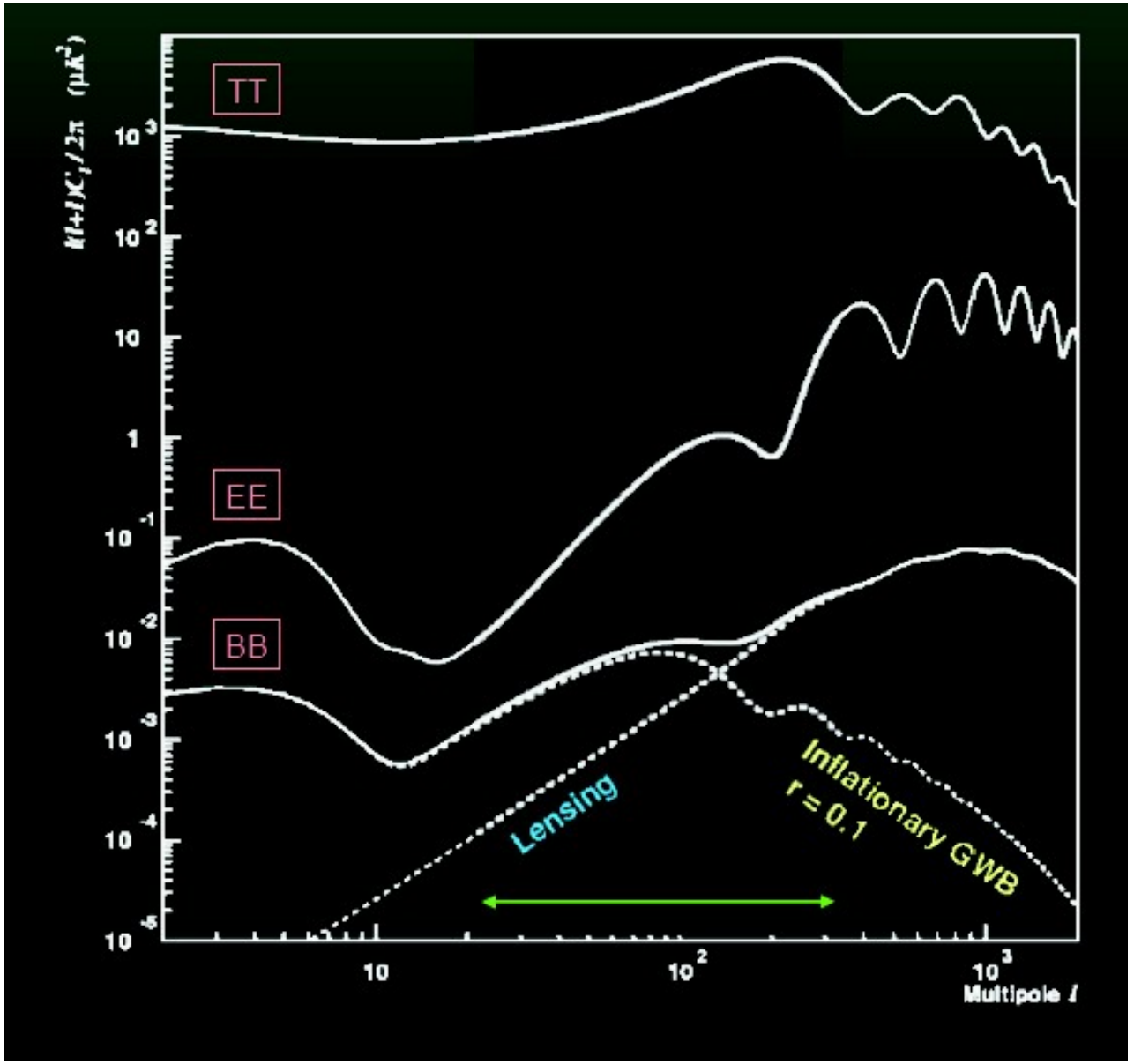

BICEP, BICEP2 & Keck
SPT: 10m
BICEP/BICEP2/Keck: 0.3m
Photo: Steff Richter
Christopher Sheehy
GLCW June 14, 2010

CMB Polarization Spectrum



•a general prediction of inflation is the presence of gravity waves in the early universe, which produce a slight curl in the polarization pattern of the CMB (B-modes)

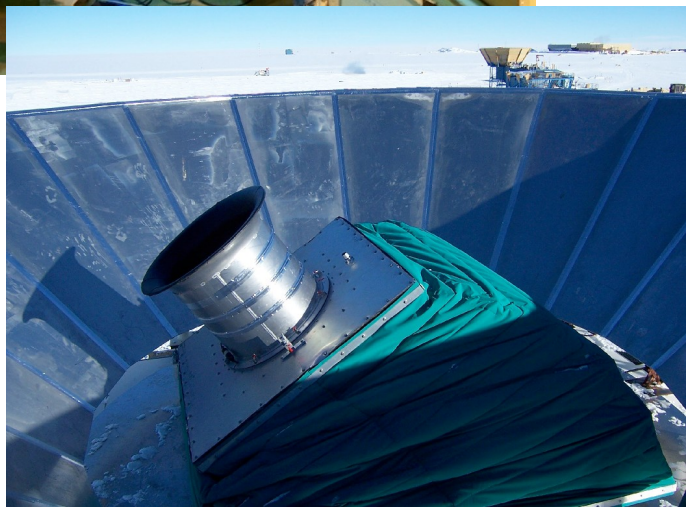
•detection of B-modes is “smoking gun” evidence for inflation, and probes GUT scale physics!

•amplitude of B-mode signal is parametrized by the tensor to scalar ratio “r”

•theorists refuse to say how large r might be

BICEP / BICEP2 / Keck all share...

- **Small aperture (30 cm)**
  - aperture filling calibrators
  - superior sidelobe suppression
  - boresight rotation



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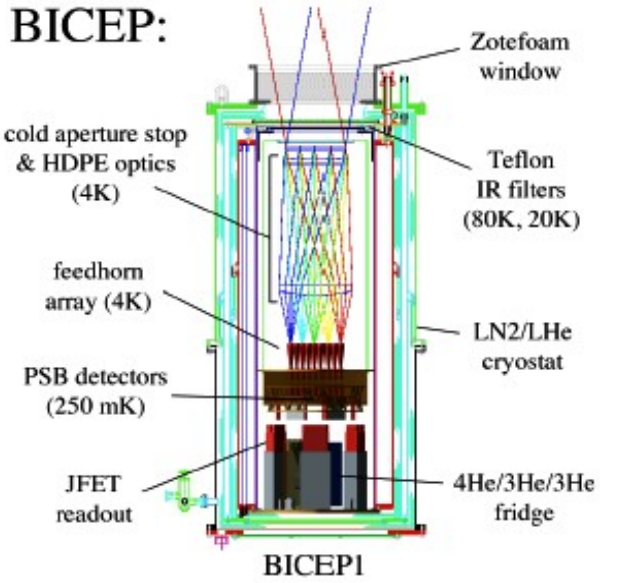
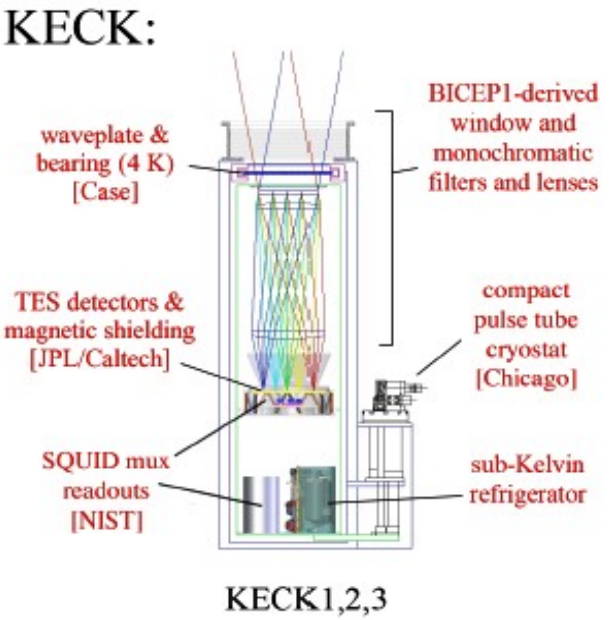
- **Cold (4K) refracting optics**
  - stable beams
  - minimize instrument induced systematics





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- **Small aperture (30 cm)**
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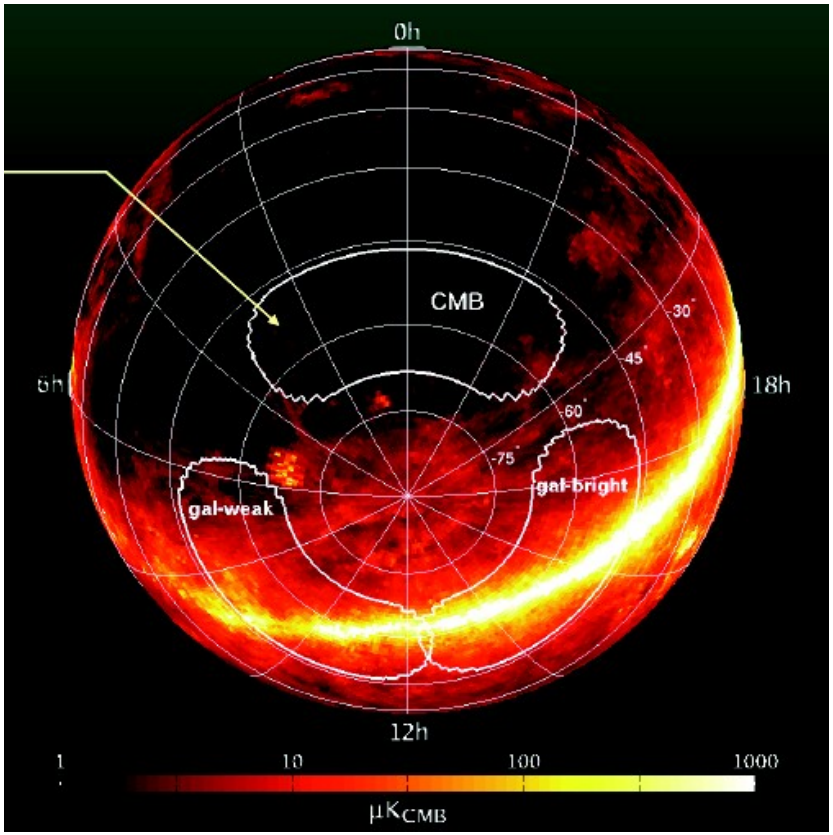
  - superior sidelobe suppression
  - boresight rotation
- **Cold (4K) refracting optics**
  - stable beams
  - minimize instrument induced systematics
- **Sited at the South Pole**
  - uniquely clean region of sky, the so-called “Southern Hole” at constant elevation above horizon 24 hours a day, 365 days a year
  - 9000 ft. elevation / low air temperature mean less water vapor in the atmosphere, the primary non-astrophysical foreground for ground-based CMB



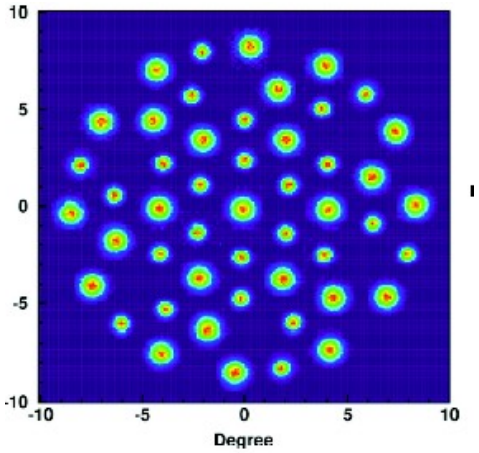
150 GHz FDS dust model

H.C. Chiang

Exponential increase in sensitivity

BICEP1

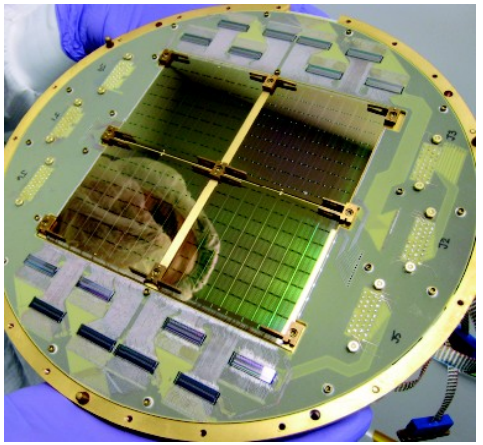
Completed 3 yrs. of observation in Nov. 2008

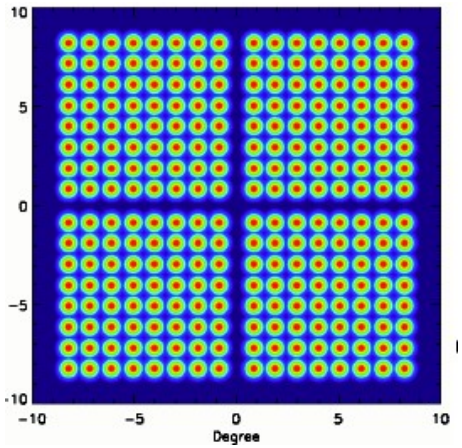


48 detectors @ 150 GHz

BICEP2

Deployed Nov. 2009, currently observing!

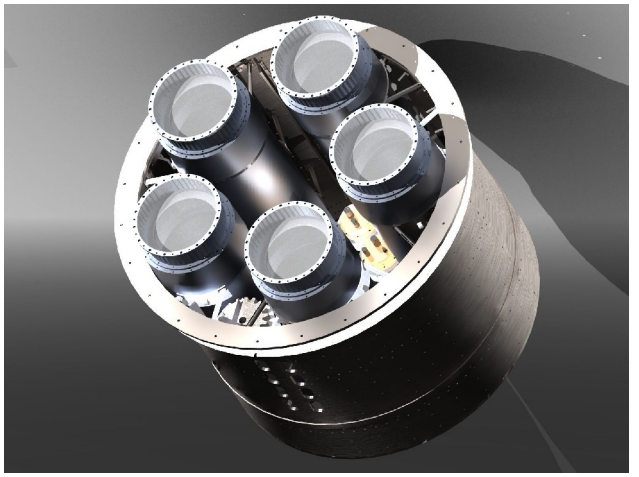


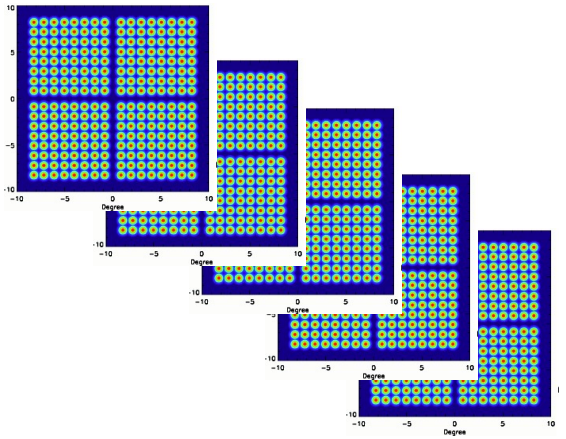


512 detectors @ 150 GHz
JPL antenna-coupled TES arrays

Keck array

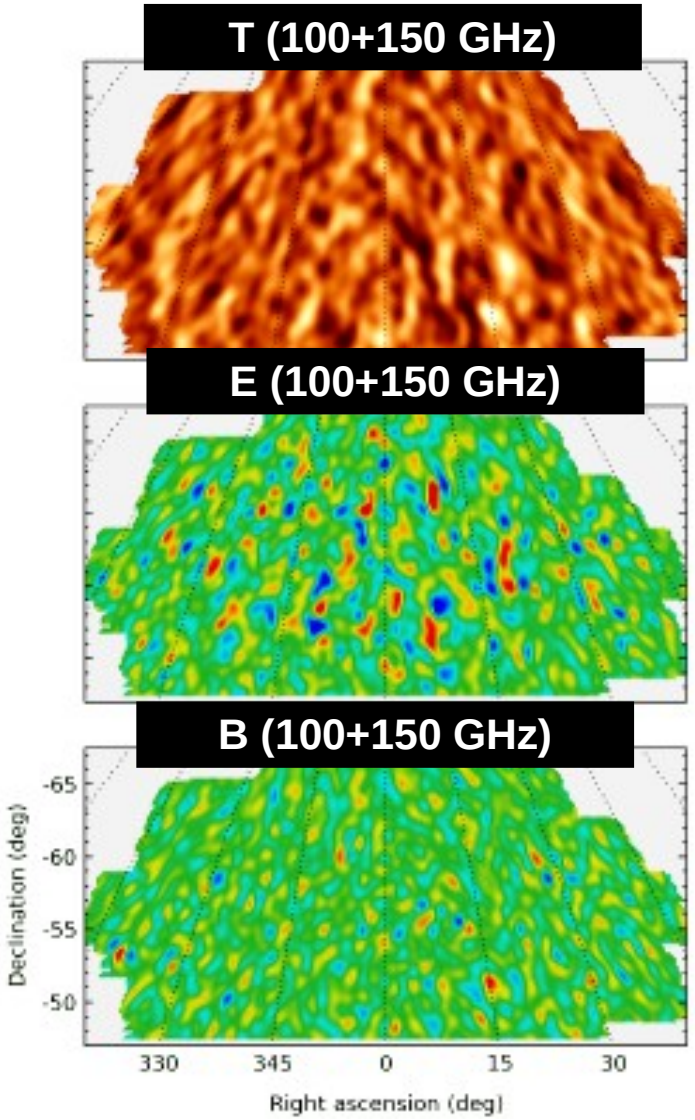
Deploying x3 in Nov. 2010, with 2 more in Nov. 2011





3 x 512 detectors @ 150 GHz
2 x 512 @ 100/220 GHz

BICEP1 two-year results



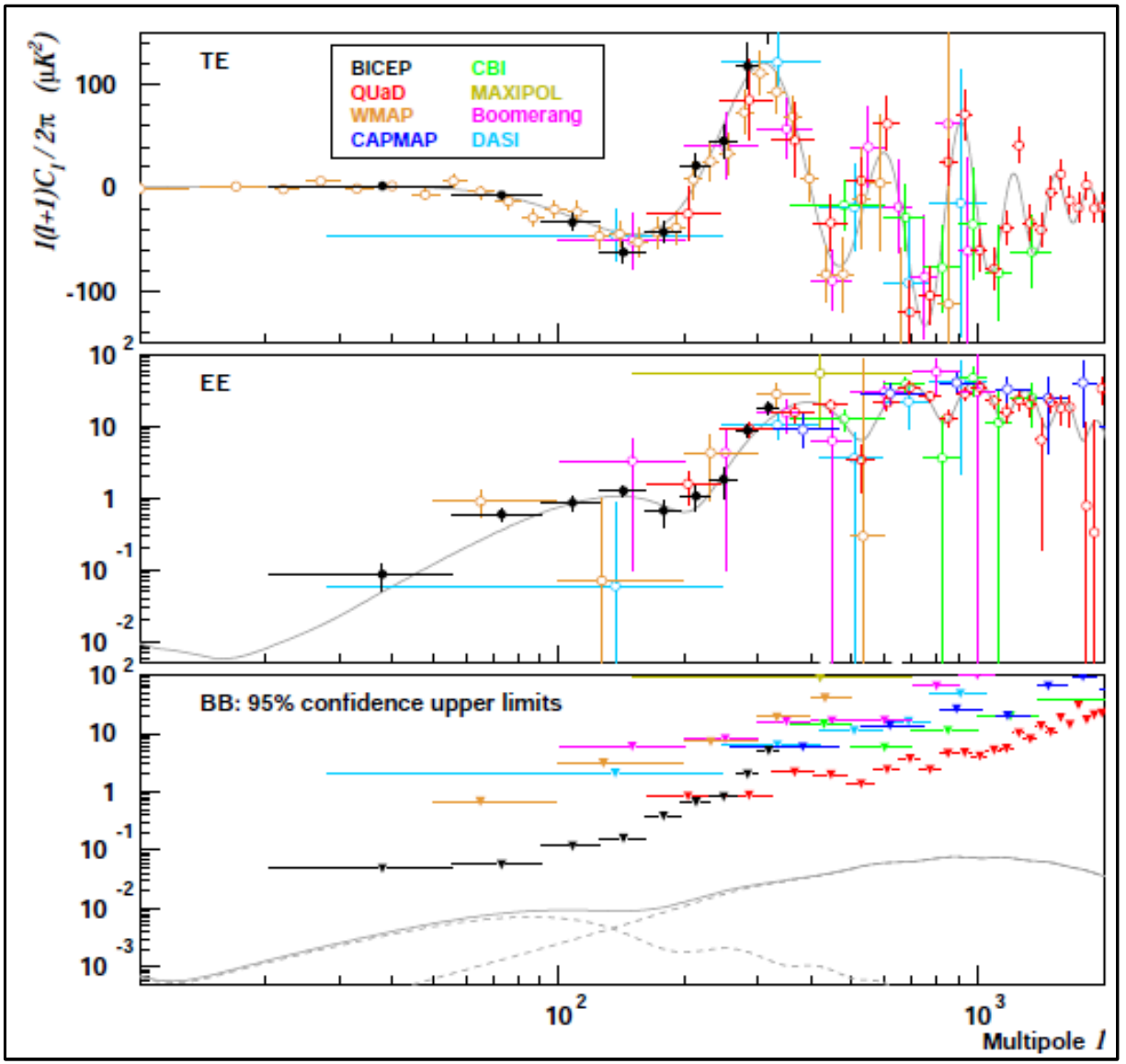
Highest S/N polarization measurements at ell ~ 100

Constraints on inflationary gravity waves ($r < 0.73$ at 95% confidence) from B-modes alone are the most powerful to date!

Demonstrates merit of a targeted approach to ell=100 B-modes

Chiang, et al. (2009)

BICEP1 two-year results



Highest S/N polarization measurements at ell ~ 100

Constraints on inflationary gravity waves ($r < 0.73$ at 95% confidence) from B-modes alone are the most powerful to date!

Systematics look controllable down to at least r=0.01

Demonstrates merit of a targeted approach to ell=100 B-modes

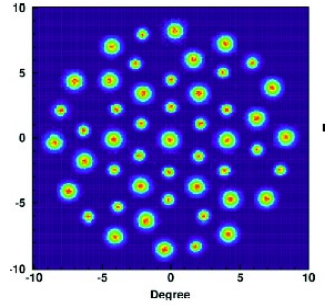
Chiang, et al. (2009)

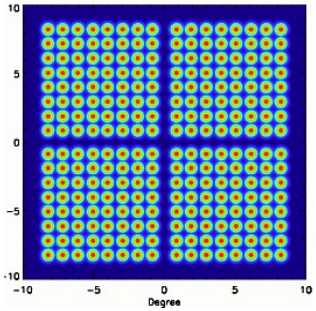
BICEP2 initial performance

To measure r = 0.02, need ~30x the sensitivity!

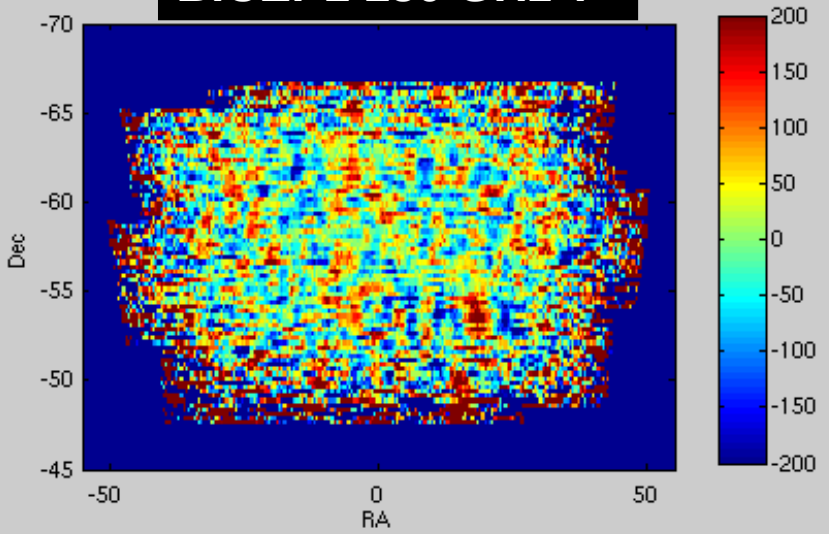
BICEP2 initial performance

each map is from 4 calendar days of data

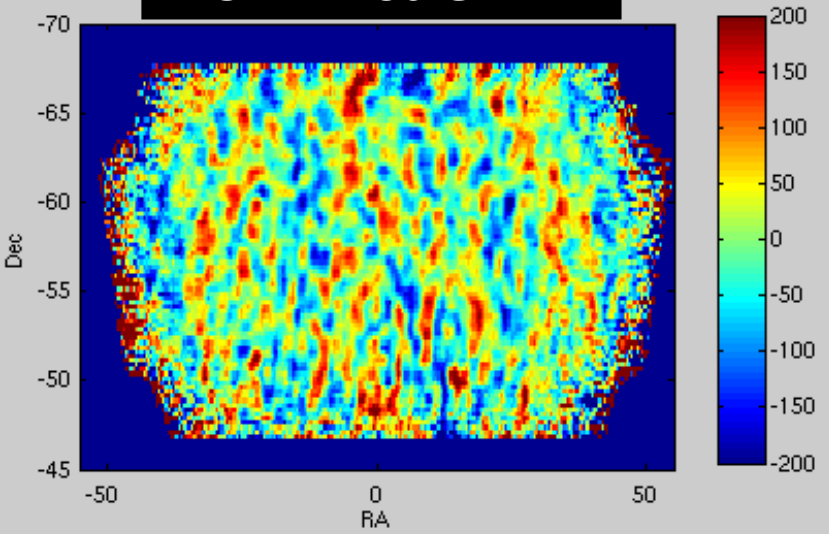




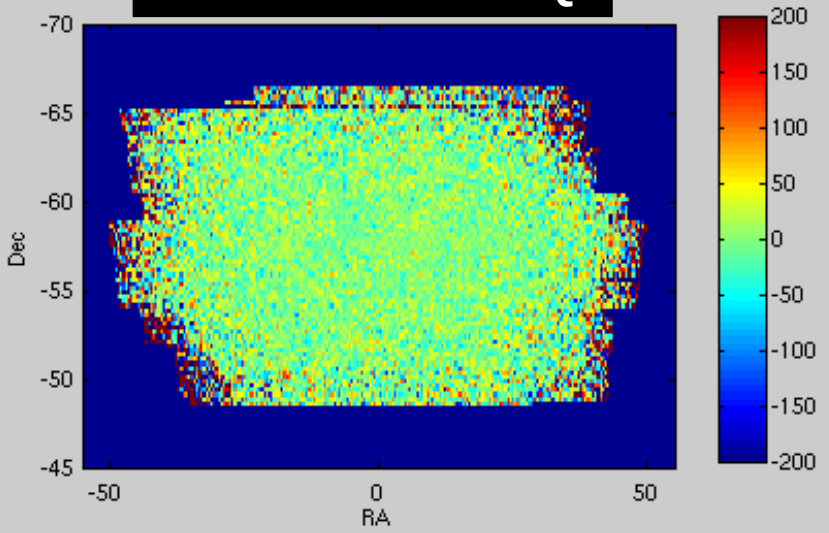
BICEP1 150 GHz T



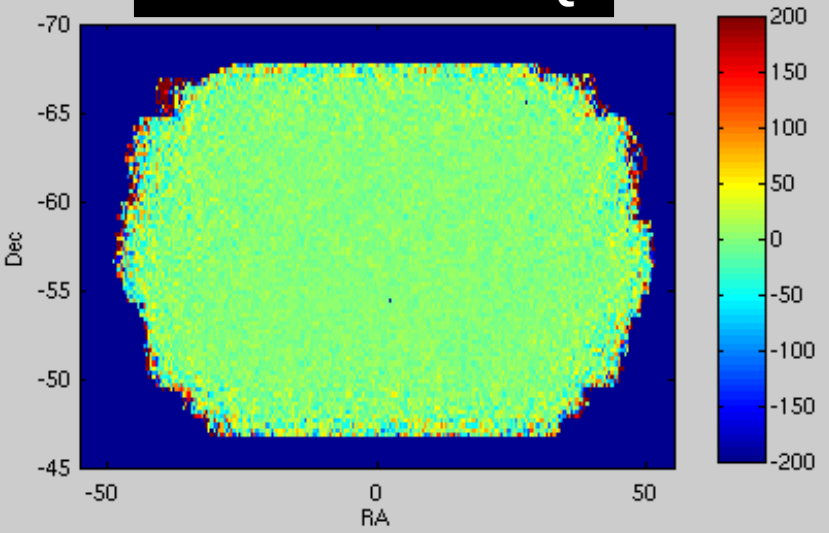
BICEP2 150 GHz T



BICEP1 150 GHz Q

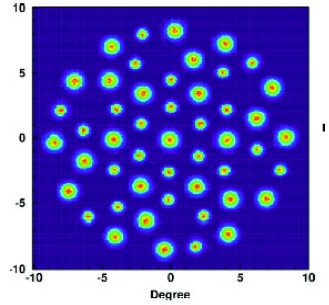


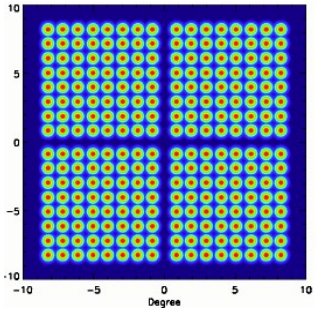
BICEP2 150 GHz Q



BICEP2 initial performance

S/N ratio from 4 days of data





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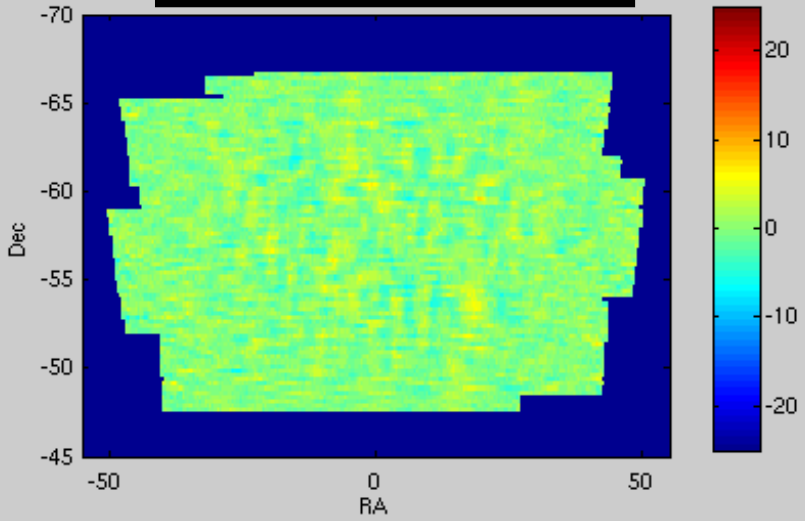
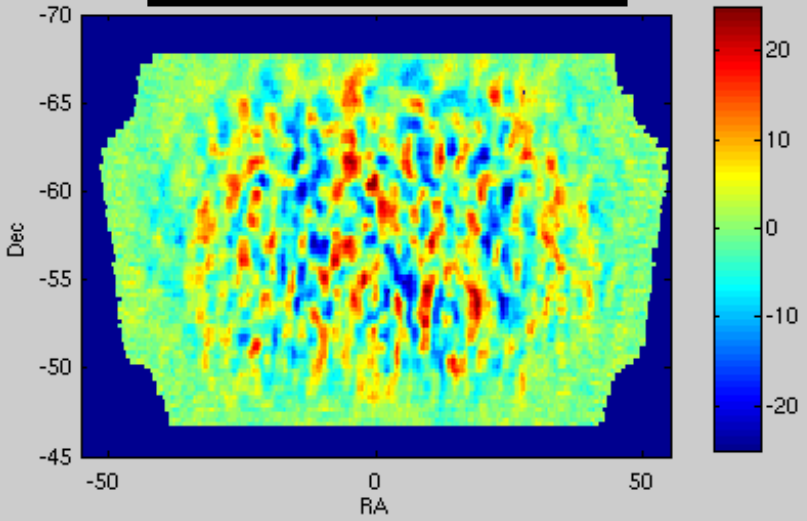
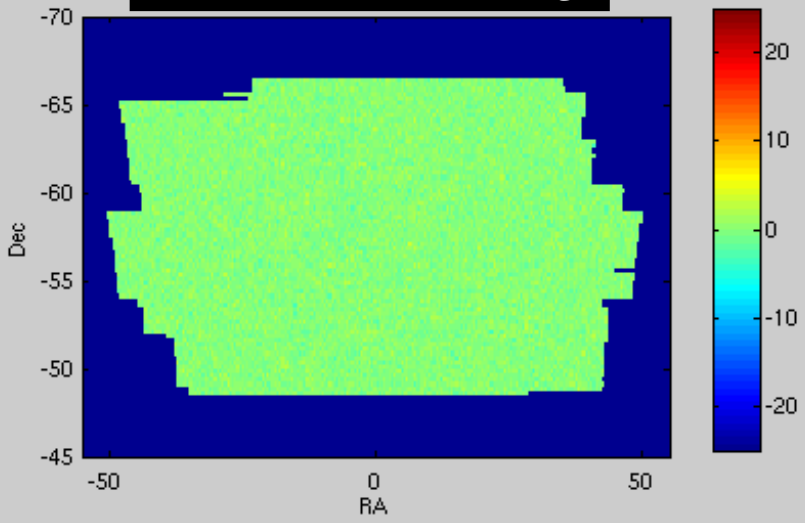


BICEP2 150 GHz T



BICEP1 150 GHz Q



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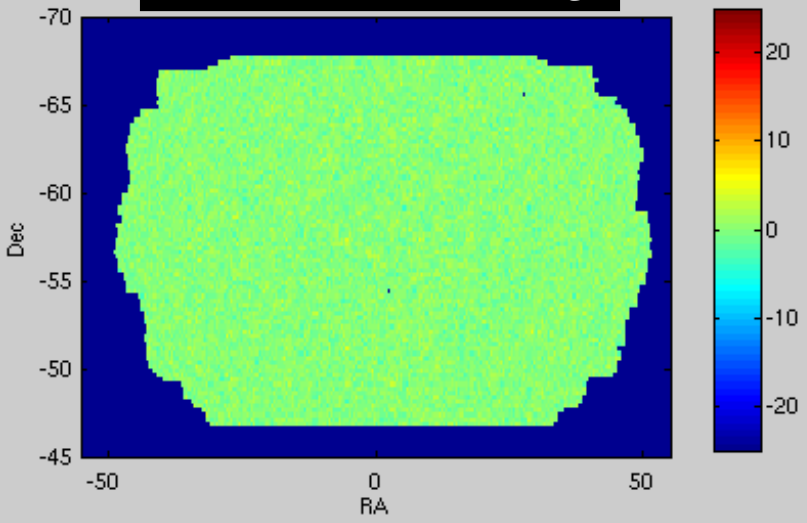
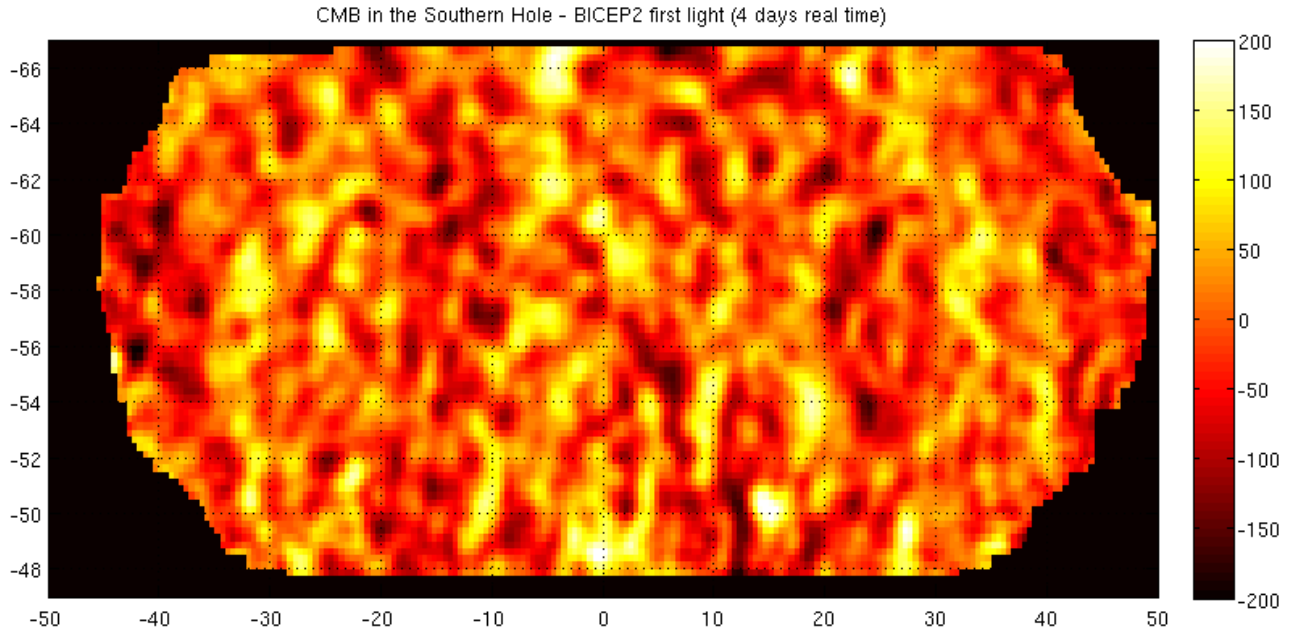
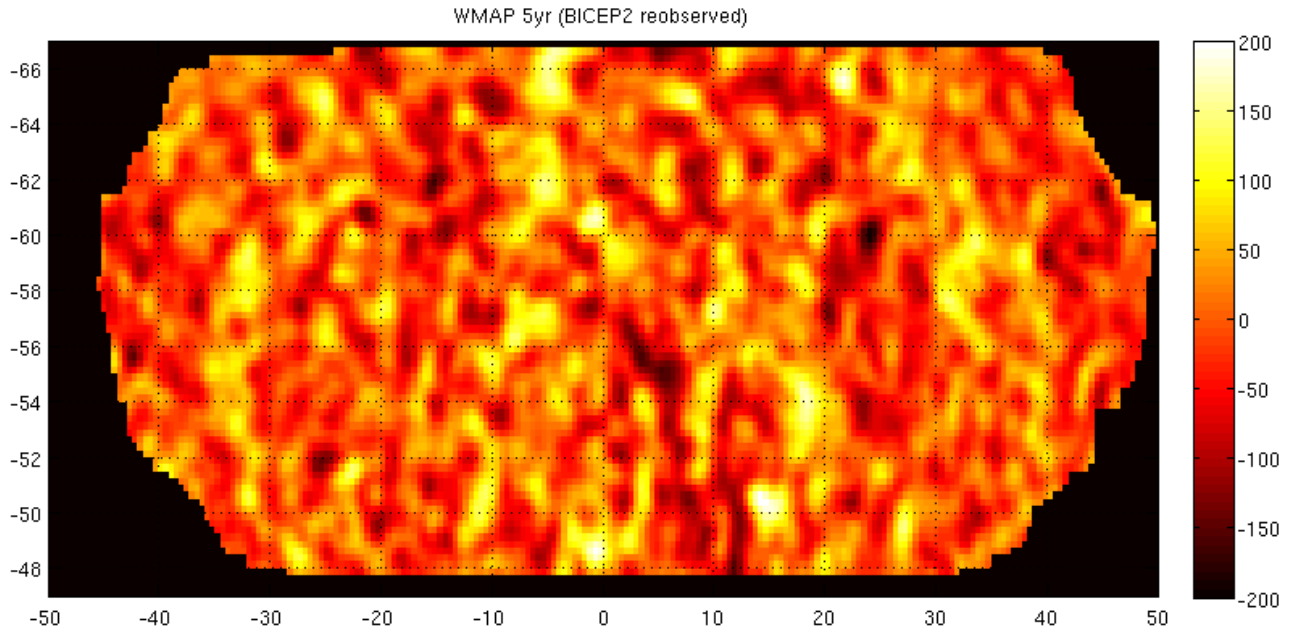


BICEP2 initial performance

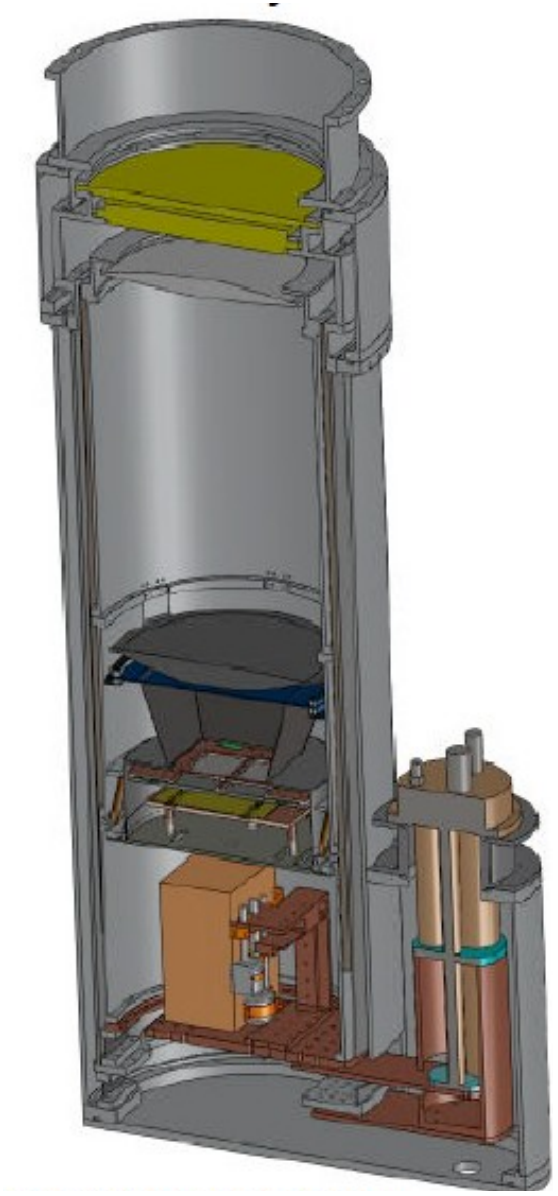


BICEP2 150 GHz
4 days



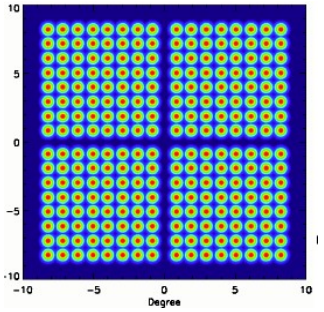
WMAP 5 year

Keck array



Compact, pulse tube cooled cryostats

Will fit 5 BICEP2 style receivers on to existing mount at the South Pole (previously used for DASI and QUAD)



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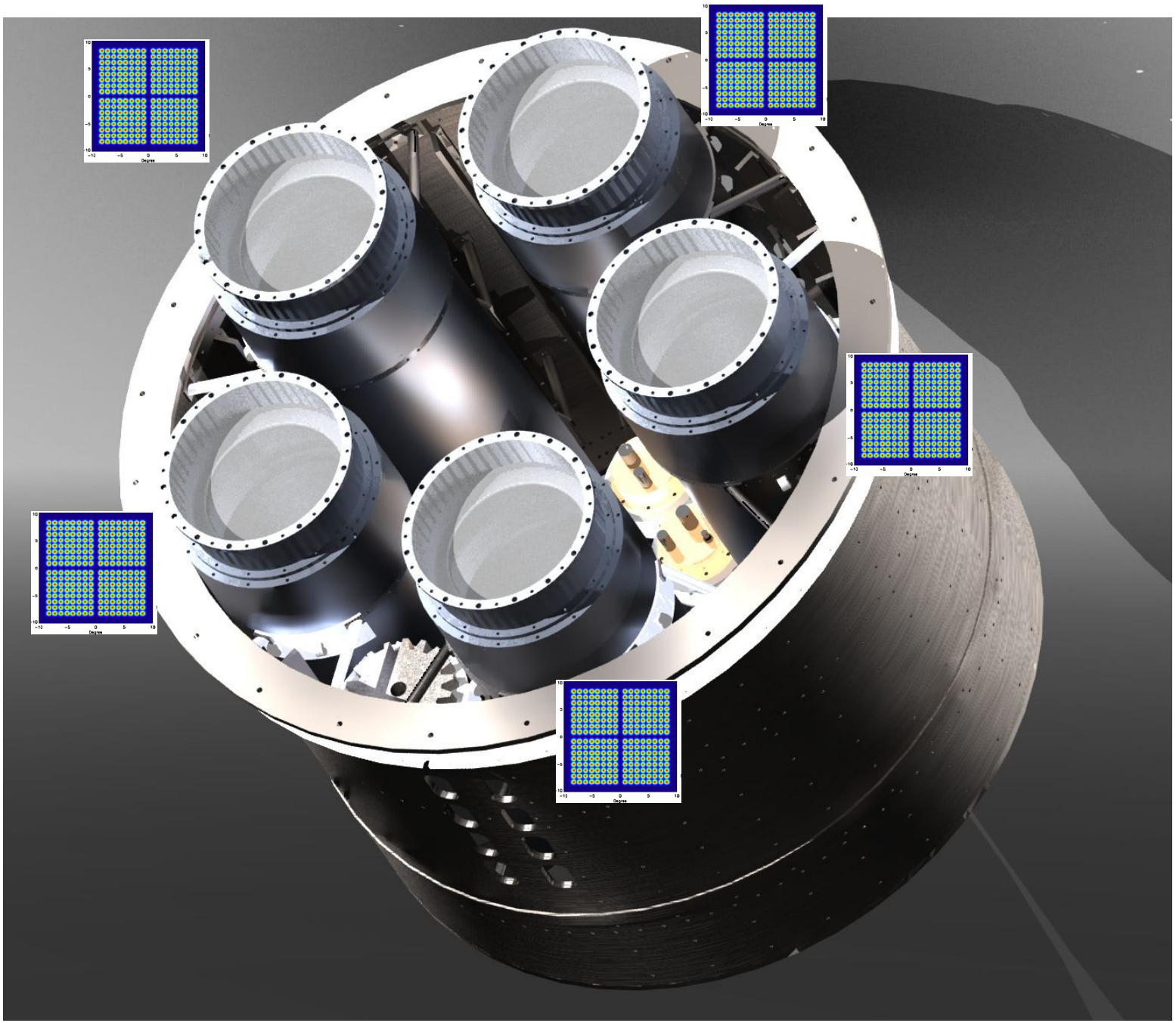
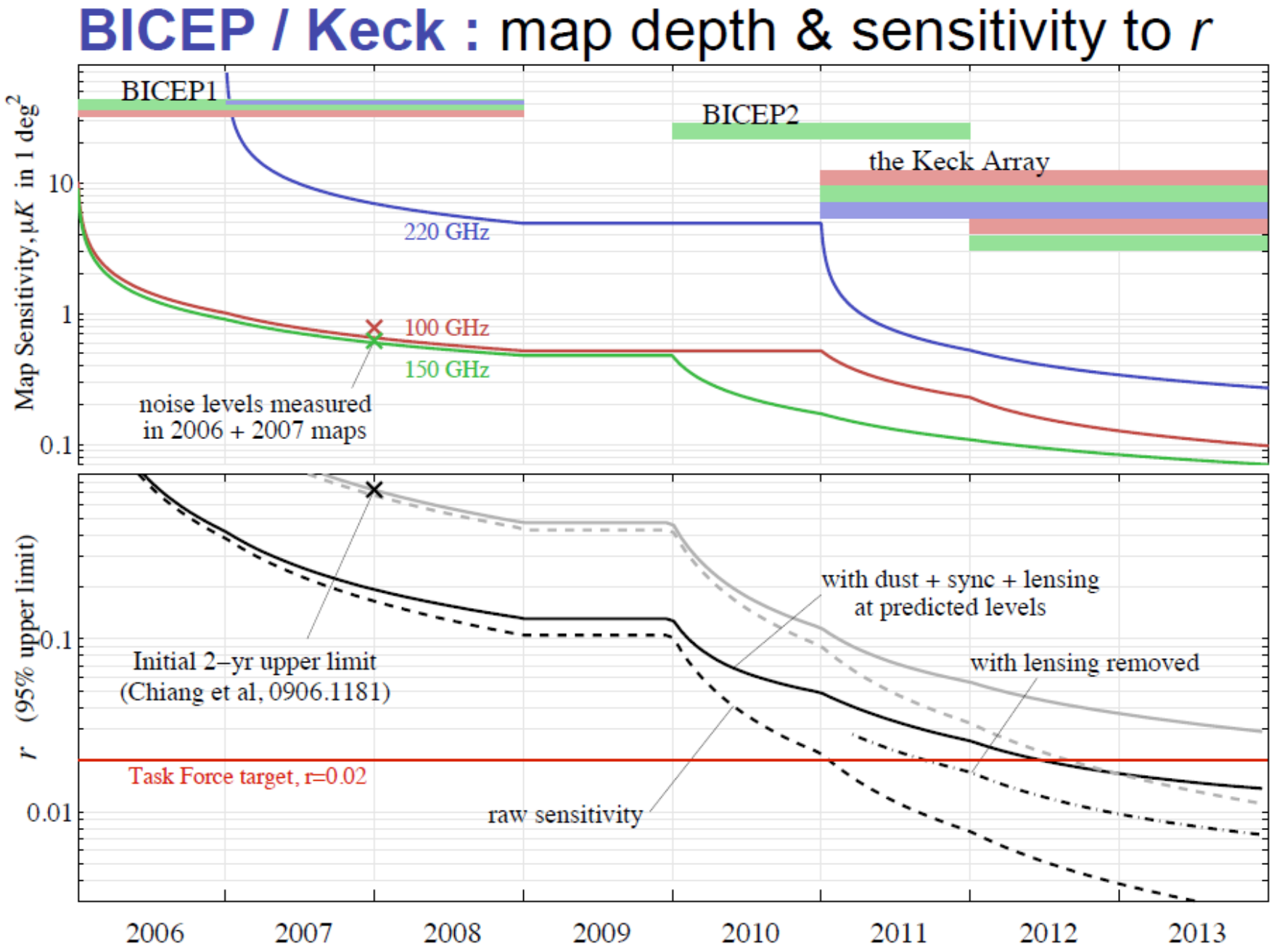


Expectations for BICEP2 and Keck



John Kovac

Conclusions

- BICEP1 has best limits on inflationary gravity waves to date from B-modes alone ($r < 0.73$)
- BICEP2 currently taking data and has at least 10x increase in sensitivity to r over BICEP
- Keck deploys Nov. 2010 and should achieve raw sensitivity to $r > 0.02$ before end of 2012