



HAL
open science

Positron transmission imaging of histological slices

Adrien Hourlier, F. Boisson, D. Brasse

► **To cite this version:**

Adrien Hourlier, F. Boisson, D. Brasse. Positron transmission imaging of histological slices. 2023 IEEE Nuclear Science Symposium, Medical Imaging Conference and International Symposium on Room-Temperature Semiconductor Detectors (NSS MIC RTSD), Nov 2023, Vancouver, France. IEEE, pp.1-1, 10.1109/NSSMICRTSD49126.2023.10338628 . hal-04751834

HAL Id: hal-04751834

<https://hal.science/hal-04751834v1>

Submitted on 24 Oct 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



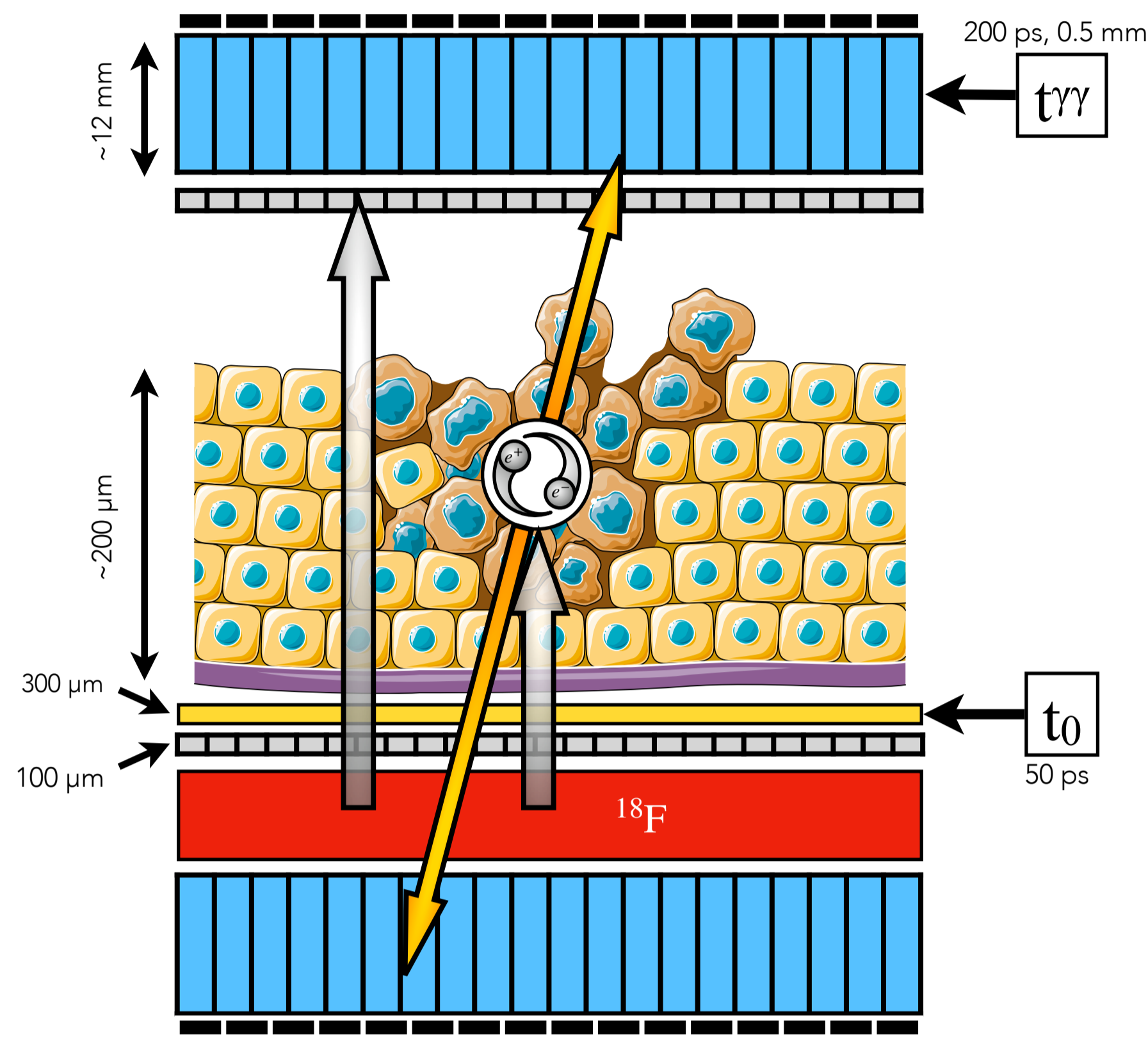
CONTEXT

Positron lifetime imaging

- Traditional 2γ positron emission tomography (PET) reconstructs the topological biodistribution of an injected radio-labeled molecule
- Biological information extracted from the specificity of the tracer to a biological function
- Information on the annihilation tissue encoded in the positron lifetime
- Ortho-positronium (O-Ps) state's lifetime sensitive to physical and chemical state of the annihilation medium (PALS)
- O-Ps lifetime not used in clinical PET yet

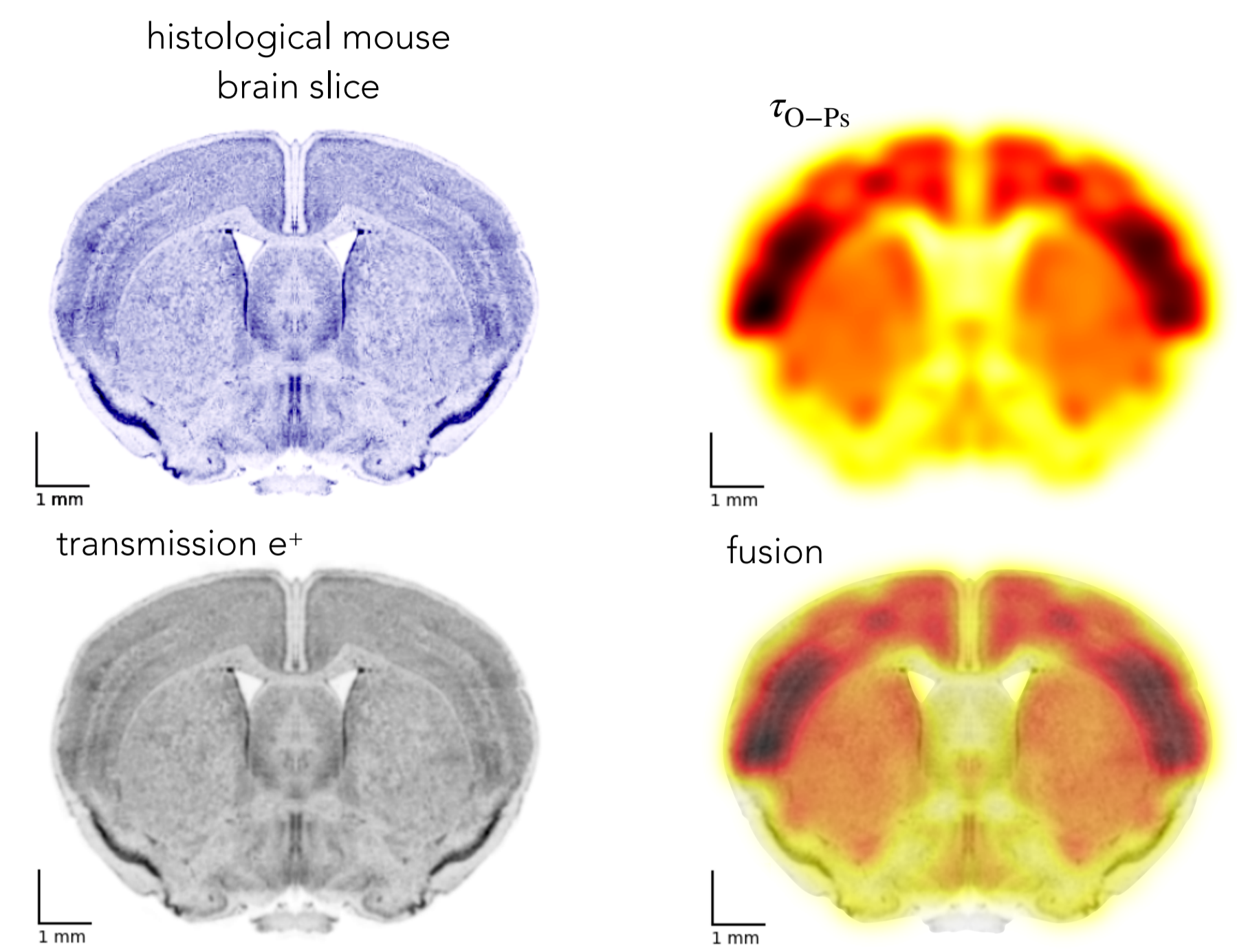
3D in-vivo positron lifetime imaging

- Measuring a lifetime requires a trigger of positron time of emission : (β^+ , γ) emitters $\Rightarrow 3\gamma$ coincidences (J-PET, uExplorer, Xemis, ...)
- Requires high sensitivity, excellent coincidence time resolution tomographs
- New upcoming technology
- Challenges :
 - Information restricted to the biodistribution
 - High statistics per voxel required to untangle the different lifetimes
 - Still poor understanding on the biological causes of τ_{O-PS} changes (correlation to pathologies, lesions, chemical imbalance, ...)



TRICERA τO-PS

- **TRIPLE COINCIDENCE EVENTS** from β^+ **RA**diotopes to image **TO-PS**
- 2γ τ_{O-PS} Imaging : usual β^+ isotope (^{18}F)
 - Emission time from plastic scintillator
 - Annihilation γ detected by LYSO:Ce crystal matrix + SiPM
- Measurement **INDEPENDANT** from radiotracer biodistribution
 - Uniform high activity source
 - Remove biodistribution dependency
 - Allows for pixelized tissue-related τ_{O-PS} studies
- **e+ transmission** imaging
 - Pixelized detection layers upstream and downstream of tissue sample
 - Measure positron attenuation in tissue
 - High resolution reference anatomical imaging for τ_{O-PS} image comparison
 - Possible technologies :
 - CMOS \Rightarrow focus on this technology in this poster
 - MWPC
 - MicroMegs
 - Fibrous hodoscope
- Both imaging modalities acquired **simultaneously**
 - Limit tissue slice ageing
 - No need to image registration
- **TRICERA τO-PS** will allow us to bridge the gap between PALS measurements of large biological samples and 3D in-vivo measurements in 3γ PET scans
- **High resolution, high activity, τ_{O-PS} imaging** of tissue slices will improve our knowledge of τ_{O-PS} variation for various tissues and pathologies and of the underlying biological reason for such change



Illustrations of the planned imaging modalities

Image reconstruction

- Simulations

- Simulations performed with Gate 9.1
- ^{18}F source
- CMOS : 100 μm thick Si layer, 50 μm pixelization
- Trigger : 300 μm thick scintillating PMMA
- Si Derenzo phantom : 200 μm thick, inserts ranging from 600 to 100 μm

- Tissue layer position reconstruction

- Assume straight line from CMOS-pixel to CMOS-pixel
- Error from true tissue layer crossing : ~ 0.15 mm

- Attenuation factor evaluation

- Comparison between pixel i in the tissue-image I_i and water-only image $I_{0,i}$:

$$\mu_i = -\frac{1}{\langle \Delta z \rangle} \ln \left(\frac{I_i}{I_{0,i}} \right)$$
 with $\langle \Delta z \rangle \sim 250$ μm the average path in the tissue layer

In this poster, we will focus on the novel concept of positron transmission imaging

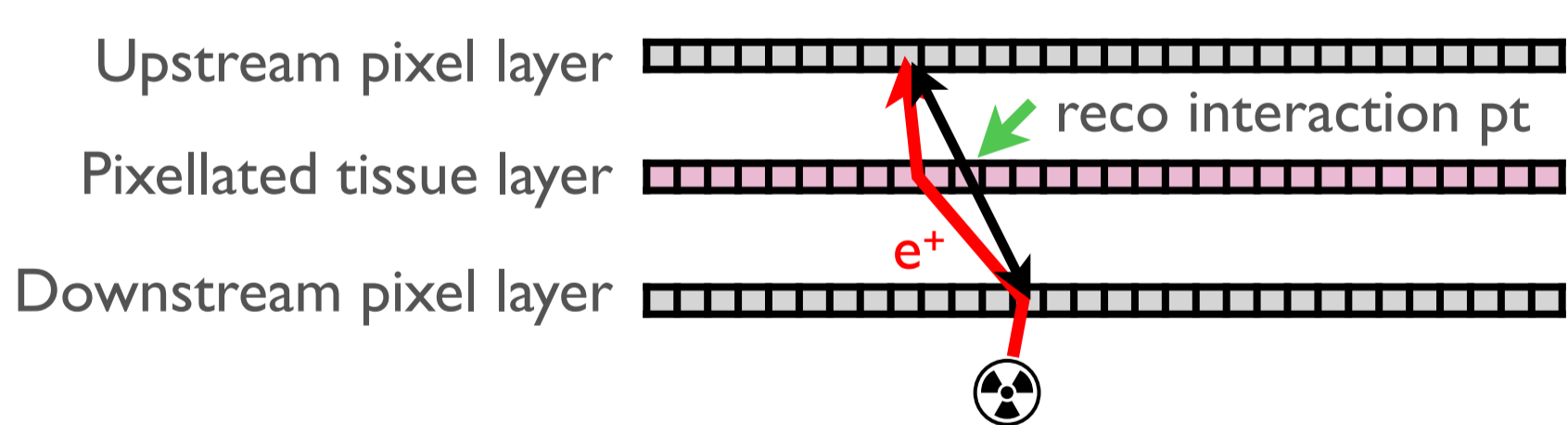
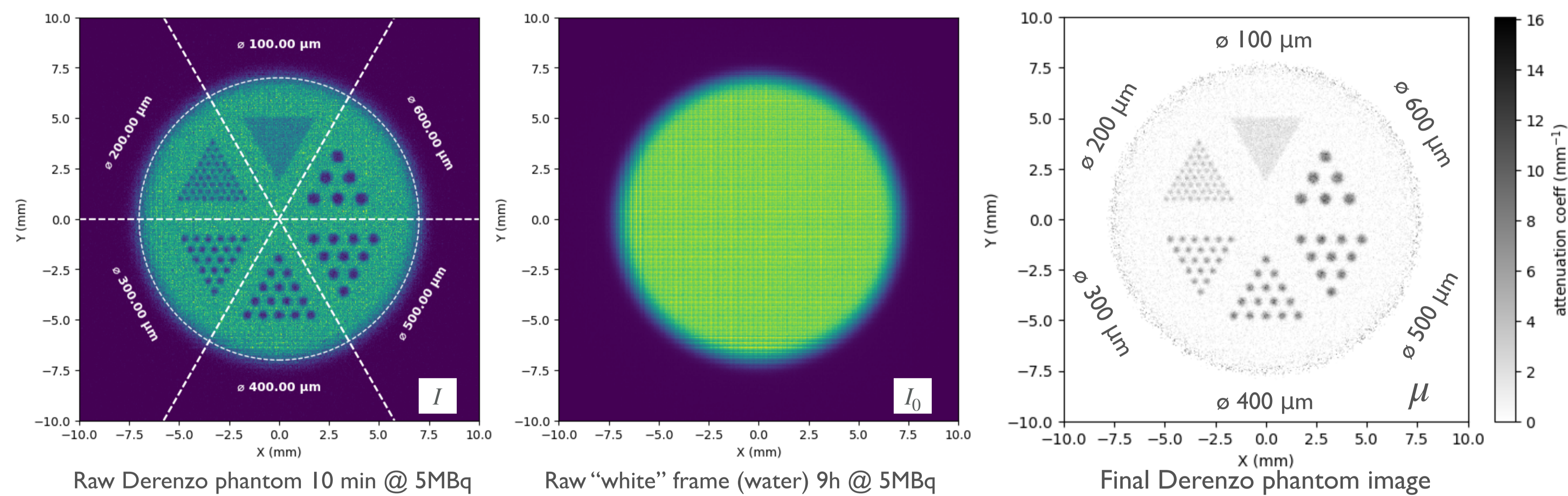
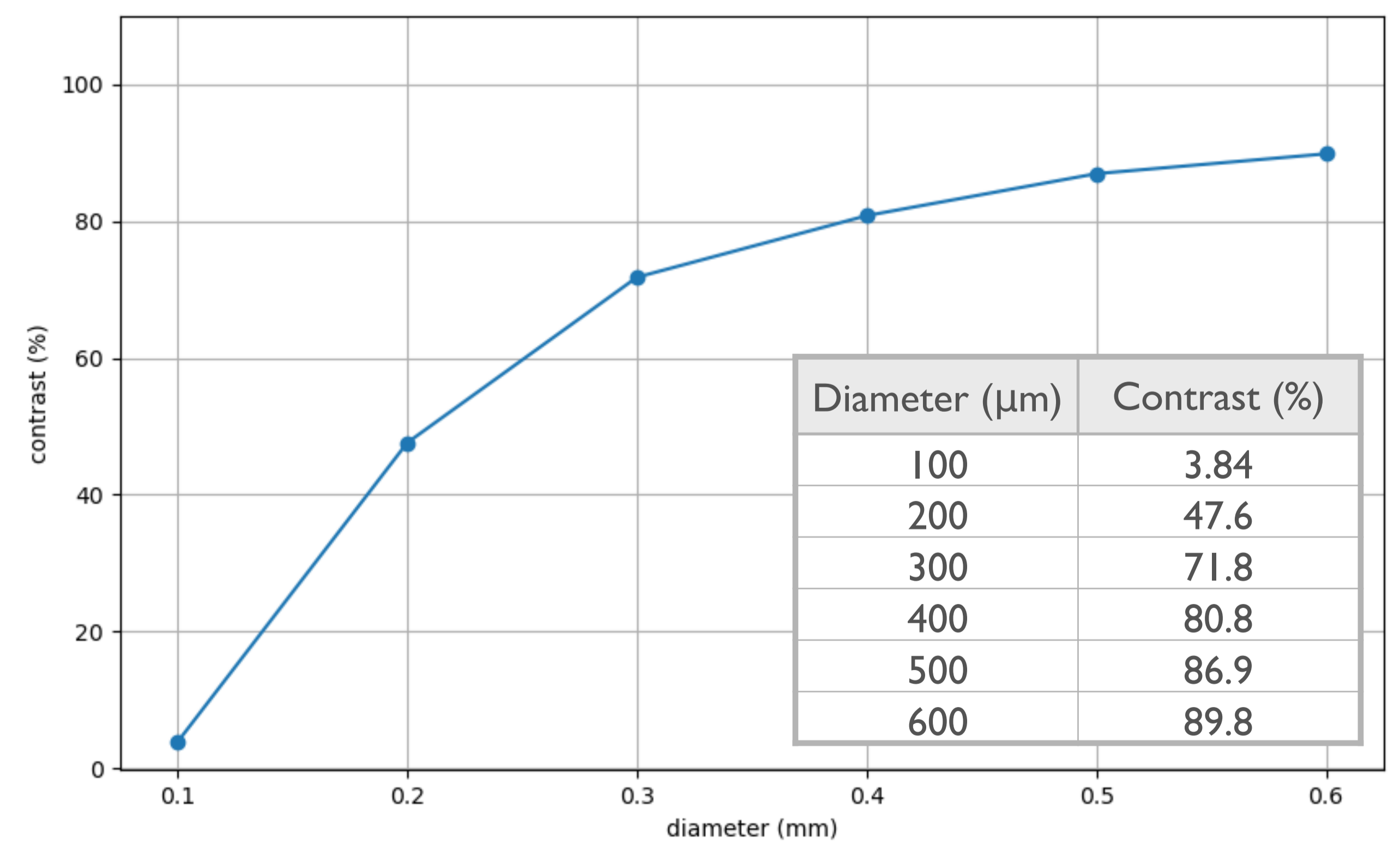
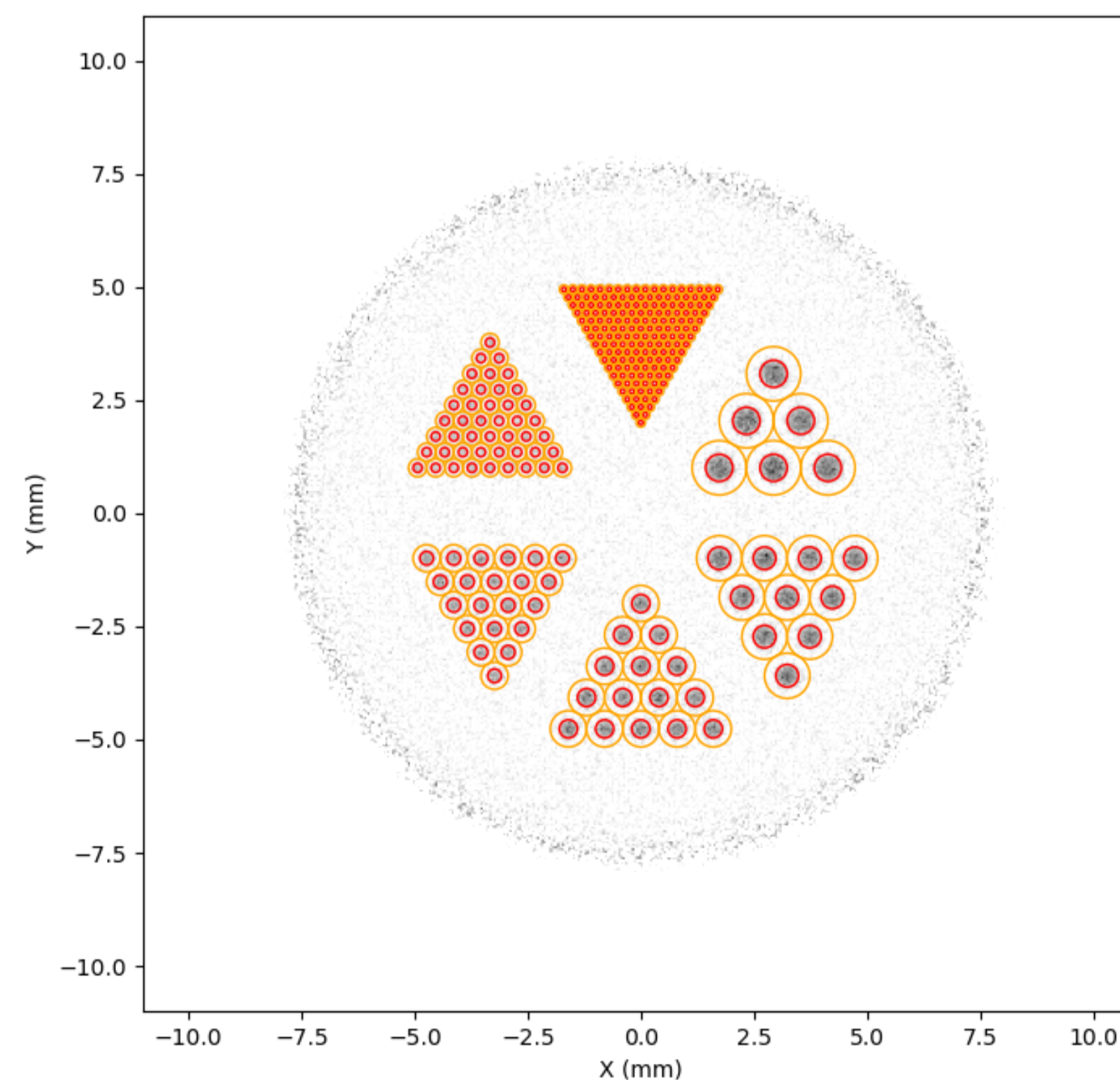


Image evaluation

- ROIs centered on each phantom inserts
- signal ROI (red) : $r_{\text{pix-ROI center}} < r_{\text{insert}}$
- background ROI (orange) :
 $r_{\text{insert}} < r_{\text{pix-ROI center}} < 2 \times r_{\text{insert}}$
- contrast : $\frac{\langle \mu_i \rangle_{\text{signalROI}}}{\langle \mu_i \rangle_{\text{backgroundROI}}}$
- Good contrast ($\geq 50\%$) down to 200 μm



Summary

- Conclusions

- A **novel imaging** technique : **positron transmission imaging** will serve as a high resolution anatomical reference image
- A first study with a dense material provides a limit on spatial resolution for high contrast images
- Preliminary studies show a < 200 μm spatial resolution using two CMOS.
- Resolution limited by tissue layer diffusion : ~ 0.15 mm

- Perspectives

- Other possible technologies, each with their advantages :
 - **MWPC** (upstream) \Rightarrow provides (X,Y) and **e+ directionality**
 - **MicroMegs** (downstream) \Rightarrow provides high resolution (X,Y)
 - **Scintillating fibers hodoscope** \Rightarrow provides (X,Y) and **trigger time**
- **Iterative reconstruction** \Rightarrow account for e+ scattering, improving spatial resolution
- Sensitivity studies : **contrast and resolution achievable with biological tissues?**