Quantum Sensors for mm Cosmology

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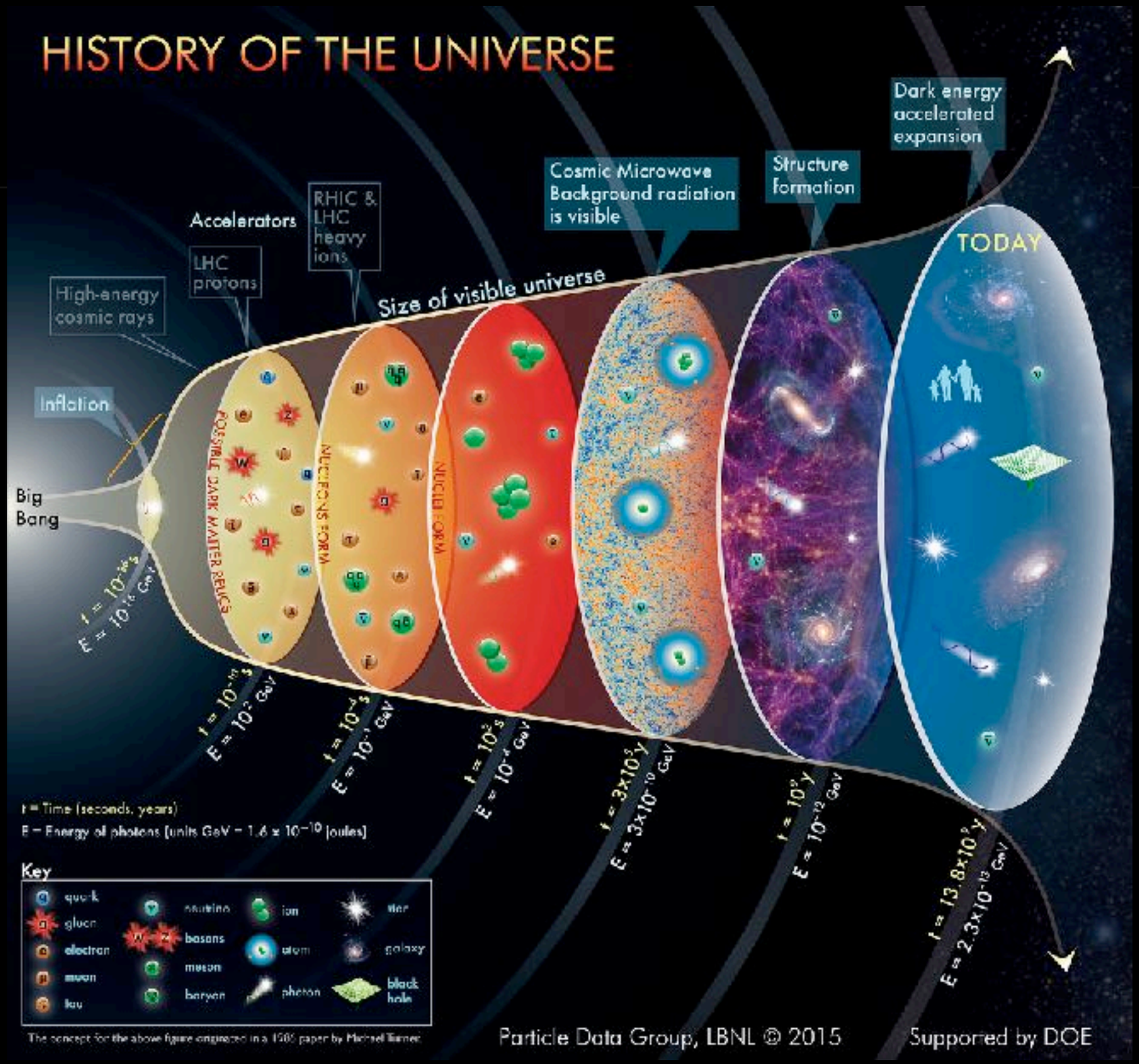
Quantum Sensing Workshop

April 8, 2022

Start with quantum fluctuations



Simons Observatory

- One 6m Large Aperture Telescope
- Three 0.5m Small Aperture Telescopes
- Five-year survey planned starting in 2023
- 5200m (17,000 feet) altitude

Cerro Toco, Atacama Desert

More sensitivity = More detectors

$$\sigma^2_{Poisson} = \frac{h\nu P_\gamma}{\tau}$$

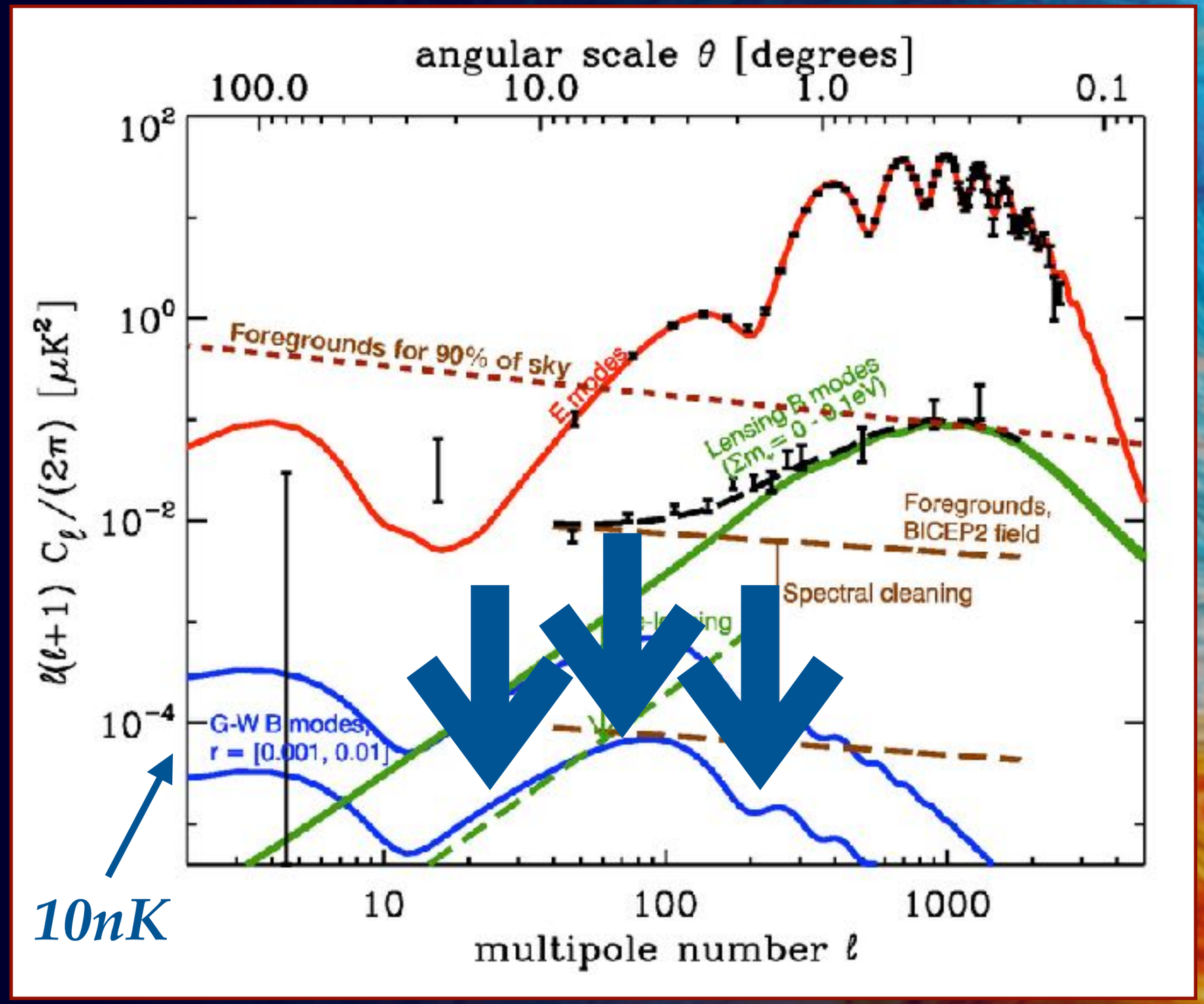
$$\sigma^2_{Bose-Einstein} = \frac{P^2_\gamma}{\Delta\nu\ \tau}$$

$$\sigma^2_{detector} = 4k_B T_b^2 G$$

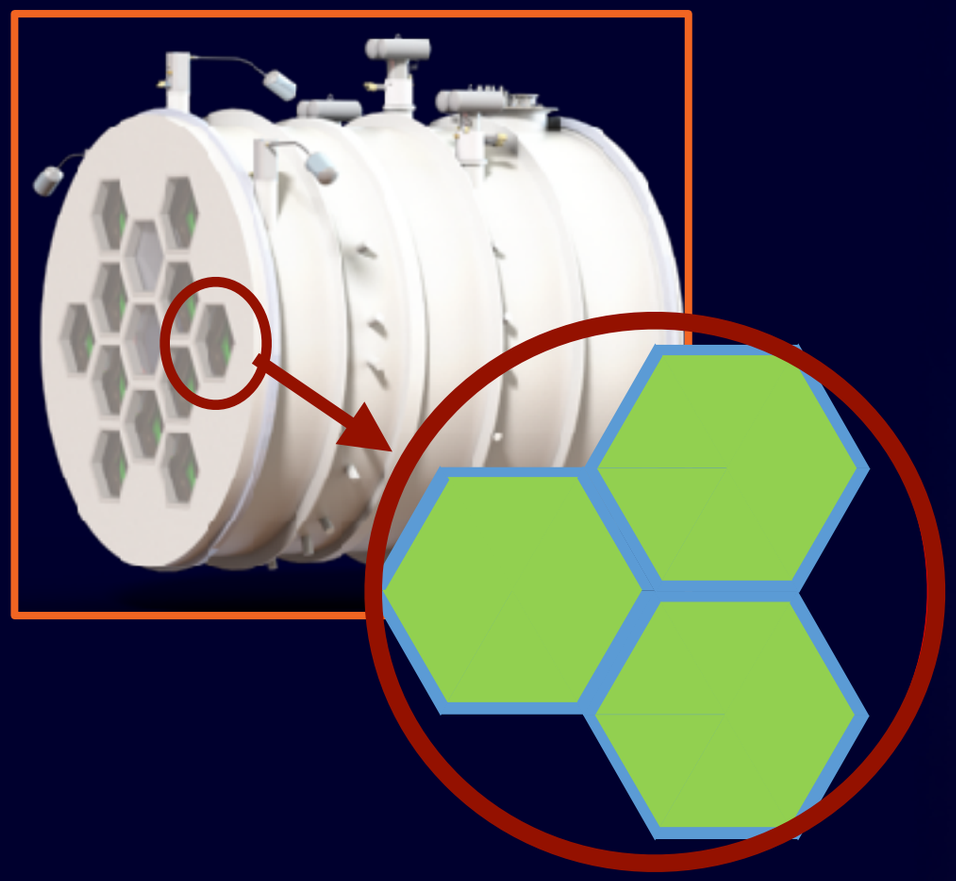
100mK detectors: photon noise dominated!

<u>BETTER</u> detectors won't helps us

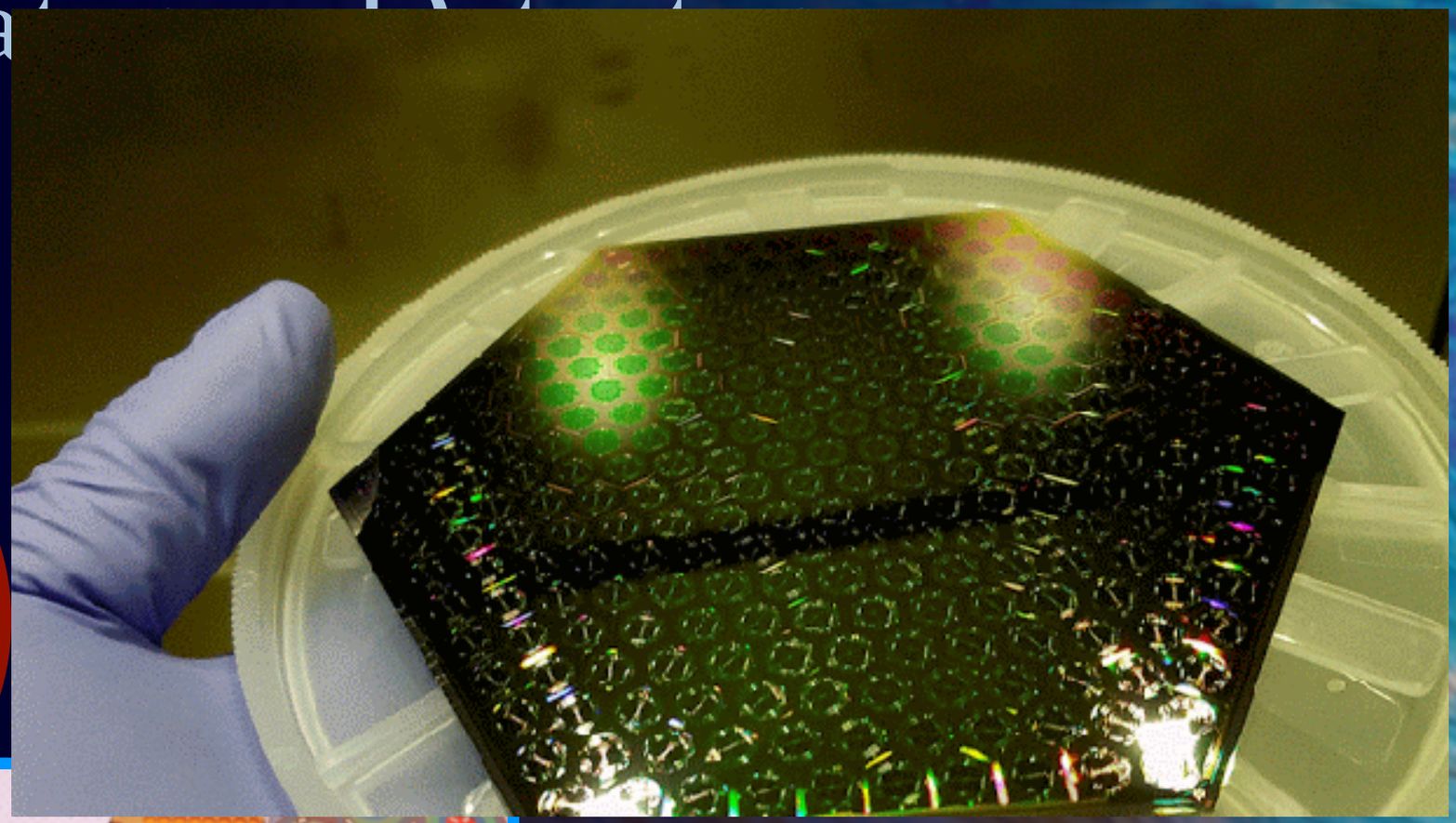
<u>MORE</u> detectors helps us ~50,000 detectors (x5 increase)

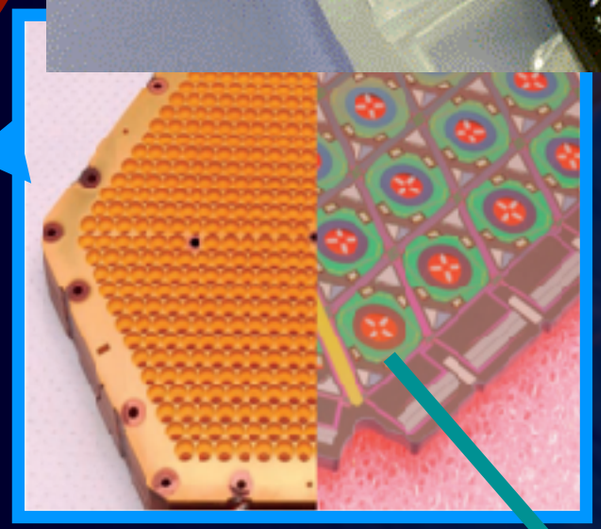


Simons Observatory - Detectors

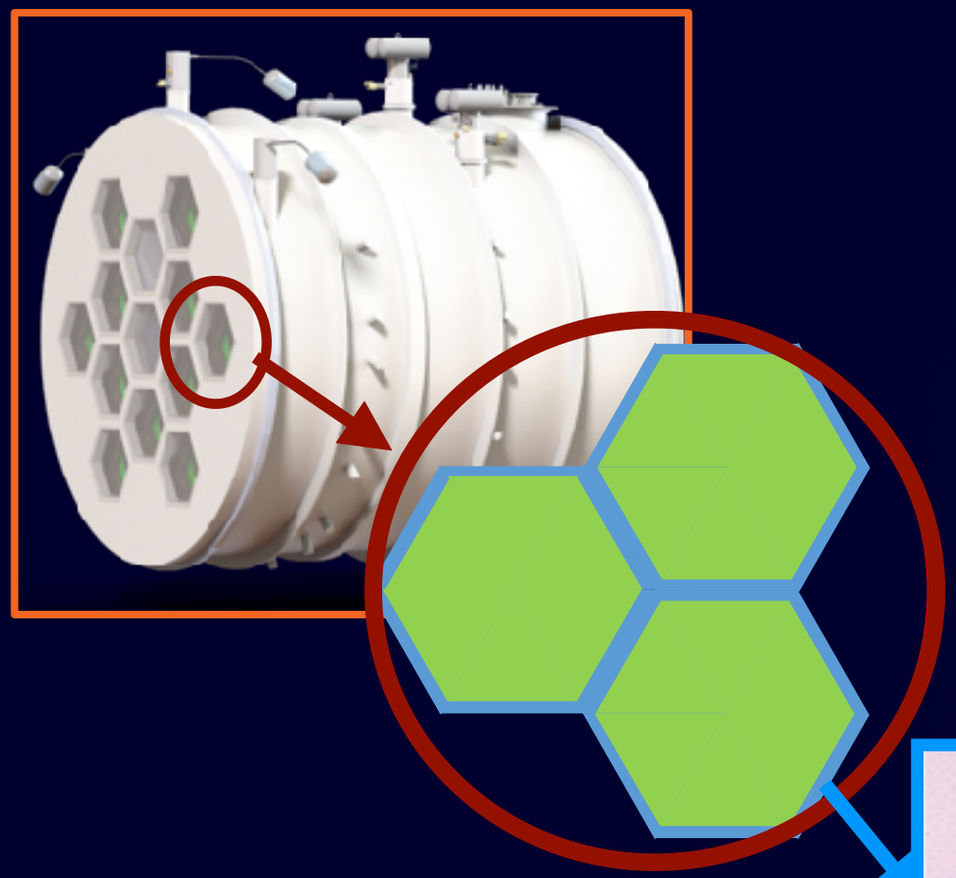


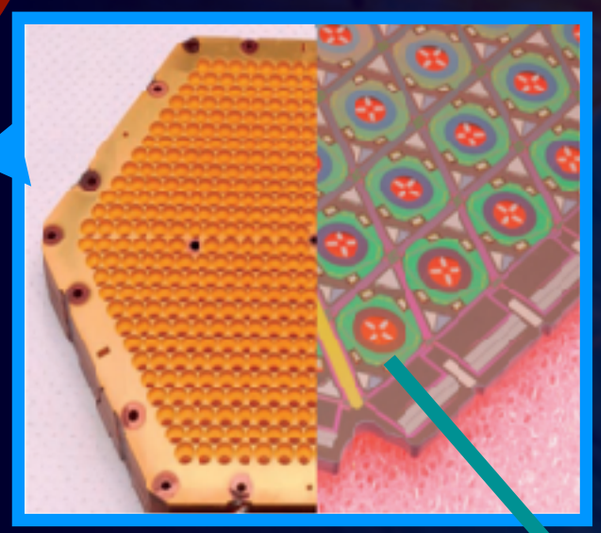
Simons Observa

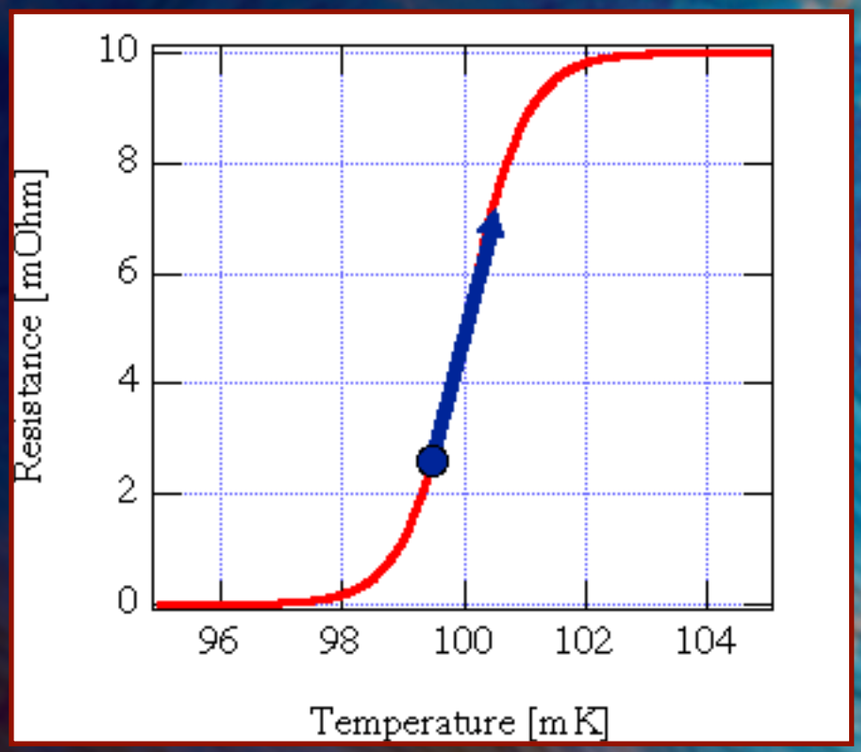


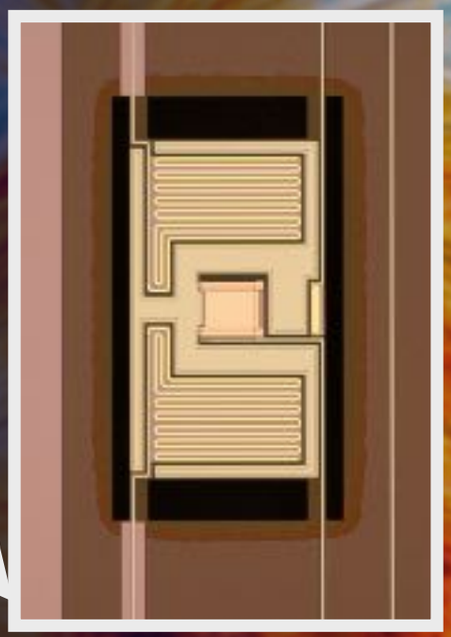


Simons Observatory - Detectors







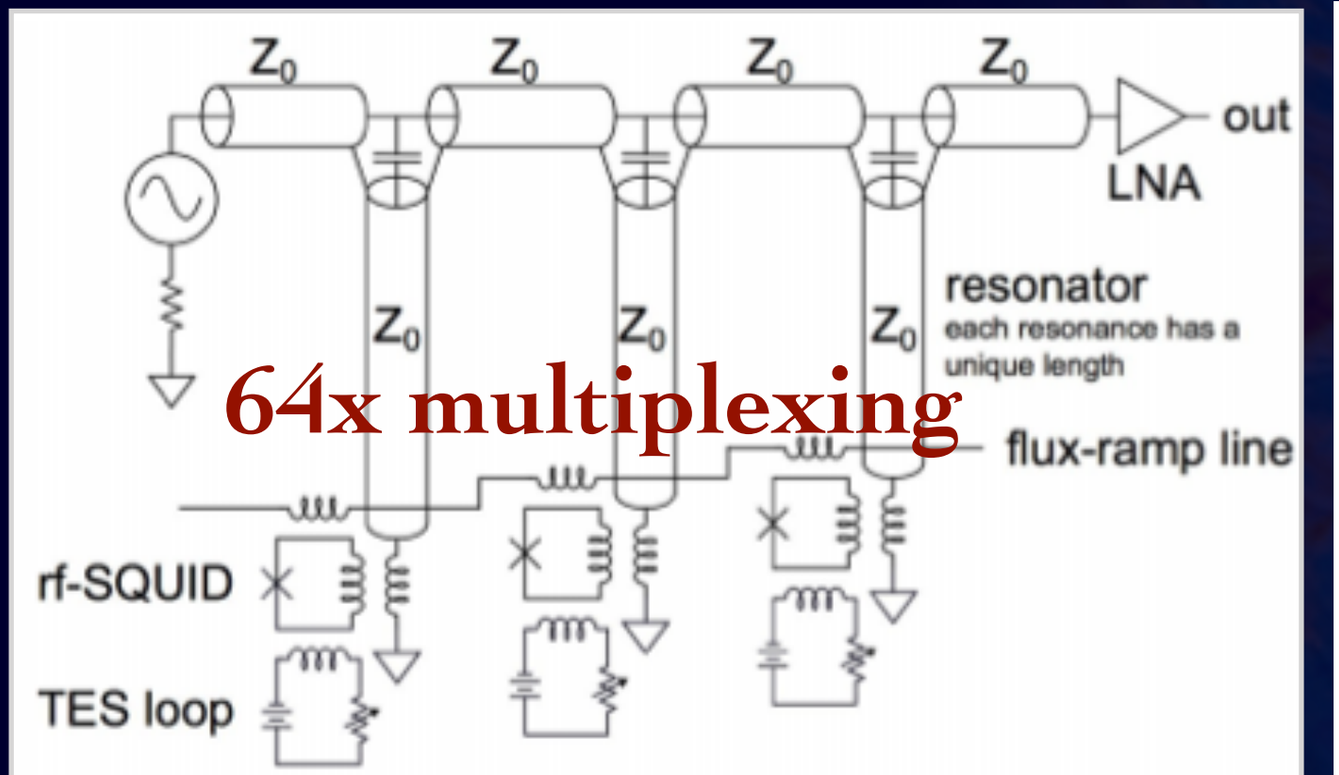


Galitzki et al, SPIE 10708, 2018 (SAT)
Koopman et al, Proc SPIE 11452, 2020 (Software)
Zhu et al, ApJS 256, 1, 2021 (LAT)
McCarrick et al, ApJ 922, 2021 (Readout)

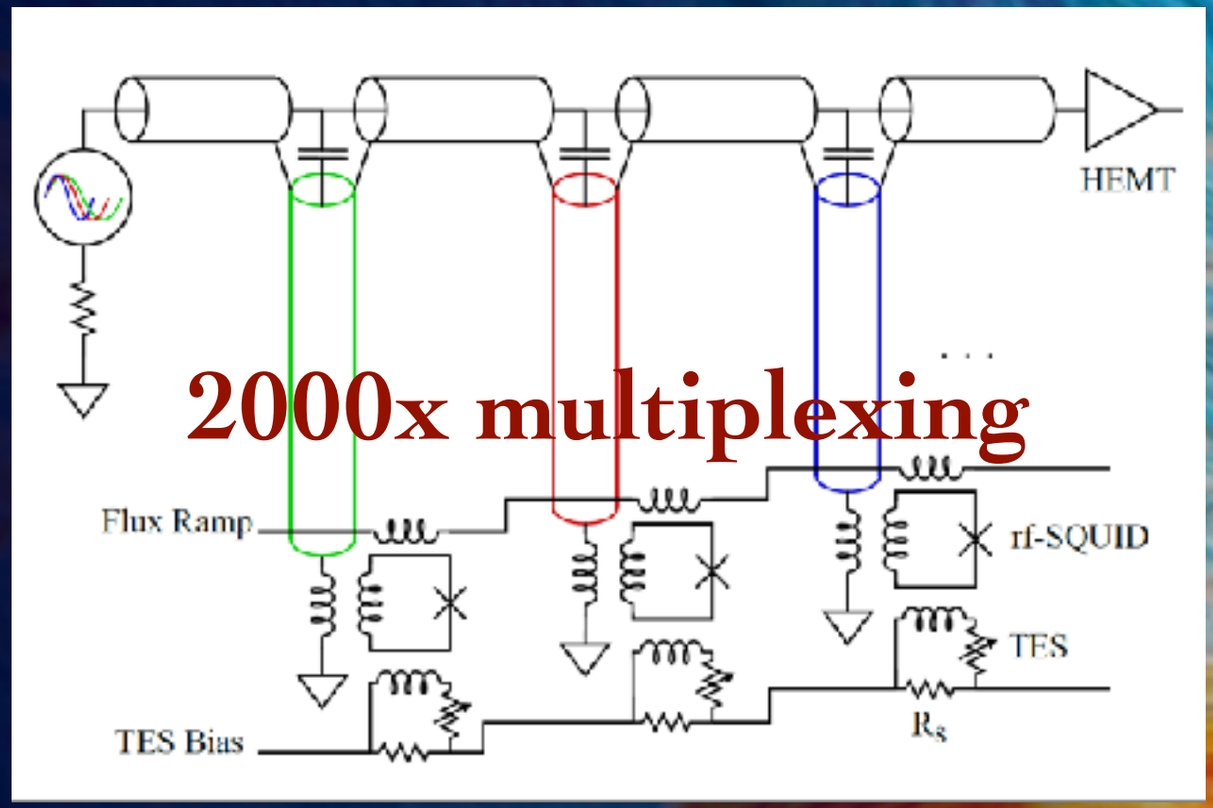
SQUID amplifiers + multiplexing

- Dilution refrigerator can handle **500uW** of loading at 100mK — must be very careful about the connections between the 300K ambient and cold stages to a minimum.

- Must read many detectors out on a single line: multiplexing



64x multiplexing



2000x multiplexing

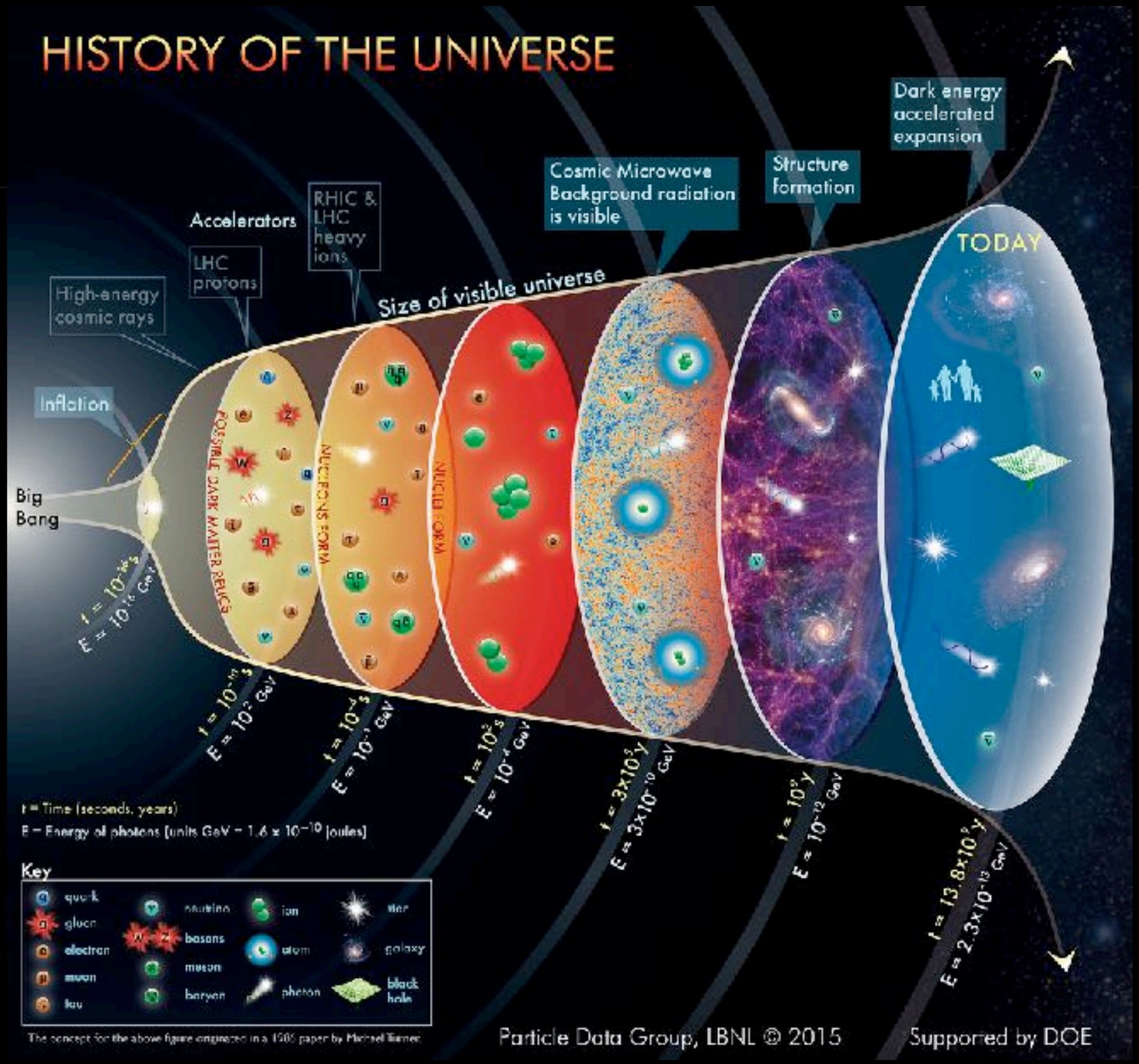
Current technology used for ~6,000 detectors: 64x mux factor and requires 3 crates

30,000 detectors = 15 crates and 5x more wires. Or:

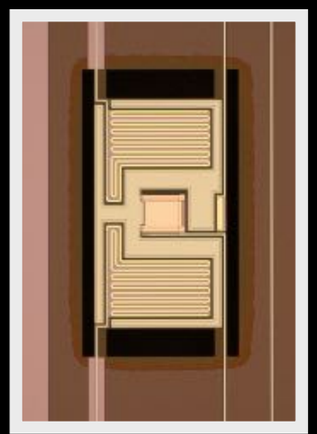
microwave multiplexing: 2000x mux factor!

Henderson et al, Proc SPIE 10708, 2018

Start with quantum fluctuations



Detect with quantum sensors



Thanks!