Antriebs- und Fahrwerktechnik

# Chassis Design using Composite Materials – MBS-Modeling and Experiences

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Calculations and Simulations
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# Chassis Design using Composite Materials – MBS-Modeling and Experiences

## Task

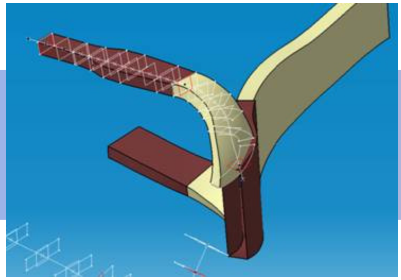
- ➔ Creating axle models for the design of lightweight axles with fiber reinforced plastic components
- ➔ Elastic struts define kinematics & compliance of axle
- ➔ Exact kinematics of elastic bodies is important
- ➔ Fast models for advanced engineering projects

## Contents

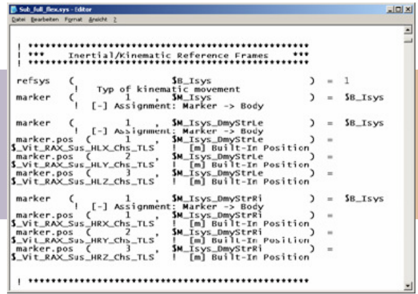
- ➔ Modeling of Elastic Components
  - ◆ Experiences, Improvements, Correlation
- ➔ Automated Postprocessing

# Modeling of Elastic Components

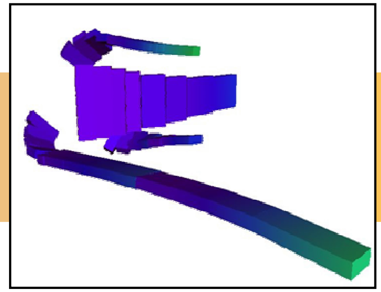
- Elastic bodies are discretised using beam elements
  - Geometric stiffening terms yield non-linear kinematics
  - MBS: isotropic material



CAD Modell
with geometric data
Export geometry



Scripts to generate
SIMPACK source code



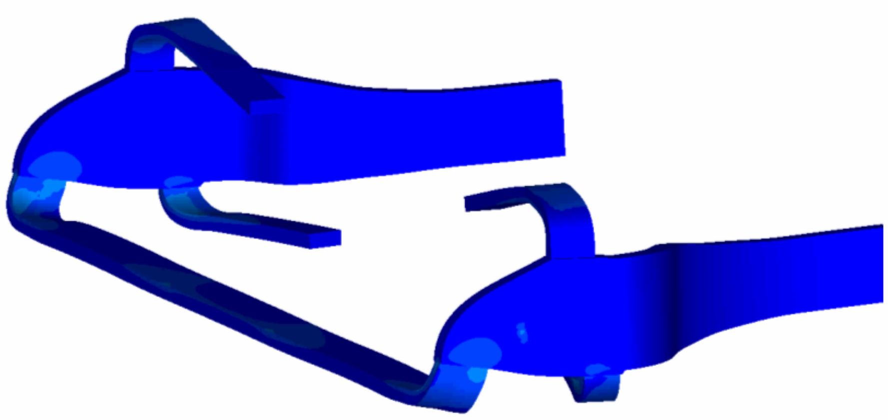
SIMPACK
Simbeam Modell

- automated generation of Simbeam definitions
  - manual generation of FBI and SID-Files (FEMBS)
  - manual assembly and calculation of preload

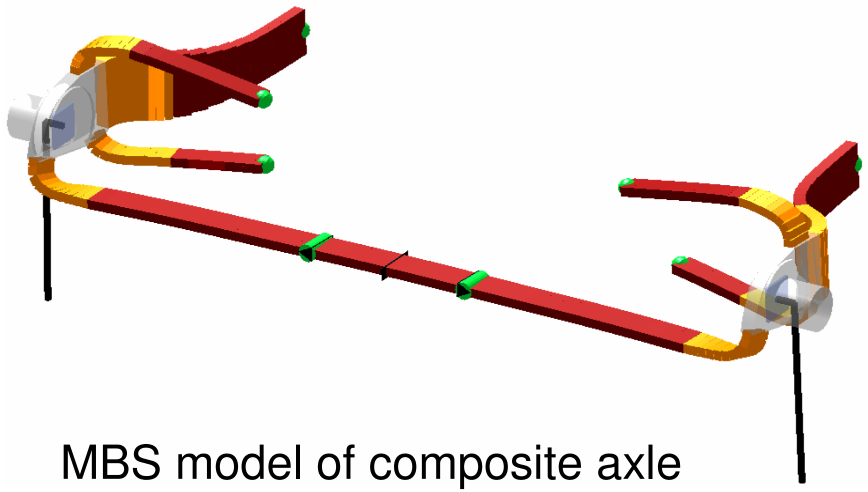
# Modeling of Elastic Components

## First comparison MBS – FEM

- Specification of axle
  - Design concept: one body with integrated flexible components
  - FEM: Orthotropic material – MBS: Isotropic material
  - Comparison of deformations and rotations at wheel centre
  - Good correlation of results



FE model of composite axle

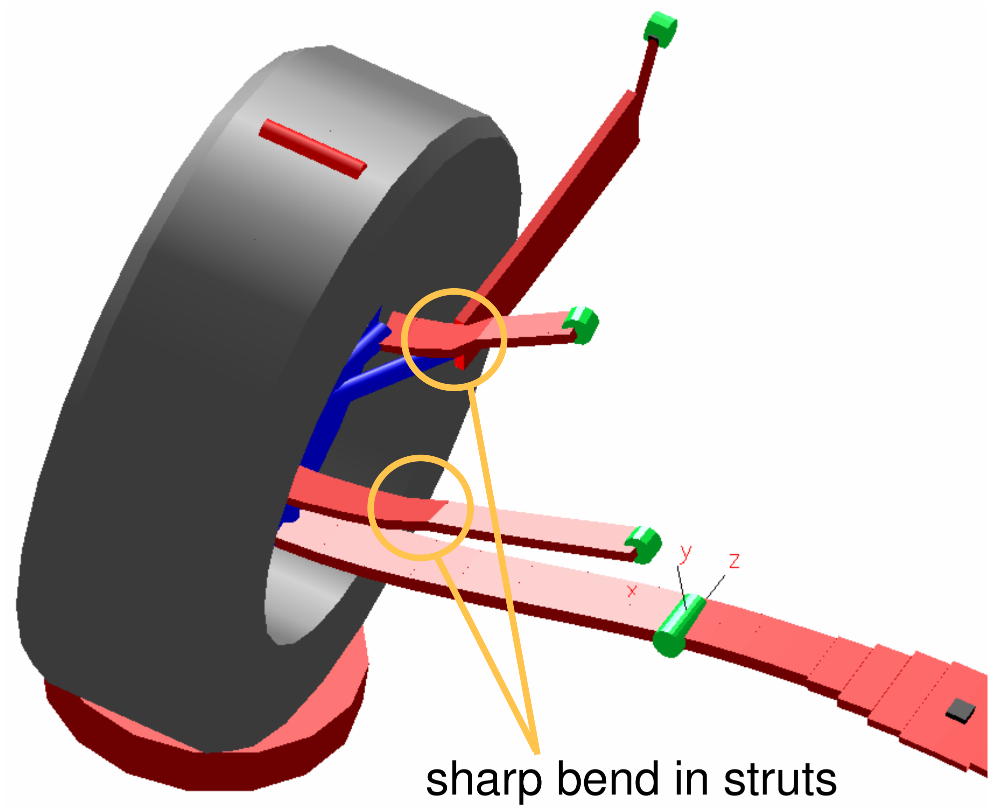


MBS model of composite axle

# Modeling of Elastic Components

## Experiences

- ➔ Use of modeling approach for investigation of several axle concepts
- ➔ Intermediate version of axle design:
  Non plausible sharp bend in struts under wheel load
- ➔ Reasons:
  - no physical buckling
  - elastic struts are composed of two segments
  - due to parameterised assembly definition: poor numerical conditions



# Modeling of Elastic Components

## Improvements

- Problem solving: SIMPACK AG and ZF Friedrichshafen AG
- Improvements in SIMPACK
  - Orientation of markers is defined by quaternions (starting SIMPACK 8903beta)
- Changed approach to couple segments of elastic bodies
  - 6 dof joints for reference system
  - additional 6 dof constraint to couple the segments
- Approach has been verified in several following models
  - comparison with nonlinear FE results
- Stable Simulation results for several variations of axle
  - even with extreme deformations

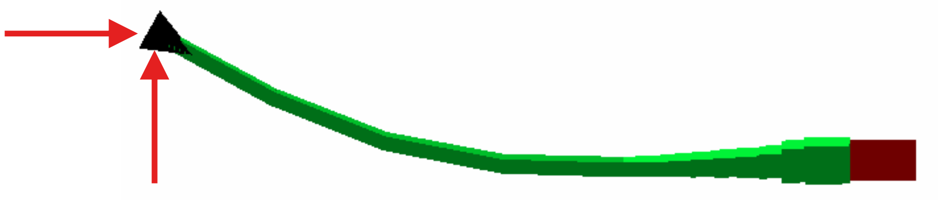
# Modeling of Elastic Components

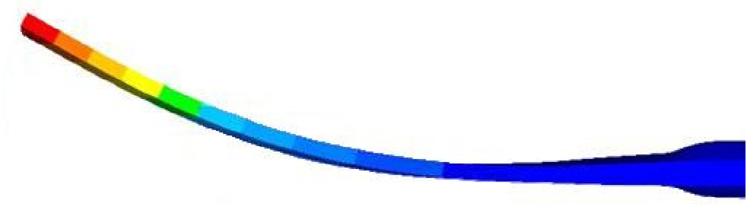
## Correlation of SIMPACK with nonlinear FEM

➔ Deformation of a single elastic strut at maximum deflection and different load cases

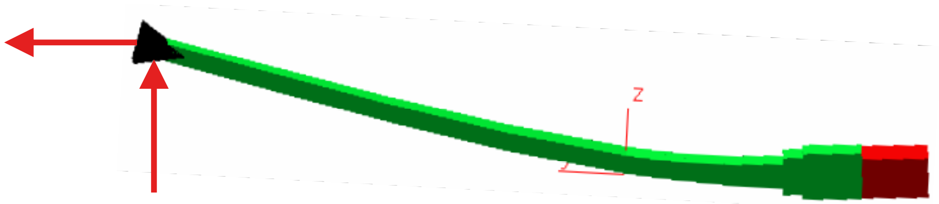
| SIMPACK isotropic material | FEM orthotropic material |
|---|---|

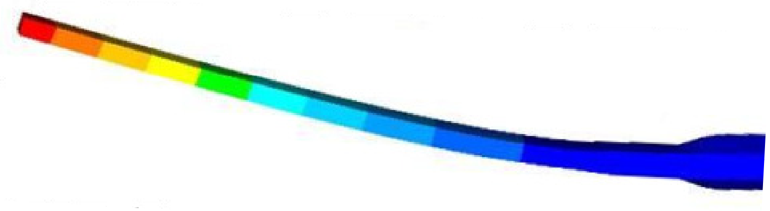
1. additional bending due to compression force





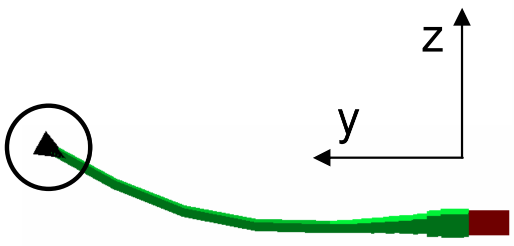
2. straightening due to tension force



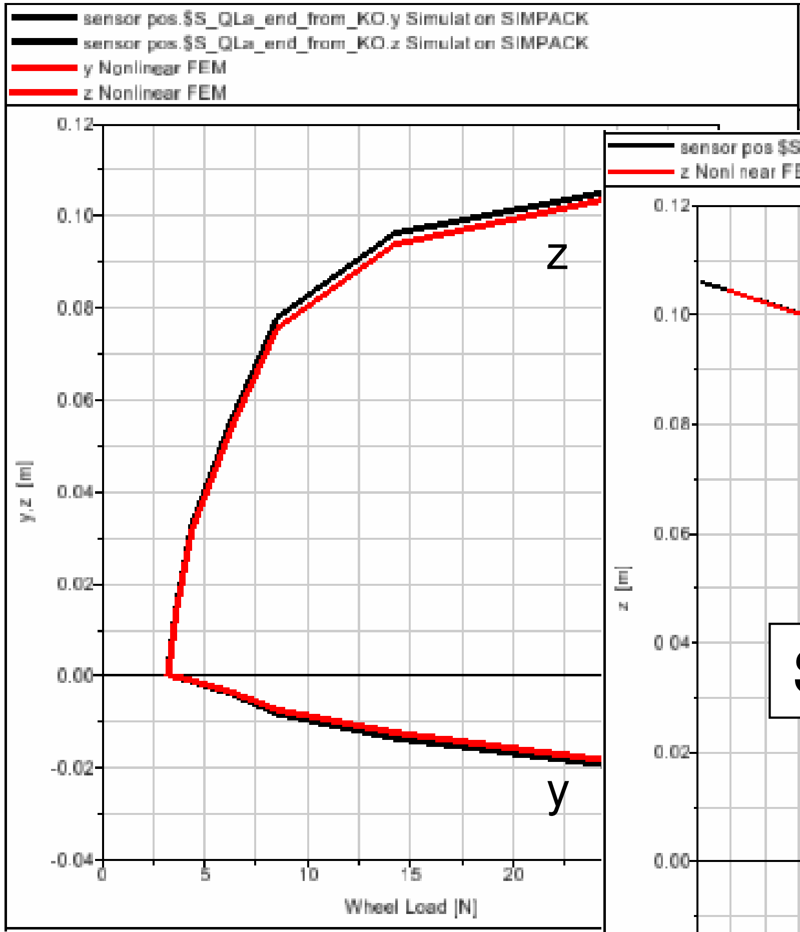



# Modeling of Elastic Components

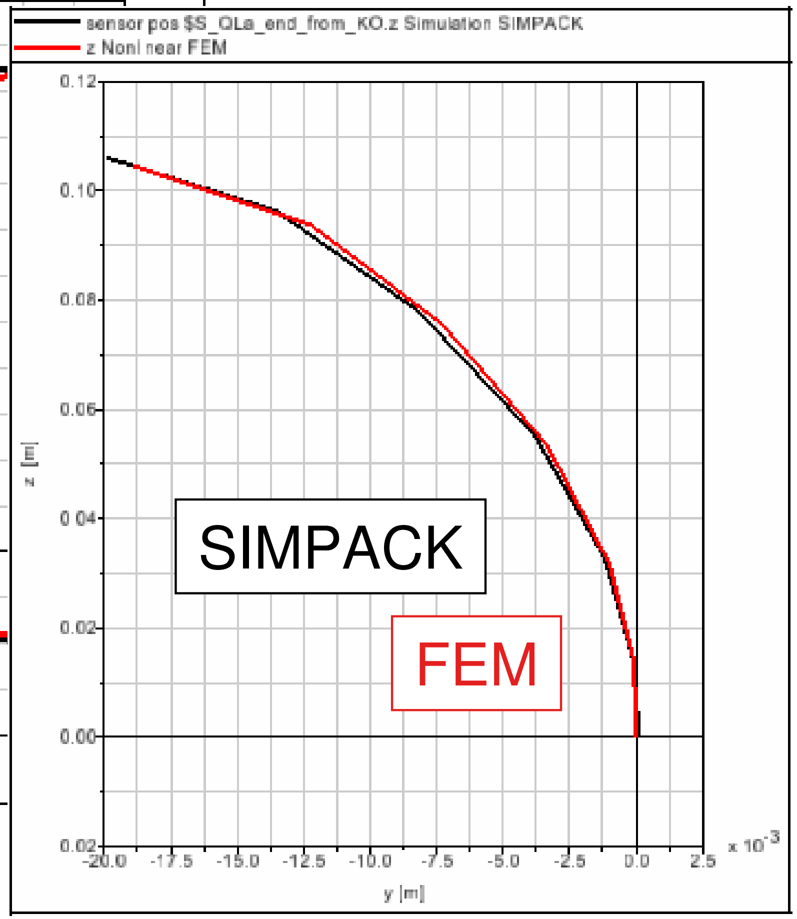
## Correlation of MBS with FEM




Deformation over Wheel Load




Path of End Point



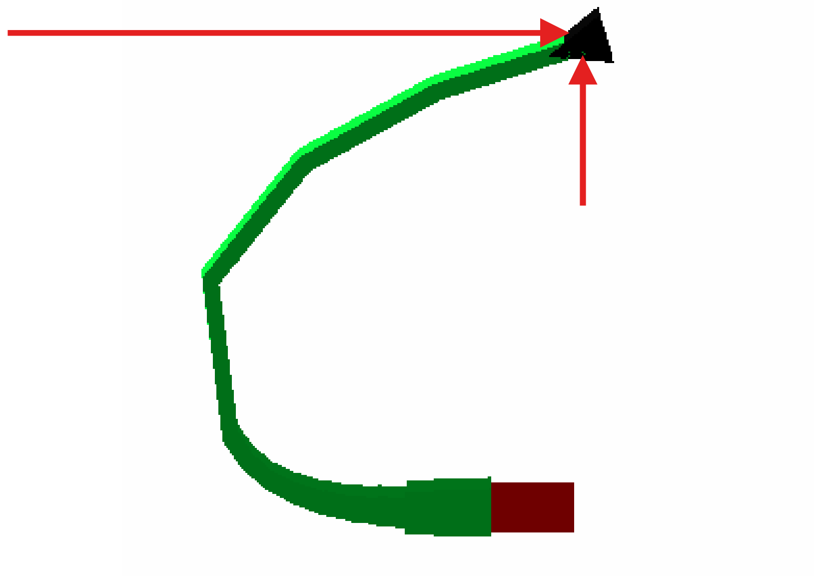

➔ Good correlation of nonlinear kinematics

# Modeling of Elastic Components

## Robustness of the approach

- ➔ calculation of single strut without axle assembly
- ➔ unrealistic high compression load on struts
- ➔ second stable static equilibrium is found by SIMPACK and FEM
- ➔ robust simulation even beyond field of application

SIMPACK

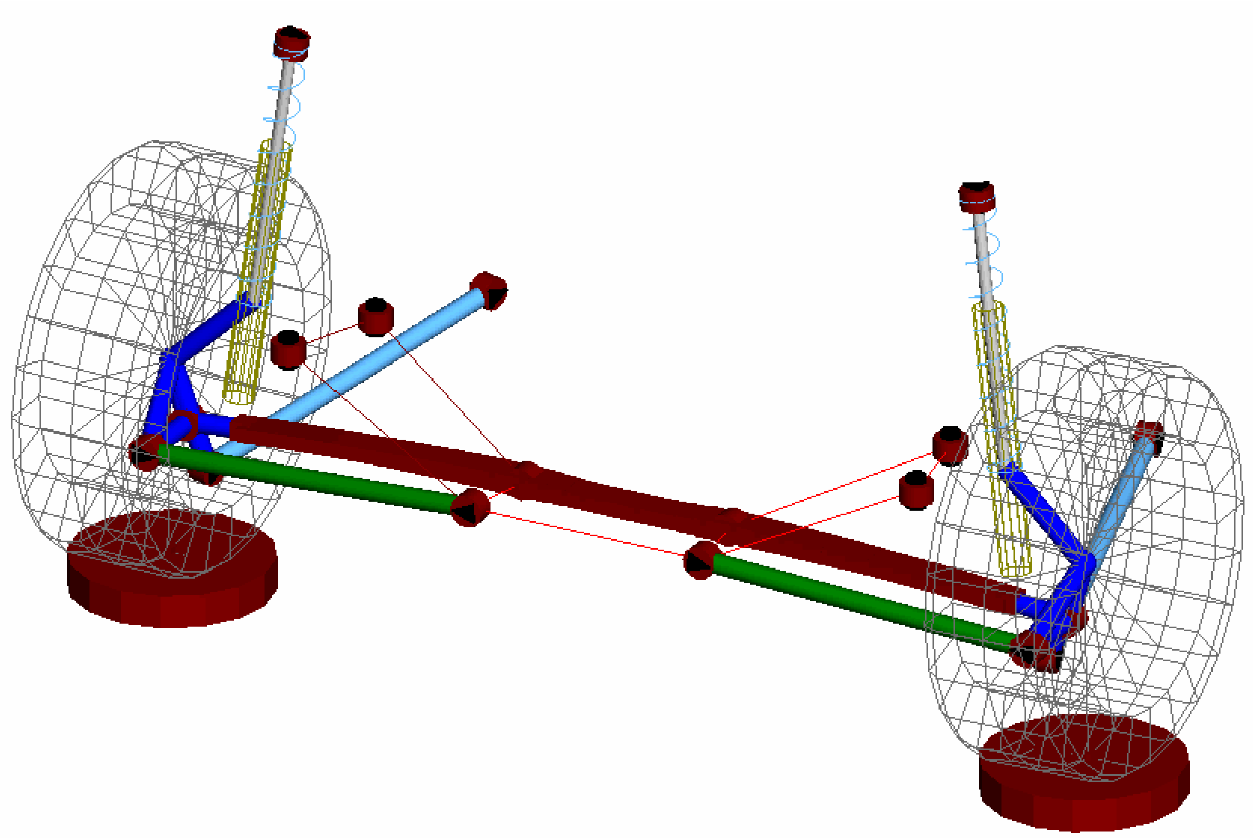


FEM

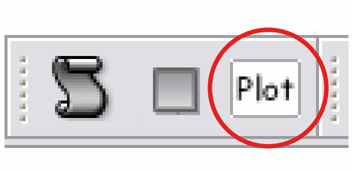
# Automated Postprocessing

Virtual K&C Test Rig

- ➔ parallel wheel travel
- ➔ opposite wheel travel
- ➔ brake / drive torques
- ➔ lateral forces
  at tire contact point

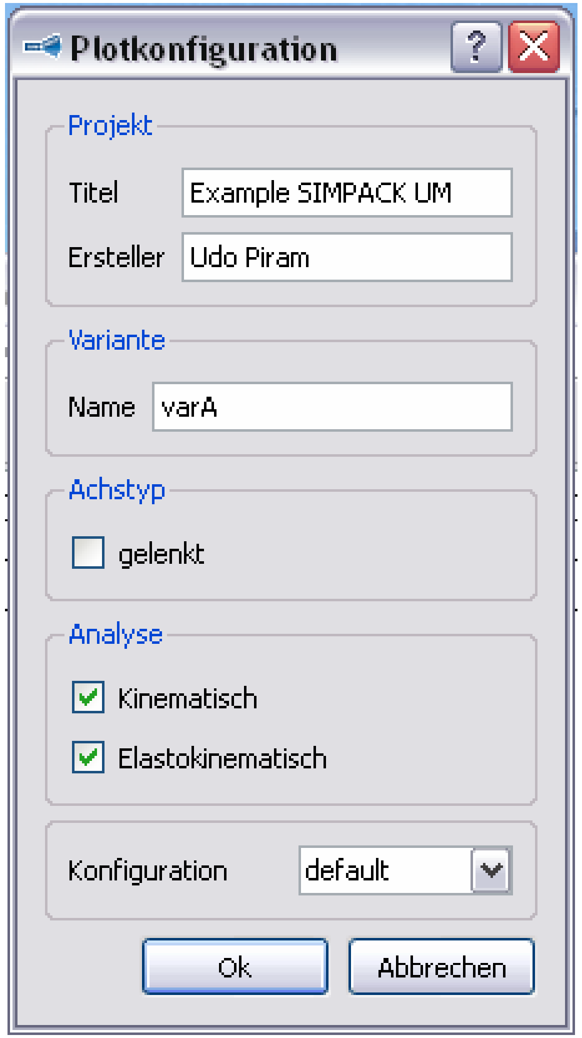


# Automated Postprocessing




Main script

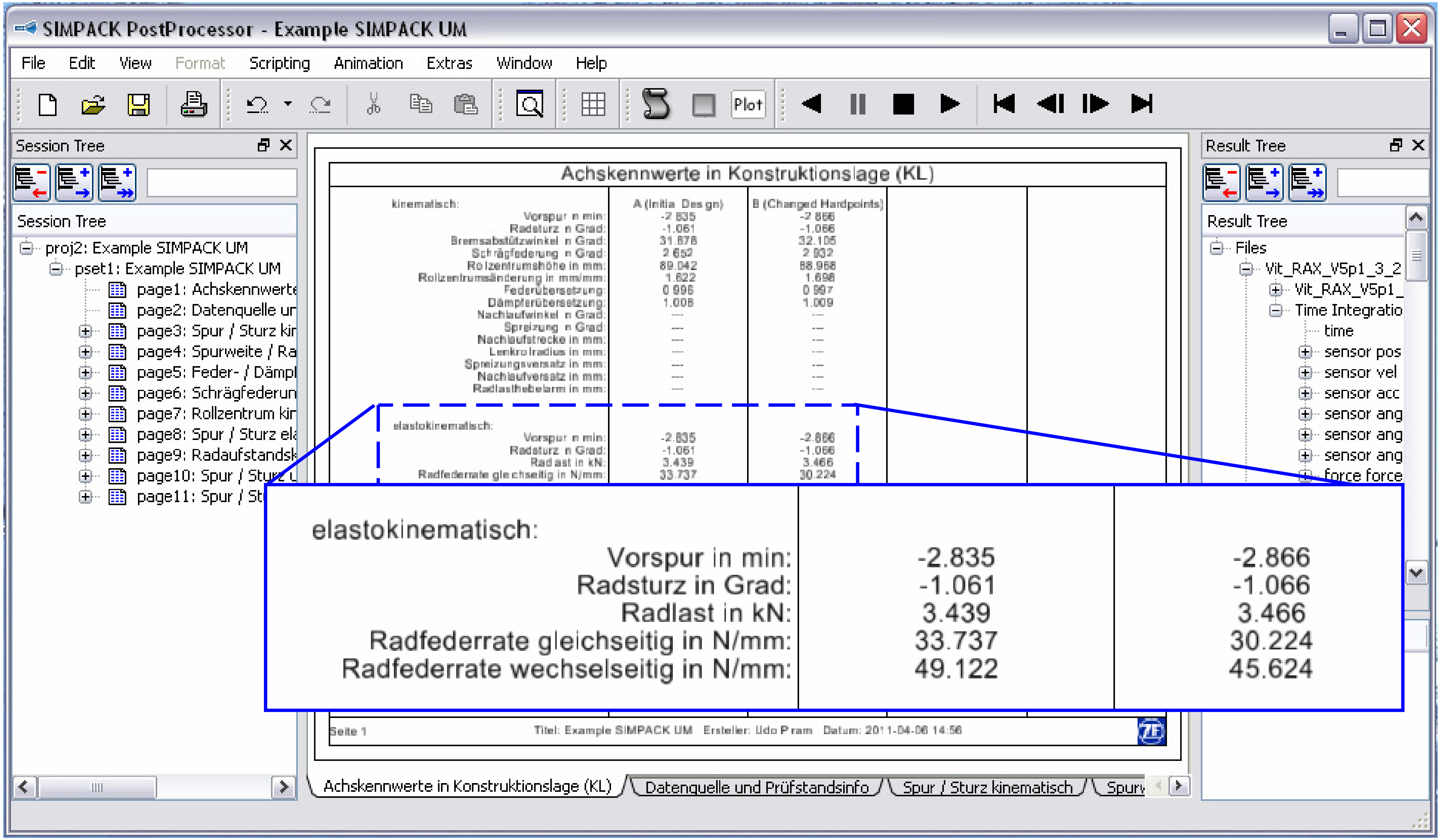
- ➔ Starting a new project
- ➔ Adding curves




- ➔ Calculation of typical axle parameters
- ➔ Generation of plots incl. scaling, windowing ...
- ➔ Up to 4 variants in one plot
- ➔ Language can be selected globally

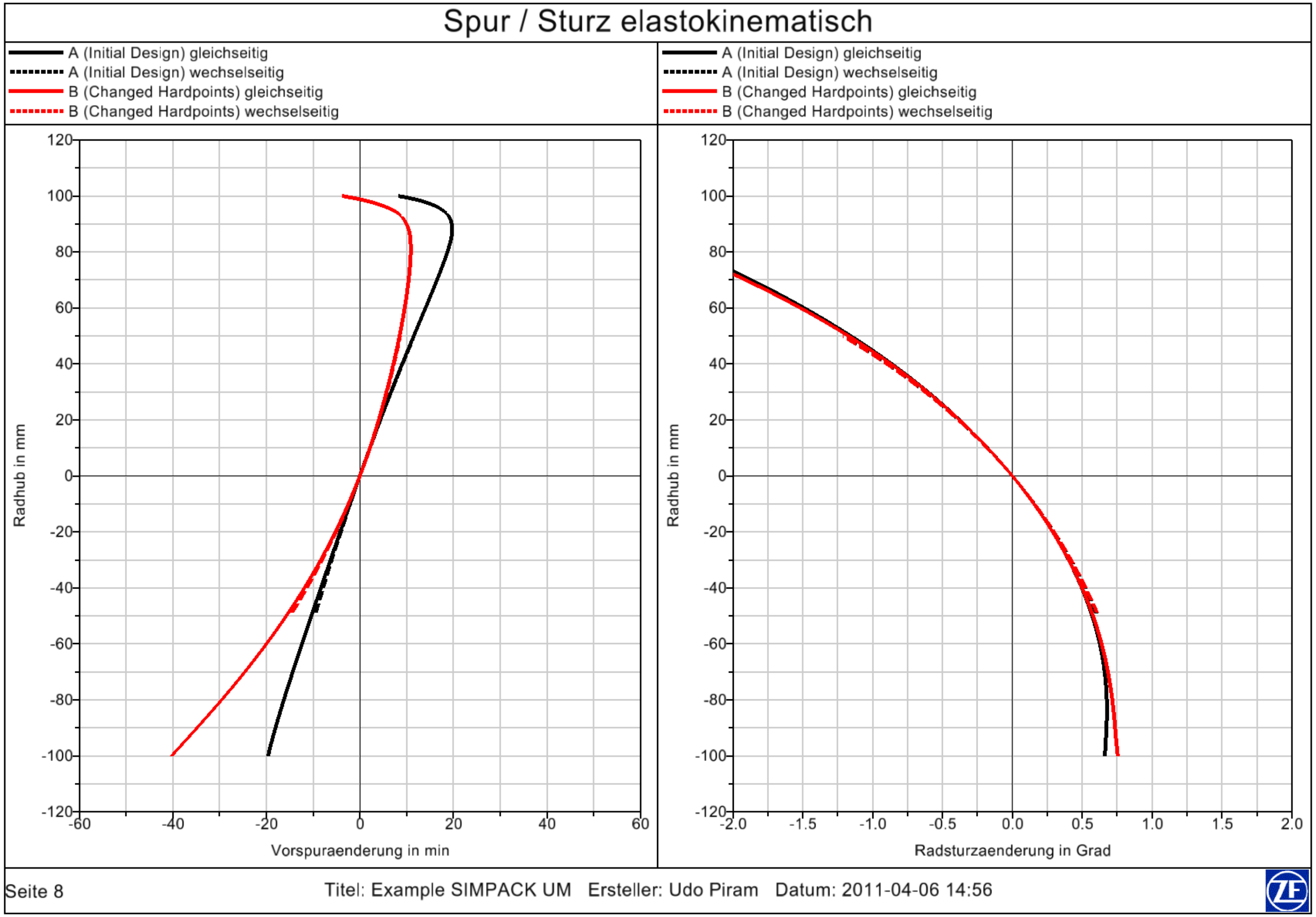
# Automated Postprocessing

## Scalar Axle Parameters (Example Numbers)

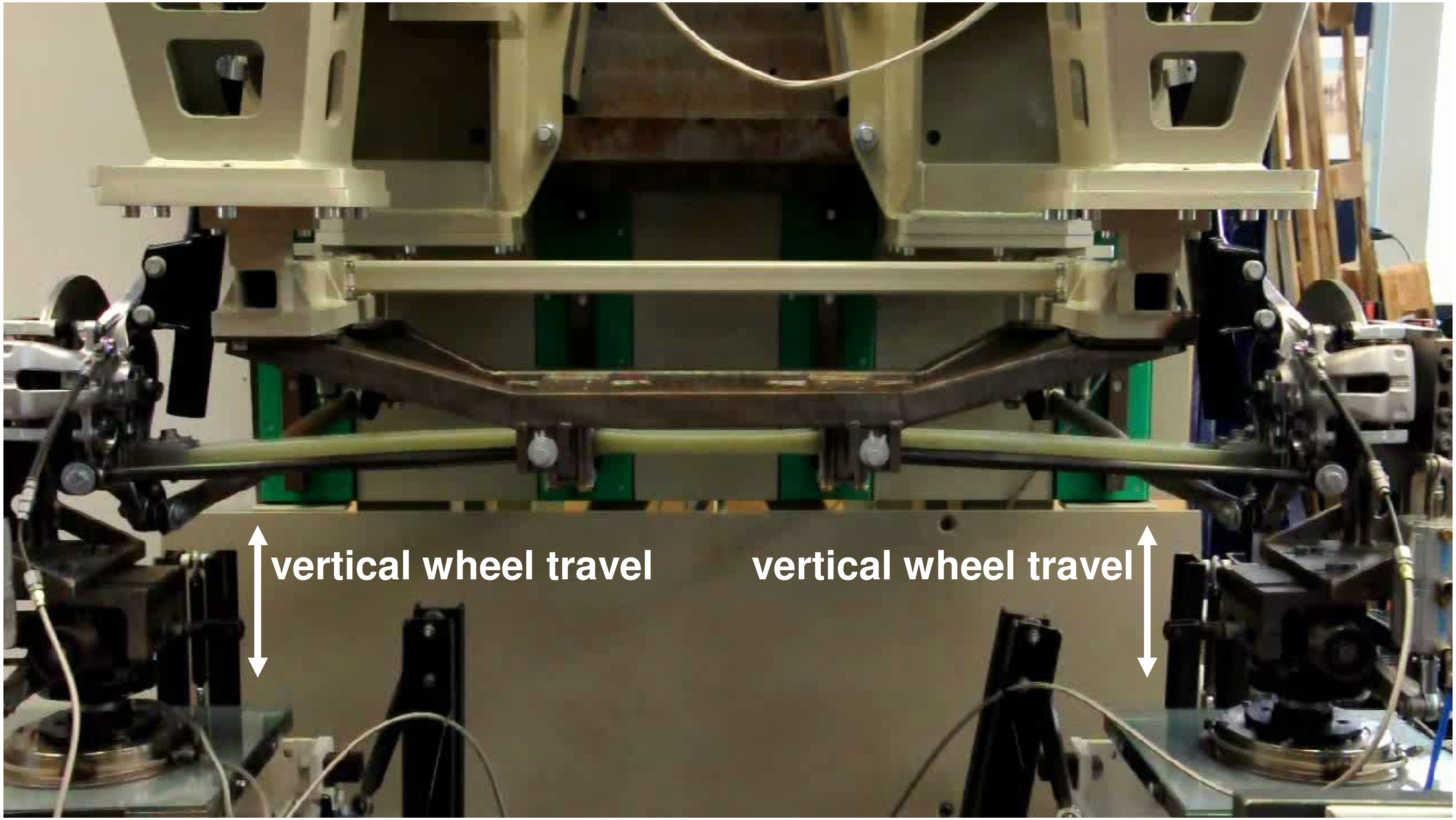


# Automated Postprocessing

## Example Plot

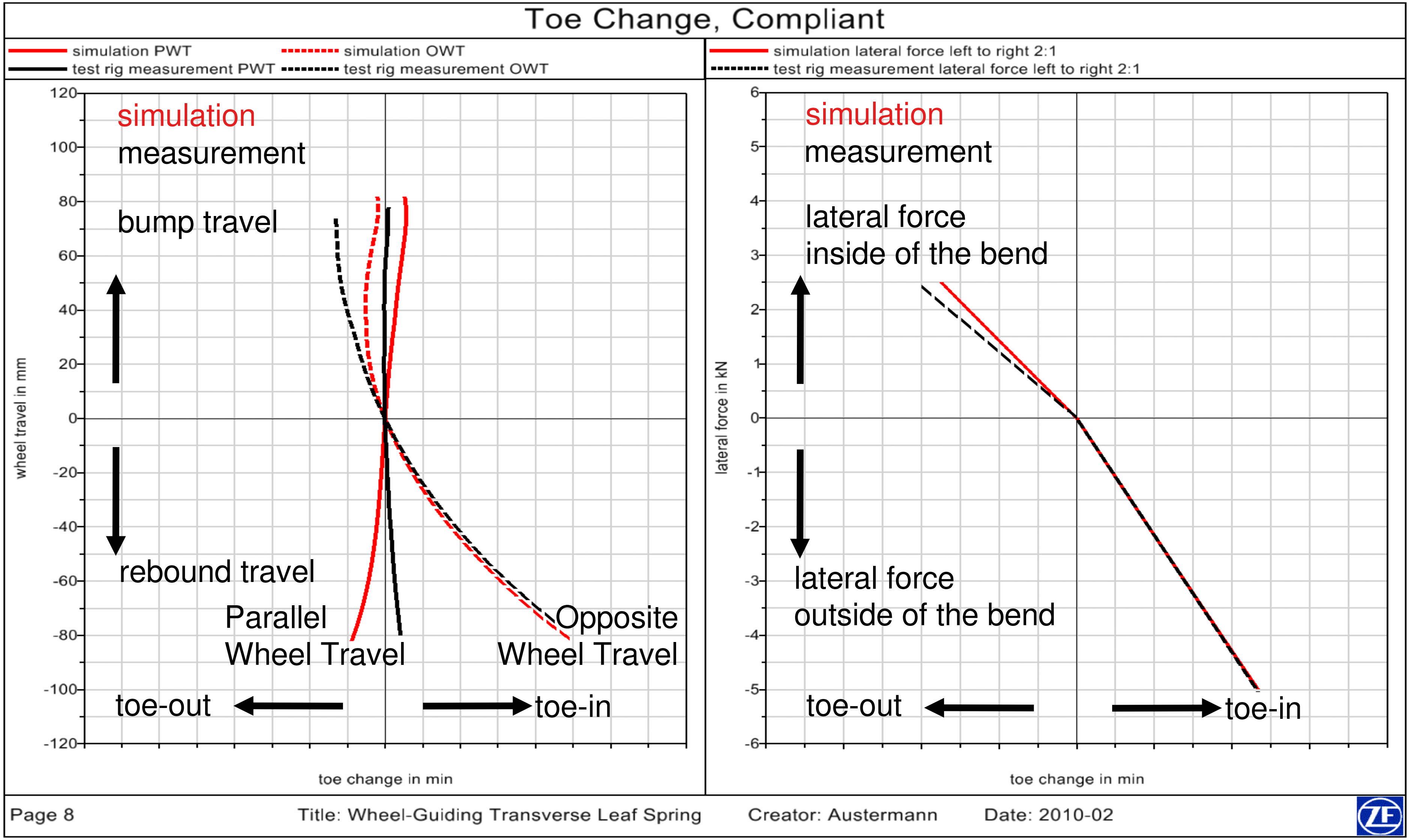


# Automated Postprocessing
## Wheel-Guiding Transverse Leaf Spring



# Automated Postprocessing

## Correlation with K&C test bench



# Summary

- ➔ SIMPACK models of elastic axle components made of composite material using Simbeam elements
  - ➔ Automated creation of beam models using scripts
  - ☺ Approach was successfully used in several axle design projects
  - ☹ Manual generation of FBI and SID-Files (FEMBS)

- ➔ Automated Postprocessing of K&C-Simulation
  - ➔ Standard Simulation Maneuver
  - ☺ Scripting Language of SIMPACK to generate plots and key figures