Automation of t0 finder

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Introduction

For time-solved experiments, which comprises a large portion of beam times at the X-Ray Pump Probe (XPP) experimental hutch, the relative timing of the x-ray and the optical laser is changed by motor stages that modify the path length of the optical laser.

At the beginning of a beam time, the settings of the motors for which the x-ray and laser arrive on average at the same time must be determined. This time is called "t0". Takahiro Sato has developed the t0 finder that makes this procedure simpler and repeatable.

Keywords: XPP, t0 finder

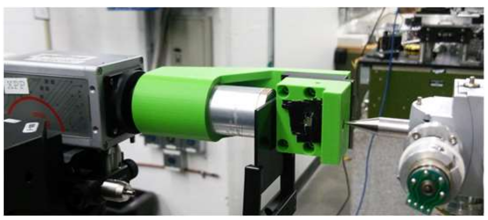


Figure 1: The t0 finder located in the XPP hutch. This picture was taken from the t0finder_summary PowerPoint created by Takahiro Sato.

Problem Statement

Before the automation of the t0 finder, scientists manually performed the spatial and temporal overlap. This forced scientists to have to focus their efforts on "mechanical" tasks, rather than optimizing the beam time.

Purpose and Solution

The purpose of this project was to automate the t0 finder, to easily find the spatial and temporal overlap of the monochromatic x-ray based on optical transmission measurement. Automating the t0 finder saves beam time, and the precision achieved by this automatic procedure does not depend on the operator. In order to accomplish the automation, two main steps are necessary:

- The first scan is the Spatial Overlap Scan. This scan utilizes the function 'walk_to_pixel', which is a BlueSky plan from the pswalker (a beam alignment module). This scan will align the laser's centroid to the x-ray's centroid, by moving the two lens motors.
- The second scan is the Binary Search Scan which uses BlueSky plans to determine the laser delay stage position for which the x-ray and the laser on average arrive at the same time. As the search range is rather large, using a binary search will speed up this process.

The Process

During the development process, I learned about tools such as Python, Unix, Jupyter Notebooks, and GitHub. I also learned about BlueSky, a Python library that is utilized for experimental control and scientific data collection.

Before designing the code, I understood the basics of BlueSky with a jupyter notebook tutorial. This notebook was essential, for it showcased the crucial setup of a BlueSky Scan.

After understanding the basics of BlueSky, I worked with Silke and progressively implemented multiple necessary attributes to the code, in order to simulate as close to a real situation as possible.

The simulated Spatial Overlap Scan consisted the following necessary components:

Function: Centroid_from_motor_cross

- This function finds the current position of the motor and calculates the centroid's position.

Class: Imager_cross

- This class establishes the relationship between the motors and centroids.

BlueSky Plan

- In this plan, using walk_to_pixel, the scan will align any beam to a position on a screen, when two motors move the beam along the two axes. The most precise alignment will be achieved by using an iterative procedure. Synchronously, the LivePlots will be updated, showing the paths taken to achieve this alignment.

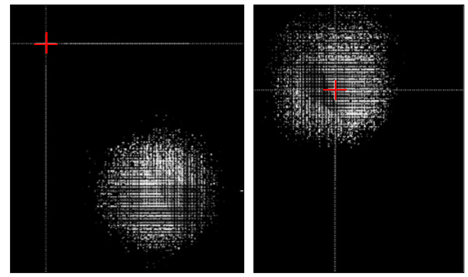
Experimental Setup

In order to test the Spatial Overlap Scan, Takahiro and Silke had a set up where we observed a laser beam using an OPAL1k camera using an EPICS IOC (OPAL1). The set-up had a screen to view the laser profile, which was connected to OPAL1. By turning on the small green laser, one can see the profile on OPAL1.

Once the scan was executing, I entered by hand the desired position, which was the OPAL1's red global marker's location. Using two standard laser motors, m.las_tt_lensv and m.las_tt_lensh, the laser spot moved in two dimensions. The movements were viewed with the camera.

Figures 3,4, and 5 are images from the Spatial Overlap Scan.

Figures 3&4: Before(left) and after(right) running the Spatial Overlap Scan



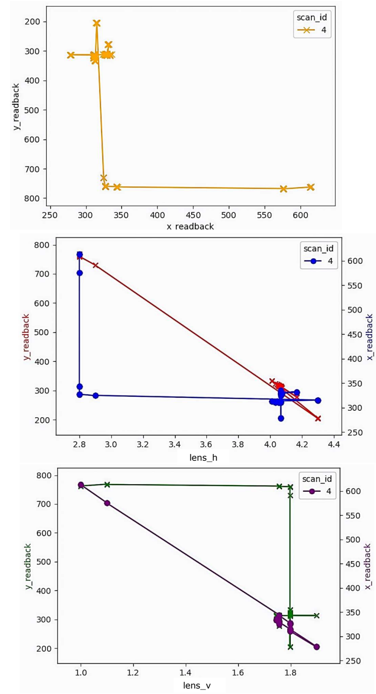


Figure 5: Beamline devices' lens_h and lens_v, paths

Conclusions

The Spatial Overlap Scan is nearly complete and can be implemented for a variety of beamline devices. The motors will move until the beam spot aligns with the desired target on the screen.

This scan is in the next phase of development where its robustness will be increased by solving edge cases such as dealing with the limits of the motor motion.

The Binary Search Scan is also underway and is anticipated to be a partially functioning scan by the end of this summer internship. This scan will look at the correlation of the laser spot and incident x-ray intensity, correspondingly changing the laser x-ray delay.

Acknowledgments

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