VLBA TEST MEMO 66

FIXING THE 0.7° VLBA POINTING WOBBLE

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1 Fine Encoder Operation

Periodic pointing errors in the VLBA telescopes have been observed with pn3db pointing tests (see VLBA test memo 65). Those occuring with a period of 1.4° or 0.7° are thought to result from miscalibration of the fine encoders. The fine encoders on the azimuth and elevation axes of the VLBA telescope each measure two quantities that are used to determine the direction that the telescope is pointing:

$$\begin{aligned} X_{256} &= \cos 256\,\theta \\ Y_{256} &= \sin 256\,\theta, \end{aligned}$$

where theta is the angle being measured. The information from these numbers can only determine the angle modulo 1.406°; the coarse encoder is used to resolve this ambiguity. The angle is recovered by taking the arc-tangent of Y_{256}/X_{256}.

A periodic wobble at half the angular scale of the encoder, 0.7°, will arise if the peak-to-peak amplitudes of X_{256} and Y_{256} are not identical. Each signal passes through about 7 op-amps and more than 10 meters of cable *en route* to the digitizer. While the encoders may have been properly tuned prior to installation, combinations of aging components and differences in components on the converter/processor board are most certainly responsible for unequal amplitudes at the present date. A 1% difference in gain will produce a wobble with peak-to-peak amplitude of 8 arc-seconds, a signature very easily detected with a pn3db pointing test.

2 Measurements

The amplitudes of the X_{256} and Y_{256} signals can be measured at test points on the inductosyn converter/processor board, located within the NPL encoder box inside the pedestal room. Using a peak-holding precision voltmeter, the maximum and minimum values of each signal are recorded over several 1.4° cycles while the telescope is slowly slewing. It is interesting to note that the peak-to-peak values change with encoder angle, however the difference between the amplitude of X_{256} and Y_{256} remains very nearly constant. The changing amplitude with encoder angle may be indicative of other pointing problems. It is also observed that the signals have a small offset from 0 volts. An offset of the magnitude observed should produce a noticeable periodic wobble with a 1.4° period, but this is not observed. It is believed that the electronics are robust against this offset.

3 Tuning the Encoders

On the inductosyn preamp board, located within the encoder enclosure, there is a resistor for each of X_{256} and Y_{256} that controls the fine gain tuning. The schematic for this board states, "R5 & R18 are selected to match gain to within .02%". It is likely that these resistors were selected based on voltage measurements made on this board, not at the converter/processor board, meaning that the downstream electronics were left out of the calibration. In any case, one of these two resistors can be changed to equalize the amplitudes of X_{256} and Y_{256}. Installation a precision trim pot instead of a fixed-value resistor will make future tuning easier.

4 An Example : Los Alamos

Paul Johnson tuned the elevation axis at Los Alamos. Before the tuning, the peak-to-peak amplitudes of X_{256} and Y_{256} were measured four times. The amplitudes were measured again after the tuning. These numbers appear in Table 1. It is encouraging that their ratio is constant to the precision of the meter over a two week period, indicating that tuning may not be required often.

A pn3db test showed that Los Alamos had a 0.7° pointing wobble with roughly 8 arc-second peak-to-peak amplitude (see Fig. 2). The measurements made on the encoder converter/processor board also indicated an 8 arc-second wobble. The predicted wobble is shown in Fig. 1. After equalizing the X_{256} and Y_{256} gains, a second pn3db test was performed, showing no sign of the periodic wobble (see Fig. 3).

Date	P-P X_{256} (Volts)	P-P Y_{256} (Volts)	Ratio
07/17/2001	7.9902	8.0656	1.00944
07/20/2001	7.5482	7.6188	1.00935
07/20/2001	7.9198	7.9935	1.00931
08/01/2001	7.896	7.974	1.00988
08/01/2001	8.249	8.252	1.00036

Table 1: Peak-to-peak amplitudes for Los Alamos elevation encoder measured at four times. The two measurements on 07/20/2001 were made at different elevations. The last measurement was made after the fix.

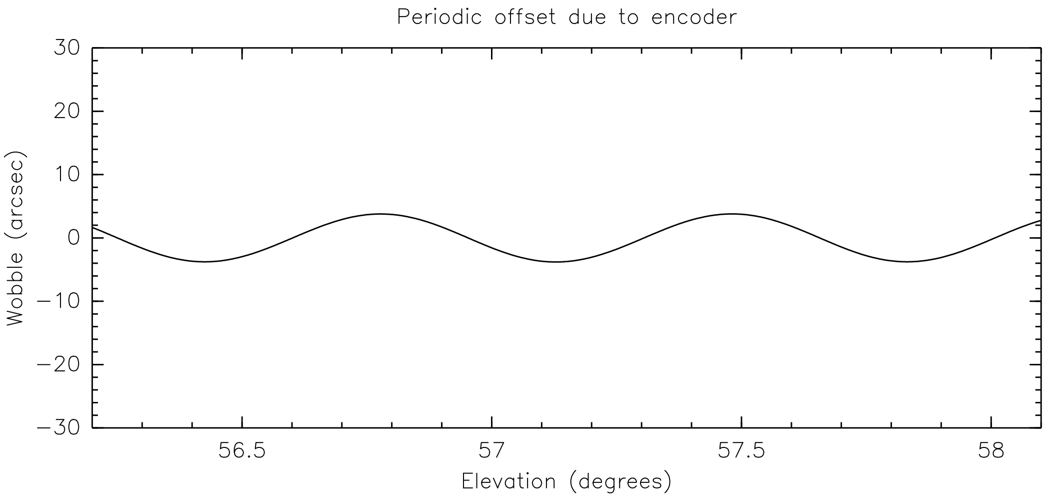

Figure 1: Predicted wobble pattern at Los Alamos for the measurements in Table 1.

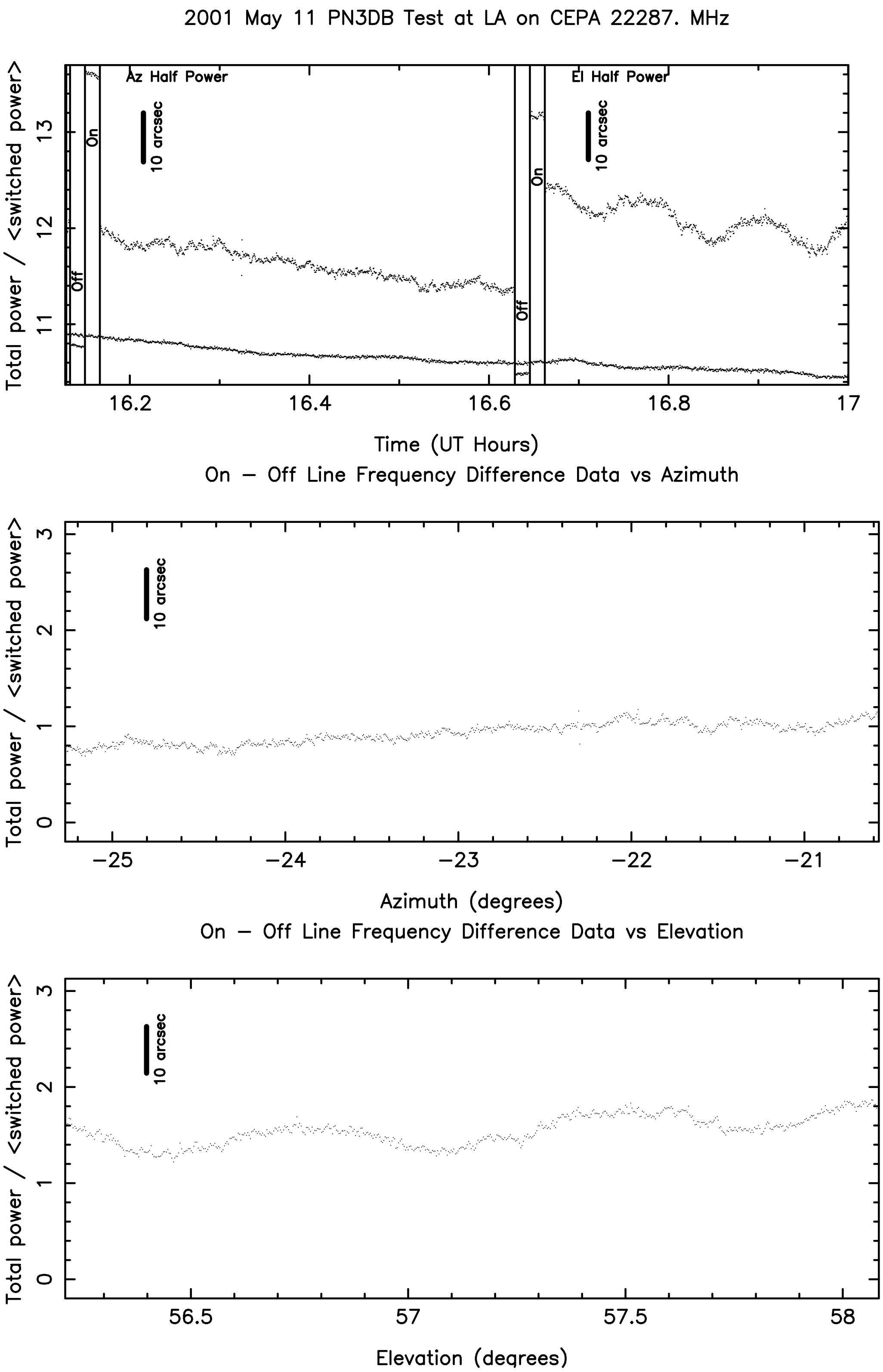

Figure 2: May 11, 2001 pn3db test on Los Alamos. Note 0.7° wobble in declination.

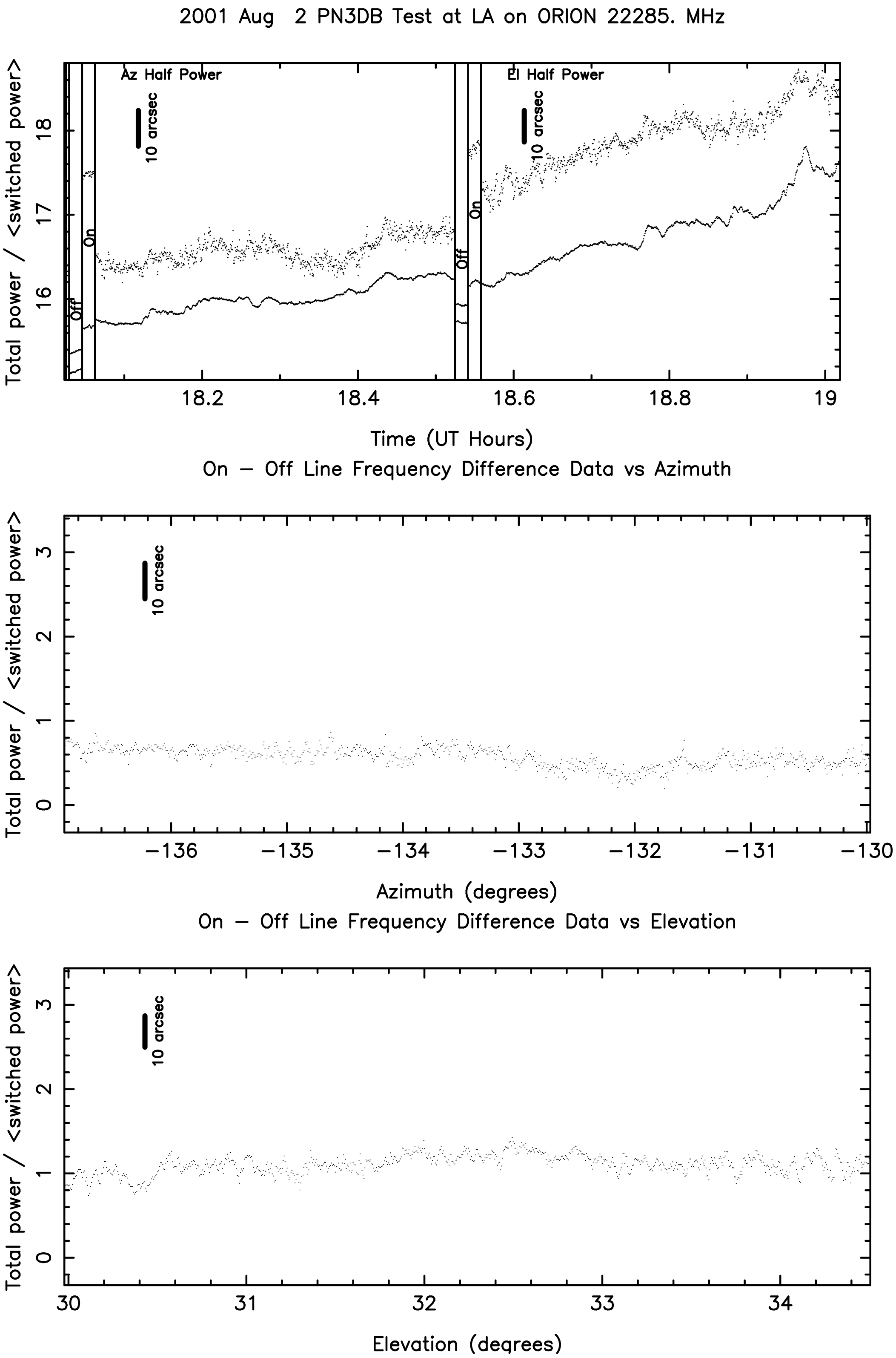

Figure 3: Aug 2, 2001 pn3db test on Los Alamos. The wobble is gone.