LA4/Vulcan Pointing Mismatch Investigation

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Introduction

An essential part of Vulcan laser operations involves the careful alignment of the beam, ensuring its arrival into the target areas so our users can achieve optimal experimental results.

The Booth experiment of June 2017 utilised the 2 Hz Optical Parametric Chirped-pulse Amplification (OPCPA) laser through the beam 7 line into Target Area Petawatt (TAP). The experiment focused on the resistivity of warm, dense plasmas where a detailed study of resistive plasmas at low temperatures required varying the laser parameters such as the pulse duration and focal spot size [1]. Targets created for the experiment tend to be as small as 20 microns.

Investigation

Misalignment arose with the laser beam failing to meet the target, which led to questions in the alignment procedure, particularly in the pointing to the laser area.

It was speculated that the mismatch was caused by the mechanical stresses exerted by the sliding mirror on the table; consequently, moving the position of the pointing. To investigate, the LA4 table incorporated the use of a red diode laser, as shown in figure 1.

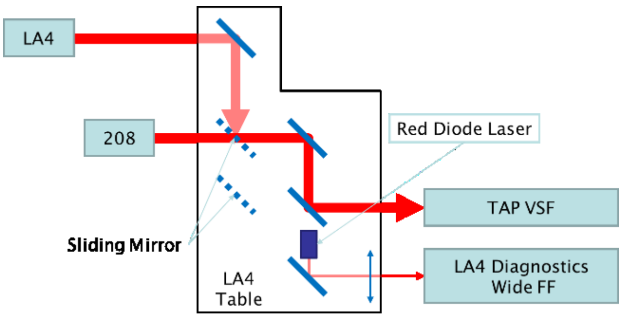

Figure 1: *LA4 table with the sliding mirror, showing the test setup using the red diode laser.*

The pointing of the beam before and after the movement of the sliding mirror were measured using the wide far-field (FF) channel on the LA4 and TAP diagnostics, calculating the centroid of the image of the focal spot.

Analysis

The pointing in LA4 shows a highly scattered plot in Figure 2, compared to the TAP data points.

The standard deviation of the data collected from the TAP images was 32% in the X values and 12% in the Y values; smaller compared to the standard deviation from the LA4 images, which were 78% and 67%, respectively. The Vulcan continuous-wave (CW) laser acted as reference to compensate for the error; therefore, the analysis in the data suggests that it provided little improvement.

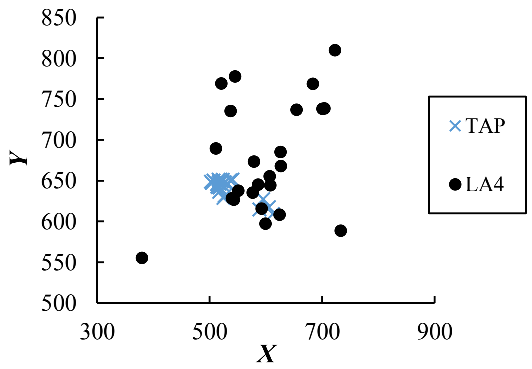

Figure 2: *Centroid data comparison between LA4 and TAP far-field images obtained from the Booth experiment.*

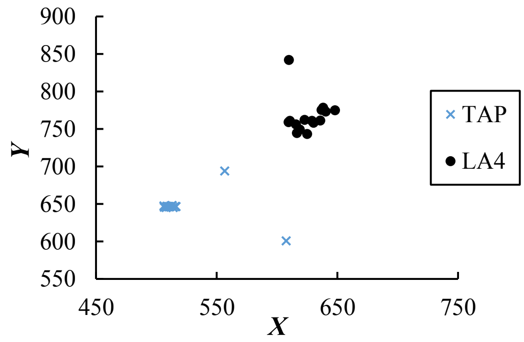

Figure 3: *Centroid data comparison between LA4 and TAP during the Lancaster experiment.*

Fixing the mirror onto the frame of the table was the suggested approach to counteract the shift. Figure 3 shows a less dispersed plot in the LA4 pointing, with improved standard deviation values of 13% in X and 47% in Y. Comparisons between the TAP far-field images for both experiments show that the pointing arrives fairly at the same position, with the Lancaster experiment having less spread in the data. However, the weakness of the table was not free from the influence of mirror vibrations.

Conclusions

Vulcan has considered replacing the table supporting the sliding mirror with a sturdy optics bench, to correct the mismatch further. This will effectively dampen the effects of the vibrations emanating from the sliding mirror.

References

[1] N. Booth, J. Green, P. Hakel, R.C. Mancini, P.P. Rajeev, A.P.L. Robinson, N.C. Woolsey, "*Anisotropy measurements of resistive plasmas for investigating the microphysics of warm dense matter*", Nature Communications **6**:8742 (2015)