Chemistry is our world, Responsibility is our way

Cécile DEMAIN - Confidentiel

Simulation Engineer
Part Simulation and Validation Laboratory
POLYAMIDE Group
Lyon Research and Technology Center

European Users Conference 2011

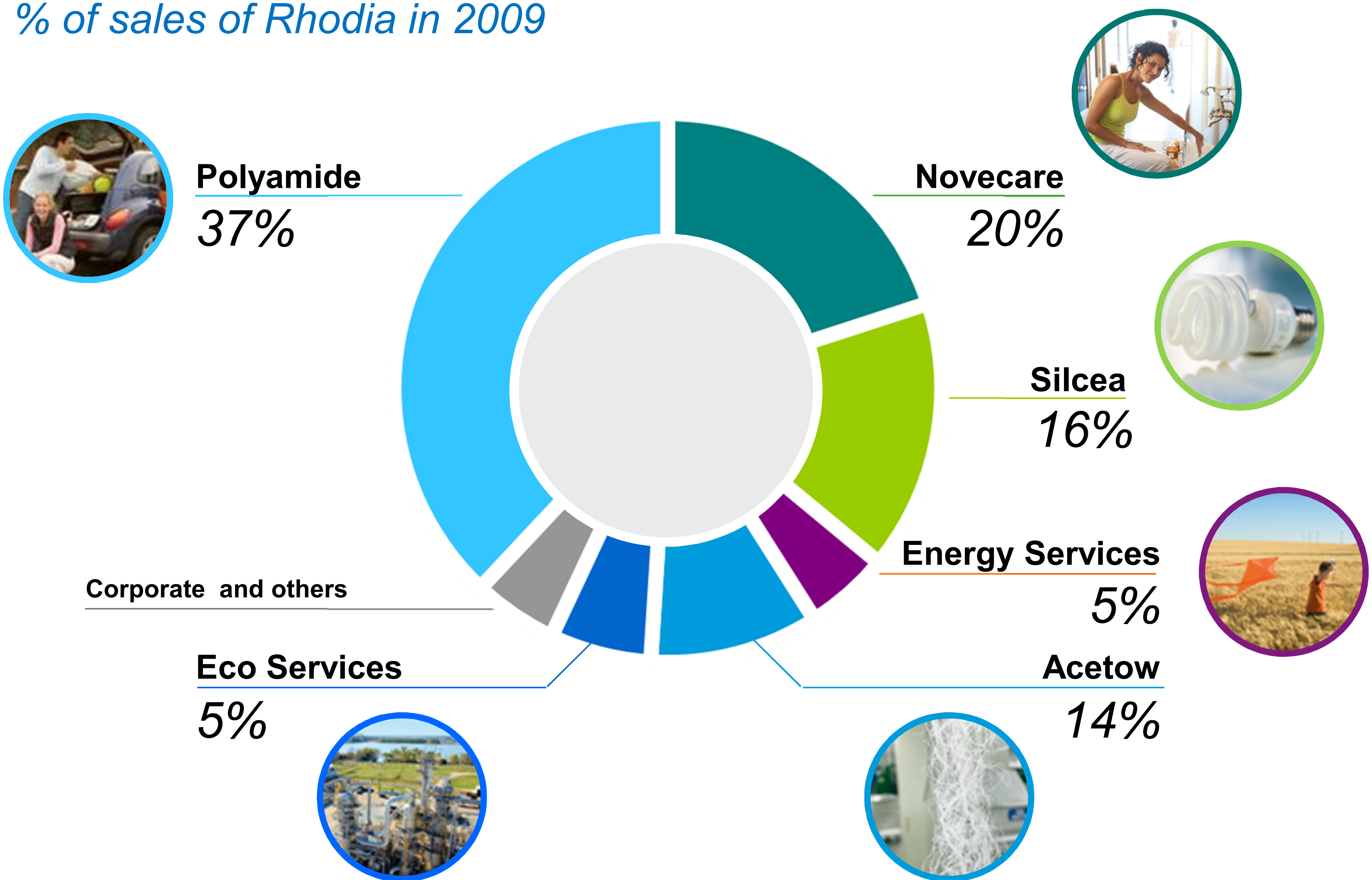
Improving the Prediction of LS-DYNA Calculations with Rhodia Data and Digimat

Summary

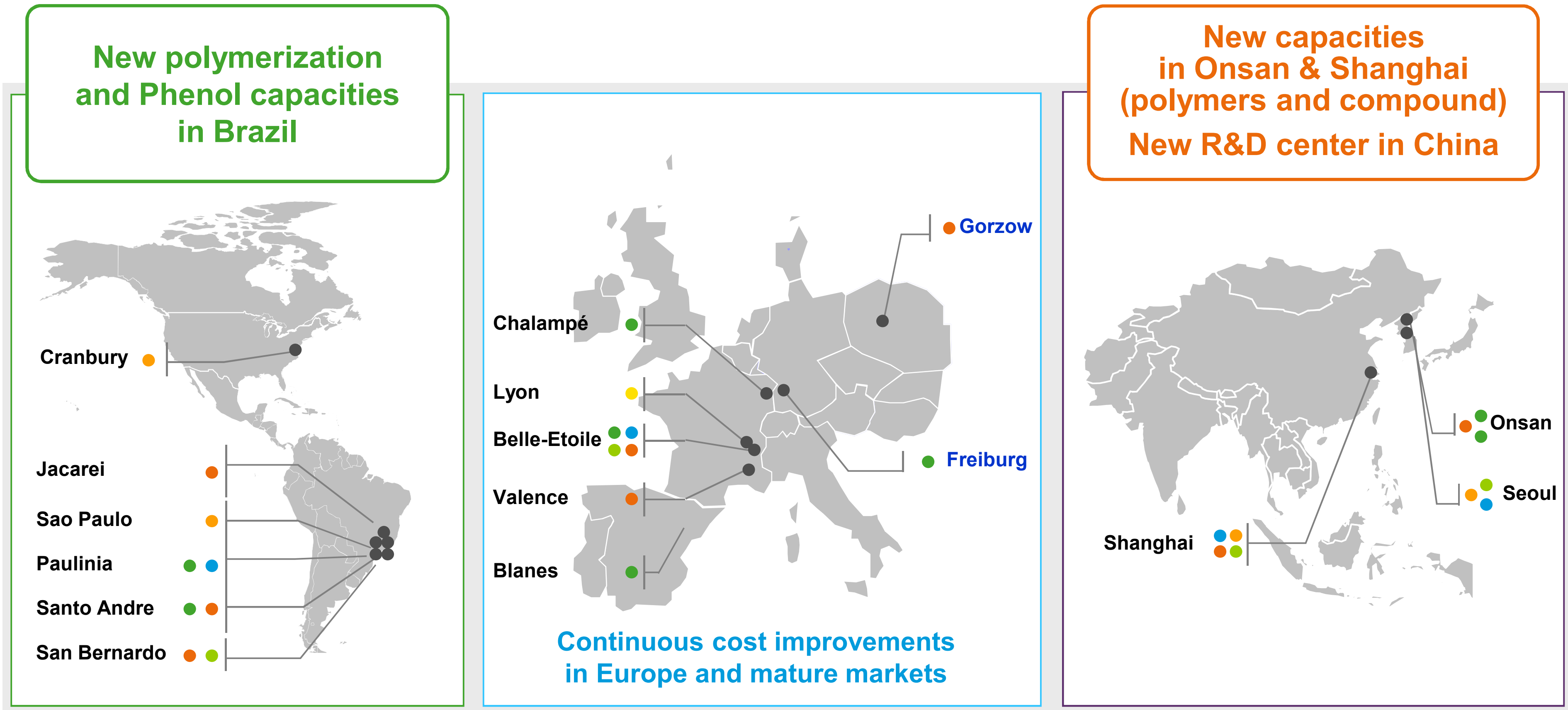
- RHODIA Polyamide
- MMI ConfidentDesign
  - Matrix behavior
  - Composite behavior
- Presentation of the MMI Beam
  - Injection & Microstructure
- Correlation using DIGIMAT to LS-DYNA
  - Material behavior
  - Model and results
- Conclusions

RHODIA : Six enterprises, leaders in their markets

% of sales of Rhodia in 2009



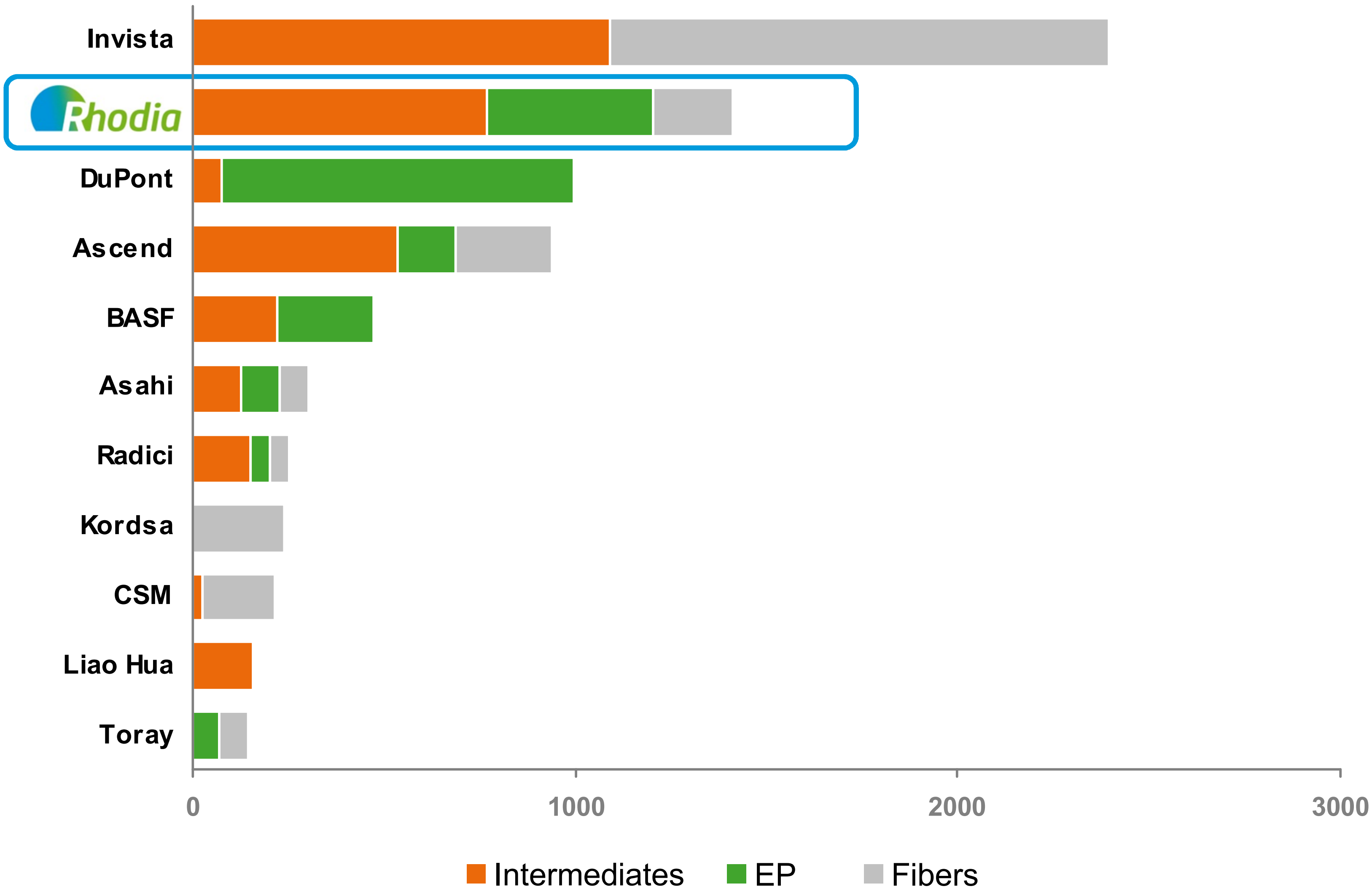
RHODIA Global presence



- Worldwide Headquarter
- Regional Headquarter
- Application & Technology Development Centre
- R&D Centers
- Manufacturing Plant upstream
- Manufacturing Plant downstream

RHODIA is the only fully integrated Polyamide 6.6 player with a strong position in Engineering Plastics

2008 Sales in €m*



* Rhodia estimates

Cécile DEMAIN - Confidentiel

Simulation Engineer
Part Simulation and Validation Laboratory
POLYAMIDE Group
Lyon Research and Technology Center

MMI Confident Design

Powered by DIGIMAT

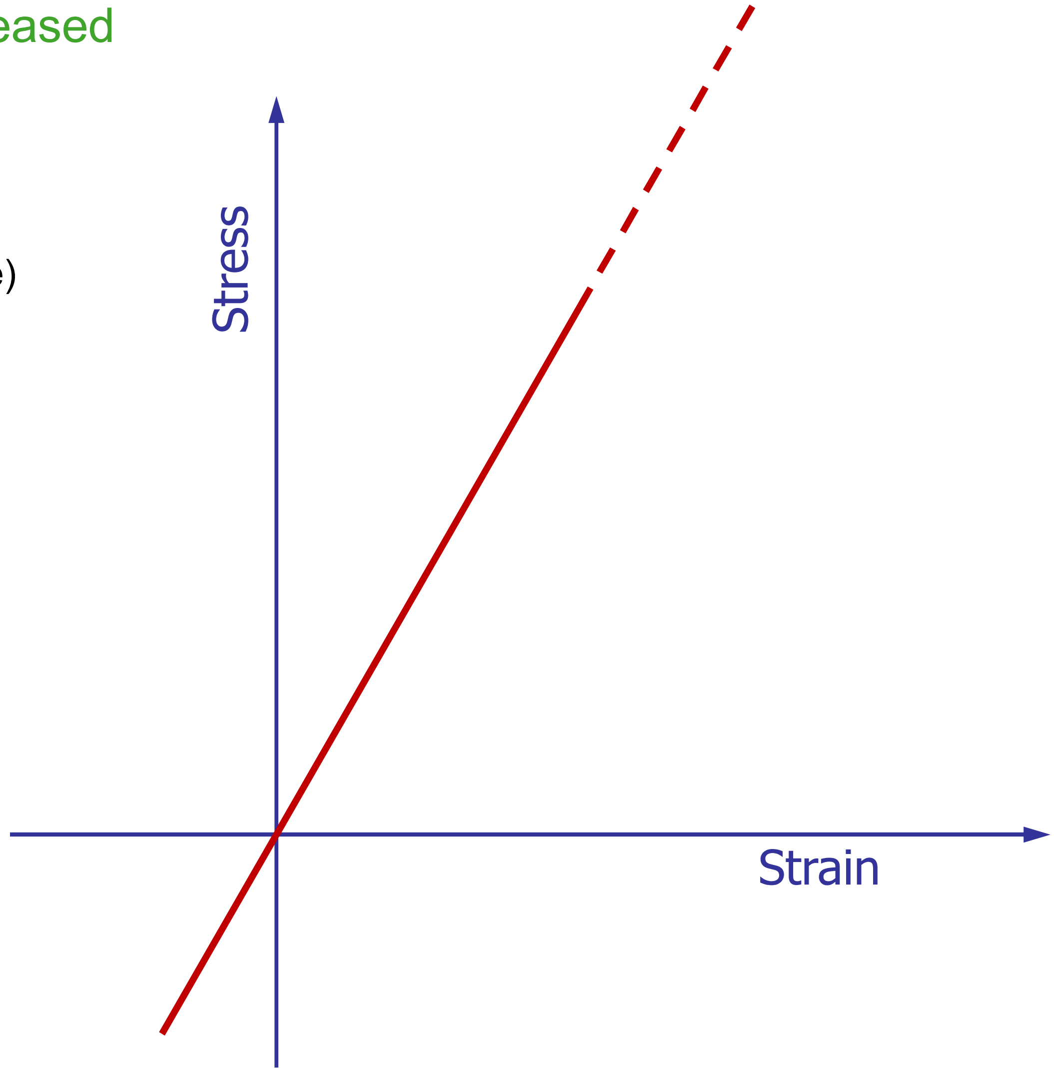
The TOOLS, The DATA and The EXPERTIZE that you need to develop optimal polyamide parts.

Summary

- RHODIA Polyamide
- MMI ConfidentDesign
  - Matrix behavior
  - Composite behavior
- Presentation of the MMI Beam
  - Injection & Microstructure
- Correlation using DIGIMAT to LS-DYNA
  - Material behavior
  - Model and results
- Conclusions

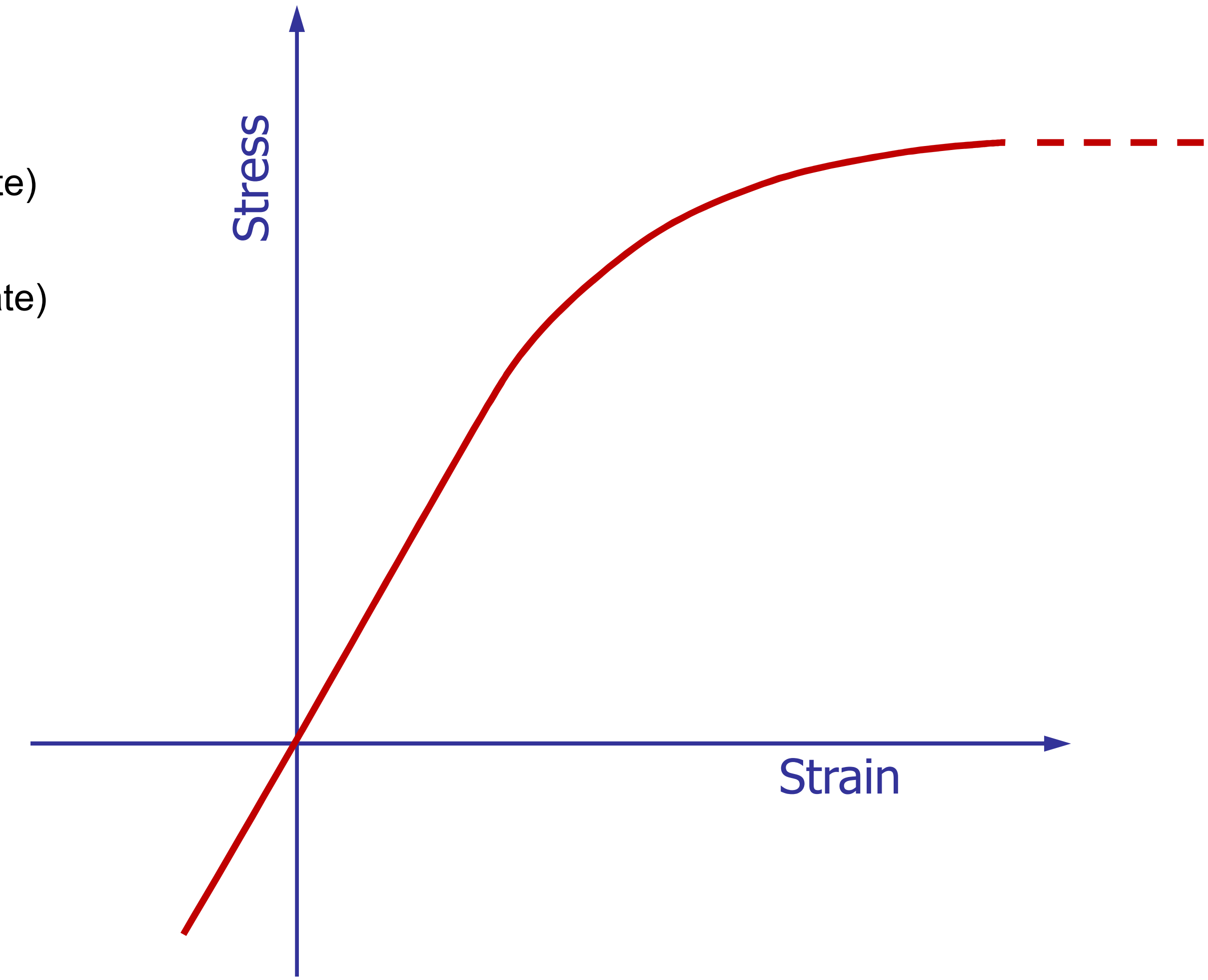
TECHNYL® polyamide matrix behavior

- Constitutive models of increased complexity :
  - Elastic
    - =f(temperature, strain rate)



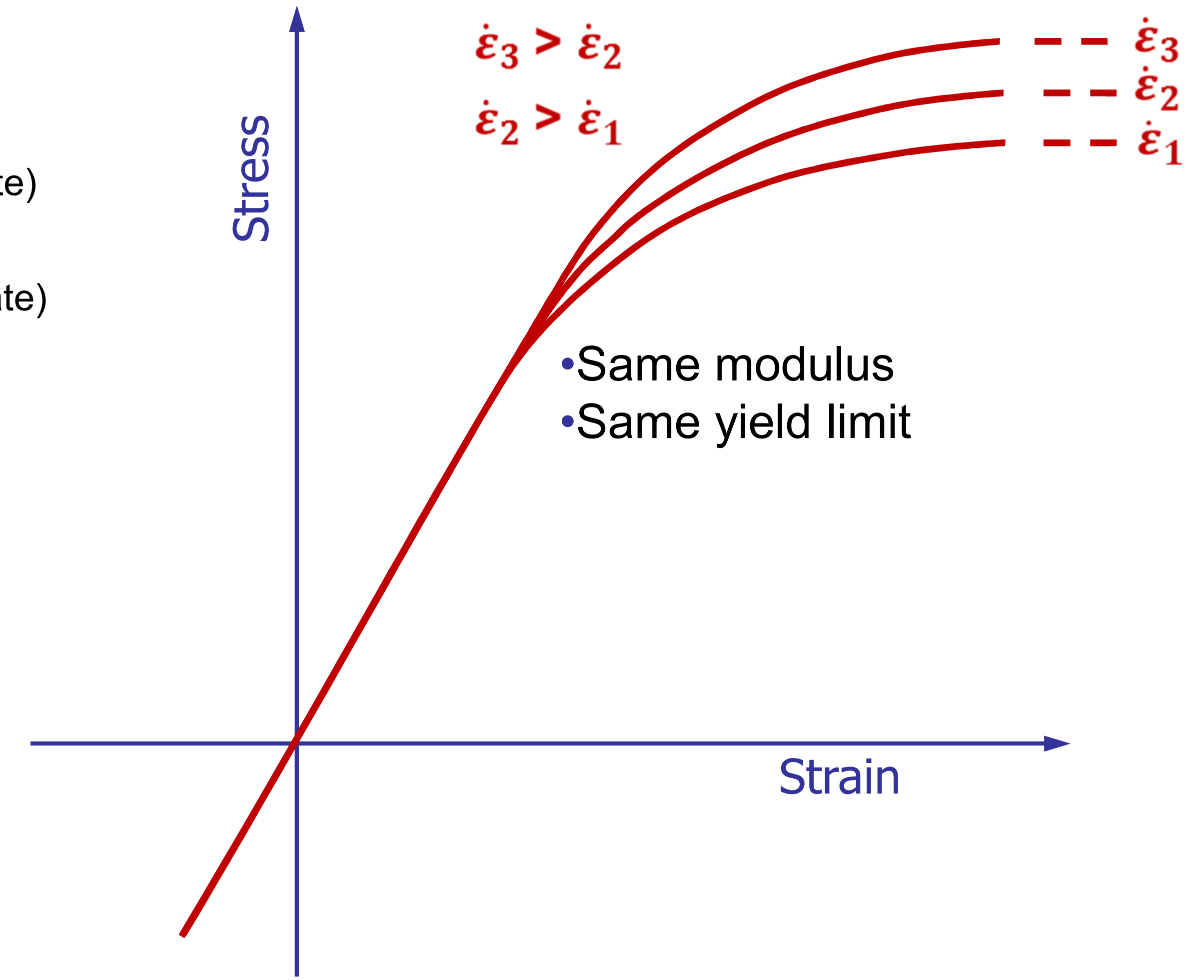
TECHNYL® polyamide matrix behavior

- Constitutive models of increased complexity :
  - Elastic
    - =f(temperature, strain rate)
  - Elastoplastic
    - = f(temperature, strain rate)



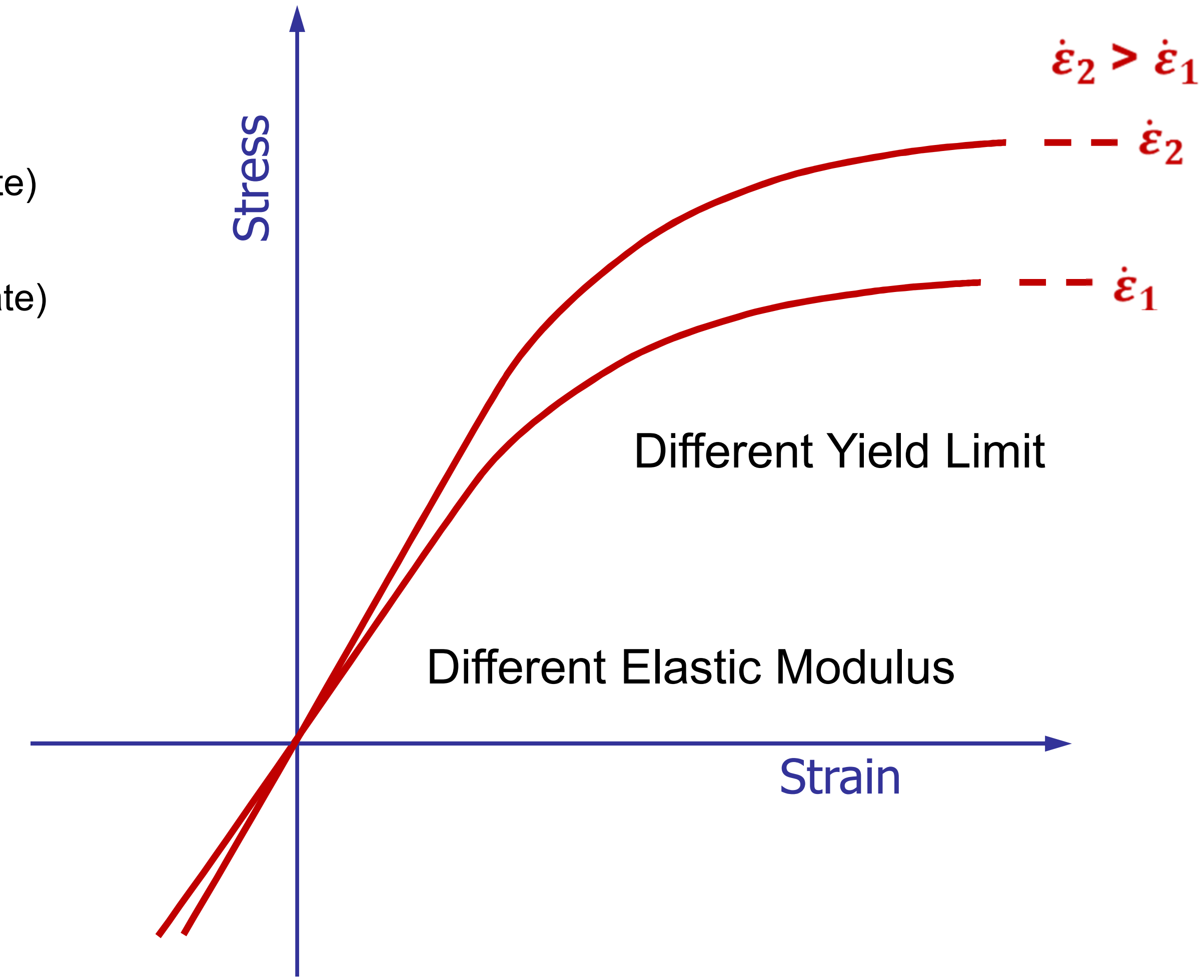
TECHNYL® polyamide matrix behavior

- Constitutive models of increased complexity :
  - Elastic
    - =f(temperature, strain rate)
  - Elastoplastic
    - = f(temperature, strain rate)
  - Elasto-viscoplastic
    - = f(temperature)



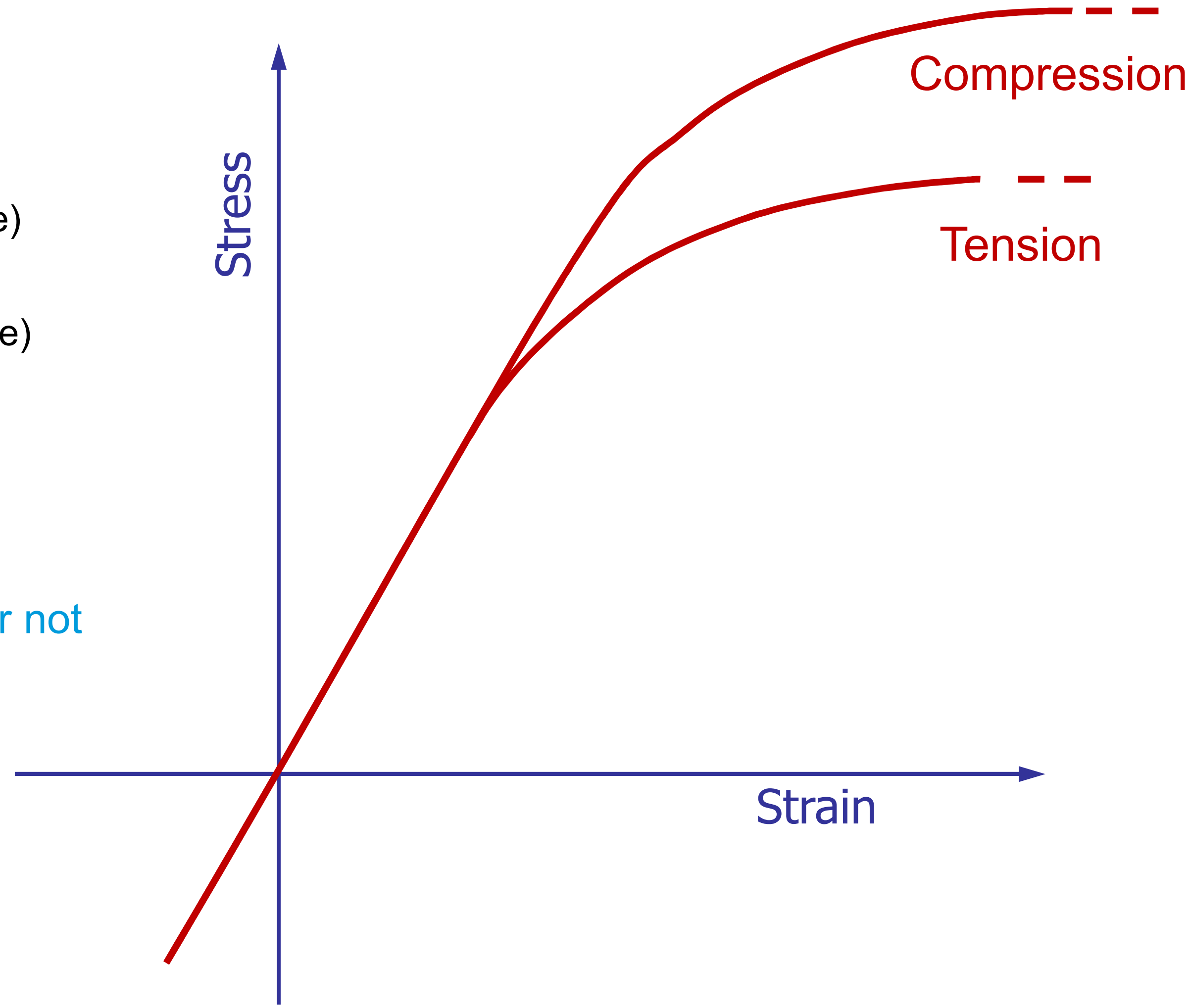
TECHNYL® polyamide matrix behavior

- Constitutive models of increased complexity :
  - Elastic
    - =f(temperature, strain rate)
  - Elastoplastic
    - = f(temperature, strain rate)
  - Elasto-viscoplastic
    - = f(temperature)
  - Viscoelastic-viscoplastic
    - = f(temperature)



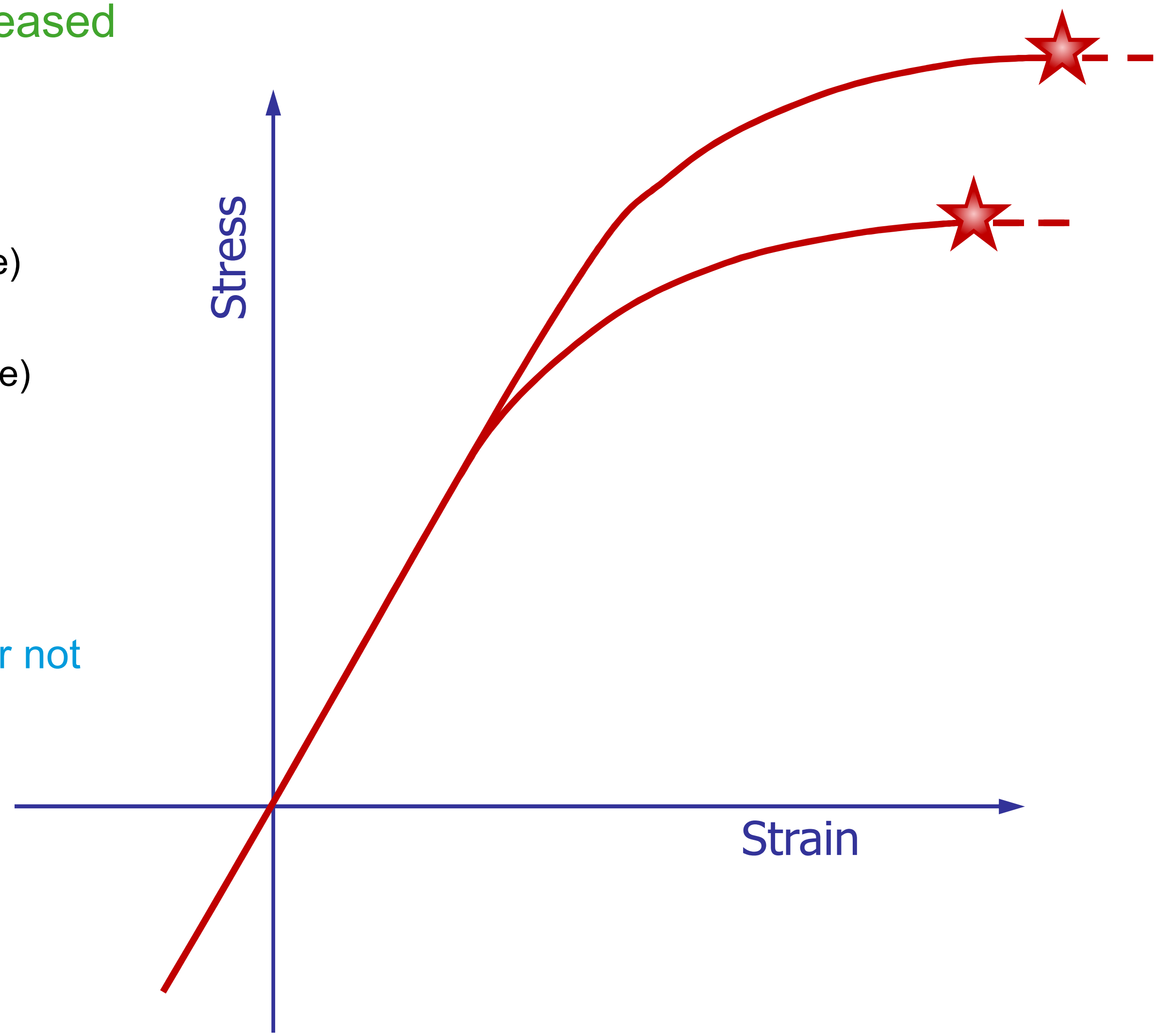
TECHNYL® polyamide matrix behavior

- Constitutive models of increased complexity :
  - Elastic
    - =f(temperature, strain rate)
  - Elastoplastic
    - = f(temperature, strain rate)
  - Elasto-viscoplastic
    - = f(temperature)
  - Viscoelastic-viscoplastic
    - = f(temperature)
  - Yield surface dependant or not
    - Tension = compression
    - Tension<>compression



TECHNYL® polyamide matrix behavior

- Constitutive models of increased complexity :
  - Elastic
    - =f(temperature, strain rate)
  - Elastoplastic
    - = f(temperature, strain rate)
  - Elasto-viscoplastic
    - = f(temperature)
  - Viscoelastic-viscoplastic
    - = f(temperature)
  - Yield surface dependant or not
    - Tension = compression
    - Tension<>compression
  - Failure criteria

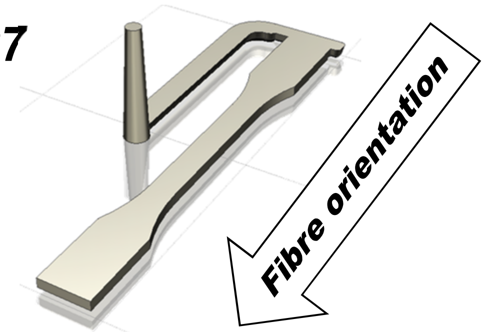


Summary

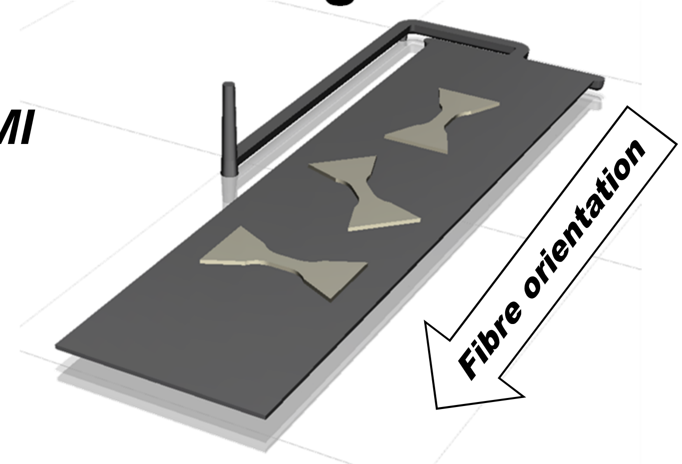
- RHODIA Polyamide
- MMI ConfidentDesign
  - Matrix behavior
  - Composite behavior
- Presentation of the MMI Beam
  - Injection & Microstructure
- Correlation using DIGIMAT to LS-DYNA
  - Material behavior
  - Model and results
- Conclusions

Better TECHNYL® composite understanding.

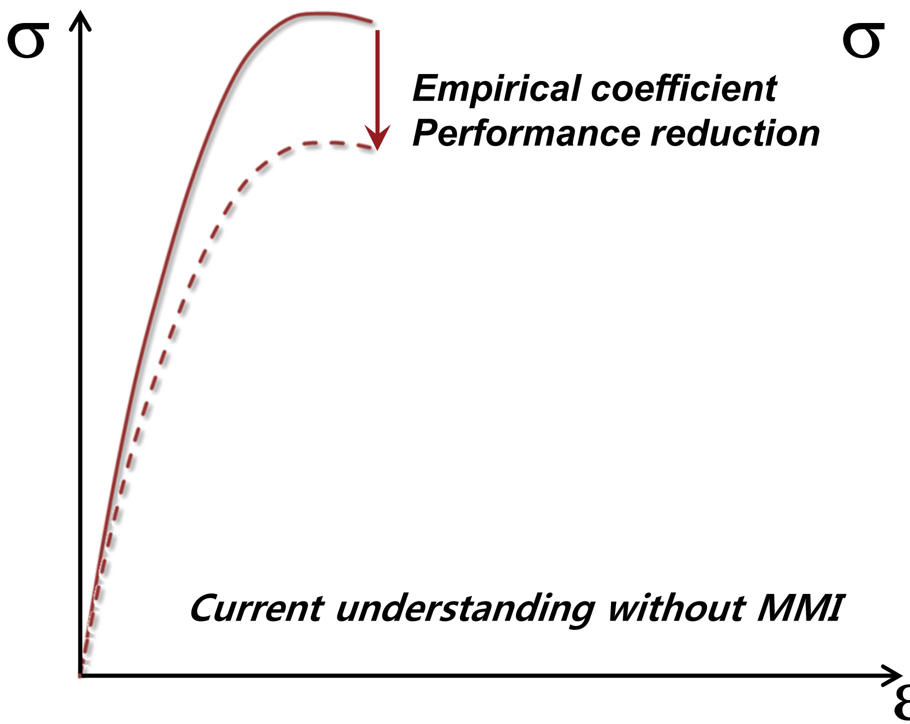
ISO 527

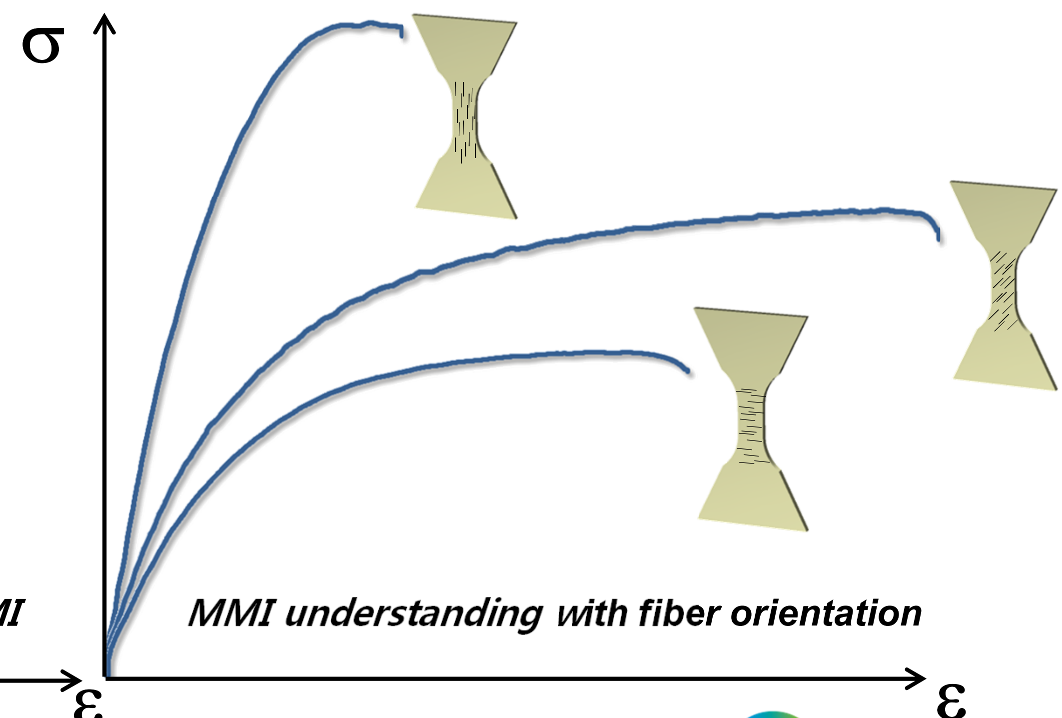


MMI

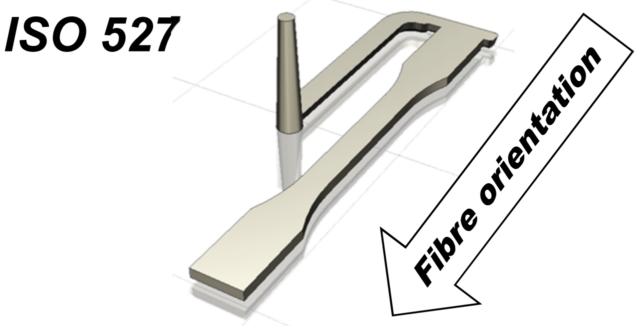


Same material !

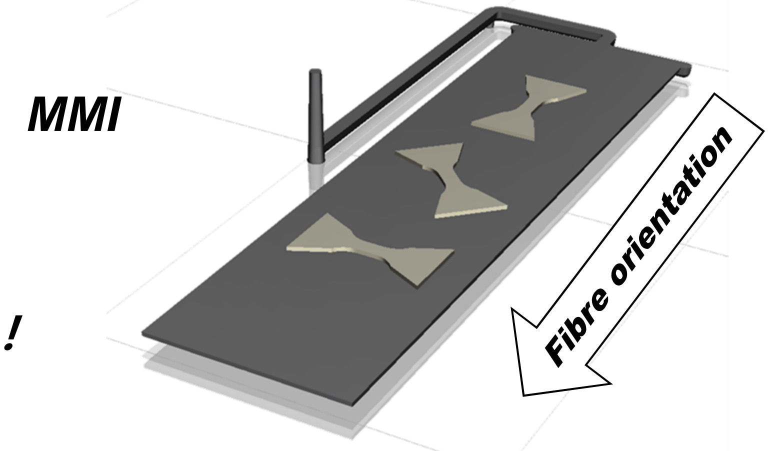


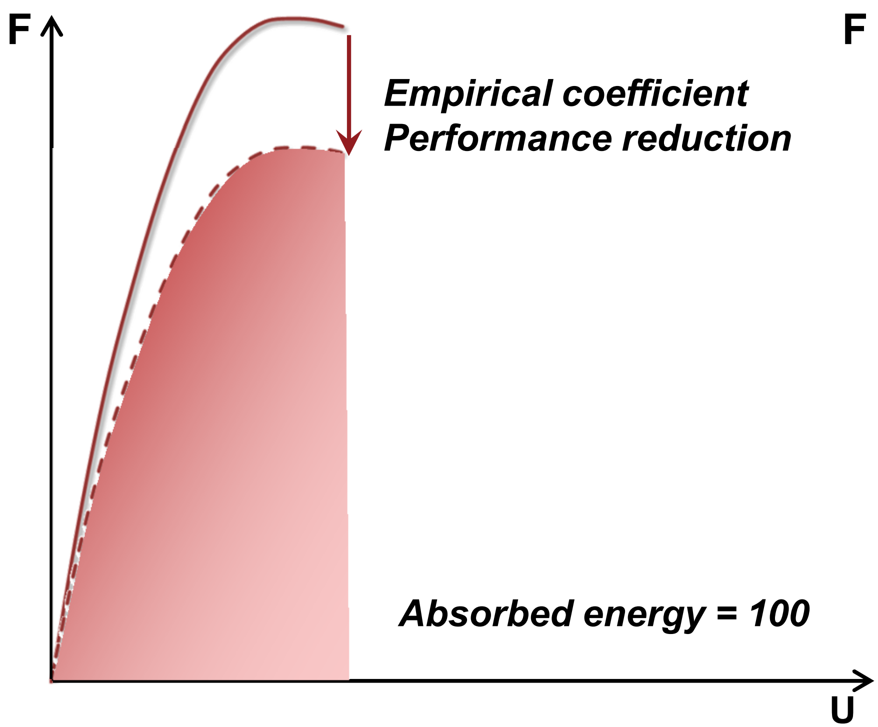


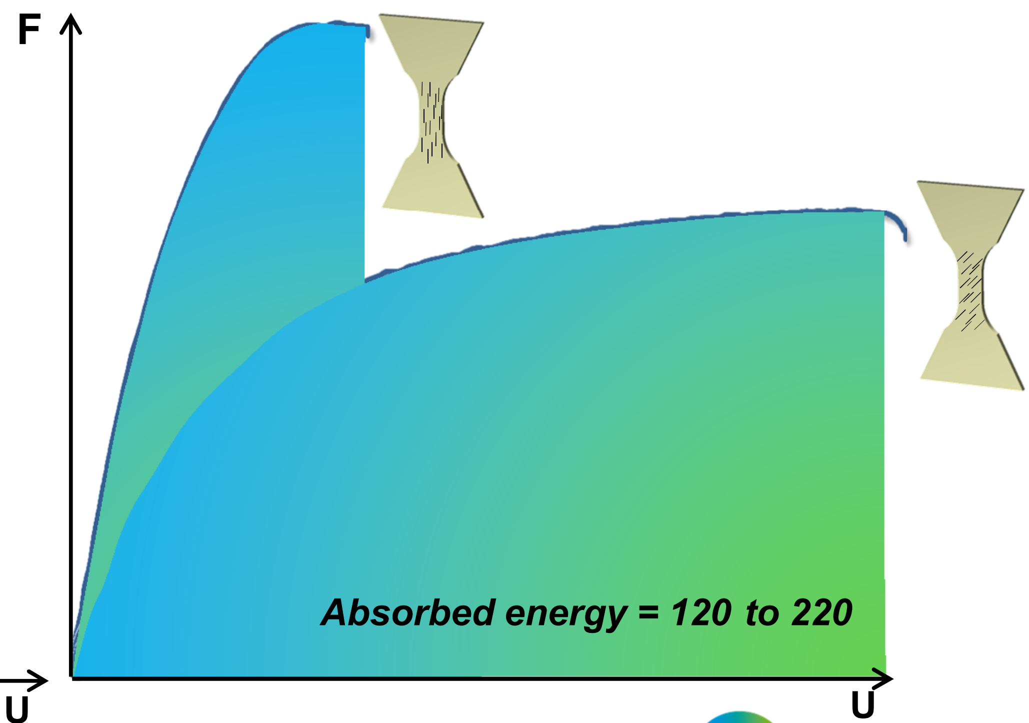
Better TECHNYL® composite understanding.



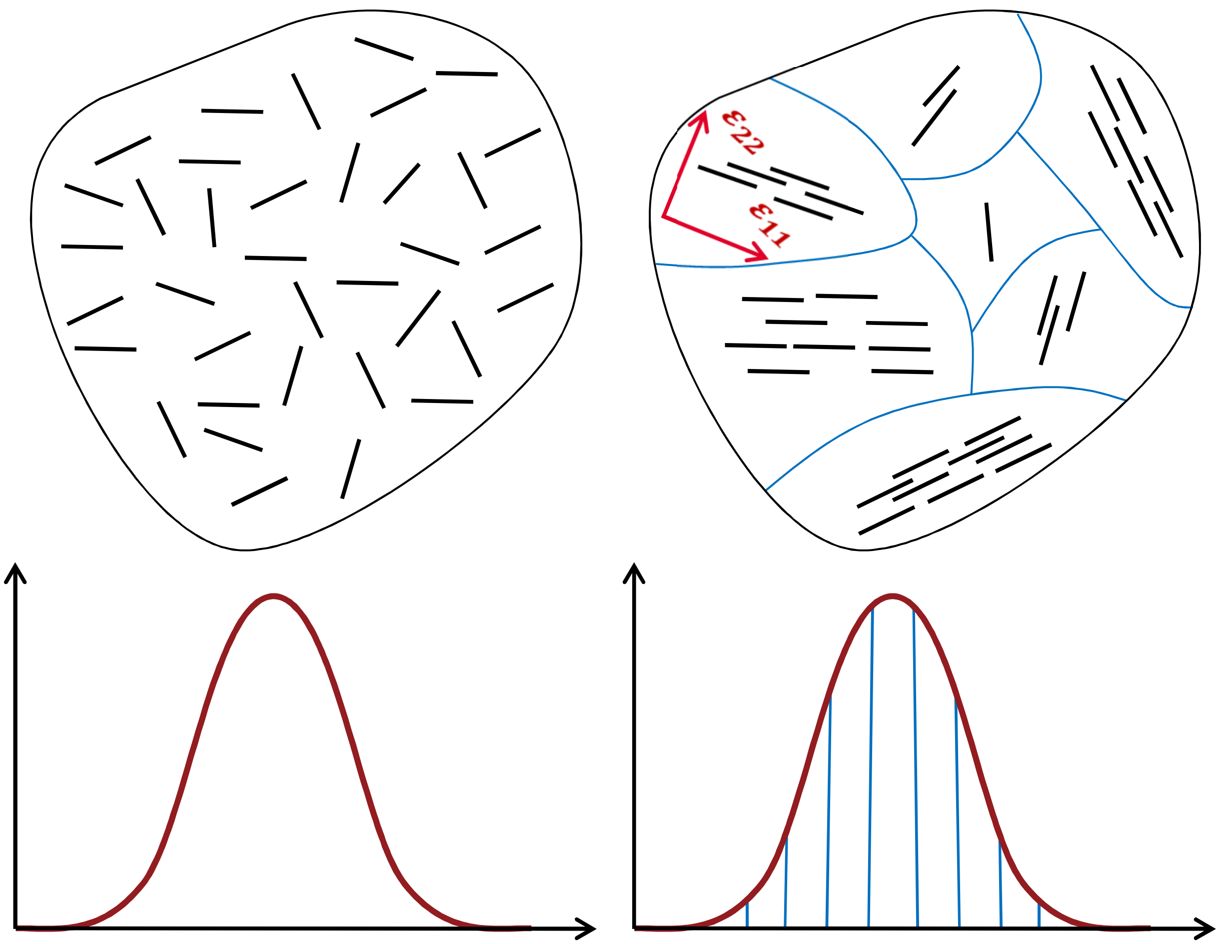
Same material !







First Pseudo Grain Failure at integration point



Apply failure indicators on unidirectional composite pseudo grain :

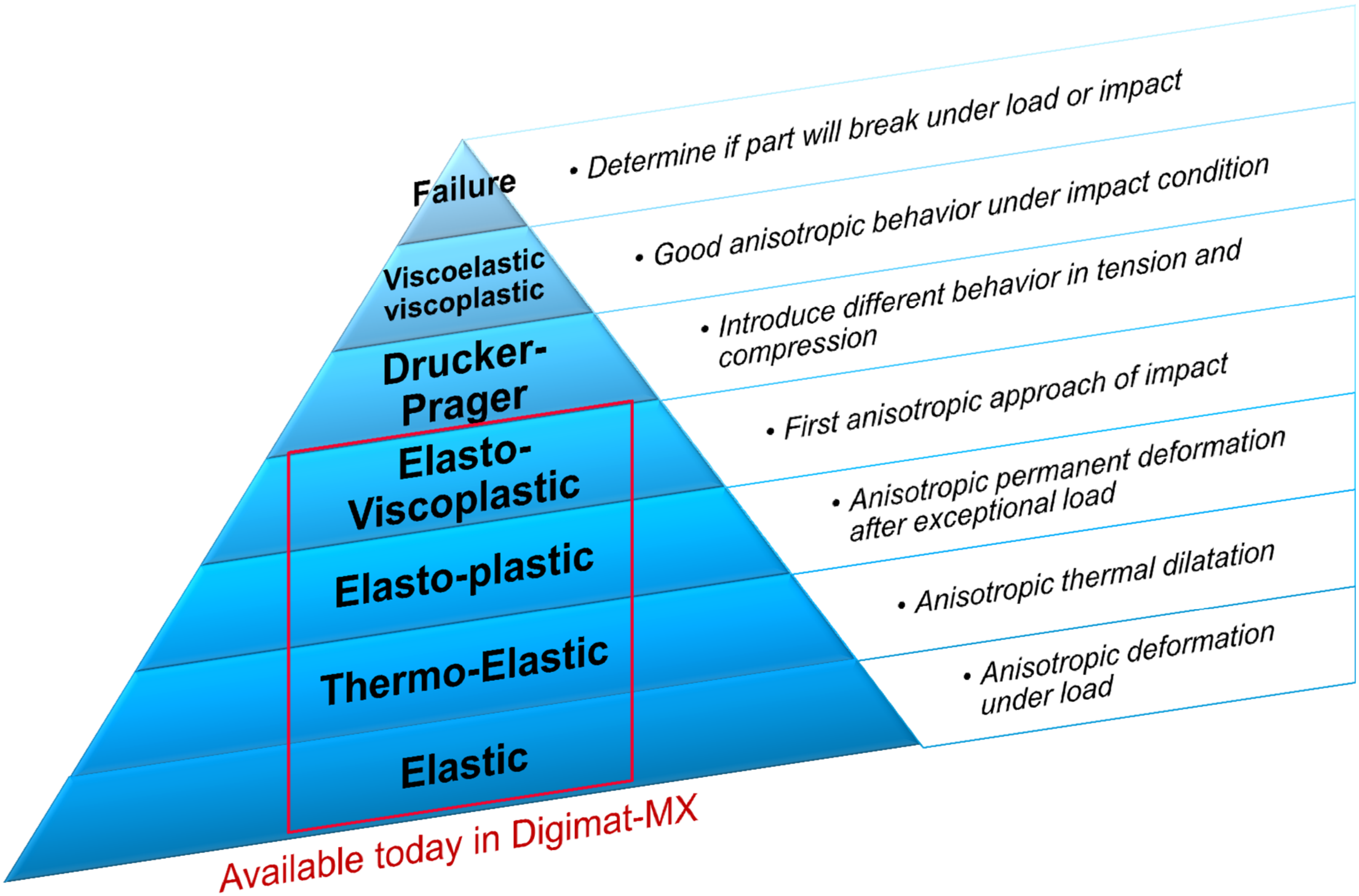
Tsaï Hill 2D strain

$$f_A = \frac{\varepsilon_{11}^2}{X_\varepsilon^2} - \frac{\varepsilon_{11}\varepsilon_{22}}{X_\varepsilon^2} + \frac{\varepsilon_{22}^2}{Y_\varepsilon^2} + \frac{4\varepsilon_{12}^2}{S_\varepsilon^2}$$

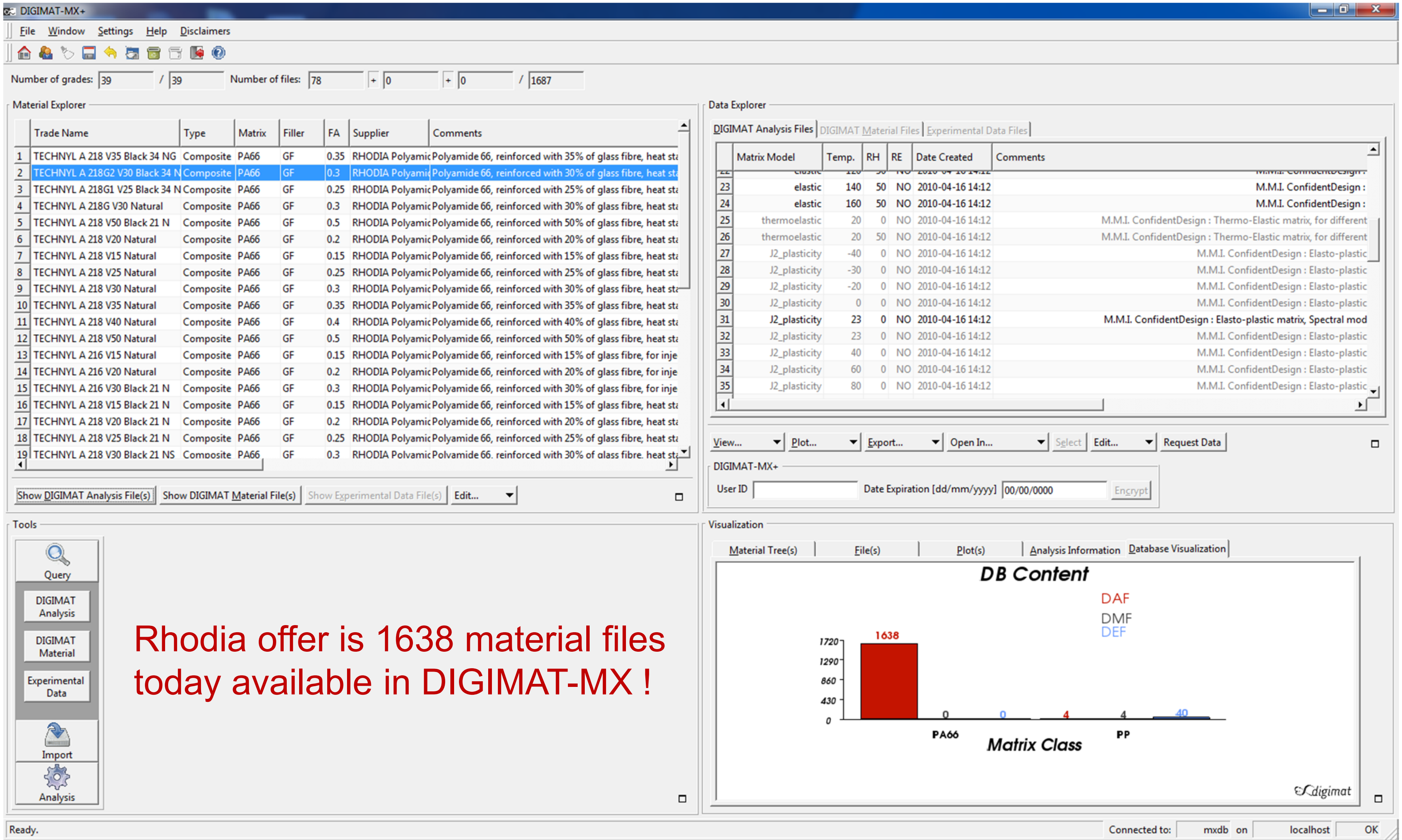
A micro-structure dependent failure indicator !

A critical number of failed pseudo grain must be defined to activate failure.

MMI ConfidentDesign : Data availability



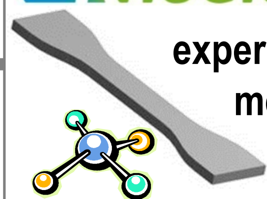
MMI ConfidentDesign : Rhodia offer in Digimat-MX



Rhodia offer is 1638 material files today available in DIGIMAT-MX !

M.M.I. simulation process

Rhodia Unique advanced experimental database on mechanical behaviour

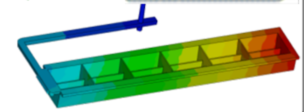


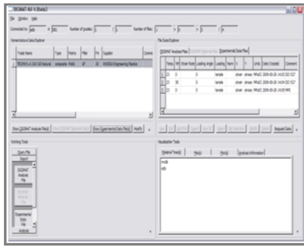
Matrix, Fillers

Injection Moulding Simulation

moldflow REM3D

Glass fibre orientation

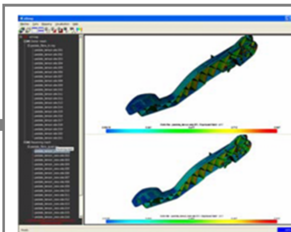




e-Xstream ENGINEERING

Digimat-MX

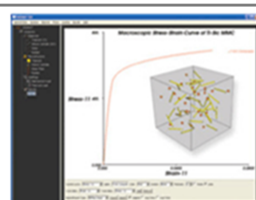
Material Database



e-Xstream ENGINEERING

Mapping tensors

from Moldflow mesh to structure mesh



Impact and Damage

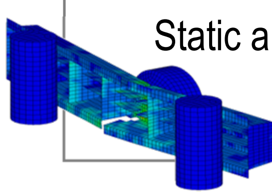
Material laws

Multi-scale modelling

by e-Xstream ENGINEERING and Rhodia

High level mechanical calculation

Static and dynamic / Impact / Creep



ANSYS ESI SIMULIA Altair Engineering LSTC Livermore Software Technology Corp.

Rhodia

Summary

- RHODIA Polyamide
- MMI ConfidentDesign
  - Matrix behavior
  - Composite behavior
- Presentation of the MMI Beam
  - Injection & Microstructure
- Correlation using DIGIMAT to LS-DYNA
  - Material behavior
  - Model and results
- Conclusions

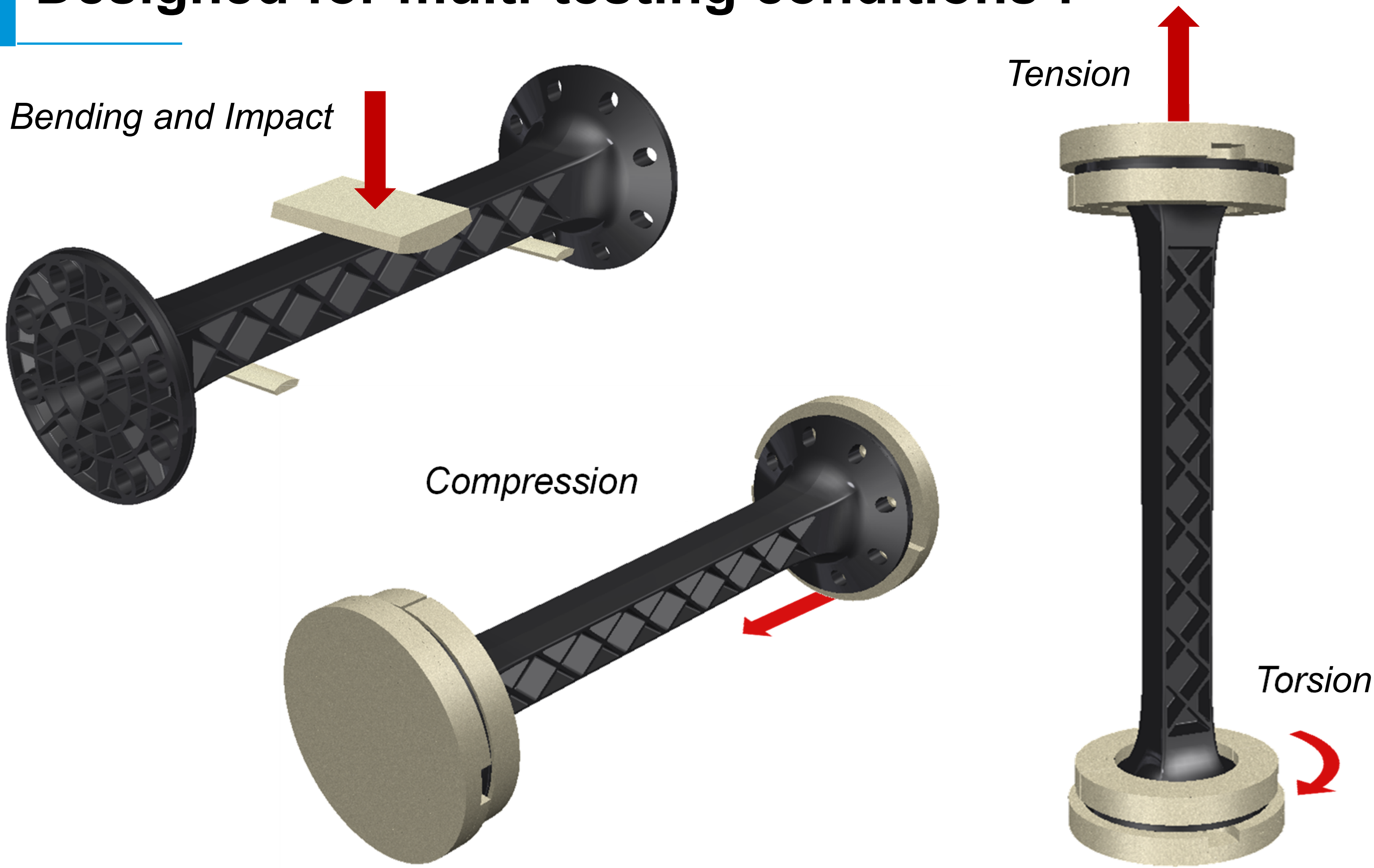
Cécile DEMAIN - Confidentiel

Simulation Engineer
Part Simulation and Validation Laboratory
POLYAMIDE Group
Lyon Research and Technology Center

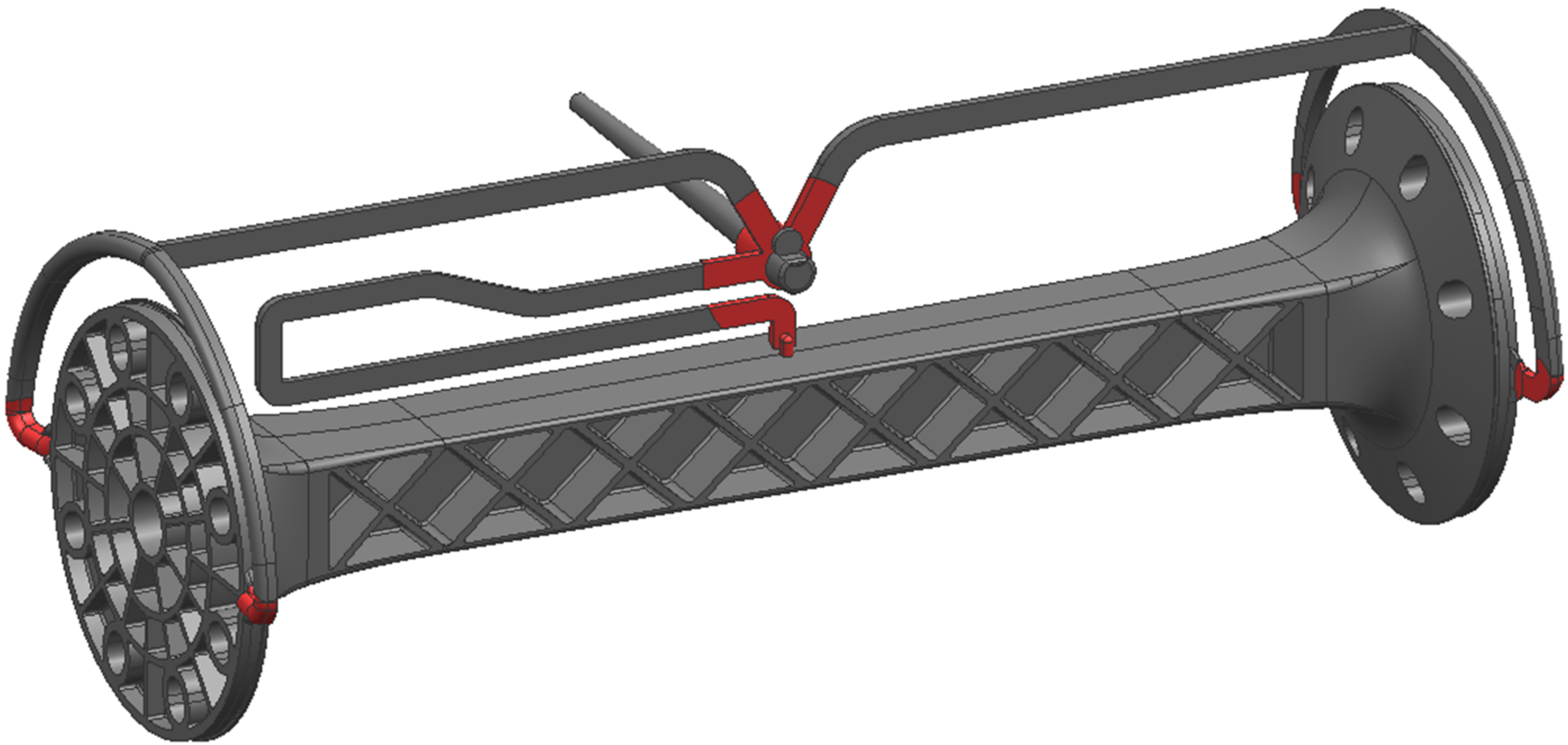
The MMI Beam

A new tool to get closer to structural parts

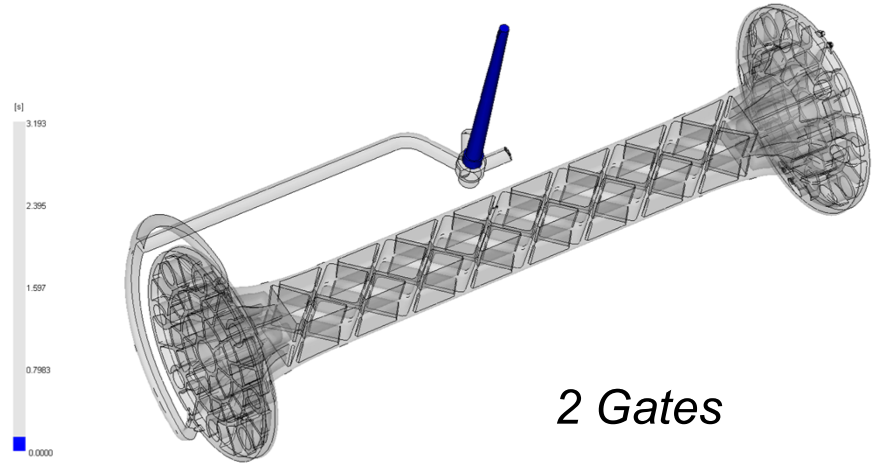
Designed for multi-testing conditions :

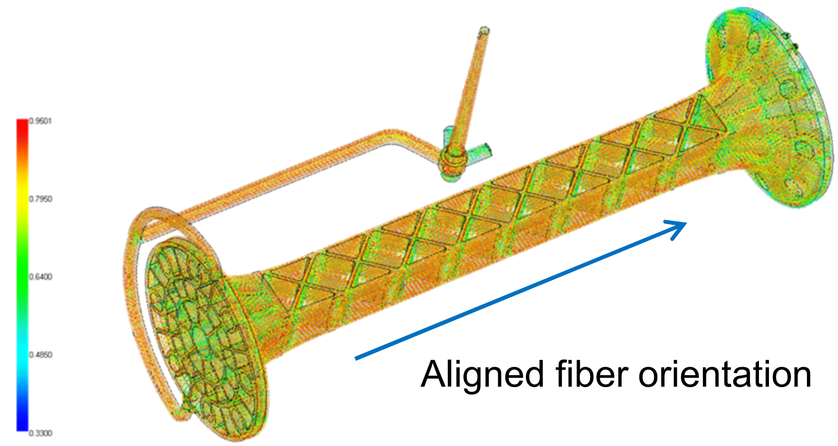


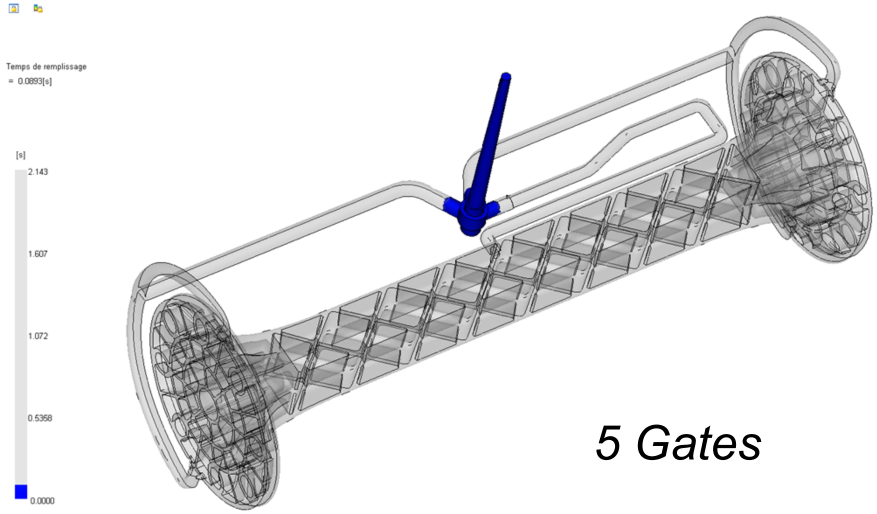
A multi gating design …

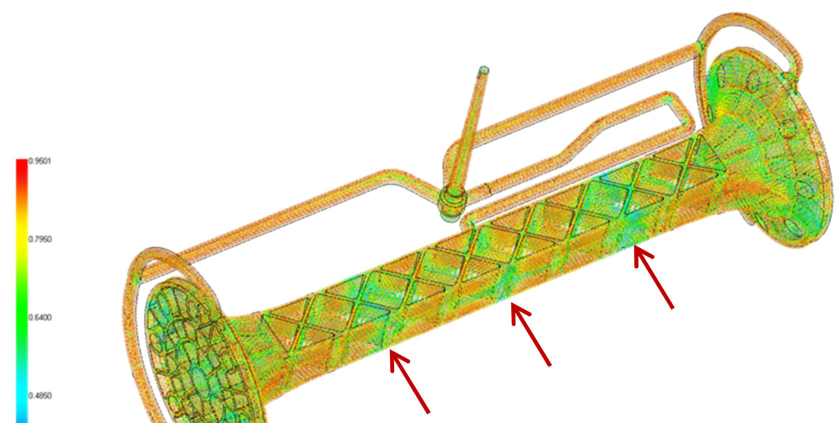


… to get many different micro-structures









Diffuse fiber orientation with weld lines

Cécile DEMAIN - Confidentiel

Simulation Engineer
Part Simulation and Validation Laboratory
POLYAMIDE Group
Lyon Research and Technology Center

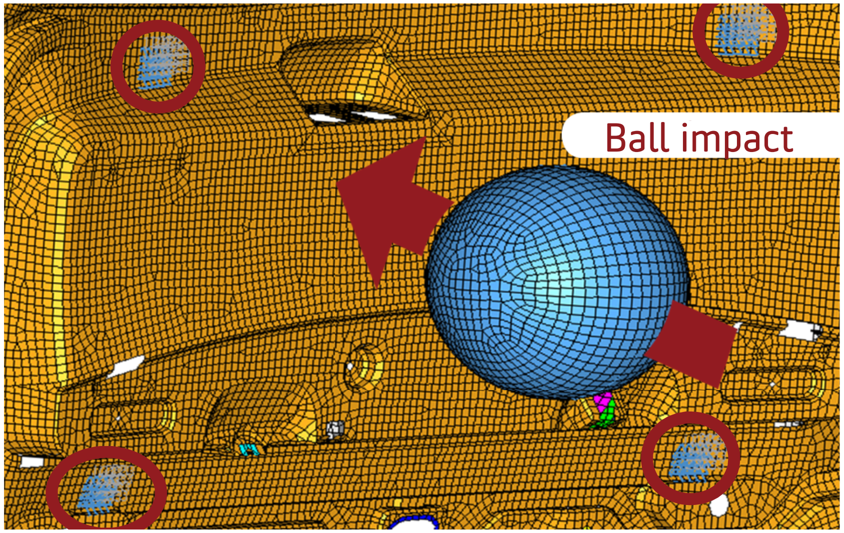
Digimat to LS-DYNA Simulation

Summary

- RHODIA Polyamide
- MMI ConfidentDesign
  - Matrix behavior
  - Composite behavior
- Presentation of the MMI Beam
  - Injection & Microstructure
- Correlation using DIGIMAT to LS-DYNA
  - Material behavior
  - Model and results
- Conclusions

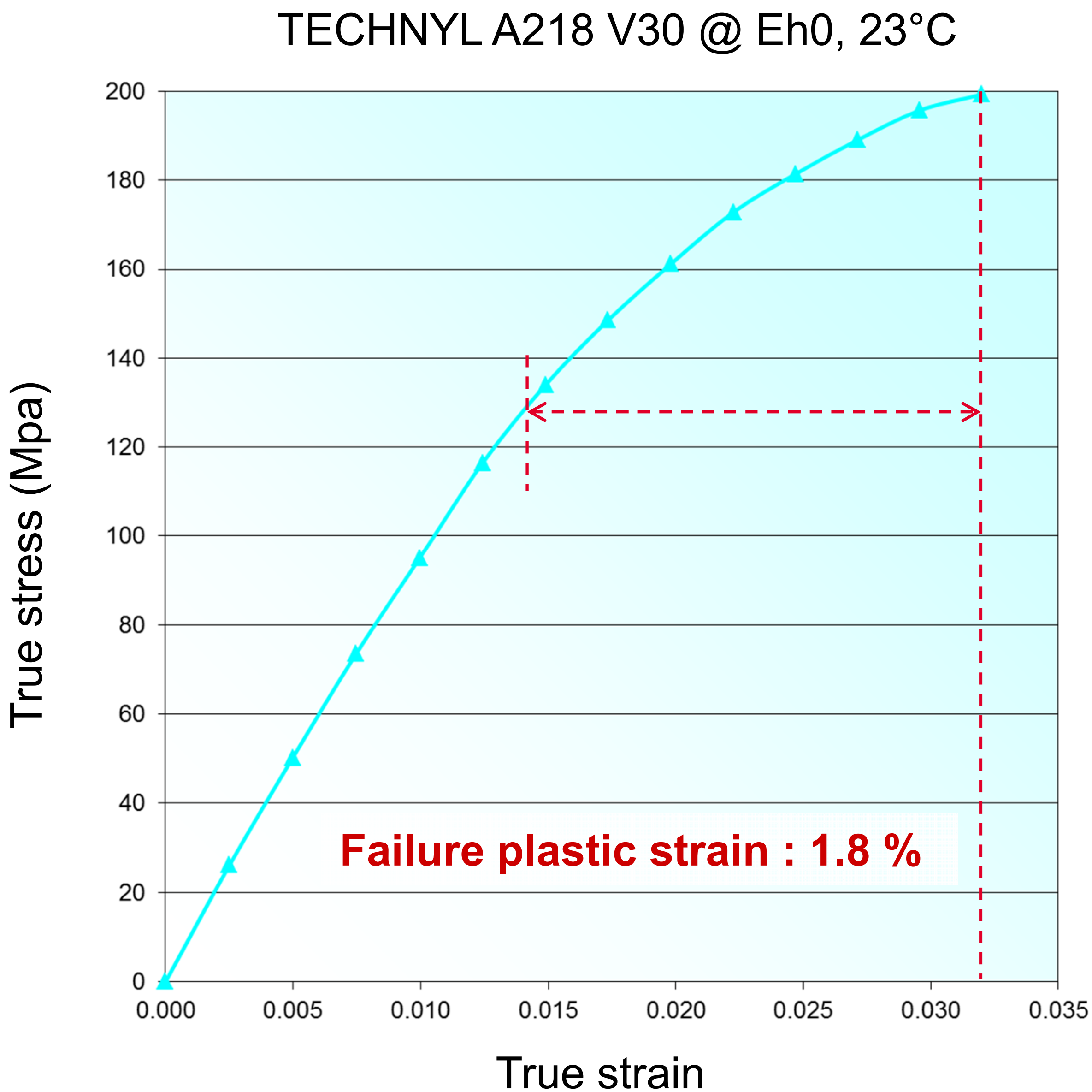
Real impact test on a large ribbed part
Boundary conditions

Fixations



Courtesy of

Real impact test on a large ribbed part
Isotropic Material



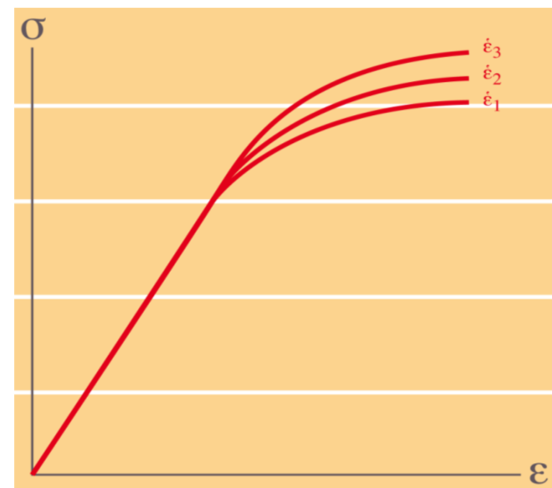
Real impact test on a large ribbed part
M.M.I Material

- High end use of Digimat software : combining anisotropy and strain rate dependency

- Glass Fiber :
  - Elastic
  - Aspect Ratio
  - Weight fraction
  - Orientation on all the part

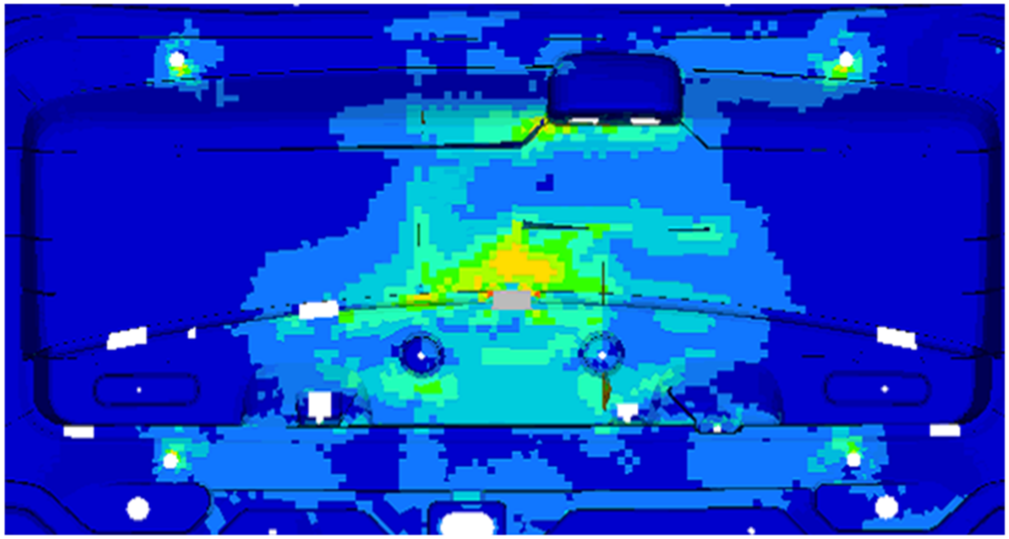
- PA66 Matrix :
  - Elasto-Viscoplastic
  - Fitted by M.M.I. ConfidentDesign approach

- Failure criteria :
  - Total strain



Real impact test on a large ribbed part
Isotropic Material

With the courtesy of

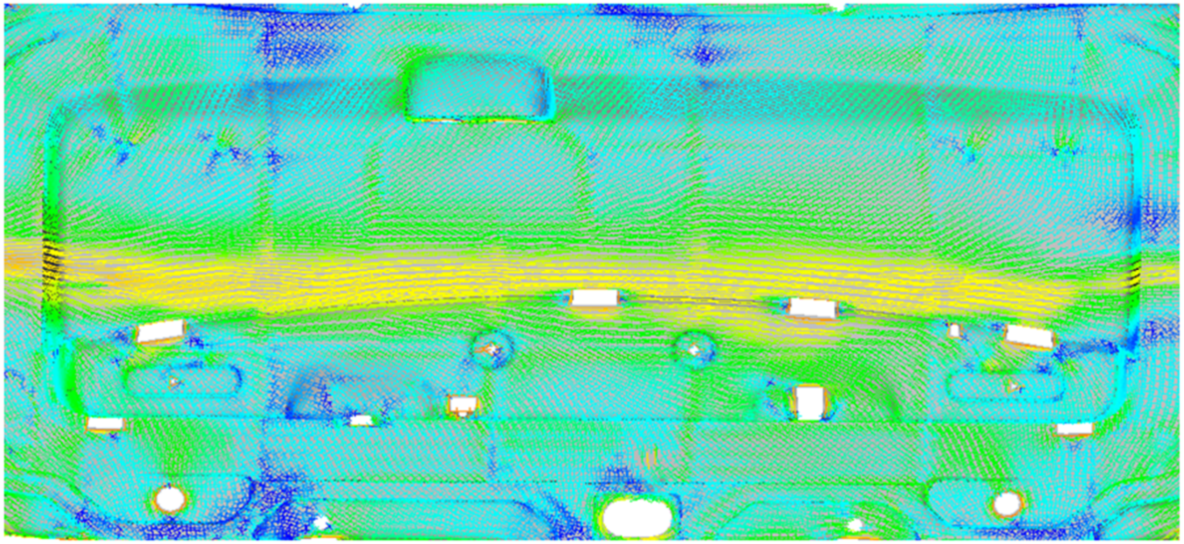


➡ With isotropic material the model do not break

➡ The part fails in real life

Real impact test on a large ribbed part
MMI – injection simulation

Fiber orientation

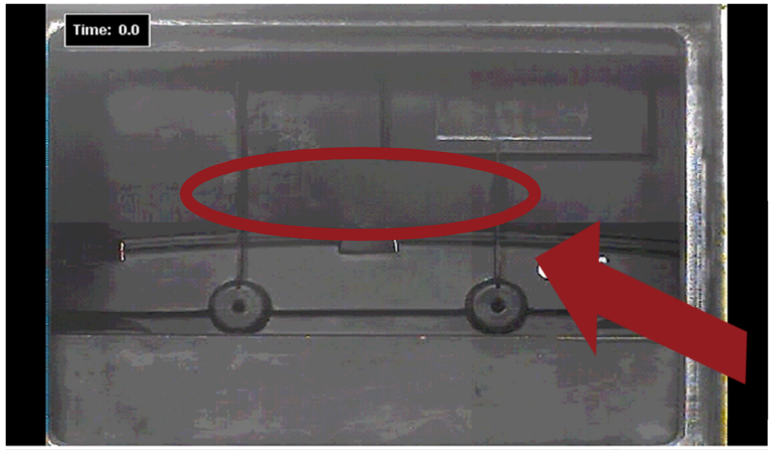


Courtesy of PLASTIC OMNIUM

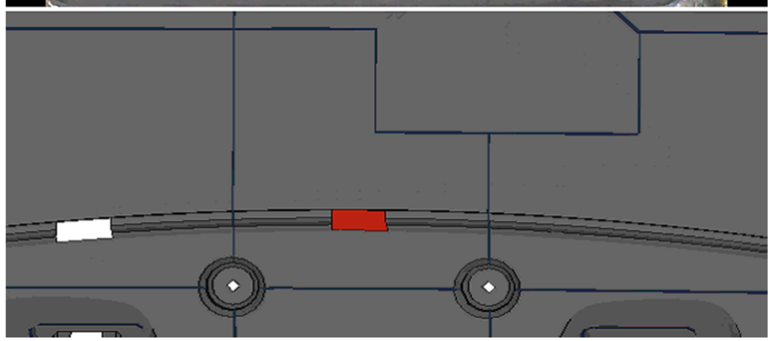
Rhodia

Real impact test on a large ribbed part
MMI – impact result

Part test



With MMI

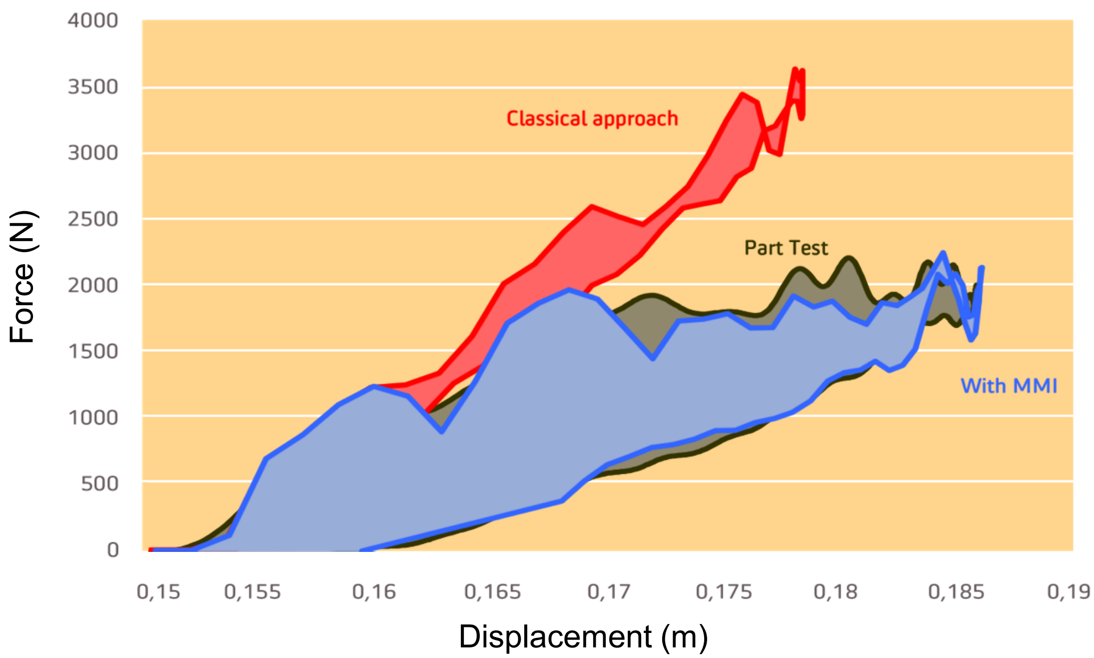


➡ Failure area: good correlation achieved with MMI

Courtesy of PLASTIC OMNIUM

Rhodia

Real impact test on a large ribbed part
MMI – energy absorption

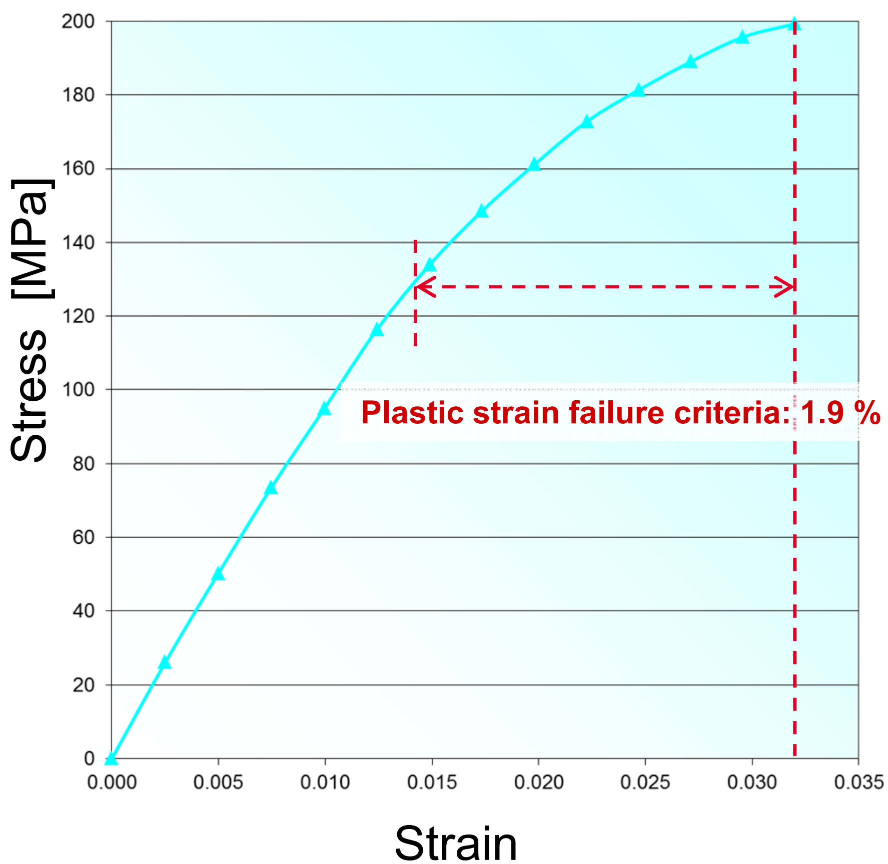


Courtesy of PLASTIC OMNIUM

With MMI, excellent energy absorption correlation

Material
isotropic approach

	Technyl A218 V30 23°C EH0
Density (g/cm3)	1.37
Young modulus (MPa)	9000

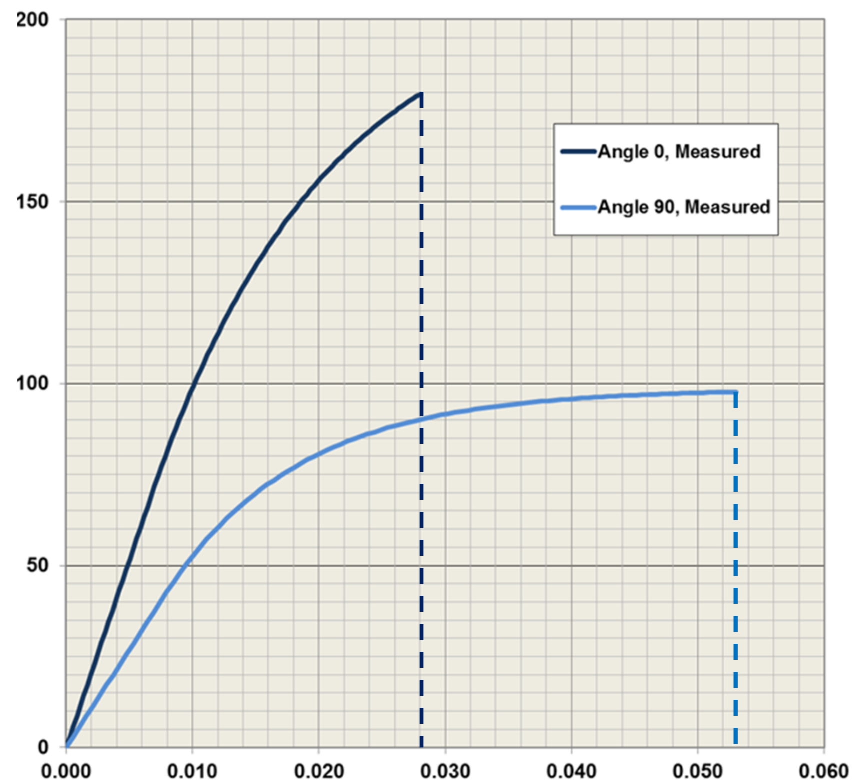


Material
MMI approach

- High end use of Digimat software :
  - Glass Fiber :
    - Elastic
    - Aspect Ratio
    - Weight fraction
    - Orientation on all the part
  - PA66 Matrix :
    - Elasto-Viscoplastic
    - Fitted by M.M.I. ConfidentDesign approach
  - Failure criteria :
    - FPGF (First Pseudo-Grain Failure)
    - Fast determination of FPGF parameters

- MMI material definition fitted Elasto-viscoplastic with Basic FPGF

Max strain used as FPGF Inputs for Tsaï Hill 2D strain, Critical factor 0.85, no reverse engineering



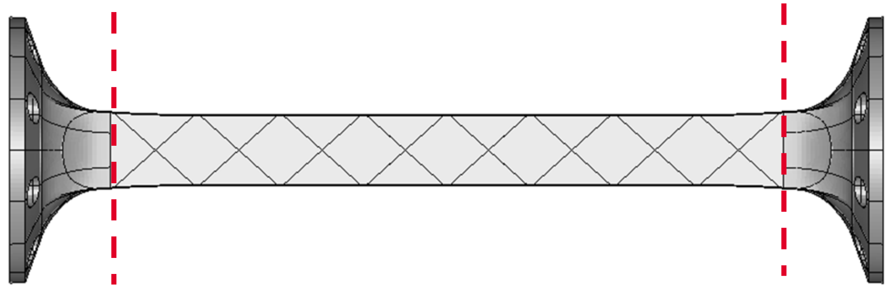
Summary

- RHODIA Polyamide
- MMI ConfidentDesign
  - Matrix behavior
  - Composite behavior
- Presentation of the MMI Beam
  - Injection & Microstructure
- Correlation using DIGIMAT to LS-DYNA
  - Material behavior
  - Model and results
- Conclusions

MMI beam
presentation of impact model

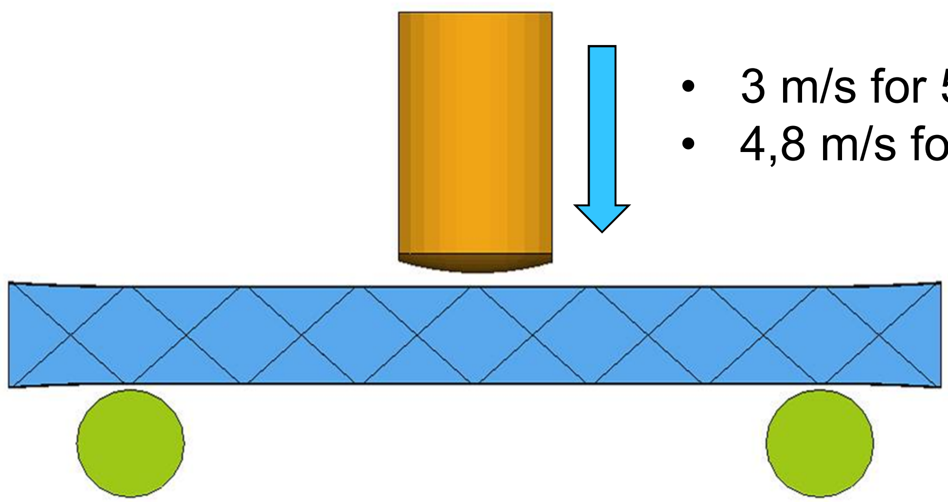
- Beam

The sides were cut off



- Dynamic flexion test

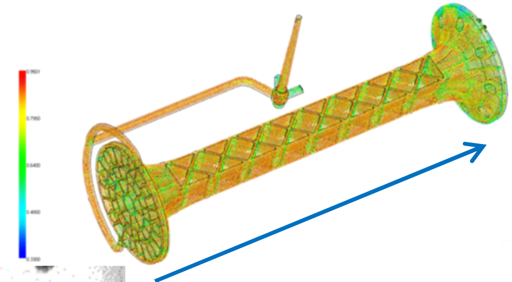
Mass of 18 kg

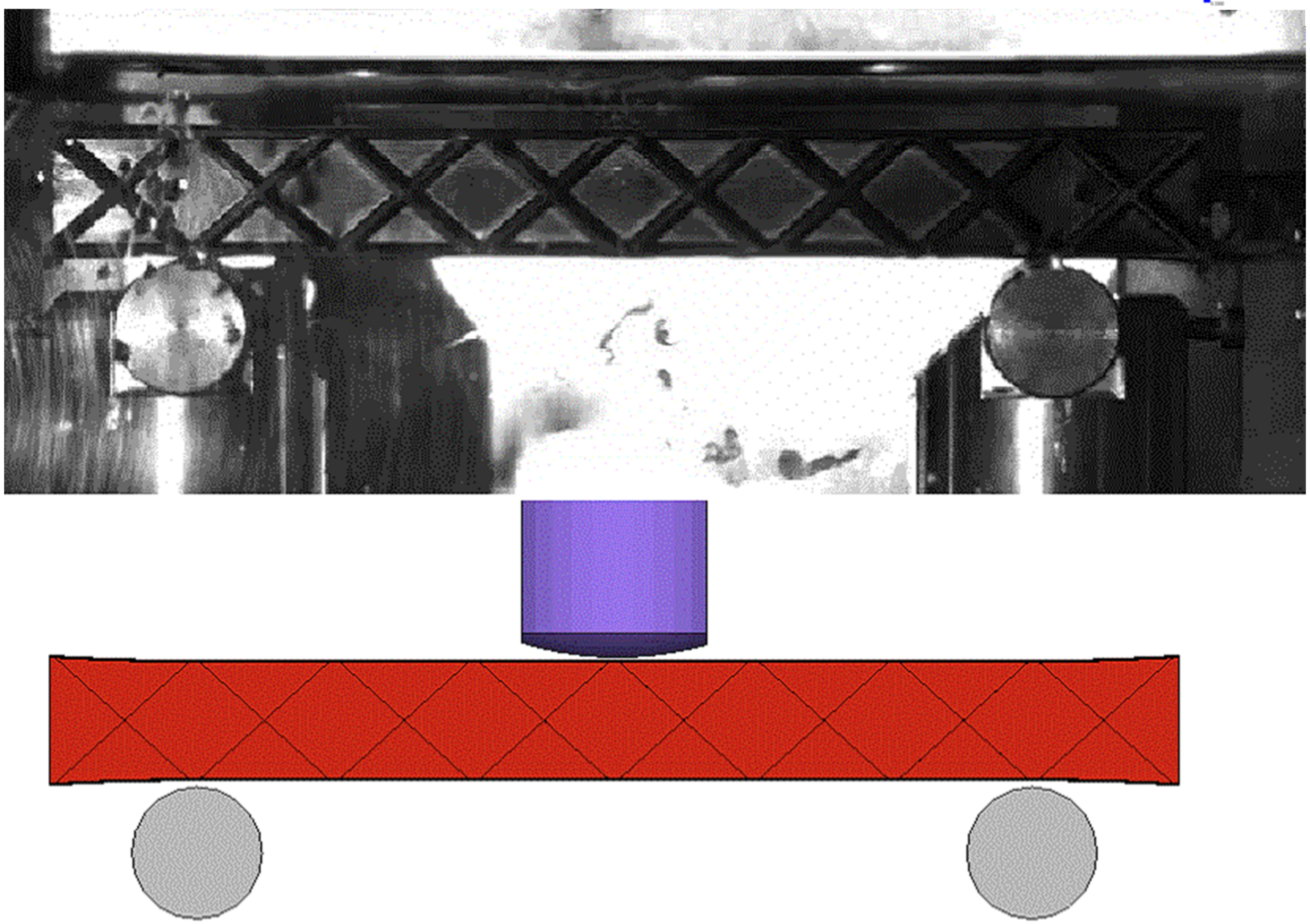


- 3 m/s for 5 gates
- 4,8 m/s for 2 gates

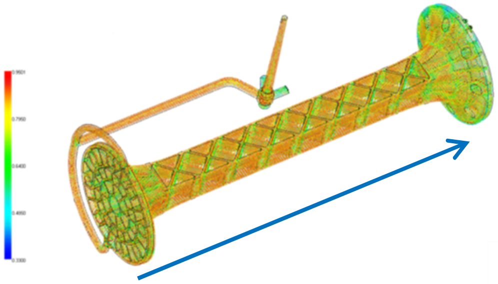
MMI beam – 2 gates

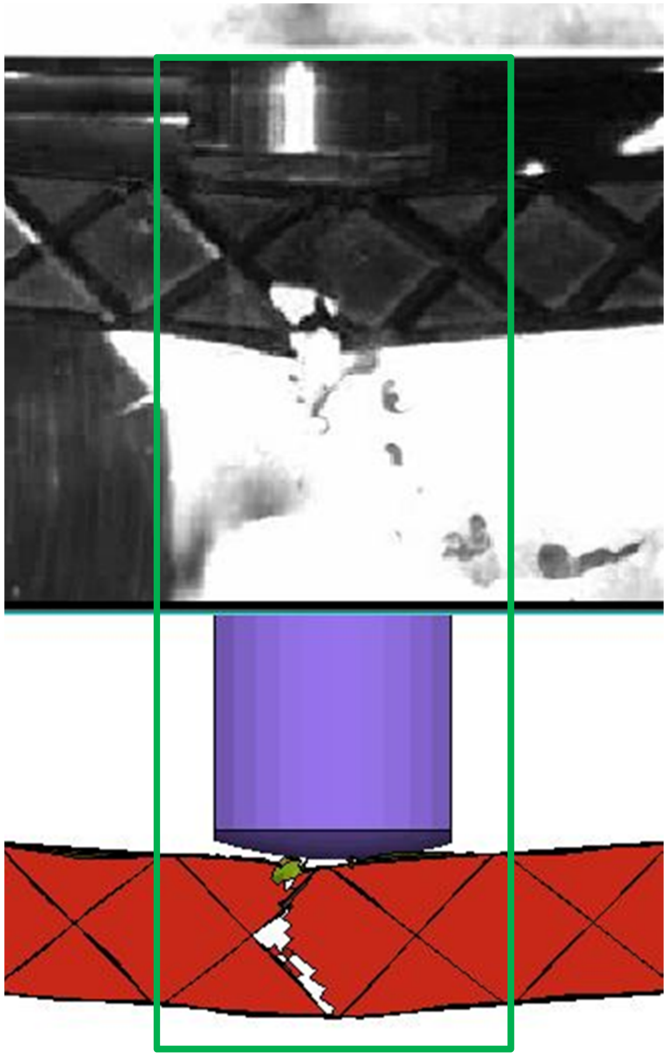
correlation experiment / MMI



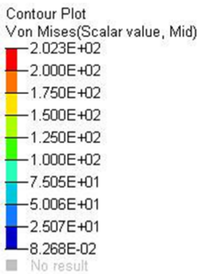


MMI beam – 2 gates
correlation experiment / MMI



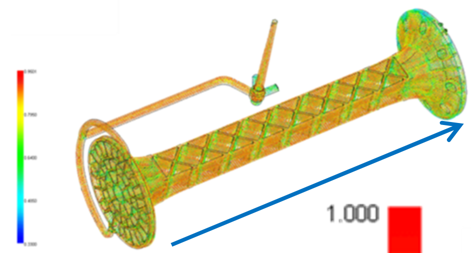


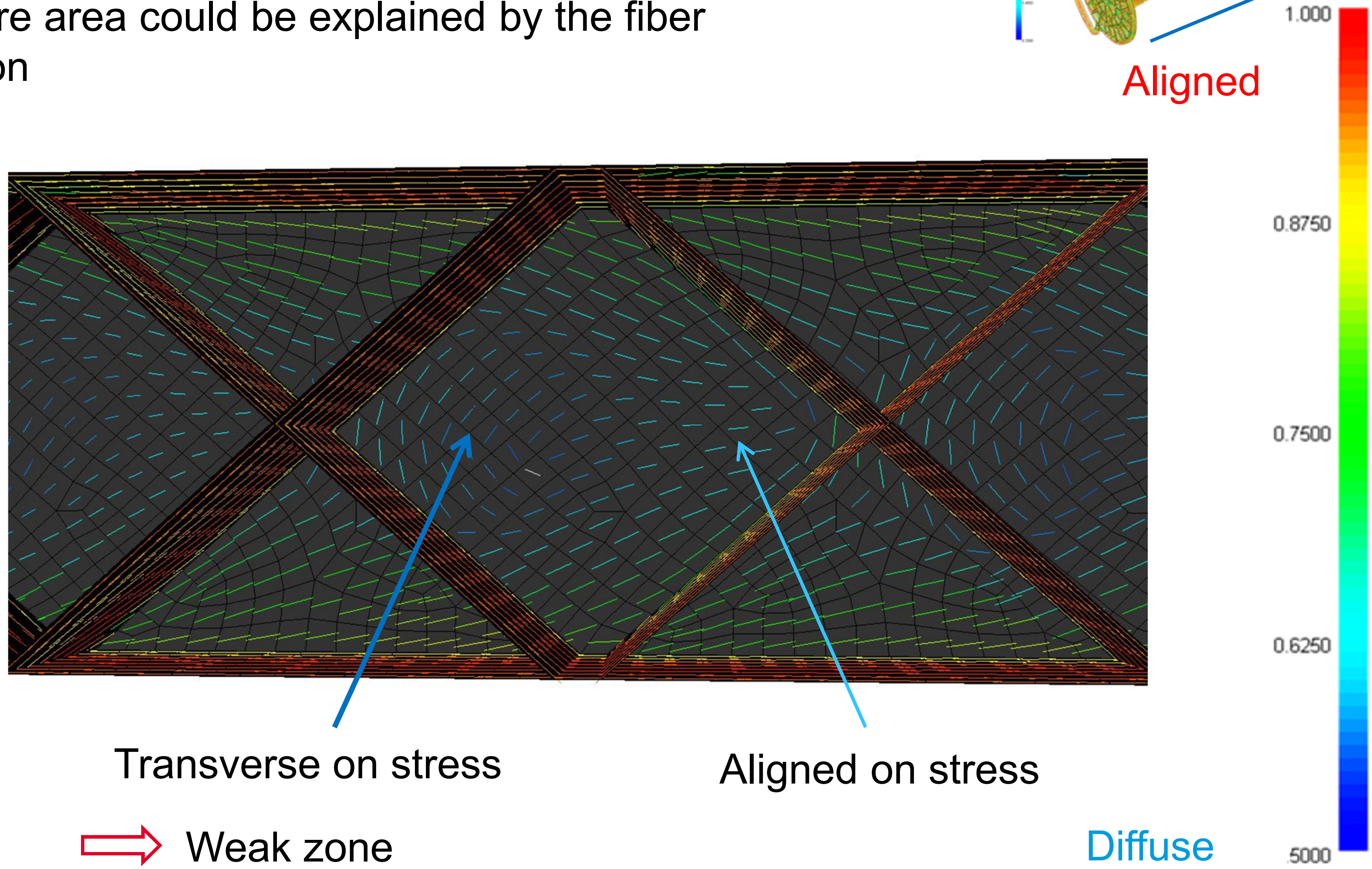
Failure at the same time



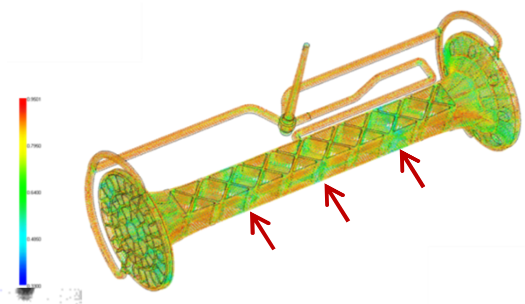
MMI beam – 2 gates
Failure prediction

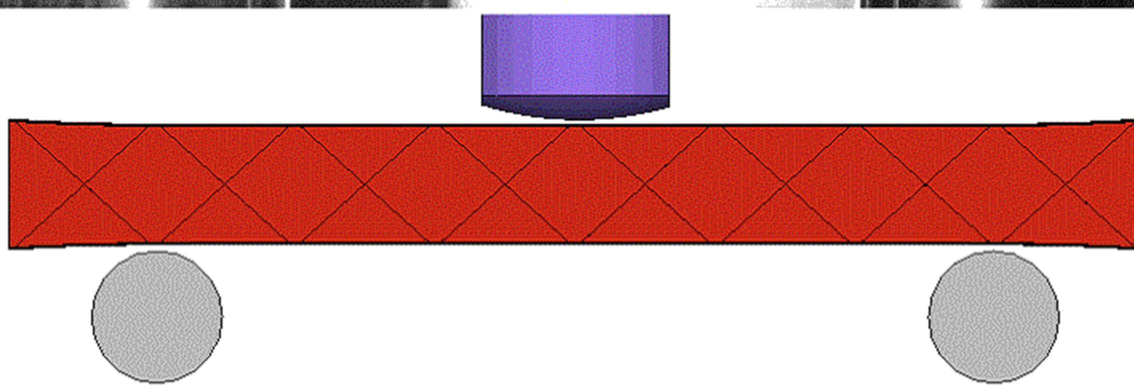
The failure area could be explained by the fiber orientation



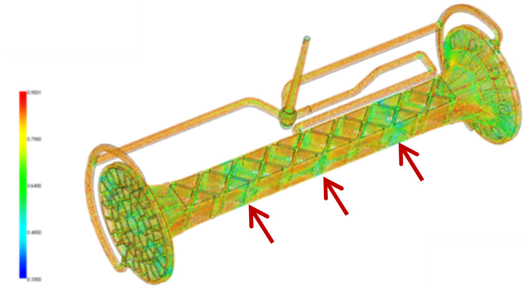


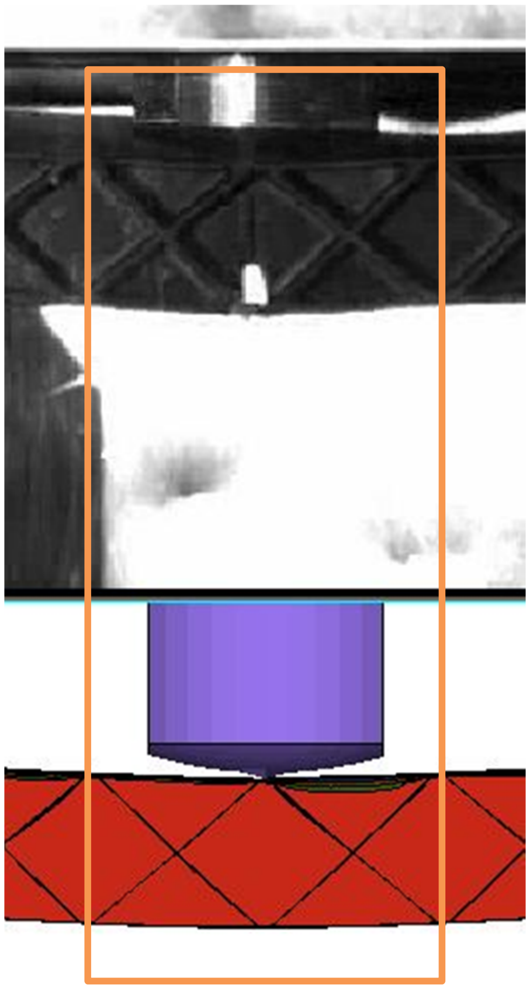
MMI beam – 5 gates
Failure prediction





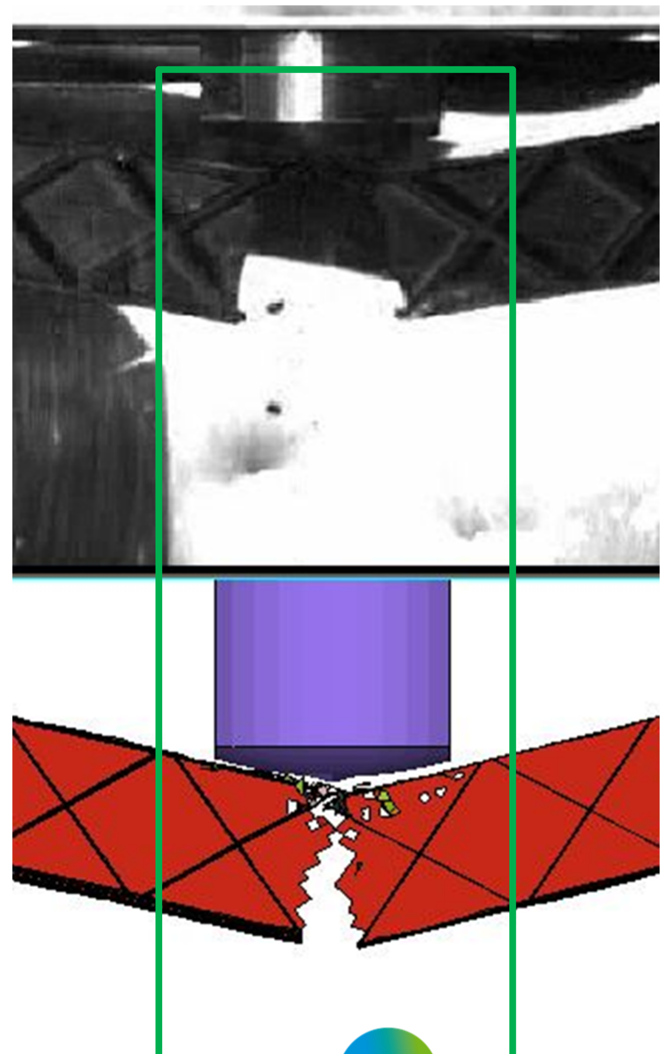
MMI beam – 5 gates
Failure prediction



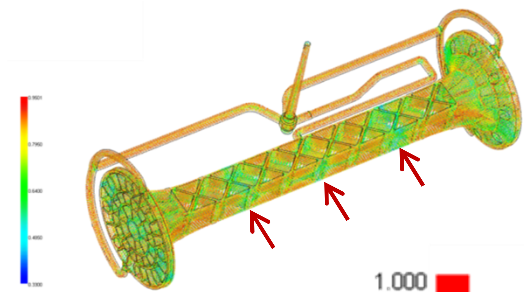


Failure occurs too late

Same failure area

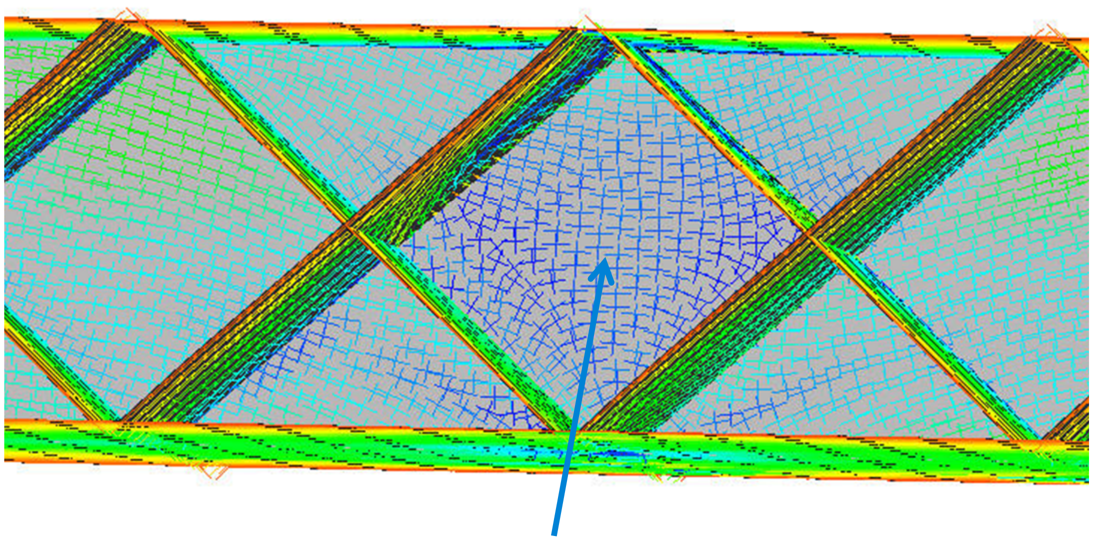


MMI beam – 5 gates
Failure prediction



The failure area could be explained by the fiber orientation

Aligned



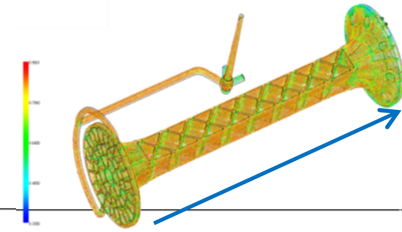
diffuse

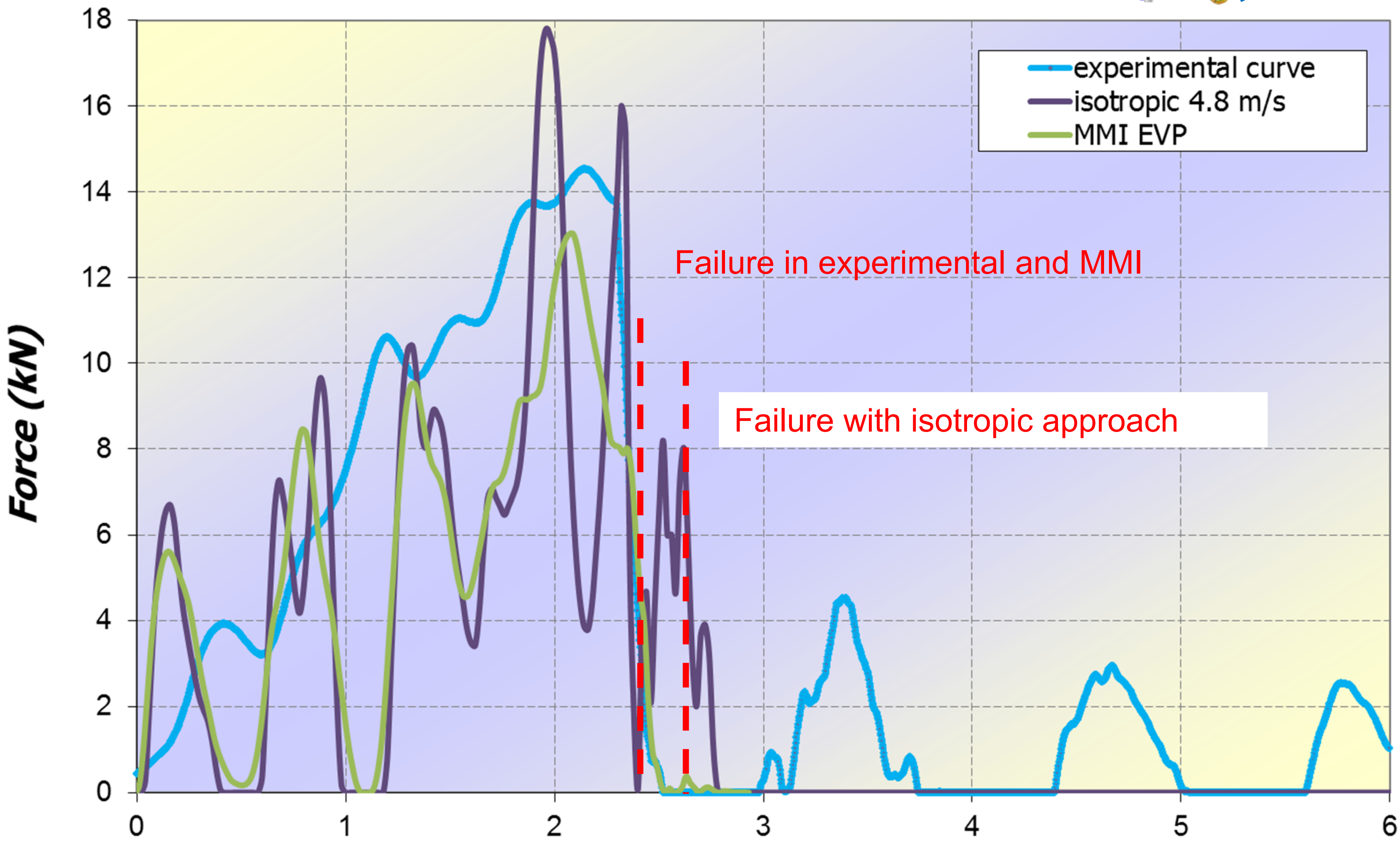
Diffuse

⇨ Weak zone

MMI beam – 2 gates

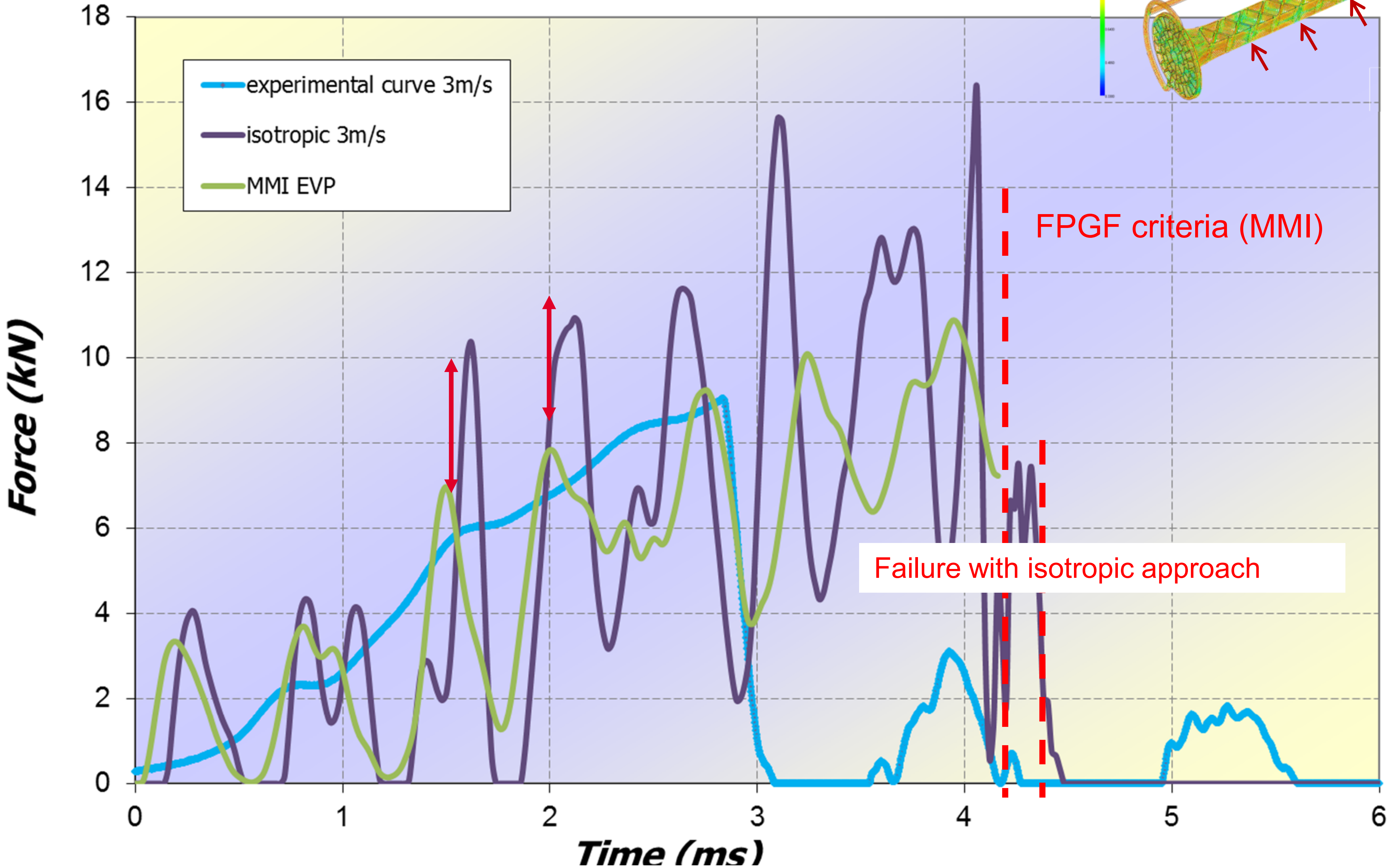
Force correlation

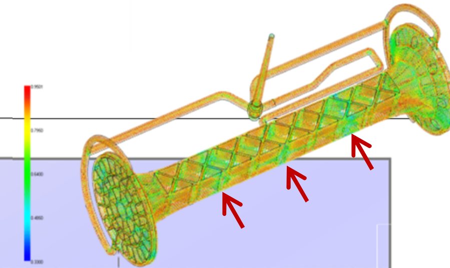




Good correlation in force and failure

MMI beam – 5 gates
force correlation





No correlation in failure with FPGF criteria,
MMI approach is closer to test in stiffness

Chemistry is our world, Responsibility is our way

Cécile DEMAIN - Confidentiel

Simulation Engineer
Part Simulation and Validation Laboratory
POLYAMIDE Group
Lyon Research and Technology Center

Conclusion

Conclusions

- With the FPGF failure model
  - We obtain some interesting results in 2 gates case :
    - Correlation in term of failure and force
    - Failure related to microstructure
  - The failure model is very promising

- To be improved :
  - FPGF parameter
    - Run MMI fitting process on FPGF parameters to get better value on transverse and shear !

  - Material behavior
    - Add hydrostatic pressure dependency (tension/compression behavior)

Q&A

MMI

ConfidentDesign

Rhodia