Sidelobes characterization for the Atacama Cosmology Telescope

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Atacama Cosmology Telescope

- 5200 m altitude in the driest desert worldwide
- Off-axis Gregorian design
- 6 m effective primary mirror
- 2 m secondary mirror
- arcmin resolution
- Large comoving and ground shield
- Receiving cabin with 3 optical tubes, dichroich: 2x 90/150, 1x 150/220 GHz
- Nowadays at its third generation of detectors (Advanced ACTPOL)

1 arXiv:1605.06569
2 arXiv:1510.02809
Big telescopes issues

• Usual atmospheric contamination (as for every ground based experiment)

• Ground pick-up → ground shield

• Direct atmospheric contamination to cameras → secondary mirror baffle

  BUT

  these frames may introduce unexpected features in the beam
How to optically characterize the telescope

- Use of specific software (e.g. GRASP or ZEMAX) to perform electromagnetic simulations
- For sidelobes study, one needs to include baffle, ground shield etc
- GRASP is very powerful and versatile, it calculates currents generated by a chain of reflectors, and finally propagating the fields at a specified surface
- Unfortunately is not trivial at all to define a geometrical model including the external frames of a big telescope like ACT
Drawing telescope model

- In GRASP, each reflector requires the definition of specific coordinate system, surface and rims.
- For CAD models, that information lives in the file itself, and it just need to be extracted.
- It would be great if drawing in GRASP were as easy as doing it in a CAD software (e.g. SolidWorks).
- CAD models can easily implemented in different ways.
- In this case I used a point cloud obtained with fotogrammetry.
From CAD (.step) to GRASP (.tor) files

Performed by a python code which does the following

Procedure:
1. Read the STEP file
2. Extract useful geometrical information
3. Calculate suitable Euler matrixes to define nice coordinate systems
4. Write the tor file with the correct syntax
5. Enjoy your model in GRASP
Probing sidelobes with GRASP

- Primary guard ring (green) included
- Scheme: camera → panel(s) on secondary baffle → primary mirror and guard ring.
- Fields collected on azimuth-elevation grid
- Orthographic projection for a direct comparisons with available maps
- Measured camera beam (credit Nicholas Clothard and Michael Niemack)
Comparing simulations with maps

• All the following maps have been obtained combining TODs with the Sun near the beam center in order to emphasize sidelobes features
• Sidelobes ONLY appear when the Sun is the nearby of the beam
• The amplitude of these feature spans from -60 (polarization maps) dBt to -40 dBt (temperature maps)
• No affection to ACT results published so far about the power spectrum
• A little attention to future releases at high multipoles
Injected power 1.65 pW

Sun temperature maps

Panels projection

dBi

Credit Sigurd Kirkevold Næss
Injected power 0.44 pW

Sun temperature maps

Panels projection

Credit Sigurd Kirkevold Næss
Injected power 0.51 pW

Sun temperature maps

Credit Sigurd Kirkevold Næss
Sun polarization maps

Injected power 0.51 pW

Q_middle_upper

Credit Sigurd Kirkevold Næss
Sun polarization maps

Injected power 0.37 pW

Panels projection

Credit Sigurd Kirkevold Næss
Power on panels with eccosorb

\[ P = k_B T \Delta \nu \frac{\Omega_{\text{panel}}}{\Omega_0} \nu \]

Given by GRASP

\[ \Delta \nu = 58 \text{GHz} \]

\[ T = 300 \text{K} \]

\[ \frac{\Omega_{\text{panel}}}{\Omega_0} \approx 10^{-3} \]
Taking measures at cerro Toco
Optical loading by eccosorb onto baffle panels

Power bias differences in IV curves with (on) and with no (off) eccosorb mounted → emission by eccosorb. Focal plane temperature changes should be considered, but it is quite good as a preliminary result.

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On schedule

• Go on with further panel to verify all the loadings to panels responsible of sidelobes ( -40 to -60 dBi)

• Collect TODs to obtain maps where the Sun or the Moon are in a suitable position to highlight sidelobes

• If panels responsible are covered with eccosorb then the sidelobes should not appear in maps
Conclusions

• Importing models into GRASP is a powerful tool to characterize systematics of telescopes
• Understanding these systematics can help in adjusting scanning strategy
• Finding a suitable compromise between S/N and sensitivity
• Use for further experiment in design stage

Thanks for your attention