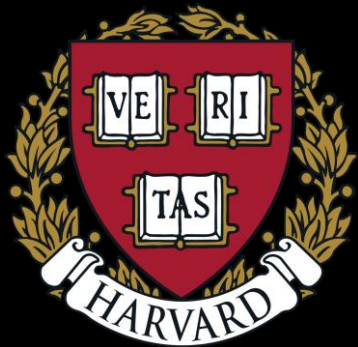


Thin Laminate Polyethylene Windows for BA Receivers

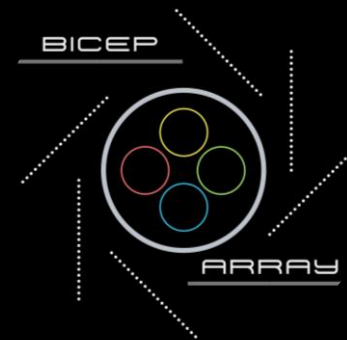


Miranda Eiben

Harvard University

Advised by John Kovac

5th Year Graduate Student



Astrophysical Motivation

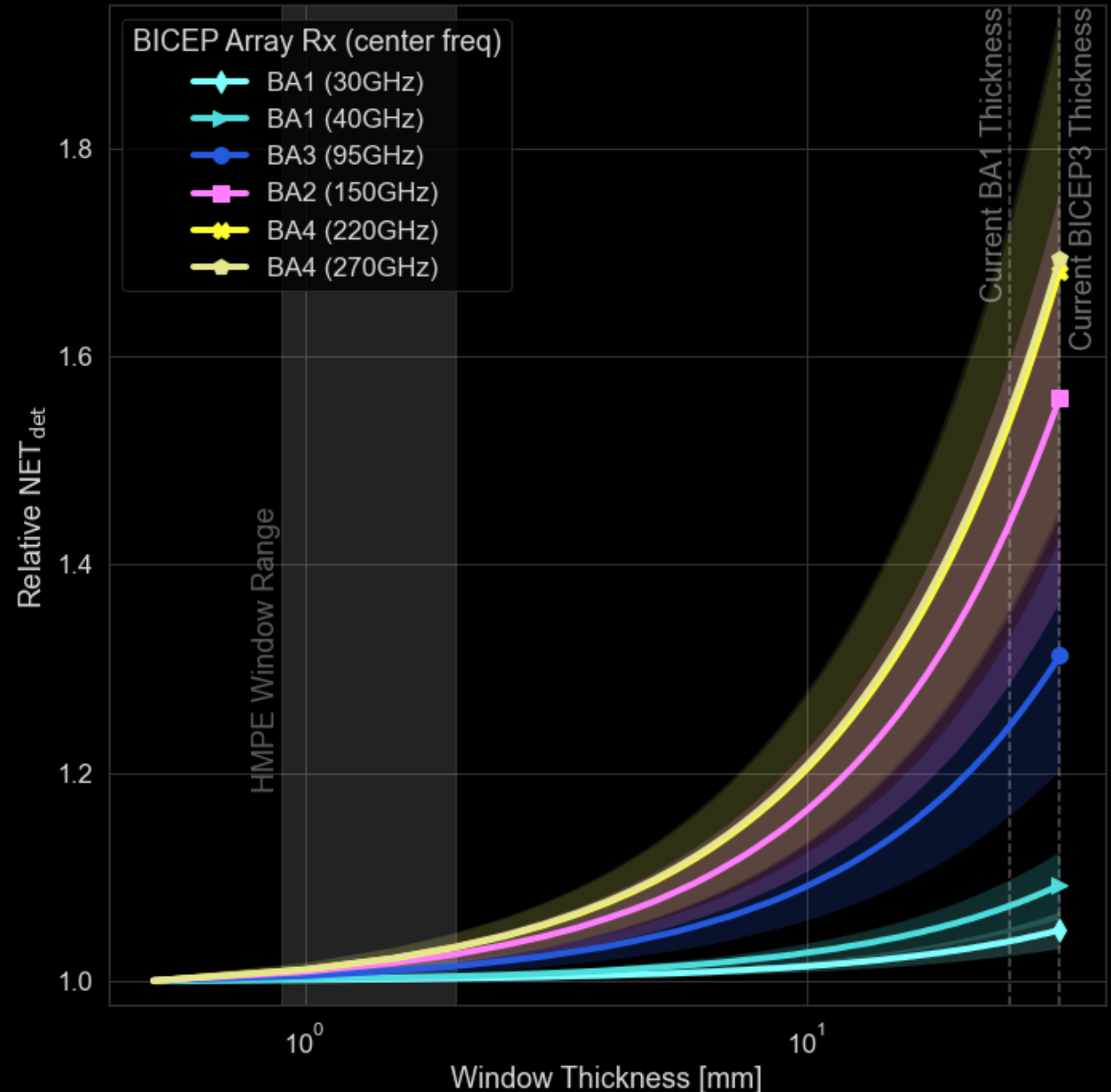
Why are we doing this?

Includes:

- Relative NET gains
- Overview of polyethylene

BA Relative Per Det NET

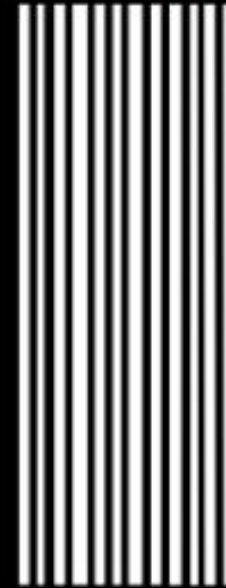
- Decreasing thickness will decrease noise on detectors, decreasing map noise
 - BA1 (30/40 GHz): Low noise reduction of 6-10%
 - BICEP3/BA3 (95 GHz): Noise reduction of 20-40%
 - BA2 (150 GHz): Noise reduction of 30-70%
 - BA4 (220/270 GHz): Noise reduction of 50-80%
- Simulation uses BoloCalc
 - Shaded bands show NET uncertainty based on PE $\tan\delta$ uncertainty from 20-300GHz
 - PE $\tan\delta \sim 2e-4$ to $4e-4$



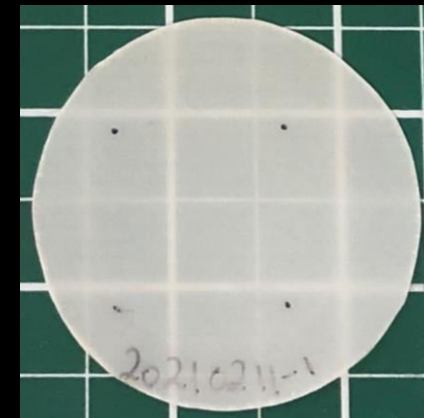
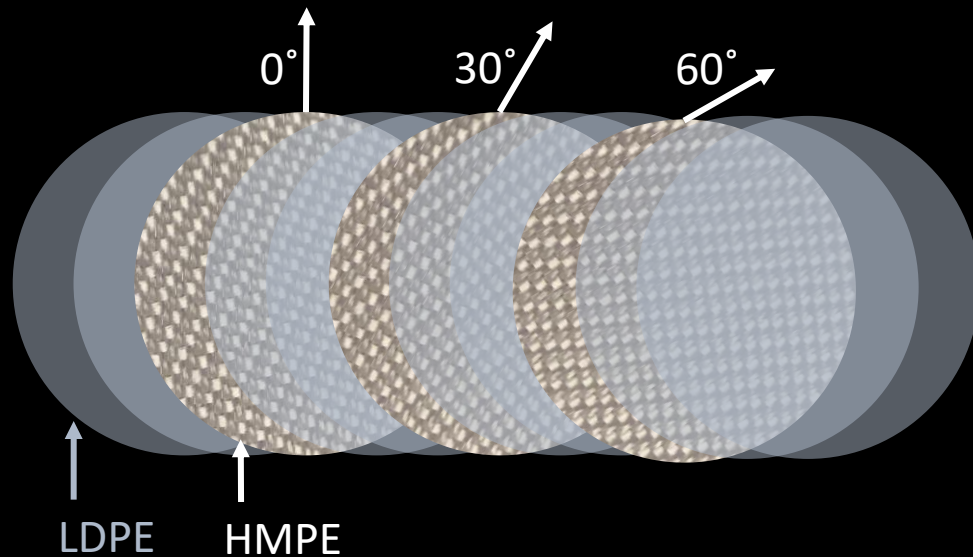
Differences between Grades of Polyethylene

- Most common plastic in the world
- Comes in different grades that have different properties
 - Low Density Polyethylene (LDPE)
 - High Density Polyethylene (HDPE)
 - High Modulus Polyethylene (HMPE, commercial name Dyneema)

High modulus polyethylene



Regular polyethylene



Mechanical Properties

Will it fail during normal operation, or cause failure?

Includes:

- Safety Factor

Can we model the safety factor?

$$\delta = K \left(\frac{\Delta P R^4}{Et} \right)^{\frac{1}{3}}$$

$$\sigma_{max} = Z \left(\frac{E \Delta P^2 R^2}{t^2} \right)^{\frac{1}{3}}$$

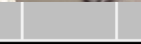
Window Material	Ultimate Tensile Strength (MPa)	Safety Factor
HDPE	17.5-21	0.54-0.65
UHMWPE	27.6-40	0.73-1.06
HMPE Laminate	120-135	3.17-3.67



Can we measure the safety factor?

1/4-28 bolts →  ← C-clamps



1/4-28 nuts → 

(the water is)

(the vacuum
over)

Can we measure the safety factor?



We got to **85**
pounds per
square inch

Safety factors of **5.7** at sea level, **8.2** at South Pole

Optical Properties

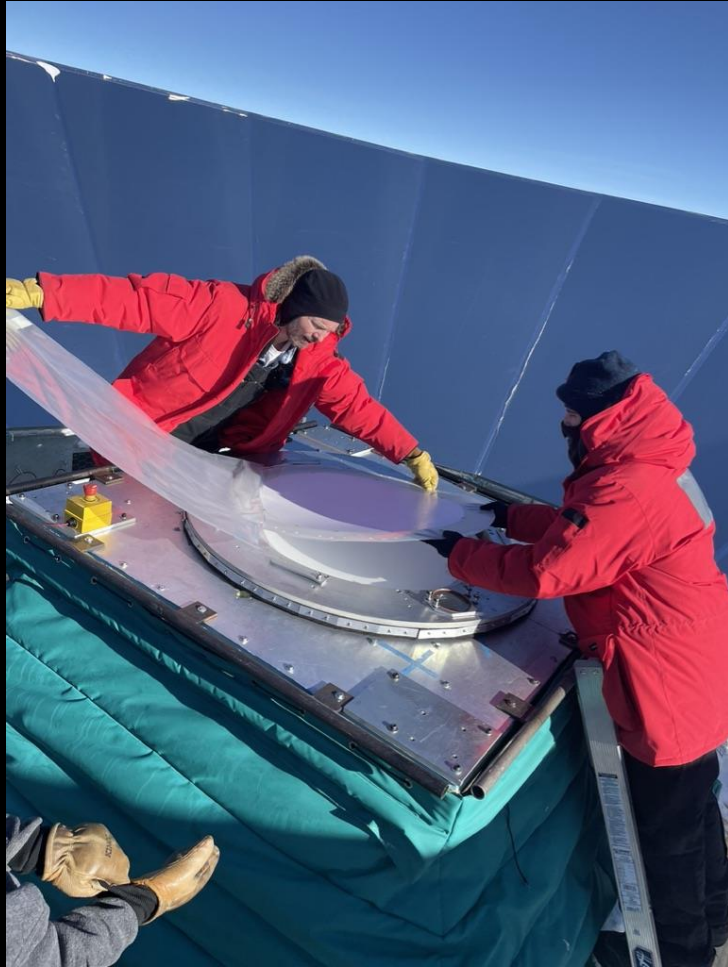
Will it impact observations in positive or negative ways?

Includes:

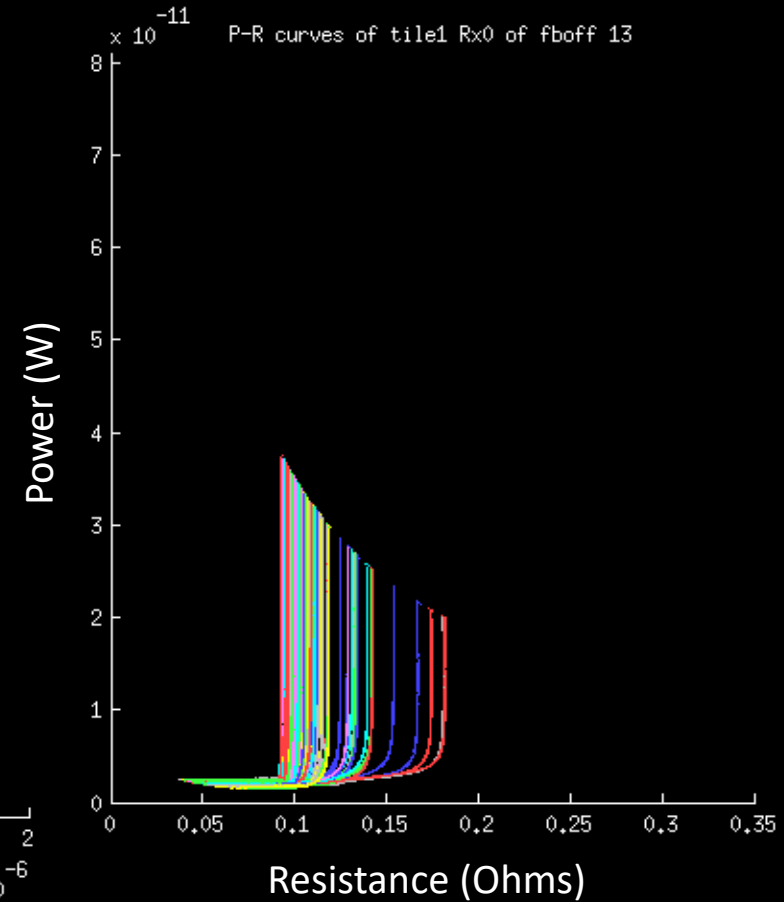
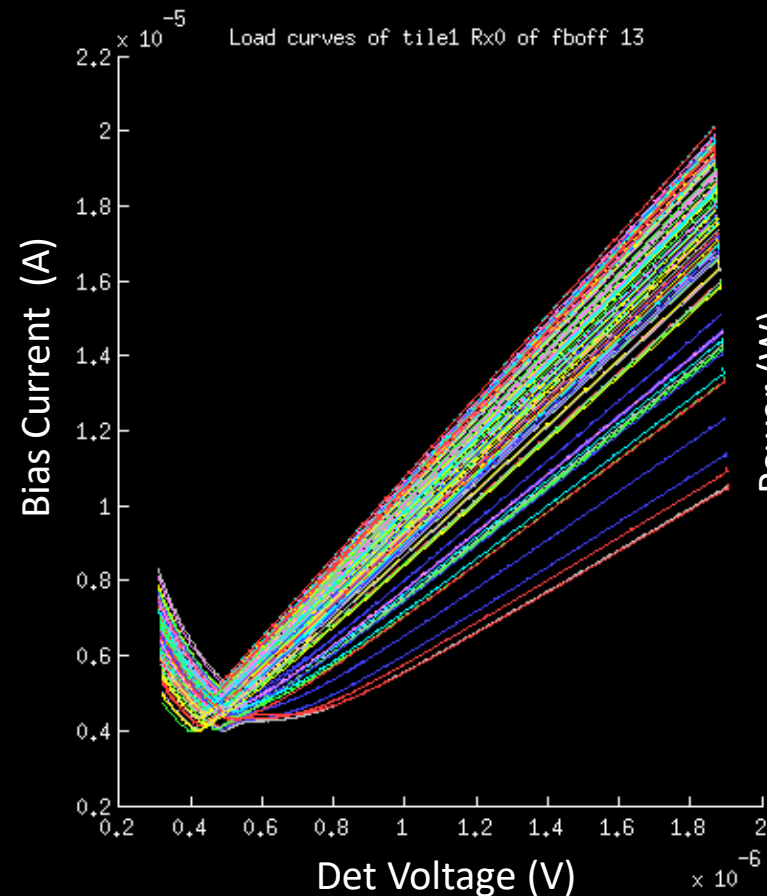
- Radiometric tests
- NET measurements

What can we measure?

Optical Load



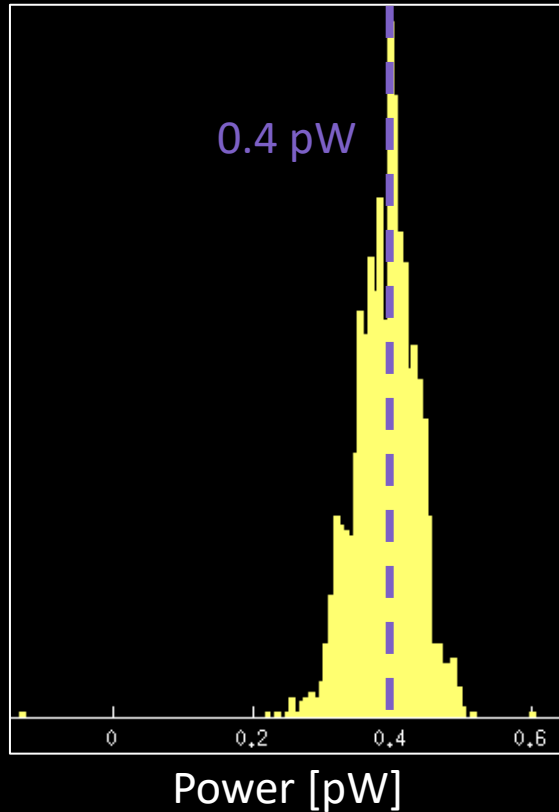
Radiometric measurements made by Jamie Cheshire, John Kovac, and Thomas Leps



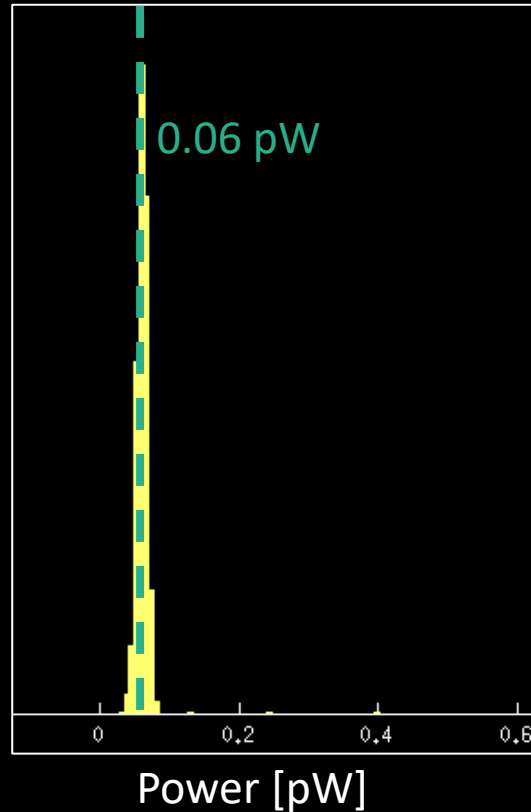
What can we measure?

Optical Load

Spare Slab
HDPE Window



Replacement
Thin Window



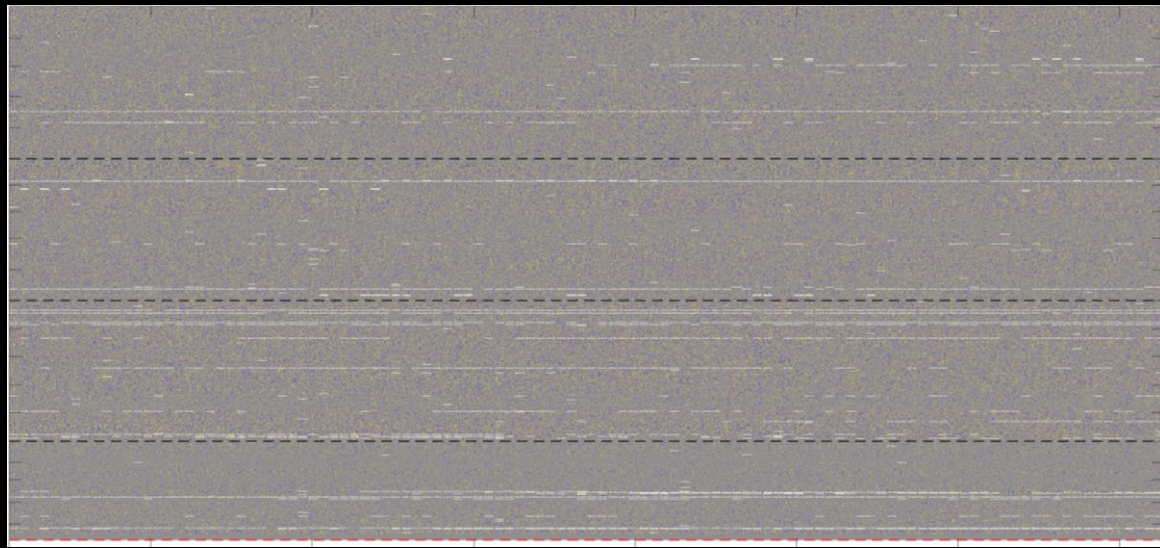
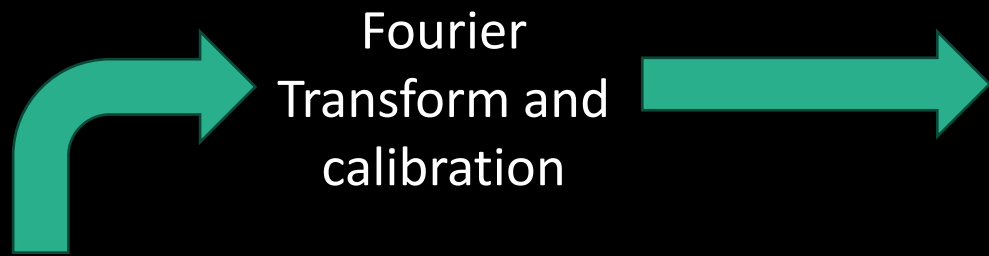
BICEP3 Total
Instrumental
Optical Loading

1.1 pW

Hui, et al. *BK-XV: The BICEP3 CMB Polarimeter and the First Three Year Data Set* (2022)

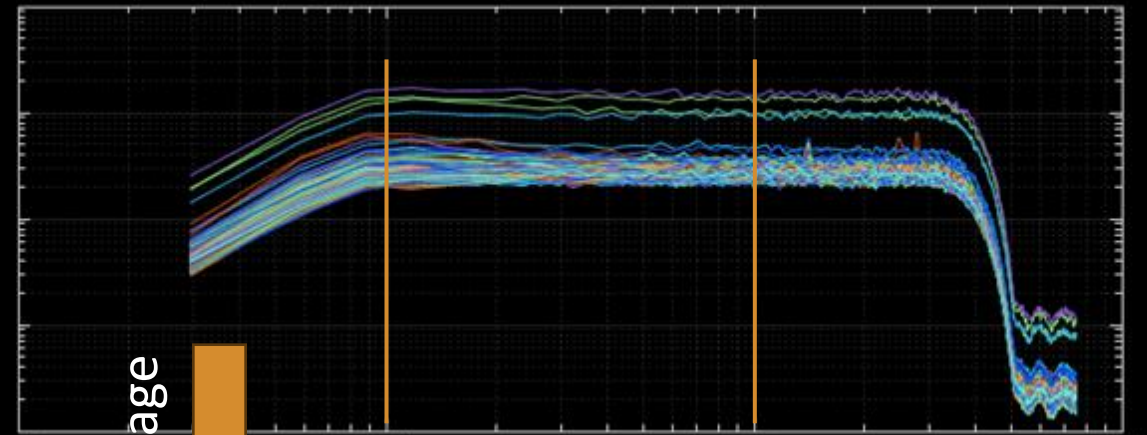
What can we measure?

Noise



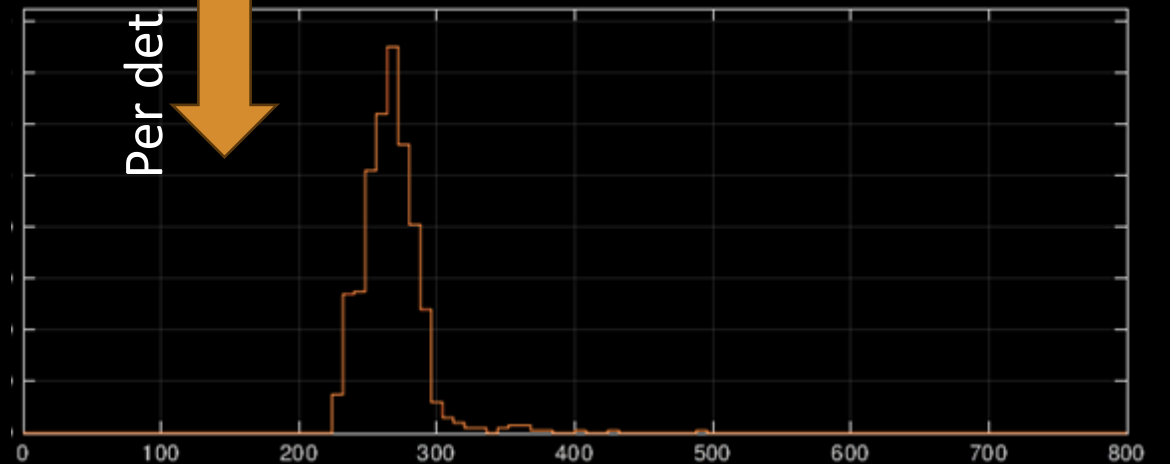
Raw Data

Noise Eq. Temp



Frequency (Hz)

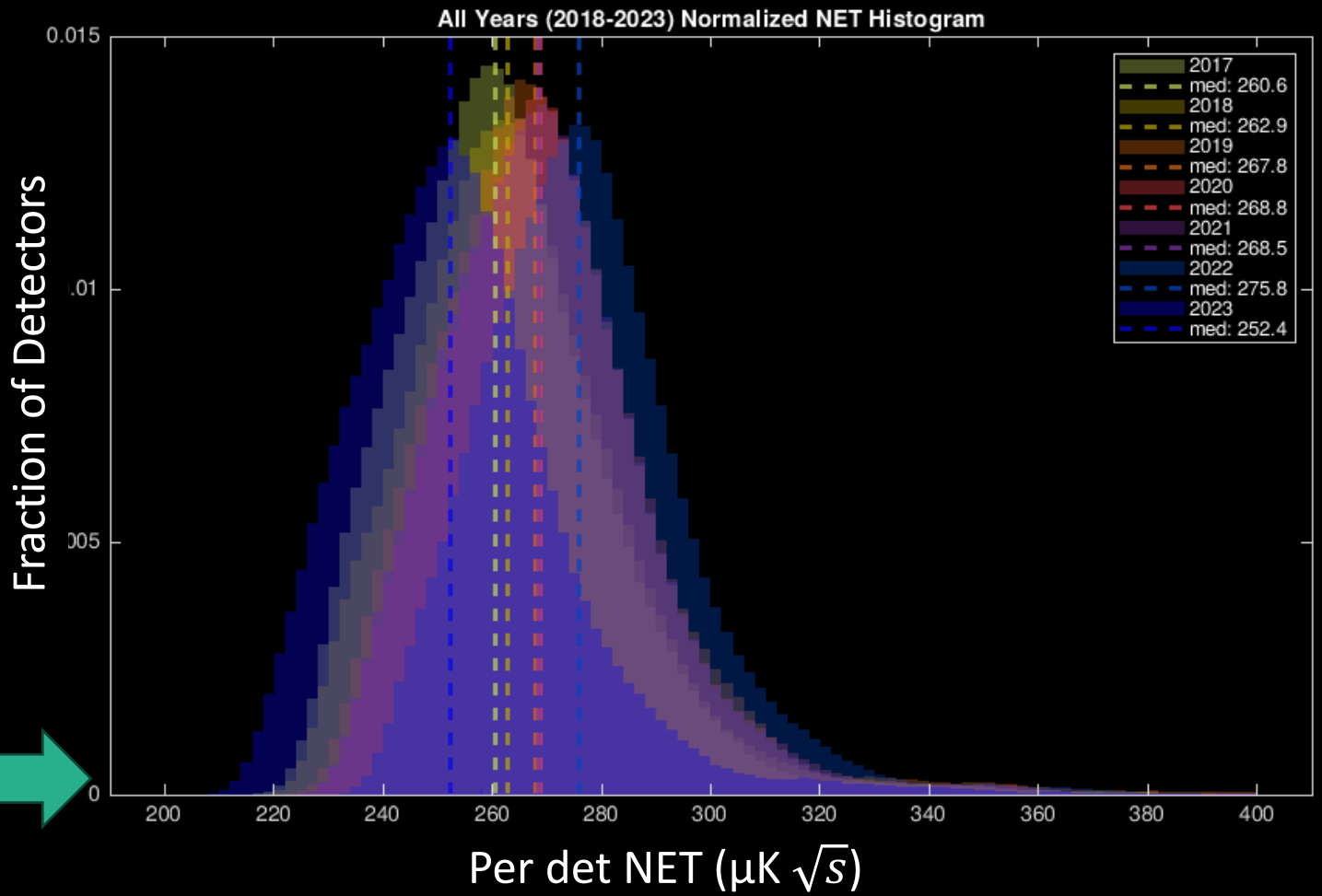
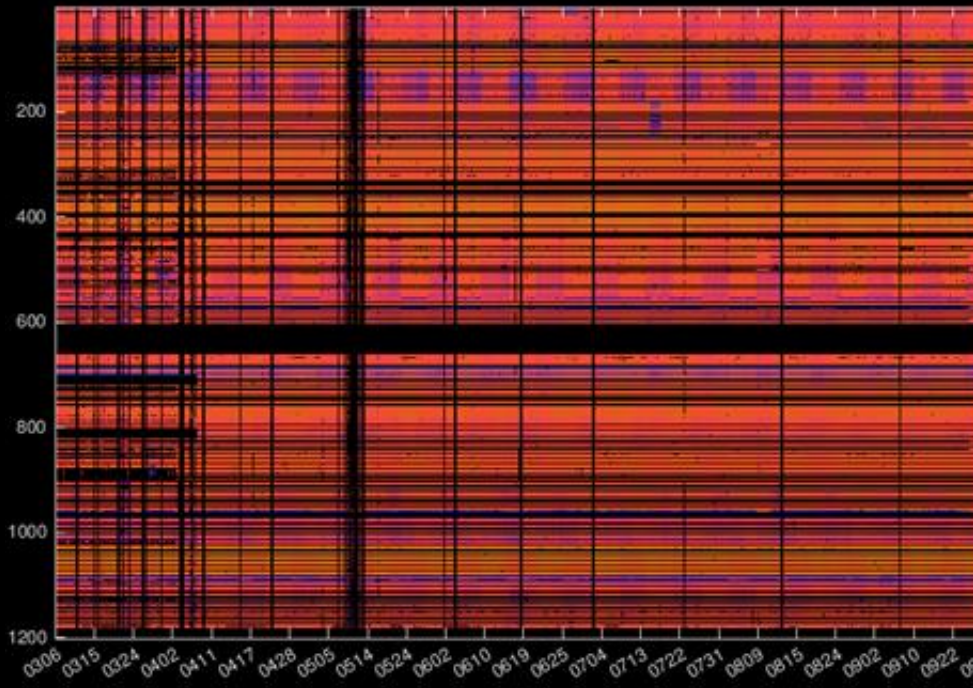
Per det average



Per det NET in range 0.1 to 1 Hz ($\mu\text{K} \sqrt{s}$)

What can we measure?

Noise



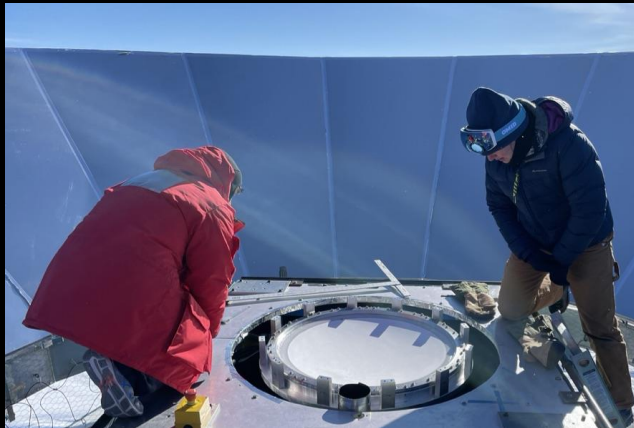
Take a median over the year and compare years



Summary

Thin Windows Work!

- Constrained many mechanical and optical properties
 - Look out for a paper on thin windows coming soon!
- Have operated on two receivers at South Pole for over a year!
 - And will hopefully operate on CMB-S4 receivers in the future!



Thanks to everyone
who helped make
this possible!

