VLBA TEST MEMO 76

Rail Determination from Pointing Measurements at BR

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The VLBA antennas have wheel-and-track mounts. The four wheels are mounted to the telescope base in an approximately square configuration. The track is nearly, but not quite planar. The track non-planarity influences the telescope pointing. This effect may be represented by two terms. In the first term, the four wheel attachment points remain in a plane, and the telescope is tipped fore-and-aft and side-to-side by track variations. The fore-and-aft motion is reflected in the elevation pointing, and the side-to-side motion is reflected in the azimuth pointing. The second term represents the distortion of this plane, hereafter referred to as "racking". This may be represented as the lines connecting diagonally opposite wheel attachment points do not intersect and the base square is distorted out of a plane. This distortion can be represented as a twist of the upper structure relative to the base such that the elevation axis rotates in an approximately horizontal plane. This term therefore affects only azimuth pointing.

Elevation pointing is thus affected only by the fore-and-aft tilt of the first term. We further note that this effect should be antisymmetric. That is, if you have rail irregularities that cause the telescope to tip up, and rotate the telescope by 180 degrees, with the front wheels in the position originally occupied by the back wheel and vice versa, the telescope should tilt down by the same amount. (This assumes that the flexure of the track is not a function of azimuth,) Therefore, one need only measure pointing over half a turn of azimuth to completely determine this term. Such a measurement was made on October 27, 2022. The source 1030+41.5 was tracked for seven and a half hours, doing pointing continuously. At the Brewster VLBA station, this resulted in a change of azimuth by more than 180 degrees, half a turn. To avoid confusion with the old rail heights measured by theodolite, those corrections were turned off.

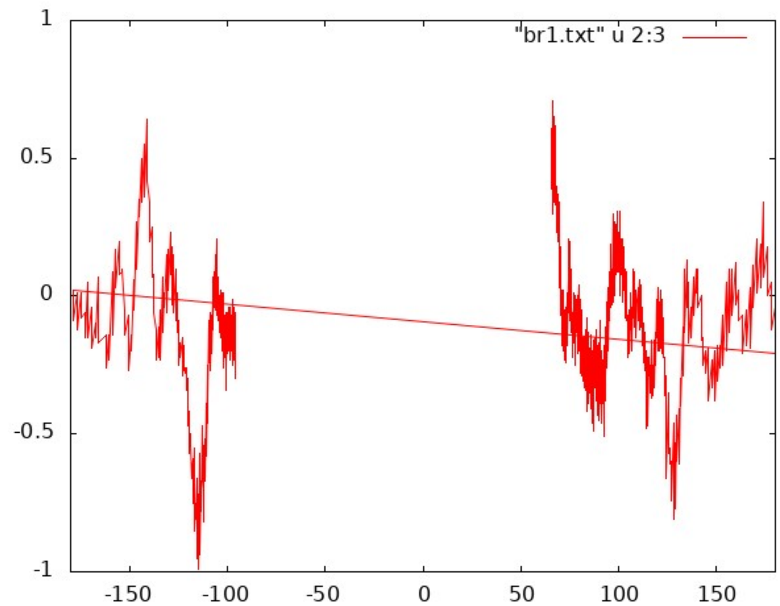

Figure 1. The raw elevation pointing measurements.

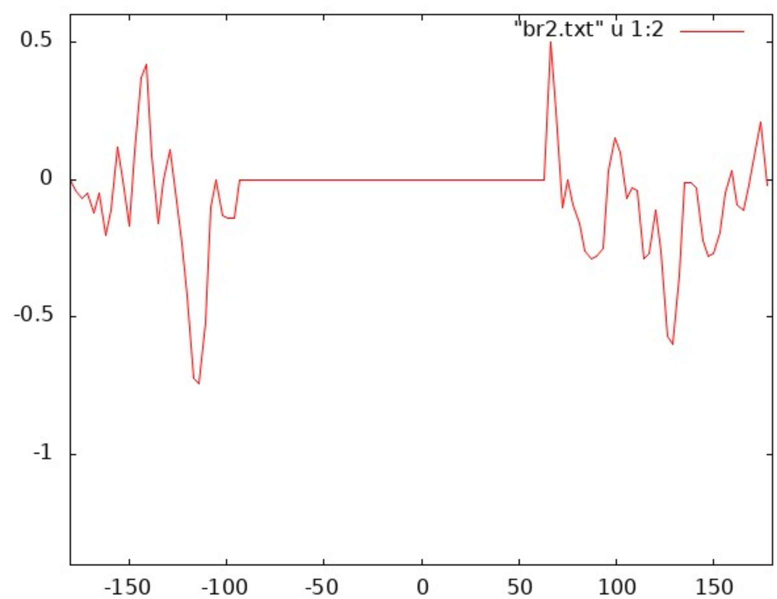

Figure 2. Elevation errors averaged into three degree bins.

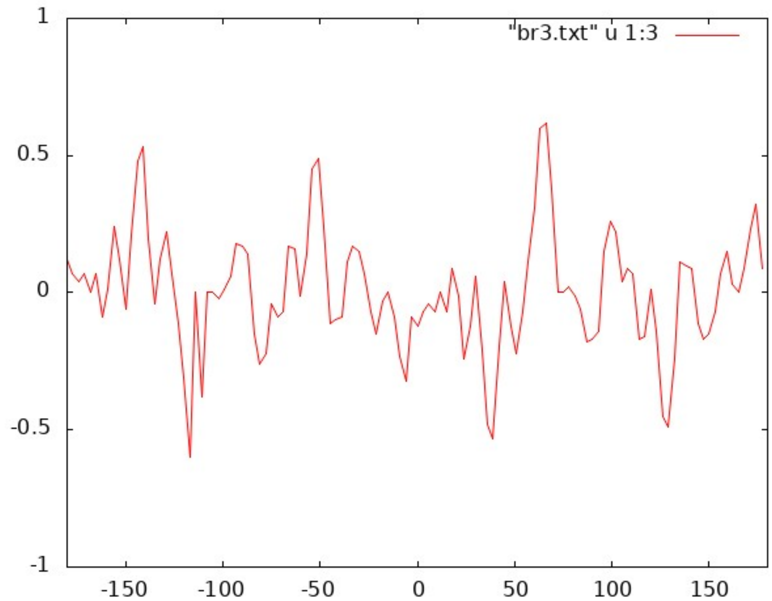

Figure 3. The measurements in figure two did not exactly show antisymmetry in their region of overlap, around -75 degrees and +105 degrees. Adding a small collimation offset of 0.12 arcminutes makes the antisymmetry better. Figure 3 employs the antisymmetry to show the elevation correction for all azimuths.

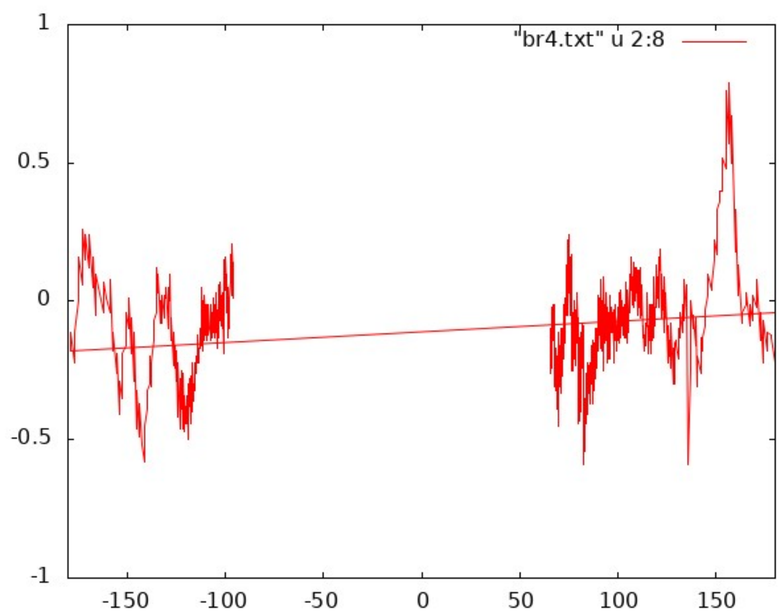

Figure 4. The raw azimuth pointing errors as a function of azimuth

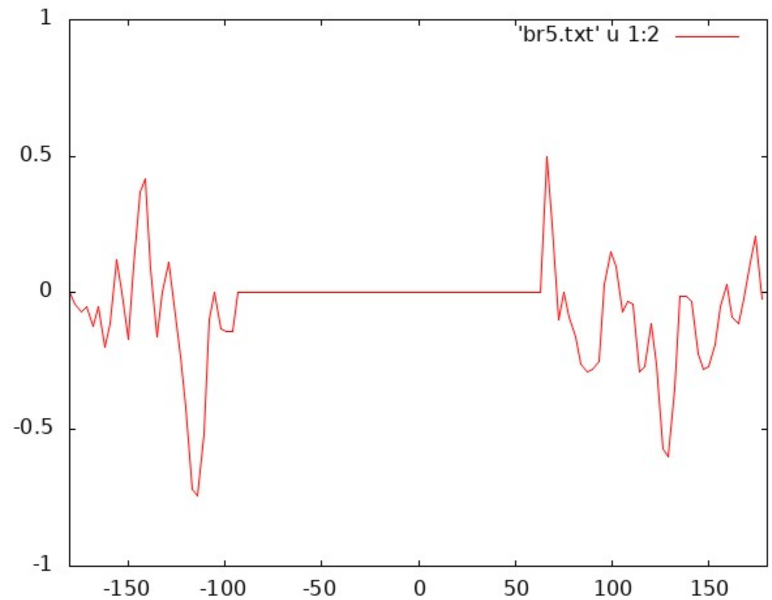

Figure 5. Azimuth pointing errors are the sum of the two types. We may assume the rigid base effect contribution is from the tilt left-right, which is the fore-and-aft tilt from ninety degrees away. This tilt has no effect on azimuth pointing when the telescope is pointed at the horizon (it is a rotation around the beam), and varies with elevation as the sine of elevation. The rack correction varies as cosine of elevation. Dividing the measured pointing errors by cosine elevation has the unfortunate result of increasing errors where the elevation is high, near the meridian. The above is the azimuth pointing errors corrected for the base tilt, divided by cosine elevation, and binned into three degree bins in azimuth.

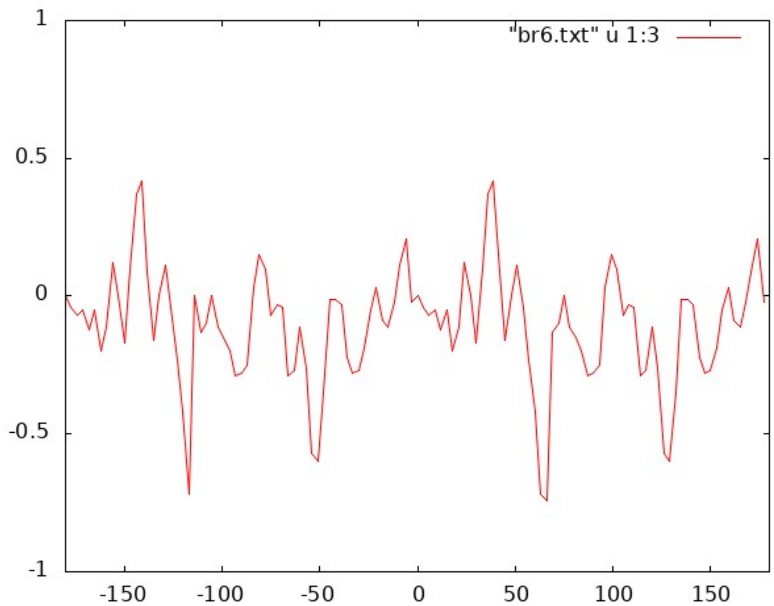

Figure 6. The rack correction is symmetric as a function of azimuth. The even symmetry is applied to the data of figure 5 to display the total rack correction. The azimuth measurements were closely the same in the overlap region, so no correction analogous to the collimation error used to make figure 3 was needed. If one had been needed it could have taken the form of an east-west tilt term.