

# Traitement d'images MEB-FIB et segmentation IA

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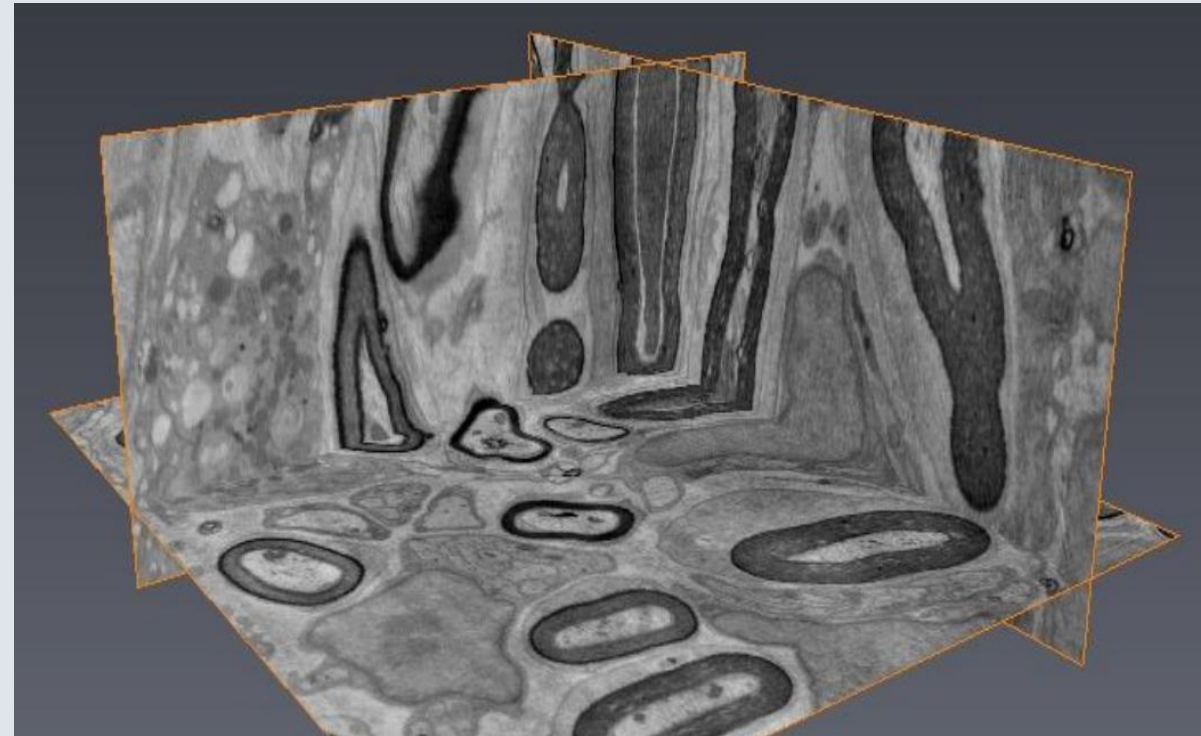
**McGill**



# Introduction

- Haute résolution (nm) dans tous les axes spatiaux
- Quantité importante de données
- Taches d'analyses nécessitent des logiciels de traitement d'images

Katya Rechav, 2020



# Plan

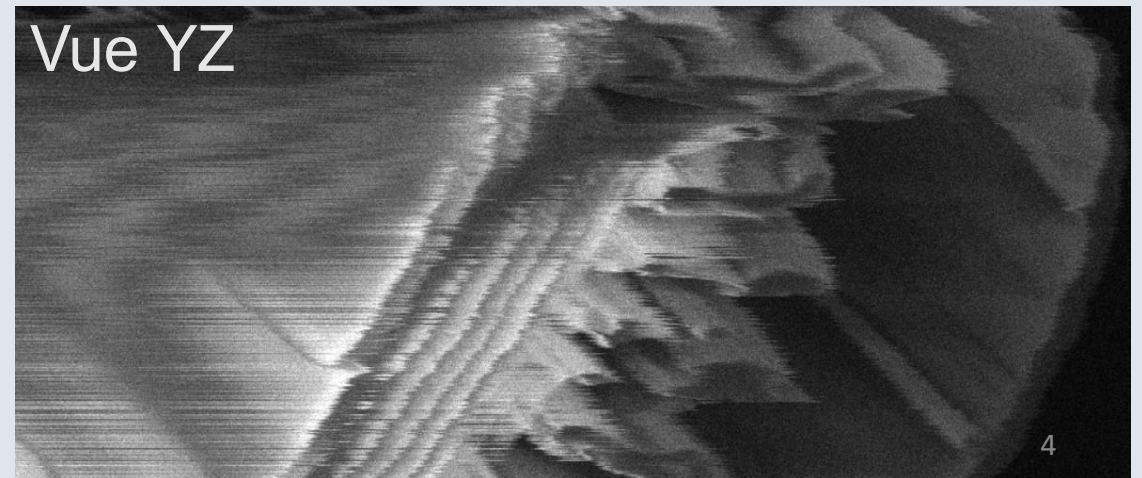
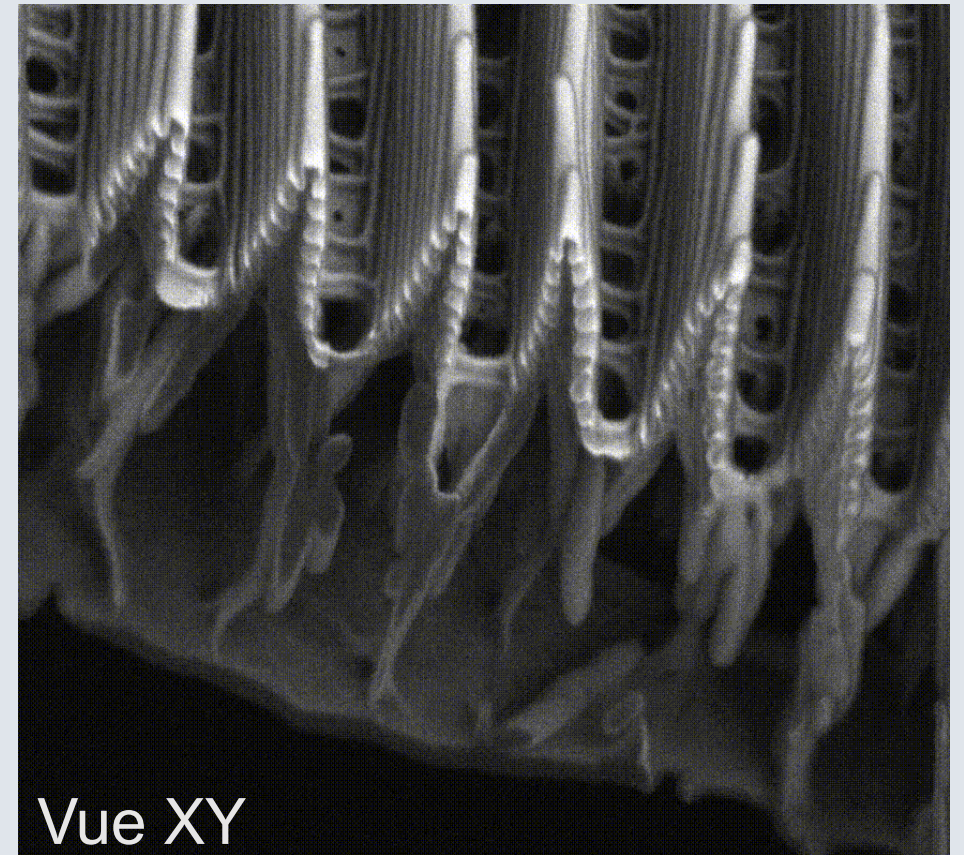
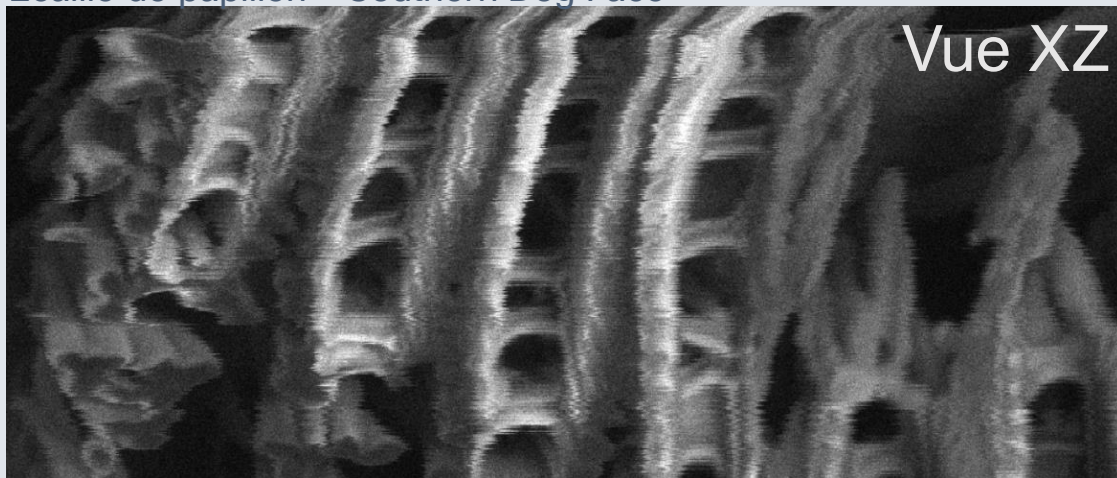
- Reconstruction 3D
  - Recalage de tranches
  - Visualisation
- Filtrage
  - Compensation d'intensités
  - Correction chargement
  - Débruitage
- Segmentation IA

# Reconstruction 3D

## Recalage de tranches

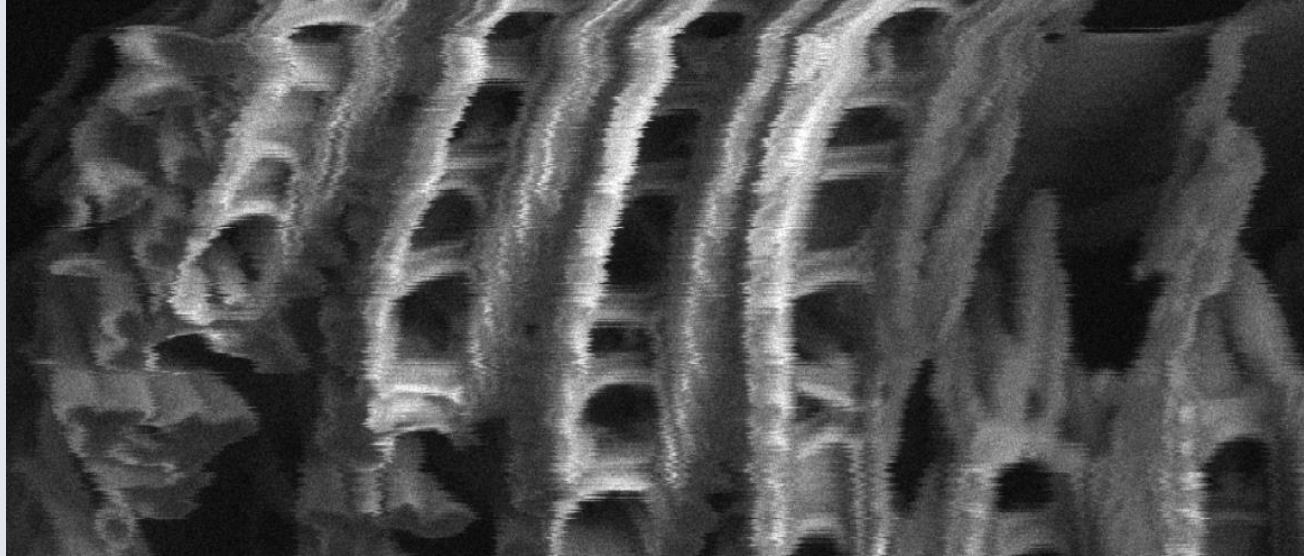
- SSD (sum squared differences)
- SIFT (scale-invariant feature transform)
- Information mutuelle

Écaille de papillon – Southern Dog Face



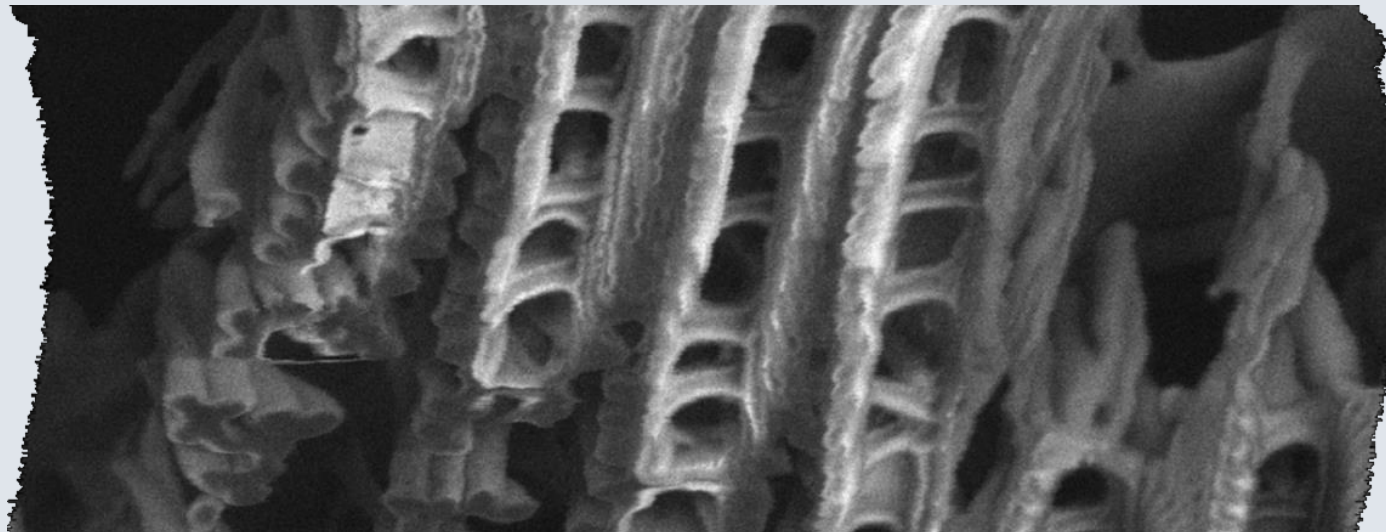
# Reconstruction 3D

## Recalage de tranches



ORIGINALE

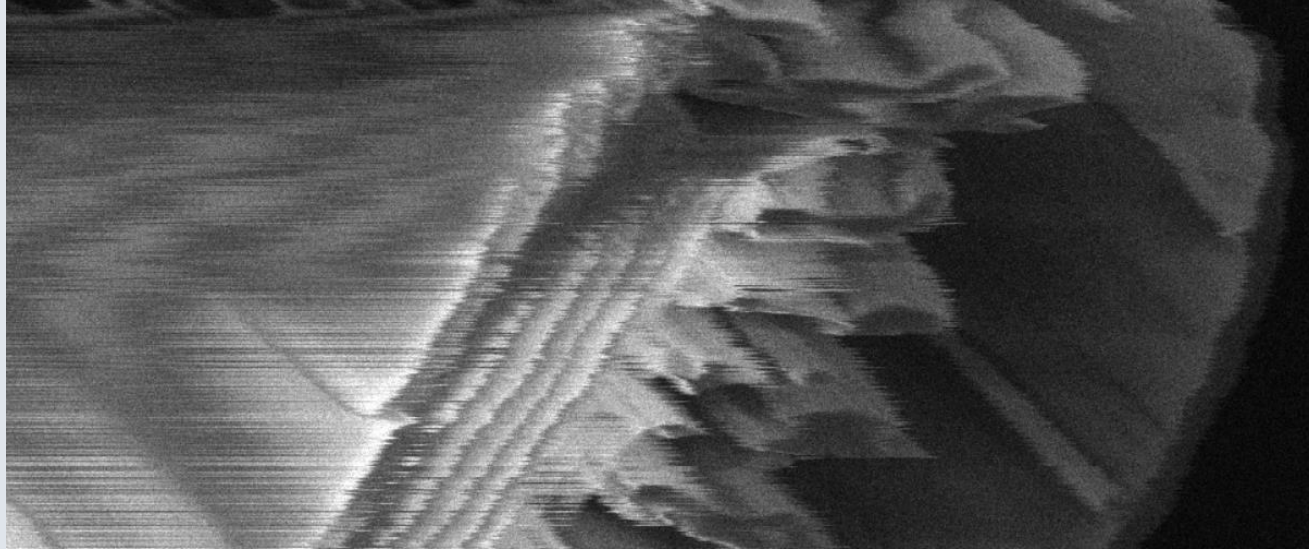
Vue XZ



RECALLÉE  
Information mutuelle

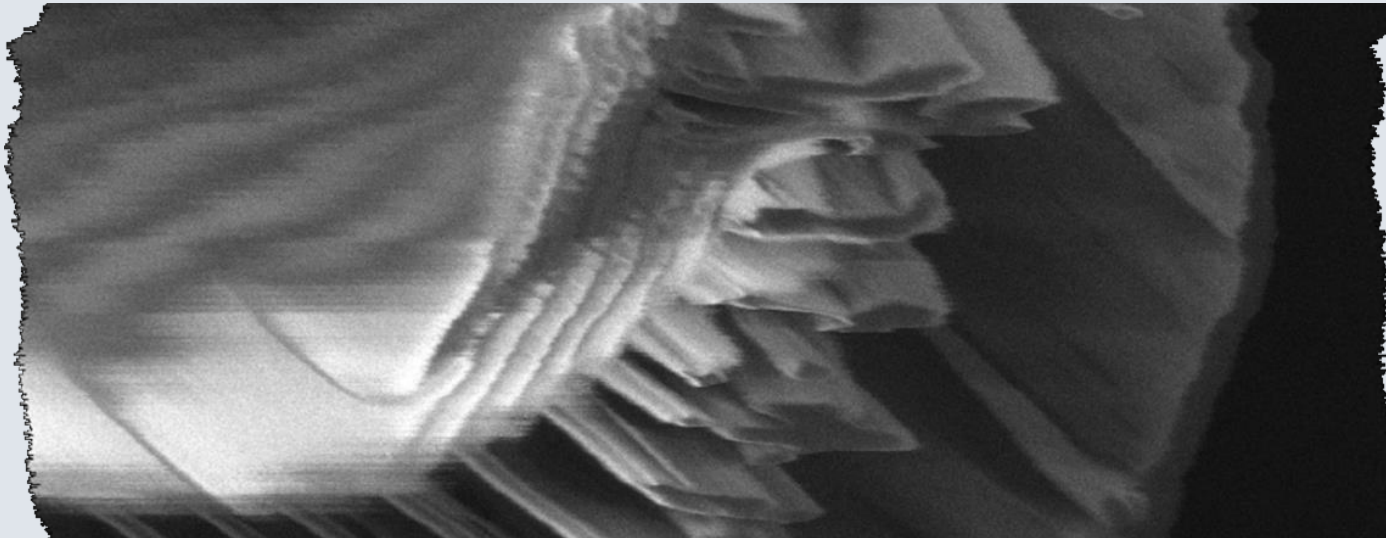
# Reconstruction 3D

## Recalage de tranches



ORIGINALE

Vue YZ



RECALLÉE  
Information mutuelle

# Reconstruction 3D

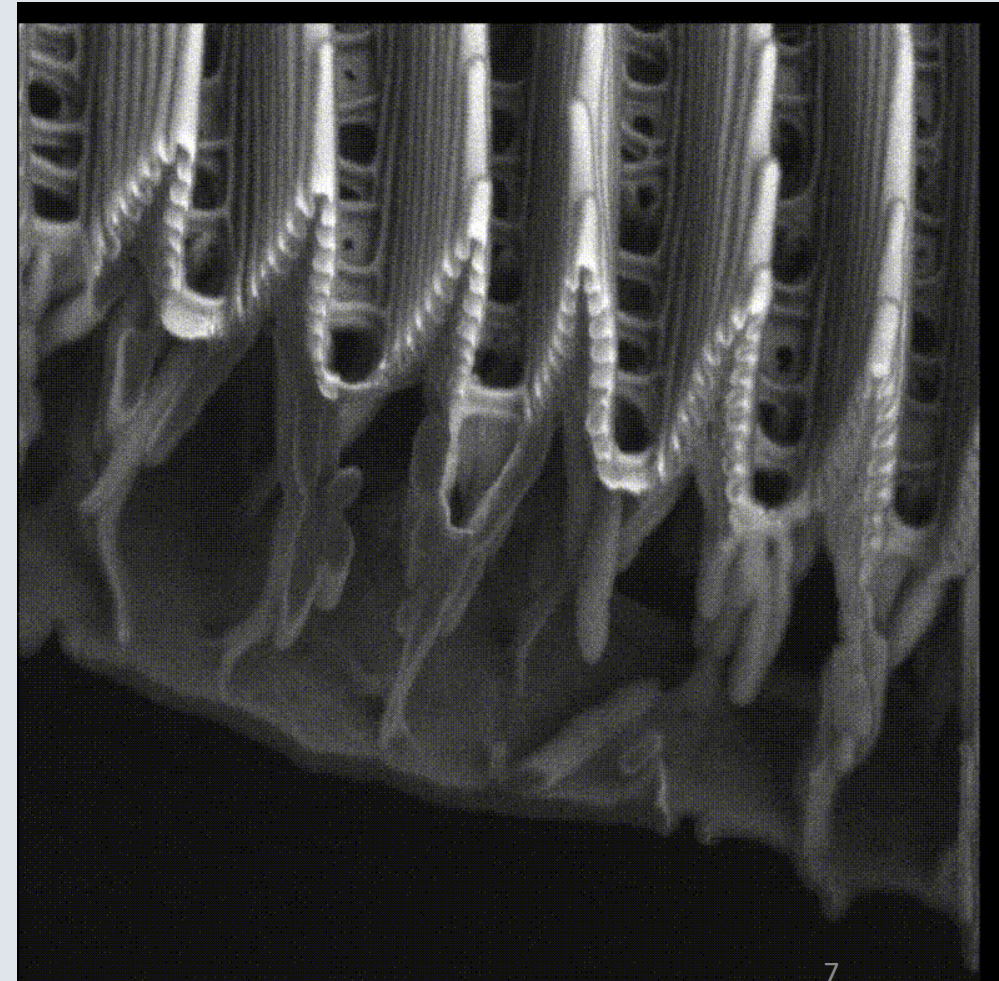
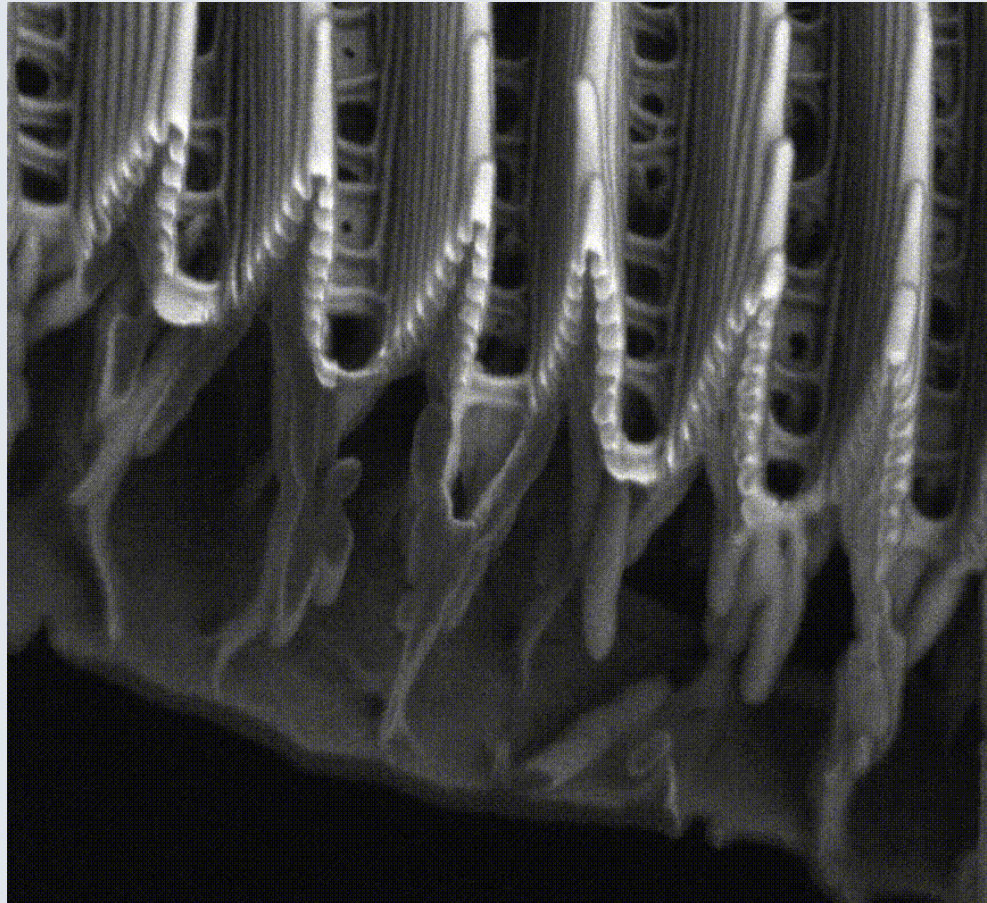
## Recalage de tranches

ORIGINALE

RECALLÉE

Information mutuelle

Vue XY



# Reconstruction 3D

## Visualisation

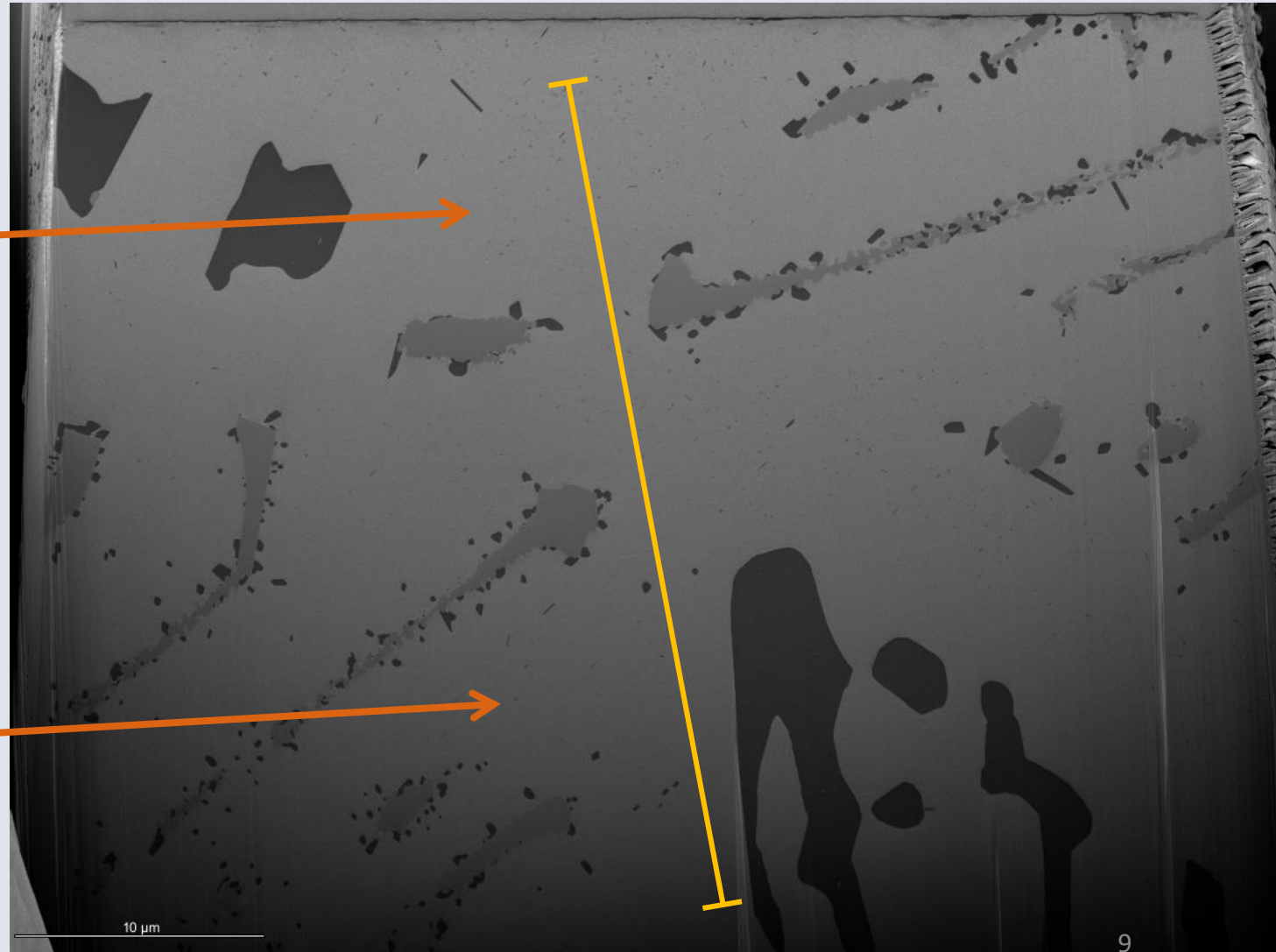
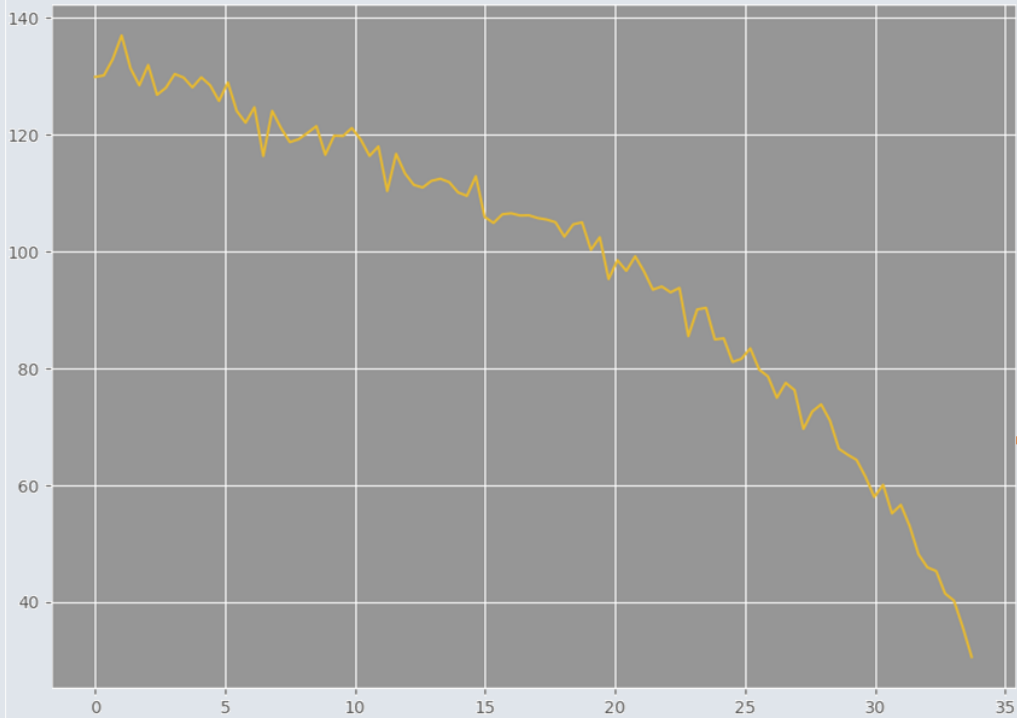


# Filtrage

## Compensation d'intensités

Zeiss, 2020

### Variations d'intensité



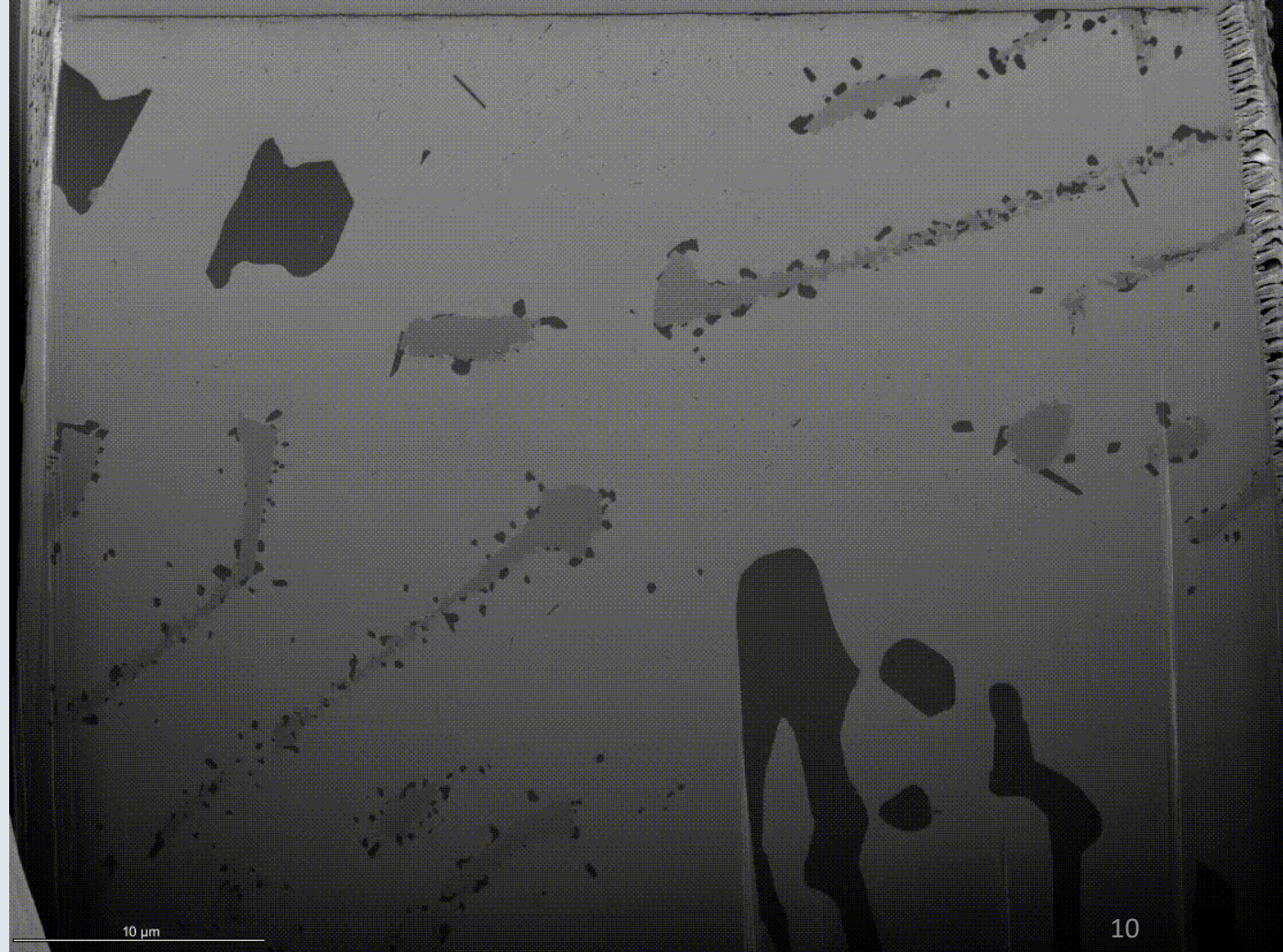
Nickle Carbide

# Filtrage

## Compensation d'intensités

- Balancement d'histogramme
- Minimisation d'entropie locale
- RBF manuel (radial basis function)
- Polynomiale

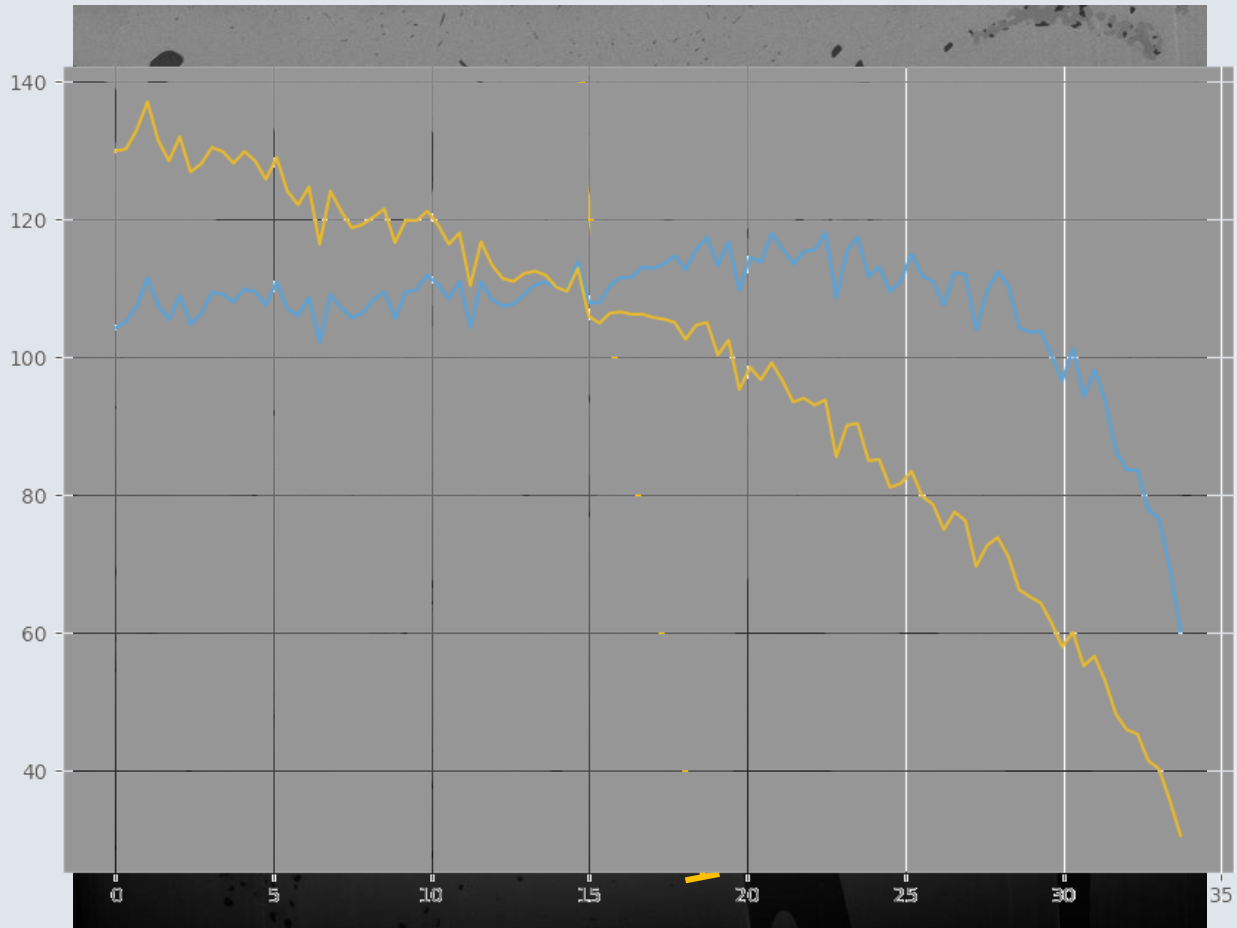
## Seuillage



# Filtrage

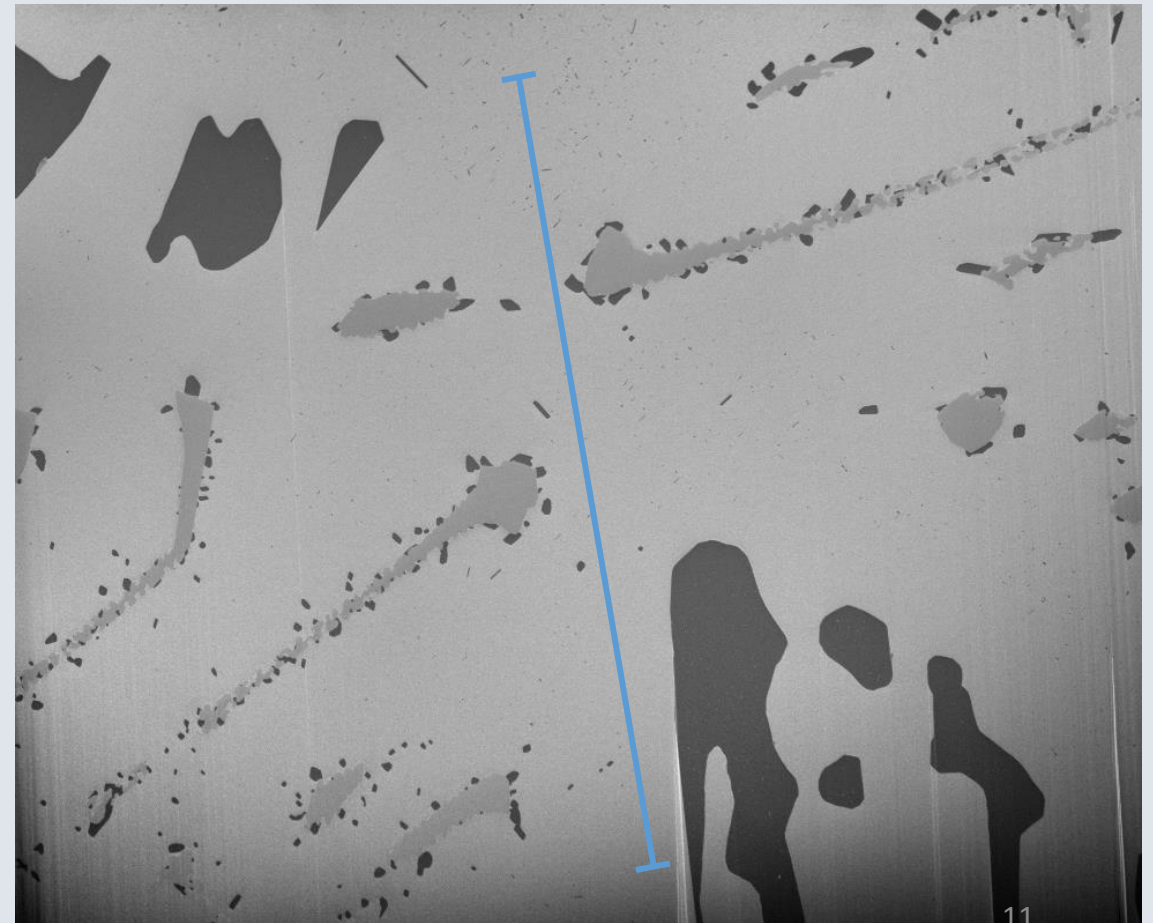
## Compensation d'intensités

ORIGINALE



FILTRÉE

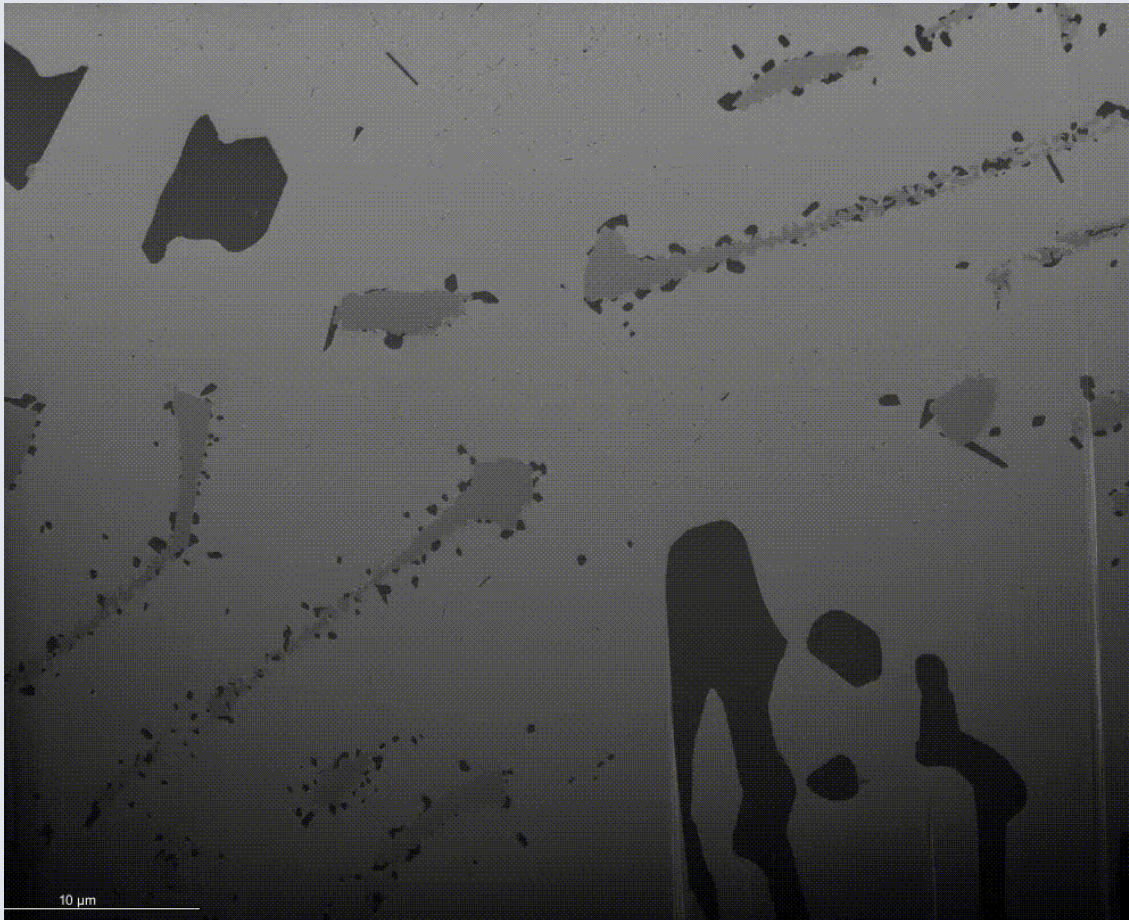
Minimisation d'entropie locale



# Filtrage

## Compensation d'intensités

ORIGINALE



FILTRÉE

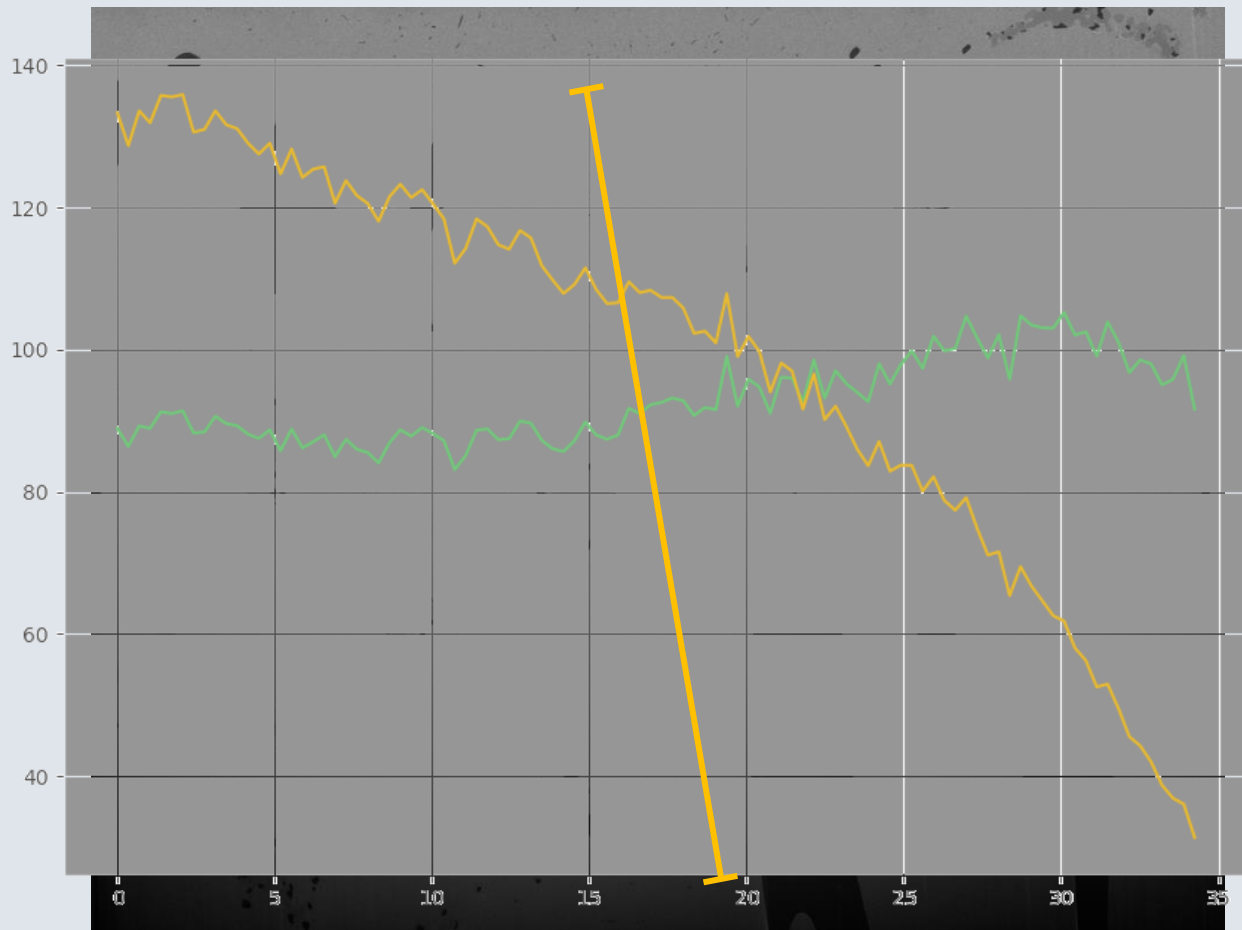
Minimisation d'entropie locale



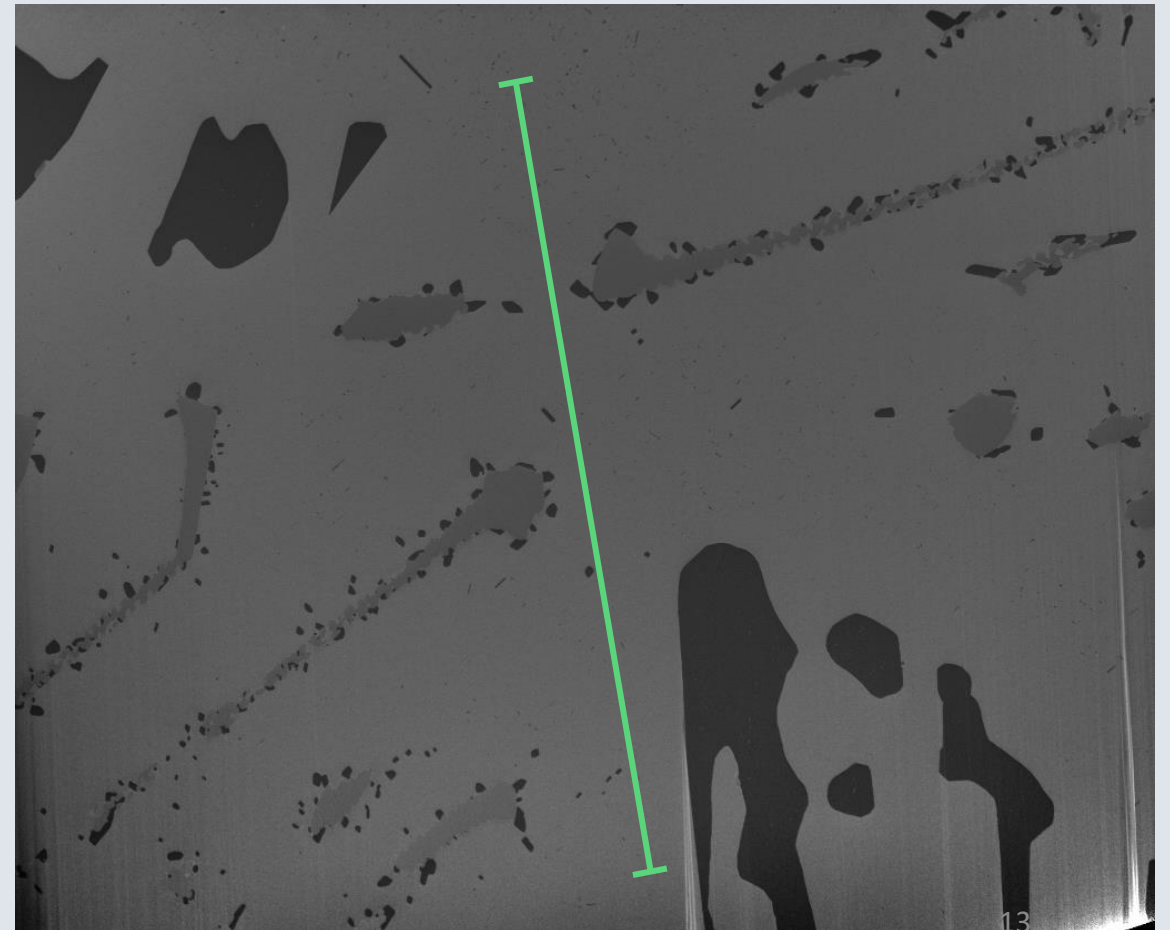
# Filtrage

## Compensation d'intensités

ORIGINALE



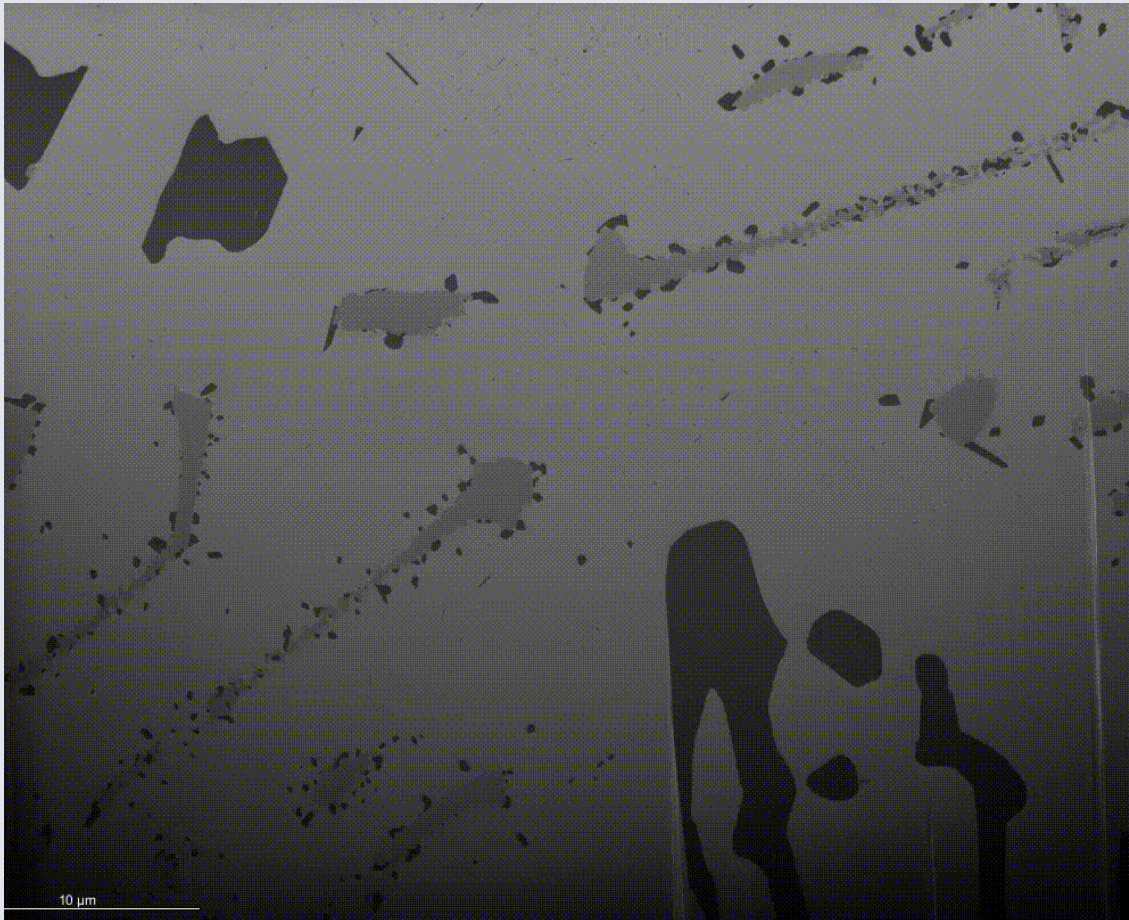
FILTRÉE  
Filtre polynomiale



# Filtrage

## Compensation d'intensités

ORIGINALE



FILTRÉE  
Filtre polynomiale



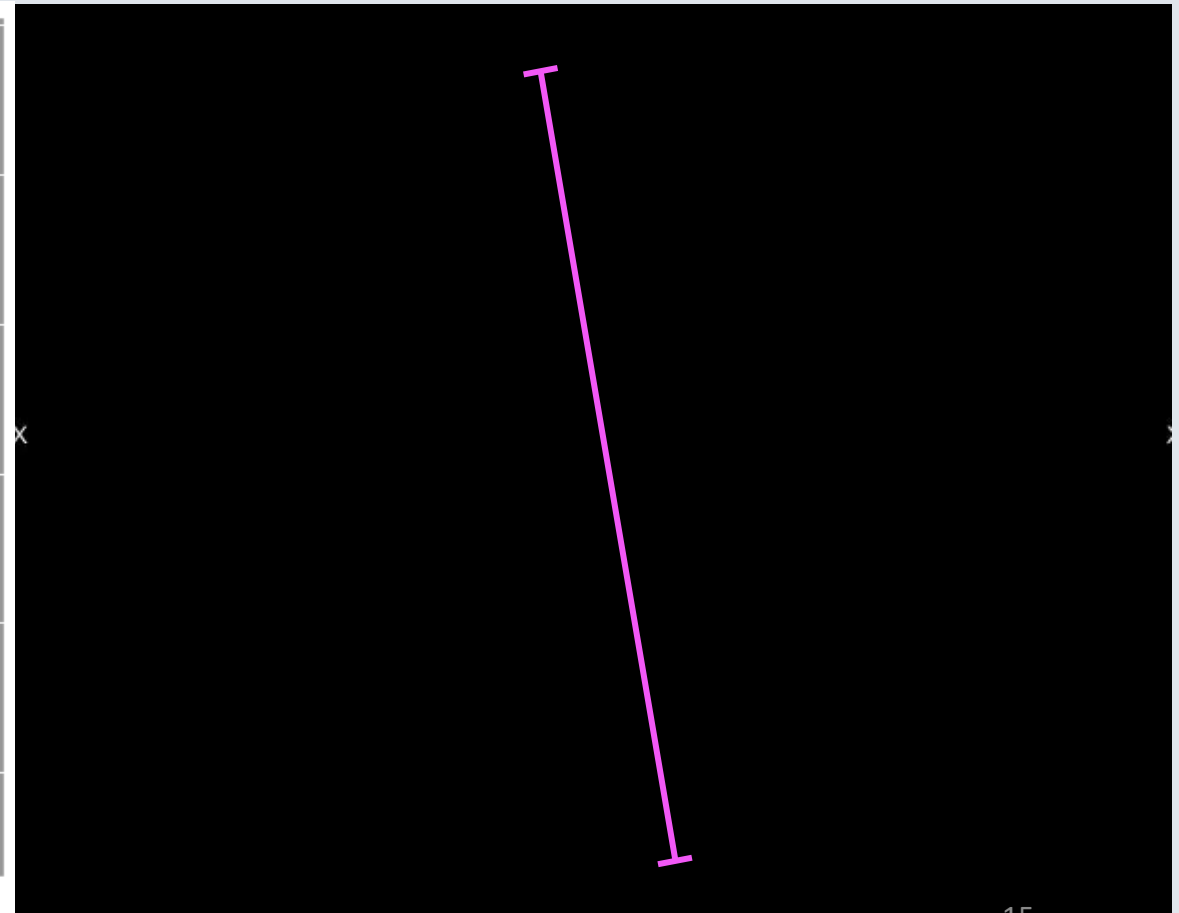
# Filtrage

## Compensation d'intensités

ORIGINALE

FILTRÉE

RBF manuel (radial basis function)

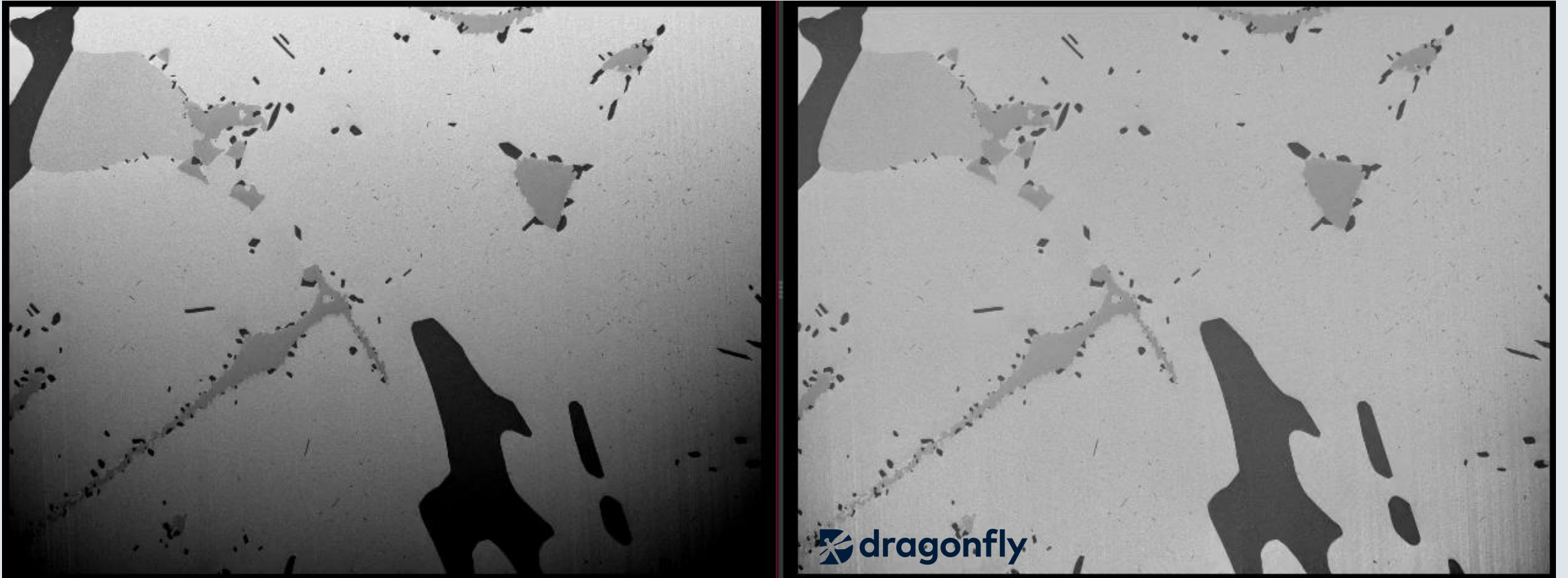


# Filtrage

## Compensation d'intensités

Appliquer le filtre sur chaque tranche

Nickle Carbide



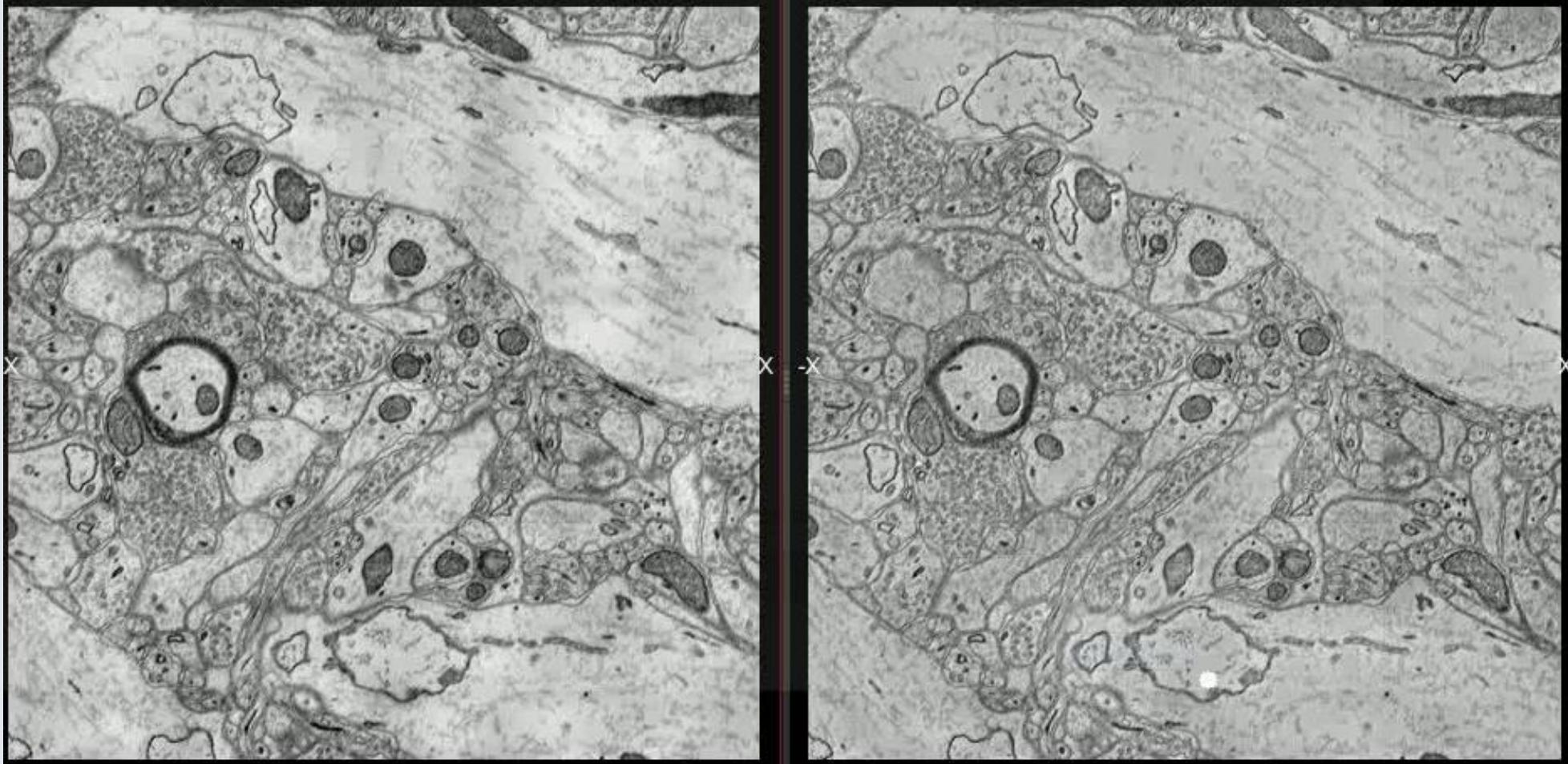
ORIGINALE

FILTRÉE

# Filtrage

## Correction chargement

### Gradient domain fusion



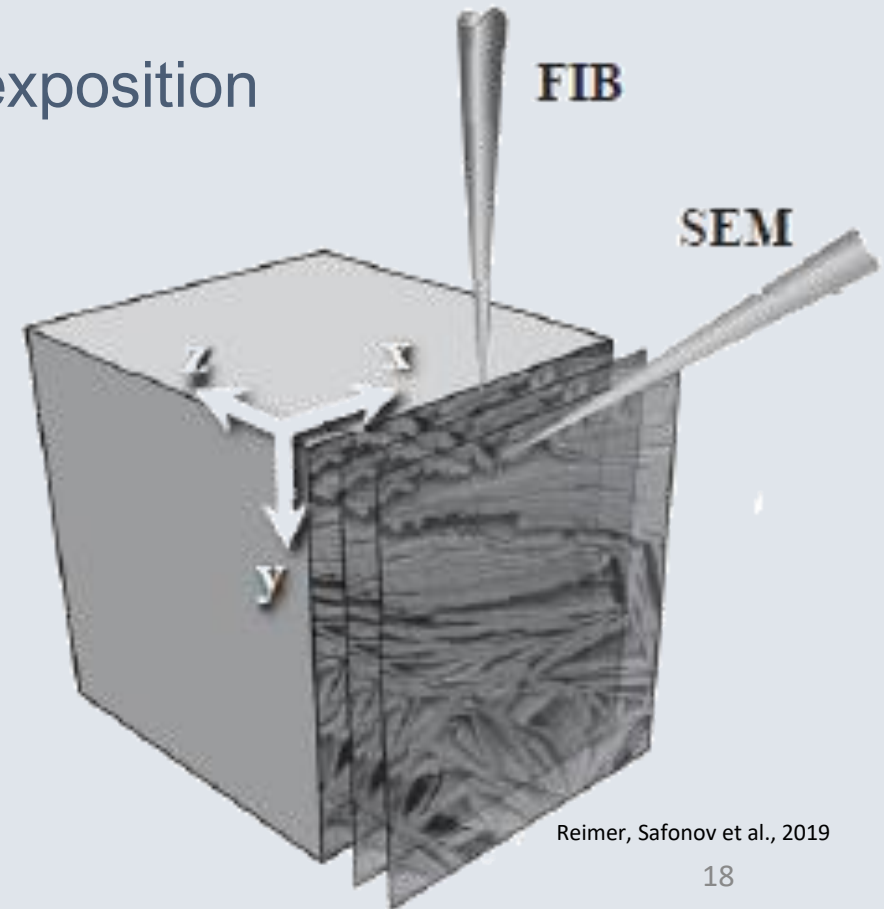
# Filtrage Débruitage

MEB FIB : Acquisitions de longues durées

Réduire le temps par tranche en diminuant la durée d'exposition

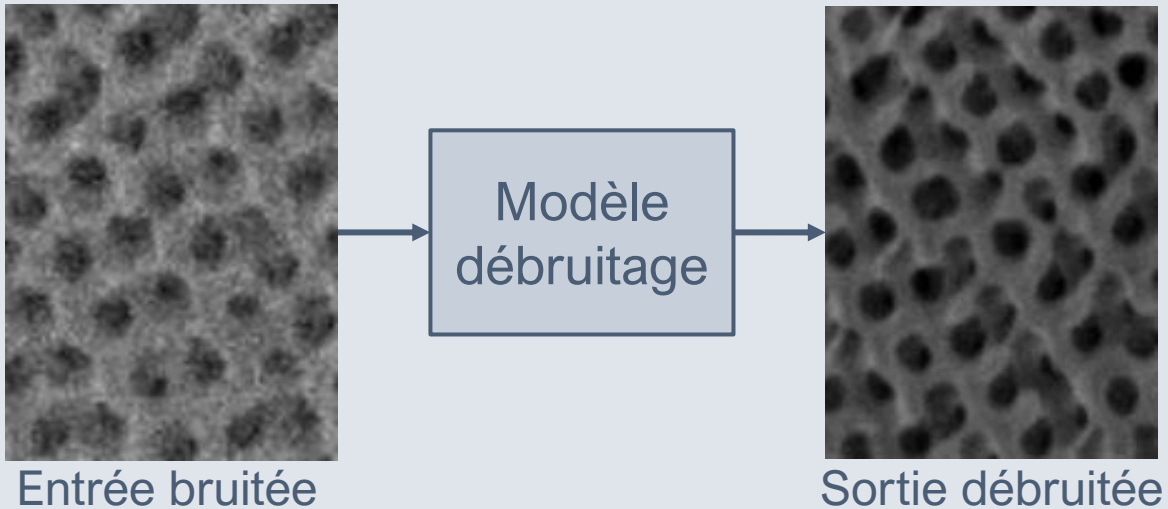
Filtres: Gaussien, Médian, Moyenneur

Débruitage avec apprentissage profond



# Filtrage Débruitage

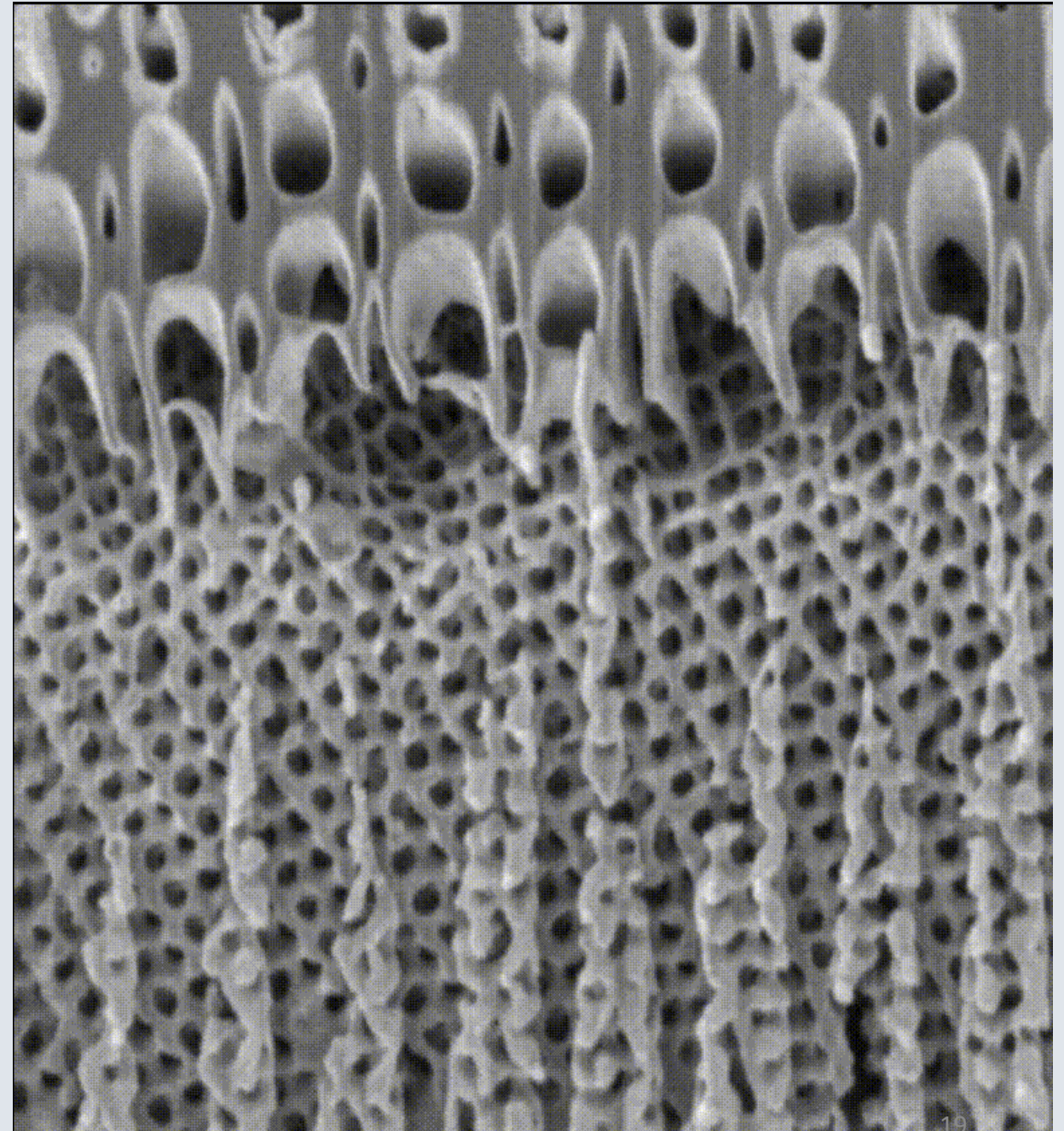
## 1. Couplage image bruitée et débruitée



## 2. Noise to Noise

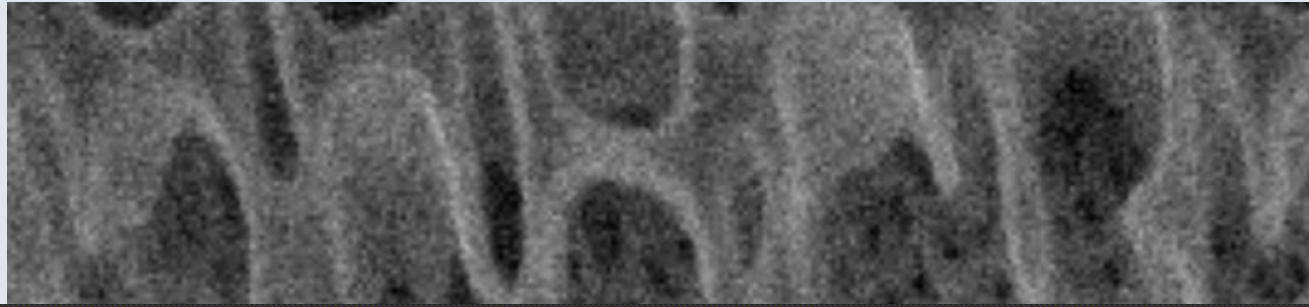
$$I + B \rightarrow I + B'$$

## 3. Noise2Void – apprentissage auto-supervisé



Écaille de papillon

# Filtrage Débruitage



Waiting for more data points

## Controls

Epochs:

Metrics: loss, val\_loss

## Progress

Epochs:

1%

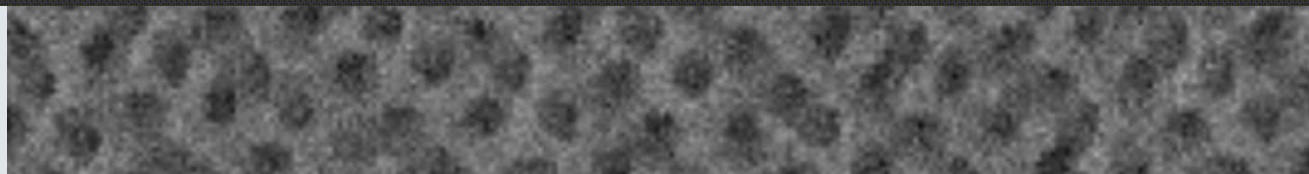
000/100

Time remaining: estimating...

Steps:

100%

18/18



# Filtrage Débruitage

Bruitée

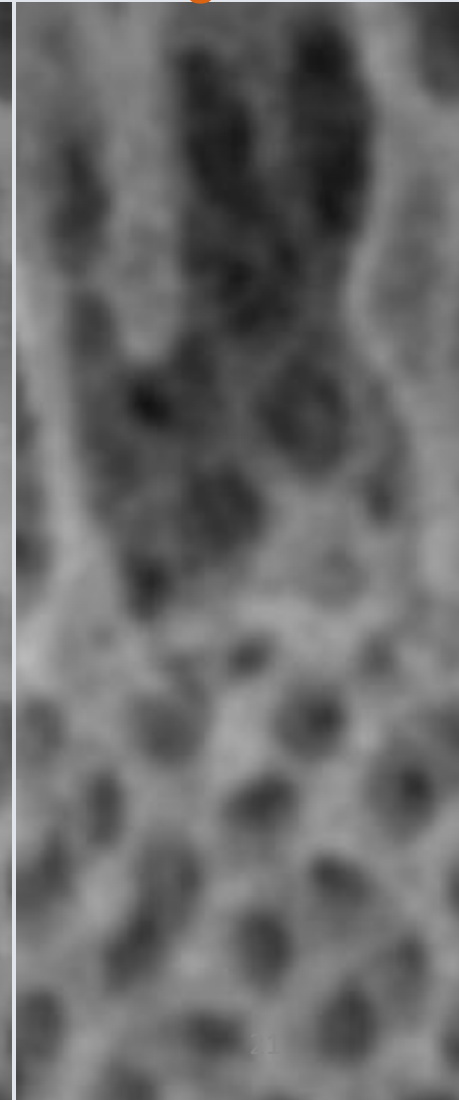
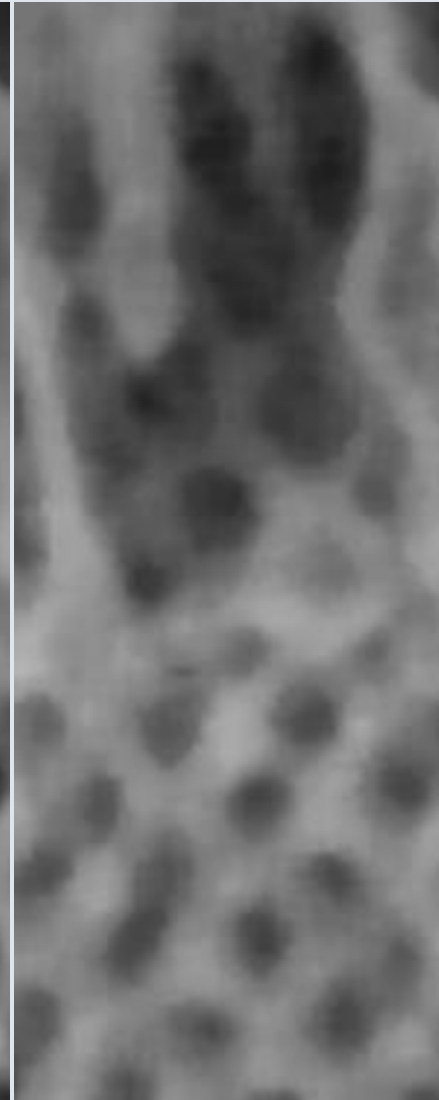
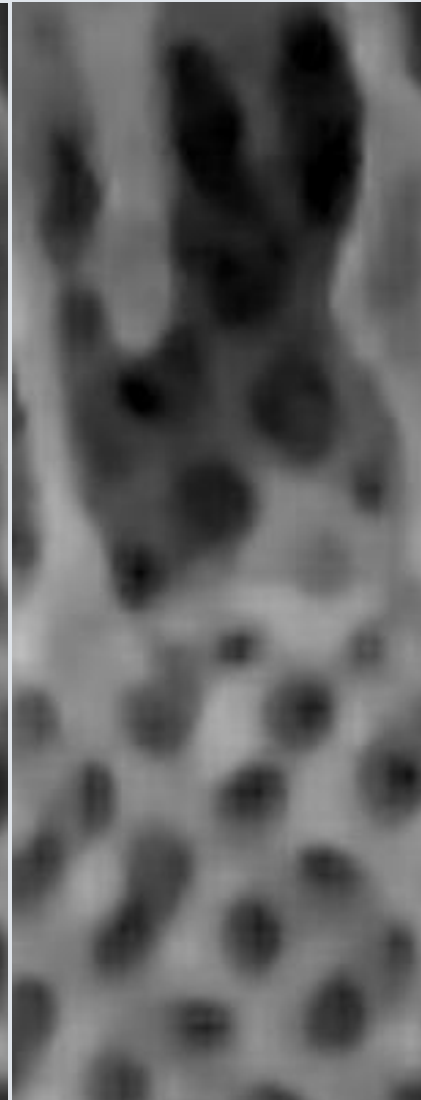
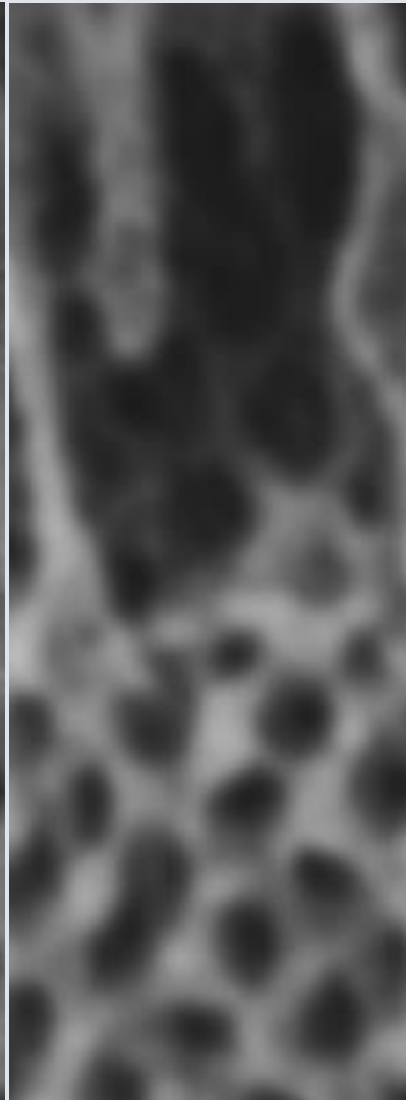
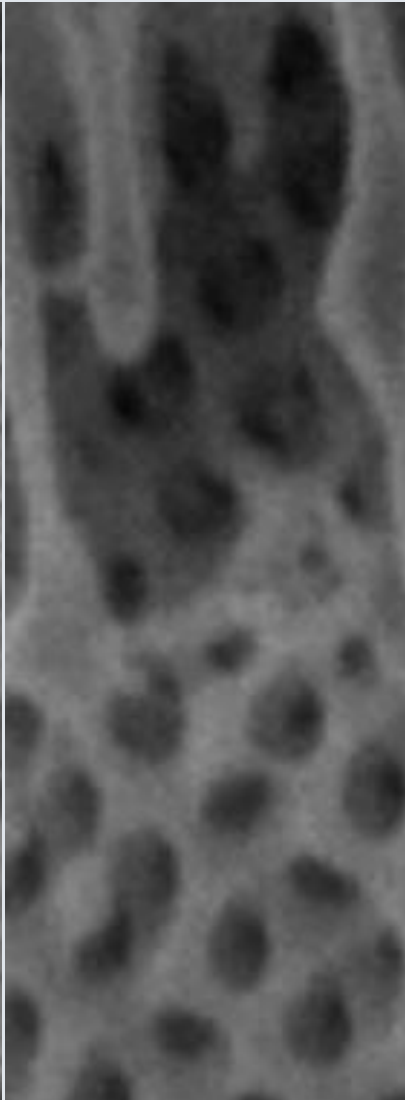
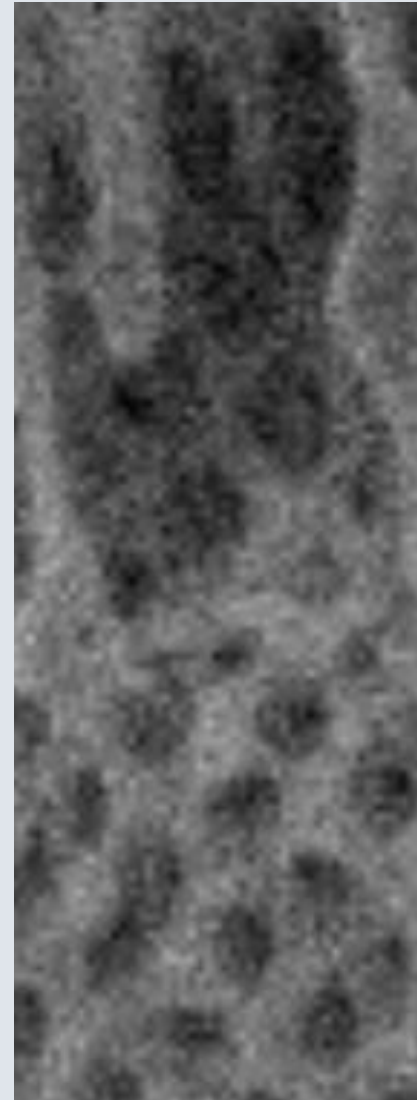
Débruitée

Modèle  
bruitée-  
débruitée

Modèle  
Noise2Void

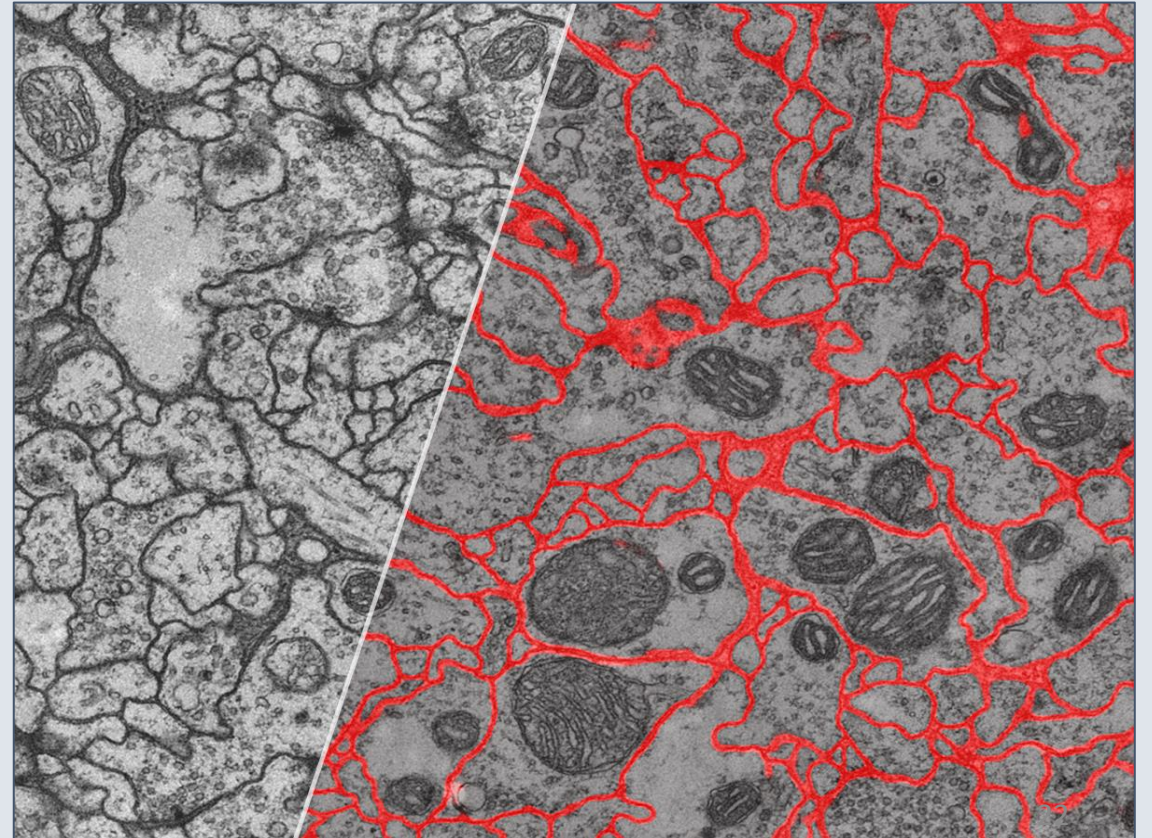
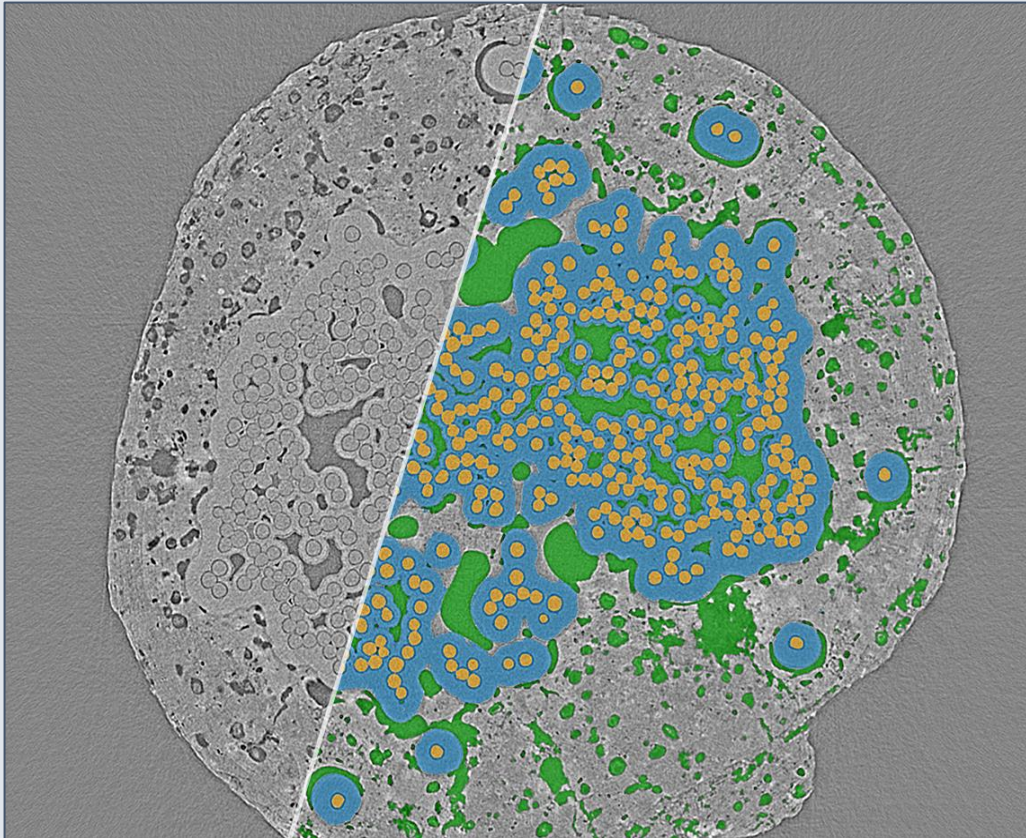
Filtre médian

Filtre gaussien



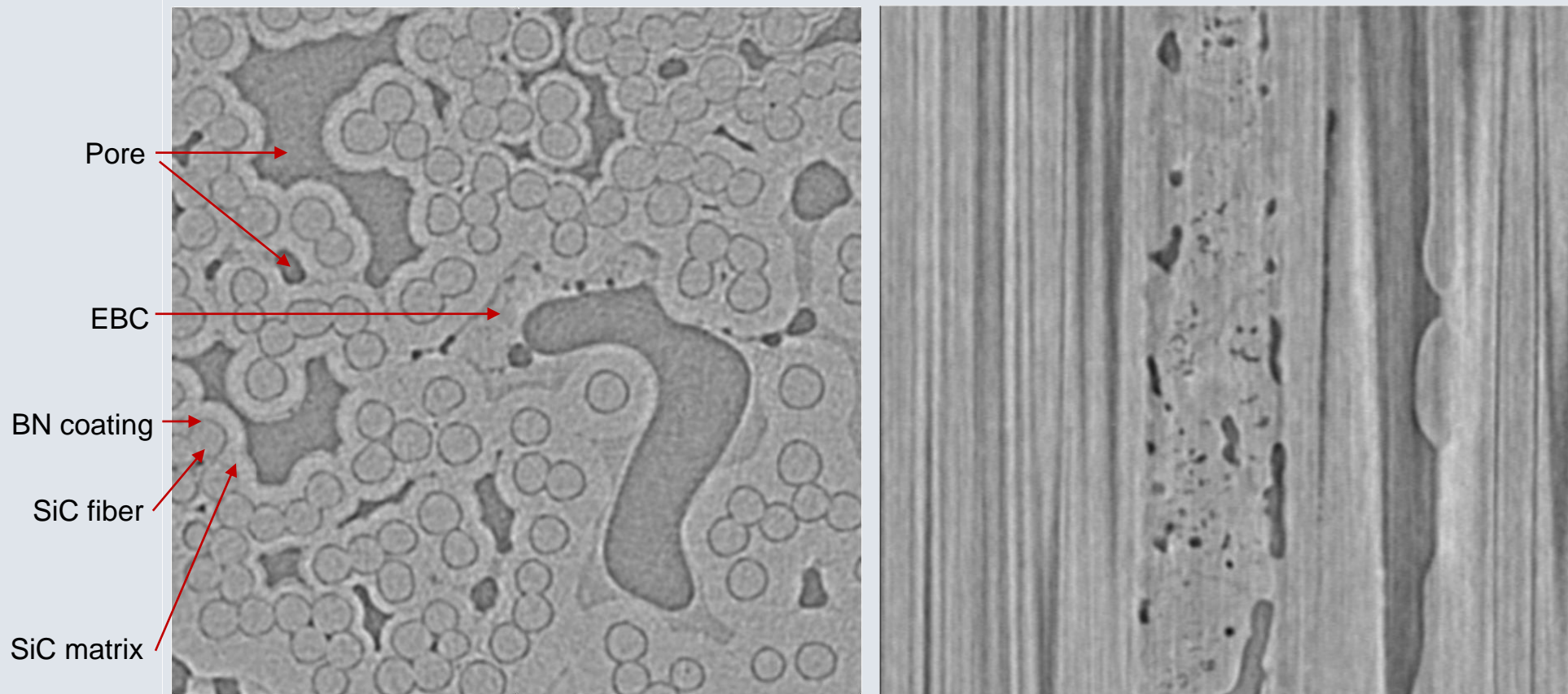
# Segmentation IA

La segmentation est une étape nécessaire pour l'analyse quantitative  
L'apprentissage profond peut remplacer la segmentation manuelle



# Segmentation IA

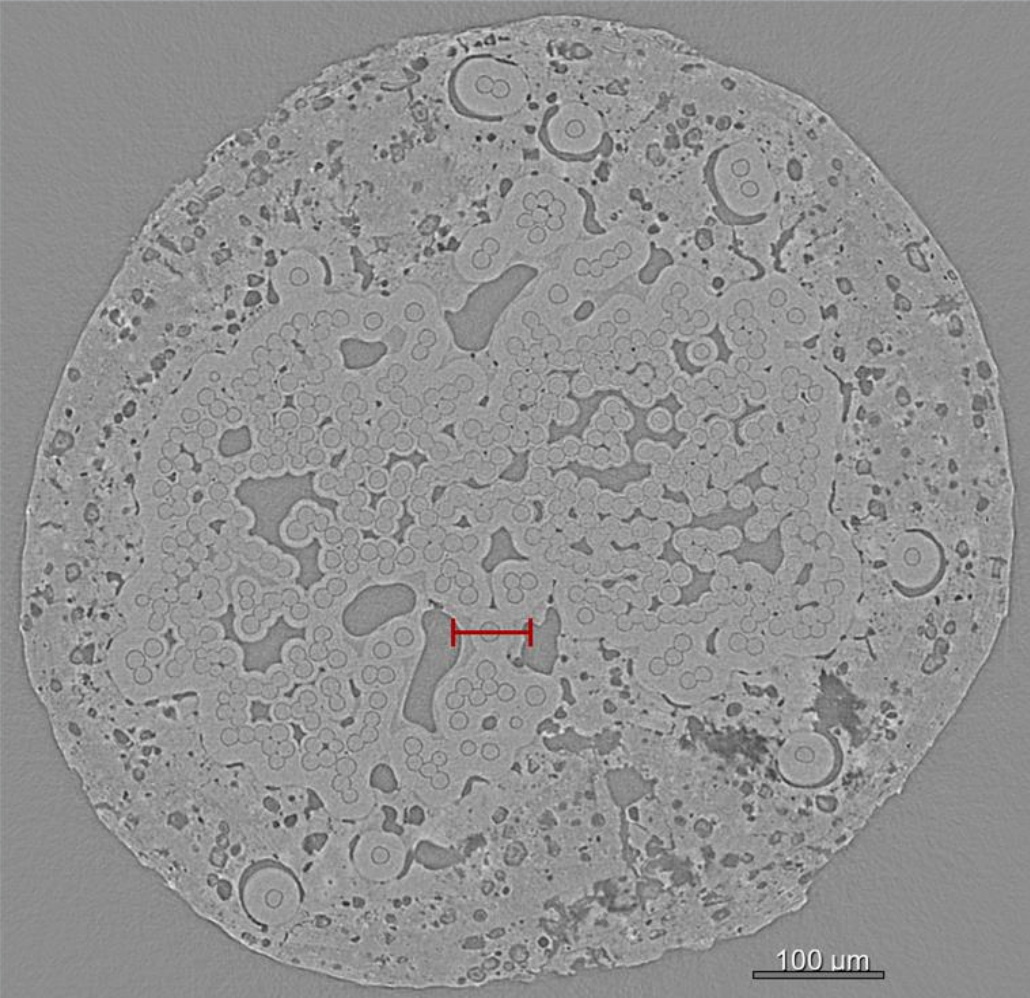
Quantifier la porosité pour chaque phase  
Bas contraste entre les composantes



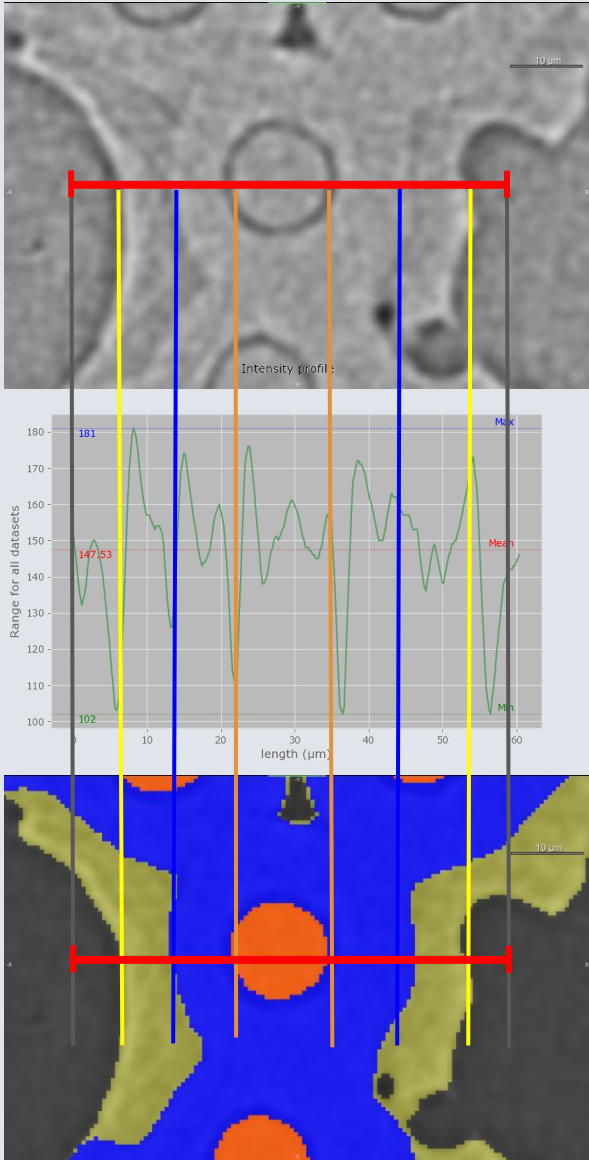
Ceramic matrix composite

# Segmentation IA

## Profil d'intensités



Ceramic matrix composite



# Segmentation IA

## U-Net



Dragonfly Pro ViciServer (RTX8000) (E1A Version 2021.2 Build 1052)

File Help

Main Segment

Manipulate

Window Leveling

1,062.98 X:841.09 µm

W: 248 C: 132

Slice 1081 / 2160

-X

-Y

Segmentation Wizard

Input Models Settings

Frames

Training frame

Classes and labels

Name	Count	Label
SIC matrix	109,820	1
SIC fibers	92,199	2
pores	91,411	3
EBC	315,562	4
exterior	417,728	5

Add Remove Merge

Background class: Drag class here ✓ None

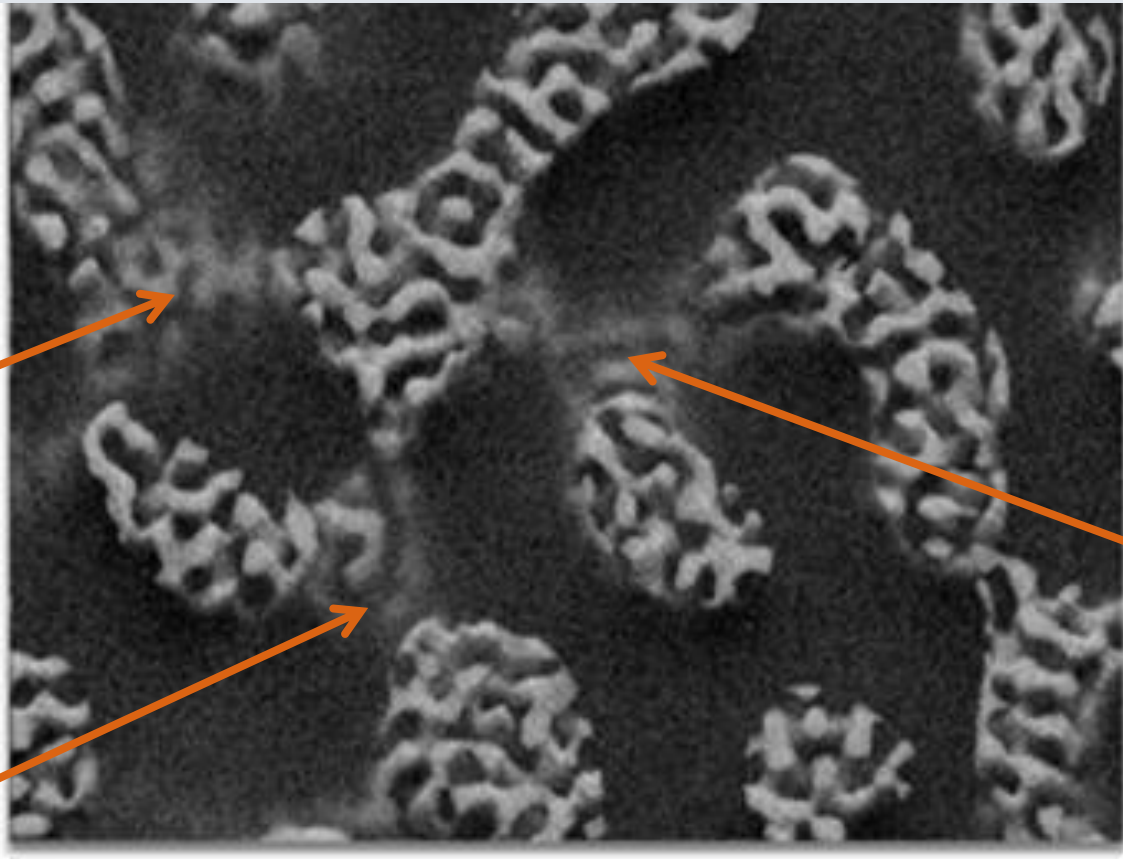
Labels opacity: [Slider]

Predict Train Export Exit

# Segmentation IA

Manque de données segmentées pour entraînement

Matériaux nanoporeux susceptibles à l'effet « shine-through »



**Training Deep Neural Networks to Reconstruct Nanoporous Structures From FIB Tomography Images Using Synthetic Training Data**

*Trushal Sardhara<sup>1\*</sup>, Roland C. Aydin<sup>2</sup>, Yong Li<sup>3</sup>, Nicolas Piché<sup>4</sup>, Raynald Gauvin<sup>5</sup>, Christian J. Cyron<sup>1,2</sup> and Martin Ritter<sup>6</sup>*

# Segmentation IA

Simulateur MC-Xray: Générer des images BSE synthétiques

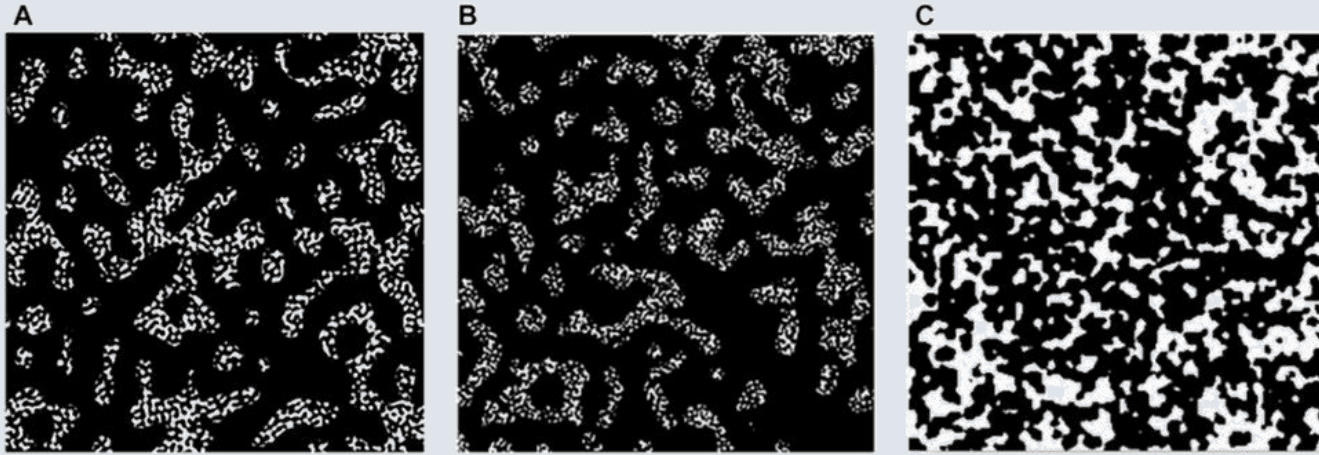
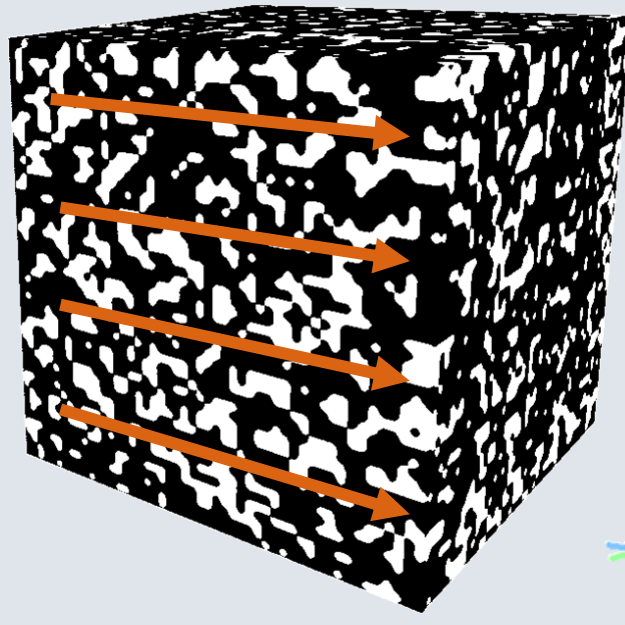


FIGURE 2 | Virtual microstructures generated by (A) levelled wave method (B) self-similarity method (C) random pore generation method.



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# Segmentation IA

Entraîner un modèle de segmentation avec des images simulées

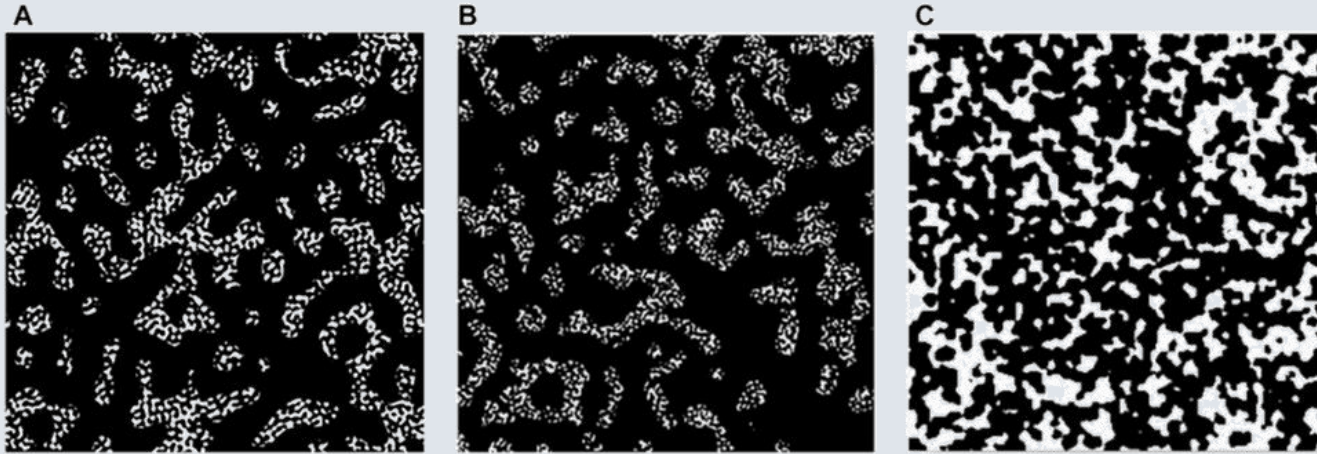


FIGURE 2 | Virtual microstructures generated by (A) levelled wave method (B) self-similarity method (C) random pore generation method.

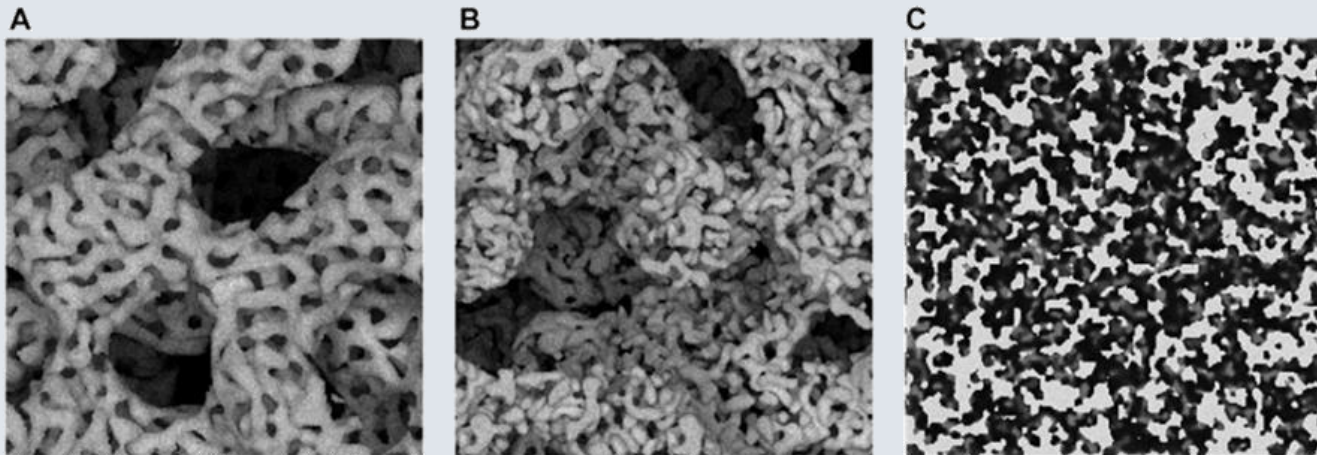
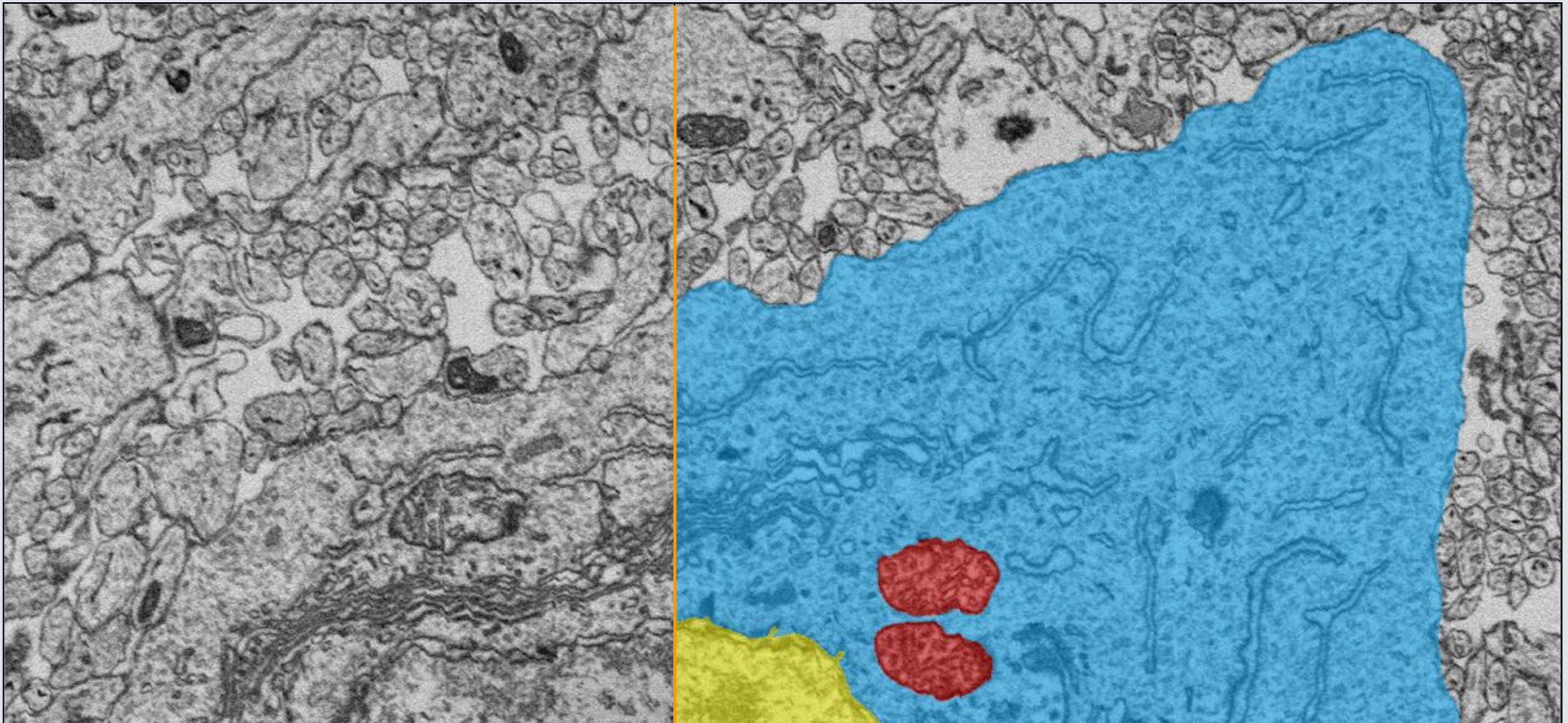


FIGURE 3 | Simulated BSE images using Monte Carlo simulation method and data generated using (A) LWM as initial virtual structure (B) SSM as initial virtual structure (C) RPGM as initial virtual structure.

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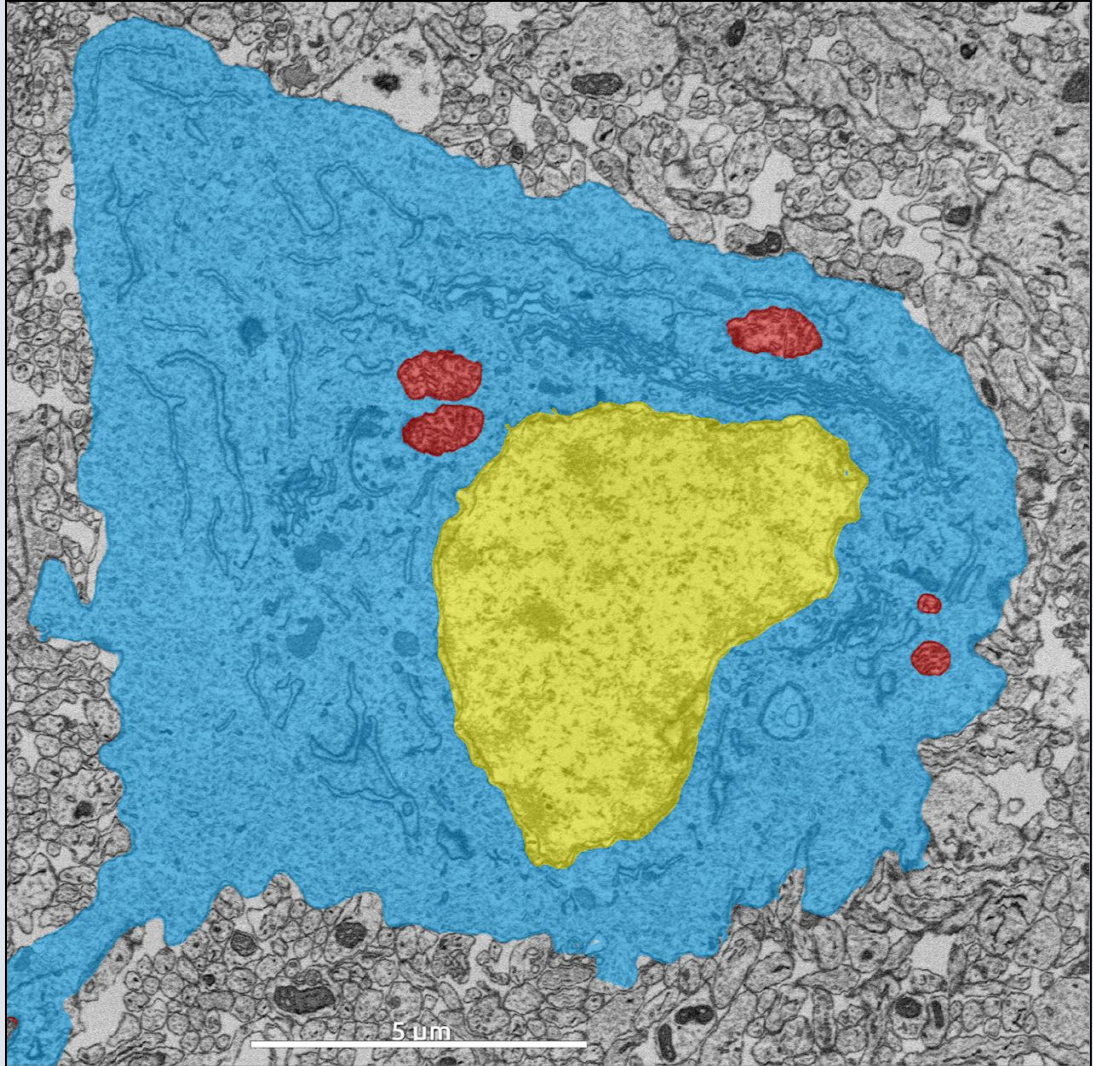
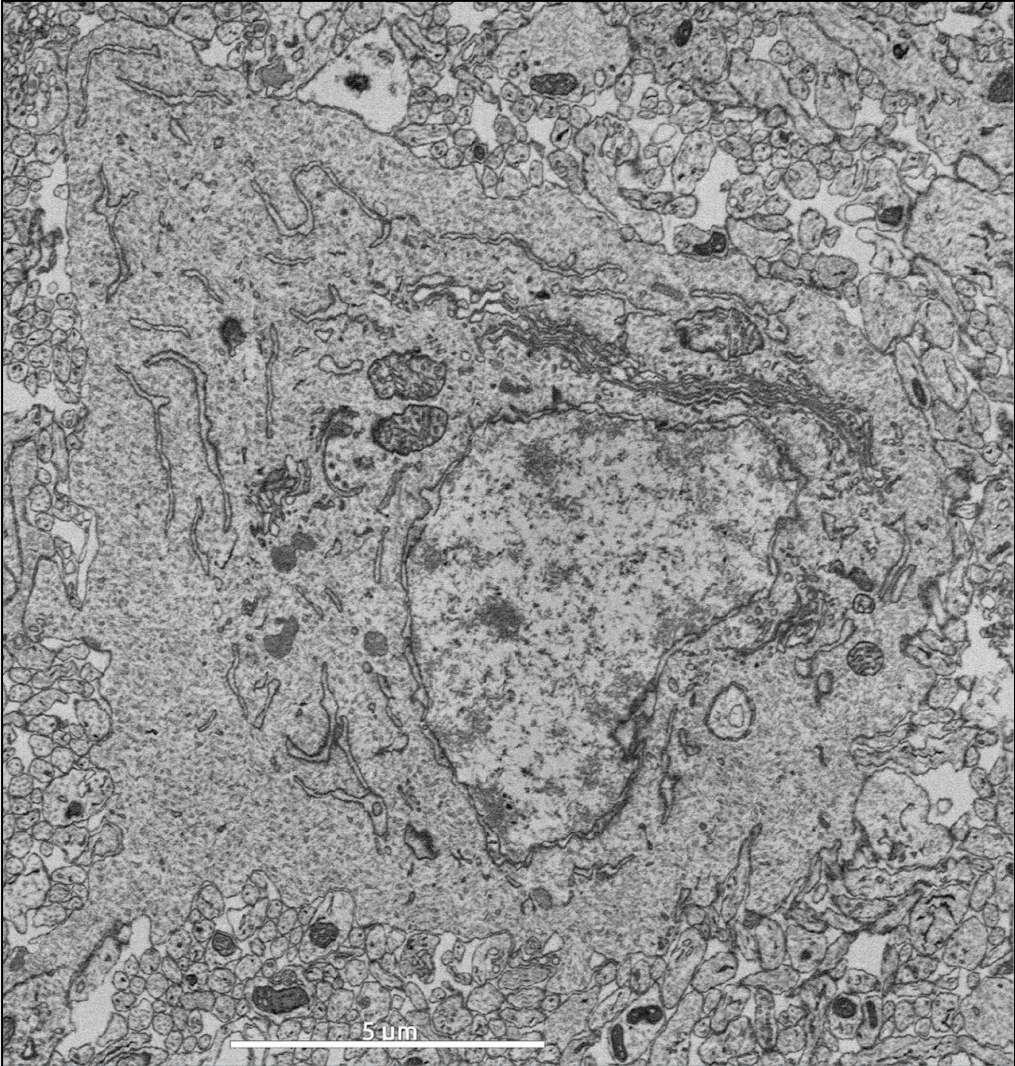
*Trushal Sardhara*<sup>1\*</sup>, *Roland C. Aydin*<sup>2</sup>, *Yong Li*<sup>3</sup>, *Nicolas Piché*<sup>4</sup>, *Raynald Gauvin*<sup>5</sup>, *Christian J. Cyron*<sup>1,2</sup> and *Martin Ritter*<sup>6</sup>

# Segmentation IA



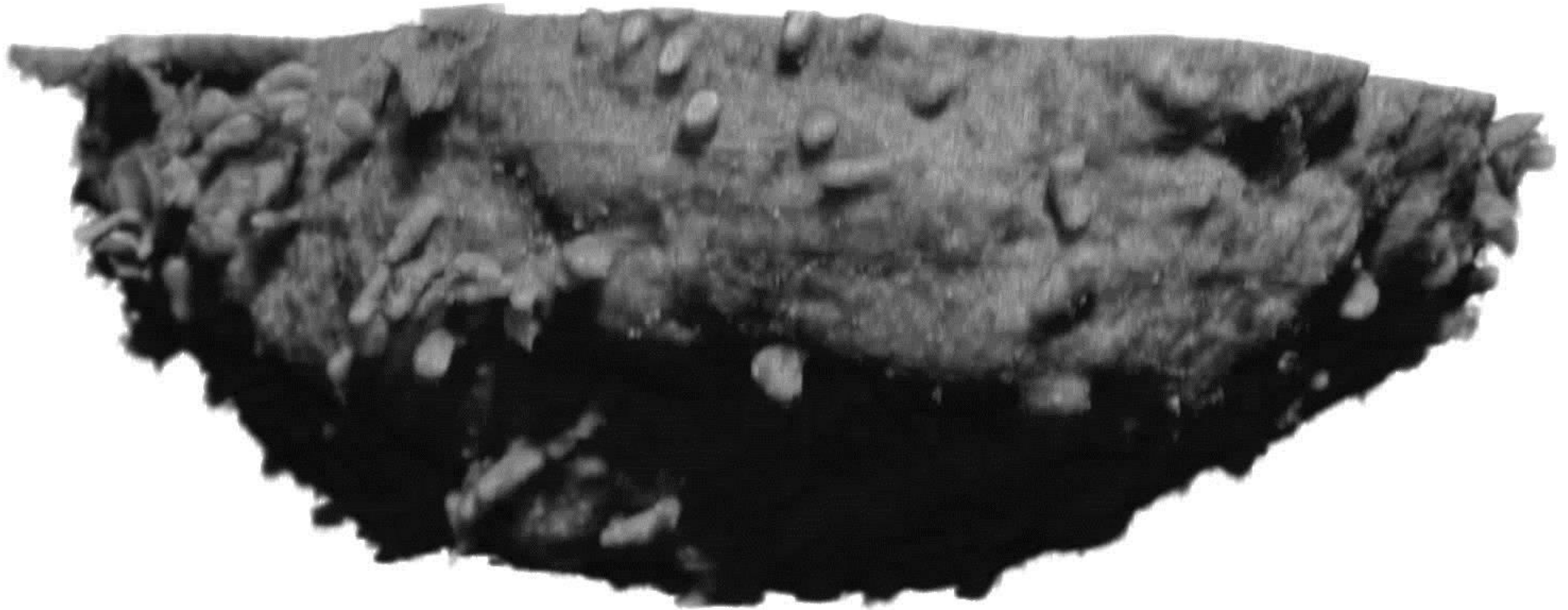
Neurones de rat

# Segmentation IA



Neurones de rat

# Segmentation IA



# Références

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- Neurones de rat, Angel Paredes, FDA, SBFSEM image on Zeiss Merlin microscope