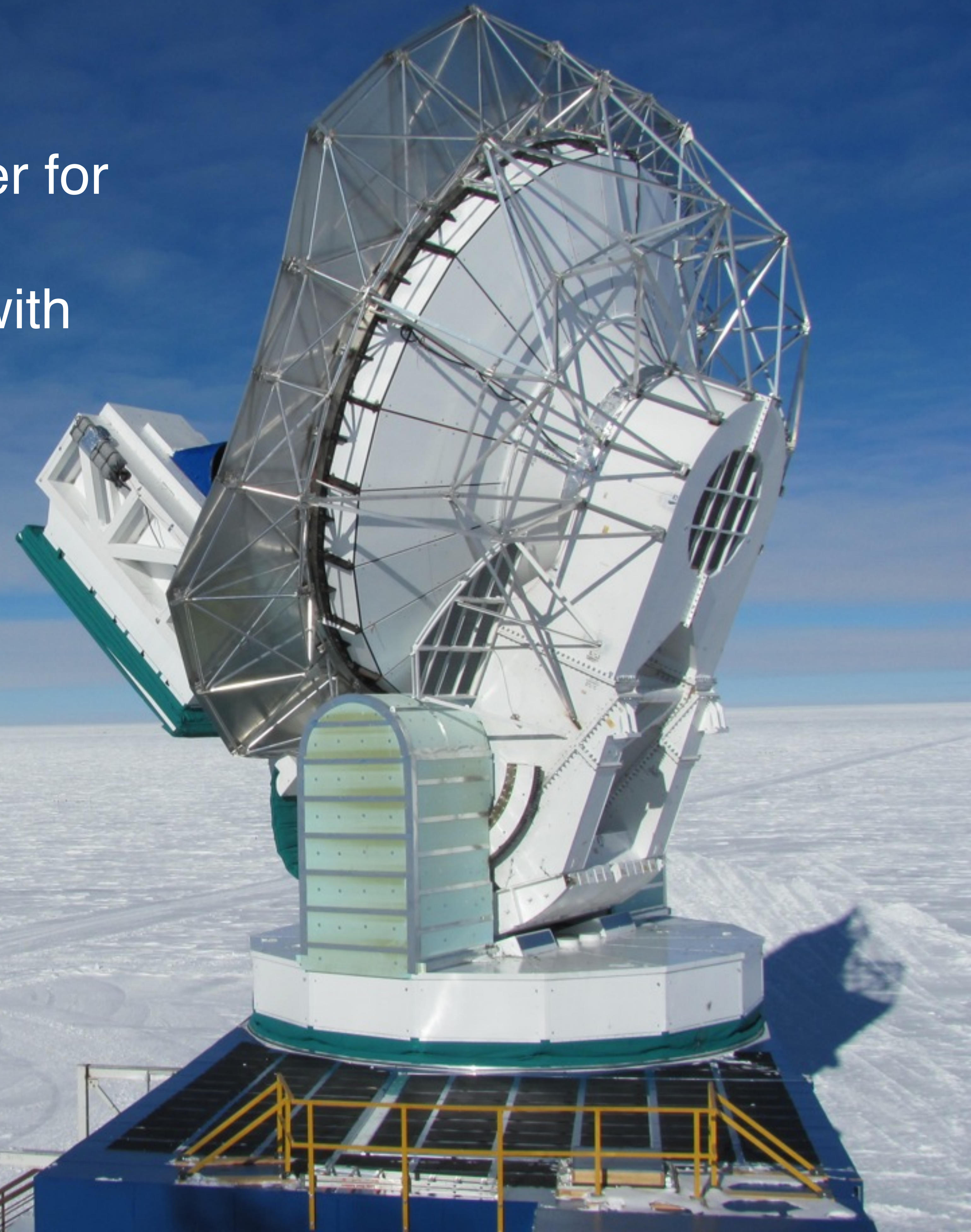
SPT-3G:

The Next Generation Receiver for Polarized Cosmic Microwave Background Measurements with the South Pole Telescope

Amy N. Bender
on behalf of the SPT-3G Collaboration
DPF 2015
2015-08-05



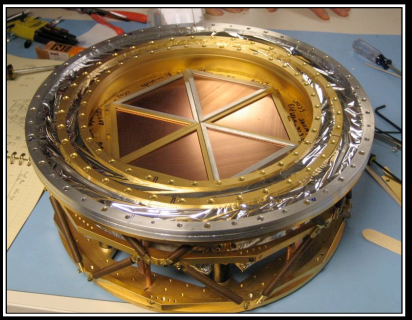
The South Pole Telescope Collaboration

The South Pole Telescope (SPT)

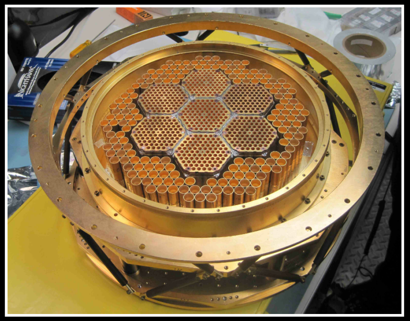
10-meter sub-mm quality wavelength telescope

100, 150, 220 GHz and
1.6, 1.2, 1.0 arcmin resolution

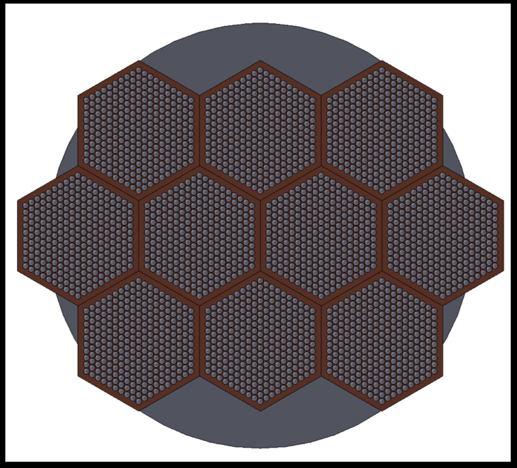
2007: SPT-SZ
960 detectors
95,150,220 GHz

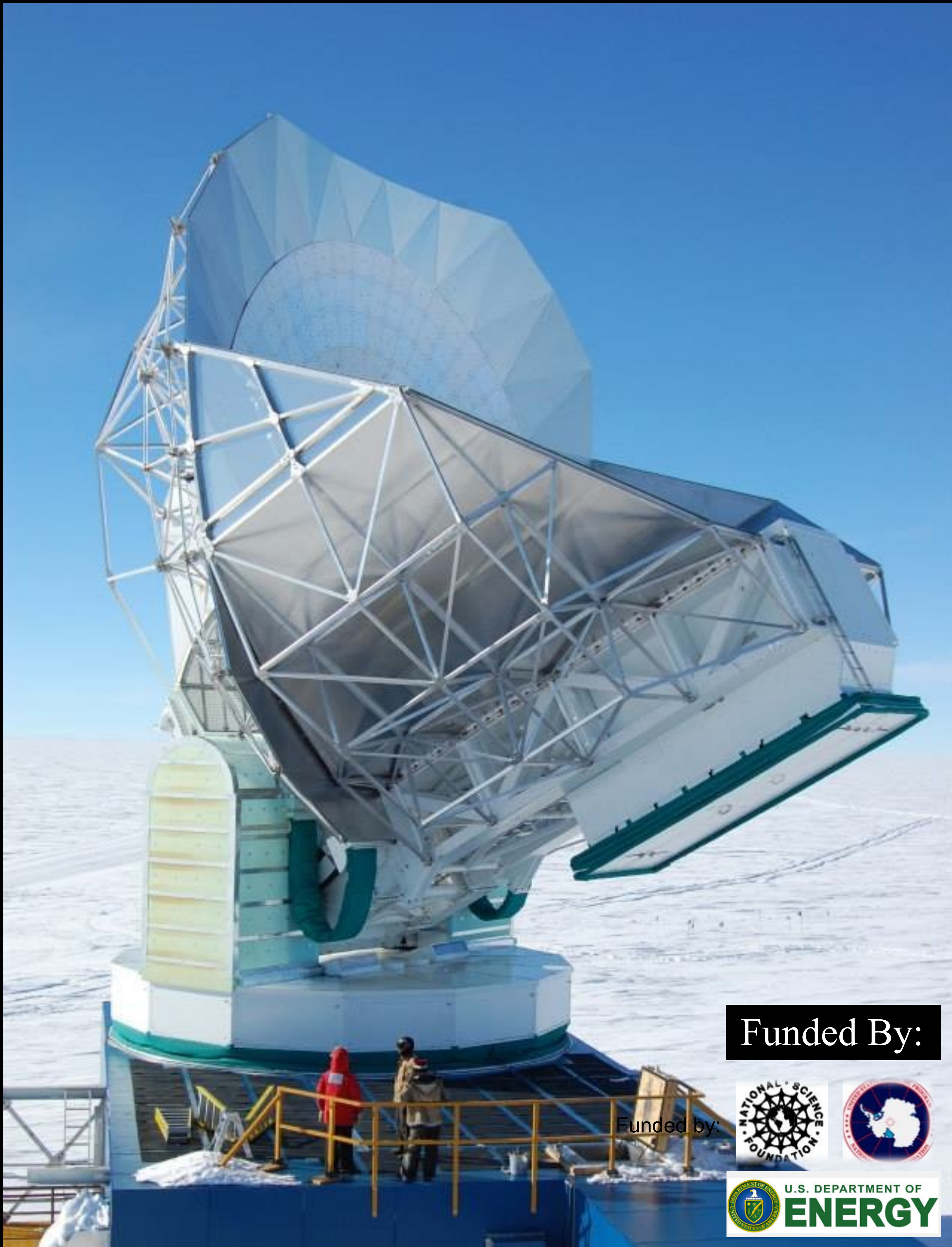


2012: SPTpol
1600 detectors
95,150 GHz
+Polarization

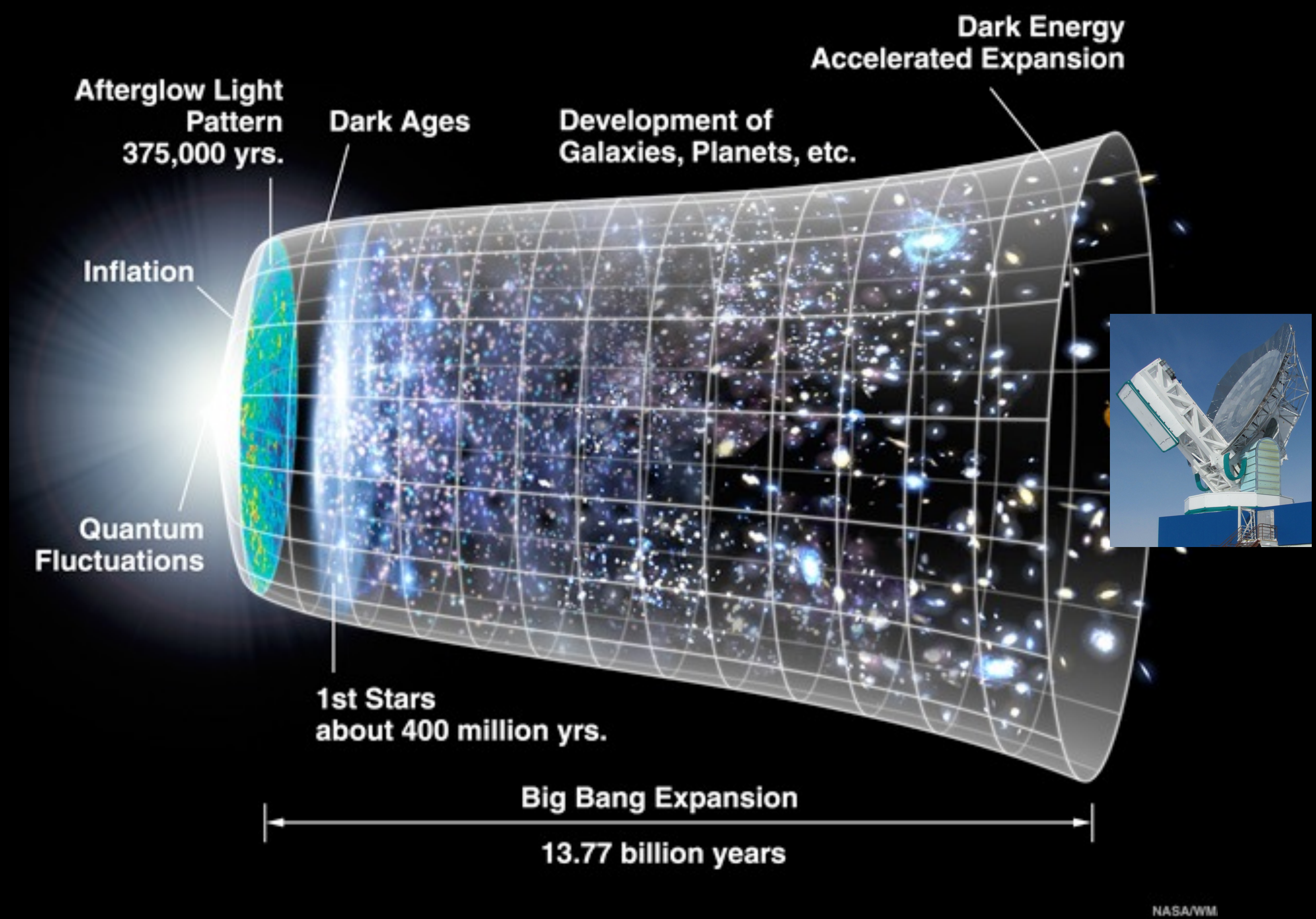


2016: SPT-3G
~16,000 detectors
95,150,220 GHz
+Polarization

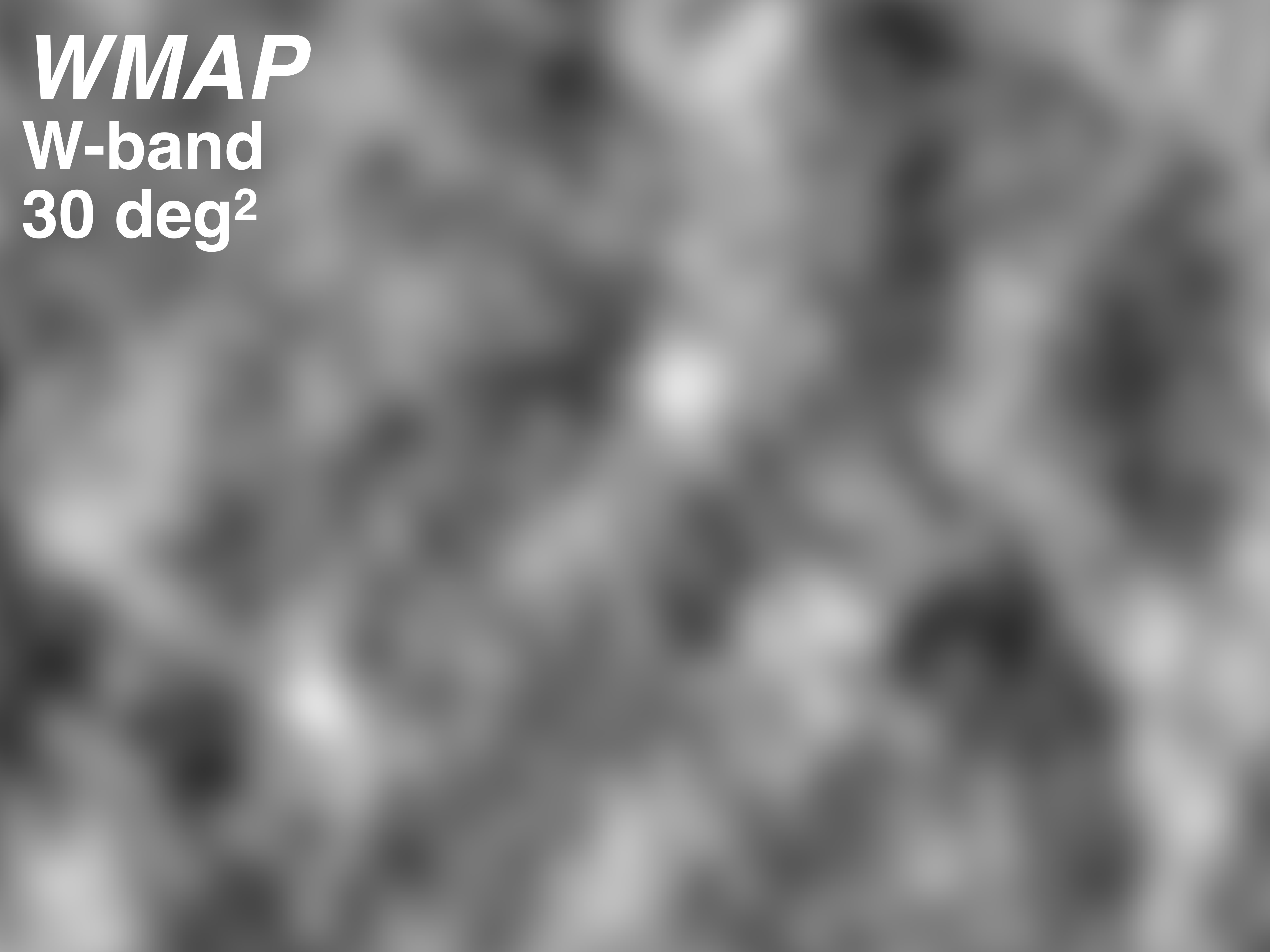


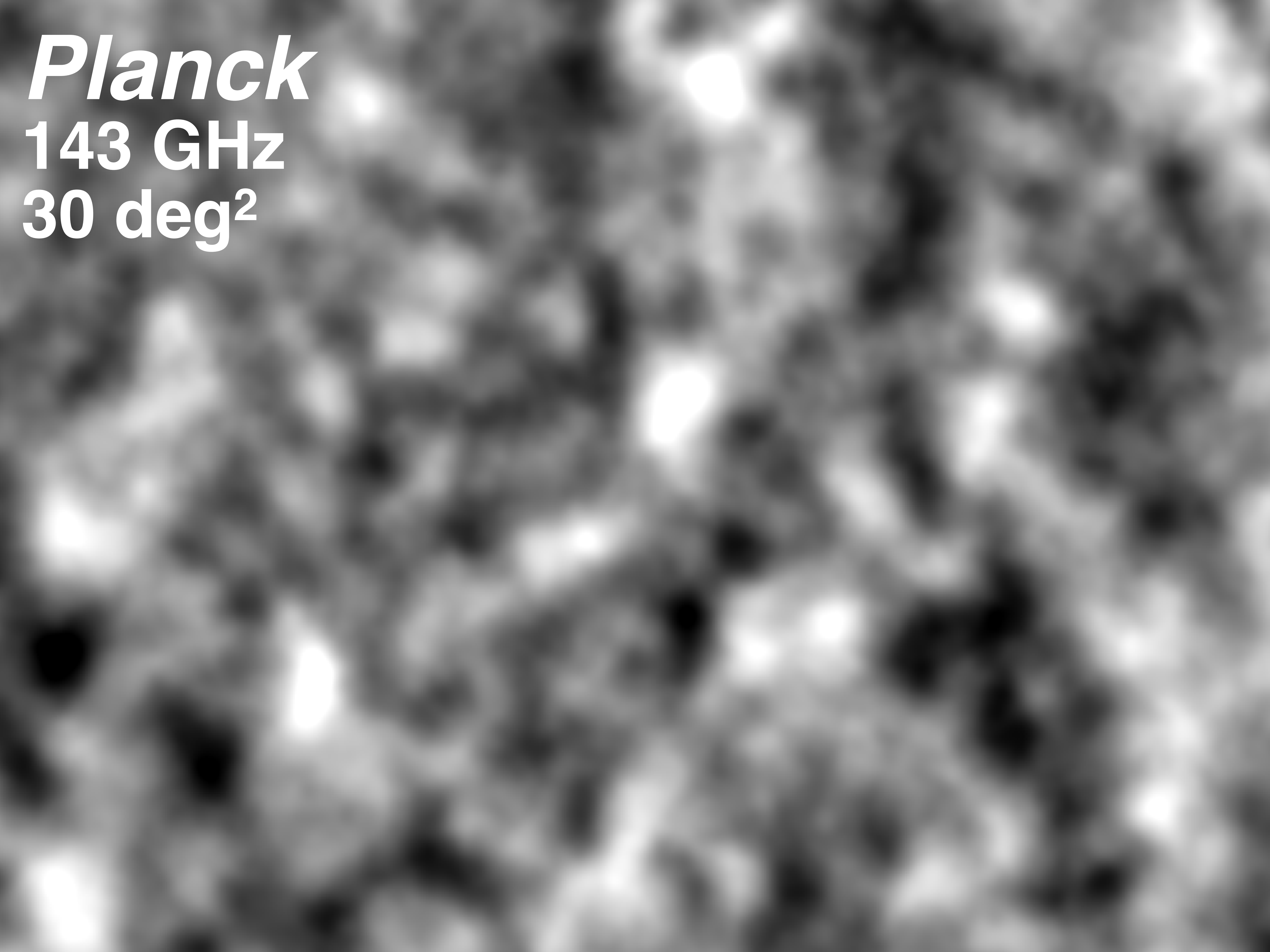


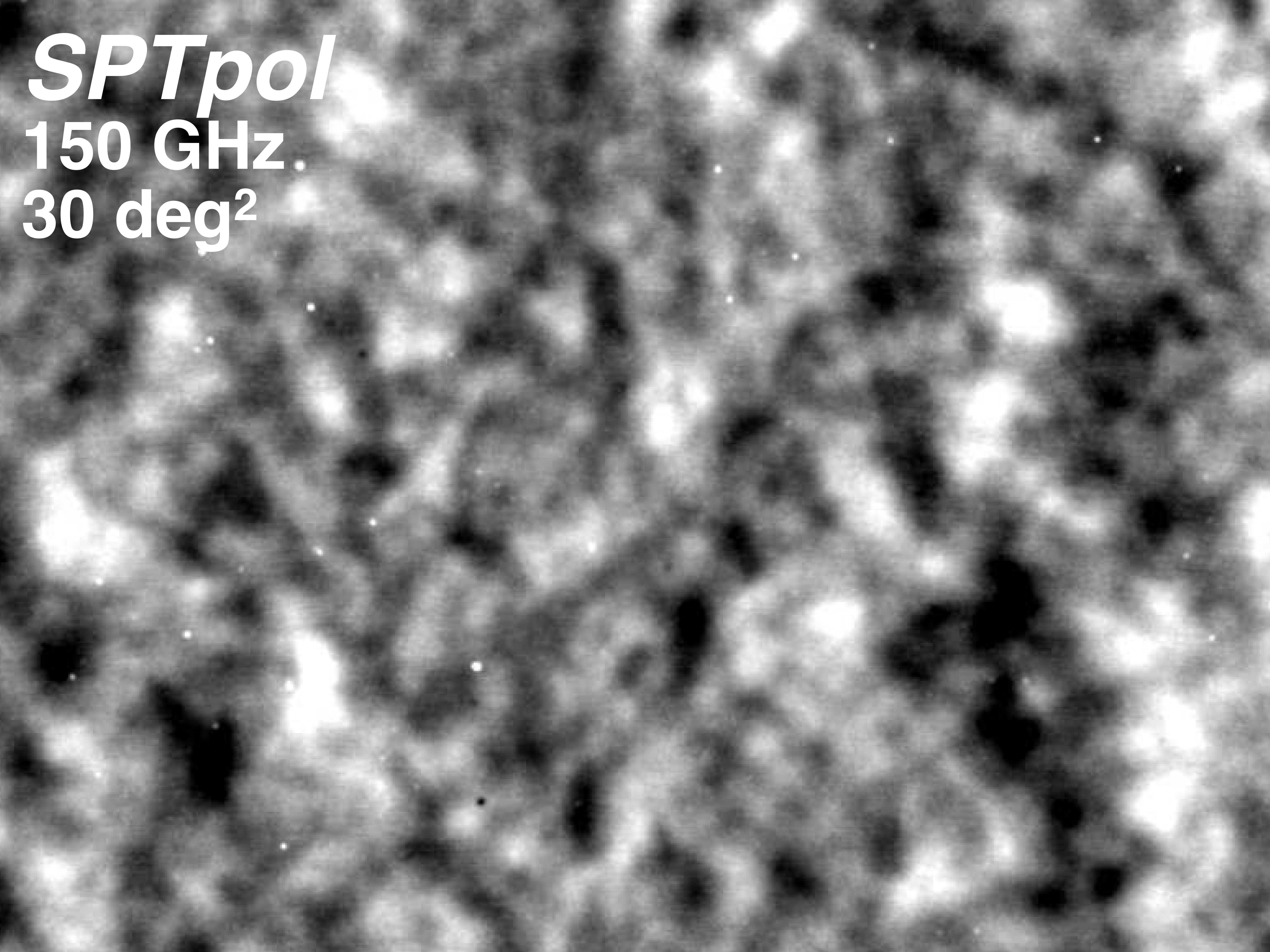
The Cosmic Microwave Background

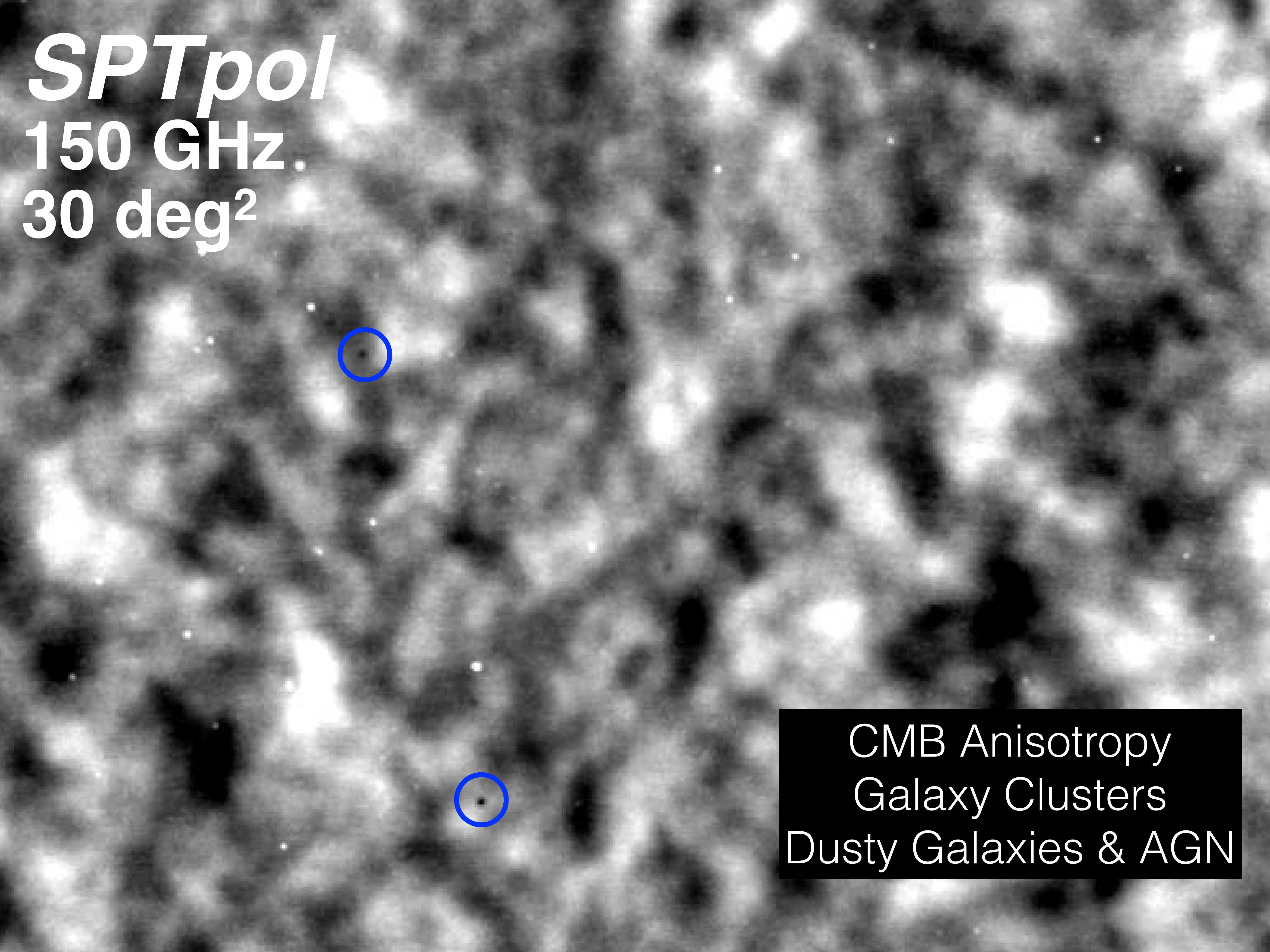


credit: NASA/WMAP Science Team


WMAP
W-band
30 deg²

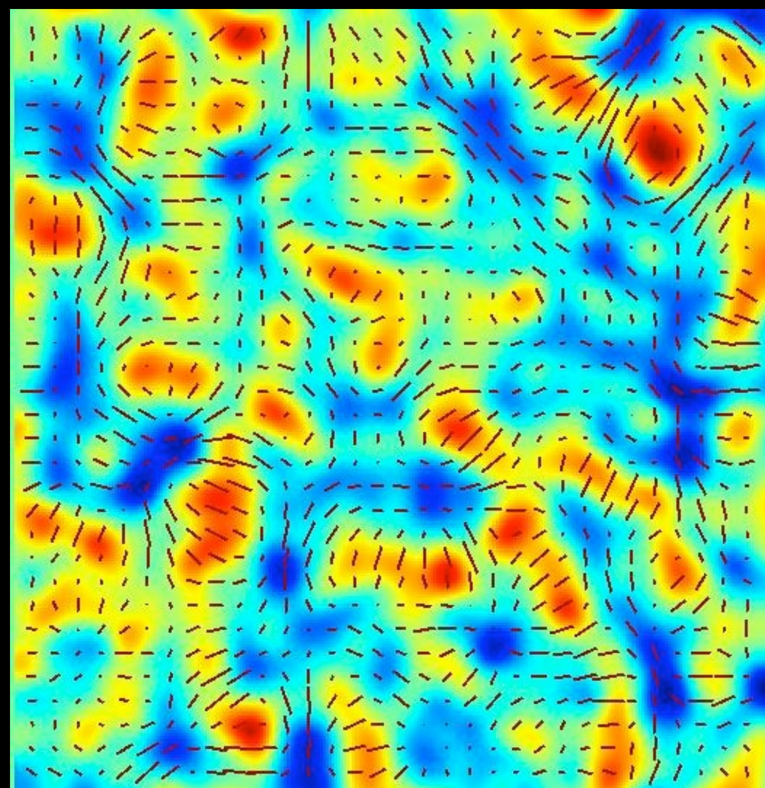

Planck
143 GHz
30 deg²

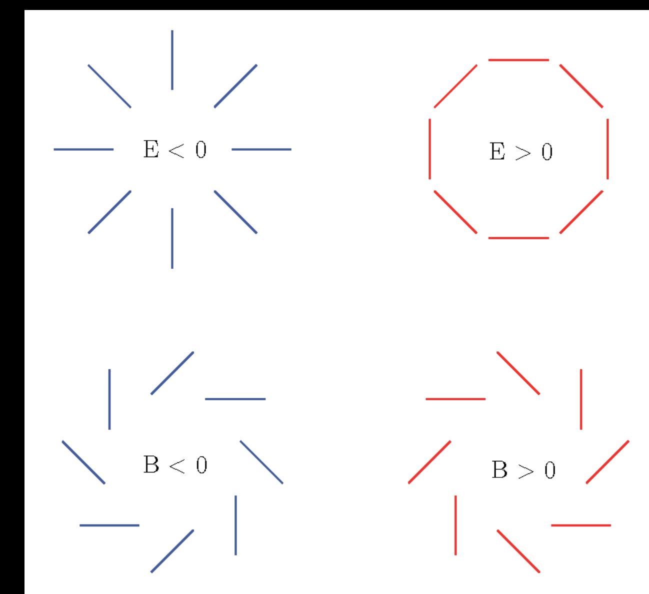

SPTpol
150 GHz
30 deg2


SPTpol
150 GHz
30 deg²
CMB Anisotropy
Galaxy Clusters
Dusty Galaxies & AGN

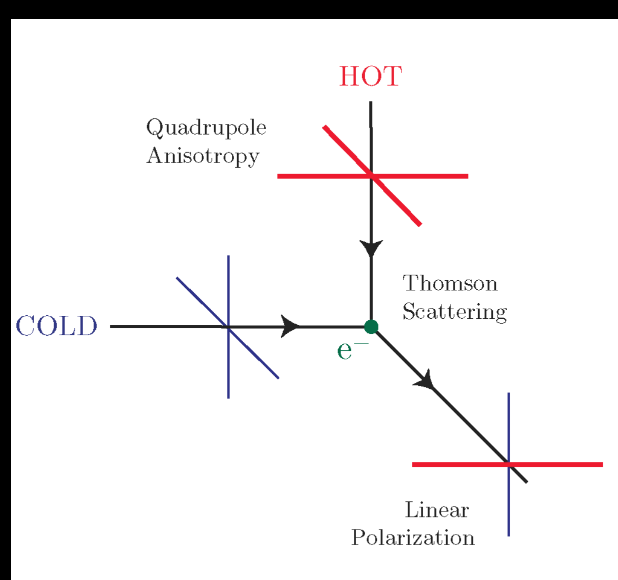
Polarization of the CMB

Seljak & Zaldarriaga 1998



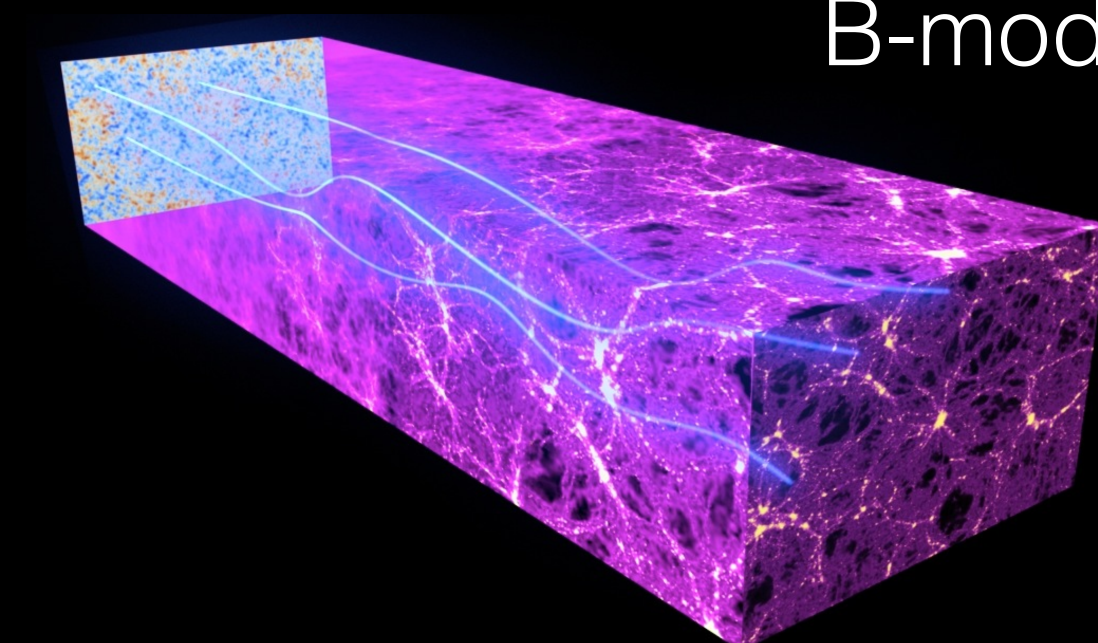


E-modes



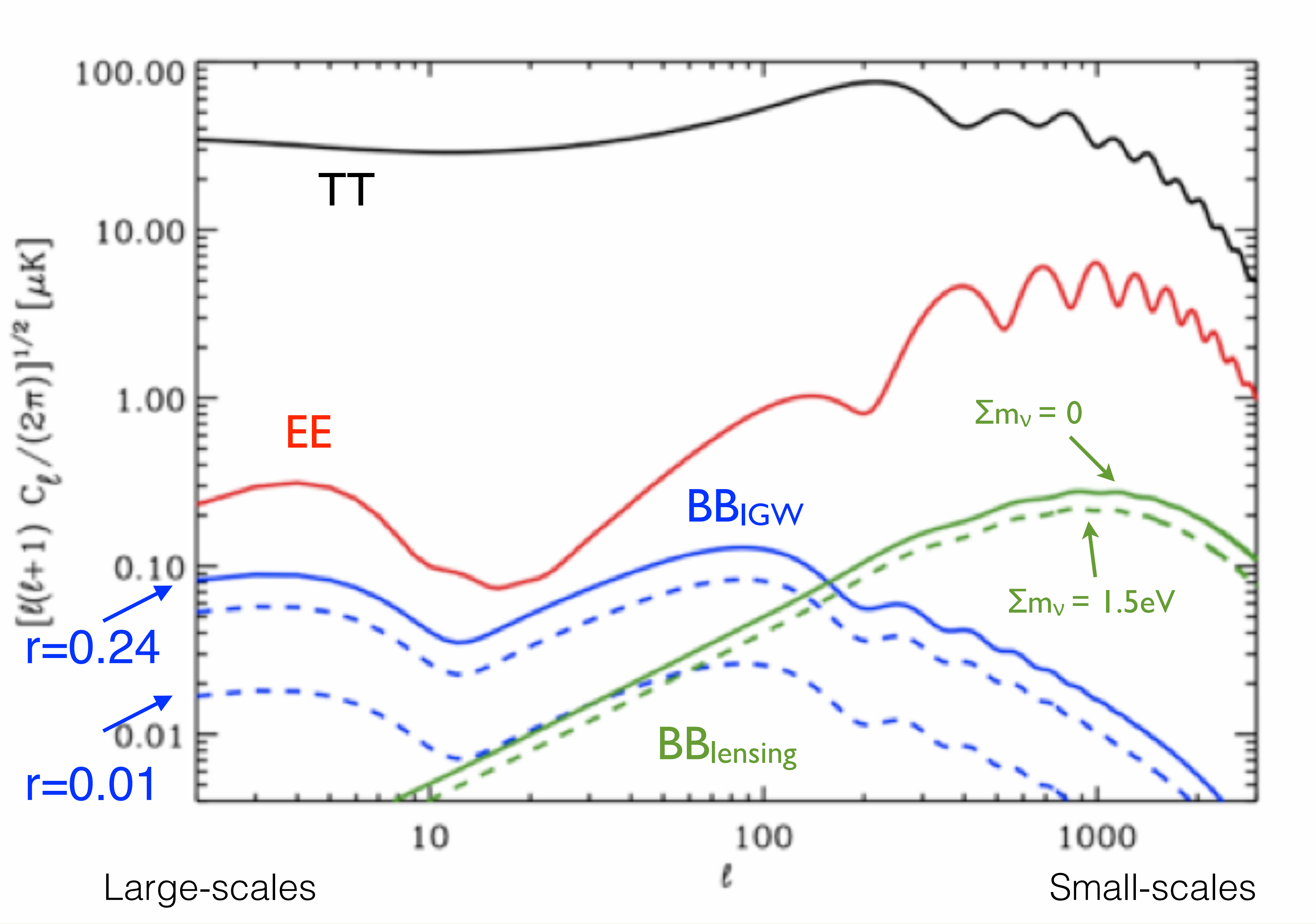
Baumann 2009

B-modes



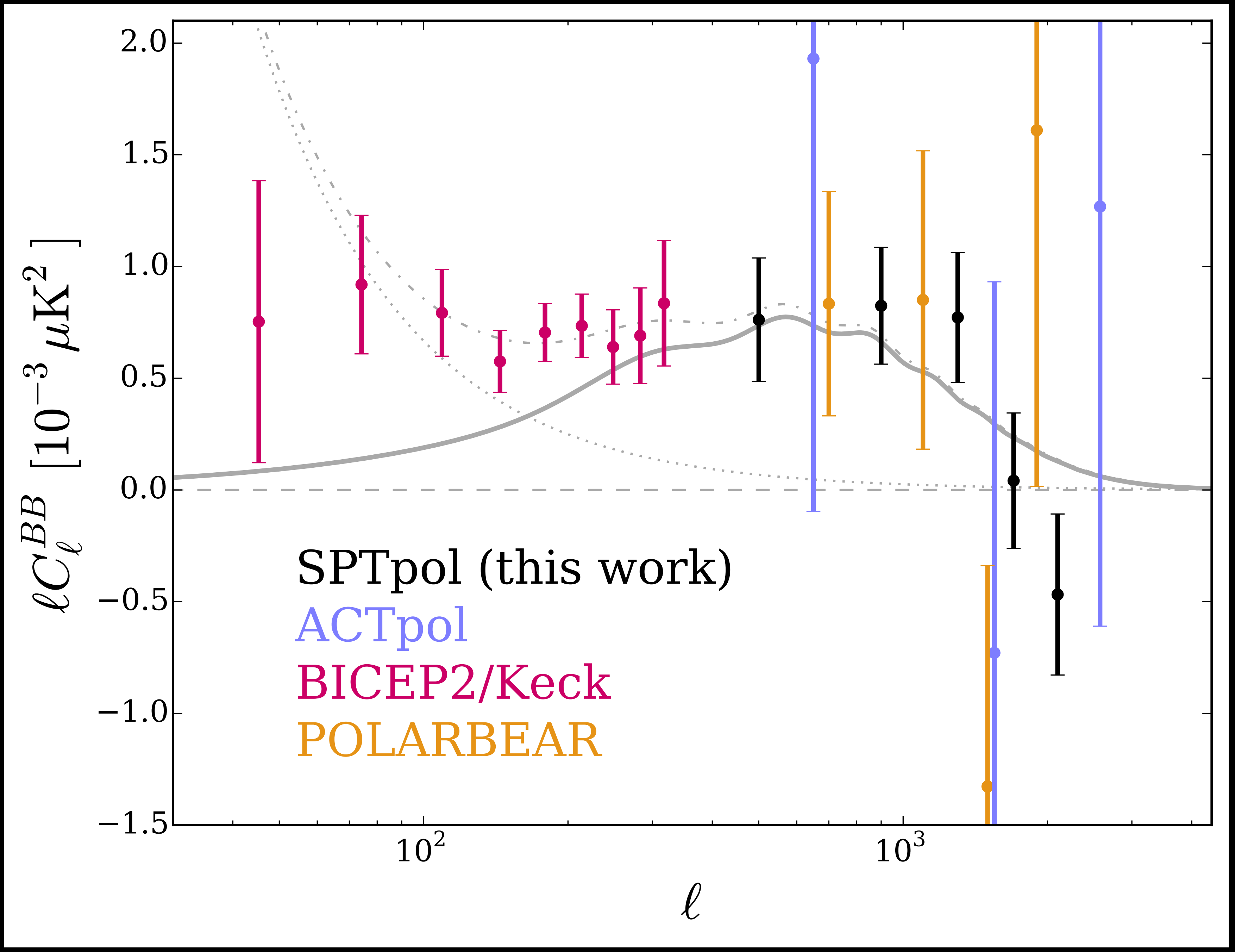
credit: ESA and the Planck Collaboration

The Power of CMB Polarization



SPTpol B-mode Measurements

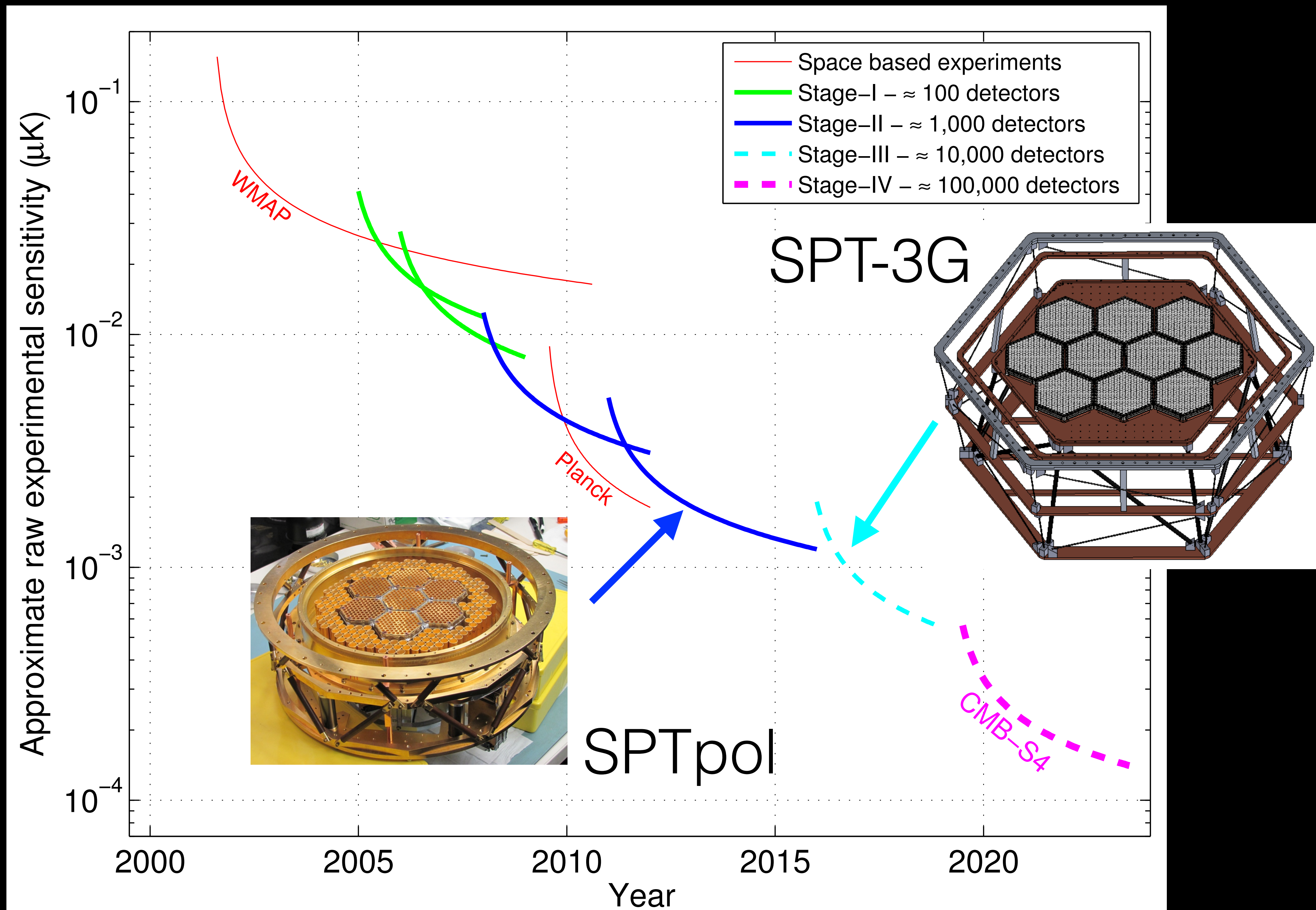
4.3σ detection of lensing B-modes in the autospectrum from ~1st year of observations



Keisler et al. 2015

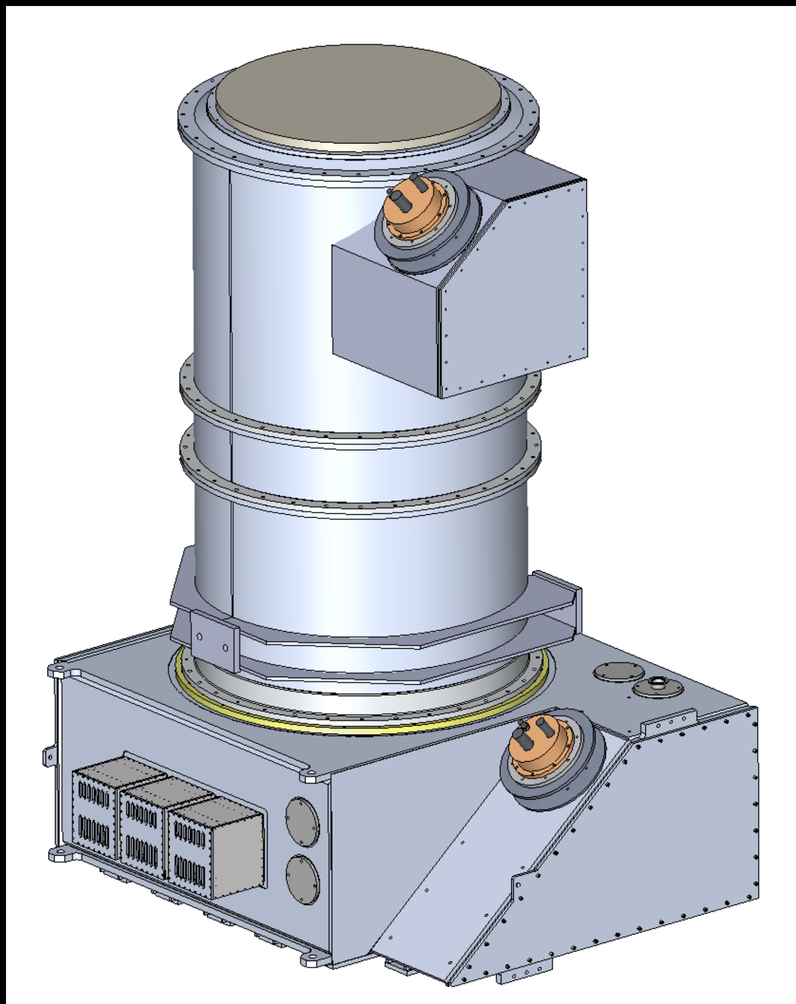
Currently analyzing 2.5 years of additional data over a larger sky area (extending to lower-ell)

Focal Plane Evolution

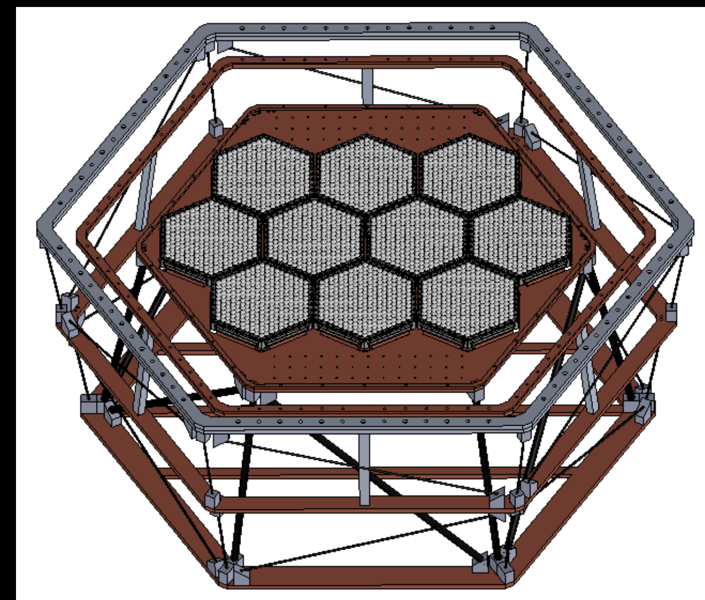


Snowmass; arXiv:1309.5383

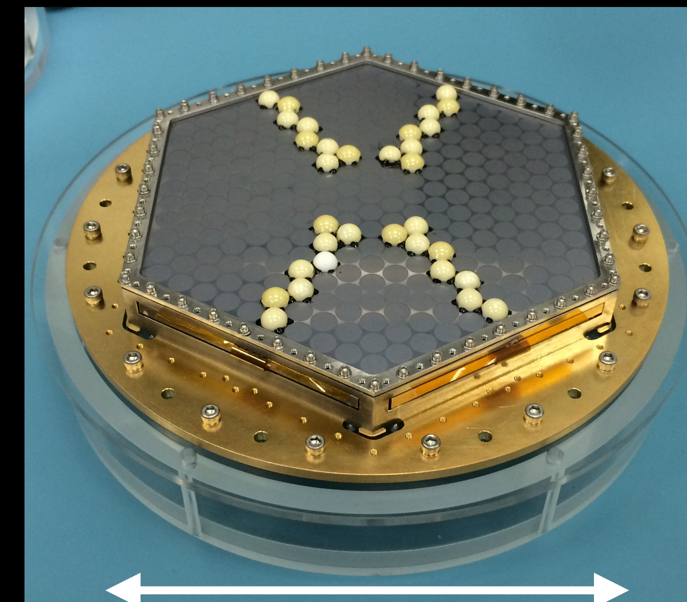
The SPT-3G Receiver



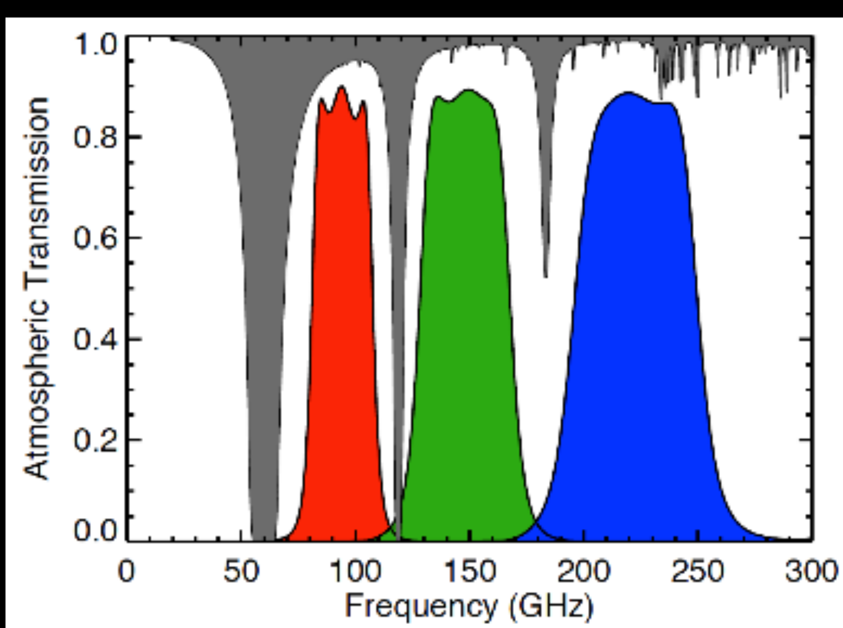
2.2 m



0.9 m

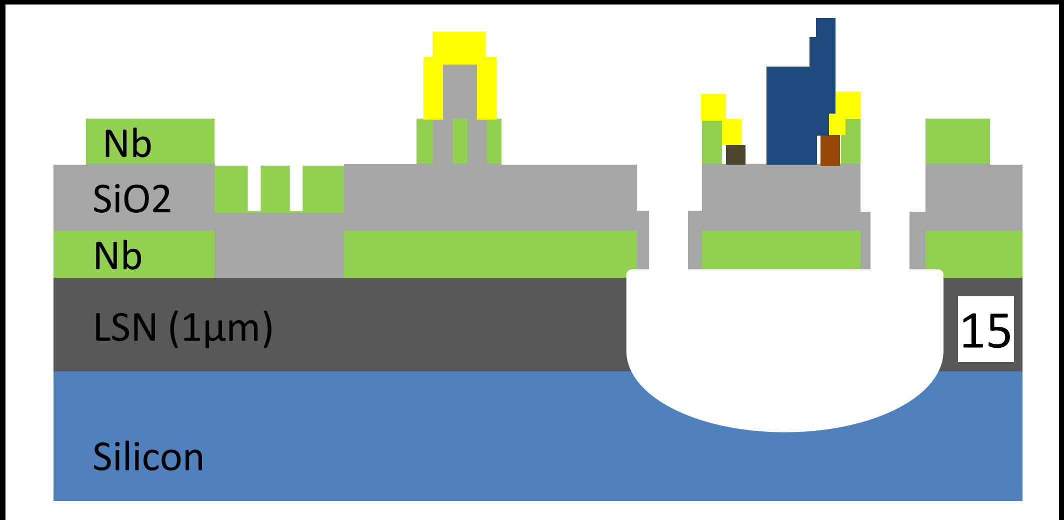


0.15 m

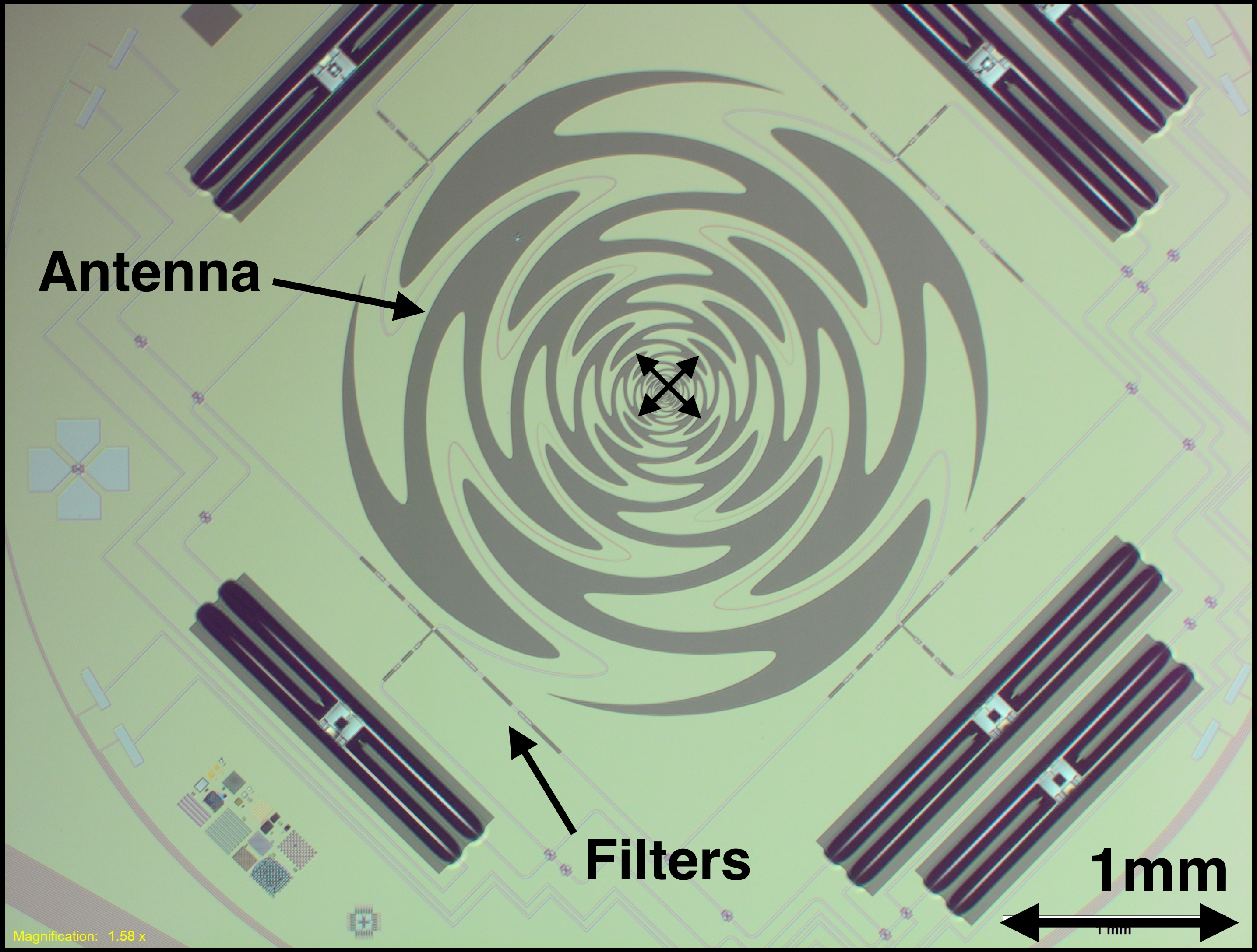


- 1.9 deg field of view (2.8 deg^2)
- 16,262 Transition-edge sensor bolometers operated at 250 mK
- 3 Observing bands: 95, 150, 220 GHz
- ~20x faster mapping speed than current instrument (SPTpol)

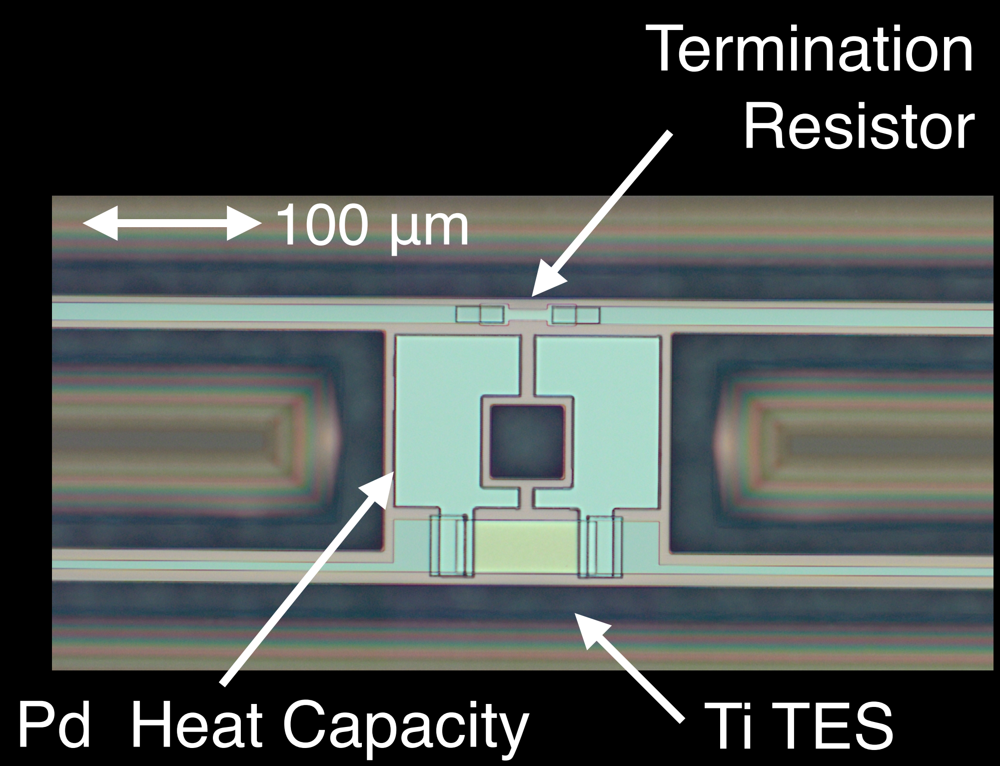
Detector Architecture



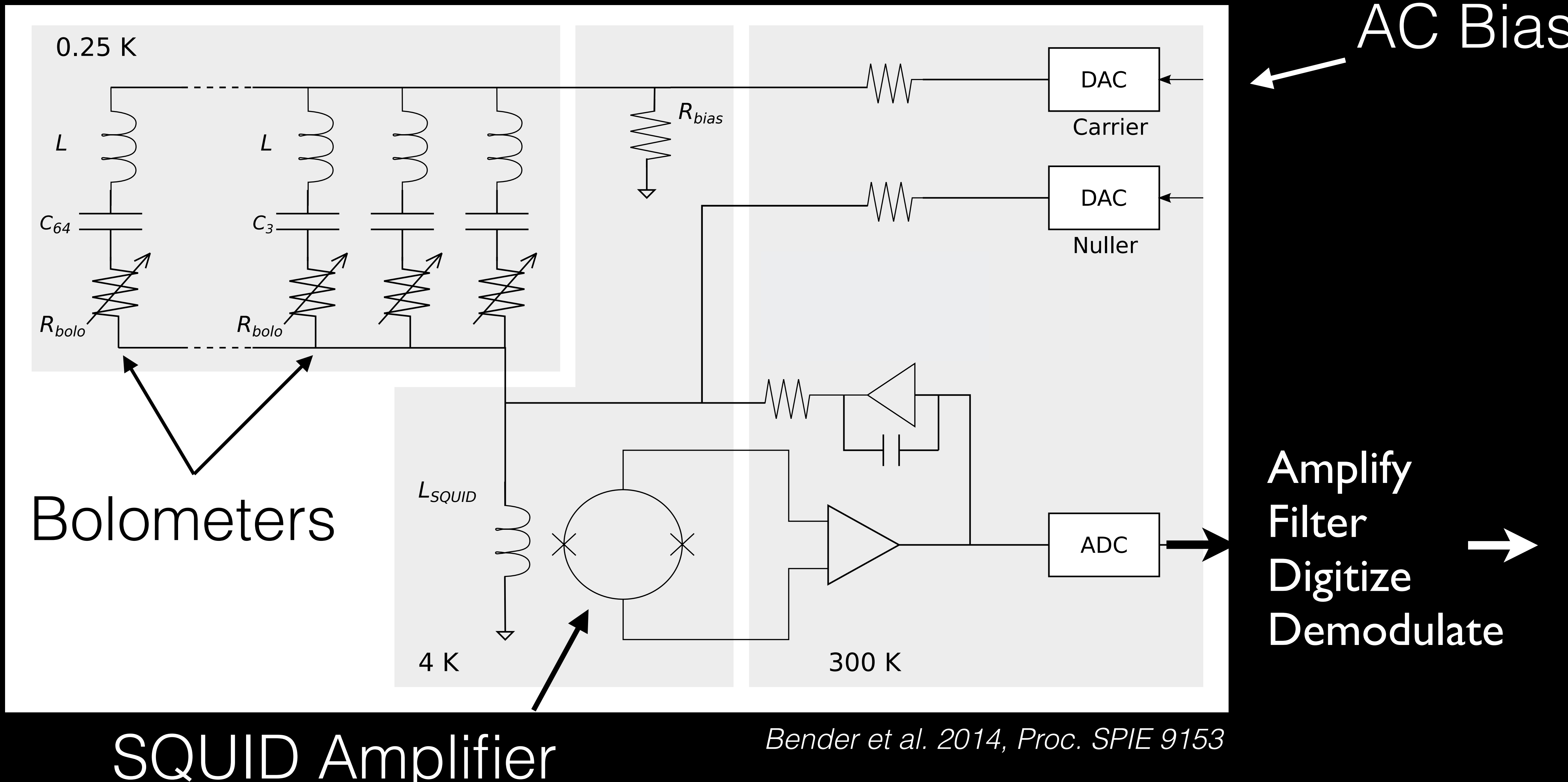
Posada et al. 2015, Superconductor Science and Technology



- Multichroic dual-polarization pixel (adapted from design from UC Berkeley)
  - Broad-band sinuous antenna microstrip in-line filters
  - 6 separate TES islands per pixel (3 bands & 2 polarizations)
  - 271 pixels fabricated monolithically on a 6" wafer



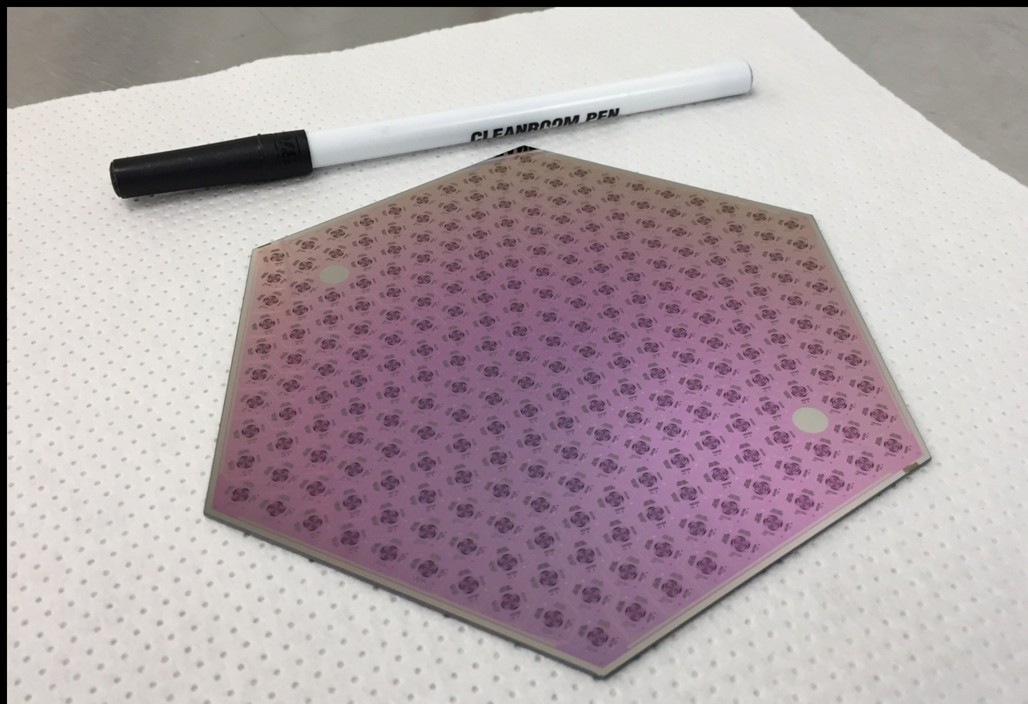
Multiplexing Readout Architecture



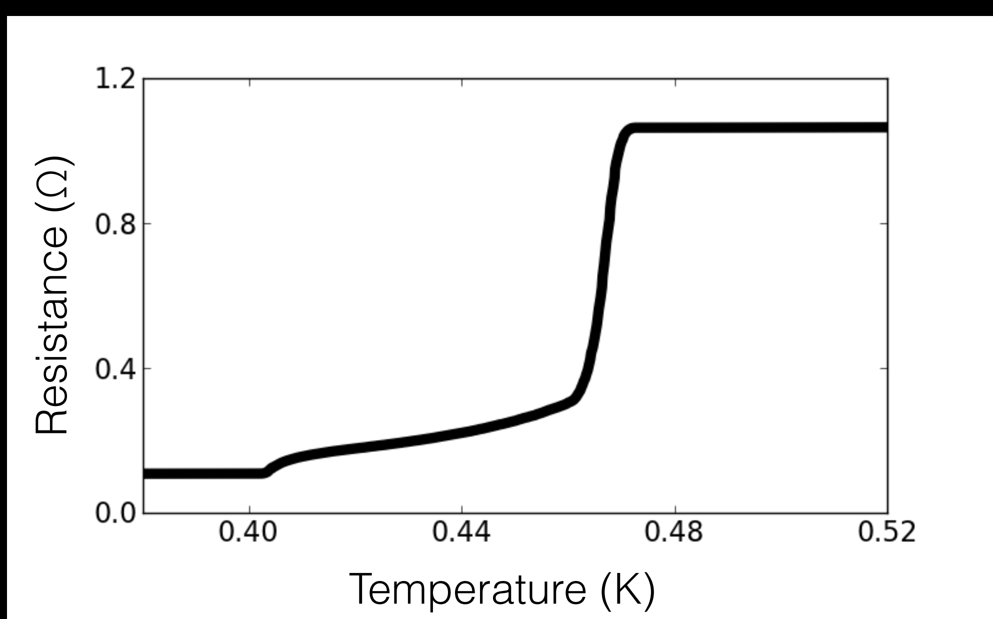
Bender et al. 2014, Proc. SPIE 9153

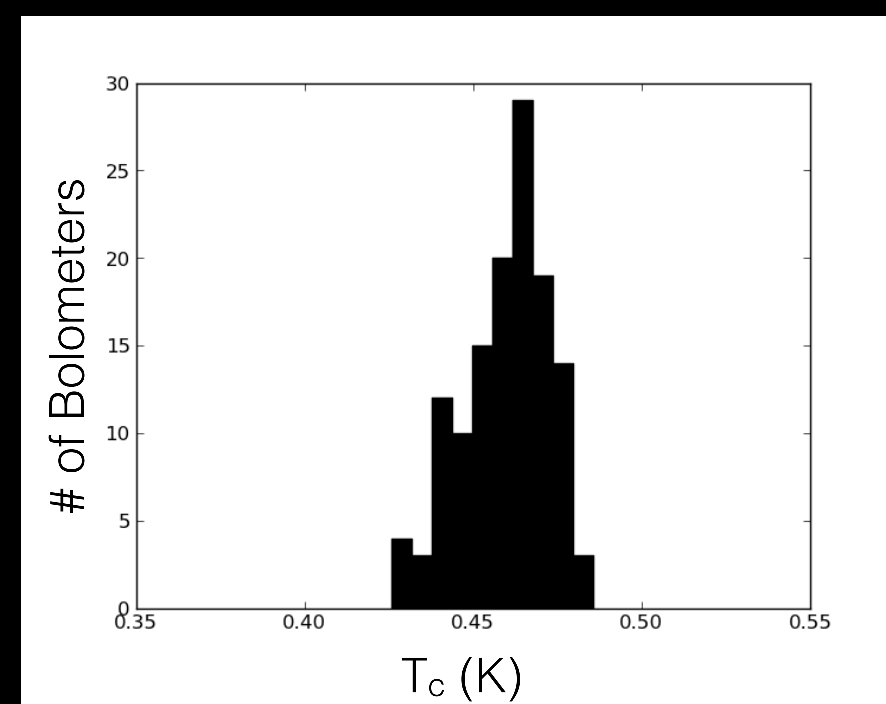
Readout 64 bolometers on single pair of wires using LC resonators to select an AC voltage bias

Recent Performance



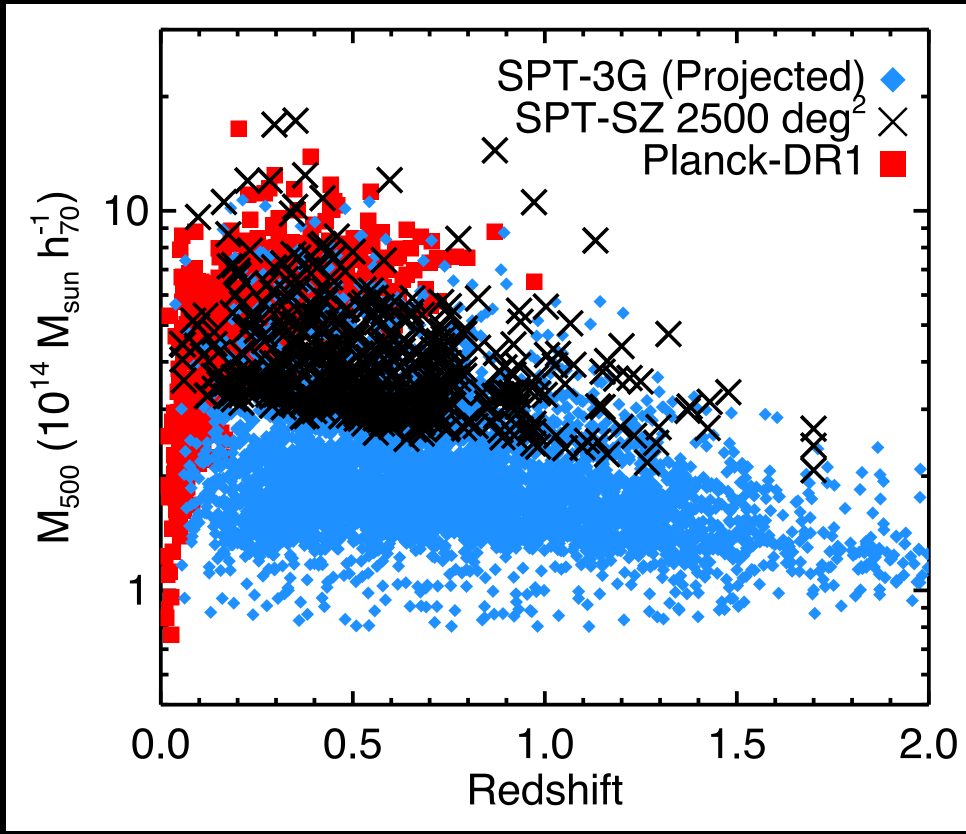
- **Performance Criteria:**
    - Sensitivity (NET)
    - Stability
    - Crosstalk
    - Uniformity across the focal plane



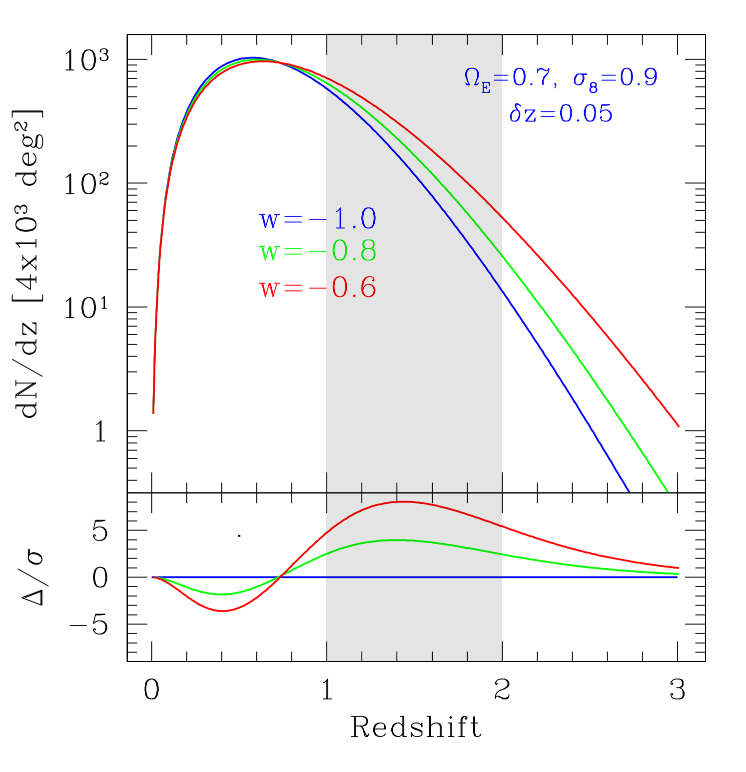


SPT-3G Cluster Survey Forecasts

- 2500 square degree survey of the CMB for a duration of 4 years
  - 2.5 μK (3.5 μK) in T (P) @150 GHz
  - 4.3 μK (6 μK) in T(P) @ 95/ 220 GHz
- ~10,000 new galaxy clusters
  - Astrophysics of galaxy clusters
  - Constrain growth of large-scale structure & evolution of dark energy (w, w_a)
  - CMB - cluster lensing to calibrate the mass of clusters



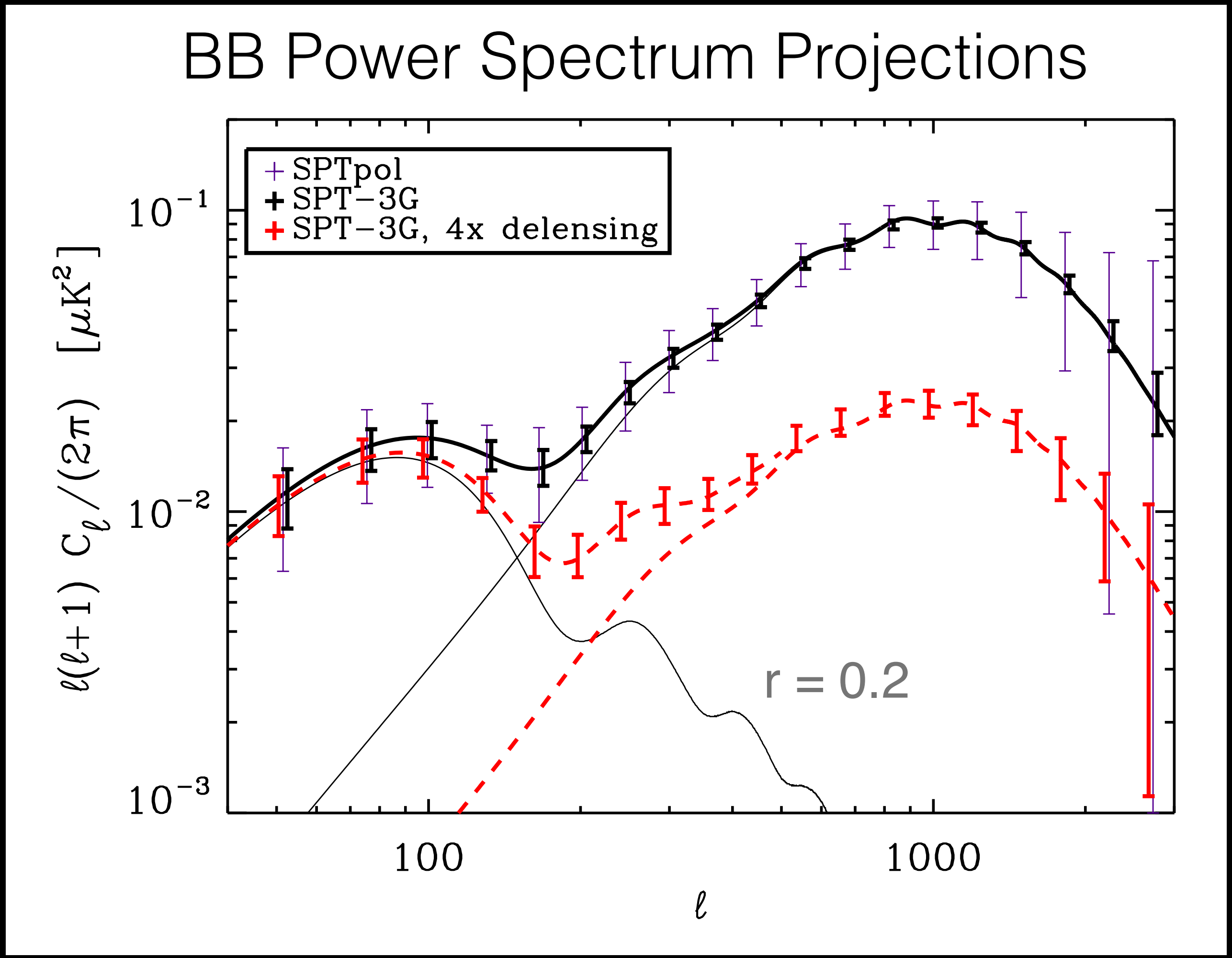
Benson et al. 2014, Proc. SPIE 9153



Mohr 2005

SPT-3G Projected Power Spectrum

- High S/N measurement of gravitational lensing B-modes
  - constrain sum of neutrino mass through growth of structure
  - de-lensing of inflationary spectrum



Benson et al. 2014, Proc. SPIE 9153

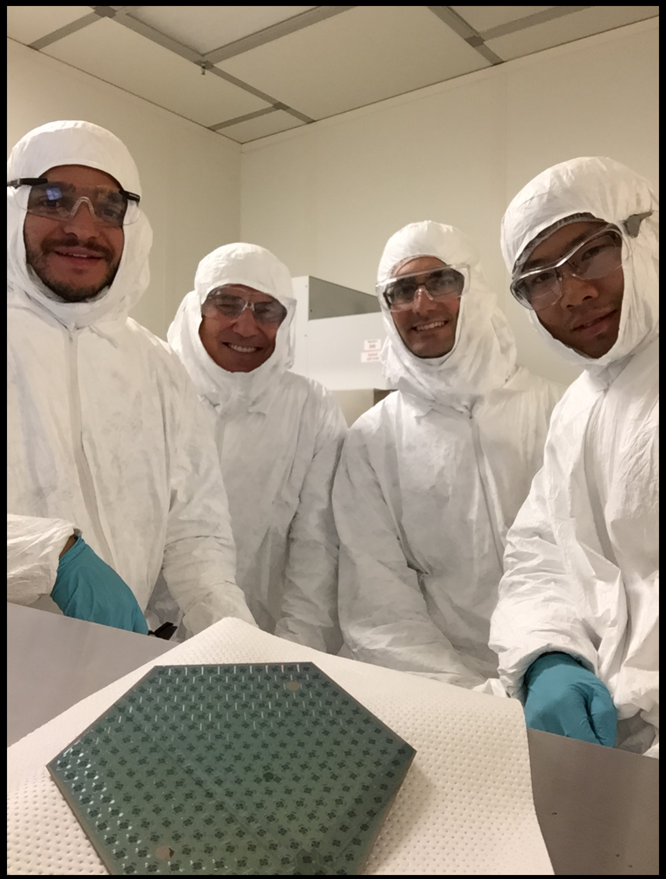
2019 Projections

Priors from Planck + BOSS

σ(r)	0.011
σ(Σm	0.061 eV

Summary

- CMB polarization is a powerful cosmological probe
- SPT-3G will map 2500 square degrees of the millimeter-wavelength sky in both temperature and polarization to exciting new depths
  - Both detector and readout technology have made significant advances with a focal plane of ~16,000 detectors
  - Constrain the evolution of dark energy, neutrino mass, and inflationary gravity waves



credit: D. Hrubes