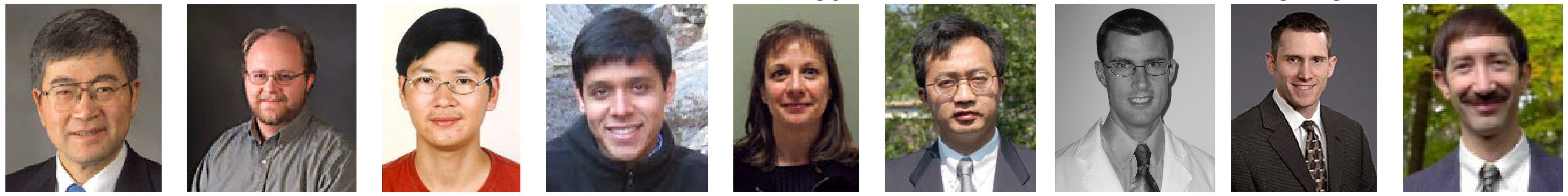
Biomedical Imaging Division
VIRGINIA TECH – WAKE FOREST UNIVERSITY
School of Biomedical Engineering and Sciences

SBES Advanced Multi-scale CT Facility at Virginia Tech

— From Multi-scale to Multi-energy and Multi-Parameter Imaging Capabilities



Ge Wang, Chris Wyatt, Hengyong Yu, Kriti Sen Sharma, Renee Prater, Shuhai Xiao, Chad Markert, Justin Saul, Edward Fox, Spencer Lee, Michael Feser, S H Lau, Wenbing Yun, Steve Wang
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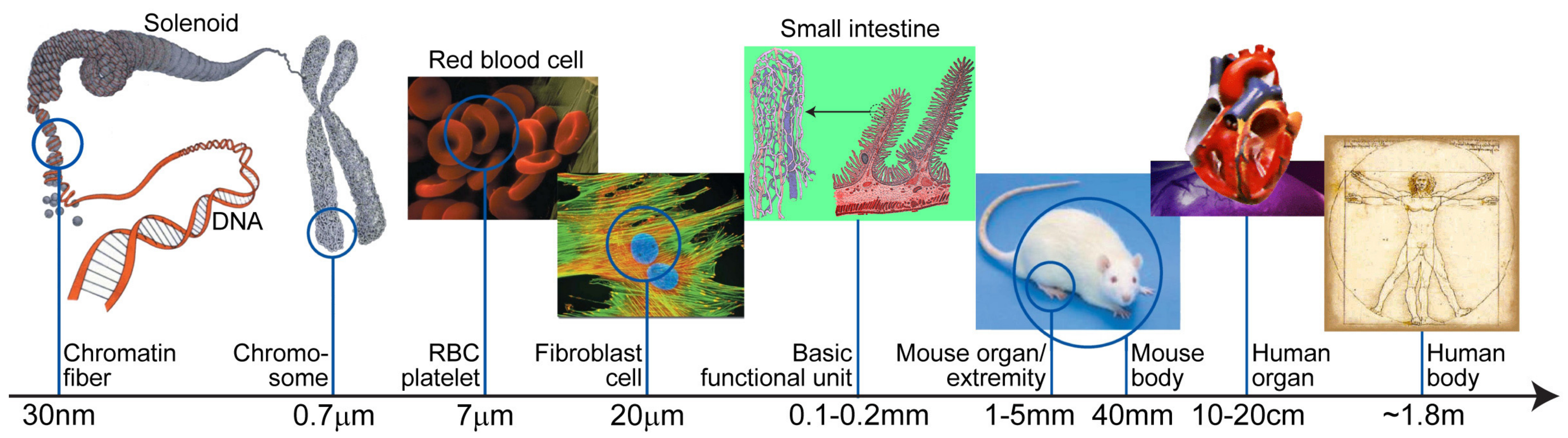
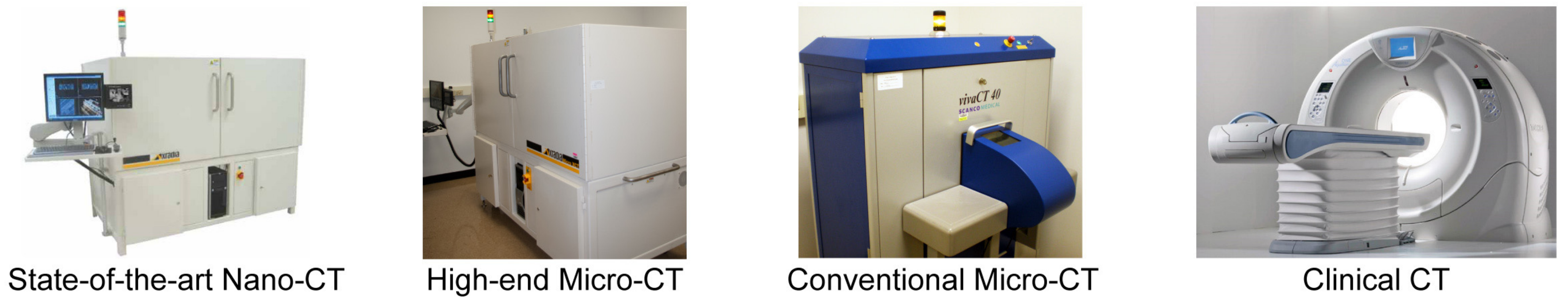
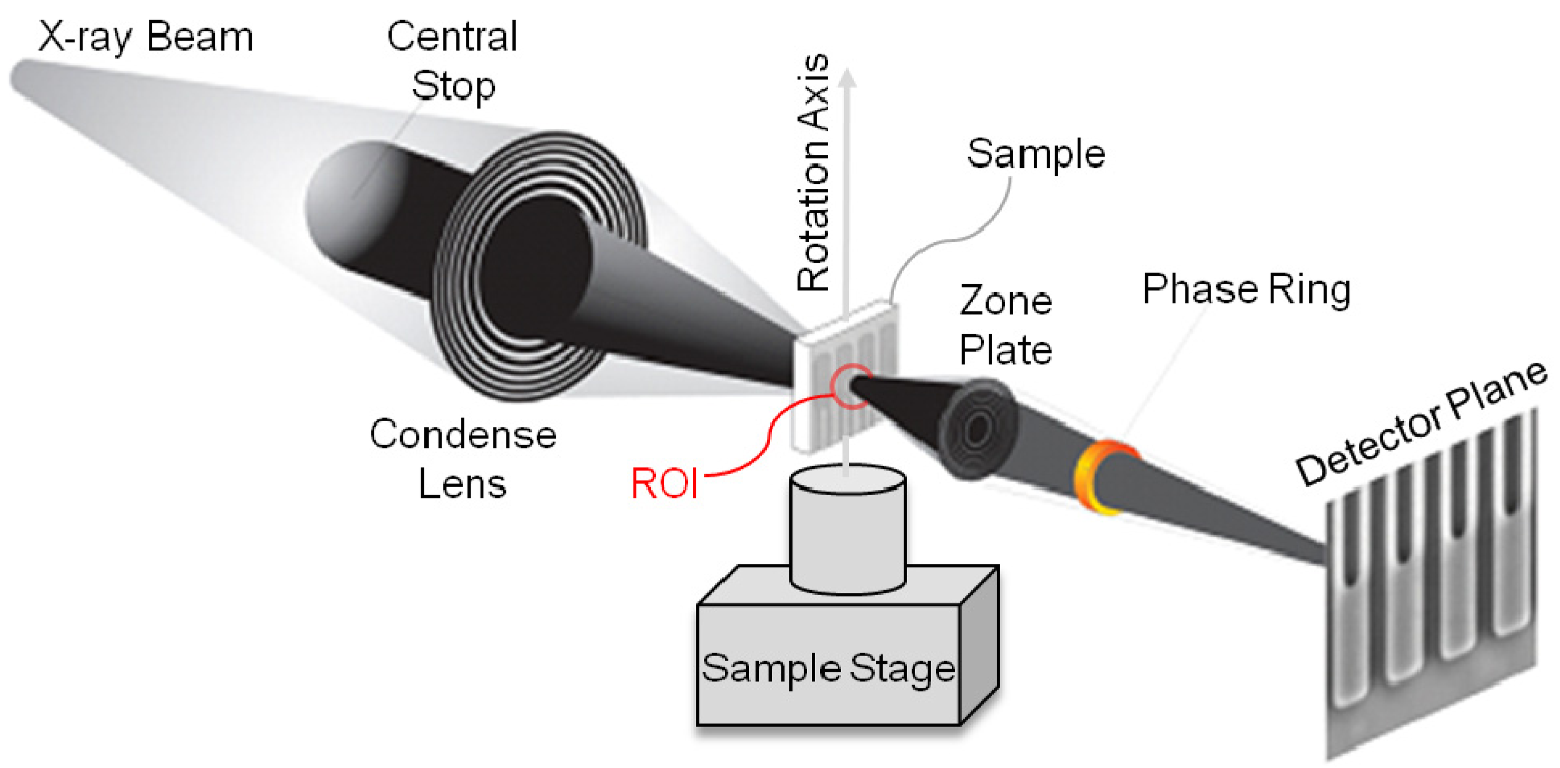
Multi-scale CT Facility





While clinical CT scanners are available at our medical school, for preclinical imaging we have a Scanco micro-CT scanner, an Xradia micro-CT scanner and an Xradia nano-CT scanner. With all these scanners, we can cover image resolution and sample size over six orders of magnitude. The Scanco scanner has resolution 16 μm and FOV 20-38 mm. The Xradia micro-CT scanner, purchased using an NIH SIG grant in 2008, is the highest resolution micro-CT system on the market. It produces 0.5 μm resolution and handle samples of up to 100 mm diameter. The Xradia nano-CT scanner, purchased using an NSF-MRI grant in 2009, has 50 nm resolution and represents the state-of-the-art. It allows tomographic imaging in either the attenuation or Zernike phase contrast mode. For the high-resolution performance of the micro-/nano-CT systems, special housing is vital to ensuring technical development and biomedical applications. We have a dedicated space for these systems in the Institute for Critical Technologies and Applied Sciences (ICTAS; http://www.ictas.vt.edu) Building A, adjacent to the Nanoscale Characterization and Fabrication Lab (NCFL; http://www.ictas.vt.edu/NCFL) at Virginia Tech, which hosts most other cutting-edge imaging systems under one roof.

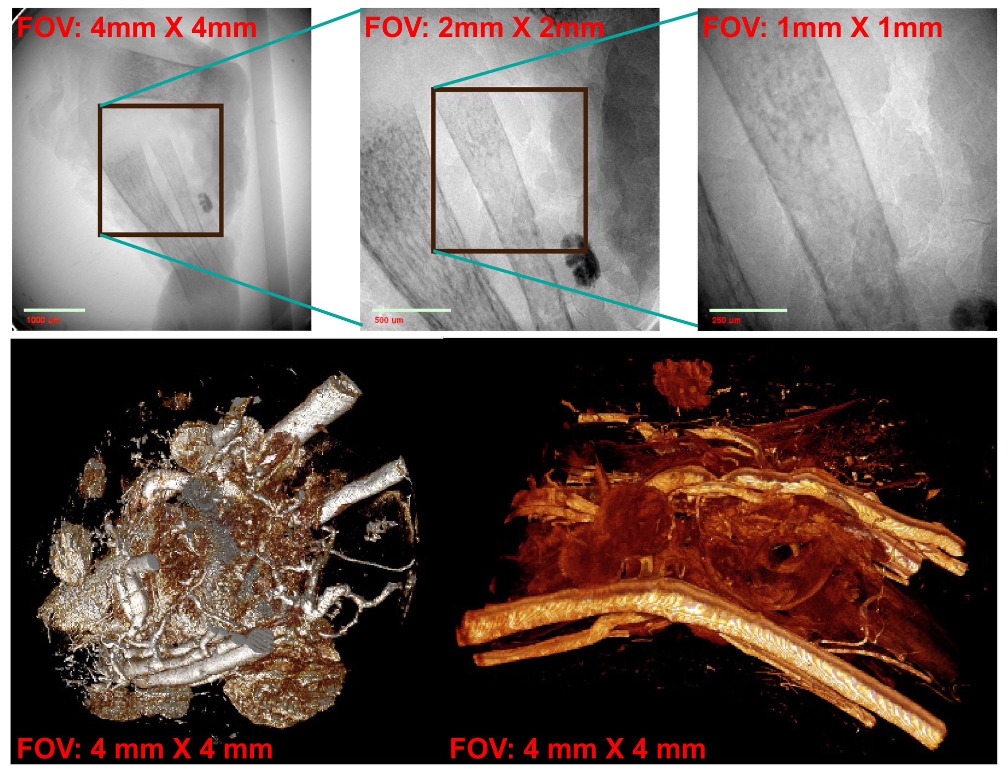
Interior Nano-CT Research and Development



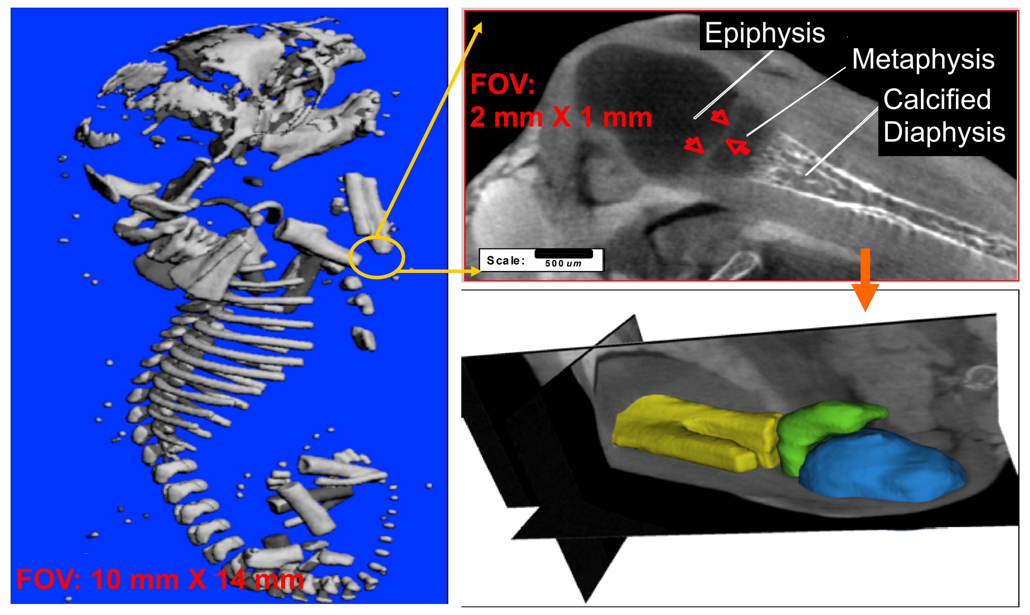
X-ray CT reveals internal structures of an object based on its shadows from an x-ray source. Filling in the performance gap between light and electron microscopy, x-ray nano-CT enables or facilitates biomedical, material, geological, industrial and other applications. However, a major barrier to realizing its full potential is the inaccuracy encountered when an interior region of interest (ROI) in a large object is imaged with a narrow beam of x-rays only through the ROI (known as “the interior problem”). Also, nano-CT demands intensive x-ray radiation that may damage biological samples. To meet these challenges, we are developing the next-generation nano-CT system with targeted scanning and interior reconstruction capabilities, in collaboration with the leading nano-CT company Xradia under NSF support.

Wang G, Ye YB, Yu HY: Interior tomography and instant tomography by reconstruction from truncated limited-angle projection data. Virginia Tech Patent Disclosure VTIP 07-071, May 15, 2007; U.S. Patent 7,697,658, April 13, 2010
Ye YB, Yu HY, Wei YC, Wang G: General local reconstruction approach based on truncated Hilbert transforms. International Journal of Biomedical Imaging, Article ID 63634, 8 pages, 2007
Yu H, Wang G: Compressive sensing based interior tomography. Physics in Medicine and Biology 54:2791-2805, 2009
Yang JS, Yu HY, Jiang M, Wang G: High-order total variation minimization for interior tomography. Inverse Problems 26:1-29, 2010
Wang G, Yu HY, Sharma KS, Wyatt C, Wang L, Andric T, Freeman J, Wang S, Feser M, Lau SH, Yun WB. To appear in the Proceedings of The First International Meeting on Image Formation in X-Ray Computed Tomography, Fort Douglas/Olympic Village, Salt Lake City, Utah, USA, June 6-9, 2010

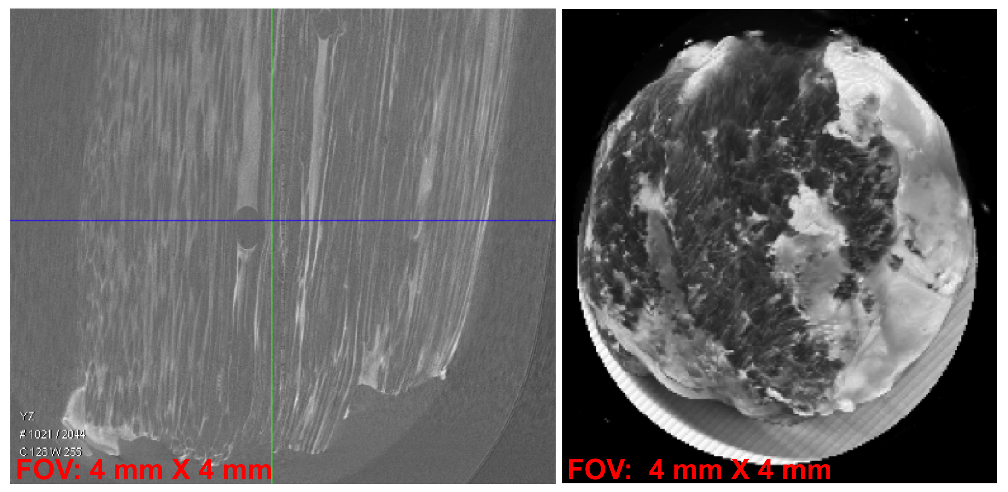
Multi-scale CT Applications and Training



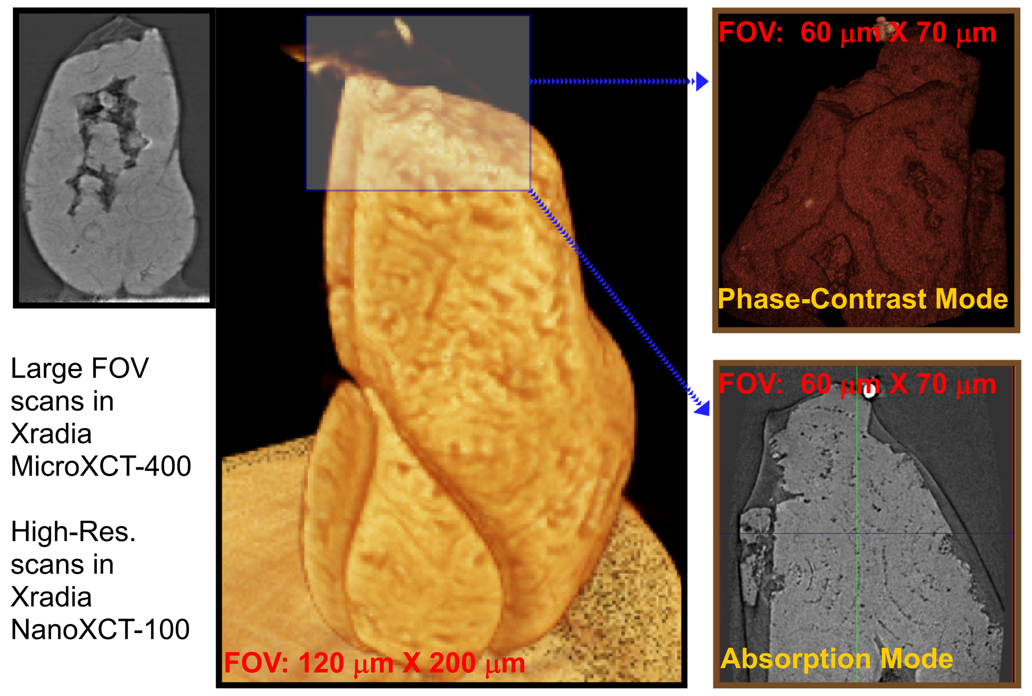
Example 1: Mouse Skeletal Study by Chris Wyatt *et al.*, Chad Markert *et al.*



Example 2: Mouse Skeletal Study by Renee Prater *et al.*



Example 3: Scaffold Study by Justin Saul *et al.*



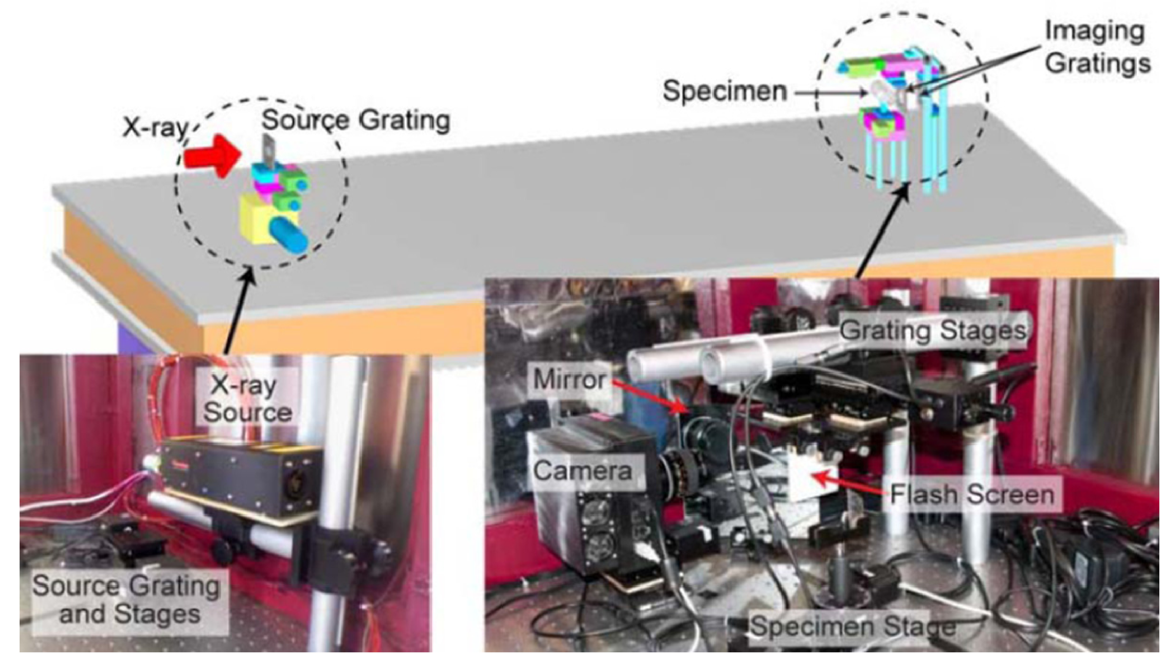
Example 4: Microfossil study by Shuhai Xiao *et al.*

Workshops and hands-on training sessions are effective for utility of the SAM CT facility, outreach for new users, and collaboration across disciplinary boundaries. Also, we developed the Second Life Aided Training Environment (SLATE) to make training cost-effective. In SLATE, a user becomes acquainted with the scanner without fear of damaging expensive components or reviews what has been taught in hands-on sessions.

Spectral Detection and Grating-based Imaging

The Medipix is a sophisticated electronic imaging chip which moves x-ray imaging from black and white to real-color images. We are collaborating with Dr. Butler’s group to develop spectral interior tomography to make our CT facility multi-spectral.

Chronicle 45, page2, Univ. of Canterbury, Jan., 2010



Based on the Talbot effect, groundbreaking work was reported in Europe and Japan, using 1D gratings for x-ray phase-contrast and dark-field imaging with a hospital-grade x-ray tube instead of a synchrotron radiation facility. We are working in this direction to have multi-parameter imaging capabilities.

Jiang M, Wyatt LW, Wang G: X-ray phase-contrast imaging with three 2-D gratings. Intl. J. of Biomedical Imaging 2008:Article ID 827152, 8 pages, 2008

Advanced Photon Source (APS) at Argonne National Laboratory is funded by US Department of Energy, and open to everyone who has a need for extremely brilliant x-ray photon beams. We are collaborating with Dr. Steve Wang and his colleagues on synergistic projects between Virginia Tech and APS, such as for interior reconstruction and system calibration.

Acknowledgment: This work was partially supported by Grants NIH/NCRR RR025667 and NSF/CMMI 0923297.

SBES/ICTAS Advanced Multiscale CT Facility: http://samct.imaging.sbes.vt.edu

April 5, 2010