Setting Hartmann Wavefront Sensor Parameters

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The AOS Hartmann wavefront sensor (HWFS) software allows the user a great deal of freedom to optimize the performance of the HWFS. This document describes how a user might set the parameters to achieve good performance.

Centroid Threshold

To determine the average slope over an individual Hartmann sub-aperture, the AOS HWFS software calculates a centroid (a.k.a. first moment) on the intensity pattern and then calculates the ratio of the spot motion (relative to a reference spot location) to the separation between the Hartmann array and the imager. The software provides two different ways to set the centroid threshold: absolute and relative. These are each important in different conditions.

An absolute threshold allows the user to remove fixed pattern and dynamic sensor noise that can skew the centroid measurement. The relative threshold allows the user to remove the light outside the central spot of the intensity pattern. Since sensor noise and operating conditions vary, there is no one threshold setting answer that

is appropriate for all situations, but there are some ways to determine these values based on experimentation and theory.

Figure 1 shows a cross-section through the sinc intensity pattern that is expected from a square aperture. ***A relative threshold of 5% is enough to limit the intensity being considered in centroiding to the central peak.*** When using a circular aperture a slightly lower peak is acceptable because the intensity profile falls off more rapidly. This analysis indicates that we should use at least a 5% relative threshold, but this does not address any of the noise sources that can be present in the lab.

Figure 1 - Cross-Section of a Sinc Intensity Pattern
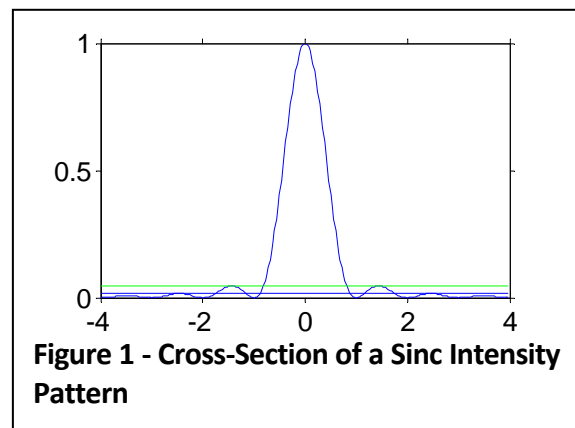
The absolute threshold can be set to minimize the effect of noise on the wavefront sensor measurements. In relatively good conditions (low ambient light levels, no large EMI sources, etc.) an ***absolute threshold of ~10 to 20 counts is good*** to remove the external

noise. Below this level, the noise can cause a dramatic effect on the centroid results. Beyond this level, you begin throwing away data that affects the accuracy of your measurement.

Another piece of advice is to ***use the threshold that was used for the reference creation***. To show this effect, we did an experiment in which we set the threshold relatively high (50 counts) and established a good reference with a 100 frame intensity average and then did a series of measurements looking at the RMS wavefront error with varying values of absolute threshold. Figure 2 shows the results of this experiment. A clear minimum can be seen near the 50 count limit. This is probably due to the sensor using different sets of pixels for the measurement than were used for the reference creation.

Figure 2 - Experiment results showing an optimum absolute threshold near the threshold used for reference creation.