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Title: EPICS Controlled Collimator for Controlling Beam Sizes in HIPPO

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EPICS Controlled Collimator for Controlling Beam Sizes in HIPPO

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Abstract: Controlling the beam spot size and shape in a diffraction experiment determines the probed sample volume. The HIPPO - High-Pressure-Preferred Orientation– neutron time-of-flight diffractometer is located at the Lujan Neutron Scattering Center in Los Alamos National Laboratories. HIPPO characterizes microstructural parameters, such as phase composition, strains, grain size, or texture, of bulk (cm-sized) samples. In the current setup, the beam spot has a 10 mm diameter. Using a collimator, consisting of two pairs of neutron absorbing boron-nitride slabs, horizontal and vertical dimensions of a rectangular beam spot can be defined. Using the HIPPO robotic sample changer for sample motion, the collimator would enable scanning of e.g. cylindrical samples along the cylinder axis by probing slices of such samples. The project presented here describes implementation of such a collimator, in particular the motion control software. We utilized the EPICS (Experimental Physics Interface and Control System) software interface to integrate the collimator control into the HIPPO instrument control system. Using EPICS, commands are sent to commercial stepper motors that move the beam windows.

A picture of the collimator taken at HIPPO taken by my mentor Sven Vogel.
The device will be mounted underneath the door where I am sitting.

Controlling Beam Sizes in HIPPO

Introduction

The objective of my project is to integrate two stepper motors inside a device called a collimator to adjust the shape and size of the neutron beam that passes through (Vogel & Priesmeyer). The collimator contains two pairs of neutron absorbing boron-nitride slabs as windows. More specifically, I have to make sure that when the project is finished, the collimator can be interfaced by a computer. The computer must be able to send commands to home the motors and adjust the opening of the window via Ethernet.

Description of the Project

There is a need for a device that can control the beam size and shape in the High-Pressure-Preferred Orientation neutron time-of-flight diffractometer located at the Los Alamos Neutron Science Center (LANSCE) of Los Alamos National Laboratory. Controlling the beam spot size affects the volume of the sample interrogated by the beam, e.g. allowing to scan a sample in slices along its axis. Using the collimator, we can define a certain beam spot size in horizontal and vertical dimensions by adjusting the distances between the two pairs of neutron absorbing slabs. The slabs were installed in a unit developed by the company ADC and were used on a beam line at LANSCE which was decommissioned. The motion control for the original unit was outdated, e.g. using RS232 interfaces, and the goal of this project was to revise the device with modern motion control. To implement this, we used two Schneider LMDE75 motors controlled via ethernet and the Experimental Physics and Industrial Control System (EPICS) (Kraimer et al.) to interface with the motors. One motor controls the vertical and the other controls the horizontal movement of the collimator windows. We also designed a mount for the collimator to be attached to the beam opening.

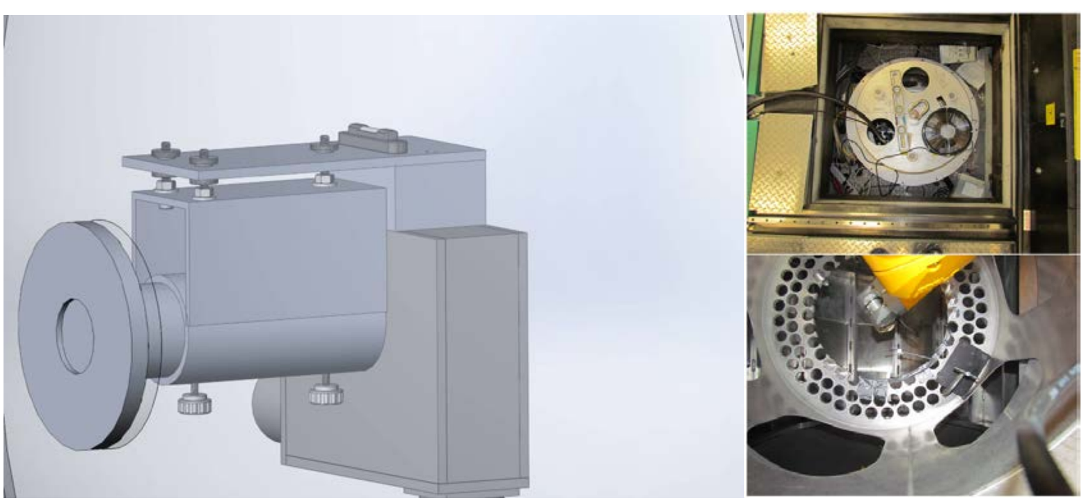

Figure 1. On the left image is the latest model for the collimator mounting system. The collimator is the rectangular box with the two motors shown as cylindrical shapes. The HIPPO beam pipe is the round structure on the left. The robotic sample changer inside HIPPO is shown on the right.

During experiments, the user must be able to define the desired window opening using a *caput* command to EPICS. One of the derived requirements for this system is to make use of the limit switches inside the collimator to home the position of the windows. The motors include programmable I/O pins that can be used to detect the status of limit switches and stop the motor slew whenever they are pressed. Making use of the four switches inside the collimator, a pair of max and min limit switches for each direction, homing of the windows is possible. Another task, is to convert the motors' steps to linear motion of the windows. To figure out the correct conversions, a linear models between the motors' rotation (in microsteps) and the movement of the windows (in mm) is created. Using a caliper and feeler gauges, data between the two variables is acquired. The table in **Figure 2** (x-axis scaled by a factor of 10^{-5}) shows a linear relationship between one of the motors revolution (51200 microsteps) and its corresponding window opening. The same method is used for the motor that moves the vertical windows.

Motor Revolutions	Window Opening
1	2.16 mm
2	3.49 mm
3	4.99 mm
4	6.49 mm
5	7.98 mm
6	10.11 mm
7	11.48 mm
8	12.81 mm
9	14.50 mm
10	15.80 mm

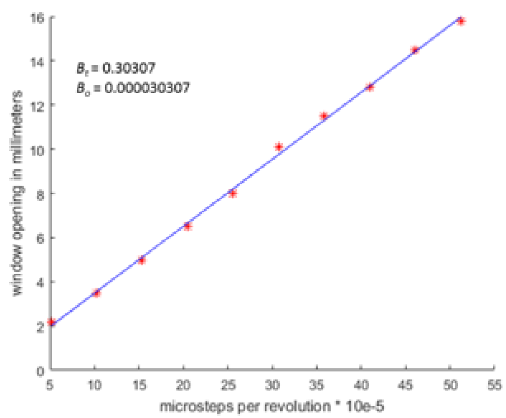

Figure 2. Data and plot of motor revolutions (51200 microsteps/revolution) v. opening (mm)

The slope of this linear model, calculated to be approximately 0.00003 mm/microstep (after taking account for the transformation in, is then used to convert the requested millimeter opening into microsteps for the motor.

When starting the EPICS for the system, the motors will perform a subroutine for homing and for setting various parameters such as velocity, acceleration, and deceleration of both motors. The homing algorithm basically closes the windows in the collimator until a switch is activated and initializes the current window openings to 0 millimeters. EPICS can do the appropriate conversion from mm to microsteps during runtime when the user sets the beam size in mm via the *caput* command. For the user to check the current opening of the windows in the collimator, a *caget* command can also be used. It is important to know that homing only happens at the start of the program and the EPICS code knows whether to rotate the windows in the closing or opening direction depending on the input opening size.

Figure 3. Front and rear view of the collimator. A sample is placed in the center of the opening where the neutron beam will enter. The beam hits the sample and diffraction data is taken for the material. The data is then analyzed in LANSCE.

Contribution Made to the Project

For this project, I am responsible for

- Setup of the computer to be used for development (hosting the EPICS server)
- Developing the Schneider motor code to move the collimator windows,
- Creating EPICS variables to interface with the motors located in the collimator.
- Calibrating the collimator to precisely provide the desired opening
- Contribute to the design of the adaptor to the HIPPO instrument
- Refurbish the mechanics and switches of the collimator

What new skills and knowledge did you gain?

In this internship I learned the various stepper motor concepts and terminologies and how to use EPICS to interface with hardware via Ethernet. I learned more about the steps into implementing motion control to a system as well as the challenges that comes with it. Doing the calibration of the windows in the collimator along with testing, I can understand how misplaced parts and loose screws can greatly affect the functionality of a mechanical device. I also learned new commands to set up Linux machines for development with EPICS as well as using *awk* language for text processing.

Most importantly I acquired a better view of what a research environment looks like, what kind of work people do in there, and what it means to them. Also, the people I met in this facility have shared valuable knowledge about their experiences in graduate school and their research. Through them, I feel less intimidated to be in the field of research and development. On top of that, LANL has a lot of opportunities for a broad range of fields and offers great amount of support for their researchers' learning and progress. Anything from conference flights to requested parts for experiments are provided by the facility. It truly is a great place for people to work on things yet to be discovered.

Internship Experience Impact on My Academic/Career Planning

My stay here in LANL made me want to progress my academic degree as soon as possible and be in the field of research. Before this internship, I do not have a strong feeling about going to graduate school right after finishing my degree in Computer Science. Now, I'm considering advancing my degree. I liked what I did here in LANL and the facilities provided everything I needed to work on my project.

Relevance to the mission of DOE EERE Advanced Manufacturing Office

Automation provides efficiency among many areas of the industry and motion control is one of the main area of automation. My project relates to the mission of DOE EERE Advanced Manufacturing Office in a way that it helps experiments to be conducted faster through automation. The previous collimator used a cadmium slit that is hard to align and modifying the size of the slit requires cutting a new slit in a different sheet of Cd. A collimator that can change the size and shape of the beam for different experiments in one command solves this problem. This device can replace a person manually adjusting the regulating windows in the beam line.

My project shows how it aids with efficiency and, ultimately, adherence to the mission of DOE EERE Advanced Manufacturing Office. It also shows an act of implementing a technology that adds to a facility's research and manufacturing capabilities which is also one of the missions. HIPPO, and LANSCE in general, also conducts research in the field of Additive Manufacturing, in particular HIPPO characterizes the microstructure of AM fabricated specimen, made of e.g. steels (Brown et al., Clausen et al.), Ti alloys or U-Nb (Wu et al) alloys. The collimator from my project will be used for such characterizations in the future, enabling characterization in scan-mode. Overall, I believe that this project can give benefits to the facility that are yet to be discovered.

Acknowledgements

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