CHARA Technical Report

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Pericope mounts and the DL front positions

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1. INTRODUCTION TO THE CHARA ARRAY PROJECT

The Center for High Angular Resolution Astronomy (CHARA) of Georgia State University has built a facility for optical/infrared multi-telescope interferometry, called the CHARA Array. This array consists of six telescopes distributed over an area approximately 330 m across. The light beams from the individual telescopes are transported through evacuated pipes to a central laboratory, which contains optical delay lines, beam combination optics, and detection systems. The facility consists of these components plus the associated buildings and support equipment, and is located at the Mount Wilson Observatory in southern California. The CHARA Array is funded by Georgia State University, the National Science Foundation, the Keck Foundation and the Packard Foundation.

2. OVERVIEW

On occasion, a few error reports have been made by observers when a delay line (DL) cart was approaching the front or home positions. These manifested themselves as image wander from center alignment at the M10 mirror, even when an adjacent (i.e. independent) DL cart was near the front position. The following is an attempt to verify and quantify this effect for each delay line.

3. THE EXPERIMENT

Alignments to the system were performed in the usual nightly manner, using the HeNe laser and beams 5 & 6. Alignments were made from the optical tables on out to the DL carts and back. A telescope/delay line pair were chosen, and the laser spot aligned to its M10 mirror while its DL cart was in the back position. This served as an image fiducial for the rest of the experiment. The size of the laser spot was optimized at the laser iris to create a small center spot for ease of centroiding.

Beginning with the back position, an image was grabbed and saved using XV image application (Figure 1). All images were saved in GIF format. The DL cart was then moved (in

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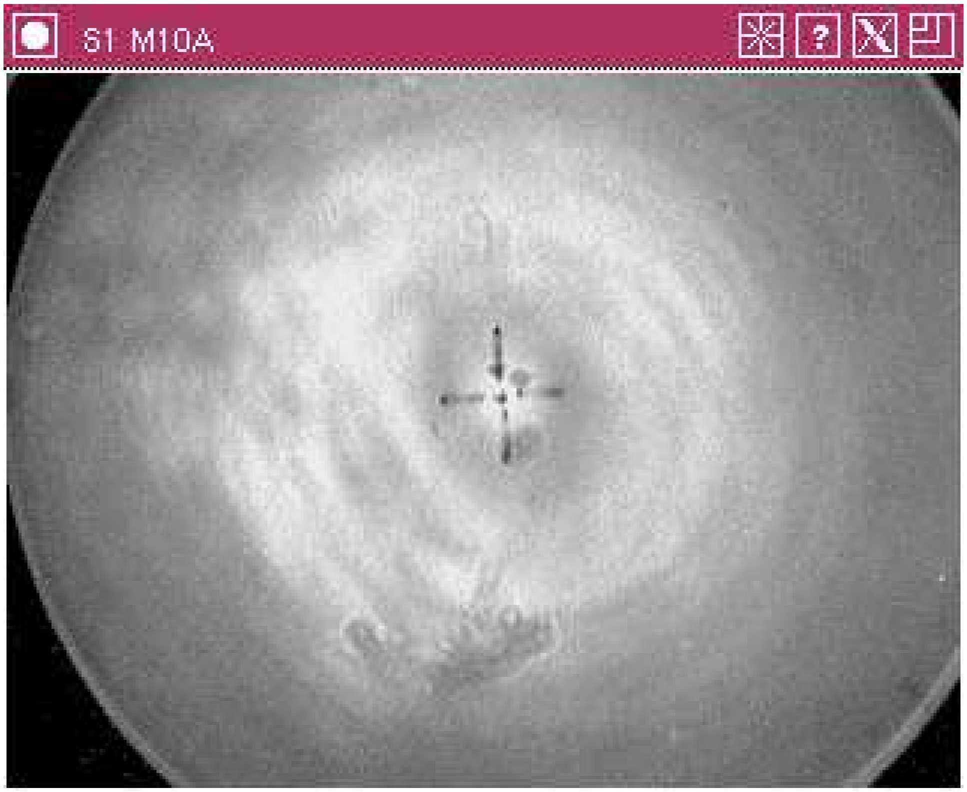

FIGURE 1. An example of an M10 image from the S1 telescope TV monitor, with DL cart in back position. This position serves as the (0,0) image position for S1.

TRACK mode, manual offset) to a position farther up the DL line, and another image taken. Between 2000 and 4400 cm, the DL cart was moved in increments of 500 cm. Between 200 and 2000 cm, the increment was 100 cm. Smaller increments were then chosen. Between 0 and 200 cm, the DL cart moved by 10 cm increments. Finally, during the negative DL range inward to -130 cm, it was chosen to be 5 cm. Again, at each stopping point an image was taken, with the file name equivalent to the DL position in (cm). For negative distances, "n" precluded the file name.

For each array arm, two experiments were performed. As a control, the first was to run the DL cart along, say, E1 rail while imaging E1 M10. For this, the E2 cart is stationary and in the back position. Secondly, to test mechanical coupling, the E2 cart was moved while still imaging E1 M10, with the E1 cart now stationary and in the back position.

In order to get the image scale, a cm ruler was placed on the translucent screen below each TV monitor. The ruler was then illuminated and an image was taken. This was done only once per telescope, namely E1, W1, S1. One needs only to resize the resulting image large enough to count pixels between ruler graduations. The plate scales are: E1 = 23.0 pix/cm, W1 = 22.5 pix/cm and S1 = 25.0 pix/cm in XV's GIF format. Since the M10s for the second telescope stations were not imaged, no plate scales were taken for E2,W2,S2.

4. RESULTS

With data images taken for 6 individual runs, it was then time to record the centroid positions of the laser spots in each image. An IDL program was written to record the center of each spot via mouse clicks, and these positions were saved as pixel positions to a txt file. The image used to initially align the spot on M10 while in the DL back position defined the image fiducial $[X_0, Y_0]$. Distances to each subsequent spot center (x_i, y_i) were calculated and converted to linear units via the plate scales found above.

Since each spot center was manually determined (best eyeball), the error in defining each spot center is ± 1.5 pixels. This translates to a maximum peak-peak error of around 1 mm. The error bars are not presented in each offset plot for clarity.

Image offsets for most of the distance on each rail deviated only slightly, of the order a few mm maximum. This represents minor rail alignment issues due to changes in temperature or seismic phenomena since the last full-scale manual rail alignment. The order of this effect is usually not an issue for normal observations.

Yet, in each of the 6 cases, image wander begins around DL position +250 cm , and continues almost exponentially up to each DL back position (-134cm). This critical area on the DL rail effects the periscope position, as the weight of the DL cart depresses the periscope mount position.

The most extreme case is the East rail system. In the E1-E1 case, the spot center deflected 5 cm in both axes. However, depending on which experiment was run (E1-E1, E1-E2, S1-S1, S1-S2, W1-W1, W1-W2), the position of the spot center was a matter of how each individual periscope mount coupled to the rail system. In all cases, mechanical coupling is seen between the 1st and 2nd rails, with the weight of cart 2 deflecting the spot at periscope 1.

In 5 of the 6 cases, the spot deflected toward the IV quadrant or Cartesian (+,-), in each image. However, while moving S2 and imaging S1 M10, the spot wandered toward the III quadrant (-,-). It was noticed that the S1 periscope sits about 8 cm out in front of the other 5 periscopes, in order to get around a POP junction. This may have something to do with this behavior.

5. A SOLUTION

Lazlo Sturmann fabricated a notched braced which would limit the motion of the hollow square beam supporting the DL rails. The application of this brace is shown in Figure 5. Initial tests show that when the S1 DL cart is brought to the front position, the gauge (shown in Figure 5) showed movement of 2/1000 in. After the brace was installed, the cart was again moved to the front position and movement decreased to 0.4/1000 in., or a factor of 5 in improvement.

The S1-S1 experiment was run again with the brace in place, this time data from DL positions [-134,1000] cm were taken. Shown in Figure 6 are data from both the unbraced and braced image wander. The brace tended to move the spot center slightly higher in the Y-axis between [200,1000] cm, on the order of only 1 or 2 mm from the unbraced spot positions. However, the most dramatic improvement was a decreased spot wander in the X-axis. Spot wander is now limited to 1 cm at the extreme position of -134 cm (front position). This represents a 2.5-fold improvement from the unbraced data. For the

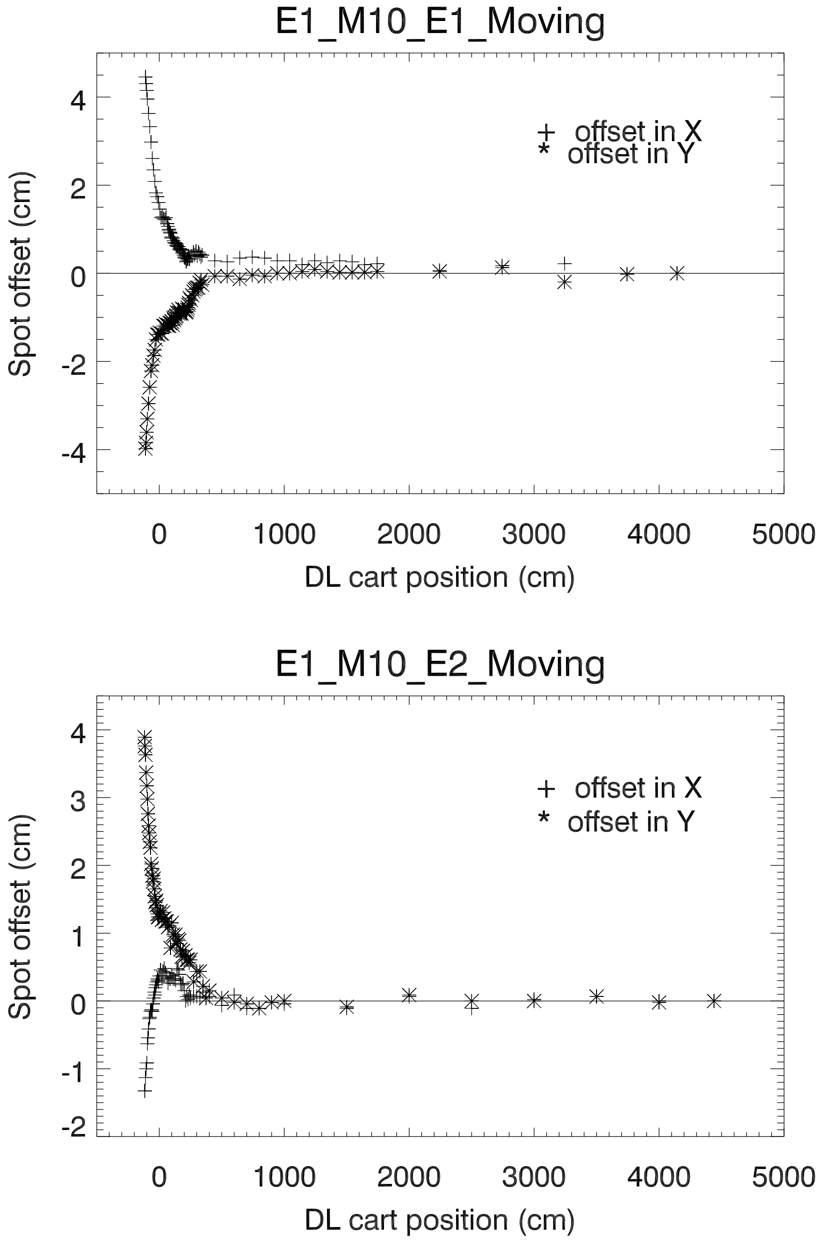

FIGURE 2. Top: Laser spot offset for E1 M10 while moving the E1 cart. Bottom: Same E1 M10 imaging, but now moving the E2 cart.

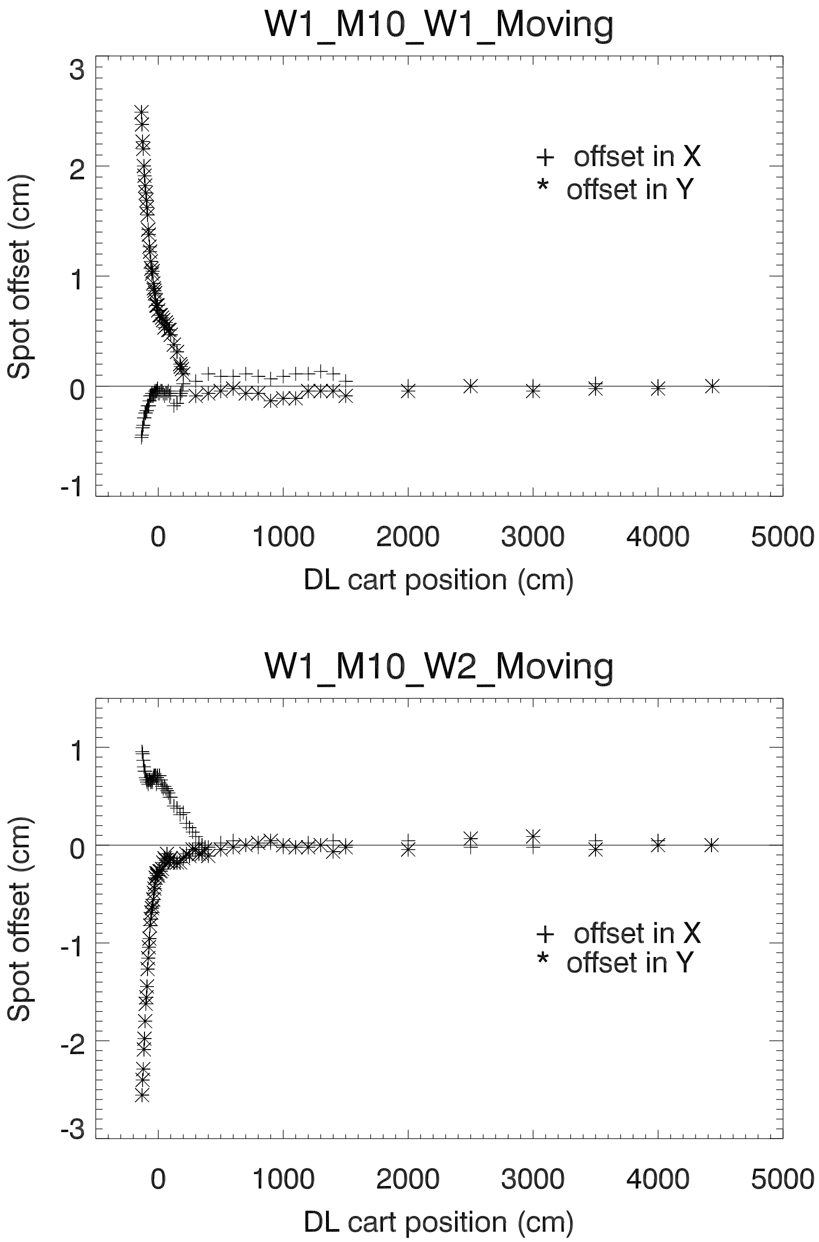

FIGURE 3. Top: Laser spot offset for W1 M10 while moving the W1 cart. Bottom: Same W1 M10 imaging, but now moving the W2 cart.

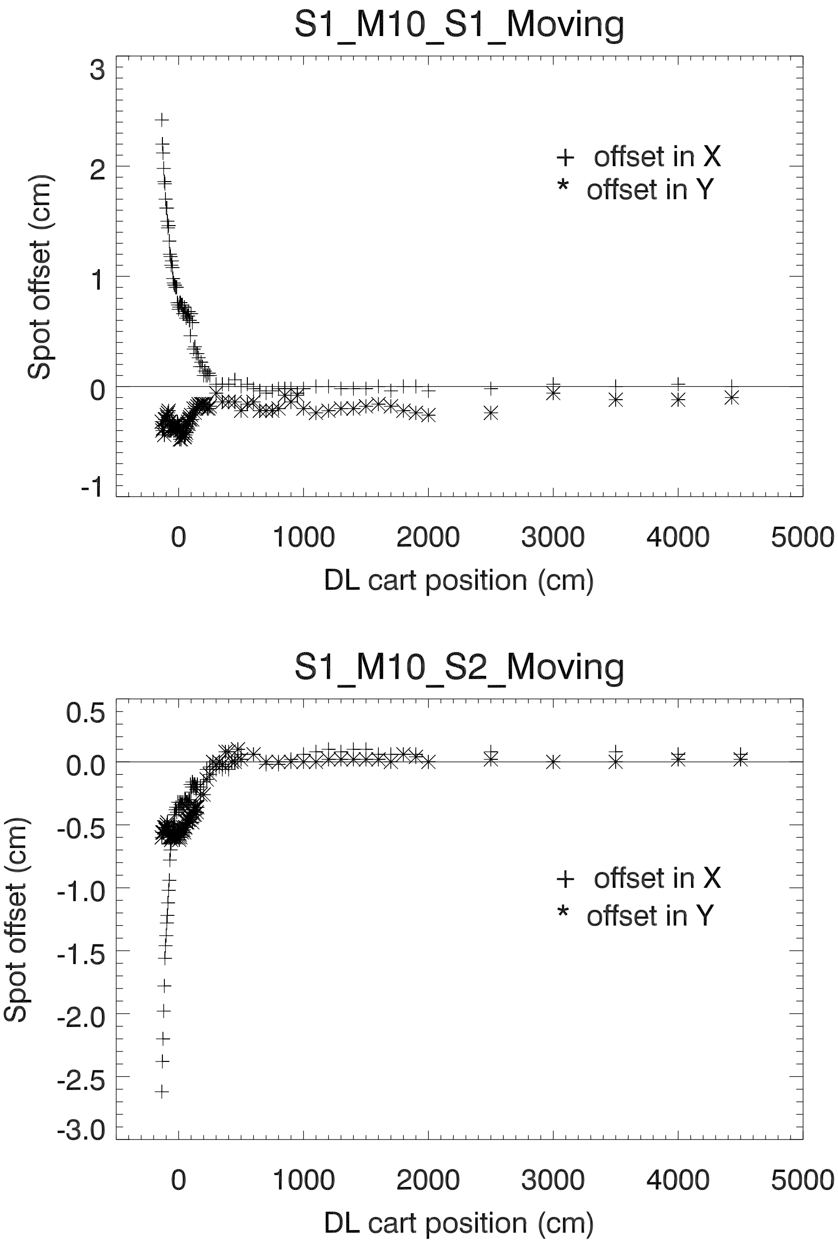

FIGURE 4. Top: Laser spot offset for S1 M10 while moving the S1 cart. Bottom: Same S1 M10 imaging, but now moving the S2 cart.

FIGURE 5. Image showing the steel notched brace located under the square beam. The notch fits into the beam, while tension screws above and below adjust the desired stiffness.

Y-direction, improvement was slight, a matter of only 1-3 mm.

6. CONCLUSIONS

Clearly, the current periscope mounting scheme is not optimal. While observations continue normally, this still leaves around 10% of the length of each rail system questionable - or at worst - unusable. For programs which require lengthy observations on low declination targets, this could impact the number of fringes acquired.

Discussions have ensued as to the best course of action regarding the periscope mounts. The goal is to stabilize the mounting systems so that they remain either independent of the rail structure, or supported in such a way as to decouple from the weigh (forces) of the DL carts on the rails near the front positions.

A solution was attempted such that a brace to stiffen the square beam supporting the rails was attached. This resulted in a 2.5-fold improvement in spot wander in the worst axis (X). Furthermore, if one wishes to define "usable delay" at the point where maximum deflection is less than or equal to 0.5 cm, then this occurs at -85 cm, and the usable delay is now at 99 % of maximum length.

The notched brace represents a viable and inexpensive solution to support the periscope

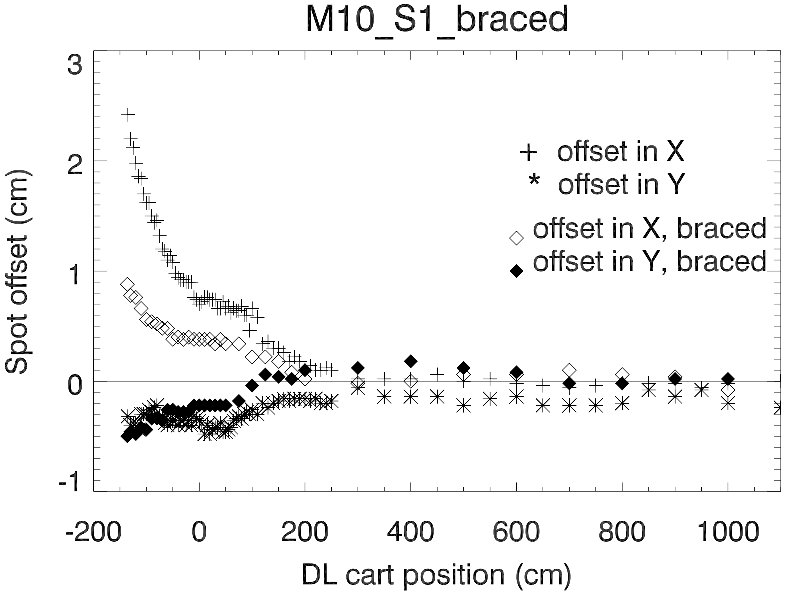

FIGURE 6. Results of the S1 M10 S1-Moving experiment, showing both the unbraced and braced image wander data. Only the first 11 meters of delay are shown (-135,1000) cm.

mounts. Plans are to fabricate 5 more braces for the other DL lines. As they are manufactured and installed, follow-up tests will be conducted, including the tests for mechanical coupling.