Development of a plug-and-play diagnostics base for faster in-target area experiment setup

Contact *david.carroll@stfc.ac.uk*

D.C. Carroll, P. Brummitt, R.J. Clarke, M. Harman, R. Heathcote, and M.M. Notley

Central Laser Facility, STFC RAL, Oxfordshire, OX11 0QX, UK

Introduction

A significant amount of time during experiments is dedicated to building the setup of the experiment, typically 1 to 1.5 weeks of a 5 week experiment. During this year on Vulcan there were 9 scheduled experiments. Reducing the amount of time spent setting up experiments in the target area will improve the utilisation of the facilities so that more time can be dedicated to experimental data shots. In addition, a major bottleneck in the experimental setup is the target chamber as physical access is limited, reducing the number of internal diagnostics which can be installed / aligned at any one time. To address this, a prototype plug-and-play breadboard system has been developed. This enables diagnostics to be setup and aligned externally and then placed within the experimental setup with minimal chamber access time. This system has been recently tested during a system access period on TAW using a Thomson ion spectrometer.

Plug-and-Play Design

The aim of this system is to remove as much of the alignment and set-up of diagnostics from the interaction chamber as possible. This will enable more work to be carried out in parallel during the set-up of an experiment.

The system is designed with a breadboard, 30 cm x 30 cm for the prototype, which has kinematic legs that enable it to be placed on-top of pre-positioned feet. There are two sets of feet for each breadboard, one set in the interaction chamber and the second set located where the alignment will take place and positioned relative to a dummy target. Figure 1 shows images of the feet and breadboard.

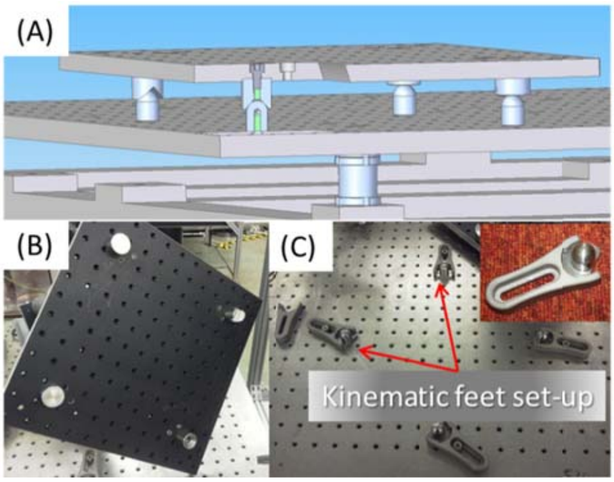

Figure 1: (A) Breadboard on kinematic system. Positioning defined by legs, one is conic, one is slotted and two are flats. (B) Photo of kinematic legs on bottom of breadboard. (C) Pre-positioned feet clamped in place.

The feet positions are defined using a cross piece that has two lasers mounted on it that can be crossed at different distances to define target position. The cross piece legs are all conic shaped to enable adjustment of the feet positions while keeping them correctly spaced for the breadboard kinematic legs. Figure 2 shows images of the cross piece with the lasers mounted. A four leg system was chosen over using three legs as this enables the breadboard to take weight in any position whereas a three leg system, can only be loaded centrally.

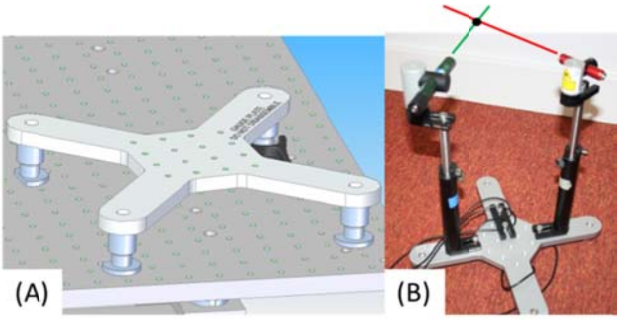

Figure 2: (A) Cross piece shown mounted on feet. (B) Photo of cross-piece with lasers mounted on top that cross at the target position.

The procedure for using the system is as follows:

1. Use cross piece with twin lasers crossing at target to define position of diagnostic relative to target and set the position of the feet in the interaction chamber.
2. Use same cross piece to position a second set of feet relative to a dummy target.
3. Align the diagnostic on the kinematic breadboard using the dummy target.
4. Transfer diagnostic to target chamber and place on feet positioned in step 1.

Testing the system

In February 2014 there was a three week access period in Target Area West (TAW) for diagnostics development and characterisation . During this period the plug-and-play system was tested using a Thomson ion spectrometer with a 100 µm pin hole.

The Thomson spectrometer was set-up following the procedure outlined above. The position was set in the interaction chamber with the cross piece such that the Thomson would sit 70 ± 5 cm from target and a few degrees off the target normal axis. A dummy target and kinematic feet were setup using the same cross-piece in Target Area East (TAE). The Thomson spectrometer was then mounted, as shown in Figure 3(A), and aligned in TAE to the dummy target. This process was performed in parallel to the rest of the set up inside the interaction chamber. After alignment the Thomson was taken to TAW and installed. No further checks were made of its alignment before shots were taken. A total of 3 minutes access time in TAW was used for the entire set-up of this diagnostic. In practice all alignment to the dummy target can be completed pre-experiment and the cross-piece then used to simply set the in-chamber feet at the start of the experiment and drop the pre-aligned diagnostic into position.

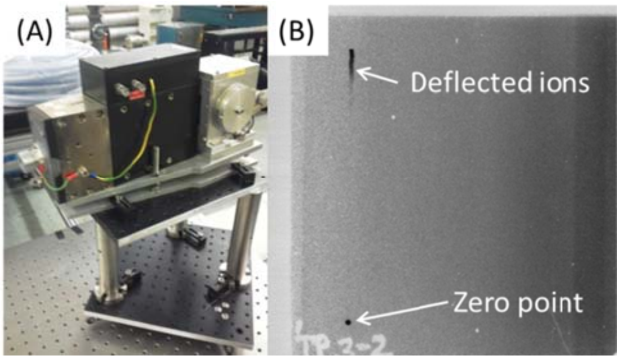

Figure 3: (A) Thomson spectrometer mounted on plug-and-play breadboard after alignment in TAE. (B) Scan of image plate that was used as the detector for the Thomson, the location of the zero point (point of no deflection) is well placed showing good alignment.

Figure 3(B) shows a scan of the image plate used as a detector after a shot on 20 µm Cu. No voltage was applied to the electrodes so the ions are only deflected by the magnetic field in the vertical direction. The deflected ions and zero point (neutral particles / x-rays) are clearly seen in the image. The spectrometer was removed from the experimental set-up and replaced on several occasions with no realignment. All data sets show excellent reproducibility.

Conclusions

A plug and play breadboard system for setting up and aligning diagnostics offline has been demonstrated. A Thomson ion spectrometer was aligned in a separate area and then installed in the interaction chamber with minimal access times. The image plate scans indicate that the Thomson was aligned correctly and was able to maintain alignment even when removed and replaced. The next steps are to develop the system further for diagnostics that require a larger breadboard and to implement the system on an experiment. In future, specific diagnostic positions could be pre-set for use by all experiments, whilst maintaining the flexibility to quickly install (and remove) diagnostics as required – even potentially on a shot-to-shot basis.