Determination of Pointing offsets of the telescope

1 Goal of the experiment

The main aim of this experiment is to align 3-m telescope at NCRA East Campus with the proper Alt-azimuth coordinate system allowing it to be pointed to a given radio astronomy source. This requires determining offsets of electronic reference of the telescope with respect to that of Alt-azimuth coordinate system at the observatory. 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 experiment is described next which also includes a warm-up exercise to generate familiarity with operation of the telescope and receiver system, useful in all subsequent experiments. The observation section provides a log of the experiment, which requires observations of Sun to determine azimuth and altitude offsets. This is followed by an analysis section, describing the analysis procedure followed by analysis log. Finally, a results section is provided for listing results alongwith the sources of error in the experiment.

2 Brain Teaser

1. Go out on the terrace and identify different directions on the sky. If sun is visible (i.e. it is not cloudy), 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.

2. Three strong radio sources are CRAB, CASA and CYGA. Which constellation harbour these ? Indicate below the names of the constellations and whether these sources are visible at the time of experiment. If yes, find the area of sky where these will be located.

3. Our galaxy - Milky way - forms a bright band in the sky visible on a dark night. Find out how the galaxy lies in the sky at the time of the experiment and draw it approximately on the hemisphere of the sky visible to us in the space provided below. Indicate whether the Galactic center, which is believed to harbour a supermassive black hole, is visible at the time of the experiment.

4. 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? Answer in the space provided below

5. Indicate the approximate time in IST today when the sources with following RA and Dec can be observed using our 4-m telescope at NCRA East Campus

01h30m	33d20'
05h31m	21d10'
04h37m	-56d01'
17h10m	-30d23'
21h25m	+40d21'

3 Operation of telescope and the procedure for the experiment

The operation of telescope and the receiver is described in this section followed by the procedure for this experiment. The former part is common to all experiments and will be referred to in the procedure for subsequent experiment.

3.1 The 3-m SRT

The telescope consists of the following subsystems

1. 3-m dish mounted on an altitude-azimuth mount
2. Drives
3. 21-cm feed mounted on a quadripod and Receiver
4. Stamp Controller
5. Control Laptop

3.2 Initialization of telescope

1. 3-m telescope is located on the roof of NCRA East Campus and is powered from a wall socket on the wall through an extension board. Switch on the extension board.
2. Connect Controller to power extender board and power it.
3. Connect Laptop to power extender board and power it.
4. Connect controller to serial port of the Laptop using the cable provided.
5. Connect the coaxial RF cable from the antenna receiver to the controller.
6. Click on SRT icon on the Laptop desktop. This will open s display as shown in Figure 1 of SRT manual.

7. Familiarize yourself with the various display areas and buttons as explained in the SRT manual. In particular, understand the functions of "Stow", "Azel", "freq", "offset", "track" and "record" buttons on the 15-button command toolbar for this experiment.

8. Set the frequency mode using "freq" button to 1420.0 4 (RF frequency 1420.0 MHz and bandwidth of 1.2 MHz and 156 channels across bands). The local oscillator and the receiver bandwidth is set using this command producing a 156 point spectrum across the band.

9. Initialize the telescope coordinate system by moving the telescope to the stow position (0 deg az, 10 deg elevation) by pressing "Stow" button.

In case of problem contact myself or Sudip.

3.3 Procedure for the pointing experiment

Do the initialization of the telescope control and receiver as explained above. This experiment can be done by pointing the antenna approximately at Sun visually if the sky is not cloudy. To do this, rotate antenna approximately in the direction of the Sun and look for the shadow of the feed at the center of the dish. Rotate the antenna till the shadow is centered approximately. This method will not work if there are clouds or the altitude is too high. Then the telescope can be pointed to Alt-Azimuth of Sun at the current time by looking at the Annexure 1. Slew in Azimuth and altitude repeatedly to get to peak deflection on Sun in the receiver by looking at the value pointed in the chart recorder part of the display. Then, the following procedure is to be used.

1. Move 10 degrees away from the position of Sun in altitude. Press "Azel" followed by the required Azimuth altitude position.

2. Start recording data. Press "record" followed by a filename such as "RAS_OFF_batch1_el_ddmm_hhmm". Press "record" again to start recording data

3. Wait for 5 seconds to record data

4. Move towards the position of the Sun and 10 degrees beyond in steps of 1 degree. Each time, press "Azel" followed by the required Azimuth altitude position.

5. At each position in the last step wait for 5 to 10 seconds to record data

6. Stop recording the data. Press "record".

7. Repeat the above steps in opposite direction for a second scan in Elevation.

8. Position the antenna on the position of the Sun again

9. Repeat steps 1 to 7 two Azimuth Scans

4 Observation Log

1. Altitude Scan - 1

   (a) Scan Data file name :

2. Altitude Scan - 2

   (a) Scan Data file name :

3. Azimuth Scan - 1

   (a) Scan Data file name :

4. Azimuth Scan - 2

   (a) Scan Data file name :

5 Analysis Procedure and Log

5.1 Procedure

1. Open the data file in EXCEL spreadsheet format in the laptop.

2. The typical data file has the following format - time, Az, Alt, azimuth offset, altitude offset, RF, freq resolution, receiver mode, number of channels, powers in ch1, ch2, ..., ch N.

3. To get continuum power, add the powers in all channels and store it in the last column of the spreadsheet

4. Export time, azimuth, altitude and sum column to ASCII file using excel export option to write to an ASCII file with similar name but .asc extension.

5. Repeat this for all data files.

6. Copy exported data files to a PEN drive and transfer to MATLAB PC (located in Room No 8 on the first floor) for analysis.

7. Copy data files to MATLAB local working directory and rename to shorter names such as "altscan1.data" and so on.

8. load data in MATLAB using "load altscan1.dat"

9. Generate X axis using "x=zeros(1,n)" where n is the number of data-point "time=zeros(1,n)" and Y axis by "y=zeros(1,n)"

10. Load Xaxis by (for azimuth) "for i=1:n x(i) = altscan1(2,i);end" Load Xaxis by (for elevation) "for i=1:n x(i) = altscan1(3,i);end"

11. Load Time axis by "for i=1:n time(i) = altscan1(1,i);end"

12. Load yaxis by "for i=1:n y(i) = altscan1(4,i);end"

13. plot data using "plot(time,y)" and "plot(x,y)"

14. Choose the datapoints near the peak of the deflection on sun.

15. Copy these data points to two arrays datax, time and datay

16. Type “cftool” to go to curve fitting tool box
17. select datax and datay as X and Y arrays in DATA tab
18. Select “New fit” and “Gaussian fit” in fit tab. This will fit a Gaussian and display its parameters and errors
19. select time and datay as X and Y arrays in DATA tab
20. Select “New fit” and “Gaussian fit” in fit tab. This will fit a Gaussian and display its parameters and errors. The parameter “b” gives the time at the peak.
21. Look up Sun Alt-Azimuth at the time of the scan from the Annexure provided. The difference is the offset. The offset needs to be scaled for altitude position in case of Azimuth.
22. Enter the above in the Log provided below and attach fitted plots

5.2 Log

1. Altitude Scan - 1
   - (a) Datapoint selected : to
   - (b) Peak of Gaussian : degrees ±
   - (c) Peak of Gaussian : time ±
   - (d) FWHM of Gaussian : degrees ±
   - (e) Expected Azimuth : degrees
   - (f) Expected Altitude : degrees
   - (g) Offset : degrees
2. Altitude Scan - 2
   - (a) Datapoint selected : to
   - (b) Peak of Gaussian : degrees ±
   - (c) Peak of Gaussian : time ±
   - (d) FWHM of Gaussian : degrees ±

(e) Expected Azimuth : degrees
(f) Expected Altitude : degrees
(g) Offset : degrees

3. Altitude Scan - 1

   (a) Datapoint selected : to
   (b) Peak of Gaussian : degrees ±
   (c) Peak of Gaussian : time ±
   (d) FWHM of Gaussian : degrees ±
   (e) Expected Azimuth : degrees
   (f) Expected Altitude : degrees
   (g) Offset : degrees

4. Altitude Scan - 2

   (a) Datapoint selected : to
   (b) Peak of Gaussian : degrees ±
   (c) Peak of Gaussian : time ±
   (d) FWHM of Gaussian : degrees ±
   (e) Expected Azimuth : degrees
   (f) Expected Altitude : degrees
   (g) Offset : degrees

6 Results and Discussion

The estimate of pointing offsets are as follows

1. Azimuth Offset : degrees
2. Altitude Offset : degrees

The sources of error in my experiment are as follows