optiWood

Development of a numerical tool for the optimization of glued laminated timber

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WEIMAR OPTIMIZATION AND STOCHASTIC DAYS

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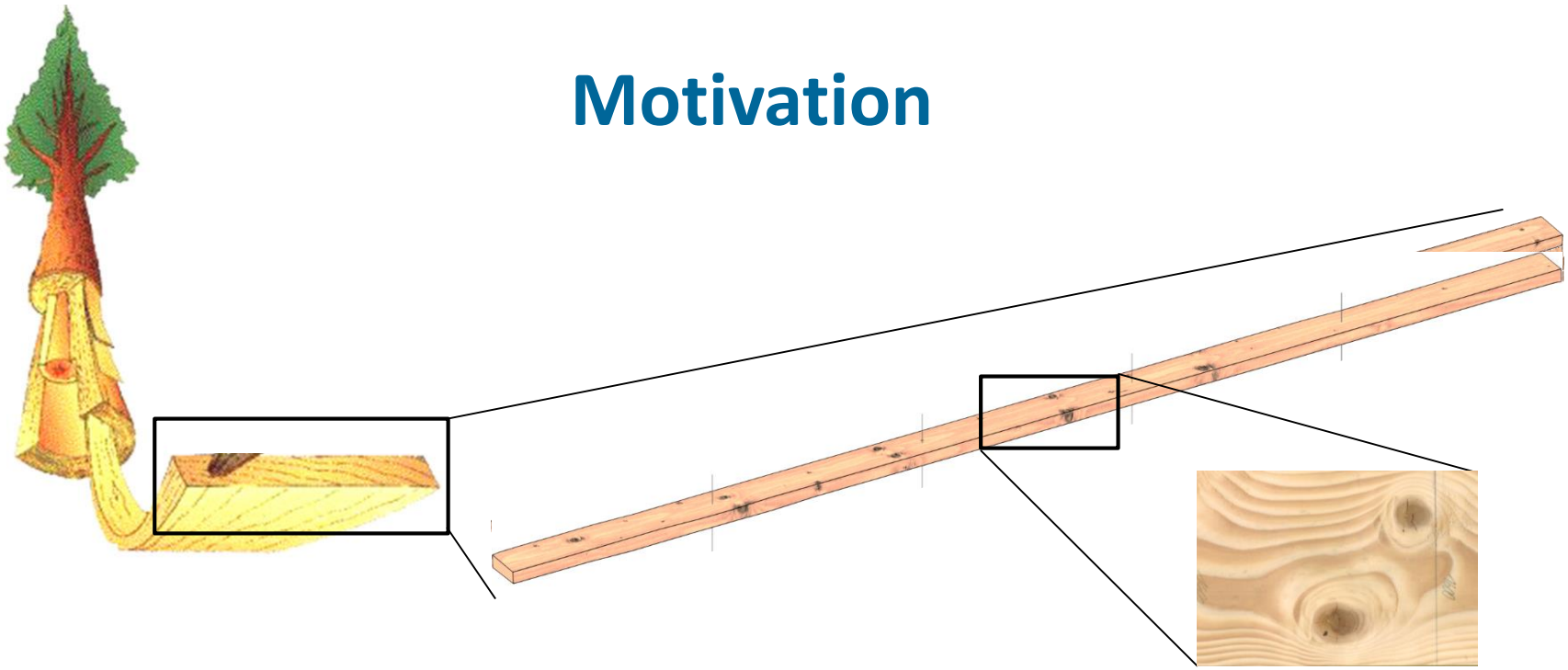
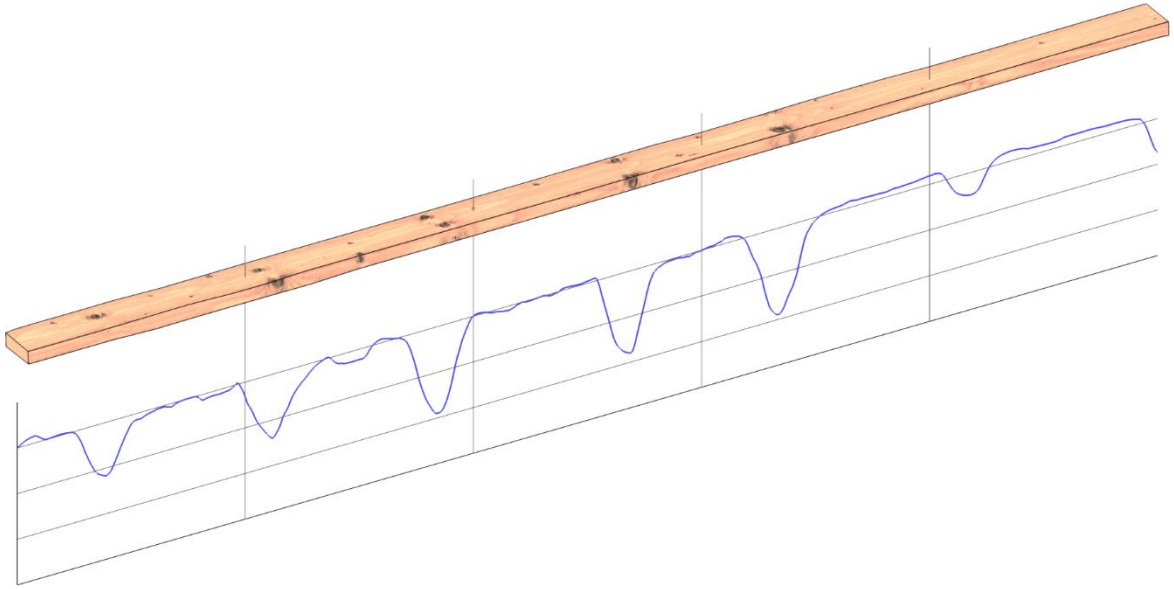
Motivation



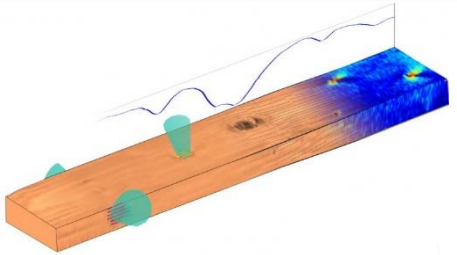
- **Variation of mass density, knots & moisture content** lead to material property fluctuations in wooden boards

Motivation

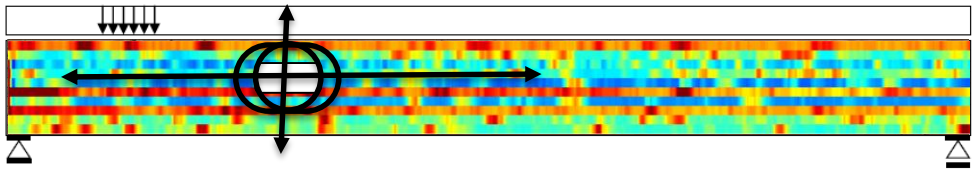


- **Variation of mass density, knots & moisture content** lead to material property fluctuations in wooden boards

Motivation for optiWood



- For a reliable and efficient design of wood products and timber structures a **probabilistic approach** is required

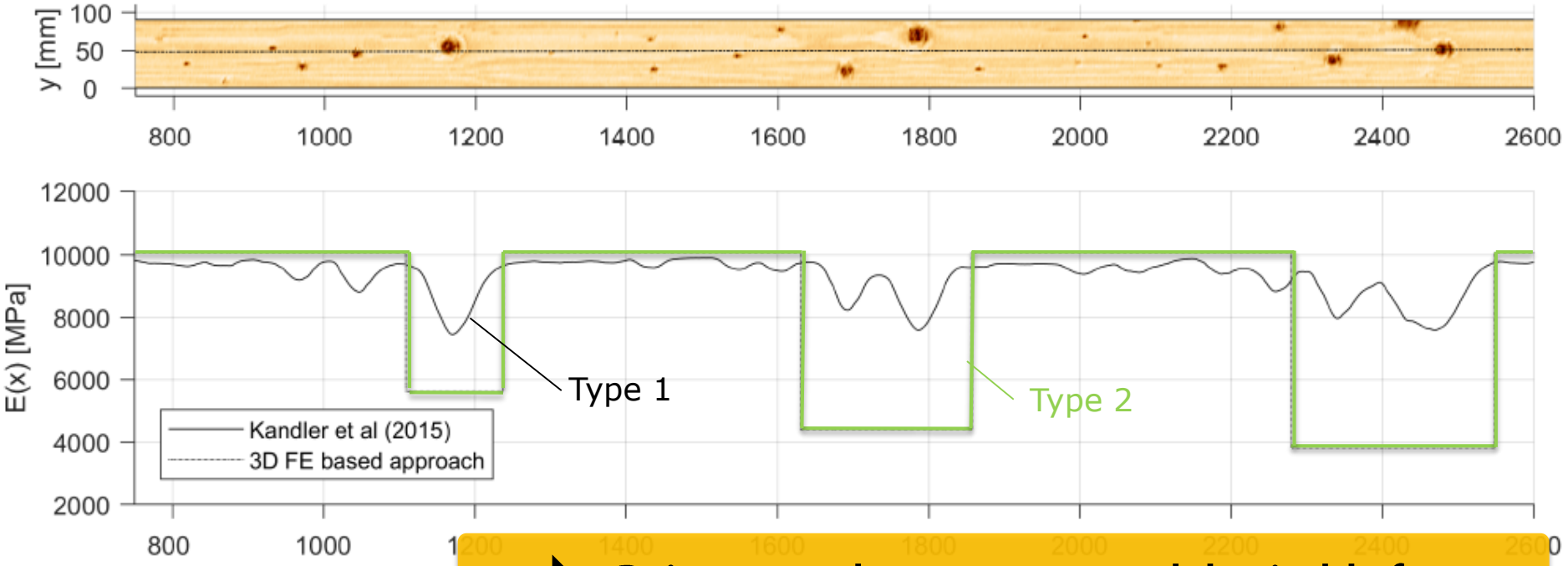


Design variables *X*:
- Hole dimensions
- Hole position
- Hole type

- **Framework** taking **random fluctuations** of individual laminations into consideration
  - ➢ **Random process model for material properties** (SoS)
  - ➢ Sensitivity analysis (optiSLang)
  - ➢ RDO with regards to
    - stresses
    - **deflections** (optiSLang & SoS)

Material fluctuations - random process model

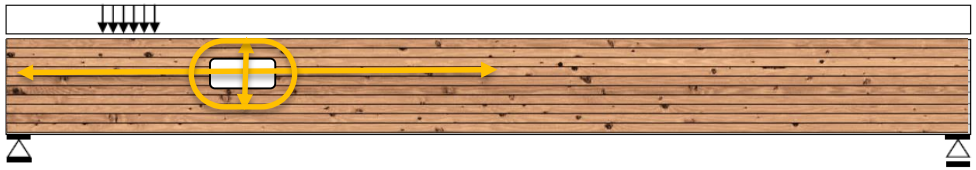
- Sample size of 275 boards/signals



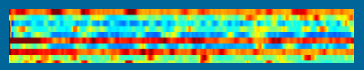
- Decision between two different types of stiffness profiles
- SoS: **no meaningful correlation found for Type 1**

Poisson random process model suitable for modelling stiffness and strength fluctuations

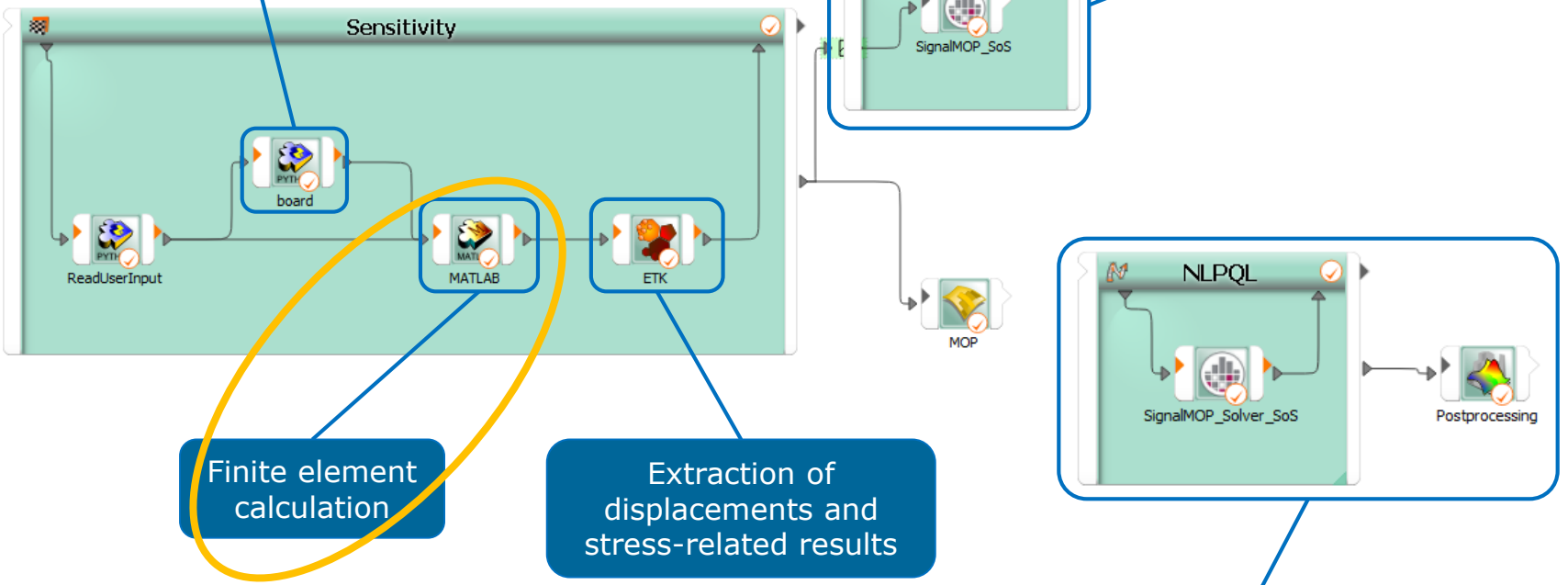
optiSLang workflow



Generation of stiffness- and strength profiles



SoS:
FMOP for deflection signal



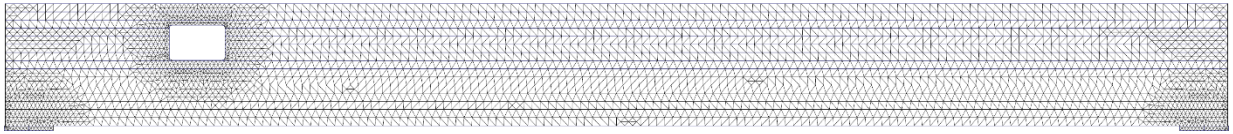
Finite element calculation

Extraction of displacements and stress-related results

Optimization on FMOP

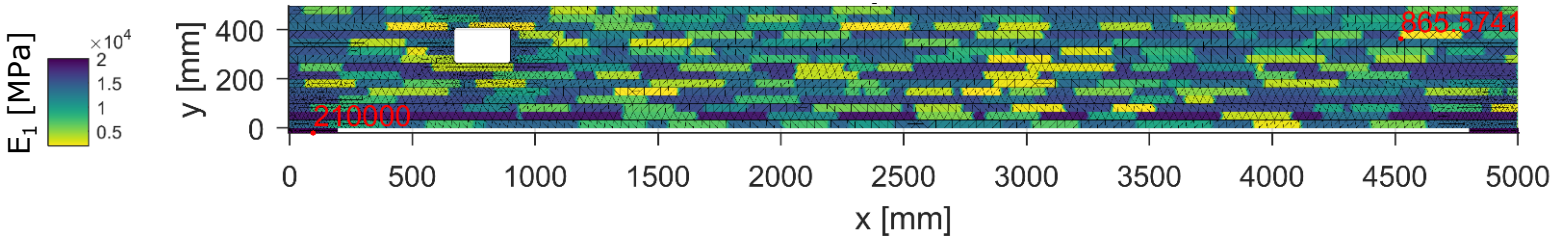
Mechanical model

- **Linear 2D finite element simulation**
  - Meshing in gmsh



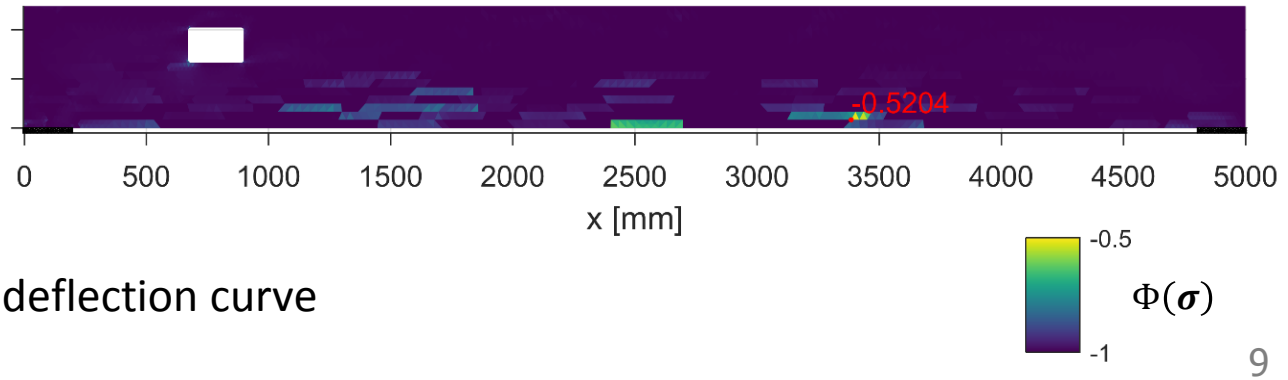
  - FE calculation in MATLAB

Randomly generated stiffness- and strength profiles for each run



- **Results:**
  - Stress results → Tsai-Wu criterion (orthotropic material behaviour)

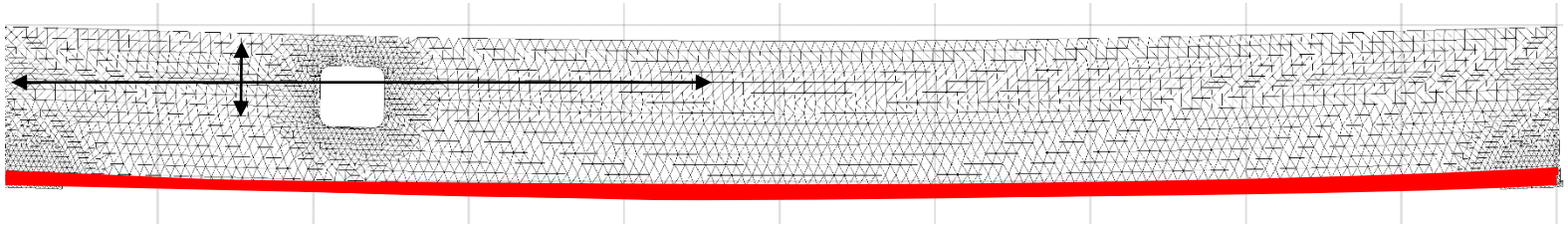
$$\Phi(\boldsymbol{\sigma}) = a_{LL}\sigma_{LL} + a_{RR}\sigma_{RR} + b_{LLLL}\sigma_{LL}^2 + b_{RRRR}\sigma_{RR}^2 + 2b_{LLRR}\sigma_{LL}\sigma_{RR} + 4b_{LRLR}\tau_{LR}^2 - 1 \leq 0.$$



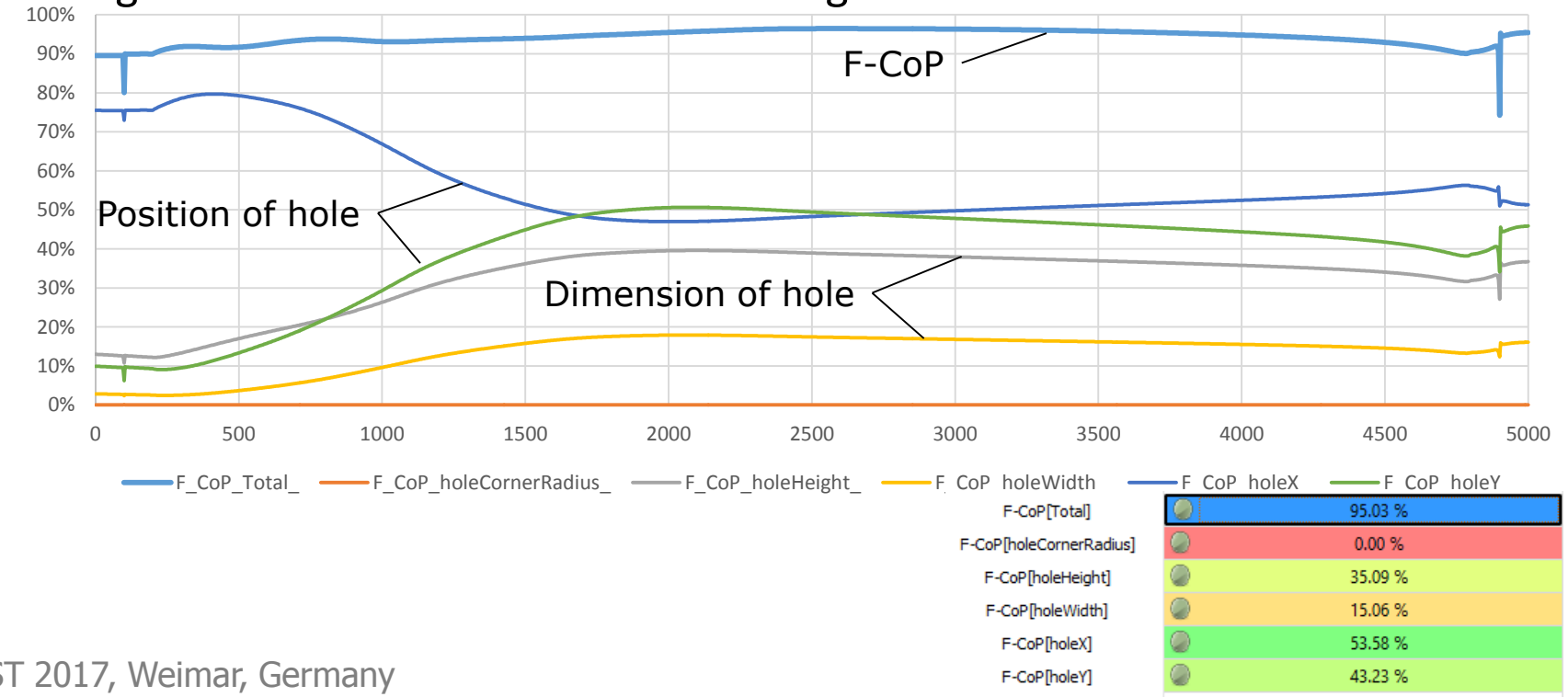
  - Displacements → deflection curve

Signal MOP

- Displacements → deflection curve (1 signal for each design)

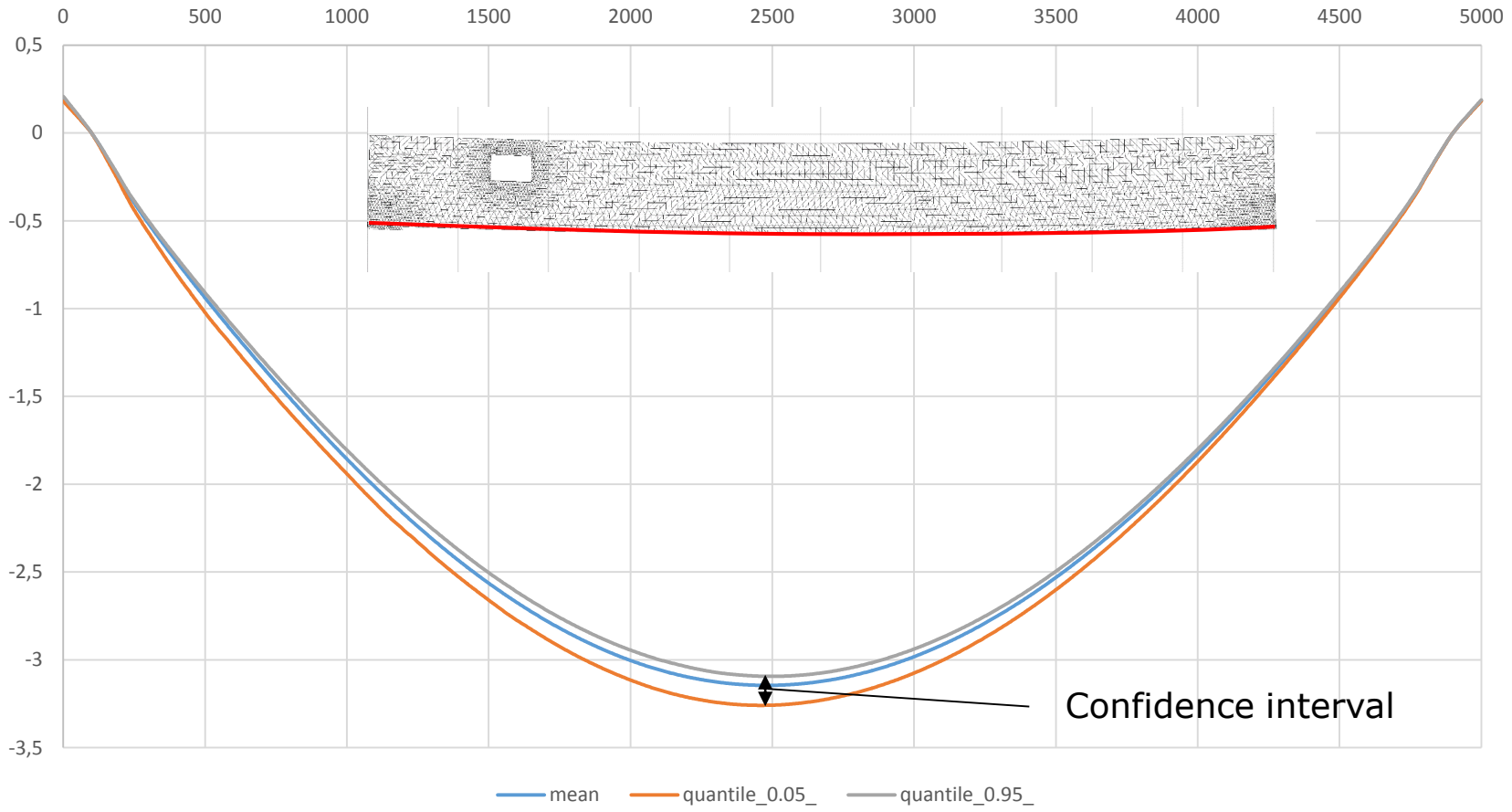


- Signal MOP for collected deflection signals – F-CoP



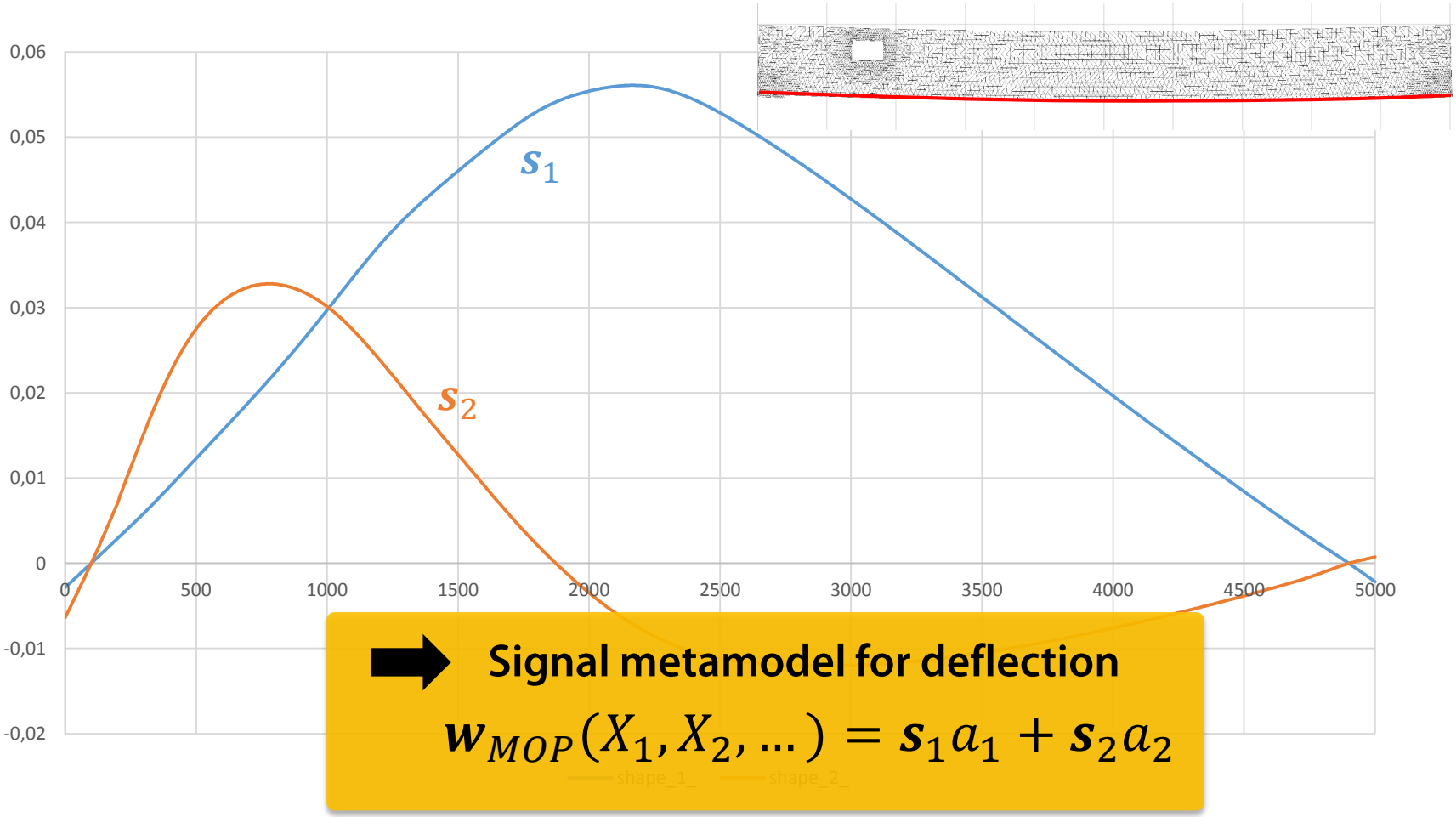
Signal MOP

- Signal MOP for deflection – **mean curve**



Signal MOP

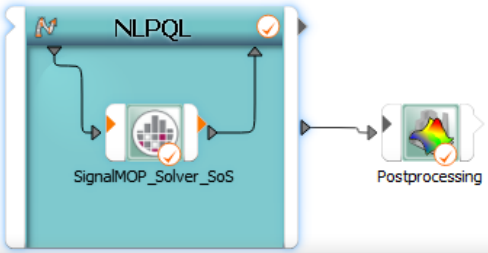
- Signal MOP for deflection – **principal shapes**



Signal metamodel for deflection

$$\boldsymbol{w}_{MOP}(X_1, X_2, \dots) = \boldsymbol{s}_1 a_1 + \boldsymbol{s}_2 a_2$$

Optimization on Signal MOP



NLPQL

Parameter | Start designs | Criteria | NLPQL | Other | Result designs

Parameter

Name	Value
holeCornerRadius	0.254996
holeHeight	0.225019
holeWidth	0.399952
holeX	2.59995

Responses

Name	Value
deflection_chan_0.MinValue	-3.10808

Criteria

Name	Type	Expression	Criterion	Limit	Evaluated expression
obj_deflection_chan_0.MinValue	Objective	abs(deflection_chan_0.MinValue)	MIN		3.10808

Create new

f(x) Variable | Objective | Constraint | Limit state

Prefer criteria from slot | Instant visualization | Import criteria from system

Show additional options | OK | Cancel | Apply

Conclusion

- Material properties: Random process model for stiffness- & strength fluctuations
- Deflections/system response: Remarkable performance of signal MOP
- Step towards fully probabilistic analysis of timber structures

Thank you!

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vienna business agency

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