Blind Pointing Model Development and the Alignment of Feeds in a BWG Antenna

Paul Richter, Section 331

August 2, 2001

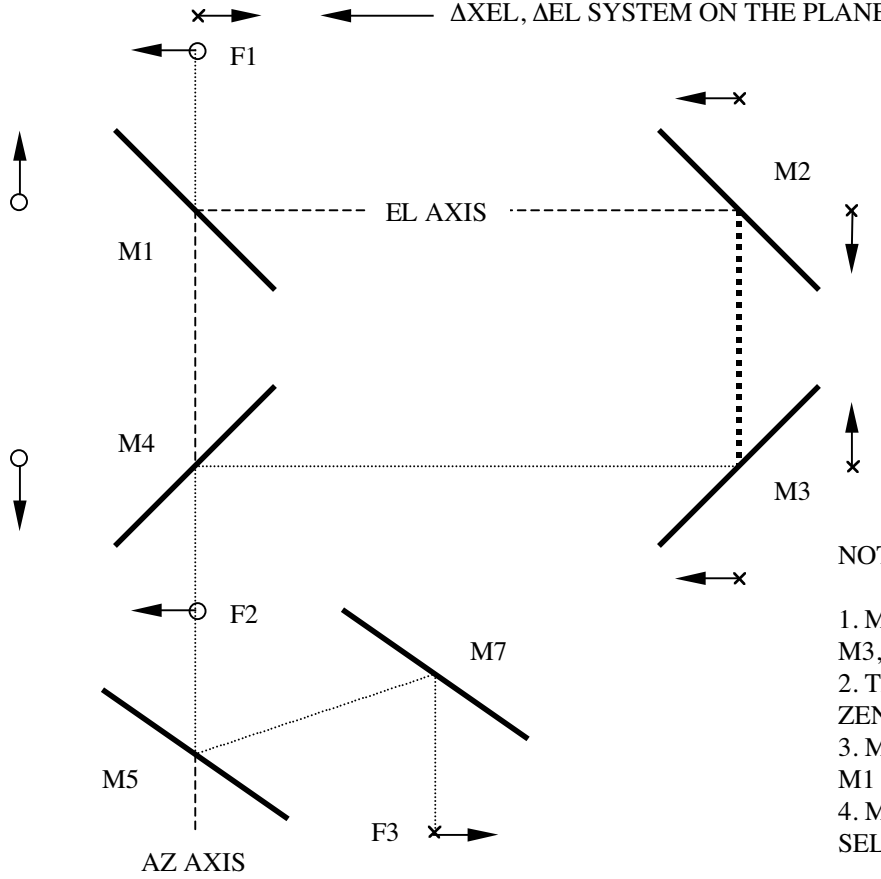
Feed Alignment Errors and Pointing Models

- A systematic method of properly aligning a feed at an F3 focus is presented
- If a feed is properly aligned, the pointing model for that feed is the same as that for any other properly aligned feed
- Thus, only a single pointing model is required for all feeds in the pedestal room, irrespective of location or operating frequency, if alignment is done properly

Rotation of the ΔXEL, Δ EL Coordinate System at F3

- The orientation of the **Δ**XEL, **Δ** EL coordinate system at F3 depends on the location of the feed and the AZ and EL of the source

The Geometry - Elevation View of BWG Antenna for AZ=0, EL≈90, Showing Δ XEL, Δ EL System



× OUT OF THE PAGE

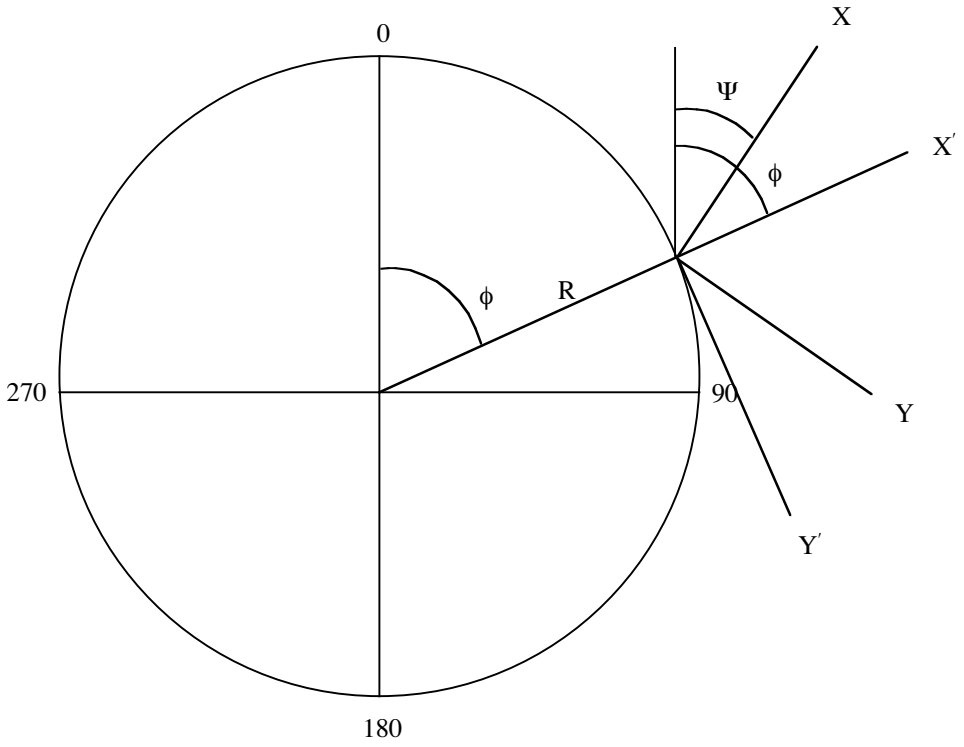
○ INTO THE PAGE

→ ΔXEL AXIS

NOTES:

1. M1, M4, & M7 ARE FLAT MIRRORS, WHILE M2, M3, & M5 ARE ELLIPSOIDAL MIRRORS
2. THE PLANE OF THE FIGURE IS DEFINED BY THE ZENITH DIRECTION AND EAST
3. M1 ROTATES ABOUT THE ELEVATION AXIS, AND M1 - M4 ROTATE ABOUT THE AZIMUTH AXIS
4. M5 ROTATES ABOUT THE AZIMUTH AXIS TO SELECT DIFFERENT FEED POSITIONS ONLY

The Geometry - Plan View of Pedestal Room Floor Showing Δ XEL, Δ EL System

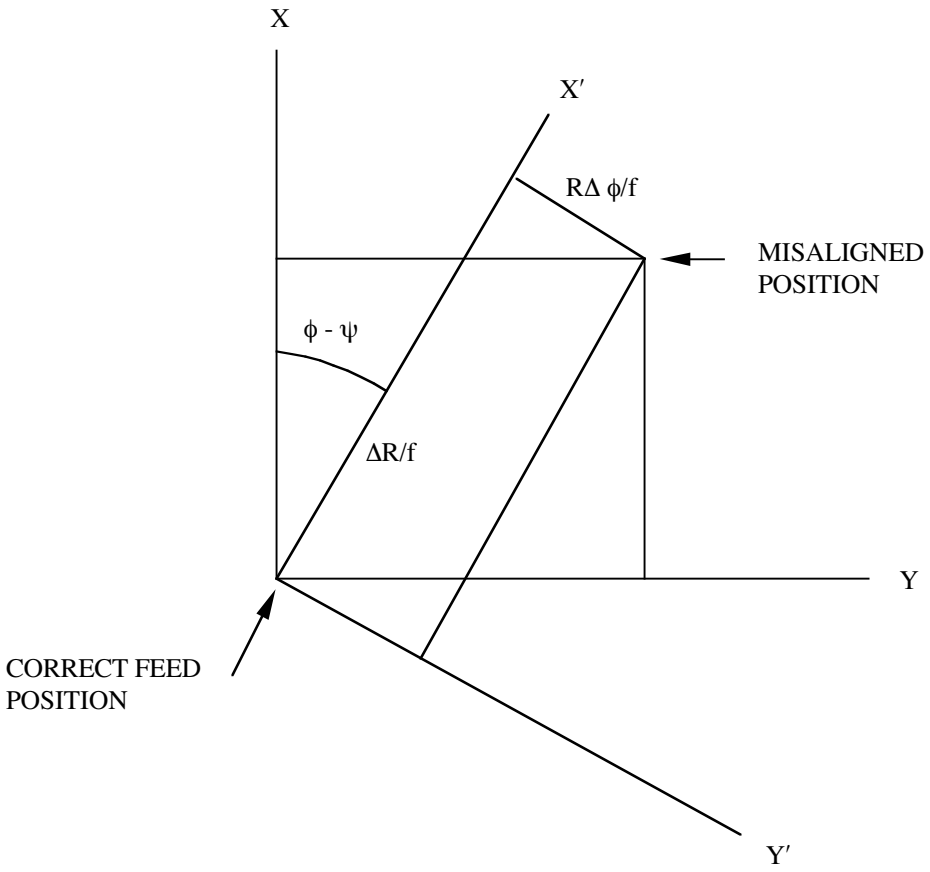


Ψ=EL-AZ

X=ΔXEL

Y=ΔEL

The Geometry - Plan View of Feed Location Showing Relation Between Correct and Misaligned Feed



$\Psi = EL - AZ$

$X = \Delta XEL$

$Y = \Delta EL$

$\theta = \phi + AZ - EL$

f = EFFECTIVE FOCAL LENGTH OF ANTENNA

$\Delta EL = (R\Delta\phi/f)\cos\theta + (\Delta R/f)\sin\theta$

$\Delta XEL = -(R\Delta\phi/f)\sin\theta + (\Delta R/f)\cos\theta$

$$R\Delta\phi/f = \Delta EL\cos\theta - \Delta XEL\sin\theta$$

$$\Delta R/f = \Delta EL\sin\theta + \Delta XEL\cos\theta$$

Effect of Random Pointing Errors

- The pointing error determined from a single boresight measurement is the sum of the error due to the feed misalignment and a random blind pointing error

$$\Delta\mathrm{XEL}_i' = \Delta\mathrm{XEL}_i + \delta\mathrm{XEL}_i$$
$$\Delta\mathrm{EL}_i' = \Delta\mathrm{EL}_i + \delta\mathrm{EL}_i$$

  where $\Delta\mathrm{XEL}_i, \Delta\mathrm{EL}_i$ are the pointing errors at AZ_i, EL_i due to a misaligned feed, and $\delta\mathrm{XEL}_i, \delta\mathrm{EL}_i$ are the random blind pointing errors for a source at AZ_i, EL_i

  – The random blind pointing errors depend on the pointing model being used, and it is assumed that this model has been created with a properly aligned feed

Effect of Random Pointing Errors

- Substituting

$$\Delta\mathrm{XEL}_i = \Delta\mathrm{XEL}'_i - \delta\mathrm{XEL}_i$$
$$\Delta\mathrm{EL}_i = \Delta\mathrm{EL}'_i - \delta\mathrm{EL}_i$$

into the previously derived relations for the feed offset errors we have

$$\mathrm{R}\Delta\phi/f = \left(\Delta\mathrm{EL}'_i - \delta\mathrm{EL}_i\right)\cos\theta_i - \left(\Delta\mathrm{XEL}'_i - \delta\mathrm{XEL}_i\right)\sin\theta_i$$
$$\Delta\mathrm{R}/f = \left(\Delta\mathrm{EL}'_i - \delta\mathrm{EL}_i\right)\sin\theta_i + \left(\Delta\mathrm{XEL}'_i - \delta\mathrm{XEL}_i\right)\cos\theta_i$$

where $\theta_i = \phi + AZ_i - EL_i$

Effect of Random Pointing Errors

- By selecting a specific trajectory in the AZ, EL plane, we may set $\theta_i = \phi + AZ_i - EL_i = 0$ so that the above become

$$\mathrm{R}\Delta\phi/f = \Delta\mathrm{EL}'_i - \delta\mathrm{EL}_i$$
$$\Delta\mathrm{R}/f = \Delta\mathrm{XEL}'_i - \delta\mathrm{XEL}_i$$

  - Averaging these we have

$$\langle\Delta\mathrm{EL}'_i\rangle = \mathrm{R}\Delta\phi/f + \langle\delta\mathrm{EL}_i\rangle \cong \mathrm{R}\Delta\phi/f$$
$$\langle\Delta\mathrm{XEL}'_i\rangle = \Delta\mathrm{R}/f + \langle\delta\mathrm{XEL}_i\rangle \cong \Delta\mathrm{R}/f$$

- Alternatively, any trajectory for which $\theta_i = \theta =$ constant may be used, giving the results

$$\mathrm{R}\Delta\phi/f \cong \langle\Delta\mathrm{EL}'_i\rangle\cos\theta - \langle\Delta\mathrm{XEL}'_i\rangle\sin\theta$$
$$\Delta\mathrm{R}/f \cong \langle\Delta\mathrm{EL}'_i\rangle\sin\theta + \langle\Delta\mathrm{XEL}'_i\rangle\cos\theta$$