VLBA TEST MEMO 65
RESULTS of a VLBA PN3DB TEST

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A PN3DB test is designed to test the quality of tracking on an antenna. The [redacted] by Peter Napier (hence the "pn") long ago for the VLA, is to track with a strong source at the half power point of the primary beam. Tracking irregularities will show up as amplitude fluctuations. Only one dimension can be checked at a time. The azimuth tracking is checked by putting the strong source at the half power point in azimuth. The elevation tracking is similarly checked by putting the strong source at the elevation half power point.

A PN3DB test was done on May 11, 2001 on all VLBA antennas except NL between 11 and 17 UT. Note that this is day time so there will be thermal effects. Each source was observed for one hour. The hour began with 1 minute observations on and off source followed by tracking at the azimuth half power point for the remainder of the first half hour. Then the pattern was repeated tracking at the elevation half power. All of the sources observed were 22 GHz H2O masers, although, if the LST had been different, some would have been at 43 GHz. The strongest sources (W49N, W3(OH), and ORION) were just observed in total power in a channel on the line frequency. The weaker source (CepA) was observed in both line and off line channels so the difference could be used to remove the effects of atmospheric contributions to the system temperatures.

Generally, atmospheric contributions proved to be small. But despite that, I am inclined to use on and off channels for all sources in the future. To use the differences, I scale for the very different system temperatures on and off the very strong masers using the ratio of average switched powers.

There are a number of characteristic plots attached. There is a separate page for each antenna/source so the main file has 53 pages. I have only included one characteristic one per antenna plus an extra on FD which can be used to contrast the total and difference power methods and show that extent that results can vary between sources (pointing directions).

The short summary is that we have some problems on the array. Below I describe the situation for each antenna. Two flavors of problem are seen. One is clear periodic oscillations as a function of either azimuth or elevation. These are most likely due to problems with the encoders and related electronics. The second is drifts or other variations that are much larger than the quality of pointing we are trying to achieve. Since these are day time observations, such variations could be the result of thermal effects. But note that some of the drifts seen in the plots are due to atmospheric variations, not pointing variations. When off-line data are present, this is obvious. Otherwise look at changes in the on and off source data before the az and el scans. Any changes are atmospheric.

Oscillations seem to have one or both of two possible periods. The strongest oscillations have a period is about 0.7 degrees in azimuth or elevation. Bob Broilo informs me that the VLBA uses a 512-pole inductosyn so the expected period is $360/512 = 0.7$ degrees, matching well with what I see. One might expect that the other period would be half that (0.35 deg), but it seems to be a bit longer, about 0.45 deg (see FD plot). This needs a bit more study and I should probably set up to

do a spectral analysis.

- St. Croix (SC): T = 27-31 C, Wind 5-10 mph, gusts to 17 (max 19).

  There are drifts of up to 15" in az, 10" in el and obvious pointing errors of at least that magnitude.

  There is an azimuth oscillation of about 6" with a period of about .70 deg. If there is an elevation oscillation, it is hidden in the other fluctuations.

  There are rapid fluctuations of 5-10" with time scales of roughly 30 seconds. I would guess that these are wind induced.

- Hancock (HN): T = 13-27 C, Wind 0-4 mph, gusts to 12 (peak 16).

  No oscillations.

  Pointing fluctuations 6-10". Some 15-20" spikes in pointing later in run might be wind gust responses.

- North Liberty (NL): Did not participate.

- Fort Davis (FD): T = 14-27 C, Wind 0-3 mph to about 14:30. Then picking up to 10 mph. Gusts below 5 mph at first. At end, highest is 20 with most below 12.

  There are strong indications of an oscillation of about 4" p-p and a period near 0.45 deg in some, but not all, scans. It may be superimposed on something with another period. I may need to do a spectral analysis.

- Los Alamos (LA): T = 11-21 C, Wind 0-8 with gusts to 12 (peak 16).

  Az oscillation of about 4" with 0.7 deg period on only some sources, mainly the first (not the one in the attached plots). El oscillation of about 8" with 0.7 deg period on all sources.

- Pie Town (PT): T = 12-22 C, Wind about 5 mph, with gusts to 11.

  There are what appear to be oscillations in elevation with a p-p amplitude of about 3", but the period is a bit obscure. There may be beating of multiple frequencies going on. The shortest is similar to the 0.45 deg seen at FD. Again, I think I need a spectral analysis.

- Kitt Peak (KP): T = 18-24 C, Wind 5-7 mph, gusting to 11, with some higher gusts to around 16 mph around 16:20.

  There are some high frequency oscillations in elevation with amplitude about 3" and period near the 0.45" of FD and PT. Again, there is confusion and a spectral analysis may be needed. The oscillations are smaller than the drifts, which look to be up to 10".

- Owens Valley (OV): T = 8-26 C, Winds calm with gusts to about 7 mph.

  The 0.45" period is there in elevation with an amplitude of 2 to 5". The azimuth pointing looks good.

- Brewster (BR): T = 10-18 C, Winds calm to about 14 hr, then rising to about 4 mph. Gusts only about 2 mph over average wind.

There are some small drifts, but no oscillations are obvious. This may be our best pointer for short term stability. Too bad it has the worst efficiency (probably thanks to the subreflector).

Note that the example plot starts with an event, presumably weather, that shows up in both on and off line channels (see top panel). The difference data on the second panel shows that the difference technique has removed the event entirely.

- Mauna Kea (MK): T = 3-8 C, Winds mostly near 3 mph, rising to about 10 for an hour or so near 15:50. Gusts about 8, rising when average does to a peak of about 14 mph.

  There is a pronounced elevation oscillation with 0.7 deg period and amplitude of about 8". It is not a perfect sinusoid. Some peaks are somewhat asymmetric and not all are the same.

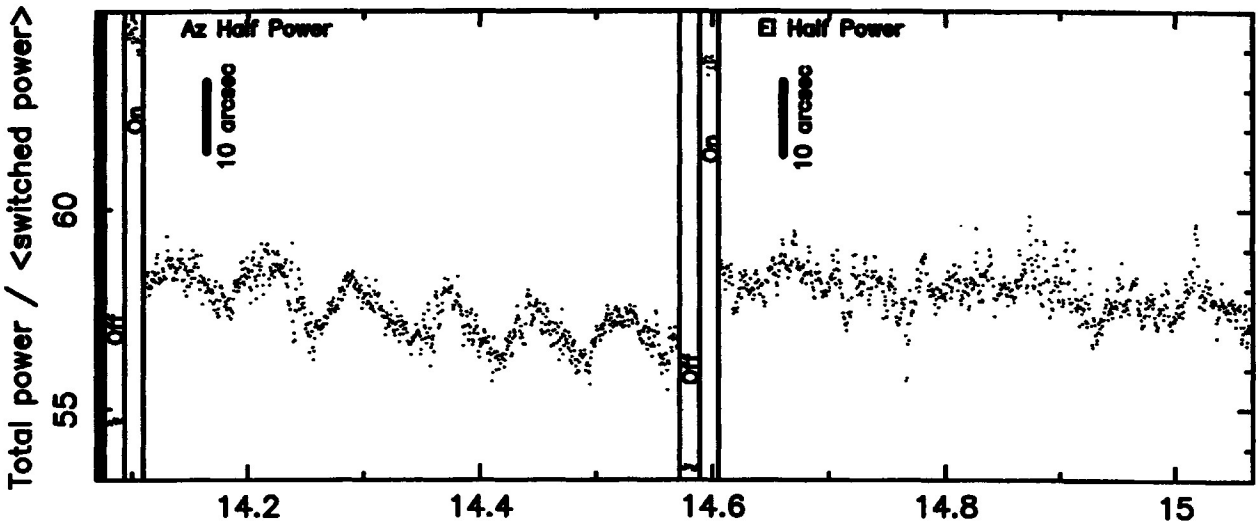
This memo is intended as a "heads up" for some problems with pointing on the VLBA. We have known for a long time that such problems exist because these are not the first PN3DB observations that have been done. But, with other priorities taking our attention, not much has happened in this area. Now we want the array to work at 86 GHz, so we need to get to it.

Some tasks that need to be done are given below. I plan to work on most, but the work on the encoders must be done by others.

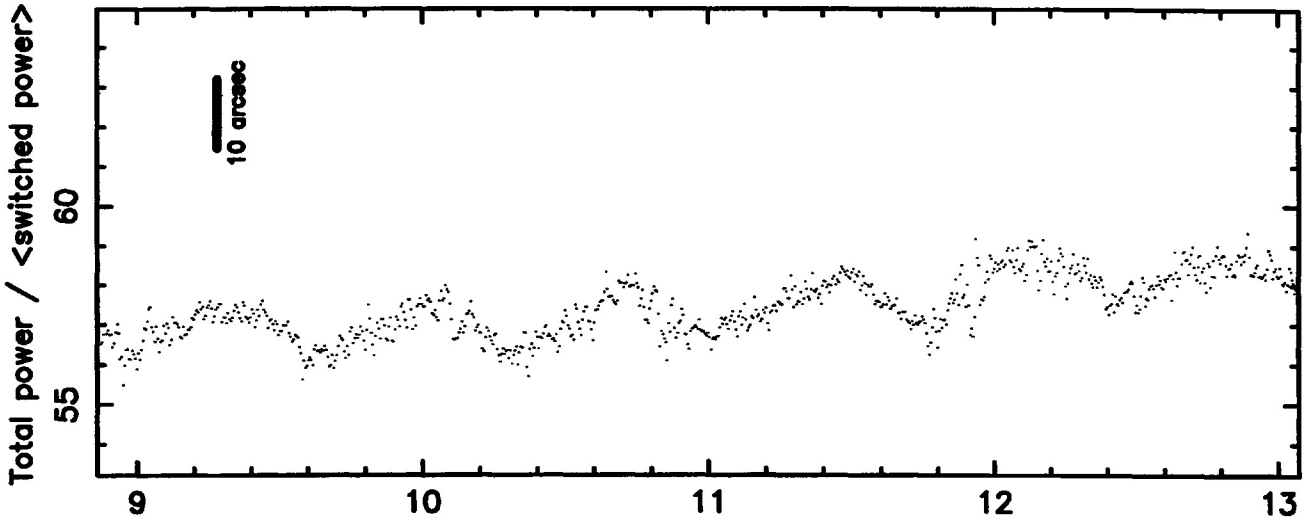
- Get NL data.
- Reobserve with all sources in line mode.
- Work on the encoders to remove the oscillations.
- Try to understand the drifts. This is going to be a big and complicated job and is part of trying to improve the overall pointing.
- Make PN3DB observation a more standard part of array maintenance.

The plots mentioned above for one source at each station are attached. The full set of plots are available, at least for a while and for people with fast links, from my VLBA testing page at http://www.aoc.nrao.edu/~cwalker/vlbatest/vlbatest.htm.

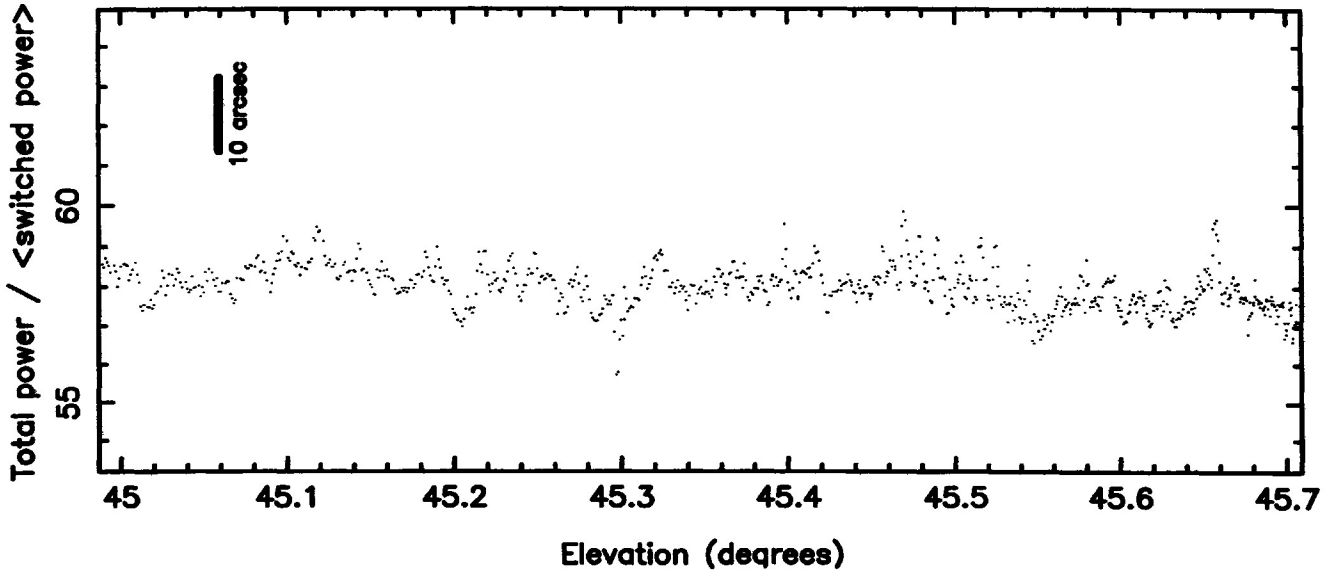
2001 May 11 PN3DB Test at SC on W3OH 22239. MHz



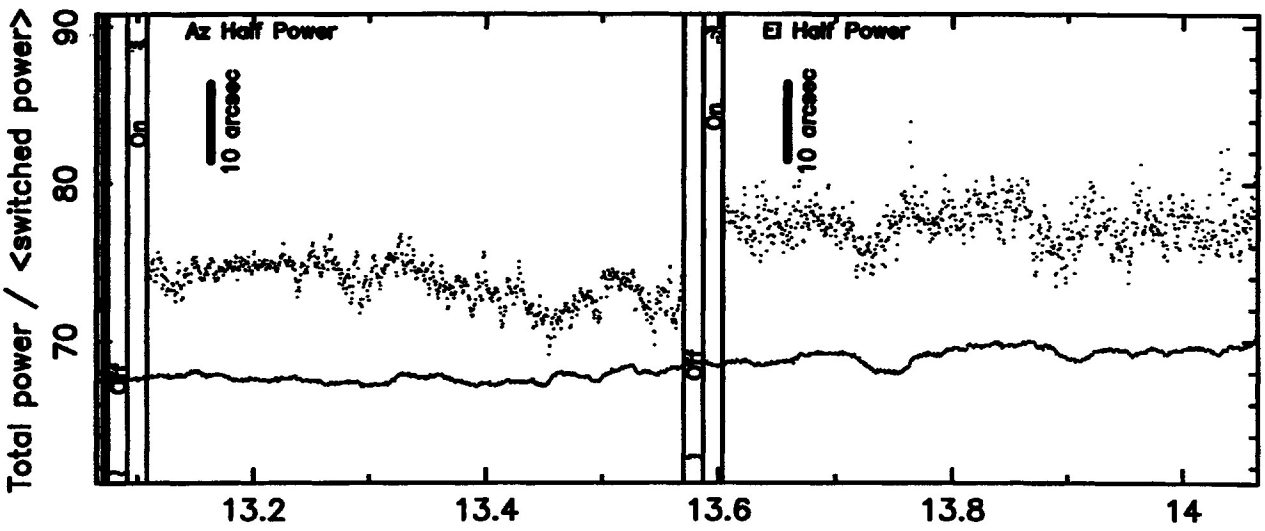
Total / Switched Power Ratio vs Azimuth



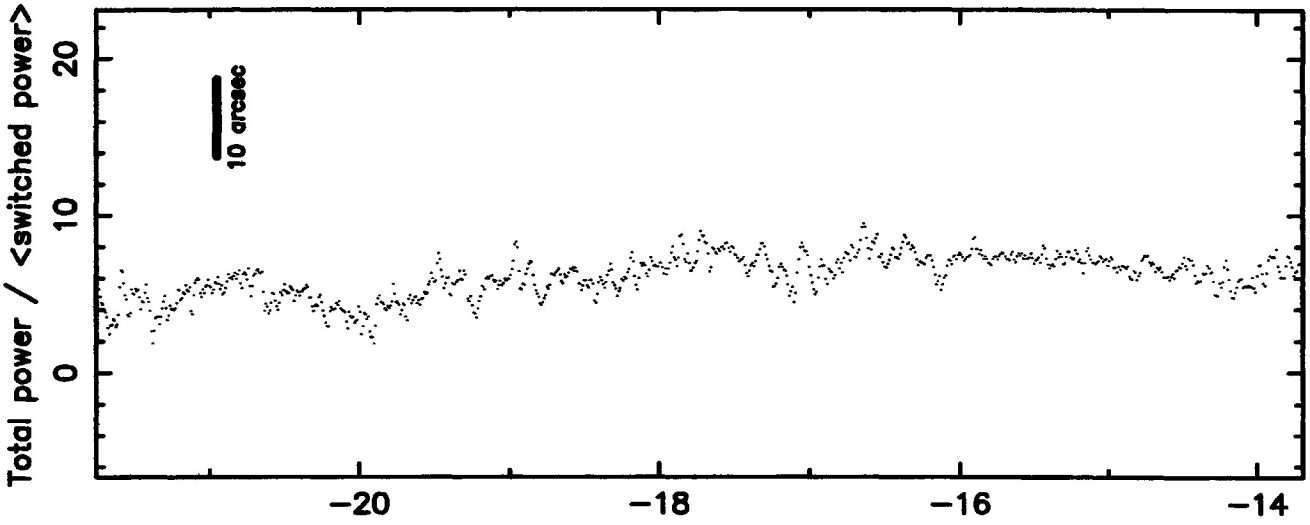
Total / Switched Power Ratio vs Elevation



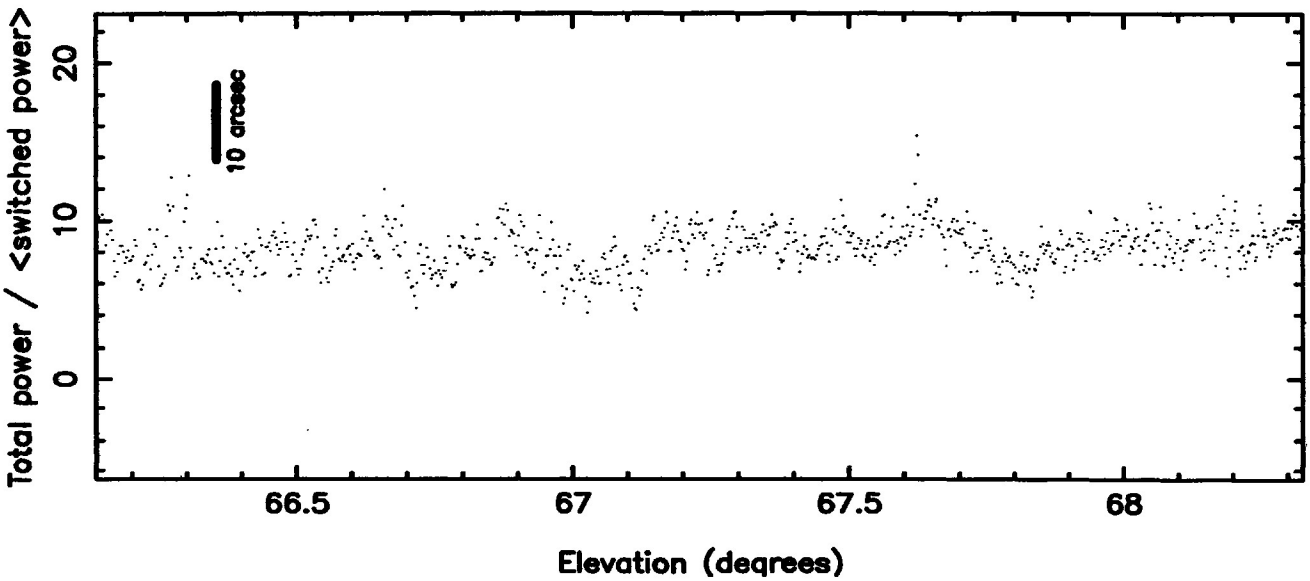
2001 May 11 PN3DB Test at HN on CEPA 22287. MHz



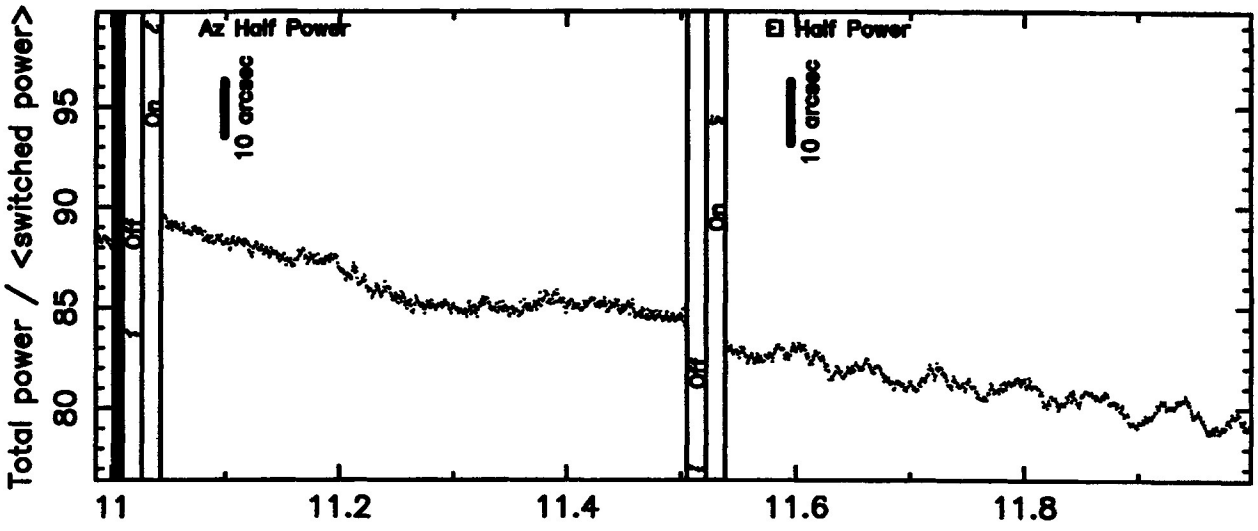
On − Off Line Frequency Difference Data vs Azimuth



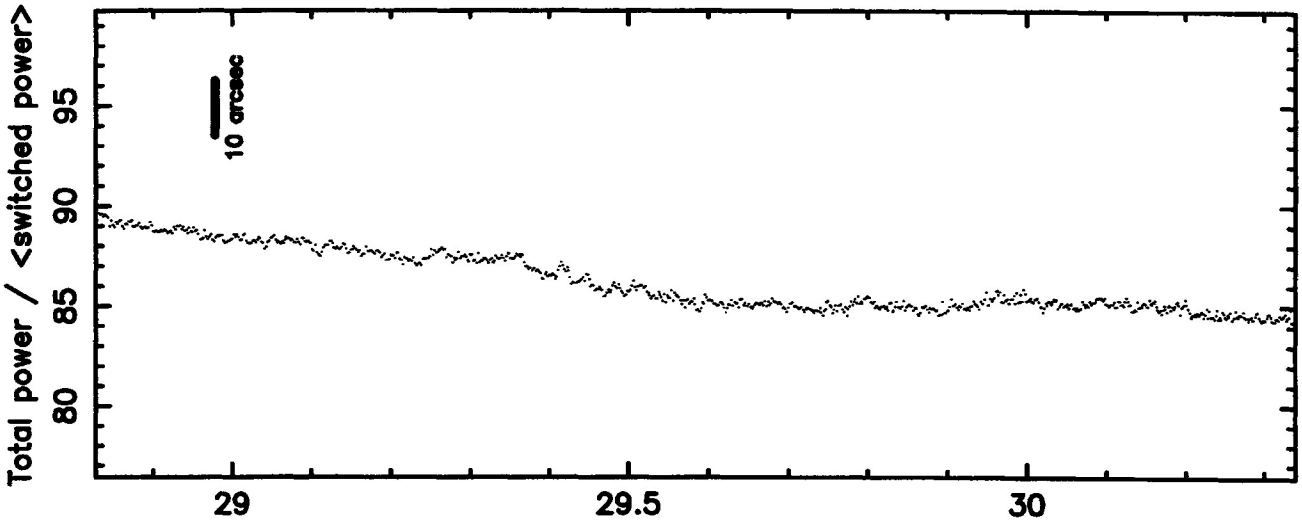
On − Off Line Frequency Difference Data vs Elevation



2001 May 11 PN3DB Test at FD on W3OH 22239. MHz



Total / Switched Power Ratio vs Azimuth



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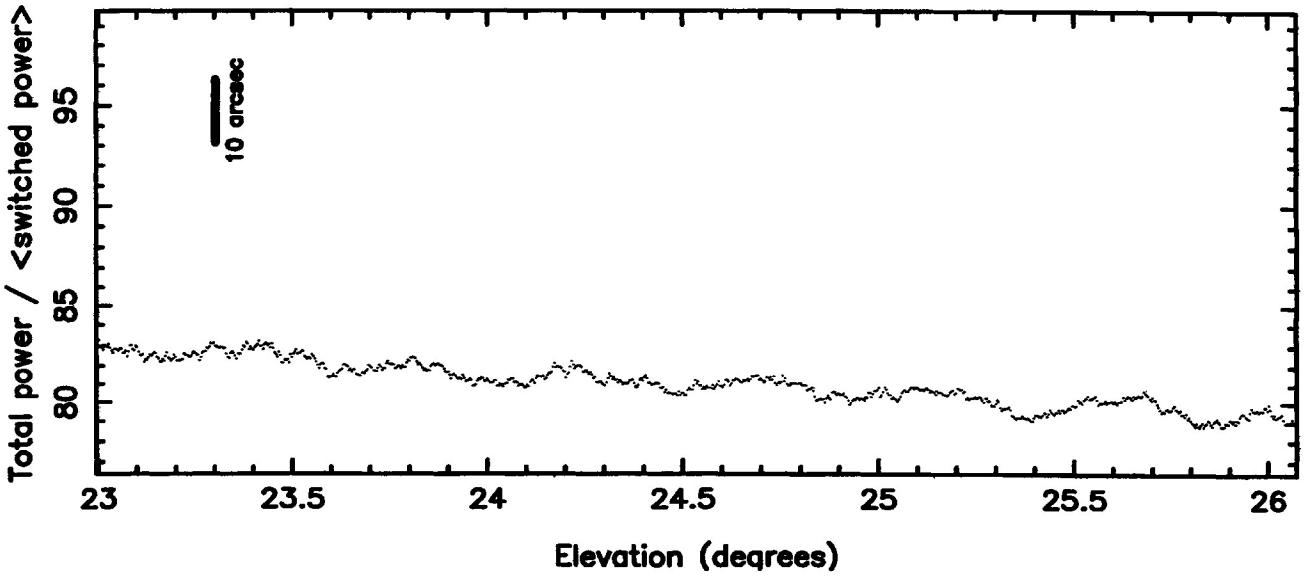
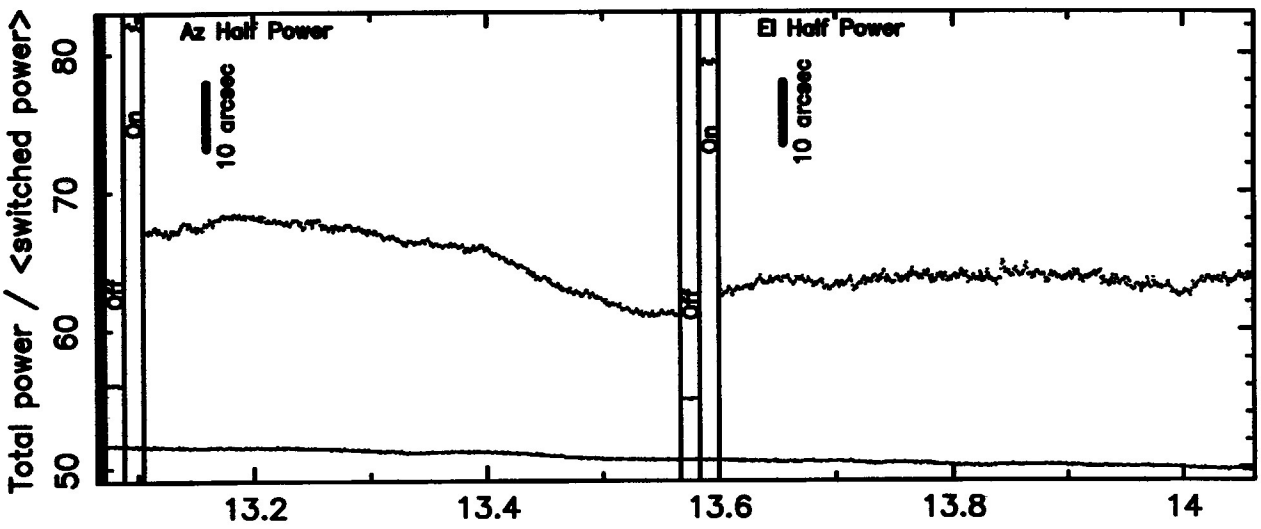
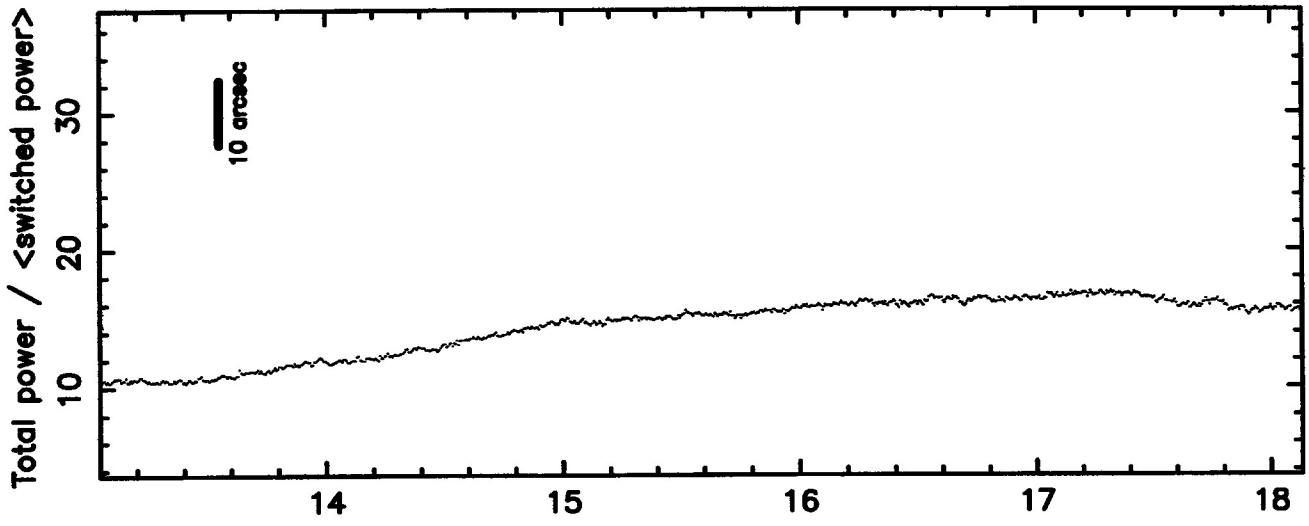


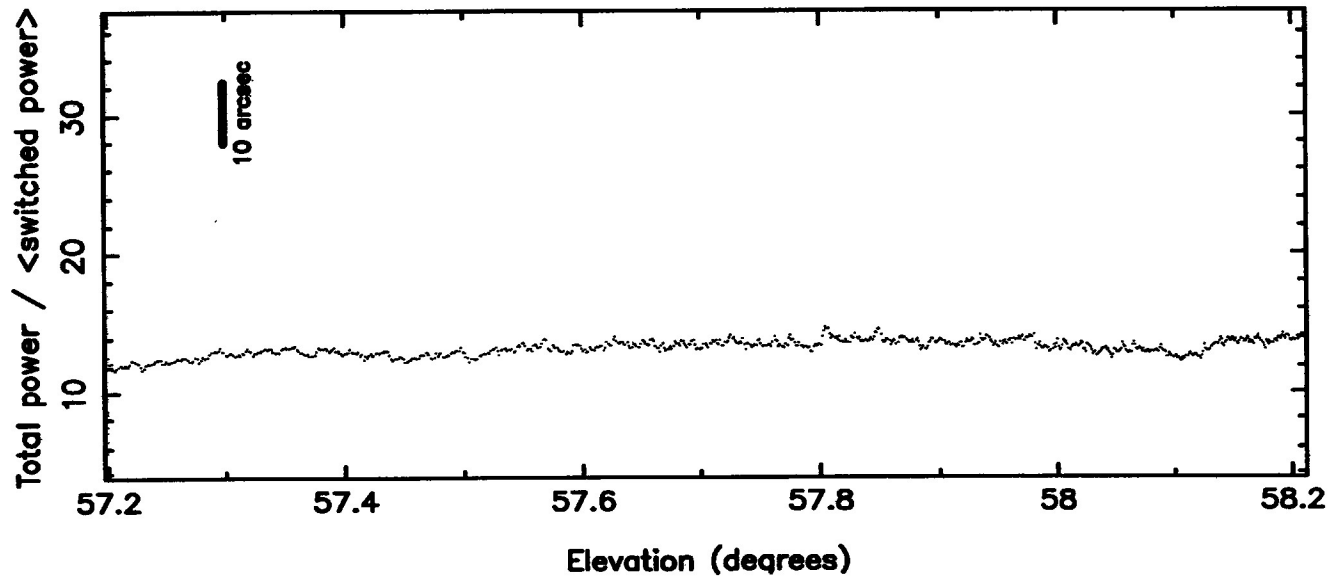
2001 May 11 PN3DB Test at FD on CEPA 22287. MHz



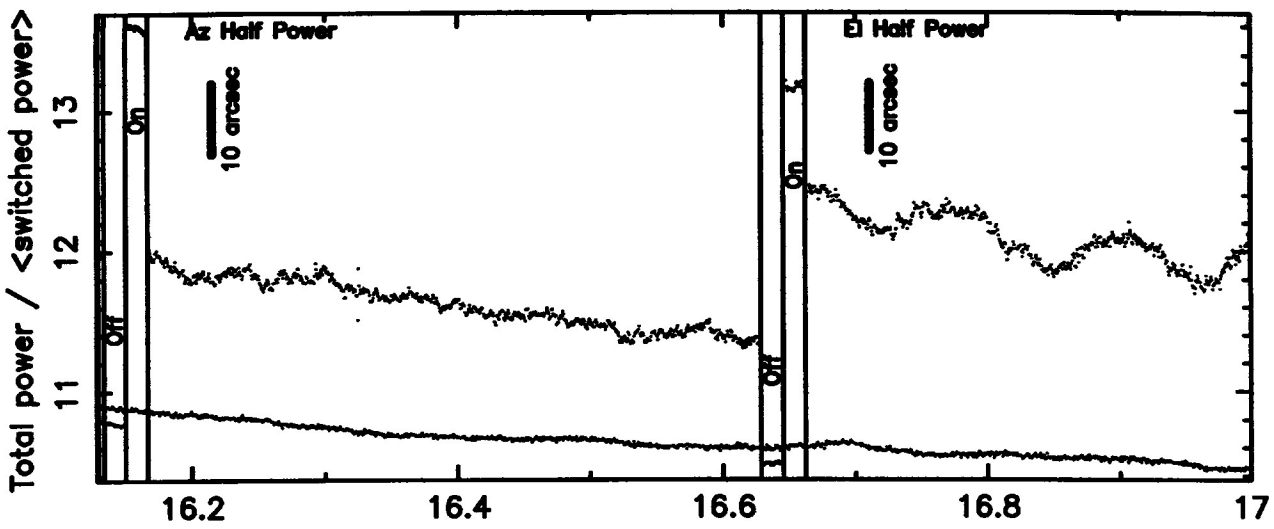
On – Off Line Frequency Difference Data vs Azimuth



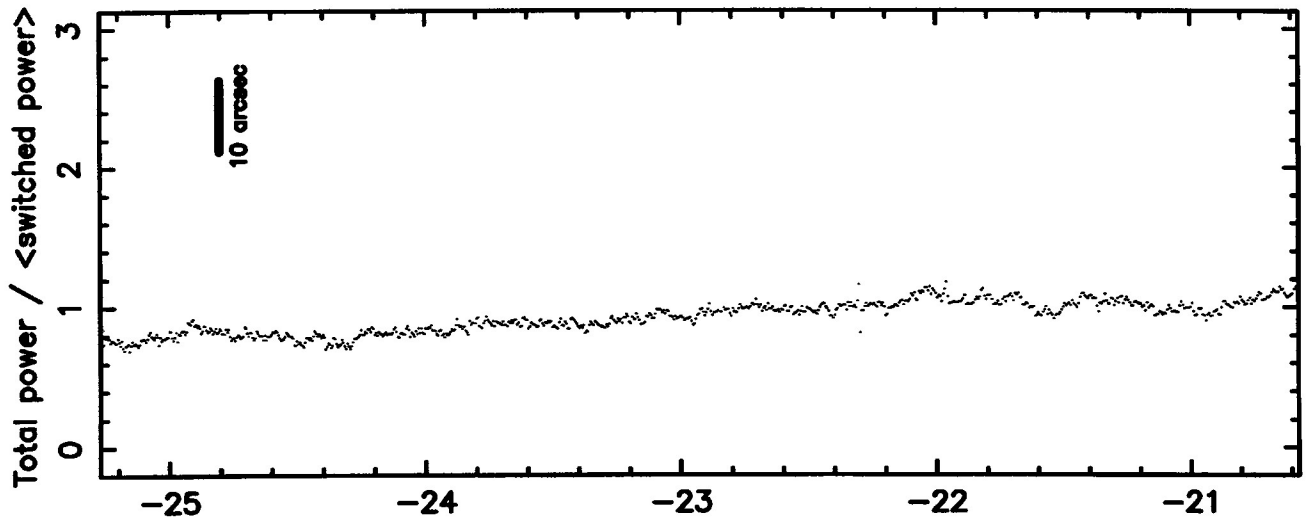
On – Off Line Frequency Difference Data vs Elevation



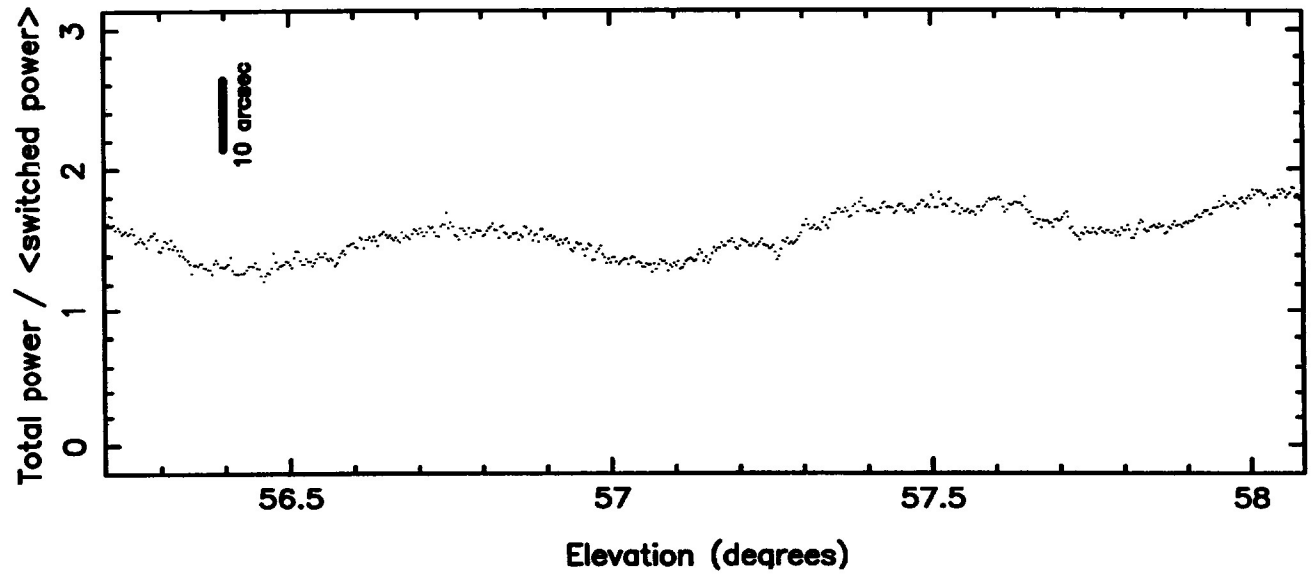
2001 May 11 PN3DB Test at LA on CEPA 22287. MHz



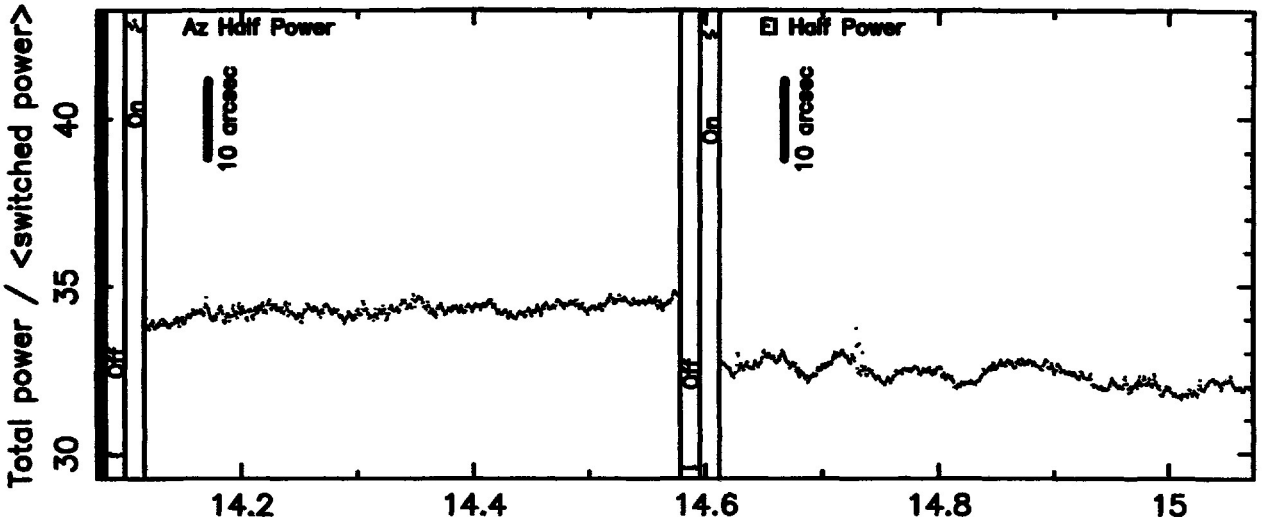
On – Off Line Frequency Difference Data vs Azimuth



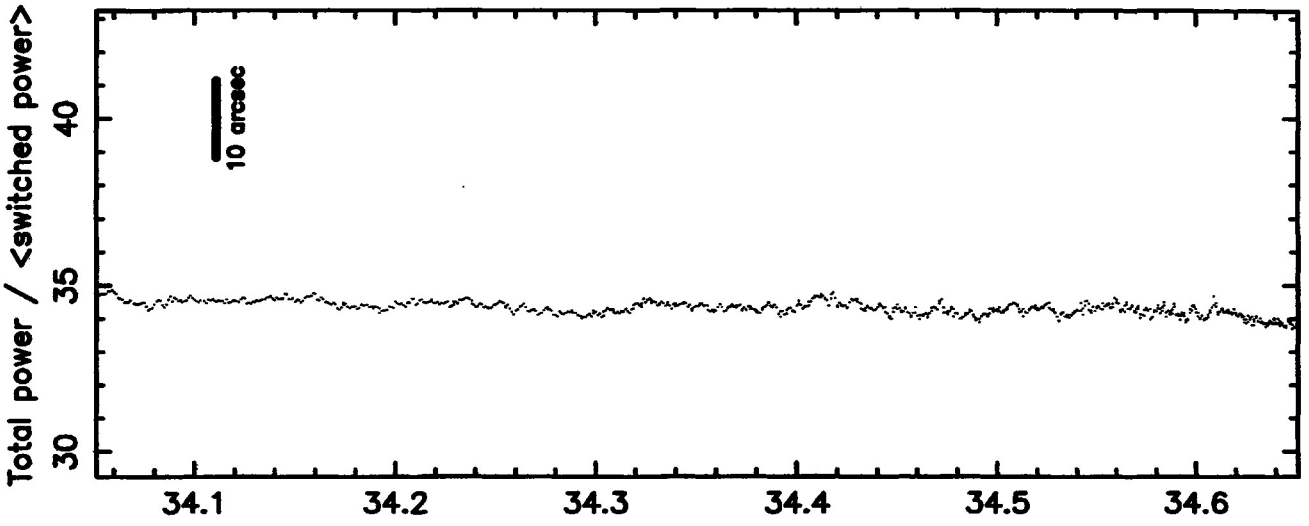
On – Off Line Frequency Difference Data vs Elevation



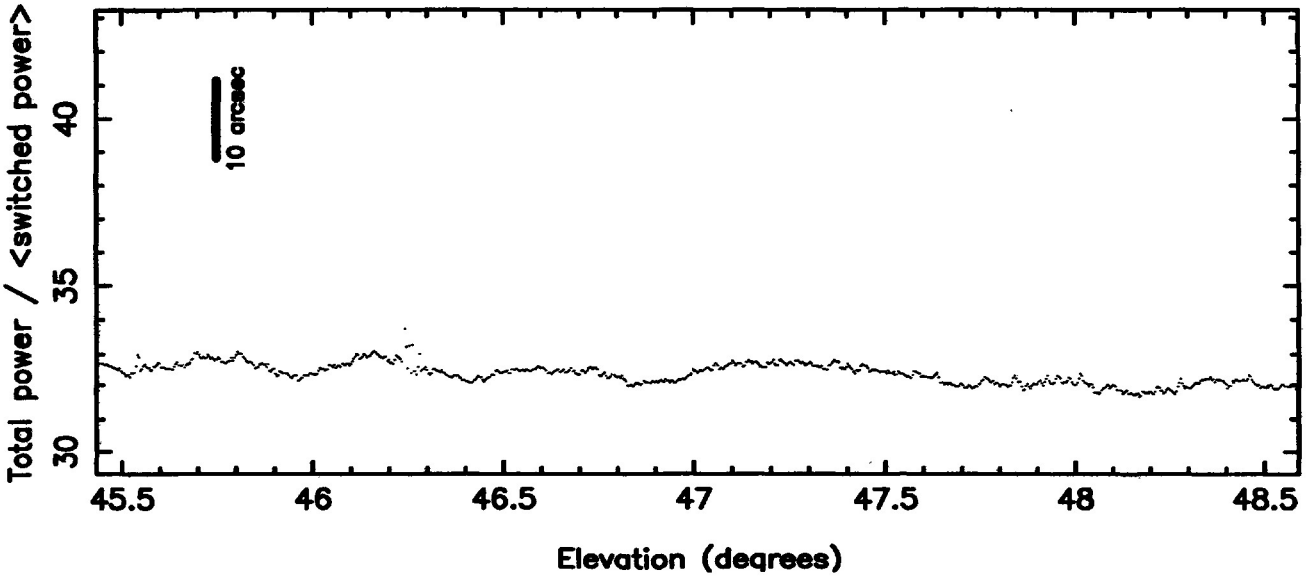
2001 May 11 PN3DB Test at PT on W3OH 22239. MHz



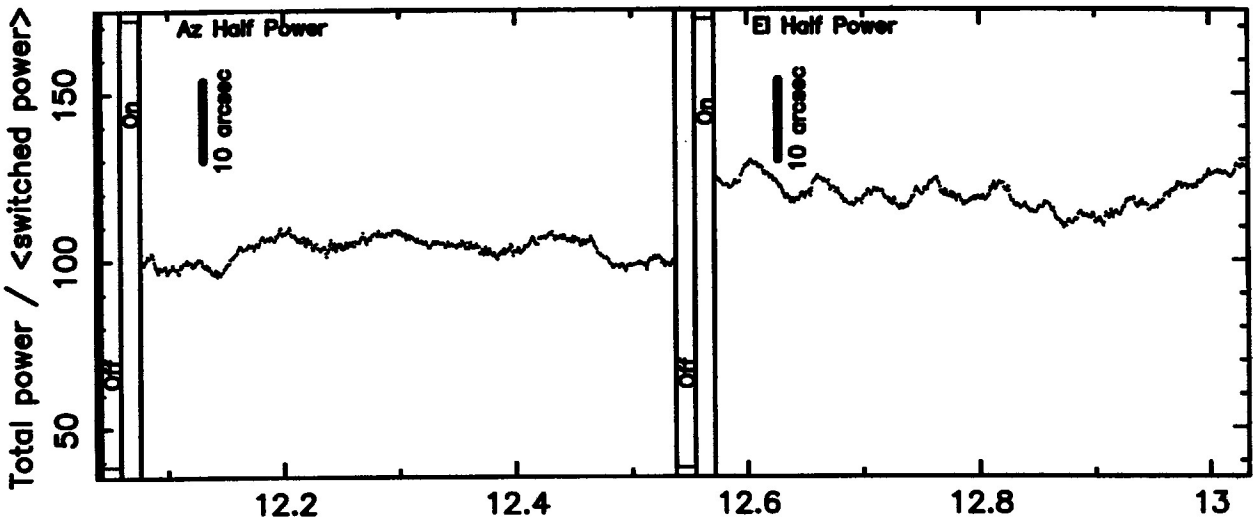
Total / Switched Power Ratio vs Azimuth



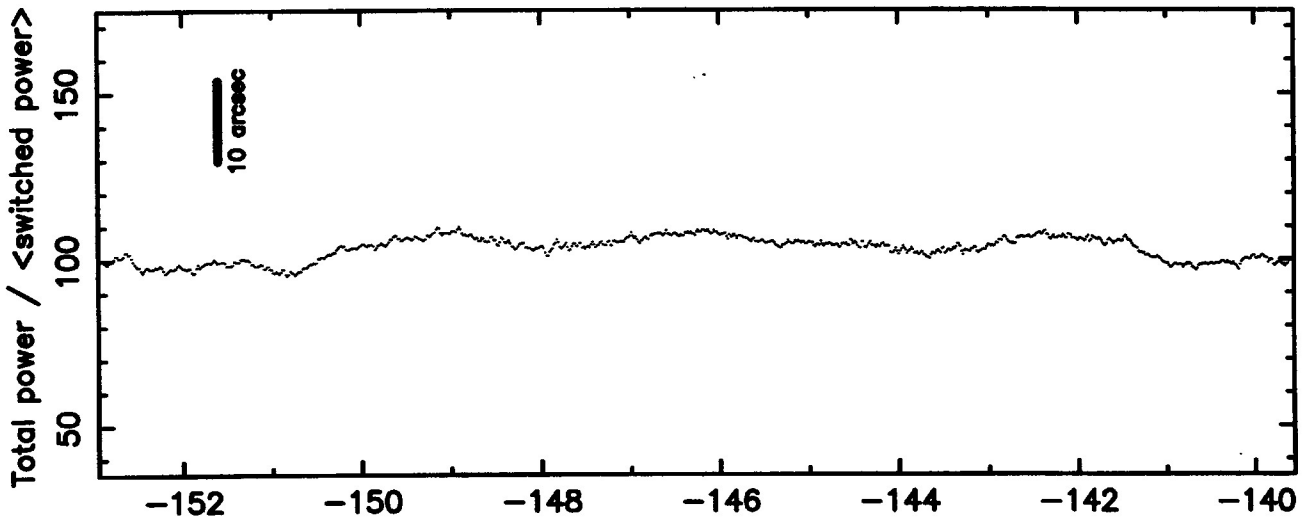
Total / Switched Power Ratio vs Elevation



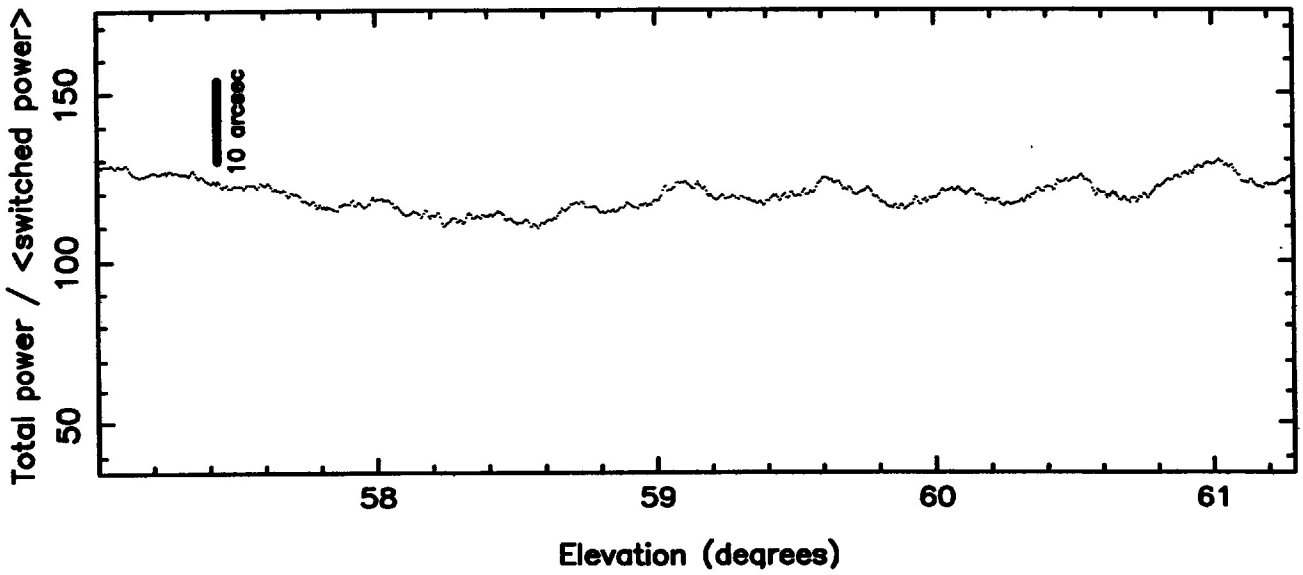
2001 May 11 PN3DB Test at KP on W49N 22237. MHz



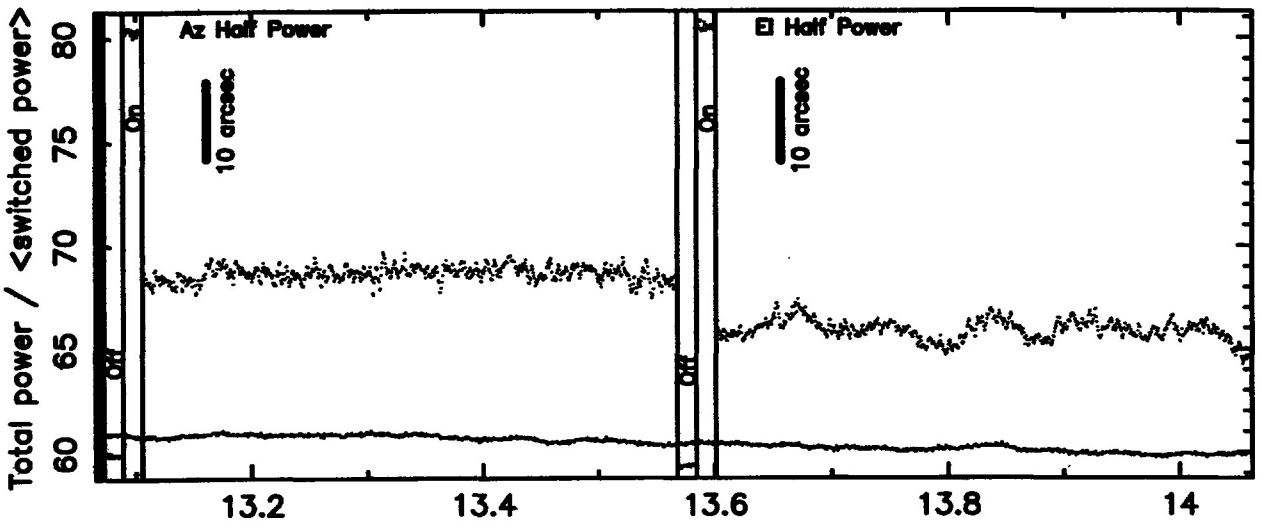
Total / Switched Power Ratio vs Azimuth



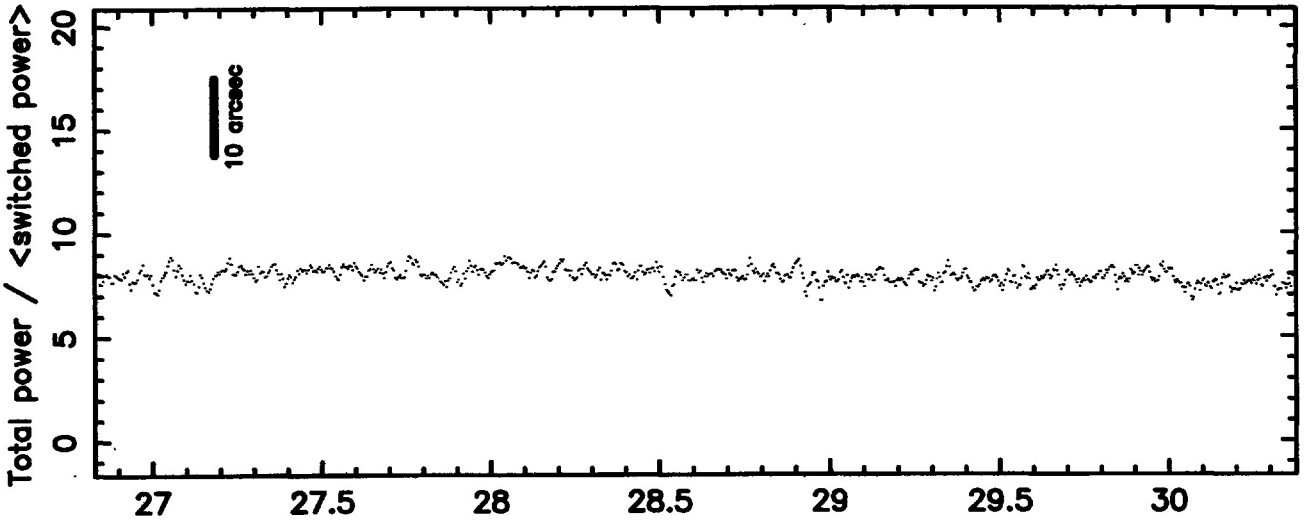
Total / Switched Power Ratio vs Elevation



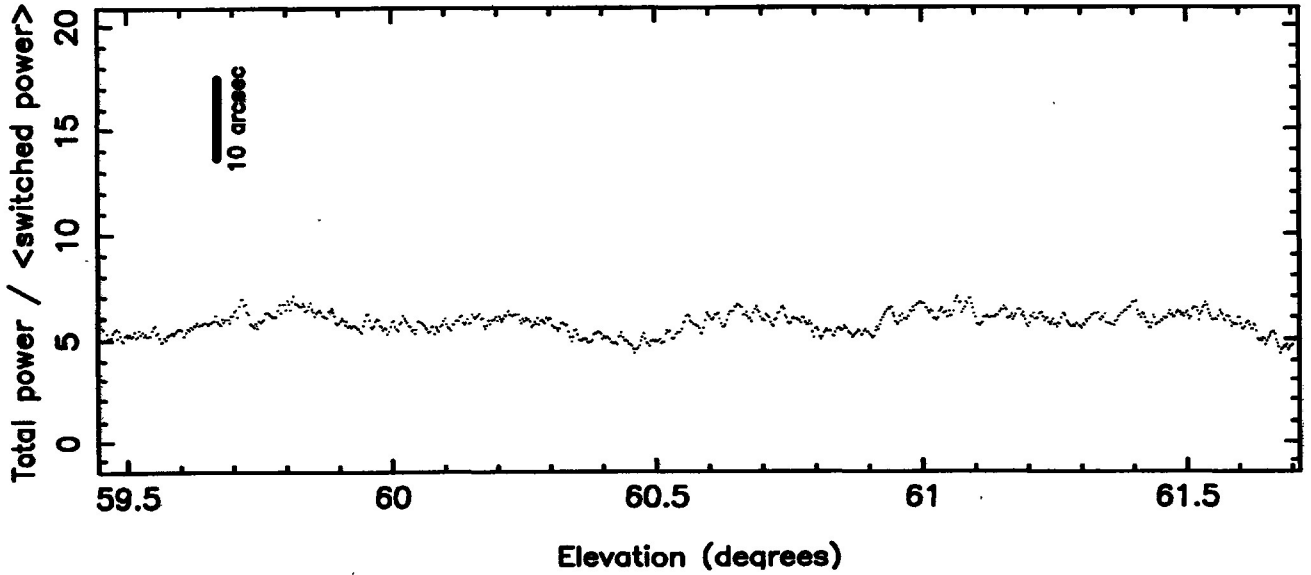
2001 May 11 PN3DB Test at OV on CEPA 22287. MHz



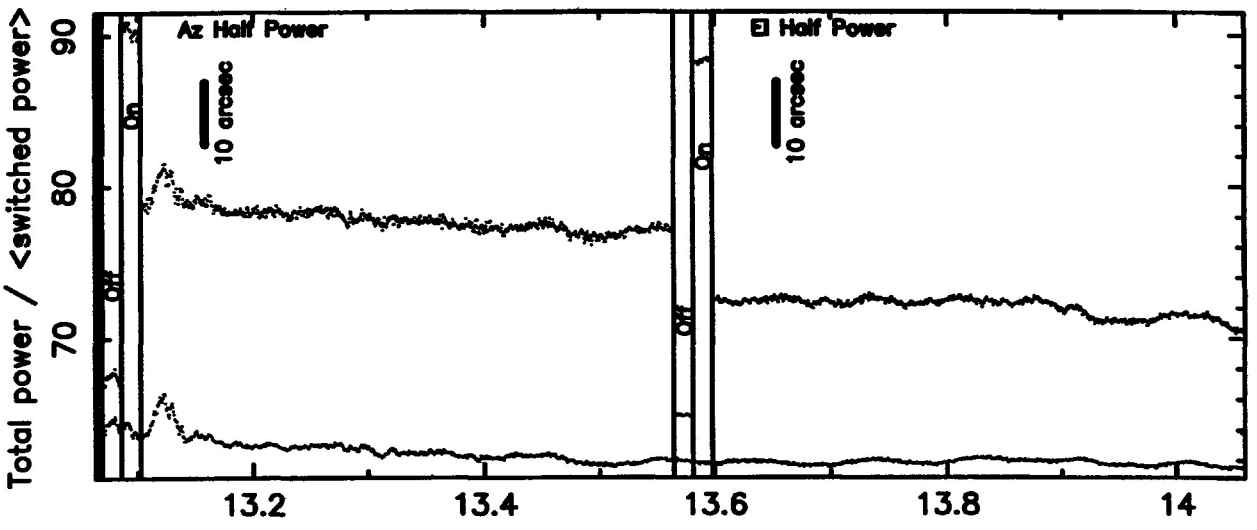
On – Off Line Frequency Difference Data vs Azimuth



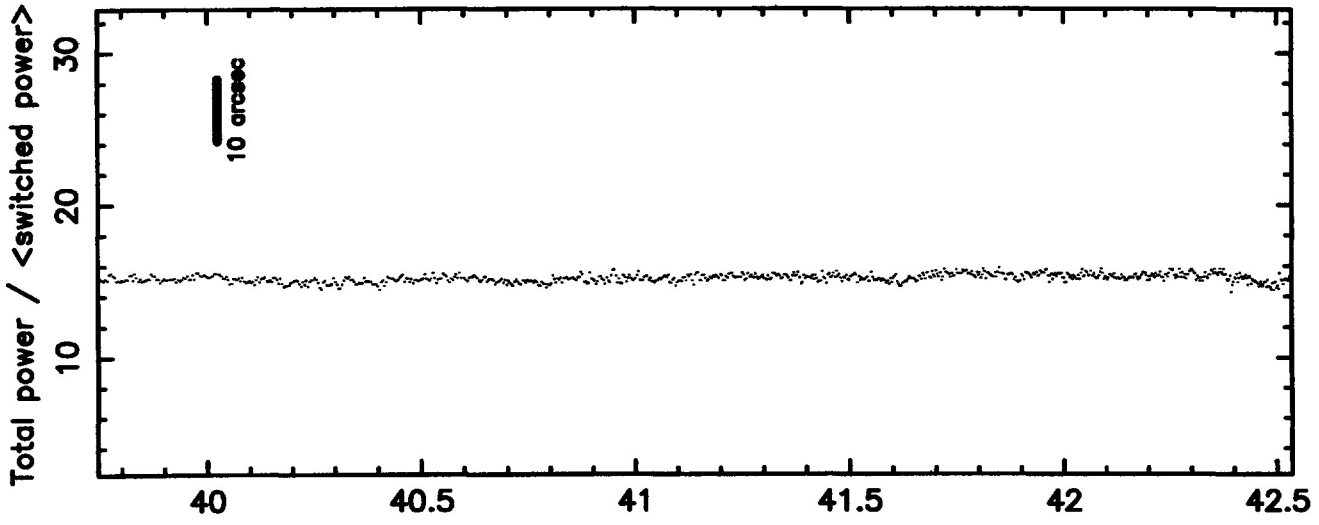
On – Off Line Frequency Difference Data vs Elevation



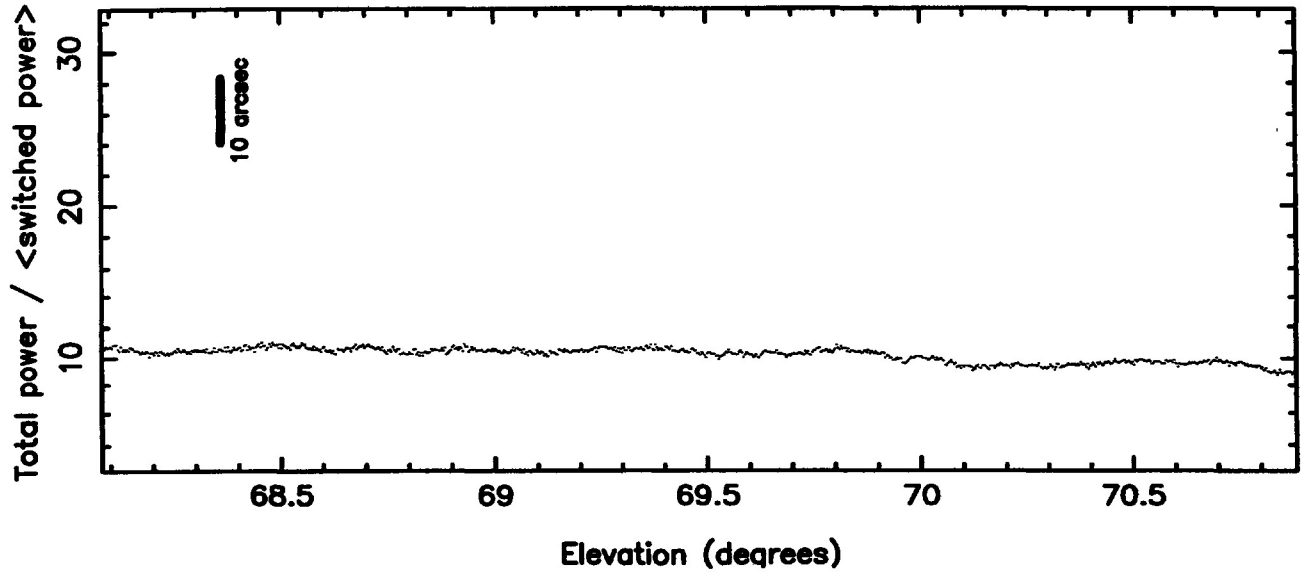
2001 May 11 PN3DB Test at BR on CEPA 22287. MHz



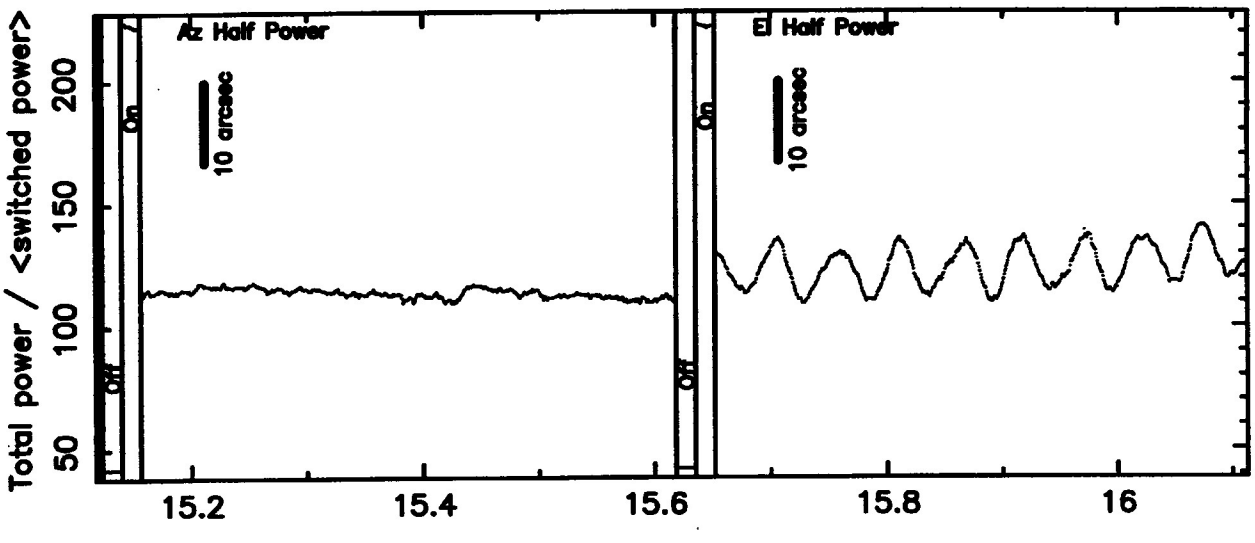
On – Off Line Frequency Difference Data vs Azimuth



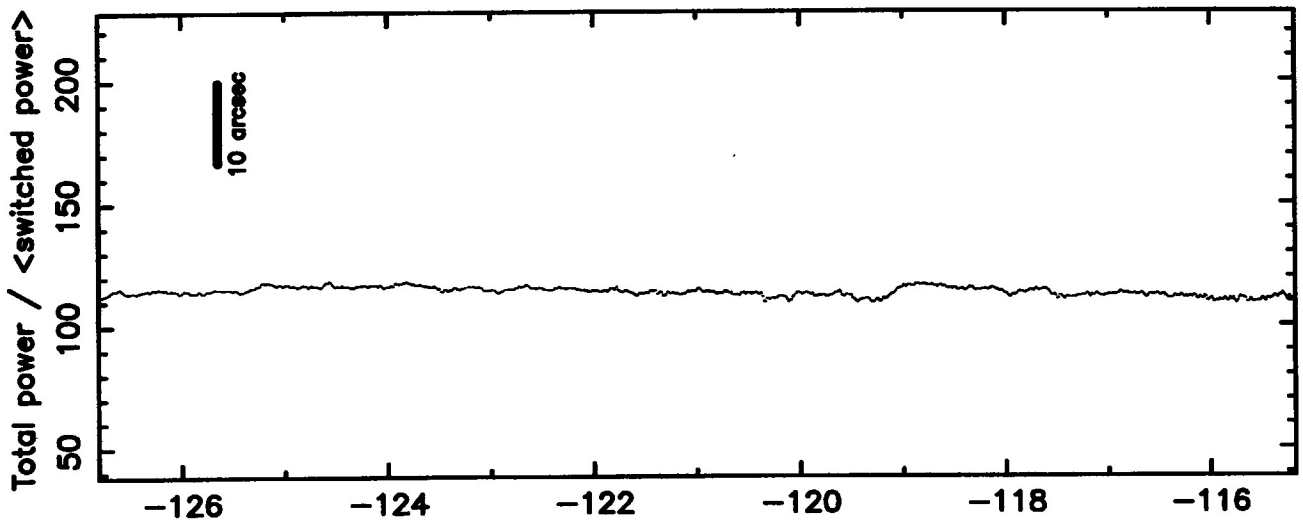
On – Off Line Frequency Difference Data vs Elevation



2001 May 11 PN3DB Test at MK on W49N 22237. MHz



Total / Switched Power Ratio vs Azimuth



Total / Switched Power Ratio vs Elevation