Integration of a hybrid photon counting detector into a lab-based µCT scanner for 3D X-ray histology

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Previous work has demonstrated the general capability of hybrid photon counting (HPC) detectors for computed tomography (CT) [1, 2]. These studies have not investigated imaging very low internal X-ray contrast specimens such as Formalin-Fixed Paraffin-Embedded (FFPE) soft tissue. Imaging of FFPE soft tissue has been demonstrated using energy integrating detectors [3]. HPC detectors allow the simultaneous acquisition of multiple images based on different energy thresholds, narrowing the range of the detected X-rays and providing energy-dependent information. This enables energy-resolved X-ray imaging and thus spectral CT, such as dual X-ray imaging for K-edge imaging, an imaging mode previously impractical with a broad polychromatic X-ray beam, typically produced by lab-based µCT scanners.

The aim of this study was to µ-CT scan FFPE soft tissue samples on a Nikon XH 225 ST µCT scanner by integrating a DECTRIS SANTIS 3204 HR detector, which required the development of custom hardware and software (Figure 1). The raw projections produced by the SANTIS detector exhibit horizontal and verticals gaps throughout the image (Figure 2a), due to the construction of the detector. To reduce the impact of these lines, a custom image acquisition and post-processing routine has been developed to enable artefact-free 3D volumes to be reconstructed (Figure 2b, Figure 3). A sample of FFPE rat lung was imaged at 80 kVp, 6.9 W (32µm voxels, 2401 projections), with two energy thresholds (8.7 keV and 20 keV) captured, below and above the characteristic energies of the molybdenum target. As the aim of this work was to integrate systems, the imaging conditions were not optimised.

Having shown that it is possible to integrate a HPC detector into a commercial µ-CT scanner, future work includes optimising acquisition parameters and reconstruction algorithms to improve image quality and to fully realise the potential of HPC detectors when imaging soft tissue samples.

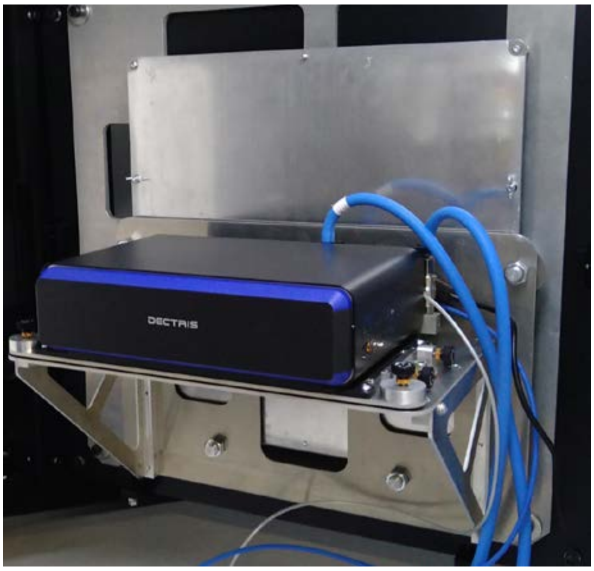

Figure 1: DECTRIS SANTIS 3204 HR mounted in a Nikon XH225 ST µCT scanner, using a multi-axis adjustable mount developed in-house.

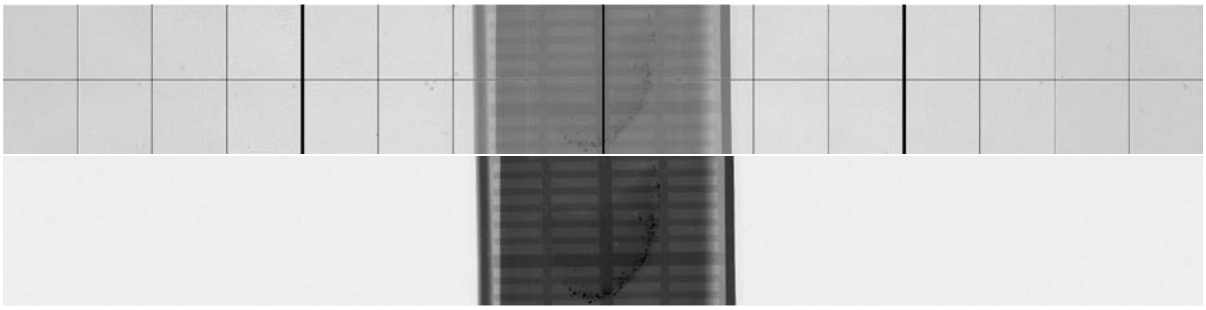

Figure 2**:** Example raw and processed radiographs acquired using the DECTRIS HPC detector, showing the plastic cassette holding the FFPE sample in the centre of the image. (A) Raw detector image showing the gaps caused by the construction of the detector. (B) Processed radiograph showing the result of the applied bad pixel and gap-filling corrections.

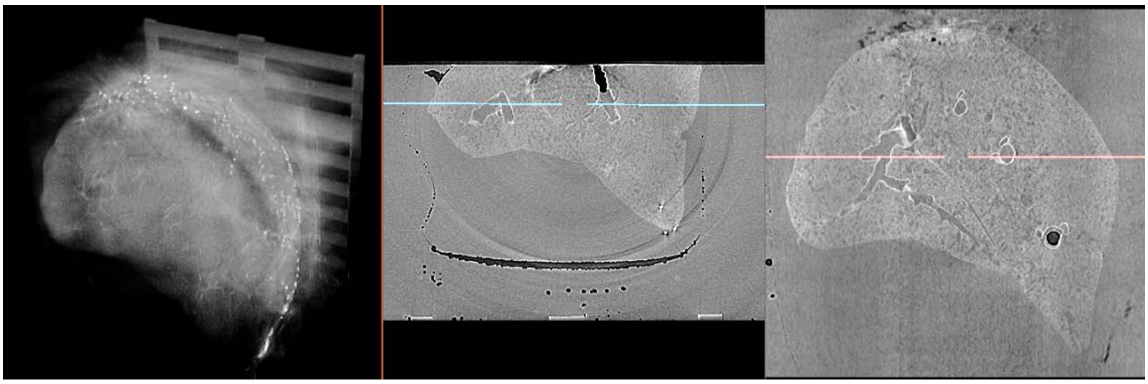

Figure 3 Example reconstructed data from the DECTRIS detector A) 3D rendering showing the tissue on the cassette with wax thresholded out. B) Single-slice normal to the histologically relevant plane. C) Resliced data showing the histologically relevant plane (parallel to the cassette). Image-quality and acquisition protocol optimisation are currently ongoing

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