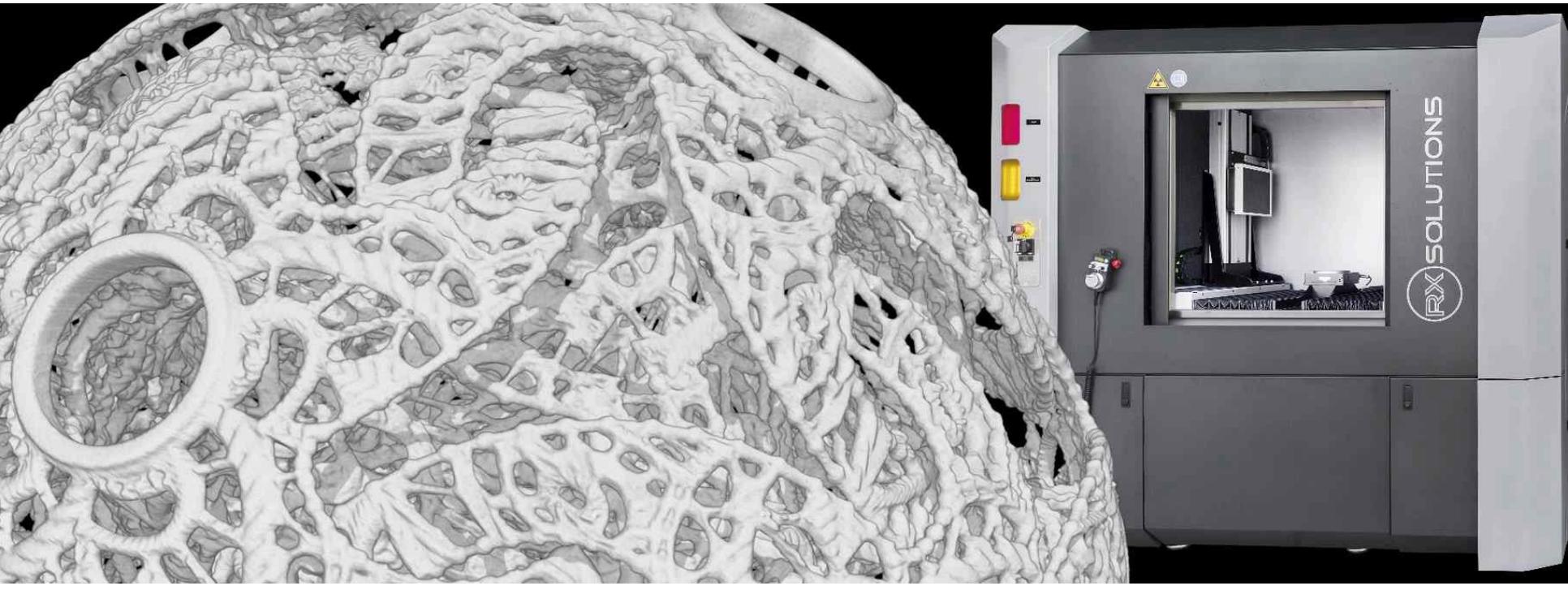


La tomographie multiéchelle pour la R&D

S.Valton

RX Solutions

Journée tomographie PRECEND 14 mai 2019



- **Fondé à Annecy en 2006**
- **Fabricant d'équipements de microtomographie par rayons X:**
  - Gamme de machine "standards" du micro au sub-micro
  - Projets sur mesure
  - Clients dans la recherche et l'industrie
- **Prestataires de services :**
  - 3 équipements dédiés à la prestation de 230 kV à 300 nm
  - Acquisition/reconstruction/Analyse qualitative des données, sous 2 à 15 jours
- **Réseau de distribution mondial**
- **Certifications:**
  - ISO 9001 version 2015
  - COSAC (NDT in Aerospace / COFREND)



# RX Solutions : les familles d'équipements



## EasyTom S



### Compact Micro CT system

- An incredible scanning volume coupled with one of the smallest footprint on the market
- The best device to control and inspect with easiness various components

## EasyTom



### Micro & Nano CT System

- A lot of capabilities in a medium size CT system
- Possibility to scan important workpieces thanks to the moving axes
- Automatic doors, with leaded windows

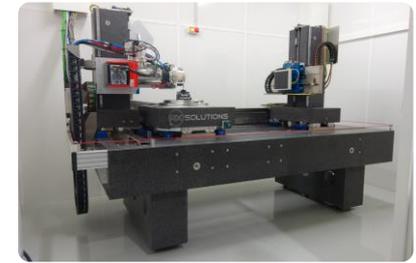
## EasyTom XL



### Large Micro & Nano CT System

- A huge scanning volume
- Ideal for *in situ* testing
- Wide automatic door with a large leaded window, helping loading and unloading large workpieces

## UltraTom



### Lab CT System in bunker

- Micro & Nano configurations,
- Large scanning volume,
- Completely flexible and customizable
- Automatic axes on air bearing systems

# Références



CentraleSupélec



SMART TECHNOLOGY  
FOR SMARTER CARS



Empa

Materials Science and Technology



ÉCOLE POLYTECHNIQUE  
FÉDÉRALE DE LAUSANNE



UNIVERSITY  
OF APPLIED SCIENCES  
UPPER AUSTRIA



Max Planck Institute  
of Colloids and Interfaces

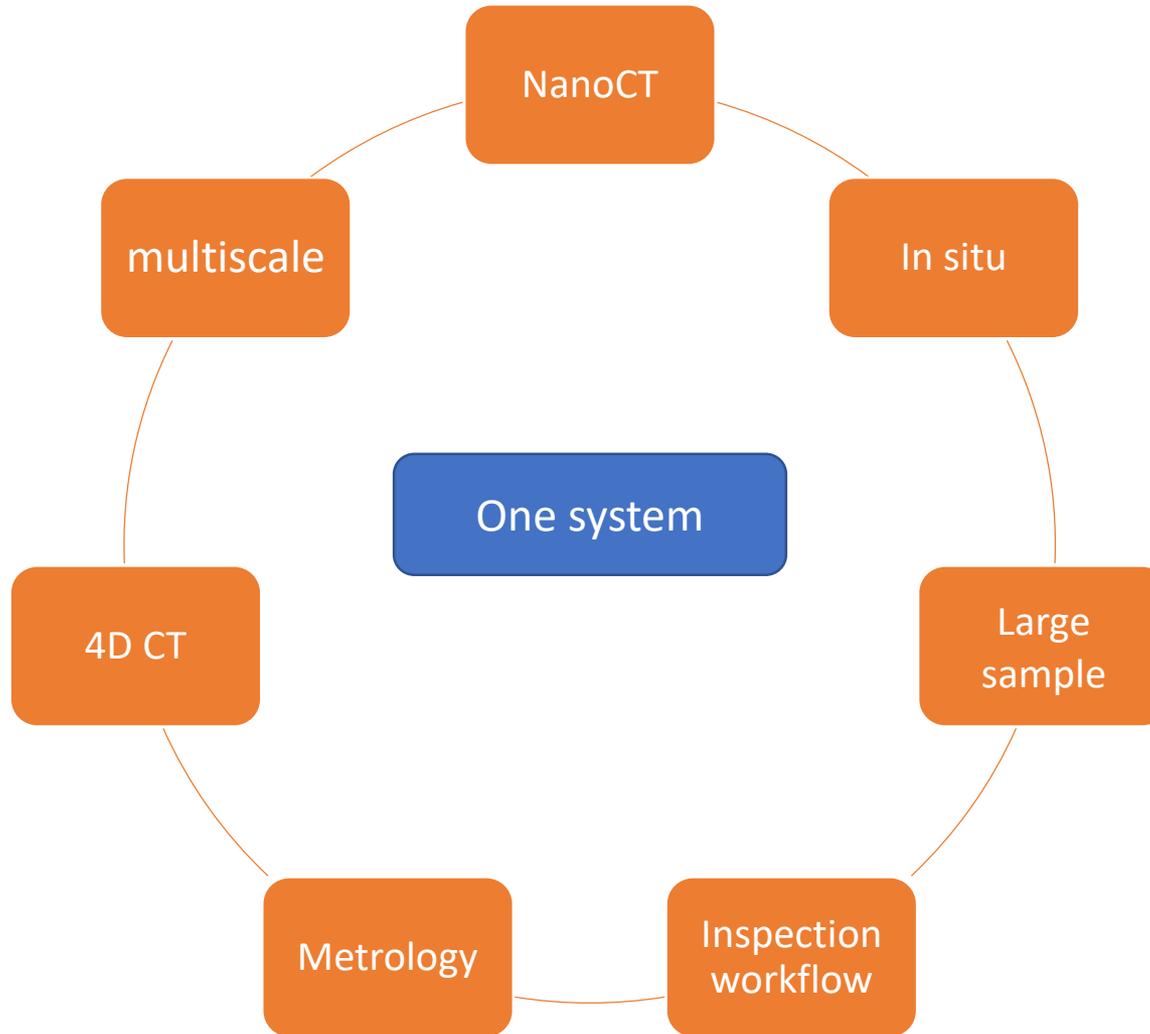
Hochschule Bochum  
Bochum University  
of Applied Sciences



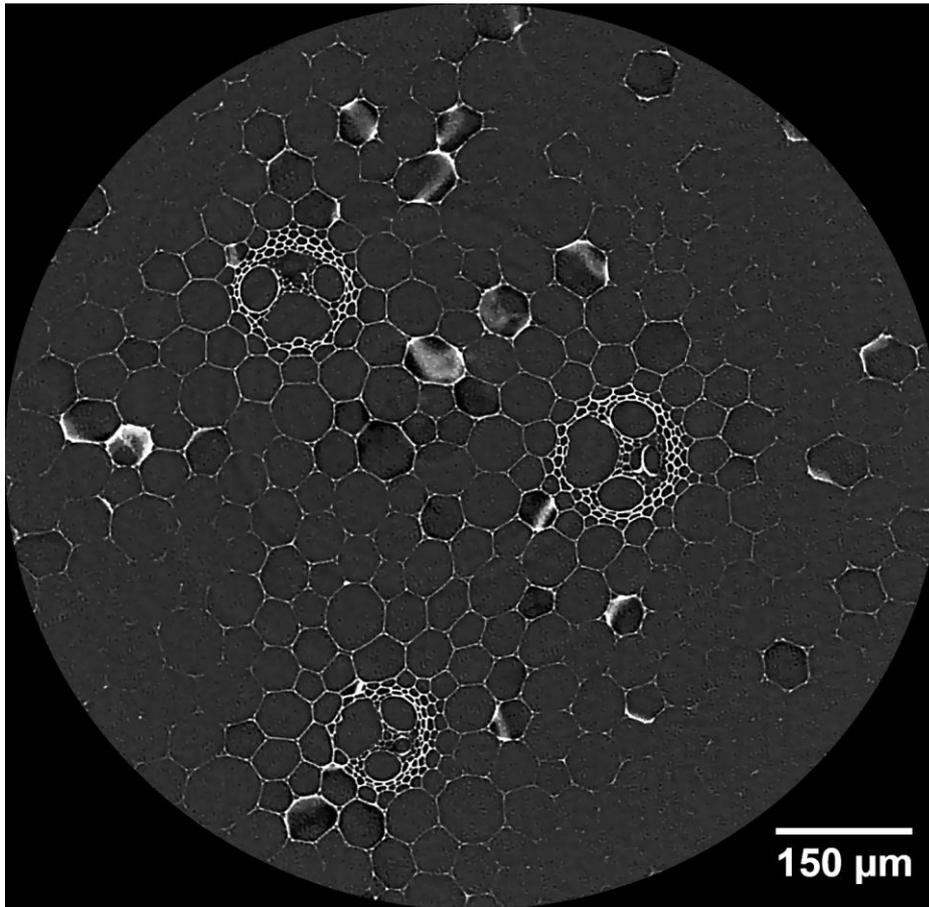
LUXEMBOURG  
INSTITUTE  
OF SCIENCE  
AND TECHNOLOGY



# Tour d'horizon des applications d'un microtomographe à rayons X



# Submicron resolution



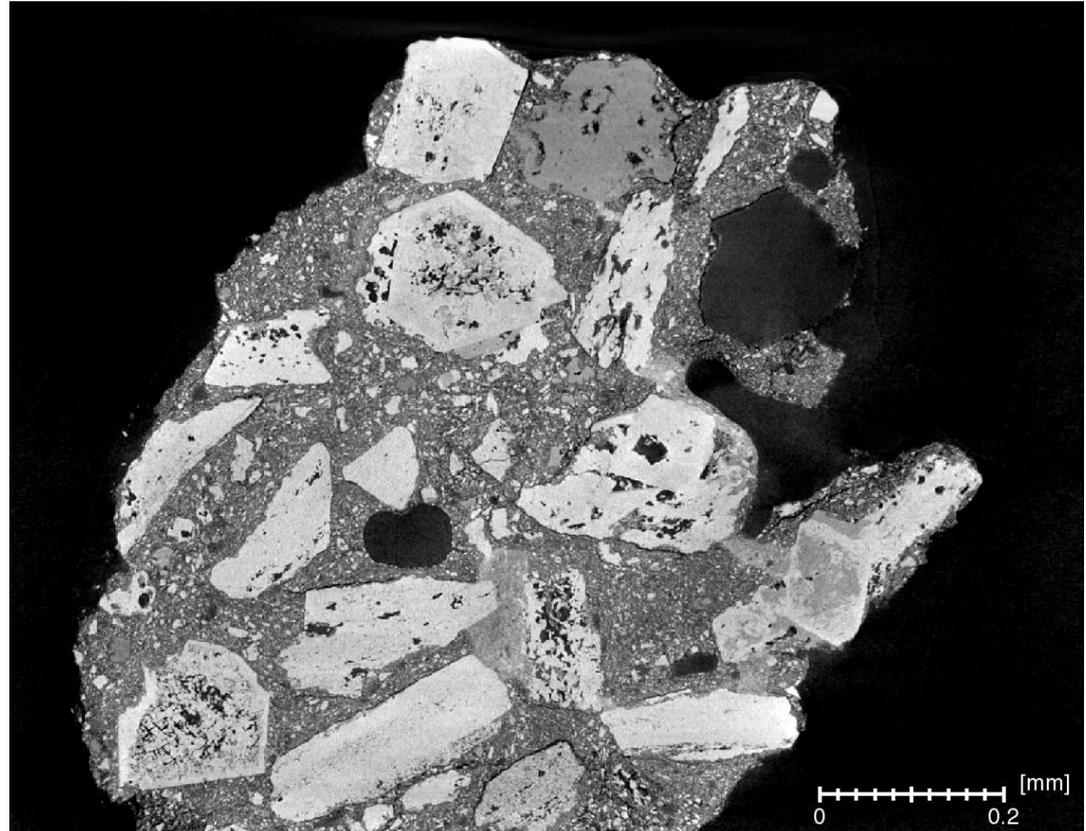
Centrale supelec

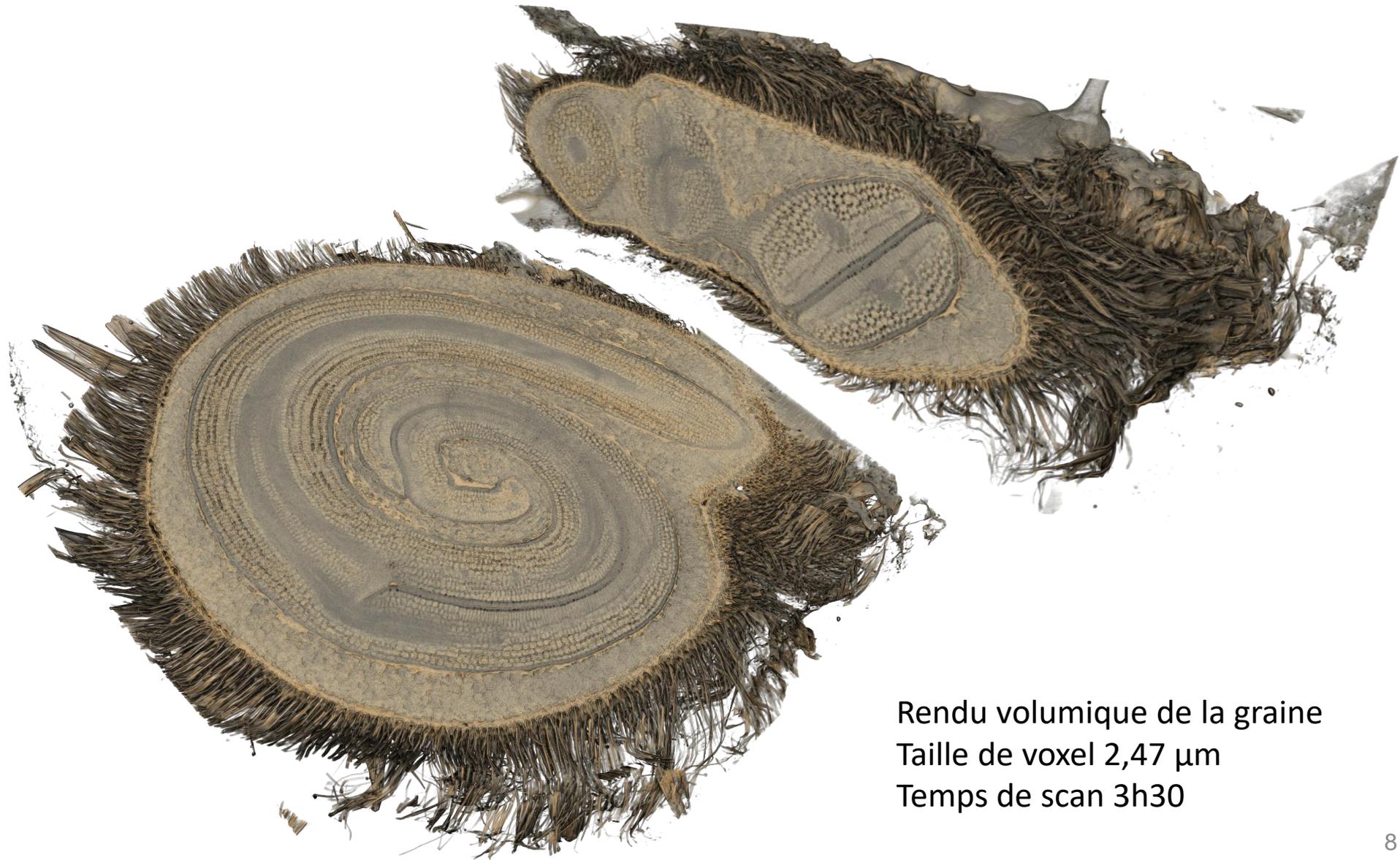


Miscanthus.  
Voxel size 300 nm.  
Scan time 90 min

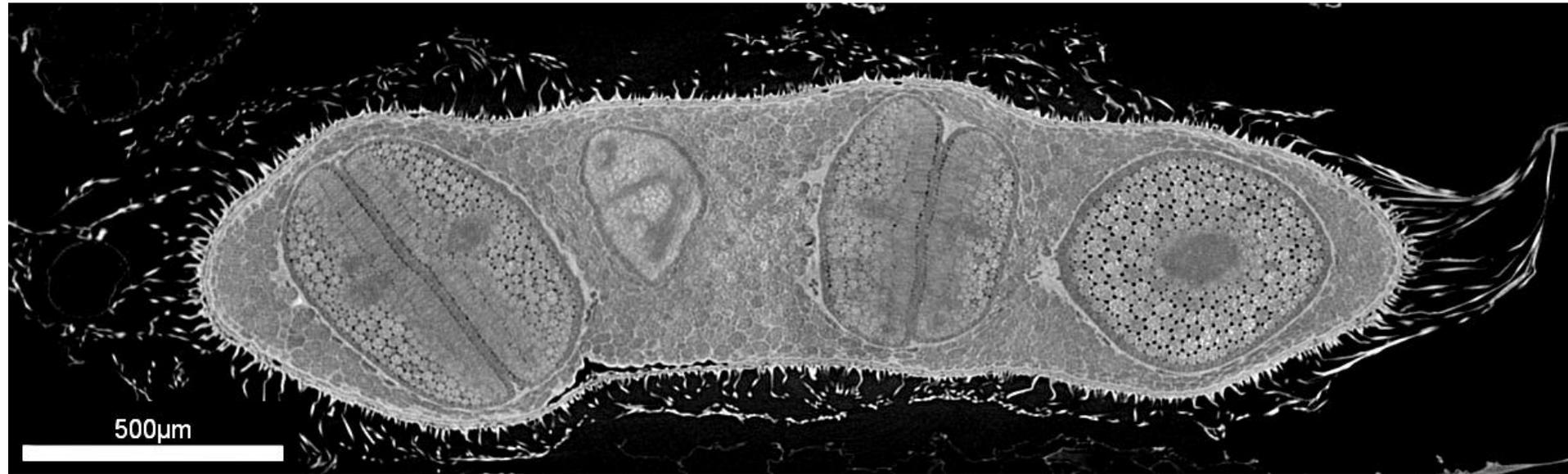
# Submicron resolution

Fe-based mineral.  
Voxel size 760 nm.  
Scan time 6 hours

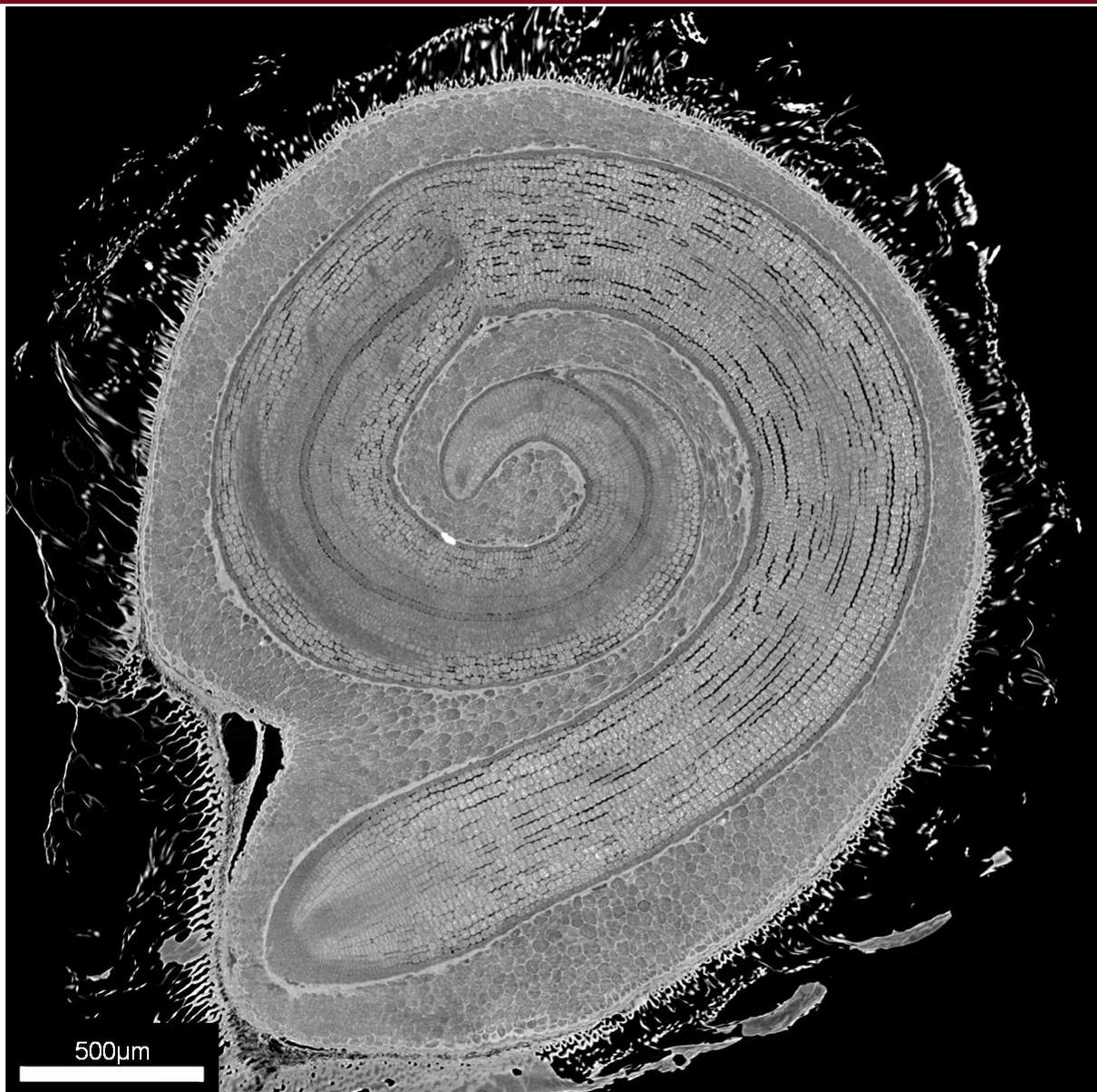




Rendu volumique de la graine  
Taille de voxel 2,47  $\mu\text{m}$   
Temps de scan 3h30

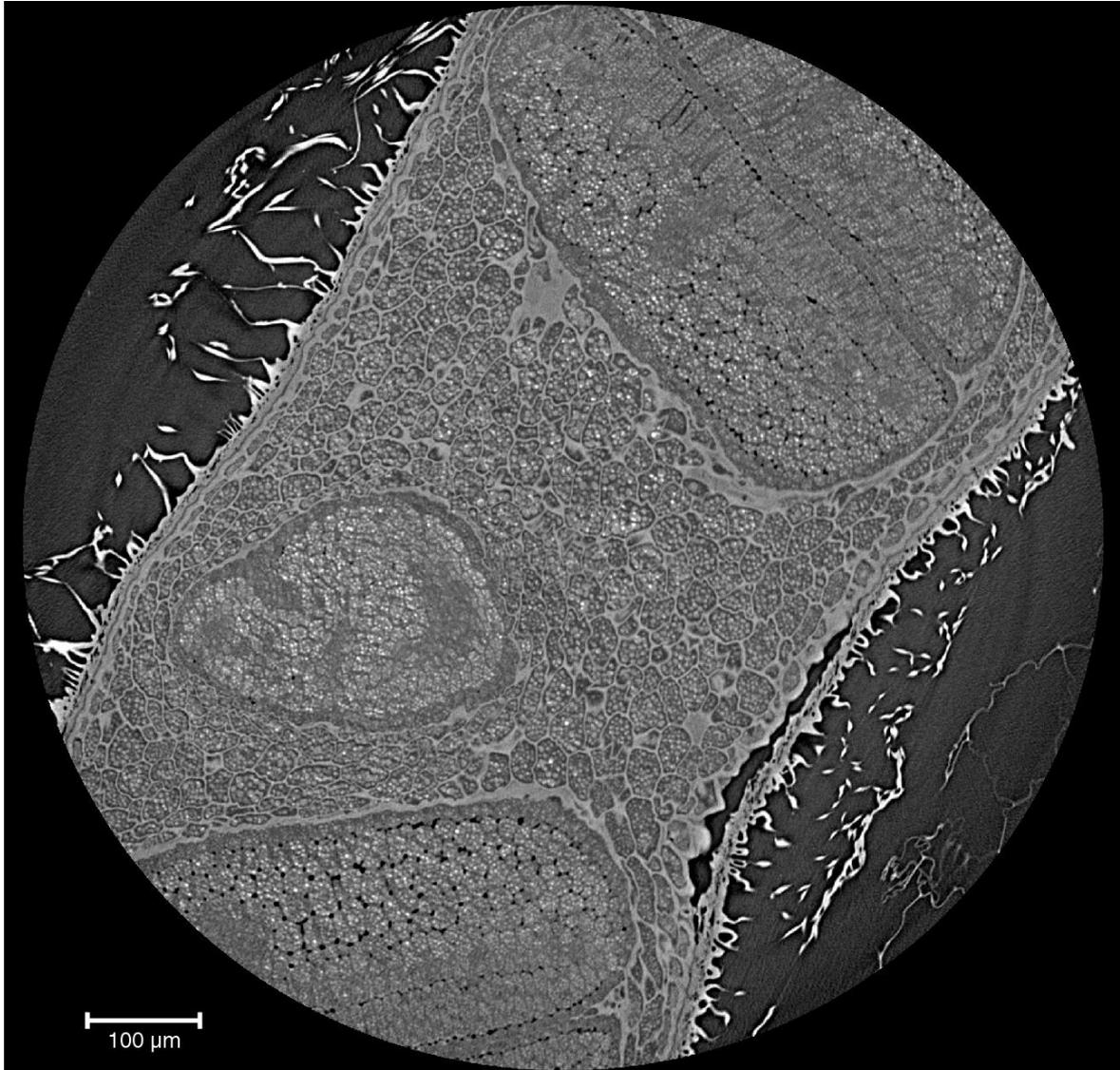


Coupe horizontale



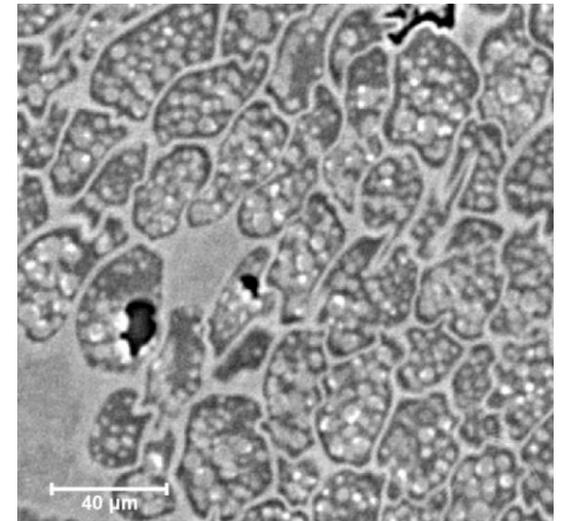
Coupe verticale

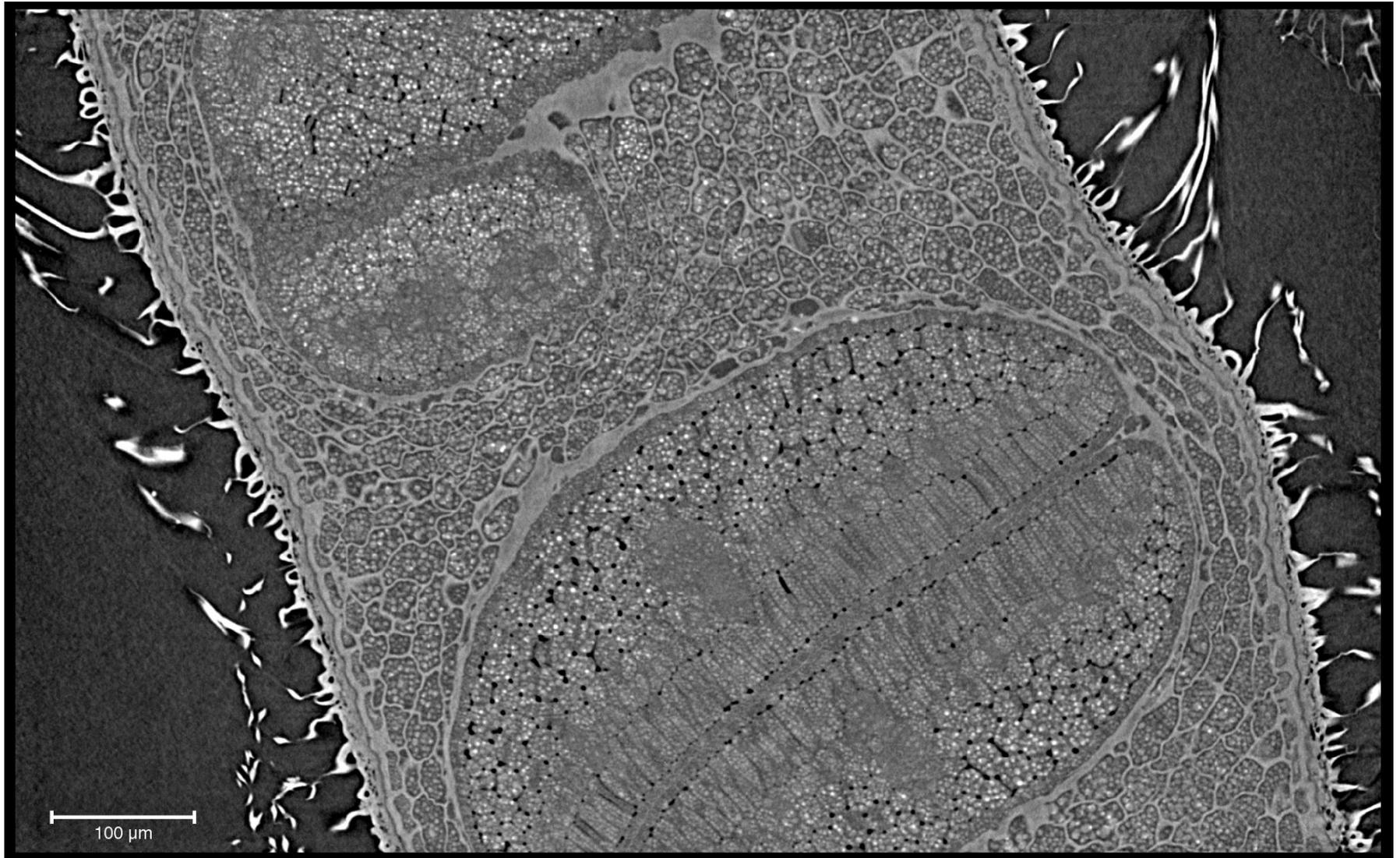
500µm



Coupe horizontale

Scan local haute résolution  
Taille de voxel 0,48 μm  
Temps de scan 8h45

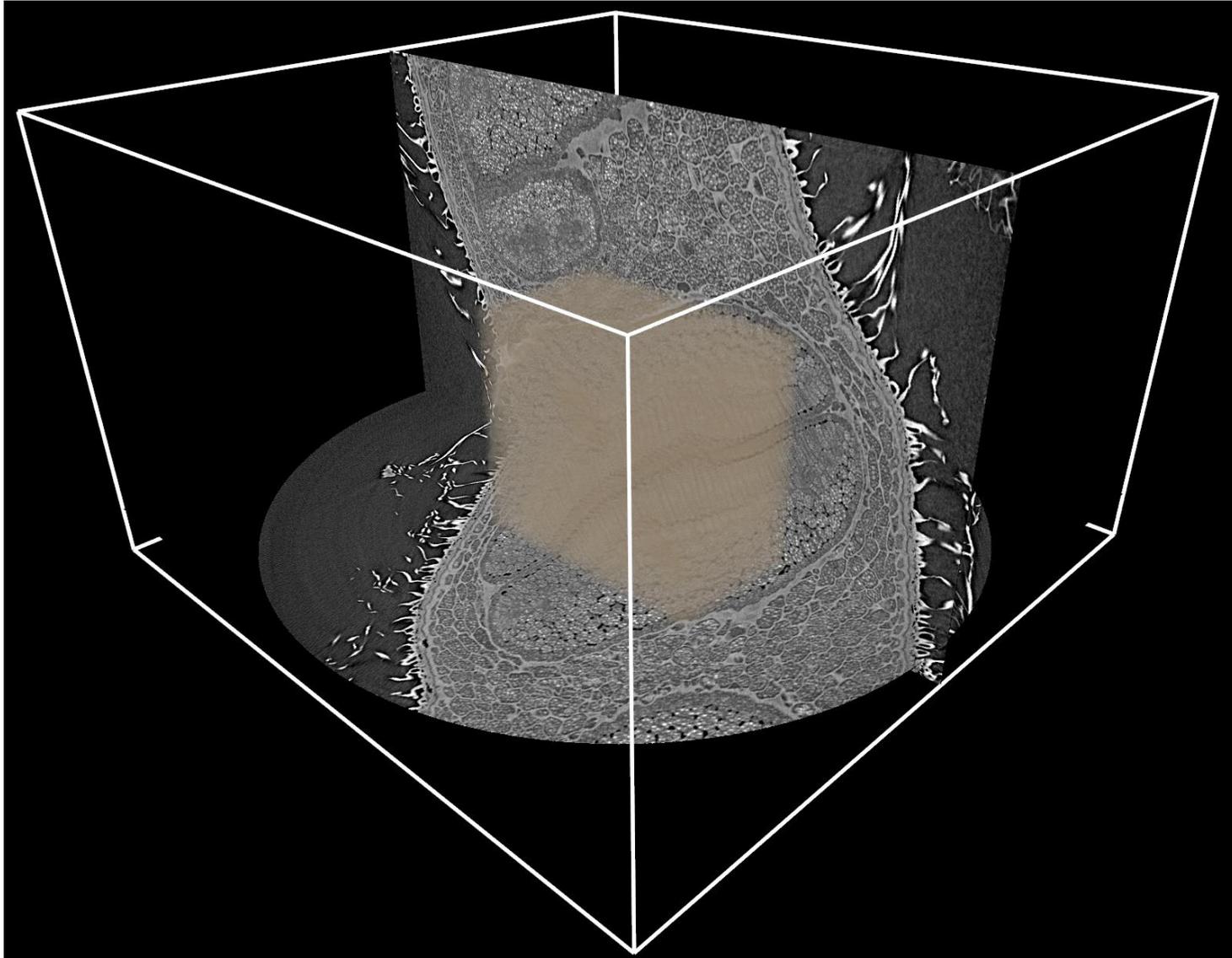




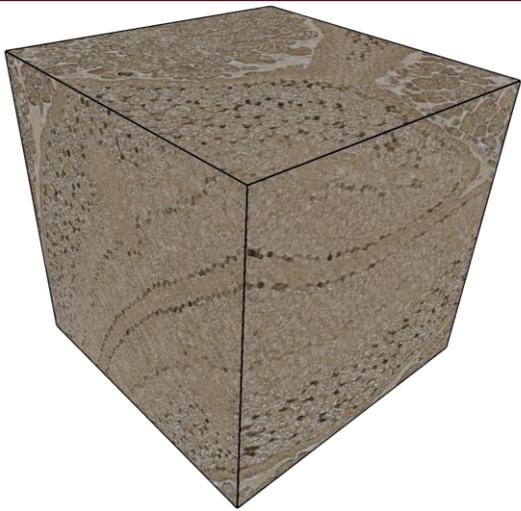
Coupe verticale

# Graine de tomate – Haute résolution

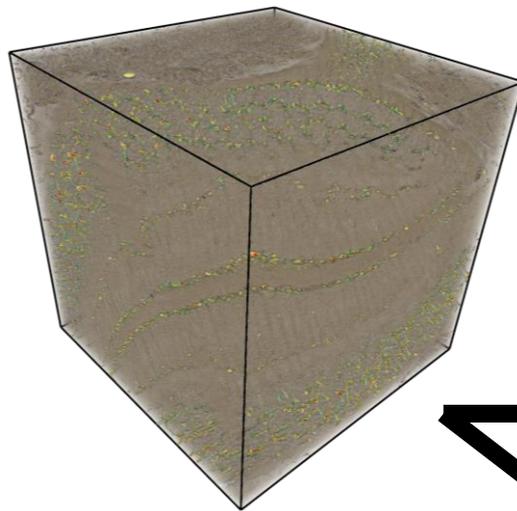
Extraction d'un sous-volume de  $335\ \mu\text{m} \times 335\ \mu\text{m} \times 335\ \mu\text{m}$  – Analyses avec Avizo 9.5



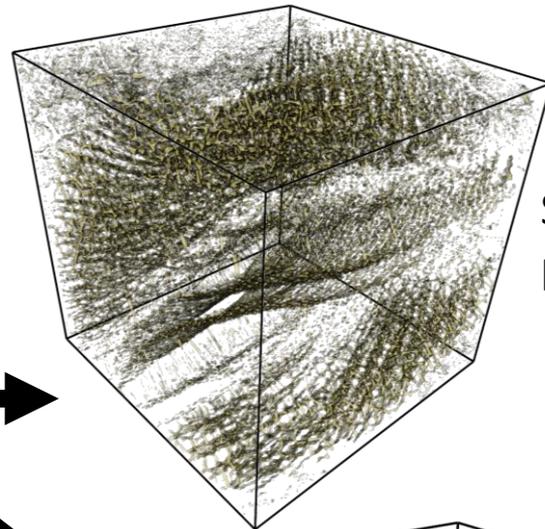
# Graine de tomate – Haute résolution



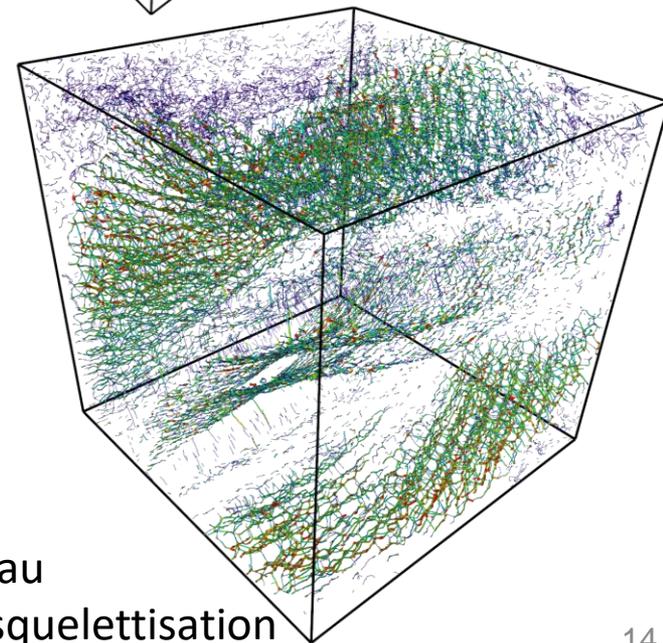
Sous-volume  
(335  $\mu\text{m}$  x 335  $\mu\text{m}$  x 335  $\mu\text{m}$ )



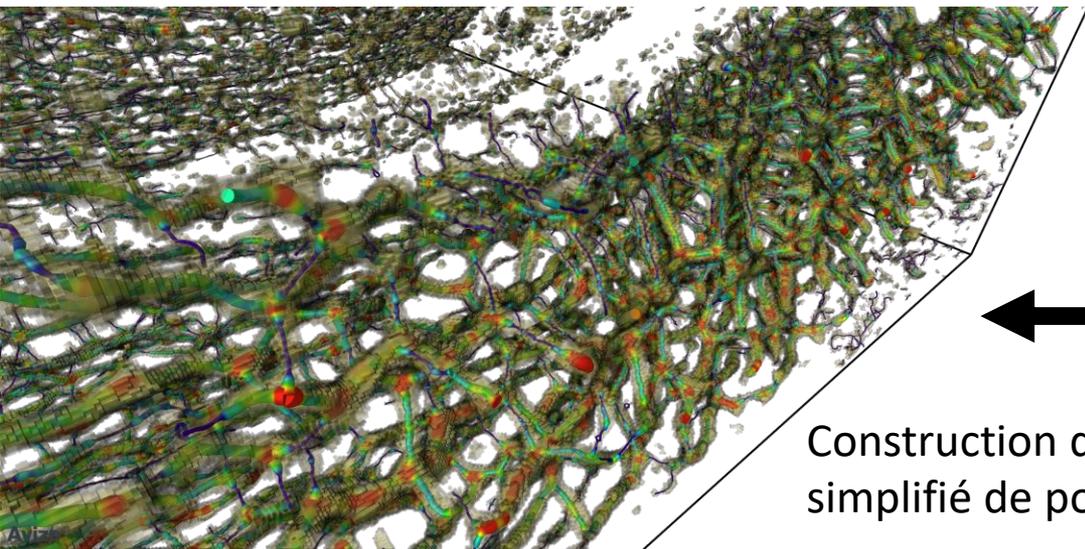
Extraction de  
la porosité



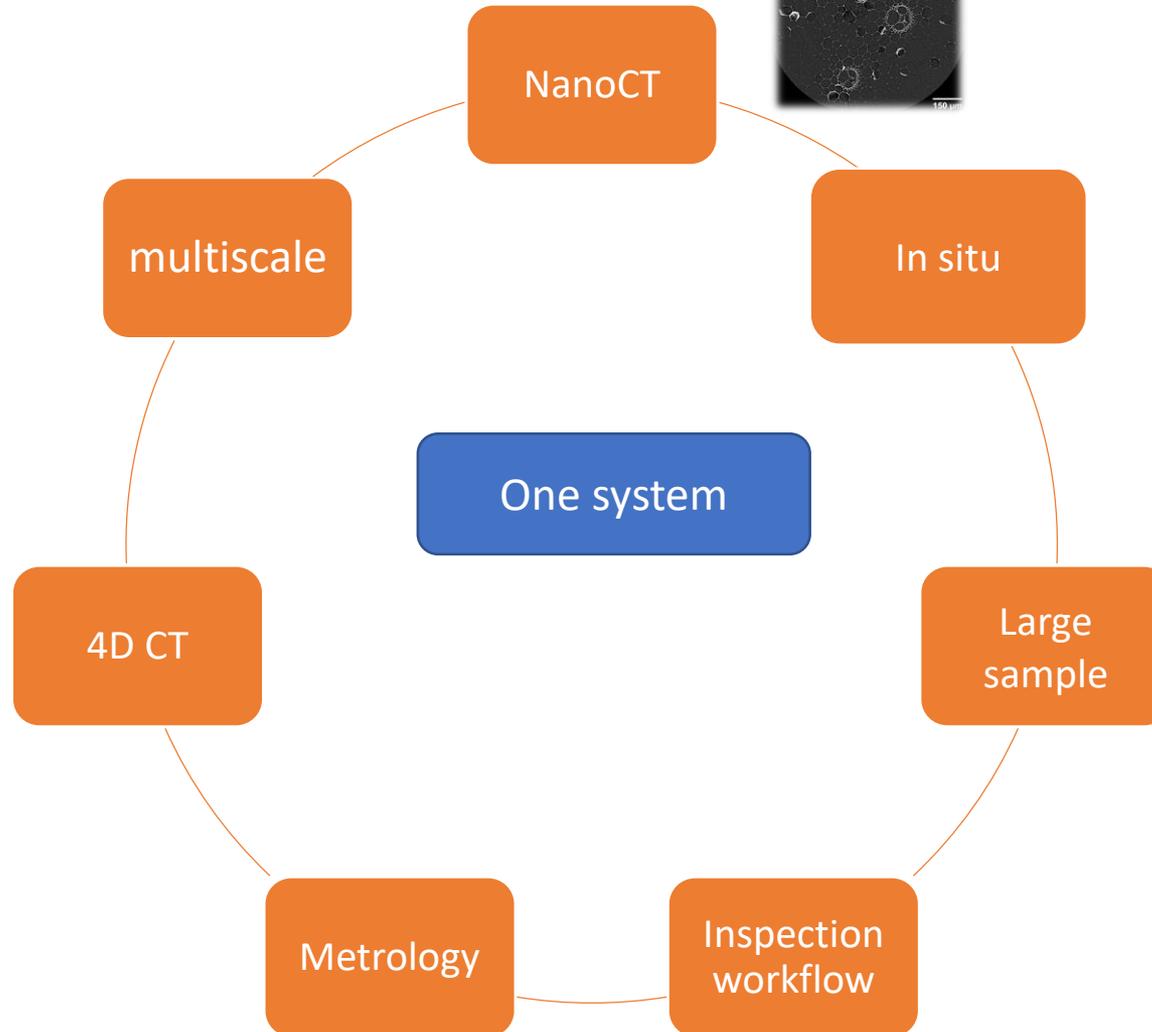
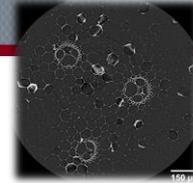
Structures  
poreuses

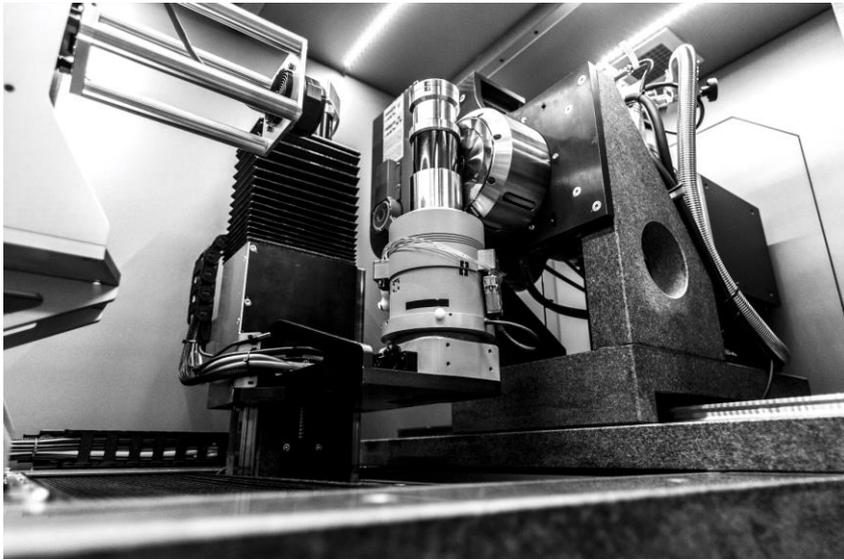


Construction d'un réseau  
simplifié de pores par squelettisation



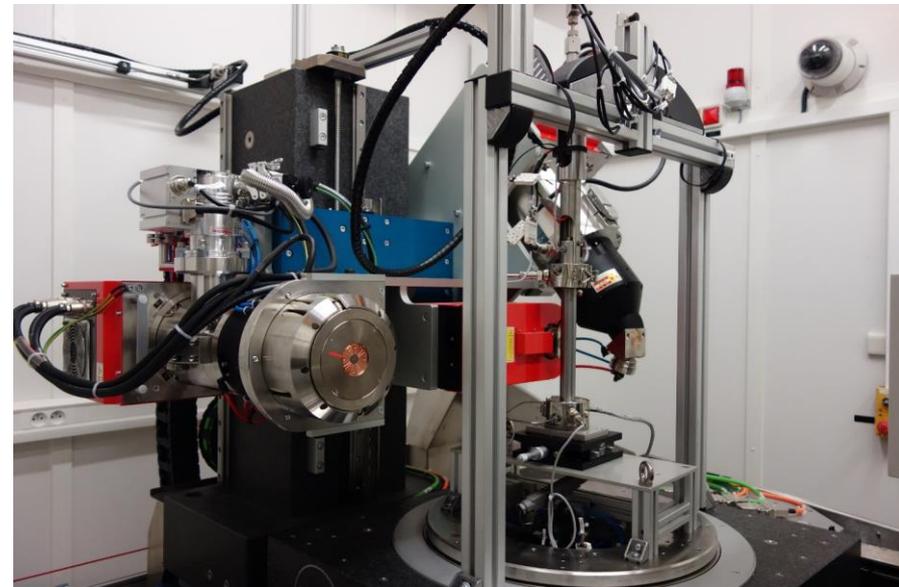
# Tour d'horizon des applications d'un microtomographe à rayons X



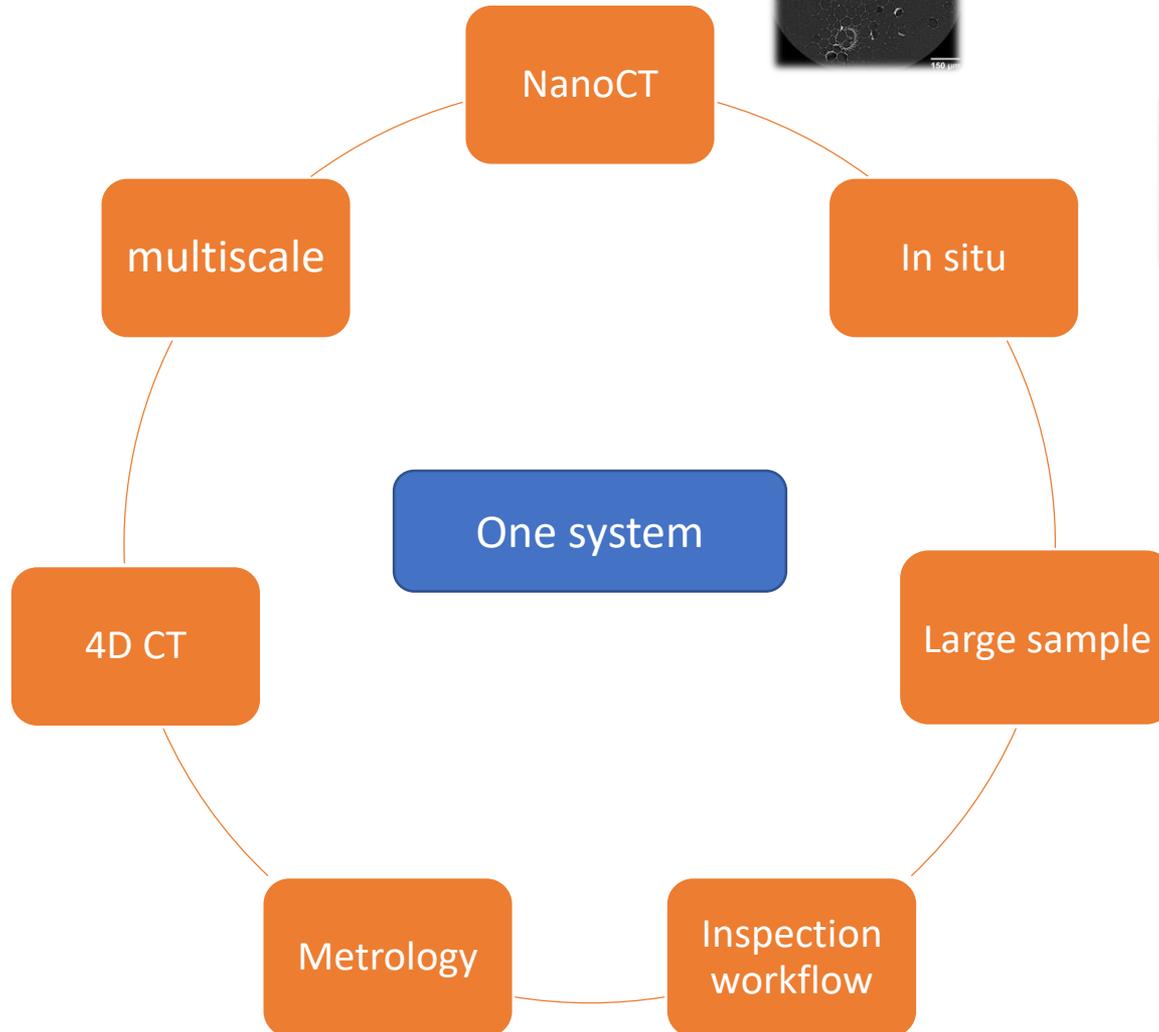
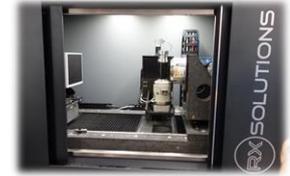
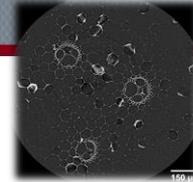


Cellule Deben dans un EasyTom 150-160

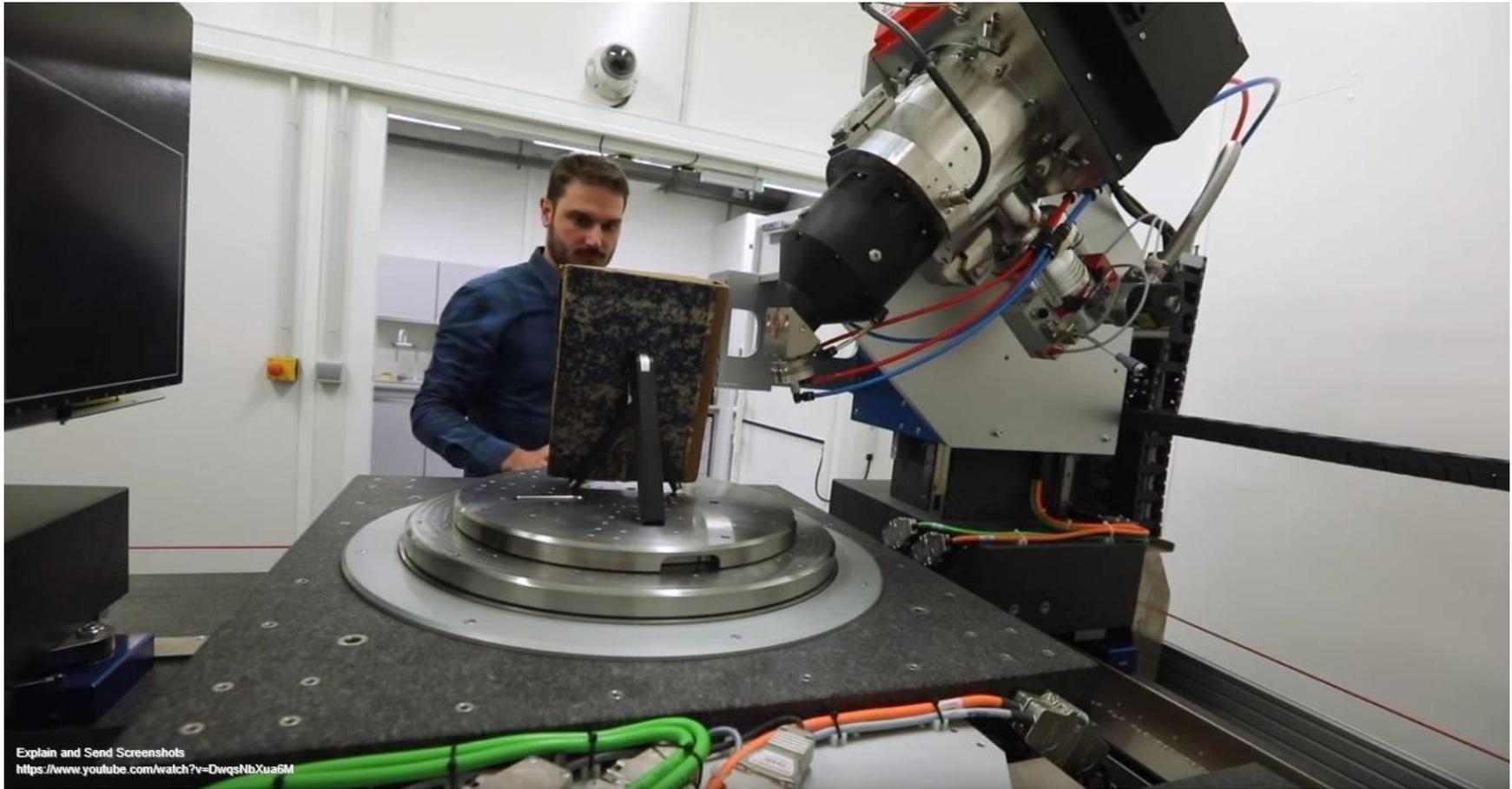
Environnement gazeux à l'ENSMA (Poitiers, France)



# Tour d'horizon des applications d'un microtomographe à rayons X

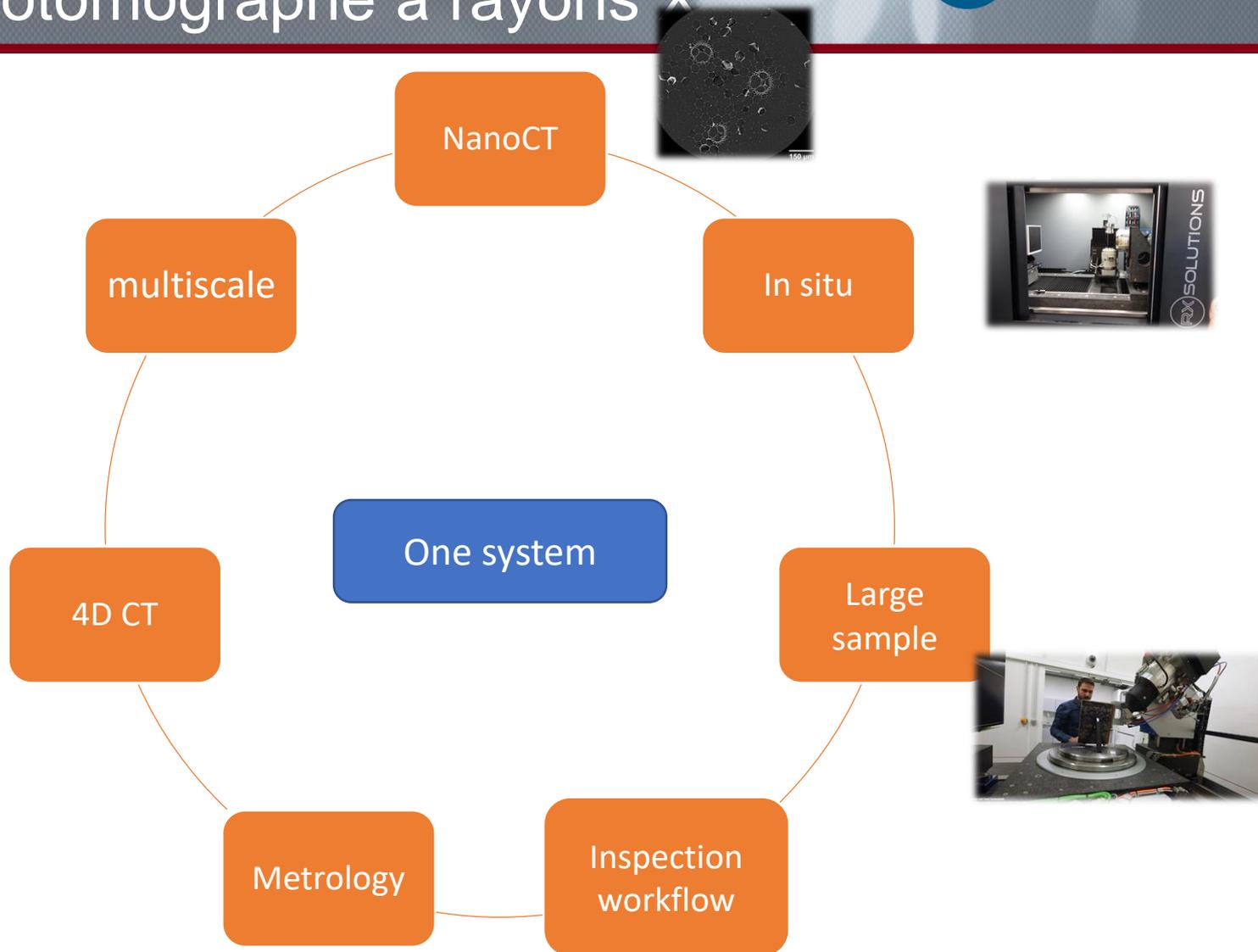


# Large échantillon

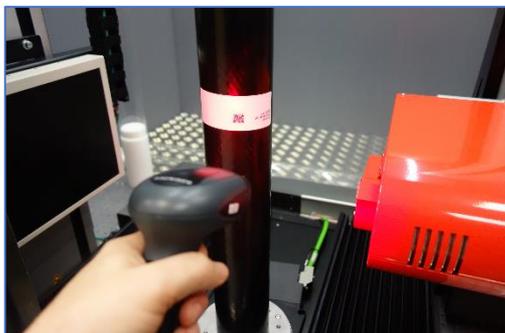


XIVth century Venezian manuscript at EPFL

# Tour d'horizon des applications d'un microtomographe à rayons X



# En production



Lecture de code barre

Reference produit



Acquisition parameters template



Reconstruction parameters template



Volume processing routine

Créé par un utilisateur expert

Acquisition automatique

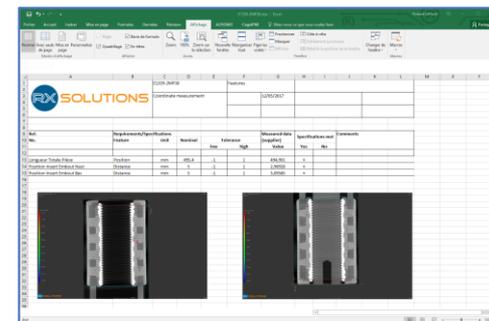
Reconstruction automatique

Post Processing automatique

FAIL

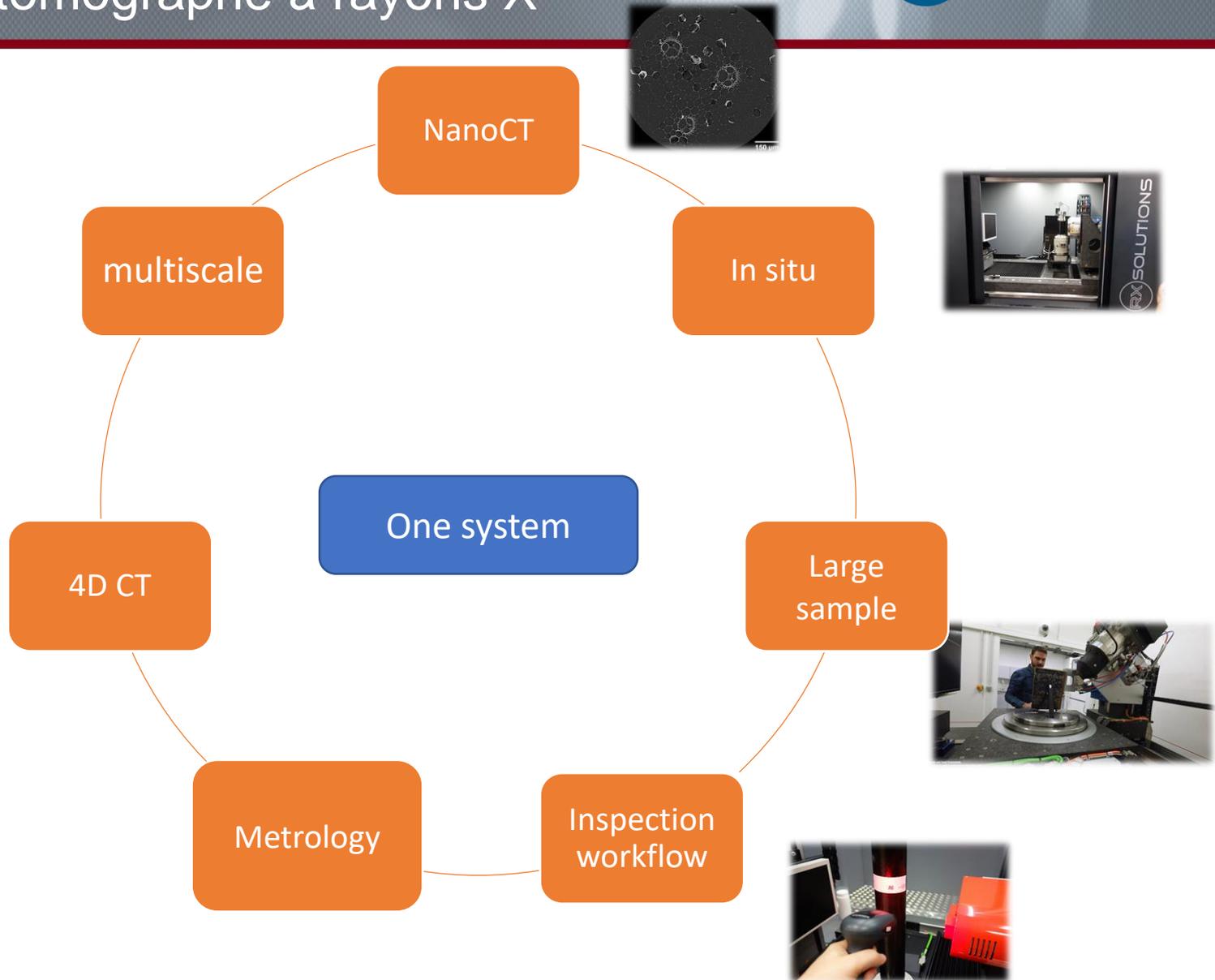
PASS

Lancé par l'opérateur

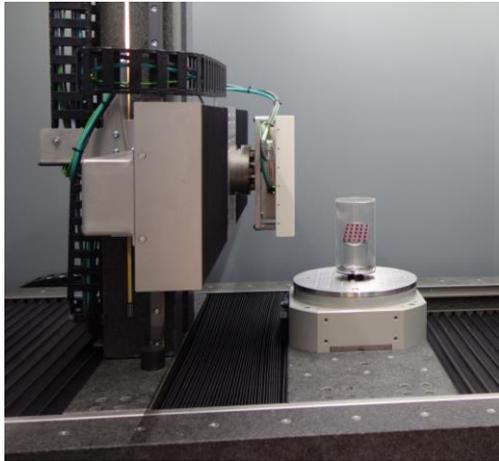


Rapport de contrôle

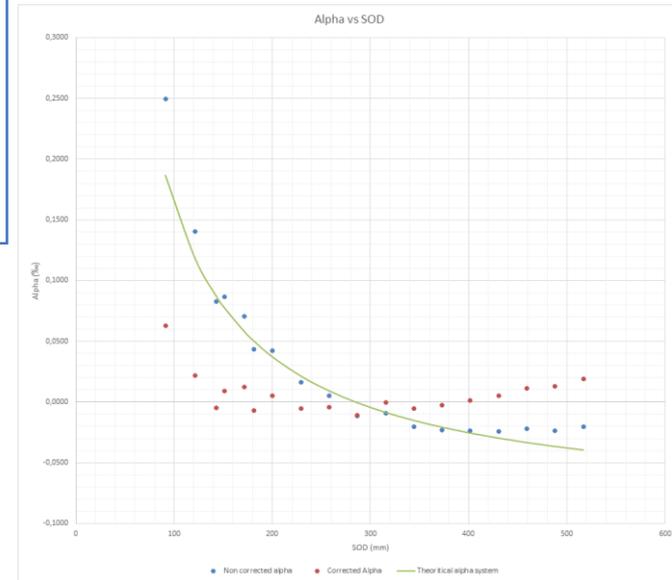
# Tour d'horizon des applications d'un microtomographe à rayons X



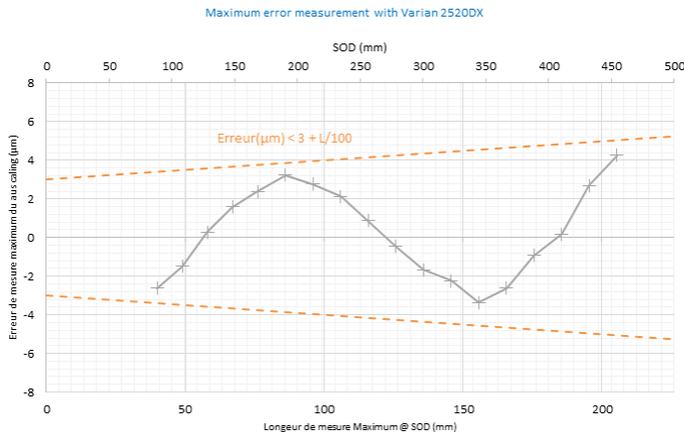
# Qualification métrologique



Evolution  
mécanique des  
équipements pour  
plus de précision  
et de stabilité.



Erreur de mesure sur l'Ultratom

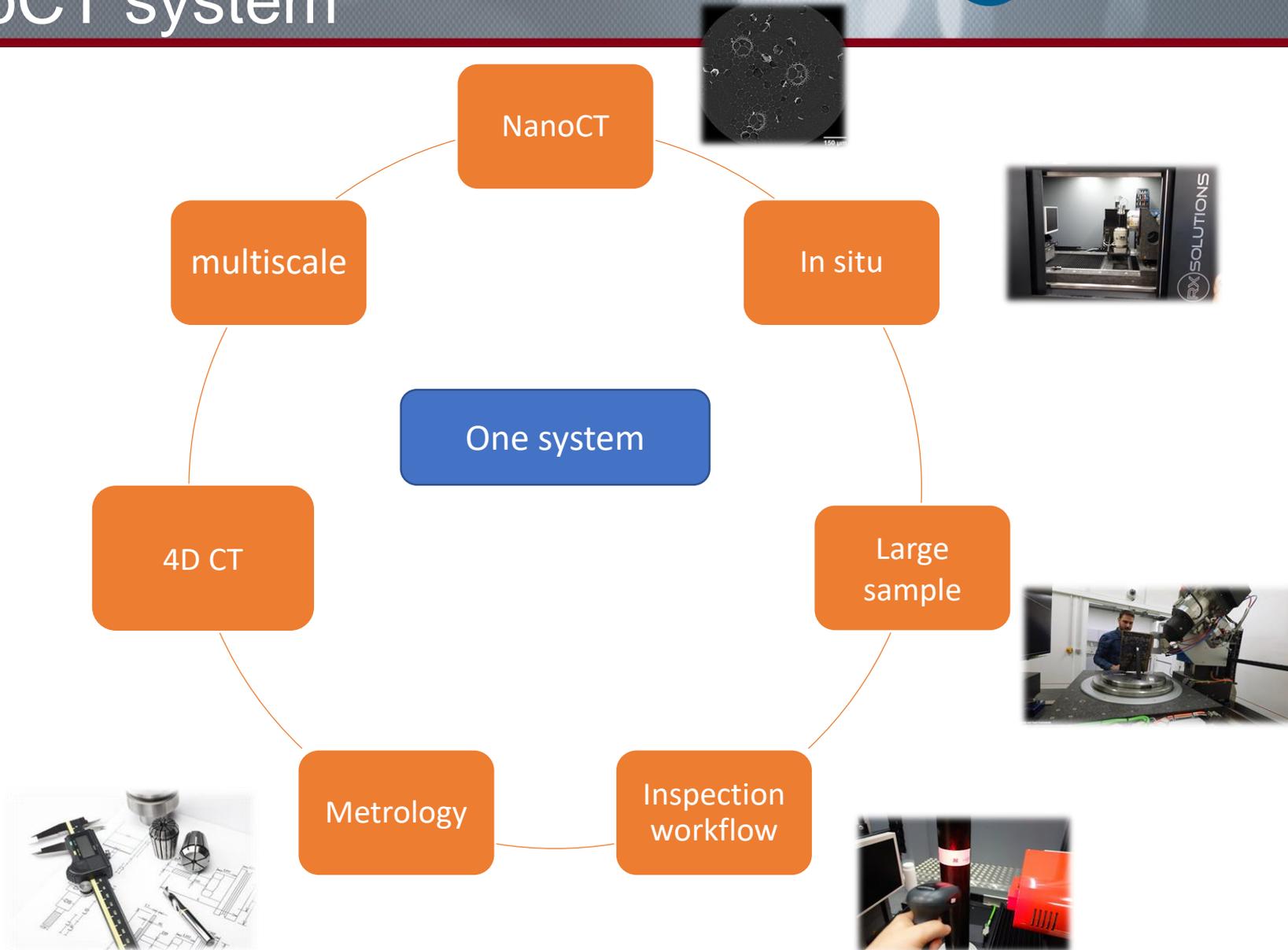


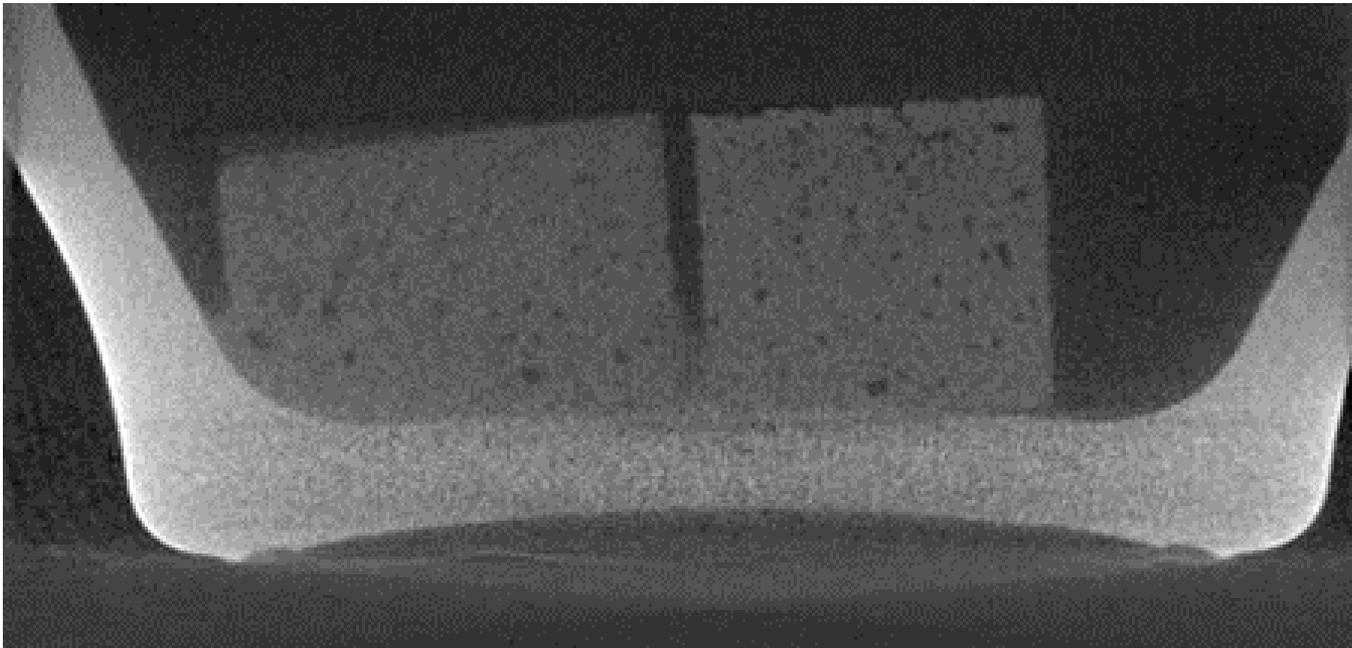
Qualification de l'EasyTom 160 selon la norme allemande VDI/VDE 2630 1.3

Objectif de la démarche : se raccorder au système métrologique international.  
Manque de standard clair, difficultés liés aux artéfacts.

-> R&R

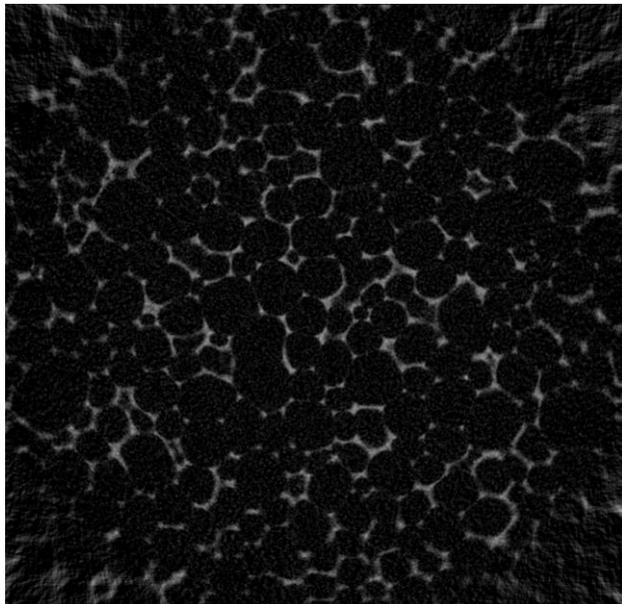
# What can we do with a microCT system



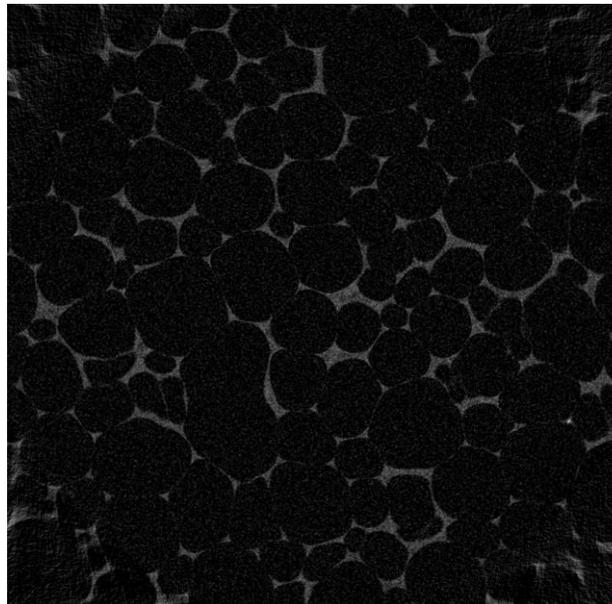


Exemple d'application de scan 4D : fonte de morceaux de sucre dans l'eau.

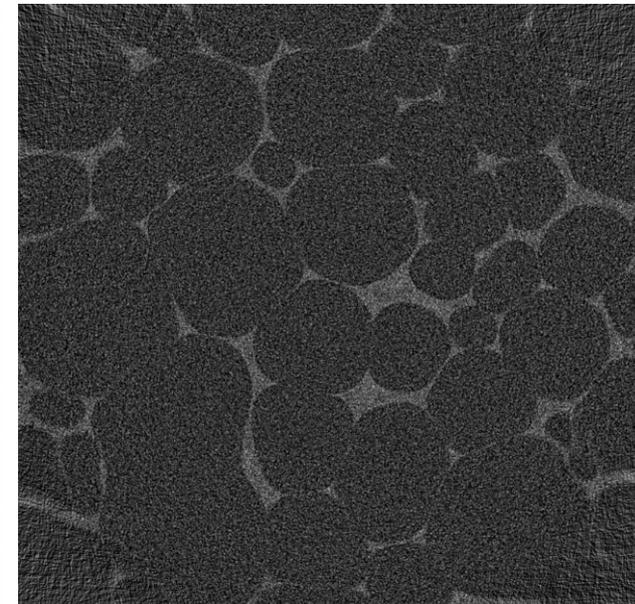
Temps de scan total 34 secondes, 4 rotations. Taille de voxel : 110  $\mu\text{m}$



10 secondes  
7  $\mu\text{m}$

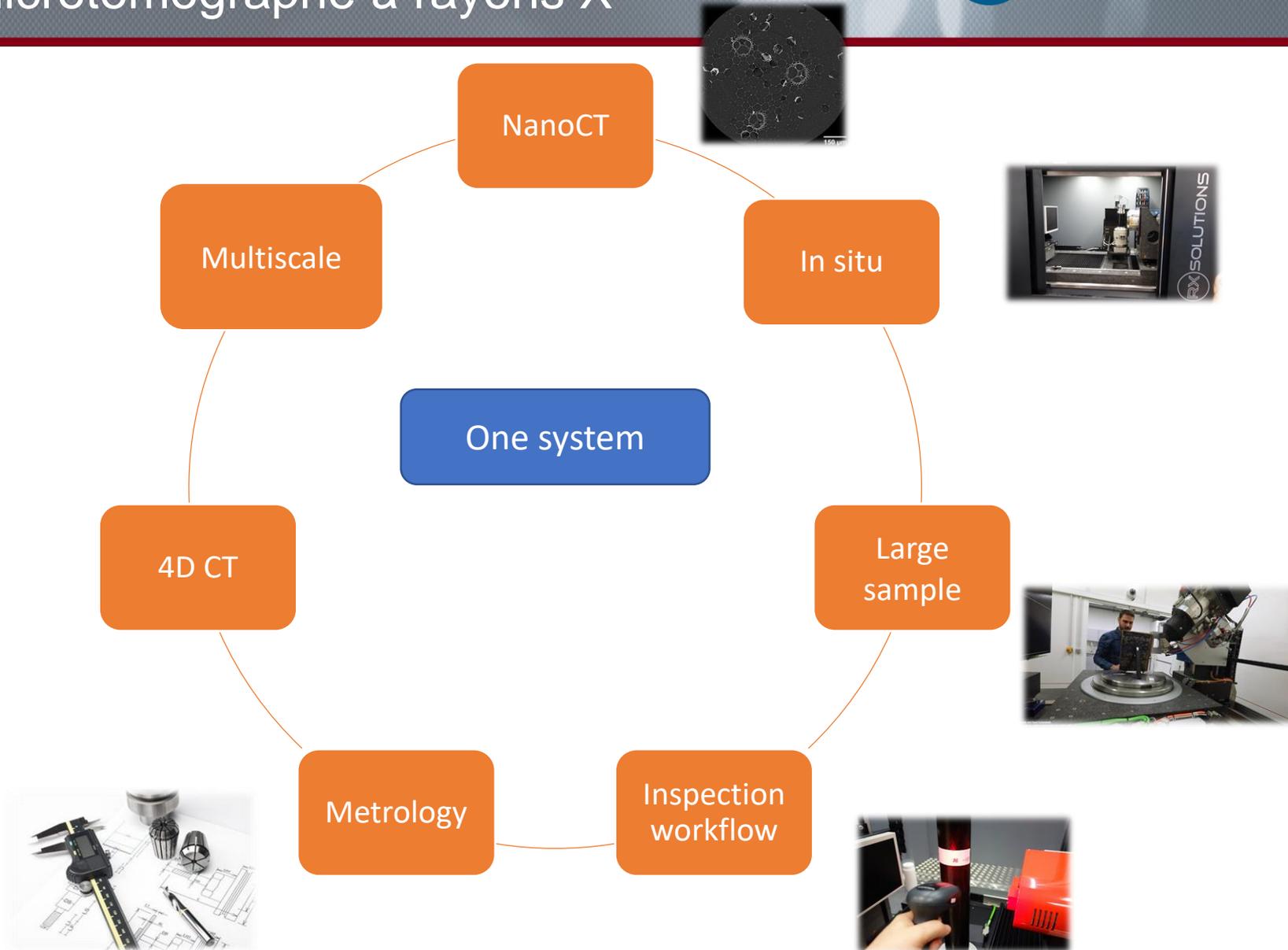


60 secondes  
4  $\mu\text{m}$



60 secondes  
2  $\mu\text{m}$

# Tour d'horizon des applications d'un microtomographe à rayons X



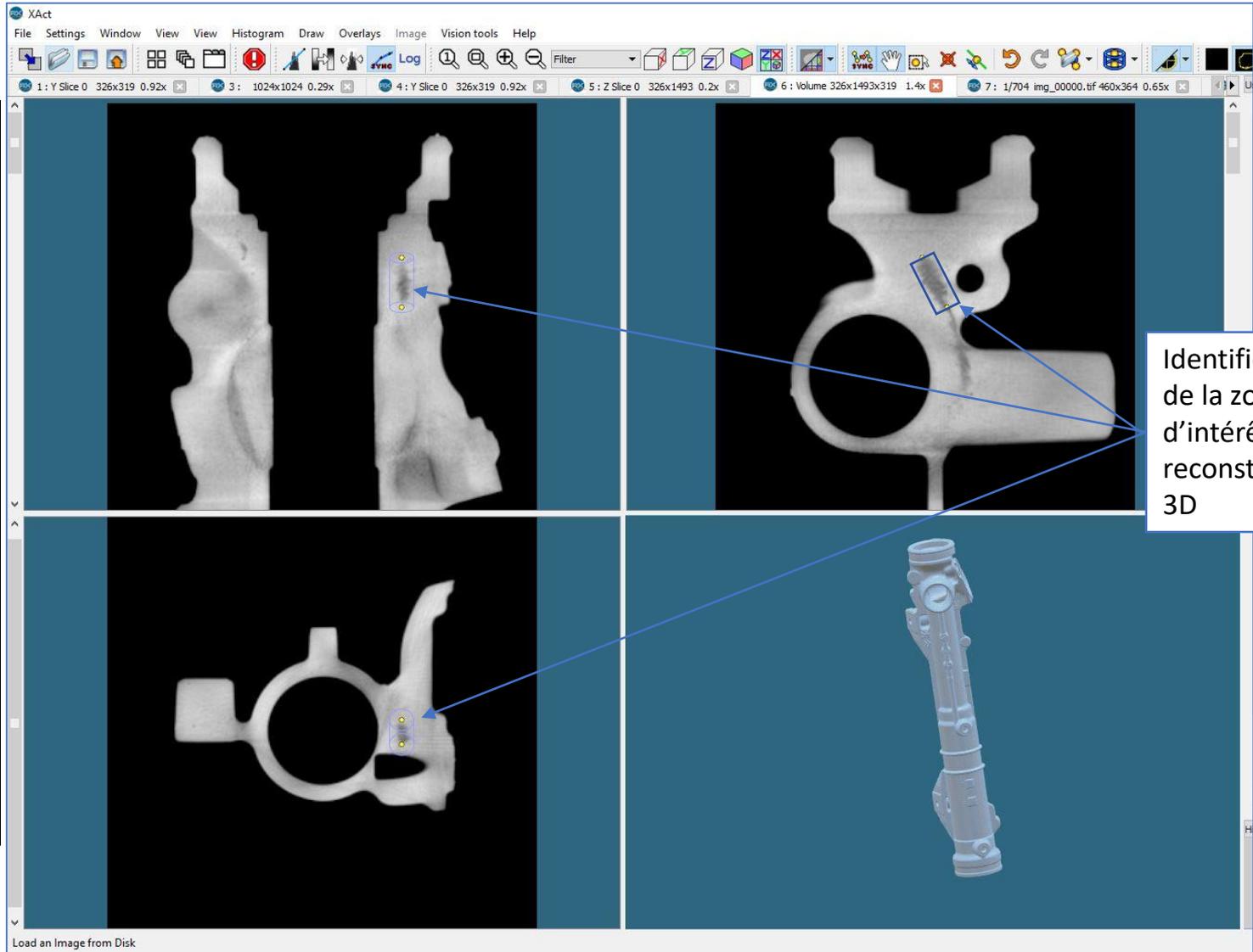
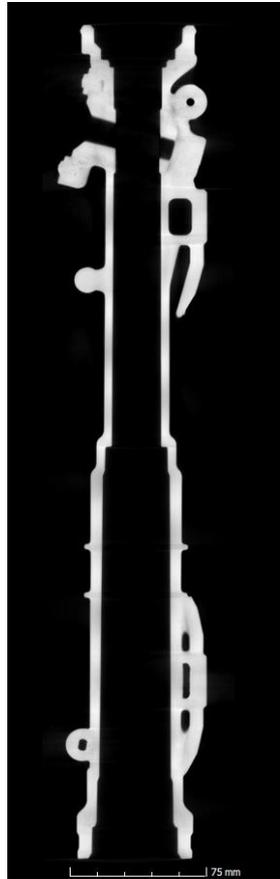
# Fonderie Aluminium Echelle 1: pièce entière



Temps de scan : 10 min  
Taille de voxel: 300  $\mu$ m

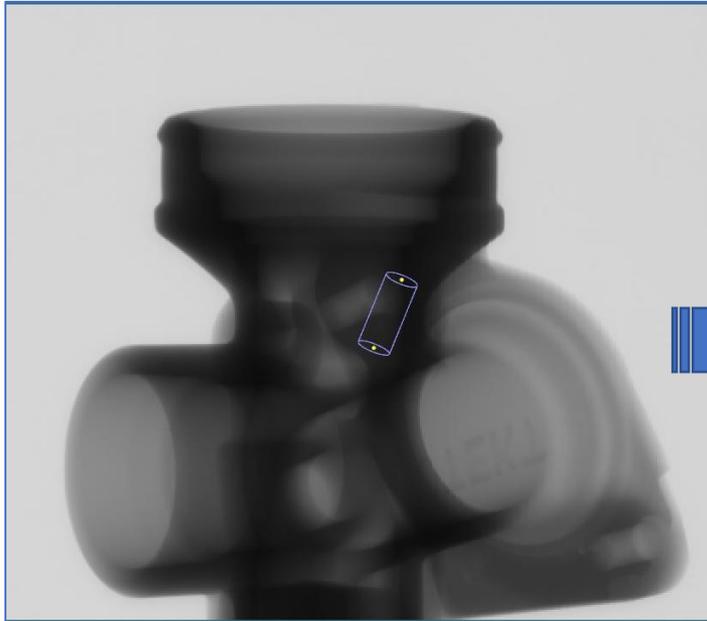


# Echelle 1: pièce entière

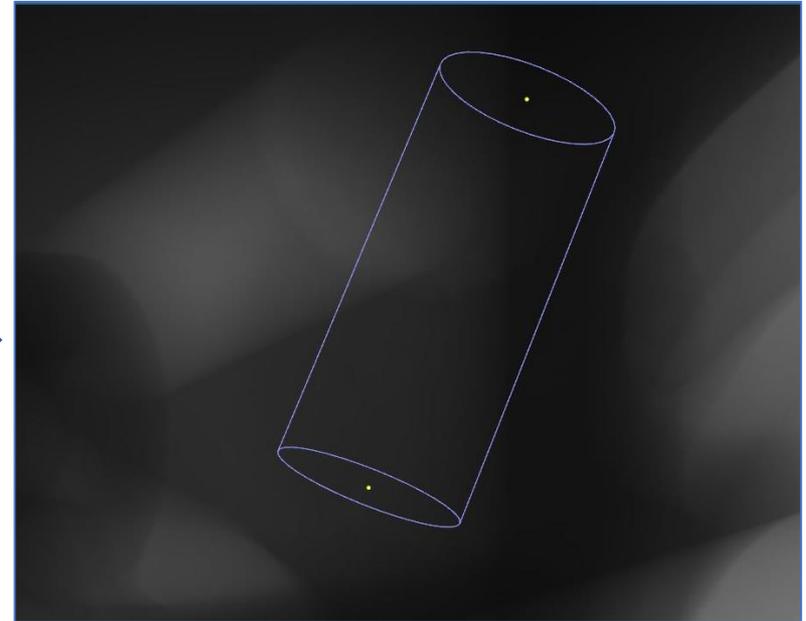


Identification de la zone d'intérêt sur la reconstruction 3D

# Echelle 2 : scan local

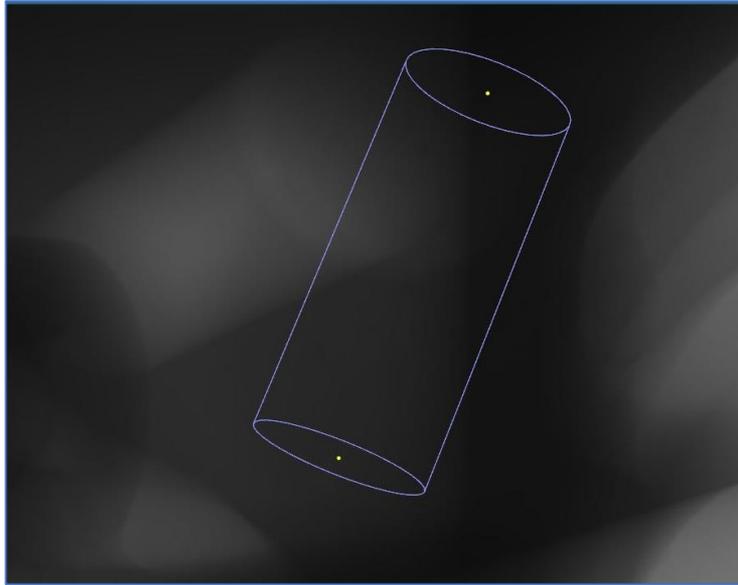


Affichage en temps réel de la zone d'intérêt sur l'échantillon dans la machine

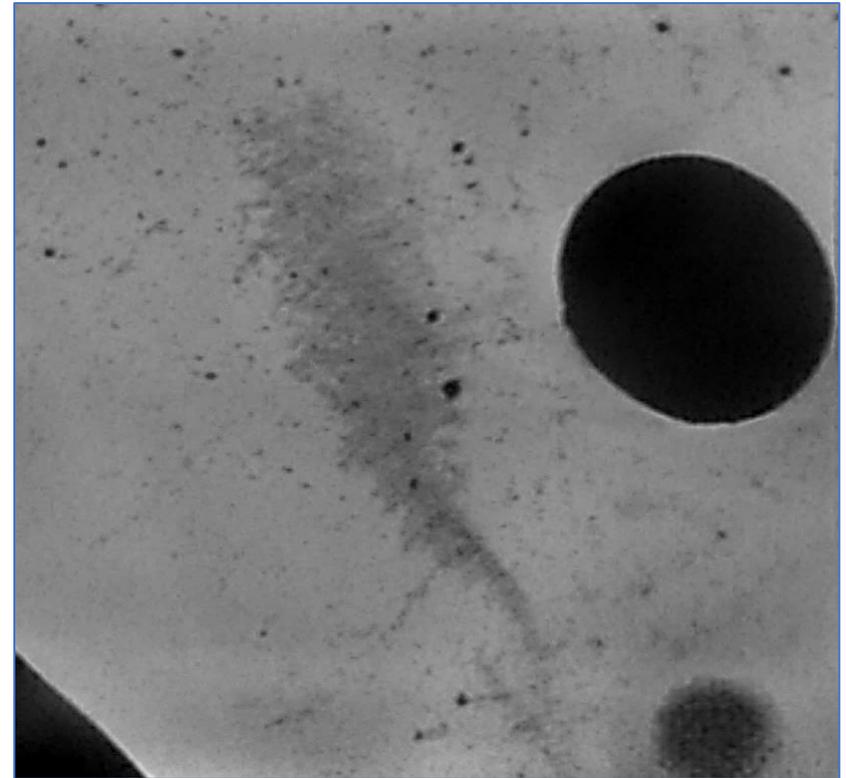


Ajustement et centrage de la zone pour le scan local

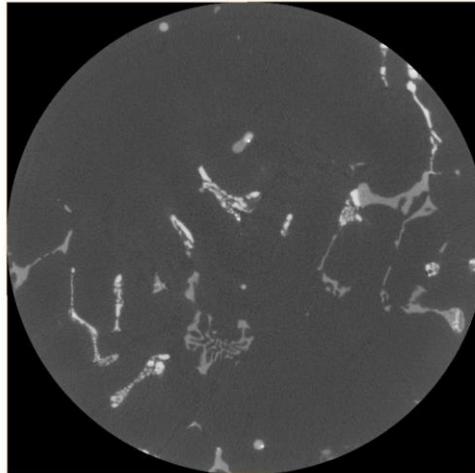
# Echelle 2 : scan local



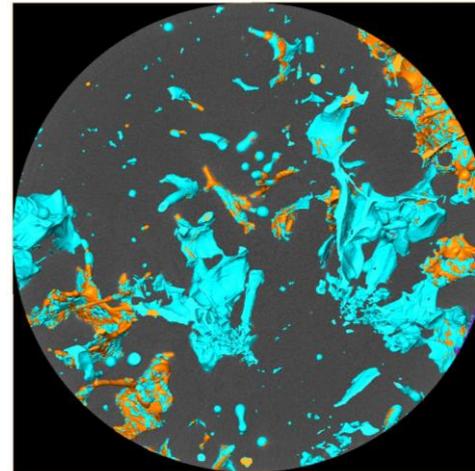
Résultat du scan local.  
Taille de voxel : 70  $\mu\text{m}$



# Echelle 3: Eprouvette



[μm]

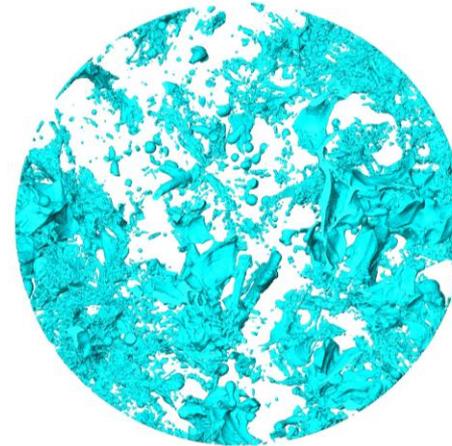


0 400 [μm]

Alliage d'aluminium  
Taille de voxel 400 nm



0 400 [μm]

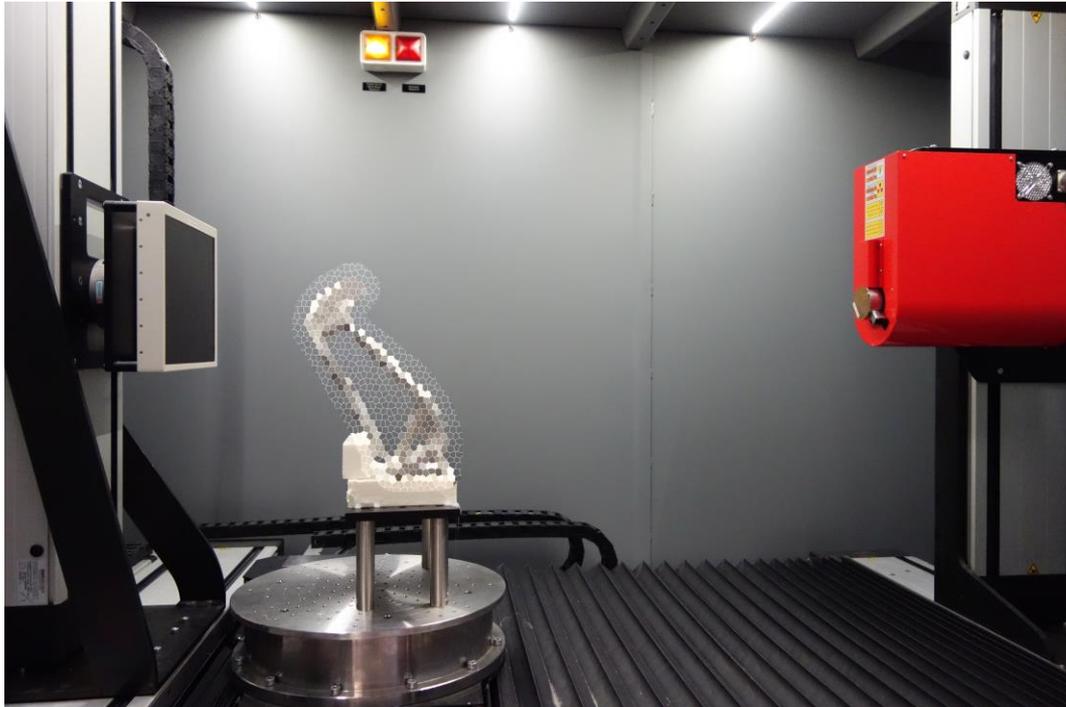


0 400 [μm]

Phase cuivre

Phase Aluminium

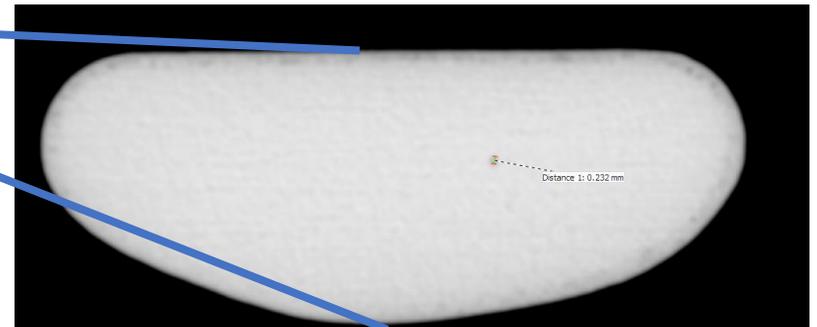
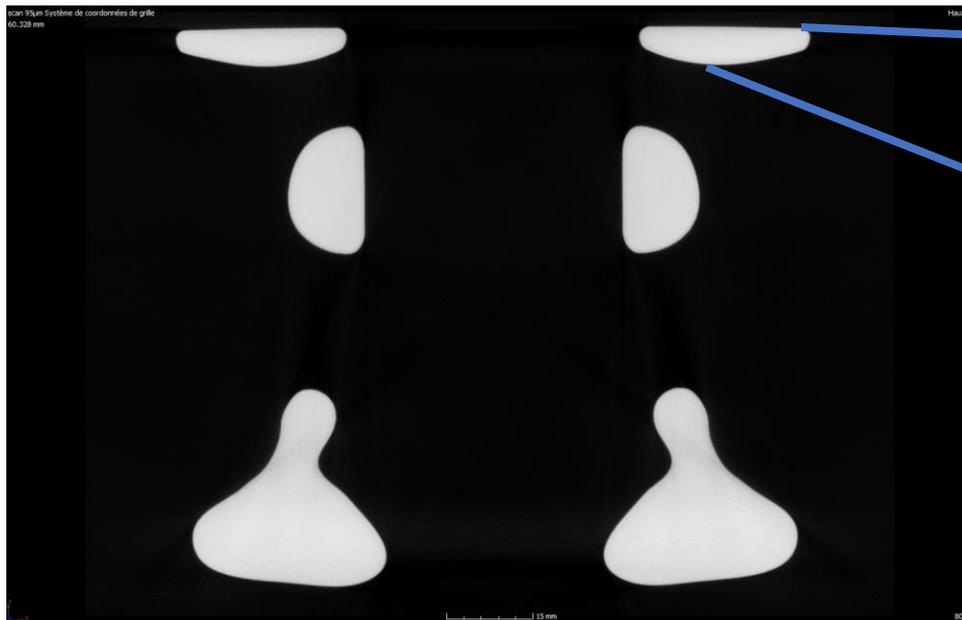
# Fabrication additive: Echelle 1 : pièce entière



Contrôle de la pièce  
entière après  
impression 3D

Taille de voxel 100  $\mu\text{m}$   
Temps de scan : 2  
heures

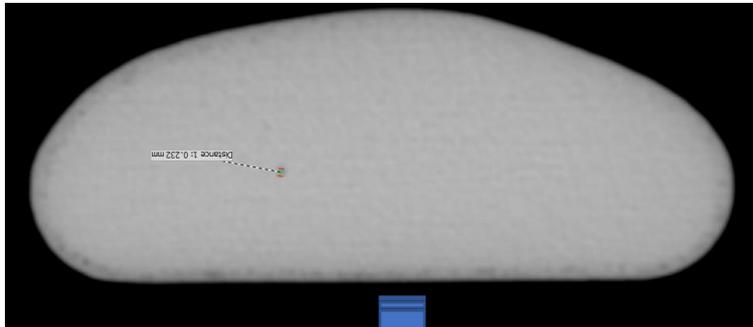
# Echelle 1 : pièce entière



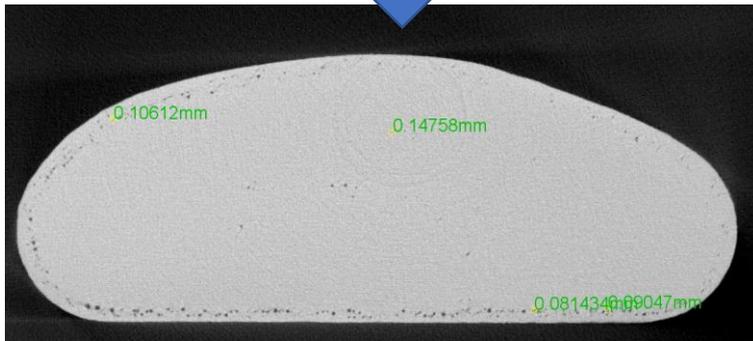
Résultat de l'analyse de détection de porosités :  
aucune porosité supérieure à 0,3 mm

Suspicion de défauts < 0,3 mm

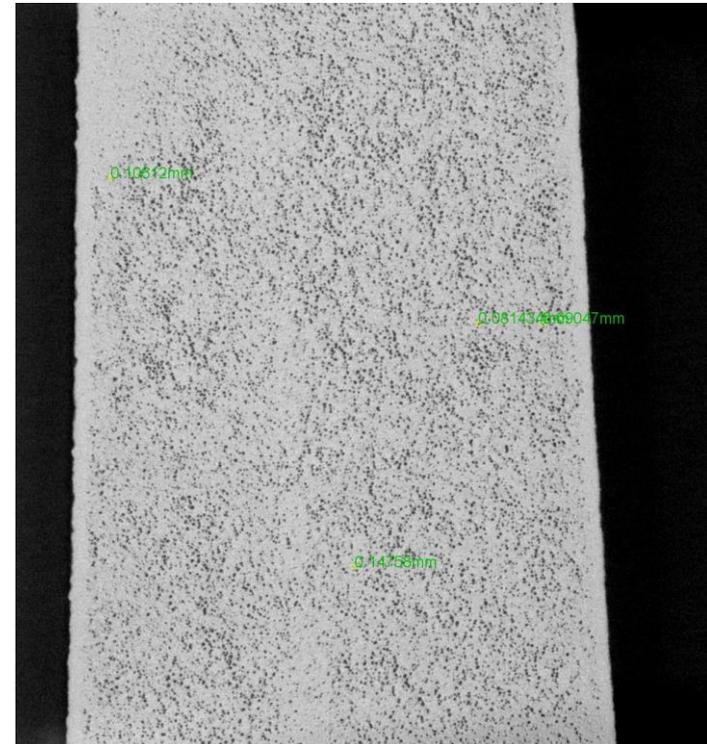
# Echelle 2 : Scan local



Scan 100µm



Scan 20µm



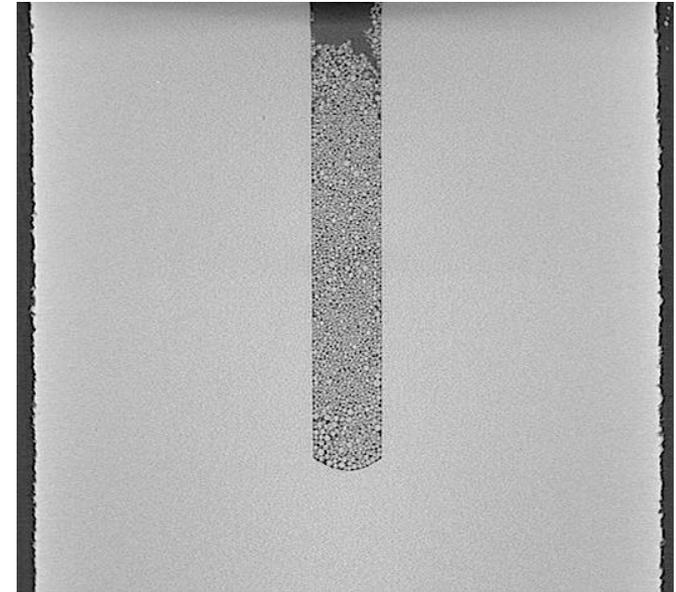
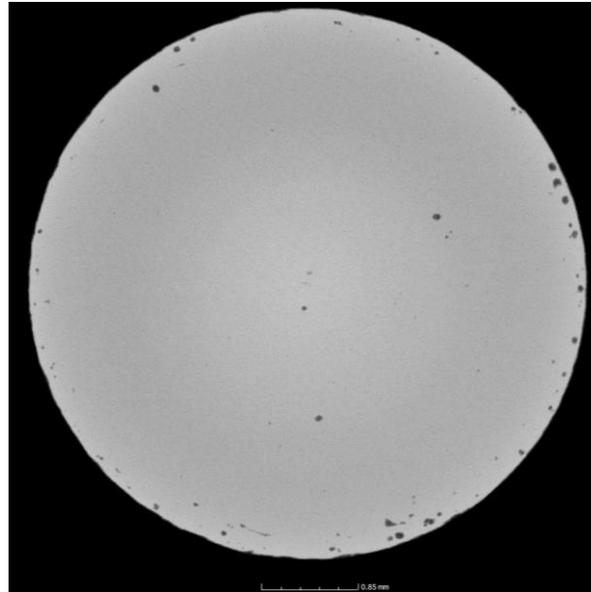
Pièce intacte -> contrôle non destructif

Quantification de microporosités dans le volume scanné.

Attention :

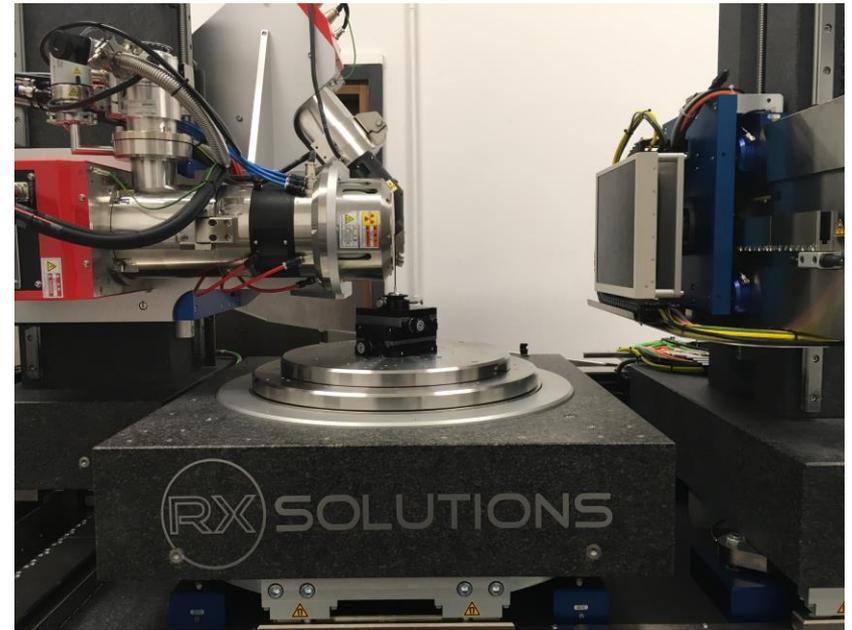
- scan de la pièce entière à haute résolution est techniquement possible (différentes techniques de mosaïques au niveau de l'acquisition ou du post-traitement),
- MAIS implique des temps de scans et de traitement ainsi que des volumes de données colossaux

# Echelle 2: Eprouvette de caractérisation



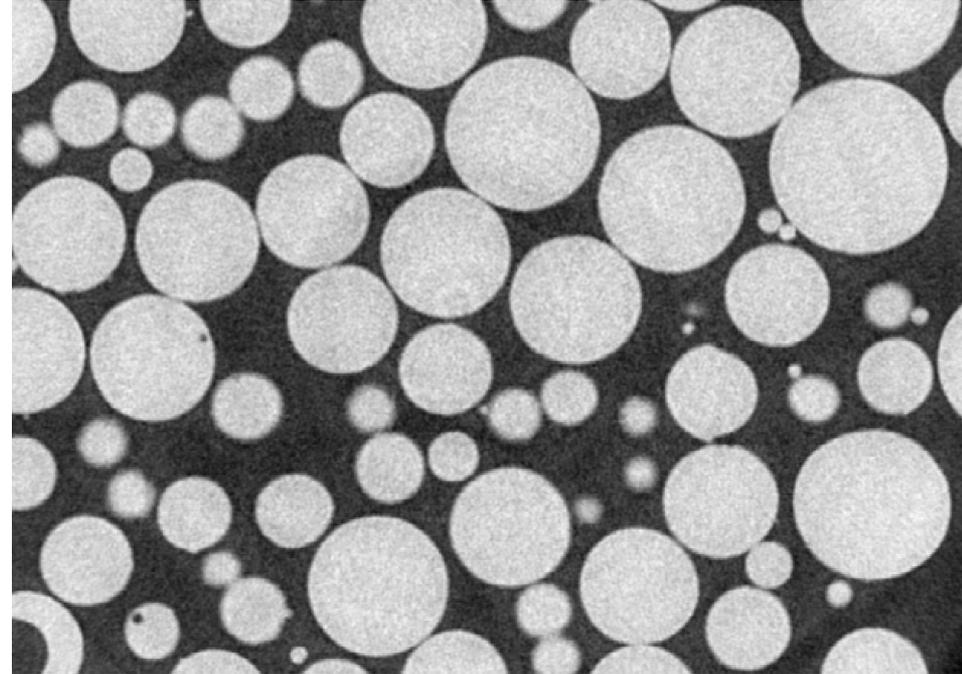
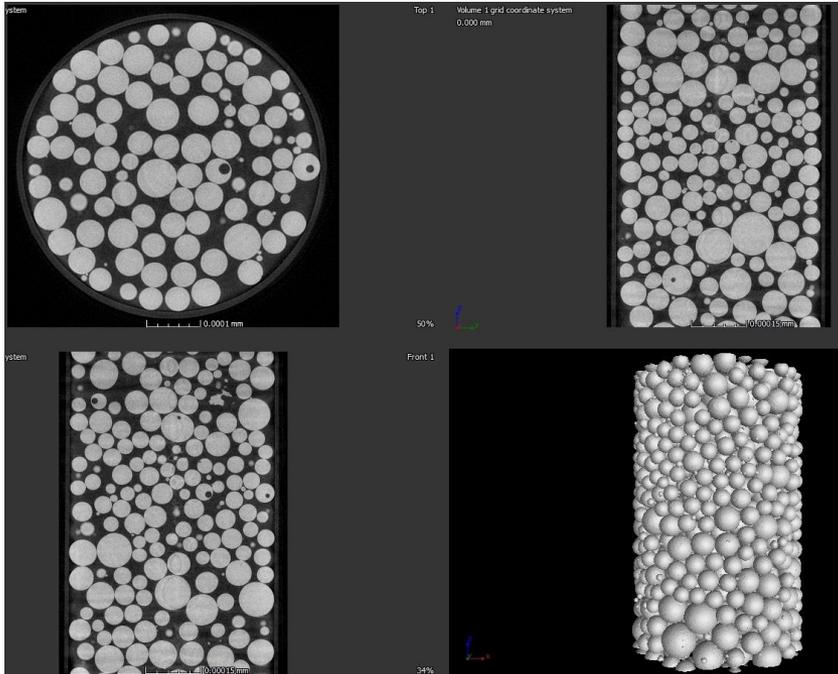
Cylindre en titane, fabrication additive. Taille de voxel 20  $\mu\text{m}$

# Echelle 3: eprouvette de poudre de TA6V



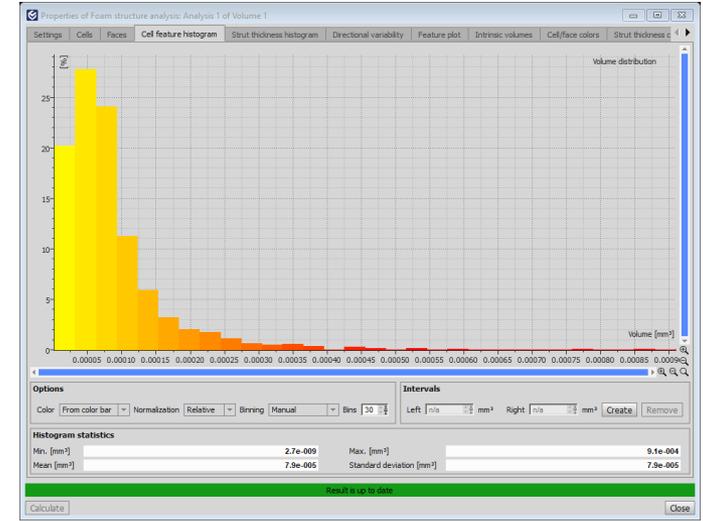
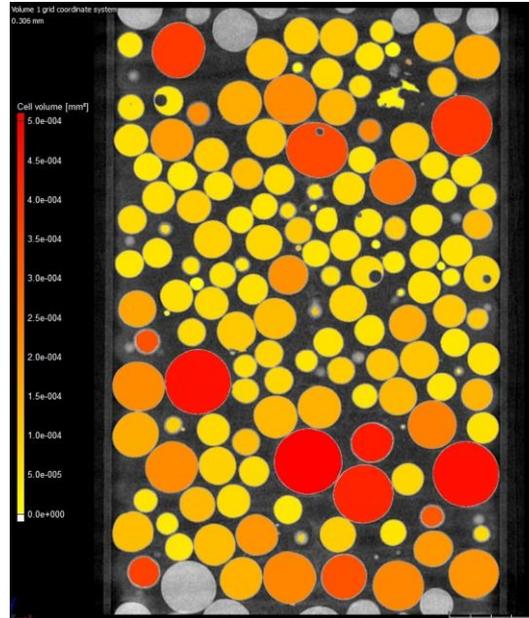
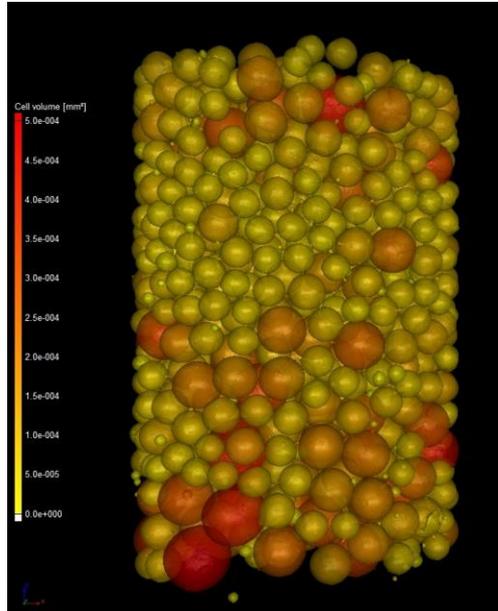
Voxel size : 0.7  $\mu\text{m}$

# Echelle 3: Eprouvette



Taille de Voxel : 0.7  $\mu\text{m}$

# Echelle 3: Eprouvette



Analyse statistique des diamètres de sphères

# Merci !

