



# X-ray phase nano-tomography for bone research

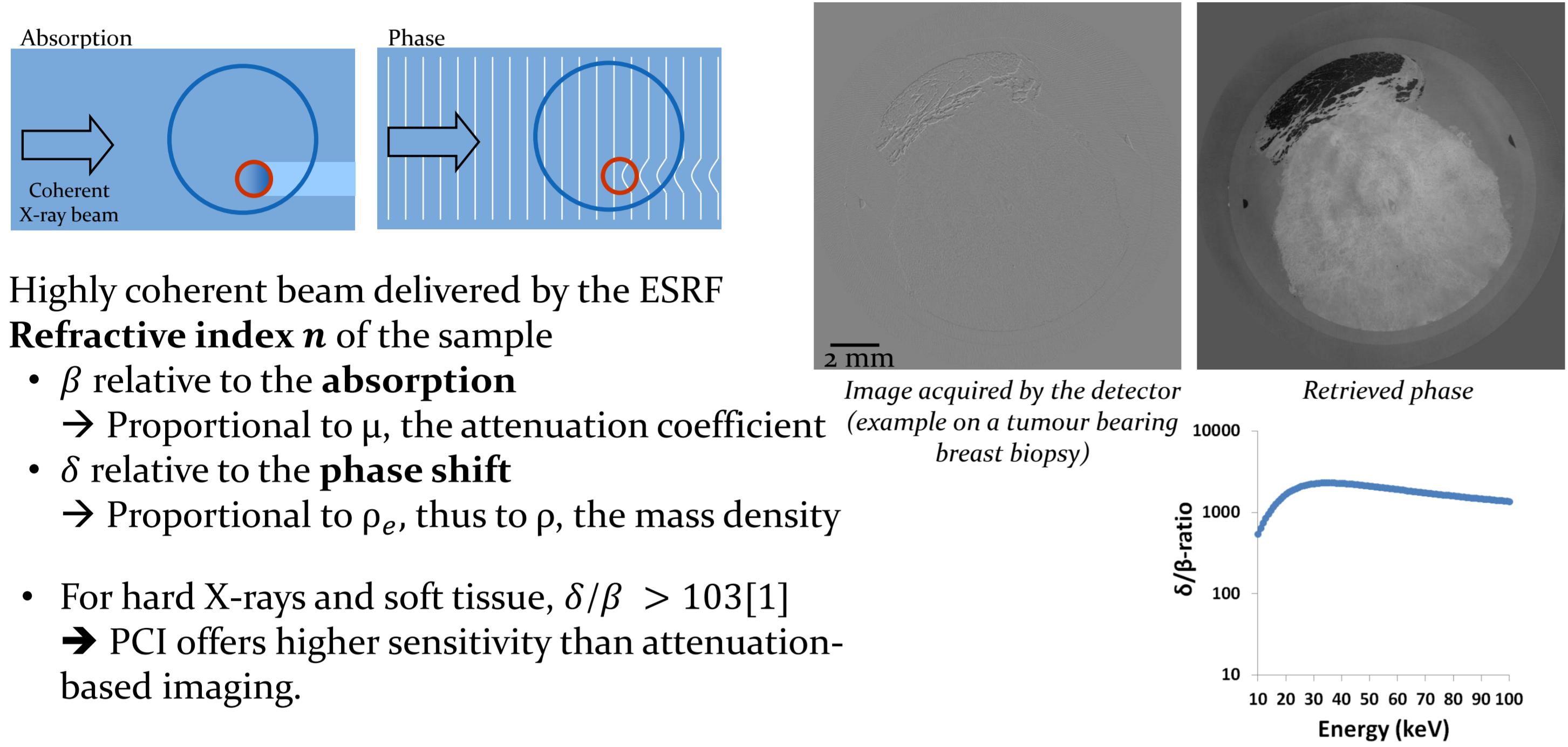
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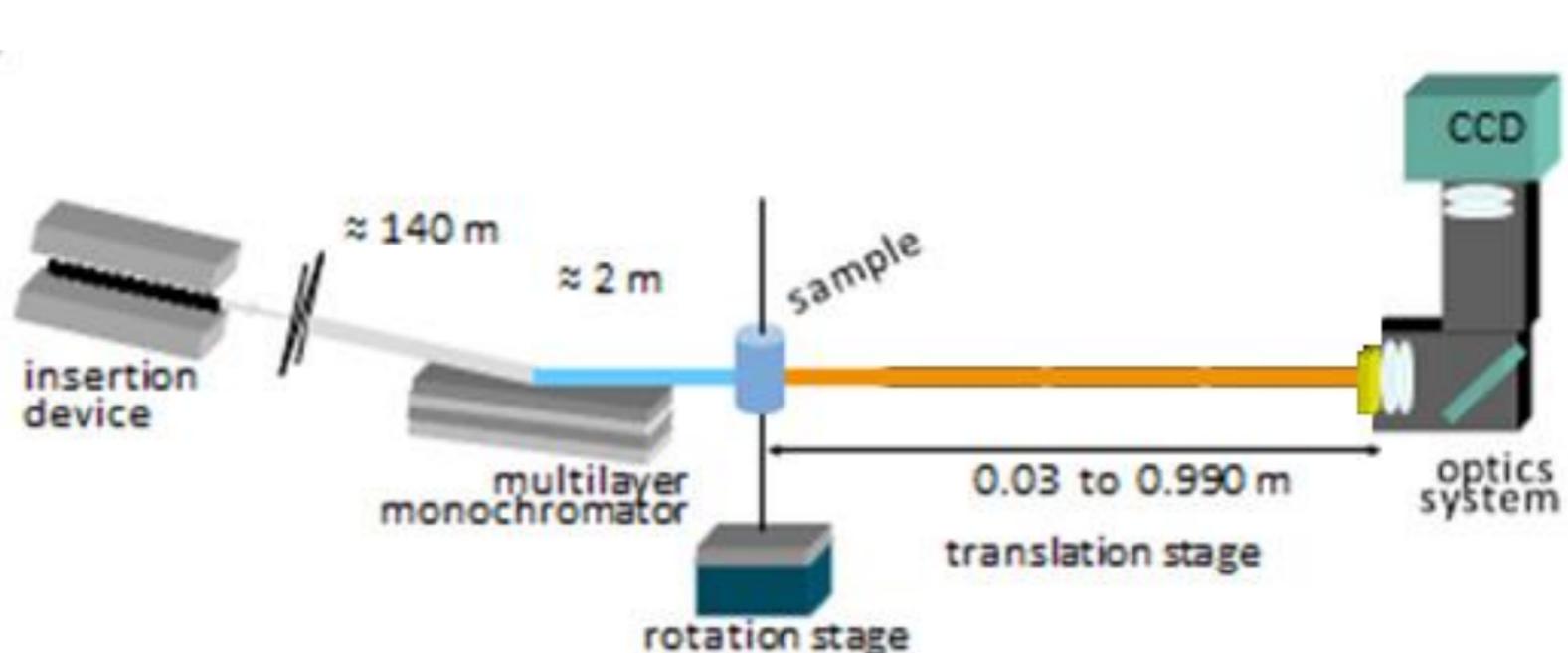
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## Absorption imaging vs. Phase contrast imaging

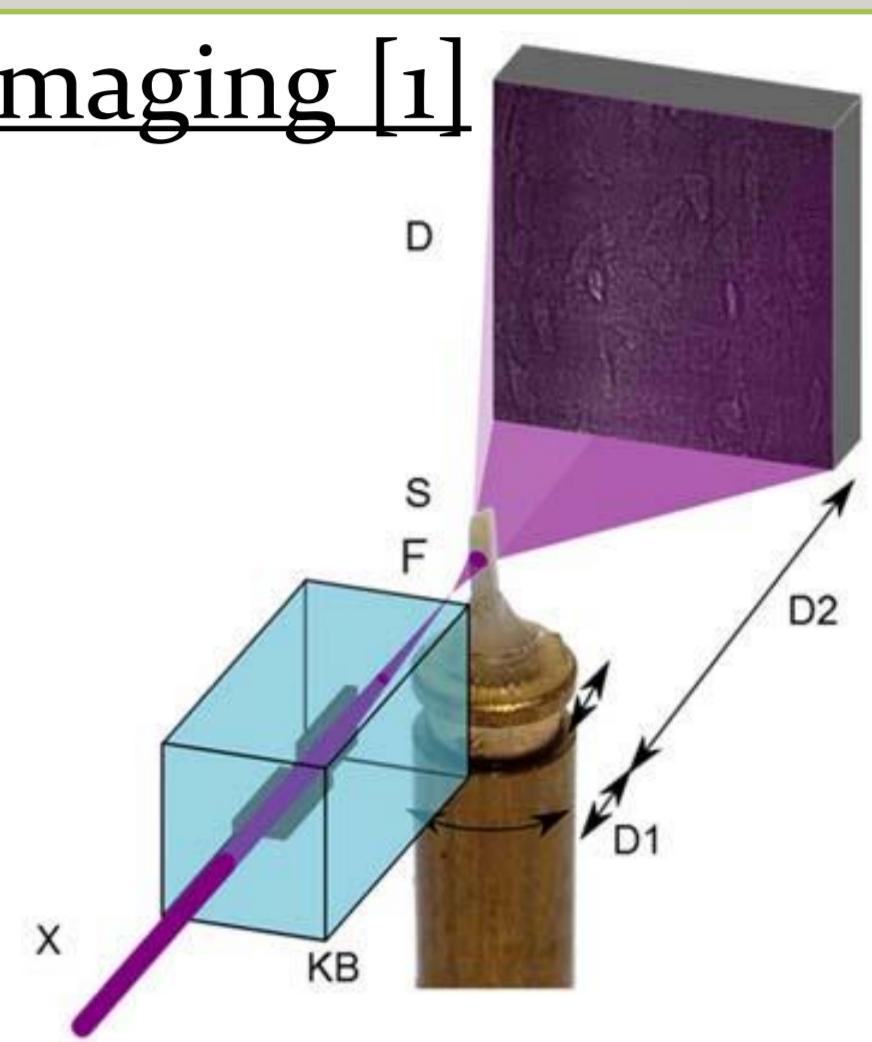


## Set-up for micro- and nano-imaging [1]



## Micro-tomography [2]

- Parallel beam
- Achieve micrometric resolution ( $\sim 0.3 \mu\text{m}$ )
- Quantitative
- Very high sensitivity



## Nano tomography [3]

- Divergent beam → magnification
- Achieve micrometric resolution ( $\sim 20 \text{ nm}$ )
- Quantitative
- Very high sensitivity

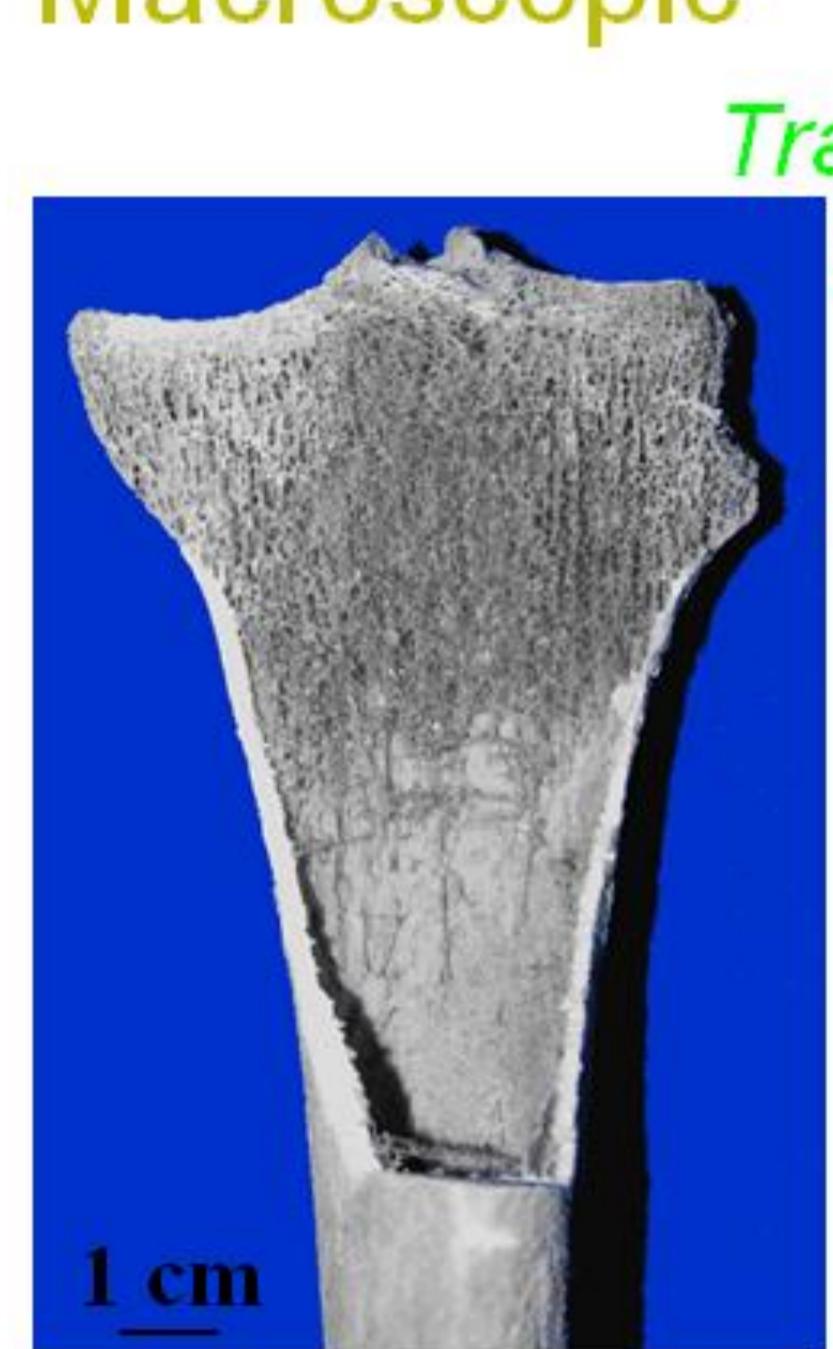
## Clinical CT

## p QCT

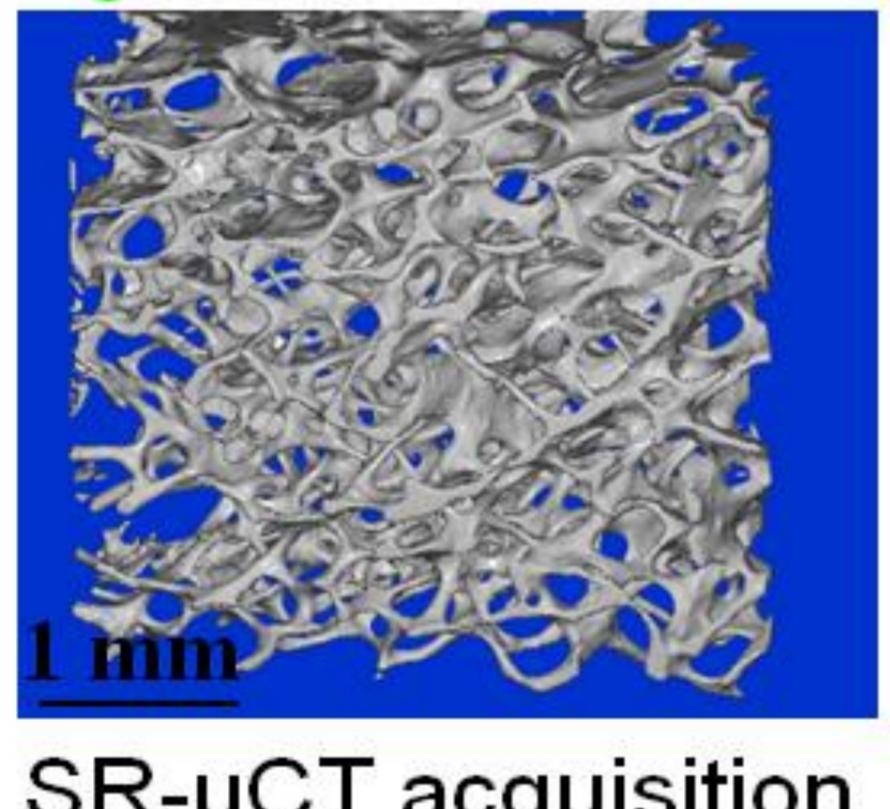
## $\mu$ CT

## Synchrotron $\mu$ CT & nCT

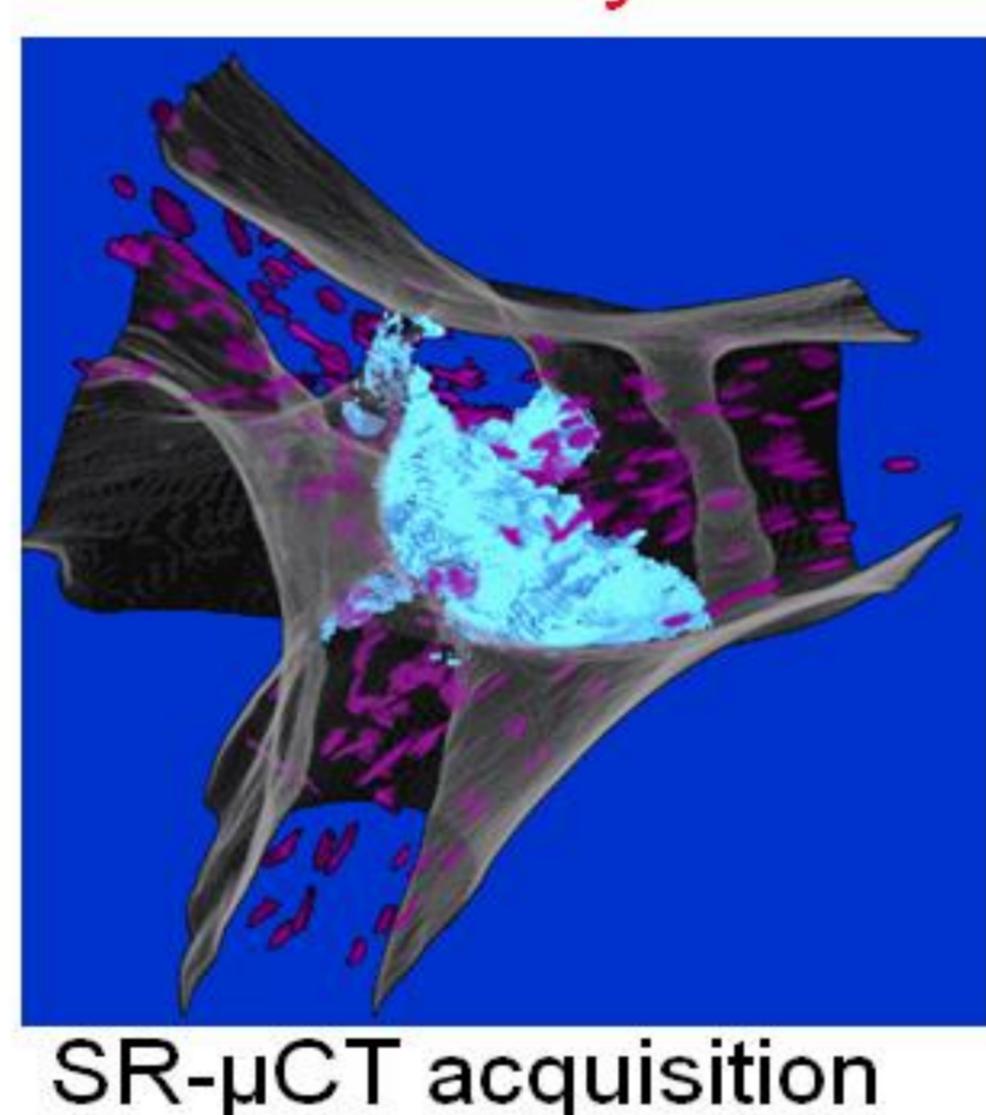
500  $\mu\text{m}$   
**Macroscopic**



150  $\mu\text{m}$   
**Micro-architecture**

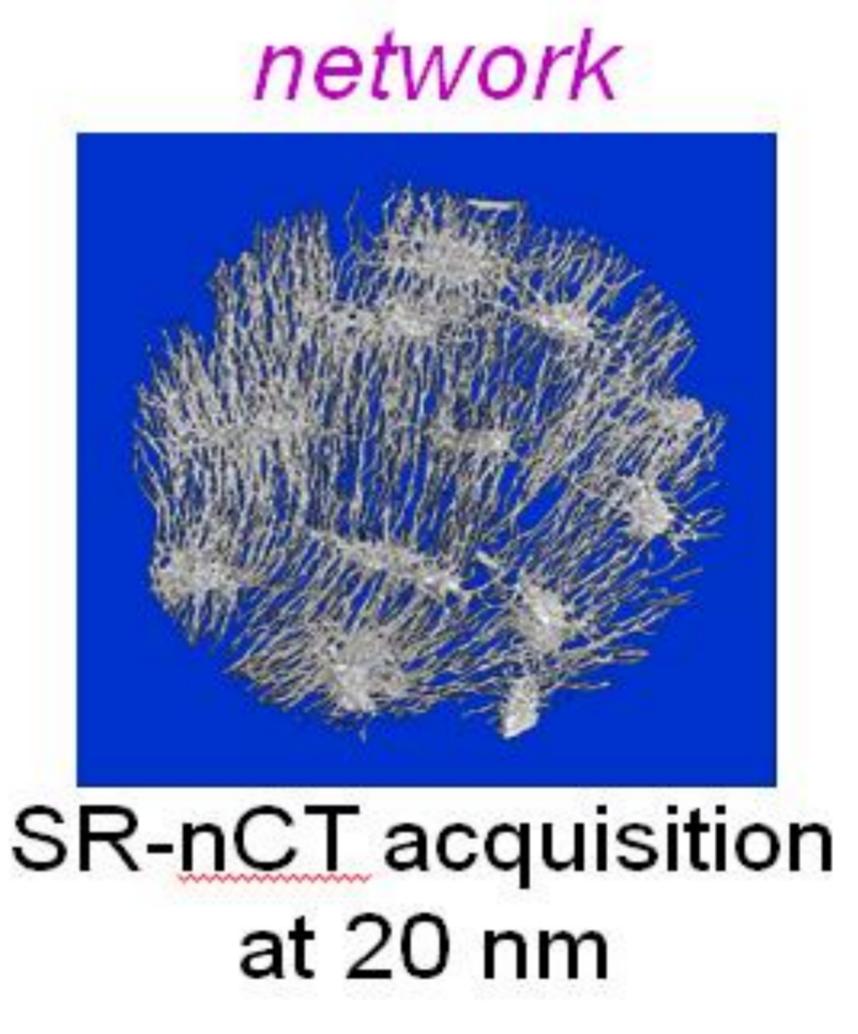


10  $\mu\text{m}$   
**Ultra-structure**

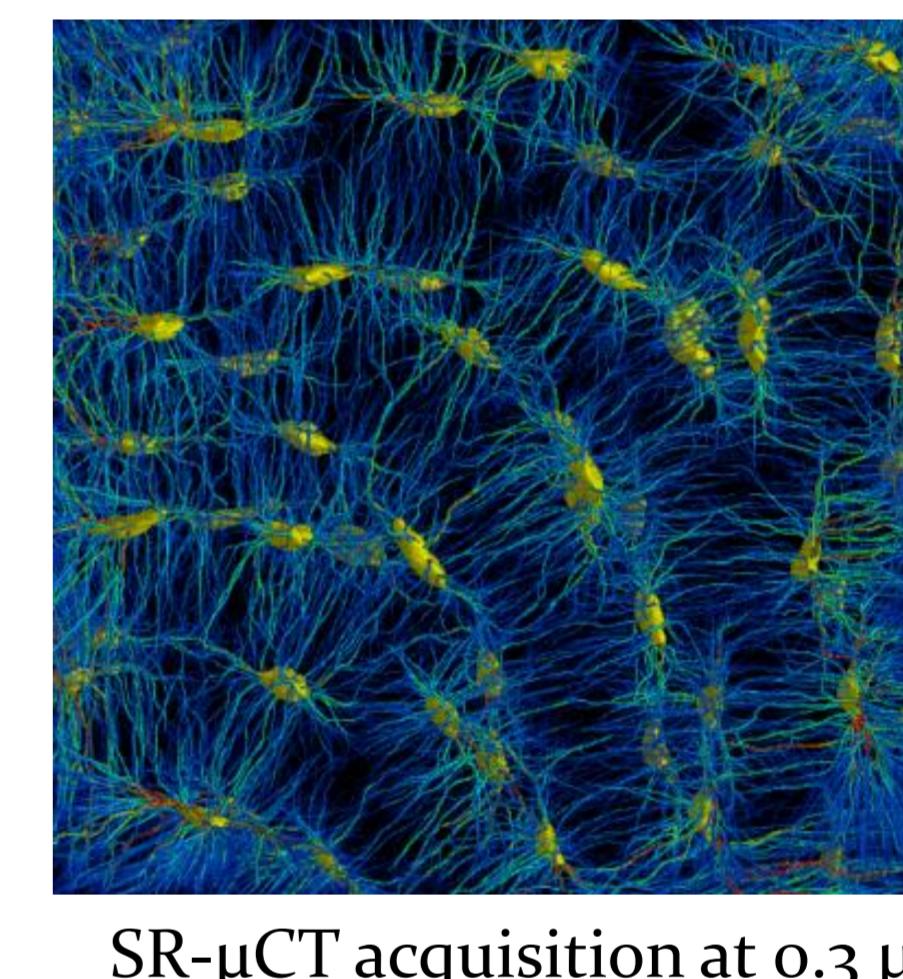
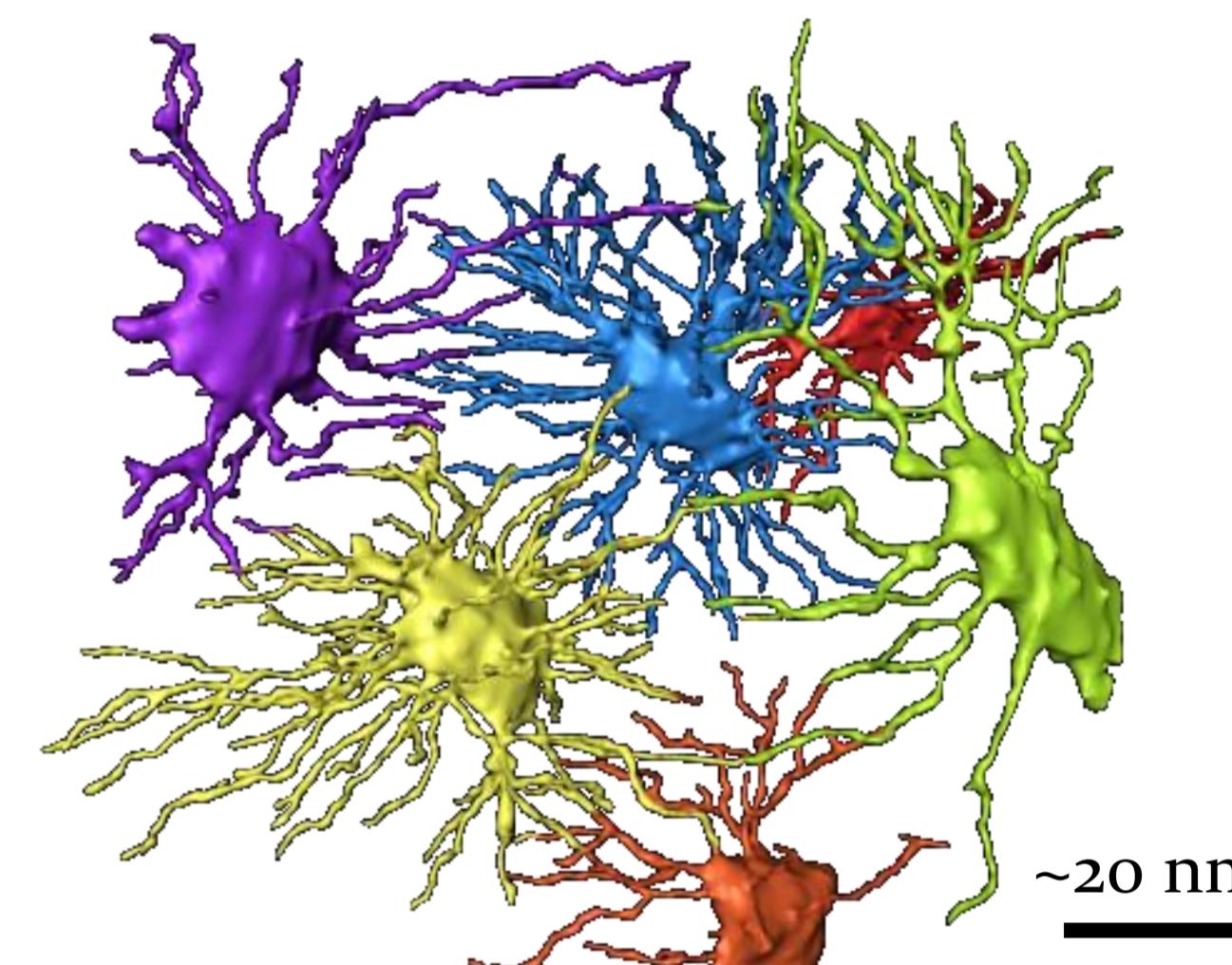


Haversian system  
Osteocytes

50nm  
20nm  
**Cellular network**



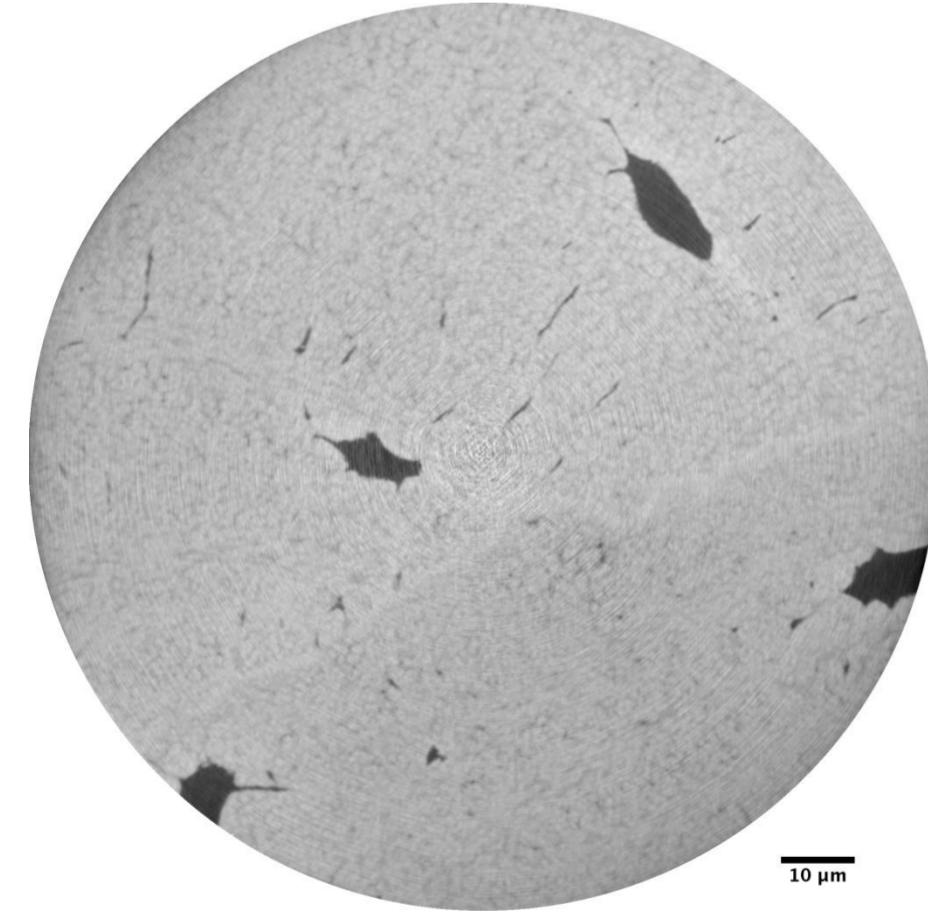
Lacuno-  
canalicular  
network



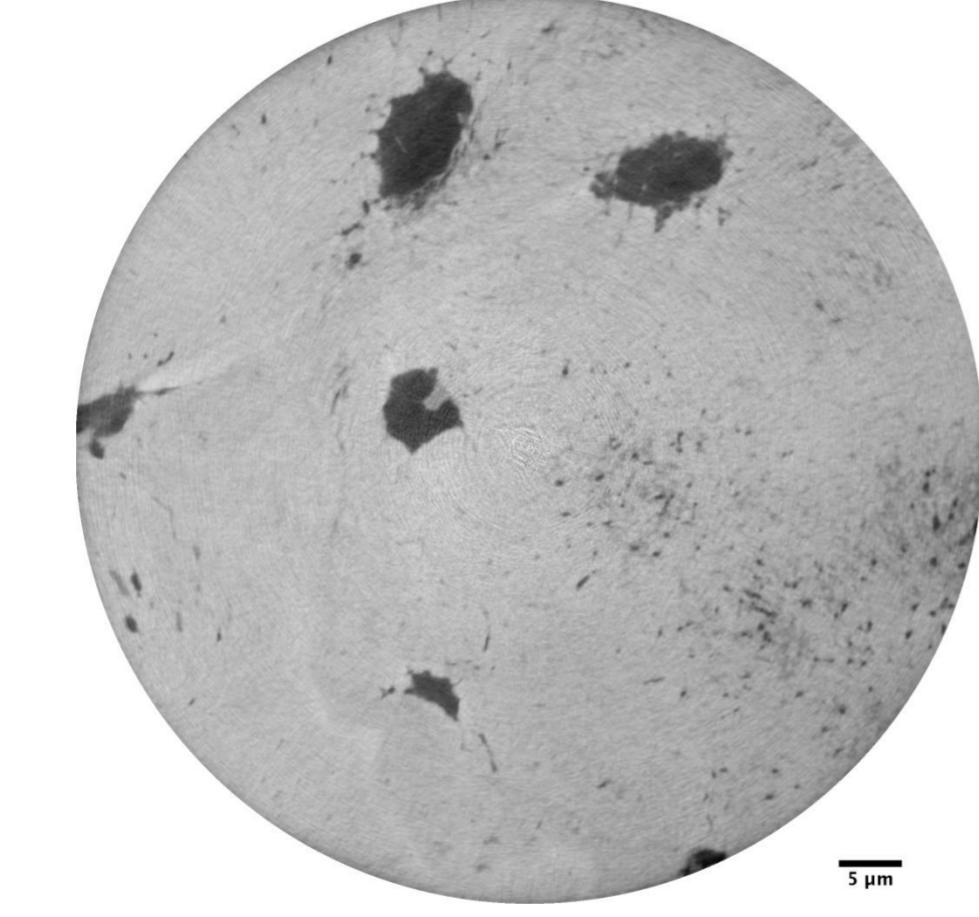
## Imaging of the lacuno-canalicular network (LCN)

- Segmentation using region growing (hysteresis thresholding)
- Tools for LCN description: Lacunae volume, Lacunae shape, Lacunae orientation

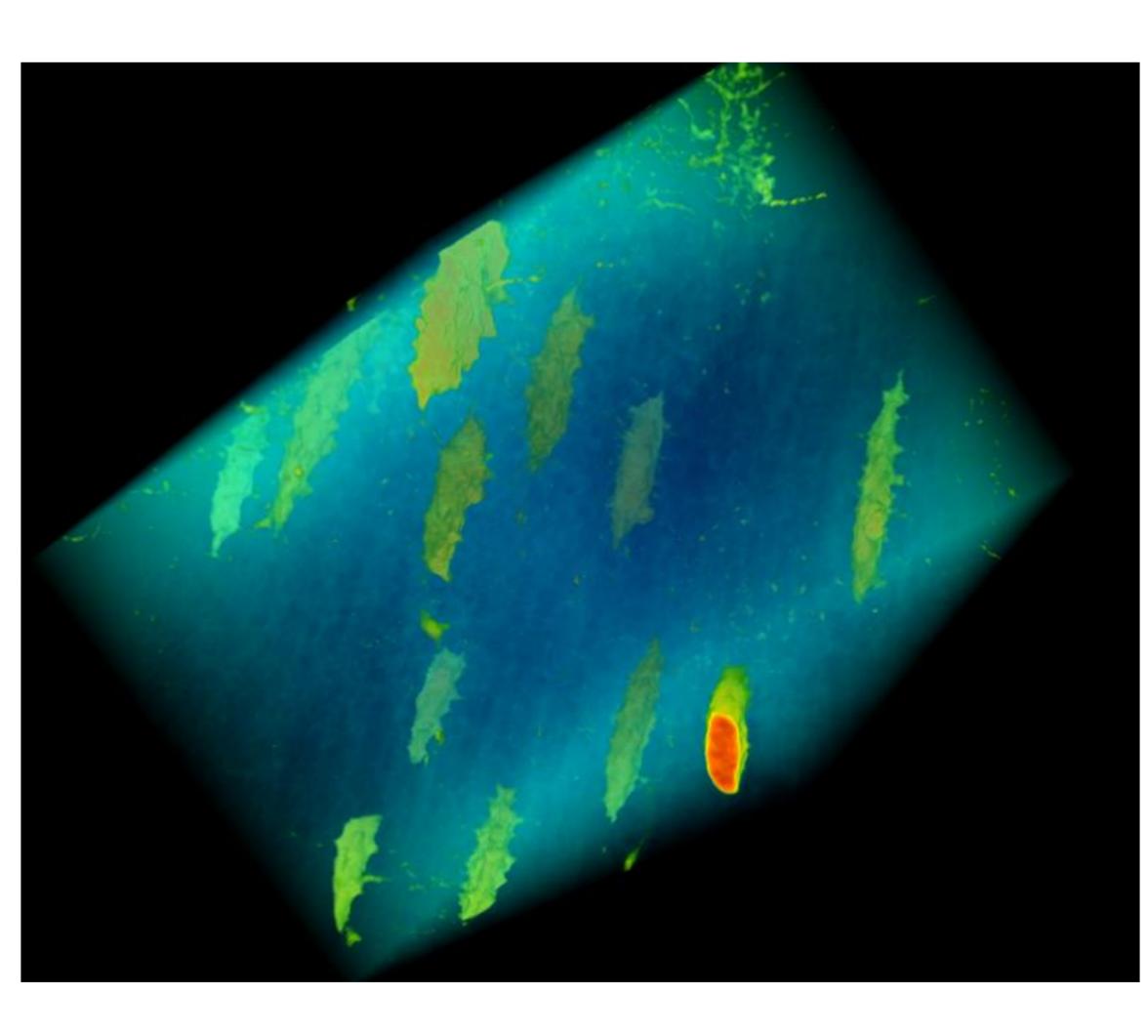
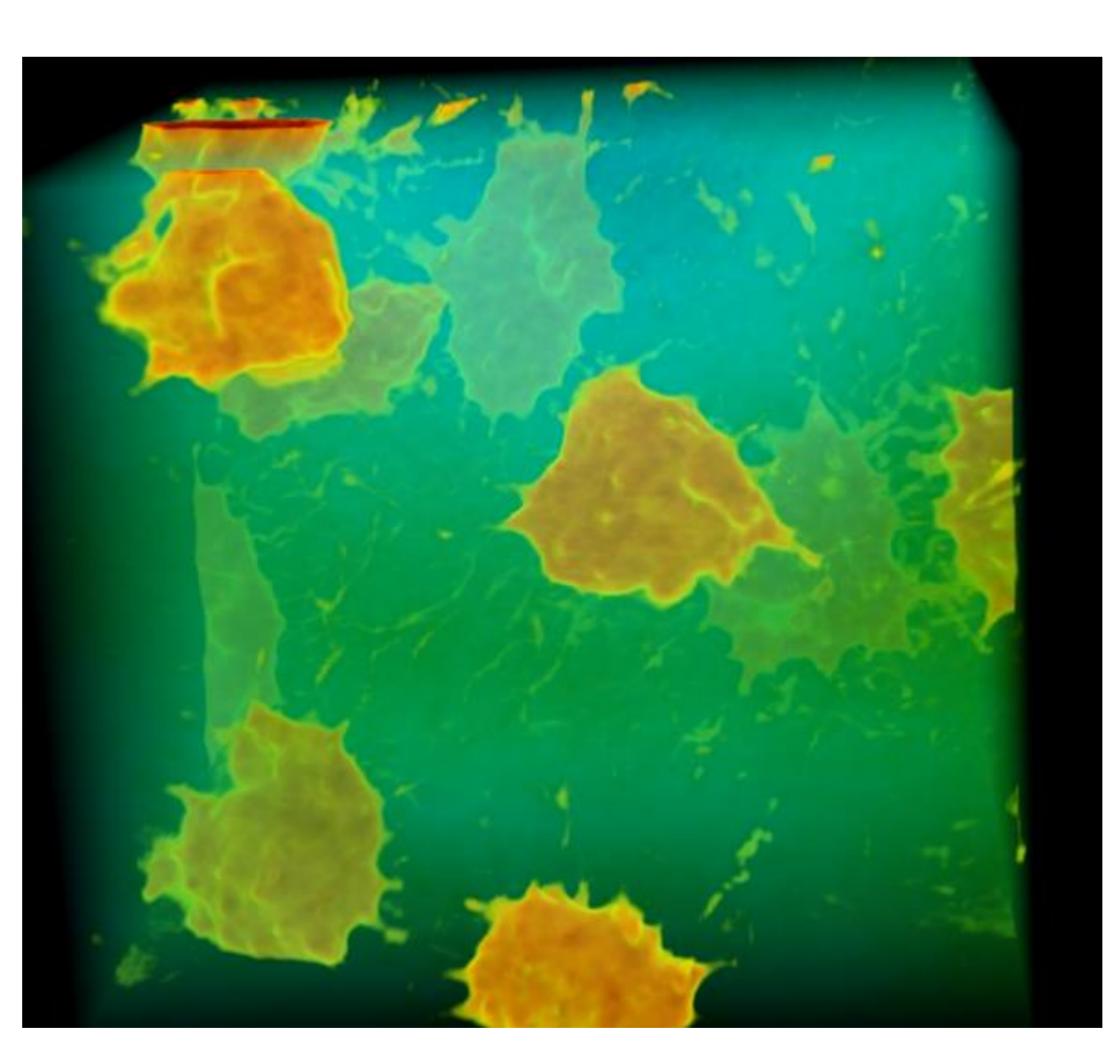
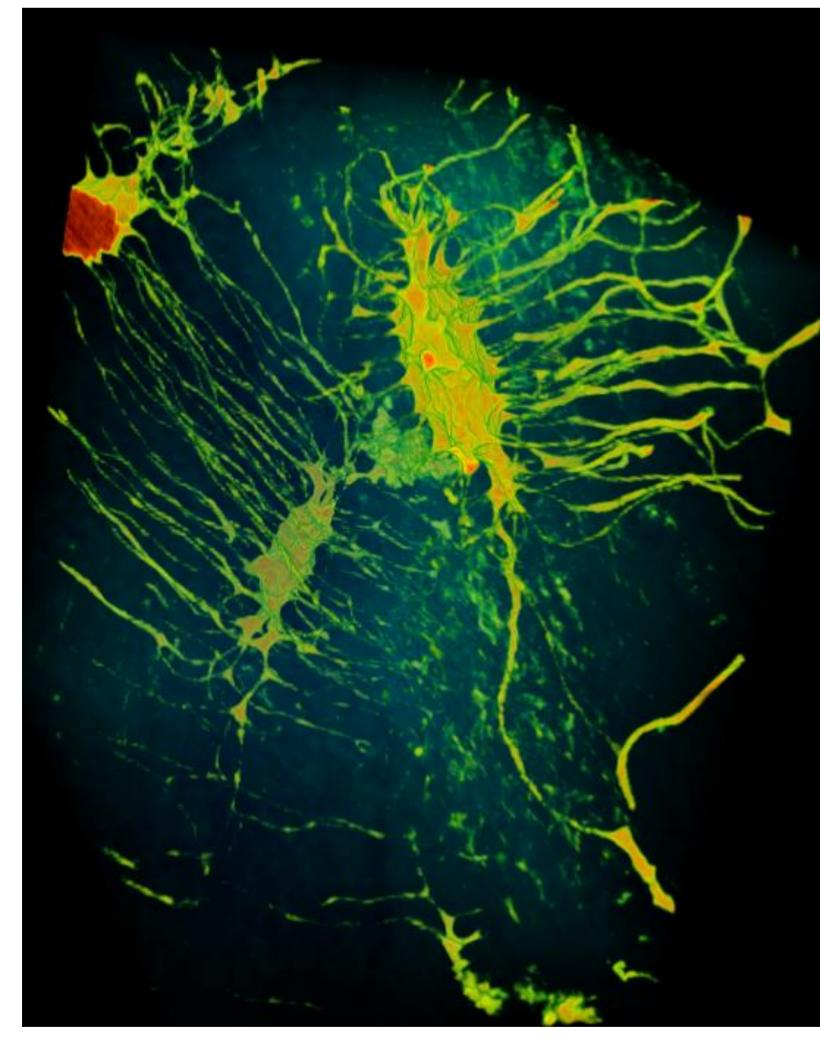
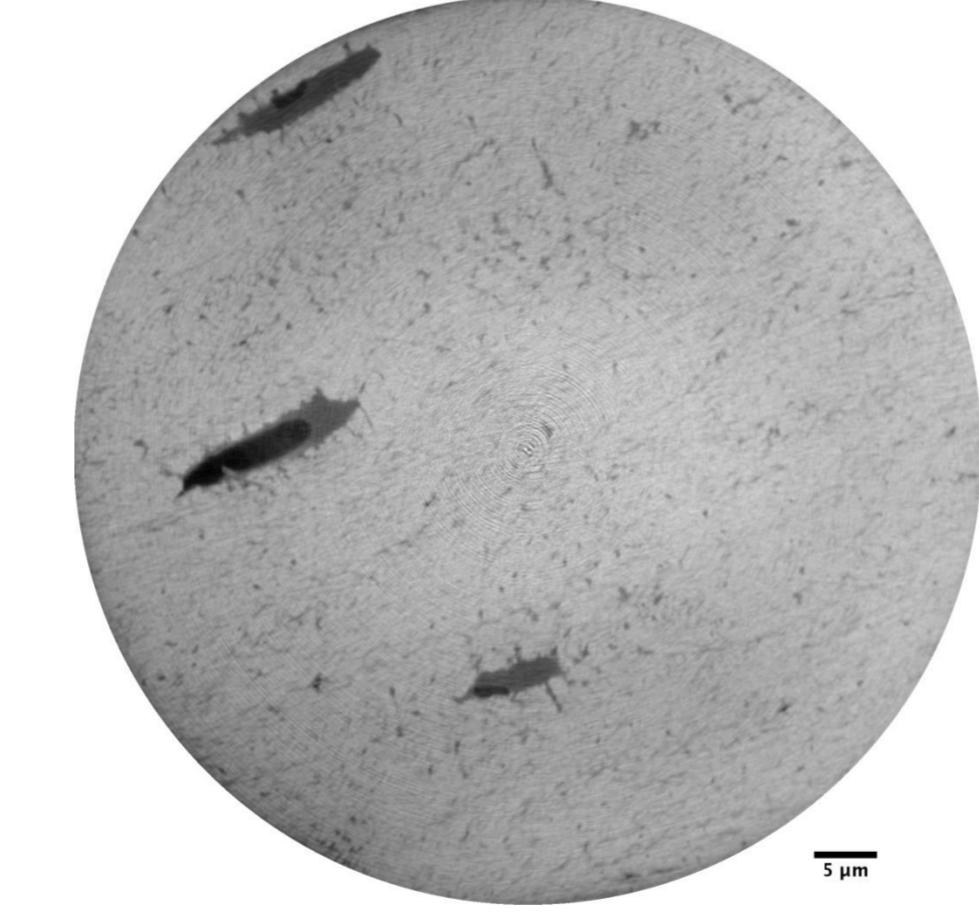
### Healthy bone



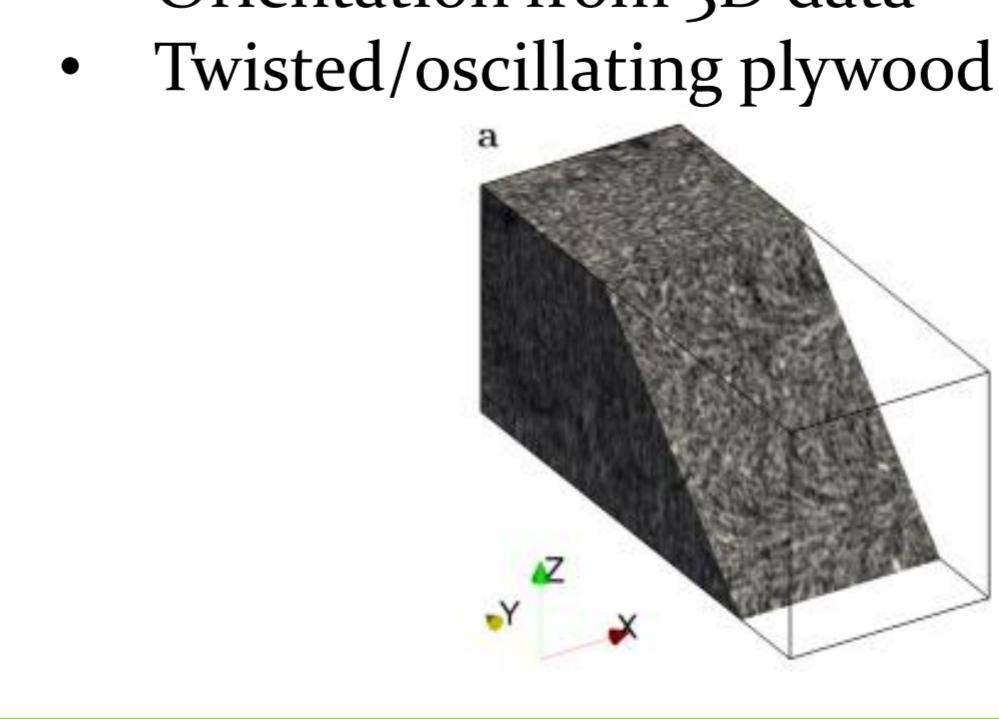
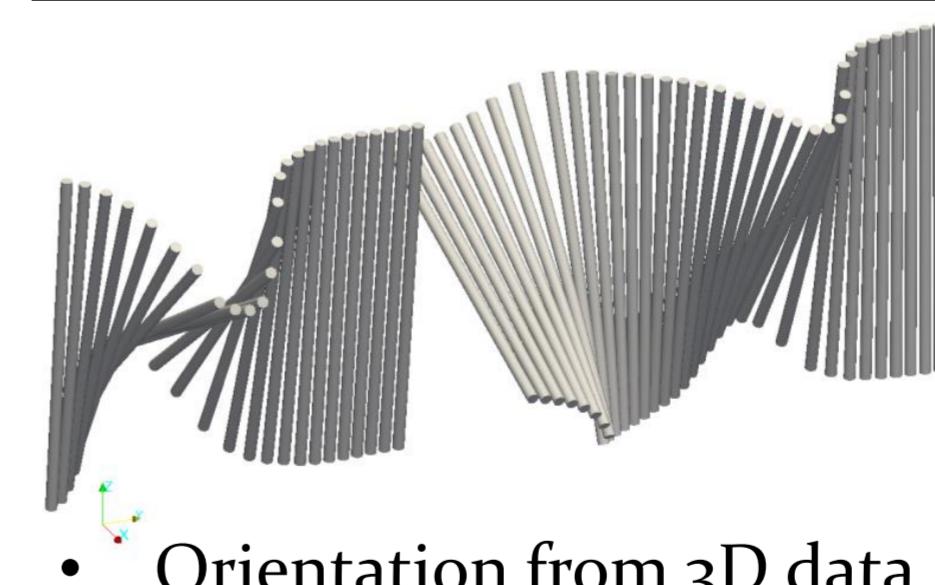
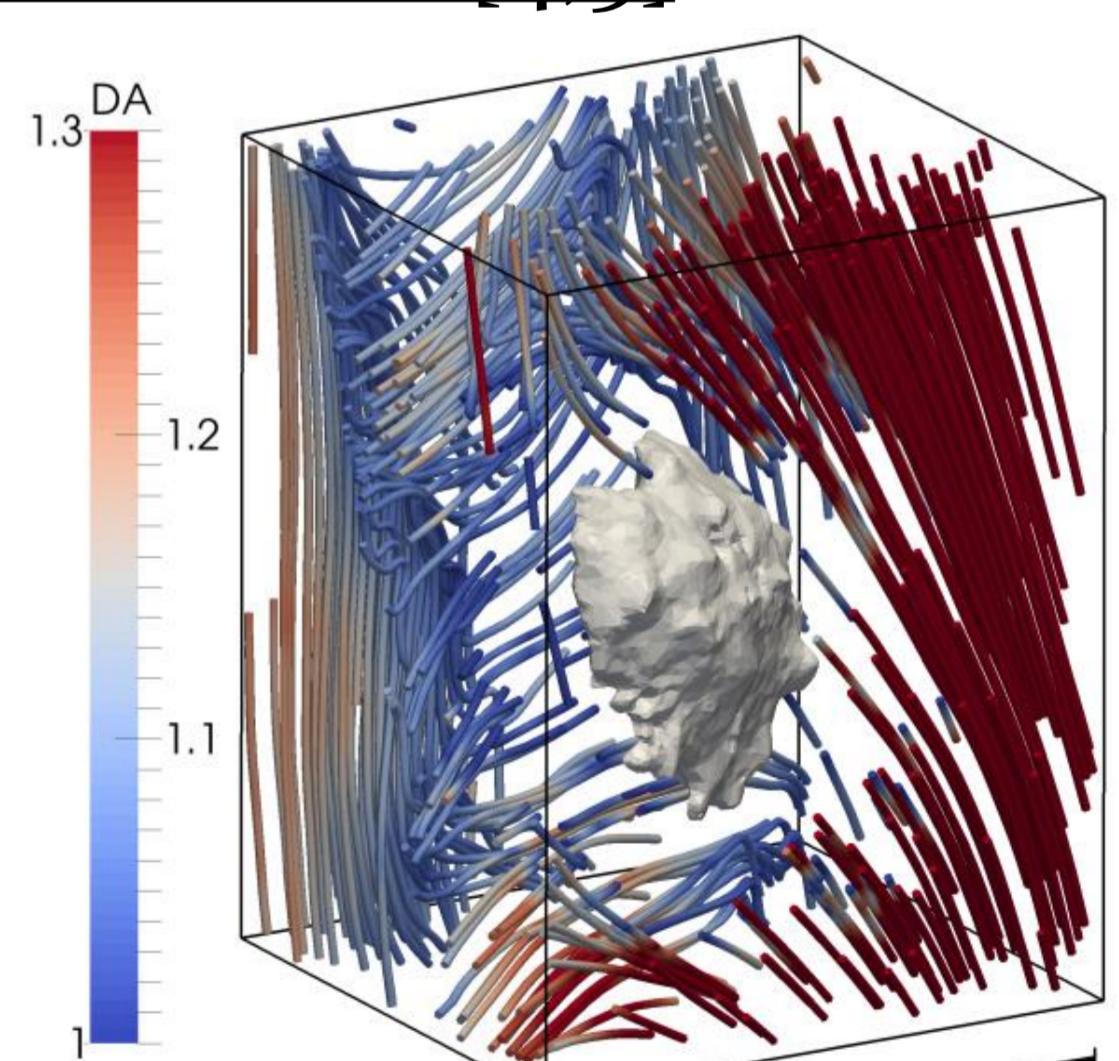
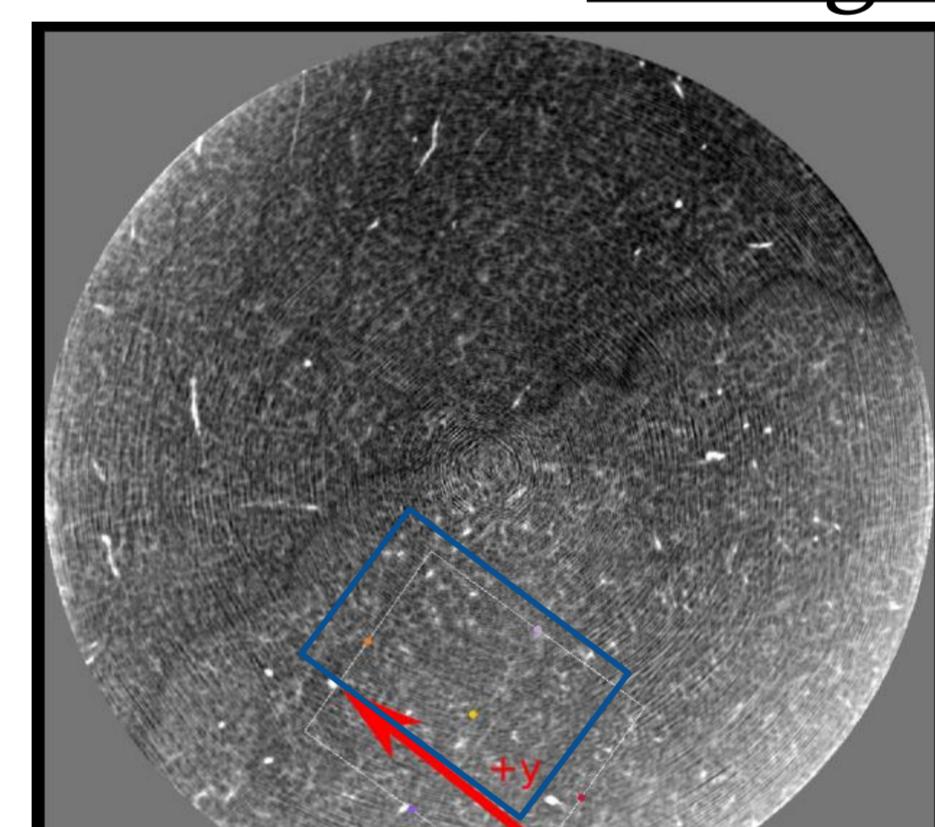
### Osteoarthritic (OA)



### Osteoporotic (OP)



## Collagen orientation [4,5]



Mineralized collagen fibril orientation around an osteocyte lacuna, Colour of the cylinders represents the degree of anisotropy. Scale bar: 5  $\mu\text{m}$ .

## Acknowledgements

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