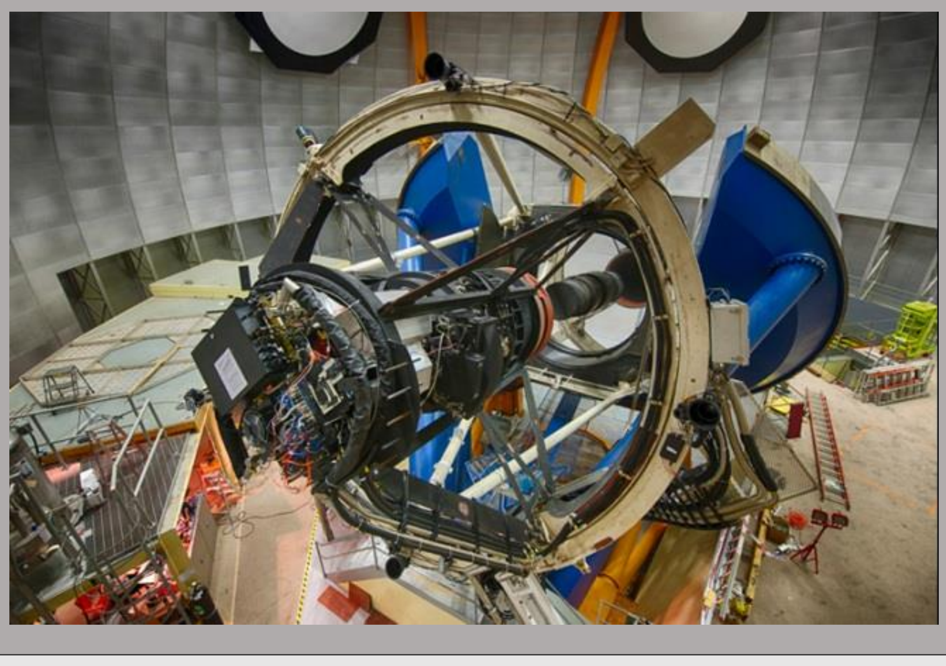
Scientific Verification Study of the Dark Energy Camera



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Background

Dark Energy:

In the late 1990's it was observed that the universe was expanding at an accelerating rate. The cause of this expansion is still unclear. One possible explanation is the existence of a new energy component with negative pressure, called "dark energy", that is driving the expansion. The other explanation is that general relativity breaks down on cosmological scales.

Dark Energy Survey (DES):

A survey of 5000 square degrees of sky, about one eighth of the sky, in high detail, using the 4 – meter Blanco telescope at the Cerro Tololo Inter-American Observatory. It is an international collaboration of 23 institutions. It will measure the following as probes of Dark Energy:

- Type IA Supernovae
- Baryon Acoustic Oscillations
- Galaxy Clusters
- Weak Lensing

Scientific Verification

The Dark Energy Survey officially began on August 31, 2013.

The survey uses the Dark Energy Camera, or DECam, a 570 Megapixel composed of 74 custom CCDs made to be sensitive to long wavelength red and infrared light.

The purpose of these studies are to reveal possible issues that, if corrected, may increase the quality of exposures taken by the DECam and prevent delays in its operation.

Engineering Regressions

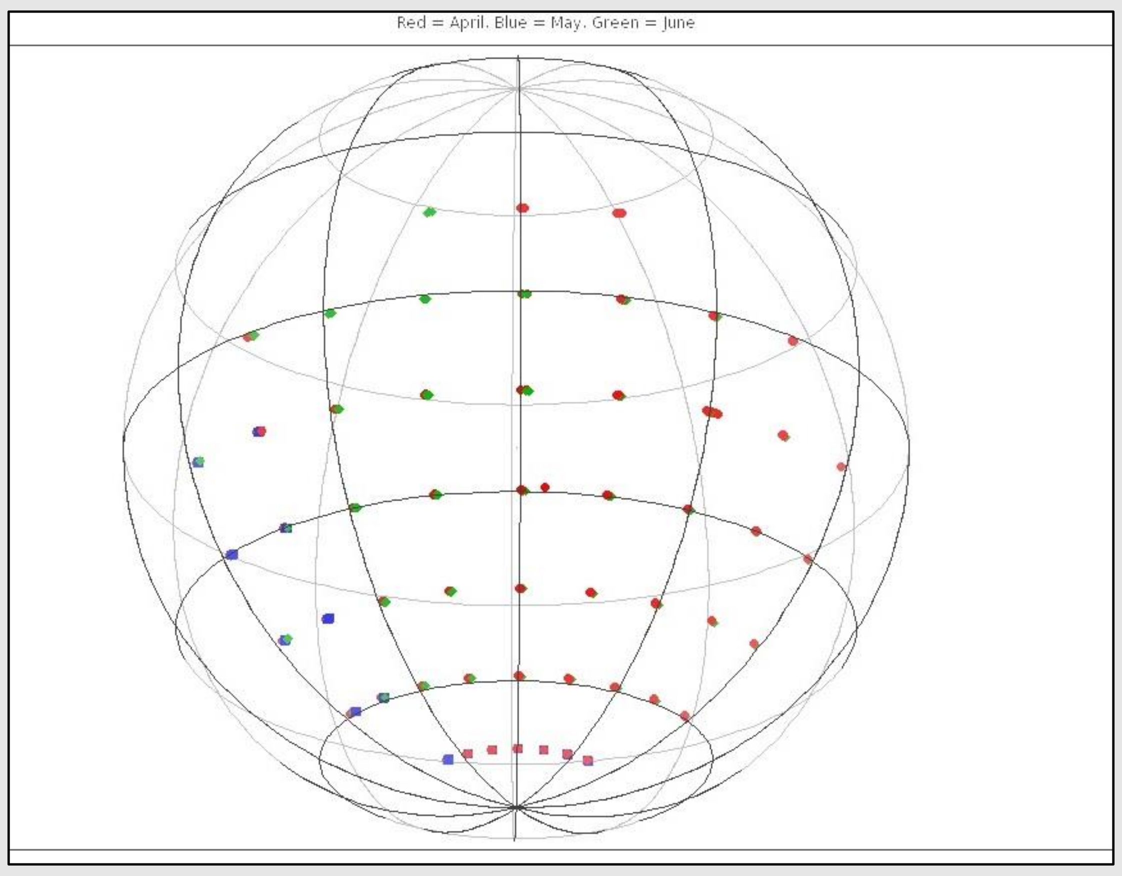

Fig. 1: Engineering Regression Locations

The figure above shows the locations on the sky of the engineering regression exposures, which are taken in standard locations for testing.

Hexapod

The hexapod controls small adjustments to the focal plane of the Dark Energy Camera (DECam), the camera responsible for taking the exposures.

Before each exposure, the hexapod makes an adjustment to bring the focal plane into the best alignment possible. These adjustments are on the scale of microns and arcseconds. This adjustment is determined by the AOS (Active Optics System).

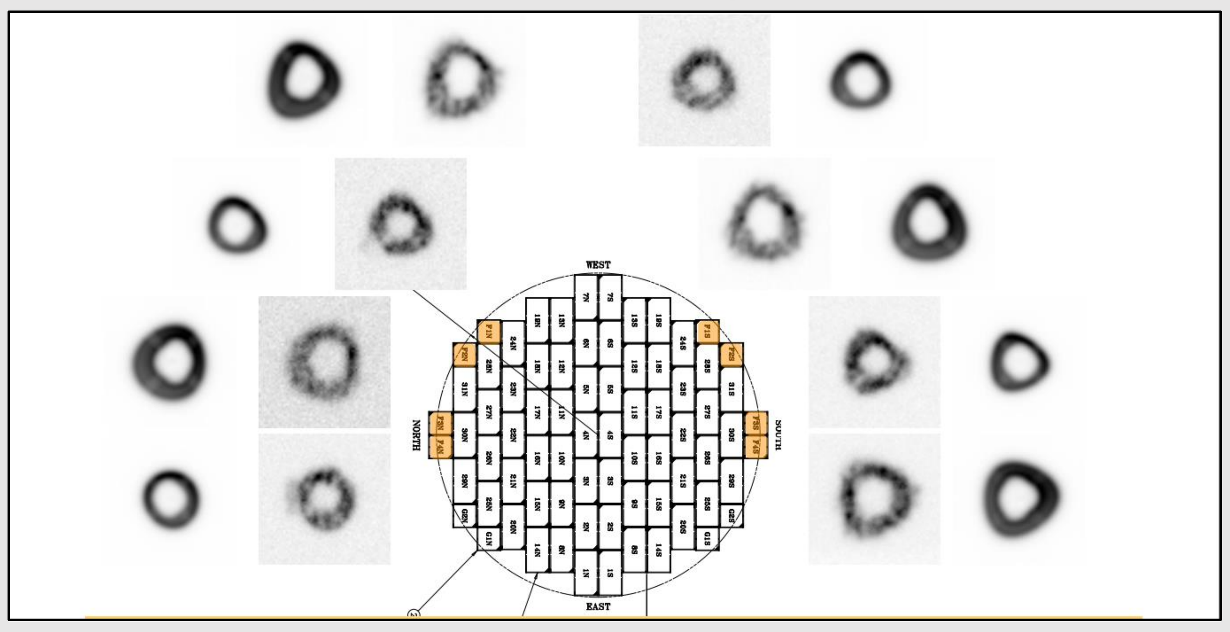

Fig. 2: AOS focusing system, which uses special out of plane CCDs

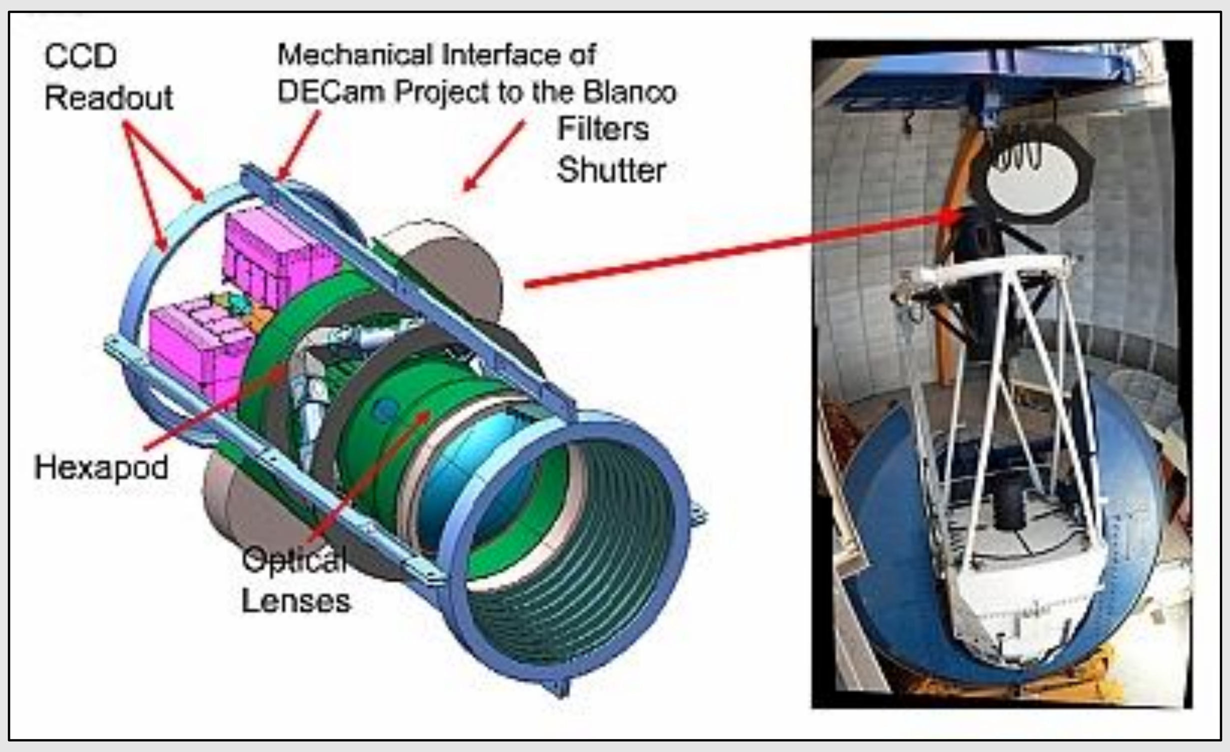

Fig. 3: DECam system

AOS Testing

One study performed was a study of the effectiveness of the Active Optics System, or AOS.

In these tests, the AOS brought the focal plane into its optimal alignment. The focal plane was then moved off axis by 2000 microns along the direction being tested, and a series of exposures were taken while moving the focal plane through steps of 500 microns.

Then the indicators of image quality, such as the whisker (ellipticity) were examined for the various positions. One example, along x, is below.

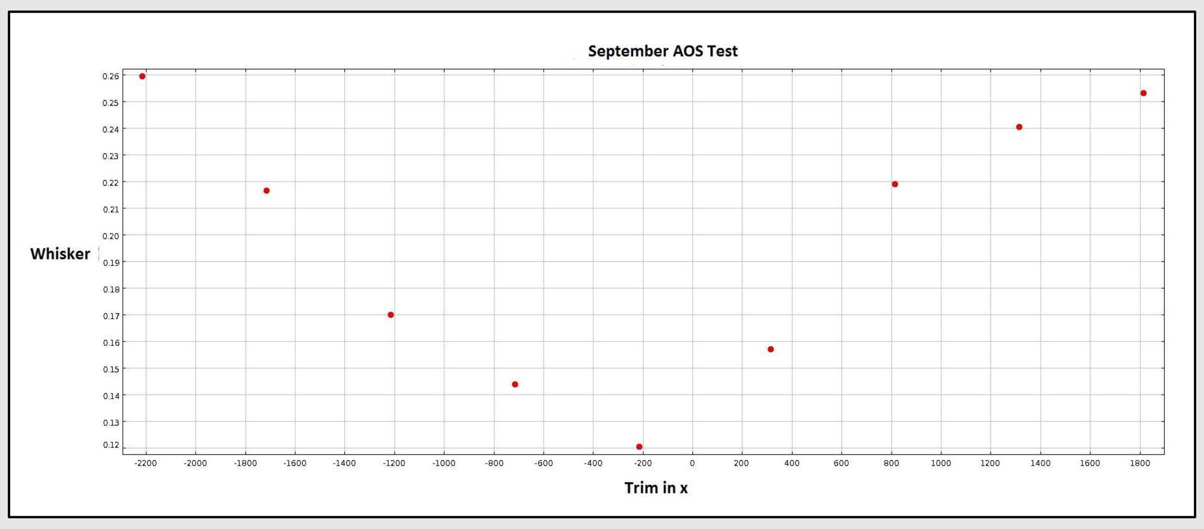

Fig. 4: Trim x values for the hexapod (relative x position) vs. Whisker, a measure of ellipticity. AOS x value: -214.33 microns.

Pointing Model

The pointing model is the model that determines the telescope's physical position when given a location to point at on the celestial sphere.

When the model was built the hexapod was put into optimum alignment for the exposure. Then the position of known objects in the image were recorded. These data points were interpolated to form the pointing model.

When exposures are taken in the survey the hexapod stays stationary over the course of the tracking to compensate for earth's rotation. Tracking uses the pointing model. This causes a different hexapod position than the pointing model is prepared for when the tracking completes. This then causes position offsets.

The offsets are the differences between where the telescope "thinks" it is pointing, and where it is actually pointing. These offsets reduce the efficiency of studies that require overlapping images of the same region over time, such as the type IA supernova studies. By reducing the offsets, more data can be used.

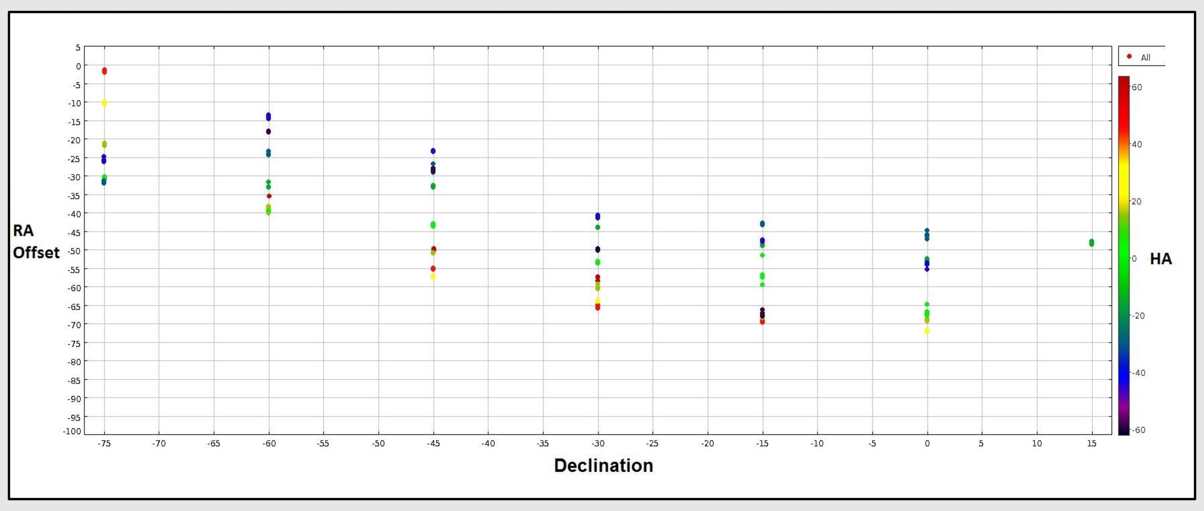

Fig. 5: RA offset corrected for hexapod tweak values vs. Declination (x) vs. Hour Angle (Color)

With the effect of the hexapod tweaks removed from the offset, there is still a correlation between the offset and the telescope position on the sky.

This provides evidence that the current pointing model is flawed.

Conclusion

The study of the AOS system provided evidence that the AOS system functioned properly. The study of the pointing model provided evidence that a new model would be required for greater accuracy. There are currently plans to develop an improved pointing model.

These particular studies were two of many performed over the course of this project. These studies, and others, contributed to a group of studies done by the collaboration that determine the state of the DECam and its surrounding systems. Their data is being used along with the results of the other studies performed by the collaboration to determine how to best maintain and improve the DECam.

References:

http://www.darkenergysurvey.org/

.http://www.noao.edu/news/2013/pr1310.php

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http://www.darkenergysurvey.org/collaboration/

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