Feed farm concept: an initial look

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Collaborators

The concept has been around since people began talking about a CMBPol mission. The following is one version that was spawned as a result of discussions with collaborators on the Hinshaw *et al.* "A Mission Concept Study for the Einstein Inflation Probe," ~Jan. 2004 (with C. Bennett, M. Devlin, D. Fixsen, W. Hu, K. Irwin, N. Jarosik, A. Kogut, A. Kosowsky, M. Limon, S. Meyer, A. Miller, S. H. Moseley, B. Netterfield, A. Oliveira-Costa, L. Page, J. Ruhl, U. Seljak, D. Spergel, S. Staggs, M. Tegmark, B. Winstein, E. Wollack, E. Wright, & M. Zaldarriaga). Additional developments came from the Staggs *et al.* "Broadband Cryogenic Feedhorn Arrays for Cosmic Microwave Background Polarimetry," Jun. 2005 (with N. Jarosik and L. Page)

Toy Model

Please fill out this table; for the limit on r, give a footnote on how that was calculated (ie what foreground model if any, etc)

Angular resolution	180-360	Arcminutes
Frequency Coverage	150-300 (for a start)	GHz
Sky Coverage	Full	Square Degrees
Multipole Coverage	2-100(?)	-
Polarization Modulation?	Spin + OMT	-
Types of Detectors	Bolometers	-
Location	e.g., L2	(Balloon/Ground/Space)
Instrument NEQ	40 uKsec^{1/2}/feed	$\mu K\ s^{1/2}$
Expected/Current limit on *r*	Need full FG analysis.	-
Status	On paper/Future	(Funded/Proposed/ Future)

Instrument and Observing Strategy

Please describe the following items, as well as anything else we need to know to understand how you're going to make polarization maps

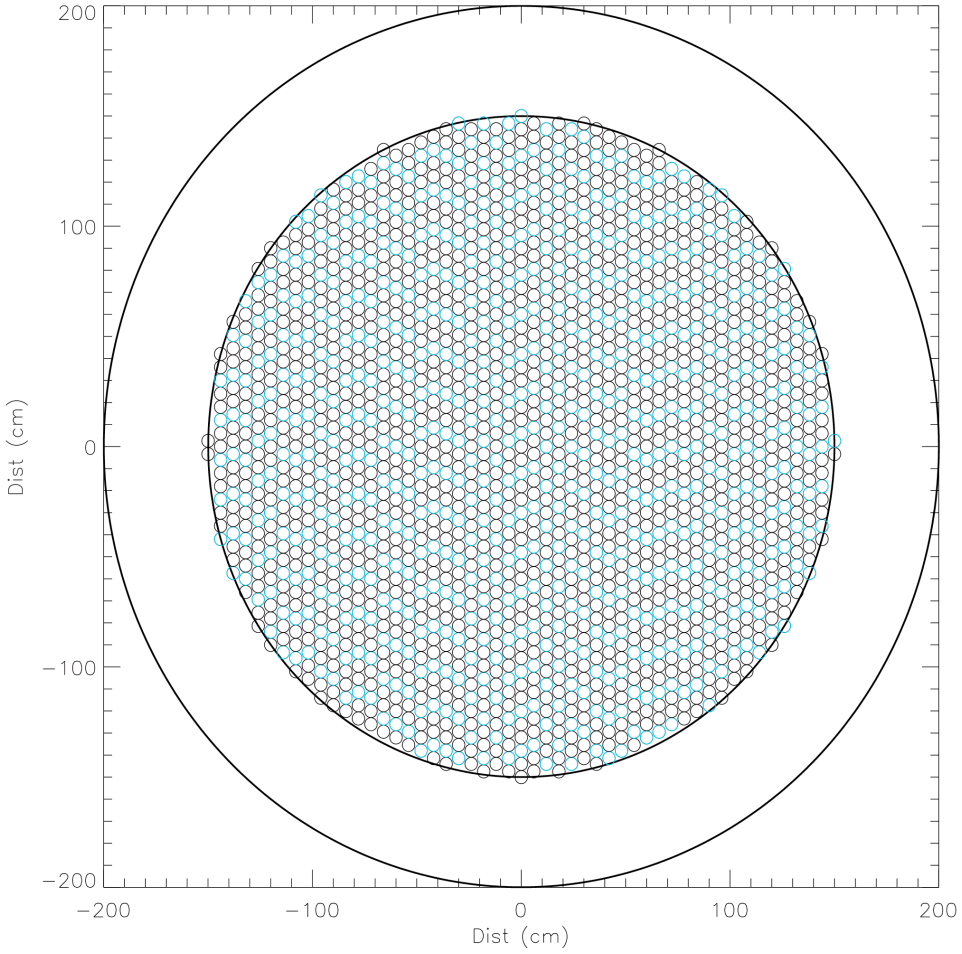
- Optics: Feeds
- Band definitions: Stripline filters
- Polarization selection: Planar OMT
- Polarization modulation: Spin
- Scan strategy: Slow precession
- Pointing reconstruction (accuracy): need sim

Optics:

- The beam shape is computable to high accuracy.
- The beam can be made symmetric. I'm not aware of a more symmetric beam pattern than that from a corrugated feed.
- The feeds can be machined at least up to 190 GHz and multiple copies made of a single design.
- Can probably get ~80% efficiency.

- The feeds have to support a thermal gradient of ~0.1 K to 35 K. The loss is in the bottom 15 or so grooves.
- A 150 GHz 3 deg FWHM feed has an aperture of 6 cm and is 35 cm long. The length can probably be shortened with profiling. One needs high gain feeds to get the decoupling area. Making these feeds is the biggest challenge. To my knowledge, one has not been made.
- Feed alignment may be a challenge (J. Ruhl) but 1' possible.

Schematic of MIDEX shroud:



This figure has 1959 feeds

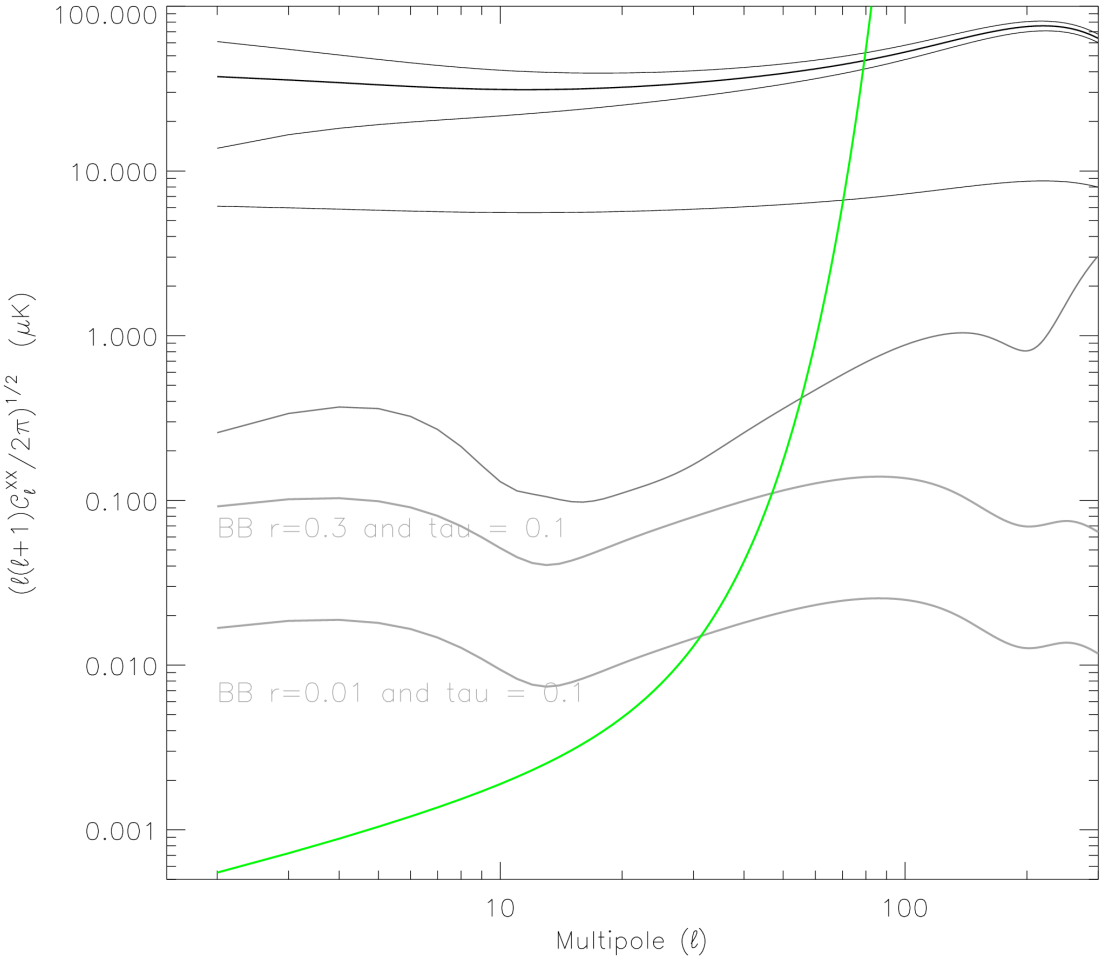
Cryo area is 2 m across. This requires challenging but possible thermal engineering. Teams already run cold fingers that cover 1 m.

Higher frequency feeds are almost “free” but lower freq ones cost real estate. Could optimize with Clive’s program. One has the same trade for any layout.

Orbit and Scan:

- Feeds are mostly parallel with a few pointed off the spin axis with angles up to +/- 20 deg. These are for cross linking the T measurements. In one rotation, a 43 deg diam patch is covered.
- Primary modulation is the spin at 2 RPM (4x WMAP). Can sync average over a spin cycle to lower the data rate. For polarization, the most important quantity is the value in one direction. Cross linking is not as important as for T. May need flasher for calibration.
- Precess the axis slowly (6 hours) to cover a lot of sky. Solve for gain and baseline with T maps. Slowly fill out full sky map.
- Clearly a real sim is needed to pick the best parameters. A BOE calculation shows that even with a 7 deg feed pointing 20 deg off the spin axis on a precessing platform with a modest sun shield sees just 10 nK of diffracted power.

Sensitivity



1500 150 GHz feeds at 40 uk-sec^{1/2} per feed (Weiss report)

EE

Green line is det sens for 3 deg beam.

Issues/Lessons/Concerns

- For an experiment in development, what are your major concerns?

  Can a feed be made with a 1.5 deg FWHM? (e.g., with lenses)

  What is the best way to calibrate?

  Main concern is with foregrounds, not with the instrument.

Systematics to consider: TBD

Below is a list of potential systematic effects. Please address whatever effects you can from here in your talk; feel free to add more or qualify/expand on these. Quantitative limits (measured, calculated, or estimated) on these effects would be helpful, as would results of simulations with your observing strategy that take them to a power spectrum.

Systematic	Effect
Crosspolar beam	$E \rightarrow B$ (is better possible?)
Polarization angle errors	$E \rightarrow B$ ditto
Pointing errors (on Q/U)	$E \rightarrow B$ (~5", WMAP)
Main beam asymmetry (before differencing)	$dT \rightarrow B$
Sidelobes	$dT \rightarrow B$ (computable but OK)
Instrumental polarization	$dT \rightarrow B$ (is better possible?)
Relative calibration errors	$dT \rightarrow B$ (needs work)
Pointing errors before differencing	$T \rightarrow B$ (depends on OMT)
Gain drift before differencing	$T \rightarrow B$
Optics and spillover T variations	$dT_{opt} \rightarrow B$
Scan modulated cold stage variations	$dT_{CS} \rightarrow B$ (can make very small)
Band shape errors, including modulator effects	foregrounds $\rightarrow B$
Others?	?