Design of the EBEX-IDS Detectors

F. Aubin[1,†], S. Hanany[1], B. Johnson[2], A. Lee[3], A. Suzuki[3,4], B. Westbrook[3], and K. Young[1].

[1]**School of Physics and Astronomy, University of Minnesota**; [2]Columbia University; [3]University of California, Berkeley; [4]Lawrence Berkeley National Laboratory. [†]Corresponding author: faubin@umn.edu

EBEX-IDS

- Cosmic microwave background (CMB) polarimeter
- Balloon-borne platform
- 20 days at float circumnavigating Antarctica
- Proposed launch in December 2021

Science Objectives

- Characterize the polarization of Galactic dust
- Detect primordial gravity waves

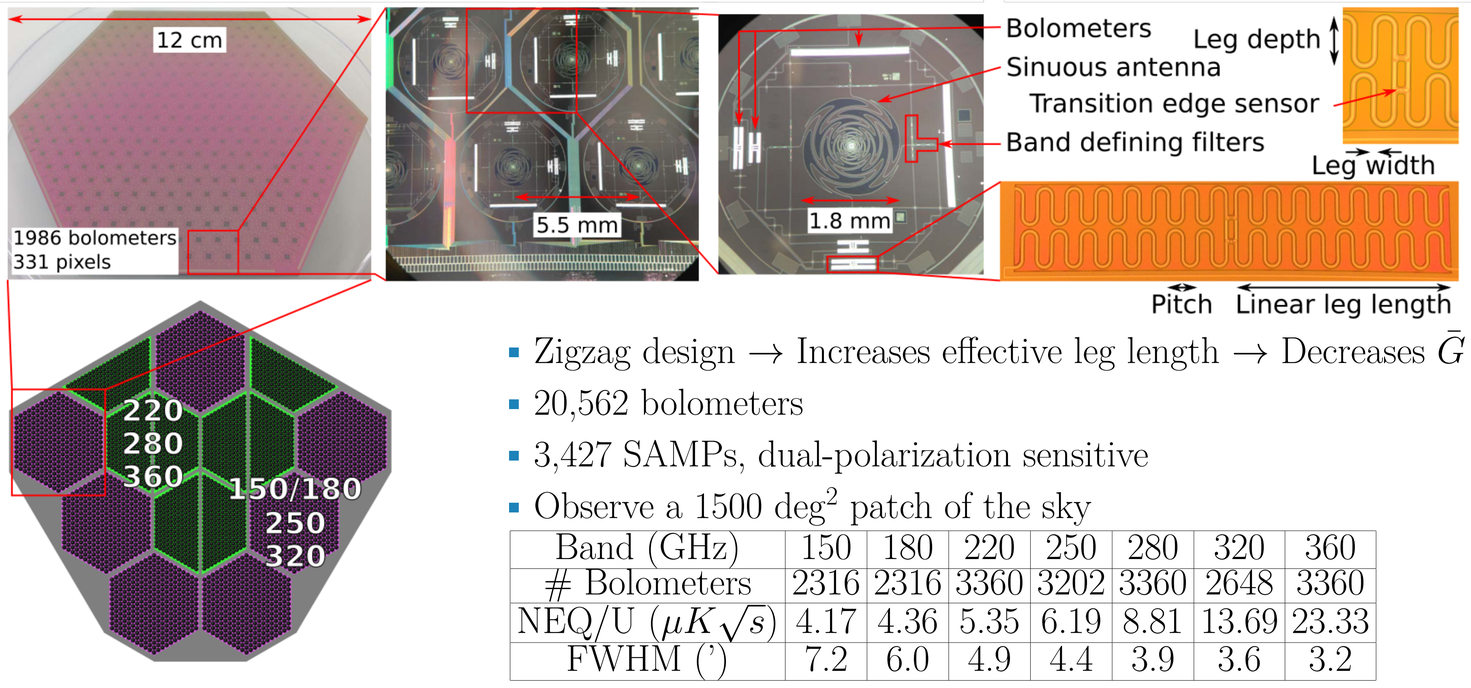
Motivations

- Deep maps at 3.2-7.2 arcmin resolution
- 7 frequency bands between 150-360 GHz
  - 250-360 GHz complementary to ground-based telescopes
- Observe the same patch of sky as ground-based:
  - POLARBEAR/Simons Array instrument
  - BICEP/Keck Array instrument

Technology Development

- **First** operation of sinuous antenna multichroic pixels (SAMP) on a balloon platform
- Development of **low** thermal conductance bolometers: $\bar{G} = 9$ pW/K
  $\rightarrow$ higher instantaneous sensitivity
- Implementation of the **largest** to date frequency domain multiplexing (FDM) factor: $\times 105$

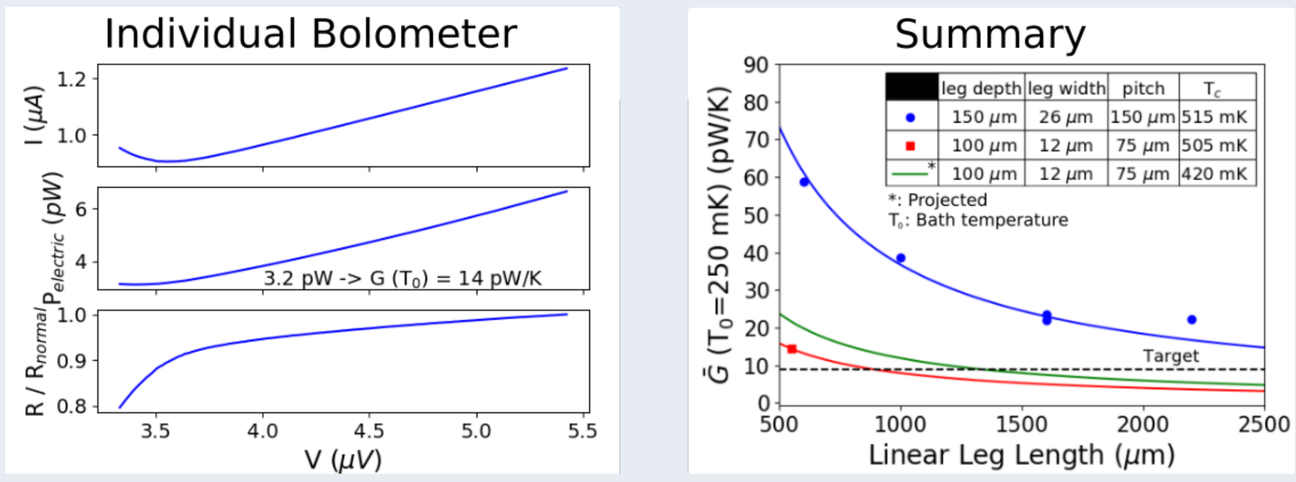
Low Thermal Conductance Bolometers



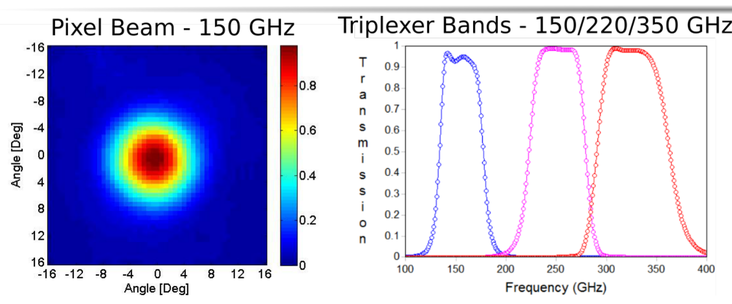
- Zigzag design $\rightarrow$ Increases effective leg length $\rightarrow$ Decreases $\bar{G}$
- 20,562 bolometers
- 3,427 SAMPs, dual-polarization sensitive
- Observe a 1500 deg^2 patch of the sky

Band (GHz)	150	180	220	250	280	320	360
# Bolometers	2316	2316	3360	3202	3360	2648	3360
NEQ/U ($\mu K\sqrt{s}$)	4.17	4.36	5.35	6.19	8.81	13.69	23.33
FWHM (')	7.2	6.0	4.9	4.4	3.9	3.6	3.2

Measurements of $\bar{G}$

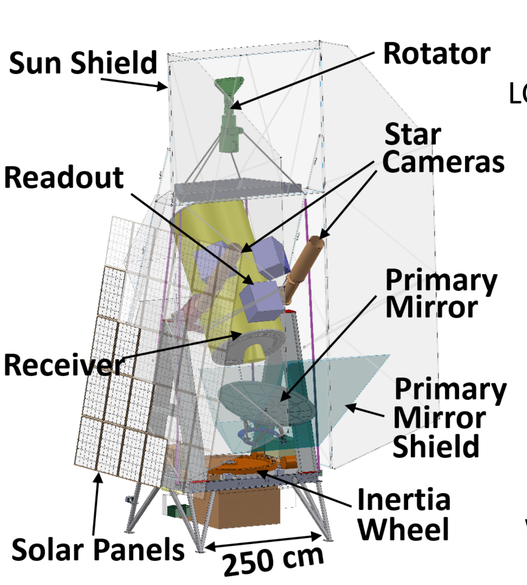


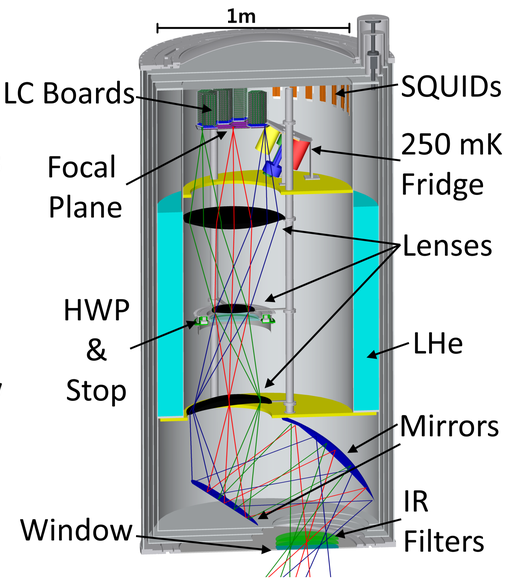
Optical Properties



- Individual lenslet for every pixel[5]
- Measurements as expected on EBEX-IDS-like pixels

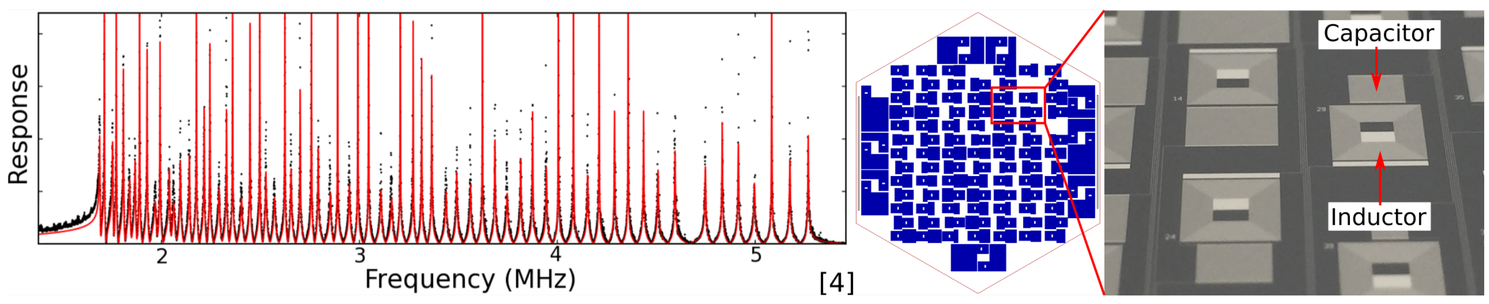
Payload





- 1.5 m aperture Gregorian Mizuguchi-Dragone telescope
- 4 K secondary and tertiary mirrors
  $\rightarrow$ Minimizes the loading form the instrument
- Achromatic half-wave plate
- Re-use of EBEX flight tested hardware [1, 2, 3]

Readout



- Frequency domain multiplexing (FDM) readout: ICE motherboards [4]
- Multiplexing factor of $\times 68$ demonstrated [4]. Increasing to $\times 105$ by:
  - Extending the bandwidth to 0.4 - 5.3 MHz
  - Developing new 250 mK inductor/capacitor chips to be tested by the end of 2017

Conclusions

- A prototype of a 9 pW/K bolometer achievable for 1320 μm leg length. Next:
  - High yield geometry (●): symmetric design
  - Low thermal conductance (■): 12 μm wide legs
  - Critical temperature of 420 mK
- Fabrication of EBEX-IDS bolometer wafers demonstrated
- Demonstration of the Increased FDM multiplexing factor in progress

Acknowledgements

The EBEX-IDS Collaboration would like to thank the support from NASA (NNX17AH30G).

References

[1] The EBEX Collaboration et al. *The EBEX Balloon Borne Experiment - Optics, Receiver, and Polarimetry.* Submitted to ApJ (arXiv:1703.03847), 2017.

[2] The EBEX Collaboration et al. *The EBEX Balloon Borne Experiment - Detectors and Readout.* To be submitted to ApJ, 2017.

[3] The EBEX Collaboration et al. *The EBEX Balloon Borne Experiment - Gondola, Attitude Control, and Control Software.* Accepted in ApJ (arXiv:1702.07020), 2017.

[4] Bender, A. N. et al. *Digital Frequency Domain Multiplexing Readout Electronics for the Next Generation of Millimeter Telescopes.* Proc. SPIE 9153, 91531A (arXiv:1407.3161), 2014.

[5] Siritanasak, P. et al. *The Broadband Anti-reflection Coated Extended Hemispherical Silicon Lenses for Polarbear-2 Experiment.* Journal of Low Temperature Physics 184, 553–558, 2015.