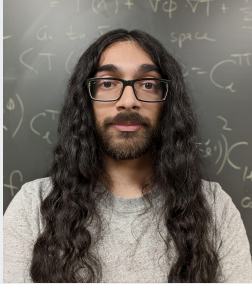


# Extragalactic CO in CMB Surveys

Work in prep with...



Yogesh  
Mehta  
(ASU)



Alexander  
van Engelen  
(ASU)



Anirban Roy  
(NYU)



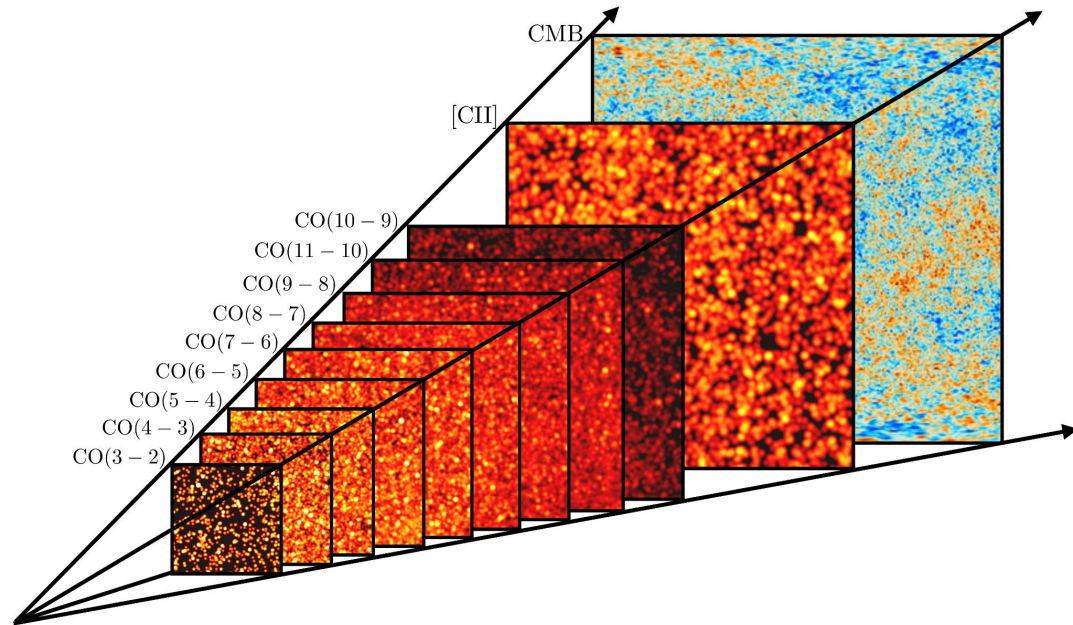
Nicholas  
Battaglia  
(Cornell)



Simon  
Foreman  
(ASU)

# Extragalactic CO in CMB Surveys

- Broad bandpass picks up multiple line transitions at different redshifts
  - e.g. ACT bandpass is 60 GHz at 150 GHz
  - CO<sub>1→0</sub> at 115 GHz
- Not as well-explored as other CMB foregrounds



# Extragalactic CO...

## ... as a Foreground

- CO autospectrum and CIB x CO may be significant foreground in CMB measurements<sup>3,4</sup>, like kSZ detections<sup>5</sup>
- Important for current (ACT, SPT-3G) and future CMB experiments (SO, CMB-S4, etc.)

## ... as a Signal

- Possibly already in existing CMB datasets

SPT



ACT

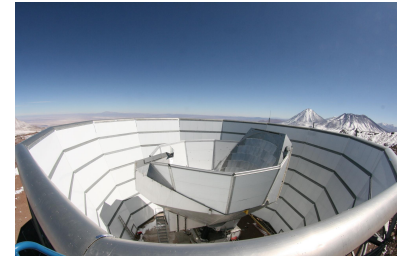


Image: M. Devlin, University of Pennsylvania



<sup>3</sup> Maniyar, A. S. et al. Phys. Rev. D 107, 123504 (2023)

<sup>4</sup> Kokron, N., Bernal, J. L. & Dunkley, J. arXiv (2024)

<sup>5</sup> Reichardt, C. L. et al. arXiv (2020)

# This work

- Explore power from a range of CO models in the literature
  - $M_{\text{halo}} \rightarrow \text{SFR relations}$
  - $\text{SFR} \rightarrow L_{\text{CO}} \text{ relations}$
- Use Gadget2<sup>6</sup> and LIMpy<sup>7</sup> to simulate these models

<sup>6</sup> Springel, V. Mon. Not. R. Astron. Soc. 364, 1105–1134 (2005)

<sup>7</sup> Roy, A., Valentín-Martínez, D., Wang, K., Battaglia, N. & Engelen, A. van. Arxiv (2023)

The screenshot shows the GitHub repository page for 'Anirban Roy / Limpy'. The repository is public and has 2 branches and 0 tags. It contains 41 commits. The file list includes 'data', 'examples', 'images', 'limpy', '.gitignore', 'LICENSE', 'README.md', and 'setup.py'. The README section is visible, showing a logo for LIMPY and a description: 'A python package for multi-line intensity mapping'. The repository has 3 stars and 1 fork.

File	Commit Message	Time
data	added untracked files	3 months ago
examples	bad commit	2 months ago
images	initial commit	last year
limpy	bad commit	2 months ago
.gitignore	moved functions in analysis.py to powerspectra.py	last year
LICENSE	Create LICENSE	last year
README.md	Update README.md	last year
setup.py	added untracked files	3 months ago

**README** MIT license

**LIMPY**

A python package for multi-line intensity mapping

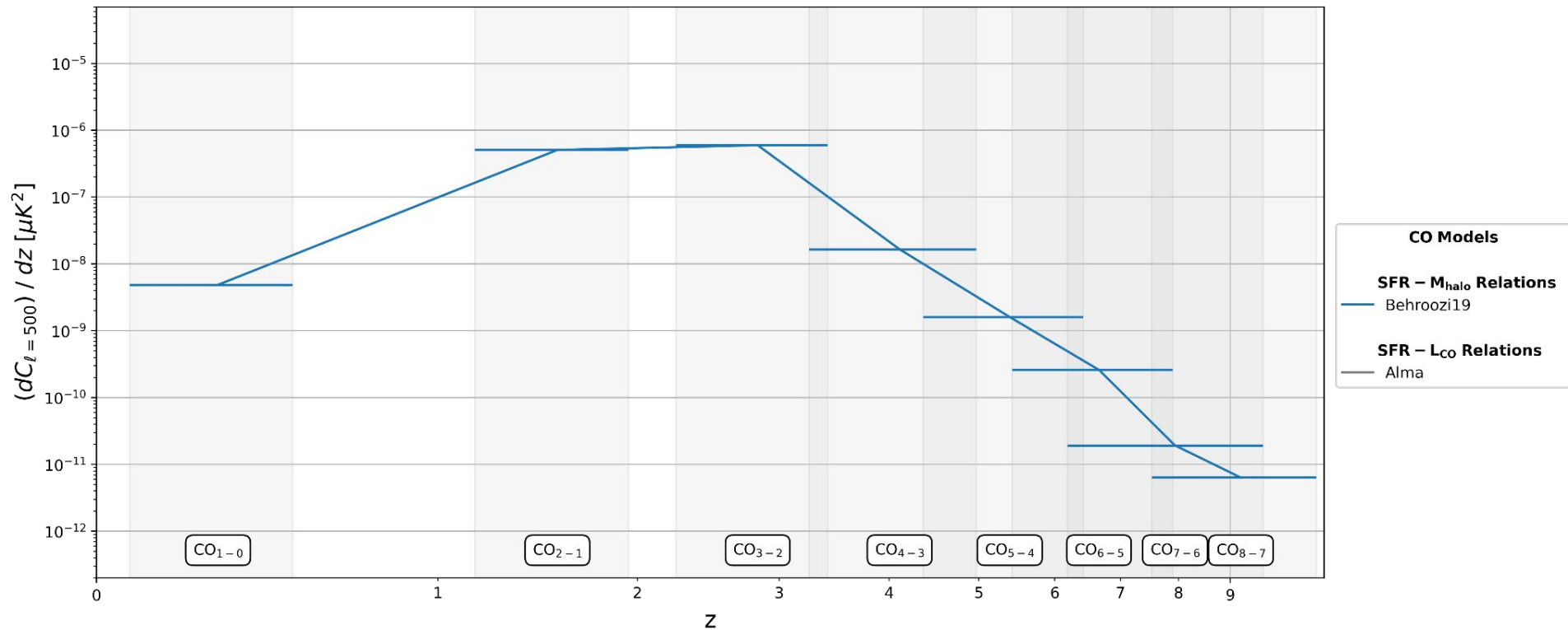
Readme  
MIT license  
Activity  
3 stars  
1 watching  
1 fork  
Report repository

**Releases**  
No releases published

**Packages**  
No packages published

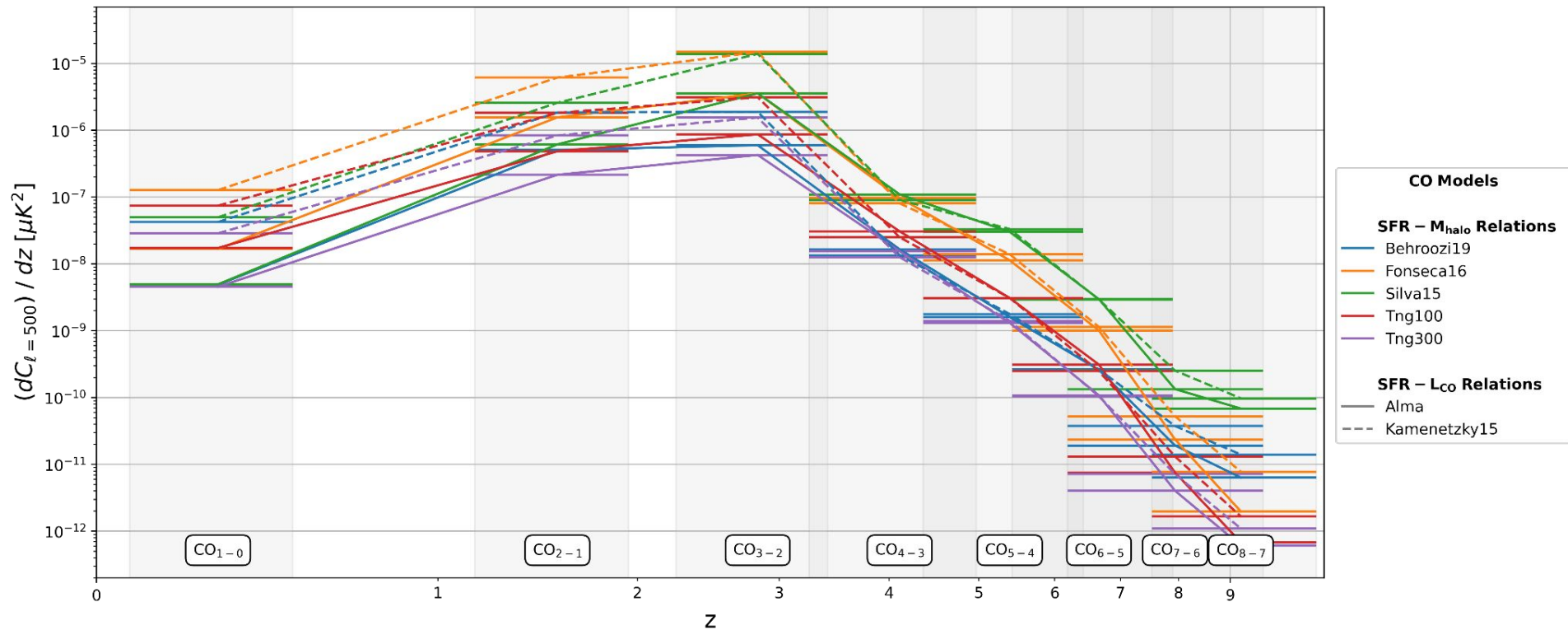
**Languages**  
Python 100.0%

90 GHz,  $\ell = 500$

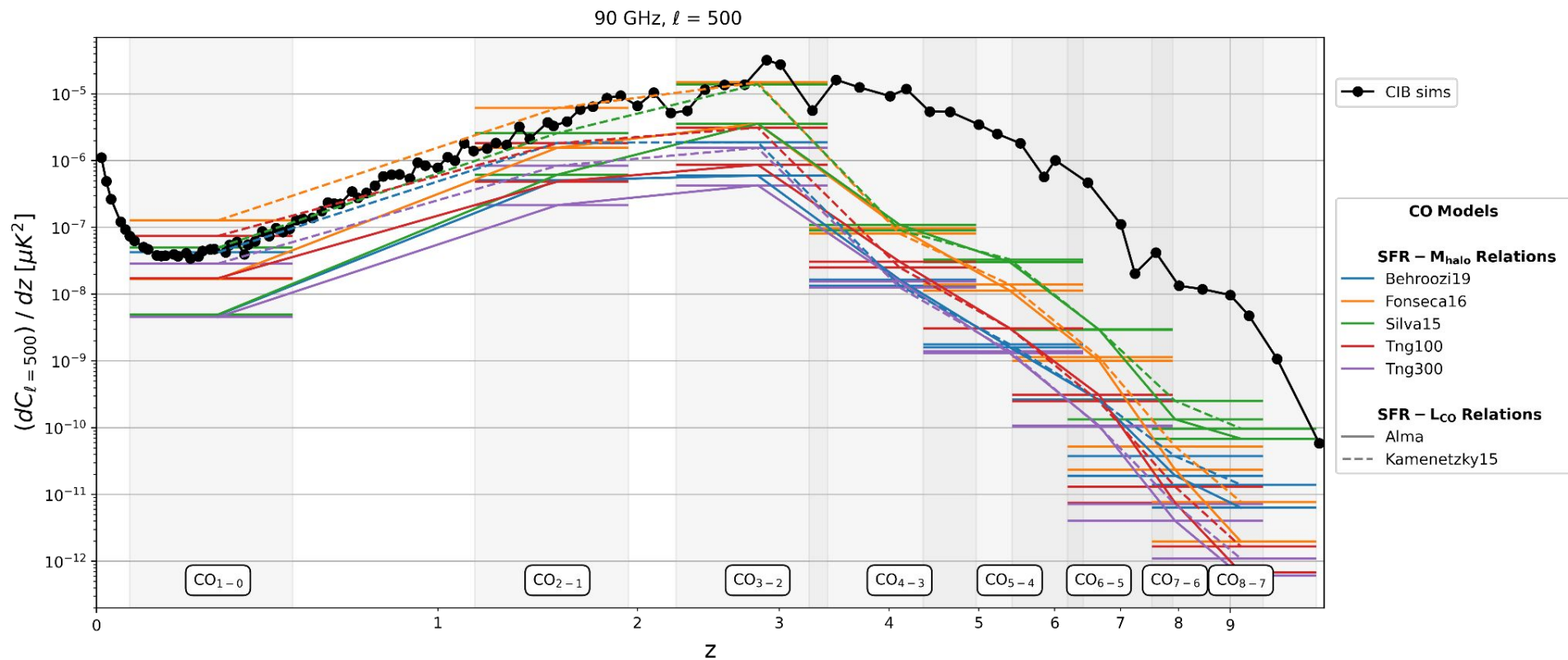


- Broad bandpass → wide redshift ranges
- CO<sub>3-2</sub> is the strongest contributor, but depends on model and observing frequency

90 GHz,  $\ell = 500$

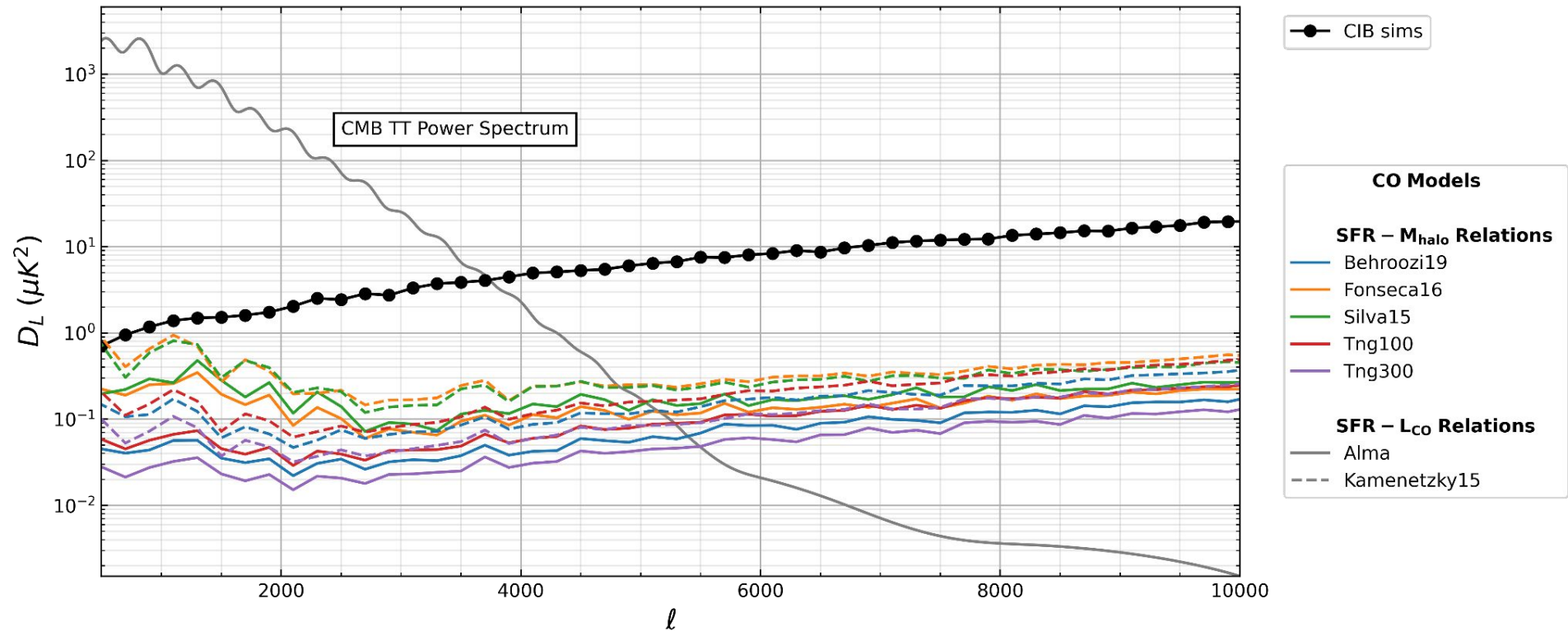


- Large theoretical uncertainty
- CO traces star formation



● Similar redshift evolution for CO and CIB → highly correlated

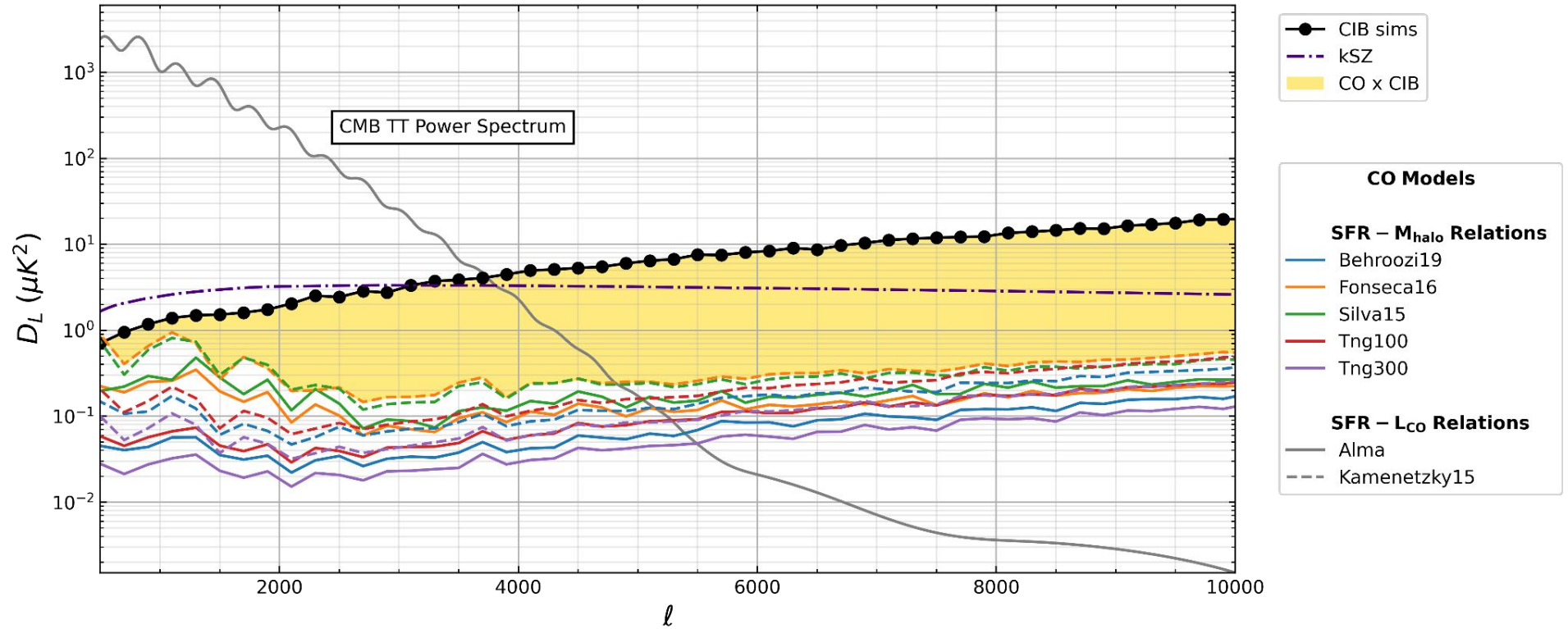
90 GHz,  $z \sim 0.01 - 11.98$



- CO's detectability in current CMB data depends on the model



90 GHz,  $z \sim 0.01 - 11.98$



● CIB x CO may bias kSZ detections



## Conclusions - Extragalactic CO in CMB Surveys

- **As a Signal:** May be detectable in current data
  - Great theoretical uncertainty on modeling
- **As a Foreground:** Must be understood for future CMB science (e.g. kSZ)
  - Ongoing work: quantify CO x CIB for various CIB models
- Other work in progress: Extragalactic CO as a CMB lensing bias