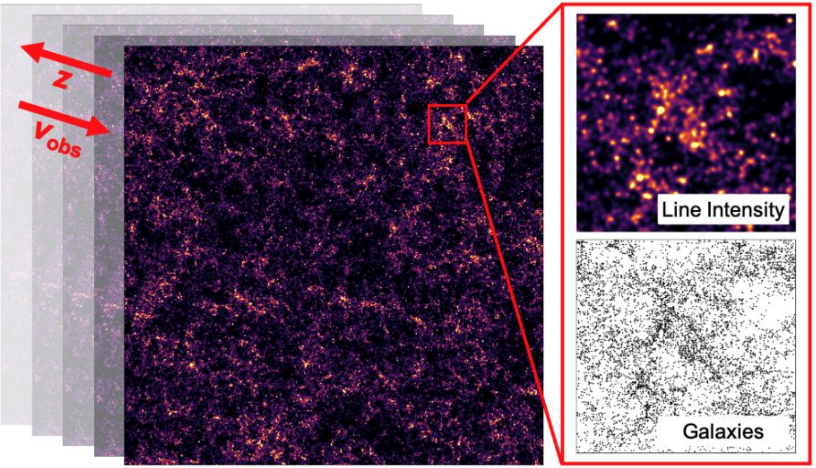
Millimeter-Wave Line Intensity Mapping: A Next-Generation Cosmological Probe

Kirit Karkare (SLAC), Adam Anderson (FNAL), Zhaodi Pan (ANL) – see Snowmass White Paper arXiv:2203.07258



Spec-hrs	Example	Time scale	$\sigma(M_\nu)$ [eV]	Primordial FoM
10^5	TIME, SPT-SLIM	2023		0.0015
10^6	TIME-Ext	2026	0.047	0.1
10^7	SPT-3G+, 1 tube	2028	0.028	1
10^8	SPT-3G+, 7 tubes	2031	0.013	10
10^9	CMB-S4, 85 tubes	2037	0.007	100

Low resolution, spectroscopic observations detect line emission from unresolved galaxies. Target far-IR lines such as CO/[CII] which redshift to the millimeter range. Reuse existing CMB facilities and detector heritage.

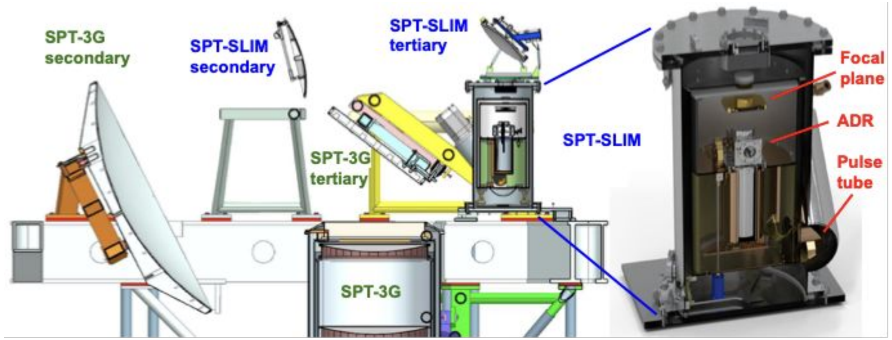
Efficiently measure LSS beyond the reach of optical surveys: a single instrument could detect $0 < z < 10$!

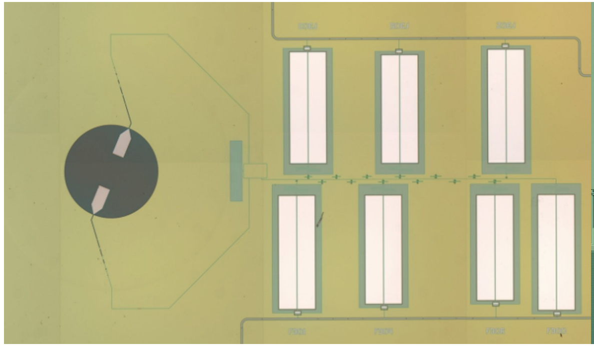
We need to improve sensitivity by several orders of magnitude for next-generation cosmological constraints.

Progress is driven by advances in detector technology (e.g., on-chip spectrometers) and pathfinder experiments that are now being fielded.

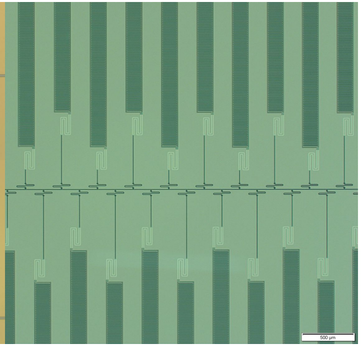
The SPT-SLIM Pathfinder and Detector R&D

Karkare et al. (arXiv:2111.04631)





Prototype SPT-SLIM spectrometer



On-chip filter bank (T. Cecil)

Small pathfinder experiments are *essential* for testing detector technology and measurement techniques in realistic on-sky conditions. SPT-SLIM is an example of such a pathfinder to demonstrate the on-chip spectrometer technology for mm-wave LIM, supported by NSF and Fermilab LDRD (~$2M total).

Will make sensitive measurements of the CO power spectrum using the South Pole Telescope in the 2023–24 austral summer.

Silicon wafers are ideal for building high-density integrated spectrometer arrays, based on CMB detector heritage.
State of the art: O(10) spectrometers with O(100), R~100 spectral channels

Challenges towards O(100-10000) spectrometer arrays: increased packing density, spectral resolution, optical efficiency, and sensitivity. DOE detector R&D support is critical for enabling this progression.