GBT PF 800 MHz: Pointing

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Abstract

Initial commissioning observations to determine the prime focus 800 MHz pointing are discussed. Using estimates for two of the pointing coefficients, corresponding to the local pointing corrections, typically produces a pointing accuracy of $\pm 4'$. The pointing typically varies by $\sim 0\mathrm{'}\!.15$ per degree in elevation with an rms value of $\sim 8''$. The pointing is not very sensitive to changes in the PF axes Focus and Polar. As expected the pointing does change significantly when the X focus is varied. A complete traditional pointing model will be determined later at a higher frequency and tested at PF 800 MHz.

1 Introduction

Pointing involves changing the telescope optics such that the telescope's beam is located at a specified position on the sky, while focus tracking keeps the feed at the prime focus (PF) to optimize gain. From a control standpoint pointing is altered by moving the primary reflector (Az, El) while focus tracking involves changing the PF axes (Focus, Polar, X)[1]. In practice these two operations—pointing and focus tracking—are coupled. That is, by changing the focus the beam on the sky may also change without moving the primary reflector.

The strategy that has been adopted is to first determine the optimal focus as a function of telescope position. Then to use this information to keep the feed at the prime focus while performing an all sky pointing survey to determine a traditional pointing model. Because a more accurate traditional pointing model can be determined at higher frequencies only a limited pointing survey was initially planned.

Three major problems have delayed the observations required to calculate some of the pointing coefficients: radio frequency interference, servo trajectory errors, and the inability of the data reduction software to provide feedback fast enough to the M&C system. Recently each of these problems have been either solved or improved. We have since moved to S Band observations with the Gregorian focus. Nonetheless several important results have been made with these initial observations.

[1]Focus is the axial focus, Polar is the polar focus, and X is the lateral focus.

2 Observations

The observations were taken between 05–23 February 2001. The center frequency was set at 790 MHz with a bandwidth of 20 MHz. The half-power beam-width is $\sim 16'$ at 790 MHz. The DCR was set in 2 phase mode (CAL ON/CAL OFF) with a switch period of 1 second and an integration time of 1 second.

Initial estimates of the optimal focus position were provided from the theoretical design. The Polar direction should be independent of focus and pointing and was typically set at $0\,°$. For a symmetrical telescope the Focus direction should not alter the pointing but may be a factor for the offset design of the GBT. The optimal Focus direction was estimated to be 39 inches. The X direction is expected to significantly change the pointing and to be a function of elevation.

Metrology measurements indicated that there was an azimuth encoder offset of $8'55''$. This large offset was presumably the result of a surveying error by the contractor.

Initial astronomical observations attempted to optimize the focus by changing each focus axis independently in discrete steps and then perform a cross scan to check the pointing. Because of RFI, servo trajectory errors, and the inability to quickly reduce the data the source elevation changed significantly during these measurements.

3 Results

3.1 Focus

Details of the focus measurements are discussed in another report. Here we only discuss how the focus measurements affected pointing. Initial measurements estimated that the optimal focus positions were approximately Focus = 39 inches, Polar = $0\,°$, and X = 22 inches and that these numbers were not a strong function of source position (Az, El). Therefore these values were used as defaults.

The Focus direction was varied from 10 to 40 inches by increments of 10 inches. After each focus change a cross scan was made and the local pointing corrections (LPCs) measured but not updated. This was performed for three different elevations ($\sim 70\,°$, $40\,°$, and $20\,°$). In each case the LPCs in both Az and El changed by $\lesssim 0\rlap{.}'5$, consistent with the normal drift observed in pointing with time (see §3.2).

The Polar direction was varied from –90 to $90\,°$ by increments of $45\,°$ for both linear and circular polarization. Again the LPCs only changed by $\lesssim 0\rlap{.}'5$. The LPCs were identical within the uncertainty for each of the linear polarizations. Beam squint was observed at circular polarization, primarily in the ΔAz2 LPC with a magnitude of $\sim 2\rlap{.}'3$.[2]

The X direction was varied from 5 to 35 inches by increments of 5 inches. After each Az scan

[2]The linear/circular polarization switch was reversed in the PF 800 MHz receiver.

the LPCs were updated in this case. The pointing was significantly altered in elevation, as expected, where the LPCs changed by $\sim 35'$.

3.2 Pointing

Although an all sky pointing run was not made it was determined that nominal LPCs of (ΔAz2 = $5'.6$, ΔEl = $4'.8$)[3] were sufficient to provide an accuracy in pointing to $\pm 4'$. Figure 1 shows how the pointing varies with elevation using these constant LPCs. The measured pointing offsets vary smoothly with elevation and are well modeled by a linear fit over 10° in elevation. Note, however, that there appear to be small amplitude sinusoidal variations in the data. The rms to the linear fit is $8''$.

The pointing repeatability was also checked with respect to the PF boom. A series of cross scans were made before and after the PF boom was retracted and then extended. Figure 2 plots the LPCs as a function of elevation. Between each cross scan the PF boom was retracted and extended. Although in theory the PF boom can be moved while at any elevation, for these observations the operator had to move to access position to move the PF boom. Therefore the elevation varied between 35–75° during these measurements. Hence the LPCs changed significantly, although the variations are approximately consistent with the normal observed drift discussed above.

4 Conclusion

The initial commissioning observations to determine the PF 800 MHz pointing model involved first understanding the focus. After nominal values were determined for the three focus axes (Focus, Polar, and X), the pointing was investigated.

Using local pointing corrections (ΔAz2 = $5'.6$, ΔEl = $4'.8$) the pointing was accurate to $\pm 4'$. The pointing typically varies by $\sim 0'.15$ per degree in elevation with an rms value of $8''$. The pointing did not significantly vary with changes in the Focus and Polar PF axes. There were large changes in pointing when the X focus was varied, as expected. Retracting and then extending the PF boom did not have any significant effect on the pointing.

[3] ΔAz2 corresponds to $d^{el}_{0,0}$ and ΔEl to $d^{az}_{0,0}$ in the traditional pointing model.

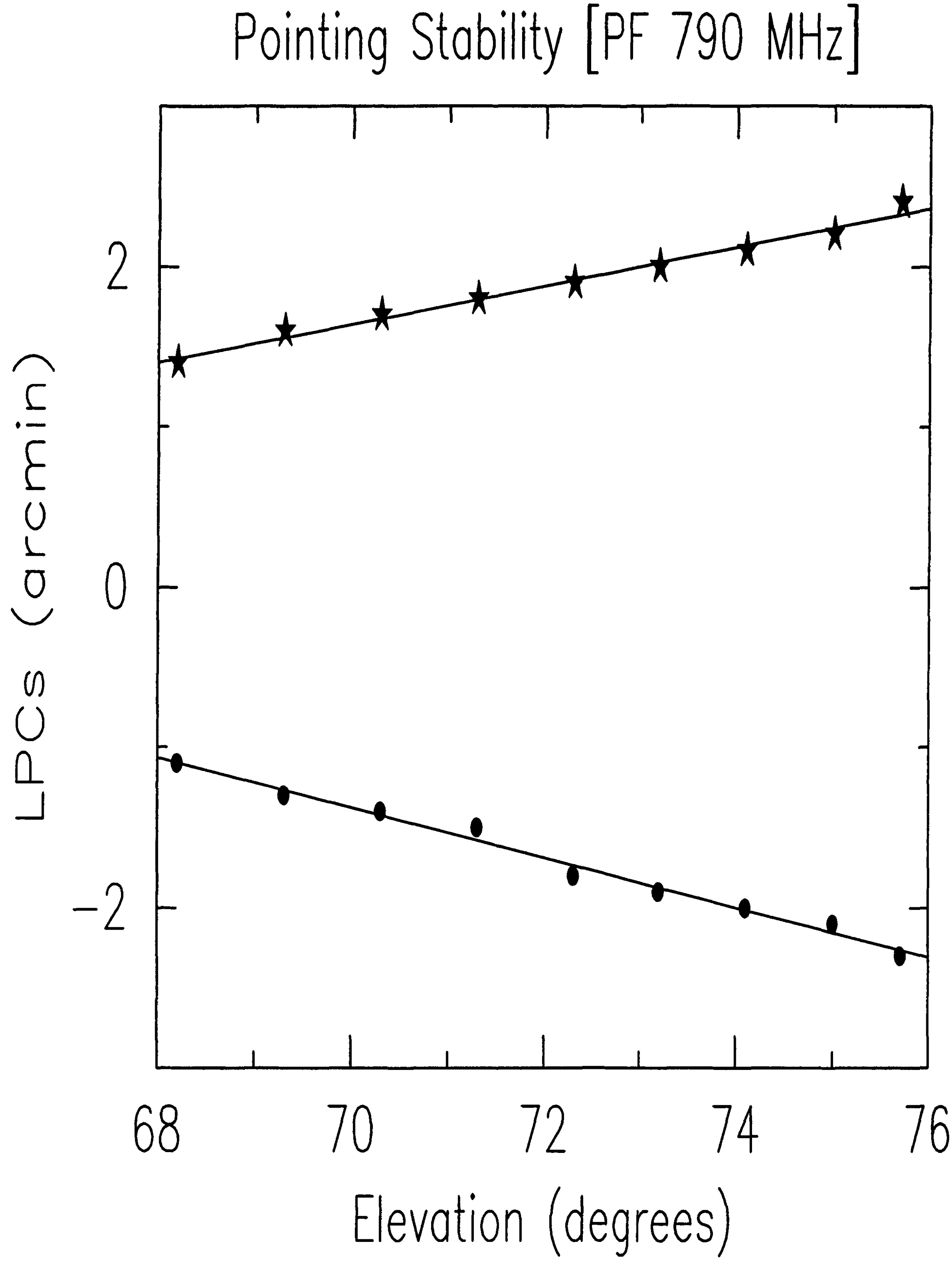

Figure 1: The local pointing corrections (LPCs) are determined from cross scans made on 3C147 as a function of elevation. The nominal LPCs (ΔAz2 = 5$'$.6, ΔEl = 4$'$.8) are used and not updated after each cross scan. The filled circles are ΔAz2 and the filled stars ΔEl. A least-squares linear fit is made to each LPC. ΔAz2 is changing 0$'$.15 per degree in elevation, while ΔEl is changing 0$'$.12 per degree in elevation. The fits is good to within $\sim$ 5%.

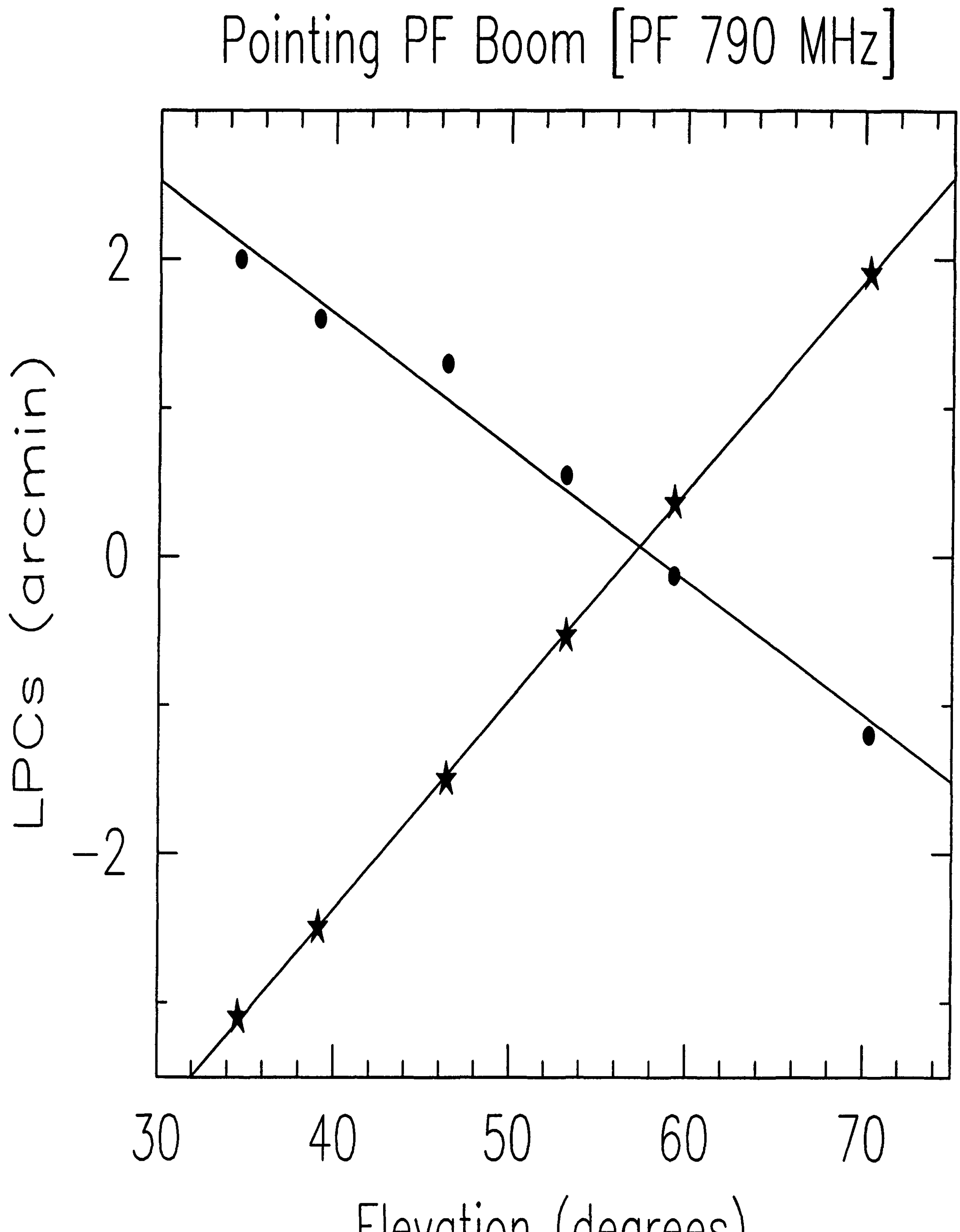

Figure 2: The local pointing corrections (LPCs) are determined from cross scans made on 3C147 as a function of elevation. Between each measurement the PF boom was retracted and then extended. The filled circles are ΔAz2 and the filled stars ΔEl. A least-squares linear fit is made to each LPC. ΔAz2 is changing 0.′09 per degree in elevation, while ΔEl is changing 0.′14 per degree in elevation.