# Forecasting with foregrounds:
## searching for optimal spectral distortion mission configurations

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Spectral Distortions Workshop

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# Overview

- *Prospects for Measuring Cosmic Microwave Background Spectral Distortions in the Presence of Foregrounds.*
  - Abitbol, Chluba, Hill, and Johnson, MNRAS 471, 1 (2017).
  - doi.org/10.1093/mnras/stx1653

# Overview

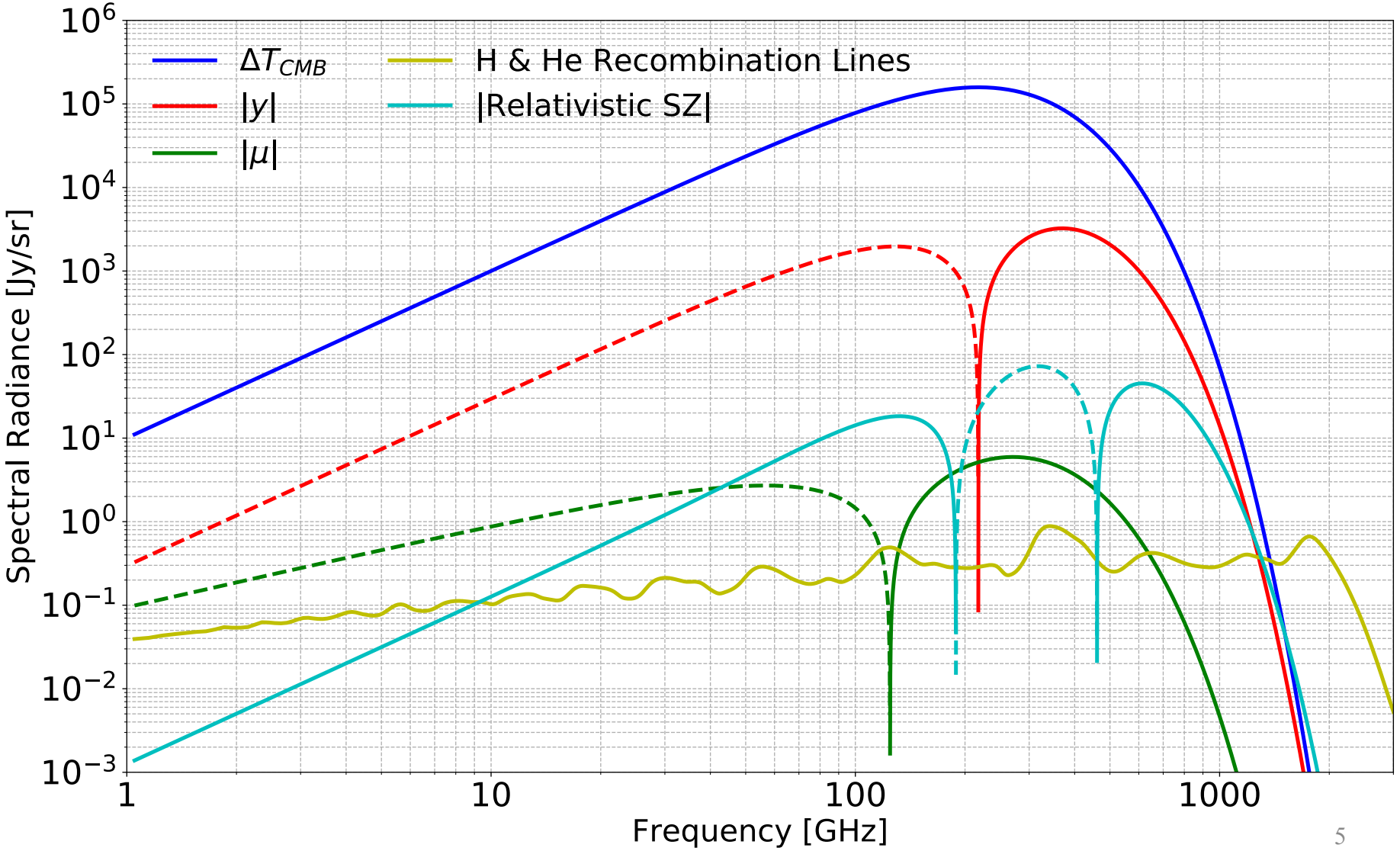
- Spectral distortion sensitivity forecasts, with known foregrounds, for PIXIE and PRISTINE.
  - Previous forecasts did not include detailed foreground modeling.
  - MCMC and Fisher methods to estimate bias and uncertainties.
- Varied mission parameters to maximize spectral distortion detection.

# Uncertainty Estimation

- Fisher:
  - Parametric modeling.
  - Turn experiment sensitivity into parameter uncertainties.
- CMB Signals:
  - CMB monopole temperature, y distortion, relativistic correction to y distortion, and mu distortion.
- Foregrounds:
  - Thermal dust, cosmic infrared background, synchrotron, free-free, spinning dust, integrated CO.

# Spectral Distortion Signals

$\Delta T/T = 1.2\text{x}10^{-4}$, $y = 1.77\text{x}10^{-6}$, $kT_{eSZ} = 1.245$ keV, $\mu = 2\text{x}10^{-8}$



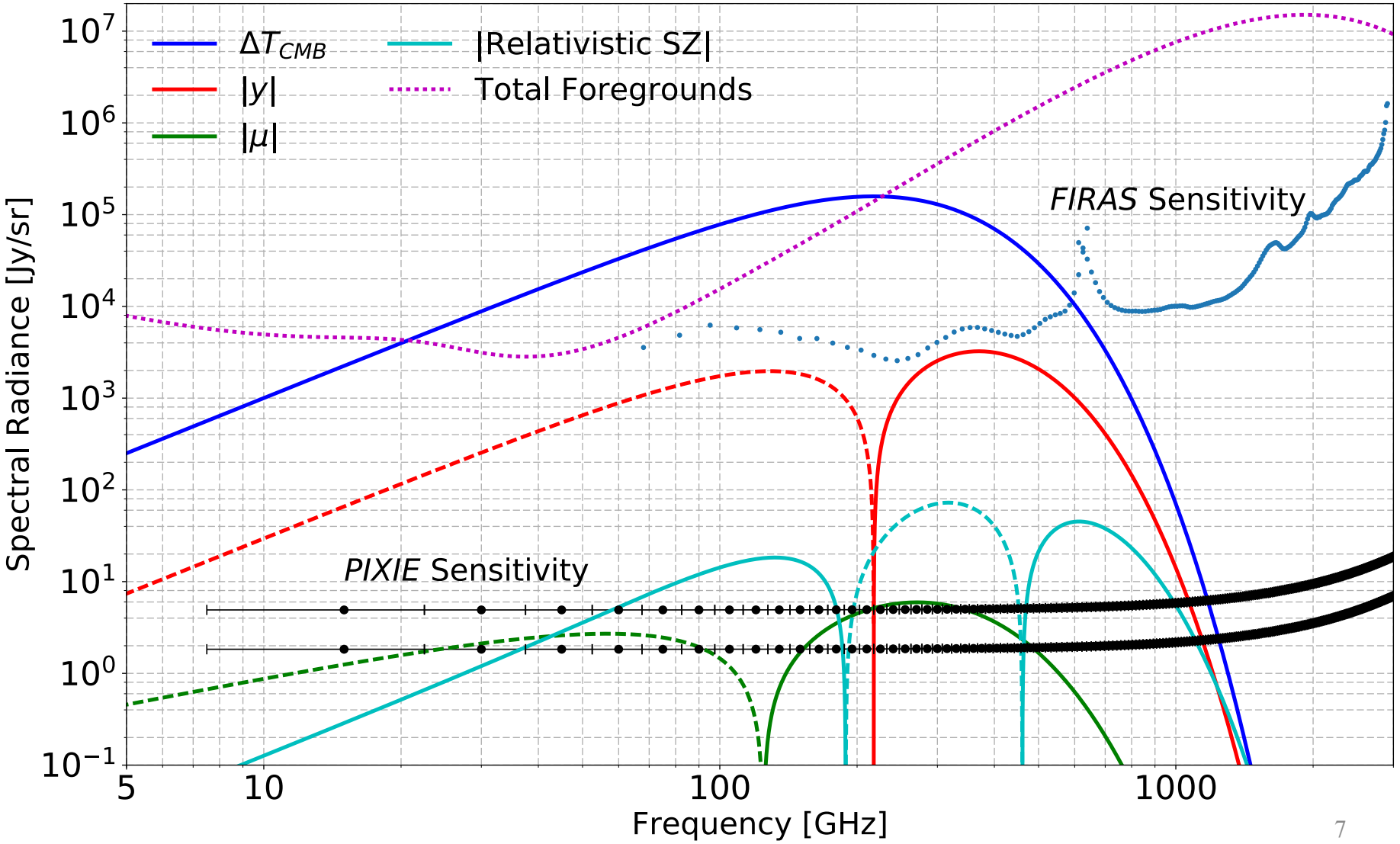
# PIXIE Example

- Absolutely calibrated Fourier transform spectrometer.
- 15 – 6,000 GHz frequency coverage, 15 GHz channel width.
  - Center Frequencies:

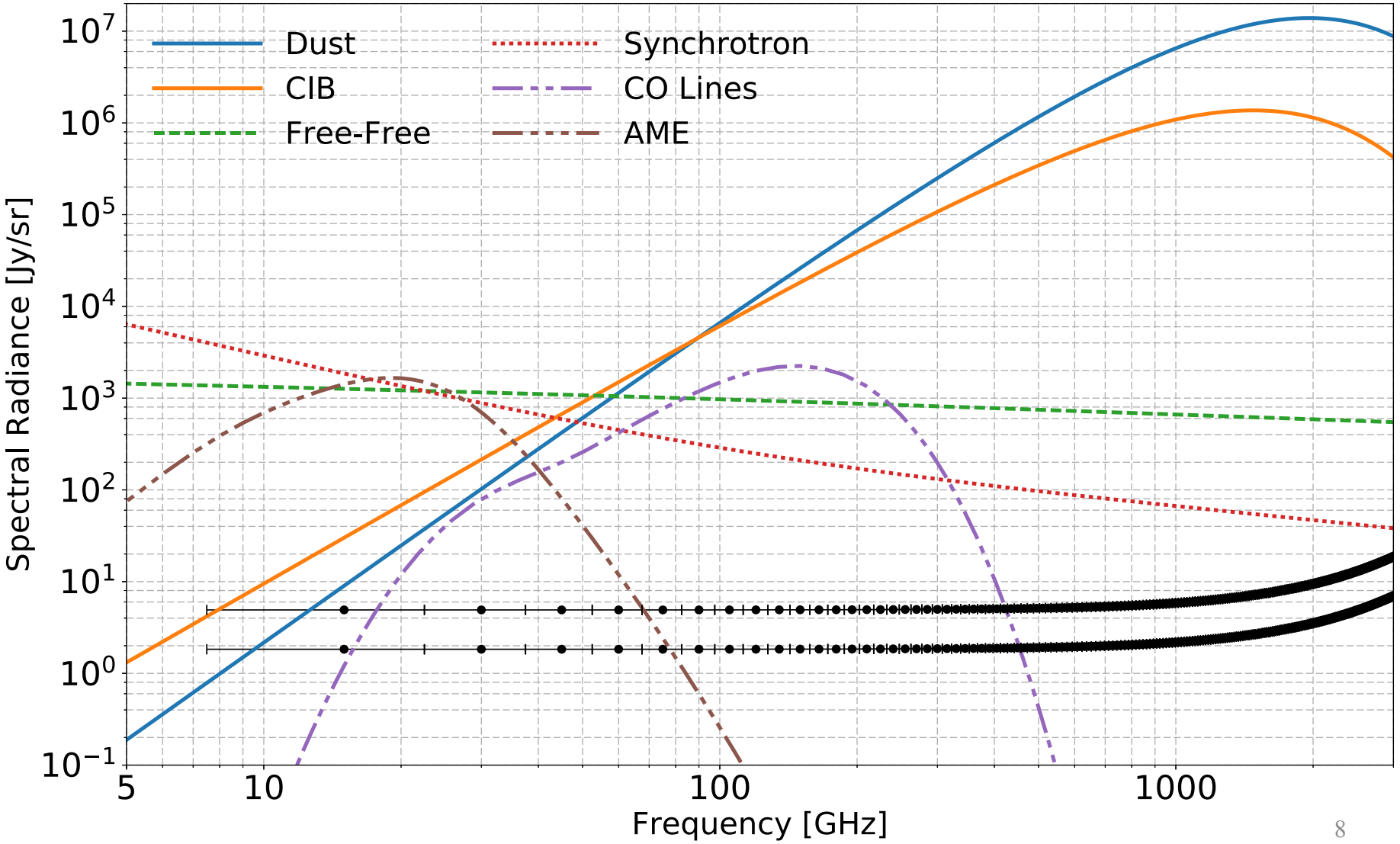
    15, 30, 45, 60, …, 6000 GHz
  - Band Edges:

    7.5 – 22.5, 22.5 – 37.5, 37.5 – 52.5 GHz, etc.

# PIXIE Sensitivity



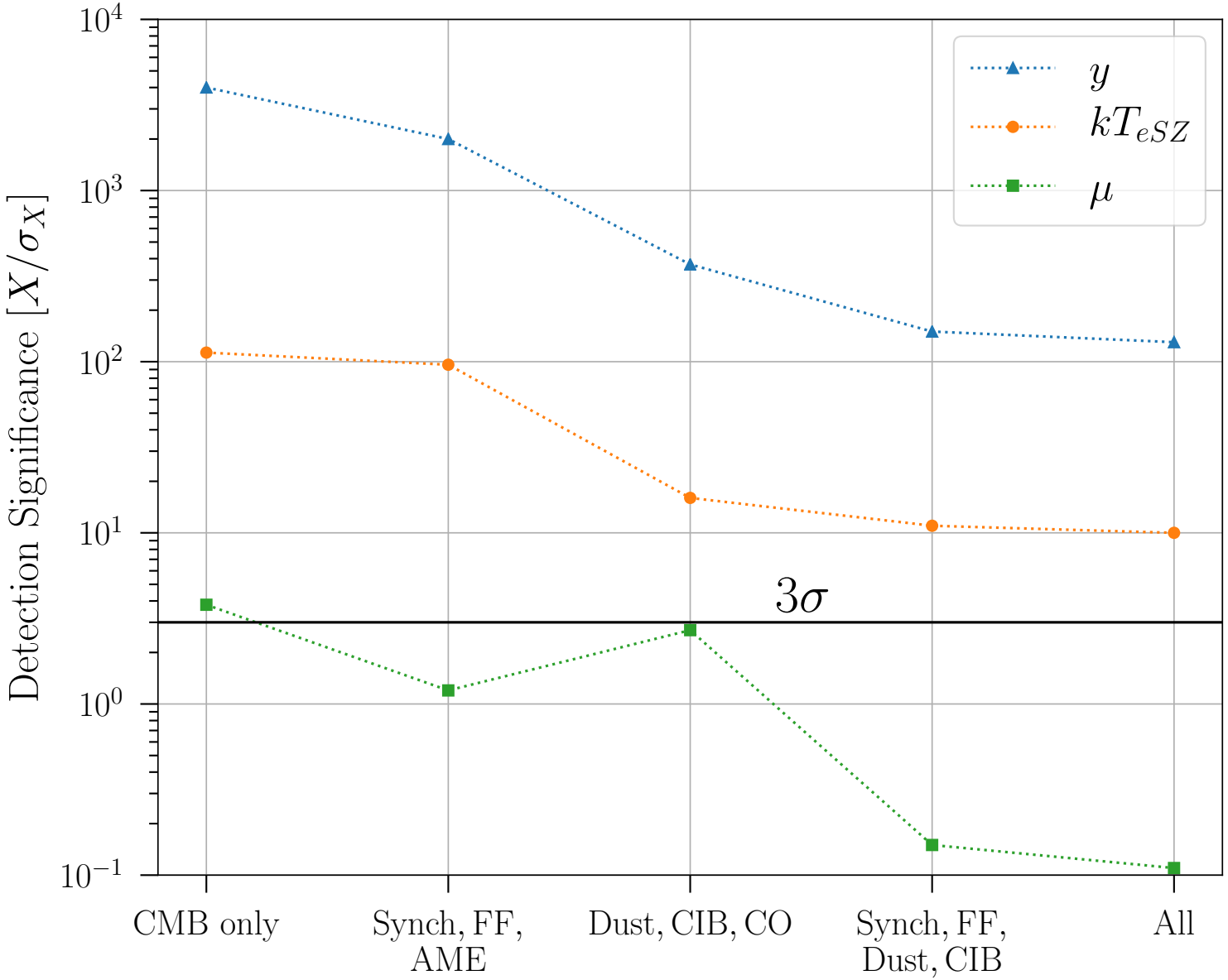
# Foregrounds



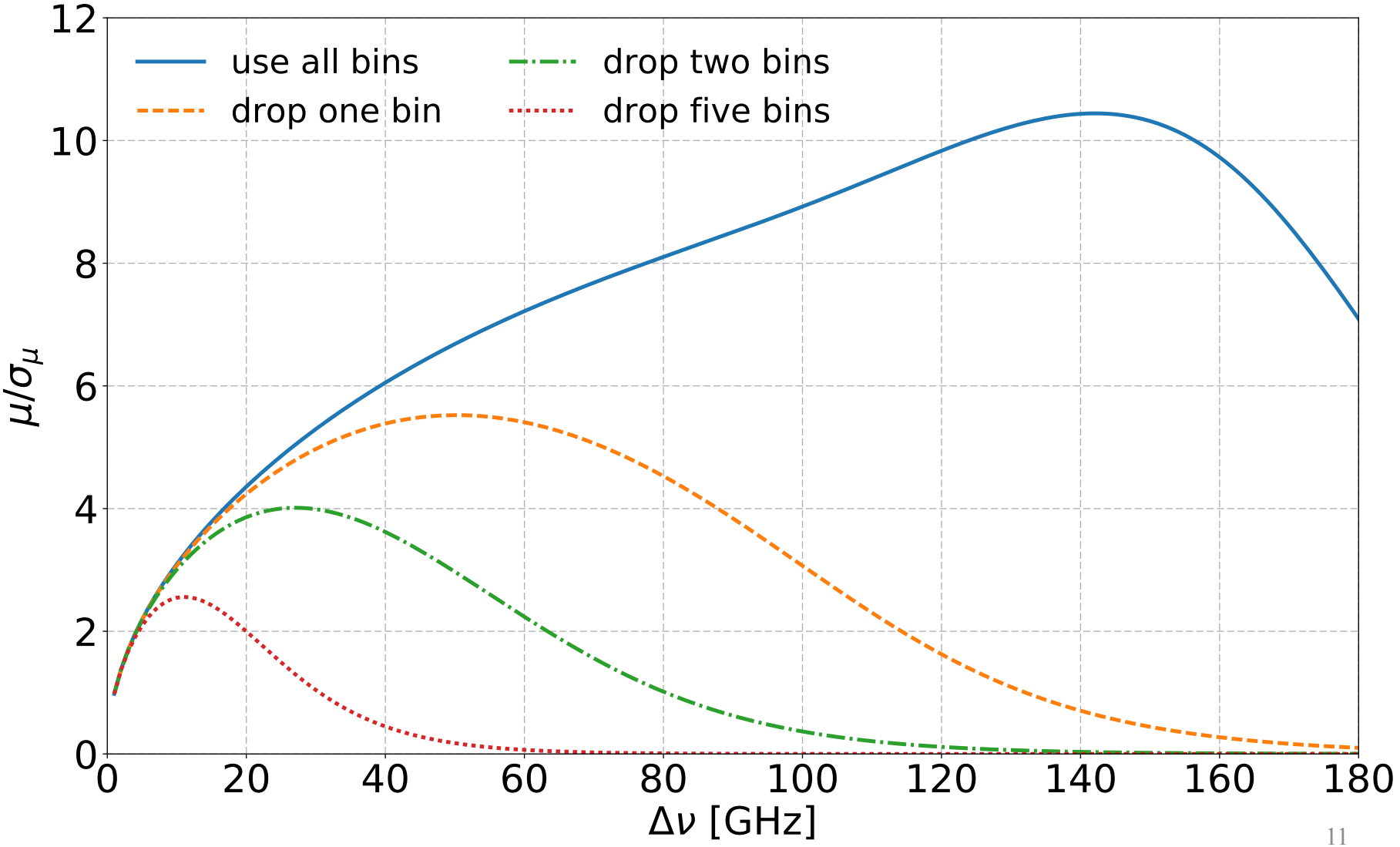
# Fisher Uncertainty Estimation

$$F_{ij} = \sum_{a,b} \frac{\partial(\Delta I_\nu)_a}{\partial p_i} C^{-1}_{ab} \frac{\partial(\Delta I_\nu)_b}{\partial p_j}$$

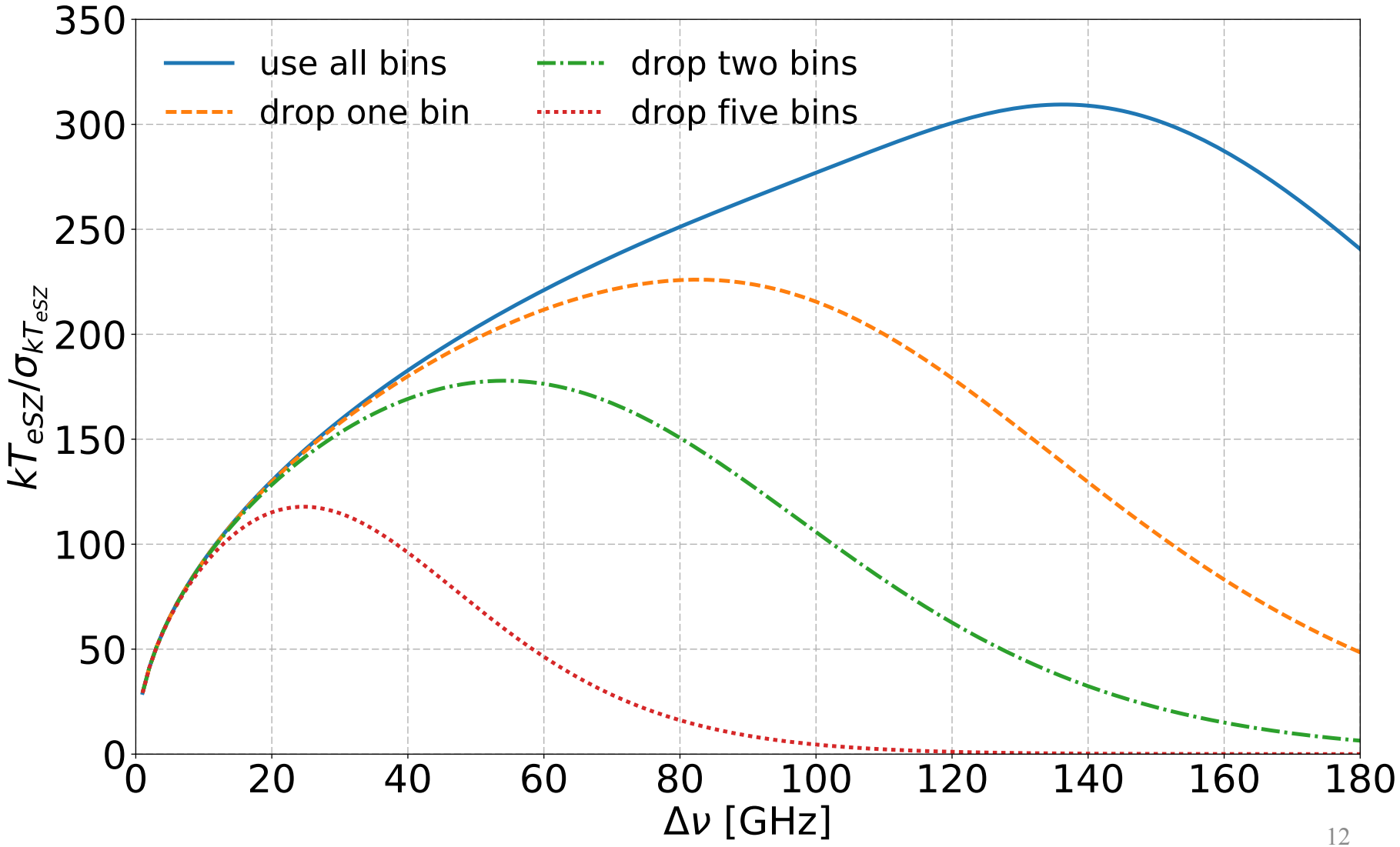
# Forecast with Foregrounds



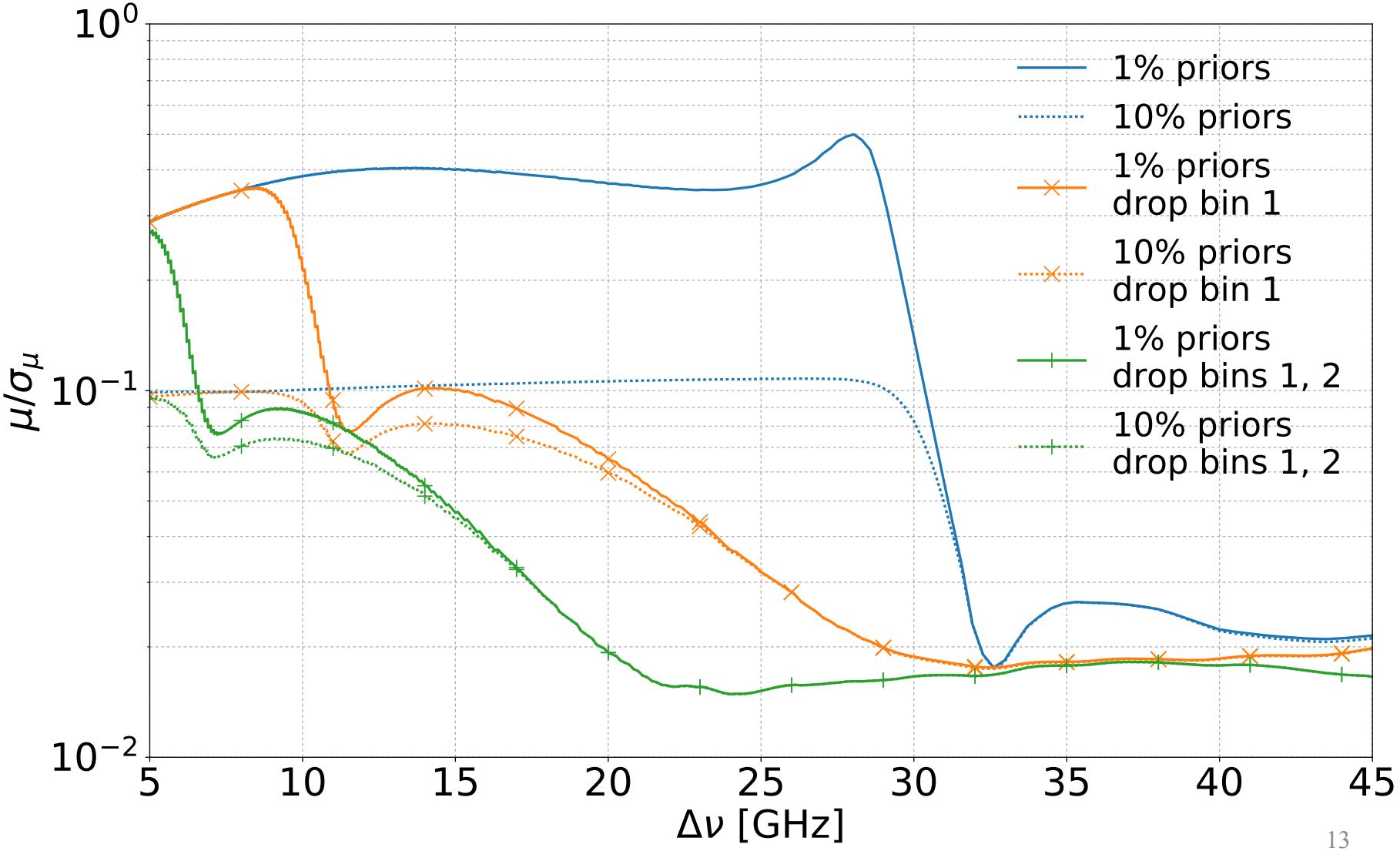
# Mu detection – CMB only



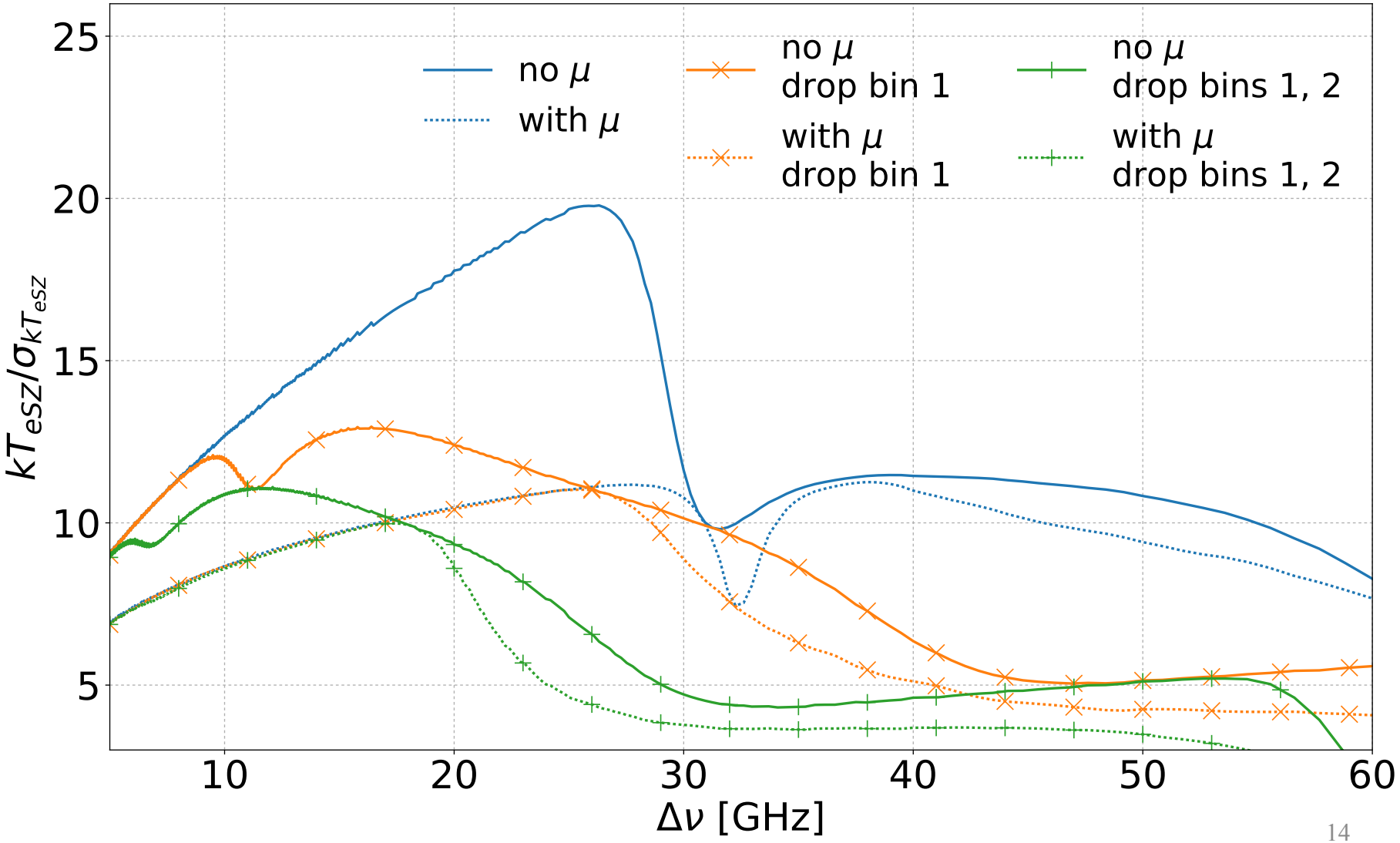
# Relativistic SZ detection – CMB only



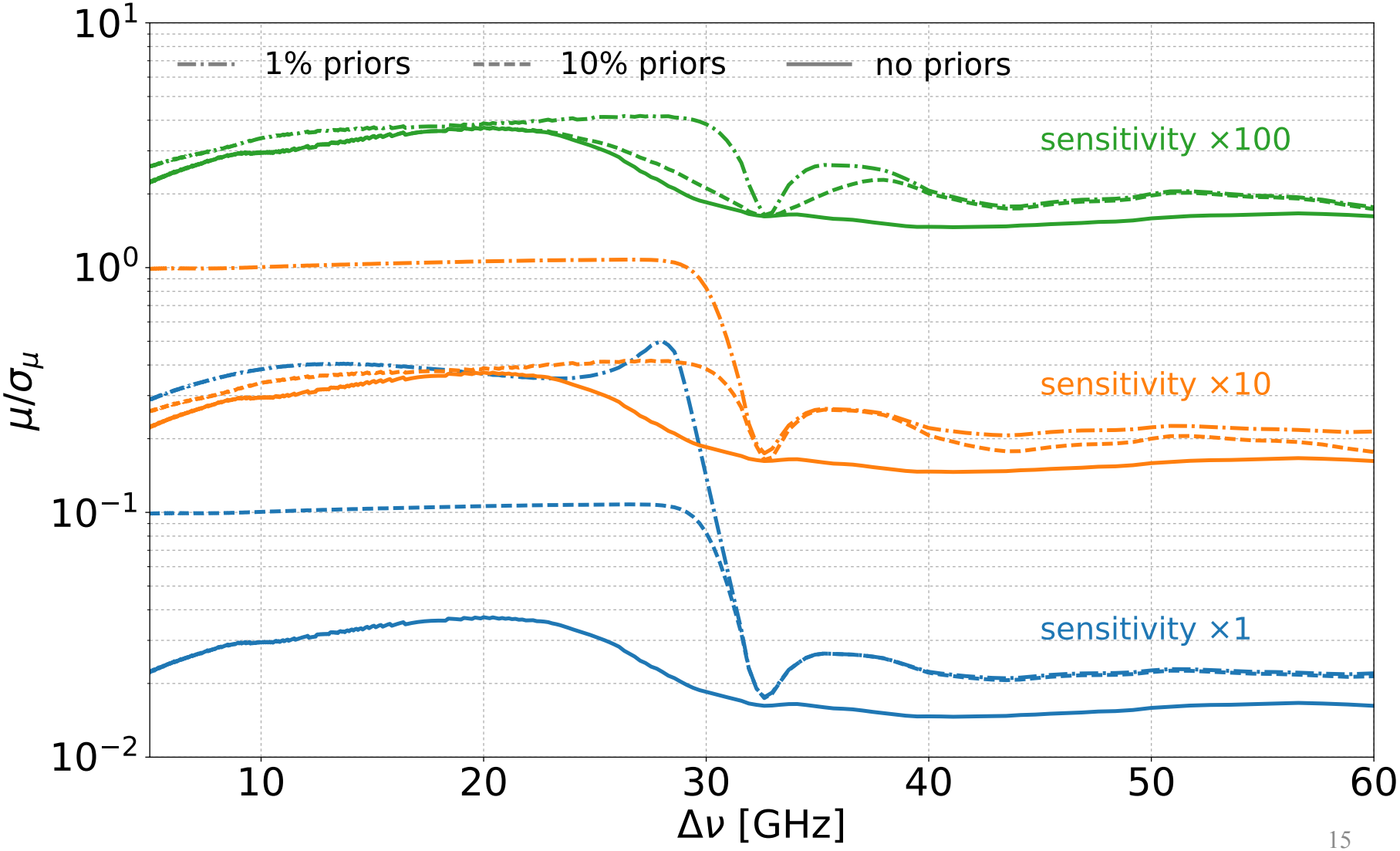
# Mu detection – with foregrounds



# Relativistic SZ detection – with foregrounds



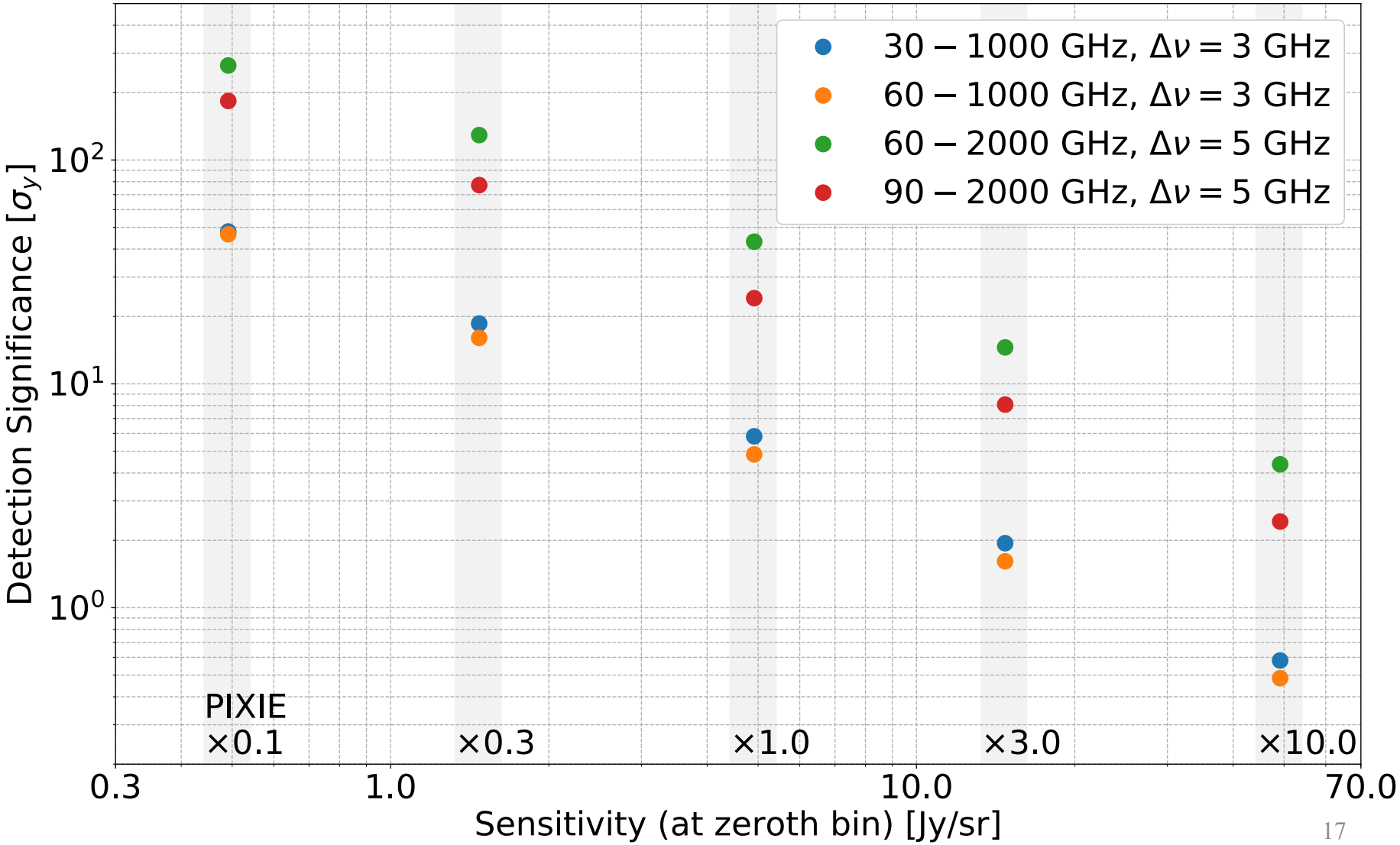
# Mu detection – increasing sensitivity



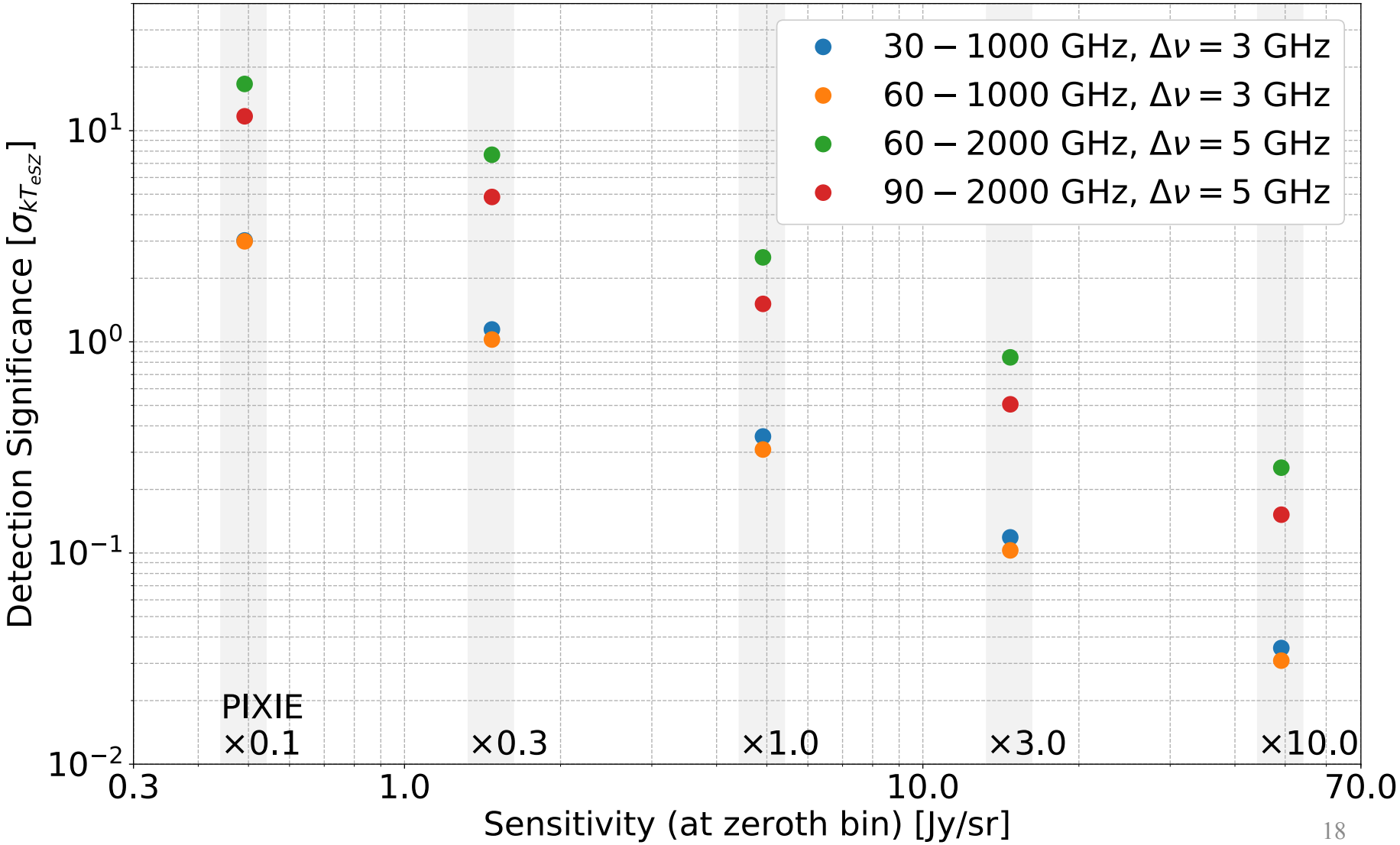
# PRISTINE

- Proposed FTS spectral distortion mission .
  - PIXIE-like
- Possible options:
  - 30 – 1000 GHz, 3 GHz spacing
  - 60 – 1000 GHz, 3 GHz spacing
  - 60 – 2000 GHz, 5 GHz spacing
  - 90 – 2000 GHz, 5 GHz spacing

# Y detection – PRISTINE configurations



# Relativistic SZ detection – PRISTINE



# Conclusions

- Foregrounds dominate spectral distortions signals.
  - Low frequency (10 - 100 GHz) sensitivity is important to detect mu.
  - High frequencies (100 GHz - 2THz) is needed for y and the relativistic correction.
- PIXIE detects y and the relativistic correction with high significance even with foregrounds.
- Future Work:
  - More general instrument optimization.
  - Super PIXIE could detect mu.
  - Spatial information is not yet included!