Feedhorn-coupled MKIDs fabricated from TiN/Ti multilayer films

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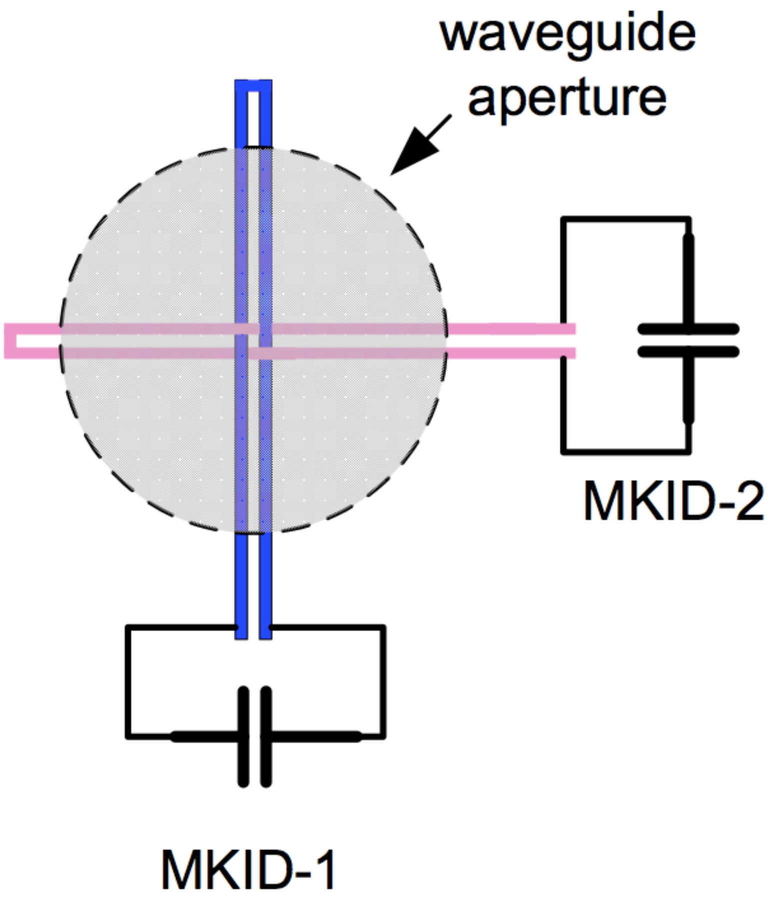
Project goals

- develop general purpose MKID technology that covers 0.075-1.4 THz
- technology includes
  - optical coupling
  - MKID detector arrays
  - wide-bandwidth amplifiers
  - warm readout electronics



Application: BLAST-TNG

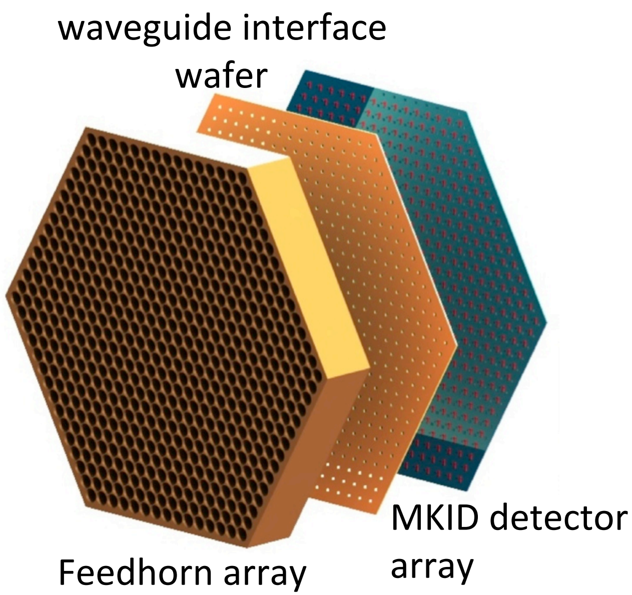
- **Motivation:** study role of magnetic fields in star formation

- **Experimental approach:** observations of polarized dust emission at sub-mm wavelengths from a balloon using arrays of polarization sensitive MKIDs at 250, 350 and 500 micron

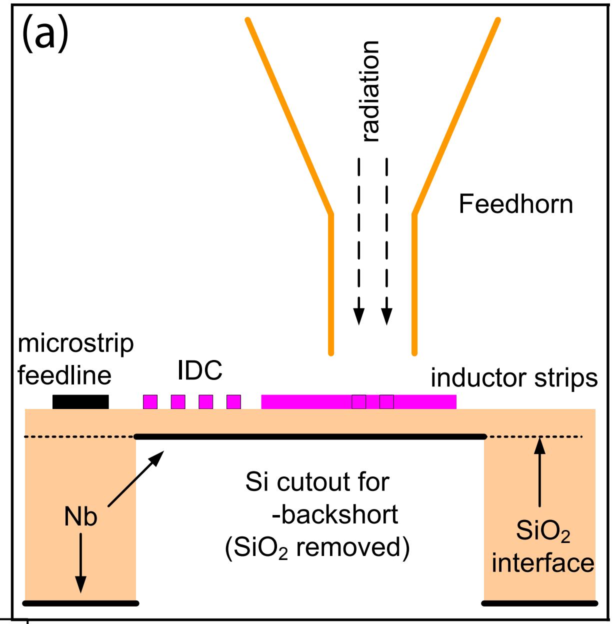
BLAST: Balloon-Borne Large Aperture Submillimeter Telescope

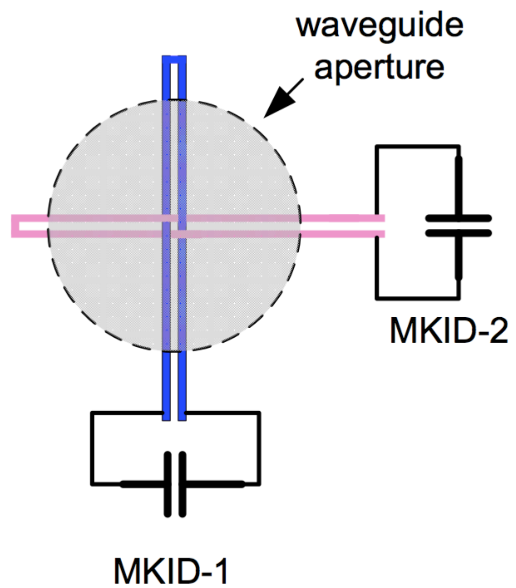
PI: Mark Devlin (UPENN)

Feedhorn-coupled, dual-polarization sensitive MKIDs



Hubmayr et al. *IEEE Trans Appl Sup* 2013

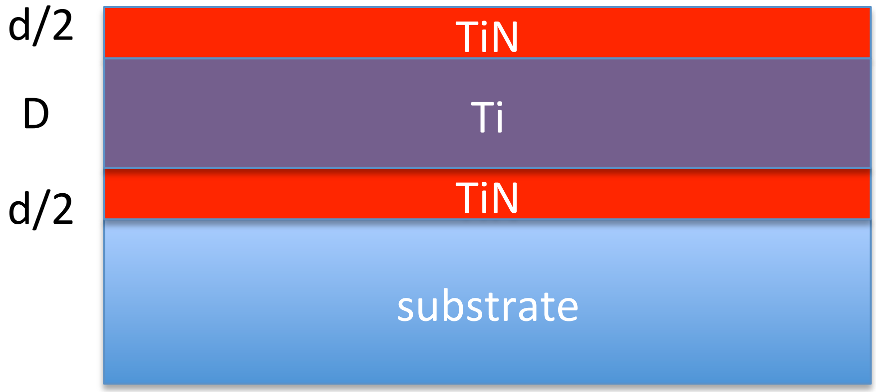




- feedhorn-coupled
- TiN/Ti multilayer superconducting material
- lumped element kinetic inductance detectors

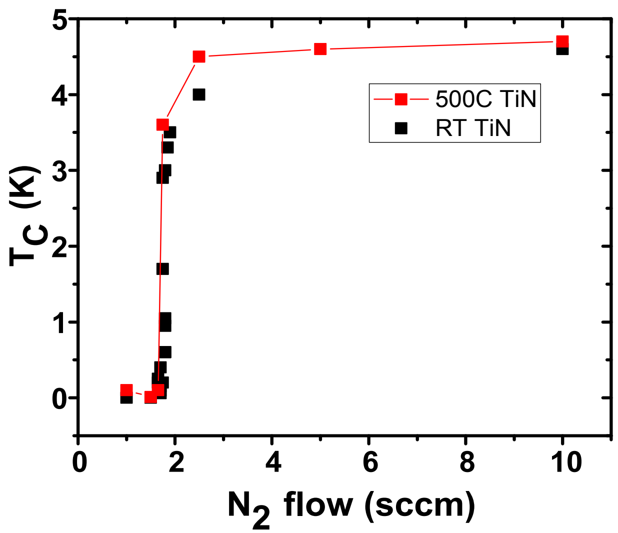
- scalable to large detector-count cameras
- dual-polarization sensitivity
- beam properties defined by feedhorns
- once designed, fast to produce
- low number of focal plane interconnects

TiN multilayers



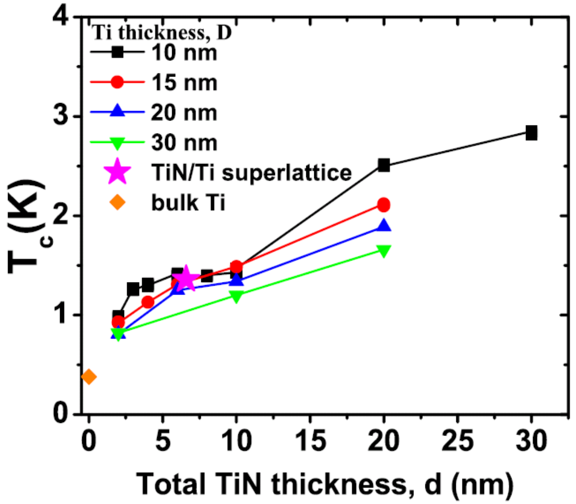
- based on TiN work from Caltech/JPL
- high spatial Tc uniformity increases array yield
- adjustable Tc and ρ enable optimization for detection over broad wavelength range and loading conditions

TiN tunability



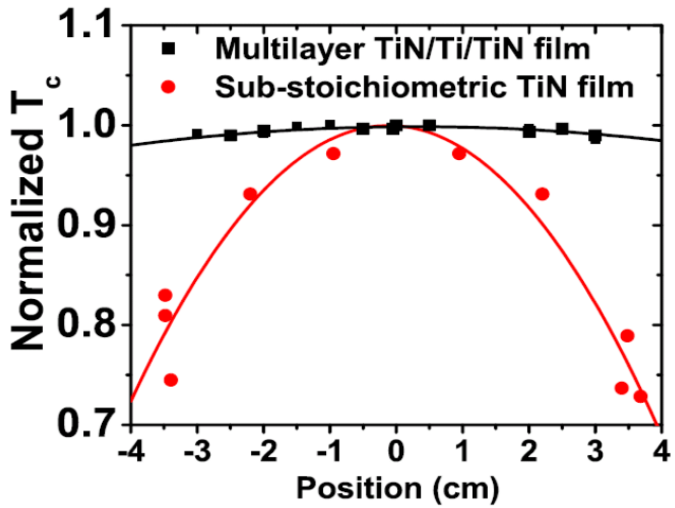
(a)

TiN multilayer tunability



(b)

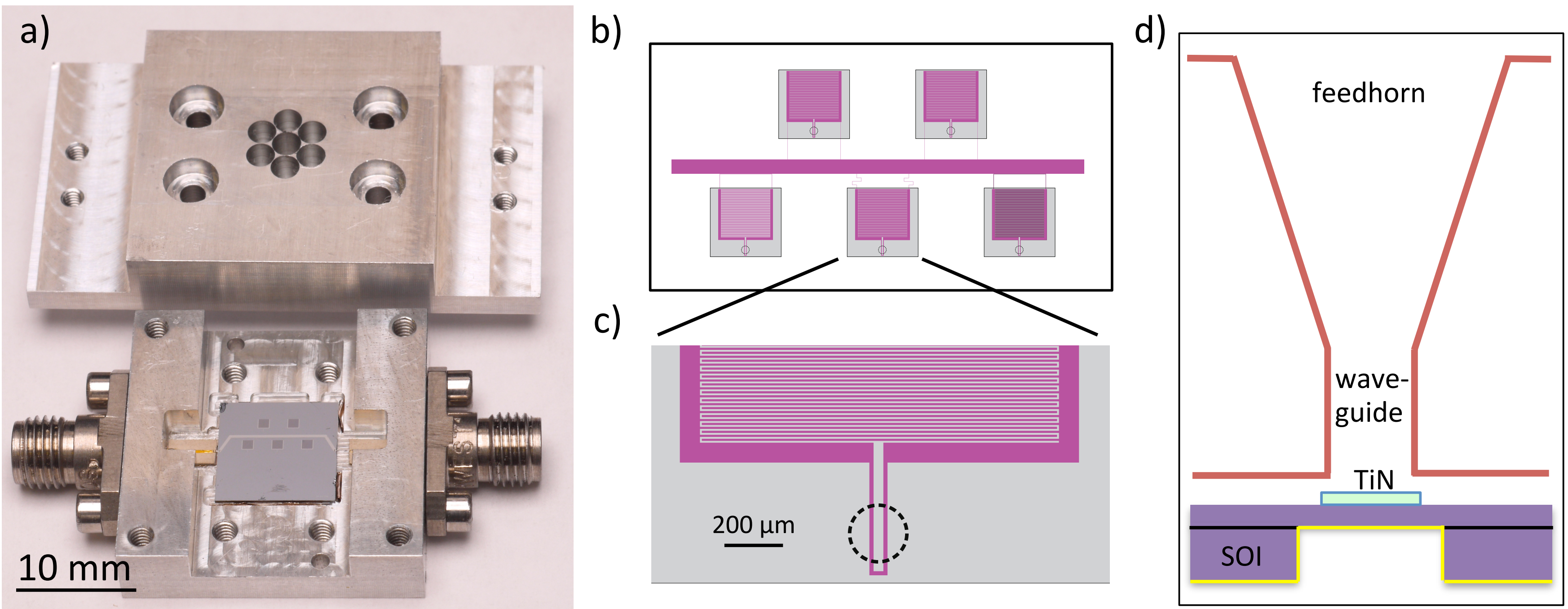
uniformity comparison



(c)

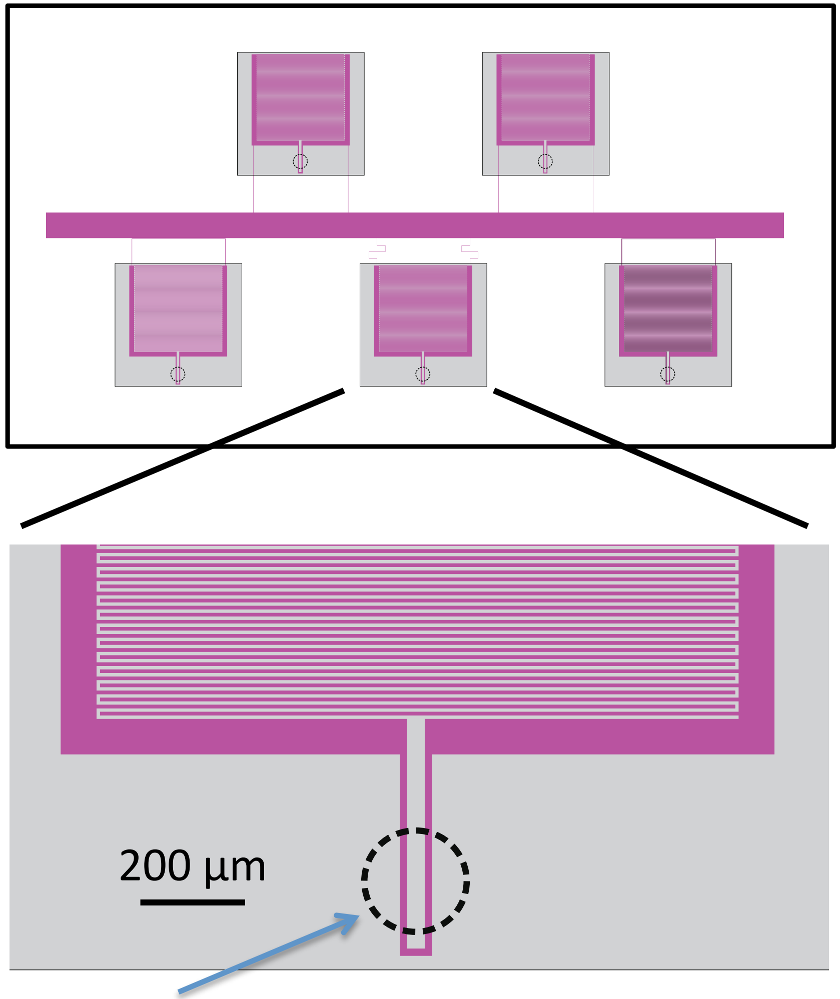
Vissers et al APL 2013

lab-based sensitivity experiment



device design

microstrip feedline coupled



shaded region is backside etched to create 18um thick Si backshort

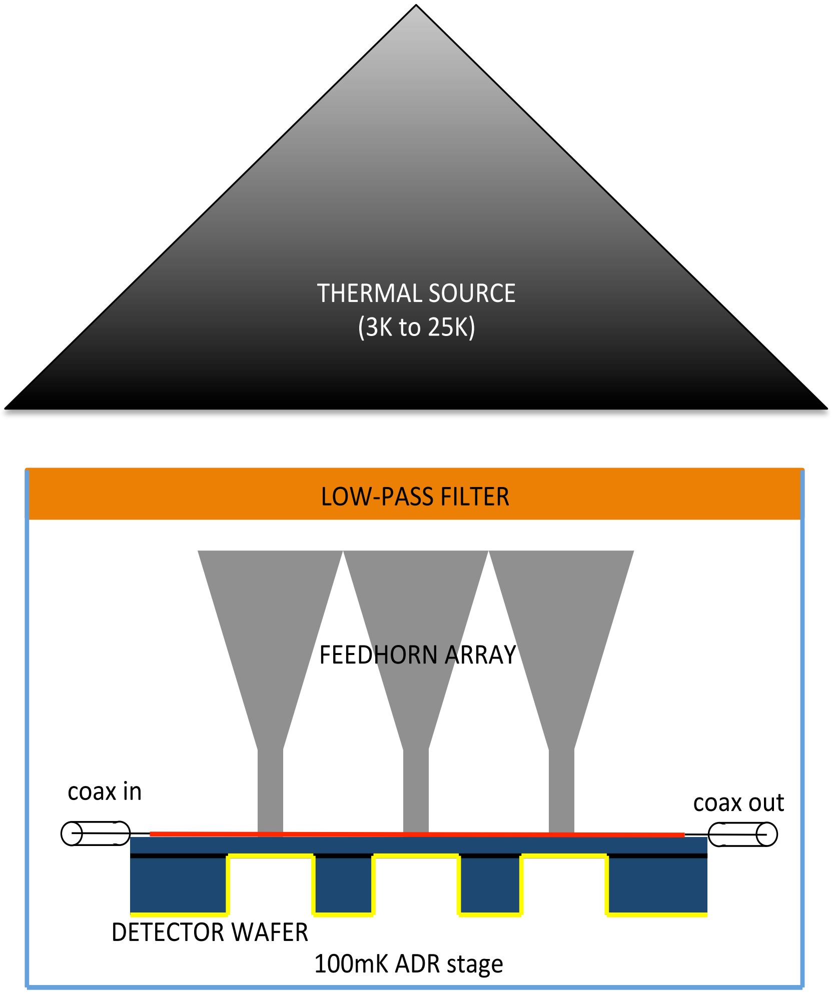
f ~ 1 GHz

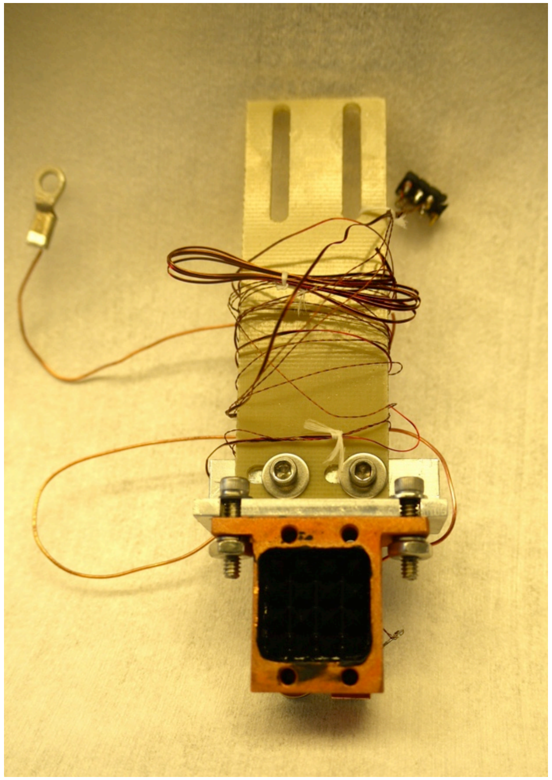
IDC capacitor:
5um finger/gap

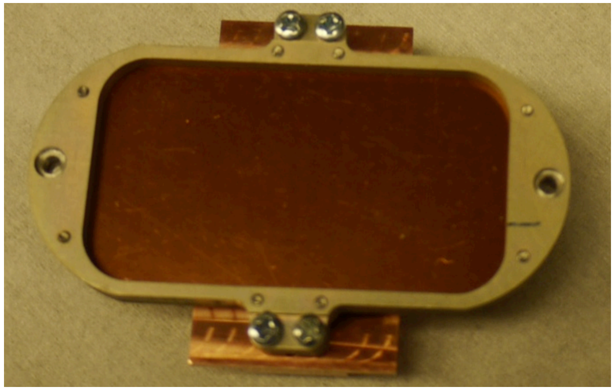
1-turn inductor:
10um wide
Absorber volume = 85 um^3

waveguide diameter

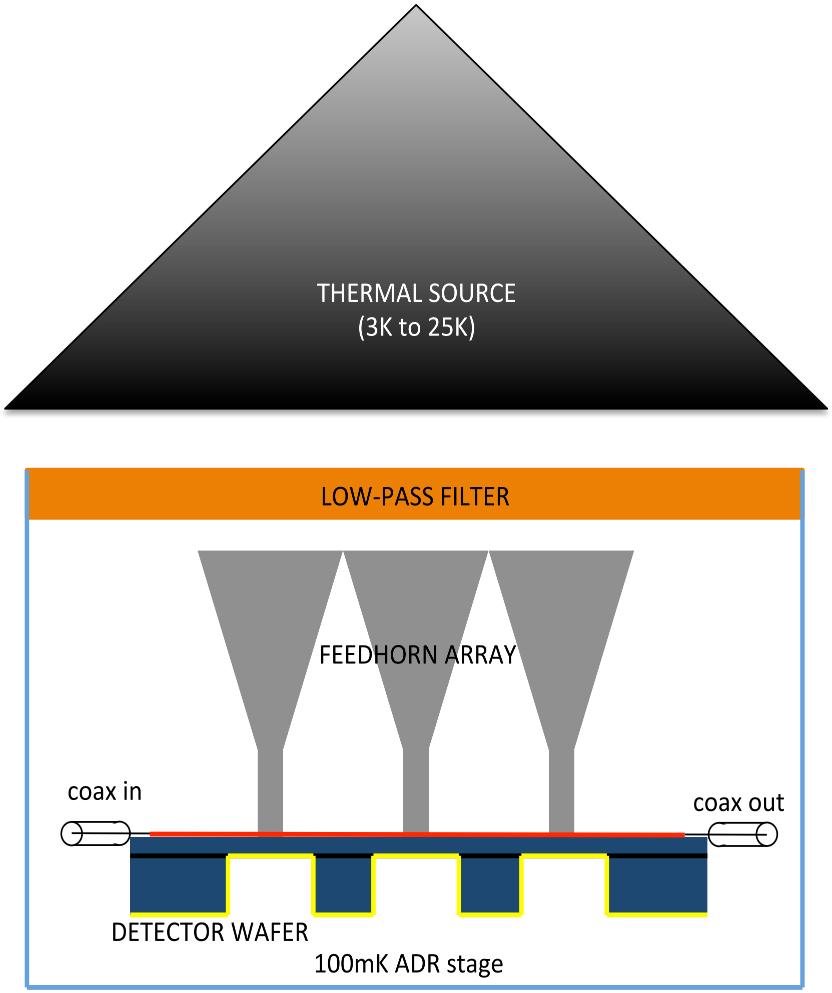
thermal load experimental setup

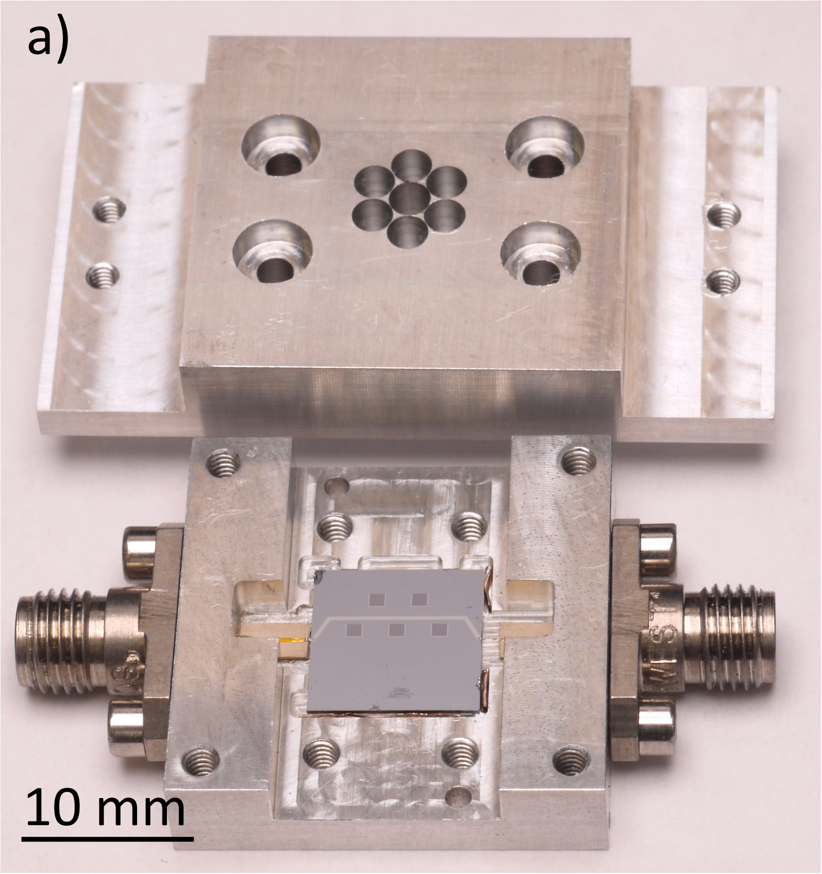




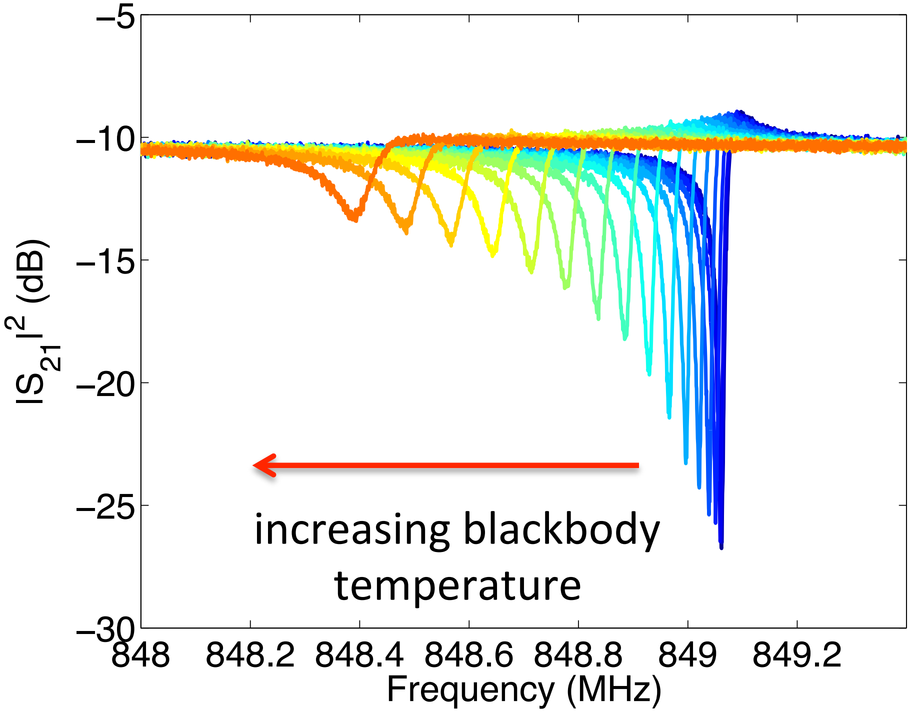


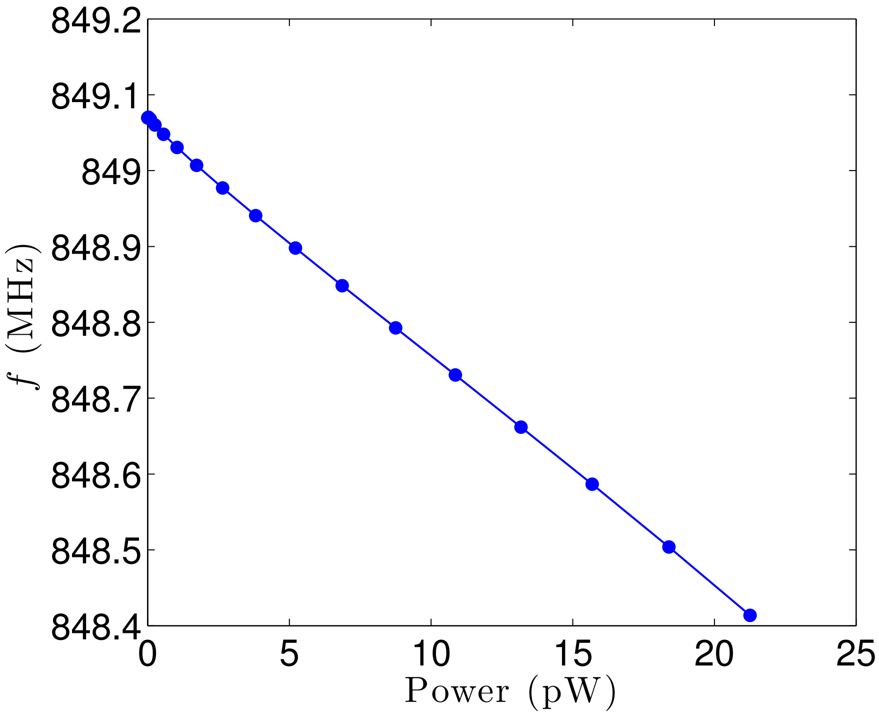
thermal load experimental setup



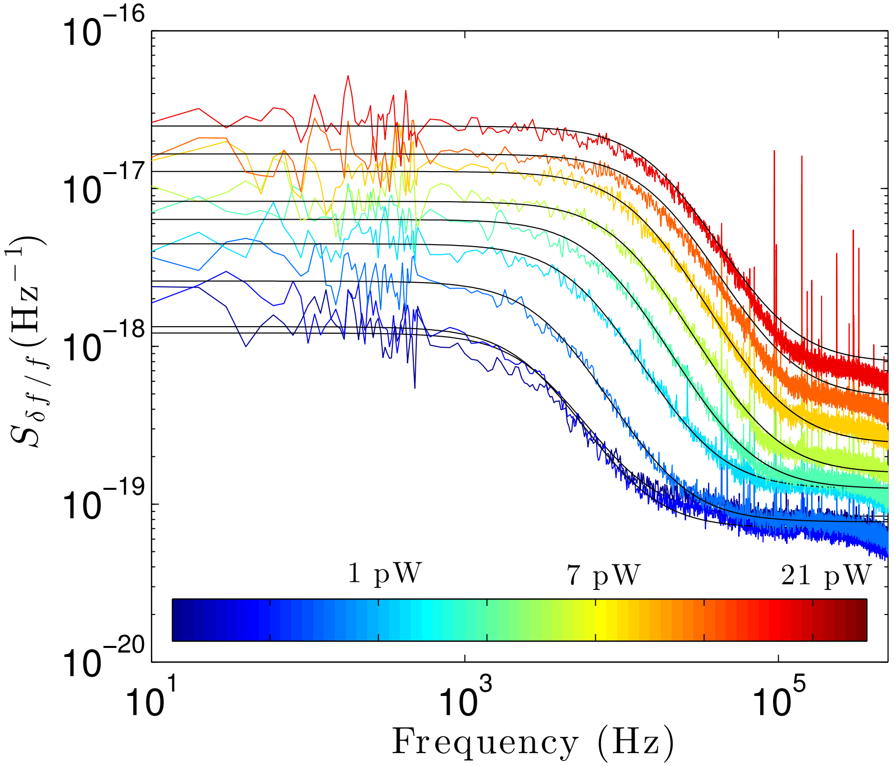


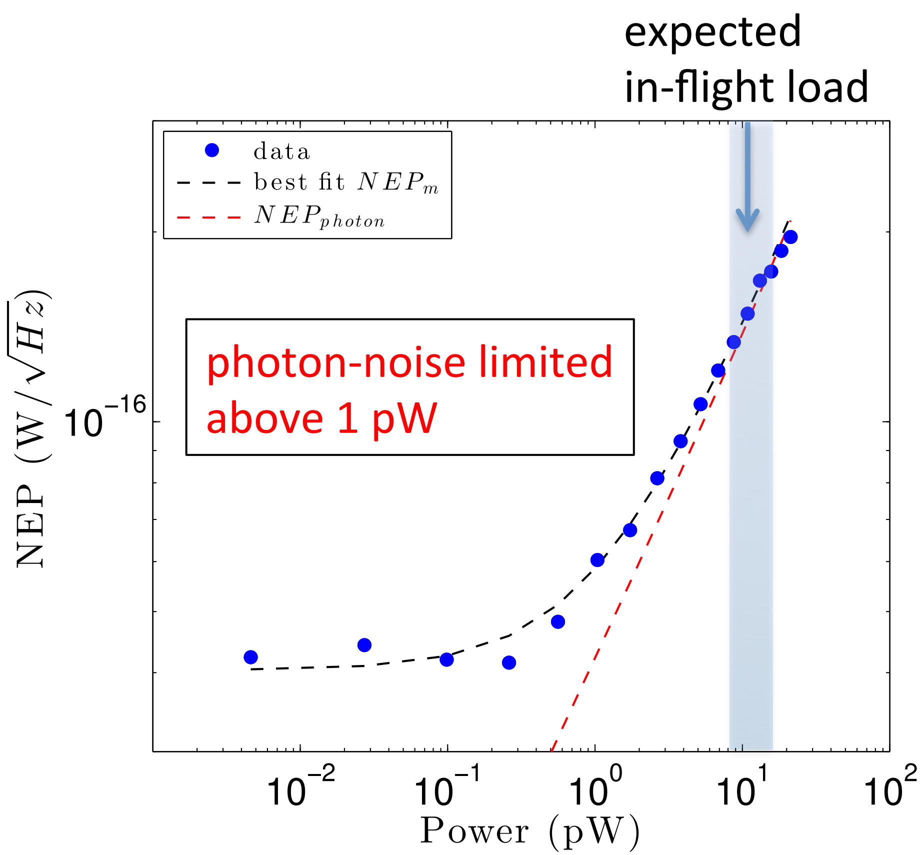
device response





photon-noise limited





Hubmayr et al. APL **106**, 7 (2015)

Dual-polarization sensitive MKID demonstration

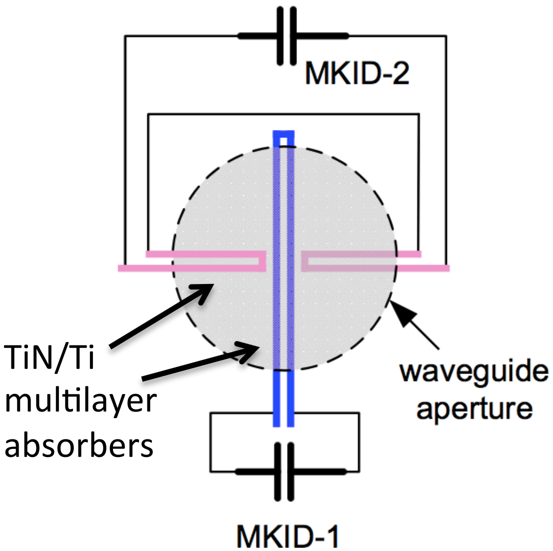
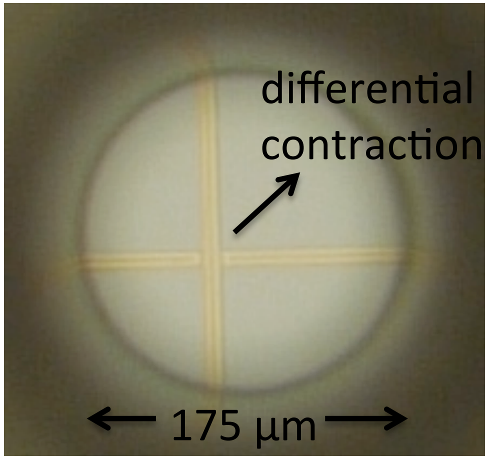
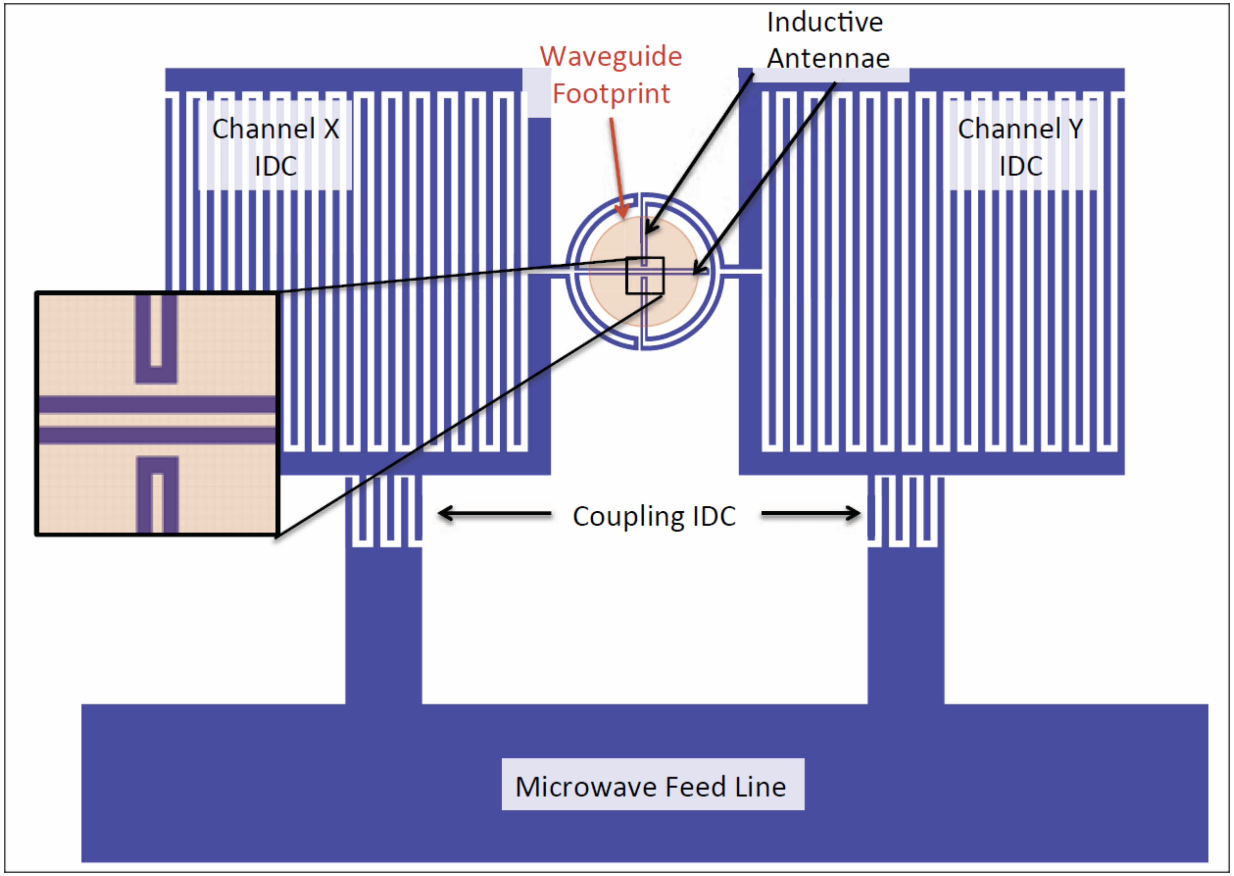


Photo down waveguide



pixel design
single metal layer with no cross-overs



Dober et al. submitted to *JLTP*

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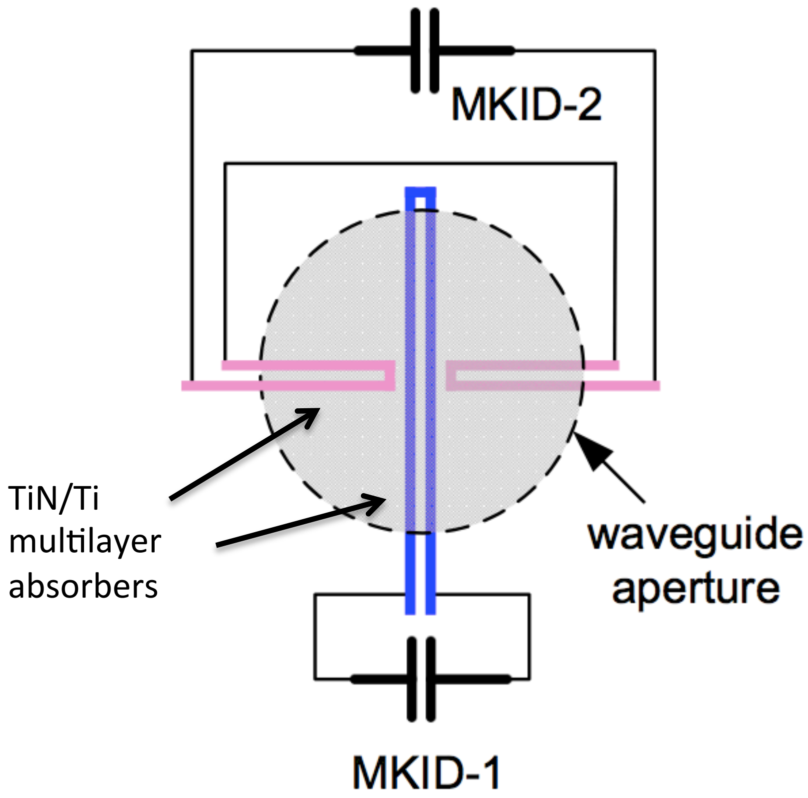

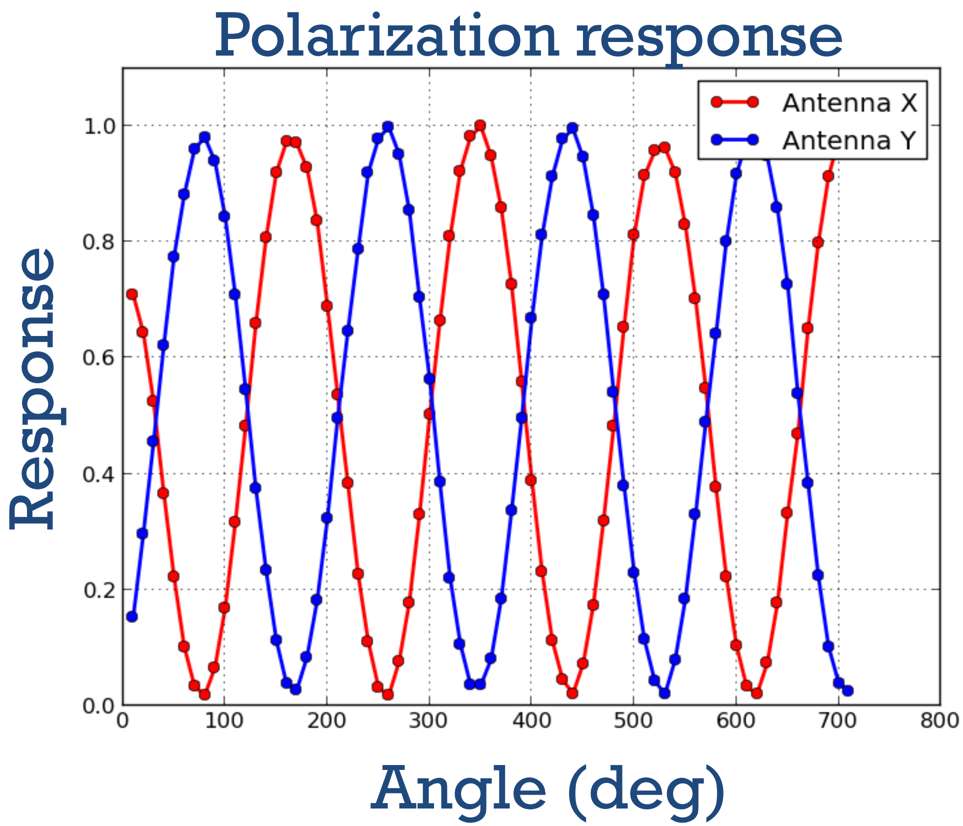

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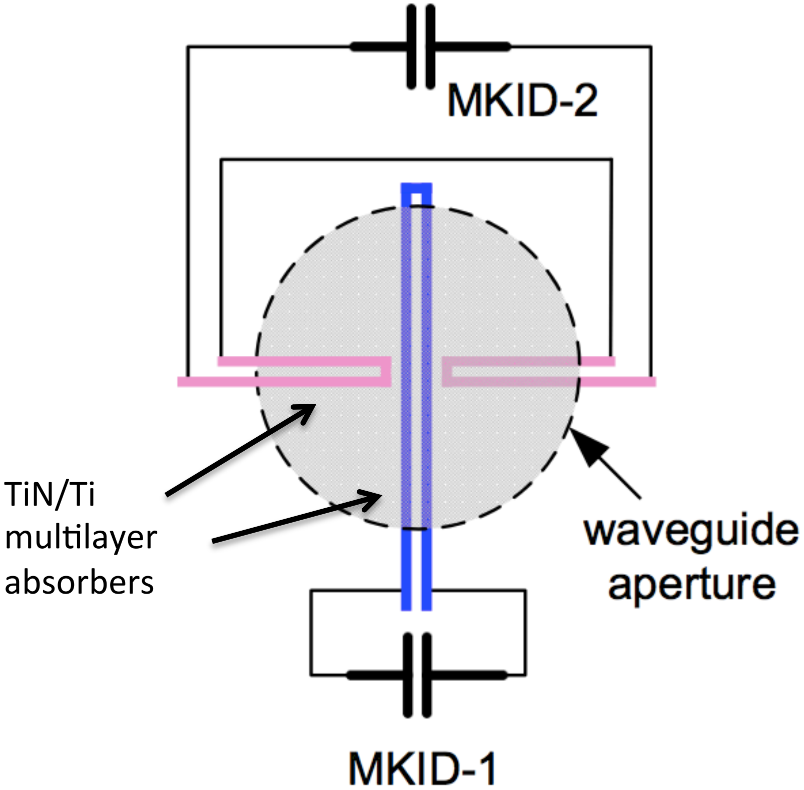
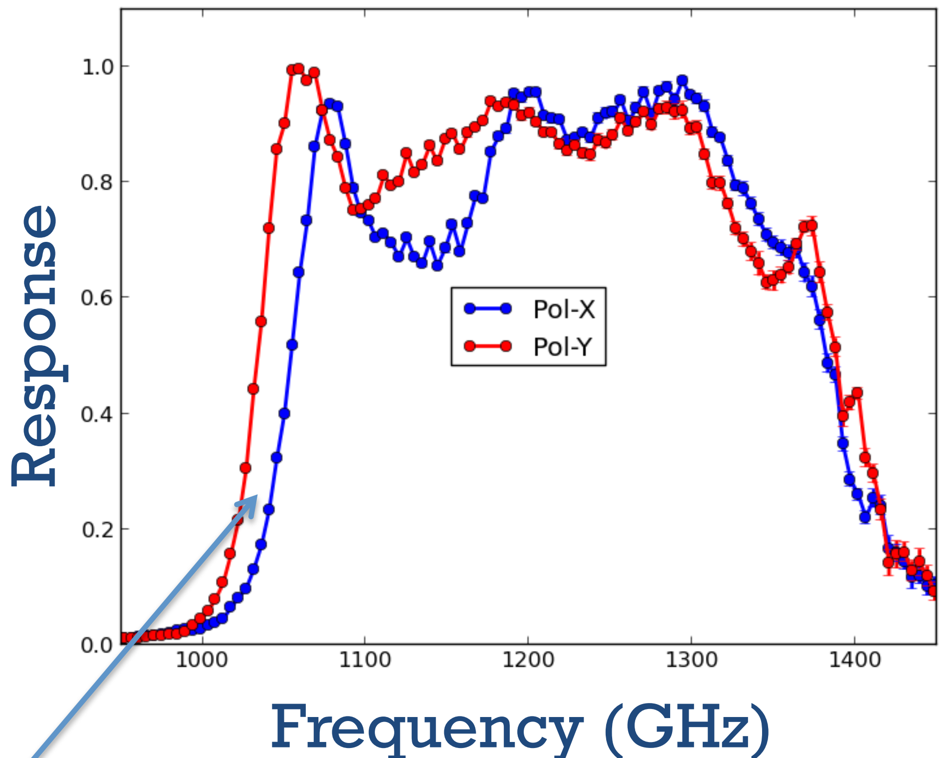


Passbands



likely due to oval-shape
waveguide from direct machining

Dual-polarization sensitive MKID demonstration

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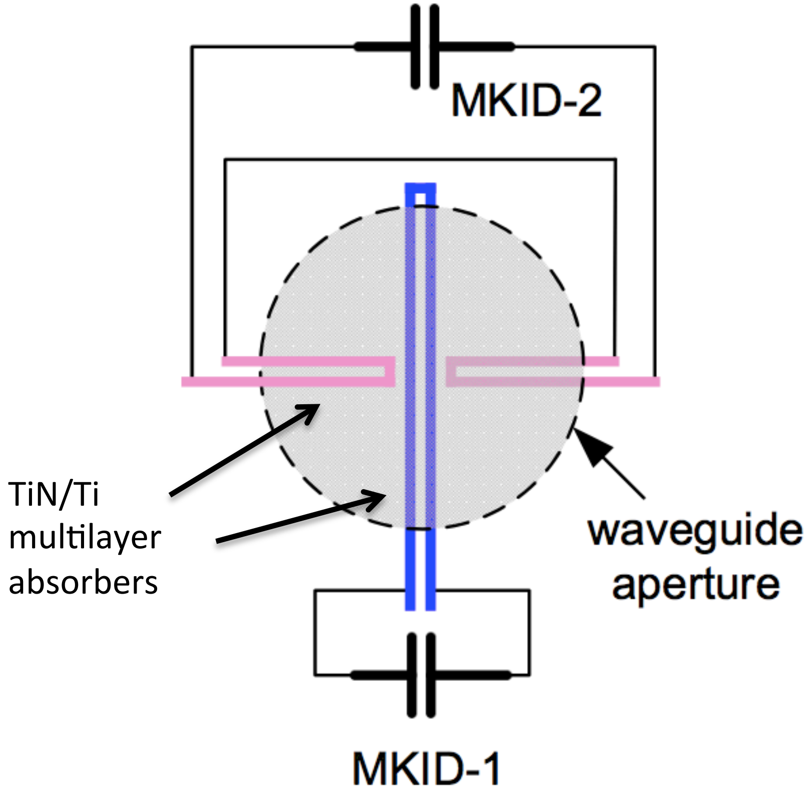
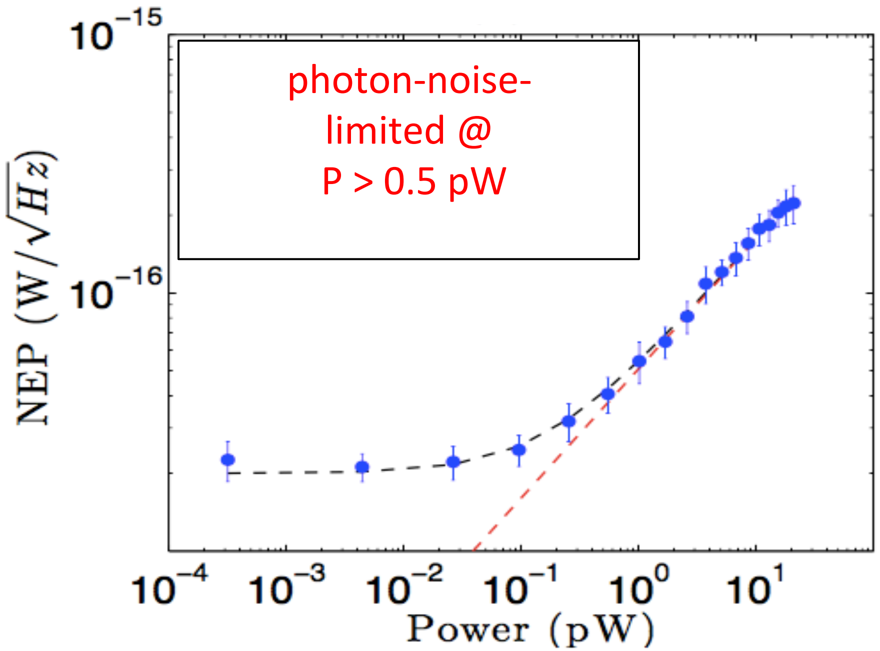
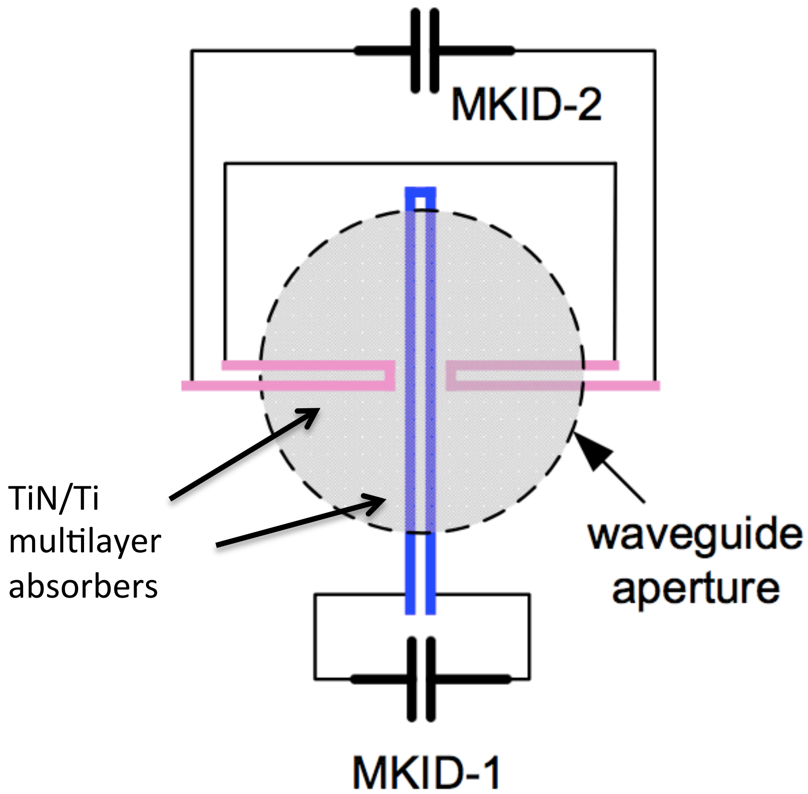
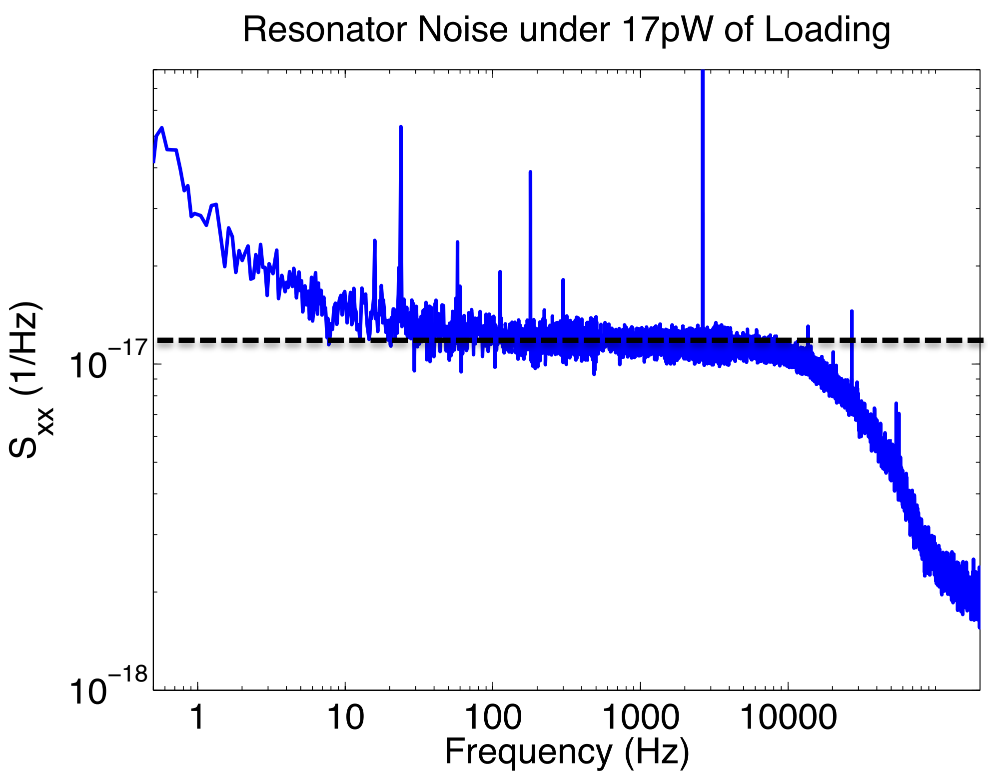




η_{opt} = 75% relative to 1-1.4THz top hat band
This matches HFSS coupling simulations

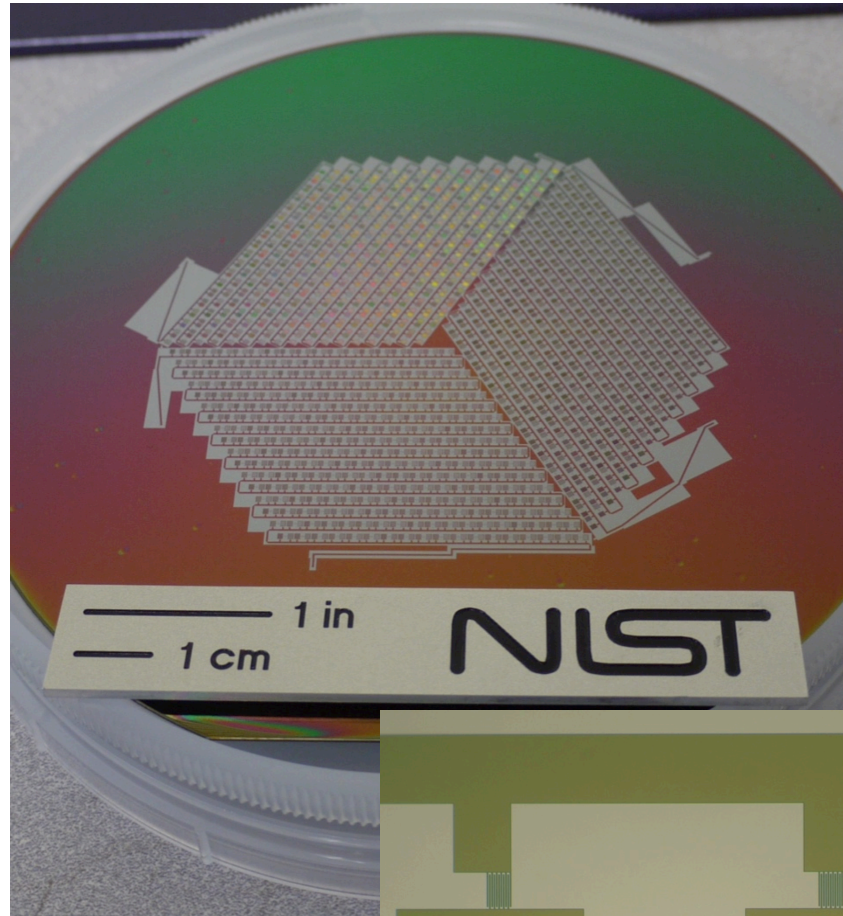
Low Frequency Noise

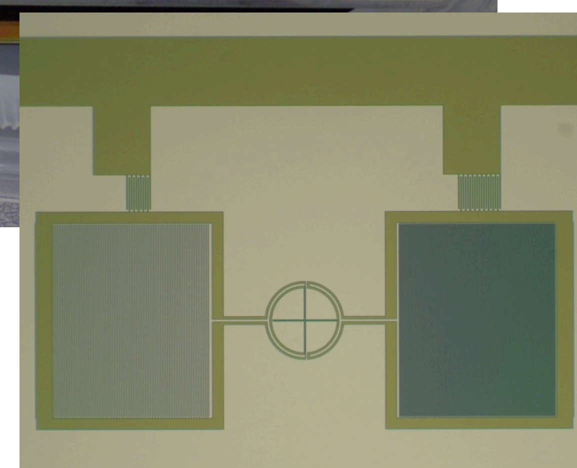




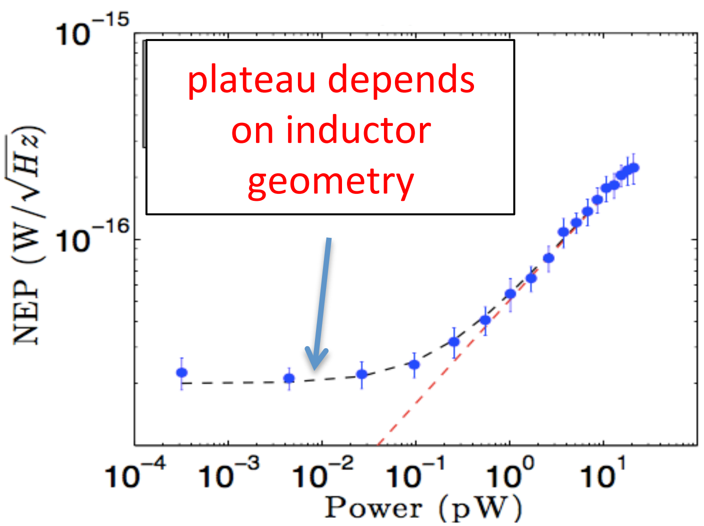
Array fabrication

- BLAST-TNG 250um array
- 918 dual-polarization pixels
- 1836 MKIDs
- three microwave feedlines
- ~600 channels per feedline driven by total ADC bandwidth of readout
- all stepper-defined lithography

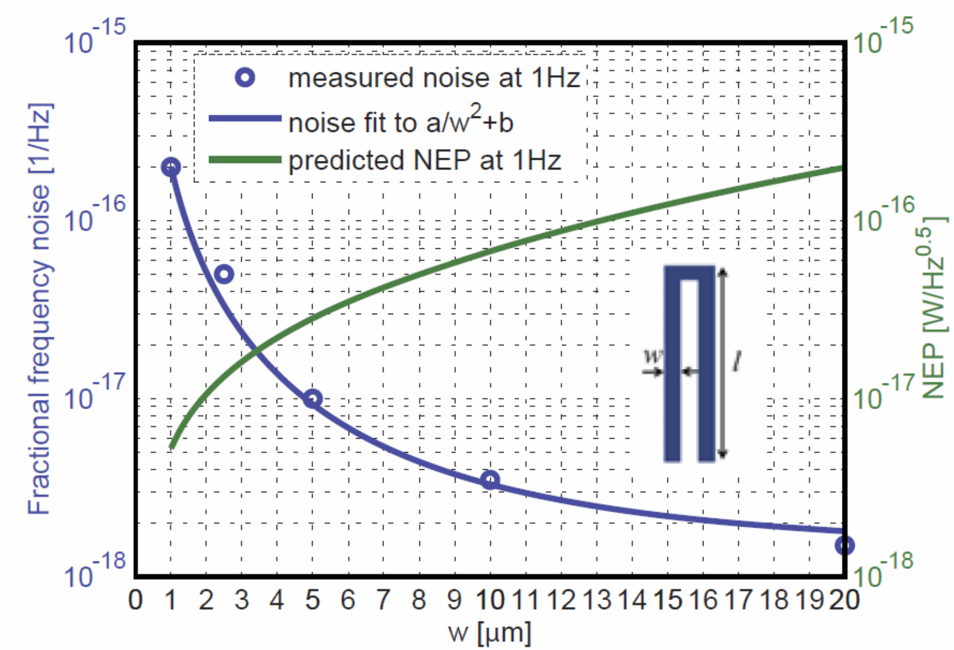




Detector noise scaling



- NEP proportional to inductor width
- consequence of observed inductor noise + linear responsivity



to make a more sensitive detector, shrink the inductor width

summary

achievements

- BLIP sensitivity at 250um
- dual-pol demo at 250um
- empirical noise model developed
- array fabrication process

next steps

- Balloon-borne implementation at 250, 350 and 500 micron on BLAST-TNG
- demonstrate 90 GHz dual-pol direct absorber approach
- develop OMT-coupled MKIDs