NATIONAL RADIO ASTRONOMY OBSERVATORY
TUCSON, ARIZONA
12th November, 1287

MEMORANDUM

To : D T Emerson, J M Payne, J Davis (Texas)

From : James Lamb JWL

Subject : Error correction by nutating secondary

Introduction

In considering the possibility of correcting surface abberations in the primary surface of the 12m antenna by figuring the secondary with opposite abberations the question arises as to whether the nutation of the secondary is likely to limit the amount of compensation that can be achieved. To get some feel for the this I have calculated how the tilt of the secondary affects the mapping of points on the secondary to the primary. In other words, if we trace a ray which strikes a given point on the secondary to see where it hits the secondary does this point on the secondary move a distance larger than the correlation size of the errors which we are trying to correct as the secondary is tilted ?

Calculations

The attached tables and graphs show how points on the secondary map, according to the laws of geometrical optics, on to the secondary (assuming a perfect paraboloidal secondary and hyperboloidal secondary) . In the tables the radial position at which a ray strikes the secondary and the corresponding radius on the primary are given. It also shows the difference between the positions with the secondary untilted and tilted at the given angle, and these differences are also shown on the graphs. The points are given only in the plane of tilt, but points at other azimuthal positions are not expected to be significantly worse. Obviously the mapping would not change precisely the same way for a shaped secondary since the surface slopes vary more, but that effect is likely to be relatively minor.

Results

Parameters used :-

Primary focal length = 5080.00 mm
Secondary eccentricity = 1.063538
Interfocal length = 7874.00 mm
Secondary radius = 279.00 mm
Distance from primary focus to rotation centre = -145.20 mm
(Note: -ve direction is towards secondary vertex, away from primary focus)

NOTE : 0.741 degrees gives a 2 arcsec beamthrow on the sky.

Angle of rotation (degrees) = 0.000

R_{sec} (mm)	R_{prim} (mm)	delta R (mm)
0.00	0.00	0.00
27.90	602.52	0.00
55.80	1204.66	0.00
83.70	1806.00	0.00
111.60	2406.19	0.00
139.50	3004.82	0.00
167.40	3601.53	0.00
195.30	4195.96	0.00
223.20	4787.74	0.00
251.10	5376.52	0.00
279.00	5961.98	0.00

Angle of rotation (degrees) = 0.118

R_{sec} (mm)	R_{prim} (mm)	delta R (mm)
0.00	20.15	20.15
27.90	622.80	20.28
55.80	1225.16	20.50
83.70	1826.87	20.87
111.60	2427.56	21.38
139.50	3026.85	22.03
167.40	3624.35	22.82
195.30	4219.70	23.74
223.20	4812.53	24.80
251.10	5402.50	25.98
279.00	5989.27	27.29

Angle of rotation (degrees) = 0.235

R_{sec} (mm)	R_{prim} (mm)	delta R (mm)
0.00	40.39	40.39
27.90	643.09	40.57
55.80	1245.67	41.02
83.70	1847.76	41.75
111.60	2448.97	42.78
139.50	3048.91	44.09
167.40	3647.20	45.67
195.30	4243.48	47.53
223.20	4837.38	49.65
251.10	5428.55	52.02
279.00	6016.63	54.65

Angle of rotation (degrees) = 0.353

R_{sec} (mm)	R_{prim} (mm)	delta R (mm)
0.00	60.62	60.62
27.90	663.38	60.86
55.80	1266.20	61.54
83.70	1868.66	62.66
111.60	2470.39	64.21
139.50	3070.99	66.17
167.40	3670.09	68.56
195.30	4267.31	71.35
223.20	4862.28	74.55
251.10	5454.65	78.13
279.00	6044.06	82.08

Angle of rotation (degrees) = 0.471

R_{sec} (mm)	R_{prim} (mm)	delta R (mm)
0.00	80.81	80.81
27.90	683.68	81.16
55.80	1286.73	82.08
83.70	1889.58	83.58
111.60	2491.84	85.65
139.50	3093.11	88.29
167.40	3693.02	91.49
195.30	4291.18	95.22
223.20	4887.23	99.50
251.10	5480.81	104.29
279.00	6071.56	109.58

Angle of rotation (degrees) = 0.589

R_{sec} (mm)	R_{prim} (mm)	delta R (mm)
0.00	101.00	101.00
27.90	703.99	101.47
55.80	1307.28	102.63
83.70	1910.52	104.51
111.60	2513.31	107.12
139.50	3115.26	110.43
167.40	3715.98	114.45
195.30	4315.10	119.14
223.20	4912.24	124.50
251.10	5507.03	130.51
279.00	6099.13	137.15

Angle of rotation (degrees) = 0.706

R_{sec} (mm)	R_{prim} (mm)	delta R (mm)
0.00	121.27	121.27
27.90	724.31	121.79
55.80	1327.84	123.19
83.70	1931.47	125.47
111.60	2534.80	128.61
139.50	3137.43	132.61
167.40	3738.98	137.44
195.30	4339.06	143.10
223.20	4937.29	149.56
251.10	5533.31	156.79
279.00	6126.77	164.79

Conclusions

The maximum error in position of the rays from the secondary depends on secondary tilt angle and radial position. Typically, for a beam throw on the sky of 2 arcmin (±2 arcmin gives a 4 arcmin beamthrow) the error is less than 100mm, which is much less than the holographic resolution on the surface. Furthermore, at higher frequencies where the abberations are worse in wavelength terms the beamthrow may be less so that problem is further reduced. From this point of view shaping the secondary should not be a problem.

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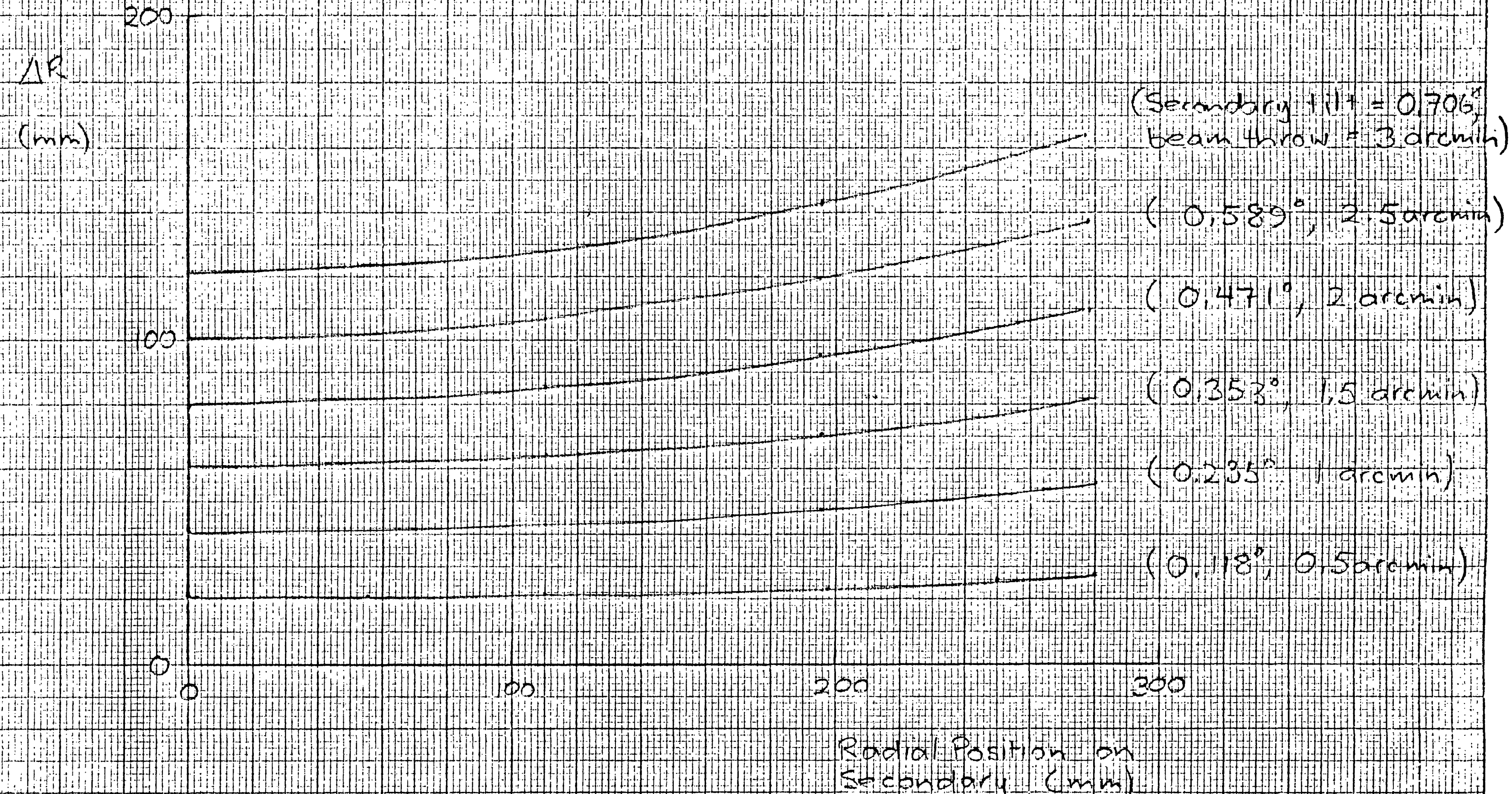
CHANGE IN MAPPING OF POINTS ON PRIMARY TO POINTS ON SECONDARY



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