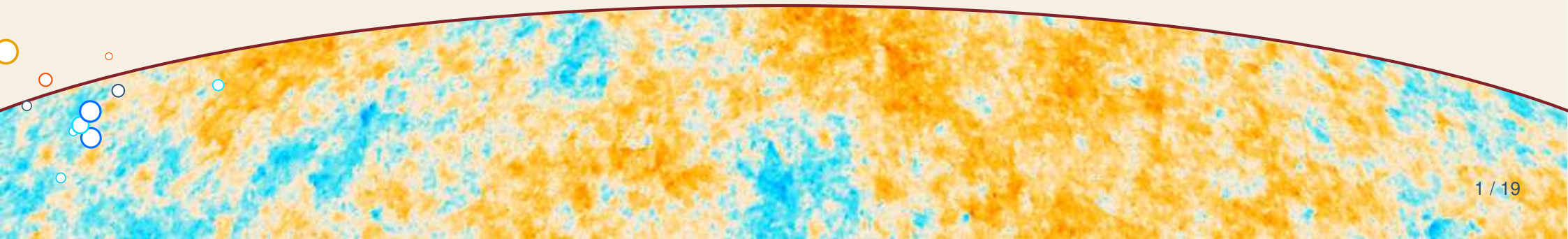
Detection of B-modes by BICEP2

Sorry for the ugly slides

this talk has been made in 2 hours

Louvain-la-Neuve, 26/03/2014



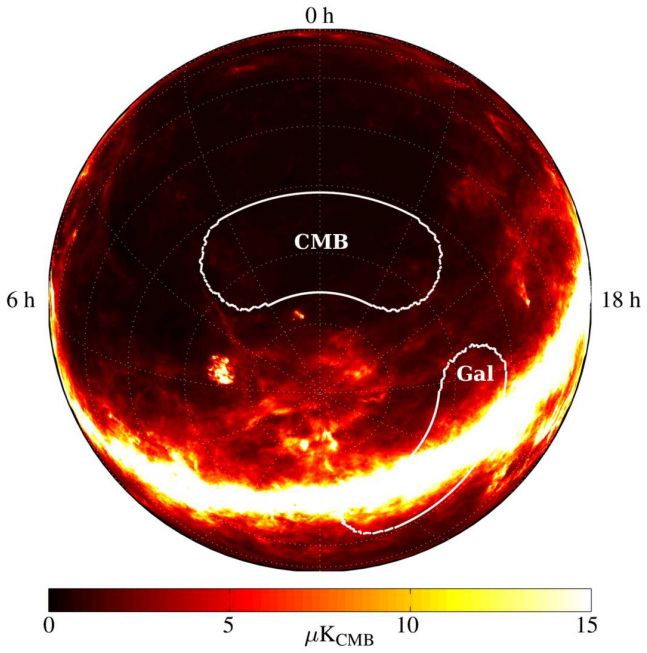
BICEP2 results

BICEP experiment: a “Get Lucky” strategy

- Dedicated to an unprobable detection of a very particular signal

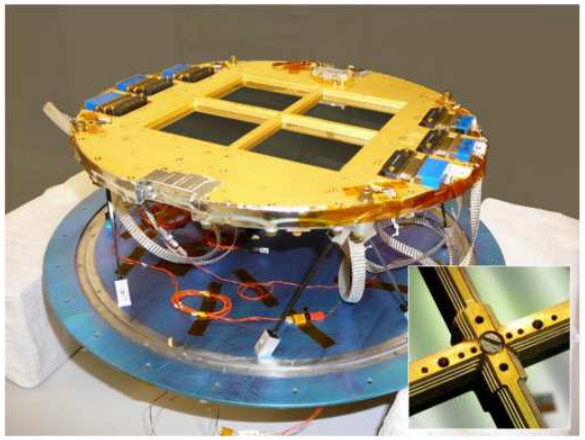
  curl polarization of the CMB anisotropies on large angular scales

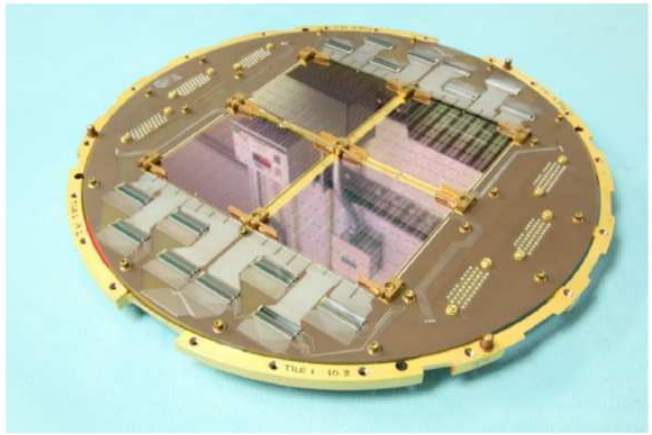
- Look only in the cleanest spot in the sky from the cleanest place on earth



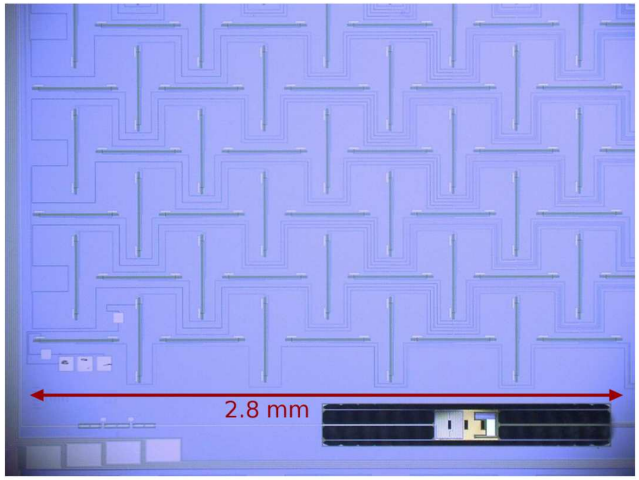
BICEP experiment: JPL's bolometers trader

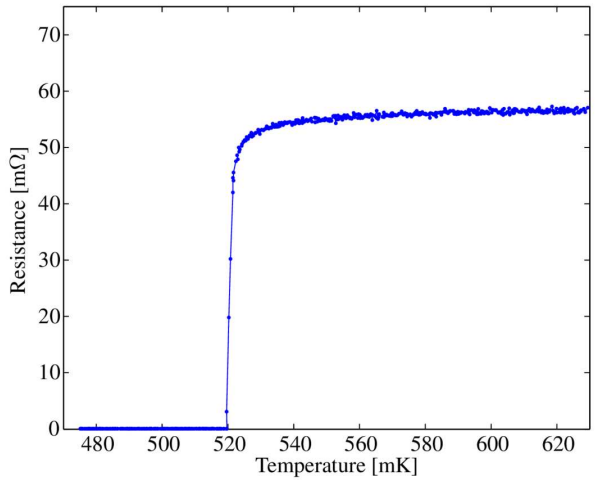
- To get high sensitivity, increase their number (by shit a lot!)





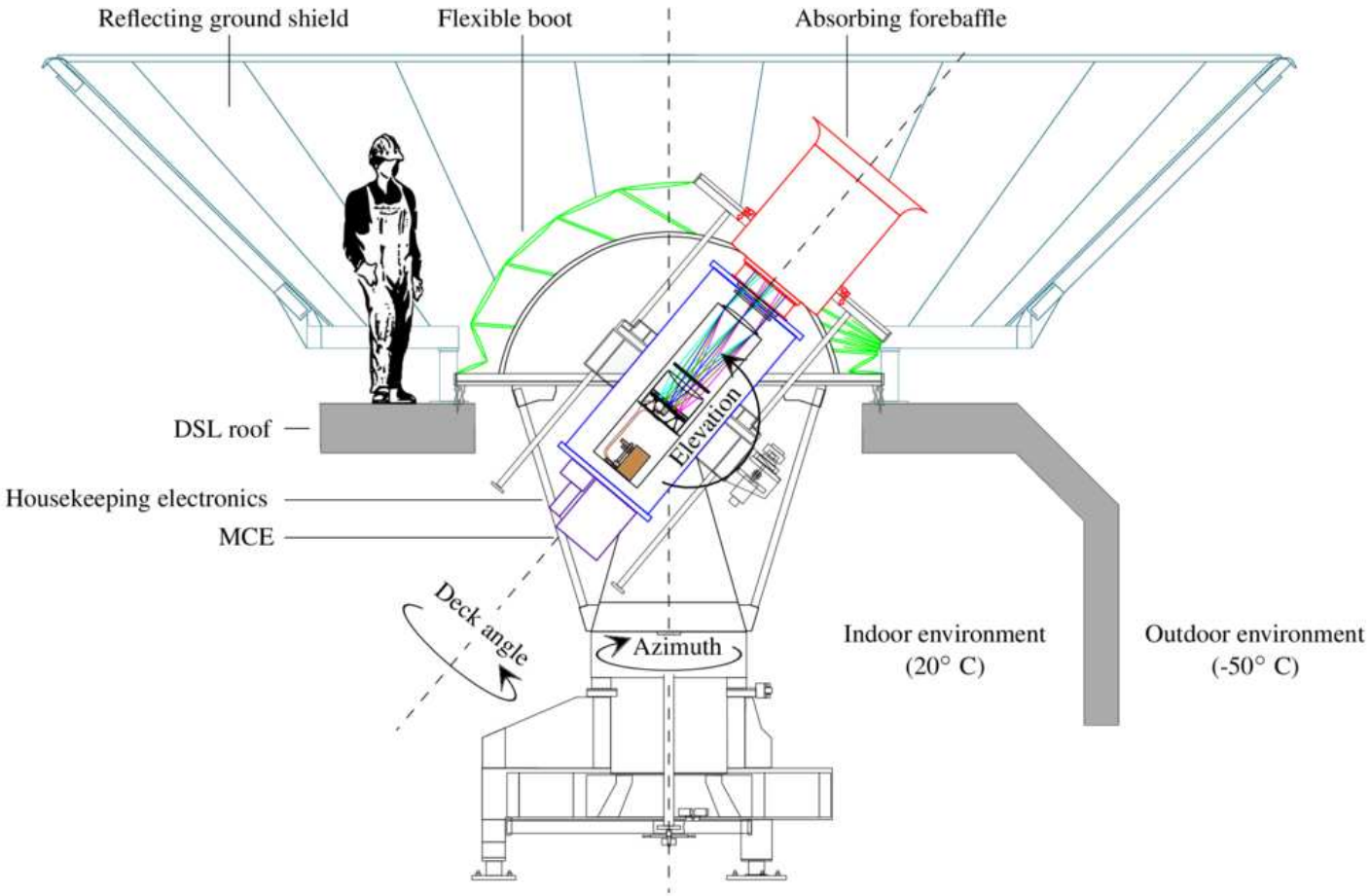
- 512 superconducting bolometers sensitive to polarization (TES)





To be kept in mind

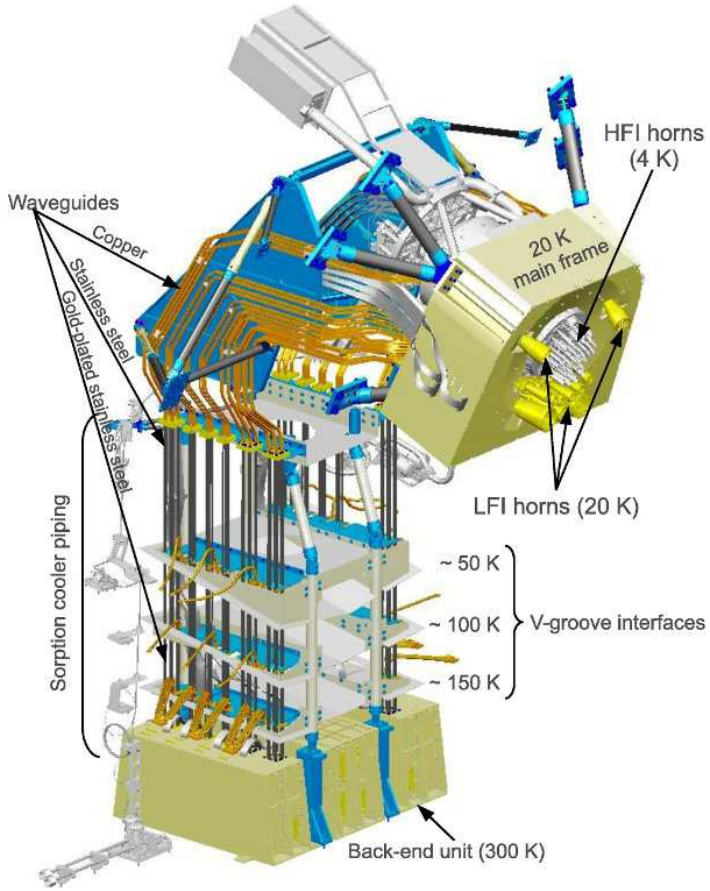
- Very small telescope (20cm) = optimized for the sky's hole

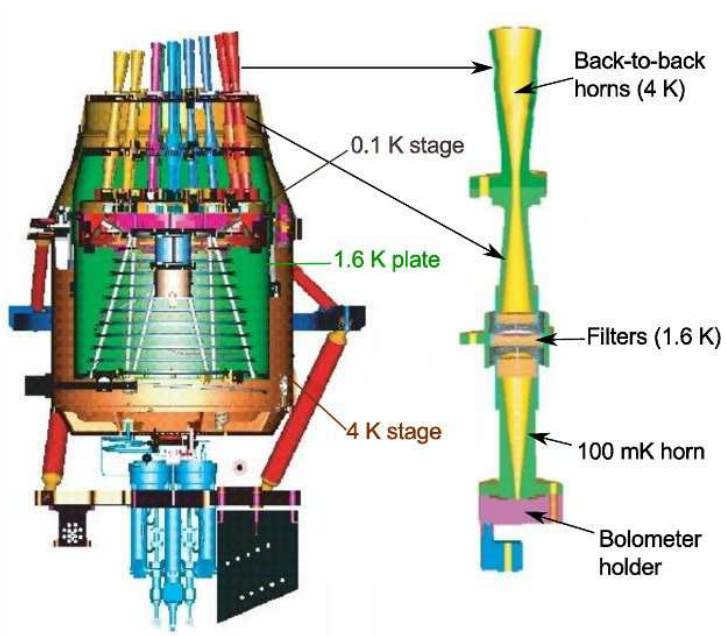


- Only one frequency (150 GHz): cannot do component separation

Compared to Planck?

- Planck has a huge mirror 1.5m (full sky) + 9 frequencies

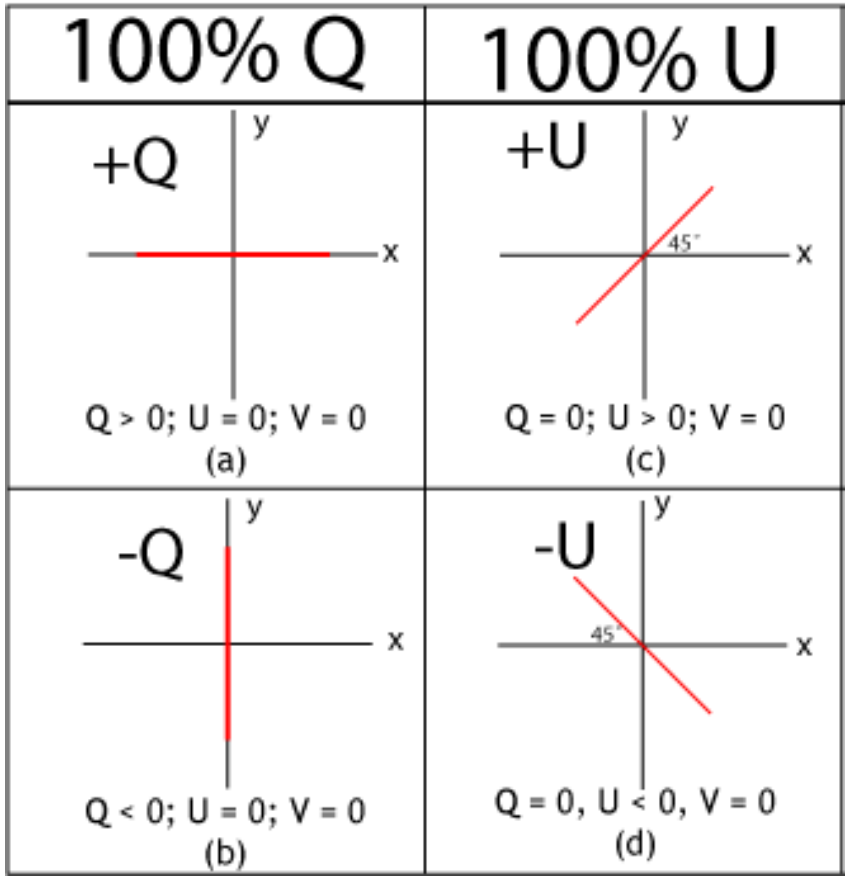




- And only 9 "old generation" polarization bolometers: sensitivity is tenish times less

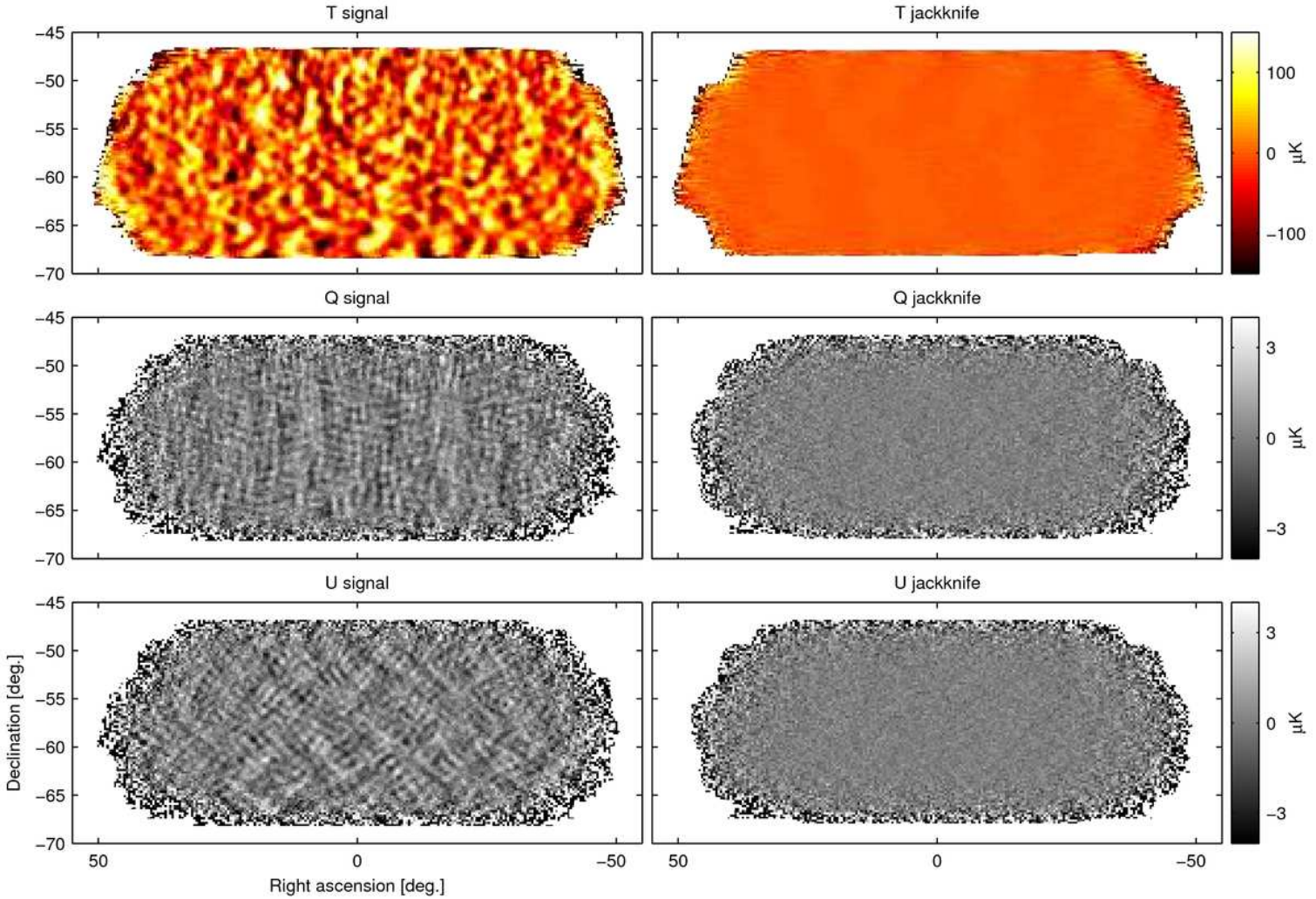
BICEP polarization maps

- Stokes parameters



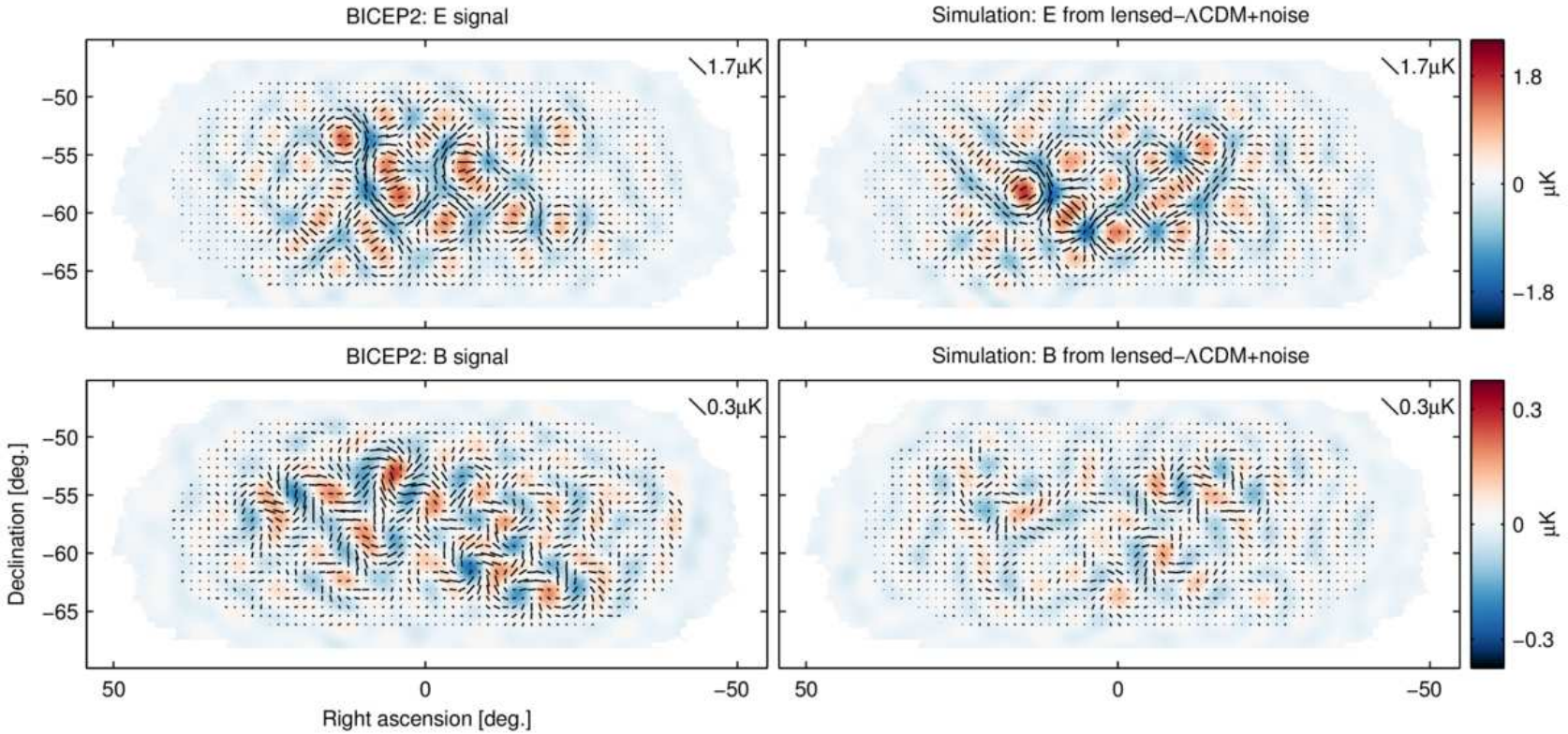
BICEP polarization maps

- Stokes parameters



E and B modes map

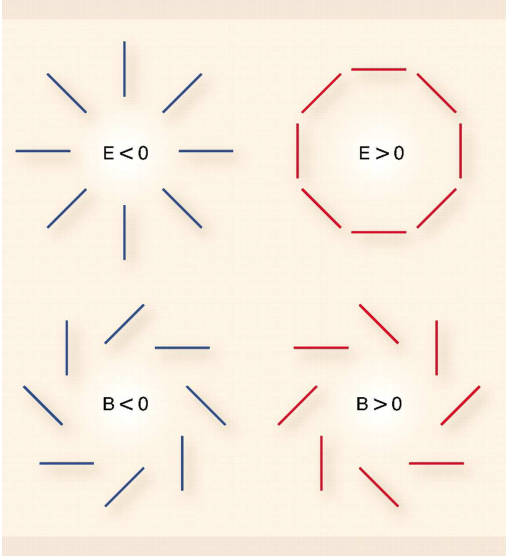
- E and B maps (divergence and curl polarization basis)

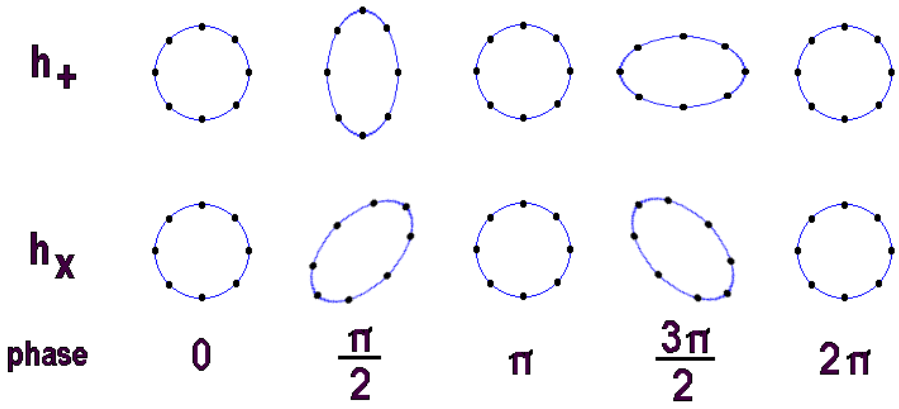


Every cosmologist got an orgasm because B is not vanishing on large scales

Why?

- Because only gravitational waves and vector perturbations can make ionized matter in the cosmic plasma moving such as it generates a curly polarization

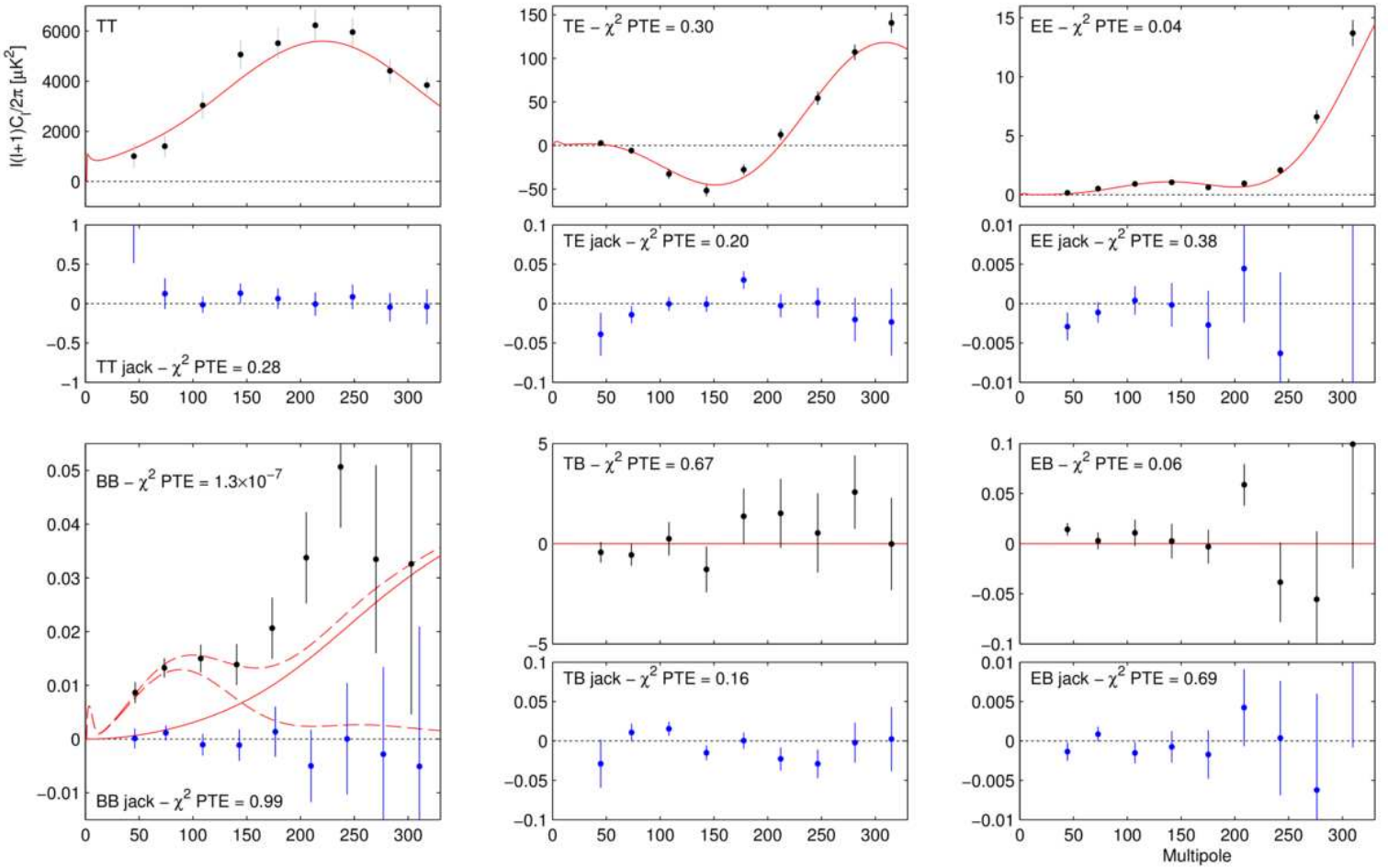




- Gravitational waves at that time can only come from inflation
- Vector perturbations at that time can only come from cosmic strings and/or modified gravity
- This is new physics: so, after the orgasm, serious cosmologists should be a bit skeptic

Angular power spectra

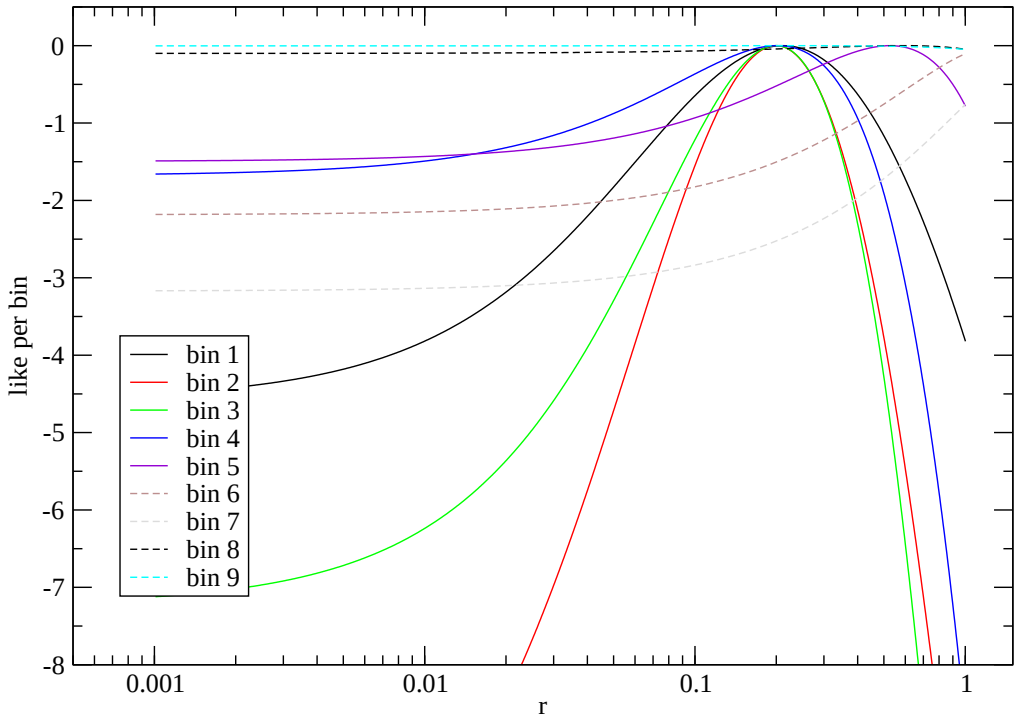
- They match well with primordial gravitational waves



- Up to some funny points that would rather match cosmic strings

The likelihood is a bit funny...

- Let's define r the tensor-to-scalar amount of primordial super-Hubble power
- Only the first four/five bins are consistent with GW



- That sounds like a bit of leakage from T→B
- The first four bins are the most important and seem robust

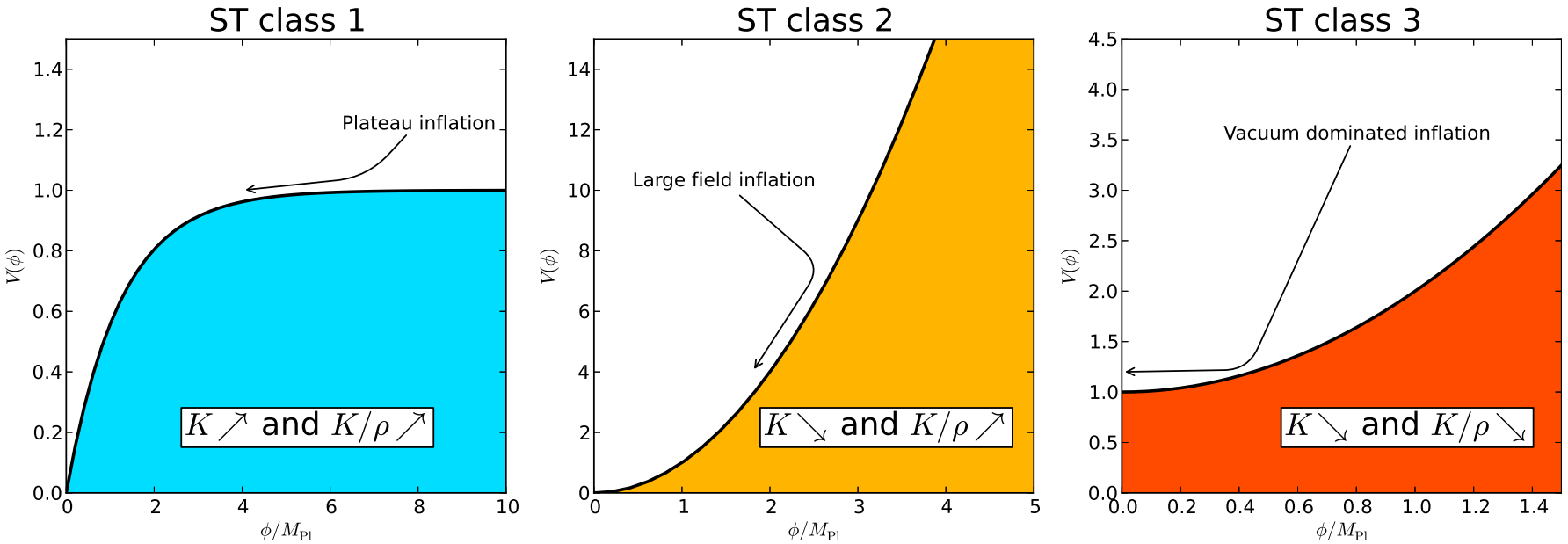
Implication for slow-roll single field inflation

Single field inflation

- Universe dominated by a slow-rolling scalar field in $V(\phi)$
- Triggers acceleration for $\dot{\phi}^2 \ll 1$

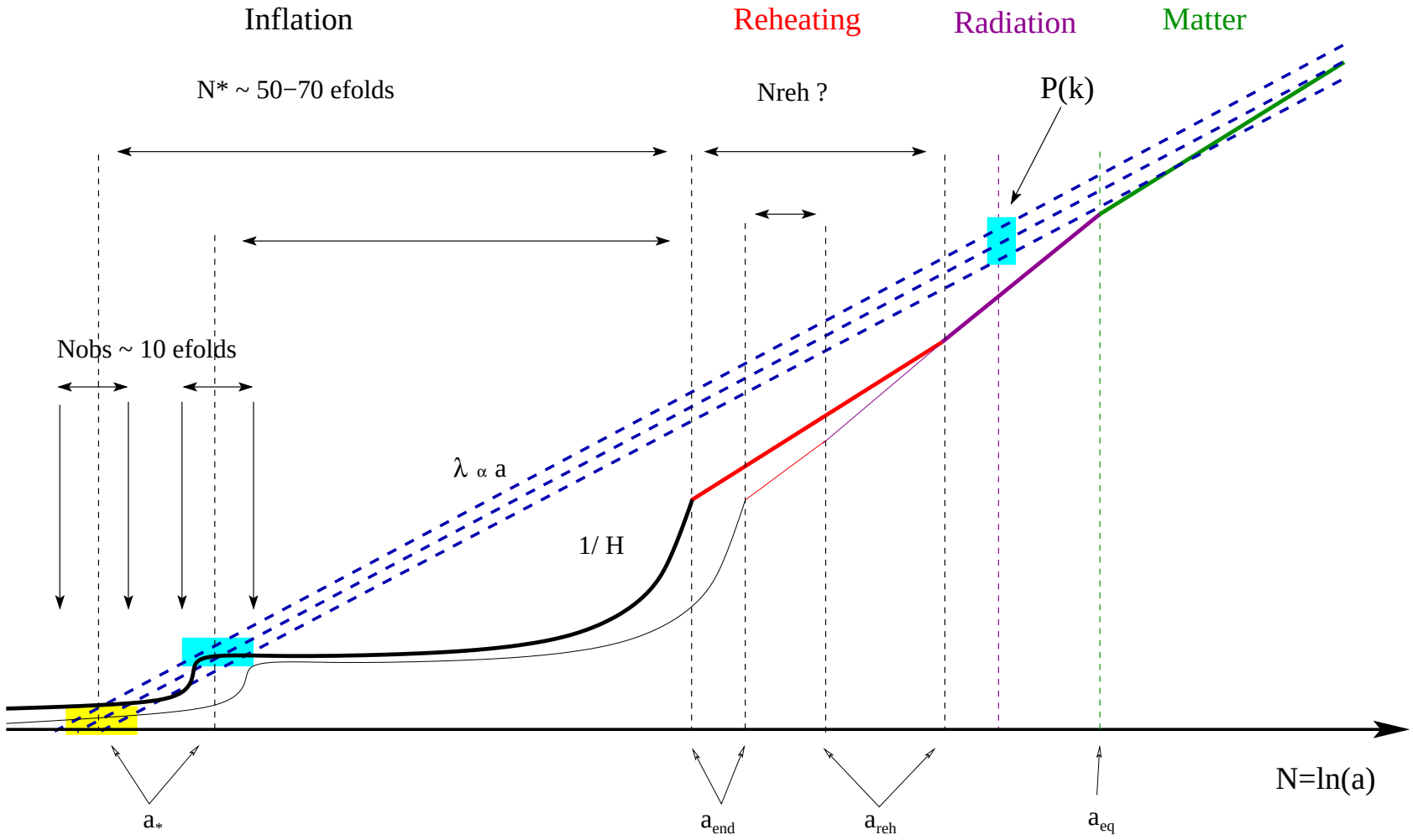
$$K = \frac{1}{2}\dot{\phi}^2 \qquad \rho = K + V \qquad P = K - V \simeq -\rho$$

- Schwarz and Terrero-Escalante classification



- Field-metric quantum fluctuations $\Rightarrow P(k)$

Inflationary universe history



- Model testing: reheating effects must be included!

Primordial power spectra

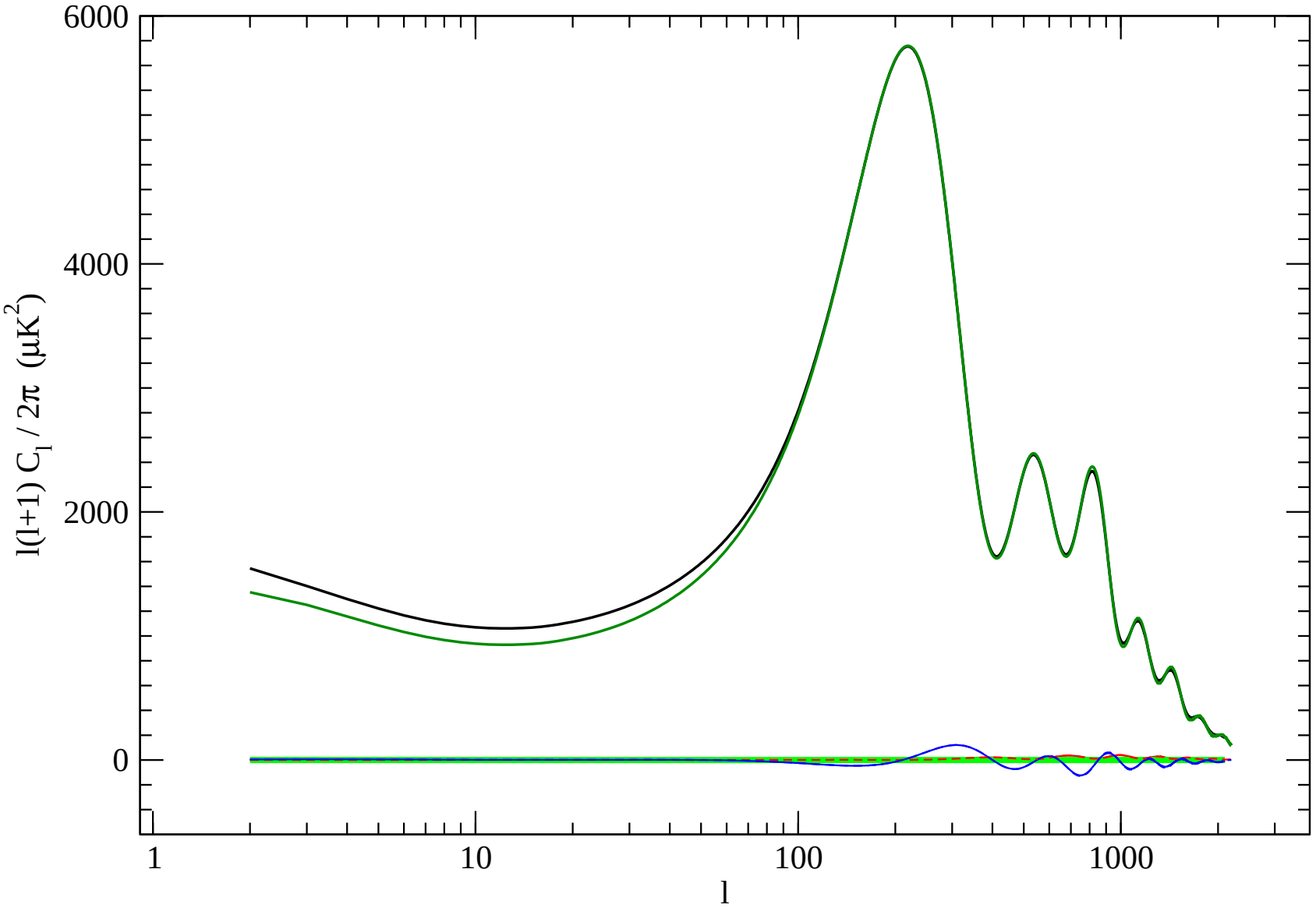
- Slow-roll inflation predicts [arXiv:1303.2120, arXiv:1303.2788]

$$\mathcal{P}_\zeta = \frac{H_*^2}{8\pi^2 M_{\rm P}^2 \epsilon_{1*} c_{s*}} \left\{ 1 - 2(1+C)\epsilon_{1*} - C\epsilon_{2*} + (2+C)\delta_{1*} + \left(\frac{\pi^2}{2} - 3 + 2C + 2C^2\right)\epsilon_{1*}^2 \right.$$
$$+ \left(\frac{7\pi^2}{12} - 6 - C + C^2\right)\epsilon_{1*}\epsilon_{2*} + \left(\frac{\pi^2}{8} - 1 + \frac{C^2}{2}\right)\epsilon_{2*}^2 + \left(\frac{\pi^2}{24} - \frac{C^2}{2}\right)\epsilon_{2*}\epsilon_{3*}$$
$$+ \left(\frac{\pi^2}{8} - 1 + C + \frac{C^2}{2}\right)\delta_{1*}^2 + \left(-\frac{\pi^2}{24} + 2 + 2C + \frac{C^2}{2}\right)\delta_{1*}\delta_{2*} + \left(-\frac{\pi^2}{2} + 4 - 3C - 2C^2\right)\delta_{1*}\epsilon_{1*}$$
$$+ \left(-\frac{\pi^2}{4} + 3 - C - C^2\right)\delta_{1*}\epsilon_{2*} + \Big[-2\epsilon_{1*} - \epsilon_{2*} + \delta_{1*} + (2+4C)\epsilon_{1*}^2$$
$$+ (-1+2C)\epsilon_{1*}\epsilon_{2*} + C\epsilon_{2*}^2 - C\epsilon_{2*}\epsilon_{3*} + (1+C)\delta_{1*}^2 + (2+C)\delta_{1*}\delta_{2*} - (3+4C)\delta_{1*}\epsilon_{1*}$$
$$- (1+2C)\delta_{1*}\epsilon_{2*}\Big] \ln\left(\frac{k}{k_*}\right)$$
$$\left. + \left[2\epsilon_{1*}^2 + \epsilon_{1*}\epsilon_{2*} + \frac{1}{2}\epsilon_{2*}^2 - \frac{1}{2}\epsilon_{2*}\epsilon_{3*} + \frac{1}{2}\delta_{1*}^2 + \frac{1}{2}\delta_{1*}\delta_{2*} - 2\delta_{1*}\epsilon_{1*} - \delta_{1*}\epsilon_{2*}\right] \ln^2\left(\frac{k}{k_*}\right) \right\},$$

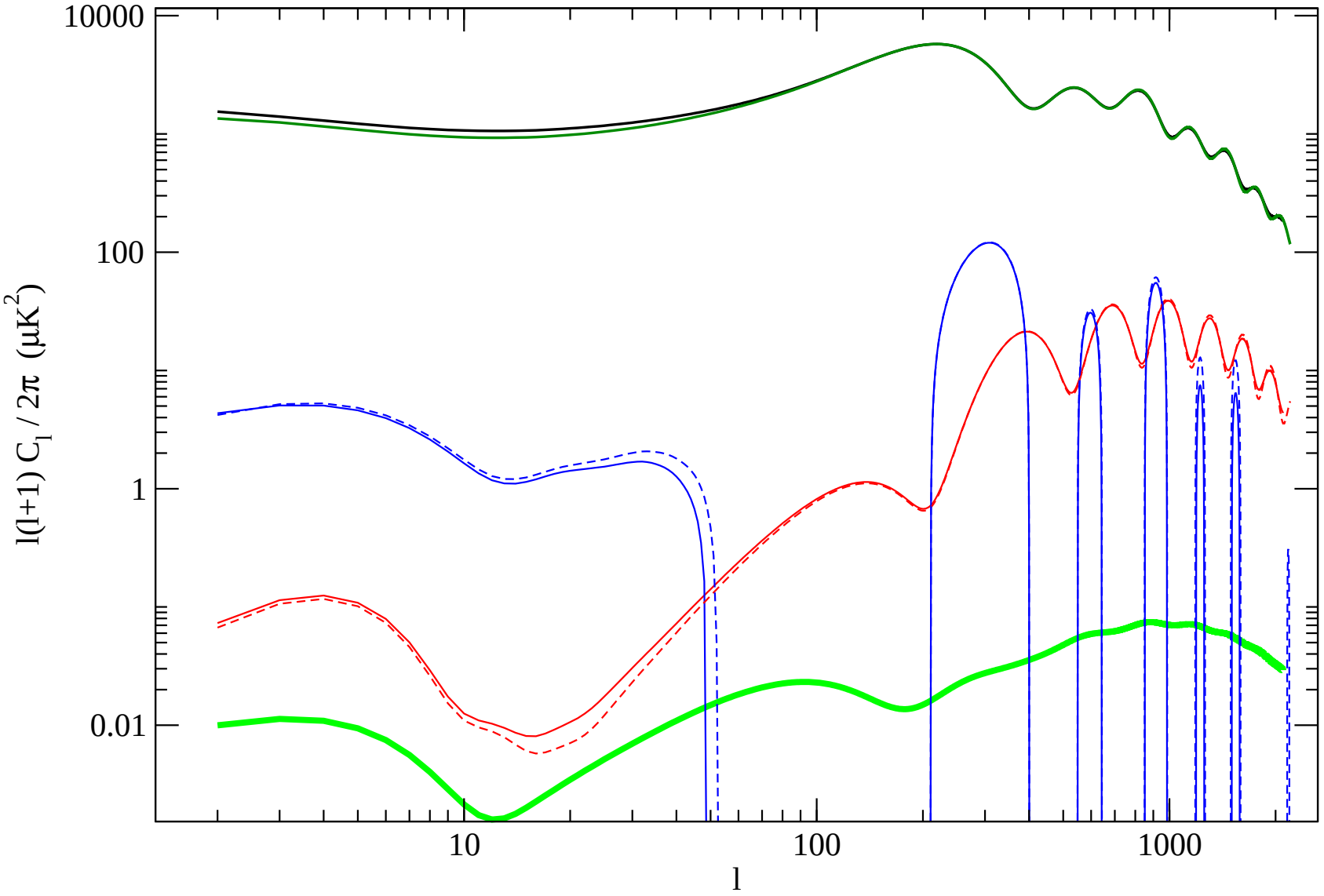
$$\mathcal{P}_h = \frac{2H_*^2}{\pi^2 M_{\rm Pl}^2} \left\{ 1 - 2(1 + C - \ln c_{s*})\epsilon_{1*} + \left[-3 + \frac{\pi^2}{2} + 2C + 2C^2 + 2\ln^2 c_{s*} - 2(1+2C)\ln c_{s*}\right]\epsilon_{1*}^2 \right.$$
$$+ \left[-2 + \frac{\pi^2}{12} - 2C - C^2 + 2(1+C)\ln c_{s*} - \ln^2 c_{s*}\right]\epsilon_{1*}\epsilon_{2*} + \Big[-2\epsilon_{1*} + (2 + 4C - 4\ln c_{s*})\epsilon_{1*}^2$$
$$\left. + (-2 - 2C + 2\ln c_{s*})\epsilon_{1*}\epsilon_{2*}\Big] \ln\left(\frac{k_*}{k}\right) + \left(2\epsilon_{1*}^2 - \epsilon_{1*}\epsilon_{1*}\right)\ln^2\left(\frac{k_*}{k}\right) \right\}$$

- Model dependence is only through H_*, ϵ_{i*} ...

CMB angular power spectra

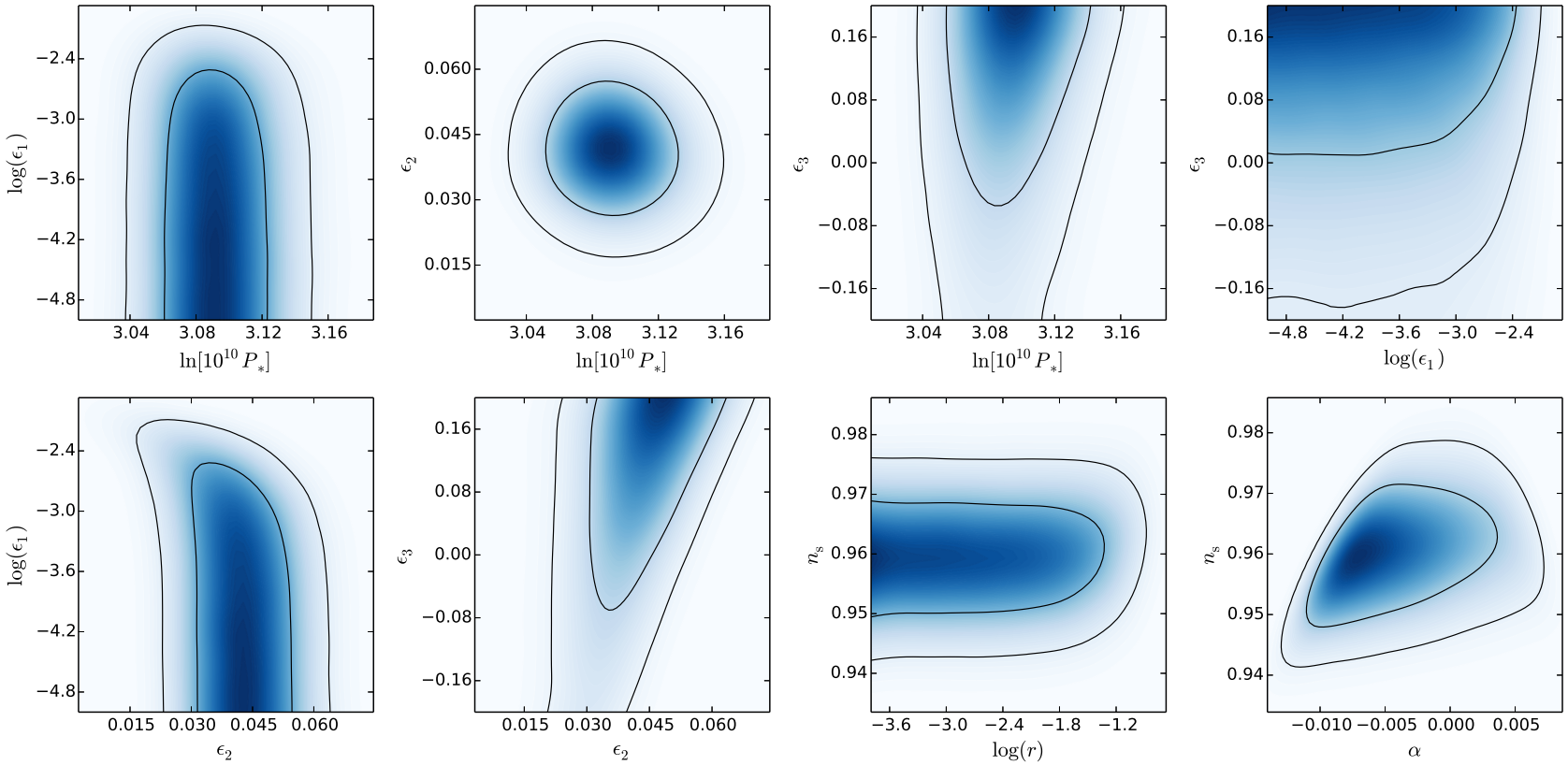


The primordial B contribution



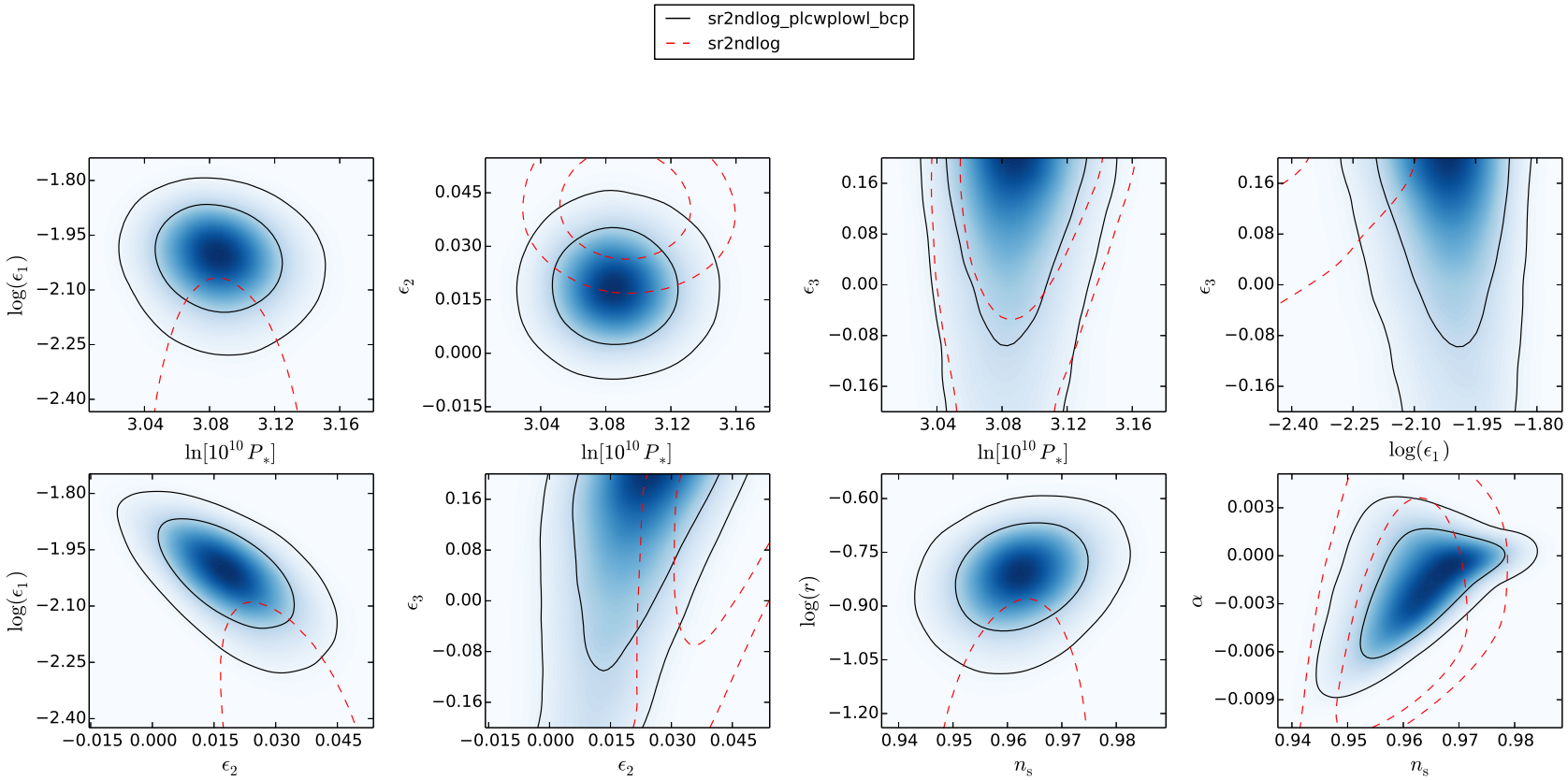
Data analysis I

- Planck alone



Data analysis II

- Slow-roll inflation with Planck + BICEP2



- Clearly a 2σ tension between Planck and BICEP2