

POLARBEAR: Ultra-High Energy Physics with Measurements of CMB Polarization

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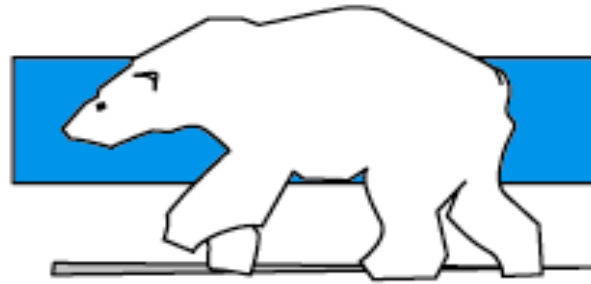
Group is part of JPL-led EPIC CMBPOL study

*Principal Investigator

Summary

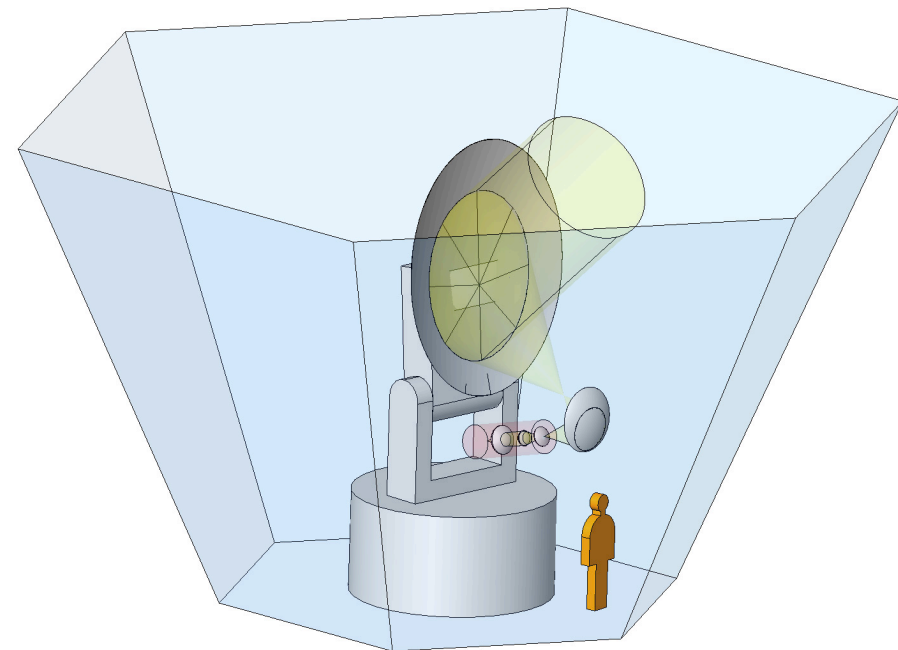
- **Science Goals are of Highest Interest**
 - Probe Inflation via signature in CMB polarization
 - Inflation Questions = High-Energy Physics Questions
- **POLARBEAR: new generation of experiment**
 - Enabling Technology “Radiometer on a chip” (Demonstrated)
 - => 1000 detector arrays
 - Stringent systematic uncertainty controls/measures
 - ==> POLARBEAR covers 1/2-2/3 of observable theory space
 - ==> **Pathfinder for challenging measurement => CMBPOL**
- **Three-year study done: Ready to start construction**
 - Two phases: PB-I (320 detectors) and PB-II (1200 detectors)

Experiment

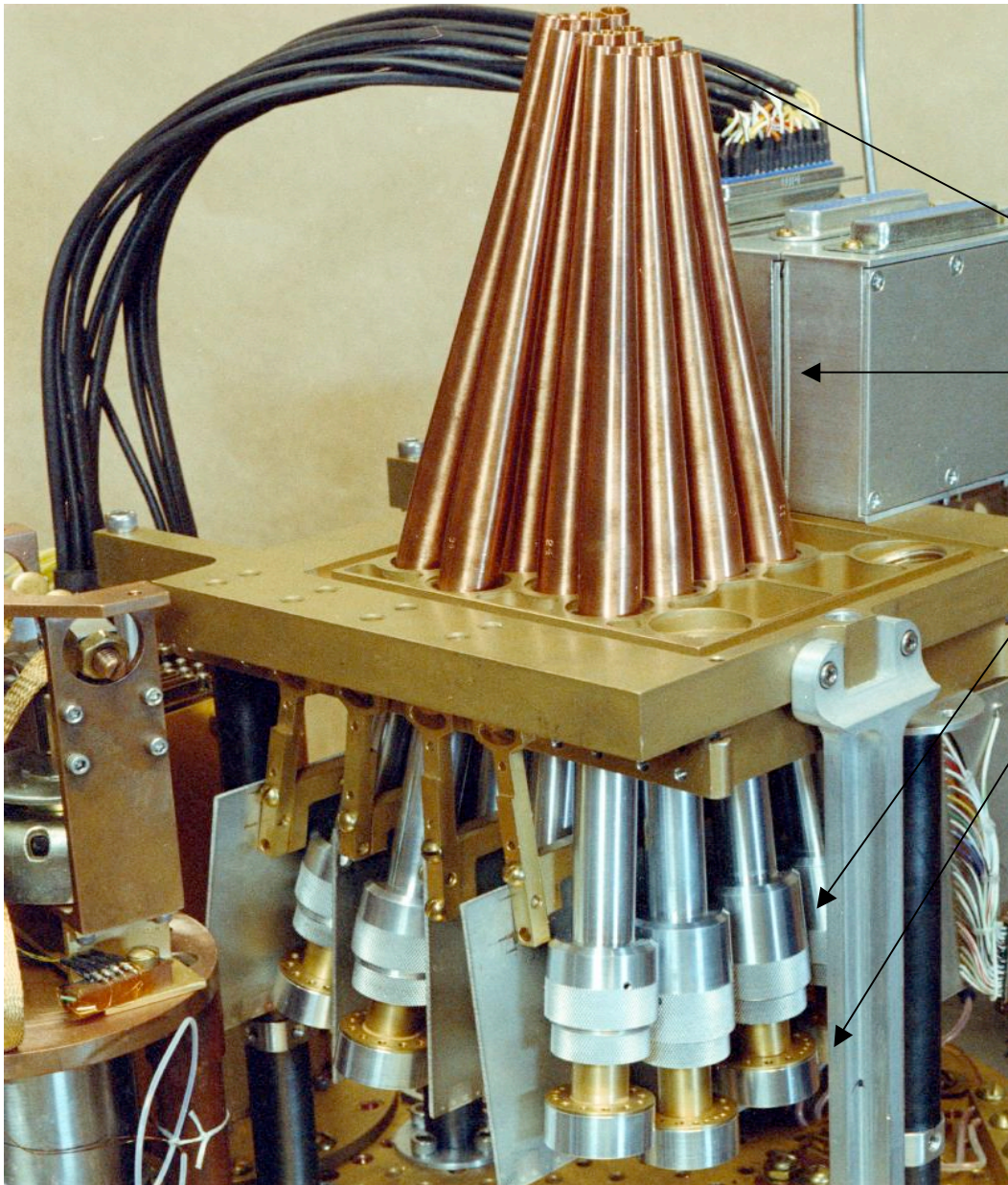


POLARBEAR

- Experiment using 3 meter Telescope at White Mountain CA
 - Characterize E-modes, B-mode Lensing
 - Search for Inflationary B-modes
- First Light mid 2006
 - LDRD seed funding (2001-2003)
- 90, 150, 220 GHz
- 4' beam @ 150 GHz
 - (resolves lensing)



Conventional Radiometer (MAXIMA)



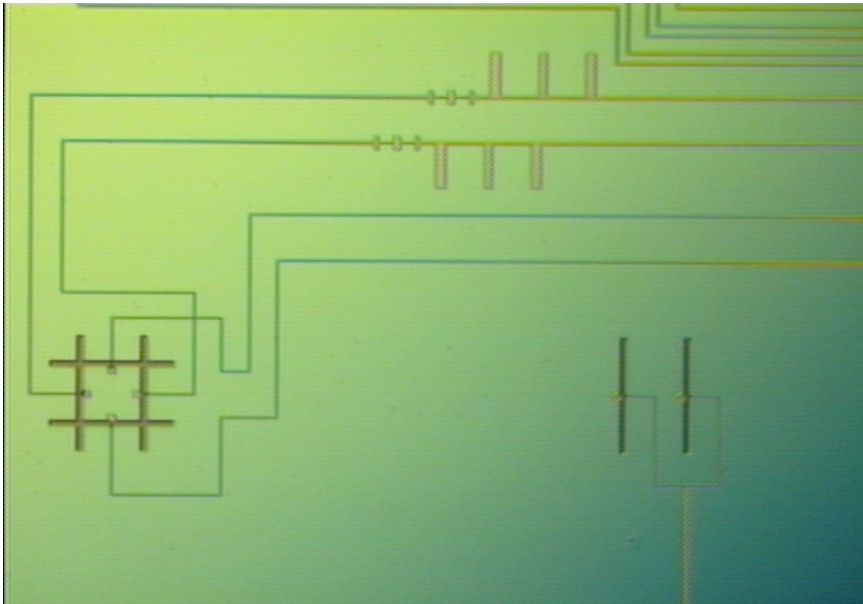
Focal plane horns

Waveguides

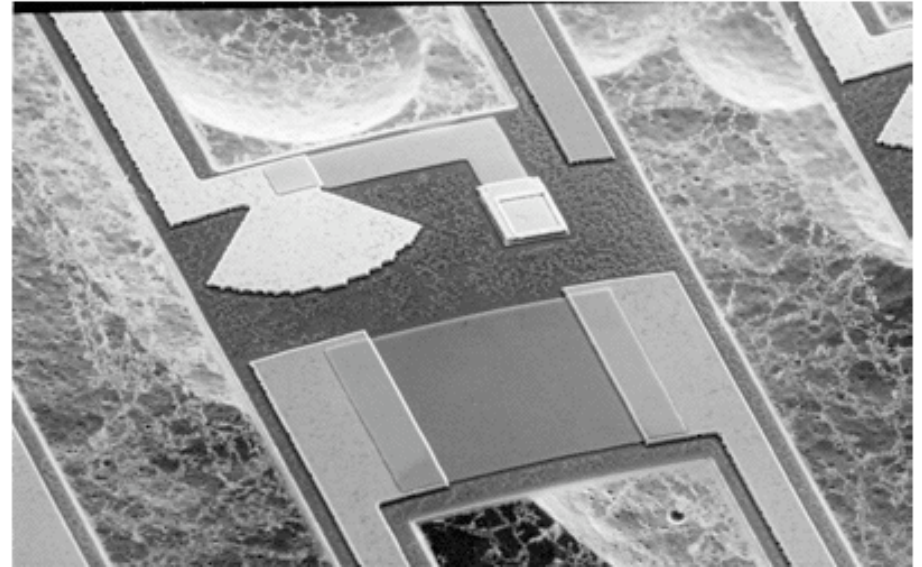
Filters

Bolometers

New Detector Technology: **Radiometer on a Chip**



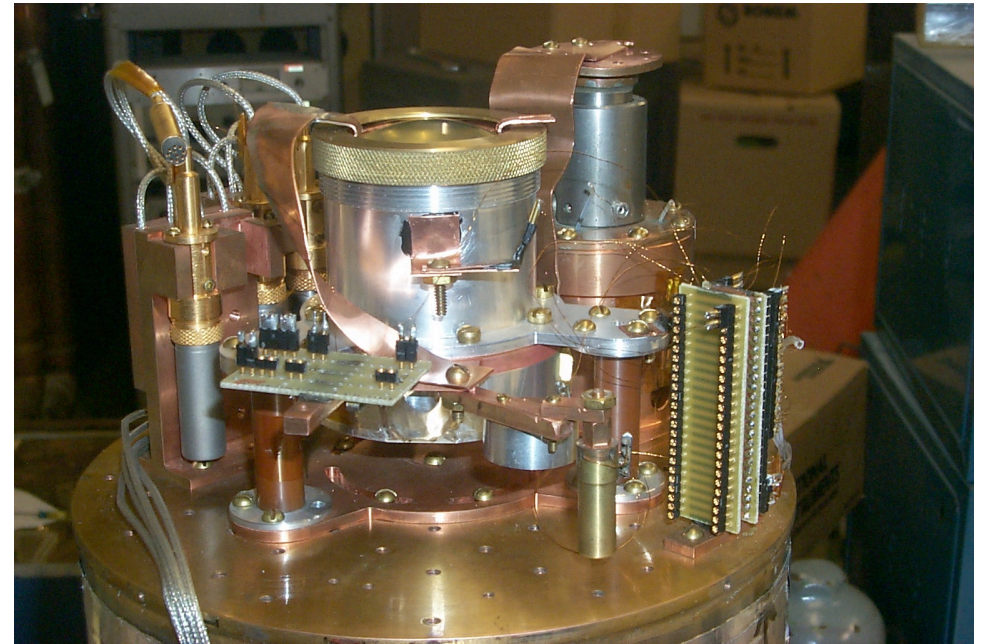
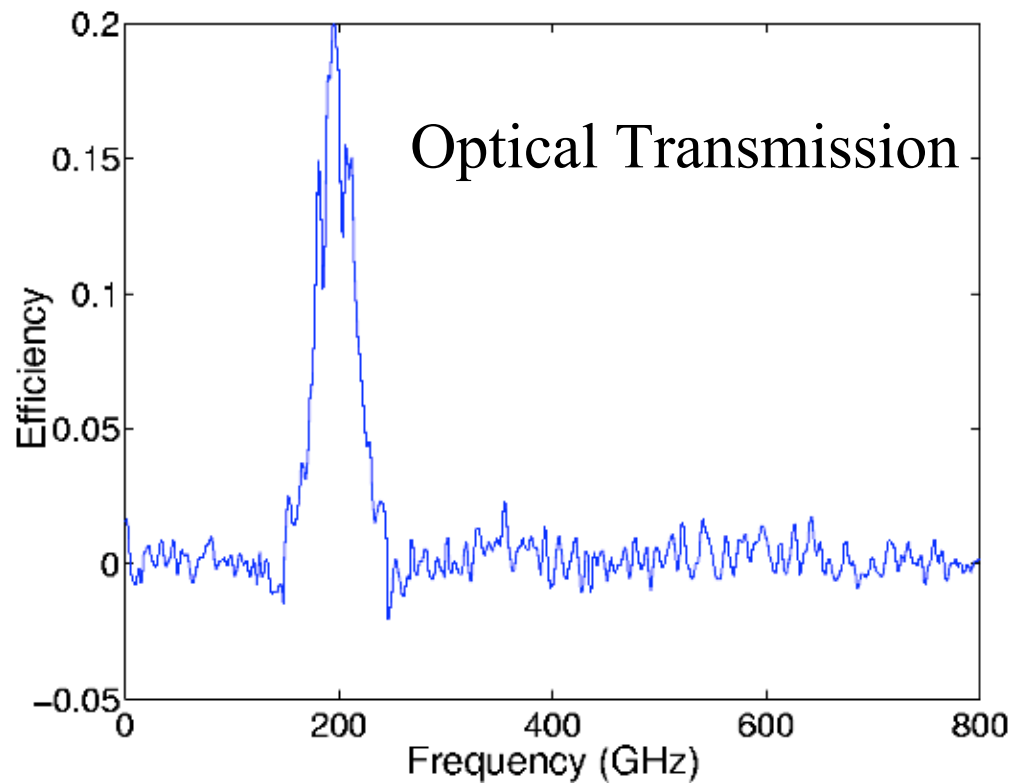
↔
1 mm



↔
50 micron

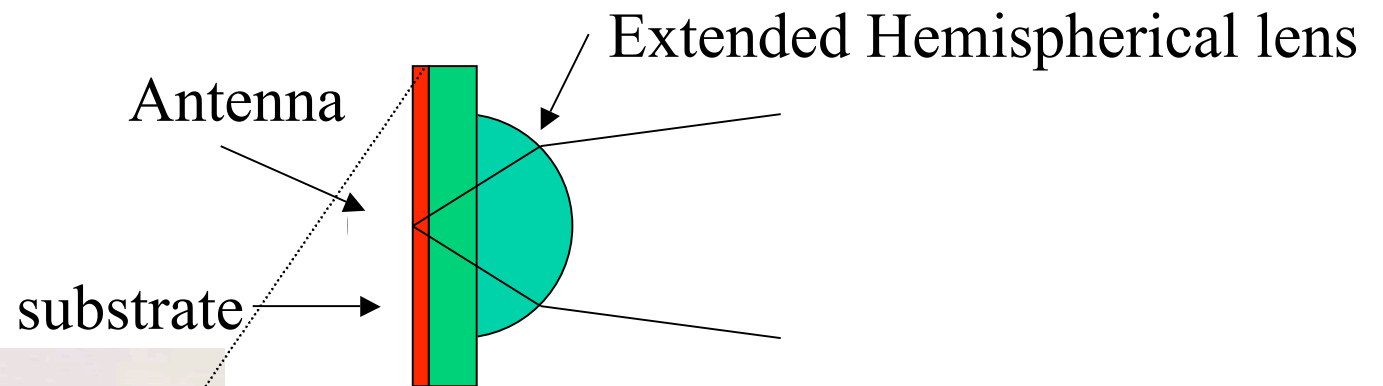
- TES Bolometer Detector at 300 mK (Berkeley played pioneer role)
 - **Required Sensitivity Achieved**
- Large Arrays possible using photolithography (scalable technology)

Optical Efficiency Demonstrated

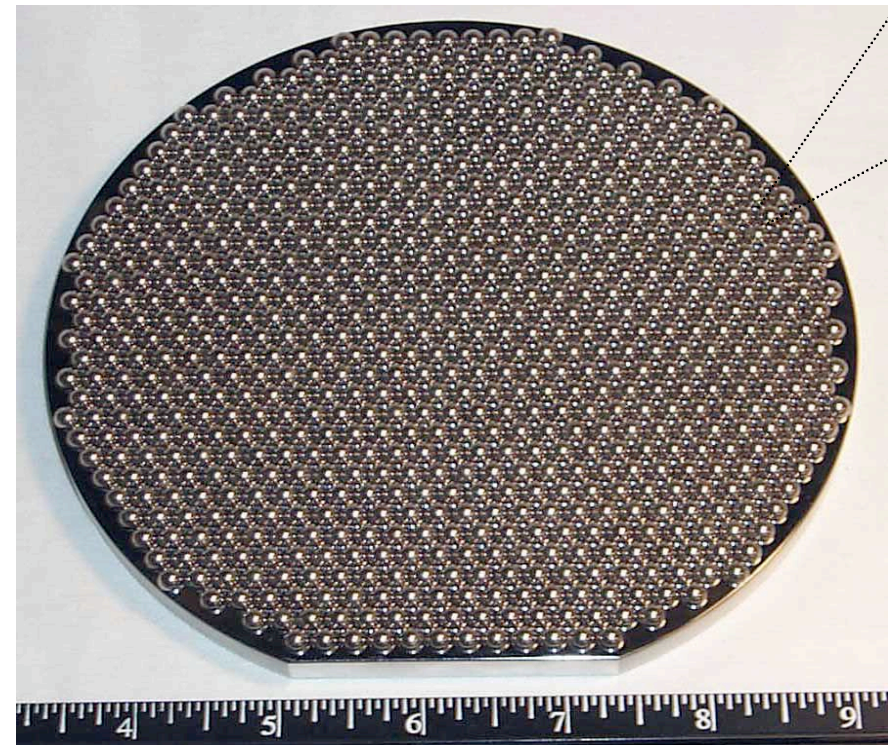


- Performance Adequate
- >x2 Improvement Expected
(Planck Spec 30% eff)

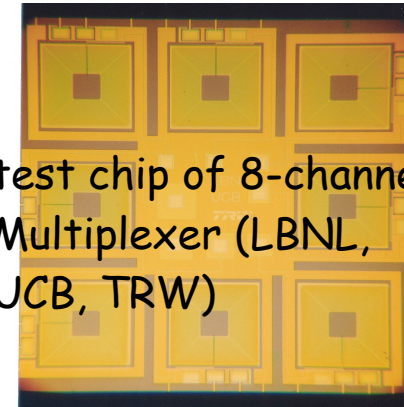
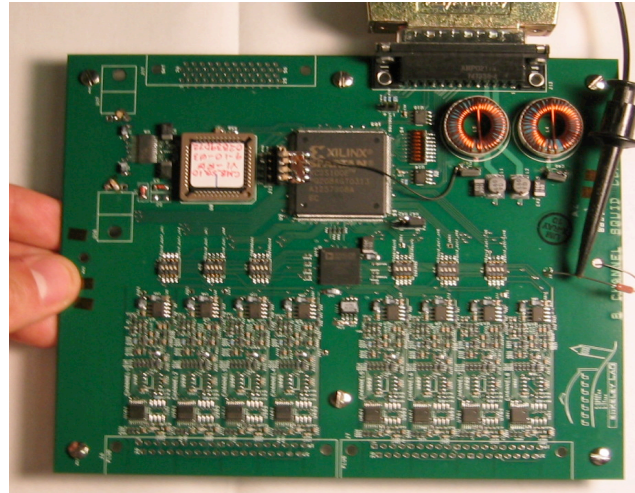
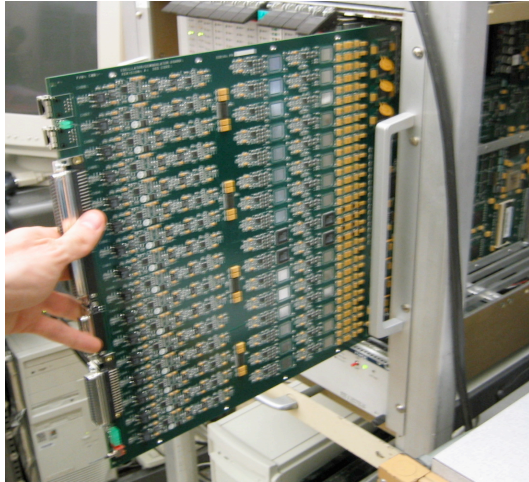
Monolithic Array with Lenslets



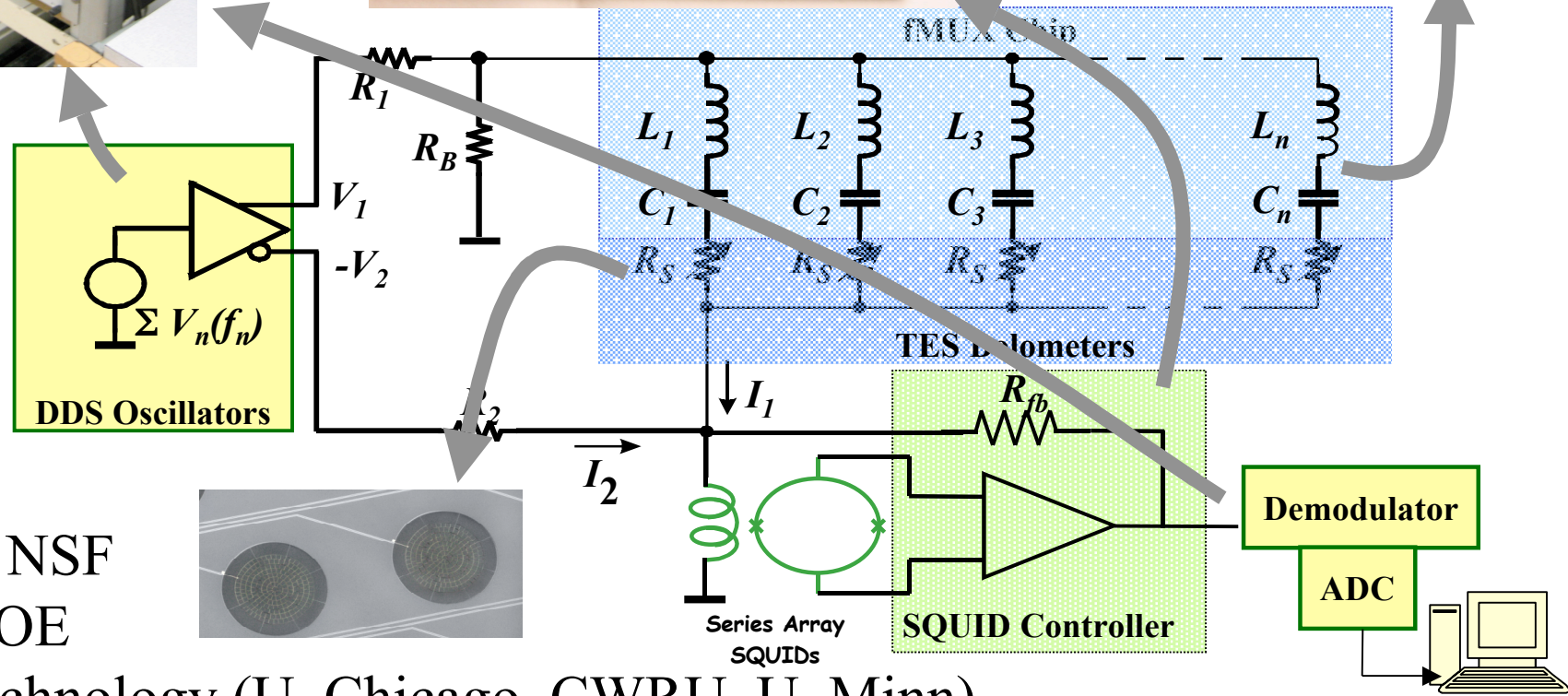
- POLABEAR-I 320 detectors
- POLARBEAR-II 1200 detectors



Freq-Domain Multiplexer Demonstrated



test chip of 8-channel Multiplexer (LBNL, UCB, TRW)

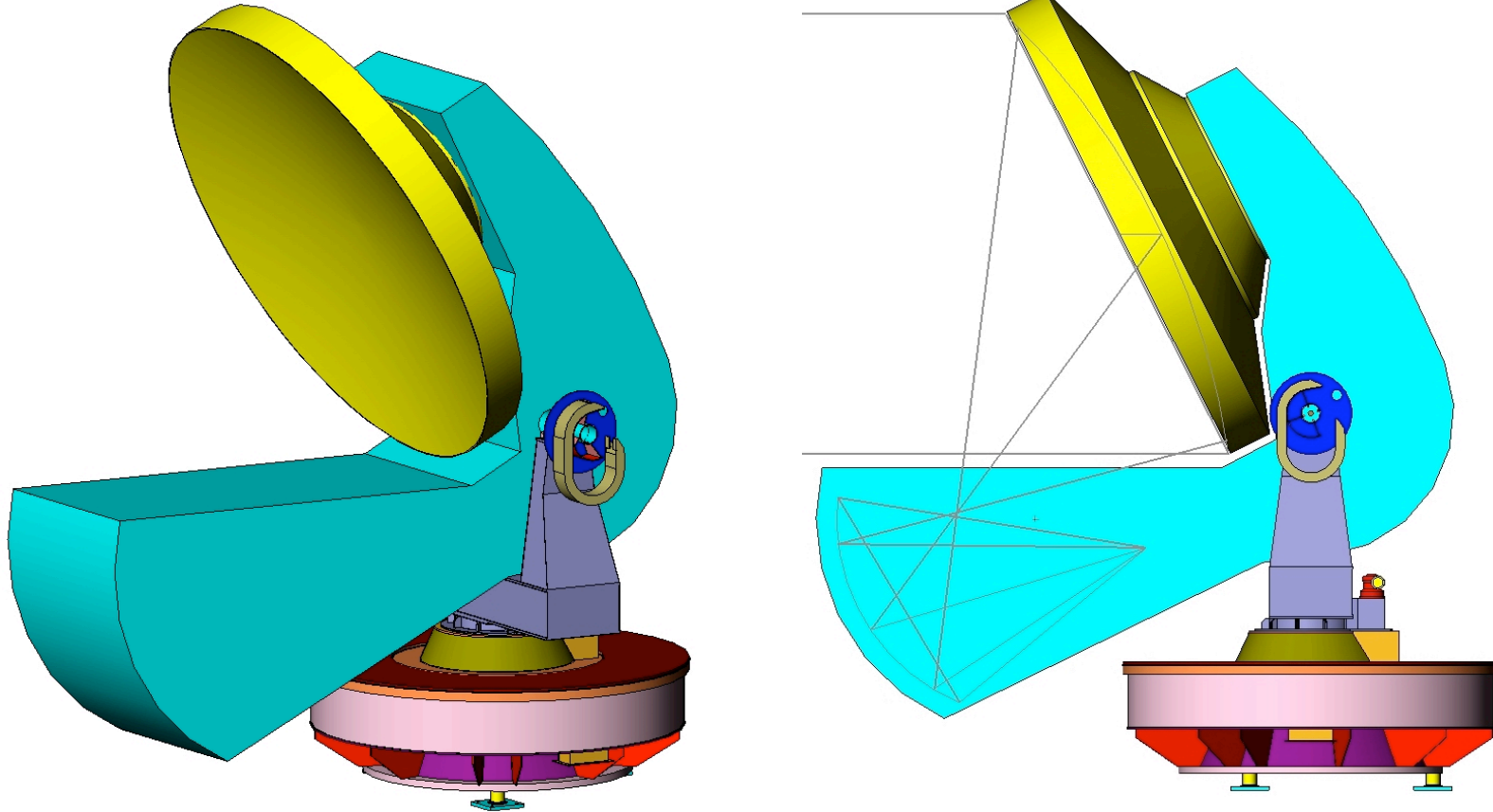


Initial Work: NSF

Evolution: DOE

Exporting Technology (U. Chicago, CWRU, U. Minn)

Turn-Key Telescope from Vertex Corp.



VERTEX Telescopes: DASI, ALMA prototype, SPT,

White Mountain, CA



- 12,470 ft altitude
- ~1 mm Precip. Water Vapor
- Accessible by road during Summer
- University of CA infrastructure
- Electricity, Plumbing, Internet, Dormitories
- **Rotation of Sky Orientation**
- Robust enclosure required for winter

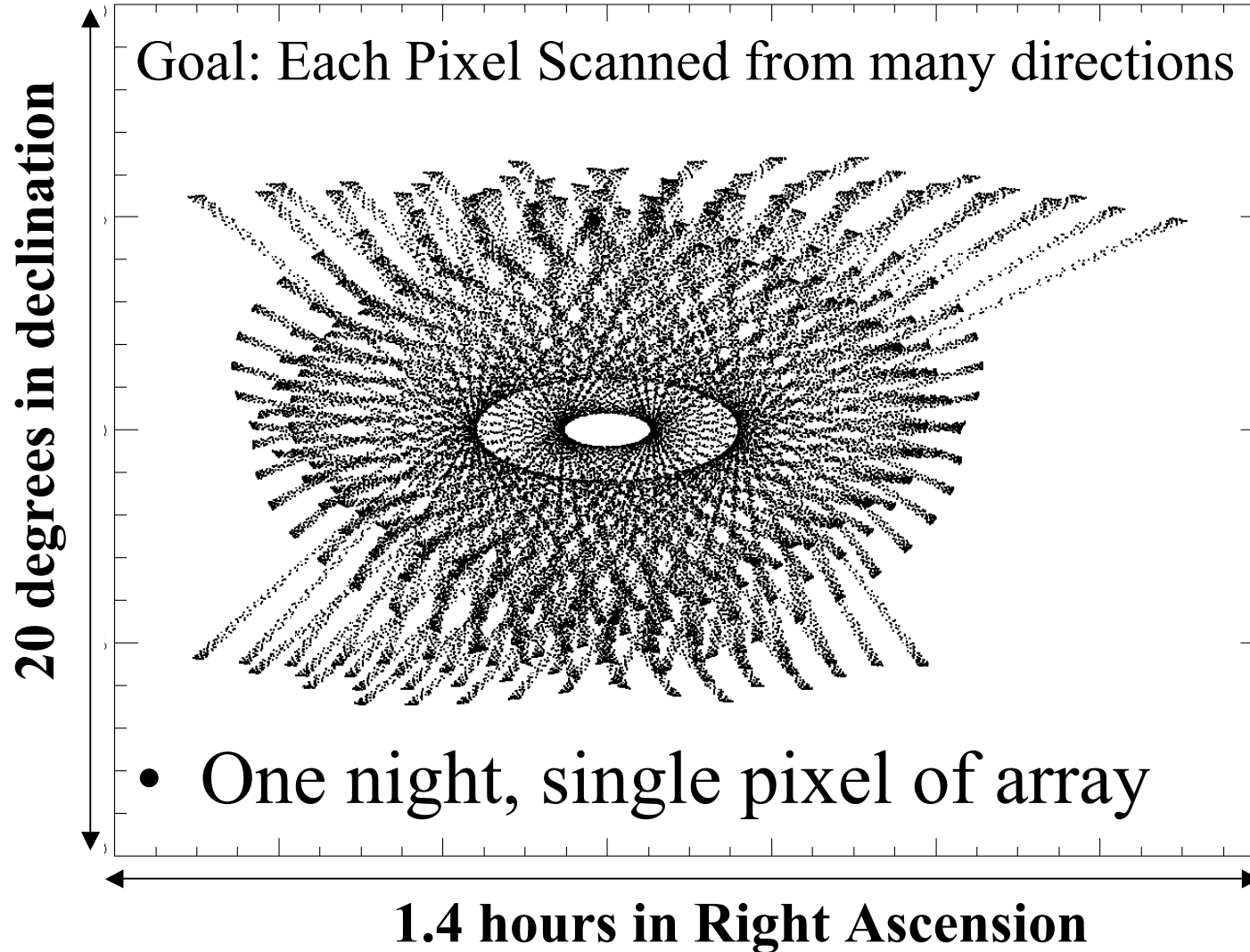
Systematic Uncertainties

Systematic Uncertainties

- Observation Strategy (5 “chops” total)
 - Polarization modulation
 - Dual polarization modulation
 - differencing at pixel
 - HWP (MAXIPOL: Continuously Rotating Wave Plate)
- Optics
 - Polarization purity, sidelobe response
 - POLARBEAR optimized for polarization measurements
- Foregrounds
 - Dust, Synchrotron
 - Multi-frequency measurements

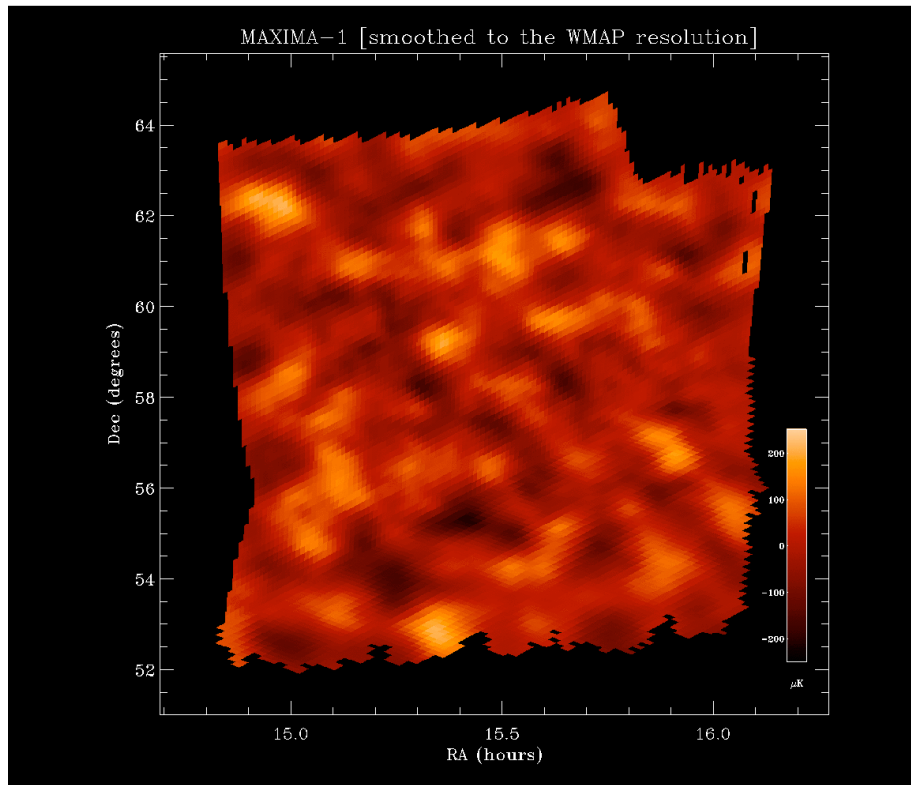
Observation Strategy

POLARBEAR scan pattern, Northern Sky

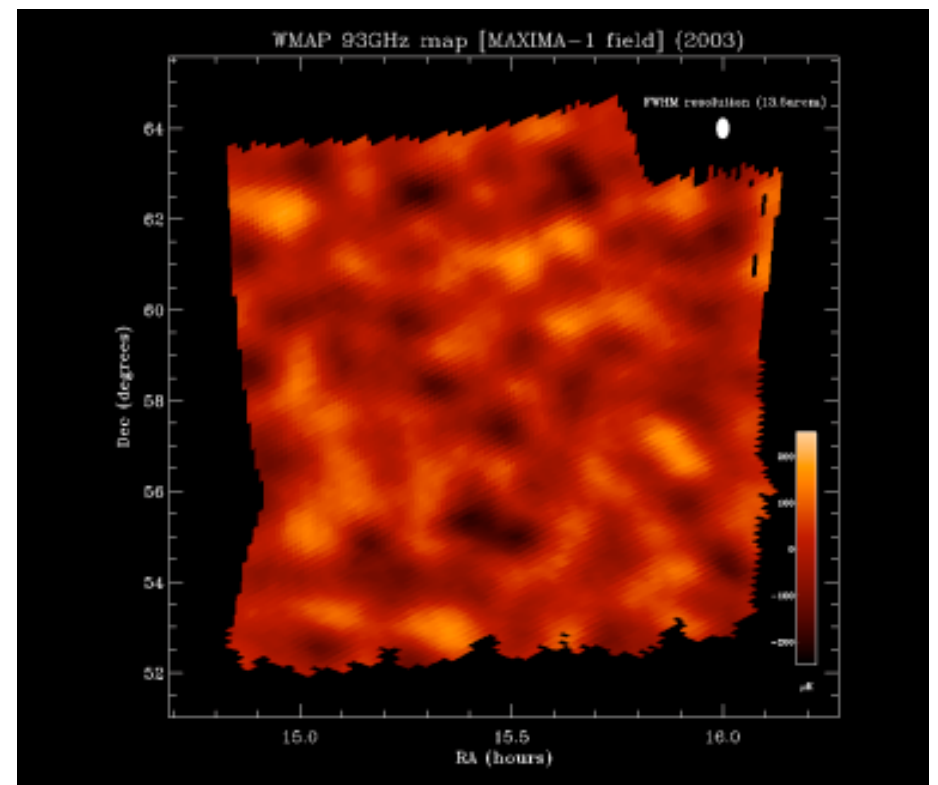


MAXIMA and WMAP

MAXIMA

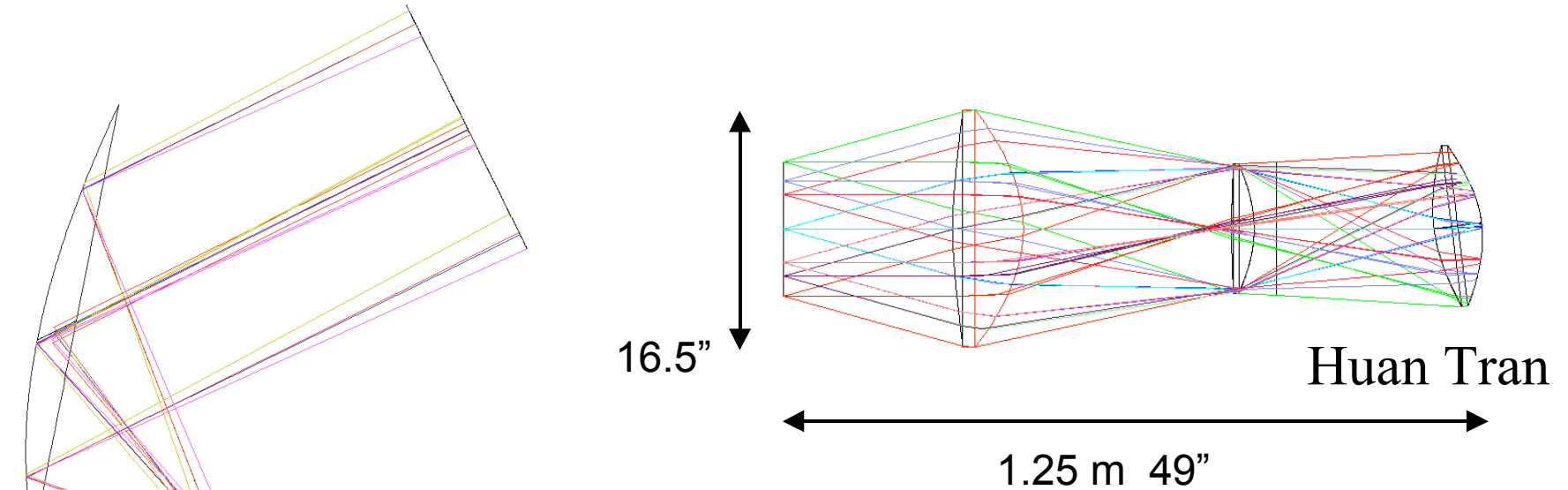


WMAP

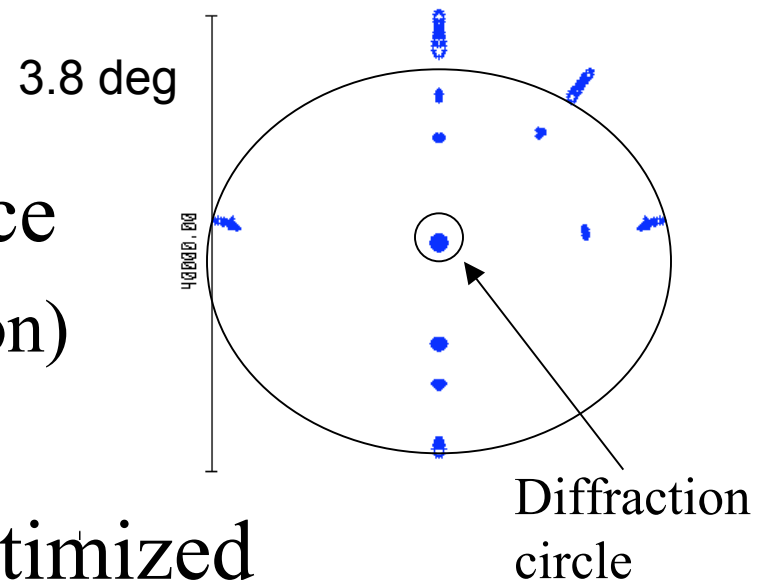


Statistically Consistent Measurements
(MAXIMA: better resolution and SNR)

POLARBEAR Optics

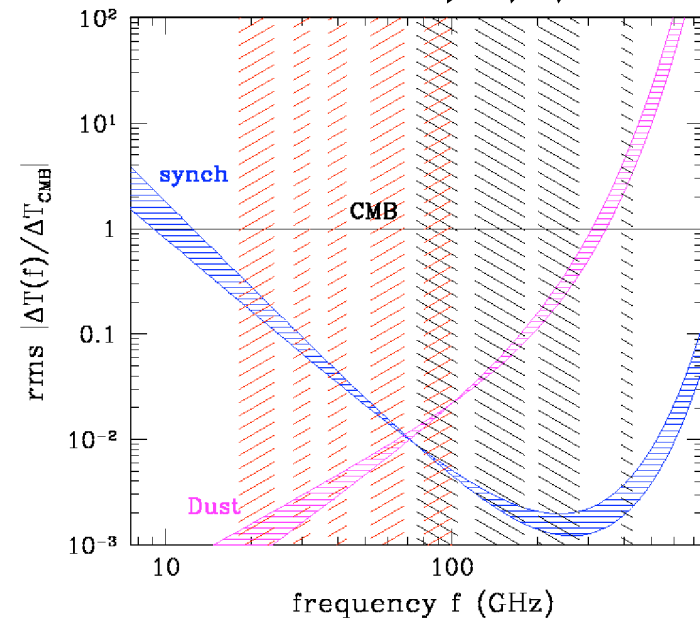
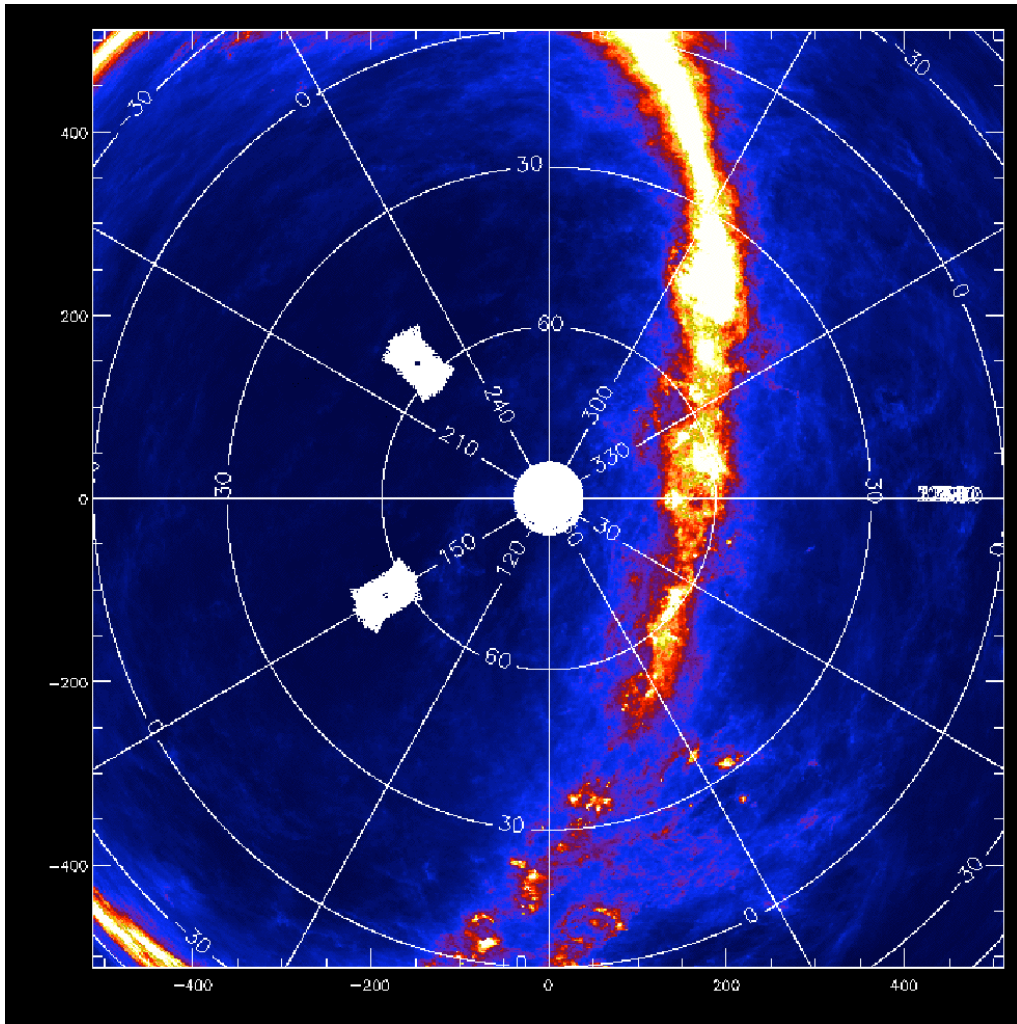


- Breaks new ground in performance
 - Low Cross-Pol (polarization rotation)
 - 3.8 deg. Field-of-View
- Classic optical techniques, but optimized



Foregrounds

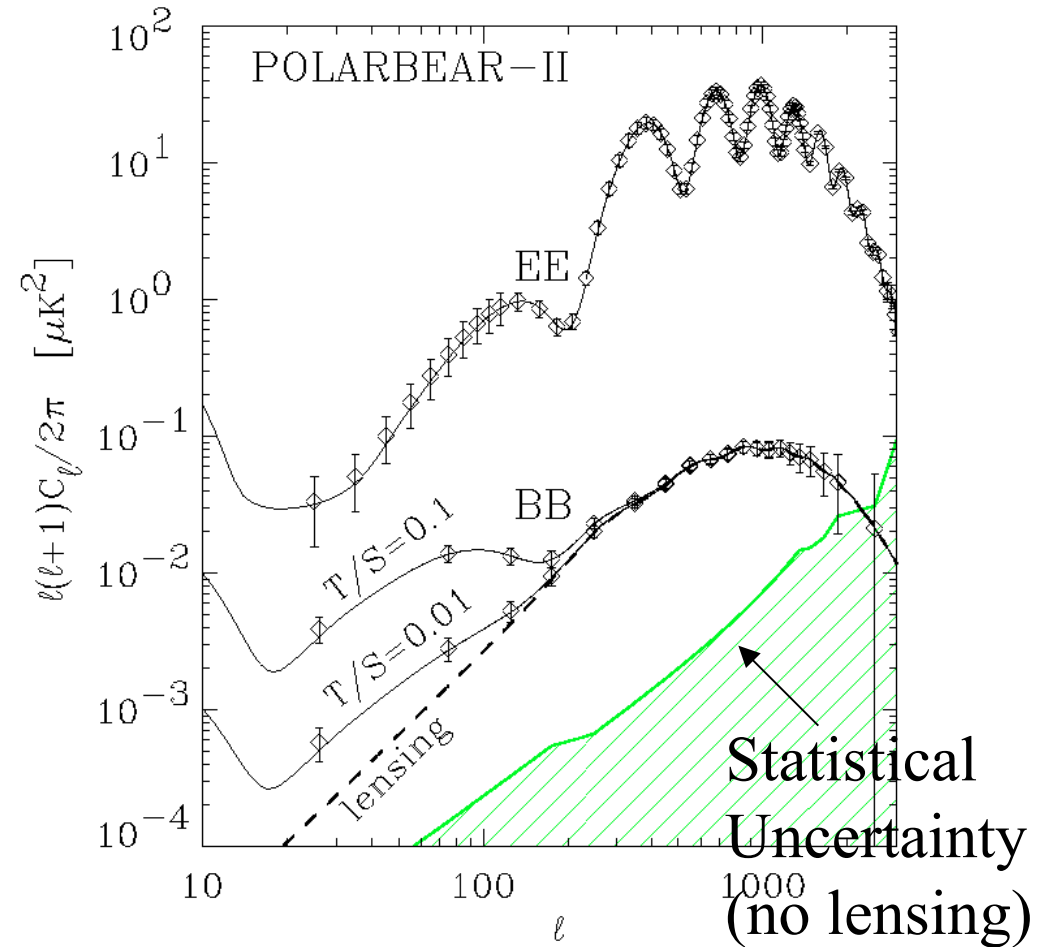
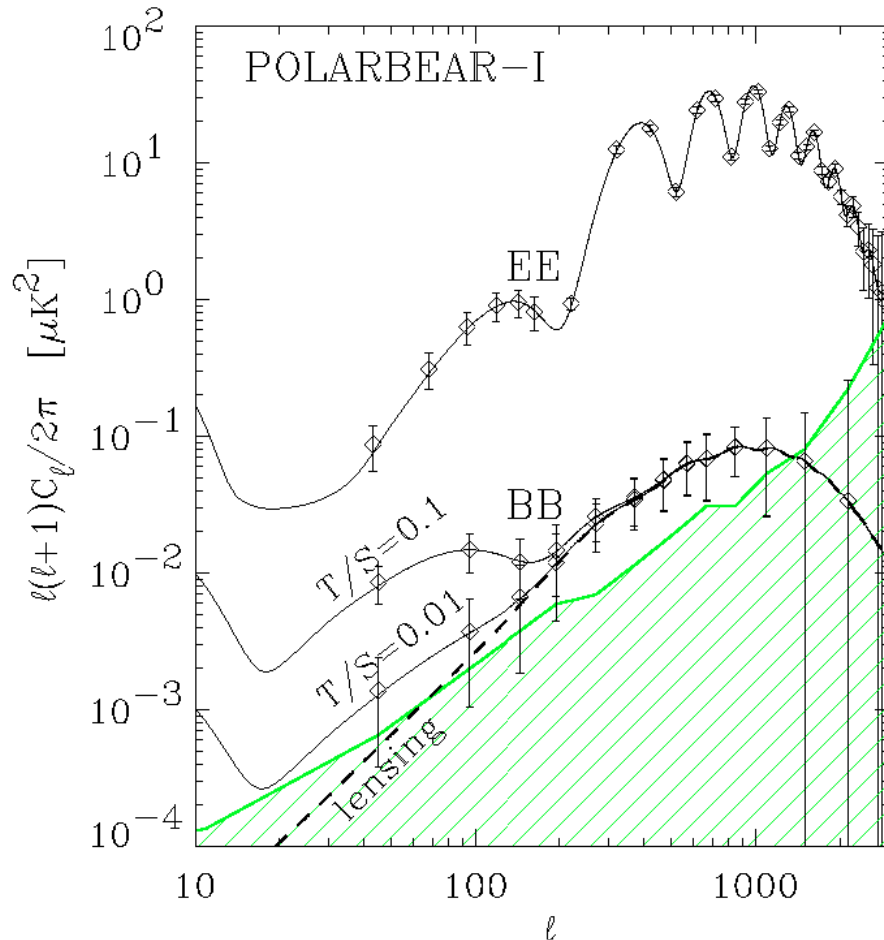
POLARBEAR Bands



- Choose low-dust sky
 - MAXIMA field
 - 2 μKrms dust intensity
 - Dust <10% polarized
- Use 3 freq. bands to discriminate/subtract

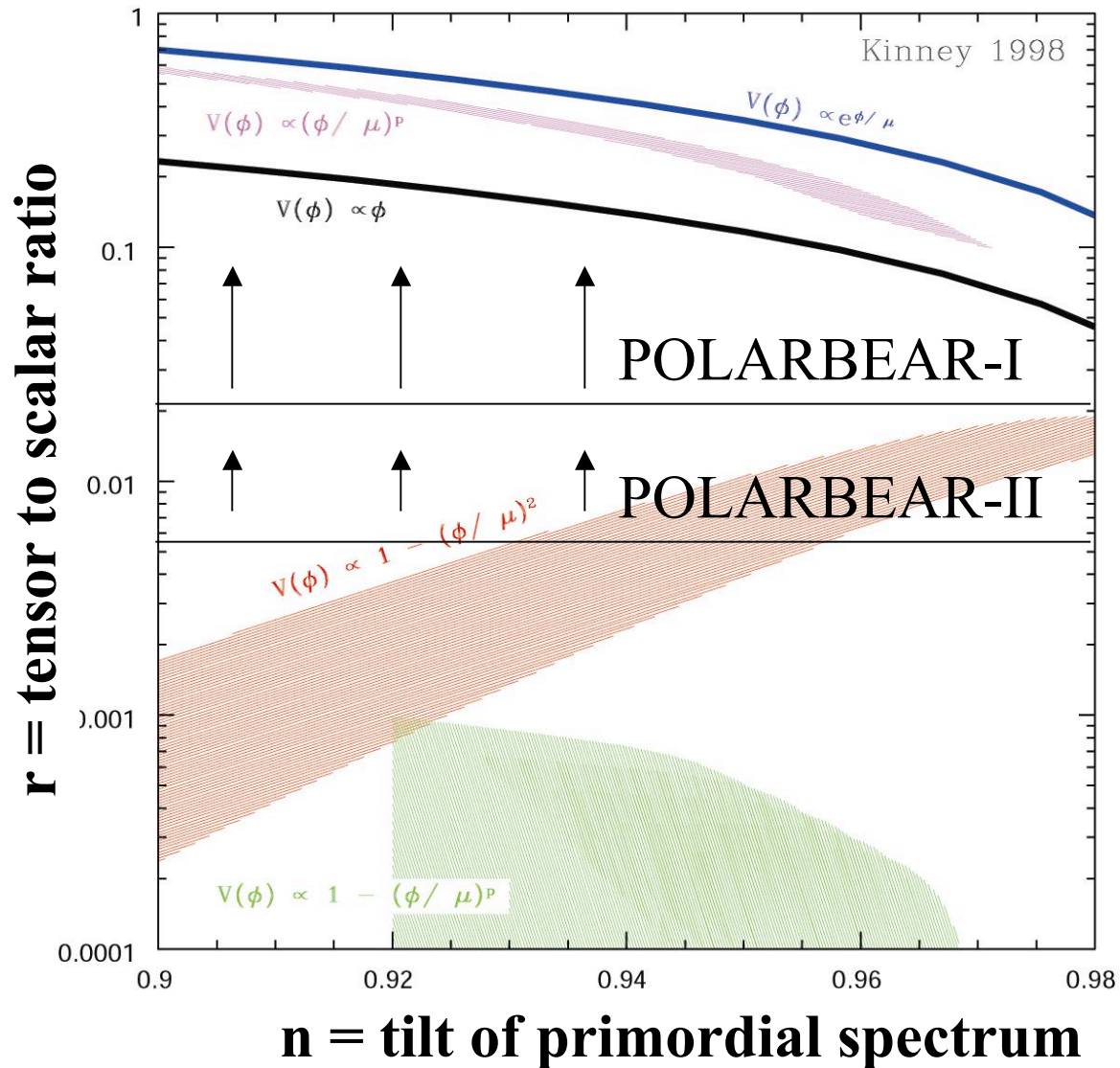
Science Output

POLARBEAR Sensitivity



- Large Arrays + 3 Years Integration
 $\implies 10^5$ Effective Integration Time compared to MAXIMA
- Conservative Estimate using **Achieved Sensitivity**

POLARBEAR Performance



(300 Bolometers
@ 300 mK)

(1200 Bolometers
@ 300 mK)

Includes Effects
of Lensing

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STOP