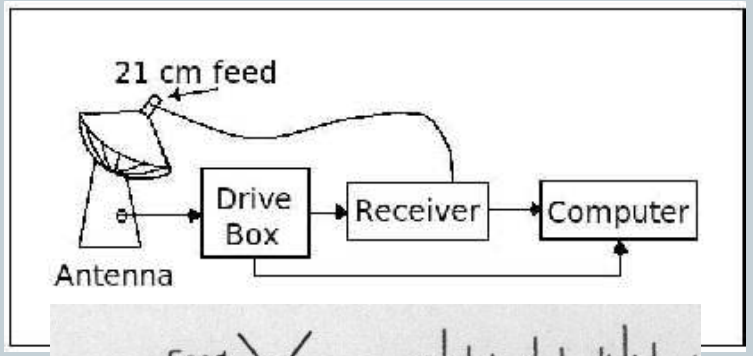
Determination of Pointing Offsets and Beam Pattern for 4 m Radio Telescope

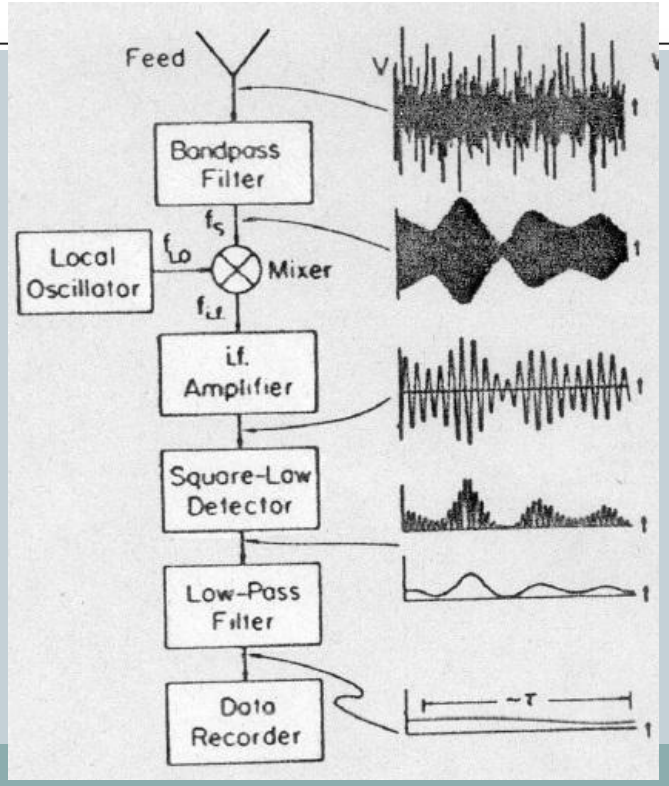
GROUP 4 "BOSE", RAWS
28TH DECEMBER, 2012
NCRA, PUNE

Theory and Equipment

The 4 m Radio Telescope

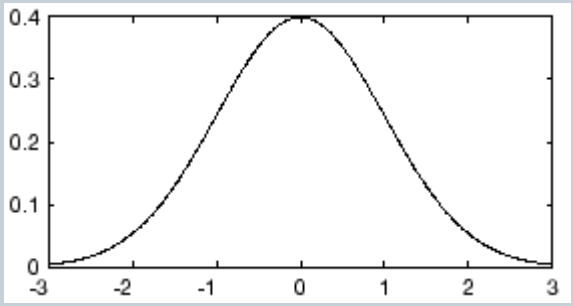
- Operates at the 21 cm range
- Uses a superheterodyne receiver





Gaussian Distribution

- Mean μ
- Standard deviation σ
- FWHM $2\sigma\sqrt{2ln2}$



$$y = f(x \mid \mu, \sigma) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(x-\mu)^2}{2\sigma^2}}$$

Error bounds

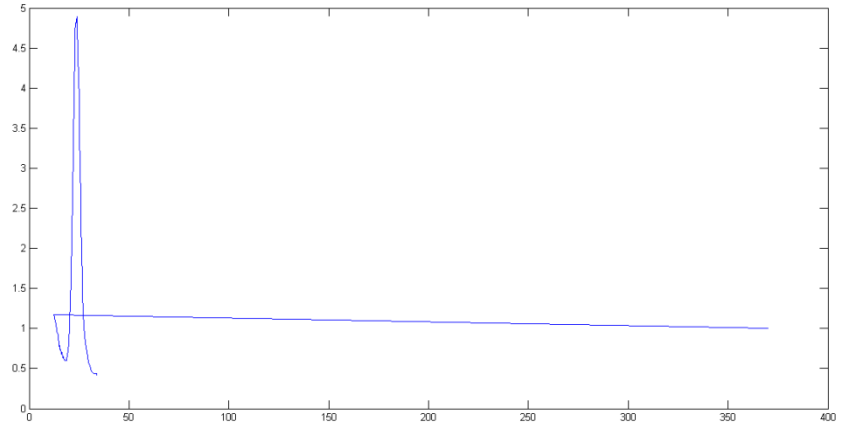
- Chi squared fitting
- Degrees of freedom
- Root mean square error

$$SSE = \sum_{i=1}^{n} w_i (y_i - \hat{y}_i)^2$$

Data and Analysis

Data Flagging

ORIGINAL



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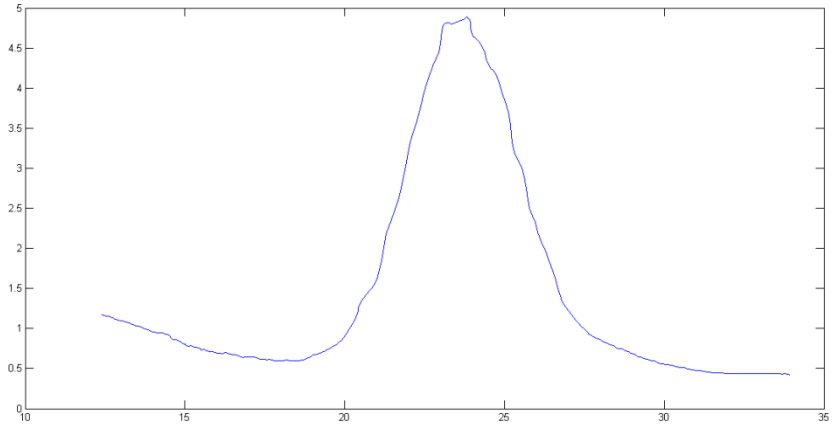
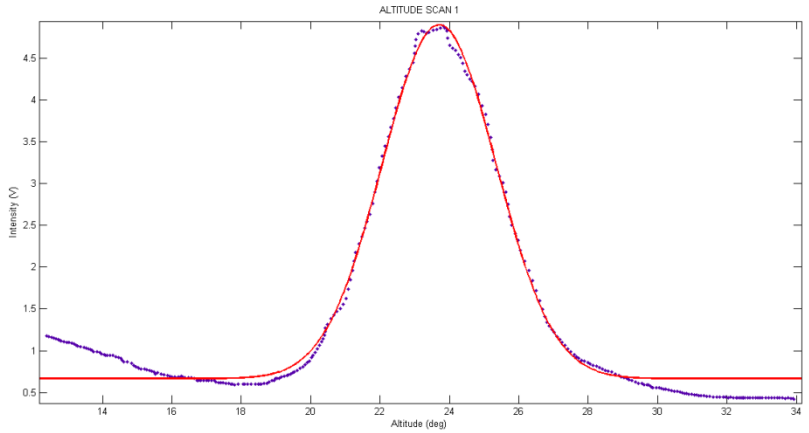
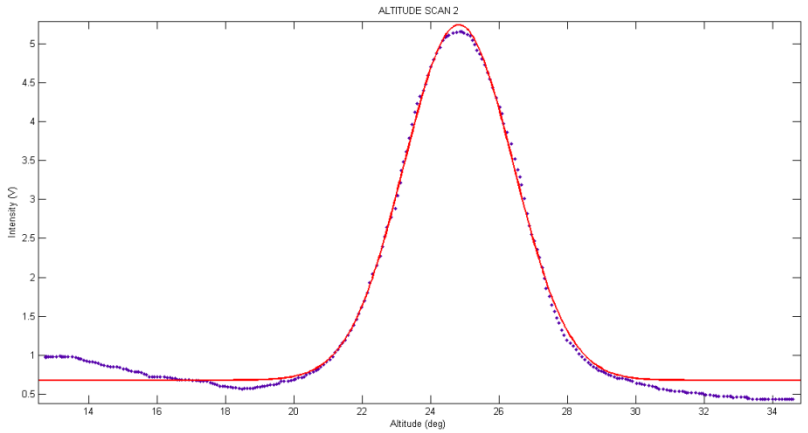


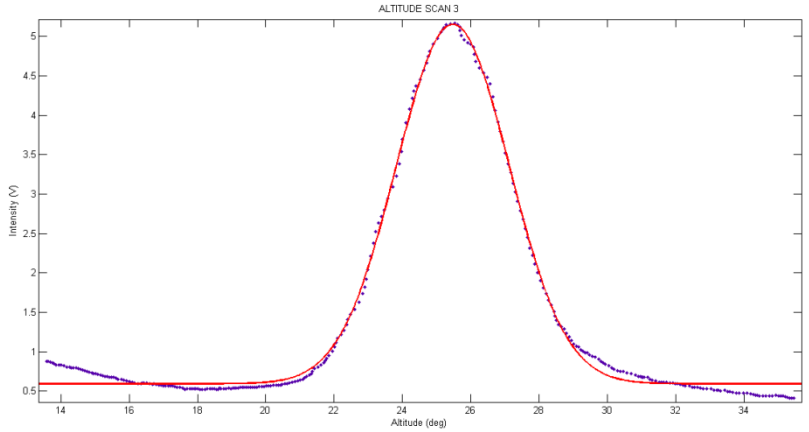
Curve Parameters

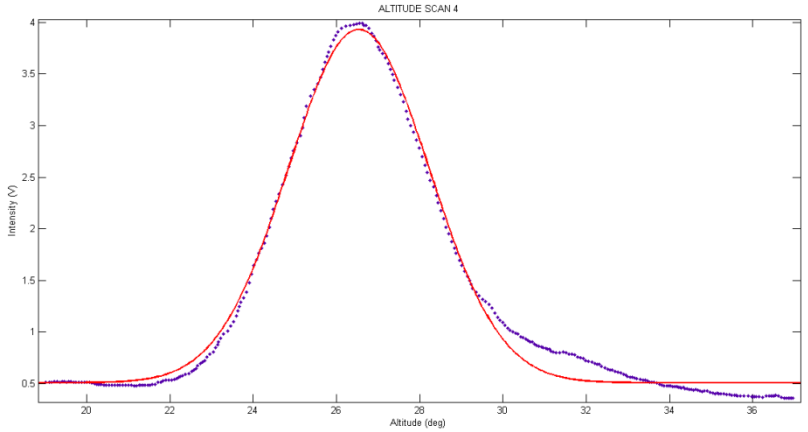
	Altitude Scan - I	Altitude Scan - II	Altitude Scan - III	Altitude Scan - IV
Peak of Gaussian	23.70°	24.82°	25.47°	26.54°
FWHM of Gaussian	3.86°	3.76°	3.88°	3.98°
Expected Altitude	24.51°	25.25°	26.18°	26.91°
Offset	-0.81°	-0.43°	-0.71°	-0.37°
RMSE	0.1694	0.1549	0.0945	0.1065

Curve Fitting





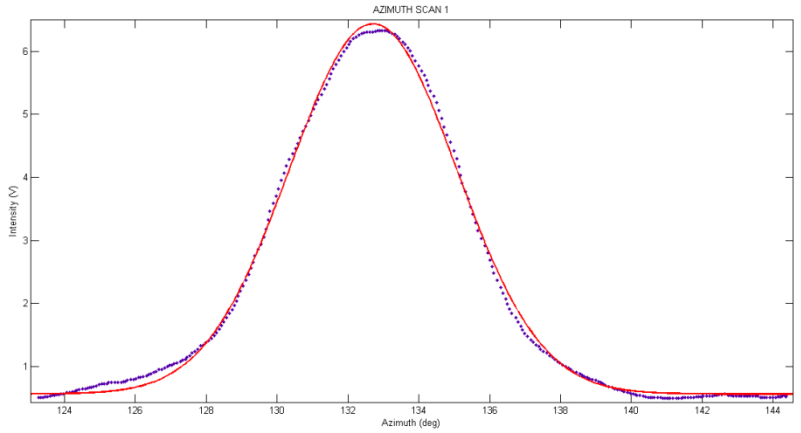


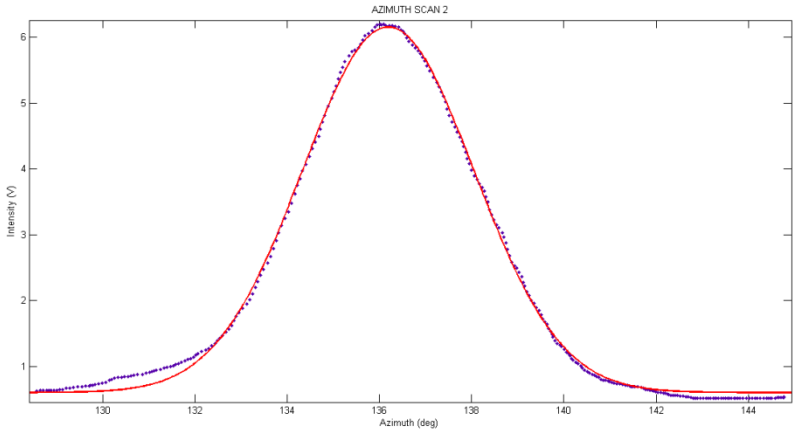


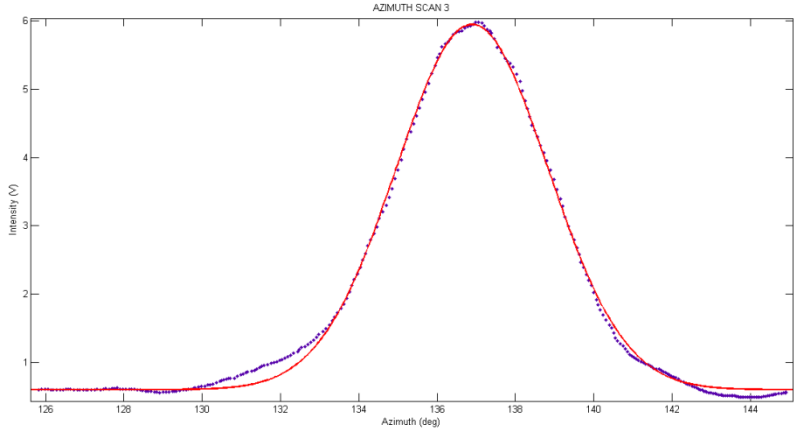
Curve Parameters

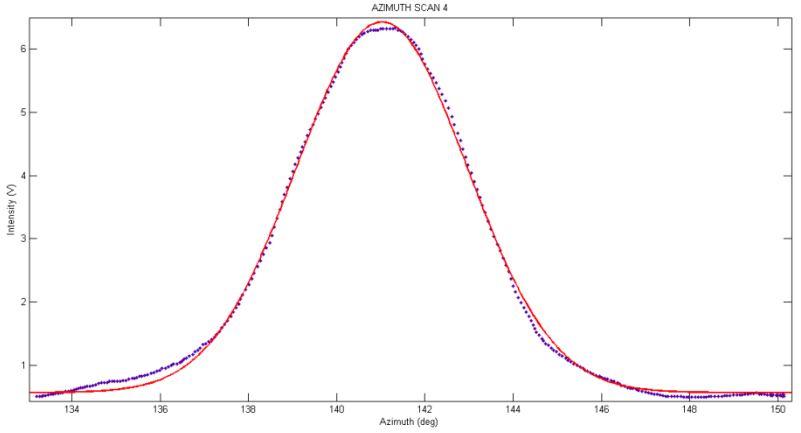
	Azimuth Scan - I	Azimuth Scan - II	Azimuth Scan - III	Azimuth Scan - IV
Peak of Gaussian	132.7°	136.2°	136.9°	141.0°
FWHM of Gaussian	5.57°	4.39°	4.56°	4.56°
Expected Azimuth	125.95°	126.64°	127.34°	131.00°
Offset	6.75°	9.56°	9.56°	10.00°
RMSE	0.0932	0.0819	0.0860	0.0819

Curve Fitting

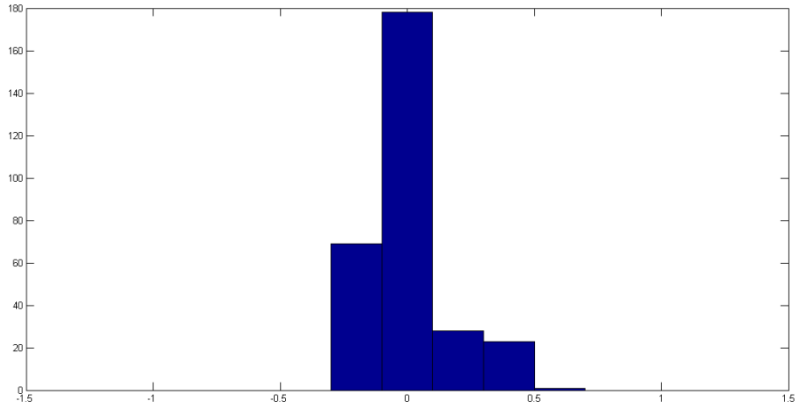


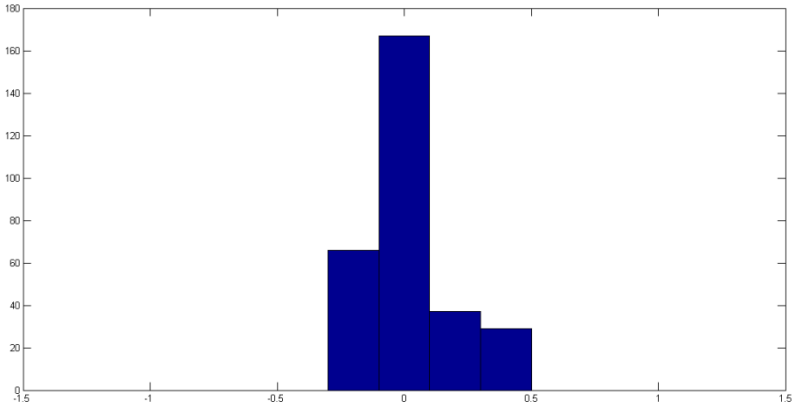


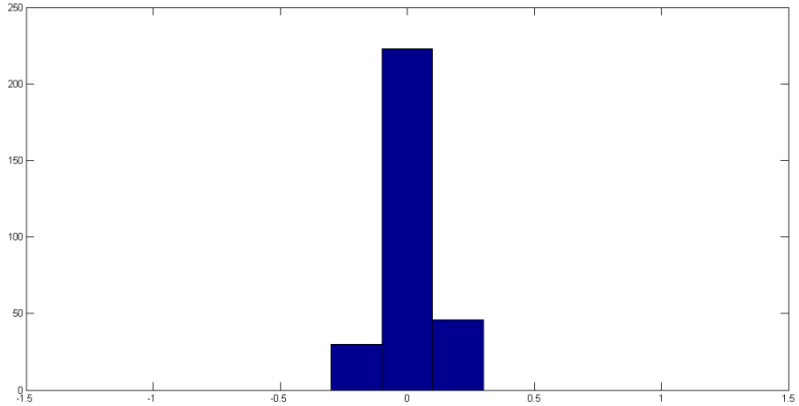


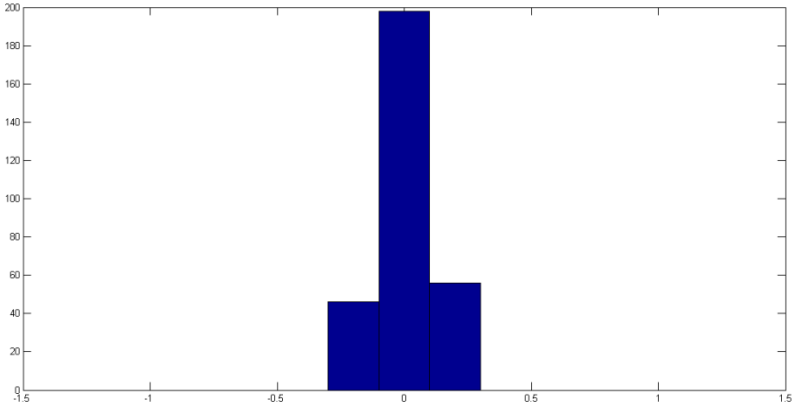


Error Spread









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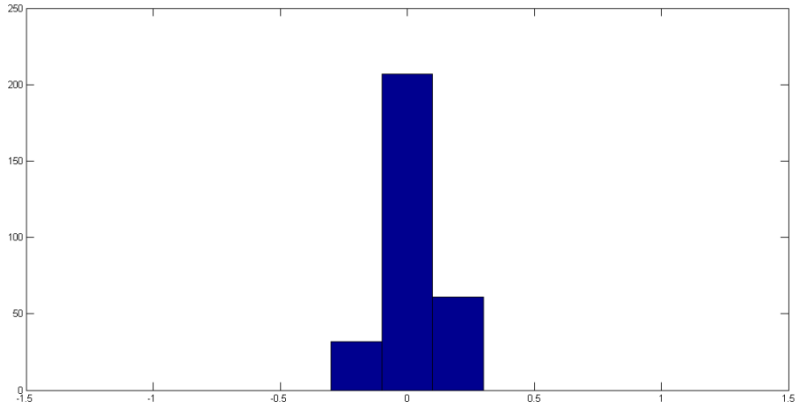
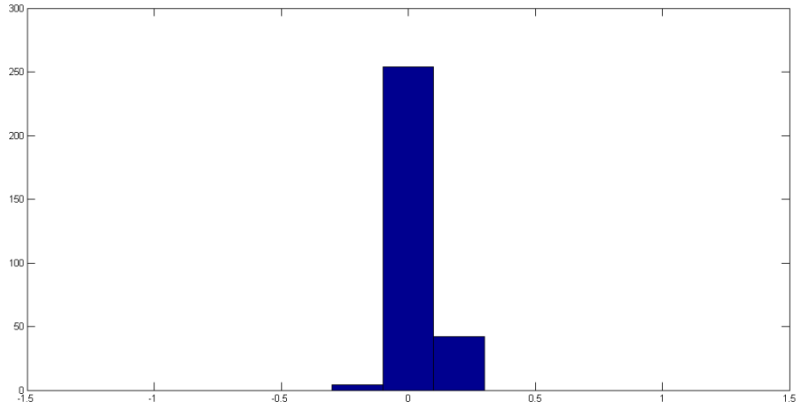
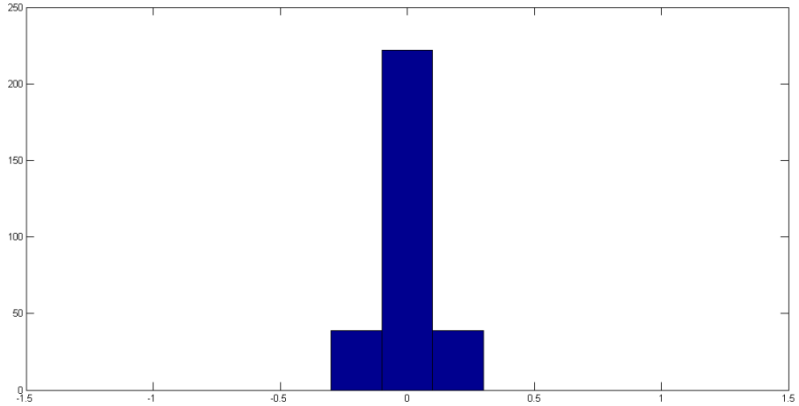
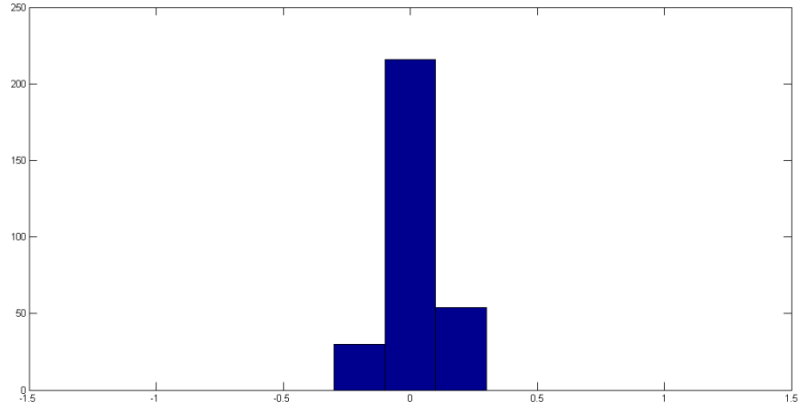




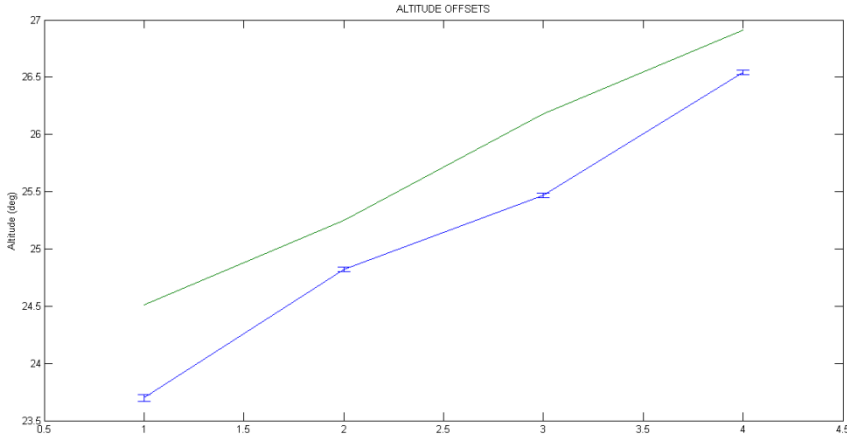


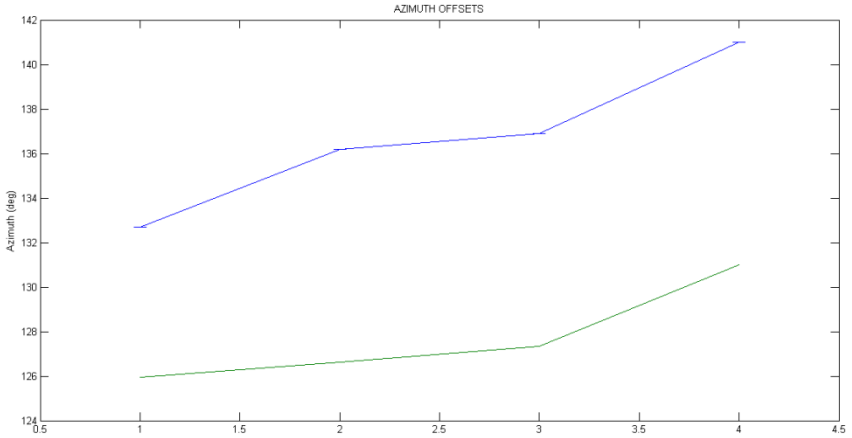


Pointing Offsets

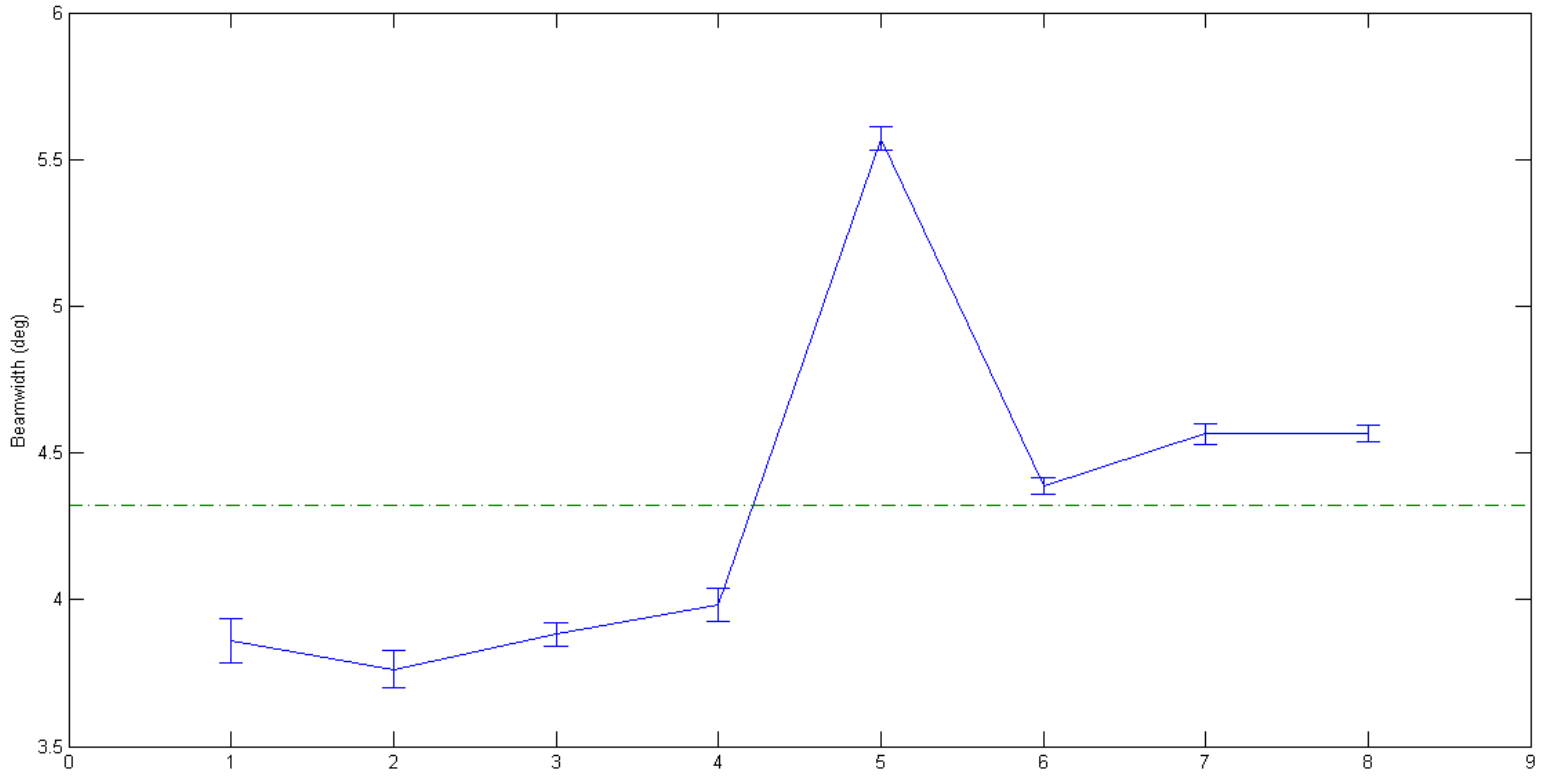
AZIMUTH

ALTITUDE





Beam Width



Results and Discussion

Findings

- Estimate of pointing offsets:
  - Azimuth Offset: -0.6±0.1 °
  - Altitude Offset: +9±1 °
- Beam Width or FWHM from beam pattern:
  - Experimental: 4.3±0.3 °
- Theoretical beam width:

$$\theta = \frac{1.22\,\lambda}{D} = \frac{1.22 \times .211}{4} = 0.064 = 3.69°$$

Inferences

- Offsets follows Gaussian error distribution
- Sun's angular diameter is less than 4.3°
- Ground also has a prominent radio signature
- Baseline interferometry can resolve the Sun and find its angular diameter

Sources of error

- Low power manmade radio sources
- Shortwave band interference
- Fluctuation in encoder readouts
- Fluctuations in solar power output

Questions