# BL03XU
# Advanced Softmaterial

## 1. Introduction

A high-speed shutter is a key component for conducting small-angle X-ray scattering (SAXS) measurements with intense X-rays because excessive X-ray exposure to samples can lead to unwanted radiation damage. We have decided to install a rotating X-ray shutter, which was originally developed at SACLA [1], to BL03XU. The shutter is robust and compatible with the in-vacuum operation for reducing background scattering as much as possible.

## 2. Design

The shutter system consists of an in-vacuum rotating cylinder with four apertures controlled by a stepping motor. Figure 1 shows the mechanical design. The cylindrical shutter is linked to the shaft of a rotary feedthrough, which incorporates ferrofluid, to transfer the rotary motion of the motor to the in-vacuum cylinder without mechanical or thermal issues. The aperture size of the rotating cylindrical blade in the driving direction is 7.8 mm (45 degrees), and the aperture in the height direction is 10 mm. The blade is made of tantalum with a thickness of 2 mm to block X-rays.

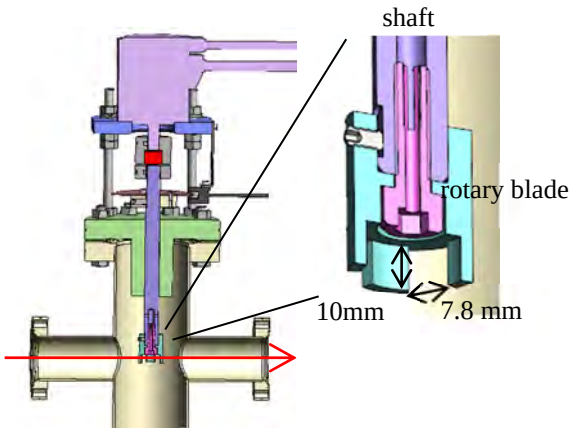


Fig. 1. Mechanical design of shutter system. An in-vacuum rotating cylindrical shutter with four apertures is controlled with a closed-loop stepping motor via a rotary feedthrough.

## 3. Control system

The rotating blades are controlled by a controller with the following functions. Through TCP/IP communication, commands are given to the driver's IO to initialize the motor position to the shutter-closed state. The controller receives a TTL signal and rotates the blades 45 degrees on the rising and falling edges. The stepping motor acceleration is set to 3.6 degree/ms$^2$, and the maximum speed is 7200 degree/s. The dead time from when the motor driver receives the TTL signal to when it starts moving is about 4 ms. The minimum time taken to change the status (open to close, or close to open) is 14 ms with a repetition rate of 35 Hz. Figure 2 shows the control system of the rotating shutter for synchronization with an external trigger.

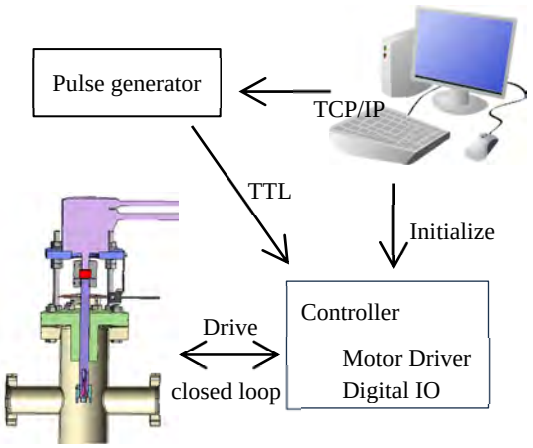


Fig. 2. Control system of the rotating shutter using TTL timing signal and TCP/IP communication.

The pulse generator usually acts as a slave mode. It is also possible to move the shutter continuously at a preset speed by using TCP/IP communication from a PC. In this case, the shutter system becomes the master, and the detector is driven in synchronization with the TTL signal output from the controller. The shutter can be opened and closed at a maximum speed of 80 Hz. The shutter was installed at the beamline in March 2024 and will be tested soon.

MASUNAGA Hiroyasu
Japan Synchrotron Radiation Research Institute

Reference:

[1] T. Kudo, T. Hirono, T. Nagasono, M. and Yabashi, M. (2009). *Rev. Sci. Instrum.* **80**, 093301.