Workshop Plan and Weiss Report Overview

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CMBPol study goals for systematics

Either:

(a) convince ourselves and decadal community that systematics are not going to limit CMBpol’s effectiveness,

or

(b) identify the worrisome systematics, and propose a program for overcoming them.
This workshop’s goals

1. Review the list of systematics,
2. Document where things stand in terms of understanding them (days 1 and 2),
3. Try to understand how those feed into an all-sky measurement (mostly day 3).
4. Figure out what still needs to happen to accomplish goal (a).

Our hope:

• The proceedings of this workshop will document the details of all this.
• The systematics section of the study report will be a high-level summary, and will refer to the proceedings for details.
This workshop’s format

Morning and early afternoon:

• talks
  • dedicated “note-takers” taking notes on specific systematics we will have to address in the final report.

Late afternoon:

• Panel discussion to review and revise those notes.

Those notes will feed heavily into the systematics section of the final report.
Categories of systematics
(for notes and afternoon discussions)

1. Beam issues
   Crosspolar beam
   Main beam asymmetry (before differencing)
   Sidelobes
   etc
   E->B
dT->B
dT->B

2. Pointing issues
   Polarization angle errors
   Pointing errors (on Q/U)
   Pointing errors before differencing
   etc
   E->B
   E->B
   T->B
   etc

3. Calibration issues (including gain, bandpass and freq response)
   Relative calibration errors
   Gain drift before differencing
   Band shape errors, including modulator effects
   etc
   dT->B
   T->B
   foregrounds->B
   etc

4. Environmental stability issues
   Optics and spillover T variations
   Scan modulated cold stage variations
   etc
   dTopt -> B
   dTcs -> B
   etc

5. Other issues
   Instrumental polarization
   ? (look for additions that don't fit in above categories)
   dT->B
## The “notetakers”

<table>
<thead>
<tr>
<th></th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Beams</strong></td>
<td>Page</td>
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<td>Page</td>
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<tr>
<td><strong>Pointing</strong></td>
<td>Kogut</td>
<td>Kogut</td>
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<tr>
<td><strong>Calibration</strong></td>
<td>Staggs</td>
<td>Staggs?</td>
<td></td>
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<tr>
<td><strong>Environment</strong></td>
<td>Lawrence</td>
<td>Lawrence</td>
<td>Lawrence</td>
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<tr>
<td><strong>Other</strong></td>
<td>Timbie</td>
<td>Timbie</td>
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Weiss Report Basics

DOE/NASA/NSF “Task Force on CMB Research”


Final report available at:
   http://www.nsf.gov/mps/ast/tfcr.jsp

Members:
   Bock, Church, Devlin, Hinshaw, Lange, Lee, Page, Partridge, Ruhl, Tegmark, Timbie, Weiss, Winstein, Zaldarriaga
T1) We recommend technology development leading to receivers that contain a thousand or more polarization sensitive detectors, and adequate support for the facilities that produce these detectors.

T2) We recommend a strategy that supports alternative technical approaches to detectors and instruments.

T3) We recommend funding for development of technology and for planning for a satellite mission to be launched in 2018.

T4) We recommend strong support for CMB modeling, data analysis and theory.
Systematics Section

For $r = 0.01$, B-mode signal rms is about 30nK.

Weiss report estimated control of various parameters required to ensure each individual systematic effect contributed rms $< 3nK$.

No attempt to discuss effects as a function of $\ell$, eg low-$\ell$ bump vs. high-$\ell$ bump.

(TFCR believed you need to get both)
### Weiss report table

**Table 6.1: Instrument Performance Goals**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Effect</th>
<th>Goal</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross-Polar Beam response</td>
<td>$E \rightarrow B$</td>
<td>$&lt; 0.003$</td>
<td>Rotate Instrument, Wave Plate</td>
</tr>
<tr>
<td>Main lobe ellipticity (0.5° beam)</td>
<td>$dT \rightarrow B$</td>
<td>$&lt; 10^{-4}$</td>
<td>Rotate Instrument, Wave Plate</td>
</tr>
<tr>
<td>Polarized sidelobes (response at Galaxy)</td>
<td>$dT \rightarrow B$</td>
<td>$&lt; 10^{-6}$</td>
<td>Baffles/shielding/measure</td>
</tr>
<tr>
<td>Instrumental polarization</td>
<td>$dT \rightarrow B$</td>
<td>$&lt; 10^{-4}$</td>
<td>Rotate Instrument, Wave Plate</td>
</tr>
<tr>
<td>Polarization angle</td>
<td>$E \rightarrow B$</td>
<td>$&lt; 0.2 \degree$</td>
<td>Measure</td>
</tr>
<tr>
<td>Relative pointing (of differenced samples)</td>
<td>$dT \rightarrow B$</td>
<td>$&lt; 0.1''$</td>
<td>Dual-polarization pixels</td>
</tr>
<tr>
<td>Relative calibration</td>
<td>$dT \rightarrow B$</td>
<td>$&lt; 10^{-5}$</td>
<td>Modulators</td>
</tr>
<tr>
<td>Relative calibration drift (scan synchronous)</td>
<td>$T \rightarrow B$</td>
<td>$&lt; 10^{-9}$</td>
<td>Modulators</td>
</tr>
<tr>
<td>Lyot Stop Temperature (10% spill, scan synch.)</td>
<td>$dT_{\text{opt}} \rightarrow B$</td>
<td>$dT_{\text{opt}} &lt; 30 \text{ nK}$</td>
<td>Measure</td>
</tr>
<tr>
<td>Cold stage T drifts (scan synch.)</td>
<td>$dT_{\text{CS}} \rightarrow B$</td>
<td>$dT_{\text{CS}} &lt; 1 \text{ nK}$</td>
<td>Improve uniformity, measure</td>
</tr>
</tbody>
</table>

**TABLE 6.1** Performance goals for a CMB B-mode measurement. The first eight parameters describe instrumental effects that transform various sky signals into false B-mode signals; here we use $T$ to indicate intensity, $E$ to indicate the E-mode polarization signal, and $dT$ to indicate CMB temperature anisotropies. The listed “Goal” is the level at which an individual instrumental effect will begin to cause a 10% contamination (in units of temperature) of an $r = 0.01$ B-mode signal in the most naïve experimental design. Clever scan strategies and partial correction of known levels of contamination can relax these requirements. See the text for more details.
## Systematics Table
### sent out for this workshop

<table>
<thead>
<tr>
<th>Systematic</th>
<th>Effect</th>
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<tr>
<td>Crosspolar beam</td>
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<td>Main beam asymmetry (before differencing)</td>
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<td>Gain drift before differencing</td>
<td>$T \rightarrow B$</td>
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<tr>
<td>Optics and spillover $T$ variations</td>
<td>$dT_{opt} \rightarrow B$</td>
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<td>Scan modulated cold stage variations</td>
<td>$dT_{CS} \rightarrow B$</td>
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<td>Band shape errors, including modulator effects</td>
<td>$\text{foregrounds} \rightarrow B$</td>
</tr>
<tr>
<td>Others?</td>
<td>?</td>
</tr>
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</table>

### Notes:
- **Not $dT \rightarrow B$**
- **Total power beam**
- **Sky side of modulator**
- **Before differencing**
- **Not in Weiss report**

Suzanne Staggs adds: absolute calibration, beam measurement quality, space-specific issues (noisy belt, charge accumulation, etc)