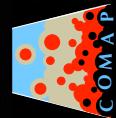




# The CO Mapping Array Pathfinder (COMAP)

Kieran Cleary (Caltech)  
AME Workshop, June 23, 2016



# What is COMAP?

- **Aim:** ultimately, to trace LSS at EoR. In short term, focus on lower-redshift science

## • CO

- Common star-formation tracer at low redshift
- Bright, even at high z
- Traces photon sources responsible for the ionization
- Emits in line 'ladder'

## • Mapping

- Intensity mapping:
- aggregate line emission from unresolved galaxies
- Measure spectra: trace evolution with redshift - 'tomography'

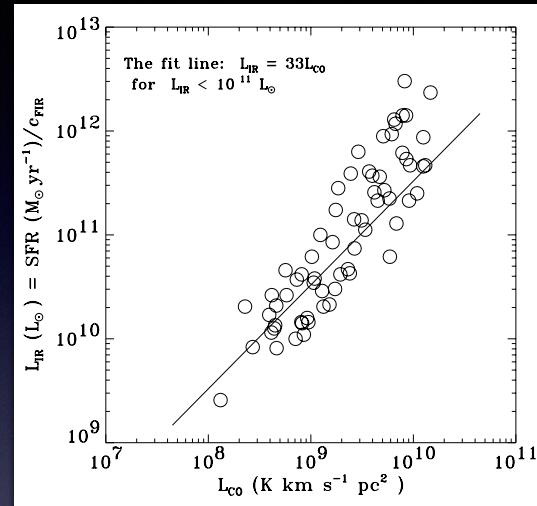
## • Array

- Single-dish, focal-plane array
- All-sky, 1000-element arrays, broadband backends ultimately required

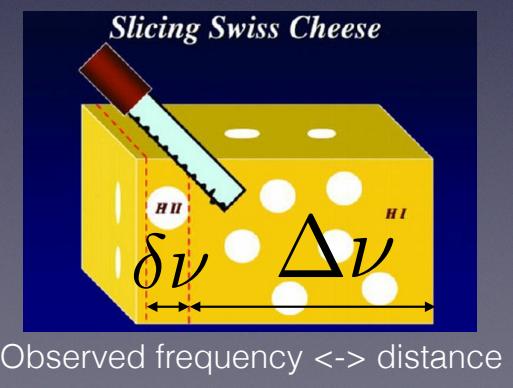
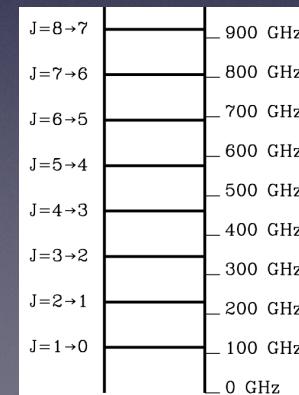
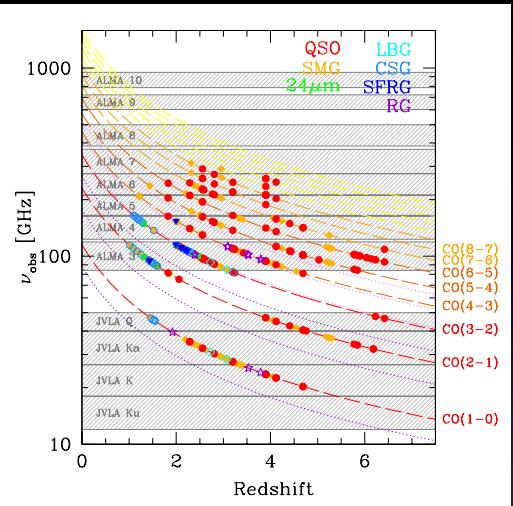
## • Pathfinder

- Test technology and focus on intermediate redshift,  $z \sim 2-3$ .

Gao & Solomon (2004)



Carilli & Walter (2013)





# COMAP collaboration

## Caltech

K. Cleary (PI)  
Tony Readhead  
Tim Pearson  
James Lamb  
David Woody

## Stanford

Sarah Church  
Risa Wechsler  
Tony Li  
Dongwoo Chung



Todd Gaier  
Charles Lawrence  
Brandon Hensley



Andrew Harris



Joshua Gundersen



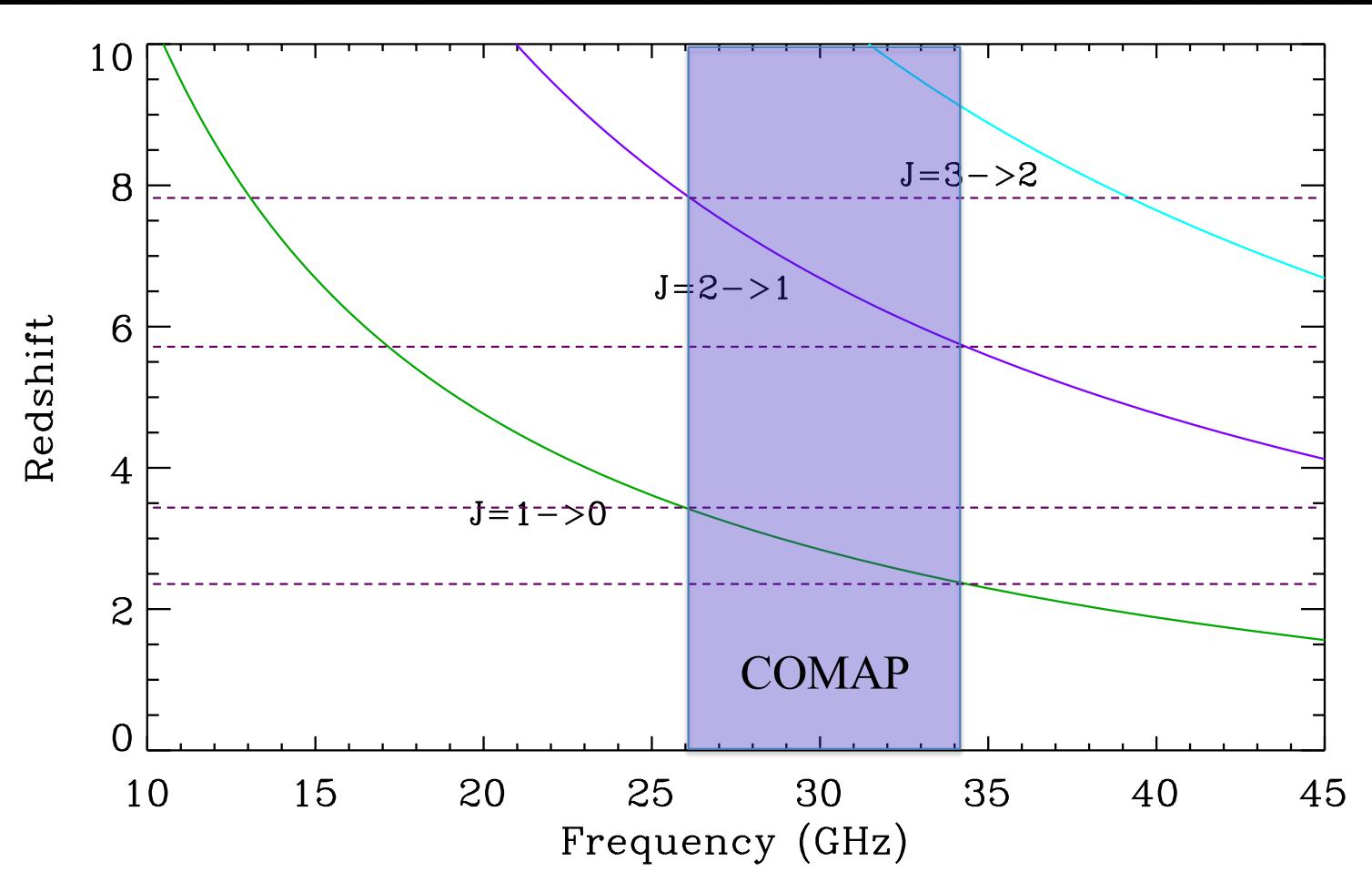
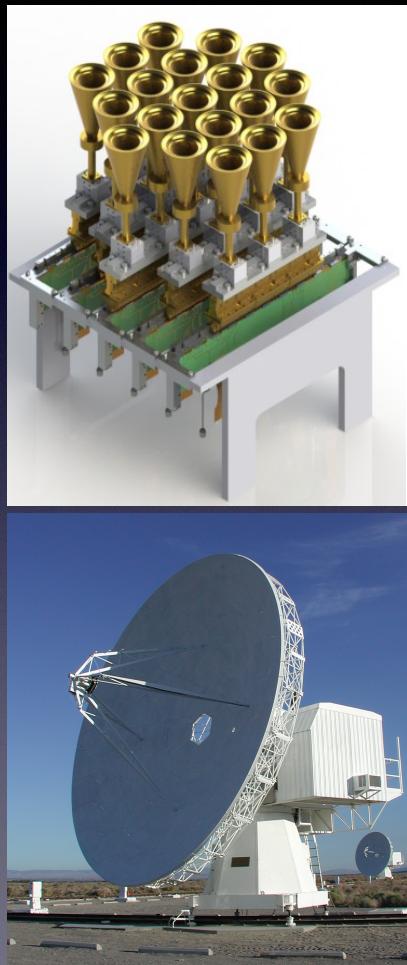
Clive Dickinson  
Stuart Harper



Hans Kristian Eriksen  
Ingunn Wehus

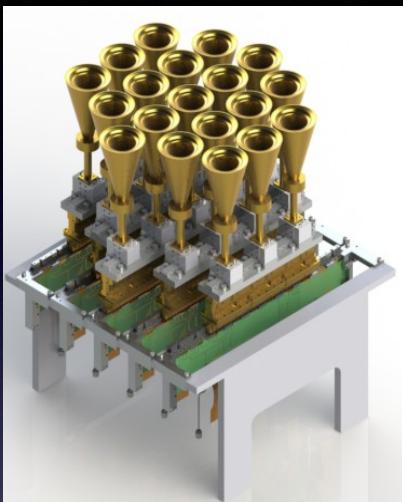


# COMAP Phase I





# COMAP Phase I



## COMAP Phase I

26-34 GHz  
Focal-plane array  
19 single-pol  
pixels

10m  
telescope



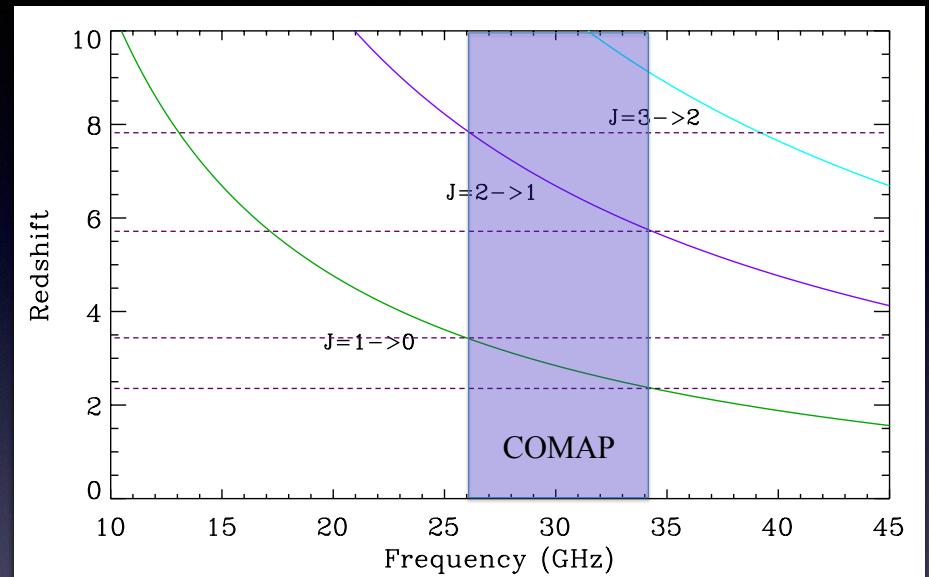
NSF AAG



Observe for 2 years  
10m telescope at OVRO

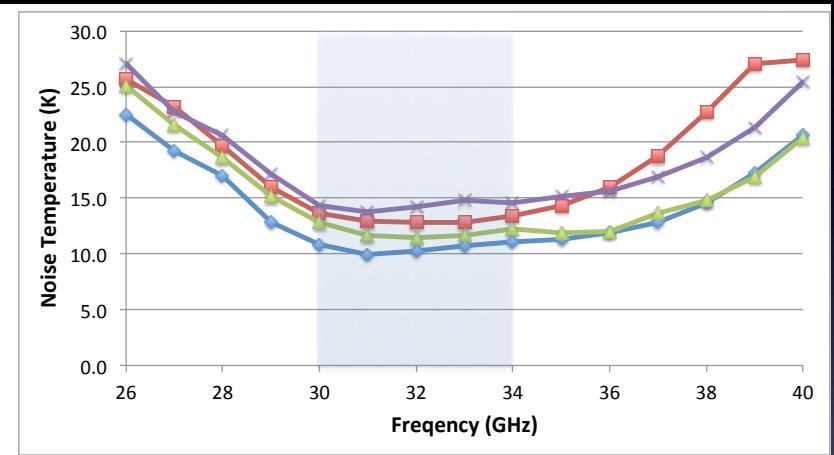
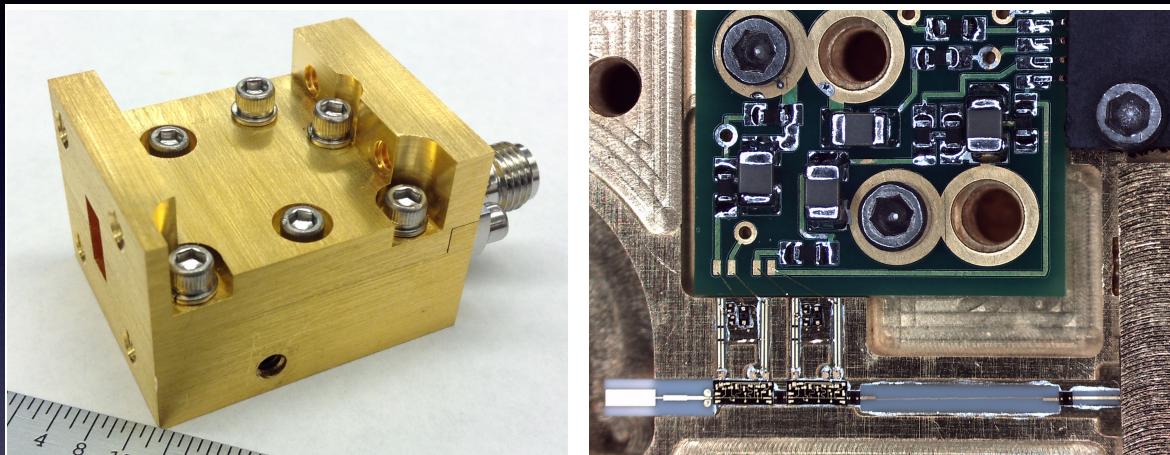
NSF MRI

19 x 8 GHz backend  
CASPER-based





# COMAP LNA modules



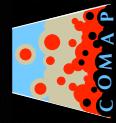
40 LNA modules already built (JPL R&TD)  
Using existing MMIC LNA designs (100 nm)  
Evaluating new 35 nm designs (<12 K noise from 26-34 GHz noise)  
Nominal  $T_{sys}=44$  K (assumes 16 K amplifier noise)



# Experiment Parameters

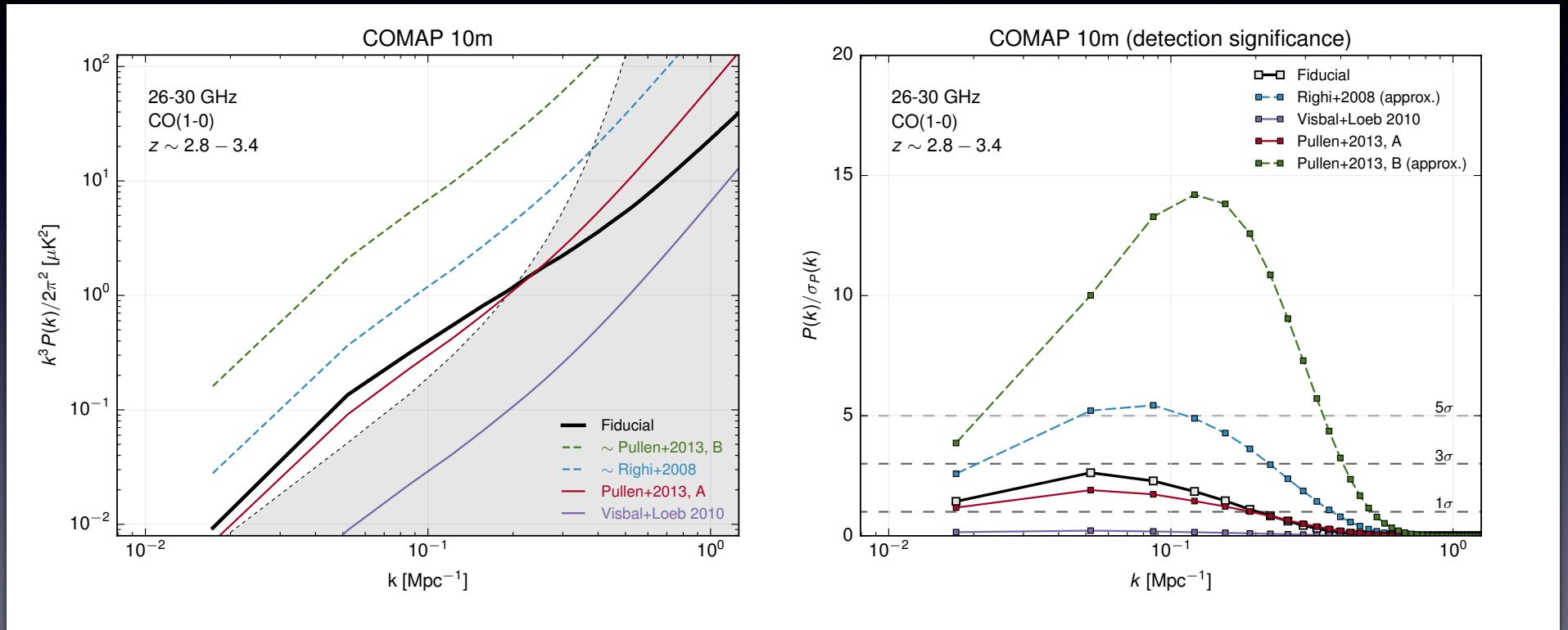
COMAP Parameters	
Angular resolution (arcmin)	~4'
Number of pixels	19
System temperature (K)	44
Frequency coverage (GHz)	26-30 30-34
Spectral resolution (R)	~800
Final map sensitivity per 4 GHz band in single field ( $\mu\text{K}$ )	1.33

- Four fields, each 2.5 sq deg
- 2,000 hrs observing
- Chosen to overlap with galaxy surveys, e.g. COSMOS, DES

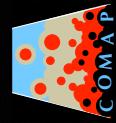


# Phase I sensitivity

Tony Li

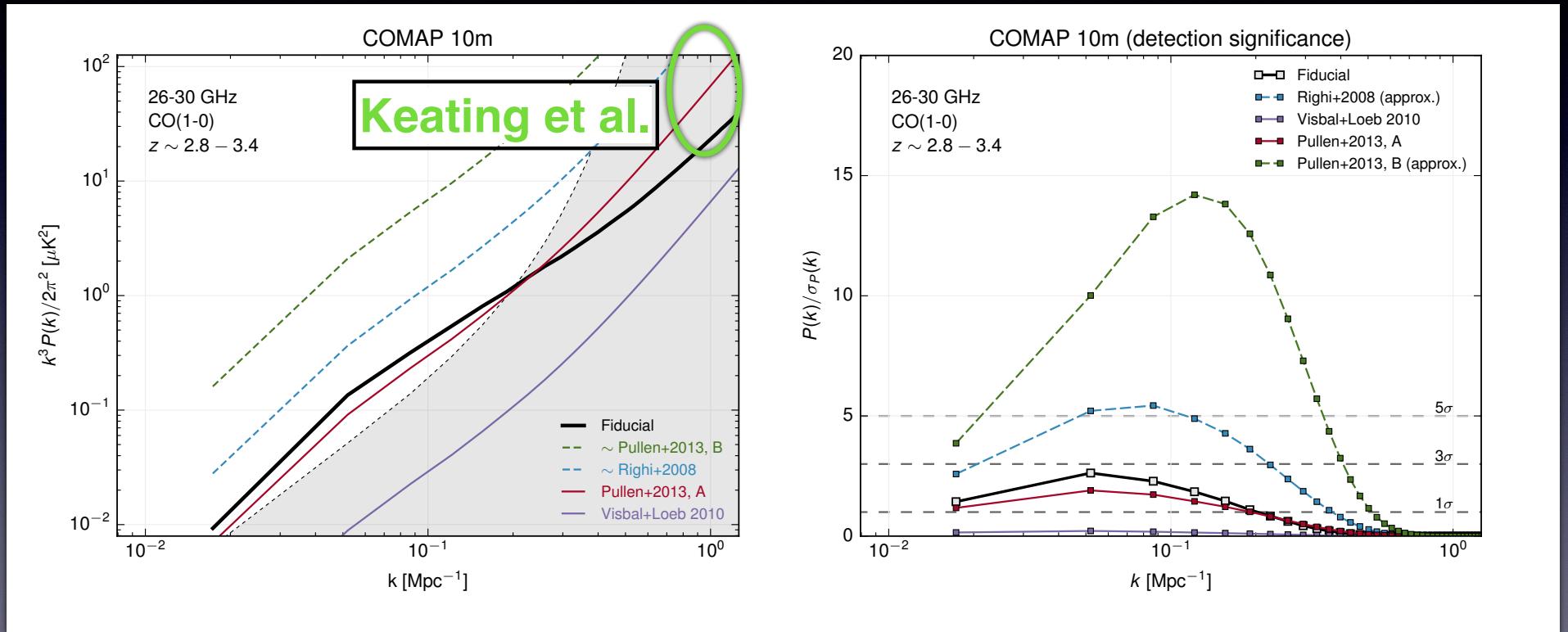


Single 4-GHz band

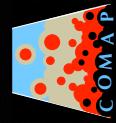


# Phase I sensitivity

Tony Li

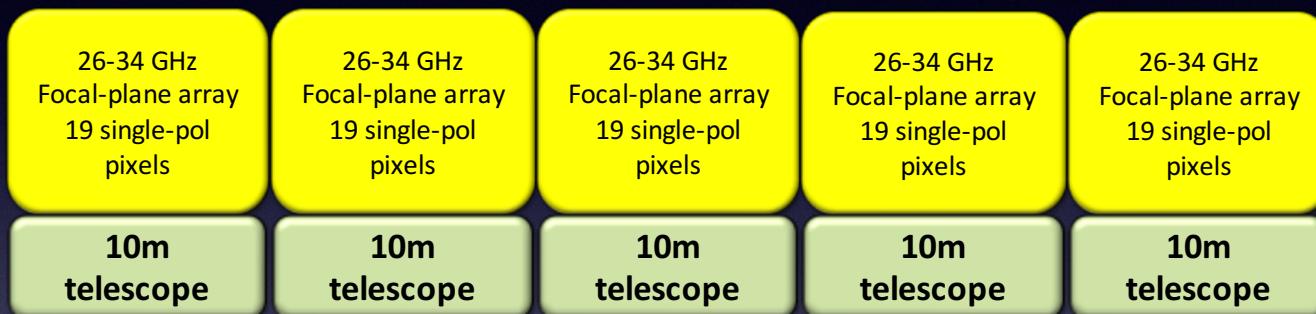


Single 4-GHz band

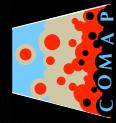


# Phase II

## COMAP Phase II

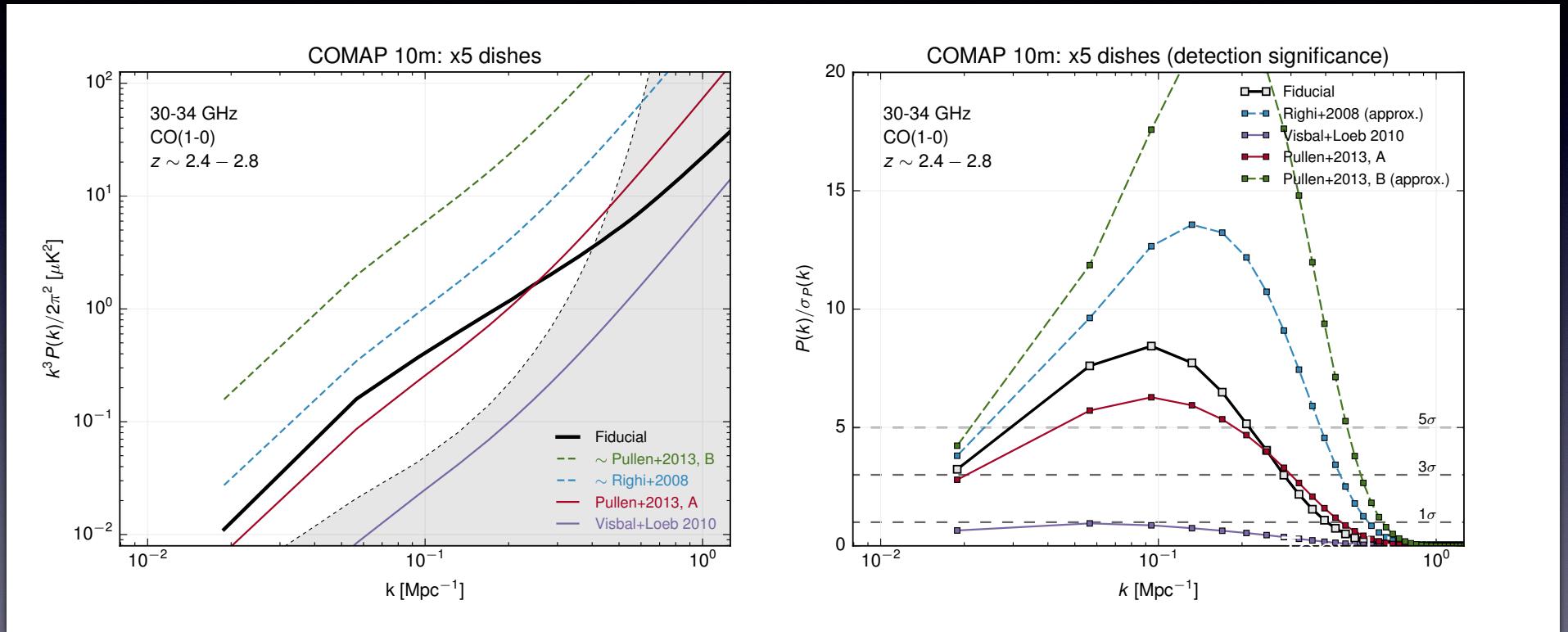


**Observe for 3 years**  
4 GHz backend  
5x10m telescope at OVRO



# Phase II sensitivity

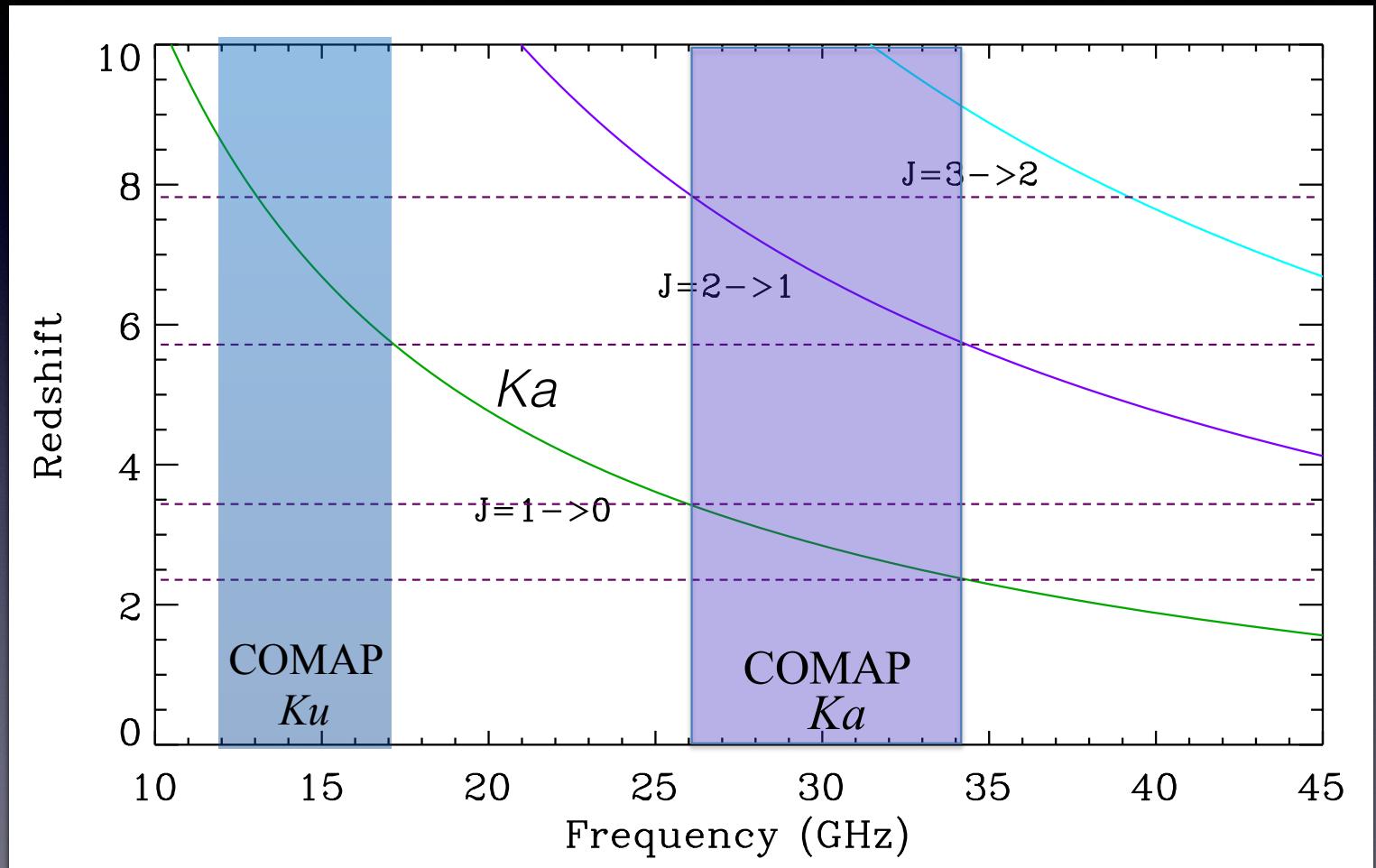
Tony Li

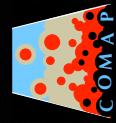


**COMAP Phase II**



# COMAP Phase III





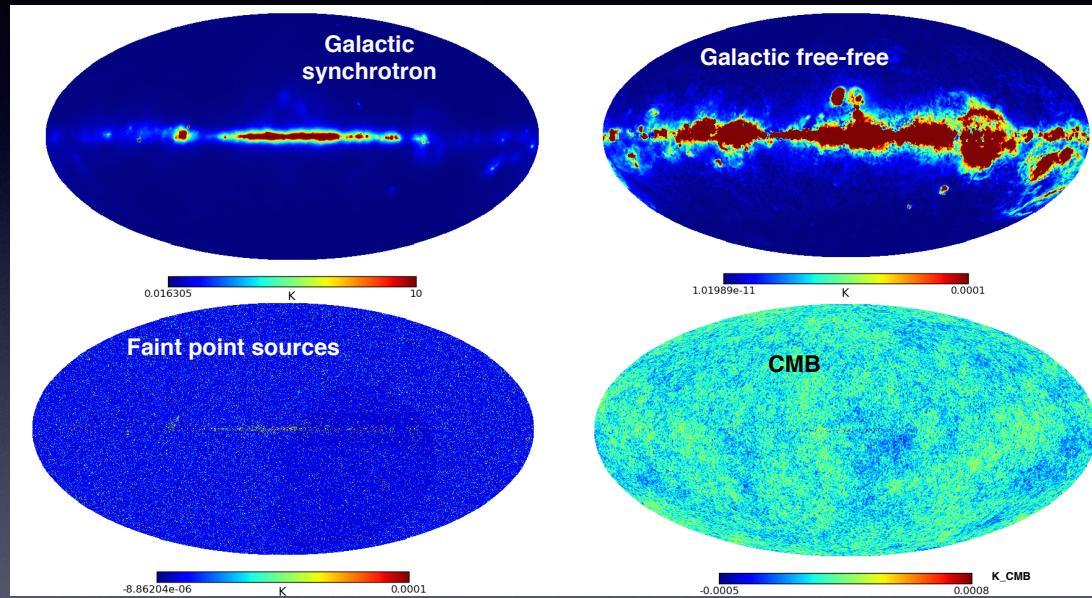
# Foregrounds

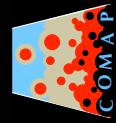
## • Continuum foregrounds

- Free-free
- CMB
- Synchrotron
- Point sources
- Foreground continua fitted out as low-order modes

## • Line foregrounds

- Other lines redshifted into 26-34 GHz band
- HCN (1-0), CN (1-0), CS (1-0), HCO<sup>+</sup>
- Brightest line foreground sub-dominant





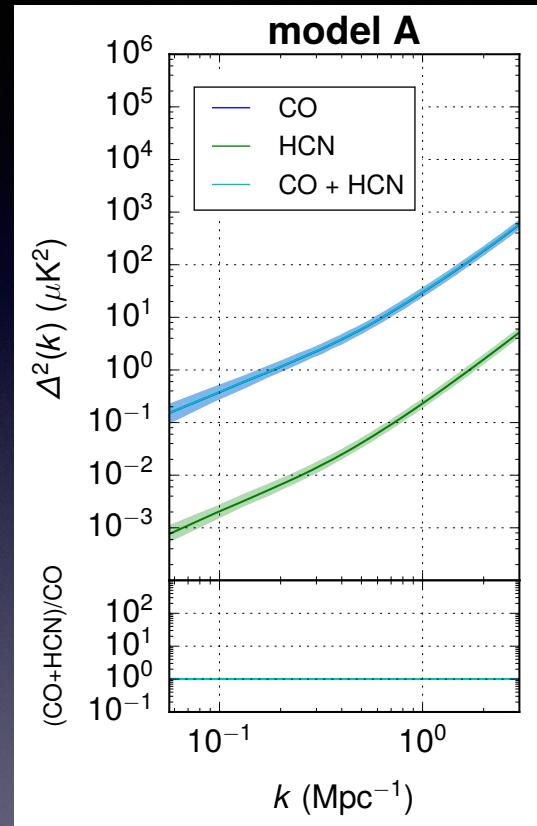
# Foregrounds

## • Continuum foregrounds

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Dongwoo Chung



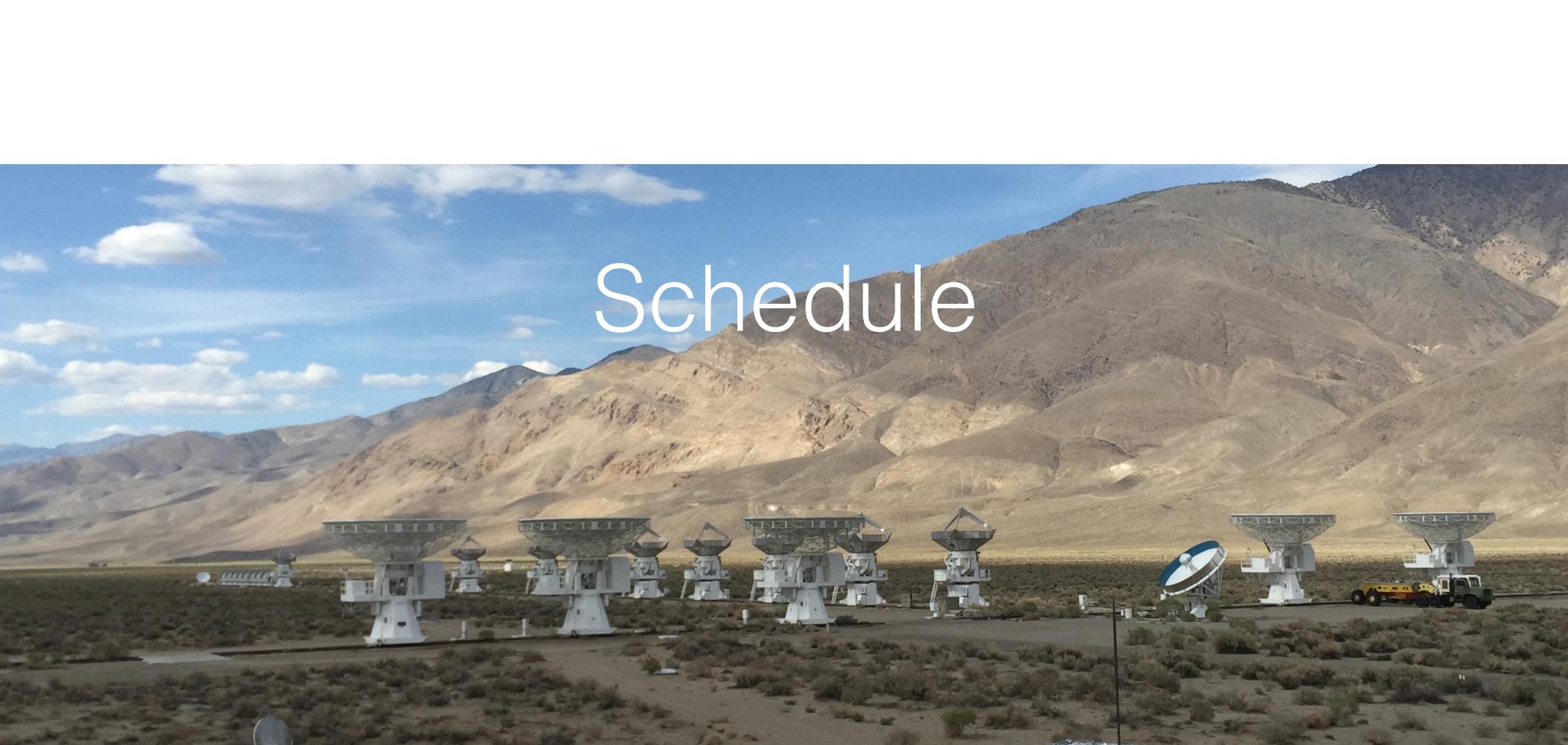
# AME Science

Mapping of extended areas:

- Galactic: NCP, compact targets
- Nearby galaxies

1 MHz spectral resolution (higher possible?)

COMAP Parameters	
Angular resolution (arcmin)	~4'
Number of pixels	19
System temperature (K)	44
Frequency coverage (GHz)	26-30 30-34
Spectral resolution (R)	~800
Final map sensitivity per 4 GHz band in single field ( $\mu\text{K}$ )	1.33



# Schedule

- COMAP Phase I fully funded by NSF (AAG + MRI), KISS, Caltech, Stanford, JPL, Miami, Manchester, Oslo
- 4-year project: 2-year build, 2-year observation
- Start observing October 2017!