Automatic beam alignment system for Astra: second stage

K. Ertel, C. J. Hooker and J. L. Collier
Central Laser Facility, STFC, Rutherford Appleton Laboratory, Chilton, Didcot, Oxon., OX11 0QX, UK

Main contact email address **k.ertel@rl.ac.uk**

Introduction

After the first part of the alignment system was successfully installed on the Astra front end [1], the system has been extended and improved.

Hardware modifications

The original system controlled the beam path up to the input of the first amplifier, using 5 channels (5 cameras and 5 motorised mirrors). Five more channels were added, so the beam path is now actively controlled through the first amplifier, the beam expander between the first and second amplifiers and as far as the first pass through the second amplifier. The locations of all cameras and motorized mirrors are shown in Fig. 1.

The system is now controlled by two PCs, with the first one handling eight channels. In order to operate eight cameras at a fast update rate, both PCs have been fitted with dual-host FireWire controller cards (IOI-4601-22, Firstsight Vision).

Software modifications

A maximum of four cameras are now connected to one FireWire bus, with the dual-host cards allowing the connection of eight cameras to one PC. The acquisition processes on all cameras now run in parallel, which greatly improves the update rate. Image acquisition has been speeded up by introducing partial scans (only a part of the CCD chip is read out) and the elimination of resource-hungry matrix operations. Previously it took 2 seconds to acquire images from 5 cameras, whereas now it takes 0.2 seconds to acquire images from 8 cameras.

In the previous version, if the signal on one camera was too weak, e.g. because an amplifier was not being pumped, the whole system would remain inactive. Now the beam path is aligned as far as the last camera with a good signal; mirrors downstream from this camera are not moved. This way the beam alignment can start while parts of the laser system are still being powered up. Also, if the beam path is so badly misaligned that the beam gets lost at some point, active alignment of the beam upstream from this point might bring the beam back into the field of view.

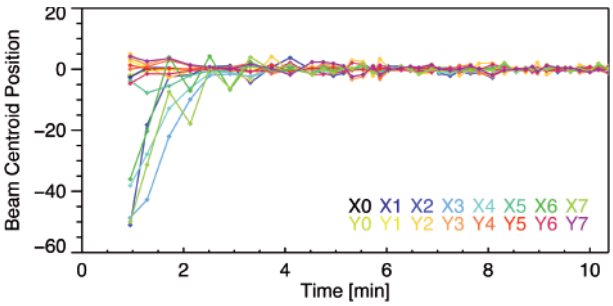

Figure 2. Deviation of beam positions after switch-on of laser system. Shown are positions on cameras connected to first PC.

Performance of the new version

In terms of alignment accuracy, the system performance is largely identical to the previous version. The initial alignment after switch-on still takes a few minutes (see Fig. 2), but the main limitation is now the time it takes to move all the Picomotors. The larger degree of automation has made setting up the laser system quicker and more reproducible. After the initial convergence at start-up, no significant deviations from the set beam positions could be found in the recorded data.

Outlook

Cameras and motors have also been installed to control the beam path through the second amplifier. However, we discovered that the standard highly reflective laser mirrors

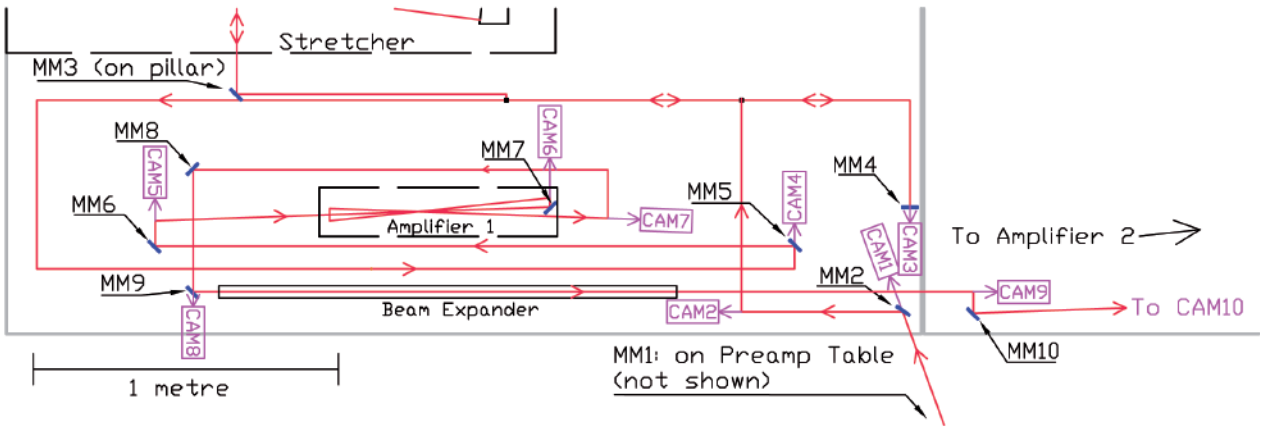

Figure 1. Drawing showing the locations of cameras (CAM) and motorised mirrors (MM).

used do not transmit well enough to obtain good image contrast between the laser beam and stray light. Custom made "leaky" mirrors with a transmission of 0.05% were damaged by the high intensities after the later passes of the amplifier. Once this problem has been solved, the activation of these extra channels will be straightforward. The next step will be to extend automated alignment through the third amplifier, which will be more challenging due to the higher energy, 18 mm beam diameter and the shortage of space on the optical table.

Another system which has been developed and is awaiting installation consists of a single, piezo-stack-driven mirror and one camera. This will be used to stabilize the beam pointing direction at the end of the Astra laser chain at the full laser repetition rate of 10 Hz. The effect will be reduced shot-to-shot pointing fluctuations for Target Area 2 and for Astra Gemini.

References

1. K. Ertel, E. J. Divall, C. J. Hooker and J. L. Collier; *Automatic beam alignment system for Astra, first stage CLF Annual Report,* RAL-TR-2006-025, **187**, (2006).