

SPTpol's Search for Inflation Begins

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University of Chicago
27 June 2013



The South Pole is dry, has a stable atmosphere, and has good logistics.



A Good Place to Live



The South Pole



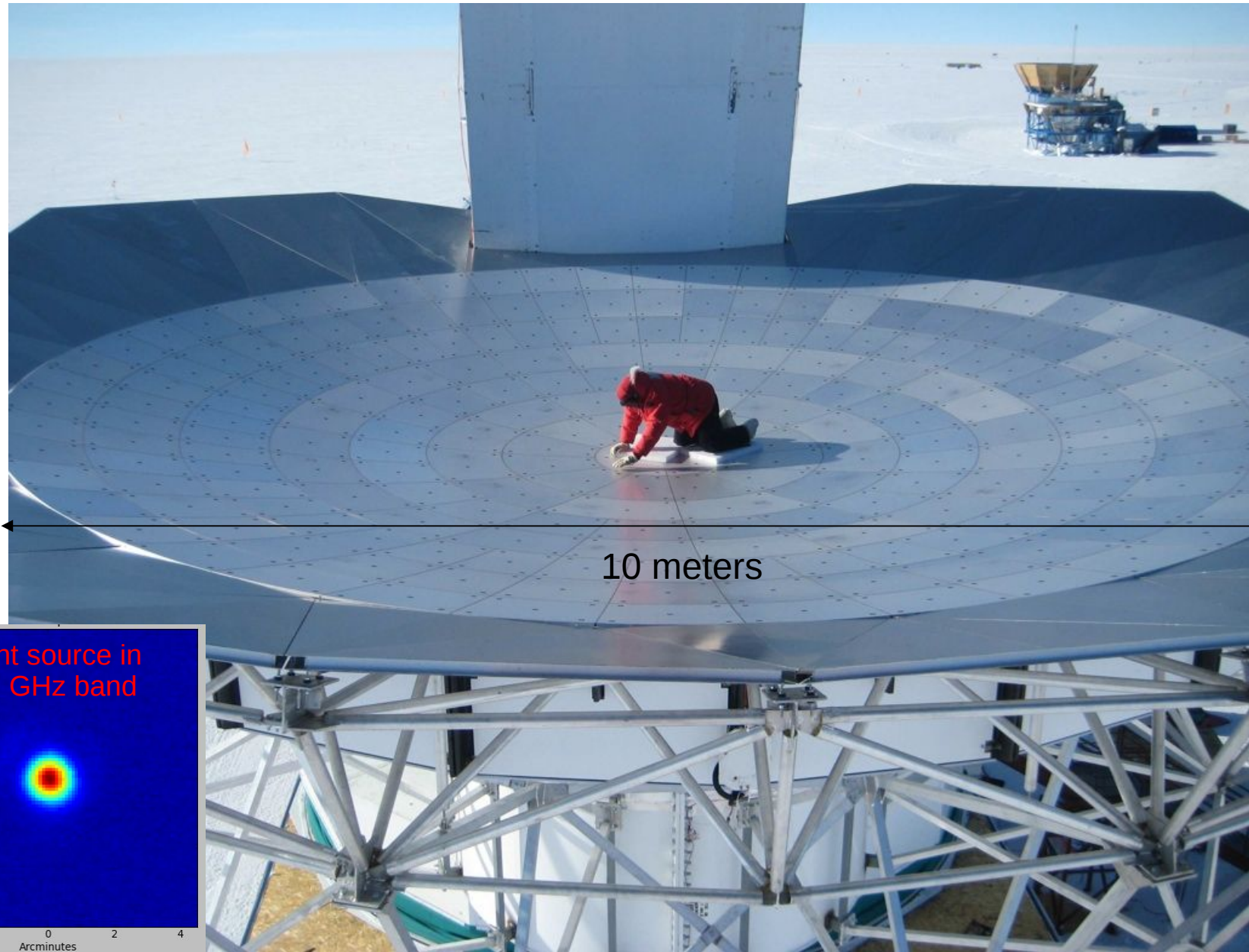
The SPT



To the rest of the world

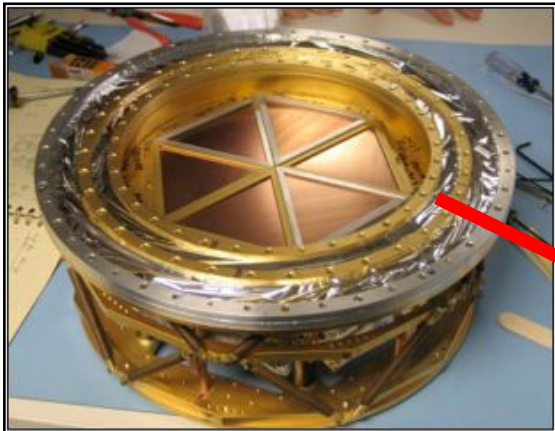


A 10 meter dish gives us 1 arcminute resolution for 2 mm light.

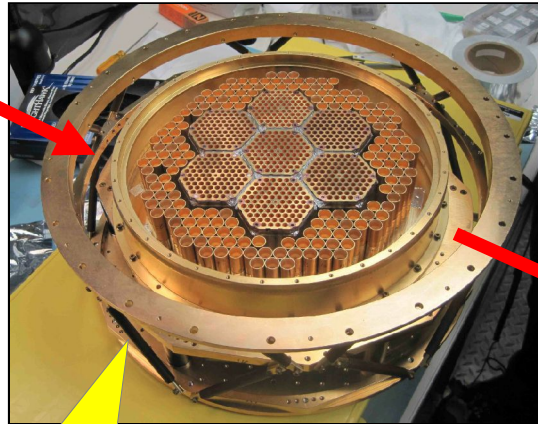


The SPT's capabilities increase as we develop and install new instruments.

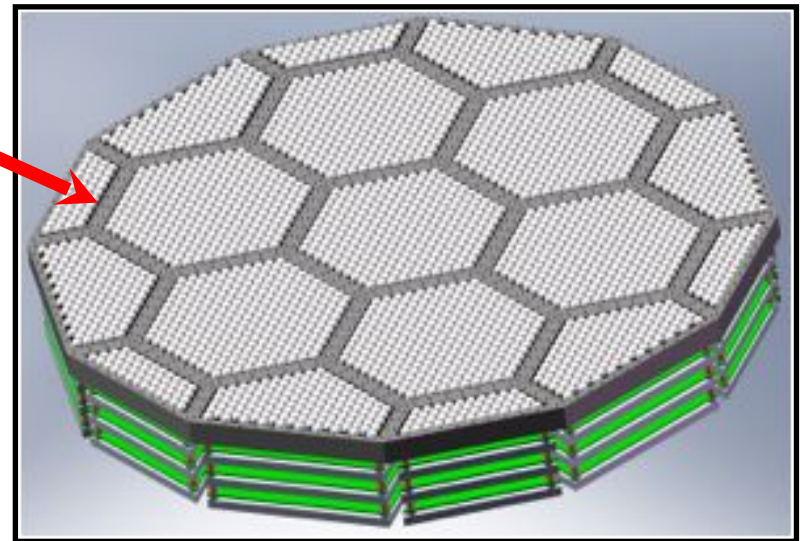
2007-2011: SPT
960 detectors



2012-2015: SPTpol
~1600 detectors



2016: SPT-3G
~15,200 detectors

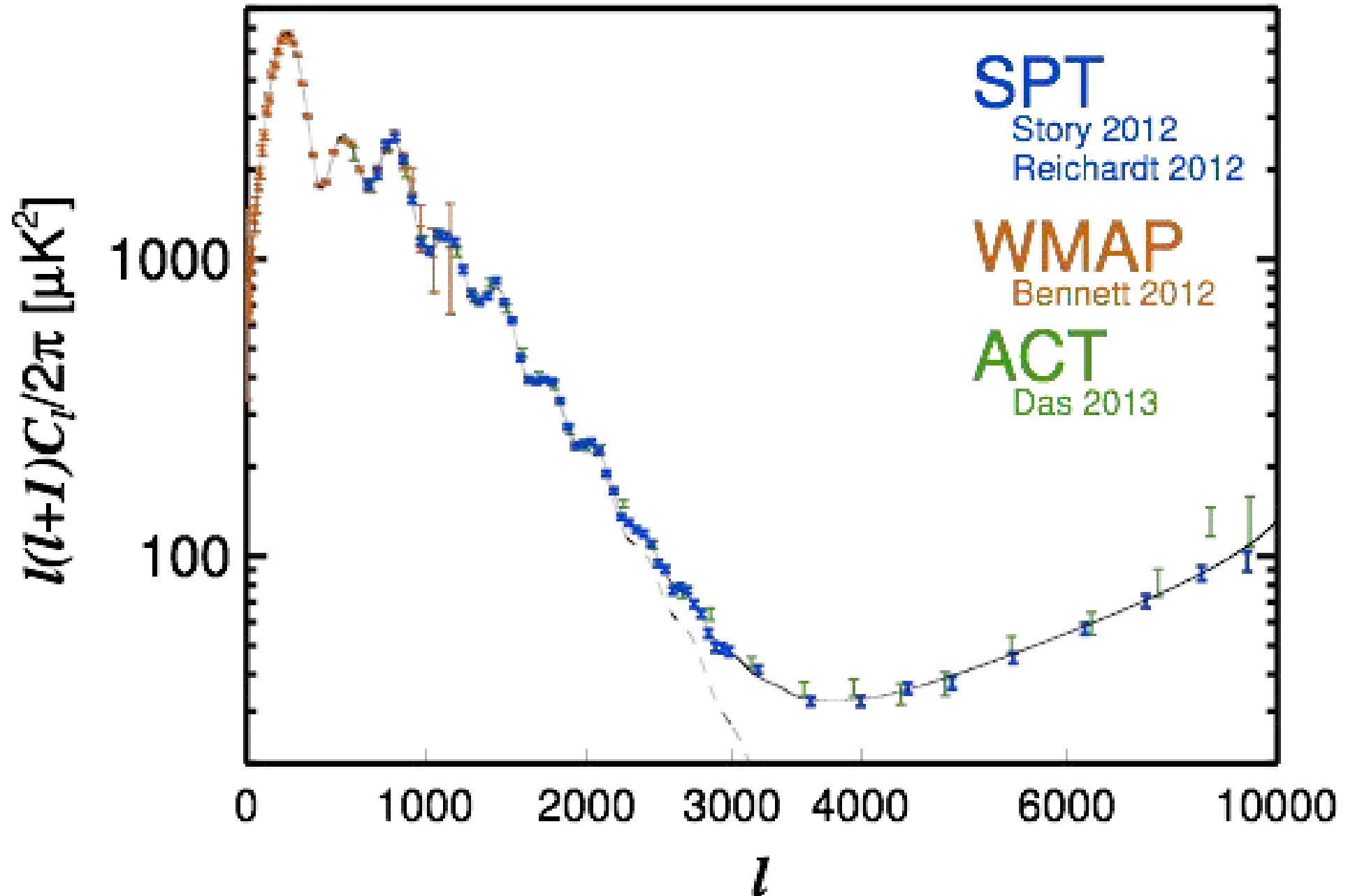


Now with polarization!

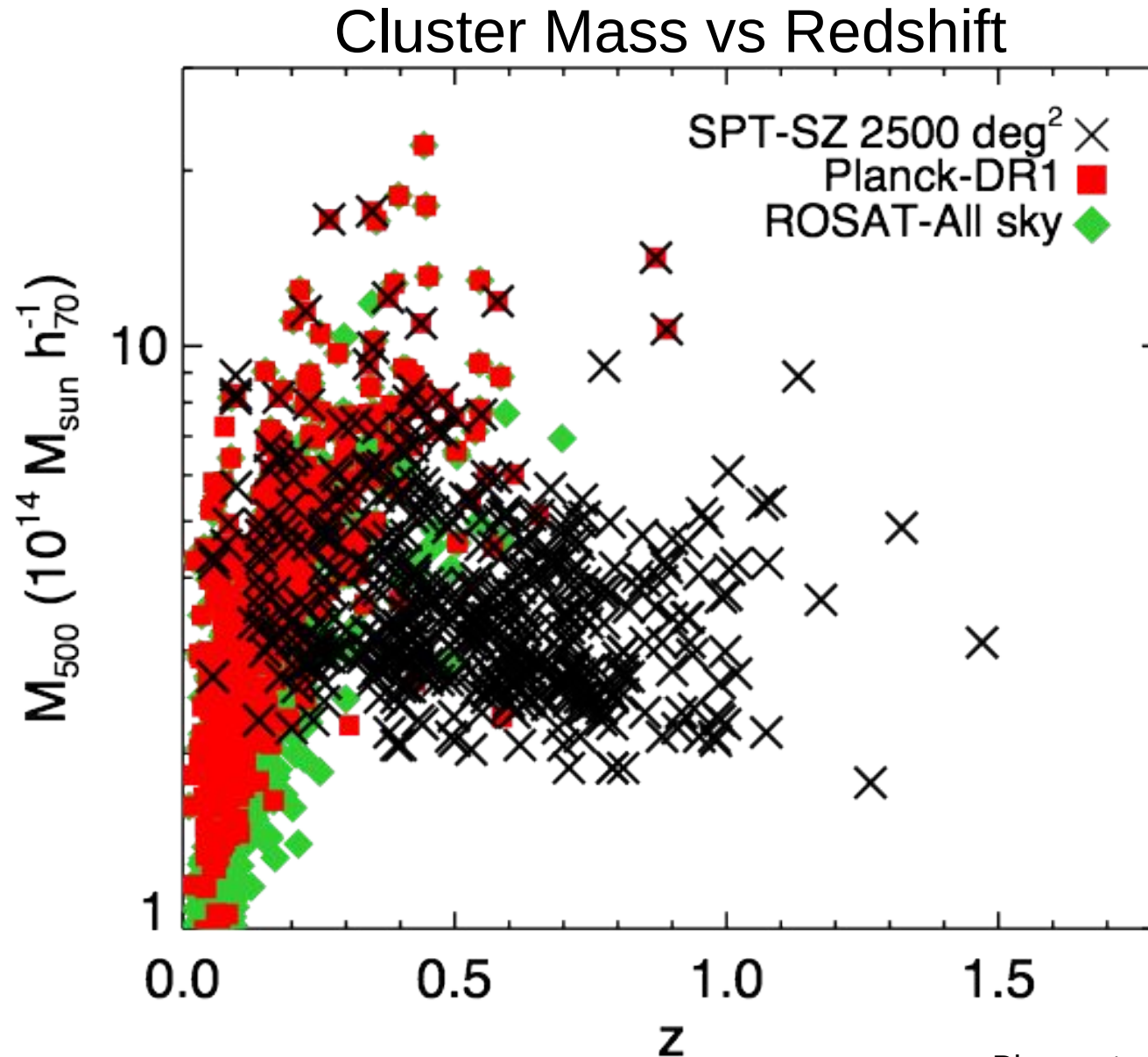
What Has Come Before



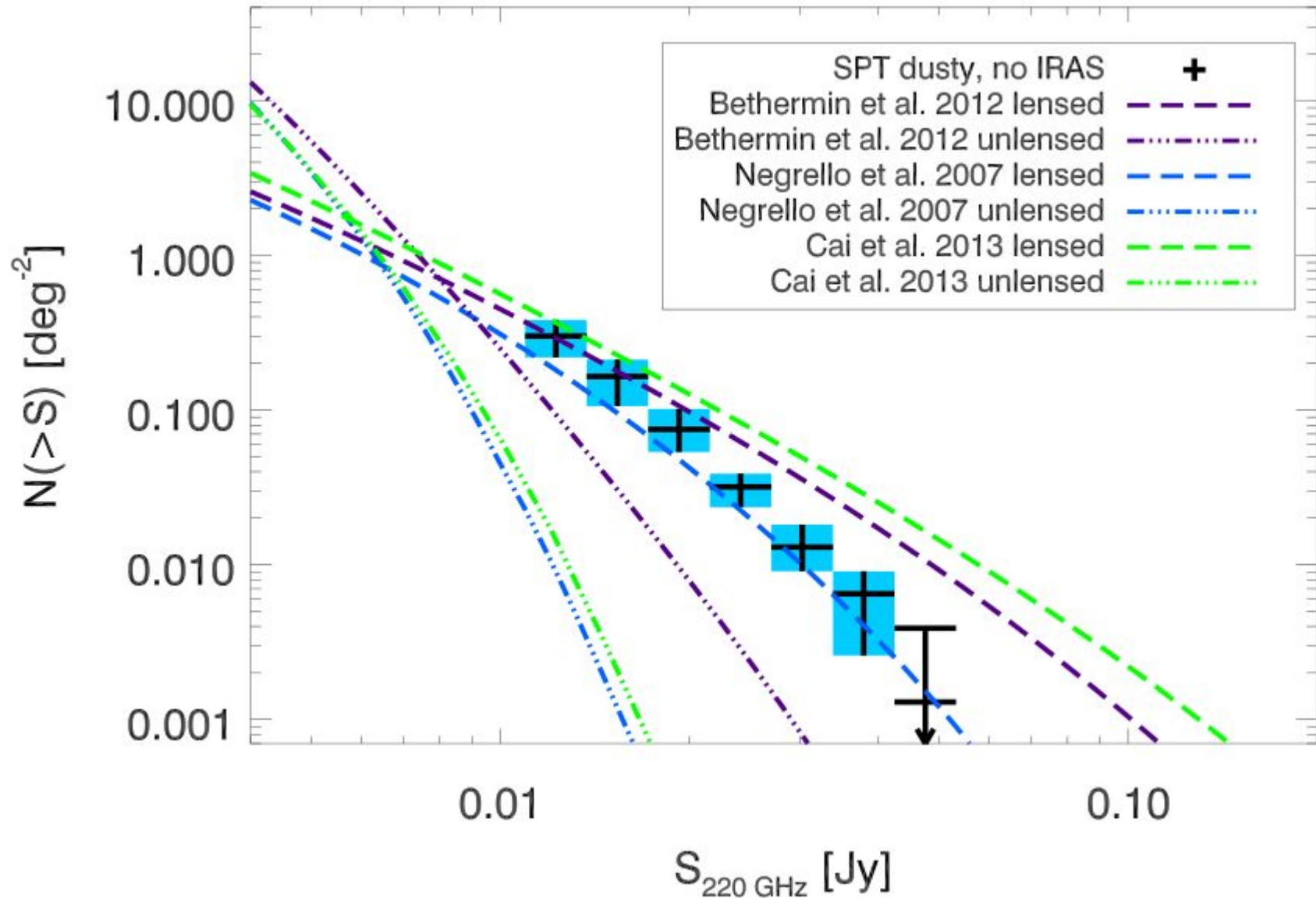
The SPT is a superb tool for small-scale CMB science.



The SPT SZ-effect cluster search has found > 400 galaxy clusters.

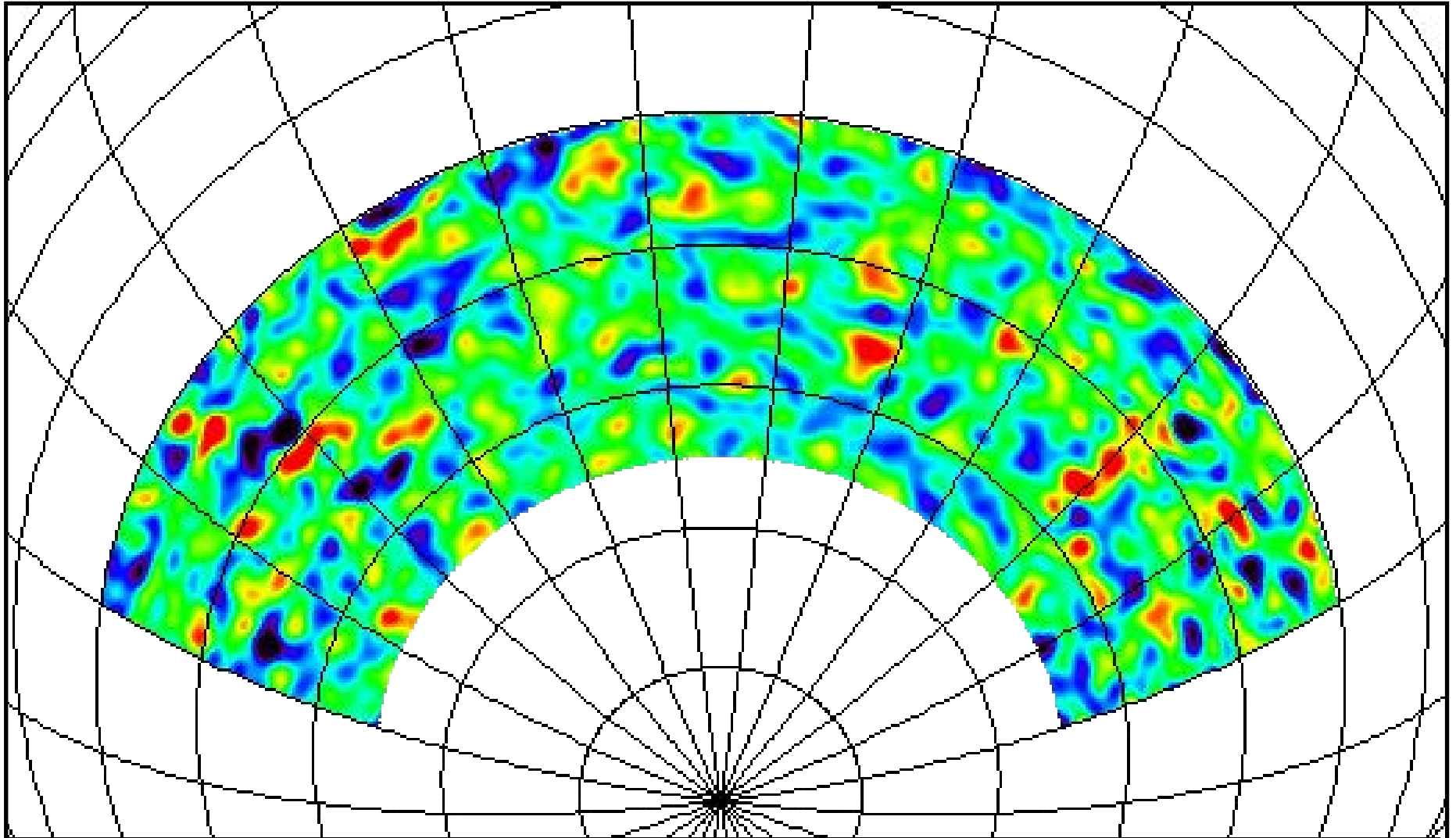


We catalog extragalactic foregrounds.

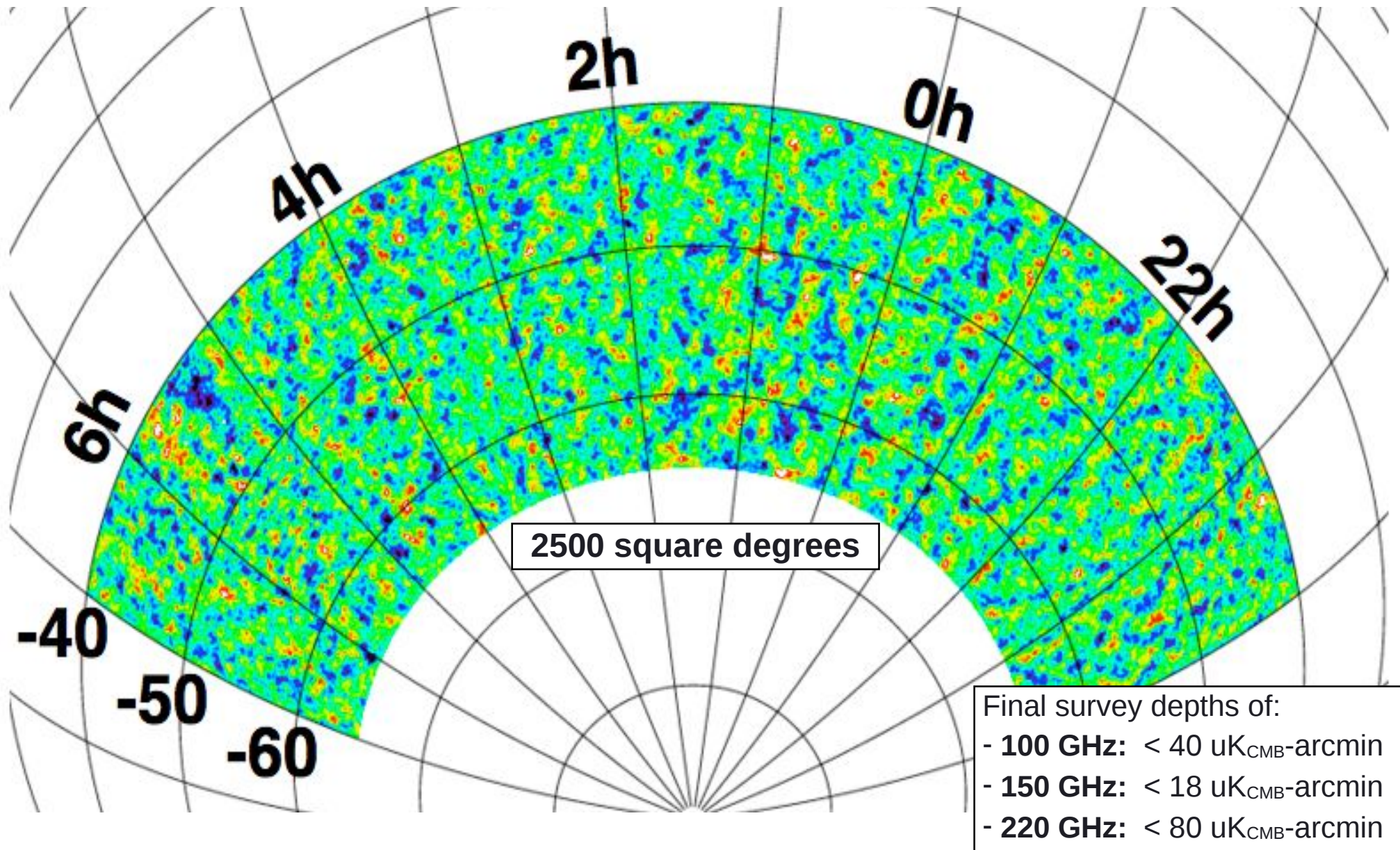


We use the effect of lensing on the CMB to reconstruct the mass distribution using SPT data.

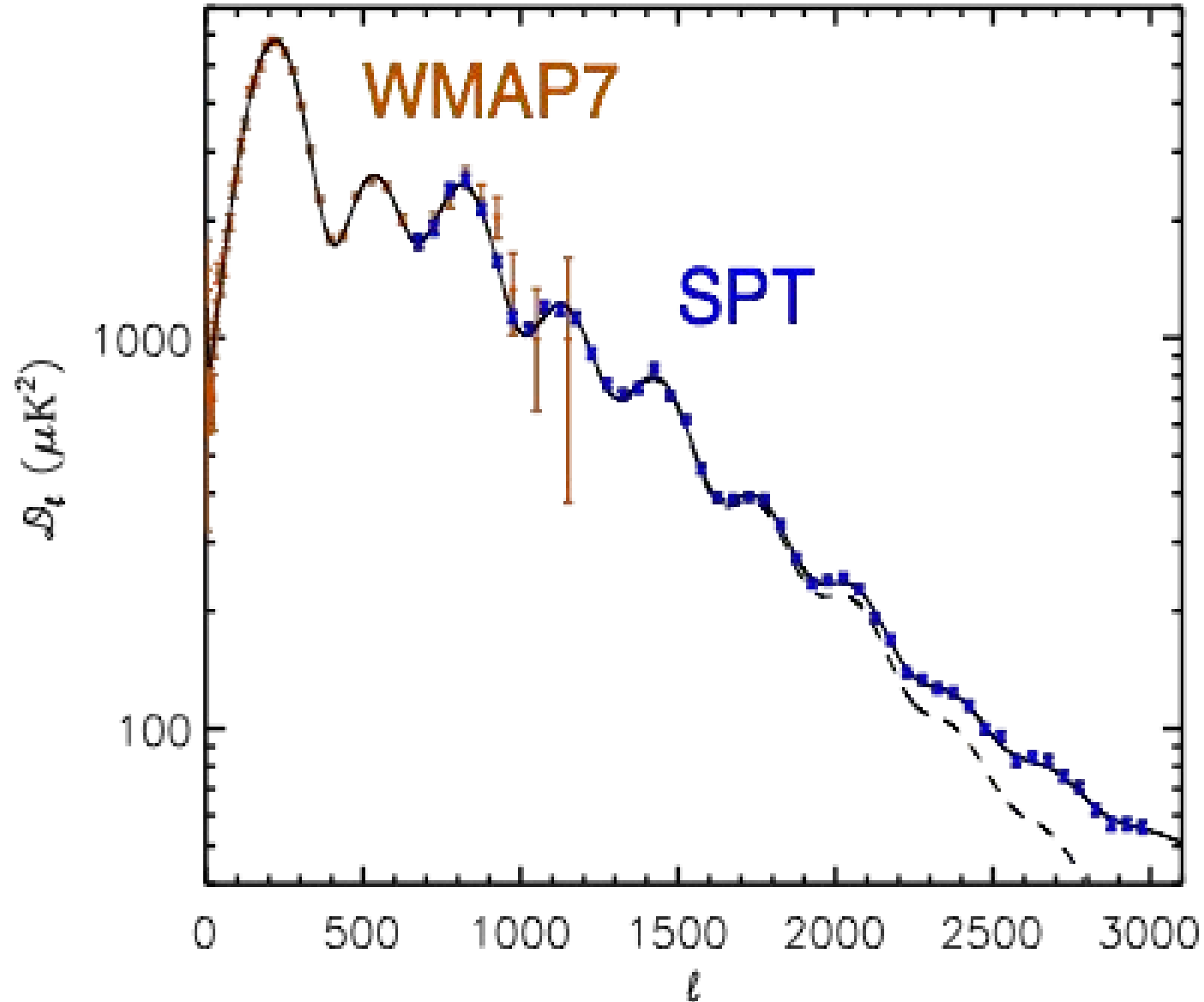
Mass fluctuation map smoothed to 1 deg resolution from CMB lensing analysis of SPT 2500 deg² survey



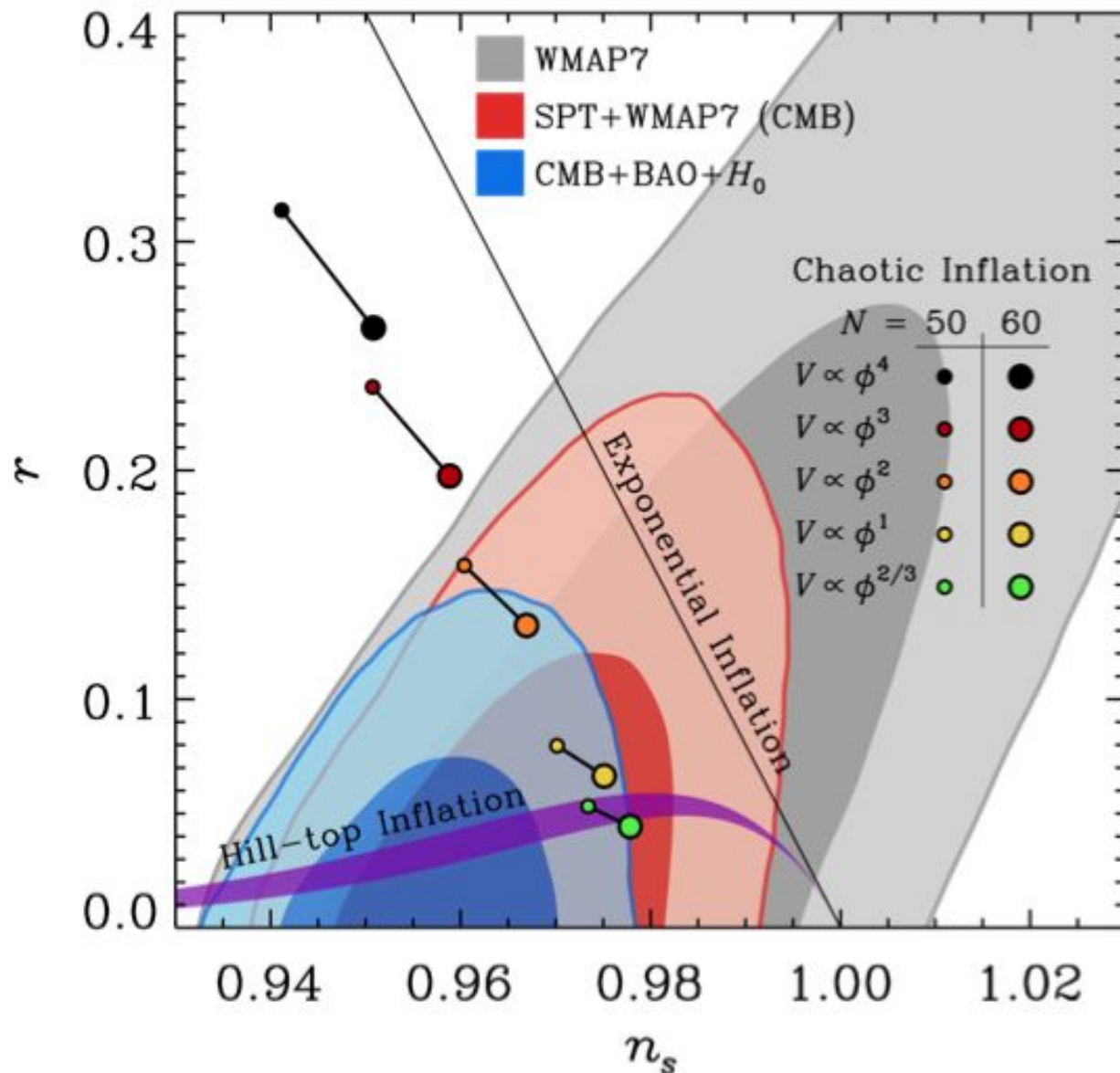
The completed SPT-SZ temperature survey has information about inflation.



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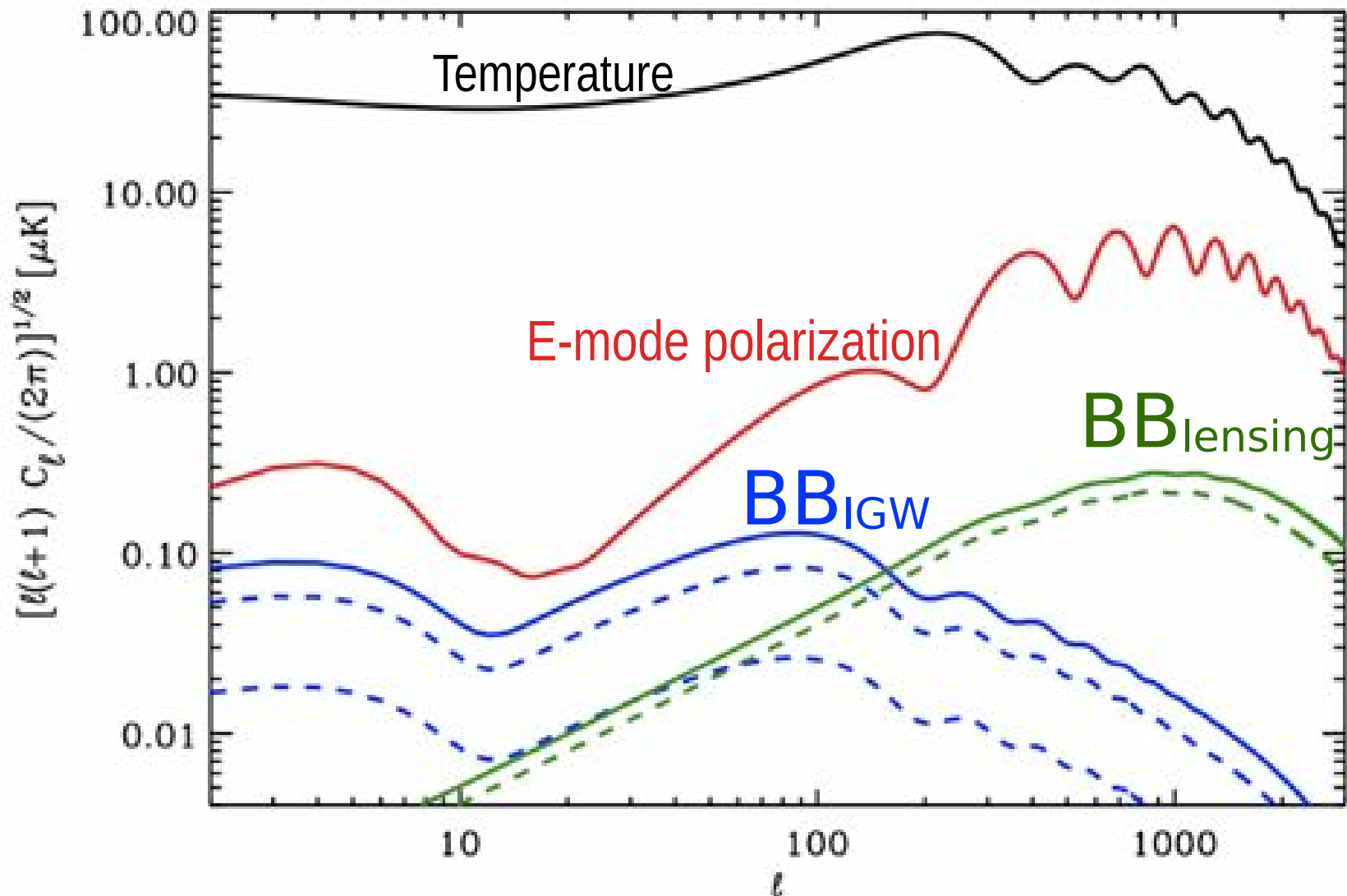
Combining with other datasets, SPT data constrain n_s and r .



- $n_s < 1$ at nearly 6-sigma:
- $n_s = 0.9538 \pm 0.0081$

Tensor-to-scalar ratio,
 $r < 0.11$ at 95% confidence.

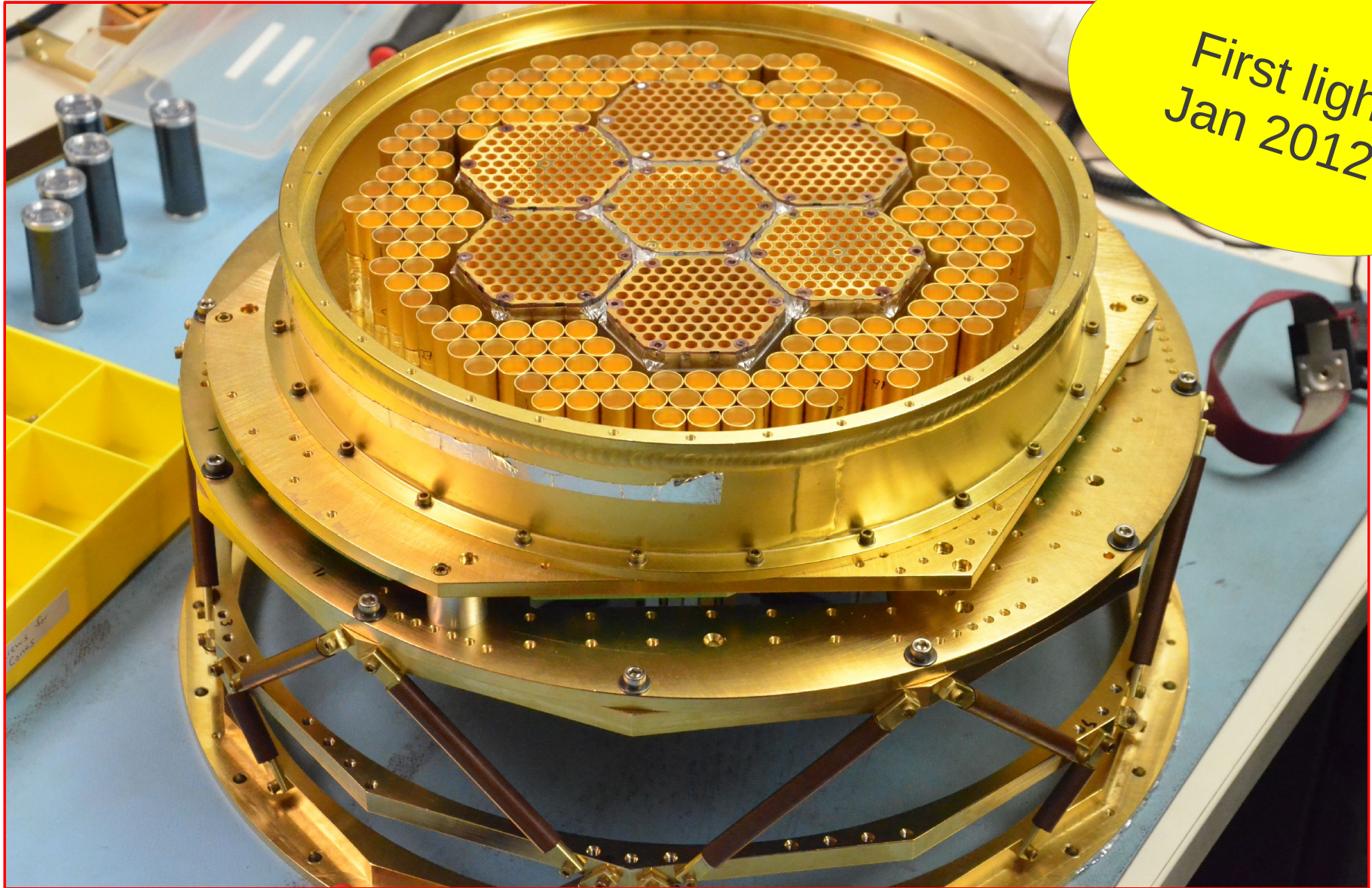
Now the SPT measures polarization.



The Rise of SPTpol



SPTpol exists



First light
Jan 2012!

The SPT's receiver uses bolometers to measure emission from the CMB.

Optical power (CMB light)



Absorber



Thermometer

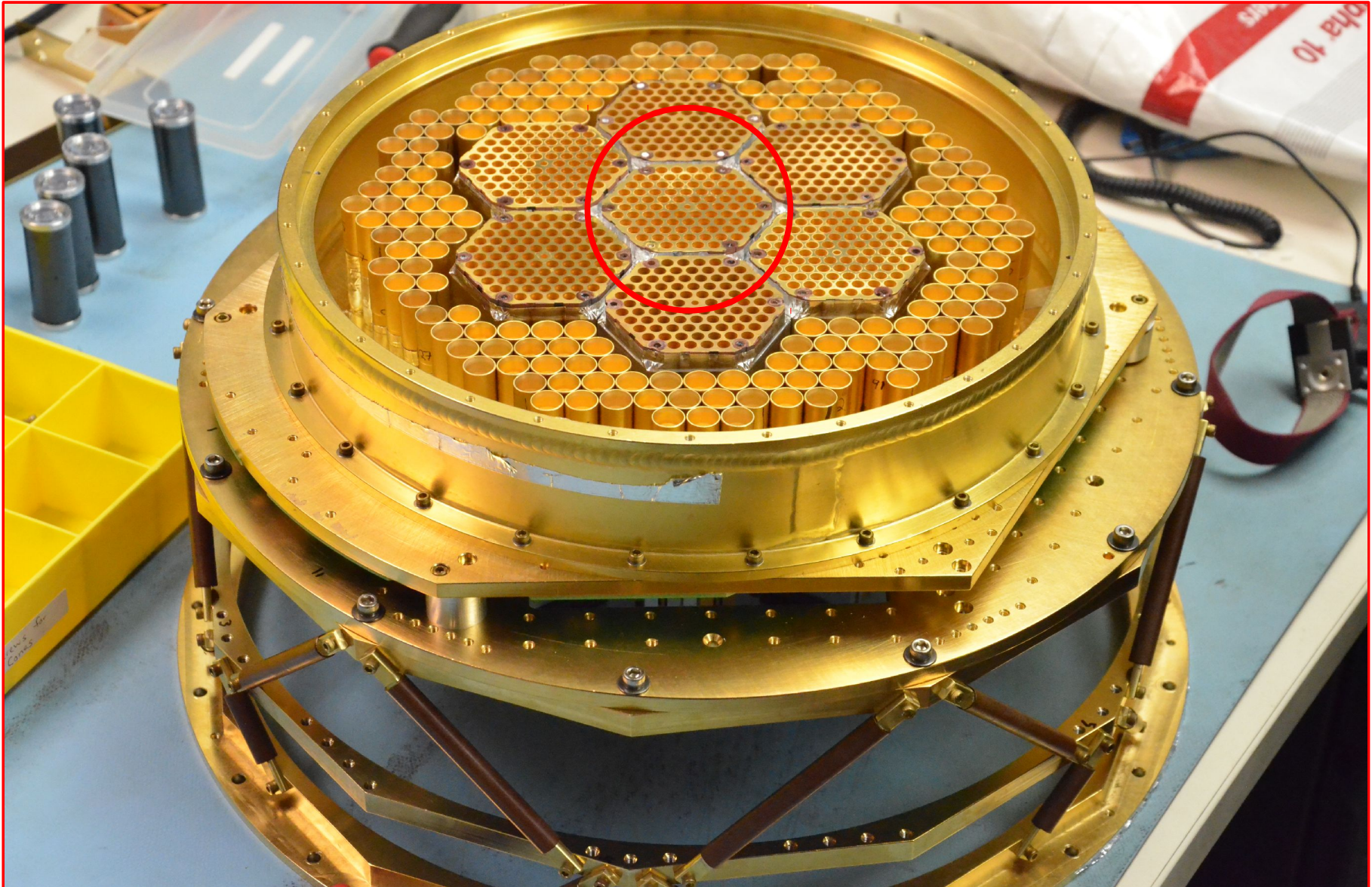


Weak thermal link

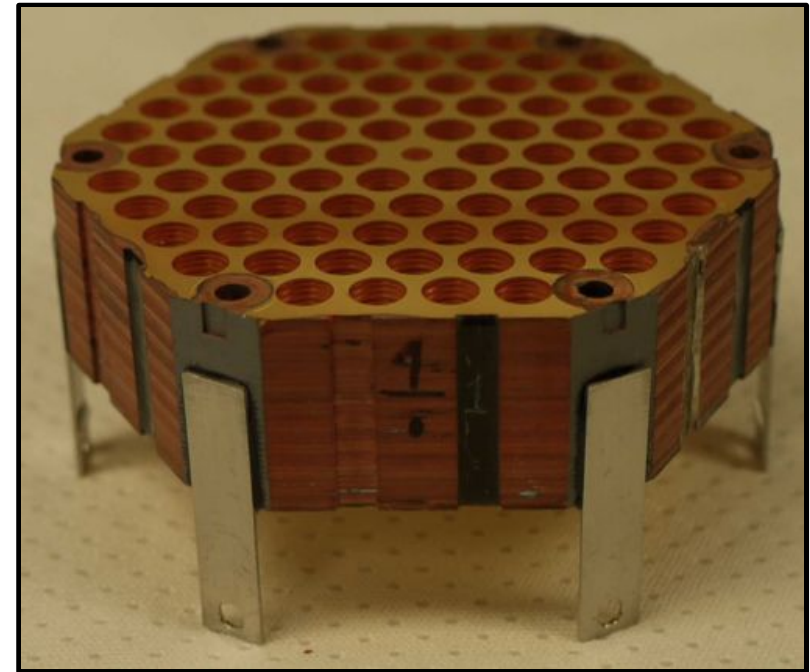
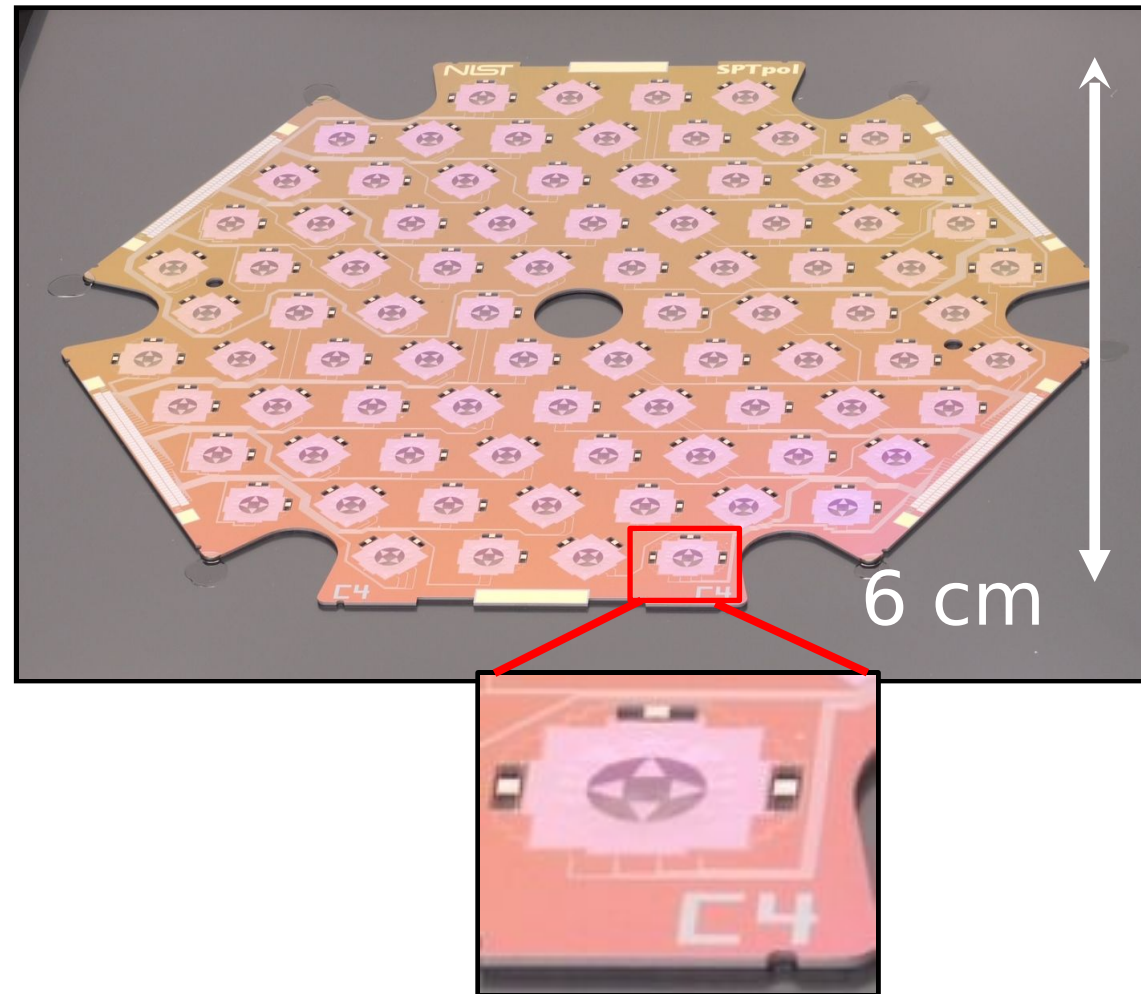
Thermal Bath



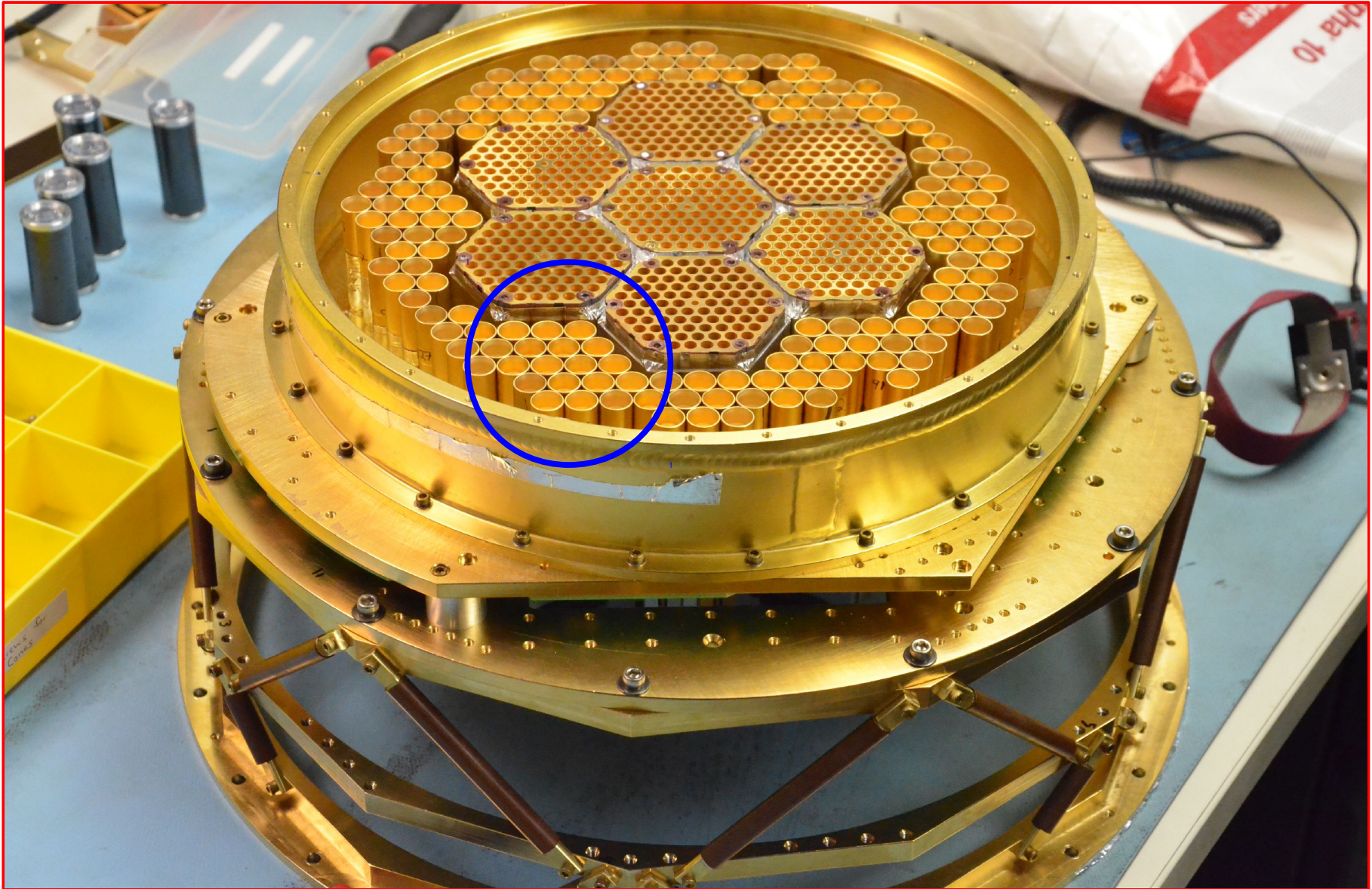
588 dual-polarization 150 GHz pixels



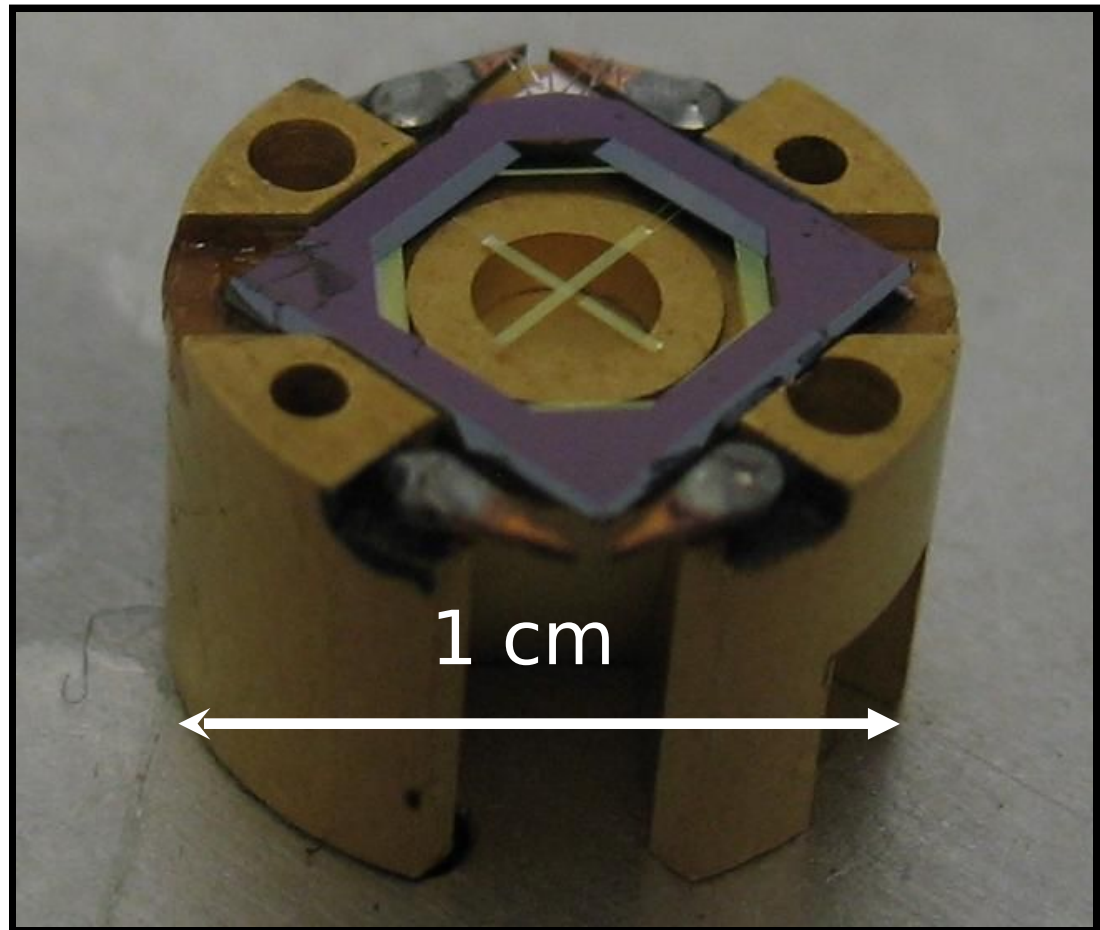
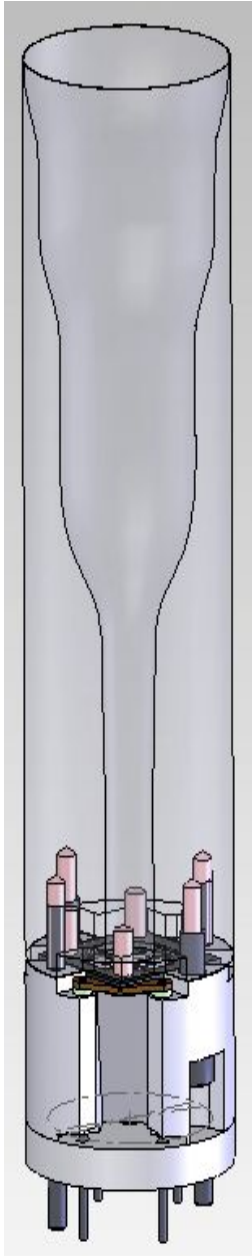
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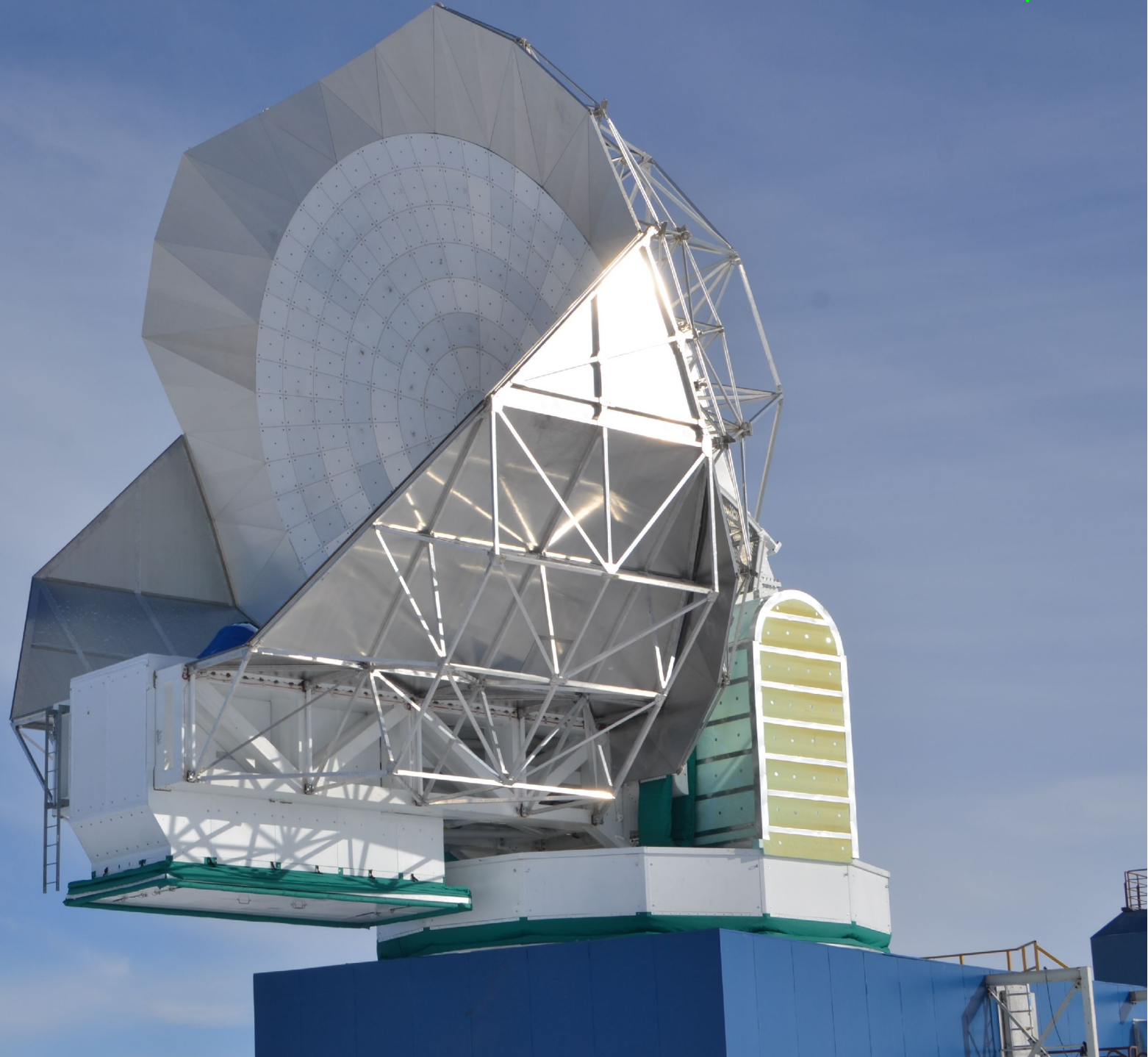
180 dual-polarization 90 GHz pixels



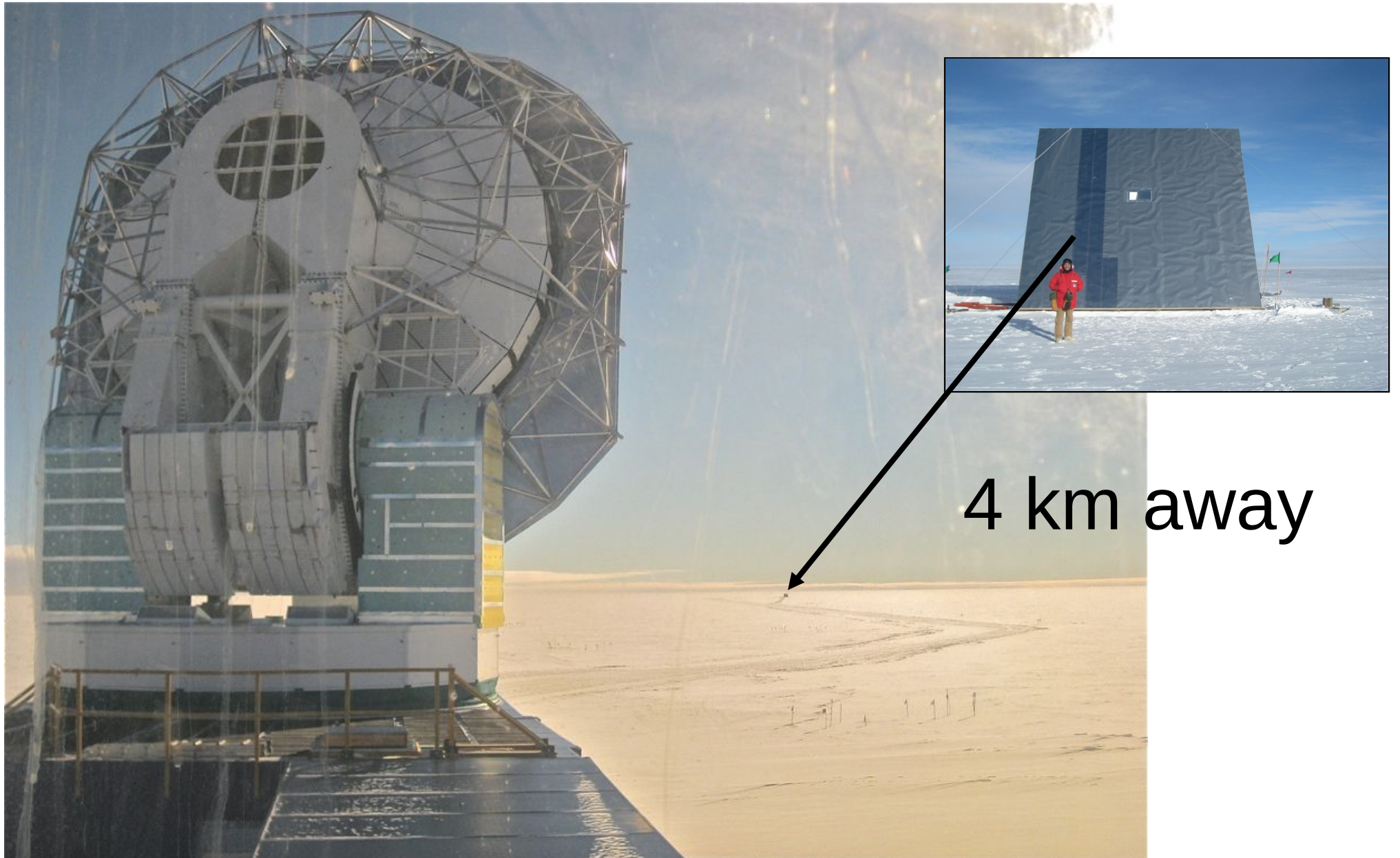
180 dual-polarization 90 GHz pixels



The Many Calibrations and Cross-Checks of SPTpol

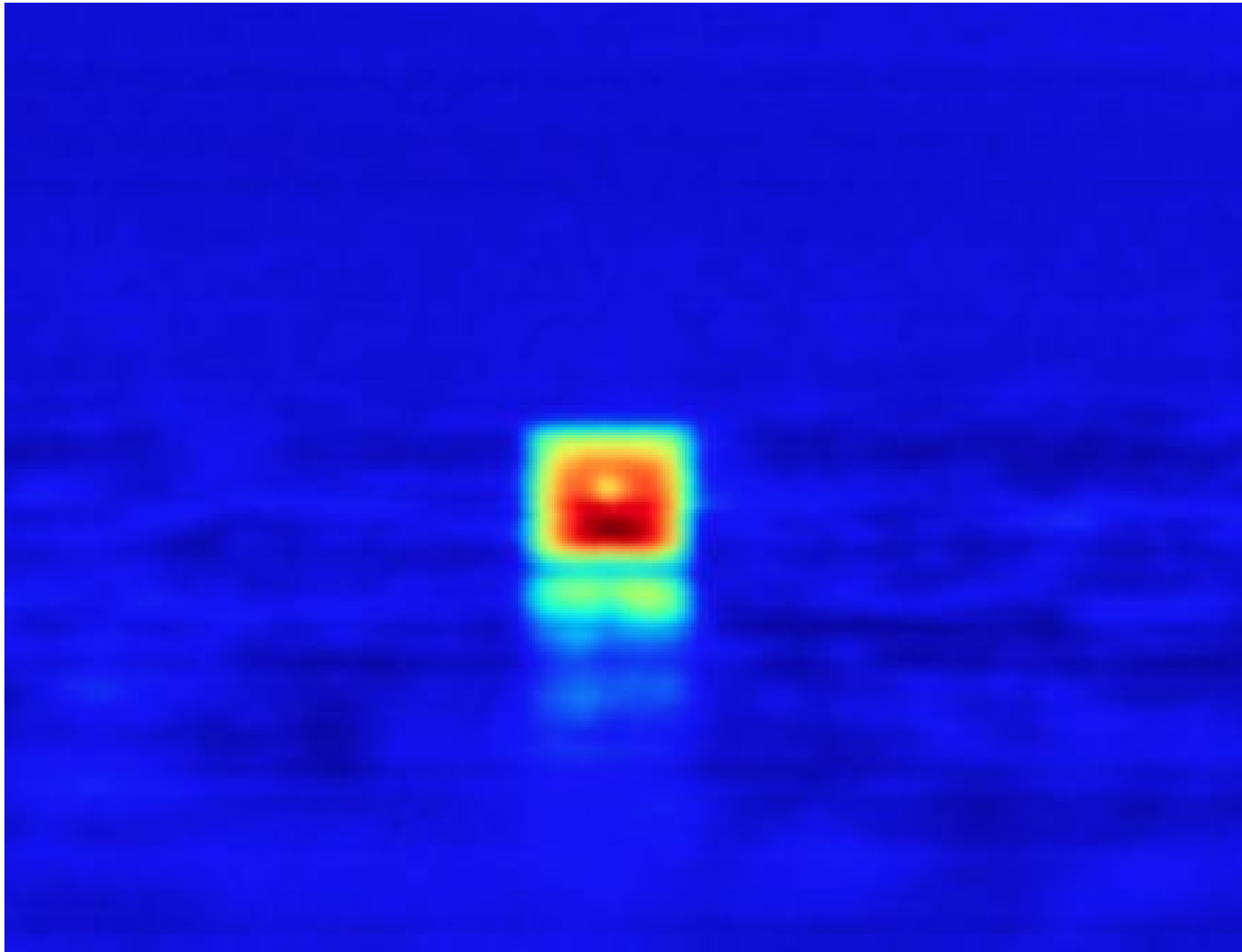


SPTpol uses a polarized source on the ground to calibrate polarization angles.



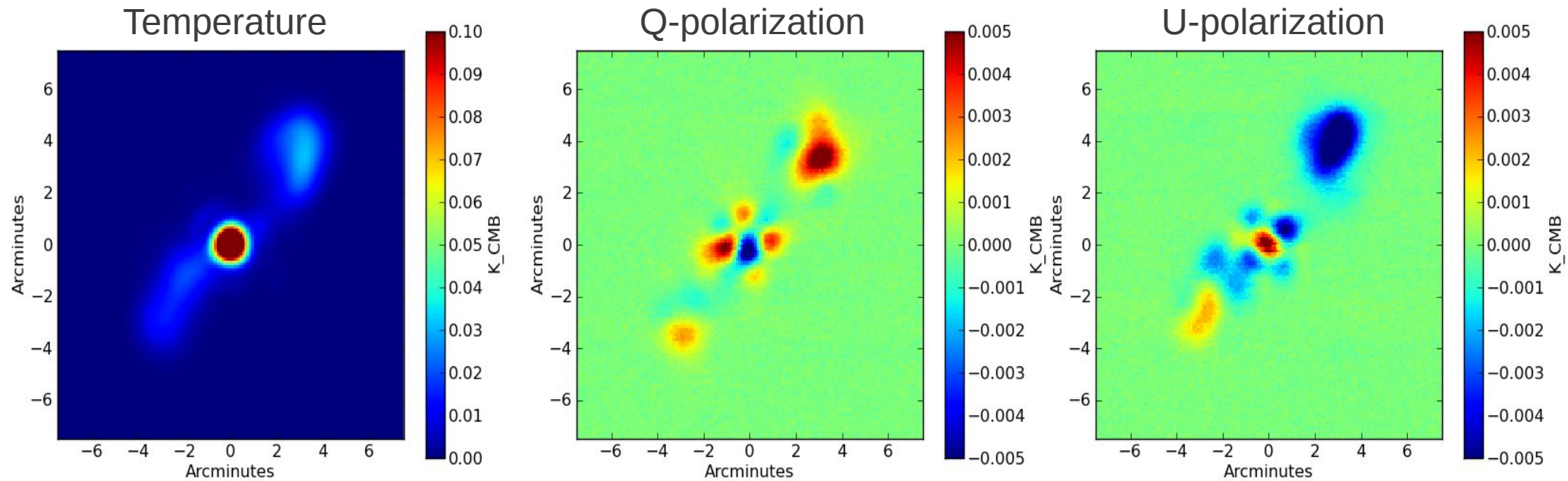
4 km away

Each detector takes a turn watching the polarized source.

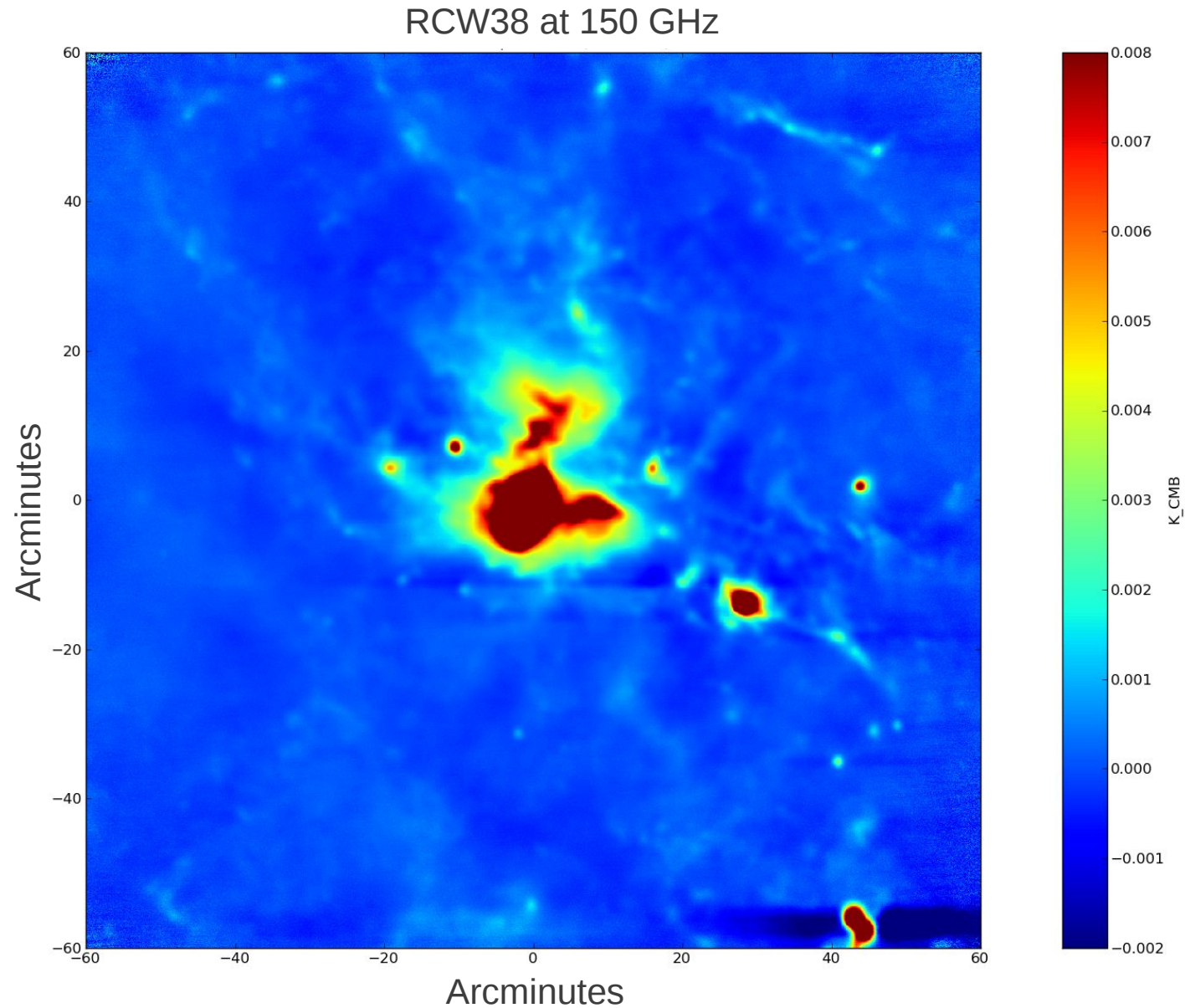


(Red=cold, blue=hot)

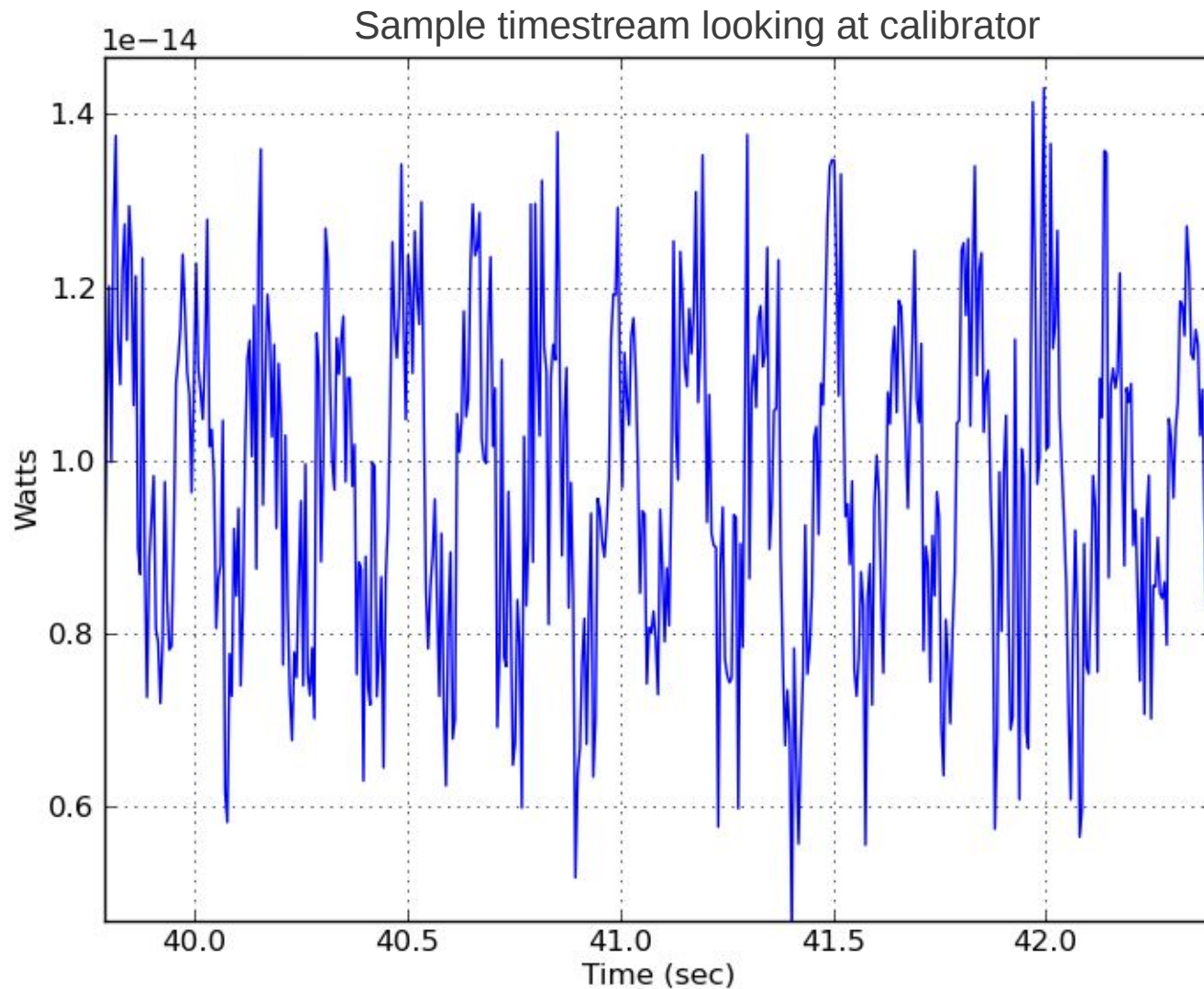
We can check our calibration with measurements of Centaurus A.



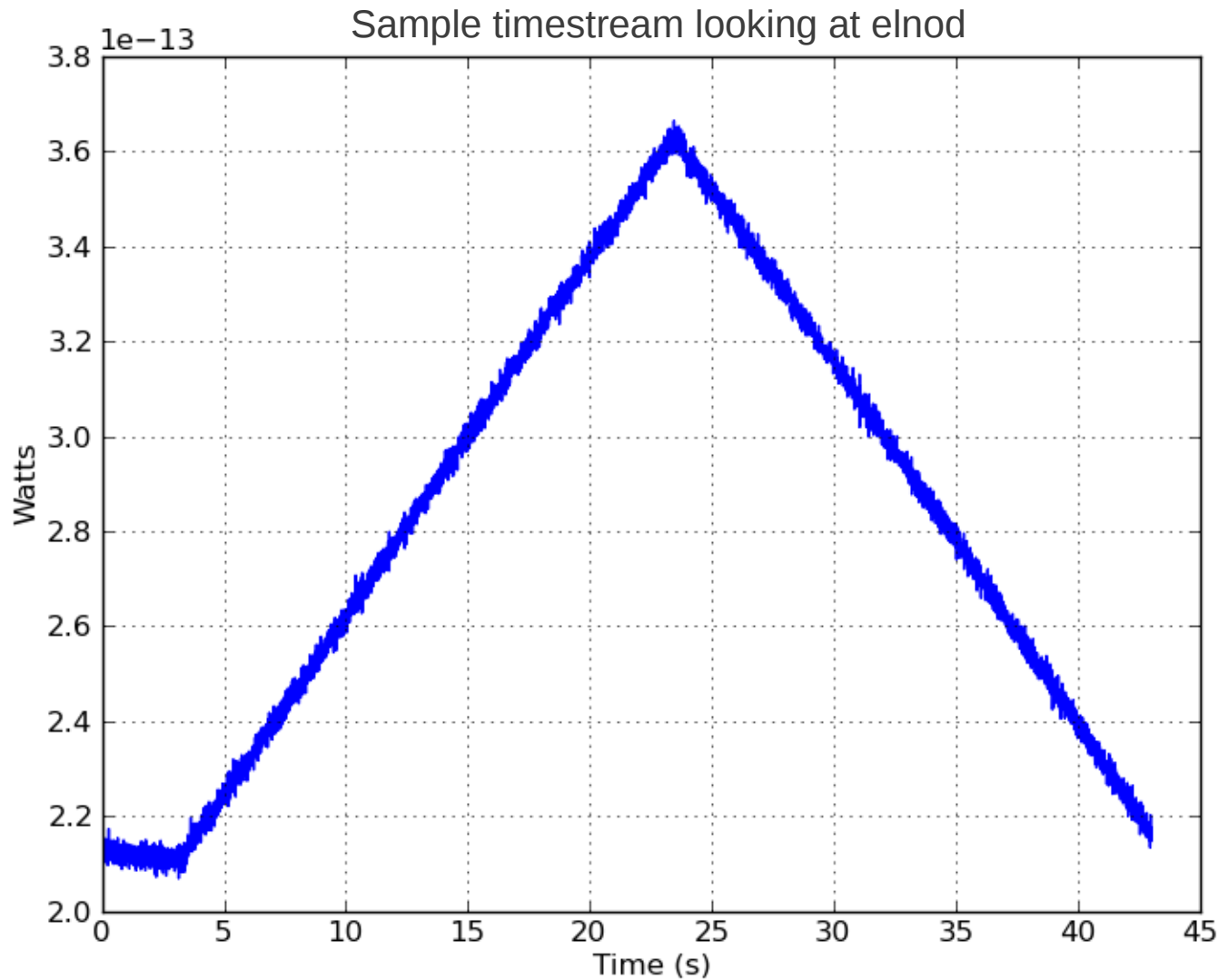
We use observations of RCW38 to measure atmospheric opacity.



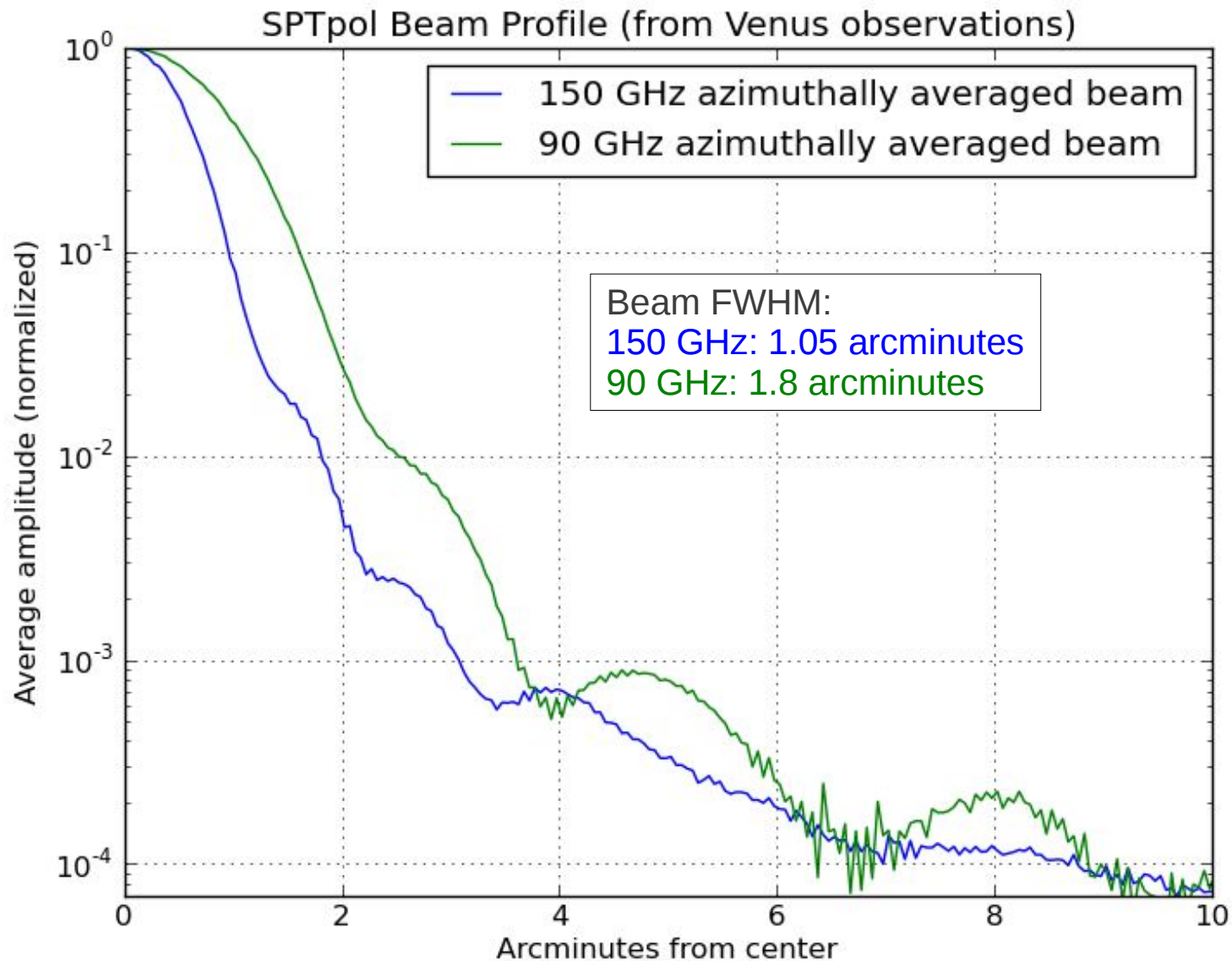
Together, RCW38 and an onboard thermal source give $ADC \rightarrow K_{CMB}$



Short scans in elevation measure response to atmospheric power.



Observations of Mars and Venus give us SPT's detailed beam shape.



What SPTpol sees



The first year's observations have yielded good data.

- Observed ~ 100 deg² field in low-foreground region of southern sky
 - $-50 < \text{declination} < -60$
 - $23\text{h} < \text{RA} < 24\text{h}$
- Full-season map noise
 - ~ 7 $\mu\text{K-arcmin}$ in temperature @ 150 GHz
 - ~ 10 $\mu\text{K-arcmin}$ in polarization @ 150 GHz
 - ~ 25 $\mu\text{K-arcmin}$ in temperature @ 90 GHz
 - ~ 28 $\mu\text{K-arcmin}$ in polarization @ 90 GHz

2012 deep field T maps redacted
[preliminary, not for posting]

2012 deep field polarization maps redacted
[preliminary, not for posting]

Creating a Power Spectrum



Create maps from each individual observation.

2012 deep field polarization map redacted
[preliminary, not for posting]

Project out a copy of the T map from
the Q and U polarization maps.

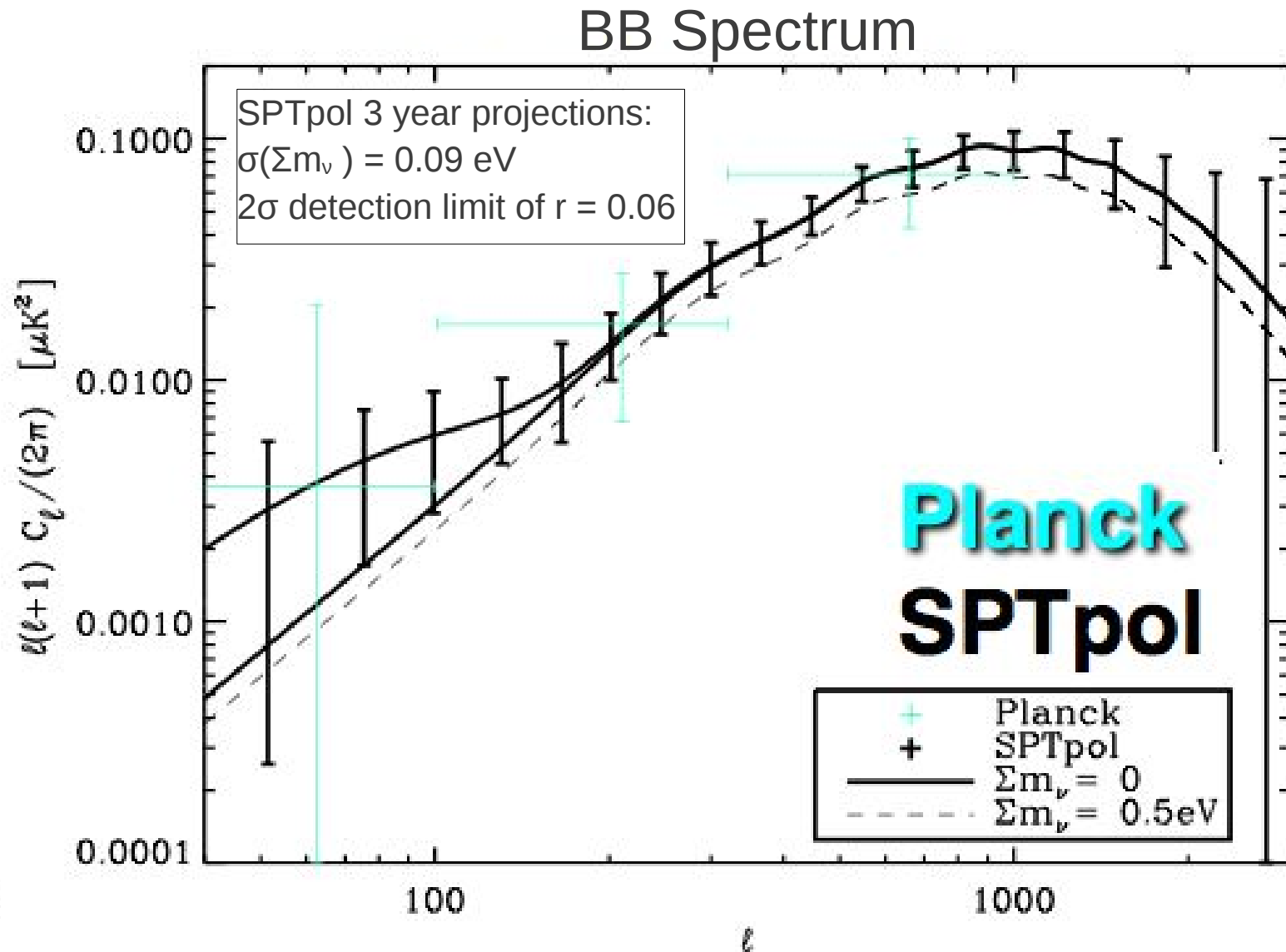
$$[Q \text{ or } U \text{ map}] - (TQ/TT)^* [T \text{ map}]$$

Use a pseudo- C_ℓ cross-spectrum analysis to find the power spectrum.

E map from observation (A) \times E map from observation (B)

$$\langle \tilde{C}_\ell^{ii} \rangle = \sum_{\ell'} M_{\ell\ell'}[W] F_{\ell'} B_{\ell'}^2 \langle C_{\ell'} \rangle$$

SPTpol will make a strong detection of B-mode polarization.



SPTpol has three more years of observing in a larger field.

- March 2012 – May 2013
 - 100 square degree deep field
- May 2013 – end of 2015
 - $-50 < \text{dec} < -65$
 - $22\text{h} < \text{RA} < 2\text{h}$
 - ~500 square degrees
 - Overlap with BICEP and Keck array / SPICE
- 2016 -
 - SPT-3G

The first month of the full survey
field already has a beautiful T map!

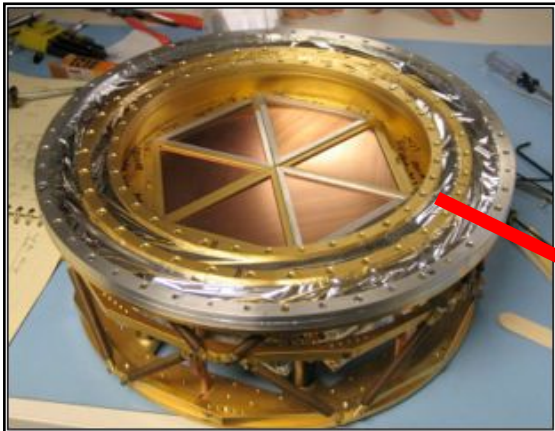
1-month survey field map redacted
[preliminary, not for posting]

The Continuing Adventures of the South Pole Telescope

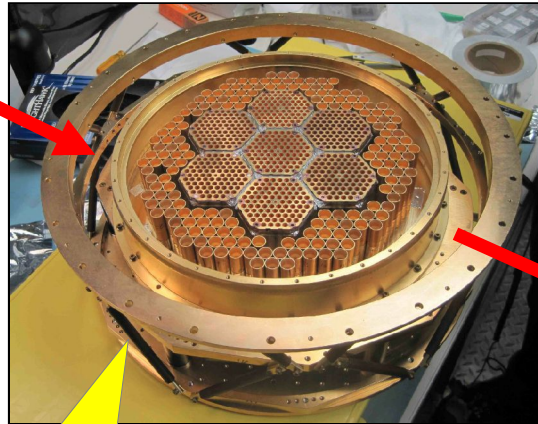


“SPT-3G” will mark a dramatic improvement in SPT's capabilities.

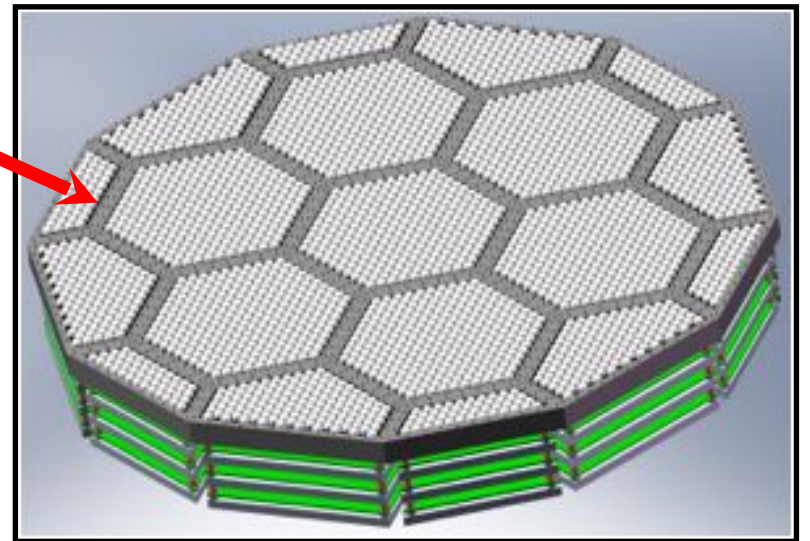
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960 detectors



2012-2015: SPTpol
~1600 detectors

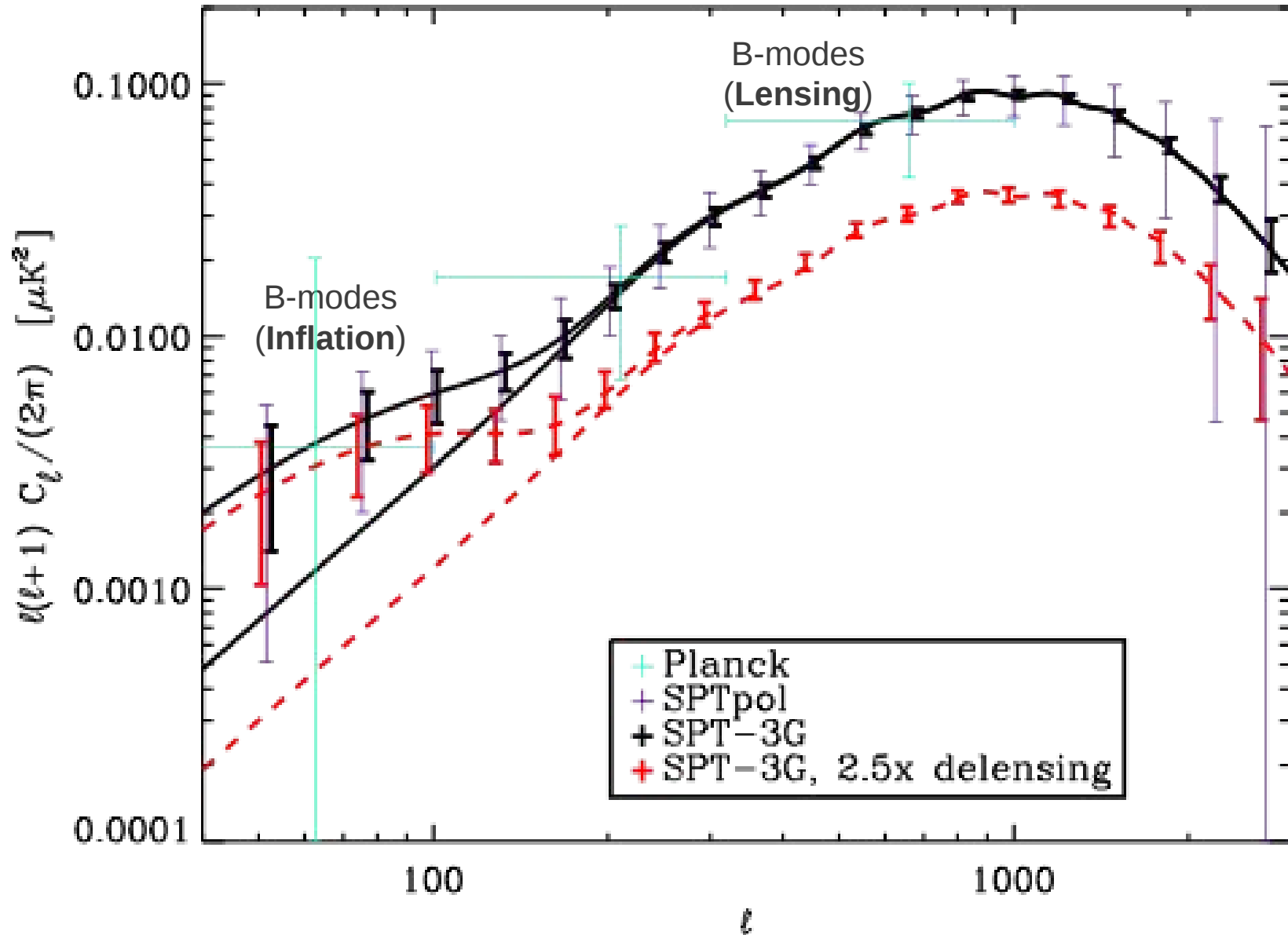


2016: SPT-3G
~15,200 detectors

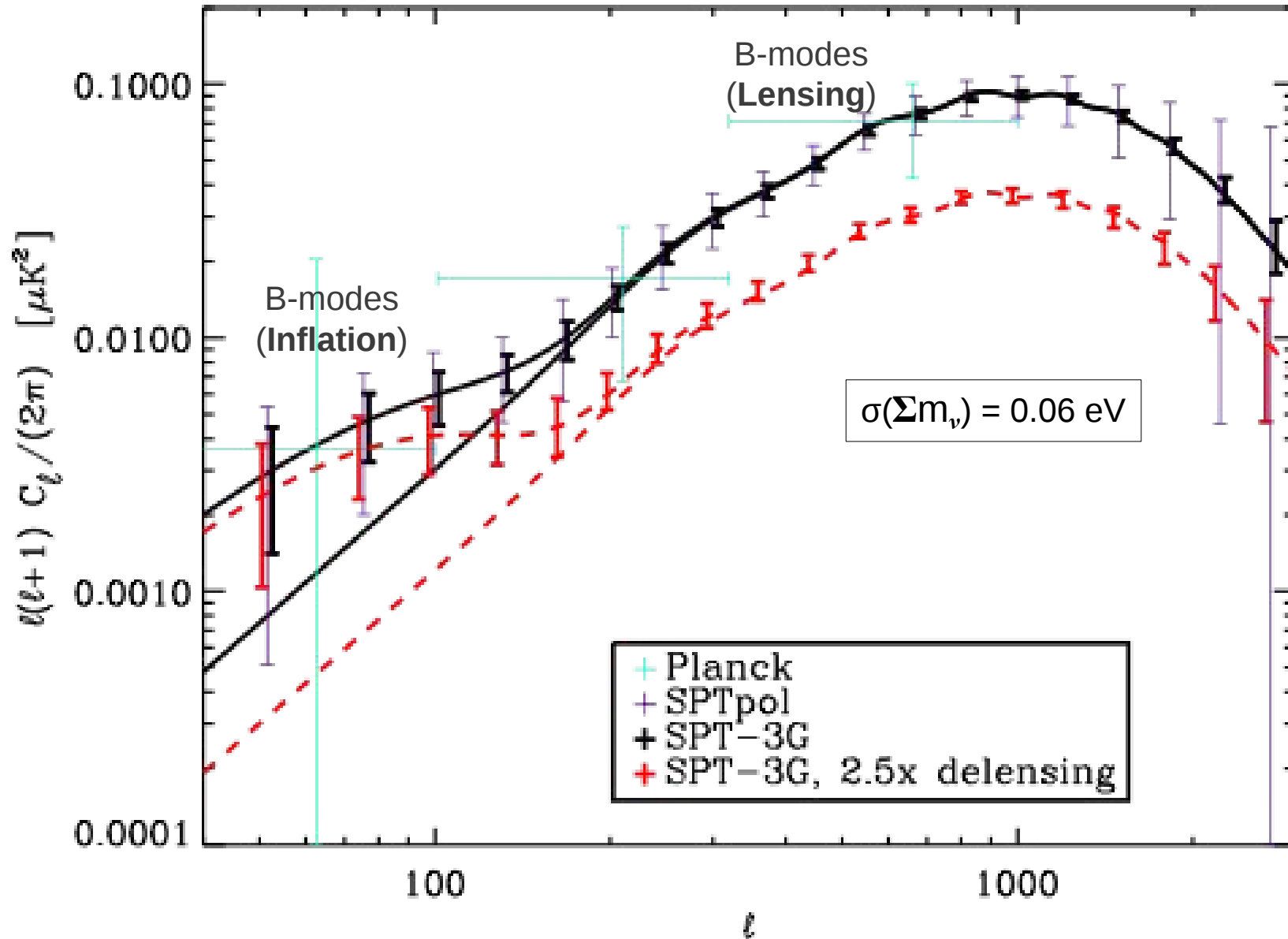


Now with polarization!

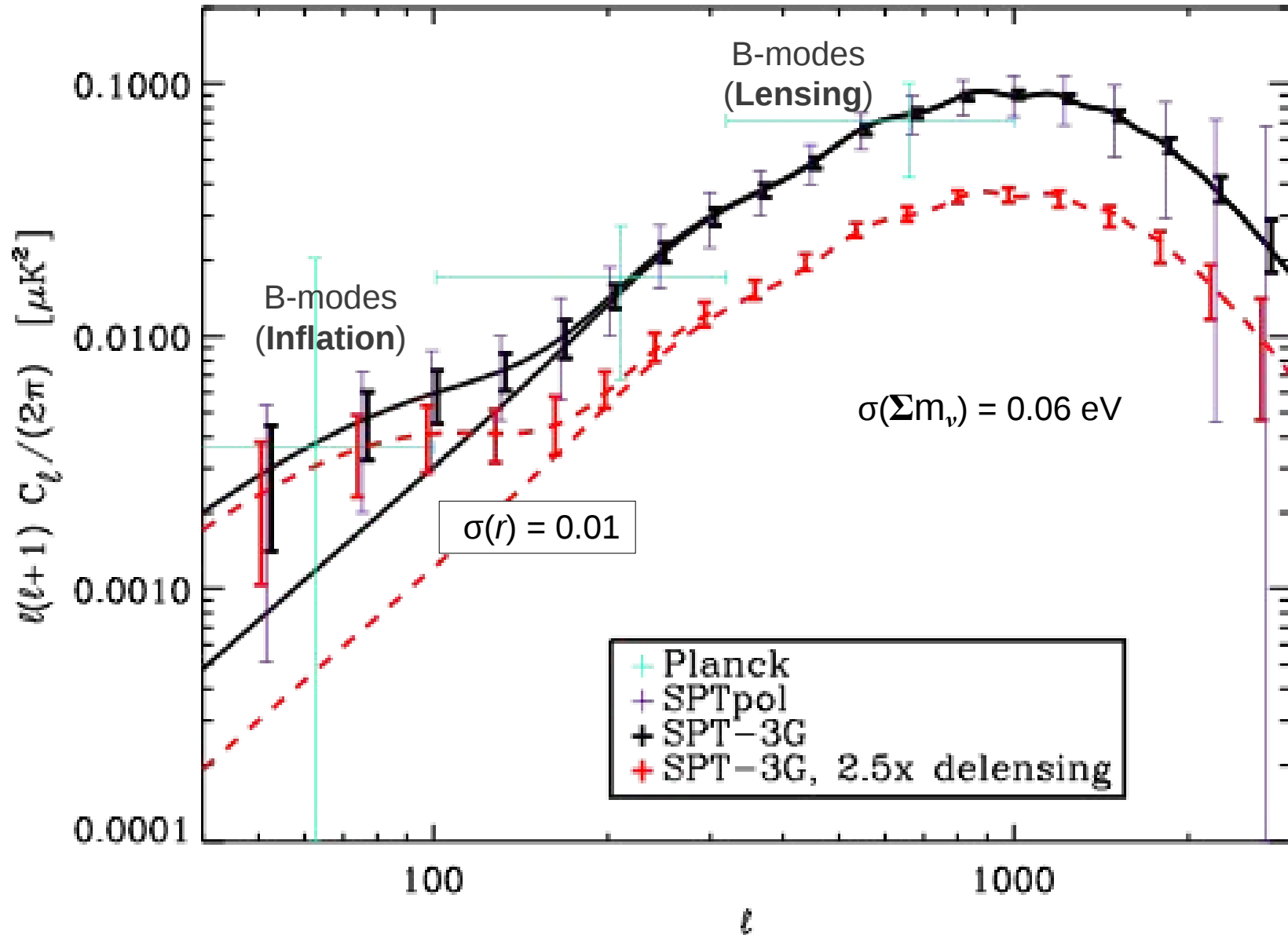
SPT-3G will go beyond the pioneering B-mode measurements of SPTpol.



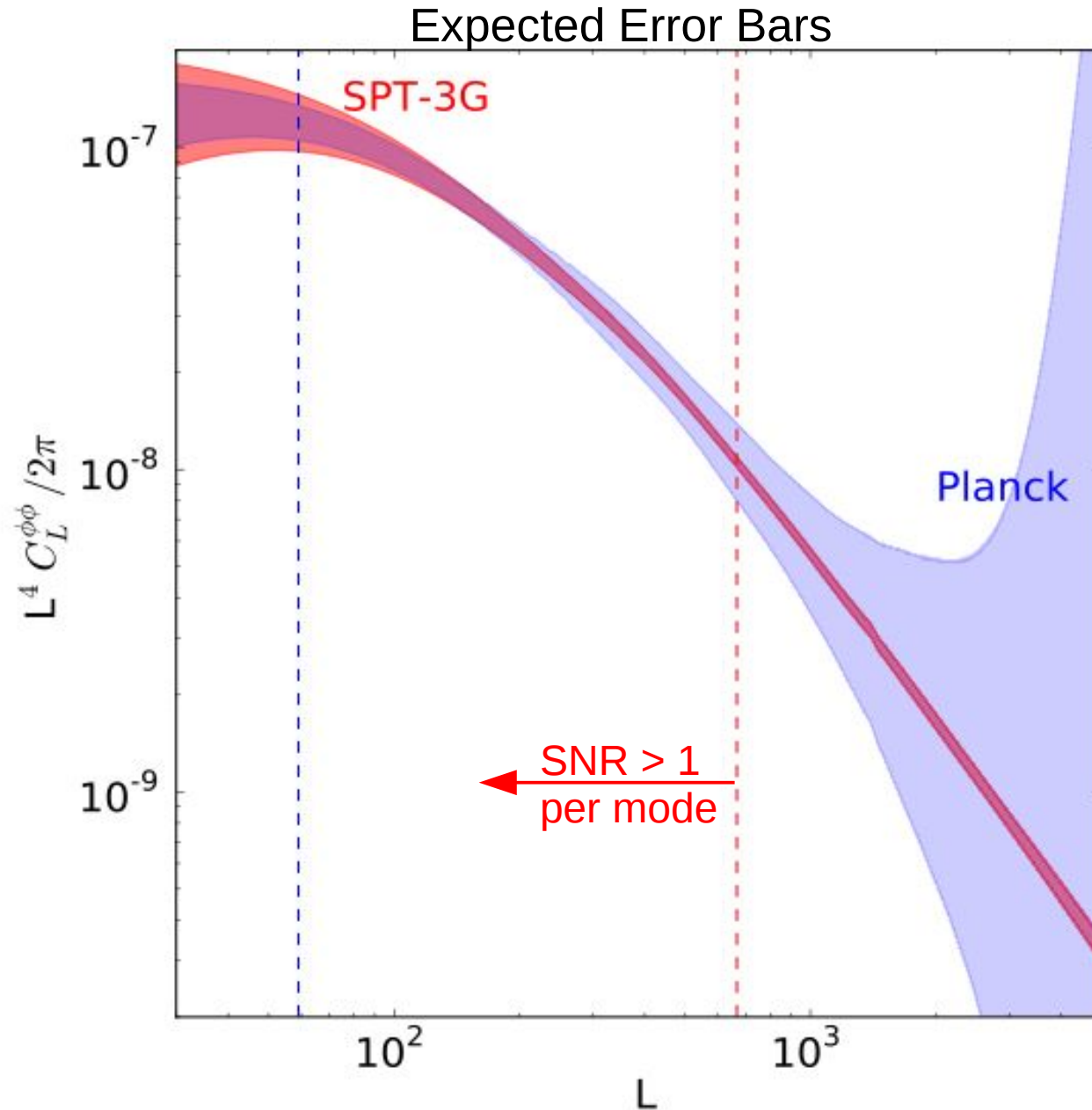
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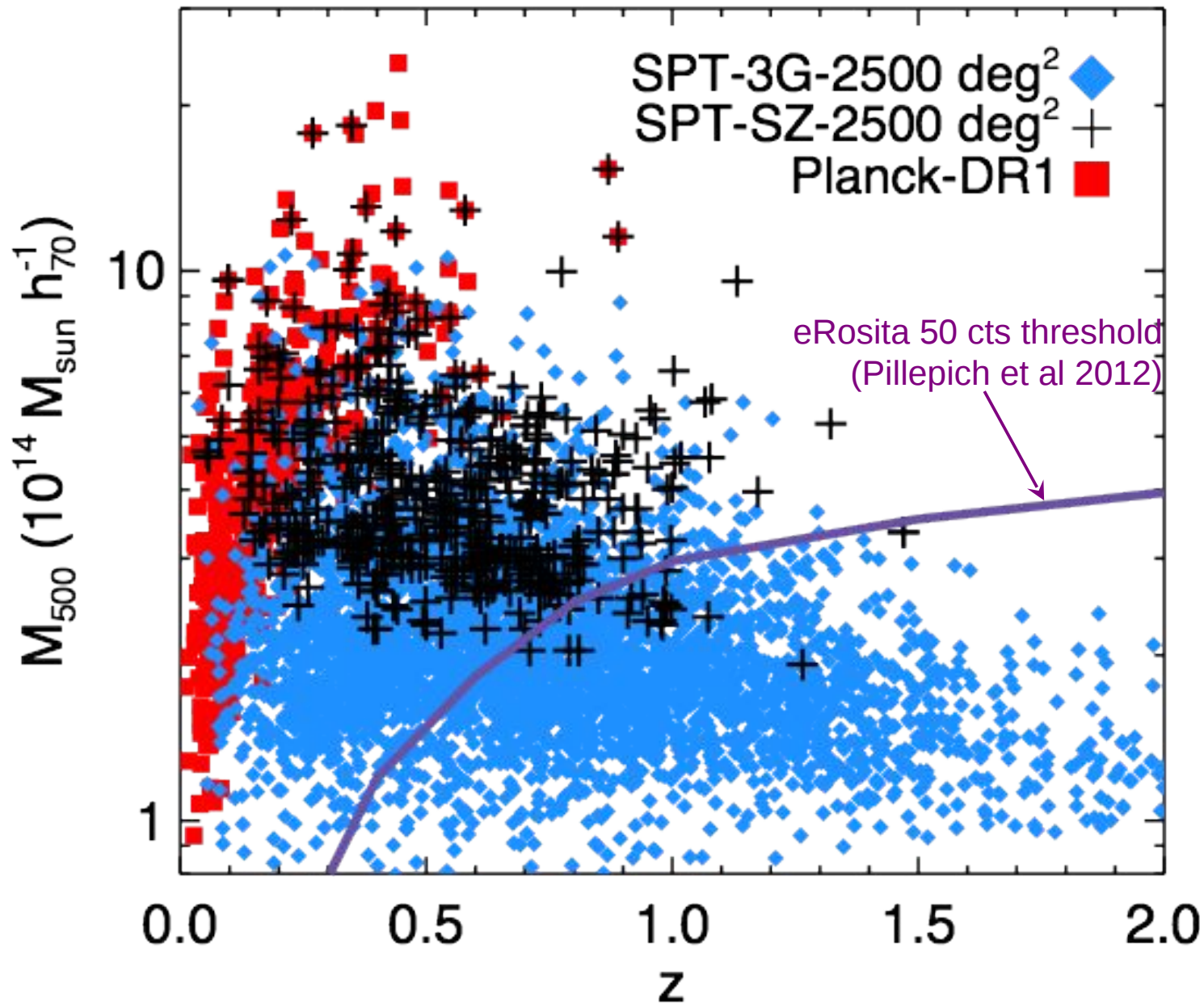
SPT-3G will go beyond the pioneering B-mode measurements of SPTpol.



SPT-3G will make a $150\text{-}\sigma$ detection of lensing by large scale structure.



SPT-3G will find $\sim 10x$ more galaxy clusters than SPT-SZ or SPTpol.



The SPTpol survey is running smoothly.

- Deep field polarized power spectra this year
- Full field in year 1 of 3-year survey
- SPT-3G on the way

