

Status and Recent Results from the BICEP Suite of Experiments at the South Pole

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University of Chicago
TeVPA, August 2017

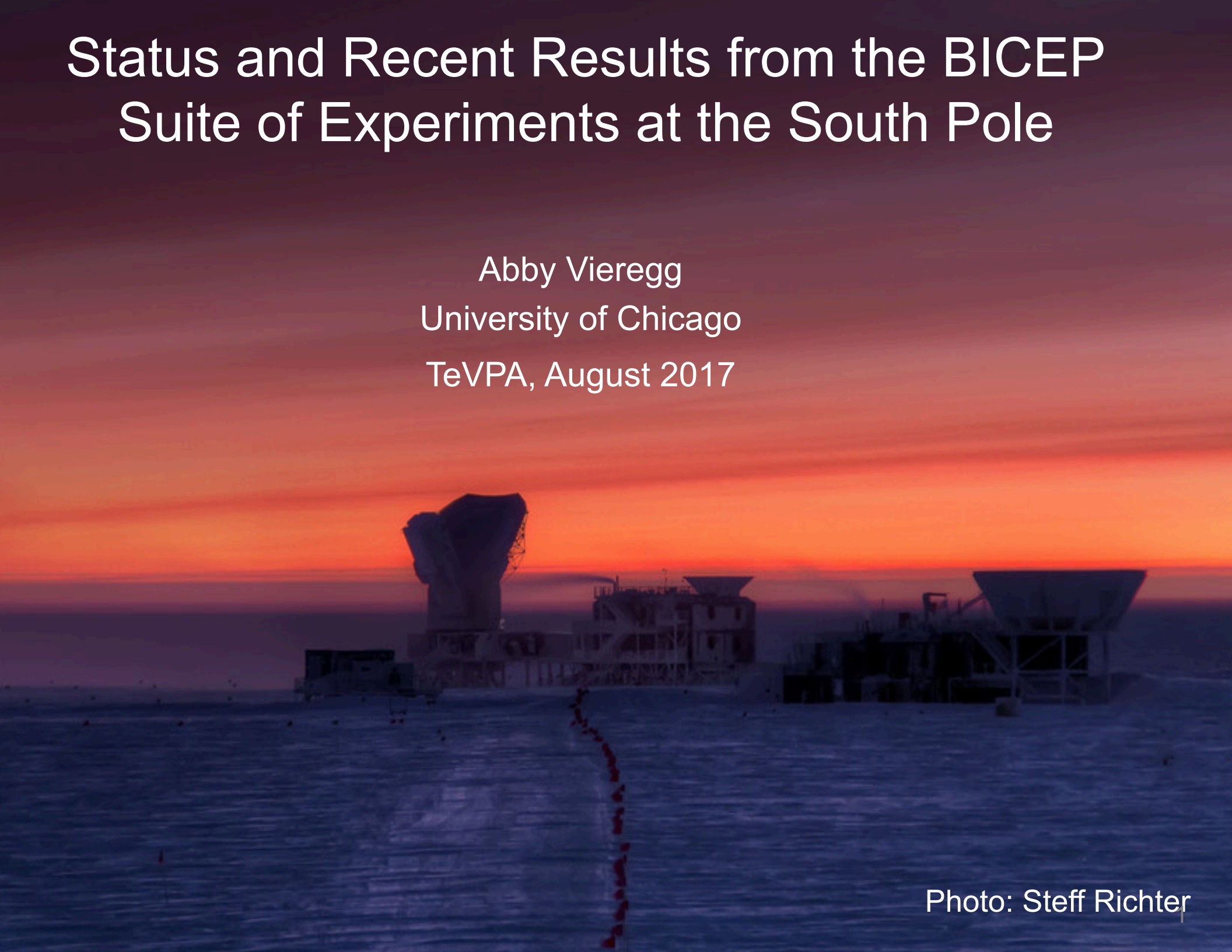
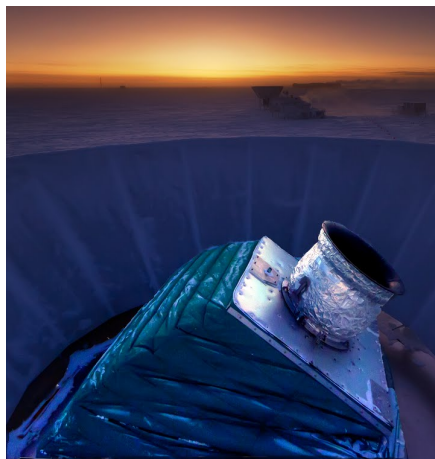


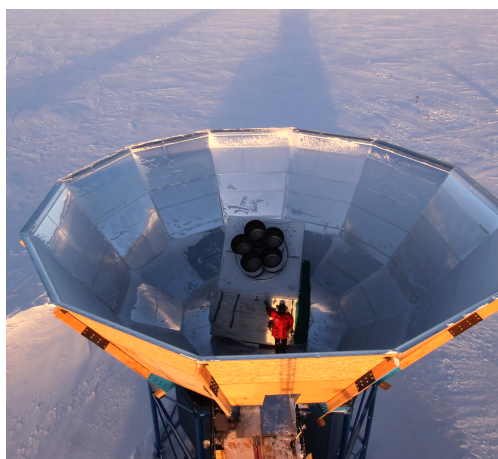
Photo: Steff Richter

Stage 2

BICEP2
(2010-2012)

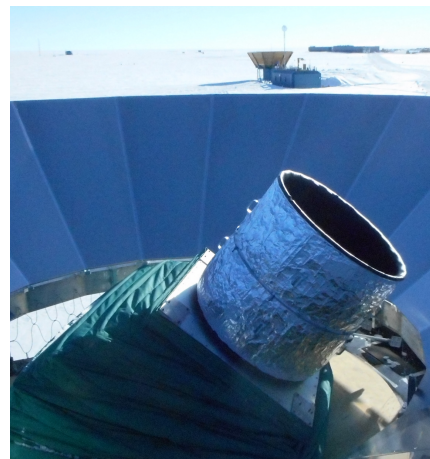


Keck Array
(2012-2018)

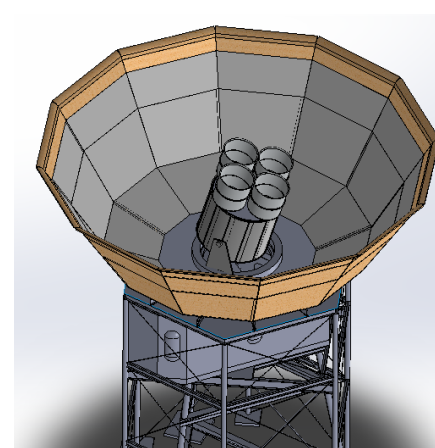


Stage 3

BICEP3
(2015-)

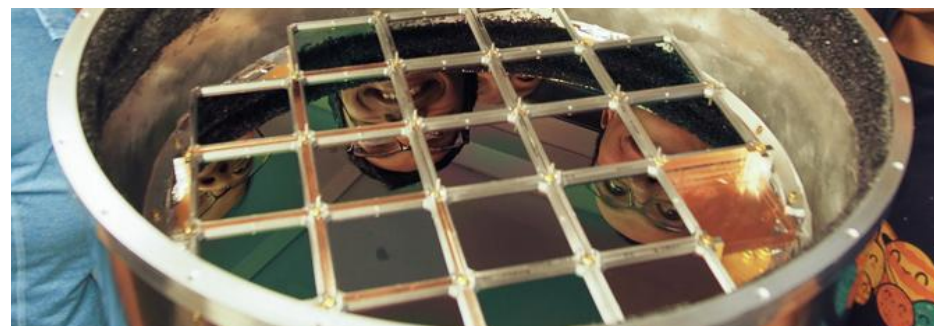
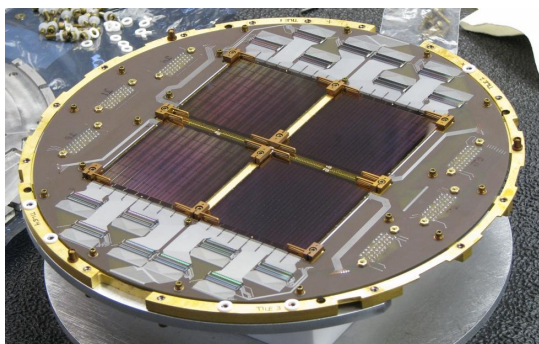


BICEP Array
(2018-)

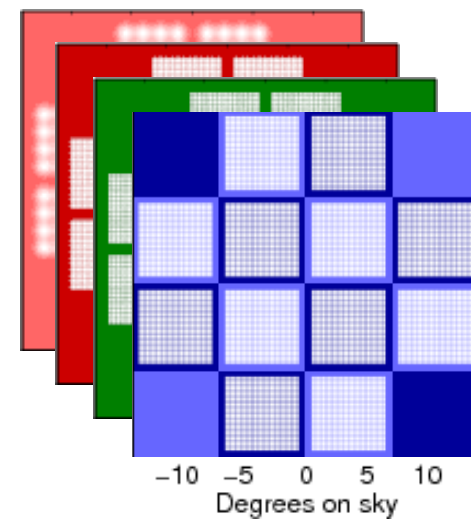
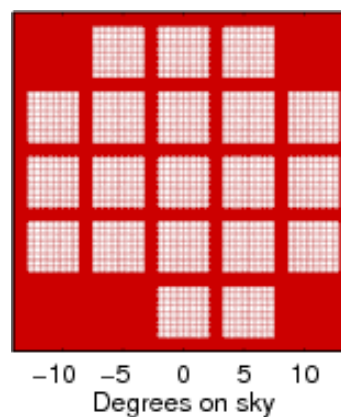
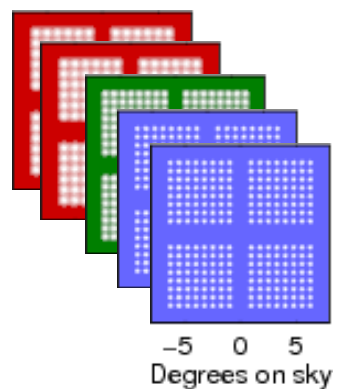
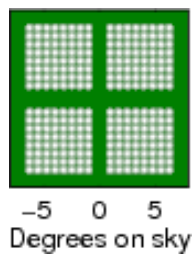


Telescope and Mount


Focal Plane



Beams on Sky



Experimental Strategy

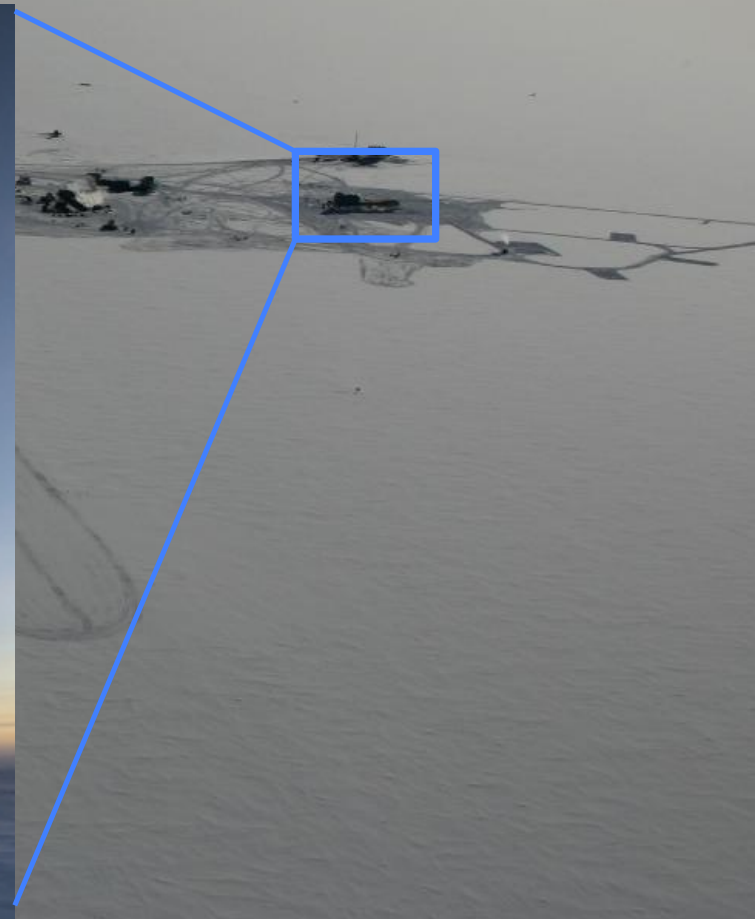
- 
- Small aperture telescopes
 - Target the ~ 2 degree peak of the Primordial B-mode spectrum
 - Observe a small patch of clean sky
 - Integrate continuously from South Pole (high, dry, stable site)

Experimental Strategy

The Dark Sector Lab

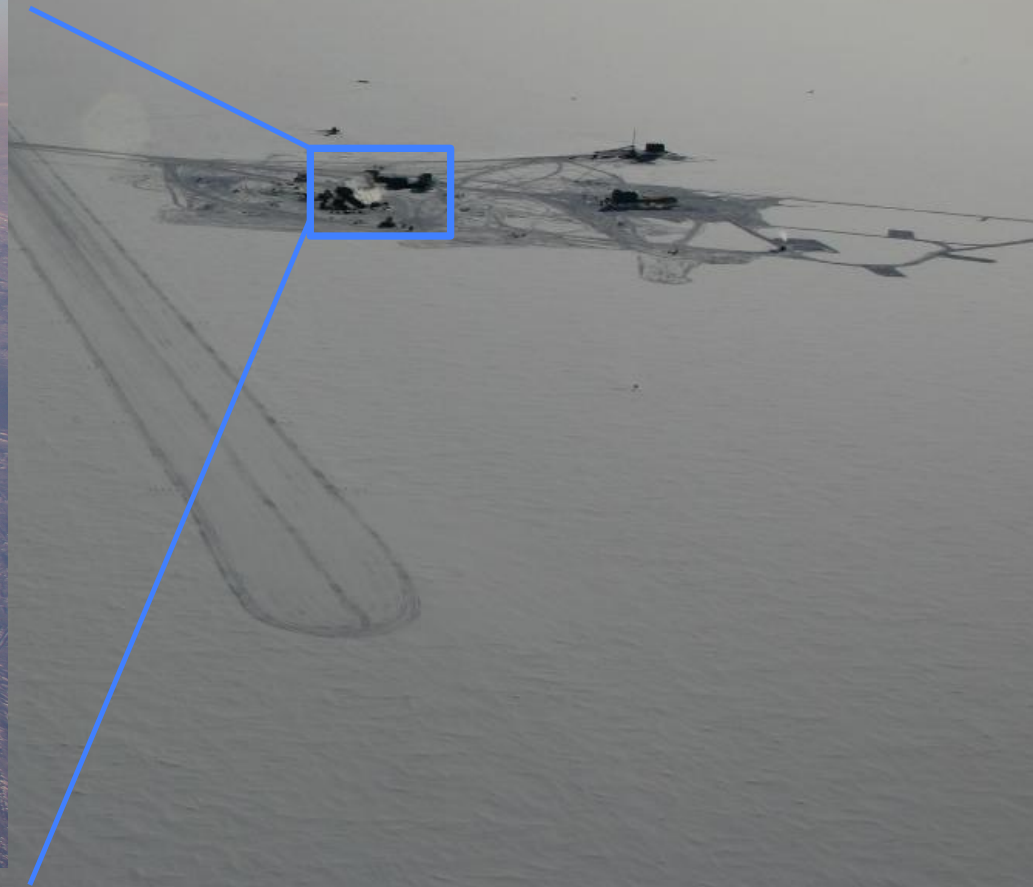
BICEP2/3

SPT



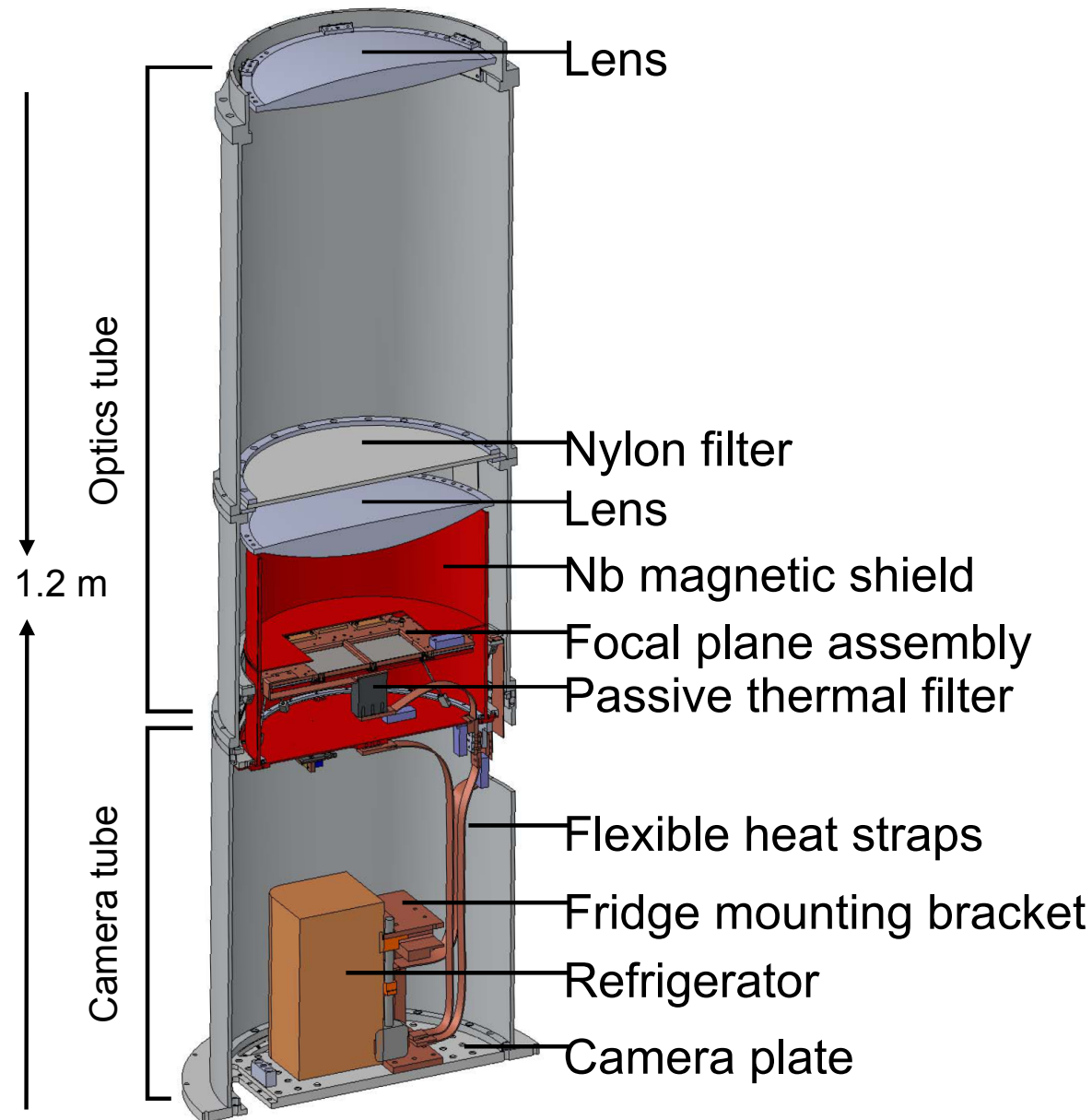
Experimental Strategy

The Keck Array/BICEP Array



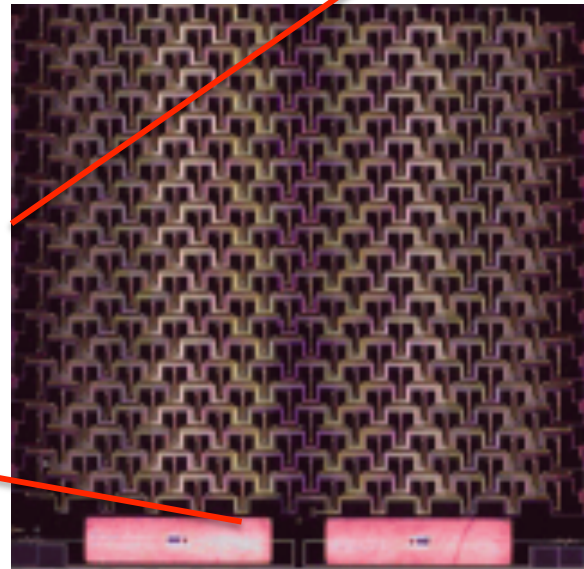
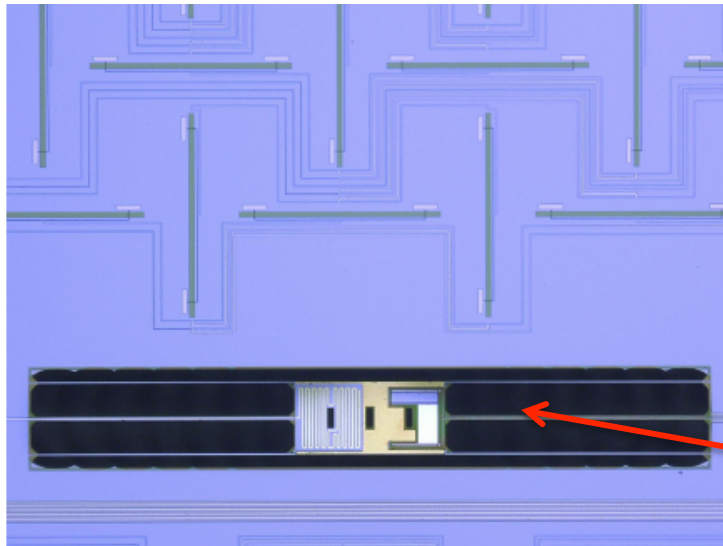
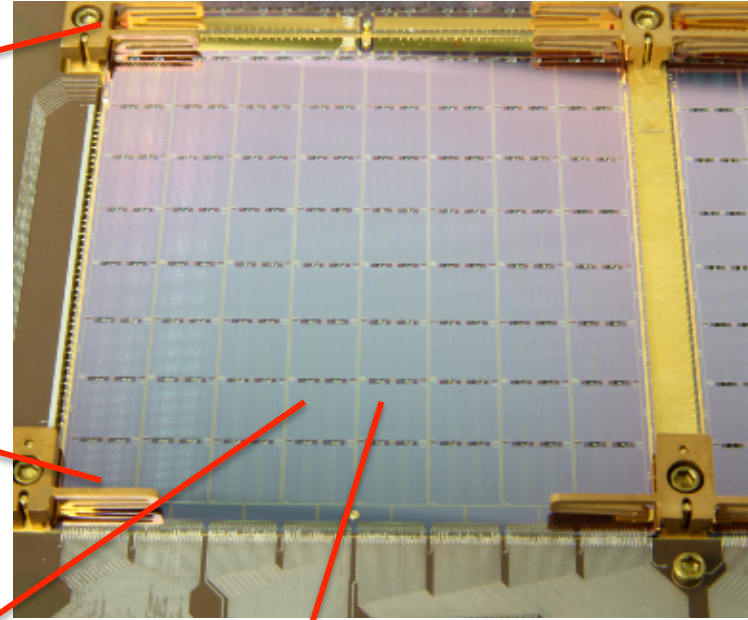
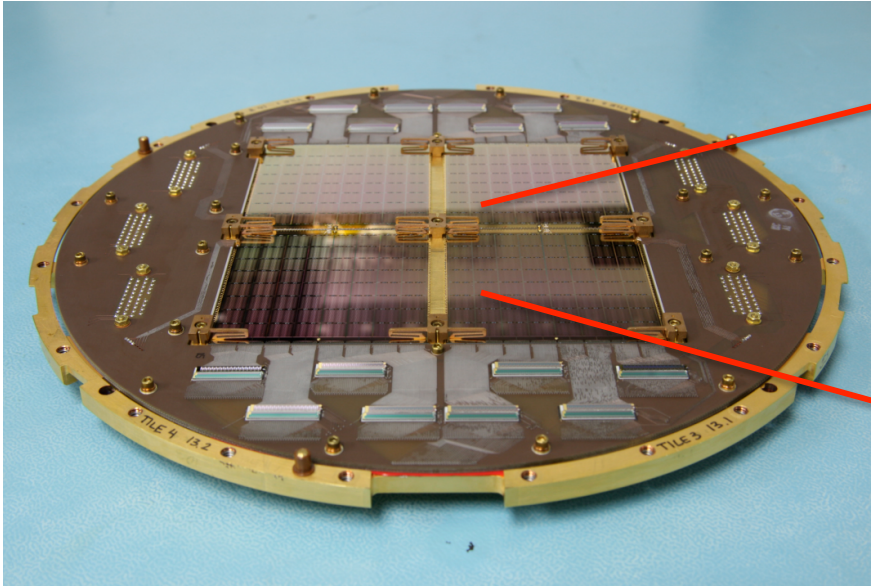
BICEP/Keck Telescope

- Cold (4K), on-axis, refractive optics
- Small aperture \rightarrow ~ 0.5 degree beams
- Compact telescope for tight systematics control and ability to rotate around optical axis
- Detectors cooled to 250 mK using a helium sorption refrigerator



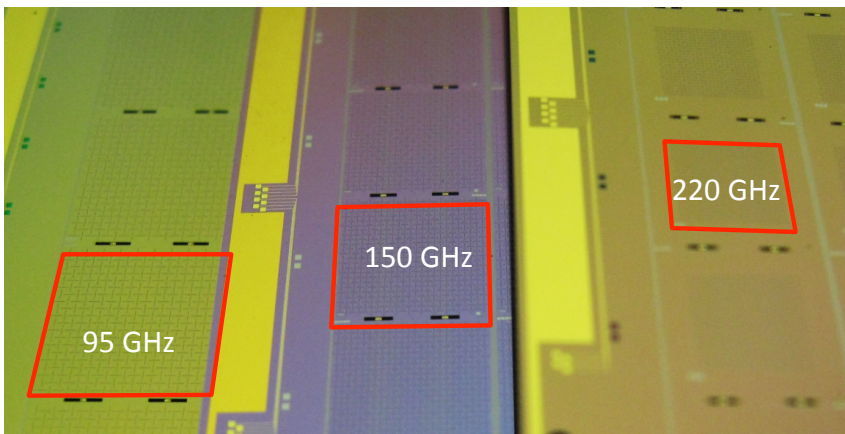
Background Limited, Scalable Detectors

BICEP Focal Planes, Made at JPL

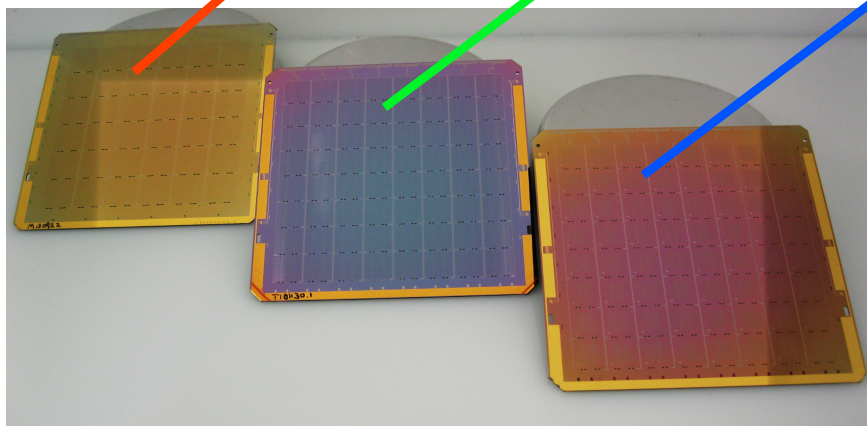


- Ti Transition Edge Sensor (TES) Bolometers
- **Background limited detectors: only way to do better is more detectors**

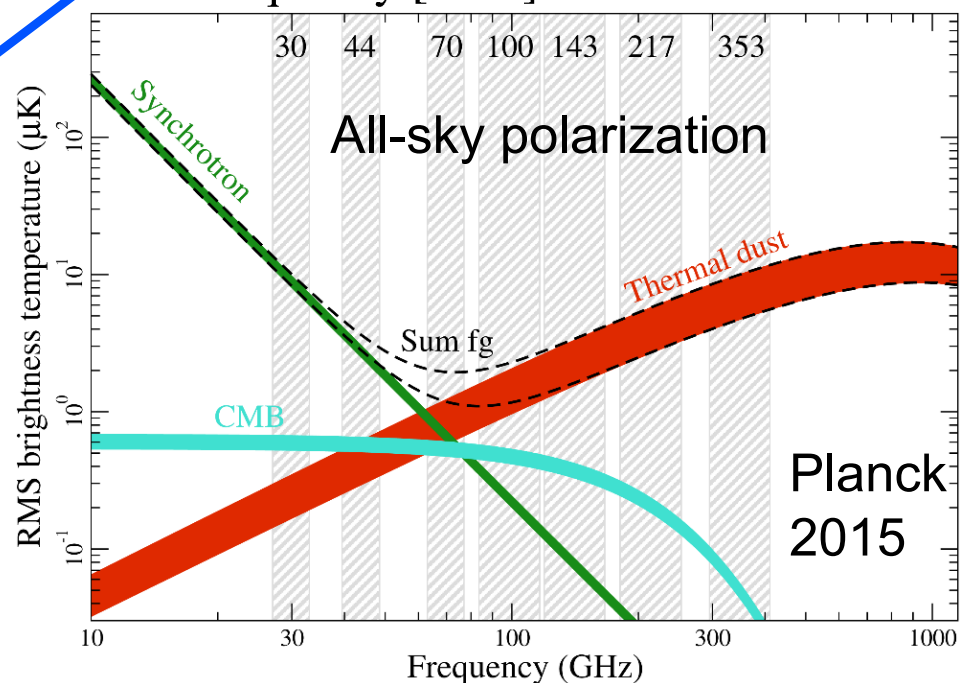
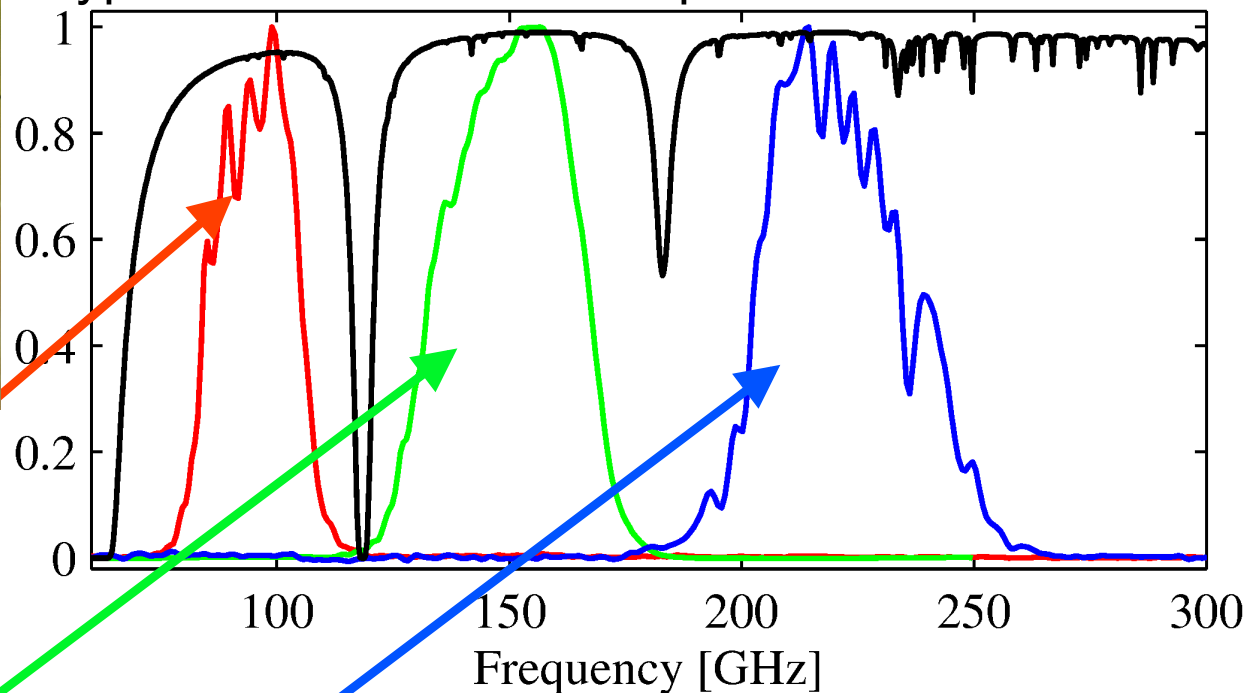
Multiple Frequency Bands



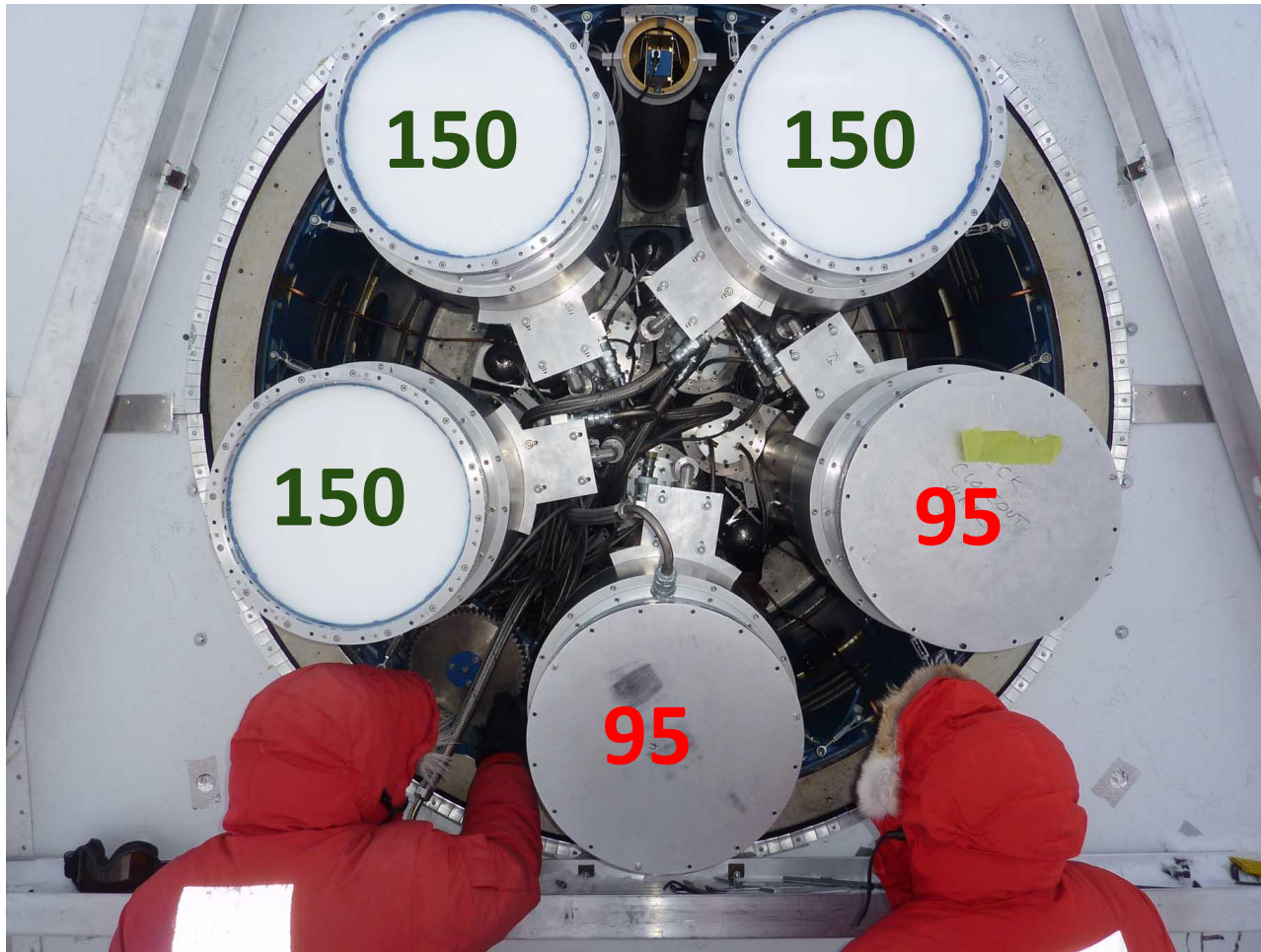
Detectors designed to scale in frequency



Typical South Pole atmospheric transmission



Published BICEP/Keck Dataset (BK14)



BICEP2 2010-2012
150 GHz

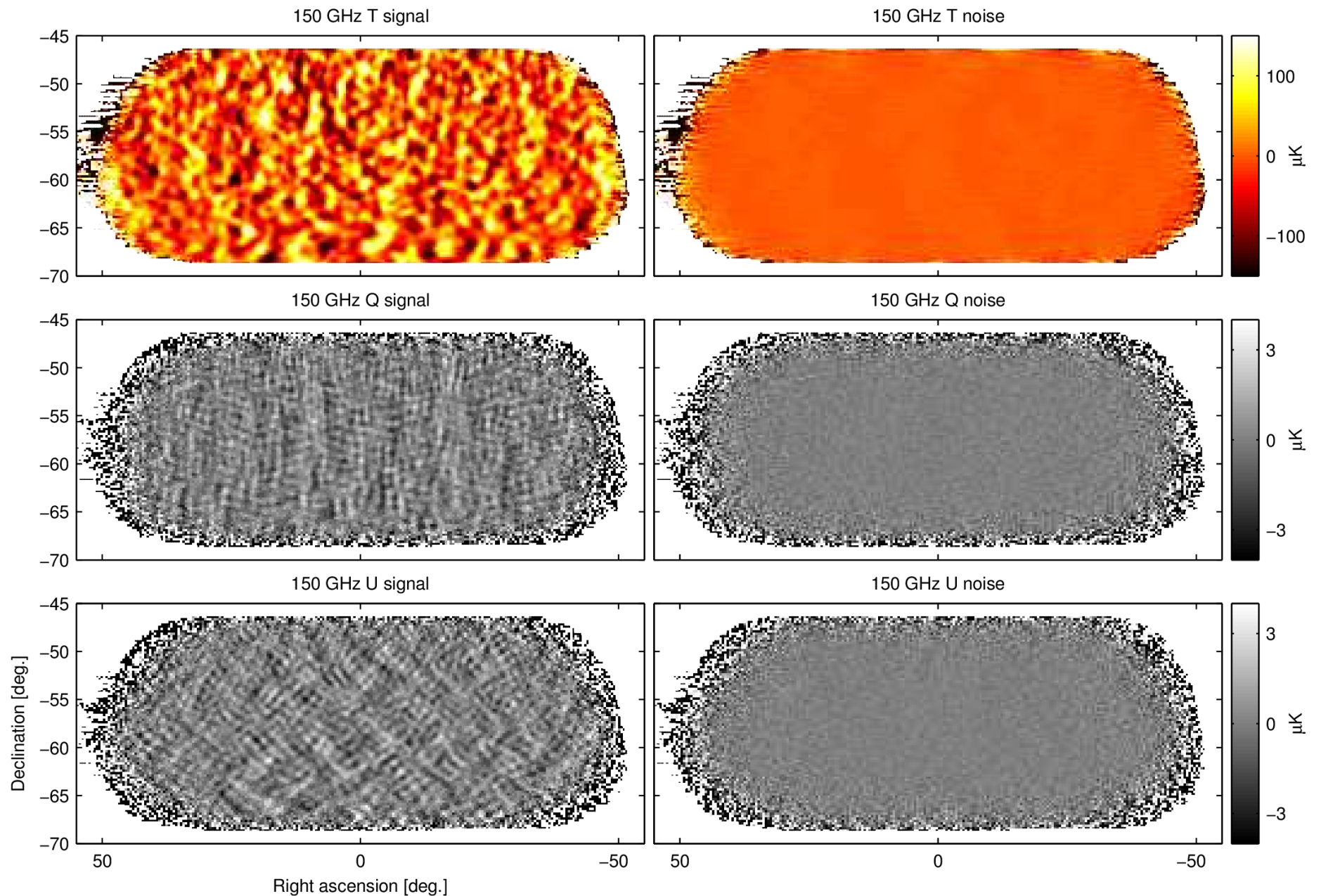
5x Keck 2012-2013
150 GHz

2x Keck 2014
95 GHz

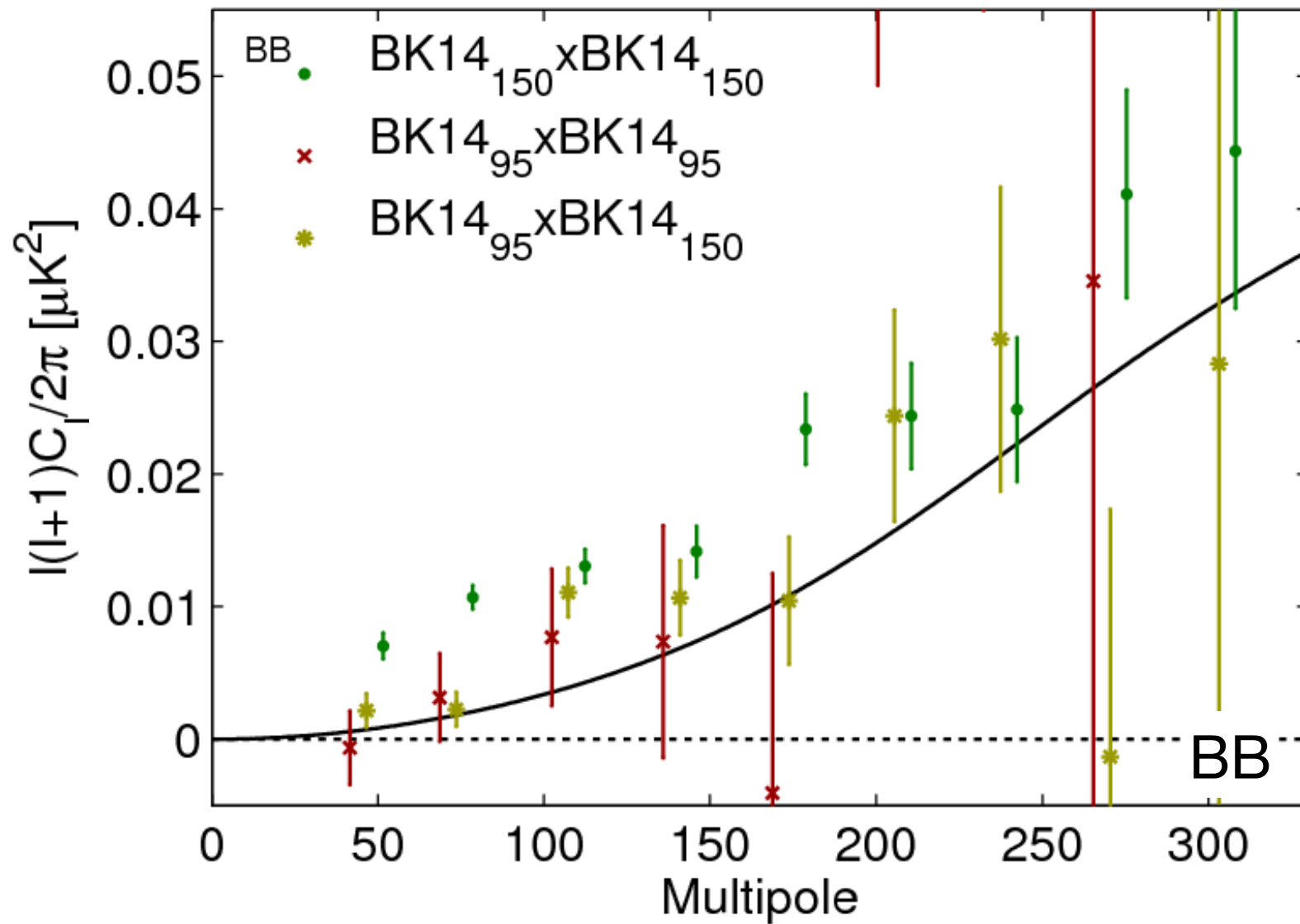
3x Keck 2014
150 GHz

2014 Configuration

150 GHz Maps

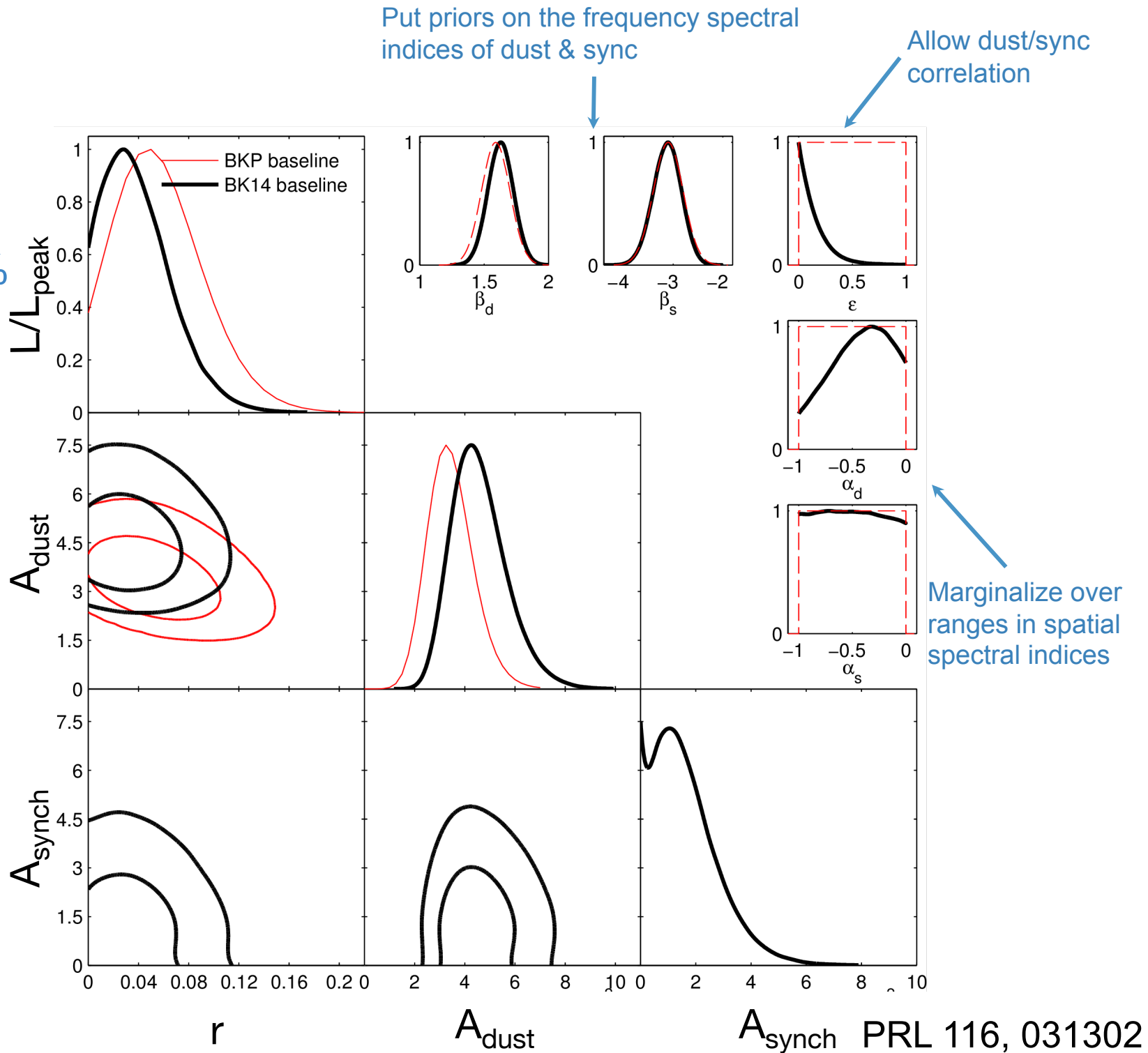


BICEP2 + Keck BB auto and cross-spectra

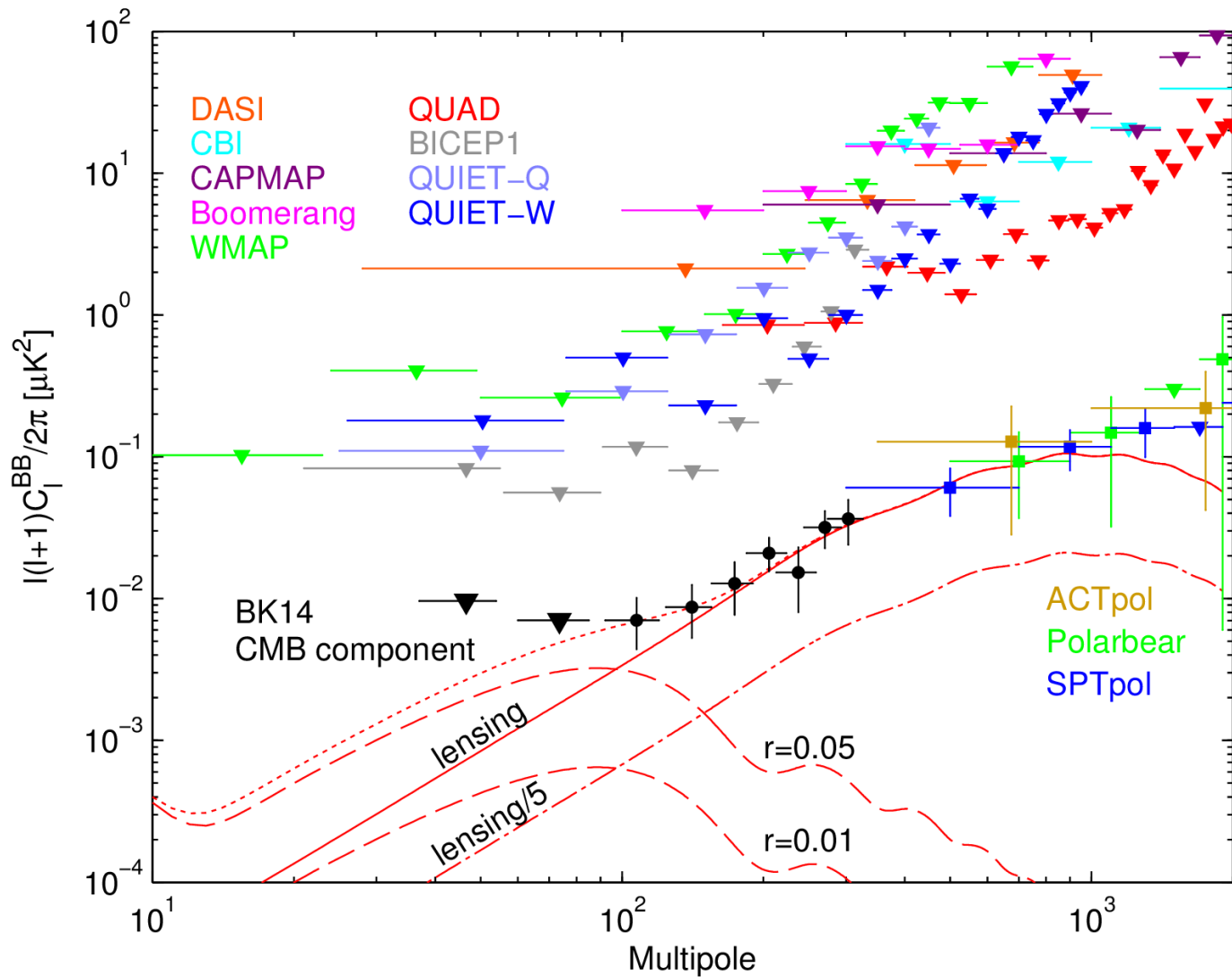


$r < 0.09$ @ 95%

(now beats temperature constraints)



Published B-Mode Measurements



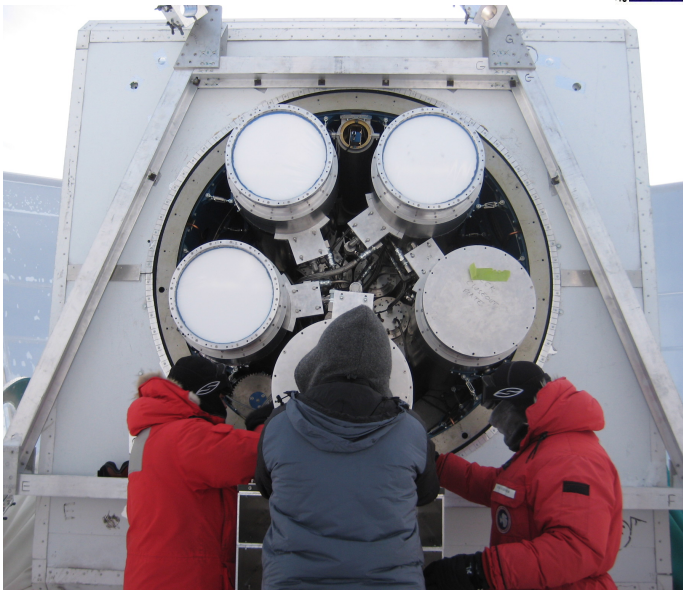
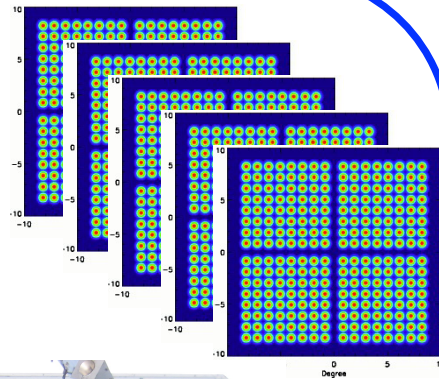
As of Nov 2016

BK14 = BICEP/Keck maps through 2014, 150 and 95 GHz

Uncertainties on r will shrink as component separation improves with deeper multiband maps.

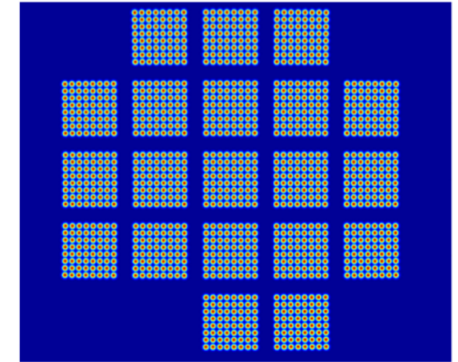
What Additional Data Do We Have in the Can?

Keck Array



2015: includes 2 x 220 GHz
2016: includes 4 x 220 GHz
2017: includes 1 x 270 GHz

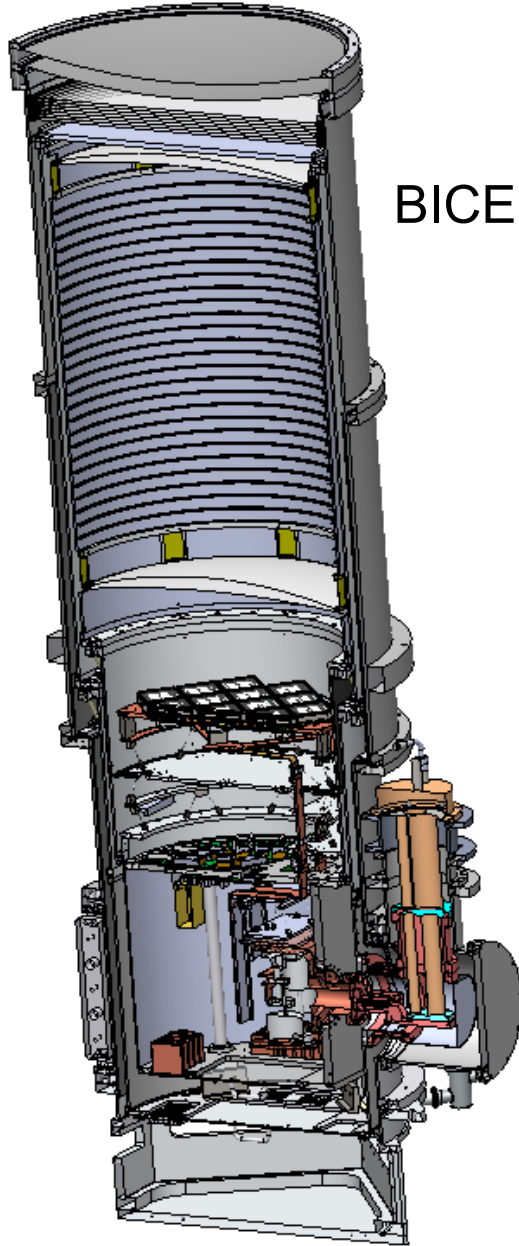
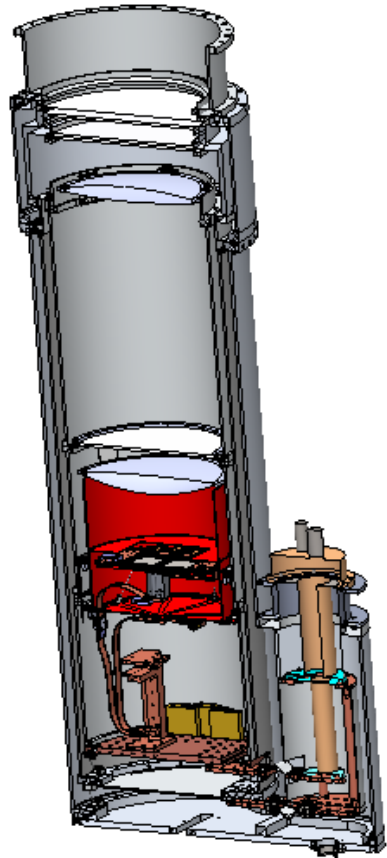
BICEP3



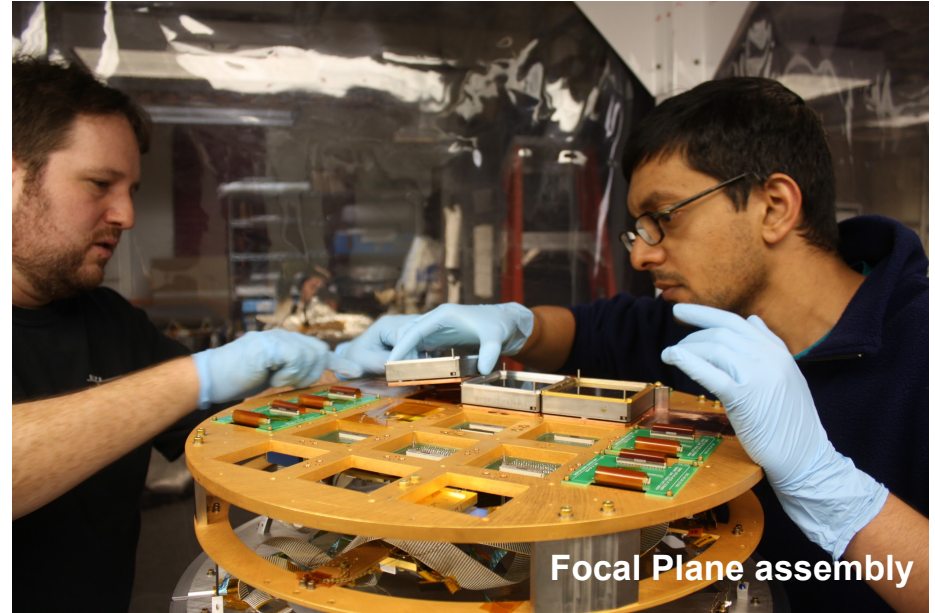
2400 detectors
@ 95 GHz since 2016

BICEP3: 2400 detectors @ 95GHz since 2016

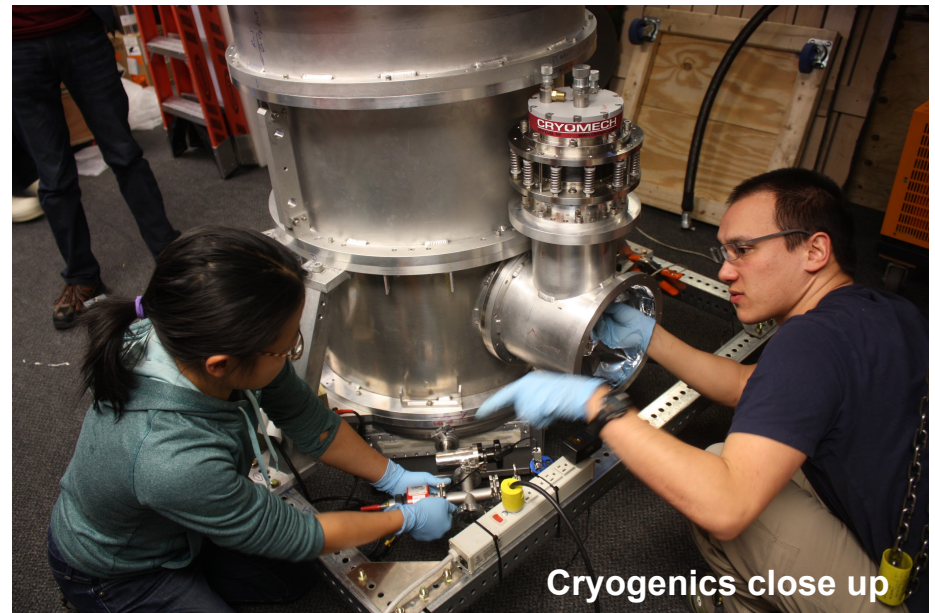
Keck receiver



BICEP3

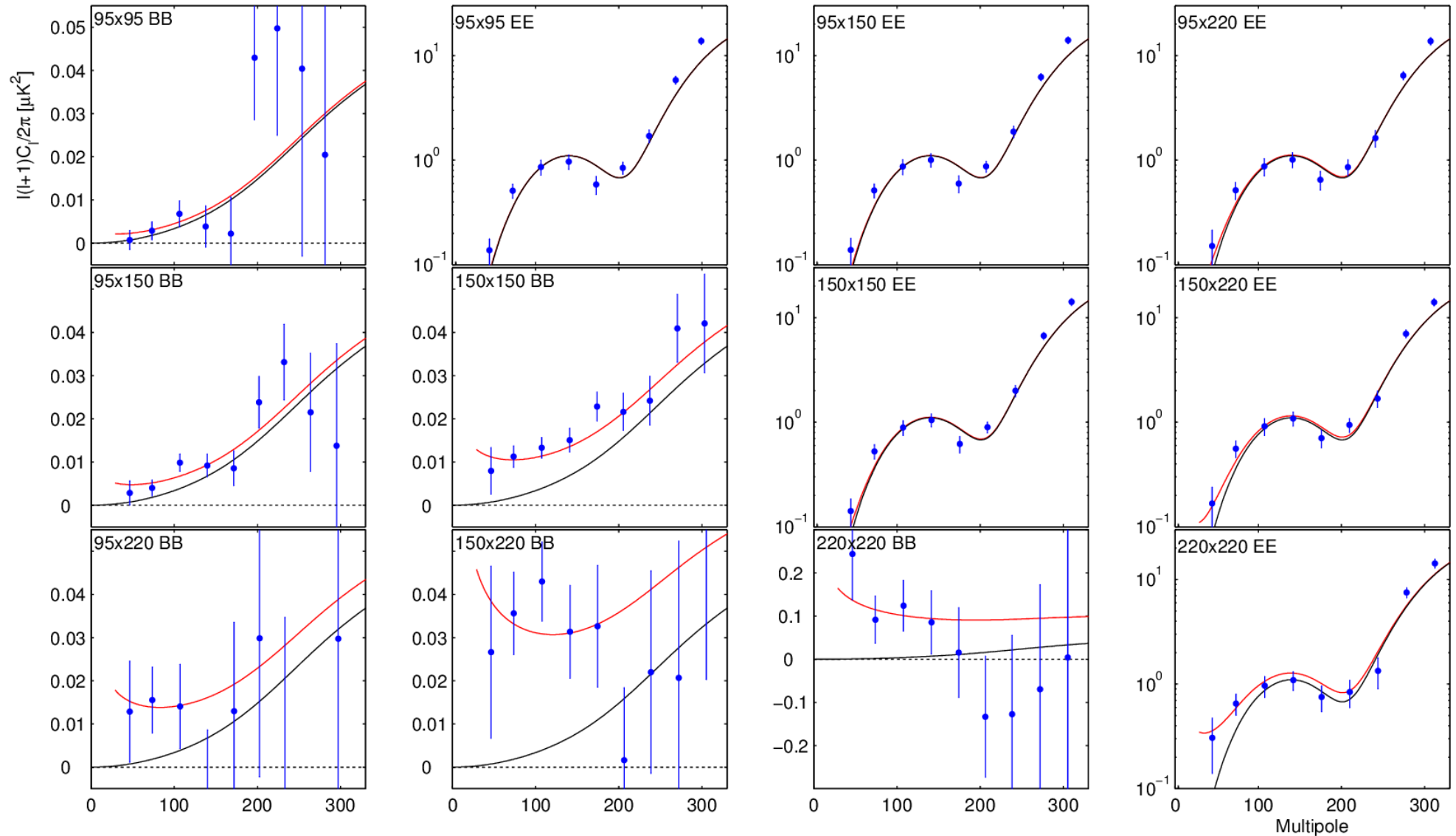


Focal Plane assembly



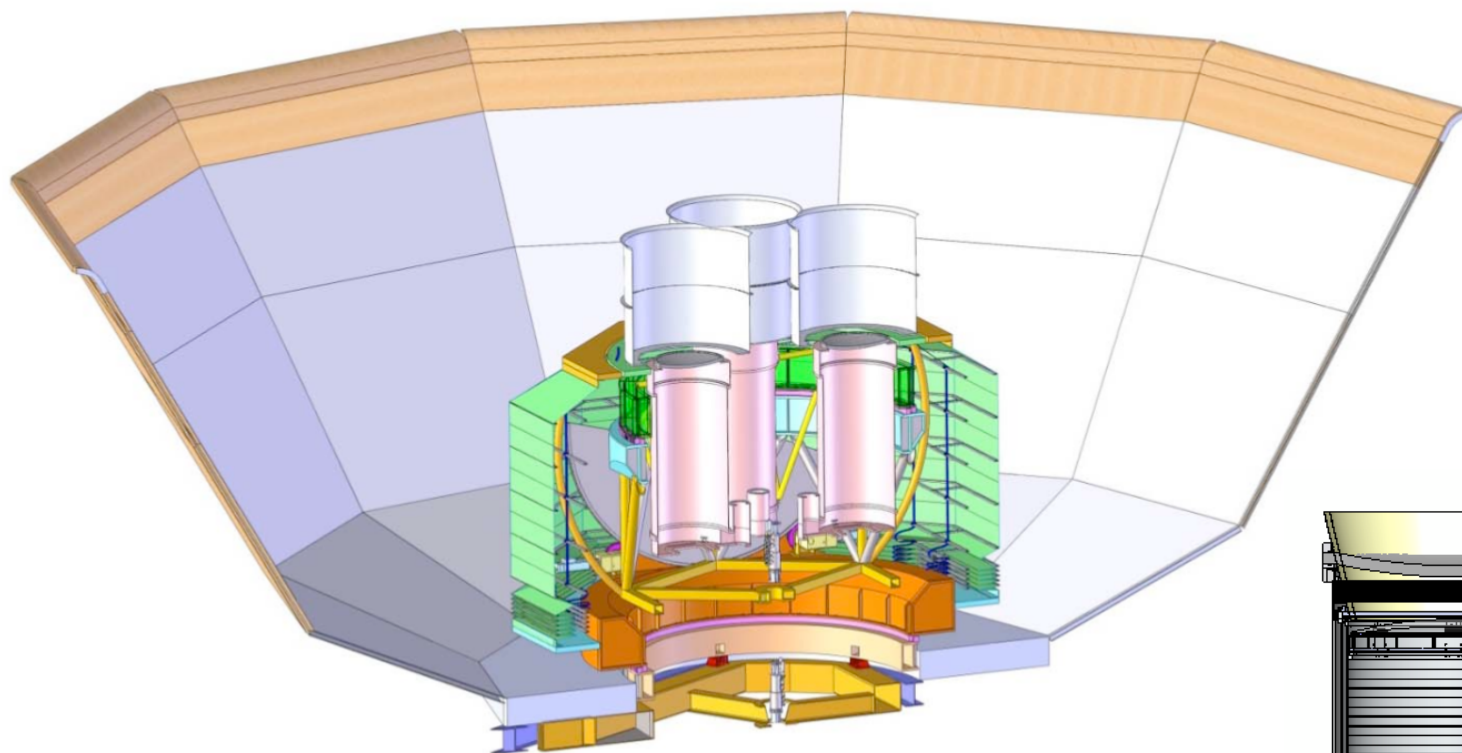
Cryogenics close up

Upcoming BK15 spectra

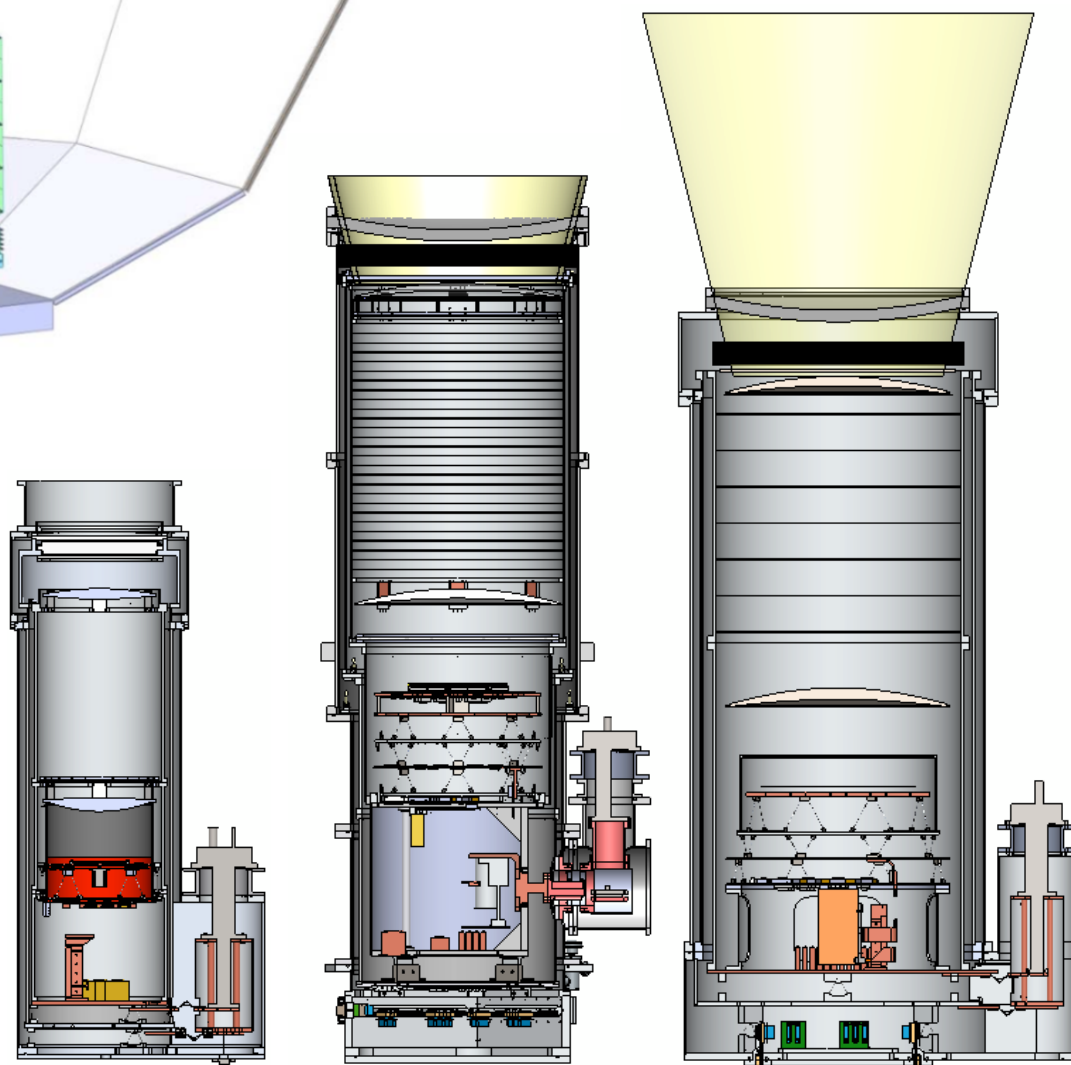


Spectra using all data up to and including 2015 - **for the first time**
adding **Keck 220GHz**

BICEP Array Design is Underway



Targeting deployment
in late 2018



Stage 2

Stage 3

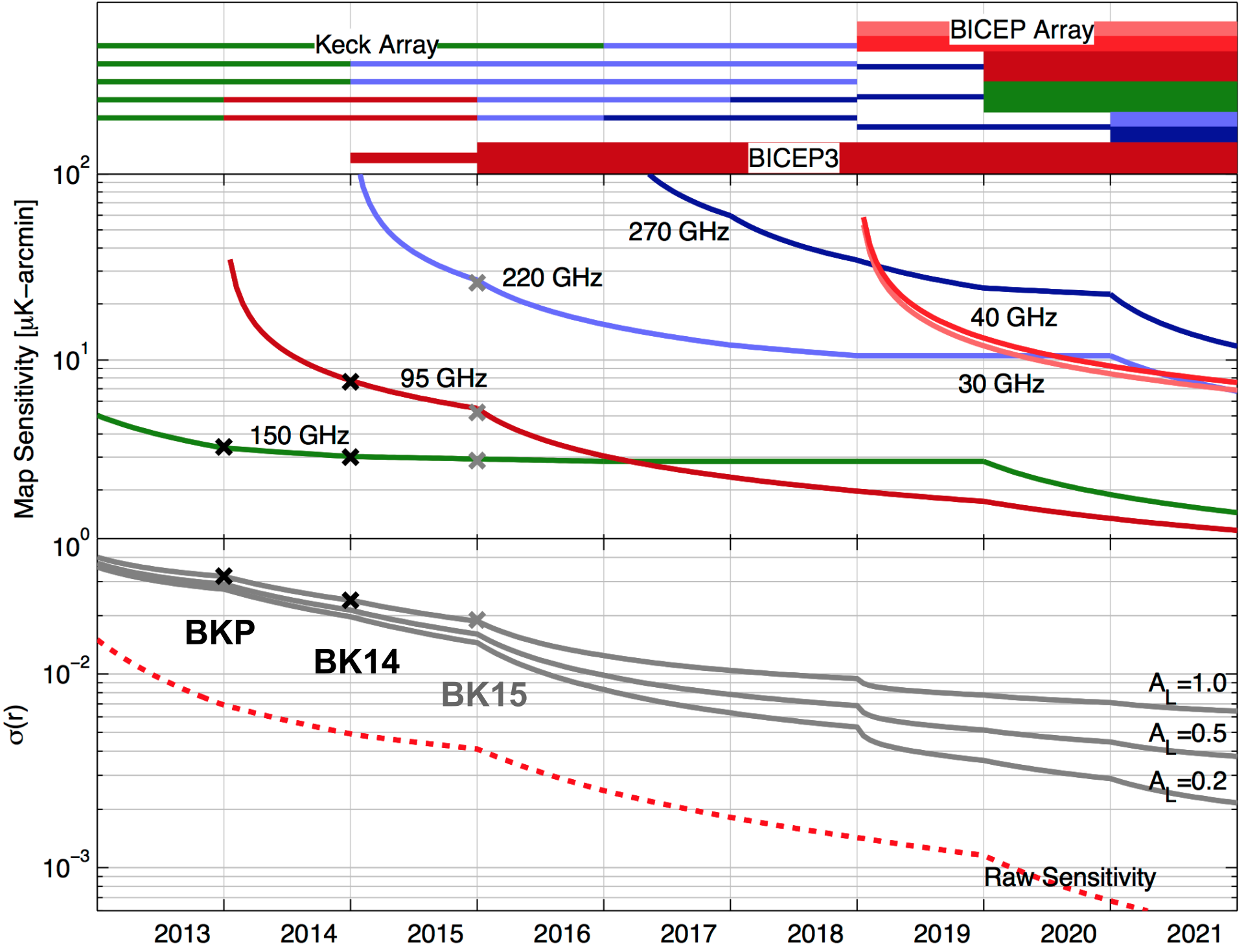




photo: Keith Vanderlinde