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19th NOVEMBER 2019

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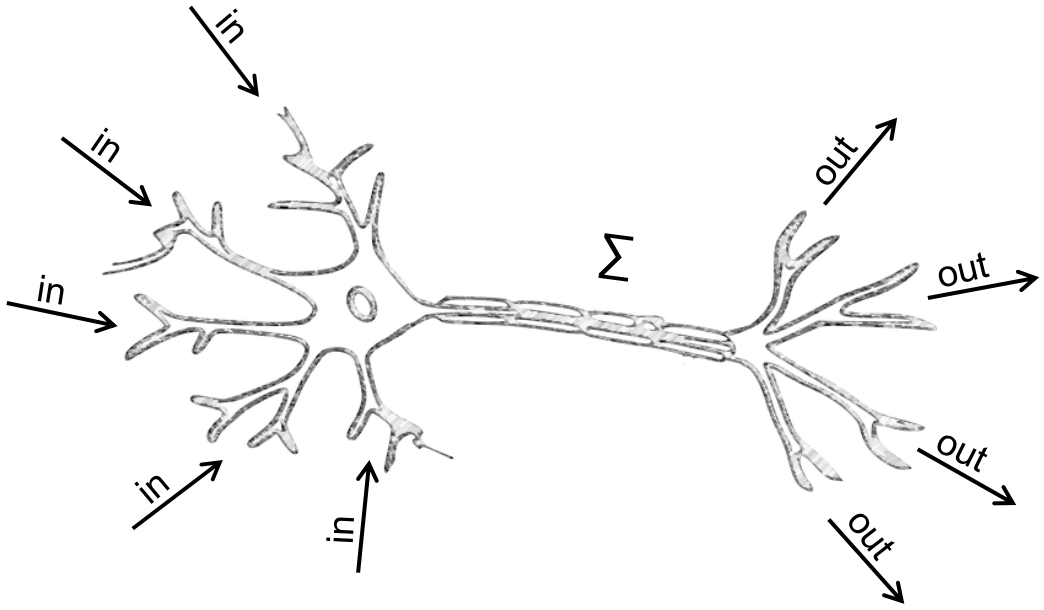
APPLICATION OF MACHINE LEARNING TECHNIQUES THROUGH SIMULATION DATA MANAGEMENT (SDM)

Agenda

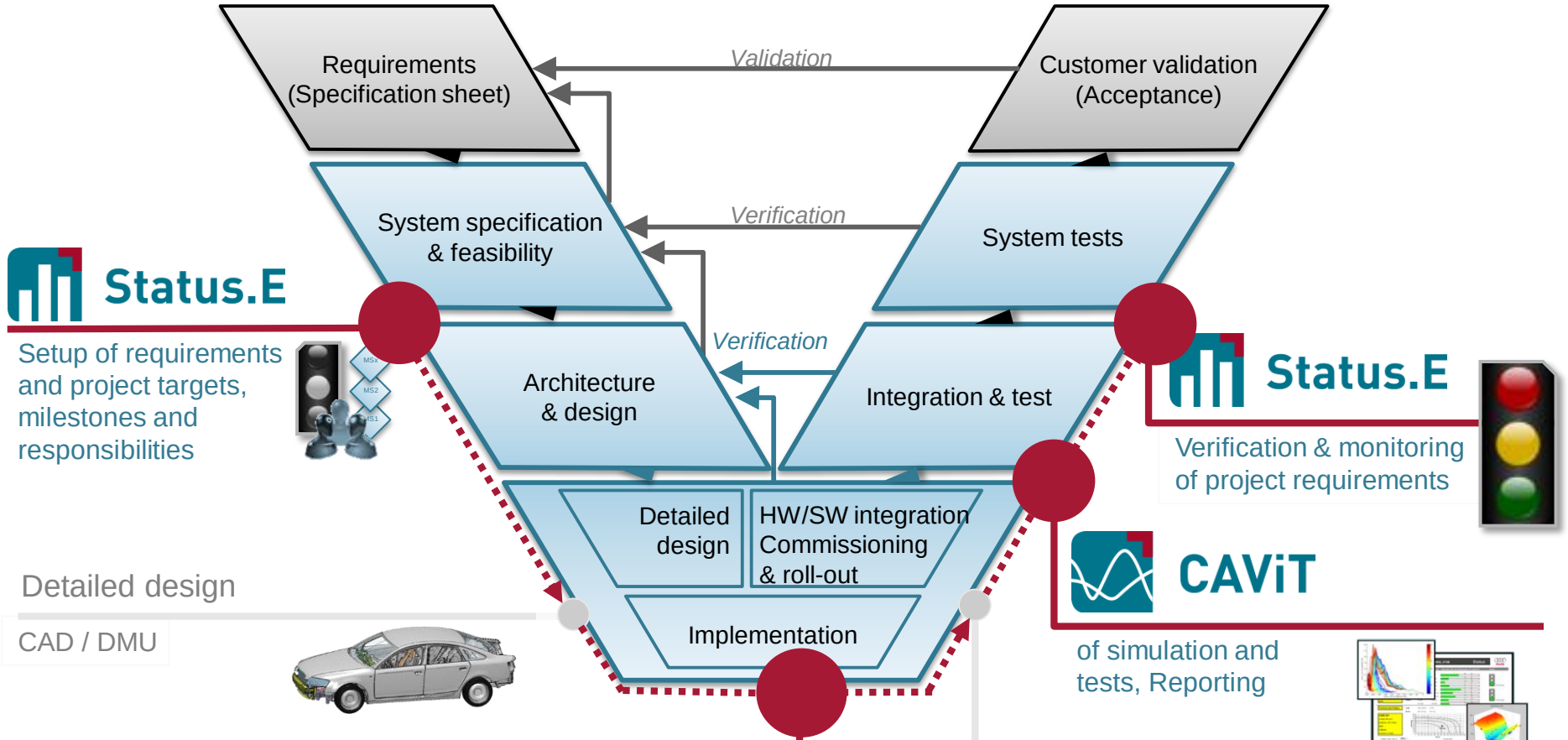
- Loop of virtual Product Development

- Simulation Data Management (SDM)
  - Applying changes
  - Collaboration
  - Result assessment
  - Automatic data processing (results)

- Machine Learning (ML) and SDM
  - What is ML?
  - Examples of ML to solve some narrow tasks
  - Big Data / Data mining



Loop of virtual Product Development



Status.E

Setup of requirements and project targets, milestones and responsibilities

Status.E

Verification & monitoring of project requirements

CAViT

of simulation and tests, Reporting

Detailed design

CAD / DMU

LoCo

Setup of simulation models

Solving / Testing

Perform simulation & test

Loop of virtual Product Development

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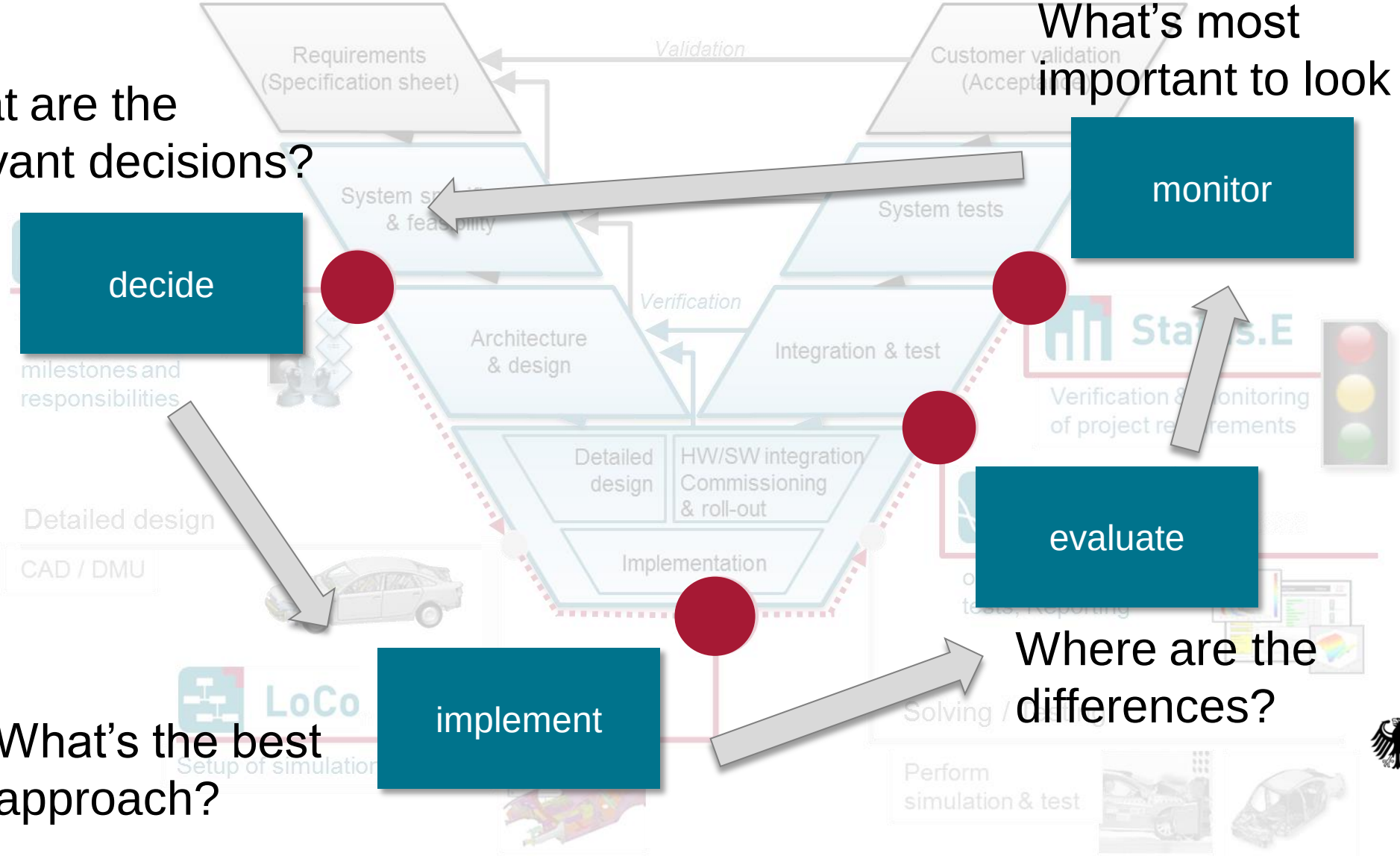
What are the relevant decisions?

What's most important to look at?



decide

monitor

evaluate

implement

What's the best approach?

Where are the differences?

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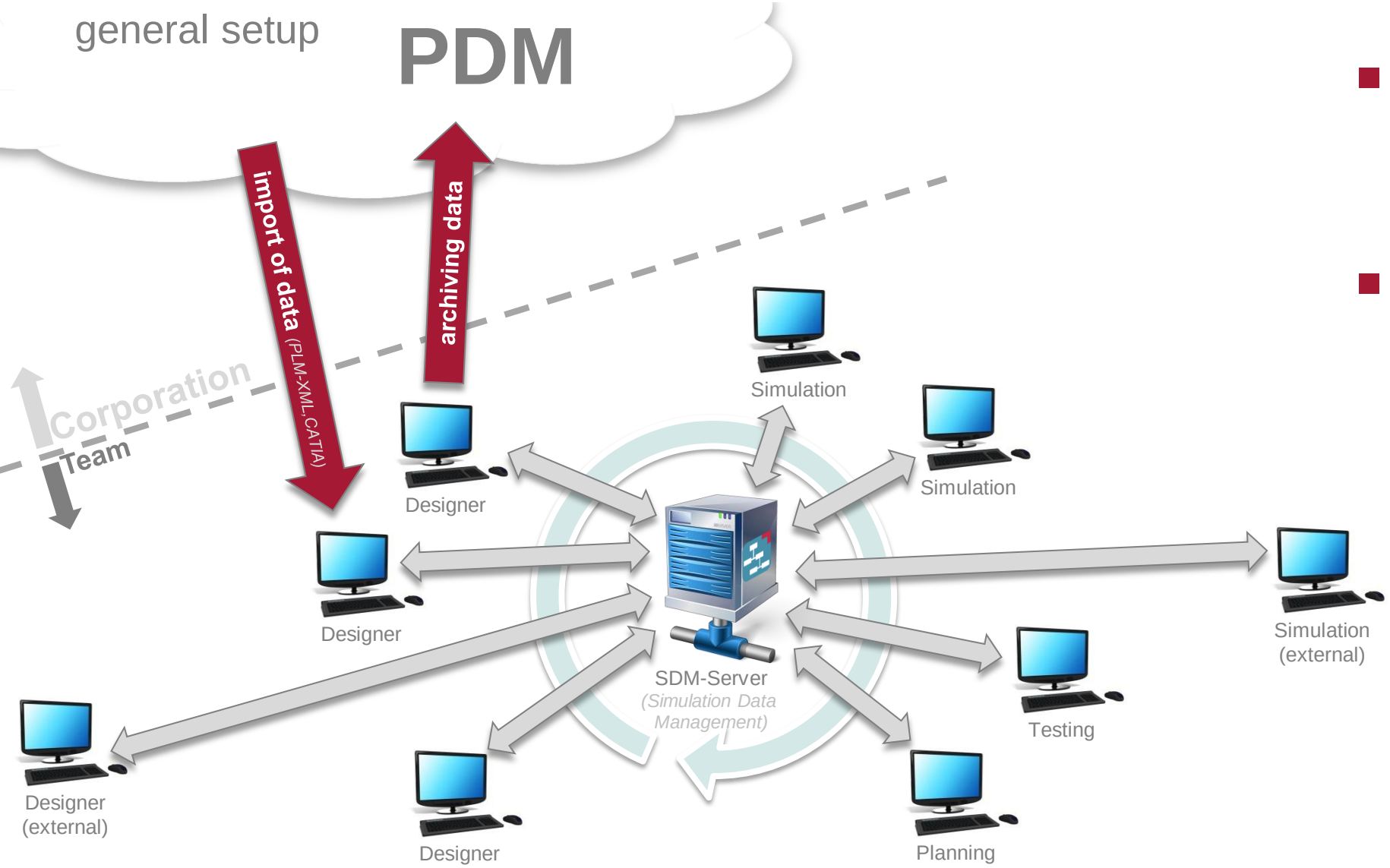
Simulation Data Management



- PDM used as data source
  - all data comes from PDM
  - all work results go to PDM
- SDM used for virtual product development
  - Interactive collaboration
    (including internal and external team members)
  - All data always at hand for every team member in real time
  - No files, no file system
  - **CAD** and **CAE** directly integrated
  - Tight integration of common tools
    (CATIA, ANSA, HW, Animator, META, LSPP, …)

Simulation Data Management

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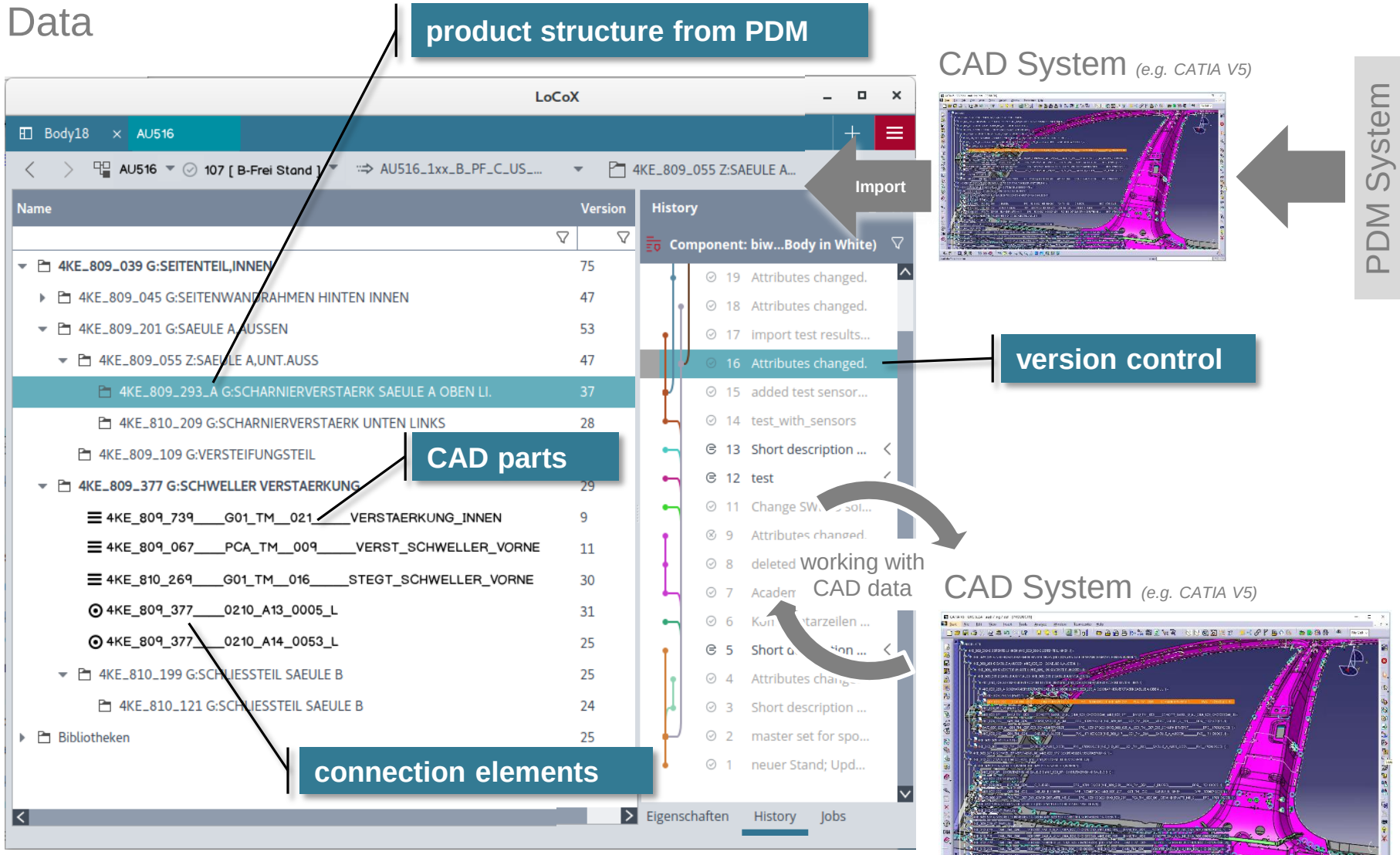
import and work with CAD Data

- Import from PDM system *(interface)*
- Integrate
  - Apply changes
  - Version control
  - No files
    - no file system
    - no up- and downloading
  - Connection elements
  - Variant control
    (which parts are used for what product variants)



Simulation Data Management

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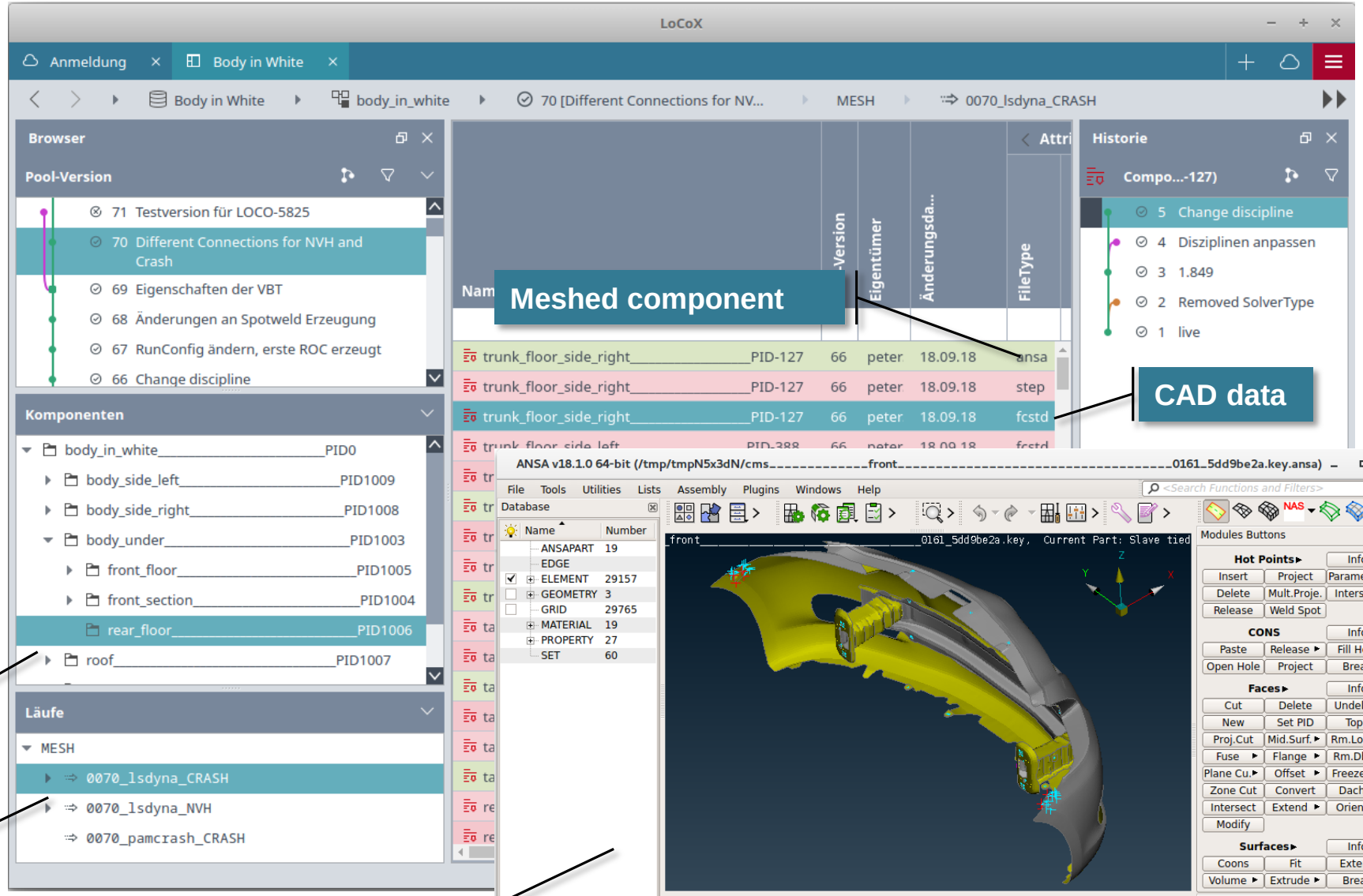
meshing and modelling

- Directly on imported CAD data
- Process
  - CAD Data opened in meshing tools
  - Collaborative working *(multiple users)*
  - Several solver representations for the same meshed data
  - Mesh directly integrated with simulation models.



product structure from PDM / CAD-System

create multiple solver representations

open data directly for meshing

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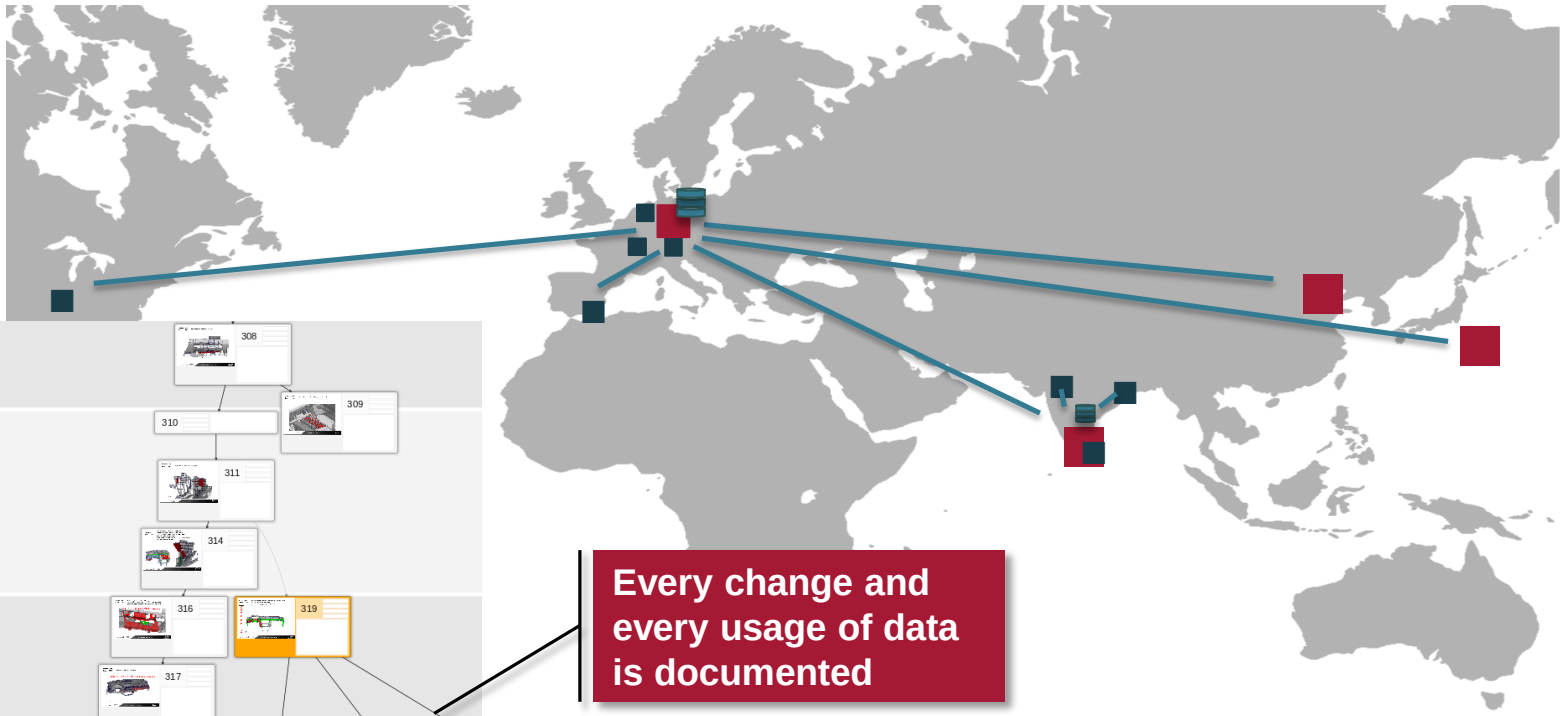
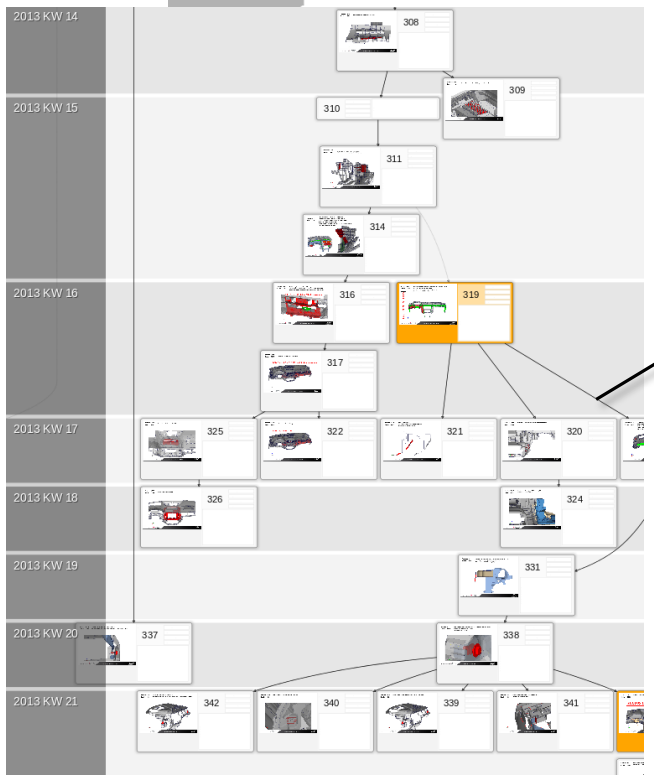
Simulation Data Management

collaborate and track changes

- Multitude of
  - Product variants
  - Users and sites
  - Projects sharing data
  - **Simulation results!**
- Version control is the key!
  - Each **object** is versioned
  - Every **change** is tracked and documented
  - The complete audit trail of all data is preserved
- Synchronization
  - Data is automatically synchronized between all users
  - No file handling





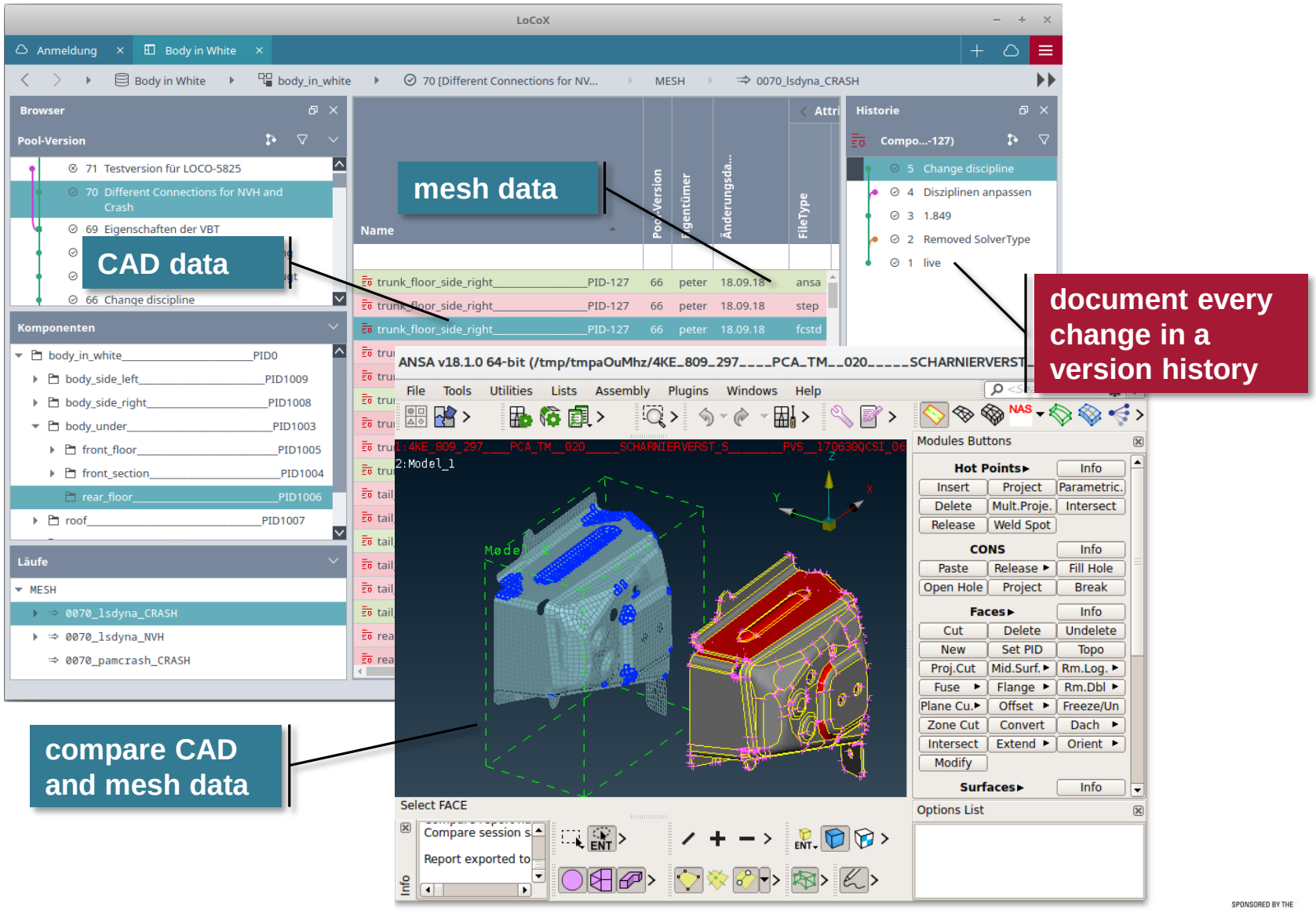
Every change and every usage of data is documented

Simulation Runs
Folders
Scripts **Modules**
Meshes Parameters

Simulation Data Management

document changes

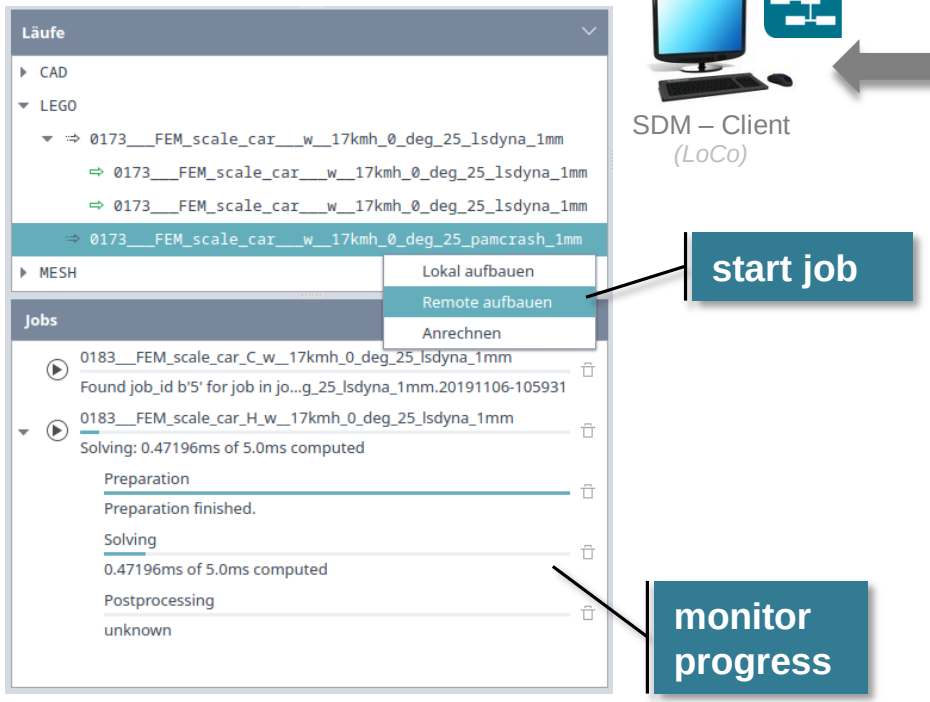
- Documentation
  - Users describe each change
  - Pictures and other documents can be attached
- What is missing for Machine Learning?
  - Classification of the change
  - Intention and reason of the change
  - Rating of the effectiveness of the change

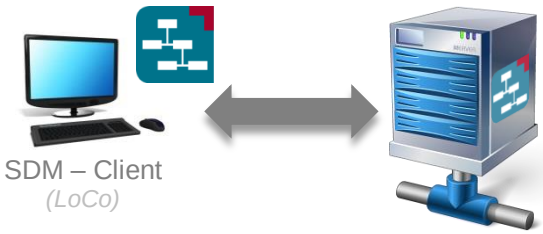


Simulation Data Management

job submit and solving

- Data handling and HPC process completely automatic
- One change is easily applied to multiple simulations
- Many jobs can be submitted at once!





start job

monitor progress

job submit

store result data

HPC-comservice (Runner)

HPC

Preprocessing

Solving
(LS-DYNA, PAMCRASH, Abaqus, Nastran, …)

data reduction
(FEMZIP)

Post-Processing
(GECO) – Photo / Video / Channels / KeyResults /…

Simulation Data Management

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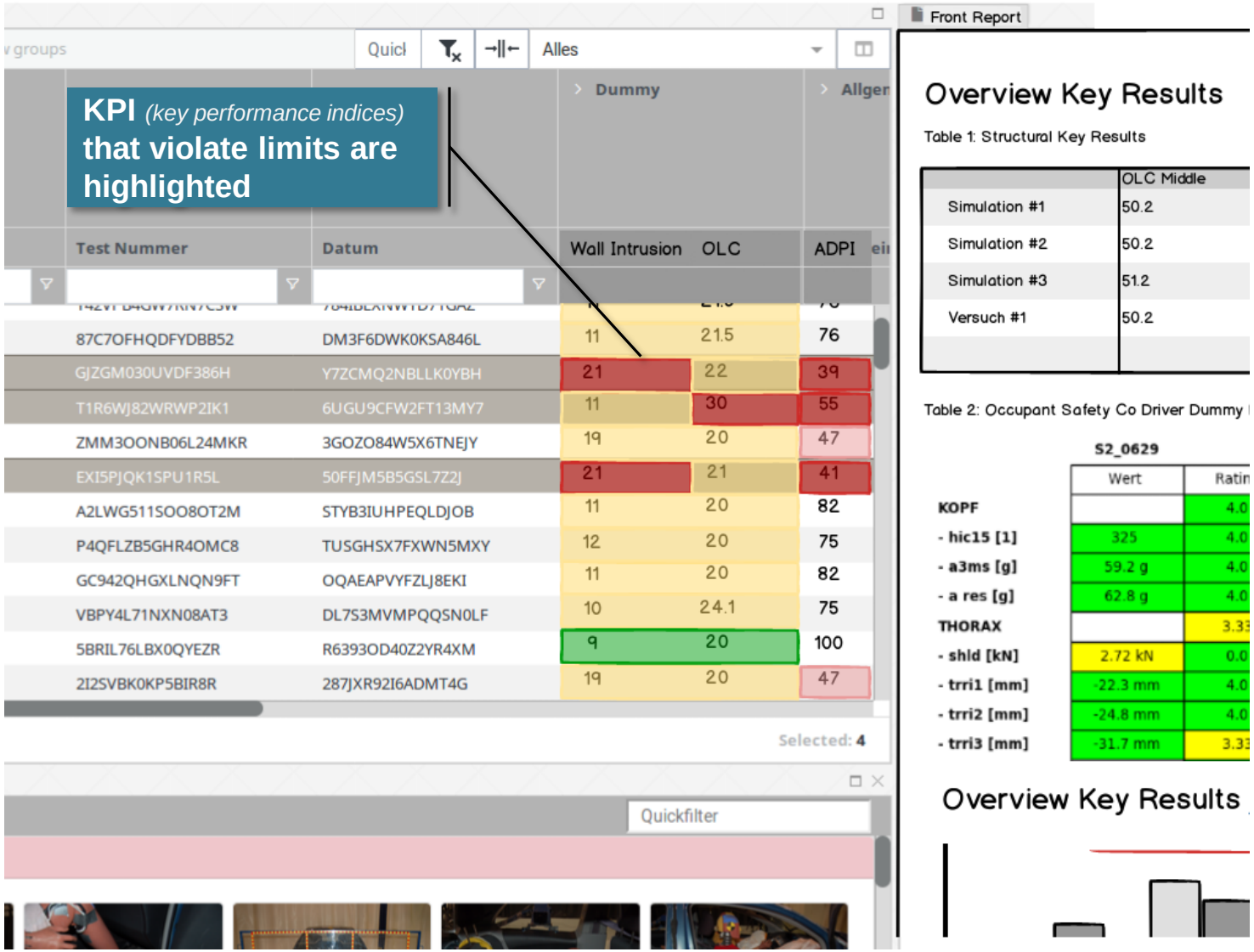
result assessment

- Browse results of large amounts of simulation and test data
- Search, group and filter
- Highlighting of critical KPIs
- Access all related simulation data
  (reports, movies, pictures, channels, solver result files)

- What is missing for Machine Learning (ML)?
  - Autom. detection of unexpected behavior
  - Tracking of certain behavior
  - Link between certain behavior and applied changes



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Simulation Data Management

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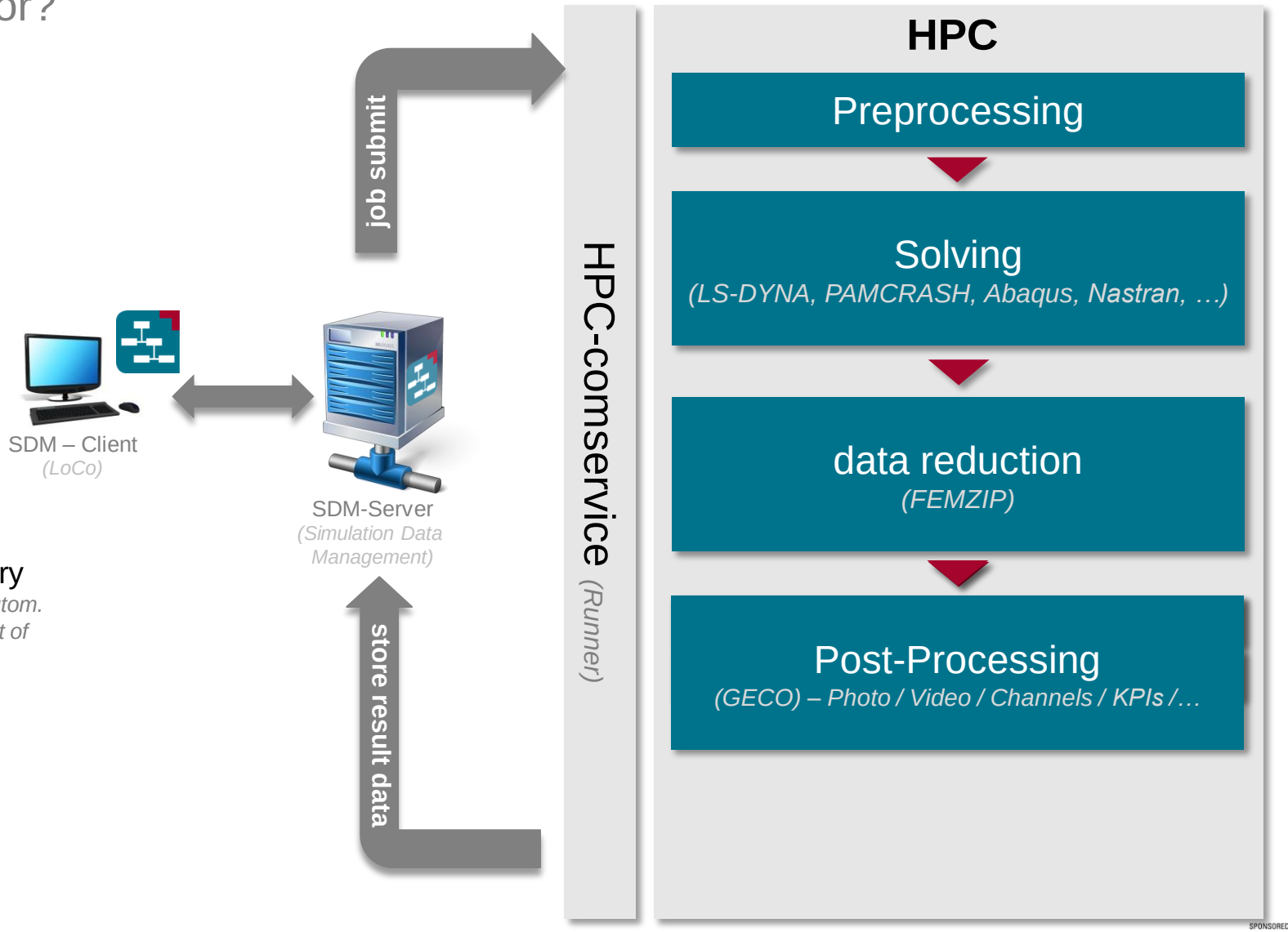
but what about unexpected behavior?

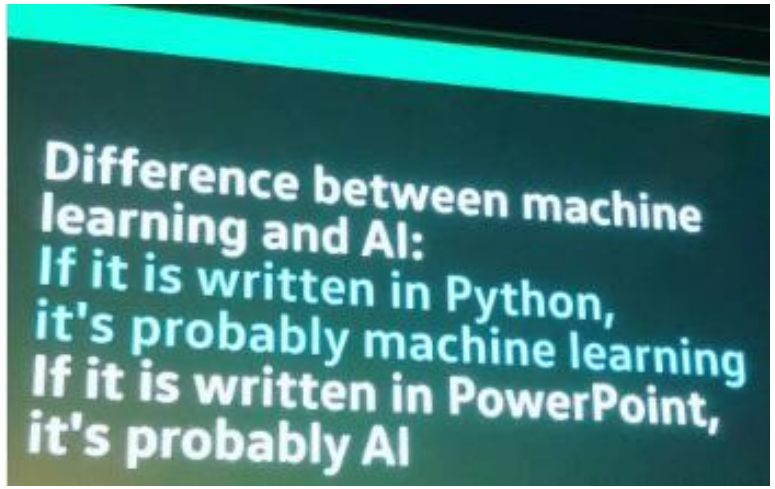
- Only previously defined KPIs are automatically monitored
  - Data is extracted during postprocessing on HPC
  - Only fixed limits are used for monitoring
- What would be needed to detect unexpected behavior?
  - Outlier analysis for KPIs
  - Detection of unseen behavior on geometry
    (needs an database of result data that can be used for autom. searching and analyzing of similar behavior on a large set of simulations)
- How to integrate in process?



Machine Learning

differences between AI and machine learning

- AI: Artificial Intelligence
  - *„… the term "artificial intelligence" is often used to describe machines (or computers) that mimic "cognitive" functions that humans associate with the human mind …". Wikipedia*
  - Strong AI vs. weak AI de.wikipedia.org
    - **Strong AI:** attainment of cognitive abilities
    - **Weak AI:** focused on narrow tasks



Machine Learning

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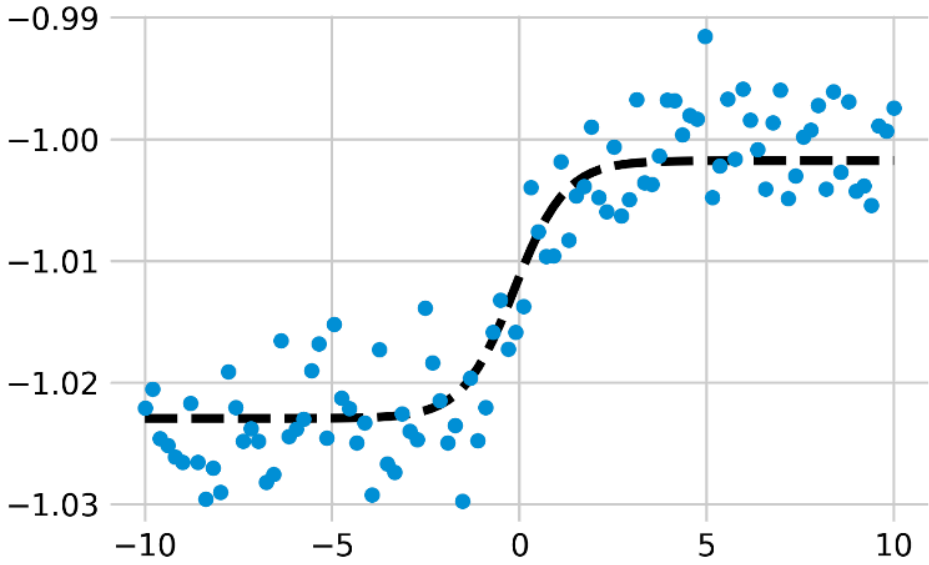
so what is machine learning?

- Different mathematical methods to solve weak AI problems
- Learning from collected/existing data
- Supervised learning: *(supervised, semi-supervised, reinforcement, active)*
  - Pairs of input data and their results are provided
  - Algorithm can deliver prognoses based on that
- Unsupervised learning:
  - Autonomous data arrangement and clustering
  - Data simplification before learning

    (e.g. Main components analysis)



Machine Learning

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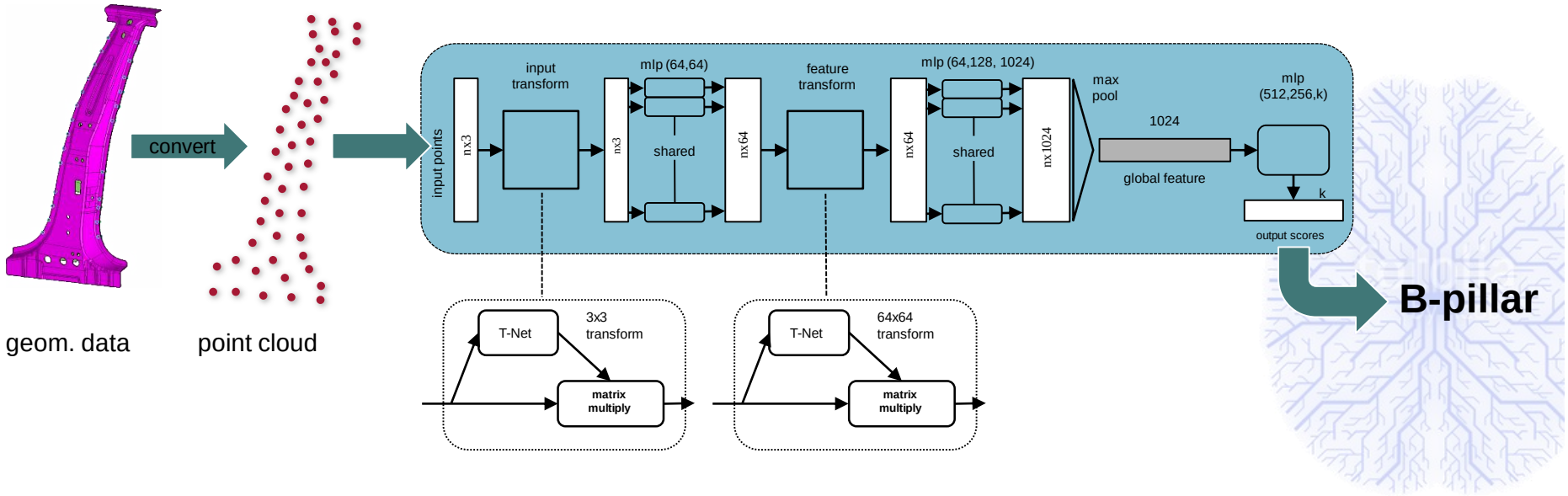
example: geometry recognition



- **Big Data:** Provision, conversion and evaluation of countless components from SDM-System
- **Deep Learning:** Different neural networks with many „hidden“ layers are combined and trained
- Artificial Intelligence: ability to detect components was reproduced *(weak AI)*

Machine Learning

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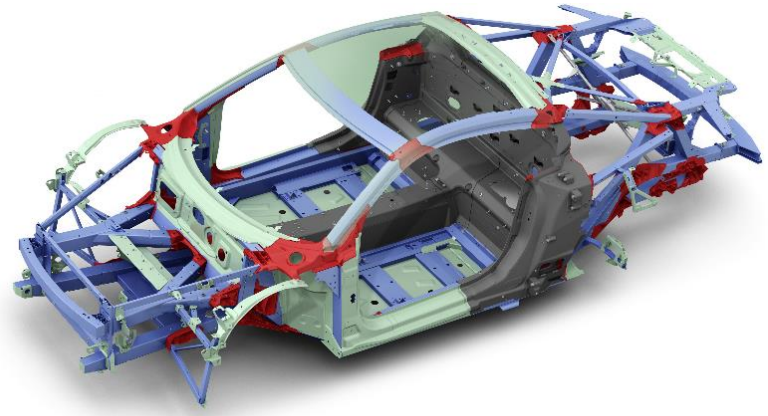
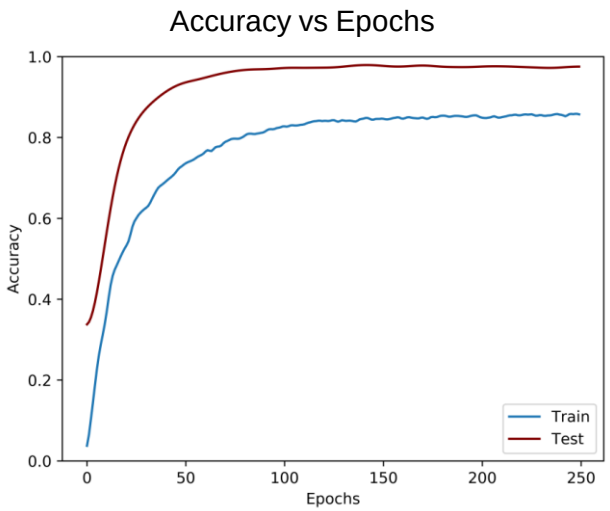
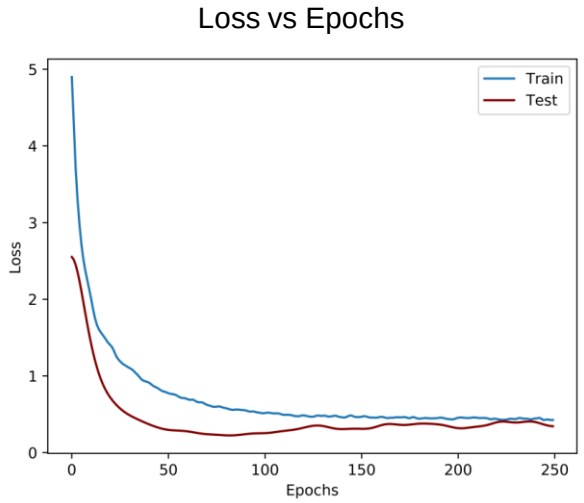
example: geometry recognition

- 5367 versions of body in white includes *(2011-2018 extracted from LoCo)*
- ~1TB PAM-CRASH includes of the same body in white
- ~580 individual parts in total *~5000* different versions







- ~561 von 580 Parts were identified correctly

- Next Steps
  - Identify parts across multiple different vehicles
  - Identify a part group structure

Machine Learning

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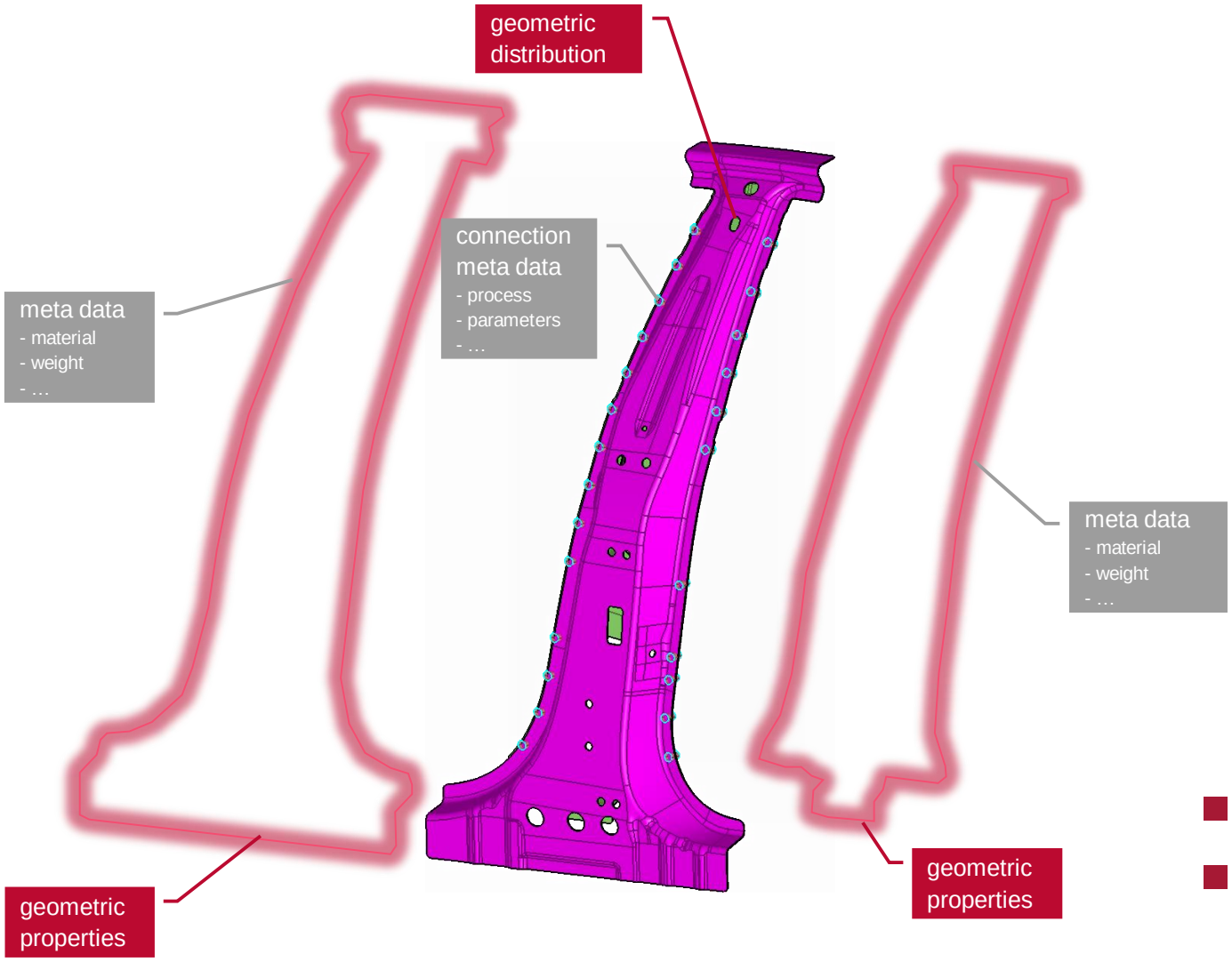
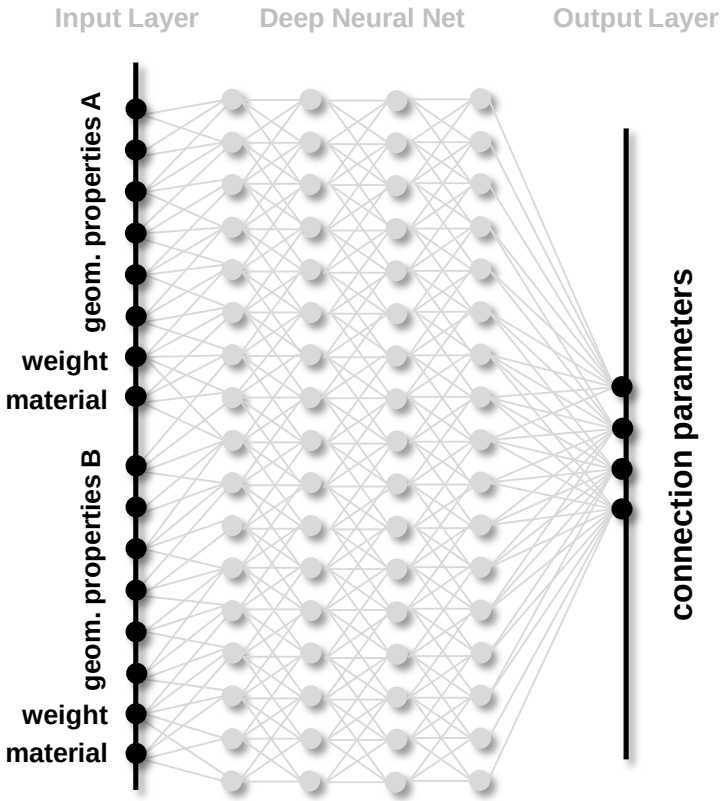
example: autom. spotweld design





- Extract training data from existing FEM data
- Estimation for initial spot weld layout with NeuralNet

Machine Learning

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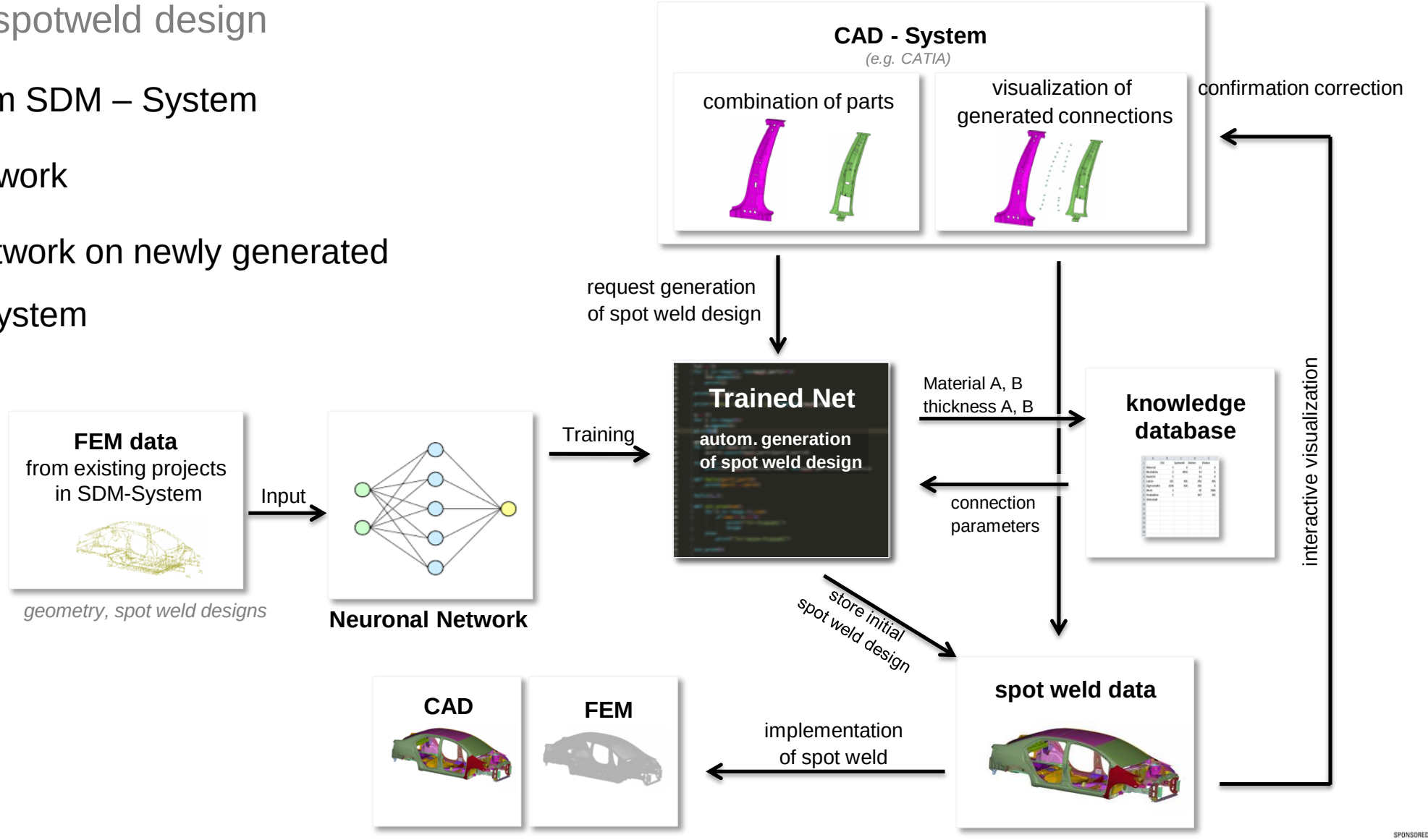
example: autom. spotweld design

- Extract data from SDM – System
- Train neural network
- Apply neural network on newly generated data in SDM –System



Machine Learning

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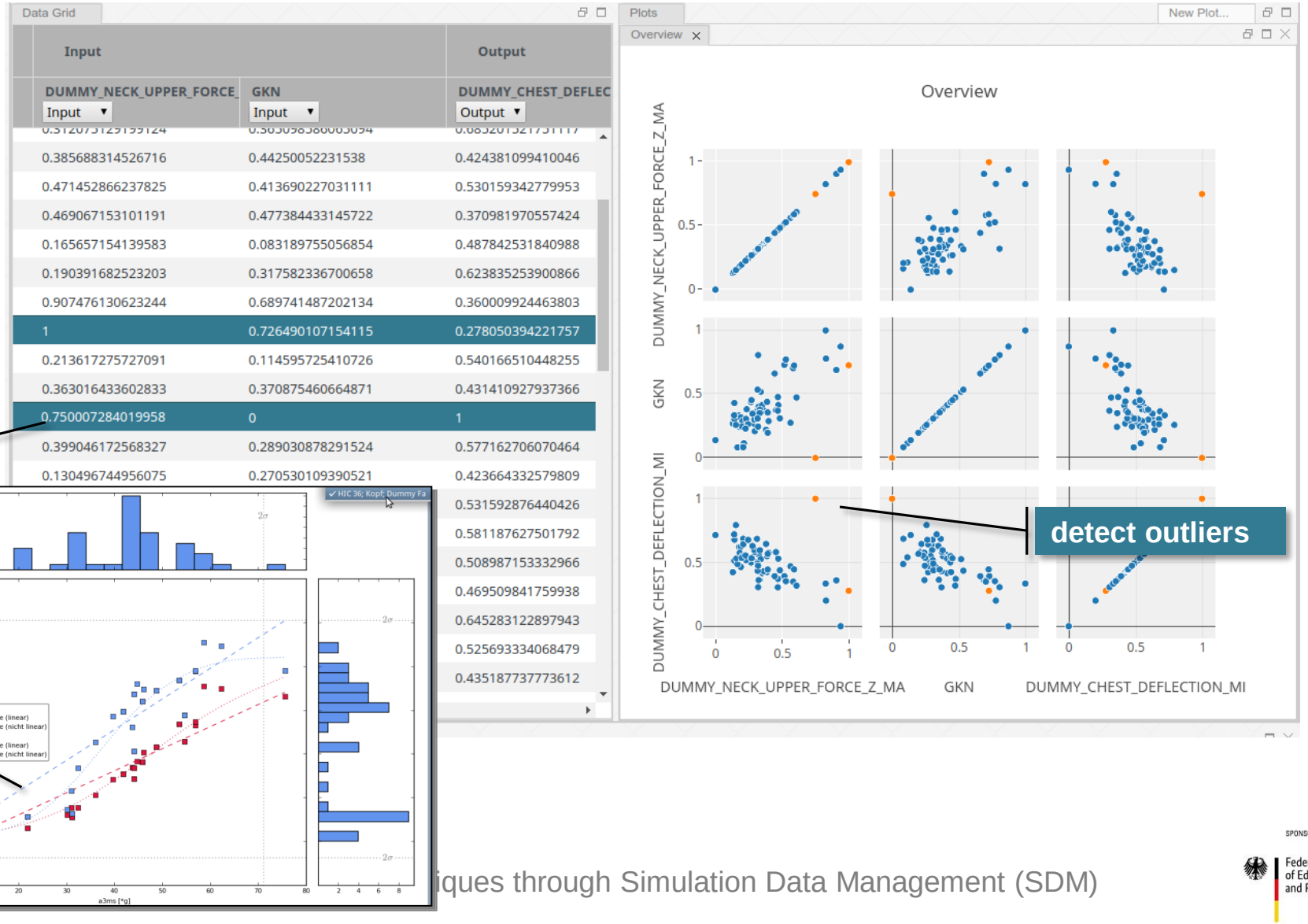
how to access data of many, many, many simulations

- All simulation results are accessible in SDM-System
  - KPIs of all simulations can be browsed, filtered, searched, grouped, …
  - Statistics can be performed on existing simulation results
  - Big amounts of data can be analyzed

browse, sort, filter KPIs of all simu-lations and tests

create models analyze trends

detect outliers



Conclusions

- SDM Systems are the basis for ML because…
  - many CAE tasks can be automated
  - data from different users, disciplines, product variants are centrally located and stored
  - dataset can be related to each other

- Challenges to implement ML based assistants in SDM systems
  - Capturing the relationship between data
  - Gathering the relevant data from the user

- Prospects
  - ML (weak AI) will help to further automate tasks in SDM systems
  - Discovery of relevant data and trends

- Without structured and related data there will be no ML

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