MatchID
Metrology beyond colors

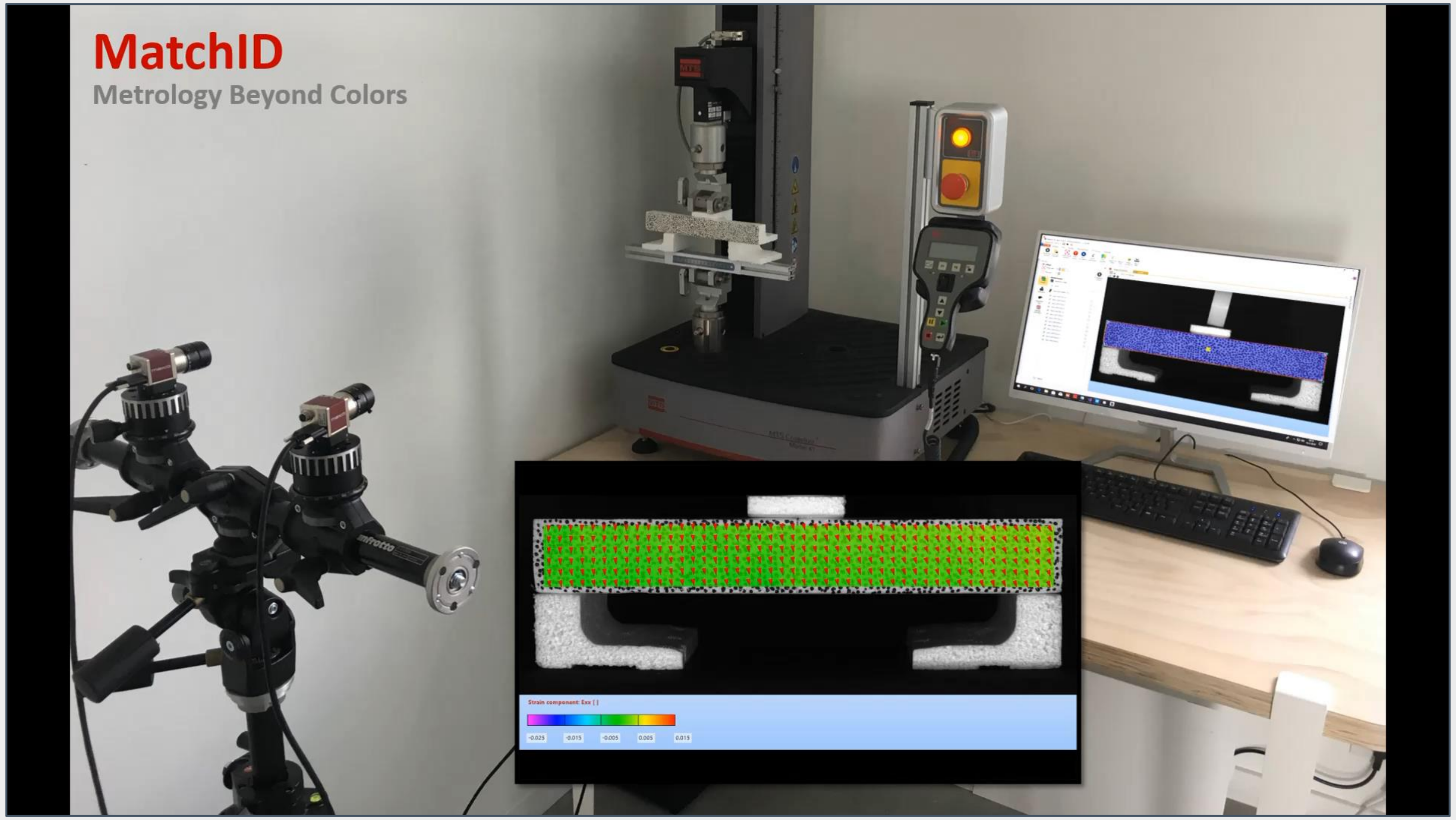
MatchID's material testing 2.0 platform

From images to parameters – a seamless and uncertainty vetted workflow

VForm-xSteels

Metal Plasticity 2024

DIC – Digital Image Correlation?



Digital image correlation is an **optical-numerical** measuring technique, which offers the possibility of determining complex **shape**, **displacement** and **deformation fields** at the surface of objects under **any kind of loading.**

Our Team

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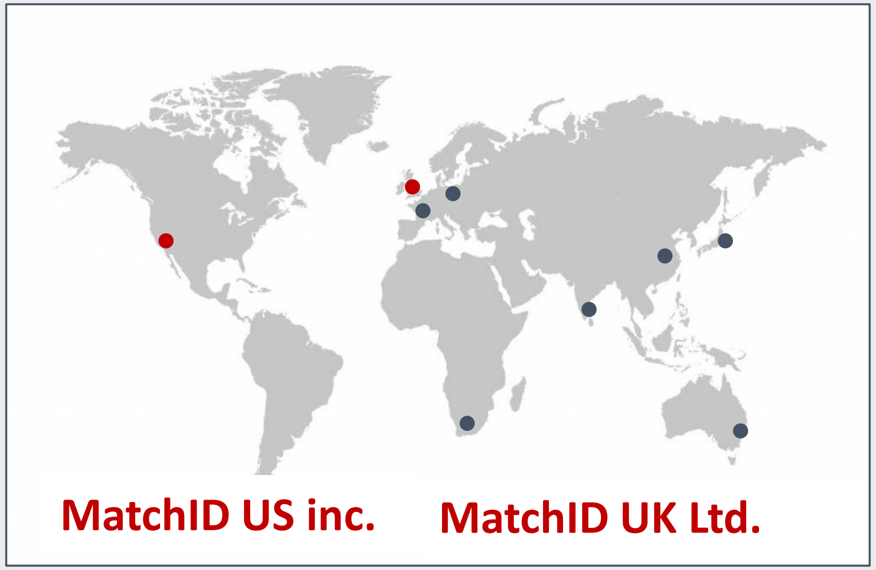
MatchID Gent - Belgium



MatchID US inc.

MatchID UK Ltd.

It's not just DIC... it's integrated

Calculator	Transform Frame	Rigid Body Motion	Relative Motion	Compare Datasets	Surface Inspection	Curvatures	VSG Study	Strain	Stress
Equilibrium Gap	Force Reconstruction	Velocity Acceleration	Strain Rate	Fast Fourier Transform	Temporal Filter	Polynomial Fit	External Data	Set Dataset Noise Levels	MatchID Apps
Extensometer	Vector	Extract	Geometry	Export as Data	Export Statistics	Export as Image	Export as Video	Export Simcenter	Screen Recording
Export to database	FEA Validation	Crack Path Detection	Crack Opening Data	Williams Series Expansion	J-Integral	J-Integral Study	FLC Curves	Forming Limit Diagram	Average Images
Operational Deflection Shape	Temperature Import	Elastic constants	ISO 6892 Extensometry	VDI 2626 VDI	Speckle information	Acquisition Data	Performance Analysis	Virtual Fields Method	FE Deformation

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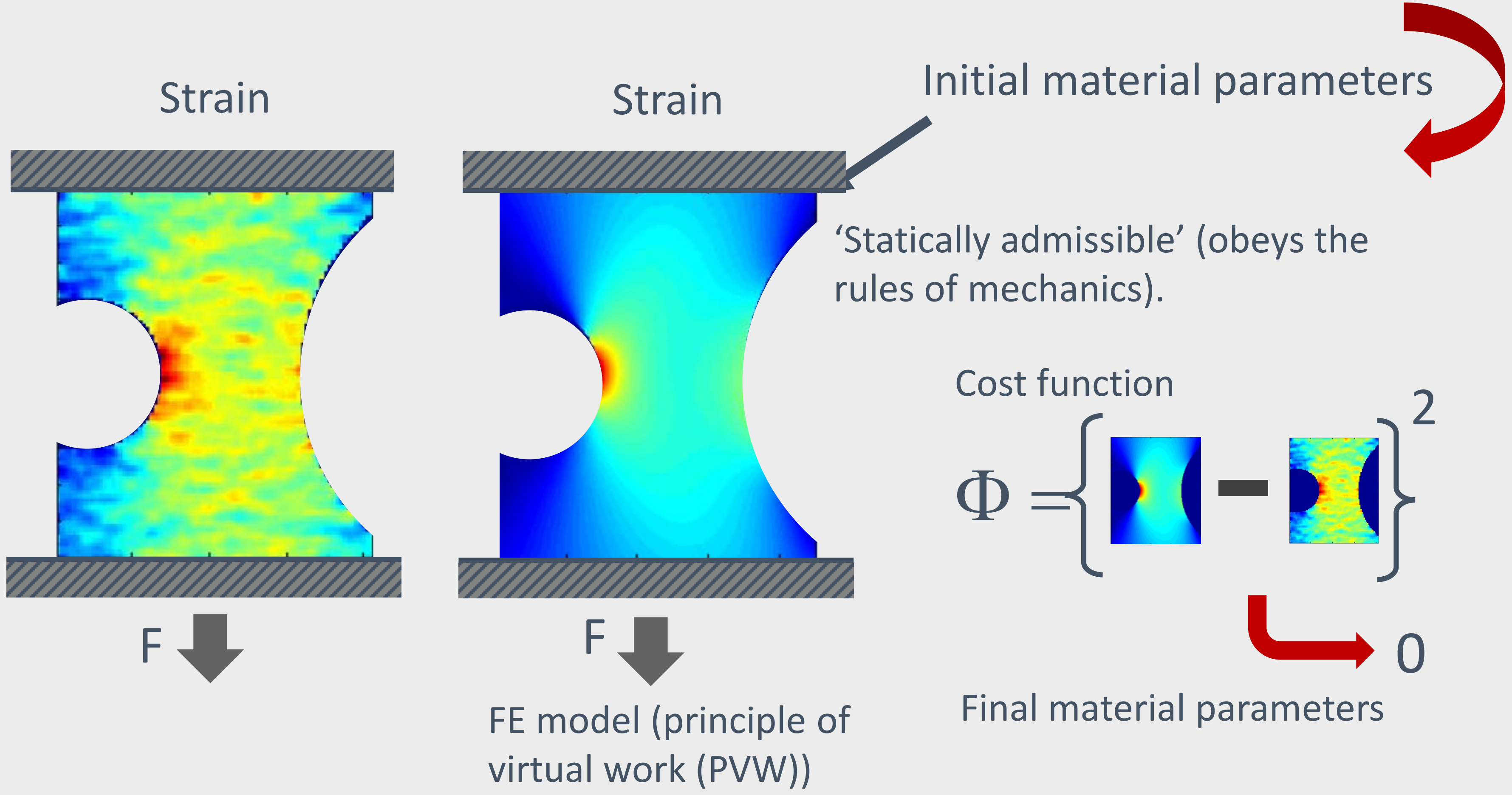
Integrated material identification

Material testing 2.0

Finite Element Model Updating



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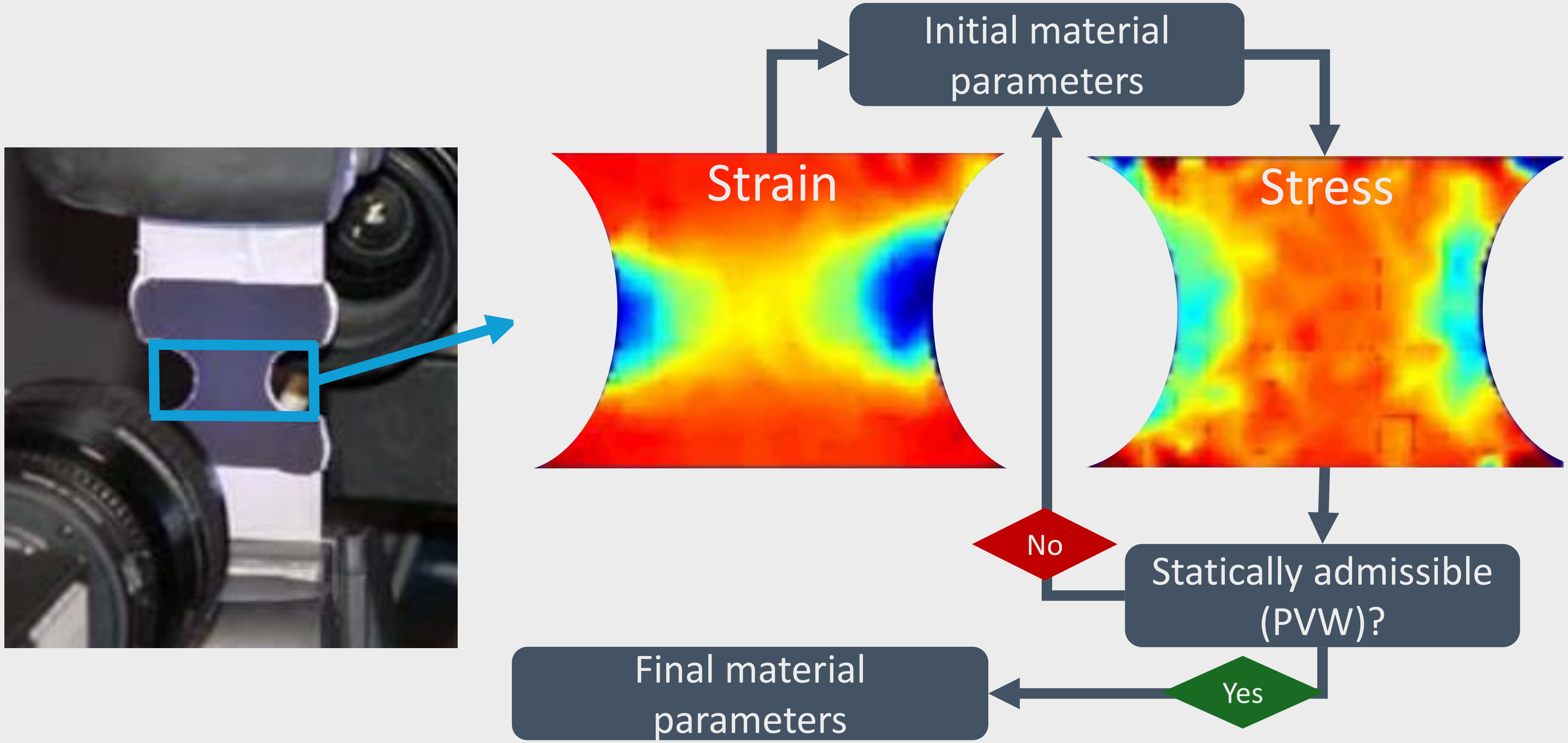
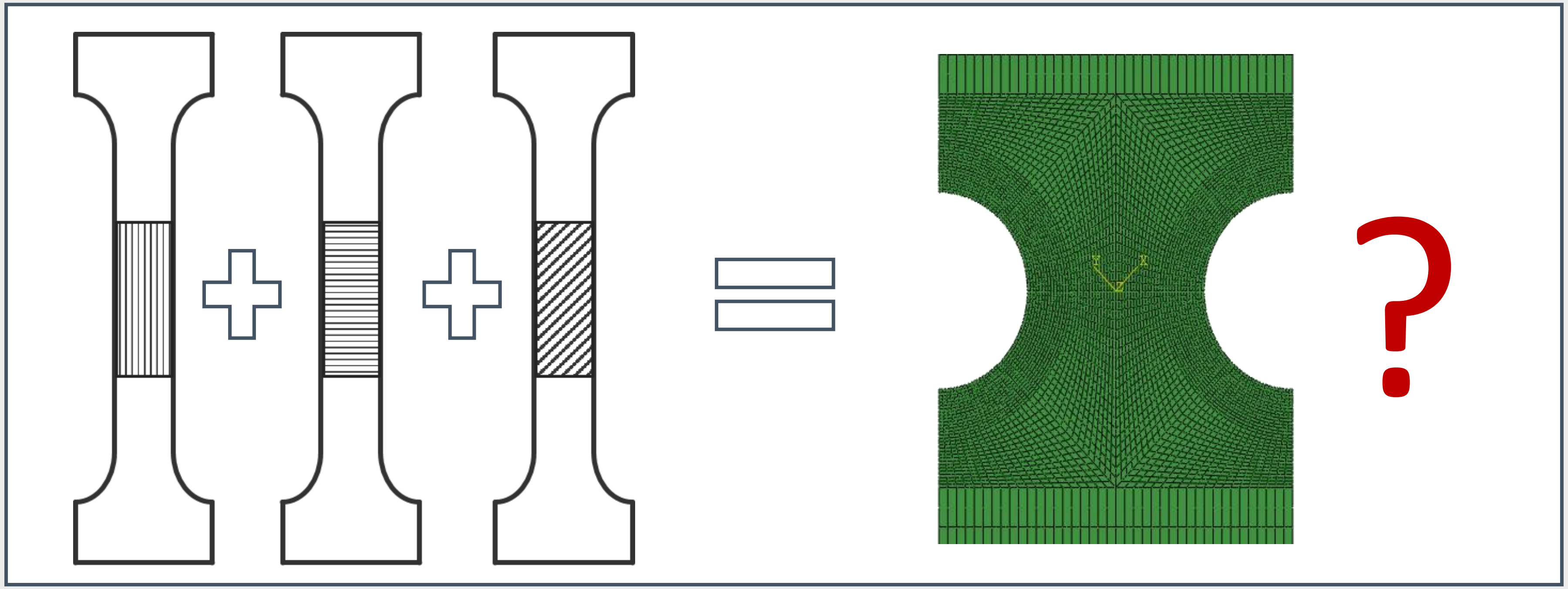
The Virtual Fields Method

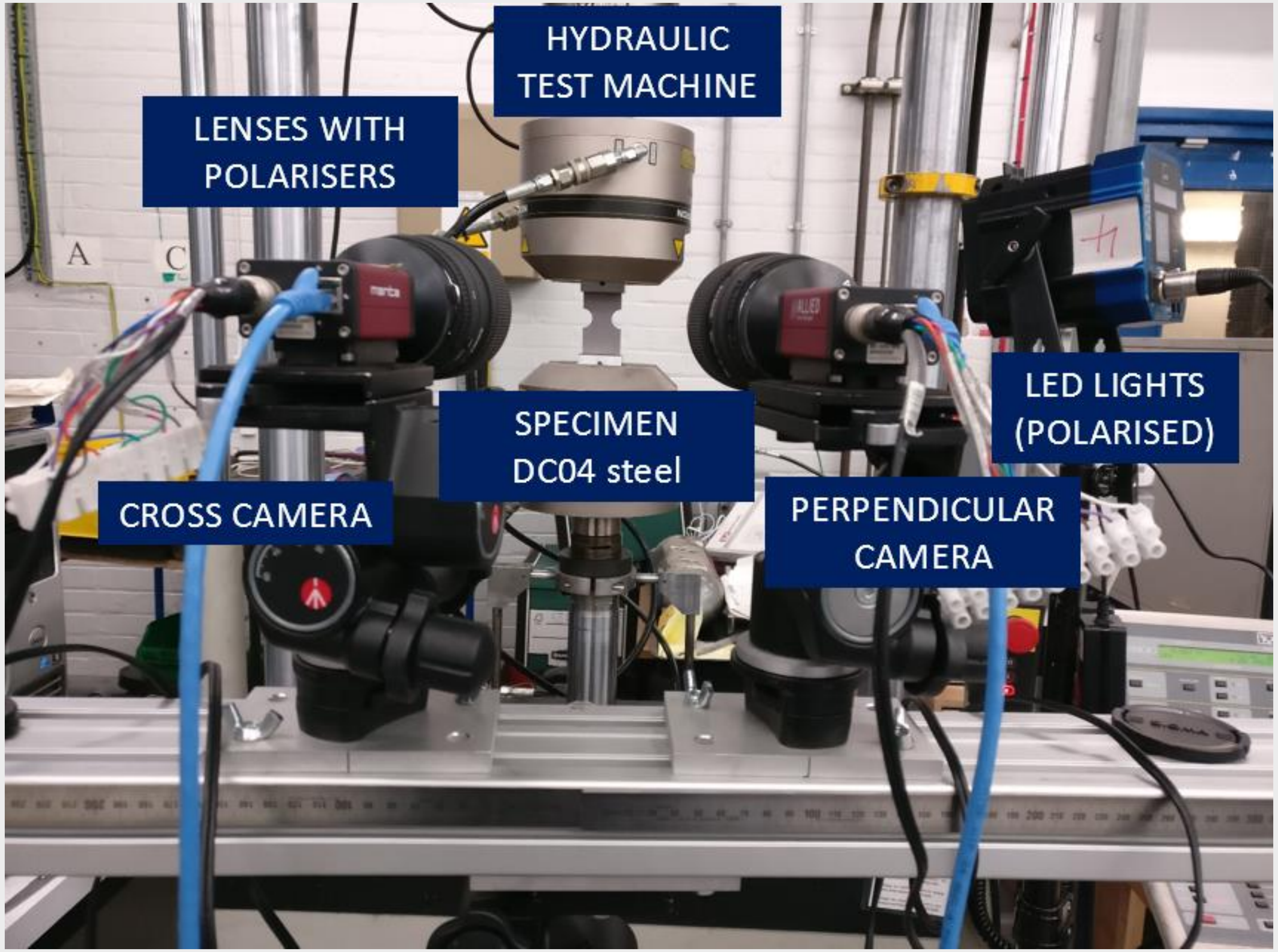


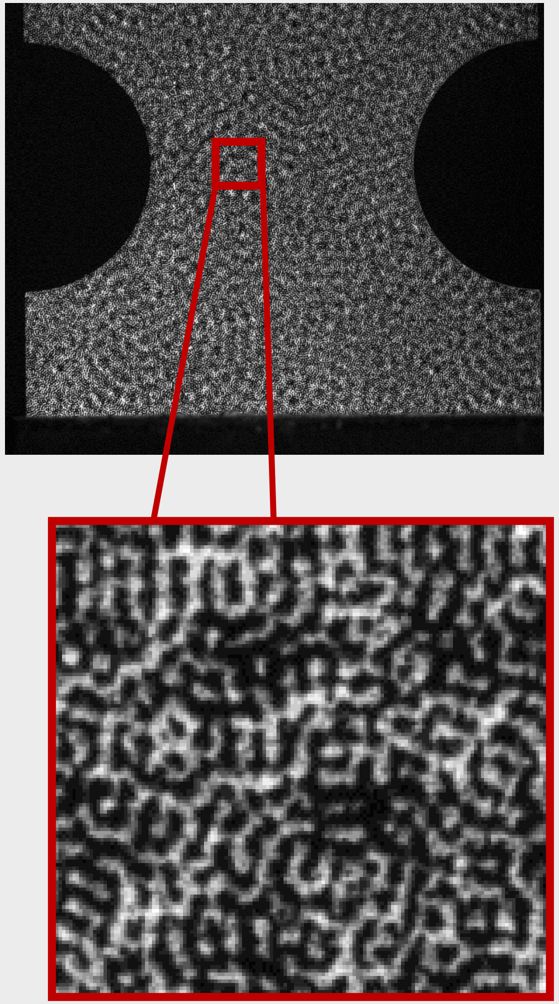
Case study

- DC04 steel (cold-rolled steel) – Anisotropic properties
  - Hill48 (4 parameters)
- One test to replace multiple?



Experimental setup





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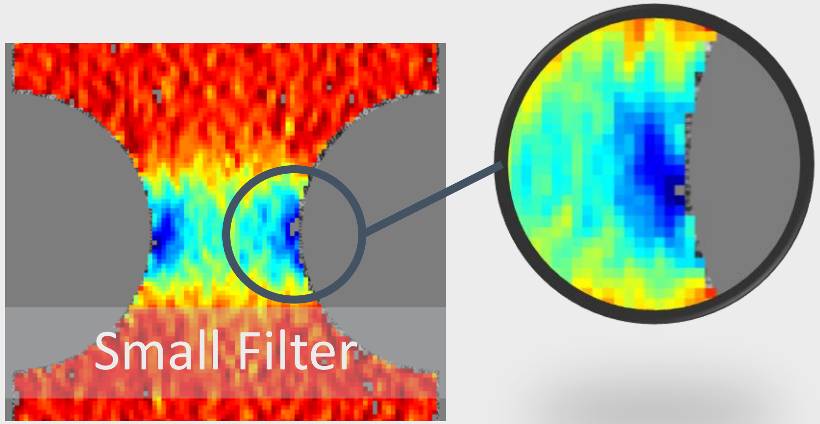
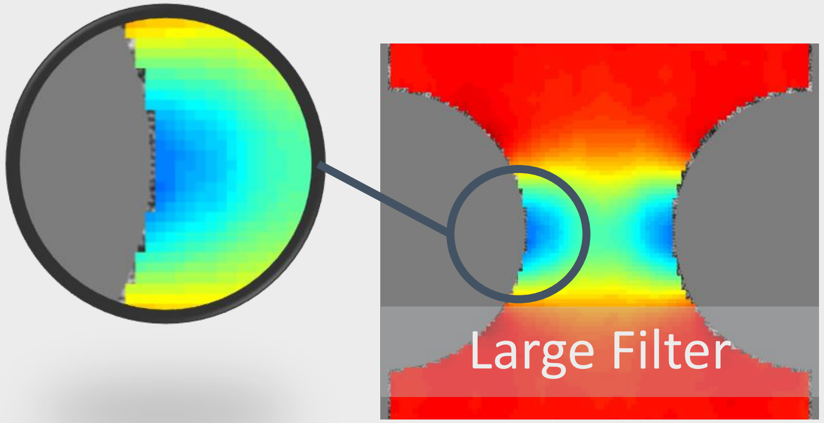
DIC Analysis involves filtering

Selection of DIC parameters is an optimum between noise reduction and signal reconstruction

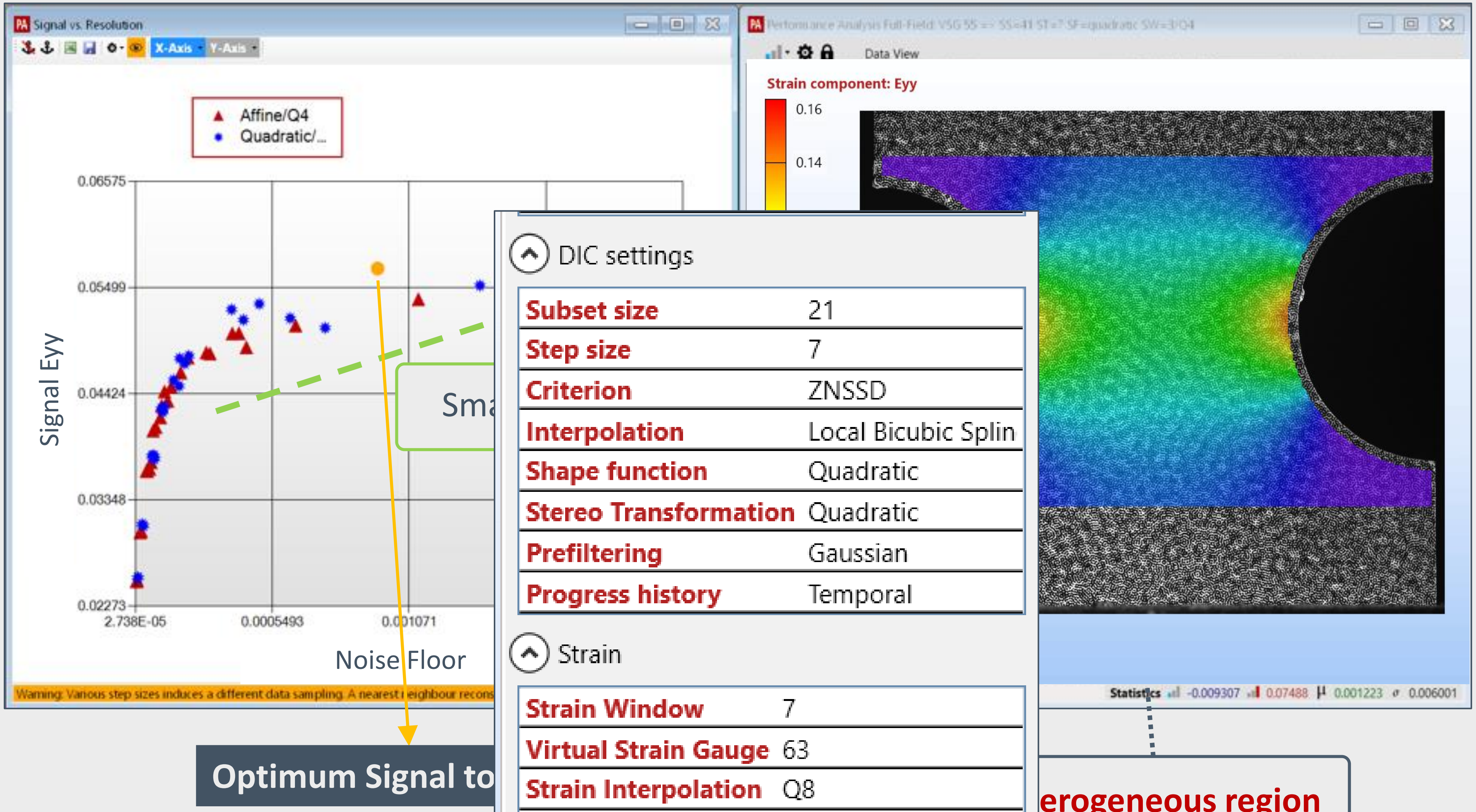


Accurate but not Precise
Large *Random* Error
Small *Systematic* Error



Precise but not Accurate
Small *Random* Error
Large *Systematic* Error

Optimized DIC Analysis: Performance Analysis Module



DIC settings

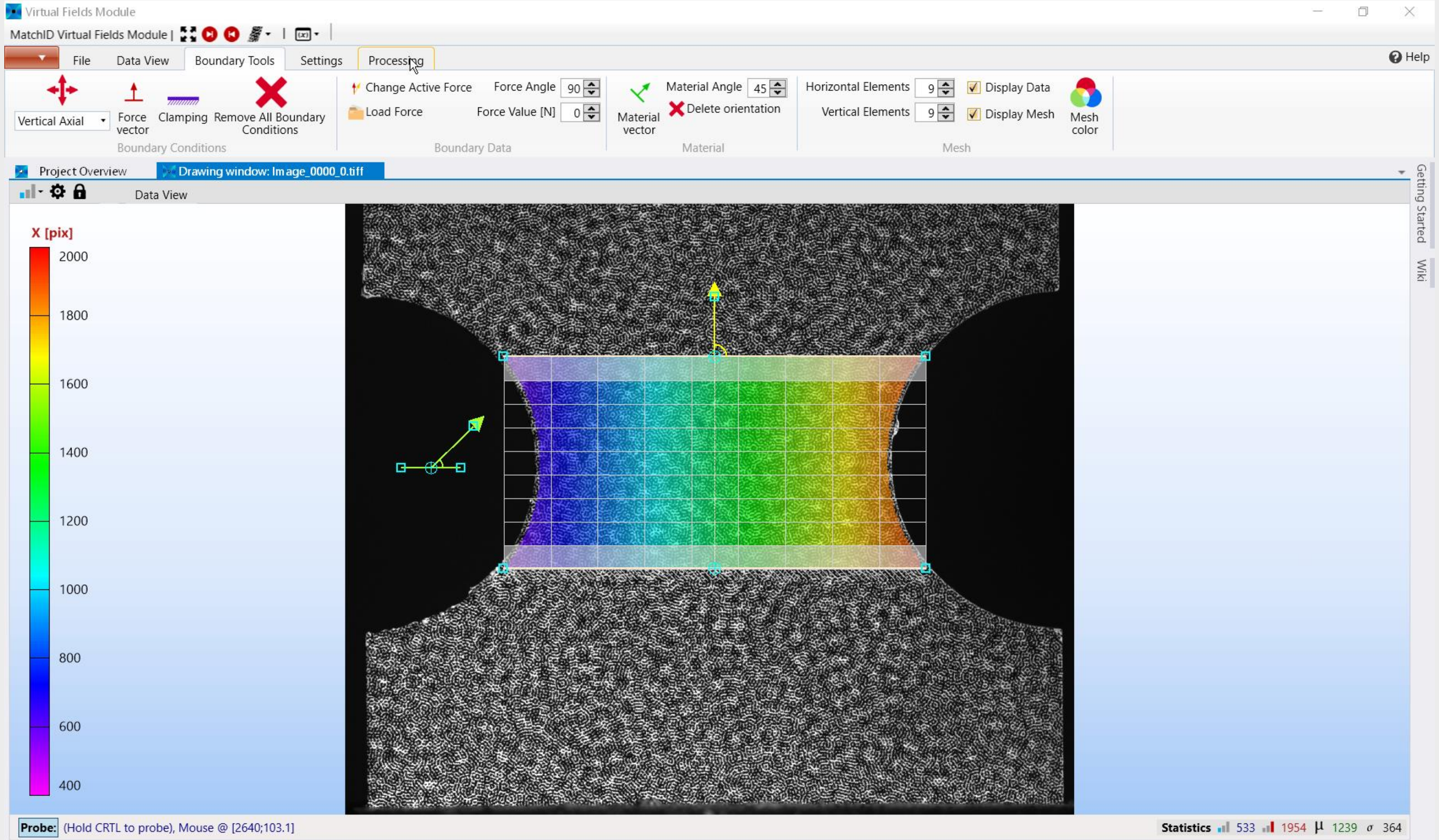
Subset size	21
Step size	7
Criterion	ZNSSD
Interpolation	Local Bicubic Splin
Shape function	Quadratic
Stereo Transformation	Quadratic
Prefiltering	Gaussian
Progress history	Temporal

Strain

Strain Window	7
Virtual Strain Gauge	63
Strain Interpolation	Q8
Strain Tensor	Log. Euler-Almansi

VFM Module

Assign boundary conditions → Select material model → Establish equilibrium



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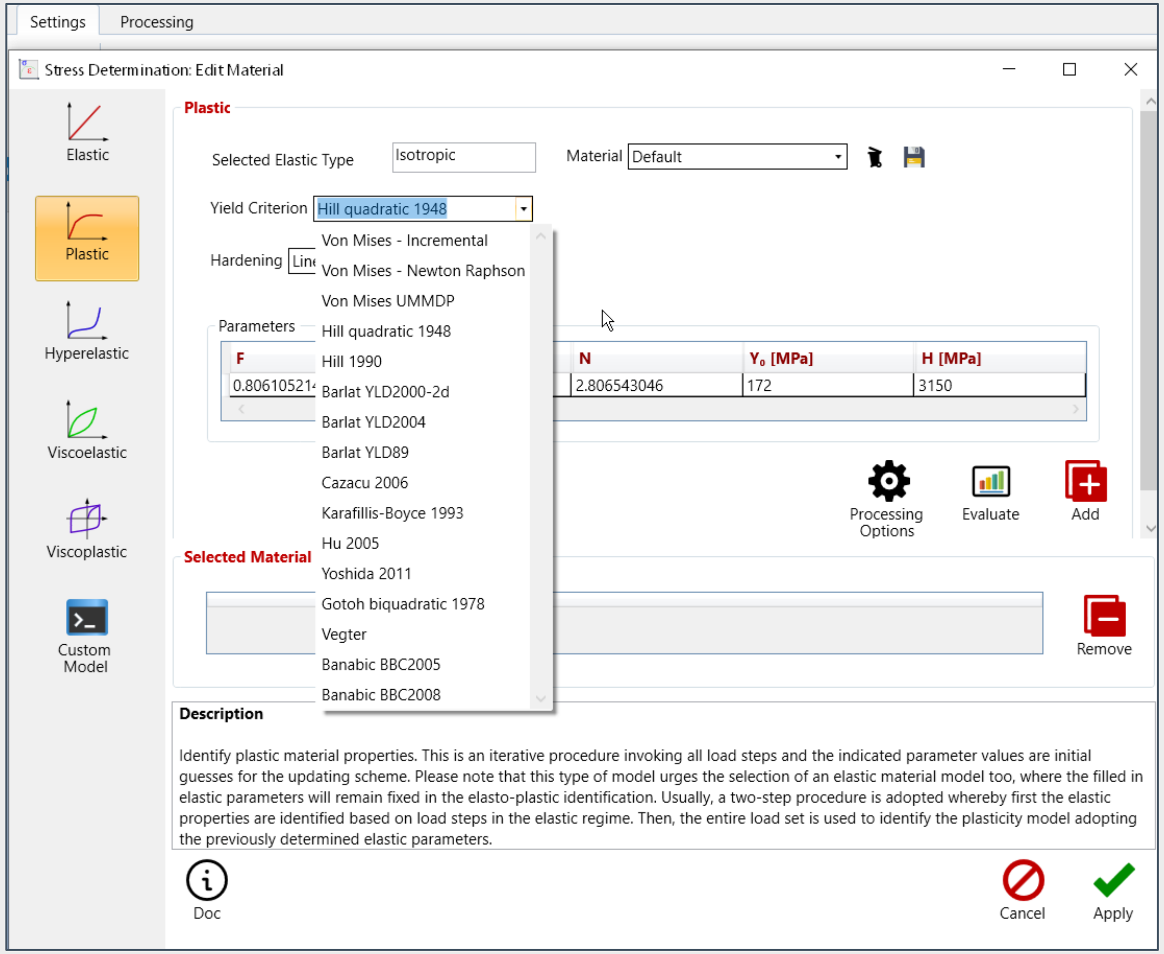
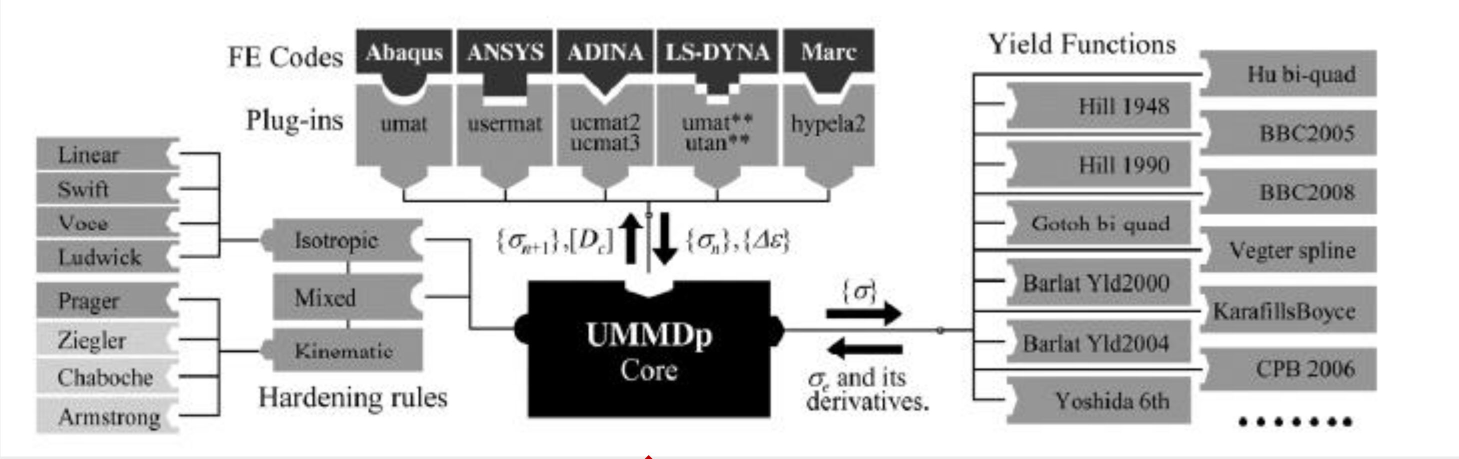
VFM Module

Assign boundary conditions | **Select material model** | Establish equilibrium



A large set of material models

- Unified Material Model Driver for Plasticity (UMDDp) open library (http://www.jancae.org/annex/annexUMMDe/index.html). The UMDDp is a user-subroutine library for anisotropic plasticity models, which is commonly applicable to major commercial FE codes



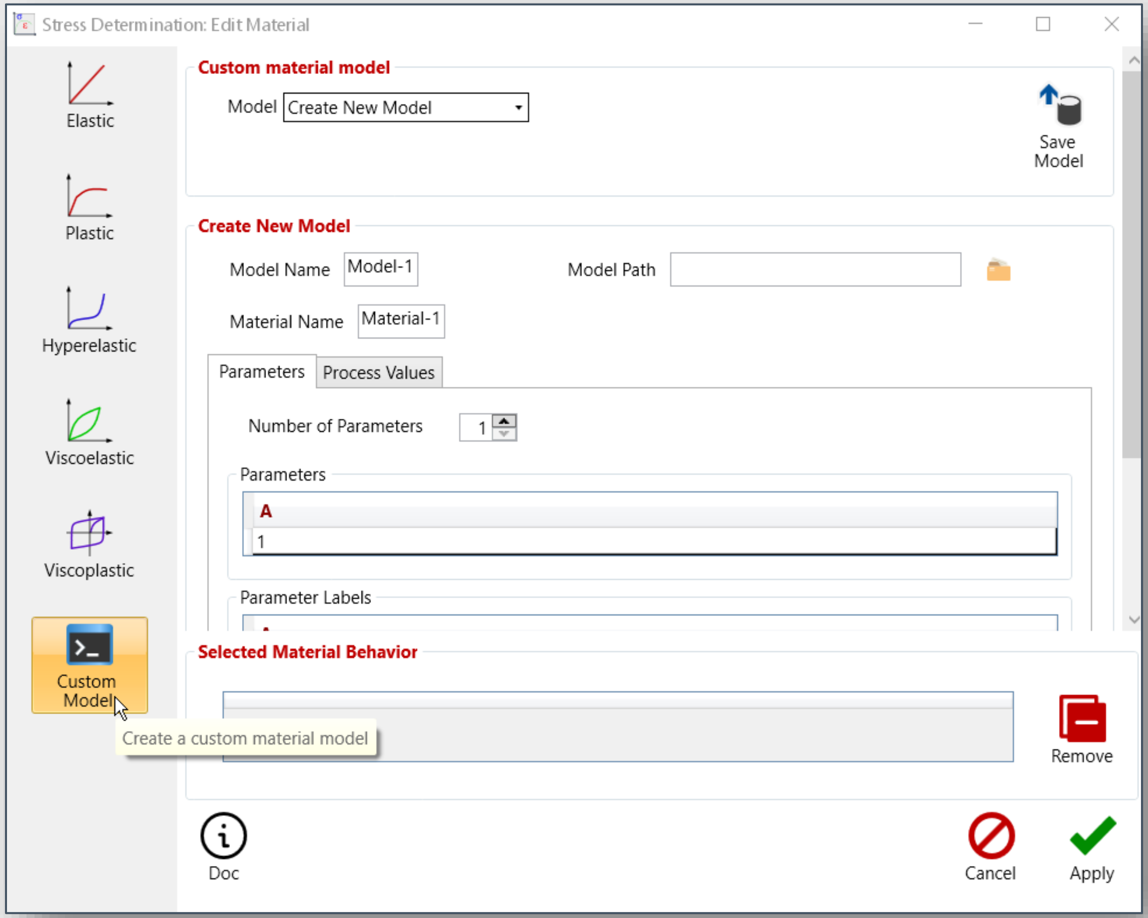
VForm-xSteels

The CMAT allows to user our VFM as a solver

MatchID embeds a **large versatility** of these….

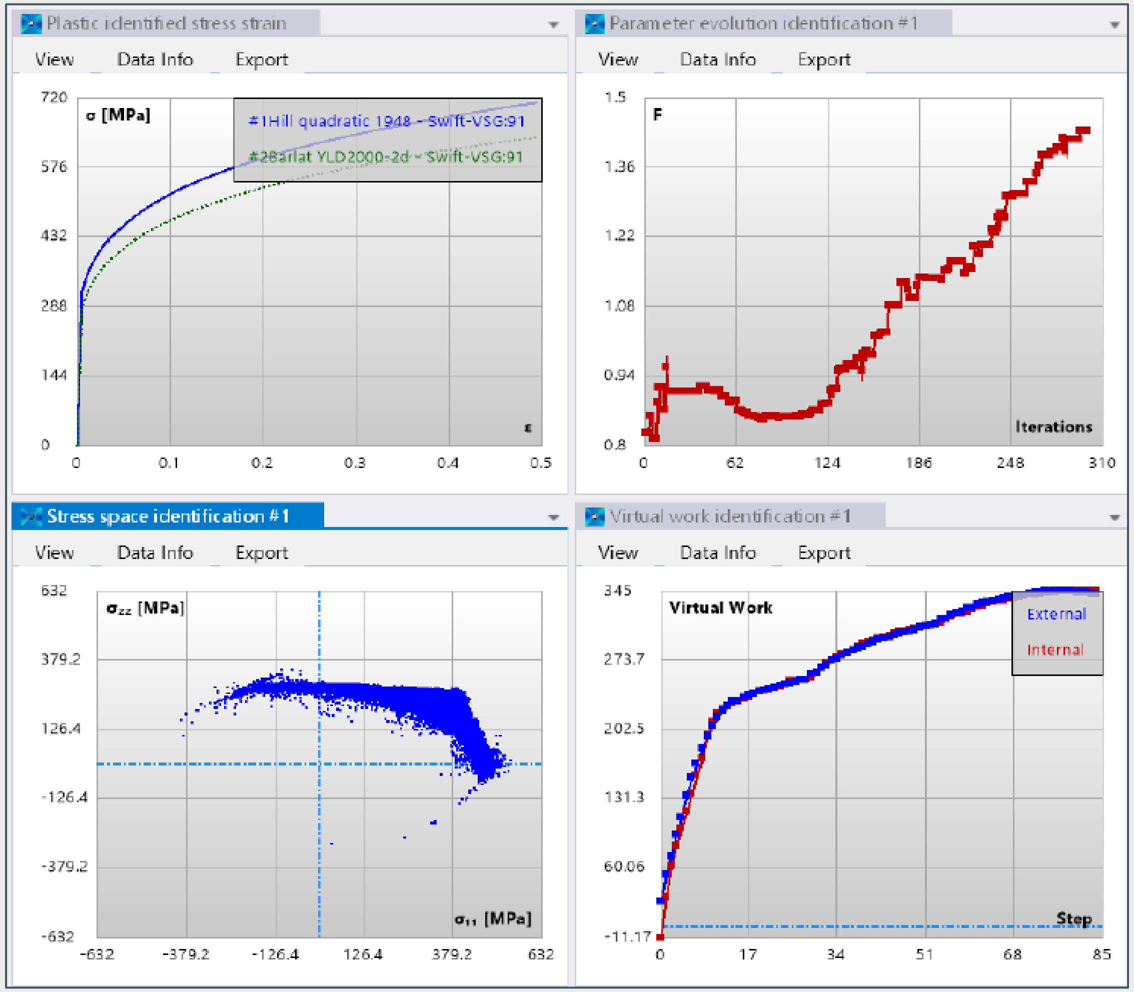
But what to do for custom or novel material models?

CMAT structure



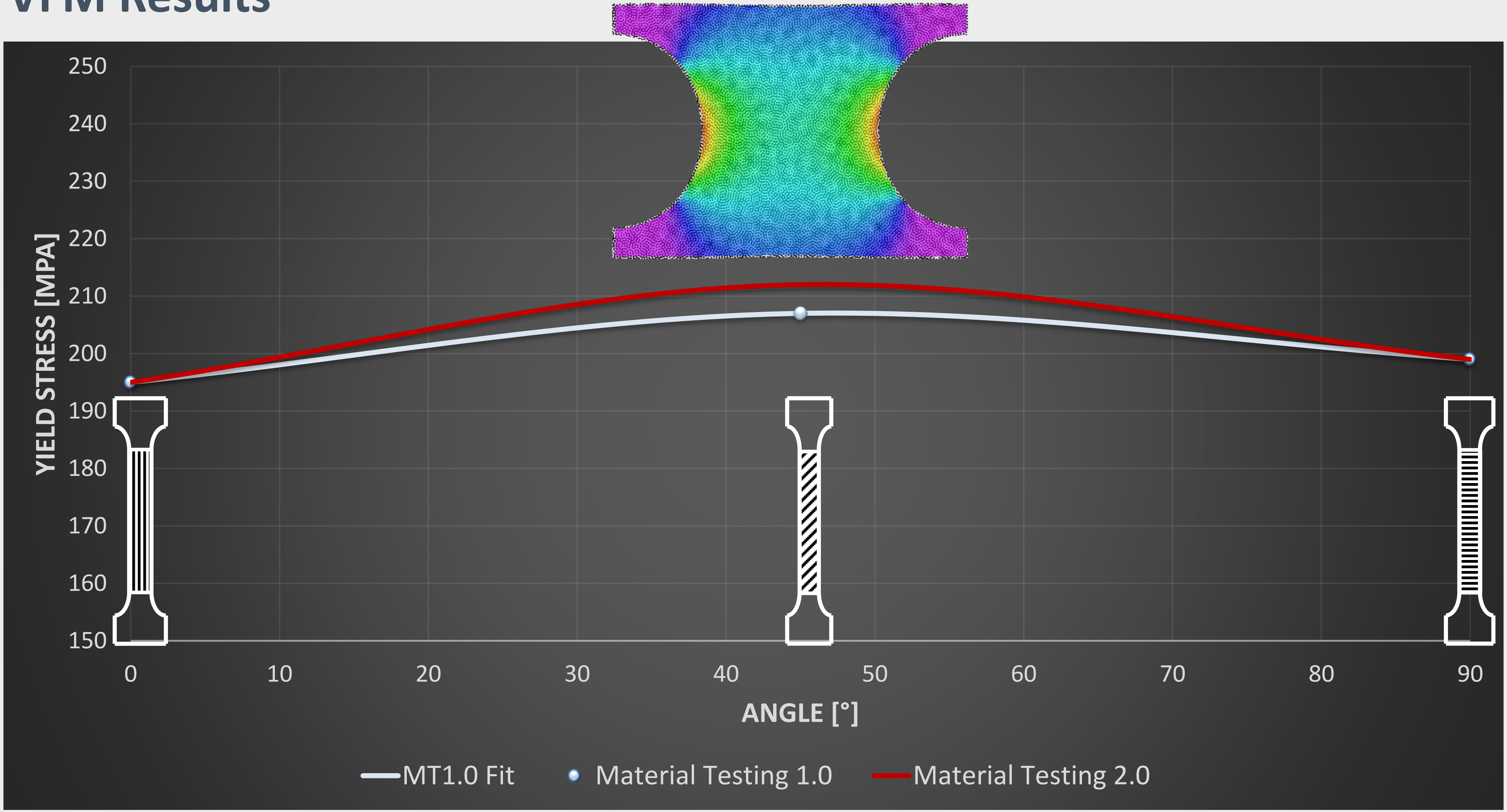
VFM Module

Assign boundary conditions | Select material model | **Establish equilibrium**



- 85 load steps
- ~25k data points
- 6 min
- No FEA model needed

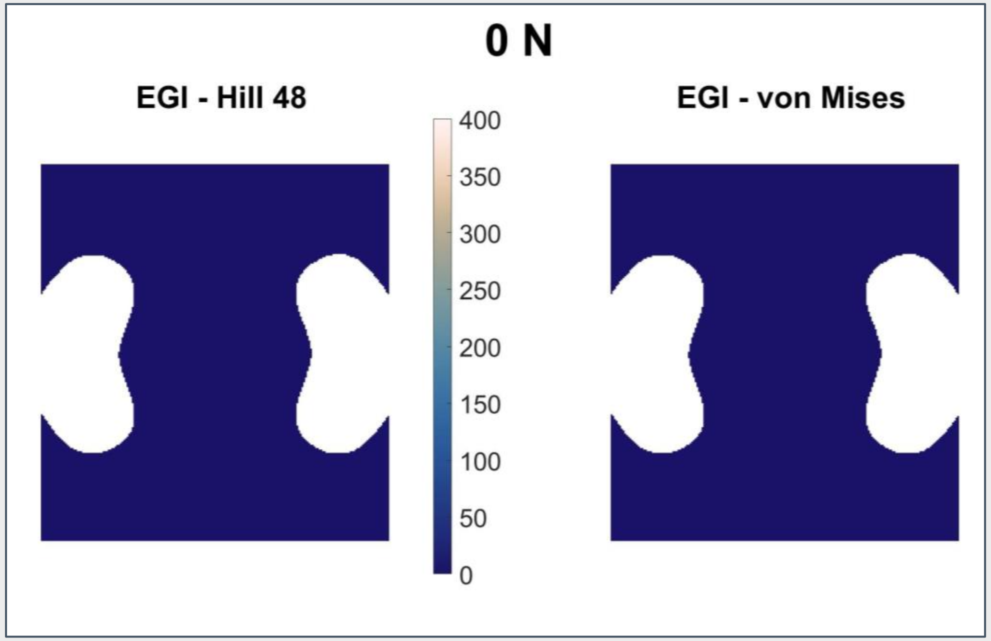
VFM Results



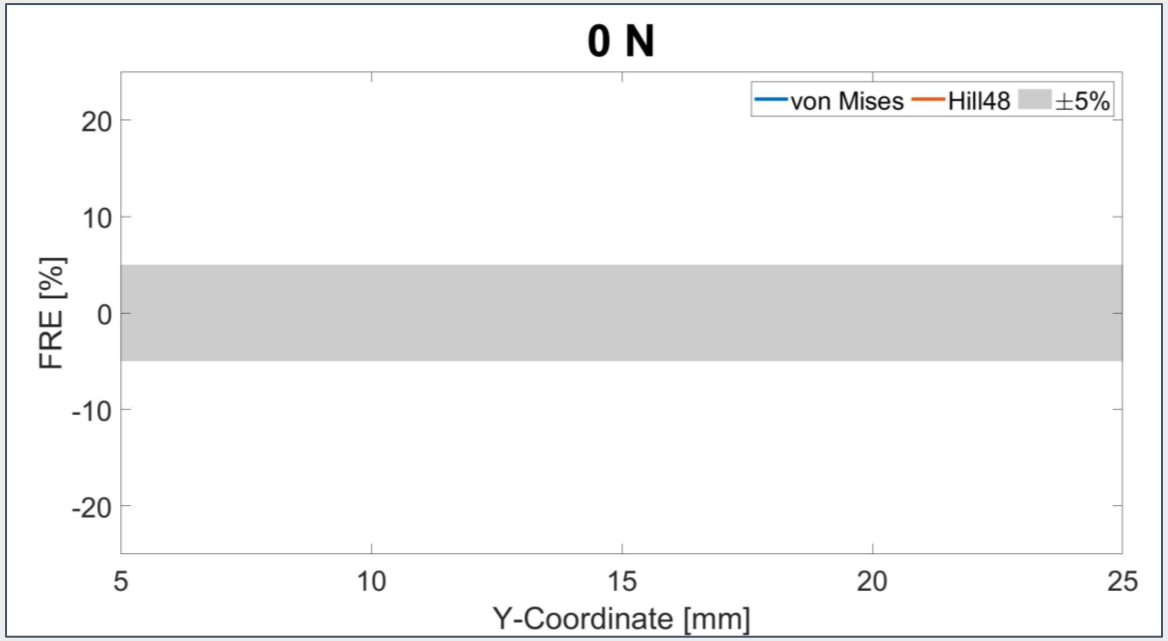
250
240
230
220
210
200
190
180
170
160
150
YIELD STRESS [MPA]
0
10
20
30
40
50
60
70
80
90
ANGLE [°]
MT1.0 Fit
Material Testing 1.0
Material Testing 2.0

Integrated metrics for model fitness evaluation

Equilibrium Gap Indicator



Force Reconstruction Error



Metrics to evaluate constitutive model fitness based on DIC experiments. A. Peshave, F. Pierron, P. Lava, D. Moens, D. Vandepitte (2024). *Strain*

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Digital twin in test design

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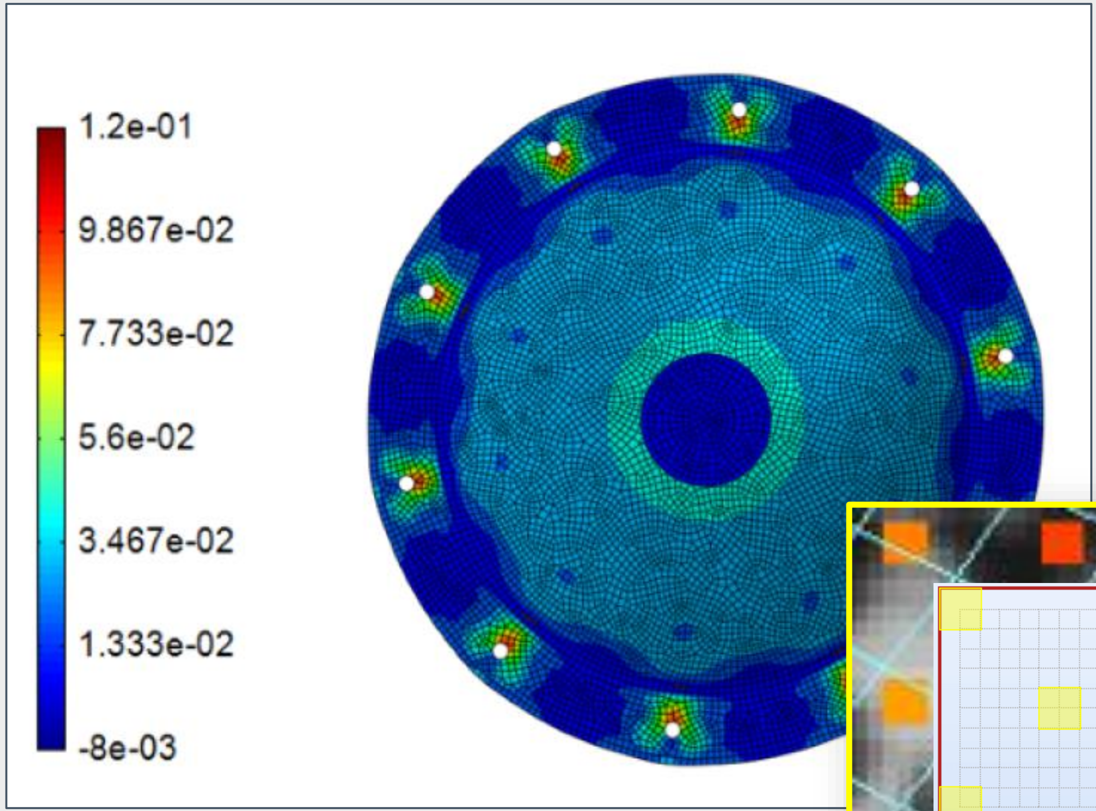
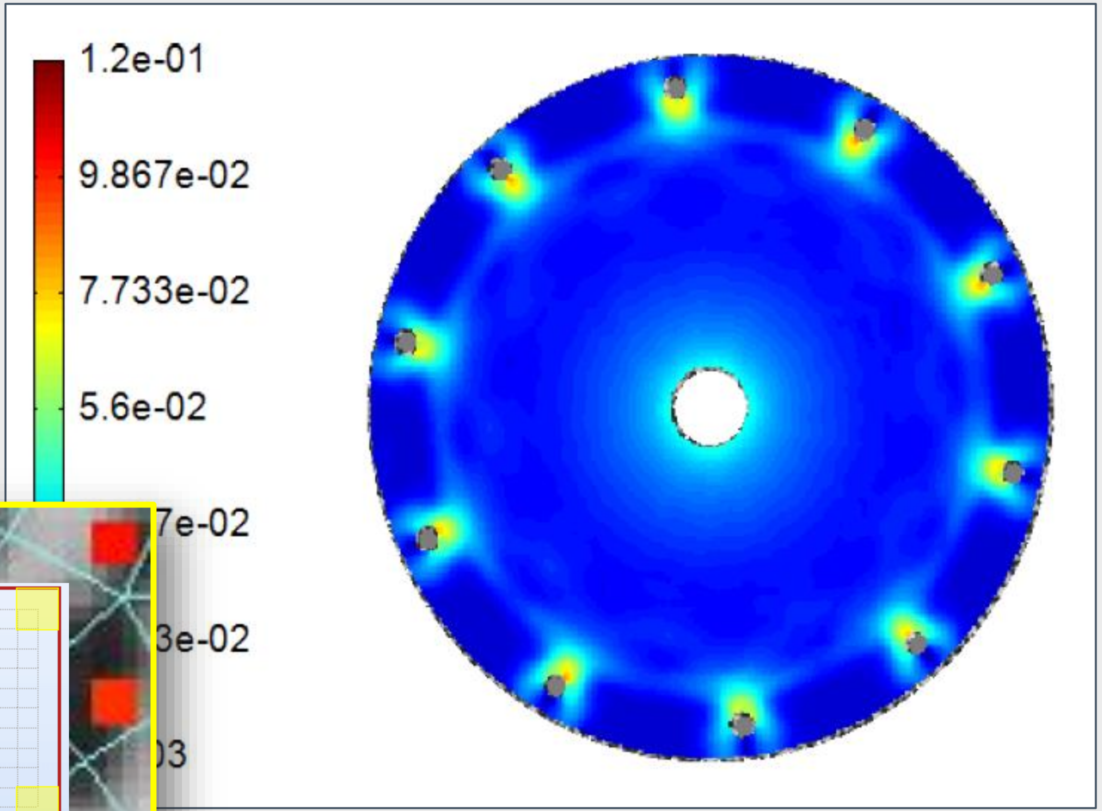
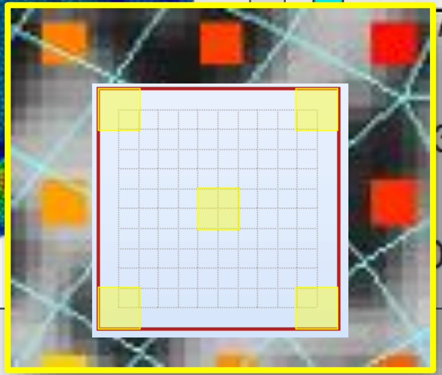
DIC and FEA act at a different regularization level

E1 - FEA



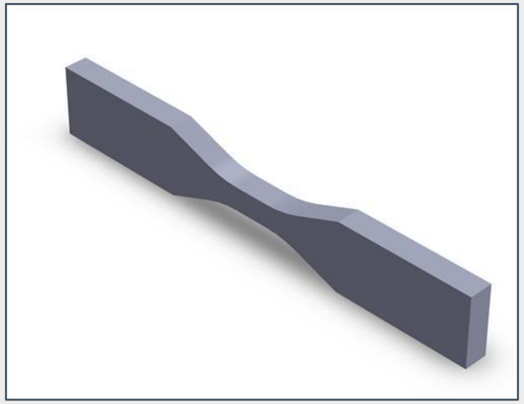
E1 - DIC

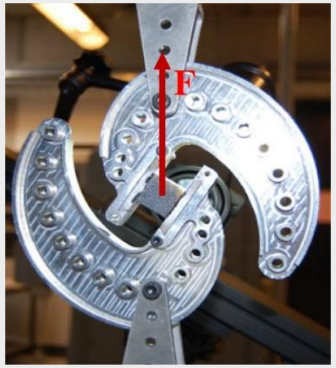


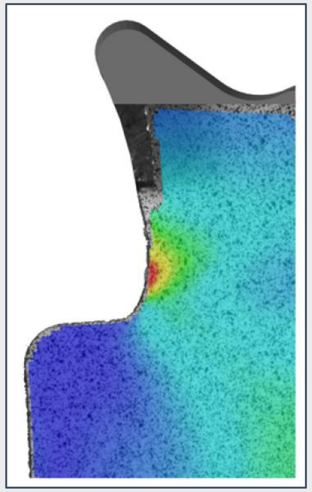


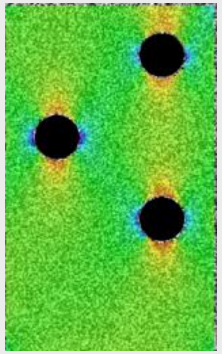
Test design and “new” standards

Traditional → Innovative









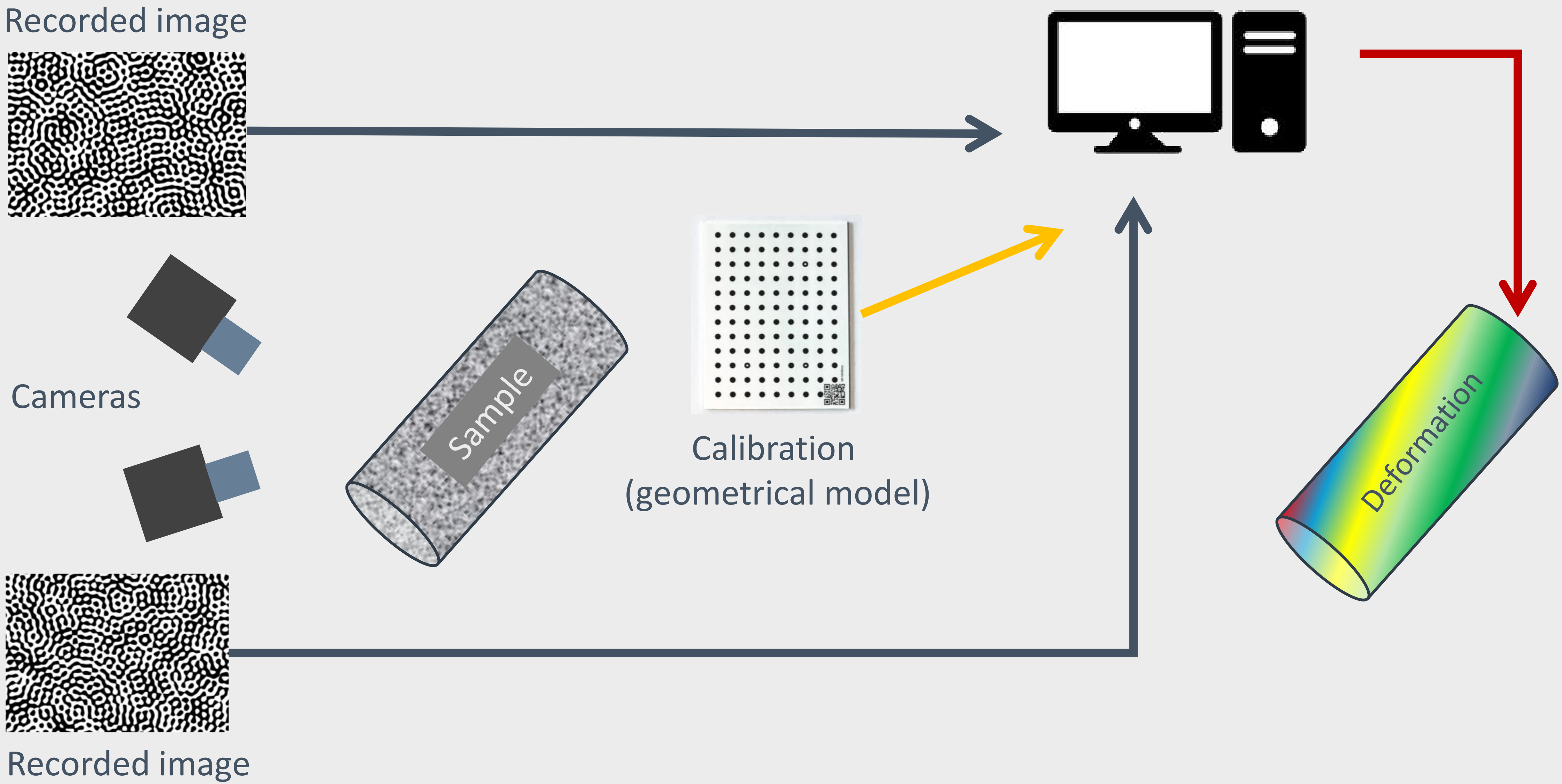
Which test configuration yields the smallest errors?

High Heterogeneity
activate all involved material properties

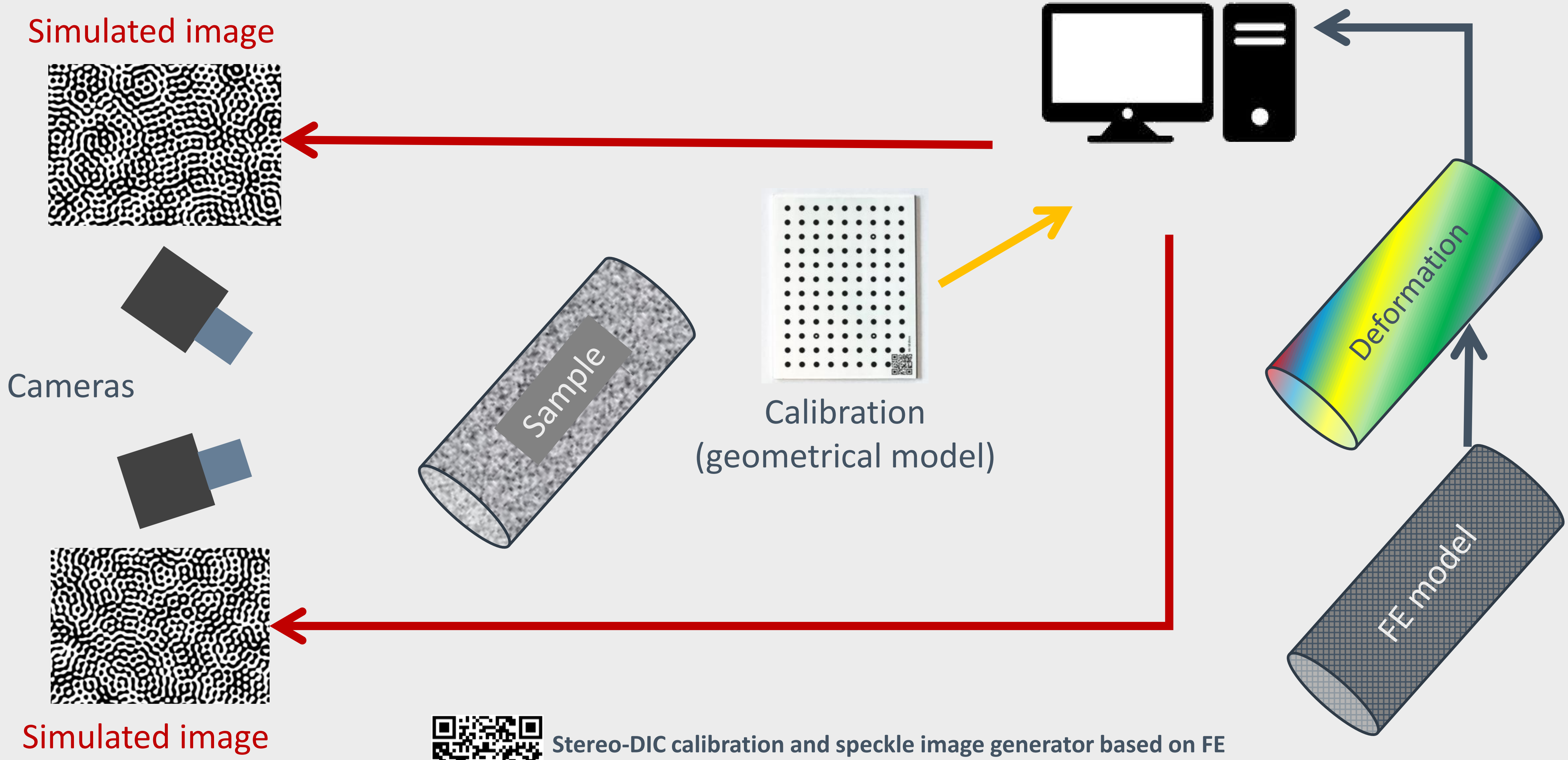
↔

Low Heterogeneity
reconstruction error of full-field technique

Stereo Digital Image Correlation

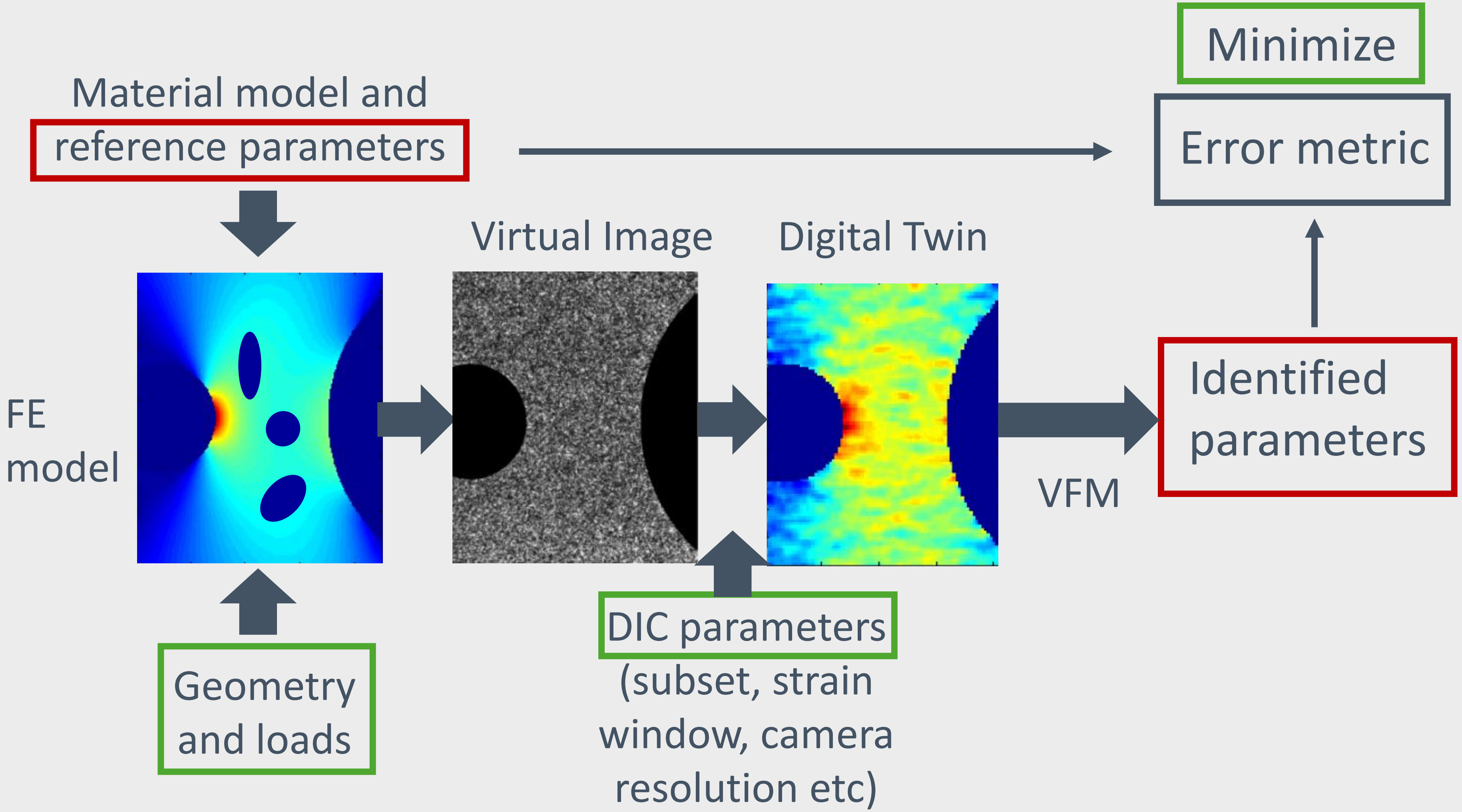


Digital Twin (DT): FEDEF Module



Stereo-DIC calibration and speckle image generator based on FE formulations. R. Balcaen, L. Wittevrongel, P. Reu, P. Lava, D. Debruyne (2017). *Experimental Mechanics, 57 (5).*

Digital Twin: simulate the entire identification chain



Optimised Experimental Characterisation of Polymeric Foam Material Using DIC and the Virtual Fields Method. P. Wang, F. Pierron, M. Rossi, P. Lava and O.T. Thomsen (2016). *Strain 52, 59–79*.

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Digital twin in model updating

Material testing 2.0

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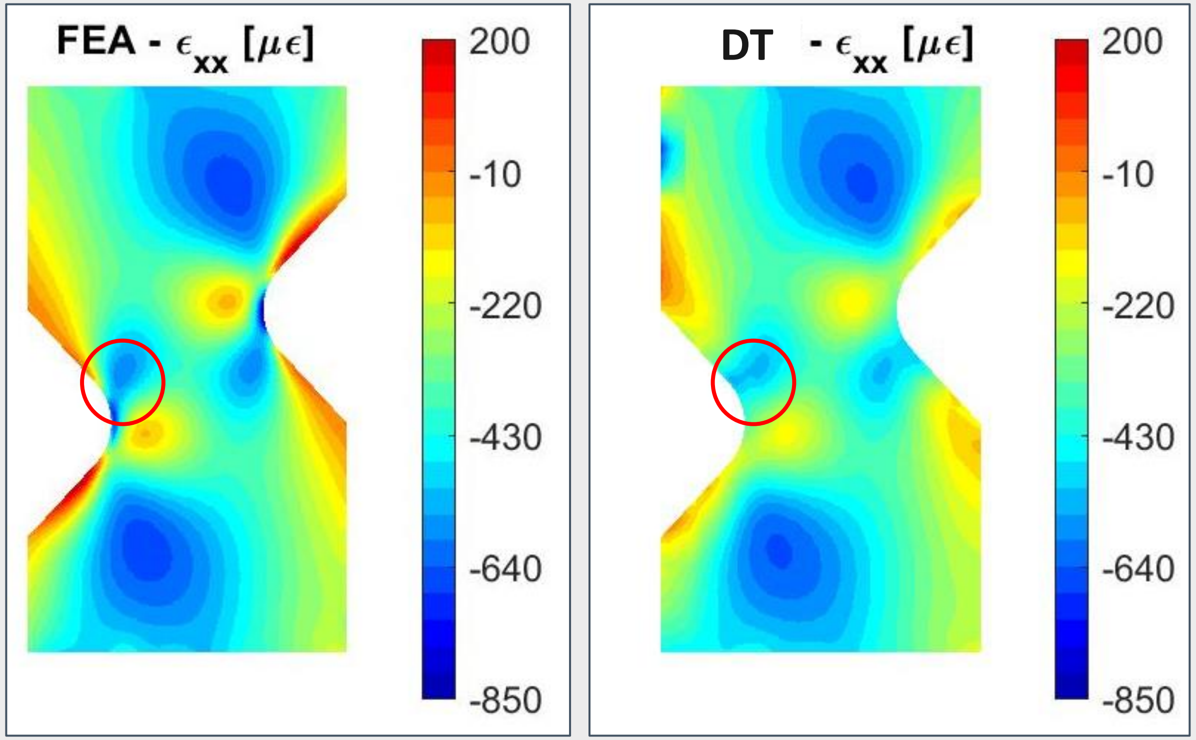
The levelling approach to truly bridge the gap



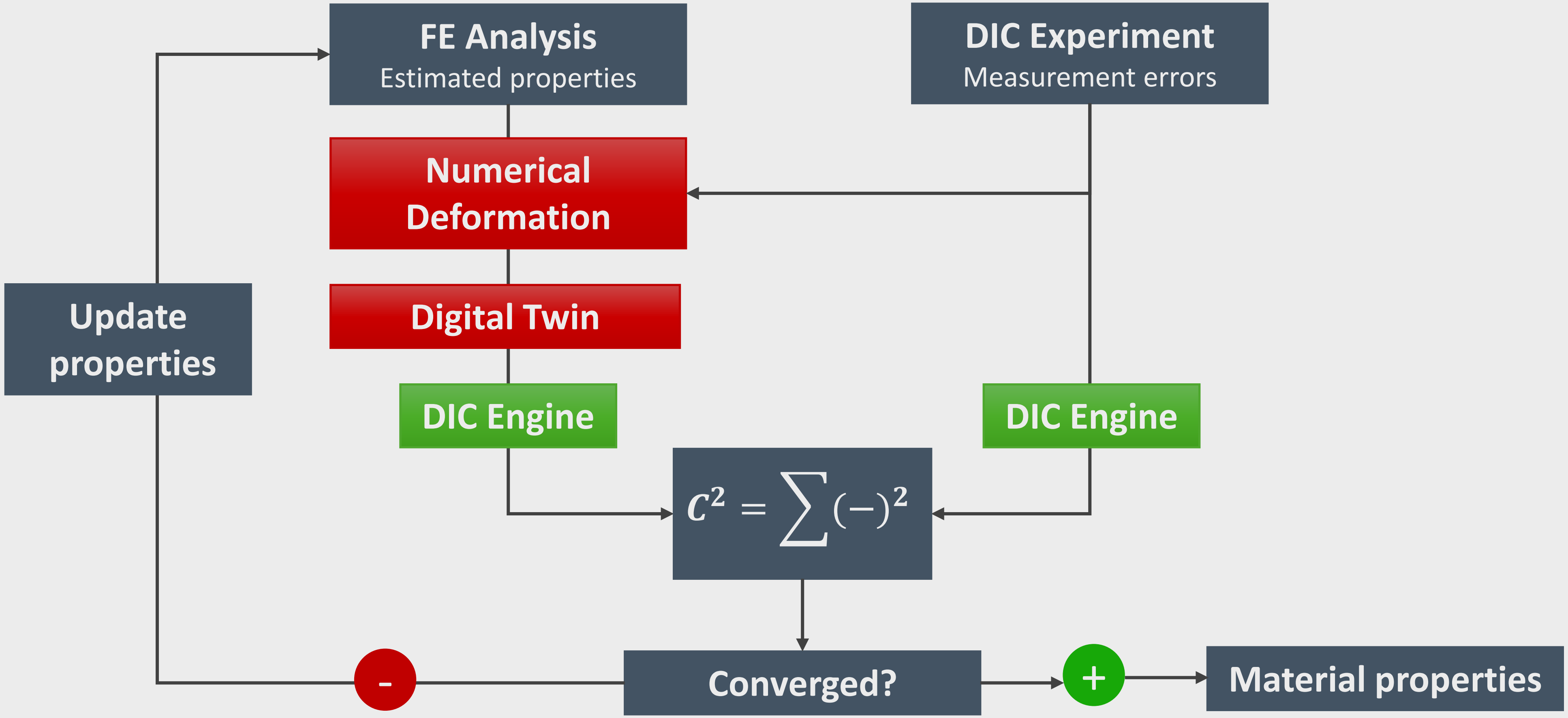
DIC and FEA apply a different mesh size

Unique procedure that **levels** FEA and DIC

Assurance that offsets arise from inherent properties and **NOT** from the solver procedure

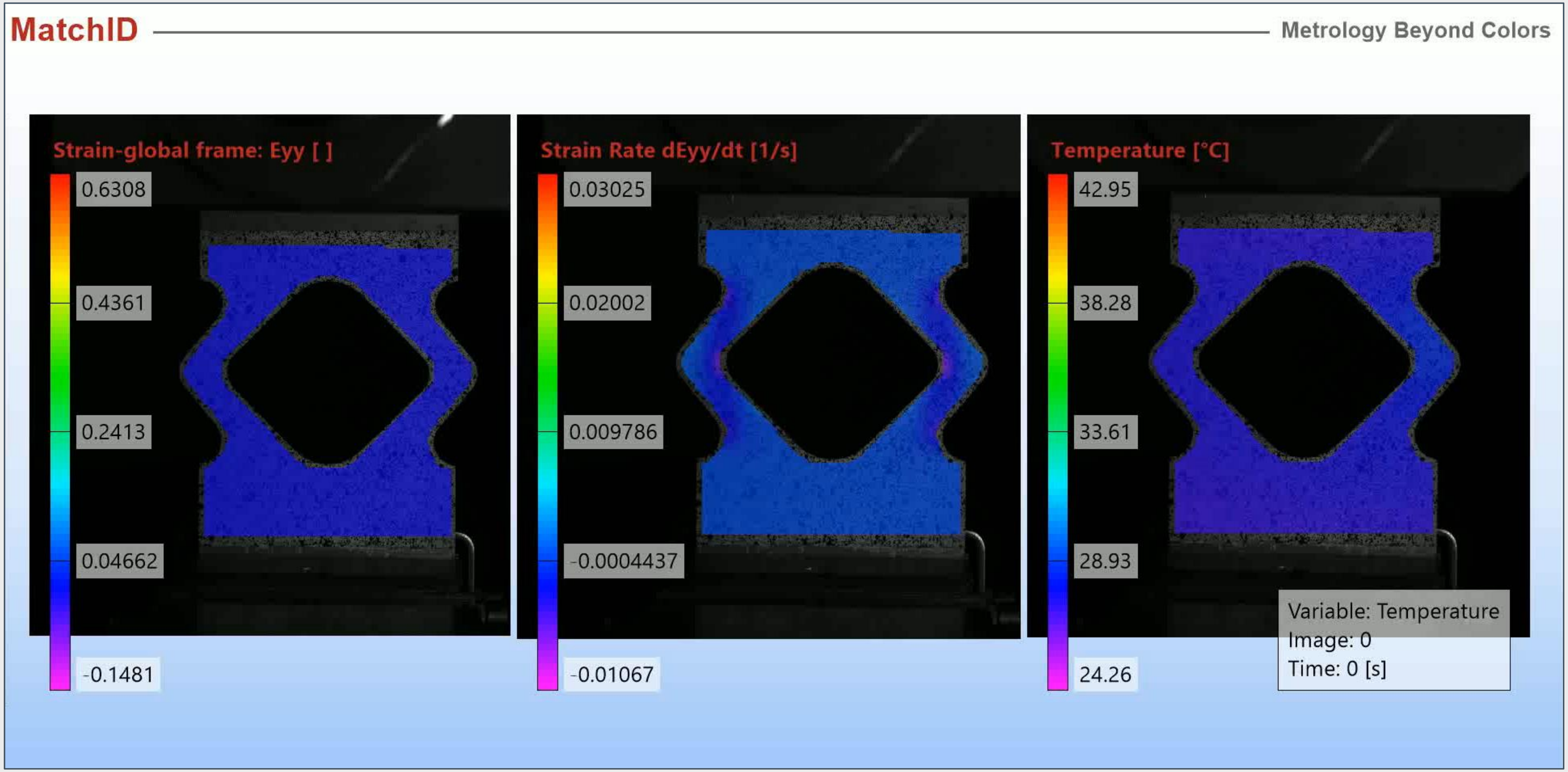
Validation of finite-element models using full-field experimental data: Levelling finite-element analysis data through a digital image correlation engine. P. Lava, E. Jones, L. Wittevrongel, F. Pierron (2020). *Strain, 56(4)*

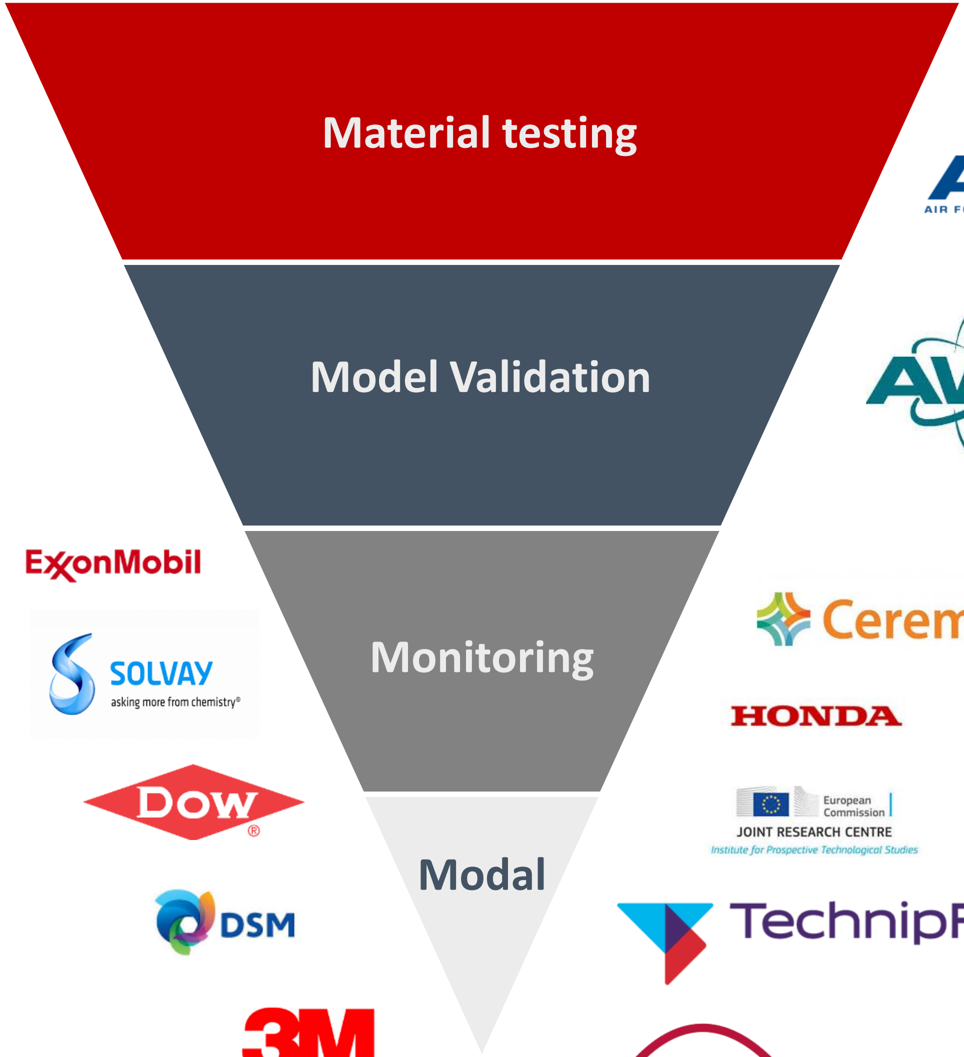
Future: FEMU engine levelling DIC and FEA



On the Importance of Direct-Levelling for Constitutive Material Model Calibration using Digital Image Correlation and Finite Element Model Updating. S. S. Fayad, E. M. C. Jones, D. T. Seidl, P. L. Reu, J. Lambros (2022). *Exp Mech*

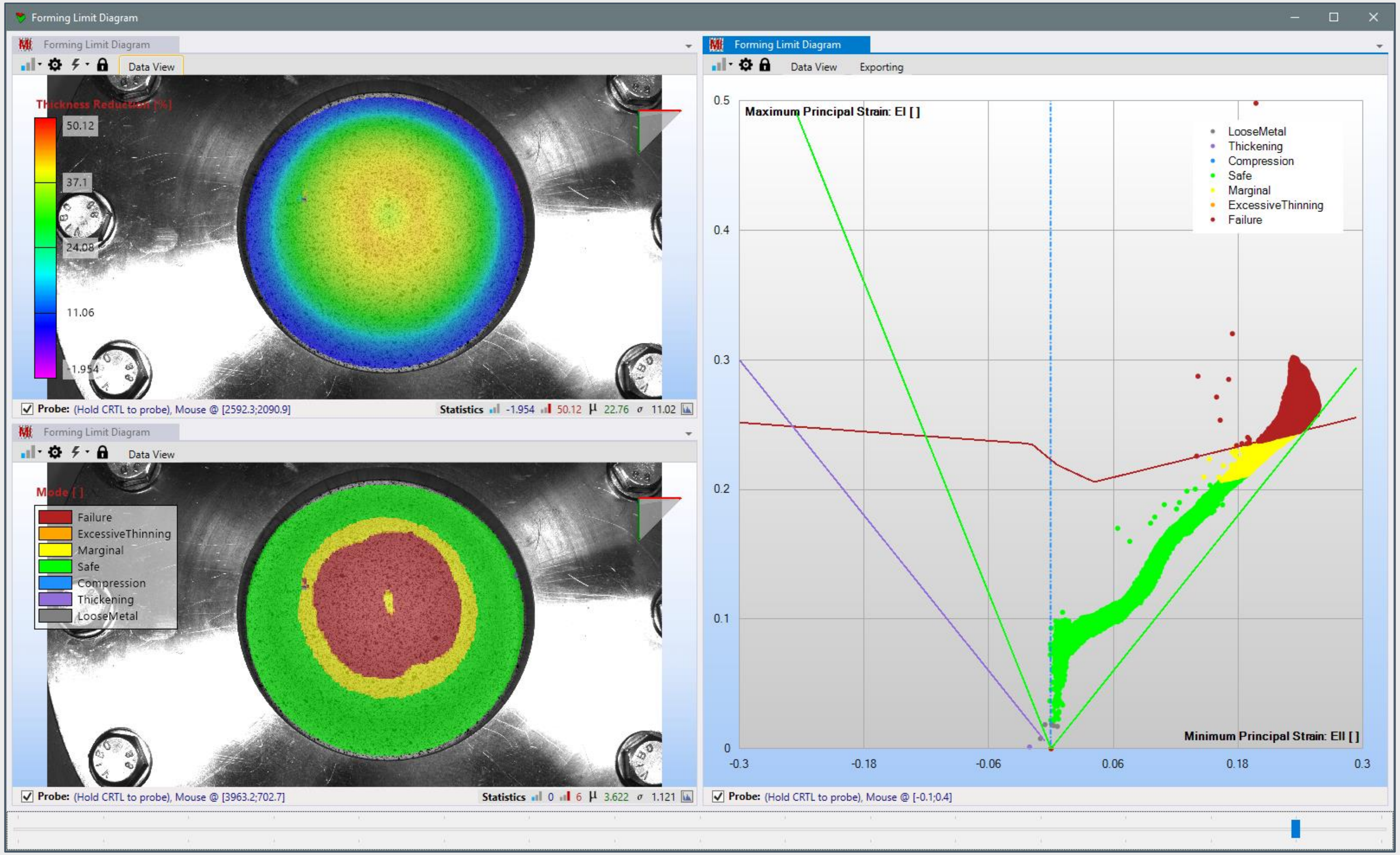
Future: Material Identification including thermal measurements





ExxonMobil
SOLVAY asking more from chemistry®
DOW
DSM
3M
Applus+ laboratories
AFRL AIR FORCE RESEARCH LABORATORY
KU LEUVEN
ARL
AWE
Université Bretagne Sud ubs
MINES
Canada NRC·CNRC
UNIVERSITY OF OXFORD
NREL NATIONAL RENEWABLE ENERGY LABORATORY
Boston Scientific
NISSAN
Sandia National Laboratories
NIST
Cerema
HONDA
TU Delft
ITP Aero
UK Atomic Energy Authority
NASA
European Commission JOINT RESEARCH CENTRE Institute for Prospective Technological Studies
Fraunhofer
Forest Service U.S. Department of Agriculture
TechnipFMC
TU/e
OCAS
JÖNKÖPING UNIVERSITY
Taiyuan University of Technology 1902
Dalian University of Technology 1949
UNIVERSITEIT GENT
magma

ISO12004-2: Forming Limit Diagram



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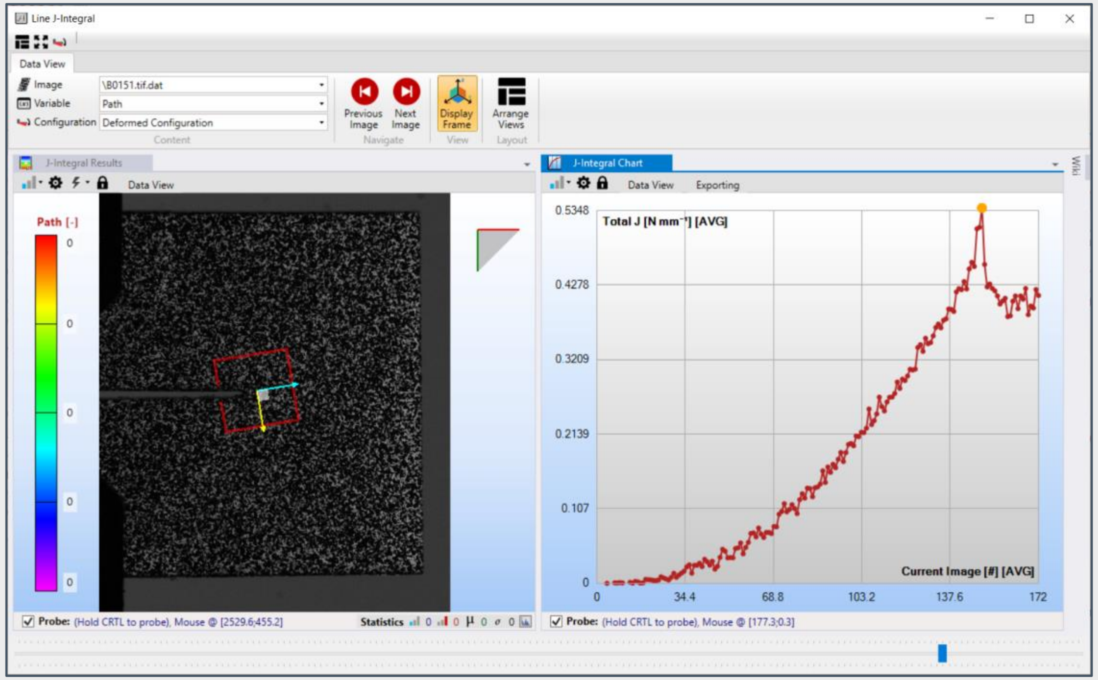
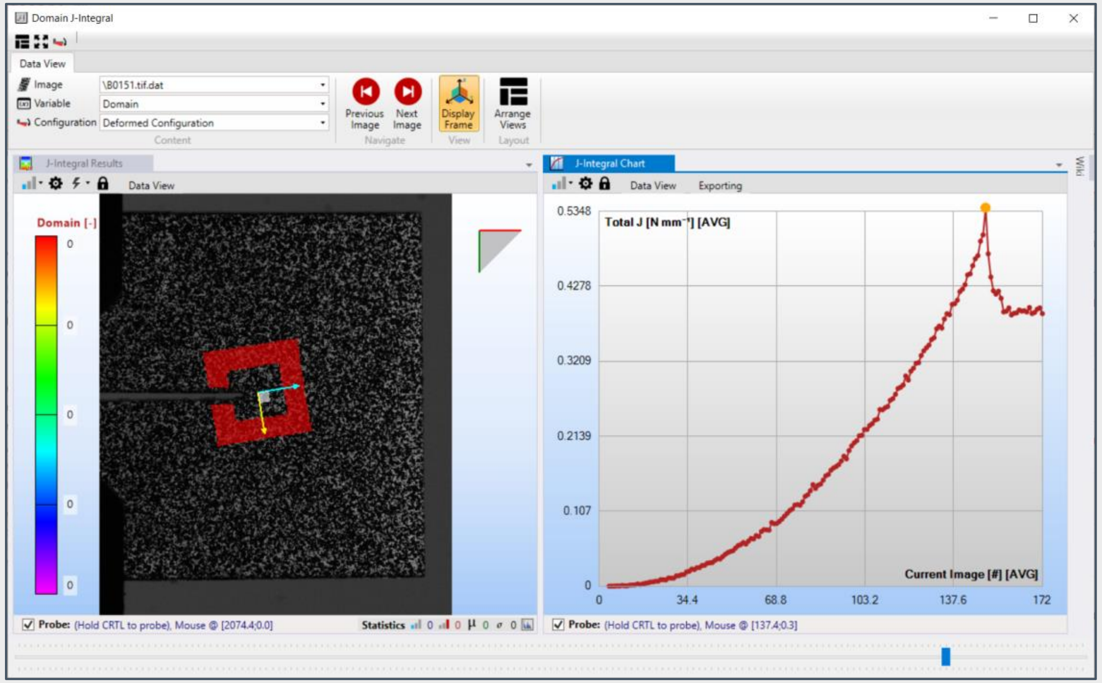
Fracture Mechanics: J-Integral Module

Path J-Integral



Domain J-Integral



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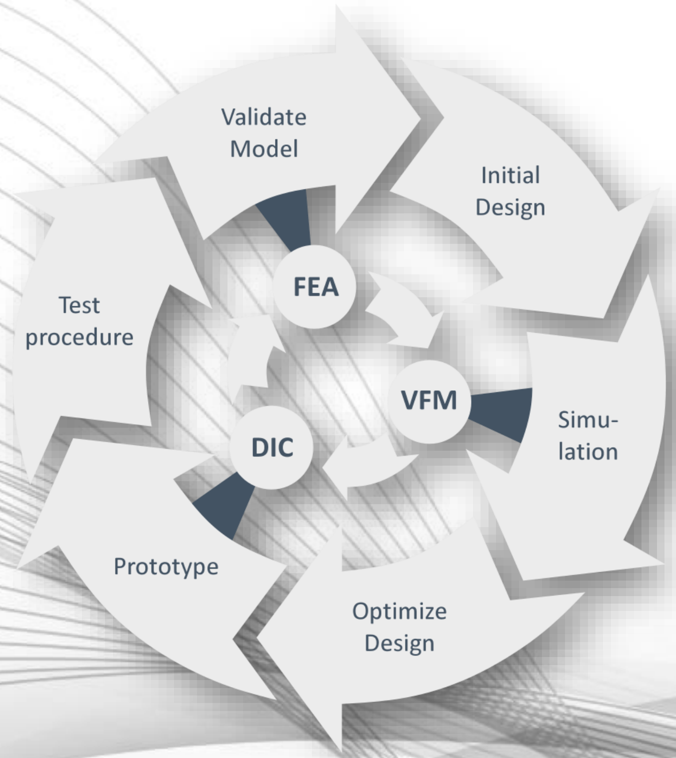
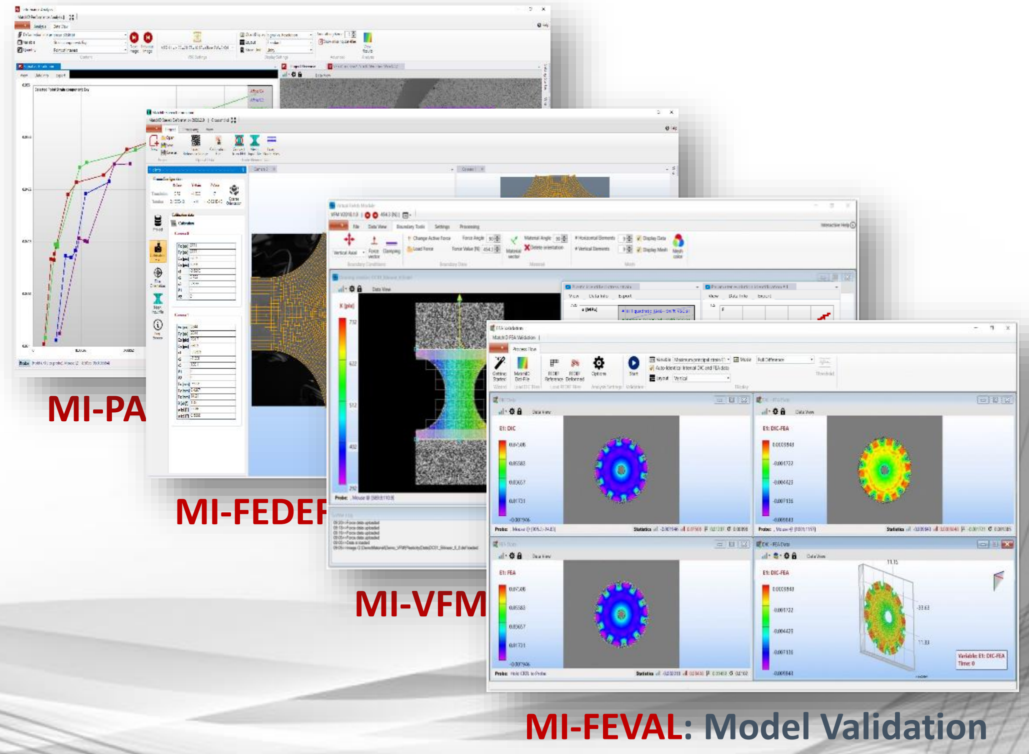
Quantitative imaging techniques to assess materials and structures





"… it's not just DIC, it's integrated"

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