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A NOVEL FILTER AUTO-MOUNTER FOR THE BIOXAS BEAMLINES AT THE CLS

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Abstract

The BioXAS beam-lines are a recently completed group of beam-lines at the Canadian Light Source (CLS). The Biological X-ray Absorption Spectroscopy (BioXAS) – Extended X-ray Absorption Fine Structure (EXAFS) beamlines host three 32-element germanium detectors. There was a need to introduce an exchangeable filter between the soller slits and the 32-element germanium detectors. It was further required to have an automated filter exchange system so that users could quickly vary filter thicknesses and types to determine the effect on the signal. An auto-mounting filter system was created to meet these requirements and allows users to quickly exchange filters without breaking experimental hutch lockup. The auto-mounter cartridge can hold up to ten slides that measure 100 mm X 55 mm in cross-section. The device inserts slides in an extremely small envelope between the soller slits and the liquid helium cryostat. The auto-mounter assembly also houses the stages required to actuate the soller slits laterally and vertically. During device commissioning we performed 800 consecutive successful filter exchanges as part of a stress test. The spatial constraints, mechanics, and fabrication of the device will be presented. Software development will also be discussed.

INTRODUCTION

The BioXAS beamlines are a recently completed group of three beamlines at the CLS. The two EXAFS beamlines are sourced from a single "flat top" hybrid wiggler and were designed to be capable of extremely high resolution EXAFS measurements. They are capable of measuring biologically relevant concentrations of metals in dilute samples.

The SIDE EXAFS beamline hosts one 32-element germanium detector mounted at 90° to a liquid helium sample cryostat.

The MAIN EXAFS beamline hosts two 32-element germanium detectors mounted at 90° to a liquid helium sample cryostat (mounted inboard and outboard of the cryostat).

Part of the beamline scope is to allow users to quickly vary filters between the sample and the detector so that they can determine the effect on the signal. Individual users will decide on the type and thickness of filter material. It was decided that the filter exchange would be automated so users could change filters without breaking experimental hutch lock-up.

A Filter Auto-Mounter (FAM) (Fig. 1) was designed to meet these requirements.

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Figure 1: Main Beamline Endstation with 2 FAM units.

Constraints/ Requirements

The following were determined to be the FAM design constraints and requirements:

- The design of the FAM has to work for both EXAFS beamlines.
- Users need to be able to pre-load a set of filters according to their needs.
- Two FAM systems are required on the MAIN beamline.
- The system needs to also house the Soller slits and provide them XZ translation.
- Distance from 32-el detector snout and sample is 81mm.
- 1 mm of space between Soller slit and detector snout.
- The sample cryostat is motorized in XYZ, +/- 10 mm in all directions.
- Filters to be placed immediately in front of Soller slits. The available thickness for the filter insert mechanism is 13 mm after accounting for Soller slit thickness, detector position, and cryostat travel.
- The only available route for filters to enter is to be lowered in from above the 32-el detector snout.
- FAM system to be fully automated with the ability to keep track of filter position in order to prevent collisions.
- FAM units to be removable for service without detaching other endstation critical hardware.

DESIGN FEATURES

The overall FAM assembly (Fig. 2).

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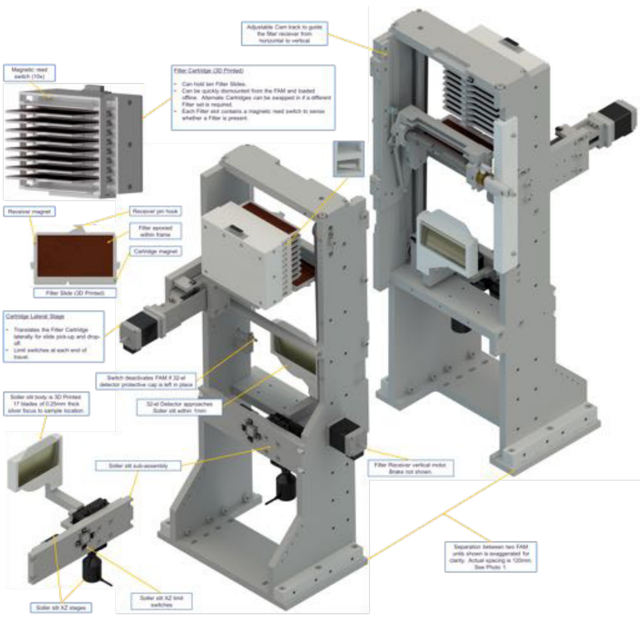

Figure 2: General overview of the FAM setup.

Filter Receiver Assembly

Transfers Filter Slides from the Cartridge (Fig. 3) to the installed position (installed position is between the Soller slits and sample cryostat). A linear bearing slides along a precision shaft to provide smooth vertical motion. As the Filter Receiver Assembly travels vertically, a cam rotates the Filter Slide from horizontal (for cartridge engagement) to vertical (for installed position). A motor, timing belt, and timing pulleys move the assembly vertically. A custom pneumatic cylinder engages a lock pin to lock the filter in place so it is restrained when the filter leaves the cartridge. A magnetic reed switch in the receiver body senses the presence of a Filter Slide. Limit switches are placed at the top and bottom of receiver stroke. Before placing or removing a slide in the cartridge, the receiver calibrates position from the top limit switch.

Filters

The Receiver inserts a Filter into the top of a Cartridge slot (Fig. 4). The Filter is then lowered to the bottom of the Cartridge slot. As the Filter is lowered, it engages hook features within the Cartridge. The Receiver lock pin is retracted. As the Receiver is withdrawn, the Filter remains with the Cartridge. The reverse process occurs for removing Filters from the Cartridge.

PLC Control

The FAM software is built on EPICS 3.14.12 and makes use of SNL (State Notation Language) as the state engine. There are two state machines. One keeps track of all the Filters to make sure that all of them are accounted for, and simply displays a message to the user. The second state machine does all the actual control of the FAM. Each step in the process of changing Filters is a state in the state machine.

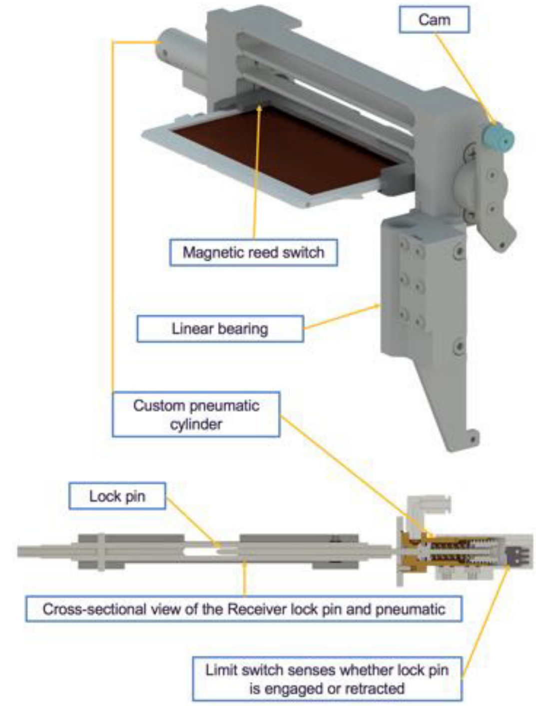

Figure 3: Detail illustration of the Filter Receiver Assembly.

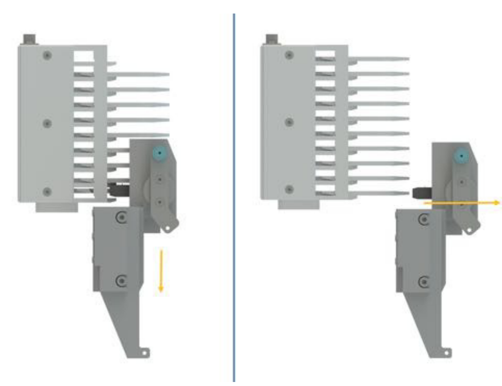

Figure 4: Illustration showing the cartridge & slide installation. Inserted (left) orientation. Receiver withdrawing (right) after depositing a slide.

There is only one path through all of the states, and all conditions must be met within the expected amount of time or the state machine goes into an error condition. There is also a simple state machine in the machine protection PLC Fig. 5) which determines when motors are allowed to move based on limit signals and location of the Filters. Since there are no encoders, each motor is calibrated to a limit switch on every Filter change. The position of the top limit is used as the calibration point for the vertical motor. All subsequent moves are calculated based on the measured position of the first Filter. The program knows the position of the first Filter, the distance between Filters, the lift distance to unseat a Filter, and the drop distance to seat a Filter. All calculations are based on this simple information. For testing purposes,

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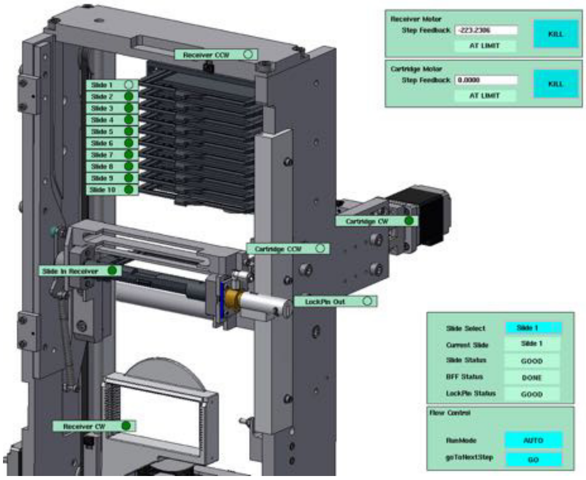

Figure 5: Screenshot of the commissioning screen.

the software can be made interactive and it can wait at the transition of each state so that the user has to allow the state machine to proceed.

CONCLUSION

Three identical Filter Auto-Mounters were successfully built for use on the two BioXAS EXAFS beamlines. All spatial constraints were met without sacrificing device performance. All three units have been tested and commissioned. During device commissioning we performed 800 consecutive successful filter exchanges as part of a stress test. Mounting of various filter types within the 3D printed Filter frames is still ongoing. Software recently enhanced to shorten slide change interval. Beamline staff and users are now able to remotely switch filters without breaking experimental hutch lock-up.