

ON-SKY DEMONSTRATION OF A SUPERCONDUCTING FILTER BANK SPECTROMETER ON SPT-SLIM

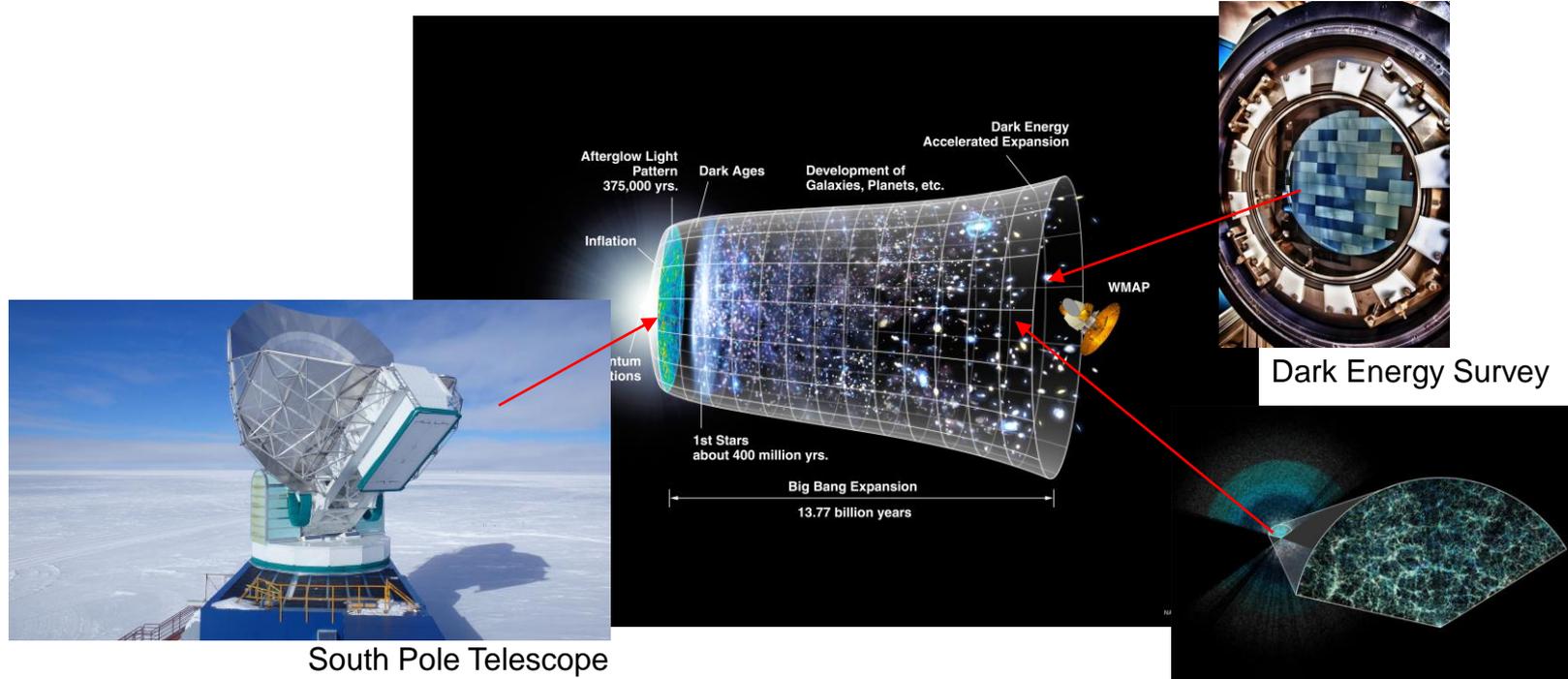
CYNDIA YU

Argonne National Laboratory/University of Chicago

2025 Oct 09

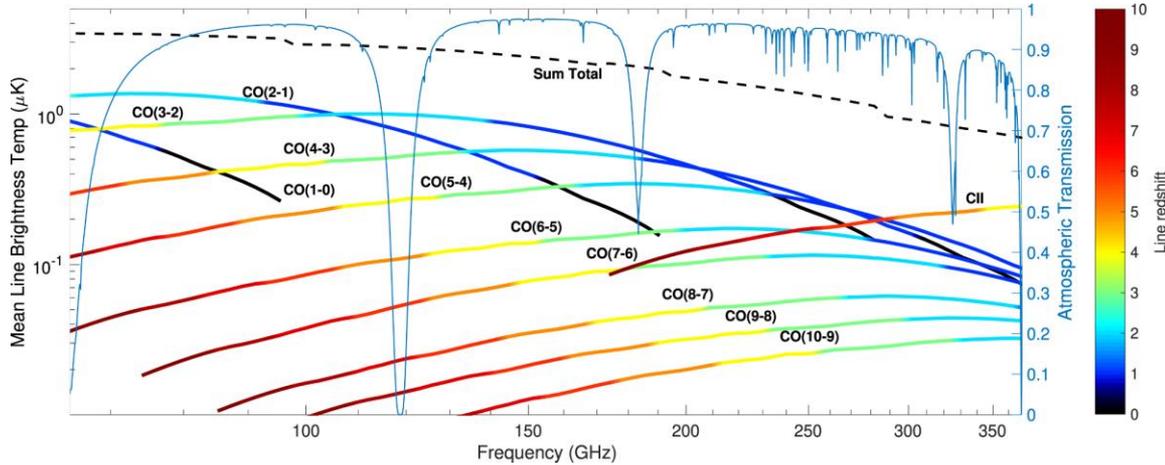
THE CASE FOR MM-WAVE LIM

Probing unresolved structure formation at “cosmic noon”

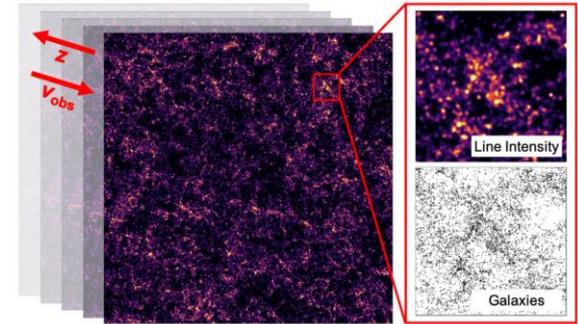


THE LIM TECHNIQUE

Probing unresolved structure formation at “cosmic noon”



A.M. Dizgah, ApJ (2021)



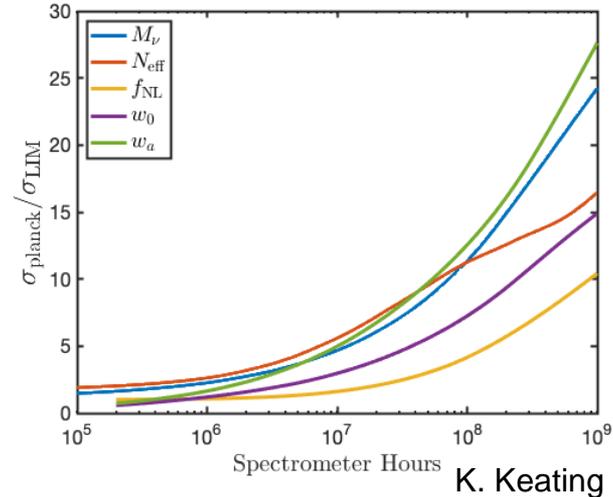
K.S. Karkare, Snowmass White Paper (2022)

COMPACT MICROWAVE SPECTROSCOPY

The case for on-chip spectrometers

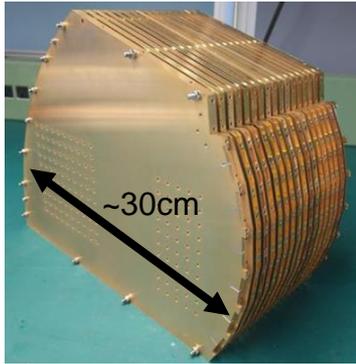
Need:

- Narrow-band spectral filters (R=300 target)
- Each connected to a photon noise-limited detector
- In a **massively scalable** architecture



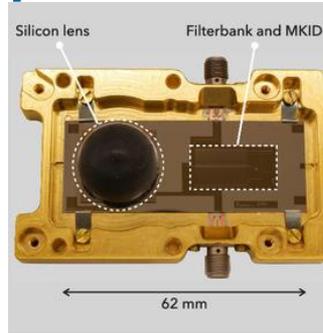
COMPACT MICROWAVE SPECTROSCOPY

The case for on-chip spectrometers

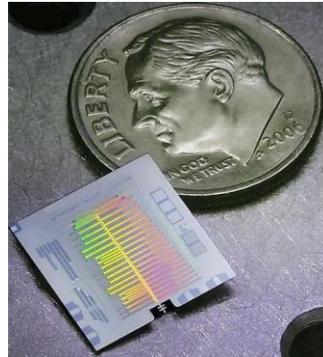


TIME
Li+ 2018

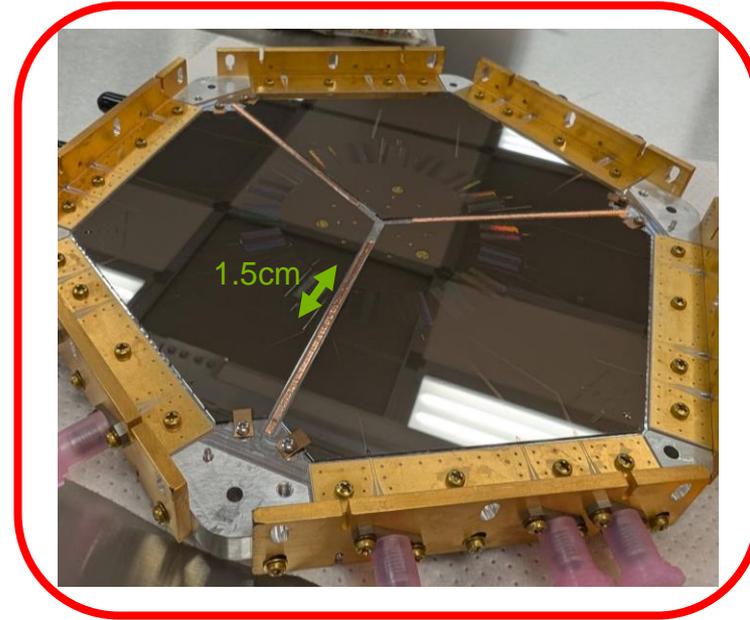
VS



DESHIMA
A. Taniguchi, JLTP 209 (2022)



SuperSpec
E. Shirokoff, Proc. SPIE 8452 (2012)



SPT-SLIM: THE SHIROKOFF LINE INTENSITY MAPPER

Argonne:

T. Cecil
C. Chang
M. Lisovenko
V. Yefremenko
C. Yu

Boston University

K. Karkare
A. Lapuente

Cardiff:

P. Barry
C. Benson
G. Robson

Fermilab:

A. Anderson
B. Benson
M. Young

Harvard:

G. Keating

McGill / t0:

M. Adamic
M. Dobbs
J. Montgomery
M. Rouble
G. Smecher

U. Arizona:

D. Kim
H. Tailor
D. Marrone

SLAC

C. Zhang

U. Chicago:

J. Carlstrom
K. Dibert
K. Fichman
T. Natoli
A. Rahlin
J. Zebrowski

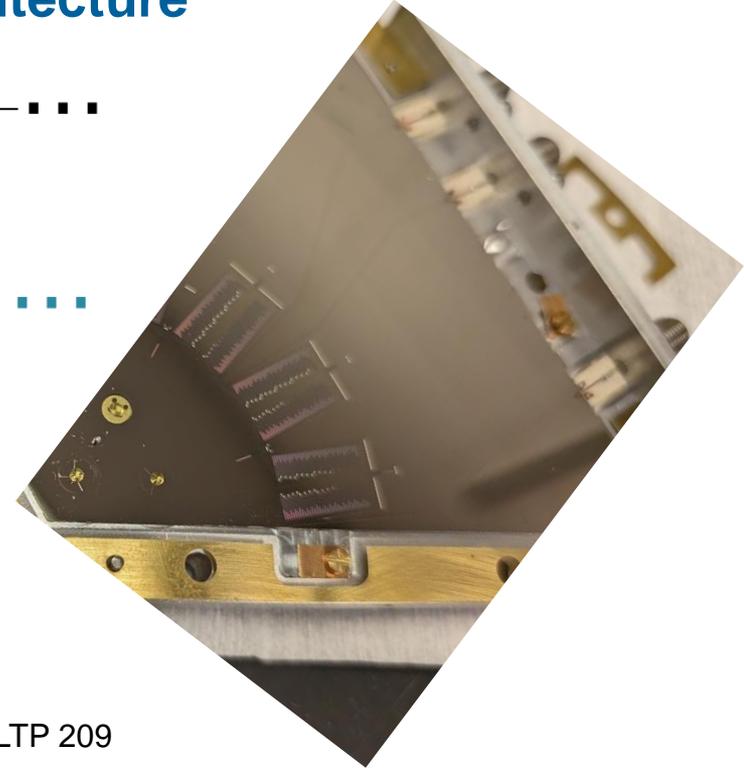
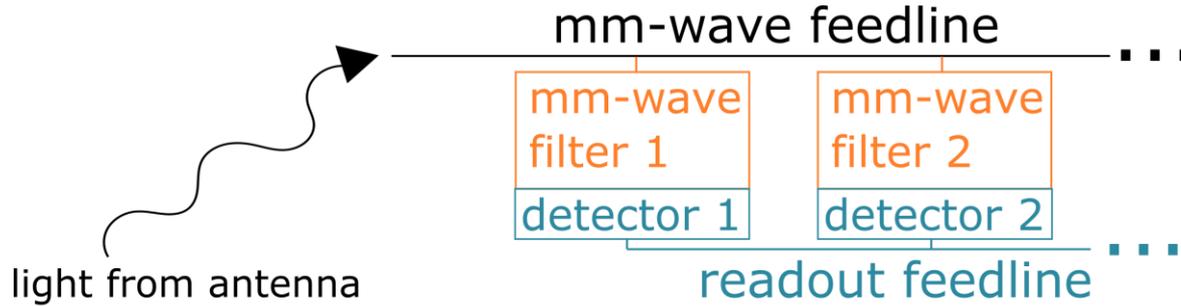


Erik Shirokoff
(Chicago)



THE SLIM SPECTROMETER CONCEPT

A flexible superconducting filter bank architecture

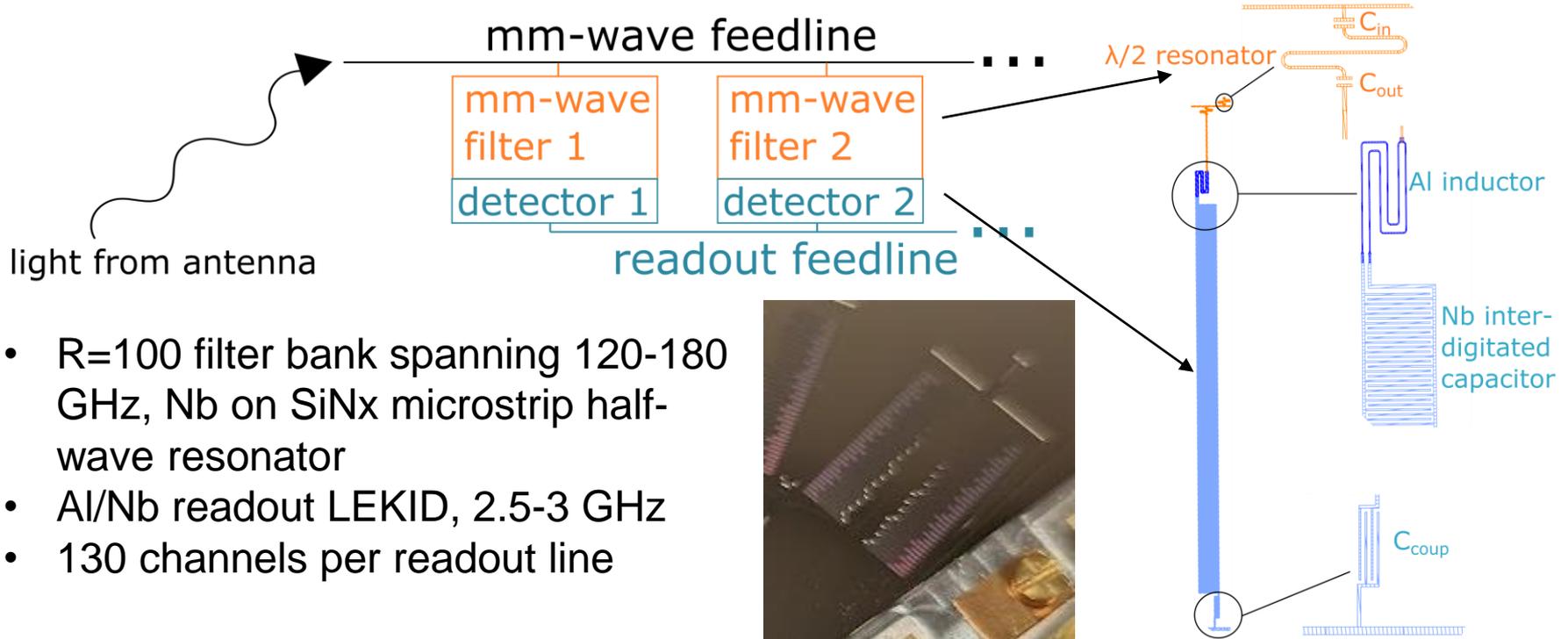


- Feedhorn-coupled OMT for dual-polarization sensitivity
- 2 polarizations x 3 pixels x 3 submodules = 18 total filter banks on 9 readout lines (1 per pixel)

See also: P. Barry JLTP 209 (2022), G. Robson JLTP 209 (2022), G. Robson PhD thesis (2024)

THE SLIM SPECTROMETER CONCEPT

A flexible superconducting filter bank architecture

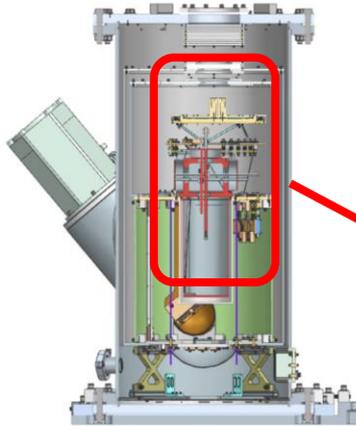


- R=100 filter bank spanning 120-180 GHz, Nb on SiNx microstrip half-wave resonator
- Al/Nb readout LEKID, 2.5-3 GHz
- 130 channels per readout line

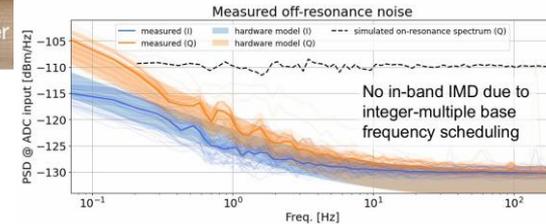
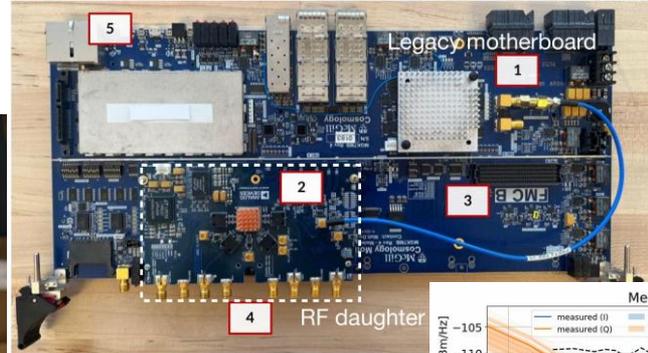


TAKING SPECTROMETERS TO THE SPT

A lightweight platform for rapid installation



Installed in ADR
(Dec 10, 2024)
cooled to 100mK...
M. Young, JLTP (2025)

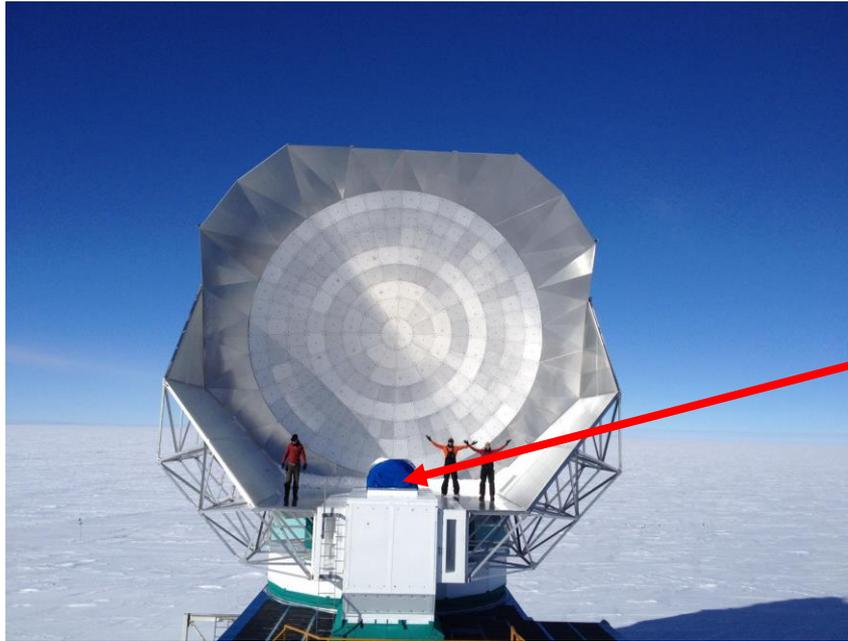


Read out by RF-enabled ICE electronics
(legacy platform for SPT-3G), up to 1024
channels x 2 RF chains per board in 500
MHz

M. Rouble ++, Proc. SPIE 12190 (2022)

TAKING SPECTROMETERS TO THE SPT

A world-class mm-wave site and platform

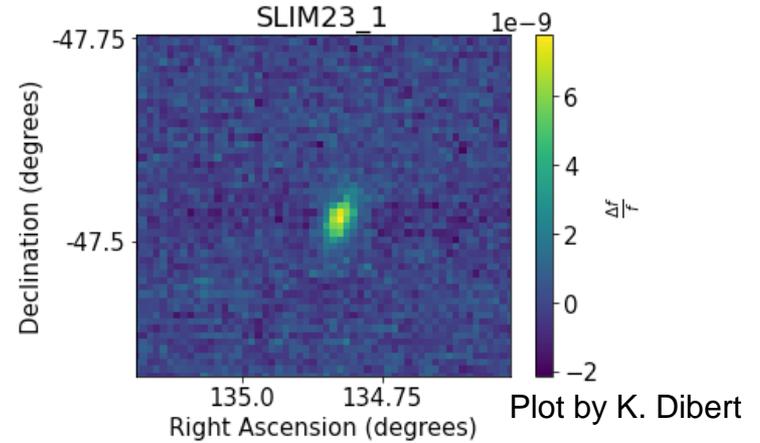


K.S. Karkare, JLTP 209 (2022)
Optical design: H. Tailor, in prep.

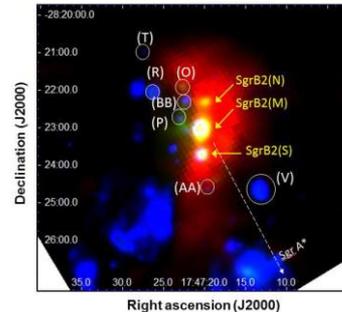
FIRST LIGHT FOR SPT SLIM



Installing the cryostat on the SPT (January 5, 2025)

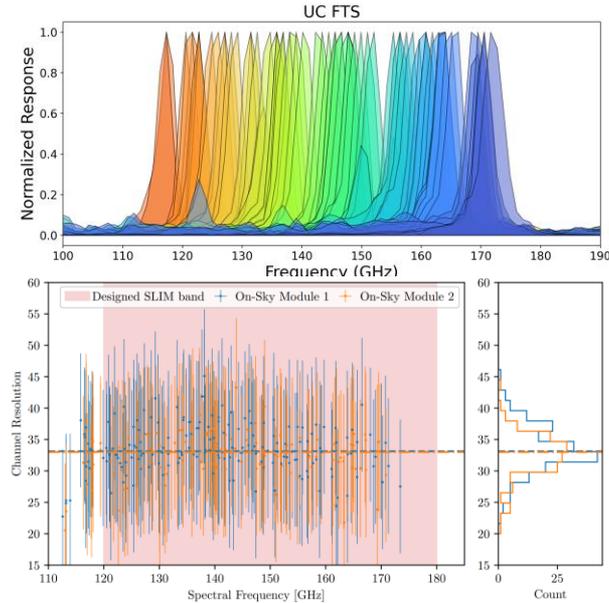


Compare with IR satellite data:



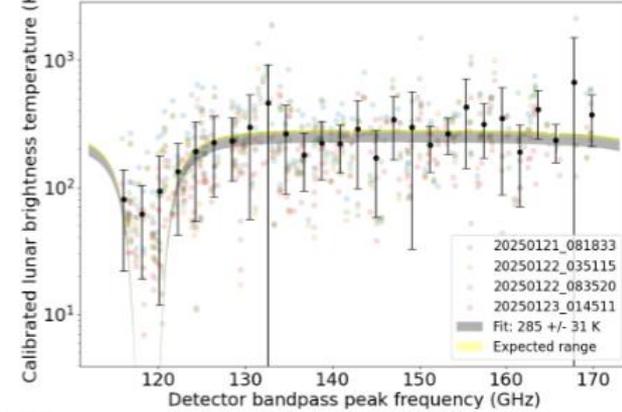
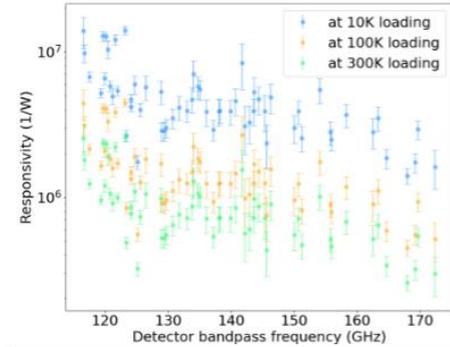
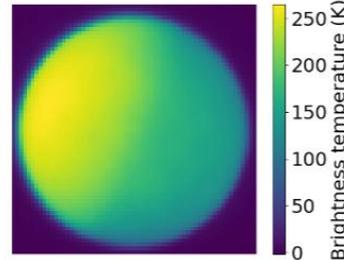
First observation of astronomical sources!
(January 15, 2025)

FIRST LIGHT FOR SPT SLIM



C. Benson, K. Fichman, JLTP (2025)

Achieved $R \sim 33$, limited by high loss in the microstrip...



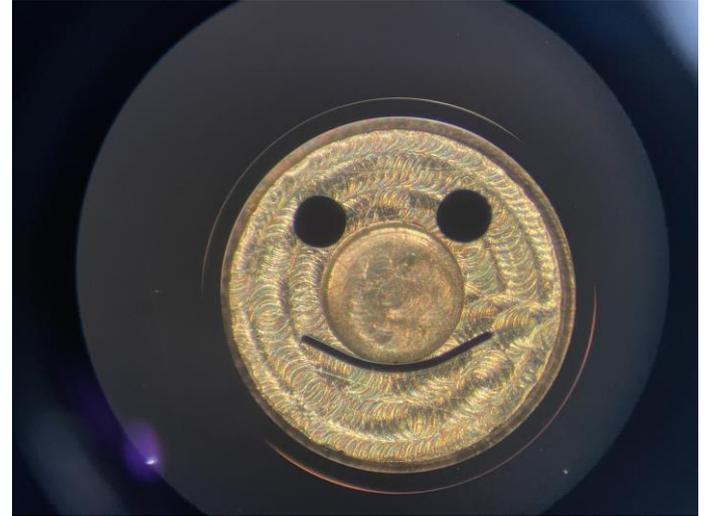
K. Dibert, JLTP (2025)

...but achieve a calibrated spectrum of astronomical objects as proof of end-to-end measurement!

LOOKING AHEAD

A bright future for mm-wave LIM

- Exploring new materials and architectures to improve optical efficiency/minimize dielectric loss
- Other experiments are coming online too! (COMAP, TIME, DESHIMA, SuperSpec have data; TIM, CCAT-EoR Spec)
 - + rich cross-correlations with other lines (21-cm, OIR)
- Non-cosmological applications: Argonne Wakefield Accelerator (ongoing!), broadband axion searches from 90-300GHz?, your idea here!





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