QUIET: Status and Plans

JPL Polarimeters

• Polarimeters
• B-mode Science
• Collaboration
• Module Calibration/Optimization
• Performance
• Where we must improve

“Report from the Field”
CAPMAP

Princeton, Chicago, Miami, JPL Collaboration

Crawford Hill, NJ

16 Correlation Polarimeters:
  12 W-Band (84-100 GHz)
  4 Q-Band (35-45 GHz)

Same LNAs as QUIET
Different packaging

3 months of data (2004/5)
E-mode Results

11 σ detection: best, with CBI (later eclipsed by QUAD)
QUIET’s 90 GHz Radiometer on a Chip
QUIET L/R Correlator: Simultaneous Q/U measurements

\[ |L \pm R|^2 = \left| (E_x + iE_y) \pm (E_x - iE_y) \right|^2 = 4E_x^2, 4E_y^2 \]

50Hz

4kHz phase switching

\[ \left| (L \pm R) + i(L \mp R) \right|^2 = |L \mp iR|^2 = |L|^2 + |R|^2 \mp 2 \text{Im}(RL^*) \]

\[ \text{Im}(RL^*) = \text{Im}(E_x + iE_y)^2 = 2E_xE_y = E_a - E_b \]
High Speed Sampling
18 bits @ 800 kHz

Q/U measurement every 250 µs
Monitors high-frequency noise
Permits Quadrature Samples
– TOD noise with no signal
Demodulation with FPGA
Polarization Modes

E: from Density Perturbations
B: only from Gravity Waves
Key Advances Will Come From Isolation of B-modes
Optimism for Gravity Waves?
(Pagano et al., astro-ph 0707.2560)

\[ n_s \approx 1 - 6\varepsilon + 2\eta \]

\[ r \equiv \frac{T}{S} = 16\varepsilon \]

\[ n_s \neq 1 \implies r \neq 0 \]

\[ \varepsilon = \frac{m_{PL}^2}{16\pi} \left( \frac{V'(\phi)}{V(\phi)} \right)^2 \]

\[ \eta = \frac{m_{PL}^2}{8\pi} \left( \frac{V''(\phi)}{V(\phi)} \right) \]

WMAP 1(2) \( \sigma \) bounds
Simulated sky with T/S=0.2
10 deg by 10 deg field
Simulated sky with T/S=0.0
10 deg by 10 deg field
Q/U Imaging ExperimenT Collaboration

5 countries, 12 institutes, ~30 people
Q-Band (44 GHz)

W-Band (90 GHz)

„Radiometer on a Chip“
Q-band Receiver
(Integrated at Columbia operating since 10/08)
QUIET has been deployed

Electronics

Brizius

I. Buder
The Moon in Q-band

Total power

Polarization
The Galaxy in Q-band
(Hardware & Analysis: D. Samtleben, MPI)

QUIET simulation

WMAP

~5hrs of QUIET data
CMB Patches
(D. Samtleben)

Map precision on 1x1 degree pixel:
- Planck: 1 µK (100 GHz)
- QUIET: 10^{-1} µK (90 GHz)
Operations Supported by Saint & NSF
QUIET & Polarbear

We’ve agreed to scan the same patches
(surely CLOVER will follow)

Hugely positive for systematics and the study and removal of foregrounds
Q-band array Performance in the Field: 17 Modules

- Proposal: $40\text{uks}^{0.5}$
- Actual: $70\text{uks}^{0.5}$
Recent Activity, W-band Modules

- JPL-Chicago-(MPI)
- 5 times more modules than Q
- Our “money channel”
  - ~5 times less foreground level
- Most of the effort in the collaboration
QUIET Calibration/Optimization

\[ U_{\text{observed}} = (U_{\text{reflected}} + U_{\text{observed}}) \]
\[ = -\sqrt{4\pi \nu \rho \varepsilon_0 (\cos \beta - \sec \beta)} (T_{\text{plate}} - T_{\text{load}}) \]
\[ \approx 116 \text{ mK (Al)} \]
Polarized Gain/Sensitivity

M0A3-Q1

M0A3-U1

M0A3-U2

M0A3-Q2

Amplitude (mV)

Amplitude (mV)

Amplitude (mV)

Amplitude (mV)

$T_{\text{pol}}$ (K)

$T_{\text{pol}}$ (K)

$T_{\text{pol}}$ (K)

$T_{\text{pol}}$ (K)

Ti

SS

Al
• Down-hill simplex optimization
  – Starting with JPL bias values
  – Works on 10 gate and drain voltages

• ~5 hours to optimize the array
The Full W-band Array
Modules: K. Cleary
Statistics on the 84 Modules

• Gains from TP and Polarized signals
  – Measured with 77 and 87 K loads
  – Consistent results on average
    • Implies arms are on average phased correctly
    • Larger systematic on TP gain

• $<\text{BW}> : \sim 12 \text{ GHz}$ (proposal said 18)
• $<T_{\text{rec}}> : 125 \text{ K}$ (proposal said 45)
• Best $T_{\text{rec}} : 65 \text{ K}$
• **We may be saturating at 77K (hopefully)**
  – 20 K load available in about a week
  – Will know for sure when we get to the site
For the experts: comparing TP gains with Polarized gains
Phase II Telescopes

1000 detectors
Should reach
$r=0.02$
QUIET: phase II forecasts (90 GHz alone)
What We’ve Said about Schedules vs Time
(Dec 2007)

Better fit to a line
Better slope

~15 man years towards understanding modules from
students and postdocs outside CIT/JPL

3/23/09 KISS Workshop
Plan to Achieve This Goal

• This technology is clearly worth pursuing
• QUIET Phase II would use perhaps 1500 Modules
  – Need to improve performance: $T_{\text{rec}} \sim 50$ K (10Q.L.)
    • Otherwise can’t compete with Bolometers
  – Need a plan to produce them more rapidly (18 months)
    • Last 64 Phase I modules came at 10/month
    • FNAL is interested here as are other groups within QUIET
  – Proposal needs to be submitted in August
    • Production of new modules: 3/10 - 3/11
  – L/R OMT leakages need improvement
• Upgrades to $T_{\text{rec}} \sim 3Q.L.$ will make for a long-lived, productive program
THE END