Upgrade of Optical Pointing Guidescopes for the SMA

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Following every reconfiguration of the SMA, we need to calibrate the pointing correction terms in the mount model. The largest changes in pointing are typically due to azimuth encoder DC offset (azimuthal error in the setting of an an- tenna on the new pad), and the tilt of the azimuth axis (de- viation of the azimuth axis from the local vertical). We observe about 200 bright stars all over the sky, with an optical guidescope that is mounted in the back-up structure of each of the SMA antennas. The Electrim EDC-1000 CCD camera that is used in these guidescopes is getting old and is now completely obsolete. We have replaced 5 of the SMA antennas with a newer and more sensitive camera: the Santa Barbara Instrumentation Group's STi auto guider camera. The ST-i camera is also much lighter and smaller compared to the Electrim; the entire guidescope as- sembly including the 100 mm focal length lens is only about 20 cm long (Figure 1) The small size and cylindrical shape of the camera allows it to be mounted rigidly on the telescope's central hub.

Figure 1: (Left) SBIG ST-i guidescope mounted on the carbon fiber central hub of the backup structure of SMA antenna-1. (Middle) Rob Christensen comparing the sizes of the old and new guidescope tubes! (Right): STI-i guidescope with the mounting bracket.

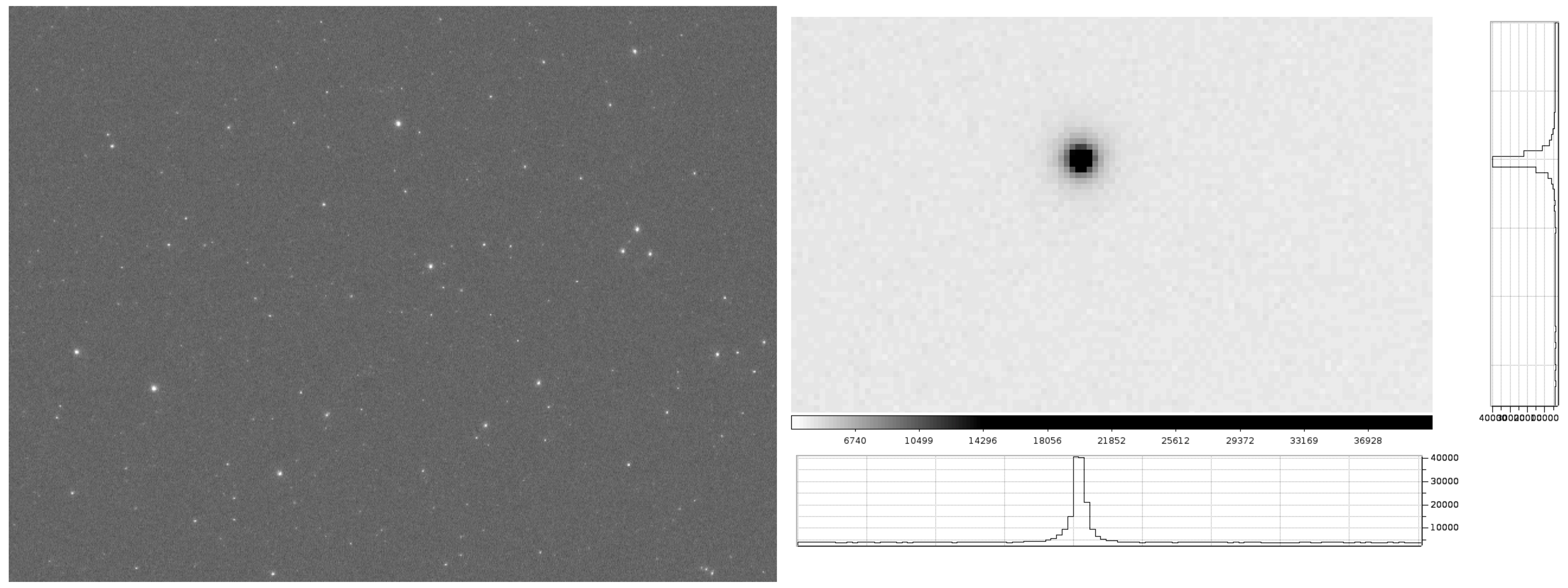

Figure 2: (Left) A one second exposure of a 2.7 degree wide field taken during a science track, showing a number of stars detected. Several of these stars have sufficient S/N and spreading of light across pixels to allow centroiding for offset measurements. (Right): An 800 ms exposure on Polaris with a cut across the horizontal and vertical directions through the center to show the intensity profiles.

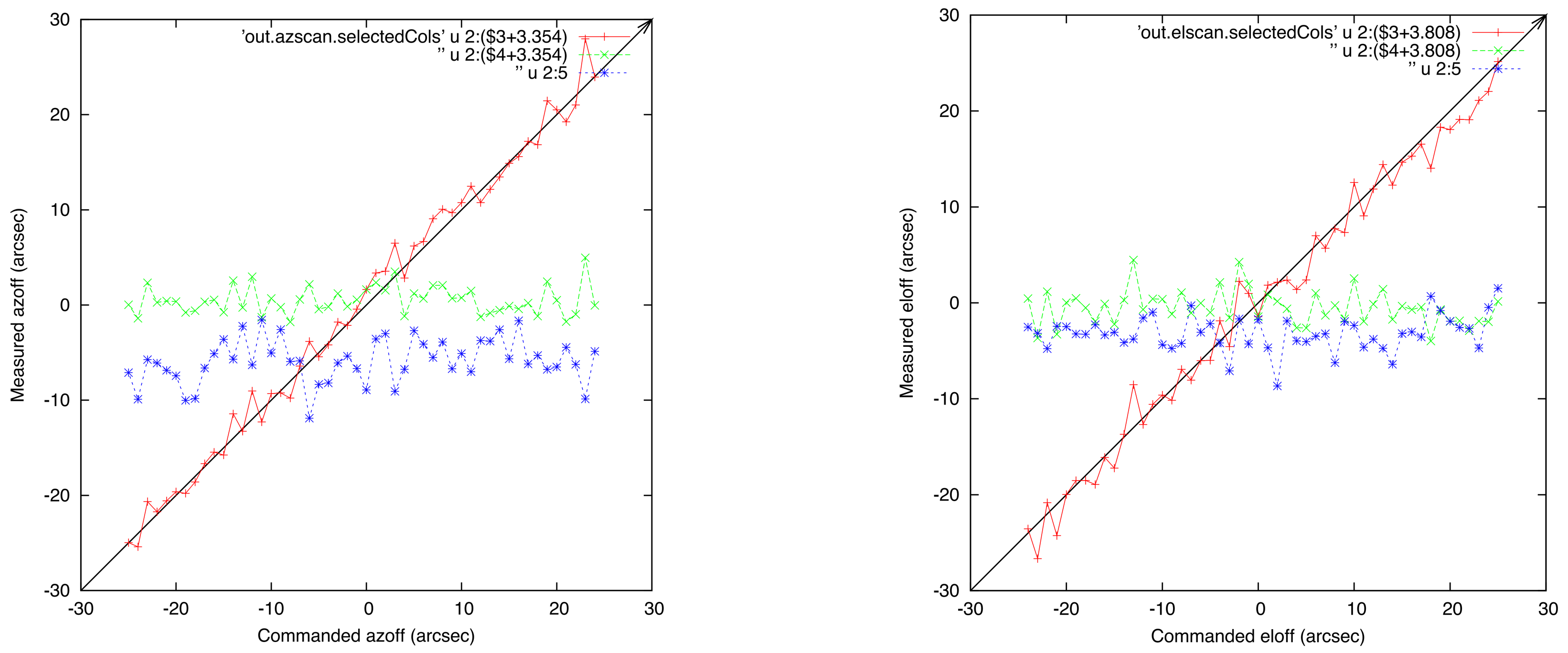

Figure 3: Test of centroiding accuracy on Polaris. The antenna was stepped in one arcsecond offsets along azimuth (left) and elevation (right). The red curve shows the measured offsets plotted vs commanded offsets and the green curves show the difference. A mean value of measured offsets has been removed (3.8" for eloff and 3.3" for azoff). The blue curve shows the eloff on the azscan plot, and azoff on elscan plot. The residual offsets have an rms of 1.3" and 1.7" for azoffs and eloffs, respectively. .

We use the Source Extractor program (http://www.astro- matic.net/ software/sextractor) for centroiding on bright stars to measure pointing offsets. The plate scale provided by the 100 mm focal length lens is rather coarse, 15.2 arcsec- onds per pixel, but the star light is spread over several pixels (due to poor optical performance, and internal scattering caused by insufficient baffling), and one can obtain sub-pix- el centroided offsets. Figure 2 (right) shows an image of Po- laris with intensity profile cuts. Centroiding works because of the spread in light across several pixels, but we need to over-expose the image, and yet stay below saturation. To as- sess how well the centroiding works, we measured pointing offsets as a function of given antenna offset, by driving the antenna along azimuth and elevation in steps of one arcsec- ond, and acquiring images on the same star. The exposure time was 800 ms and the star is Polaris (2nd magnitude).

These results are shown in Figure 3. The rms of residual off- sets are 1.3″ and 1.7″ in azoff and eloff. This performance is slightly better than our old guidescopes but we can improve it further by centroiding on multiple stars in the frame. We are investigating the optimal exposure time for stars of var- ious magnitudes, and also developing the software for mul- tiple star centroiding .

Our tests show that the ST-i cam- era guidescope can be used for arcsecond accuracy pointing model calibration following array reconfigurations. Off- set-guiding real-time corrections in pointing will require multi-star centroiding and a careful characterization of the plate-rotation. The compact size of this system allows for the possibility of mounting multiple guidescopes on different parts of the antenna structure providing direct measure- ments of mechanical flexure as a function of elevation.