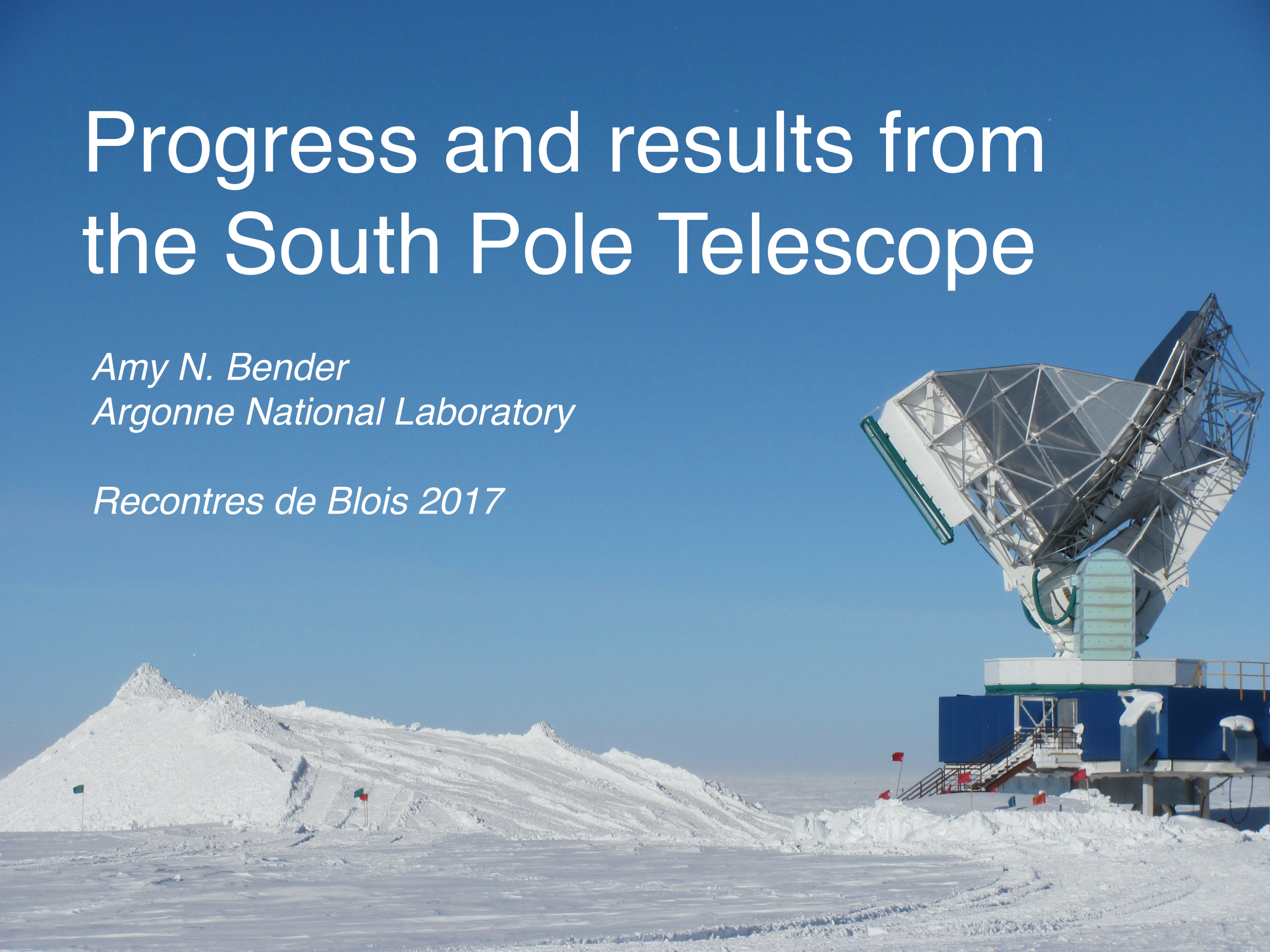
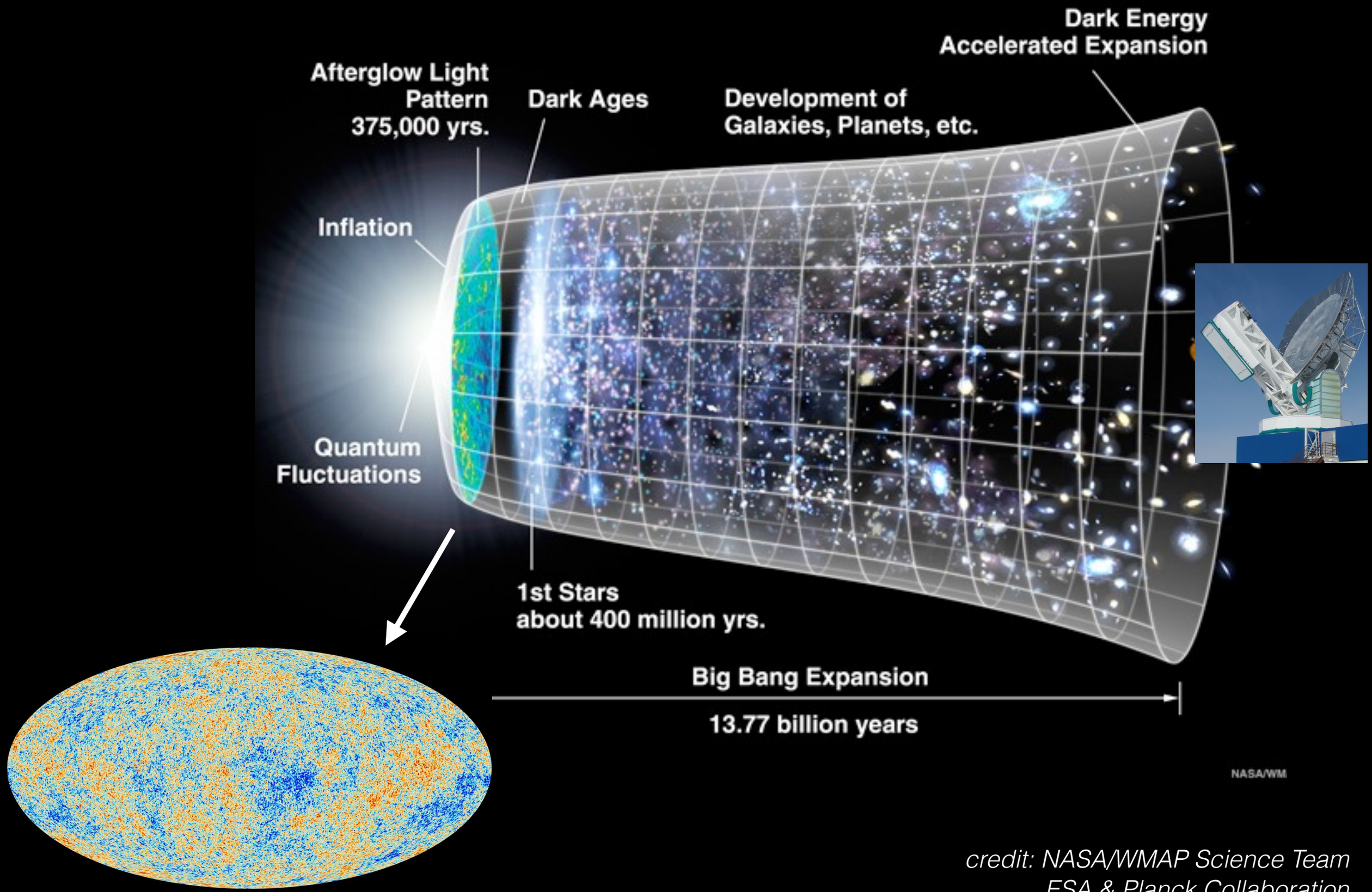
Progress and results from the South Pole Telescope

Amy N. Bender
Argonne National Laboratory

Recontres de Blois 2017



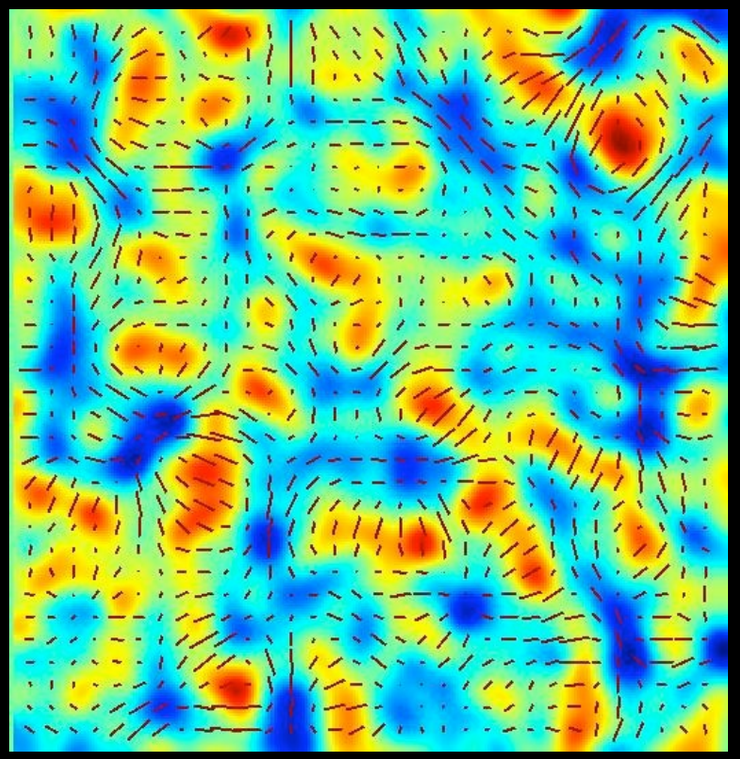
The History of Everything

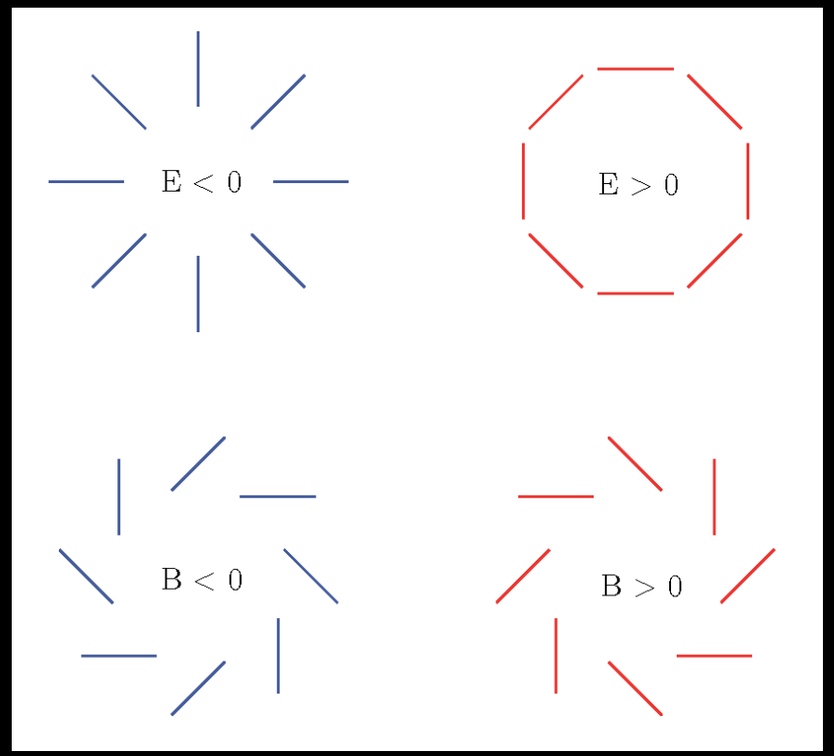


credit: NASA/WMAP Science Team
ESA & Planck Collaboration

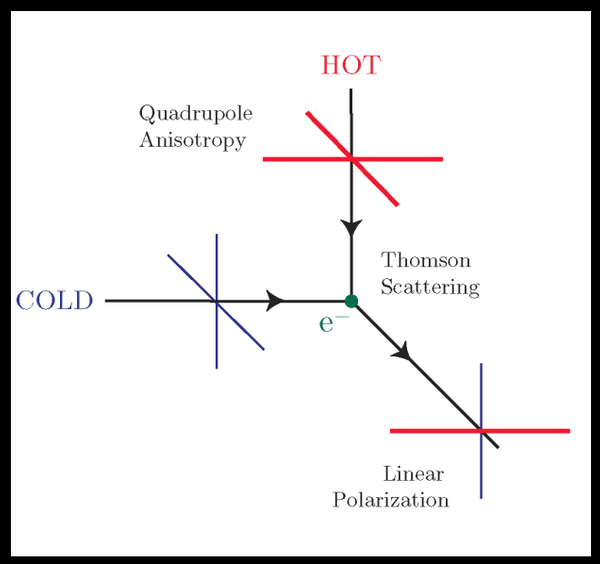
CMB Polarization

Seljak & Zaldarriaga 1998



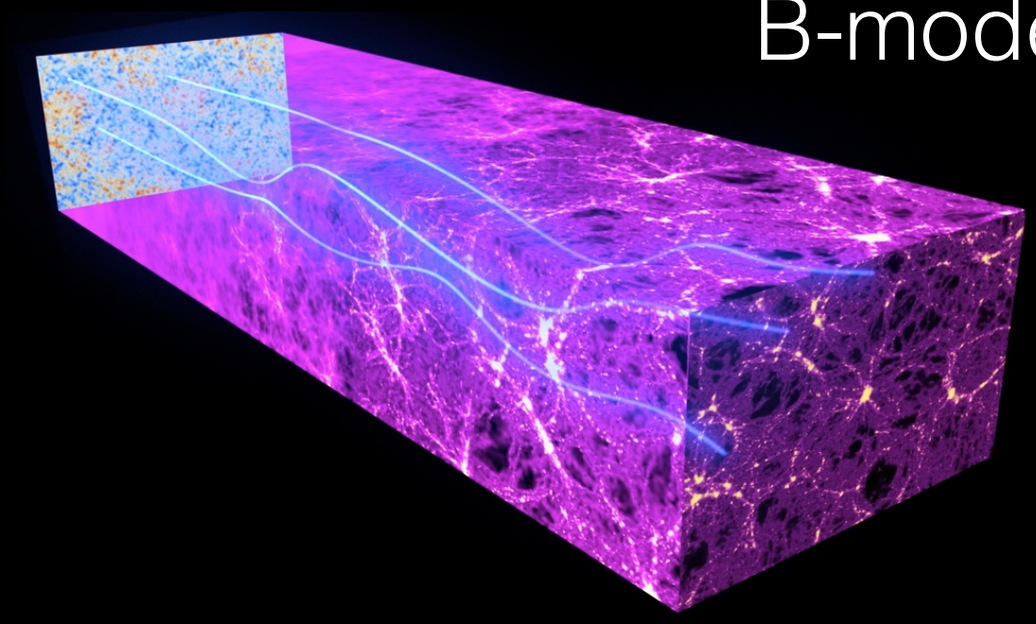


E-modes



Baumann 2009

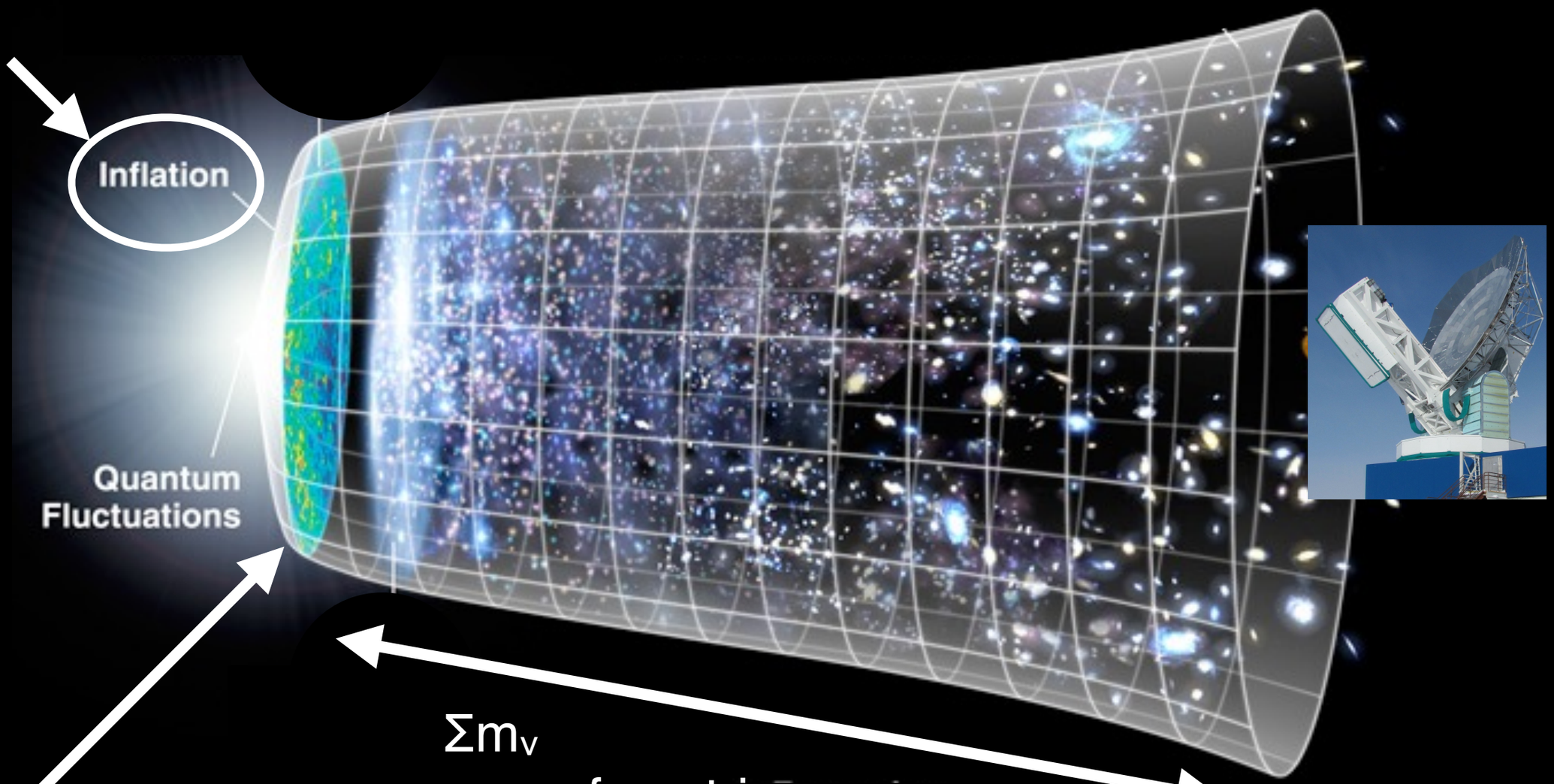
B-modes



credit: ESA and the Planck Collaboration

The Universe as a Laboratory

r: tensor to scalar ratio

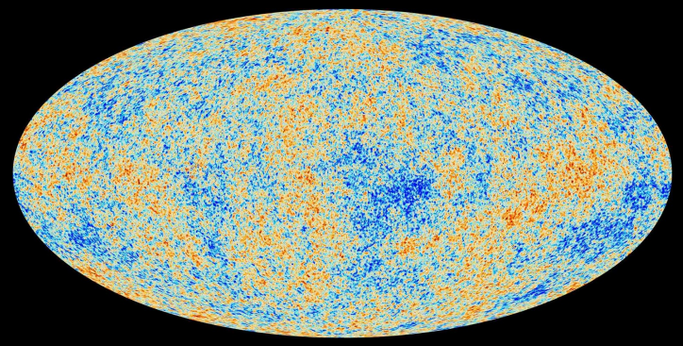


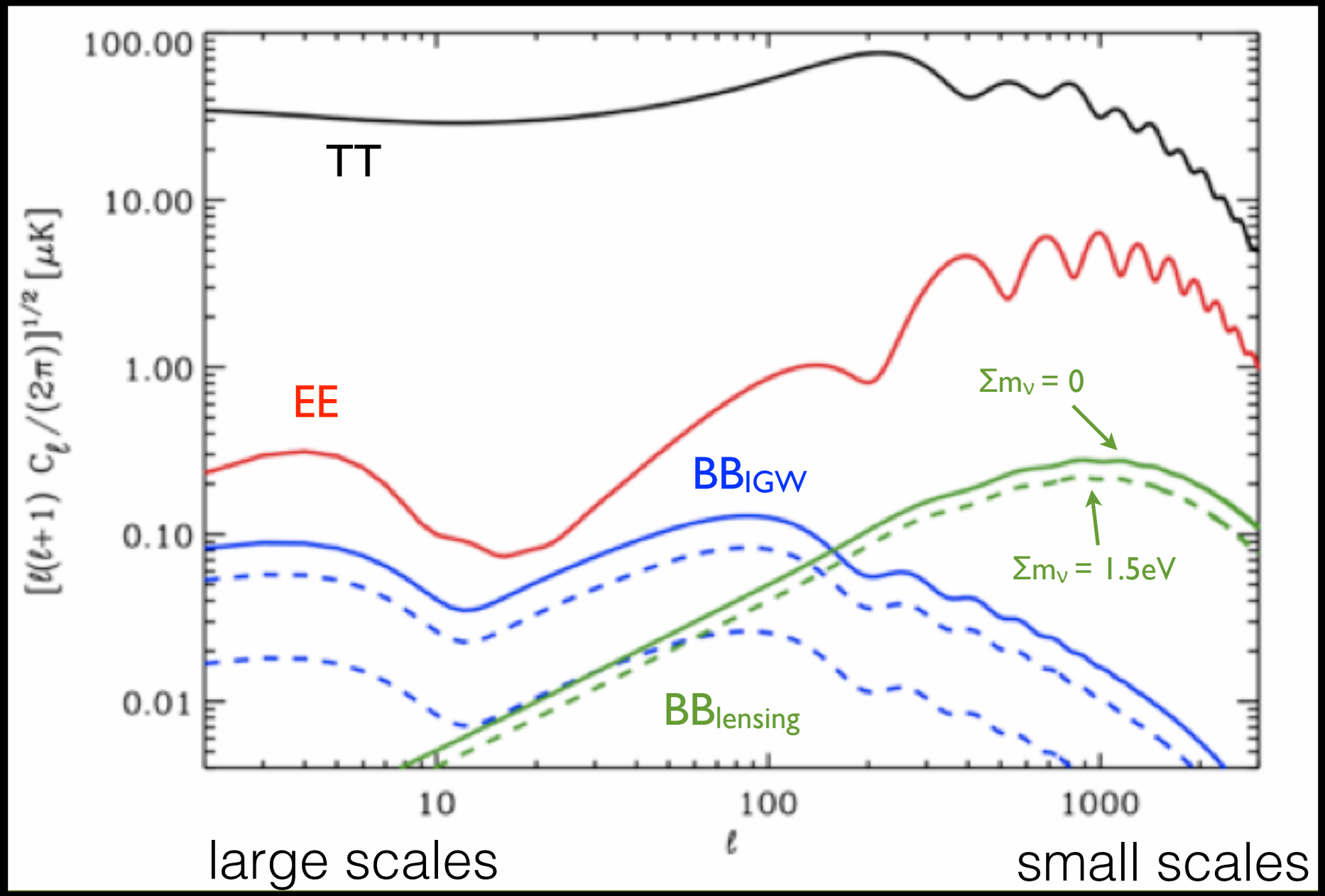
Σm_ν
sum of neutrino mass

N_{eff}:
effective number of neutrino species

credit: NASA/WMAP Science Team

CMB Power Spectra

FFT () →



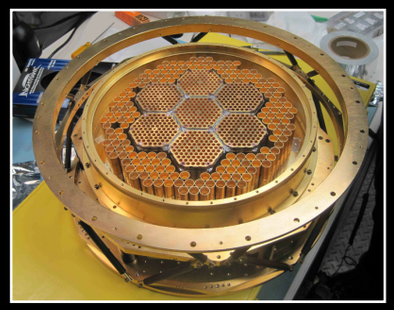
The South Pole Telescope (SPT)

10-meter sub-mm quality wavelength telescope

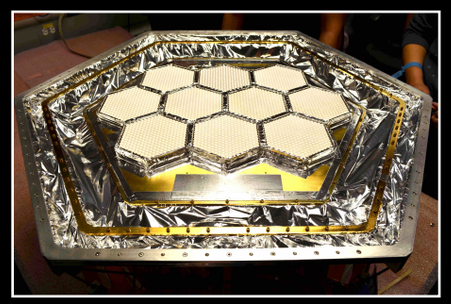
95, **150**, **220** GHz and
1.6, **1.2**, **1.0** arcmin resolution

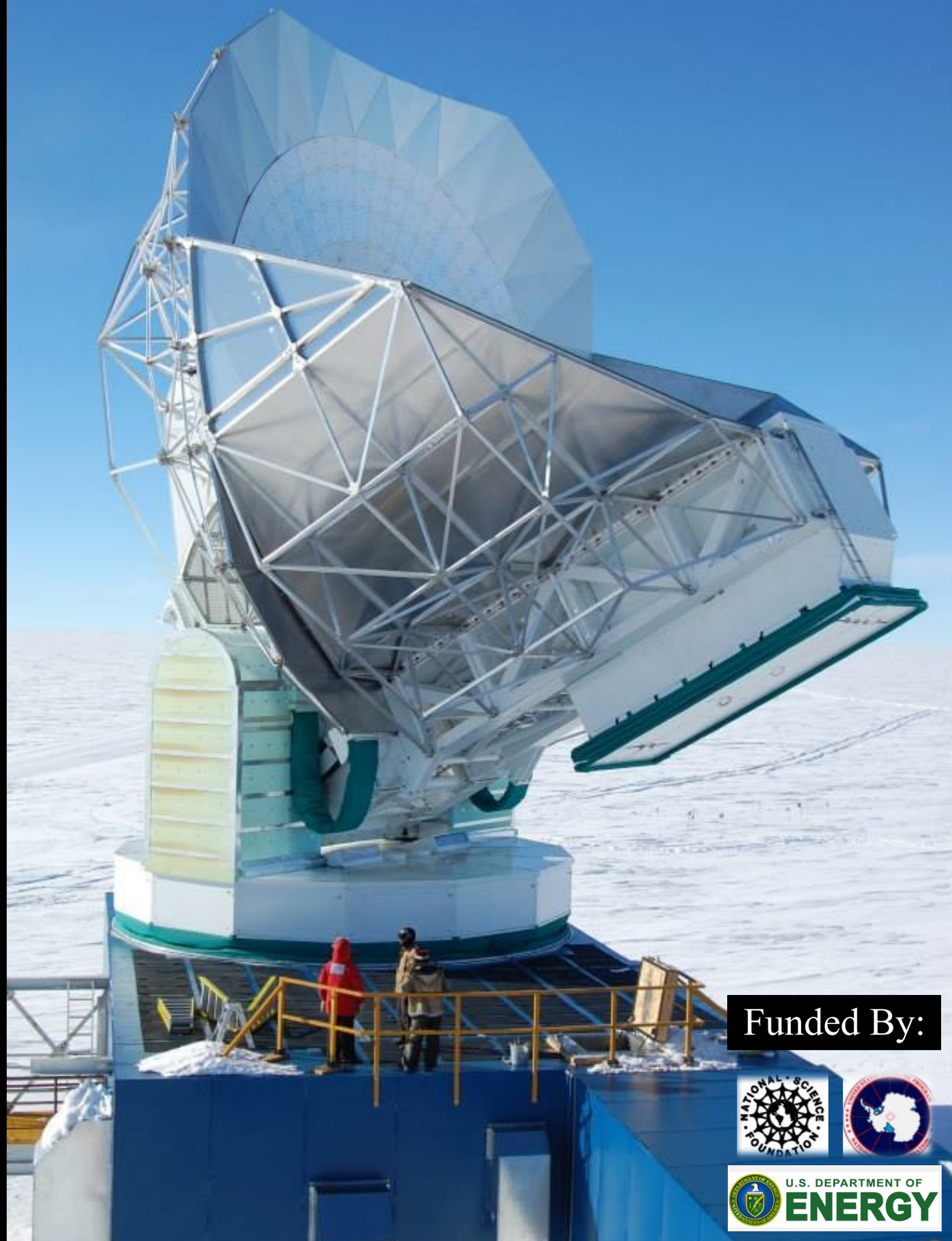
2007: SPT-SZ
960 detectors
95,150,220 GHz

2012: SPTpol
1600 detectors
95,150 GHz
+Polarization



2017: SPT-3G
~16,000 detectors
95,150,220 GHz
+Polarization





Funded By:

National Science Foundation

U.S. Department of Energy

The SPT Collaboration

Argonne NATIONAL LABORATORY

Berkeley Lab

NIST

Fermilab

ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

KICP
Kavli Institute
for Cosmological Physics
AT THE UNIVERSITY OF CHICAGO

Berkeley
University of California

Case
CASE WESTERN
RESERVE UNIVERSITY

McGill

Colorado
University of Colorado at Boulder

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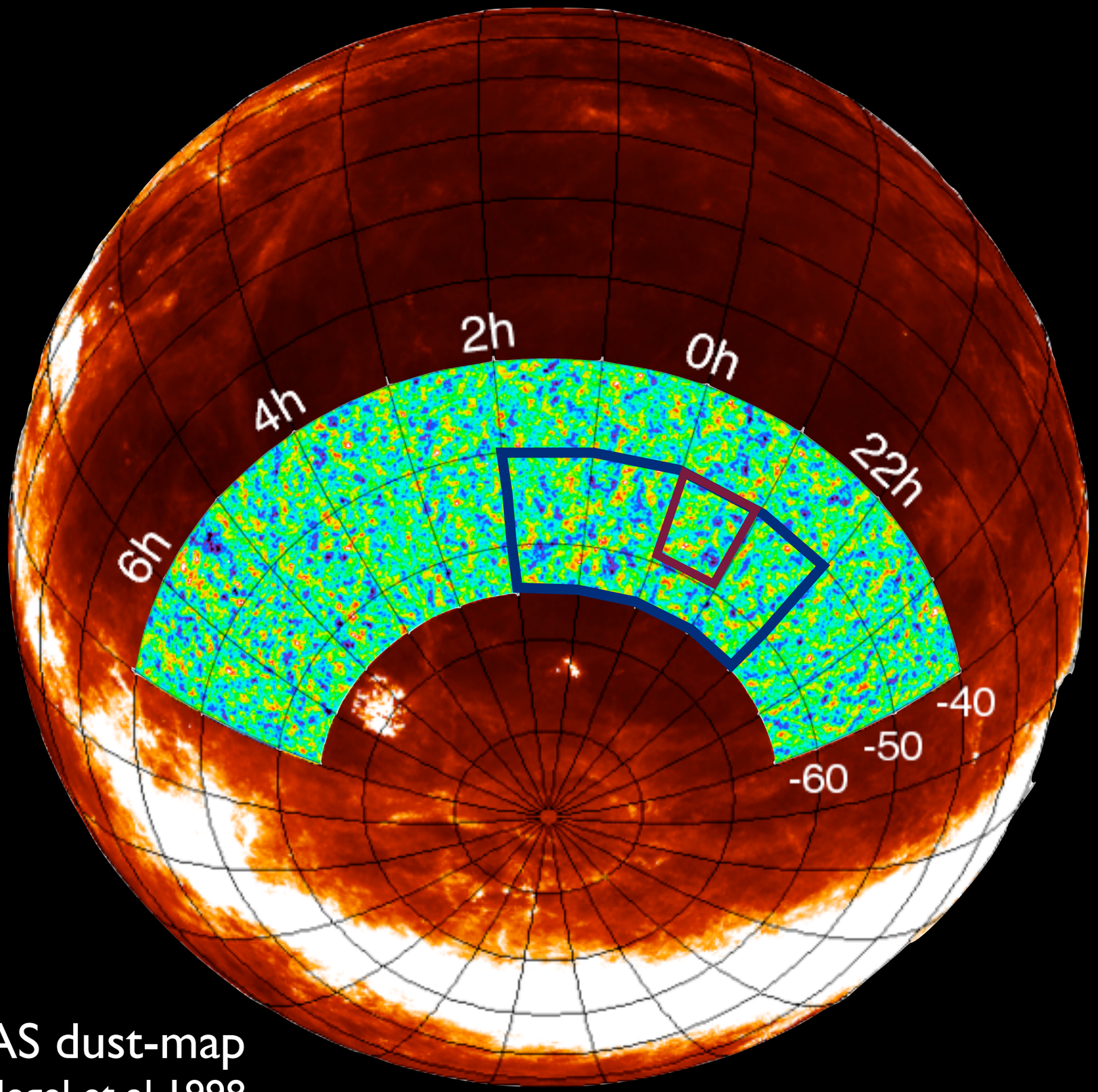
ENERGY

SPTpol: 100 d and 500 d surveys



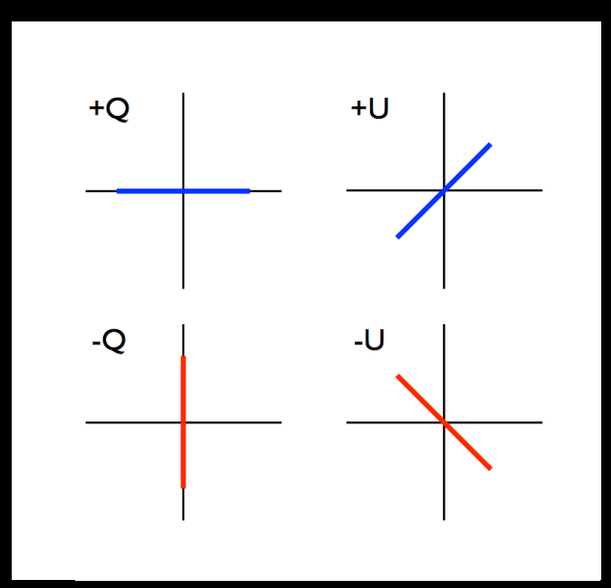
IRAS dust-map
Schlegel et al 1998

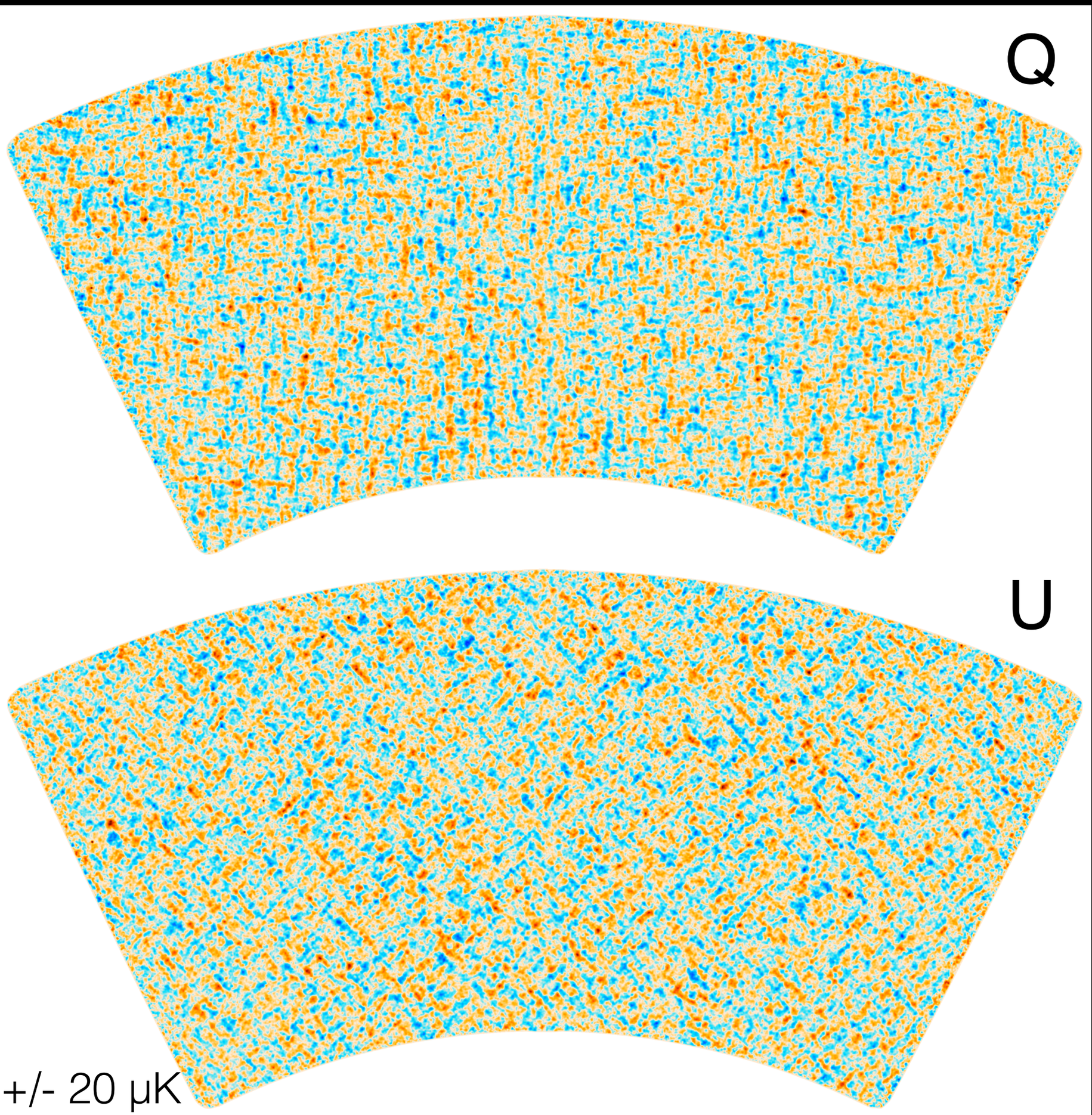
2012-2013:
100 sq degree
"Deep Field'

Polarization Depth:
9 μK arcmin (150 GHz)
17 μK arcmin (95 GHz)

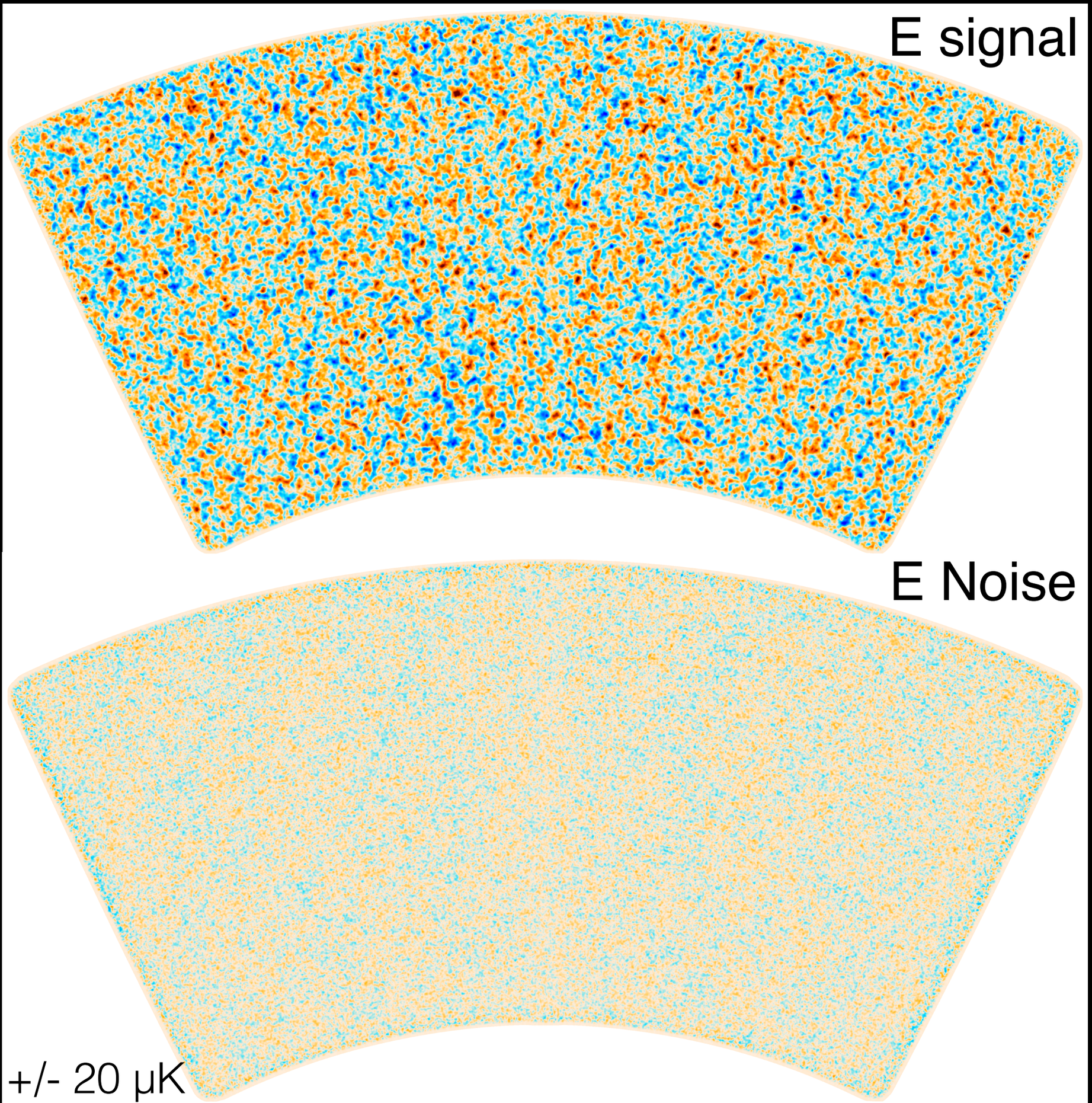
2013-2016:
500 sq degree
full survey

Main Survey
150 GHz



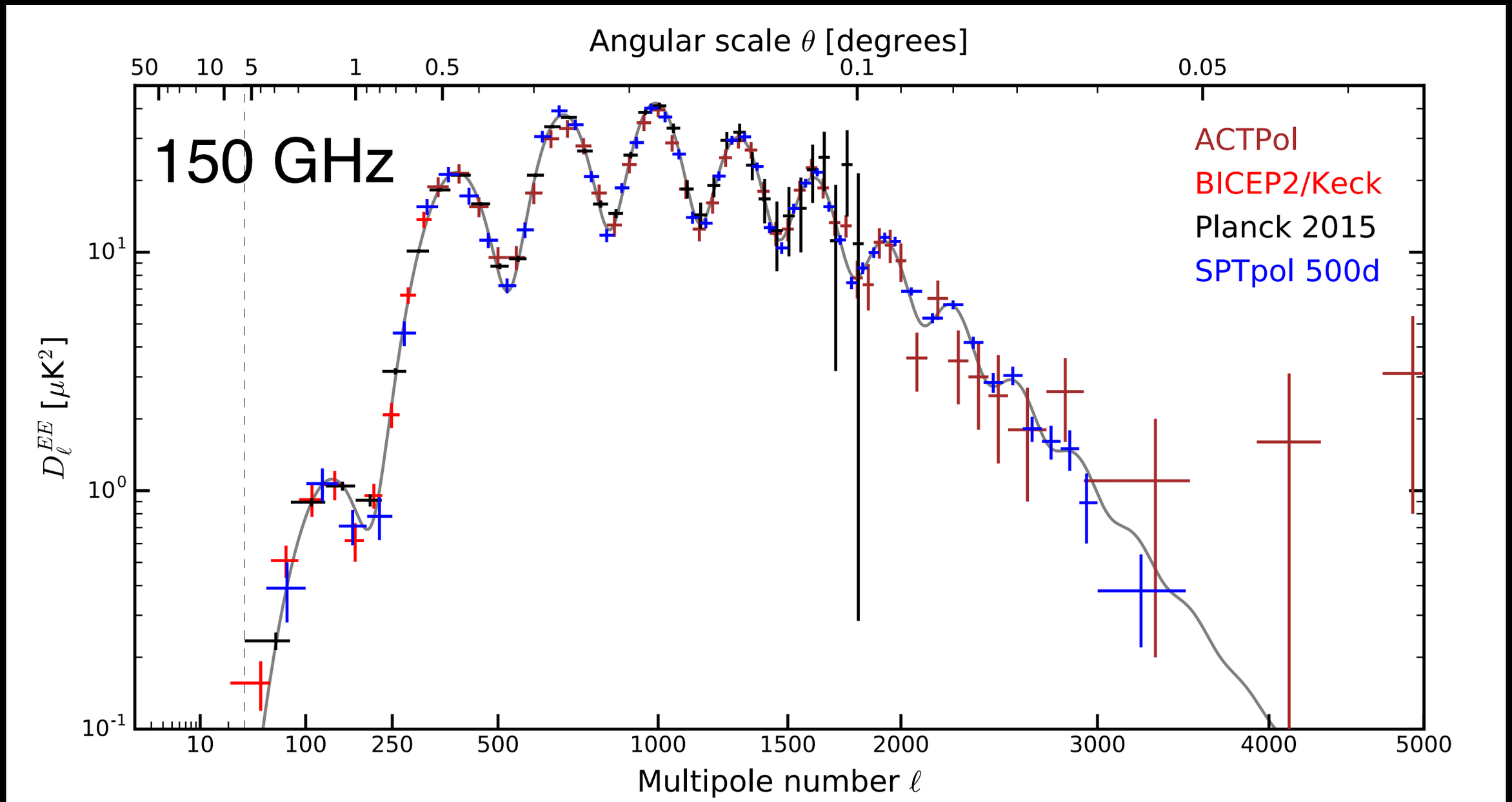


Main Survey
150 GHz



EE Power Spectrum

Henning 2017
(submission soon)

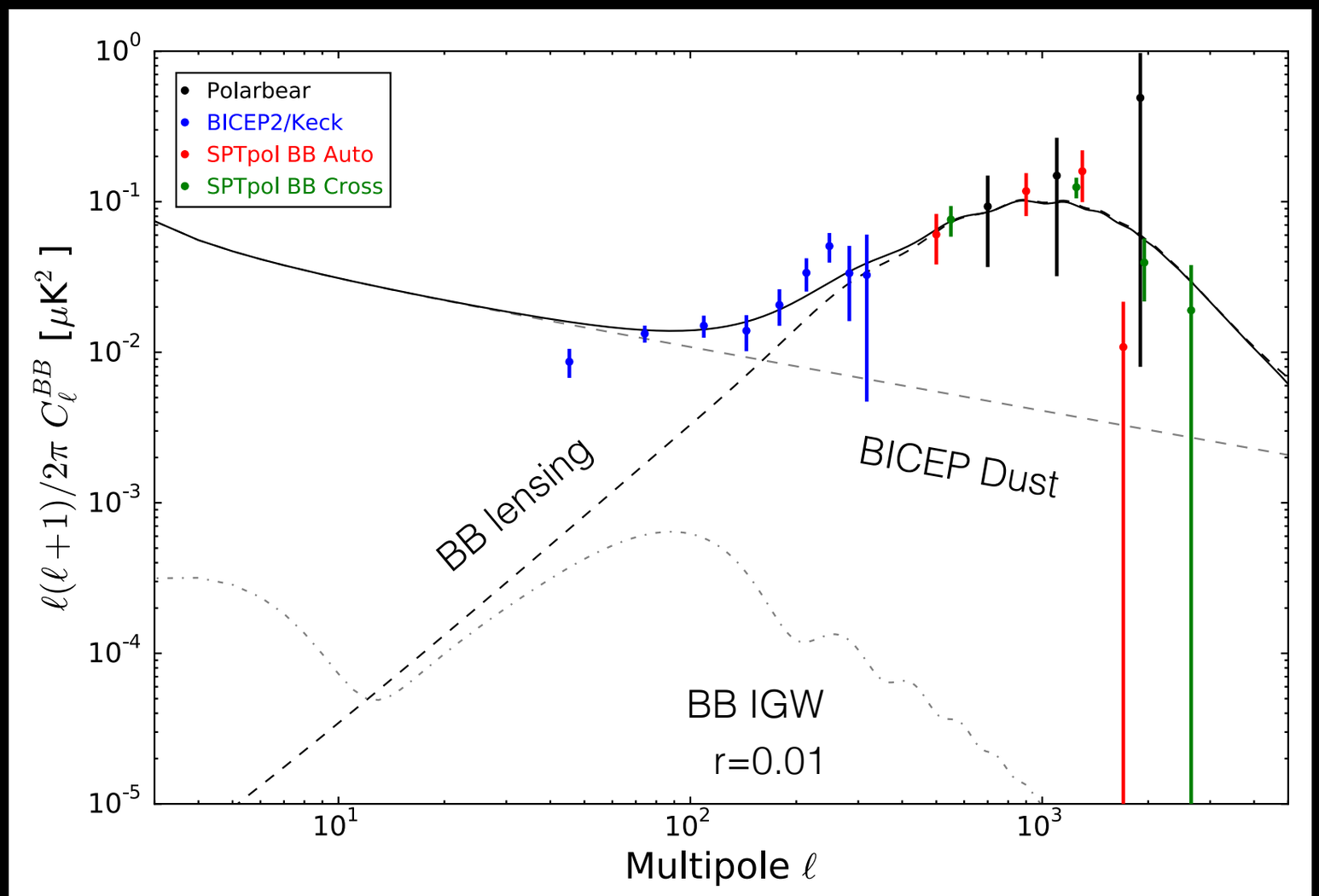


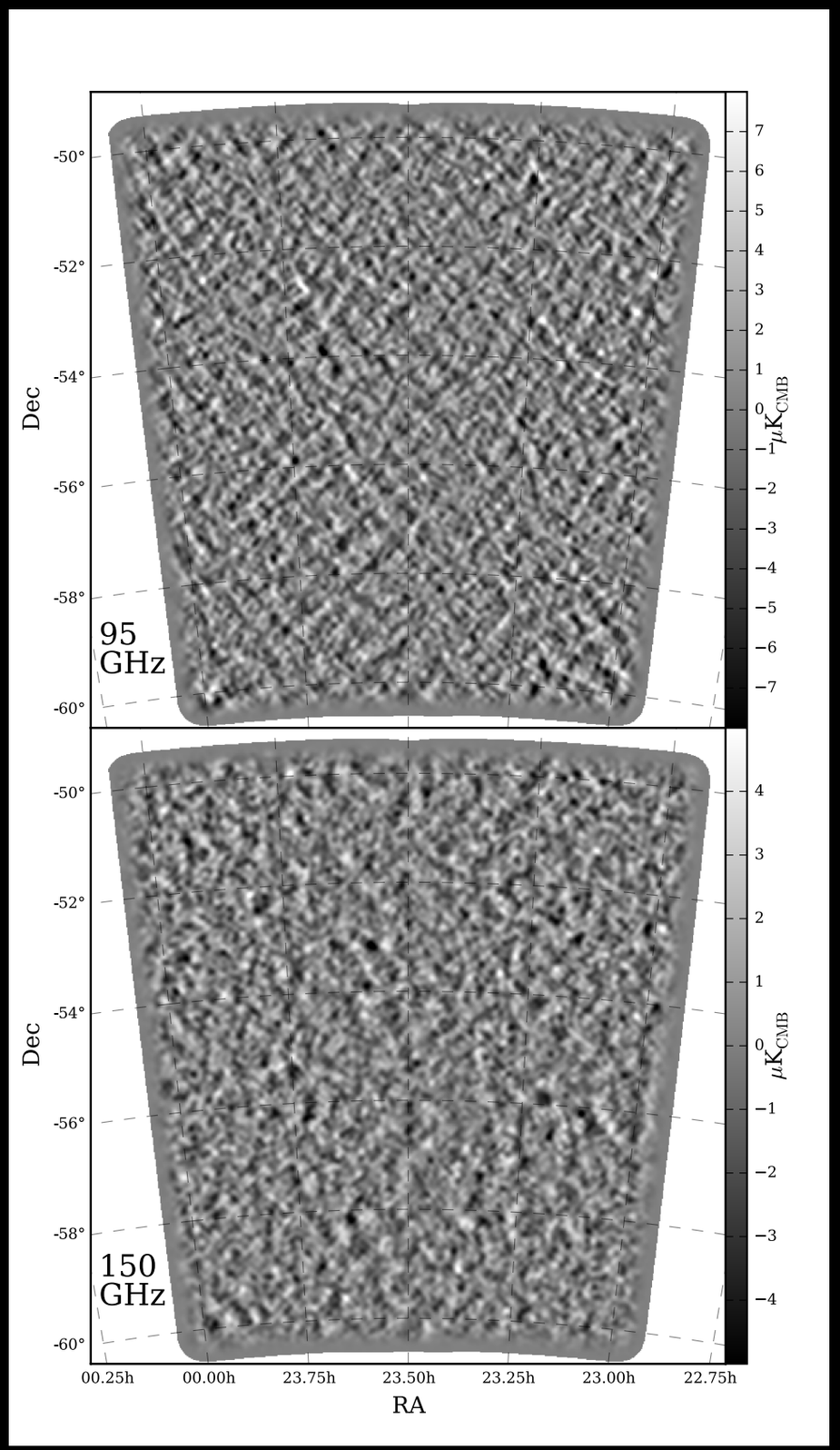
$50 < \ell < 10{,}000$

LCDM + Y_p + N_{eff}: SPTpol data reduces parameter volume by x2 compared to Planck alone

BB Analysis

Kiesler 2015



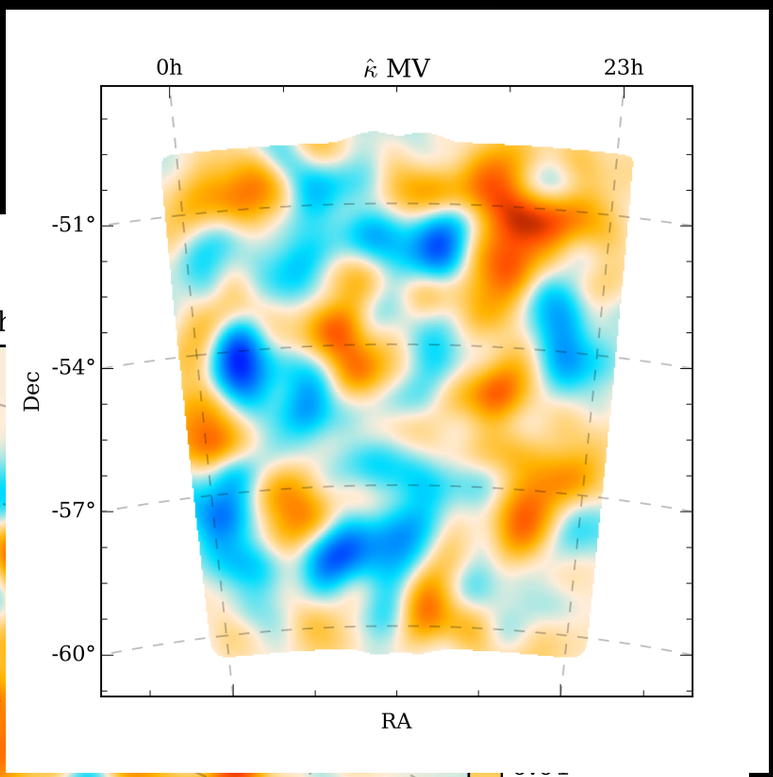


4.3 preference for lensing

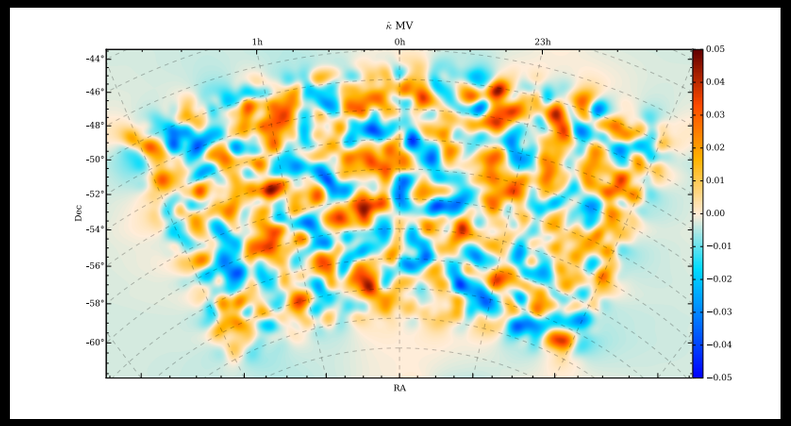
Main survey BB analysis is ongoing.

CMB Lensing

Story 2015



CMB Lensing Spectrum

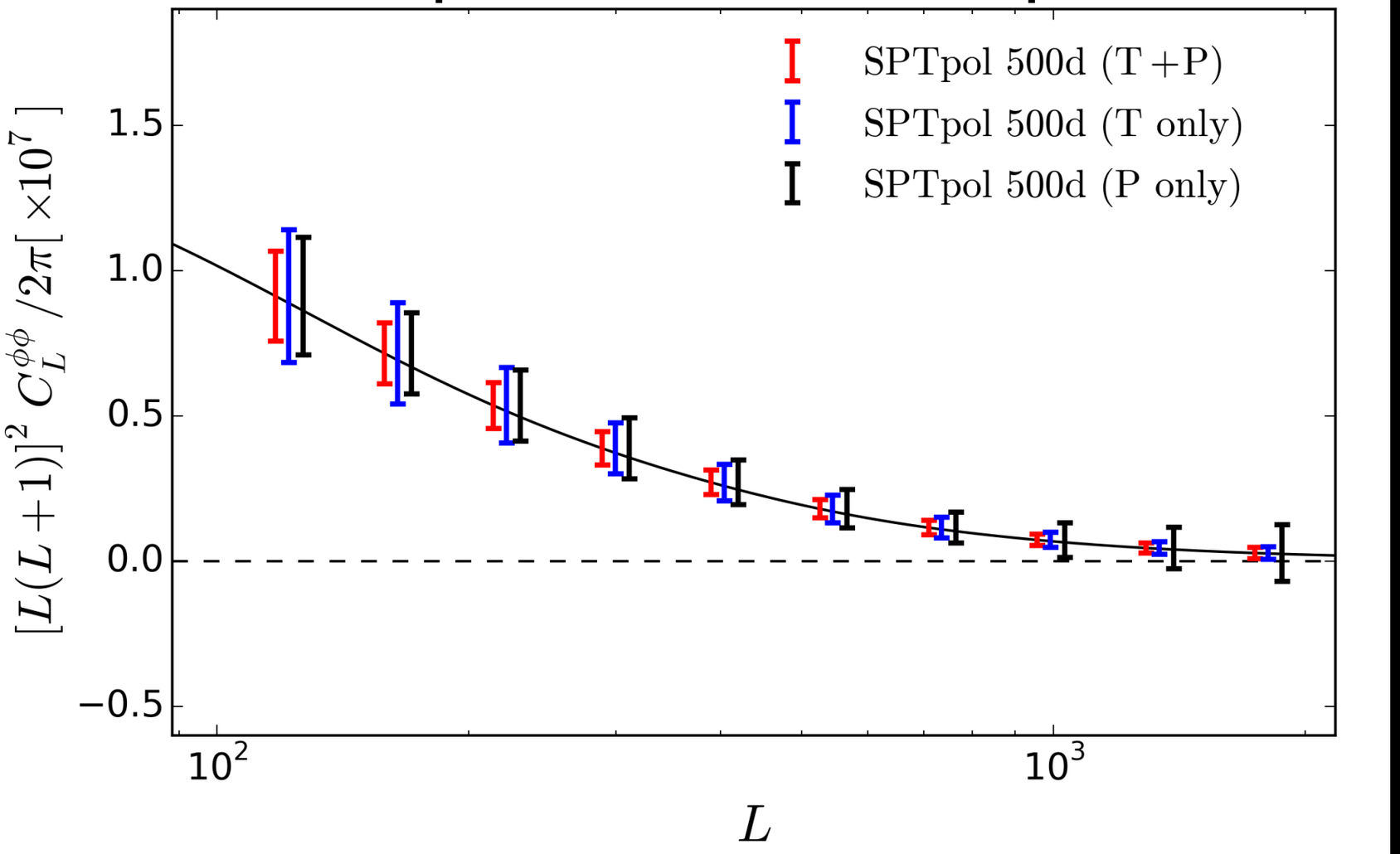
FFT (

) →

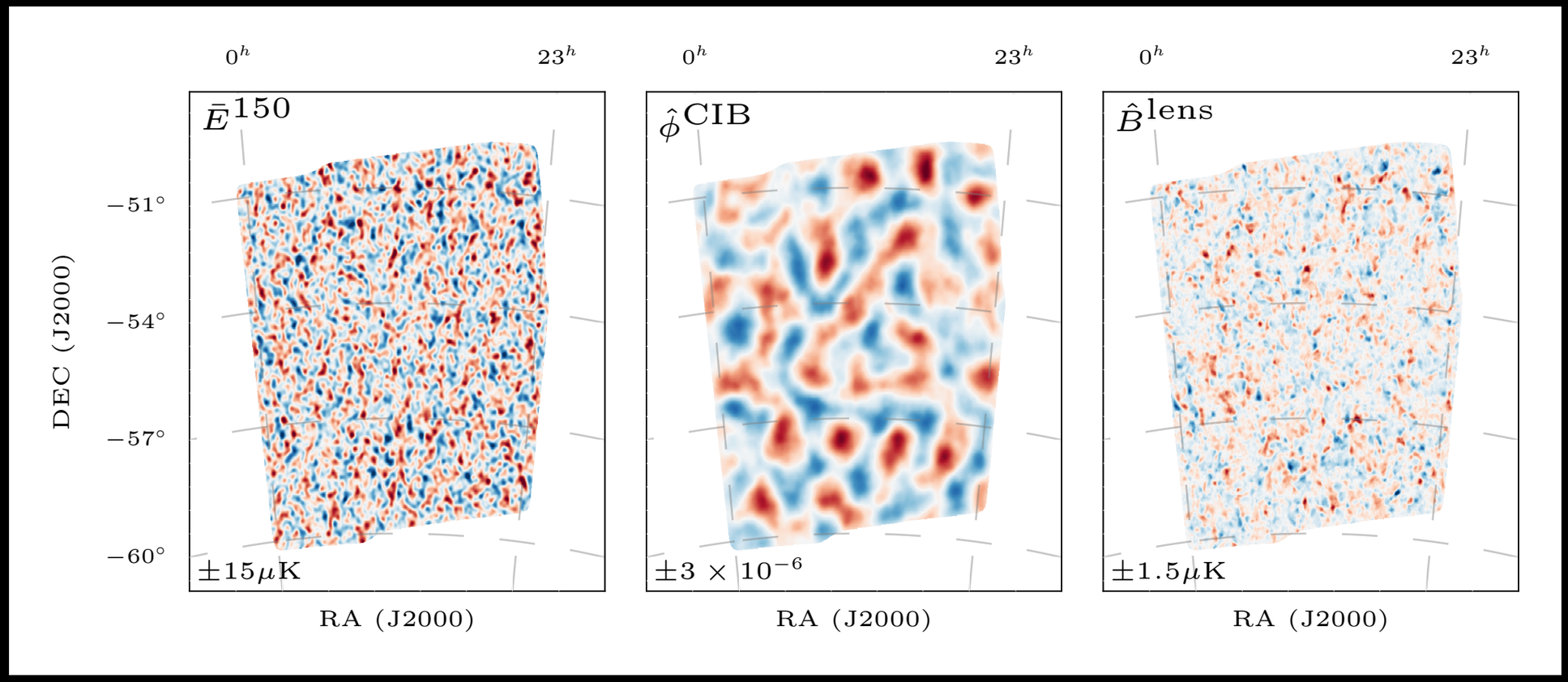
M. Mocanu

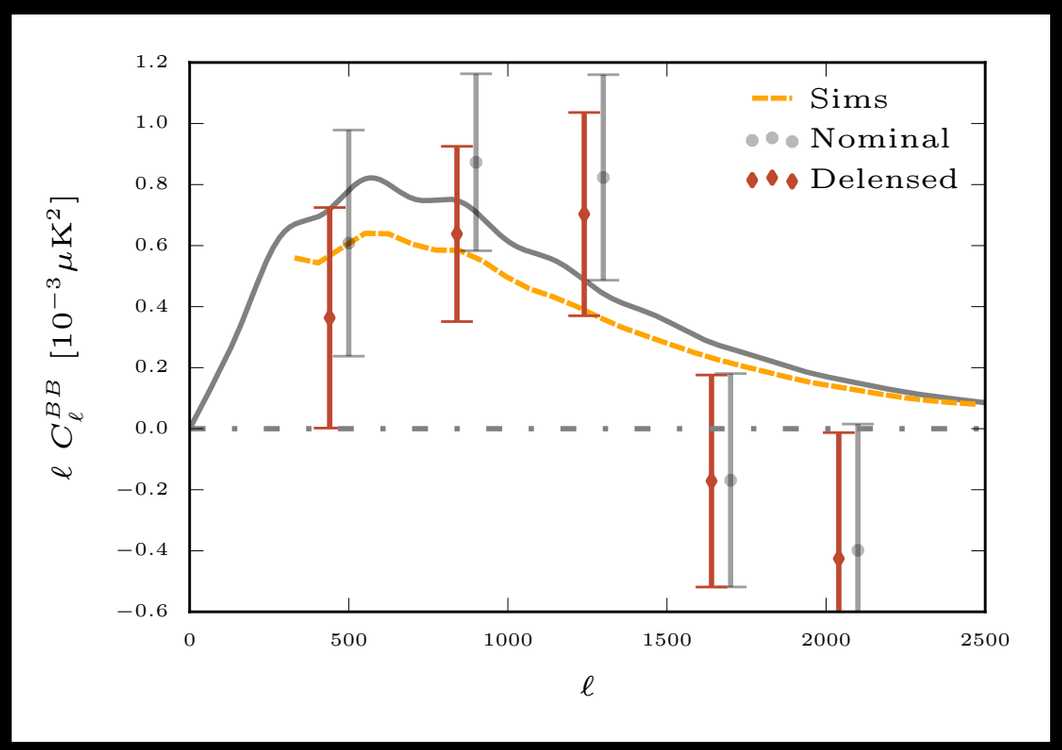
Preliminary!

Simulated Spectrum with SPTpol errors



De-lensing with SPTpol





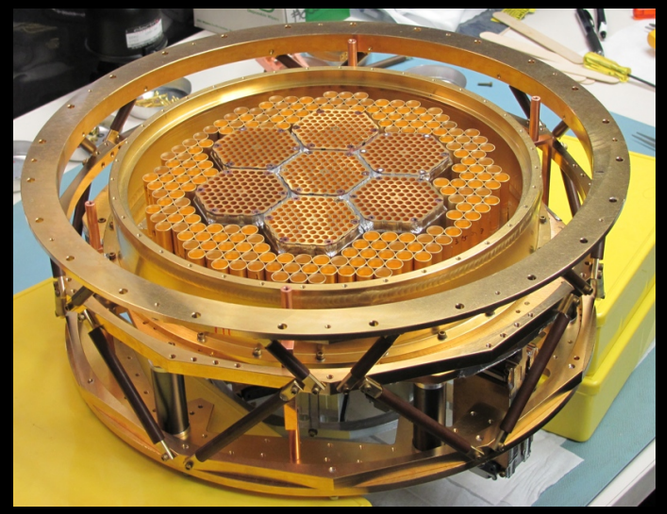
28% reduction in lensing power using Herschel to trace the cosmic infrared background

Manzotti 2017

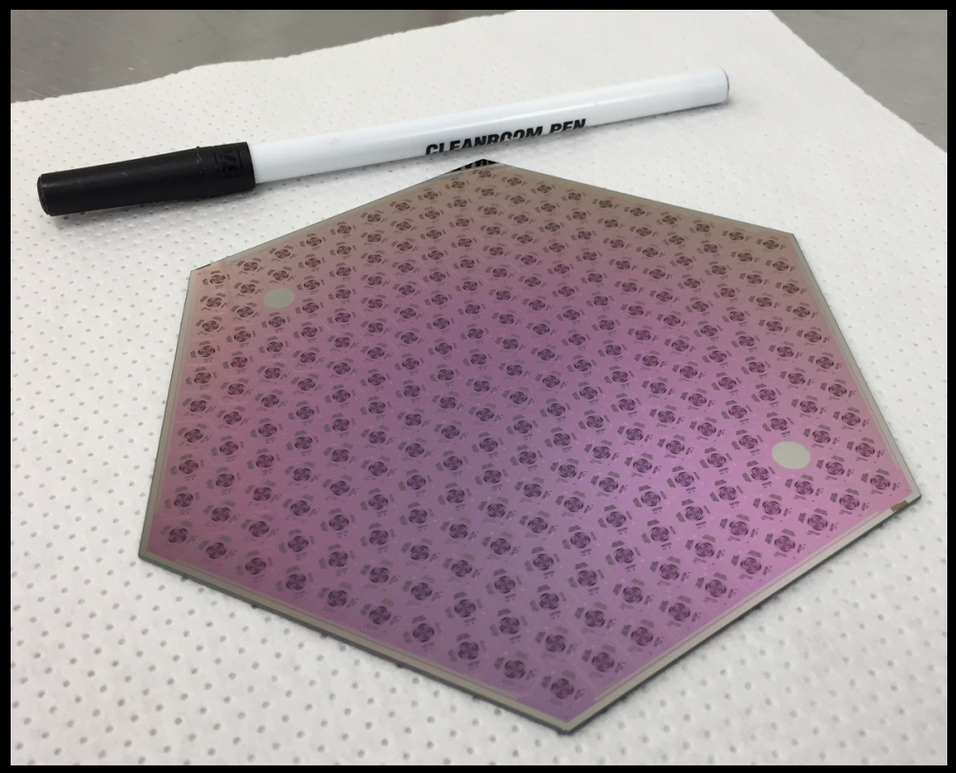
The SPT-3G Receiver

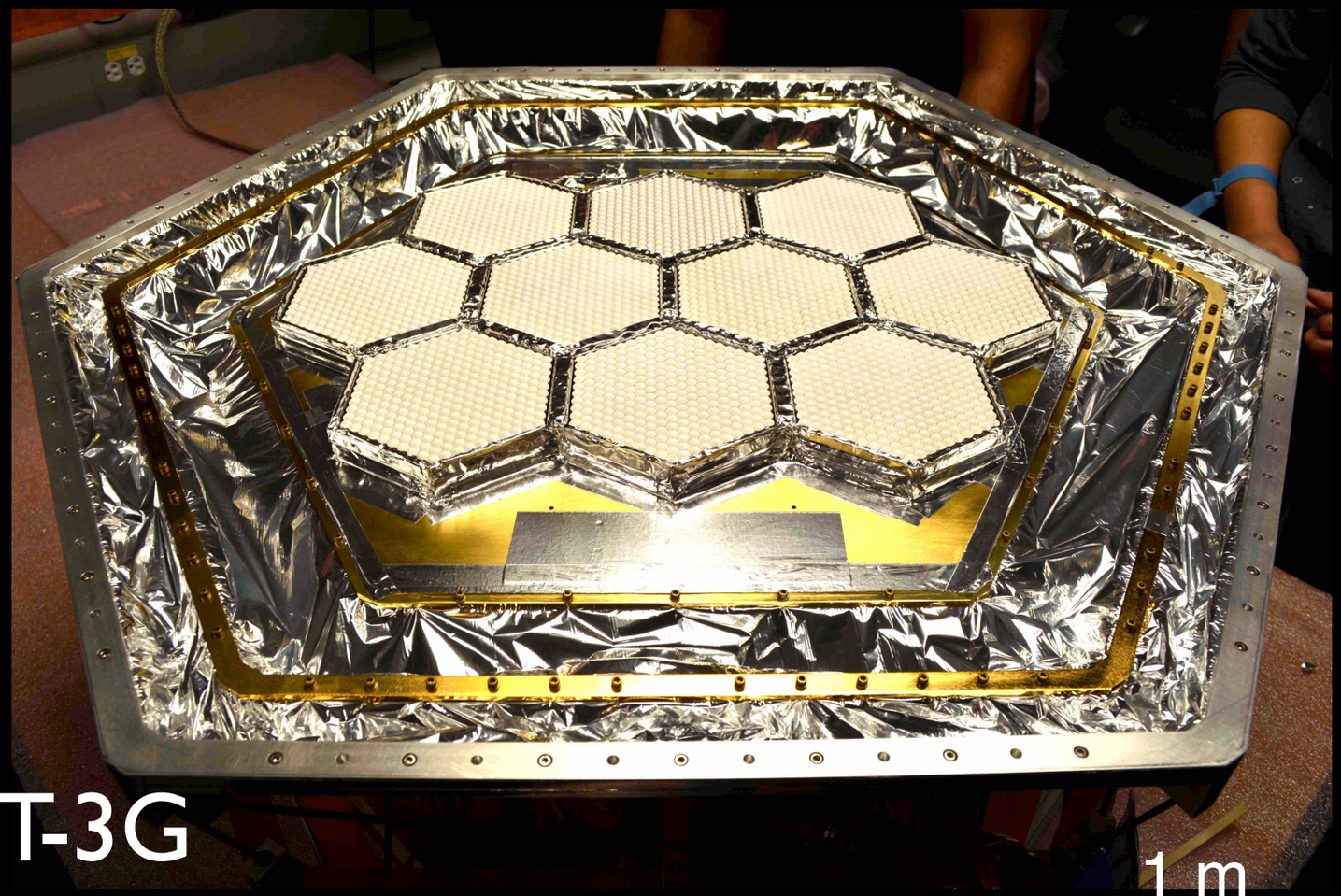
- ~16,000 superconducting detectors
- 3 observing bands
- polarization sensitive
- Installed Jan 2017

SPTpol



Relative Scale
Accurate

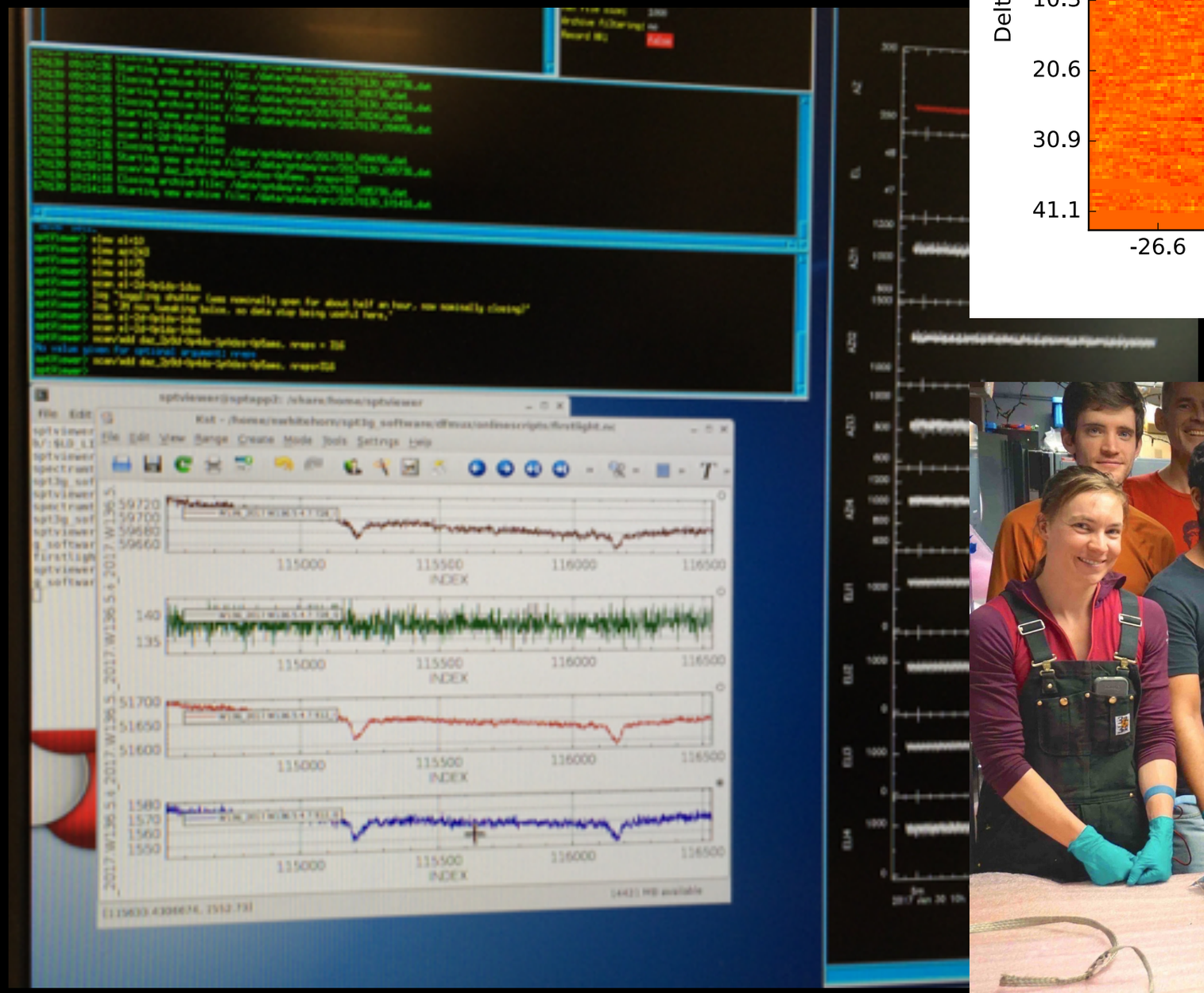


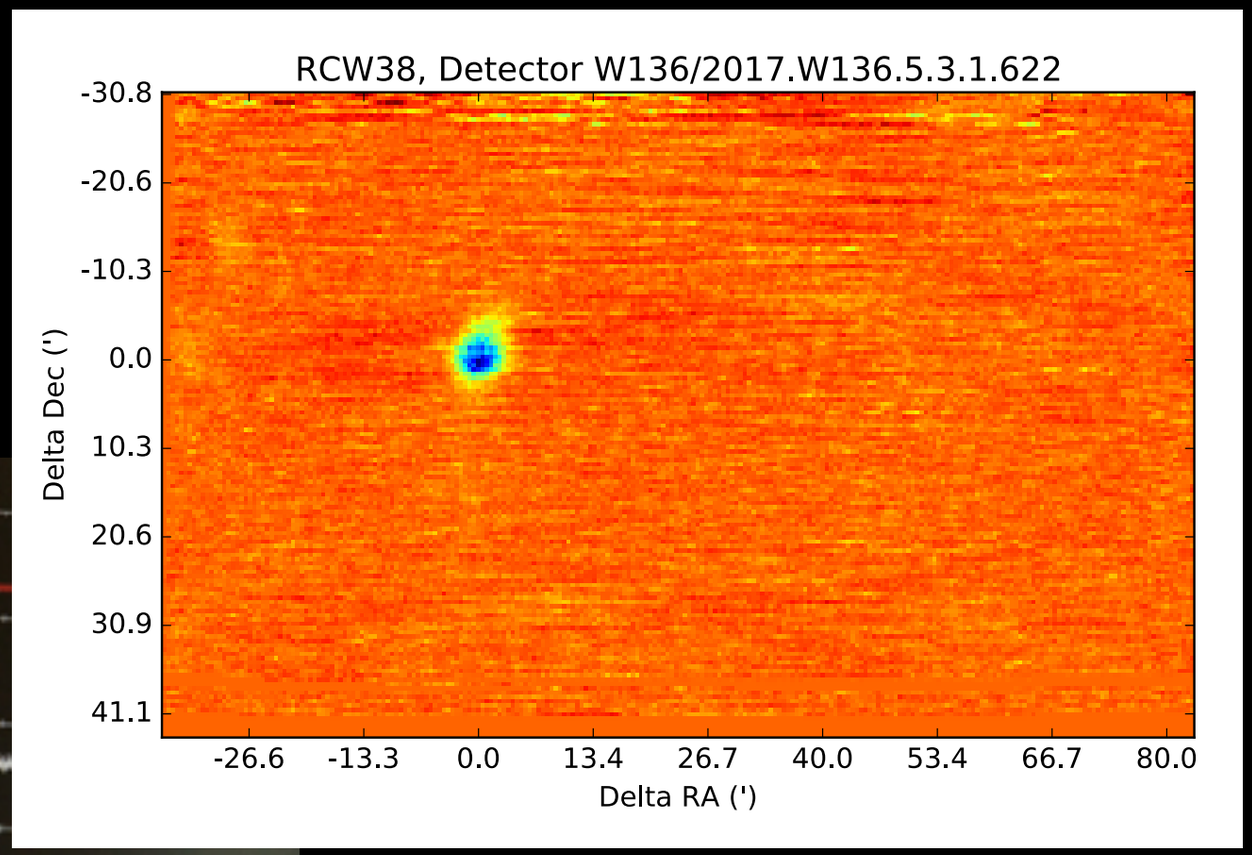


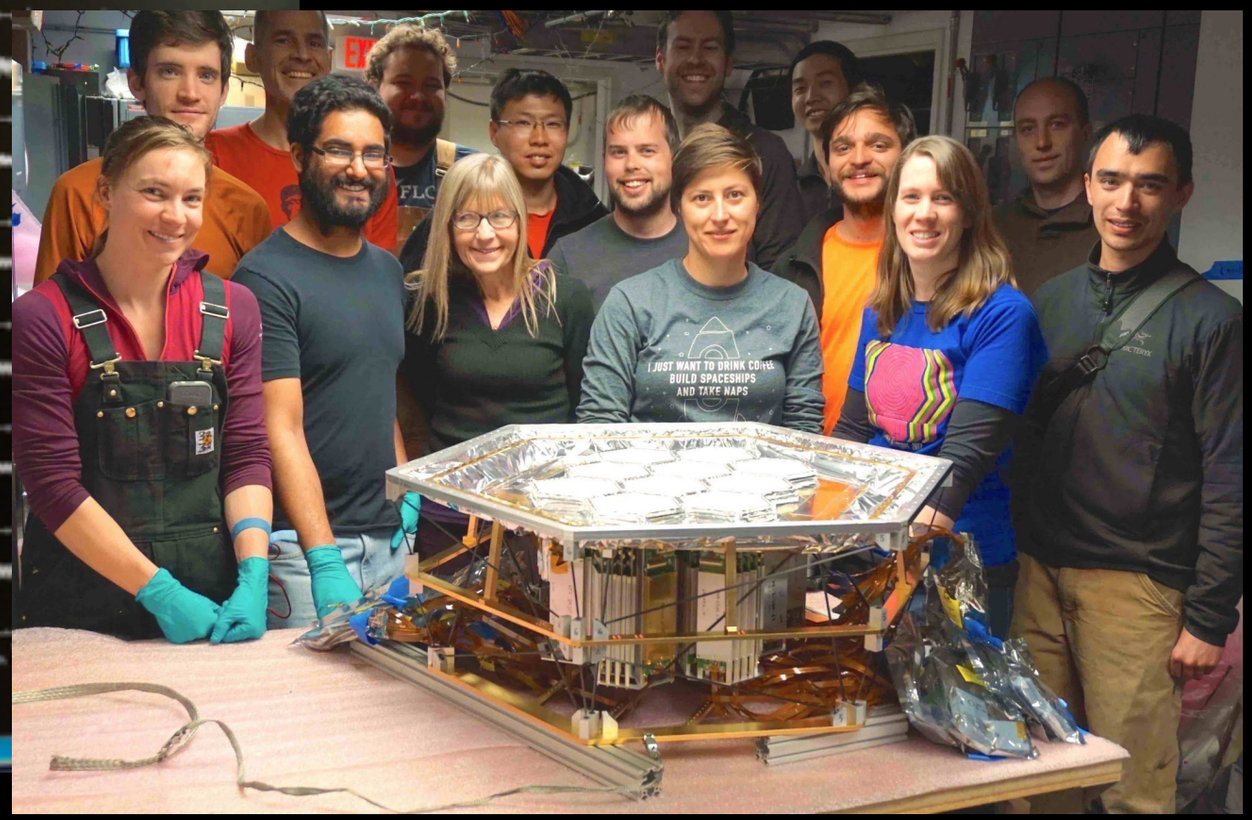
SPT-3G

1 m

SPT-3G First Light
January 30, 2017



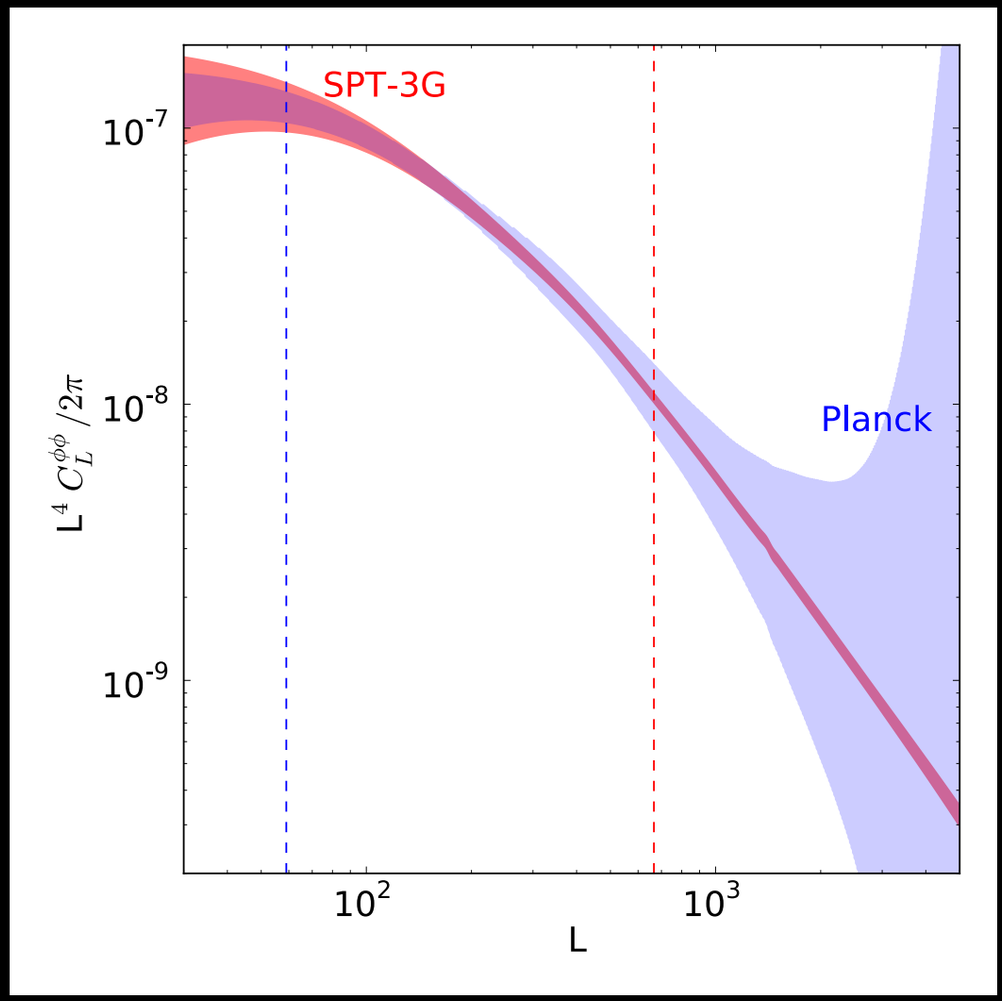




SPT-3G Forecasts

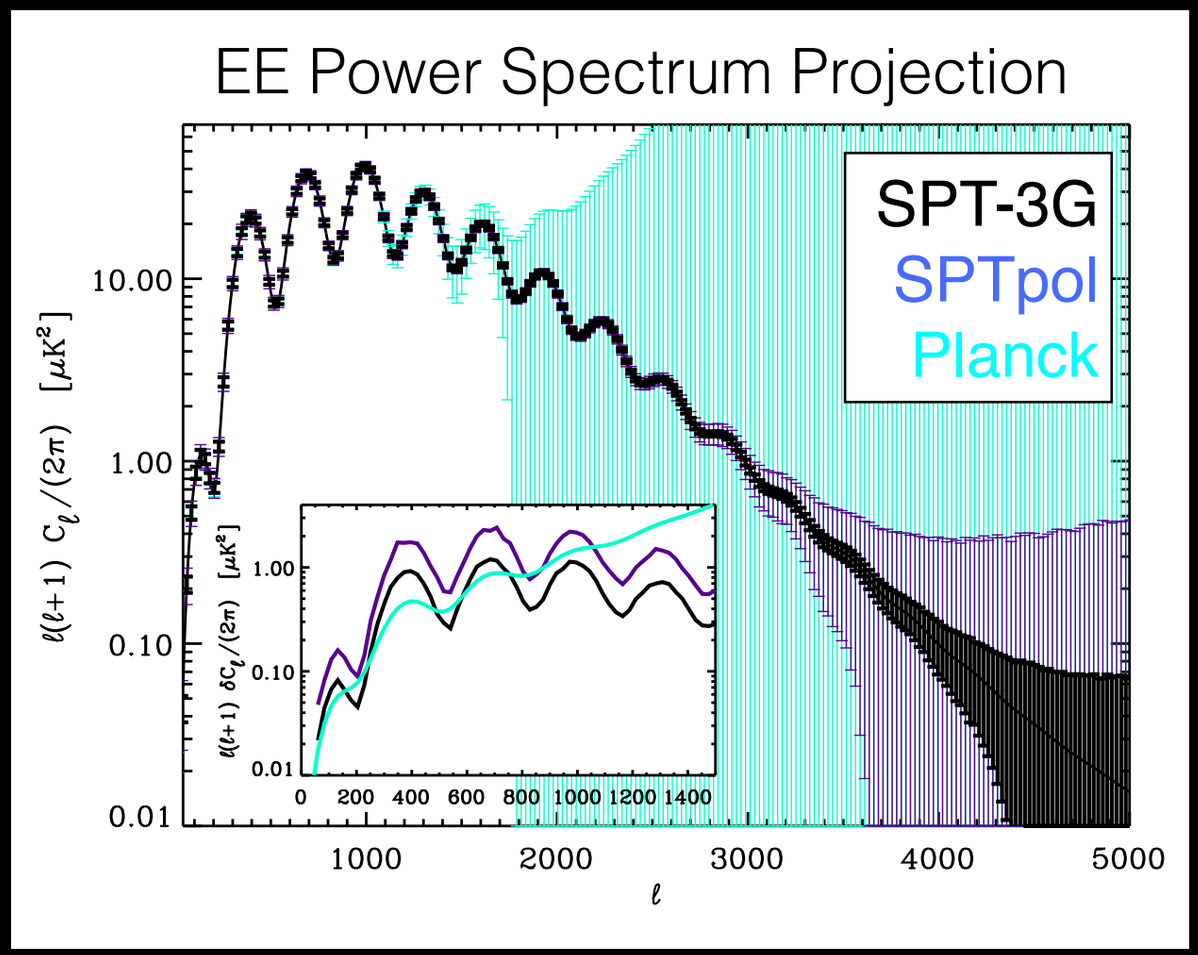
- 2500 square degree survey for 4 years
  - 2.5 μK (3.5 μK) in T (P) @150 GHz
  - 4.3 μK (6 μK) in T(P) @ 95/ 220 GHz
- Overlap with BICEP/Keck
- High S/N measurement of gravitational lensing B-modes
  - constrain sum of neutrino mass
  - de-lensing of B-mode power spectrum

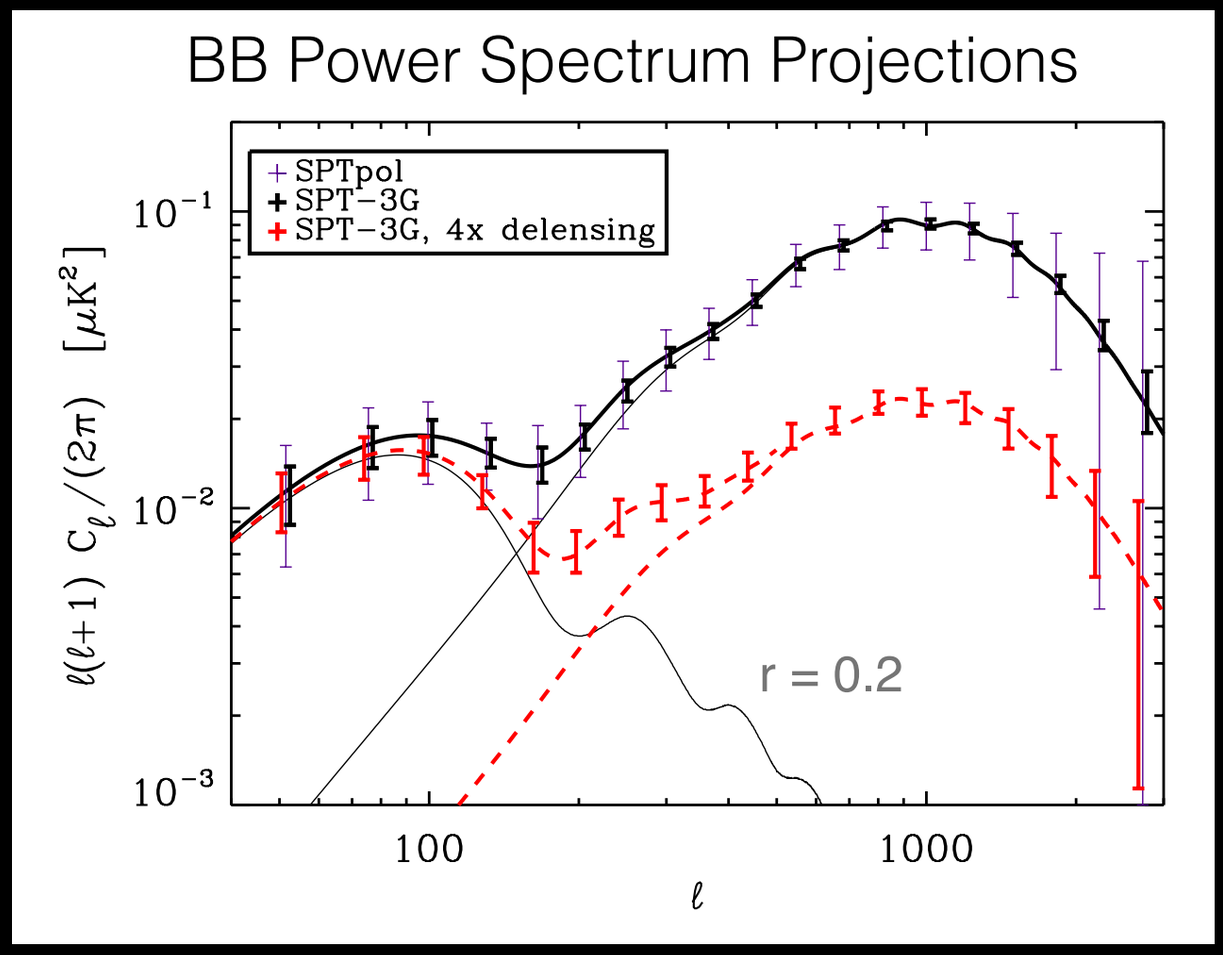
Lensing Forecast



Benson 2014

SPT-3G Projected Power Spectra





Benson 2014

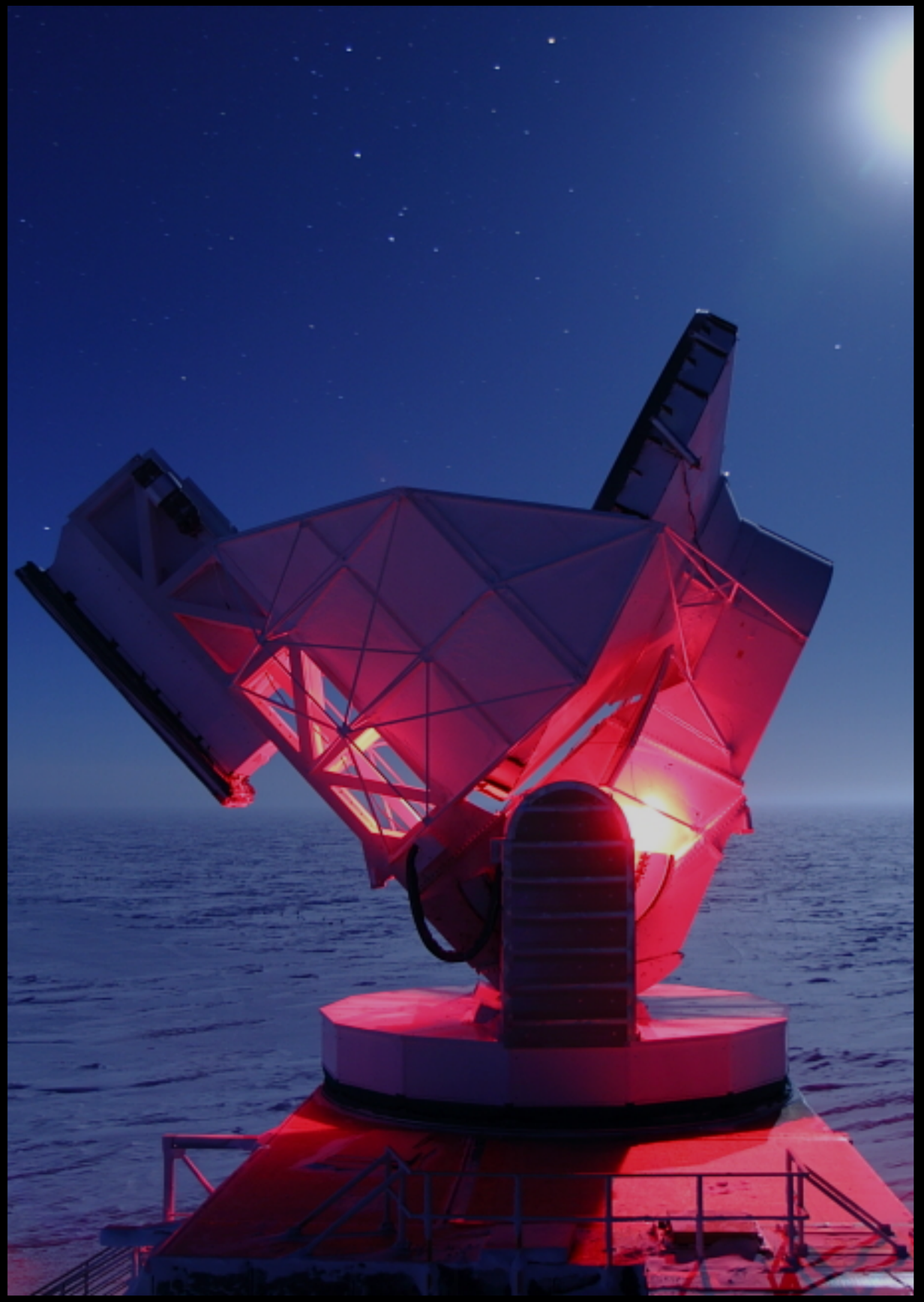
2020 Projections

Priors from Planck + BOSS

$\sigma(r)$	0.011
$\sigma(\Sigma m_\nu)$	0.061 eV
$\sigma(N_{eff})$	0.058

Summary

- SPT maps the CMB with high-resolution
  - probe the neutrino sector and inflation
- Measurements of E-modes, B-modes and CMB lensing
- Demonstration of de-lensing of CMB data
- SPT-3G is now in engineering mode, more soon!



Backup

Forecast Table

Dataset	Cosmological parameter constraints								
	$\sigma(\Omega_b h^2)$ $\times 10^4$	$\sigma(\Omega_c h^2)$ $\times 10^3$	$\sigma(A_s)$ $\times 10^{11}$	$\sigma(n_s)$ $\times 10^3$	$\sigma(h)$ $\times 10^2$	$\sigma(\tau)$ $\times 10^3$	$\sigma(N_{\rm eff})$ $\times 10^1$	$\sigma(\Sigma m_\nu)$ [meV]	$\sigma(r)$ $\times 10^2$
Planck	1.93	2.02	5.36	7.07	1.88	4.96	1.39	117	5.72
+ SPT-POL	1.64	1.71	4.92	6.19	1.58	4.95	1.17	96	**2.75**
+ SPT-3G	**1.02**	**1.25**	**4.18**	**4.61**	**1.14**	4.94	**0.76**	**74**	**1.05**
Planck + BOSS	1.34	1.21	4.01	4.54	1.21	4.92	0.74	88	5.72
+ SPT-3G	**0.85**	**0.95**	3.71	3.91	**0.94**	4.90	**0.58**	**61**	**1.05**

Table 2. Expected $1\,\sigma$ constraints on cosmological parameters using SPT-3G power spectrum and lensing reconstruction data, assuming a 9-parameter ΛCDM+$N_{\rm eff}$+Σm_ν+tensor model. Parameters for which adding SPT-3G improves the constraint by at least a factor of 1.5 over the *Planck* or *Planck*+BOSS constraint are marked in **blue**, while those for which the constraints improve by at least a factor of 1.25 are marked in **orange**.