Data Analysis for Space Missions

Introduction

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The 2nd B Mode from Space in Berkeley
Berkeley, CA
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Planck lessons learned:

https://www.cosmos.esa.int/documents/387566/1178903/Planck+Lessons+Learned+Phase+1

Point #1

“Data analysis” for CMB experiments is dominated by the search for and mitigation of systematic errors, and the removal of foregrounds (including lensing).

This will be even more true in the future.

Point #2

Systematics and foregrounds don't come wrapped in pretty packages with labels on them. They come all jumbled up, mixed together, interacting with each other, and making a general mess.

- Two nice examples from yesterday:
  - From EBEX: half-wave plate + detector non-linearity
  - From Planck HFI: 4-K cooler EM interference + detector non-linearity

The first and often hardest part is to figure out what the problems are.

Identifying Problems, Points # 3 and # 4

- You may be able to tell that you have problems from power spectra, but a lot of information is lost in going from maps to power spectra. Sooner or later (and it *will* be sooner!), you will be trying to sort things out in maps.

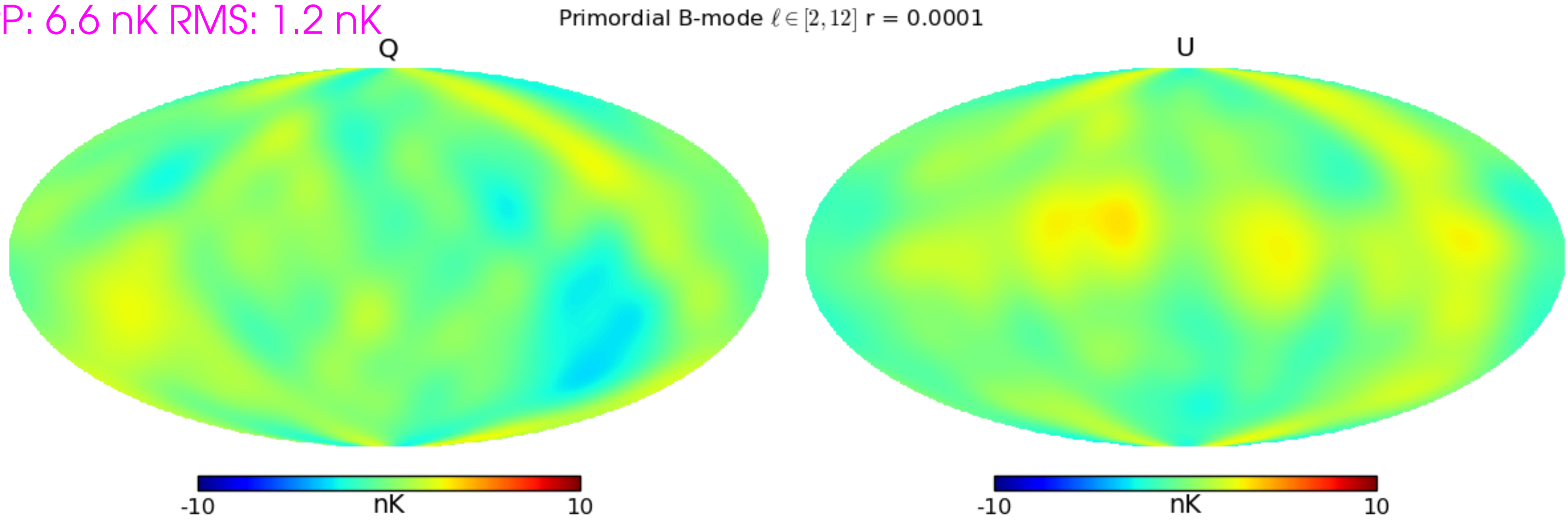
> IT'S THE NOISE LEVEL IN THE MAPS THAT MATTERS ULTIMATELY, NOT IN THE POWER SPECTRA.

- How can you tell that a systematic effect has been identified and (hopefully!) corrected?
  - An instrumental cause is identified
  - Simulations including that instrumental behavior show that the effect on the data is as observed
  - Simulations confirm that whatever mitigating action is taken produces a good outcome

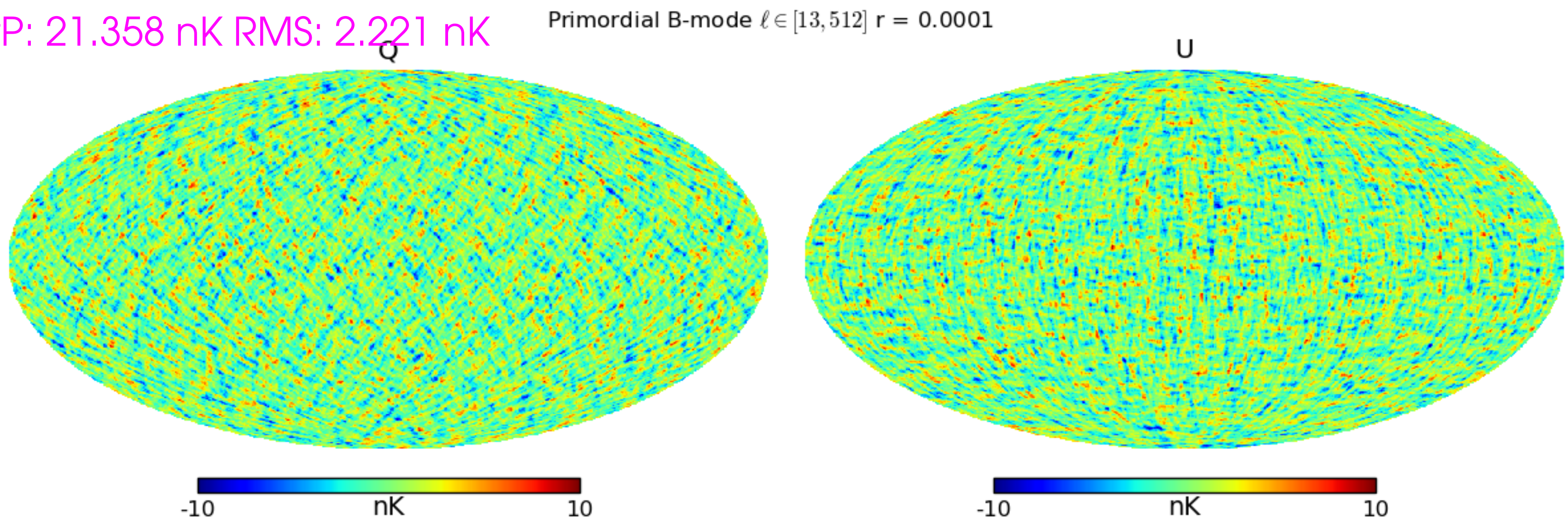
> TOD SIMULATIONS ARE GENERALLY REQUIRED TO REPRESENT INSTRUMENTAL SYSTEMATICS.

$r = 0.0001$ B mode

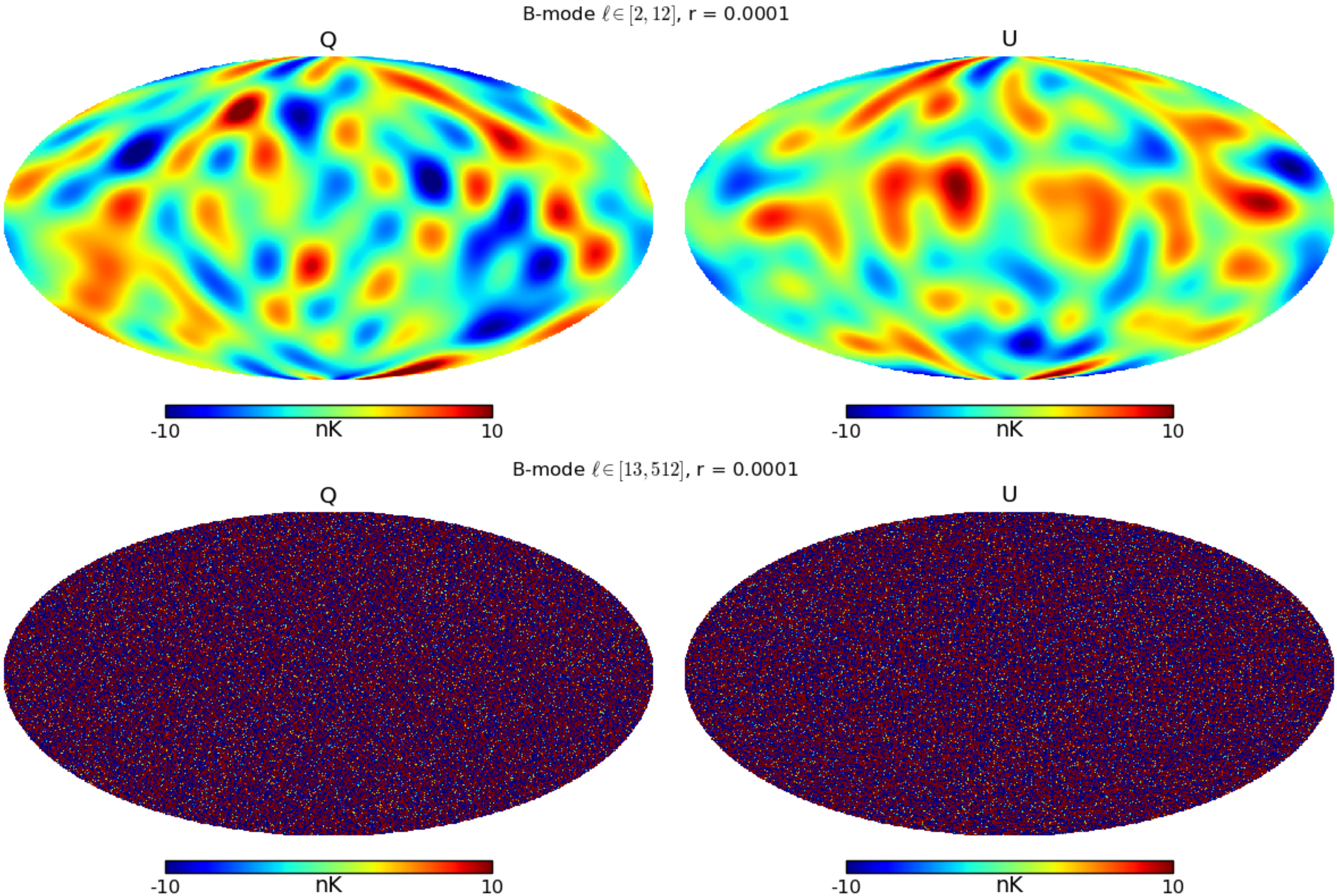
PtP: 6.6 nK RMS: 1.2 nK



PtP: 21.358 nK RMS: 2.221 nK



$r = 0.0001$ B mode, plus lensing

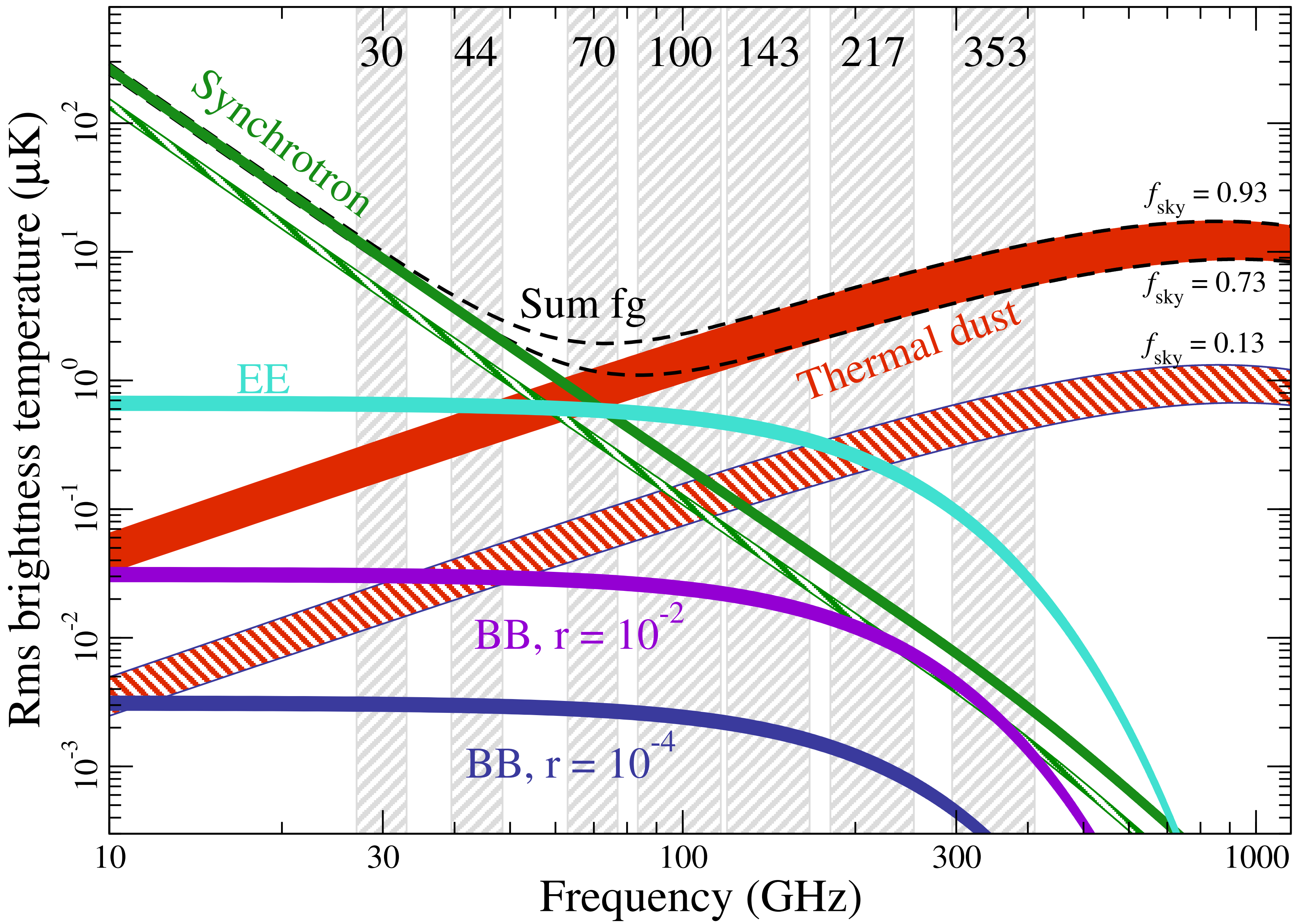


Point #5

$$\boxed{\boldsymbol{r = 0.0001 \leftrightarrow 1\,\mathrm{nK!!}}}$$

This is not a mathematical statement, just a reflection of reality!

Polarized Foregrounds!



POINT # 6

There is no escape from foregrounds, neither the "low frequency" ones ("synchrotron") nor the "high frequency" ones ("dust").