

# CMB and next decade of cosmology instrumentation/technology

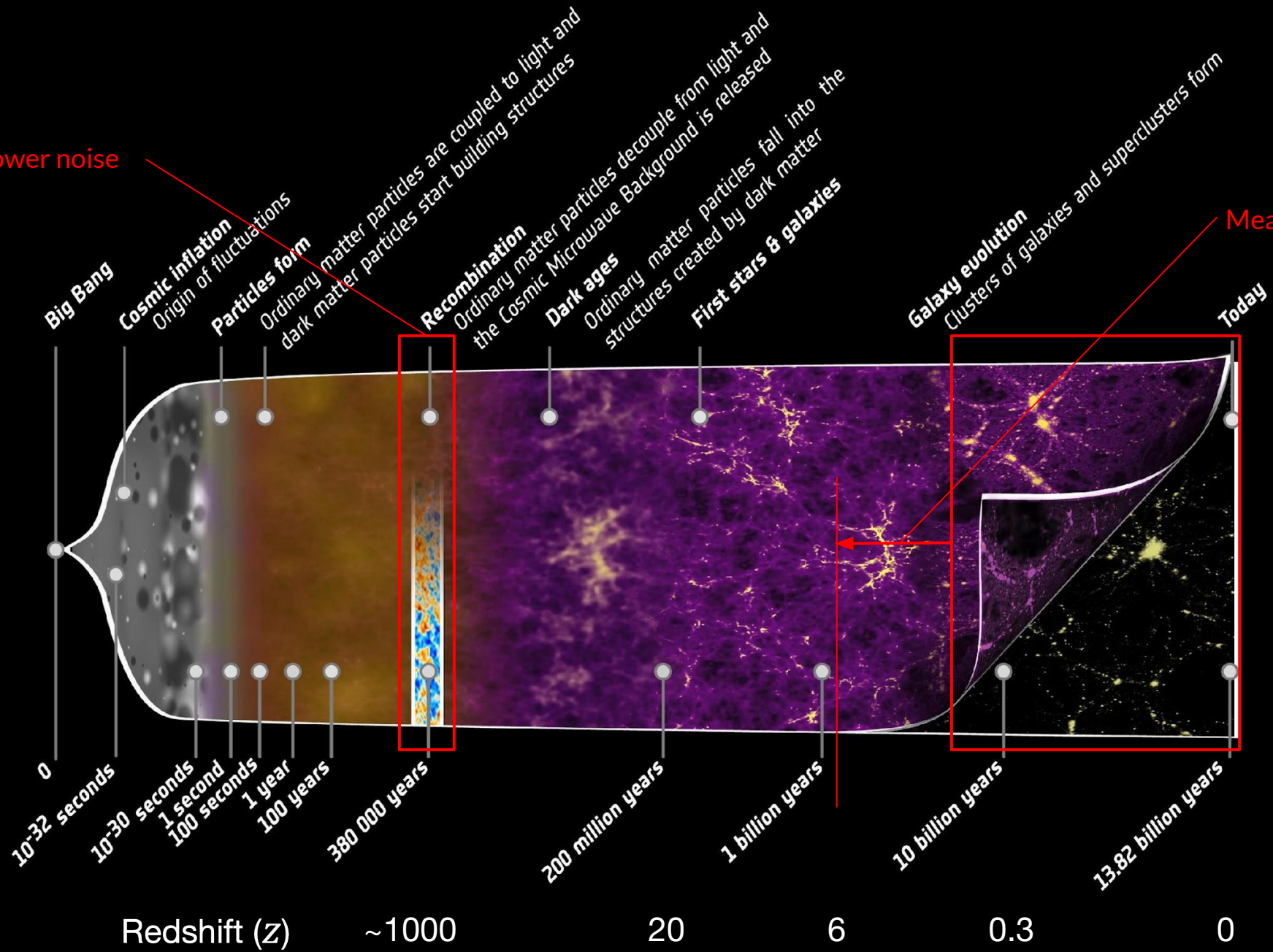
TID/ID Instrumentation Seminar: HEP Part 1

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Zeeshan Ahmed

March 29, 2023

Measure with lower noise

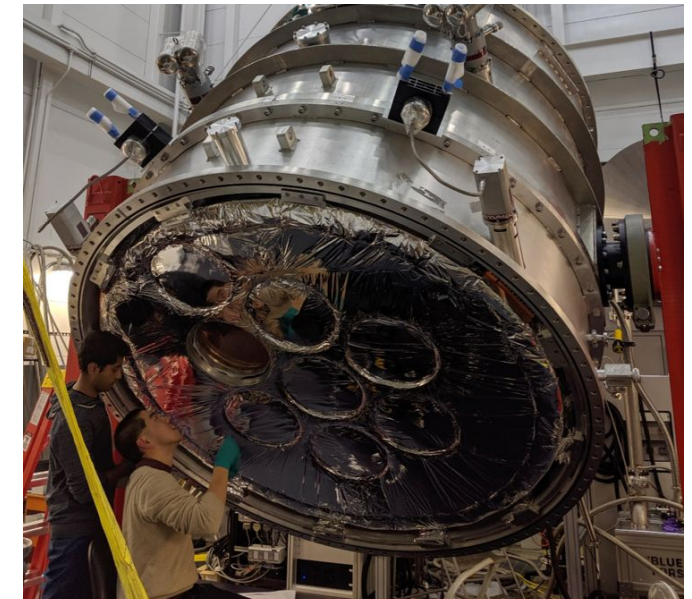
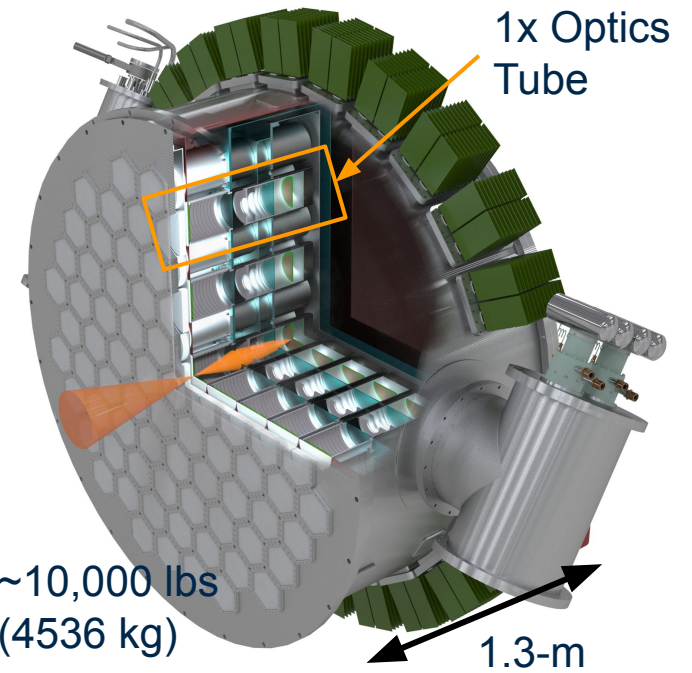
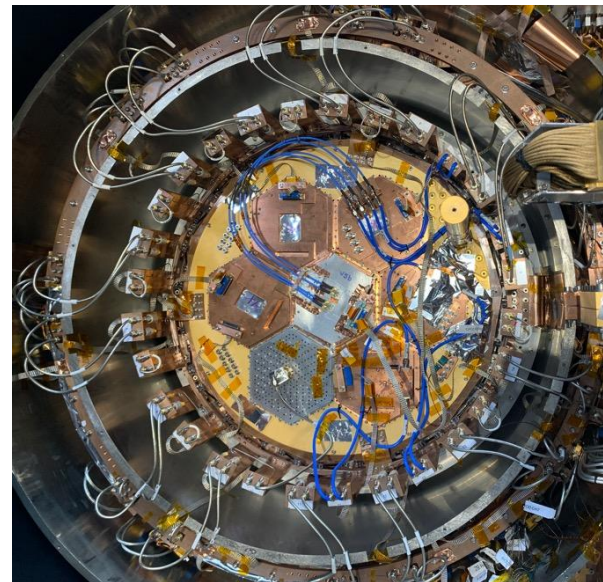
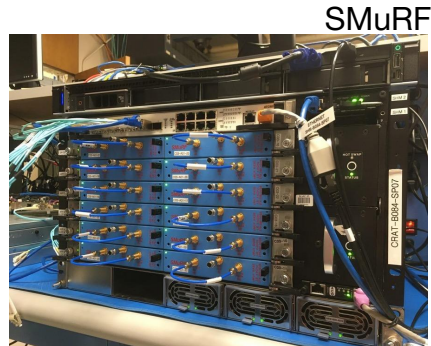


Measure more volume

# CMB R&D

## Lower noise by using more sensors at a time to sample the CMB sky

- Challenge: Enormous cryogenic focal planes
  - Reduce wire counts/complexity from room temperature to 0.1K
- R&D paths
  - 4K
    - ADCs, DACs, ASICs
    - Low-power optical digital links
  - 300K
    - Low-noise custom front ends
    - Compact, low-power electronics
      - MHz
      - GHz



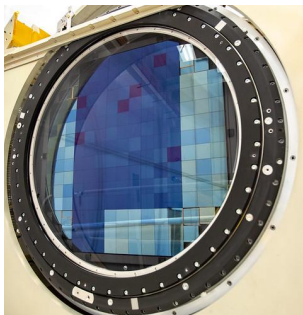
# Cosmology scientific direction in the 2020s and 30s

More cosmological volume to constrain inflation and dark energy. Higher, more precise redshifts

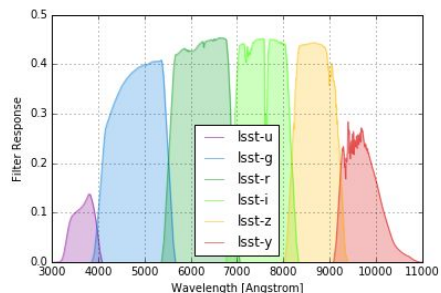
Imaging with few colors



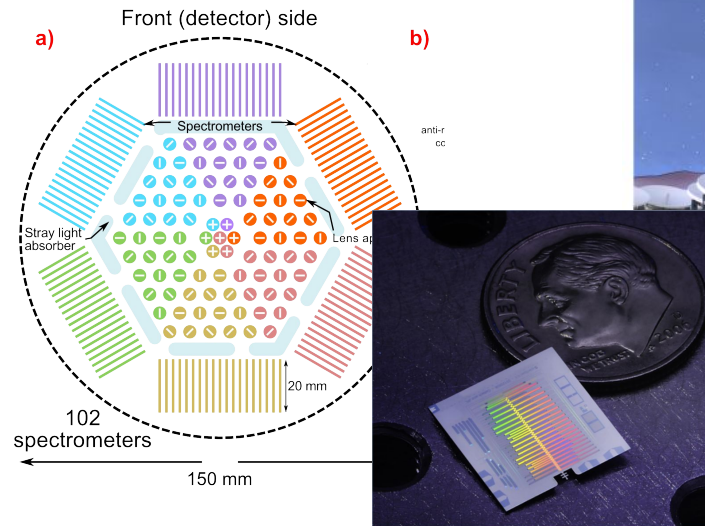
CMB-S4



Rubin LSSTcam



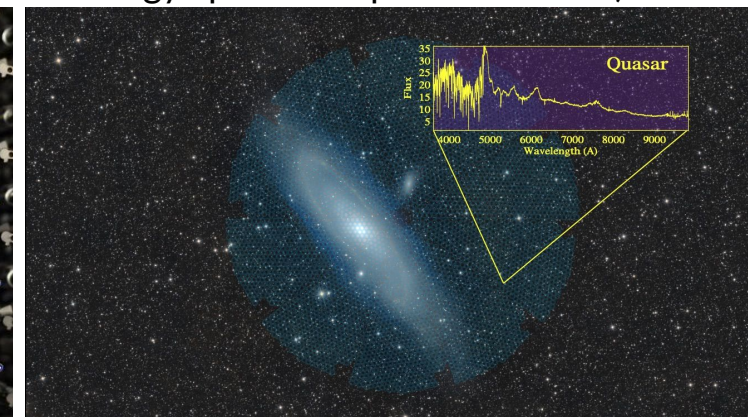
Spectroscopy with R~3000



Spec-S5 (successor to Dark Energy Spectroscopic Instrument)



HI and C Line Intensity Mapping



# Cosmic Frontier R&D roadmap (from HEP Detector R&D BRN)

Science Goal	Measurement	Technical Requirement (TR)	PRD
Fully sample the epoch of late-time cosmic acceleration	500M Galaxy spectra ( $R \sim 3000$ ) to $z < 4$	For Optical/IR spectroscopy TR 4.1: Sensitivity at wavelengths beyond the 1eV Silicon cutoff. TR 4.2: Ten-fold increase in multiplexing relative to current experiments	7, 11, 26
Distinguish between single vs. multi-field inflation by measuring $f_{NL}$ down to 1	Multiple Intensity mapping surveys to measure flux from 2.9B galaxies to $z < 6$	For 21-cm Intensity Mapping: TR 4.3: Pico-second timing synchronization across $\sim$ km TR 4.4: Direct digitization and real-time calibration	21, 22, 23, 26
		For mm-wave Intensity Mapping: TR 4.5: On-chip mm spectrometers with $R > 200$ TR 4.6: Fabrication and readout of 1M detectors	7, 8, 26

Ge CCDs

SMuRF and accelerator timing successors

DMF

