LMT Performance

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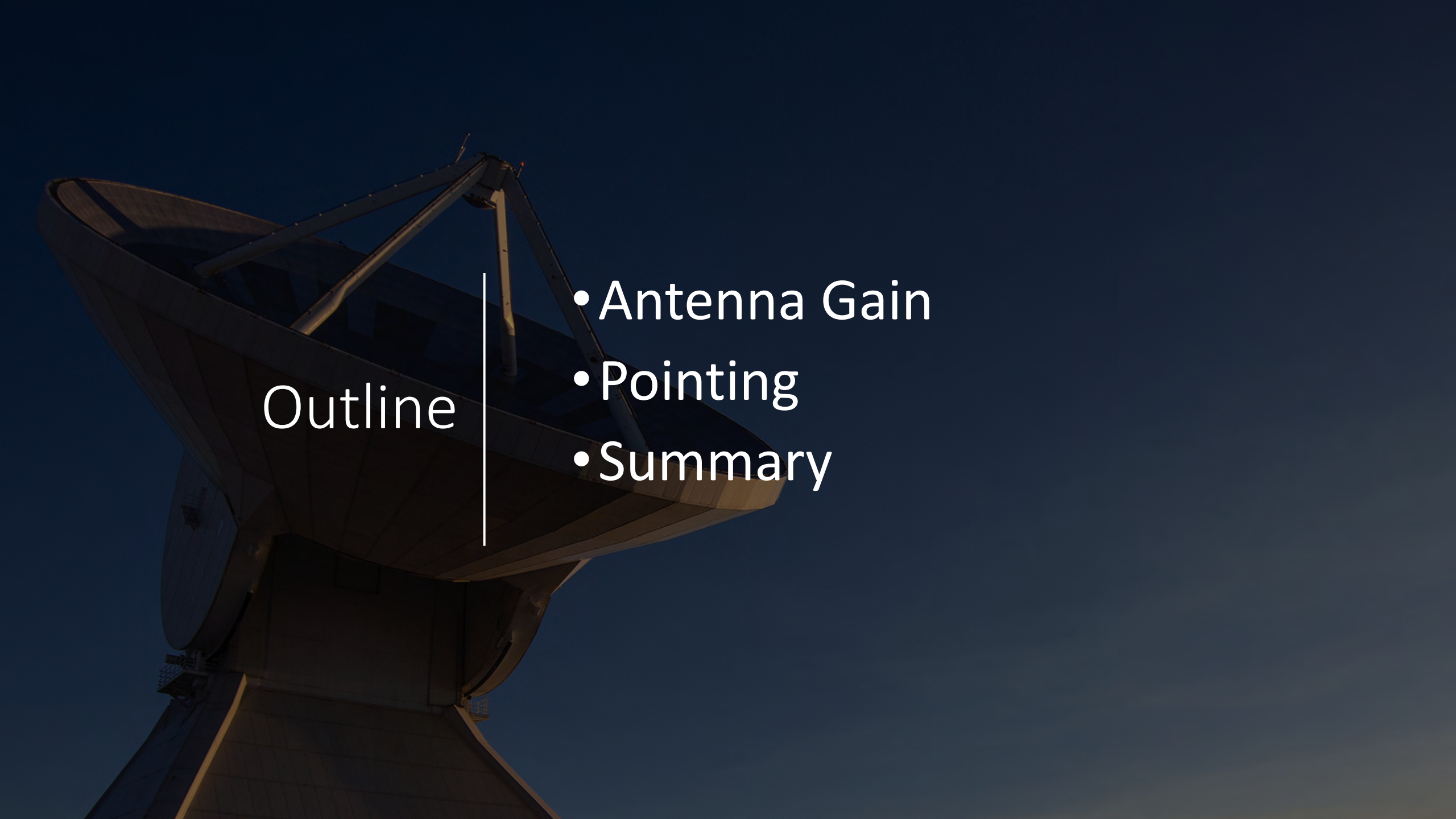
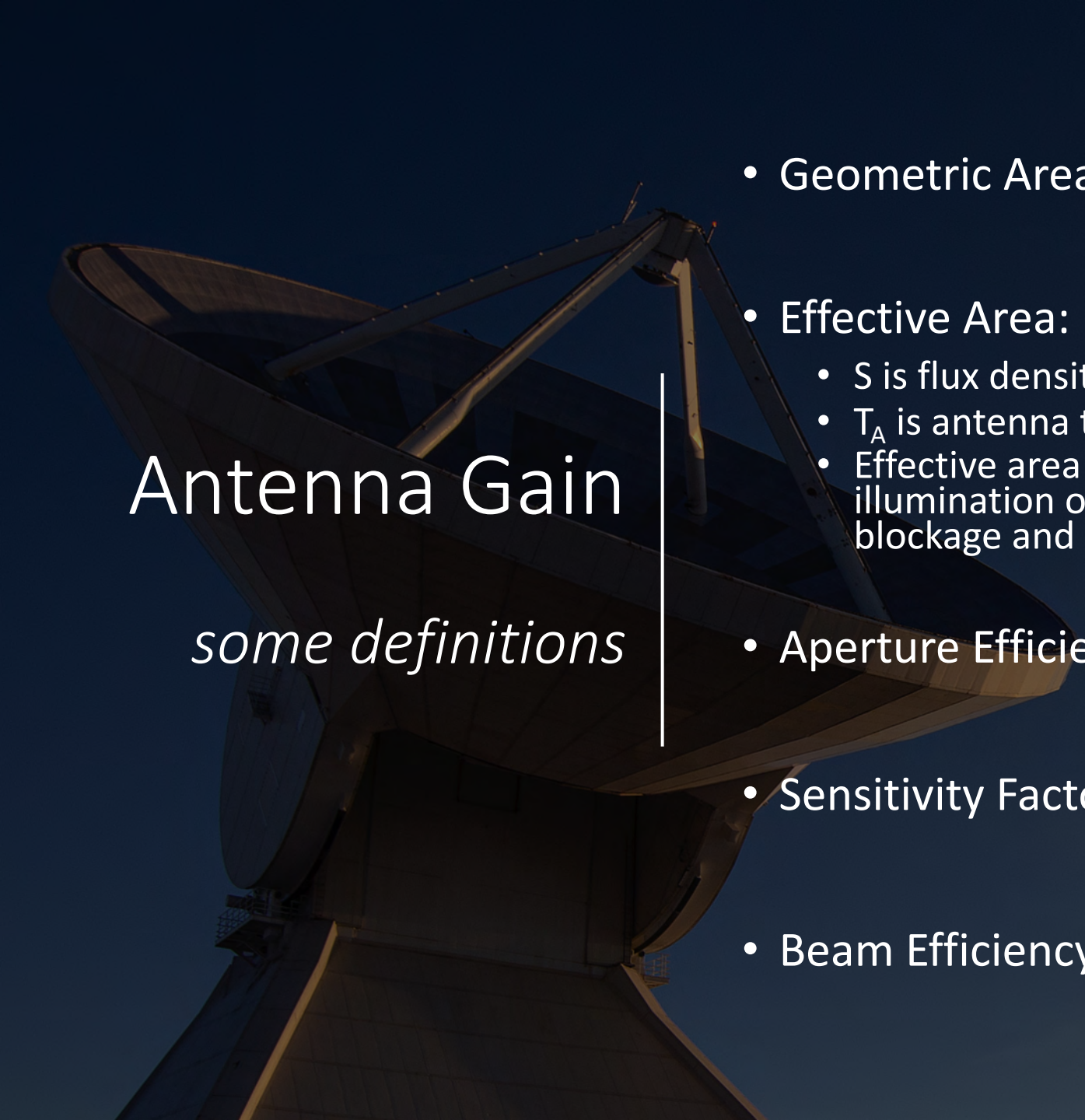
LMT Community Meeting
December 4, 2020



Outline

- Antenna Gain
- Pointing
- Summary



Antenna Gain

some definitions

- Geometric Area : $A_G = \frac{\pi}{4} D^2 = 1963.5\ m^2$
- Effective Area: $A_E = \frac{2kT_A}{S}$
  - S is flux density of calibration source
  - T_A is antenna temperature observed on source
  - Effective area is always less than geometric area due to illumination of aperture by receiver, antenna surface errors, blockage and shadowing of the aperture.
- Aperture Efficiency: $\eta_A = \frac{A_E}{A_G}$
- Sensitivity Factor: $G = \frac{2k}{A_E}\ Jy\ K^{-1}$
- Beam Efficiency (Main) $\eta_B = \frac{\iint_{MB} B(x,y)\,dx\,dy}{\iint_{-\infty}^{+\infty} B(x,y)\,dx\,dy}$

B(x,y) is the power pattern of the antenna

Antenna Gain

Expected Frequency Dependence

- Frequency Dependence of Effective Area is well described by *Ruze Theory*[1]

$$A_E(\nu) = A_E(0)\, e^{-\left(\frac{4\pi\nu}{c}\epsilon\right)^2}$$

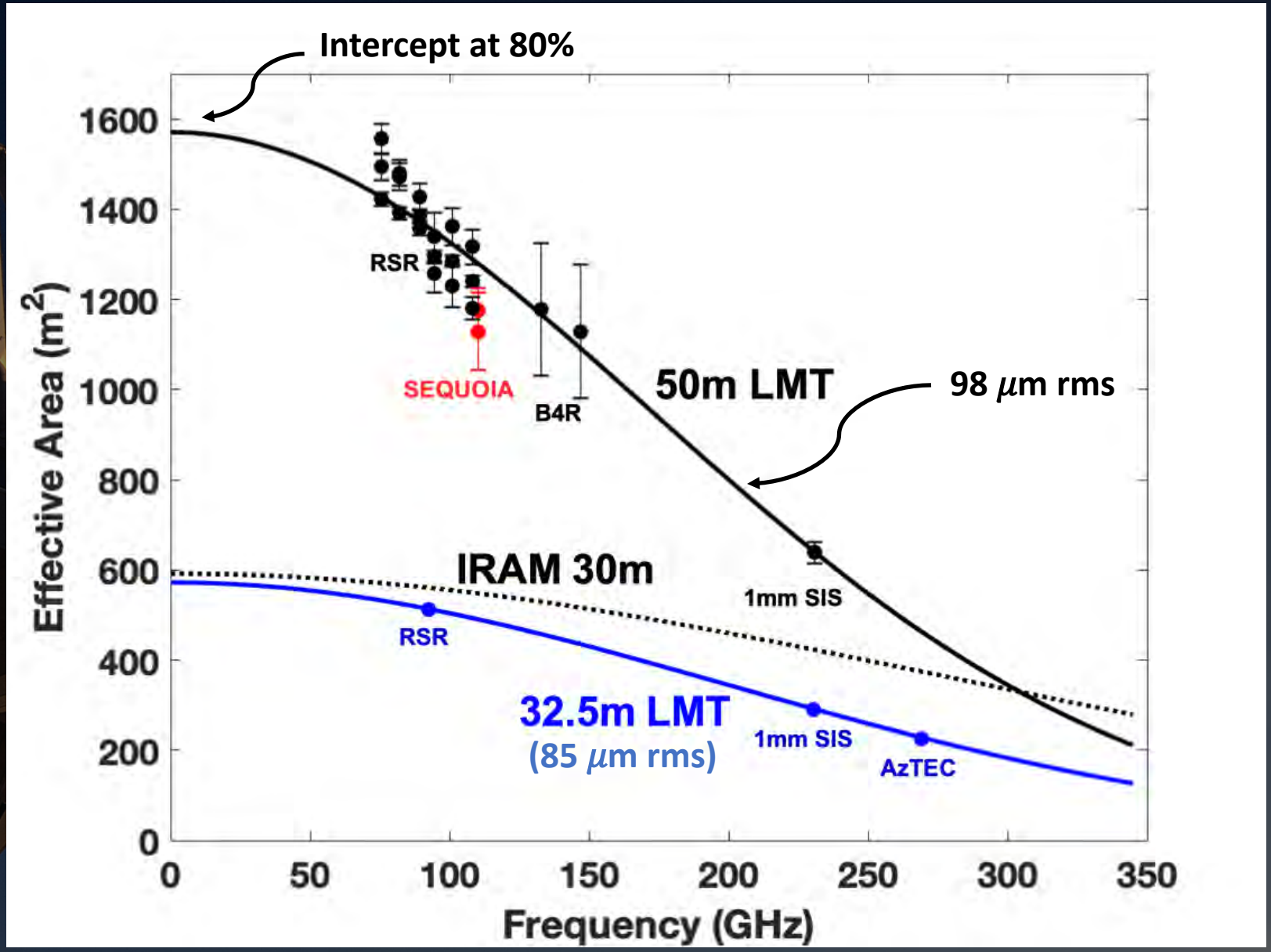
where ε is rms surface error; ν is frequency

- $A_E(0)$ is effective area at 0 frequency. It includes effects of:
  - antenna blockage and shadowing
  - receiver illumination of primary

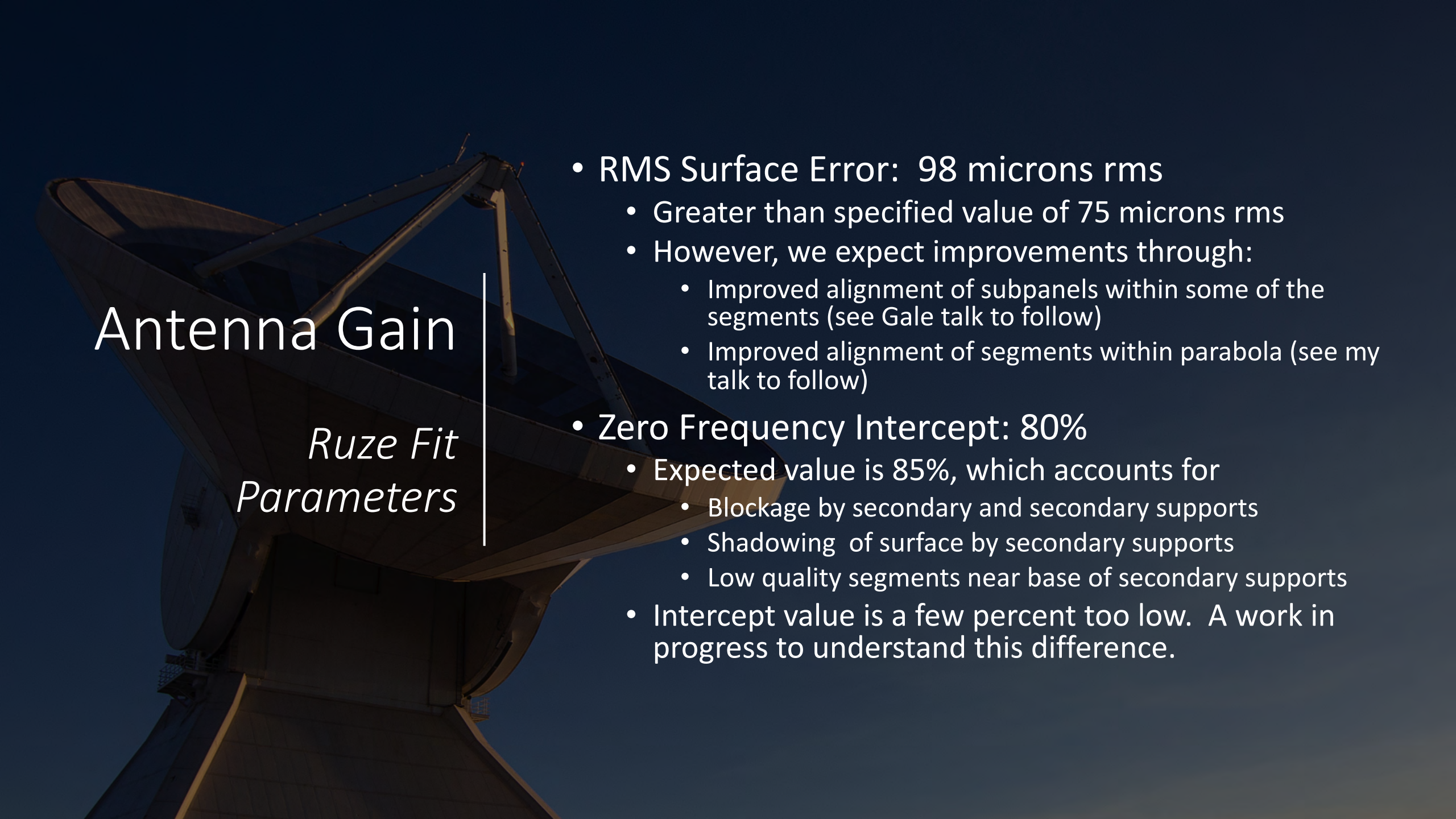
[1] J. Ruze, Proceedings of the IEEE, vol. 54, pp 633-642 (1966)

Antenna Gain

Ruze Plot



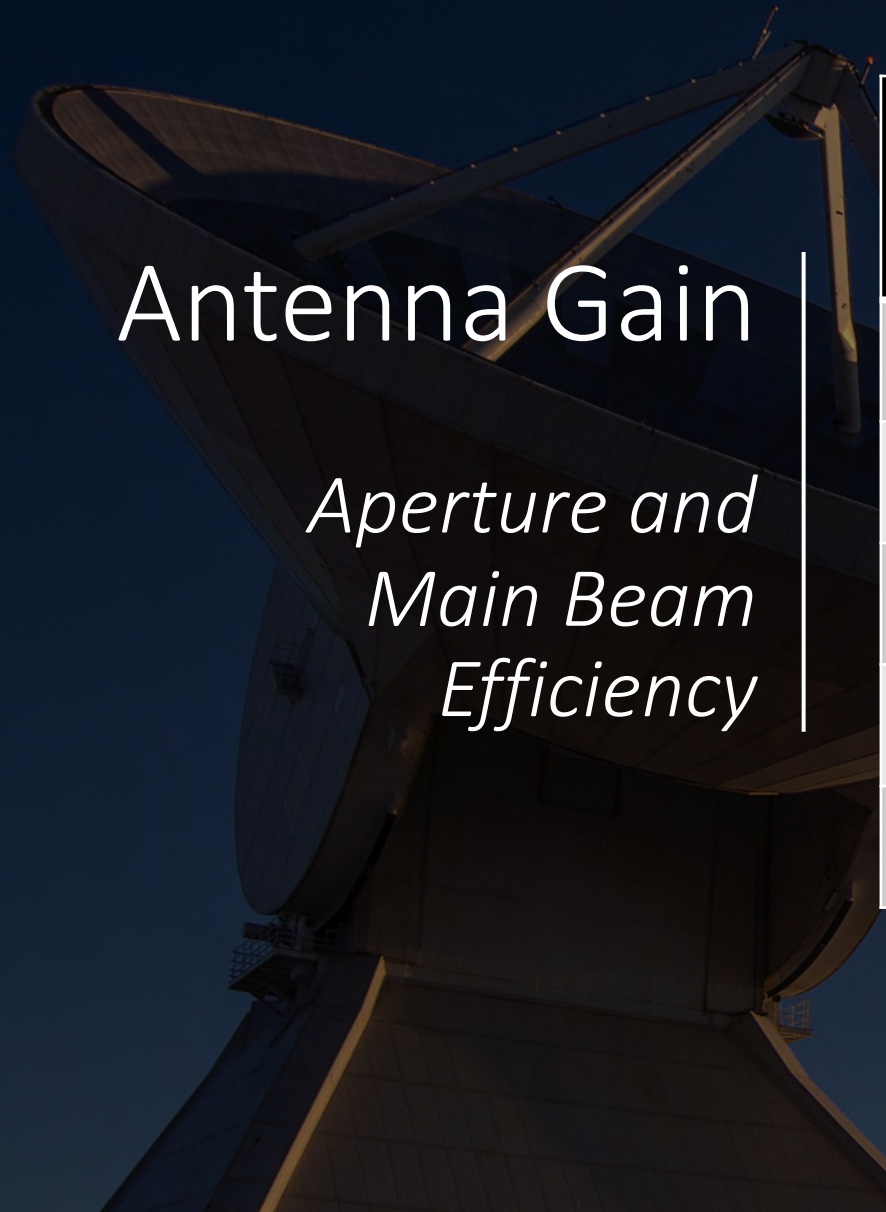
Note: Effective area is corrected for receiver illumination of primary in this plot.



Antenna Gain

Ruze Fit Parameters

- RMS Surface Error: 98 microns rms
  - Greater than specified value of 75 microns rms
  - However, we expect improvements through:
    - Improved alignment of subpanels within some of the segments (see Gale talk to follow)
    - Improved alignment of segments within parabola (see my talk to follow)
- Zero Frequency Intercept: 80%
  - Expected value is 85%, which accounts for
    - Blockage by secondary and secondary supports
    - Shadowing of surface by secondary supports
    - Low quality segments near base of secondary supports
  - Intercept value is a few percent too low. A work in progress to understand this difference.



Antenna Gain

Aperture and Main Beam Efficiency

FREQUENCY (GHz)	η_A	η_{MB}	G (Jy/K)
85	0.58	0.68	2.42
100	0.55	0.65	2.56
115	0.52	0.61	2.70
140	0.47	0.55	2.99
230	0.27	0.31	5.21

Aperture efficiency based on Ruze fit; Main beam efficiency is estimated

Antenna Pointing

some definitions

Absolute Pointing

Ability to point at any location in the sky

We think this is about 2” rms

Relative (Offset) Pointing

Ability to point after a pointing check on a nearby (~10 degrees) radio source

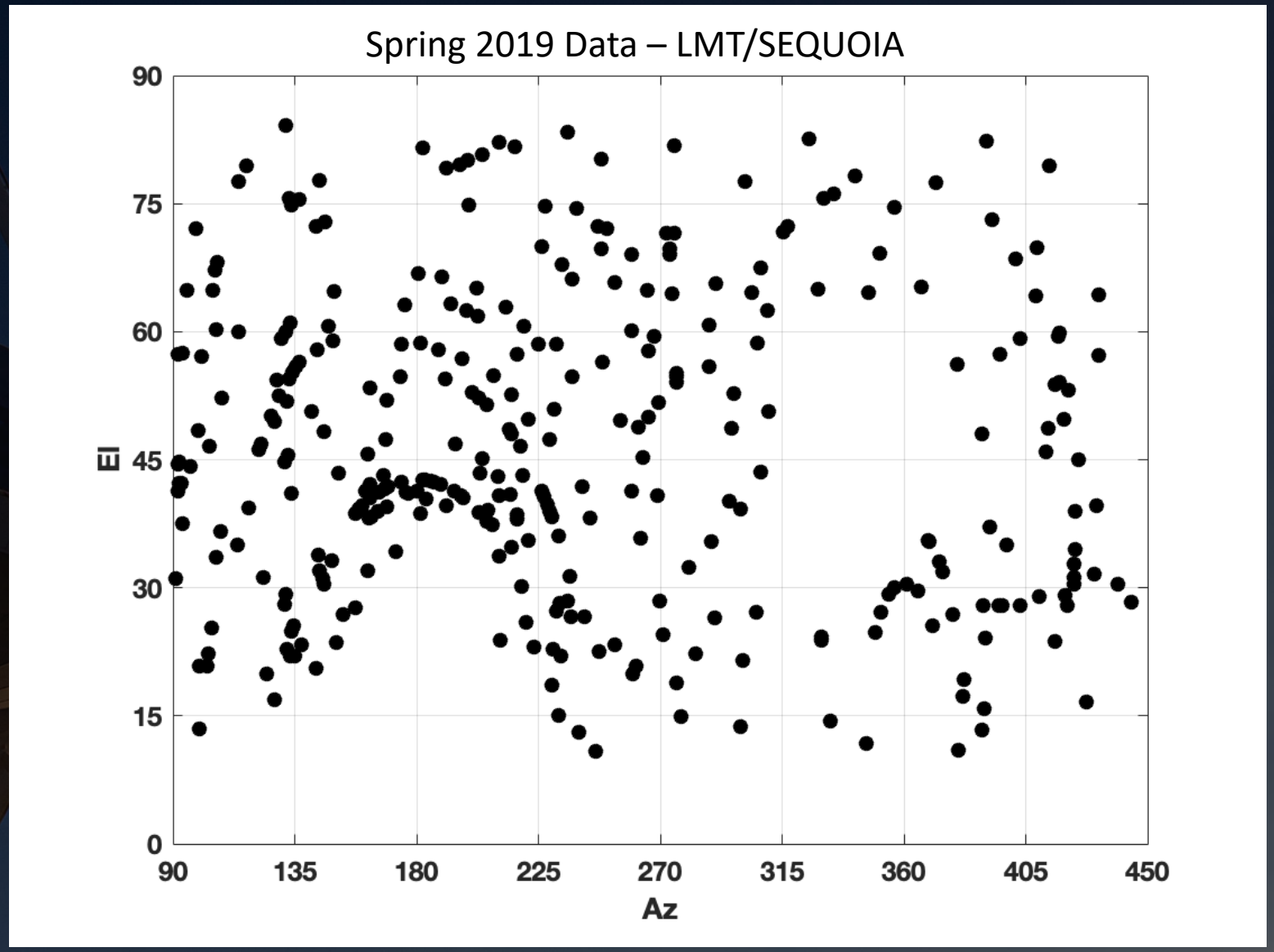
We think this is about 1” rms

Note: Pointing is not strongly affected by winds less than operational design limit of 10 m/s.

Antenna Pointing

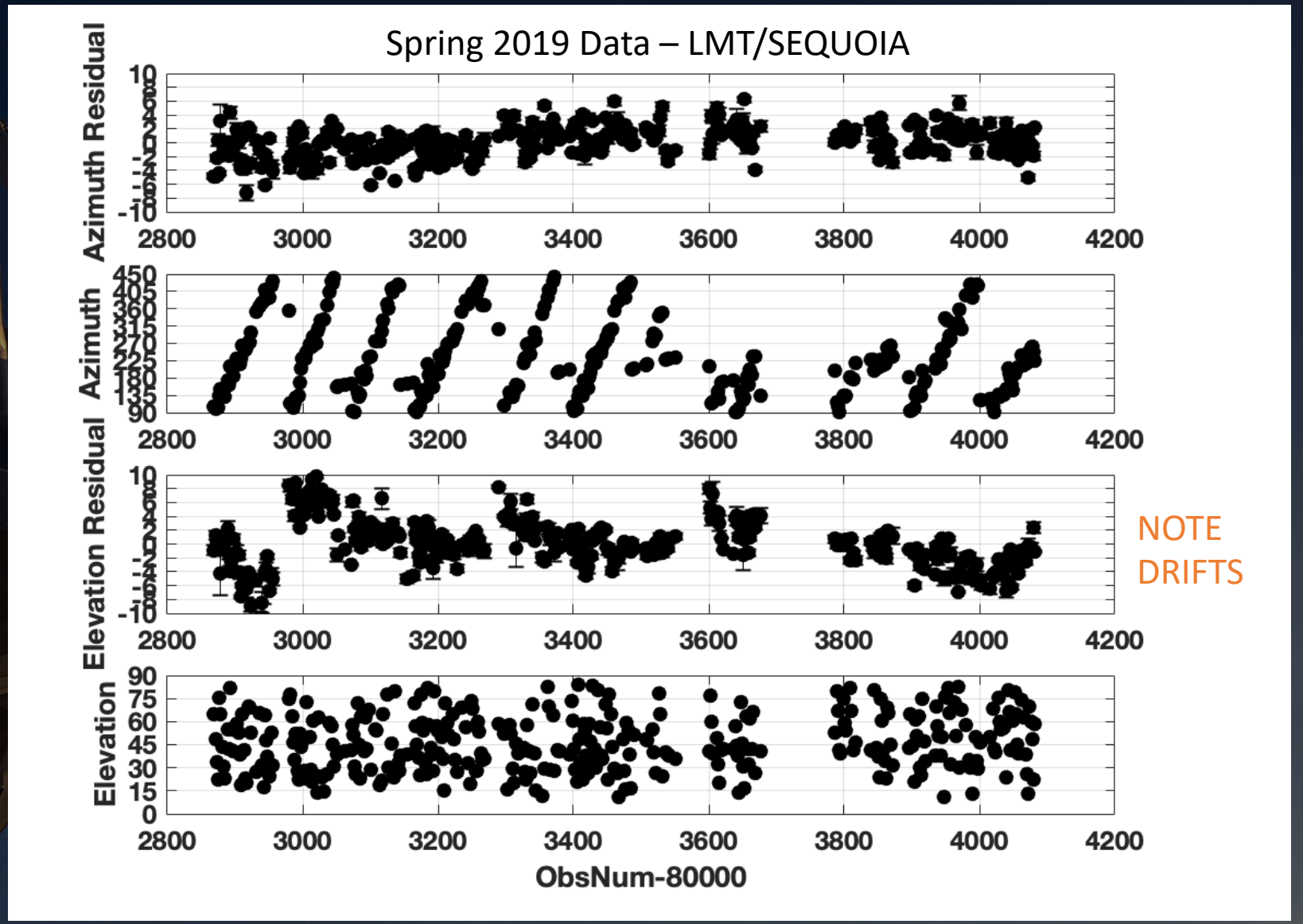
All Sky Data

Spring 2019
5 nights
LMT SEQUOIA



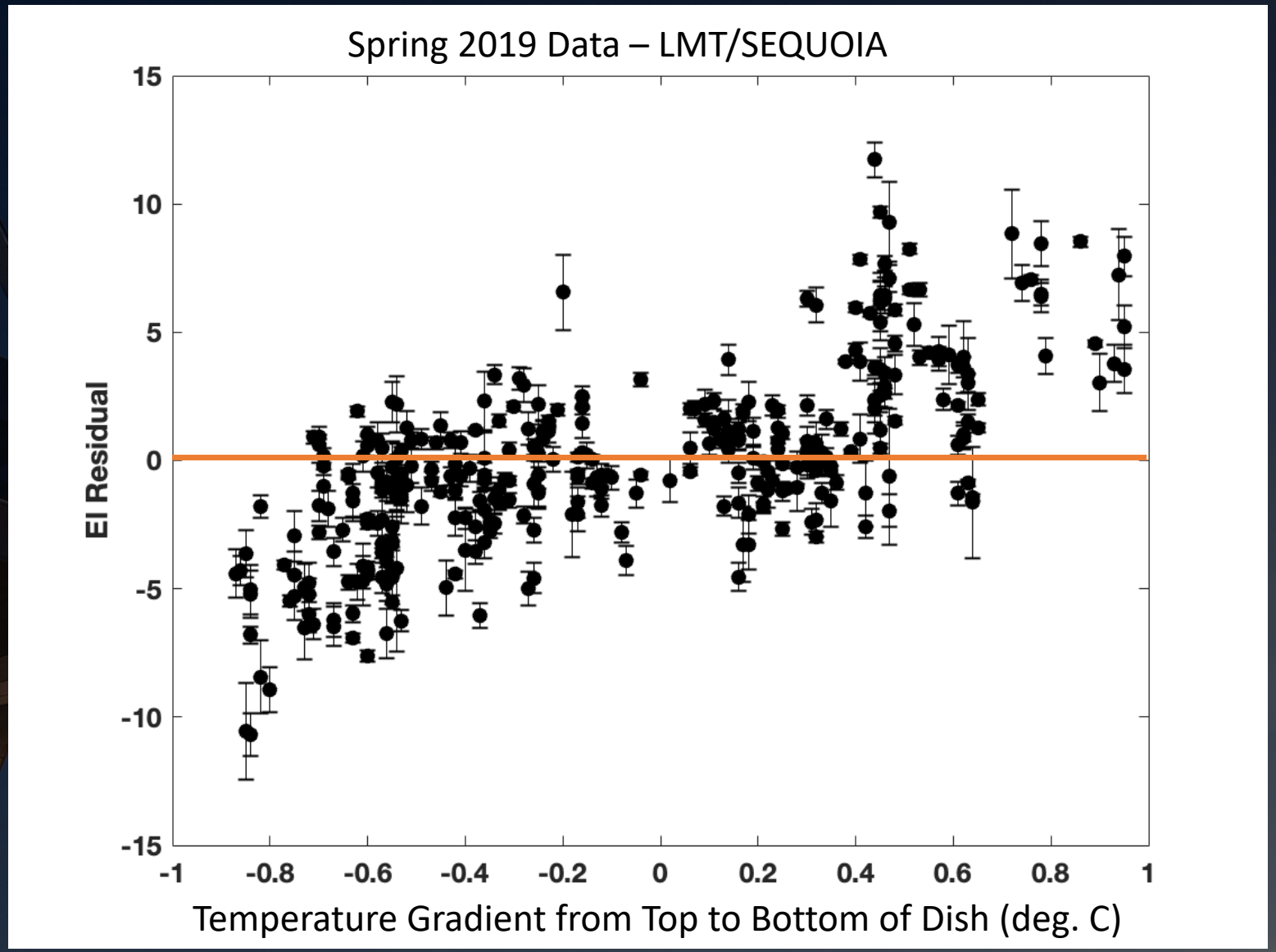
Antenna Pointing

Residuals to All Sky Pointing Model



Antenna Pointing

Residuals compared to temperature gradients

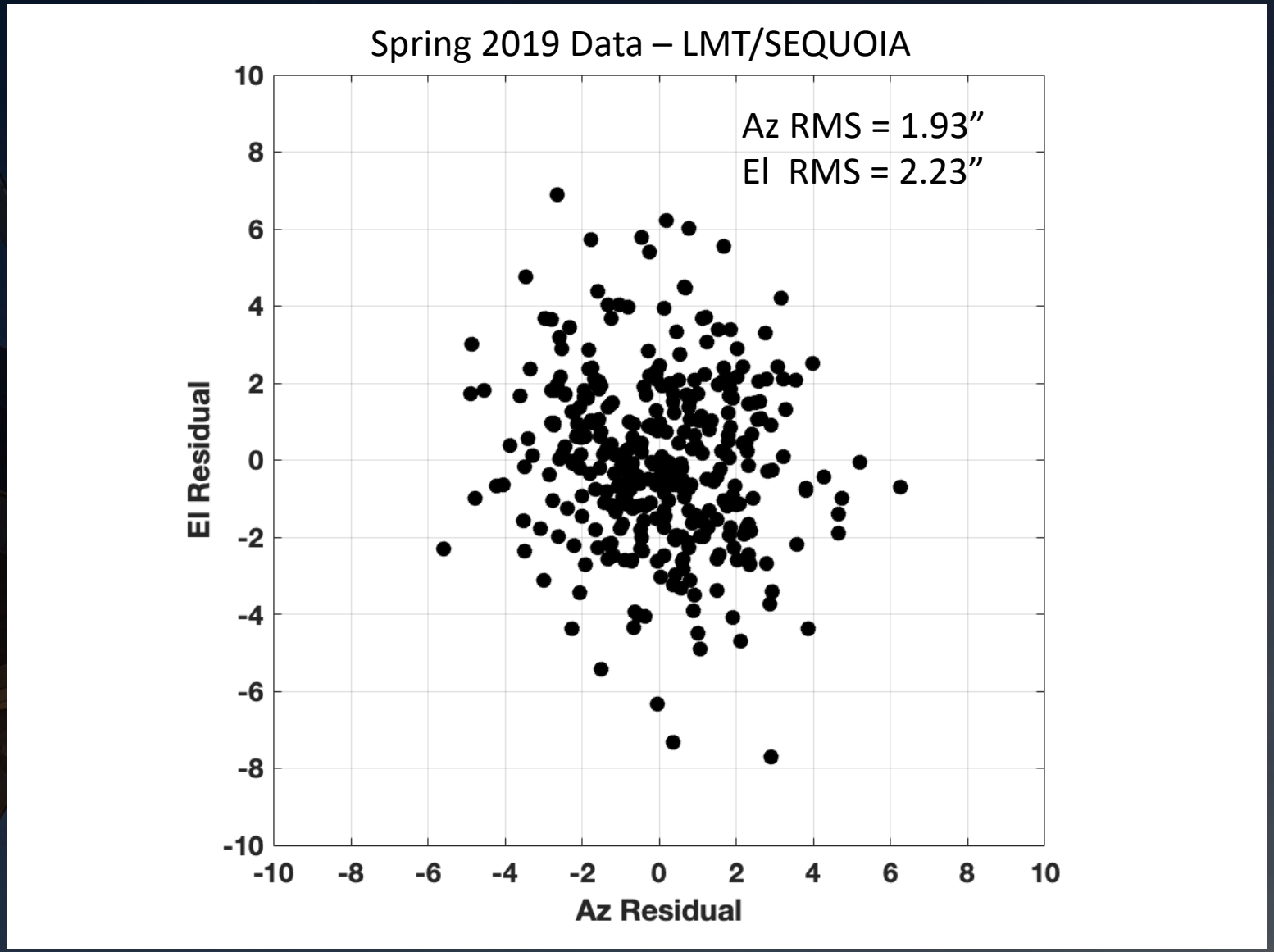


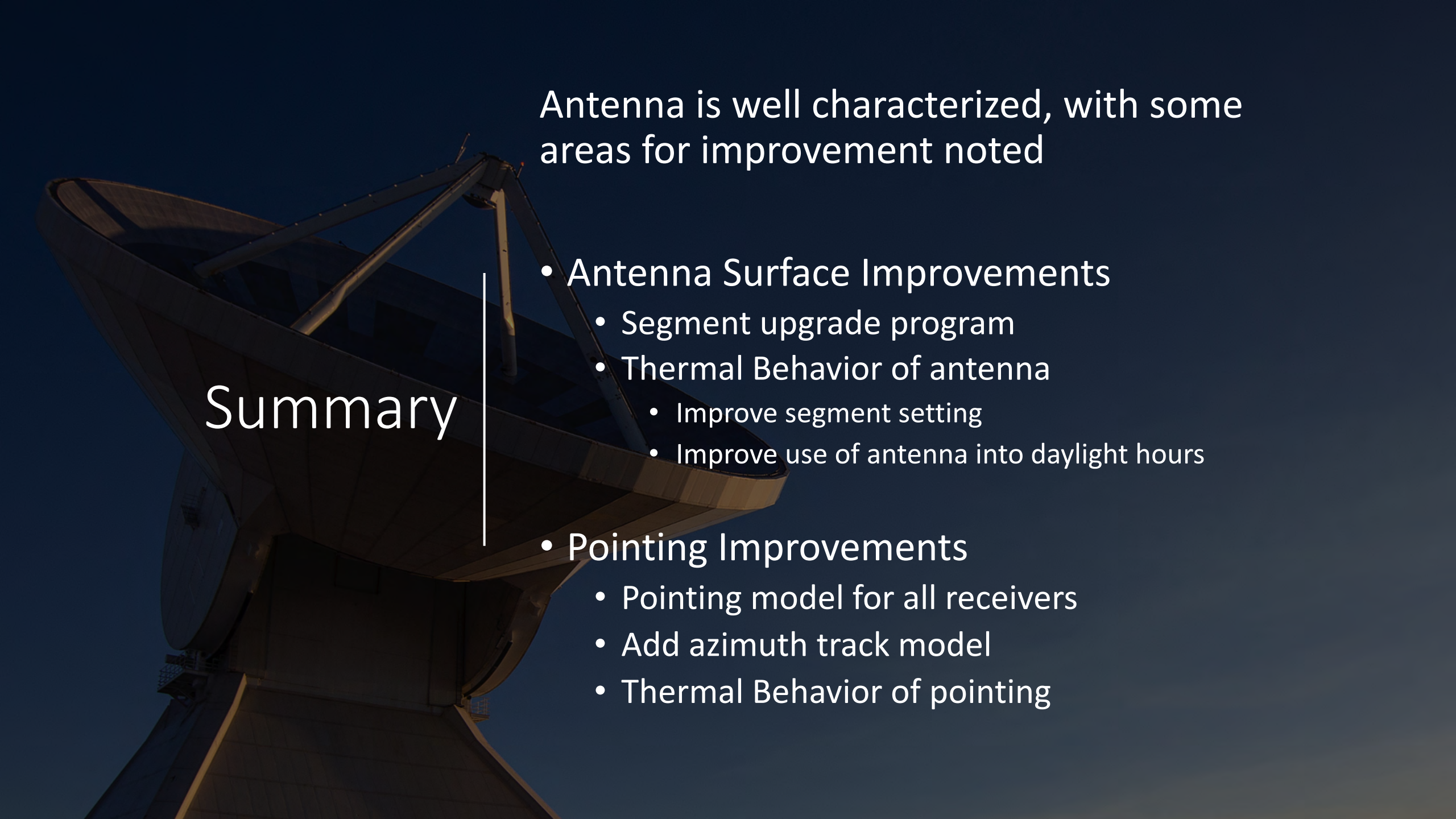
Observed drifts are probably thermal in nature

Antenna Pointing

Pointing Residuals

(assume repointing periodically during night)





Summary

Antenna is well characterized, with some areas for improvement noted

- Antenna Surface Improvements
  - Segment upgrade program
  - Thermal Behavior of antenna
    - Improve segment setting
    - Improve use of antenna into daylight hours
- Pointing Improvements
  - Pointing model for all receivers
  - Add azimuth track model
  - Thermal Behavior of pointing