

CPAD2018
Review of the
Superconducting Detector
Sessions

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Overview

Attempted to survey current state of instrumentation + future technology directions

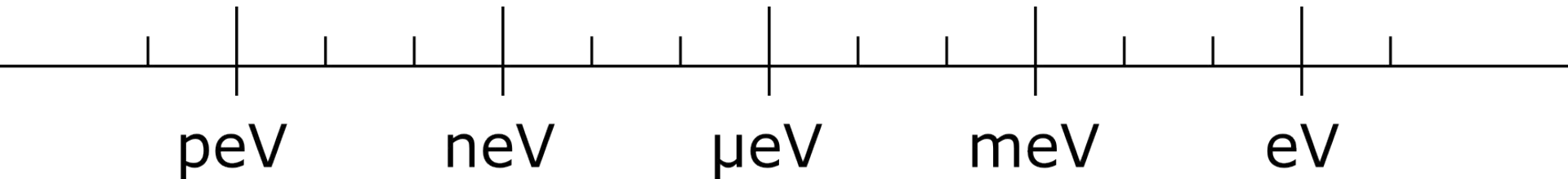
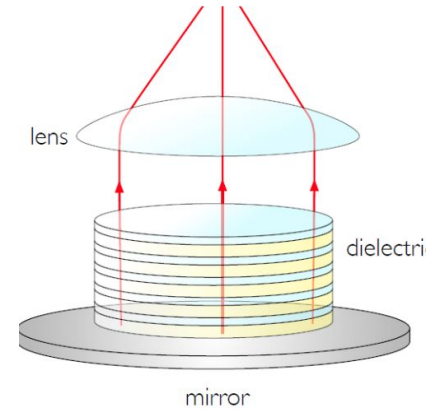
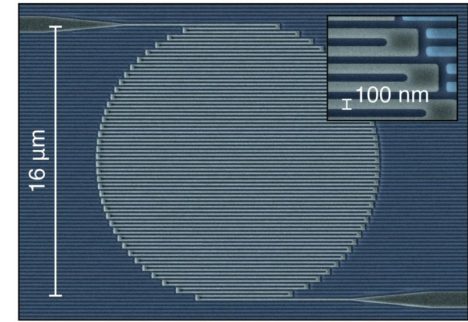
3 parallel sessions

- Dark matter and $0\nu\beta\beta$
- Cosmic Microwave Background (CMB)
- Readout technologies

Dark Matter

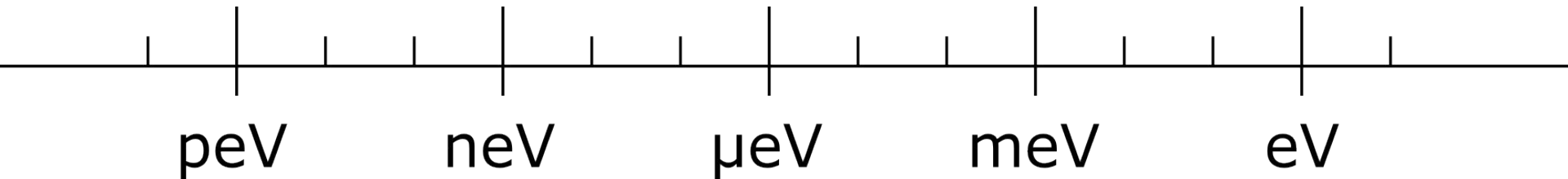
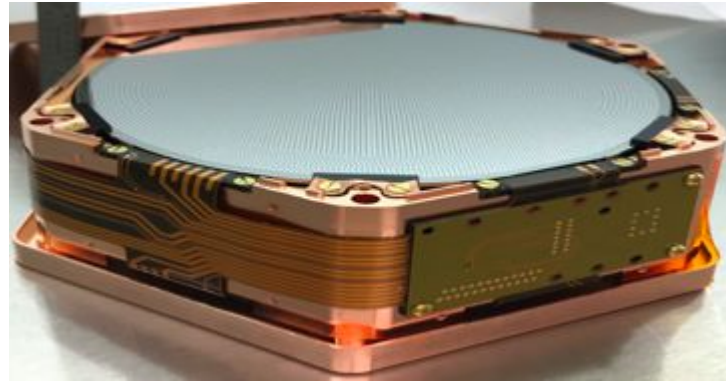
Superconducting nanowire
detector for optical
haloscope

- < 1 dark count per
second per sq. cm

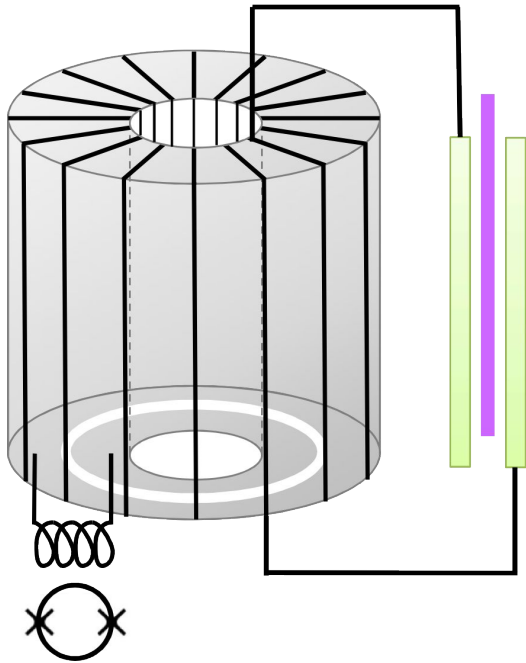


Dark Matter

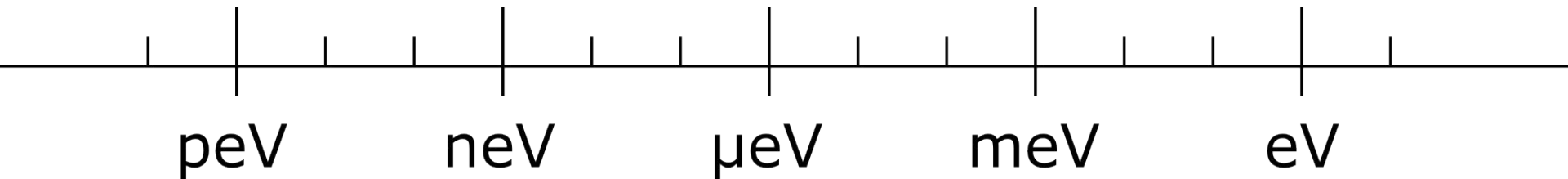
Transition-edge
sensors for detector of
optical phonons



Dark Matter

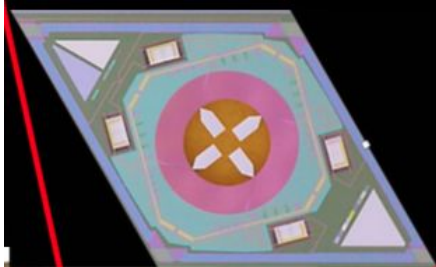
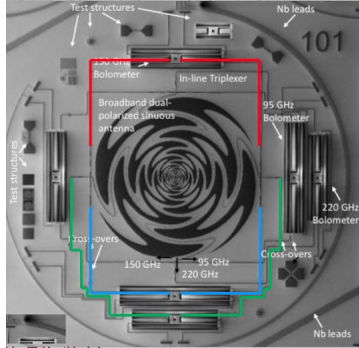
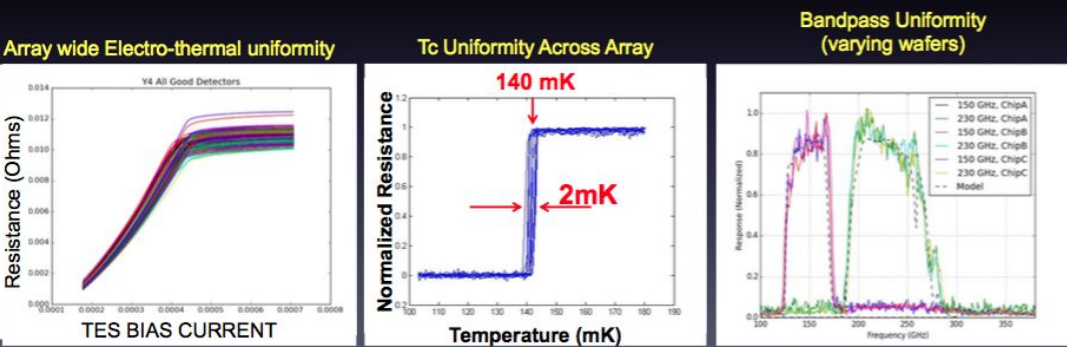
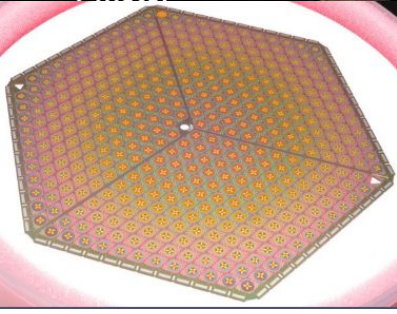
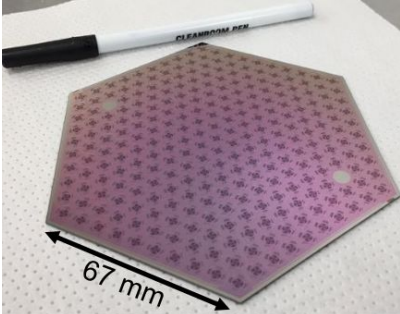
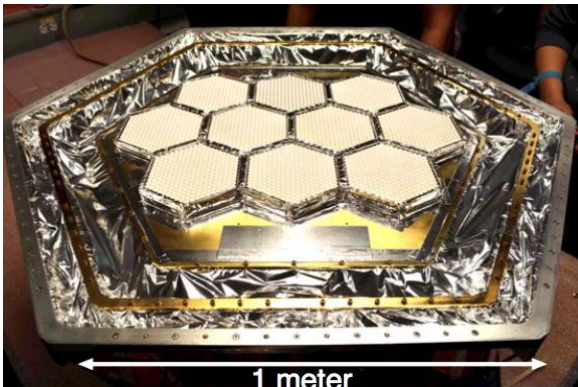


Superconducting
lumped-element
resonators for QCD
axions



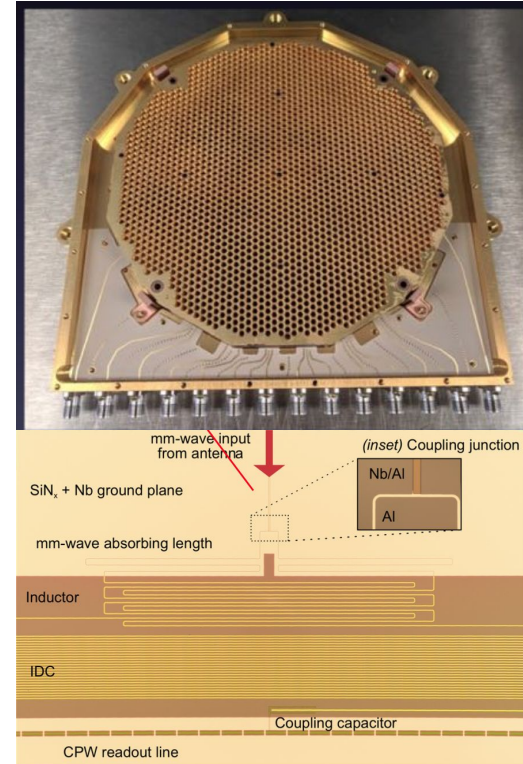
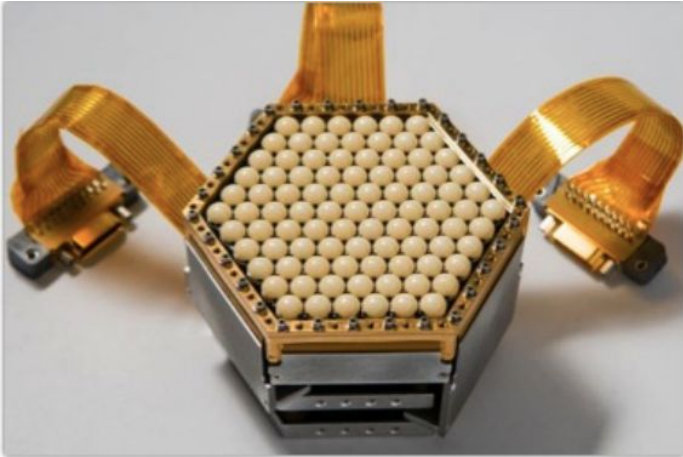
Cosmology (CMB)

- Manufacture of TES detectors has matured over last 12 months → preparation for CMB-S4
 - Required sensitivity/detector routinely achieved
 - Uniformity across 6 inch wafer is sufficient for CMB-S4
 - Improvements in yield have been a major achievement
- Quality control and assembly are the next challenges to solve for large scale arrays

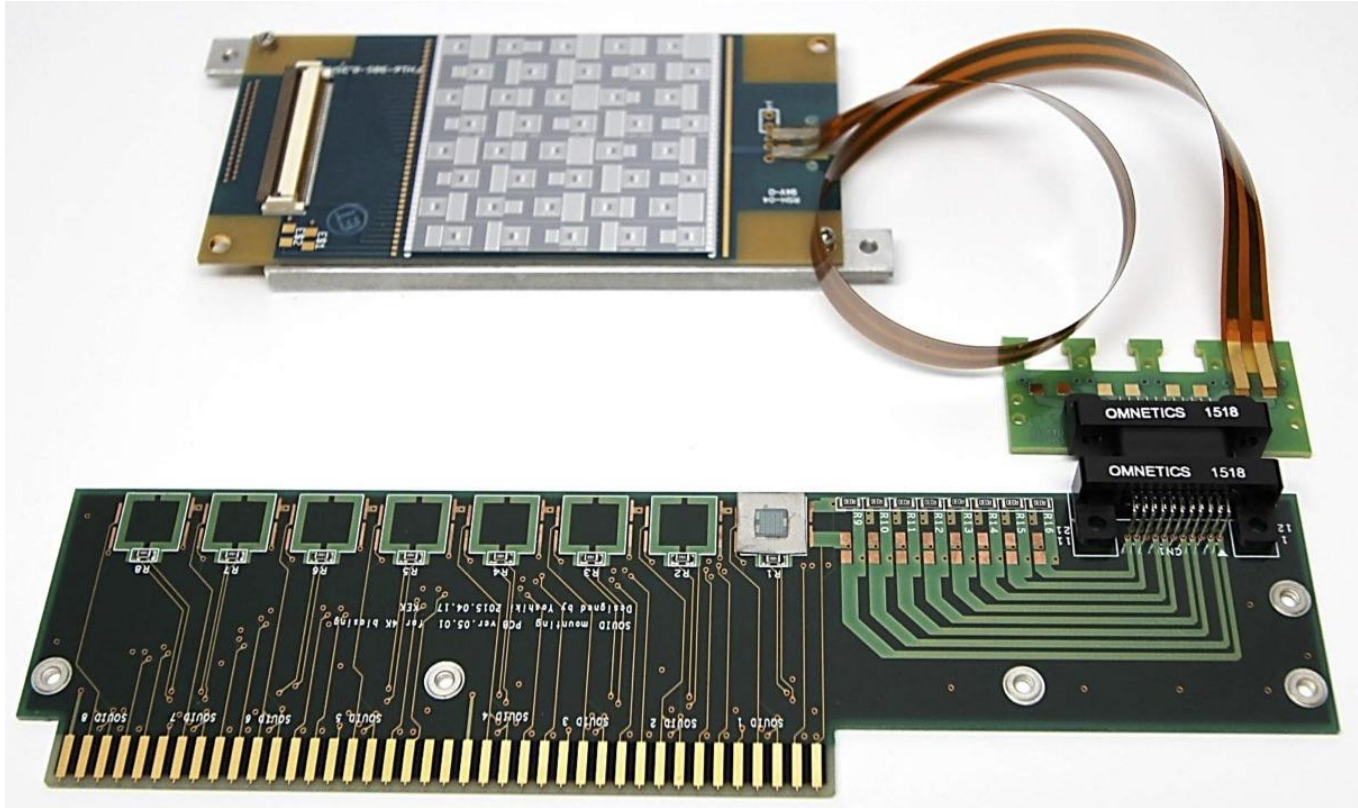


Cosmology (CMB + beyond)

- What comes next? CMB-S4 (~50k/telescope ~ 500k detectors) → ???
- Extrapolating from trend over previous 15 years → even more detectors → need to push toward ~MPixel arrays
- MKIDs
 - Built-in multiplexing offer elegant solution to massively multiplexed arrays
- Frequency domain multiplexing of TESs

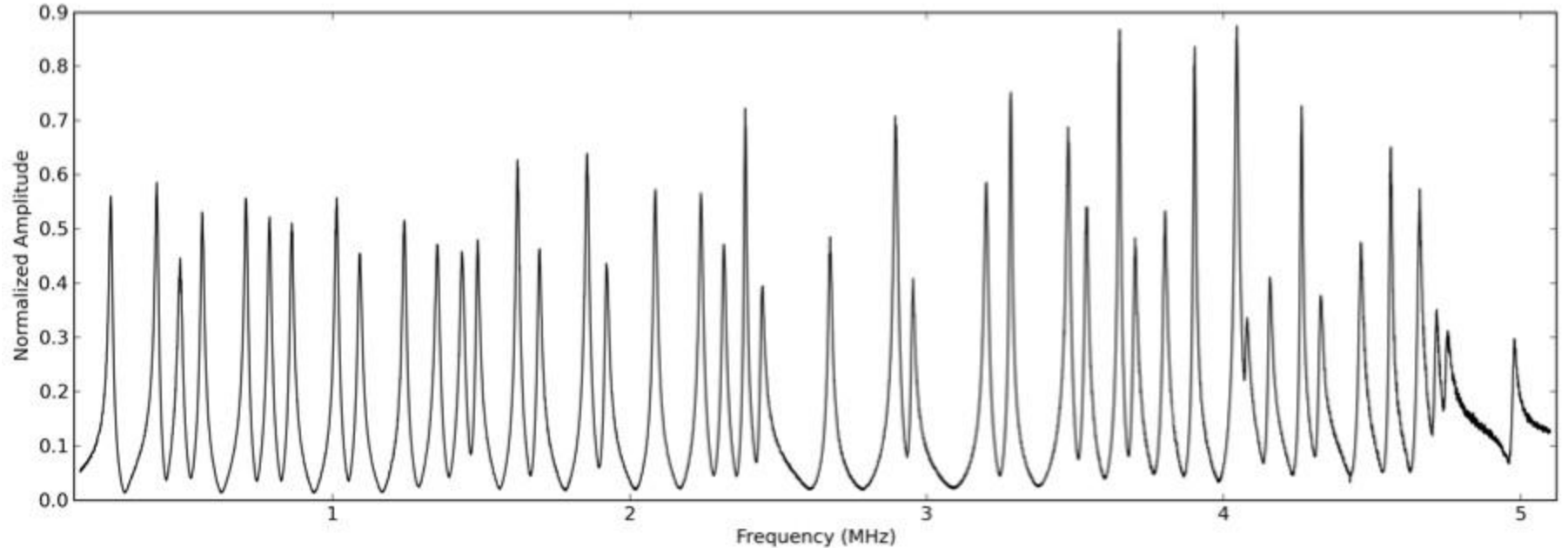


Readout: MHz Frequency Multiplexing



Each detector modulates a distinct MHz carrier

Readout: MHz Frequency Multiplexing

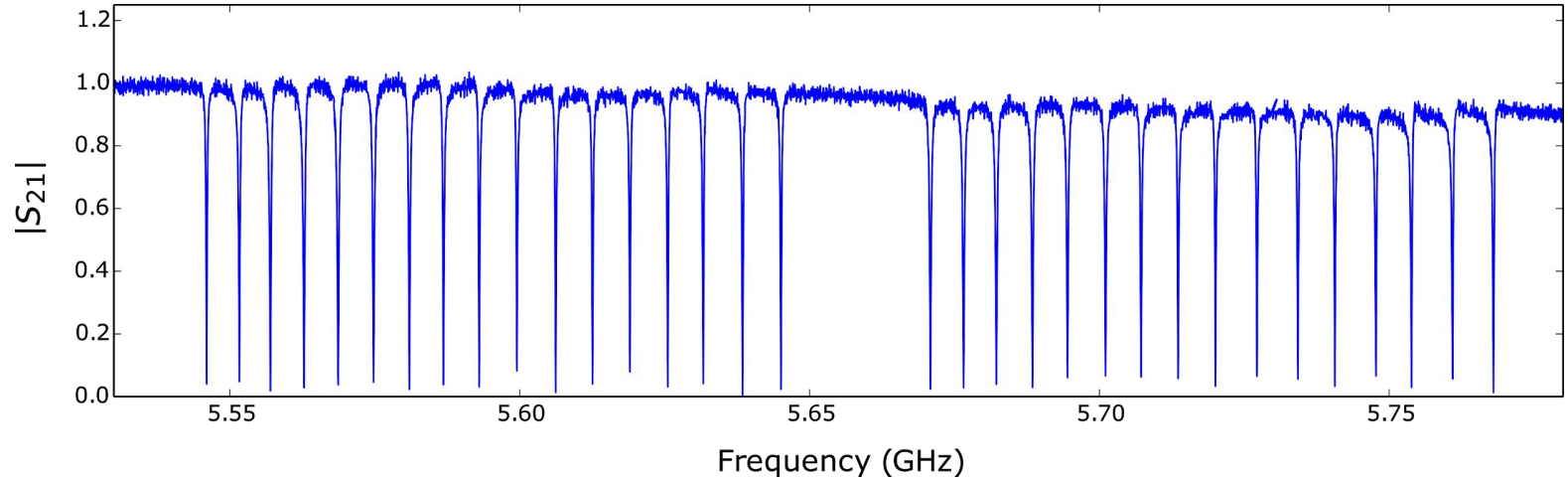
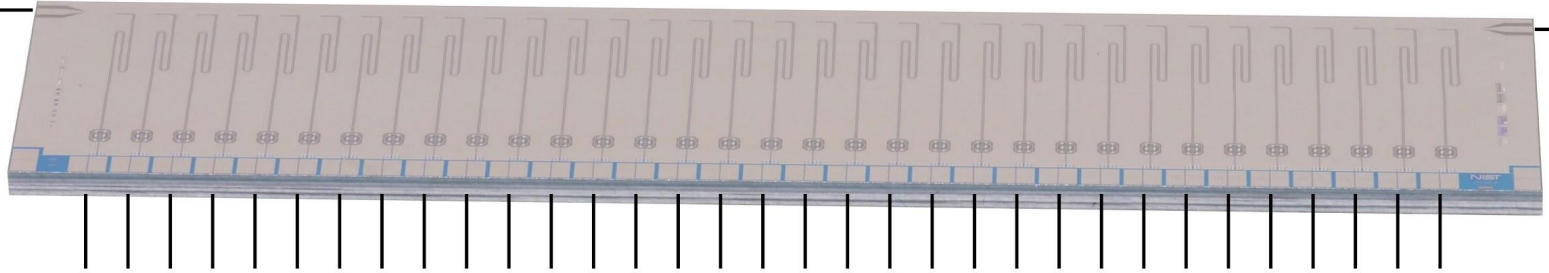


68x multiplexing factor demonstrated on fielded instrument

Readout: GHz Frequency Multiplexing

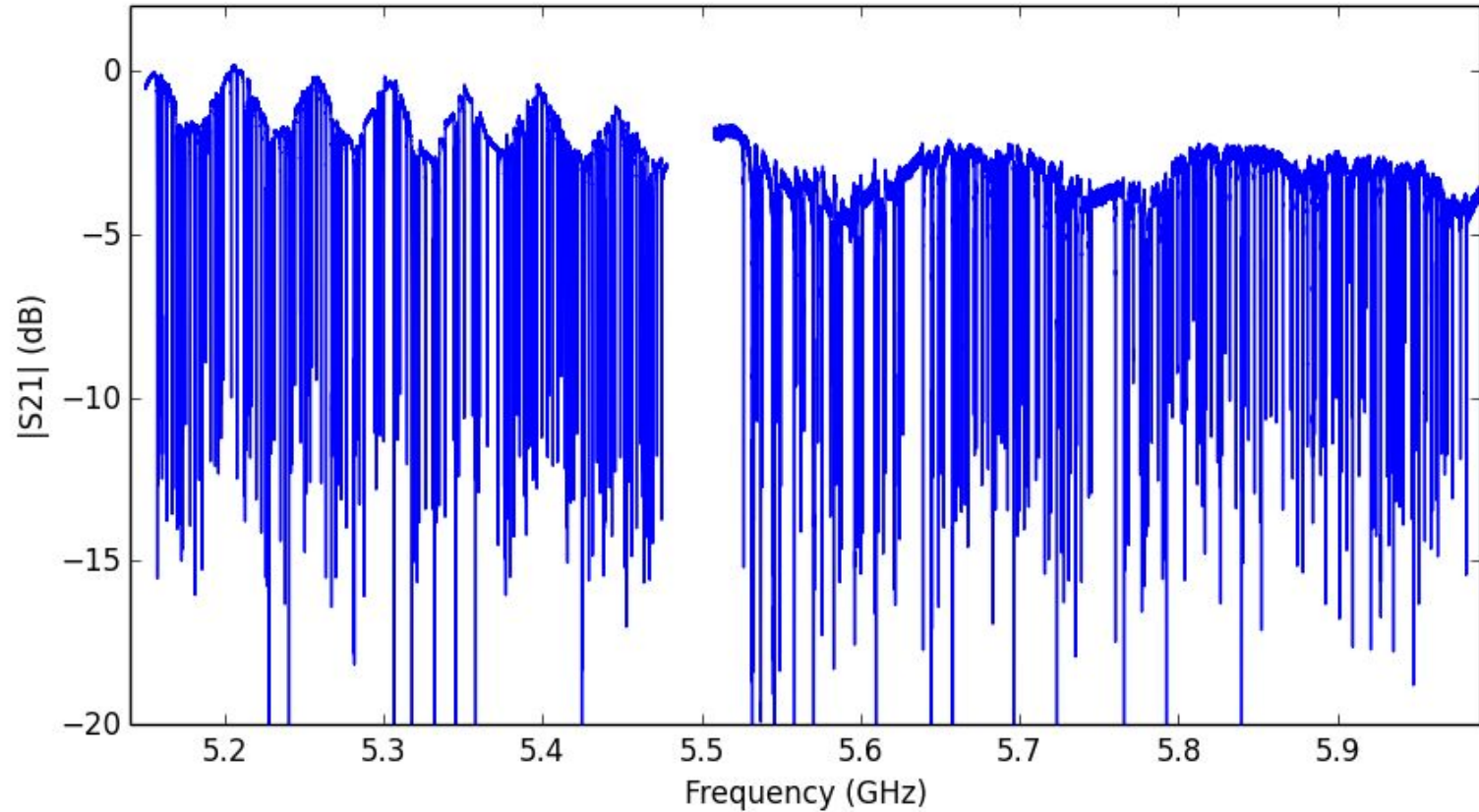
Port 1

Port 2



Each detector modulates distinct GHz resonance

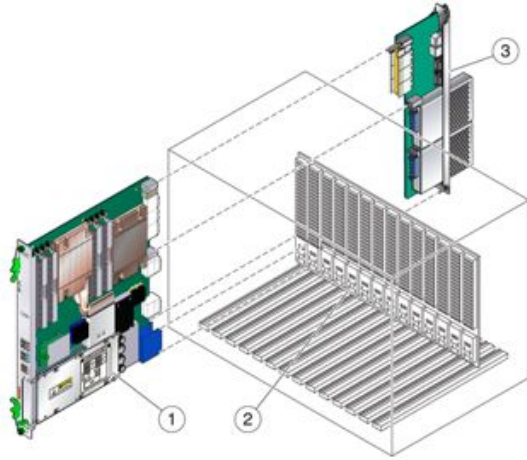
Readout: GHz Frequency Multiplexing



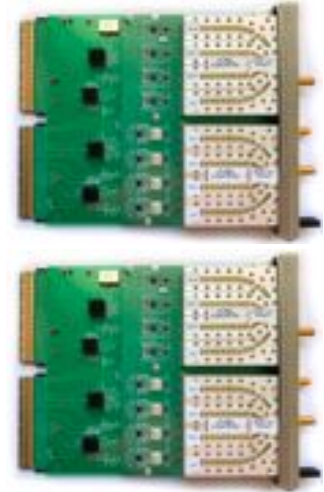
Targeting ~2000 channels in 4 GHz for CMB

Readout: Software-defined Radio

Room-temperature digital electronics critical for practical readout



SMuRF readout, built on
SLAC common platform



Readout electronics generate and demodulate GHz carriers (e.g. SMuRF)

Readout: System-on-a-chip

RFSoc = FPGA+CPU+DAC+ADC

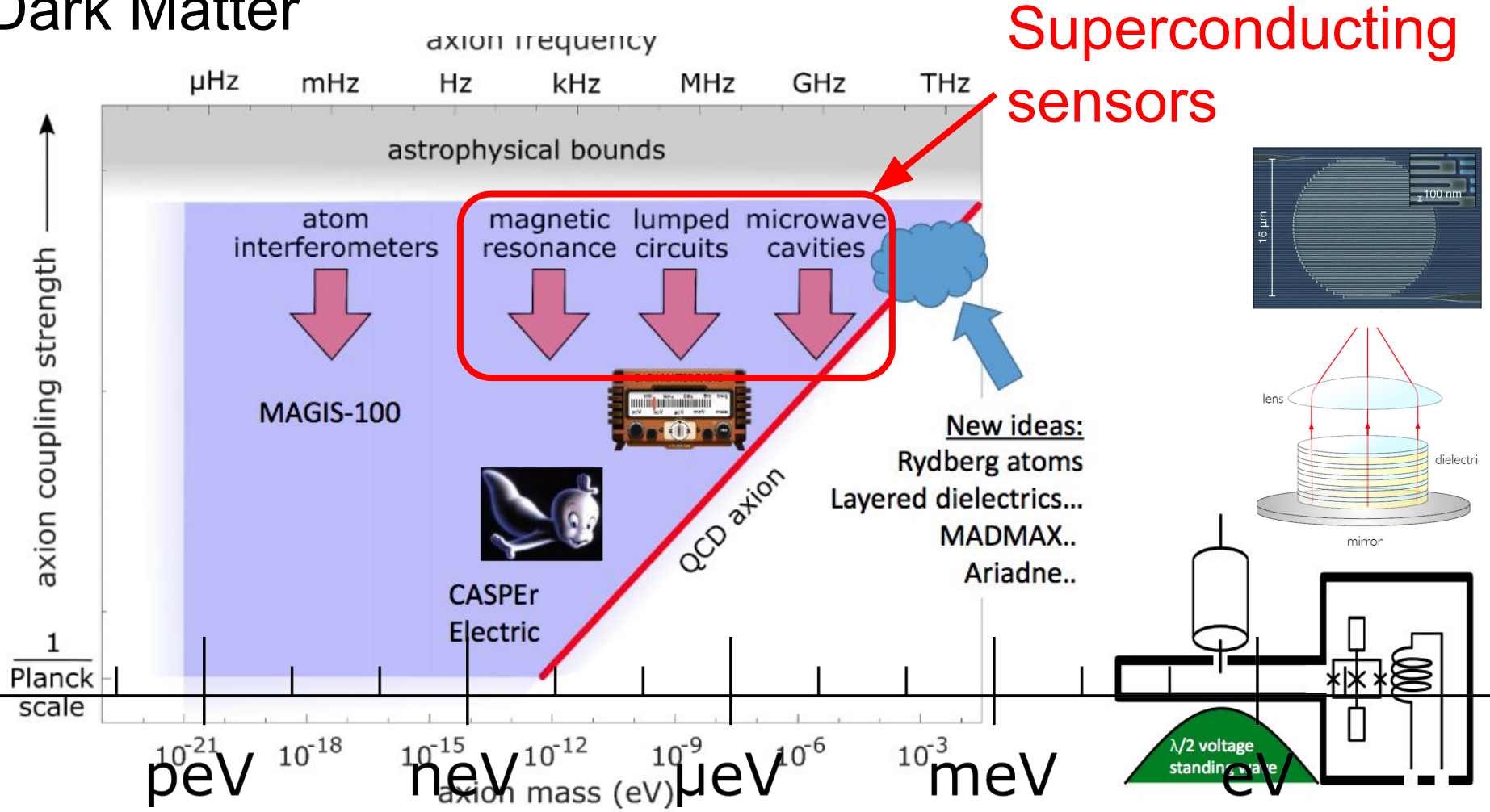
- 8x 4 GS/s 12-bit ADCs
- 8x 6.4 GS/s 14-bit DACs

Simplify and reduce cost



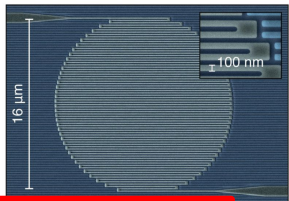
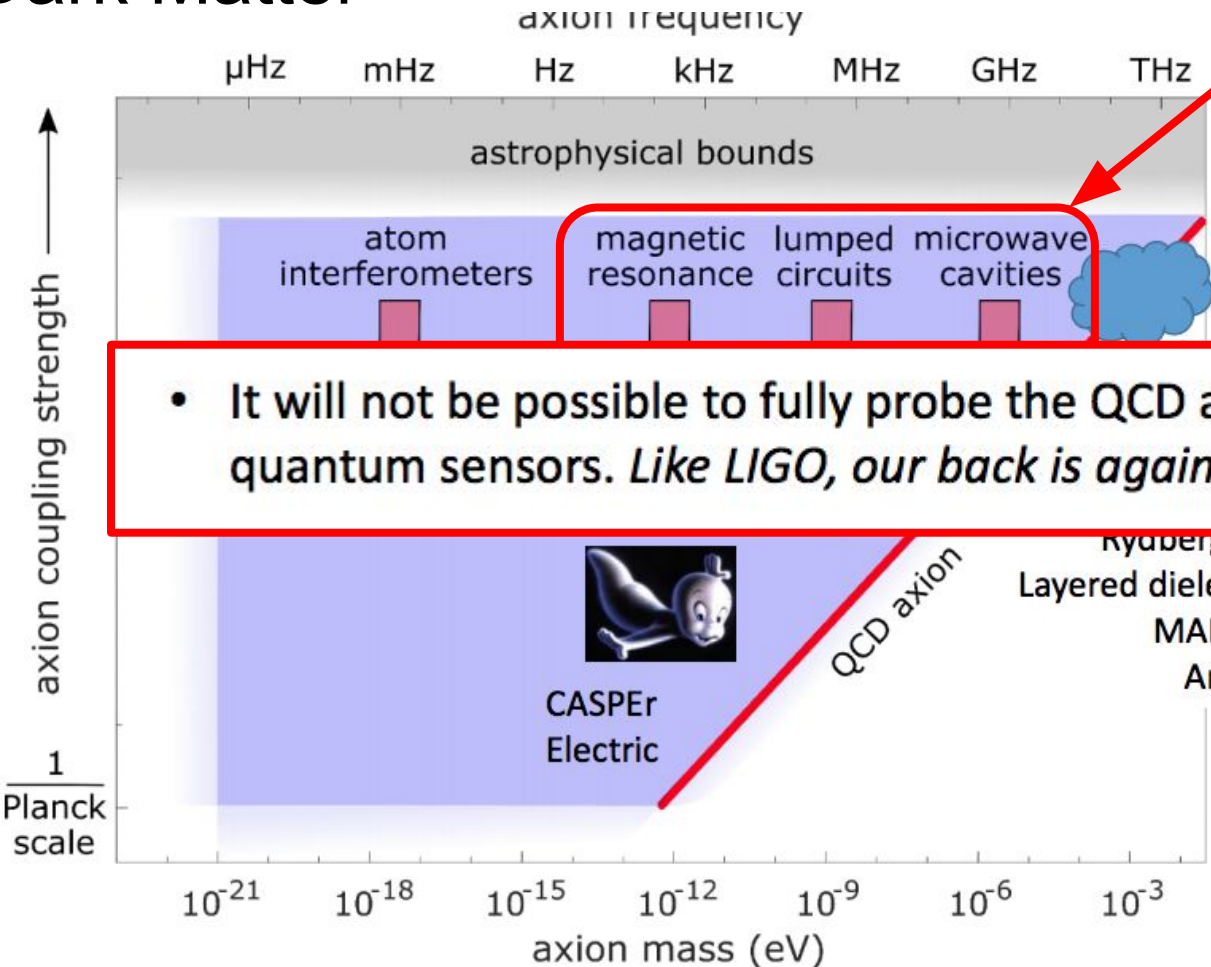
Future: readout of complete GHz multiplexer on a single chip

Dark Matter



Dark Matter

Superconducting sensors



It will not be possible to fully probe the QCD axion band without quantum sensors. *Like LIGO, our back is against the wall.*



CASPER Electric

Rydberg atoms
Layered dielectrics...
MADMAX..
Ariadne..

