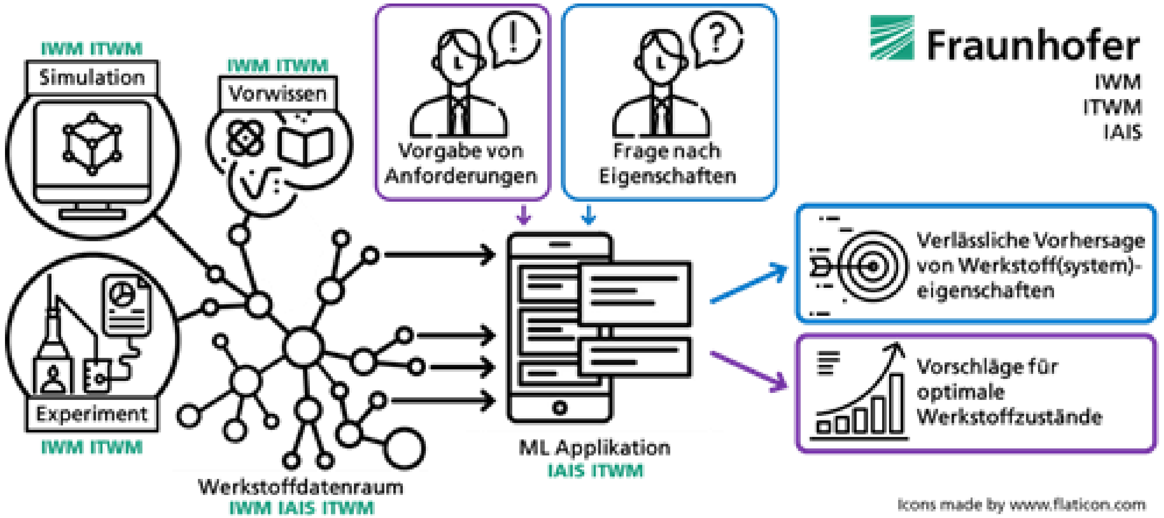
ONLINE-VERANSTALTUNG

Design of Experiments in R&D

Abschlusskolloquium
des Fraunhofer-Konsortiums »UrWerk«
zur Entwicklung von unternehmensspezifischen
Werkstoff(system)-Datenräumen



Moderation Dr. Michael Luke
Projektleiter »UrWerk«
Geschäftsfeldleiter »Bauteilsicherheit und Leichtbau«
am Fraunhofer-Institut für Werkstoffmechanik IWM

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Design of Experiments in R&D

Unternehmensspezifische Werkstoff(system)-Datenräume zur beschleunigten Produktentwicklung

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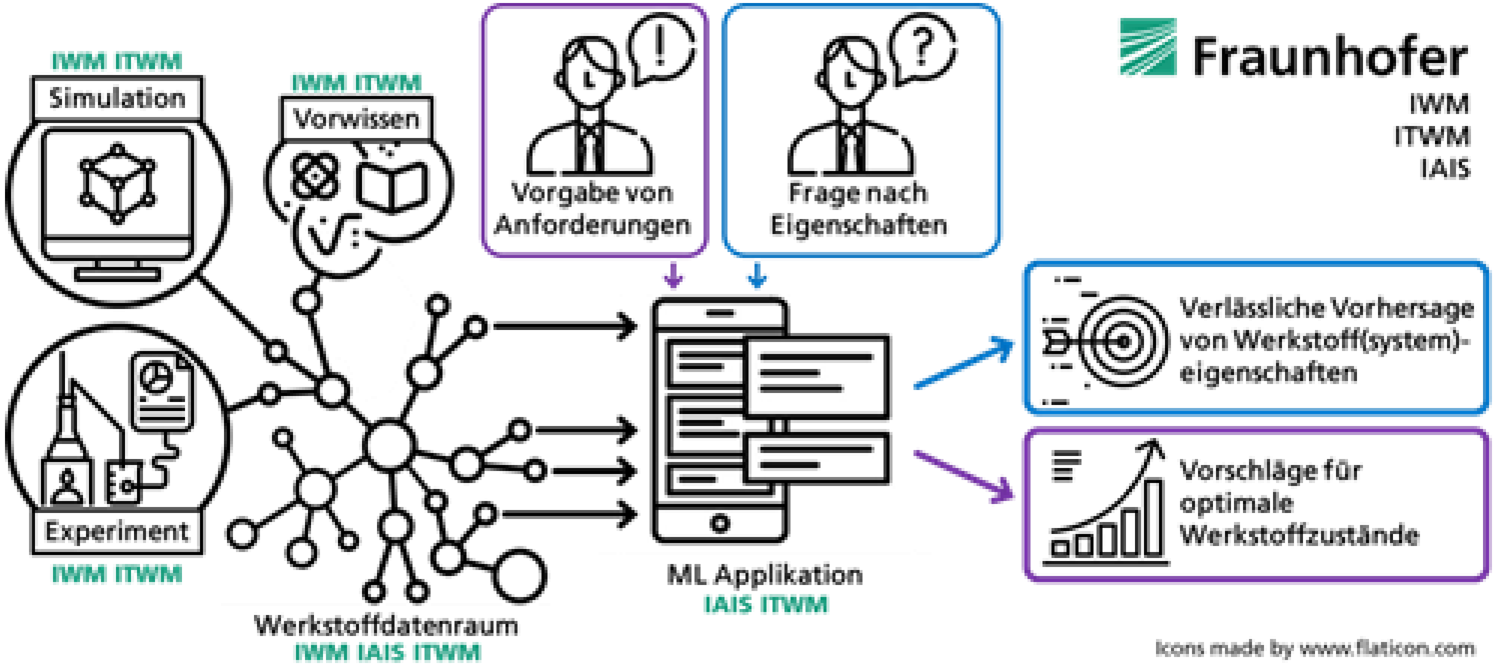

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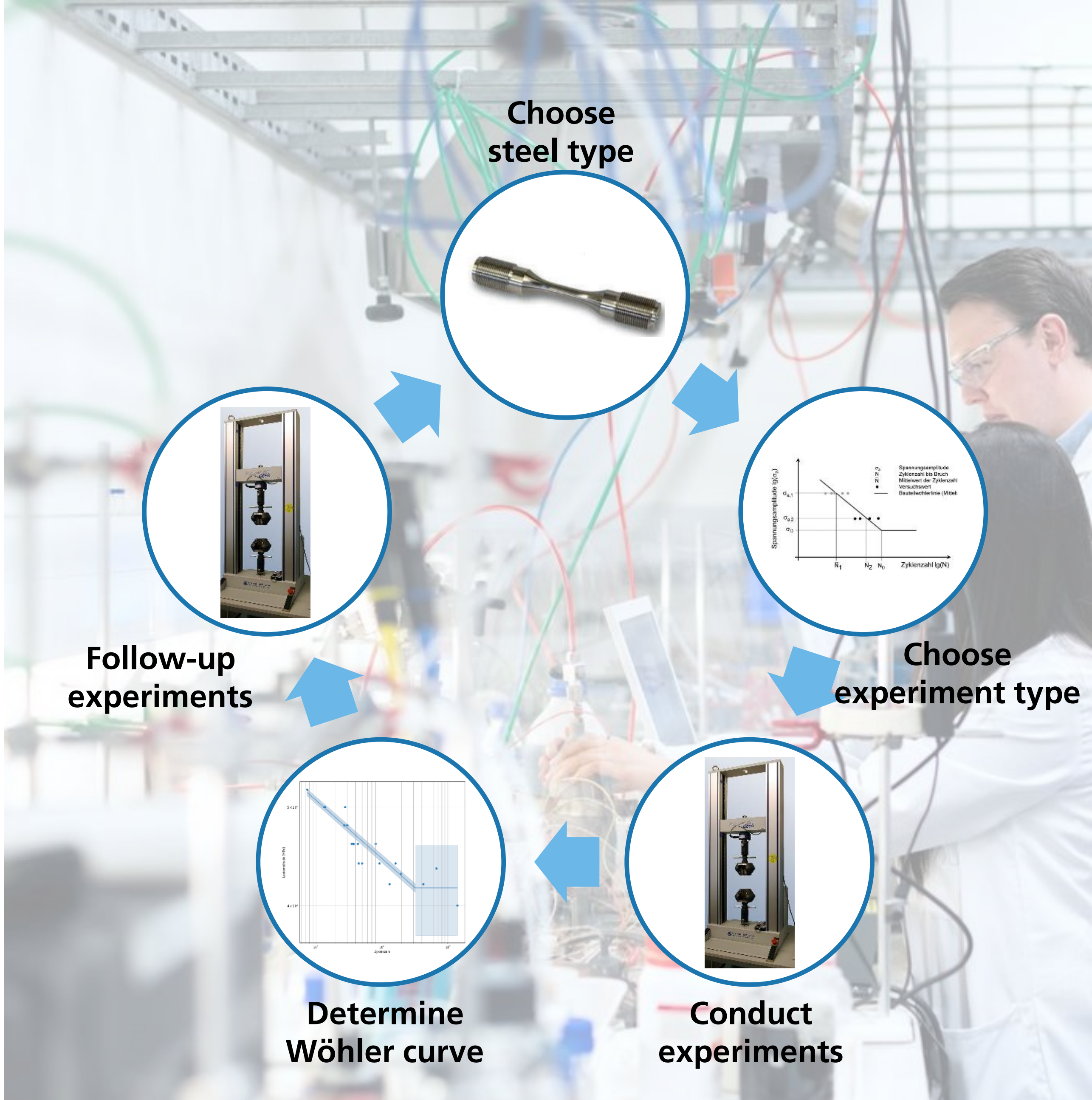
Challenges in technical product development

- Product devolpment cycles often consist of several manual and time consuming steps
  - Formulation of the product
  - Designing experiments
  - Conducting the experiments
  - Evaluating the experiments
  - Follow-up of the experiments
- Often a very large number of experiments is needed to determine the optimal formulation
- Many experiments cause high costs and tie up ressources



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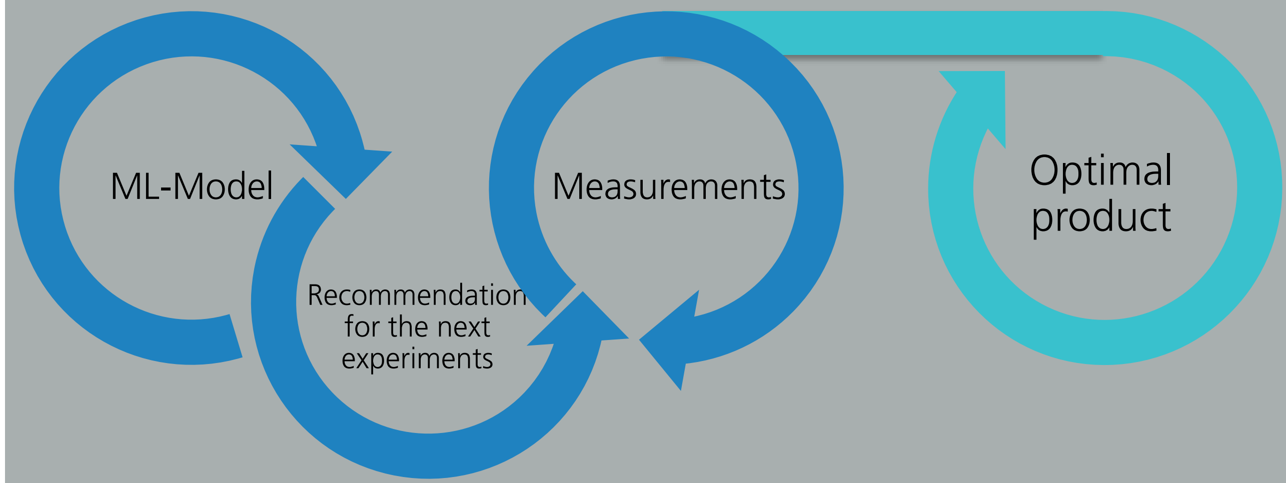
Design of Experiments

Supported by AI methods

- Design of Experiments (DoE) is an integral part of engineering and product development
- **Goal**: Apply different (statistical, ML,…) methods to minimise the number of experiments needed to find optimal parameter settings for a product
- Approaches:
  - **Classical**: Experiments are independent of each other, we do not use information from previous experiments
  - **AI-supported**: We use data from previous experiments to learn probabilistic informed ML-models, which help to predict future experimental points
- You can find our Whitepaper here: https://www.iais.fraunhofer.de/de/geschaeftsfelder/industrial-analytics/optimale-versuchsplanung-mit-ki.html



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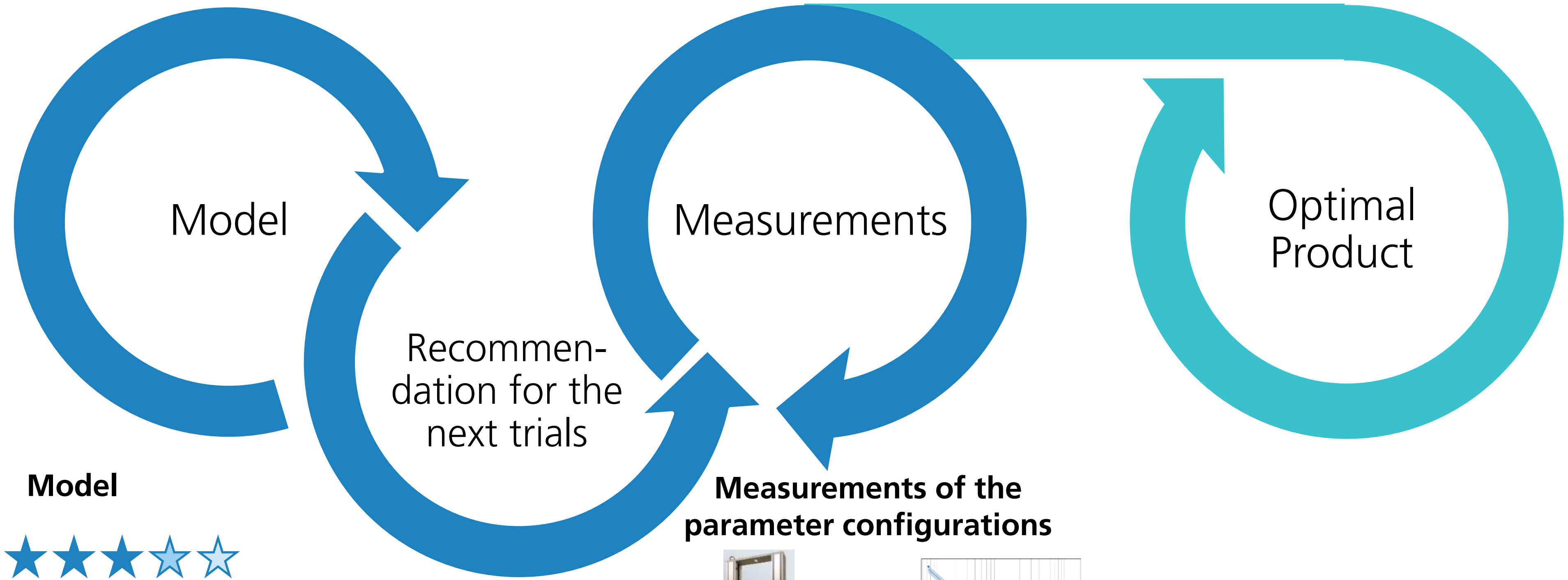
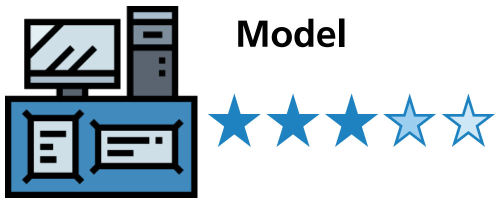
Our Approach: Sequential Experiments

For optimal Product configurations

Recommendation for the upcoming measurements:

- Unknown distributions
- Good distributions

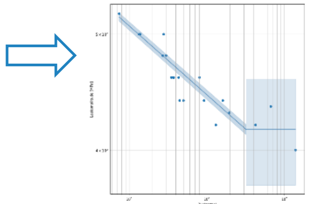




Model

Measurements of the parameter configurations

Test



Evaluate

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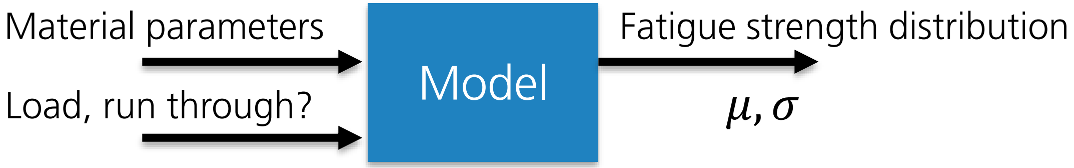
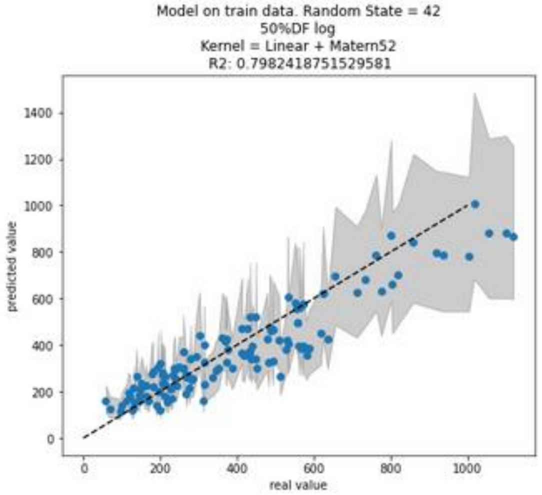
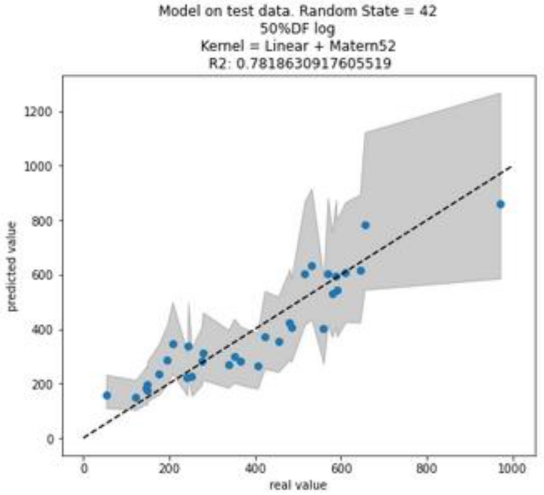
Application to fatigue experiments

- Initial idea:
  - Create a ML-Model which predicts the fatigue distribution
  - Improve the model by adding more experiments
- We use Gaussian processes to estimate the fatigue strength distribution
  - Low feature dimensionality
  - Inherent measure of variation
  - Kernel engineering allows the integration of prior knowledge







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Application to fatigue experiments II

- Construction of the posterior distribution:
  - Prior: Gaussian Process Model
  - Likelihood: Probability of number of run throughs/failures given load
- Fit (Log-)Normal distributed fatigue strength
- Determine the trial with largest influence on fatigue strength

Distribution of trials:

$$g(\mu) = p(\mu) \cdot l(s_i, s_j | \mu)$$
$$= N(\mu_m, \sigma_m) \cdot \prod_i \Phi_{\mu,\sigma}(s_i) \prod_j (1 - \Phi_{\mu,\sigma}(s_j))$$

Estimate for fatigue strength and load for the next trial:

$$\arg\max_\mu g(\mu)$$

Results on fatigue data

Prototypical application & Publication of scientific results

Application Prototype

Publication of Scientific results

- Accepted as Workshop Paper at AAAI 2023
- Submitted as contribution to an anthology on Informed Machine Learning

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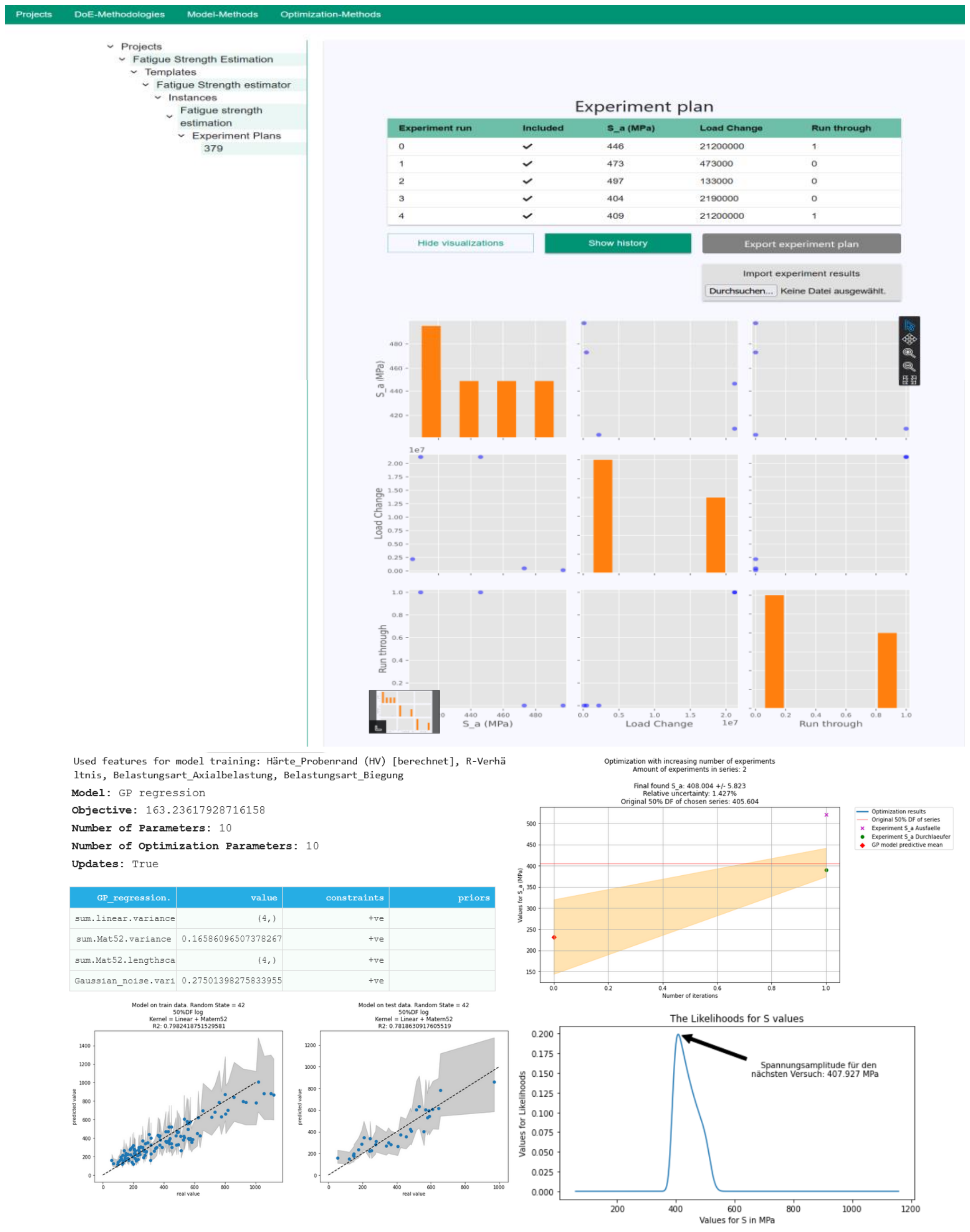
Strategic Development

Tooling for iterative Design of Experiments

- Development of a Tool for the creation of sequential DoE
- Few competitors:
  - Statistic Tools: Design Expert, Statistica, Minitab…
  - DoE: GlobalOptimize, GaussML, S-Matrix…
- High demand:
  - Every product development can benefit from targeted experiments
  - First appointments with possible customers have taken place
- Working on a Web-Service:
  - API Design with Swagger/OpenAPI
  - Python Backend
  - JavaScript Frontend:
    - React UI
    - Node.js Backend



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