



LET THERE BE LIGHT

Development of a Metrology System to Enable Daytime Observing
by the Atacama Cosmology Telescope

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Overview

Cosmic Microwave Background

- Why is it important?
- How do we study it?

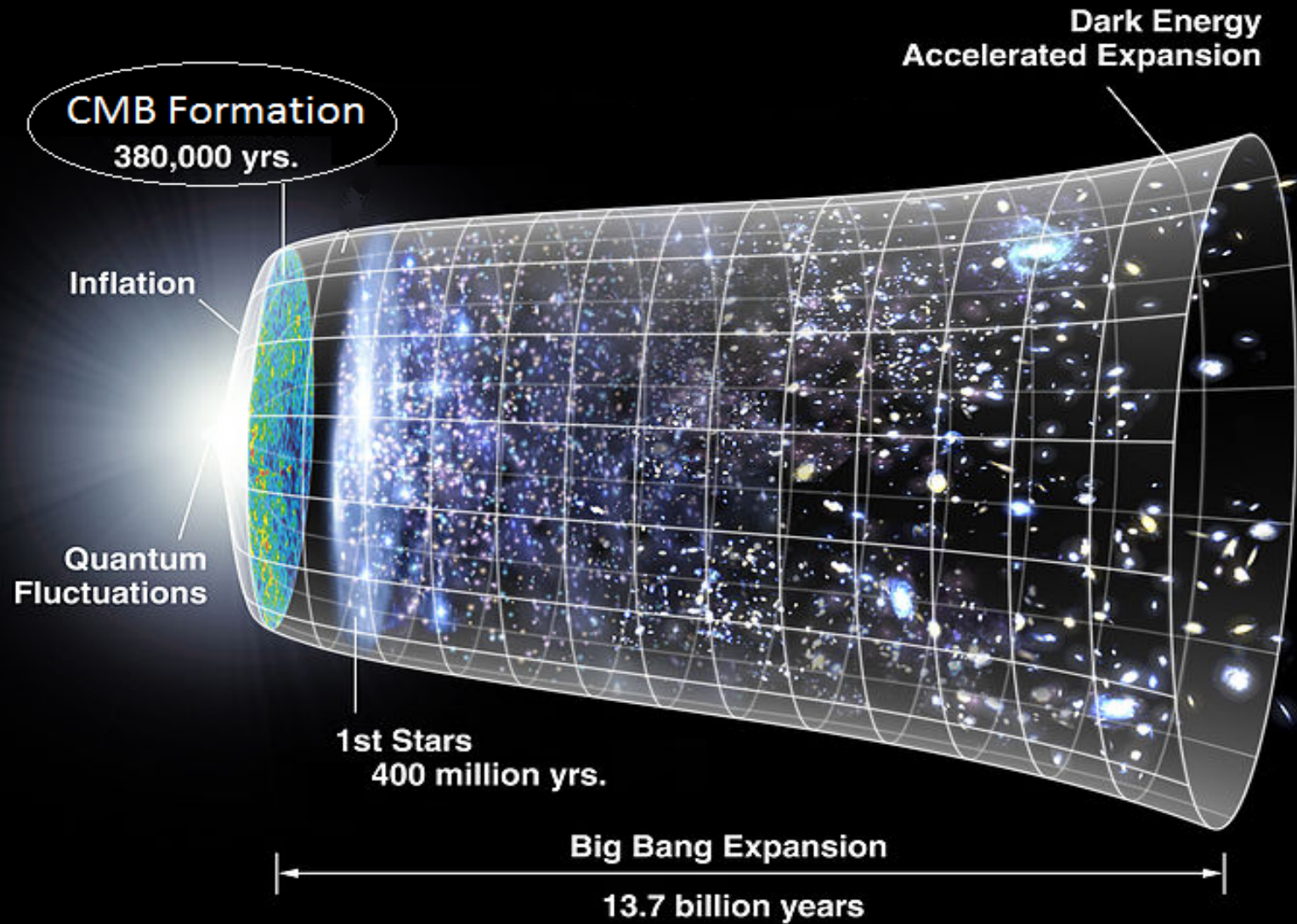
Atacama Cosmology Telescope

- How can we improve ACT?

Metrology System for Mirror Distortion Characterization

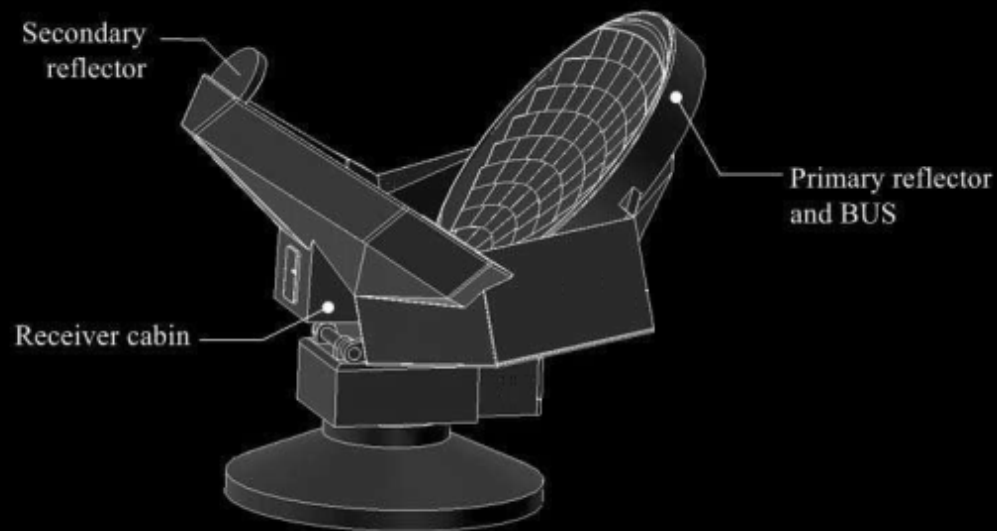
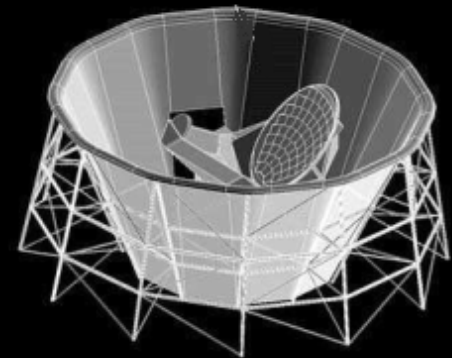
- Camera resolution
- Photogrammetry

Cosmic Microwave Background (CMB)



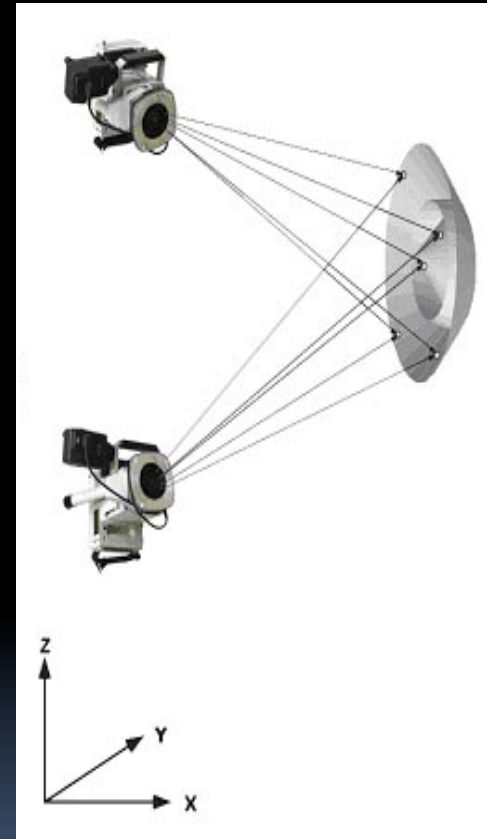
Atacama Cosmology Telescope (ACT)

- Surveys CMB
- Primary mirror warps during daytime
- Goal: Characterize lens distortion
→ with 100 micron/sigma precision



Photogrammetry

- Metrology by pictures
- Triangulation of multiple cameras
- Create 3D map of surface



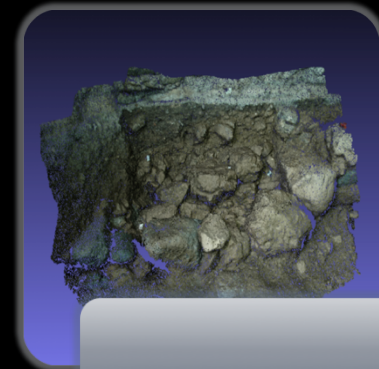
System Development



Camera
Resolution



Lens
Distortion



Photogrammetry

Camera resolution: setup

- Canon EOS 5D Mark III and ringflash



- ND filters

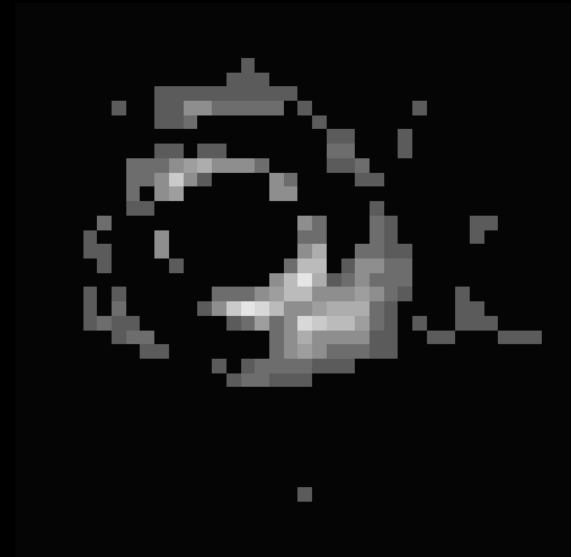
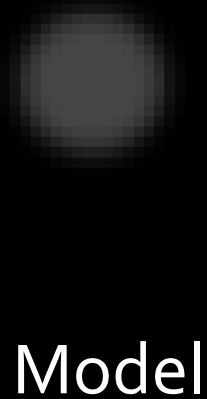
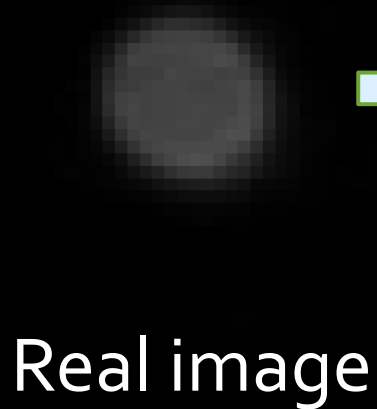
- Retro-reflectors



Camera resolution: setup



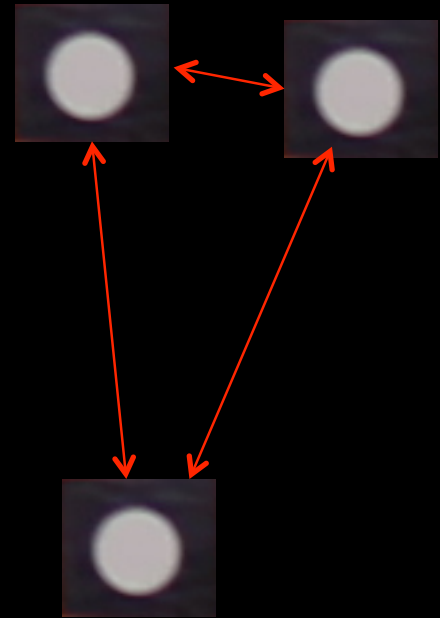
Camera resolution: Data fitting



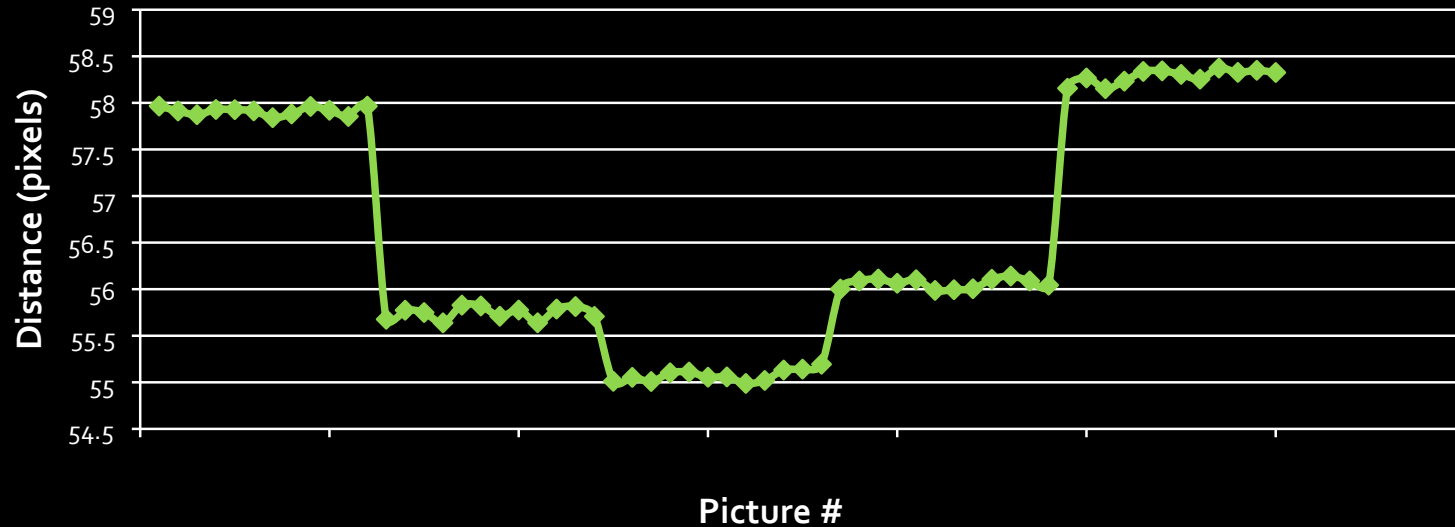
- Modeling method shows **15% improvement** over centroid method

Data collection

- Stationary pattern of retroreflectors
- 12 pictures each at 5 camera angles (60 total)



Results



- Excellent local precision:
104 micron/sigma at 10m
- Poor precision over field-of-view:
2200 micron/sigma at 10m ...Why?

Lens Distortion

- Characteristic of lens to skew image
- Shift pixel as a function of position



Simplest case for barrel distortion:

$$r + r^3 = R$$

Lens Distortion

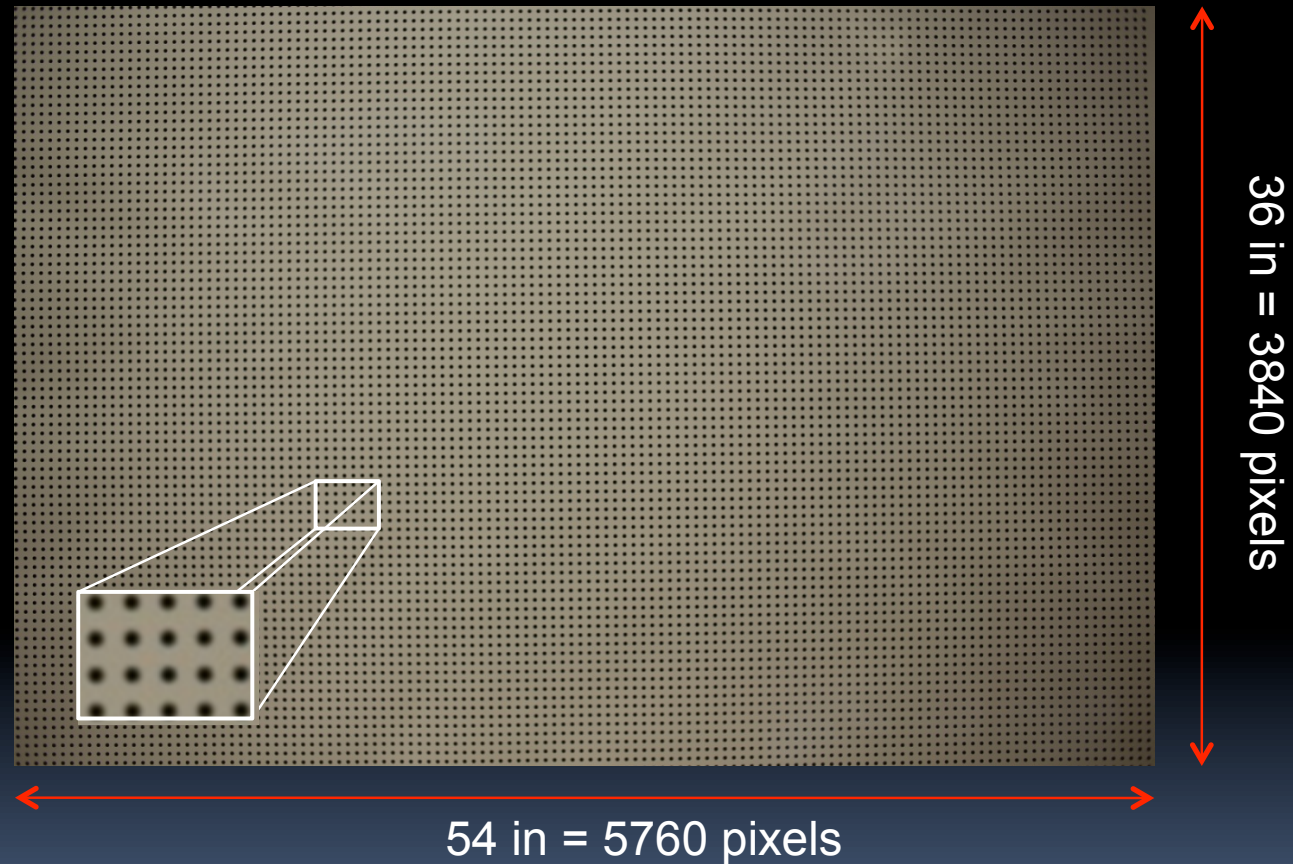
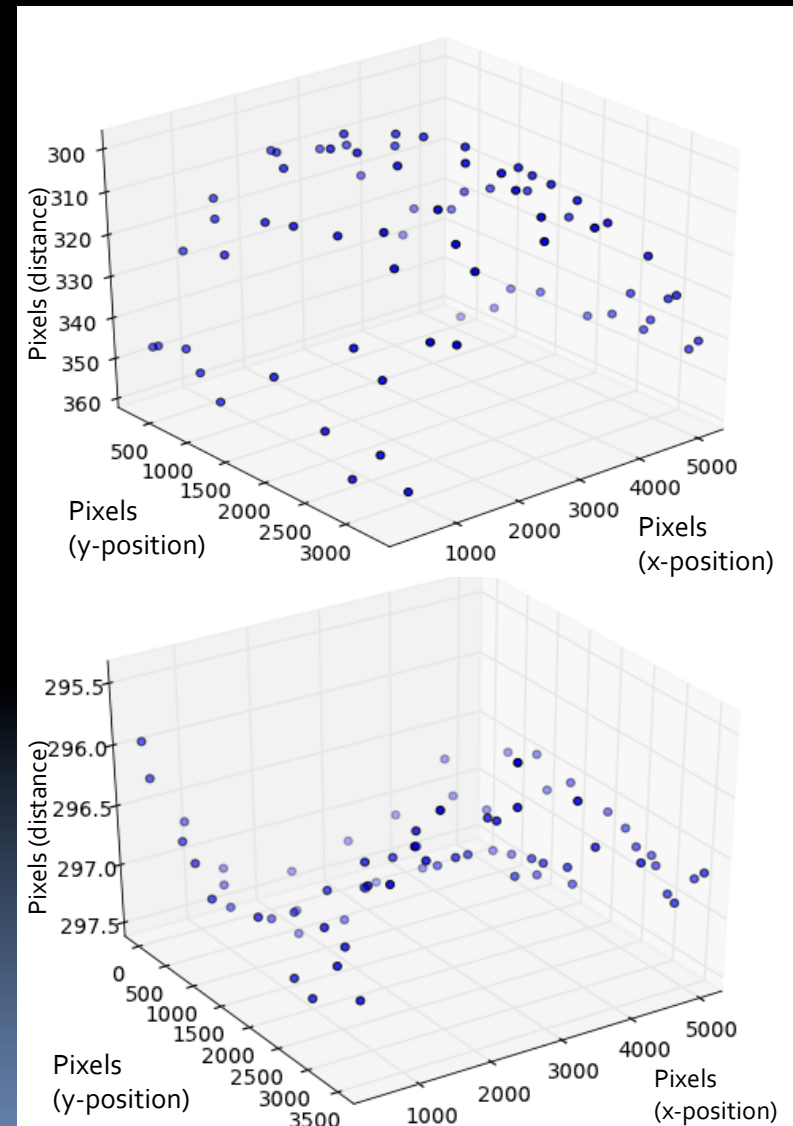


Photo of poster used to characterize lens distortion

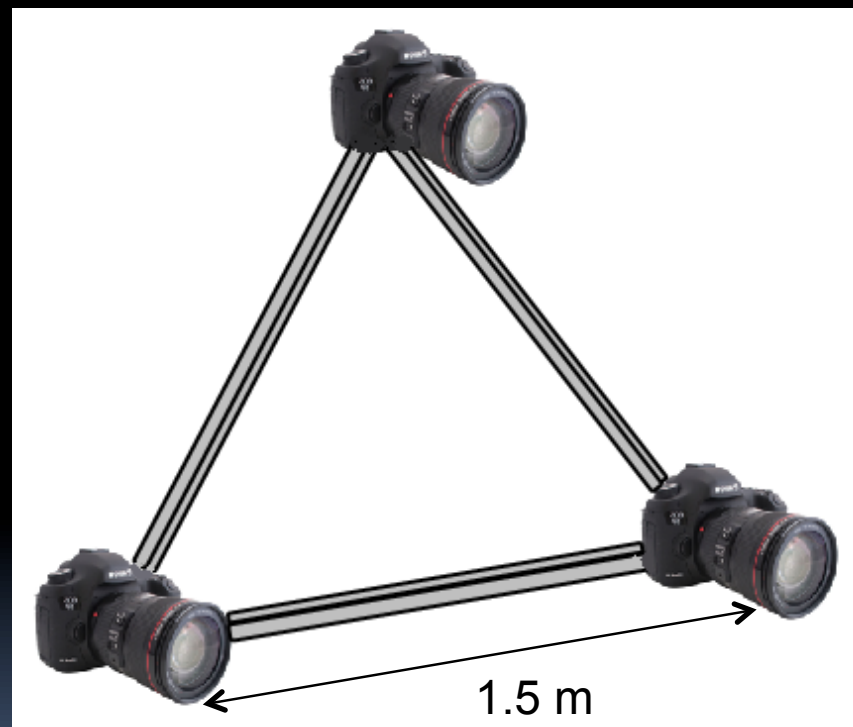
Improved results

- Original pictures:
2200 micron/sigma
- Corrected pictures:
780 micron/sigma
 - Expected to further improve as low as
~100 micron/sigma



Future work

- Build hardware and calibrate
- Implement in ACT





Conclusion

- Modeled disks and camera lens distortion
- Achieved desired 3-sigma resolution of 312 microns @ 10 m
- System will characterize mirror movement to allow daytime observation by ACT



Acknowledgements

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