laboratory notes

Journal of
Synchrotron Radiation

ISSN 1600-5775

Received 23 April 2014
Accepted 13 June 2014

A compact tool for coaxial laser alignment on a time-sharing beamline at Taiwan Light Source

Jih-Young Yuh

National Synchrotron Radiation Research Center, 101 Hsin-Ann Road, Hsinchu Science Park, Hsinchu 300076, Taiwan. E-mail: jyyuh@nsrrc.org.tw

A simple design and easily installed tool for alignment has been developed for time-sharing undulator beamlines. A laser beam is directed onto a beam splitter inside the vacuum chamber, then reflects 90° along the synchrotron beam path; this beam serves as a reference to mimic the synchrotron beam path. Use of this tool greatly abbreviated alignment of an end-station after beamline switching; both beamline diagnosis and end-station development can be completed before the synchrotron beam time begins.

Keywords: Taiwan Light Source; laser alignment; multi-branch beamline; two-stage differential pumping system.

A third-generation synchrotron as a source of radiation provides highly brilliant focused beam spots with undulator beamlines that are installed only at the straight sections of the electron-storage ring. To accommodate the diversity of frontier research, four multi-branch beamlines have been designed at the National Synchrotron Radiation Research Center (NSRRC), Taiwan (Pai *et al.*, 2010); most of these beamlines have attached mobile end-stations operated in a time-sharing mode on a weekly basis, such as for angle-resolved photo-emission spectra (Lee *et al.*, 2008) and pump–probe experiments (Song *et al.*, 2006). The quality of data in these experiments relies on an accurate alignment of the beam spot at the small detection area of the apparatus; moreover, a complicated operating procedure of the branch beamline switching makes the alignment tedious. This process takes from hours to half a day depending on the complication of the components inside the experimental chamber. To conserve the scheduled beam time, this alignment work of a new end-station or apparatus must be fully commissioned before the beam time begins. The major challenge during the engagement between the beamline and the end-station arises from the difficulty of visualizing the small beam spot without convenient view ports on the chamber (Muro *et al.*, 2009). In our experience it is difficult to recognize a small beam spot in a vacuum chamber, not to mention passing it through a pinhole, capillary or other specially designed component. It would thus be helpful for there to be a sizeable virtual synchrotron beam to serve as a reference of the real synchrotron beam path inside the chamber; furthermore, it could be conveniently turned on and off at a user's request. In this note, we report a compact system for laser alignment installed between the end-station and the refocusing mirror chamber of a beamline. By reflecting the laser beam with a beam splitter *in situ*, this laser beam can overlap coaxially with the synchrotron beam path so as to serve as a reference when the real synchrotron beam is unavailable. The time span before the experiment begins becomes greatly decreased because 90% of the alignment task is completed before the scheduled beam time begins.

Fig. 1 shows a side view of a schematic drawing of the alignment tool. The minimum space requirement is a standard 2.75-inch six-way cross chamber. A laser diode (650 nm, 5 mW) is mounted kinematically at a fixed height on a precise x–y translation stage at the top window view port. A 25 mm cube beam splitter is mounted at the center of the vacuum chamber; its vertical position is adjustable with a precise linear-feedthrough mount from the bottom. When the cube is moved to the center of the chamber, the laser beam becomes deflected 90° toward the end-station. A window gate valve is installed at the left for vacuum isolation; it passes the synchrotron white beam. To ensure that the two beam paths overlap properly, at least two positions 2.5 m apart are tested to minimize the error of coaxial alignment. The alignment is completed after a few iterations of fine-tuning the multi-axis laser mount and the position of the beam splitter; the laser mounting position is well protected with a plastic cover to avoid accidental touching of the knobs. Before the beam splitter is moved to a lower position, its vertical position is recorded with a reading on a precise micrometer (resolution step 2 μm) of the feedthrough so as to ensure the reproducibility of the beam height for its next operation.

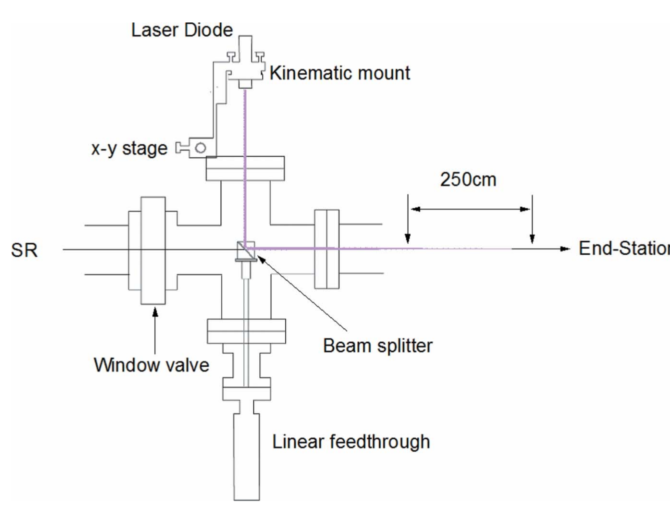

Figure 1
Schematic drawing of the laser alignment system for coaxial overlap of two beams.

Fig. 2 shows an example of an installation of a two-stage differential pumping system connected to a molecular-beam experimental end-station. From the left, the laser-alignment system was installed in a 4.5 inch six-way cross chamber. To pass the laser beam (*a*) through capillary (*c*) of diameter 2 mm and length 150 mm in the first chamber and the second capillary (*d*) of diameter 1 mm and length 150 mm in the second chamber, with this visible laser beam in air, the complicated alignment was readily performed on adjusting the positions and height of the supporting rods (*h*). Each component was aligned sequentially in an atmospheric environment (without turbo pump), which was a more benign working condition than using the synchrotron white beam that should be kept under ultrahigh vacuum. After the positions of the differential pumping system were secured to the floor, the synchrotron beam was introduced to verify the overlap of both beams. Figs. 2(*e*) and 2(*f*) show the overlapping beam spots with a pink laser-beam spot and an intense synchrotron white beam spot observed from each indicated view port position; the latter spot size is smaller because its position is nearer the focal point of the refocusing mirror. To our rough estimation with a grid on a millimeter scale, the deviation of the two beam spots is less than 0.5 mm, which is adequate for preliminary commission work.

In summary, we have applied a compact easily installed system for laser alignment at the site of branch beamline BL21 at the NSRRC; not only was the recovery time during beamline switching greatly decreased but also the tool proved to be effective for commissioning work related to an end-station and a beamline diagnostic. In the future, for more precise alignment of a beam of size less than 1 μm, the laser diode will be replaced with a He–Ne laser with a minor modification of the mounting stage.

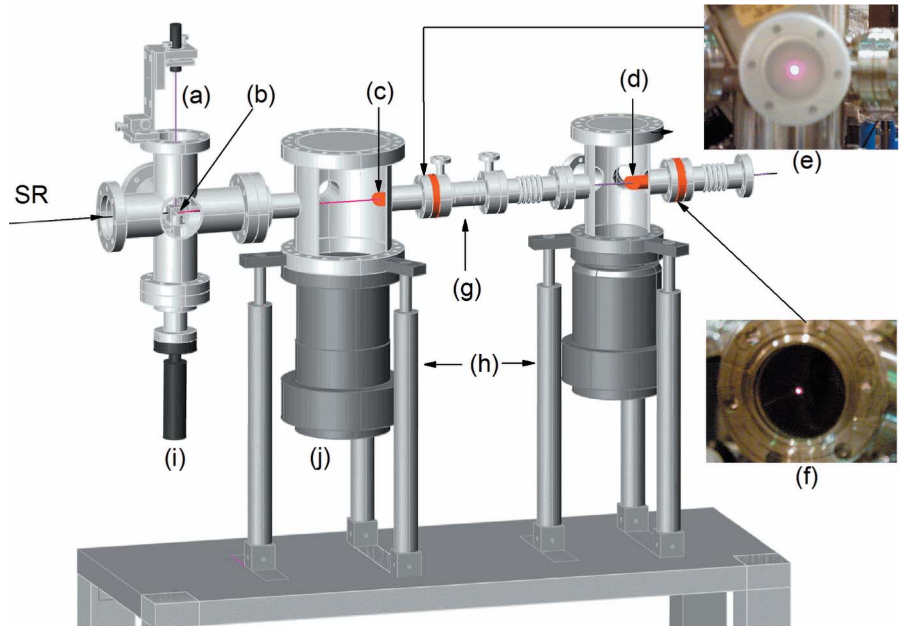

Figure 2
Installation on site of a two-stage differential pumping system with the compact system for laser alignment: (*a*) laser beam, (*b*) beam splitter, (*c*) first capillary, (*d*) second capillary, (*e*) first beam-spot image, (*f*) second beam-spot image, (*g*) gas cell, (*h*) supporting rods, (*i*) linear feedthrough and (*j*) turbo pump.

References

Lee, Y.-Y., Dung, T.-Y., Hsieh, R.-M., Yuh, J.-Y., Song, Y.-F., Ho, G. H., Huang, T.-P., Pan, W.-C., Chen, I.-C., Tu, S.-Y., Kung, A. H. & Lee, L. C. (2008). *Phys. Rev. A*, **78**, 022509.

Muro, T., Kato, Y., Kinoshita, T. & Watanabe, Y. (2009). *J. Synchrotron Rad.* **16**, 595–596.

Pai, W. W., Jeng, H. T., Cheng, C.-M., Lin, C.-H., Xiao, X., Zhao, A., Zhang, X., Xu, G., Shi, X. Q., Van Hove, M. A., Hsue, C.-S. & Tsuei, K.-D. (2010). *Phys. Rev. Lett.* **104**, 036103.

Song, Y. F., Yuh, J.-Y., Lee, Y.-Y., Chung, S. C., Huang, L. R., Tsuei, K.-D., Perng, S. Y., Lin, T. F. Fung, H. S., Ma, C.-I., Chen, C. T. & Tsang, K. L. (2006). *Rev. Sci. Instrum.* **77**, 085102.