



# Measurement of Residual Stress in Automotive Components

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# Stress

- Stress is the metric most commonly used by engineers to judge
  - how hard a material is working
  - how close to failure the material is
  - how long a material might last
  - how severe the effects of an external agent might be on a material
  - whether there may be some distortion in a material
- In automotive a knowledge of total stress can improve crash performance, durability and manufacture
- How do we determine stress?

# Some issues

- Residual stresses can affect low speed impact performance
  - how can we control these?
- Residual stresses exist in fatigue samples
  - how do they affect my fatigue data?
- Residual stresses in supplied steels are unknown and uncontrolled
  - how do we ensure that we have compressive stresses where we want them?
- Peening the surface of a component improves durability
  - how can we be sure in production that the peening is adequate?

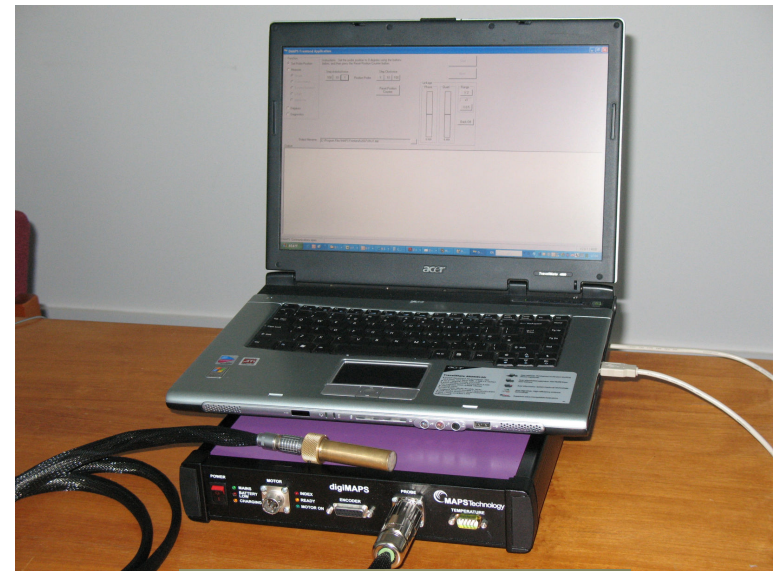
# Case Study: Rear Suspension Arm

- Three components
  - One prototype assembly
  - One assembly from production at Factory 1
  - One assembly from production in Factory 2
- Steel from same supplier and factory
- Factory 1 assembly  
–50% life
- Factory 2 assembly  
+50% life



# MAPS system

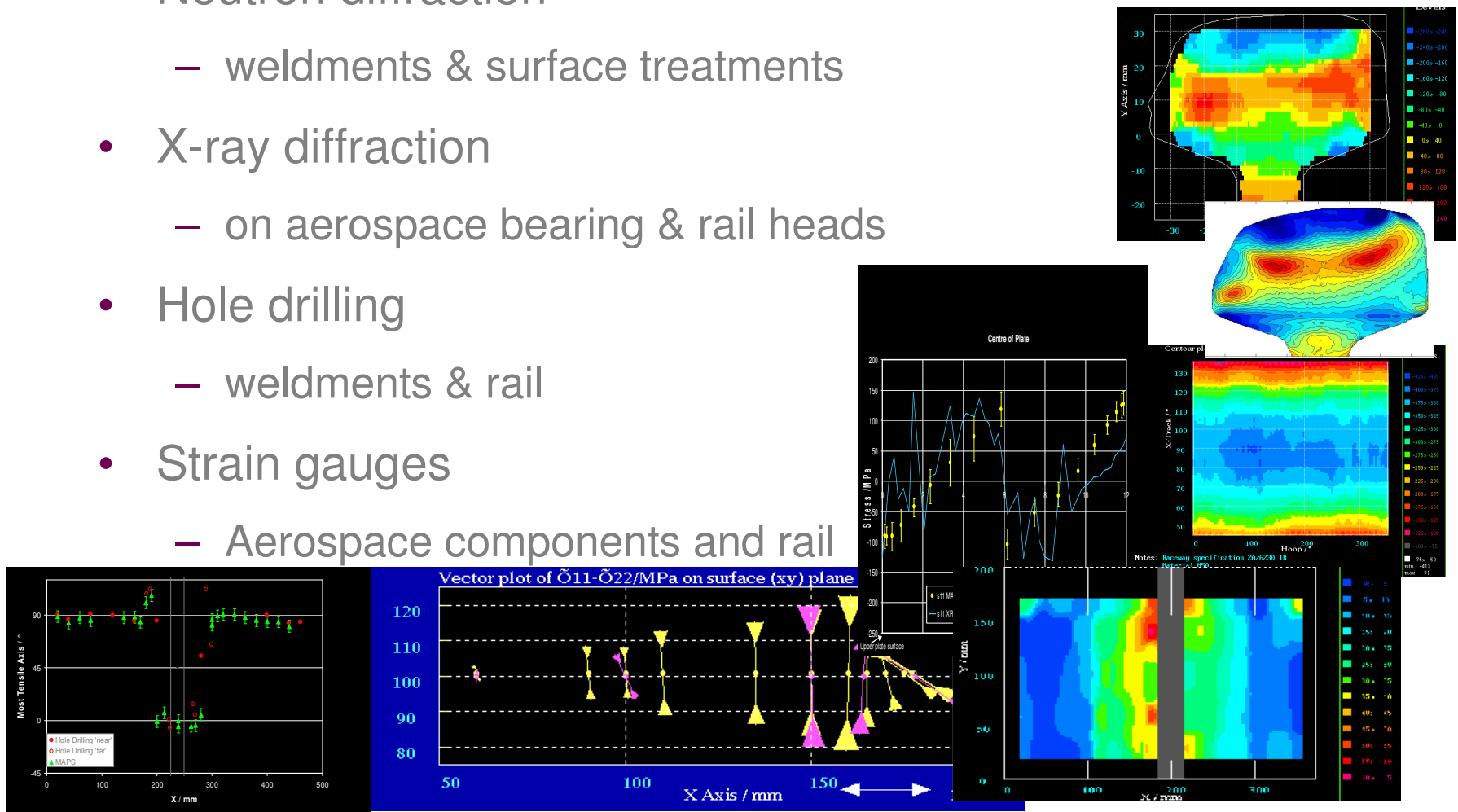
- Patented magnetic method of stress measurement
  - non-destructive, rapid
  - absolute biaxial stress
  - stress depth profiling
  - accurate to a few MPa
- Standard MAPS instrument
  - laboratory tool
  - verified against laboratory methods:  
X-ray & neutron diffraction, synchrotron x-ray



# Does MAPS Work?

## Comparisons with other techniques

- Neutron diffraction
  - weldments & surface treatments
- X-ray diffraction
  - on aerospace bearing & rail heads
- Hole drilling
  - weldments & rail
- Strain gauges
  - Aerospace components and rail



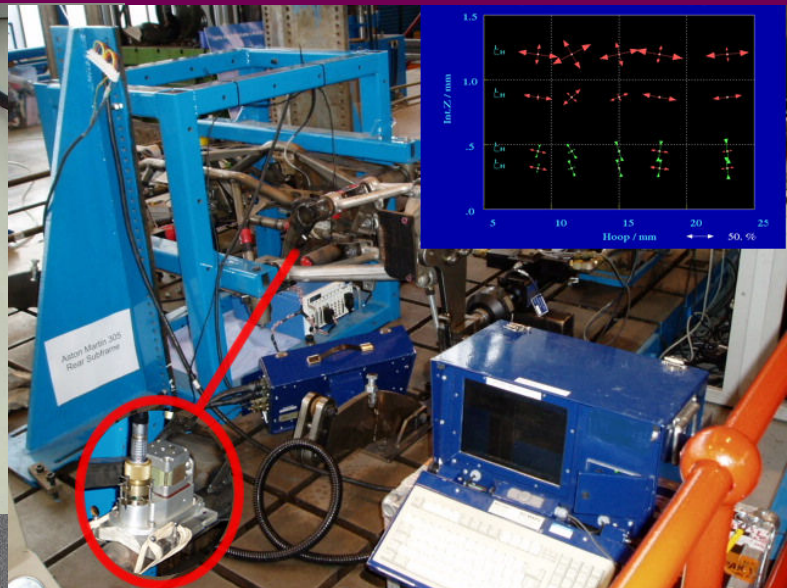


# MAPS – Independent Testing



Applied stress (from strain gauges)	MAPS result	
(MPa)	(MPa)	
Load case A	48.9	48.1
Load case B	19.6	18.9
Load case C	48.9	49.8
Load case D	67.7	68.2

# Applications Automotive Components



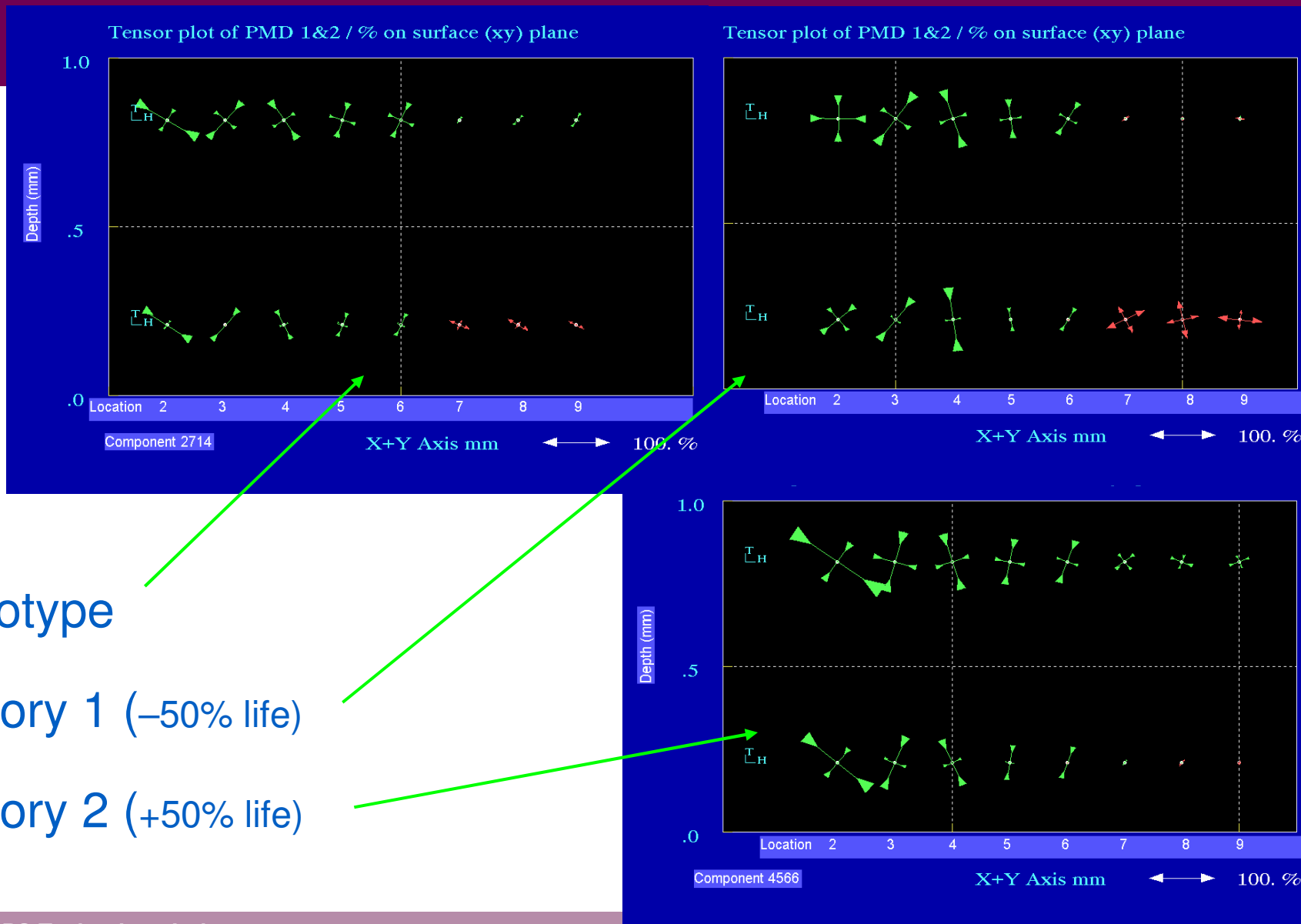


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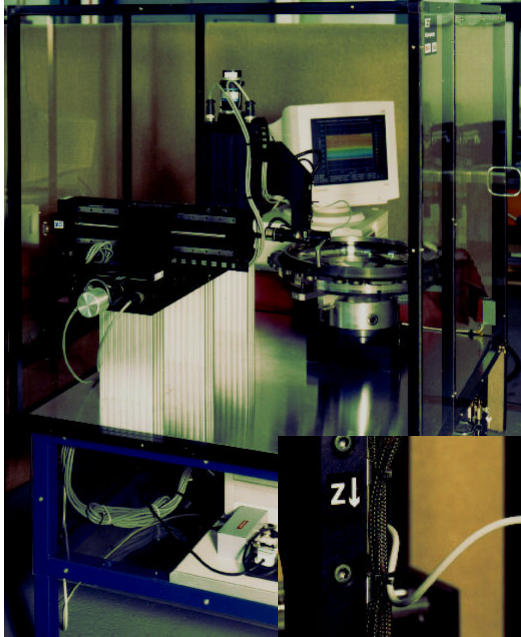


Prototype

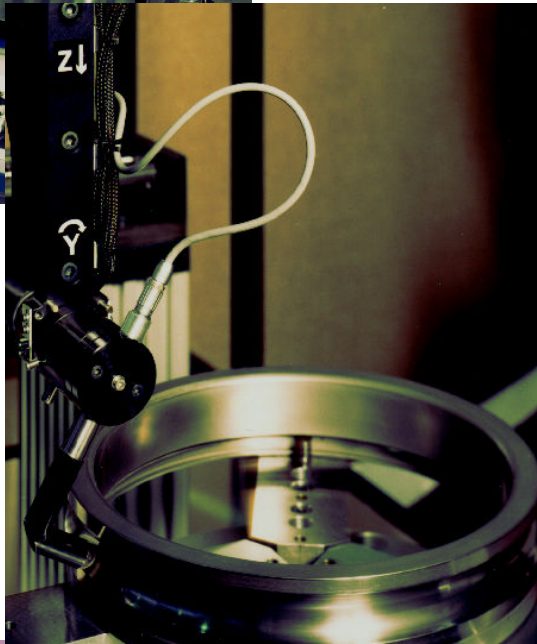
Factory 1 (-50% life)

Factory 2 (+50% life)

# MAPS Bearing Scanner



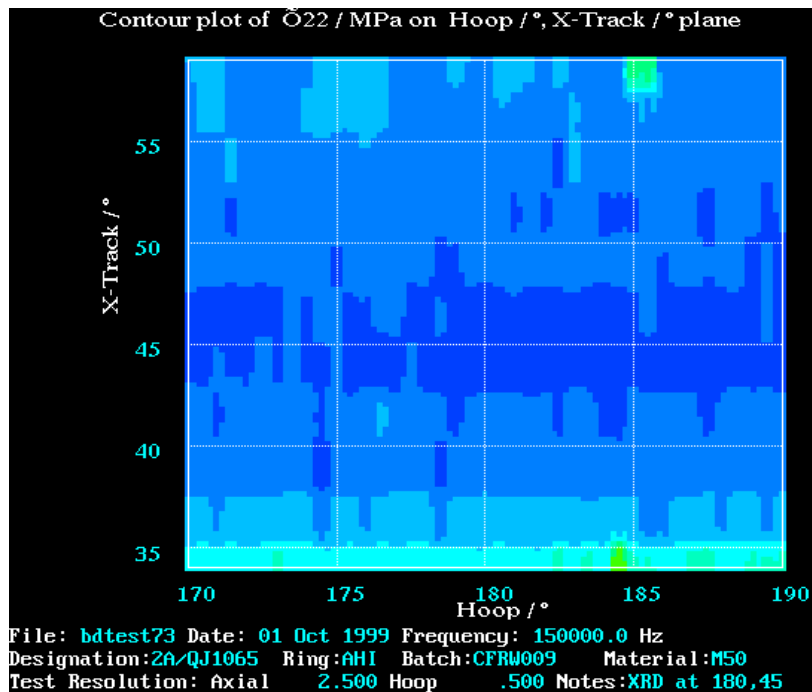
- Aerospace bearing inspection
  - surface compressive stresses desirable to improve wear
  - time available allowed X-ray diffraction measurement at 3 points on surface/bearing



- MAPS on-line measurement
  - dynamic measurement at 7m/s
  - entire surface inspected in less time than for 3 XRD points
  - non-intrusive depth profiling

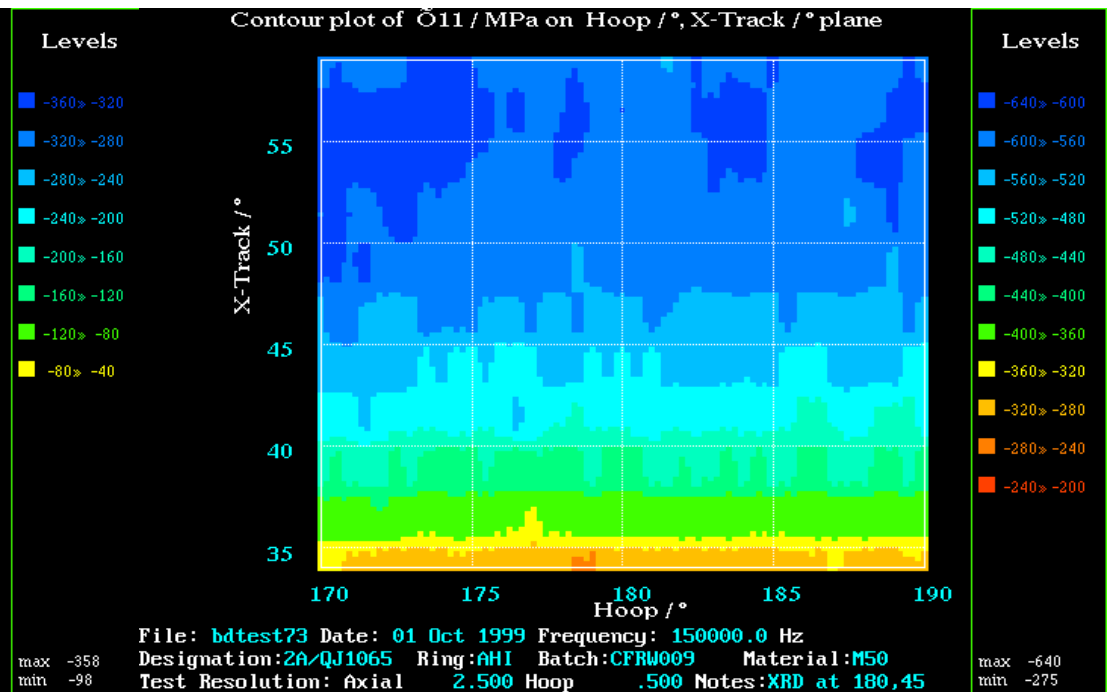
# Stress mapping on bearing raceway

## Hoop stress



Stress measurement by X-ray diffraction at 180°, 45° was -336 MPa

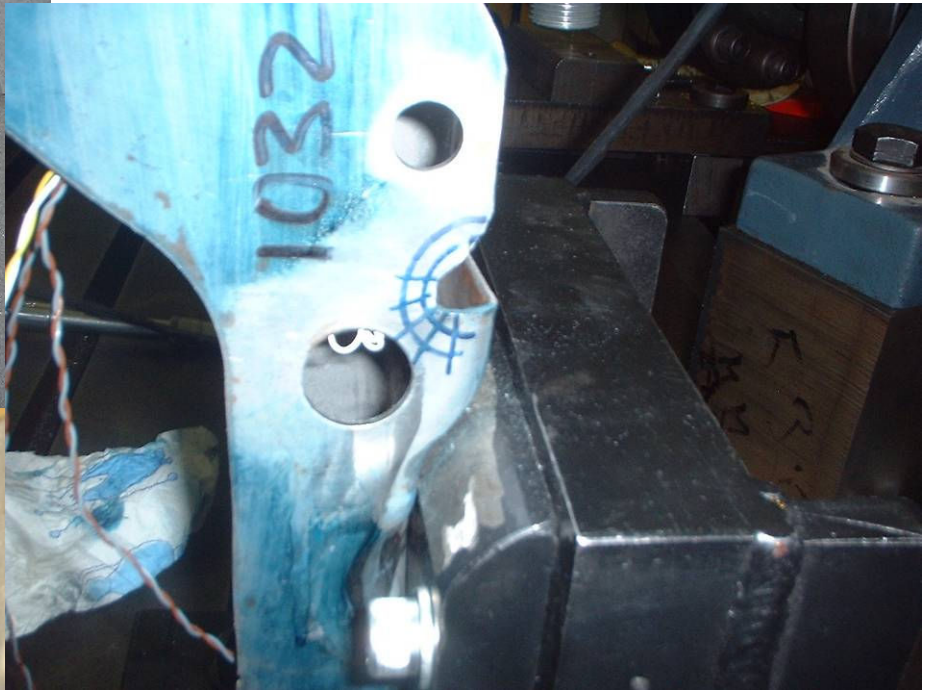
## Cross-track stress



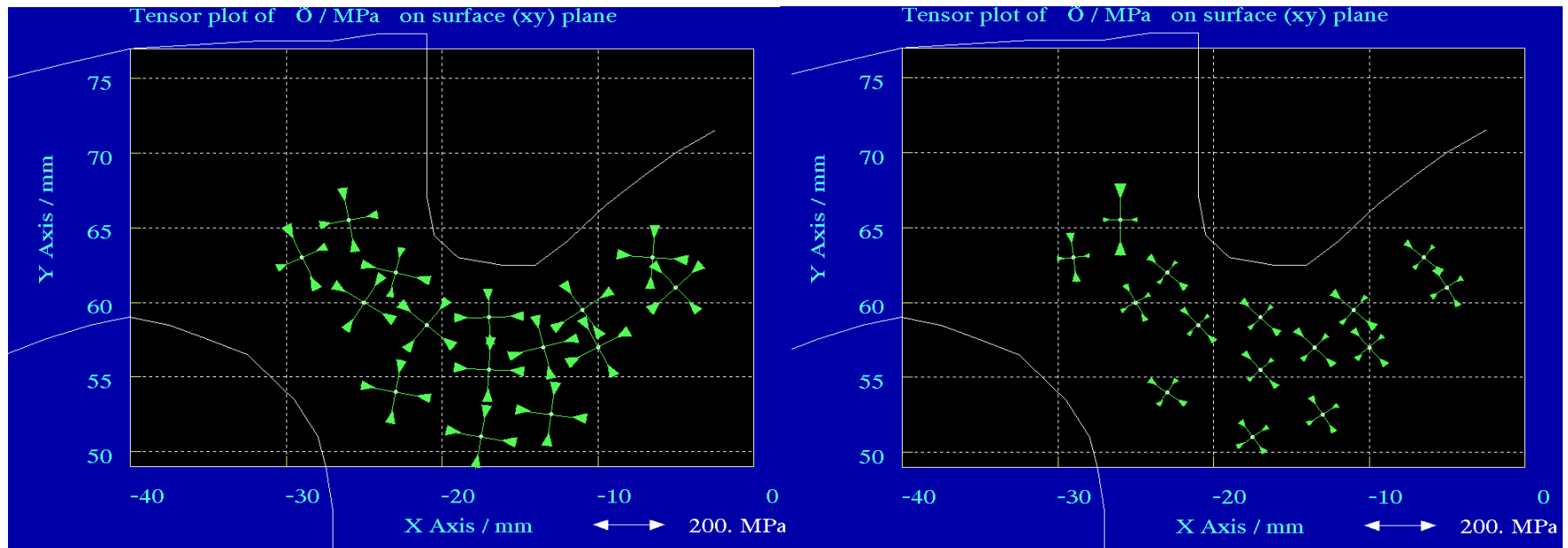
Stress measurement by X-ray diffraction at 180°, 45° was -535 MPa



# MAPS Measurements on Crossmember



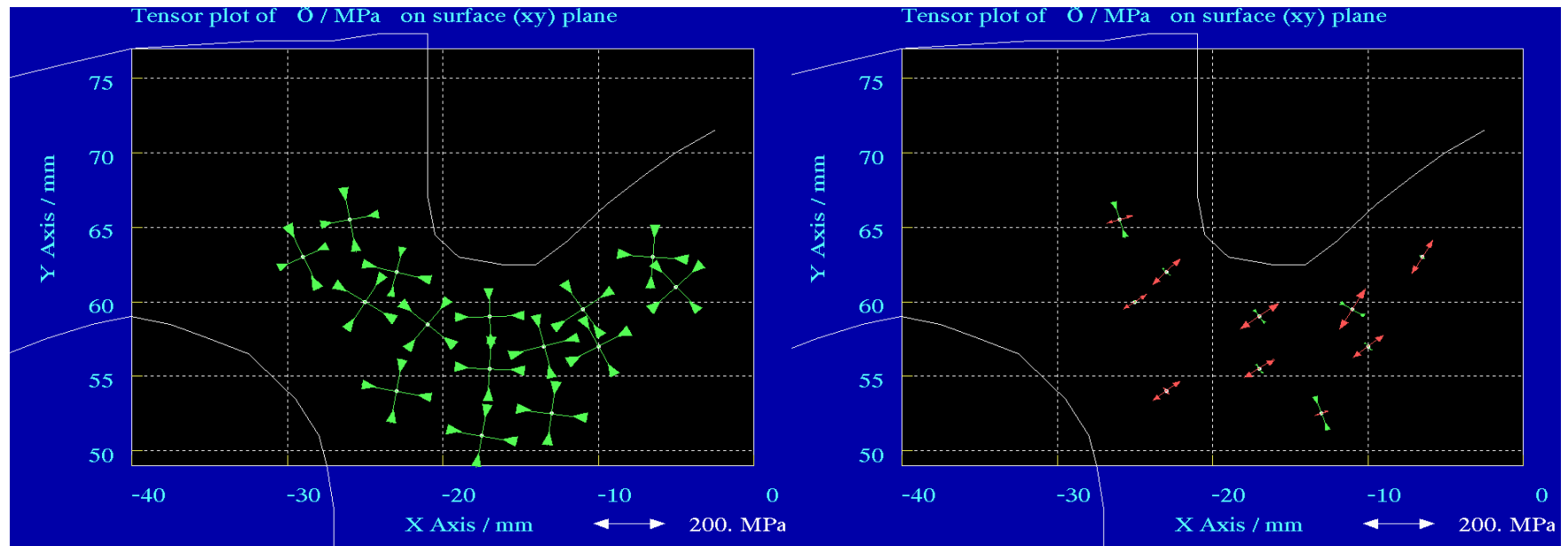
# Chassis Crossmember



Peened:  
Stresses to 0.15mm

Peened:  
Stresses to 0.5mm

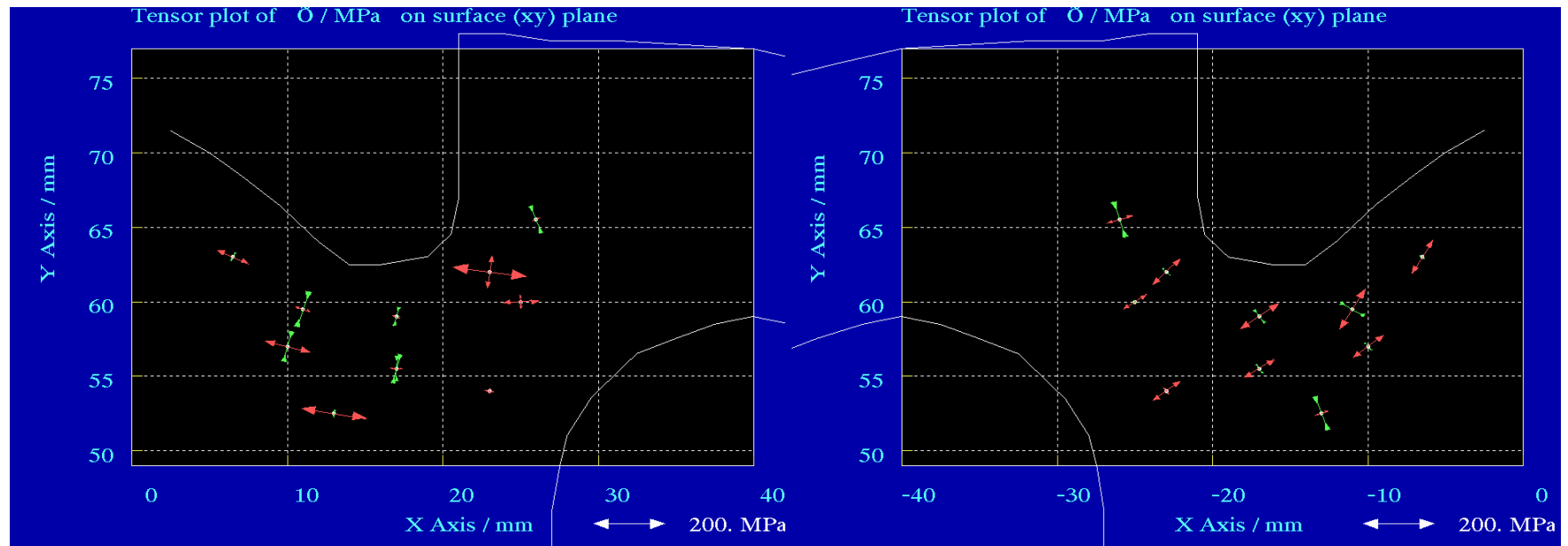
# Chassis Crossmember



Peened:  
Stresses to 0.15mm

Unpeened:  
Stresses to 0.15mm

# Chassis Crossmember

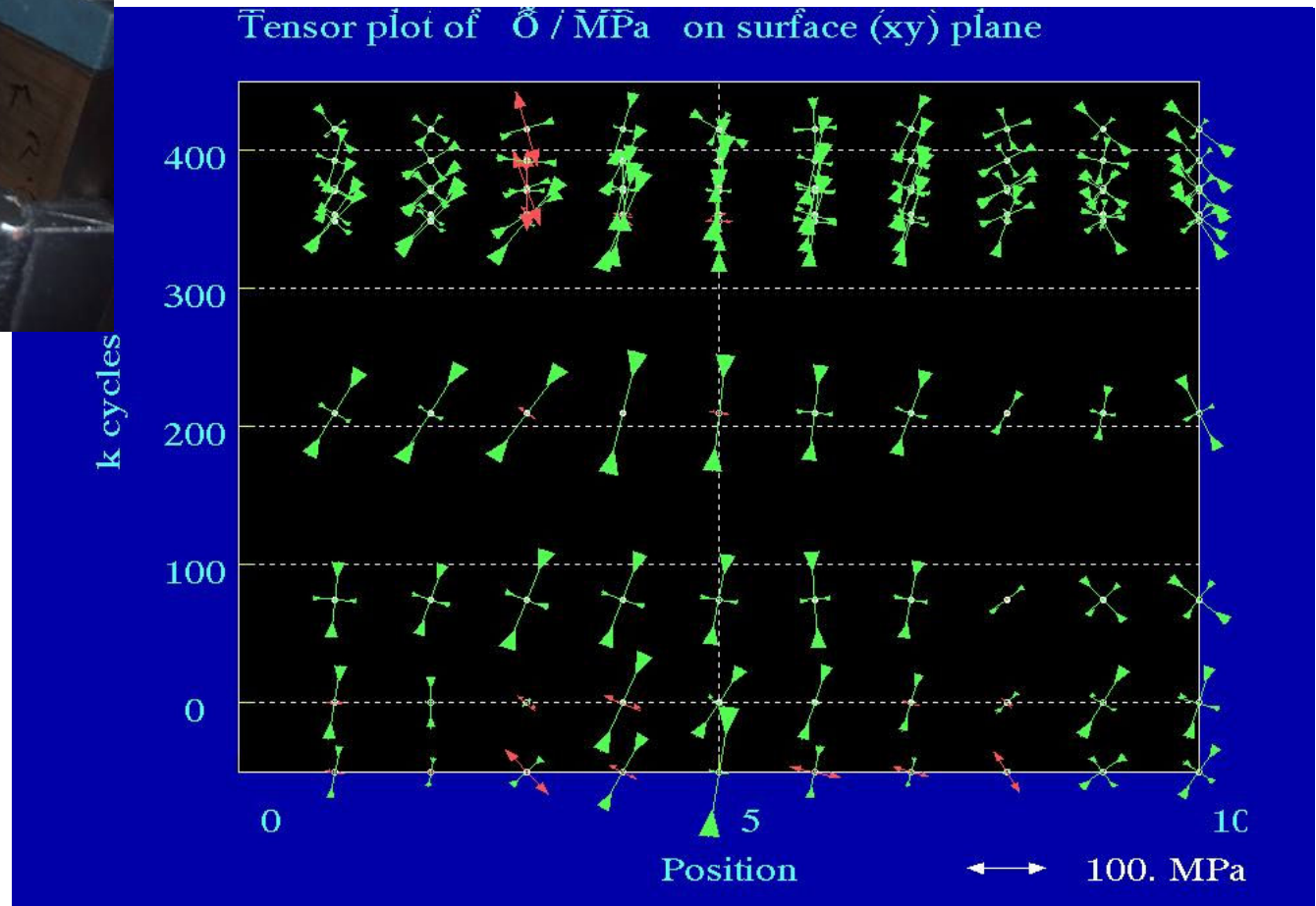
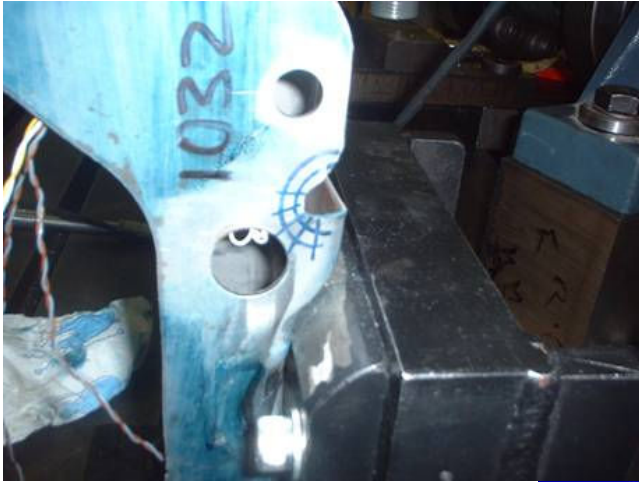


Unpeened:  
Stresses to 0.15mm  
LHS

Unpeened:  
Stresses to 0.15mm  
RHS



# Effect of fatigue on residual stress



# Effect of fatigue on material

XM1037 2300 Hz Data

