EXPERIMENTAL COSMOLOGY AT ARGONNE NATIONAL LABORATORY

Argonne NATIONAL LABORATORY

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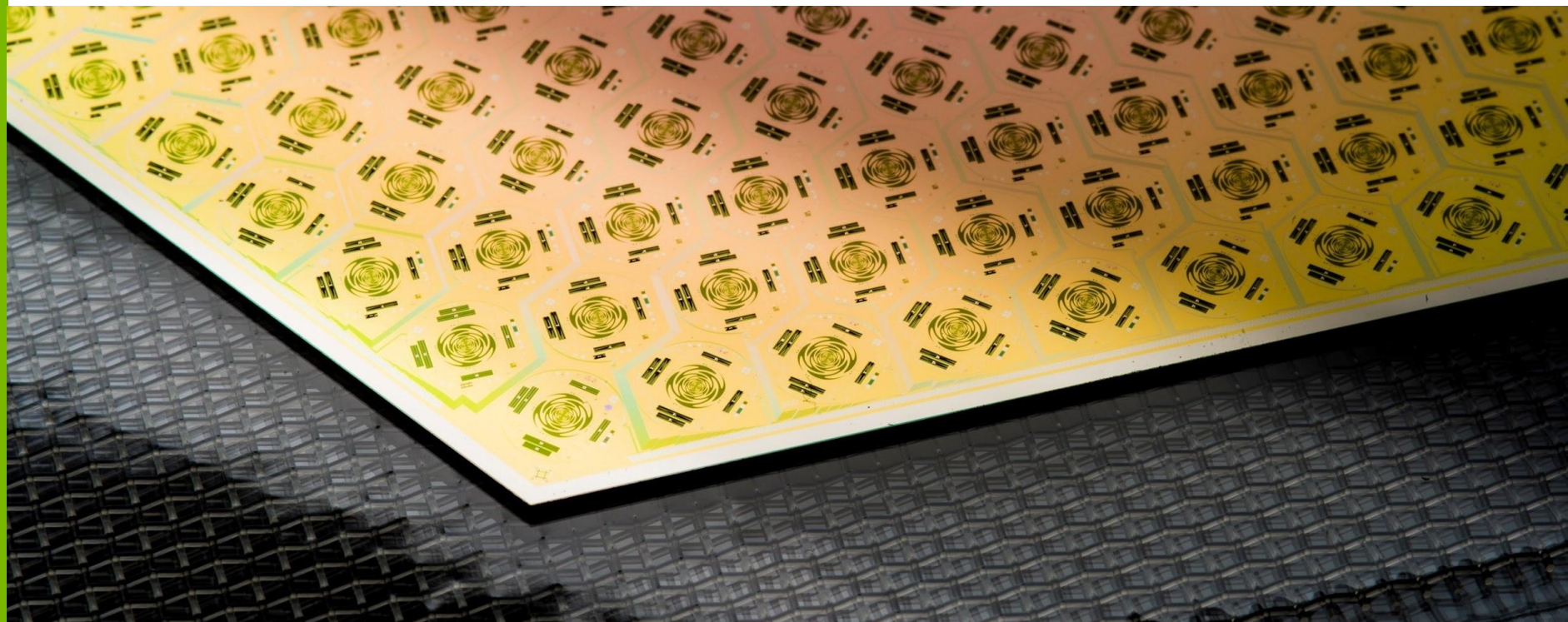
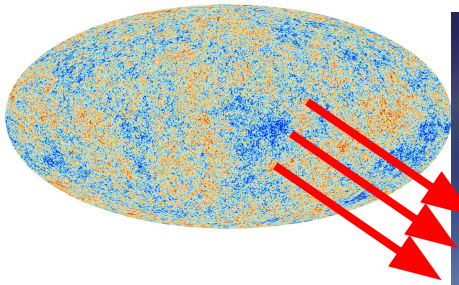
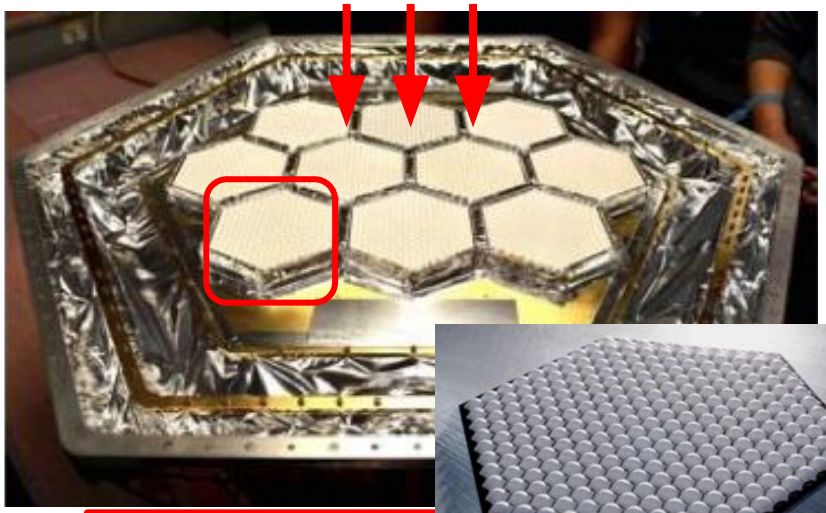


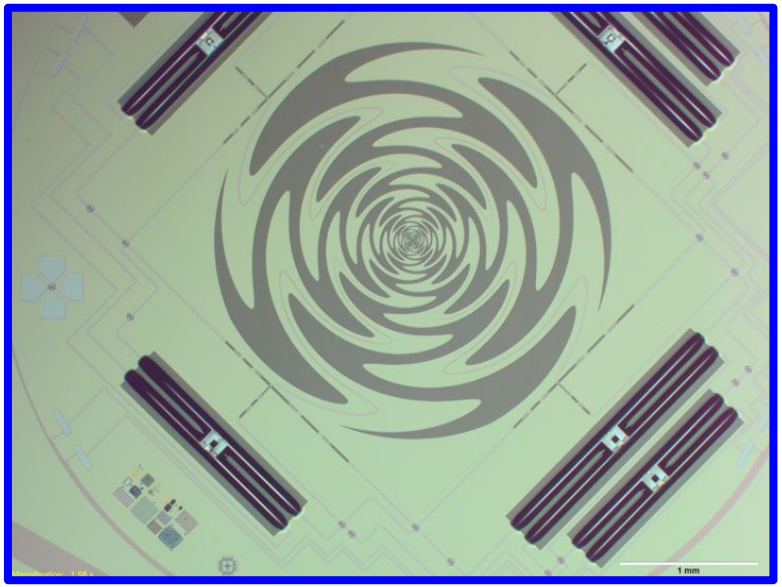
Experience

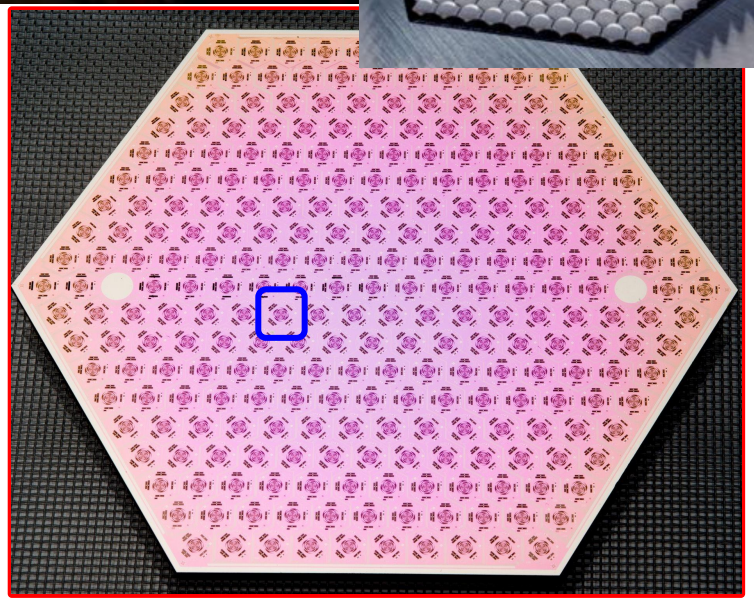
SPT-3G

~16,000 detectors
(one of the largest mm-wave focal planes)







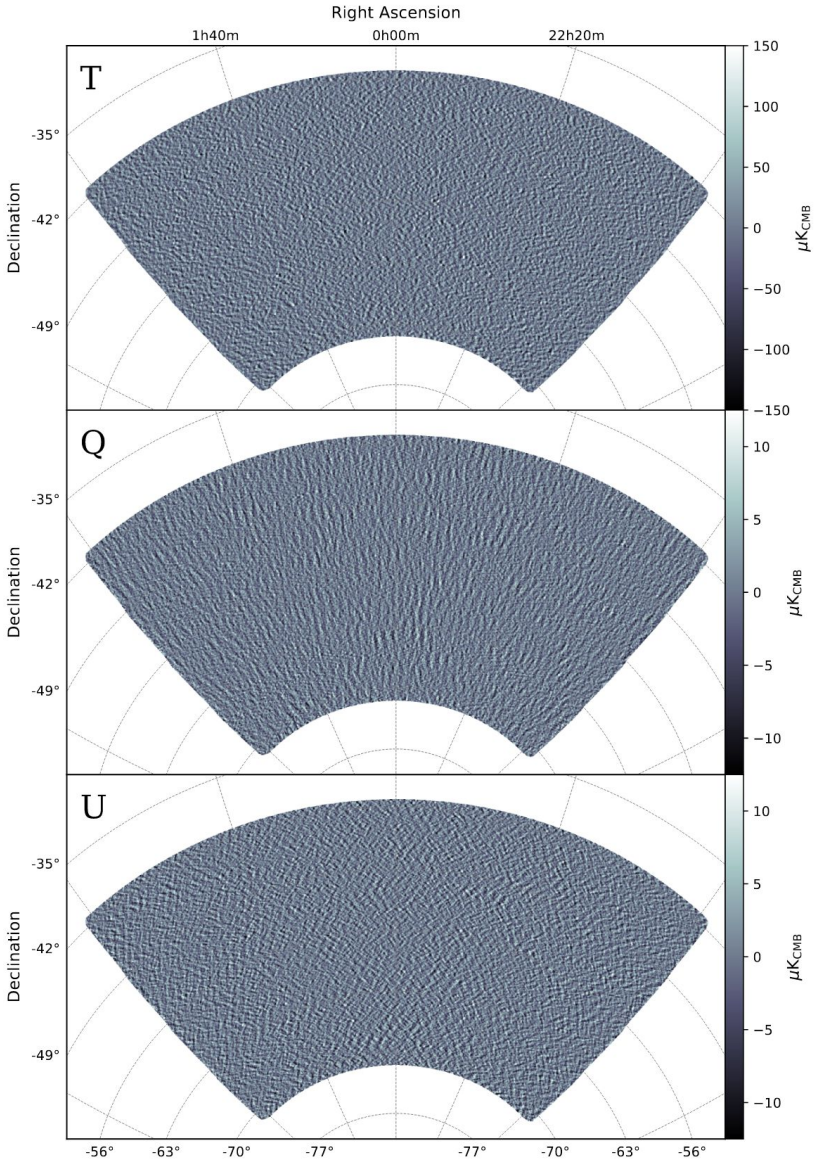


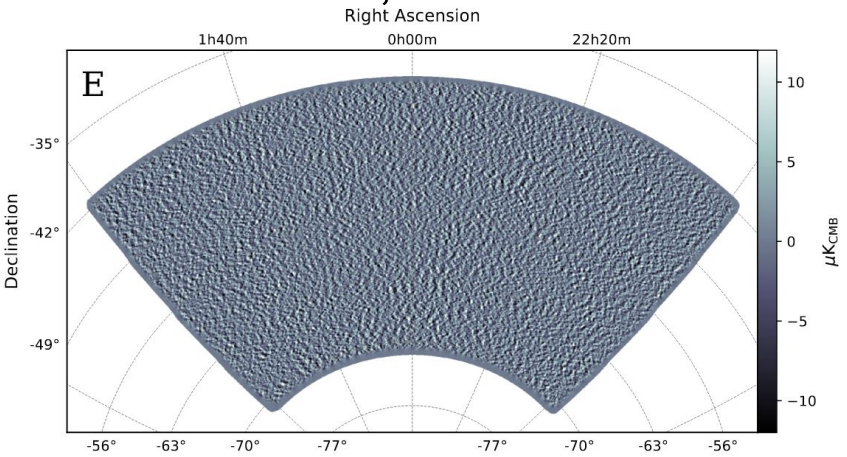
Preliminary Data...

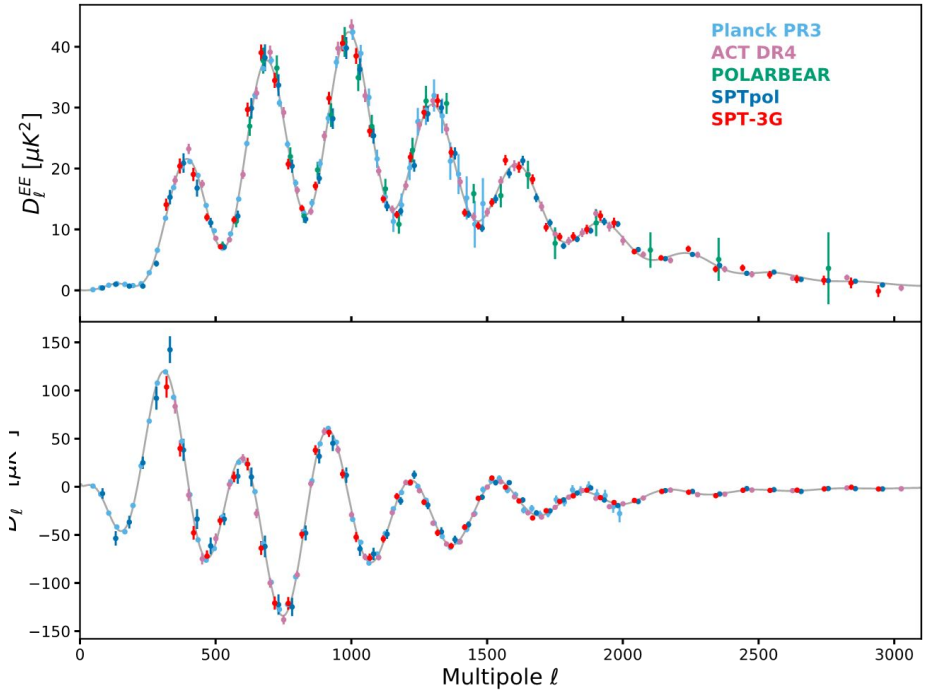
SPT-3G

2018 Data

D. Dutcher et al., arXiv:2101.01684







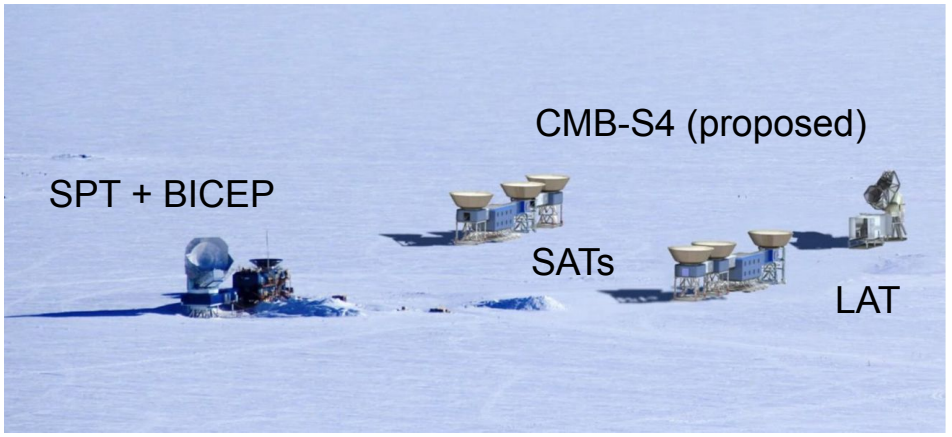
What are we doing now?

Next generation of microwave cosmology

1) Fabrication for CMB-S4

- Joint DOE/NSF project involving majority of US CMB community
- Two sites - Chile, SP
- SATs + LATs
- Total of 500k TES bolometers
  - *~ 400 wafers*
  - **more mm-wave detectors than have been fielded, ever**

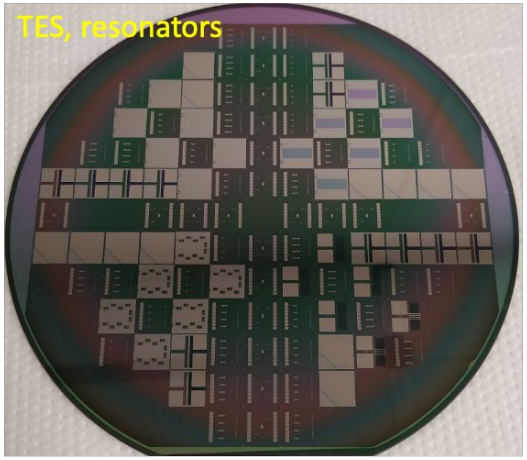
2) Next generation technology for future SPT receivers

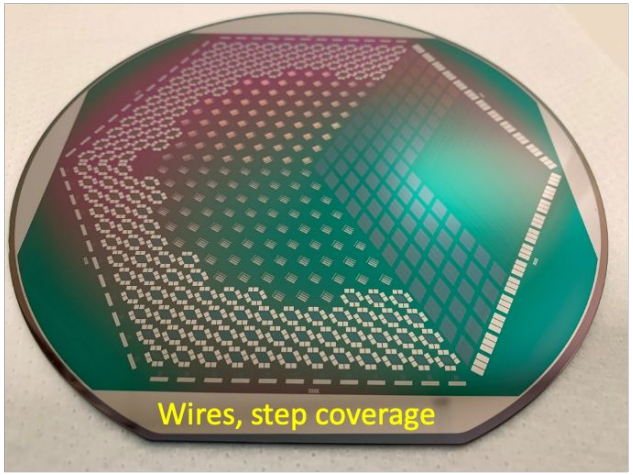


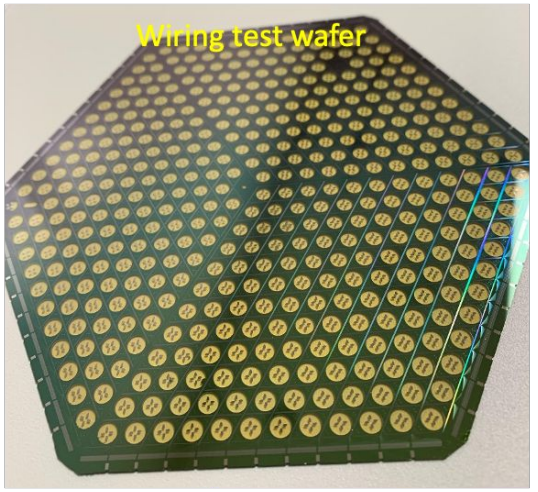
Test Structures

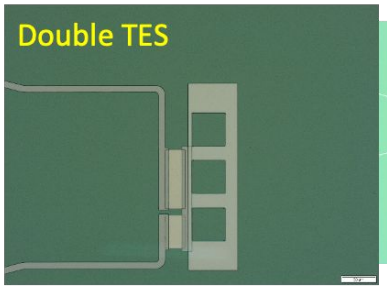
Lots of them!

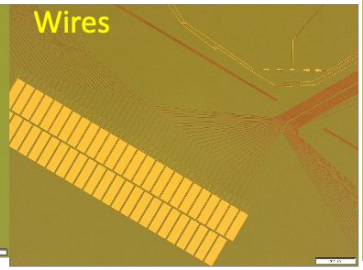
- Development of arrays for S4, building on foundation from 3G
- Require modifications to design and new processes
  - Increased process monitoring and QC
  - OMT antenna coupling (requires membrane release)

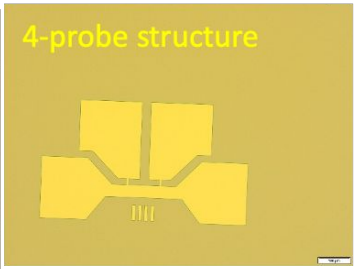










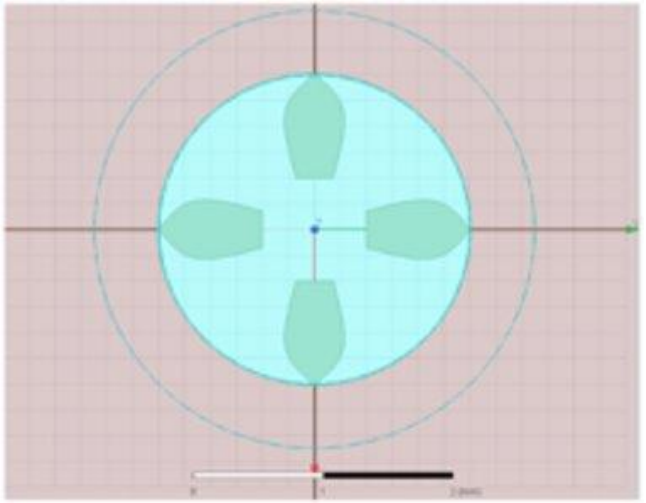


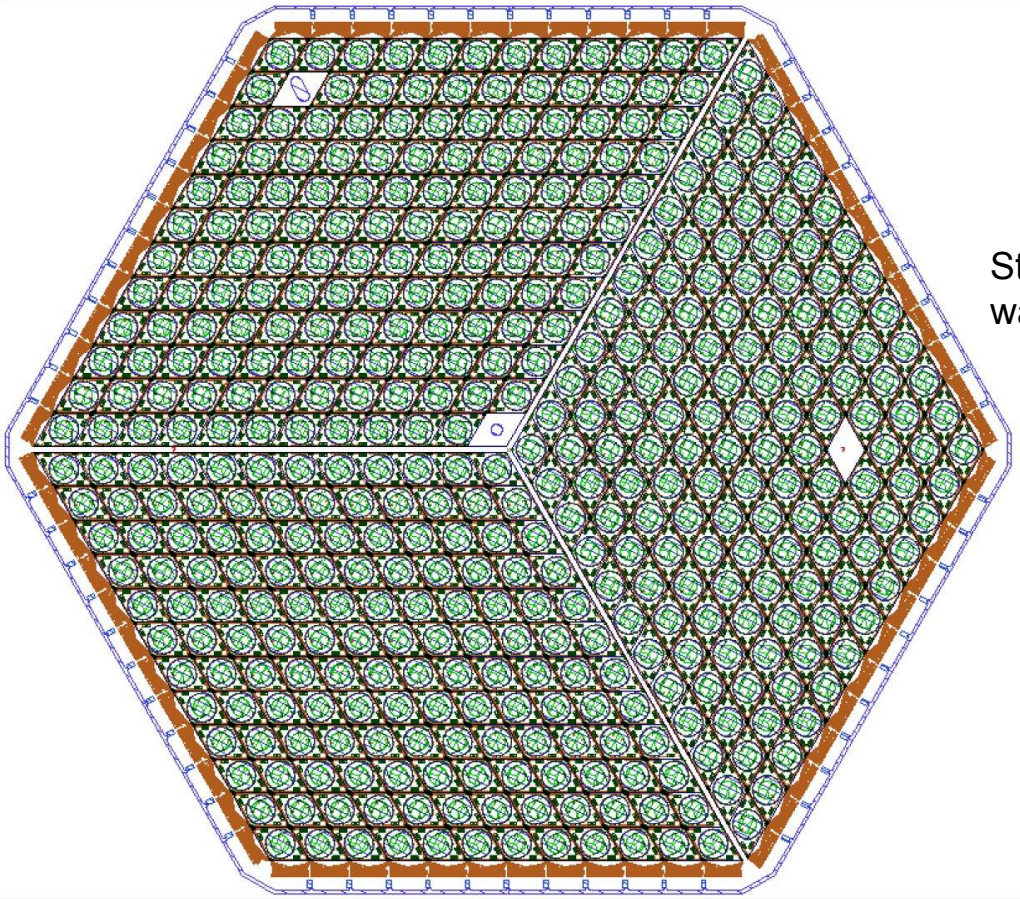
CMB-S4 pixel design

Path to prototype S4 wafers

- In collaboration with UChicago, working on new optimized S4 pixel designs

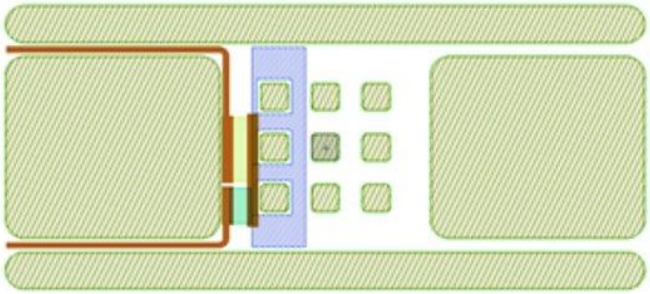
Improved OMT design (J. McMahon)





Standardized wafer layout

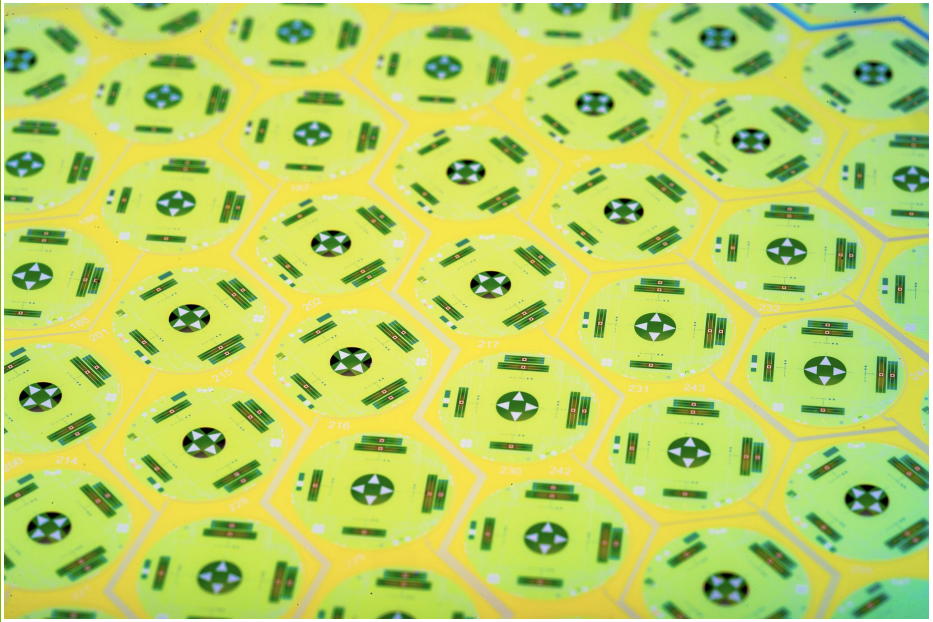
Double Tc TES



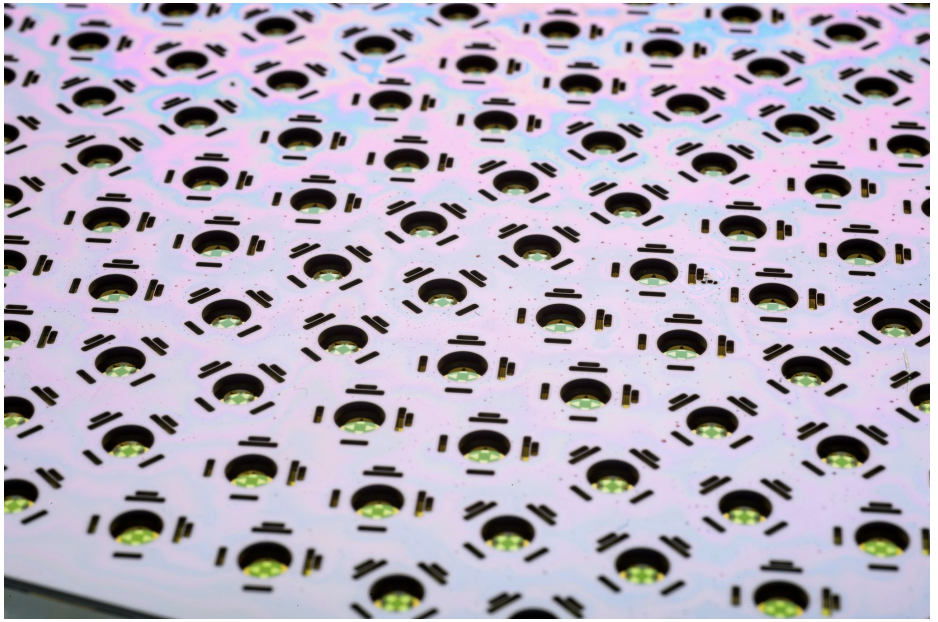
Process development

OMT-coupled bolometer arrays

- Demonstrated full fabrication process required for S4 design
- Ready to incorporate new designs and fabricate first round of prototype S4 wafers



Front side

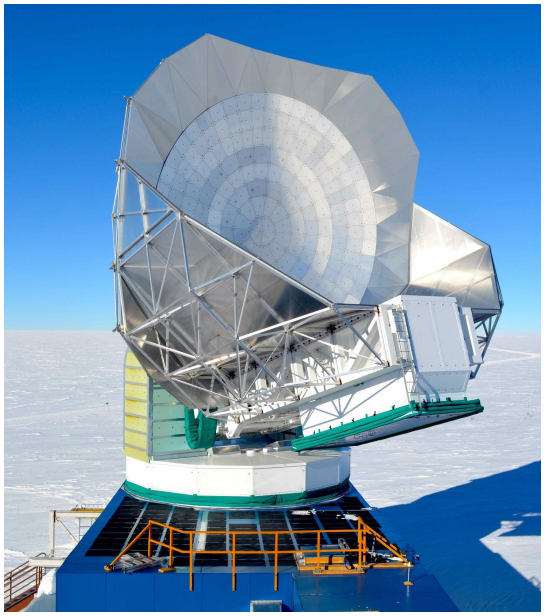


Back side

SPT-4

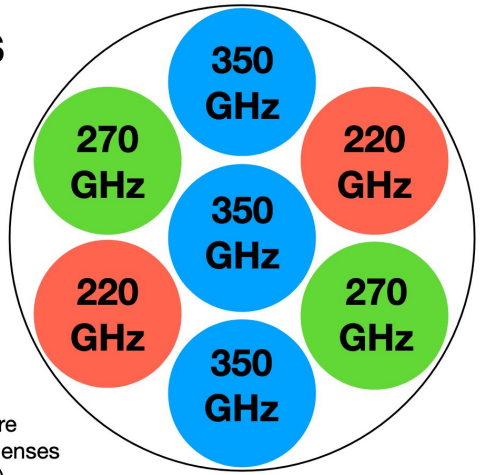
Next generation SPT receiver

- Successor to SPT-3G, planned for deployment in 2024
- Take advantage of high-frequency (400GHz) capability of site and SPT
- Platform intended to serve as technology demonstration (e.g., spectroscopy)



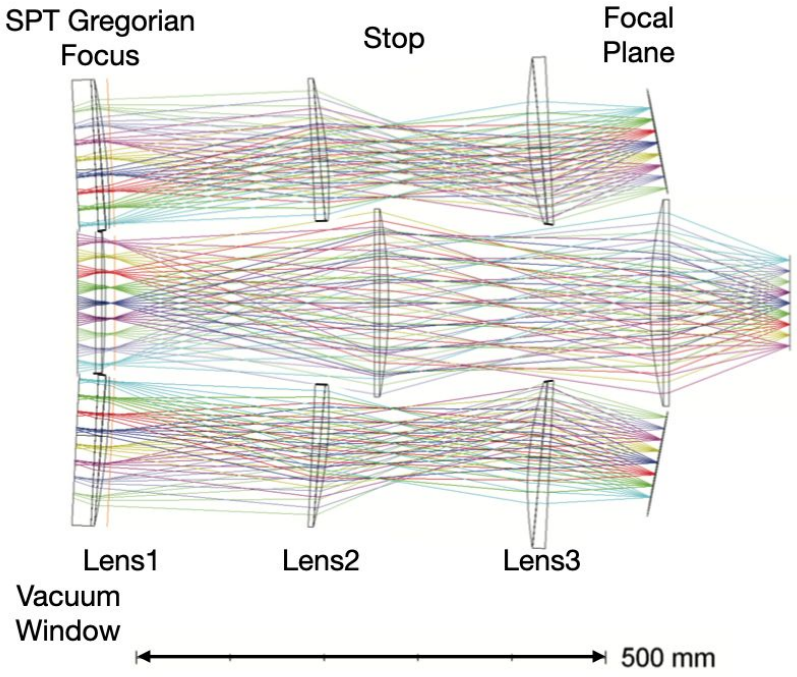
SPT4 focal plane

7 tubes



these would require
~9-10" (23cm) silicon lenses
(= totally doable)

~2 deg diameter FoV



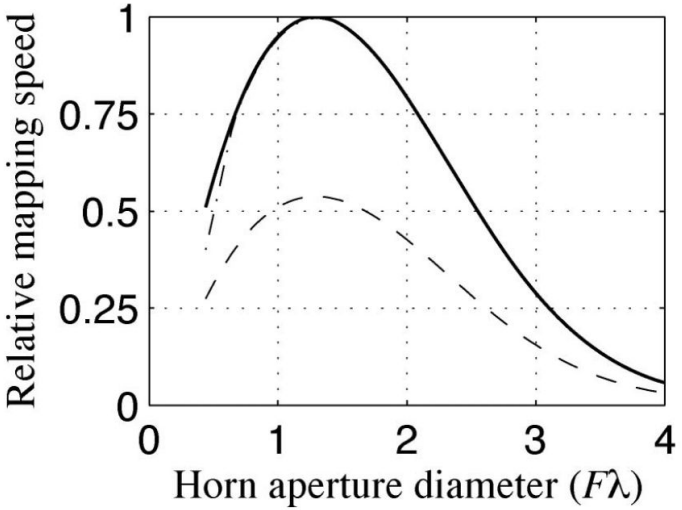
SPT-4 leKID focal plane

The case for KID arrays

- Optimal pixel spacing for maximum approx. 1.3FL
- L = 0.85 mm → ~2.2 mm dia. pixel

~ 3500 pol. detectors/ 6” wafer

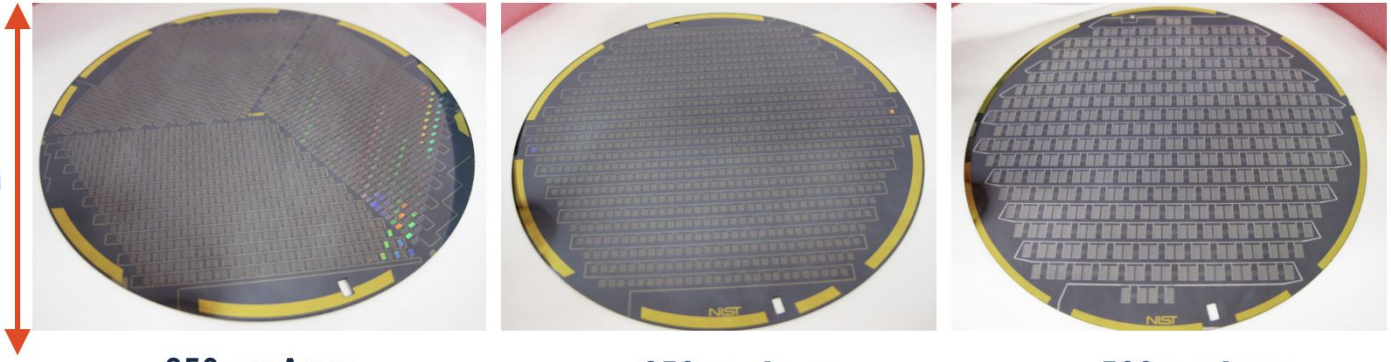
- SPT-4 7 wafers → 24.5k detectors
  - TES readout currently limited to < ~2000 det/wafer (# bond pads)



S. Padin, "Mapping speed for an array of corrugated horns," Appl. Opt. **49**, 479-483 (2010)

MKIDs offer an elegant solution to large-format arrays

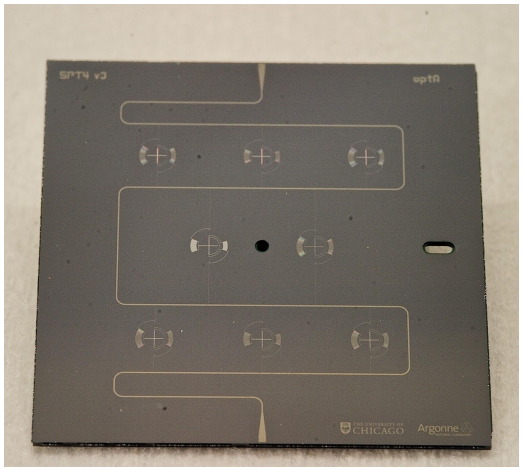
Blast-TNG (NIST)

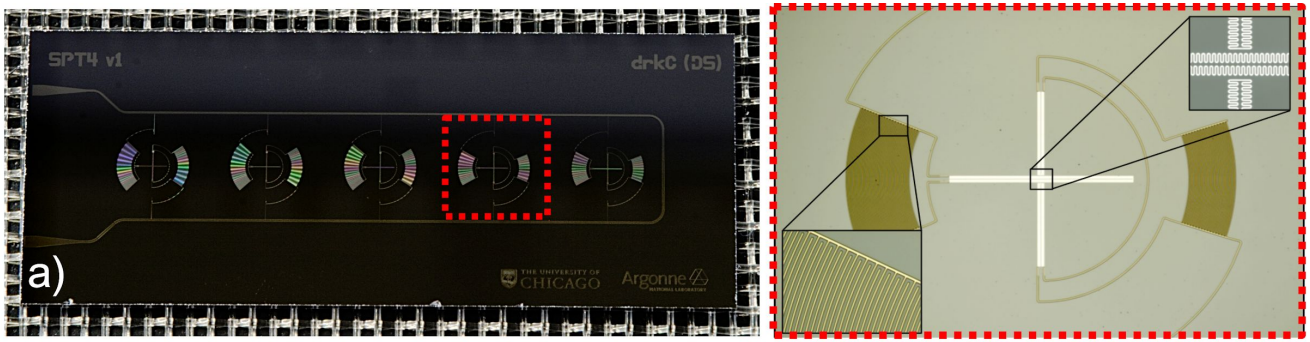


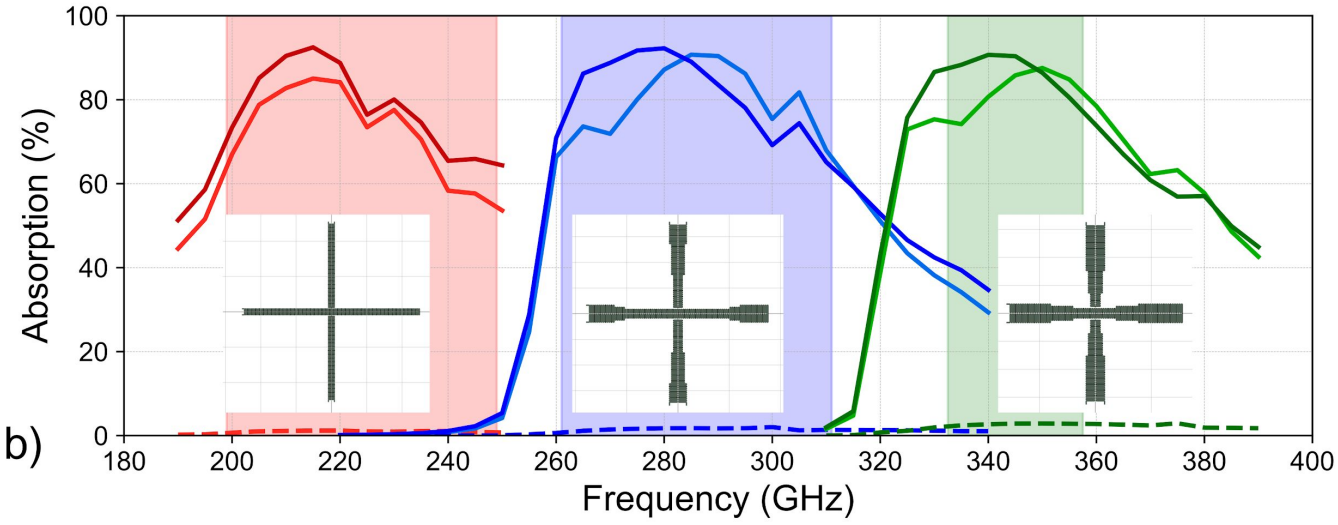
SPT-4 (imager)

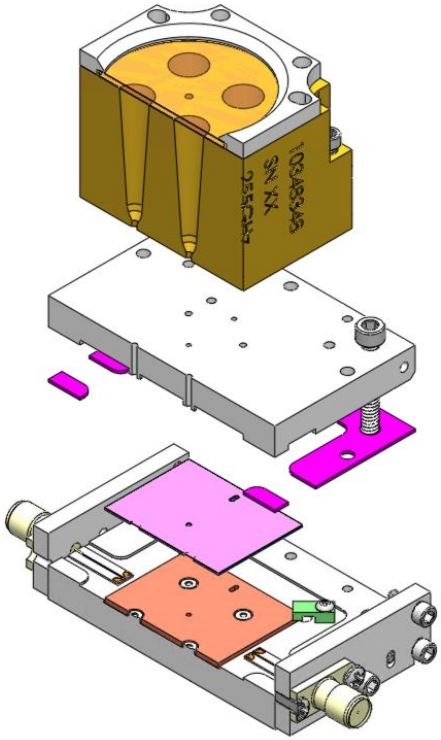
First generation detector arrays

- SPT-4 3-colour imager (225/280/345 GHz)
- Science case - *stay for Adam's talk!*
- First devices fabricated, now being testing
- Moving forward to wafer-scale arrays





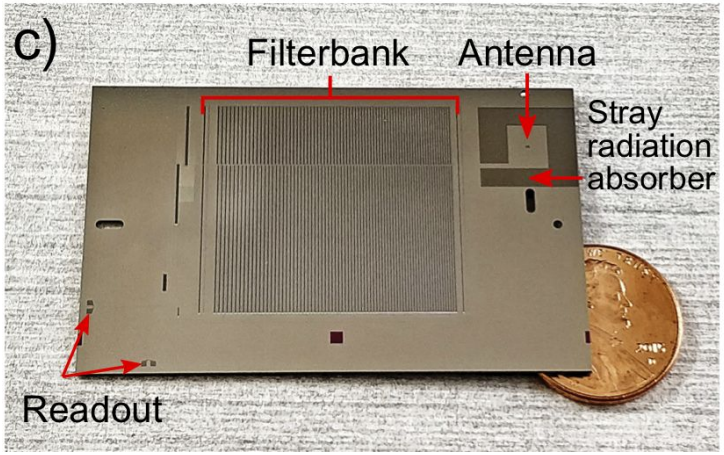


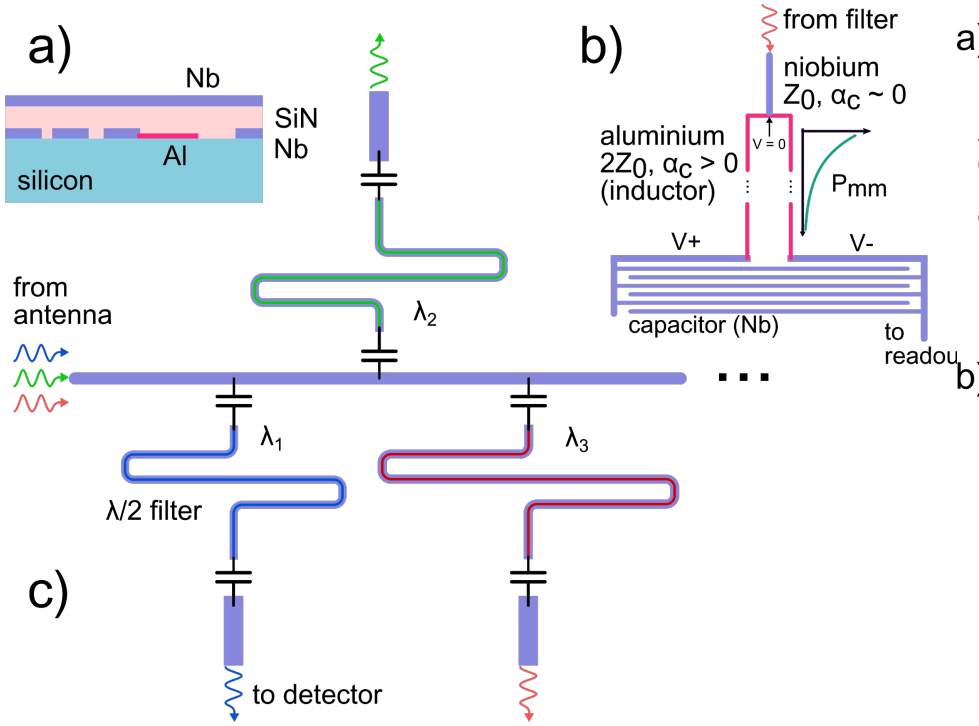


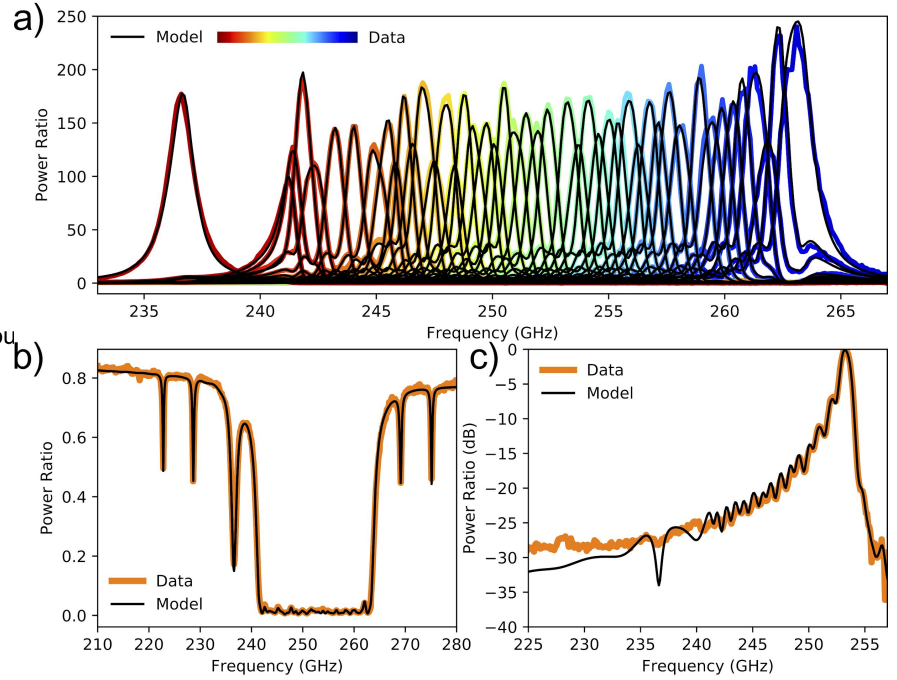
SPT-4 (spectroscopy)

Second generation detector arrays

- Extension of on-chip filtering toward superconducting filter-bank circuits
- Each ‘pixel’ now becomes a medium resolution spectrometer
- Science case: *stay for Kirit’s talk!*







SPT-SLIM

Pathfinder integral field spectrograph

- Science - line intensity mapping at mm-wavelengths
- SPT - Summer Line Intensity Mapper
- **Pathfinder for future mm-wave LIM experiments**
- Deployment set for next year
  - stay tuned!