

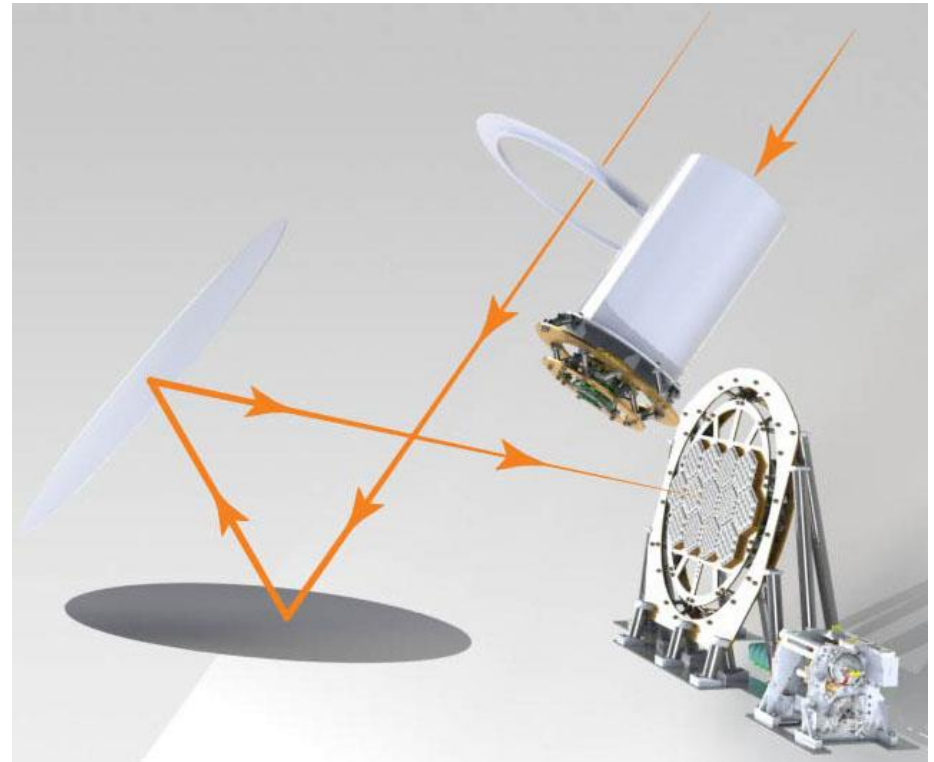
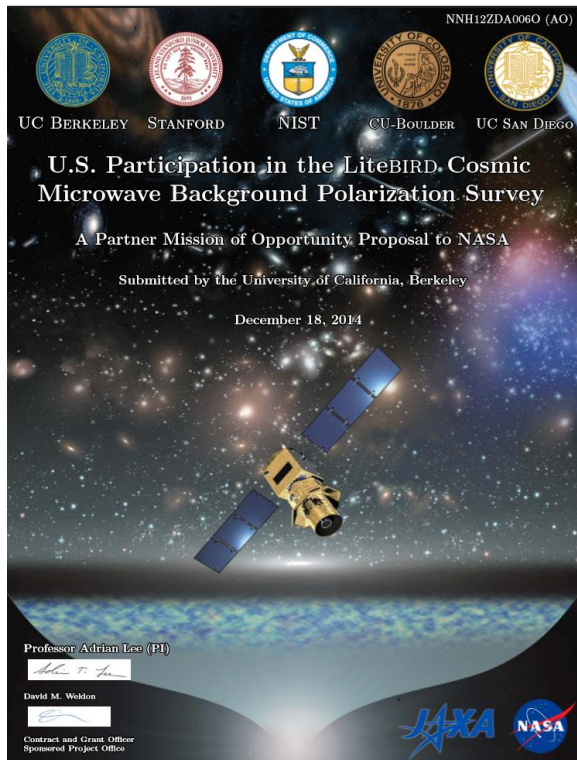
LiteBIRD Focal Plane Overview

Aritoki Suzuki

University of California, Berkeley

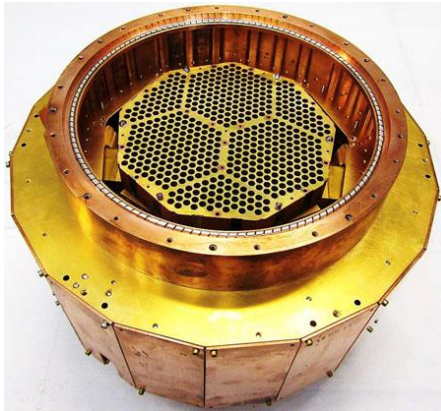
2015 December 16th

US LiteBIRD Team

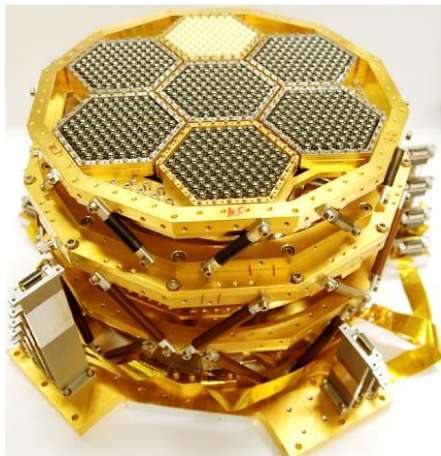


- US LiteBIRD team proposed to NASA, Mission of Opportunity to contribute
 - Analysis (Monday)
 - Sub-Kelvin cryo-coolers (Tuesday)
 - Detectors
 - Readout electronics

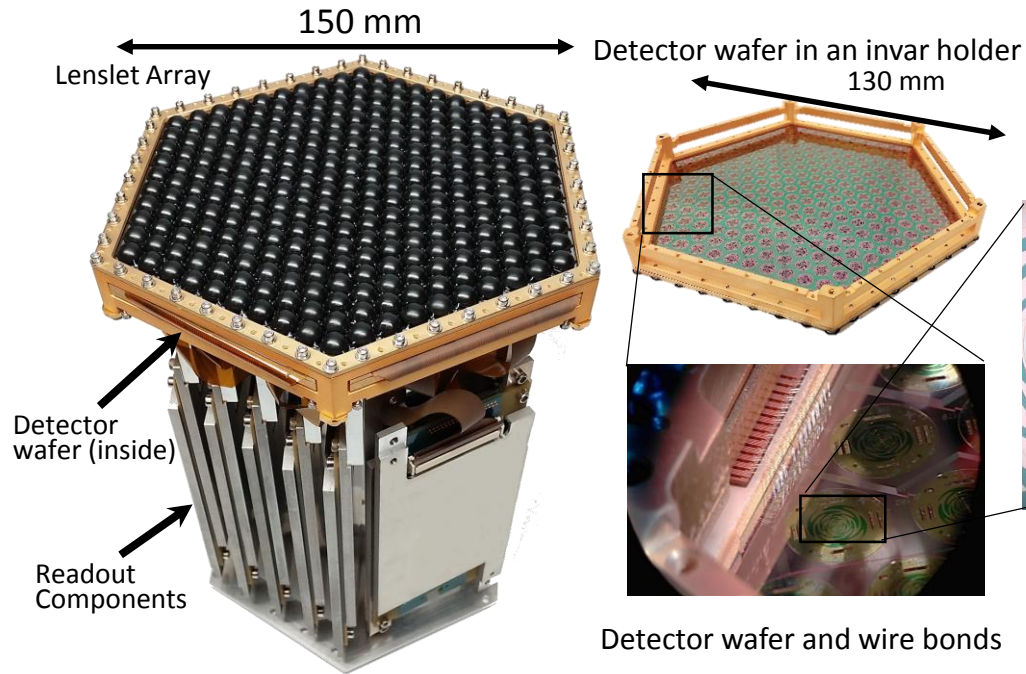
Heritage



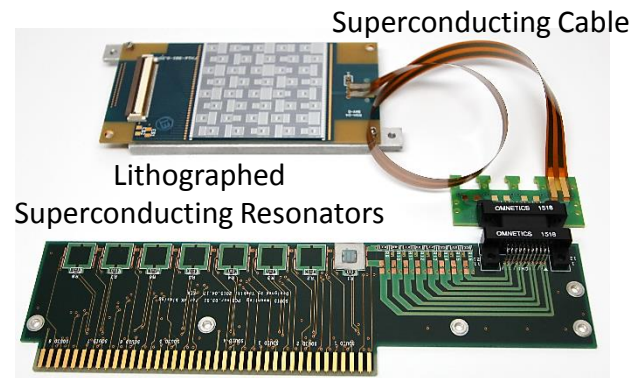
ACTpol Focal Plane



POLARBEAR-1
Focal Plane



POLARBEAR-2 Detector Module



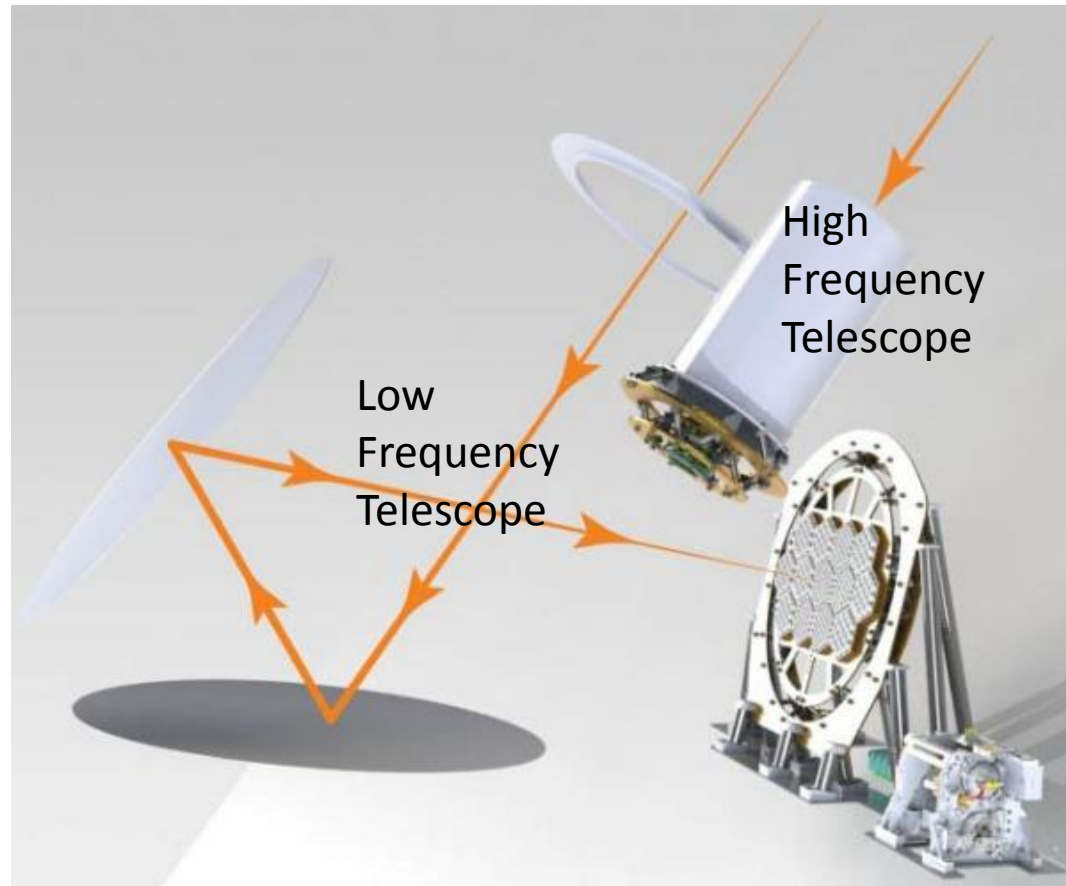
Printed Circuit Board for SQUIDs



Demodulator board

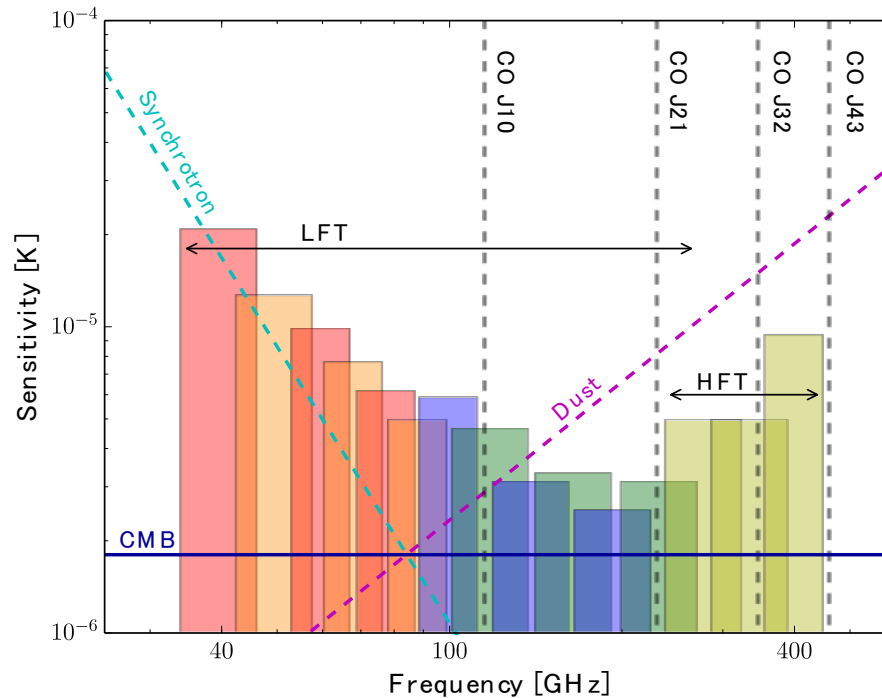
Heritage from ground and balloon based CMB experiments

Low/High Frequency Telescope



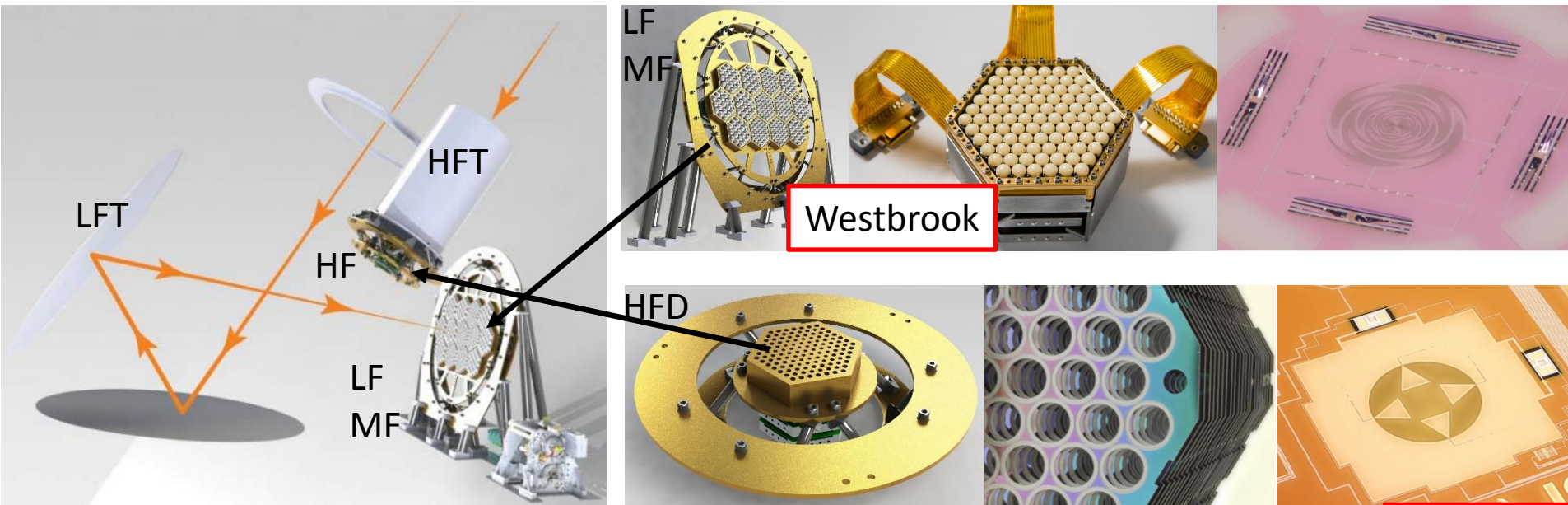
- Low Frequency Telescope → 40 GHz ~ 235 GHz
- High Frequency Telescope → 280 GHz ~ 402 GHz

Frequency Coverage



- **15 bands for foreground monitoring**
 - Multiple components dust, Synchrotron with $\Delta\beta$
- **Low Frequency Telescope (LFT)**
 - Low Frequency Detector (LF) 40~88.5 GHz 2 triplexer pixels
 - Mid Frequency Detector (MF) 100~234.9 GHz 2 triplexer pixels
- **High Frequency Telescope (HFT)**
 - High Frequency Detector (HF) 280~402.1 GHz 3 single band pixels

Feeds and Detectors



- Transition Edge Sensor bolometers → Photon noise limited performance
- Heritage from CMB polarization experiments
- **LF and MF:** Lenslet coupled broadband antenna array
 - POLARBEAR-2, Simons Array, SPT-3G
 - Talk by Ben Westbrook
- **HF:** Horn + OMT array
 - SPT-Pol, ACT-Pol
 - Talk by Hannes Hubmayr

Fabrication Facility and Team



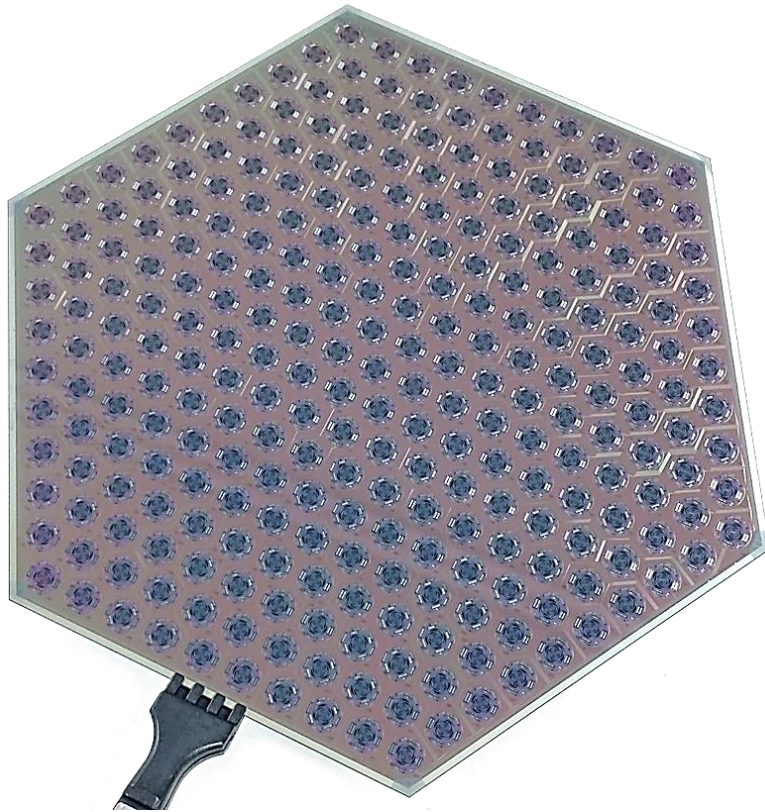
UC Berkeley Marvell Nanofabrication Facility



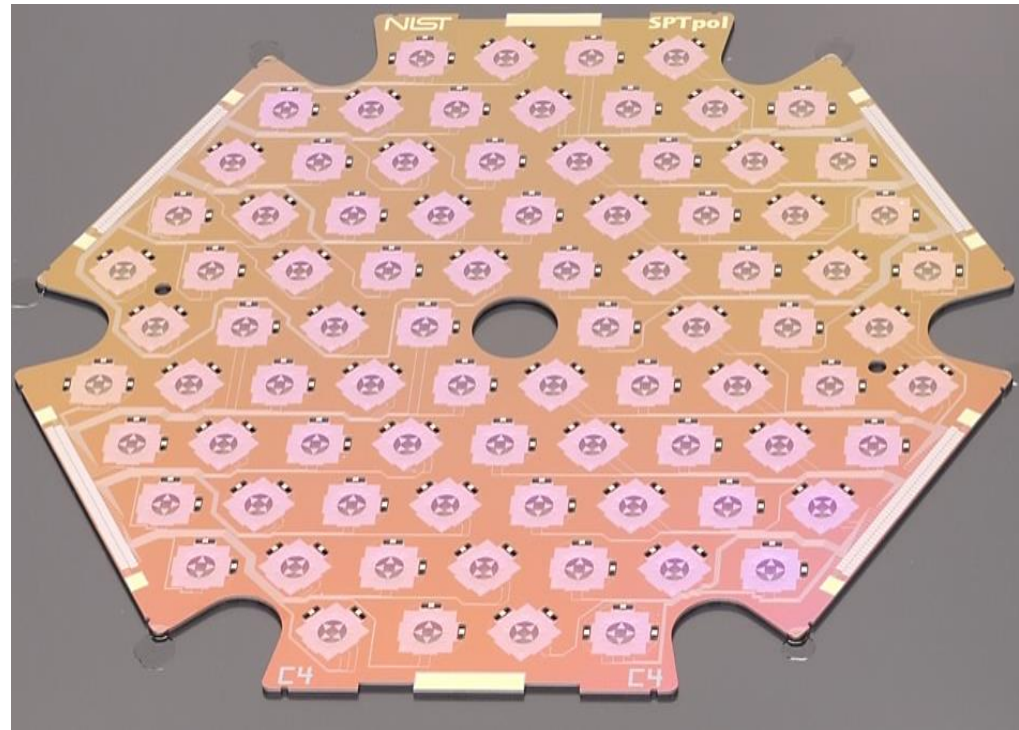
NIST Boulder Micro Fabrication Facility

- UC Berkeley Marvell Nanofabrication Facility
 - 15,000 square feet class 100 clean room
 - Two dedicated fabrication engineers and one dedicated tool engineer at UC Berkeley
 - Stanford fabrication engineer to fabricate at UC Berkeley
- NIST Boulder Micro Fabrication Facility
 - 18,000 square feet class 100 clean room
 - Two dedicated fabrication engineers for this project

Fabrication Experience



POLARBEAR-2 Detector Array fabricated
at UC Berkeley



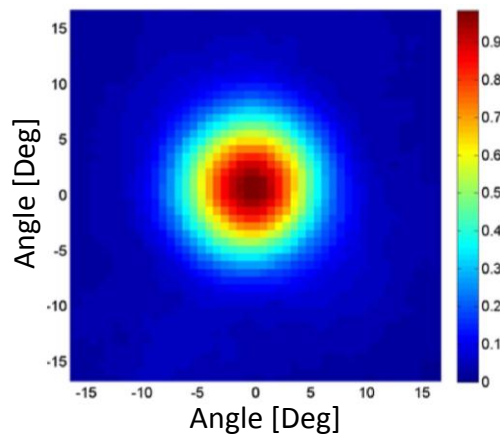
SPTpol Detector Array fabricated at NIST

History of supplying detector arrays to many CMB experiments

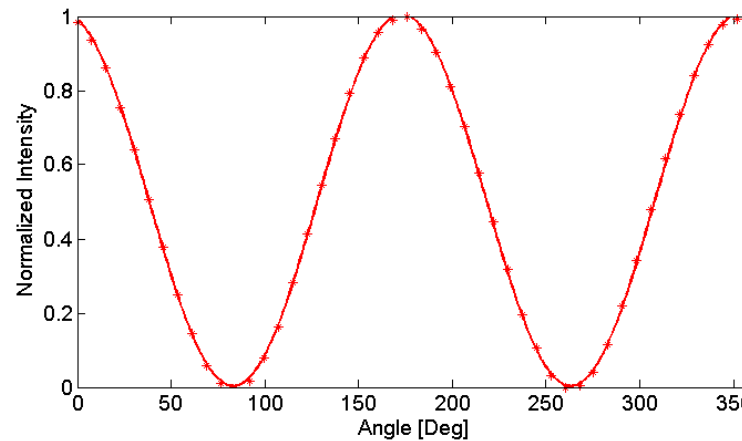
Detector Performance

- NIST fabricated TES bolometer with:
Noise Equivalent Power (**NEP**)= $4 \times 10^{-18} \text{ W}/\sqrt{\text{Hz}}$ at signal frequencies below 1 Hz
with thermal conductance of **$g = 10 \text{ pW/K}$**
Meets LiteBIRD spec

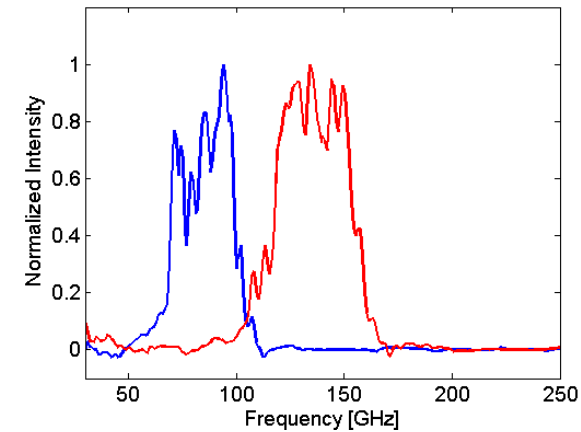
Optical performance of LiteBIRD spec sinuous antenna pixel from UC Berkeley



Beam

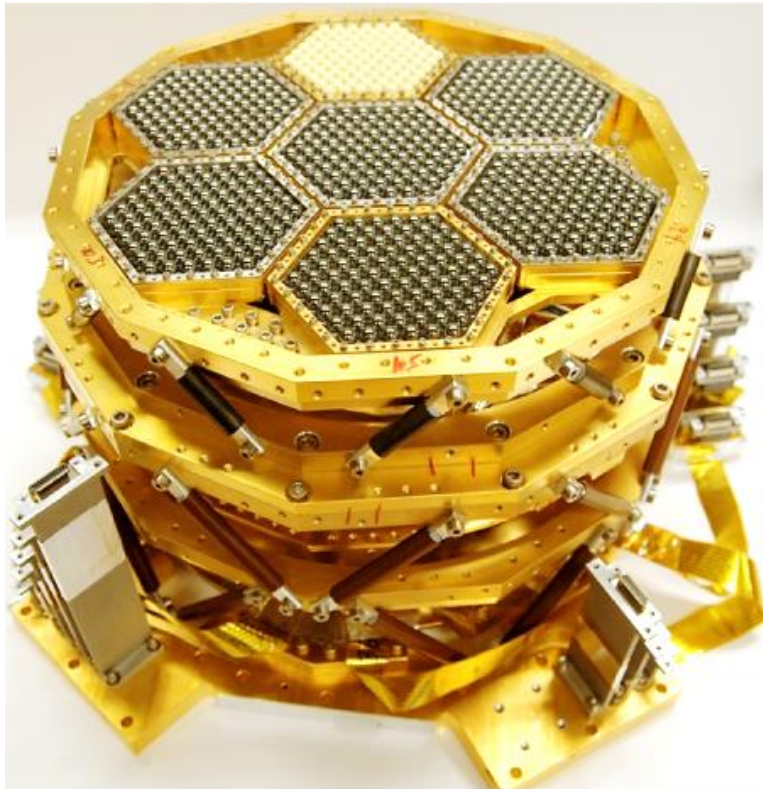


Polarization

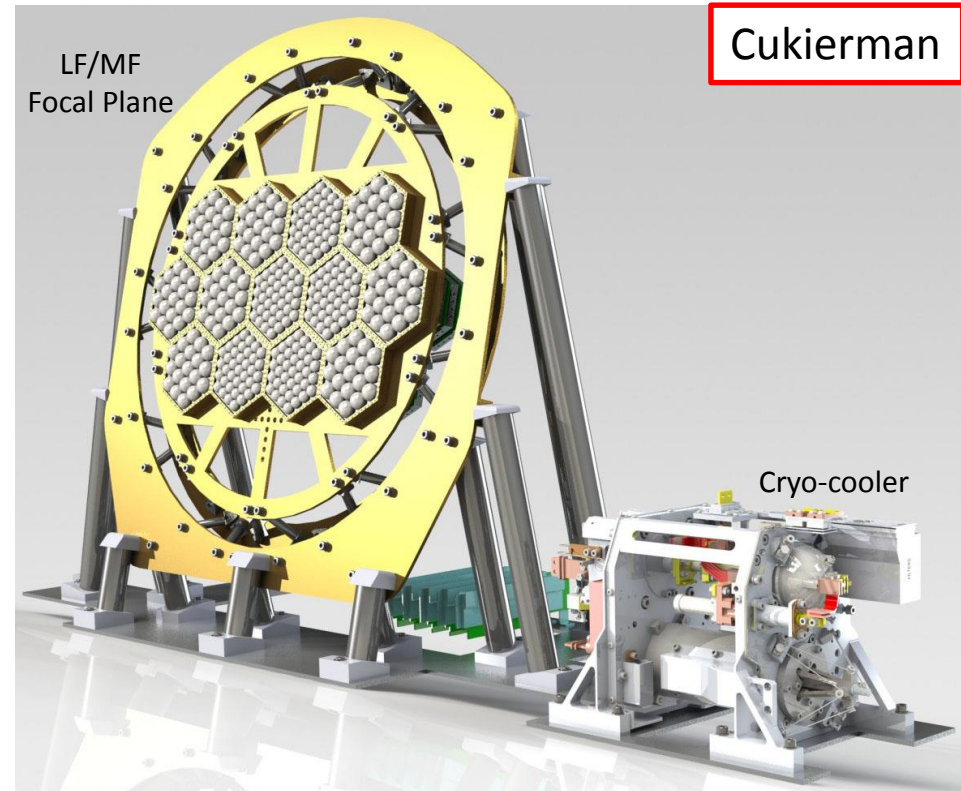


Spectra

Focal Plane Design

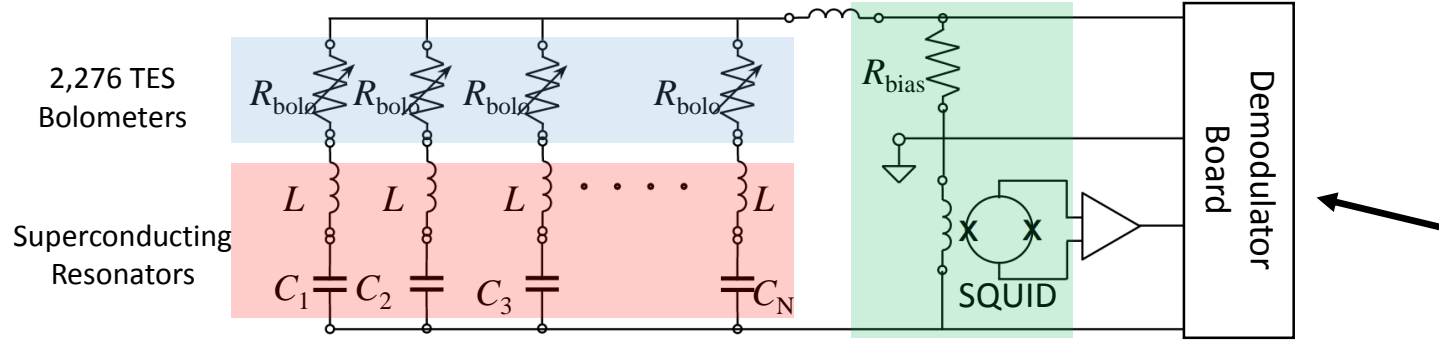


POLARBEAR-1 Focal Plane Tower

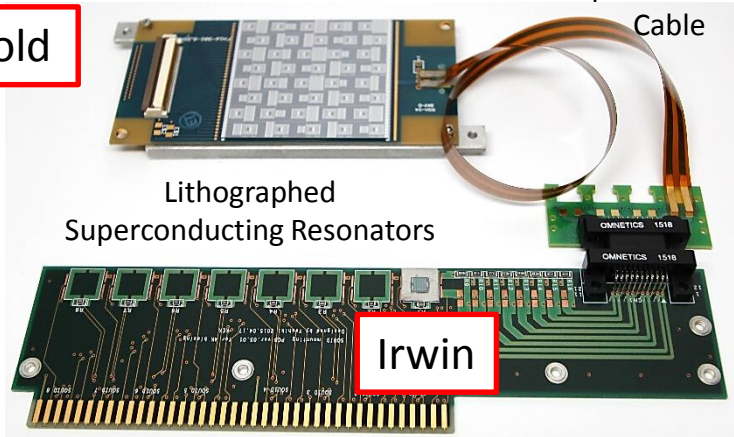


- 100 mK base temperature
- Cryo-cooler with multiple temperature stages
- Design to balance thermal load and structural strength
- Current design is based on deployed CMB experiments
- Talk by Ari Cukierman

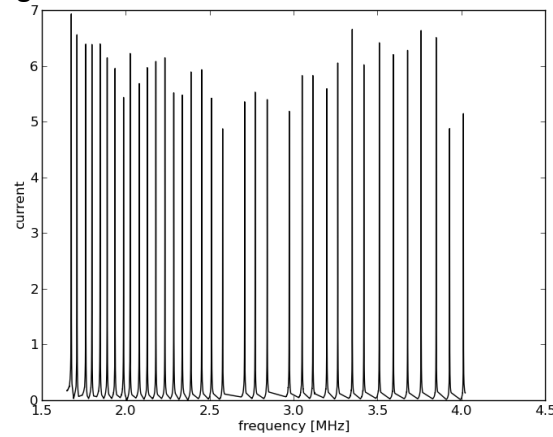
Readout Electronics



Arnold



Irwin



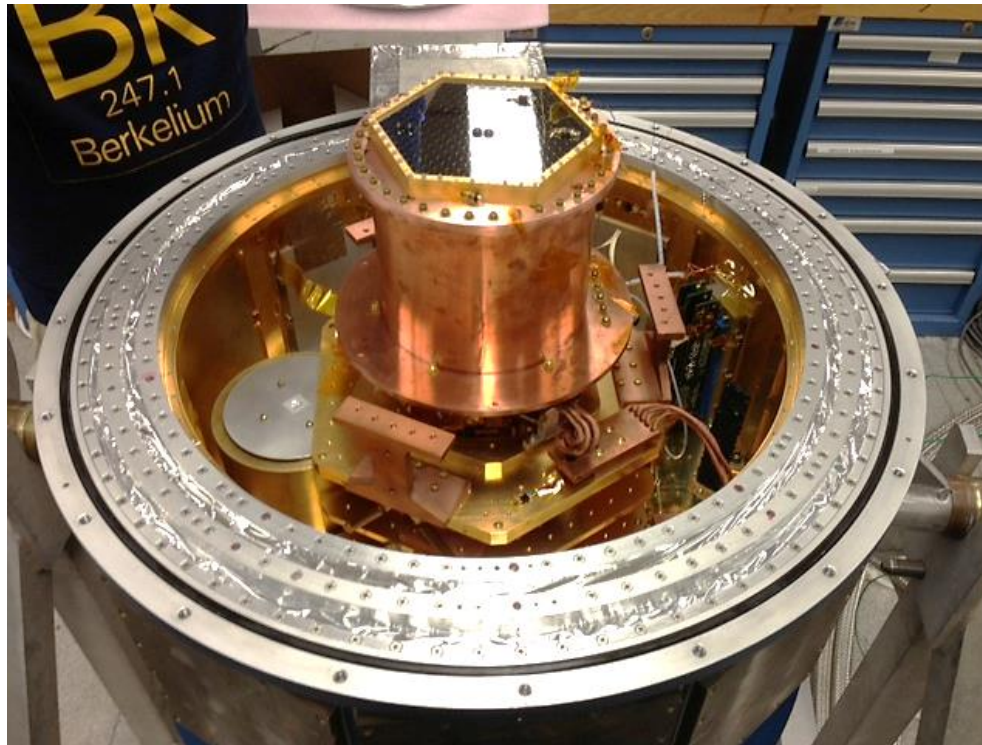
Current measurement through a comb of superconducting resonators



Dobbs

- Frequency Domain Multiplexing Readout with SQUID amplifier
- Ground and balloon CMB experiments heritage
- Talk by Kam Arnold – Cold electronics
- Talk by Matt Dobbs – Warm electronics
- Talk by Kent Irwin – SQUID in space

Test Facility



NIST

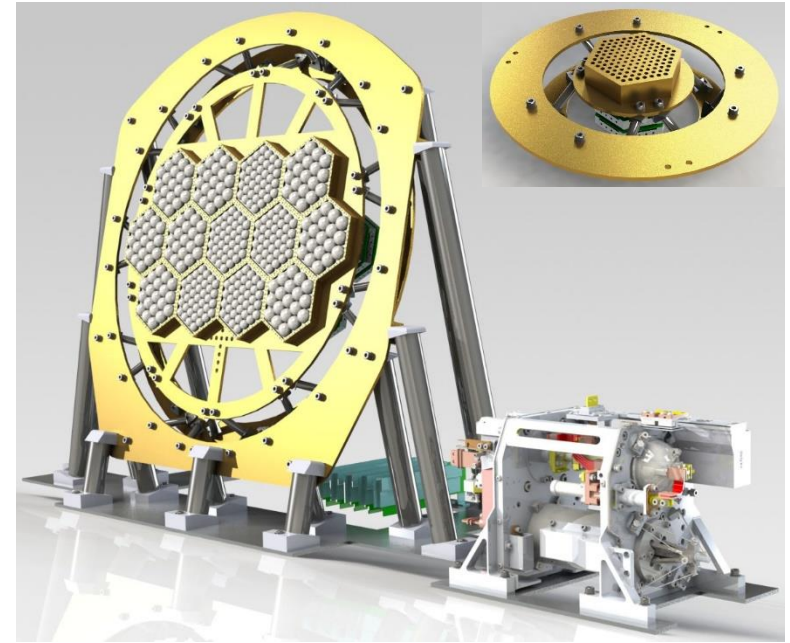
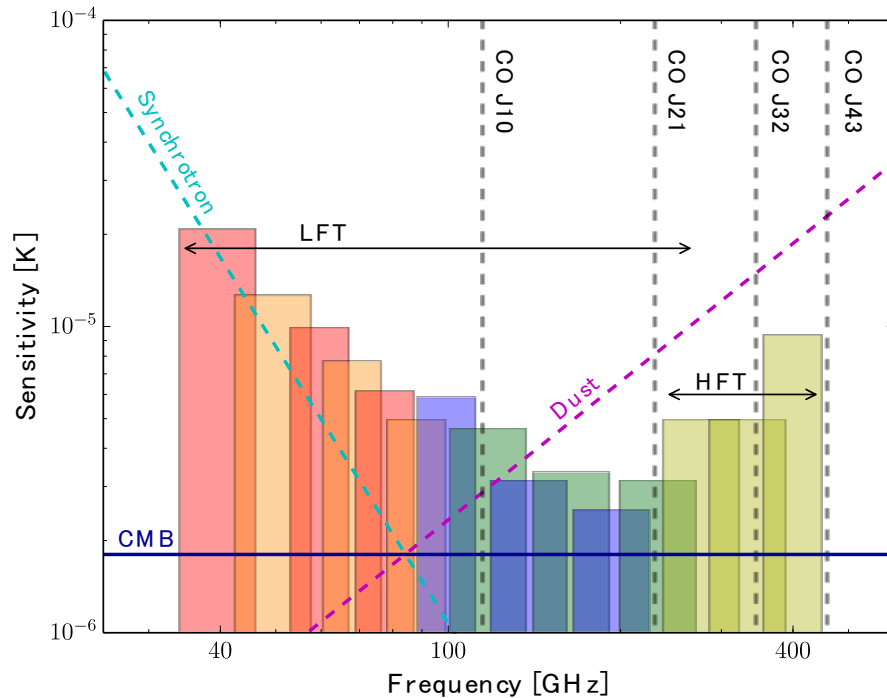


- Dedicated test cryostats at
 - Berkeley, Stanford, NIST, U of Colorado, UW-Madison

Subset of Ongoing Studies

- Robustness of frequency coverage
→ Foreground joint study group
- Radiation effects on focal plane components
→ Radiated sample at HIMAC
- Thermal and structural test
→ Vibration test at Space Science Lab, Berkeley

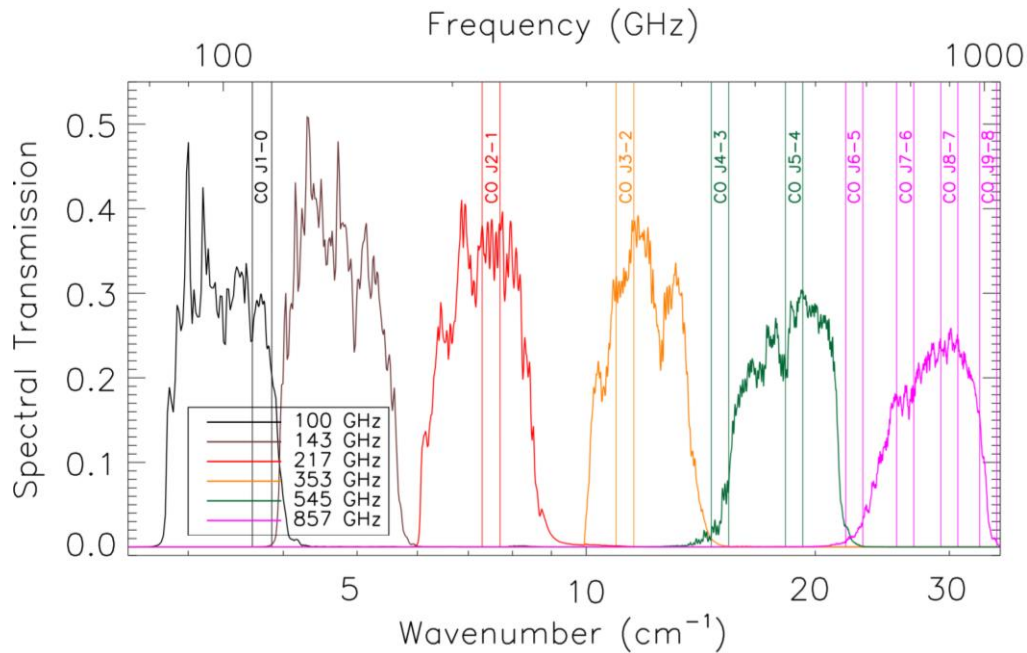
Conclusion



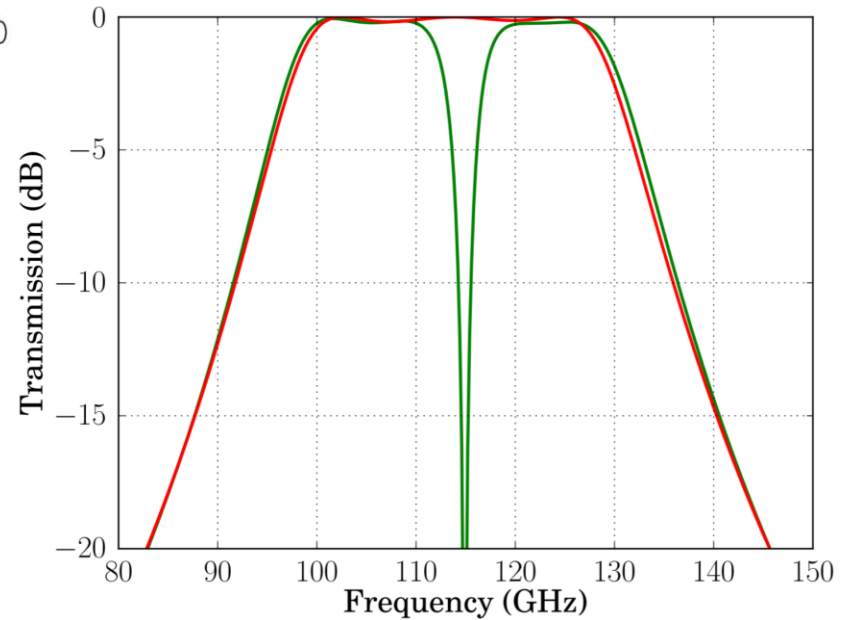
- LiteBIRD focal plane components have heritage from ground and balloon CMB polarization experiments
- 15 frequency bands for foreground monitoring
- Experienced experimental CMB team

Back Up

CO – Notch Filter



CO lines with Planck bands



Response of designed notch filter

- Notch filter to take CO line out