Sidelobe measurements and models for large aperture CMB experiments

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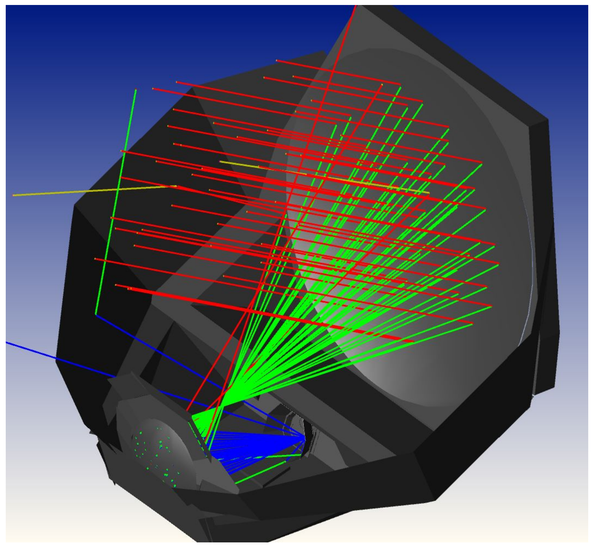
Abstract

As CMB experiments push towards higher sensitivities, the optical contamination of large angle sidelobes becomes increasingly important. We present beam profile measurements and ray trace simulations of the Atacama Cosmology Telescope (ACT) which are compared to sidelobe maps of the sun. These measurements and simulations are being used to characterize and control sidelobe effects for current and future telescopes.



Origin of Sidelobes

Far sidelobes result from interactions in non-ideal parts of the optical chain. These interactions include:

- Reflections between the telescope mirrors and the telescope structure
- Light scattering from optical components
- Sharp edge diffraction

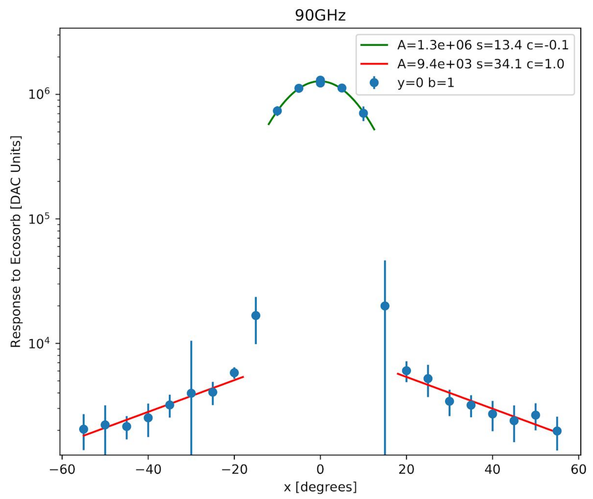
In this work we use a measured receiver beam model from ACTPol as an input to ray tracing calculations to study reflections off telescope structures at high angles.

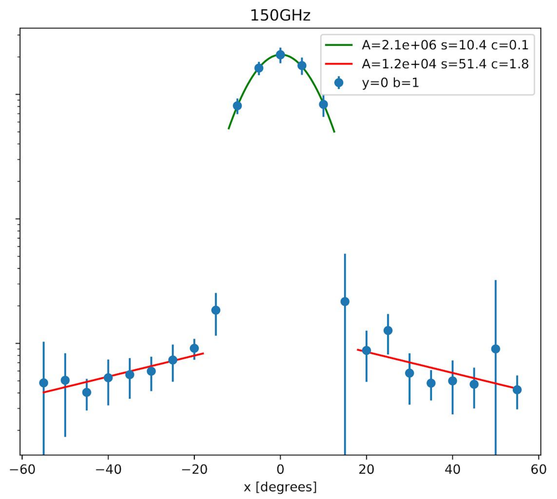
Online

ACT: http://act.princeton.edu
Simons Observatory: https://simonsobservatory.org/
CCAT-p http://www.ccatobservatory.org/

Receiver Beam Measurements

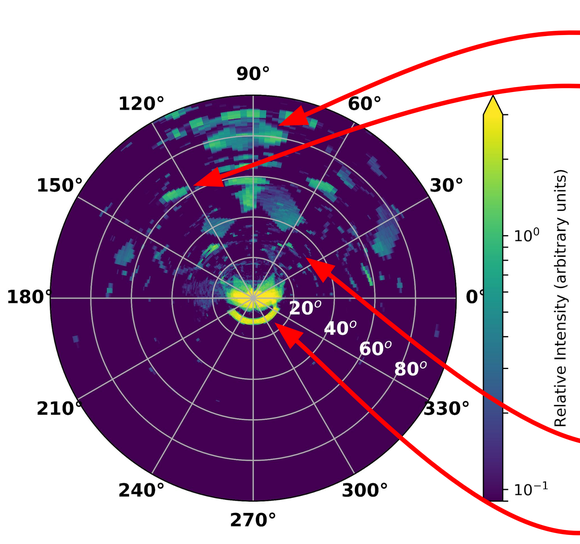
The angular profile of ACT's receiver beam was measured by waving eccosorb on a metal rod in front of the receiver. Horizontal angles were marked on a semicircular arch mounted in front of the receiver window. The beam profile was calculated by comparing the optical loading when eccosorb waved into and out of the beam. A Gaussian center beam and exponential sidelobes fit well to the profile. Improved measurements using a motorized eccosorb modulator are planned for the near future and should help to increase sensitivity at high angles.



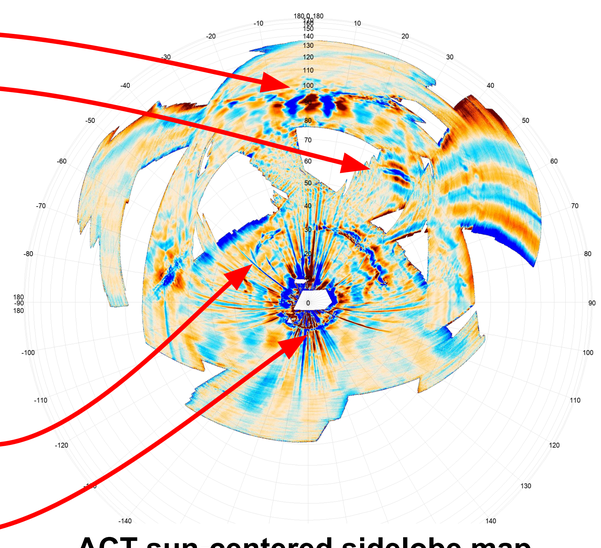


Ray Trace Simulations and Sun Measurements

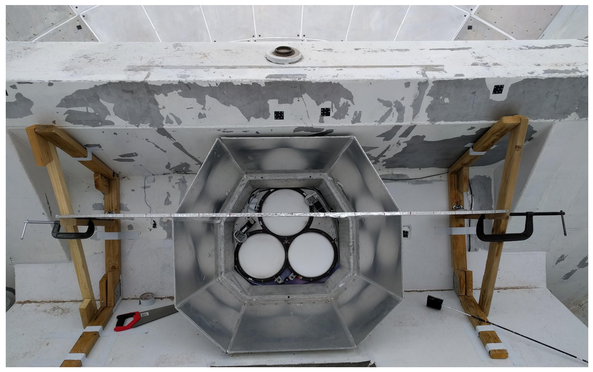
Using Zemax ray tracing software, we combine the receiver beam profile with a 3D CAD model of the telescope's upper structure to simulate the angular response of the camera. Rays are traced from the camera and onto the telescope structure including baffling panels, providing the ability to decompose the response of the system into its constitutive parts.



Ray trace sidelobe simulation [1]



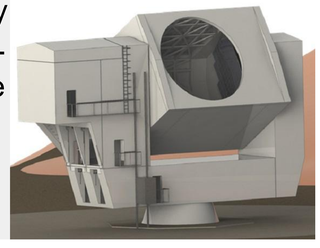
ACT sun-centered sidelobe map
By Sigurd Naess [2]



Conclusion

By evaluating the far angular response of ACT using these measurement and simulation techniques, we are able to attribute specific sidelobes to specific components in the telescope structure.

This method is being used to inform the mechanical structure and baffles for the Simons Observatory large aperture telescope and the CCAT-Prime telescope.



References

[1] Gallardo, Cothard et al. 2018 (in prep)
[2] Naess et al. "The Atacama Cosmology Telescope: CMB Polarization at 200<l<9000." doi.org/10.1088/1475-7516/2014/10/007

Acknowledgements

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