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The GMRT Antenna Pointing – I. Calibrating the FPS Positions[1]

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Abstract

This document brings out the result of a series of "pointing" measurements[1] made for the GMRT, between 14 Oct 2002 and 26 December 2002. Currently there are a large Elevation offsets (more than 5–6 arcmin) in a few of the antennas. This exercise makes an attempt to incorporate these errors either in the current Servo-Azimuth-offset or in the Servo-Elevation-offset, thereby making the Stow-position to 90° and/or modify the current FPS position, *i.e.* `tpa` for each of the four feed positions. This exercise was done in the "self" mode at 1420, 325 and 610 MHz.

1. **Basis of the experiment**

   Consider a strong, unresolved point source, whose position is known. If an antennas is moved across the source at a constant 'scan-rate' then maximum power will be observed when the beam centre crosses the source at the expected time. However, power will not peak at the expected time if there is an error in the pointing in the direction of the scan. Knowing the rate of the scanning and the difference between the expected and observed peak-time, it is thus, possible to determine the angular error in the pointing. If the position of the source is given by $(\theta_{ez}, \theta_{el})$, then the position offsets in azimuth, θ_{ez} and in elevation θ_{el} (in deg), are given by,

$$\Delta\theta_{az}(i) = (T_{exp} - T_{obs}(i)) \times \frac{cos(el) \times R_{az}}{60.0}$$

$$\Delta\theta_{el}(i) = (T_{exp} - T_{obs}(i)) \times \frac{R_{el}}{60.0}$$

   where, R_{az} and R_{el} are the scan-rates in the azimuth and elevation (in arc min per minute), T_{exp} is the expected peak-time and $T_{obs}(i)$ is the observed peak time (in hours) for the ith antenna.

2. **Observations**

   The observations were made in several parts: The first set of observations were made on 14, 15, and 20 October, 2002. The second set of observations were made on 11 and 12 Nov and the last part of observations were made on 26 Dec 2002.

[1]The observational data (all the Tables) is submitted alongwith in a CD.

The inputs from first sets of observations were used to determine the new FPS positions. The observations with these new FPS positions were made on 11 and 12 Nov 2002. We pointed our antennas towards `Cyg A` for all these observations. The results from this second set helped us to fine tune the FPS positions further and the exercise was repeated using the source `Cas A`.

3. **Procedure**

   (a) i. time of `dhanishtha` (online) machine should be same as the `UTC` time.
   ii. set time of `dual1` to `dhanishtha`'s time.
   iii. Make each antenna offsets (both Azimuth & Elevation) as zero.
   iv. Move the feeds to 1420 (sub-band 1280) MHz band.
   v. Record the FPS position for all the antennas.
   vi. Do power equalise.
   vii. Move the antennas forward ("up") at 20 arcmin per min rate across the source in "Azimuth" direction.
   viii. Do so once again in the reverse ("down") direction.
   ix. repeat the above two steps once more.
   x. Determine the offsets ("getoffsets") for each run.
   xi. load the averaged Azimuth offsets (obtained from above, steps 3(a)vii to 3(a)x).
   xii. Repeat the above steps from 3(a)vii to 3(a)ix and determine once again the Azimuth offsets. These offsets should be close to zero.
   xiii. Now repeat steps 3(a)vii to 3(a)x for Elevation axis.

   (b) Repeat steps of 3a (3(a)v and from 3(a)vii to 3(a)x) for 325 and 610 MHz feed positions (by moving at 30 arcmin per min rate).

   (c) **Important**
   i. Do not forget to check the times on `dual1` and `dhanishtha` machines.
   ii. The averaged–offsets for each antenna should be compared, only when the corresponding FPS positions are also normalised (*i.e.* made similar).

4. **Analysis**

Tables 1 and 2 show the offsets obtained at various frequencies and FPS positions for the measurements made on 14 & 15 Oct and 20 & 21 Oct 2002. FPS position at each feed position

(a) Azimuth corrections:
Determination of Azimuth pointing offsets:

$$\texttt{Say current FPS position} = X,$$

then

$$\texttt{FPS position offset} = 90 - X$$

(put this offset in Servo and change the Stow position to 00d00′).

FPS_Pos	offset (forward 130)	offset (forward 175)	offset (reverse 130)	offset (reverse 175)
1420 MHz Elevation (14 Oct) rising				
C01 11440			4	4
	1	2	3	3
C03 1445				
C04 11428	0	0	5	4
	−1	−1	4	3
C05 1197				
C06 11628	9	9	9	9
	8	8	8	8
C08 11416	9	8	10	10
	8	7	9	9
C09 11310	−9	−10	−7	−7
	−10	−10	−8	−8
C10 11642	4	4	7	7
	3	3	5	6
C11 11598		8		10
	7	8	8	9
C12 11626				
			0	0
C14 11588	−5	−5	−1	−2
	−5	−6	−2	−2
325 MHz Elevation (14 Oct) rising				
C01 16564	3	3	5	4
	2	1	6	5
C03				
C04 16640	4	4	9	10
	2	2	10	10
C05				
C06 16754	8	8	8	8
	7	7	8	8
C08 16544	5	5	7	7
	4	4	8	8
C09 16434	−1	−1	0	0
	−3	−3	0	0
C10 16796	12	13	17	17
	10	11	18	19
C12 16746	3	−2	5	0
	2	−3	5	0
C14 16708	−3	−2	−1	0
	−5	−5	0	0
610 MHz Elevation (14 Oct) transit Scintillations				
C01 1195	3	3	6	6
C03 1445				
C05 1197				
C06 1391	7	5	8	7
C08 1177	6	7	10	10
C09 1077	−5	−5	−2	−1
C10 1415	10	11	19	19
C11 16752				
C12 1389	0	0	3	3
C14 1351	−3	−2	2	2
data saturated and SCINTILLATIONS				

C01	11436	−2	−2	−1	−1
		−2	−3	−1	−1
		−1	−1	0	0
C03	11666	−22	−22	−23	−23
		−22	−21	−23	−22
		0	0	−1	0
C04	11422	−2	−2	−2	−1
		−2	−2	−1	−1
		0	−1	0	0
C05	11432	−10	−10	−10	−10
		−11	−11	−10	−10
		−1	−1	−1	0
C06	11618	1	1	3	3
		2	2	3	3
		0	0	0	0
C08	11406	1	1	4	4
		1	1	4	4
		0	−1	2	1
C09	11302	−10	−10	−8	−8
		−10	−10	−7	−9
		−2	−2	−1	−1
C10	11640	0	0	0	0
		0	0	1	0
		0	0	1	1
C11	11604		0	0	0
		0	0	0	0
		0	0	0	0
C12	11622	−6	−6	−5	−5
		−7	−7	−6	−5
		−2	−1	0	0
C14	11578			2	2
		1	1	2	1
		0	0	0	0
1420 MHz Elevation (15 Oct) rising					
C01	11436	0	1	4	4
		1	1	4	4
C03	11666	−4	−4	−4	−3
		−4	−4	−4	−3
C04	11422	0	−1	5	4
		−1	−1	4	4
C05	11432	−3	−3	−1	−1
		−3	−3	−1	−1
C06	11618	6	6	6	6
		5	5	6	6
C08	11406	5	4	9	9
		5	4	9	9
C09	11302	−14	−15	−11	−11
		−14	−14	−12	−12
C10	11640	3	4	10	10
		3	3	7	8
C11	11604	1	1	3	3
		1	1	3	3
C12	11622	−4	−4	−2	−2
		−4	−4	−2	−2
C14	11578	−7	−7	−3	−3
		−7	−7	−3	−3
325 MHz Elevation (15 Oct) rising					
C01	16564	3	2	8	7
		3	2	7	7
C03	16834	−3	−3	−3	−3
		−4	−4	−3	−3
C04	16634	5	4	12	11
		4	4	11	11
C05	16566	0	4	4	7
		0	3	4	8
C06	16758	7	7	9	9
		7	7	9	10
C08	16548	5	5	10	10
		5	5	9	10
C09	16446	−3	−3	0	0
		−3	−3	0	0
C10	16796	13	13	19	20
		13	13	19	20
C12	16750	−1		2	
		−1		2	
C14	16720	−3	0	1	4
		−4	−1	2	5
610 MHz Elevation (15 Oct) at/after transit					
C01	1195	3	3	5	6
		3	3	6	6
C03	1443	−1	0	0	1
		0	0	0	2
C05	1205	1	1	3	4
		1	1	3	4
C06	1383	5	3	7	4
		6	4	7	5
C08	1175	7	7	10	10
		7	7	10	10
C09	1073	−9	−9	−7	−6
		−9	−9	−7	−6
C10	1407	12	12	18	18
		12	12	18	18
C11	1369	7	7	8	8
		7	7	8	8
C12	1387	−3		0	0
		−3		0	1
C14	1347	−3	−3	1	2
		−3	−2	1	2

1420 MHz Elevation (15 Oct) setting					
C01	11448	2	2	6	6
		3	3	6	7
C03	11716	0	0	3	3
		1	1	2	3
C04	11516	6	5	13	12
		6	6	13	12
C05	11444	0	0	2	2
		0	0	2	2
C06	11640	5	6	7	7
		6	6	7	8
C08	11420	6	6	11	10
		7	7	11	11
C09	11316	−14	−14	−10	−11
		−14	−14	−10	−11
C10	11672	2	2	11	12
		5	5	11	12
C11	11618	2	2	3	3
		1	1	3	3
C12	11626	−6	−5	−2	−2
		−5	−5	−2	−2
C14	11592	−7	−8	0	0
		−6	−6	−1	−1
325 MHz Elevation (15 Oct) setting					
C01	16566	5	4	11	10
		6	5	8	7
C03	16834	−3	−3	−1	−1
		−1	−2	−3	−3
C04	16634	8	5	16	13
		8	6	13	10
C05	16558	1	2	4	6
		2	4	3	4
C06	16758	7	7	10	10
		9	9	8	8
C08	16550	6	7	14	14
		8	8	10	10
C09	16444	−1	−1	3	3
		0	0	1	1
C10	16794	13	14	21	22
		15	16	19	20
C12	16754	0	1	4	6
		0	1	1	4
C14	16714	−2	−1	3	4
		−2	−1	1	2
610 MHz Elevation (15 Oct) setting					
C01	1197	6	6	7	7
		6	6	7	7
C03	1443	2	3	1	2
		3	3	1	2
C05	1201	3	3	2	3
		2	3	3	3
C06	1389	9	7	8	6
		9	7	8	6
C08	1175	10	11	12	13
		11	11	12	13
C09	1073	−6	−5	−5	−4
		−5	−5	−4	−4
C10	1409	14	14	21	21
		15	15	22	22
C11	1369	11	11	10	11
		11	11	10	10
C12	1387	0	0	0	1
		0	0	0	
C14	1347	0	0	1	1
		0	0	2	2

Table 1: Azimuth and Elevation offsets obtained on 14 and 15 Oct 2002. The averaged Azimuth offsets were loaded and then Elevation offsets were determined.

FPS_Pos		offset forward (up)		offset reverse (down)	
		130	175	130	175
C01	11450	-2	-3	-2	-2
		-3	-3	-2	-2
		-2	-3	-1	-2
C04	11510	-2	-3	-3	-3
		-3	-3	-3	-3
		-1	-4	-3	-4
C05	11434	-11	-11	-11	-11
		-12	-12	-11	-11
		-2	-1	-1	-1
C08	11420	2	2	3	3
		2	2	2	3
		0	0	2	2
C09	11314		-10		-10
		-11	-11		-11
		-4	-3	-3	-3
C11	11620	0	0	0	0
		0	-1	0	0
		-1	-1	-1	-1
C12	11626	-5	-6	-8	-7
		-8	-7	-8	-7
		-2	-2		-2
C14	11576	1	1	2	1
		1	1	1	1
		0	0	1	1
E03	11614	2	2	2	3
		2	2	2	3
		2	2	2	2
E04	11320	20		21	
		19		20	
		-2	-1	0	0
E05	11670	-2	-2	-3	-3
		-3	-3	-3	-4
		-2	-2	-3	-3
E06	11756	-11	-11	-10	-11
		-11	-12	-11	-11
		-1	-1	-1	-1
S01	11684				
S02	11450	-5	-5	-4	-4
		-6	-6	-5	-5
		-2	-2	-1	-1
S03	11534	-3	-3	-8	-7
		-3	-3	-1	-1
		0	0	1	1
S06	11436	17	17	17	18
		16	16	16	16
		-3	-3	-2	-2
W01	11428	-1	-1	-1	-1
		-1	-1	-1	-1
		-2	-2	-3	-3
W02	11220	21	21	21	21
		21	20	22	22
		0	0	0	0
W03	11636	-1	-1	-1	-2
		-1	-1	-1	-2
		0	0	0	0
W04	11122	-22	-22	-22	-22
		-21	-21	-21	-21
		0	1	1	1
W05	11690	6	6	7	7
		7	7	8	8
		3	3	4	4

C01	11452	4	4	8	8
		6	6	9	9
	11556	15	16	19	20
		16	17		
C04	11510	9	8	17	16
		9	9	17	16
	11614	21	20	27	27
		21	21		
C05	*11442	3	3	6	6
		2	3	5	5
	*11398	-3	-3	0	0
		-3	-2		
C08	*11422	8	8	14	13
		10	9	14	14
	*11422	9	10	15	14
		11	11		
C09	11316	-11	-11	-8	-8
		-10	-11	-8	-8
	11422	0	0	1	1
		0	0		
C11	11620	4	4	6	6
		4	4	7	7
	11530	-3	-2	0	0
		-2	-1		
C12	11626	-3	-3	-1	-1
		-3	-3	-1	-1
	11576	-7	-7	-5	-5
		-7	-7		
C14	11594	-4	-5	0	0
		-4	-4	0	0
	11648	3	2	9	8
		6	5		
E03	1363				
	1363				
E04	11316	-2	-2	1	1
		-2	-2	2	2
	11422	7	7	12	12
		8	8		
E05	11670	-2	-2	0	0
		-2	-2	0	0
	11778	7	7	7	7
		7	7		
E06	*11758	4	5	20	20
		6	6	21	22
	*11682	1	1	18	18
		5	6		
S01	*11706	35	35	43	43
		35	35	42	42
	*11706	38		44	
		37			
S02	*11454	0	0	4	4
		1	1	4	5
	*11416	-2	-2	1	1
		-1	0		
S03	*11540	-3	-3	-1	-1
		-2	-3	0	0
	*11502	-4	-4	-2	-2
		-4	-4		
S06	11008	-8	-9	-6	-7
		-8	-8	-6	-7
	11070	-2	-2	0	0
		-1	-2		
W01	11430				
	11424				
W02	*11224	5	4	13	13
		6	6	13	13
	*11240	9	9	16	16
		9	9		
W03	11652	12	12	16	16
		12	13	16	15
	11814	29	30	31	31
		30	30		
W04	*11126	1	2	2	2
		1	2	2	3
	*11126	2	3	3	3
		2	3		
W05	11694	12	13	15	15
		12	12	16	16
	11752	18	18	21	21
		18	19		

1420 MHz
Elevation (20 Oct) rising

C01	11450	2	2	4	4
		1	1	5	5
C04	11510	5	5	12	12
		5	5	12	11
C05	11434	-2	-2	0	0
		-2	-3	0	0
C08	11420	7	6	10	9
		6	6	9	10
C09	11314	-15	-15	-12	-12
			-14	-12	-12
C11	11620	2	3	2	3
		2	3	3	3
C12	11626	-3	-4	-3	-3
		-4	-5	-3	-3
C14	11576	-7	-7	-2	-2
		-6	-7	-4	-4
E03	11614	-7	-7	5	4
		1	0	4	4
E04	11320	4	4	6	6
		3	3	5	5
E05	11670	5	5	5	5
		5	5	4	4
E06	11756	8	9	23	23
		5	5		
S01	11684				
S02	11450	-2	-1	1	1
		-1	-1	1	1
S03	11534	-4	-4	-2	-2
		-4	-4	-3	-3
S06	11436	-11	-12	-10	-10
		-12		-11	-11
W01	11428	0	0	1	1
		0	0	1	1
W02	11220	1	1	4	4
		0	0	4	4
W03	11636	7	7	8	8
		7	7	8	8
W04	11122	-4	-4	-4	-3
		-3	-3	-3	-3
W05	11690	7	7	9	9
		7	7	9	9

610 MHz
Elevation (20 Oct) after transit

C01	1195	4	5	9	10
		6	6	10	10
C04	1201				
C05	1197	5	5	8	9
		5	5	8	9
C08	1175	8	8	14	14
		9	10	14	15
C09	1073	-6	-6	-2	-2
		-6	-6	-2	-2
C11	1371	10	10	12	12
		10	10	13	13
C12	1387	-1	0	1	2
		0	0	2	2
C14	1347	-1	0	4	5
		0	0	4	4
E03	1363	-3	-2	2	3
		-2	-2	2	3
E04	1073	0	0	3	4
		0	0	3	4
E05	1427	0	1	0	2
		0	1	1	2
E06	1479	-1	0	14	15
		0	0	16	17
S01	1447	33	32	41	40
		32	33	43	42
S02	1191	0	0	4	4
		0	1	4	4
S03	1279	-1	-1	0	1
		-1	0	1	1
S06		0	0	1	1
		0	0	1	2
W01	1173	1	1	17	17
W02	1023	15	16	22	23
		13	14		
W03	1331	8	9	10	11
		9	10	11	11
W04	881	8	8	9	9
		8	8	9	9
W05	1445	9	10	12	12
		9	10	12	13

325 MHz
Elevation (20 Oct) before transit

C01	16566	3	2	7	6
		4	2	8	6
C04	16658	5	6	12	13
		5	6	13	13
C05	16566	4	6	7	8
		4	6	7	9
C08	16550	5		9	9
		5	5	9	9
C09	16448	-3	-3	0	-1
		-3	-3	0	-1
C11	16750				
C12	16752	-1	0	1	2
		-1	0	1	2
C14	16722	-3	-2	1	2
		-3	-2	1	2
E03	16732	-1	-1	0	2
		-2	-2	1	1
E04	16442	-1	-0	1	1
		2	2	6	6
E05	16794	5	6	6	5
		5	5	4	3
E06	16888	0	0	22	22
		3	3	22	21
S01	16818	30	30	38	38
		30	29	39	38
S02	16578	-1	0	1	2
		-1	-1	3	3
S03	16652	-5	-5	-3	-2
		-6	-6	-1	-1
S06	16130	-6	-4	-4	-3
		-7	-5	-4	-2
W01	16538	0	0	2	2
		0	0	2	2
W02	16350	1	2	5	6
		1	2	6	6
W03	16726	8	8	10	10
		9	9	9	9
W04	16248	3	3	2	4
		3	2	2	2
W05	16812	6	7	8	9
		7	8	9	9

Table 2: Azimuth and Elevation offsets obtained on 20 Oct 2002. The averaged Azimuth offsets were loaded and then Elevation offsets were determined.

(b) Elevation corrections:

Determination of elevation pointing offset and corresponding FPS corrections:

$$\texttt{FPS new count} = \texttt{FPS old count} - (\texttt{10.81})(\texttt{Astrnomical offset in arcmin}).$$

In other words, if A & B are the two different FPS positions and a & b are corresponding offsets. And if, A > B then a > b as well. This factor `10.81` can be found using either of the following procedures:

i. Method 1:

A. Determine the FPS position (`FPS pos_1`) and the corresponding offset (`offset_1`) for each of the antennas.

B. Move each of the feed position by another, say, 200 counts.

C. Record this new FPS position (`FPS pos_2`) and now determine the corresponding offset (`offset_2`) for each of the antennas.

D. The average of the ratio of the differences of the offset and the FPS positions would give the factor, `10.81`. This multiplicative factor converts astronomical offset into the FPS counts.

E. *i.e.* determine

$$\left\langle \left[\frac{(\texttt{FPS pos\_2}) - (\texttt{FPS pos\_1})}{(\texttt{offset\_2}) - (\texttt{offset\_1})} \right]_{\texttt{Ant i}} \right\rangle .$$

It is found to be `10.36` and `10.36` & `10.73` respectively for the 20 and 25 Oct data calculated for a few of the measurements. The averaged value is found to be $\texttt{10.52} \pm \texttt{1.41}$.

ii. Method 2:

"5 × 4096" FPS counts makes complete 360 degrees. And $10 \times \frac{5 \times 4096}{360 \times 60}$ corresponds to the `10.54` arcmin. Where 10, approximately, is due to the ratio of the focal length ($\sim$ 18 mtrs) and the distance of the feed from its axis ($\sim$ 1.8 mtrs).

For the present analysis, we would assume <u>`10.52`</u> to be correct (Table 6 uses `10.81` for the determination of new `tpa` values).

The two FPS positions on 20 Oct 2002, before and after.

FPS_Pos		offset forward (up) 130	175	offset reverse (down) 130	175					1420 MHz							
C01	11452	4	4	8	8	6	6	9	9	11556	15	16	19	20	16	17	x	x
C04	11510	9	8	17	16	9	9	17	16	11614	21	20	27	27	21	21	x	x
C09	11316	−11	−11	−8	−8	−10	−11	−8	−8	11422	0	0	1	1	0	0	x	x
C11	11620	4	4	6	6	4	4	7	7	11530	−3	−2	0	0	−2	−1	x	x
C12	11626	−3	−3	−1	−1	−3	−3	−1	−1	11576	−7	−7	−5	−5	−7	−7	x	x
C14	11594	−4	−5	0	0	−4	−4	0	0	11648	3	2	9	8	6	5	x	x
E04	11316	−2	−2	1	1	−2	−2	2	2	11422	7	7	12	12	8	8	x	x
E05	11670	−2	−2	0	0	−2	−2	0	0	11778	7	7	7	7	7	7	x	x
S06	11008	−8	−9	−6	−7	−8	−8	−6	−7	11070	−2	−2	0	0	−1	−2	x	x
W03	11652	12	12	16	16	12	13	16	15	11814	29	30	31	31	30	30	x	x
W05	11694	12	13	15	15	12	12	16	16	11752	18	18	21	21	18	19	x	x

The two FPS positions on 25 Oct 2002 at times 19:36 HRS (before) and 20:05 HRS (after) shifting by another 200 counts.

			FPS pos_1 (before)								FPS pos_2 (after)							
C00	11602	11804	1	1	11	11	1	1	5	5	21	21	24	24	21	21	25	25
C03	16836	17028	−3	−2	−3	−2	−3	−2	−1	−1	16	16	17	18	16	16	17	18
C06	11644	11834	2	1	7	7	2	1	3	3	21	21	22	22	21	21	22	22
C09	11322	11508	−8	−8	−10	−12	−8	−8	−6	−6	10	10	13	13	10	11	12	13
C10	11644	11848	0	0	10	10	1	1	5	5	19	19	23	24	20	20	25	25
C12	11620	11818	4	4	0	−1	2	1	5	5	23	23	24	24	23	22	24	24
C14	11598	11794	−3	−3	−1	−1	−4	−4	0	−1	15	15	18	18	15	15	18	17
E04	11320	11516	−1	−2	1	1	0	1	1	1	15	15	18	19	20	20	19	19
E05	11676	11870	−5	−5	−2	−2	−2	−2	−3	−2	20	20	19	19	15	16	18	18
S02	11456	11662	−1	−1	1	1	0	0	0	1	17	17	20	20	13	13	18	18
S03	11512	11716	−4	−4	−6	−6	−3	−3	−3	−3	20	19	16	16	15	15	16	16
S06	11012	11208	−5	−5	−11	−12	−6	−6	−5	−5	12	12	13	14	12	12	15	15
W03	11468	11640	6	6	10	10	3	2	5	4	22	22	22	22	21	20	26	26
W05	11676	11676	1	1	8	8	1	1	4	4	11	11	14	14	12	12	13	14

Table 3: Offsets for two different FPS positions obtained on 20 and 25 Oct 2002 at 1420 MHz pointing observations.

5. **Results**

(a) The Elevation offset for many Antennas is hour-angle dependent. The experiment to check this was done on 15 Oct for central square antennas. Each gave similar offset during the source rise and source set times (Table 4). Averaged difference when seen (*e.g.* C06, C08 etc.) was a maximum of 3 arcmin.

(b) We make offsets zero, using method explained above and we arrived at the new `tpa`'s for each antennas (exercise was mainly performed using 20 Oct data). The new FPS positions are shown in Table 6 below. The second round of pointing measurements, following the procedure explained above, were performed on 11 and 12 Nov with these new FPS positions. The Elevation offsets are shown in Tables 7, 8 and 9.

(c) Elevation offsets obtained for pointing measurements made on 11 and 12 Nov, are consistent with the predictions made above; *i.e.* most of the offsets for antennas with revised `tpa`'s are close to zero (or less than what was obtained earlier).

(d) Using observations made on 11 and 12 Nov, the `tpa`'s given in Table 6 can be once again fine-tuned for each of the antennas. The final suggested `tpa`'s for the antennas that we have observed until now are given in Table 11.

6. **Discussions**

There are several issues that we need to worry, some of them are as follows:

(a) When doing the change over from one feed position to another, the feed position of each antennas should be made as given in Table 11.

Date : 14 and 15 Oct 2002
Project : Pointing and FPS rotation (Data below is for Elevation only)

1420 MHz — Elevation (14 Oct) rising — 14 Oct 2002

	FPS_Pos	offset forward 130	offset forward 175	offset reverse 130	offset reverse 175	offset forward 130	offset forward 175	offset reverse 130	offset reverse 175
C01	11440	xx	xx	4	4	1	2	3	3
C04	11428	0	0	5	4	−1	−1	4	3
C06	11628	9	9	9	9	8	8	8	8
C08	11416	9	8	10	10	8	7	9	9
C09	11310	−9	−10	−7	−7	−10	−10	−8	−8
C10	11642	4	4	7	7	3	3	5	6
C11	11598	xx	8	xx	10	7	8	8	9
C14	11588	−5	−5	−1	−2	−5	−6	−2	−2

325 MHz — Elevation (14 Oct) rising

C01	16564	3	3	5	4	2	1	6	5
C04	16640	4	4	9	10	2	2	10	10
C06	16754	8	8	8	8	7	7	8	8
C08	16544	5	5	7	7	4	4	8	8
C09	16434	−1	−1	0	0	−3	−3	0	0
C10	16796	12	13	17	17	10	11	18	19
C12	16746	3	−2	5	0	2	−3	5	0
C14	16708	−3	−2	−1	0	−5	−5	0	0

1420 MHz — Elevation (15 Oct) rising

C01	11436	0	1	4	4	1	1	4	4
C03	11666	−4	−4	−4	−3	−4	−4	−4	−3
C04	11422	0	−1	5	4	−1	−1	4	4
C05	11432	−3	−3	−1	−1	−3	−3	−1	−1
C06	11618	6	6	6	6	5	5	6	6
C08	11406	5	4	9	9	5	4	9	9
C09	11302	−14	−15	−11	−11	−14	−14	−12	−12
C10	11640	3	4	10	10	3	3	7	8
C11	11604	1	1	3	3	1	1	3	3
C12	11622	−4	−4	−2	−2	−4	−4	−2	−2
C14	11578	−7	−7	−3	−3	−7	−7	−3	−3

325 MHz — Elevation (15 Oct) rising

C01	16564	3	2	8	7	3	2	7	7
C03	16834	−3	−3	−3	−3	−4	−4	−3	−3
C04	16634	5	4	12	11	4	4	11	11
C05	16566	0	4	4	7	0	3	4	8
C06	16758	7	7	9	9	7	7	9	10
C08	16548	5	5	10	10	5	5	9	10
C09	16446	−3	−3	0	0	−3	−3	0	0
C10	16796	13	13	19	20	13	13	19	20
C12	16750	−1	xx	2	xx	−1	xx	2	xx
C14	16720	−3	0	1	4	−4	−1	2	5

610 MHz — Elevation (15 Oct) at/after transit

C01	1195	3	3	5	6	3	3	6	6
C03	1443	−1	0	0	1	0	0	0	2
C05	1205	1	1	3	4	1	1	3	4
C06	1383	5	3	7	4	6	4	7	5
C08	1175	7	7	10	10	7	7	10	10
C09	1073	−9	−9	−7	−6	−9	−9	−7	−6
C10	1407	12	12	18	18	12	12	18	18
C11	1369	7	7	8	8	7	7	8	8
C12	1387	−3	xx	0	0	−3	xx	0	1
C14	1347	−3	−3	1	2	−3	−2	1	2

15 Oct 2002

1420 MHz — Elevation (15 Oct) setting

C01	11448	2	2	6	6	3	3	6	7
C03	11716	0	0	3	3	1	1	2	3
C04	11516	6	5	13	12	6	6	13	12
C05	11444	0	0	2	2	0	0	2	2
C06	11640	5	6	7	7	6	6	7	8
C08	11420	6	6	11	10	7	7	11	11
C09	11316	−14	−14	−10	−11	−14	−14	−10	−11
C10	11672			11	12	5	5	11	12
C11	11618	2	2	3	3	1	1	3	3
C12	11626	−6	−5	−2	−2	−5	−5	−2	−2
C14	11592	−7	−8	0	0	−6	−6	−1	−1

325 MHz — Elevation (15 Oct) setting

C01	16566	5	4	11	10	6	5	8	7
C03	16834	−3	−3	−1	−1	−1	−2	−3	−3
C04	16634	8	5	16	13	8	6	13	10
C05	16558	1	2	4	6	2	4	3	4
C06	16758	7	7	10	10	9	9	8	8
C08	16550	6	7	14	14	8	8	10	10
C09	16444	−1	−1	3	3	0	0	1	1
C10	16794	13	14	21	22	15	16	19	20
C12	16754	0	1	4	6	0	1	1	4
C14	16714	−2	−1	3	4	−2	−1	1	2

610 MHz — Elevation (15 Oct) setting

C01	1197	6	6	7	7	6	6	7	7
C03	1443	2	3	1	2	3	3	1	2
C05	1201	3	3	2	3	2	3	3	3
C06	1389	9	7	8	6	9	7	8	6
C08	1175	10	11	12	13	11	11	12	13
C09	1073	−6	−5	−5	−4	−5	−5	−4	−4
C10	1409	14	14	21	21	15	15	22	22
C11	1369	11	11	10	11	11	11	10	10
C12	1387	0	0	0	1	0	0	0	xx
C14	1347	0	0	1	1	0	0	2	2

Table 4: Elevation offsets obtained on 14 and 15 Oct 2002; the 15 Oct observations have been made at two times, rising and setting of the source (same as Table 1, with no Azimuth offsets shown here).

Date : 20 Oct 2002
Project : Pointing and FPS rotation
(Data below is for Elevation only)

---------- 20 Oct 2002 ------

1420 MHz — Elevation (20 Oct) rising

	FPS_Pos	offset forward (up)		offset reverse (down)		offset forward (up)		offset reverse (down)	
		130	175	130	175	130	175	130	175
C01	11450	2	2	4	4	1	1	5	5
C04	11510	5	5	12	12	5	5	12	11
C05	11434	−2	−2	0	0	−2	−3	0	0
C08	11420	7	6	10	9	6	6	9	10
C09	11314	−15	−15	−12	−12	−14	−12	−12	xx
C11	11620	2	3	2	3	2	3	3	3
C12	11626	−3	−4	−3	−3	−4	−5	−3	−3
C14	11576	−7	−7	−2	−2	−6	−7	−4	−4
E03	11614	−7	−7	5	4	1	0	4	4
E04	11320	4	4	6	6	3	3	5	5
E05	11670	5	5	5	5	5	5	4	4
E06	11756	8	9	23	23	5	5	xx	xx
S02	11450	−2	−1	1	1	−1	−1	1	1
S03	11534	−4	−4	−2	−2	−4	−4	−3	−3
S06	11006	−11	−12	−10	−10	−12	xx	−11	−11
W01	11428	0	0	1	1	0	0	1	1
W02	11220	1	1	4	4	0	0	4	4
W03	11636	7	7	8	8	7	7	8	8
W04	11122	−4	−4	−4	−3	−3	−3	−3	−3
W05	11690	7	7	9	9	7	7	9	9

---

325 MHz — Elevation (20 Oct) before transit

C01	16566	3	2	7	6	4	2	8	6
C04	16658	5	6	12	13	5	6	13	13
C05	16566	4	6	7	8	4	6	7	9
C08	16550	5	xx	9	9	5	5	9	9
C09	16448	−3	−3	0	−1	−3	−3	0	−1
C12	16752	−1	0	1	2	−1	0	1	2
C14	16722	−3	−2	1	2	−3	−2	1	2
E03	16732	−1	−1	0	2	−2	−2	1	1
E04	16442	−1	−0	1	1	2	2	6	6
E05	16794	5	6	6	5	5	5	4	3
E06	16888	0	0	22	22	3	3	22	21
S01	16818	30	30	38	38	30	29	39	38
S02	16578	−1	0	1	2	−1	−1	3	3
S03	16652	−5	−5	−3	−2	−6	−6	−1	−1
S06	16130	−6	−4	−4	−3	−7	−5	−4	−2
W01	16538	0	0	2	2	0	0	2	2
W02	16350	1	2	5	6	1	2	6	6
W03	16726	8	8	10	10	9	9	9	9
W04	16248	3	3	2	4	3	−2	2	2
W05	16812	6	7	8	9	7	8	9	9

---

610 MHz — Elevation (20 Oct) after transit

C01	1195	4	5	9	10	6	6	10	10
C05	1197	5	5	8	9	5	5	8	9
C08	1175	8	8	14	14	9	10	14	15
C09	1073	−6	−6	−2	−2	−6	−6	−2	−2
C11	1371	10	10	12	12	10	10	13	13
C12	1387	−1	0	1	2	0	0	2	2
C14	1347	−1	0	4	5	0	0	4	4
E03	1363	−3	−2	2	3	−2	−2	2	3
E04	1073	0	0	3	4	0	0	3	4
E05	1427	0	1	0	2	0	1	1	2
E06	1479	−1	0	14	15	0	0	16	17
S01	1447	33	32	41	40	32	33	43	42
S02	1191	0	0	4	4	0	1	4	4
S03	1279	−1	−1	0	1	−1	0	1	1
W02	1023	15	16	22	23	13	14	xx	xx
W03	1331	8	9	10	11	9	10	11	11
W04	881	8	8	9	9	8	8	9	9
W05	1445	9	10	12	12	9	10	12	13

Table 5: Elevation offsets obtained on 20 Oct 2002 (same as Table 2, with no Azimuth offsets shown here).

Antenna	Current values				New values			
name	610	150	1420	325	610	150	1420	325
C00	1372	6492	11612	16732				
C01	1203	6323	11443	16563	1114		11418	16515
C02	1313	6433	11553	16673				
C03	1456	6576	11696	16816				16559
C04	1240	6360	11480	16600				
C05	1201	6321	11441	16561	1124		11446	16497
C06	1395	6515	11635	16755				
C08	1182	6302	11422	16542	1056		11331	16480
C09	1073	6193	11313	16433	1116		11459	16467
C10	1418	6538	11658	16778				
C11	1374	6494	11614	16734	1249		11592	16747
C12	1386	6506	11626	16746	1378		11664	
C13	1319	6439	11559	16679				
C14	1347	6467	11587	16707			11630	
E02	1174	6294	11414	16534				
E03	1368	6488	11608	16728	1361		11609	16735
E04	1073	6193	11313	16433	1054		11271	16419
E05	1428	6548	11668	16788	1418		11619	16741
E06	1498	6618	11738	16858	1397			16762
S01	1453	6573	11693	16813				
S02	1200	6320	11440	16560	1168		11451	16570
S03	1286	6406	11526	16646			11569	16691
S04	1187	6307	11427	16547				
S06	761	5881	11001	16121			11126	16177
W01	1176	6296	11416	16536			11423	16527
W02	991	6111	11231	16351	823		11196	16311
W03	1358	6478	11598	16718	1224		11655	16629
W04	880	6000	11120	16240	789		11158	16225
W05	1447	6567	11687	16807	1327		11603	16727
W06	1250	6370	11490	16610				

Table 6: The modified test FPS positions (`tpa`) for later (11 and 12 Nov 2002) observations. The new FPS positions are calculated using factor `10.81`.

(b) Although by repeated back-'n-forth movements of the feed, the required FPS position can be obtained, feed do not stop at the required position. The input `tpa` for an antenna is not the same where it's feed stopped. This FPS position of the feed with respect to the input FPS position is often arbitrary and the difference can be anything.

(c) During an observation (say, of 8–10 hours duration), the FPS position in the beginning and at the end of it is sometime found to be slightly different. This is seen for a few of the antennas, the counts were off by ~ 2, except for S01 (start value = 11668, stop FPS value = 11658; at 1420 MHz on 11 Nov).

(d) The transit problem: It has been noticed in some of the GMRT antennas the pointing changes after the transit. This occurs due to faulty mechanical bearings. At 1420 MHz, 5 arcmin pointing change is equivalent to source shifting in the primary beam from its peak to 95% level; 12 arcmin corresponds to the source shifting to 75% level. Therefore,

```
                  Date : 11 Nov 2002
               Project : Pointing and FPS rotation
                         (Data below is for Elevation only)
Problems with all Antennas : C13 Servo problem
                             C14 Painting
                             S02 Flat band shape
                             E03 Feed jam
                             W05 Servo problem
                             W06 Feed problem
        Specific problems : S01 at 1420 MHz
                             W04 at 325 MHz
Each column is as follows:
       Col_1 : Antenna name
       Col_2 : FPS position
       Col_3 : Offset; Forward run for 130 MHz channel
       Col_4 : Offset; Forward run for 175 MHz channel
       Col_5 : Offset; Reverse run for 130 MHz channel
       Col_6 : Offset; Reverse run for 175 MHz channel
Col_7--Col_10 : Another repeat, as is done for Col_3--Col_6

 ** 1420 MHz **
C00 11598 +007 +007 +013 +013
C01 11414 +000 +000 +004 +004
C02 11542 +023 +023 +025 +024
C03 11666 −002 −001 −001 +000
C04 11416 −005 −005 +001 +000
C05 11436 −002 xxxx +000 +000
C06 11624 +007 +007 +008 +008
C08 11314 −002 −003 +002 +001
C09 11446 +000 +000 +003 +003
C10 11640 +002 +003 +010 +010
C11 11568 +000 +000 +001 +002
C12 11656 −002 −002 +000 +000
E02 11400 +007 +008 +013 +013
E04 11268 −004 −004 −001 −001
E05 11614 −007 −007 −002 −002
E06 11704 +002 +002 +009 +009
S03 11548 −004 −004 −001 −001
S04 11420 −013 −012 −004 −004
S06 11110 −008 −008 xxxx xxxx
W01 11398 −004 −004 −001 −001
W02 11182 −001 −001 +003 +003
W03 11510 −001 −001 +000 +000
W04 11152 −016 −015 −015 −015

 ** 325 MHz **
 Antenna with problems : S03 Struck
C00 16740 +013 +014 +019 +020 +012 +013 +021 +021
C01 16516 +001 +001 +005 +006 +001 +002 +007 +008
C02 16676 +023 +024 +026 +026 +023 +023 +028 +028
C03 16832 +003 +003 +003 +003 +002 +002 +004 +004
C04 16640 +006 +006 +012 +012 +006 +006 +013 +013
C05 16502 +000 xxxx +003 xxxx +000 xxxx +005 xxxx
C06 16754 +011 +011 +012 +012 +011 +011 +014 +014
C08 16486 +002 +002 +007 +006 +003 +002 +010 +009
C09 16478 +004 +004 +008 +008 +003 +003 +009 +009
C10 16972 +017 +016 +024 +023 +017 +017 +026 +025
C11 16770 +014 +015 +017 +018 +015 +015 +018 +018
C12 16752 +000 +002 +003 +005 +000 +002 +006 +007
E02 16538 +008 +008 +012 +012 +008 +008 +014 +014
E04 16426 +002 +002 +005 +006 +001 +002 +007 +007
E05 16748 +000 −001 +001 +000 −001 −001 +003 +003
E06 16782 +000 +000 +004 +004 +000 +000 +006 +006
S01 16830 +034 +038 +042 +046 +033 +037 +046 +049
S04 16552 −007 −007 +000 +000 −007 −006 +001 +000
S06 16188 +000 +001 +005 +005 +000 +001 +005 +007
W01 16542 +009 +009 +012 +011 +008 +009 +013 +013
W02 16320 +004 +005 +010 +011 +004 +004 +012 +014
W03 16748 +014 +014 +016 +017 +014 +014 +017 +017

 ** 610 MHz **
 A few more antennas with problems : C00 Struck
                                     W01 and W02 struck
                                     W04 also did not move
                                     S03
C01 1111 +000 +001 +007 +007
C02 1307 +009 +009 +012 +013
C03 1445 +008 +009 +009 +011
C04 1193 +000 +000 +008 +009
C05 1129 +000 +000 +003 +003
C06 1387 +012 +012 +014 +014
C08 1047 −001 −001 +006 +006
C09 1111 +000 +000 +003 +003
C10 1405 +018 +018 +026 +026
C11 1237 +002 +002 +005 +005
C12 1375 +000 +000 +003 +003
E02 1165 +009 +009 +015 +015
E04 1045 +000 +000 +007 +007
E05 1413 +002 +002 +008 +008
E06 1379 −006 −005 xxxx xxxx
S01 1443 +034 +034 +044 +043
S04 1181 −008 −009 +004 +004
S06  751 xxxx xxxx +000 +000
W02  937 +006 +007 +017 +018
W03 1193 −002 −001 +000 xxxx
```

Table 7: Elevation offsets obtained on 11 Nov 2002; procedure followed is the same as described above.

```
               Date : 12 Nov 2002 (first run)
            Project : Pointing and FPS rotation
                      (Data below is for Elevation only)
Antennas with problems : C13 Servo
                      C14 seemed working, but feed did not move to 325 and 610 MHz.
                      S01
                      W05
                      W06
     Specific problems : C05 and C06 at 325 MHz (feed not in focus)
                      W02 at 610 MHz (feed jam)
Each column is as follows:
       Col_1 : Antenna name
       Col_2 : FPS position
       Col_3 : Offset; Forward run for 130 MHz channel
       Col_4 : Offset; Forward run for 175 MHz channel
       Col_5 : Offset; Reverse run for 130 MHz channel
       Col_6 : Offset; Reverse run for 175 MHz channel
Col_7--Col_10 : Another repeat, as is done for Col_3--Col_6

 ** 1420 MHz
C00 11600 +007 +007 +013 +013 +007 +007 +013 +013
C01 11424 +000 +000 +004 +004 +000 +000 +004 +004
C02 11562 +009 +009 +011 +011 +008 +008 +010 +010
C03 11714 xxxx xxxx +005 +006 +003 +004 +005 +006
C04 11518 +005 +005 +010 +010 +004 +003 +009 +010
C05 11446 +005 +004 +007 +007 +004 +004 +007 +007
C06 11640 +011 +011 +012 +012 +011 +011 +011 +011
C08 11332 +000 −001 +003 +002 −001 −002 +003 +002
C09 11464 +002 +001 +005 +005 +001 +000 +004 +004
C10 11672 +009 +009 +015 +015 +008 +009 +015 +015
C11 11604 +004 +005 xxxx +006 +003 +004 +005 +006
C12 11664 +000 +000 +003 +002 xxxx +000 xxxx +002
E02 11418 +012 +013 +016 +016 +012 +012 +016 +016
E03 11600 +007 +007 +011 +011 +006 +006 +010 +010
E04 11270 +004 +004 +006 +007 +003 +003 +006 +006
E05 11626 +003 +003 +005 +005 +000 +000 +004 +004
E06 11754 +016 +016 xxxx xxxx +015 +015 +021 +021
S02 11436 +000 +000 +003 +003 −002 −001 +003 +003
S03 11582 +002 +002 +004 +004 +002 +001 +003 +003
S04 11434 −009 −010 −004 −005 −013 −013 −004 −004
S06 11136 −004 −005 −002 −002 −006 −007 −002 −002
W01 11398 −003 −002 +000 +000 −003 −002 +000 +000
W02 11192 −001 −001 +002 +002 −001 −001 +002 +001
W03 11658 +009 +009 +011 +011 +008 +008 +012 +012
W04 11150 +000 +000 +000 +000 +000 +000 +000 +000

 ** 325 MHz
C00 16740 +012 +013 +018 +018 +012 +012 +018 +019
C01 16520 +000 +001 +003 +004 +000 +001 +004 +004
C02 16694 +005 +005 +006 +007 +005 +006 +008 +008
C03 16576 −025 −024 −023 −023 −025 −024 −023 −023
C04 16658 +005 +005 +011 +011 +006 +006 +012 +011
C08 16494 +001 +000 +004 xxxx +000 xxxx +004 xxxx
C09 16488 +002 +002 +005 +005 +003 +003 +005 +005
C10 16808 +016 +015 +022 +021 +017 +016 +022 +021
C11 16786 +012 +012 +014 +014 +013 +013 +015 +015
C12 16756 +000 +000 +001 +003 +000 +001 +002 +003
E02 16546 +008 +008 +011 +011 +008 +007 +013 +012
E03 16746 +002 +003 +005 +007 +001 +003 +008 +008
E04 16434 +005 +005 +006 +007 +001 +002 +007 +007
E05 16758 +000 +000 +002 +001 xxxx xxxx +001 +001
E06 16798 +001 +000 +006 +005 +000 +000 +005 +004
S02 16594 +001 +002 +004 +005 +001 +002 +006 +006
S03 16720 +002 +002 +004 +004 +003 +003 +005 +005
S04 16564 −009 −010 −003 −003 −007 −007 −001 −001
S06 16200 −002 −001 +000 +002 −002 +000 +009 +003
W01 16552 −004 −005 −002 −002 −004 −004 −002 −002
W02 16326 +000 +001 +005 +006 +002 +003 +005 +007
W03 16848 +021 +022 +023 +023 +022 +021 +023 +024
W04 16240 +005 +005 +006 +006 +006 +004 +006 +006

 ** 610 MHz
C00 1361 +005 +005 +010 +011 +005 +005 +010 +010
C01 1103 −002 −002 +000 +001 −001 −001 +001 +001
C02 1301 +006 +006 +007 +008 +006 +007 +008 +008
C03 1445 +004 +005 +004 +005 +004 +005 +005 +006
C04 1183 −001 +000 +005 +004 −001 +000 +004 +005
C05 1123 −005 −004 −003 −003 −005 −005 −003 −002
C06 1389 +010 +010 +010 +010 +010 +010 +011 +011
C08 1043 −003 −003 +000 −001 −002 −001 +002 +002
C09 1107 −003 −002 +000 +000 −002 −002 +000 +000
C10 1403 +015 +015 +022 +022 +017 +017 +022 +023
C11 1235 +000 +000 +001 +001 +000 +000 +001 +001
C12 1371 −001 −001 +000 +000 −001 −001 +000 +000
E02 1151 +007 +006 +012 +012 +007 +007 +011 +011
E03 1353 +000 +001 +005 +005 +001 +001 +005 +005
E04 1045 +000 +000 +003 +004 +000 +000 +003 +004
E05 1411 +000 +001 +004 +005 +000 +001 +005 +006
E06 1373 −007 −007 −001 −001 −008 −007 −001 −001
S02 1155 −003 −002 +000 +000 −002 −002 +000 +001
S03 1273 −002 −001 +000 +000 −001 +000 +000 +000
S04 1179 −011 −011 −003 −003 −009 −009 +000 +000
S06  747 −006 −006 −002 −002 −007 −006 −002 −002
W01 1163 −006 −006 −003 −003 −006 −006 −003 −003
W03 1175 −005 −005 −003 −003 −005 −004 −004 −003
W04  791 +000 +001 +002 +002 +002 +002 +002 +002
```

Table 8: Elevation offsets obtained on 12 Nov 2002 (first run); procedure followed is the same as described above.

```
                Date : 12 Nov 2002 (2nd run)
             Project : Pointing and FPS rotation
                       (Data below is for Elevation only)
Antennas with problems : C05 Feed did not move at 610 MHz.
                       C13 Servo
                       C14 seemed working, but feed did not move to 325 and 610 MHz.
                       S01 Feed jam
                       E03 Feed jam
                       W04 Feed did not move at 325 and 610 MHz.
                       W05
                       W06
    Specific problems : C05 at 325 MHz (feed jam)
                       W02 at 610 MHz (feed jam)
Each column is as follows:
       Col_1 : Antenna name
       Col_2 : FPS position
       Col_3 : Offset; Forward run for 130 MHz channel
       Col_4 : Offset; Forward run for 175 MHz channel
       Col_5 : Offset; Reverse run for 130 MHz channel
       Col_6 : Offset; Reverse run for 175 MHz channel
Col_7--Col_10 : Another repeat, as is done for Col_3--Col_6

 ** 1420 MHz
C00 11622 +008 +008 +014 +014
C01 11428 +000 +000 +005 +005
C02 11566 +010 +010 +011 +011
C03 11714 +004 +005 +005 +006
C04 11534 +007 +007 +013 +013
C05 11436 −002 −002 +000 +000
C06 11640 +010 +010 +011 +011
C08 11338 +000 −001 +005 +004
C09 11472 +003 +003 +006 +005
C10 11678 +008 +009 +015 +016
C11 11608 +006 +005 +006 +005
C12 11670 +000 +000 +002 +002
C13 11566 +000 +000 +001 +001
E02 11428 +010 +010 +015 +016
E04 11280 −003 −003 +000 +000
E05 11628 −007 −007 −002 −002
E06 11758 +006 +006 +013 +013
S02 11464 +001 +001 +005 +006
S03 11592 +001 +001 +002 +002
S04 11442 −011 −011 −001 −001
S06 11136 −003 −004 +000 +000
W01 11448 −008 −007 −005 −005
W02 11206 +003 +003 +008 +008
W03 11742 +021 +021 +022 +022
W04 11162 +006 +007 +006 +006
W06 11488 −003 −003 −001 −001

 ** 325 MHz
C00 16740 +014 +015 +021 +022
C01 16520 +004 +005 +009 +009
C02 16690 +010 +010 +012 +013
C03 16578 −018 −018 −017 −017
C04 16680 +014 +013 +020 +019
C06 16754 +013 +014 +014 +015
C08 16494 +005 +005 +010 +010
C09 16484 +007 +006 +010 +010
C10 16800 +020 +020 +028 +027
C11 16778 +019 +019 +020 +020
C12 16752 +003 +005 +006 +008
C13 16686 +005 +005 +007 +007
E02 16546 +011 +010 +016 +016
E04 16430 +003 +003 +008 +008
E05 16756 +002 +002 +005 +005
E06 16784 +002 +001 +008 +008
S02 16588 +005 +006 +010 +011
S03 16714 +008 +007 +010 +010
S04 16564 −004 −004 +003 +003
S06 16198 +000 +000 +002 +005
W01 16556 −005 −006 −002 −003
W02 16320 +007 +008 +013 +014
W03 16822 +024 +024 +025 +025
W06 16606 +001 +001 +004 +004

 ** 610 MHz
C00 1361 +010 +010 +005 +005
C01 1109 +002 +002 +000 +000
C02 1303 +010 +010 +008 +008
C03 1443 +006 +007 +008 +009
C04 1165 +003 +004 +000 +000
C06 1391 +012 +012 +012 +012
C08 1043 +002 +003 +000 +000
C09 1107 +000 +000 −001 −001
C10 1401 +023 +023 +018 +018
C11 1225 +001 +001 +000 +000
C12 1371 +000 +001 +000 +000
C13 1321 +005 +005 +005 +005
E02 1157 +012 +012 +009 +008
E04 1041 +005 +005 +001 +001
E05 1409 +005 +006 +003 +004
E06 1377 −001 +000 −004 −004
S02 1151 +000 +001 −001 +000
S03 1273 +001 +002 +000 +001
S04 1179 −002 −001 −007 −007
S06  747 −002 −002 −004 −004
W01 1155 −008 −008 −010 −009
W03 1169 −003 −003 −004 −004
W06 1251 +002 +002 +000 +000
```

Table 9: Elevation offsets obtained on 12 Nov 2002 (second run, close to the setting of the source); procedure followed is the same as described above.

pointing change of 5′ and above can be considered significant. We assume, the offset–change (forward–reverse (or Up–Down)) of 5 arcmin (at 1420 MHz) to be serious and some of the antennas which seems to be victims are as follows:

i. Since, the above exercise for antennas C14 (at 610 & 325 MHz) and S01 (at 1420 MHz) could not performed (due to non-availability) this exercise should be performed in a similar fashion for these antennas as well.

ii. Determination of the offsets seems to be sensitive with the FPS position of the antennas. *e.g.* in W02 and W03 antennas, different FPS positions gives inconsistent offsets (please see Table 6 and 10; also see Table 11 for final suggested `tpa`'s.). This then suggests, one to do the following experiment:

Make a plot of the FPS positions as a function of offsets and determine the slopes for each antennas. We would then attempt to answer, are the above antennas (*e.g.* W02 and W03), the ones with discrepant slopes as well ? *or* it is because they are arm antennas and our model of determining offsets with one of the central-square-antennas as the phase centre is incorrect ?

7. Conclusions

The test observations using `Cas A` source were carried out on 26 Dec using the revised (recommended) FPS positions. Table 12 shows the elevation offsets obtained after incorporating the revised (Table 11) FPS positions. The offsets obtained are, by and large, consistent with our prediction that the offsets for antennas with revised `tpa`'s should be close to zero (or less than 3-4 arcmin (at 1420 MHz) which are within errorbars).

(a) Antenna S01 did not have previous FPS position measurement at 1420 MHz and hence is showing high elevation offsets (Table 12).

(b) Some of antennas which shows high offset values also have two (recommended and actual (while observing)) different FPS positions. Leaving aside such cases, there are a few probable cases, *e.g.* antennas W03 (at 1420 and 325 MHz), whereas C04 and E03 at 1420 MHz being borderline cases, which do not seem to follow our suggested model.

ADDENDUM

For each source that is observed, the elevation and the azimuth for each of the GMRT antennas are different, due to their different locations, at any instant of time. Although, 'ONLINE' allows to incorporate such corrections, no correction was applied to any antenna.

Table 10: Calculated (recommended) FPS positions for the 11 and 12 Nov 2002, which would give zero offsets.

	11_Nov_2002 OLD_FPS_position			11_Nov_2002 New_FPS_positions			12_Nov_2002 1st_Run OLD_FPS_position			12_Nov_2002 1st_Run New_FPS_positions			12_Nov_2002 2nd_Run OLD_FPS_position			12_Nov_2002 2nd_Run New_FPS_positions		
	1420	325	610	1420	325	610	1420	325	610	1420	325	610	1420	325	610	1420	325	610
C00	11598	16740		11492.8	16565.1		11600	16740	1361	11494.8	16579.6	1280.79	11622	16740	1361	11506.3	16550.6	1282.1
C01	11414	16516	1111	11393	16475.2	1071.55	11424	16520	1103	11403	16497.6	1106.94	11428	16520	1109	11401.7	16449	1098.48
C02	11542	16676	1307	11292.1	16411.7	1193.91	11562	16694	1301	11462.1	16628.2	1227.36	11566	16690	1303	11455.5	16571.7	1208.32
C03	11666	16832	1445	11676.5	16800.4	1347.69	11714	16576	1445	11664	16825.8	1395.03	11714	16578	1443	11661.4	16762.1	1364.1
C04	11416	16640	1193	11439.7	16542.7	1148.29	11518	16658	1183	11444.4	16569.9	1161.96	11534	16680	1165	11428.8	16506.4	1146.59
C05	11436	16502	1129	11446.5	16481	1113.22	11446	16180	1123	11386.8	16510.1	1162.45	11436			11446.5		
C06	11624	16754	1387	11545.1	16627.8	1250.24	11640	16364	1389	11521.6	16620.4	1281.17	11640	16754	1391	11529.5	16606.7	1264.76
C08	11314	16486	1047	11319.3	16432.1	1020.7	11332	16494	1043	11324.1	16475.6	1050.89	11338	16494	1043	11317	16415.1	1029.85
C09	11446	16478	1111	11430.2	16414.9	1095.22	11464	16488	1107	11435.1	16448.5	1118.84	11472	16484	1107	11427.3	16397.2	1112.26
C10	11640	16972	1405	11574.2	16755	1173.56	11672	16808	1403	11547.1	16610.8	1201.81	11678	16800	1401	11551.8	16550.2	1185.34
C11	11568	16770	1237	11560.1	16599	1200.18	11604	16786	1235	11554	16644	1229.74	11608	16778	1225	11550.1	16572.9	1219.74
C12	11656	16752	1375	11666.5	16719.1	1359.22	11664	16756	1371	11653.5	16742.8	1376.26	11670	16752	1371	11659.5	16694.1	1368.37
C13													11566	16686	1321	11560.7	16622.9	1268.4
C14																		
E02	11400	16538	1165	11292.2	16427.5	1038.76	11418	16546	1151	11269.4	16443.4	1055.01	11428	16546	1157	11293.9	16406.6	1049.17
E03							11600	16746	1353	11510.6	16697.3	1322.76						
E04	11268	16426	1045	11294.3	16383.9	1008.18	11270	16434	1045	11218.7	16381.4	1026.59	11280	16430	1041	11295.8	16372.1	1009.44
E05	11614	16748	1413	11661.3	16742.7	1360.4	11626	16758	1411	11594.4	16748.8	1382.07	11628	16756	1409	11675.3	16719.2	1361.66
E06	11704	16782		11646.1	16755.7		11754	16798	1373	11571.2	16770.4	1416.39	11758	16784	1377	11658.1	16734	1400.67
S01		16830	1443		16402.6	1035.35												
S02							11436	16594	1155	11424.2	16558.5	1165.52	11464	16588	1151	11429.8	16503.8	1151
S03	11548		1277	11574.3		1863.49	11582	16720	1273	11554.4	16683.2	1278.26	11592	16714	1273	11576.2	16622	1262.48
S04	11420	16552	1181	11506.8	16586.2	1204.67	11434	16564	1179	11515.5	16617.9	1239.49	11442	16564	1179	11505.1	16569.3	1223.71
S06		16188			16156.4		11136	16200	747	11175.5	16188.2	790.395	11136	16198	747	11154.4	16179.6	778.56
W01	11398	16542		11424.3	16431.5		11398	16552	1163	11411.1	16584.9	1210.34	11448	16556	1155	11513.8	16598.1	1247.05
W02	11182	16320	937	11171.5	16235.8	810.76	11192	16326		11188.1	16287.9		11206	16320		11148.1	16209.5	
W03	11510	16748	1193	11515.3	16586.3	1200.89	11658	16848	1175	11552.8	16612.6	1217.08	11742	16822	1169	11515.8	16564.3	1205.82
W04	11152			11312.4			11150	16240	791	11150	16182.1	773.905	11162			11096.2		
W05																		
W06													11488	16606	1251	11509	16579.7	1240.48

Recommended FPS positions	New_FPS_positions				New_FPS_positions		
	1420	325	610		1420	325	610
C00	11498	16565	1281	E02	11285	16426	1048
C01	11399	16474	1092	E03	11511	16697	1323
C02	11403	16537	1210	E04	11270	16379	1015
C03	11667	16796	1369	E05	11643	16737	1368
C04	11438	16540	1152	E06	11625	16753	1408
C05	11427	16495	1139	S01		16403	1035
C06	11532	16618	1265	S02	11427	16531	1158
C08	11320	16441	1034	S03	11568	16653	1268
C09	11431	16420	1109	S04	11509	16591	1223
C10	11558	16639	1187	S06	11165	16175	785
C11	11555	16605	1217	W01	11450	16538	1229
C12	11660	16719	1368	W02	11169	16244	811
C13	11561	16623	1268	W03	11528	16588	1208
C14	11630			W04	11186	16182	774
				W05	11603	16727	1327
				W06	11509	16580	1240

Antenna	Current values				New values			
name	610	150	1420	325	610	150	1420	325
C00	1372	6492	11612	16732	1281		11498	16565
C01	1203	6323	11443	16563	1092		11399	16474
C02	1313	6433	11553	16673	1210		11403	16537
C03	1456	6576	11696	16816	1369		11667	16796
C04	1240	6360	11480	16600	1152		11438	16540
C05	1201	6321	11441	16561	1139		11427	16495
C06	1395	6515	11635	16755	1265		11532	16618
C08	1182	6302	11422	16542	1034		11320	16441
C09	1073	6193	11313	16433	1109		11431	16420
C10	1418	6538	11658	16778	1187		11558	16639
C11	1374	6494	11614	16734	1217		11555	16605
C12	1386	6506	11626	16746	1368		11660	16719
C13	1319	6439	11559	16679	1268		11561	16623
C14	1347	6467	11587	16707			11630	
E02	1174	6294	11414	16534	1048		11285	16426
E03	1368	6488	11608	16728	1323		11511	16697
E04	1073	6193	11313	16433	1015		11270	16379
E05	1428	6548	11668	16788	1368		11643	16737
E06	1498	6618	11738	16858	1408		11625	16753
S01	1453	6573	11693	16813	1035			16403
S02	1200	6320	11440	16560	1158		11427	16531
S03	1286	6406	11526	16646	1268		11568	16653
S04	1187	6307	11427	16547	1223		11509	16591
S06	761	5881	11001	16121	785		11165	16175
W01	1176	6296	11416	16536	1229		11450	16538
W02	991	6111	11231	16351	811		11169	16244
W03	1358	6478	11598	16718	1208		11528	16588
W04	880	6000	11120	16240	774		11186	16182
W05	1447	6567	11687	16807	1327		11603	16727
W06	1250	6370	11490	16610	1240		11509	16580

Table 11: The suggested FPS positions (`tpa`) to be modified for any future observations.

.

(Data below is for Elevation only)
Source : Cas A
Antennas with problems : They are not shown in the Table below.
Following of them were bad:
1420 : C02 C08 C10 C13 E02 E05 S03 W01
325 : C02 C08 C10 C13 C14 E03 E05 S02 S03 W01 W05
610 : C02 C10 C13 C14 E03 E05 S02 S03 W01 W05
Each column is as follows:
Col_1 : Antenna name
Col_2 : FPS position
Col_3 : Offset; Forward run for 130 MHz channel
Col_4 : Offset; Forward run for 175 MHz channel
Col_5 : Offset; Reverse run for 130 MHz channel
Col_6 : Offset; Reverse run for 175 MHz channel
Col_7--Col_10 : Another repeat, as is done for Col_3--Col_6

** 1420 MHz

C00	11512	−001	−001	+003	+003	−001	−001	+003	+003
C01	11410	+000	+000	+003	+004	+000	+000	+004	+004
C03	11690	+002	+003	+005	+005	+003	+003	+005	+005
C04	11462	−001	+002	+012	+011	+003	+003	+011	+011
C05	11436	−002	−003	+000	+000	−003	−003	+000	+000
C06	11542	−002	−002	−001	−001	−001	−001	+000	+000
C09	11442	+002	+002	+010	+005	+002	+002	+006	+006
C11	11576	+004	+005	+006	+007	+004	+005	+007	+008
C12	11664	+002	+002	+003	+004	+002	+002	+005	+005
C14	11602	−004	−004	+001	+001	−003	−003	+001	+001
E03	11622	−006	−006	−001	−001	−005	−005	+000	+000
E04	11252	−007	−007	−005	−005	−008	−007	−003	−003
E06	11648	−005	−005	+005	+005	−004	−003	+004	+005
S01	11708	+037	+036	+044	+045	+037	+038	+046	+045
S02	11458	+000	+000	+005	+006	+000	+000	+005	+004
S04	11532	−005	−005	+010	+010	−002	−002	+010	+011
S06	11182	+000	+000	+005	+005	+000	+000	+006	+005
W02	11188	+002	+001	+007	+008	+002	+002	+010	+009
W03	11608	−022	−022	−020	−020	−022	−022	−020	−019
W04	11196	+002	+002	+002	+003	+002	+002	+003	+003
W05	11702	+006	+007	+013	+013	+007	+008	+014	+015
W06	11520	+001	+000	+005	+005	+001	+001	+005	+006

** 325 MHz

C00	16578	−001	−001	+004	+005	−001	−001	+002	+004
C01	16474	+000	+000	+004	+005	+000	−001	+000	+000
C03	16816	+003	+003	+007	+008	+000	+000	+003	+003
C04	16558	+001	+002	+008	+009	+002	+000	+007	+005
C05	16506	−005	−002	+000	+004	−005	−001	−001	+002
C06	16624	−002	−002	+001	+001	−001	−001	+000	+000
C09	16438	+005	+005	+010	+010	+004	+004	+007	+006
C11	16636	+008	+008	+012	+012	+005	+006	+007	+008
C12	16726	+005	+006	+009	+011	+003	+005	+006	+008
E02	16442					+000	+003	+002	+010
E04	16394	−002	−002	+003	+003	+001	+001	+003	+003
E06	16786	+000	−001	+008	+007	+002	+001	+007	+007
S01	16416	+006	+007	+020	+015	+006	+002	+005	+010
S04	16606	−006	−007	+007	+006	−007	−008	+000	+000
S06	16202	+003	+003	+010	+010	+000	+000	+002	+004
W02	16262	+002	+002	+008	+010	−002	−001	+003	+004
W03	16774	−013	−010	−008	−006	−010	−011	−008	−009
W04	16198	+000	+000	+001	+001	−002	−002	−001	−001
W06	16590	+000	+000	+005	+006	−001	−001	+001	+002

** 610 MHz

C00	1271	−003	−002	+002	+003	−003	−001	+002	+003
C01	1079	−003	−003	+000	+000	−005	−002	−001	+000
C03	1359	−001	+000	+001	+002	−001	+000	+001	+002
C04	1129	−003	−003	+002	+003	−002	−002	+003	+003
C05	1133	−005	−005	−002	−002	−005	−005	−002	−002
C06	1249	−003	−003	−002	−002	−003	−003	−002	−002
C08	1169	+009	+009	+013	+013	+009	+010	+014	+014
C09	1101	+000	+000	+003	+003	+000	+000	+003	+003
C11	1195	+000	+000	+002	+002	+000	+001	+002	+002
C12	1361	+000	+001	+003	+003	+000	+001	+003	+003
C13	1317	+004	+004	+005	+005	+005	+006	+006	+008
E02	1033	−005	−005	+000	+000	−003	−002	+000	+001
E04	1005	−002	−002	+000	+000	−003	−002	+000	+000
E06	1381	−006	−005	+001	+002	−004	−003	+002	+002
S01	1021	+000	−002	+005	+005	+000	−001	+007	+006
S04	1213	−013	−013	−001	−001	−010	−010	+000	+001
S06	773	−007	−007	−002	−001	−005	−005	+000	−001
W02	989	+011	+012	+015	+016	+013	+012	+016	+016
W03	1305	+005	+005	+006	+007	+004	+006	+007	+007
W04	767	−004	−005	−005	−004	−006	−005	−004	−004
W06	1233	−002	−001	+001	+001	−001	−001	+001	+002

Table 12: Elevation offsets obtained on 26 Dec 2002; procedure followed is the same as described above. These above offsets are obtained after incorporating the suggested FPS positions (as shown in Table 11).