Hutch 4 (XCS) Laser System Commissioning

SLAC NATIONAL ACCELERATOR LABORATORY

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Introduction

Hutch 4 (XCS) hosts experiments involving hard x-ray photon correlation spectroscopy and coherent hard x-ray scattering. A new 800 nm Ti:sapphire ultrafast laser system was added to this hutch to enable optical pump, x-ray probe experimental capability. To allow the laser light to travel from the laser room to the sample in the hutch, an entirely new beamline was created using two separate optical tables. The requirements of this new beamline included generating 400 nm and 266 nm light from the original 800 nm light, accurately varying the arrival time between x-ray and optical pulses, and creating up to far infrared light using an optical parametric amplifier (OPA).

Keywords: laser, beamline, XCS, commission

Research

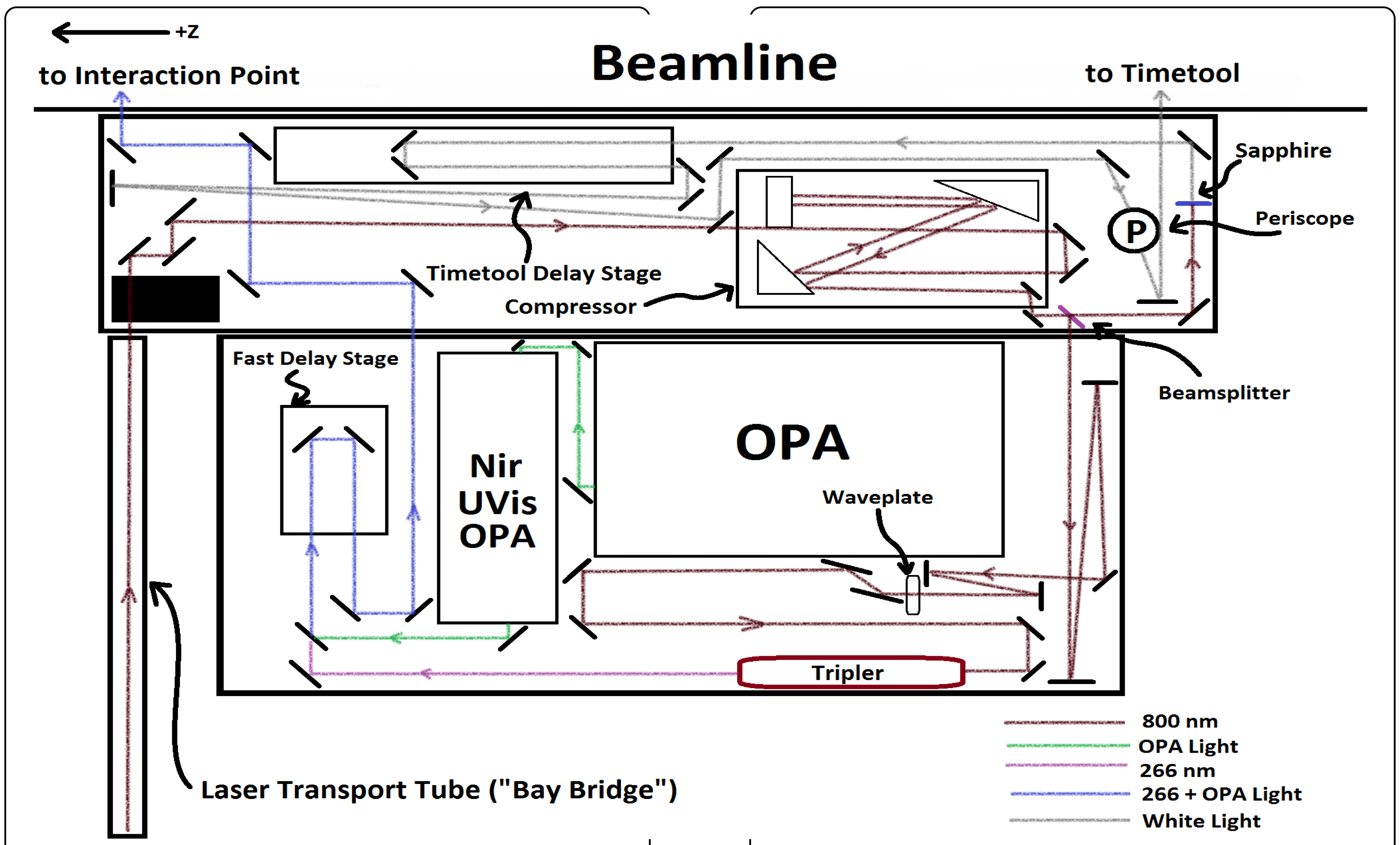
The scope of work was as follows:

- Aid in alignment through irises onto target
- Secure mirrors, lenses, and polarizers in their mounts
- Characterize beam at interaction point using beam profiler camera
- Calculate theoretical and actual path lengths along white light, OPA, and tripler beam paths

To comply with LCLS II goals, the table on which the OPA and frequency tripler are placed is mounted on wheels for enhanced mobility. However, the table's wheels added an unacceptable amount of instability. This was circumvented by cleverly anchoring the wheeled table to the immobile laser table closer to the beamline.

The first commissioning experiment used 800 nm light to create phonons in bismuth which were observed directly. Figure 1 shows an ideal result for an experiment of this type; however, it was not created from data collected in this exact experiment. The existence of this signal demonstrates not only the beamline's precise control over the relative arrival time between x-ray and laser pulses using the delay stages but also its low energy loss from laser room to target.

A challenging aspect of establishing this beamline was the constraint that the timetool white light beam path and the 800 nm/OPA beam paths had to differ by exactly the distance between the interaction point and the timetool itself on the beamline (Figure 3). This necessitated the use of two separate "dog-legs" that added path length without interfering with the rest of the beamline.



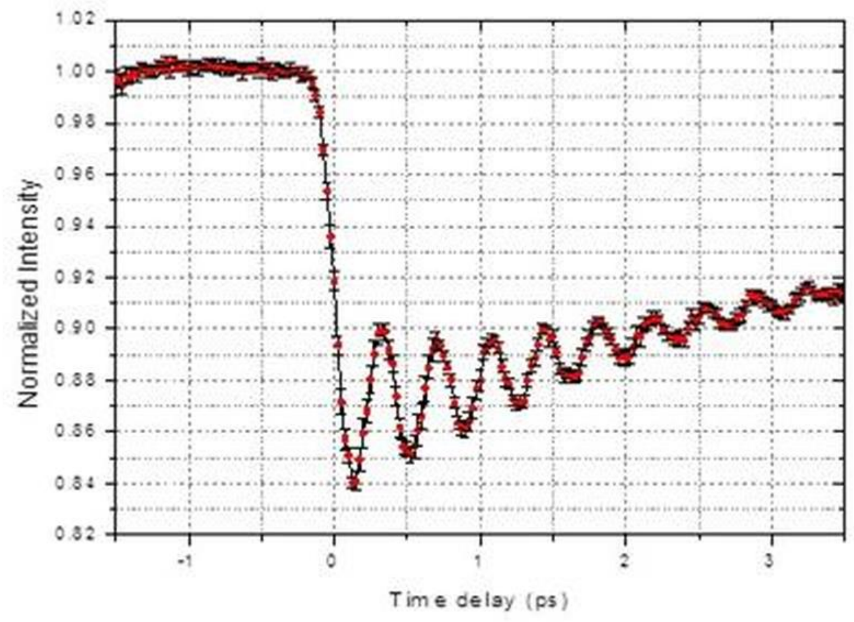


Fig 1.[3] X-ray diffraction Bragg intensity oscillations for bismuth, similar to those produced in the first commissioning experiment. The oscillations were a result of optically generated lattice motion in the bismuth crystal. Image courtesy of PAL-xFEL.

The second commissioning experiment involved the observation of charge carrier density changes in a liquid transition metal coordination compound with cyanide ligands. These changes were induced by an optical pump of 400 nm light, made from frequency doubled 800 nm light (Figure 2).

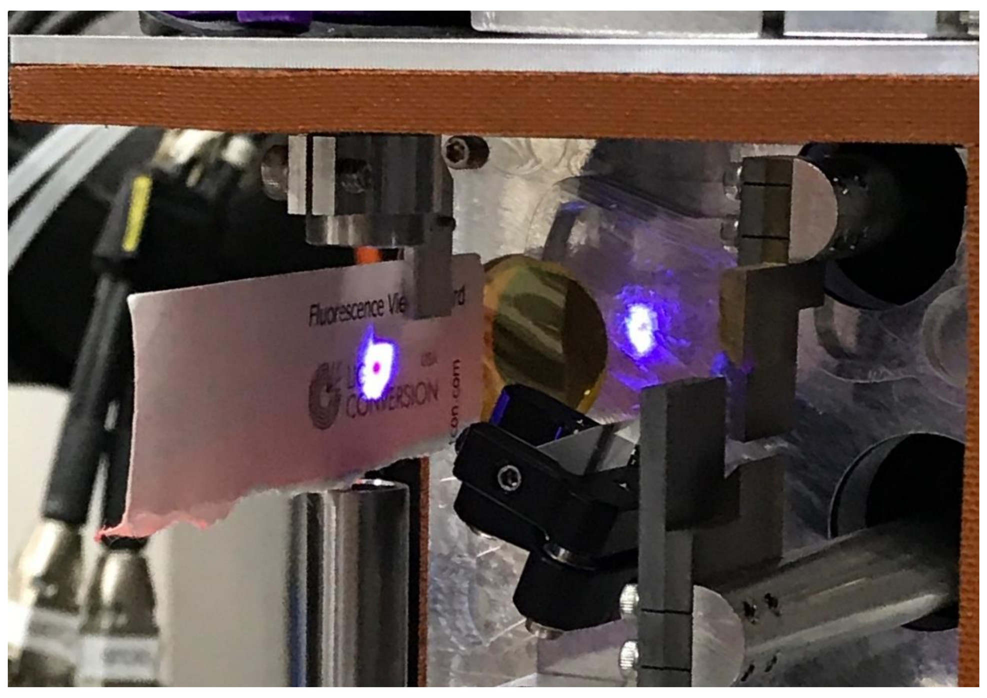


Fig 2. Visible 400 nm light, created from invisible 800 nm light, illuminating a sample placeholder used in the second commissioning experiment.

Fig 3. Schematic of the XCS laser beamline. The difference in path length between the white light and OPA/tripler beamlines is such that the x-ray and optical pulses that interact at the timetool are the same pulses that meet at the interaction point. Put simply, the difference is precisely the distance between the interaction point and timetool.

Conclusions

Laser beamline commissioning is an uncommon event at LCLS. This commissioning can teach that an initial layout schematic is a most useful tool in alignment while working within constraints, such as path length difference.

Later experiments will necessitate the use of the OPA to generate light with wavelengths ranging from about 200 nm to 20 µm. This beam path was not tested as thoroughly as the tripler beam path and adjustments will need to be made using the delay stages.

With the installation of this laser system complete, XCS will be able to host a wider range of experiments, including types previously hosted by Hutch 3 (XPP).

Acknowledgments

Use of the Linac Coherent Light Source (LCLS), SLAC National Accelerator Laboratory, is supported by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences under Contract No. DE-AC02-76SF00515.

[3]http://pal.postech.ac.kr/paleng/Menu.pal?method=menuView&pageMode=paleng&top=7&sub=5&sub2=0&sub3=0

Date: 08/09/2017