



## 4a Summer School



# Evaluating and checking test data Interpretation of typical results

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Traboch, 14.07.2020



## 2<sup>nd</sup> week - Advanced topics



**14. July** - Evaluating and checking test data  
interpretation of typical results

**15. July** - general yield surface (\*MAT\_187) and other material models,  
failure approaches and comprehensive Autofit setup

**16. July** - Fiber reinforced plastics and their modelling approach  
an extensive guide

**17. July** - Python: a powerful tool with VALIMAT®,  
user defined material cards/specimen

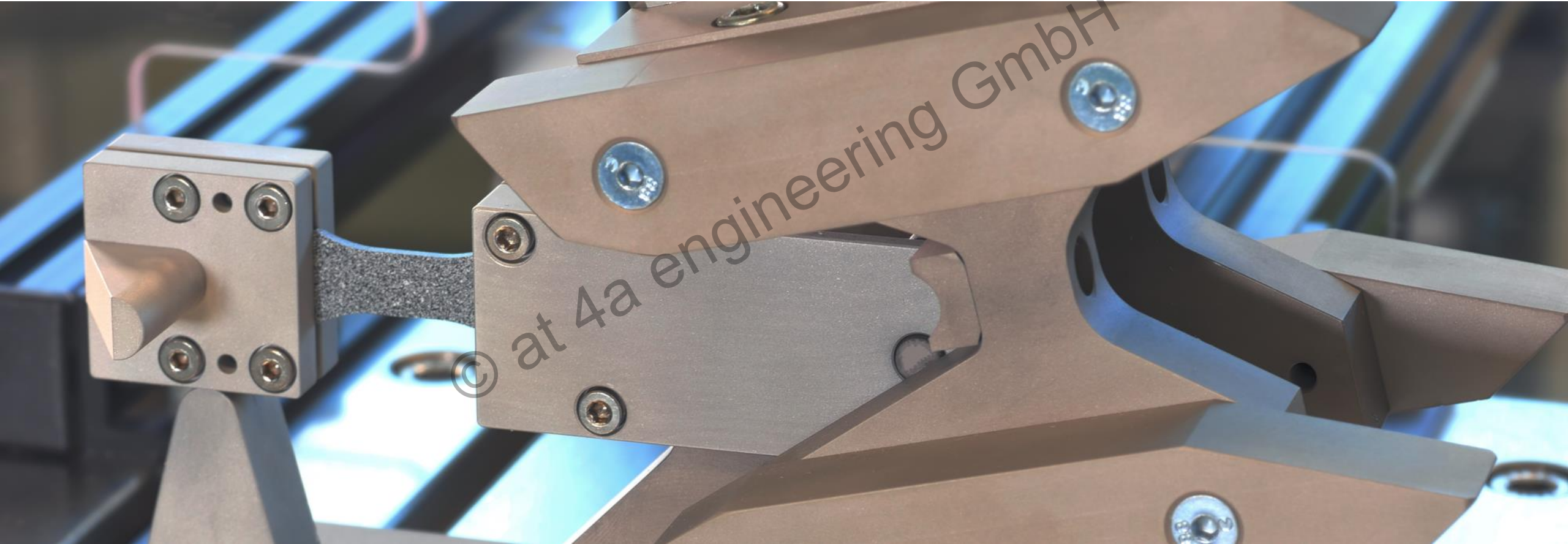
## Content of session 5

**IMPETUS<sup>®</sup>** - new efficient dynamic tensile test

**VALIMAT<sup>®</sup>** - import external test data

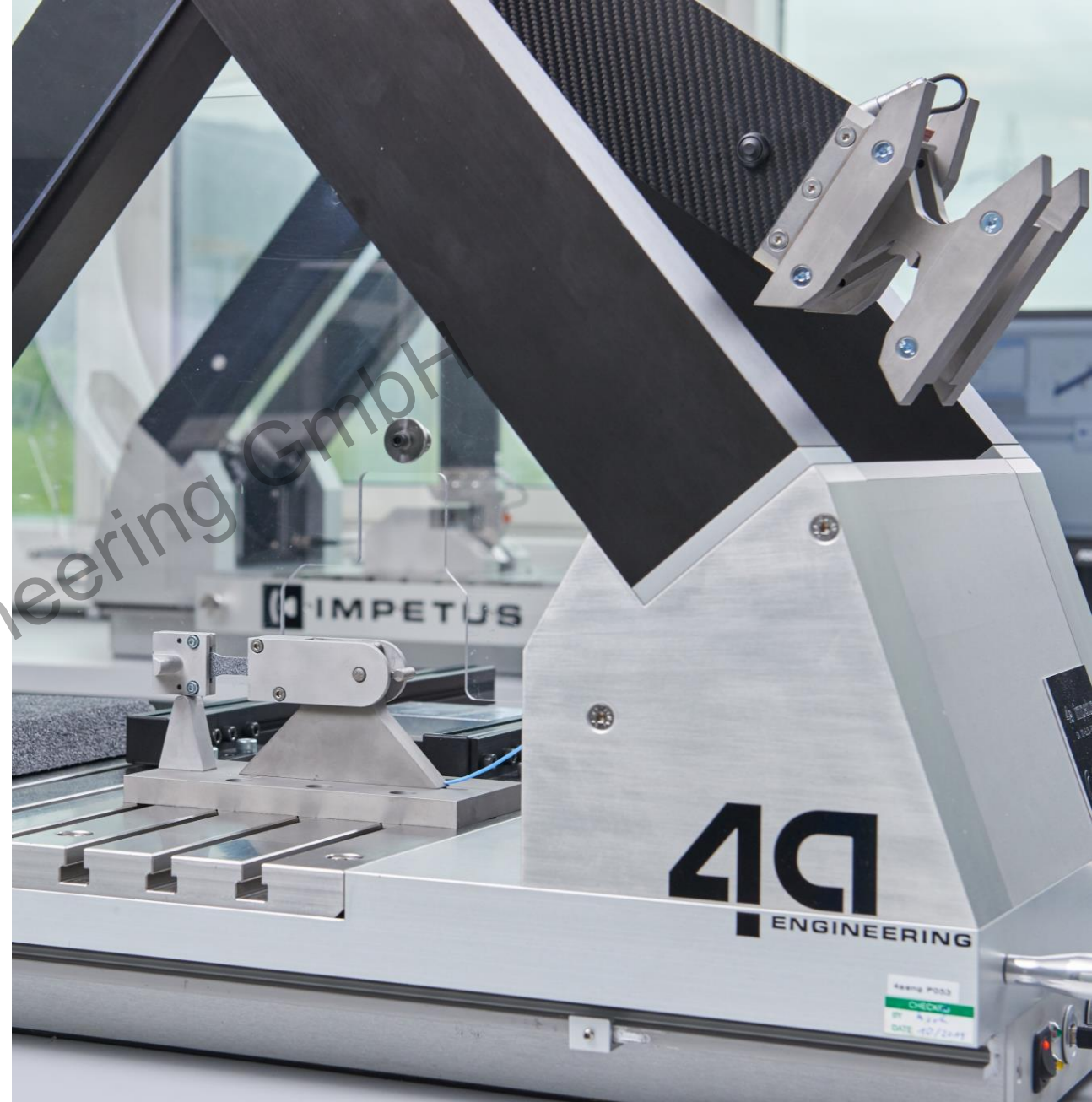
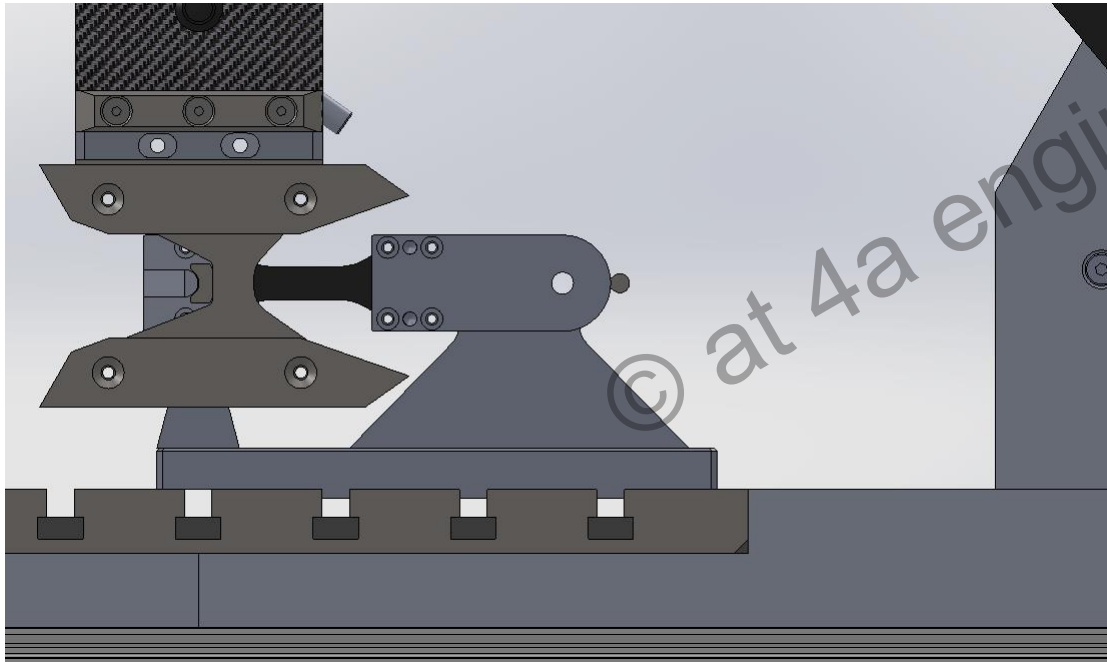
**Evaluating and checking test data** - Interpretation of typical results

# IMPETUS<sup>®</sup> - new efficient dynamic tensile test



# IMPETUS® - dynamic tensile test

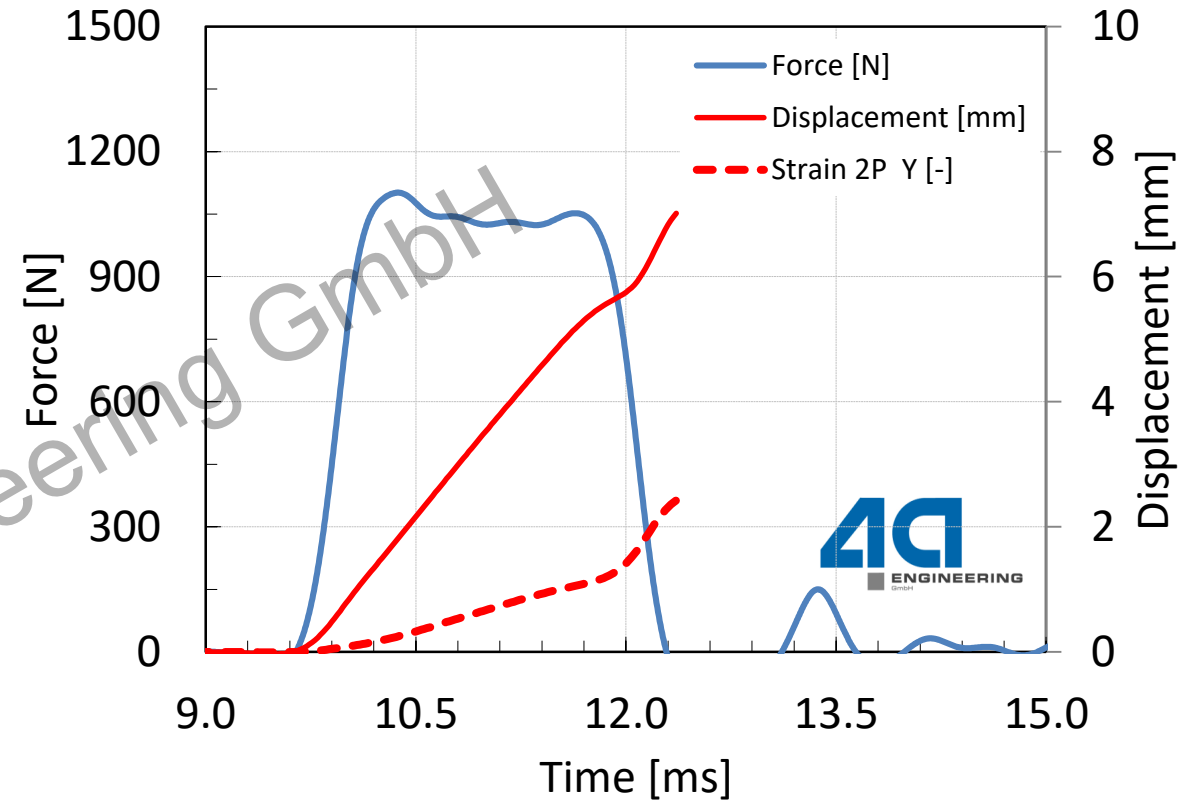
- Hardware consists of 3 main parts
  - counter bearing system
  - sample clamping
  - pendulum impactor head
    - Ease of use operation!



# Measurement technique

What we basically measure during the test?

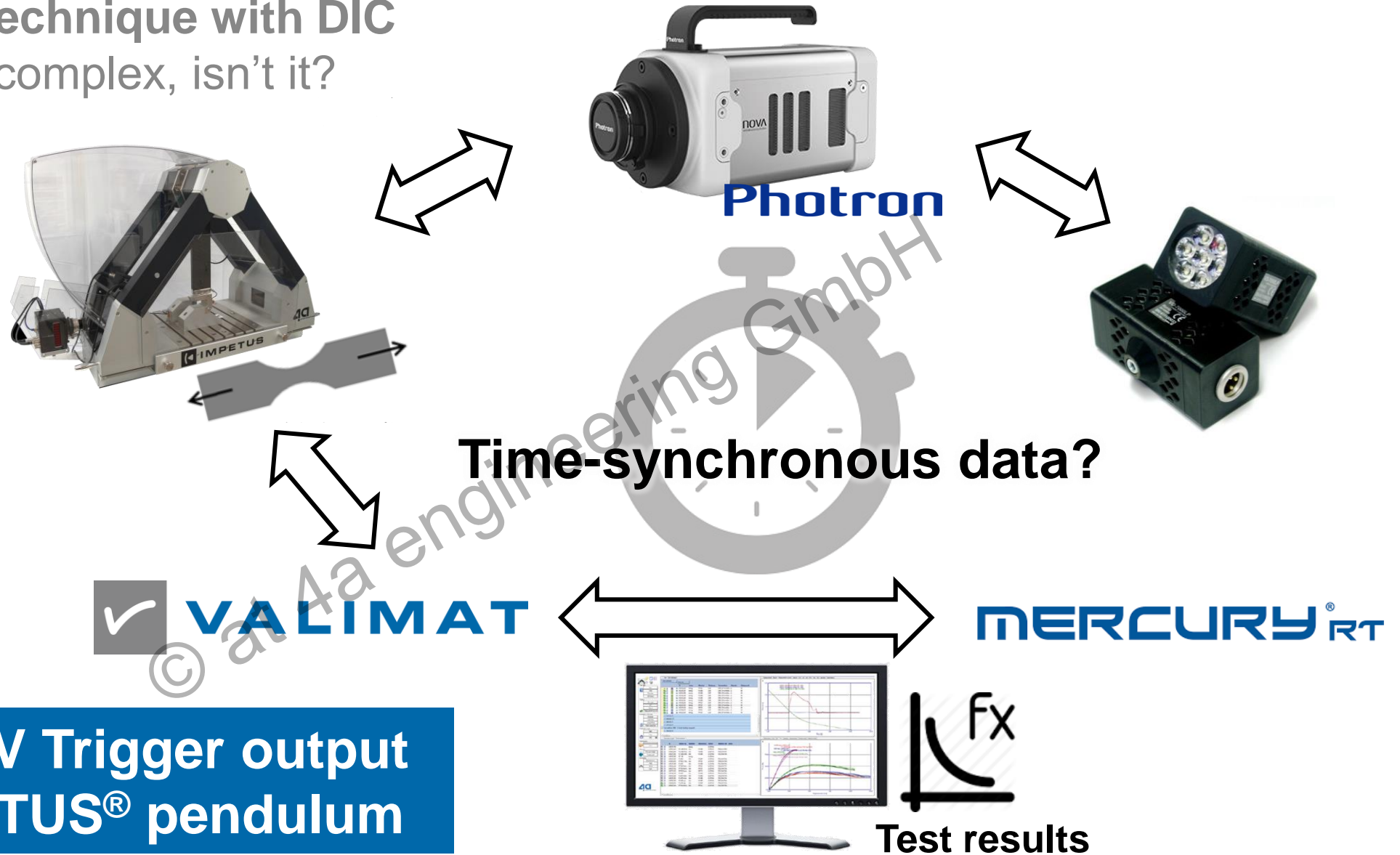
- Time [ms]
  - time-synchronous data is essential
- Force [N]
  - piezo load cell 20 kN
- Stroke [mm]
  - incremental angle sensor
  - **digital image correlation (DIC)** →



Now it's getting complex, isn't it?

# Measurement technique with DIC

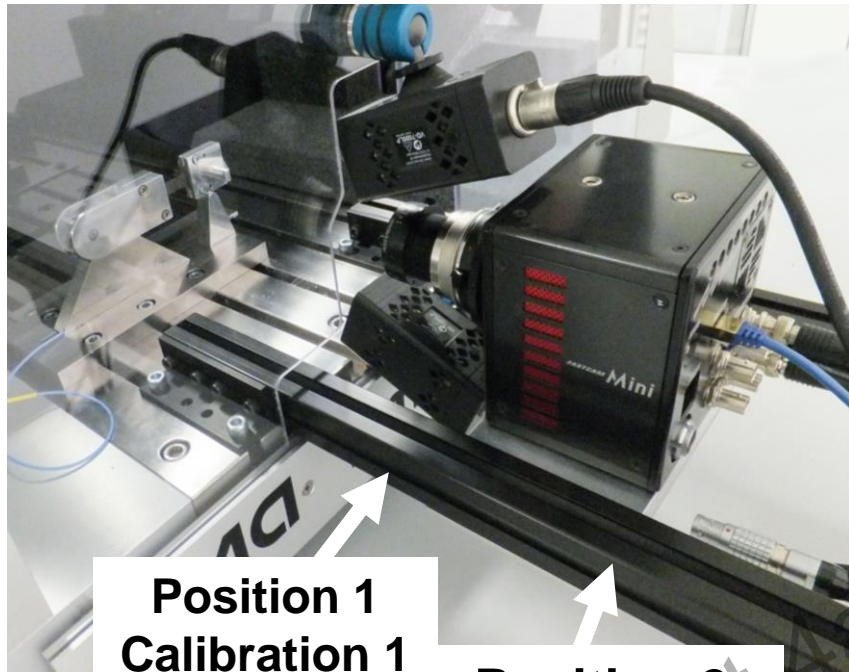
Now it's getting complex, isn't it?



**Integrated 5V Trigger output  
at the IMPETUS® pendulum**

# Measurement technique with DIC

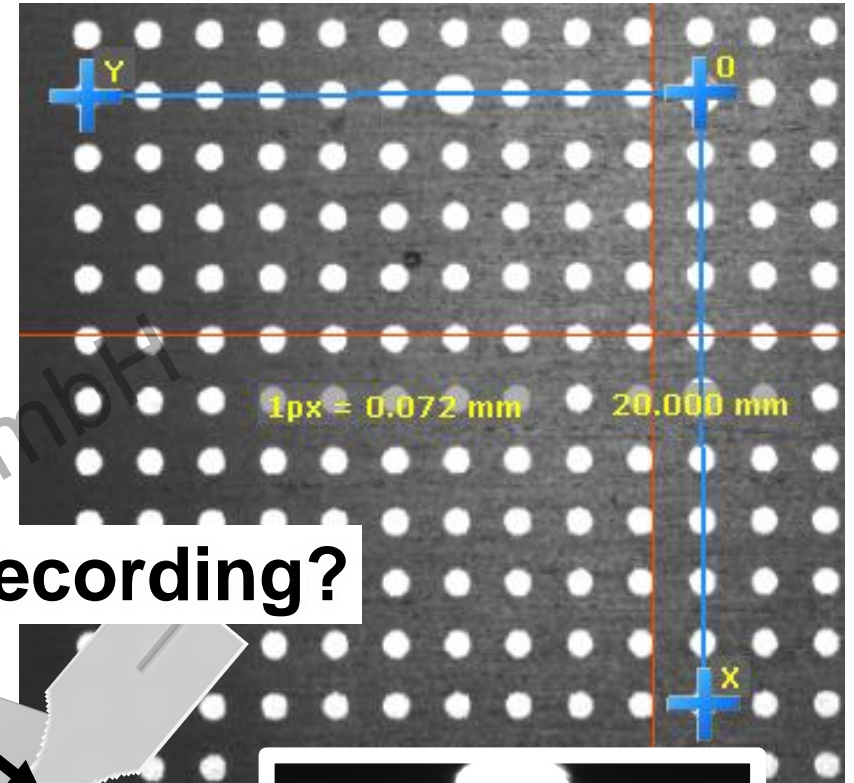
Now it's getting complex, isn't it?



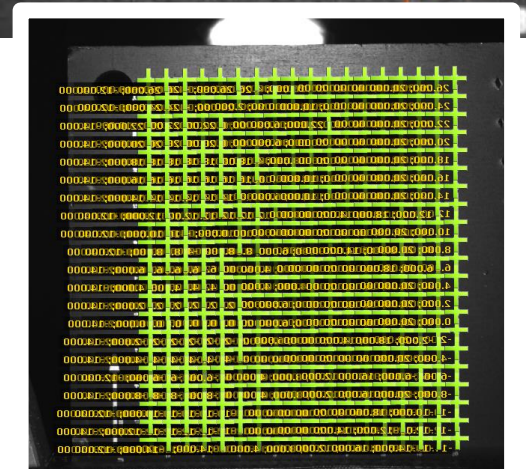
Position 1  
Calibration 1

Position 2  
Calibration 2

**Predefined camera positions attached to the pendulum**



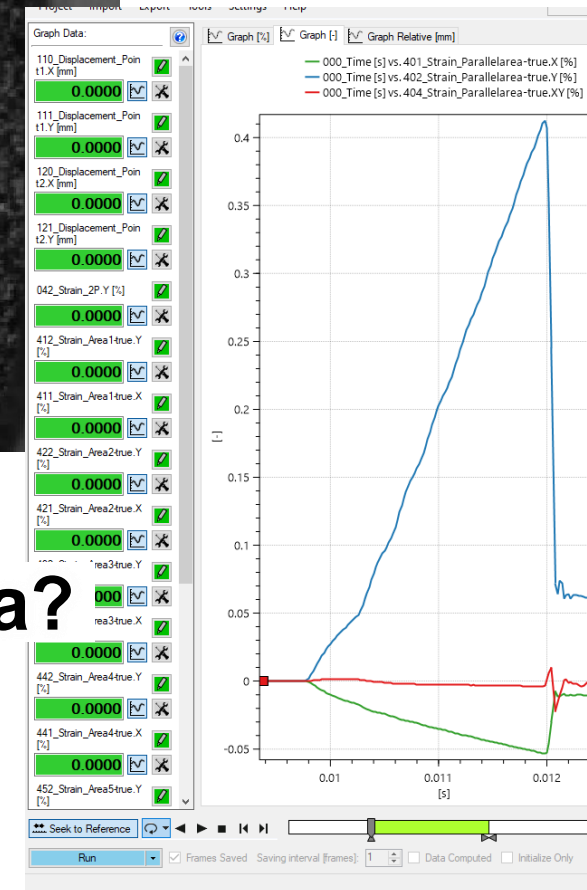
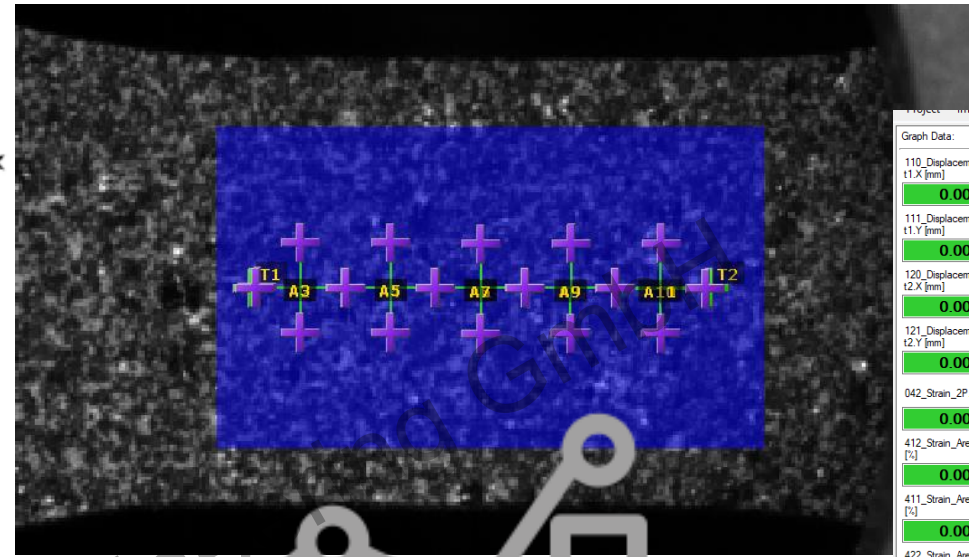
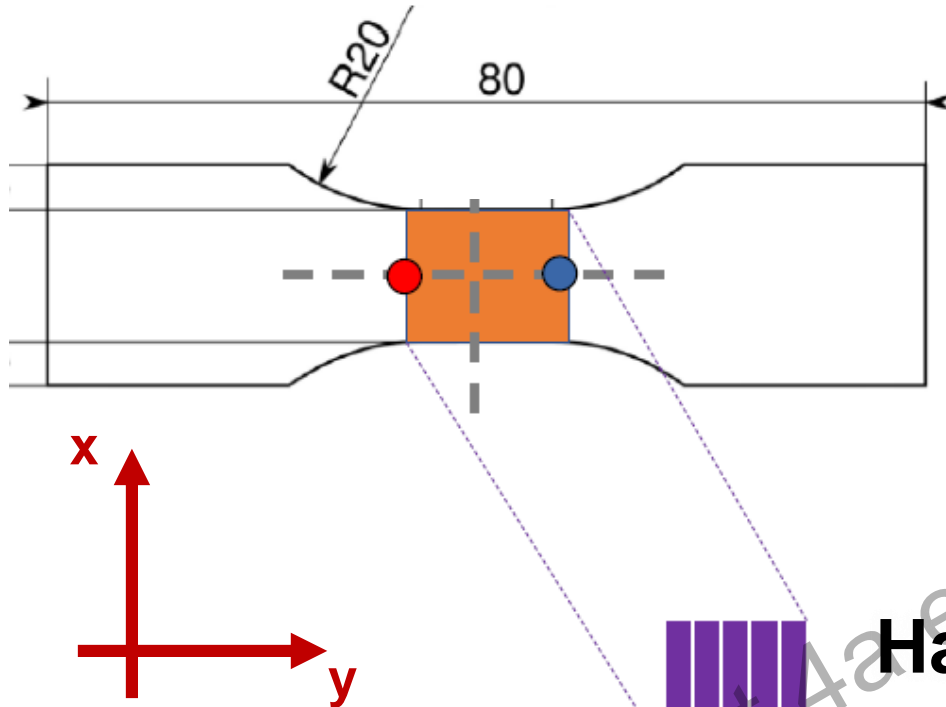
**Calibrated DIC recording?**





# Measurement technique with DIC

Now it's getting complex, isn't it?



Handling the recorded data?

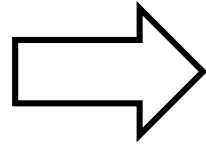
DIC "standard" nomenclature for optical measurement data

# Measurement technique with DIC

It's not complicated!

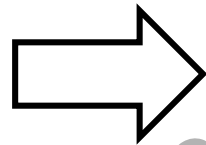


Integrated 5V Trigger output at the IMPETUS® pendulum



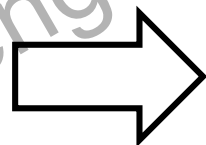
**Time-synchronous data!**

Predefined camera positions attached to the pendulum

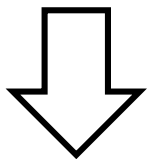


**Calibrated DIC recording!**

DIC "standard" nomenclature for optical measurement data



**Easy data handling!**

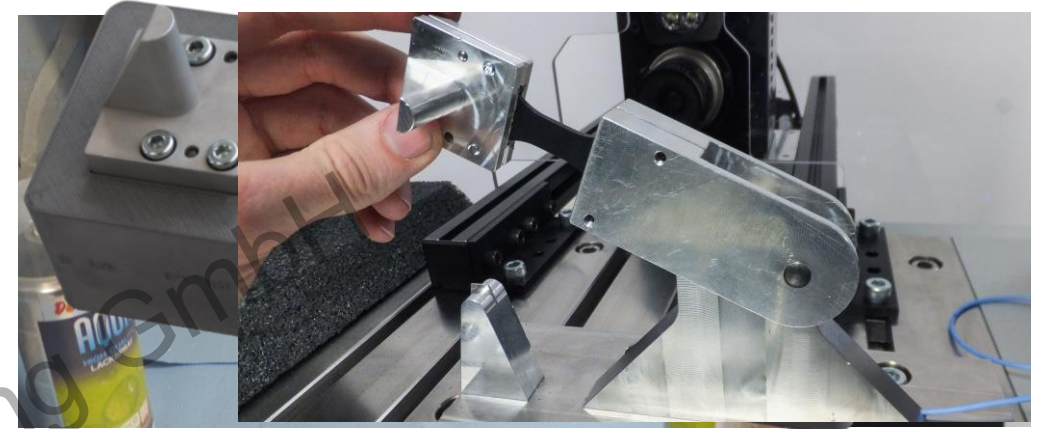


**Efficient dynamic testing!**

© 4a engineering GmbH

## Testing procedure

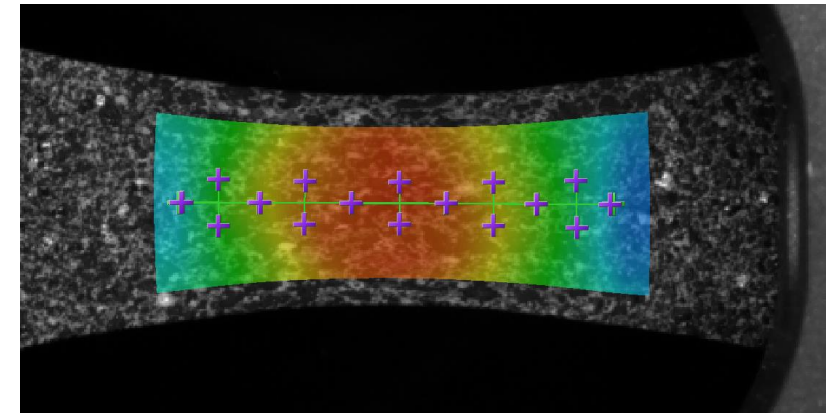
- Sample preparation with the speckle pattern
- Attaching the jig to the specimen
- Put the prepared sample at the counter bearing
- Perform the dynamic tensile test



**Have to be done manually**

- Activate the bright lights
- Start the recording of the high-speed camera
- Immediately evaluate the DIC images
- Finally store the recorded data in the VALIMAT database

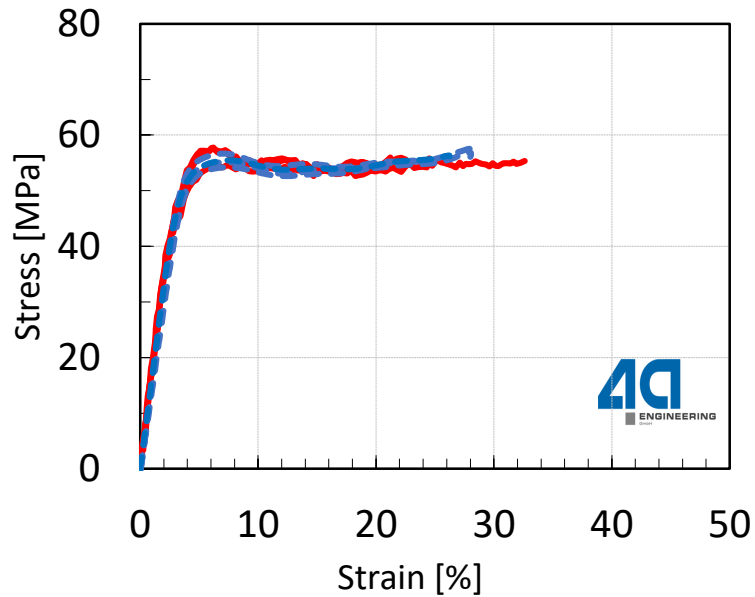
**Is executed automatically**



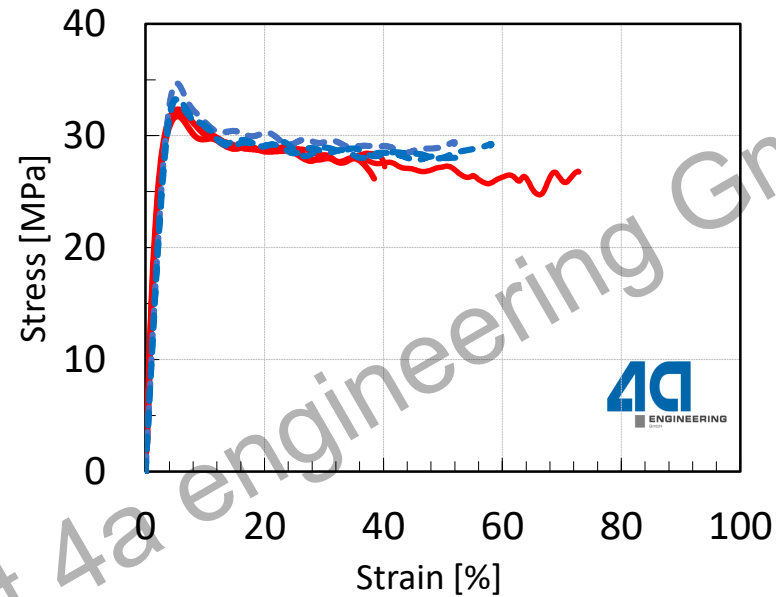
# Dynamic tensile test - unreinforced plastic comparison 4a IMPETUS<sup>®</sup> / external ZWICK

External ZWICK  
4a IMPETUS

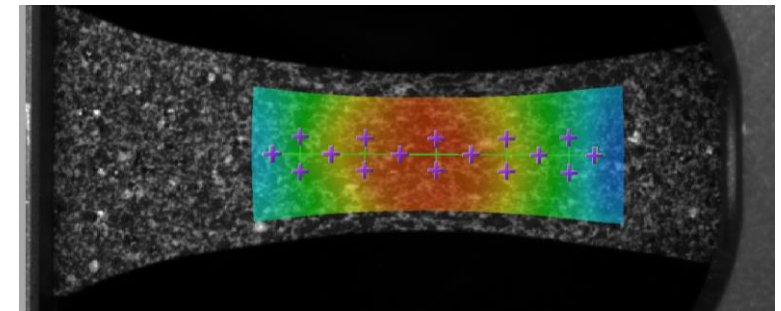
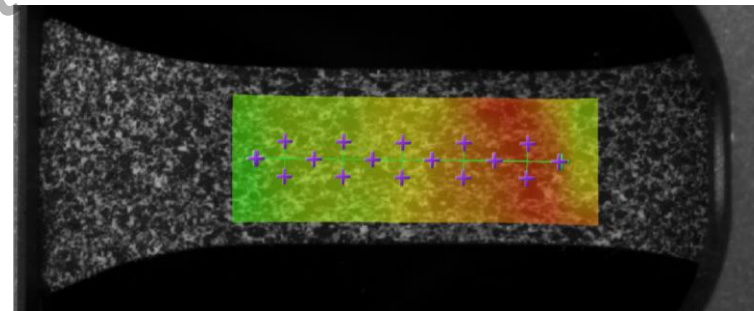
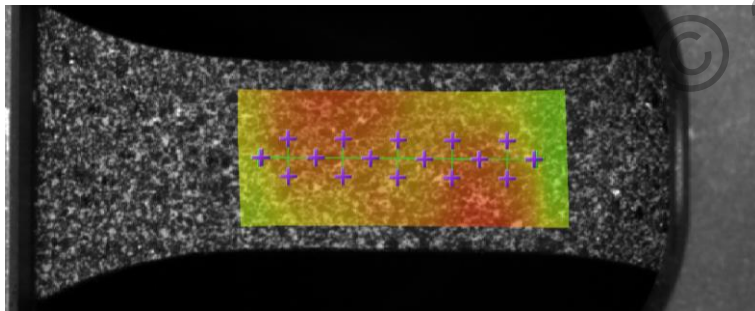
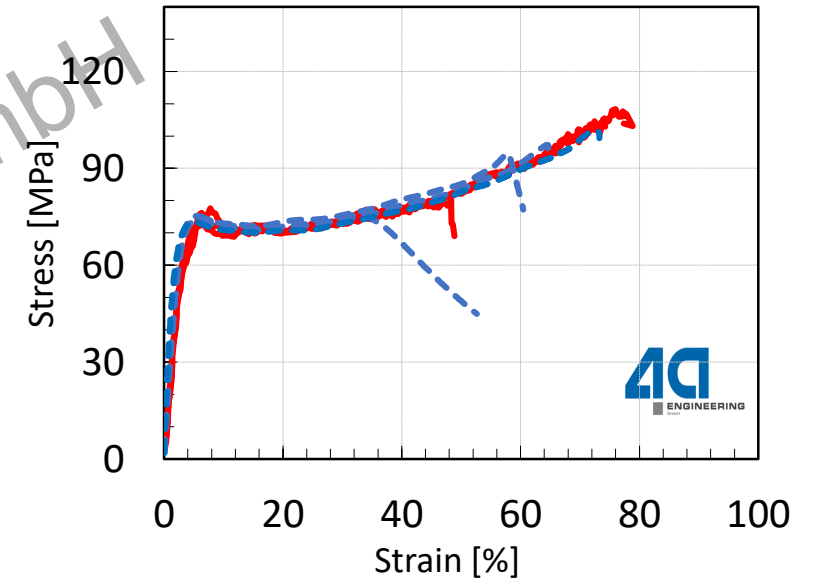
Typ A, 3m/s



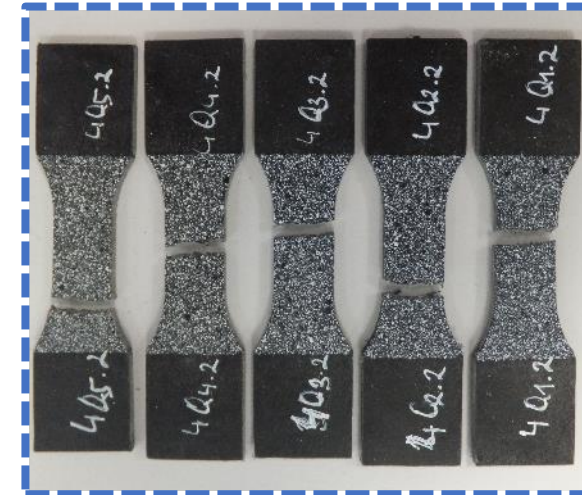
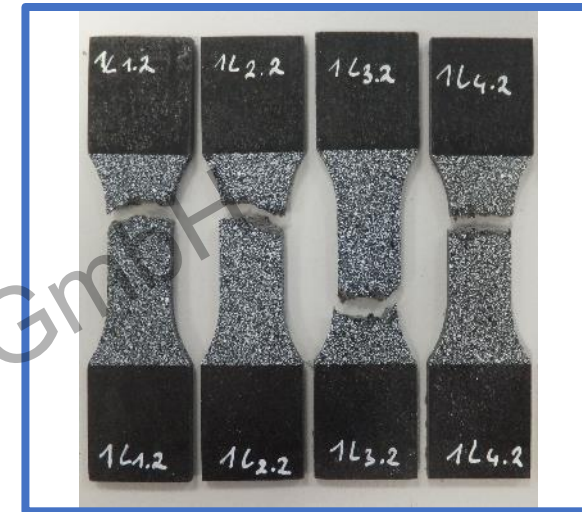
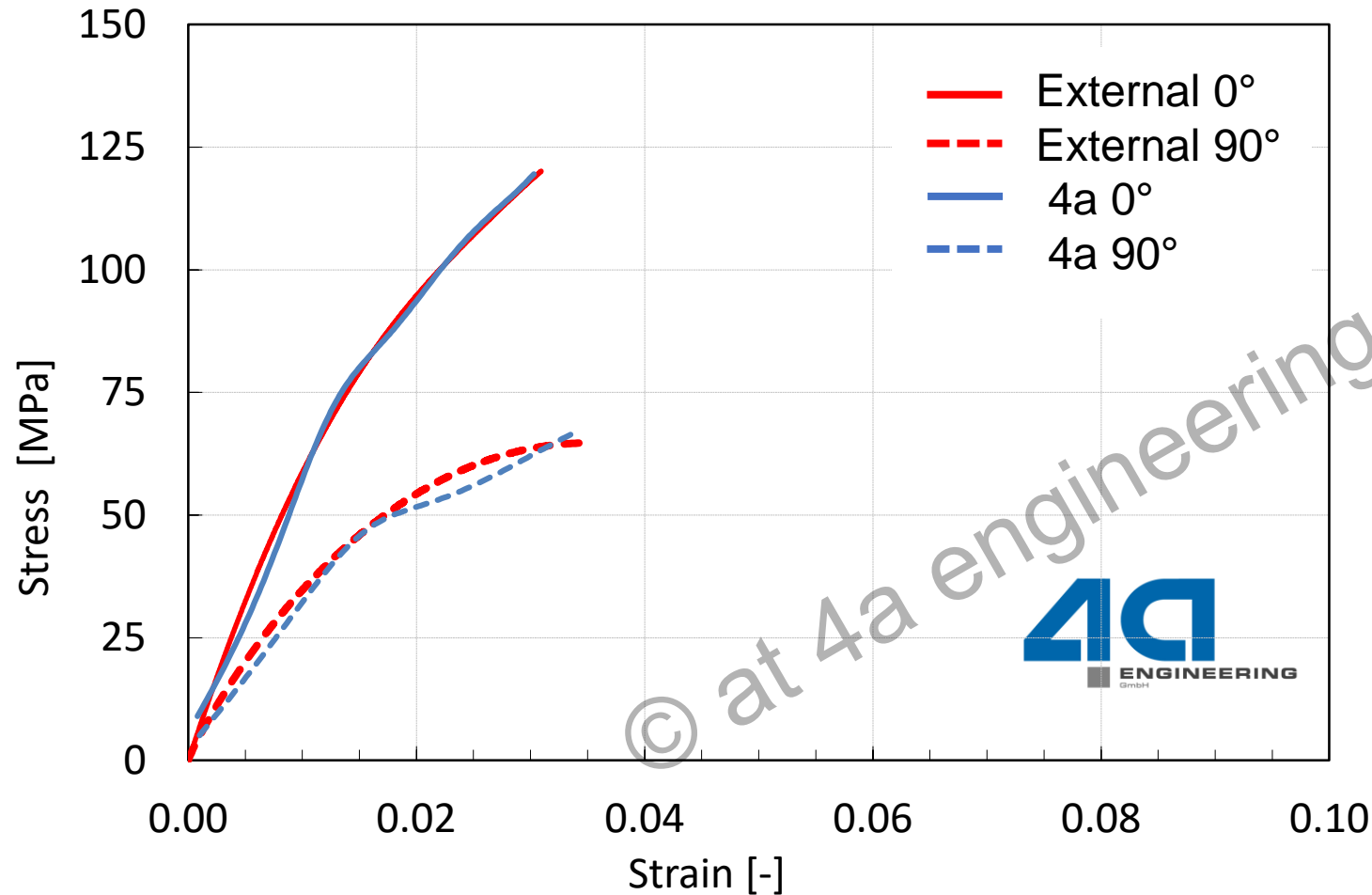
Typ B, 3m/s



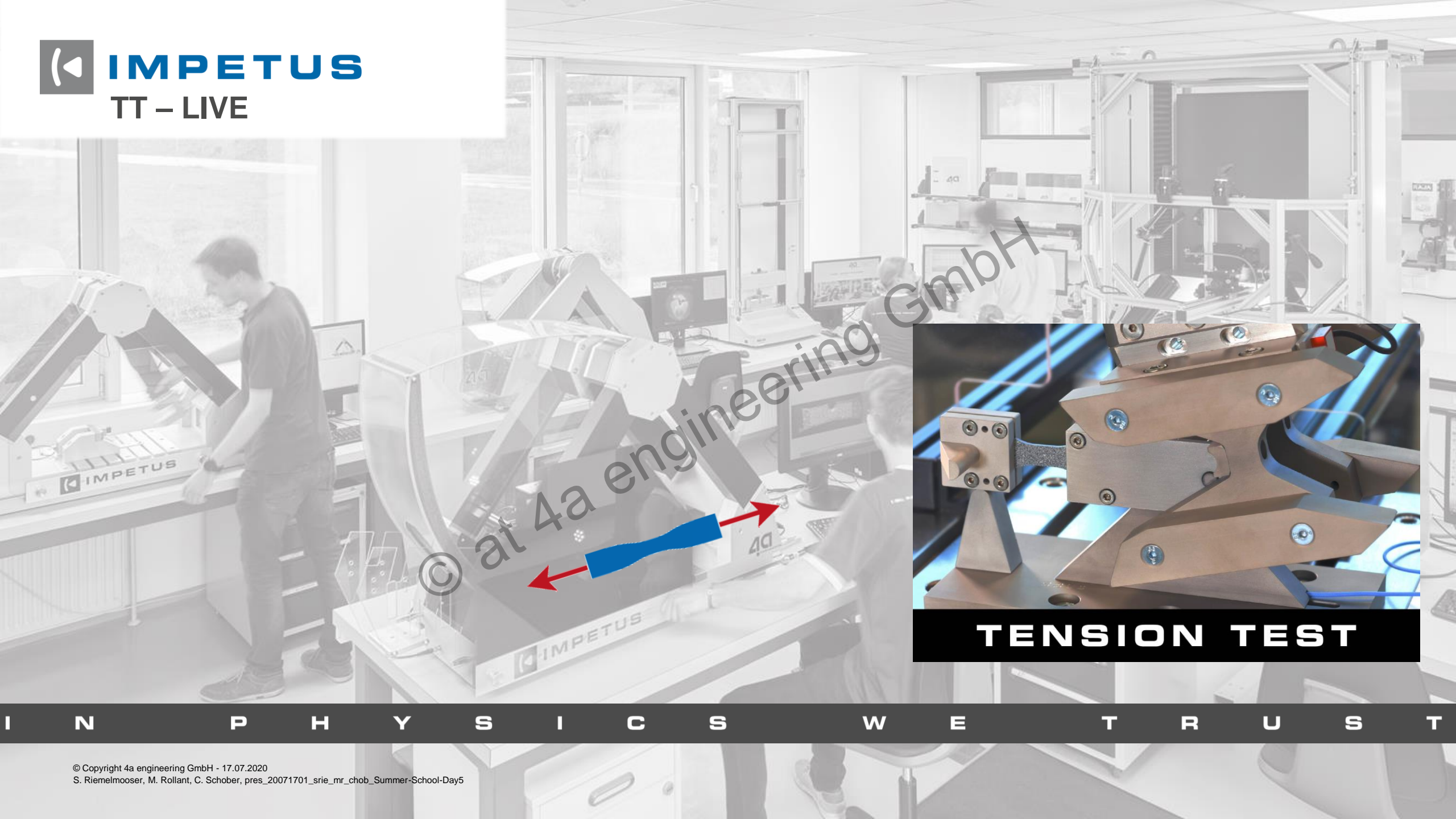
Typ C, 3m/s



# Dynamic tensile test – reinforced plastic PPLGF30 comparison 4a / external



With the kind support by  **Celanese**



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**TENSION TEST**

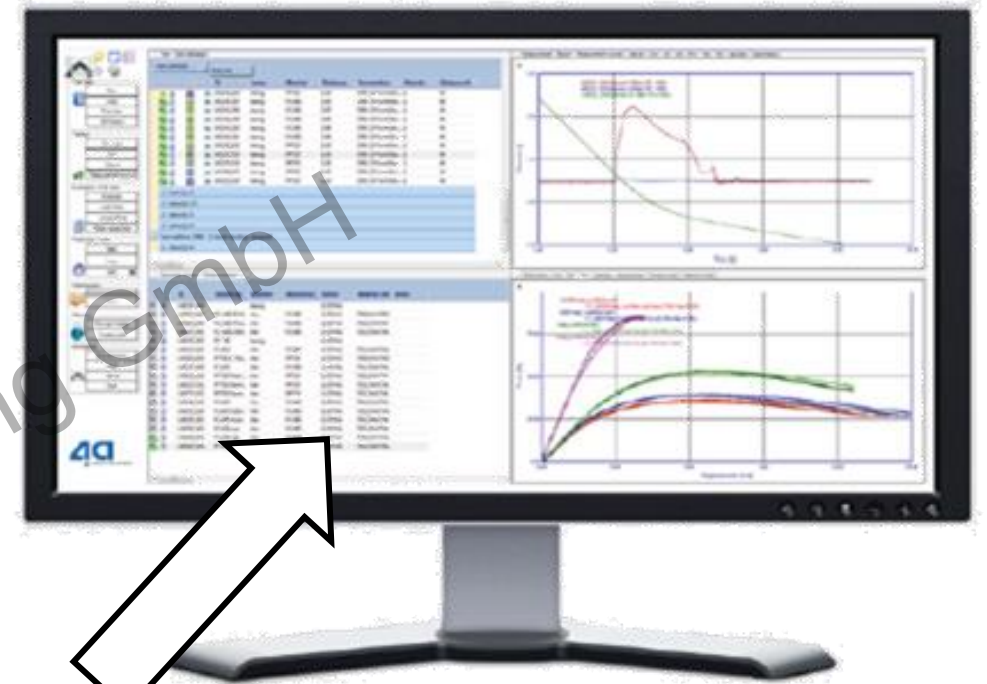
I N P H Y S I C S W E T R U S T

# VALIMAT<sup>®</sup> - import external test data



## VALIMAT

engineering plastics  
production  
smart data handling  
simulation  
concepts  
lightweight prototypes

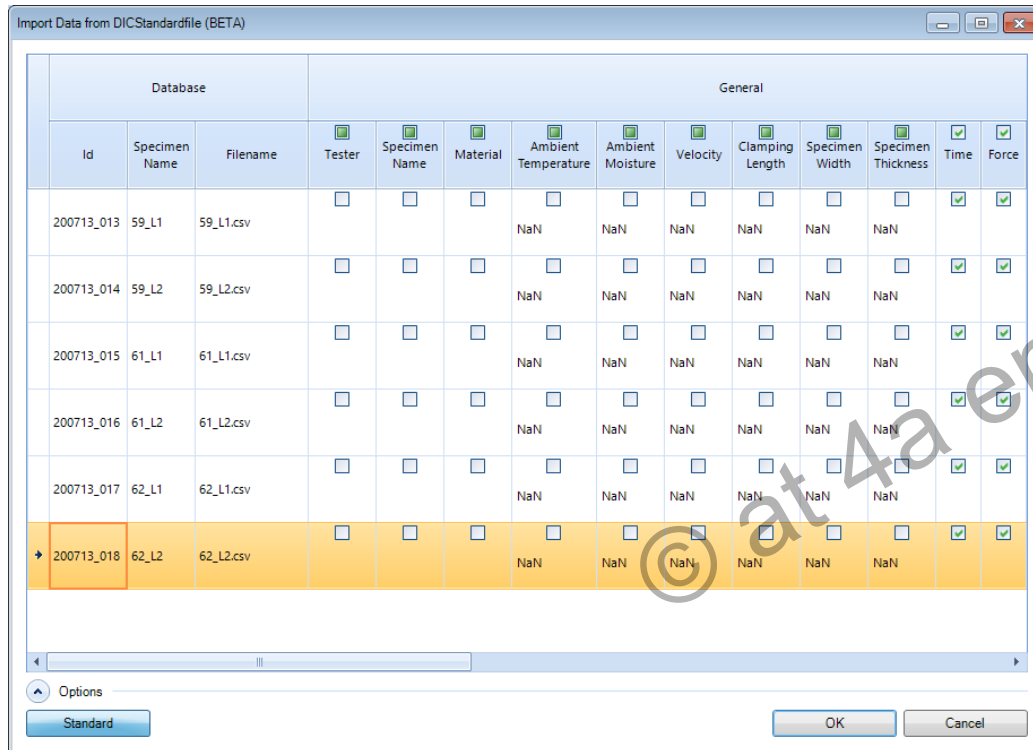


external Test data

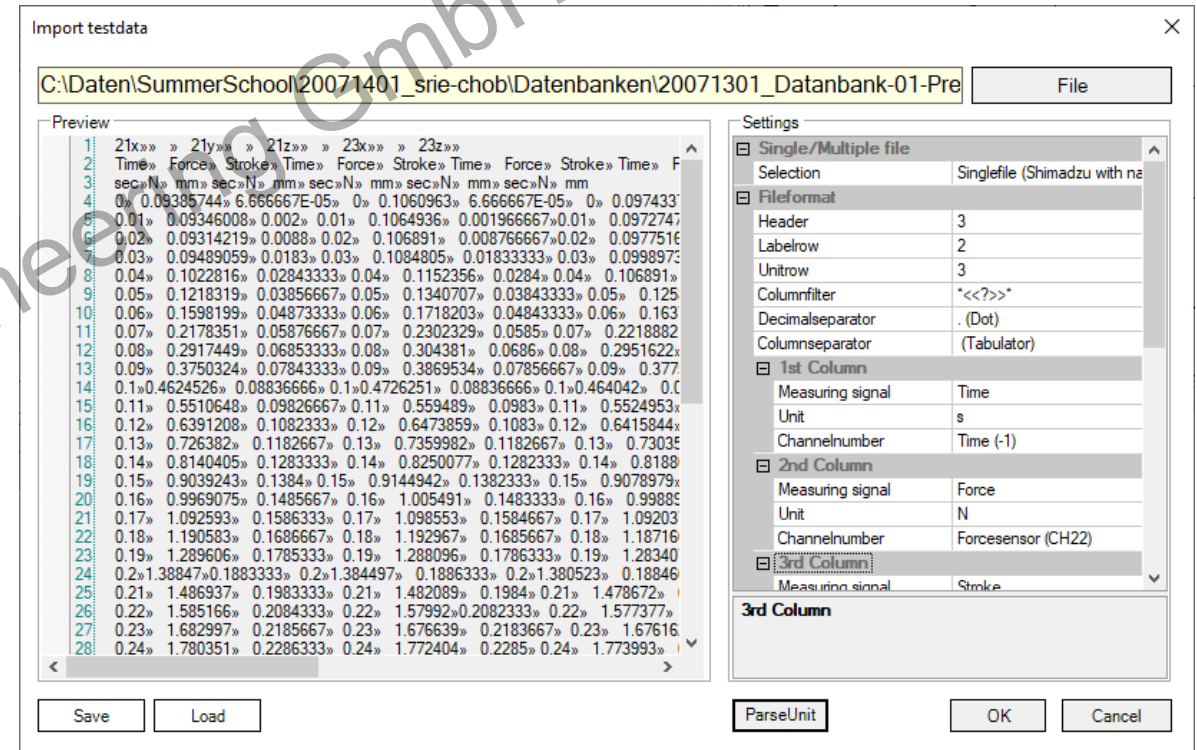
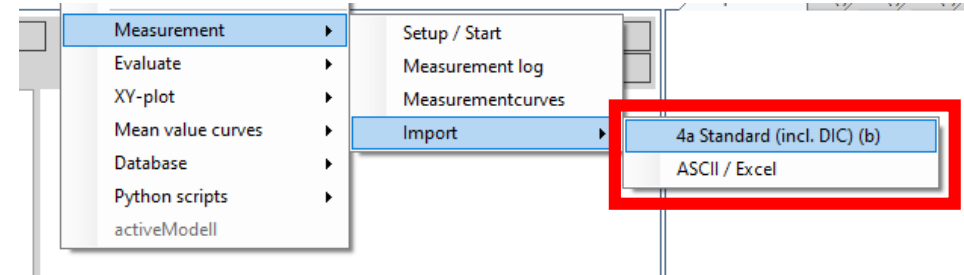
# VALIMAT® - import external test data

## 2 different import options

- 4a Standard (incl. DIC)



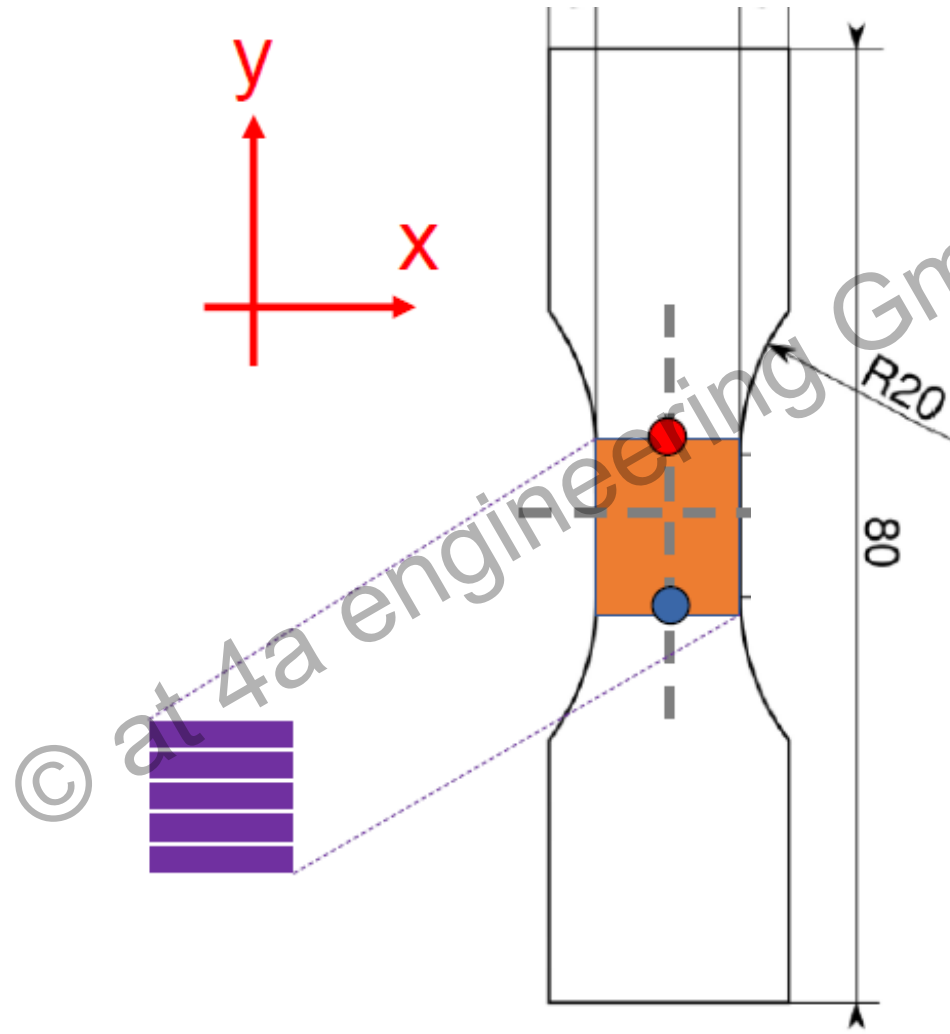
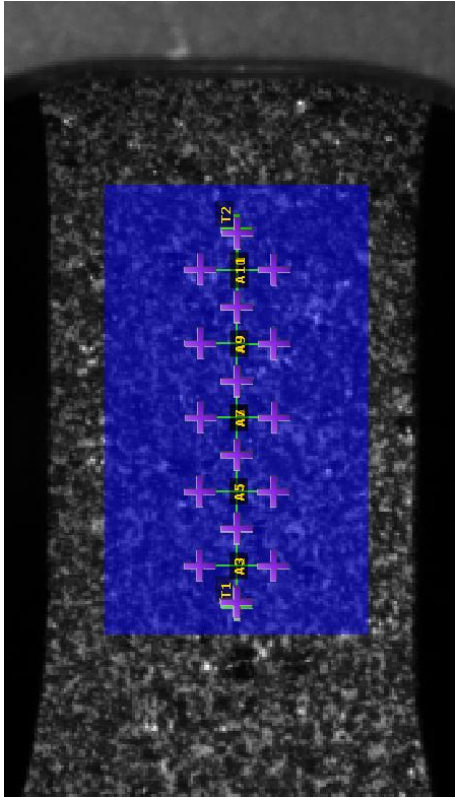
- ASCI / Excel





# VALIMAT® - import external test data

## 4a Standard (incl. DIC)



4a DIC standard designation
000_Time [s]
022_Force [N]
010_Displacement_Crosshead.Y [mm]
042_Strain_2P.Y [%]
030_Stress_Parallelarea-tech [MPa]
032_Stress_Parallelarea-true [MPa]
110_Displacement_Point1.X [mm]
111_Displacement_Point1.Y [mm]
112_Displacement_Point1.Z [mm]
120_Displacement_Point2.X [mm]
121_Displacement_Point2.Y [mm]
122_Displacement_Point2.Z [mm]
011_Displacement_2P.Y [mm]
401_Strain_Parallelarea-true.X [%]
402_Strain_Parallelarea-true.Y [%]
403_Strain_Parallelarea-true.Z [%]
404_Strain_Parallelarea-true.XY [%]
411_Strain_Area1-true.X [%]
412_Strain_Area1-true.Y [%]
413_Strain_Area1-true.Z [%]
414_Strain_Area1-true.XY [%]
...
500_Strainrate_2P.Y [%/s]
502_Strainrate_Parallelarea.Y [%/s]
900_Trigger [-]
901_Trigger_AfterPreLoad [-]

# Evaluating and checking test data

## Interpretation of typical results

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# VALIMAT® - Setting options in the evaluation

- Filter
- Evaluation of the displacement
- Evaluation of the velocity
- Zero-point-evaluation
- Identification of failure
- Stress / strain evaluation
- Results

Valimat ver. 3.7

Database

- Data directory
- Test plan
- DB-Import

Test data

- New
- Copy

Measurement

- Setup / Start
- Import
- Show curves

Evaluation of the test

- Evaluate
- Load Plots
- Unload Plots
- Mean value plots

Parameter model

- New
- Copy

Optimization

- Create
- Edit
- Start

Test | Test database | Measurement | Report | Measurement curves | Viewer | a(t) | v(t) | s

Date\_Nr  
190813\_037

**General information**

**Test setup**









**Test specimen**

**Evaluation**






Filter	2000 CFC SAE Class
Evaluation of displacement	Angle
<input type="checkbox"/> Evaluation of the velocity	1 - Angle sensor
v0	2.985525
<input type="checkbox"/> Zero-point evaluation	5 - Accelerationsignal (without filter)
t0	0.0070167
<input type="checkbox"/> Identification of failure	1 - automatic
tend	0.0093765
tfail	0.0093765
alphamax_ep	-5
alphamax_dp	-5
Ffail	0.05
tfailfac	10
Fperc	0.8
trecovfac	20
b_criterium	0
<input type="checkbox"/> Stress evaluation	
Evaluation bending	Norm (elastic)
<input type="checkbox"/> Stiffness evaluation	
fperc_lo	0.1
fperc_up	0.3
<b>Results</b>	


# VALIMAT® - Basics information of evaluating data sets

The first symbol in the first row is for the user to mark the data sets. By right-clicking, the data sets can be marked with the following symbols:

-  invalid data set
-  check the measurement in regard to the upper/lower limit of the used sensor
-  unapproved data set
-  approved data set
-  data set marked for deleting
-  data set is compressed (7-zip)
-  data set is locked (invalid data set)
-  data set is locked (approved data set)

The second symbol shows the status of the data set:









-  new created data set
-  an error occurred in the measurement
-  an error occurred during saving
-  the test was run successfully and saved
-  the test has been evaluated


Date_Nr	
<input checked="" type="checkbox"/> 	200713_039
General information	
Material	Plastic
Series	0
Tester	srie
Project name	
Customer	

**New created data set**






# VALIMAT® - Basics information of evaluating data sets

The first symbol in the first row is for the user to mark the data sets. By right-clicking, the data sets can be marked with the following symbols:

-  invalid data set
-  check the measurement in regard to the upper/lower limit of the used sensor
-  unapproved data set
-  approved data set
-  data set marked for deleting
-  data set is compressed (7-zip)
-  data set is locked (invalid data set)
-  data set is locked (approved data set)

Date_Nr	
<input checked="" type="checkbox"/> 	200713_039
General information	
Material	Plastic
Series	0
Tester	srie
Project name	
Customer	









The second symbol shows the status of the data set:

-  new created data set
-  an error occurred in the measurement
-  an error occurred during saving
-  the test was run successfully and saved
-  the test has been evaluated






**A successfully tested / imported data set**

# VALIMAT® - Basics information of evaluating data sets

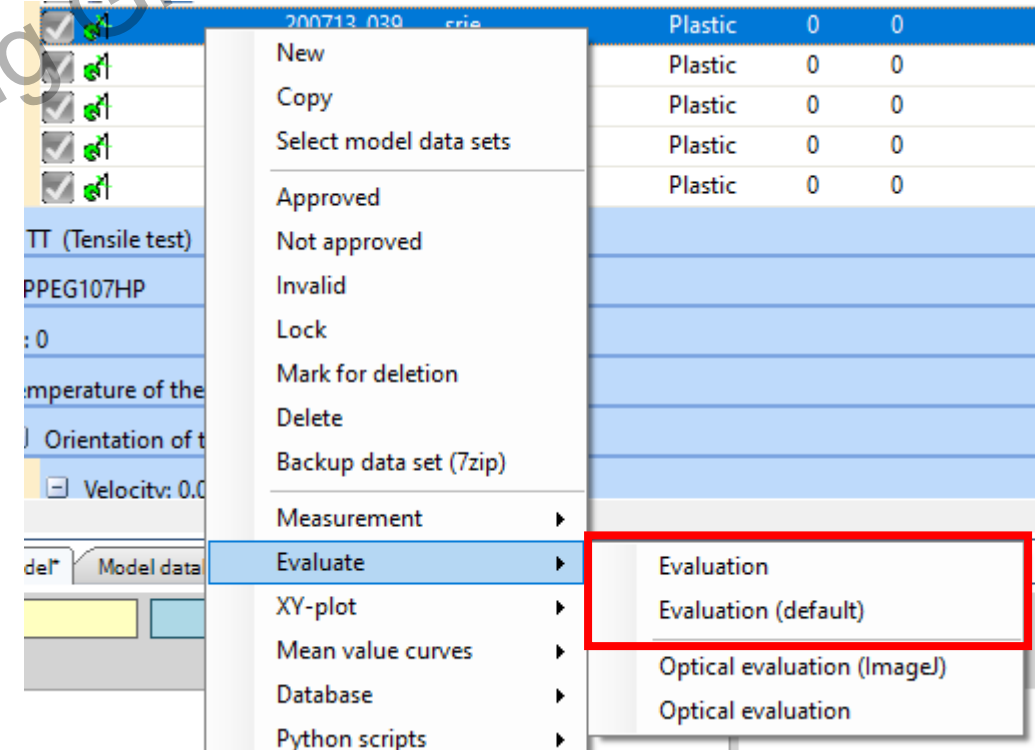
The first symbol in the first row is for the user to mark the data sets. By right-clicking, the data sets can be marked with the following symbols:

-  invalid data set
-  check the measurement in regard to the upper/lower limit of the used sensor
-  unapproved data set
-  approved data set
-  data set marked for deleting
-  data set is compressed (7-zip)
-  data set is locked (invalid data set)
-  data set is locked (approved data set)

The second symbol shows the status of the data set:

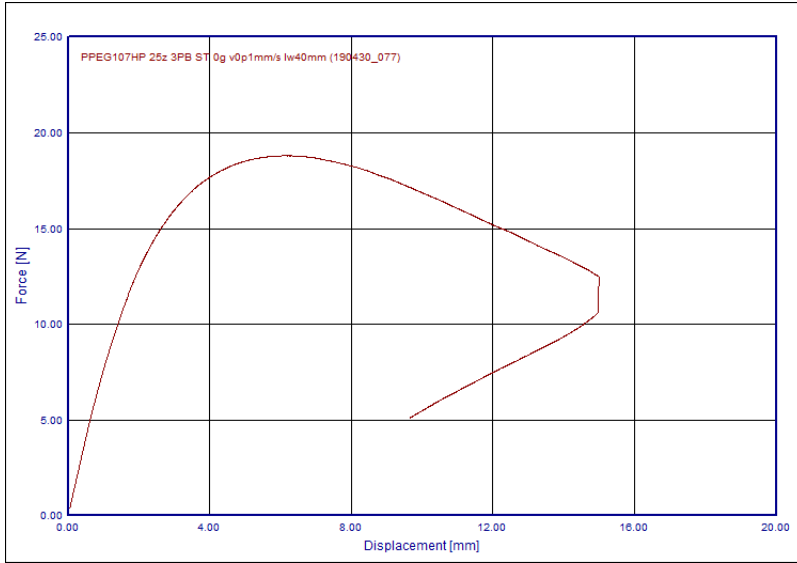
-  new created data set
-  an error occurred in the measurement
-  an error occurred during saving
-  the test was run successfully and saved
-  the test has been evaluated

**A successfully evaluated data set**

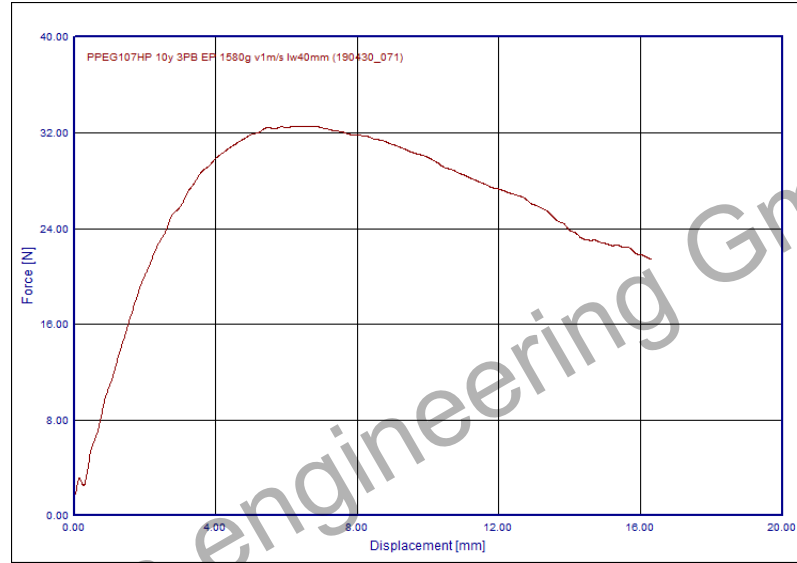


# VALIMAT® - Basic information of evaluating data sets

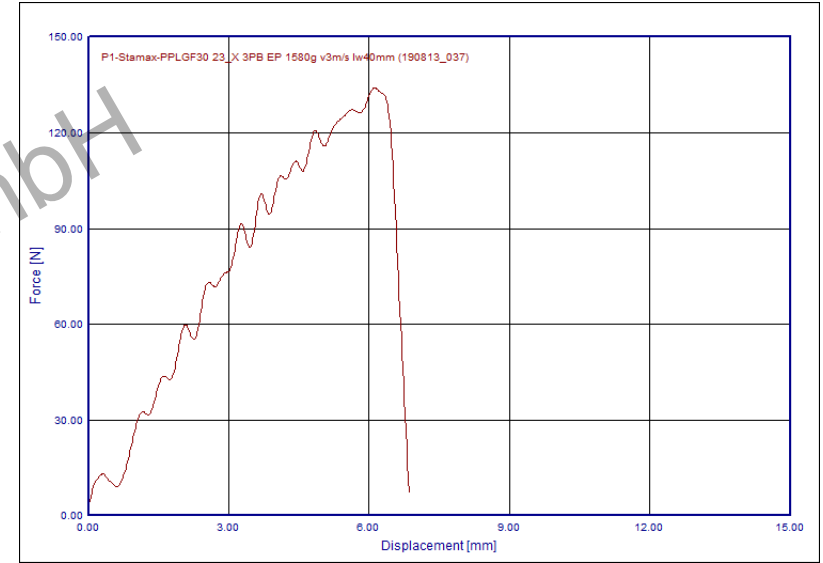
## R Recovery was detected



## D Deformed specimen



## B Clear failure was detected



Test Test database

	Date_Nr
<input checked="" type="checkbox"/> <input type="checkbox"/> <b>R</b>	190430_077

- + General information
- + Test setup
- + Test specimen
- Evaluation

Filter 0 no filter

## M Manual failure detection

# VALIMAT® - evaluation

- Filter measurement data



# VALIMAT

engineering plastics  
production  
simulation  
lightweight prototypes  
**smart evaluation**

The screenshot shows the VALIMAT software interface. A window titled 'Test database' is open, displaying a table of test data. A red box highlights a specific entry in the table, which is then shown in a larger 'Filter' configuration window. This window has a tree view on the left with categories like 'General information', 'Test setup', 'Test specimen', and 'Evaluation'. Under 'Evaluation', a list of filter settings is shown, with 'Filter' set to '2000 CFC SAE Class'. Below the list, there is a 'Filter' section with a description: 'Setting of a filter to smooth the measurement signal. NEW: 5 CFC SAE velocity optimum -> Uses the sensor-manufacturer recommended filter frequency'.

Filter	Value
Filter	2000 CFC SAE Class
Evaluation of displacement	4000 CFC SAE Class
Evaluation of the velocity	3000 CFC SAE Class
Zero-point evaluation	2500 CFC SAE Class
Identification of failure	2000 CFC SAE Class
Stress evaluation	1500 CFC SAE Class
Stiffness evaluation	1000 CFC SAE Class
Results	600 CFC SAE Class
	300 CFC SAE Class
	180 CFC SAE Class
	60 CFC SAE Class



# VALIMAT<sup>®</sup> - evaluation

- Evaluation of the displacement



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**smart evaluation**

Filter	2000 CFC SAE Class
<b>Evaluation of displacement</b>	Angle
Evaluation of the velocity	Angle
Zero-point evaluation	Acceleration
Identification of failure	1 - automatic
Stress evaluation	
Stiffness evaluation	
Results	

**Evaluation of displacement**  
Evaluation of displacement (In Tensile Impact Test also for acceleration and velocity)



# VALIMAT® - evaluation

- Evaluation of the velocity



# VALIMAT

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smart evaluation  
concepts simulation  
lightweight prototypes

The screenshot shows the VALIMAT software interface. A red box highlights a section of the interface, which is shown in a larger, detailed view below. The detailed view shows a table with the following data:

Filter	2000 CFC SAE Class
Evaluation of displacement	Angle
Evaluation of the velocity	1 - Angle sensor
v0	0 - Manual setting
Zero-point evaluation	1 - Angle sensor
Identification of failure	1 - automatic
Stress evaluation	
Stiffness evaluation	
Results	

Below the table, there is a section titled "Evaluation of the velocity" with the text "Type of evaluation of the velocity".

# VALIMAT<sup>®</sup> - evaluation

- Zero-point-evaluation



# VALIMAT

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lightweight prototypes

Test Test database

Date_Nr	
190813_037	
<input checked="" type="checkbox"/>	General information
<input checked="" type="checkbox"/>	Test setup
<input checked="" type="checkbox"/>	Test specimen
<input checked="" type="checkbox"/>	Evaluation
Filter	2000 CFC SAE Class
Evaluation of displacement	Angle
<input type="checkbox"/> Evaluation of the velocity	1 - Angle sensor
v0	2.985525
<input checked="" type="checkbox"/> Zero-point evaluation	5 - Accelerationsignal (without filter ▾)
<input checked="" type="checkbox"/> Identification of failure	0 - Manual (point in time)
<input checked="" type="checkbox"/> Stress evaluation	1 - Support
<input checked="" type="checkbox"/> Stiffness evaluation	2 - Accelerationsignal
<input checked="" type="checkbox"/> Results	4 - Support (without filter)
	5 - Accelerationsignal (without filter)
	6 - Contactangle
<b>Zero-point evaluation</b>	7 - Extrapolation force-displacement gradient

The zero-point of the measurement curve can be evaluated manually or using a specified function

# VALIMAT® - evaluation

- Identification of failure



engineering plastics production smart evaluation concepts simulation lightweight prototypes

The screenshot shows the VALIMAT software interface. A foreground window titled 'Test database' displays a table of evaluation parameters. The 'Identification of failure' section is highlighted in blue. The background monitor shows a data table and two line graphs.

Test	Date_Nr
190813_037	

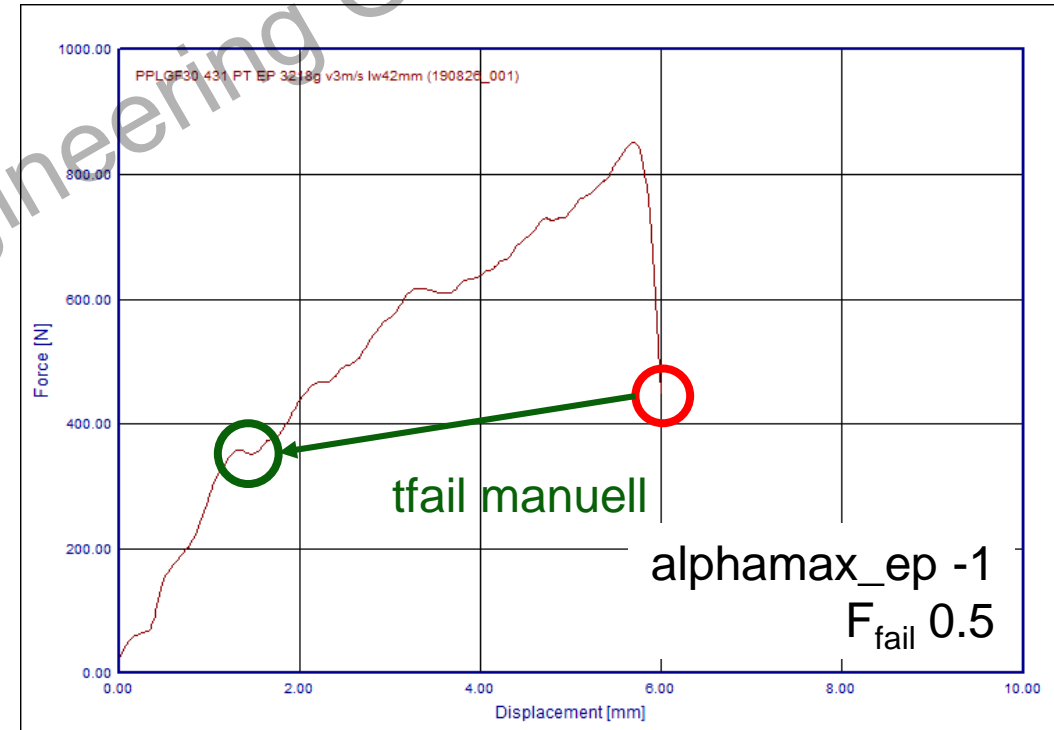
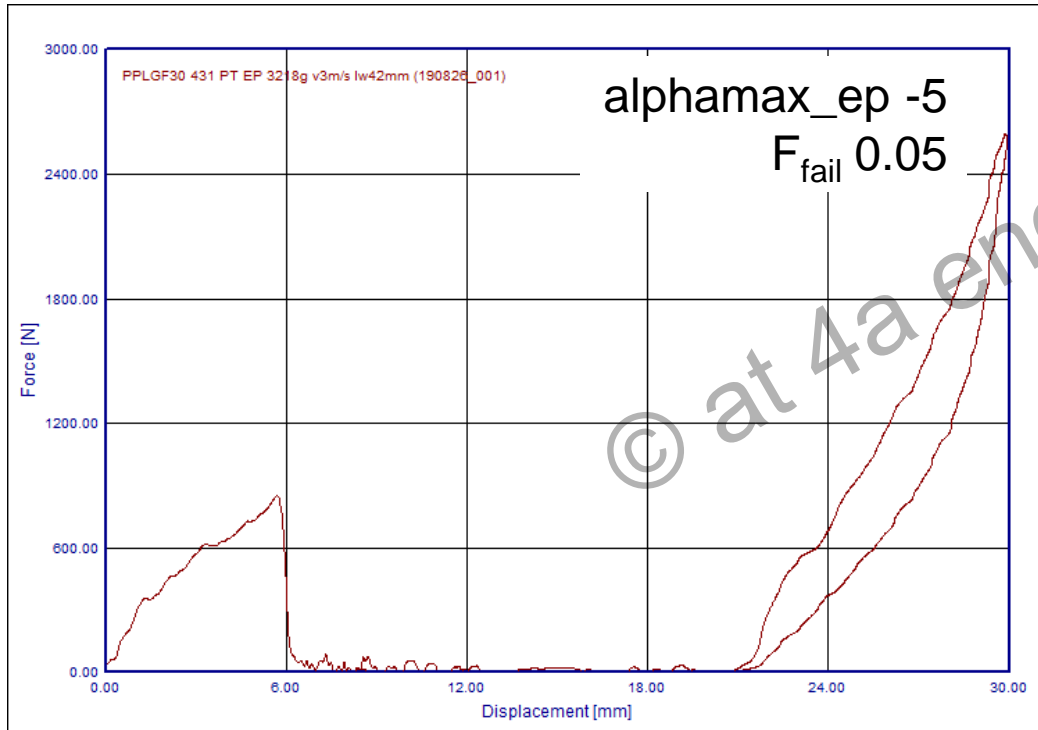
  

Evaluation	
Filter	2000 CFC SAE Class
Evaluation of displacement	Angle
Evaluation of the velocity	1 - Angle sensor
v0	2.985525
Zero-point evaluation	5 - Accelerationsignal (without filter)
Identification of failure	1 - automatic
tend	0 - Manual (point in time)
tfail	1 - automatic
alphamax_ep	-5
alphamax_dp	-5
Ffail	0.05
tfailfac	10
Fperc	0.8
troupefac	20

**Identification of failure**  
Includes all factors to identify failure during measurement

# VALIMAT® - Identification of failure manual failure settings (e.g. puncture test)

- $\text{alphamax\_ep}$  -5 (default value)  $\rightarrow$  -1 (limit the max. angle of evaluation)
- $F_{\text{fail}}$  – factor 0.05 (default value)  $\rightarrow$  0.5 (Force drop to 50% for the end point)
- The impact of the buffer is now not evaluated  $\rightarrow$  result of energy is correct



# VALIMAT® - evaluation

- Stress / strain evaluation



# VALIMAT

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simulation  
lightweight prototypes  
**smart evaluation**

The screenshot shows the VALIMAT software interface. On the left, a 'Test database' window displays a table with columns for 'Date\_Nr' and 'Filter'. The 'Filter' column contains '2000 CFC SAE Class'. Below the table, a tree view shows 'Evaluation' expanded, with 'Evaluation bending' selected. The 'Evaluation bending' section contains a table with the following data:

Filter	Value
2000 CFC SAE Class	
Evaluation of displacement	Angle
Evaluation of the velocity	1 - Angle sensor
v0	2.985525
Zero-point evaluation	5 - Accelerationsignal (without filter)
Identification of failure	1 - automatic
Stress evaluation	
Evaluation bending	Norm (elastic)
No evaluation	
4a solver for bending	
Norm (elastic)	
Norm (elastic + large deflection, EN ISO 14125:1998 + AC:2002 + A1:2011)	
Norm (elastic, 4 Pt-Bending)	

On the right, a graph displays stress-strain curves for different test conditions. A red box highlights the graph area, and a red line connects it to the 'Evaluation bending' section of the table.

# VALIMAT<sup>®</sup> - evaluation

- Results



# VALIMAT

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production  
simulation  
lightweight prototypes  
**smart evaluation**

The image shows a computer monitor displaying the VALIMAT software interface. A red box highlights a specific section of the software, which is a detailed view of a test evaluation. This view includes a table with various parameters and their values, and a graph showing test results. The highlighted section is titled 'Test database' and contains the following data:

Test	Date_Nr
✓	190813_037

Below the table, there are several expandable sections:

- General information**
- Test setup**
- Test specimen**
- Evaluation**
  - Filter: 2000 CFC SAE Class
  - Evaluation of displacement: Angle
  - Evaluation of the velocity: 1 - Angle sensor
    - v0: 2.985525
  - Zero-point evaluation: 5 - Accelerationsignal (without filter)
  - Identification of failure: 1 - automatic
  - Stress evaluation
    - Evaluation bending: Norm (elastic)
  - No evaluation
  - 4a solver for bending
    - Norm (elastic)
    - Norm (elastic + large deflection, EN ISO 14125:1998 + AC:2002 + A1:2011)
    - Norm (elastic, 4 Pt-Bending)

# VALIMAT® - Setting options in the evaluation

- Filter
- Evaluation of the displacement
- Evaluation of the velocity
- Zero-point-evaluation
- Identification of failure
- Stress / strain evaluation
- Results

Valimat ver. 3.7

Database

- Data directory
- Test plan
- DB-Import

Test data

- New
- Copy

Measurement

- Setup / Start
- Import
- Show curves

Evaluation of the test

- Evaluate
- Load Plots
- Unload Plots
- Mean value plots

Parameter model

- New
- Copy

Optimization

- Create
- Edit
- Start

Test database Measurement Report Measurement curves Viewer a(t) v(t)

Date\_Nr  
190813\_037

**General information**

**Test setup**

**Test specimen**

**Evaluation**

Filter	2000 CFC SAE Class
Evaluation of displacement	Angle
<input type="checkbox"/> Evaluation of the velocity	1 - Angle sensor
v0	2.985525
<input type="checkbox"/> Zero-point evaluation	5 - Accelerationsignal (without filter)
t0	0.0070167
<input type="checkbox"/> Identification of failure	1 - automatic
tend	0.0093765
tfail	0.0093765
alphamax_ep	-5
alphamax_dp	-5
Ffail	0.05
tfailfac	10
Fperc	0.8
trecovfac	20
b_criterium	0
<input type="checkbox"/> Stress evaluation	
Evaluation bending	Norm (elastic)
<input type="checkbox"/> Stiffness evaluation	
fperc_lo	0.1
fperc_up	0.3
<b>Results</b>	



# Thank you for your Attention!

4a summer-school - webinar and training  
Evaluating and checking test data  
Interpretation of typical results

SAVE THE DATE

**15. general yield surface (\*MAT\_187) and other material models, failure approaches and comprehensive Autofit setup**



more information on our software

$\alpha$   
Anisotropic

$\epsilon_p$   
Damage/Failure

$\Phi_p$   
Triaxiality

$\sigma_{vm}$   
Hardening

[www.4a-engineering.at/valimat](http://www.4a-engineering.at/valimat)



comprehensive test package overview

[www.4a-engineering.at/test-packages](http://www.4a-engineering.at/test-packages)