POLYCAPILLARY APPLICATIONS FOR TOMOGRAPHIC STUDIES

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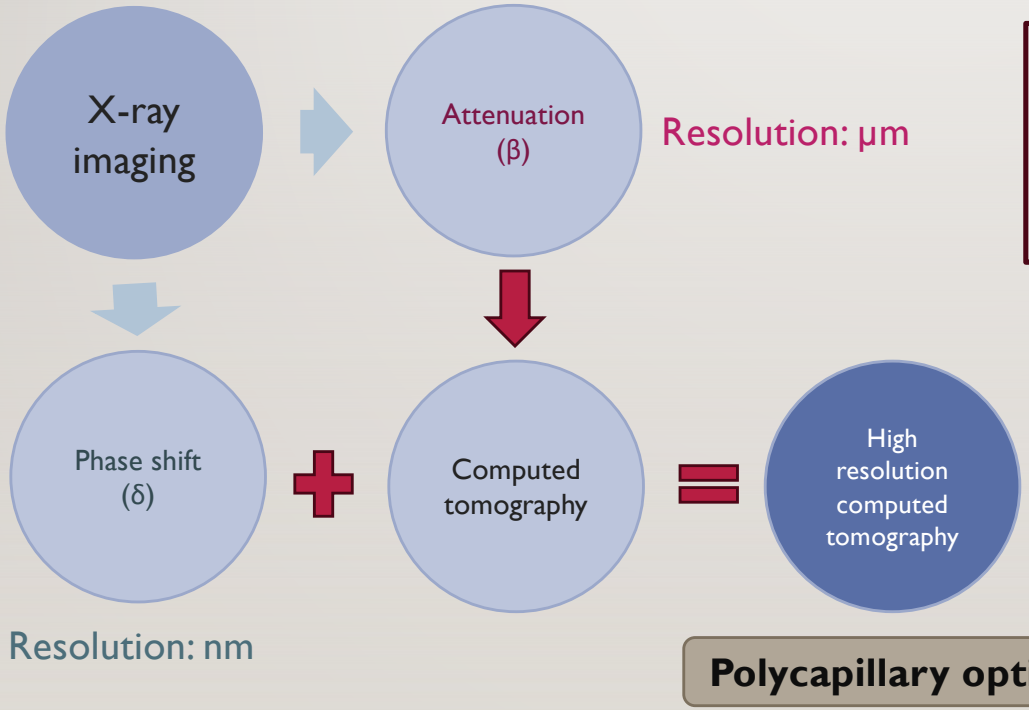
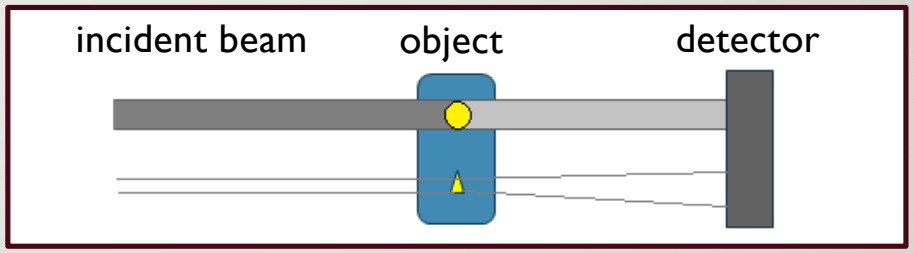
CHANNELING 2024

CONTENT

3 INTRODUCTION



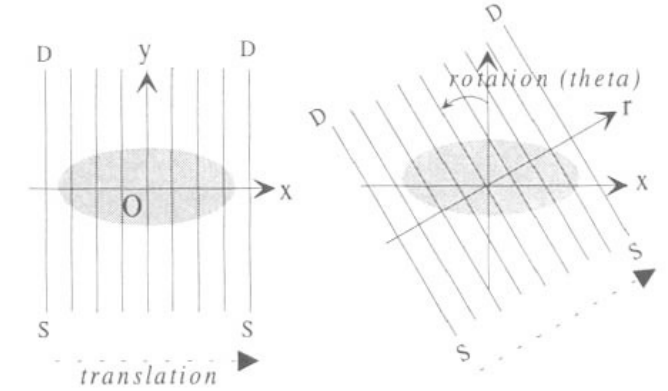


$$n = 1 - \delta + i\beta$$

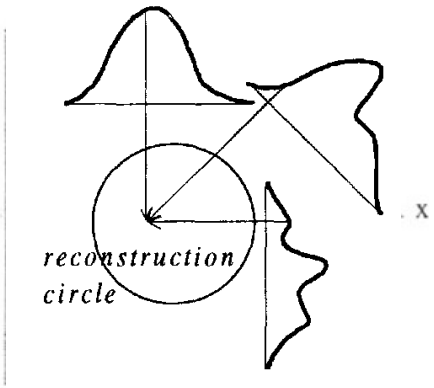
$$\beta = \frac{n_a r_e \lambda^2}{2\pi} f_2^0(\omega) \qquad \delta = \frac{n_a r_e \lambda^2}{2\pi} f_1^0(\omega)$$

β	δ
10^{-9} - 10^{-10}	10^{-6} - 10^{-7}

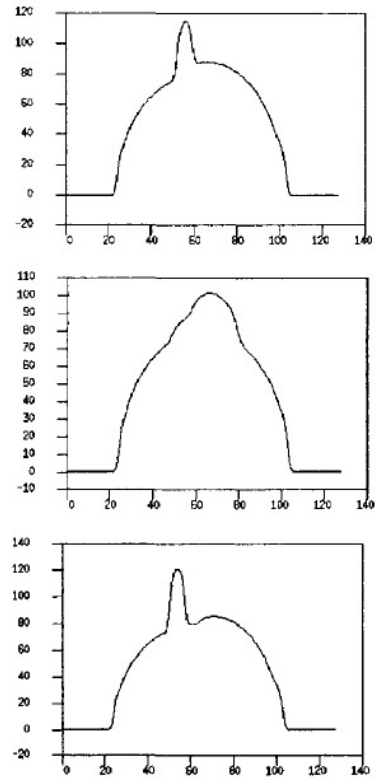
4 INTRODUCTION

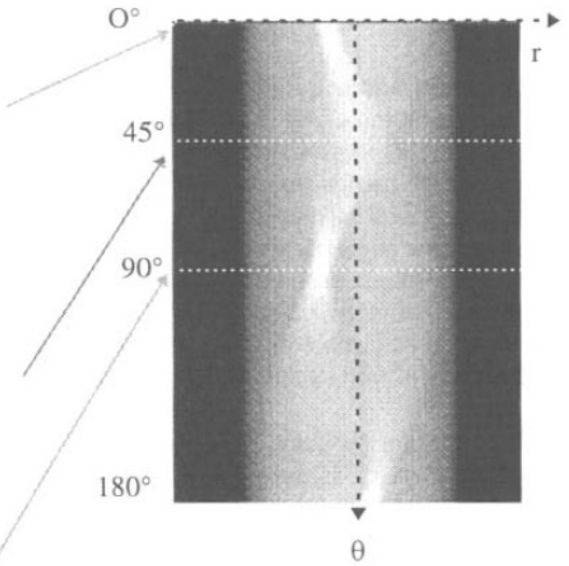


Acquisition of multiple projection images (θ angle)



Reconstructed image of the object



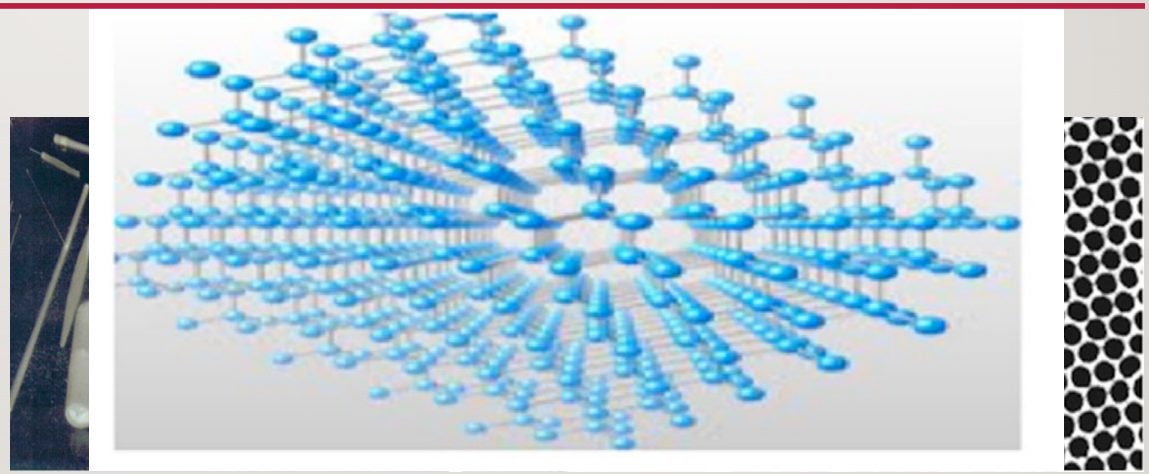


Sinogram: set of projections over 180º

Baruchel J, et al. X-ray tomography in material science. 2000.

5 INTRODUCTION

- Channeling
  - Charged particles: crystals
  - X-rays: Polycapillary Optics



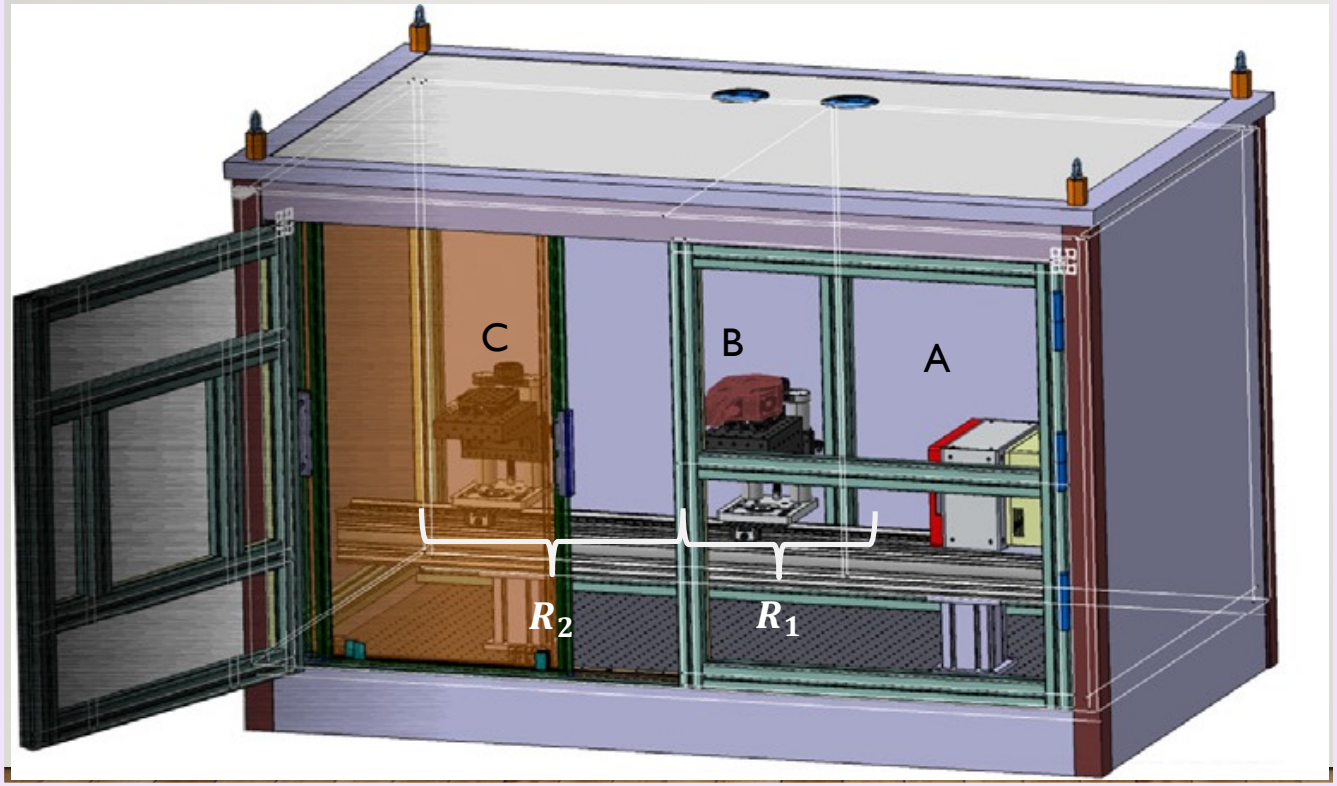
Dabagov S, Gladkikh YP, Radiat. Phys. Chem. 154, 3-16 (2019).

Objective

- To show the potential of polycapillary advanced optics (polyCO) for phase contrast imaging and tomography.

EXPERIMENTAL SETUP

Computed Tomography Station (CTS), Xlab-Frascati



A: Microfocus source (5 µm spot size – 4 W)

B: Rotation stage (0.2° step)

C: CCD detector (10.4 µm pixel size)

Two geometries:

- **Attenuation: $R_2 = 115$ mm**
  M = 2 Resolution 2-3 µm
- **Phase shift: $R_2 = 760$ mm**
  M = 8 Resolution <1 µm

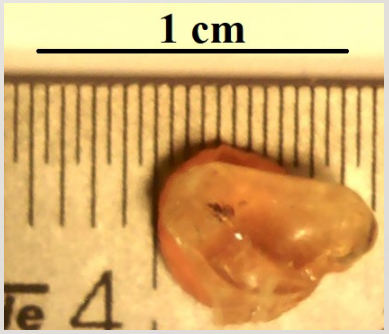
Hampai D, et al. Nuclear Inst. and Methods in Physics Research, A. 2024,169041.

CT ACQUISITIONS

Hexagonal screw (3 mm diameter)

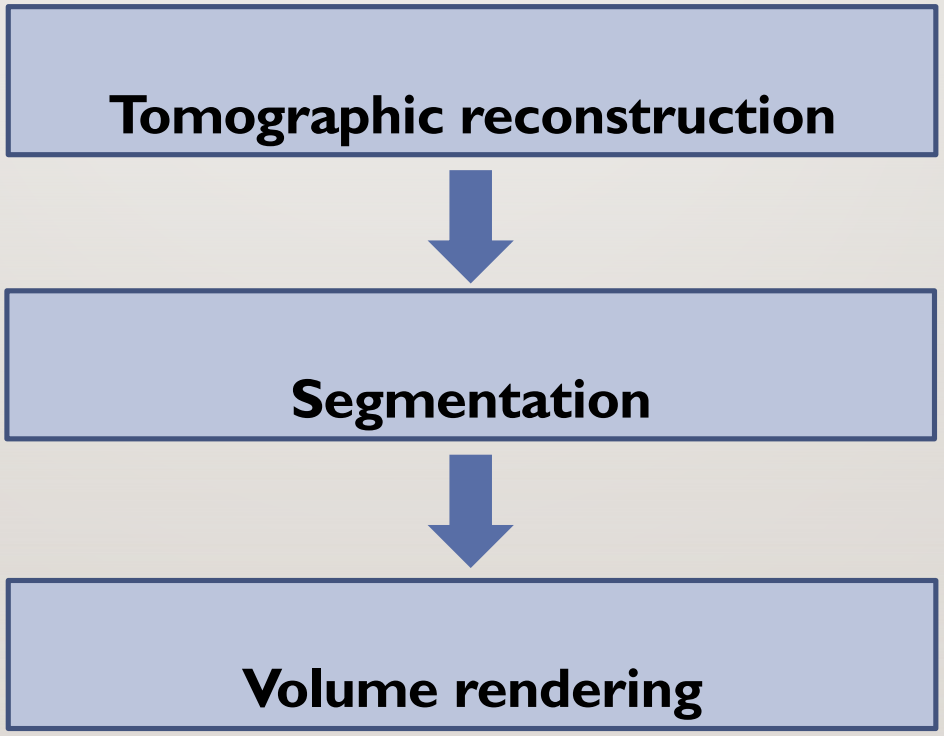
Attenuation

Insect (0.5 mm length)



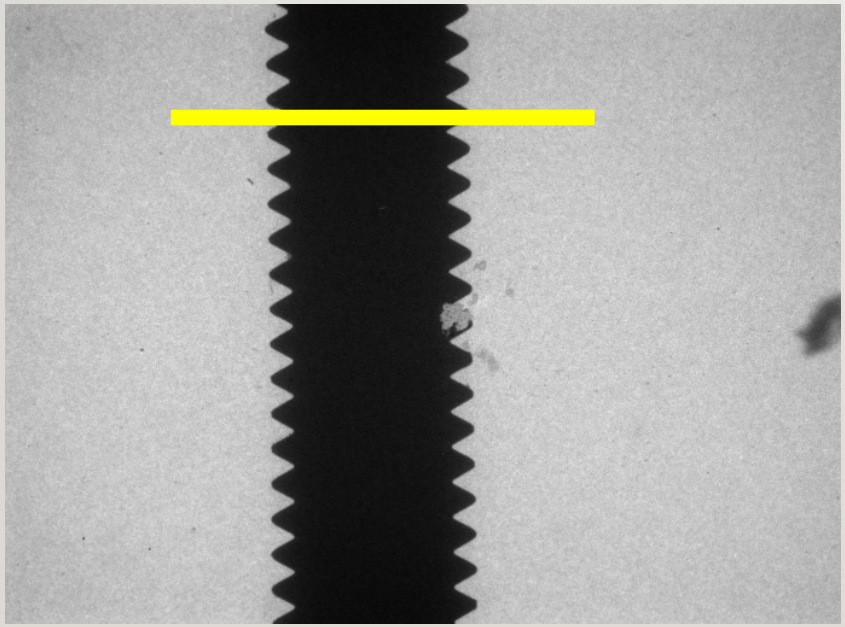
Phase contrast

ANALYSIS PROCEDURE

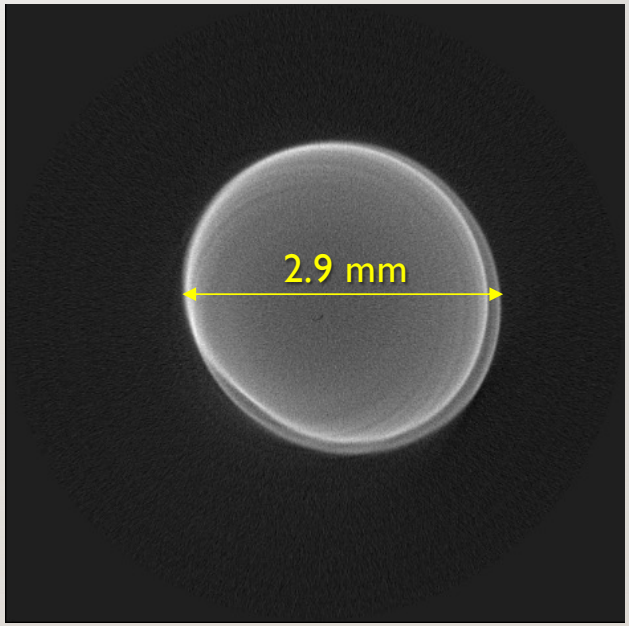


ATTENUATION-BASED CT

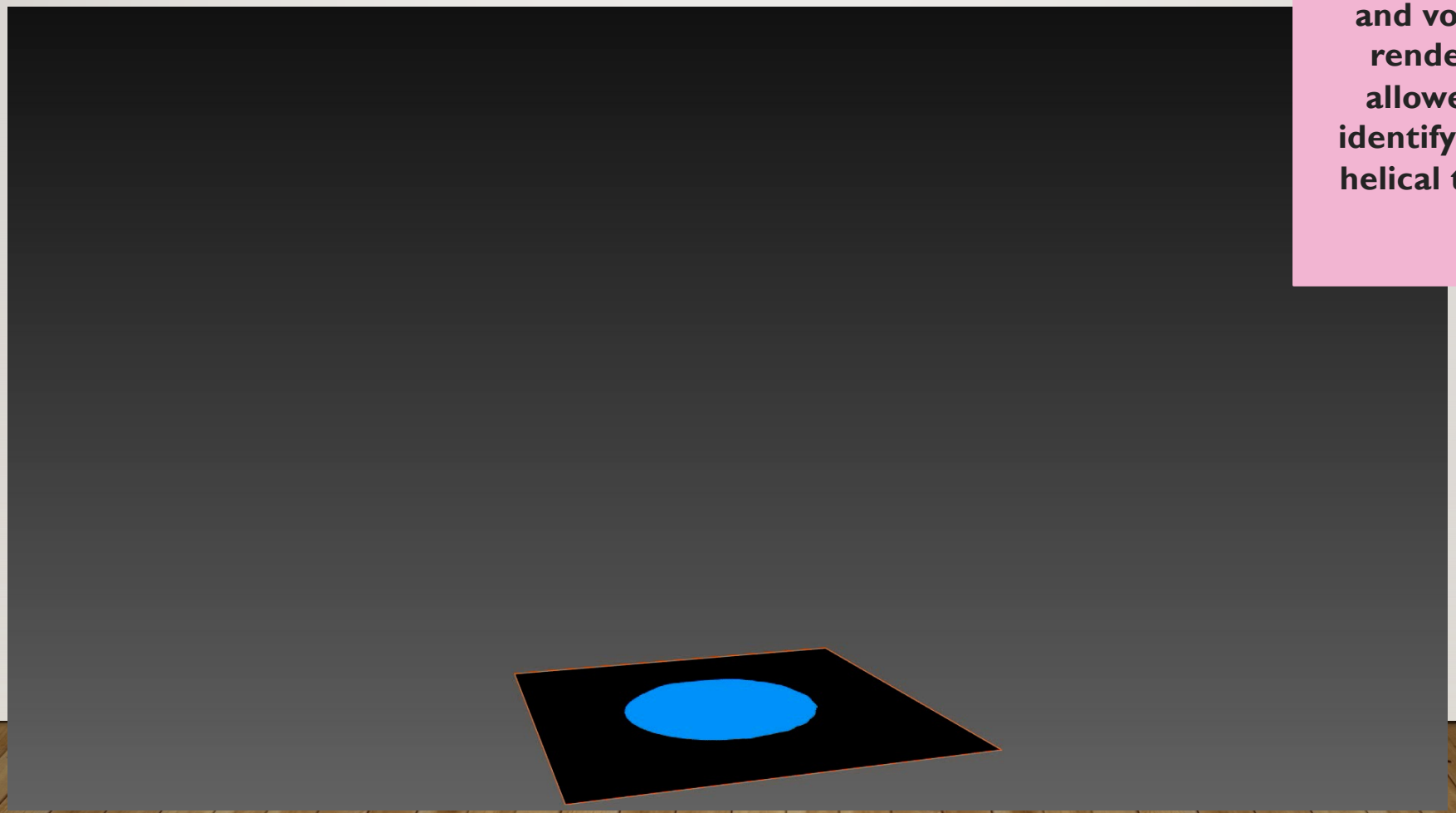
Projection images



Tomographic slice



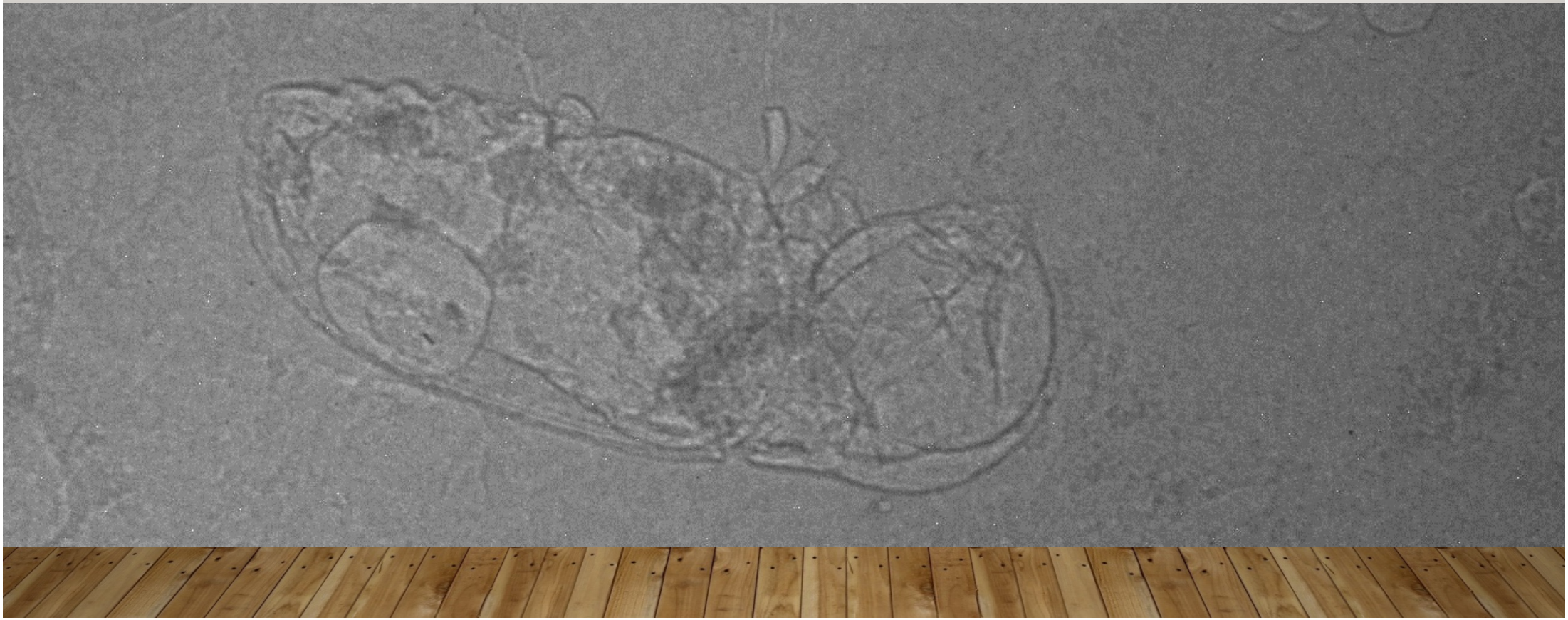
ATTENUATION-BASED CT



Segmentation and volume rendering allowed to identify screw helical thread

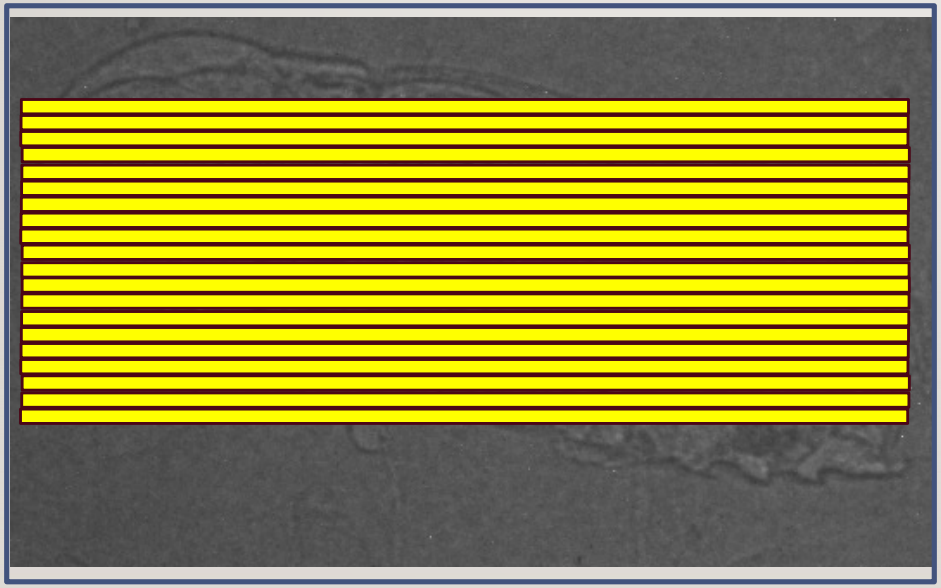
11 PHASE CONTRAST CT

Projections images over 360° of an insect embedded in amber

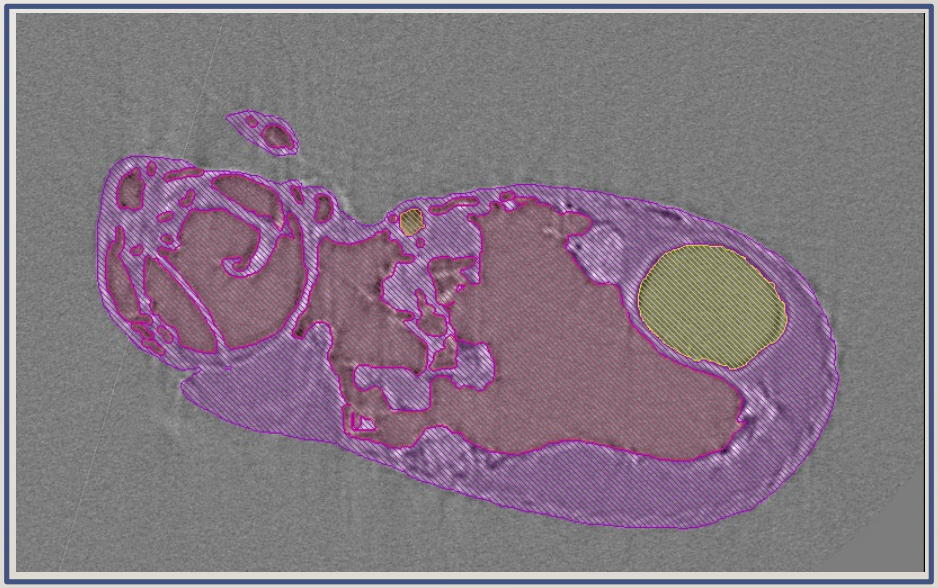


PHASE CONTRAST CT

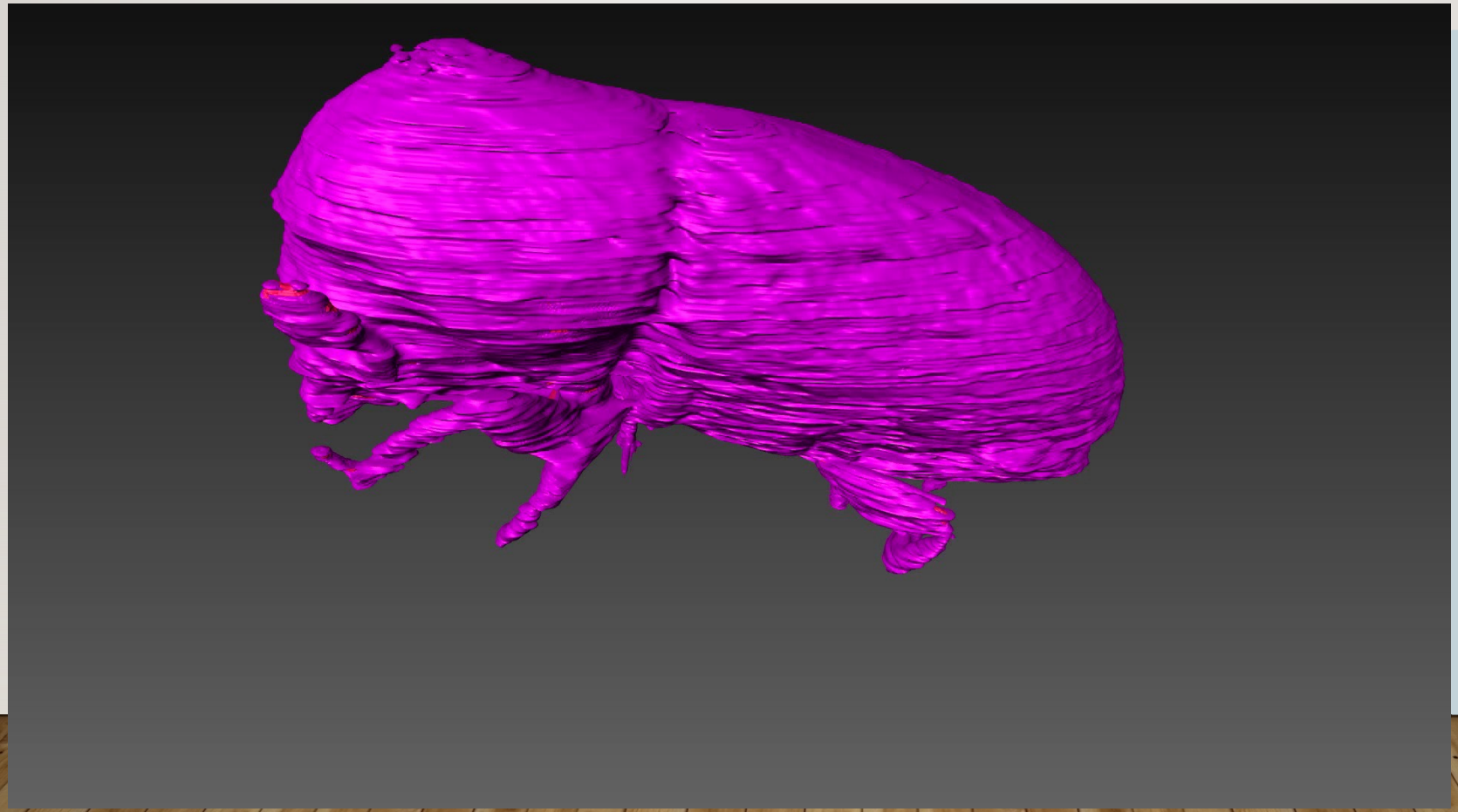
Tomographic reconstruction



Segmentation



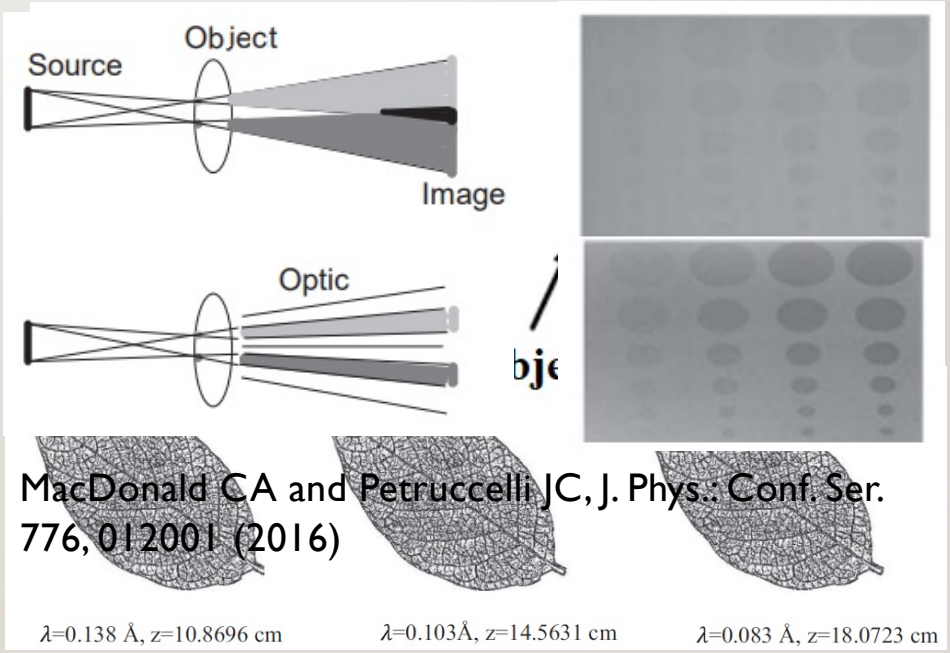
PHASE CONTRAST CT



Volume rendering enabled to identify **six paws**, **pair of antennae** and **mouthparts** of a 0.5 mm long insect.

14 POLYCAPILLARY APPLICATIONS

- Production of parallel beams
  - Extension of measurements normally performed at synchrotrons
- Removal of scattered radiation
  - Increase in signal-to-noise ratio
- Use as two-dimensional gratings in phase contrast imaging
  - Improvement in source efficiency



MacDonald CA and Petruccelli JC, J. Phys.: Conf. Ser. 776, 012001 (2016)

Sun et al., Opt. Com. 356, 202-207 (2015).

CONCLUSIONS

This experimental setup allowed to obtain high resolution tomographic images using a desktop X-ray system.

Attenuation-based CT

- Helical thread structure was observed in screw volume rendering.

Phase contrast CT

- Volume rendering enabled to identify six paws, pair of antennae and mouthparts of a 0.5 mm long insect;
- Volume data of this kind allow biologists to study detailed morphological features in three dimensions.

Polycapillary applications

- Potential of **polycapillary optics** for phase contrast imaging and tomography.

THANK YOU!

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