AI-Based Parameterization of Full Vehicle Models for Crash Simulations Project UmMatCraML

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2 divis intelligent solutions GmbH
3 Stellantis OPEL AUTOMOBILE GmbH

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Research question: Can manufacturing- dependent component properties be predicted using machine learning techniques in crash simulations?

divis SCALE
IT-Solutions for CAE

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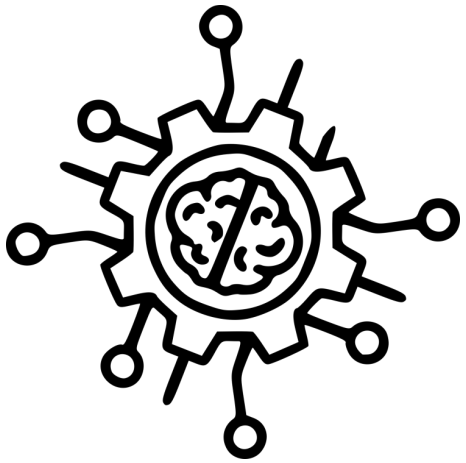
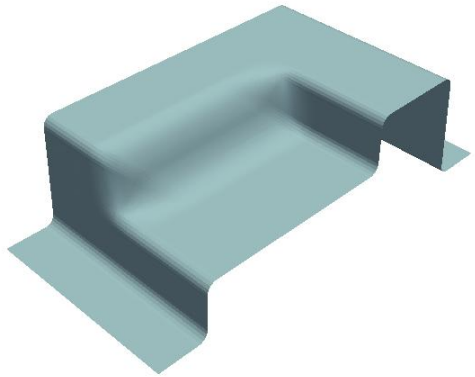
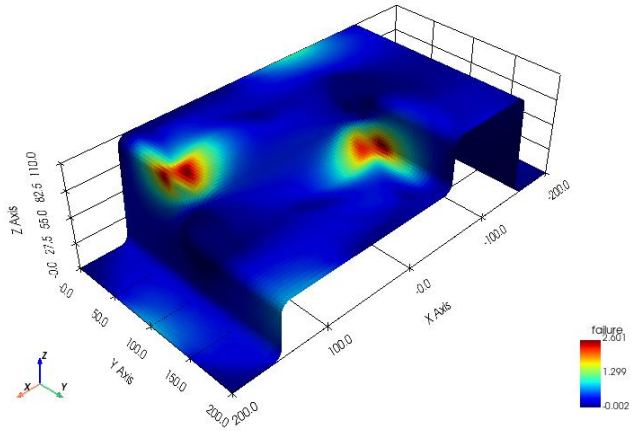


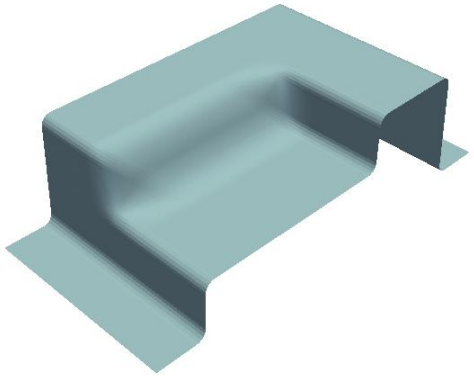


UmMatCrashML

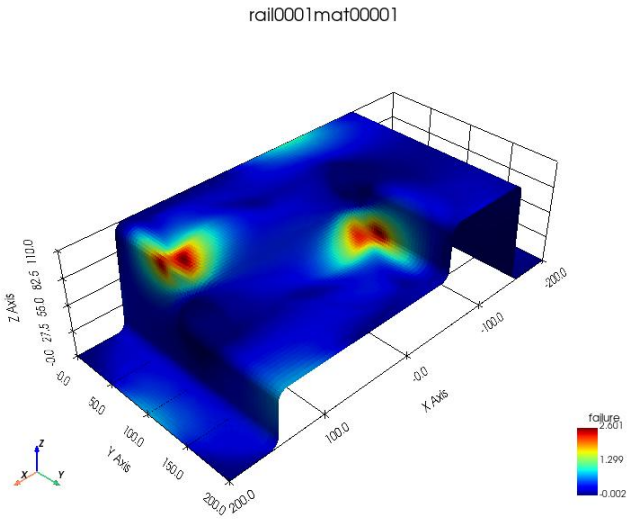


#1 UmMatCrashML workflow

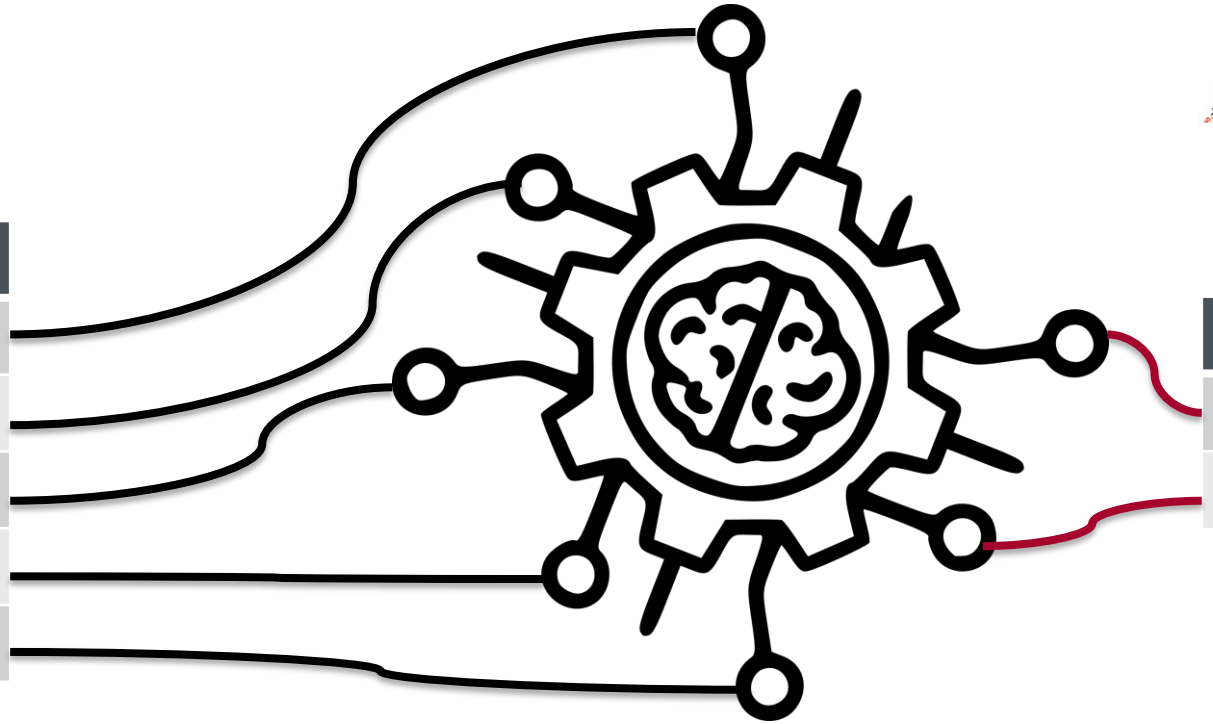
FEM model of a part



UmMatCrashML



Input vector
Geometry: Ar_uvmap
Material: sig_0
Material: sig_c
Material: eps_c
Material: sig_a



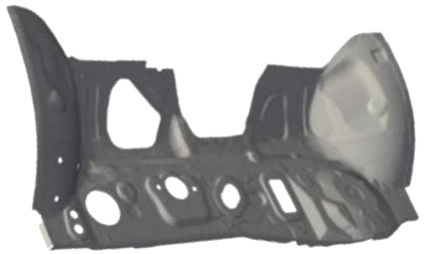
Output vector
Ar-lsdyna (sheet thickness)
effective plastic strain

ClearVu KI model

Extraktion der Strukturbauteile aus LS-DYNA FE-Modellen

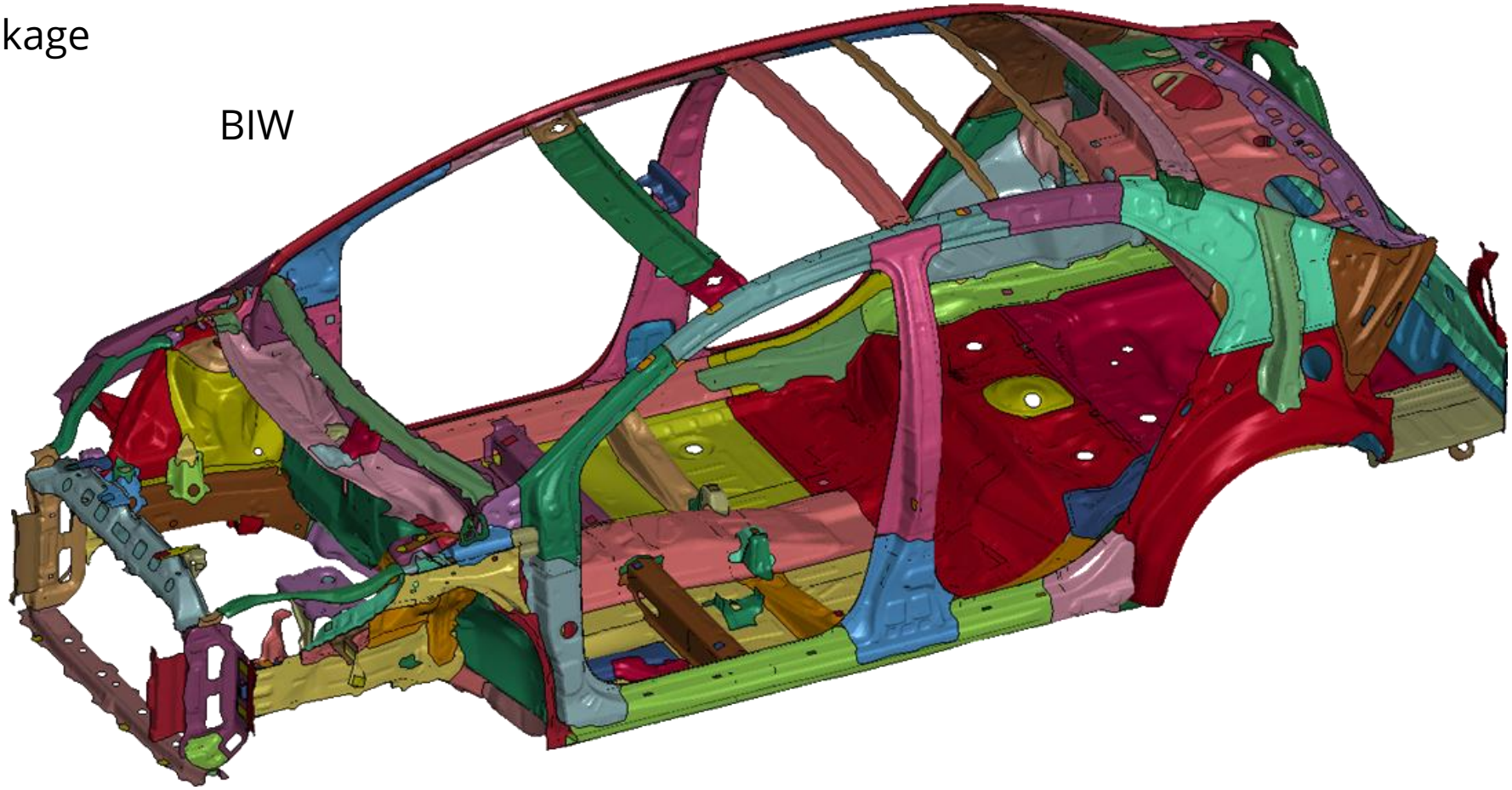
Model

- Script-based component extraction with python package scale.femscale.fem



- automatic data upload SCALE.sdm

BIW



[https://www.ccsa.gmu.edu/models/]

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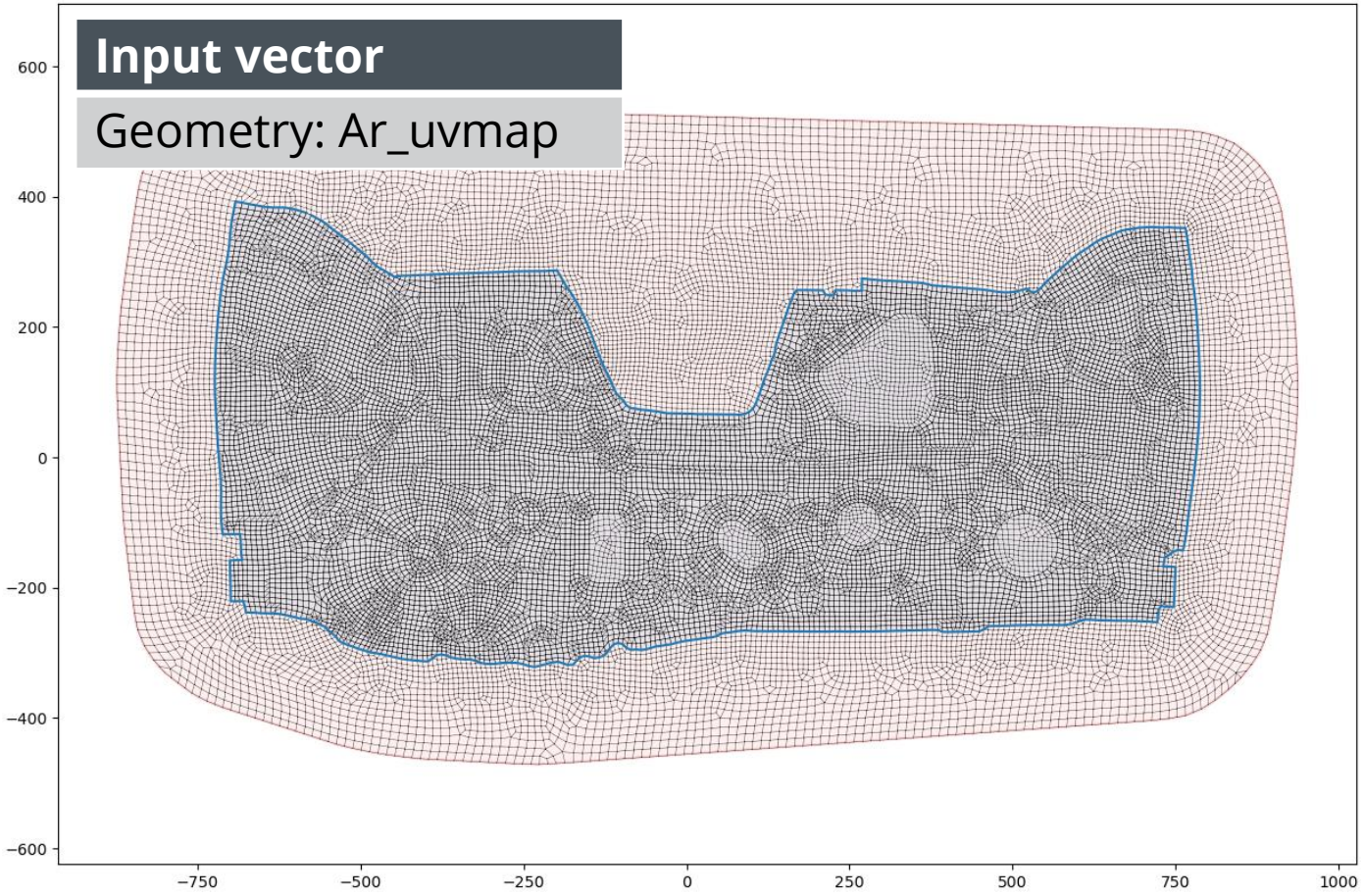
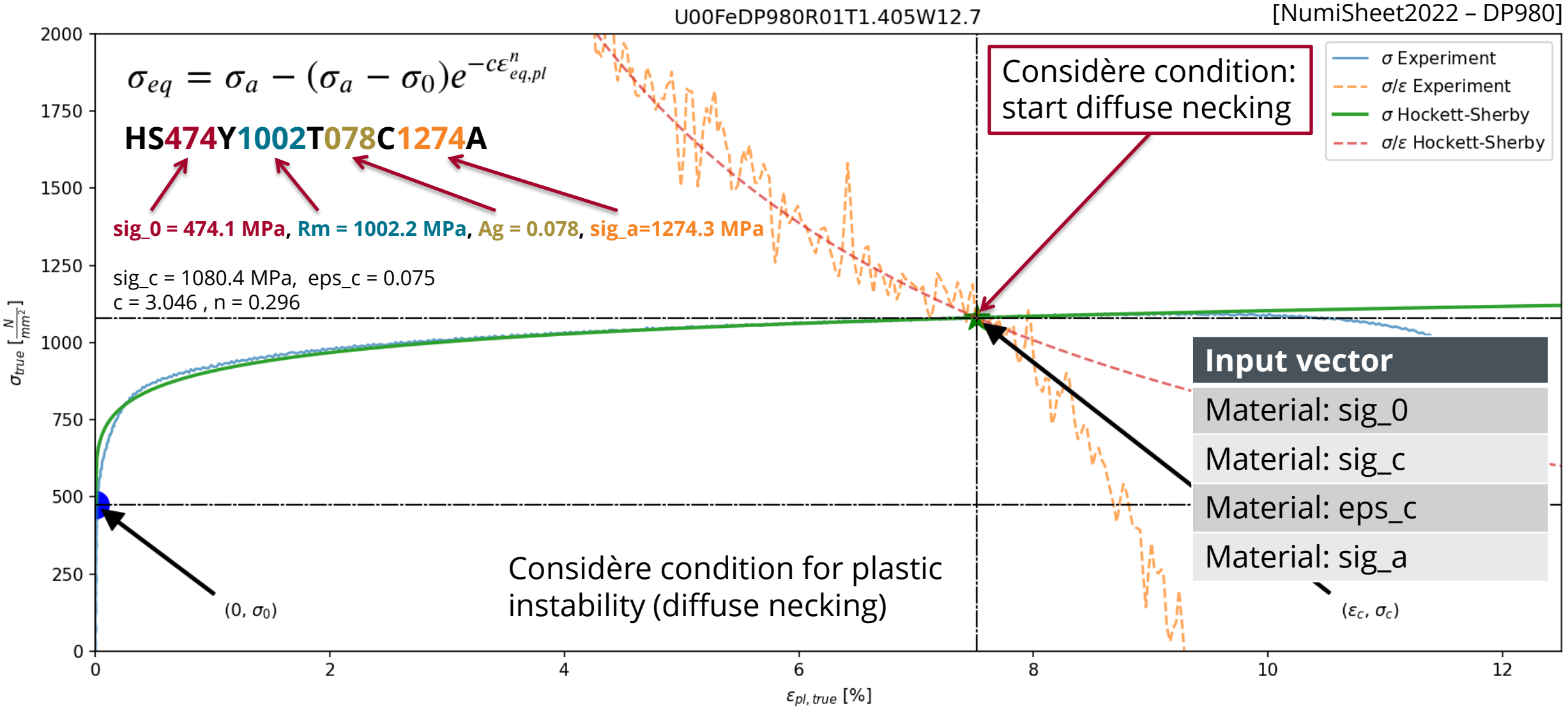
Automatic model creation - Onestepsolver

- Automatic preprocessing with scale.dynapy (Ar_uvmap)
- Optional extrapolation of the coil blank



Parametrization of the materials ($\sigma_0, \sigma_c, \varepsilon_c, \sigma_a$)



Integration

ClearVu Python Package

- CVA-Python (Python Paket)
- trained AI model package (Python Paket)
- Integrated models for fast mapping
- Updateable via standard Python mechanisms (pip)

ClearVu Python Package

```
1 import pandas
2 from cva import Base
3 from umatcra import Base
4 manager = Base.Manager()
```

```
1 manager.get_input_variable_names()
```

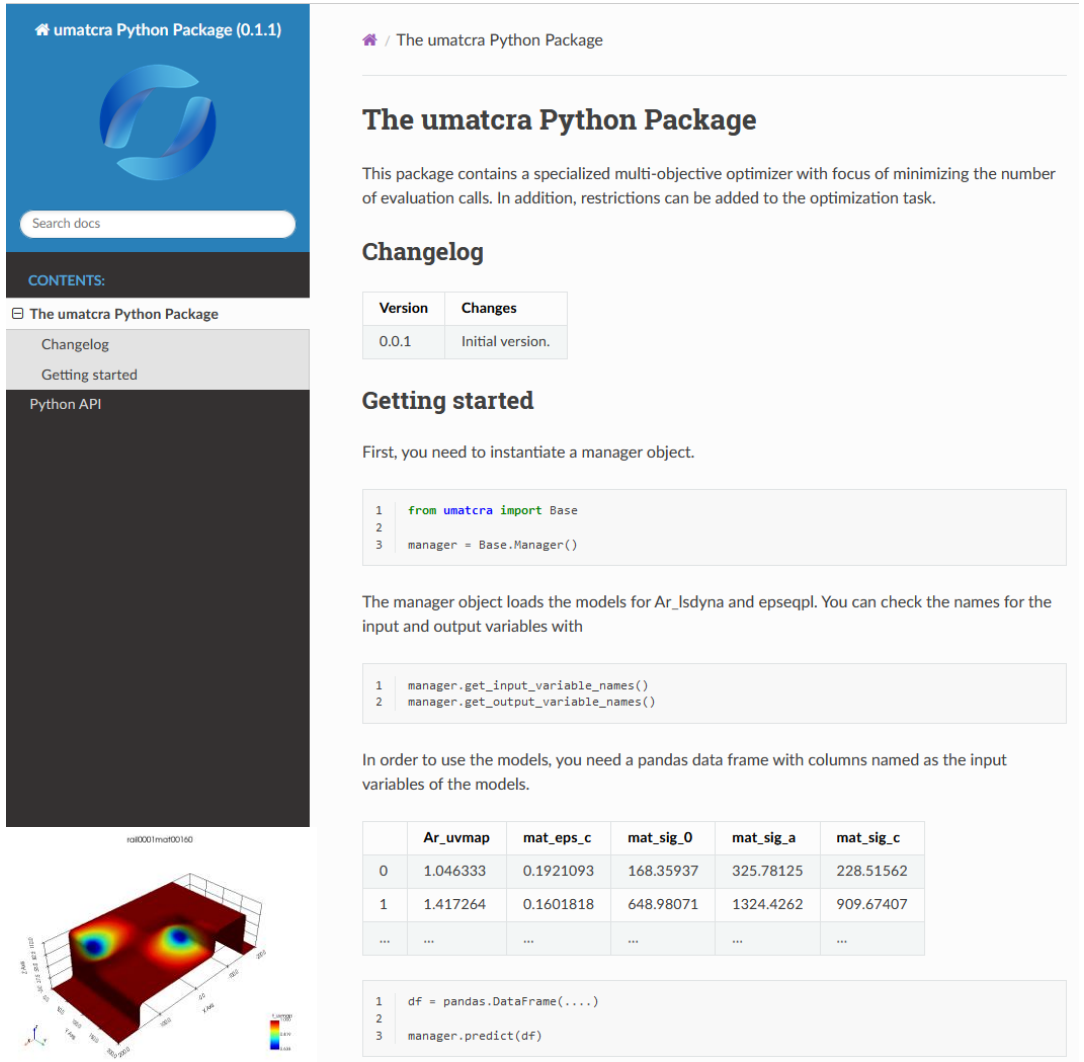
```
{'Ar_lsdyna': ['Ar_uvmap', 'mat_eps_c', 'mat_sig_0', 'mat_sig_a', 'mat_sig_c'],
 'epseqpl': ['Ar_uvmap', 'mat_eps_c', 'mat_sig_0', 'mat_sig_a', 'mat_sig_c']}
```

```
1 df = pandas.DataFrame([[.2, .1, 200., 300, 250]],
2                       columns=['Ar_uvmap', 'mat_eps_c', 'mat_sig_0', 'mat_sig_a', 'mat_sig_c'])
3 df
```

	Ar_uvmap	mat_eps_c	mat_sig_0	mat_sig_a	mat_sig_c
0	0.2	0.1	200.0	300	250

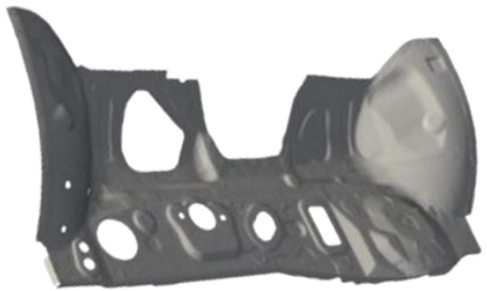
```
1 manager.predict(df)
```

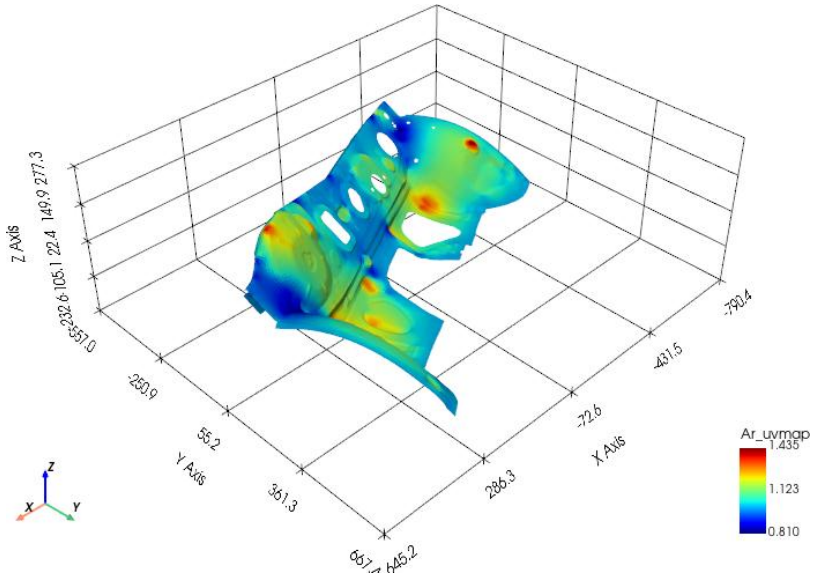
	Ar_lsdyna	epseqpl
0	1.084302	0.138254

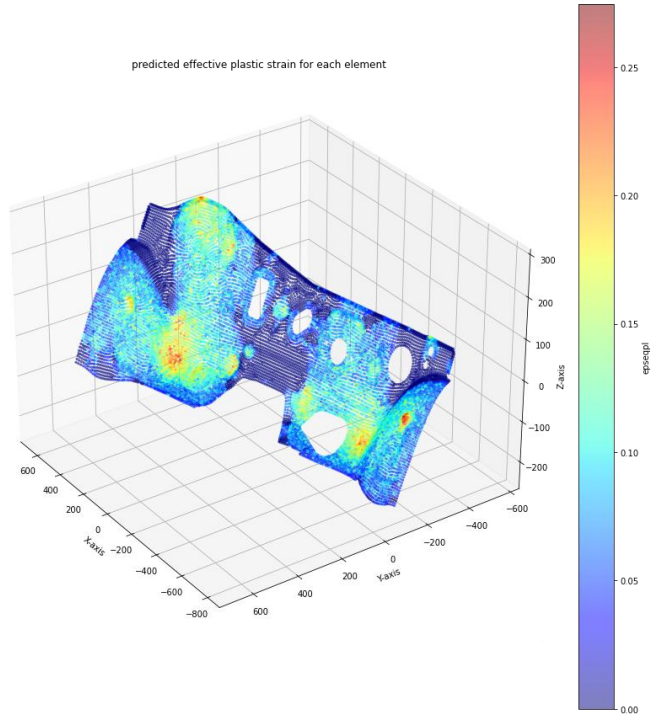


UmMatCra-ML Workflow

- Software-Demonstrator: SCALE.sdm with ClearVu







AI training data

data generation, data management

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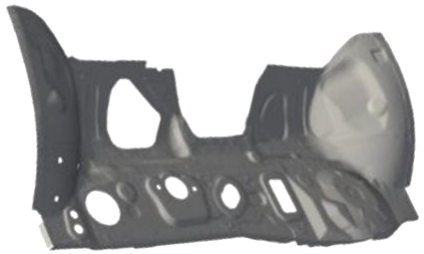
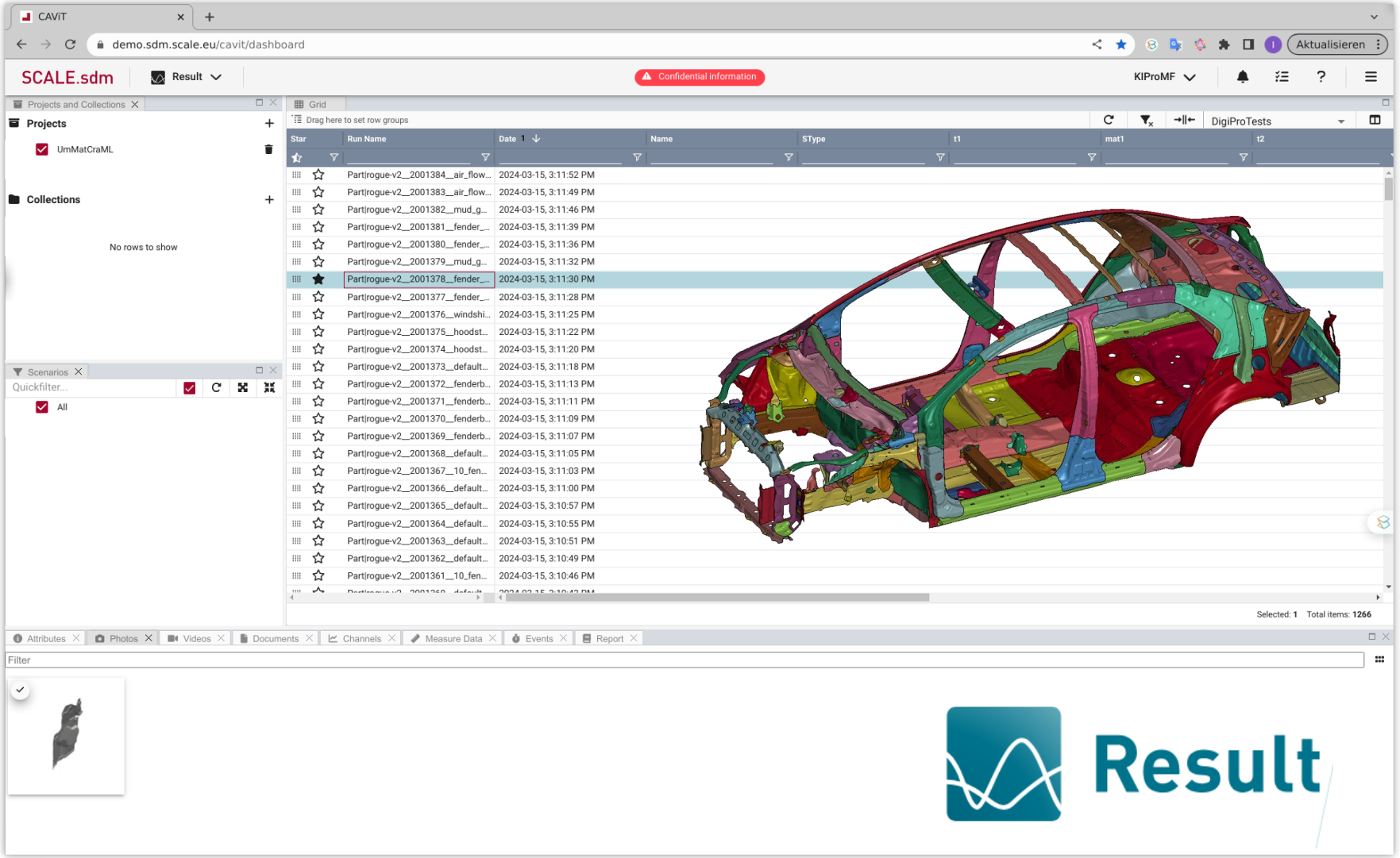
data management with SCALE.result

Data storage per part

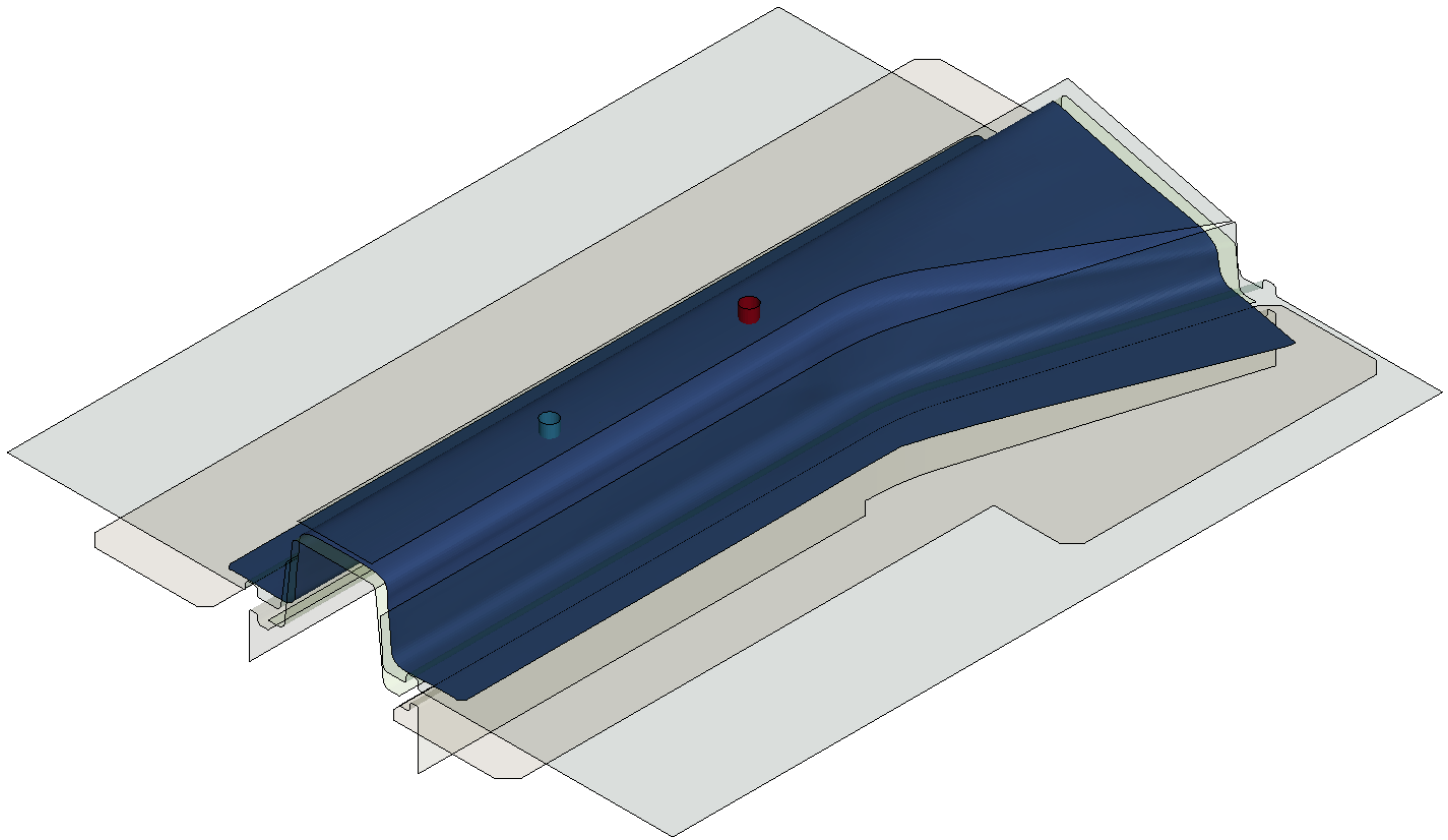


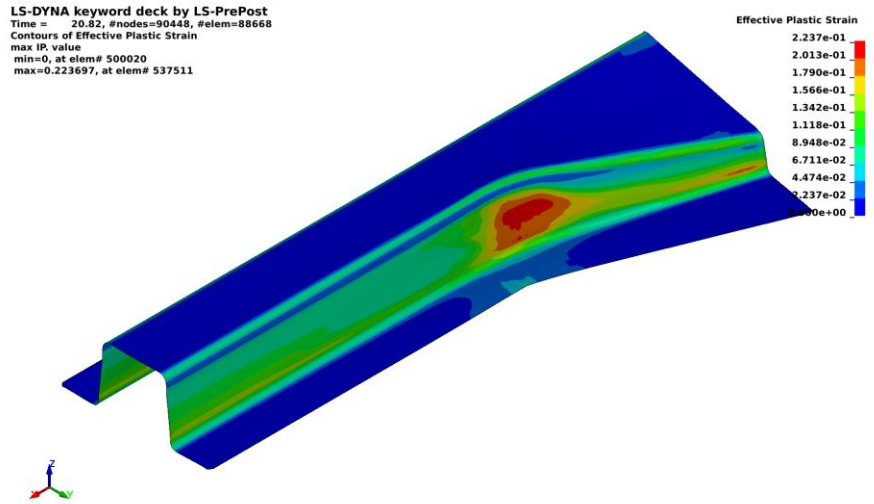


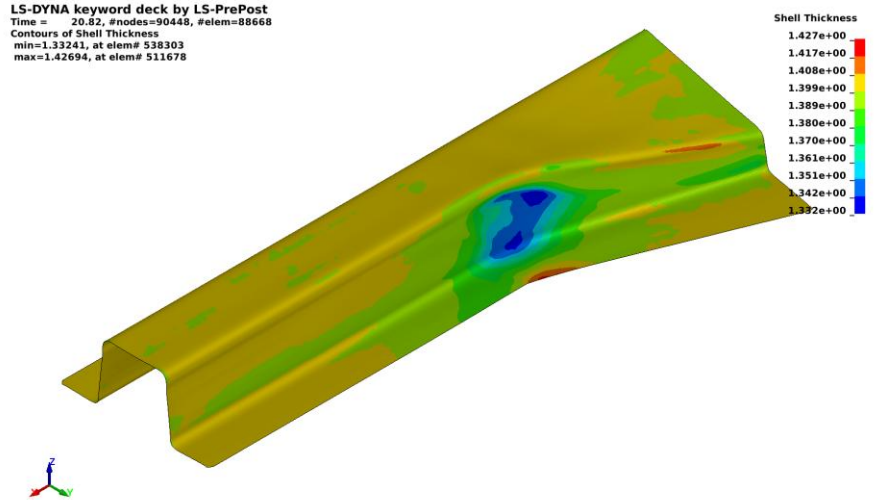
Result

HFS – parametrisiertes Tiefziehmodell

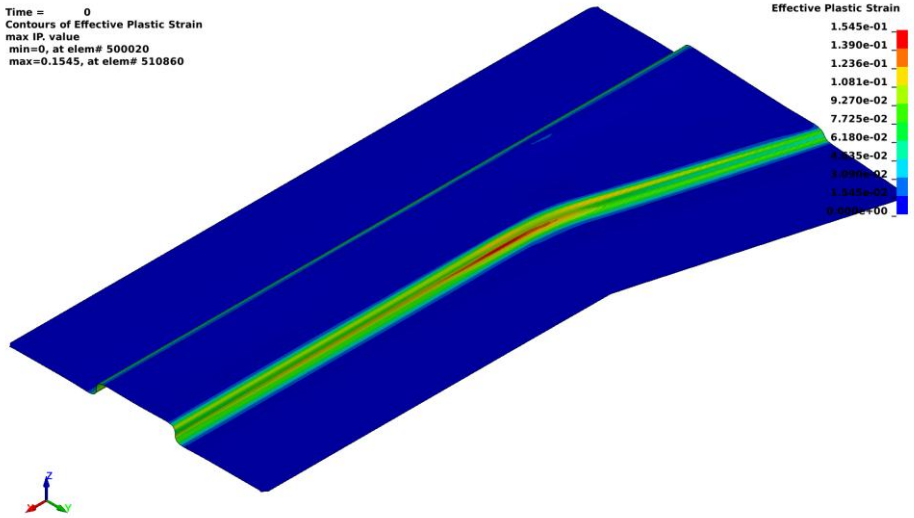
Numisheet 2021 – Benchmark 1

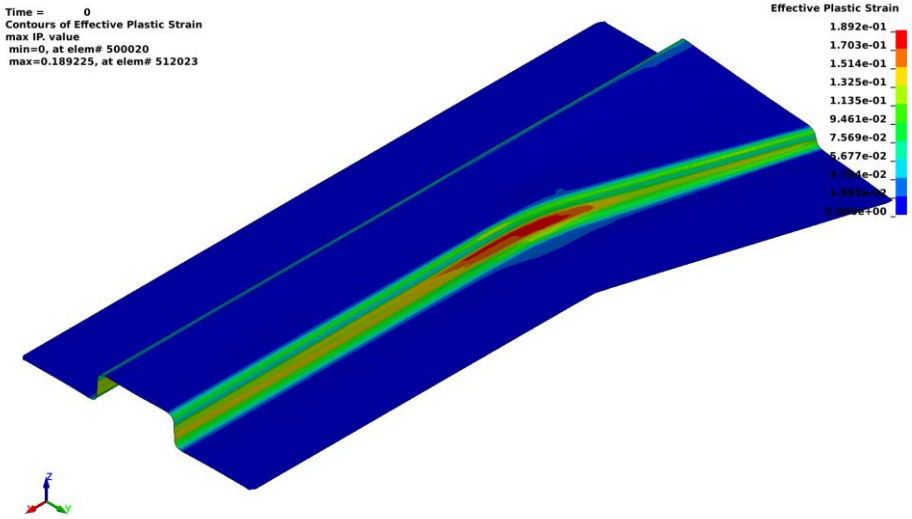


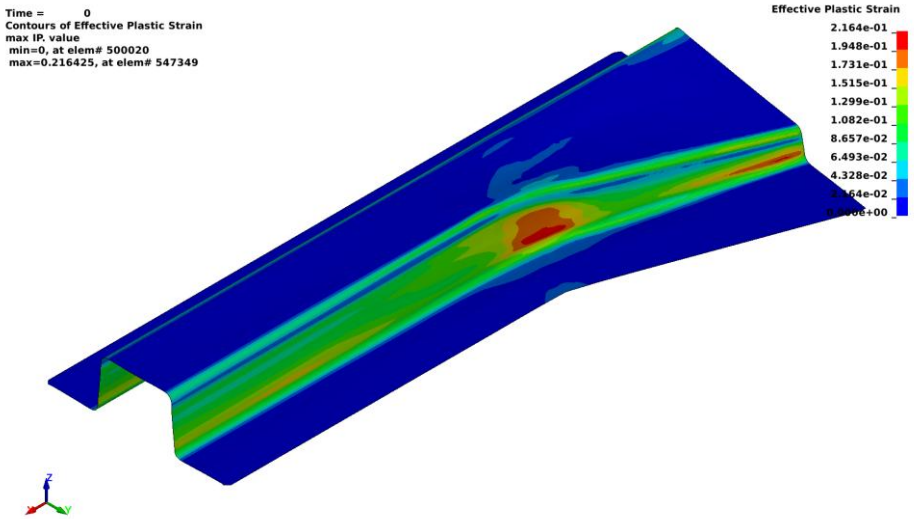


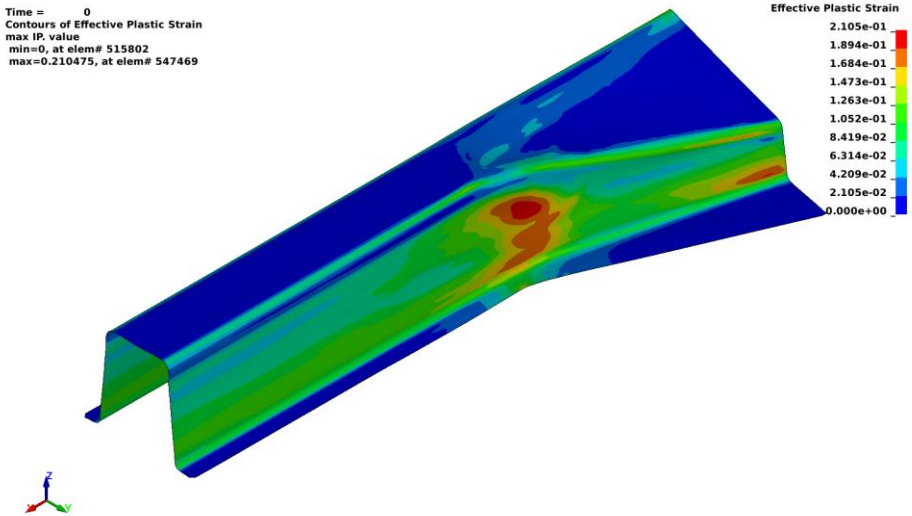


HFS-Modell #1: Geometrie-Variationen

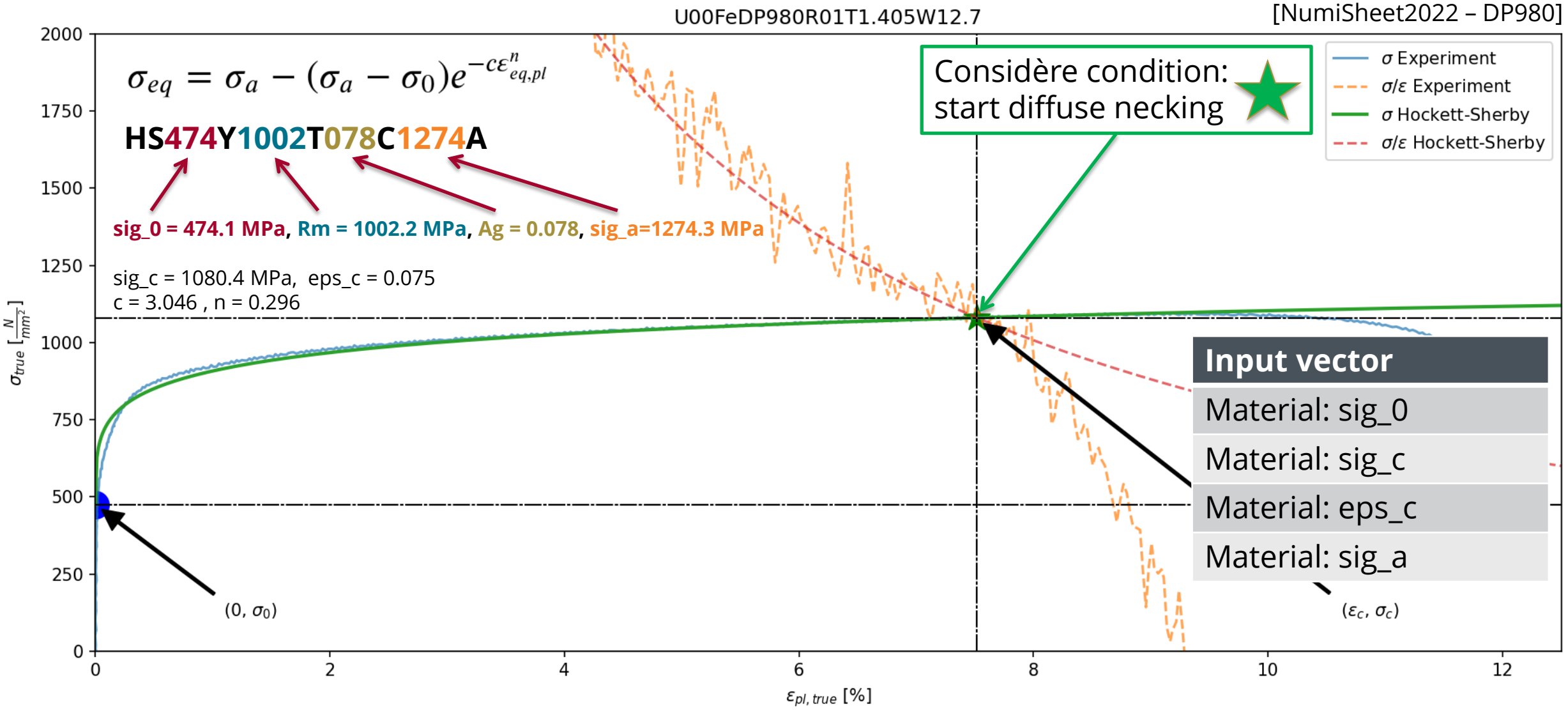




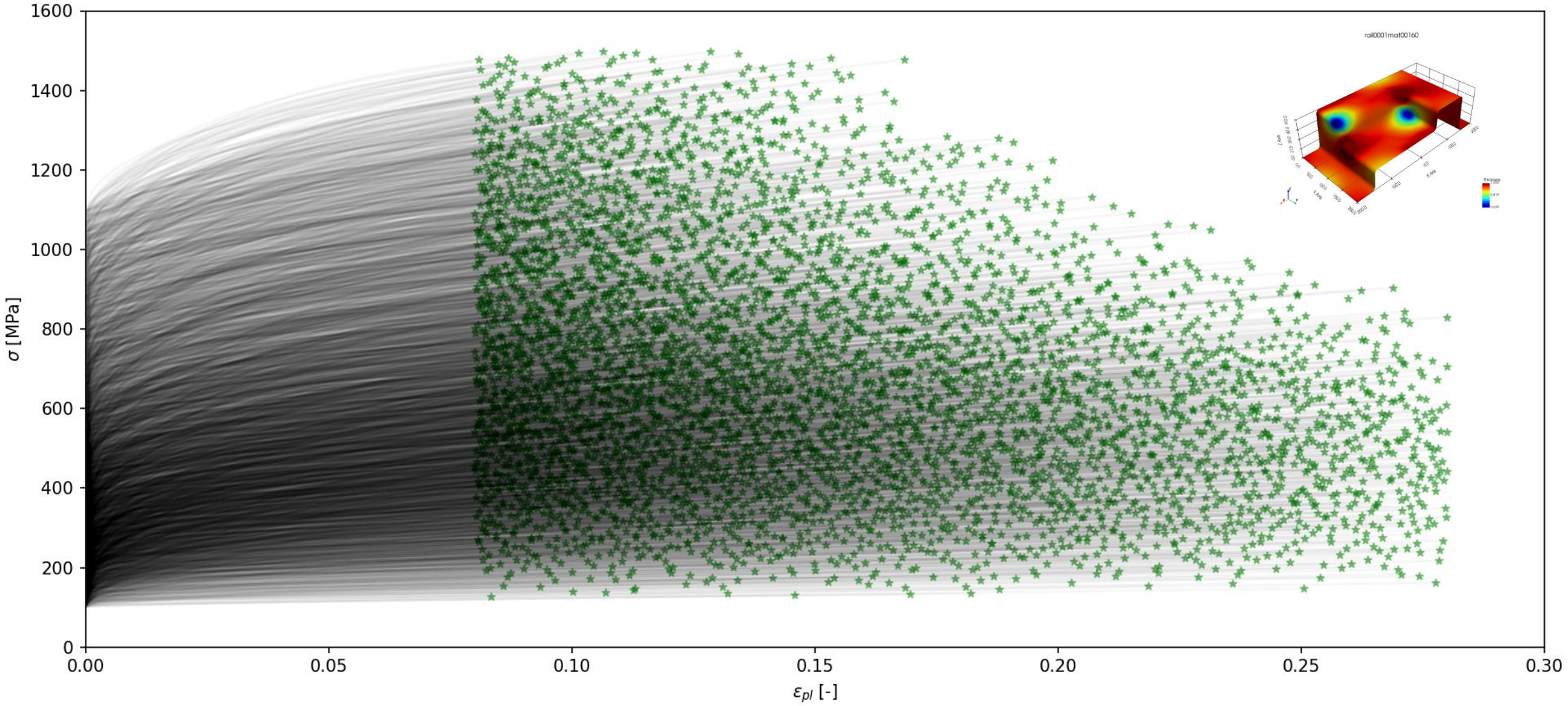




Parametrization of the materials ($\sigma_0, \sigma_c, \varepsilon_c, \sigma_a$)

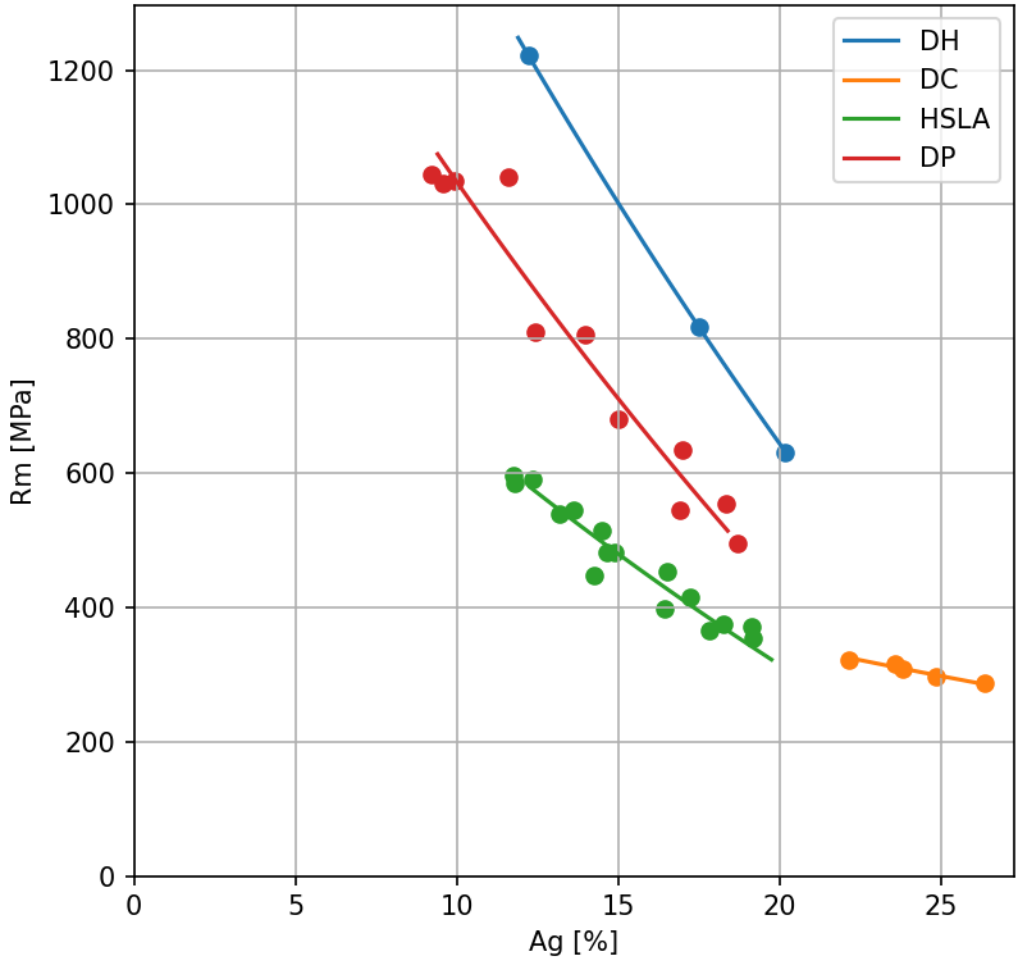


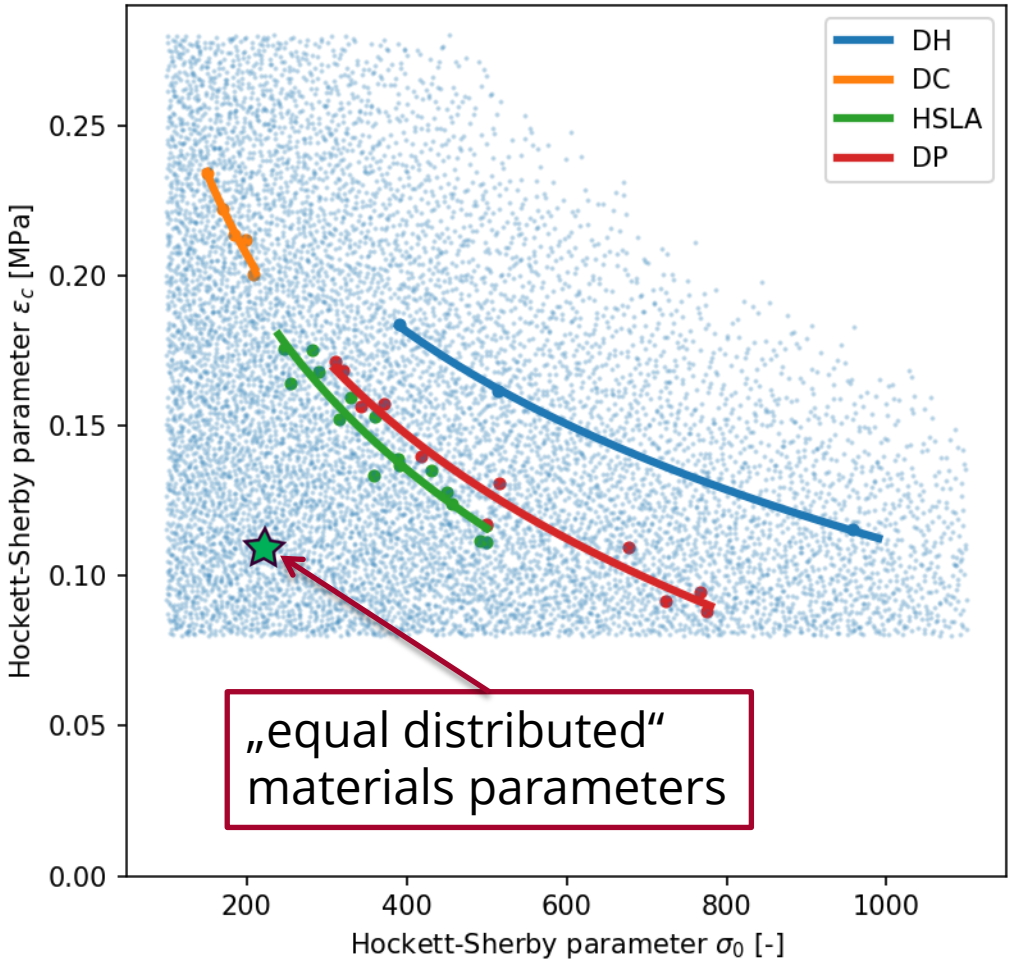
5000 generic hardening curves



AP 1: continuous „real material DB“ vs. continuous „virtual material DB“

Fit of the Hockett-Sherby parameters from real materials tests vs. sampling of virtual material parameters





ClearVu AI models

accuracy, performance

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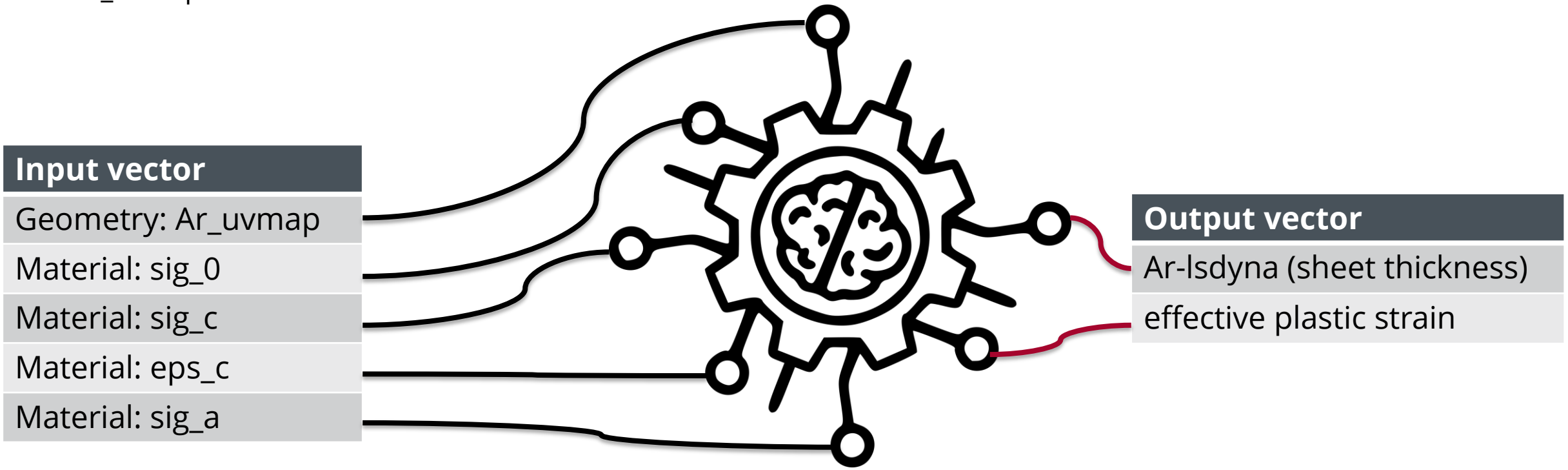
Modellierungsaufgabe

Eingangsseitig

- Bauteil spezifische Parameter
  - Werkstoff ε_c, σ_0, σ_a und σ_c
- Für jedes Flächenelement die Flächendehnung
  - Ar_uvmap

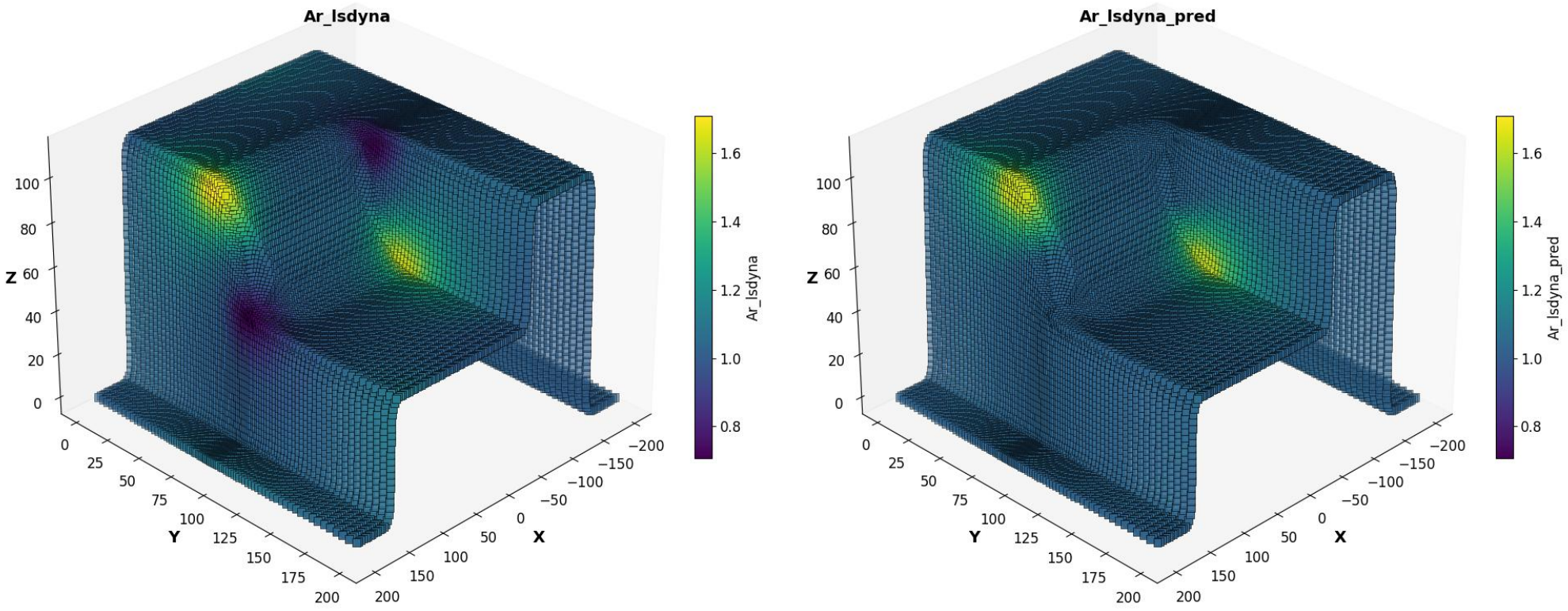
Ausgangsseitig

- simulativ ermittelte Flächendehnung und effektive plastische Dehnung
  - Ar_lsdyna
  - epseqpl



ClearVu KI model

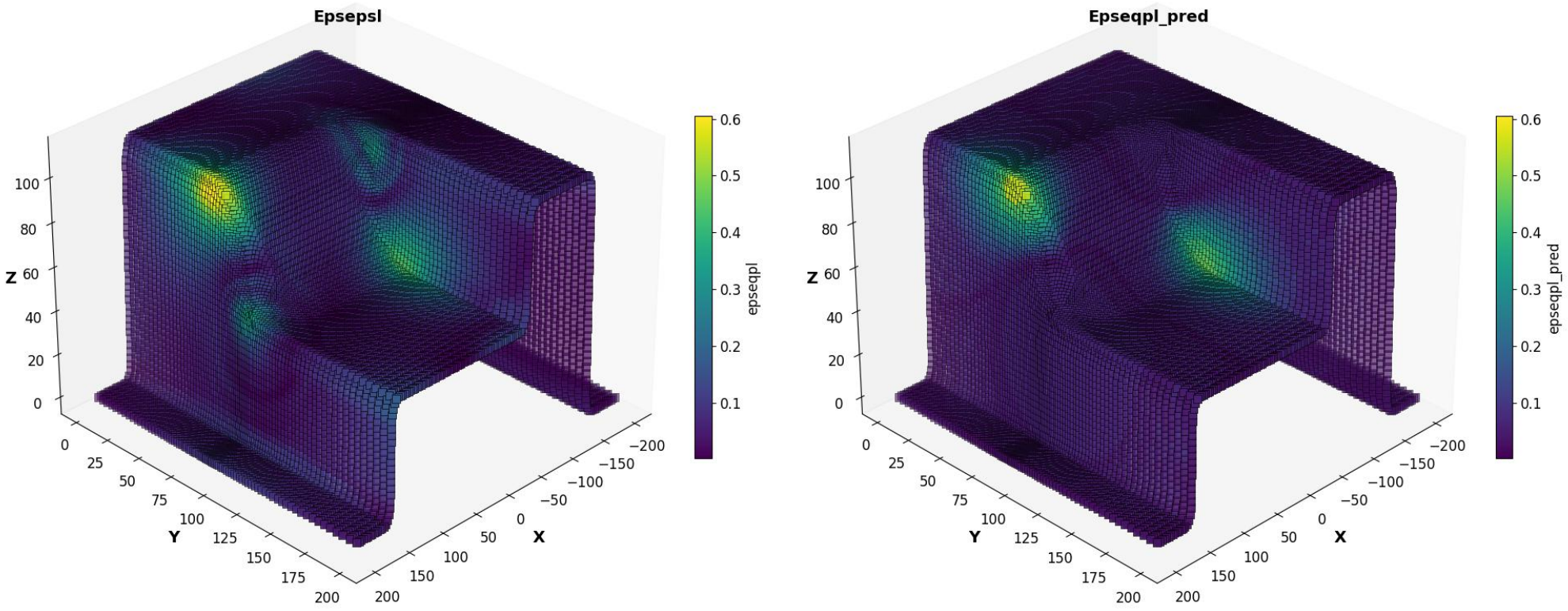
rail0001mat00296 Ar_lsdyna



rail0001mat00296 epseqpl

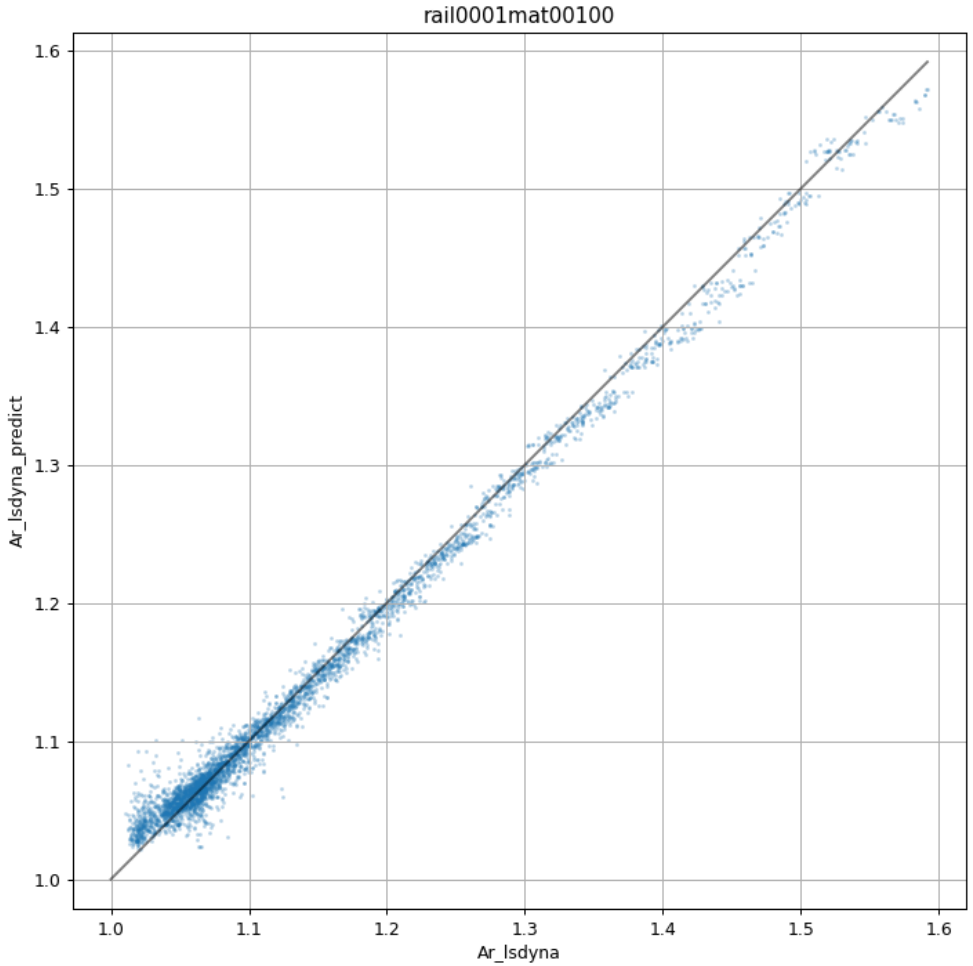
rail0001mat00296

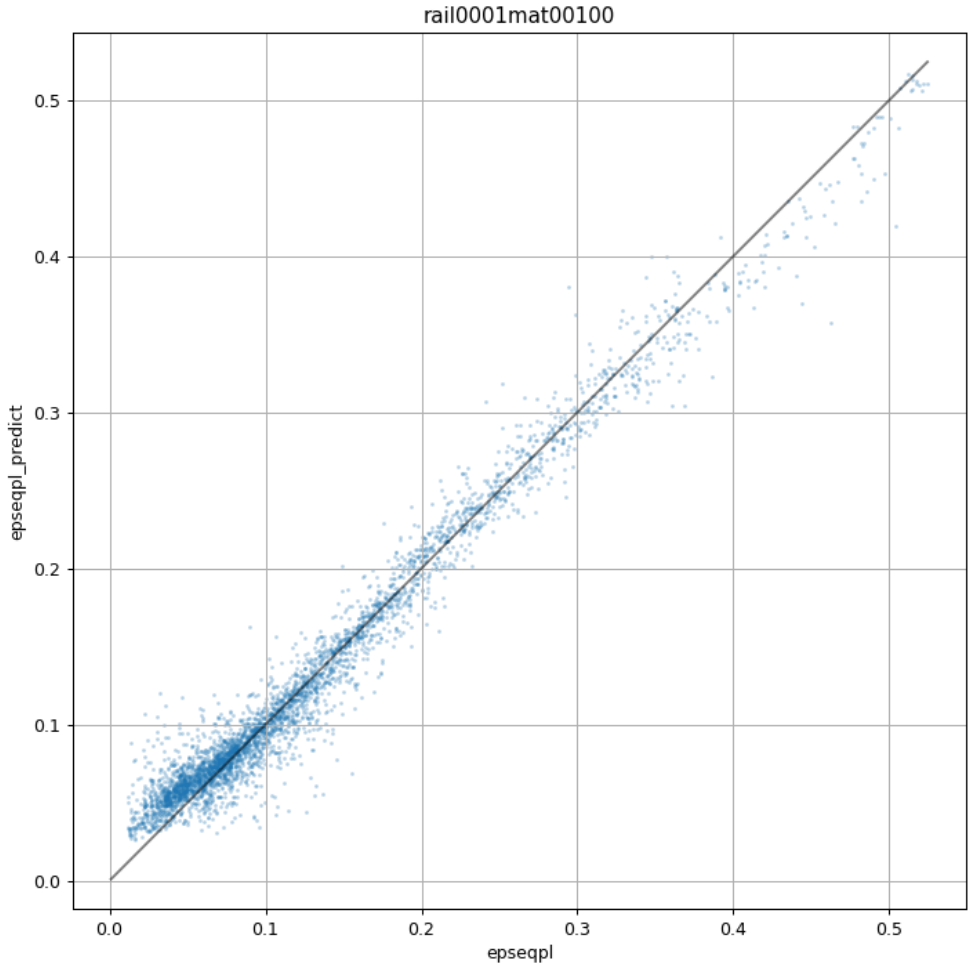
$\sigma_0 = 115.38,\ \sigma_a = 629.2,\ \sigma_e = 0.13,\ \sigma_c = 168.7$



Accuracy OSS vs. AI & Performance

- prediction time for 10000 Elements 0.767 s ± 43.3 ms o Intel i7-8550U CPU @ 1.80GHz





Challenges
Summary
Outlook

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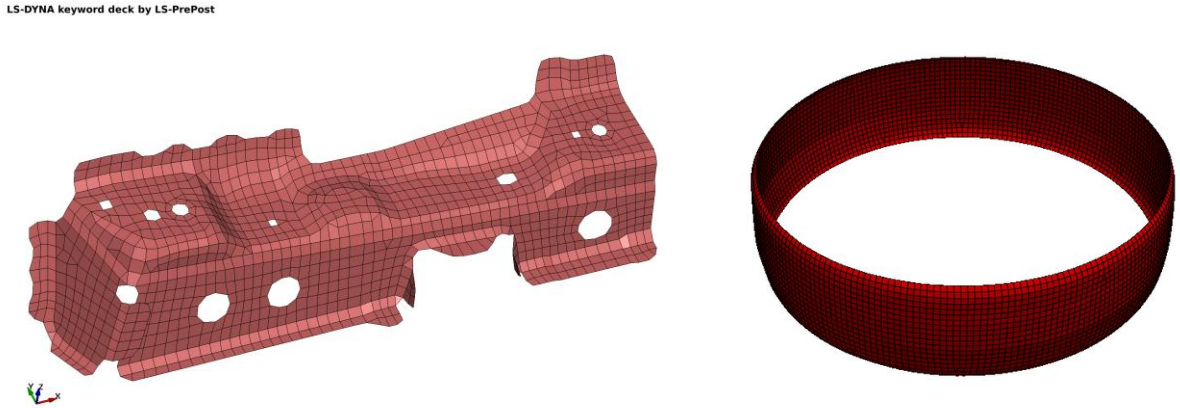
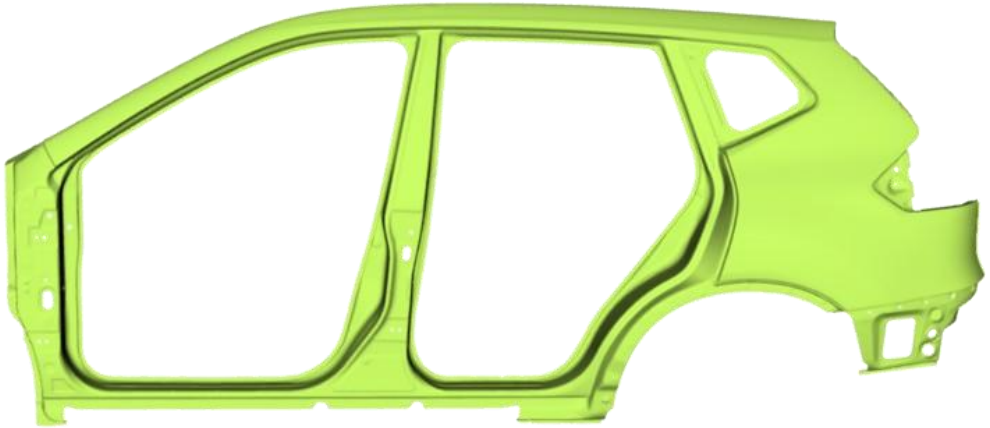
Diskussion der Herausforderungen

- Mehrstufige Herstellungsprozesse (Biegen nach Zuschnitt) und Rohre

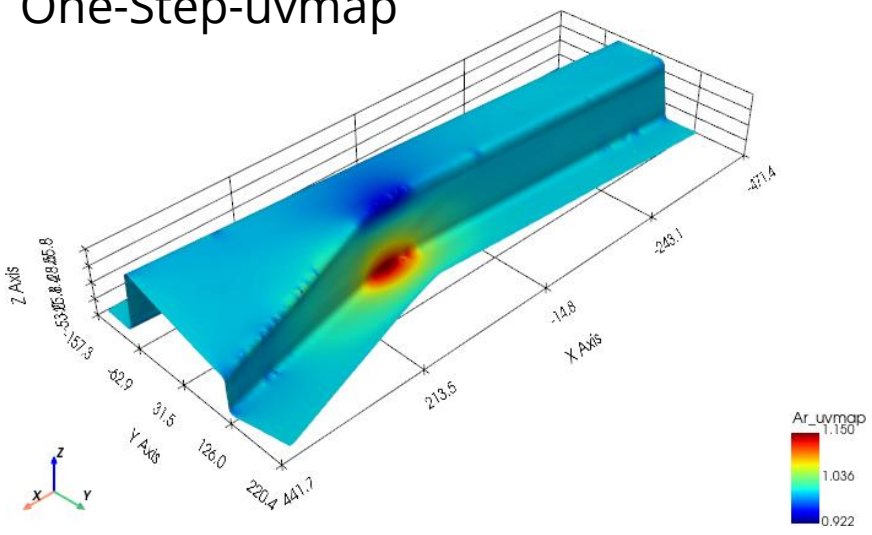


- Zuschnitt mit Loch bei Herstellung (Seitenrahmen)

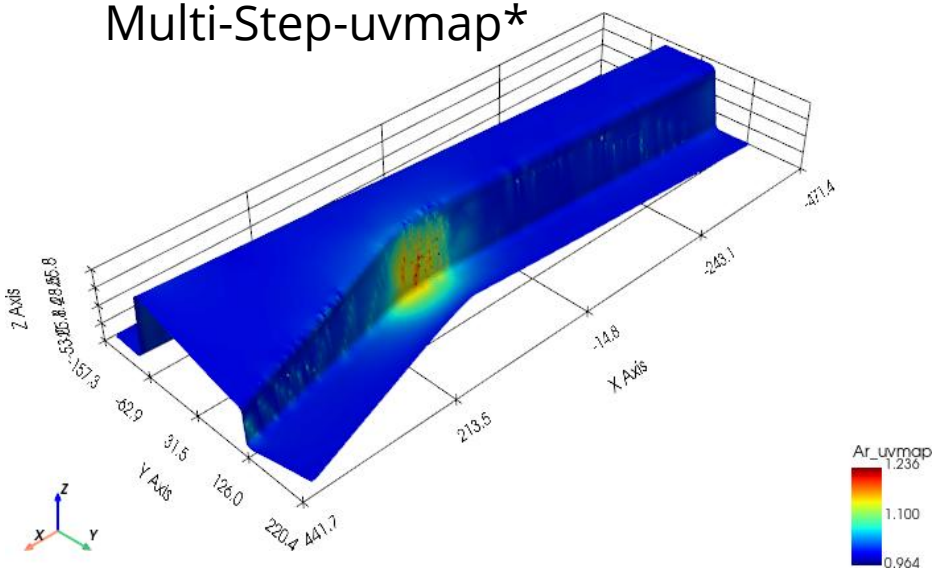


Types of training data

One-Step-uvmap

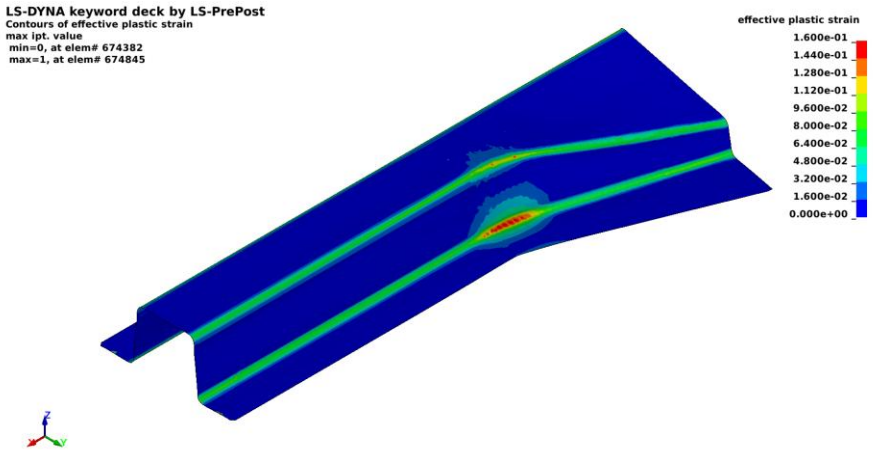


Multi-Step-uvmap*

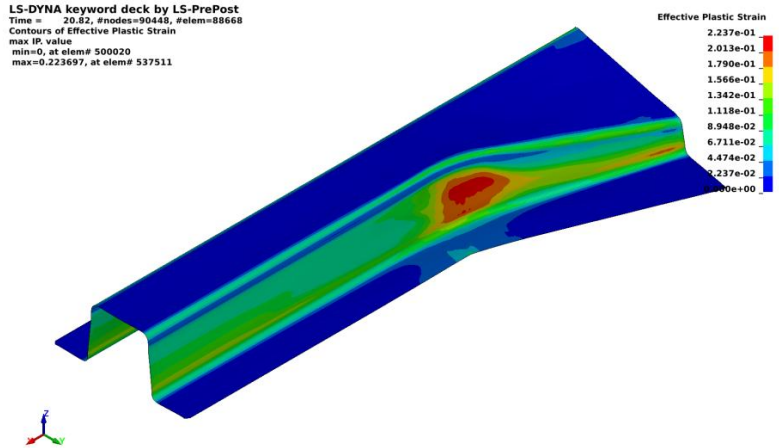


Input vector
Geometry: **Ar_uvmap**
Material: sig_0
Material: sig_c
Material: eps_c
Material: sig_a

LFS – One-Step

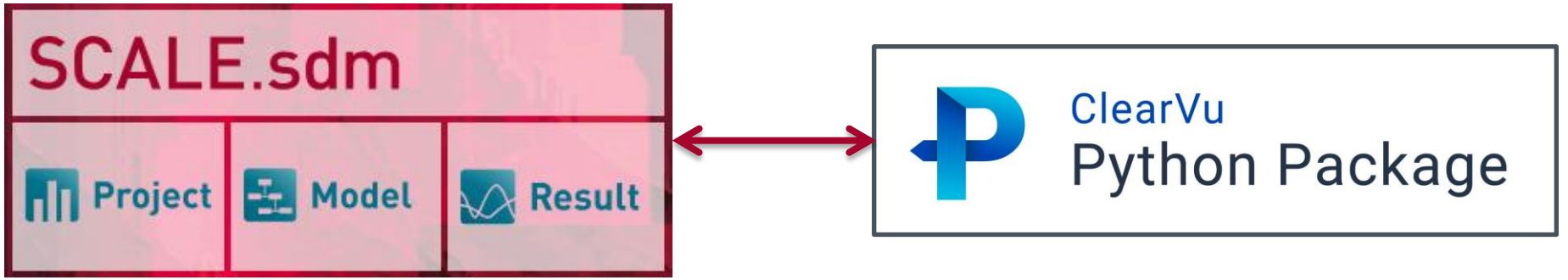


HFS – deep drawing with tools

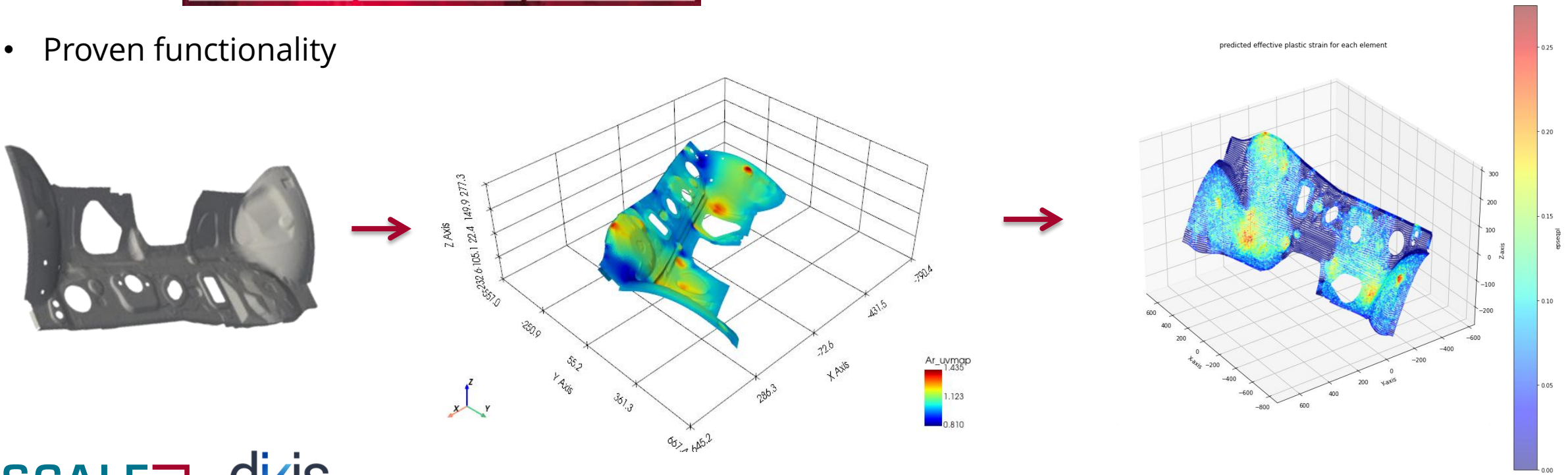


Summary

- Workflow prototypically modelled with SCALE.sdm and ClearVu



- Proven functionality



Thank you for your attention

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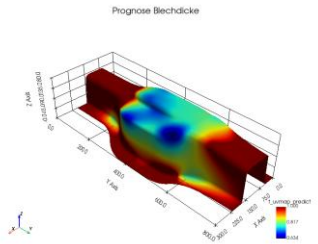

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