

Strain Analysis on an Al-Foam Structure with ESPI

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Motivation of Study

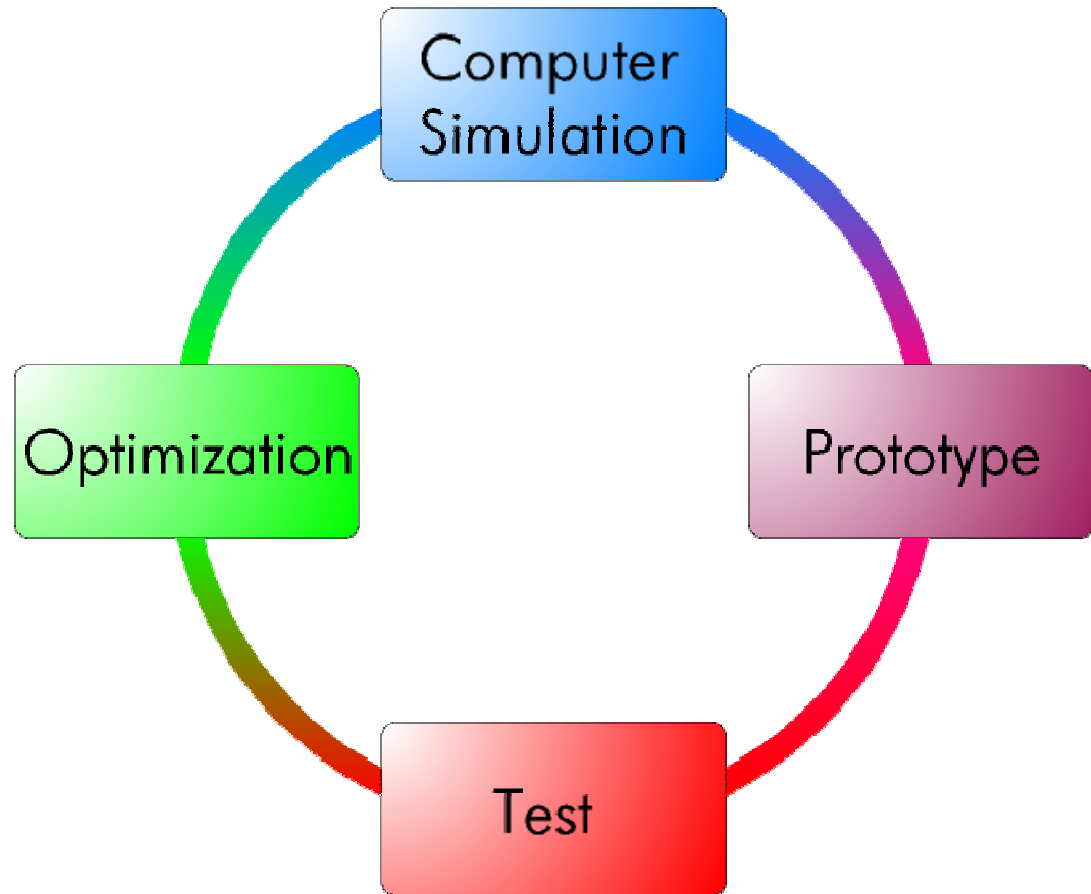
- Demand for light weight designs in automotive techniques
- Improved stiffness especially of convertible bodies
- Improvement of FEA elements and methods for new designs and structures
- Acceleration of component design



**Development time of new
Crossfire: 18 months !**

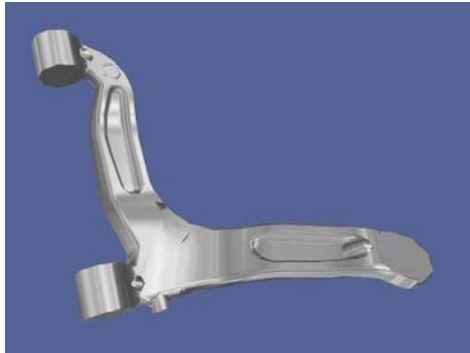
Improvement of the Development Cycle

- **Proof validity of ESPI techniques for validation of simulations**
- **Show applicability of this concept in the design phase of a new prototype**

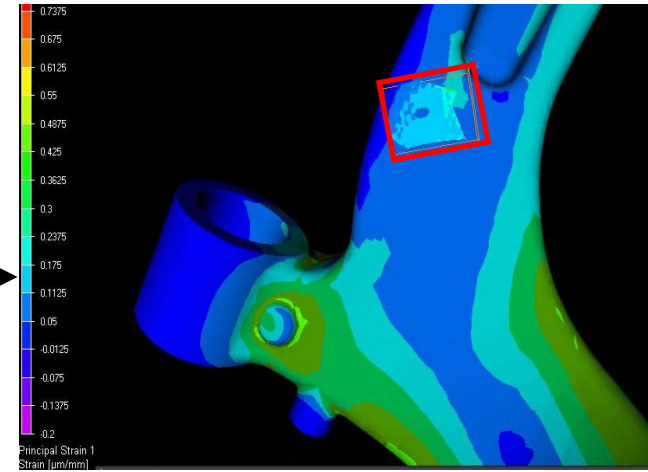


Correlation of Simulation and Experiment

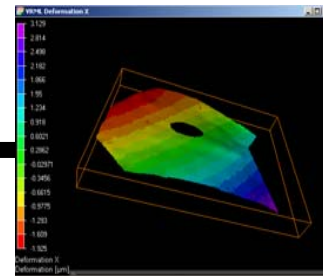
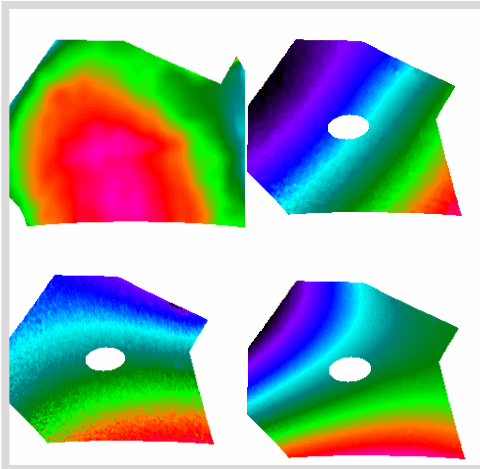
CAD



+ FEA

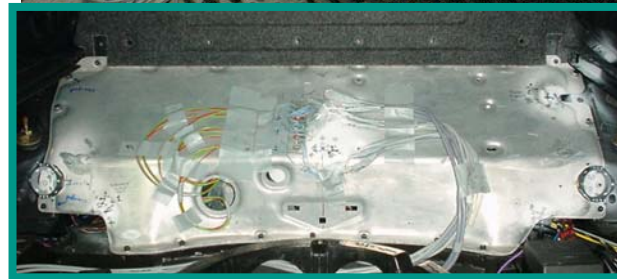
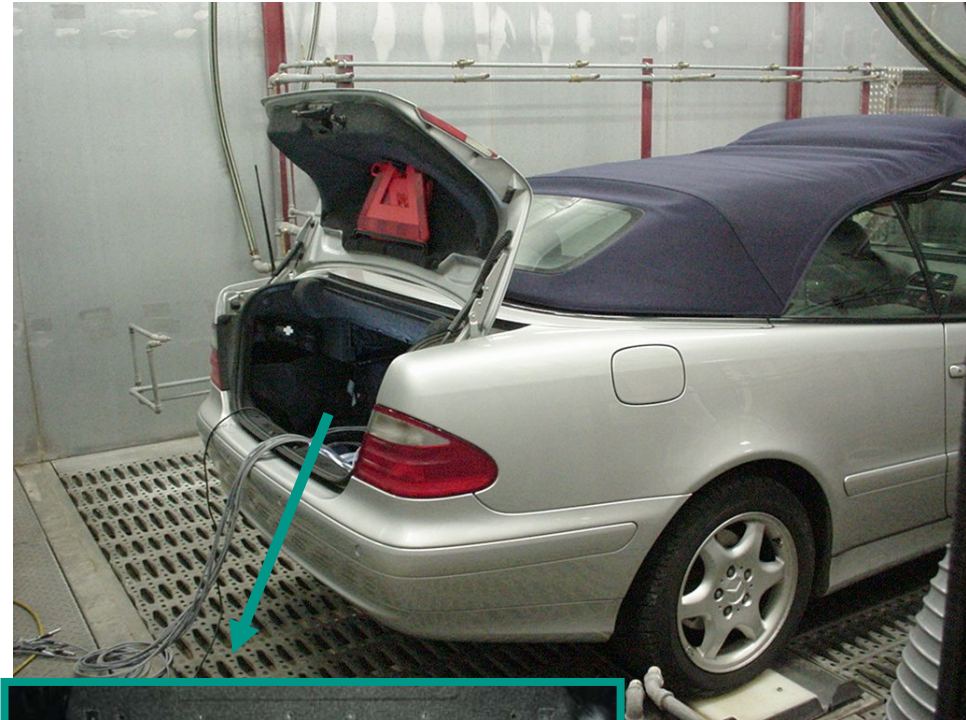


ESPI-Measurement



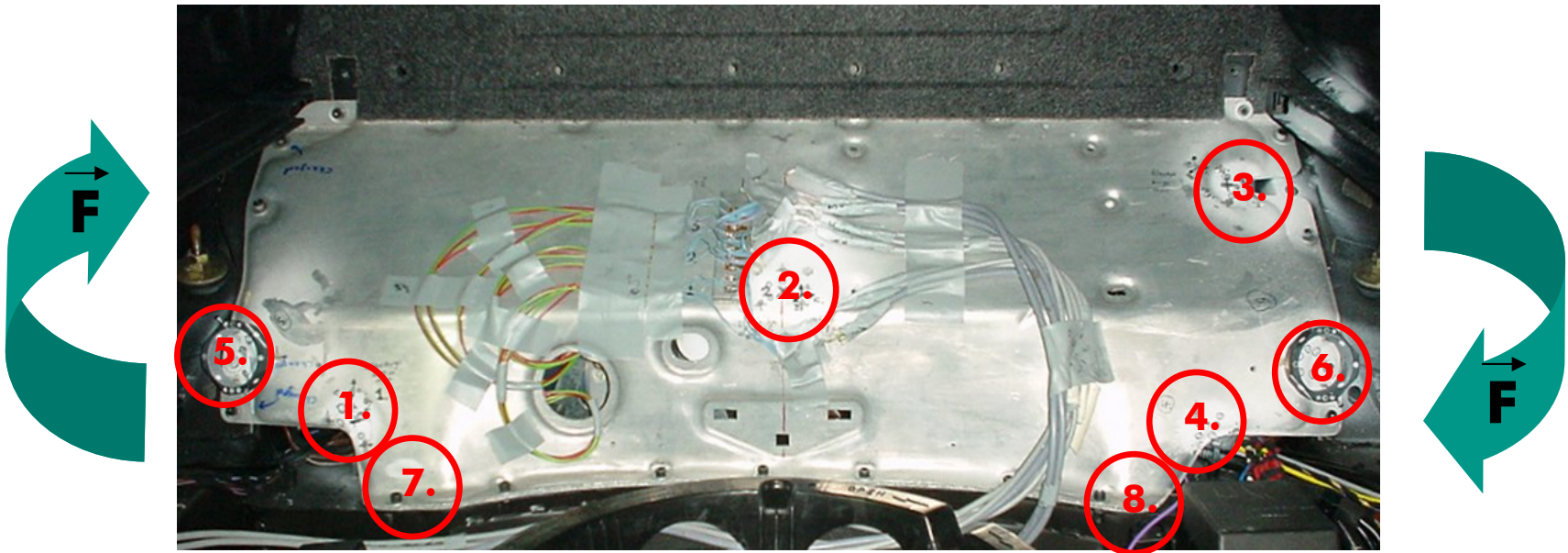
Goals

- Karmann created a test platform for foamed aluminium structures:
- Example: rear plate for Mercedes-Benz CLK model
- Validation of critical areas
- Improvement of FEA models
- Q-100 delivers the required data in the critical areas



Measuring Areas

- Contact points of AFS to body
- Areas with screws, bolts, notches



Aluminium Foamed Structure (AFS)

Test Bench

- Test car was positioned on test bench
- Each wheel can be lifted with pneumatic actuators, independently
- Lifting amplitude max. 300 mm
- Experiments with open and with closed roof



Load Conditions

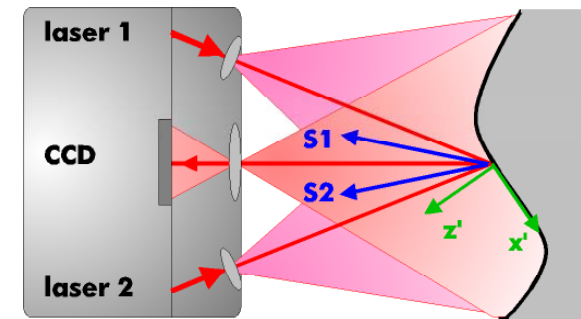
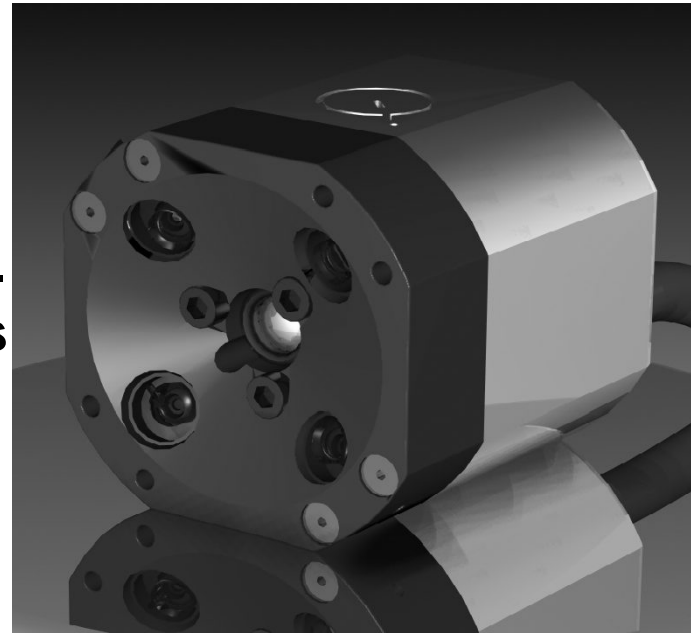
- 32 measuring series
- 8 measuring positions
- Each with 3 different loads
- HL/VR = up to 300/300mm, or HR/VL = up to 300/0mm
- Roof open / closed, opening of roof



Load condition: Torsion

Measuring Principle: Speckle Interferometry (ESPI)

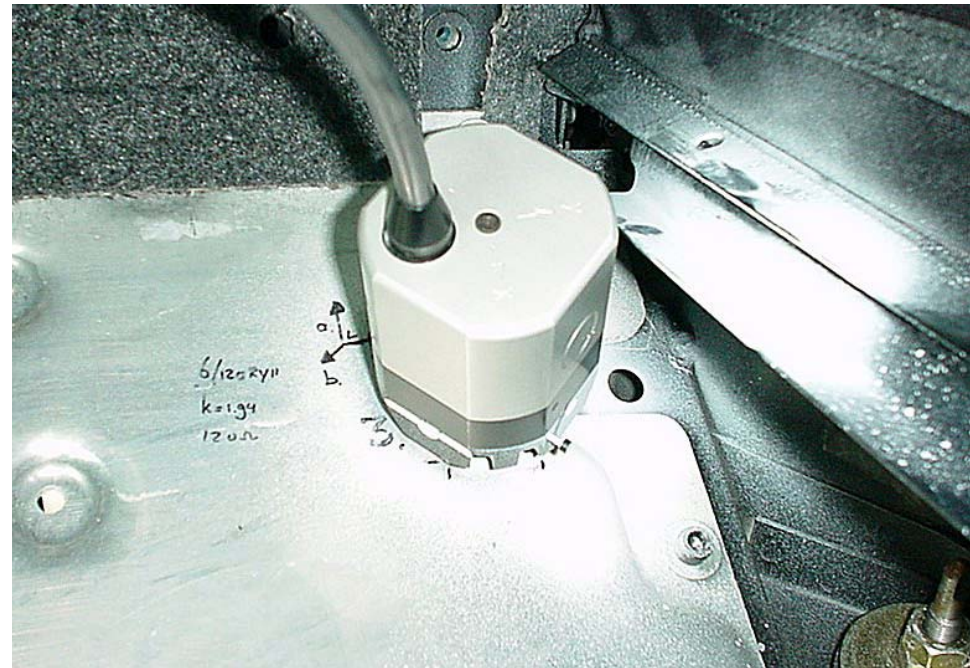
- Full field illumination with laser from 4 directions
- Observation with CCD camera
- Recording of the complete 3D-contour and 3D - deformations
- Calculation of the strains / stresses



Application of Q-100 for Strain Measurement

Procedure

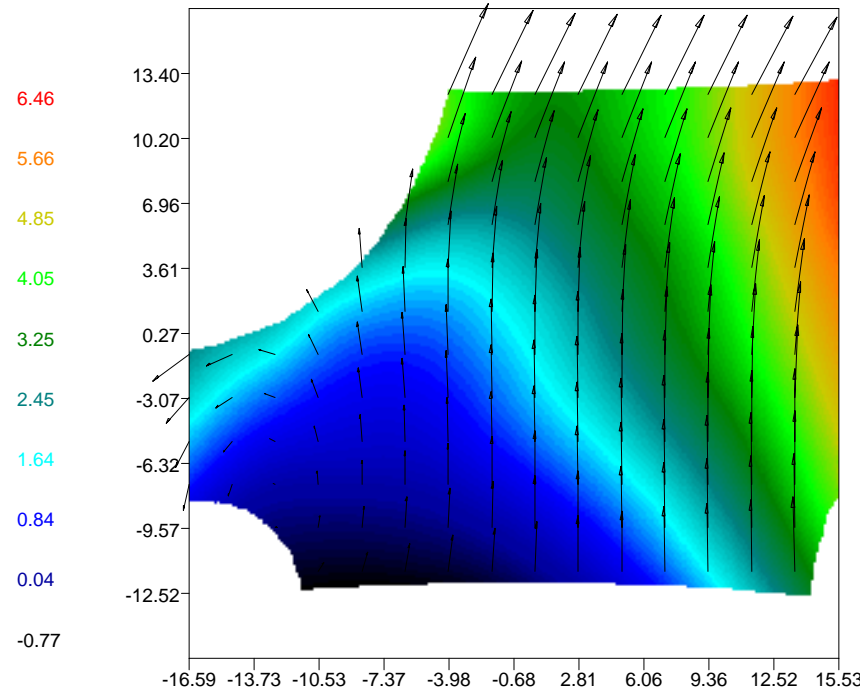
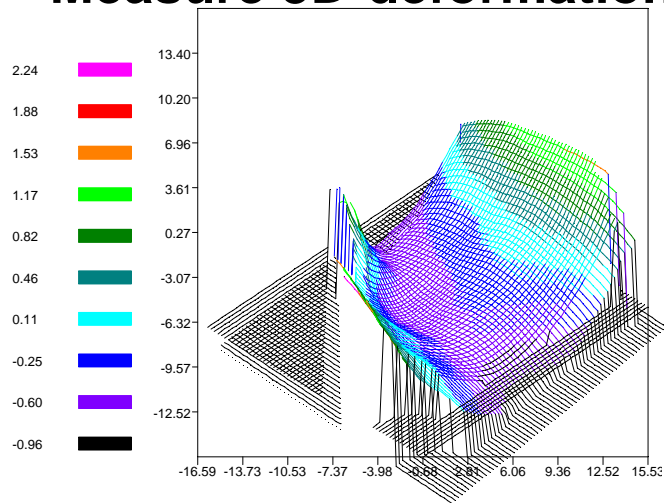
- Mount sensor to component
- Bullet etc...



Application of Q-100 for Strain Measurement

Procedure

- Mount sensor to component
- Define area of interest
- Measure 3D-deformation

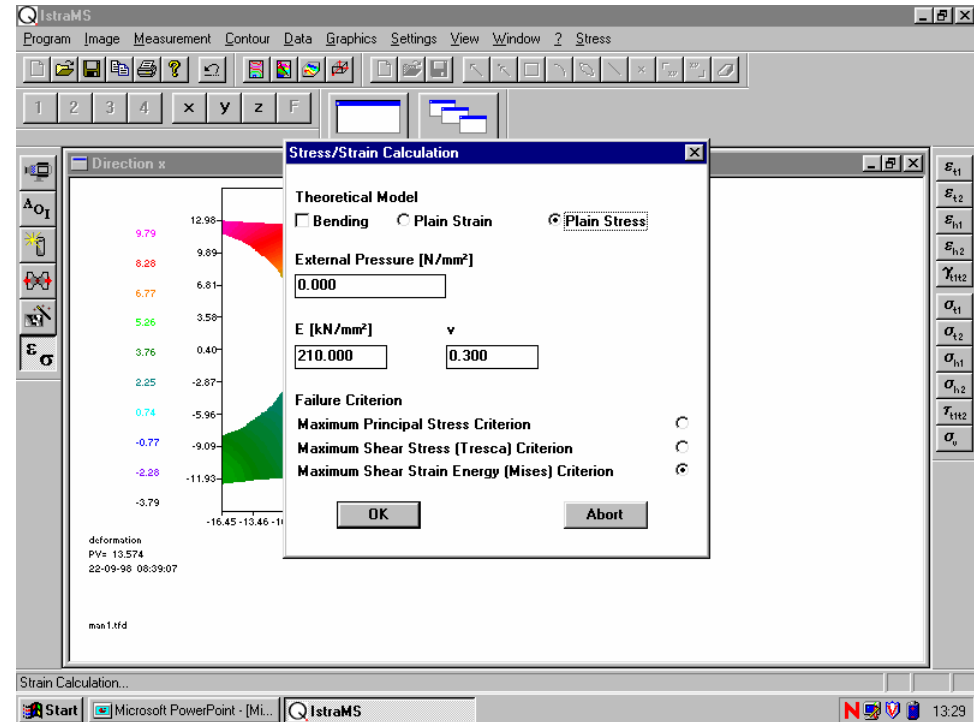


PV= 7.224
23-04-02 18:56:38
Karmann, Alu-Rückwand
Pos 1, Messung 1, Verdeck offen
VR=300, HL=300

Application of Q-100 for Strain Measurement

Procedure

- Mount sensor to component
- Define area of interest
- Measure 3D-deformation
- Introduce mechanical properties

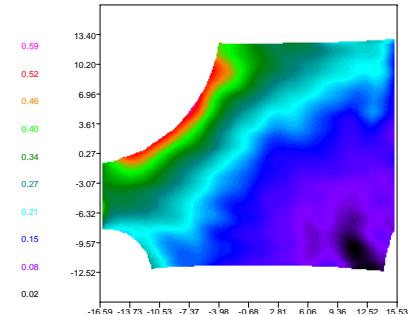


Application of Q-100 for Strain Measurement

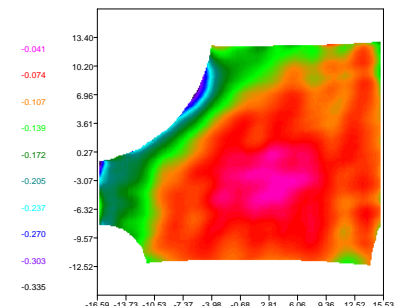
Procedure

- Mount sensor to component
- Define area of interest
- Measure 3D-deformation
- Introduce mechanical properties
- Calculate stress components, automatically

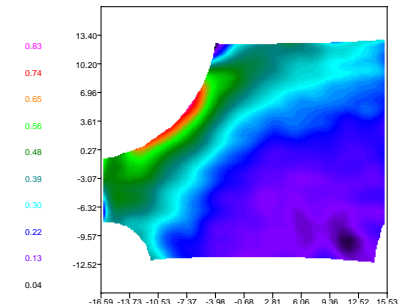
Principal stress 1



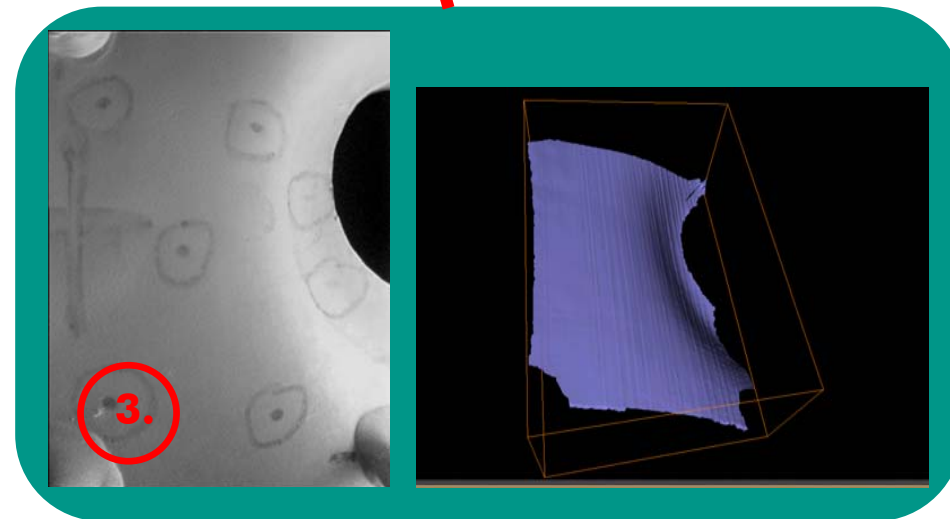
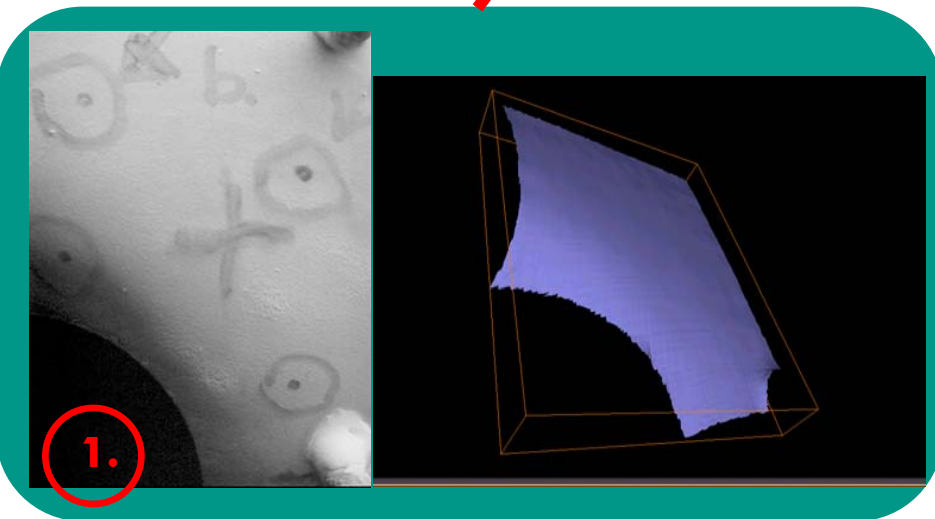
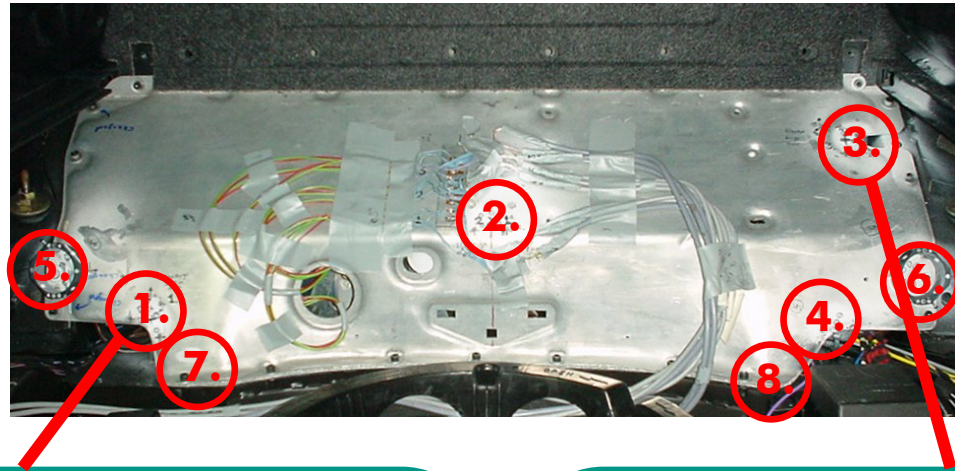
Principal stress 2



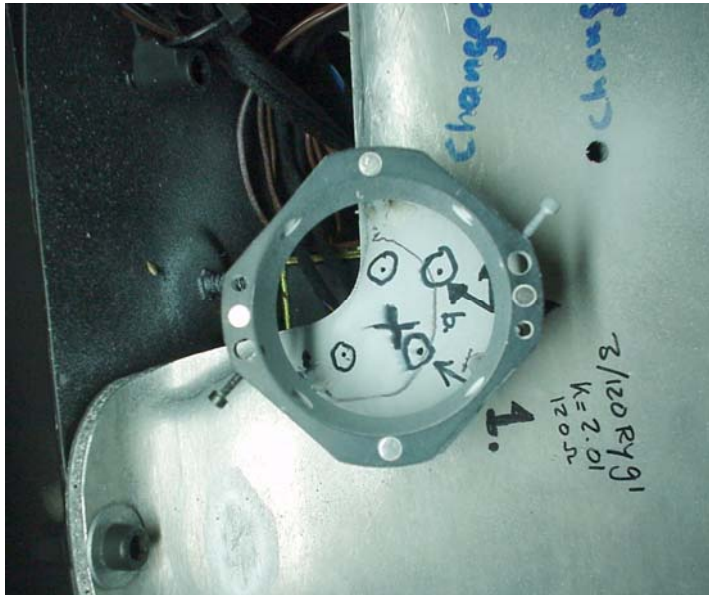
Shear stress



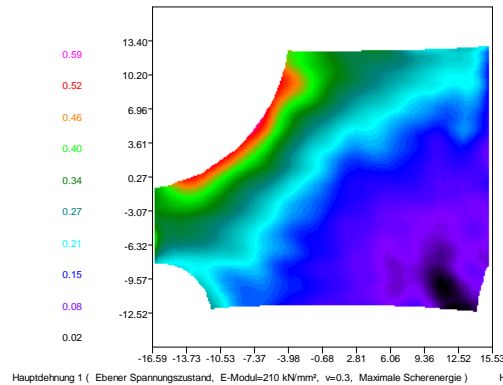
Contours as Measured with Q-100



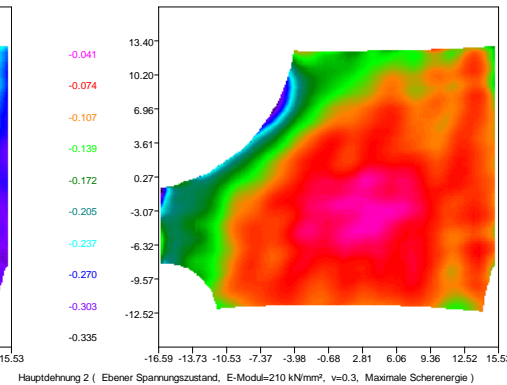
Example: Measuring Result



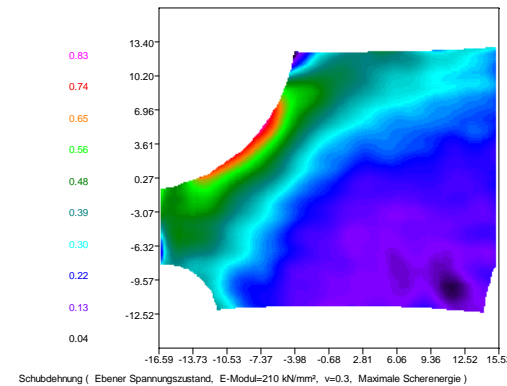
Pos. 1,
Load: HL/VR = 300/300mm
Open roof



Principal Strain 1

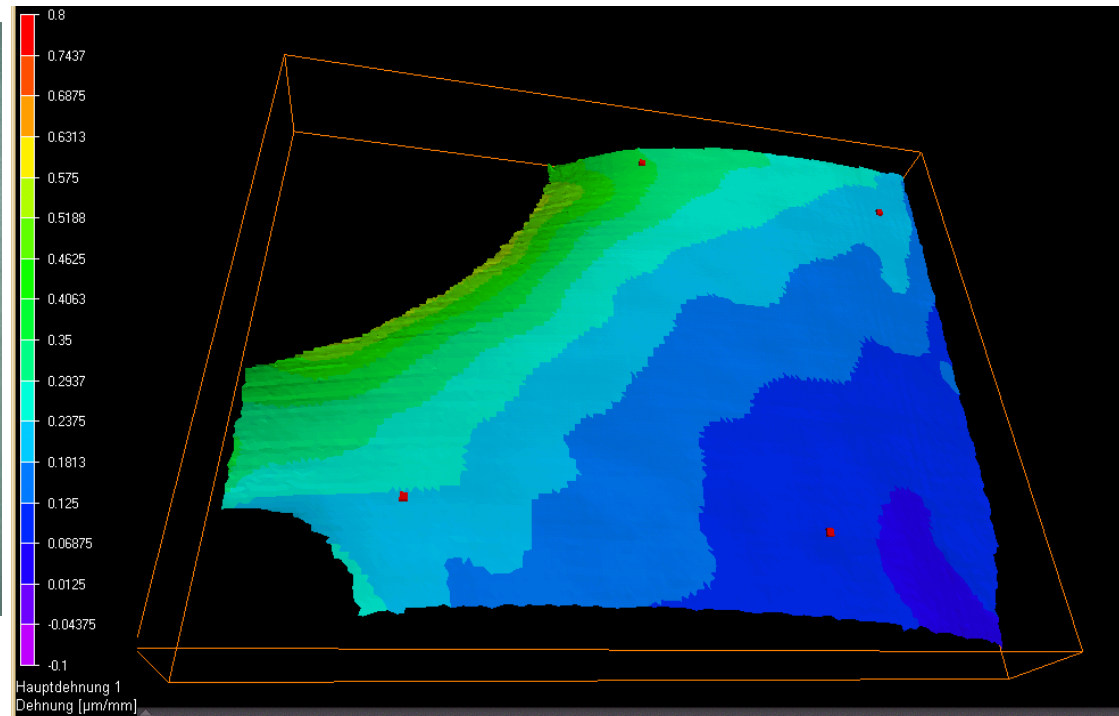
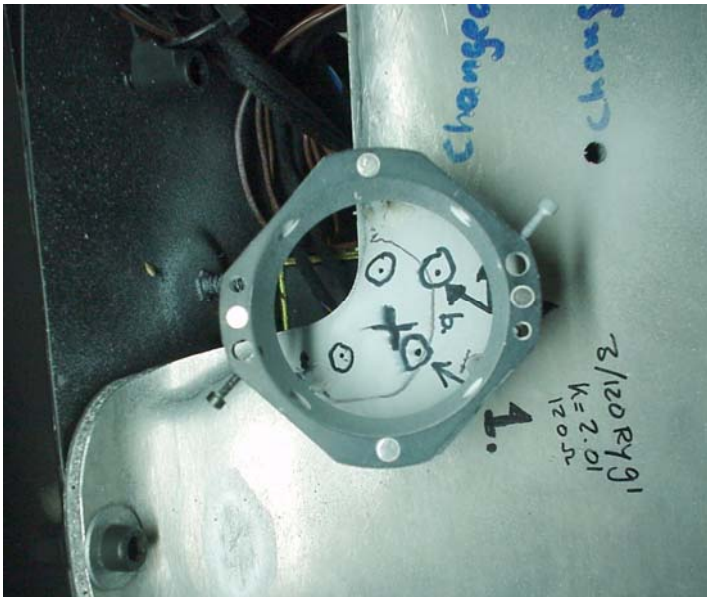


Principal Strain 2



Shear Strain

Example: Measuring Result

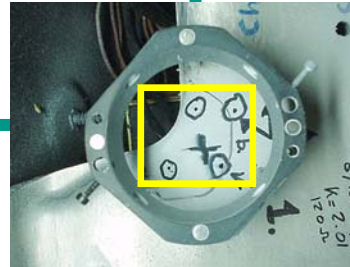


Principal strain 1

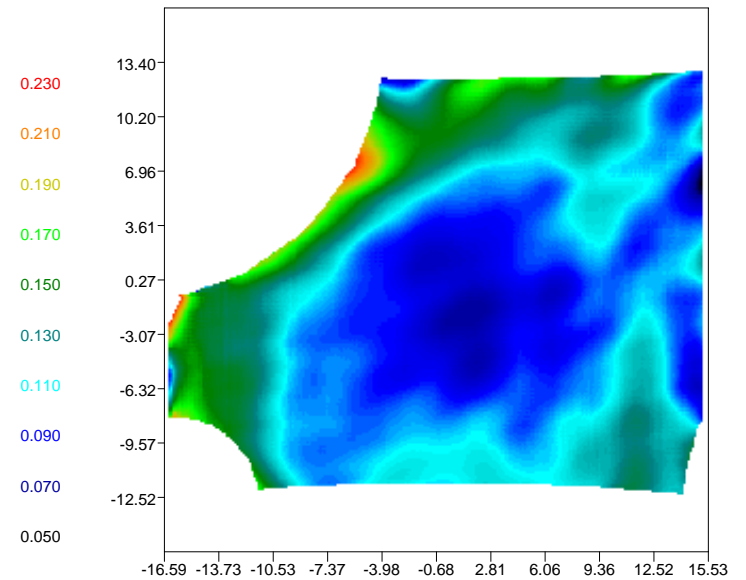
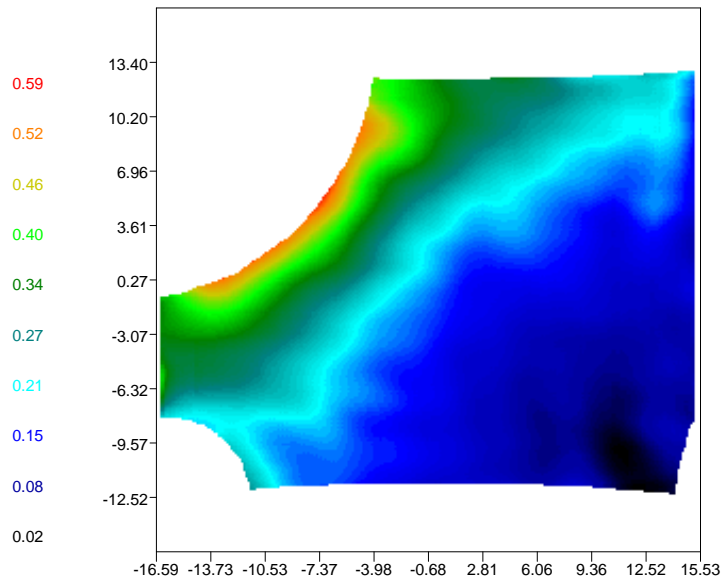
- on measured contour
- coordinates transformed into global coordinate system

Principal Strain 1 (in Pos. 1)

Load HL/VL = 300/300 mm

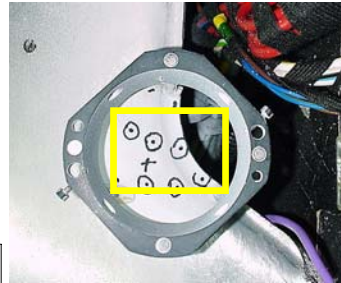


Load HR/VL = 300/0 mm

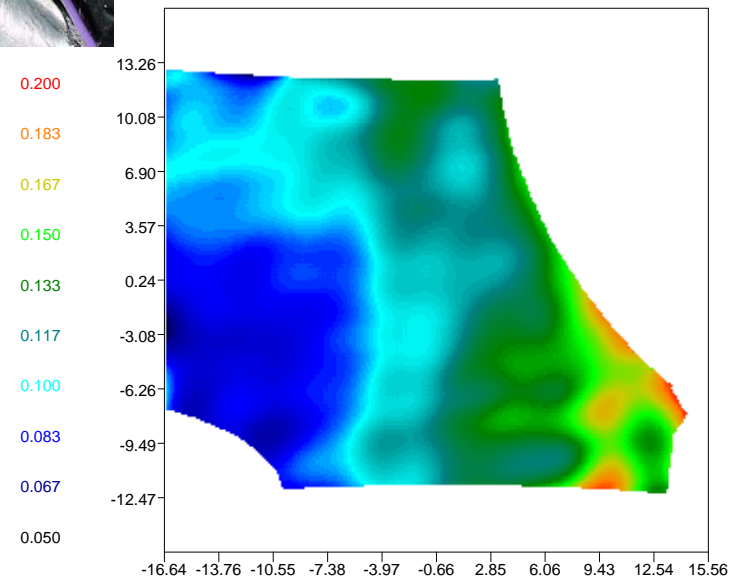
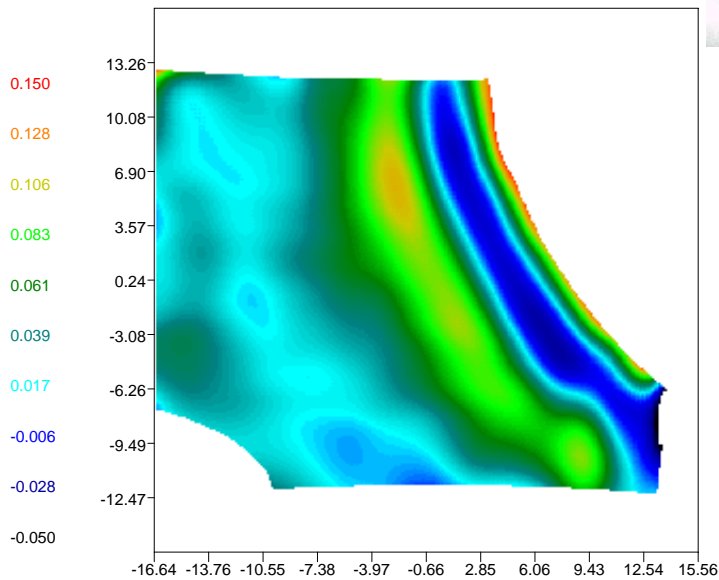


Principal Strain 1 (in Pos. 4)

Last **HL=300**, **VR=300**



Last **HR=300**, **VL=0**

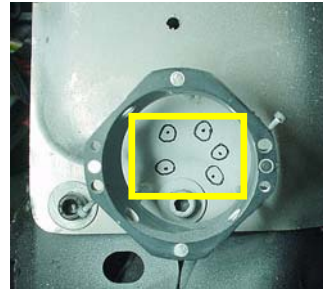


Hauptdehnung 1 (Ebener Spannungszustand, E-Modul=68.9 kN/mm², v=0.33, Maximale Scherenergie)
 PV= 0.492
 30-04-02 09:08:18
 Karmann, Alu-Rückwand
 Pos 4, Messung 1, Verdeck offen
 VR=300, HL=300
 pos4m1_1_3fstrain.TFD

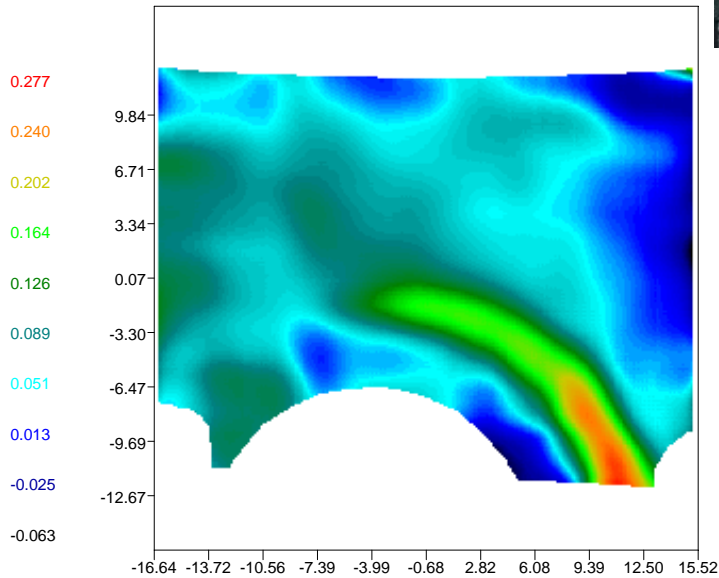
Hauptdehnung 1 (Ebener Spannungszustand, E-Modul=68.9 kN/mm², v=0.33, Maximale Scherenergie)
 PV= 0.169
 30-04-02 11:03:10
 Karmann, Alu-Rückwand
 Pos 4, Messung 3, Verdeck offen
 VL=200, HR=0
 pos4m3_1_2fstrain.TFD

Principal Strain 1 (in Pos. 6)

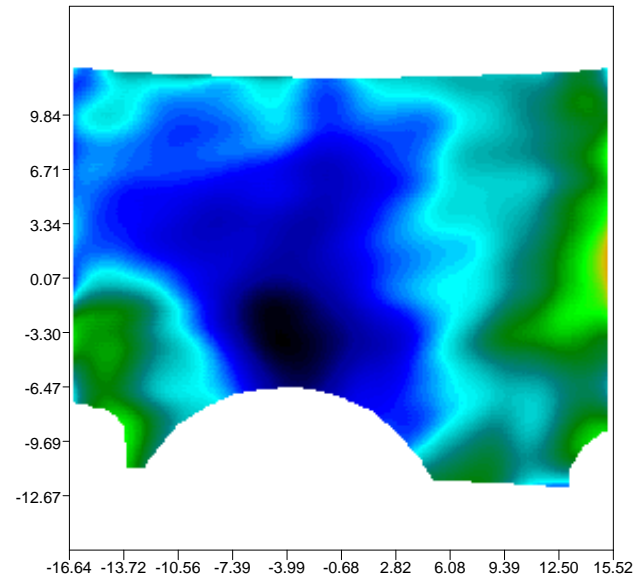
Last **HL=300**, **VR=300**



Last **HR=300**, **VL=0**



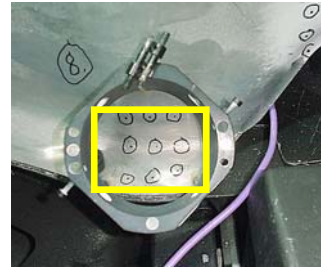
Hauptdehnung 1 (Ebener Spannungszustand, E-Modul=68.9 kN/mm², v=0.33, Maximale Scherenergie)
 PV= 0.340
 02-05-02 11:37:07
 Karmann, Alu-Rückwand
 Pos 6, Messung 1, Verdeck offen
 VR=300, HL=300
 pos6m1_1_5fstrain.TFD



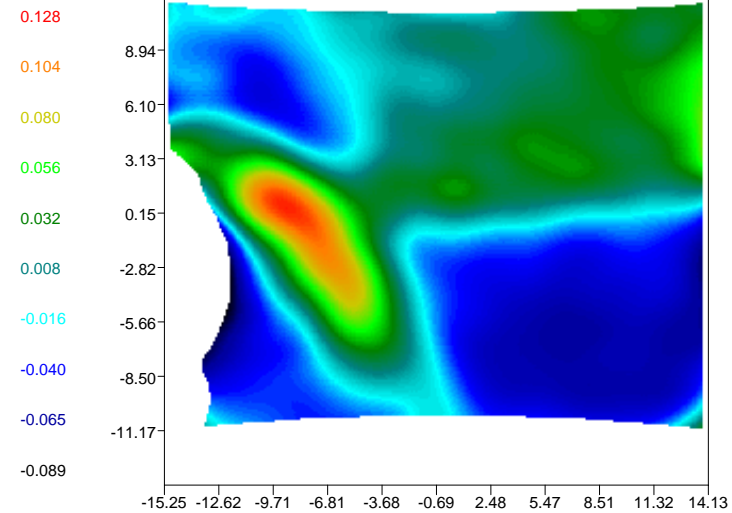
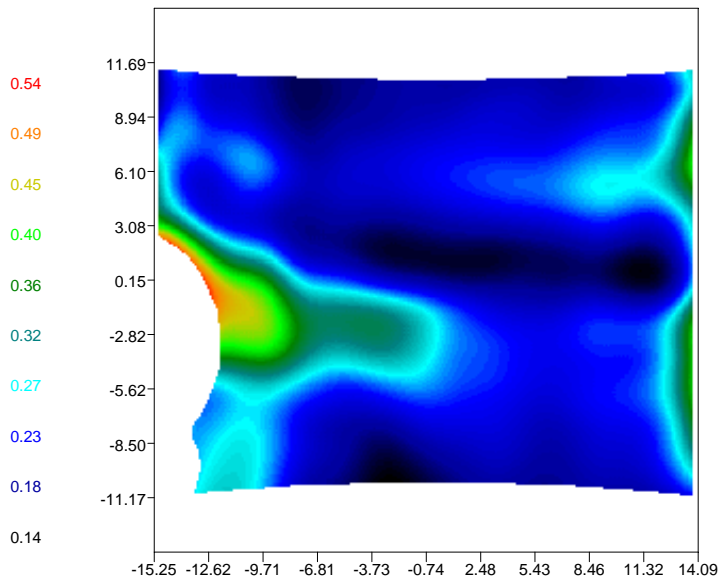
Hauptdehnung 1 (Ebener Spannungszustand, E-Modul=68.9 kN/mm², v=0.33, Maximale Scherenergie)
 PV= 0.153
 02-05-02 12:04:59
 Karmann, Alu-Rückwand
 Pos 6, Messung 2, Verdeck offen
 VL=300, HR=0
 pos6m2_1_3fstrain.TFD

Principal Strain 1 (in Pos. 8)

Last **HL=300**, **VR=300**



Last **HR=200**, **VL=0**



Hauptdehnung 1 (Ebener Spannungszustand, E-Modul=68.9 kN/mm², v=0.33, Maximale Scherenergie)
 PV= 0.400
 02-05-02 13:53:35
 Karmann, Alu-Rückwand
 Pos 8, Messung 1, Verdeck offen
 VR=300, HL=300
 pos8m1_1_5fstrain.TFD

Hauptdehnung 1 (Ebener Spannungszustand, E-Modul=68.9 kN/mm², v=0.33, Maximale Scherenergie)
 PV= 0.217
 02-05-02 15:07:05
 Karmann, Alu Rückwand
 Pos 8, Messung 2, Verdeck offen
 VL=200, HR=0
 pos8m2_1_2fstrain.TFD

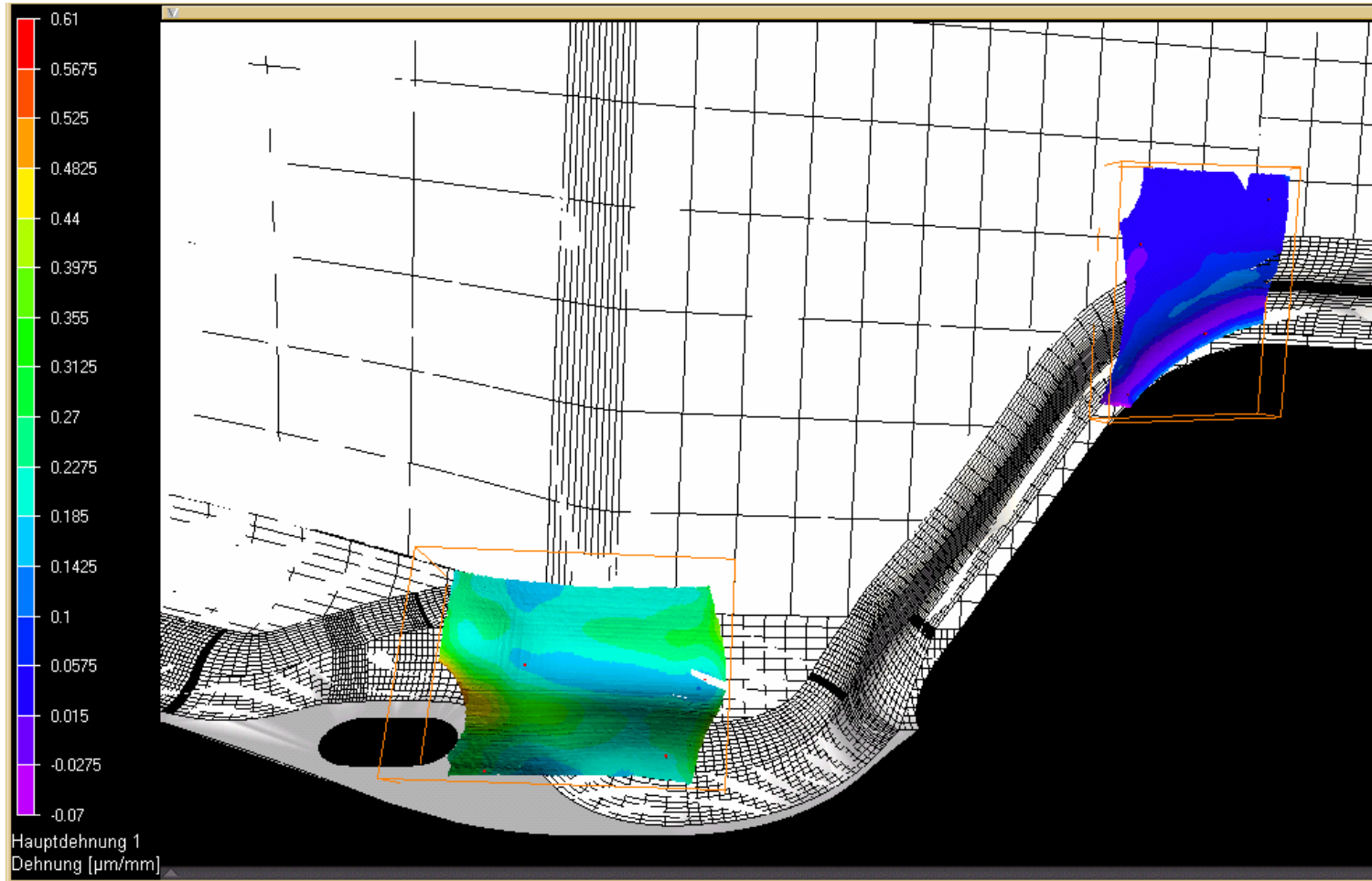
Introduction of all Measuring Areas in One VRML-File



Mapping of Strain Fields to CAD

AFS-Rear-Plate
measuring pos.
8 and 4

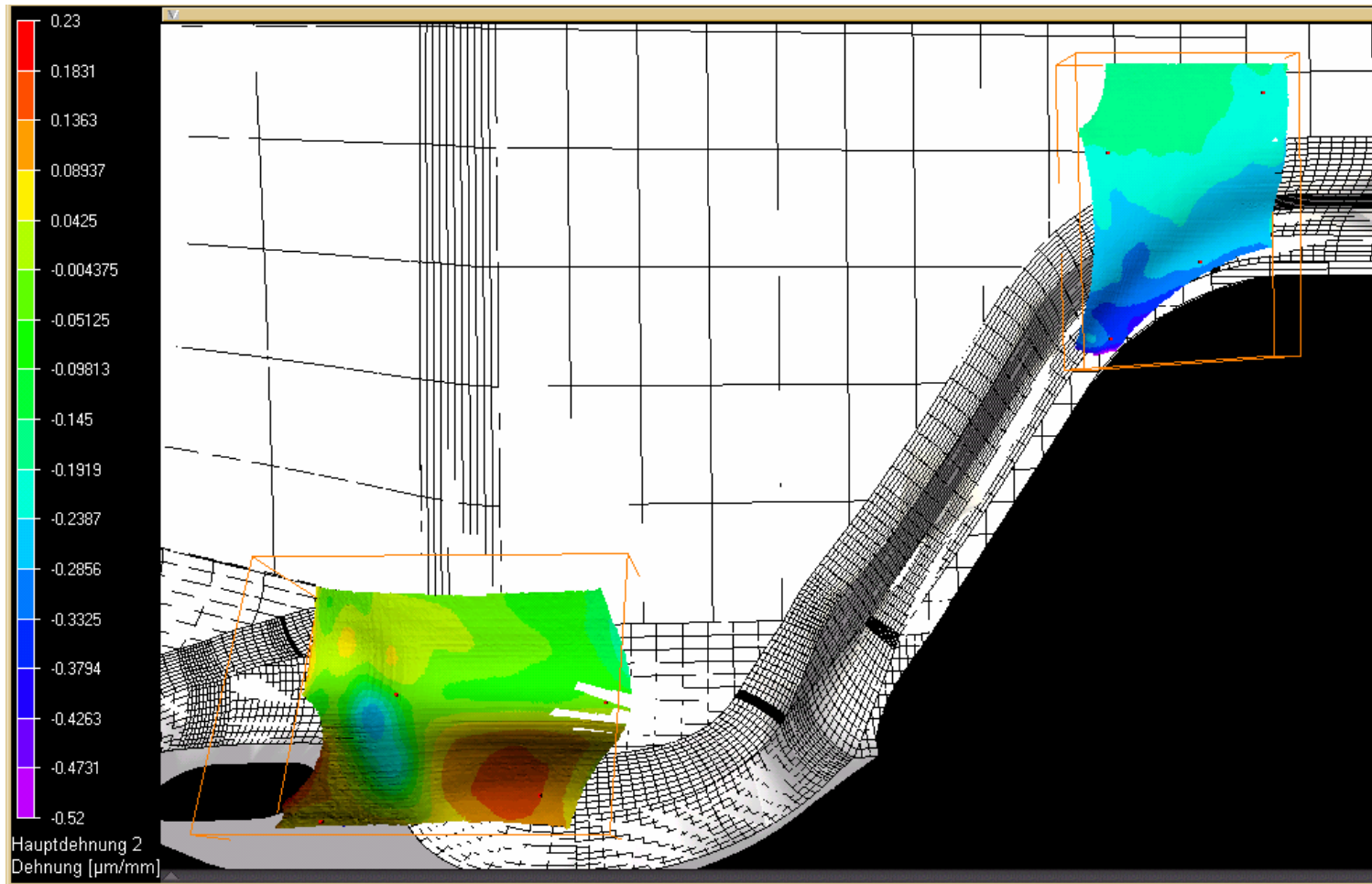
Principle Strain 1 [$\mu\text{m}/\text{mm}$]



Mapping of Strain Fields to CAD

AFS-Rear-Plate
measuring pos.
8 and 4

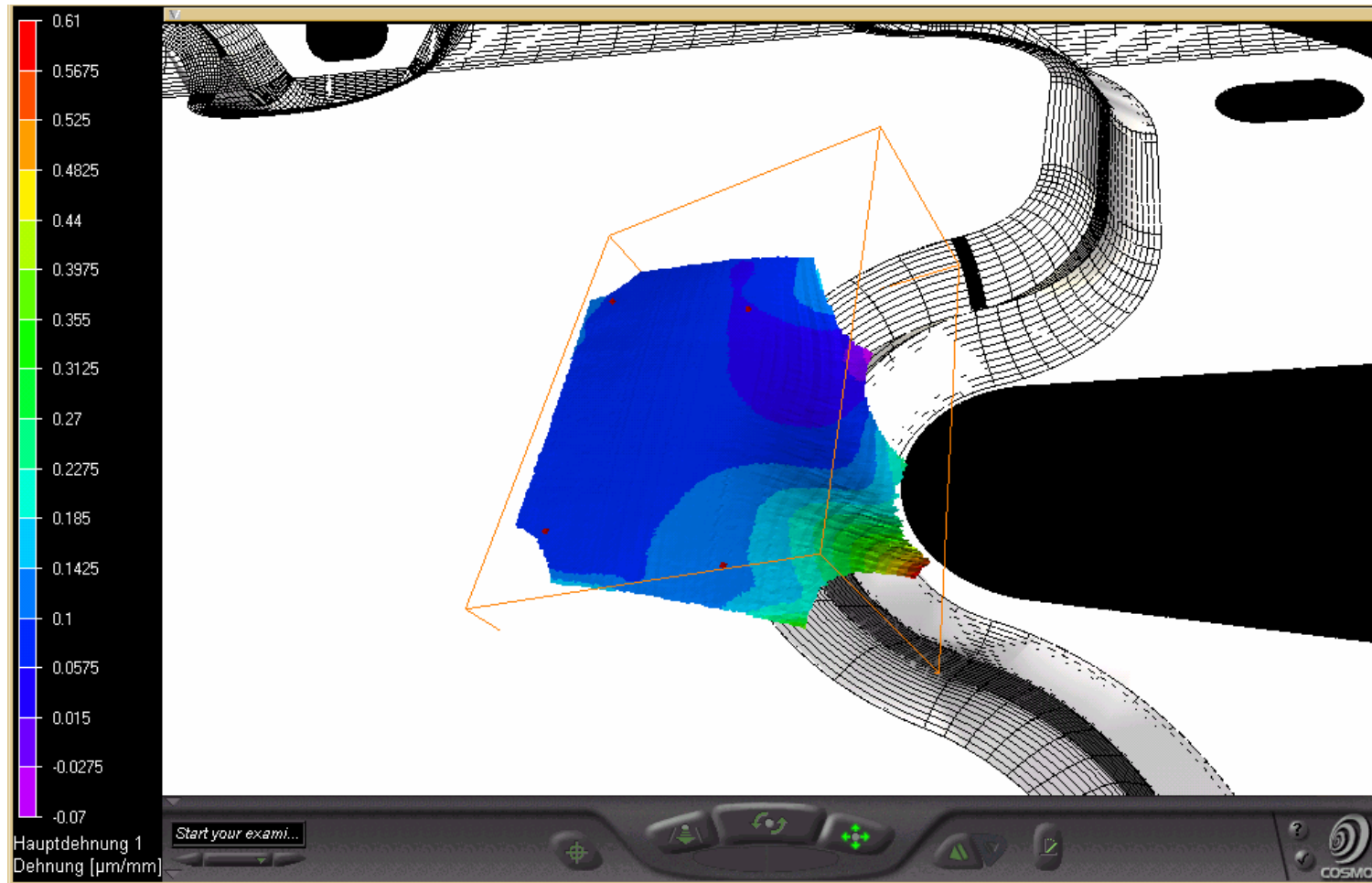
Principle Strain 2 [$\mu\text{m}/\text{mm}$]



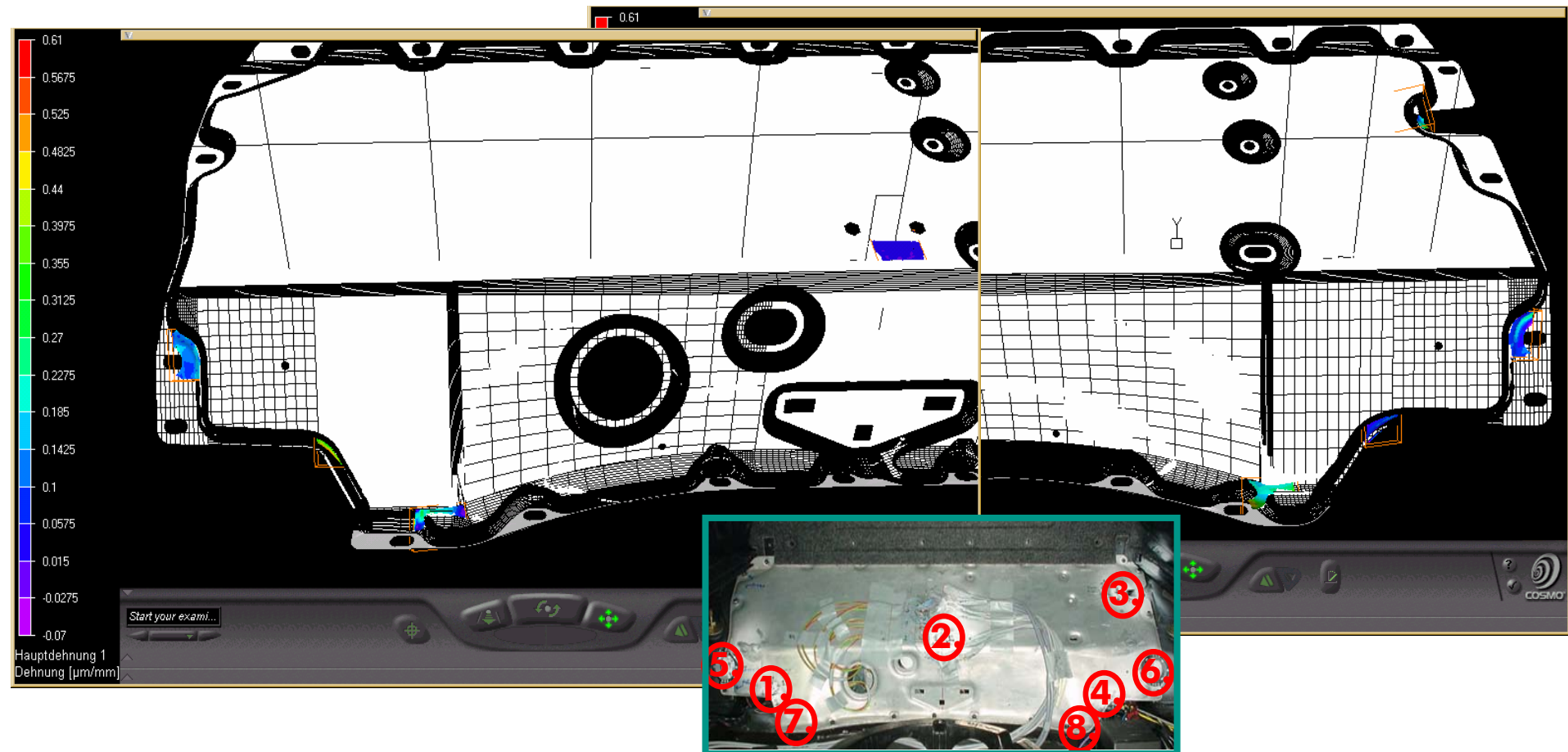
Mapping der Dehnungsfelder auf CAD

AFS-Rear-Plate
measuring
pos. 3

Principle Strain 1 [$\mu\text{m}/\text{mm}$]



Mapping of Principal Strain 1 in the CAD Model



Summary and Results

- **Critical areas of a new aluminium foam structure were analysed, where conventional measuring techniques could not be applied.**
- **Comparison between ESPI measurement and FEA was successfully done.**
- **The idea to combine simulation and ESPI measurement in fatigue testing proved to be a positive concept for future applications.**