

Determination of the Pointing Offsets and Beam Pattern for the 4-m Telescope

1 Goal of the experiment

The aim of the experiment is to align the 4-m telescope at NCRA East campus with the proper ALT/AZ coordinate system allowing it to be pointed to the given astronomical source. This requires determining the offsets between the electronic reference of the telescope and the astronomical ALT/AZ coordinate system at the observatory. Using the calculated offsets, scans in AZ and AL direction are taken to calculate the Beam-Width of the 4-m Telescope.

The understanding of the issues of practical astronomy is tested by the brain teaser section, which require solutions to problems listed in this sheet and familiarization with directions in sky.

The procedure for the initialization of the telescope and receiver should be followed first, which is given in the previous document. The procedure of the experiment is described which includes the operation of the telescope and receiver system. The observation section provides a log sheet for the experiment, which requires observations of Sun to determine ALT and AZ offsets. It is followed by an analysis section which consists of analysis procedure and log. Finally a results section is provided for listing results alongwith the errors.

2 Brain Teaser

1. Go out on the terrace and identify different directions on the sky. If sun is visible, roughly find the direction of North pole, which is one of

the reference for telescope control system. Indicate approximately the Alt-azimuth position of the telescope.

Ans.:

2. Track the path of the Sun on the sky. How does the azimuth and altitude change through the day at NCRA campus ? How would this change if you were located +50 N at the time of the experiment? How would this change if you were located -50 N at the time of the experiment?

Ans.:

3. Find out the RA/Dec of Sun and the constellation in which the Sun is, at the time of observation. Familiarize yourself with the equatorial coordinate system as it is visible from the telescope location. In what direction then RA/Dec increases/decreases? Where is the 0,0 RA/Dec point located in the sky?

Ans.:

4. Indicate the approximate time of rise and set in IST today when the sources with RA and Dec given in Table 1 can be observed using our 4-m telescope at NCRA East Campus. (Assume that the sky 17° above horizon is visible with the telescope)

RA	Dec	Time(IST)
01h 30m	+33 ⁰ 20'	
05h 31m	+21 ⁰ 10'	
04h 37m	-56 ⁰ 01'	
17h 10m	-30 ⁰ 23'	
21h 05m	+40 ⁰ 21'	

Table 1: List of sources

5. What is the angular size of Sun disk in the sky? What is the resolution of an typical optical telescope (lets take D=10cm)? What should be the diameter of the telescope at 21 cm, to achieve the same resolution?

Ans.:

3 Procedure for the experiment

Before starting with the experiment, initialization of the telescope and receiver has to be done. For this purpose please refer to the document titled 'Initialization of the 4-m Telescope System'. Follow the experimental procedure given below.

3.1 Experimental Procedure

This experiment can be done by visually pointing the antenna towards the Sun if the sky is not cloudy. Look at the shadow of the feed at the center of the dish and rotate the antenna till the shadow is centered approximately. If the sky is cloudy, then the experiment is not recommended. Then, the following procedure is to be followed.

1. Select the settings for continuum mode as shown in Table 2
2. Type "cd djgpp/bin/ " in encoder PC.

3. Type "decimal.exe" then press Enter.
4. Type the file name as "positiontemp" then press Enter.
5. Type the duration of obs as 0 and then press Enter.
6. Note down the approximate ALT/AZ of the Sun as shown on the screen
7. slew in azimuth in + or - 10 degrees using the hand crank then press Esc in encoder PC.
8. Notedown the Alt and Az angles in the log sheet.
9. then retype decimal.exe in encoder PC.
10. give filename as "SunAZ.batch<nn>.position.<hrmms.ddmmyy>". (Note: "Give different file name Each time.") (<nn> is the number of your batch and hrmms.ddmmyy is the hour, min, sec, day, month, year of the day of your experiment.)
11. Type the duration of obs as "60". Note:"Don't press Enter".
12. START the SCAN on receiver PC. Also simultaneously press Enter in the Encoder PC. Note down the start time in the log sheet and save the scan.
13. Simultaneously start rotating the hand wheel for Azimuth axis maintaining a continuous rotation speed till you have gone over the Sun to the other side by 10 degrees.
14. Repeat the steps 9 to 13, this time FROM "-10degrees TO +10degrees".
15. Go to approximate position of Sun again and rotate the antenna till the shadow is centered approximately.
16. Similarly repeat steps 3 to 13 for two Elevation Scans.
17. Copy data files from Encoder PC using an USB drive and copy data files from Receiver PC using CD (Don't use any USB in Receiver PC) and transfer to MAT- LAB PC for analysis.

Parameter	Value
IF Cont Gain	10
DC Cont Gain	5
DC Cont offset	1
Time/step	0.2
Source name	'Sundd-mm-yyyy-batchno'

Table 2: Receiver Settings

18. Once the experiment is over, do the thing which was given in the “parking the telescope” in the document titled “Initialization of the 4-m Telescope System”.

3.2 Observation Log

3.2.1 Observation Table for Azimuth Scans

	Azimuth Scan- 1	Azimuth Scan - 2
Azimuth angle	Start: End:	Start: End:
Altitude angle End:	Start: End:	Start:
Slew speed Time/Step		
Scan Rcvr Data file name 1 Scan Encoder Data file name 1 Scan Data file name 2 hline Scan Encoder Data file name 2		

3.2.2 Observation Table for Elevation Scans

	Altitude Scan-1	Altitude scann-2
Azimuth angle	Start: End:	Start: End:
Altitude angle End:	Start: End:	Start:
Slew speed Time/Step		
Scan Data file name 1 Scan Encoder Data file name 1 Scan Data file name 2 hline Scan Encoder Data file name 2		

3.3 Analysis Procedure and Log

3.3.1 Procedure

1. Login into a linux system.
2. Copy your encoder data file and receiver data to a subdirectory or Desktop in linux.
3. Open Terminal window by selecting that option in Accessories drop down menu.
4. Access your subdirectory (where data files are copied) or Desktop directory by using “cd <dirname>”.
5. Then separate the Azimuth and Elevation angles by using the command “awk '{print \$1}' <encoder file> > azimuth” (it will write the values in this file) and this will give you the Azimuth values (Eg: awk '{print \$1}' SunEL(or)AZ.batch<nn>.position.<hrmmss.ddmmyy> > azimuth)
6. Similarly, create elevation encoder data file with ”awk '{print \$2}' SunEL(or)AZ.batch<nn>.position.<hrmmss.ddmmyy> > alititude” and this will give you the Altitude values.
7. Copy receiver data file for your scan to your subdirectory as “altscan” or “aczscan” and remove the header line after noting down the start time as well as trailing zeros in the data file using an editor such as “vi” or “gedit” or “Notepad”.
8. Click on MATLAB icon
9. Change the working directory of MATLAB to the directory where you have copied your data files.
10. Load encoder data in MATLAB using load data command with your file name. “load altitude” or “load azimuth”
11. Similarly load data of Receiver values in MATLAB using “load altscan”.
12. The number of data points should be declared as “n=300”(you may change according to the length of your data.

13. Generate X axis using `>> for i=1:n x(i)=altitude(i);end`
or
`>> for i=1:n x(i)=azimuth(i);end`
14. Generate Y axis using `>>for i=1:n y(i)=altscan(i);end`
15. plot data using `>>plot(x,altscan)`
16. Choose datapoints near the peak of the deflection on Sun
17. Copy these data points to two arrays “datax” and “datay”
18. To fit a curve `>>cftool(x,y)`
This will open an interactive data plot.
19. select “datax” and “datay” as X and Y arrays in “DATA” tab
20. Click on - Fitting - New fit.
21. Select Gaussian in “Type of fit”.
22. Then select the Gaussian function $a_1e^{-(x-b_1/c_1)^2}$, from the list.
23. click “Apply”.
24. Note down values of the fitting parameters a_1, b_1 and c_1 . (Parameter b_1 =position of Gaussian/measured position of Sun.
25. From the Almanac, calculate the Al/Az coordinates of the Sun at the time of the scan. The difference between the calculated Az/Al and the Peak of Gaussian (for both Az and Al scans) are the offset of the telescope.
26. Parameter $c_1 = \sqrt{2}\sigma$, where σ is the root-mean-square width of the Gaussian. The FWHM is then calculated from σ as $FWHM = 2.35 * \sigma$
27. To save the plot obtained in cftool, go to “File-print to figure”
28. Insert labels
29. “File - save as - name.jpg - save”

3.4 Log

3.4.1 Altitude Scans

	Altitude Scan - 1	Altitude Scan -2
Datapoint selected	to	to
Peak of Gaussian (Deg.)	\pm	\pm
FWHM of Gaussian (Deg.)	\pm	\pm
Expected Azimuth	Deg.	Deg.
Expected Altitude	Deg.	Deg.
Offset	Deg.	Deg.

3.4.2 Azimuth Scans

	Azimuth Scan -1	Azimuth Scan -2
Datapoint selected	to	to
Peak of Gaussian (Deg.)	\pm	\pm
FWHM of Gaussian (Deg.)	\pm	\pm
Expected Azimuth	Deg.	Deg.
Expected Altitude	Deg.	Deg.
Offset	Deg.	Deg.

4 Results and Discussion

The estimate of pointing offsets are as follows –

1. Azimuth Offset : Deg.
2. Altitude Offset : Deg.

The Beam-Width of the 4-m telescope is the FWHM obtained from the beam pattern is Deg.

The theoretical expected value is Deg.

The sources of error in my experiment are as follows –