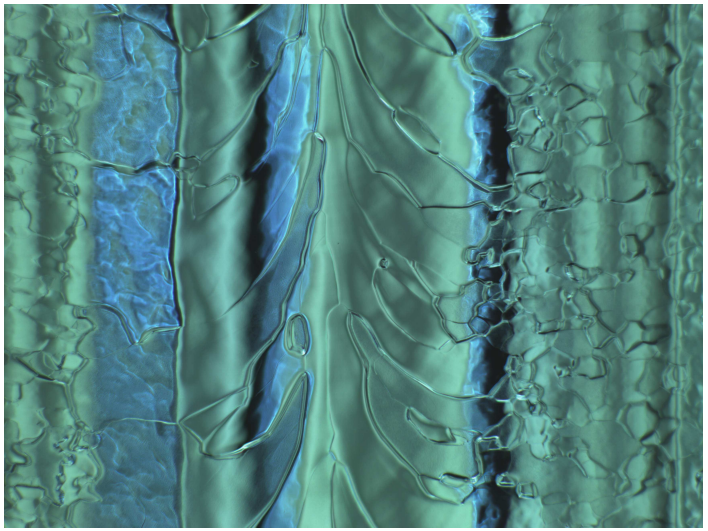
Cavity Surface Feature Recognition

How to teach a PC to see?

Status Report

- ✓ Motivation
- ✓ Optical Inspection
- ✓ Image Processing
- ✓ First Results
- ✓ Summary



Marc Wenskat
ALCPG-Meeting
Eugene, 19.-23. March 2011

HELMHOLTZ ASSOCIATION

SEVENTH FRAMEWORK PROGRAMME

PHYSICS AT THE TERA SCALE Helmholtz Alliance

DESY

Motivation

- 810 Images per Cavity (without Iris)
- 800 Cavities @ 23.5 MV/m for XFEL

- Huge amount of data!

- Is it possibly to classify patterns to describe the surface?
- How does surface treatment affect the derived cluster-parameters?
- Can we identify and find irregularities / defects automatically?

Optical Inspection

- KEK camera system @ DESY (S. Aderhold, “Optical inspection of SRF cavities at DESY”, Proc. of the 14th Workshop on RF Superconductivity, Berlin, Germany 2009)

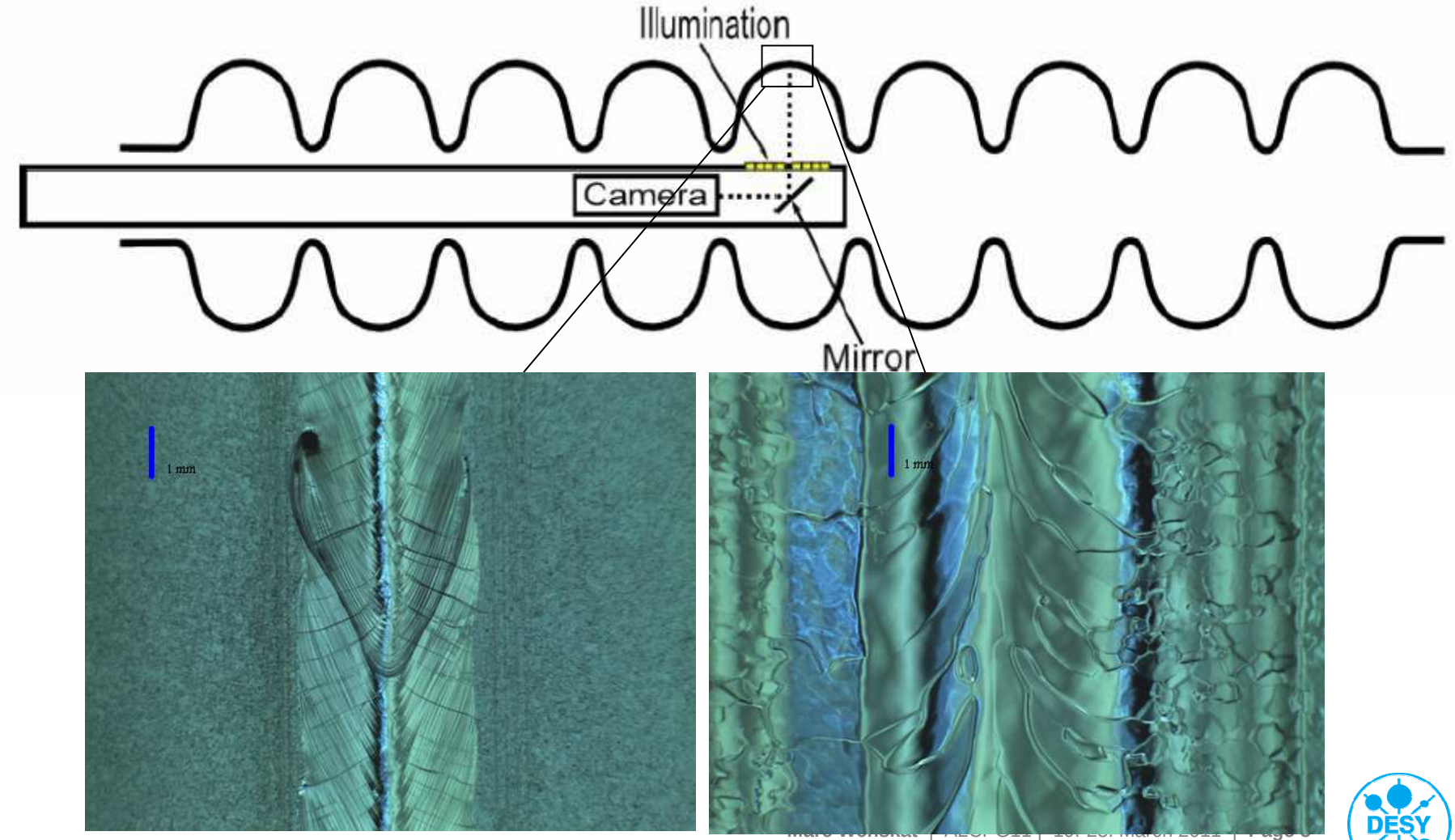


Image Processing

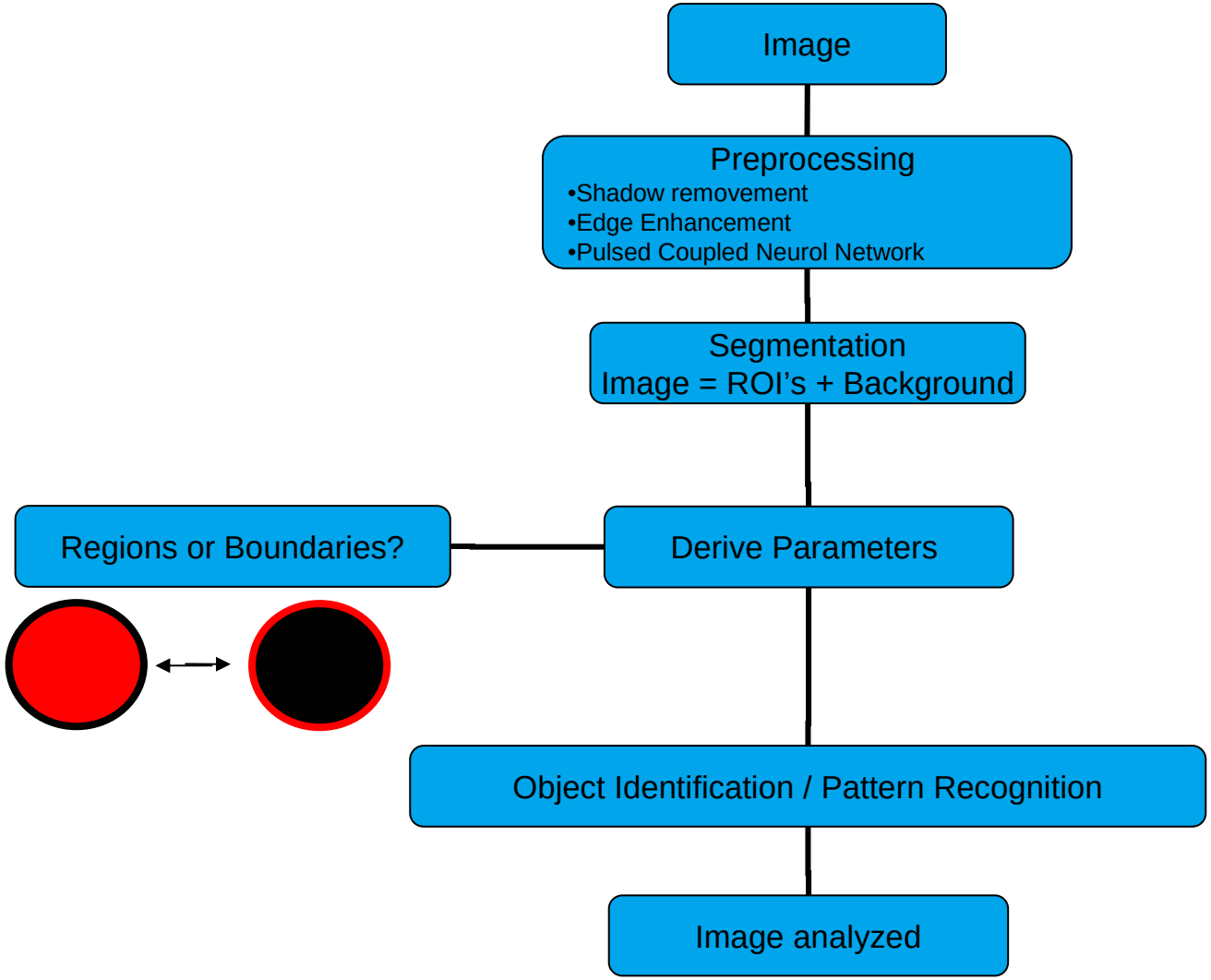
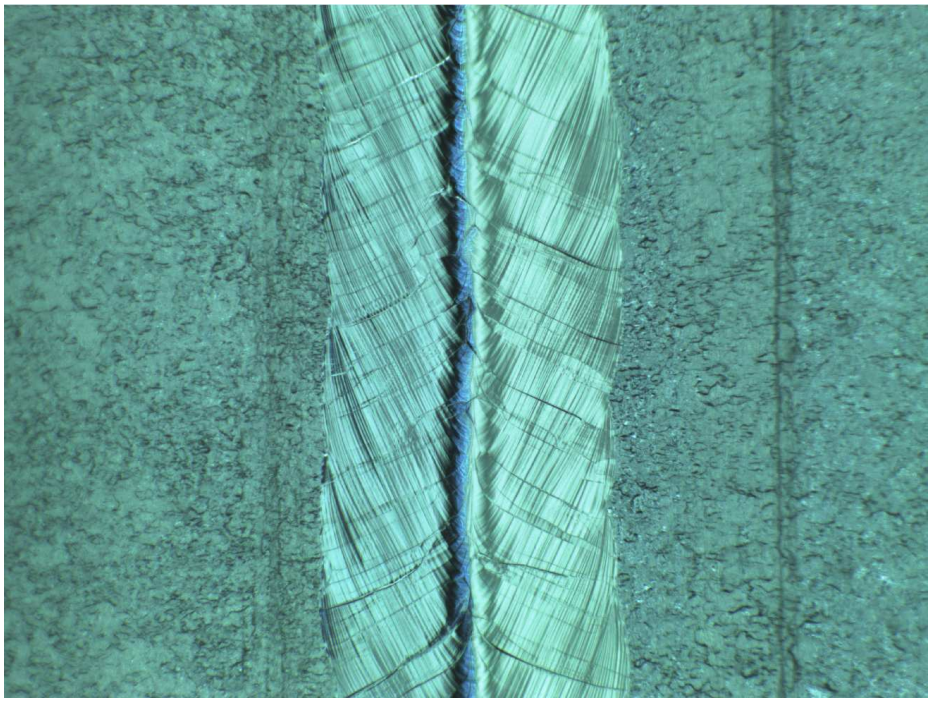
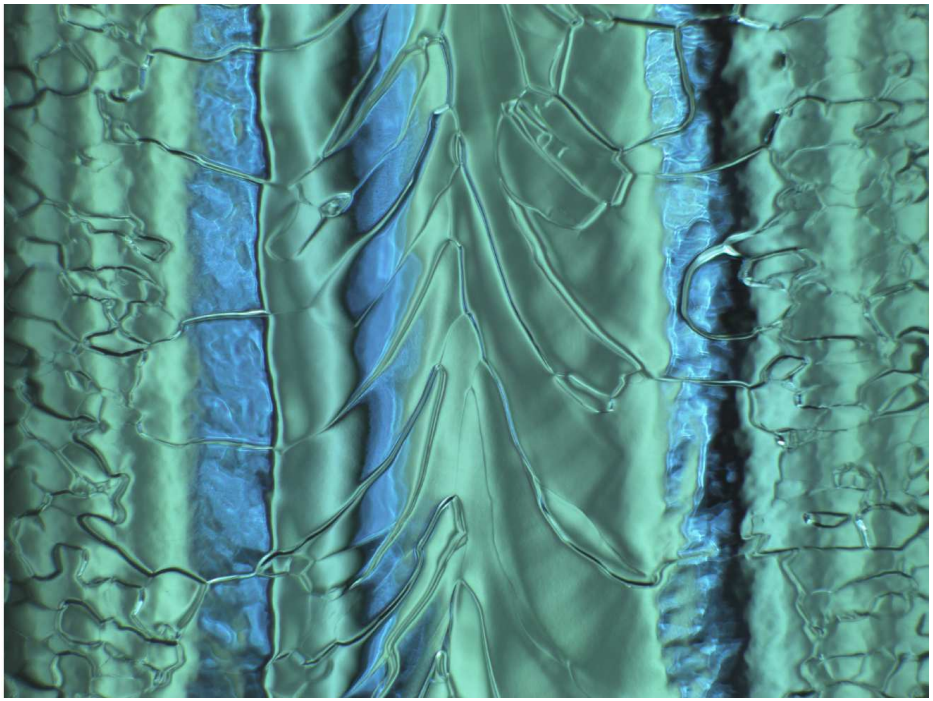


Image Understanding – Example – Original Image



Z 160

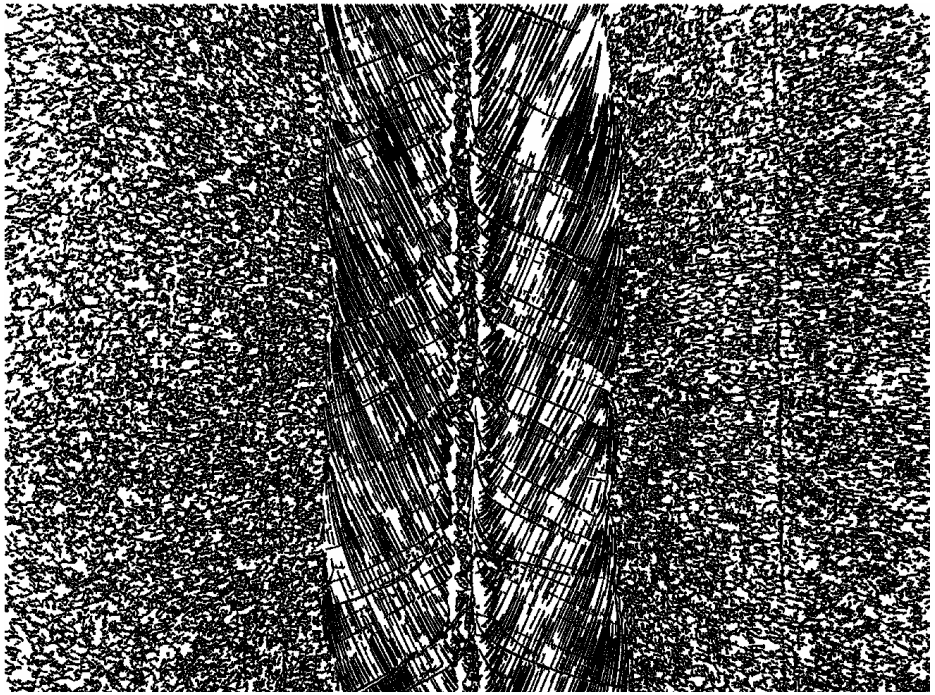
- Optical Inspection

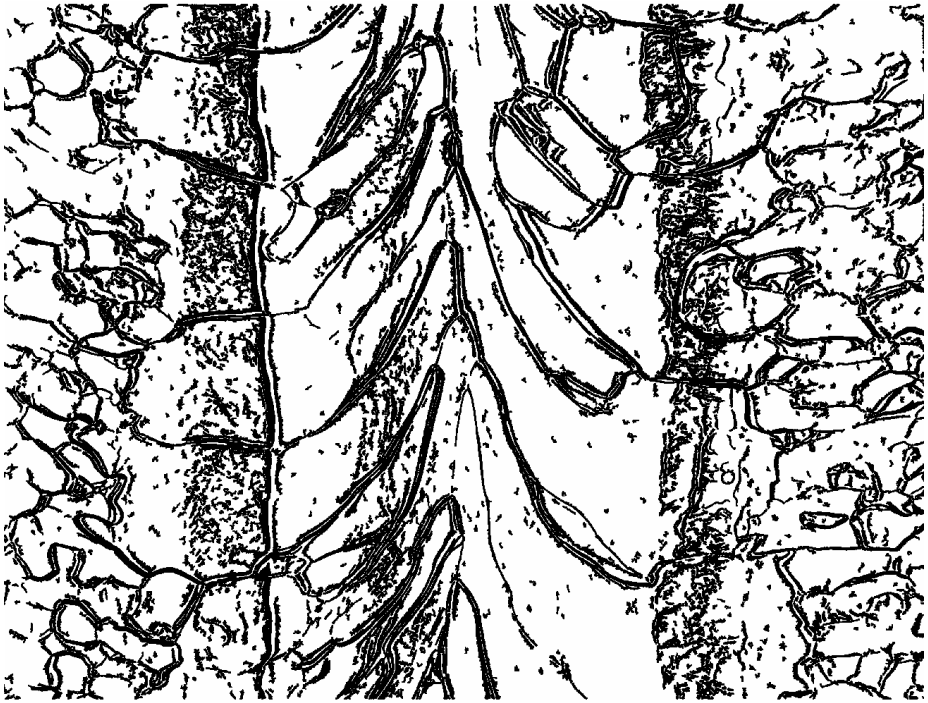


AC 126

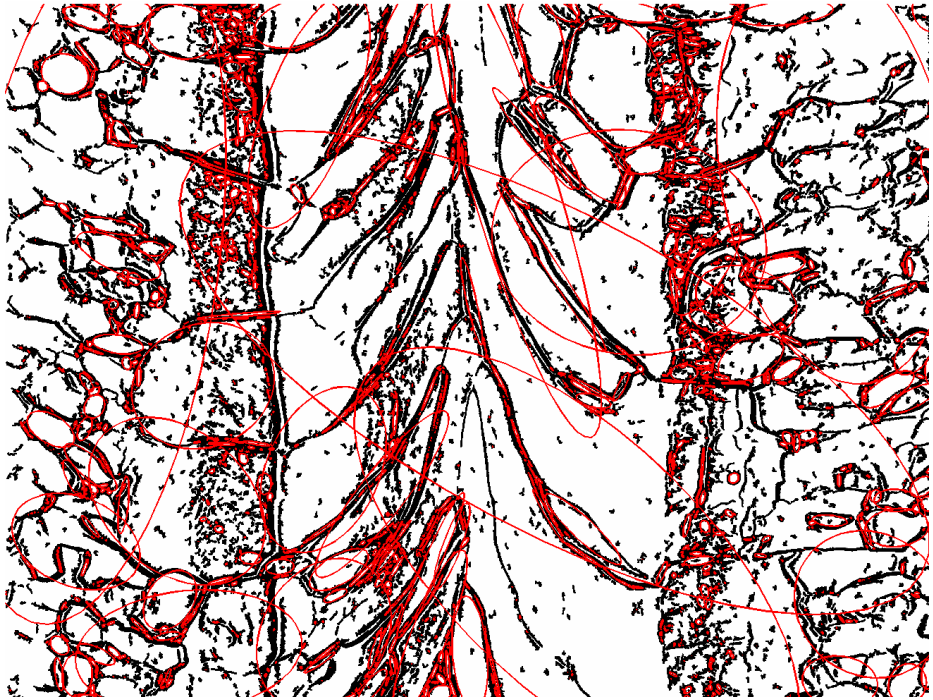
- 168 µm EP
- 20 µm BCP
- Optical Inspection

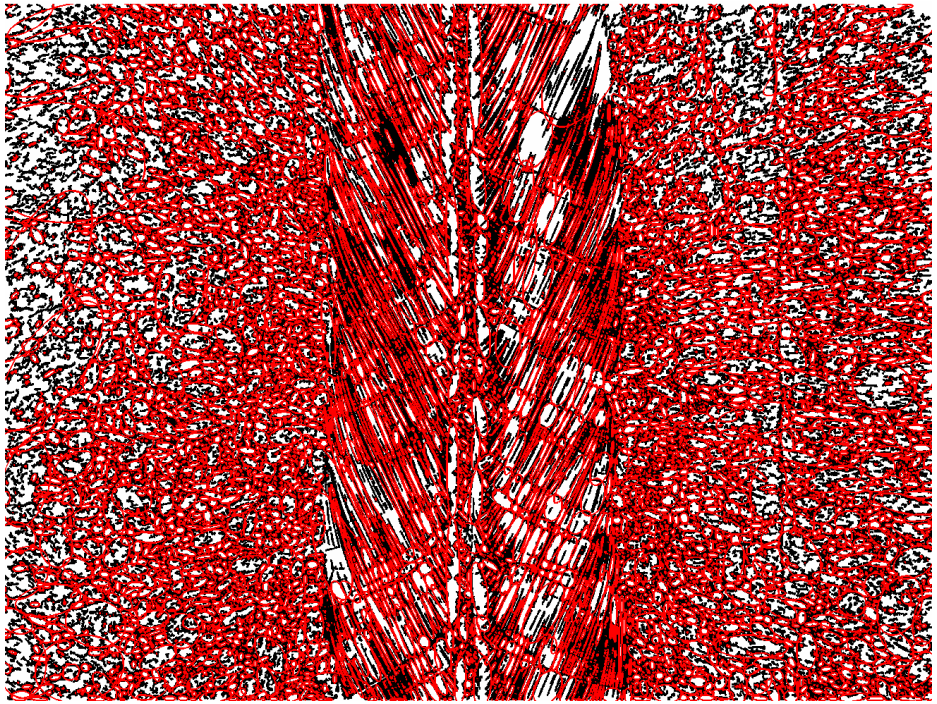
Image Understanding – Example – ROI's

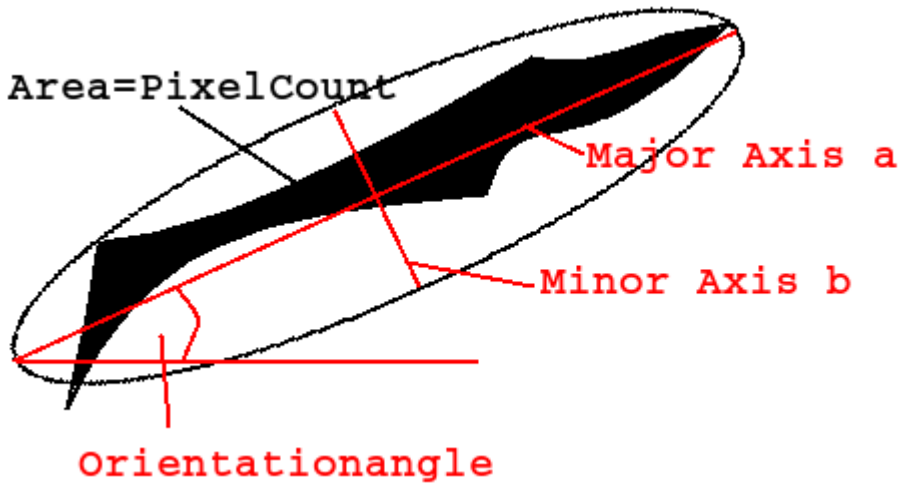




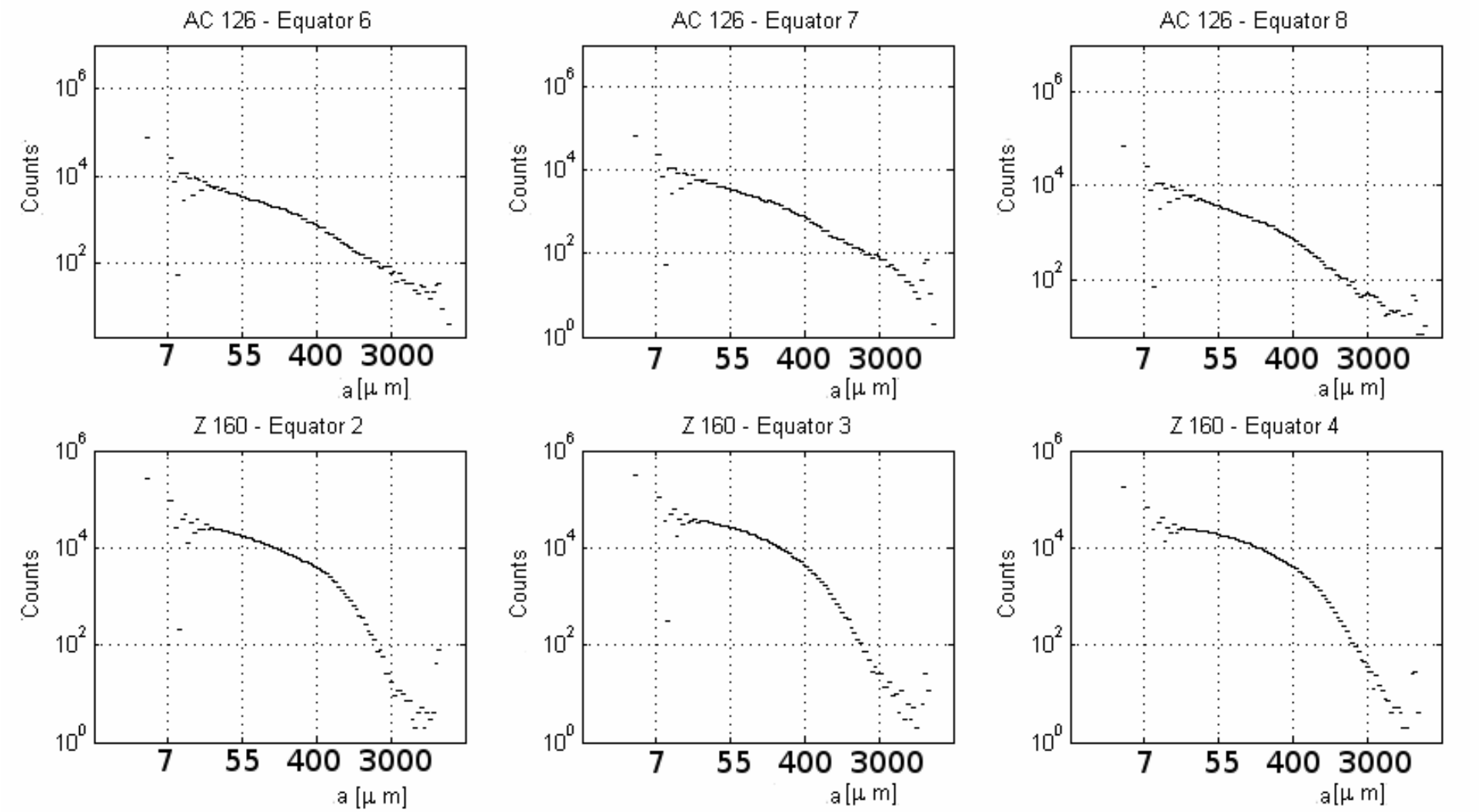
Regions: Surface Properties







Comparison of the Welding Seam (Zanon & RI)



Comparison of the Welding Seam (Zanon & RI)

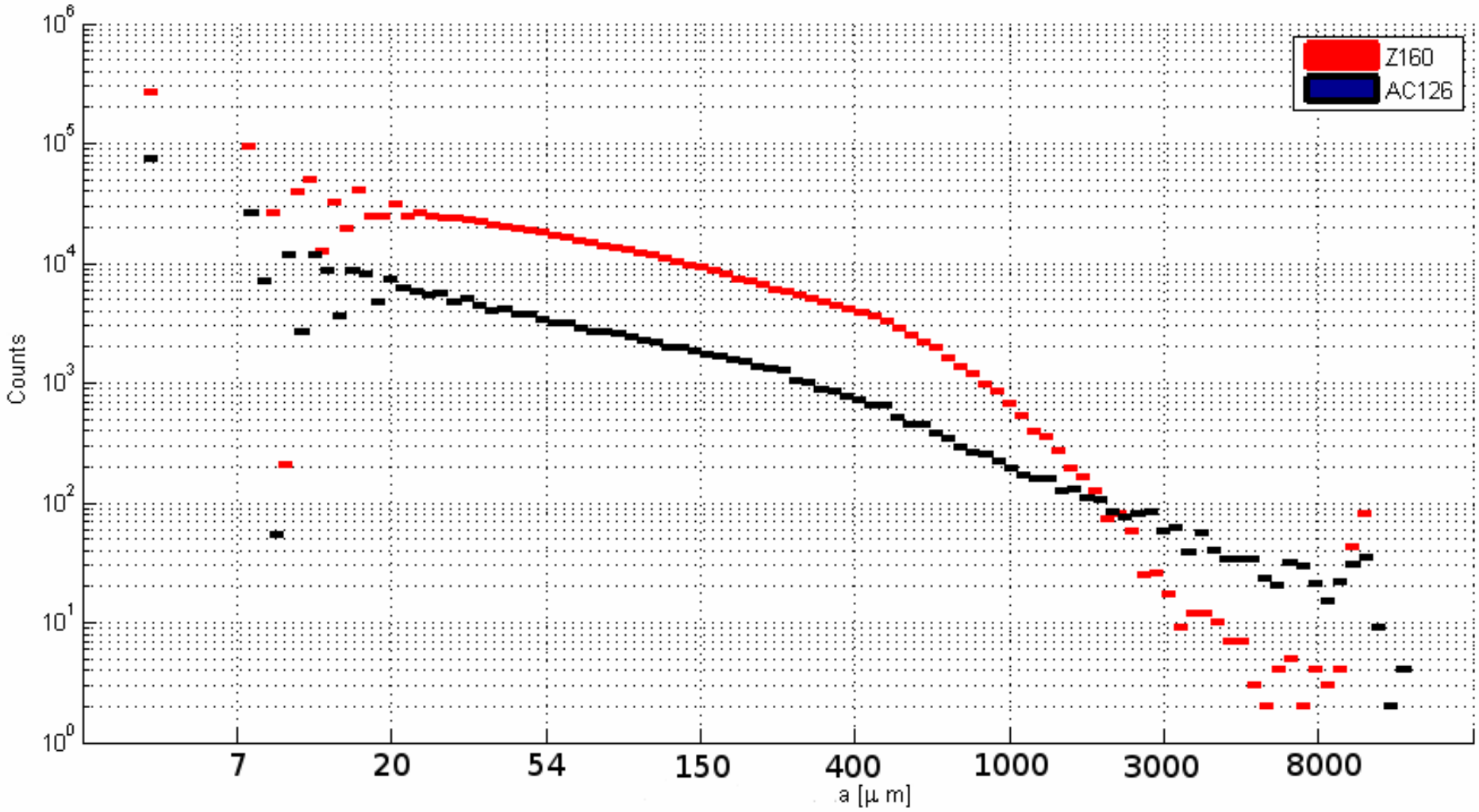
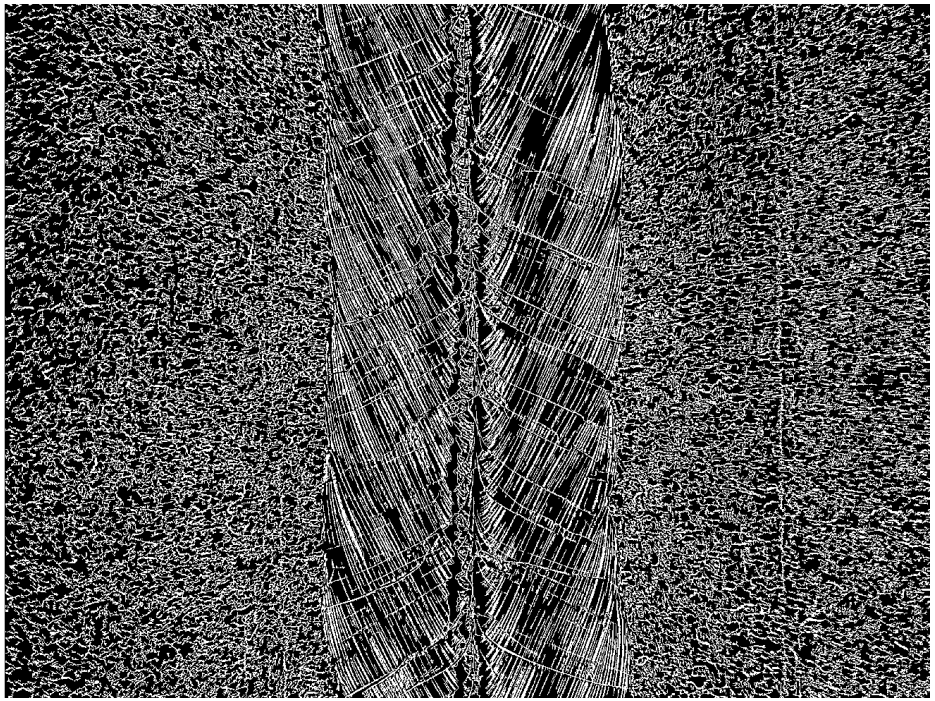
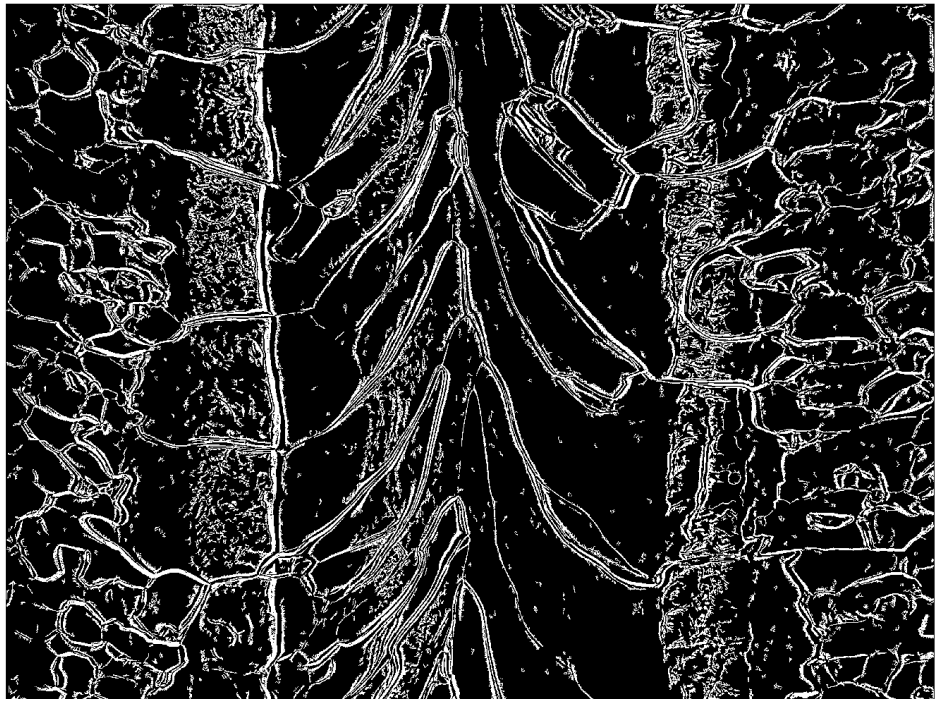
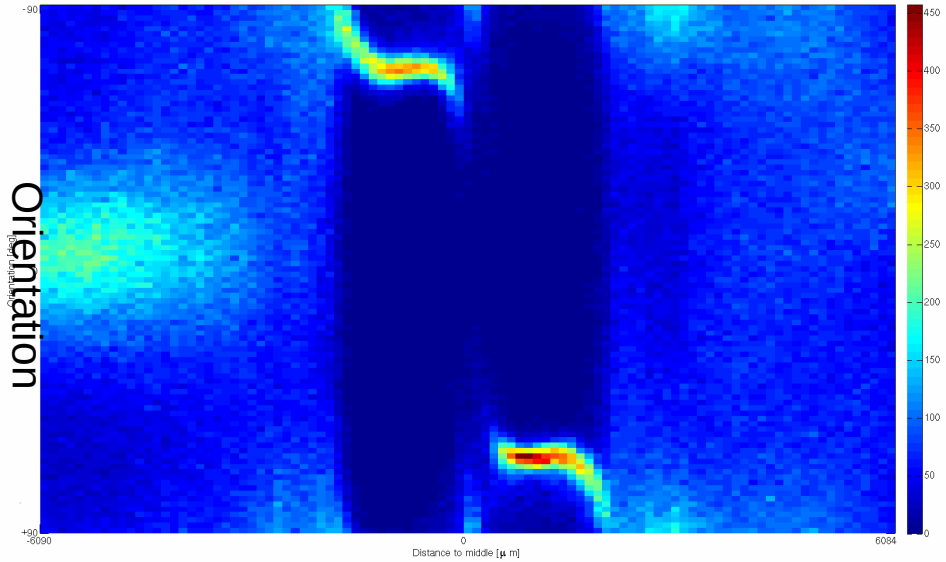


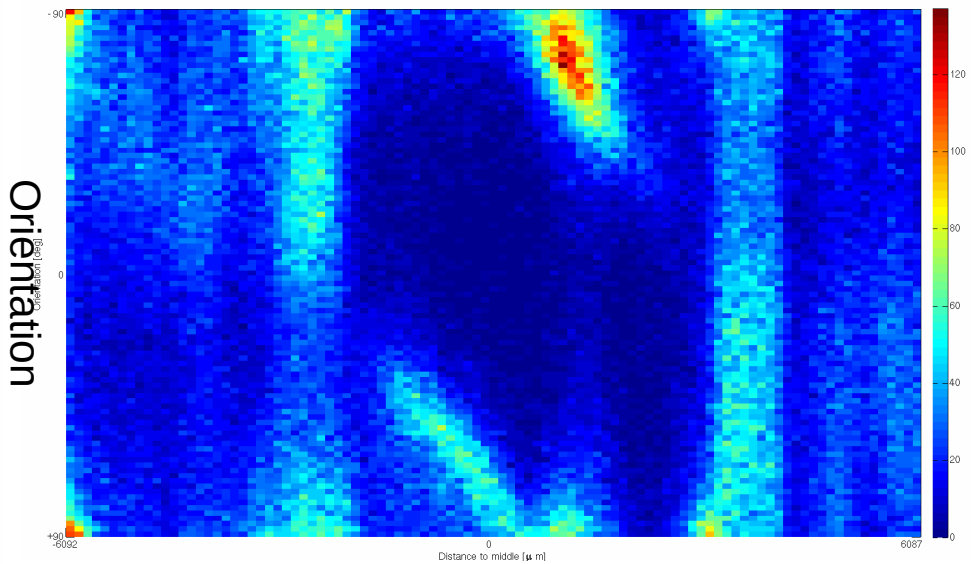
Image Understanding – Example – Boundaries



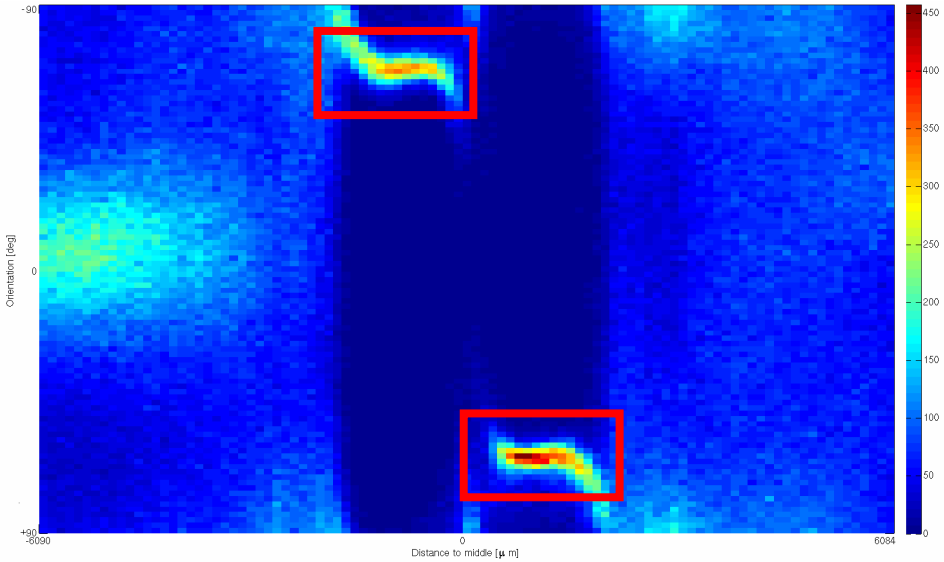


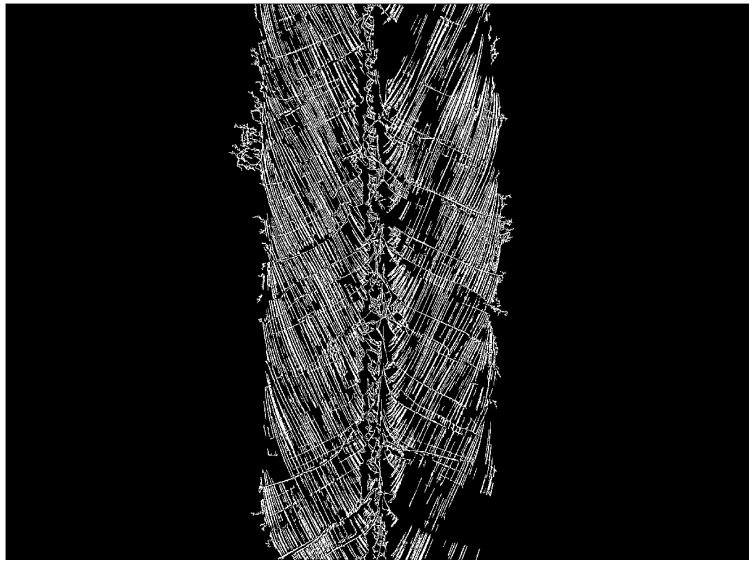
Scatterplots

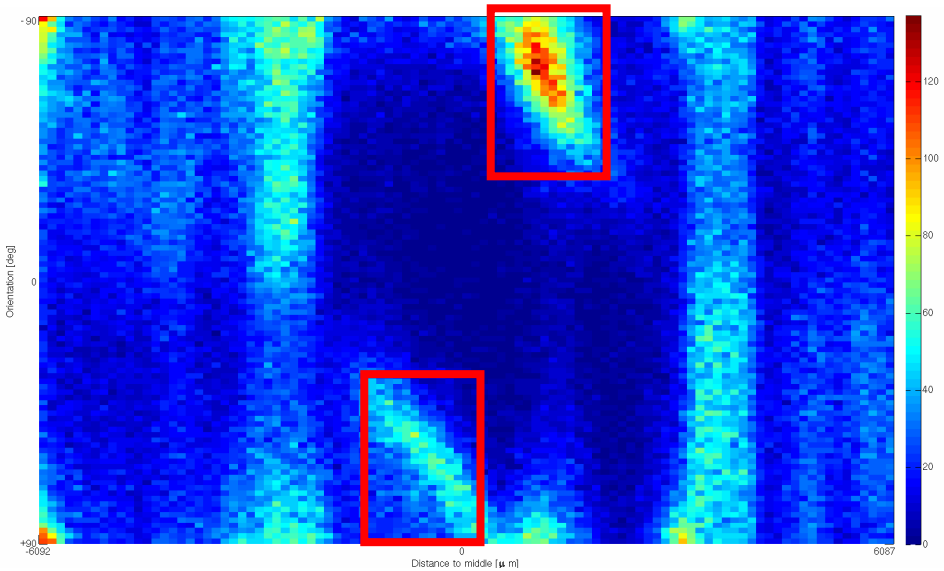


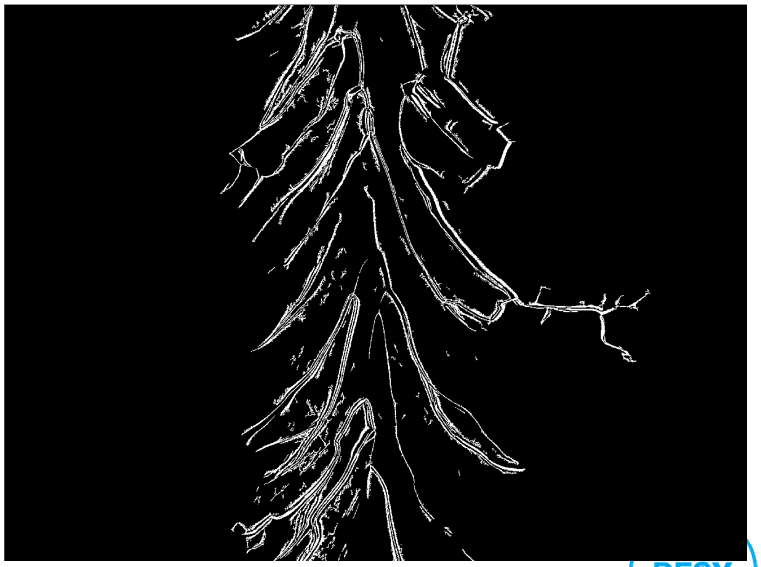


Boundaries: identifying welding seam & patterns

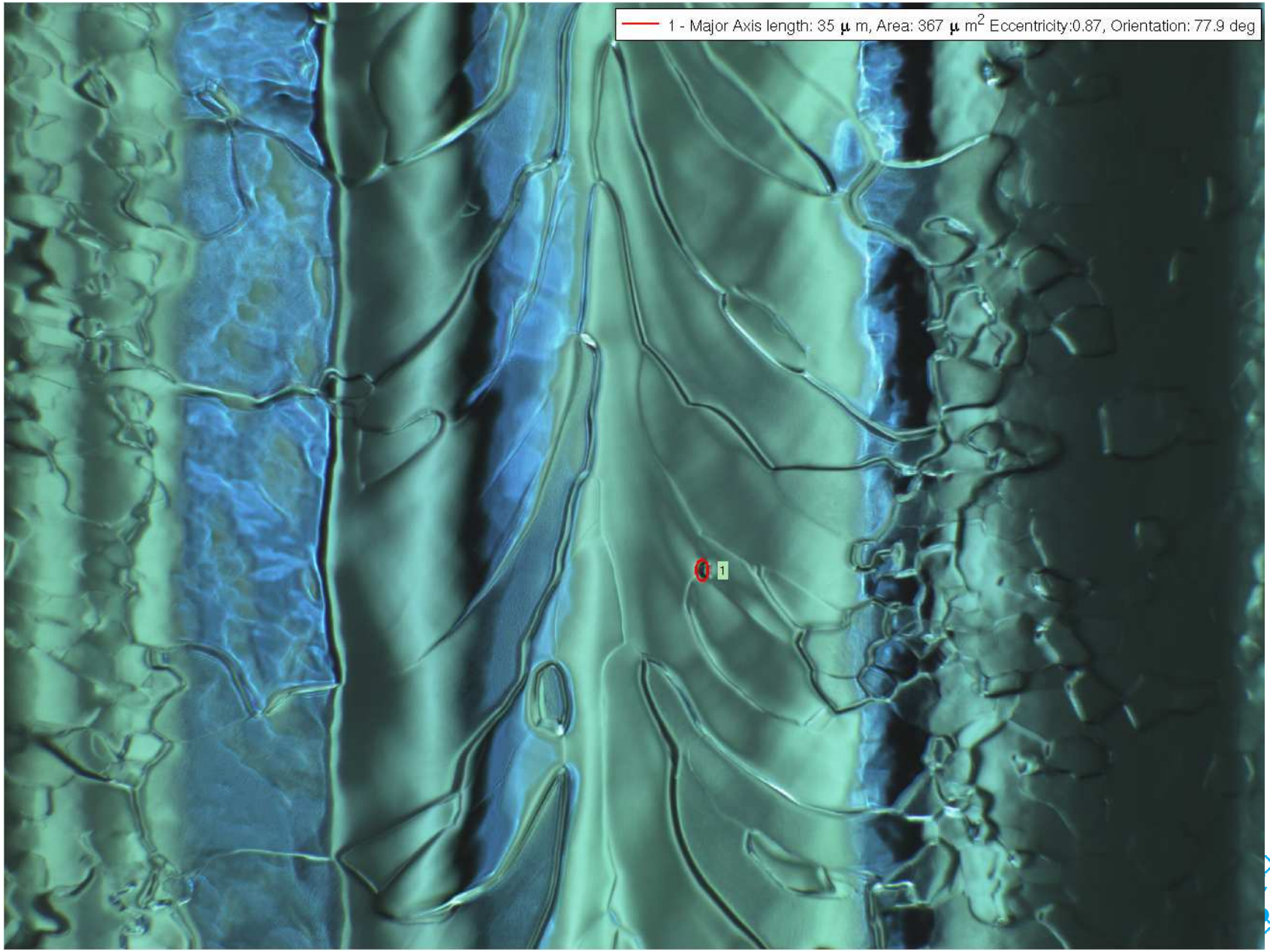




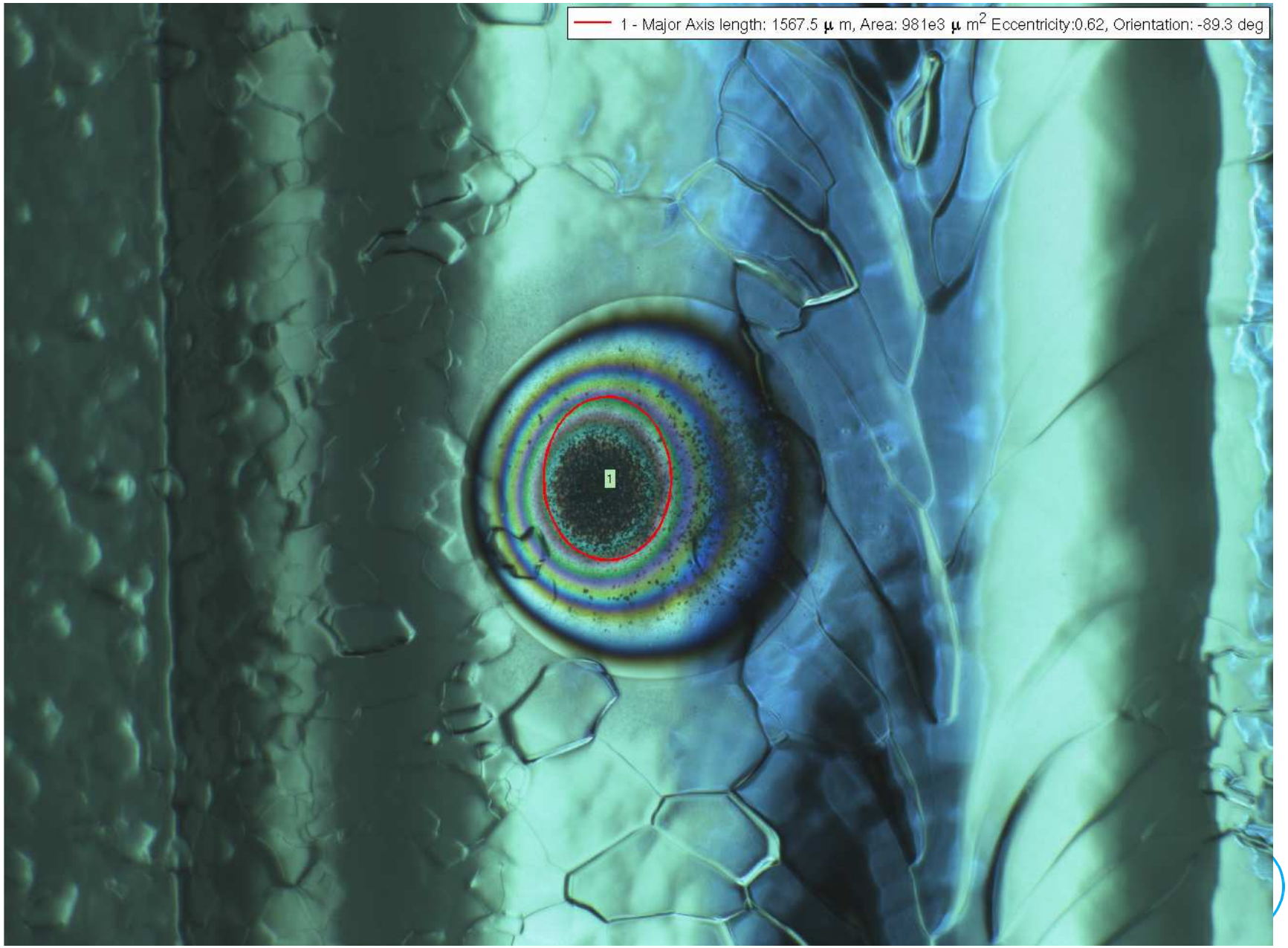




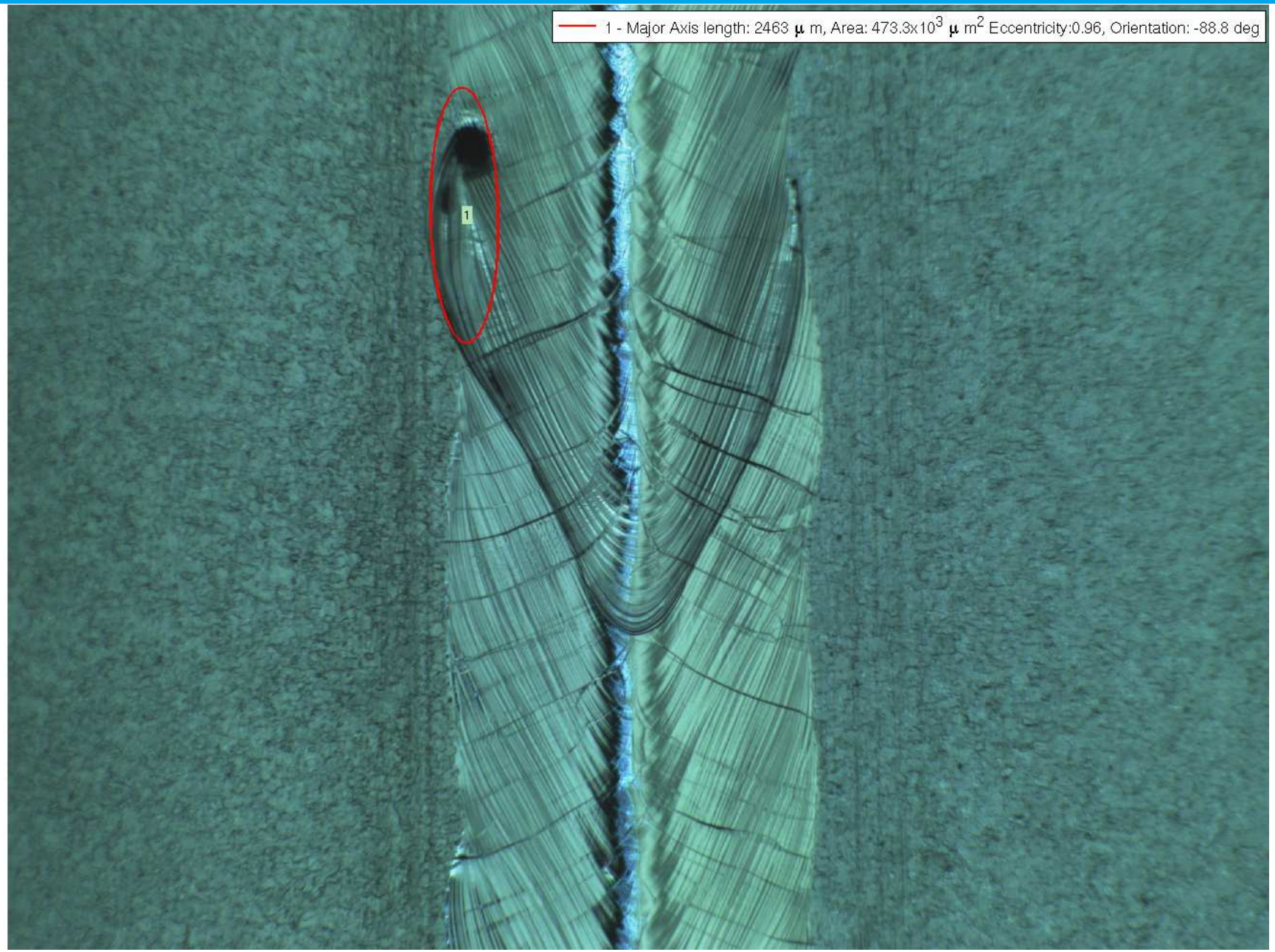
Properties of Irregularities – AC 126 Equator 1



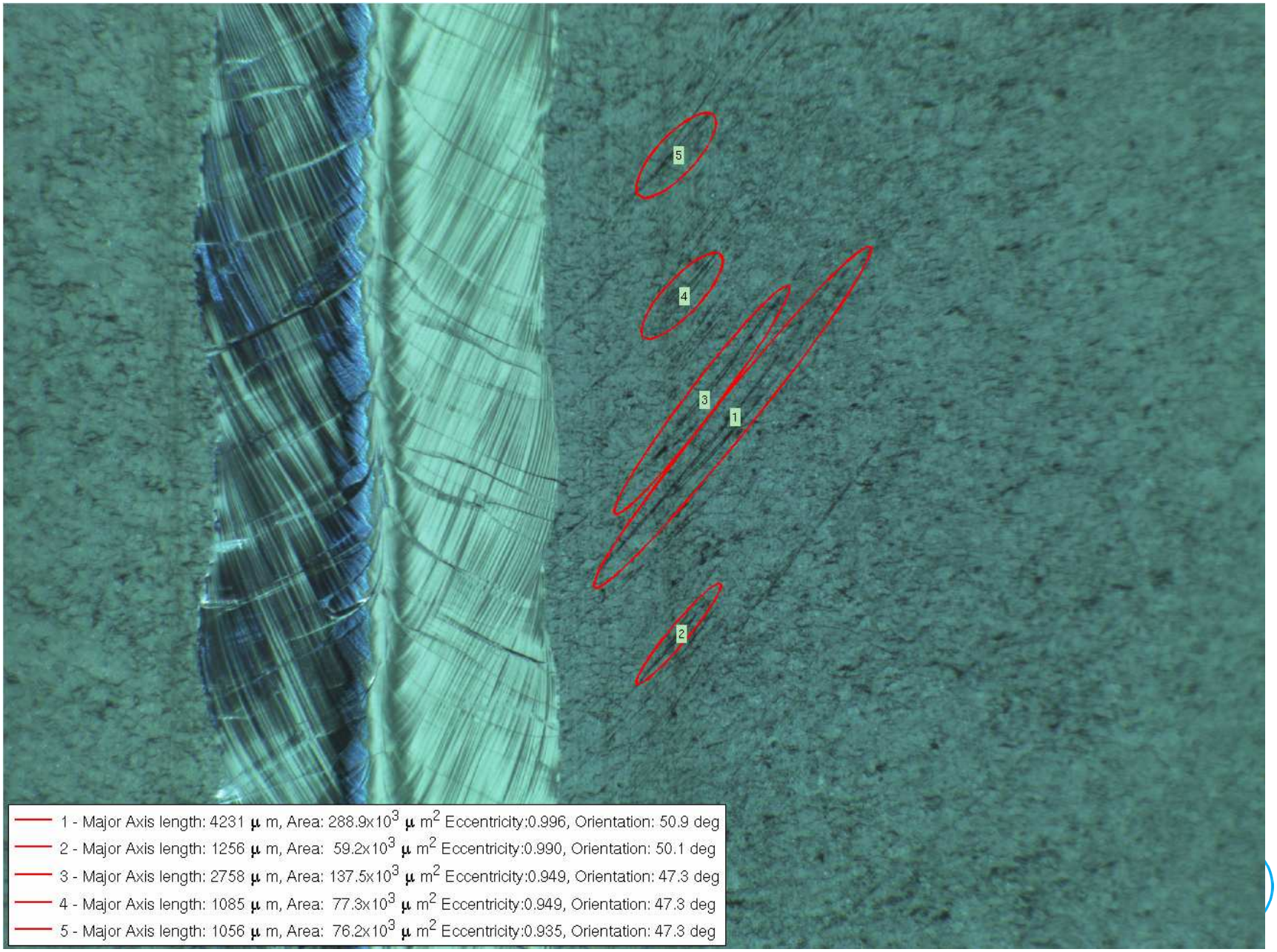
Properties of Irregularities – AC 126 Equator 3



Properties of Irregularities – Z160 Equator 6



Properties of Irregularities – Z160 Equator 7



Summary

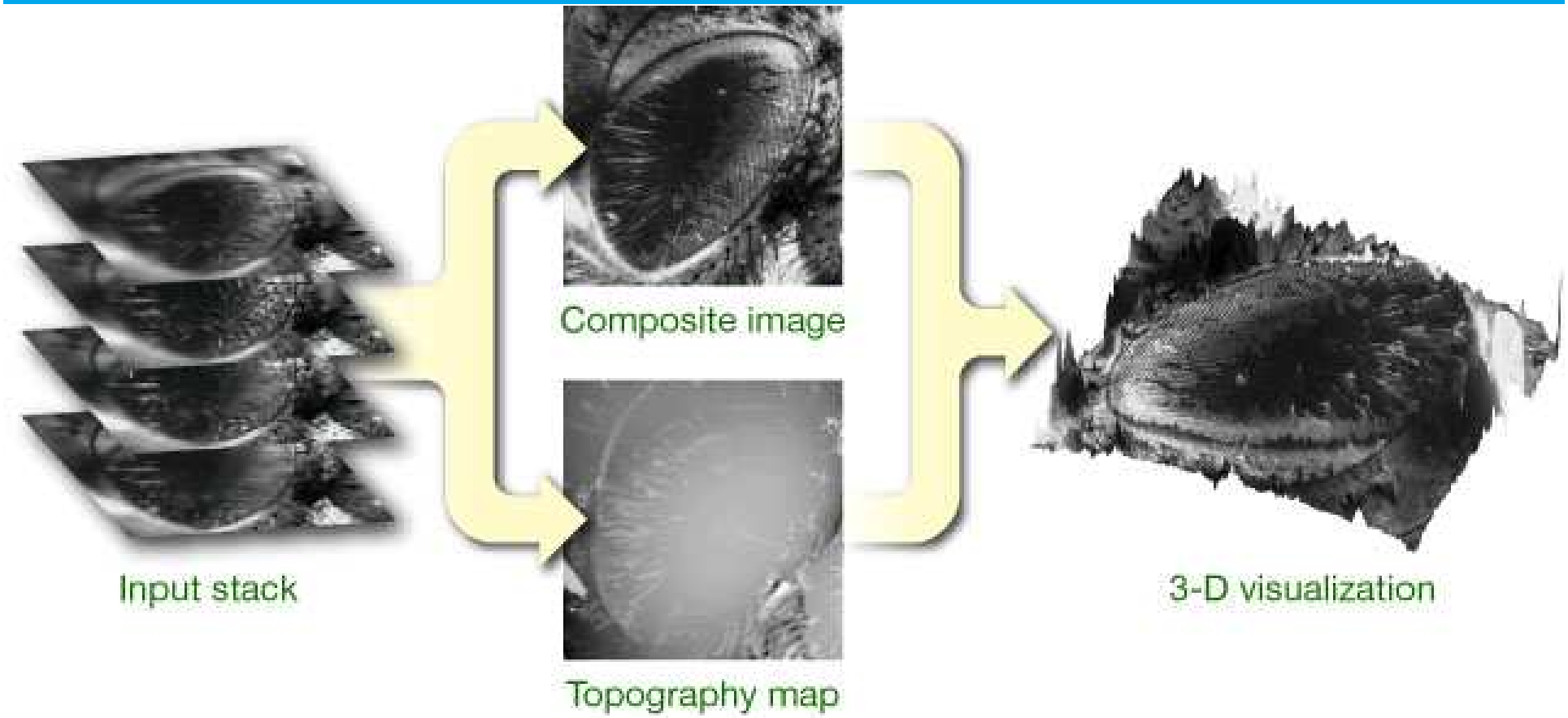
Done:

- Toolbox has been developed to analyze huge amount of images
- Classification of the objects started

We want to:

- Improve and investigate the algorithm to
  - understand the influence of illumination on parameters
  - identify individual objects (irregularities - defects) automatically
- Understand and classify the influence of surface preparation on parameters
- Dream: find correlation between defects and maximum gradient

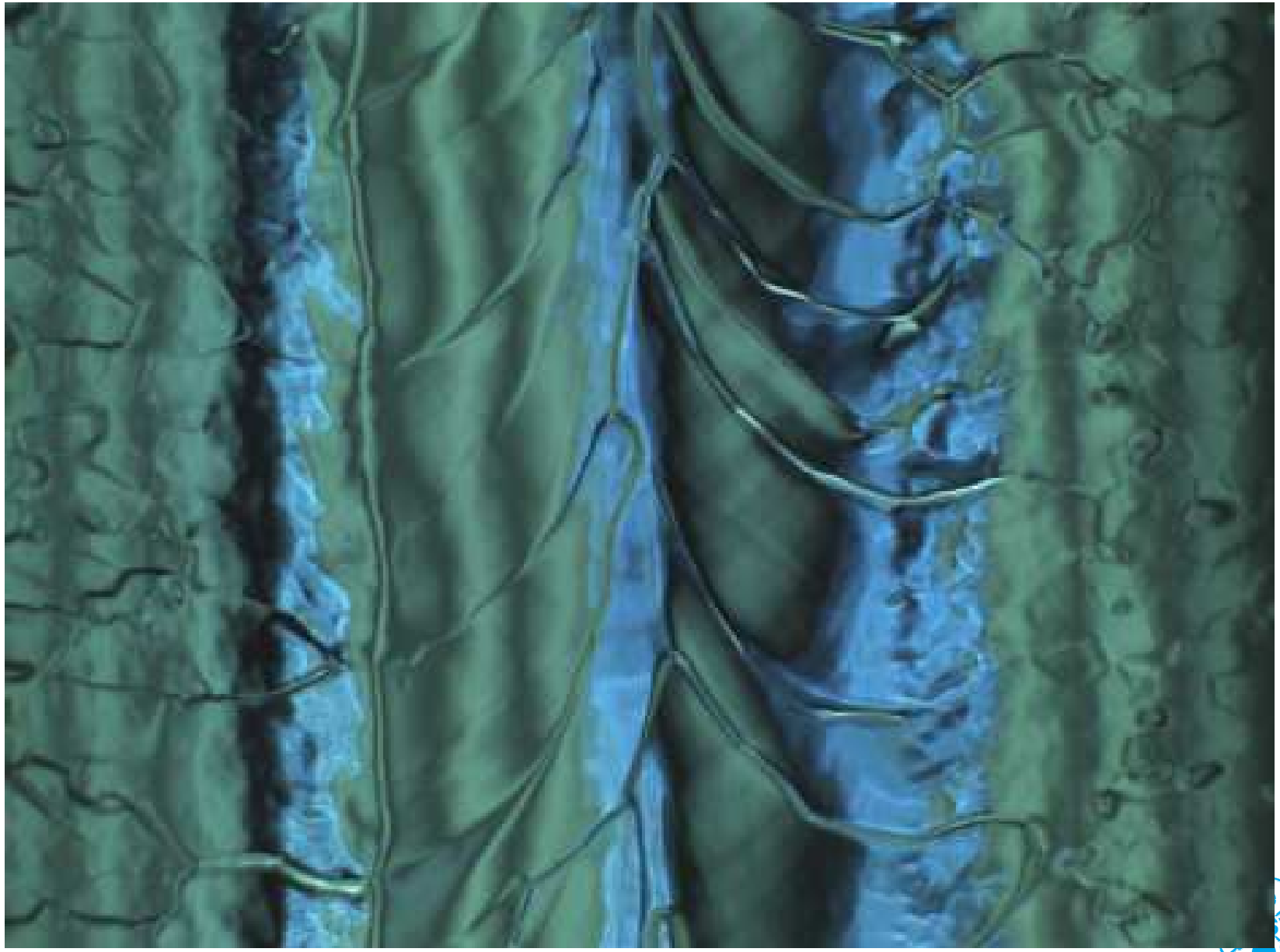
2D - 3D



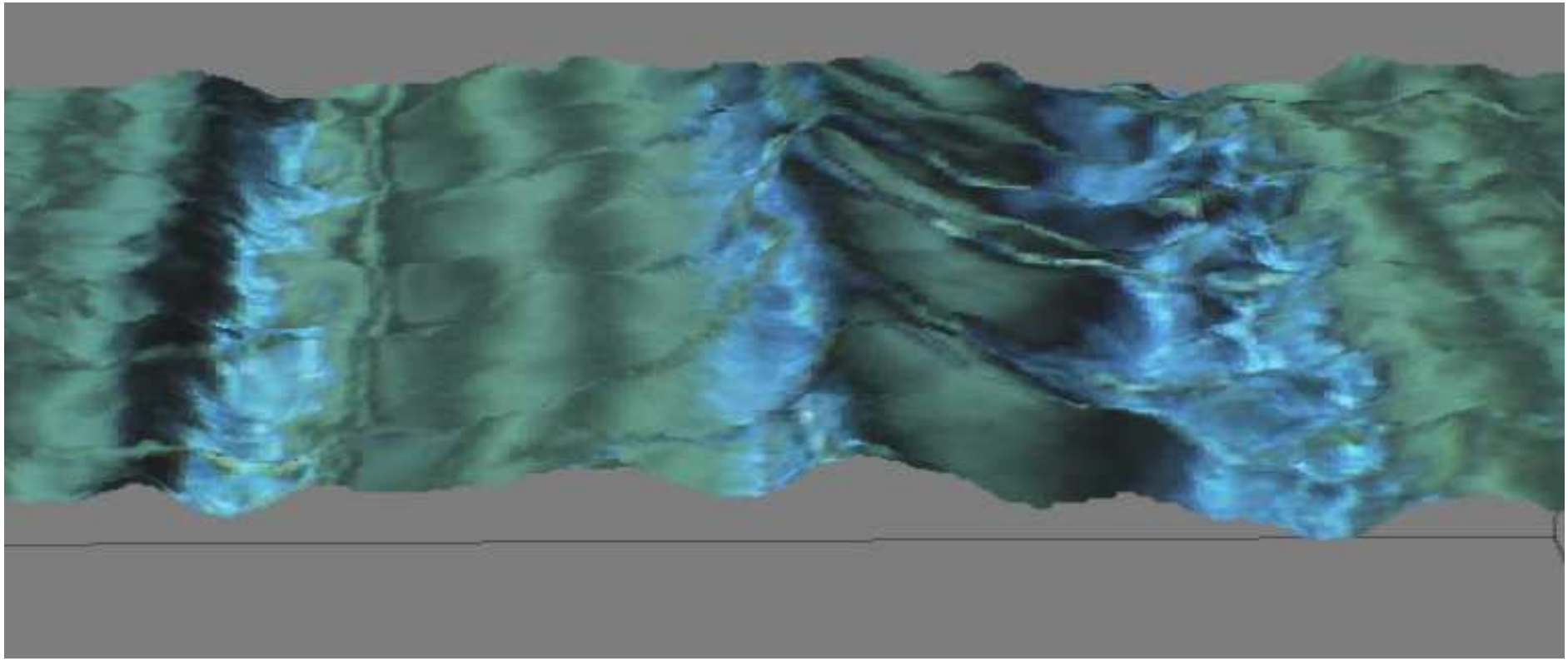
External Program – ‚Complex wavelet-based method‘ (Focus Stacking)

B. Forster, D. Van De Ville, J. Berent, D. Sage, M. Unser, " Complex Wavelets for Extended Depth-of-Field: A New Method for the Fusion of Multichannel Microscopy Images ," Microsc. Res. Tech., 65(1-2), pp. 33-42, September 2004.

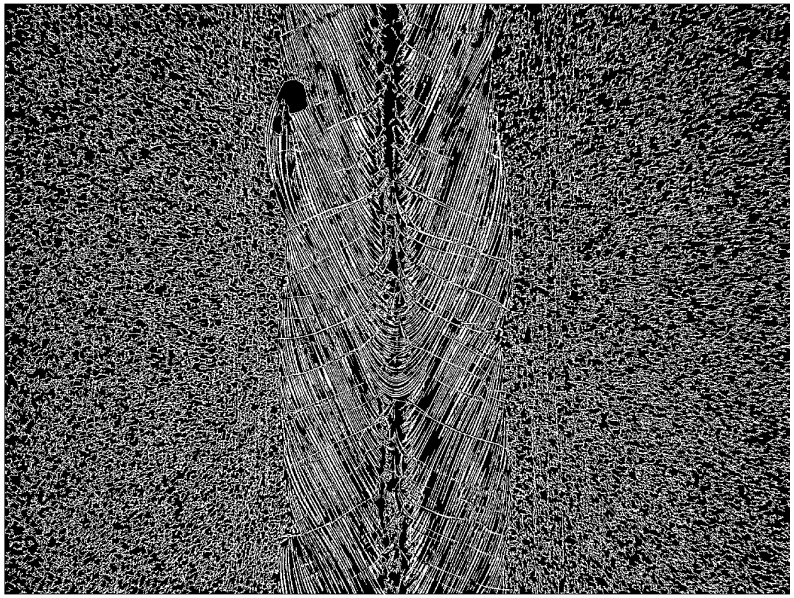
2D - 3D

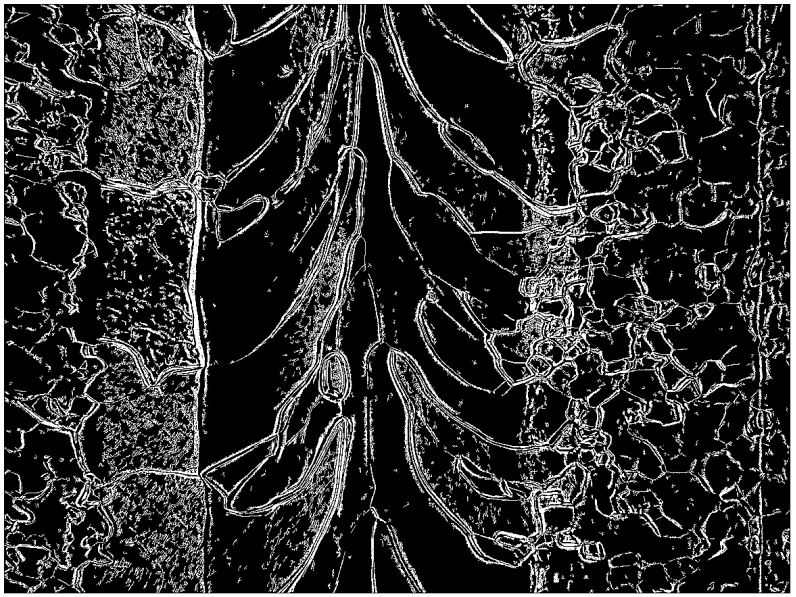


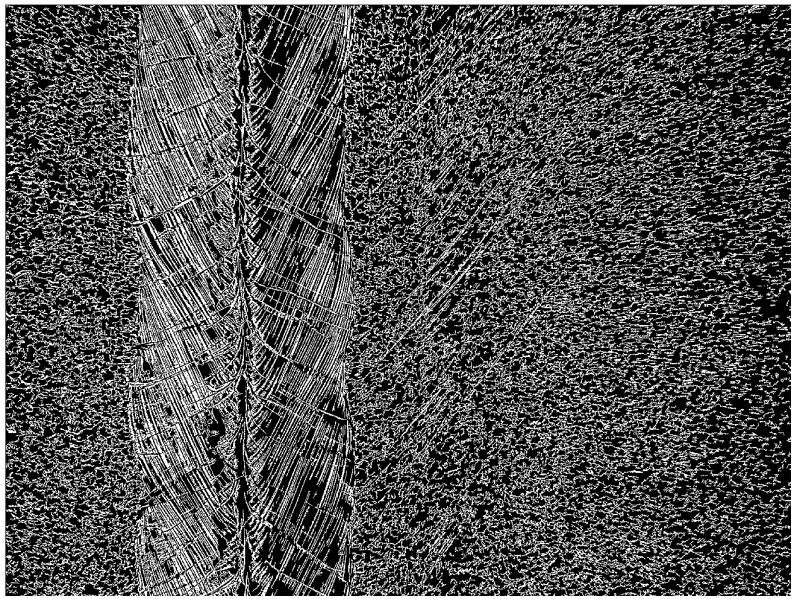
2D - 3D



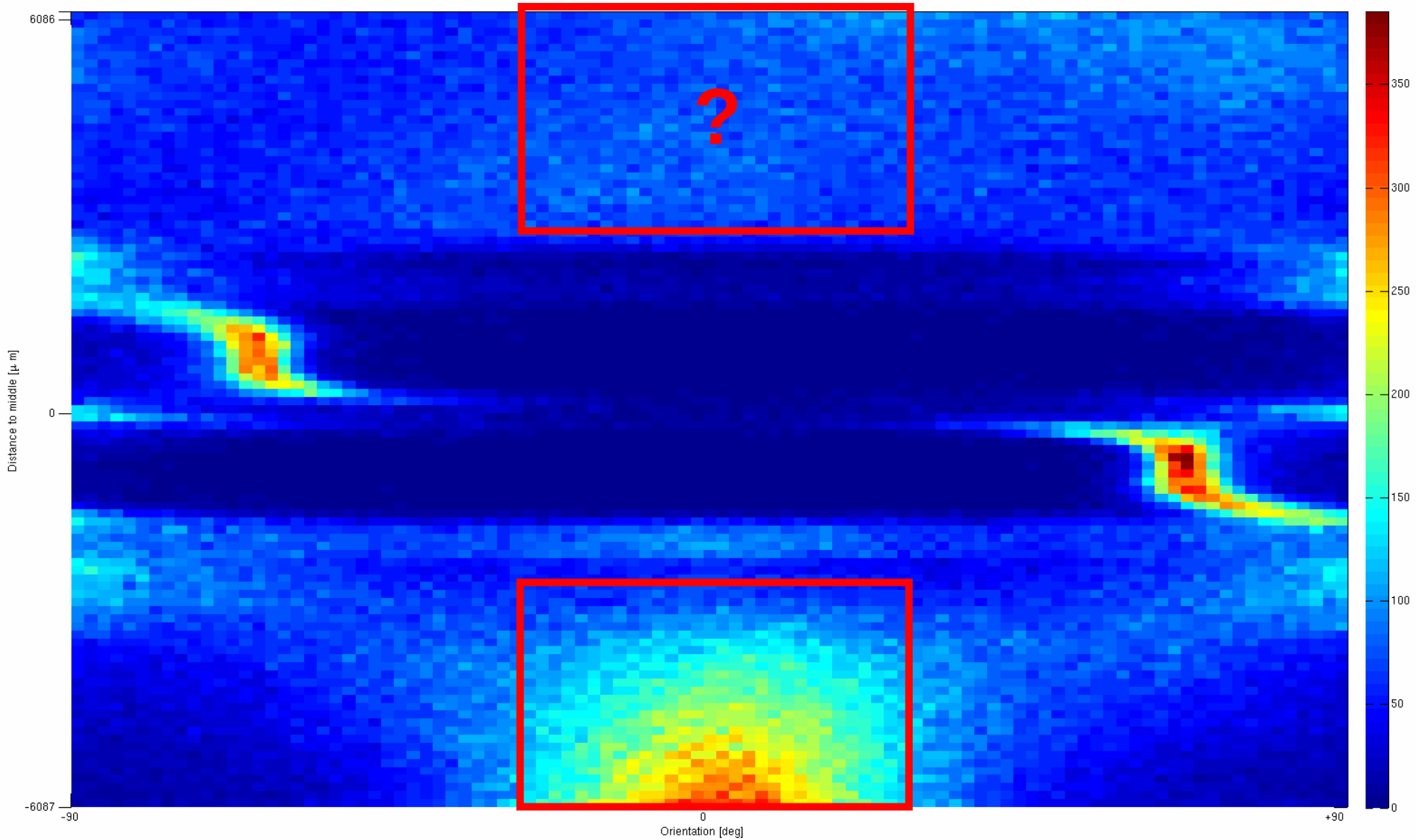
Irregularities - BW



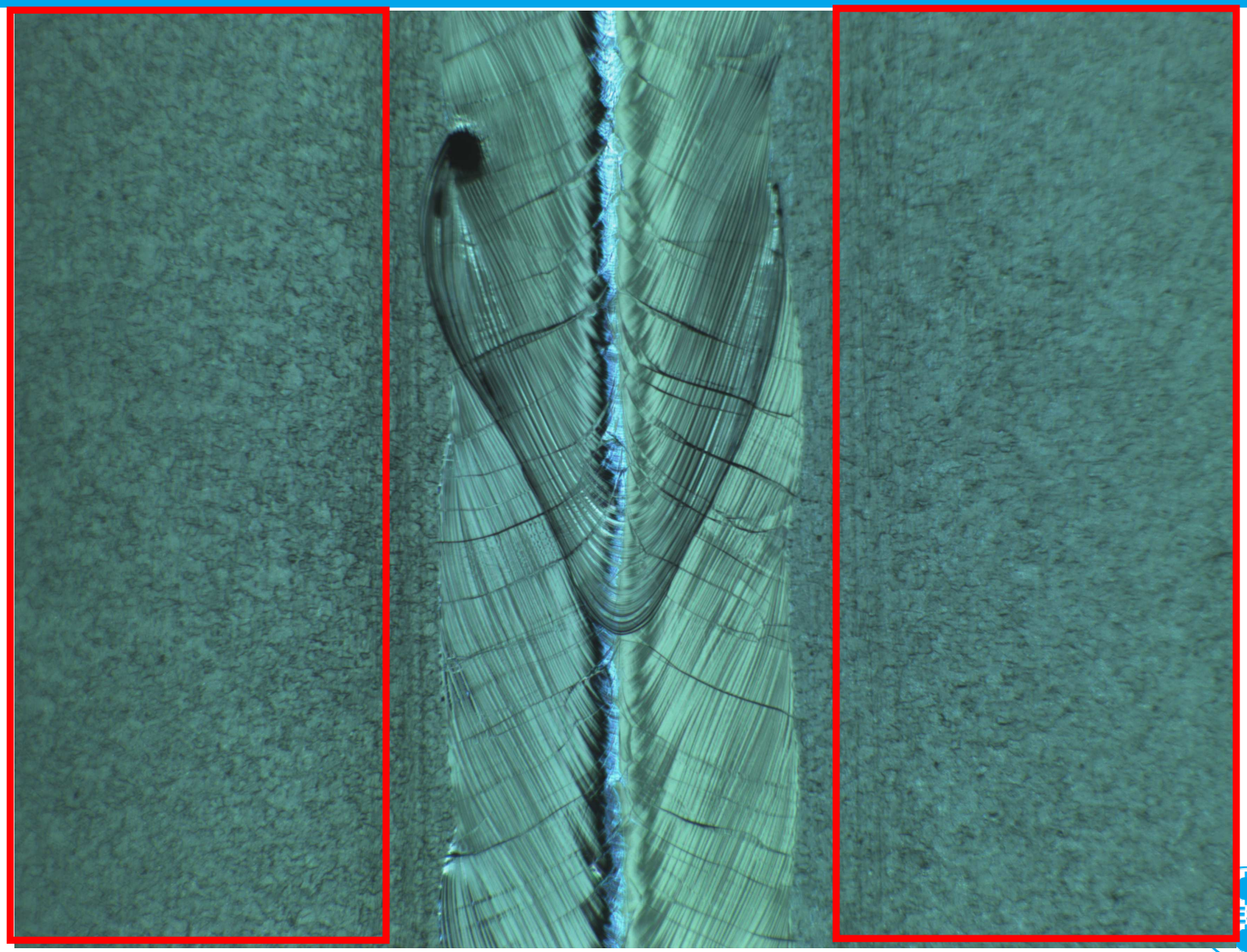


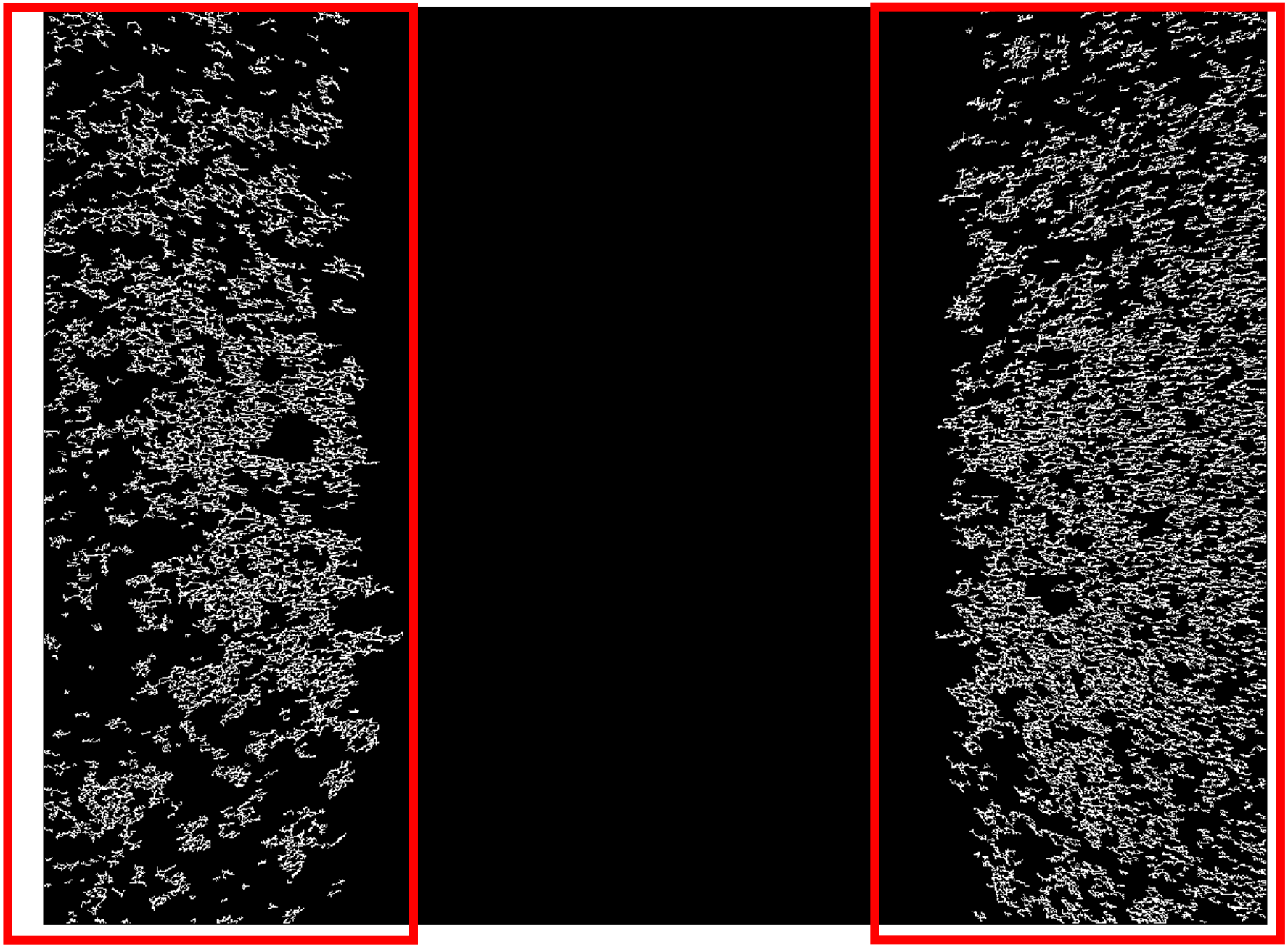


Asymmetry in Scatterplot



Example





885 Objects @ dtm<-3000, [-30°30°]

1534 Objects @ dtm>3000, [-30°30°]

Cavities

> Cavities tested with new illumination set (LED Stripes):

- Z160 - After delivery (scanned)
  - The pi-mode is limited at 24.8 MV/m with Q=4.9E9 and some FE.
  - The hotspot in the pi-mode was found in *cell 1*, the same location heats in in 6pi/9-mode. *Cell 5* is quenching in the modes 7pi/9, 5pi/9, 3pi/9 and 1pi/9. Cell 9 quenches in the 8pi/9-mode and cell 3 in the 2pi/9-mode. The 4pi/9-mode is limited by power.
  - Optical Inspection showed no irregularities at these spots
- Z161 - After delivery / USS / EP (Henkel) (scanned)
- AC126 - After multiple surface treatments (EP @ DESY, Baking, BCP, Baking) (scanned)
  - The cavity is limited at 20.4 MV/m by quench with Q=1.7E10 and no FE.
  - The quench-location for the pi-mode was found in *cell 2*. This location is also the hotspot in modes 8pi/9, 4pi/9, 3pi/9 and 2pi/9.
  - For the modes 6pi/9, 5pi/9 and 1pi/9 the quench was found in *cell 3*.
  - In the 7pi/9-mode, the cavity quenches in cell 9.
  - Time dependent Tmaps have been done for the pi-mode: Heating is observed in a large area, with the hottest spot next to the equator.
  - Optical Inspection found stains from the HPR
- Z162 - After delivery (scanned)
- Z163 - After delivery
- Z164 - After delivery

Optical Inspection

- Picture covers 5 deg.
  - 90 images per equator (edges overlap)
  - 810 images per cavity (without iris)
- 2616x3488 pixel , effective resolution of 3.5 µm/pixel
- Now bitmap, soon png
- ~ 26 MB per image