Material Models For Thermoplastics In LS-DYNA®
From Deformation To Failure

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15th German LS-DYNA® USERS CONFERENCE 2018

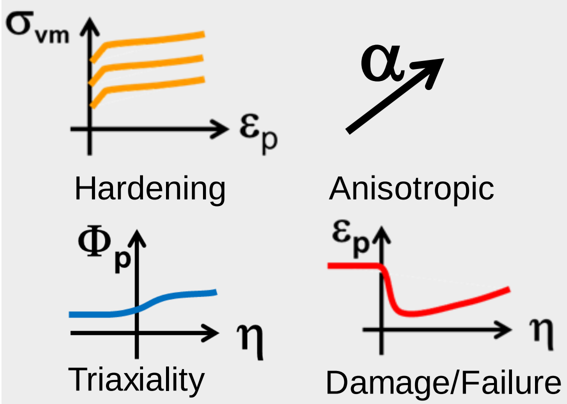
15-17th October 2018, Bamberg

AGENDA

- introduction 4a
- motivation
- material models
- material characterization
- intermediate conclusion
- outlook IMPETUS™ - dynamic impact tensile testing

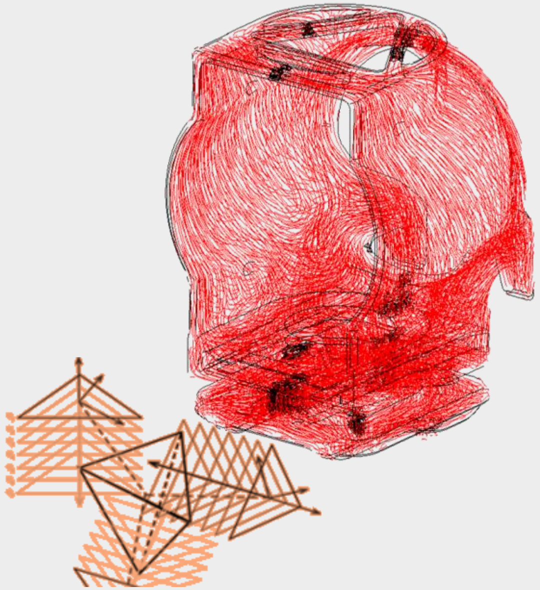
intelligent reliable solutions for plastics, composites, metals, foams, ...

VALIMAT



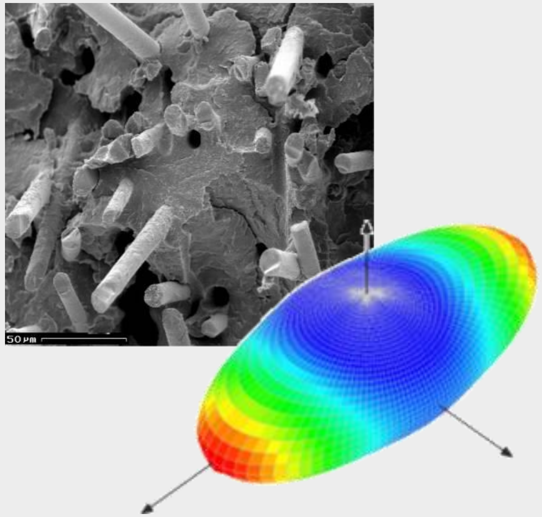
from test to validated material cards

FIBERMAP



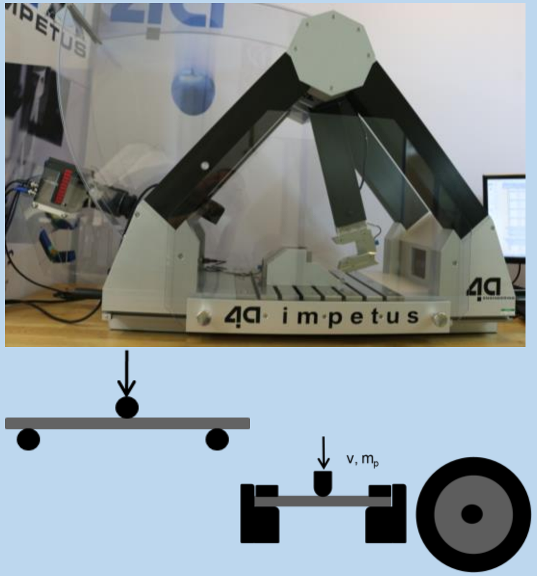
individual mapping process information

MICROMEC



3D anisotropic material cards

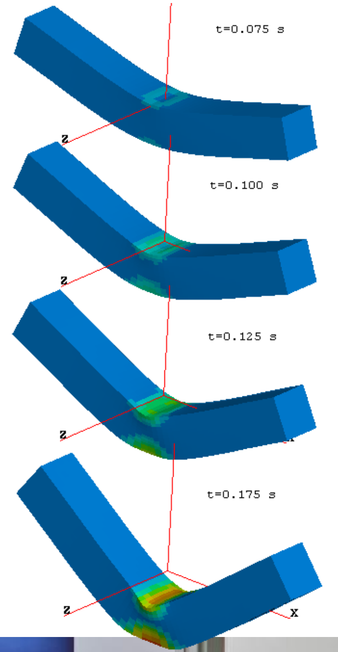
IMPETUS



efficient dynamic testing

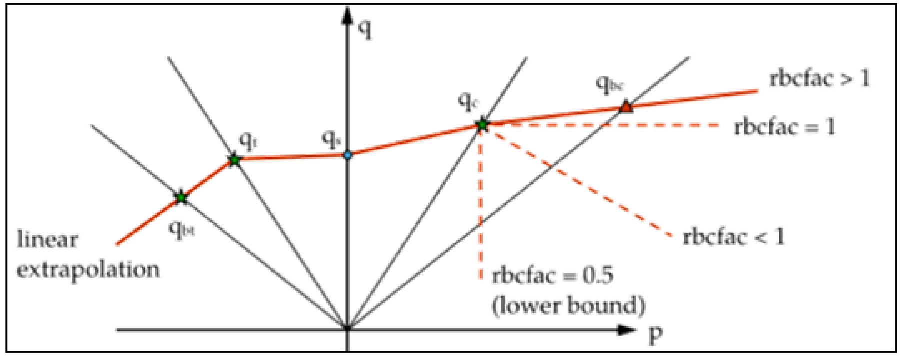
material characterization - services

- efficient high-dynamic testing
- dynamic material behaviour
- plastics, foams, composites, …
- **validated material cards ready to use for your crash-simulation**



Commonly Used Material Models For Plastics

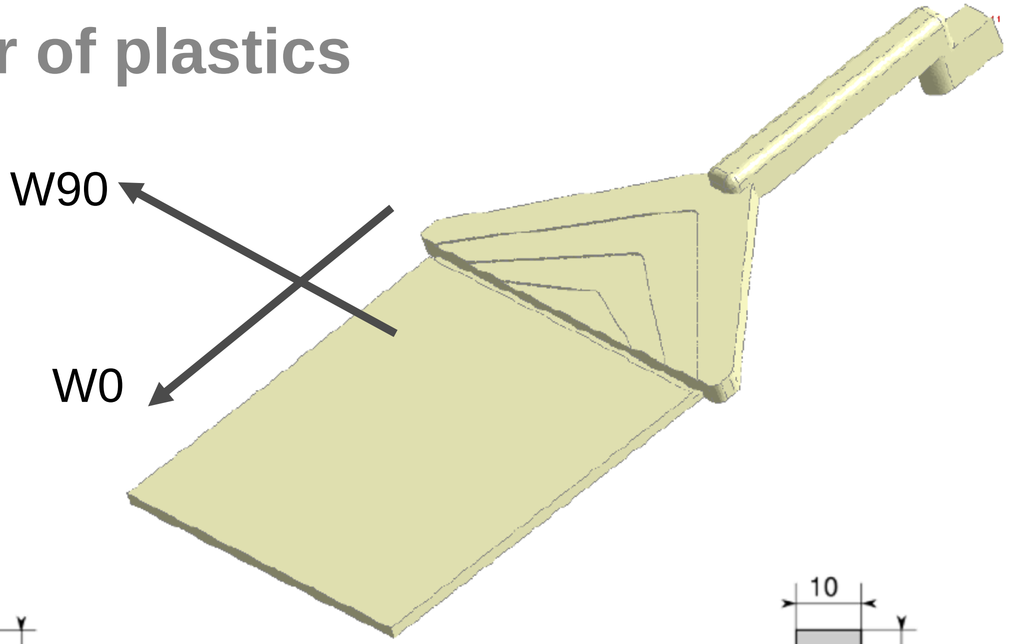
- ***MAT_024 - The workhorse**
  *(*MAT_081,*MAT_089,*MAT_123, …)*
- ***MAT_124 - The hidden**
- ***MAT_187 - The plastic expert**



[LSDYNA MANUAL]

Material model	Yield surface	Visco-elasticity	Visco-plasticity	comp./tension asymmetry	plastic Poisson's ratio
*MAT_024	von Mises	✘	✓	✘	0.5
*MAT_124	2x von Mises	✓ Pronyseries	✓	✓	0.5
*MAT_187	General over triaxiality	✓ Table	✓	✓	✓

Characterizing mechanical deformation behavior of plastics



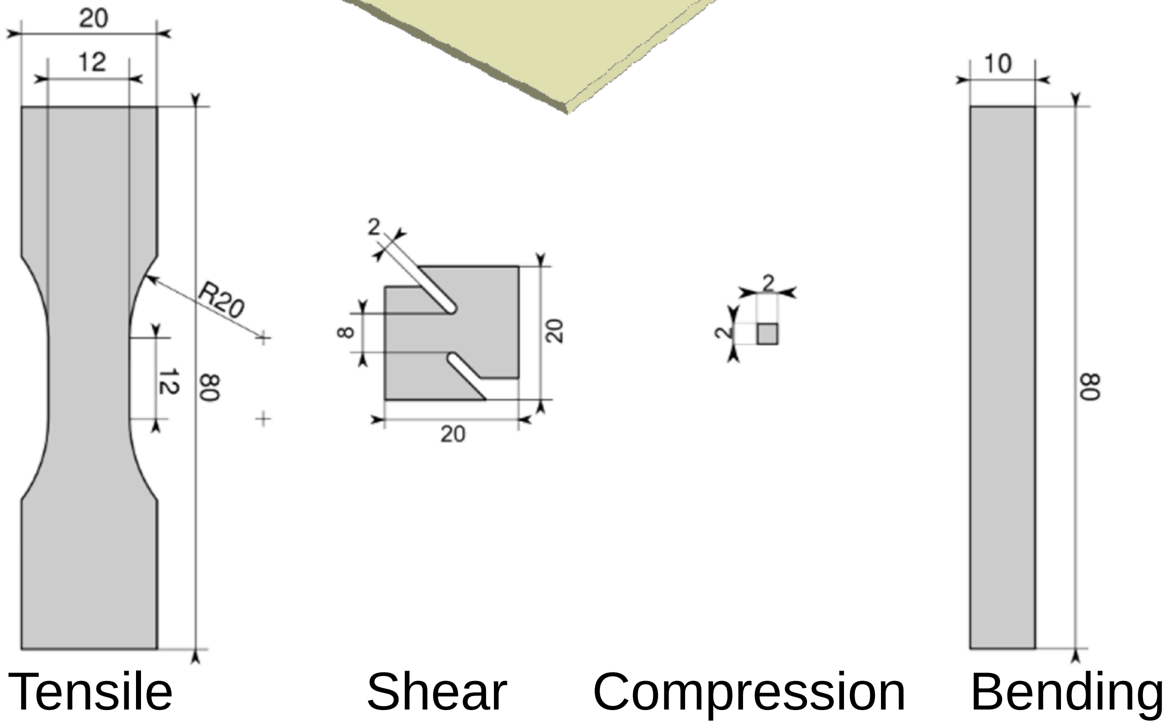
Ph.D-thesis of F. Kunkel

- Injection molded PP T16 (Hostacom XBR 169G)
- specimen milled out in W0 and W90
- classical static and dynamic tests with **DIC**

The Old School **-** material characterization as described in the material model

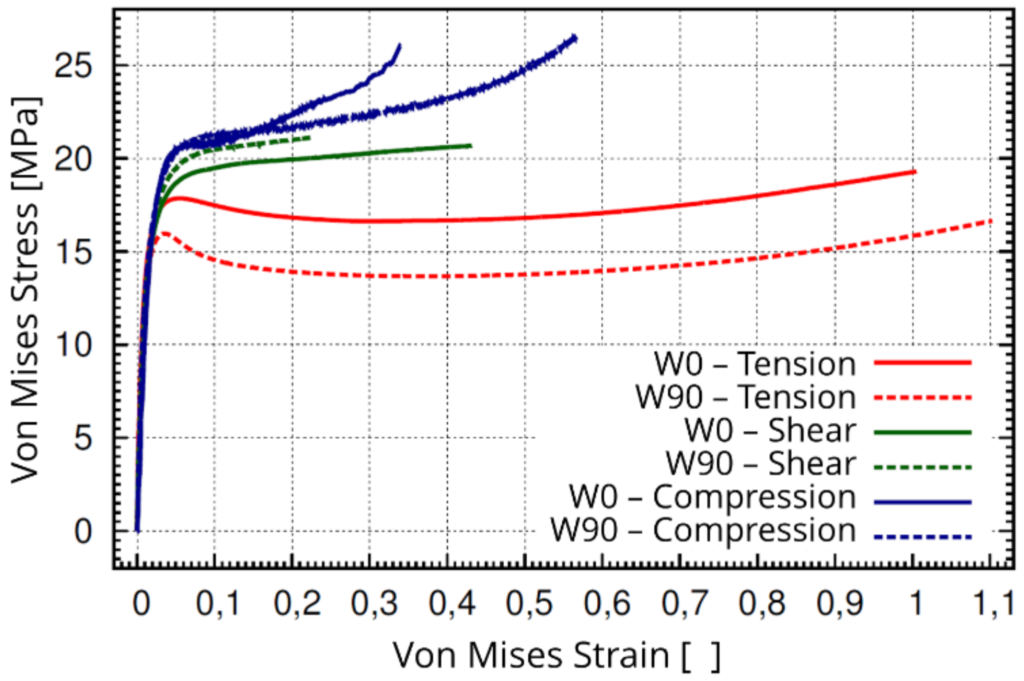
- Tensile
- Shear
- Compression

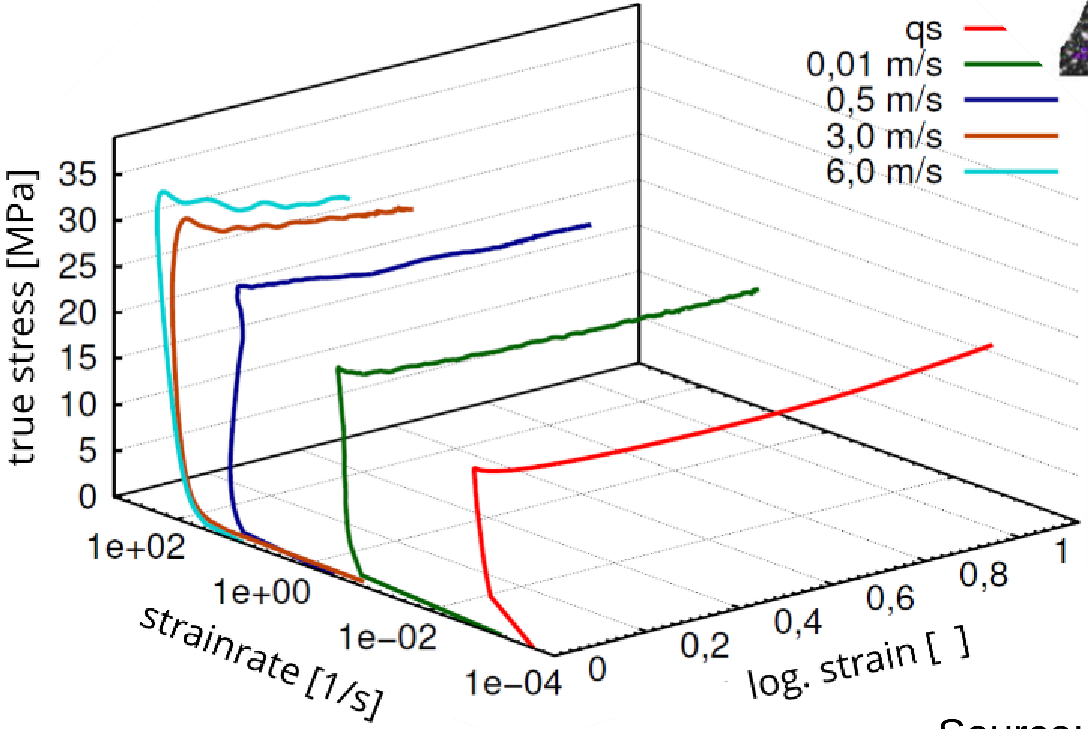
comparison IMPETUS™ bending

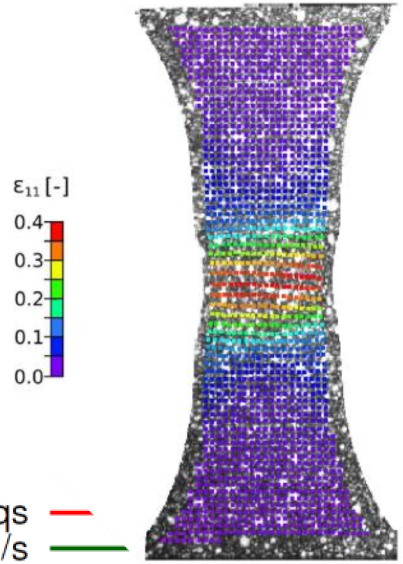


Characterizing mechanical deformation behavior of plastics

The Old School - material characterization as described in the material model





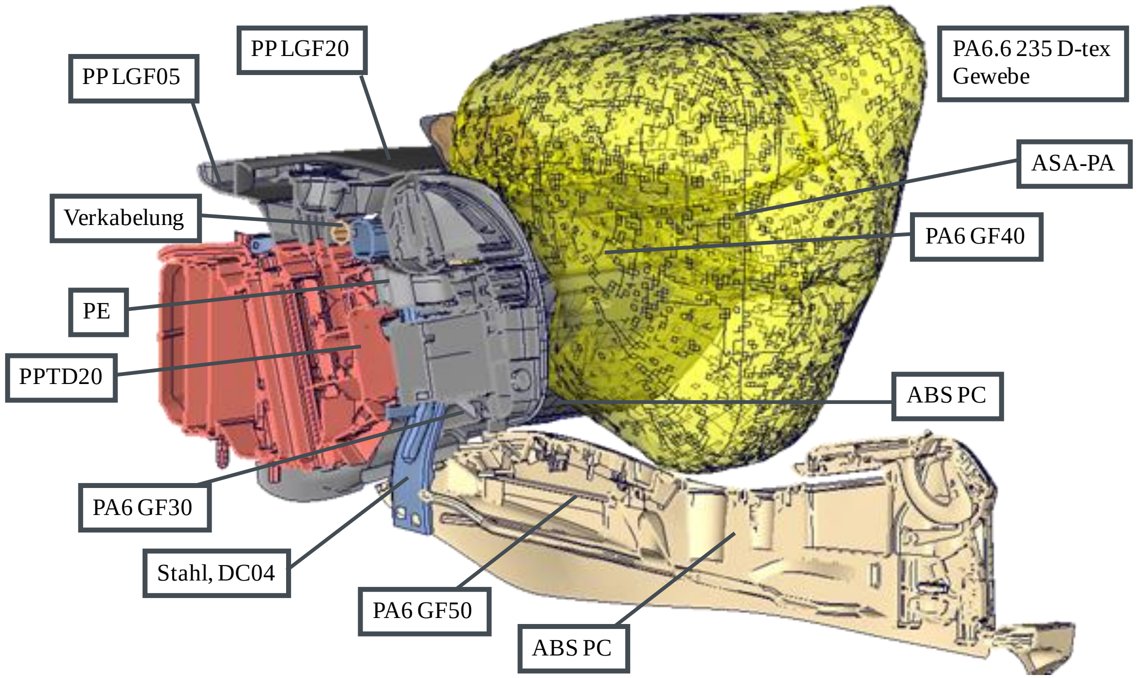


→ no constant
loading (triaxiality)
and strain rate

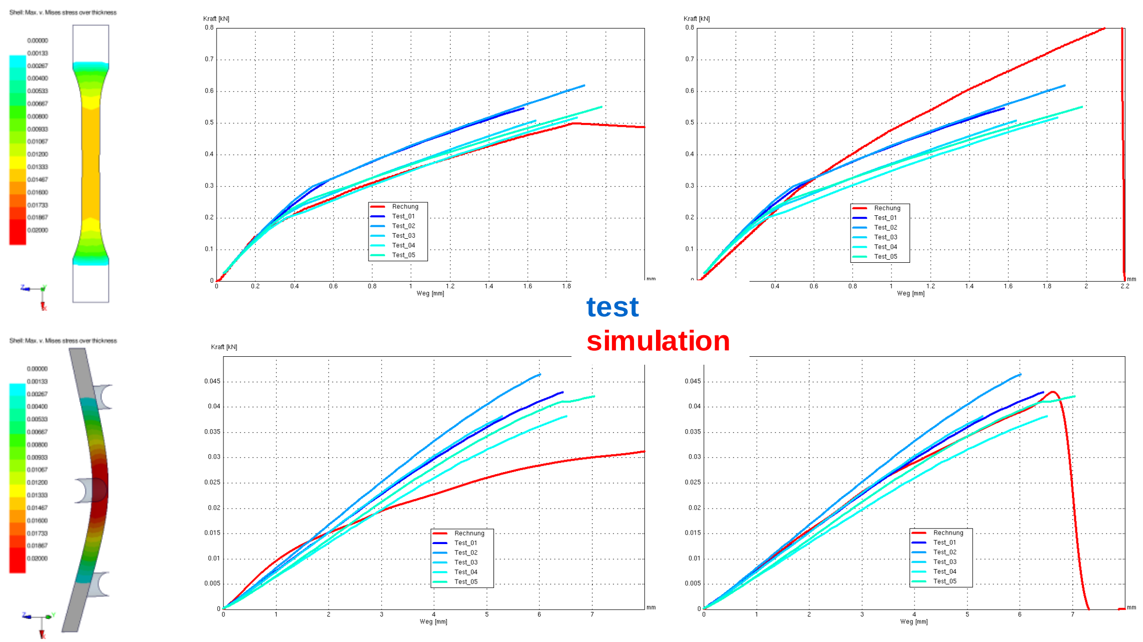
Source: F. Kunkel

2004 - motivation

material variety



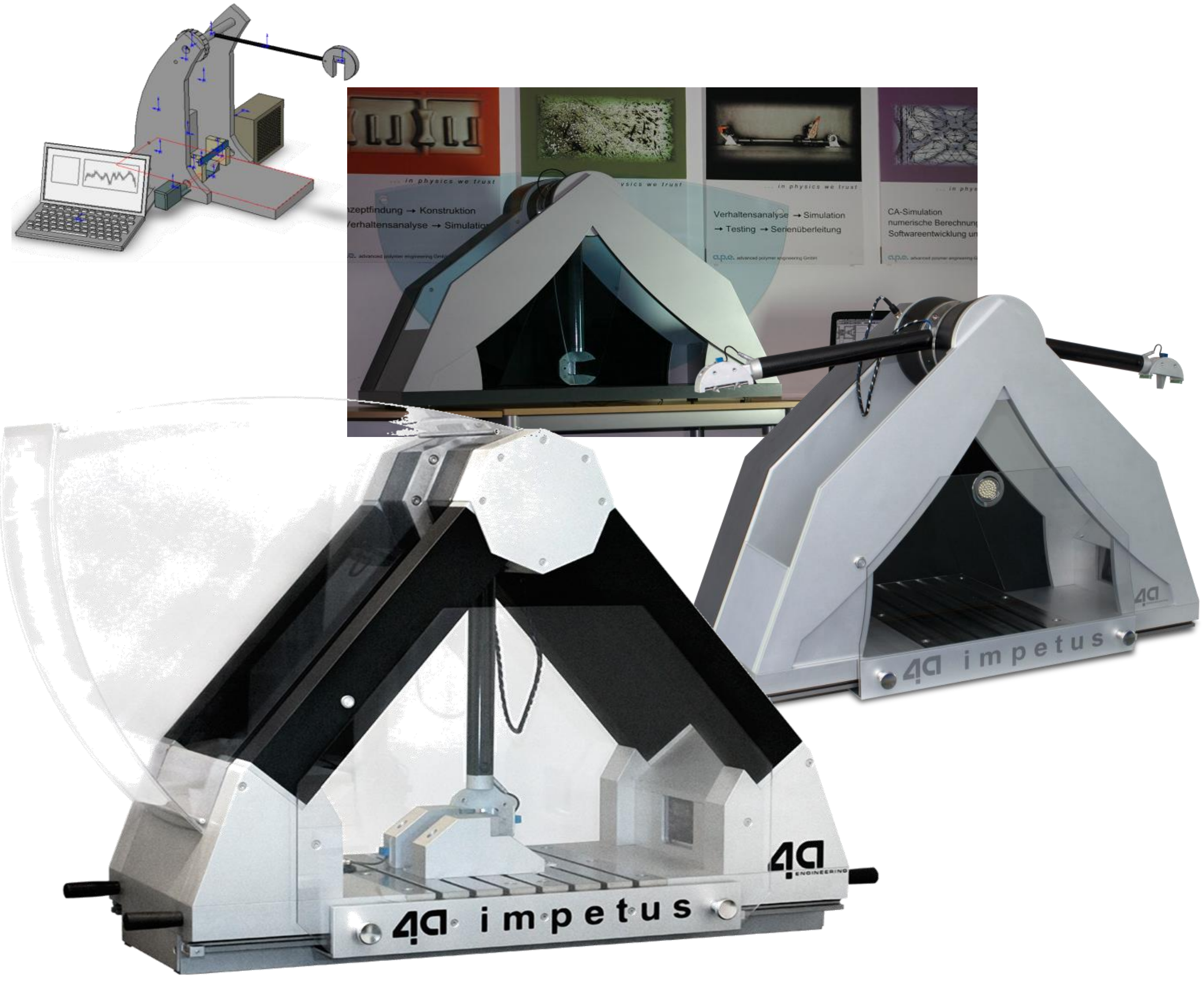
bending load case



Source: R. Luijkx - *Kunststoffmaterialien in der Interieur Funktionsauslegung bei Audi AG,* 4a Technologietag 2010

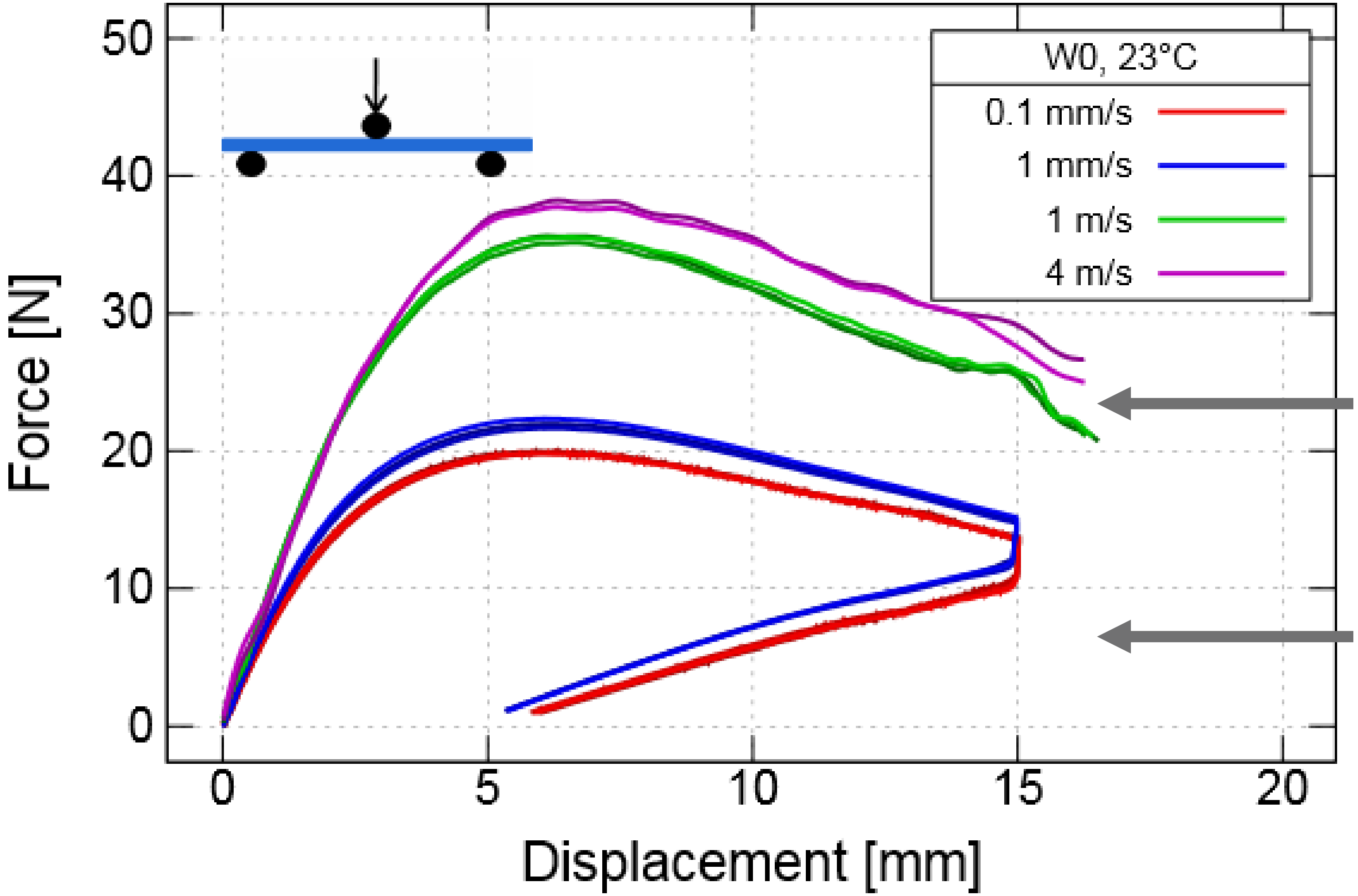
efficient dynamic testing

- desktop testing device
- instrumented high speed testing
  - acceleration → force / displacement
- impact velocity 0.5 – 4.5 m/s
- maximum energy 50 J



...

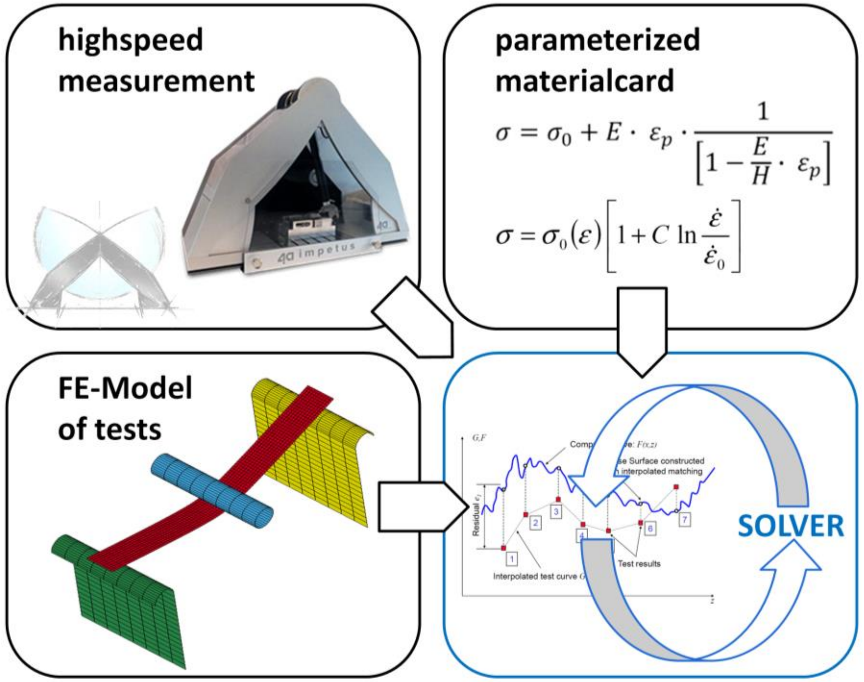
efficient dynamic testing

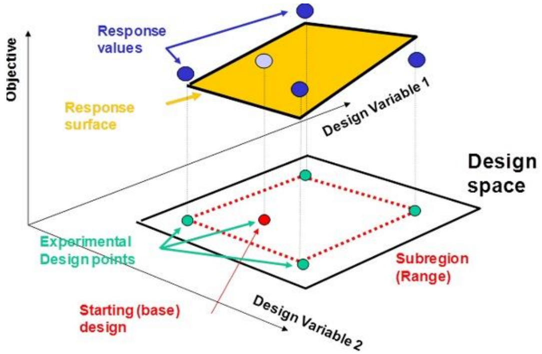


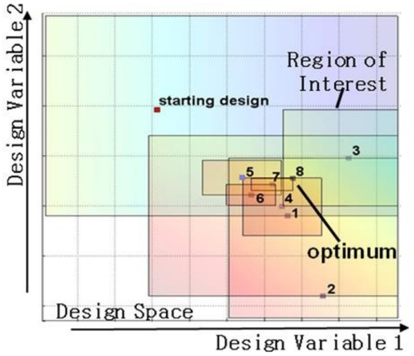
IMPETUS

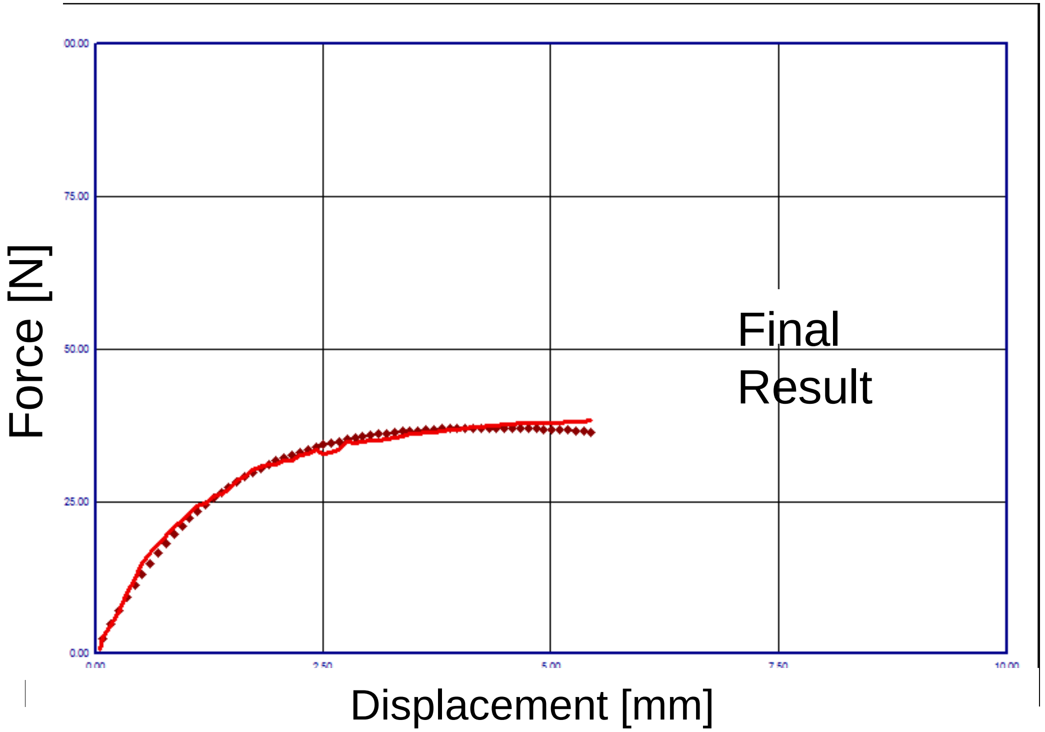
Universal static testing

reverse engineering



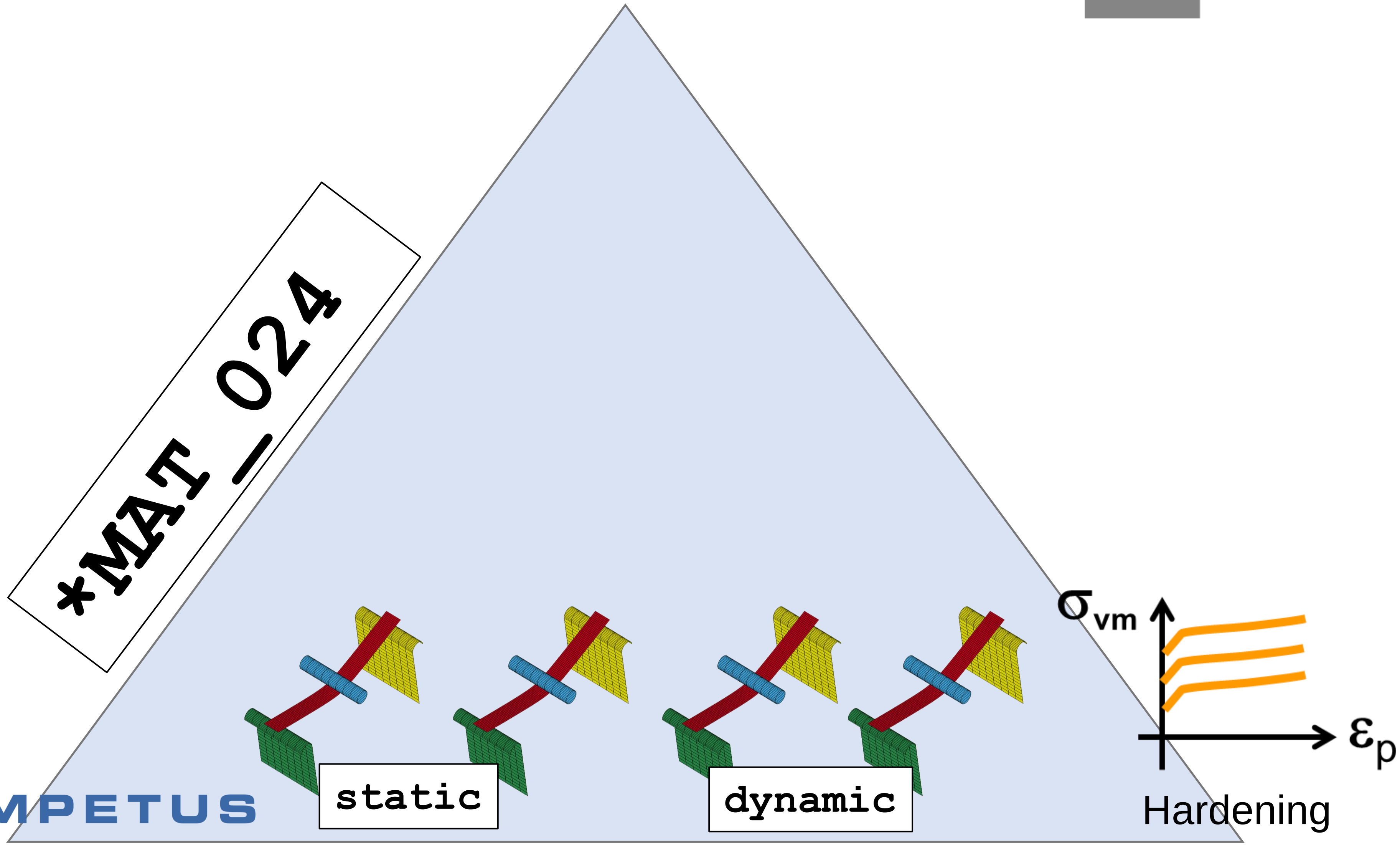




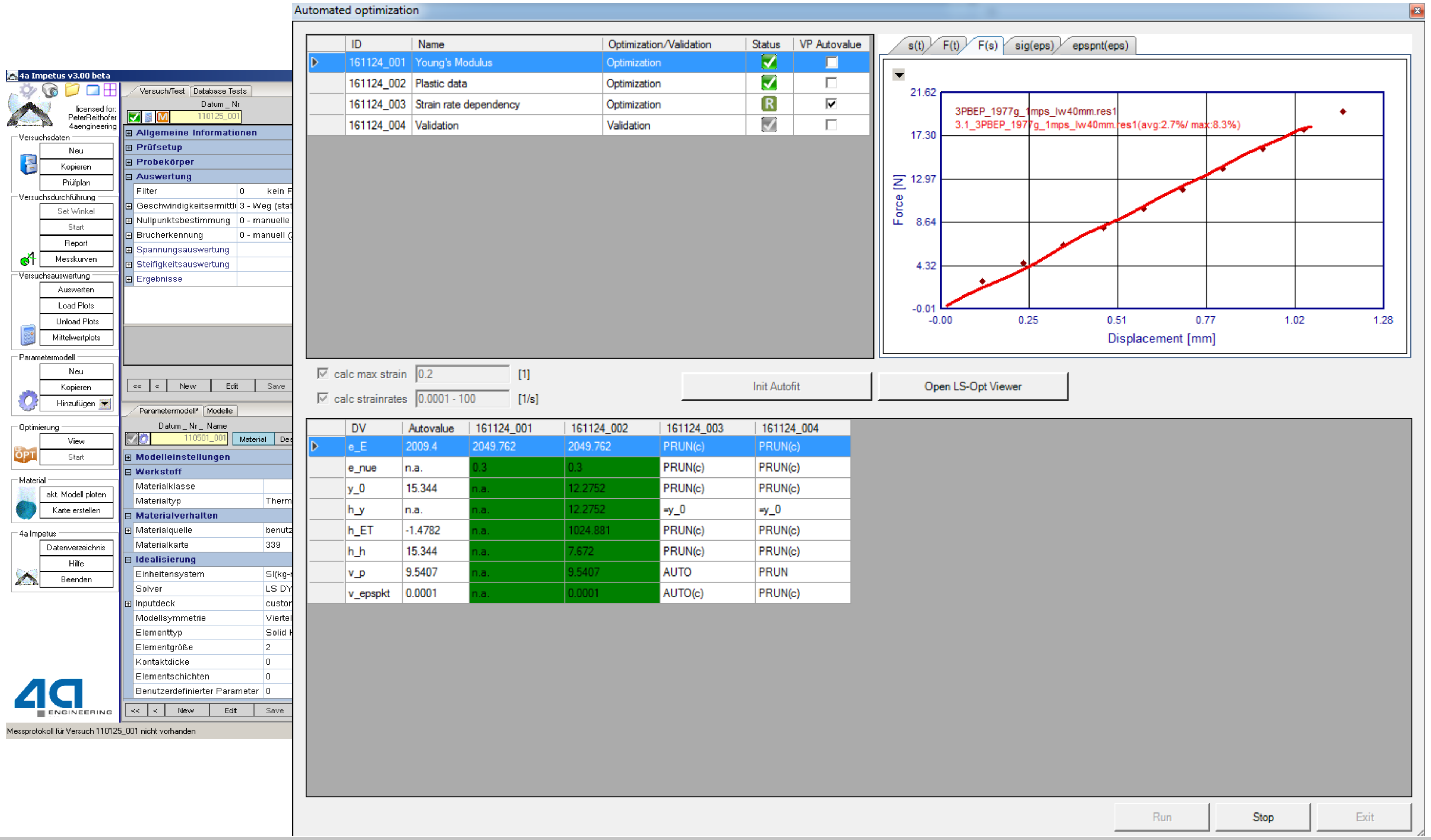


Source: Dynamic Material Characterization Using 4a impetus – PPS Conference 2015, Graz

from test to material card



from test to material card - Material Parameter Identification Process



Starting parameter

Young's Modulus

Yield

Strainrate

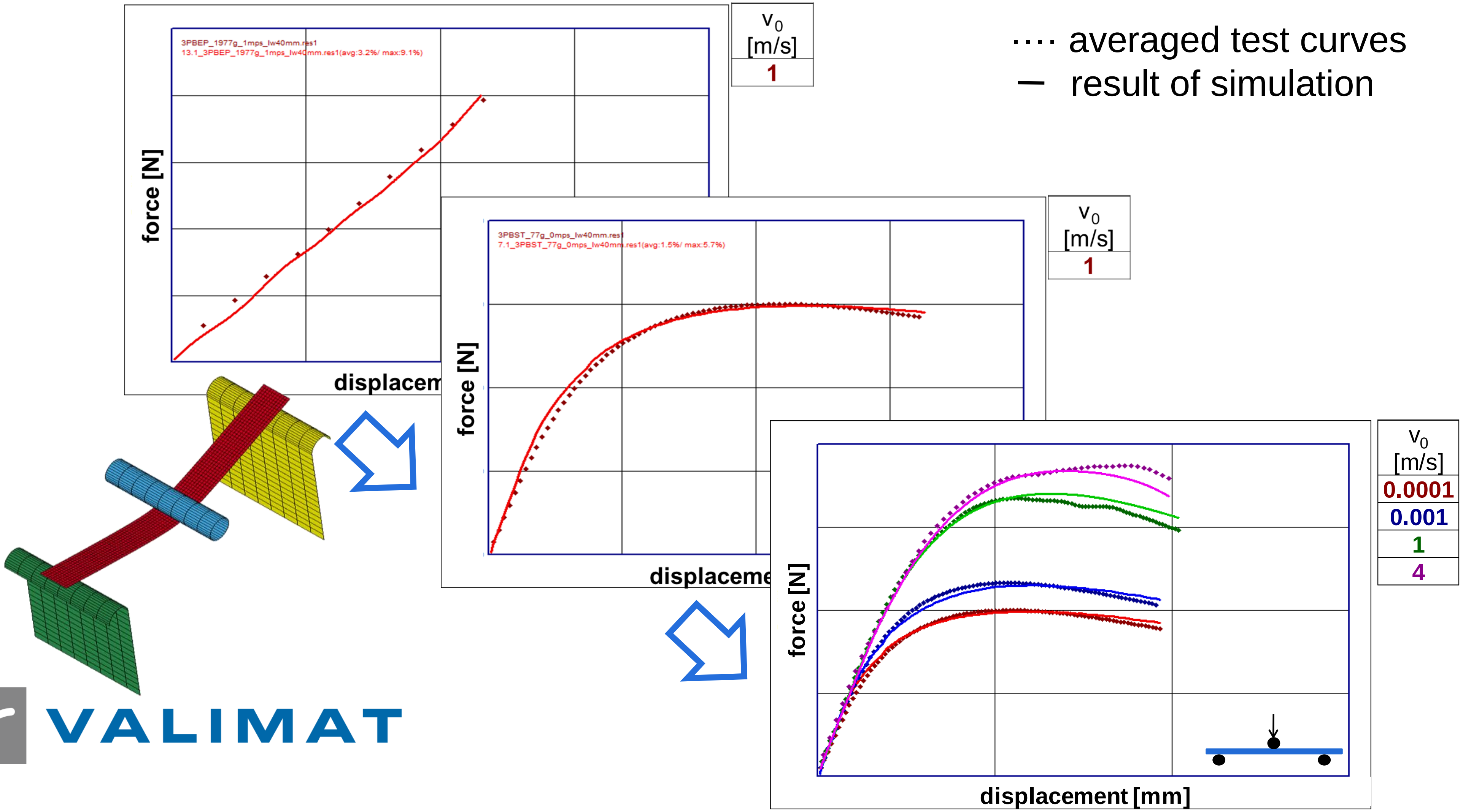
Asymmetry

Component

P. Reithofer, A. Fertschej, T. Schaffranek, pres_18131301_pr_afer_tsch_eng_DYNAFORUMBAMBERG

IN PHYSICS WE TRUST

from bending → *MAT_024



···· averaged test curves

— result of simulation

Starting parameter

↓

Young's Modulus

↓

Yield

↓

Strainrate

↓

Asymmetry

↓

Component

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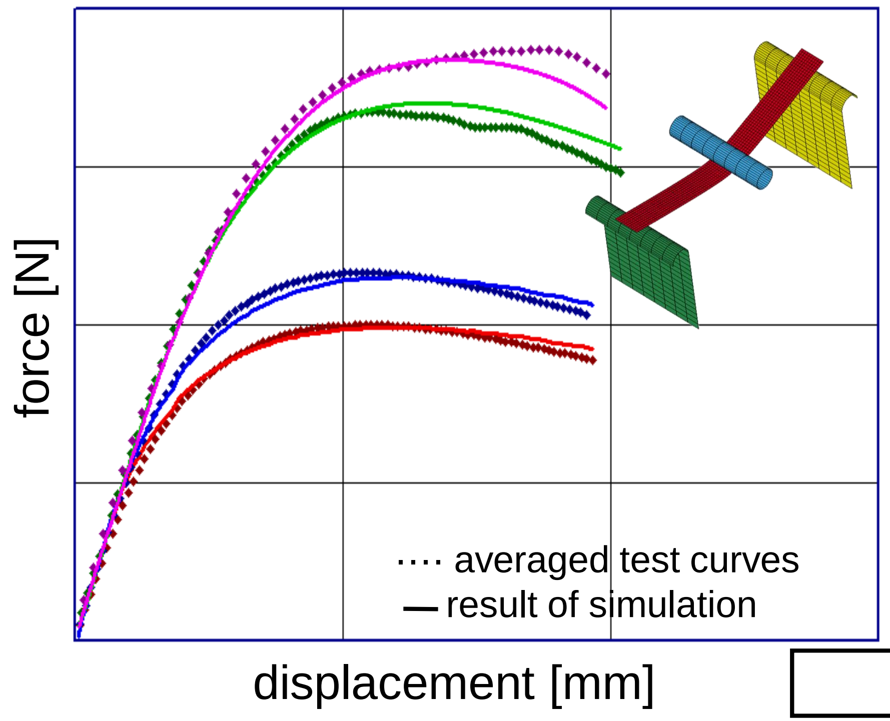
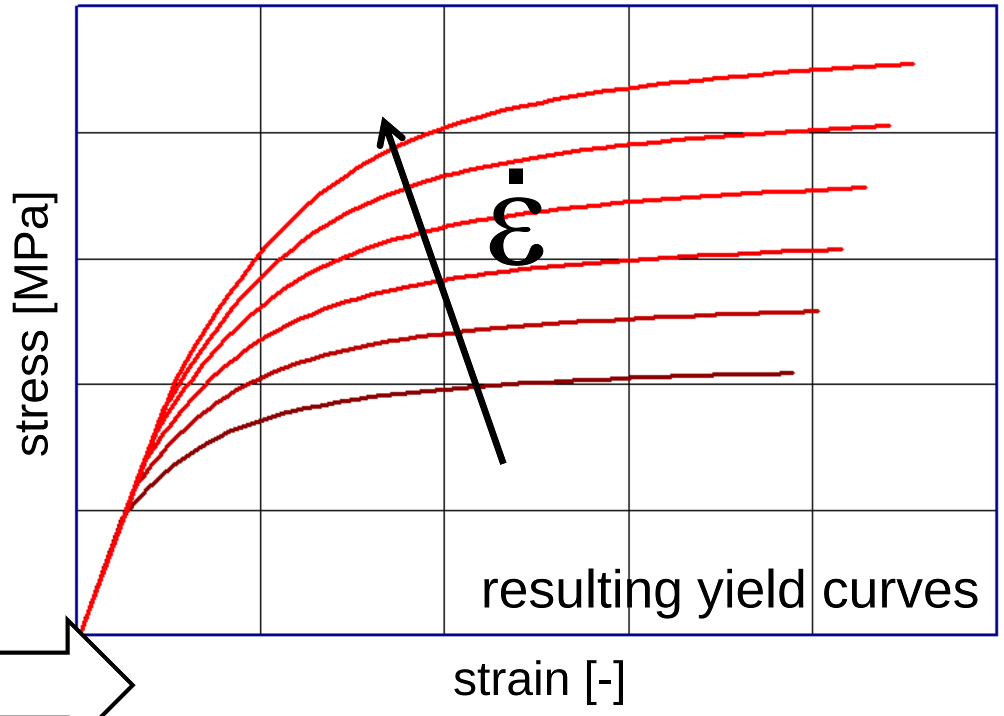
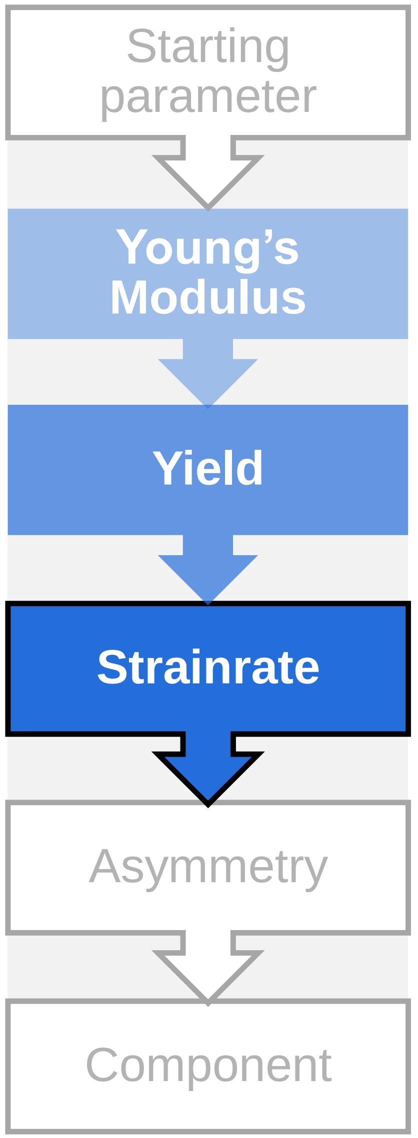
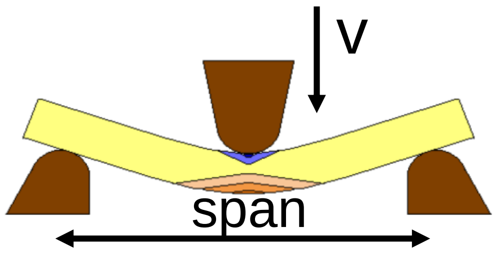
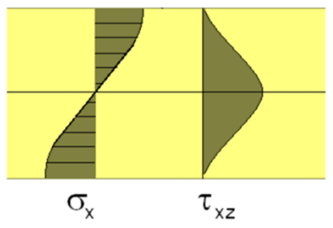


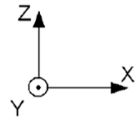




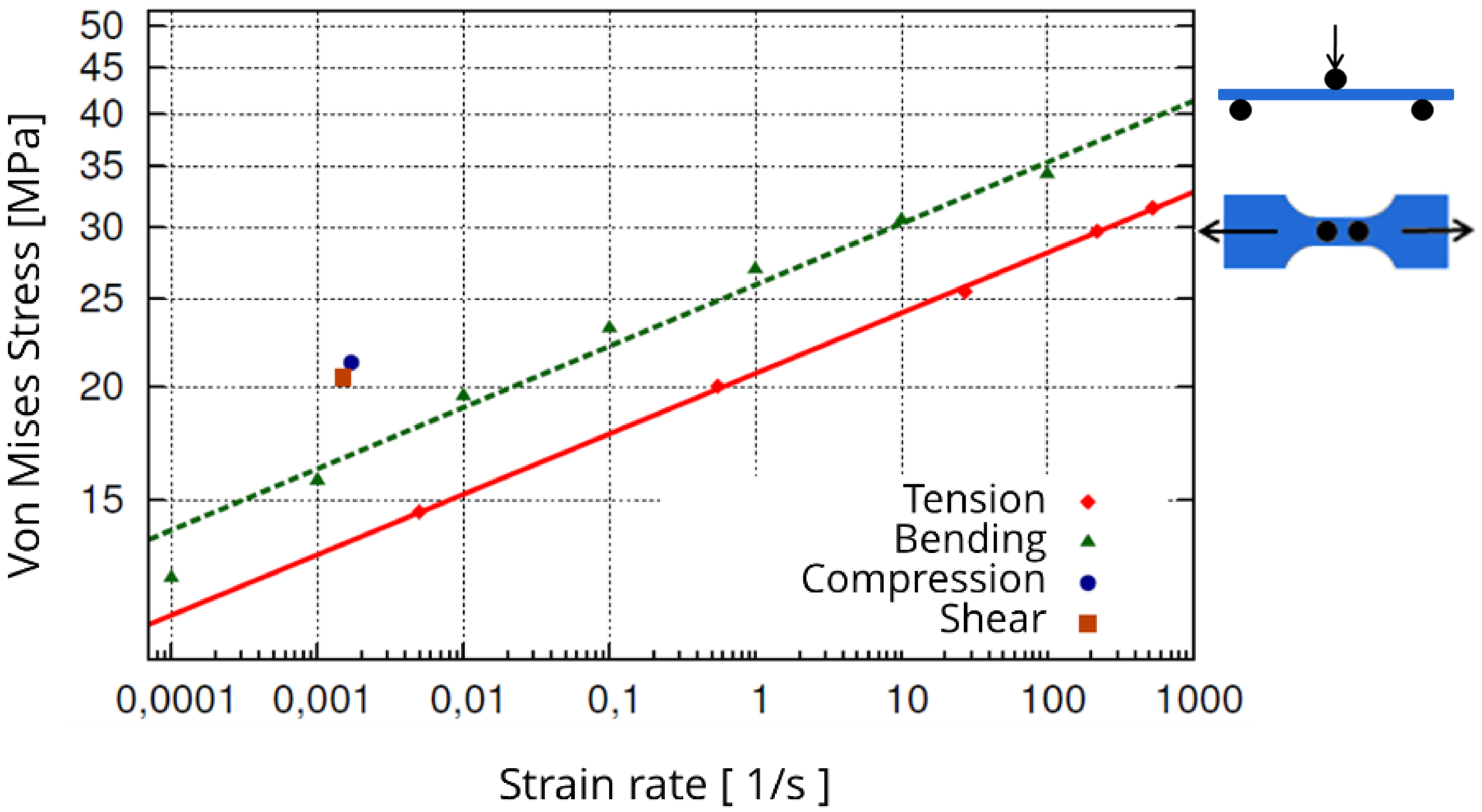
v [m/s]	span [mm]
0.0001	**40**
0.001	**40**
1	**40**
4	**40**

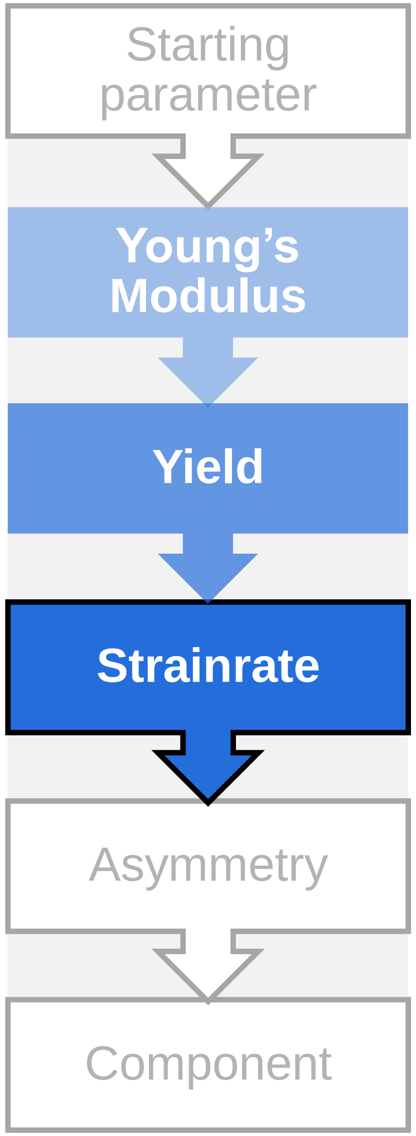




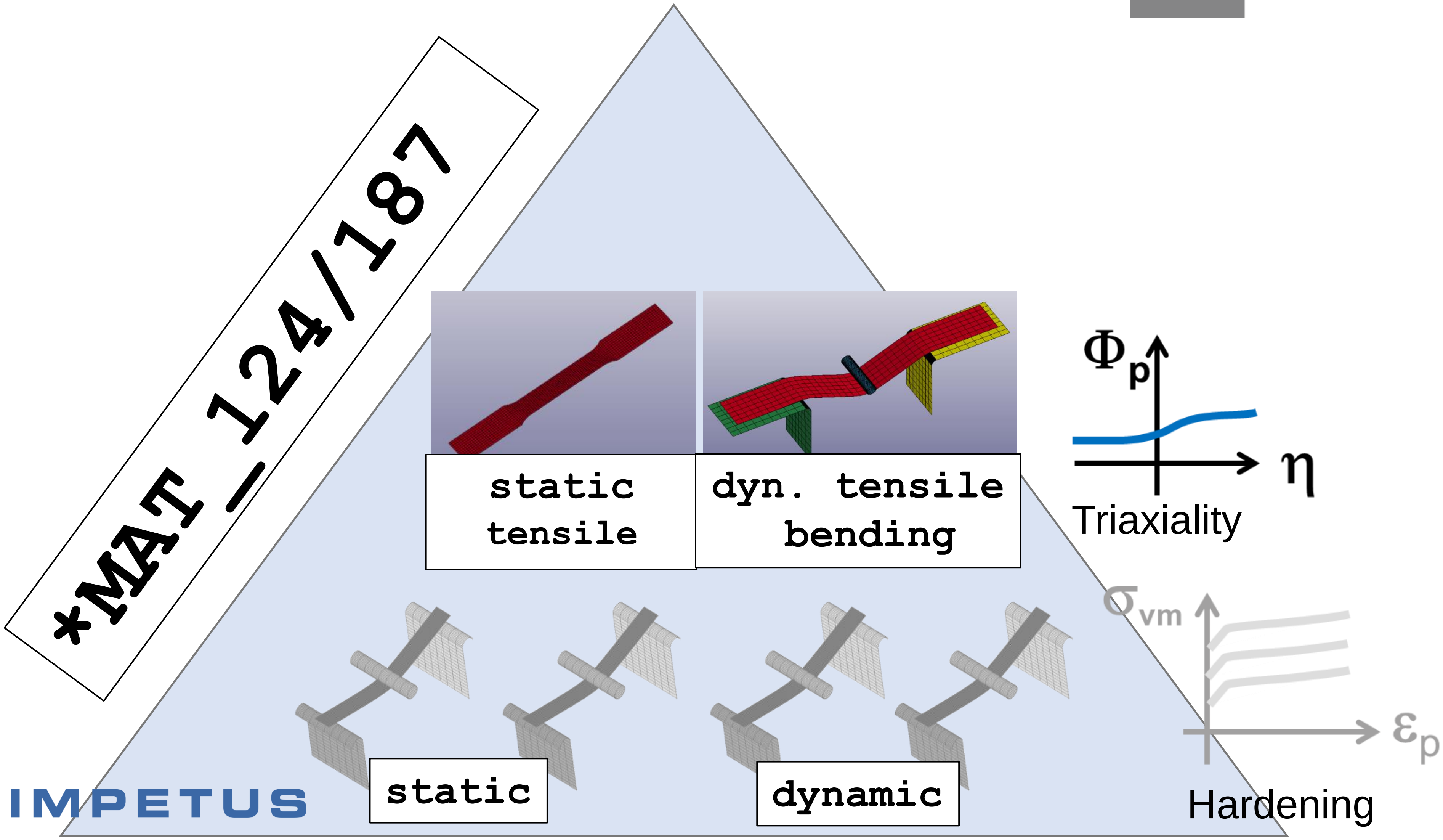


from bending → *MAT_024

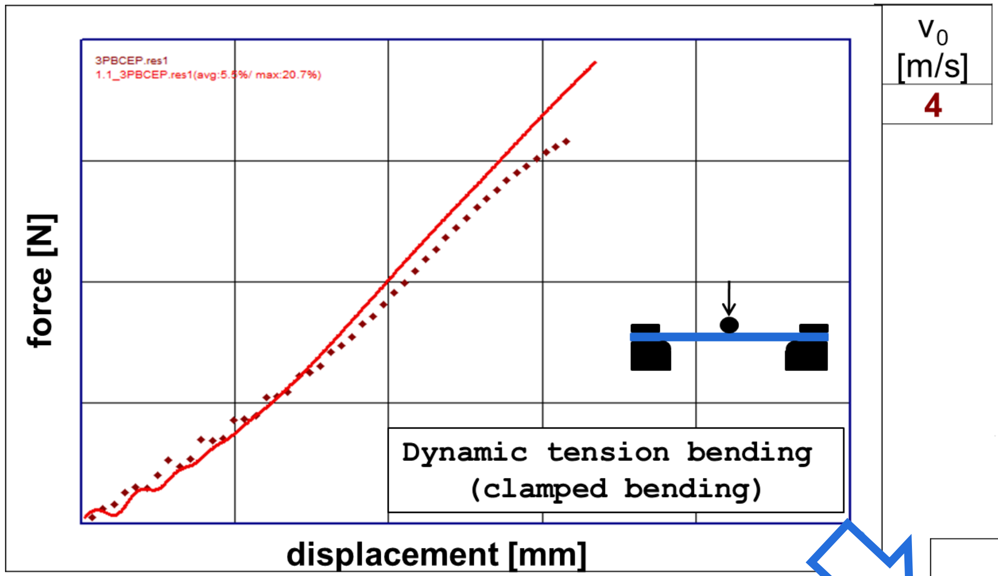


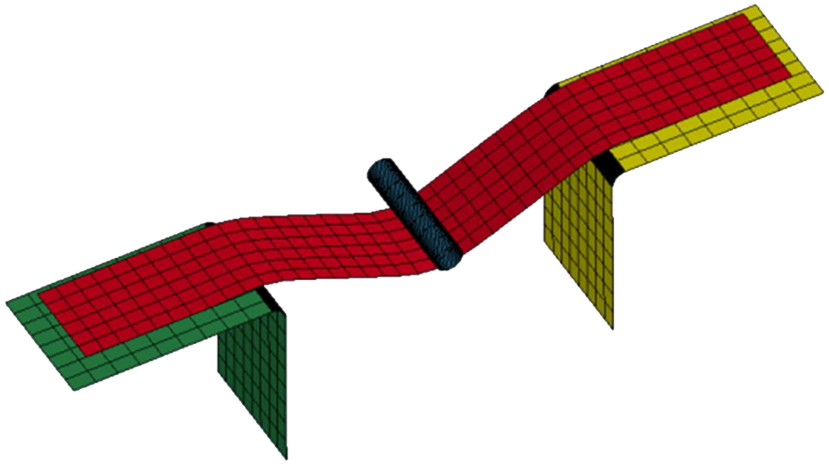


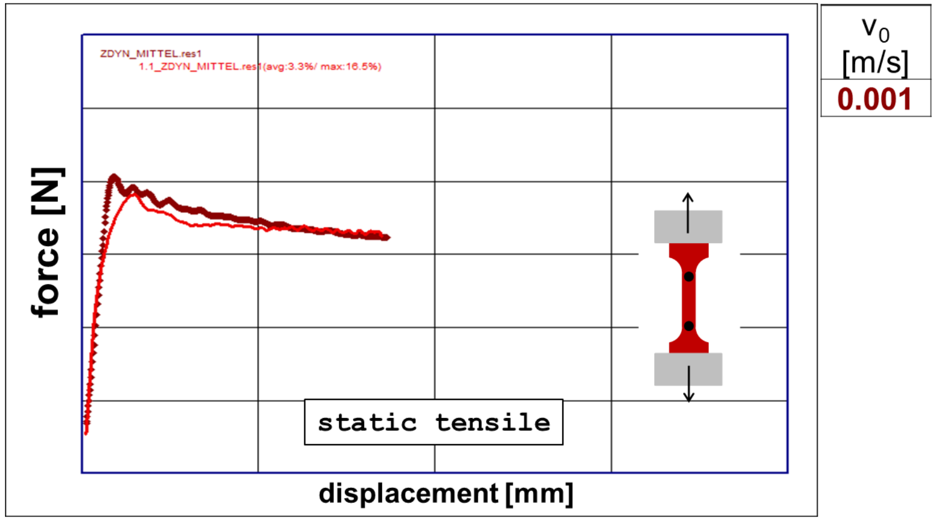
from test to material card



from tension bending → *MAT_124/187

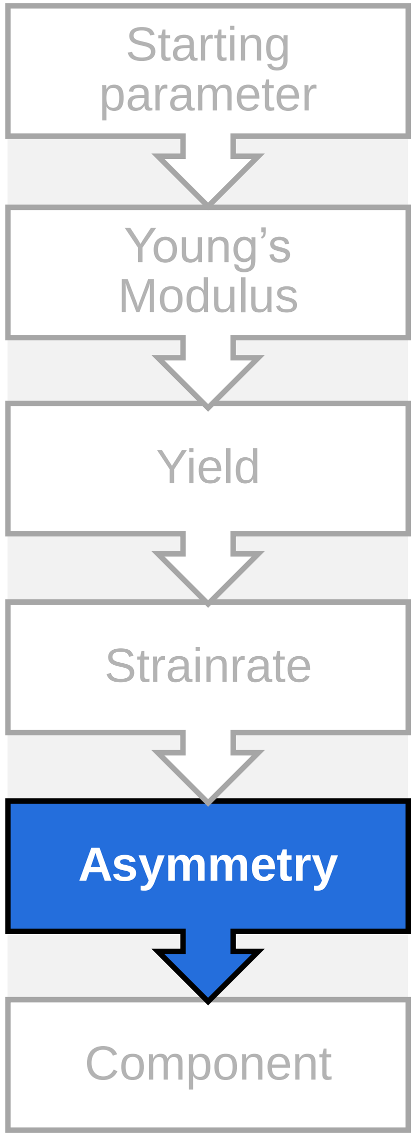






···· averaged test curves

– result of simulation



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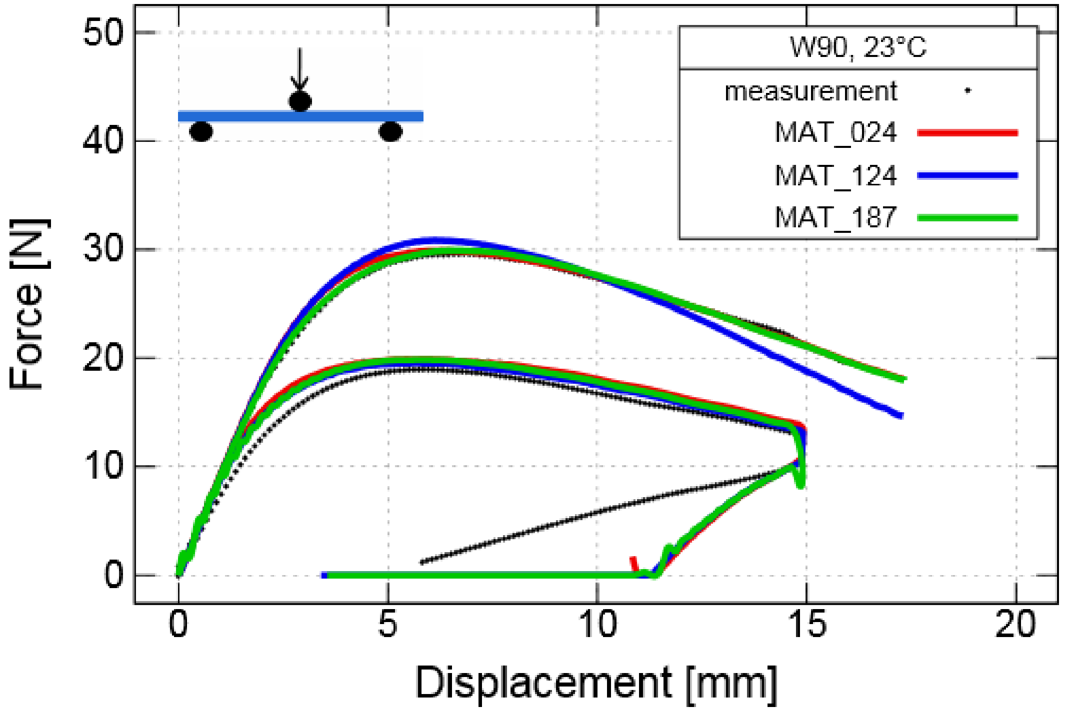
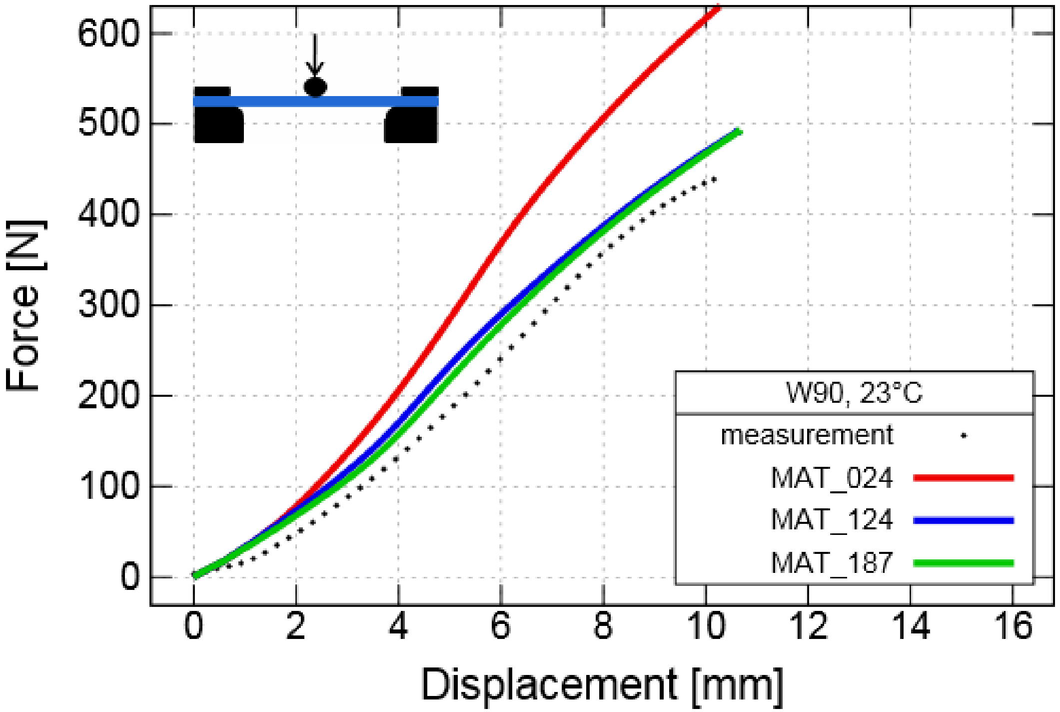
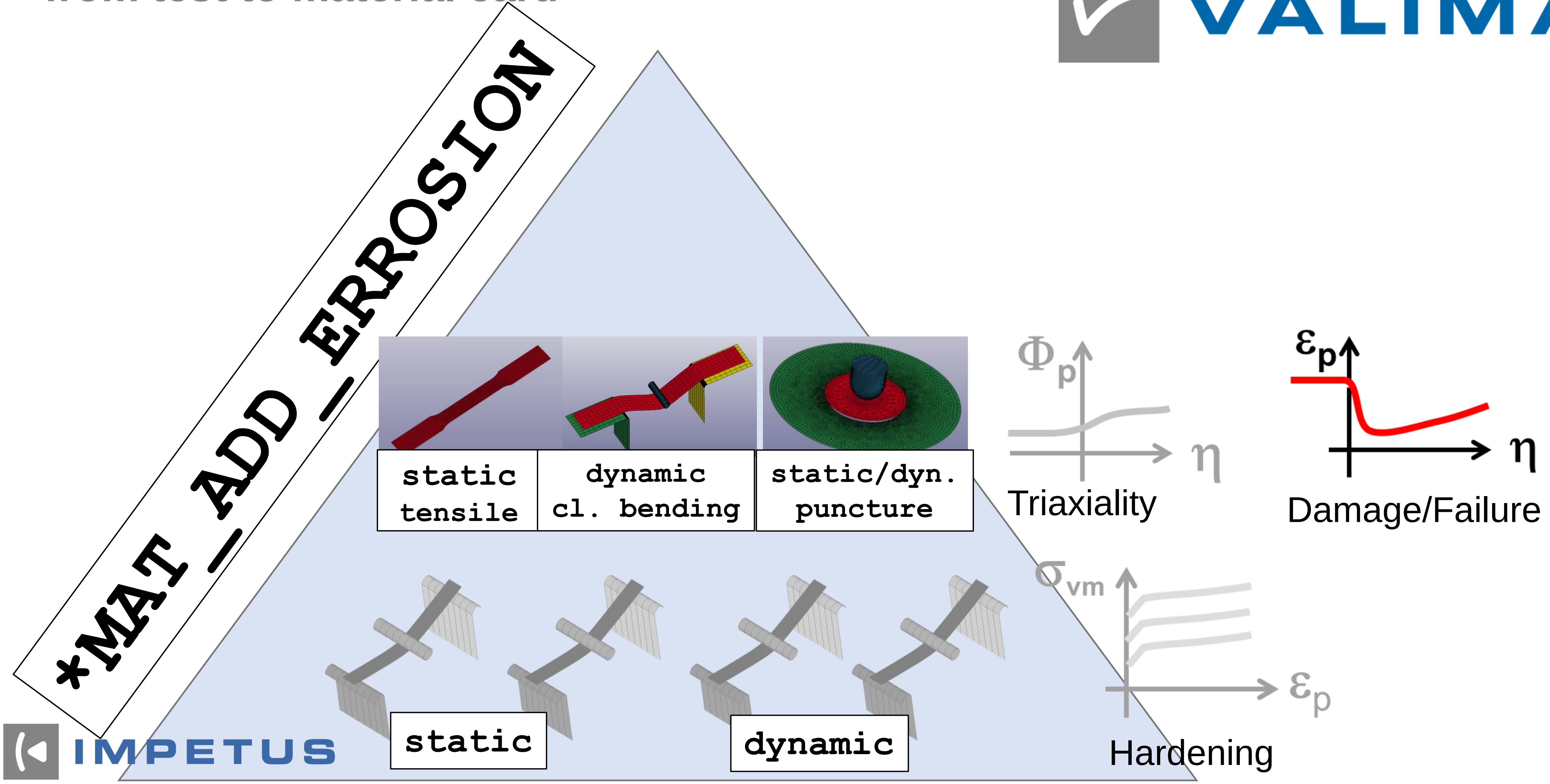
IN PHYSICS WE TRUST

comparison of results



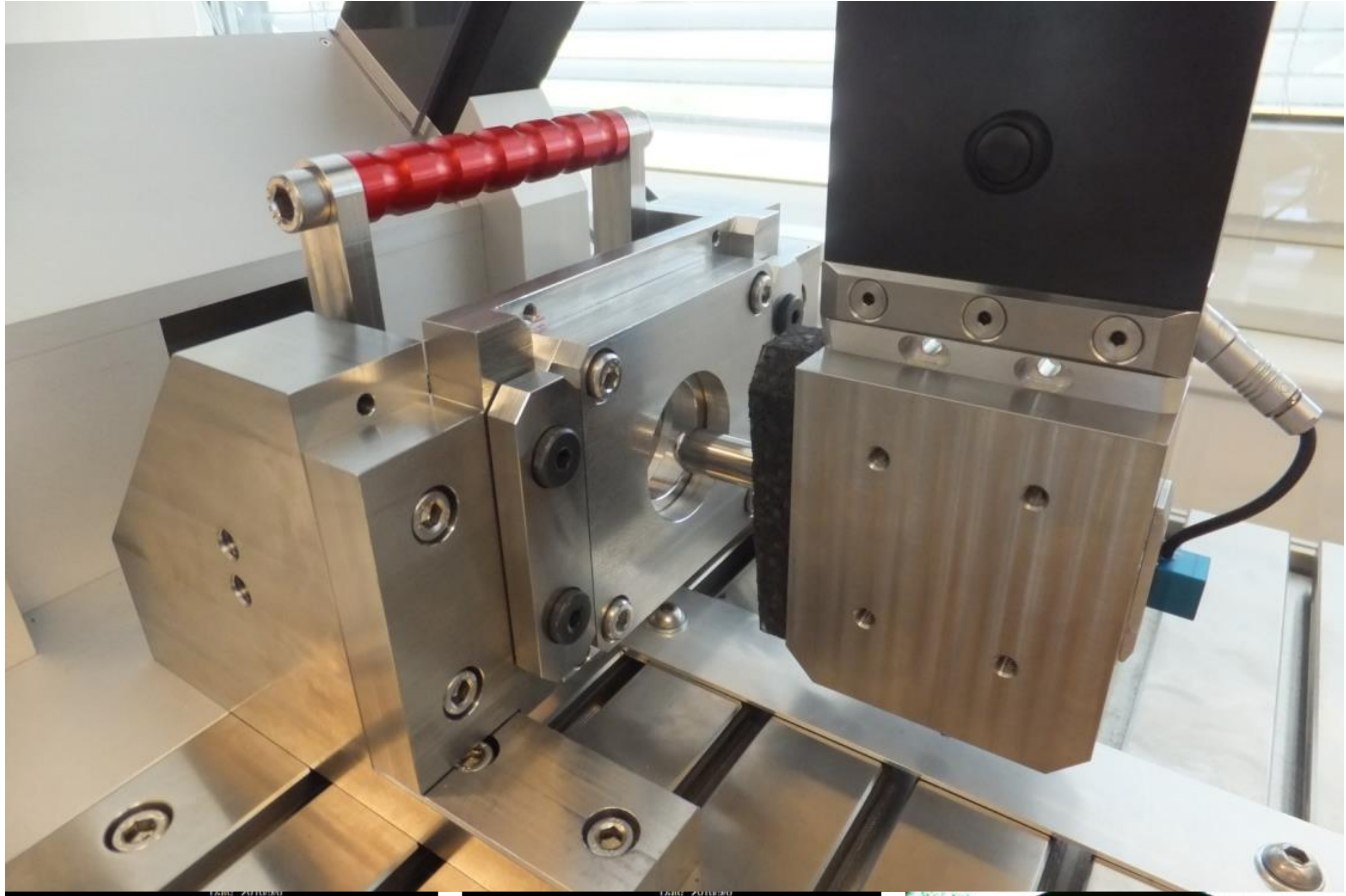


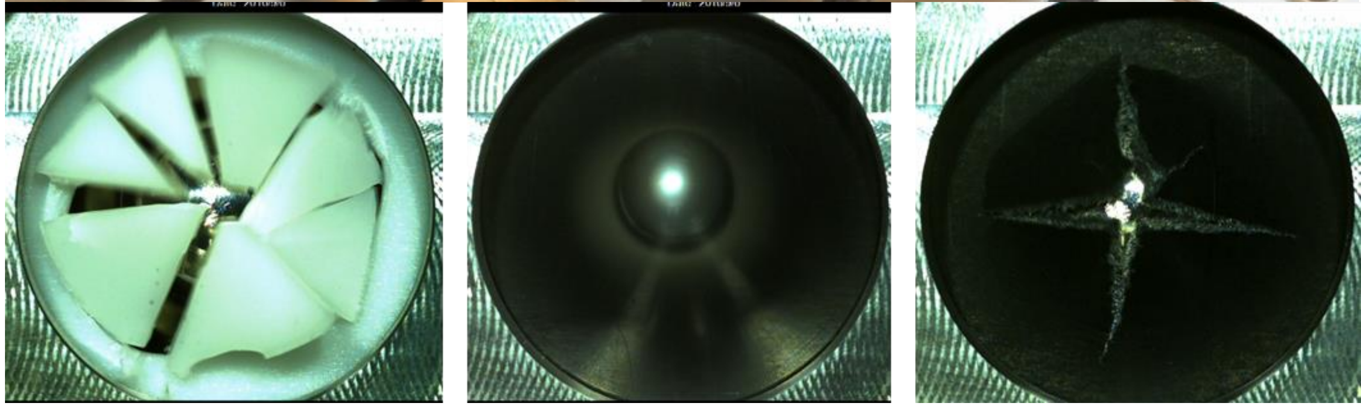
from test to material card



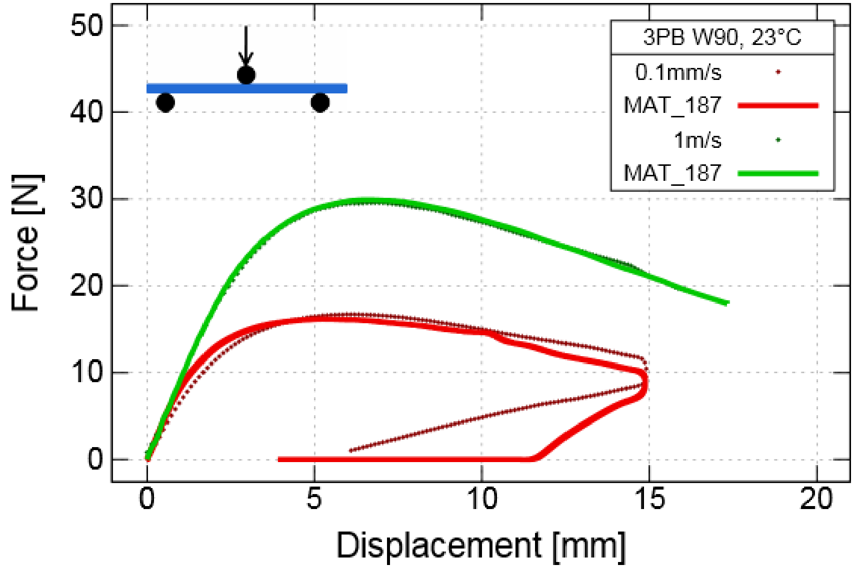
efficient dynamic testing

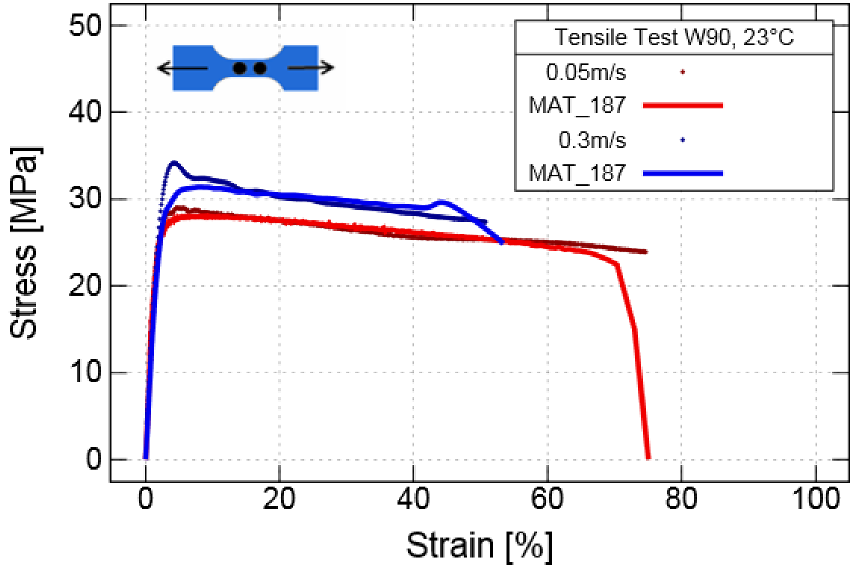
- Different load cases
  - Bending
  - Tension Bending
  - Compression
  - Puncture
  - Component
  - …
- High speed camera
  - Sync. recording
- Maximum energy 50 J
- Material Card
  Deformation → Failure

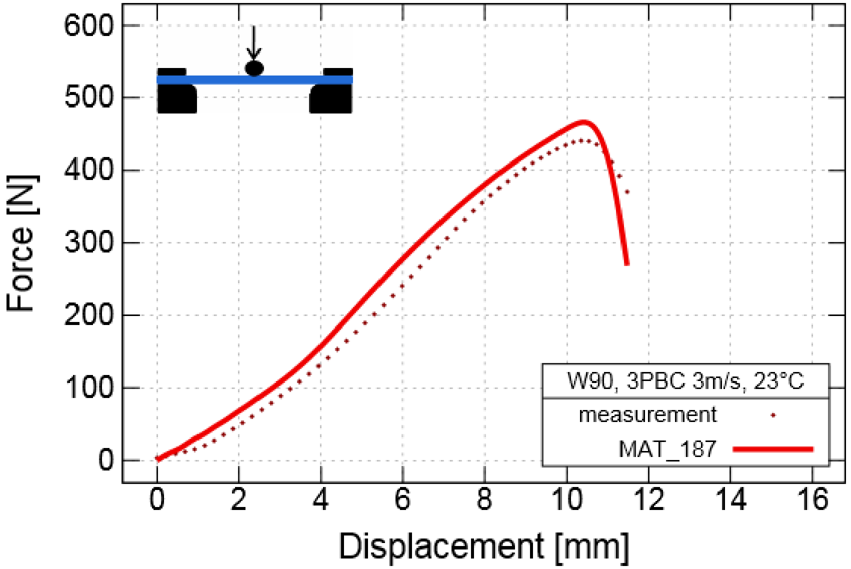


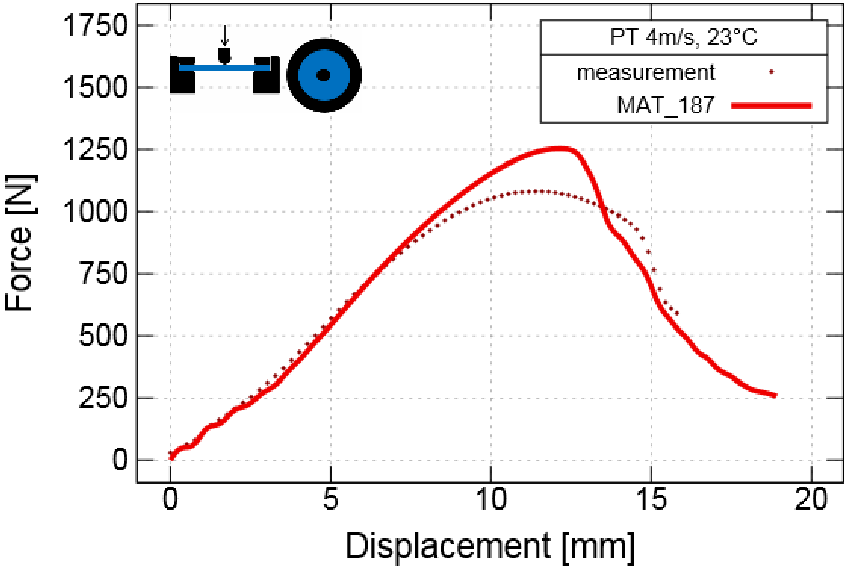


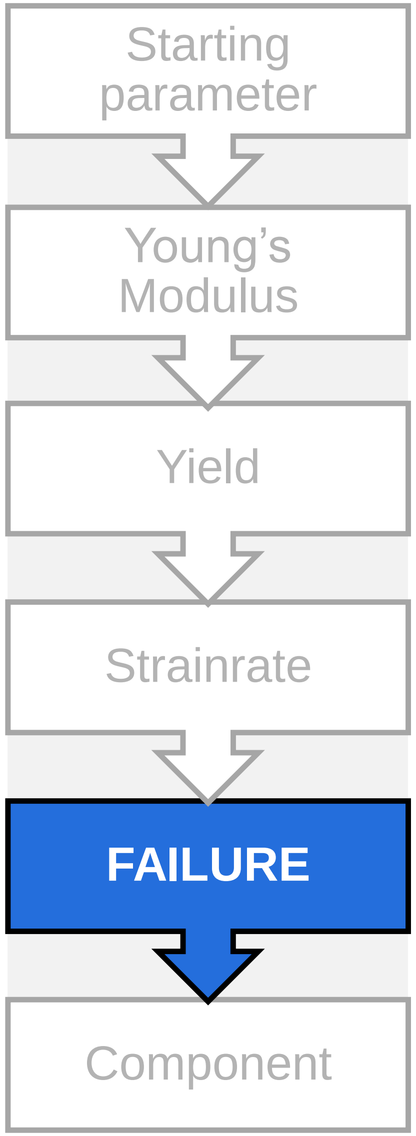
from failure → *MAT_ADD_EROSION





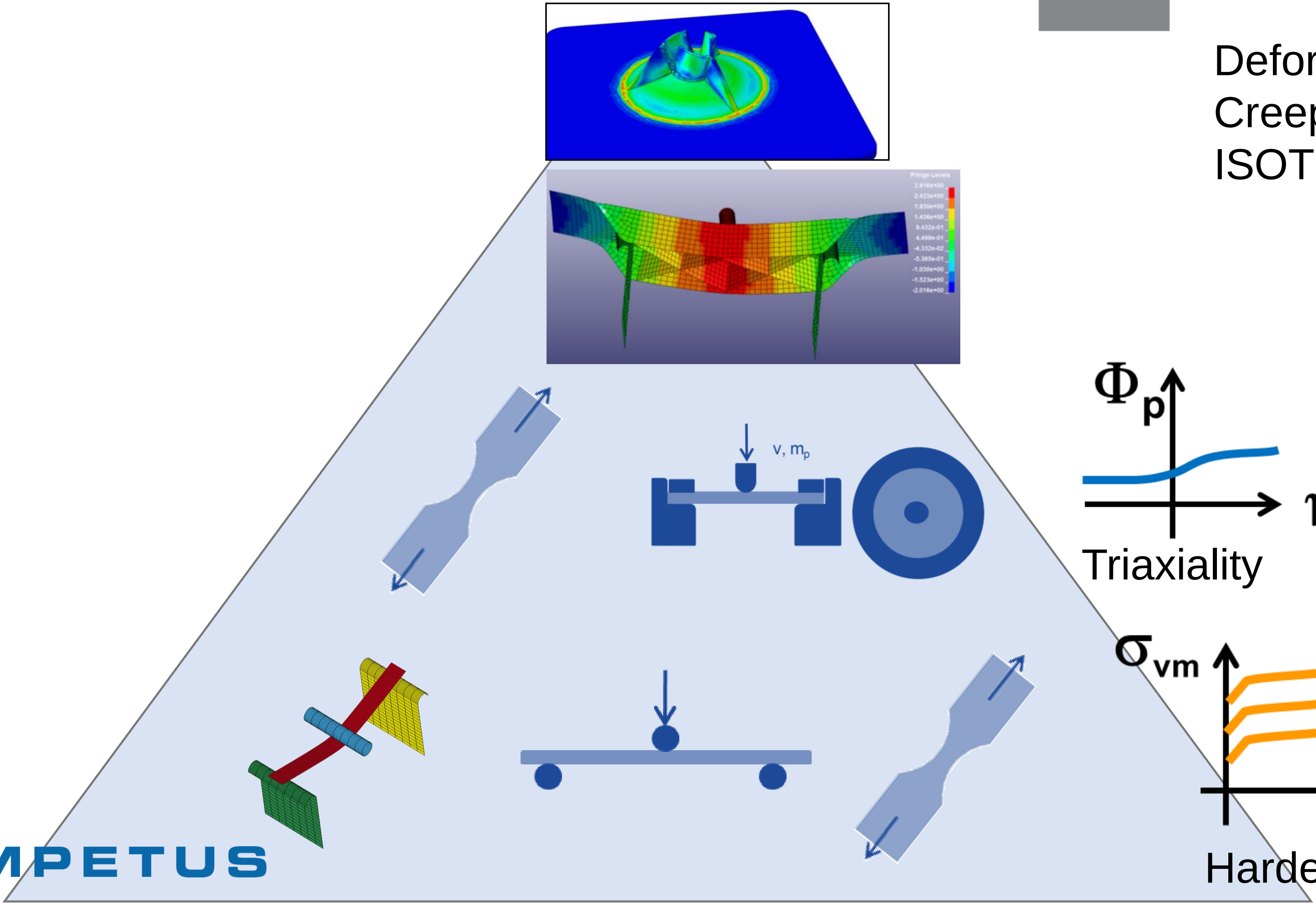


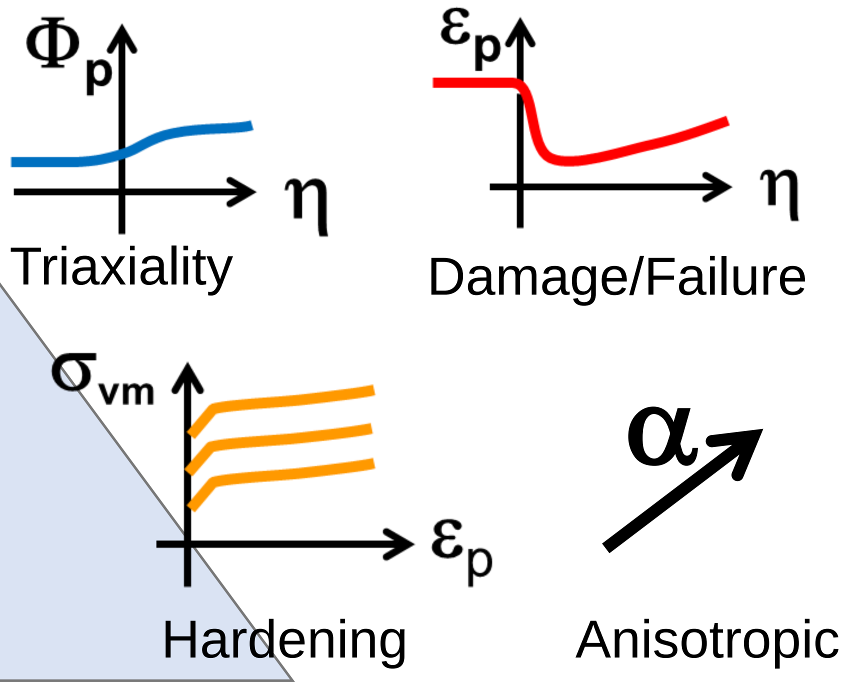




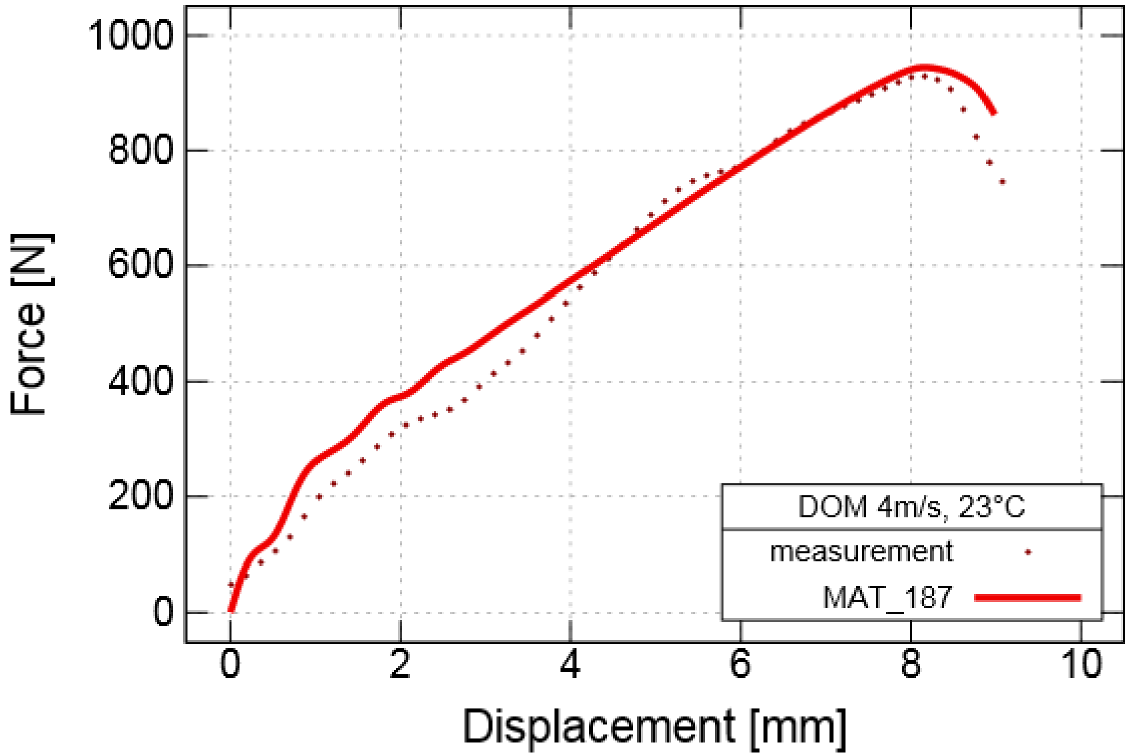
from test to material card

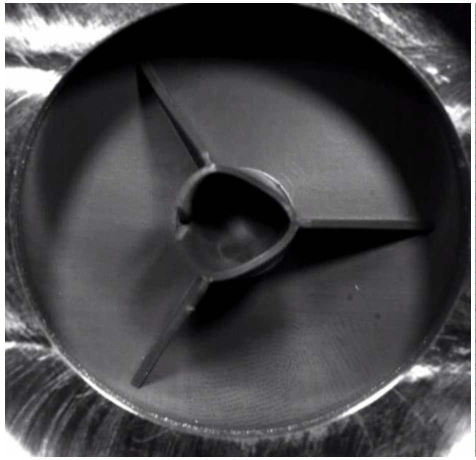
Deformation → Failure
Creep → Static → Crash
ISOTROPIC → ANISOTROPIC

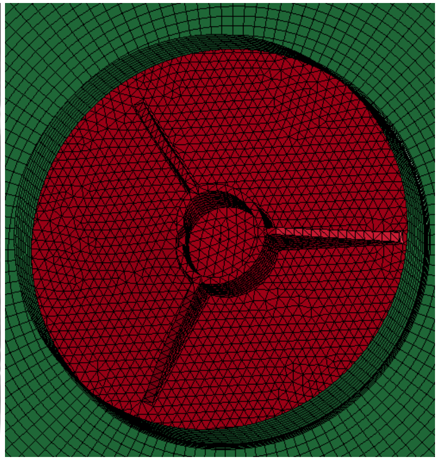


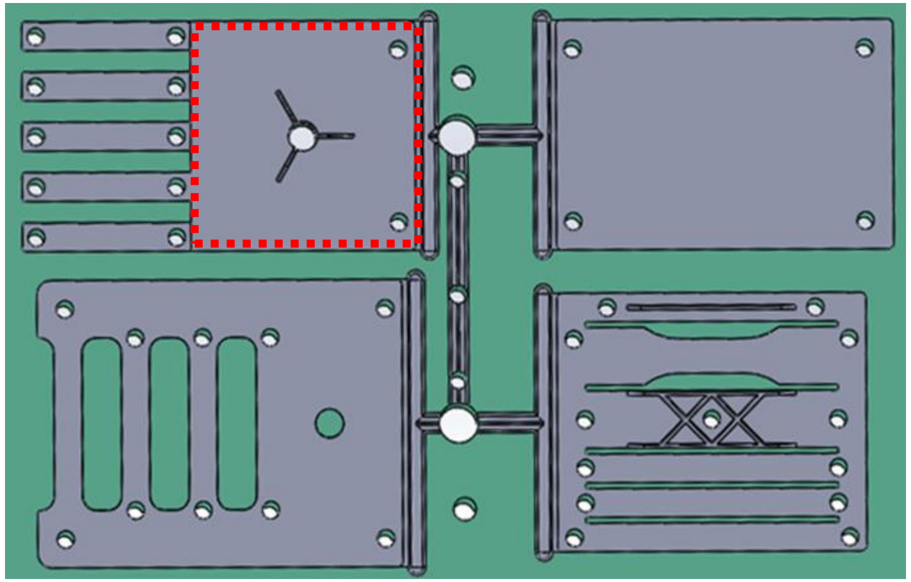


Puncture Test → Validation on component









Starting parameter

Young's Modulus

Yield

Strainrate

FAILURE

Component

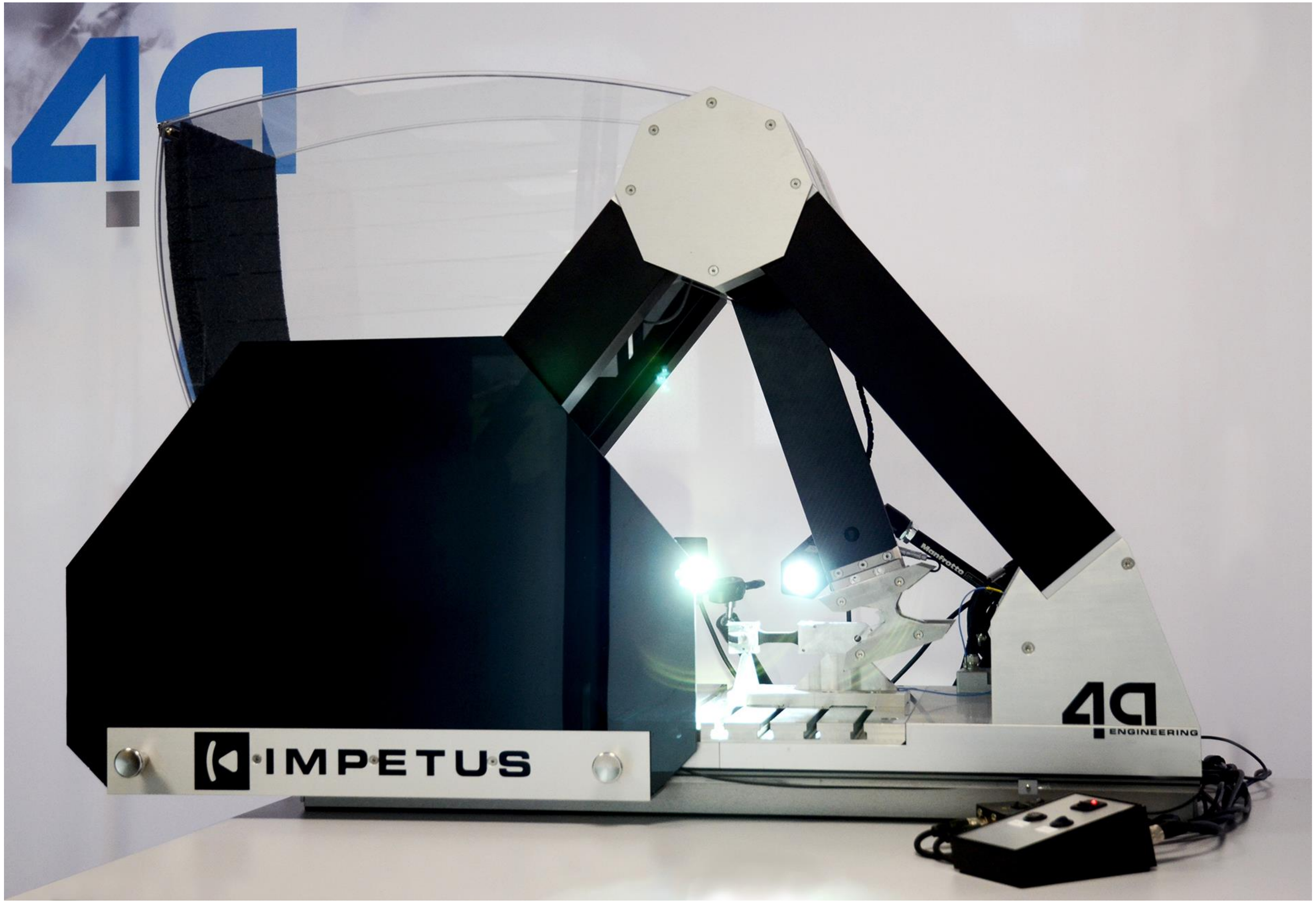
intermediate conclusion

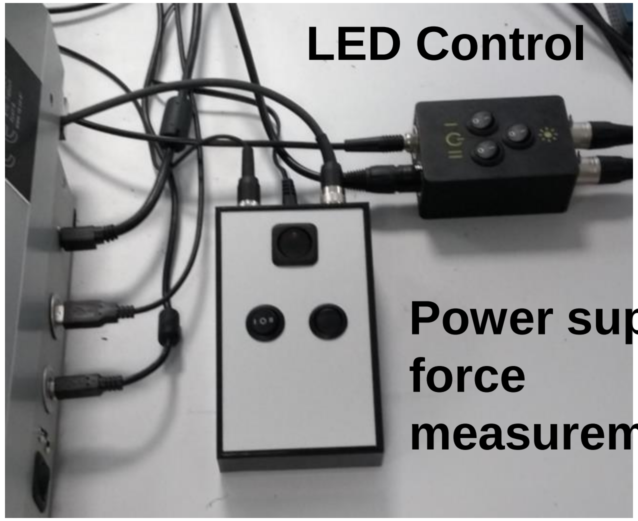
- IMPETUS™
  - efficient reliable possibility for characterizing materials
  - for unreinforced as well as fiber reinforced thermoplastics
  - different testing methods for capturing
    visco-elasticity, hardening & visco-plasticity, triaxiality, damage & failure
- VALIMAT™
  - for generating material cards reasonable and quickly
  - ****MAT_024, *MAT_124, *MAT_187, *MAT_ADD_EROSION, …***
  - MPIP → workflow for automation of the process
  - PP T16 (Hostacom XBR169): Prove of the workflow

→**Easy and accurate material modeling**

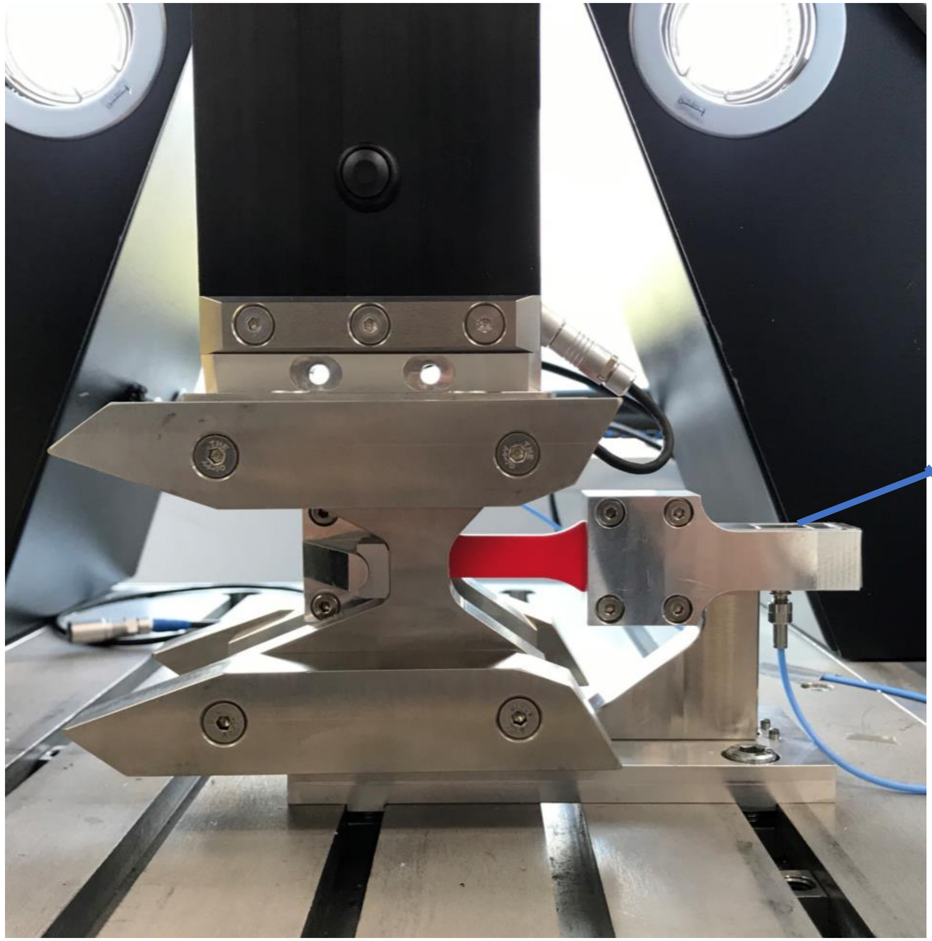
see more: [paper Int. LS Dyna Conference Detroit 2018]

Outlook - dynamic tensile test setup



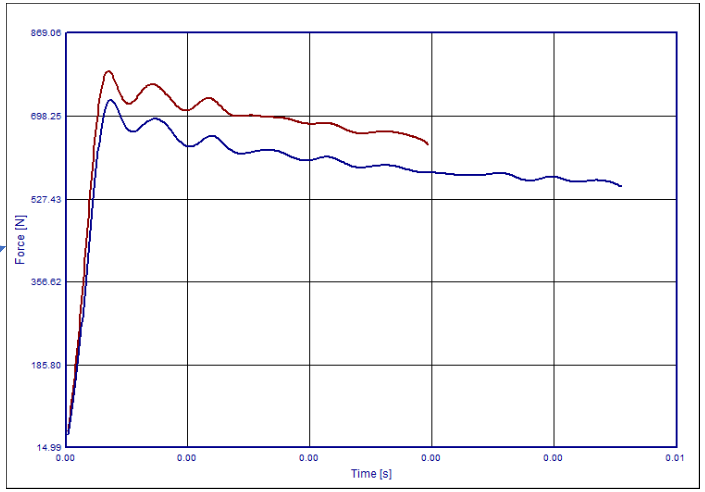


Outlook - dynamic tensile test setup

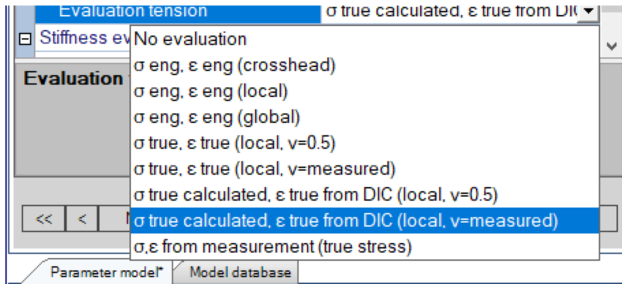


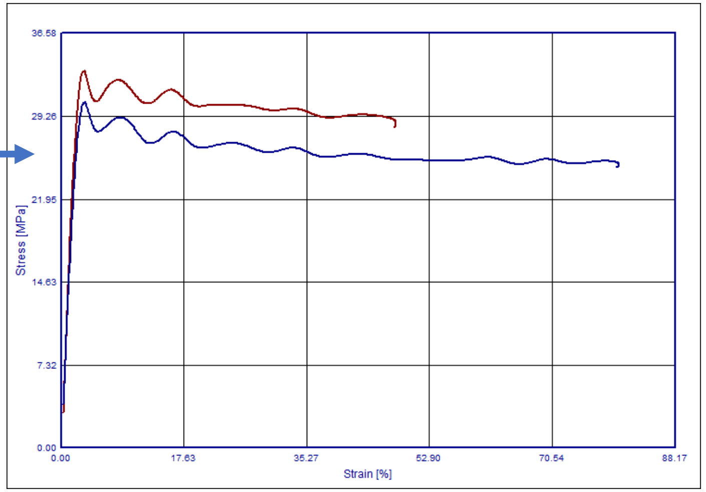
IMPETUS

Force measurement



New stress evaluation methods (support of DIC Data)

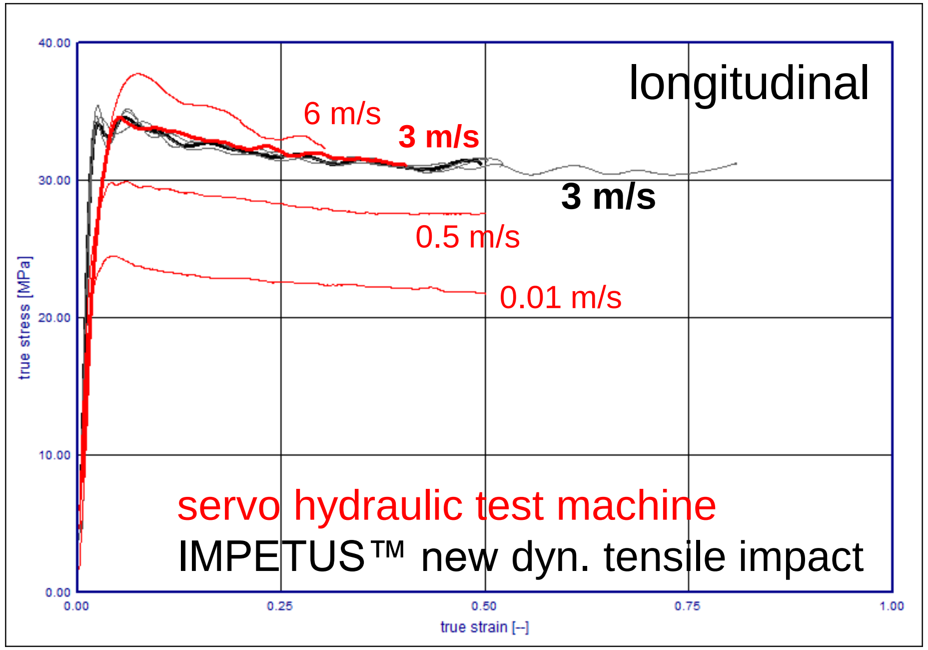


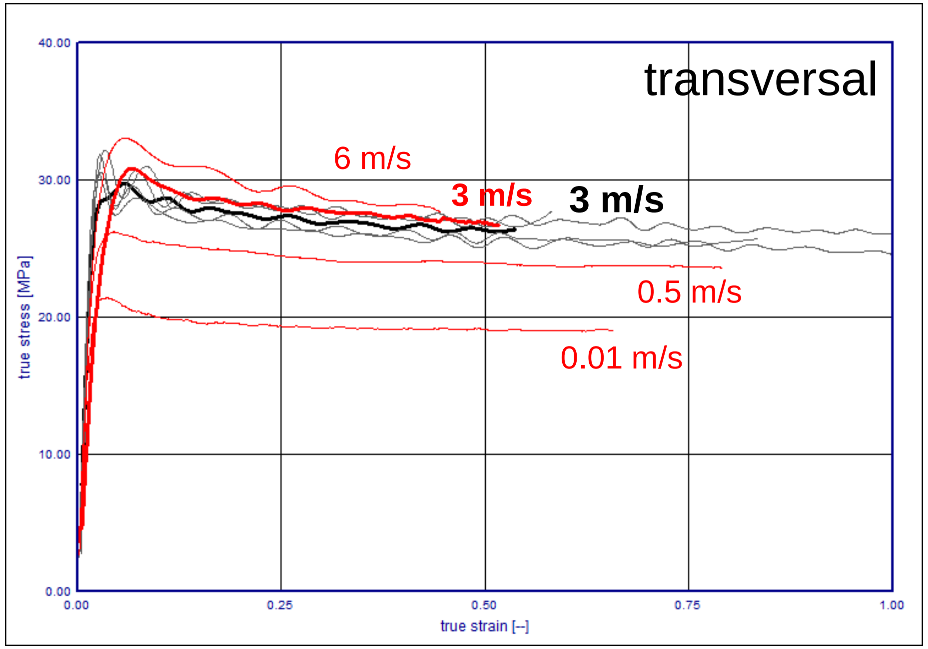


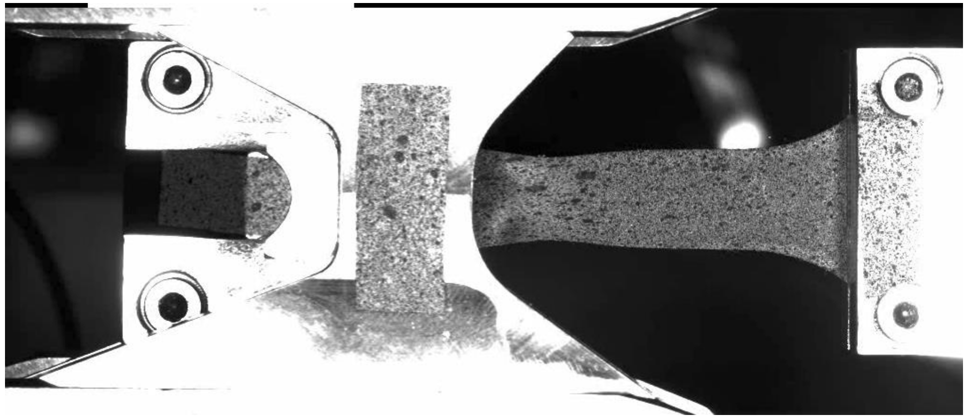
Outlook - dynamic tensile test setup

- **Comparison** on Hostacom XBR 169G (PPT16)
  - Results Ph.D Thesis F. Kunkel – 0.01, 0.5, 3, 6 m/s
  - Current investigations – 3 m/s
  - Becker 2.5 mm thick samples

- Quite good matching between both test methods !

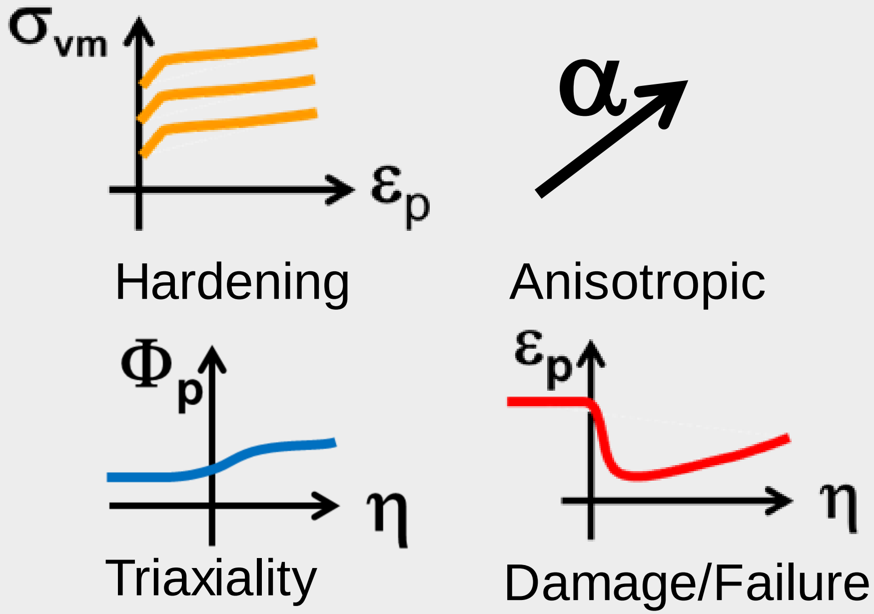






intelligent reliable solutions for plastics, composites, metals, foams, ...

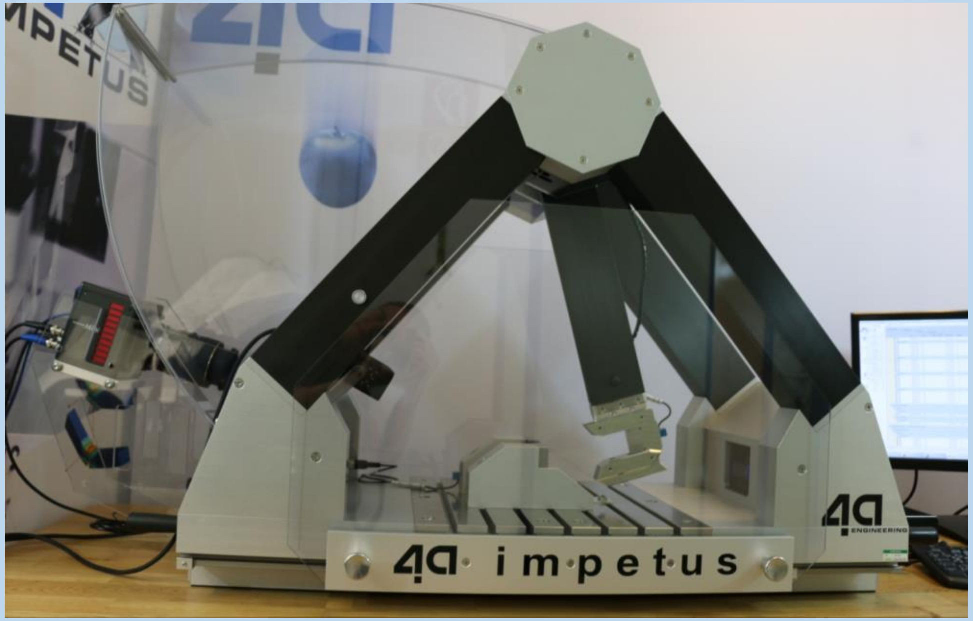
VALIMAT



for all material types

from test to validated material cards

IMPETUS



efficient dynamic testing

plastics and composites