

# RADIATION SAFETY IN THE X-RAY DIFFRACTION LAB AT UTC

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## PART 2—SHIELDING AND AUTOMATIC SHUTTER ON THE PHILIPS PW1830/3550/3710 X-RAY DIFFRACTION SYSTEM



The X-ray diffraction system consists of the PW1830 X-ray generator, the PW3550 goniometer, and various other components necessary to its operation (slit assemblies, monochromator, detector, radiation shielding, data and control electronics, computer, recirculating water chiller, etc.). The X-ray tube is contained in the X-ray tube shield, which is mounted to the top of the generator. The goniometer sits on the table top of the generator, adjacent to port #4 in the tube shield.

The entire system, excluding the computer and the water chiller, is shown in Figure 1.

The X-ray tube shield has 4 ports, each of which is fitted with an electromagnetically operated shutter. X rays are contained by the tube shield, unless one or more shutters are open. As part of the shutter interlock system, a shutter for a particular port cannot be opened unless an accessory, such as the goniometer, is correctly fitted to it.

Ports not in use are also blocked by a blank disc, as shown for port #3 in figure 2.

As the system is presently configured, X rays radiate from port #4 into the goniometer, but only when the shutter is open. X rays travel in the primary beam ( $1^\circ$ , solid arrow, Figs. 2 and 3) from the open port to the sample chamber. After encountering the sample, some of the scattered X rays ( $2^\circ$ , dashed arrow, Figs. 2 and 3) pass through the secondary-beam tunnel, through the monochromator (M, Figs. 2 and 3), and into the detector (D, Figs. 2 and 3), where the radiation is measured. Along their optical path through the goniometer, X rays also pass through primary and secondary slits ( $S_1$  and  $S_2$ , Figs. 2 and 3).

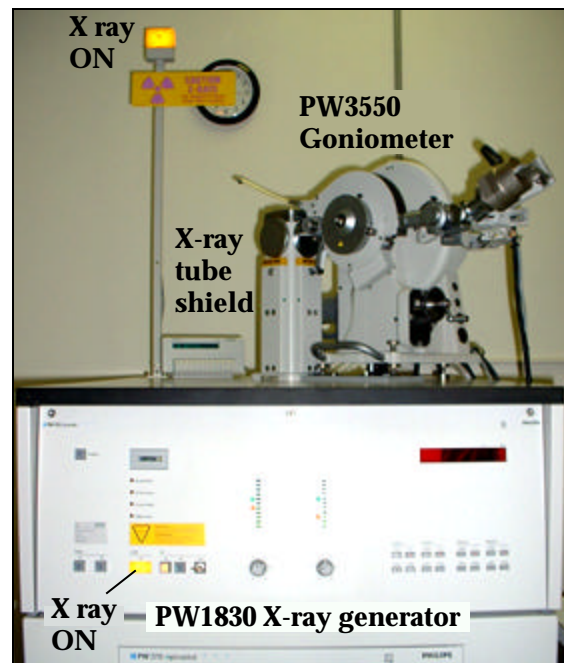


Figure 1. The X-ray diffraction system.

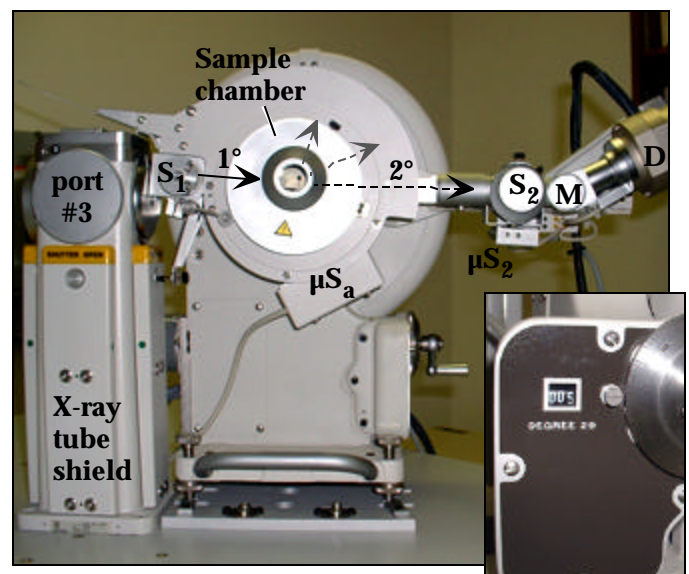


Figure 2. Front view of goniometer.

Figure 2 shows the goniometer set to a very low angle;  $2\theta = 5^\circ$  is indicated in the inset.

The optical path of X rays through the goniometer is shielded by covers to primary and secondary-slit assemblies ( $S_1$  and  $S_2$ , Figs. 2 and 3), shielding that drapes over the sample chamber, the sample-chamber cover, secondary-beam tunnels, and shielded connections between shielded components (Fig. 3).

Each shutter has a spring-loaded shutter-release button (Fig. 4) that must be pressed in order for the shutter to open. The shutter interlock mechanism applies pressure to this button and keeps it pressed as long as the cover (shield) to the sample chamber is in place. If the sample-chamber cover is removed, as is done to change samples, the interlock mechanism retracts, pressure against the shutter-release button is relaxed, and the shutter automatically closes.

The shutter interlock mechanism also engages the cover (shield) to the primary slits ( $S_1$ ) such that the cover cannot be opened (rotated counterclockwise) unless the sample-chamber cover is removed, which causes the shutter to close (Fig 4).

The shutter interlock mechanism makes contact with the sample-chamber cover via a nylon roller (Fig. 4). The nylon roller rests against a part of the cover having a larger diameter. This complicates removal and replacement of the sample-chamber cover.

Figure 5 shows the goniometer with covers to the sample chamber and secondary slits ( $S_2$ ) removed; the primary-slit cover ( $S_1$ ) is also open (rotated out of place). Note that, with the sample-chamber cover removed, the shutter interlock mechanism is freed from the shutter-release button and the shutter will not open.

A microswitch ( $\mu S_2$ , Figs. 5 and 6) checks the condition of the secondary slit cover ( $S_2$ ) and controls the shutter accordingly. If the cover to secondary slits is removed, the shutter automatically closes.

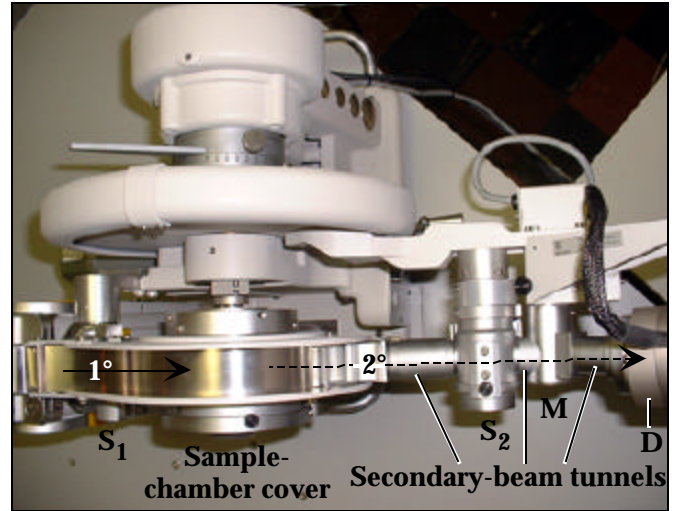


Figure 3. Top view of goniometer.

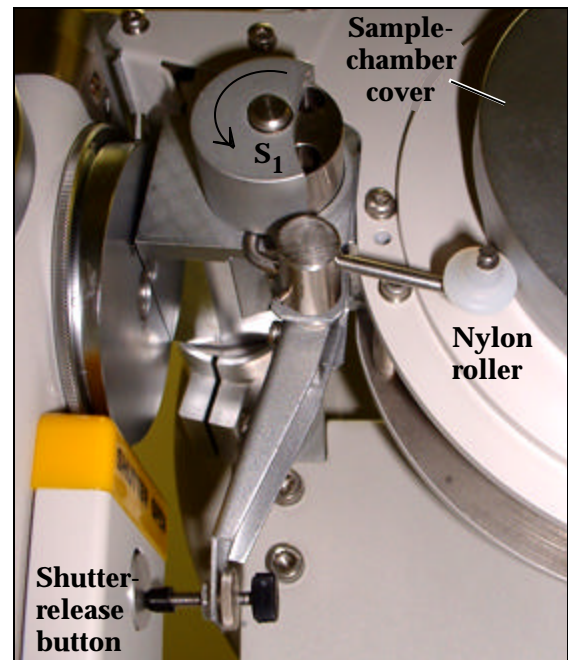


Figure 4. Shutter interlock mechanism.

A second microswitch ( $\mu S_a$ , Figs. 5, 6, and 7) causes the shutter to close if the goniometer approaches  $0^\circ$ . Such a low angle would permit the primary X-ray beam ( $1^\circ$ ) to pass directly into the detector. The low-angle limit is presently set for  $2^\circ = 2^\circ$ .

The X-ray diffraction system is also equipped with lamps that indicate the condition of the X-ray generator (X rays on or off) and the condition of shutters (open or closed). Safety circuits are configured such that a burned out indicator lamp disables the generator and closes the shutters.

X-ray-On lamps are located on the PW1830 control panel and at the top of a tower mounted to the generator's table top (Fig. 1).

Each shutter has a Shutter-Open lamp and a Shutter-Open "flag" on the X-ray tube shield (Fig. 8). The flag is a mechanical indicator; red indicates an open shutter; green indicates a closed shutter. An open shutter is also indicated by an illuminated Shutter-Open lamp. In figure 8, the shutter for port #4 is open; the shutter for port #3 is closed.

There is also a small indicator lamp for each shutter on the PW1830 control panel.

Opening a shutter requires that two widely spaced buttons on the PW1830 control panel are pressed simultaneously. This prevents accidental opening of a shutter. A single button is pressed to close a shutter.

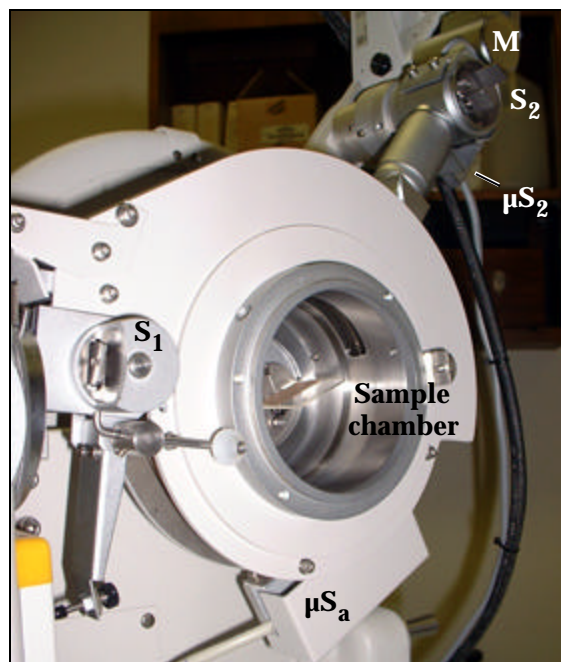


Figure 5. Goniometer with covers removed.

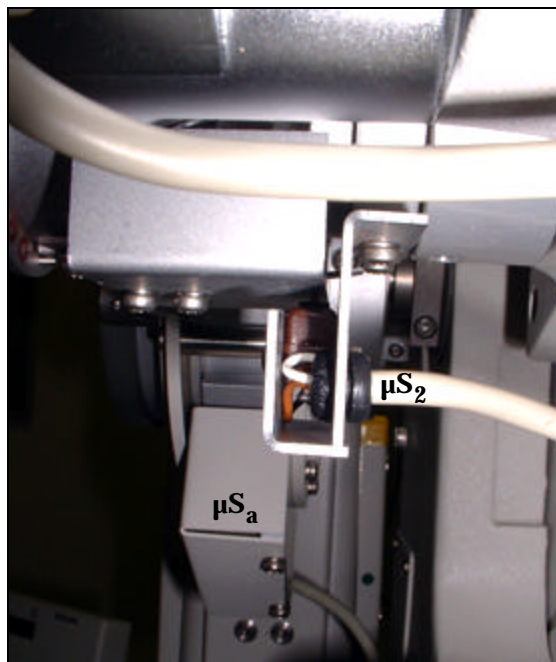


Figure 6. Microswitch for secondary-slit cover.

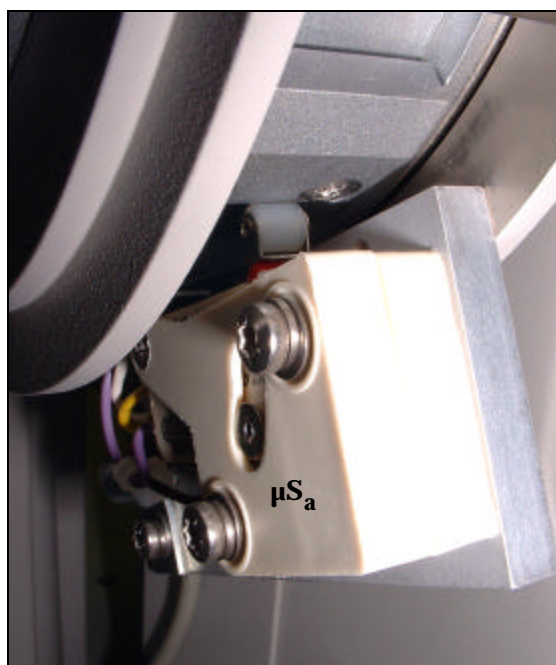


Figure 7. Microswitch for low-angle limit with its cover removed.

During routine operation of the diffractometer, shutters are operated by controls on the PW1830 control panel. Provisions for automatic closer of shutters are safety features

