# ***BMIT*** eNews | Spring 2020

*Current circulation: 400*

## Dear BMIT User,

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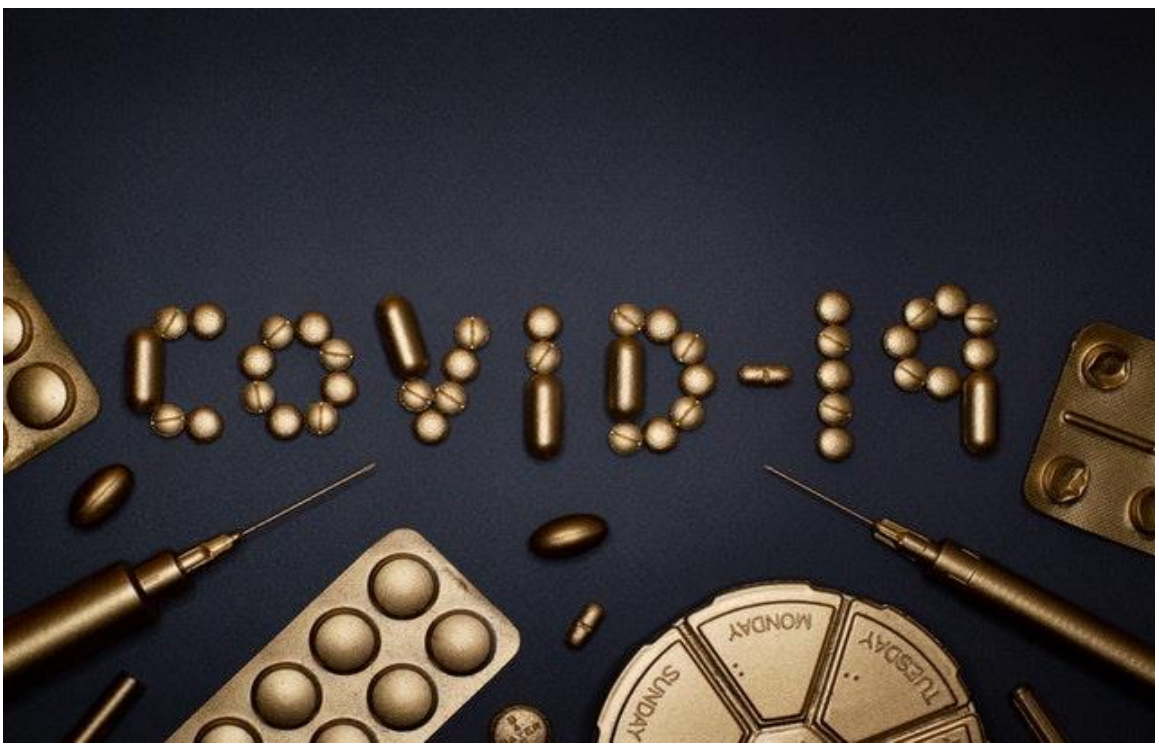
## COVID-19 Call for Proposals (Deadline May 21)




Seven weeks ago Saskatchewan imposed a State of Emergency to deal with the COVID-19 pandemic, resulting in CLS going into a warm-standby mode to protect our staff, clients and visitors. Premier Scott Moe recently announced a 5-phase plan to re-open Saskatchewan and emphasised that it is going to be a very gradual and methodical process. While current

pandemic-related safety protocols prevent us from starting-up immediately, we want to prepare for when we are able to do so.
Therefore, in an effort to help fight this global pandemic, CLS announced a special call for proposals last week for any work that will actively contribute to finding COVID-related treatments or vaccines, or improve conditions for frontline workers, including developing sensors and diagnostic tools or special surfaces with antiviral properties. Read the complete message here.

BMIT is among beamlines that can help scientific community in the battle against COVID-19. In particular:

- X-ray microtomography can be employed to reveal 3D microarchitecture of lung samples, for instance, detecting inflammation, blood clots and structural damage in the lungs of COVID positive cases. In a sub-centimeter specimen spatial resolution can be as good as 2-3 microns which is the size of small alveoli and air-ways.
- Analyzer-crystal based imaging (e.g., DEI, MIR) can be used to probe microstructure of lungs in a "statistical" sense by means of collecting ultra-small angle scattering signal (USAXS) from airways. This technique in radiography mode could be a fast method to detect inflammation in the lungs and potentially be used to assess efficacy of potential treatment(s) by observing relative changes in the USAXS signal in treatment groups. Owing to a very small radiation dose, this method can be utilized to image the same animal at multiple time points after commencing treatment.

**IMPORTANT:** All proposals should be submitted through the COVID-19 proposal type in the CLS User Portal. The deadline for proposals is **Thursday, May 21,** and we will respond within two weeks.

Please note that possibility of carrying out experiments will require approval of the CLS health and safety group and may be affected at any time by rapidly evolving health situation in Saskatchewan and Canada. **The call is limited to work that can be performed remotely, or by mail-in** – external users will not be permitted on site. Please discuss the feasibility of your proposal with the appropriate beamline staff before submission. We cannot yet anticipate when we will have beamtime available, but it is unlikely to be before July.

For up-to-date COVID-19 CLS measures information please visit www.lightsource.ca/covid19

## Remote Access for microCT Data Reconstruction and Visualization Server

Together with IT group at the CLS we have enabled remote access to one of our reconstruction servers. Users can obtain remote access to 5-10 data sets at a time, reconstruct data, and use Avizo for visualization and data analysis directly on BMIT server. Please contact Dr. Adam Webb (adam.webb@lightsource.ca) for details and scheduling. Depending on the number of requests access duration may be limited to 2-3 days.

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## CLS Annual Users' Meeting (AUM) and CT Workshop Postponed

CT data processing workshop originally scheduled for May 20-22, 2020 is postponed to a later date due to COVID-19 situation. Also CLS's Annual Users' Meeting (AUM) is postponed.

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## Staffing Change

After 11 years at CLS Denise Miller left BMIT on March 13, 2020 to assume a different position outside CLS. Denise worked at BMIT in different capacities from beamline controls software development to supporting various science projects and initiatives to being the acting beamline responsible for more than 1.5 years. Her dedication, attention to detail and leadership have been critical to BMIT's successes. On behalf of the BMIT staff, BMIT beam team and all BMIT users we wish her and her family all the best as she embarks on a new chapter in her career. Thank you and farewell Denise!

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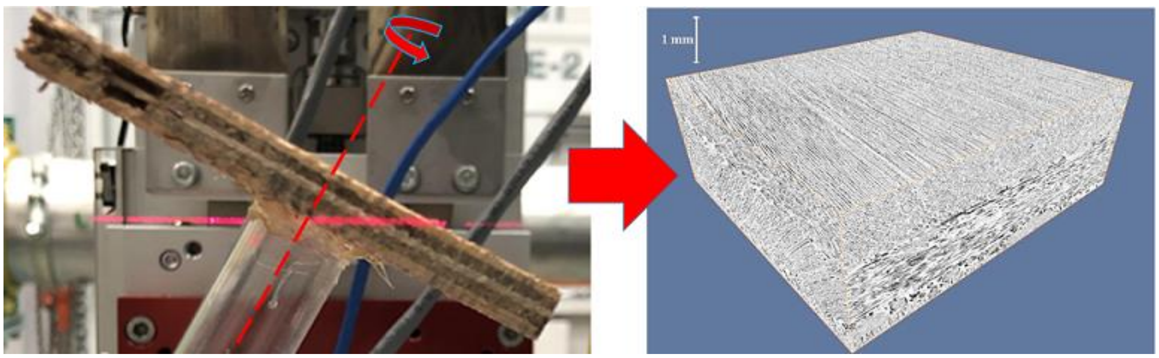
# New Technique: Laminography

BMIT recently implemented a new technique that is now open to users. Laminography is a technique that allows for reconstruction of large, flat objects by tilting the axis of rotation (as shown below, where the laser (horizontal red line) indicates the path of the beam). For the initial experiment, we scanned a flat panel of layered wood board on BMIT-BM. The resulting reconstruction shows a detailed reproduction of the layered microstructure in the wood panel.

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# 300 Publications and Counting!

In March 2020, we saw the 300th publication based on the data collected at BMIT beamlines. 61% of publications are journal articles, 21% are Doctoral and Masters' theses, 16% peer-reviewed conference proceeding and the rest book are chapters. We are proud of our users' research!

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# Cycle 32 Call for Proposals Results

We received 49 new proposals and 13 beamtime requests against active proposals for a total of 62 proposals. Peer-review process has completed, however, due to the COVID-19 situation, allocation cannot be done at this point. Provisionally we will resume normal operations in August-September and very likely we will be able accept only samples which can be mailed in and examined by a beamline scientist without the presence of users on site. Note that priority in the first days of operation will be given to COVID-related proposals. Your BMIT *Primary Point of Contact* for your experiment will contact you several weeks before experiment to confirm the details about the samples.

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## Around the Beamlines

Researchers from University of Saskatchewan used Microbeam radiation therapy (MRT) to deliver very high dose in microbeams of narrower than a human hair to blast tumours with radiation while sparing healthy tissue. Their ultimate goal is to use MRT in treatment of inoperable brain and spinal tumors. Read more here.

Al Hanson, Farley Chicilo, Whitney Curtis, Andrew Alexander, Danielle Sherin, Fred Geisler

## Reminder on BMIT User Data Back-up Policy

BMIT's data retention policy at the present time is 1 year - we will strive to keep a back-up copy of all users' data for a period of 2 years, but we cannot guarantee this. Please note that at no point will we back-up reconstructed and processed data - this is the sole responsibility of the research groups.
If you require a copy of your data, please contact the BMIT scientist that helped you with your experiment.

## Pictures of the Season

**Hyperglycemia compromises Rat Cortical Bone by Increasing Osteocyte Lacunar Density and Decreasing Vascular Canal Volume**

**Contact Information:** John E. Davies, University of Toronto

**Reference:** Ay, Birol; Parolia, Kushagra; Liddell, Robert S.; Qiu, Yusheng; Grasselli, Giovanni; Cooper, David M. L.; Davies, John E. (2020). Hyperglycemia compromises Rat Cortical Bone by Increasing Osteocyte Lacunar Density and Decreasing Vascular Canal Volume. *Communications Biology* 3(20), 1-9.

Uncontrolled diabetes is associated with increased risk of bony fractures. Reports of decreased implant stability and retention in hyperglycemic subjects support the notion of compromised bone quality. It has been demonstrated in hyperglycemic subjects that bone healing delays, growth plate thickness reduces, cortical porosity increases due to bone loss, and the crosslinking patterns of bone collagen changes with advanced glycation end products (AGEs). Yet, little has been done to elucidate the changes in bone cell density and vascular architecture in hyperglycemic bone.

Using high-resolution synchrotron micro-CT at 0.9um voxel size, researchers calculated the changes in the microstructure of femoral cortices of streptozotocin-induced hyperglycemic (STZ) Wistar Albino rats and tested the mechanical properties of the mineralized matrix by nanoindentation. In conclusion, hyperglycemia increased cellularity and lacunar density, decreased osteocyte territorial matrix, and reduced vascular girth, in addition to decreasing matrix mechanical properties in the STZ group when compared with euglycemic controls.

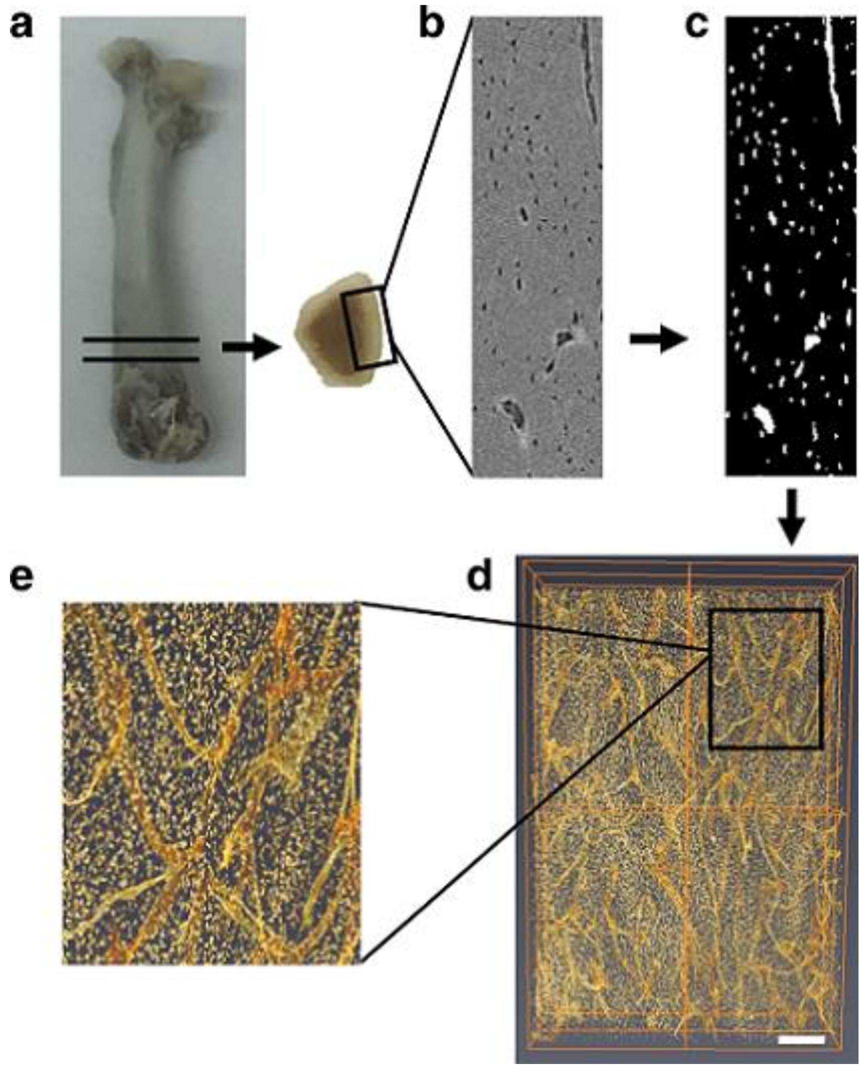


**Figure.** a) Representative image of bone slices cut from the distal femora; b) original gray-scale image obtained from SR micro-CT; c) corresponding binarized image; d, e) 3D volume rendering of the osteocyte lacunae and vascular canals obtained with Volren feature of Amira (scale bar represents 200 µm).

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## Determining elemental strontium distribution in rat bones treated with strontium ranelate and strontium citrate using 2D micro-XRF and 3D dual energy K-edge subtraction synchrotron imaging

**Contact Information:** Ana Pejovic-Milic, Ryerson University

**Reference:** Cardenas, Daniel; Turyanskaya, Anna; Rauwolf, Mirjam; Panahifar, Arash; Cooper, David; Wohl, Gregory R.; Streli, Christina; Wobrauschek, Peter; Pejović-Milić, Ana. (2020). Determining elemental strontium distribution in rat bones treated with strontium ranelate and strontium citrate using 2D micro-XRF and 3D dual energy K-edge subtraction synchrotron imaging. *X-Ray Spectrometry*. 49, 424-433.

Strontium-based medications, such as strontium ranelate, have been suggested to have therapeutic effects in patients with osteoporosis. Strontium salts available off-shelf in stores across North America are assumed to provide similar effects as strontium ranelate and thus should lead to similar distributions of elemental strontium incorporated in bone. The objective of this study was to compare the spatial distribution of strontium in animal bones following the administration of strontium ranelate and strontium citrate. Seventeen-week old Sprague–Dawley rats were split into three groups over 10 weeks and given 625 mg/kg/day of strontium ranelate and 676 mg/kg/day of strontium citrate; the control group received no additional supplementary strontium. The humeri were collected from all animals, and strontium distribution was mapped using 2D micro-XRF and 3D dual energy K-edge subtraction (KES) imaging (13um voxel size). 2D and 3D elemental mapping methods demonstrated that strontium delivered during treatment by both salts had the same spatial distribution. 3D elemental strontium maps of treated animal bones showed that strontium was largely observed in the trabecular regions under the epiphyseal (growth) plate. The thickness of the strontium layers in both the strontium ranelate and strontium citrate sample was not significantly different ($p = 0.9201$). 2D micro-XRF and 3D dual-energy KES images effectively elucidated the spatial distribution of elemental strontium in calcified tissue. These methods provide a novel approach to evaluating the potential efficacy of strontium supplements in the treatment of osteoporosis.

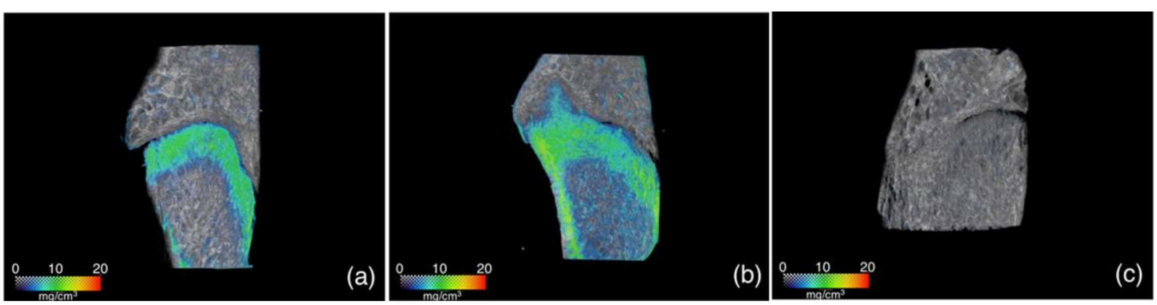


**Figure 1.** Cross-sections of the 3D elemental strontium maps of rat bones treated with (a) strontium ranelate, (b) strontium citrate, (c) and control (nontreated). Images (a) through (c) depict the epiphyseal plate within the head of each proximal humerus.

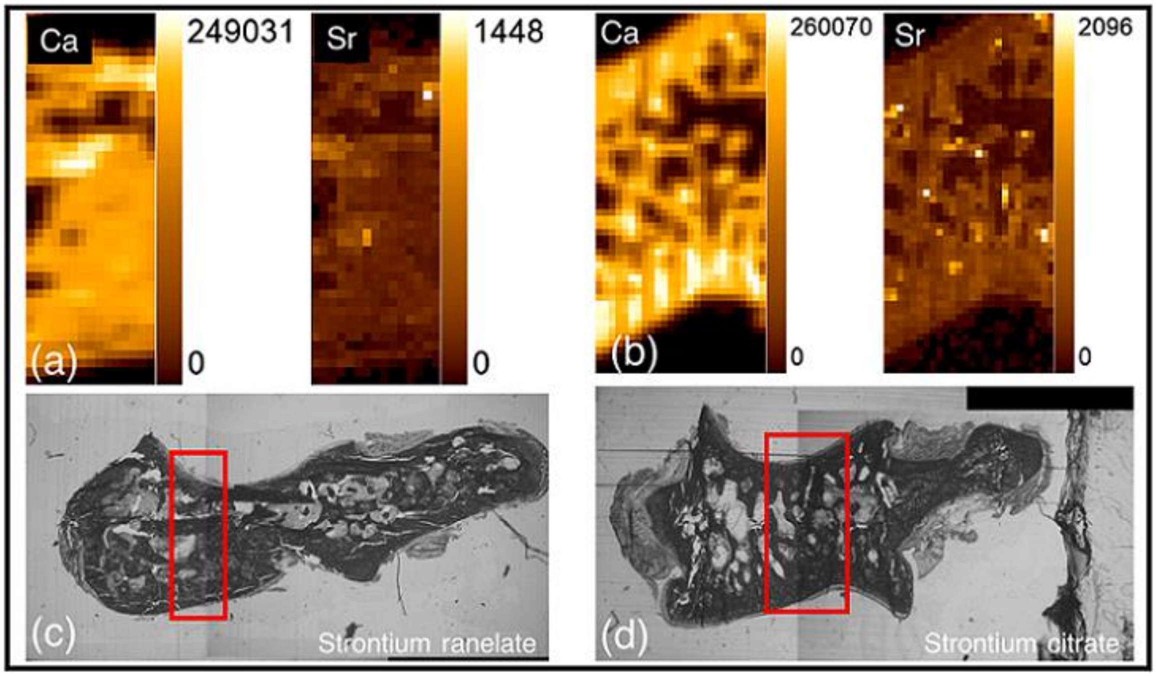


**Figure 2.** 2D elemental maps of calcium (Ca) and strontium (Sr) for (a) strontium ranelate (700 µm × 2100 µm) and (b) strontium citrate (1,250 µm × 2,700 µm). Elemental maps are displayed in terms of absolute intensities. The images below the maps are electron light microscopy scans used to select the regions of interest (c) strontium ranelate and (d) strontium citrate; regions scanned are indicated using a red frame.

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## Synchrotron X-ray Radiography and Tomography of Vanadium Redox Flow Batteries – Cell Design, Electrolyte Flow Geometry, and Gas Bubble Formation

**Contact Information:** Roswitha Zeis, Karlsruhe Institute of Technology

**Reference:** Eifert, L.; Bevilacqua, N.; Köble, K.; Fahy, K.; Xiao, L.; Li, M.; Duan, K.; Bazylak, A.; Sui, P.C.; Zeis,R. (2020). Synchrotron X-ray Radiography and Tomography of Vanadium Redox Flow Batteries – Cell Design, Electrolyte Flow Geometry, and Gas Bubble Formation. *ChemSusChem.*

Solar, wind, and hydropower plants as so-called green energy sources are naturally subject to fluctuating power output, resulting in the demand for energy conversion and storage systems. Redox Flow Batteries (RFBs) are capable of meeting these demands due to the uncoupling of power and energy capacities, potentially low costs, fast response times, and a tunable design. The wetting behavior and affinity to side reactions of carbon-based electrodes in Vanadium Redox Flow Batteries are highly dependent on the physical and chemical surface structures of the material, as well as on the cell design itself. Three different flow geometries towards the impact on the flow dynamics, and the formation of hydrogen bubbles were studied. Via electrolyte injection experiments it was shown that the maximum saturation of carbon felt is achieved by a flat flow field after the first injection and by a serpentine flow field after continuous flow. Furthermore, the average saturation of the carbon felt is correlated to the cyclic voltammetry current response, and the hydrogen gas evolution was visualized in 3D via X-ray tomography (13um voxel size).

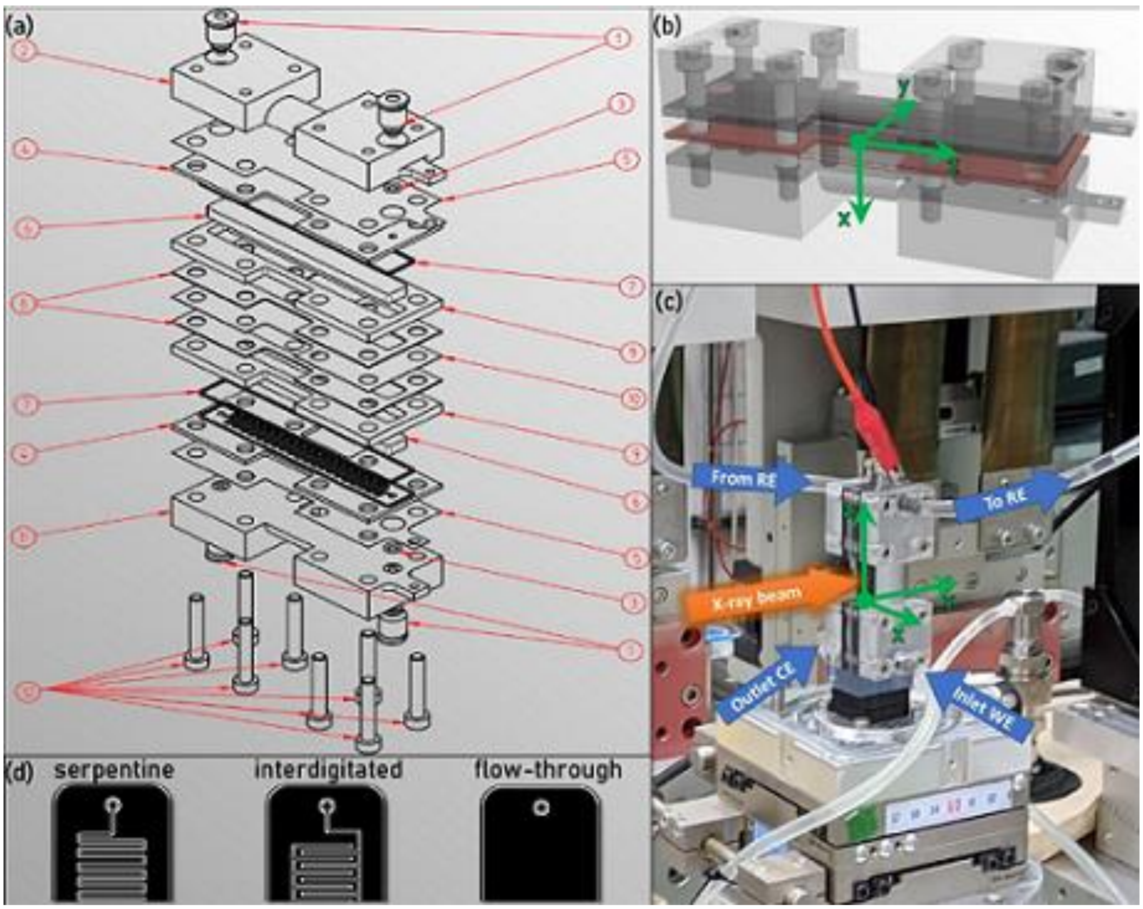


**Figure 1.** a) Exploded view of the synchrotron cell. b) 3D rendering of the assembled cell. c) Photograph of the assembled and connected cell on the sample holder at the Canadian Light Source. d) Representation of the top of the different flow field types.

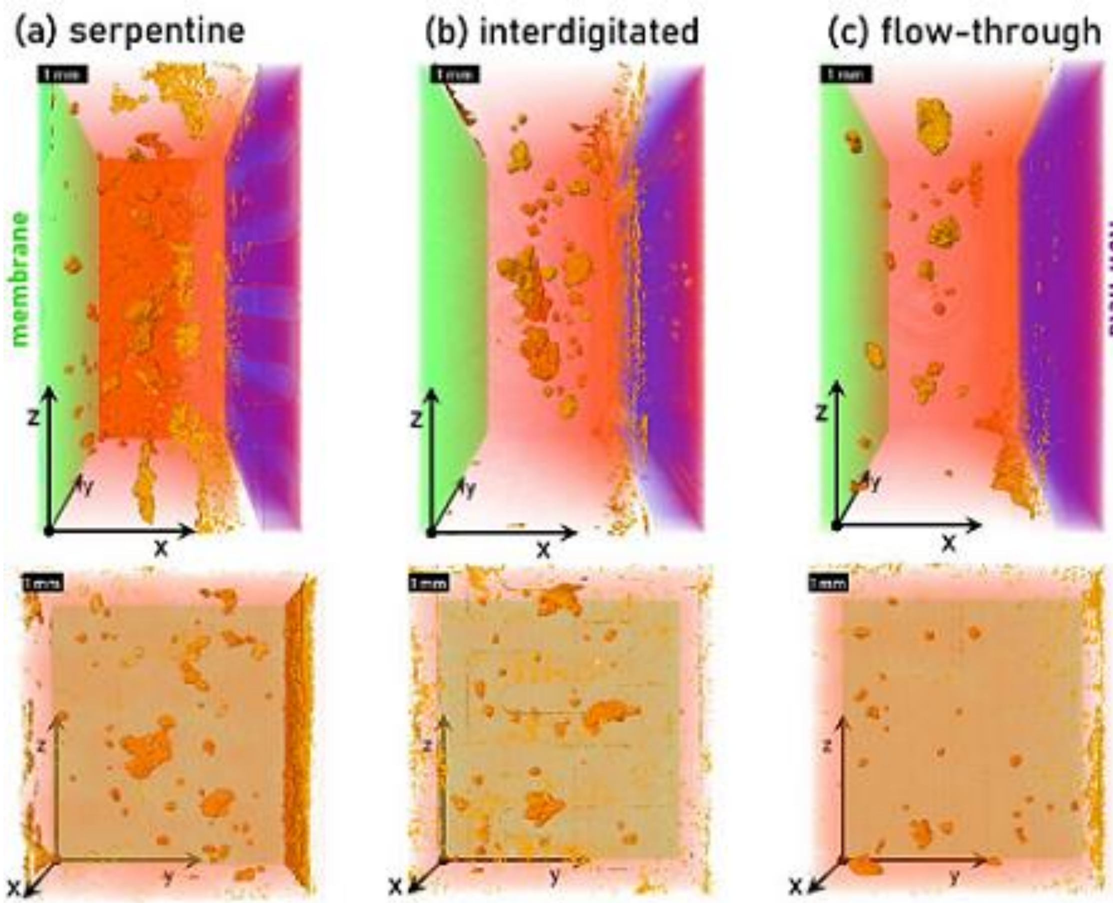


**Figure 2.** Visualization of the remaining air in the carbon felts by the means of X-ray tomography after the injection of the vanadium electrolyte through (a) serpentine and (b) interdigitated flow fields, as well as (c) a flow-through configuration. The membrane is depicted on the left (green), the flow field on the right (purple), and the remaining air pockets in between are displayed in orange. The origin of the coordinate is at the same position in the top and bottom row.

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## New publications

Publications are important factor in our funding and taken into consideration by the peer review committee. Users are encouraged to add their publications to the CLS database. Please review the publications list and ensure that all of your publications are included:

**http://bmit.lightsource.ca/publications**

To add new or missing publications to the CLS database use the CLS User Portal System:

https://user-portal.lightsource.ca

After you log in, click on 'Publications', then 'All Publications', then simply click on the **green + icon** in the top right corner to add your publication. Papers are easily added using the DOI.

## Acknowledgments

All Users and CLS Staff are required to acknowledge the work they performed, in whole or in part, at the Canadian Light Source. Authors are requested to include the following Acknowledgement when submitting or presenting results from the CLS:

**"Part or all of the research described in this paper was performed at the Canadian Light Source, a national research facility of the University of Saskatchewan, which is supported by the Canada Foundation for Innovation (CFI), the Natural Sciences and Engineering Research Council (NSERC), the National Research Council (NRC), the Canadian Institutes of Health Research (CIHR), the Government of Saskatchewan, and the University of Saskatchewan."**

Acknowledgement of any beamline staff who may have assisted in optimization and preparation of the experimental setup as well as data acquisition or data processing is very welcomed.

Moreover, if users would like to refer to technical specifications of BMIT beamlines, they may cite the following articles:

- To refer to technical specifications of the BMIT-BM beamline (*i.e.,* 05B1-1 POE-2 endstation):

Wysokinski, T. Chapman, D. Adams, G., Renier, M. Suortti, P. Thomlinson, W. Beamlines of the biomedical imaging and therapy facility at the Canadian Light Source-Part 1. Nuclear Instruments and Methods in Physics Research A, vol. 582, iss. 1 pp. 73-76, 2007.

- To refer to technical specifications of the BMIT-ID beamline (*i.e.,* 05ID-2 SOE-1 endstation):

Wysokinski, T. Chapman, D. Adams, G., Renier, M. Suortti, P. Thomlinson, W. Beamlines of the biomedical imaging and therapy facility at the Canadian Light Source-Part 3. Nuclear Instruments and Methods in Physics Research A, vol. 775, iss. 1 pp. 1-4, 2015.

- To cite the UFO-KIT reconstruction software you may cite:

Vogelgesang, M.; Farago, T.; Morgeneyer, T. F.; Helfen, L.; dos Santos Rolo, T.; Myagotin, A.; Baumbach, T. Real-time image-content-based beamline control for smart 4D X-ray imaging. Journal of synchrotron radiation, Vol. 23, iss. 5, pp. 1254-1263. 2016.

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# Reported publications using BMIT beamlines - January to April 2020


1. Eifert; L.; Bevilacqua; N.; Köble; K., *et al.* (2020). Synchrotron X-ray Radiography and Tomography of Vanadium Redox Flow Batteries - Cell Design, Electrolyte Flow Geometry, and Gas Bubble Formation. *ChemSusChem*.
2. Hirpara; Viral; Patel; Virat; Zhang *et al.* (2020). Investigating the effect of operating temperature on dynamic behavior of droplets for proton exchange membrane fuel cells. *International Journal of Hydrogen Energy*.
3. Mei; Xueshuang; Glueckert; Rudolf; Schrott-Fischer, *et al.* (2020). Vascular Supply of the Human Spiral Ganglion: Novel Three-Dimensional Analysis Using Synchrotron Phase-Contrast Imaging and Histology. *Scientific Reports,* 10(1), 5877.
4. Chicilo; F; Hanson; A L; Geisler, *et al.* (2020). Dose profiles and x-ray energy optimization for microbeam radiation therapy by high-dose, high resolution dosimetry using Sm-doped fluoroaluminate glass plates and Monte Carlo transport simulation. *Physics in Medicine and Biology*, 65(7), 075010.
5. Subash Dhakal (2020). Synchrotron Radiation Inline Propagation Based Phase Contrast Computerized Tomography (Pc-Ct) Of Human Prostate Sample. *Maters Thesis.* Supervisor: Al-Dissi, Ahmad; Buhr, Mary. Saskatchewan, Canada: University of Saskatchewan.
6. Seyedali Melli (2020). Compressed Sensing Based Reconstruction Algorithm for X-ray Dose Reduction in Synchrotron Source Micro Computed Tomography. *Doctoral Thesis.* Supervisor: Wahid, Khan; Babyn, Paul. Saskatchewan, Canada: University of Saskatchewan.
7. Loundagin; Lindsay L.; Haider; I.T.; Cooper; DML, *et al.* (2020). Association between intracortical microarchitecture and the compressive fatigue life of human bone: A pilot study. *Bone Reports*, 100254.
8. Shrestha; P.; Lee; CH.; Fahy, *et al.* (2020). Formation of Liquid Water Pathways in PEM Fuel Cells: A 3-D Pore-Scale Perspective. *Journal of the Electrochemical Society*, 167(5), 054516.
9. Cardenas; Daniel; Turyanskaya; Anna; Rauwolf; Panahifar; Arash, *et al.* (2020). Determining elemental strontium distribution in rat bones treated with strontium ranelate and strontium citrate using 2D micro-XRF and 3D dual energy K-edge subtraction synchrotron imaging. *X-Ray Spectrometry*.
10. Balakrishnan; Manojkumar; Shrestha; Pranay; Ge; Nan, *et al.* (2020). Designing Tailored Gas Diffusion Layers with Pore Size Gradients via Electrospinning for Polymer Electrolyte Membrane Fuel Cells. *ACS Applied Energy Materials.*
11. Rohani; Seyedalireza; Allen; Daniel G.; Gare, *et al.* (2020). High-resolution imaging of the human incudostapedial joint using synchrotron-radiation phase-contrast imaging. *Journal of Microscopy*.

12. Lee; CH.; Lee; J. K.; Zhao, *et al.* (2020). Transient Gas Distribution in Porous Transport Layers of Polymer Electrolyte Membrane Electrolyzers. *Journal of the Electrochemical Society*, 167(2), 024508.
13. Helpard; Luke; Li; Hao; Rask-Andersen, *et al.* (2020). Characterization of the human helicotrema: implications for cochlear duct length and frequency mapping. *Journal of Otolaryngology - Head and Neck Surgery*, 49(21).
14. Samadi; Nazanin (2020). A Real Time Phase Space Beam Size and Divergence Monitor for Synchrotron Radiation. *Doctoral Thesis.* Supervisor: Chapman, Dean. Saskatchewan, Canada: University of Saskatchewan.
15. Ay; Birol; Parolia; Kushagra; Liddell, *et al.* (2020). Hyperglycemia compromises Rat Cortical Bone by Increasing Osteocyte Lacunar Density and Decreasing Vascular Canal Volume. *Communications Biology*

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