

The Simons Observatory and BLAST-TNG: Probing the beginning of the Universe with precision polarimetry experiments

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University of California Riverside Physics and Astronomy Seminar

May 8th, 2020



@AstroDrNick

Outline



Cosmology from the polarized CMB



Devils in the dust



A unified design



The Simons Observatory

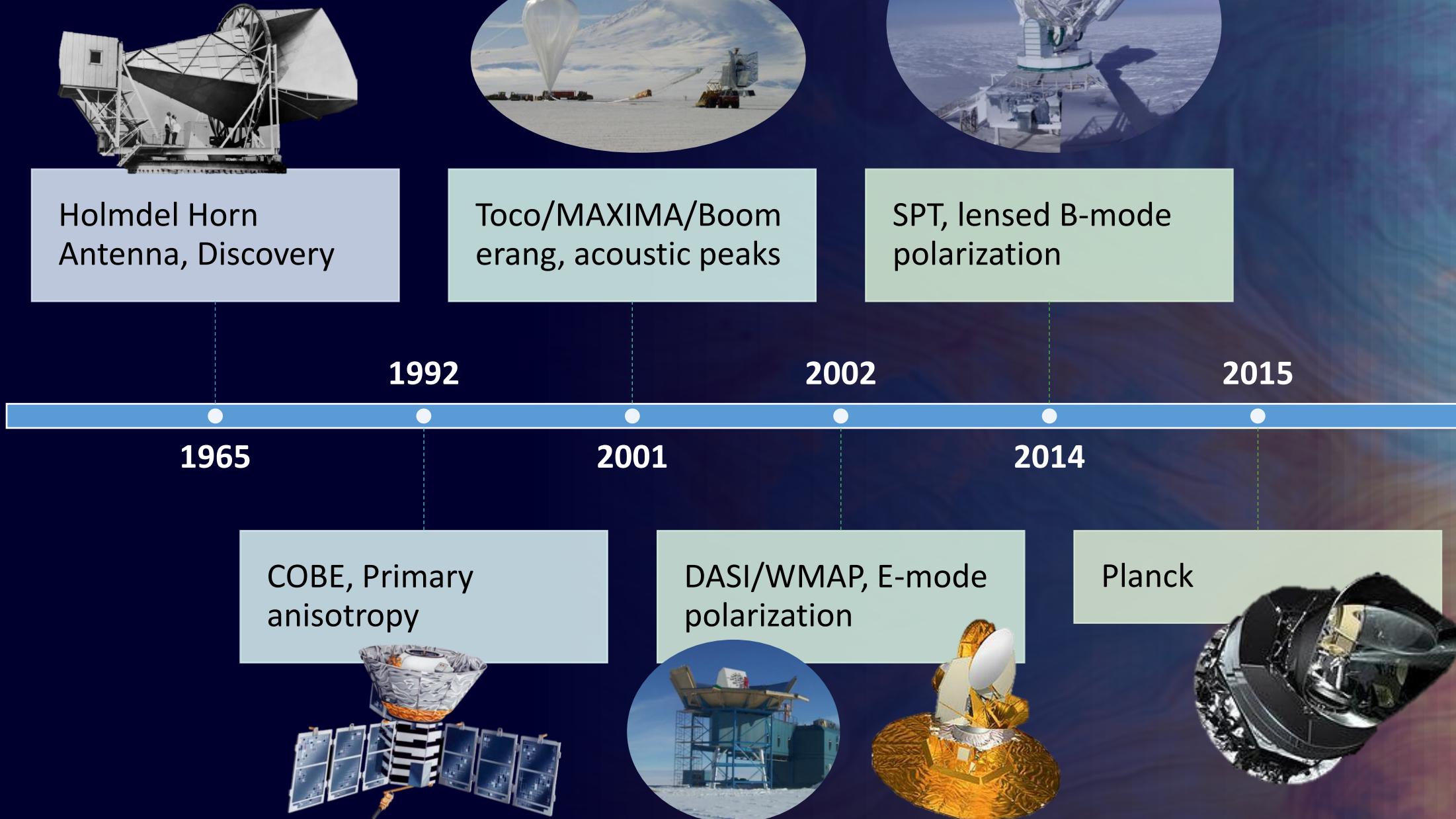


BLASTPol and BLAST-TNG

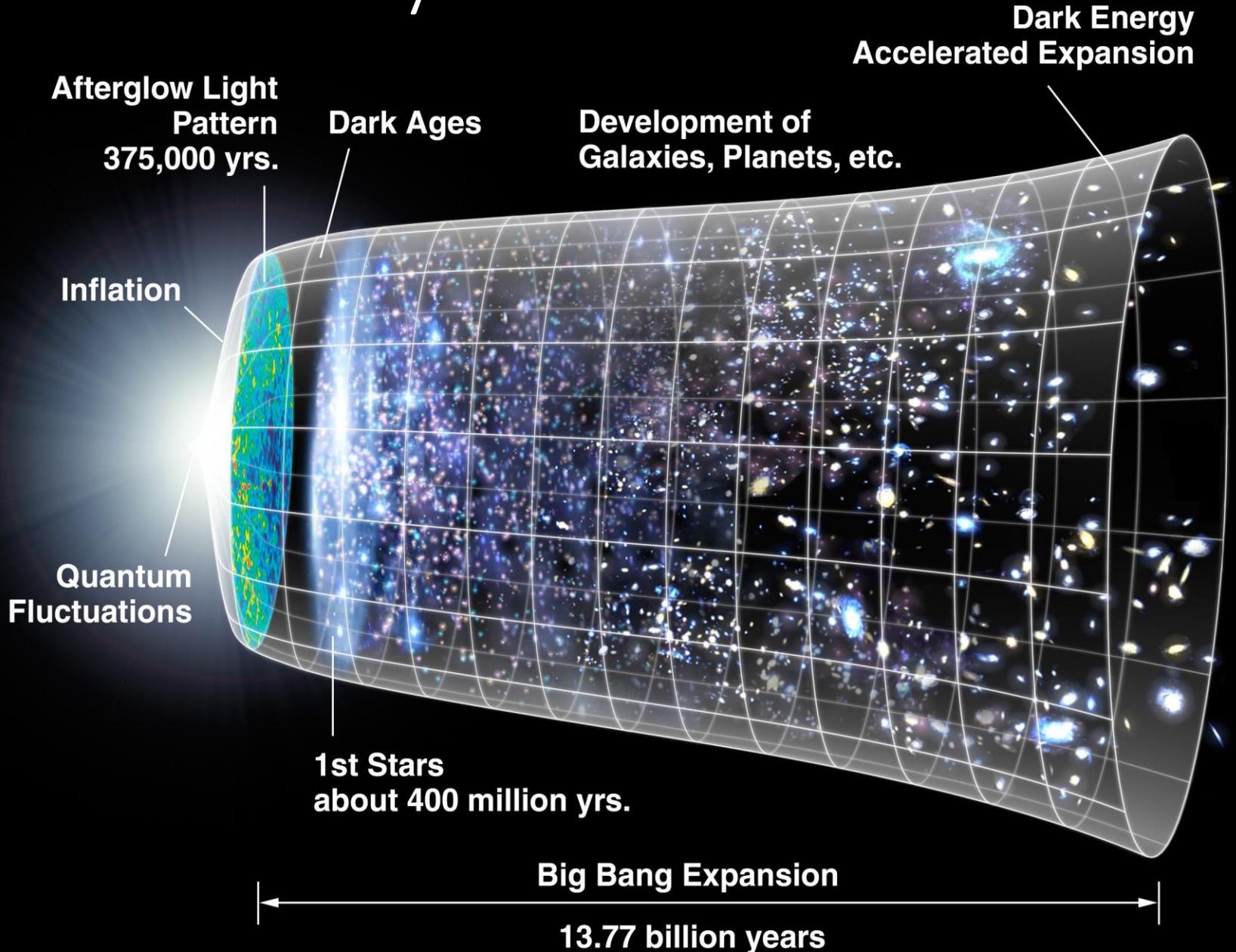


What's next?

A quick CMB history



Cosmic History



The sky with microwave eyes

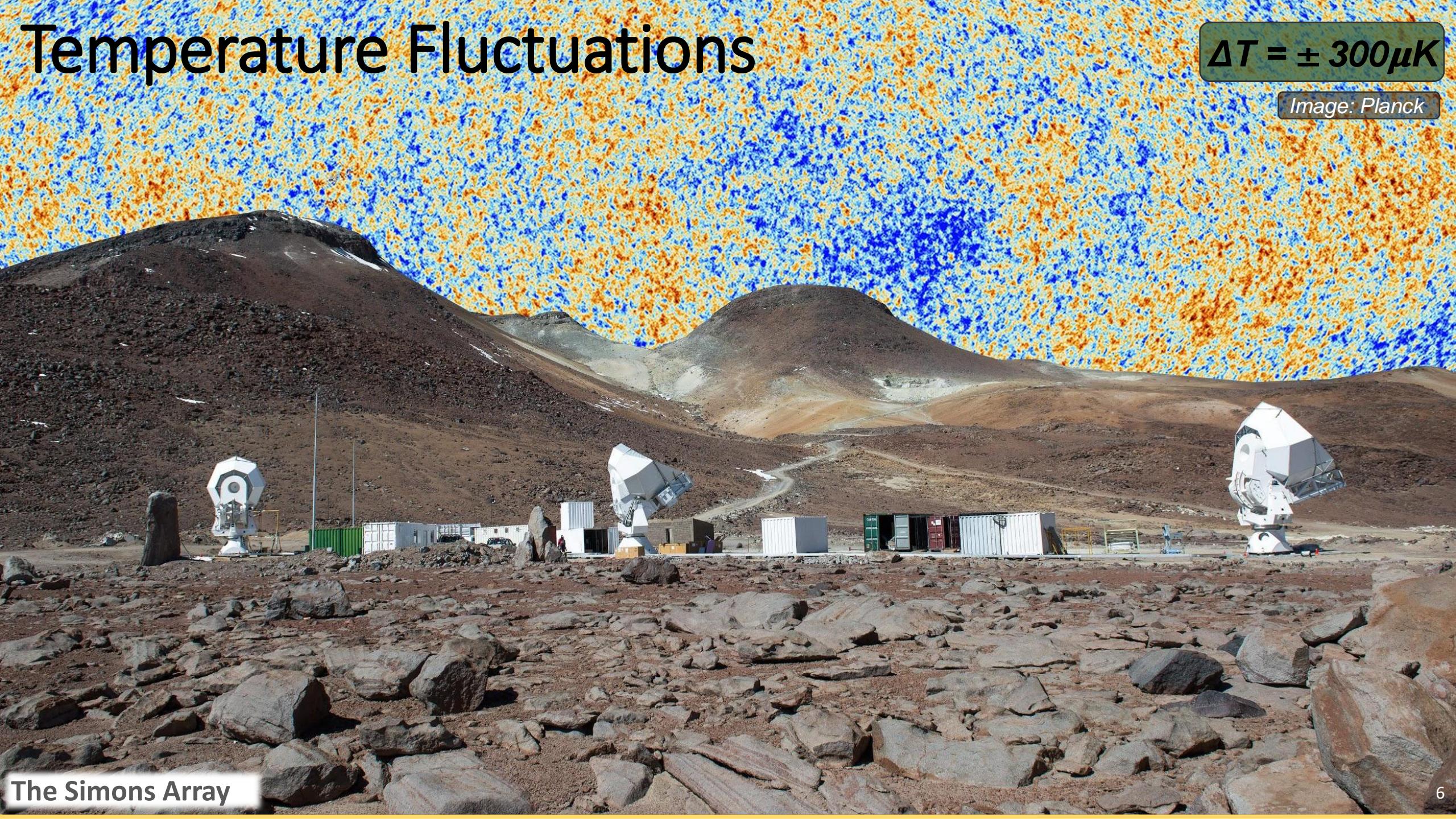
$T = 2.725 \text{ K}$



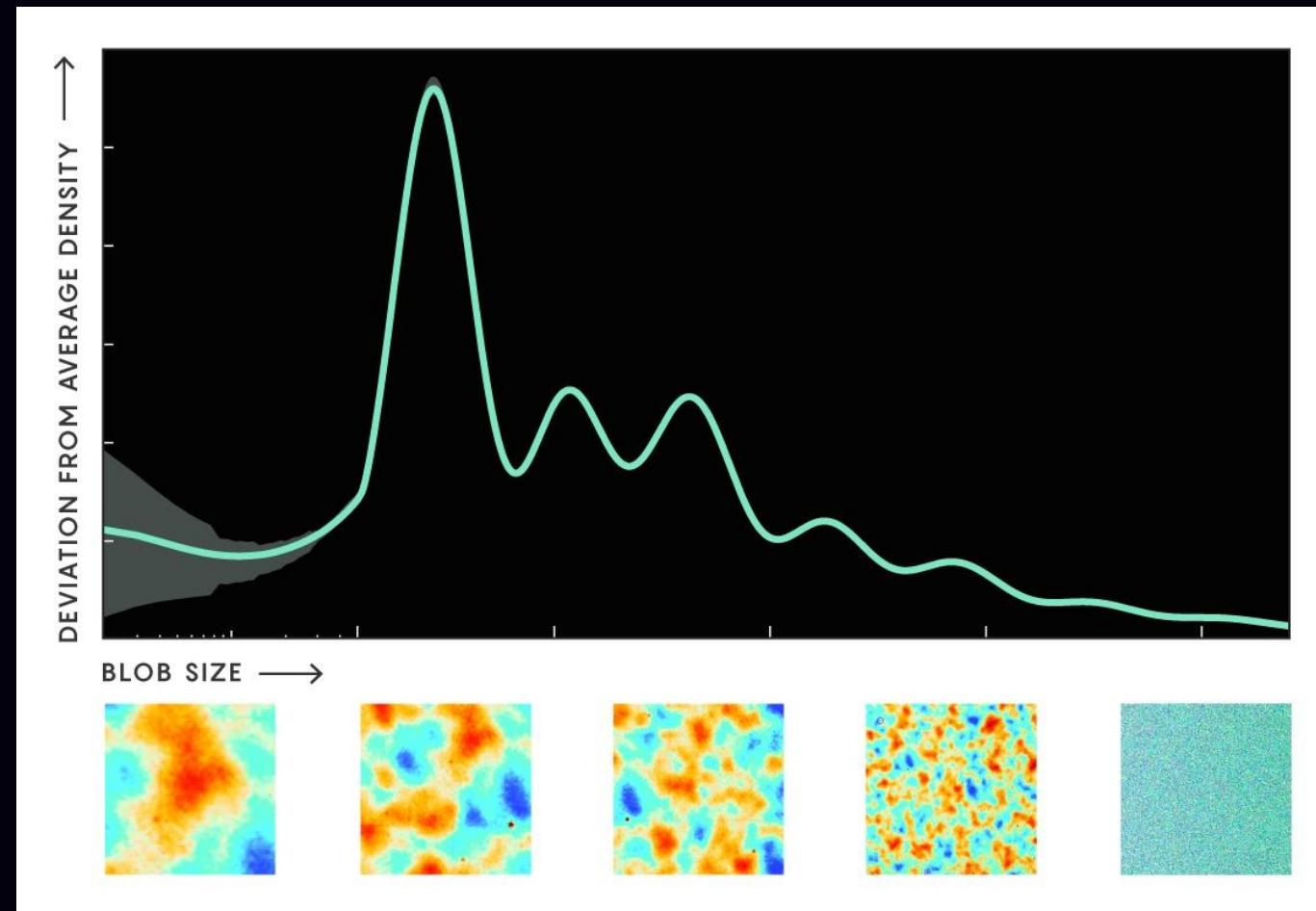
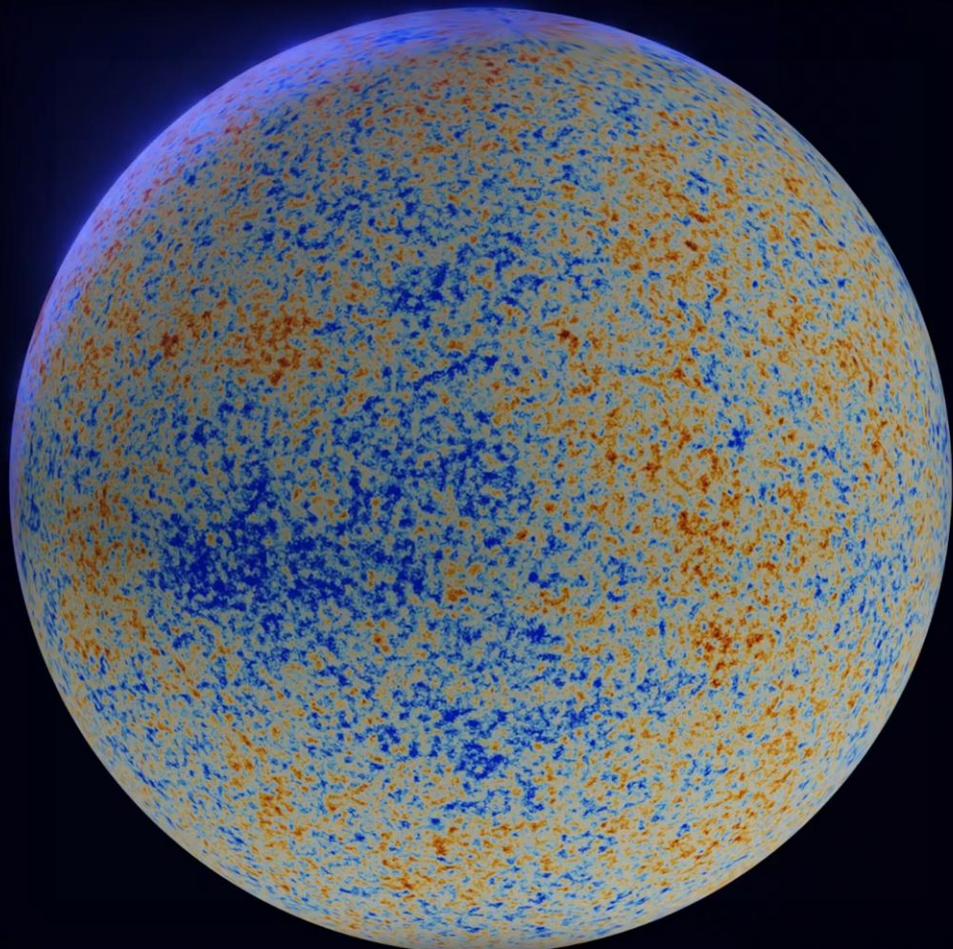
Temperature Fluctuations

$\Delta T = \pm 300\mu K$

Image: Planck



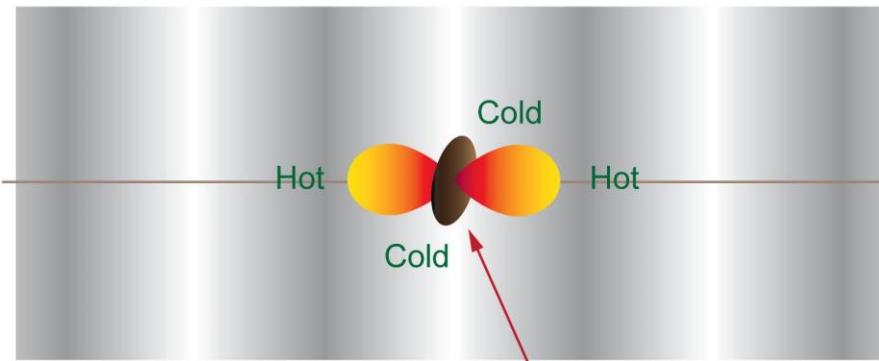
Spherical Harmonics



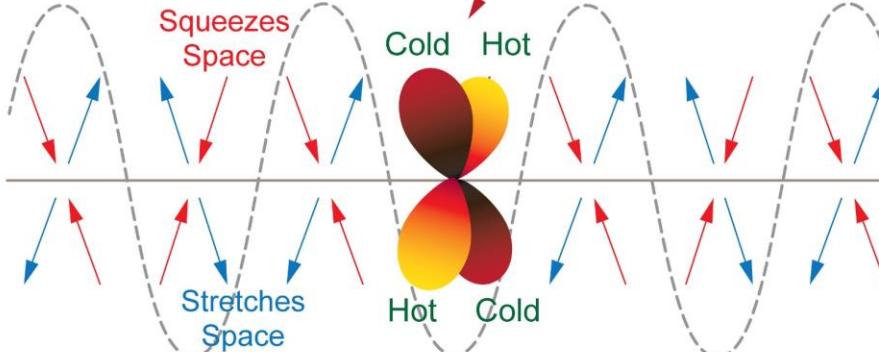
Lucy Reading-Ikkanda/Quanta Magazine; Planck 2013 XVI

The Polarized CMB

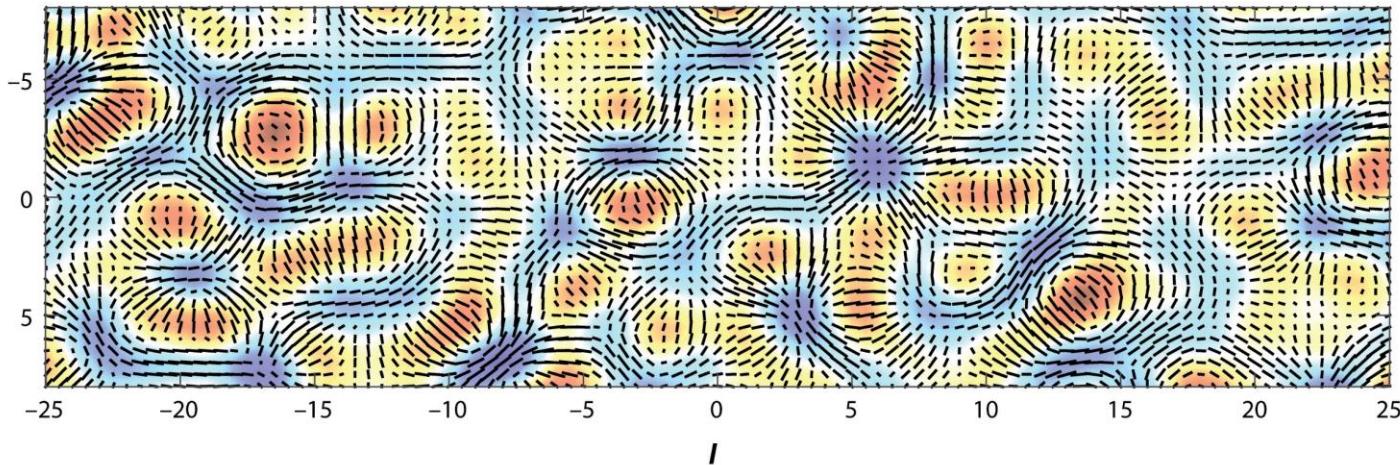
Density Wave



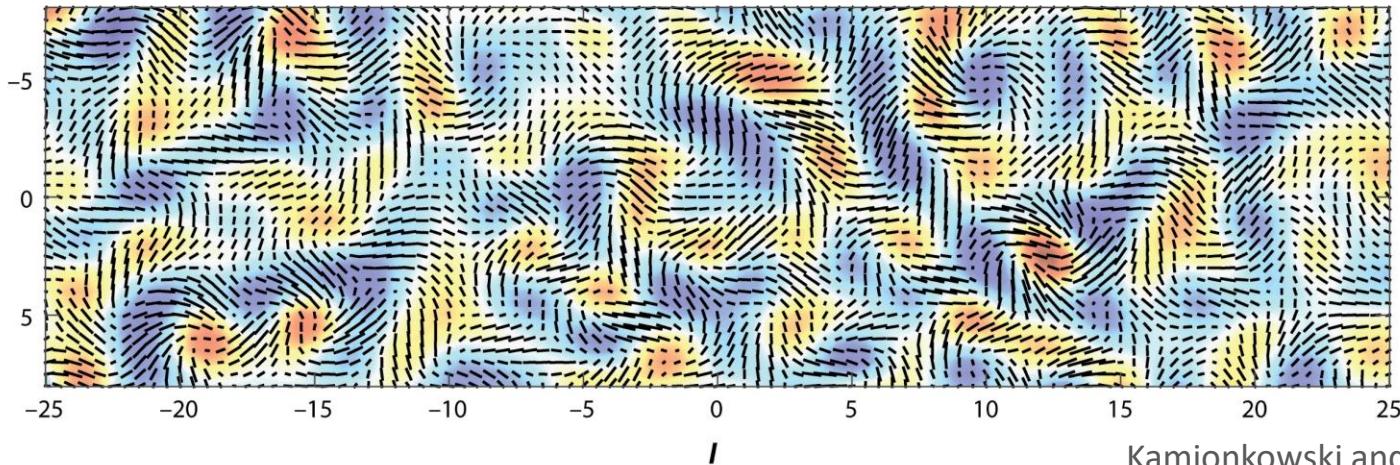
Gravitational Wave



a E-mode polarization



b B-mode polarization

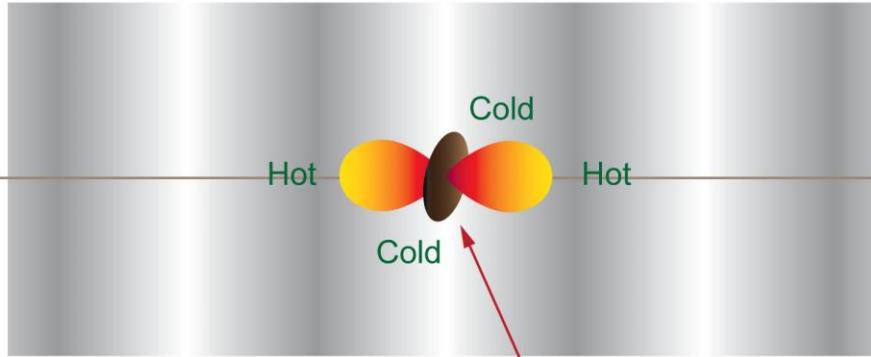


Kamionkowski and Kovetz 2015

BICEP2 Collaboration

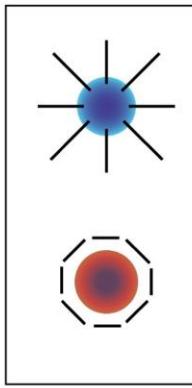
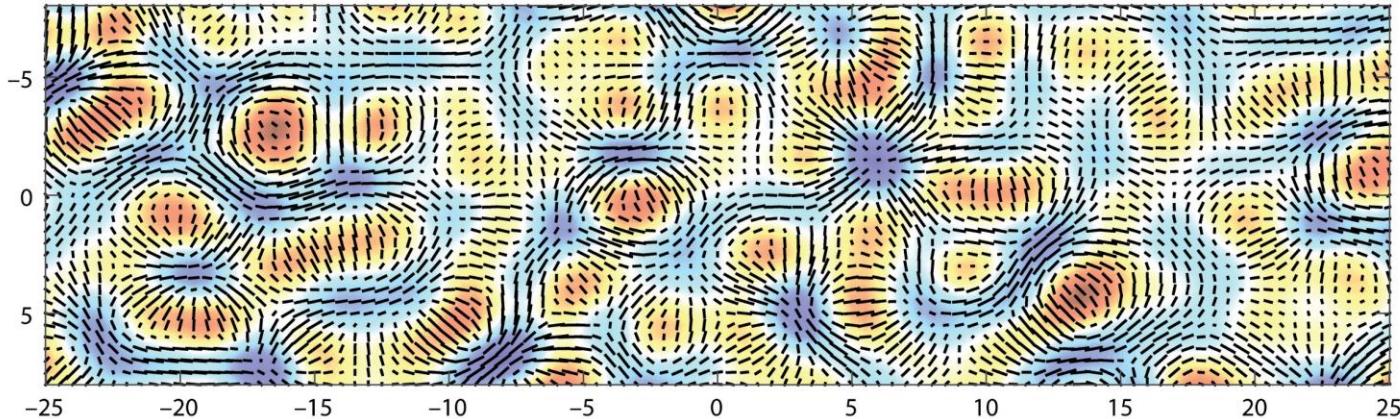
Detecting CMB E-modes

Density Wave



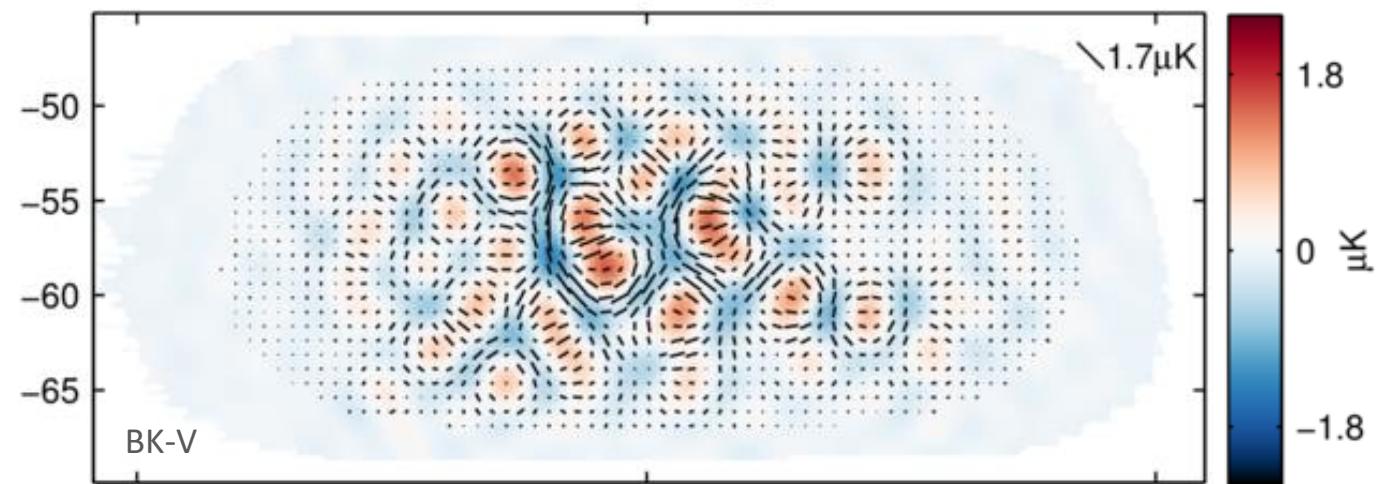
Temperature
Pattern Seen
by Electrons

a E-mode polarization

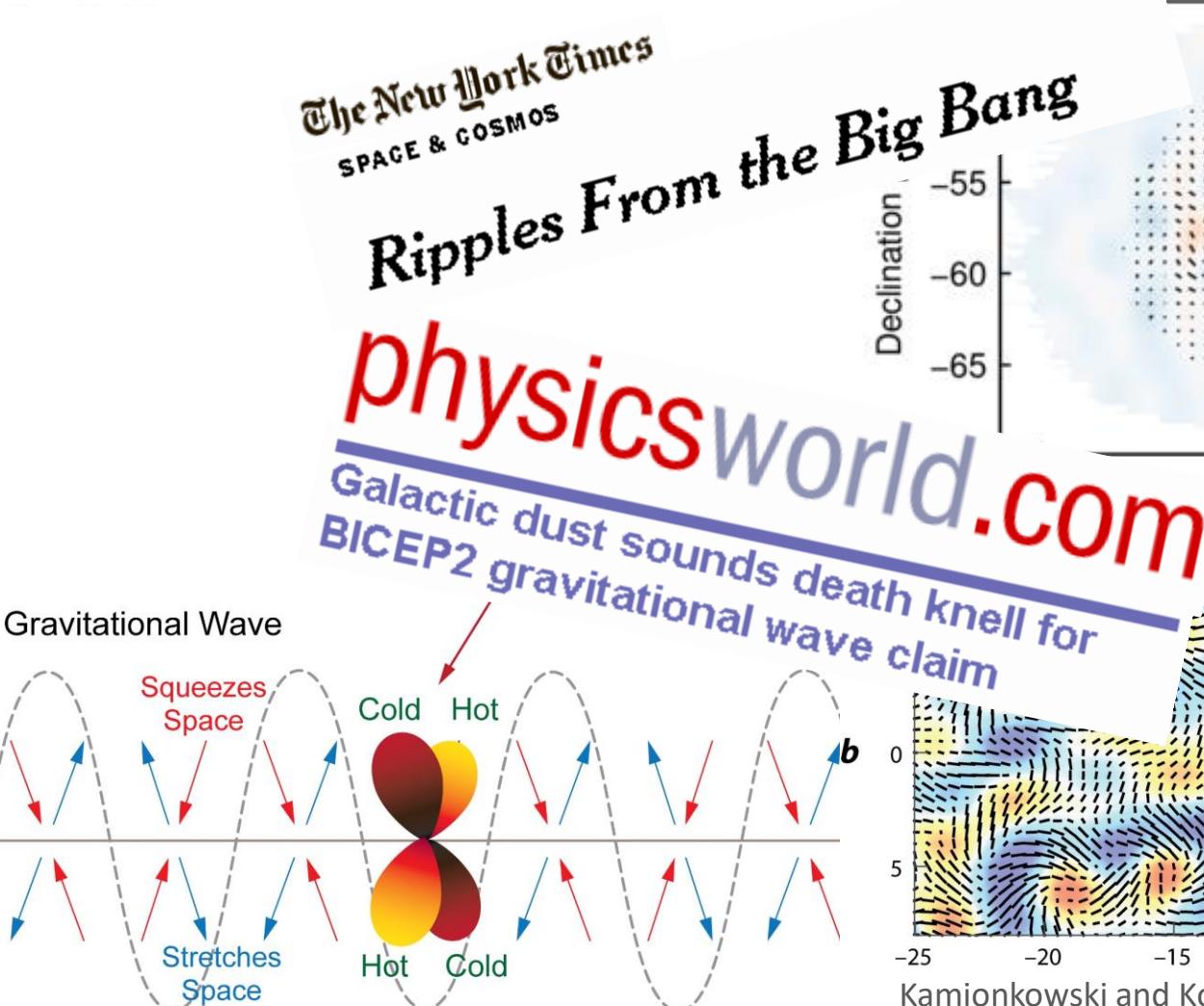


b

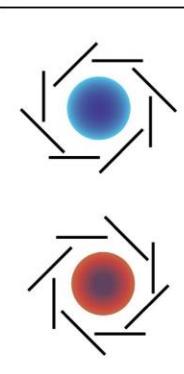
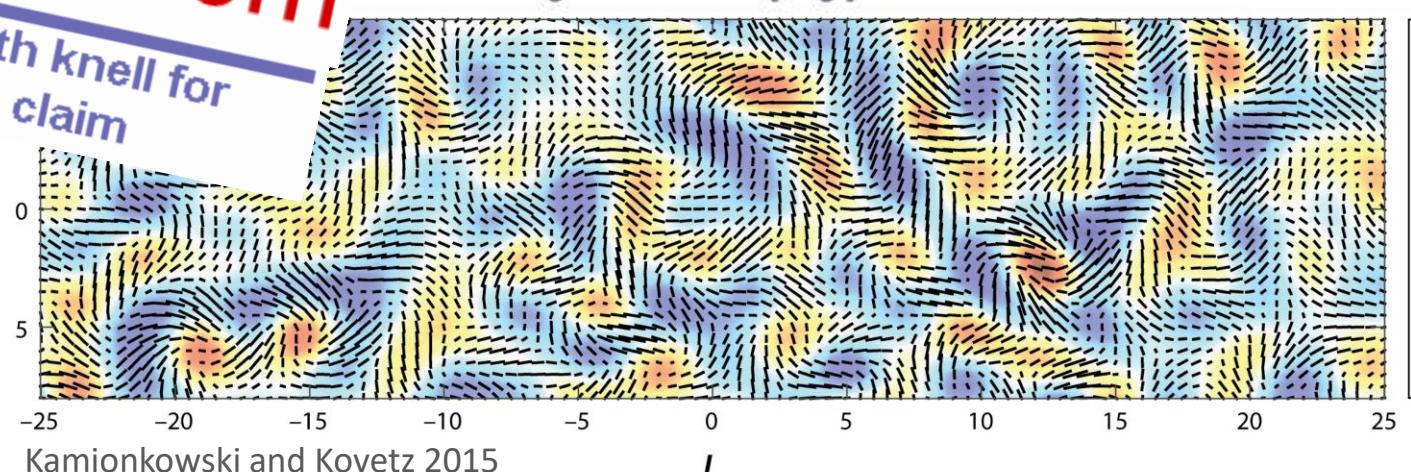
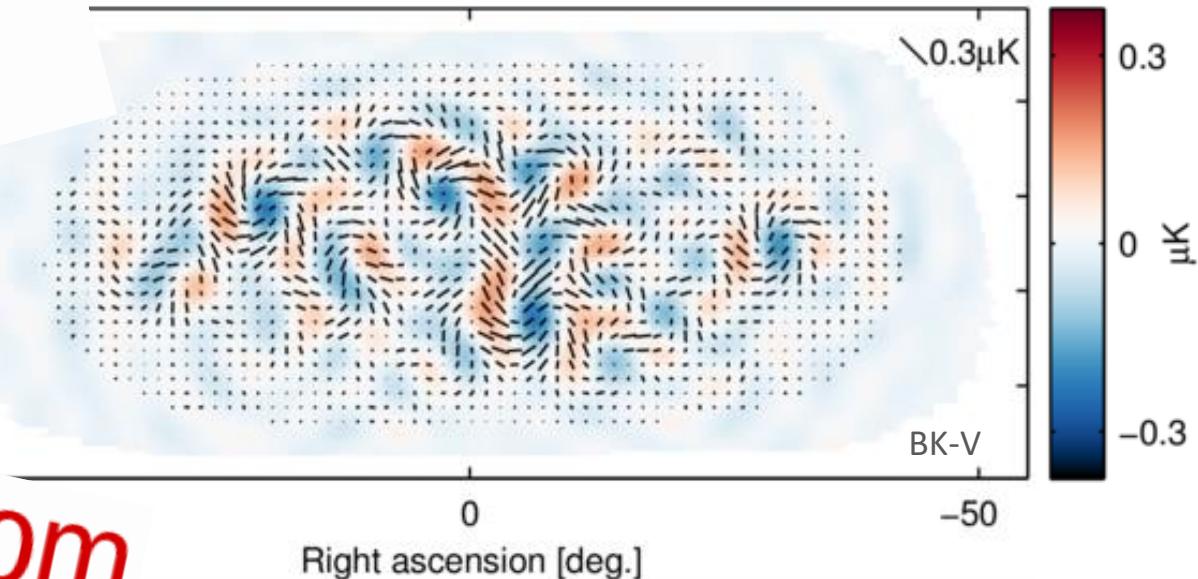
Keck Array : E signal



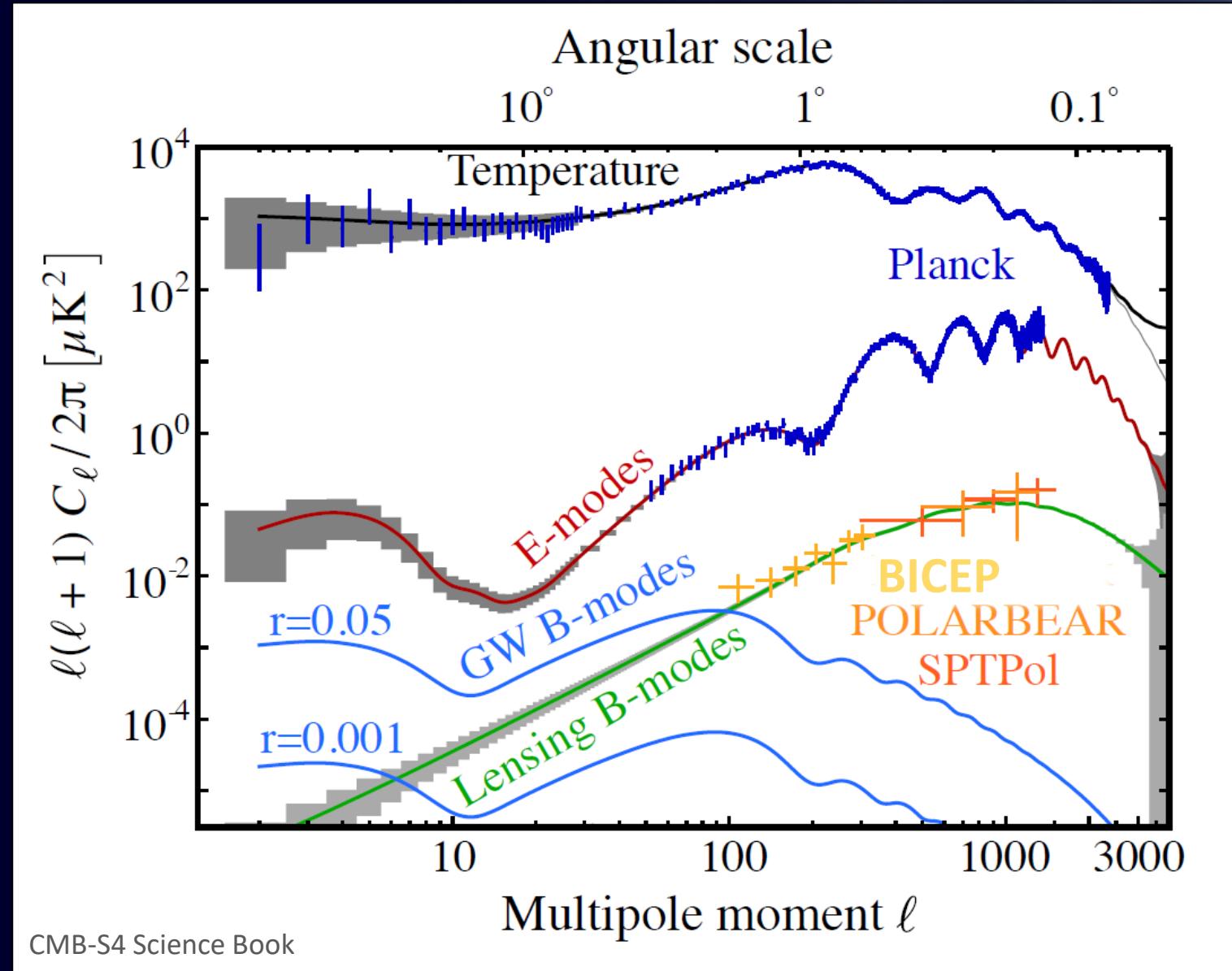
Detecting Primordial Gravitational Waves



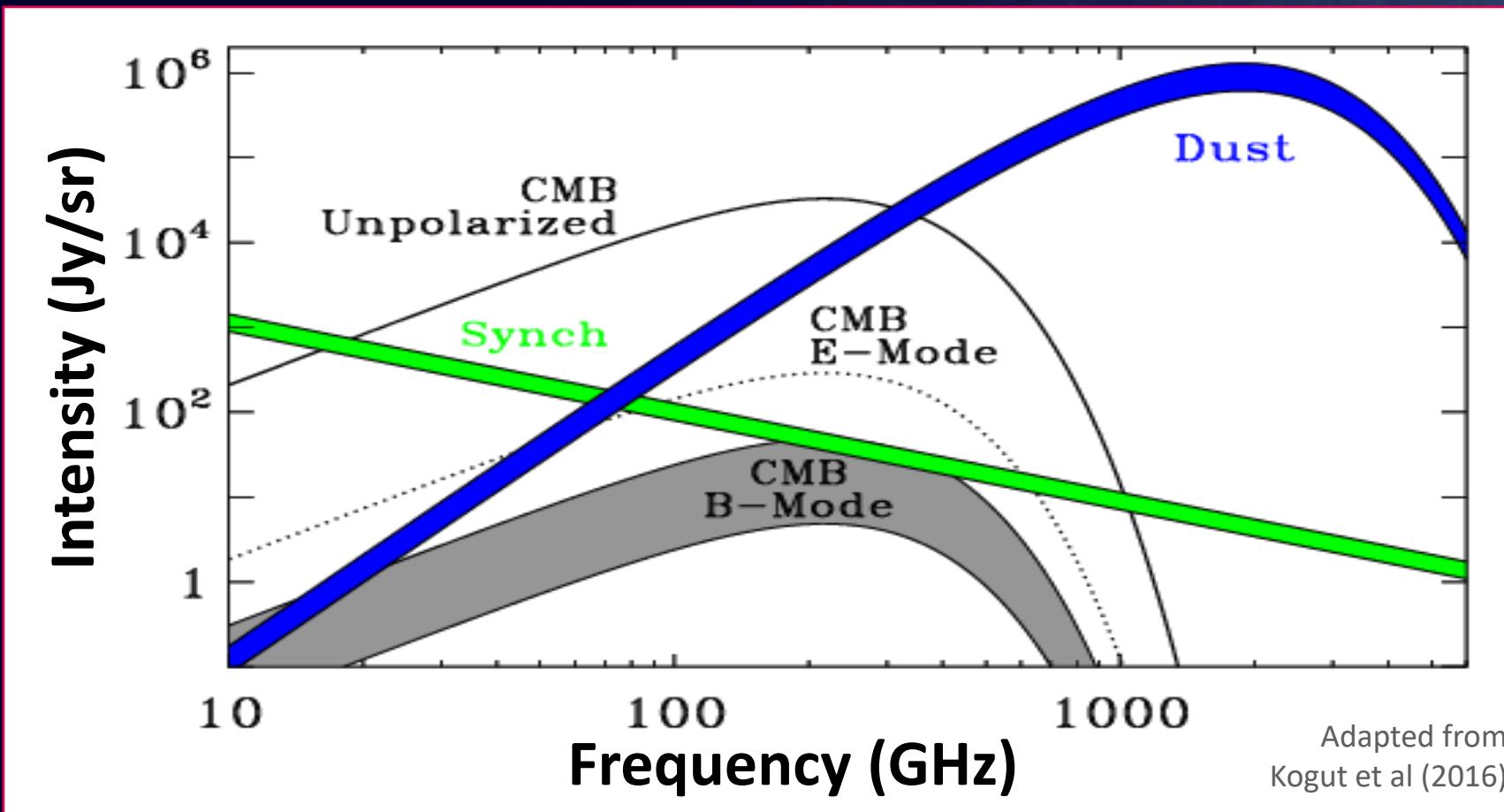
Keck Array : B signal



Amplitude vs. angular scale



Amplitude vs. Frequency



Outline



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Devils in the dust



A unified design



The Simons Observatory

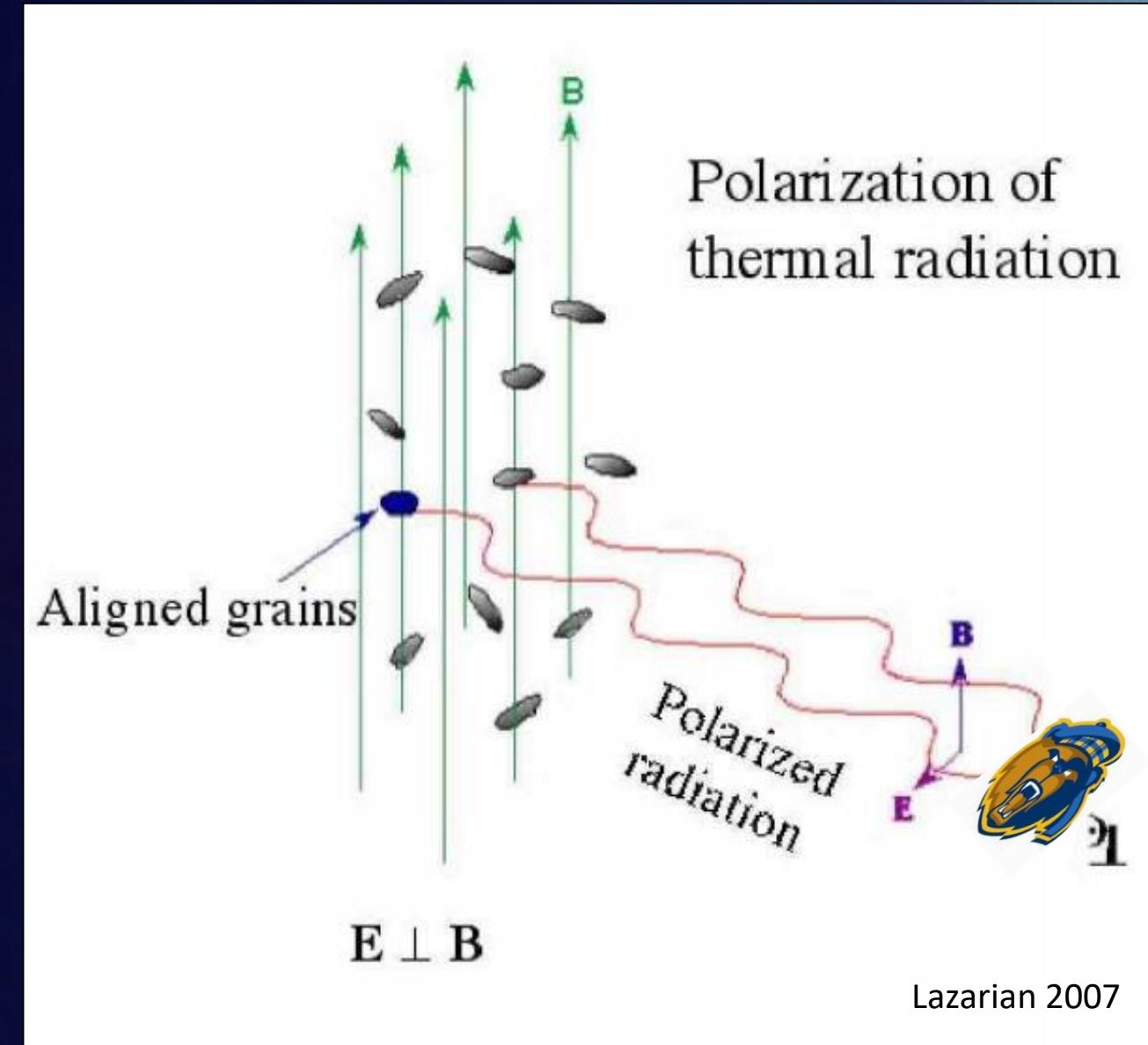
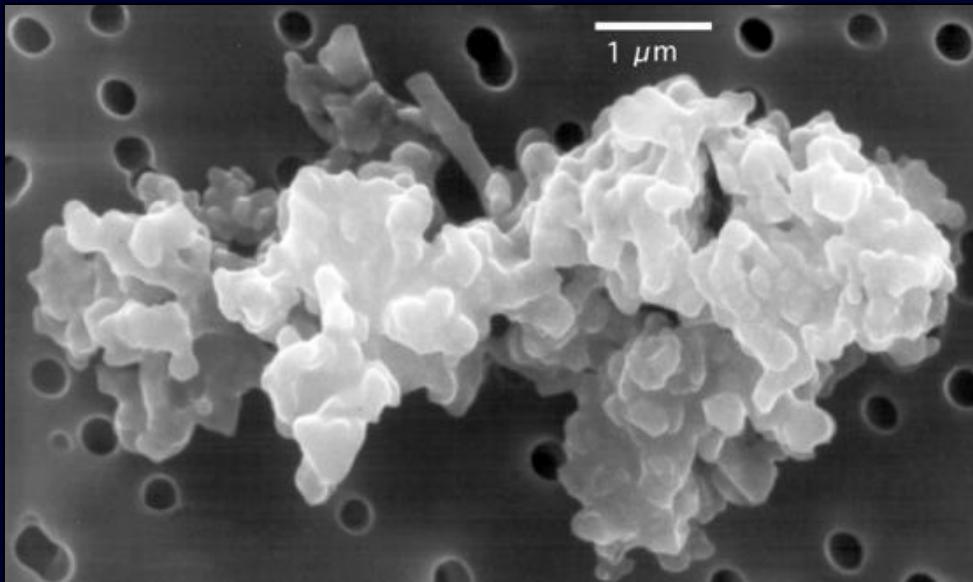


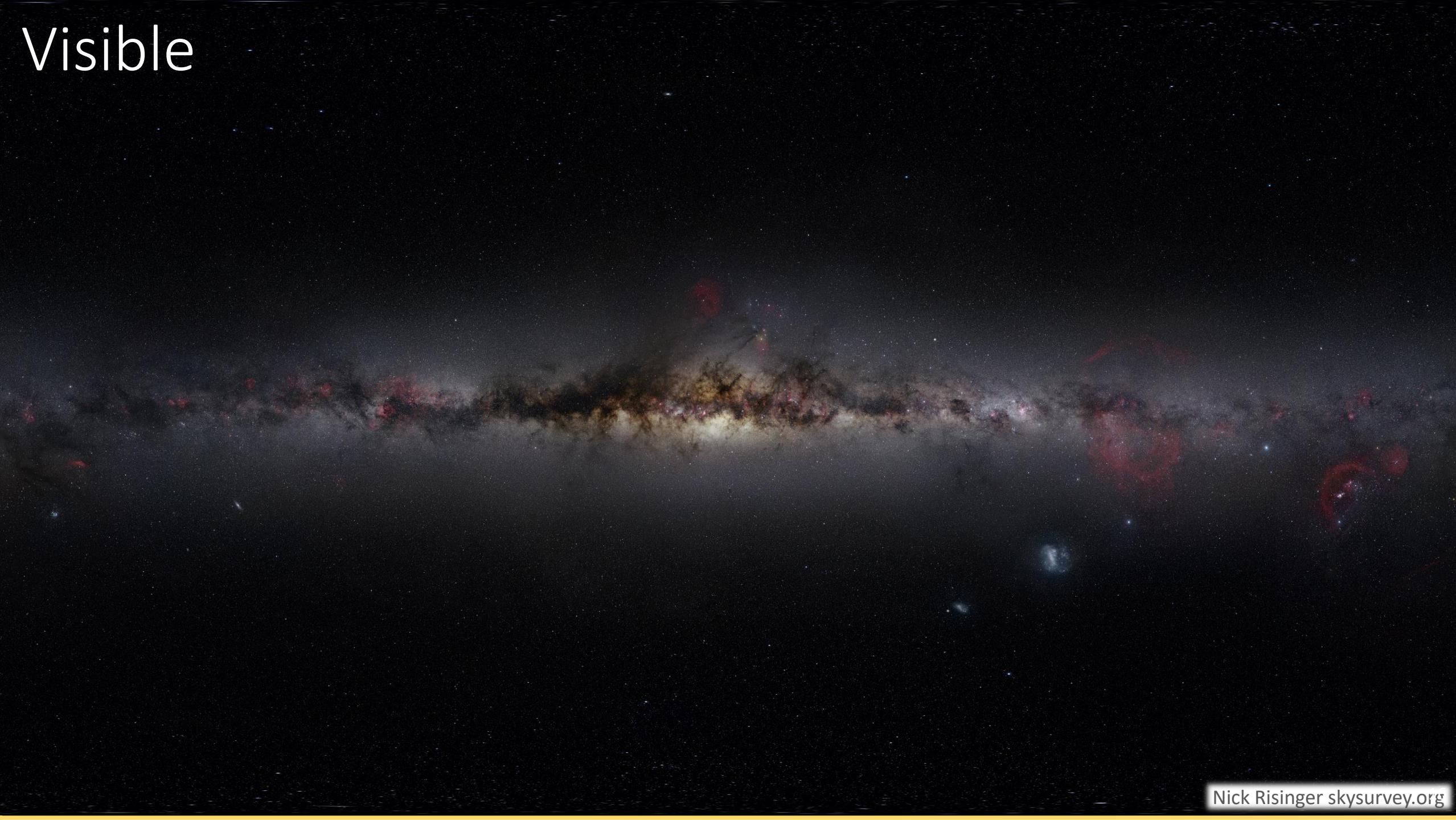
BLASTPol and BLAST-TNG



What's next?

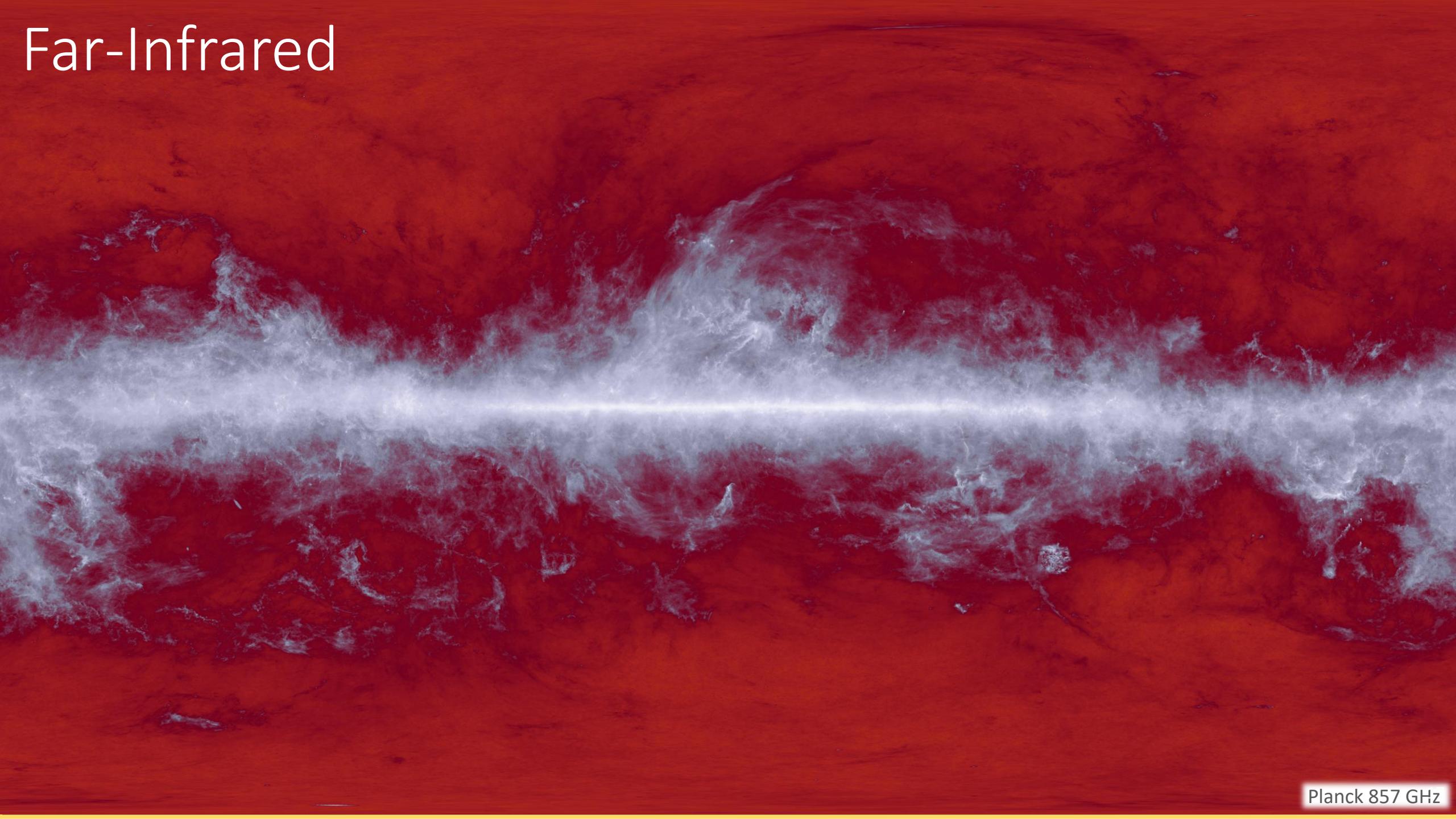
What is ISM dust?



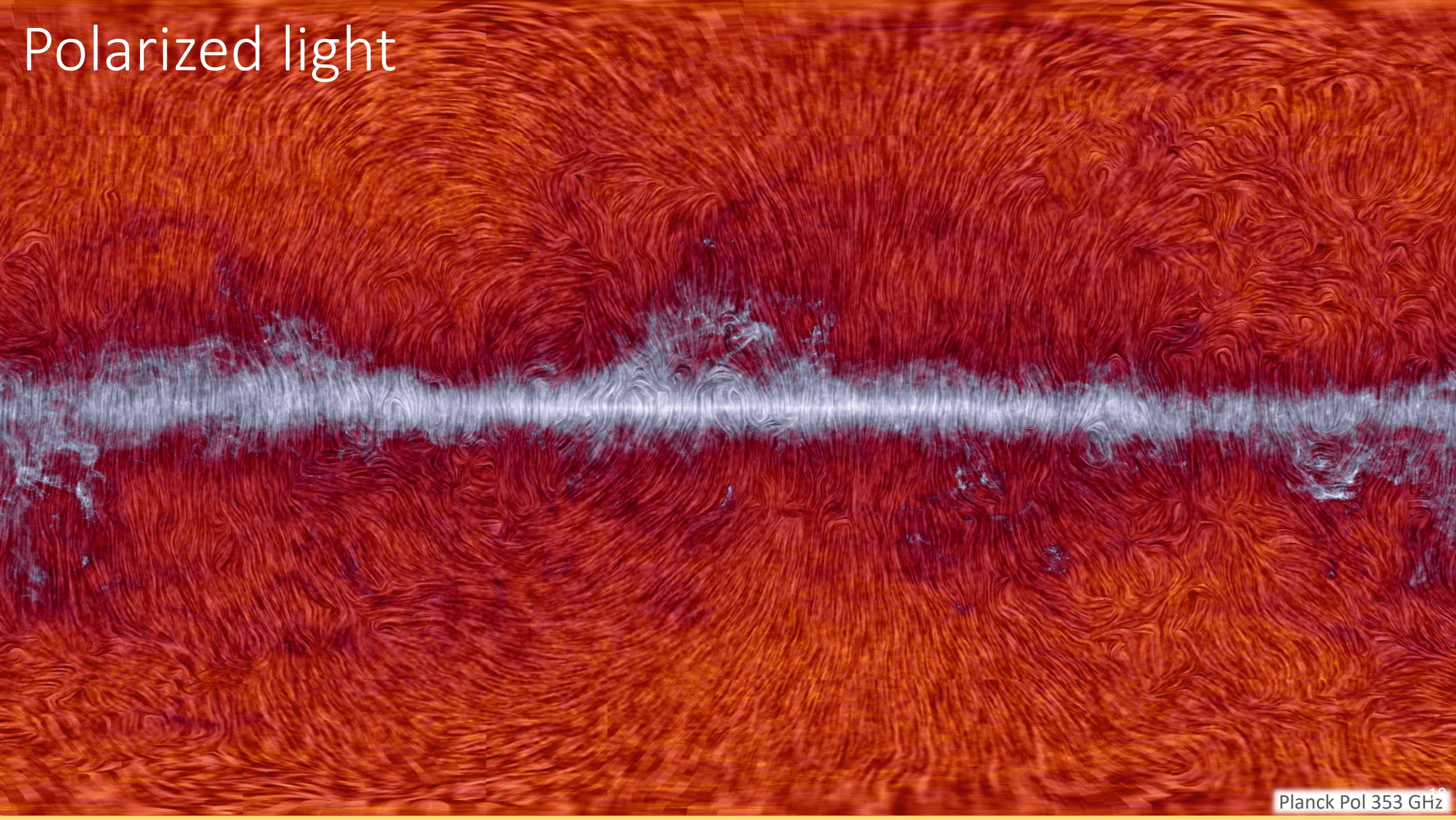


Visible

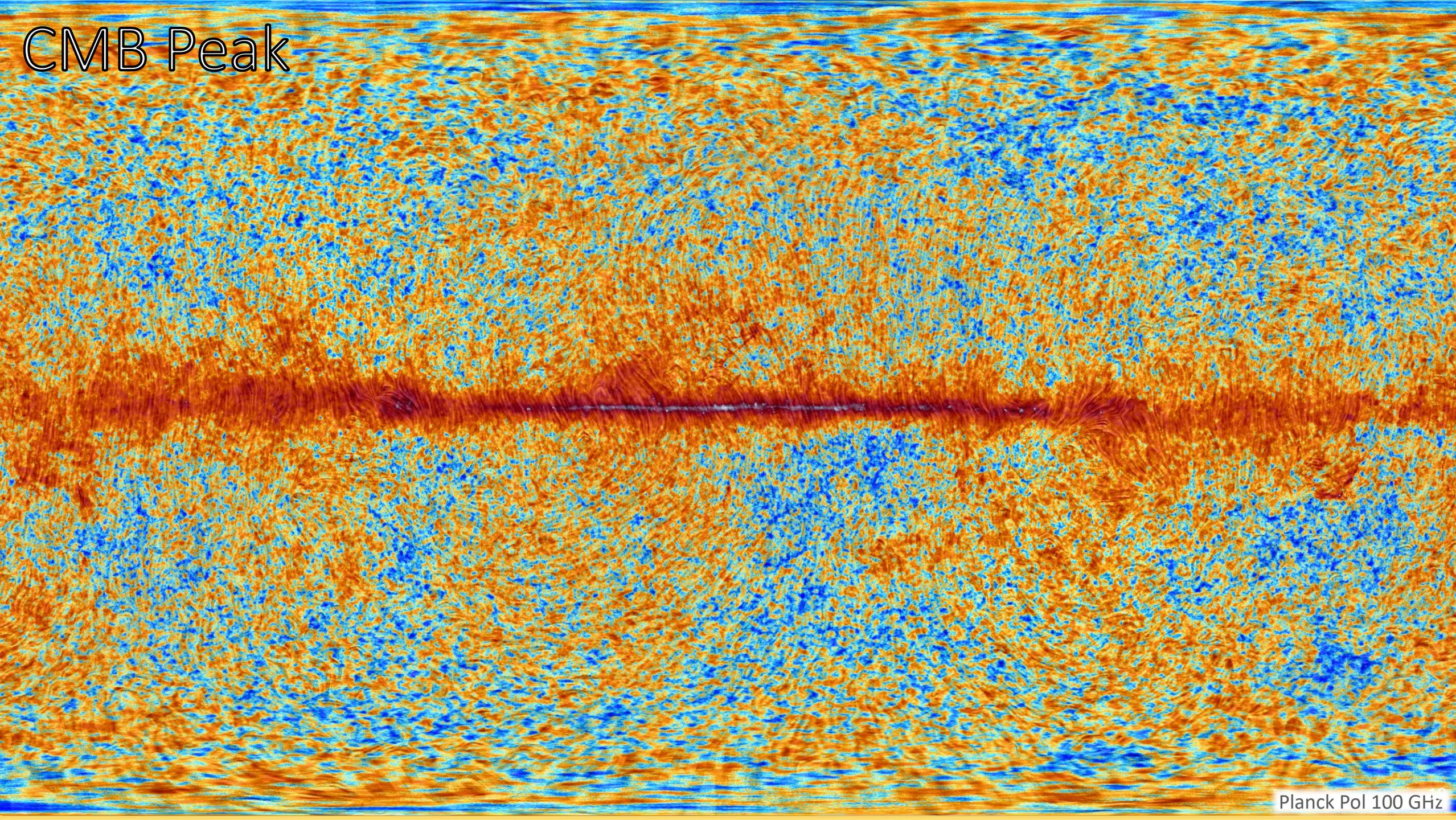
Far-Infrared



Planck 857 GHz



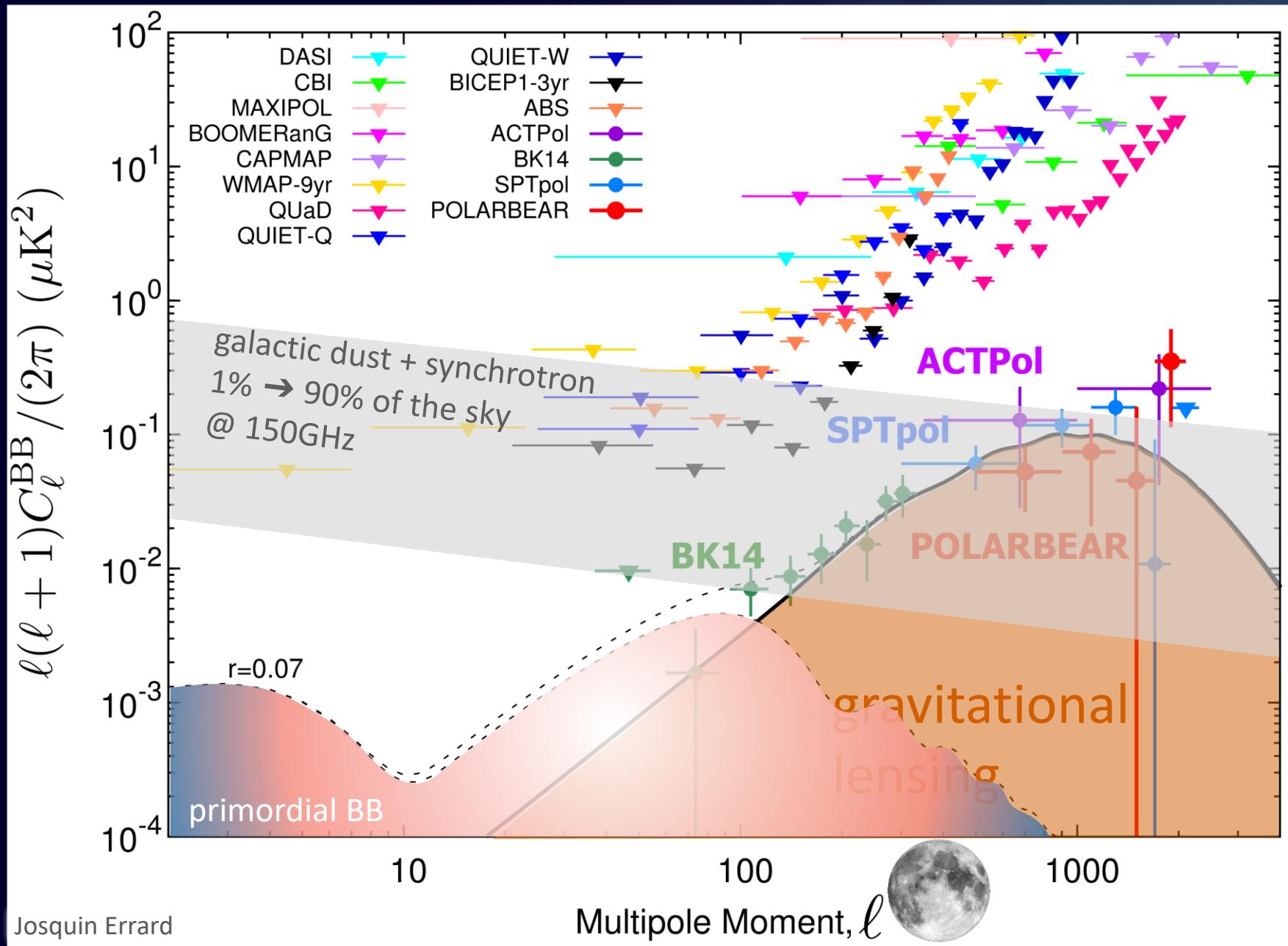
Polarized light



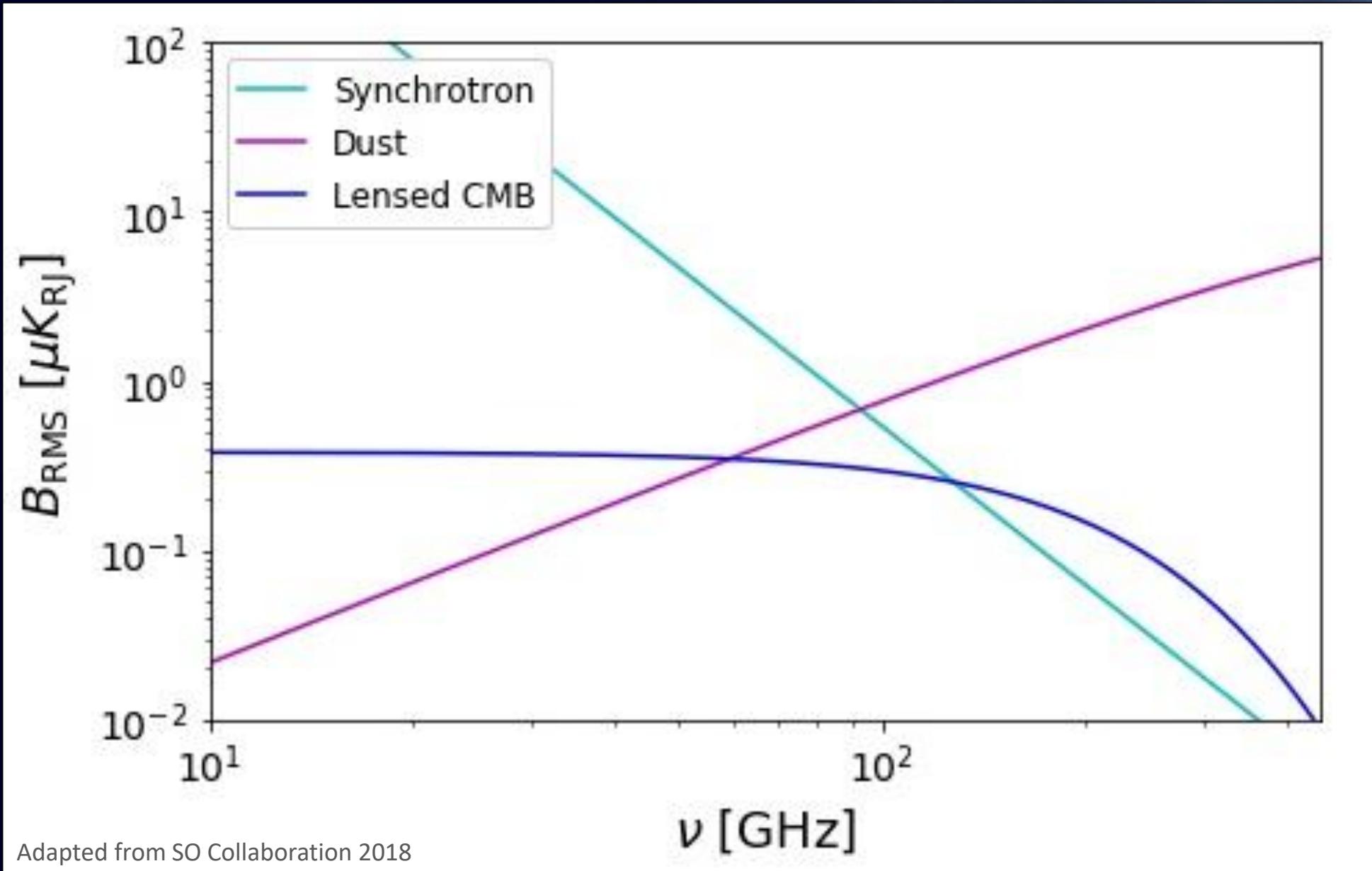
CMB Peak

Planck Pol 100 GHz

Component angular scale dependence



B-mode frequency dependence



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BLASTPol and BLAST-TNG



What's next?



How do we build an experiment to
maximize return on CMB science goals?

Experimental Parameters

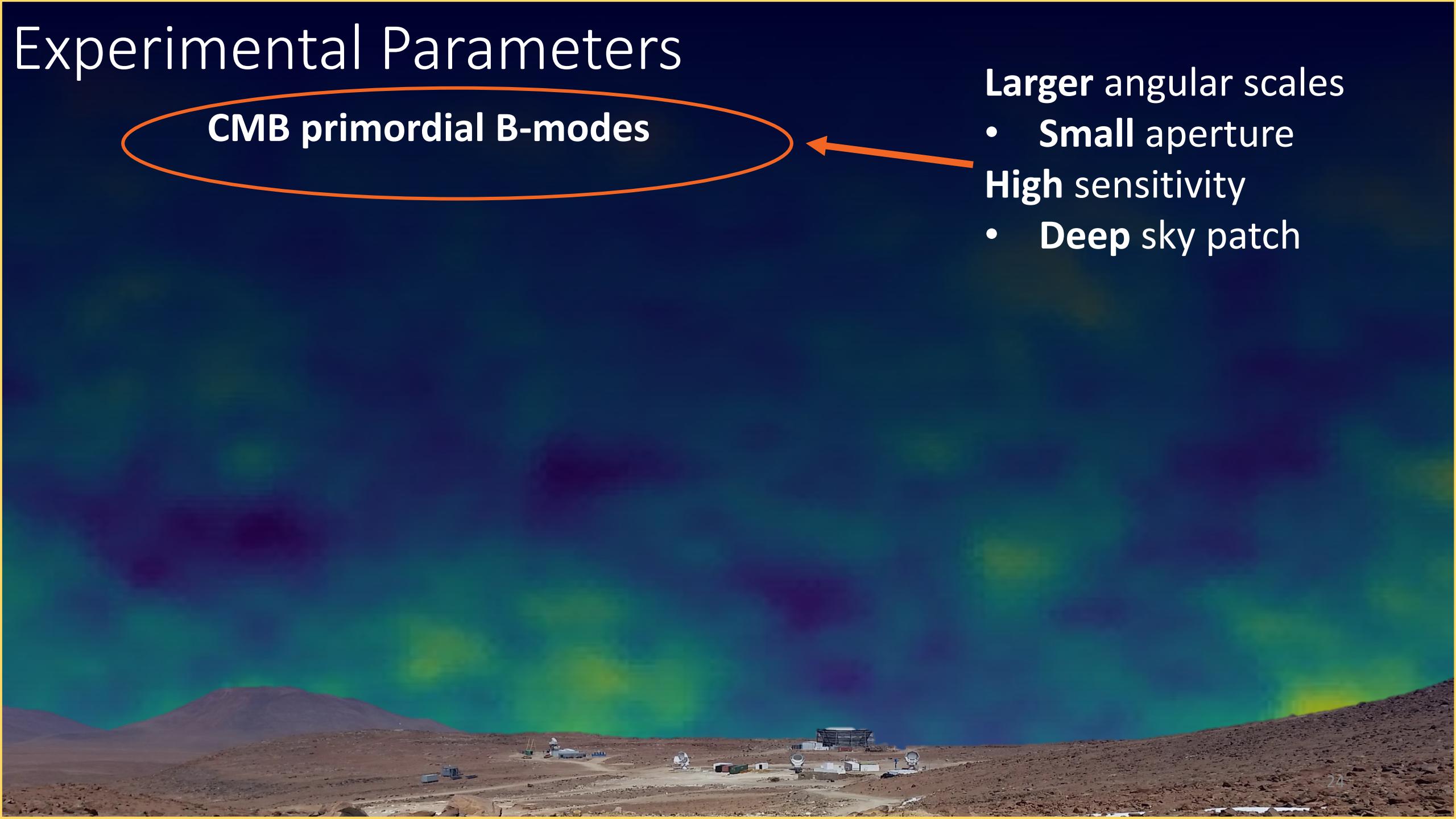
CMB primordial B-modes

Larger angular scales

- Small aperture

High sensitivity

- Deep sky patch



Experimental Parameters

CMB primordial B-modes

+ lensing of CMB fields

+ clusters + E-modes

Smaller angular scales

- **Large** aperture

Wide sky patch

Very exciting and worth a whole separate talk!

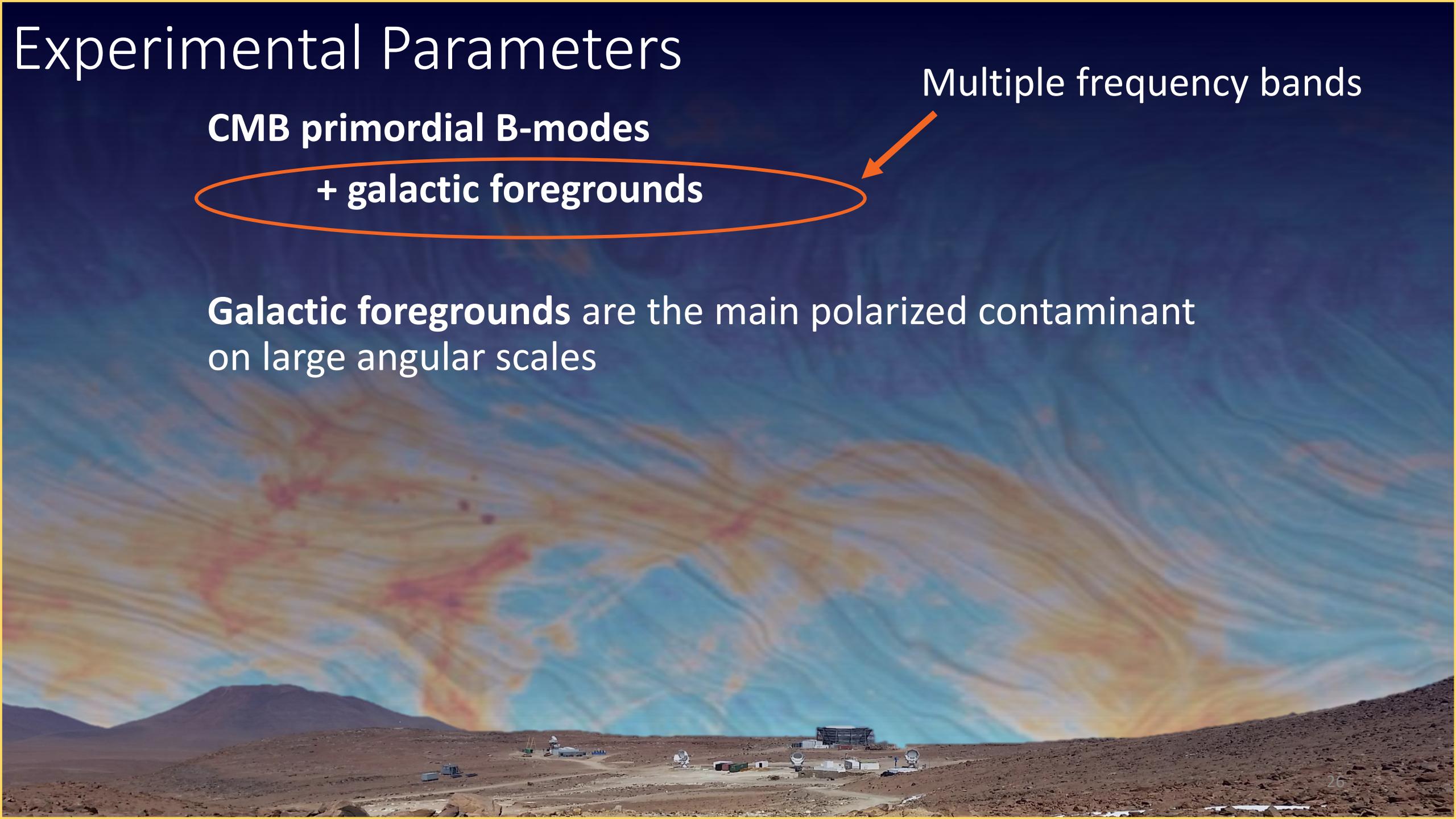
Experimental Parameters

CMB primordial B-modes

+ galactic foregrounds

Multiple frequency bands

Galactic foregrounds are the main polarized contaminant
on large angular scales



Experimental Parameters

CMB primordial B-modes
+ galactic foregrounds

+ atmosphere,
instrumental noise,
systematics

Systematic mitigation
and characterization

Calibration



F. Nati 2017

Control of instrumental systematics is one of the most important challenges for next gen CMB instruments

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BLASTPol and BLAST-TNG



What's next?

The Simons Observatory Collaboration



July 2019

29

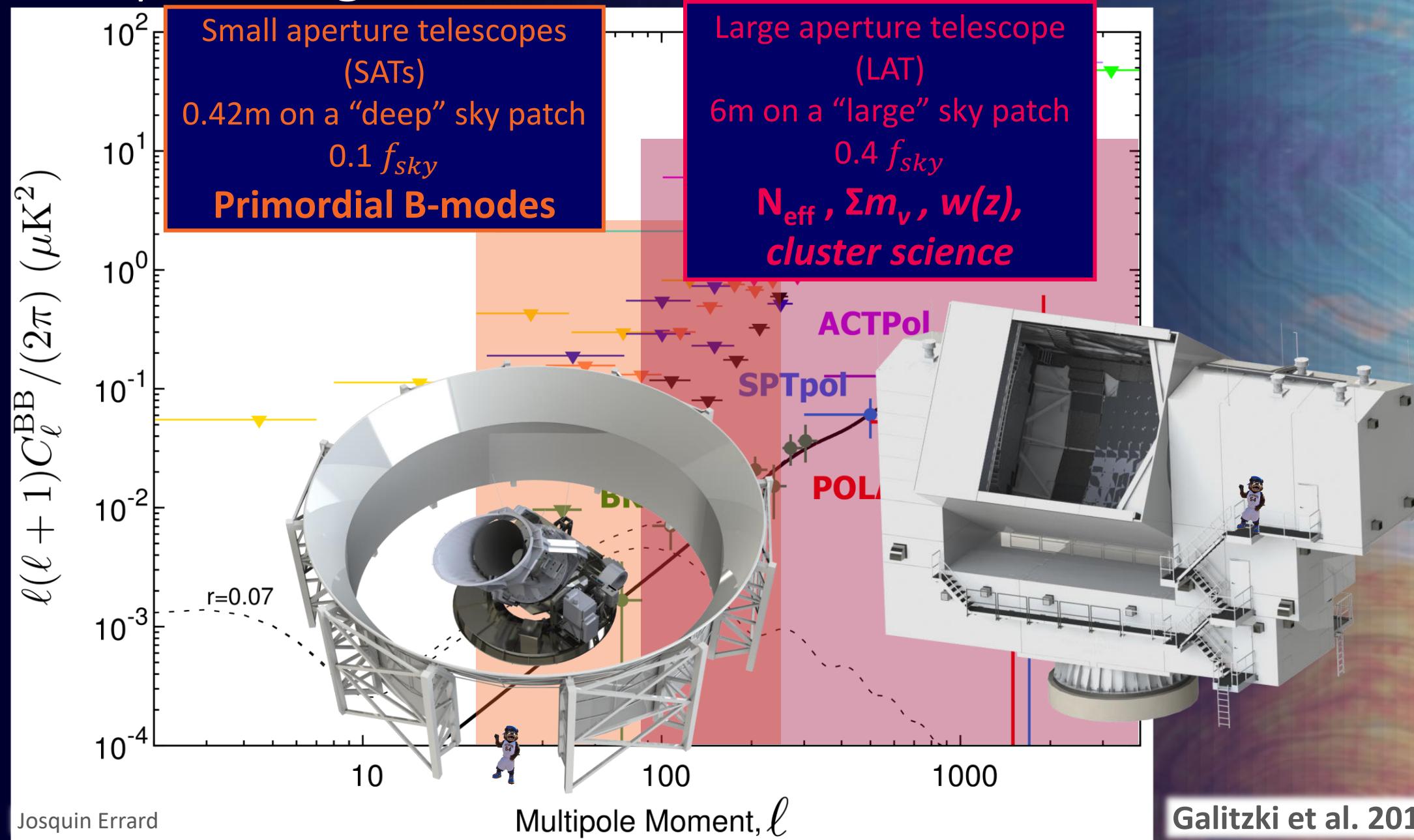
Observatory Site



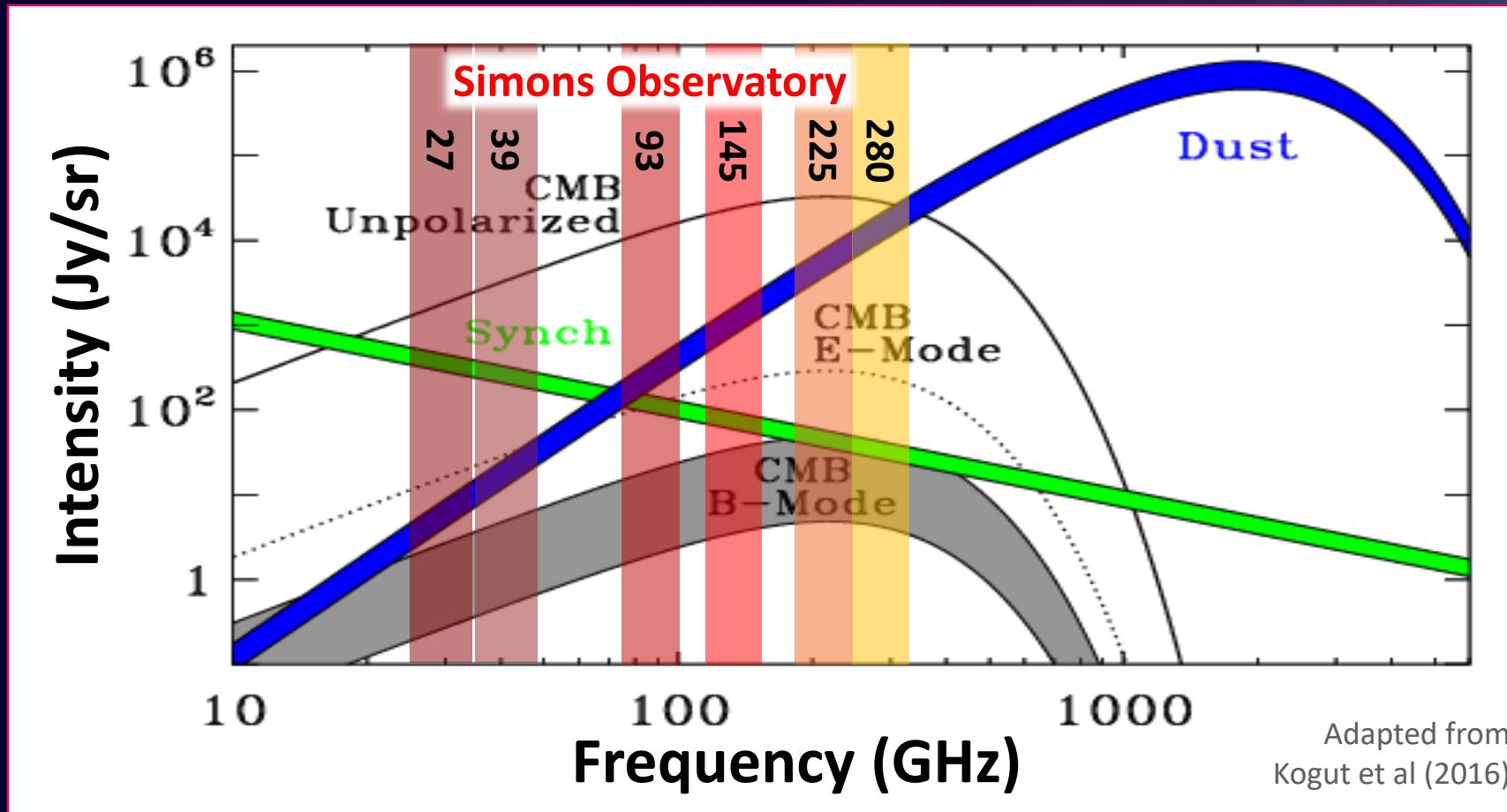
ATACAMA DESERT - CHILE

Simons Foundation

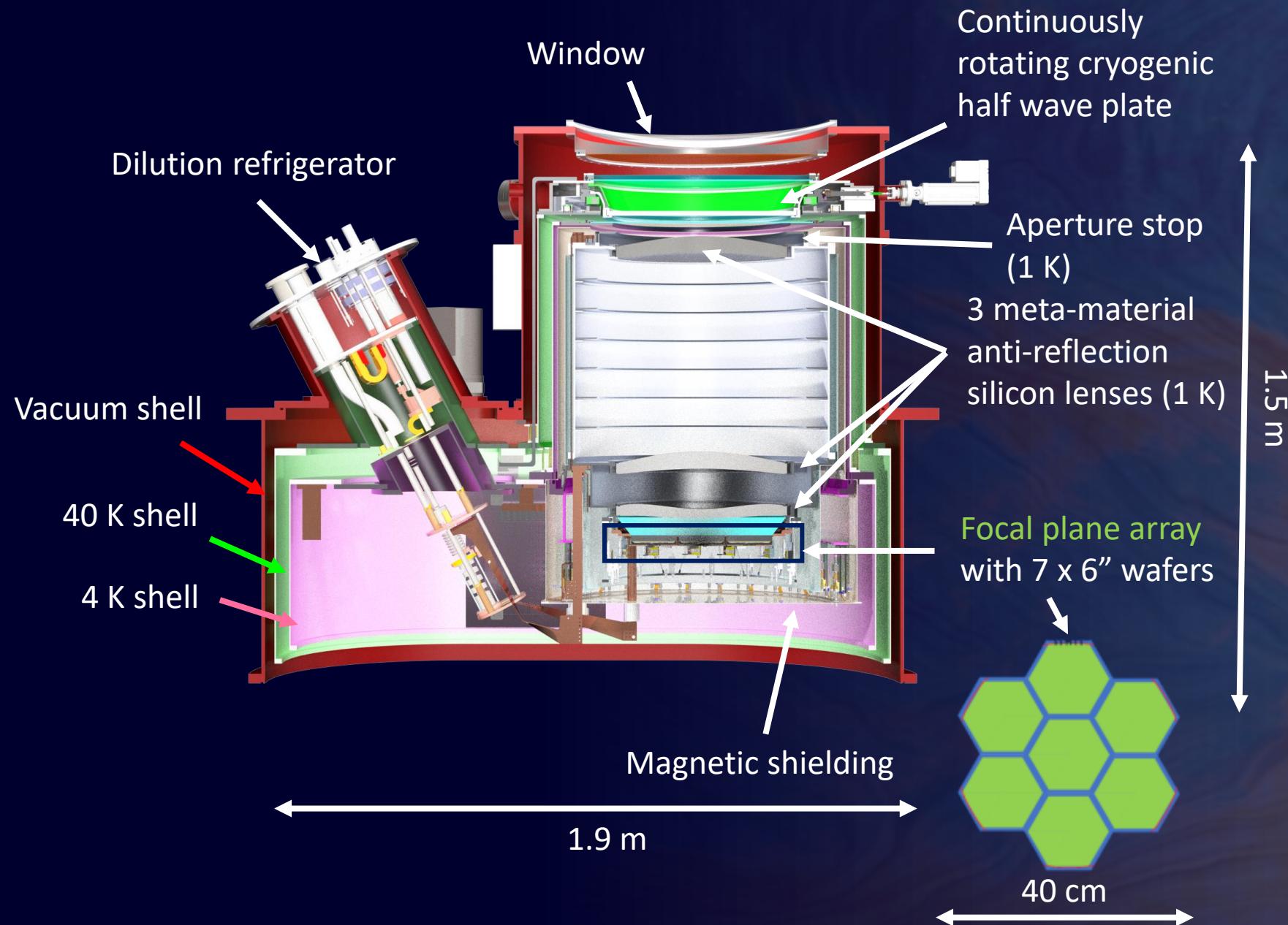
Two telescope designs

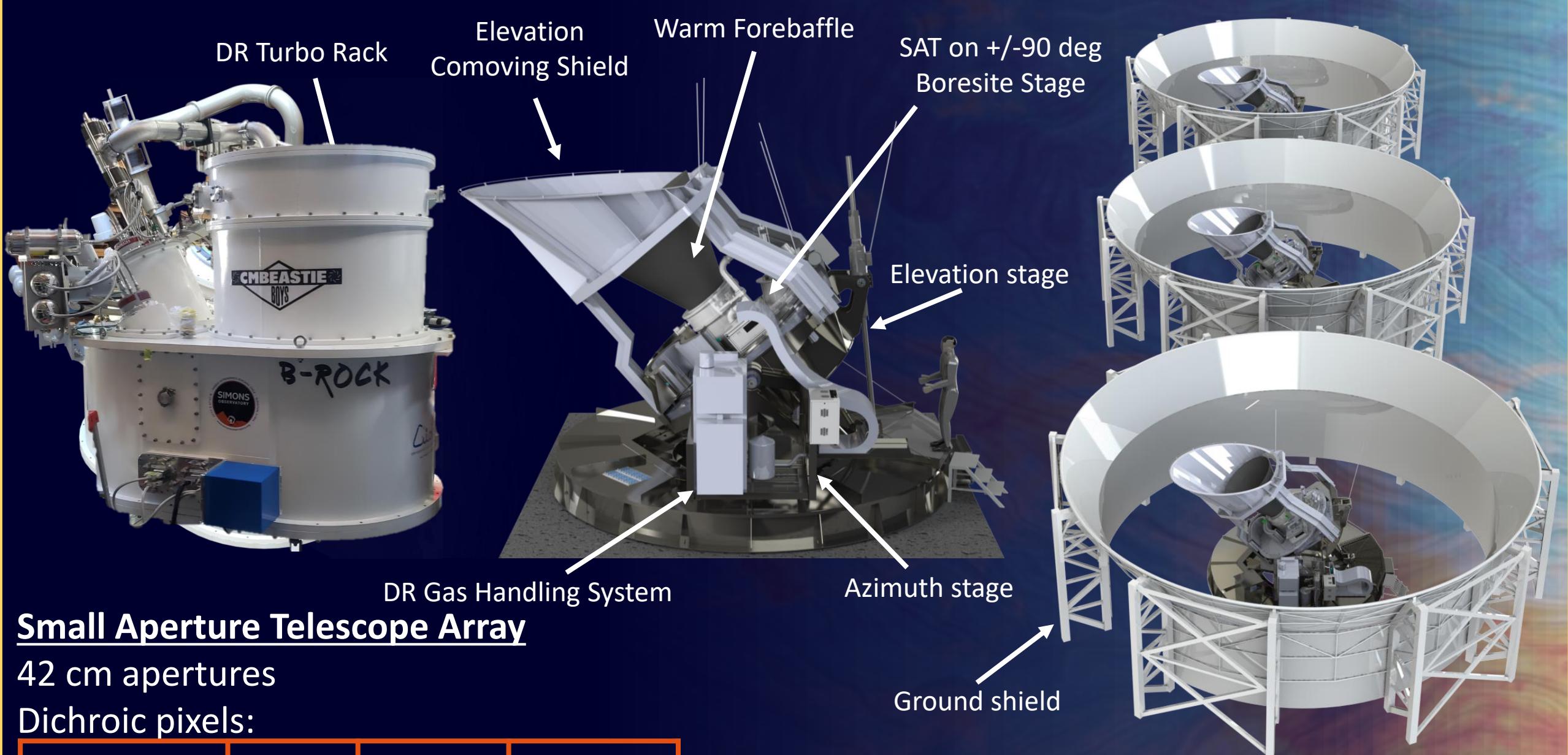


Frequency channels



Small Aperture Telescopes





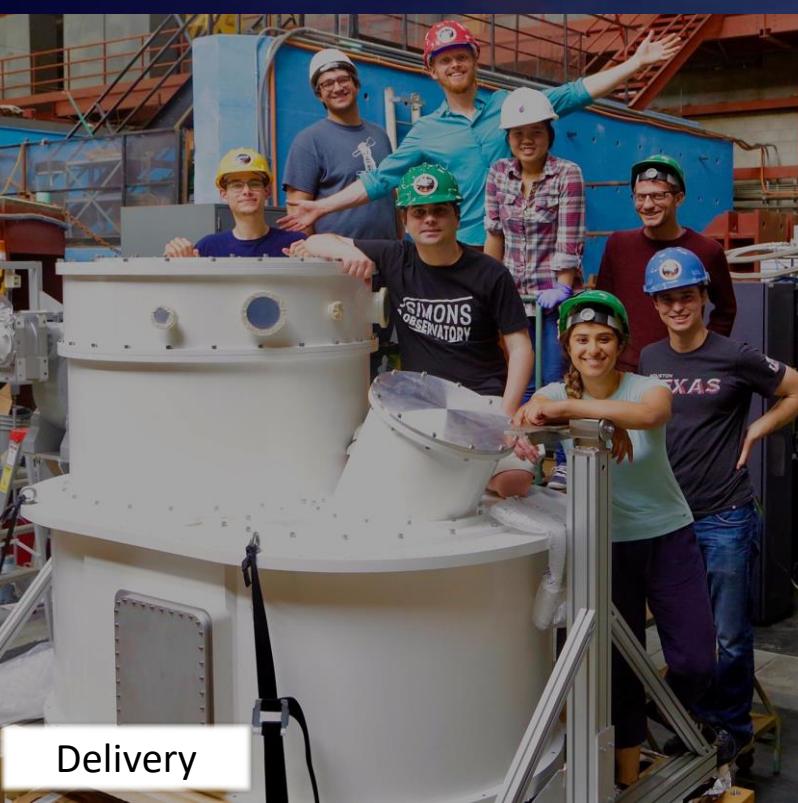
Small Aperture Telescope Array

42 cm apertures

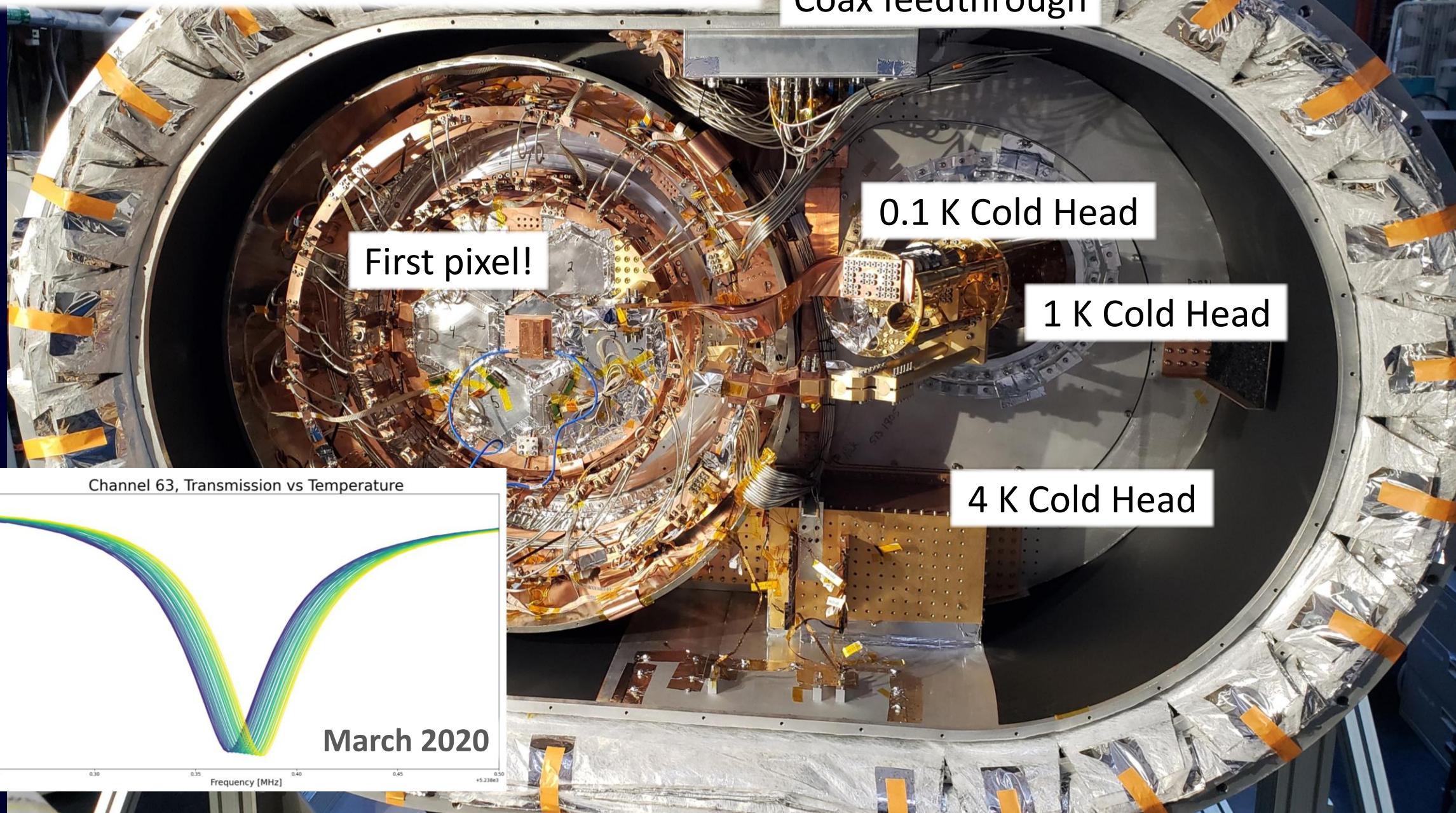
Dichroic pixels:

| | | | |
|-------------|-------|--------|---------|
| v (GHz) | 27/39 | 90/150 | 220/270 |
| # detectors | 1036 | 12096 | 12096 |

SAT Progress

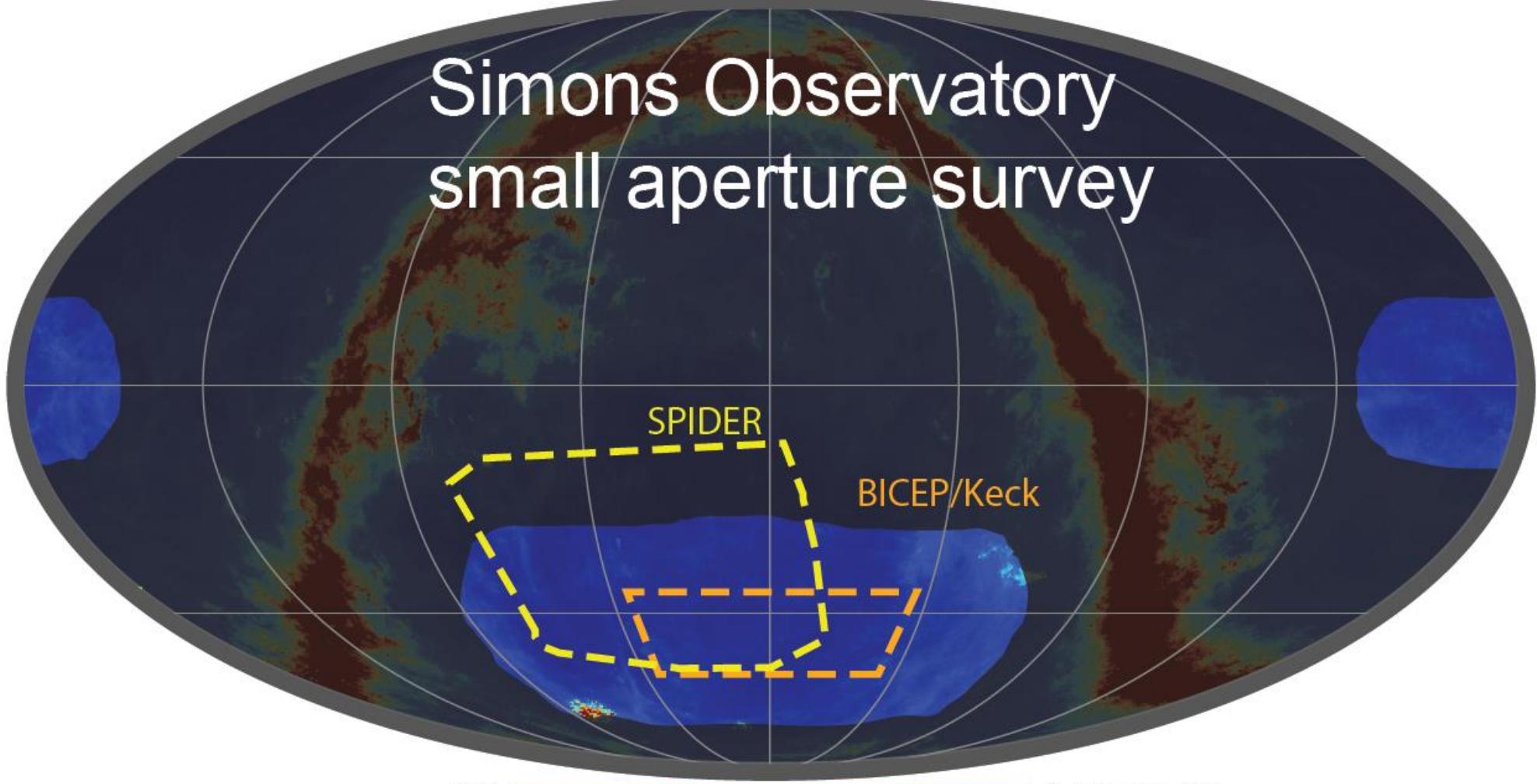


SAT Detectors and Readout



SAT sky fraction ~10%

Simons Observatory small aperture survey



SO Collaboration 2018

0.0 ————— 0.10 mK RJ
FDS dust emission

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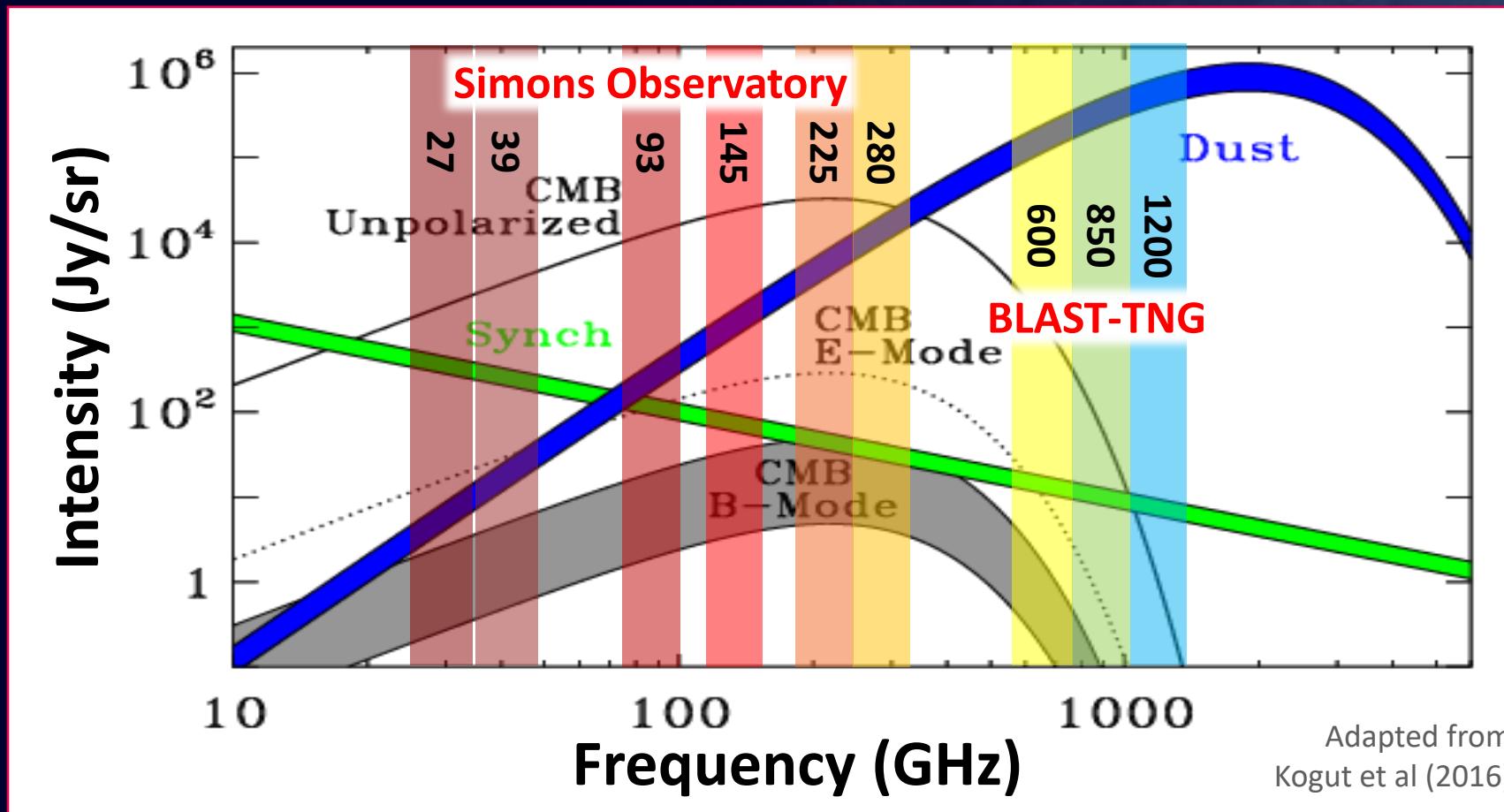


BLASTPol and BLAST-TNG



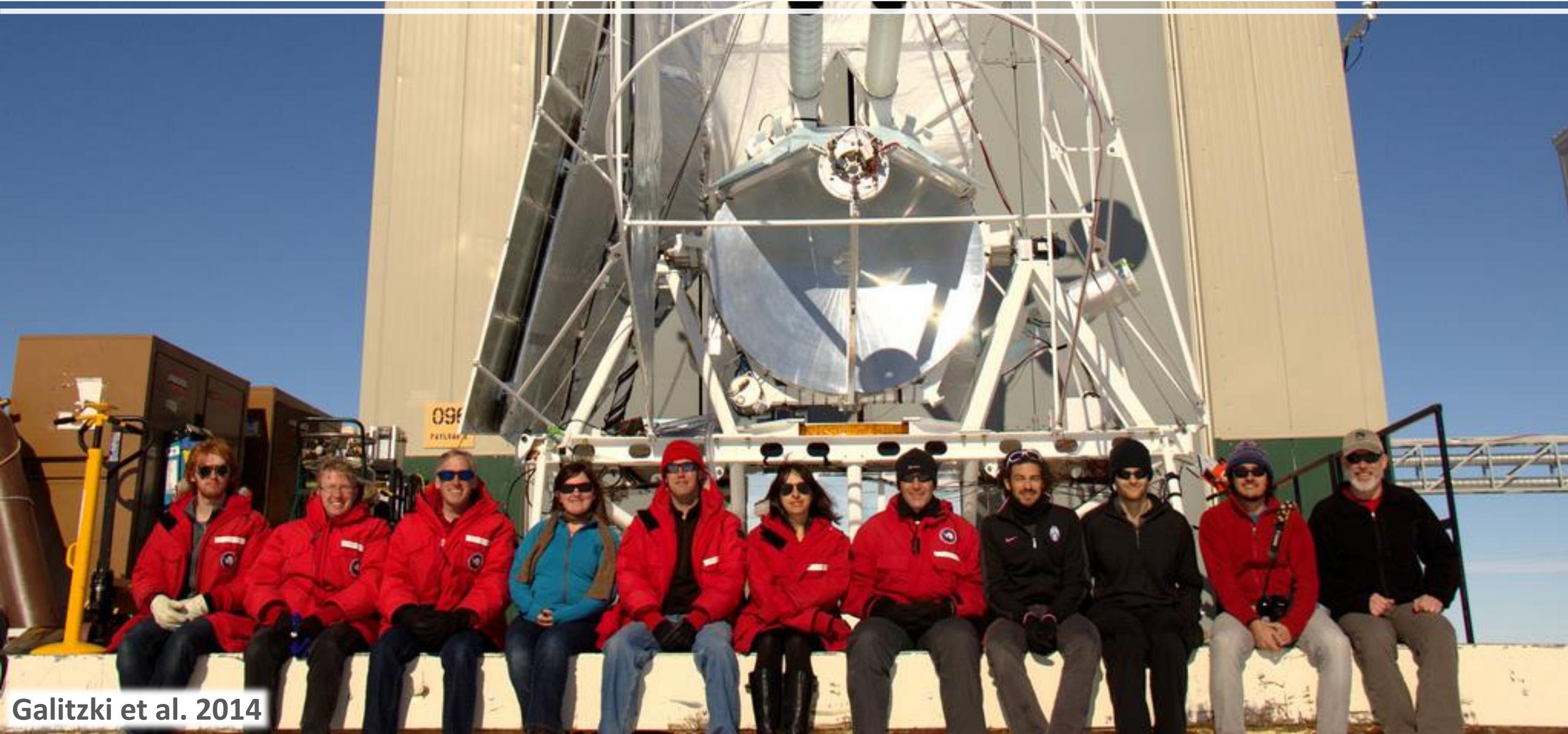
What's next?

Experimental Context

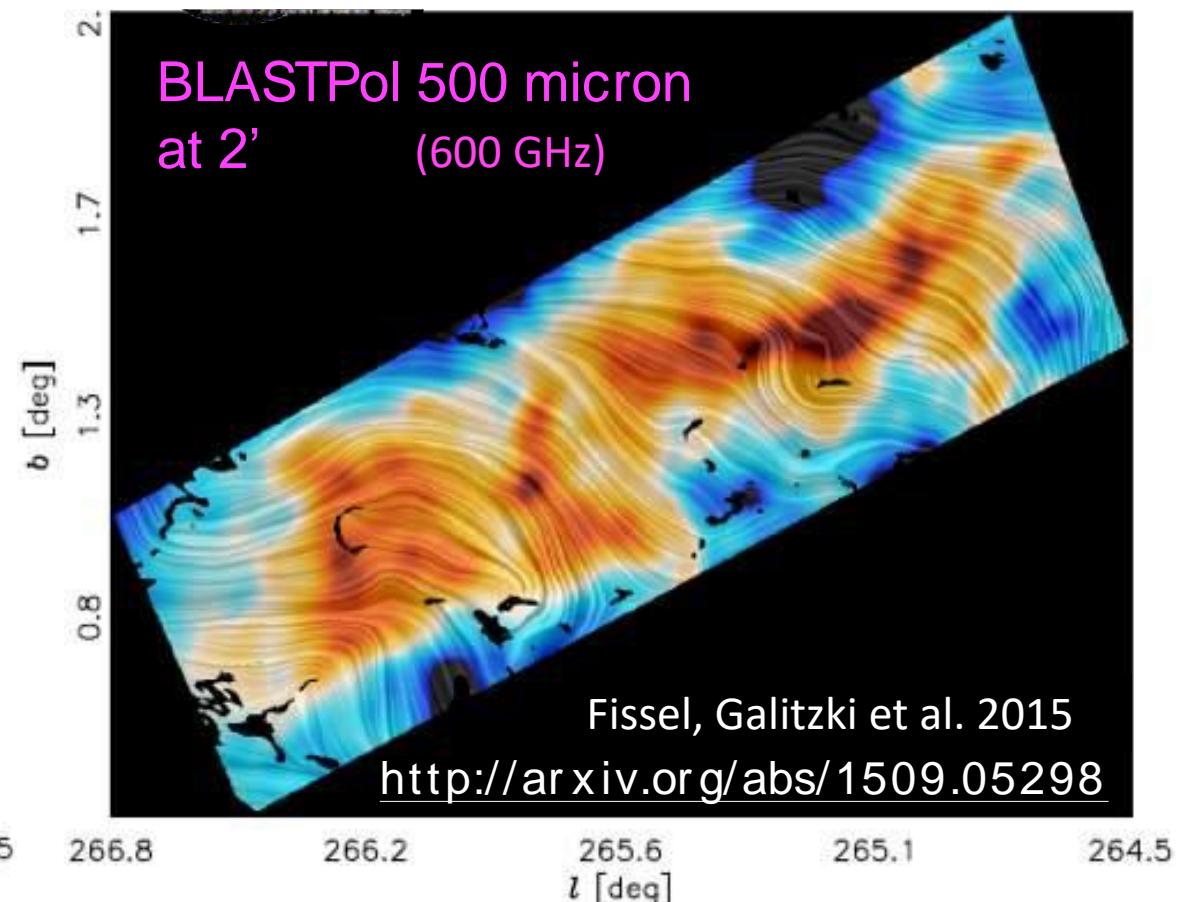
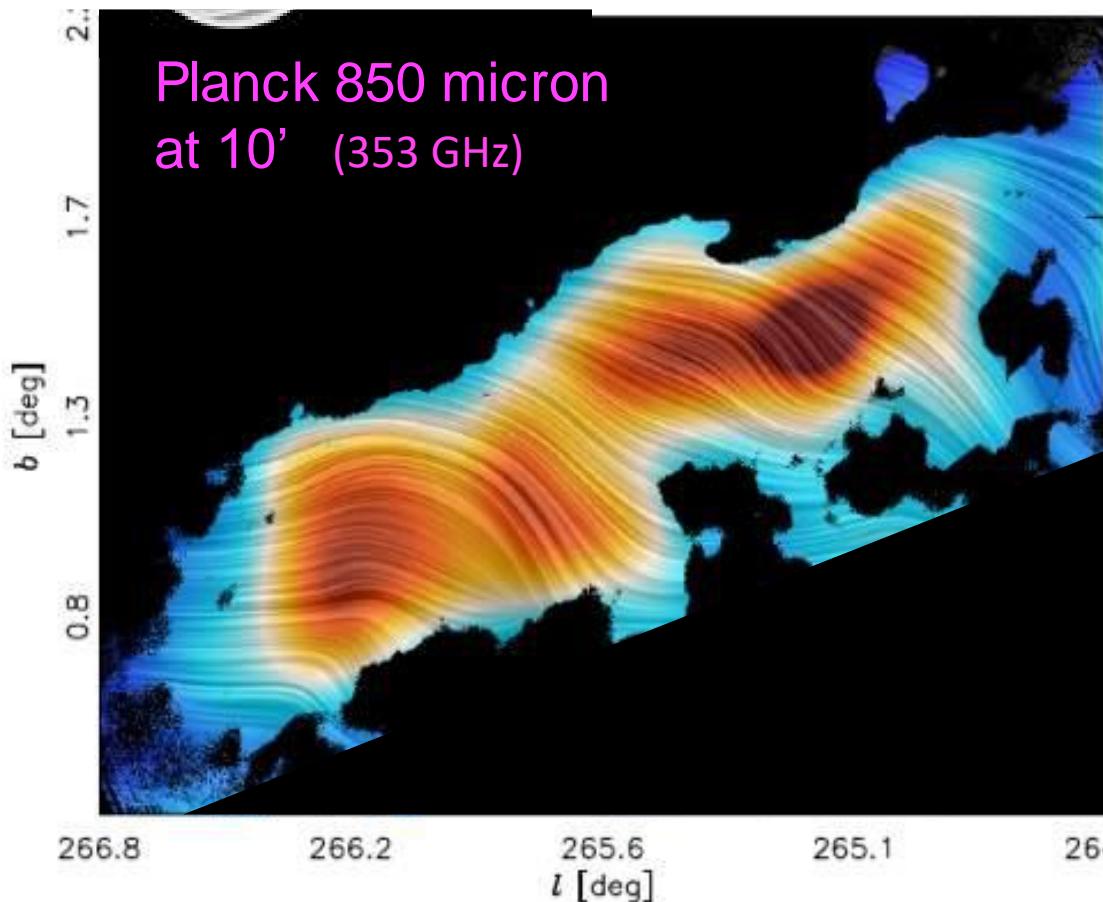


Adapted from
Kogut et al (2016)

BLASTPol 2012

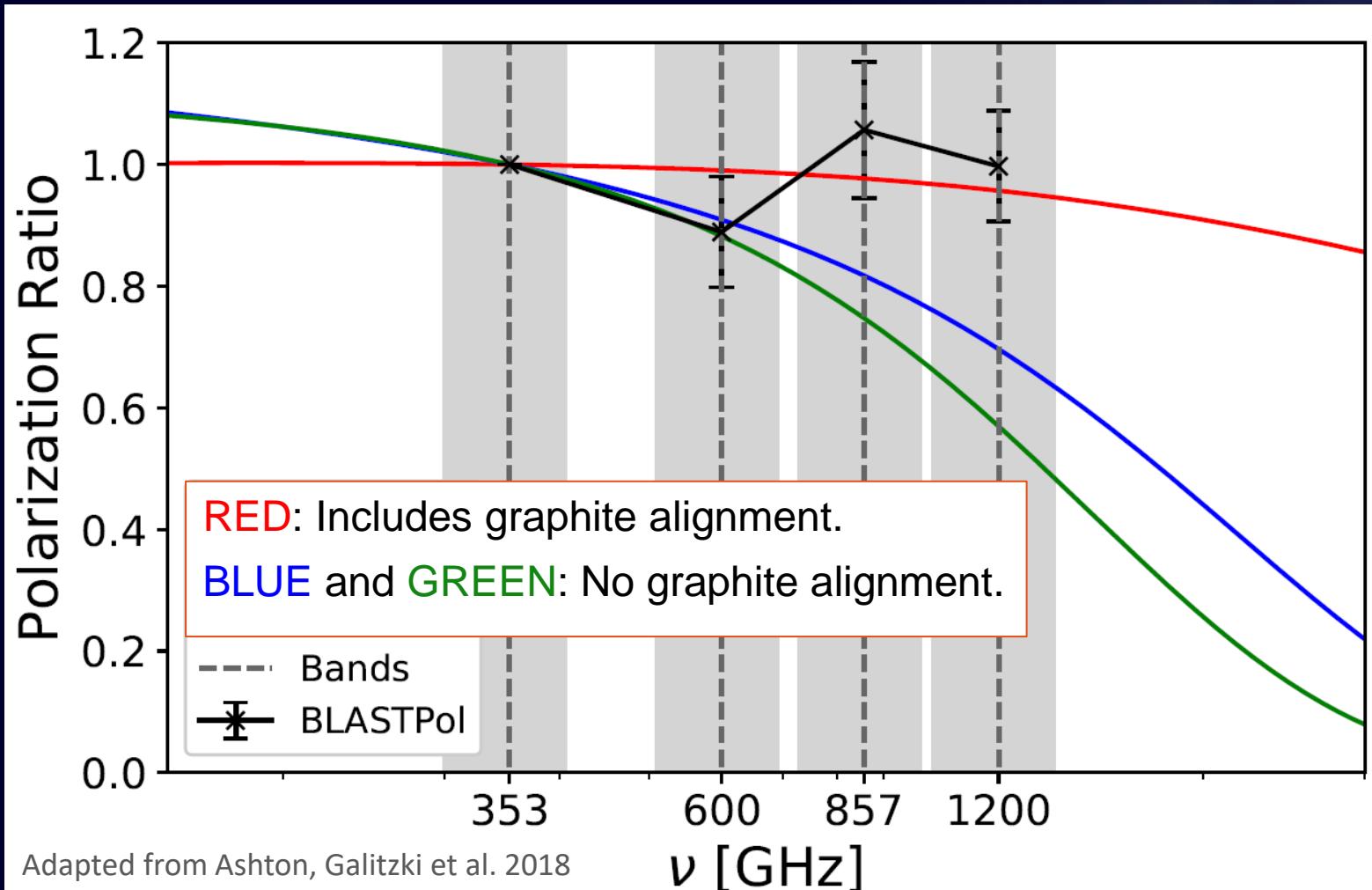


Comparison with Planck

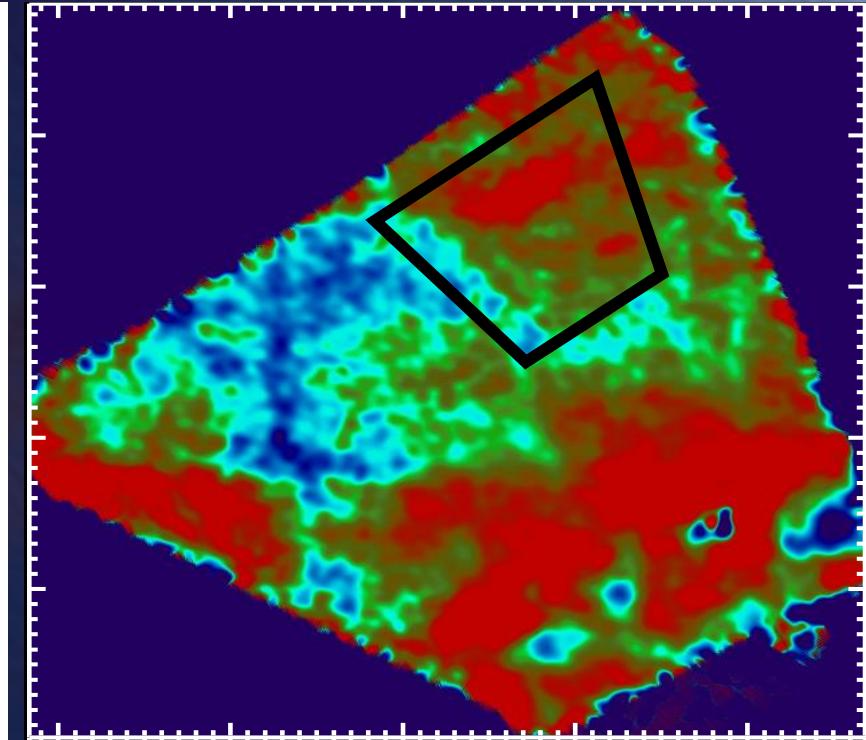


Polarization Spectrum

Normalized polarization response to Planck 353 GHz vs. frequency



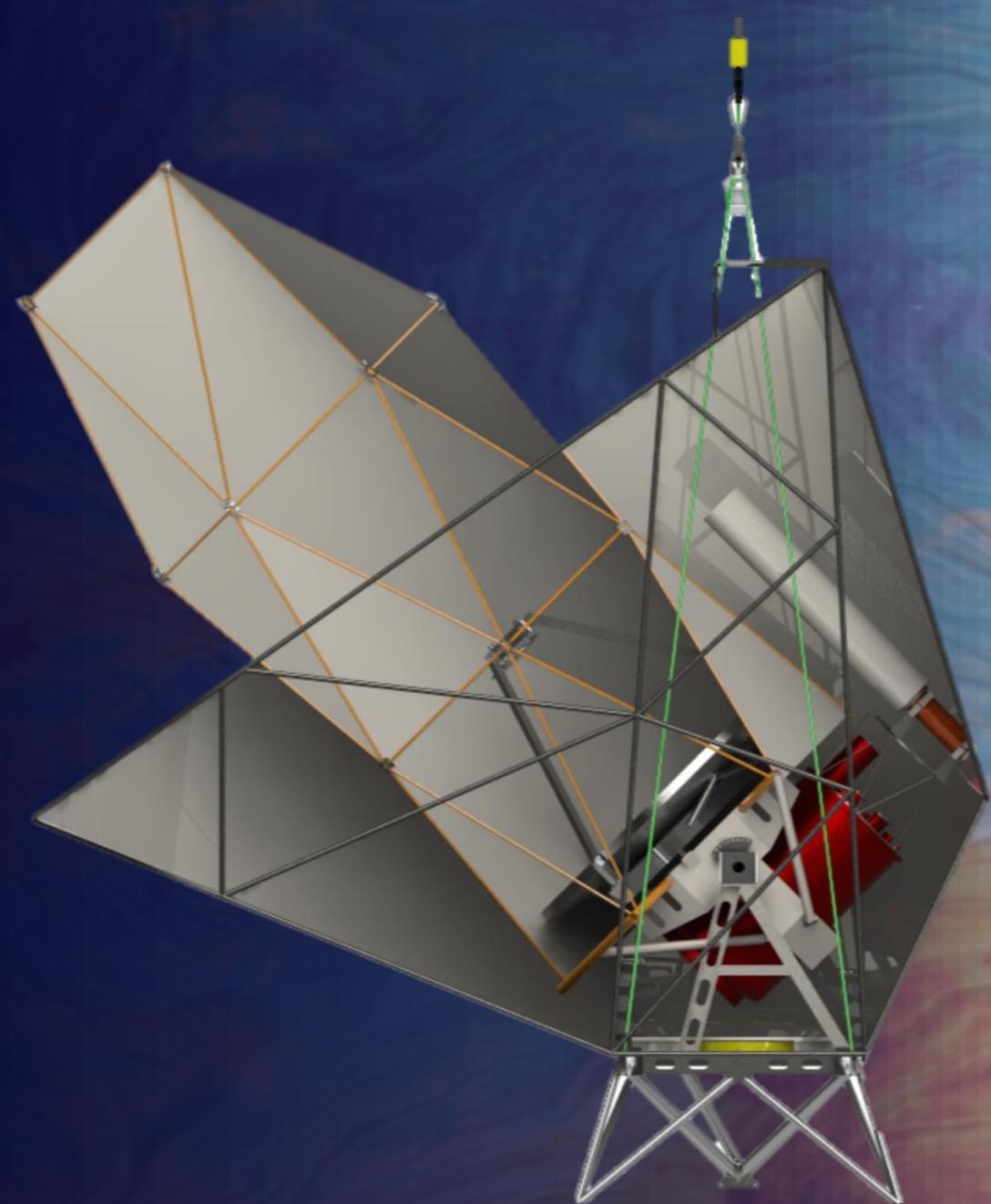
Adapted from Ashton, Galitzki et al. 2018



- **BLAST-TNG Specs**

- Primary: 2.5m
- Bands: 250, 350, 500 μm
- # of Pixels: 918, 469, 272
- FOV: 22'
- Resolution: 25'', 35'', 50''

→ **16 x BLASTPol
Mapping Speed**



Galitzki et al. 2014

BLAST-TNG Camera

250 L of liquid ^4He

Pumped ^4He Fridge:
1.3 K

Closed-cycle ^3He Fridge:
275 mK

28 day hold time.

1.7 m



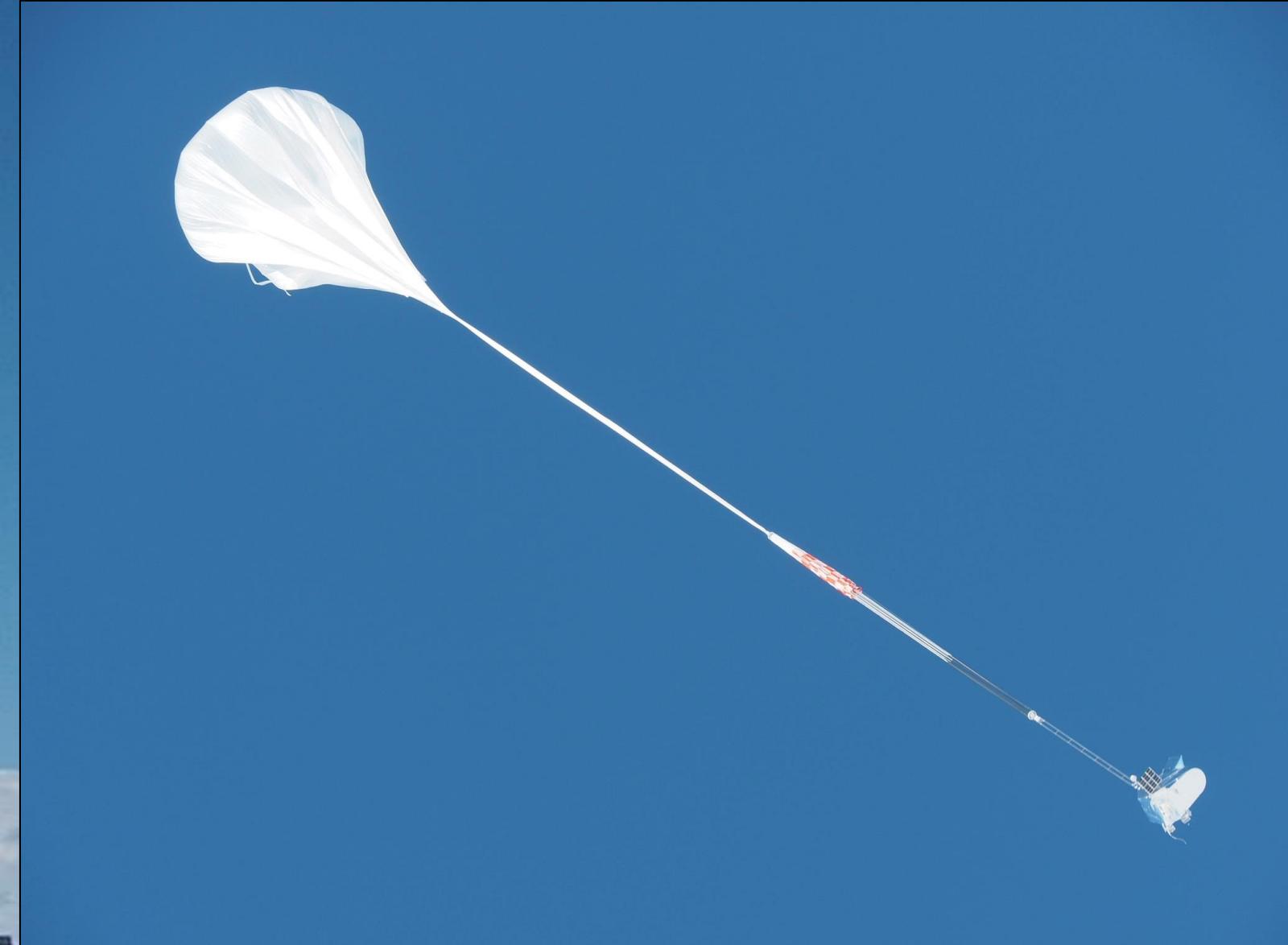
1 m

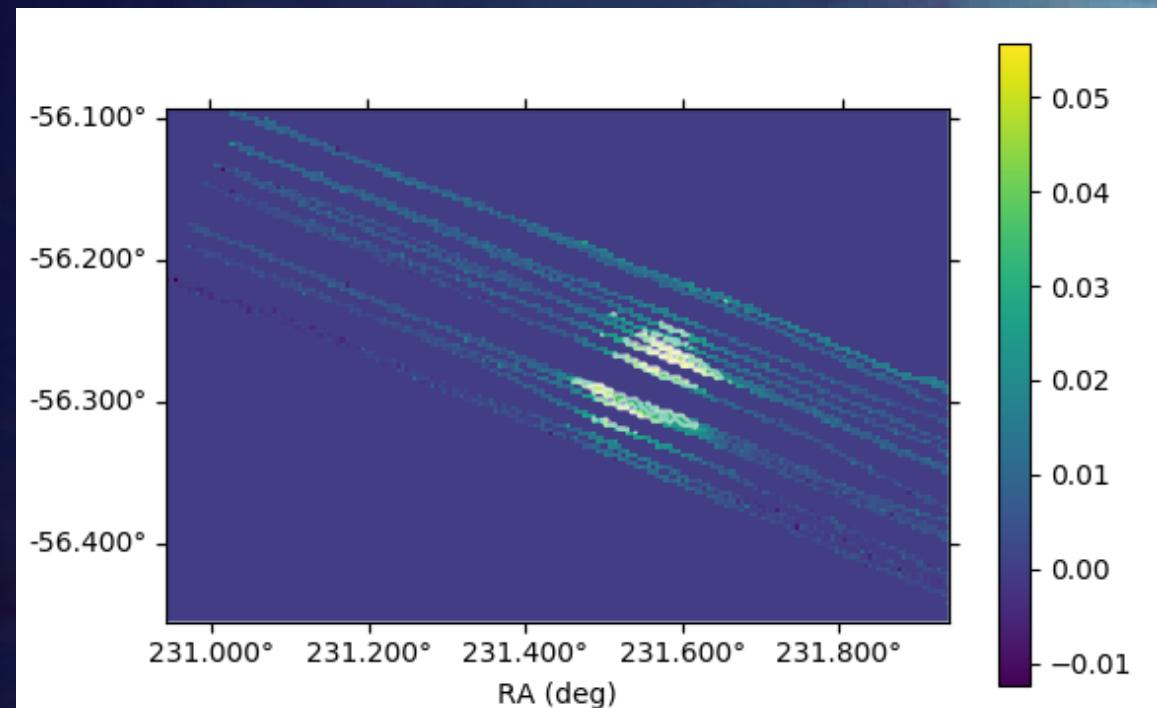
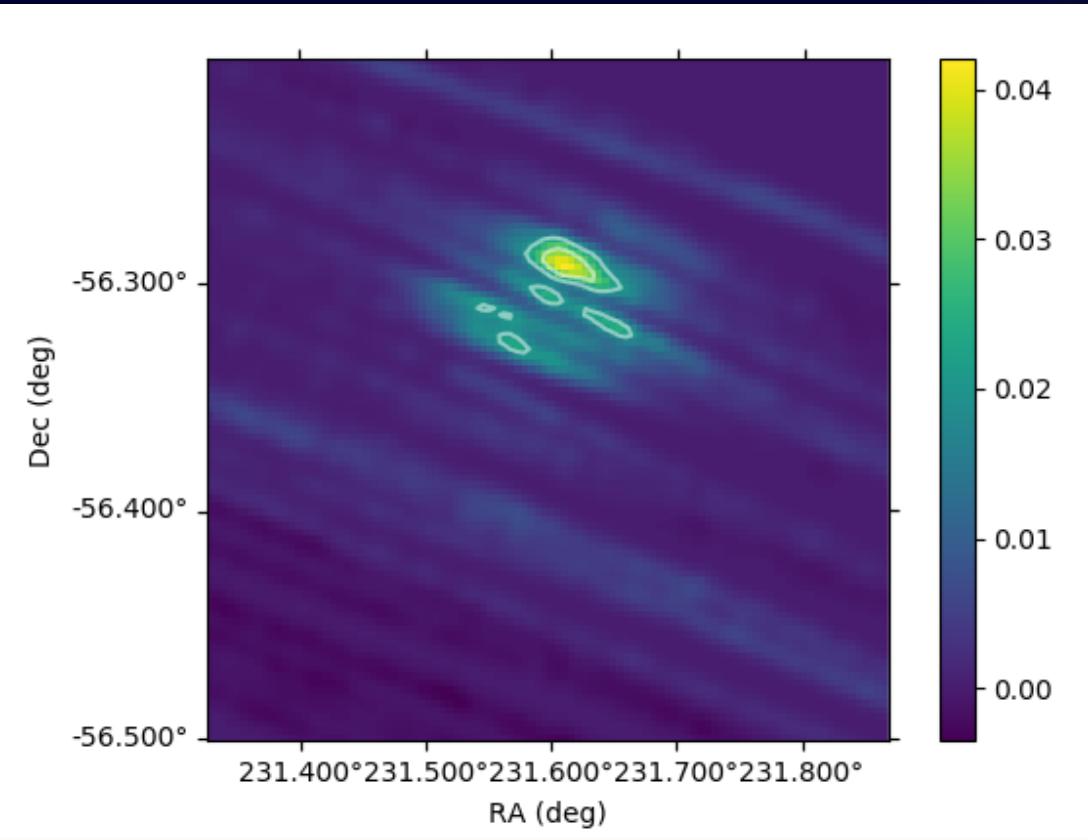
The Team





Launch January 6th 2020!





First light!

Followed by a rough landing...



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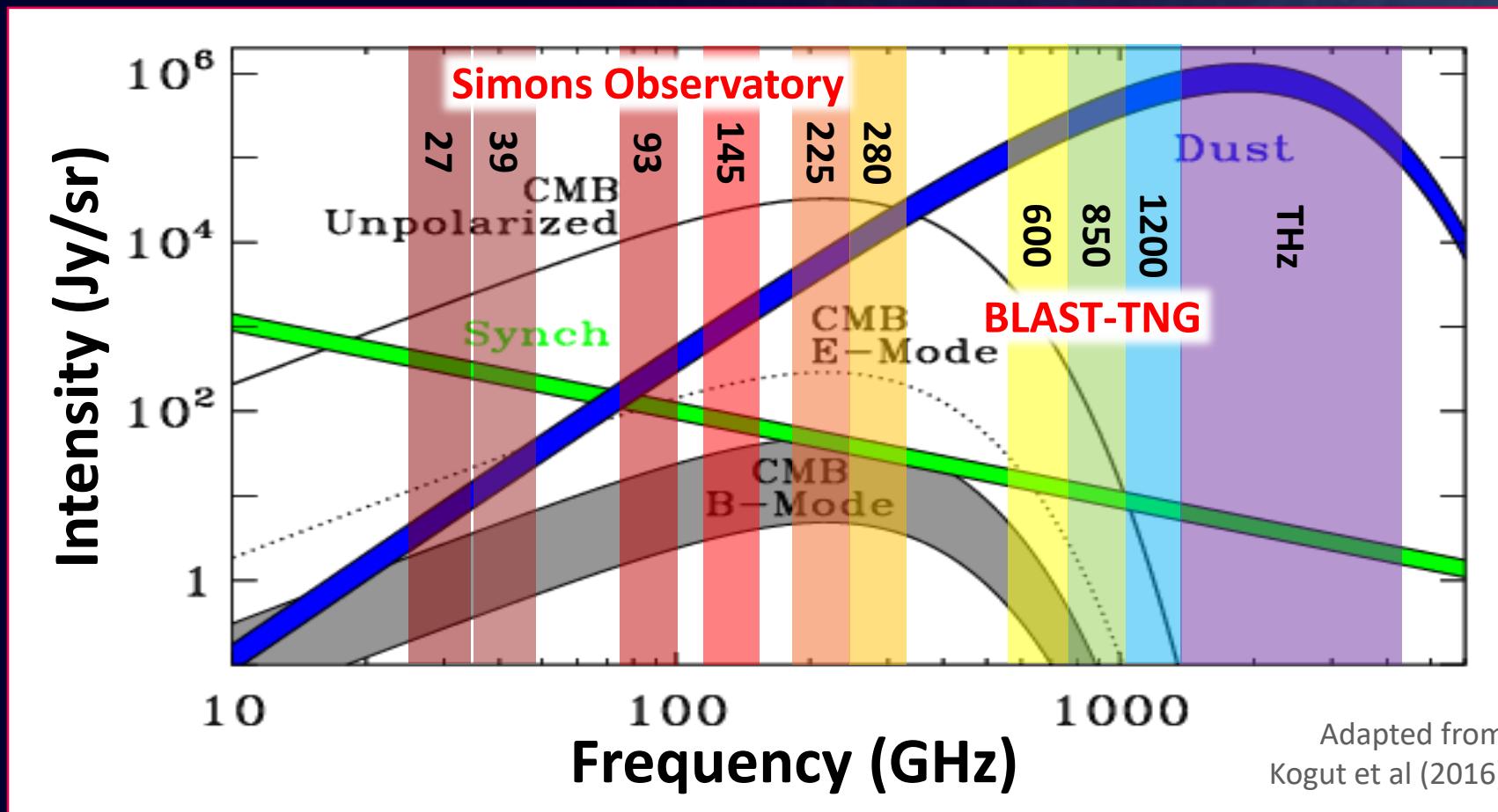


BLASTPol and BLAST-TNG



What's next?

Experimental coverage



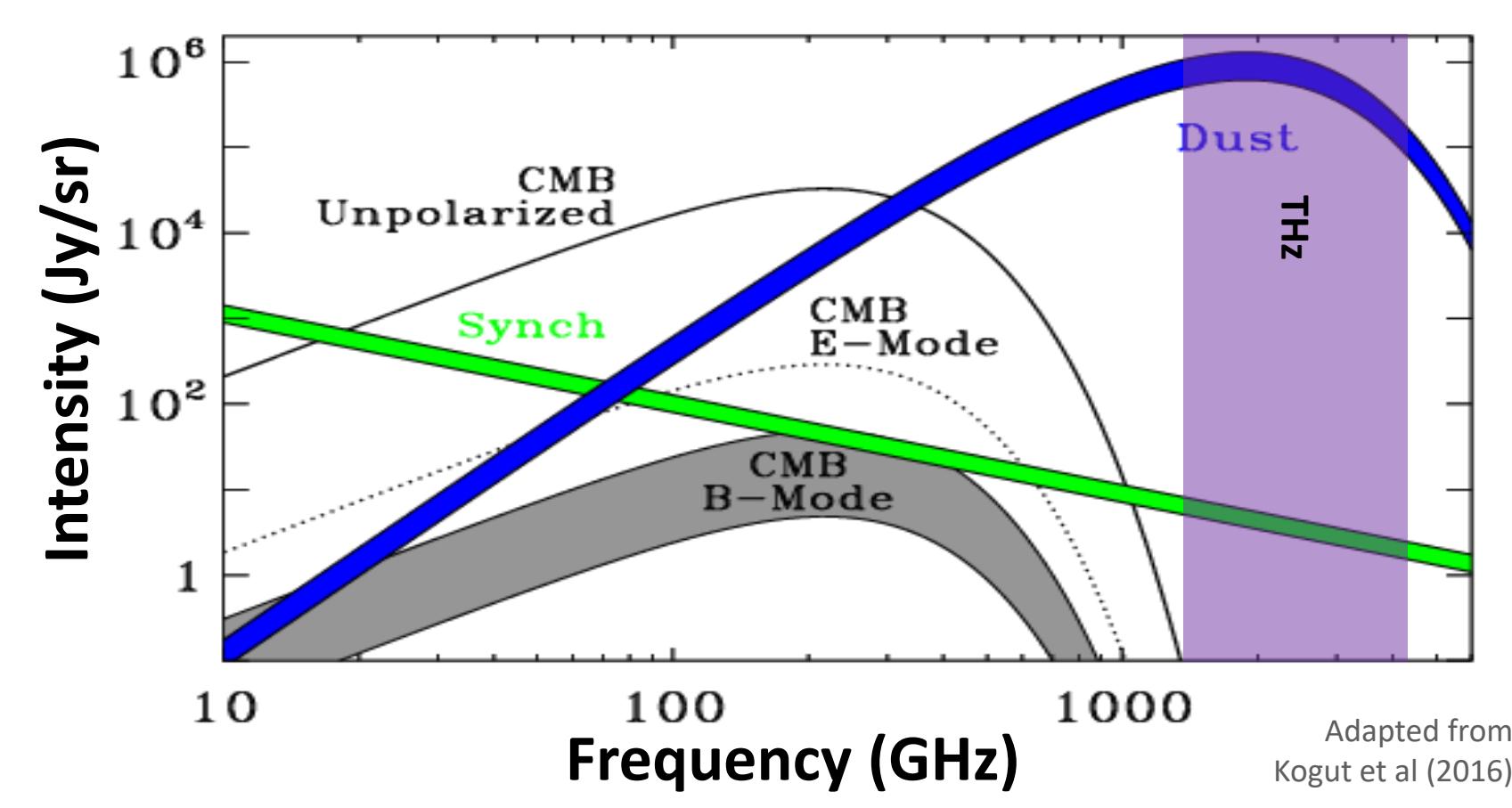


THE SIX MILLION DOLLAR TELESCOPE

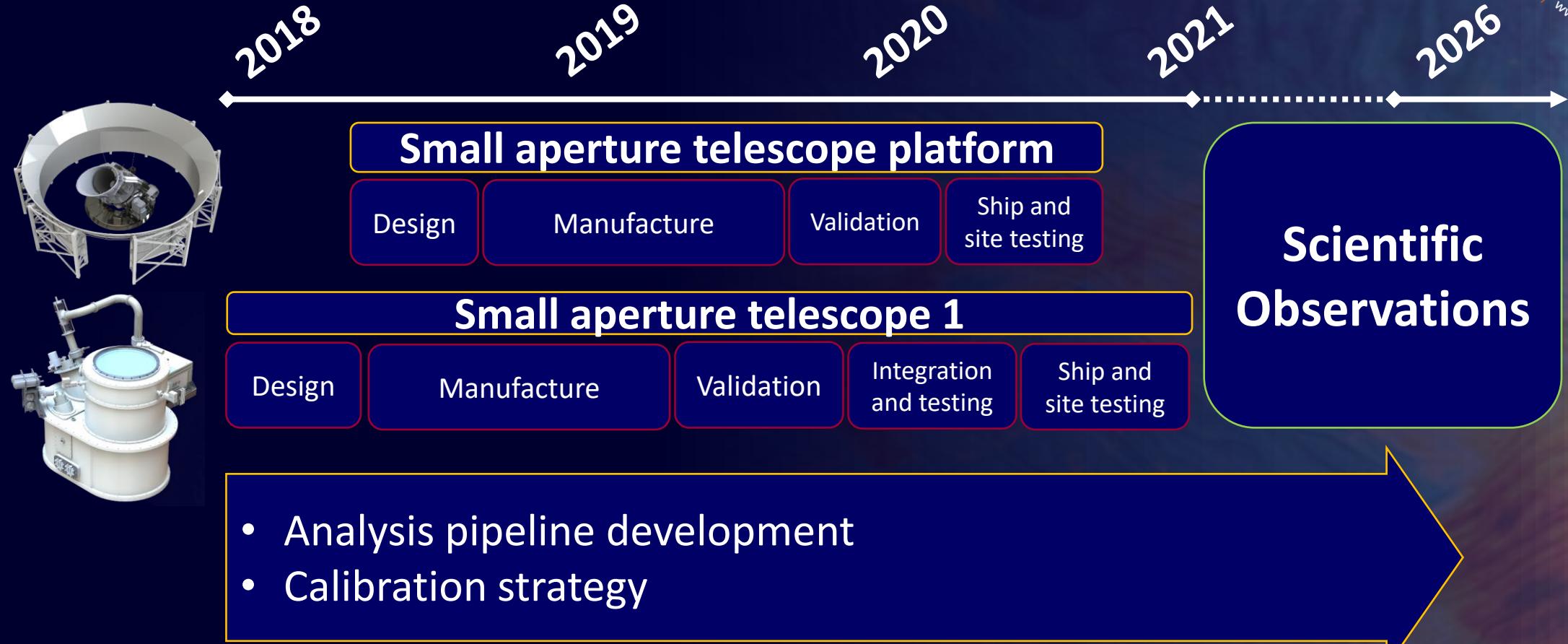


BLAST-TNG Rebuilt

THz Ultra-Long Duration Balloon



Simons Observatory



CMB-S4

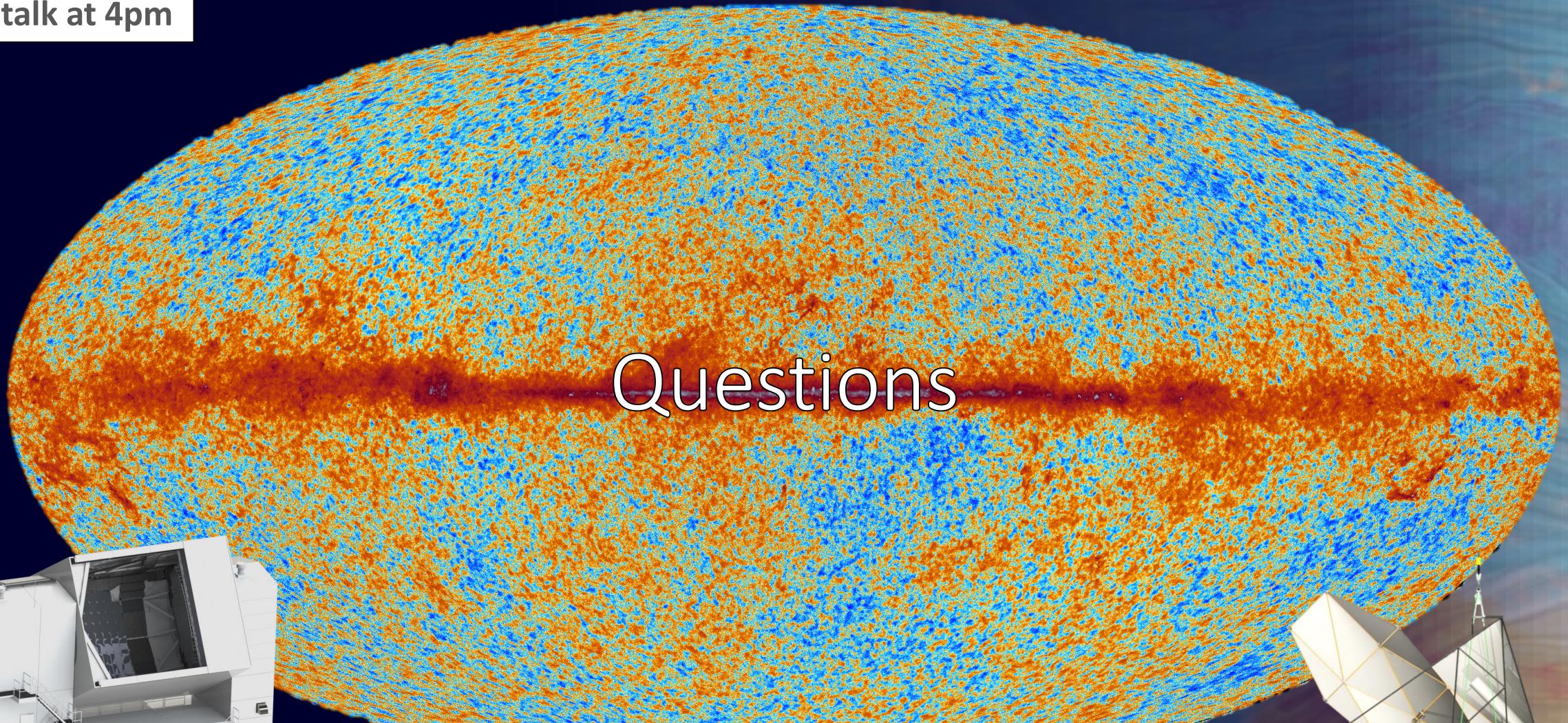


South Pole

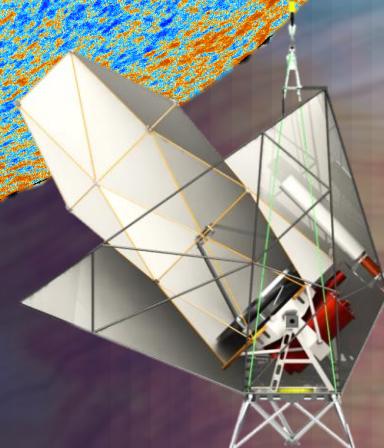
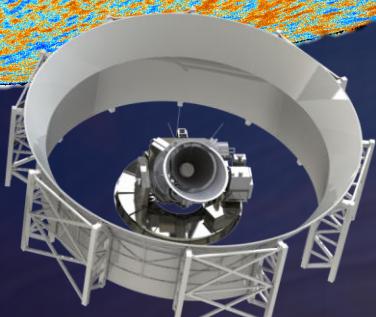
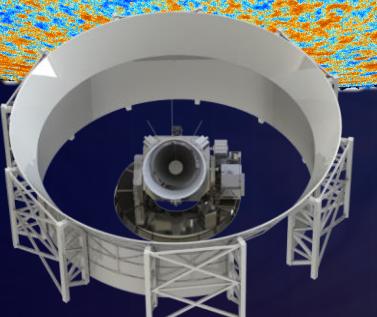
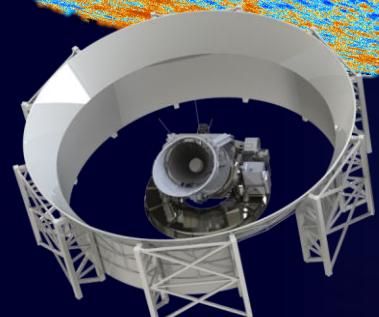
Chile

Unified with DOE and NSF support

Vision talk at 4pm



Questions



@AstroDrNick