Investigation into the effects of antenna tilts on pointing for the SMA Antennas

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Background

- SMA is located on the top of Mauna kea a dormant Volcano on the island of Hawaii.
- SMA consists of 8, 6 meter antennas that are designed to work in sub-millimeter wavelengths between 200 and 900 GHz
- Sub millimeter waves, are the form of light given off by vibrating molecules.
- It’s a new facility that just recently opened in November 2003.

Pointing

Pointing is the process of leveraging the hardware and software to drive the antenna to any point in the sky.

Each antenna has its own point model which is used during an observation to point the antenna to the science object.

A perfect antenna would not need a pointing model but real antennas deviate from ideal in a number of ways

- Tilting of the antenna
- The sag of the antenna under gravity
- Encoders may not read out in an expected way
- Bearings may be off

The current pointing model has ~1.5” (arcsecond) of mean error

An error .1” or better is require to perform all the science operations at 900 GHz

Building a pointing model

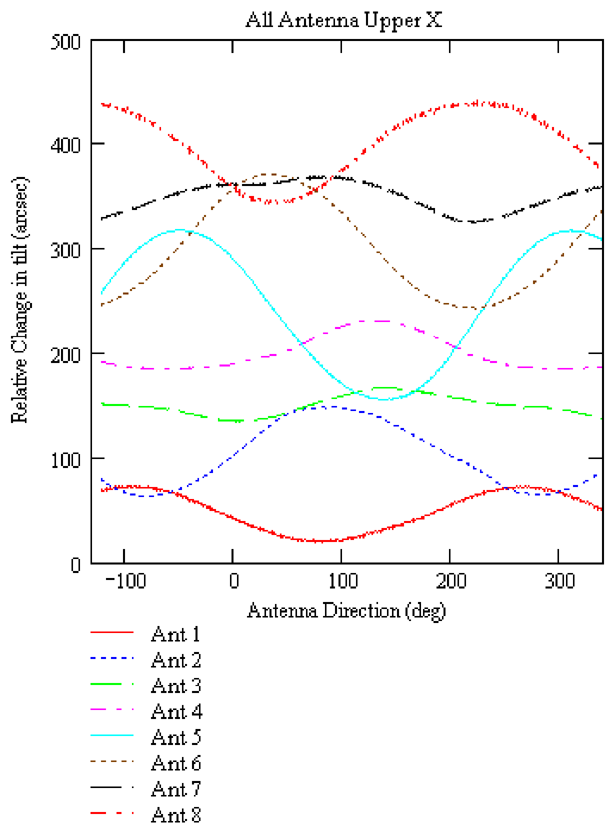
- The pointing model is built pointing the antennas sources distributed around the sky.
- A computer is then used to fit the locations of the objects to the pointing model. Including terms for gravitational sag, antenna tilt and encoder offsets.
- In the SMA model the sag and encoder terms are constants while the tilt is represented by first and second order harmonic terms

Antenna Tilt meters

Fortunately there are sensitive tilt meters in the base of each of the antennas, which measure the local tilt in part of the antenna.

Plotting the data from these sensors vs the azimuthal angle of the antenna is useful to see

The Data

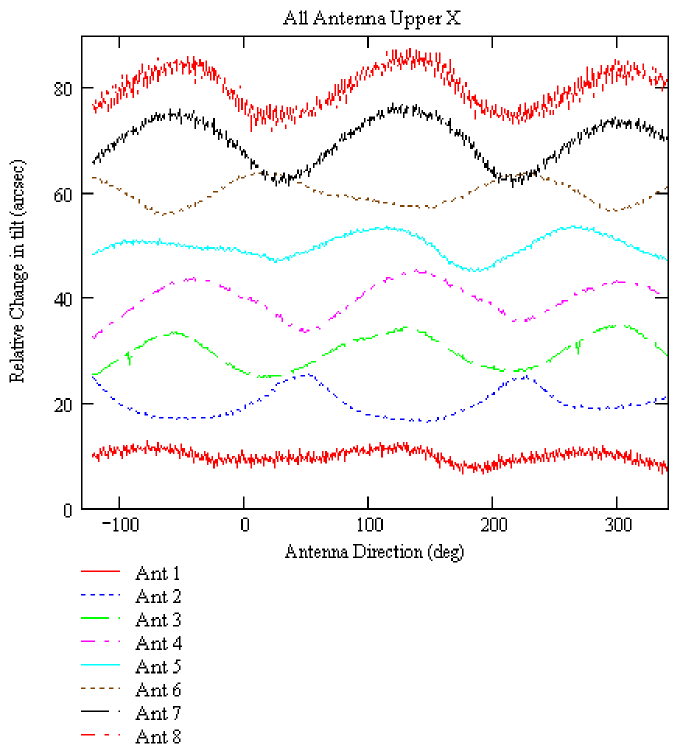


Looking at the raw data from the tilt sensors, plotted vs the direction the antenna is point we see a couple of things

- Each antenna has a different tilt
- 100” of tilt (wow 100x the pointing error)
- The Plots look like sin waves

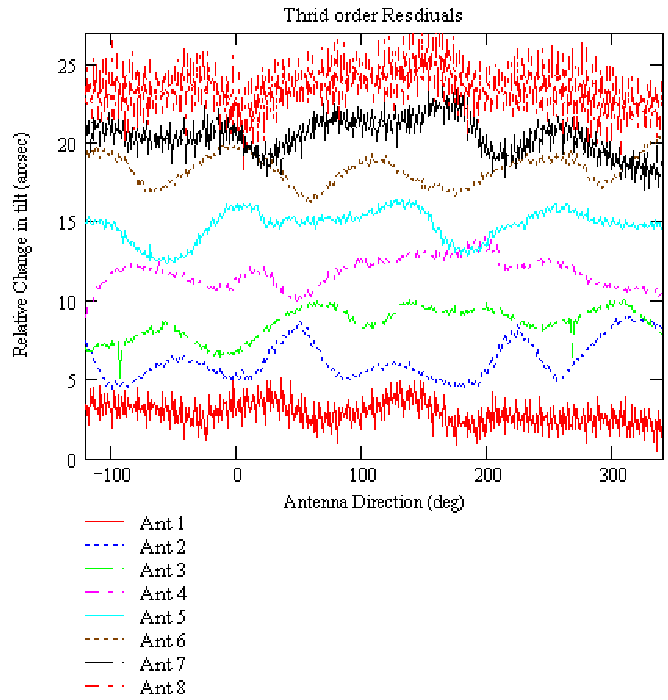
It turns out all of these can be explained by a simple leaning of the antenna

First harmonic residuals



- Error ~20”
- Plots look sinusoidal
- All the antennas seem to share common location of features
- These locations correlate to where an antenna rests on a pad

Second order residuals



•Error of about 1-1.5” RMS similar to the pointing model
•Not very sinusoidal
•The source is unknown, but likely comes from imperfect bearings.
•Noise is significant

Conclusions and future research

- The first two harmonic terms in the pointing model are physical valid, but it would not make physical sense to add a third harmonic term.
- If a model of the second order residuals could be created and applied to the pointing model the 0.1” of RMS error should be achievable.

What I Gained

- I learned some useful skills
  - MathCAD
  - Simple Perl scripts
  - More than I want to know about tilt sensors
- I learned I do in fact want to be an engineer when I grow up
- I got to meet a lot of great people.

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