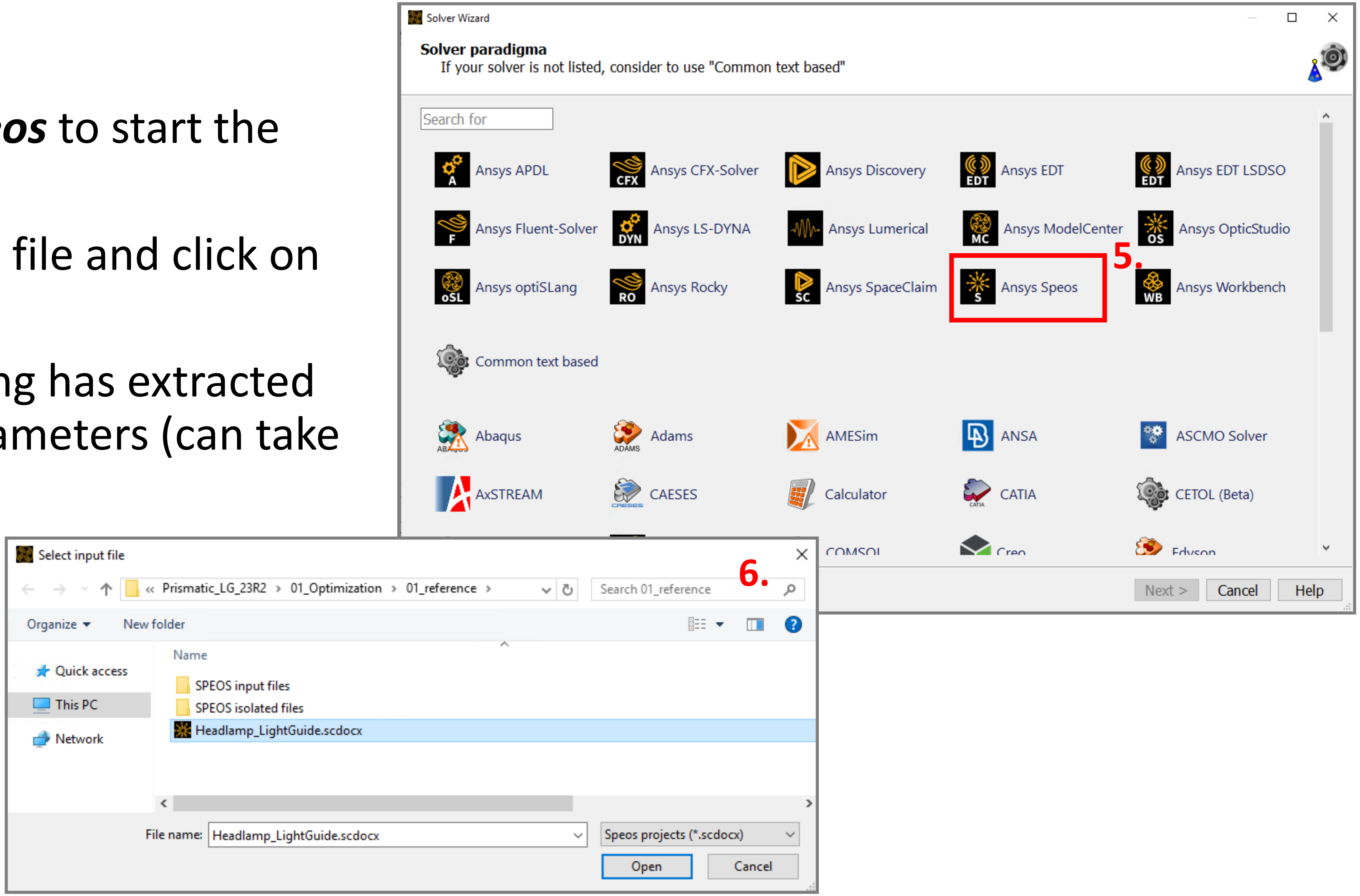
3. Save the optiSLang project
Best practices: save the project next to the reference folder to allow relative path in optiSLang

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



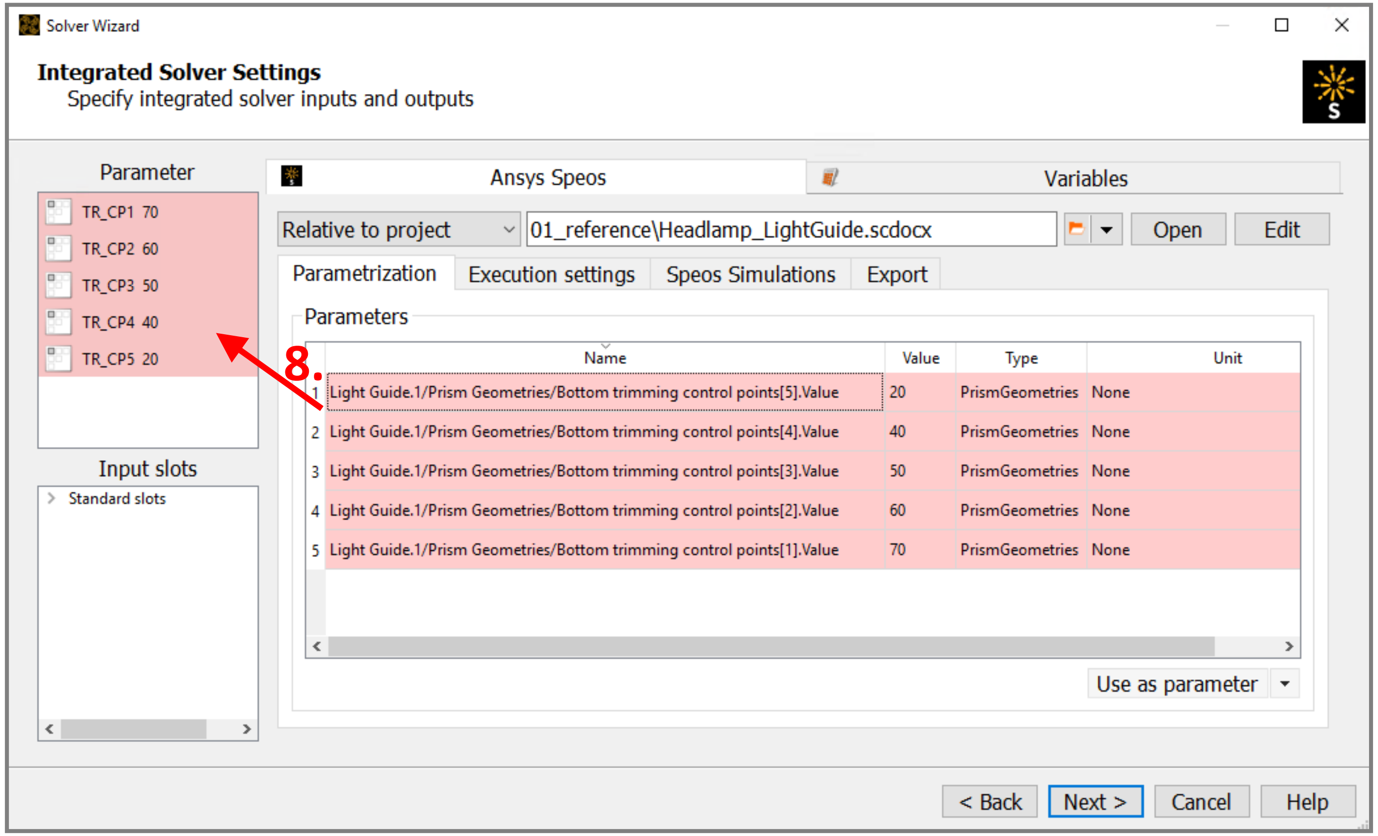
Workflow creation

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



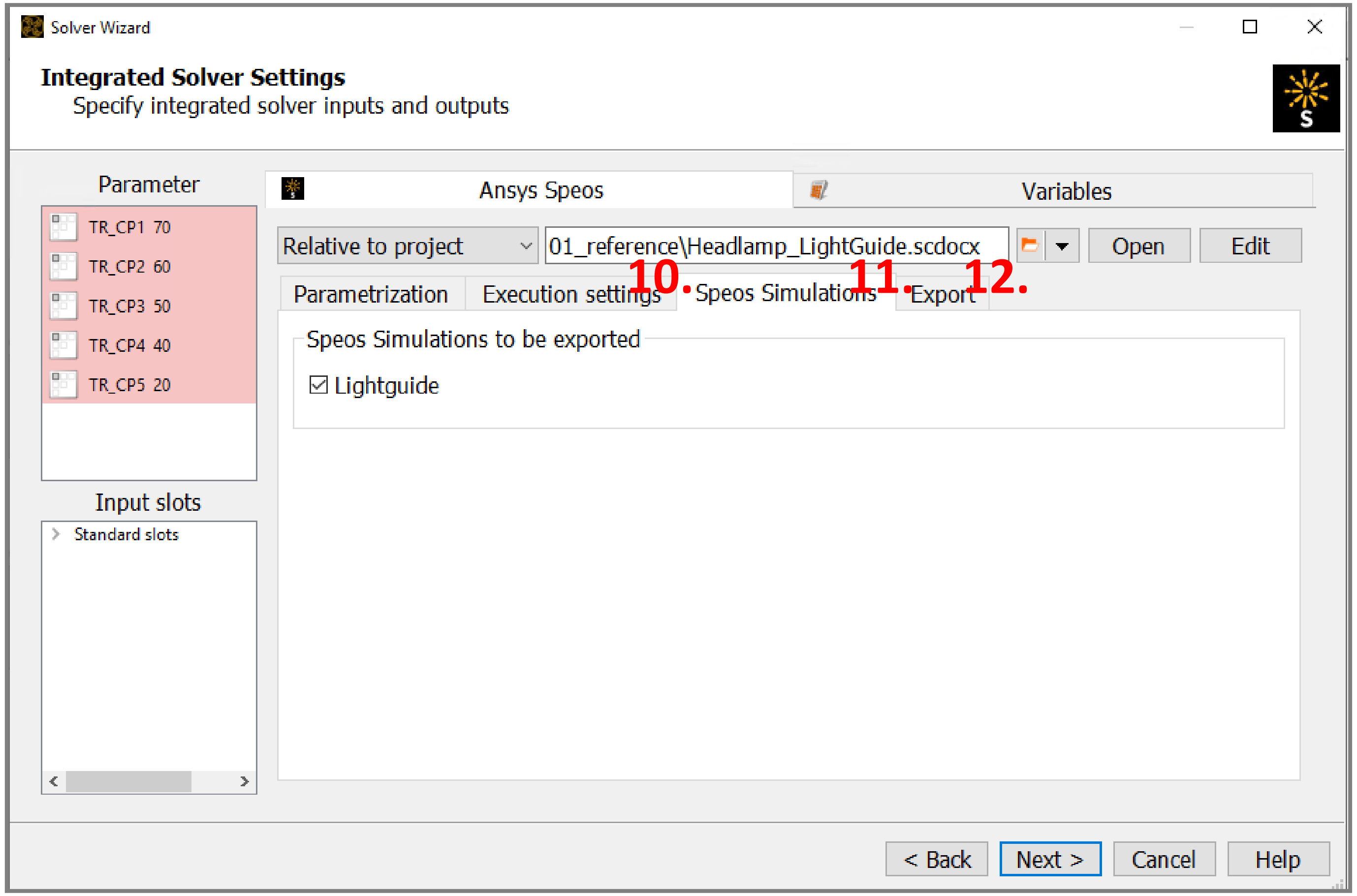
Workflow creation

8. Drag and Drop the parameters to the ***Parameter*** pane to consider them in the variation analysis
9. Rename parameter names



Optional: Workflow creation

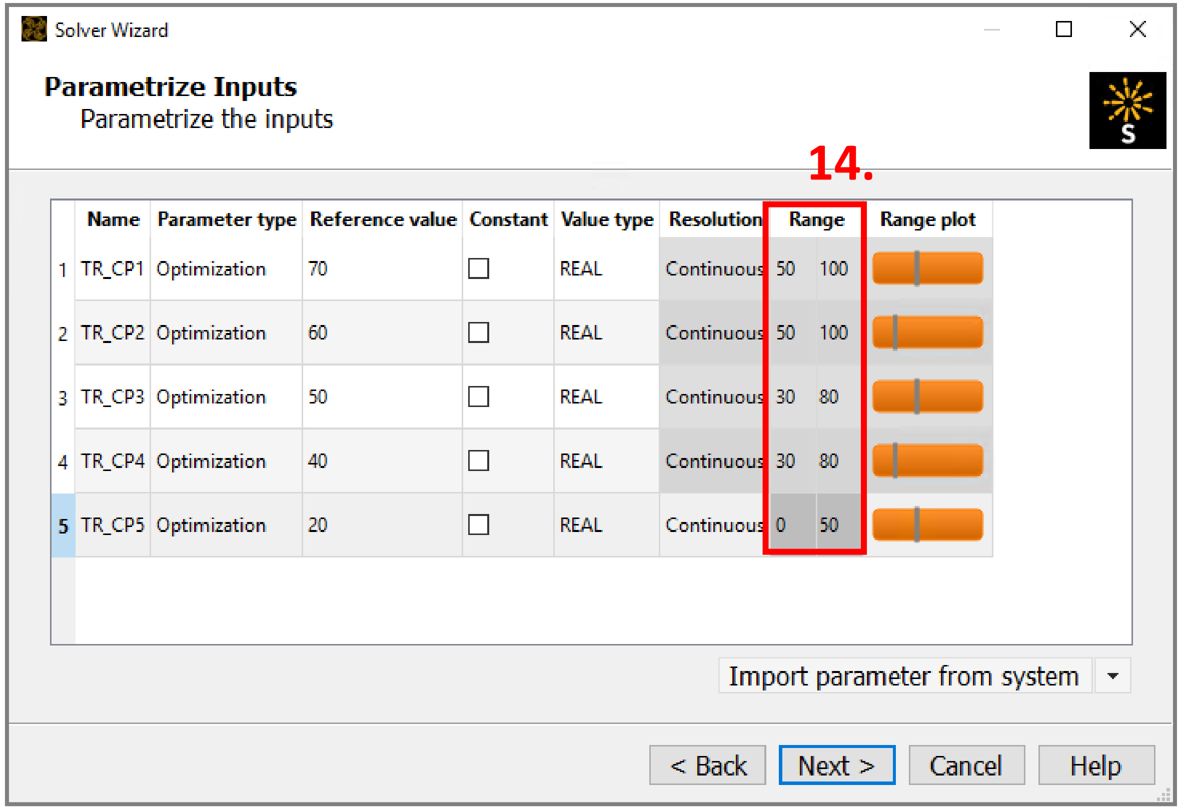
10. Optional: Under ***Execution settings*** you can add python scripts for pre or post update →*not mandatory for this tutorial*
11. Optional: Under ***Speos Simulation*** you can select which Speos simulation should be exported for the simulation →*preselected and mandatory for this tutorial*
12. Optional: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



Ansys

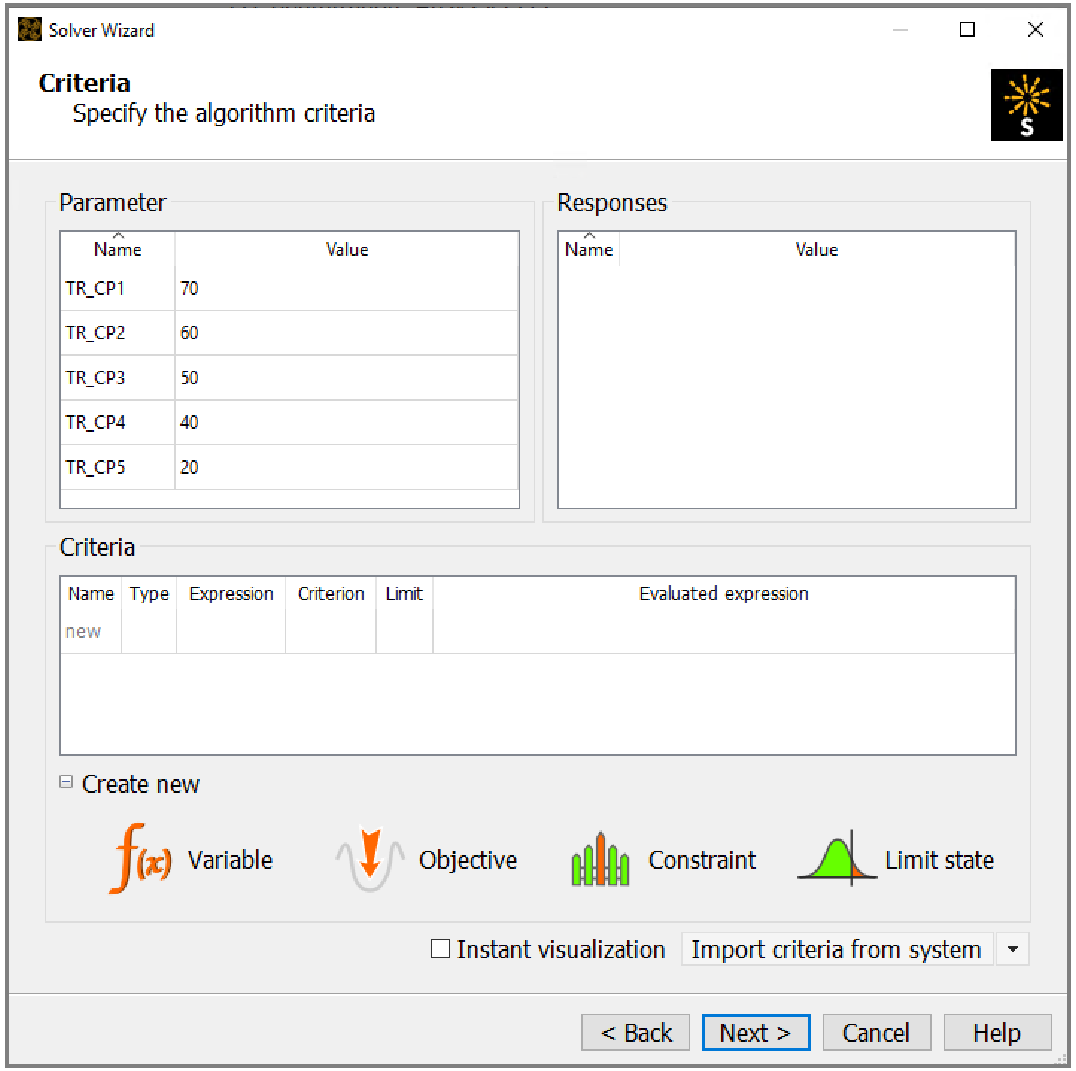
Workflow creation

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



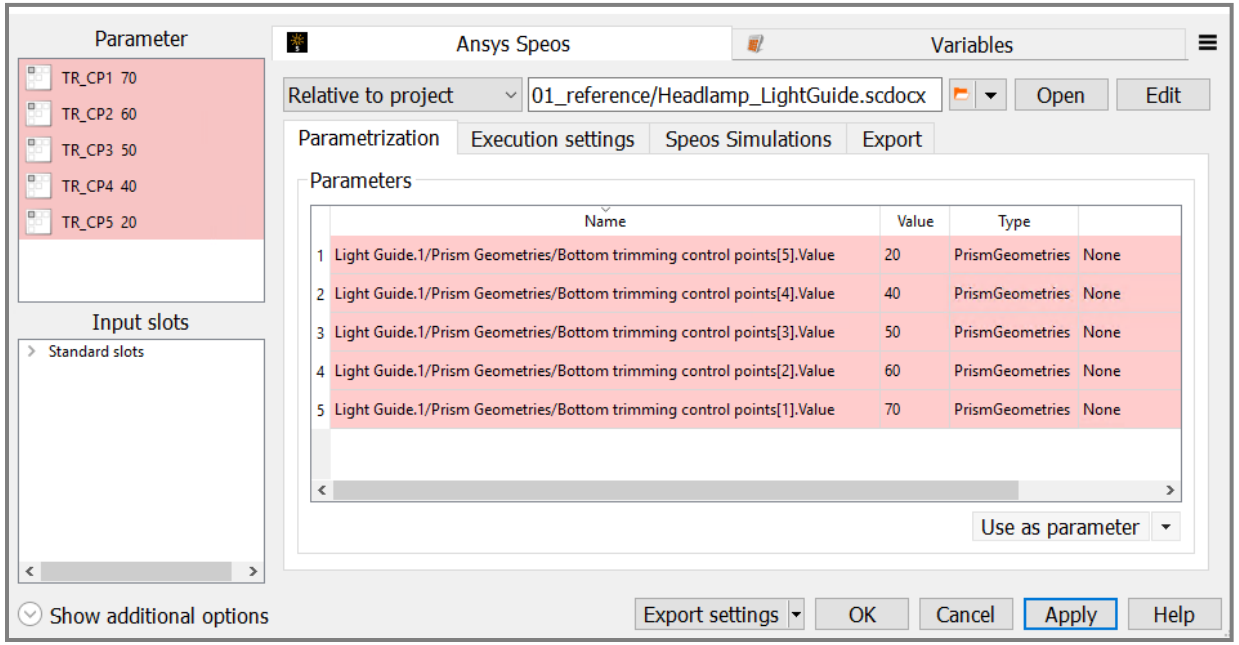
Workflow creation

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:

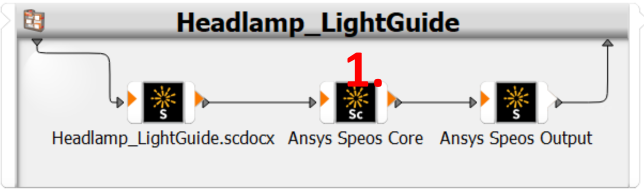


Ansys Speos Node

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

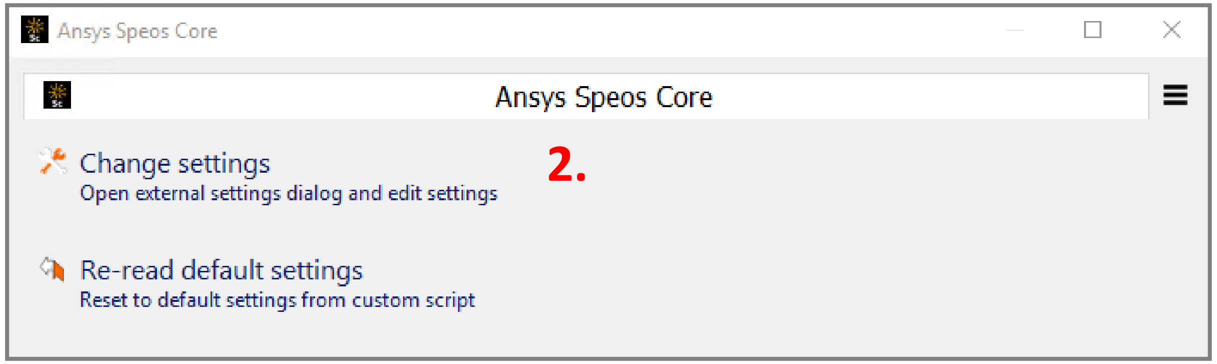


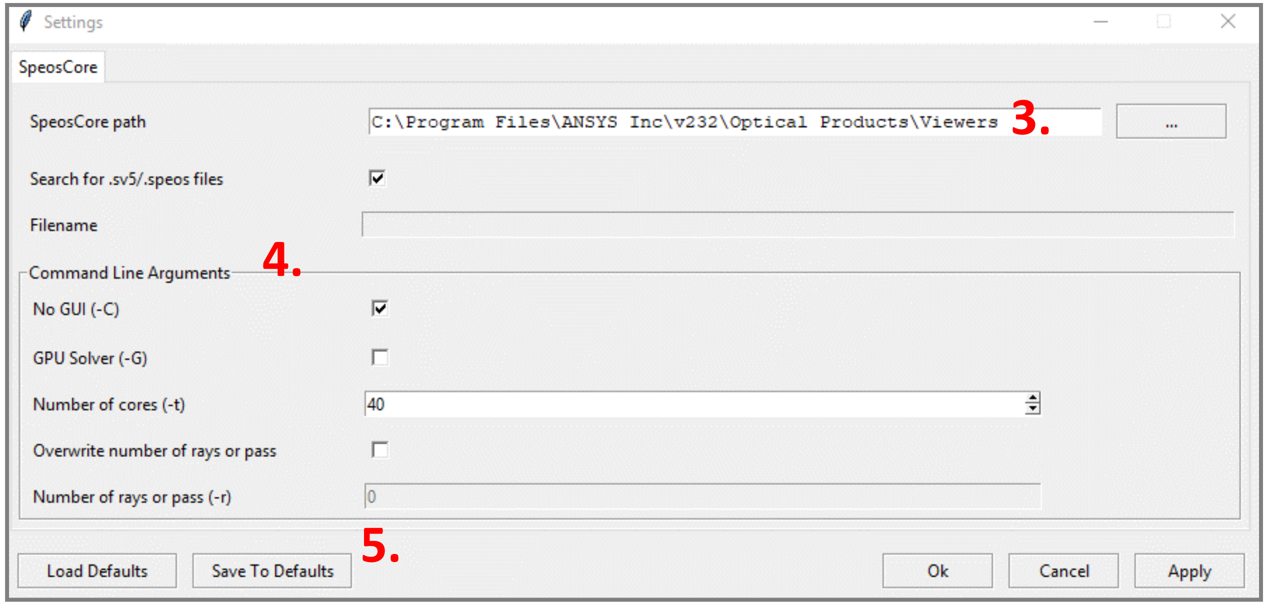
Ansys Speos Core node



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***

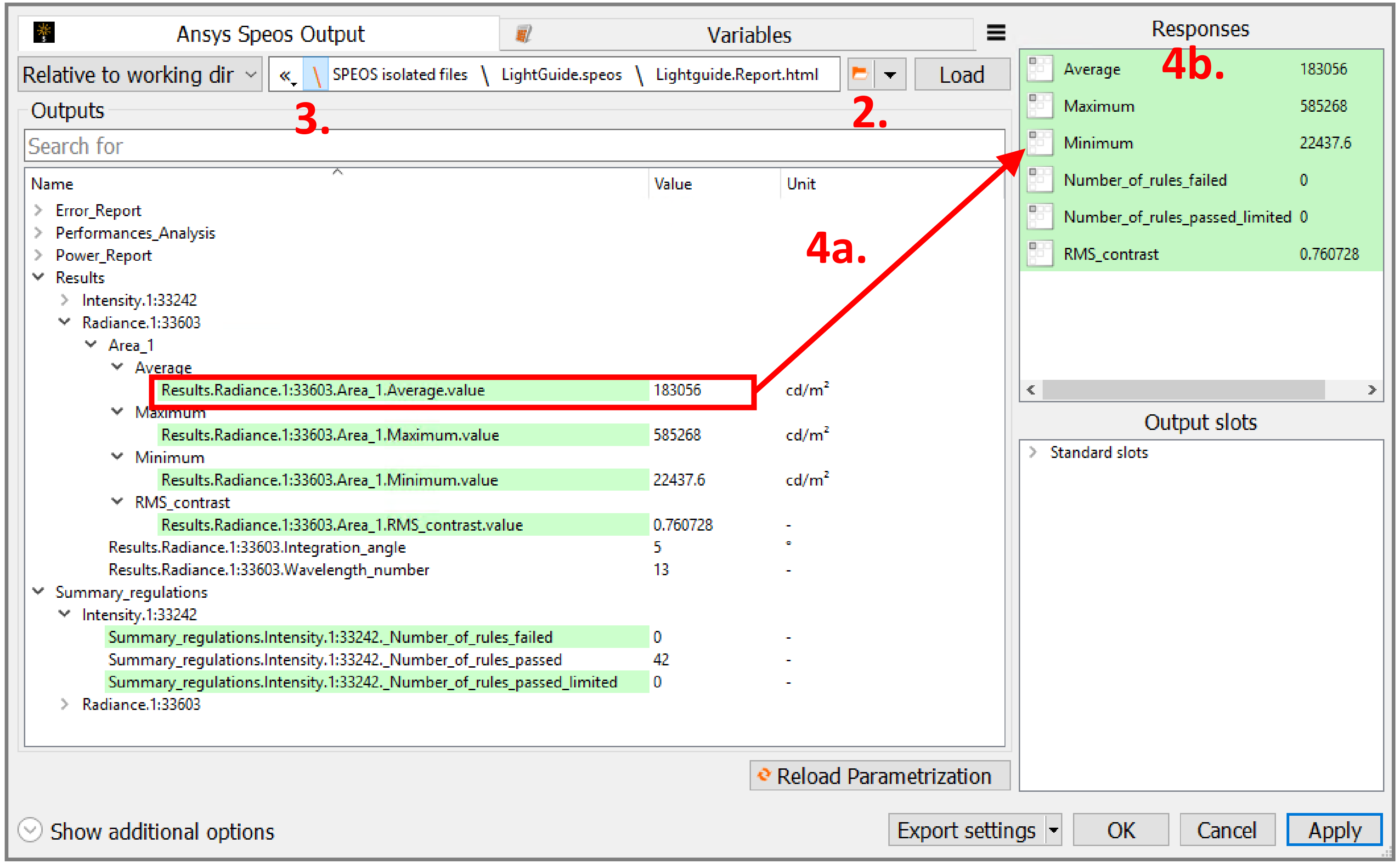




Ansys Speos Output node

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 "**Lightguide.Report.html**" in the reference files folder ("01_reference\SPEOS isolated files\Lightguide.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
5. Click ***Apply*** and ***OK***



Number of failed rules = Number of not passed regulations

Optimization Criteria Definition

In the next step the wizards ask for the optimization criteria definition.

For the **daytime running lamp the optimization goal** is to:

- obtain a **homogeneous lit appearance**
- achieve all **photometric regulations**, consider **national and customer specifications**

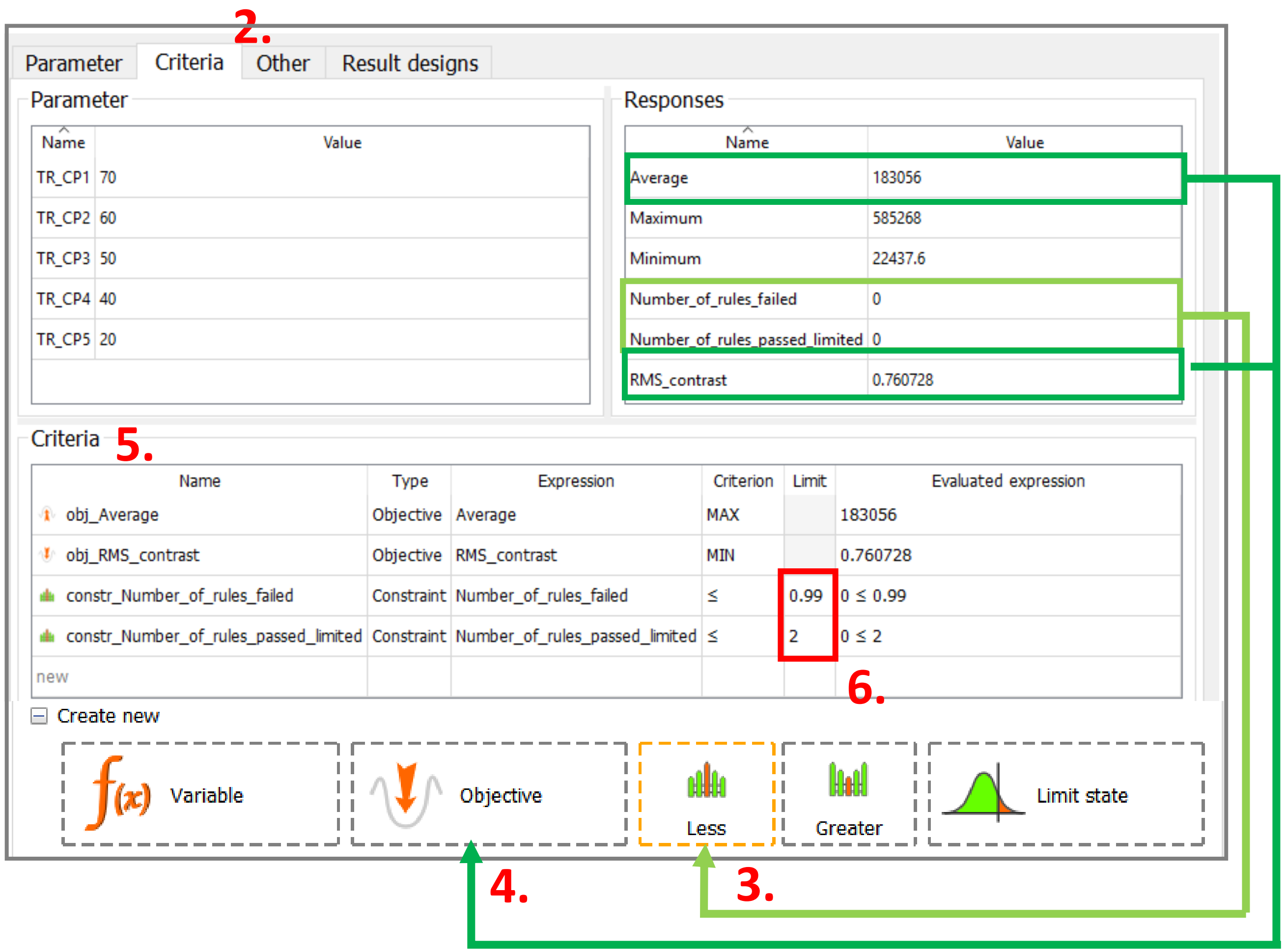
The best practice to achieve this goals is to:

- **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)
- **Constrain the number of failed rules** (not fulfilled regulations) to make sure that the design is compliant with the regulations

Criteria Definition

Define Optimization criteria's as follow:

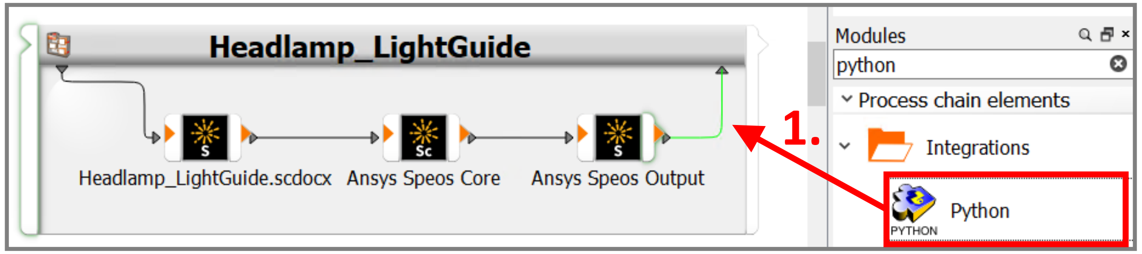
1. Double click on the systems head
2. Go to the ***Criteria*** tab
3. Drag the responses onto the ***Constraint field*** and then ***Less***:
   - "Number_of_rules_failed"
   - "Number_of_rules_passed_limited"
4. Drag the responses onto the ***Objective field***:
   - "RMS_Contrast" (Minimize)
   - "Average" (Maximize)
5. The new criterions appear in the criteria list.
6. Enter the limits for the two constraints: *(allow two not fulfilled customer specification and zero not fulfilled national regulation)*
7. Click ***Apply*** and ***OK***



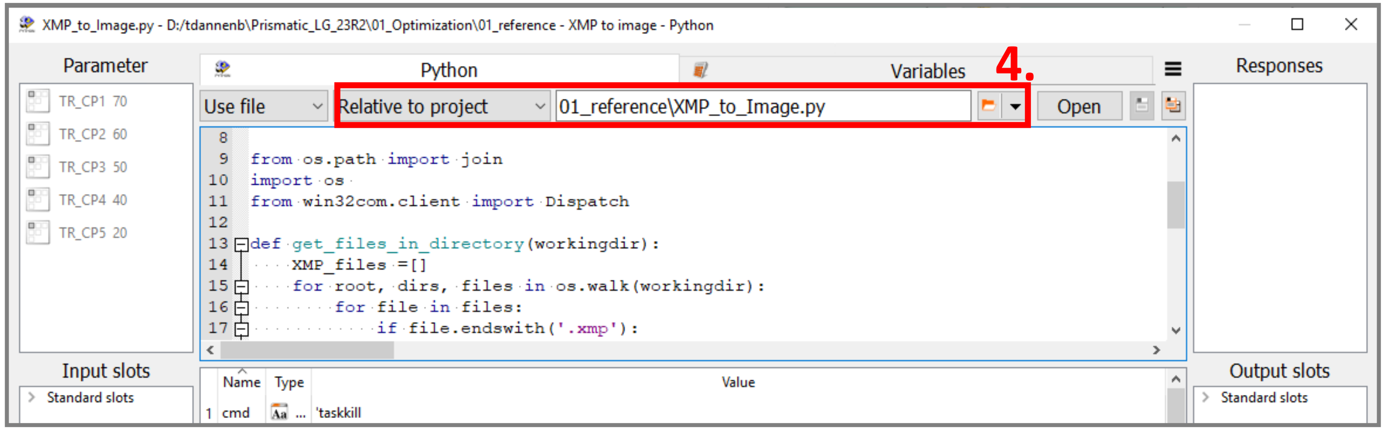
workflow extension

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

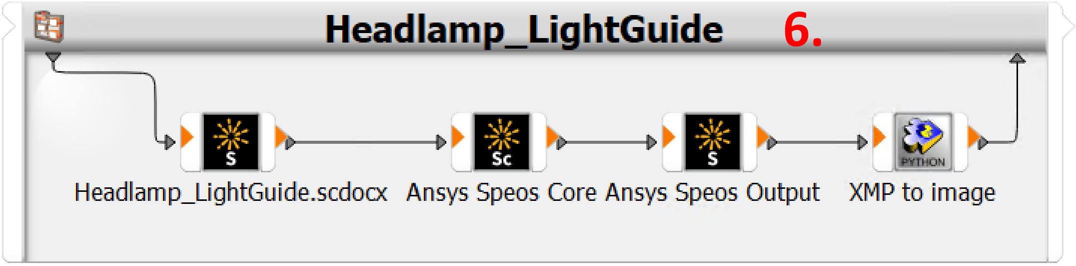


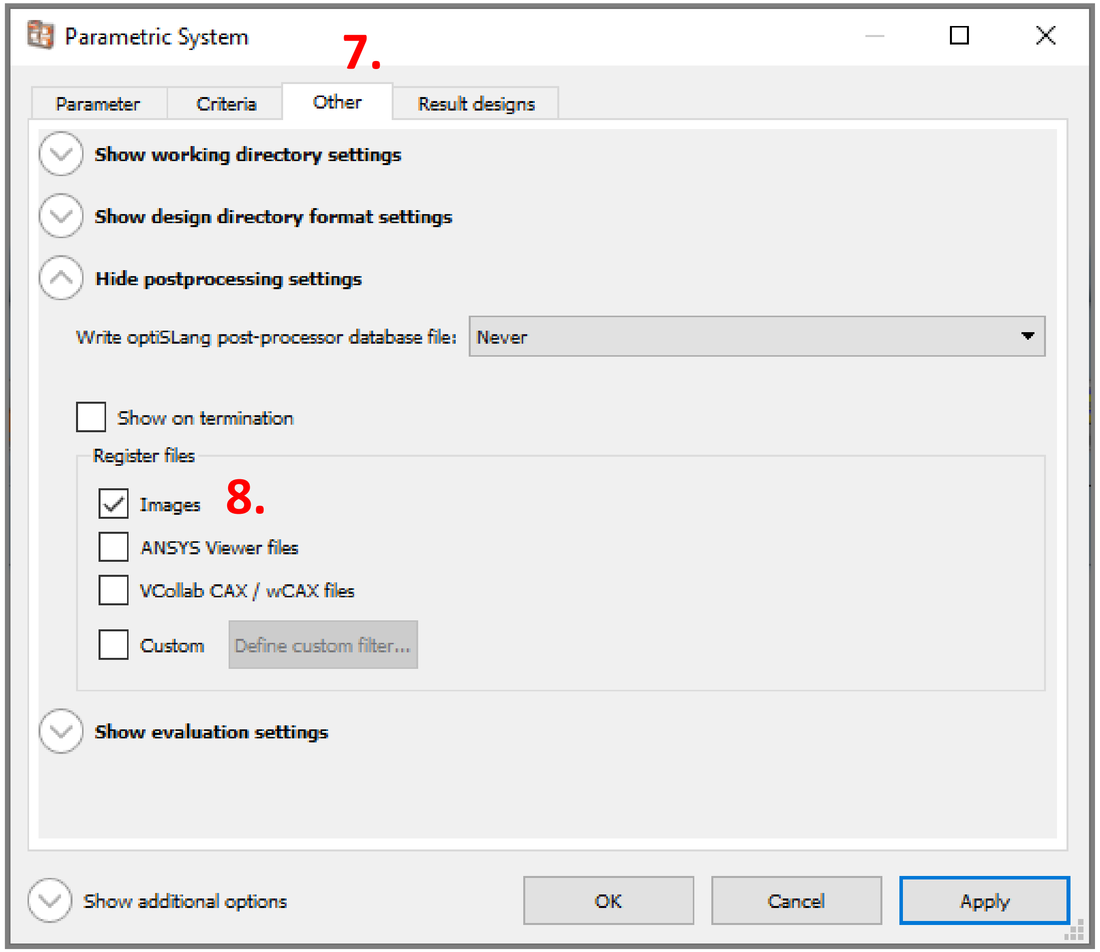
2. Rename the Python-node with F2 to "XMP to image"
3. ***Double-click*** on the Python-node
4. **Browse** for the Python script „XMP_to_Image.py" in the reference files folder ("01_reference")
5. Click ***Apply*** and ***OK***



workflow extension

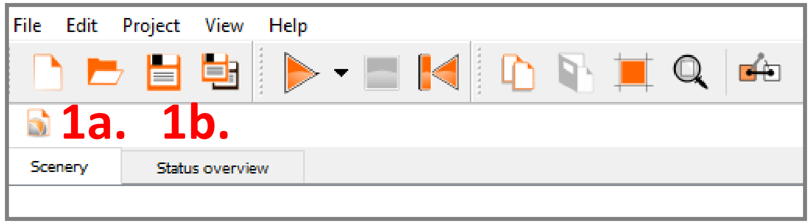
6. ***Double click*** on the systems head
7. Go to the ***Other*** tab
8. Change the postprocessing settings to import the images into the optiSLang Postprocessing automatically
9. Click ***Apply*** and ***OK***





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



Headlamp_LightGuide - Parametric System **3.**

Parameter | Criteria | Other | Result designs

	Id	Feasible	Duplicates	Status	TR_CP1	TR_CP2	TR_CP3	TR_CP4	TR_CP5	Average	Maximum	Minimum	Number_of_rules_failed	Number_of_rules_passed_limited	RMS_contrast	obj_Average	obj_RMS_contrast	constr_Number_of_rules_failed	constr_Number_of_rules_passed_limited
1	0.1	true		Succeeded	70	60	50	40	20	181405	606946	18168	0	0	0.761682	181405	0.761682	0 ≤ 0	0 ≤ 0.99

NOTE: If the Python node fails, please check the troubleshooting 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 message appears in the optiSLang message log:

```
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

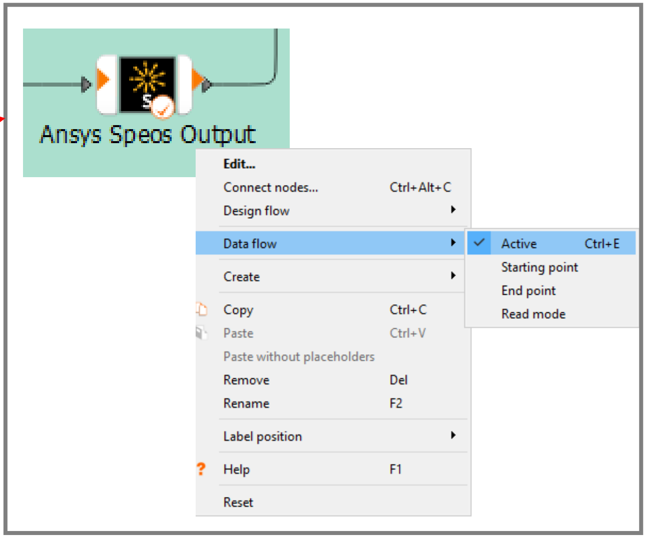
Troubleshooting: Ansys Speos Output node

- **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



Ansys

Troubleshooting: Solver Noise

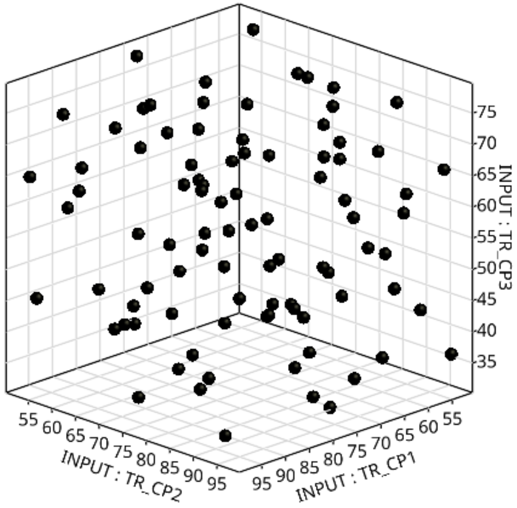
- For variation analysis like Optimization, it is important to have a high simulation quality in order to minimize the solver noise. Small Solver noise means that if the same simulation is executed multiple times, the scattering of the output values should be small.
- To ensure a high simulation quality and a good prediction for the optimization the maximum difference between the output values should be less than about 5%.
- You could improve the simulation quality e.g., by increasing the number of rays

- Optional: There is an **easy solution to fast check the solver noise** within optiSLang. How to do is shown in the Appendix at the end of the presentation in the section "Check Solver Noise"

Sensitivity Analysis

What is a Sensitivity Analysis?

The Sensitivity Analysis in optiSLang creates **a design of experiments based on the given parameter ranges of the input parameters**. The sampled designs are well distributed in the parameter space. The designs are automatically evaluated through the Speos workflow.

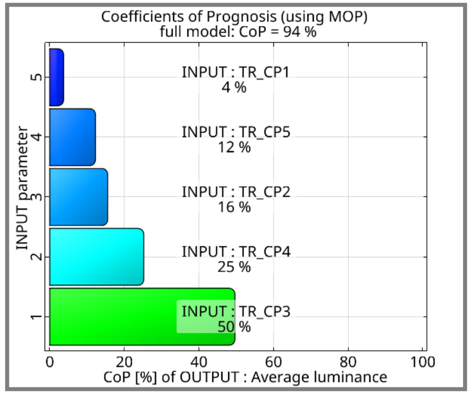


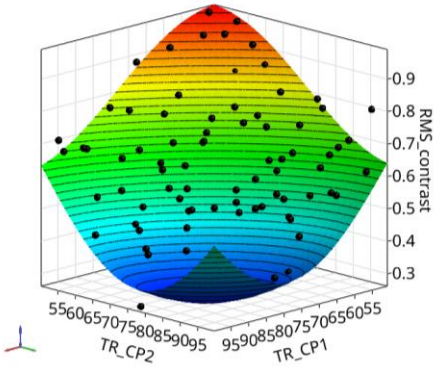
The Sensitivity Analysis will give you a high design understanding:

- **Identifies all important input parameters** that have an impact on the device response
- **Creates Metamodel with best prediction** of the system behavior for a fast and efficient design optimization
- **Reduces optimization complexity** for the optimization task by considering only the important parameter

Typical questions that can be answered:

- *"Which screws do I have to turn to improve the optical performance?"*
- *"In which parameter range are the best designs?"*
- *"Where are my requirements / constraints met?"*
- *"Are my optimization metrics in conflict with each other?"*
- *"What is the variation range of my optical performance?"*

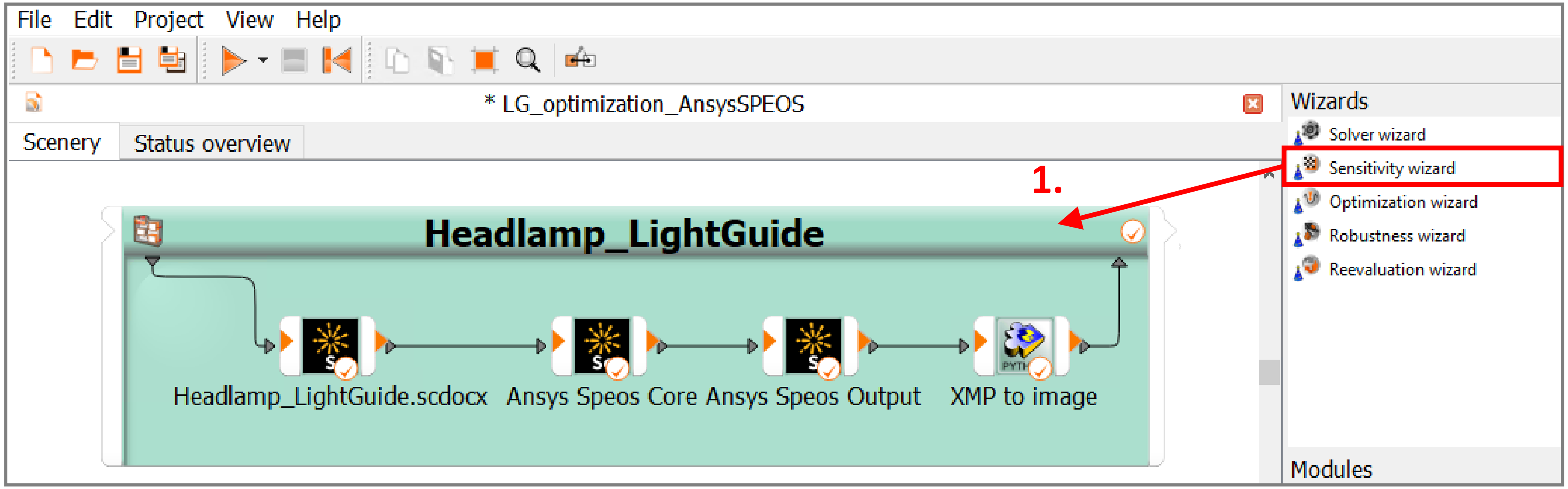




Setup Sensitivity Analysis

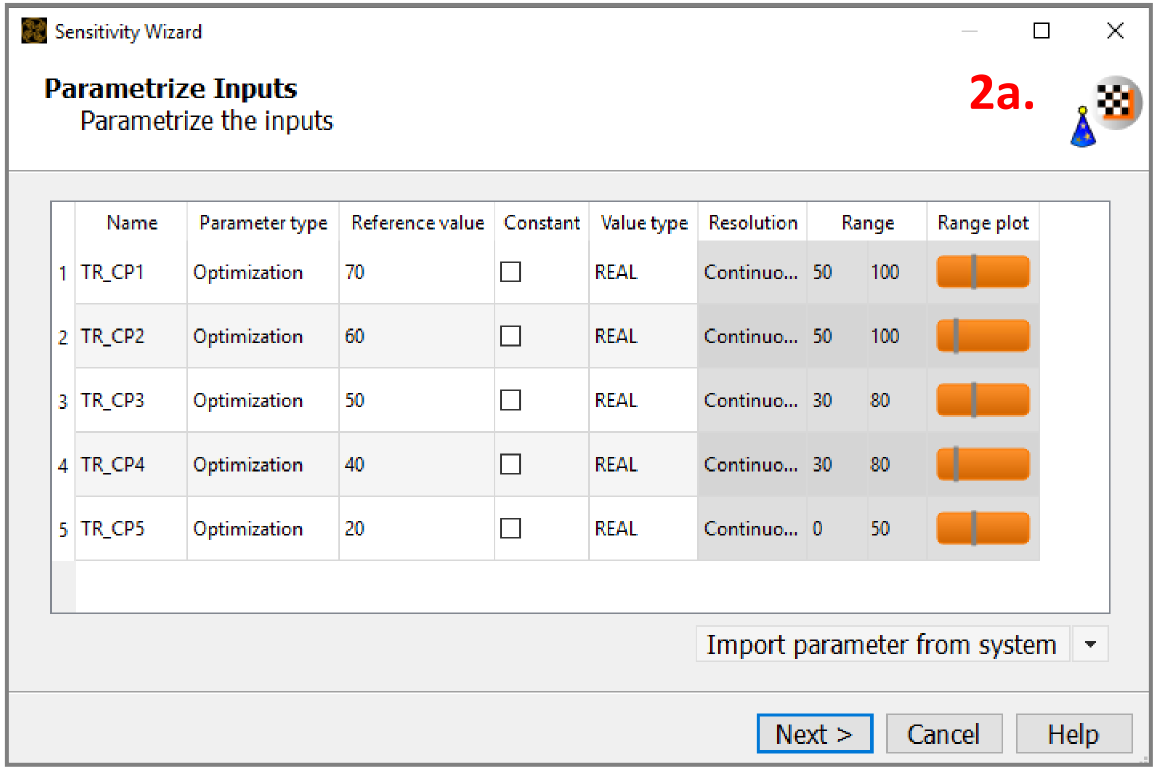
How to setup a Sensitivity Analysis and how to interpretate the results is shown in the following section:

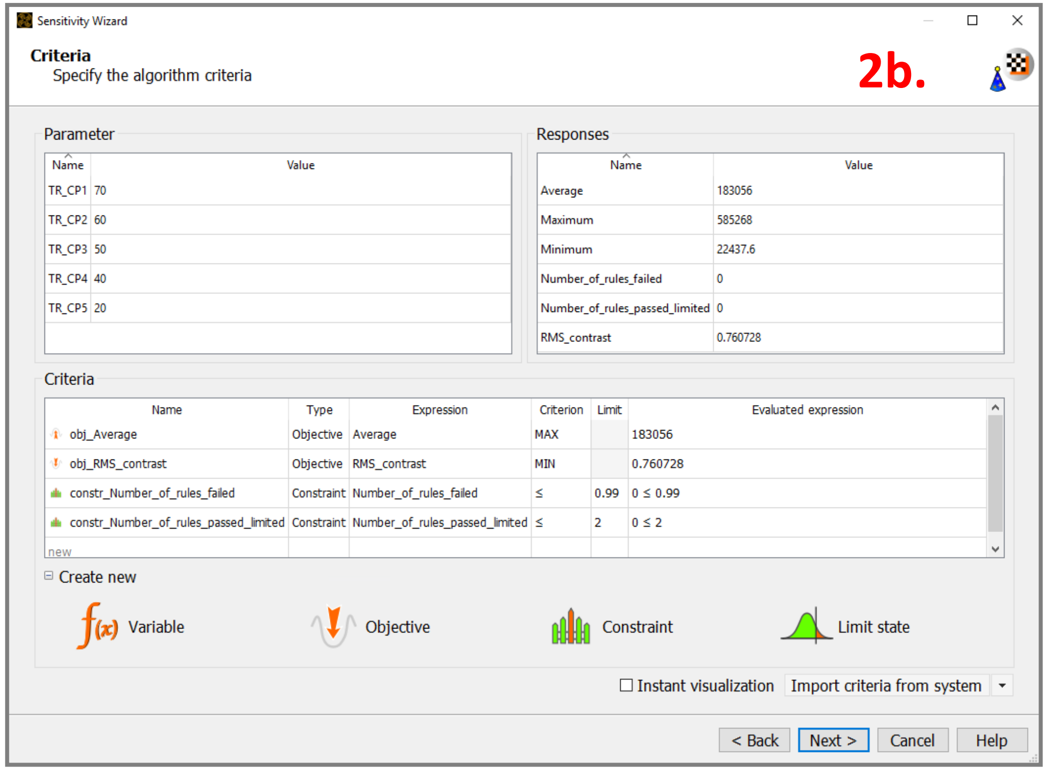
1. Drag the **Sensitivity wizard** onto the head of the solver chain



Setup Sensitivity Analysis

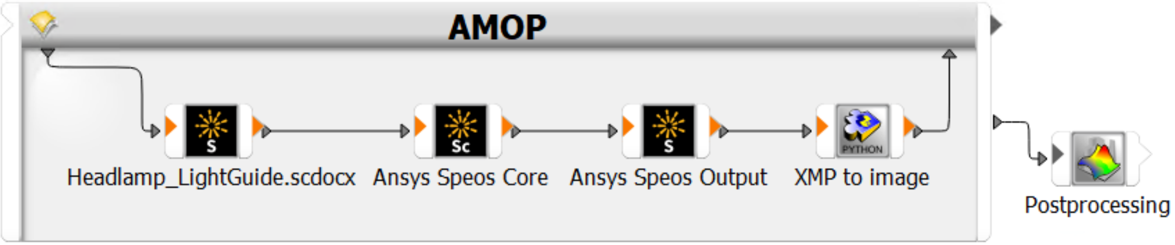
2. Keep the ranges and criteria (click **Next**)

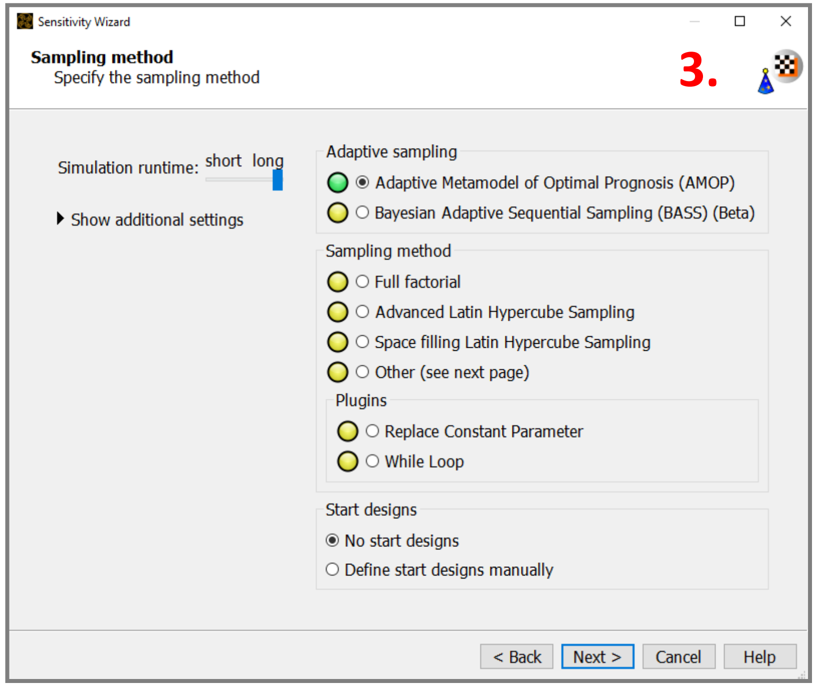


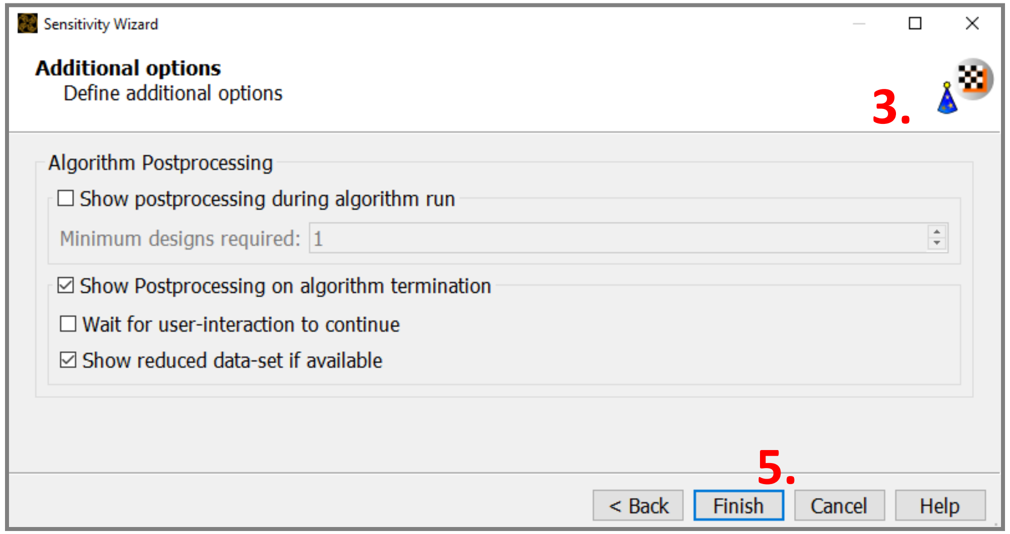


Setup Sensitivity Analysis

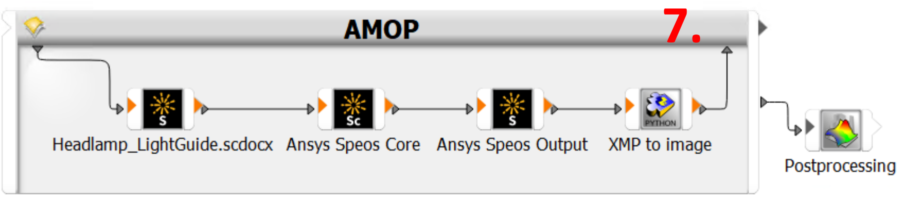
3. Keep the recommended sampling method
4. Keep the default postprocessing settings
5. **Finish** the wizard
6. The sensitivity system **AMOP** will be created automatically:







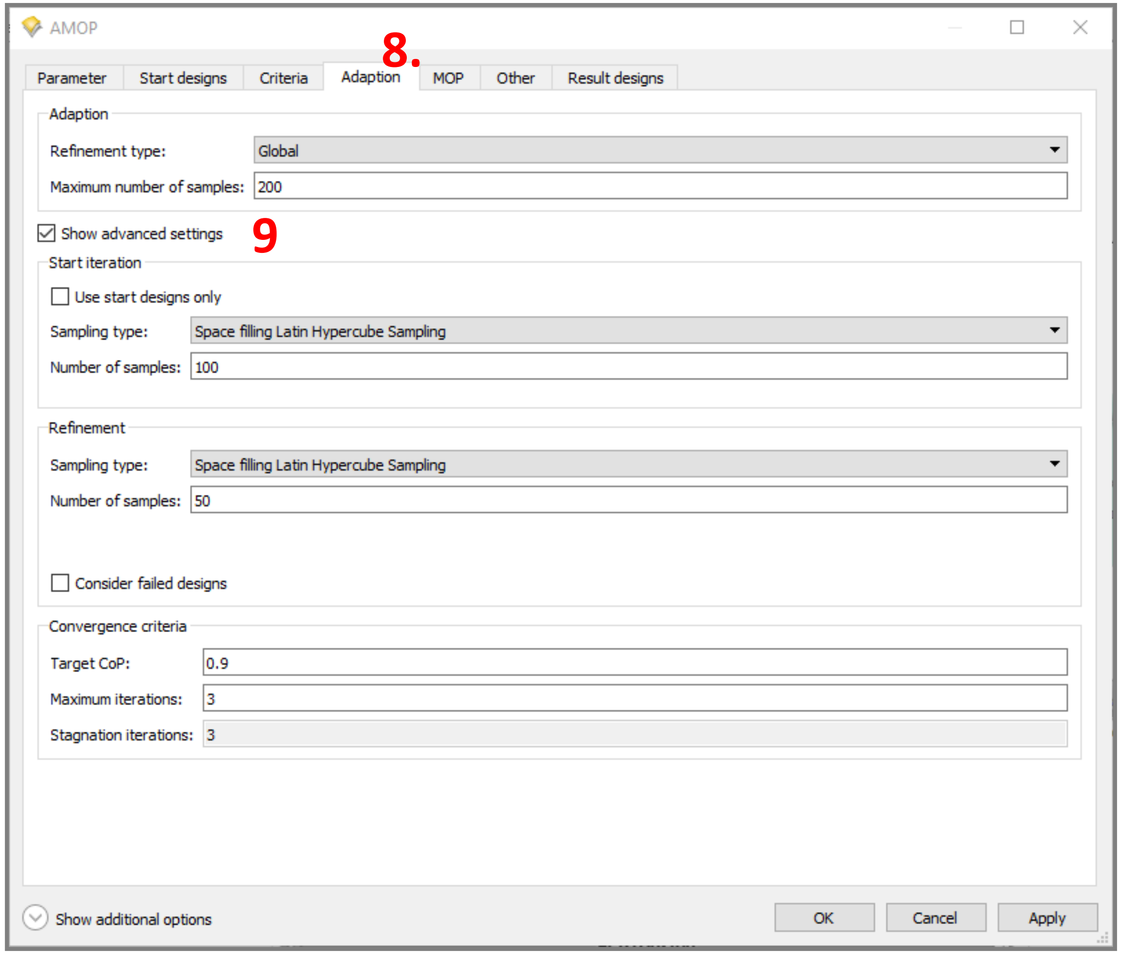
Setup Sensitivity Analysis



Optional: Possibility to change the number of created designs (samples)

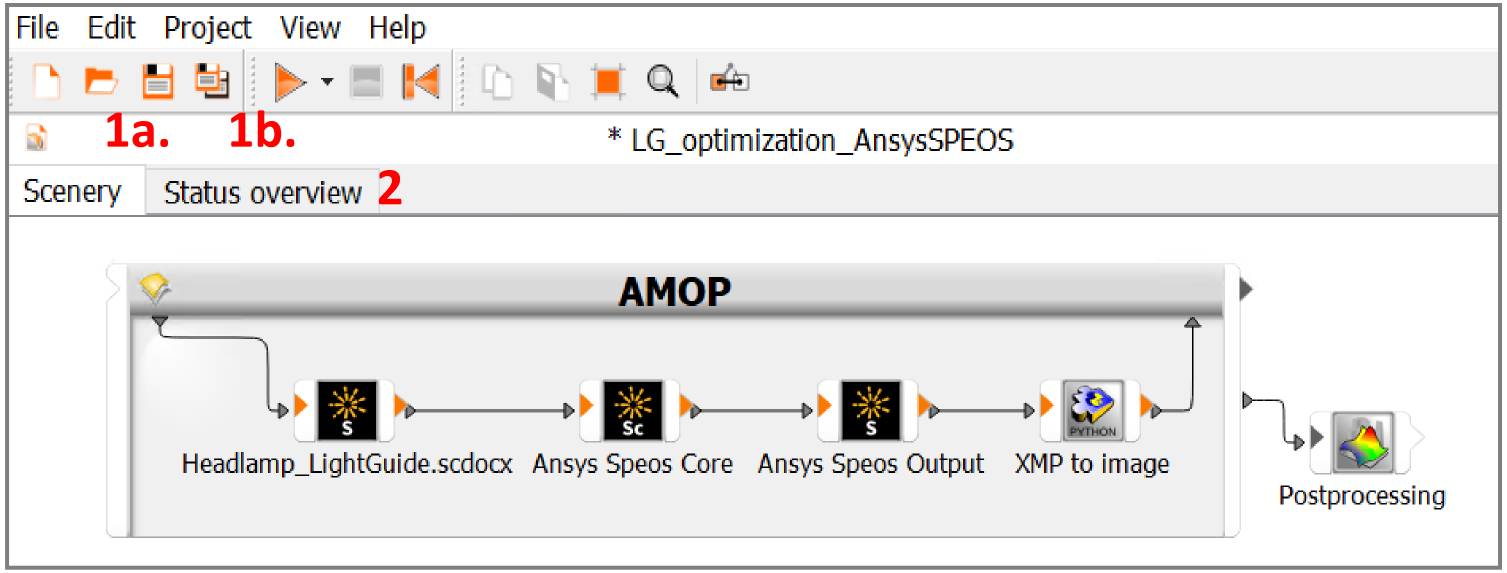
- default = maximum 300 designs
- recommended minimum = 100

7. Open the **AMOP** by **double click** on the systems head
8. Go to the **Adaption** Tab
9. Set **Number of samples** for refinement to 50
10. Press **Apply** and **OK**



Start Sensitivity Analysis

1. Save and execute the project
2. Click on **Status overview** to check the progress for each design
3. **Double click** on the **AMOP** and go to **Result designs** tab to view the results of designs that have already been run



→ Wait until the analysis is ready

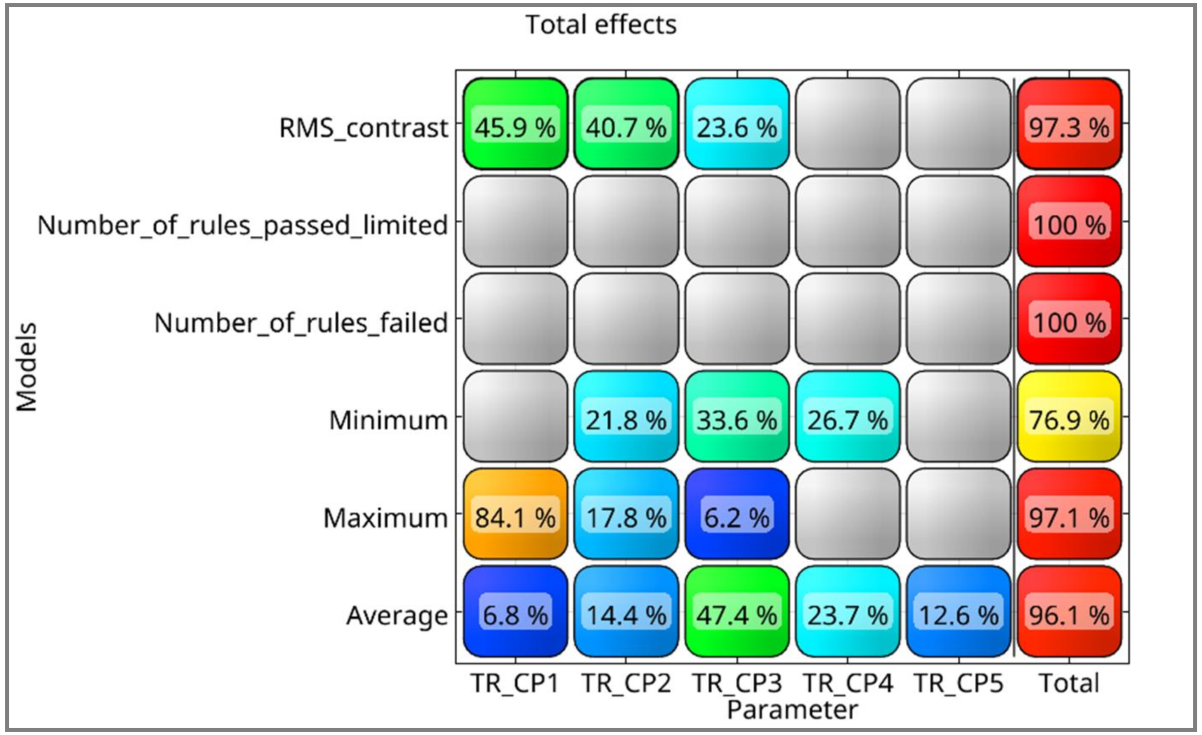
→ The optiSLang postprocessing will open automatically
(alternative, please right click on “AMOP” and click on “Show Postprocessing”)

Sensitivity Analysis - Postprocessing

The results of the Sensitivity Analysis are shown in the optiSLang post processing window:

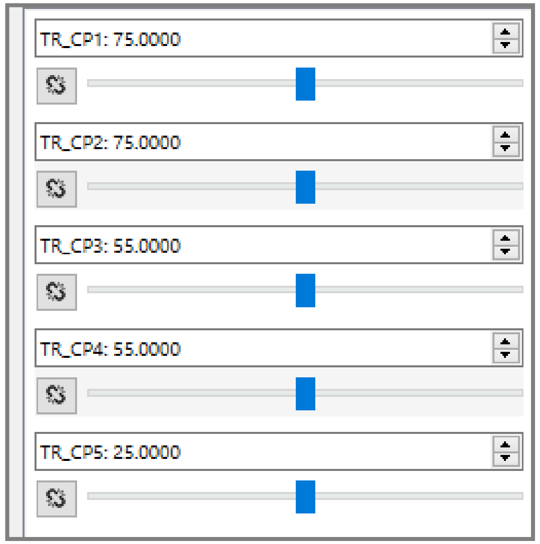
- The main concern when working with **metamodels** is the **prediction quality on how good the model is able to predict the outputs based on new given input values**. optiSLang catches this in the Coefficient of Optimal Prognosis, short COP.

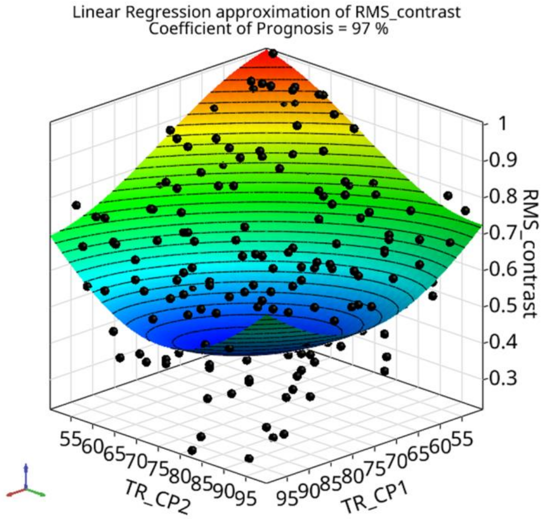
  - The best way to review the sensitivity study is to review the COP matrix. **The COP matrix shows:**
    - **that all responses are well predicted** (shown in the column **Total**)
    - the **importance of the input parameters to the responses.**
  - Since the prediction quality is high for average and RMS contrast, the metamodels can be used to optimize for homogeneity and average luminance.



Sensitivity Analysis - Postprocessing

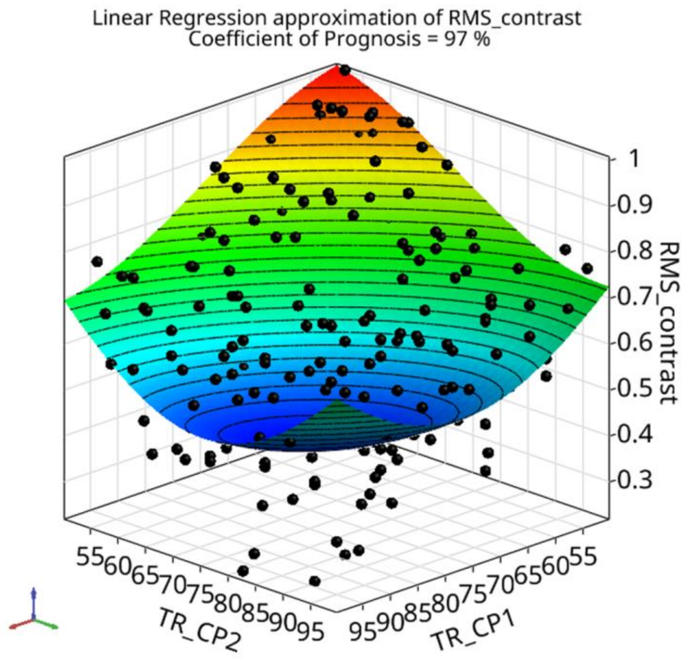
- Clicking on one of the **Total** values in the COP-Matrix shows the corresponding Metamodel of Optimal Prognosis (MOP) in the **Response Surface 3d plot**
- The **MOP approximates the response as function of all important input parameters**. This plot is the representation of the Metamodel based on the two main contributors and the remaining ones are set to a fixed value. By using the sliders you can see the influence of the other dimensions.
- **The MOP shows the variation of the responses based on the variation of the input parameters**

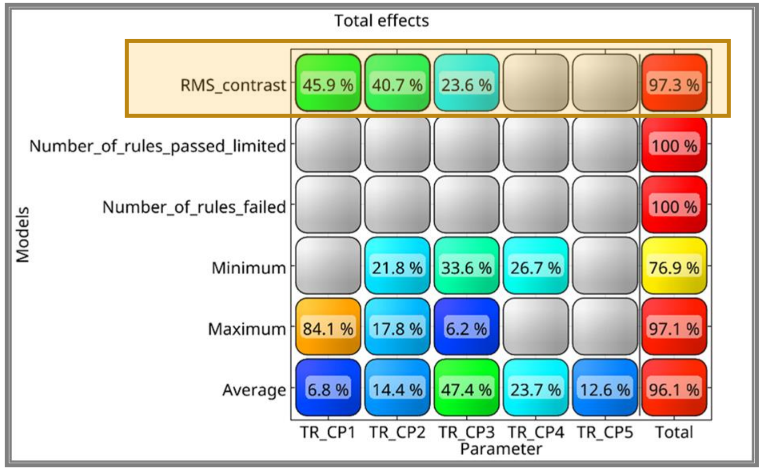




Sensitivity Analysis - Postprocessing

- The approximation quality is excellent for RMS-contrast (97 %).
- The most important inputs for RMS-contrast are trimming ratio at control point 1 and control point 2
- The trimming ratios at control point 4 and 5 have a negligible impact.
- A non-linear dependency of the trimming rations to the RMS-contrast can be identified.

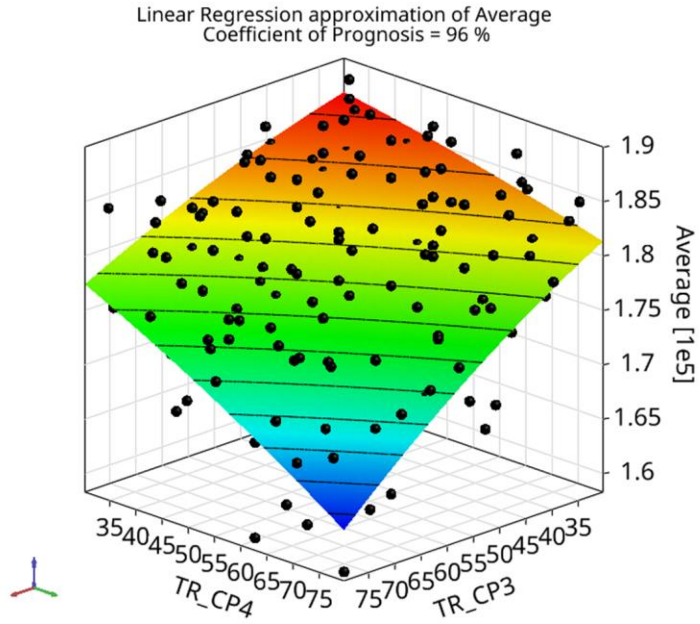


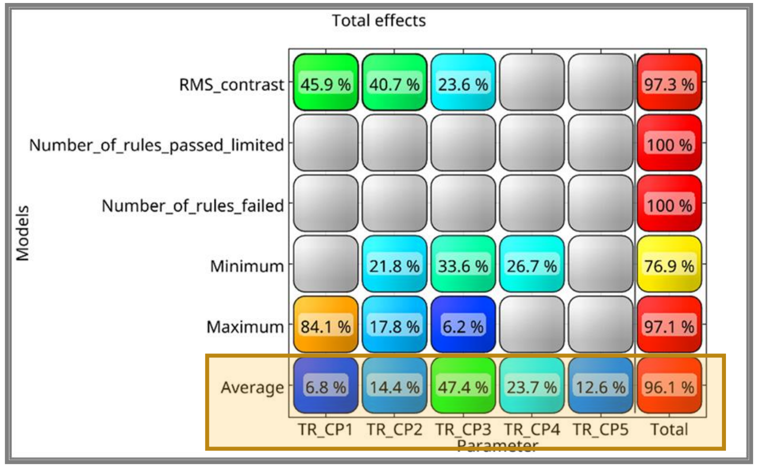


Ansys

Sensitivity Analysis - Postprocessing

- The approximation quality is excellent for average luminance (96 %).
- The most important inputs for average luminance are trimming ratio at control point 3 and control point 4
- All trimming ratios have an influence on the average luminance.
- A slightly non-linear dependency of the trimming ratios to the average luminance can be identified.





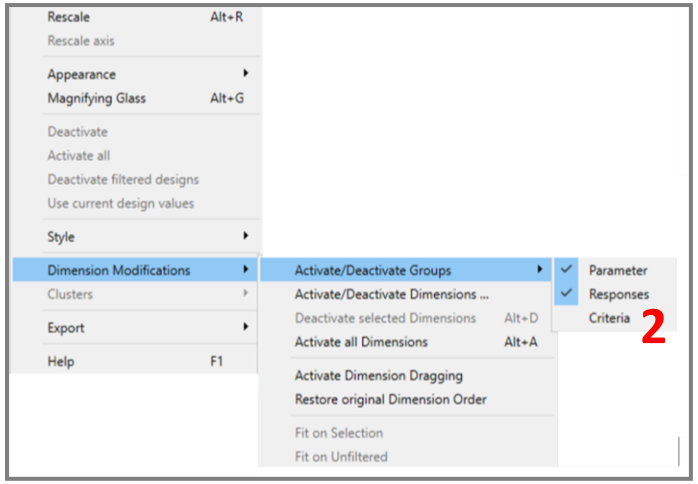
Ansys

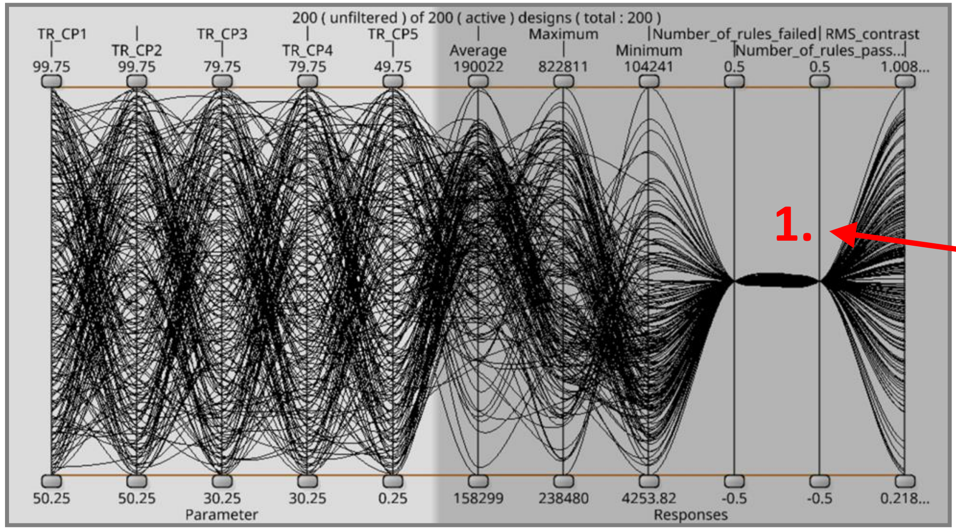
Sensitivity Analysis - Postprocessing

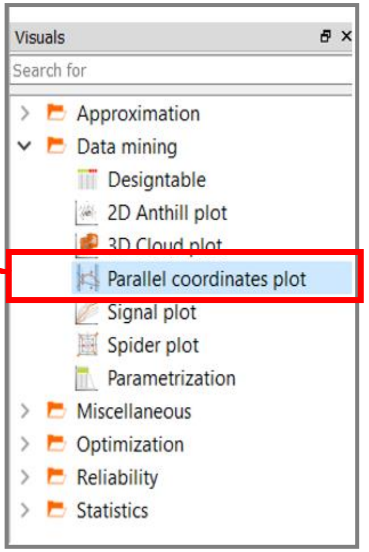
Optional: Increase your design understanding by the help of the **Parallel coordinates plot** (PCP). This plot helps you to **identify parameter ranges that lead to good designs** and **identifies trade offs** between your objectives.

1. Drag the **PCP** into the Postprocessing scenery
   (to be found under **Visuals** on the right side of the Postprocessing window)

2. Optional: **Right click** in the PCP and deactivate **Criteria** to have a better overview



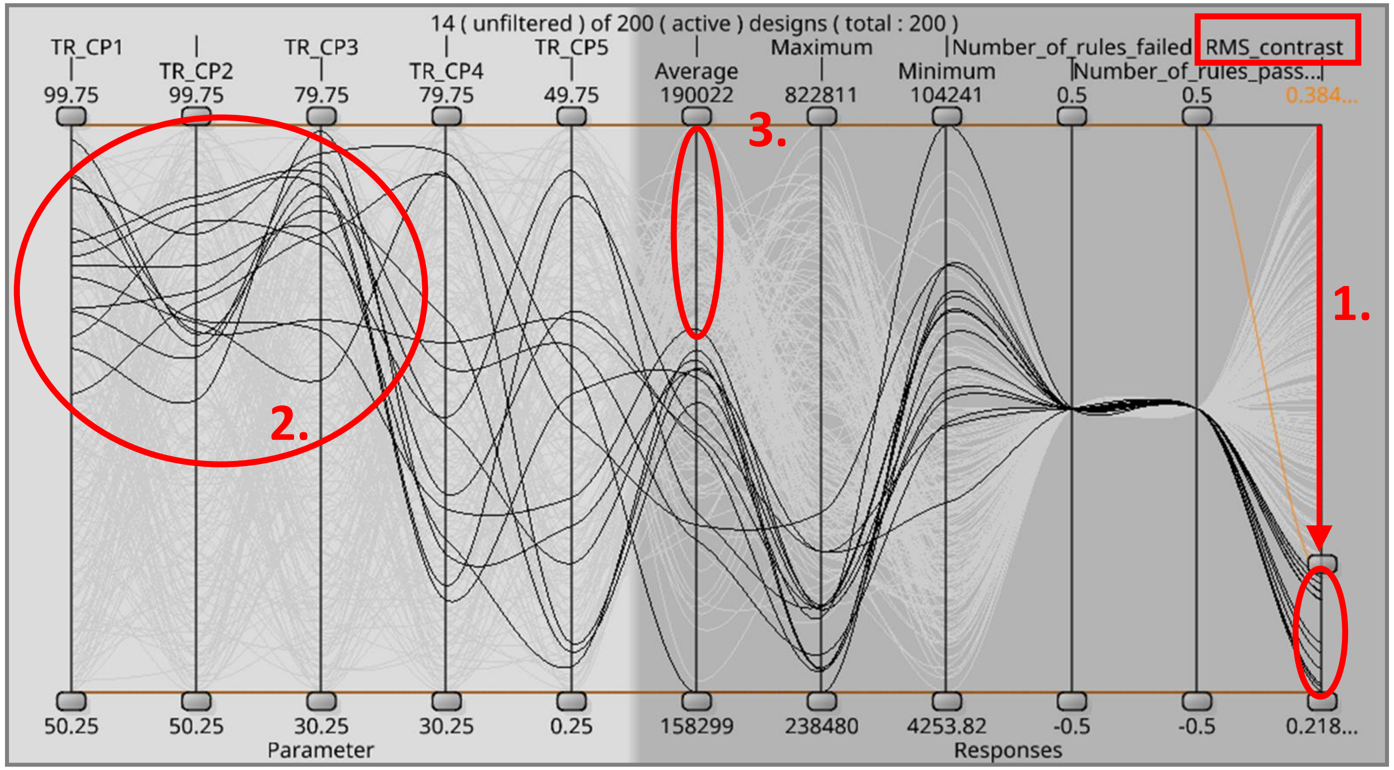




Sensitivity Analysis - Postprocessing

In the PCP, each line is one design. Each column is an input parameter or response or criteria.

1. Move down the slider for RMS-contrast to filter for designs with a low value for RMS contrast
2. Identify the ranges of the input parameters that lead to a low RMS-contrast
3. 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**



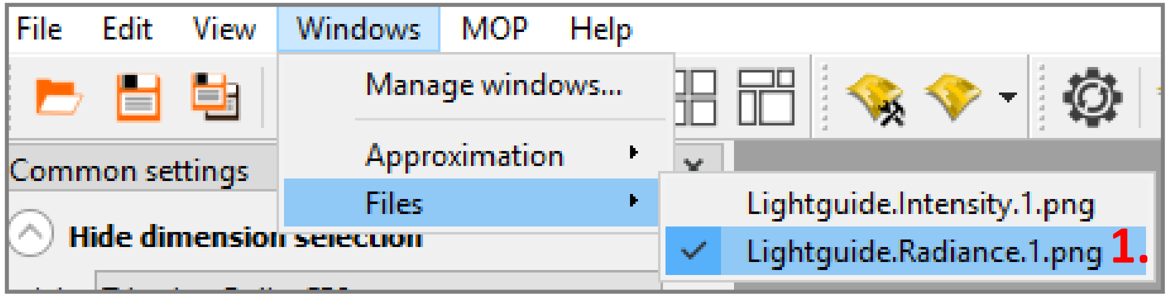
Ansys

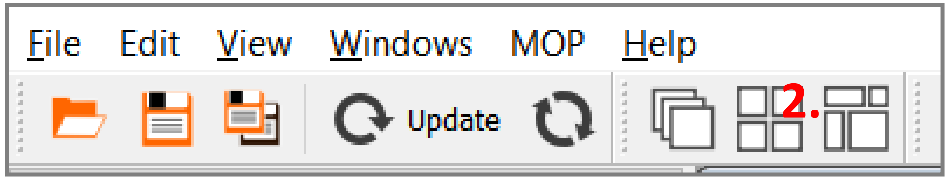
Sensitivity Analysis - Postprocessing

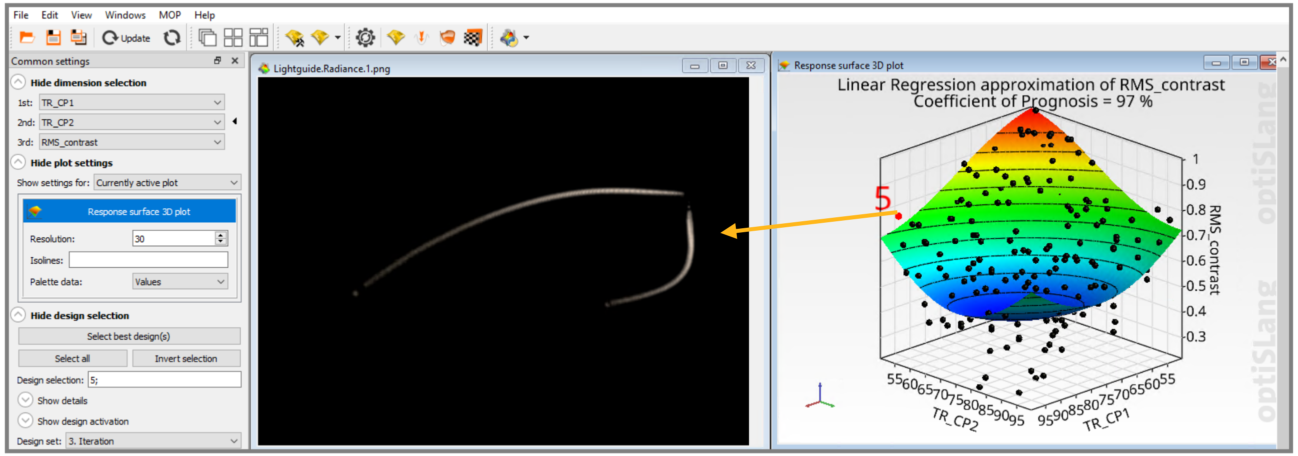
Optional: Increase your design understanding by adding the result plot

1. Click **Windows → Files → Lightguide.Radiance.1.bmp**, 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 in the **Response Surface 3D plot**
- Check physical phenomena appearing in the design space







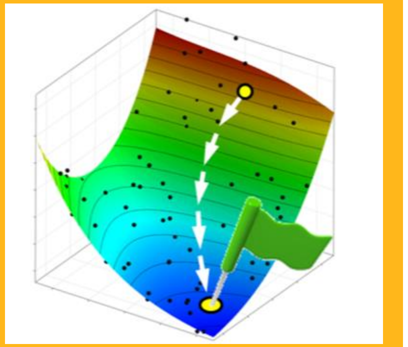
Design Optimization

Ansys

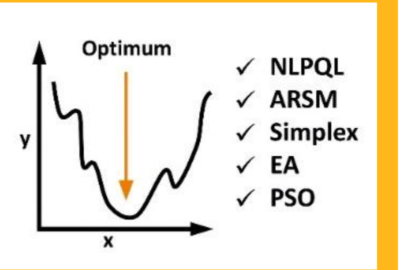
Recommended Optimization-Strategy

- The **recommended strategy for a Multi-objective optimization** is to
  1. perform a **multi-objective pre-optimization based on the metamodels**
     - **very fast optimization in order to find the pareto front**
     - the pareto front shows us the capabilities of the design and the possible tradeoff within the defined design space
     - global search approach
  2. Perform a **single, direct objective optimization, converting all except one objective to constraints** and define values for the constraints which are acceptable
     - can lead to a further improvement of the optical performance
     - local search approach by defining start designs with best designs identified by the multi-objective optimization on the Metamodel
     - Provides only one best design

Optimization using MOP



Direct optimization with algorithms



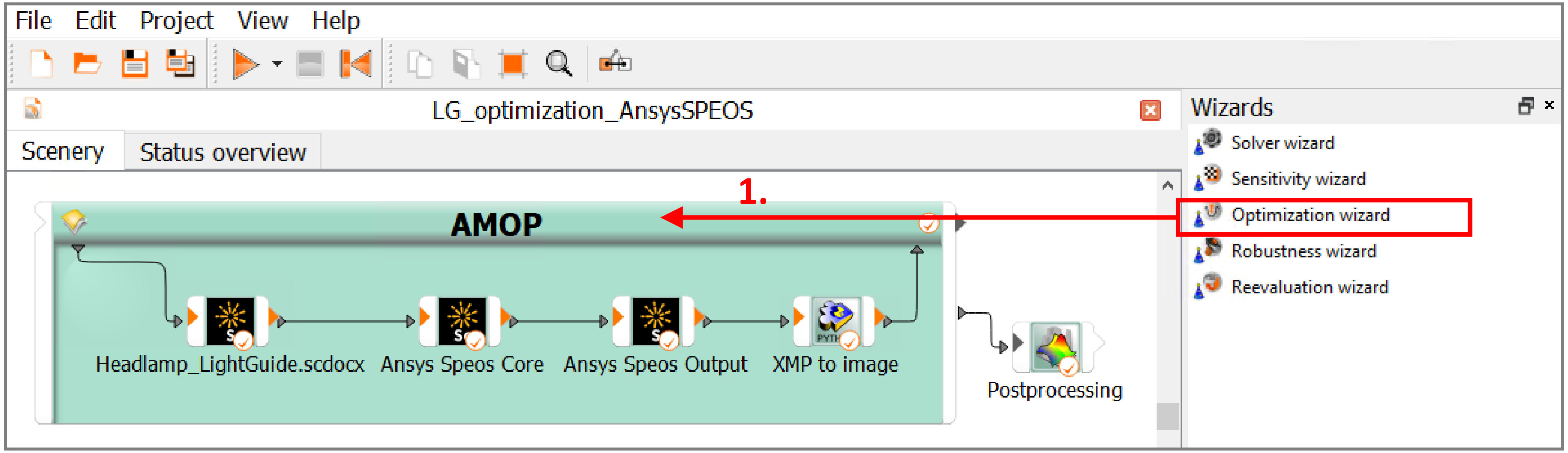
Multi-objective Optimization on Metamodel of Optimal Prognosis (MOP)

Ansys

Setup Optimization Workflow

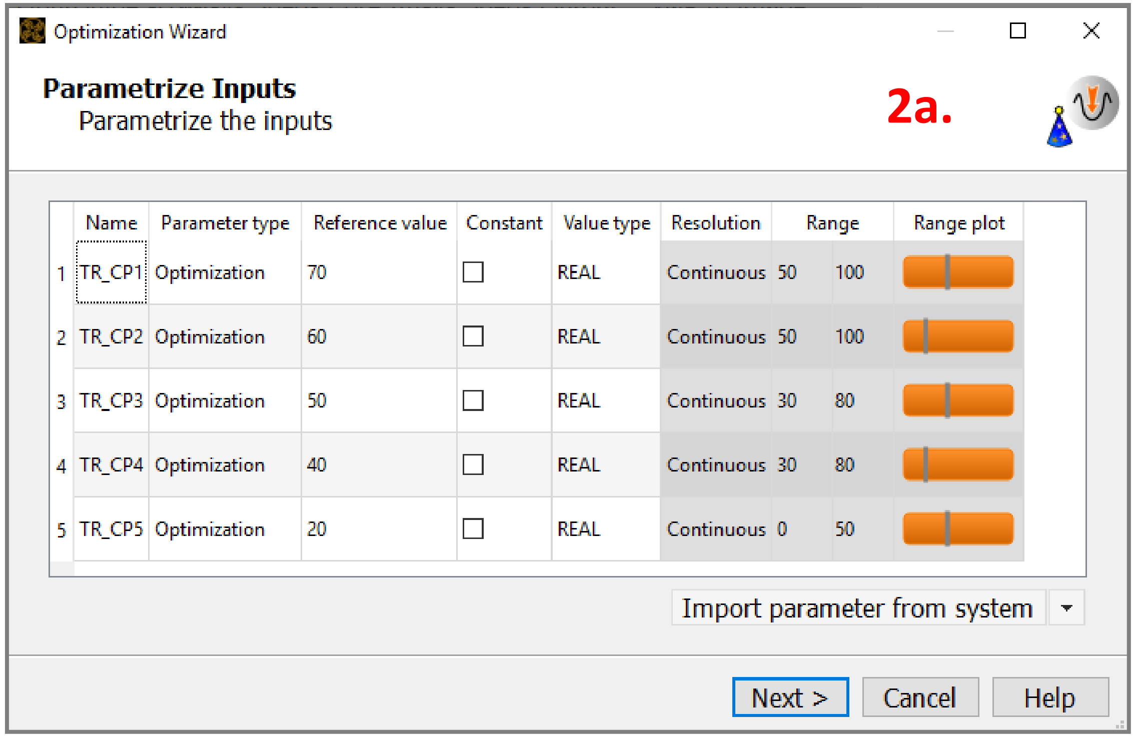
How to use the MOP for a fast design optimization is shown in the following section:

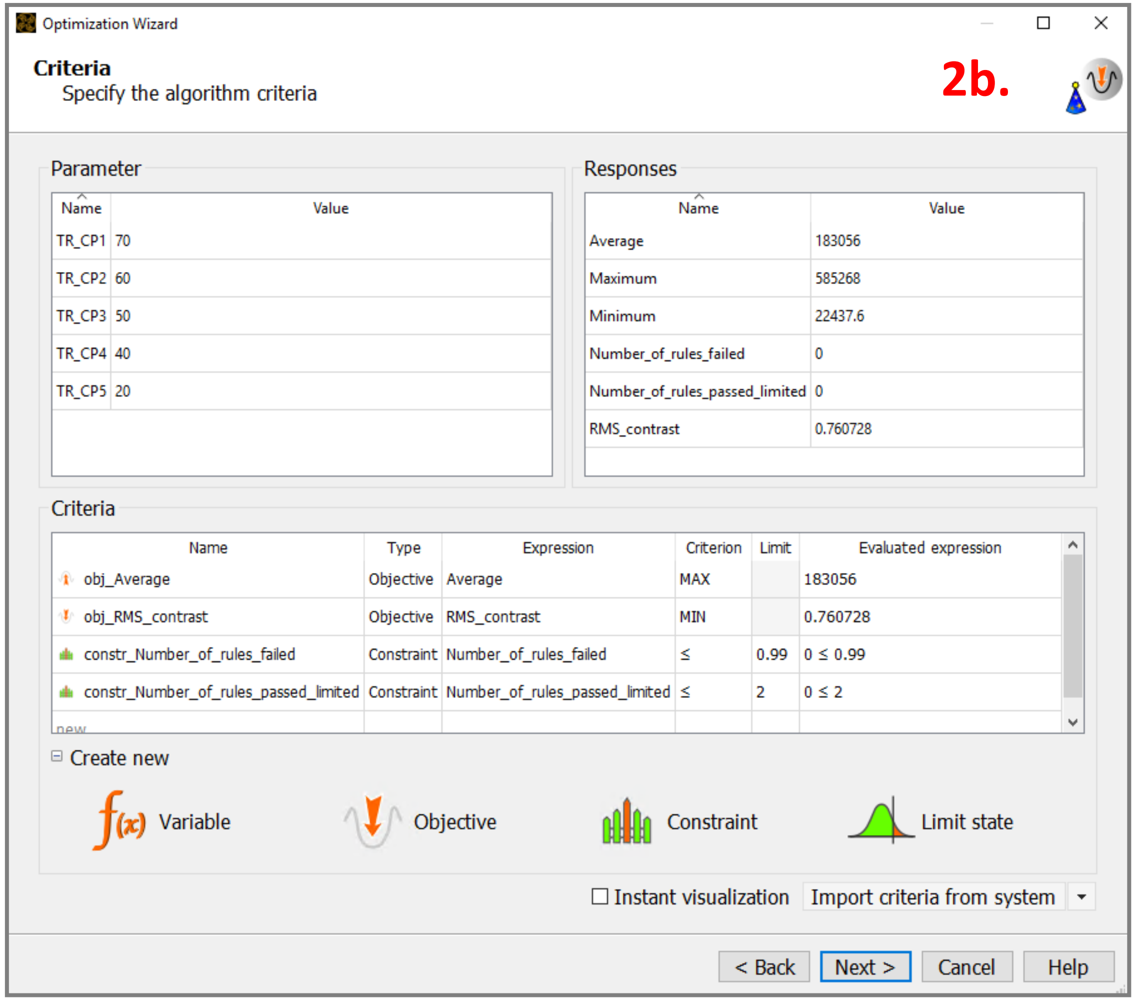
1. Drag the **Optimization wizard** onto the head of the sensitivity system



Setup Optimization Workflow

2. Keep the parameter ranges and criteria definition (Click **Next**)





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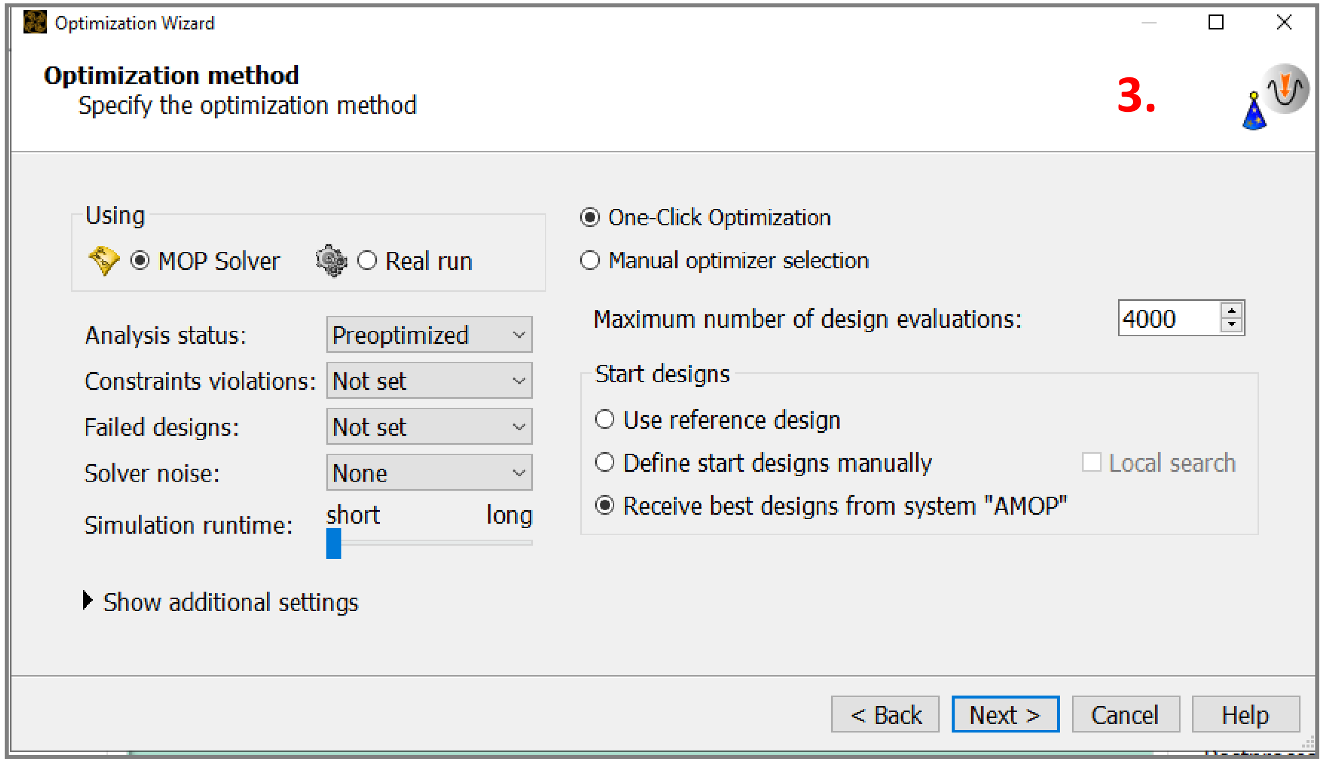
Setup Optimization Workflow

3. Keep all default optimization settings like:

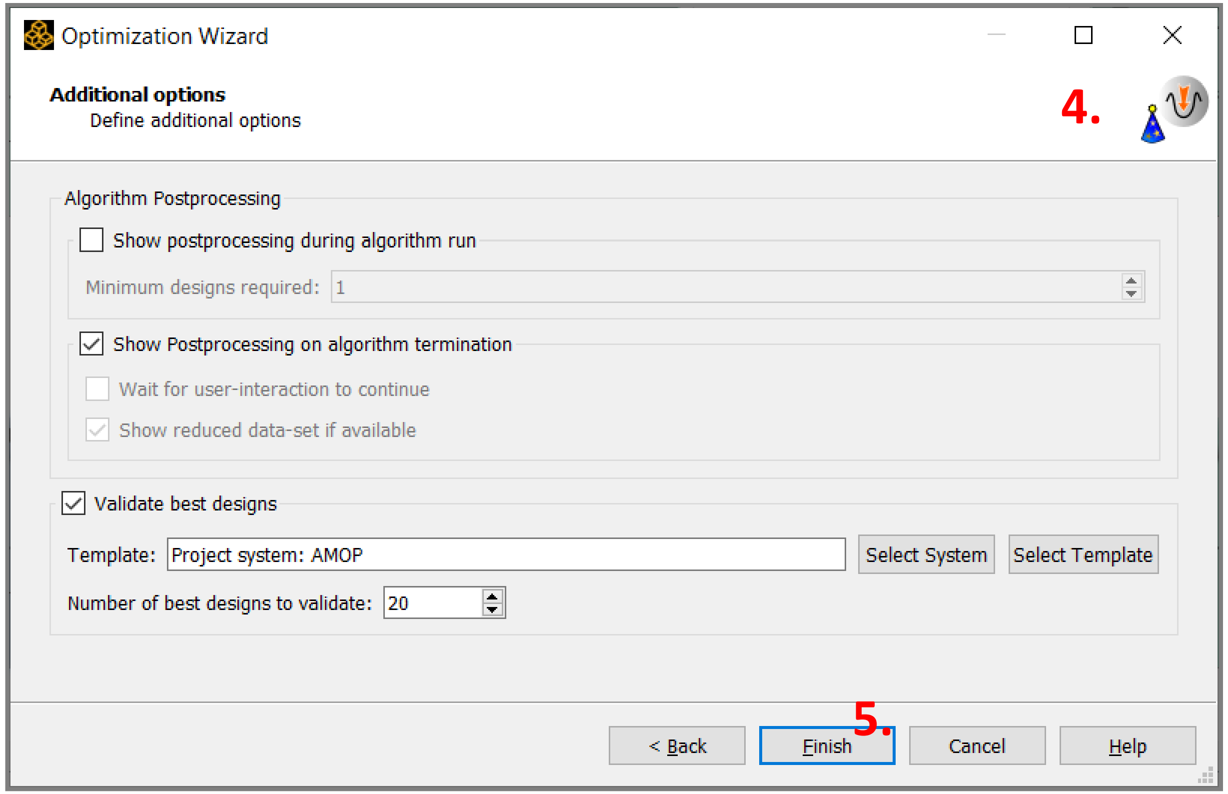
- **Using MOP Solver:** running optimization on metamodel
- **One-Click optimizer:** automatic selection of the best optimization algorithms
- **Maximum number of design evaluation:** Optimization algorithm will evaluate up to 4000 designs on the Metamodel (without solver call)



Setup Optimization Workflow

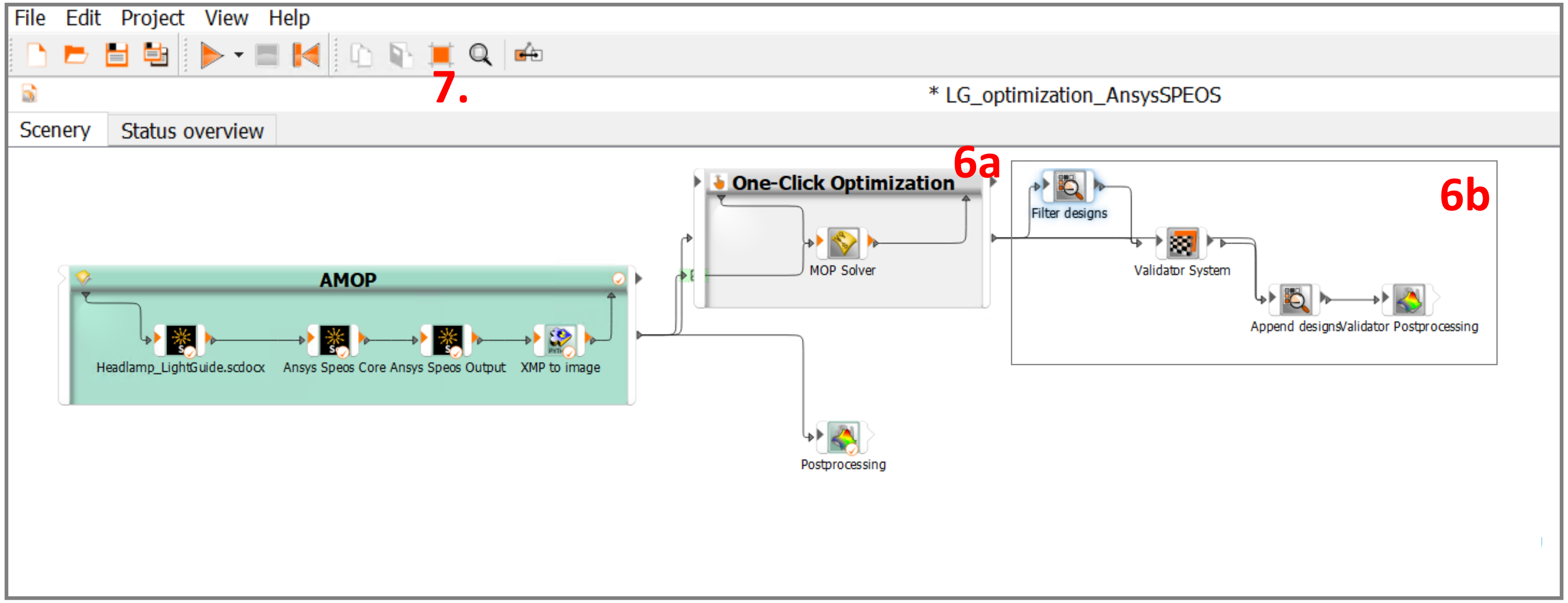
4. Keep the default **Additional options**
   (best 20 designs will be automatically validated with real solver call)

5. **Finish** the optimization wizard



Setup Optimization Workflow

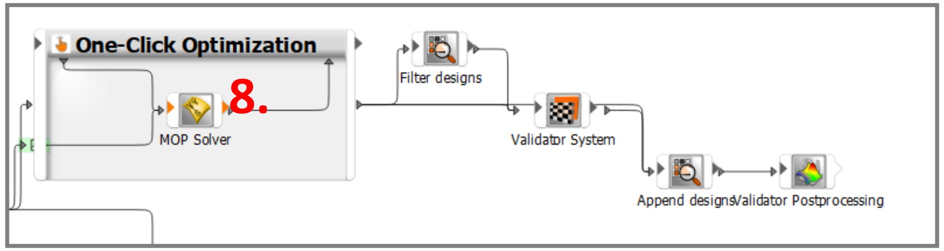
6. The workflow appears in the scenery, consisting of
   a. the One-Click Optimization system
   b. Nodes, filtering the 20 best design from the optimization system, validate them with a real solver call and append the results to the optimization postprocessing
7. Click the **Layout optimal**

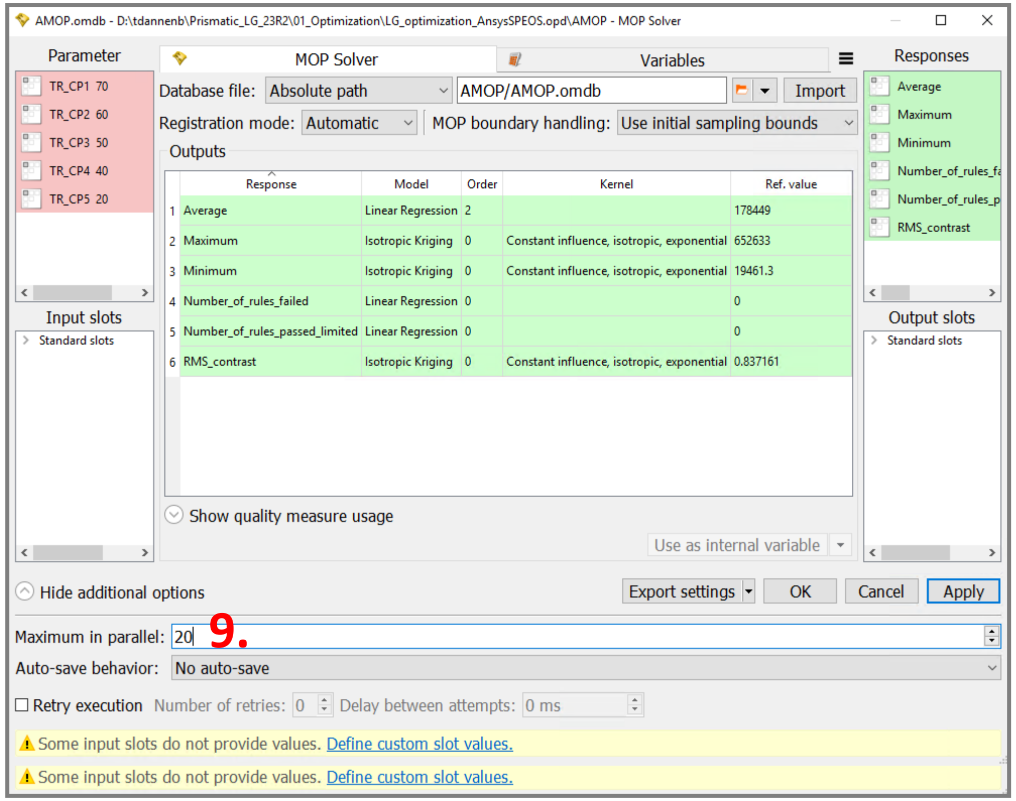


Setup Optimization Workflow

Optional: Speed up the design evaluation on the Metamodel:

8. Double click on the **MOP-Solver** node
9. Increase the number of **Maximum in parallel** for parallel execution
10. Click **Apply** and **OK**



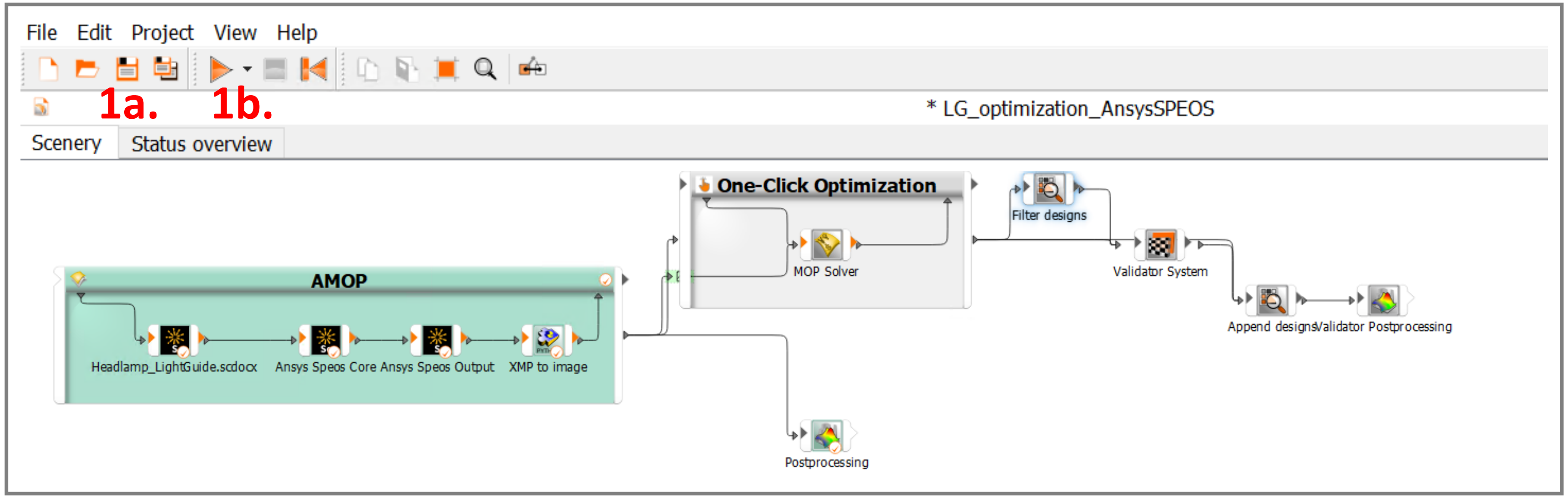


Start Optimization

1. **Save** and **Execute** the project

The optimizer will evaluate 4000 designs with different input parameter values on the Metamodel. 20 of the best designs will be automatically validated with a real solver call.

After the Optimization has finished the Postprocessing opens automatically



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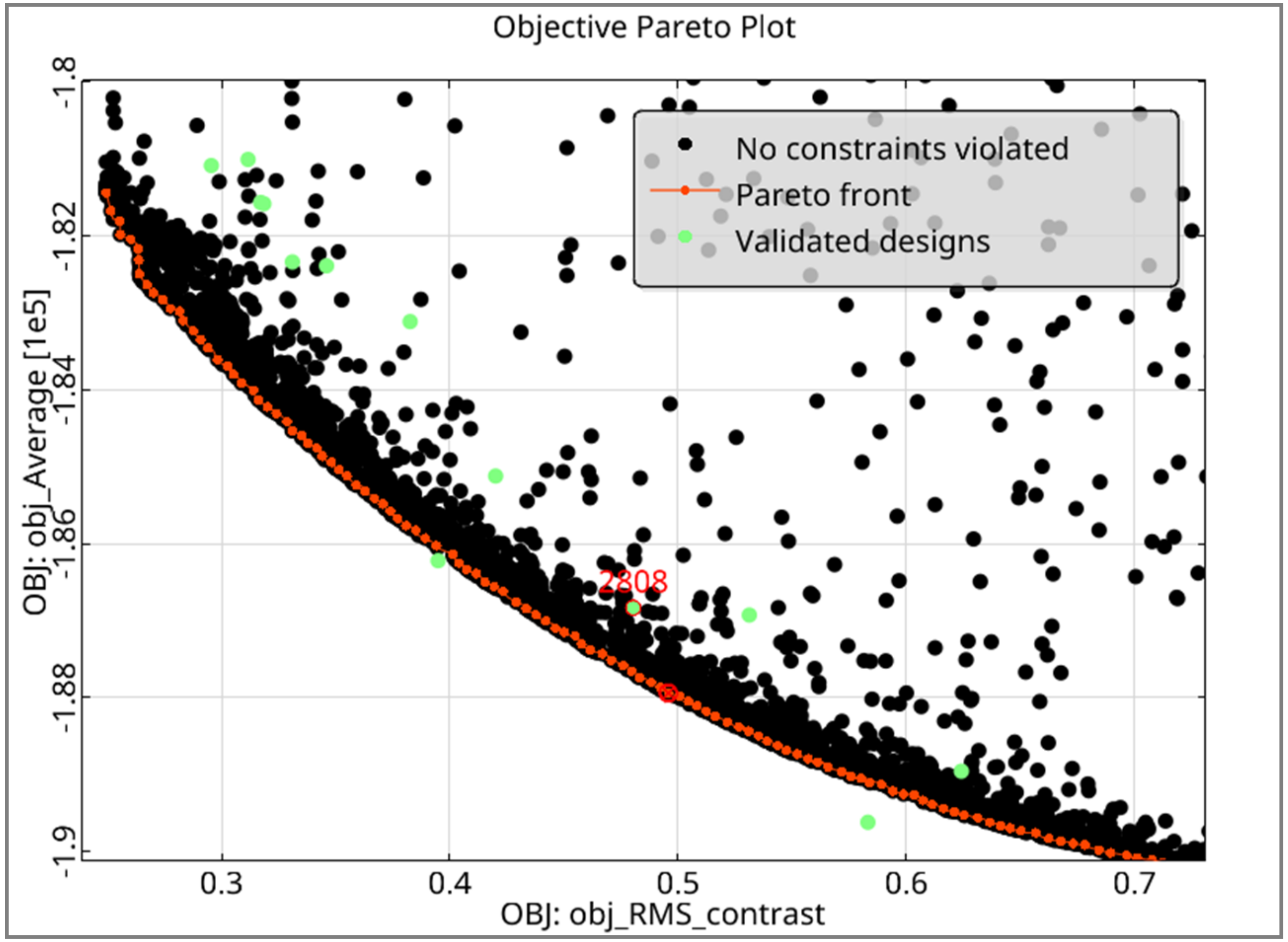
Optimization using the MOP - Postprocessing

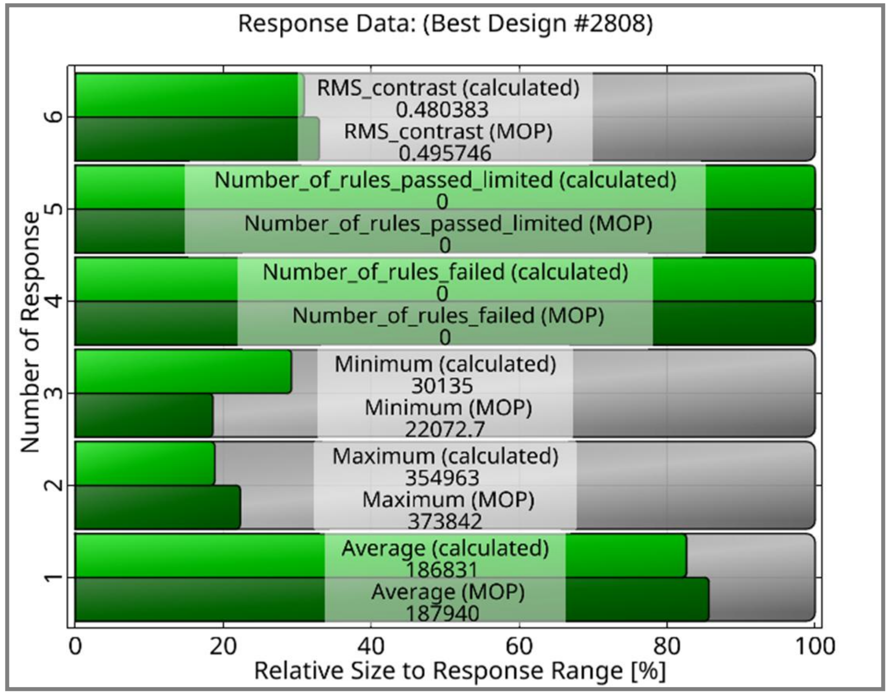
- **Fast Optimization** on Metamodel
- **Trade off** between RMS-contrast and average gets visible
- The pareto front shows all best designs.
- The responses and objective of the 20 best designs on the pareto front are validated by a solver call (results are shown in green dots).

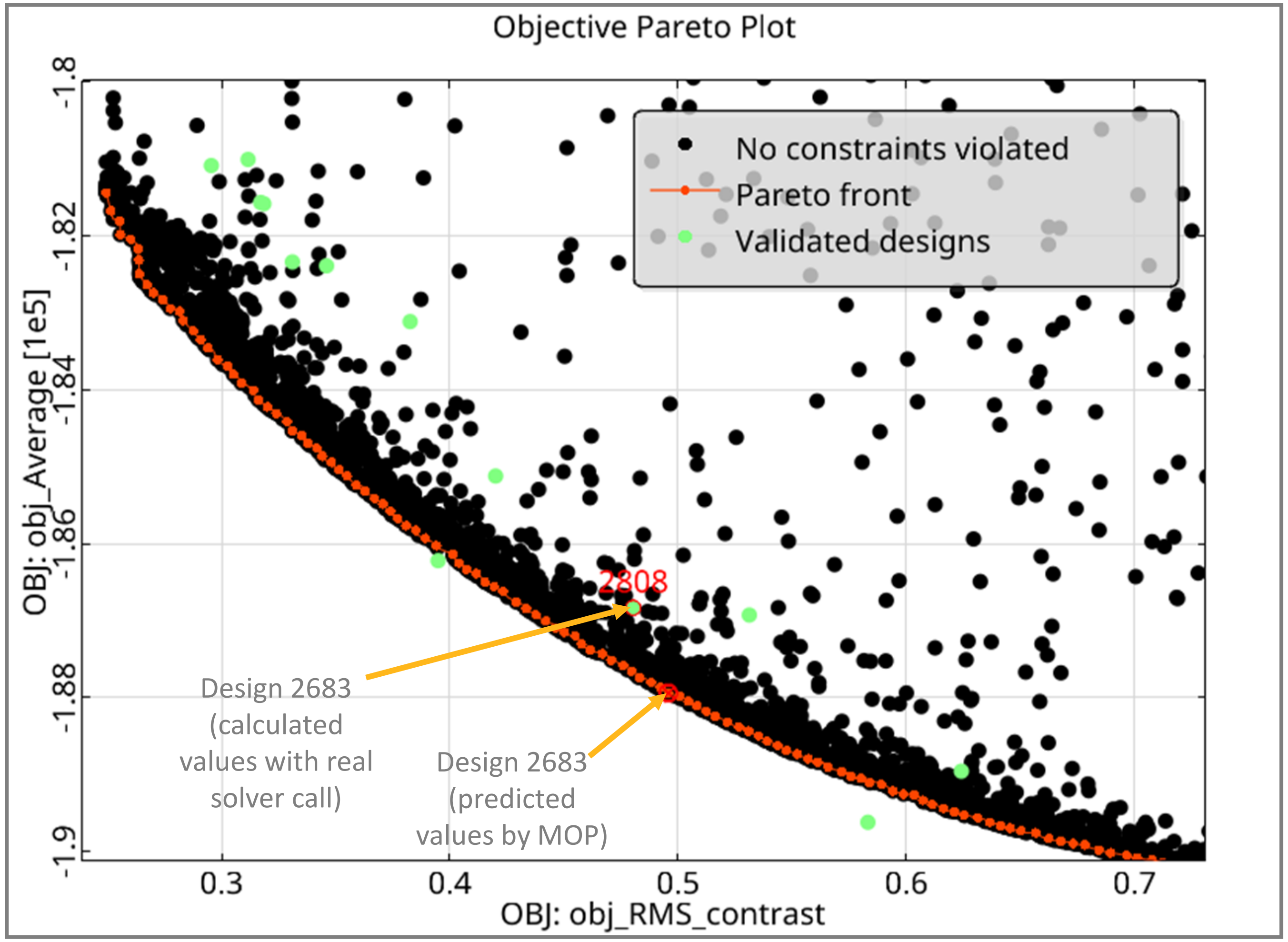
  - Due to local approximation errors in the Metamodel the estimated response value may differ from the solver result
  - validation of the best design is necessary



Optimization using the MOP - Postprocessing

- Choose a **Best Design**
  (in this case Design 2808 is choosen)





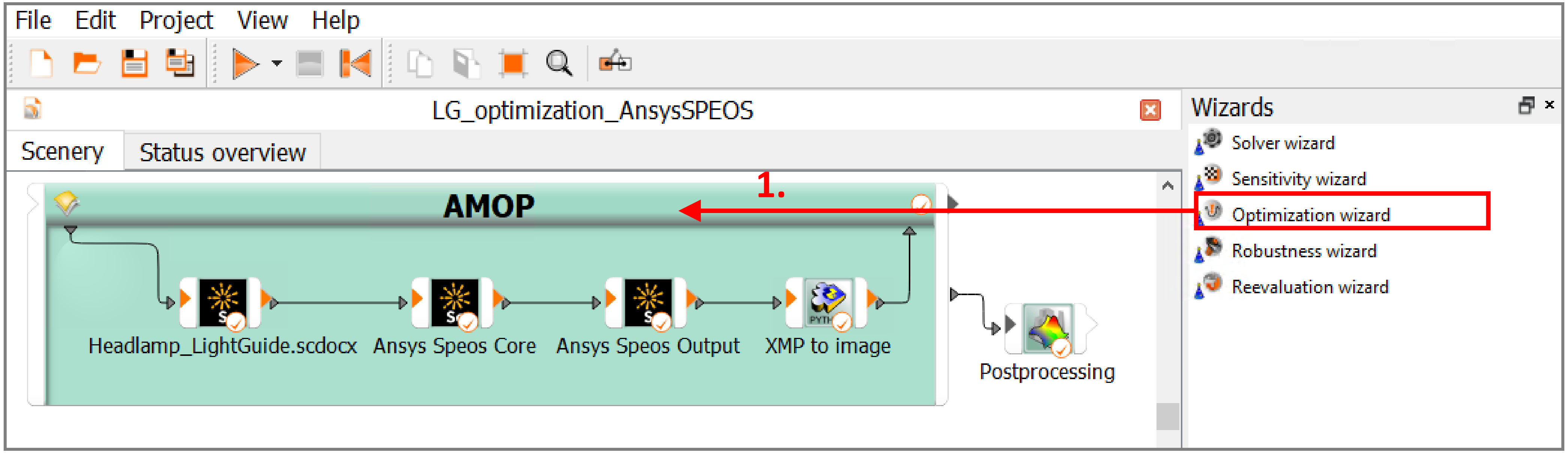
Ansys

Single-objective direct Optimization

Single-objective direct Optimization

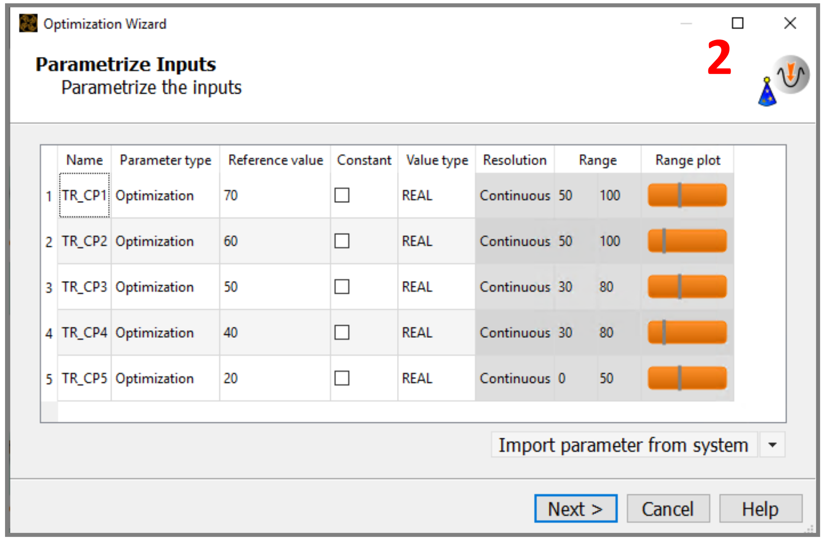
How to continue with single direct objective optimization is shown in the following section:

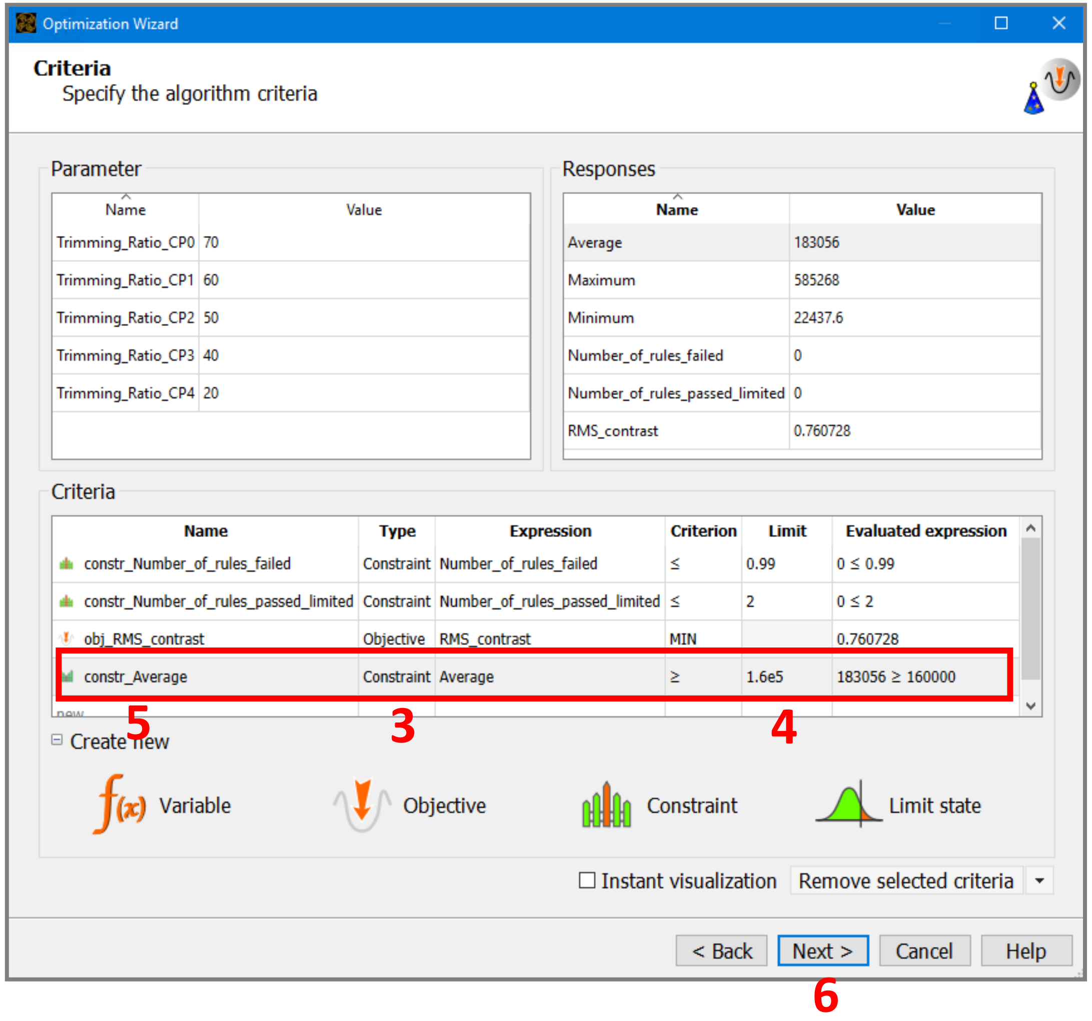
1. Drag the **Optimization wizard** onto the head of the sensitivity system



Single-objective direct Optimization

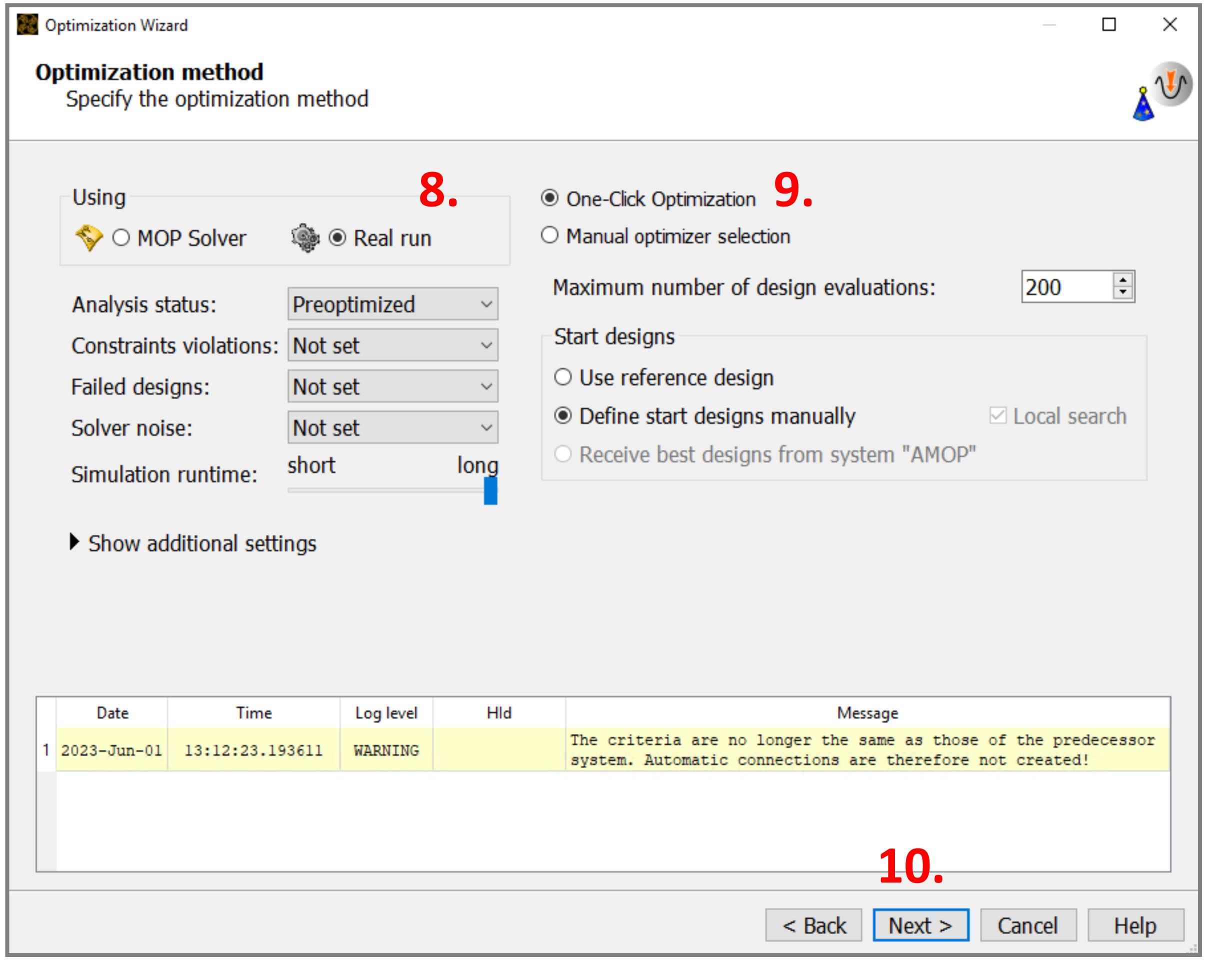
2. Keep the parameter definition and click **Next**
3. Change criteria type of **Average** from **Objective** to **Constraint**
4. Set limit to greater than 1.6e5
5. Rename the criteria name
6. Click **Next**





Single-objective direct Optimization

7. Choose **Real run** for Optimization
8. Keep the recommended **One-Click Optimization**
   (the used optimization algorithm is chosen automatically in the background)
9. Click on **Next**

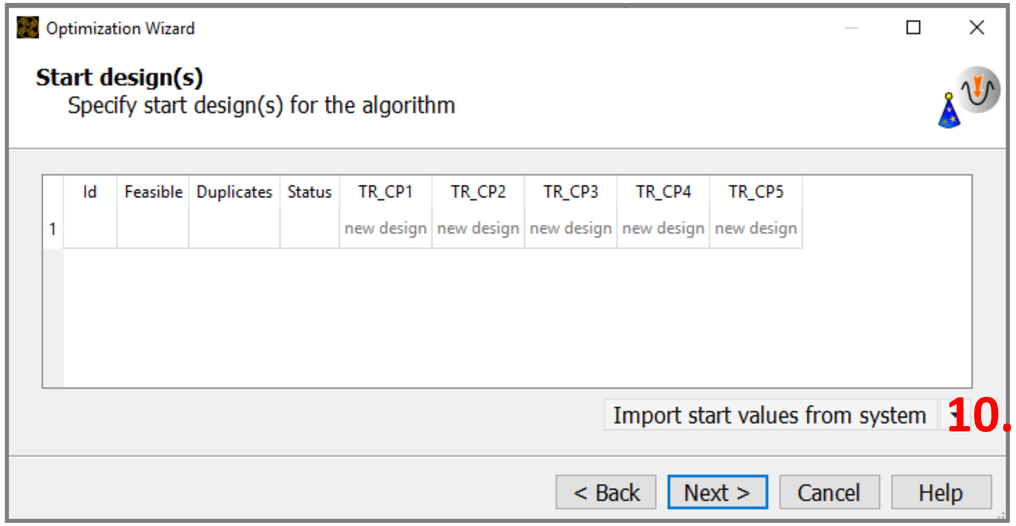


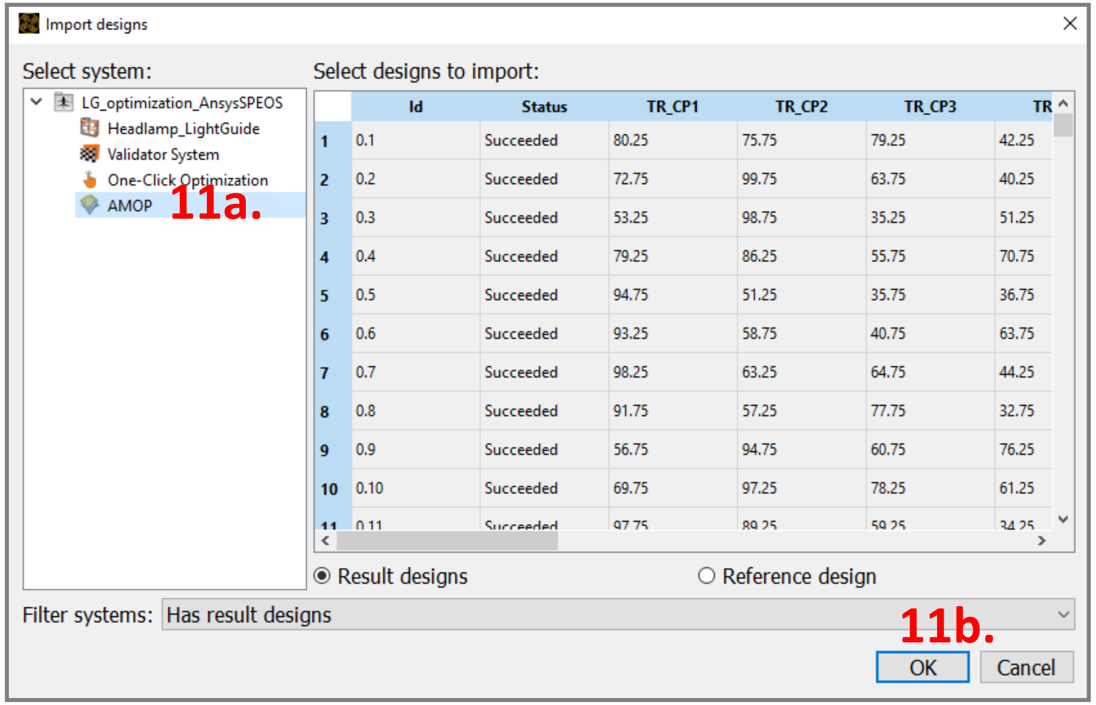
Single-objective direct Optimization

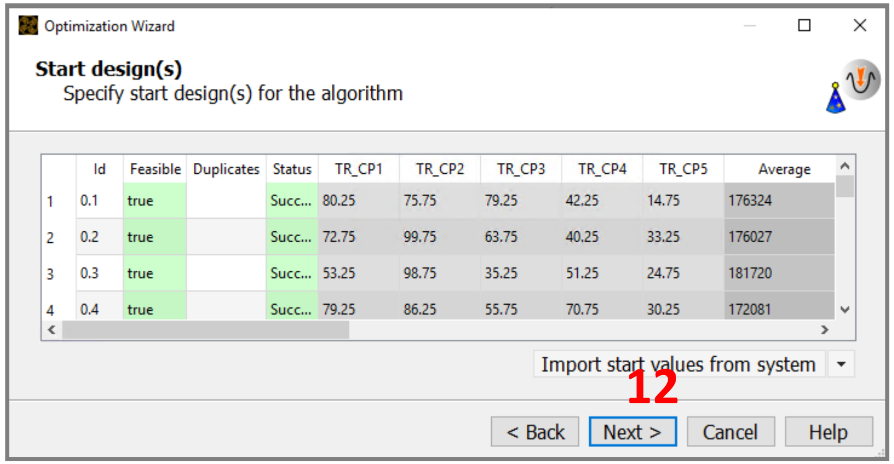
10. Click on **Import Start values from system** to reuse the already calculated designs for the optimization

11. Choose **AMOP** and click **OK**

12. Click **Next** in the wizard window







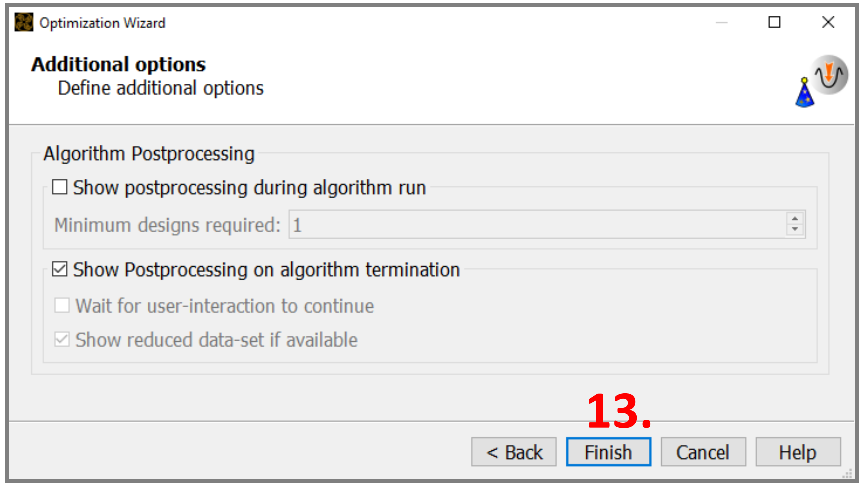
Single-objective direct Optimization

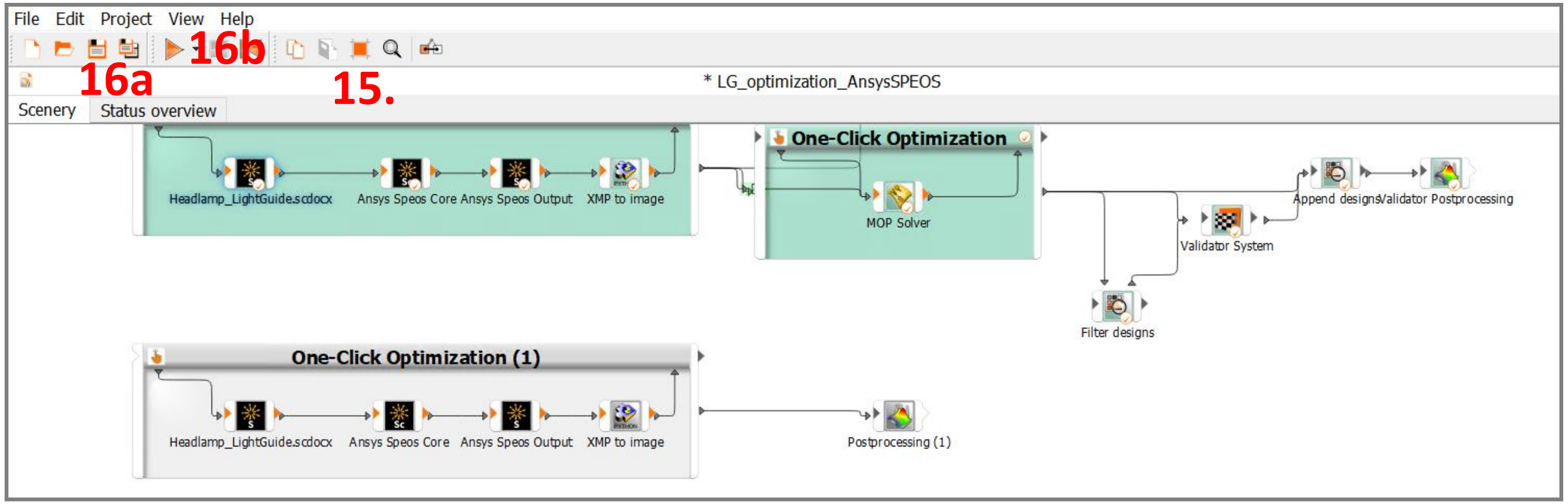
13. Finish the wizard

14. The workflow appears in the scenery.

15. Click the **Layout optimal**

16. Save and **Execute** the workflow





→ Wait until the analysis is ready

→ The optiSLang postprocessing will open automatically (alternative, **Double Click** on "Postprocessing(1)")

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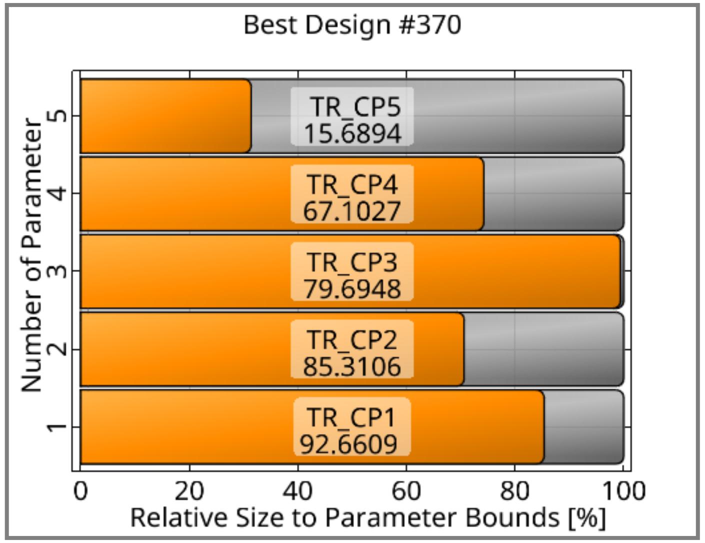
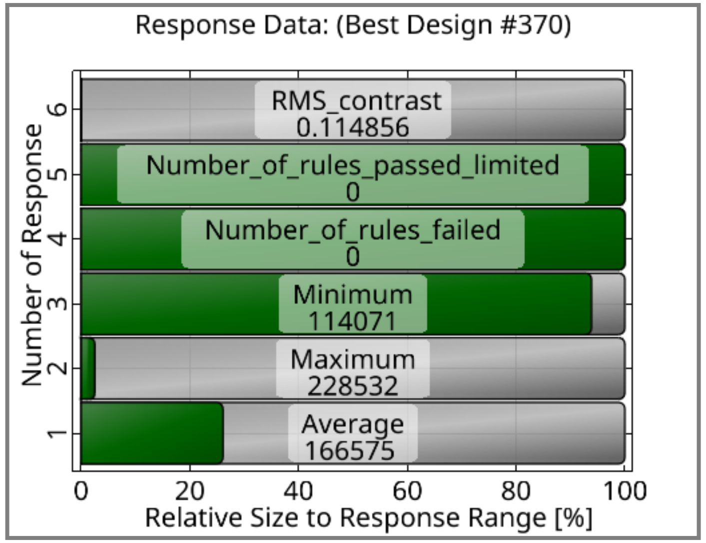
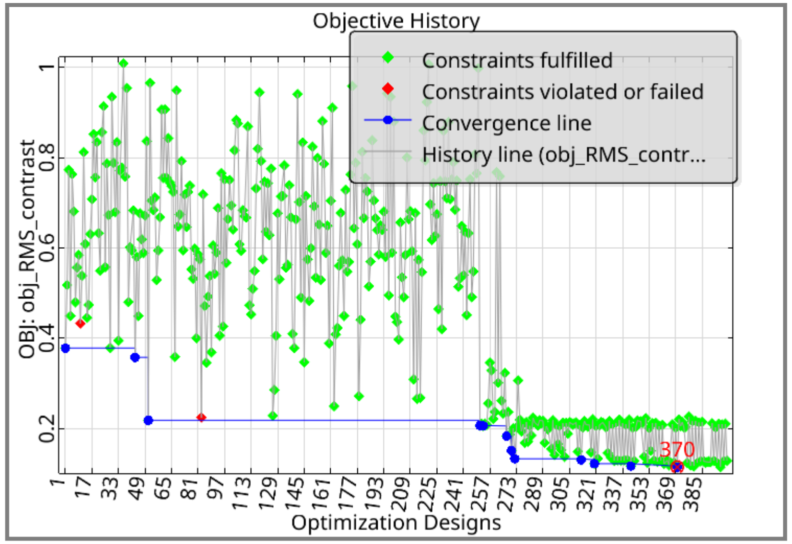
Single-objective direct Optimization

- The history plot shows the convergence of the optimization. The optimization converge very fast
- The best design is #370:







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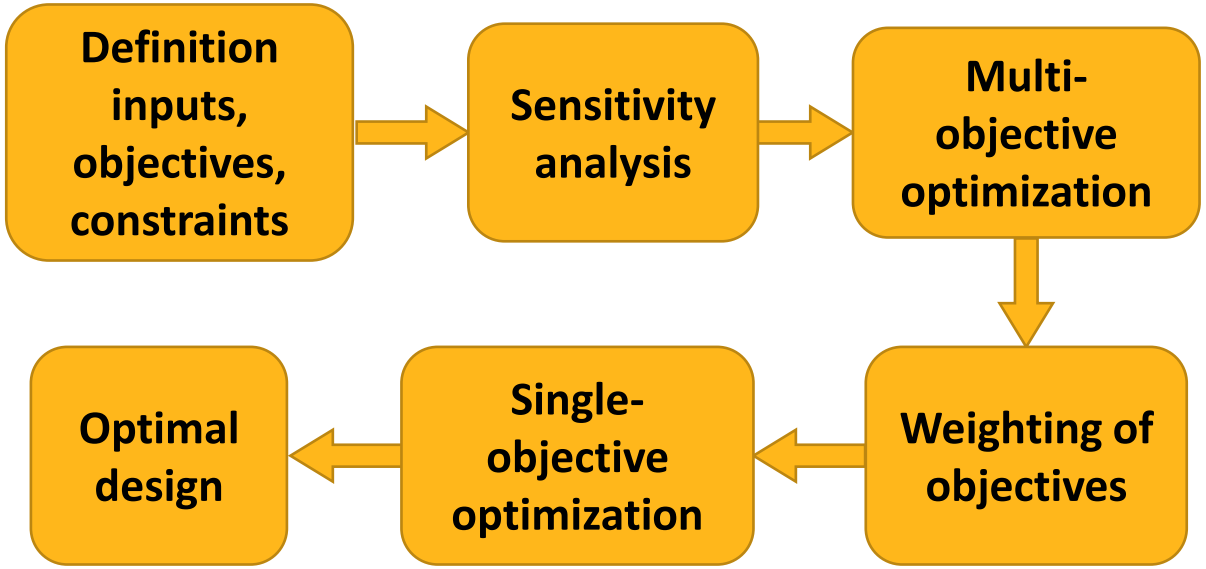
Summary

Summary Recommended Workflow for Multiple Objectives

1. Define parameter types and ranges, responses, objectives and constraints
2. Perform a sensitivity analysis using DOE and MOP to identify important input parameters, detect conflicting objectives, get information about failed or infeasible design regions, get suitable start population for the optimization
3. Perform a multi-objective optimization for all conflicting objectives
4. Derive weighting factors after selecting a suitable design
5. Run single-objective optimization using weighted objectives or changing objectives to constraints
6. Get your optimal design

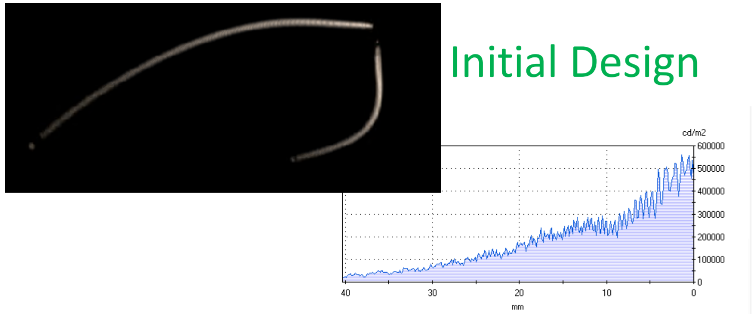


Summary

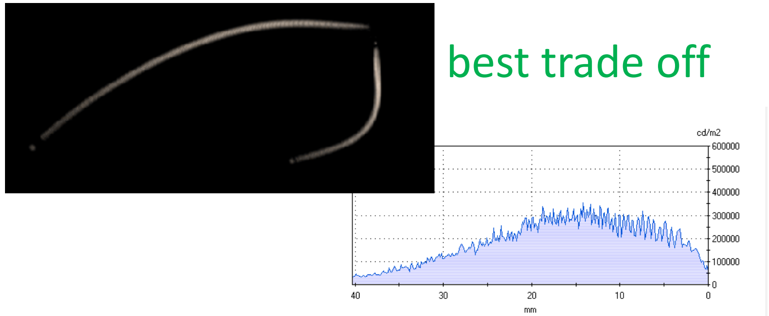
- Due the Sensitivity Analysis and Optimization:
  - the **best possible trade off** between RMS contrast and average luminance could be found
  - the **homogeneous lit appearance** could be significantly improved
  - all **photometric regulations** and **customer specifications** could be achieved

	Initial Design	best trade off (from multi-objective optimization on MOP)	best design (single-objective direct optimization)
RMS contrast	0.74	0.25 < **0.48** < 1.00 (2.1x improvement)	0.115 (6.5x improvement)
Average luminance [kcd/m²]	183	150 < **187** < 190	167 > 165 (fulfilled)
Number of not fulfilled regulations	0/42 (fulfilled)		

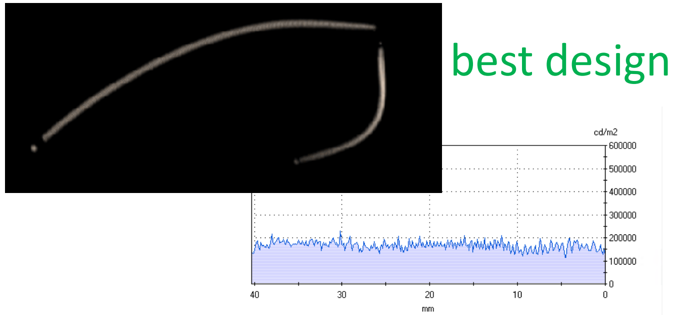
Initial Design



best trade off

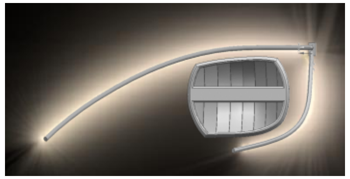


best design

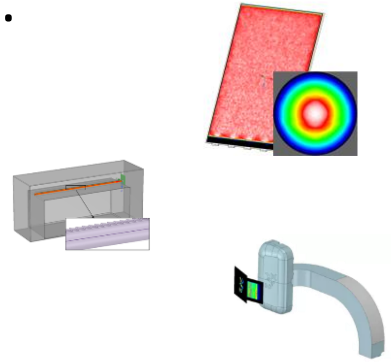


Overview of Tutorials

- Light guide tutorial: Optimization of a prismatic light guide (headlamp)
  - ✓ Workflow automation of Ansys Speos
  - ✓ Sensitivity Analysis
  - ✓ Optimization



- Further applications for optical design optimization:
  - [Backlight Unit Analysis and Optimization – Ansys Optics]
  - [Interior Lightguide Optimization – Ansys Optics]
  - [SPEOS for NX: Light guide optimization (interior lighting)]



If you have any questions on this tutorial, do not hesitate to contact: support@ansys.com

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Appendix

Check Solver Noise

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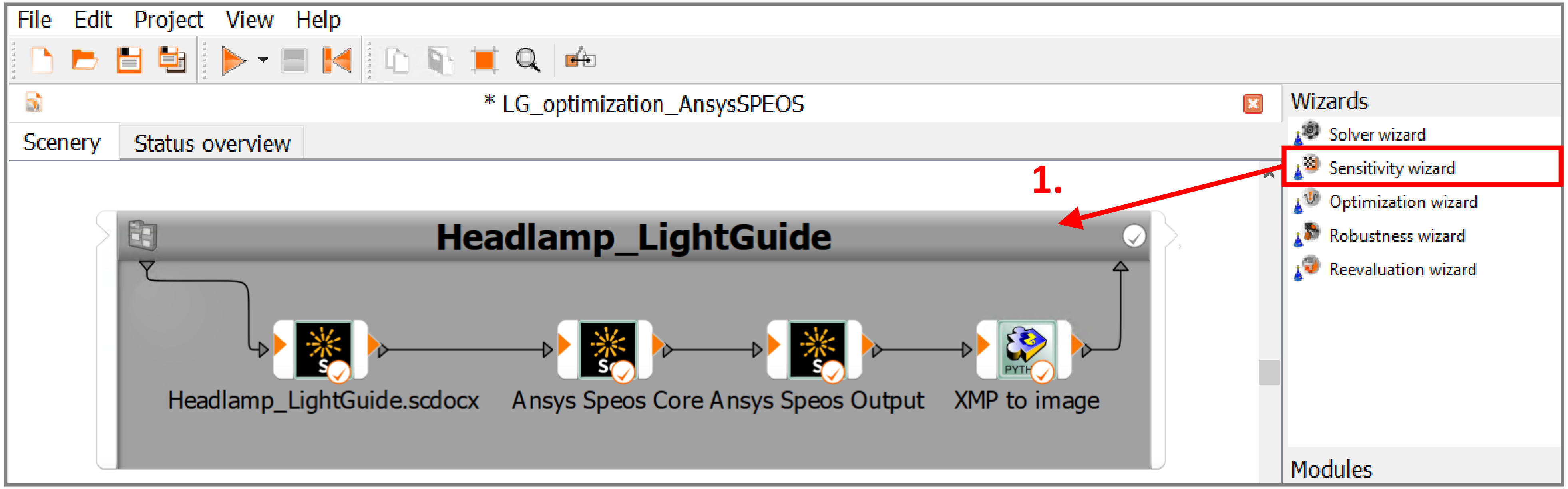
Check Solver Noise

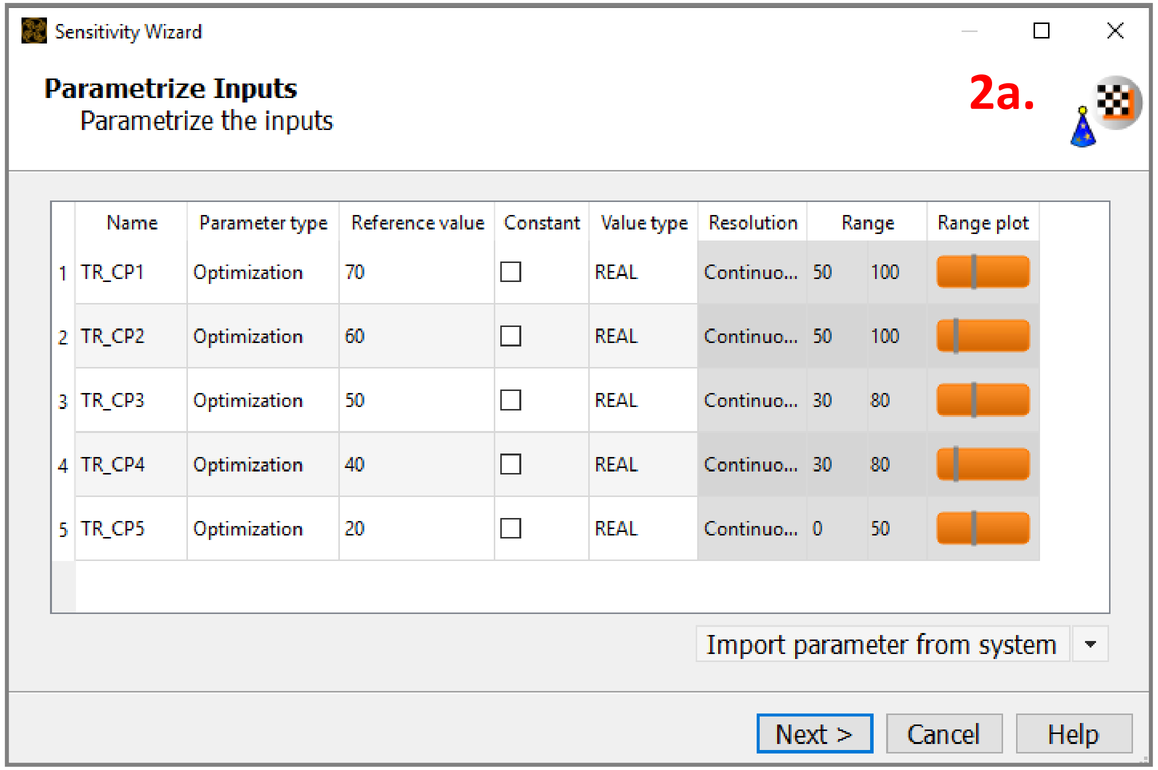
How to setup the system in order to control the solver noise is shown in the following

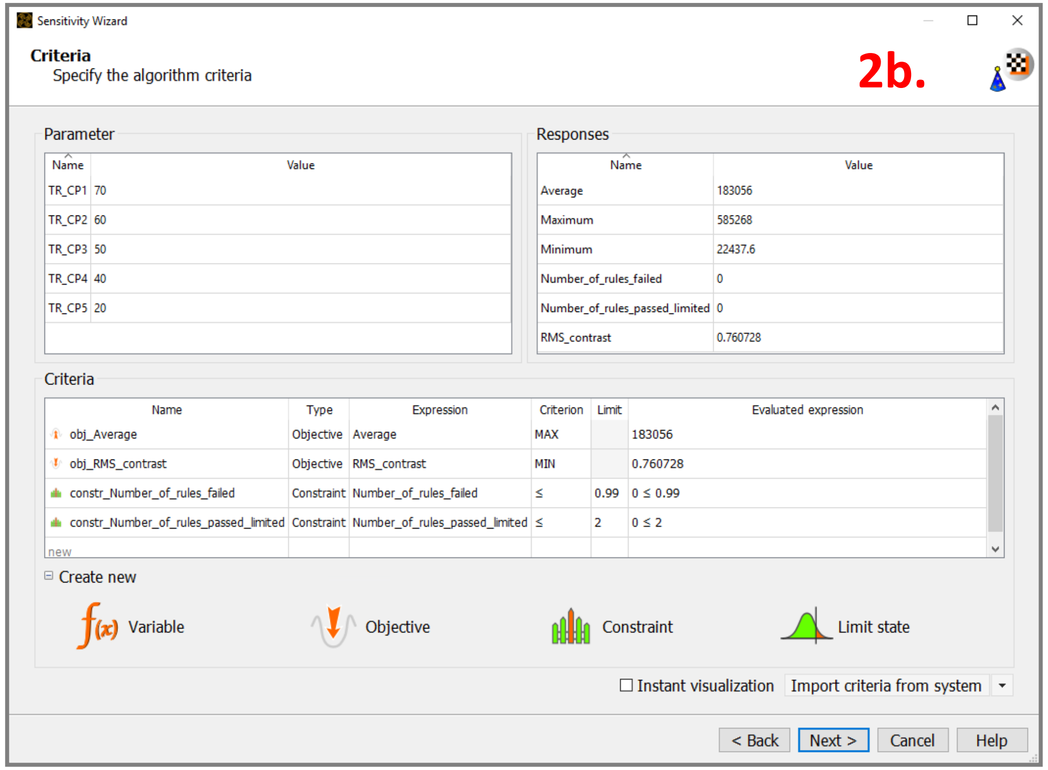
1. Drag the sensitivity wizard onto the head of the solver chain



Check Solver Noise

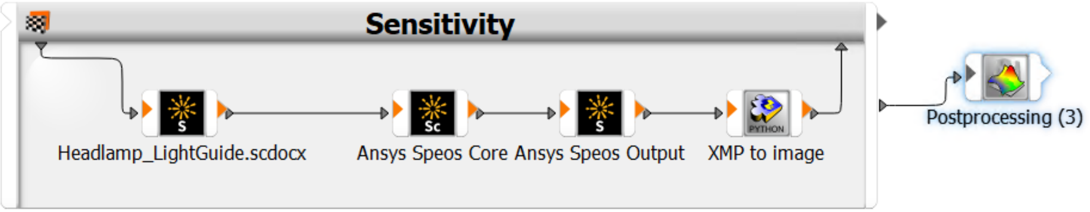
2. Keep the ranges and criteria (click **Next**)

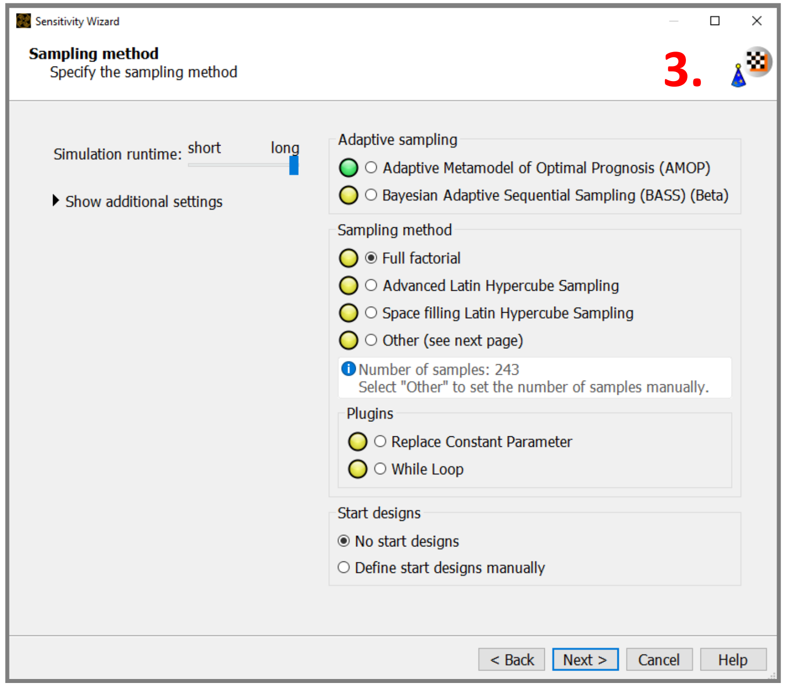


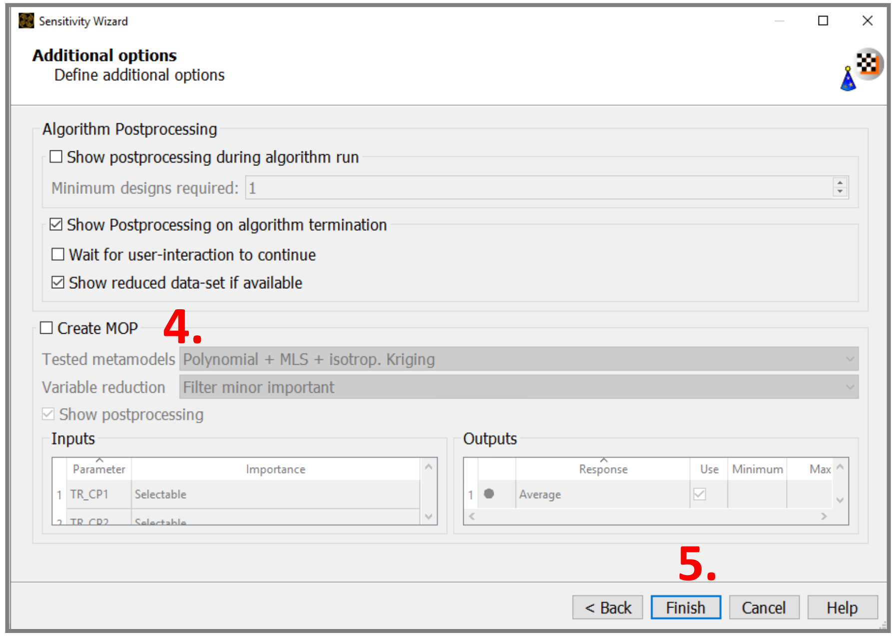


Check Solver Noise

3. Choose **Full Factorial** as **Sampling method** and click **Next**
4. Disable **Create MOP**
5. Finish the wizard
6. The new sensitivity system will be created automatically:

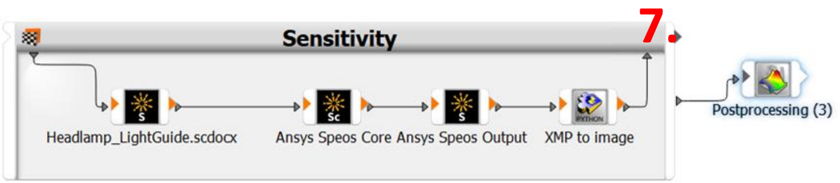




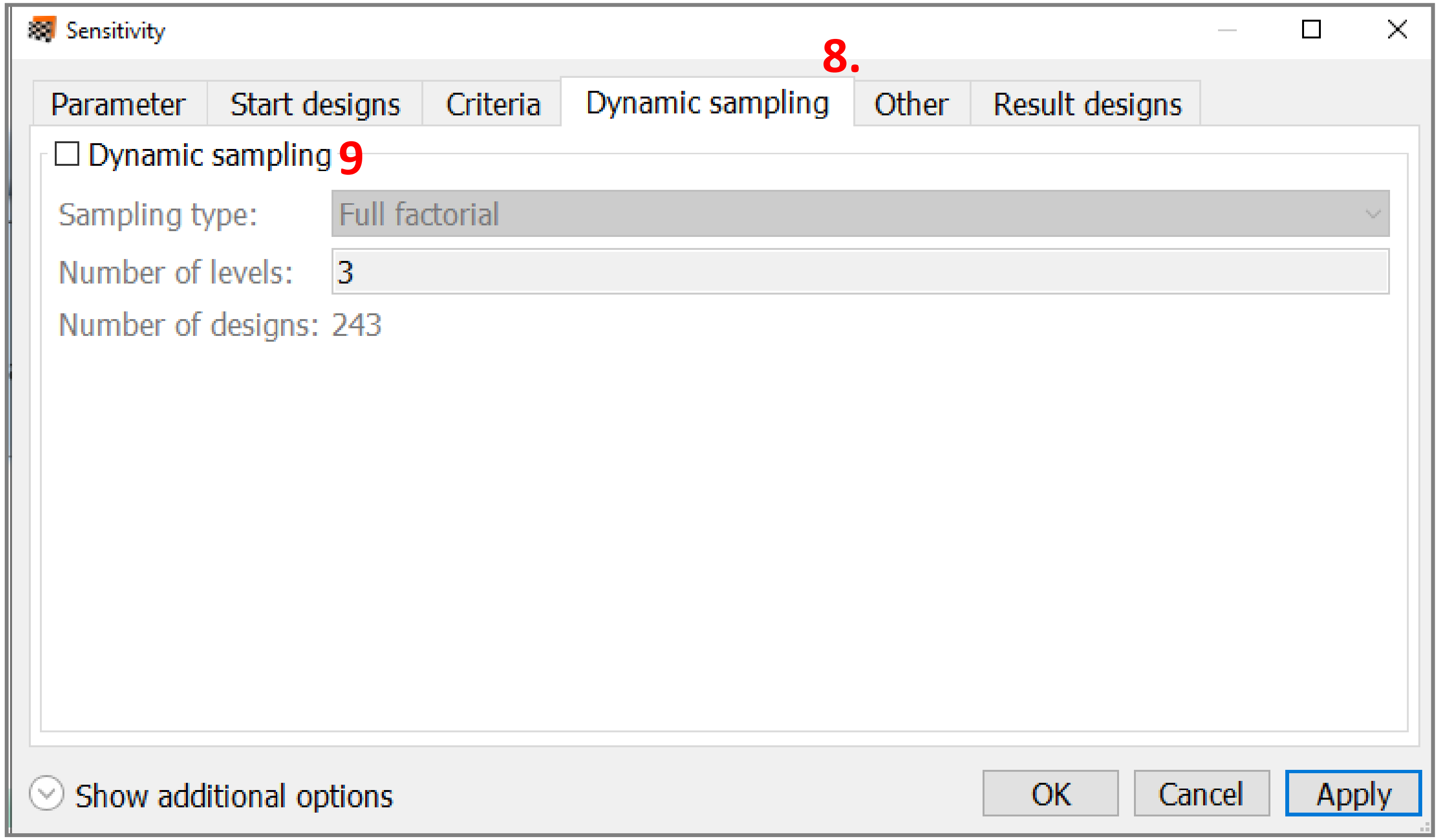


Ansys

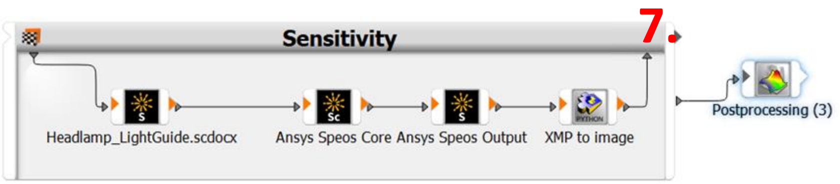
Check Solver Noise



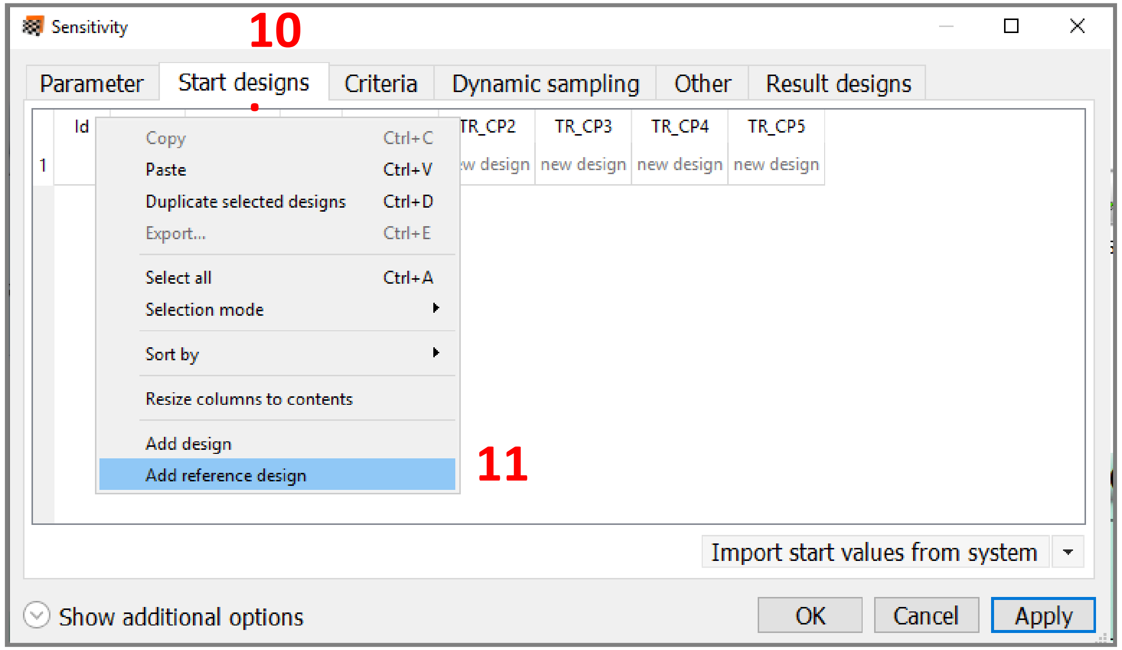
7. Open the **Sensitivity** system by **double click** on the systems head
8. Go to the **Dynamic sampling** Tab
9. Disable **Dynamic sampling**

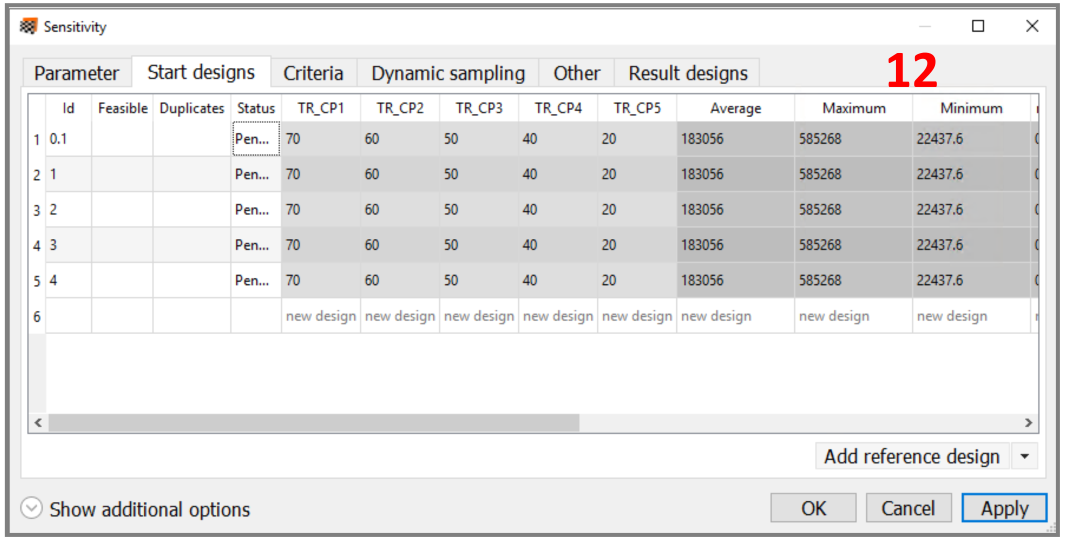


Check Solver Noise

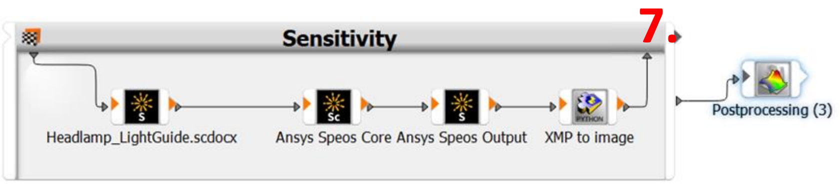


10. Go to the **Start designs** Tab
11. **Right click** in the first line to **add reference design**
12. Mark line one and duplicate the first line 5 times (e.g., using Ctrl+D)



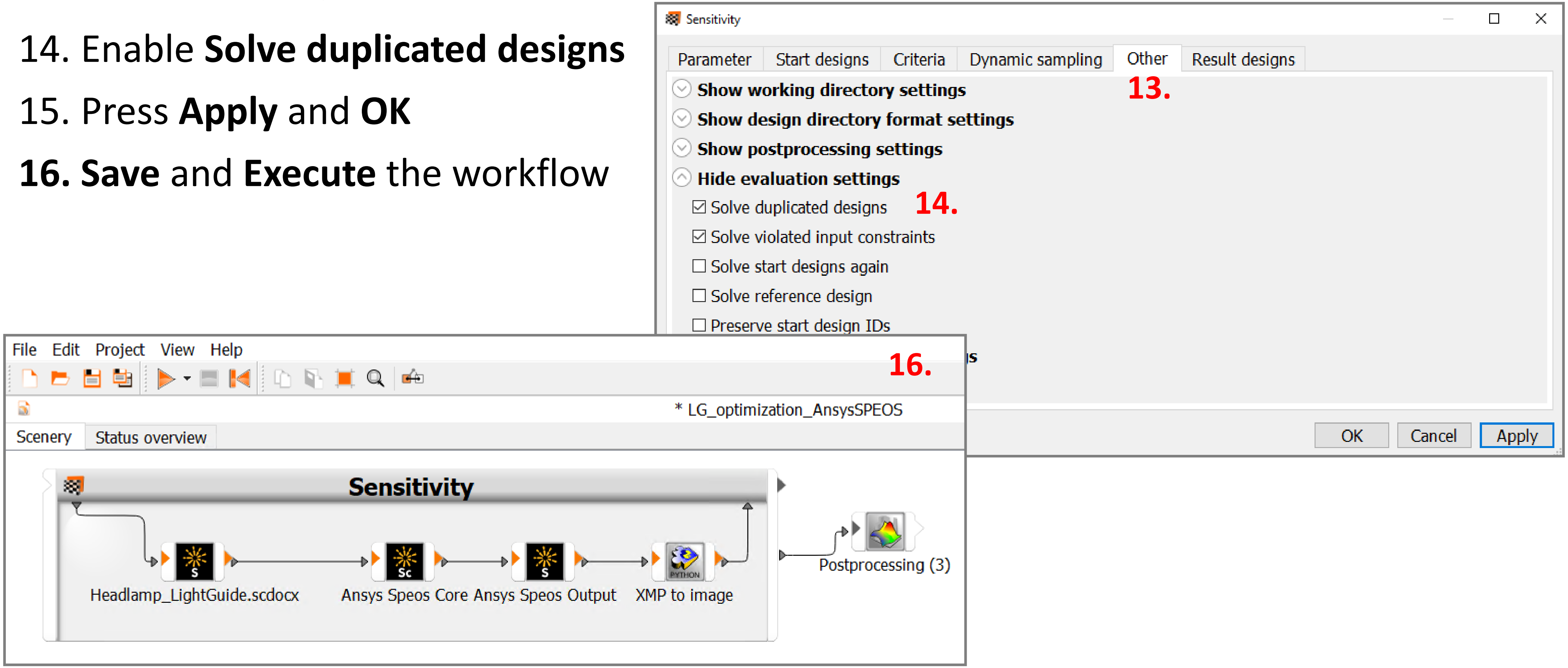


Check Solver Noise

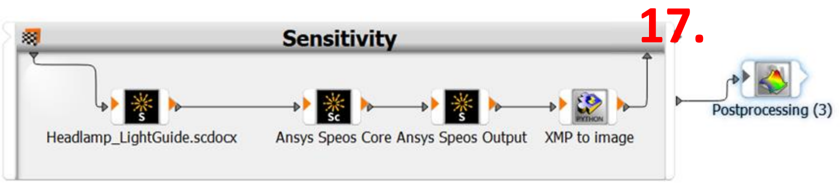


13. Go to the **Other** Tab
14. Enable **Solve duplicated designs**
15. Press **Apply** and **OK**

16. Save and **Execute** the workflow

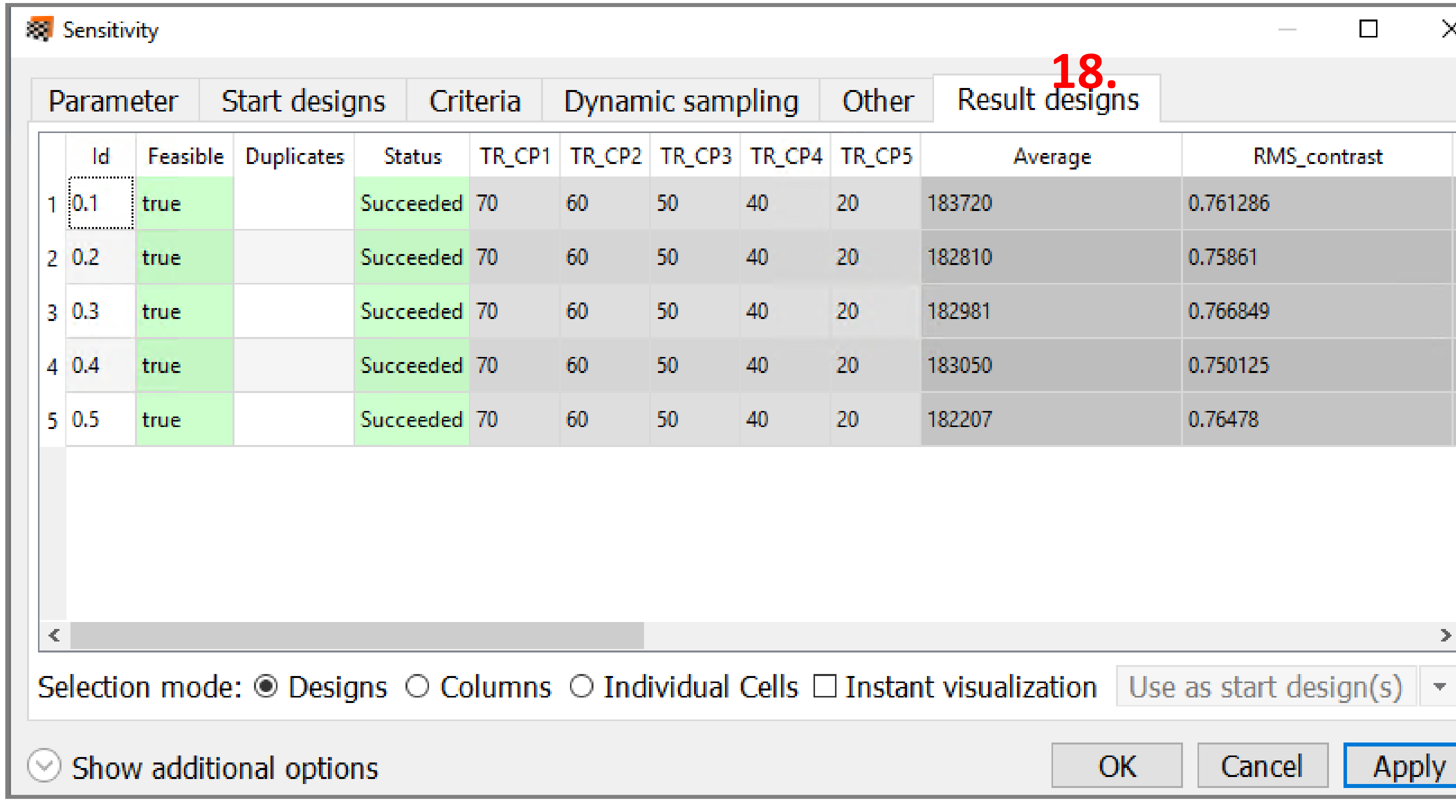


Check Solver Noise



17. Open the **Sensitivity** system by **double click** on the systems head

18. Go to the **Result designs** Tab



	Id	Feasible	Duplicates	Status	TR_CP1	TR_CP2	TR_CP3	TR_CP4	TR_CP5	Average	RMS_contrast
1	0.1	true		Succeeded	70	60	50	40	20	183720	0.761286
2	0.2	true		Succeeded	70	60	50	40	20	182810	0.75861
3	0.3	true		Succeeded	70	60	50	40	20	182981	0.766849
4	0.4	true		Succeeded	70	60	50	40	20	183050	0.750125
5	0.5	true		Succeeded	70	60	50	40	20	182207	0.76478

Check the scattering of the output values (Average + RMS contrast). To ensure a high simulation quality and a good prediction for the optimization the maximum difference between the results should be less than about 5%.

Ansys