# Segmentation and characterization of fibers

**Dahl, Vedrana Andersen**

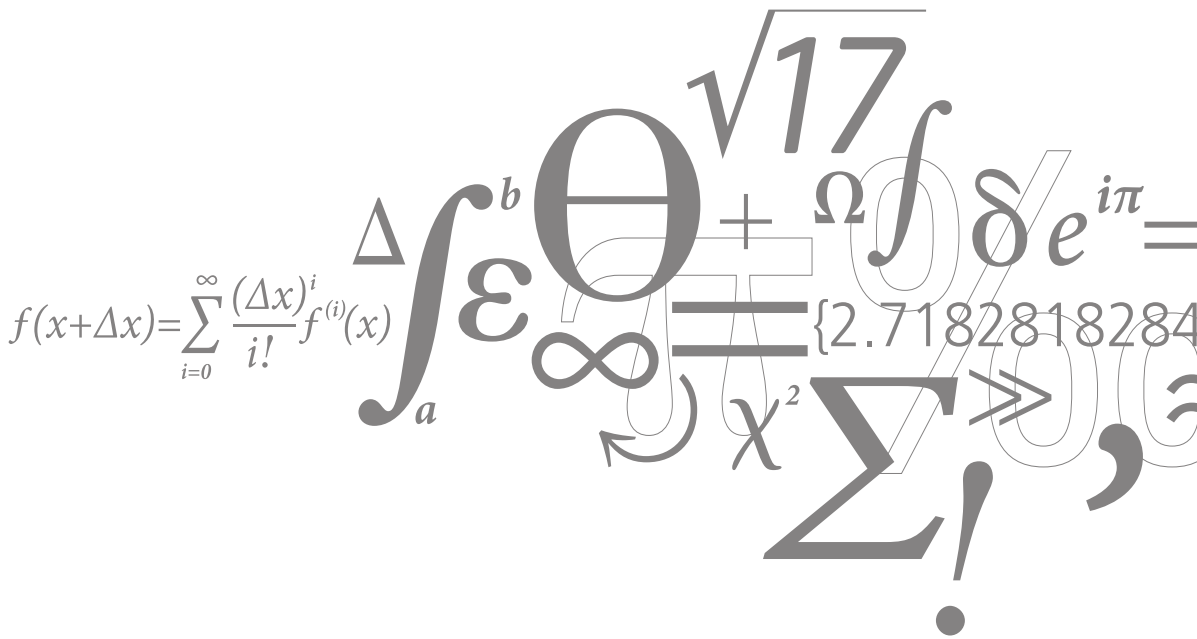
*Publication date:*
2015

*Document Version*
Peer reviewed version

# Segmentation and characterization of fibers

Vedrana Andersen Dahl, DTU Compute

September 2015




DTU Compute
Department of Applied Mathematics and Computer Science

# Introduction

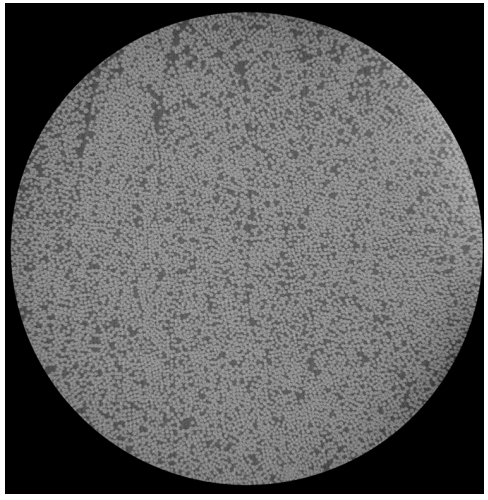
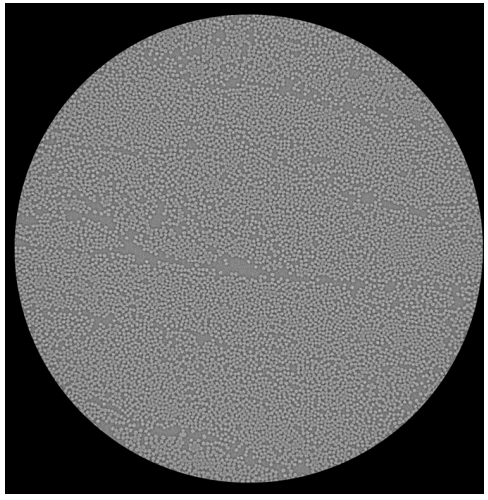
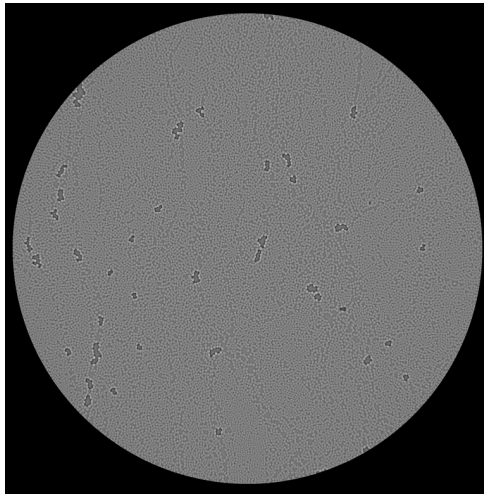
## Background

- My background
- DTU imaging industry portal, industrial application, scientific advice, and research within 3D imaging
- CINEMA, the allianCe for ImagiNg of Energy MAterials, a five year DSF project with participants from both academia and the industry
- CINEMA at DTU Compute:
  - Tomographic reconstruction using movable meshes
  - Volume segmentation using movable meshes
  - Texture based volume segmentation

## Presenting (mostly) the work of

- Monica Jane Emerson, PhD student, DTU Compute
- Anders Bjorholm Dahl, associate professor, DTU Compute

# Segmentation (and quantification) of fibers

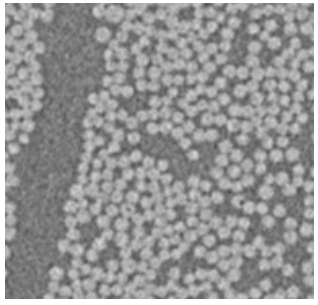
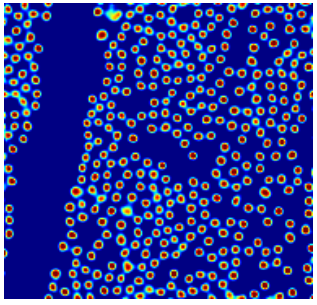
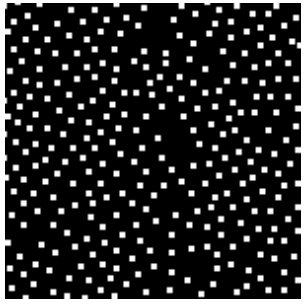
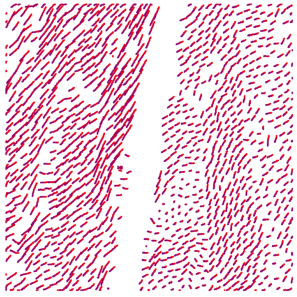
## Focus areas

- Micro-CT of glass fiber, thick carbon fiber and thin carbon fiber
- Segmentation and quantification (orientation and alignment)

## Motivation

- Quality control – mechanical tests for each production protocol. Time aspect.
- Quality control – quantification of fibers based on imaging, simulation using FEM.
- Our part: from images to fibers.

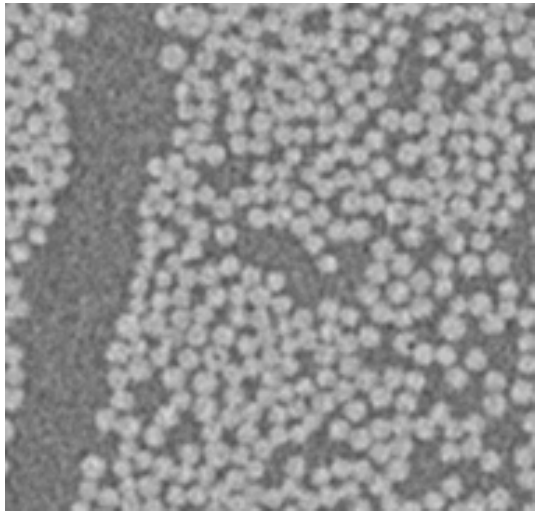
# Segmentation (and quantification) of fibers

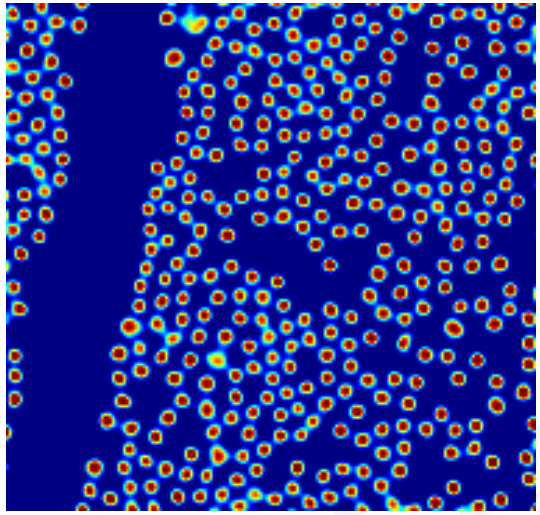






## Pipeline

- Probabilistic fiber center detection. Dictionary based.
- Discretization. Treasholding or blob detection.
- Tracking. Nearest neighbour heuristics.
- Radius estimation. Back to blob detection response.

# Probabilistic fiber center detection





## Dictionary based approach

- Fiber detection vs. fiber center detection.
- Closely related to dictionary based segmentation of textured images.

# Dictionary based segmentation of textured images

## Recent segmentation methods

- Anders L Dahl and Rasmus Larsen, *Learning dictionaries of discriminative image patches*, BMVC, 2011.

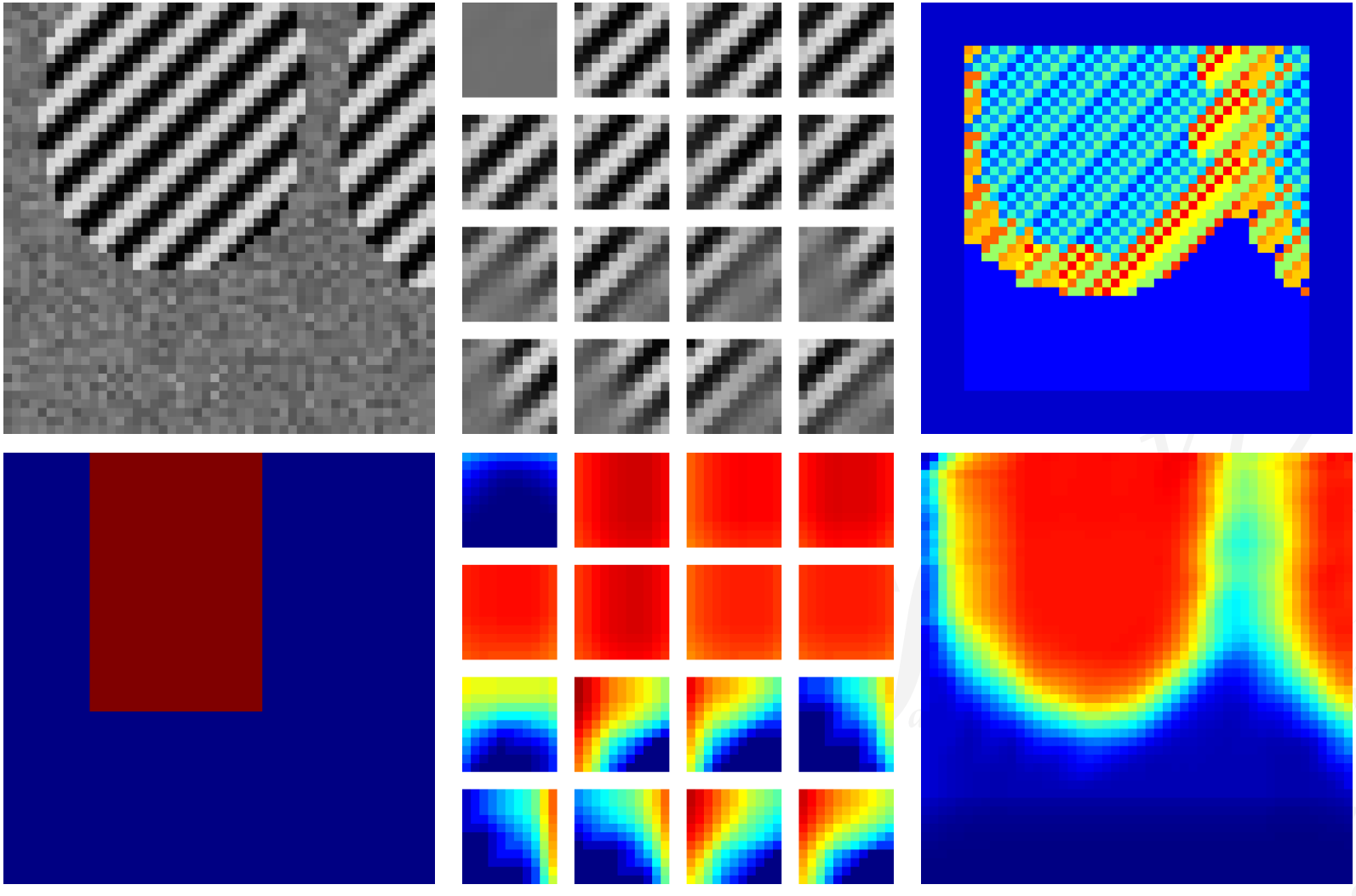
  Training-testing approach. Computation based on averaging.
- Anders B Dahl and Vedrana A Dahl, *Dictionary snakes*, ICPR, 2014.

  Deformable model, snakes. Requires initialization. Computation based on averaging.
- Anders B Dahl and Vedrana A Dahl, *Dictionary based image segmentation*, SCIA, 2015.

  Deformable model, level sets. Requires initialization. Graph based representation.
- Monica J Emerson, Kristine M Jespersen, Peter S Jørgensen, Rasmus Larsen, and Anders B Dahl, *Dictionary based segmentation in volumes*, SCIA, 2015.

  3D version. Training-testing approach.

# Dictionary based texture representation



# Dictionary based texture representation

## Graph (matrix) based representation

- Biadjacency matrix **B** representing binary relation between image pixels and dictionary elements, given by a dictionary assignment image

$$b_{ij} = \begin{cases} 1 & \text{if } i \sim j \\ 0 & \text{otherwise} \end{cases}$$

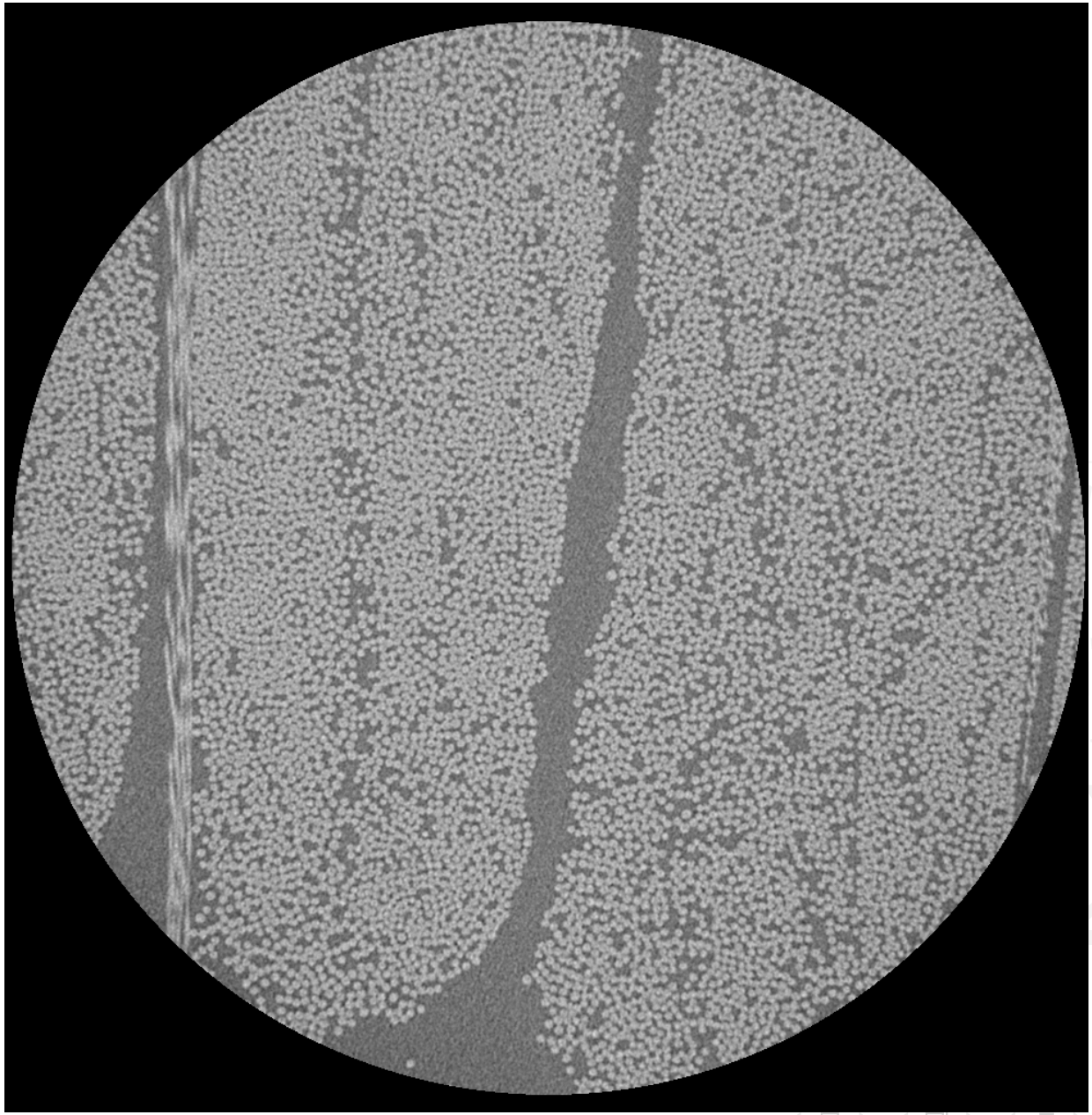
- Self similarity matrix

$$\mathbf{S} = (\mathbf{D_B})^{-1}\mathbf{B}^{\mathsf{T}}\,(\mathbf{D_{B^T}})^{-1}\mathbf{B}$$

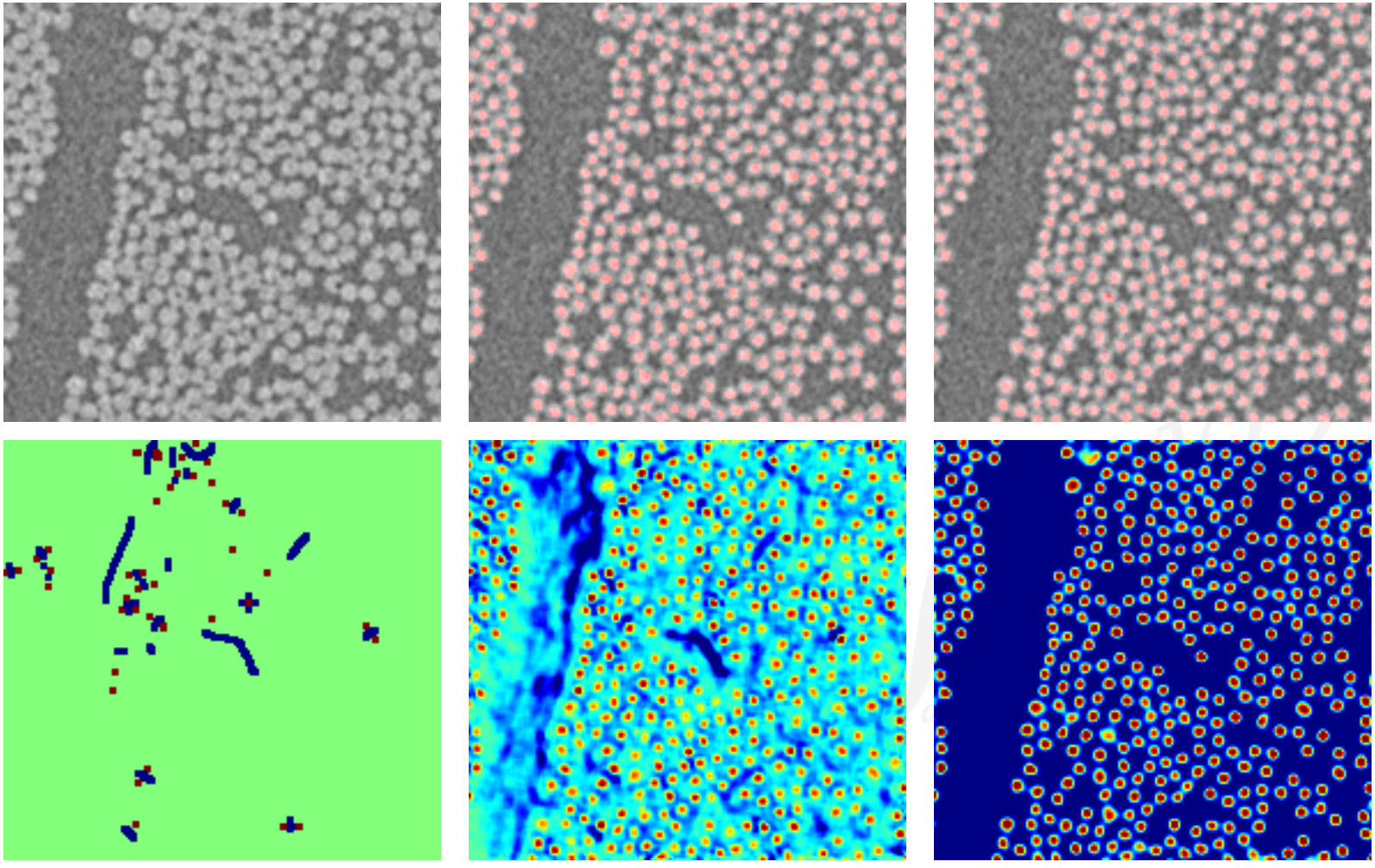
- **B** is a $n \times m$ matrix, where $n$ is the size of the image, and $m$ is the size of the dictionary.

## Demo

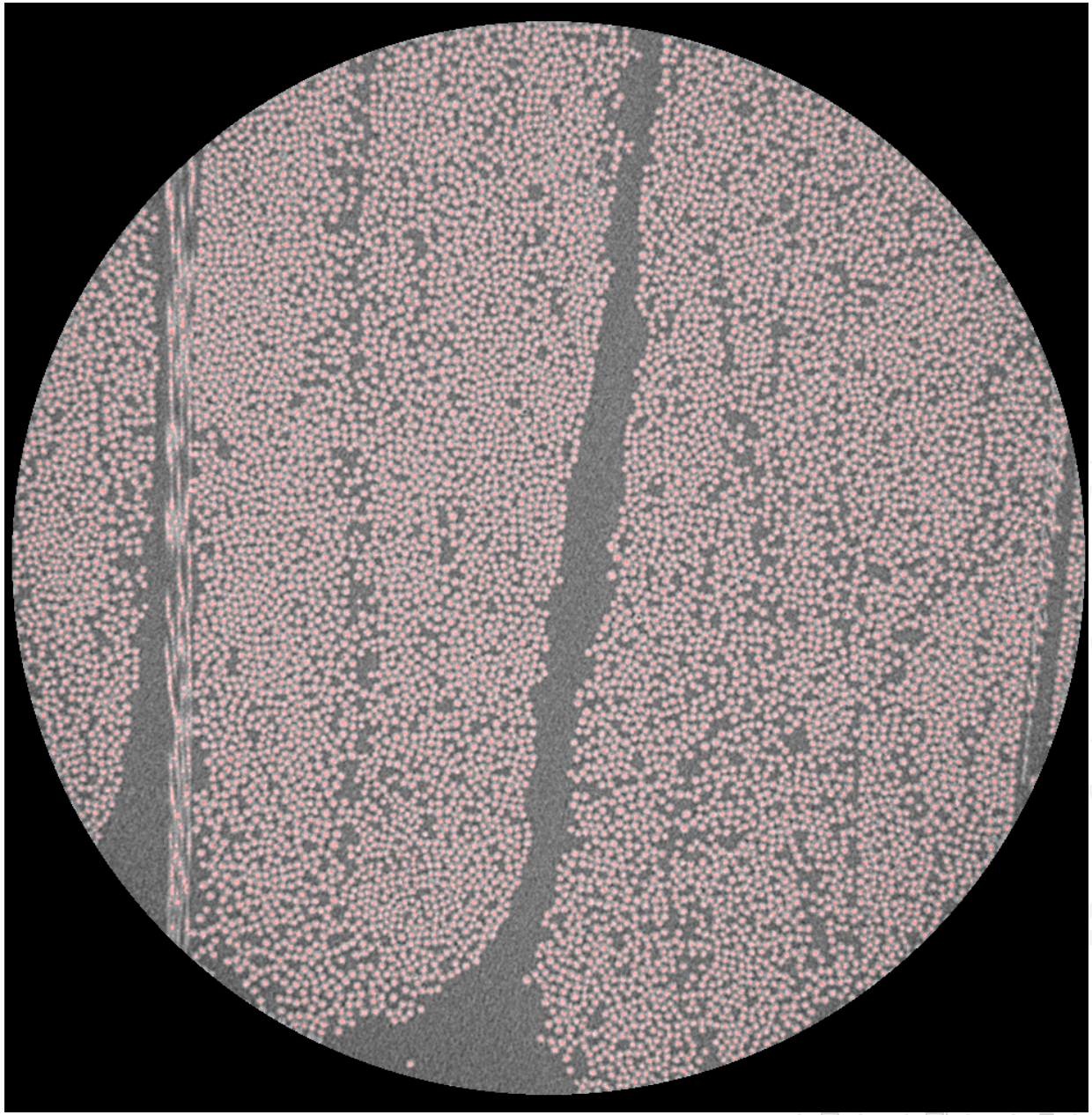
# Anders' example, glass fiber



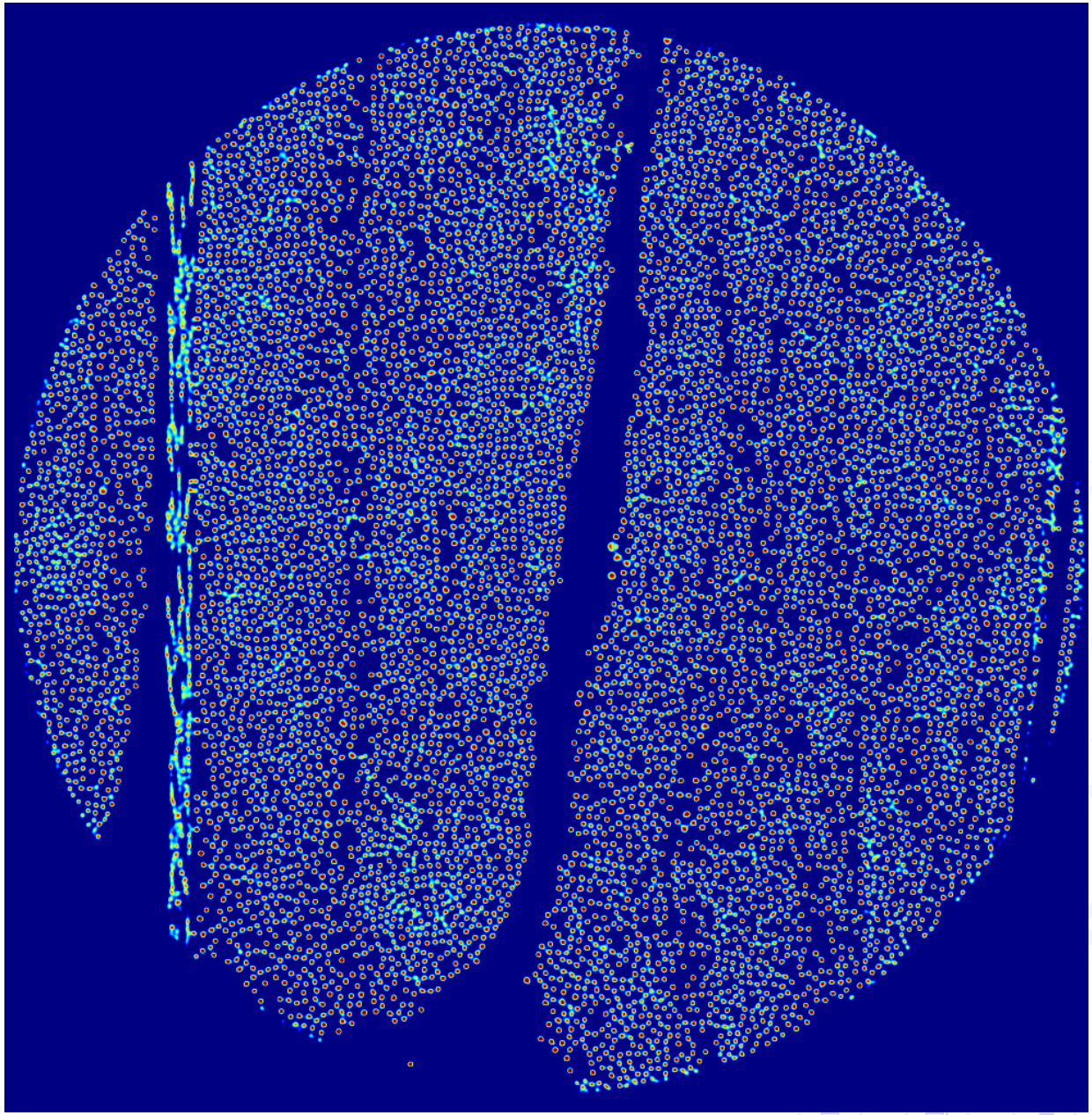
# Anders' example, glass fiber



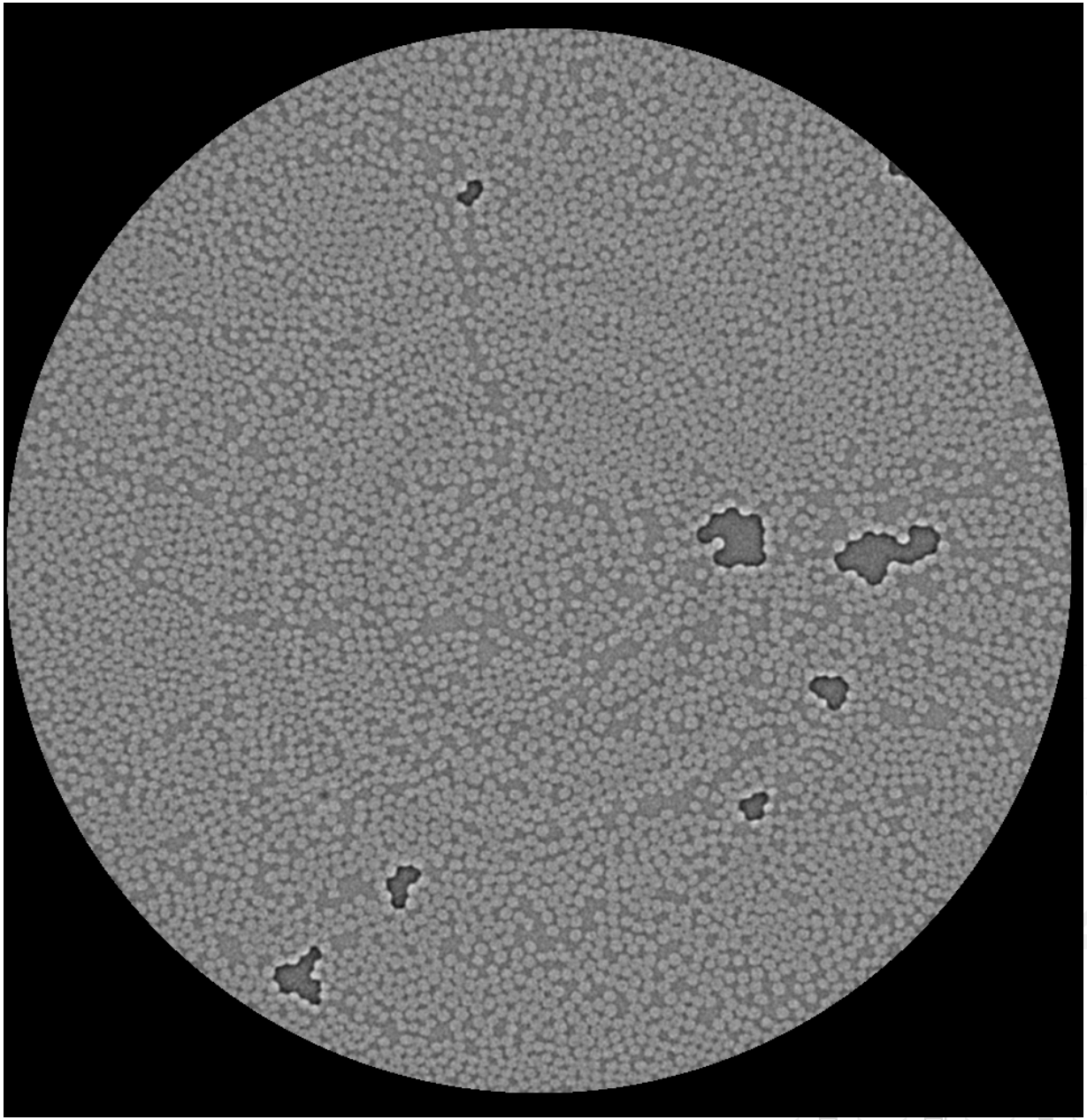
# Anders' example, glass fiber



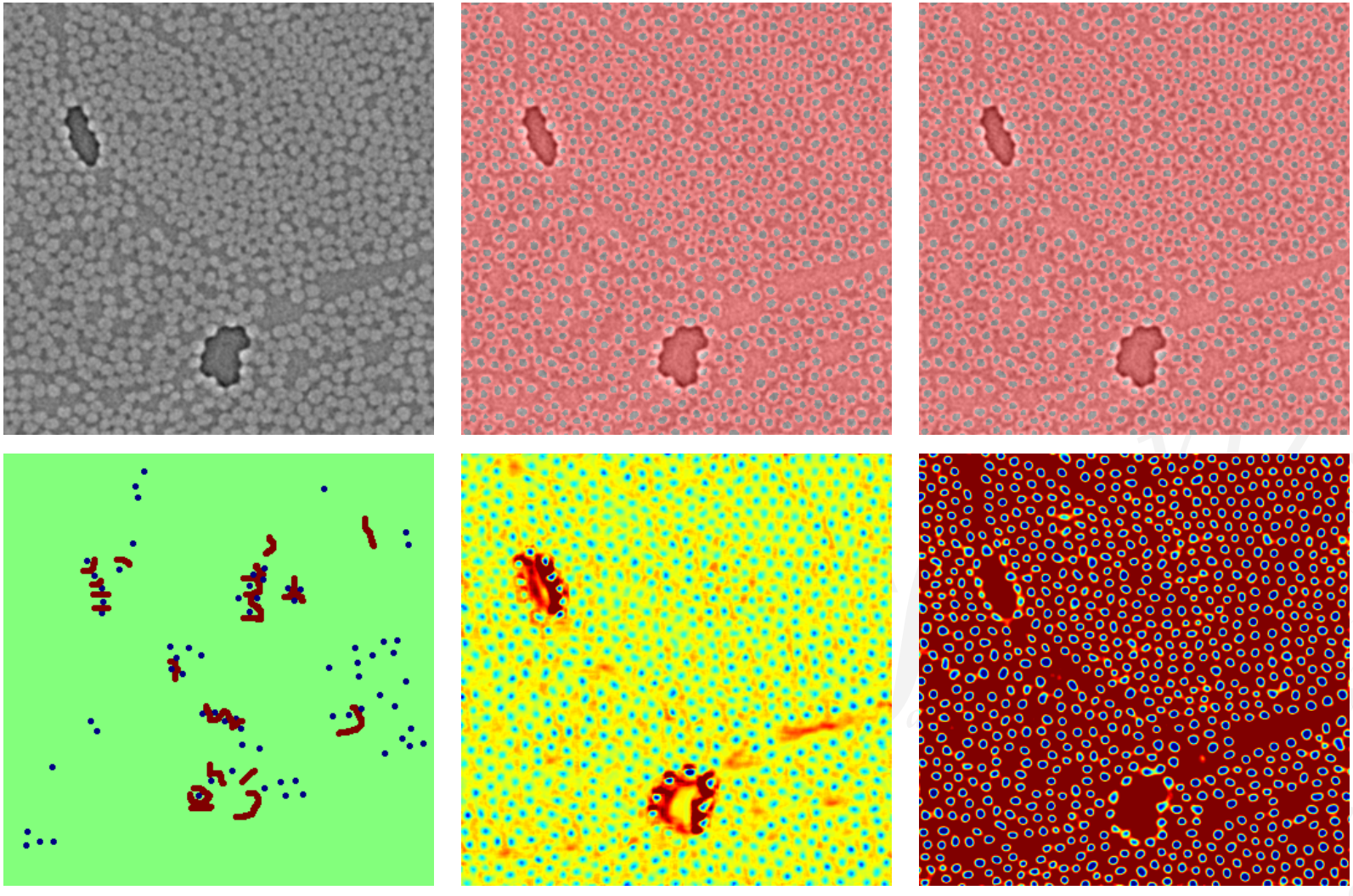
# Anders' example, glass fiber



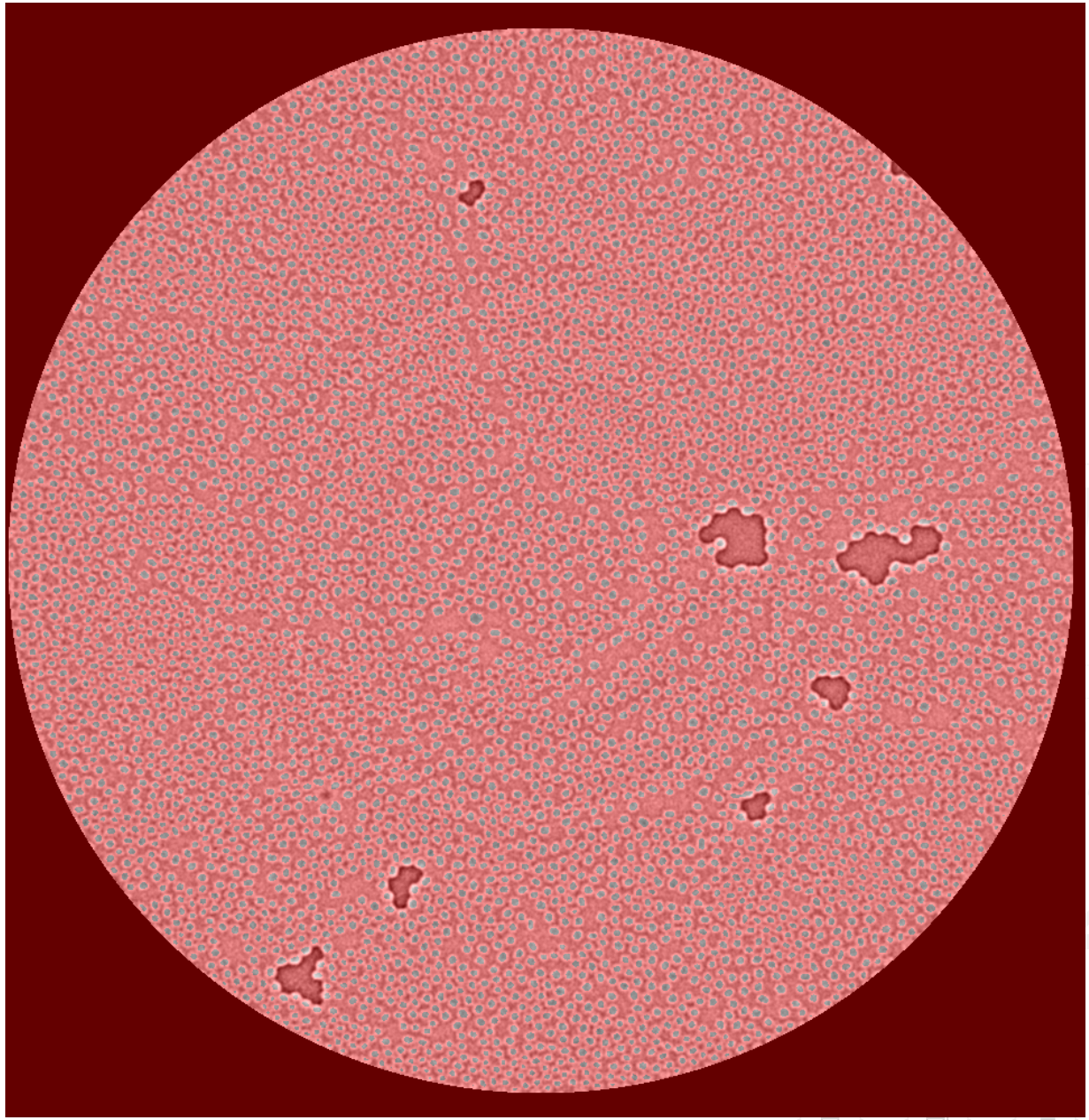
# Anders' example, carbon fiber



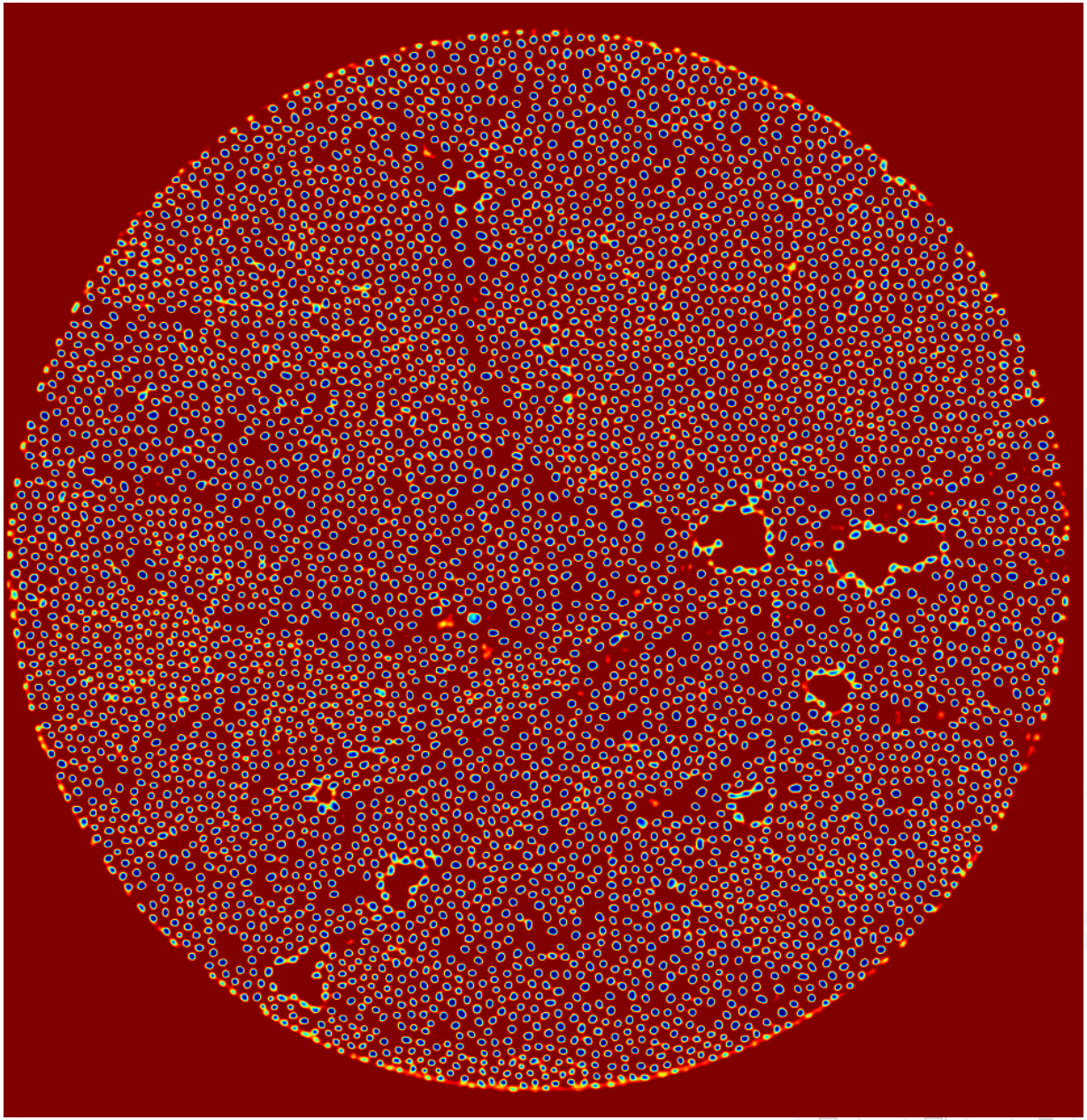
# Anders' example, carbon fiber



# Anders' example, carbon fiber



# Anders' example, carbon fiber

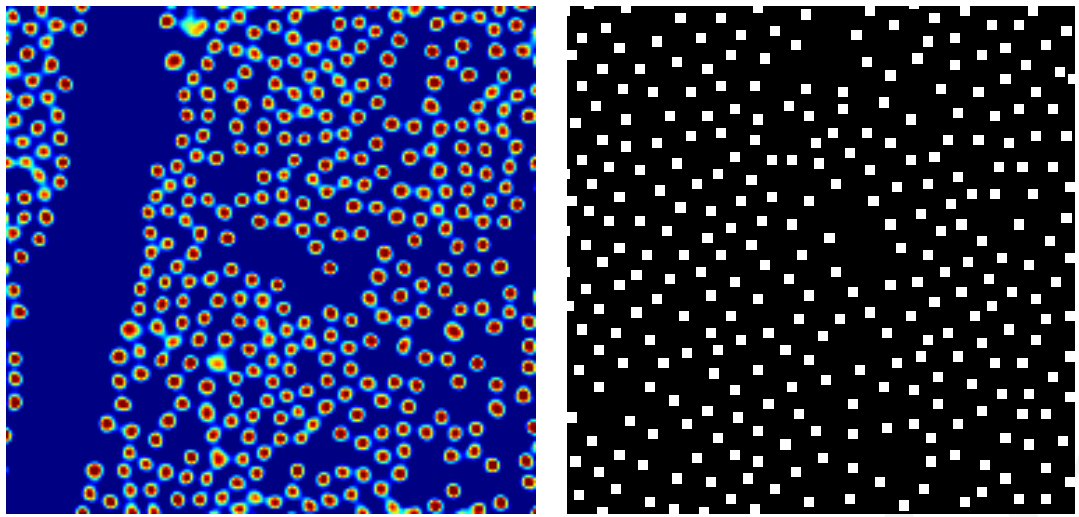


# Research topics

## Current research topics

- Generalization to 3D
- User input, small and easy
- Dictionary, when and how
- Handling big data

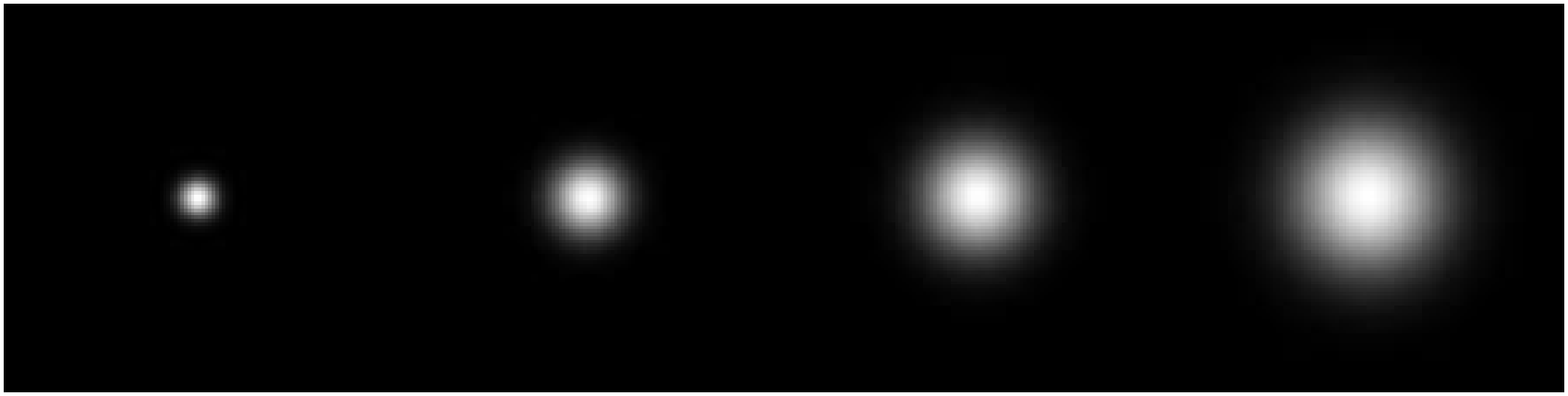
# Discretization

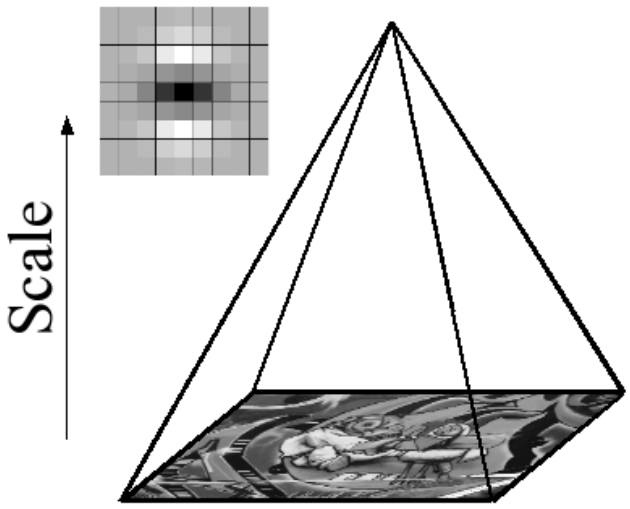


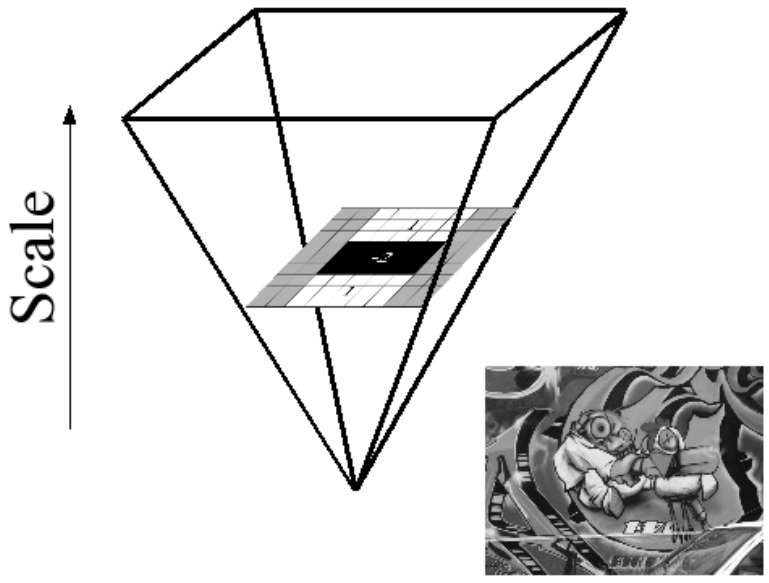
## Tested options

- Treasholding
- Scake space blob detection

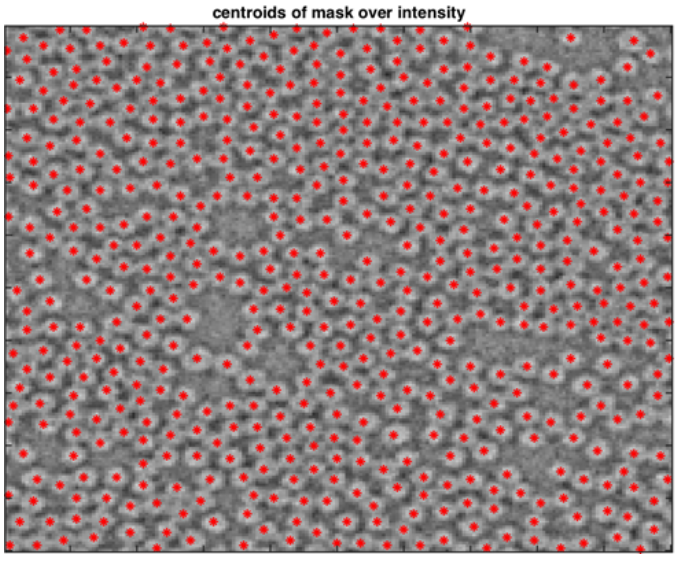
# Discretization, scale space blob detection

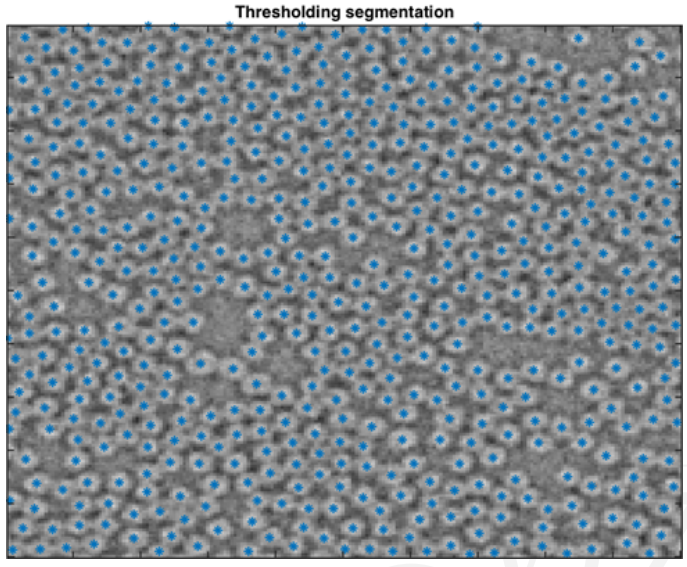


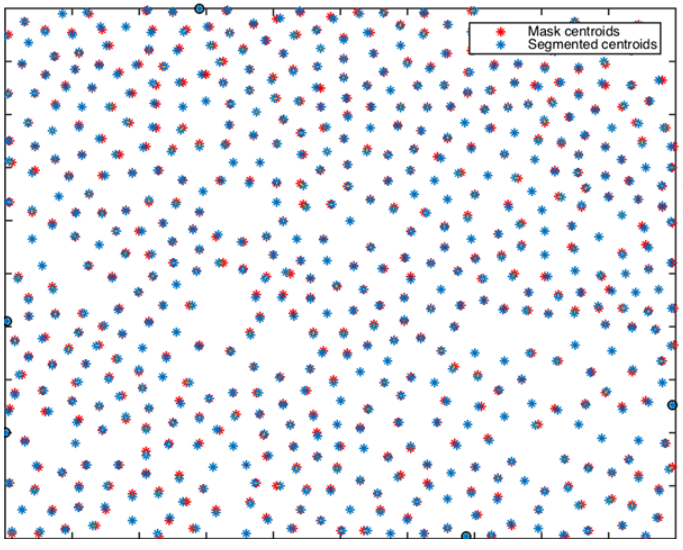


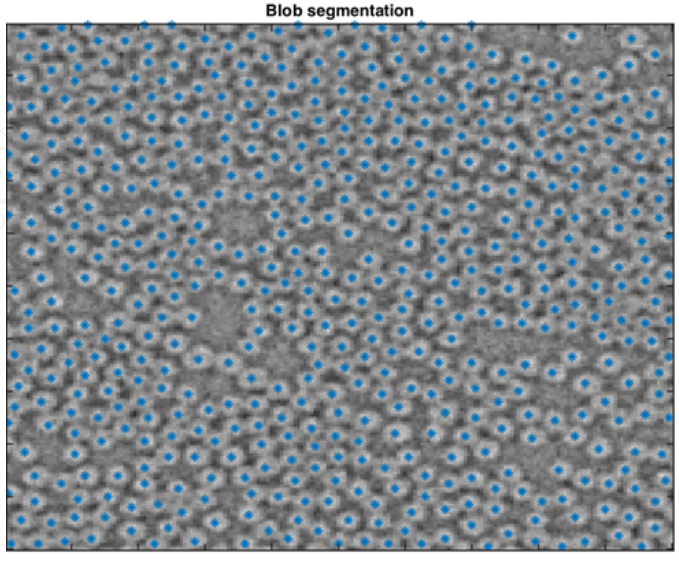



# Discretization, Monicas results



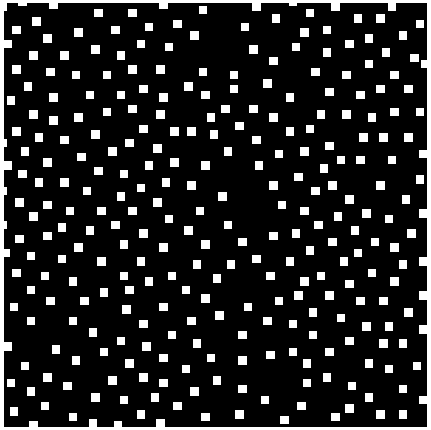
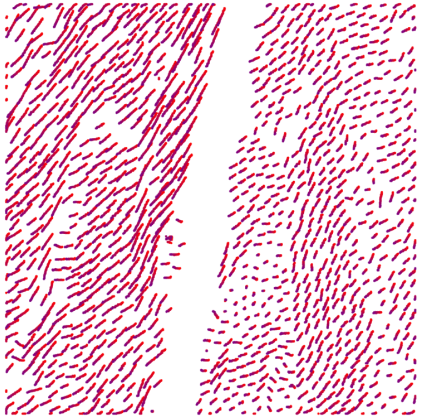



# Discretization, Monicas results

True positive ratio depending on discretization, in percentages

| | tresholding | blob detection |
|---|---|---|
| glass fiber | 99.1 | 93.4 |
| thick carbon fibre | 100 | 98.9 |
| thin carbon fibre | 95.5 | 100 |

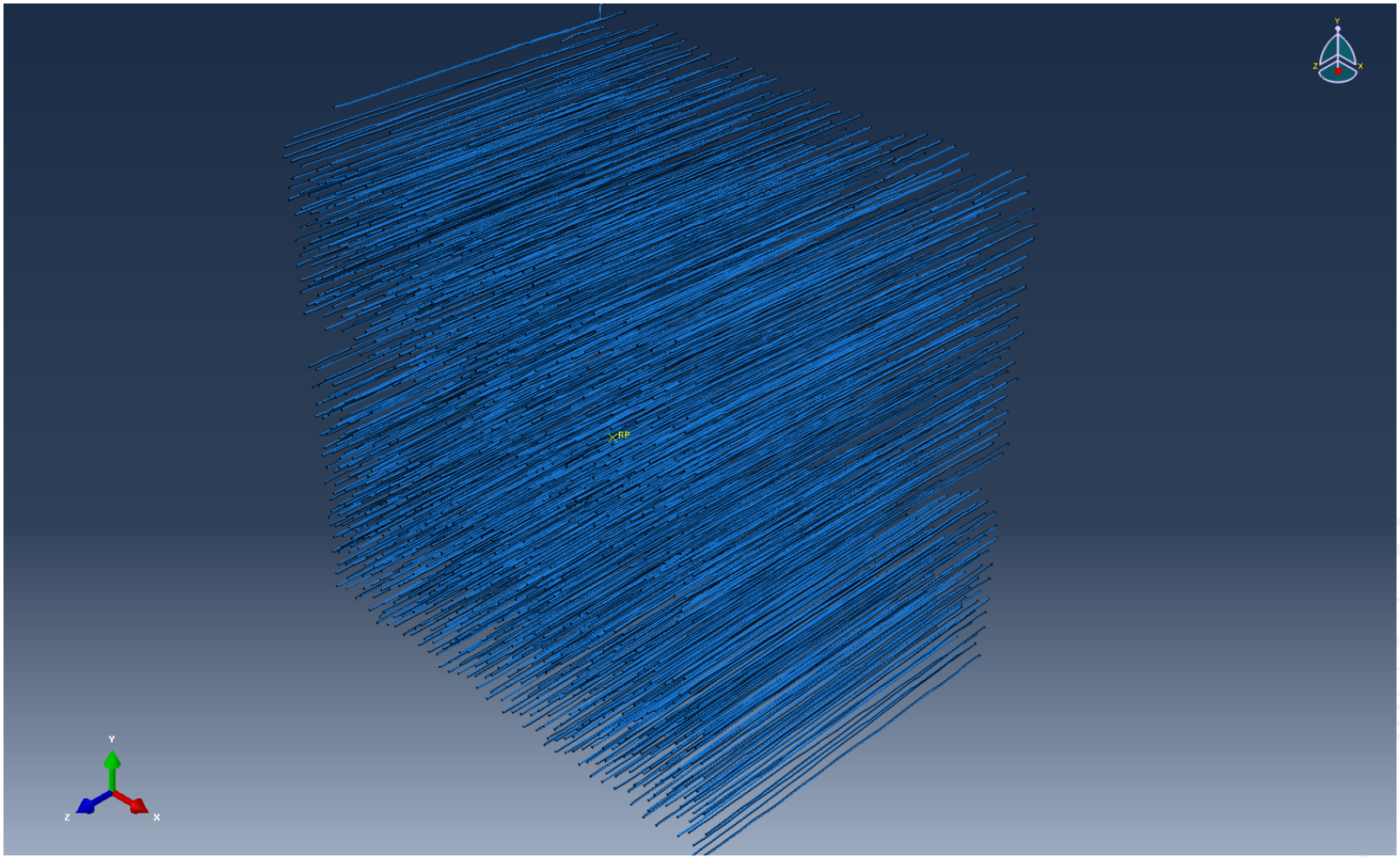
# Tracking


## Tested options

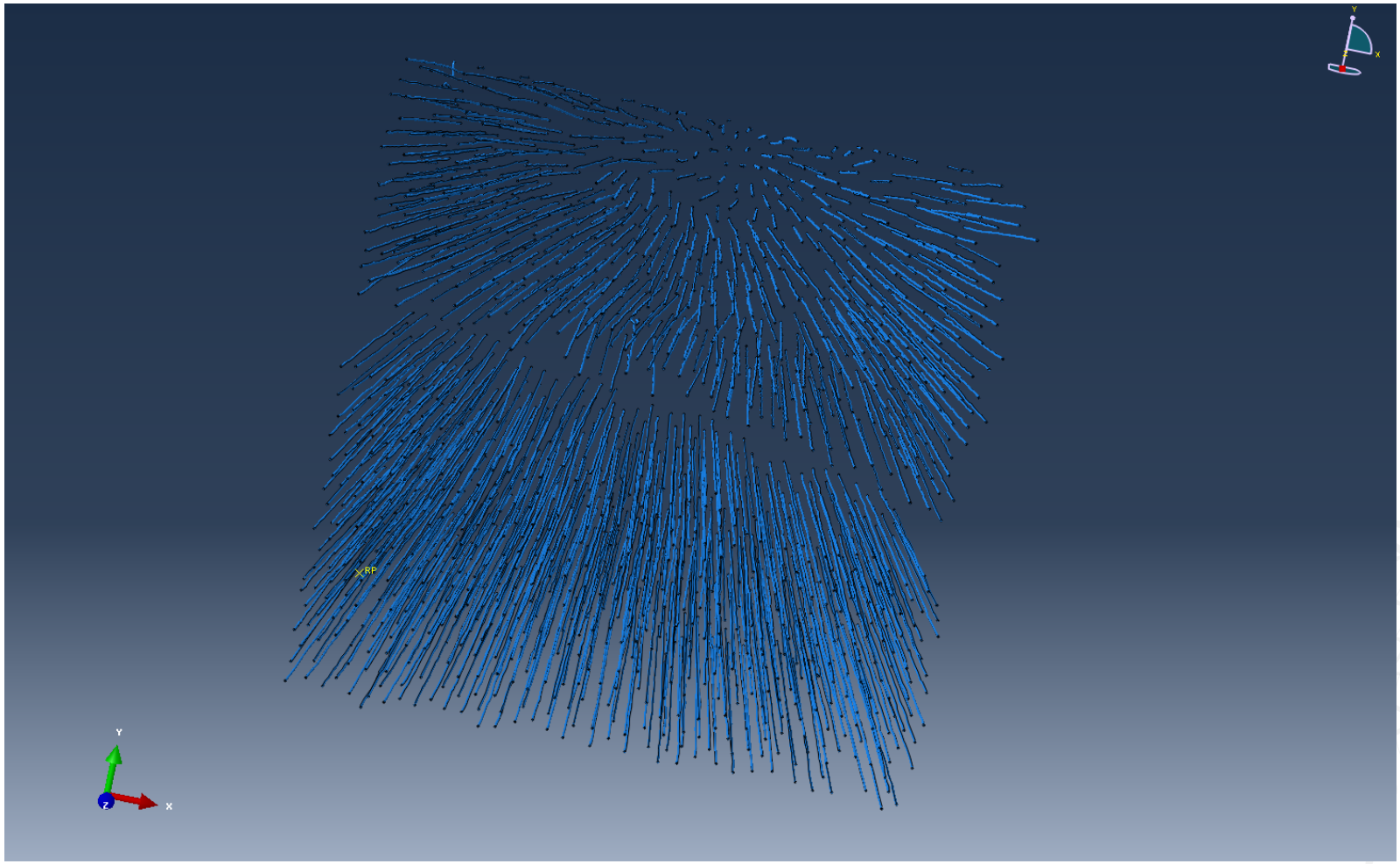
- Nearest neighbor heuristics

# Fibers in abaqus



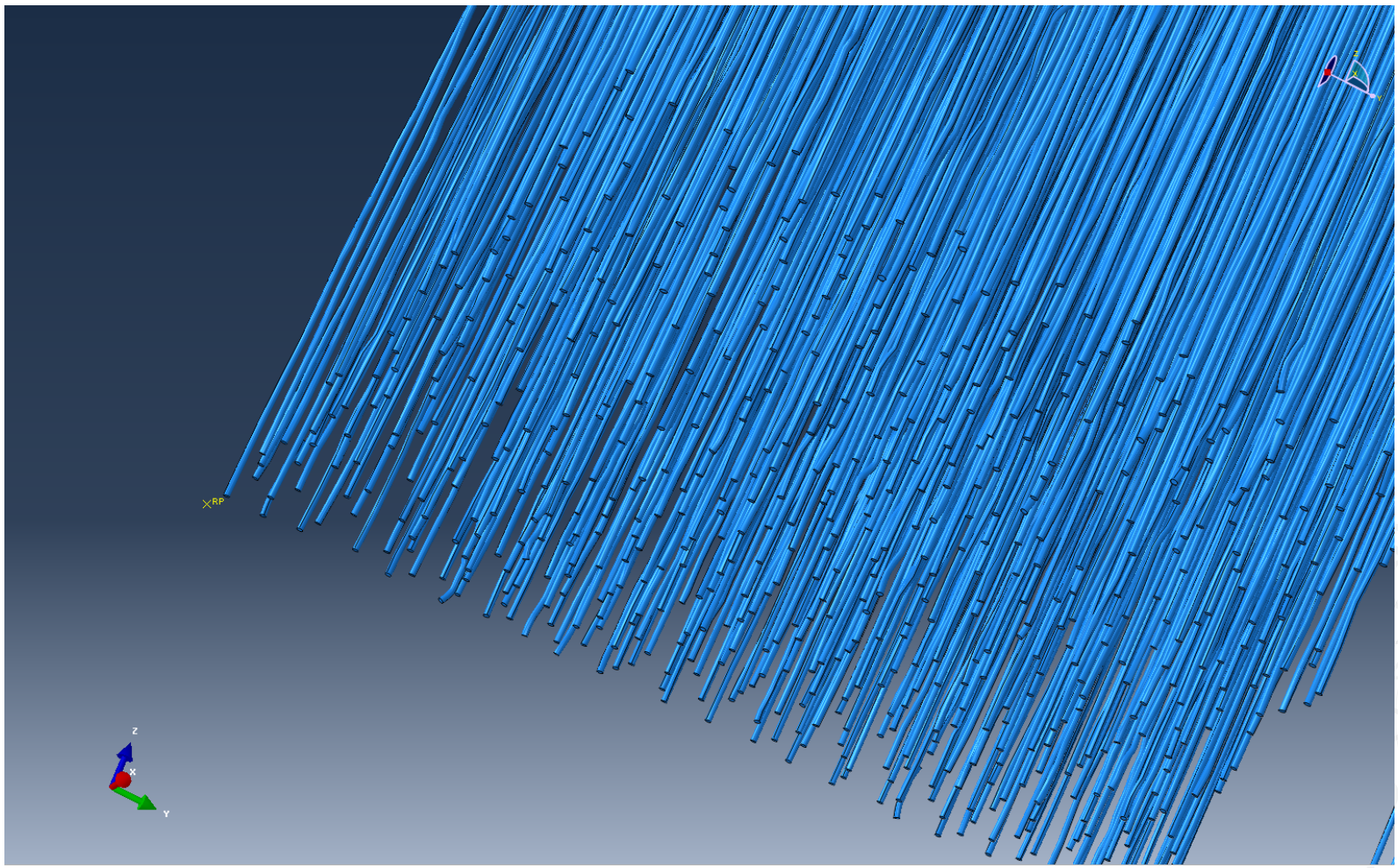

Visualization of fiber centers by Kristine Munk Jespersen, DTU Wind Energy.

# Fibers in abaqus




Visualization of fiber centers by Kristine Munk Jespersen, DTU Wind Energy.

# Fibers in abaqus

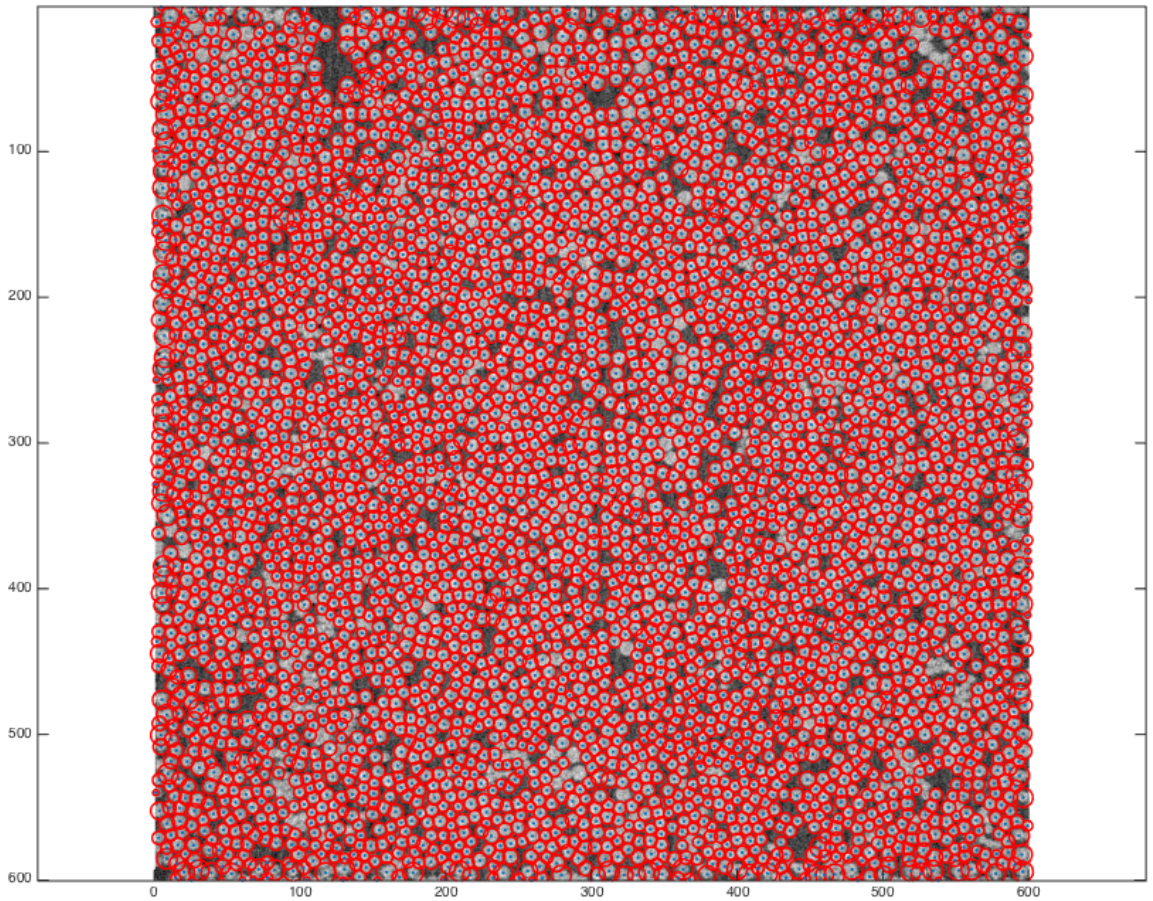



Visualization of fiber centers by Kristine Munk Jespersen, DTU Wind Energy.

# Radius estimation

## Tested options

- Blob detection response




Monicas results, visualization of fiber radii.

Thank you!

Questions?