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 electroninc 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 coordiante 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 following RA and Dec can be observed using our 4-m telescope at NCRA East Campus. (Assume that the sky 17^o above horizon is visible with the telescope)

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

5. What is the angular size of Sun disk in the sky? What is the resolution of an typical optical telescope (lets assume 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. Notedown the approximate ALT/AZ of the Sun. Then, the following procedure is to be followed.

1. Select the following settings for continuum mode.

Parameter	Value
IF Gain	10
DC Gain	5
DC offset	1.45
Time/step	0.2
Source name	'name'

2. Go to "DESIGNATE mode", select the last enter block, enter the approximate Alt and Az coordinates and ALT/AZ speeds of 0.5^o/sec. each.

3. Slew over the position of Sun FROM $+ 10^o$ TO $- 10^o$ in altitude using the designate mode and speed options. Notedown the start and end Alt and Az angles in the log sheet.

4. Also simultenously START the SCAN on receiver. Notedown the start time in the log sheet and save the scan.

5. Repeat the steps 2 and 3, this time FROM $- 10^o$ TO $+ 10^o$.

6. Go to approximate position of Sun again and Rotate the antenna till the shadow is centered approximately.

7. Repeat steps 2 to 5 for 2 times.

8. Go to approximate position of Sun again and Rotate the antenna till the shadow is centered approximately.
9. Similarly repeat steps 2 to 7 for two Azimuth Scans.
10. Copy data files on a CD (DO NOT USE PEN-DRIVES) and transfer to MATLAB PC for analysis.
11. Once the experiment is over, park the telescope as per step-9-10, mentioned in the document titled *'Initialization of the 4-m Telescope System'*.

4 Observation Log

4.1 Observation Table for Altitude Scans

	Altitude Scan -1	Altitude Scan -2
Azimuth angle	Start: End:	Start: End:
Altitude angle	Start: End:	Start: End:
Slew Speed		
Start time of scan		
Time/Step		
Scan Data file name 1)		
Scan Data file name 2)		

4.2 Observation Table for Azimuth Scans

	Azimuth Scan -1	Azimuth Scan -2
Azimuth angle	Start: End:	Start: End:
Altitude angle	Start: End:	Start: End:
Slew Speed		
Start time of scan		
Time/Step		
Scan Data file name 1)		
Scan Data file name 2)		

5 Analysis Procedure and Log

5.1 Procedure

The analysis procedure here is based on the package called as Matlab. To find out the offsets and the beam shape, plot the data power (arbitrary units) verses Az/Al angle (θ) and fit a appropriate curve (usually gaussian is expected). We are interested in the peak and width of this gaussian curve.

1. Copy data files on a pendrive and transfer it to the Matlab PC. Create a directory named Mydocuments/Matlab/Data/batch/date and save the files.

2. Open each file in notepad and delete the first raw (header line) and rename e.g. altscan1.data

3. Click on MATLAB icon and browse into the appropriate folder (Look at the top left window named 'Current directory').

4. To load data
   `>> load altscan1.data`.

5. The number of data points should be declared as
   `>> n=360` (n=360 for continuum mode and is 400 for spectral mode data files), you may change acording to the length of your data. Any other constant for example here- vel (velocity), starta (start angle) and tpers (time per step), can be declared in a similar way.

6. Generate X axis
   `>> for i=1:n x(i) = starta + (i-1)*vel*tpers; end`

7. Load Y axis
   `>> for i=1:n y(i)=altscan1(i); end`

8. plot data
   `plot(x,y)`

9. To fit a curve
   `>> cftool(x,y)` This will open an interactive data plot.
   Click on - `Fitting - new fit`. Select `gaussian` in Type of fit. Then select the gaussian fuction from the list below. For the purpose select single peaked function of the form: $a_1 e^{-(\frac{x-b_1}{c_1})^2}$, click `Apply`.

10. Note down values of the fitting parameters $a_1, b_1 and c_1$. Parameter b_1 = Mean = peak of gaussian.

11. 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.

12. Parameter $c_1 = \sqrt{2}\sigma$, where sigma (σ) is the width of the gaussian.
The FWHM is then calculated from the Width (σ) as,

$$FWHM = 2.35 \times \sigma$$

13. To save the plot obtained in cftool
got to `File - print to figure - Insert x label, y label - file - save as - name.jpg - save`

5.2 Log

5.2.1 Altitude Scans

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

5.2.2 Azimuth Scans

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

6 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 as -

3. Beam-Width: ____________ Deg.

   The theoretical expected value is -

4. Beam-Width: ____________ Deg.

The sources of error in my experiment are as follows -