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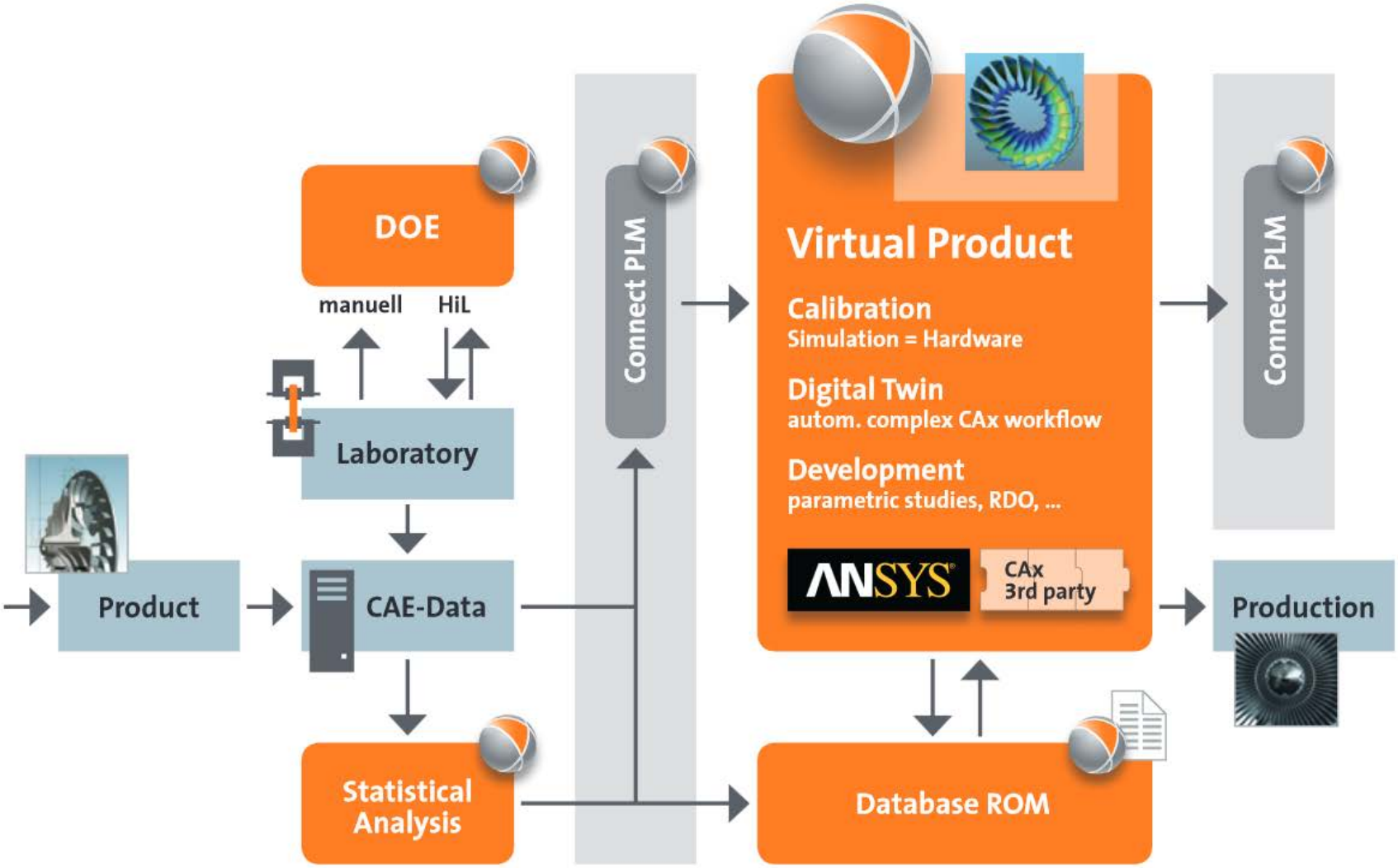

Agenda

- Interactive post-processing and data visualization
- Automatic approach for signal analysis
- optiSLang for everyone: “Democratization of simulation” & digital twins
- Nested systems “in Action”: performance maps & Co.
- Create and use reduced order models in a world of complex systems
  - Data-based ROM’s (F-MOP)
  - Physics-based ROM’s

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Interactive post-processing and data visualization

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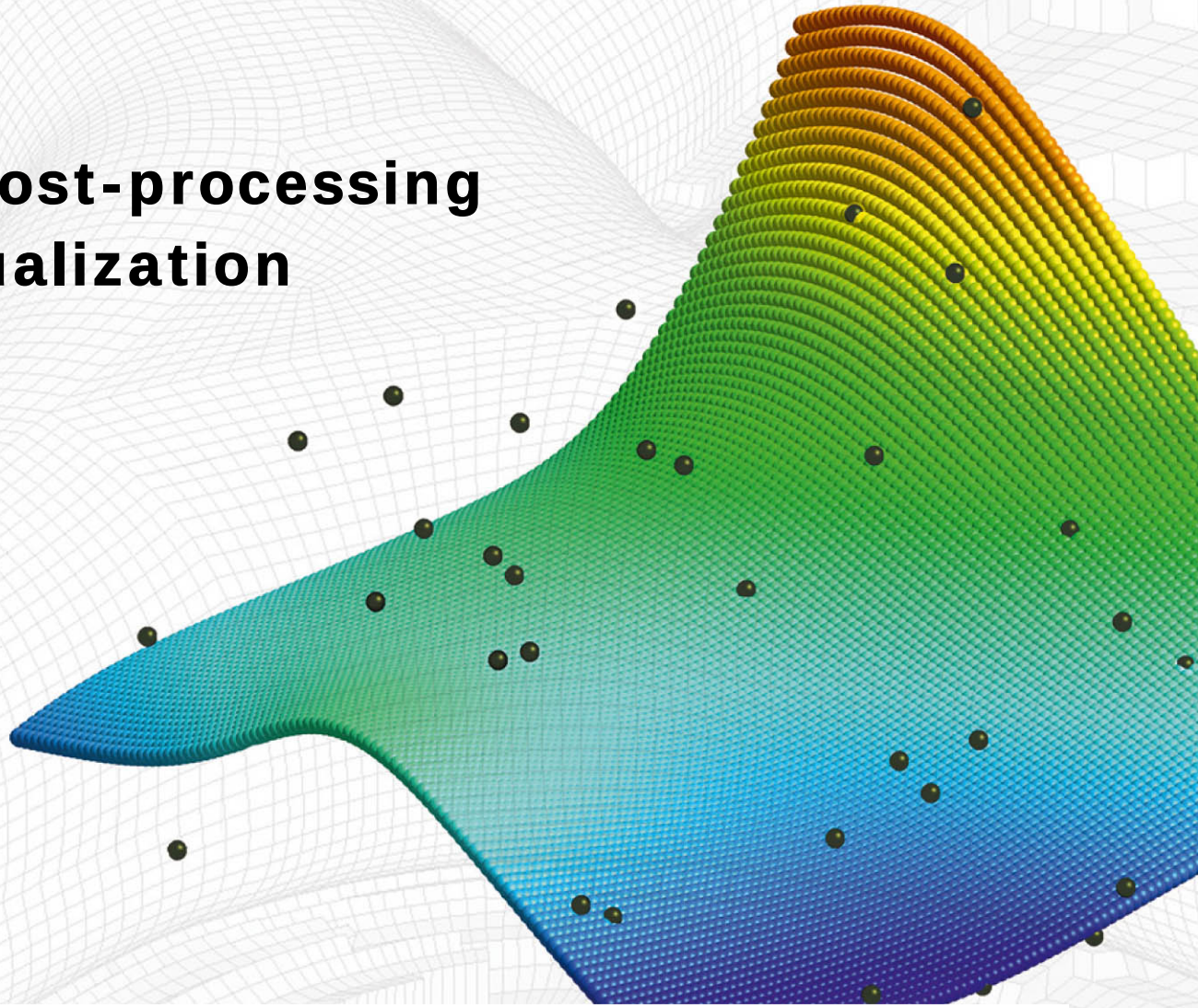
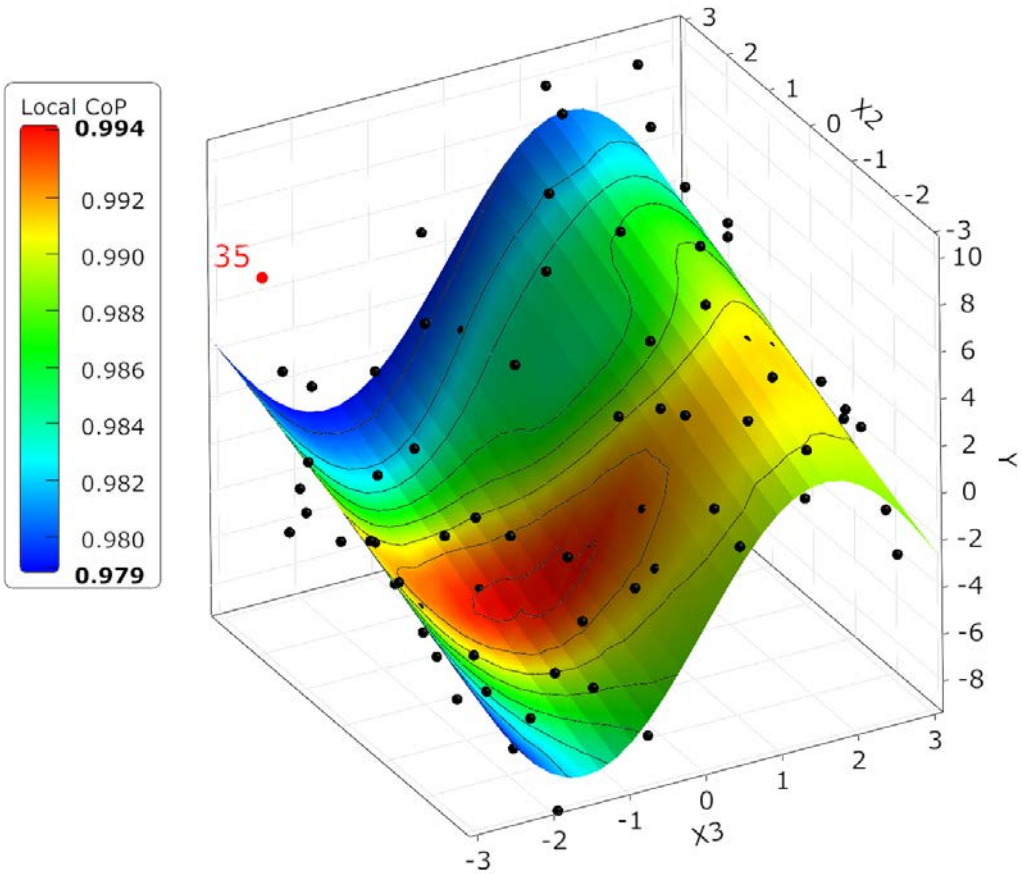


Outline

- Generate and evaluate the Metamodel of Optimal Prognosis
- Cluster analysis
- Visualization of signals, images and processes



Generate and evaluate the Metamodel of Optimal Prognosis

Experimental data analysis

- **Topic**: Ultra-short pulse laser processing of technical ceramics, 2-dimensional ablation of Al_2O_3
- **Aim**: Minimal roughness and maximal abrasion
- **Characteristics of the process**:
  - Many interacting and derived inputs
  - Technical limitations of input levels, discrete inputs
  - Non-linear process

With courtesy of ifw Jena

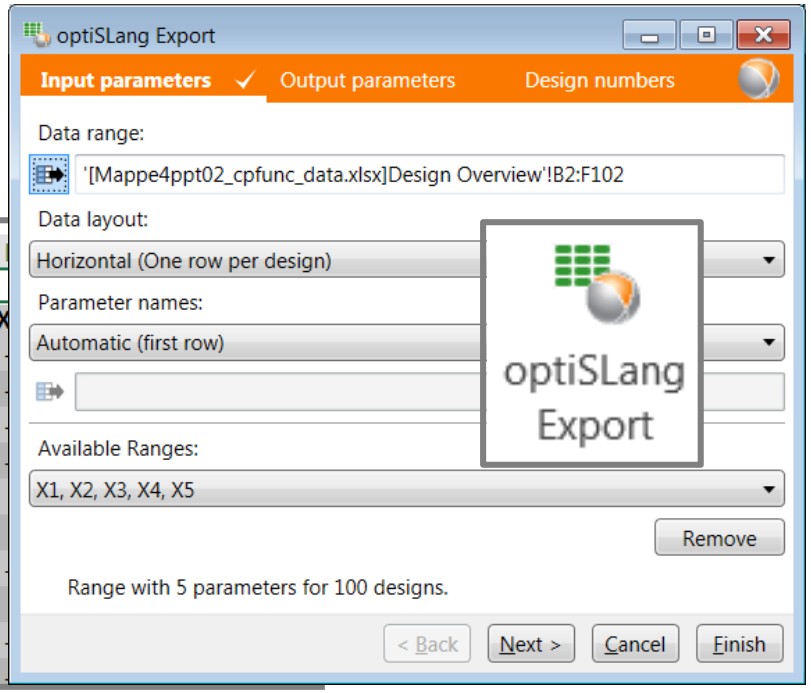
Excel Add-In

- Use the **Excel Add-In** to export your data in an optiSLang data base

➢ Statistics post-processing for data file

➢ MOP generation with external data

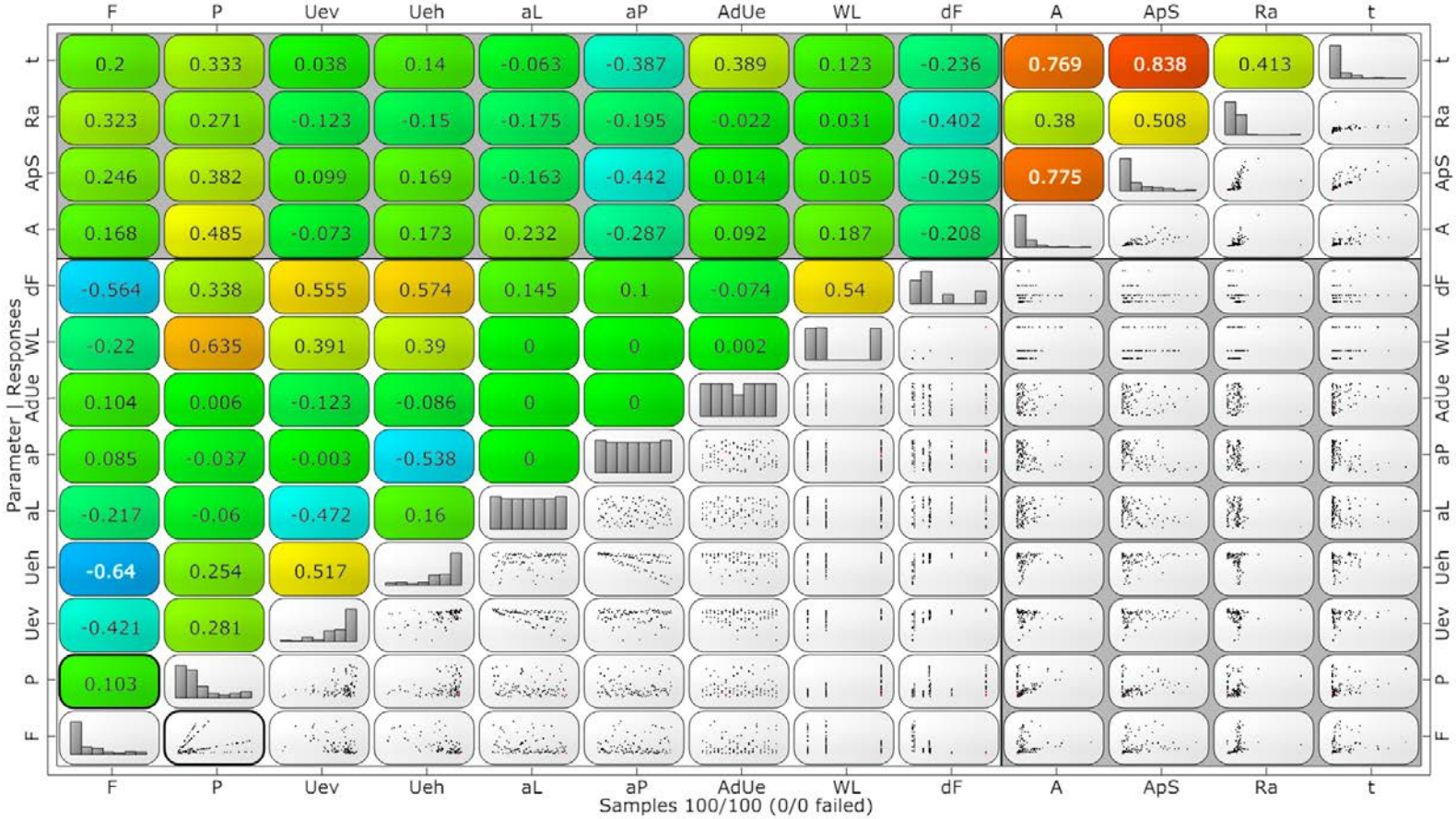
	A	B	C	D	E
1	Details	Parameters			
2	Nr.	X1	X2	X3	X4
3	1	-1,9154	-2,4178	2,2294	-2,6062
4	2	2,1038	-2,5434	-2,041	-0,9106
5	3	1,2874	-1,3502	-2,355	0,7222
6	4	-1,0362	1,8526	-2,4806	-2,7318
7	5	-1,2874	0,3454	-0,2198	-1,6642
8	6	0,7222	-1,9154	3,1086	2,041
9	7	1,4758	0,5338	-1,2246	2,1038
10	8	2,1666	-0,5966	1,099	0,8478
11	9	-2,8574	-2,8574	-2,983	-3,1086
12	10	-1,5386	2,355	-1,2874	2,6062



Tutorial: Help/Tutorials/Tools/Export_Excel
Help/Tutorials/Tools/MOP_external_data

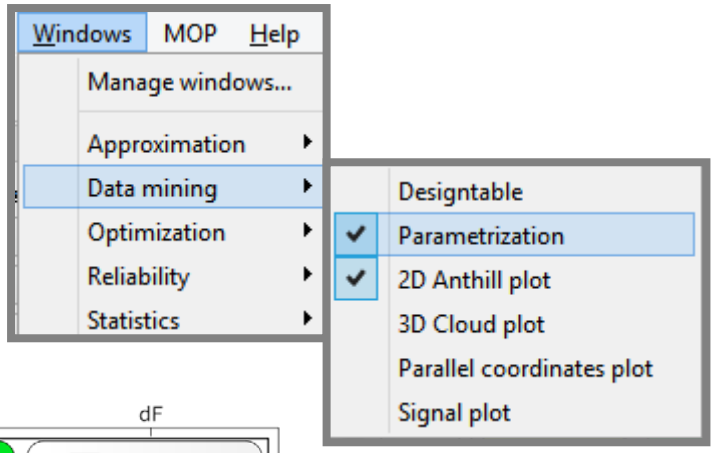
Correlation Matrix

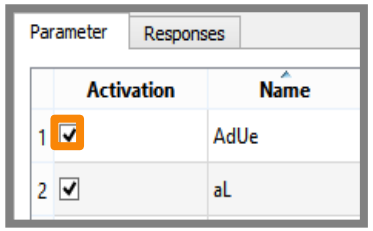
- Correlation matrix with Anthill plots and histograms to visualize correlations



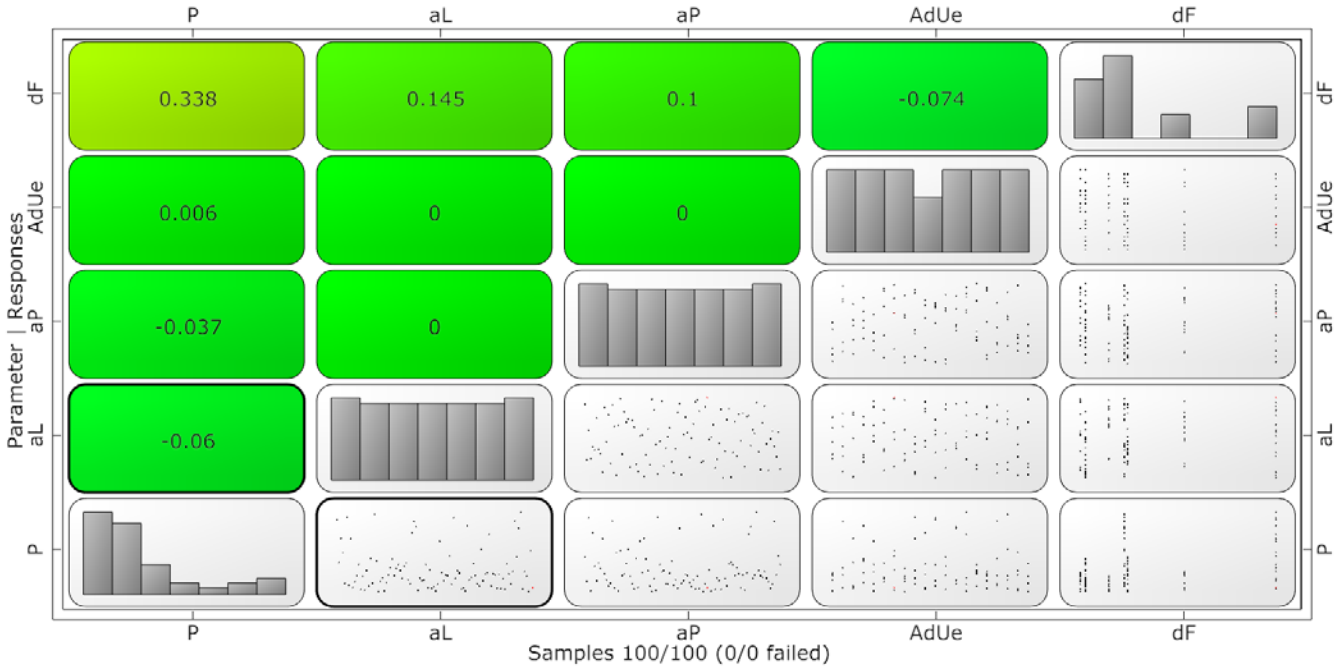
Correlation Matrix

- Deactivate parameters to see their impact on the correlations
- Manual check of reduction of input correlations possible



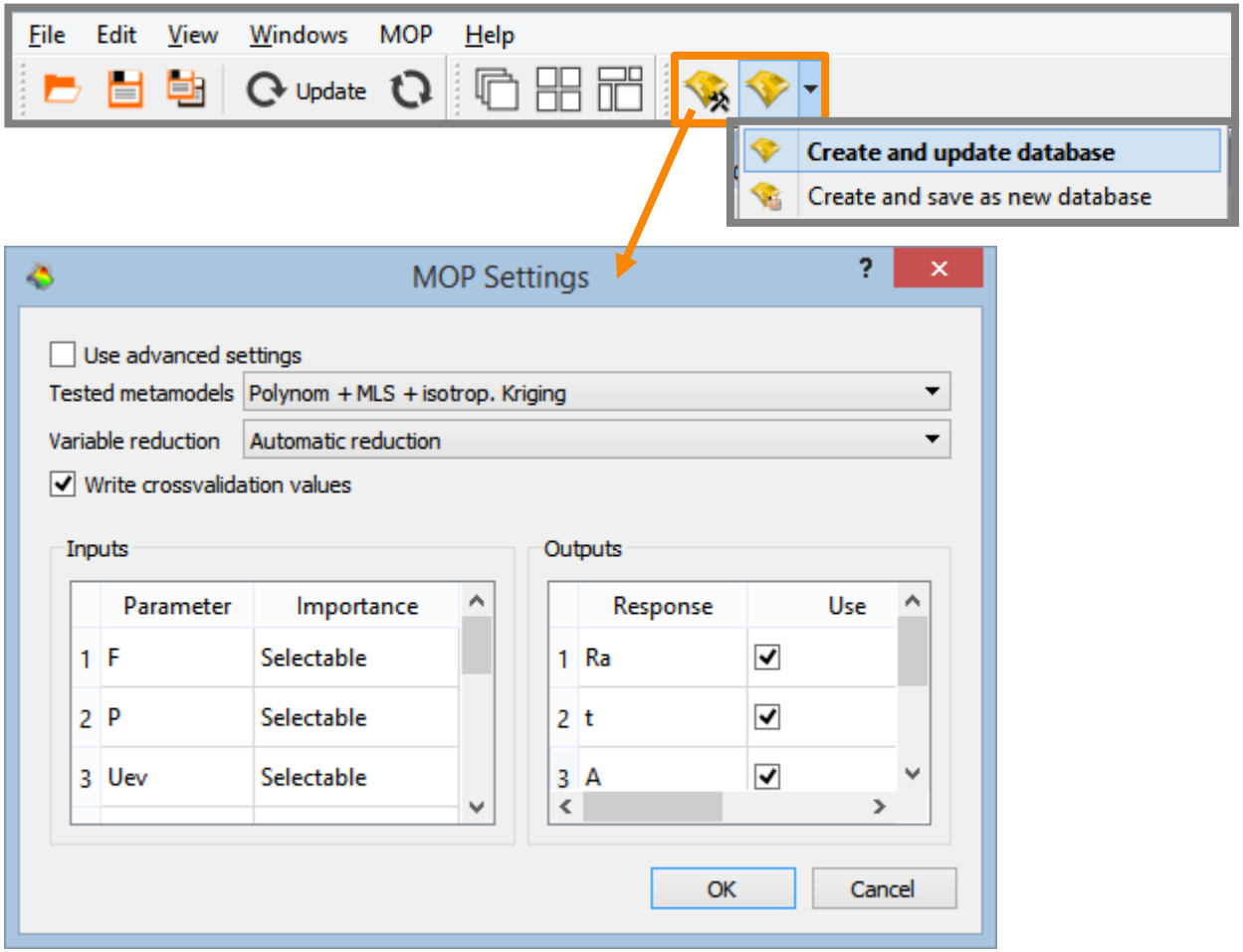


F	P	Ue_v	Ue_h	a_L	a_P	AdUe	d_F	WL



MOP generation

- MOP generation in Postprocessing is now possible!



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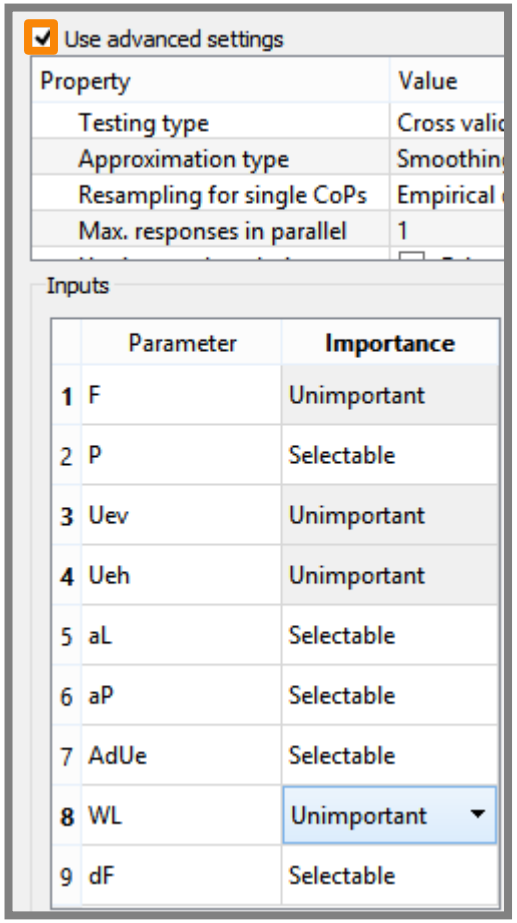
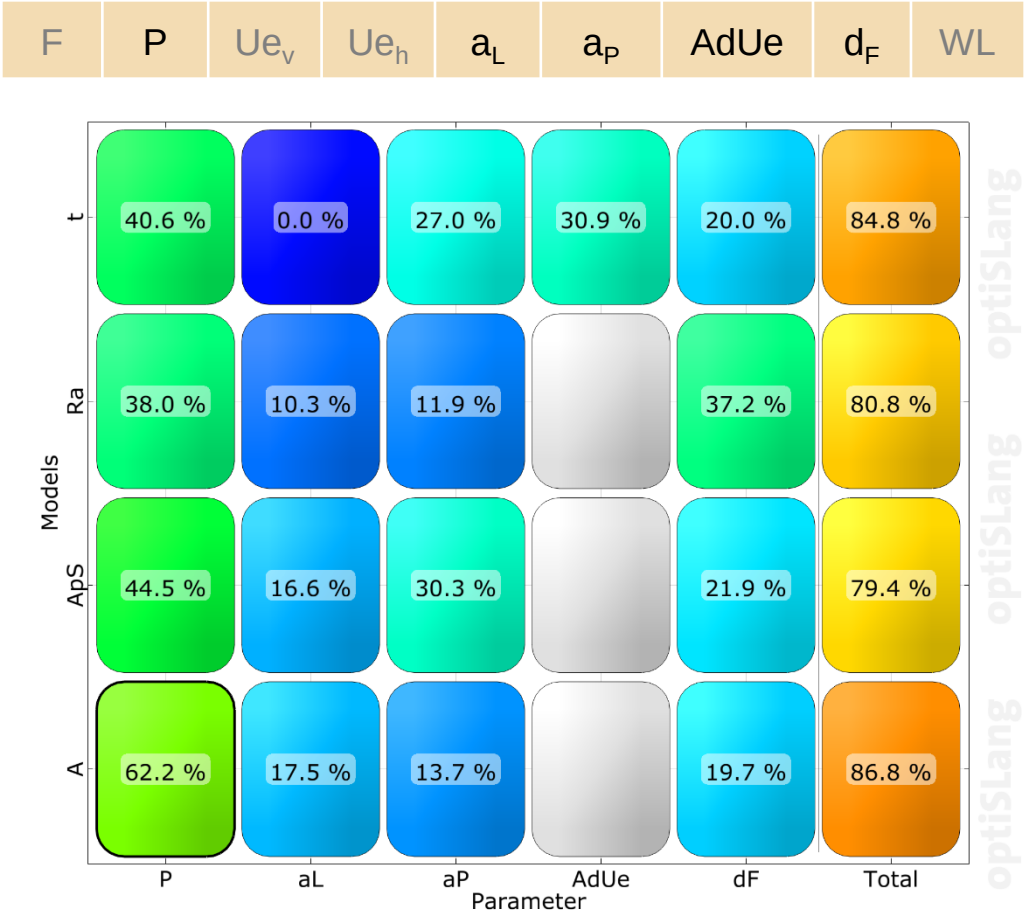
MOP generation

- MOP generated with manually deselected parameters

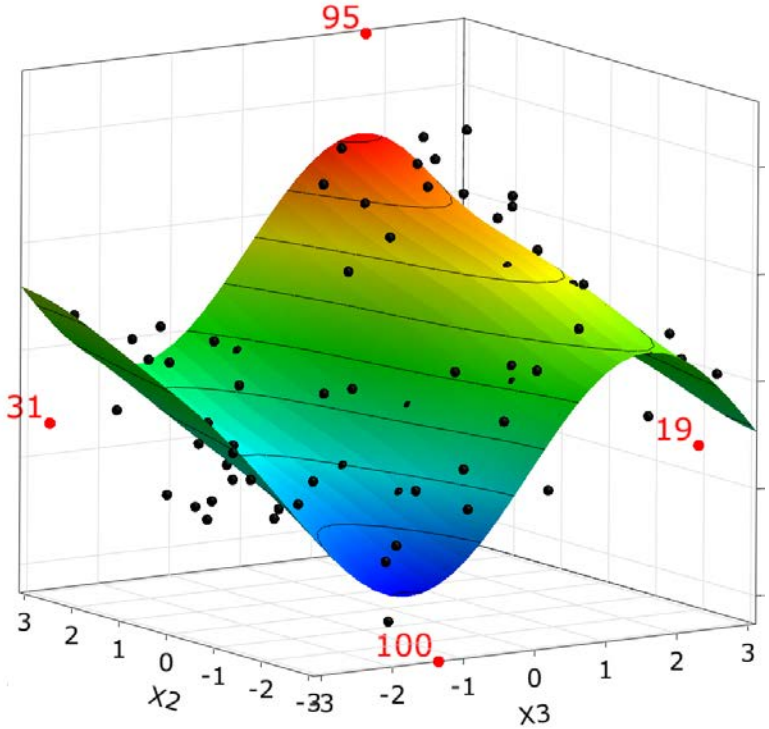


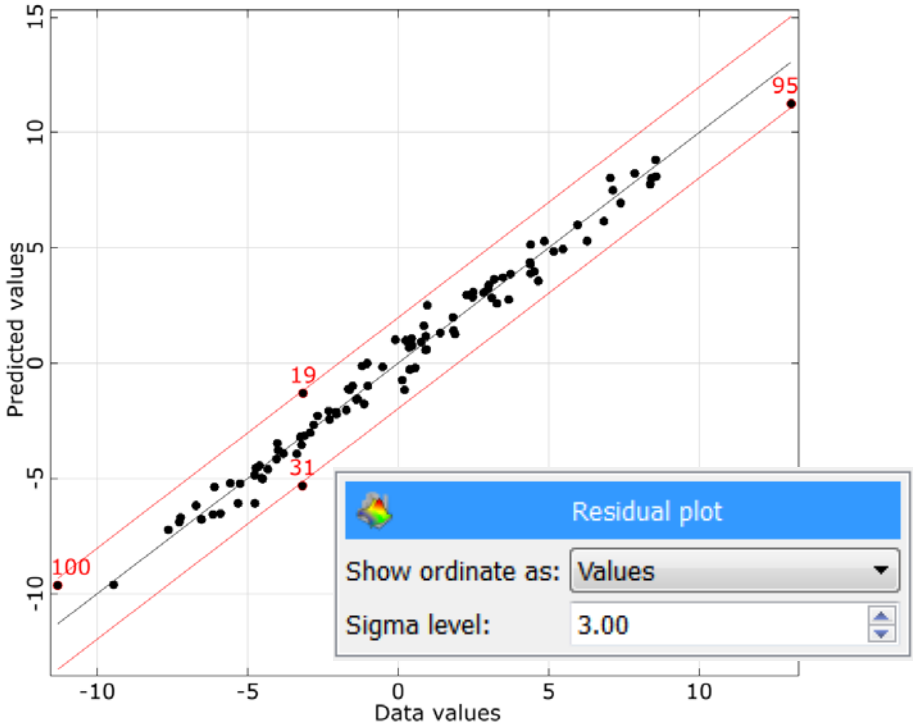


Indication of Possible Outliers

- The residual plot shows the predicted values (from cross validation) vs. the original data values by indicating lower and upper error bounds
- Error bounds are obtained from the standard deviation of the error values (RMSE) multiplied with the user defined sigma level

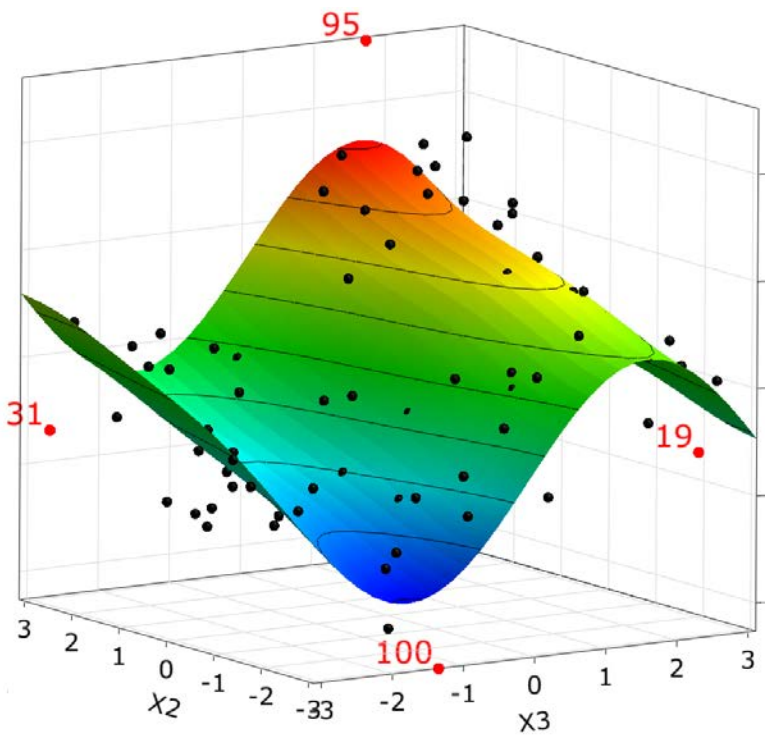
➢ Samples outside the error bounds may be possible outliers

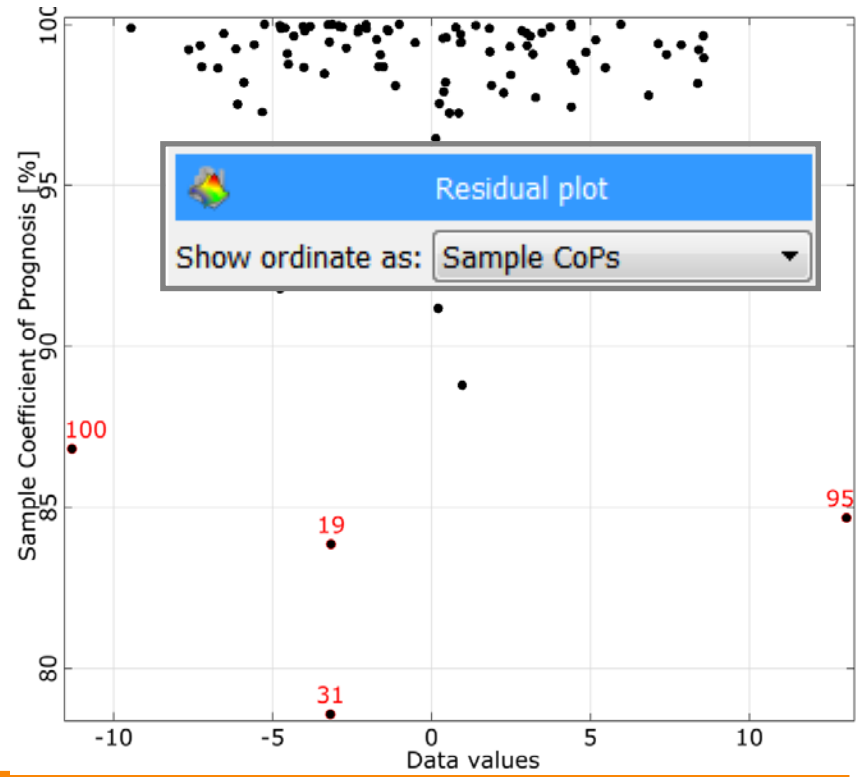




Indication of Possible Outliers

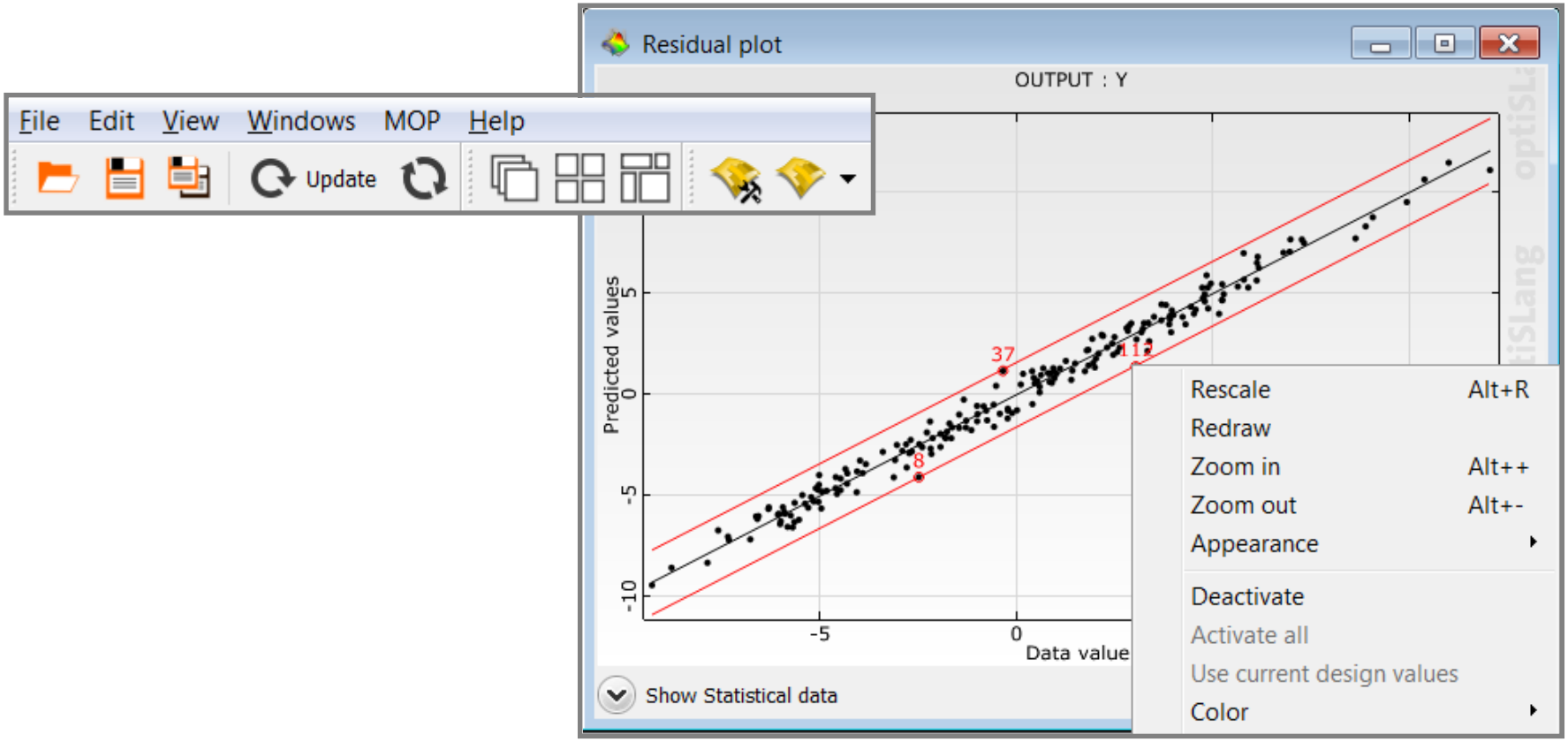
- The Sample CoP quantifies the contribution of each sample to the global CoP value
- The mean of all sample CoP values is equal to the global CoP





Neglection of Outliers

- Select outliers in the residual plot
- Deactivate them via the context menu
- Update the MOP directly in the post-processing



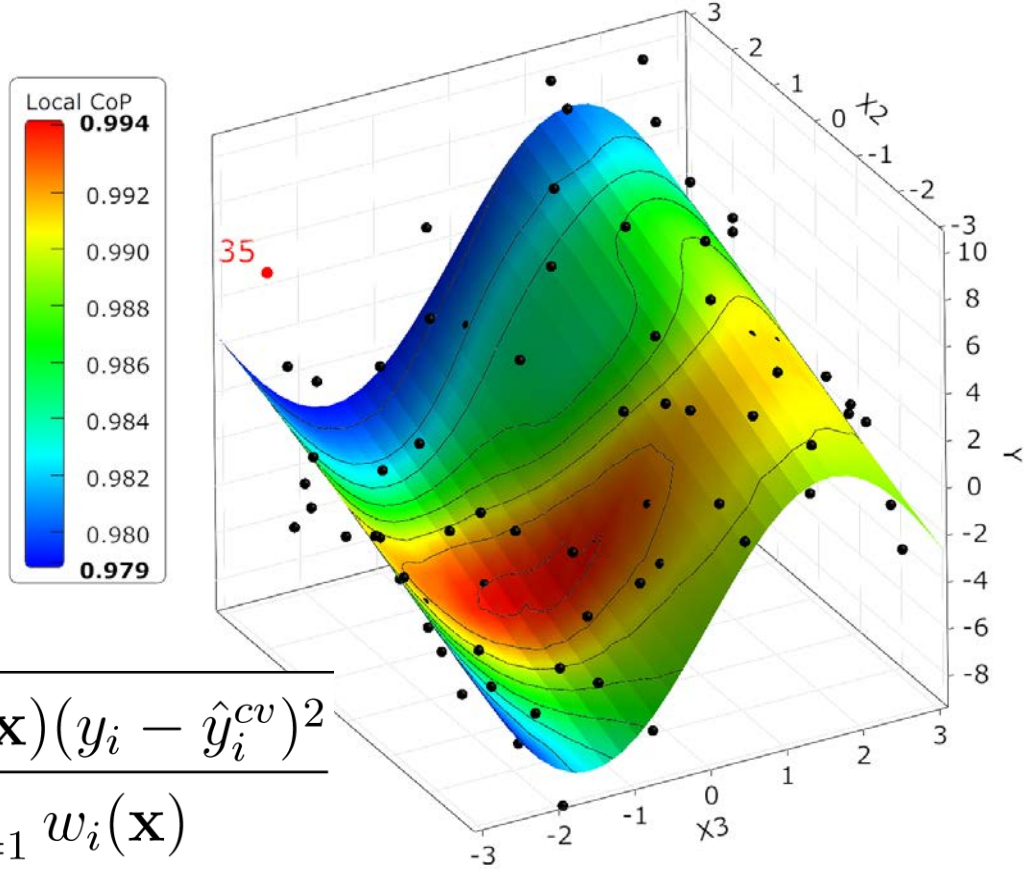
Local Prediction Errors

- Local approximation errors are estimated **model independent** from sample **cross validation errors** using **local averaging**

- Local CoP and RMSE are obtained from locally weighted squared errors

- Distance depending weights

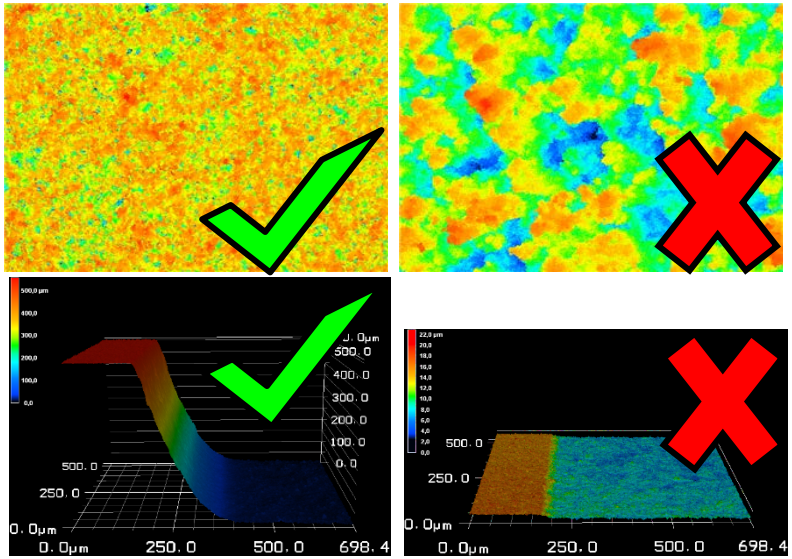
➢ Indicator for possible adaptation of meta-model

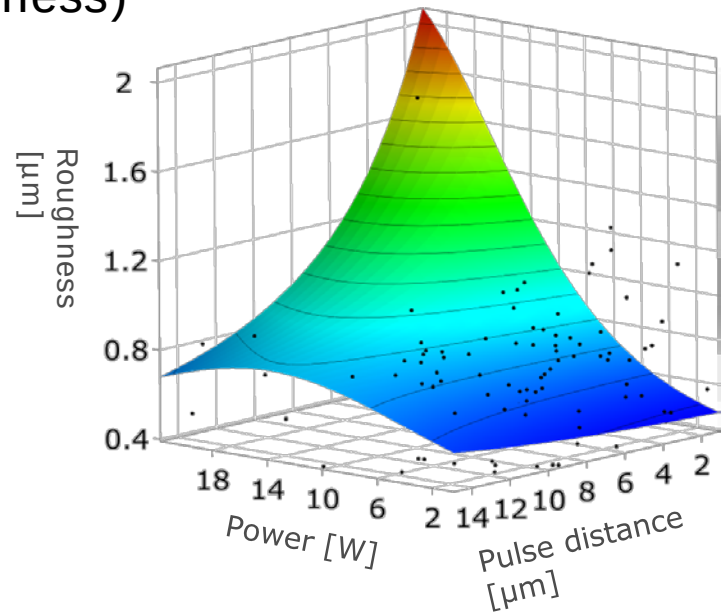


$$RMSE(\mathbf{x}) = \sqrt{\frac{\sum_{i=1}^{N} w_i(\mathbf{x})(y_i - \hat{y}_i^{cv})^2}{\sum_{i=1}^{N} w_i(\mathbf{x})}}$$

Experimental data analysis

- **Obtained results**:
  - Gain on process understanding
  - Identify the most influencing factors
  - Quantify optimization potential
  - ➢ Optimize and fine-tune process depending on application (desired abrasion and roughness)



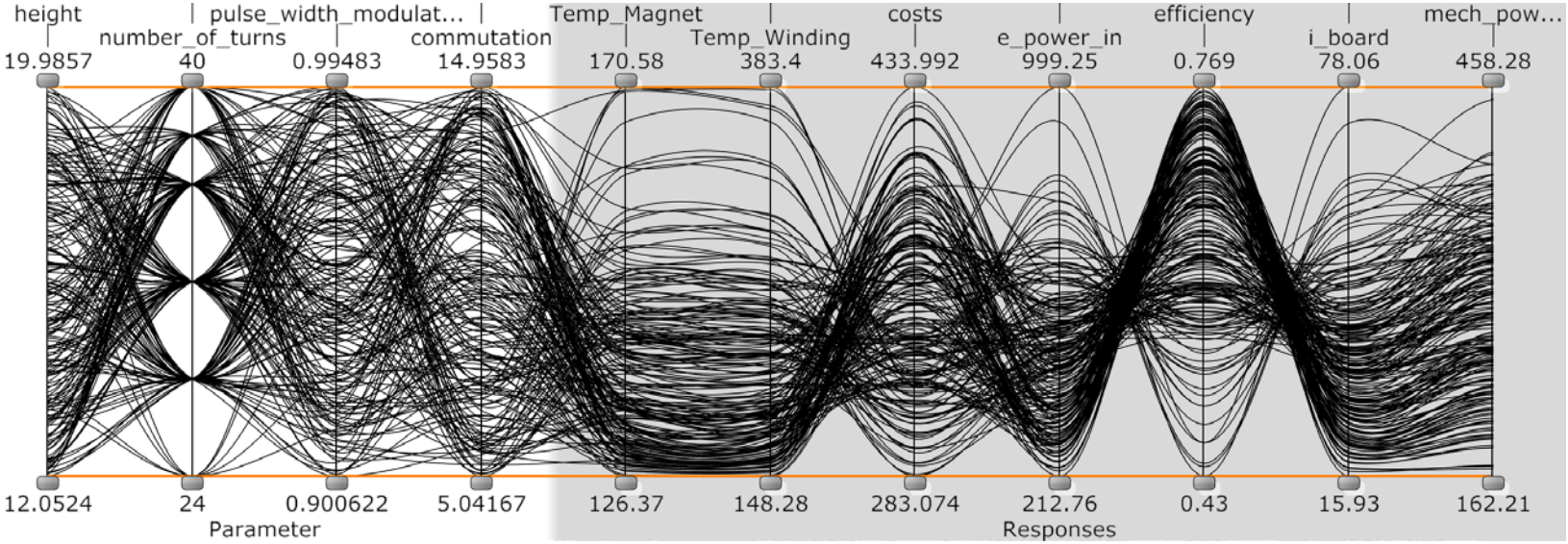


With courtesy of ifw Jena

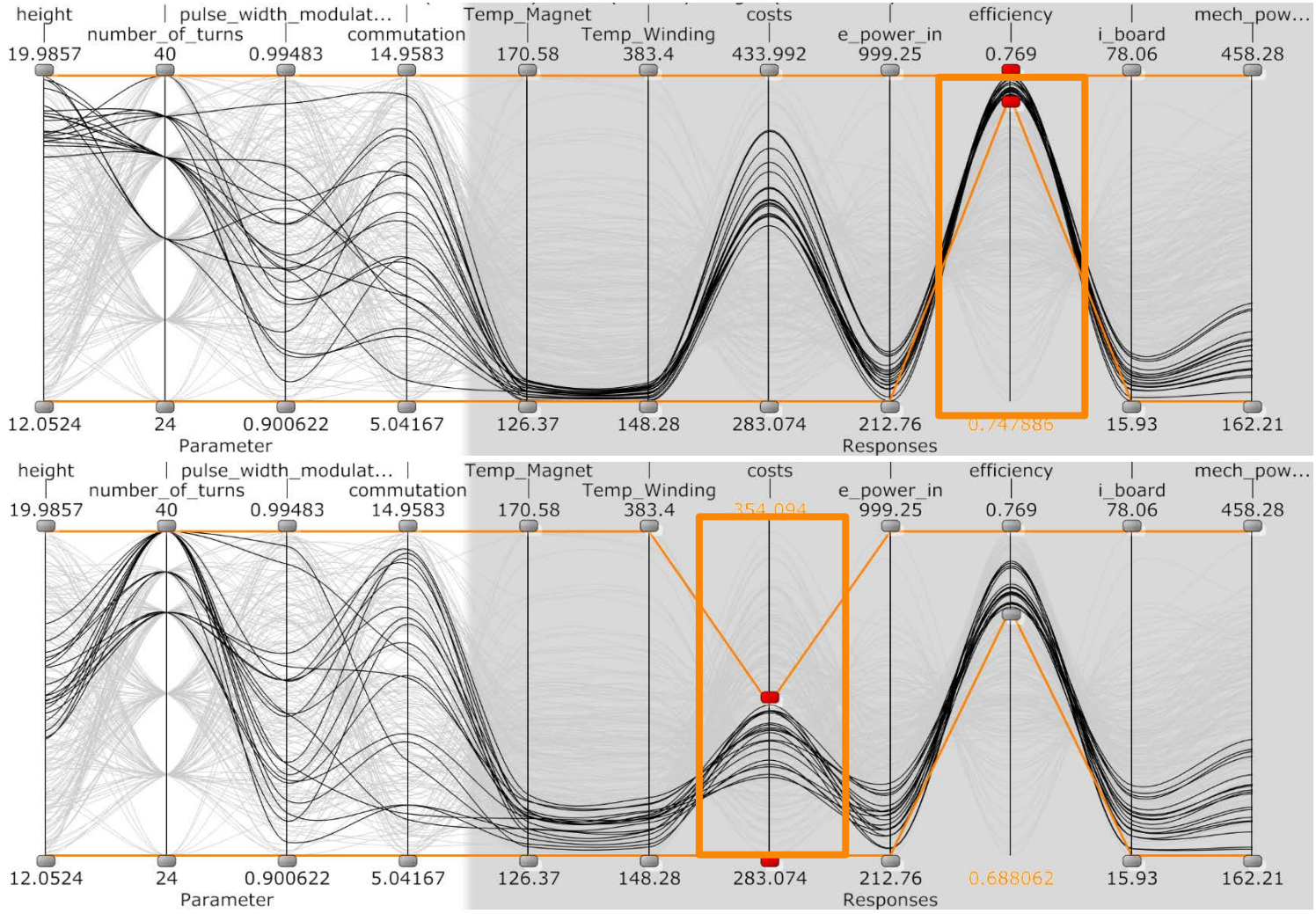
Cluster analysis

Parallel coordinates plot

- One line represents one design
- One column represents one parameter, response, objective or constraint
- For each parameter the full variation range is shown and can be modified by sliders

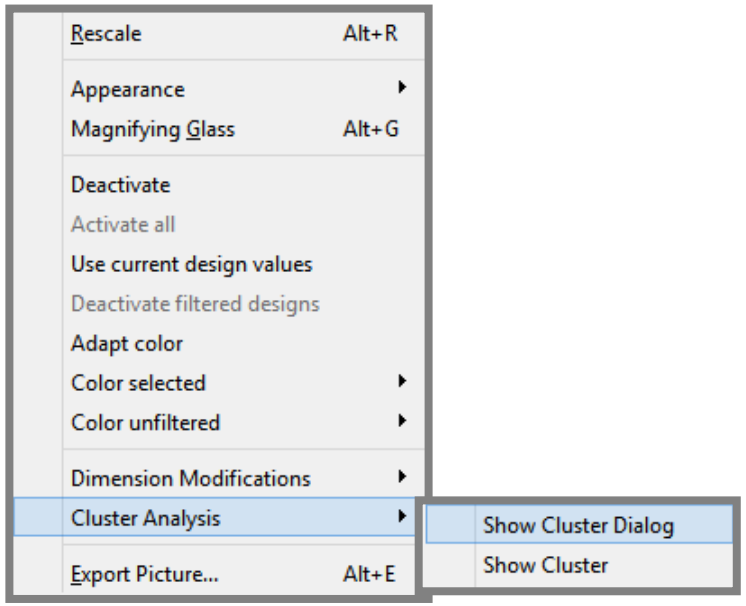


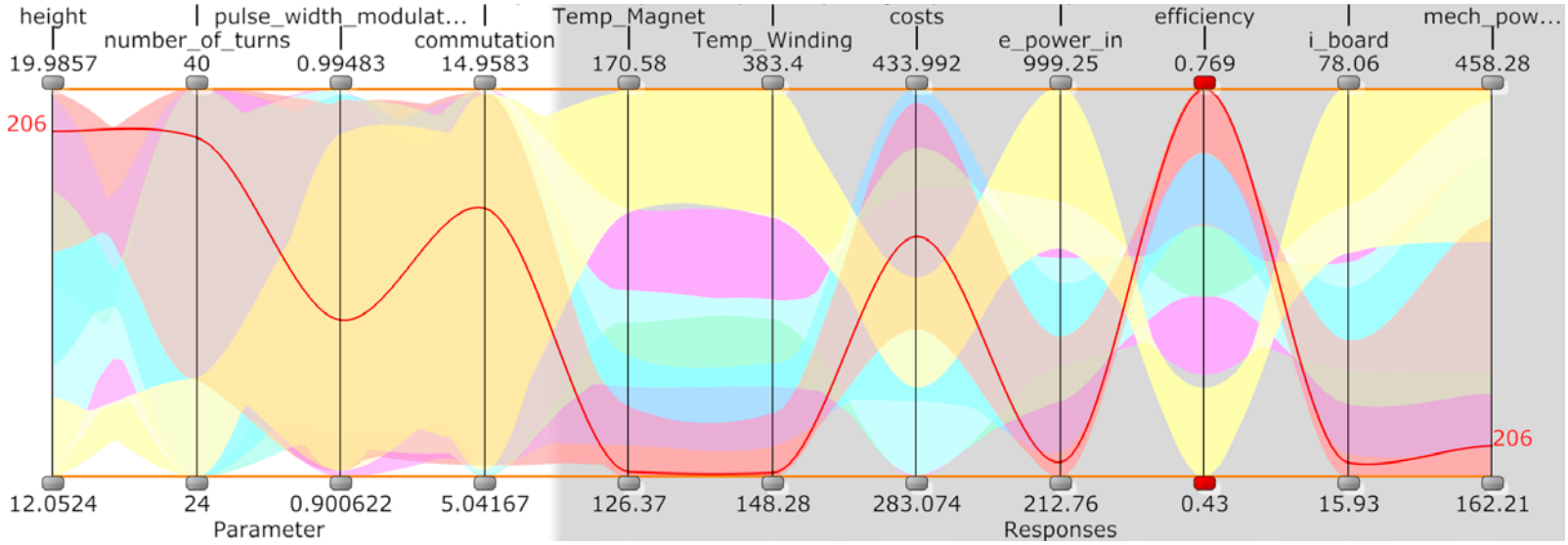
Parallel coordinates plot



Cluster analysis

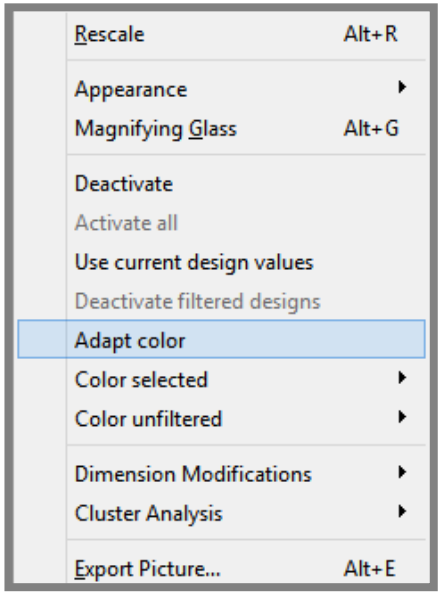
- Cluster: k-means: number of clusters to be defined for which parameter

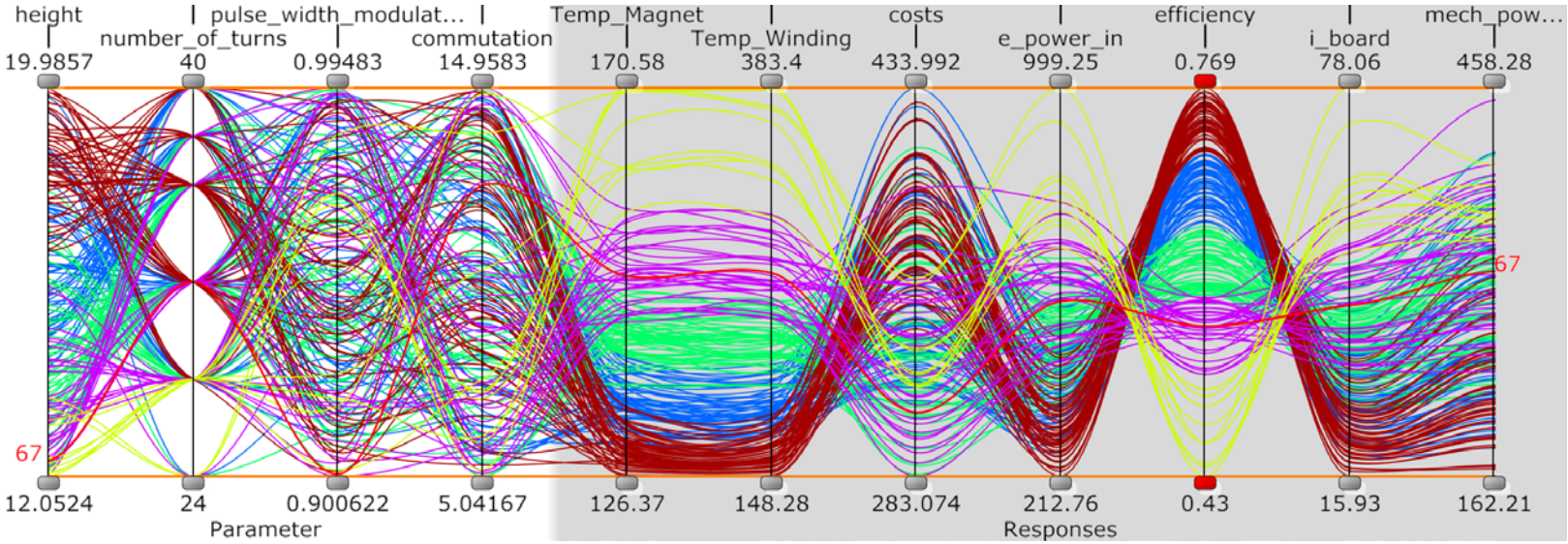




Cluster analysis

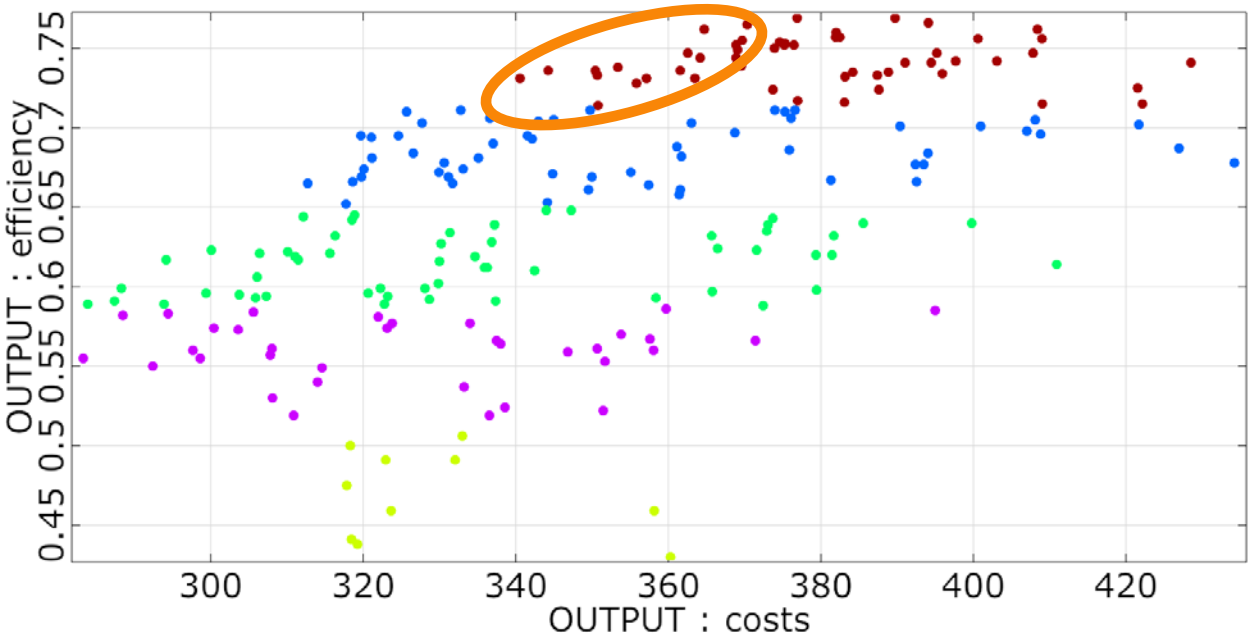
- Adapt coloring of clusters to PCP and to other plots





Cluster analysis

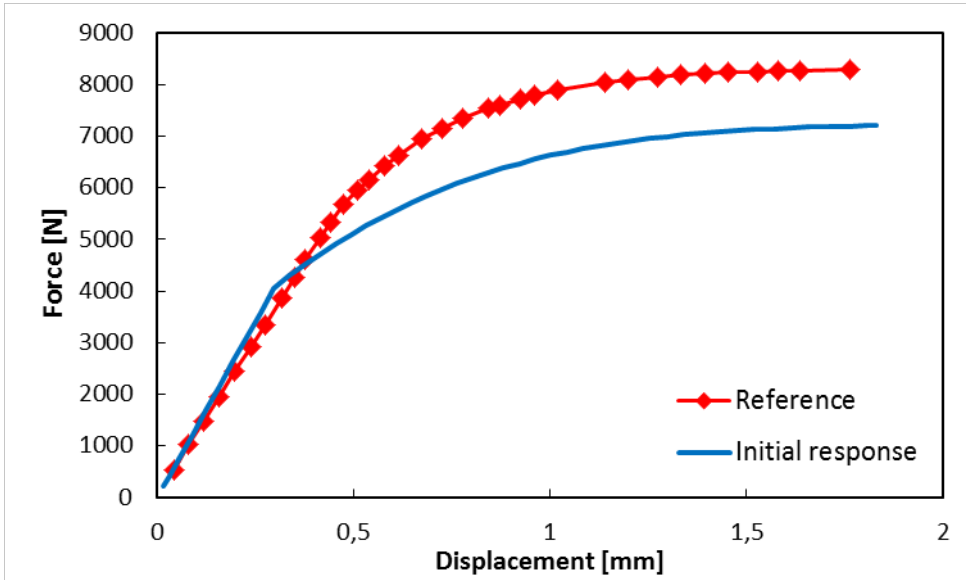
- Pareto conflict between efficiency and costs



Visualization of signals, images and processes

Spring steel example

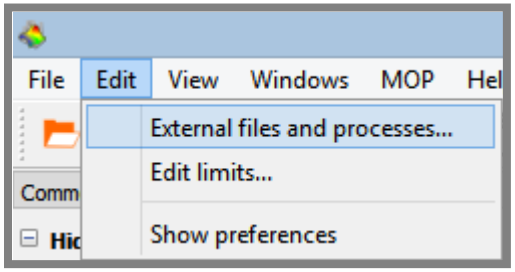
- Simulation with initial materials parameters vs. reference (measurements)

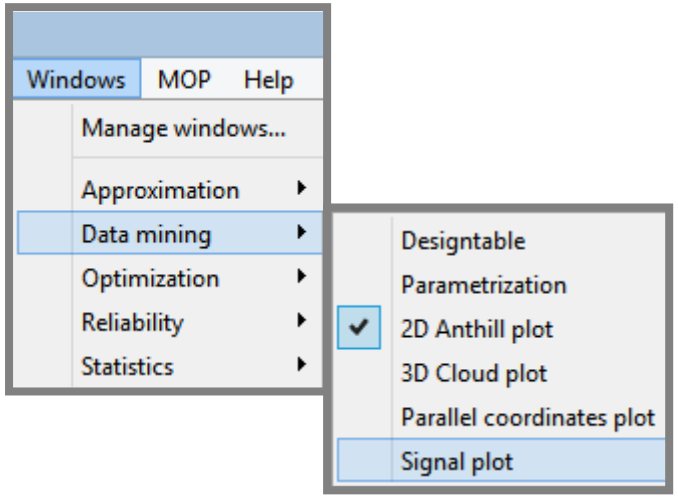


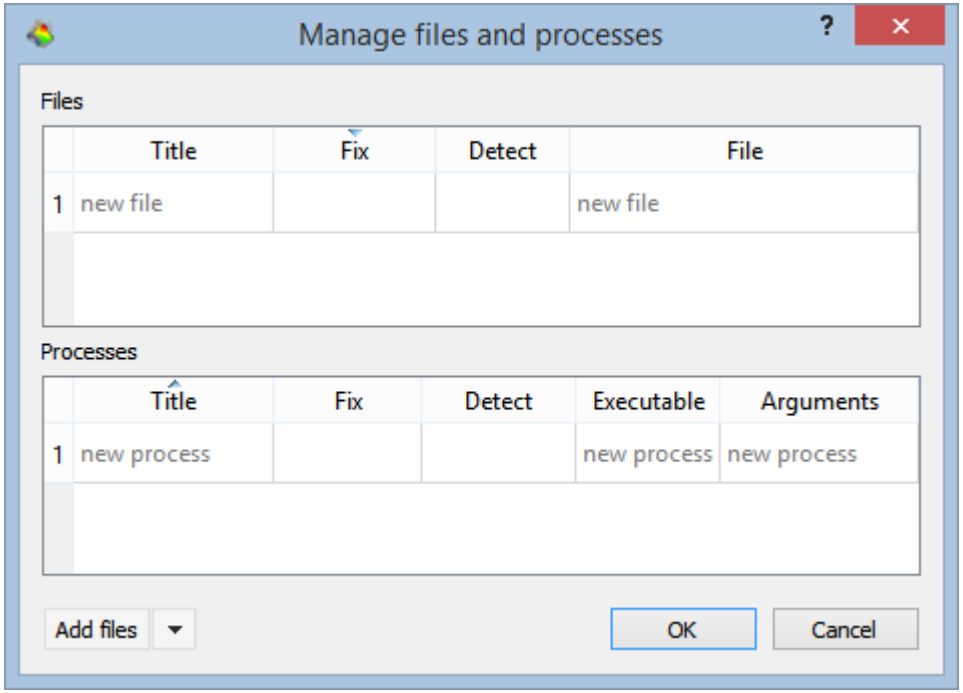
Source: customer portal Dynardo -> Tutorials

Spring steel example

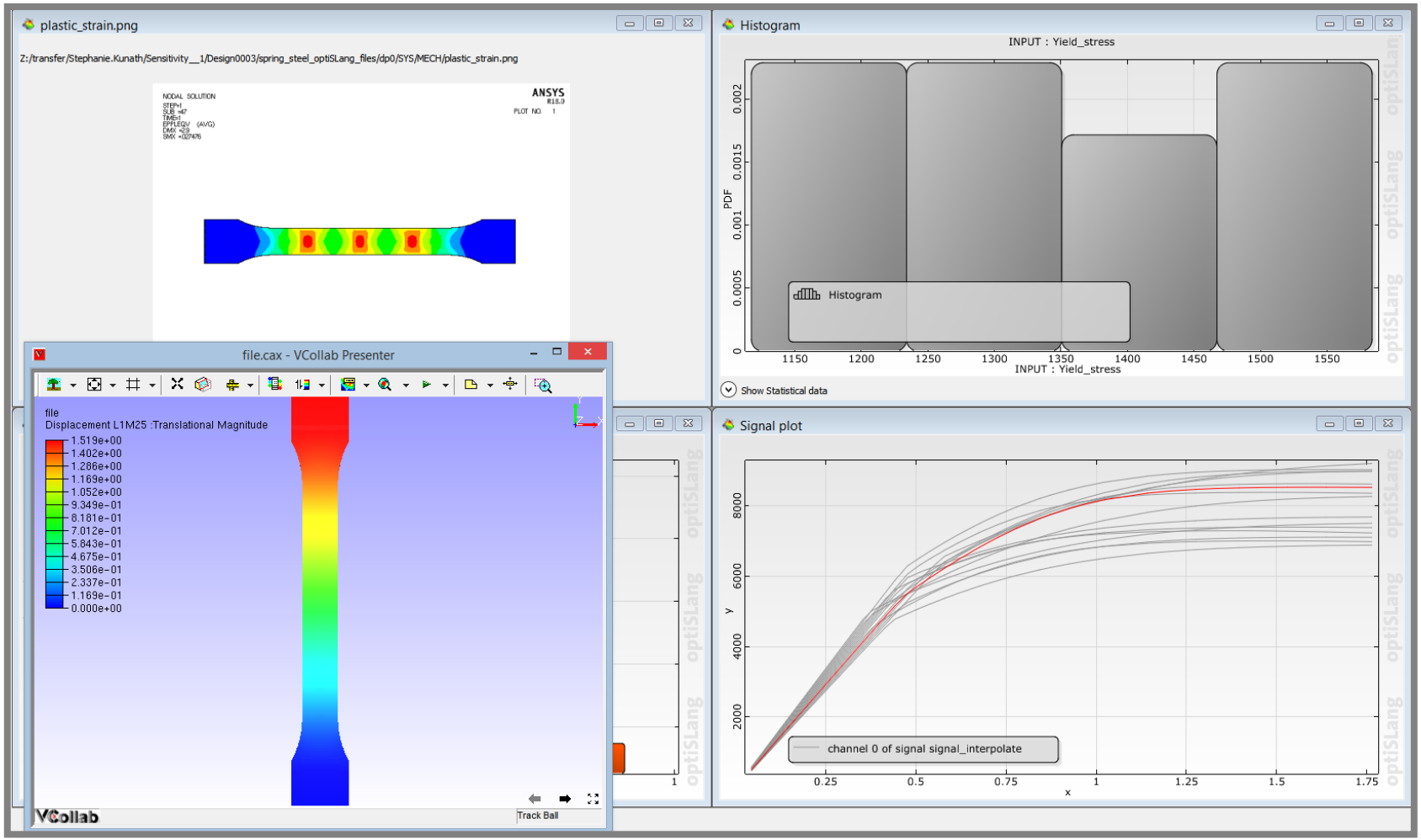
- Integrate signals, images and processes in postprocessing





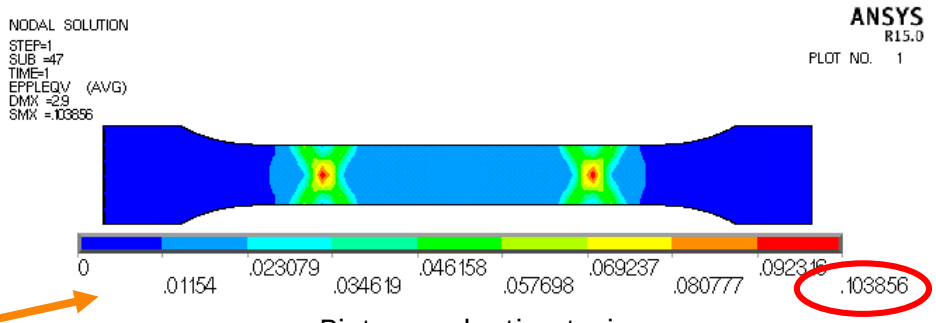


Spring steel example

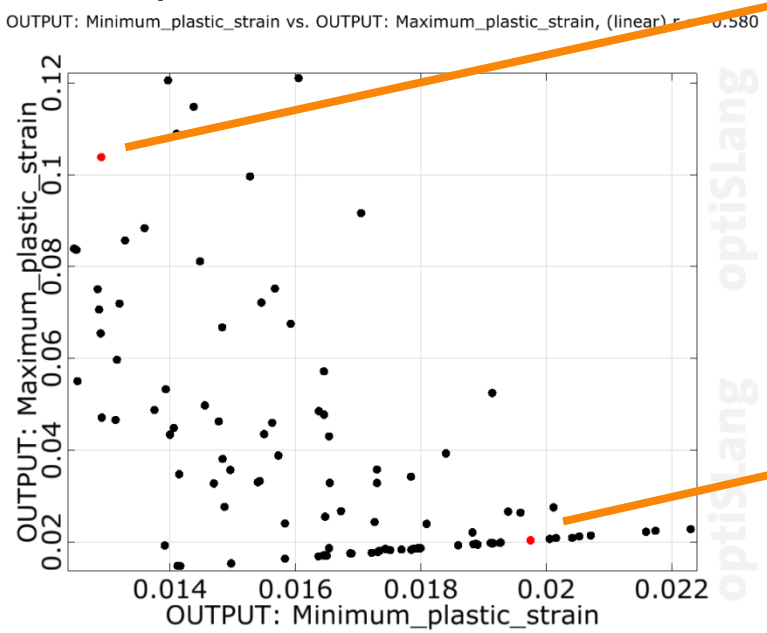


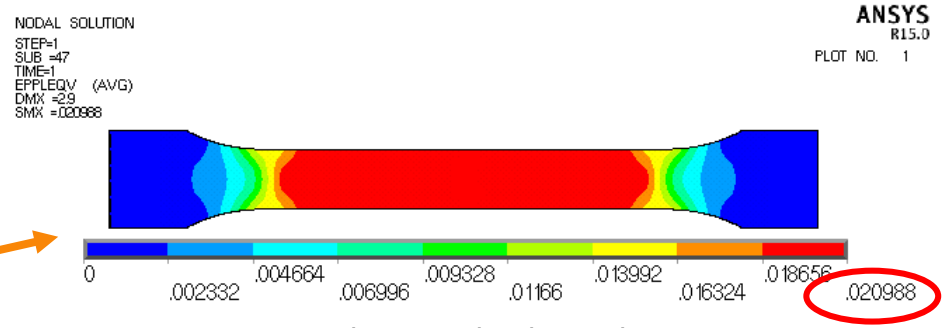
Spring steel example

- For some designs the material does not behave uniformly
- A strong localization is indicated by a large difference between minimum and maximum plastic strain



Picture: plastic strain

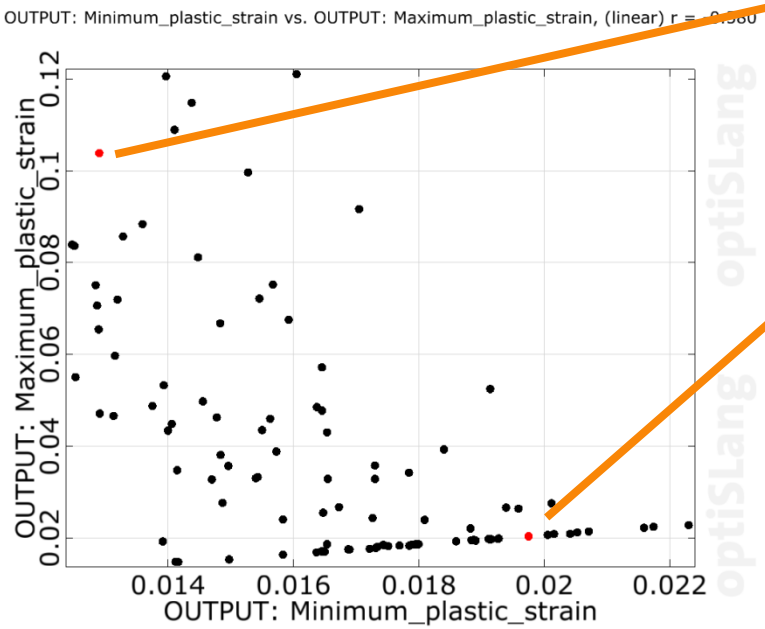


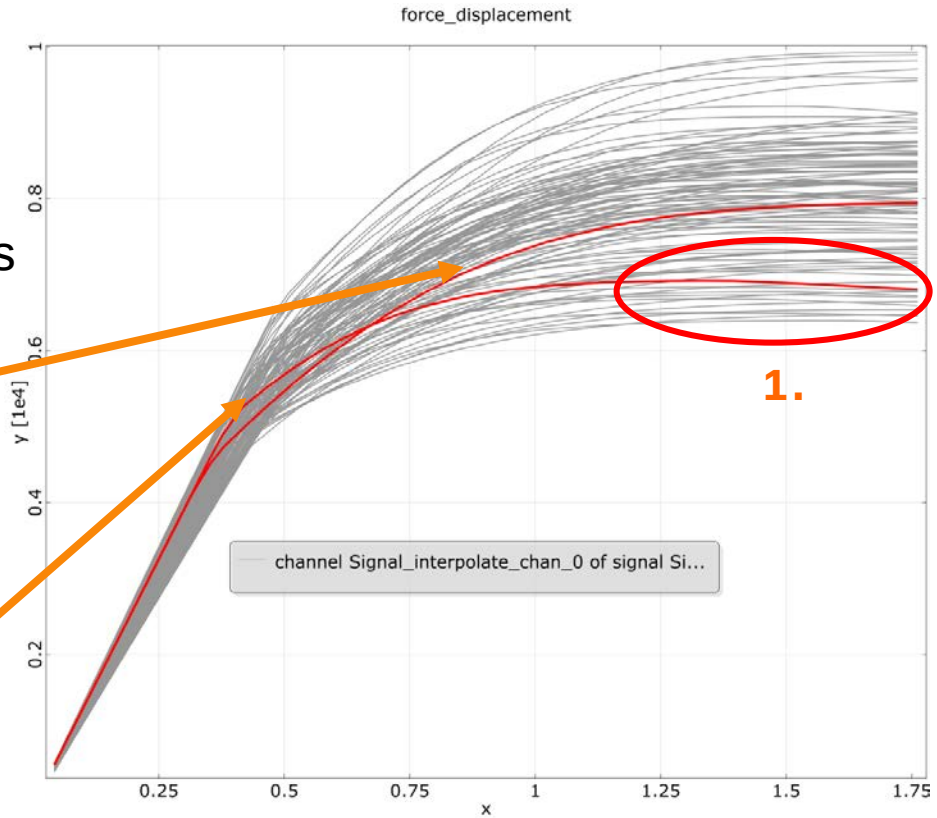


Picture: plastic strain

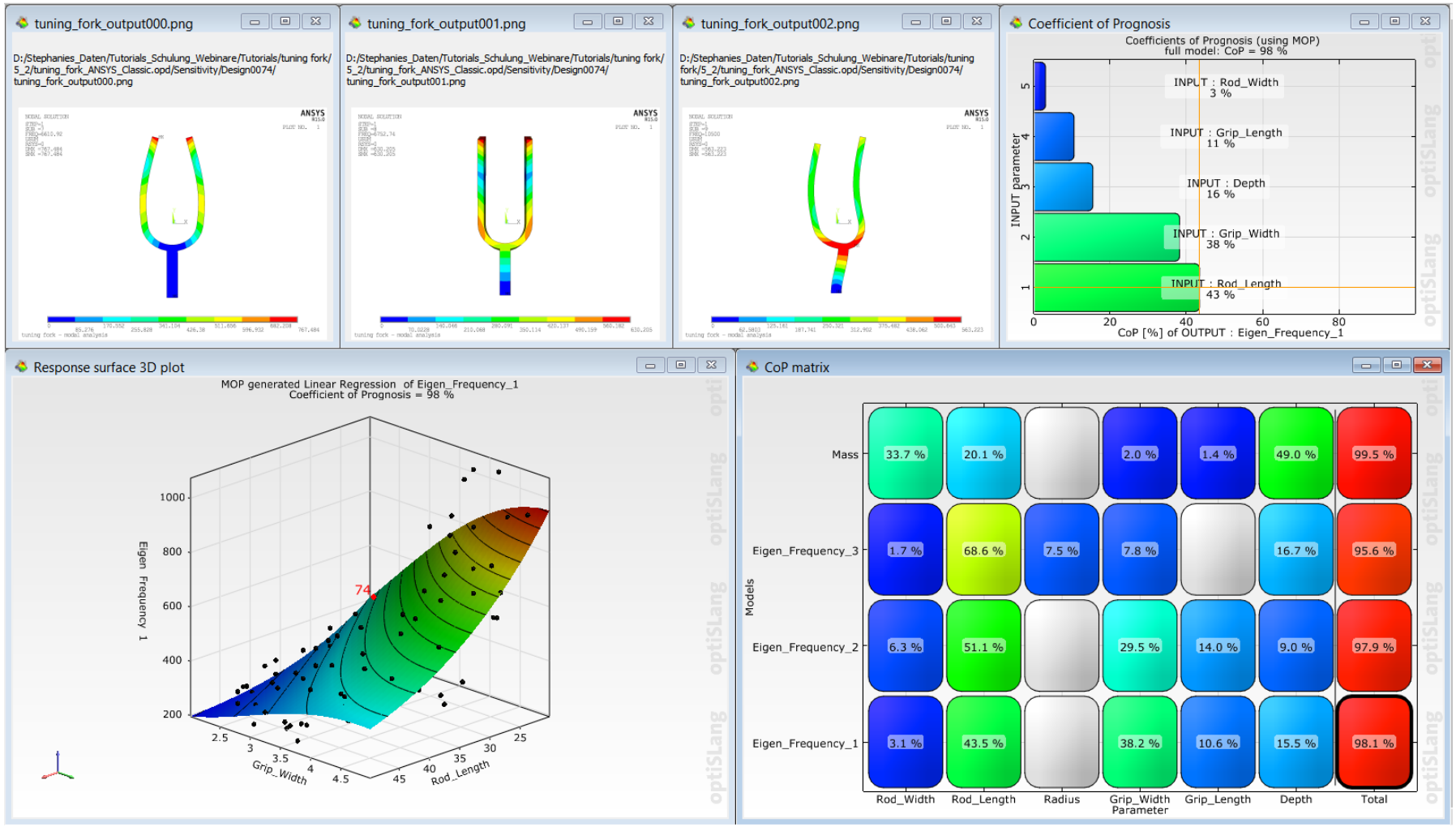
Spring steel example

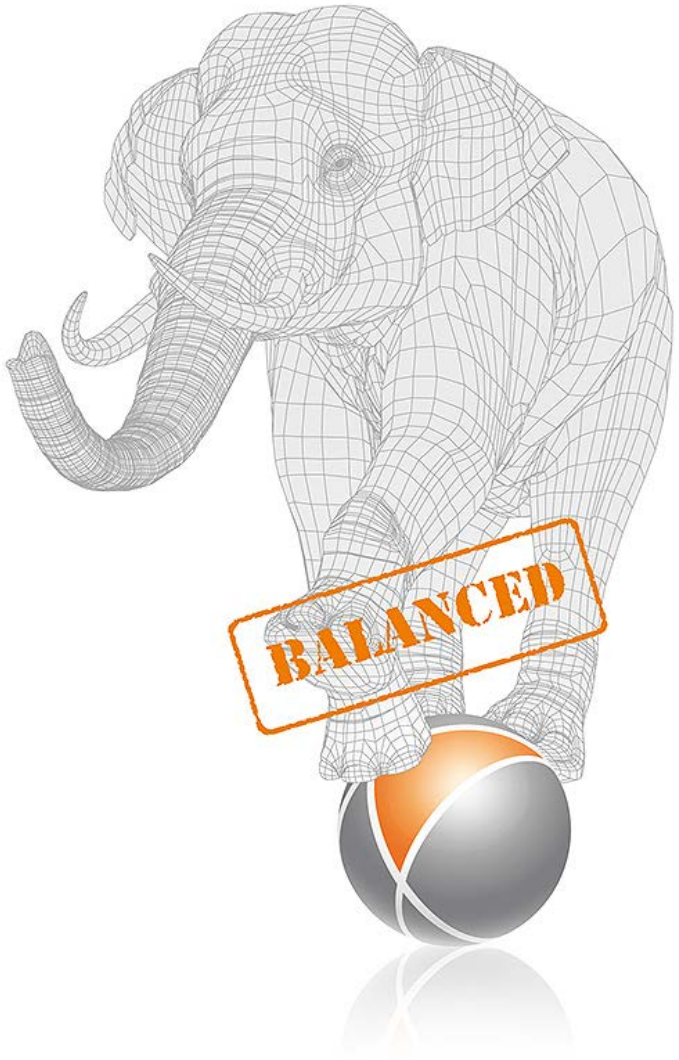
- This localization will lead to a negative gradient (1) of the force-displacement-curve.
- To avoid this situation, a positive gradient is required as constraint: “min_gradient_Signal ≥ 0”





Tuning fork example



- Unit 1 – Graphical user interface and process integration
- Unit 2 – Sensitivity analysis
- Unit 3 – Single- and multi-objective optimization
- Unit 4 – Robustness evaluation and Robust Design
- Unit 5 – Model calibration and parameter identification
- Unit 6 – optiSLang and ANSYS Workbench
- Unit 7 – Interactive post-processing and data visualization

Thank you for your attention!