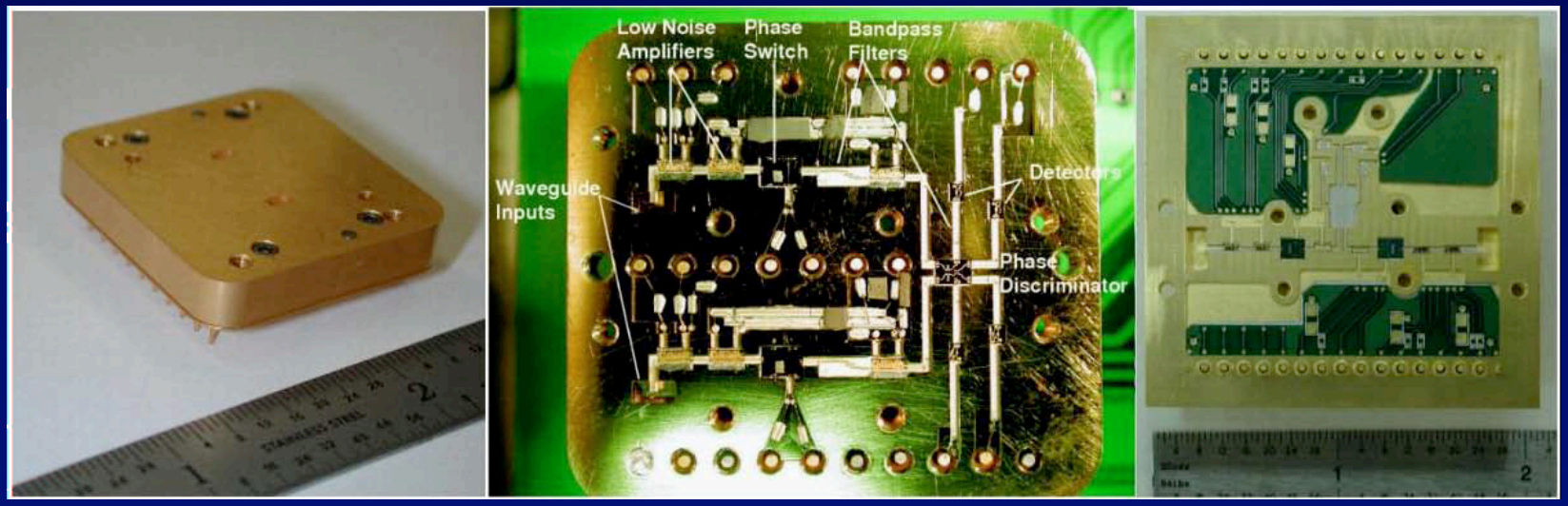
EPIC Mission Concept Study Tasks

- sensitivity analysis
- optimize l-space coverage of interferometer arrays
- data analysis
  - analysis pipeline, simulations
  - mosaicking over full sky
- foreground removal - Fourier vs map space
- beam combiner study - optical vs guided wave
- phase shifter study - review available technology
- power/mass/costs

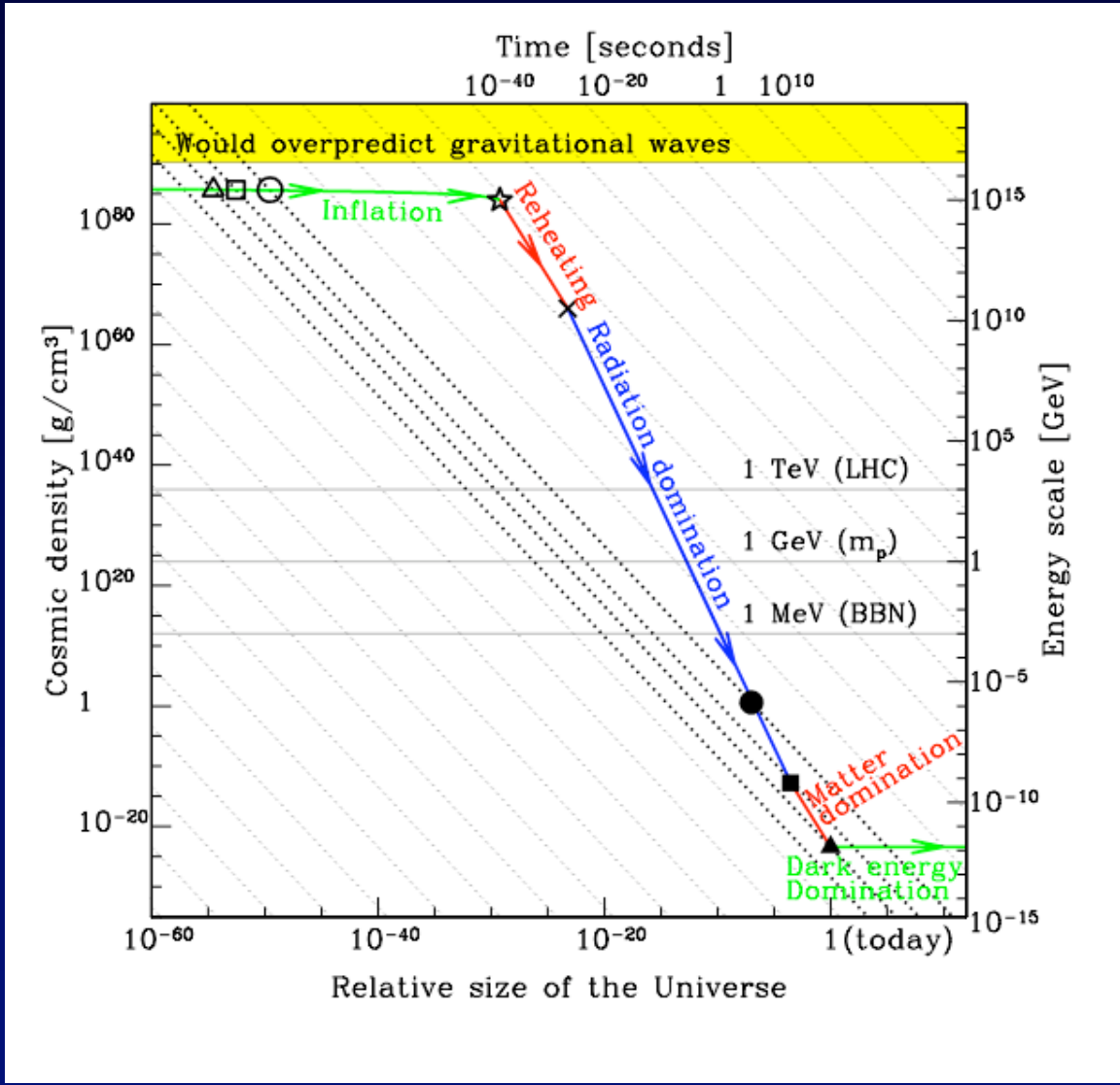
Alternate Receiver Technology: HEMT Amplifiers

- Interferometry or Imaging
- < 120 GHz
- Cryocooler power



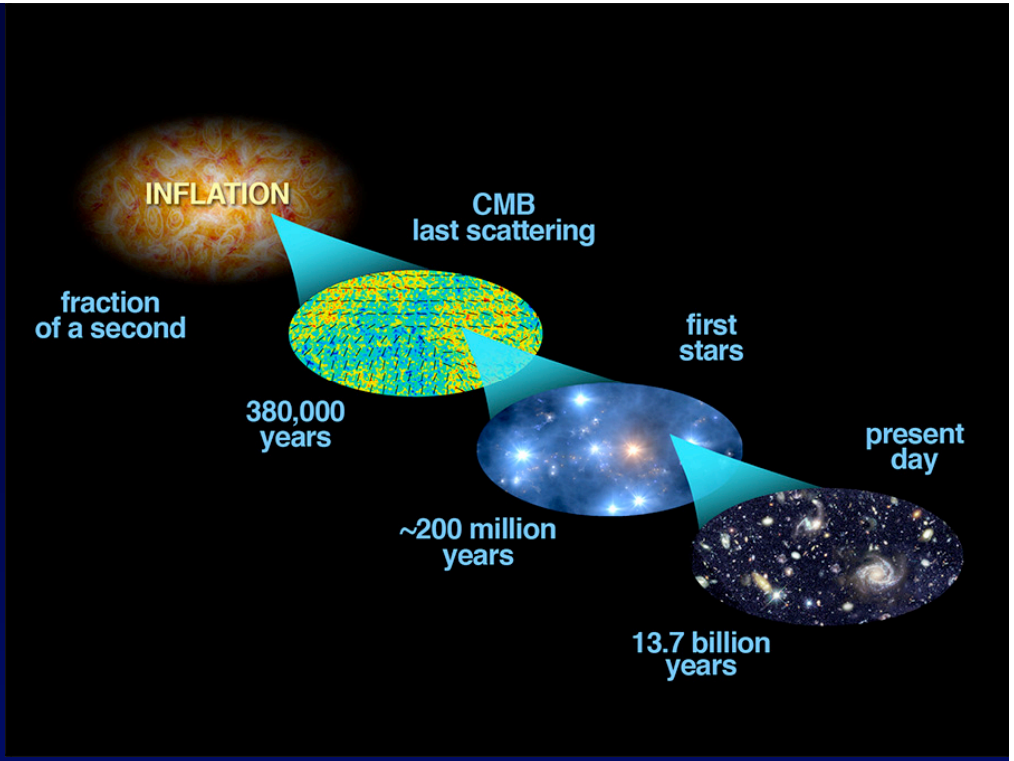
HEMT correlation polarimeter (T. Gaier, JPL)

Density vs scale factor



(TFCR)

Summary

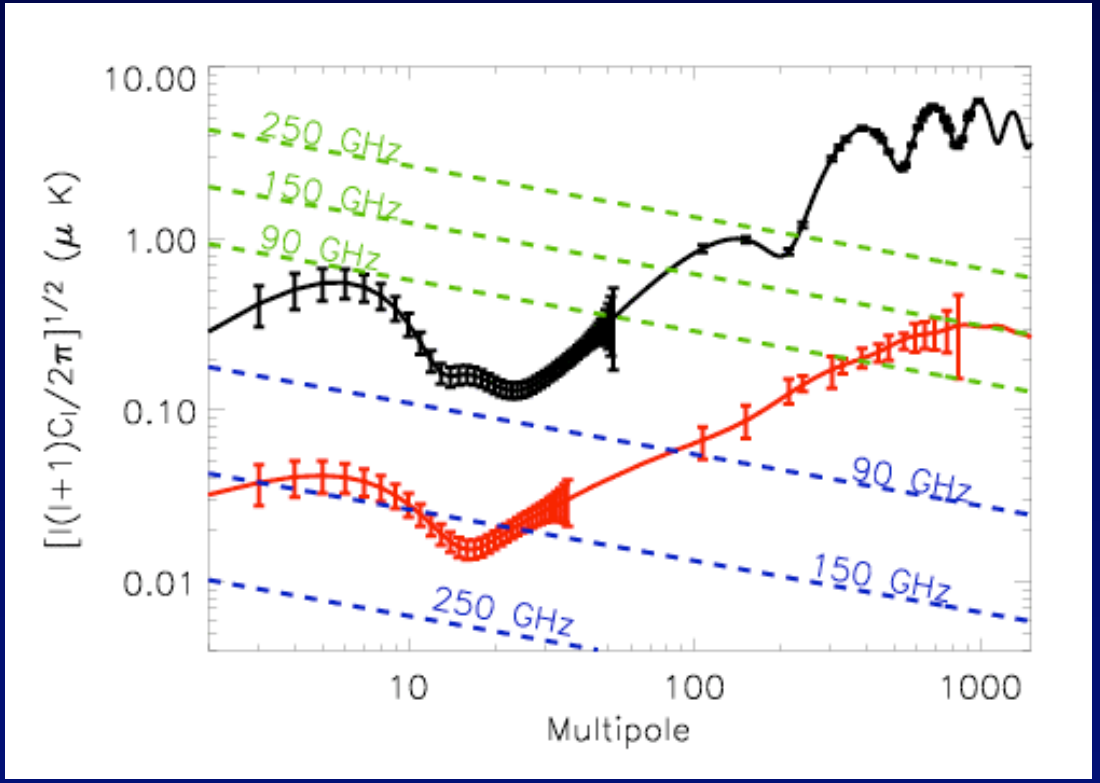


- We know what to look for
- Unique signal from ~ 10^{-38} s
- Several ways to measure it (3 studies)
- No technical breakthroughs req'd -TFCR plan

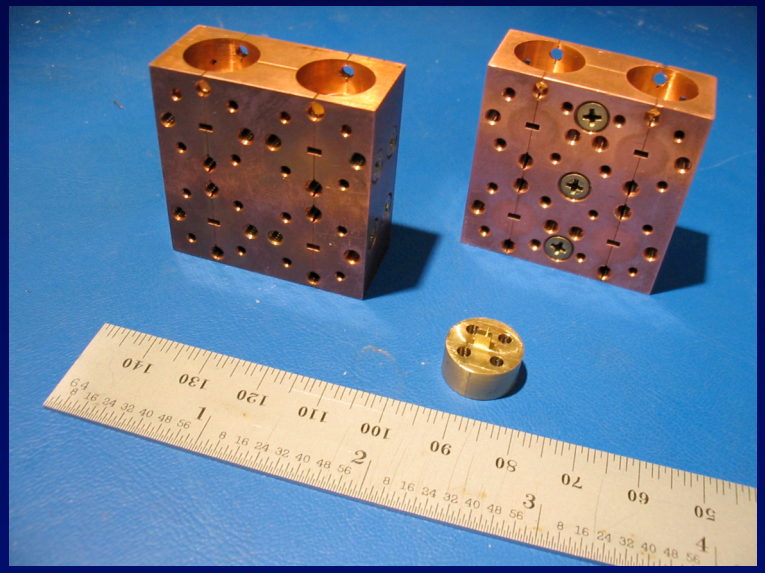
Appendix

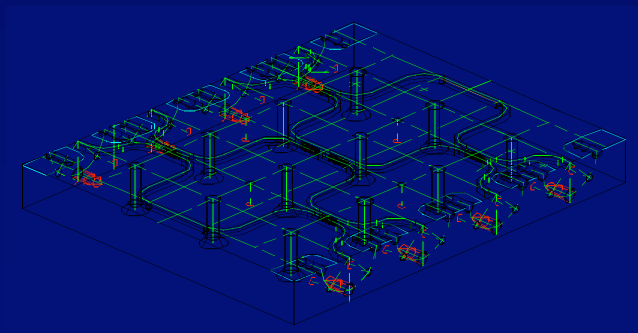
EPIC sensitivity (2)

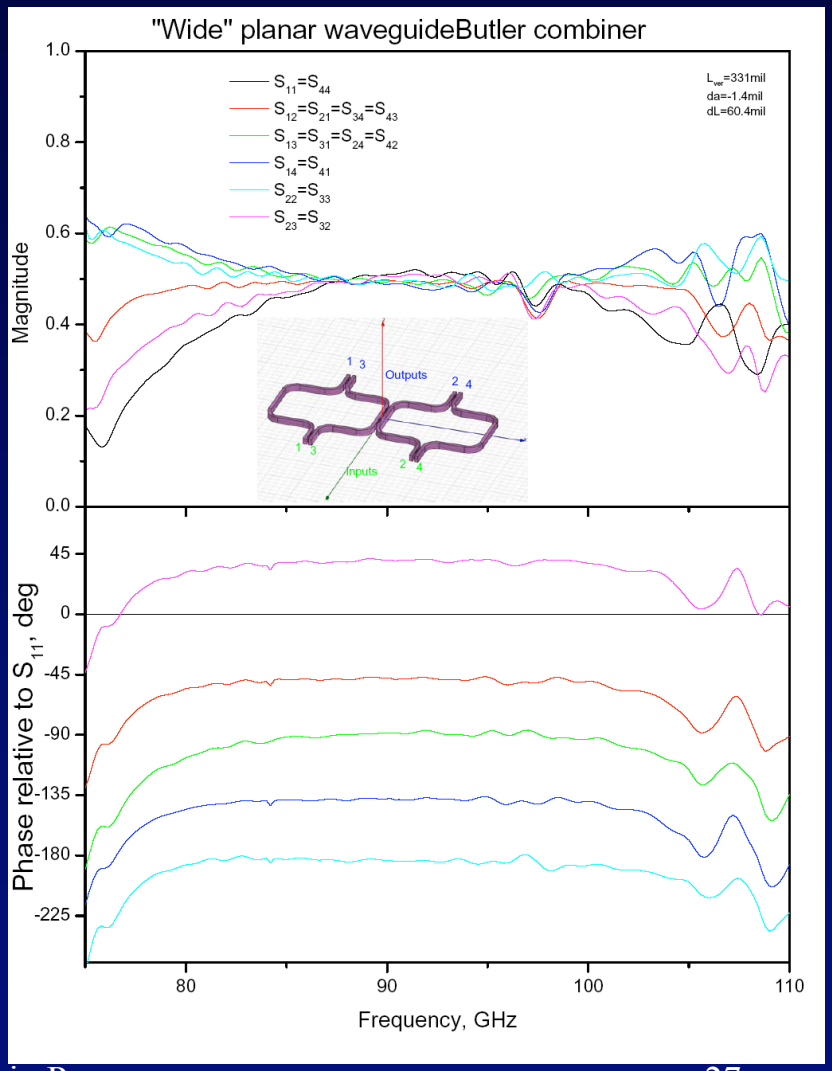
- 1024 horns
- 16 arrays of 64 horns
- 30,60,90,150,250 GHz
- 1 year observation
- T/S = 0.01



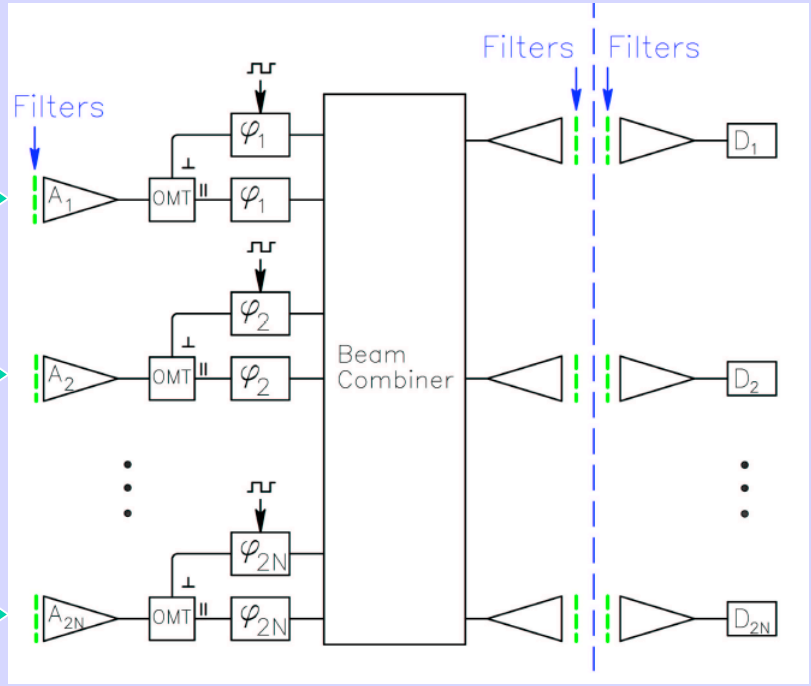
Waveguide Beam Combiner







Butler Combiner Math



$$\left|\frac{(E_{\perp 1}+E_{\parallel 1}+\ldots E_{\perp N}+E_{\parallel N})}{\sqrt{N}}\right|^2$$

Polarization interference: *2N(2N-1)/2* cross-terms

$$=\frac{(E_{\perp 1}^2+\ldots E_{\perp N}^2)+(E_{\perp 1}E_{\perp 2}+\ldots E_{\parallel 1}E_{\parallel N})+(E_{\perp 1}E_{\parallel 1}+\ldots E_{\perp N}E_{\parallel N})+(E_{\perp 1}E_{\parallel 2}+\ldots E_{\perp 1}E_{\parallel N})}{N}$$

total power

Temperature interference: *2N(2N-1)/2* cross-terms

single-horn correlation

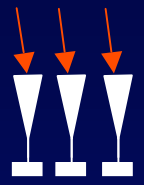
Many redundant baselines

Sensitivity Comparison

Assume: BLIP-limited detectors, low n limit, N modes, $\Delta T\ [Ks^{1/2}] \sim (\text{optical loading})^{1/2}$,

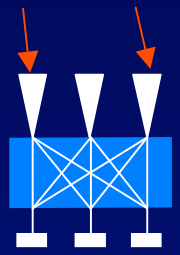
Total Power:

$\Delta T_{1\text{-ant}}$



$\Delta T_{N\text{-ant}} = \Delta T_{1\text{-ant}}/N^{1/2}$

Interferometer:



$\Delta T_{1\text{-vis}} = \Delta T_{1\text{-ant}} N/N^{1/2}$

$\Delta T_{N\text{-vis}} = \Delta T_{1\text{-vis}}/(N(N-1))^{1/2}$

$\sim \Delta T_{1\text{-ant}}/N^{1/2}$

Correlation Polarimeter:

$\Delta T_{1\text{-cp}} = \Delta T_{1\text{-ant}} N/N^{1/2}$

$\Delta T_{N\text{-cp}} = \Delta T_{1\text{-cp}}/N$

$= \Delta T_{1\text{-ant}}/N^{1/2}$

Systematic Effects

Systematic Effect	Imaging System Solution	Interferometer Solution
Cross-polar beam response	Rotation of instrument & correction in analysis	Rotation of instrument & simple, non-reflective optics
Beam ellipticity	Rotation of instrument & small beamwidth	No T to E and B leakage from beams rotation of instrument
Polarized sidelobes	Correction in analysis	Correction in analysis
Instrumental polarization	Rotation of instrument & correction in analysis	Clean, simple, non-reflective optics
Polarization angle	Construction & characterization	No T to E and B leakage from beams construction & characterization
Relative pointing	Rotation of instrument & dual polarization pixels	No T to E and B leakage from beams rotation of instrument
Relative calibration	Measure calibration using temperature anisotropies	Detector comparison not required for mapping or measuring Q and U
Relative calibration drift	Control scan-synchronous drift to 10^{-9} level	All signals on all detectors
Optics temperature drifts	Cool optics to $\sim$3 K & stabilize to $< \mu$K	No reflective optics
$1/f$ noise in detectors	Scanning strategy & phase modulation/lock-in	Instantaneous measurement of low-ℓ power spectrum without scanning
Astrophysical foregrounds	Multiple frequency bands	Multiple frequency bands

EPIC Publications

Timbie, P. T., Tucker, G. S., Ade, P. A. R., Ali, S., Bierman, E., Bunn, E. F., Calderon, C., Gault, A. C., Hyland, P. O., Keating, B. G., Kim, J., Korotkov, A., Malu, S. S., Mauskopf, P., Murphy, J. A., O'Sullivan, C., Piccirillo, L, and Wandelt, B., D. "The Einstein Polarization Interferometer for Cosmology (*EPIC*) and the Millimeter-wave Bolometric Interferometer (MBI)," to be published in New Astr. Rev. (2007)

Korotkov, A. L., Kim, J., Tucker, G. S., Gault, A., Hyland, P., Malu, S., Timbie, P. T., Bunn, E. F., Keating, B., Murphy, A., O'Sullivan, C., Ade, P. A. R., Calderon, C., and Piccirillo, L. "The Millimeter-wave Bolometric Interferometer," SPIE 6269, (2006).

Bunn, E. F. "Systematic Effects in CMB Interferometry," submitted to Phys. Rev. D. (2006).

Bunn, E. F. and White, M. "Mosaicking in Full-Sky Interferometry," submitted to Ap. J. (2006).