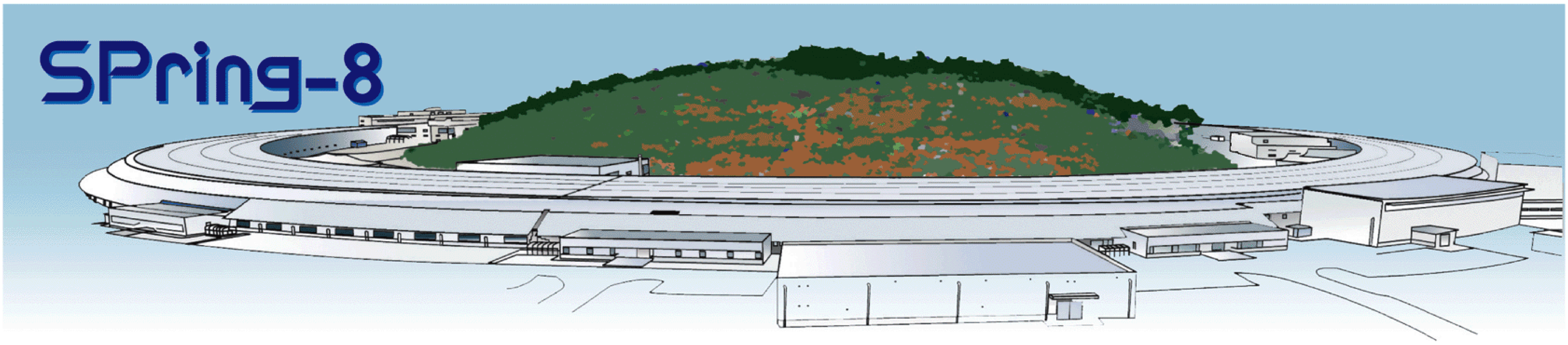

Ultra-Small-Angle Scattering at Medical and Imaging Beamline II, BL20XU

The unique properties of the beamline BL20XU are the extremely brilliant and highly coherent X-ray beam from the undulator X-ray source and the long (248 m) beam transport channel. The major application fields of BL20XU are microfocusing, holography, and other X-ray optics experiments utilizing high spatial coherence. The properties of BL20XU are also very suitable for ultra-small angle scattering experiments, because the maximum observable period of the sample structure is equal to the spatial coherent length.

In an ultra-small-angle-scattering experiment, the sample is placed in the first experimental hutch located at 80 m from the light source, and an imaging detector is set in the second experimental hutch (at about 245 m from the light source). Various imaging detectors, such as an X-ray image intensifier, a flat panel sensor, and an imaging plate detector, can be used. This ultra-small-angle-scattering setup covers a diffraction range of $q > 1.5 \times 10^{-3}$ nm^{-1}, where $q = 4\pi \sin(\theta/2)/\lambda$, θ is the scattering angle, and λ is the wavelength. A two-dimensional diffraction pattern can be recorded in an exposure time of 1 second using an X-ray wavelength of 0.54 Å.

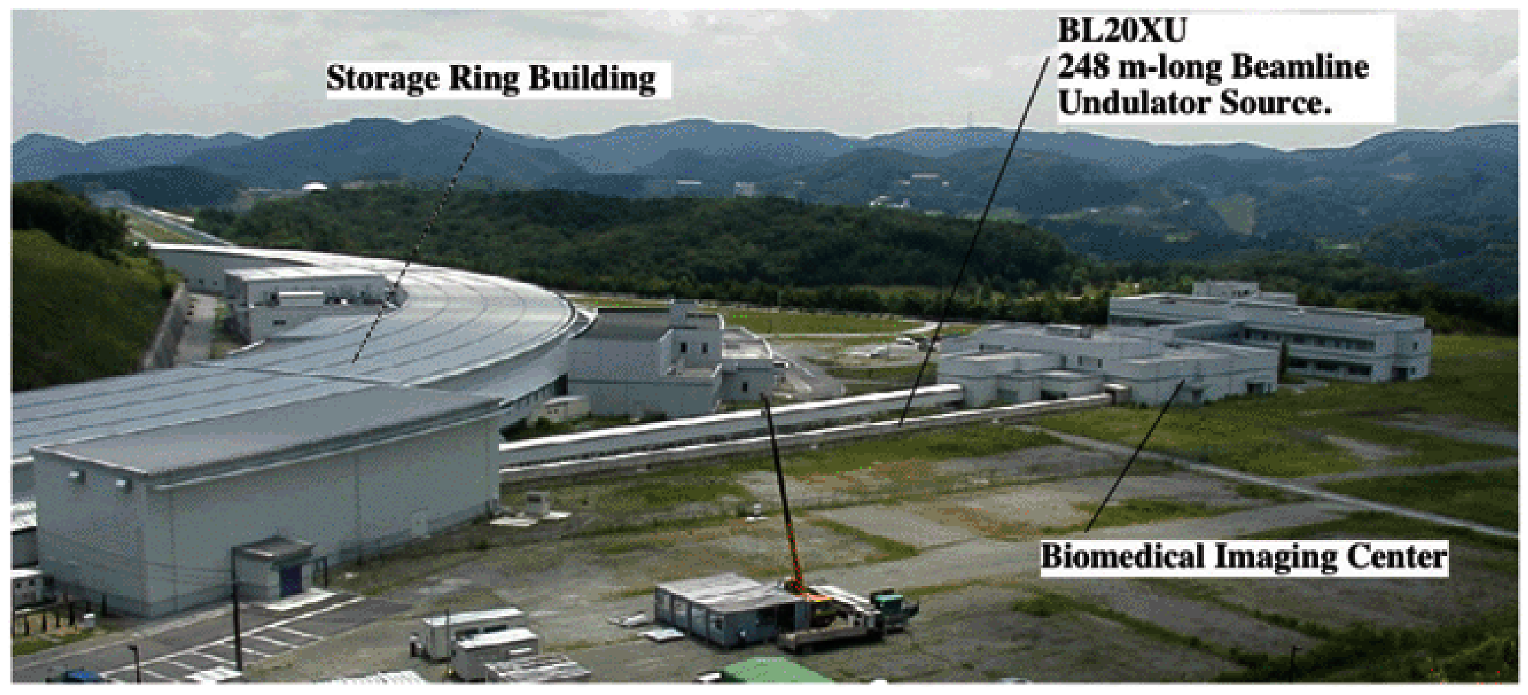

Fig. 1 Overview of Medical and Imaging Beamline II, BL20XU.

Dynamic Submicroscale Measurement by Ultra-Small-Angle X-ray Scattering

Professor Y. Amemiya (Univ. of Tokyo) and his team have developed a time-resolved two-dimensional ultra-small-angle X-ray scattering technique (2D-USAXS) at SPring-8's beamline BL20XU. The long sample-to-camera distance (~ 160 m) and highly directional X-rays enable the *in situ* observation of anisotropic structural changes in the range of 250 nm - 4 µm. They have succeeded in measuring simultaneously 2D-USAXS, the wide-angle X-ray diffraction and mechanical properties of rubber filled with nanoparticles (carbon black and silica) (Fig. 2). It revealed the relationship between the deformation of the aggregate structure of the nanoparticles, the polymer orientation, and the mechanical properties of the rubber, which is a key to improving the performance of rubber materials such as tires. Moreover, the scattering pattern can be measured within 1 second; the measurement time is shortened to 1/100,000 that for conventional USAXS measurement using a Bonse-Hart camera. As a result, it is anticipated that this technique will enable us to characterize the changes in microstructures in many areas of science, and that it will be useful for clarifying, for example, the origin of the reinforcement of rubber with nanoparticles.

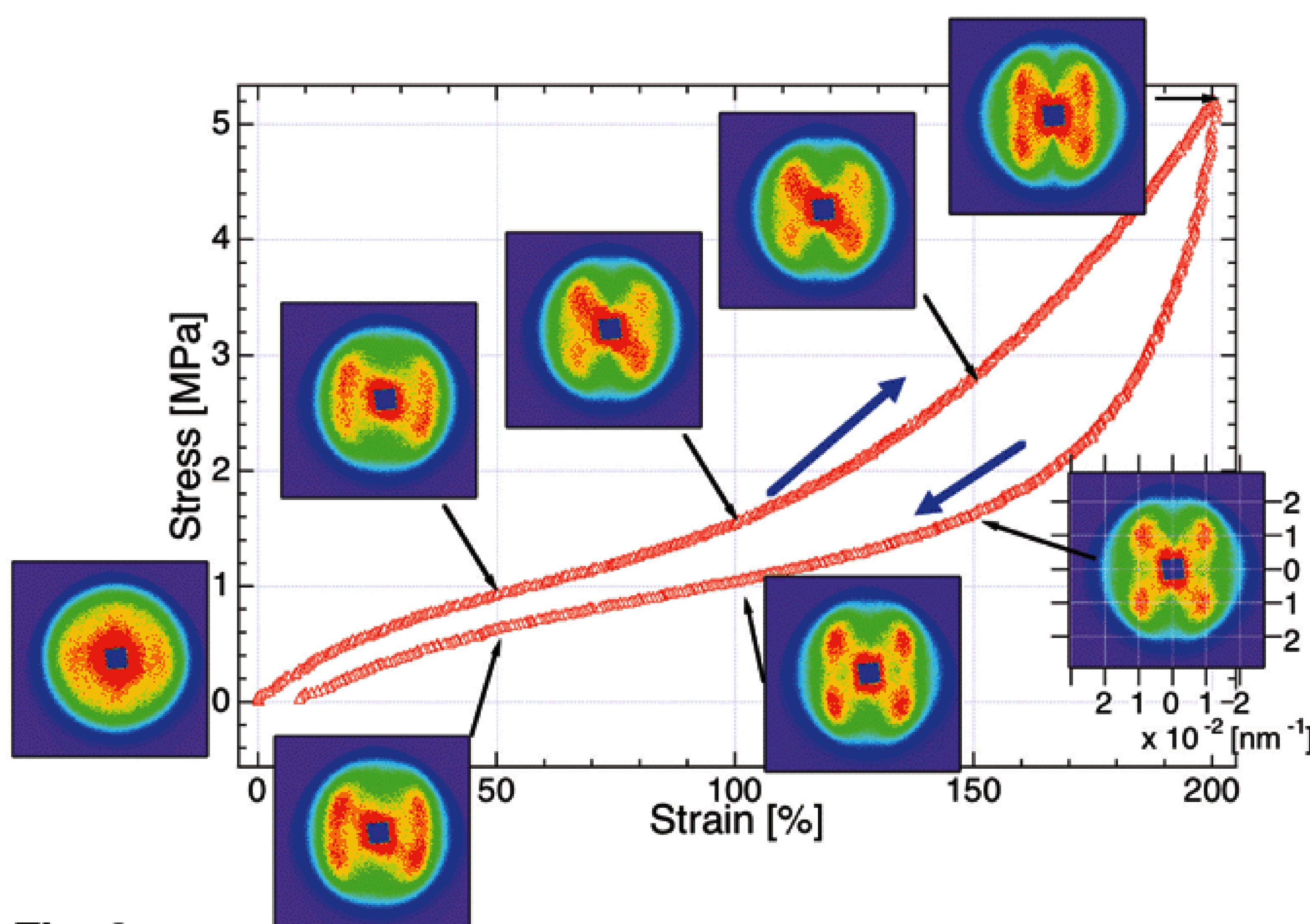

Fig. 2
Stress-strain curve of styrene-butadiene rubber filled with spherical silica nanoparticles (diameter: 300 nm) and corresponding 2D-USAXS images during loading and unloading processes. The sample is stretched in the horizontal direction.

Figure 2 is reproduced with permission from Figure 4 of Y. Shinohara, H. Kishimoto, K. Inoue, Y. Suzuki, A. Takeuchi, K. Uesugi, N. Yagi, K. Muraoka, T. Mizoguchi and Y. Amemiya, J. Appl. Cryst. (2007) Vol. 40, pp. s397-s401.