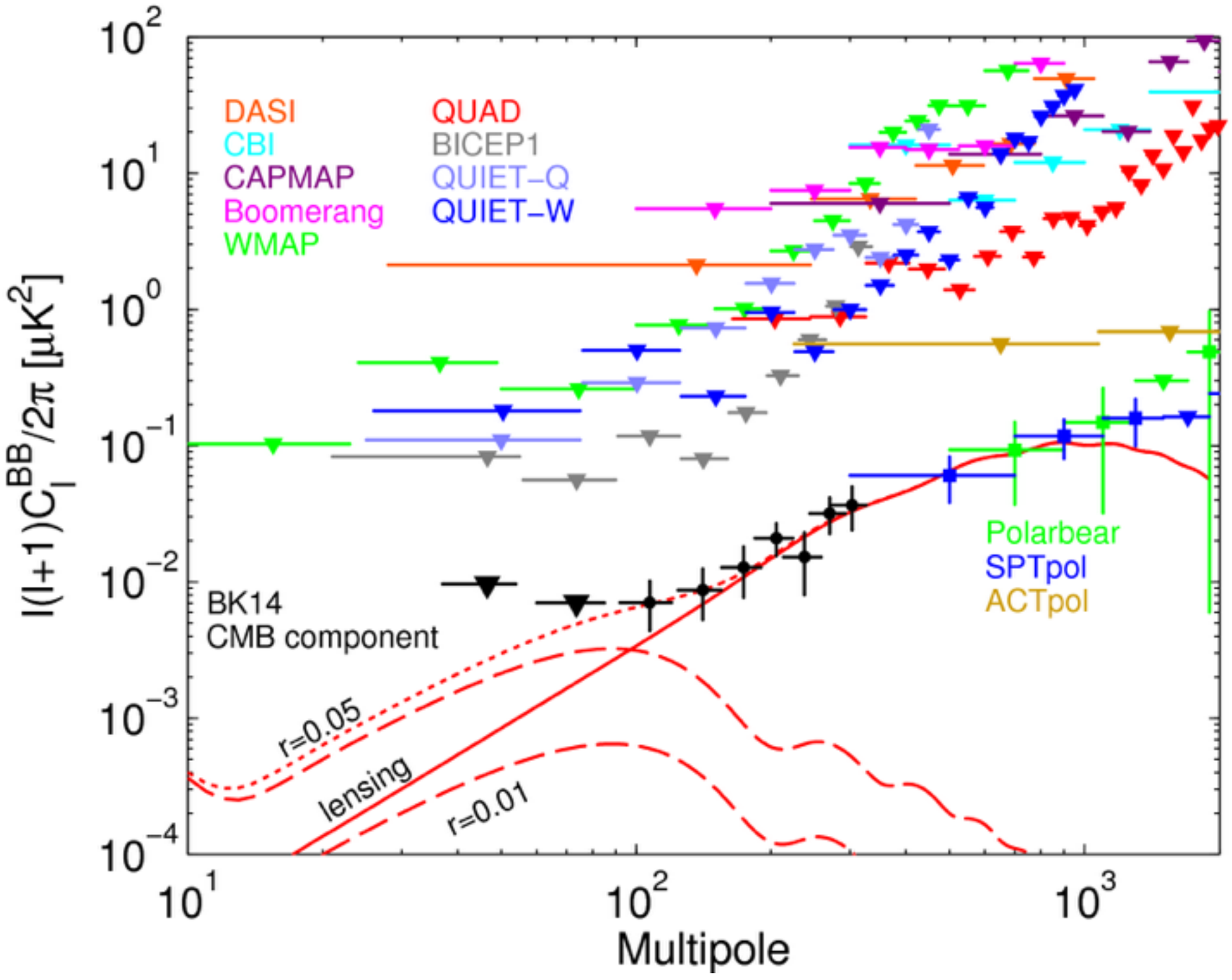
Update from the BICEP/Keck Program

Chris Sheehy
BNL cosmo group meeting
Feb 20, 2017

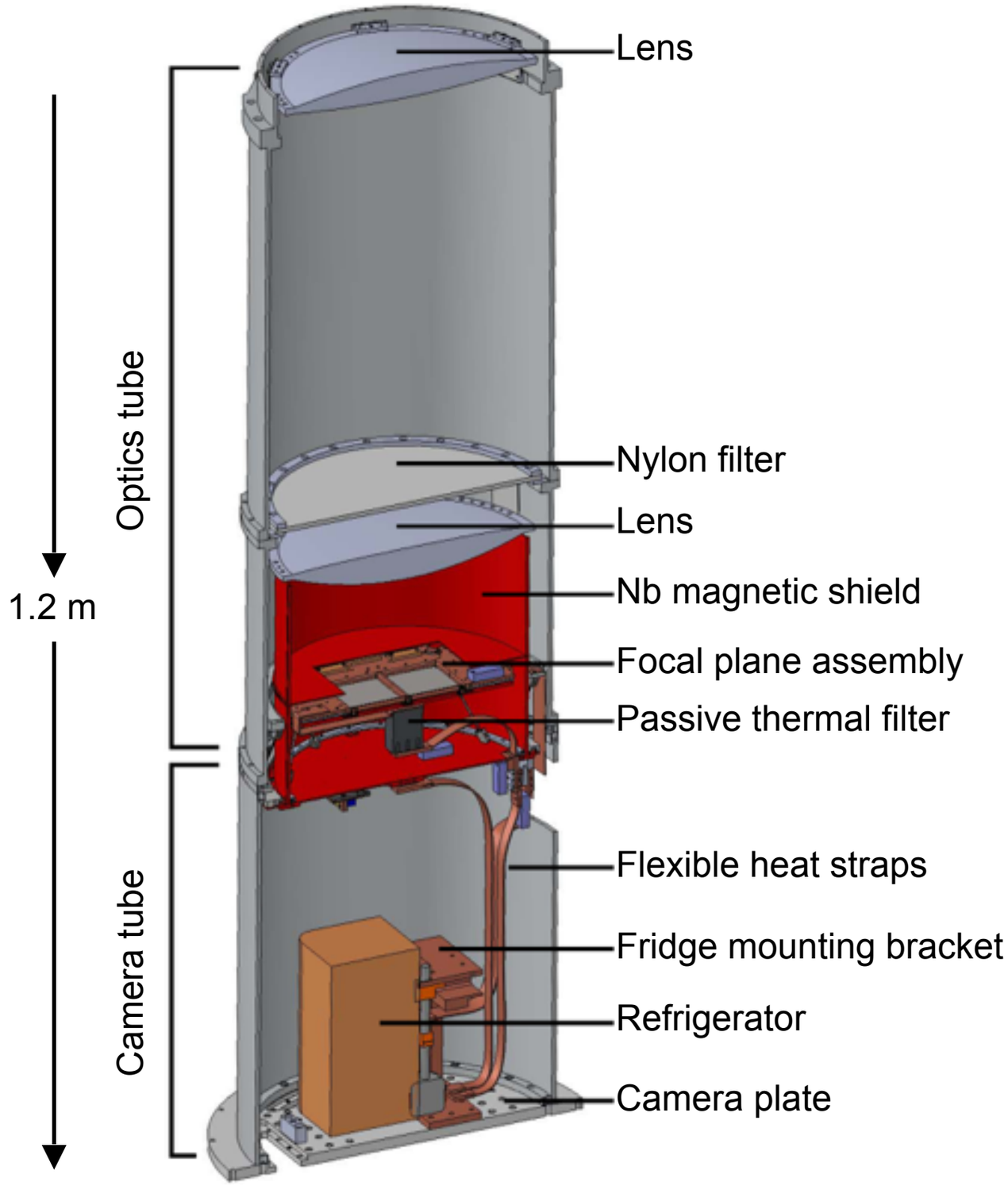
Ground based CMB at the South Pole

Current state of CMB B-modes

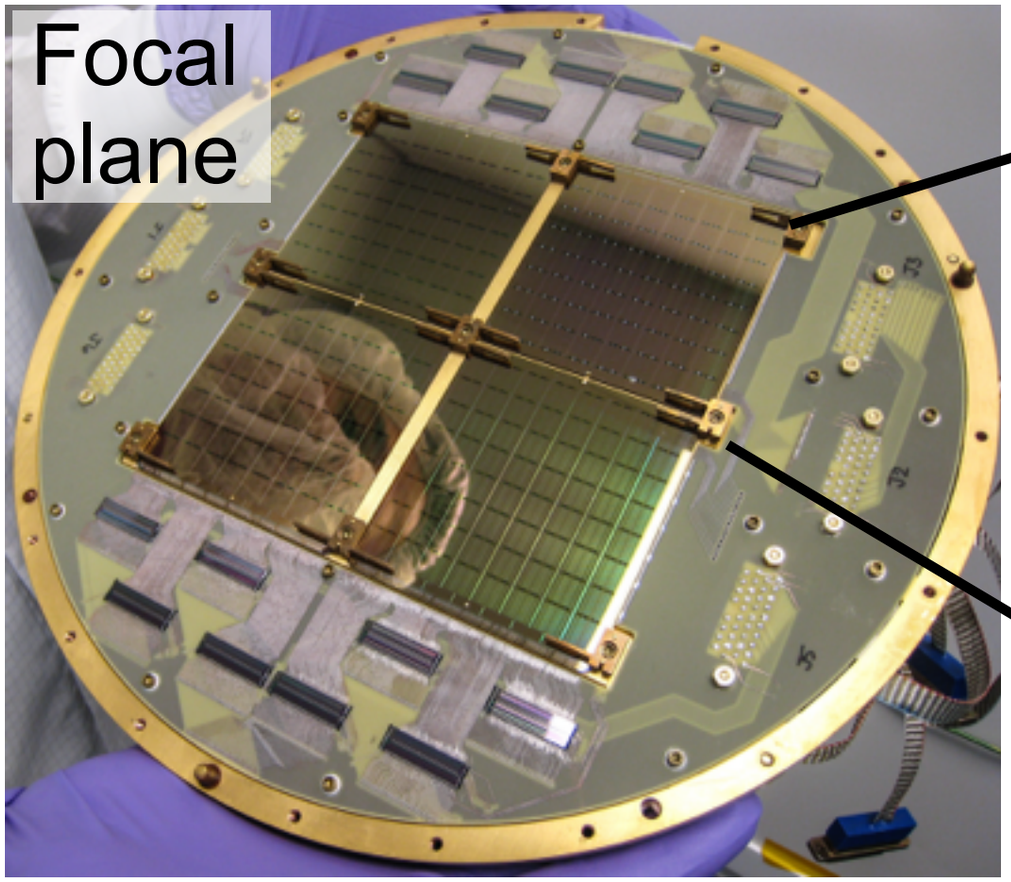


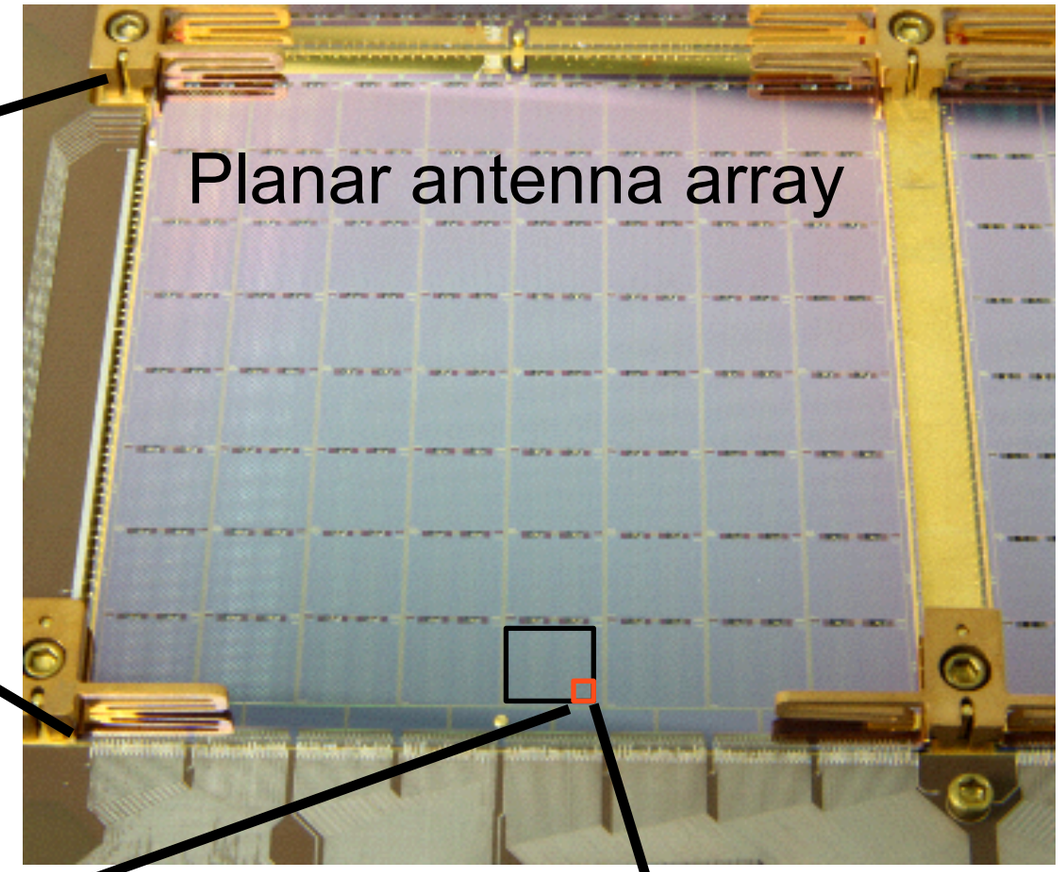
The BICEP/Keck Collaboration

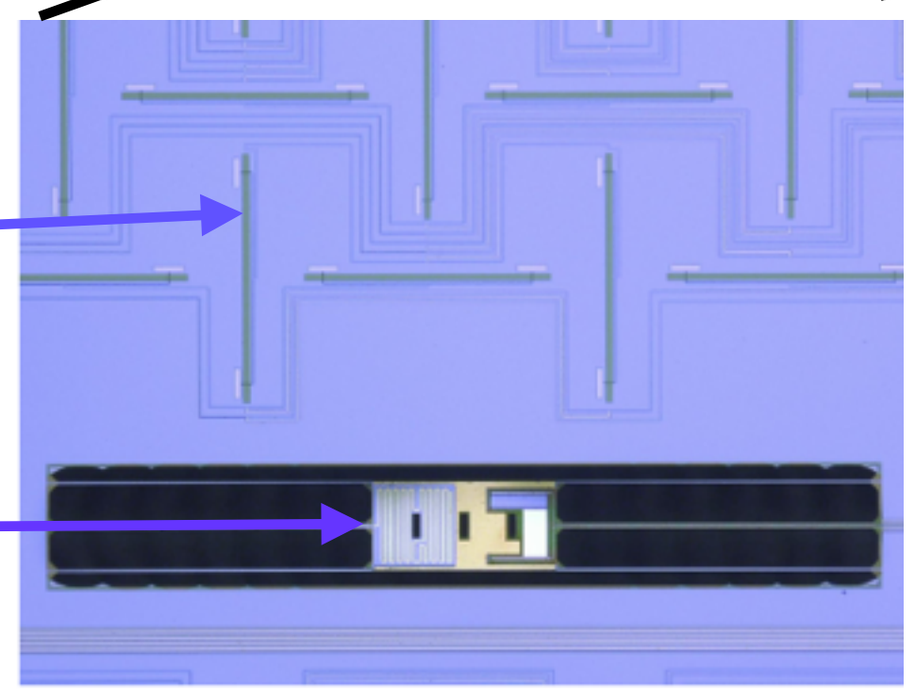
The BICEP2/Keck Telescopes



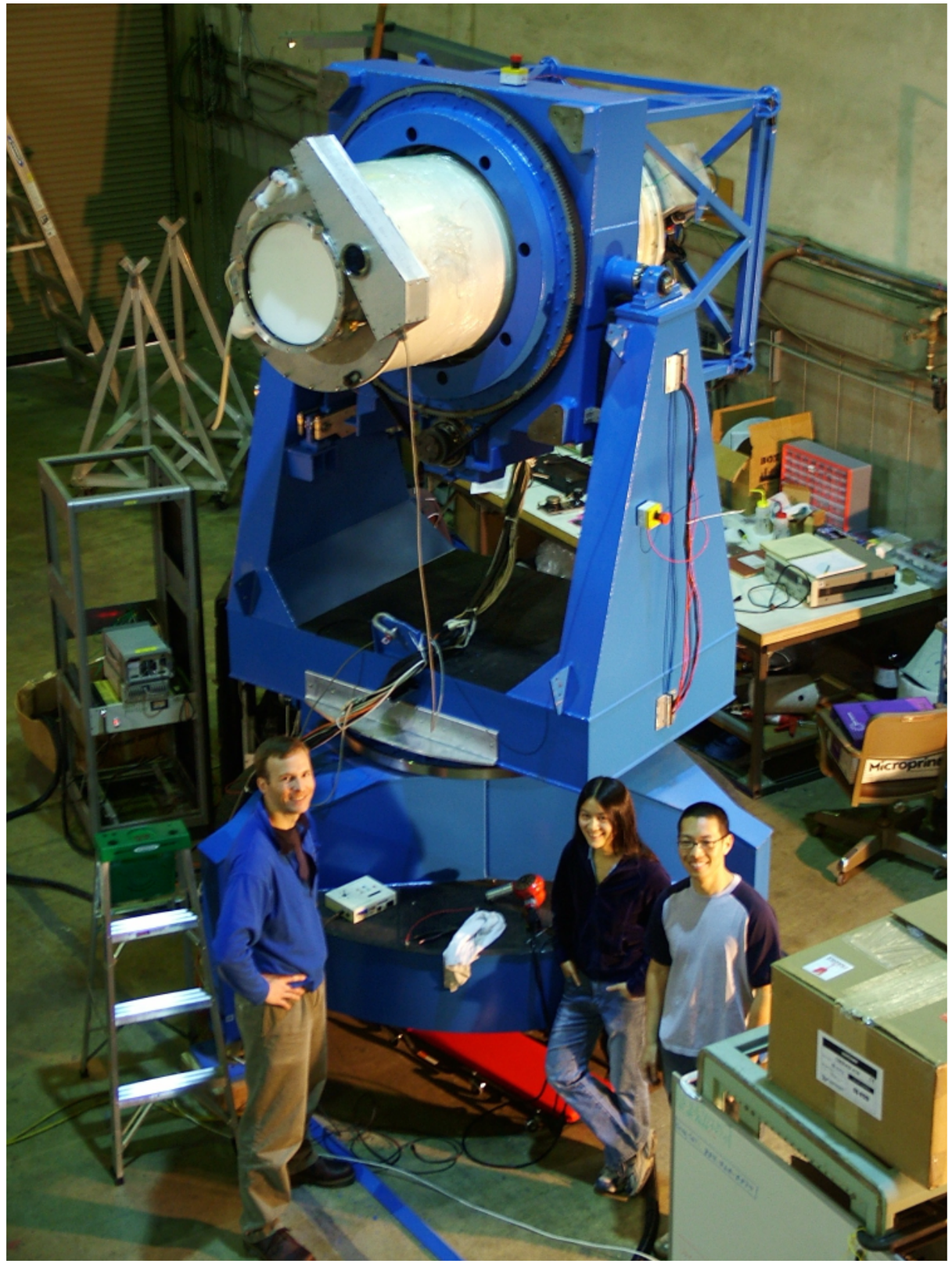
Mass-produced Superconducting Detectors







The BICEP2 Telescope



BICEP1

The Keck Telescopes

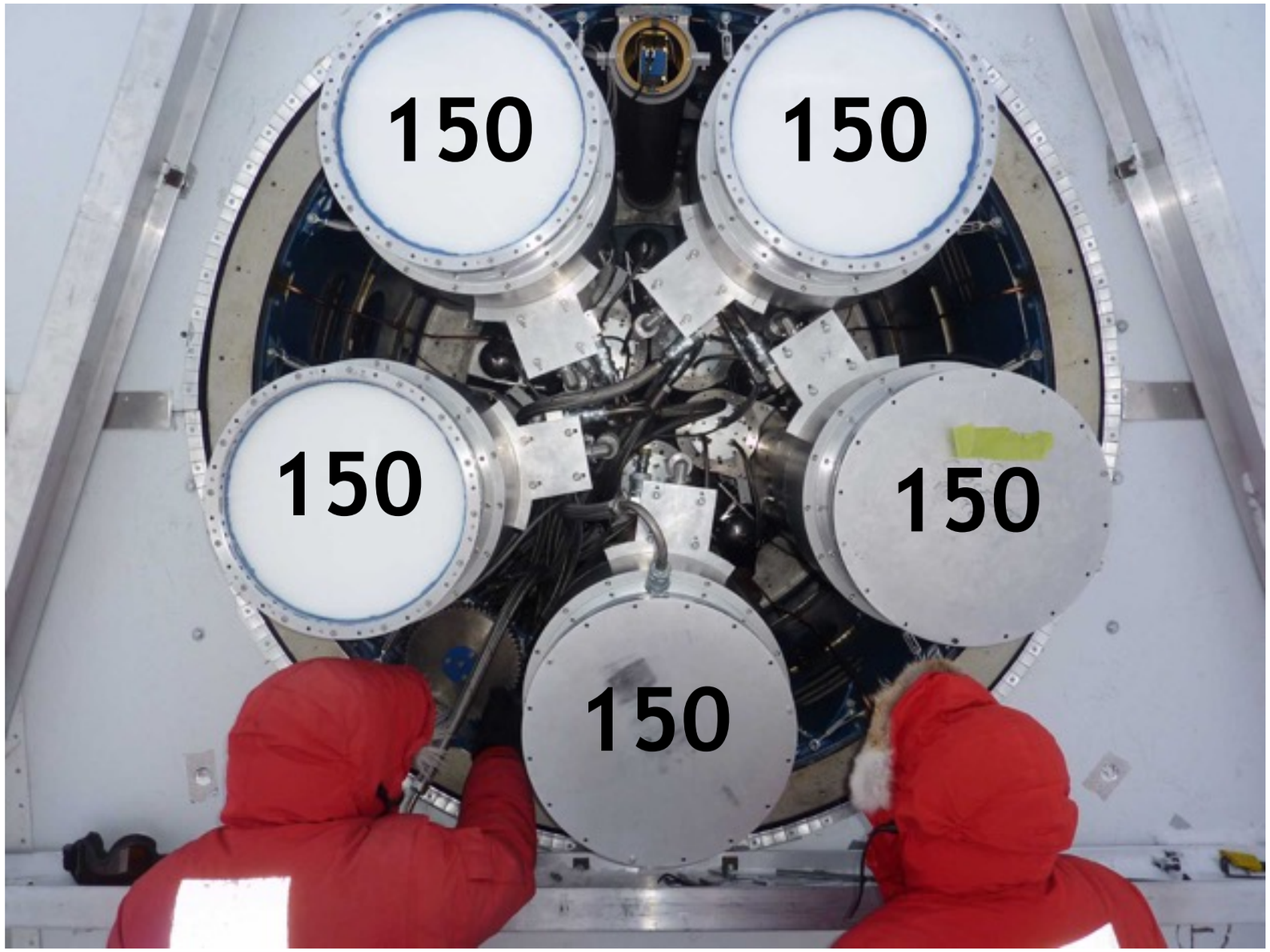
BICEP2 and Keck Array

BICEP2 x 5 =

The Keck Array

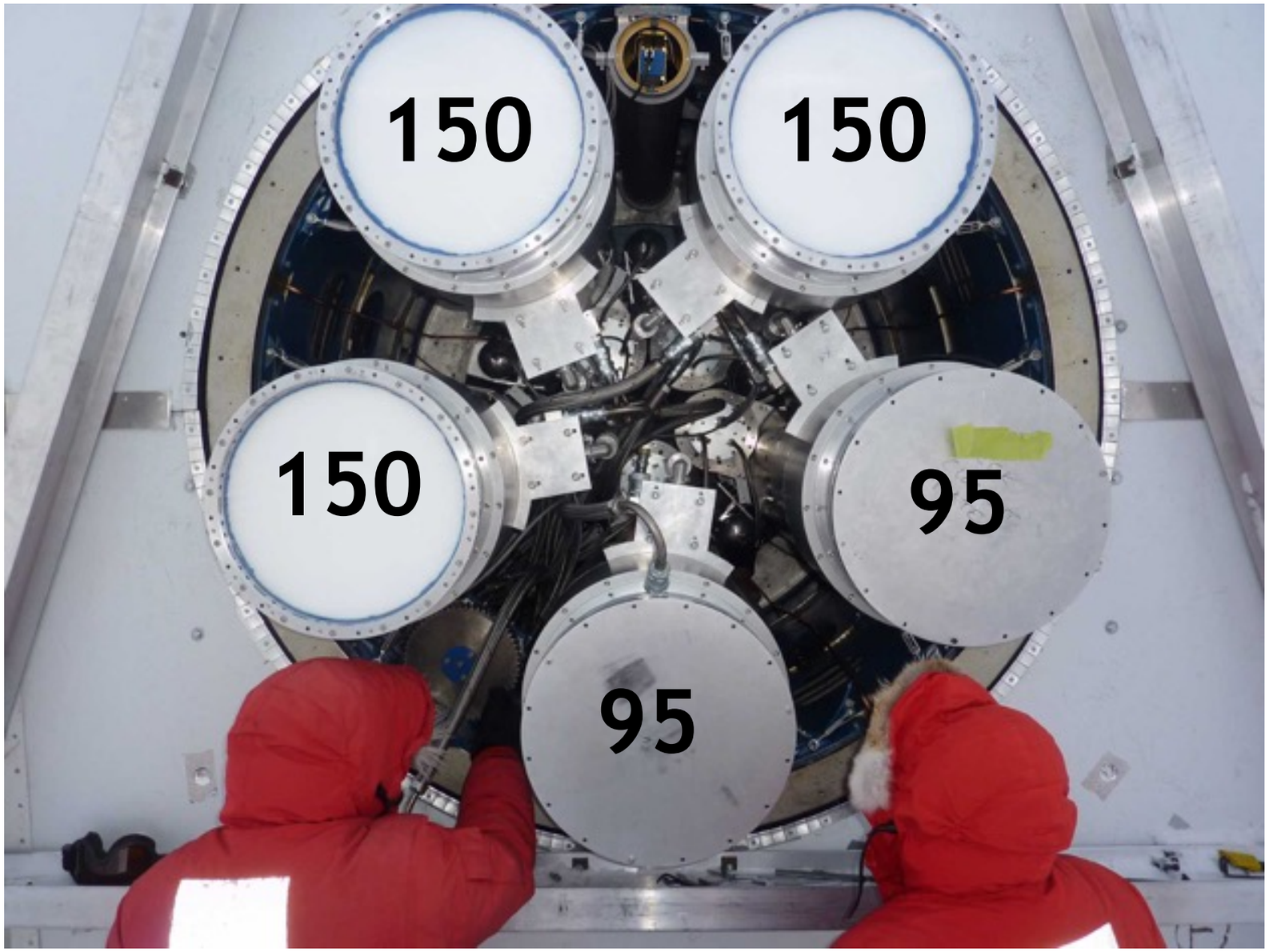
South Pole is high (~10,000 ft) and dry and has a very stable atmosphere during the 6 month long night.

Keck Array Frequency Coverage



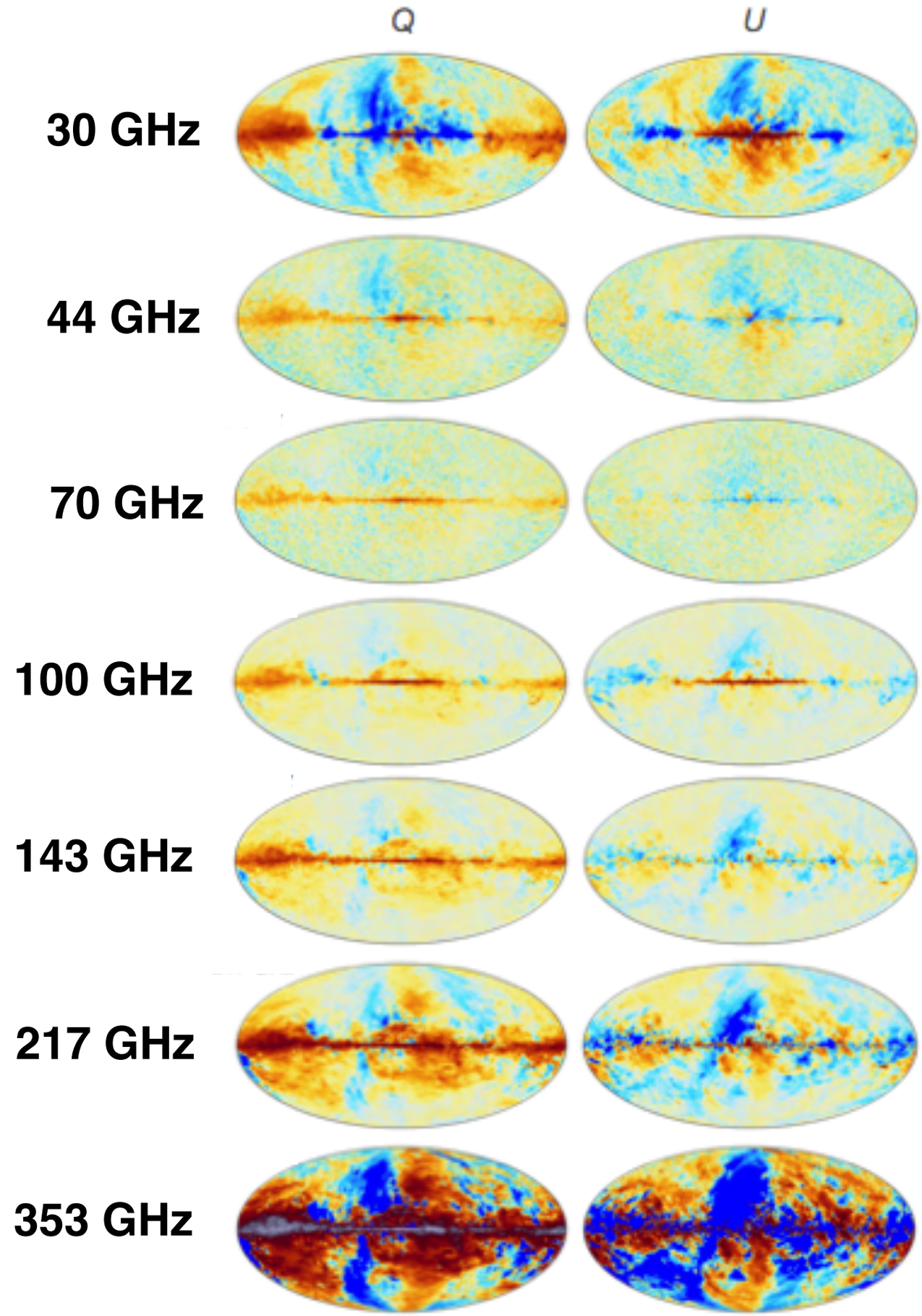
2012-2013

Keck Array Frequency Coverage



2014

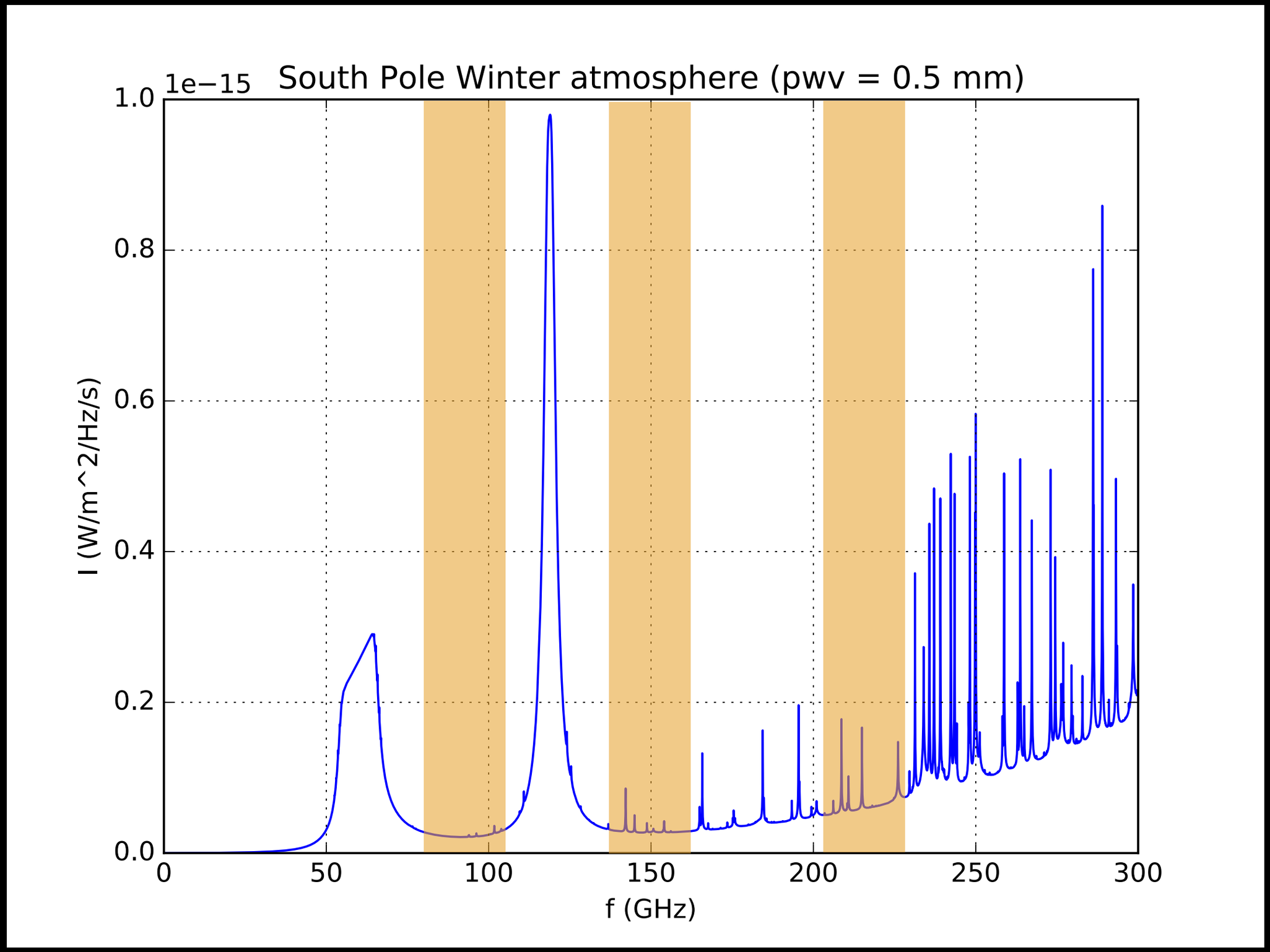
Galactic foregrounds: synchrotron at low frequencies, thermally emitting dust (~20 K) at high frequencies



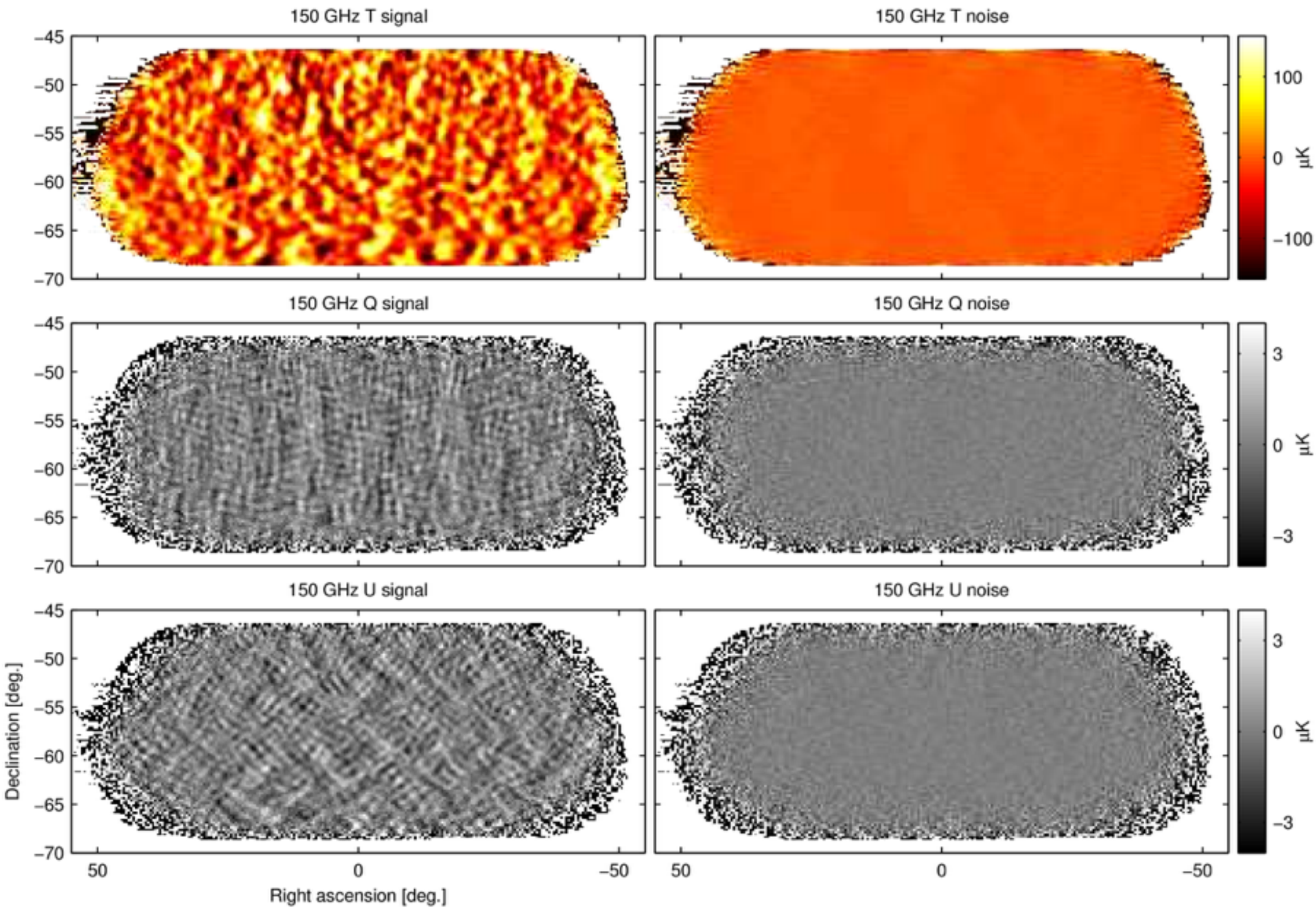
The BICEP/Keck Collaboration

Planck Collaboration

Ground windows



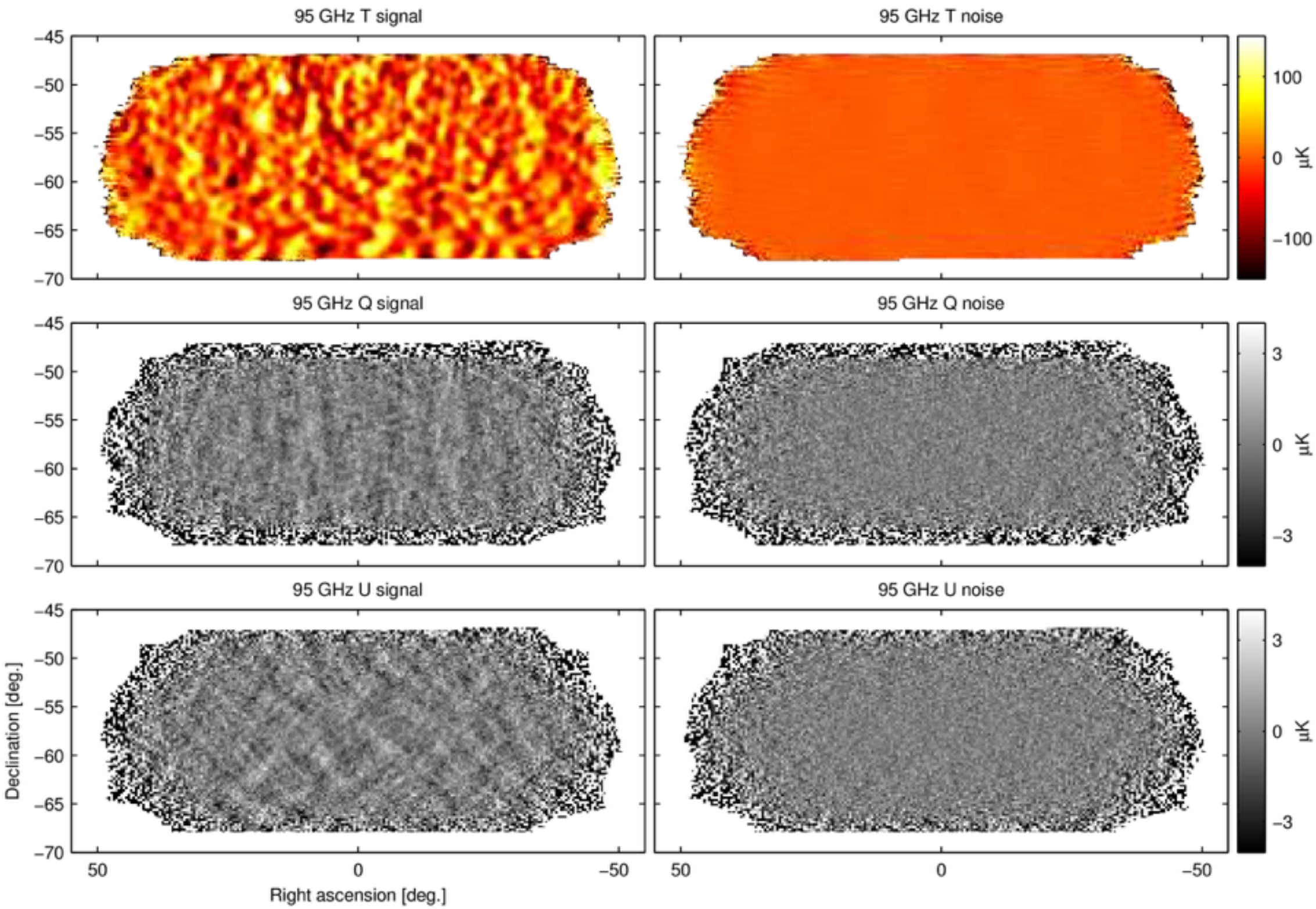
150 GHz maps



The BICEP/Keck Collaboration

BK14 150GHz – 50 nK deg (3.0μK arcmin)

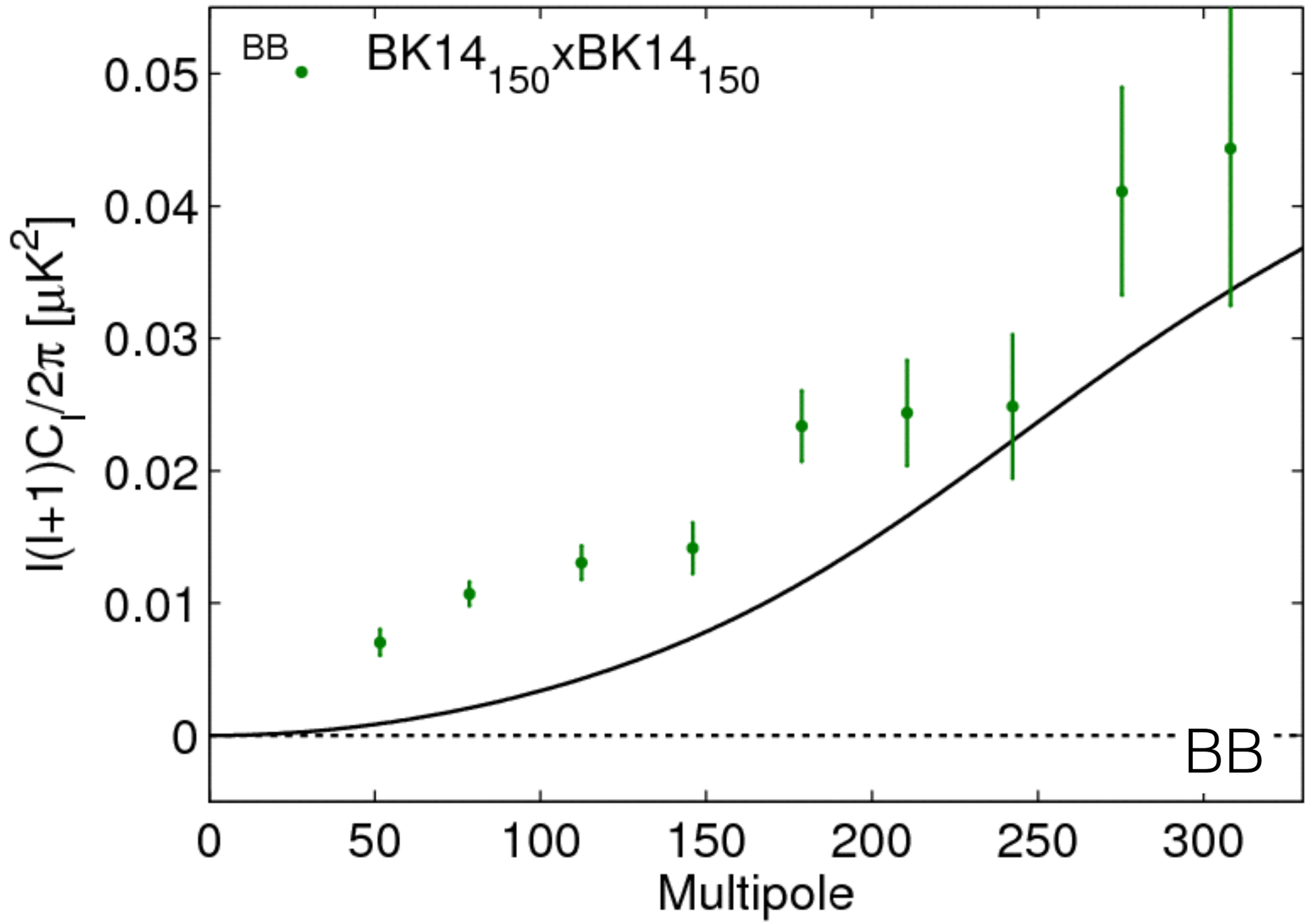
95 GHz maps



The BICEP/Keck Collaboration

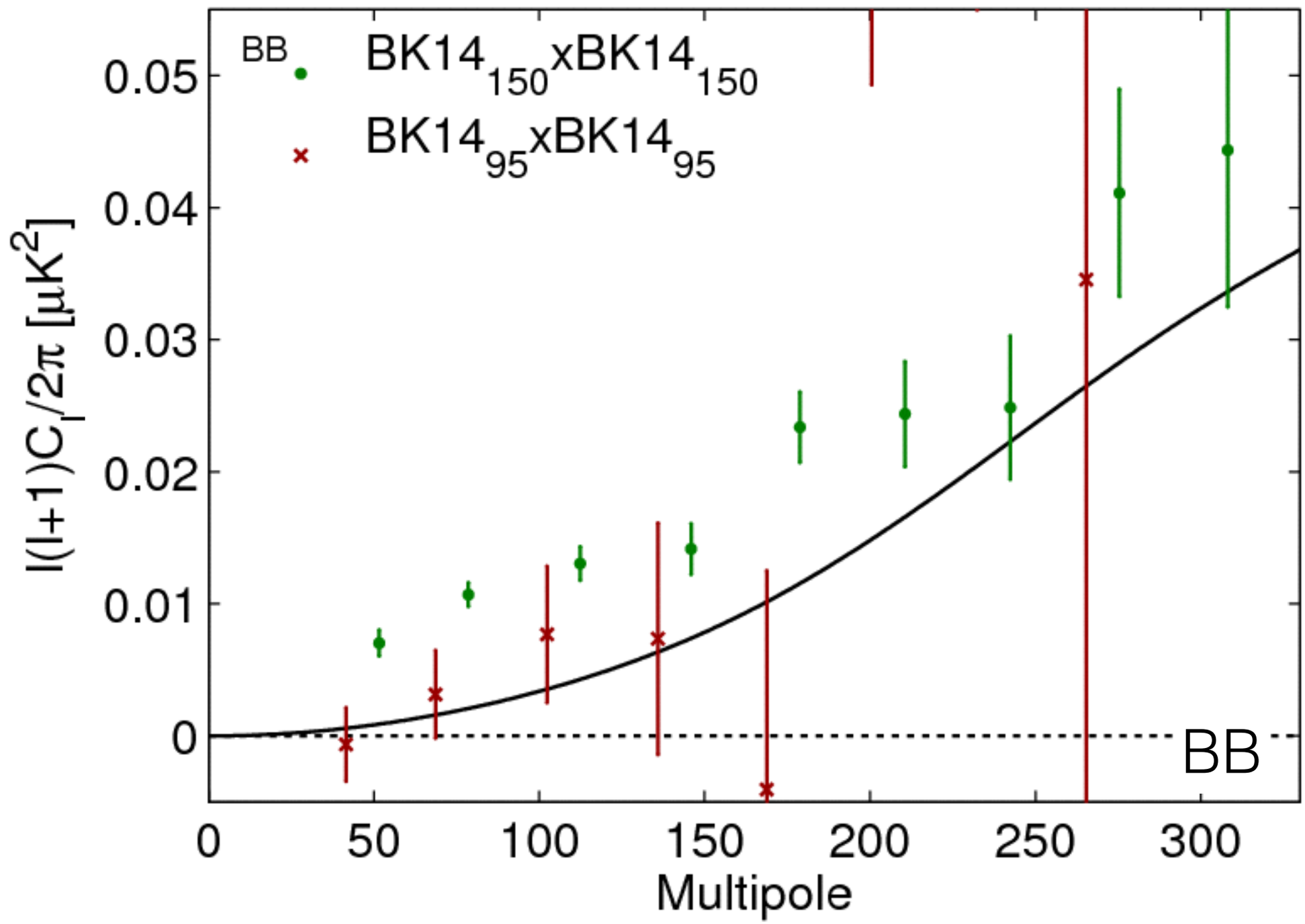
BK14 95GHz – 127 nK deg (7.6μK arcmin)

BICEP2 + Keck BB auto and cross-spectra



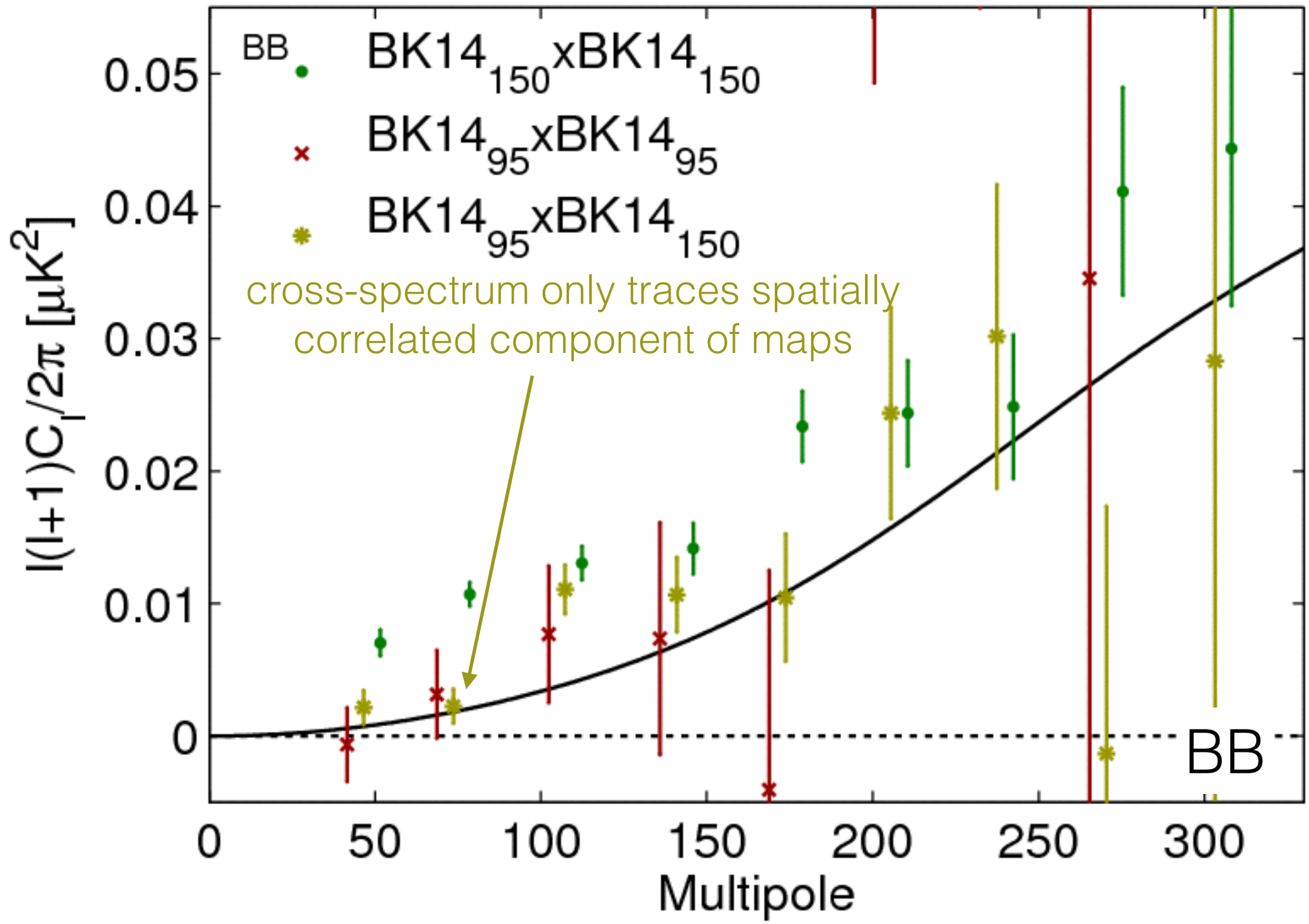
The BICEP/Keck Collaboration

BICEP2 + Keck BB auto and cross-spectra



The BICEP/Keck Collaboration

BICEP2 + Keck BB auto and cross-spectra

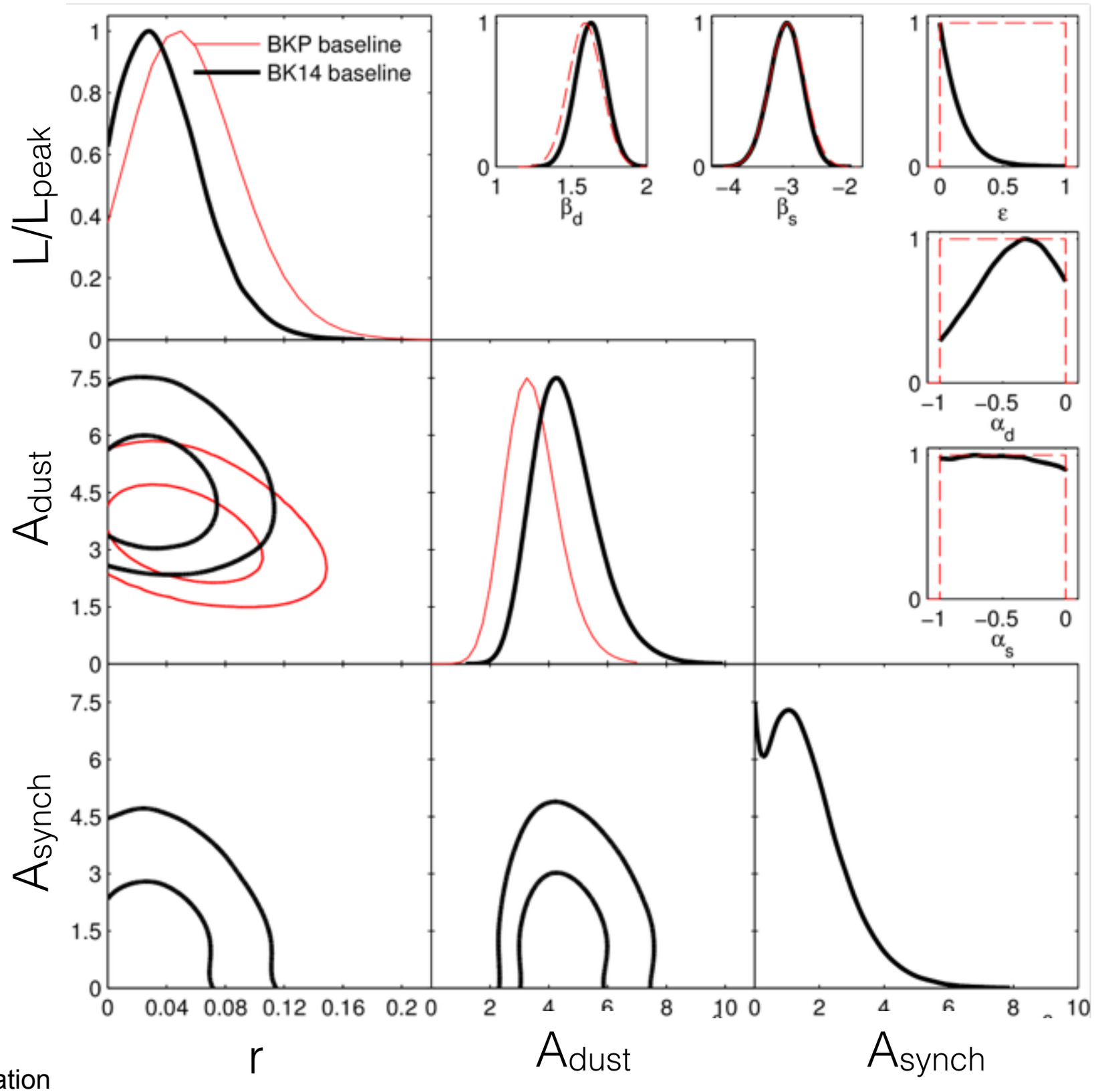


The BICEP/Keck Collaboration

Put priors on the frequency spectral indices of dust & sync

Allow dust/sync correlation

dust vs. r degeneracy lifted

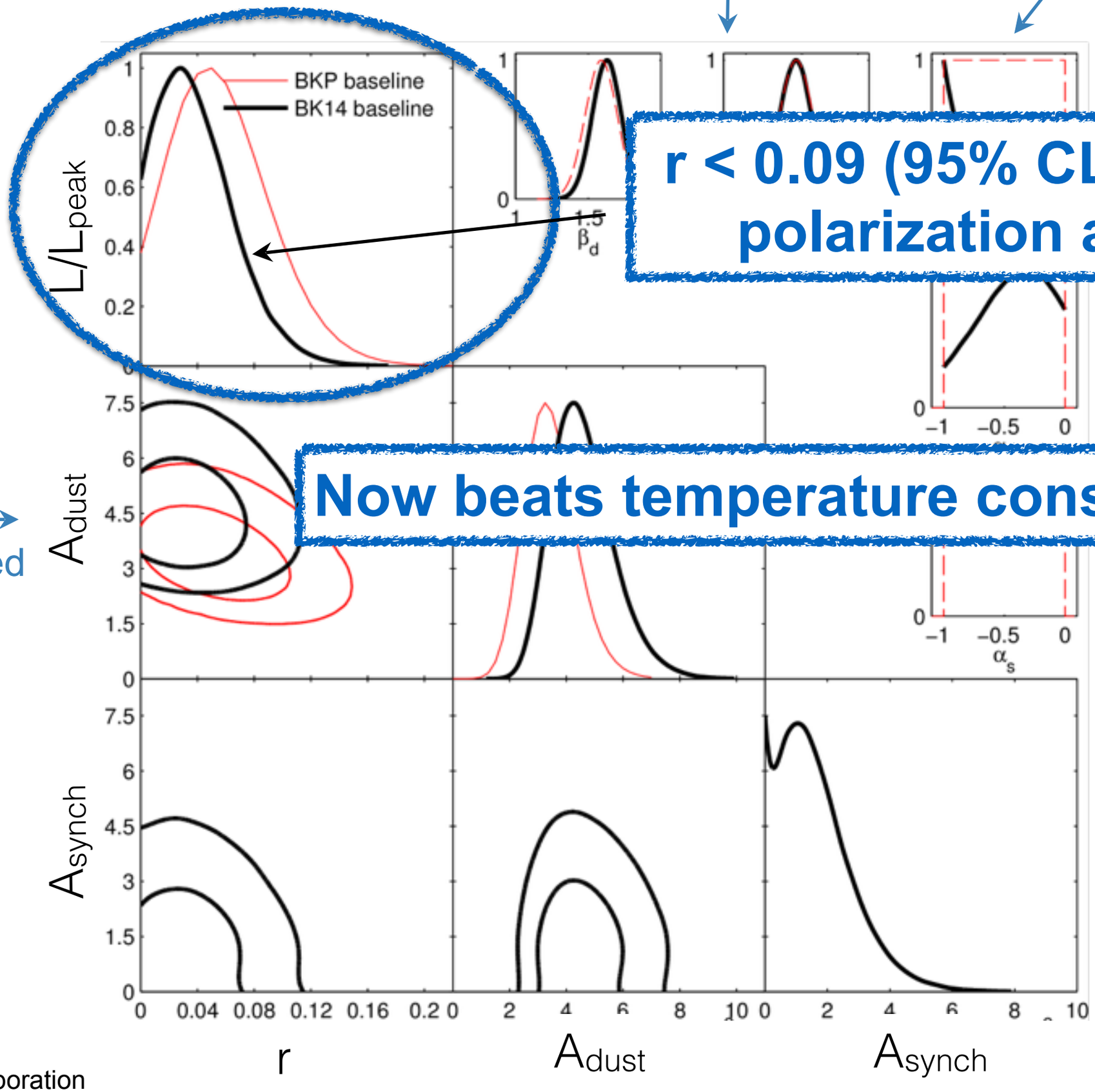


Marginalize over generous ranges in spatial spectral indices

The BICEP/Keck Collaboration

Put priors on the frequency spectral indices of dust & sync

Allow dust/sync correlation



r < 0.09 (95% CL) using polarization alone

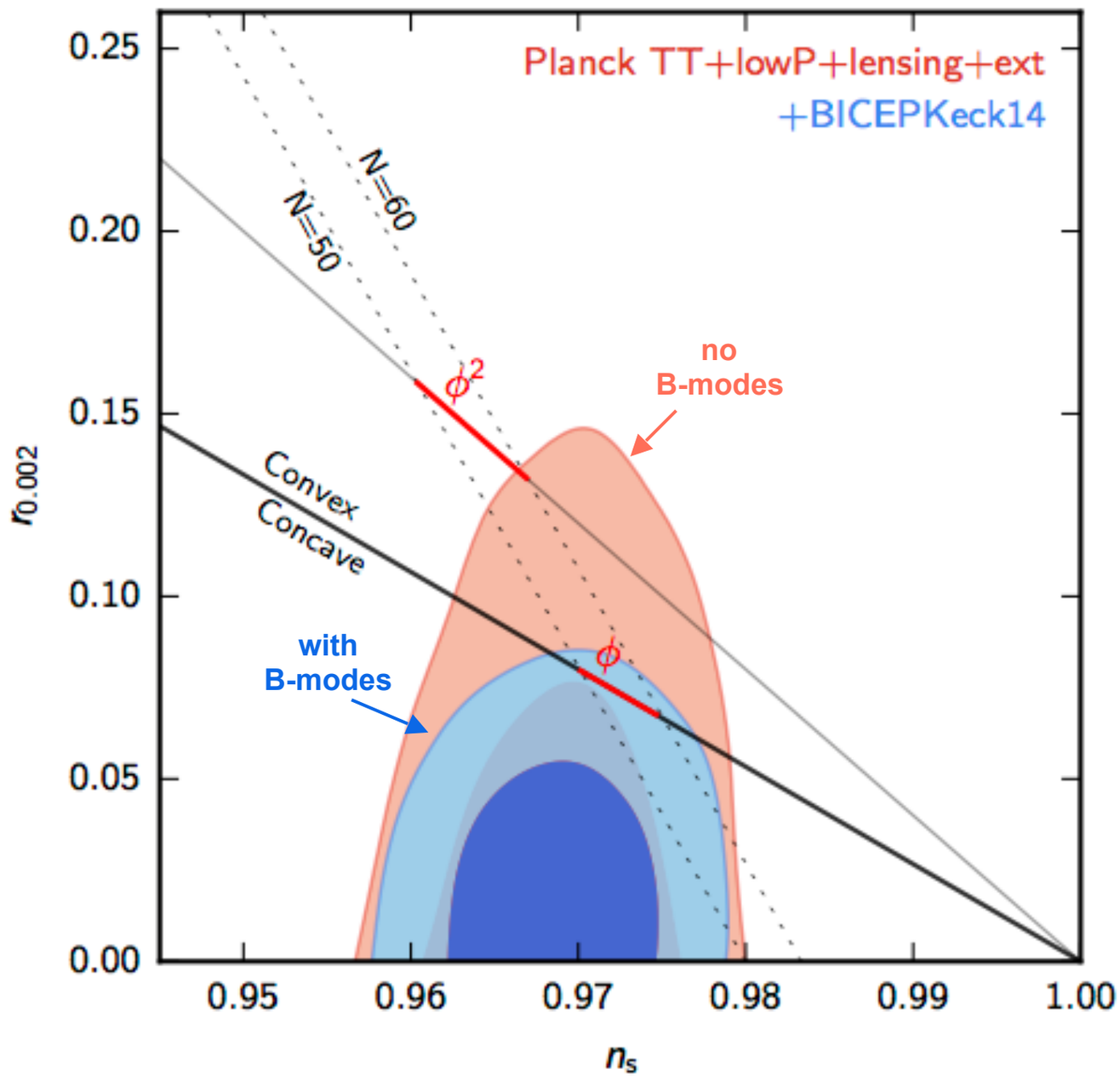
Now beats temperature constraints

dust vs. r degeneracy lifted

Marginalize over generous ranges in spatial spectral indices

The BICEP/Keck Collaboration

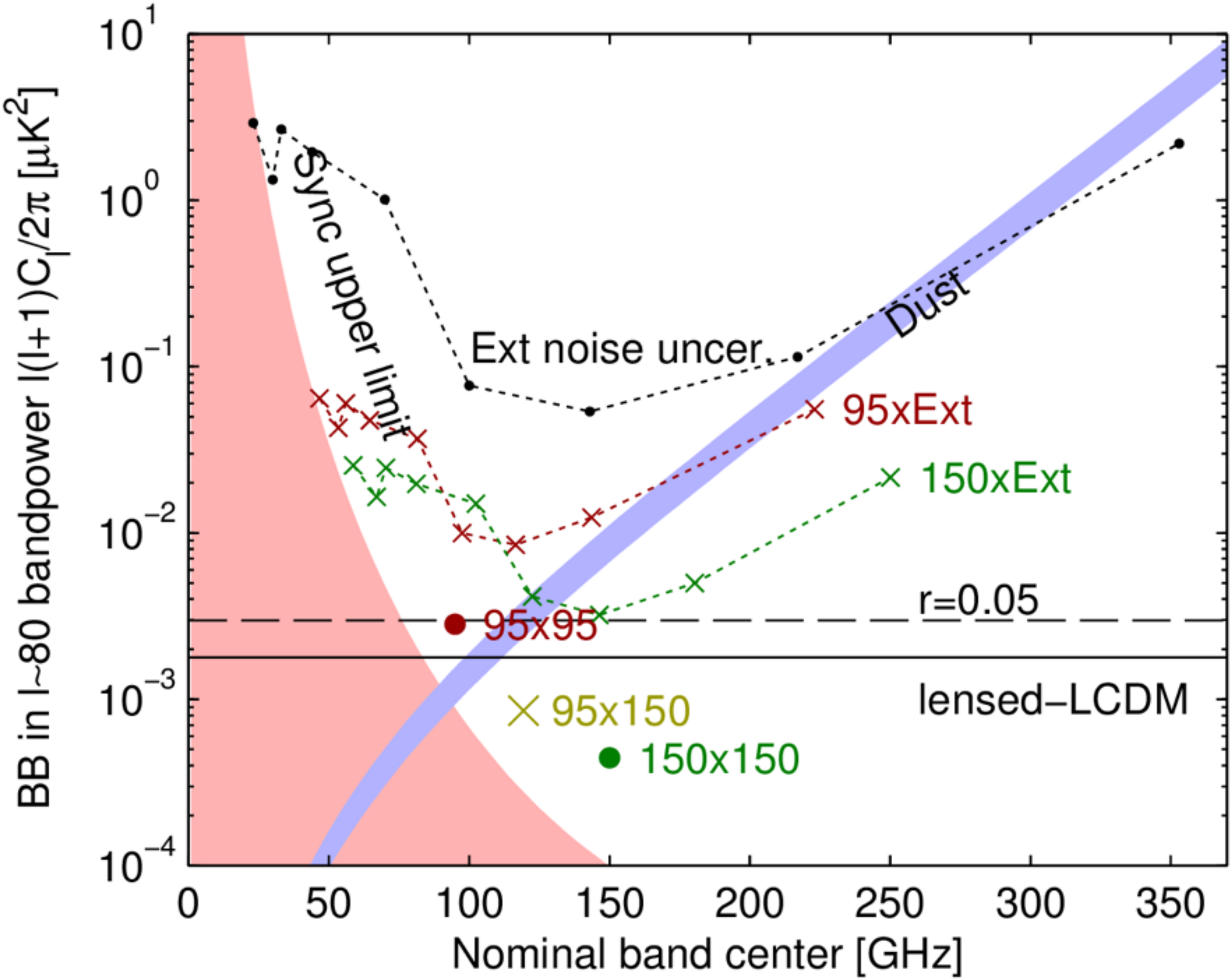
Adding in temperature



$r_{.05} < 0.07$

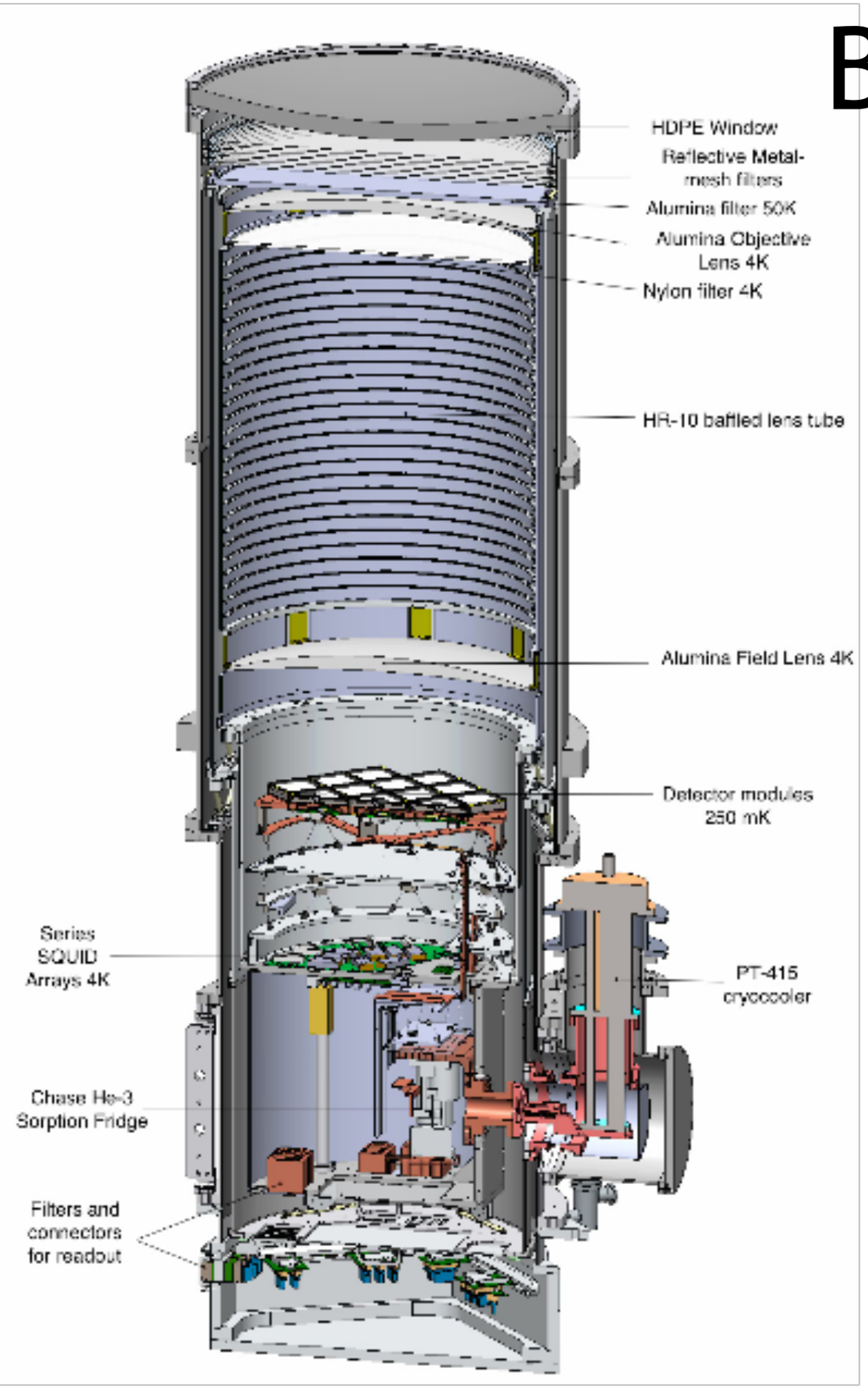
(best ever)

The BICEP/Keck Collaboration



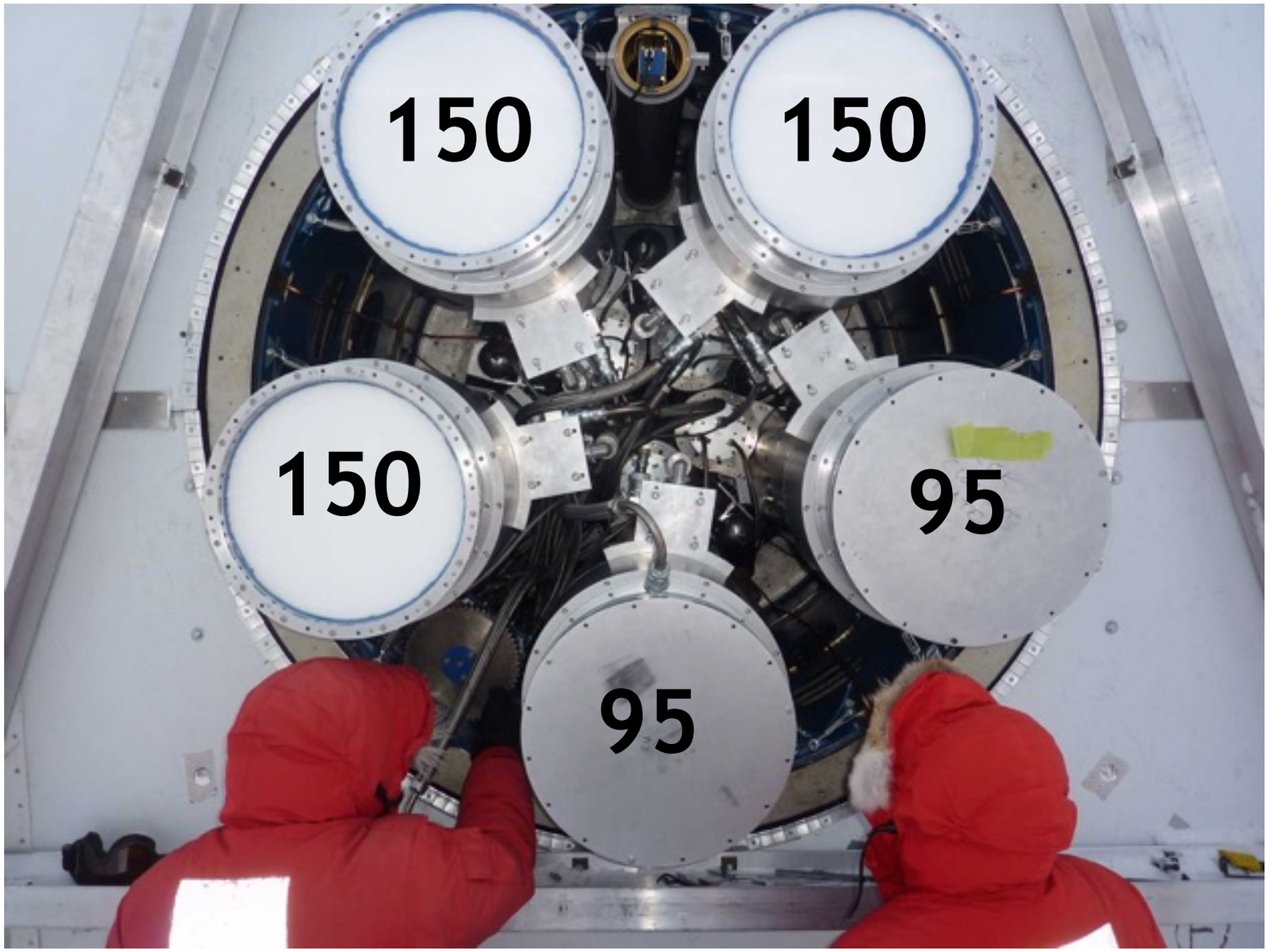
The BICEP/Keck Collaboration

BICEP3 @ 95 GHz



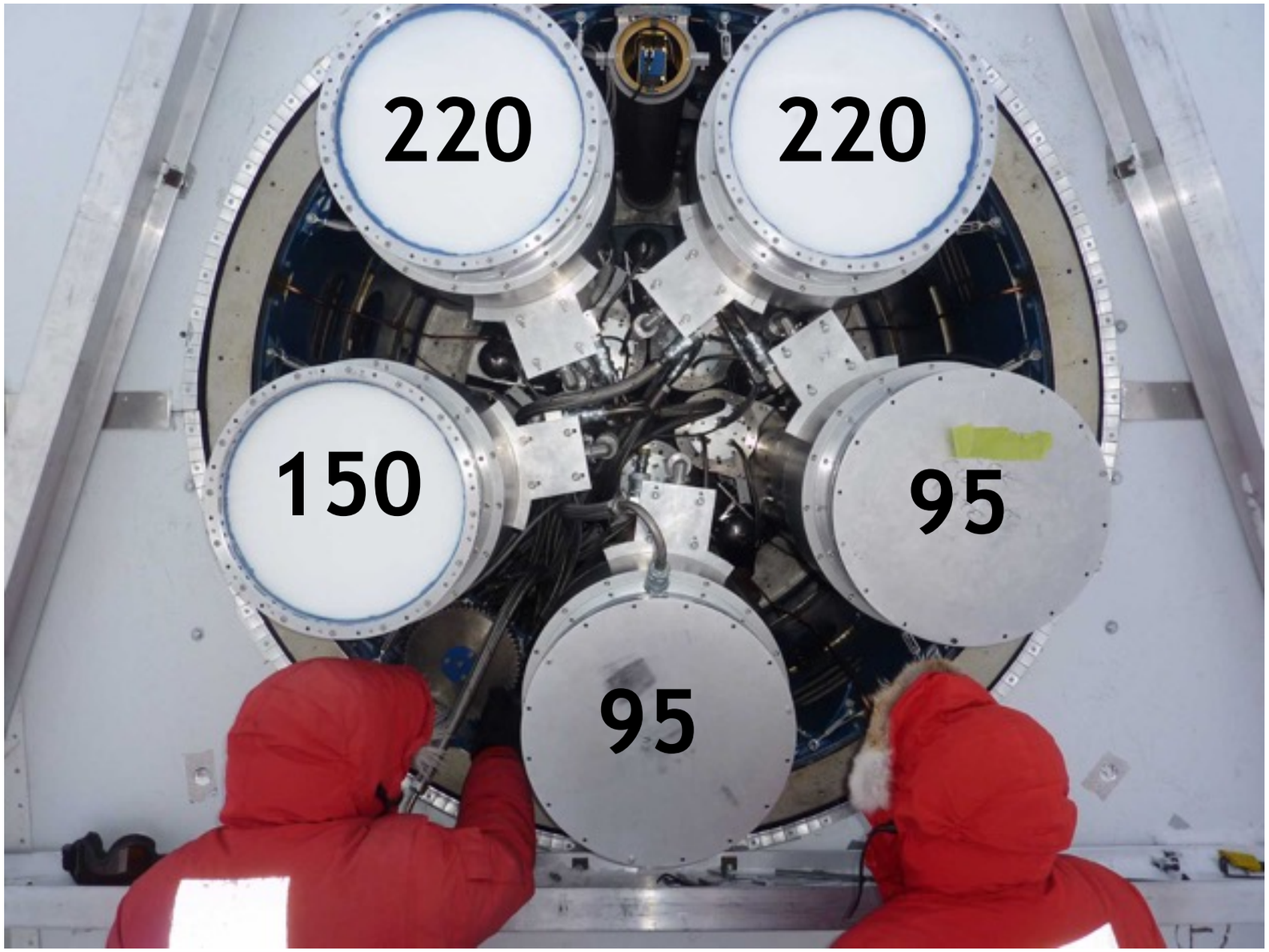
- Now taking data at the South Pole
- Roughly the same number of detectors as Keck Array, but all at 95 GHz.

Keck Array Frequency Coverage



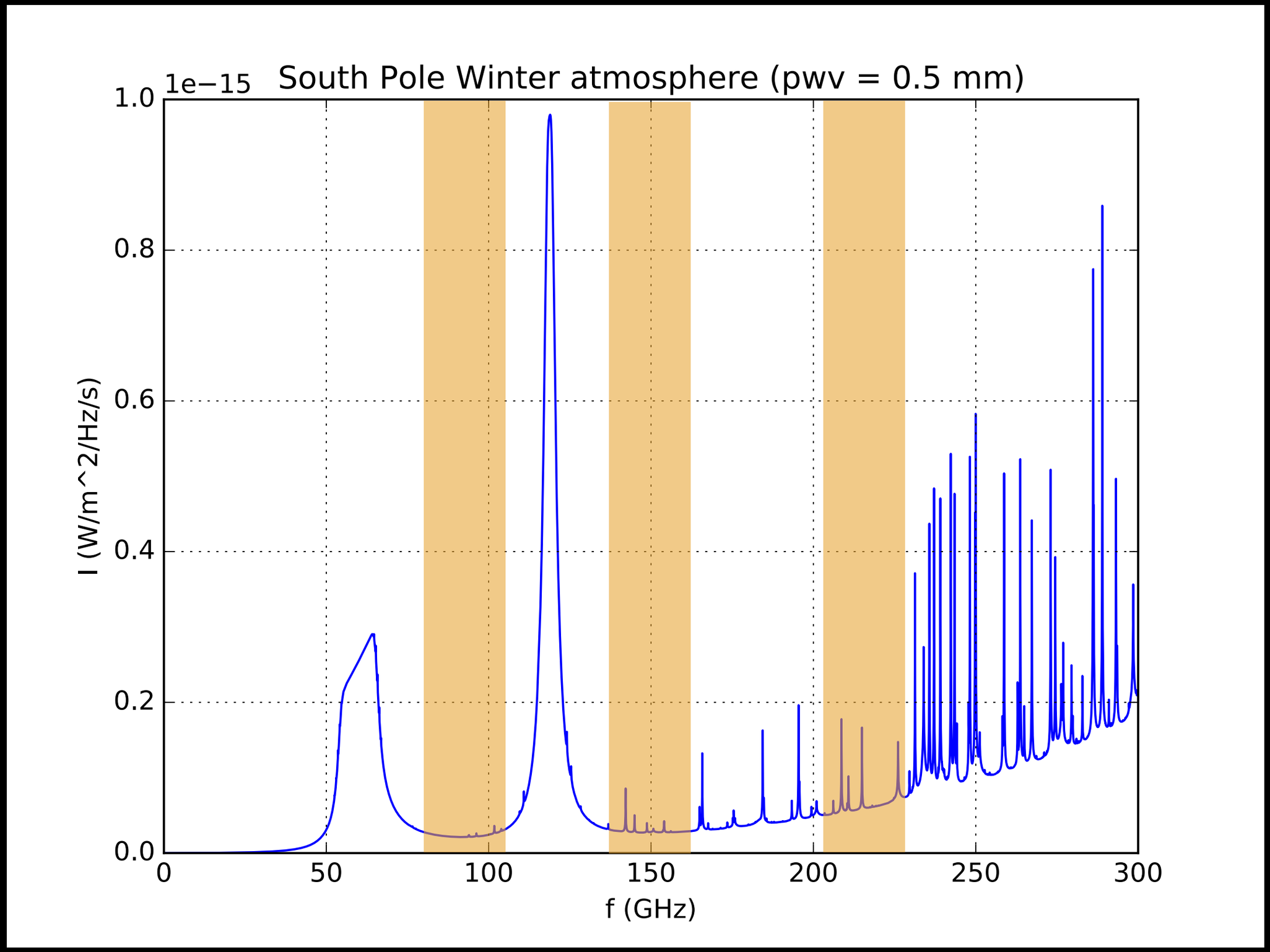
2014

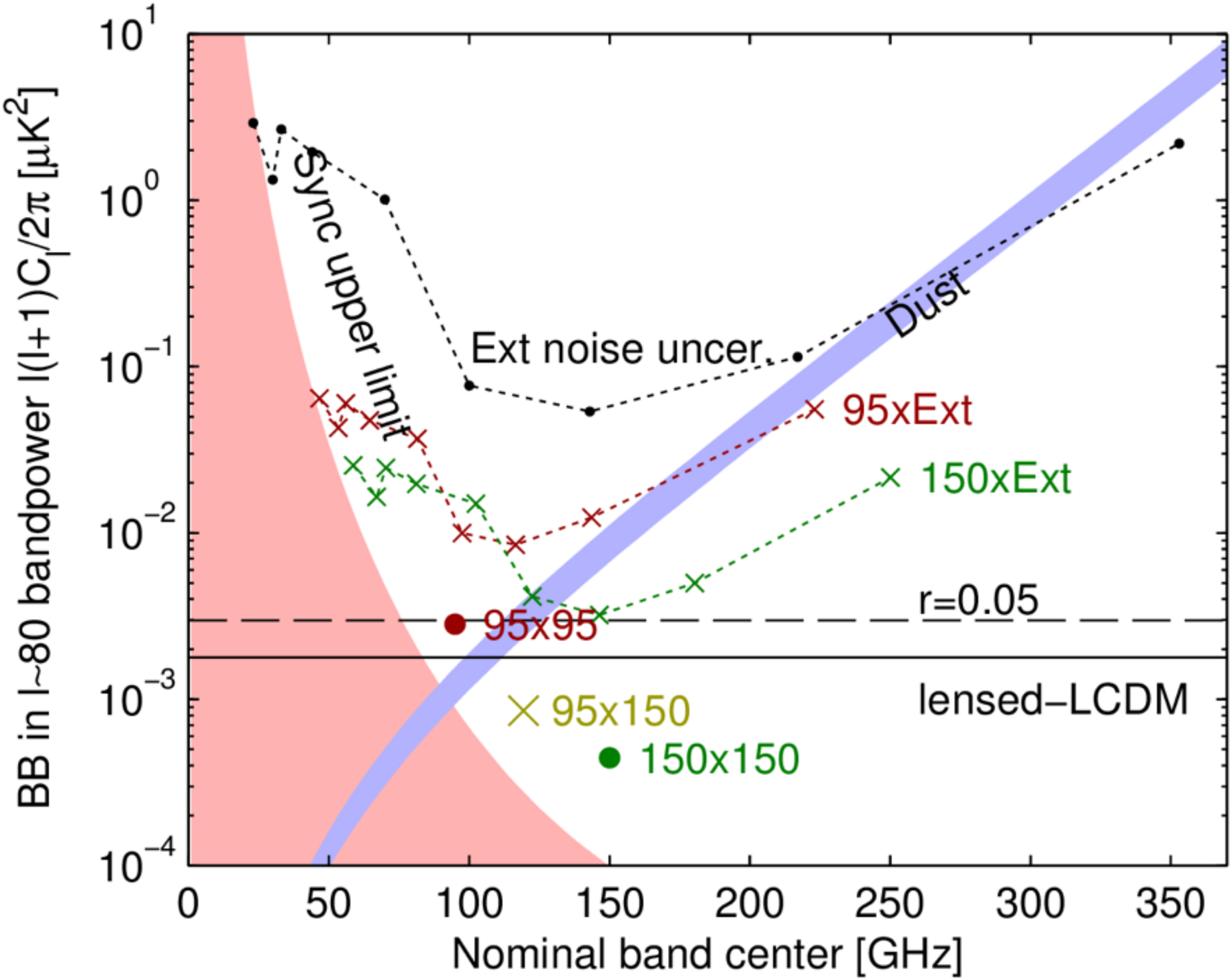
Keck Array Frequency Coverage



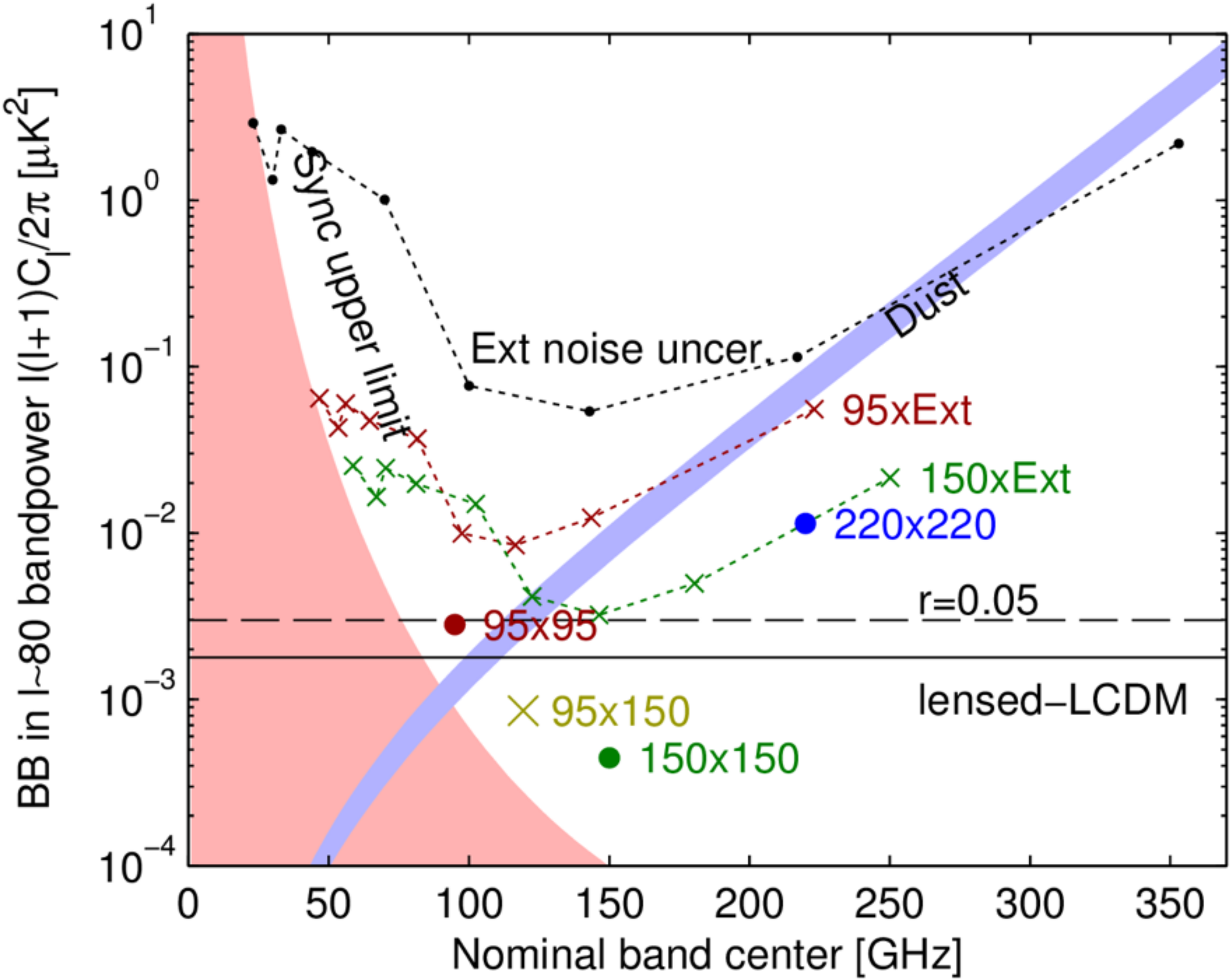
2015

Ground windows



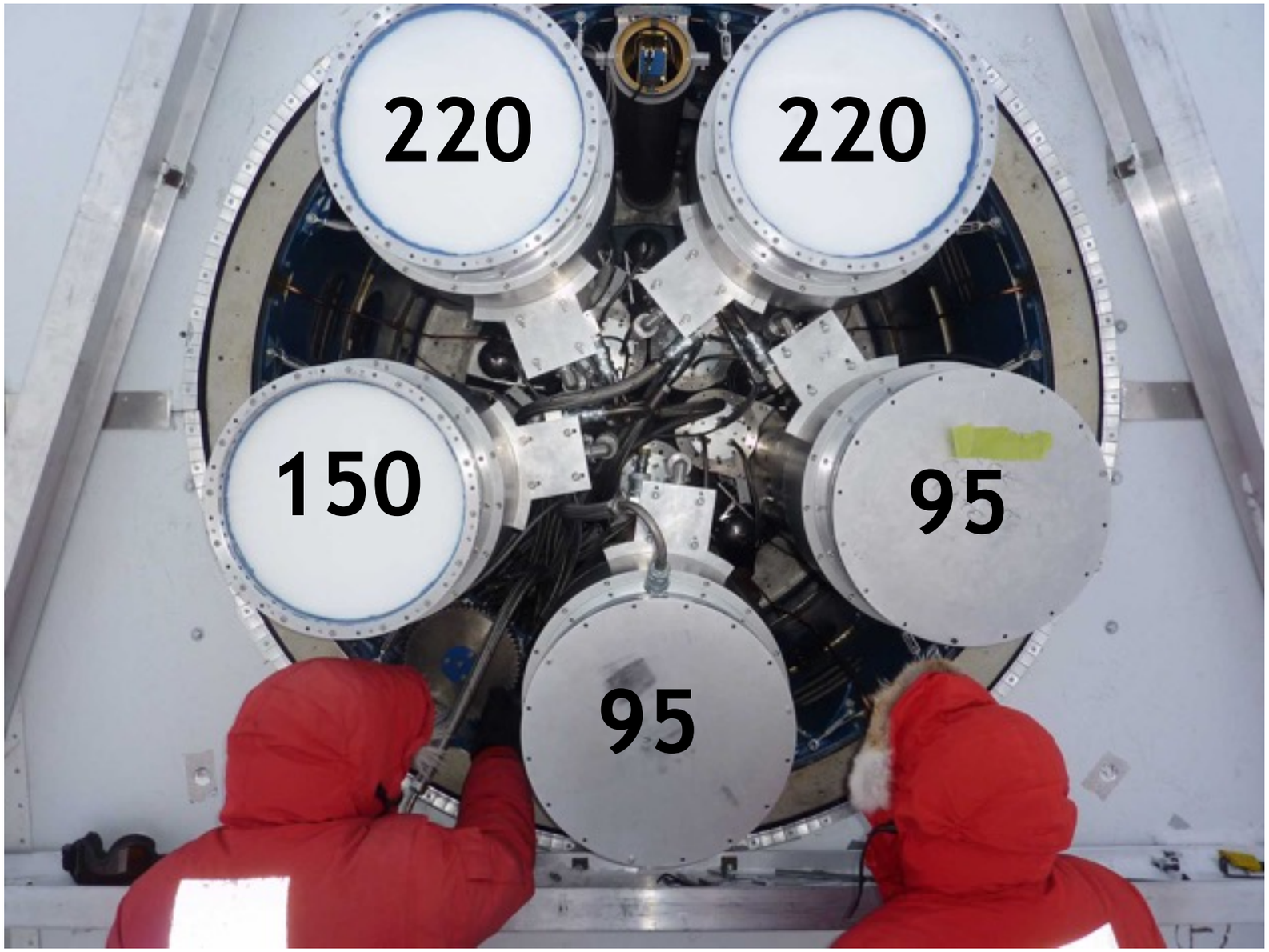


The BICEP/Keck Collaboration



The BICEP/Keck Collaboration

Keck Array Frequency Coverage



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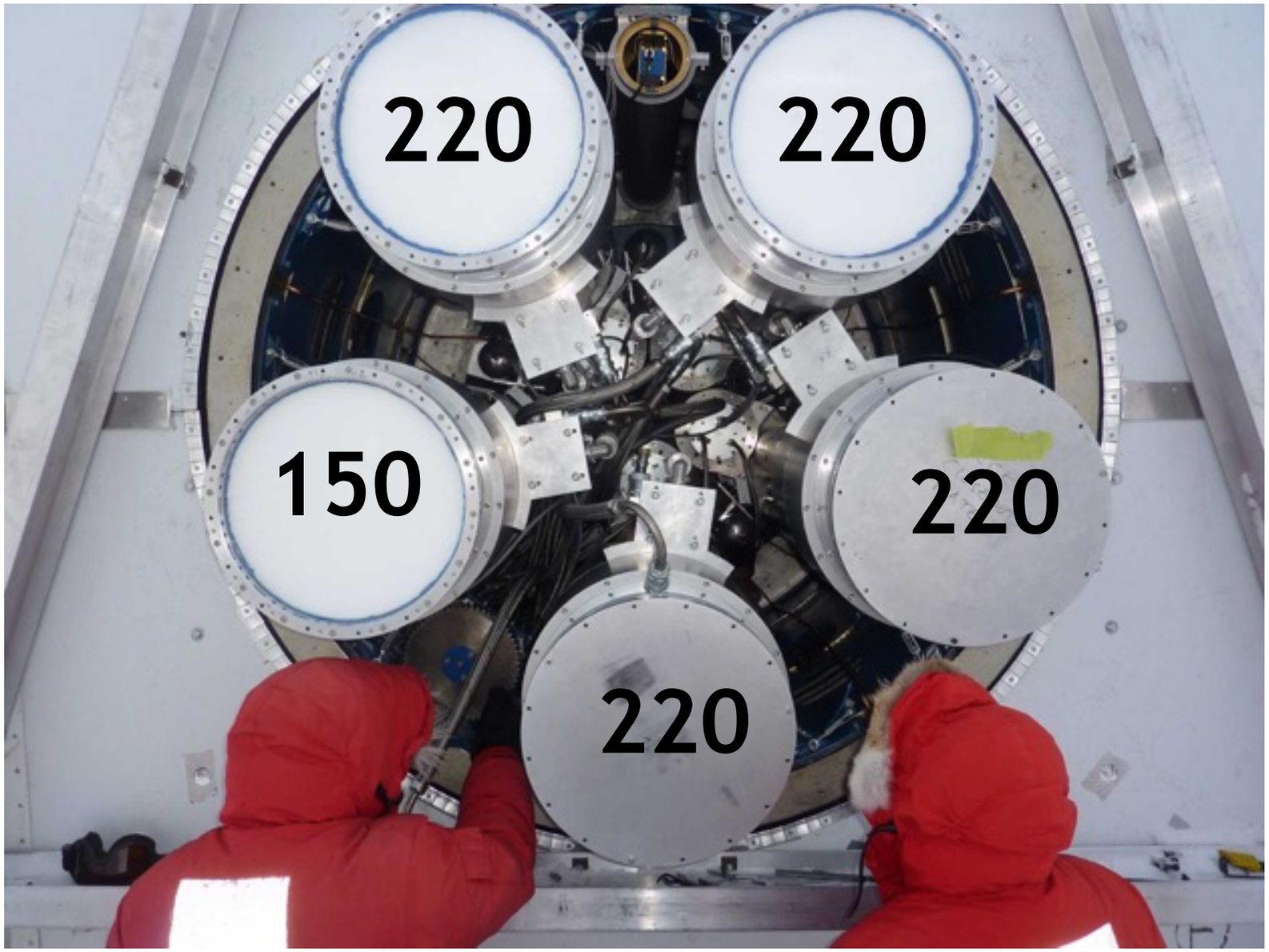
Keck Array Frequency Coverage

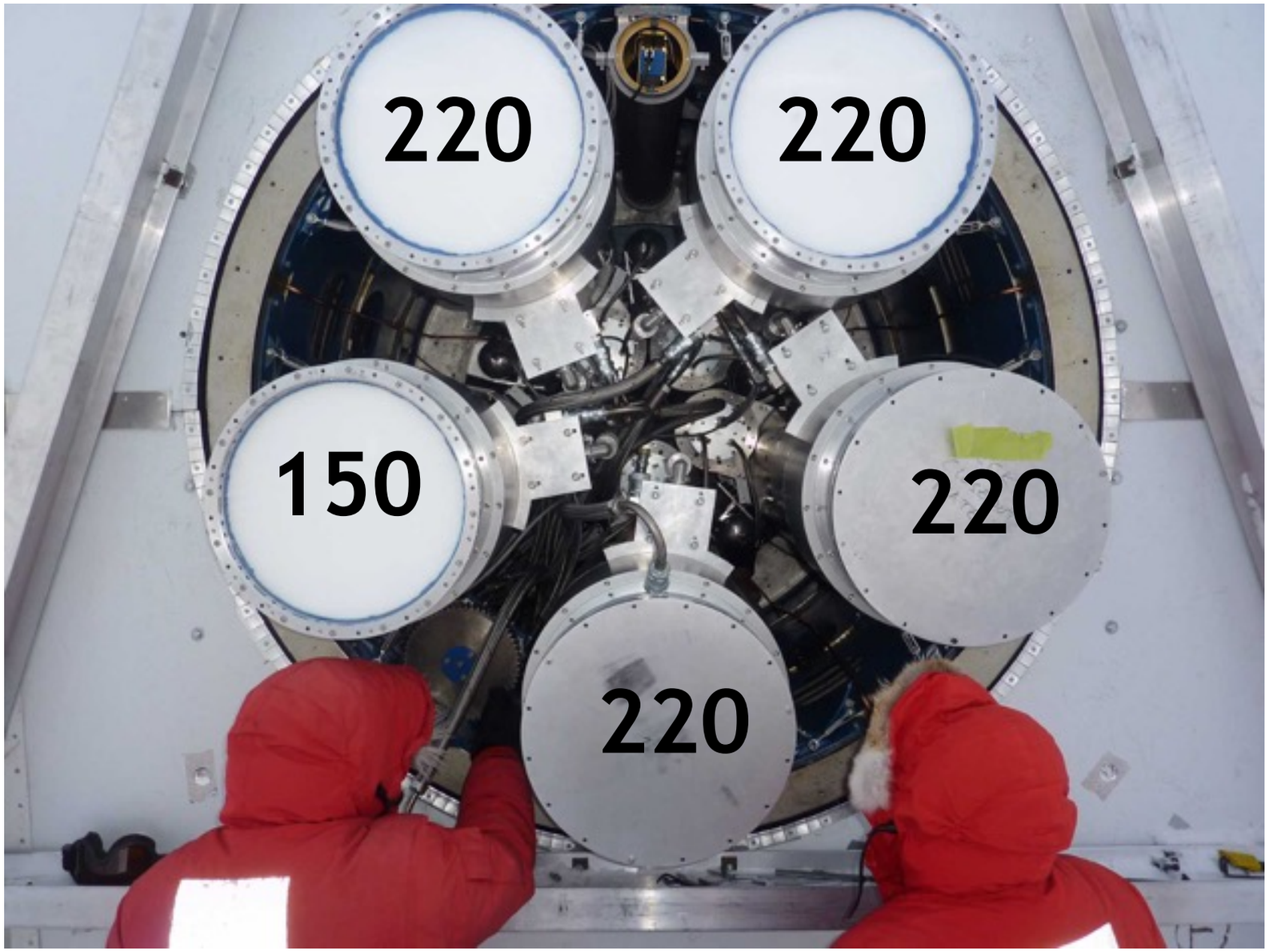


2016

BICEP/Keck maps pager

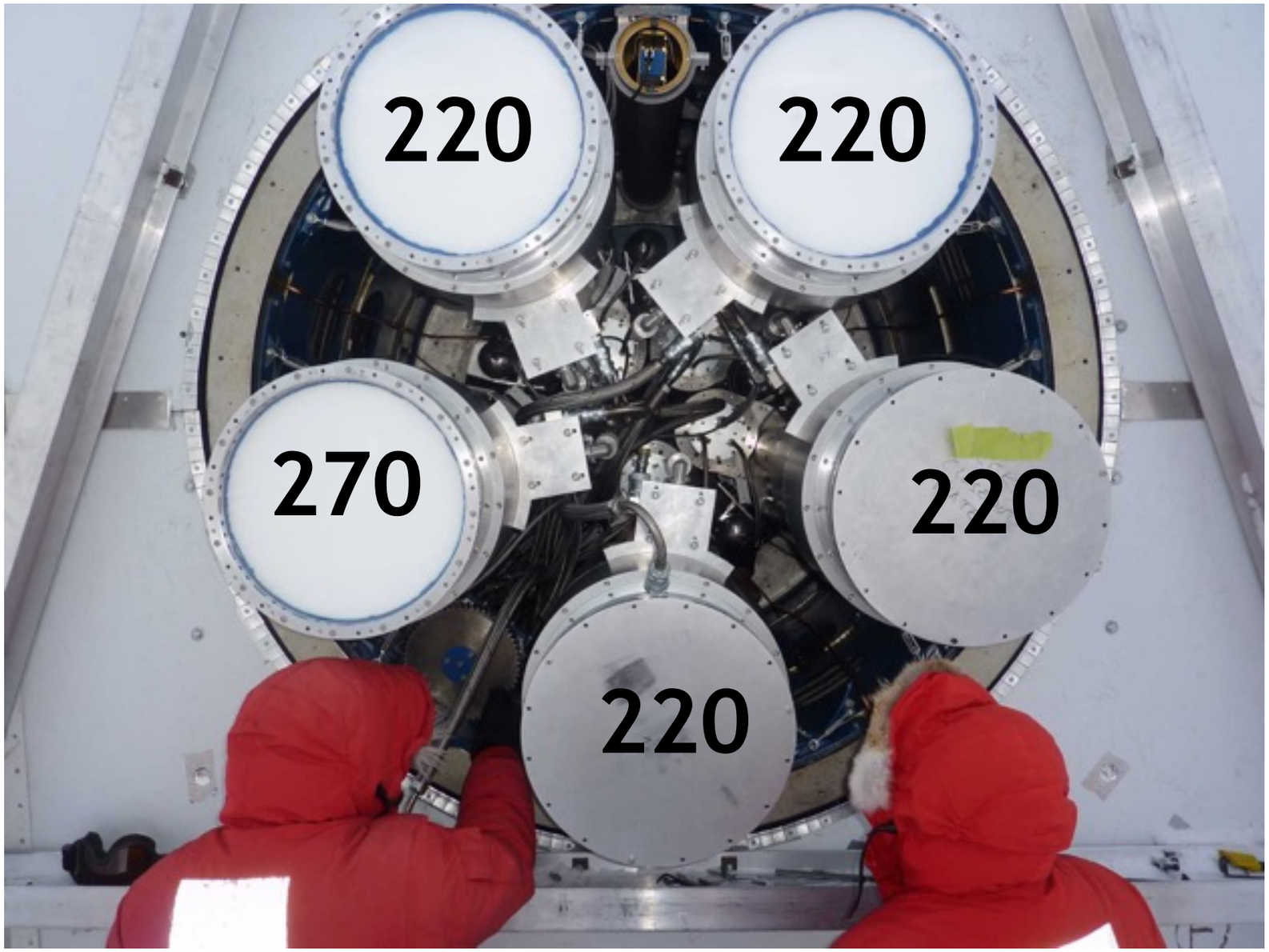
The BICEP/Keck Collaboration

Keck Array Frequency Coverage



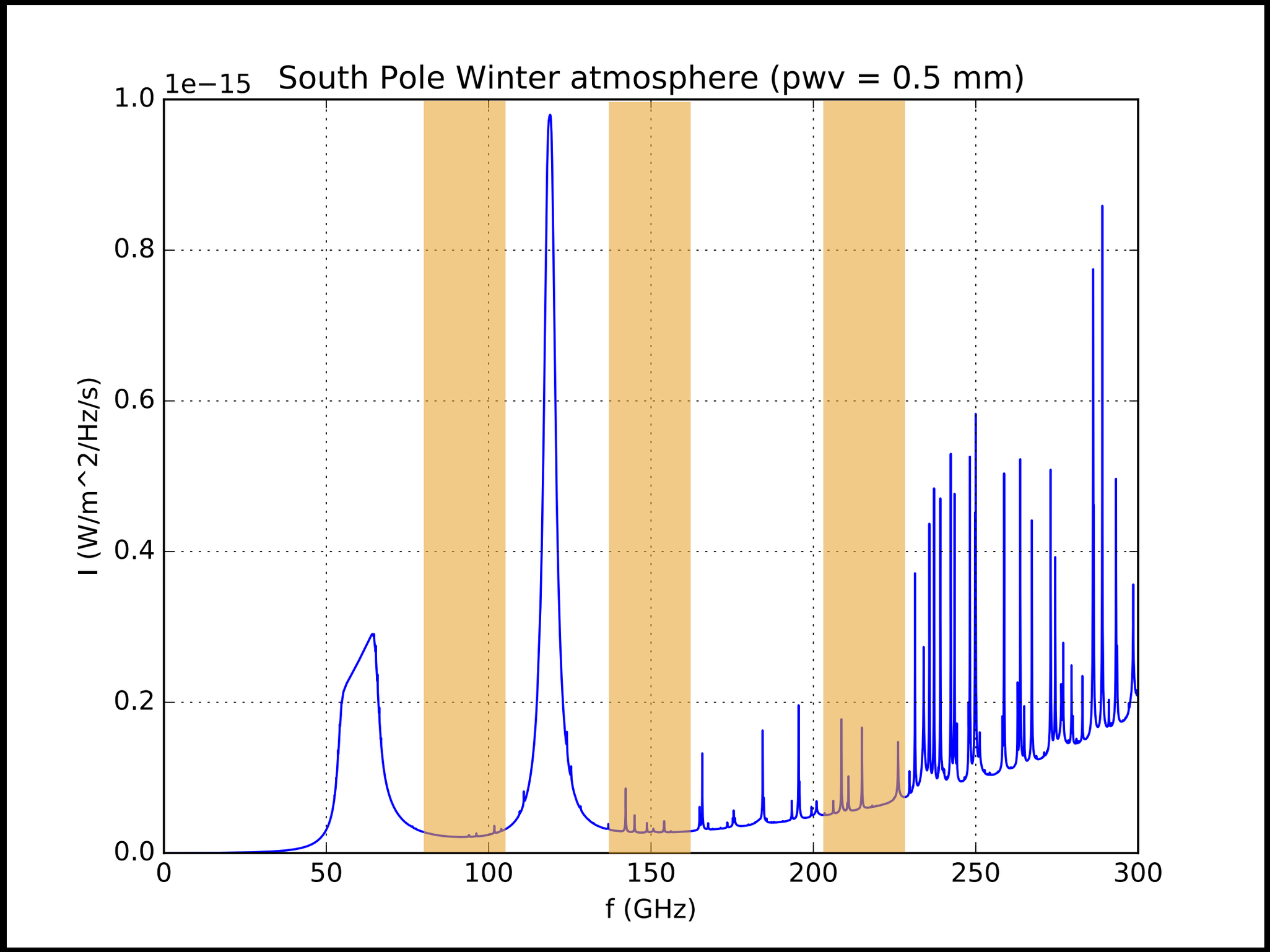
2016

Keck Array Frequency Coverage

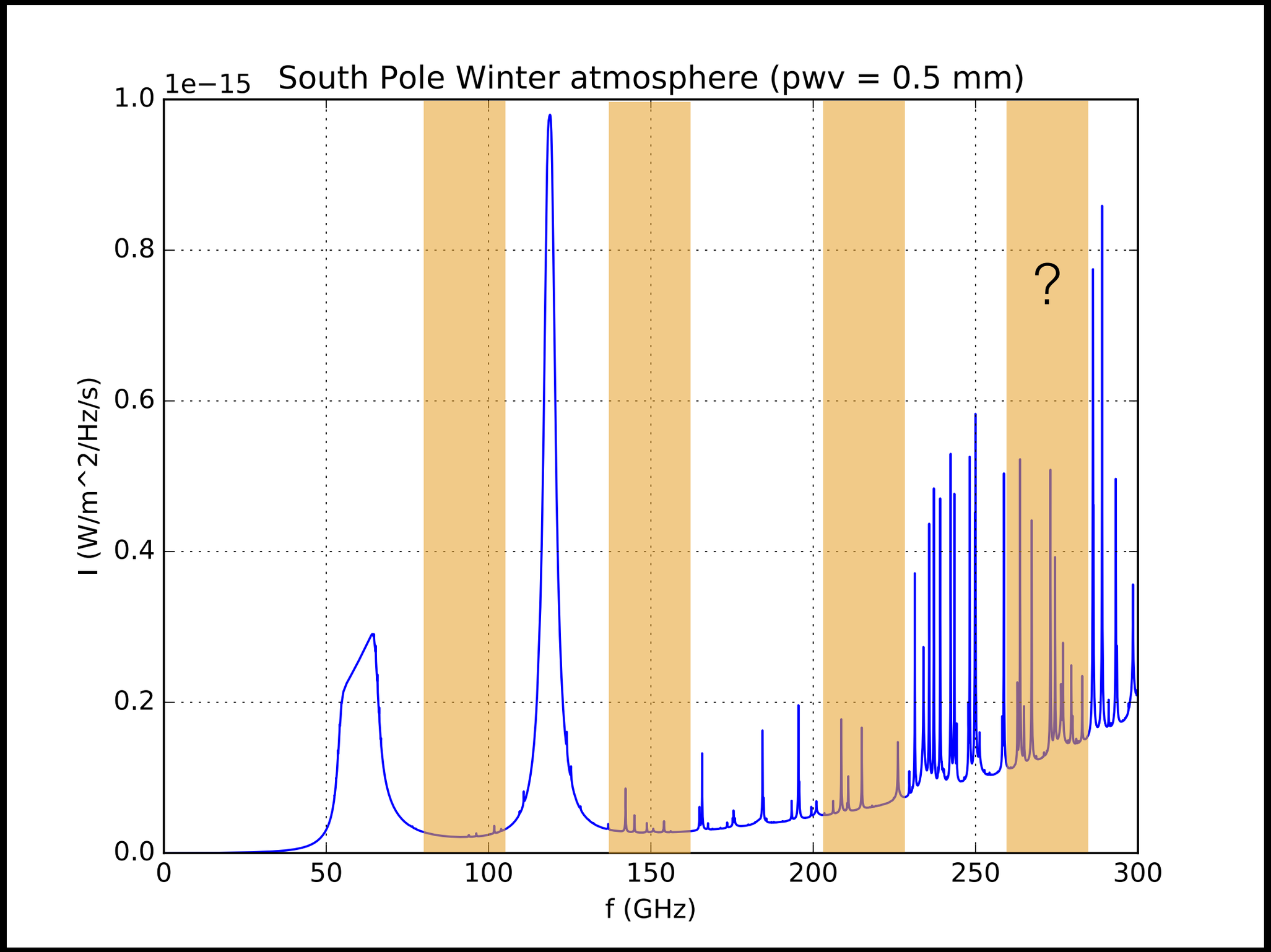


2017

Ground windows



Ground windows



Atlantic Ocean
AFRICA
Indian Ocean
South Georgia
Southern Ocean
Falkland Is.
Weddell Sea
SOUTH AMERICA
Antarctic Peninsula
East Antarctica
South Pole
West Antarctica
McMurdo
Ross Sea
Southern Ocean
AUSTRALIA
Flight Path
NEW ZEALAND
Pacific Ocean

Inside C17

At McMurdo

At McMurdo

At McMurdo

At McMurdo

At McMurdo

At McMurdo

At McMurdo

LC-130 Herc

LC-130 Herc

Transantarctic Mountains

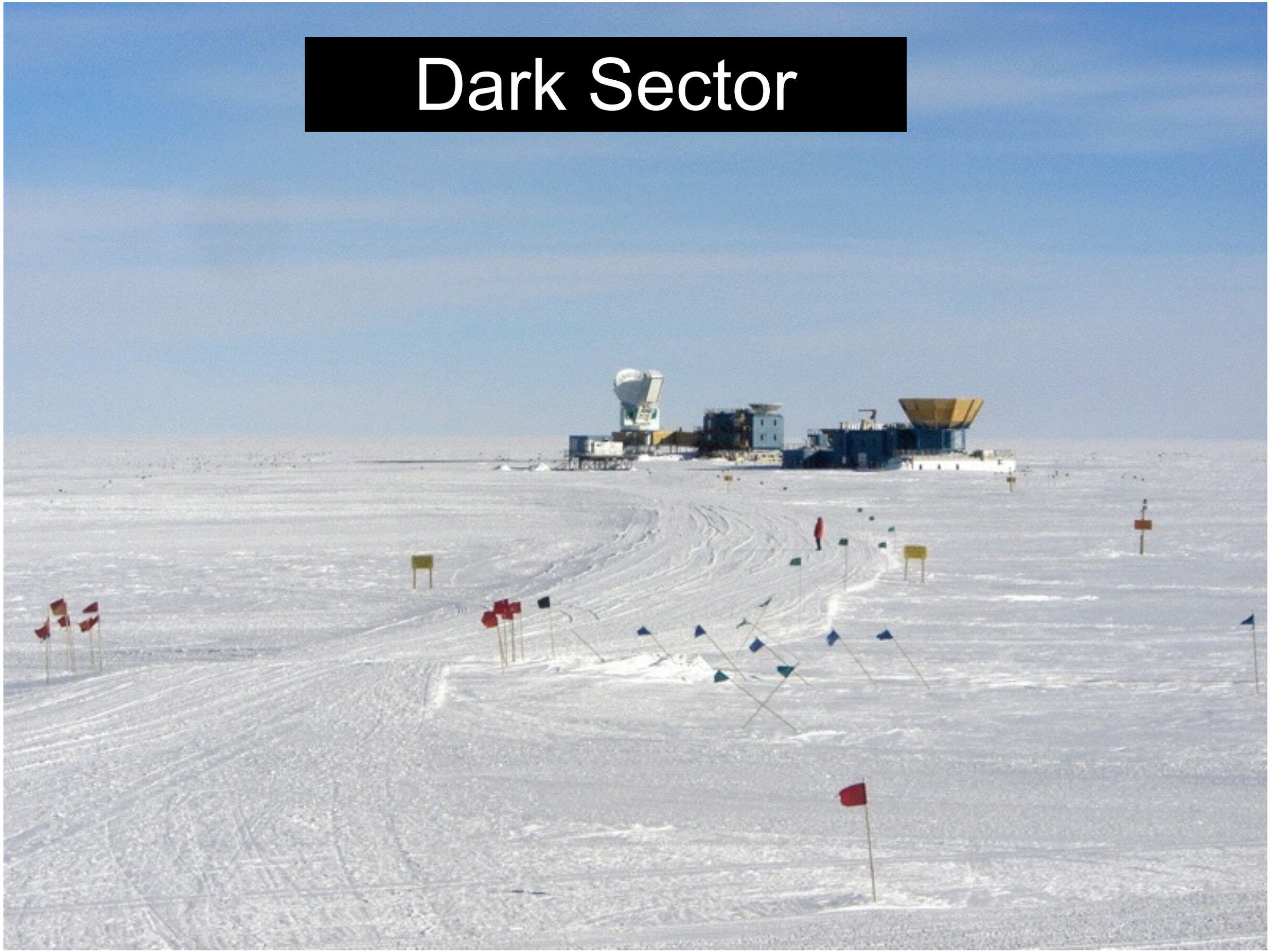
Transantarctic Mountains

Getting up on the plateau…

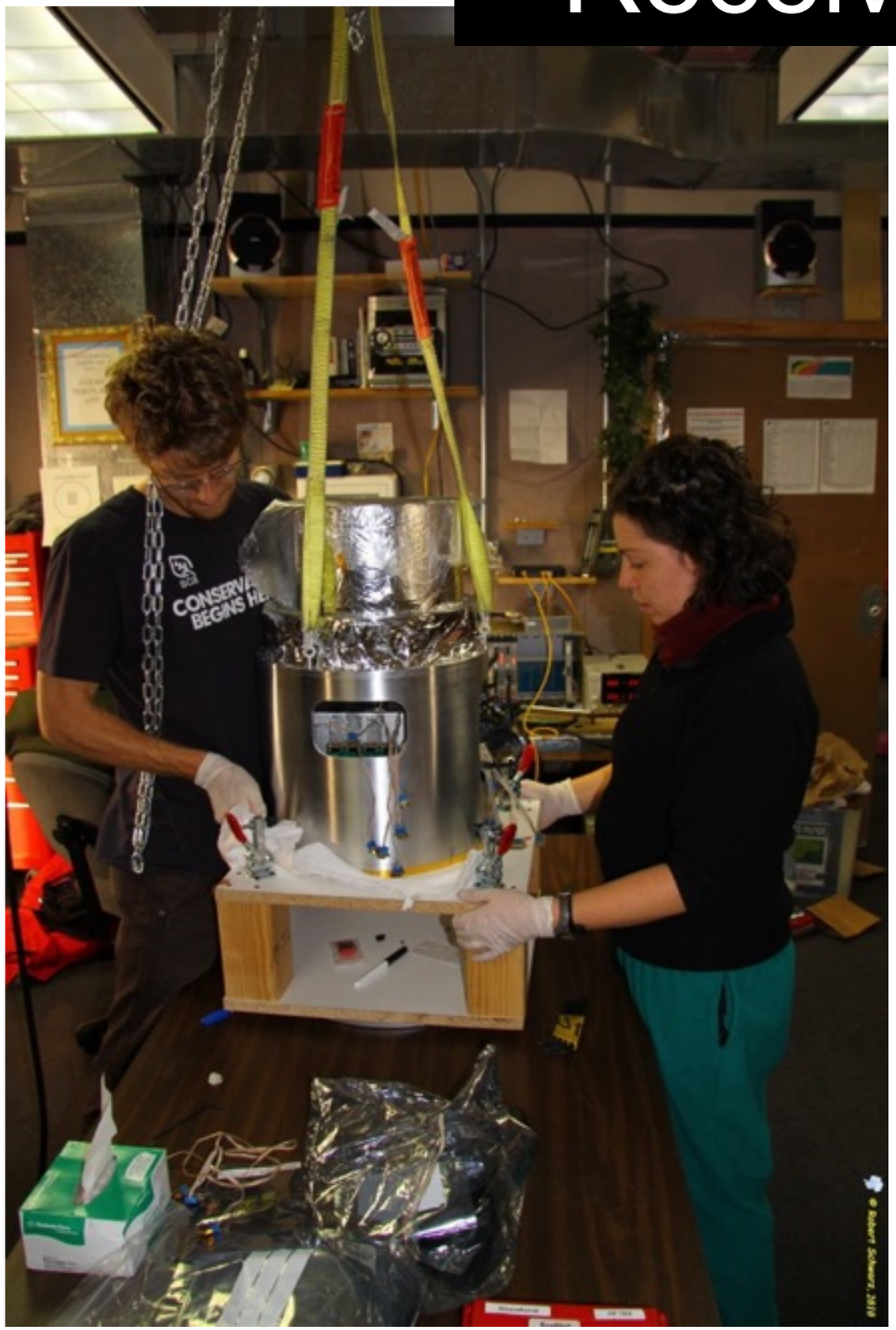
Last bit of land…

Arrival at Pole

Dark Sector



Receiver assembly



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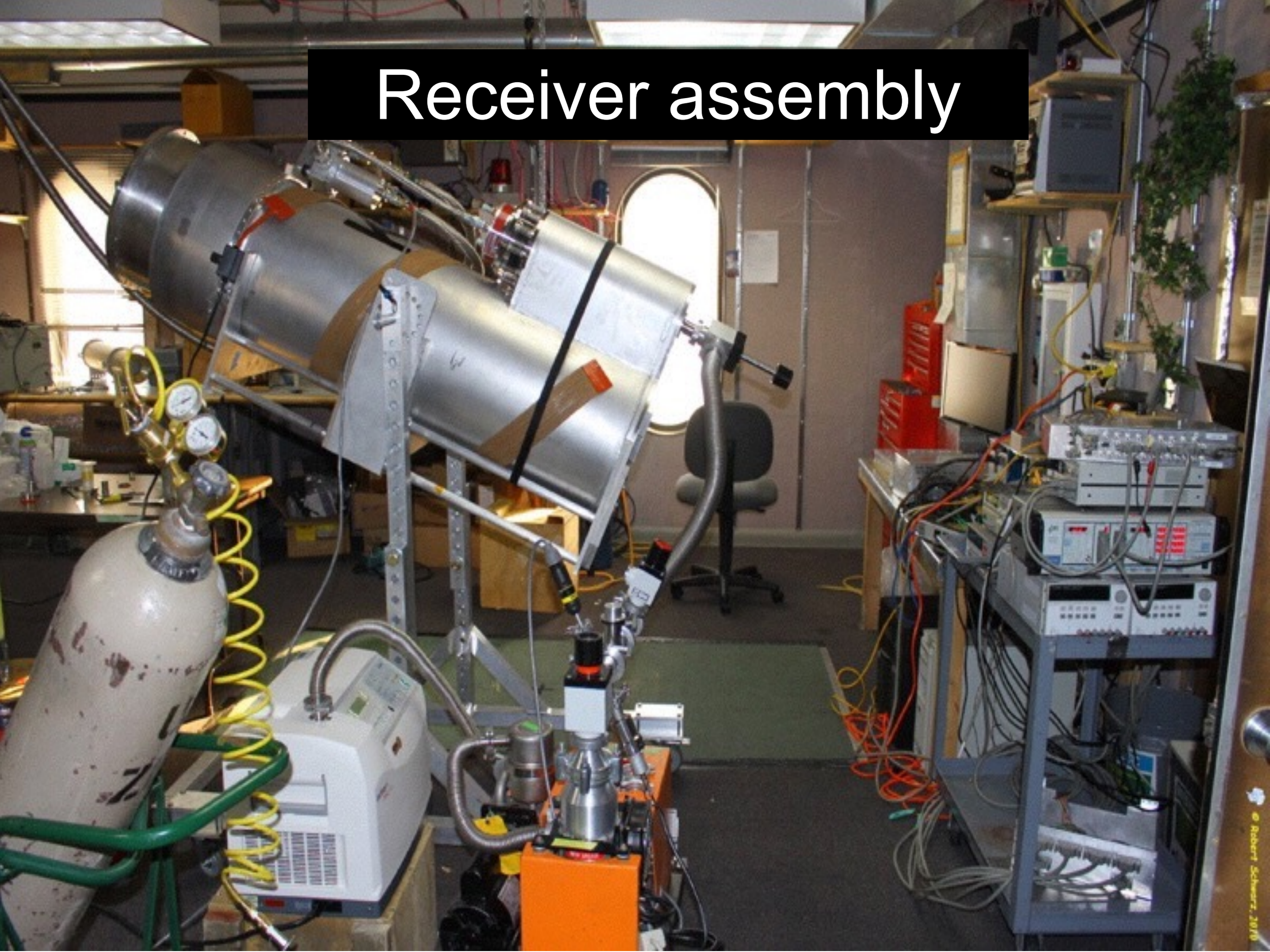
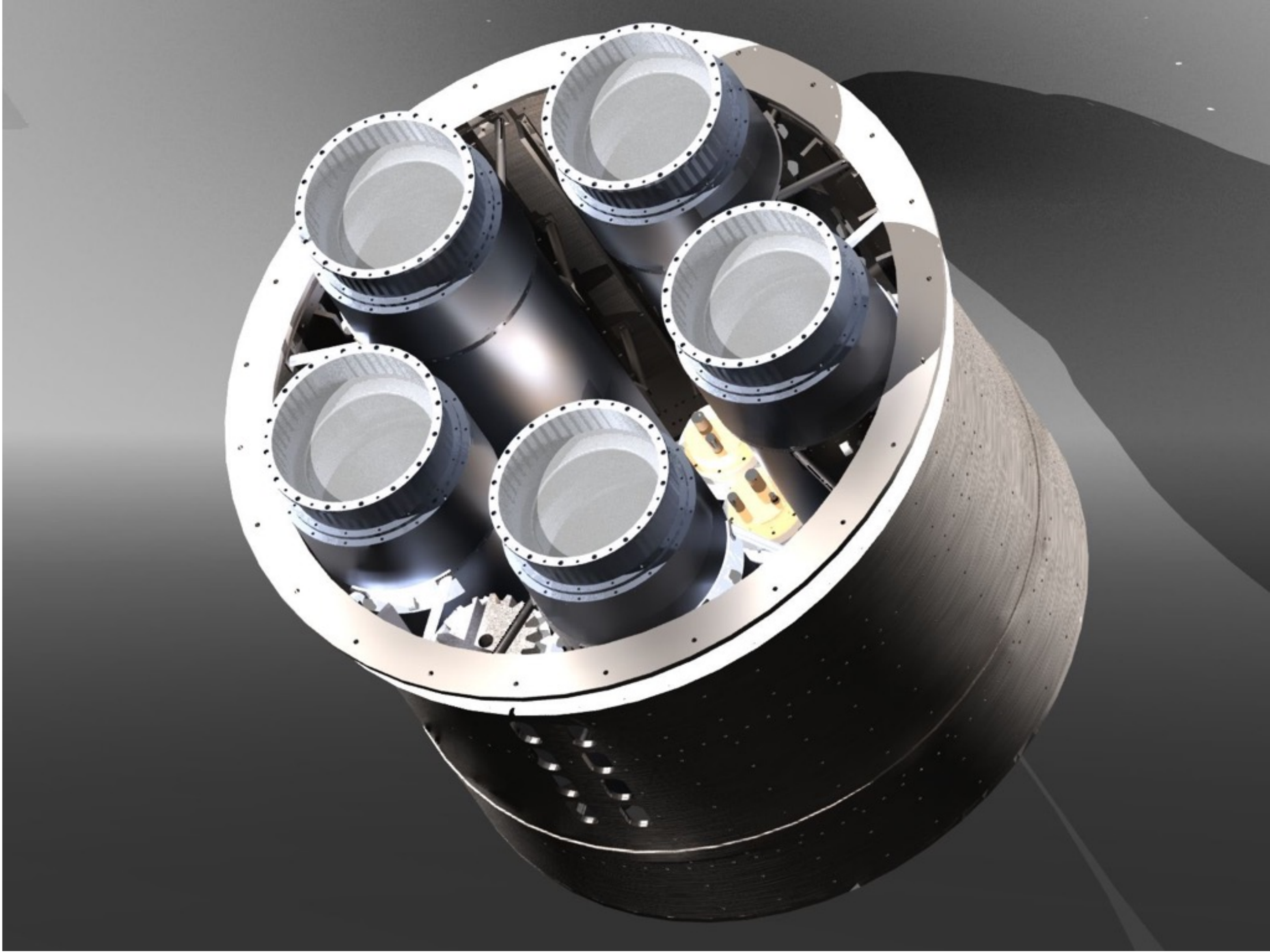


Receiver loading

Receiver loading

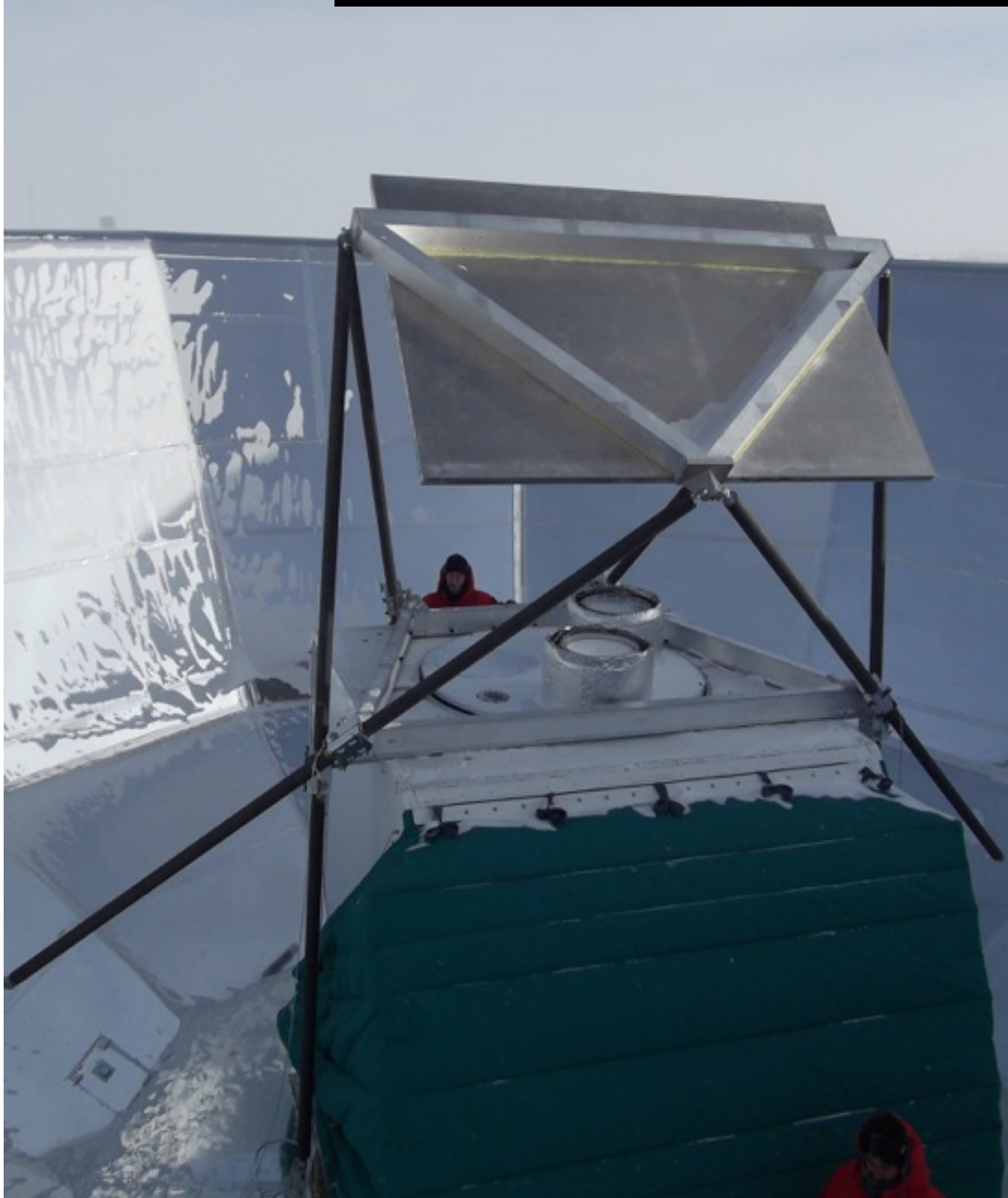


Me

BICEP3 Beam Calibration

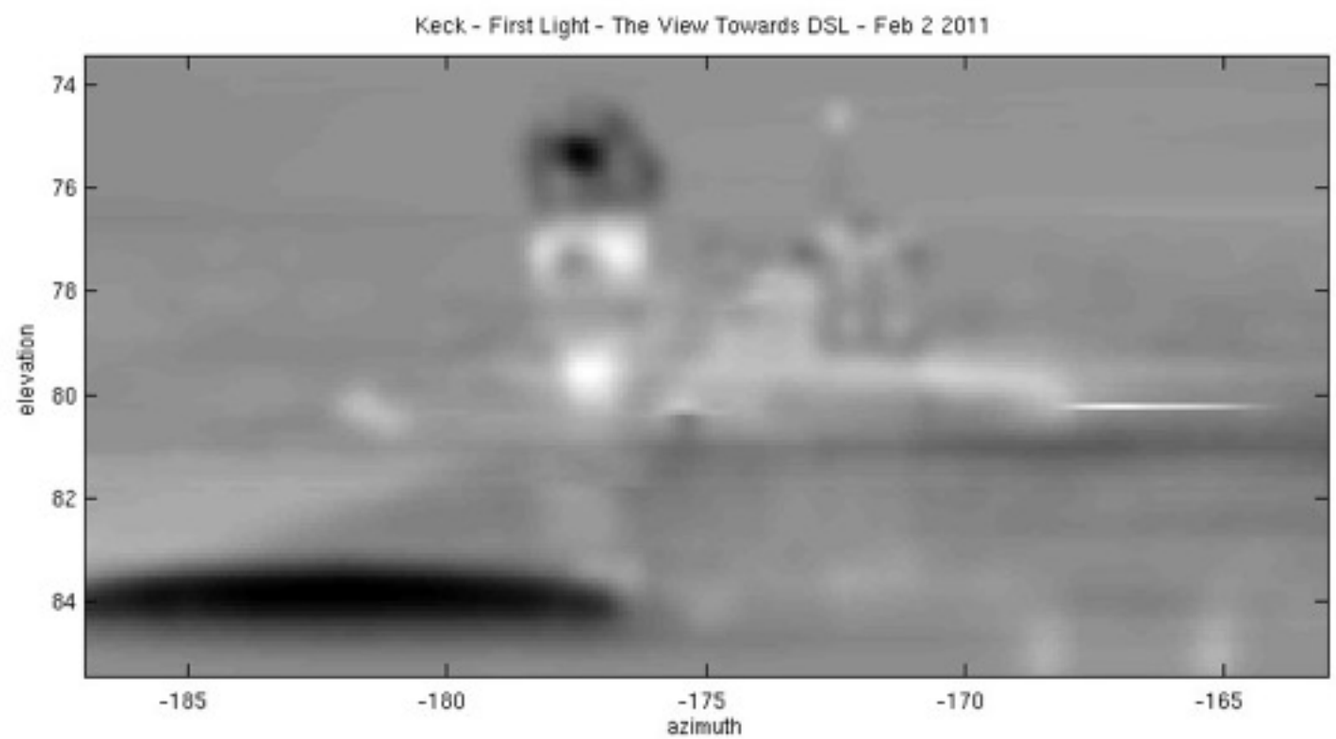
Far field beam mapping:
microwave source mounted here

Keck Beam Calibration

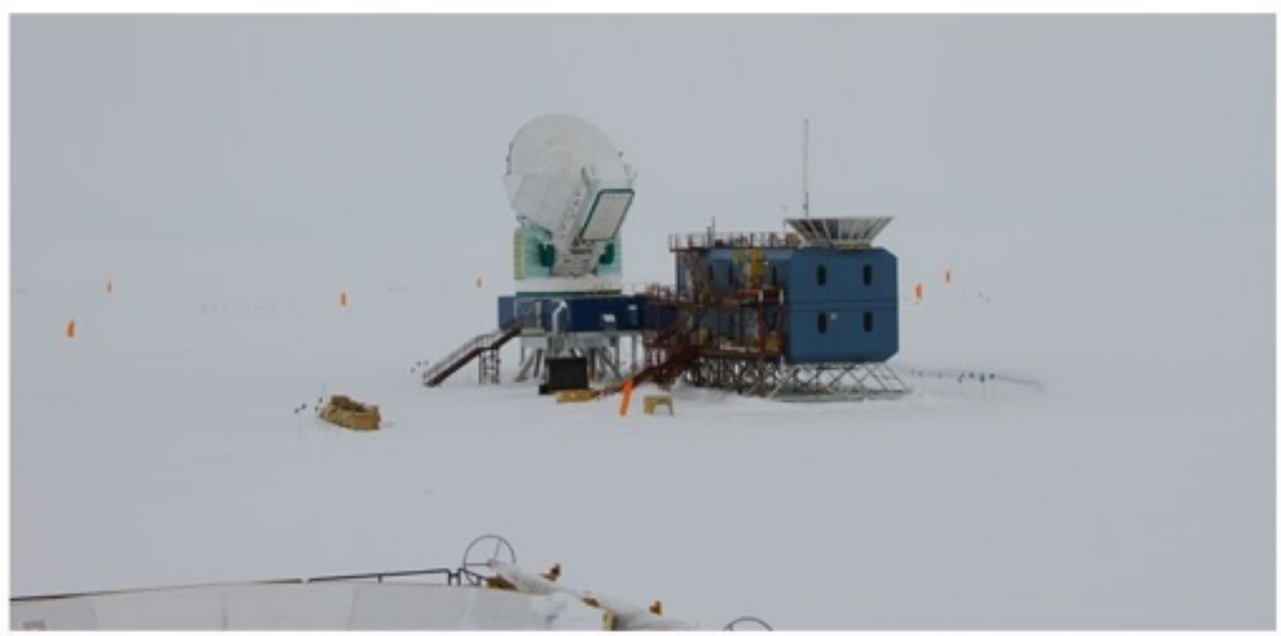


Beam map raw data

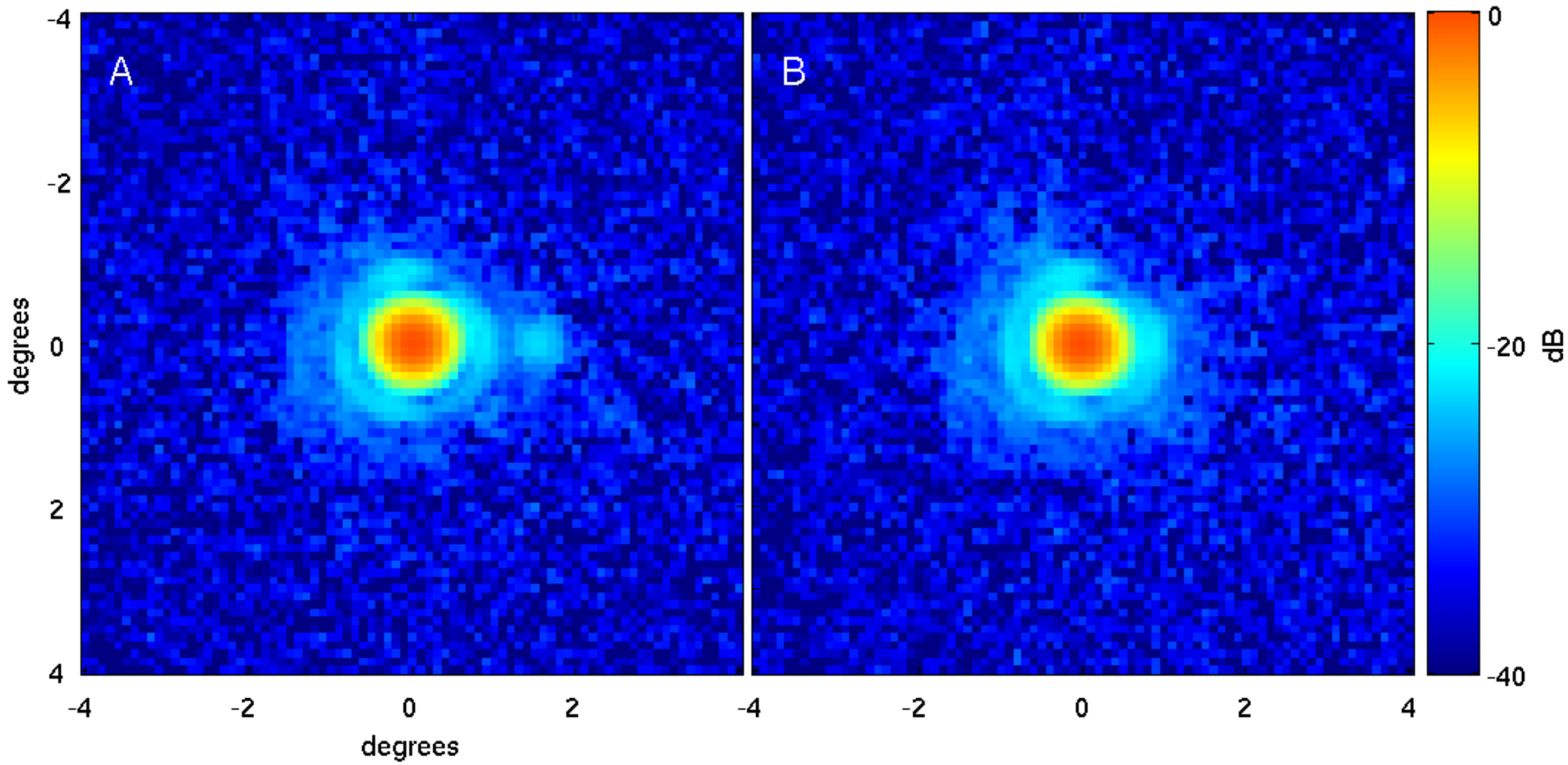
150 GHz



Visible light



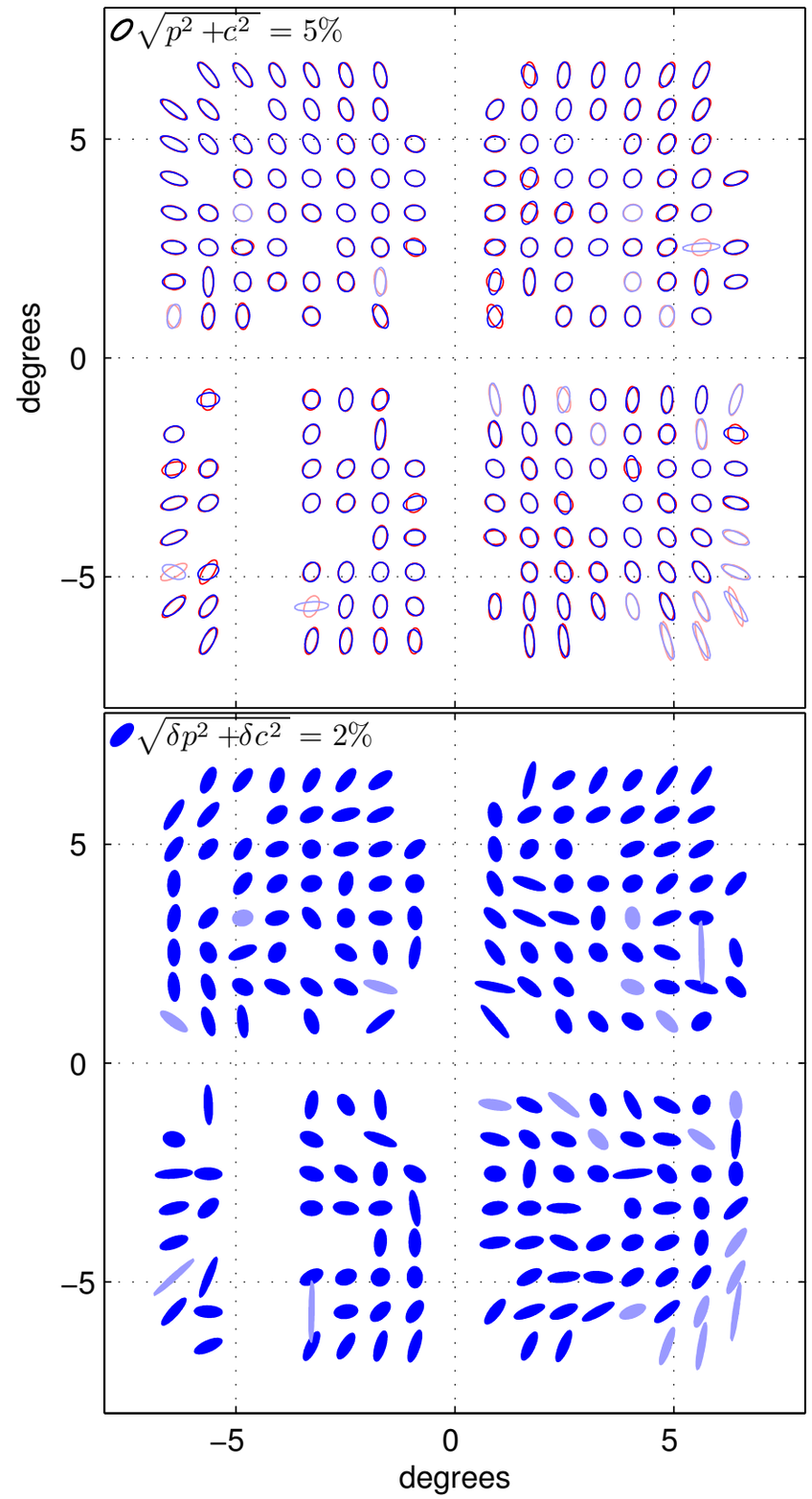
Beam maps



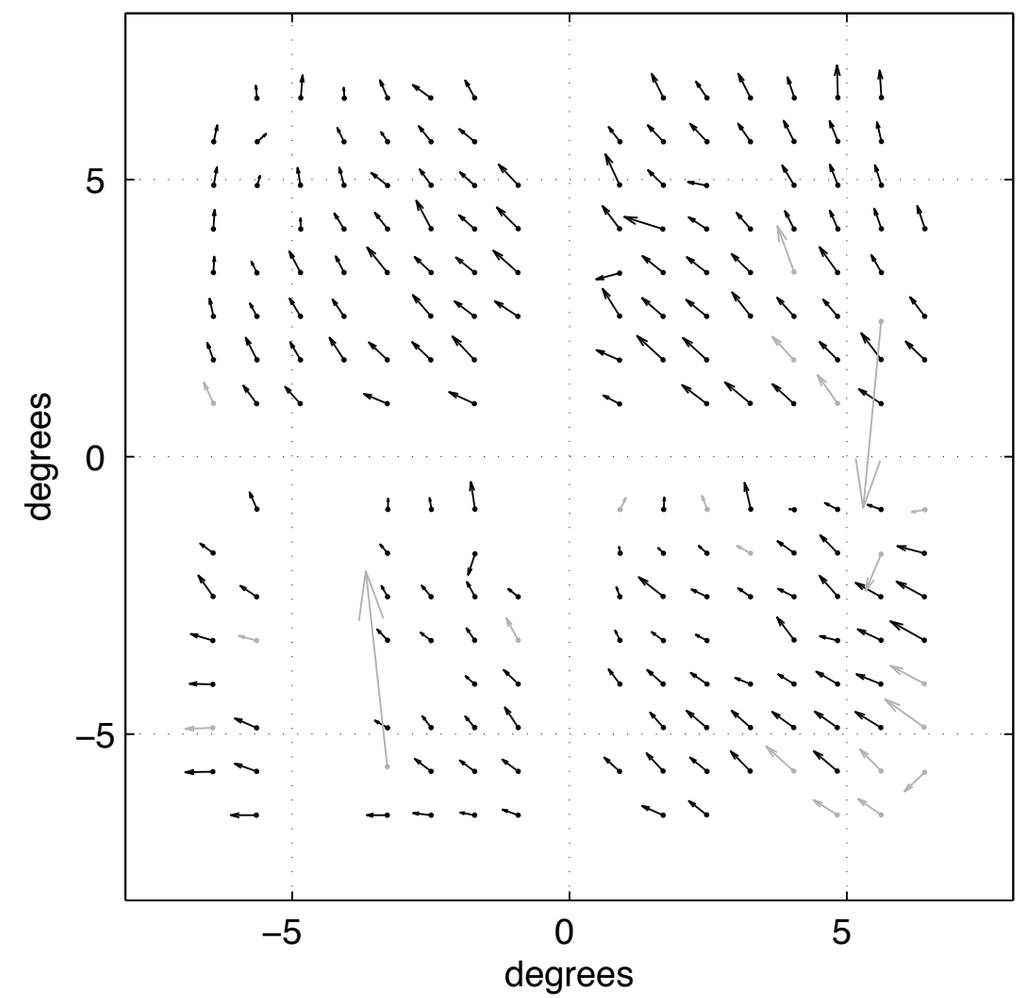
We know our beam shapes

beam ellipticity

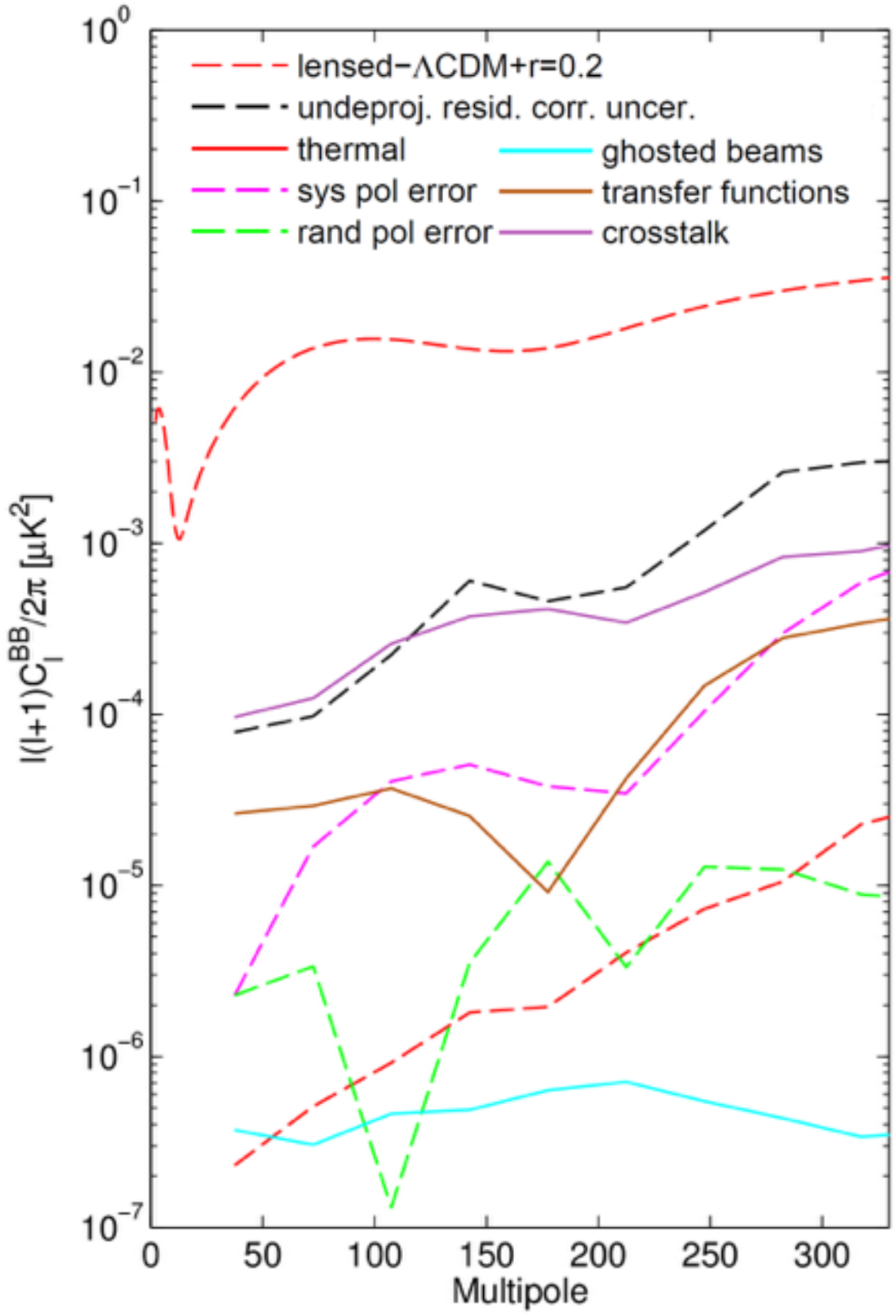
differential ellipticity



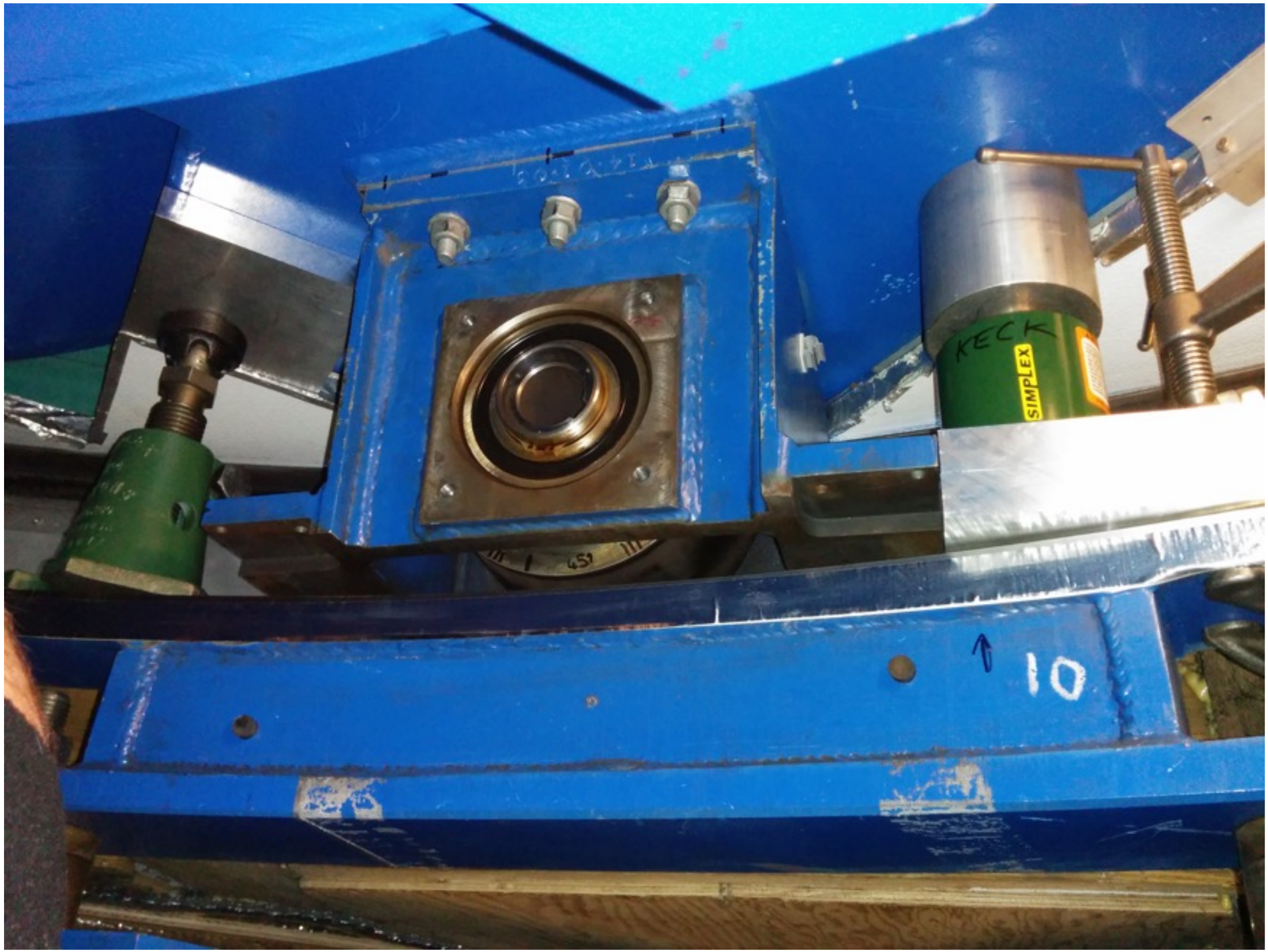
differential beam centroids (x20)



Systematics



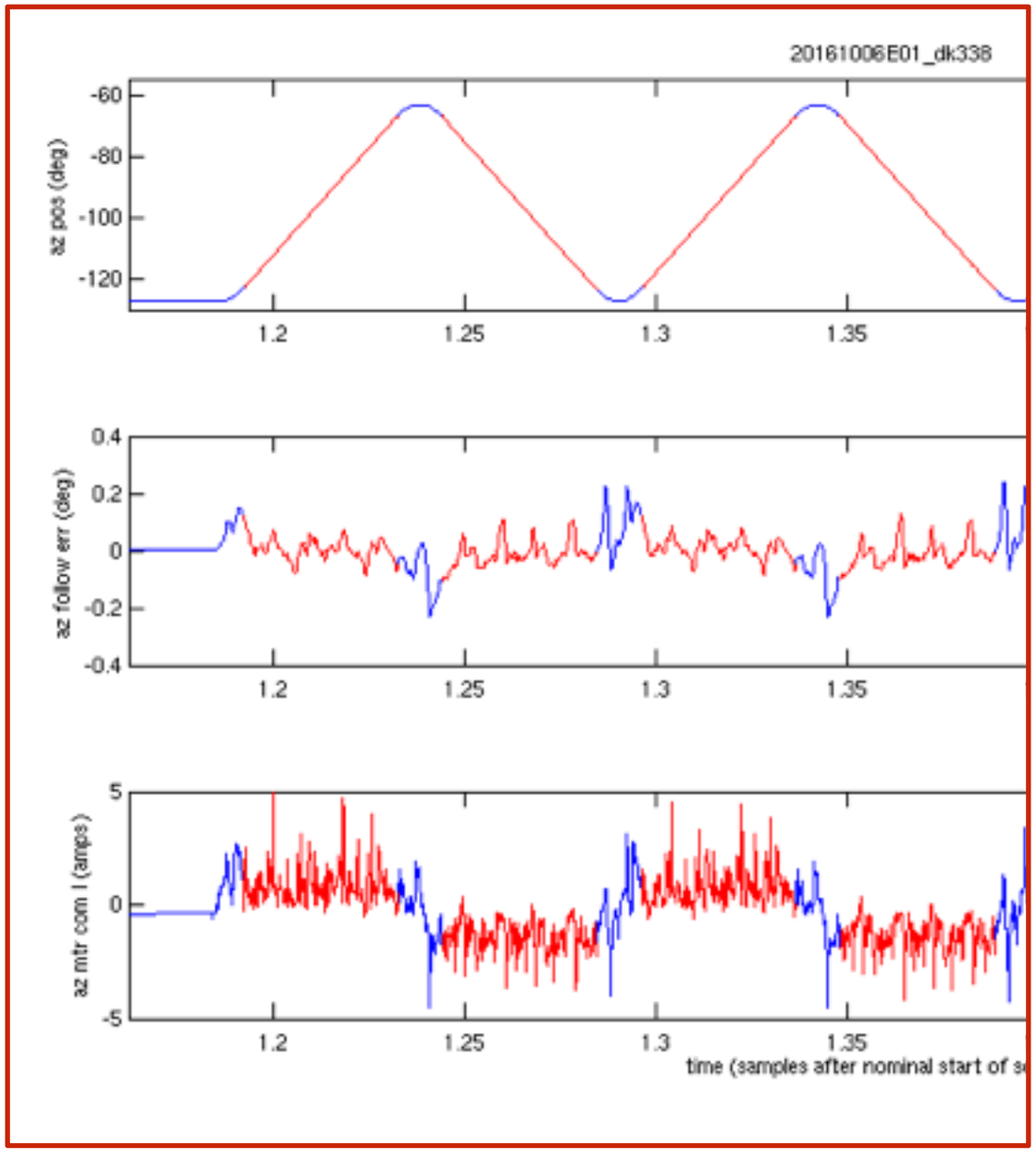
Mount and motion control upgrades



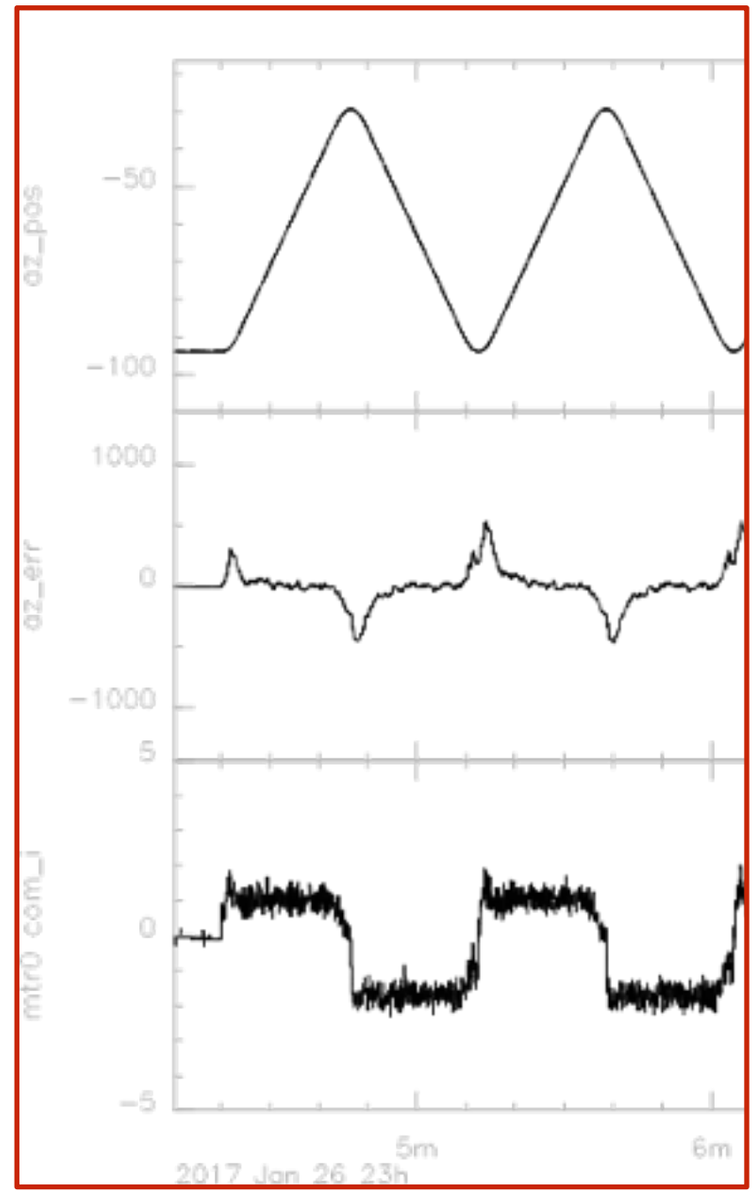
Mount and motion control upgrades

Mount and motion control upgrades

Mount and motion control upgrades



Before



After

Prep for BICEP Array, now funded

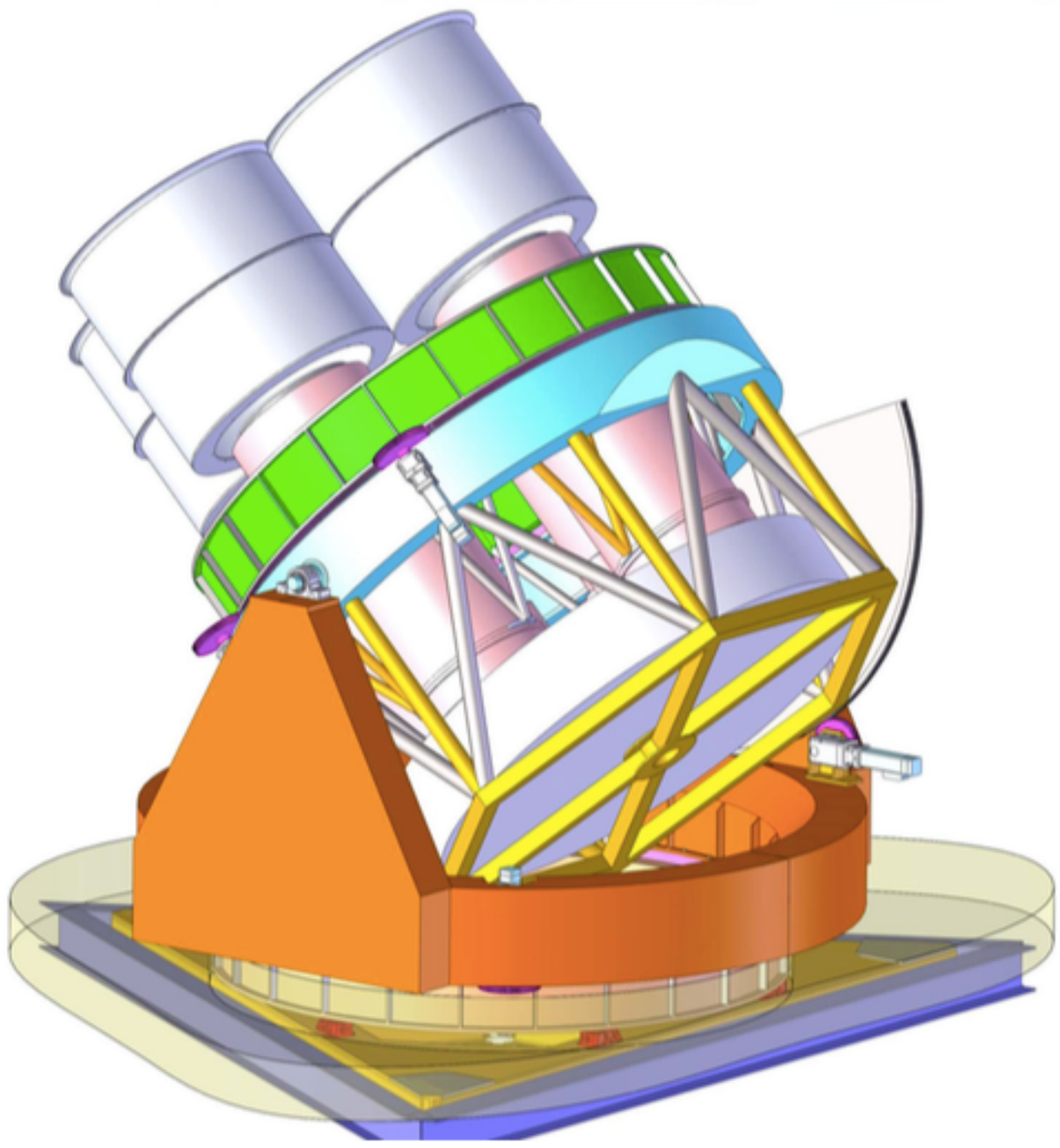


Figure 1: BA mount rear iso-view at 45° elevation

video: Robert Schwartz