

Small-angle muscle diffraction facility for F1

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X-ray diffraction is the only technique that can obtain high resolution structural information from muscle in the living, hydrated state. X-ray diffraction of muscle make unusually high demands on X-ray sources and optics. Muscles diffract relatively weakly, have many components with similar long spacings (thus diffraction is at very small angles) and the changes of physiological state in muscle and the accompanying structural changes occur in a time scale of milliseconds or a few tens of microseconds.

The promise of synchrotron radiation as a source of high intensity, well collimated X-rays for time resolved studies of muscle was recognised as early as 1971 by G. Rosenbaum and colleagues. This promise can be realized in studies that produce full two-dimensional diffraction data at high time resolution during rapid mechanical transients, thus establishing a link between muscle structure and muscle physiology.

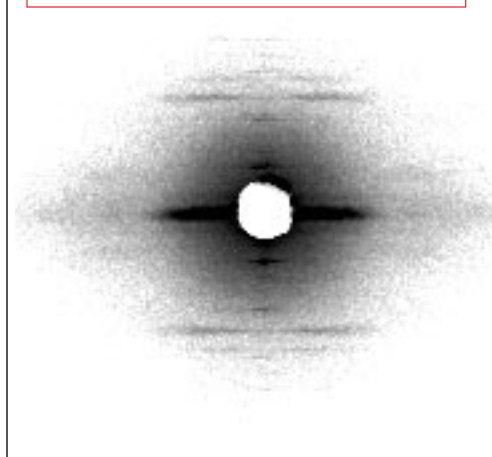
The major impediment to reaching this goal so far has been lack of x-

ray flux. All synchrotron small angle diffractometers that have been used for muscle studies to date are on bending magnet beam lines. Here we report preliminary results from, and characterization of a small angle diffractometer built (in collaboration with H.E. Huxley, Brandeis University) for the F-1 station,

an exceptionally high flux wiggler beam line.

The camera that was ultimately constructed (see above) was first tested in August of 1992. The collimation system consists of three sets of horizontal and vertical slits connected by a 1.8 m long evacuated flight tube with mica windows. The four jaws of each set of slits are individually stepper motor controlled.

50 ms exposure from sartorius muscle



Downstream of the mica window is a solenoid shutter capable of ~40 ms opening times which incorporates an ion chamber for beam intensity monitoring. This can be used in conjunction with a chopper type shutter to yield millisecond or submillisecond exposures. The sample is mounted on a two-axis vertical stage that can be used to move the sample in a raster pattern in the beam to reduce the radiation damage in any given part of the sample.

Downstream of the sample position is an evacuated flight tube, adjustable in length from 80 cm to 2 m.

mounted at one end to the X-95 rail and at the other to a stand with motorized x-y motions to align the beam stop. The focal spot size is about 3 x 0.3 mm FWHM at the 5 m point in the hutch, containing as much as 10^{13} photons/s at 13.65 KeV (0.91 Å) and 85 mA ring current, a factor of 20 greater than competing beam lines at Daresbury and the Photon Factory.

The middle figure shows a diffraction pattern from an isometrically contracting whole sartorius muscle from bullfrog muscle taken in 50 ms using a Fuji image plate with the Fuji BAS2000 scanner. Since it is possible to get over 100 tetanic contractions from a frog muscle, this rapid exposure time means that any of the features visible on this image can be resolved to 1 ms with a single specimen and with good spatial resolution. Order to order spatial resolution is (on image plates) in excess of 2500 Å.

Clearly, the F-1 small angle camera will be an excellent tool for time resolved studies of muscle, with particular application to the weaker diffraction features such as the actin layer lines. The short exposure times make it possible to obtain two dimensional diffraction data with millisecond time resolution in combined mechanical and X-ray experiments on single muscle specimens. For more information, contact Tom Irving at 607-255-2174/3607.



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