

First Results from the Q/U Imaging Experiment (QUIET)

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QUIET — A DIFFERENT ANGLE

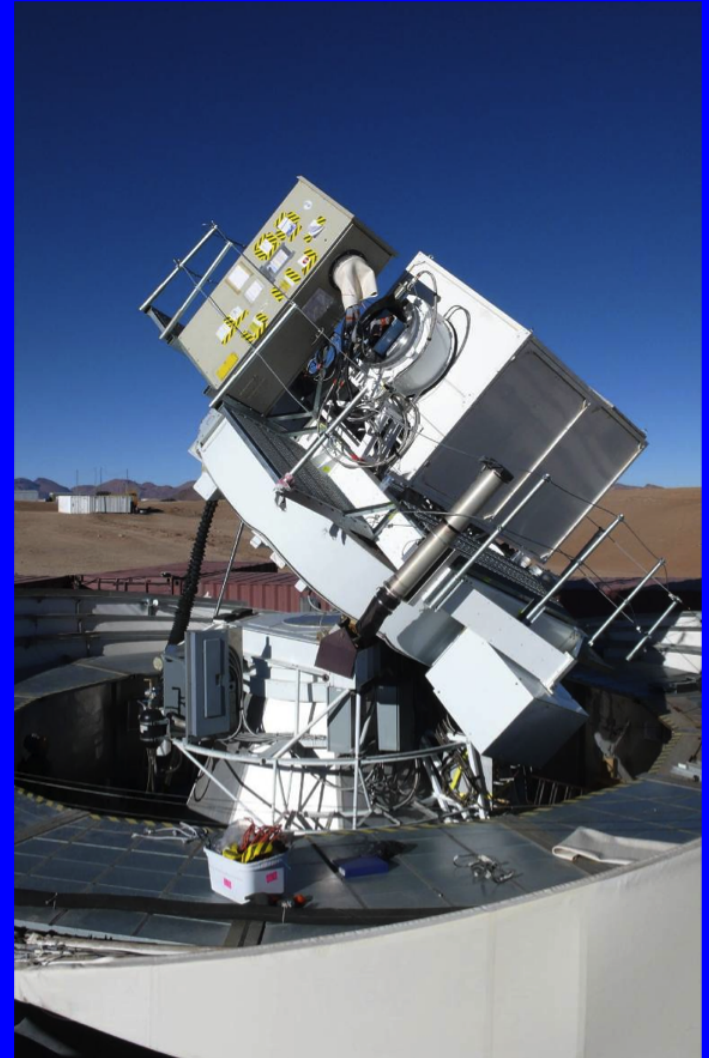
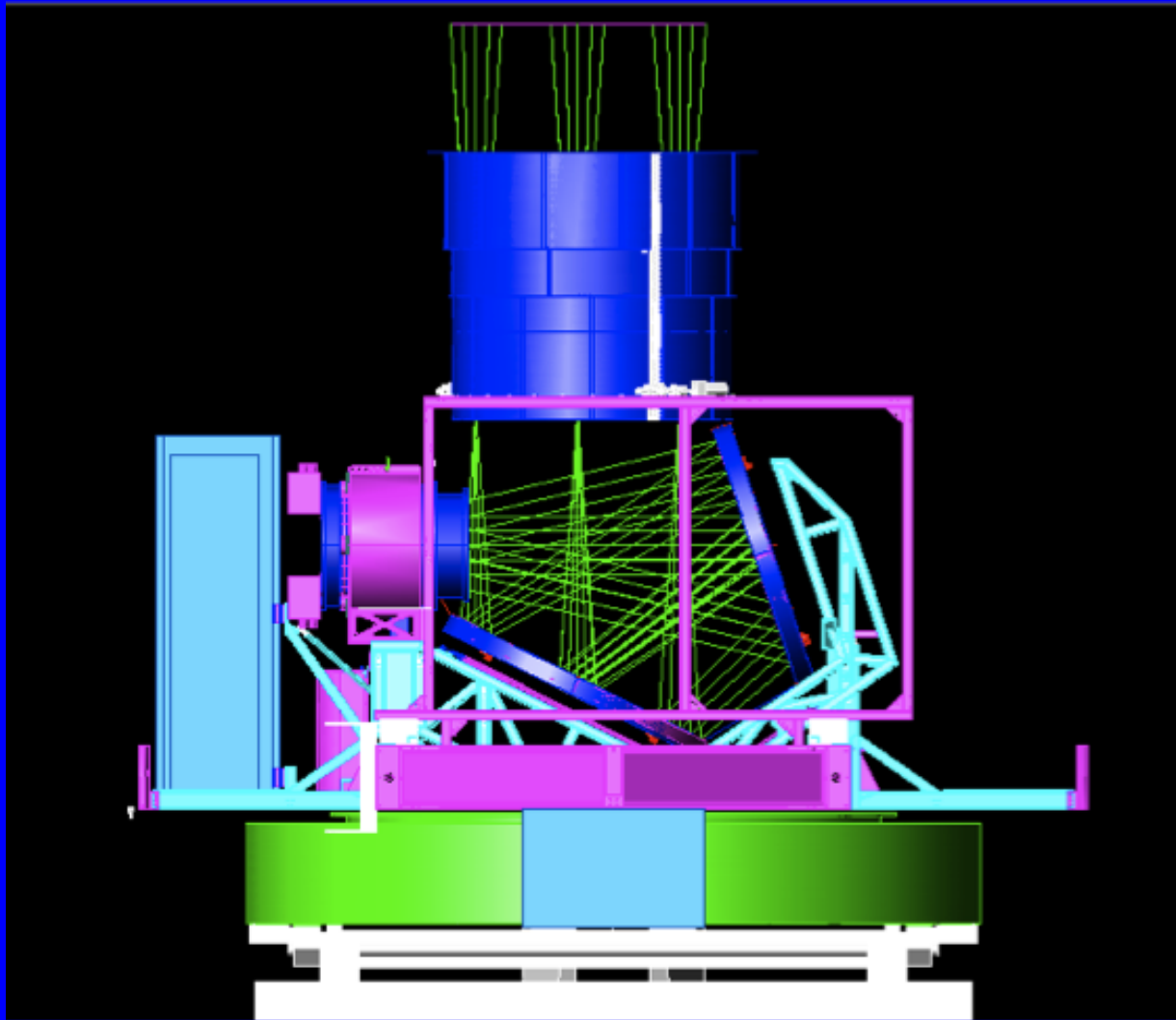


- Polarization-sensitive, ground-based CMB-imaging experiment
- Observes at 40 GHz and at 90 GHz
- Searching for primordial gravitational waves from inflation
(see Church talk)

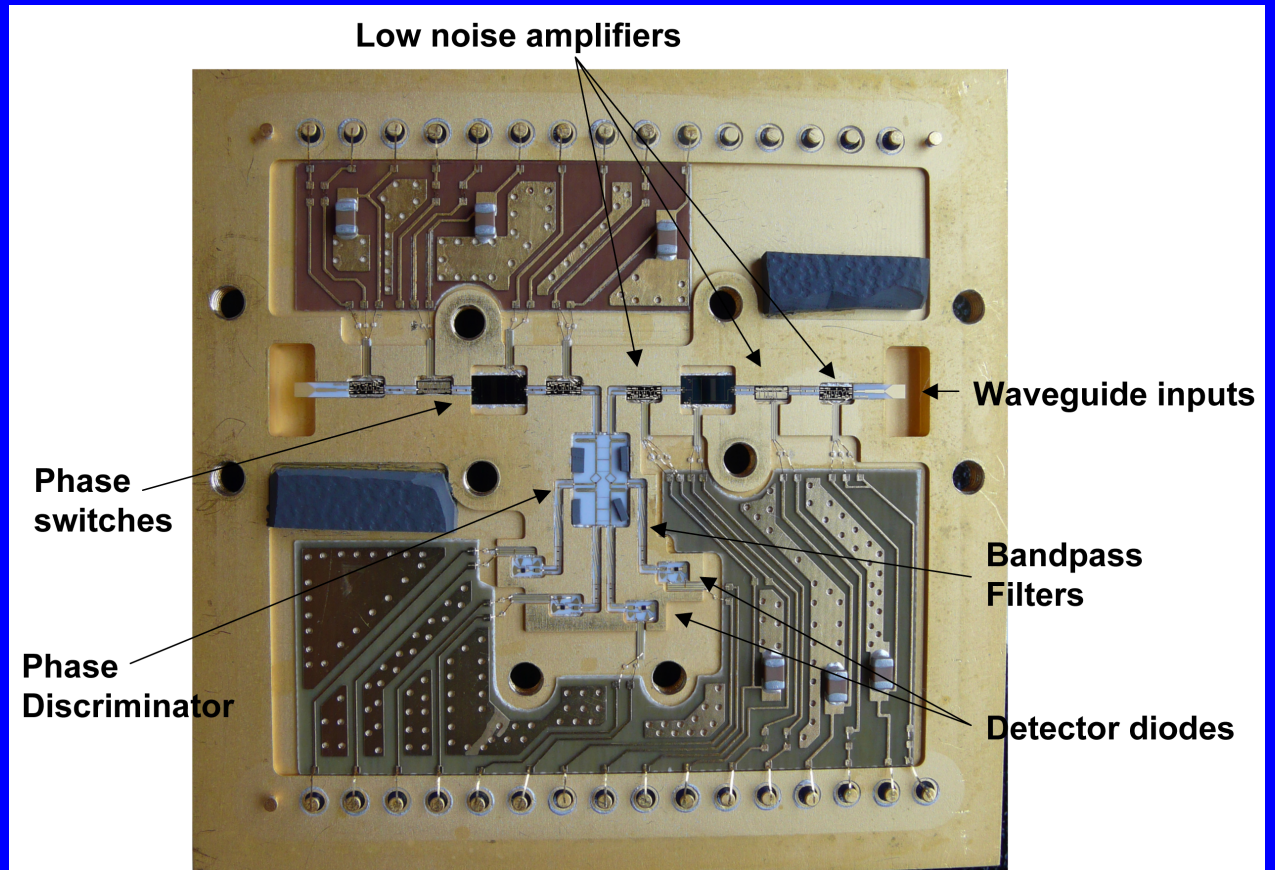
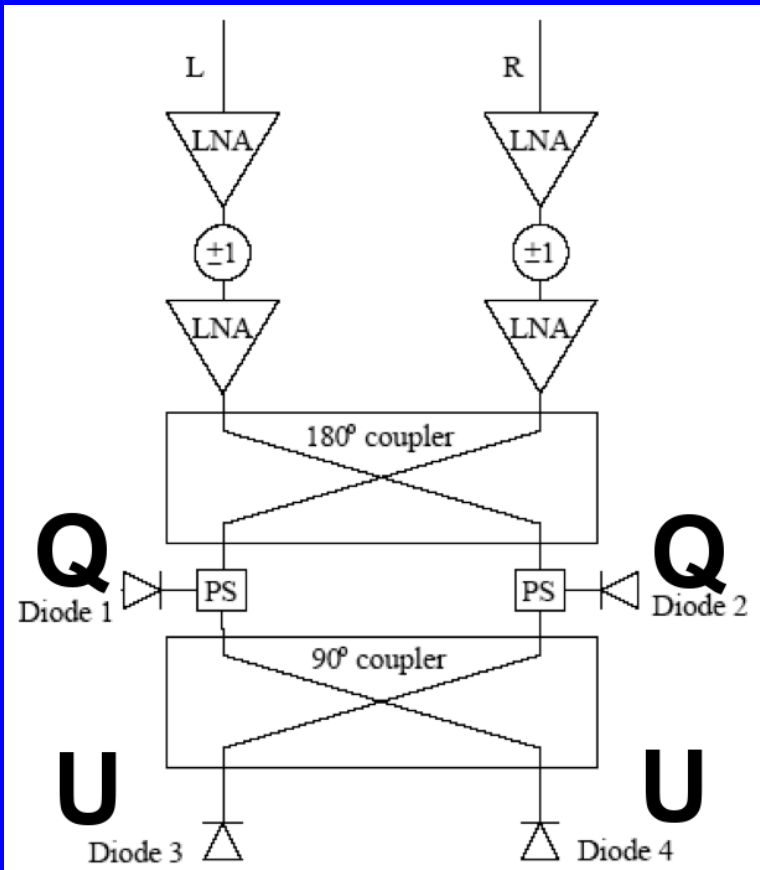
SCIENCE AIMS

- Competitively constrain or detect B-mode signal from primordial gravity waves
- Measure first three peaks of E-mode power spectrum
- Measure amplitude of polarized Galactic-synchrotron foreground

TELESCOPE

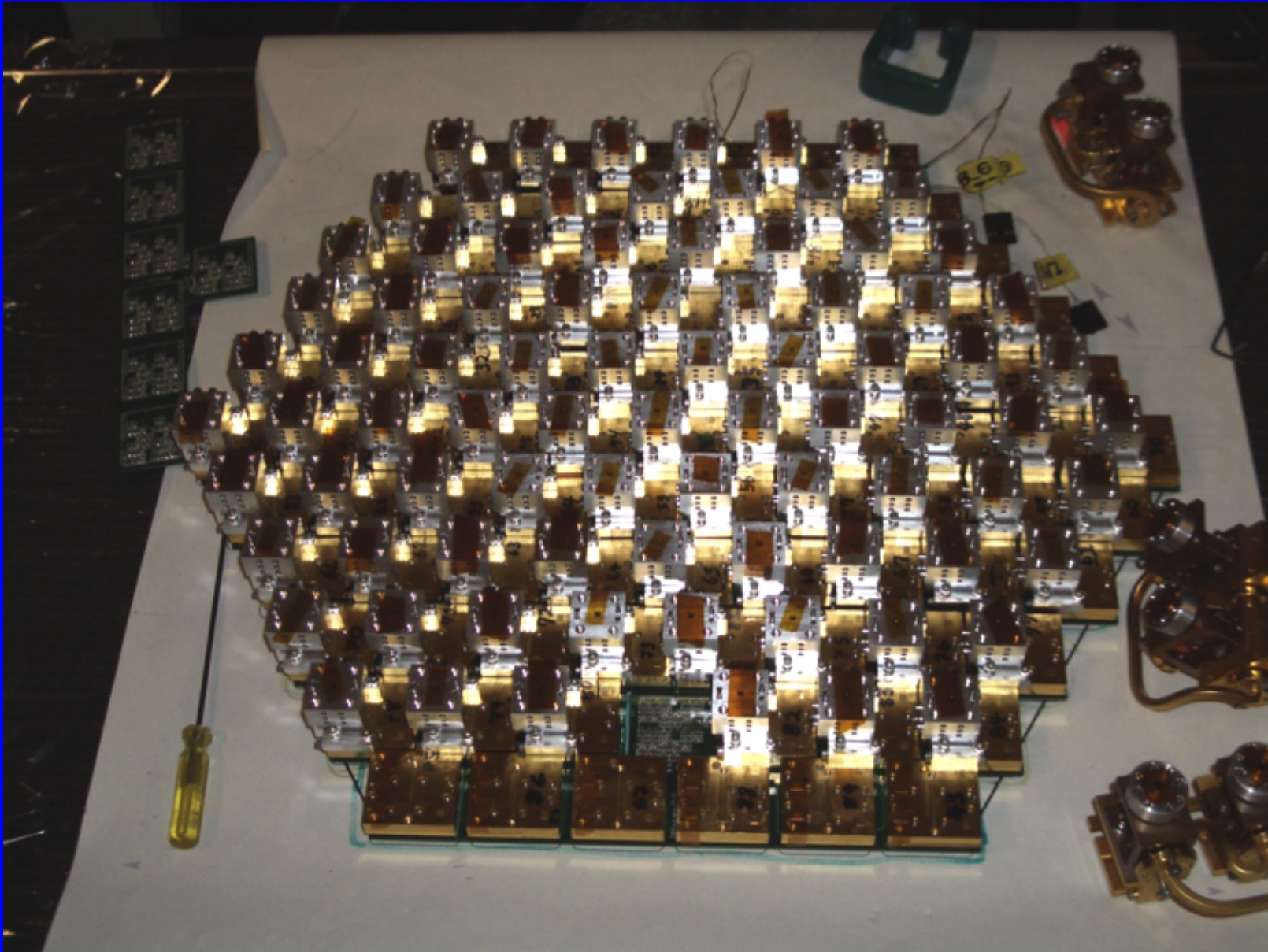


ENABLING TECHNOLOGY — POLARIMETER-ON-A-CHIP



- Coherent HEMT polarimeter
- 180° (90°) hybrid leads to two measurements of Q (U)

LARGE ARRAYS NOW VERY FEASIBLE



Q/U IMAGING EXPERIMENT

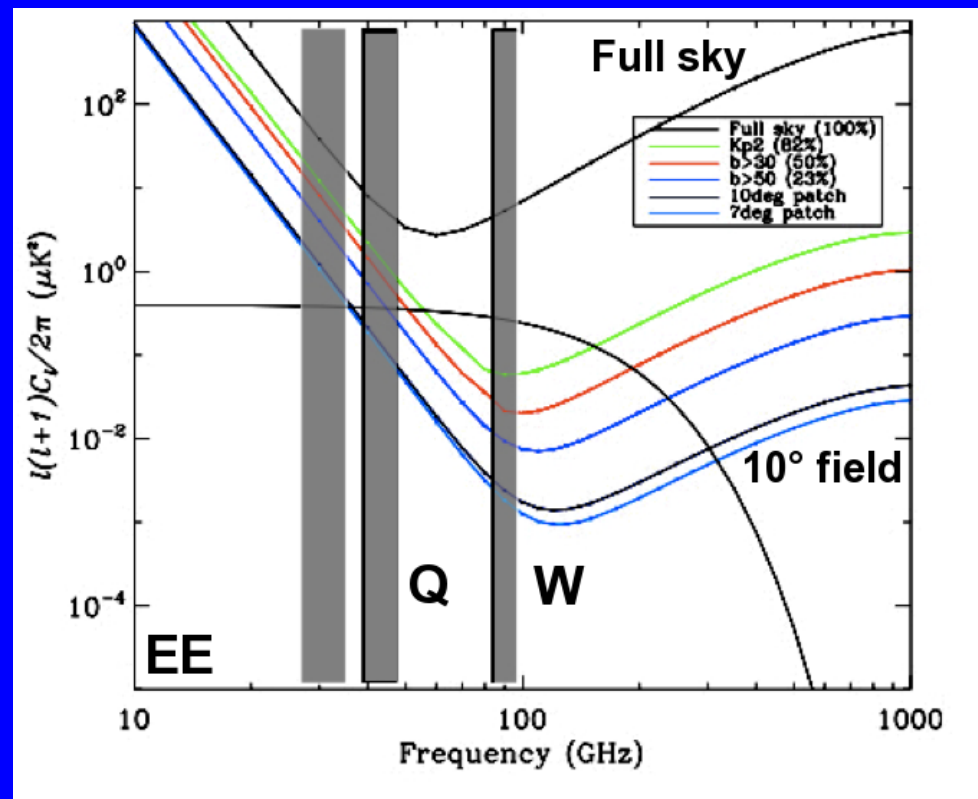
Band	Q	W
Frequency/GHz	43	95
Optics	1.4-m Mizuguchi–Dragone	
Field-of-View FWHM/'	27	12
ℓ range	25–475	25–1000
HEMT modules	17	84
Differential T assemblies	2	6
Sensitivity/ $\mu\text{K s}^{1/2}$	60–70	
Observing time/hours	3500	7600
Location	Atacama Desert, Chile	

- Year-round access from nearby San Pedro de Atacama
 - high (5080 m) and dry (median PWV 1.2 mm)
 - Efficiency \approx 65 per cent; 24 hours/day (excl. poor weather, engineering)

CHARACTERISTICS

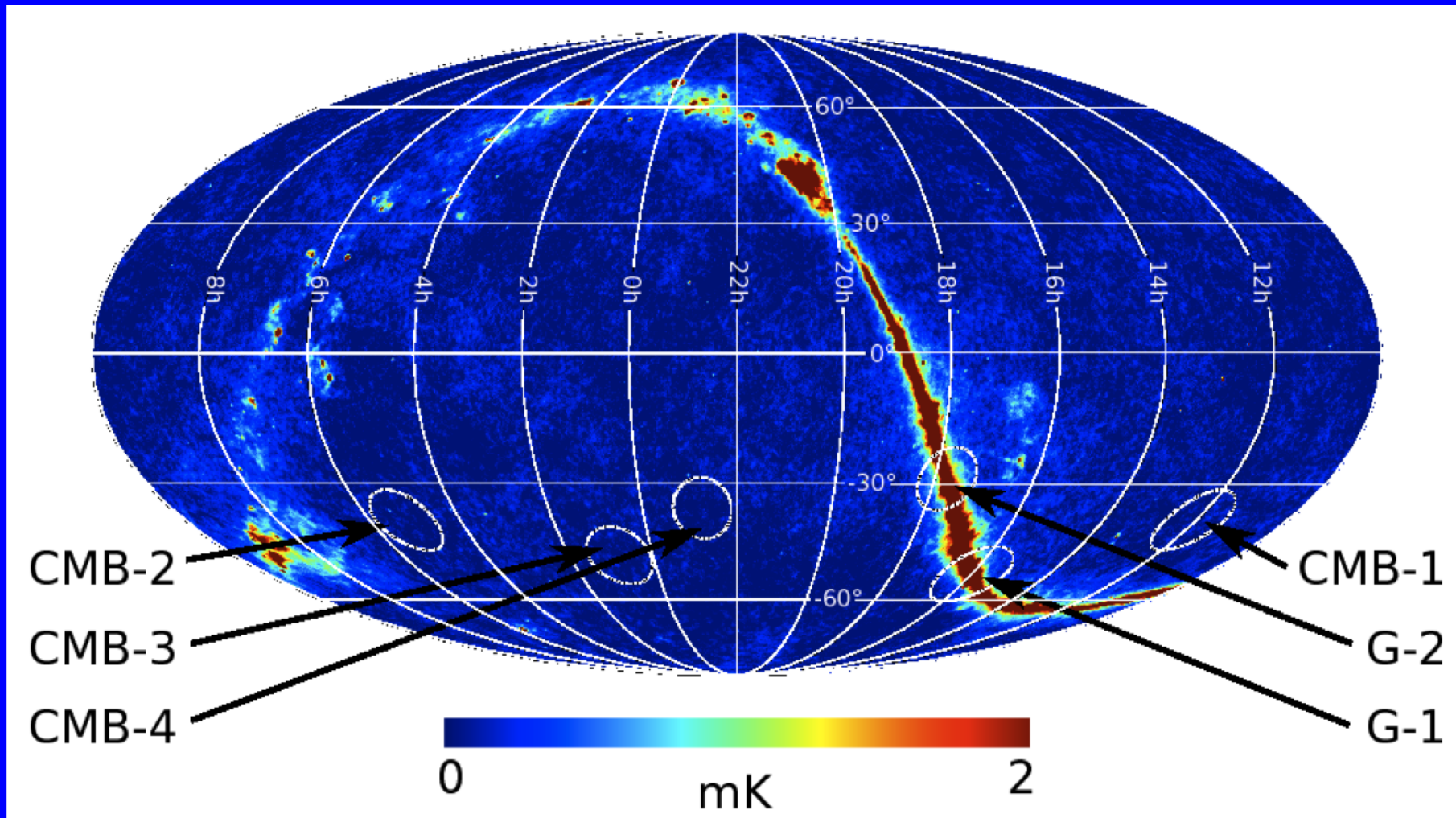
- Distinct — most other experiments designed to measure B modes use bolometers
- One of the most sensitive polarimeter arrays to date ($60\text{--}70 \mu\text{Ks}^{1/2}$ in each band)
- Particular systematic advantages:
 - Two levels of phase-switching (4 kHz, 50 Hz)
 - Simple optical design: mirror has low cross-pol and low sidelobe pick-up
 - Outscan $1/f$
 - Boresight rotation
 - Sky rotation
 - Sensitive to different (and low) foregrounds

FREQUENCIES AND FOREGROUNDS



- Grey bars show K_a , Q and W bands
- For $\ell = 80-120$ (B peak), dominant foreground is Galactic synchrotron
- Eventually combine with POLARBEAR and ABS observations of the same fields (150, 220 GHz)

OBSERVING FIELDS



- Selected to minimize Galactic synchrotron (given scheduling)
- Fields ($15 \times 15 \text{ deg}^2$): J0048–48, J0512–39, J1204–39, J2244–36

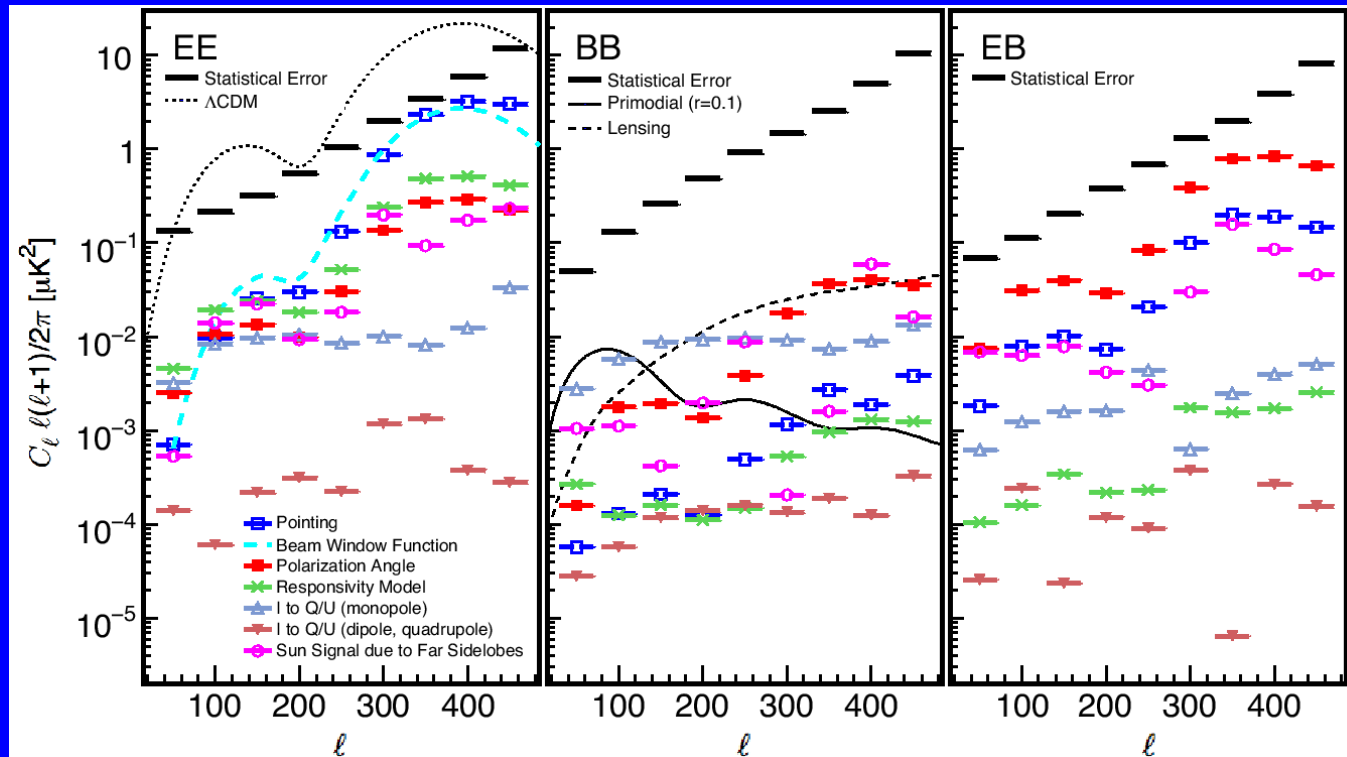
ANALYSIS METHODOLOGY

- **Blind analysis** (uncommon in RMS?)
 - Full power spectra are not viewed until data and analyses pass stringent null tests
- Two **independent** analysis pipelines for map-making and power-spectrum estimation
 - Maximum likelihood
 - Pseudo- C_ℓ

DATA SELECTION AND NULL TESTS

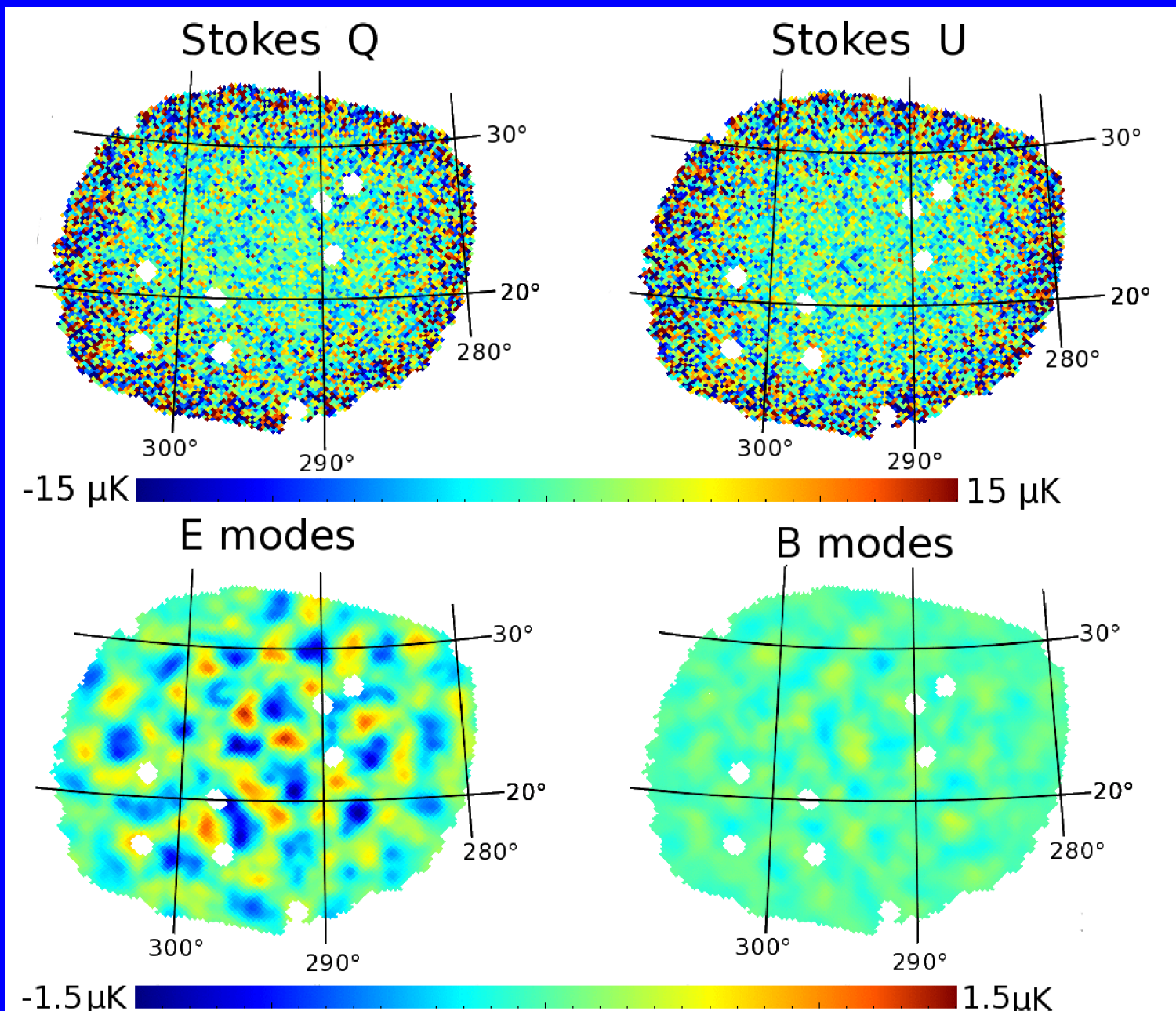
- Data selection (weather, fit to noise model, faulty detectors, etc.)
 - Efficiency ≈ 70 per cent, of which
 - 91 per cent common between the pipelines
- **Split** data in half **along some some axis** and ask:
 - Are jackknife spectra (and maps) **null** (consistent with noise)?
- 20–40 null tests, e.g. Q v U diodes, array orientation, temporal splits
- 42 (21) jackknives $\times 9 \ell$ bins $\times 3$ modes (EE, EB, BB) $\simeq 1100$ points
 - strong discriminating statistics

SYSTEMATIC ERRORS (OR LACK THEREOF)

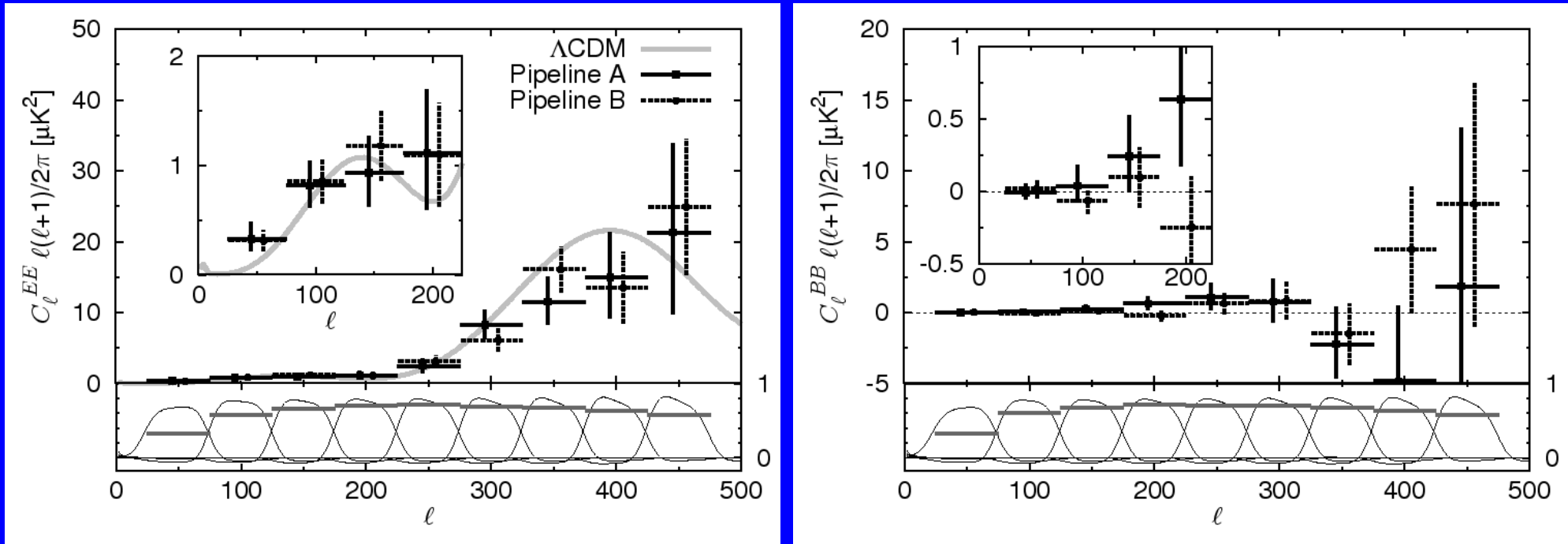


- Systematic uncertainties are lowest demonstrated in this ℓ range for a B-mode experiment
- Far from limited by systematics (good for the future)

MAPS

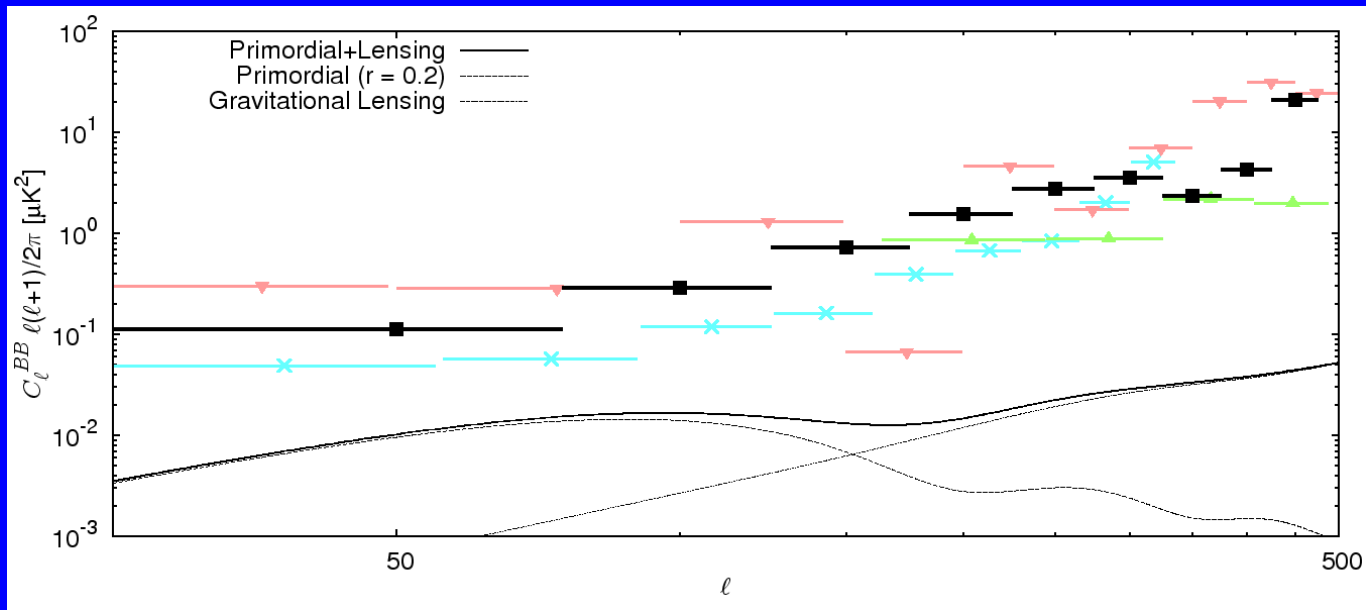
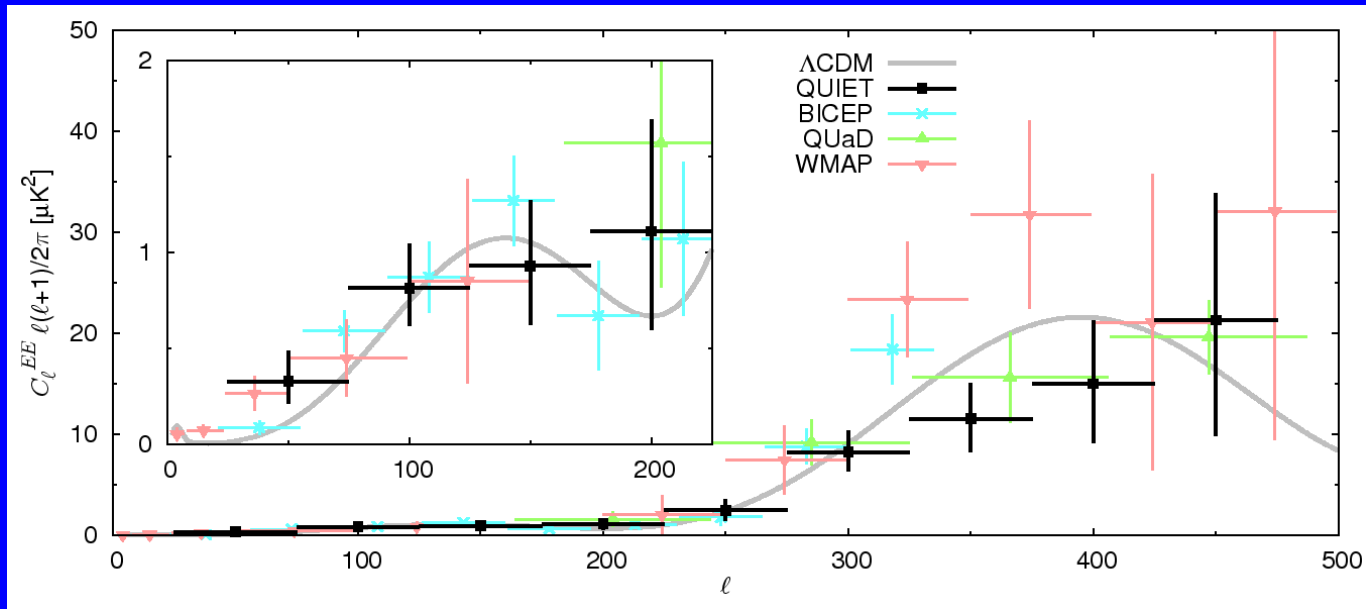


EE AND BB POWER SPECTRA



- Distinct pipelines give consistent spectra
- **Polarization only:** $r = 0.35_{-0.87}^{+1.06}$, $r < 2.2$ (95 per cent)
- CMB-1 is contaminated in **lowest** ℓ bin at 3σ by Galactic foreground (consistent with extrapolation from WMAP K)
- Analysis of W-band data to come

EE AND BB POWER SPECTRA



SUMMARY

- With QUIET we have taken a total of **11,000 hours** of data in Q and W.
- Q-band data have been analysed; W-band data being analysed now.
- A comprehensive analysis has allowed us to place a competitive **limit on B-mode power** and to **constrain foregrounds**.
- QUIET's systematics are both **unique** and **low** for these types of observations.
- **Modular polarimeter is a key enabling technology.**
 - A 500-element array is planned.
- See <http://quiet.uchicago.edu/results> for more details.
- See [astro-ph.CO/1012.3191](https://arxiv.org/abs/astro-ph.CO/1012.3191) for results.