Evaluation and Calibration of the Focusing, and Tilting and Chopping Mechanisms of SOFIA

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Background

The Stratospheric Observatory For Infrared Astronomy (SOFIA) is a 2.7 meter telescope on board a Boeing 747-SP. The telescope has been receiving upgrades to equipment and instruments; as a result the Telescope Assembly needs to be evaluated and calibrated to achieve optimal image quality.

The challenge to collimating a 2.7 meter telescope without special equipment attached to the telescope is essential for optimal observation time. This calibration needs to done in flight with science instrument in place and take only minutes to perform for maximum observing time.

Method

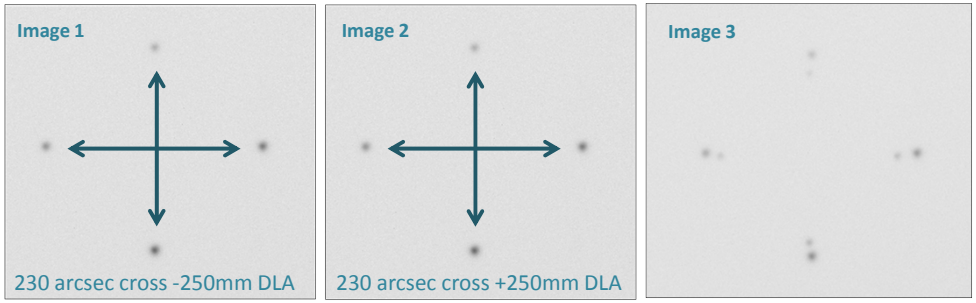
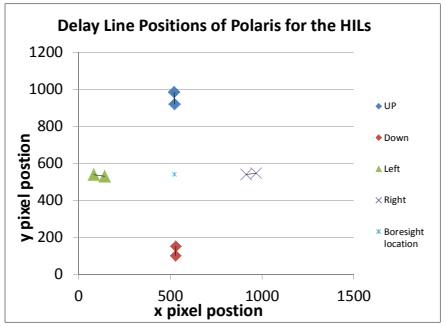
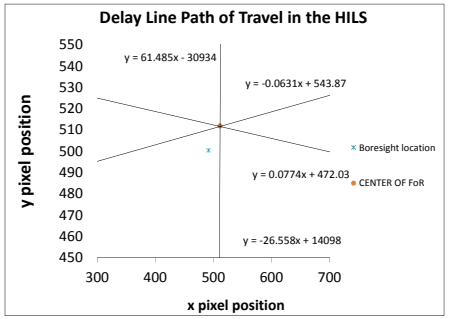


Image 1 and 2 are examples of the cross test done for the Delay Line during LineOps on two nights. These images are made from eight (four each) images taken with the Focal Plane Imager (FPI). These images were inverted for better contrast.

Collimation in the Focal Plane Imager (FPI)is achieved by the Delay Line Alignment method. This method offsets the Focus Centering Mechanism (FCM)and Tilting and Chopping Mechanism (TCM) by +/- 250 mm. Then we perform a 230 arcsec cross motion and plot the pixel positions at the extremes.

In image 3, images 1 and 2 are stacked together. This gives a visual confirmation this technique works. Connecting the points together reveals the turn point of the image.



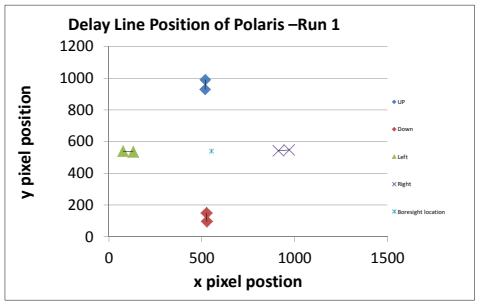


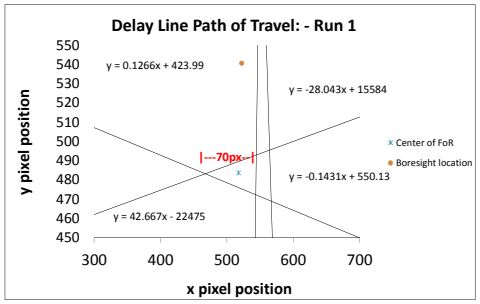
The data collected in the Hardware-In-the-Loop Simulation (HILS) gives ideal scenario conditions.

The Delay Line Alignment of all four lines meet at a single vertex. In this case, "X marks the spot" for the image's center of secondary mirror.

For this test, tracking using centroiding is turned off. The gyroscopes are used to keep the telescope pointing in the same direction.

The pixel positions of the star of both DLA positions are plotted and the solutions to the linear equation determined the center of the FCM.



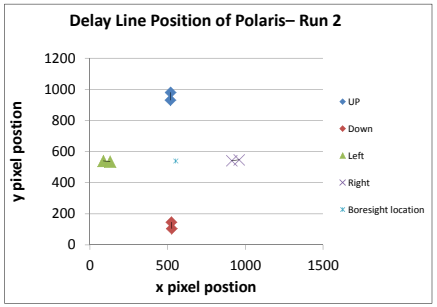


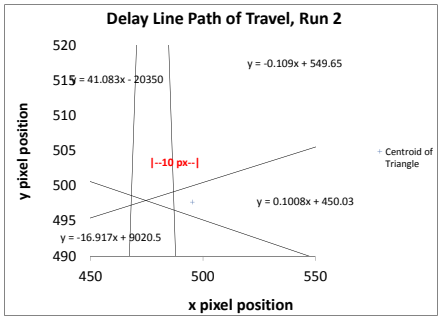
Run 1, initial analysis shows the TA is drifting 38.5 arcsec (70 px) between measurement of the two delay line, approximately 4 minutes 27 seconds. This is a significant problem that may need addressing.

For Run 2, the same test was performed showing similar results. However, there is a smaller error in the alignment of the Delay Lines (5.5 arcsec- 10 px).

The invariant pixel, (the pixel common in all images) was found by determining by averaging the centers of the triangles between the two axes.

This pixel is moved to BS to align the telescope mirrors.





Results

- Simulations in the HILS do not account for atmospheric extinction and weather conditions.
- Telescope collimation will be limited to 2 arc-second accuracy during ideal weather conditions on the ground.
- In Run 2, results determined the alignment to be accurate to .5 arcseconds or 1 pixel using the centroid of the triangles.

Further Testing

- Constant weather monitoring and sky condition should be done during ground observations .
- Monitoring the scintillation of the star in real time should be done to properly understand and determine the error in these types of measurements.

References

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Wolfram, A. (June , 11 2012). *Line-line intersections*. Retrieved from http://mathworld.wolfram.com/Line-LineIntersection.html

Funders

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