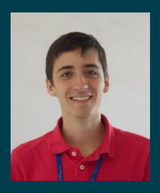

# Exploiting the phase: a step-change in x-ray imaging

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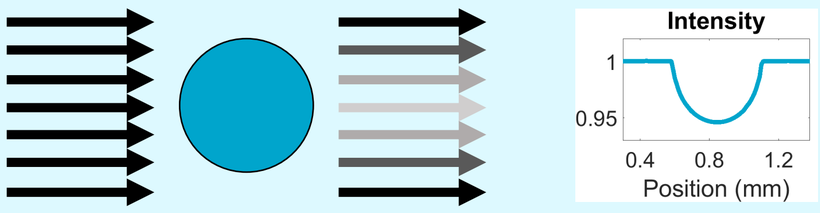
**Edge illumination phase-based** x-ray imaging is at the forefront of the x-ray imaging revolution. Let me tell you why.

## Why is phase-based imaging important?

- The image contrast in conventional x-rays is driven by **absorption**.

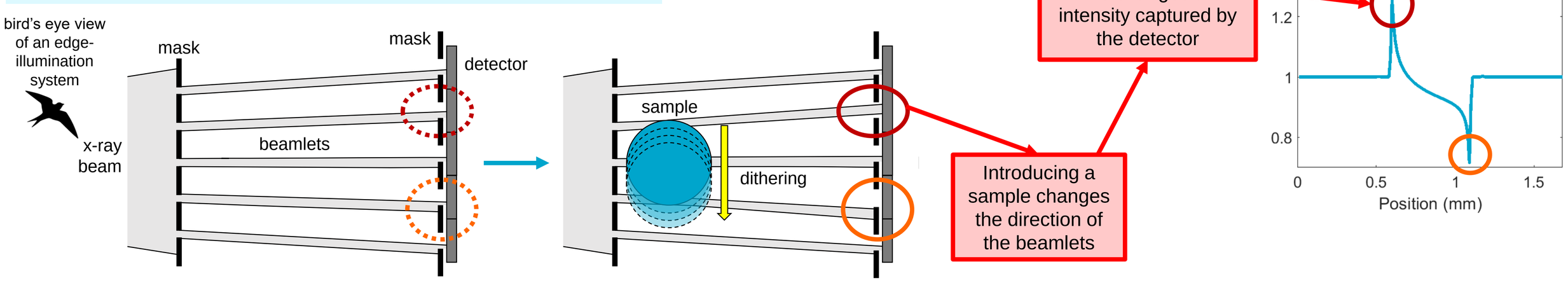



- However, **phase changes** in the beam **are often stronger**, particularly with biological tissue, but they normally go undetected. Phase-based imaging exploits them and…
  - → it offers better contrast / image quality
  - → is non-invasive
  - → is relatively inexpensive (compared to e.g. MRI)

## What is edge illumination?

- When x-rays go through an object they change their direction (like light through a glass of water): this is called **refraction** and is related to the phase.

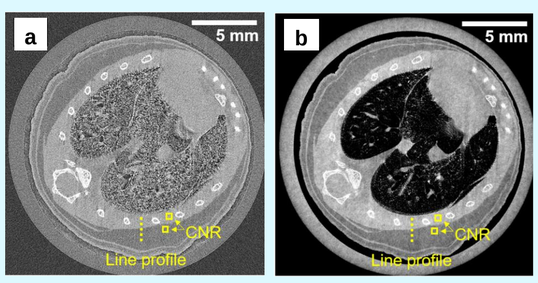

- Edge illumination uses refraction to see details that are otherwise invisible.
- To do this, we **split the x-ray beam into narrow beamlets**, and use opaque masks to capture the signal: easy to do in the lab.
- Thanks to the beamlets, high spatial resolution (the ability to see small details) is available…
  → BUT only if we do **dithering**: moving the sample laterally.




## What is it useful for?

There are **many applications** of edge illumination, thanks to its flexibility and ease of implementation. For example:

- Pre-clinical small animal imaging for drug development

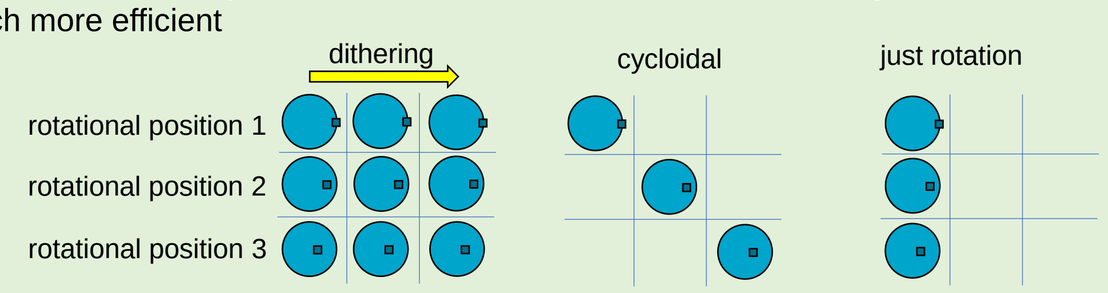



High-resolution images of a mouse chest acquired with edge illumination; (a) shows the absorption image, while (b) shows the phase image.

- Detection of tumour margins in breast tissue specimens during breast-conserving surgery
- Damage detection in composite materials, applicable for e.g. the aerospace industry.
- And many more!

## Cycloidal computed tomography

- Cycloidal CT offers a flexible, high-quality solution to the inefficiency problems of dithering.
- In cycloidal CT, the sample is **rotated and translated simultaneously**, like the wheel of a car.
  → much more efficient

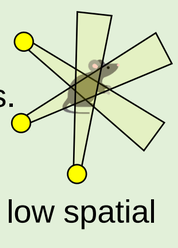



Cycloidal CT uses only a fraction of the data compared to dithering: it's **faster** and it delivers **less dose**. It uses the same amount of data as just rotation, but it spreads it in a smart pattern to improve quality.

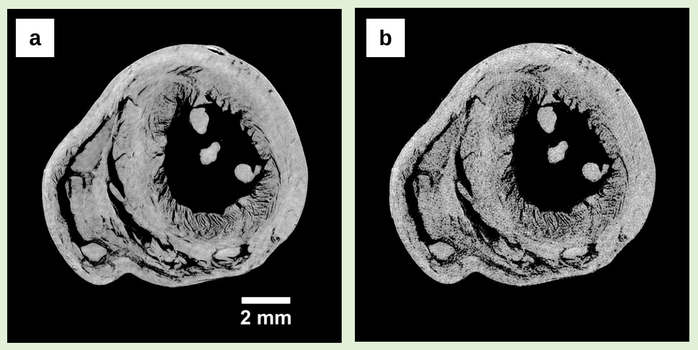
- Cycloidal CT can be implemented by starting and stopping the motion at each position ("step-and-shoot") or **continuously** – the latter is **even more efficient**! One of the favoured continuous implementations is "pixelwise" scanning, where the sample only moves within one pixel.

## Edge illumination computed tomography

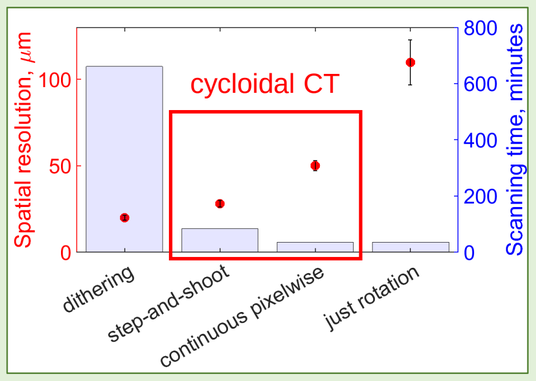
- Computed tomography ("CT") creates cross-sectional images of an object by illuminating it from several angles. This is done by rotating the source or the sample itself.



- In edge illumination CT, just rotating the sample will give low spatial resolution, so we often use dithering.
  → BUT **dithering is inefficient.** It takes a long time because we need to move the sample several steps at each rotational position.
- Instead, we can do…




Cross-sectional images of a rat heart, processed with dithering (a) and step-and-shoot cycloidal CT (b). The quality is strikingly similar even though (b) uses 1/16th of the data compared to (a). These are phase images, but the cycloidal approach can also be beneficial in absorption imaging or other forms of contrast.




The spatial resolution of cycloidal images is very close to that of dithering, while taking up to 20x less time. Just rotation, which takes the same amount of time, has much worse resolution.

We must keep looking for faster, better, more effective methods of medical imaging. **Edge illumination will help**.

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