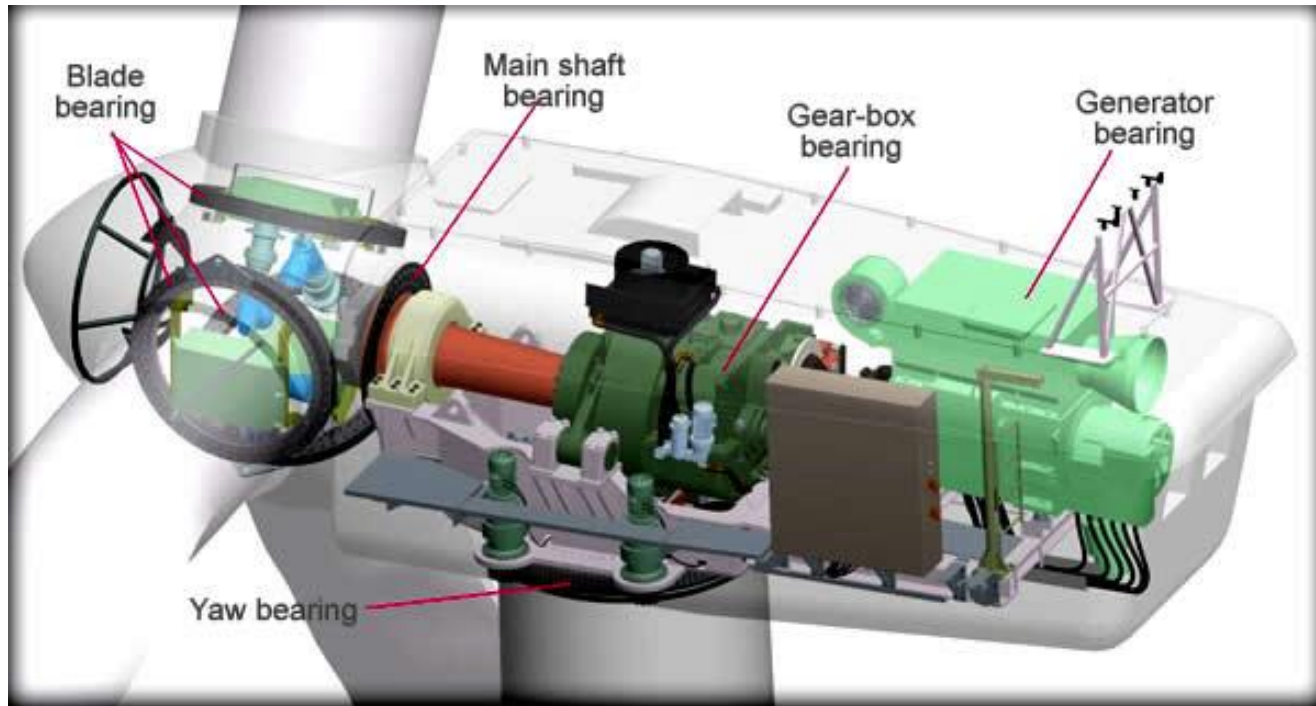


White Etching Cracks i lejer til vindmøller

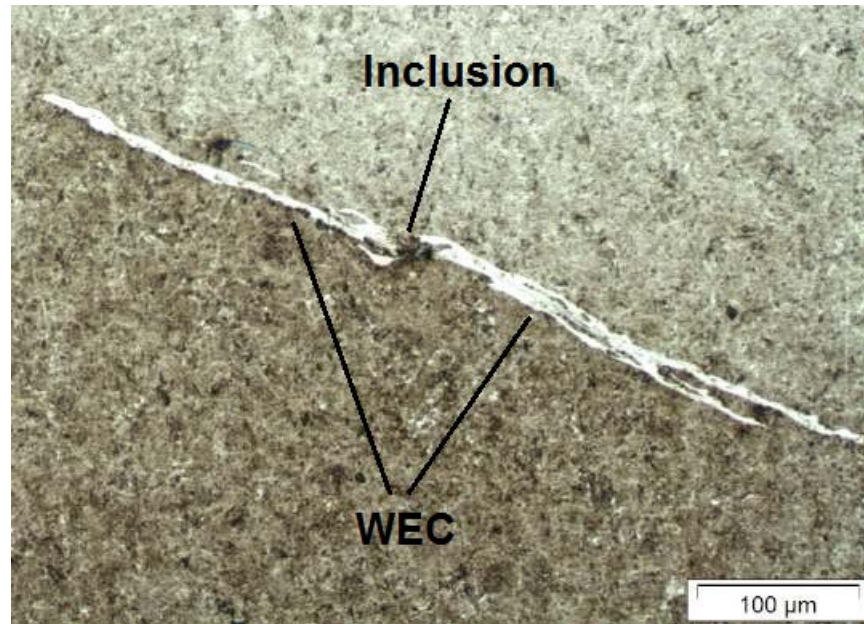
DMS Vintermøde 2016: Udfordringer i metallurgi

Hilmar Danielsen



White Etching Cracks (WEC)

“all-time most expensive failure mode for all Vestas components”



Present in gearbox-, main- and generator-bearings

Failure mechanism unknown

Gearbox bearing

Brook-Hansen gear
660kW Vestas windmill type V47
After for 10 years service

Frame



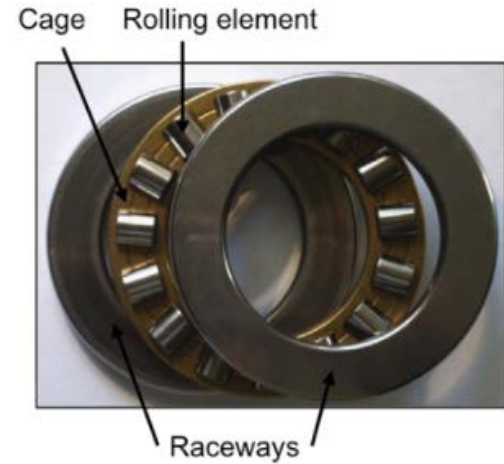
Outer ring

Inner ring

Roller

Bearing test facility

Accelerated WEC can only be done on axial cylinder roller bearings



Axial cylinder roller bearings

Double-headed test rig:

price $\approx 190,000\text{€}$

Advantages

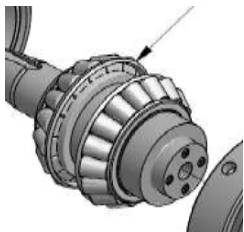
- Can reproduce WEC
- Dynamic loading and speed
- Oil and grease lubrication
- Temperature control
- Different bearing configurations
- Different material/surface treatment
- Stray currents

Disadvantages

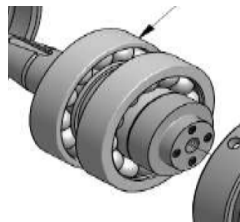
- Only axial loads
- Slip not variable



Tapered roller bearings

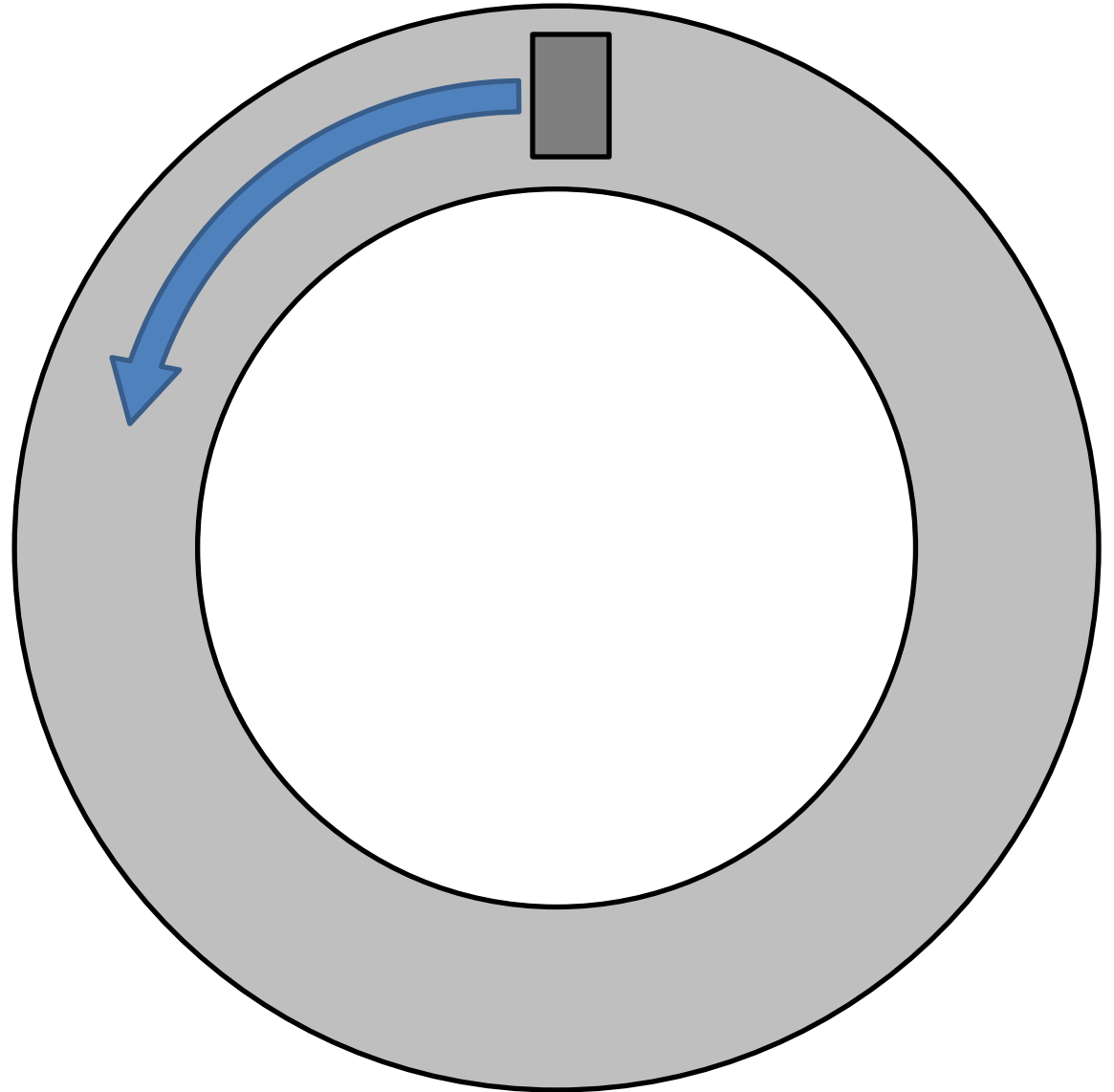


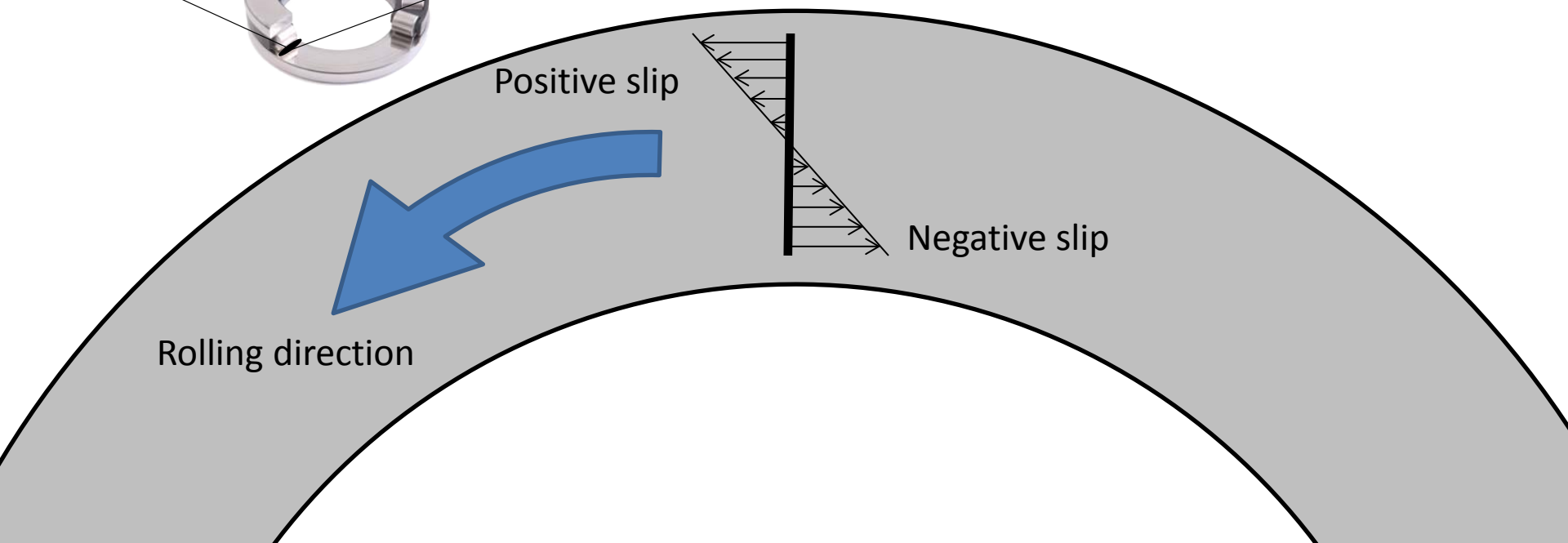
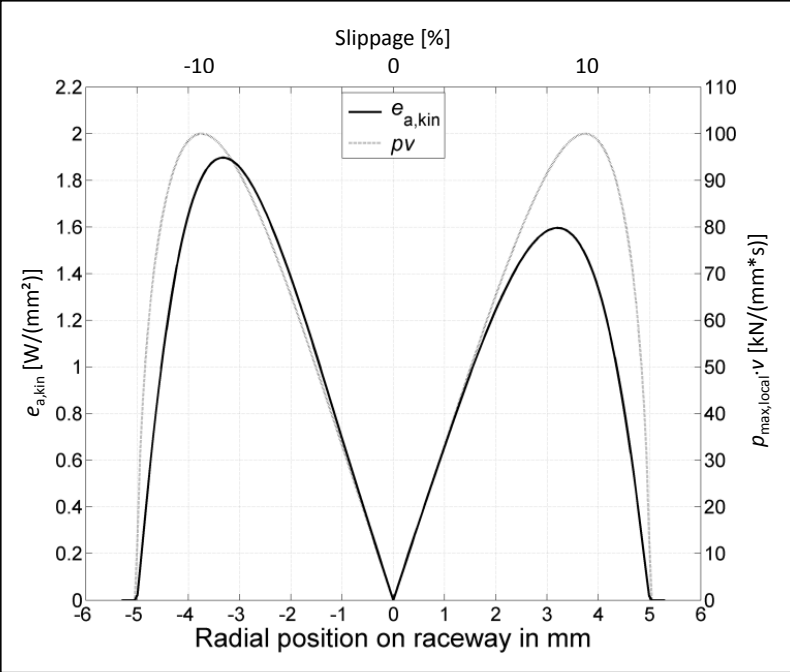
Angular contact ball bearings





1. Bearing washers
2. Rolling element
3. Polyamid cage

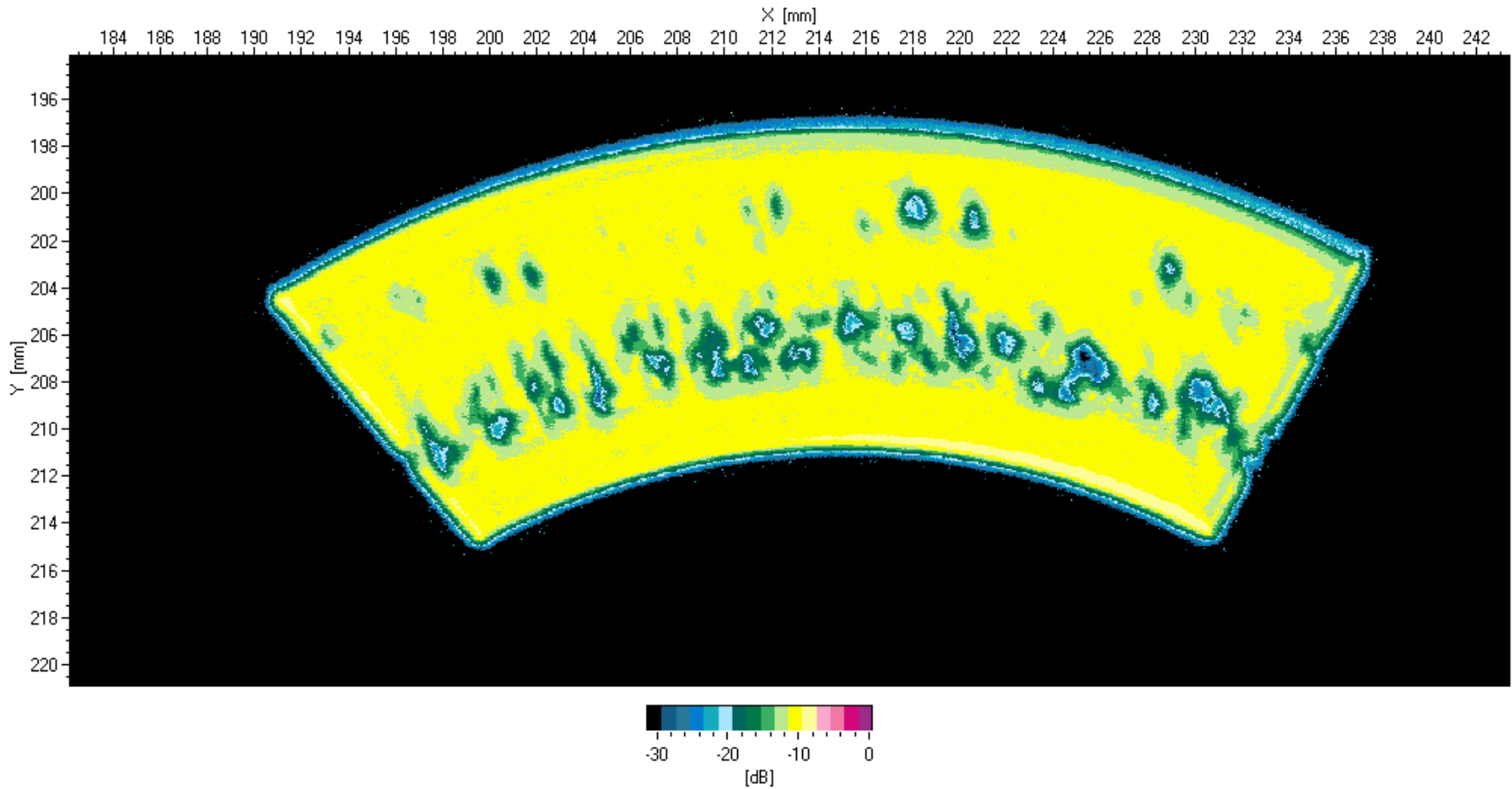




Bearing rings received
from RWTH Aachen



Ultrasonic testing

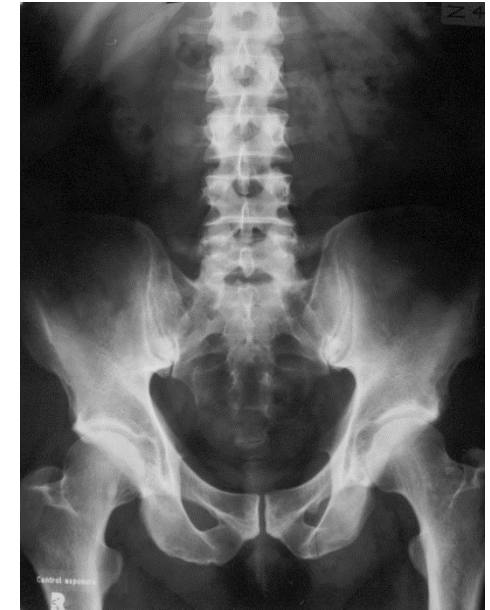


Part of raceway with WEC

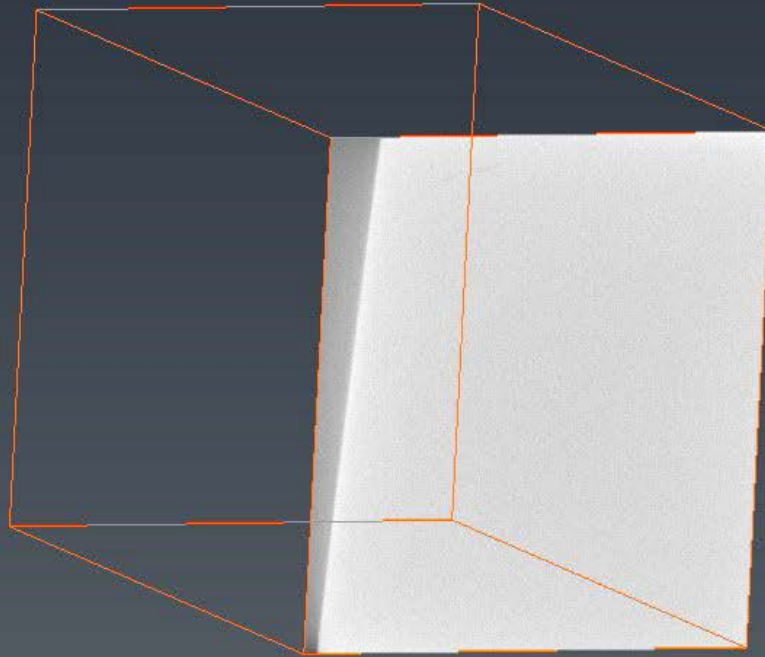
characterisation method: X-ray Computerised Tomography



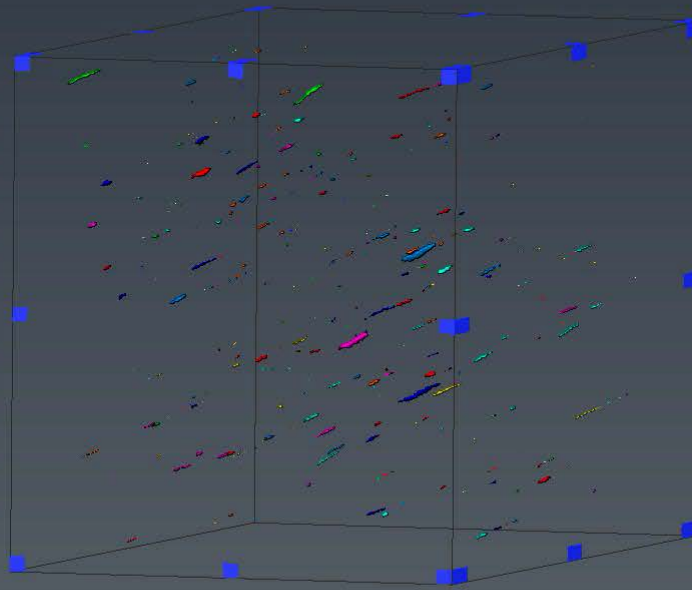
CT scanner



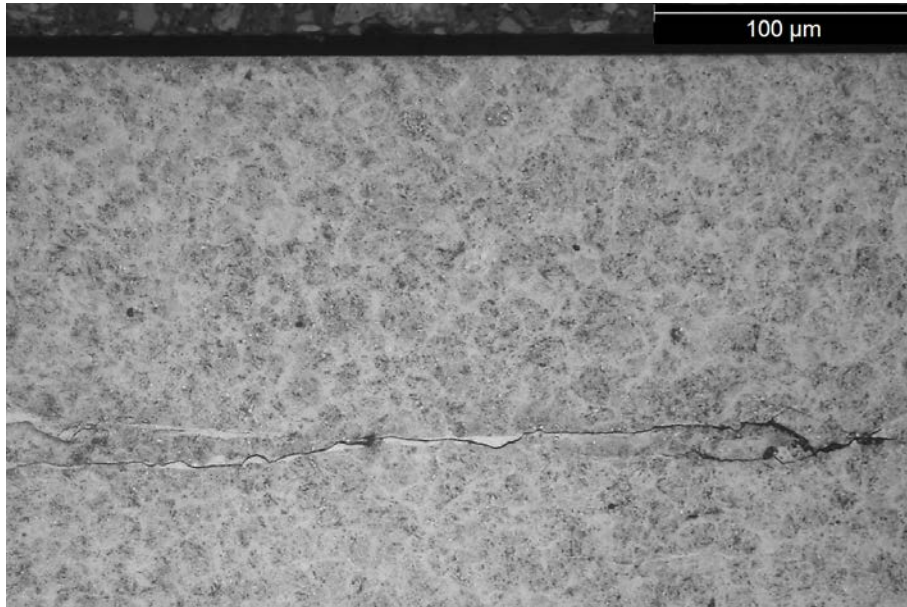
Charaterisation of bearings: Tomography



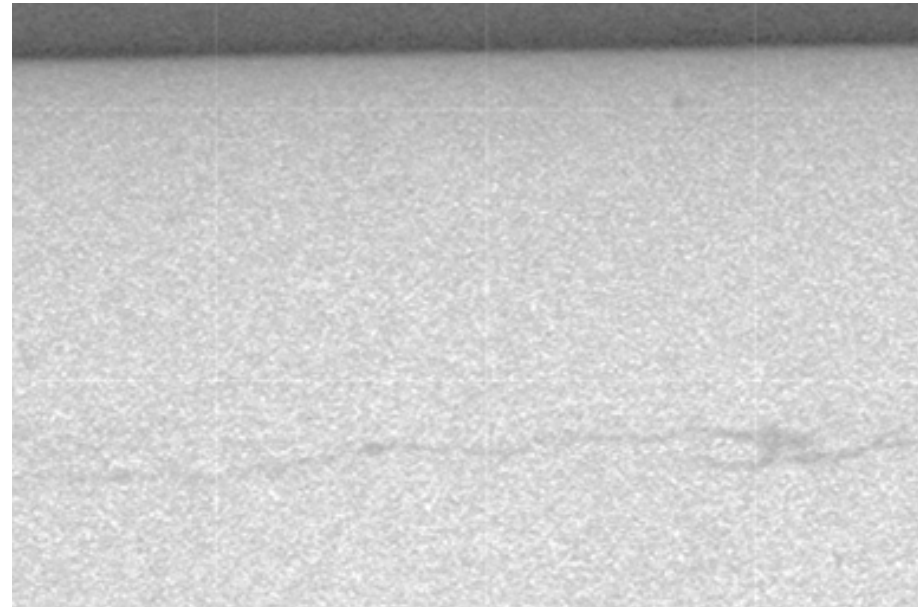
Inclusions in 1x1x1,5mm volume



X-ray tomography of WEC

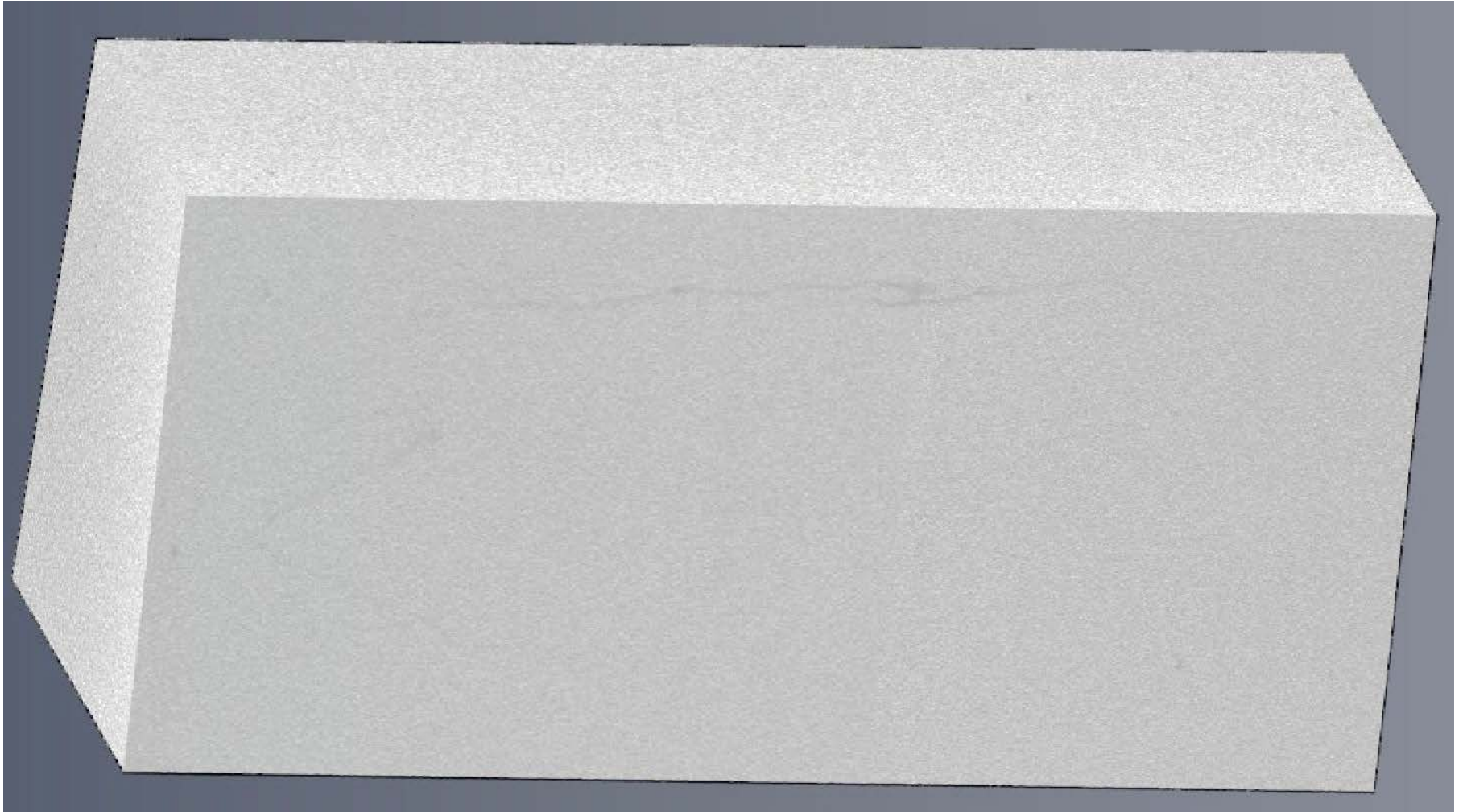


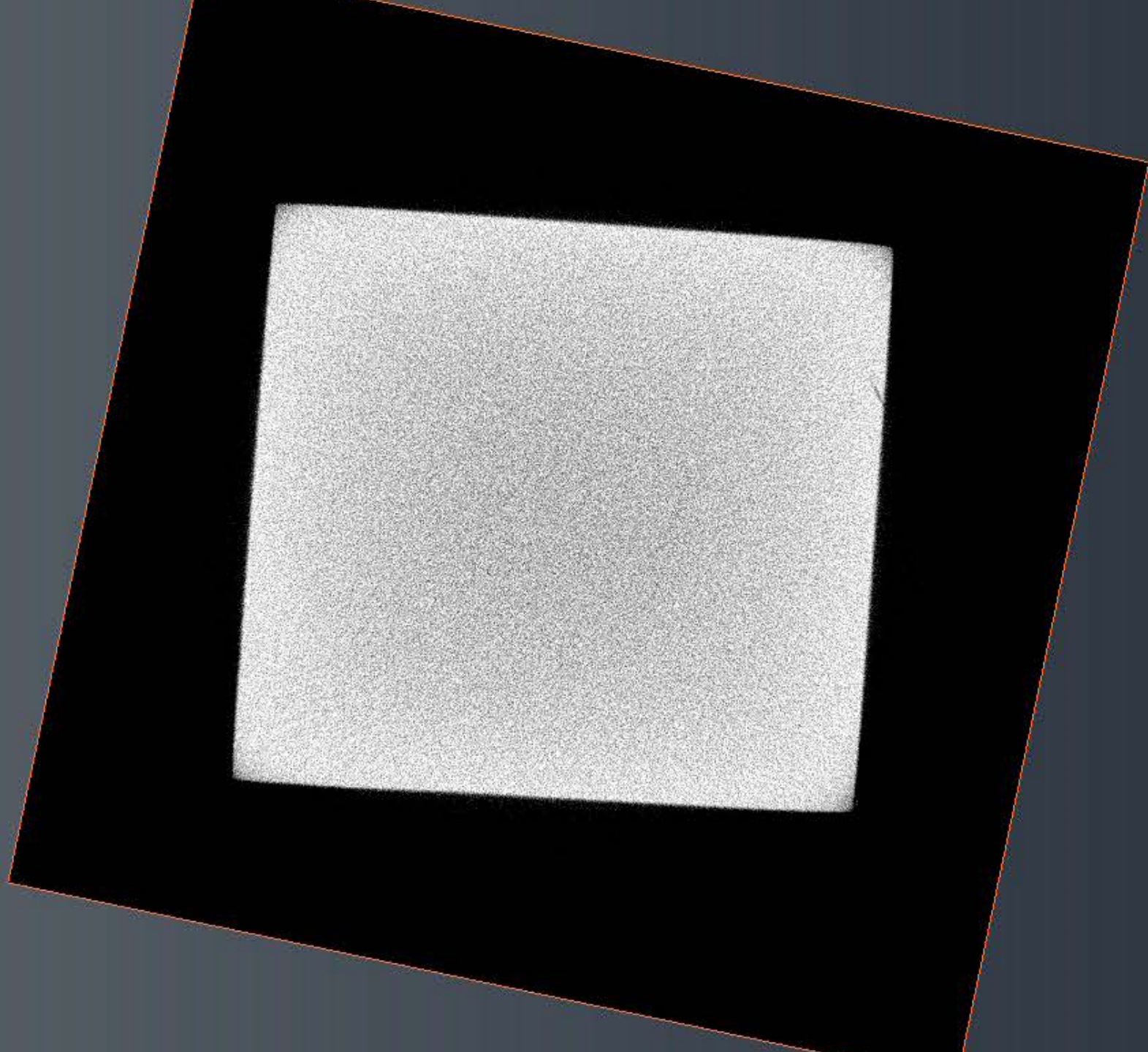
Optical microscopy



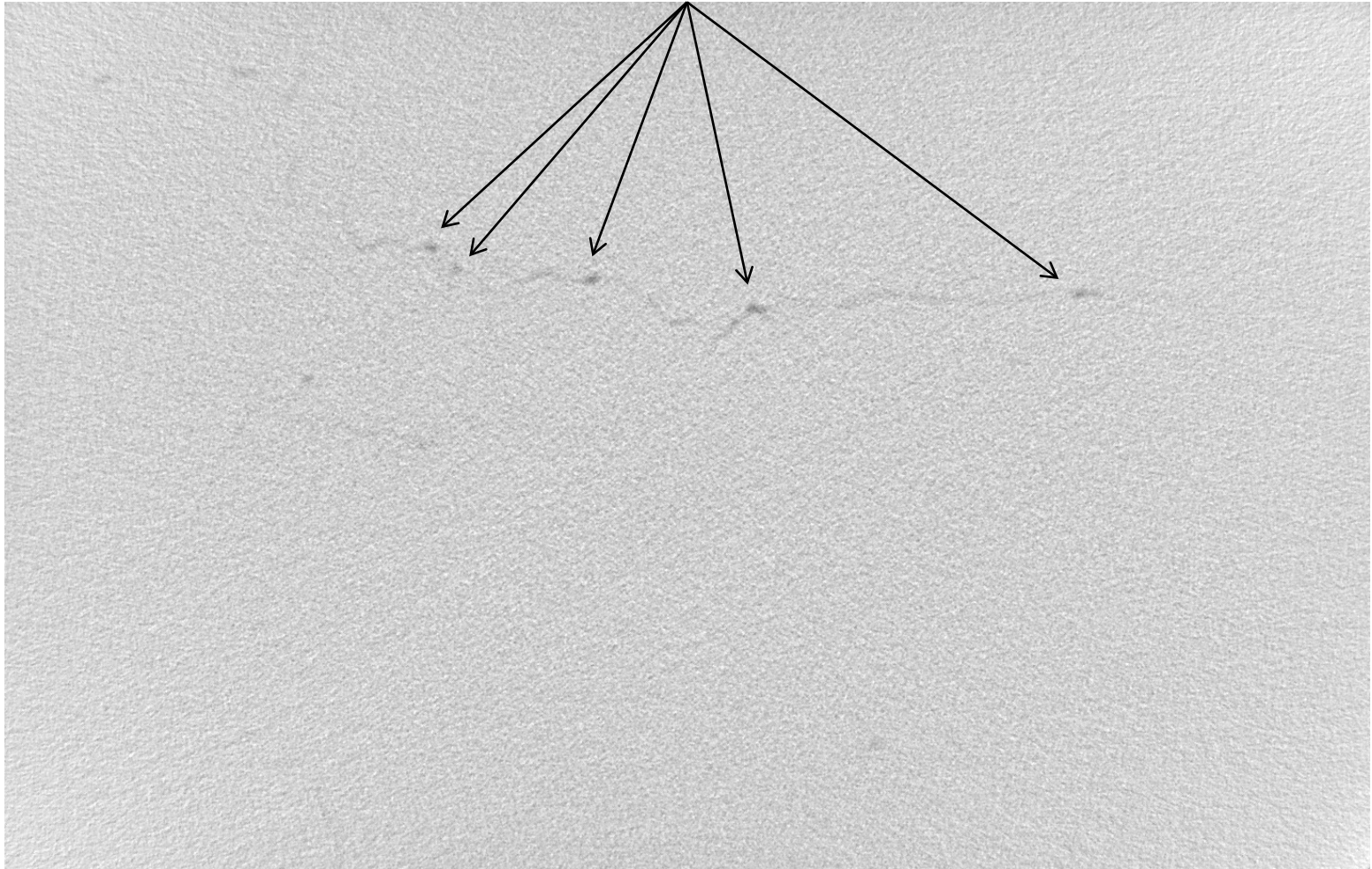
X-ray tomography

3D X-ray tomography volume



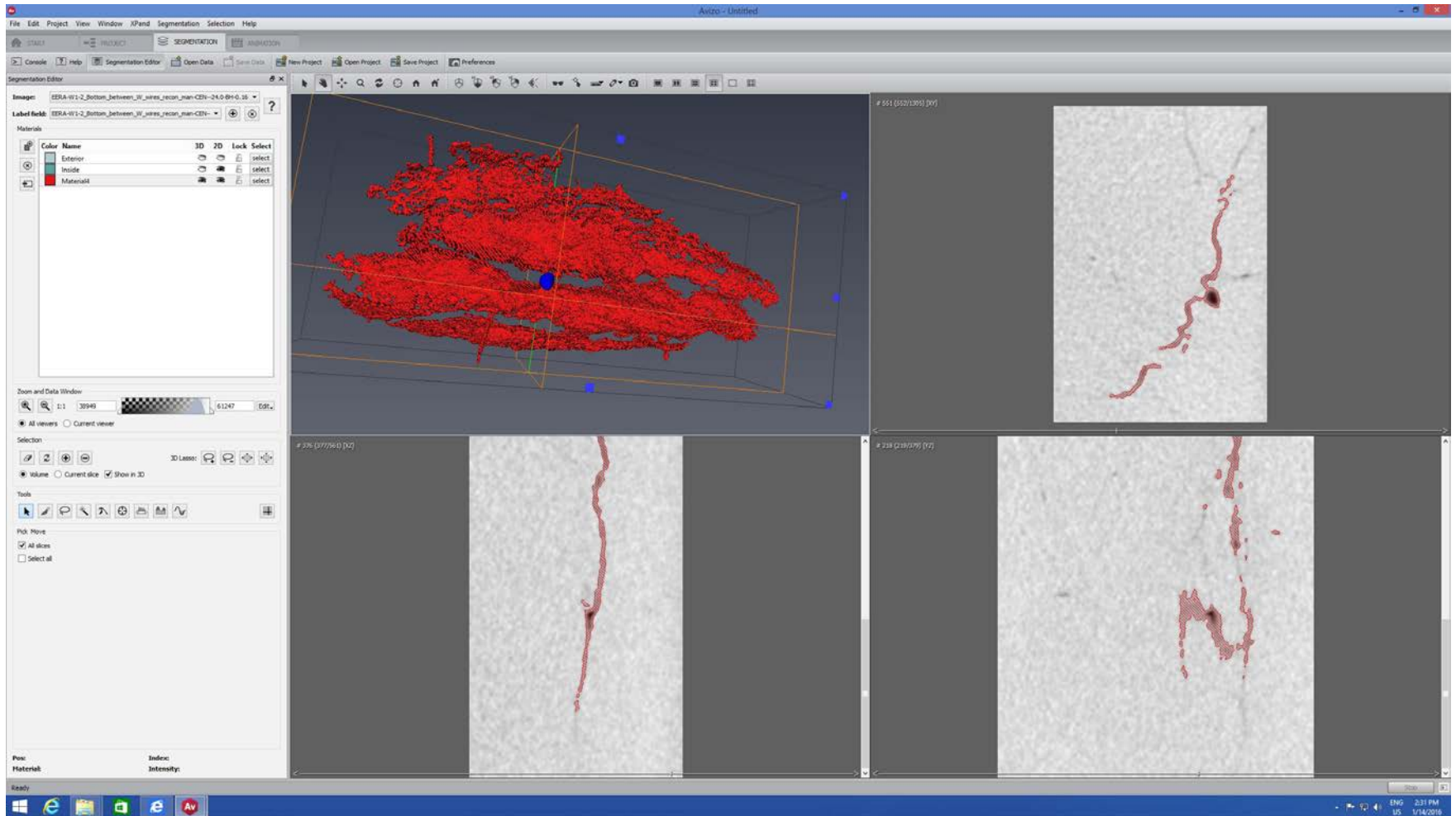


Inclusions in cracks





Imaging WEC in 3d



Imaging WEC in 3d

